ZLV

Distance
Protection IED

Instructions Manual for **ZLV** Models
M0ZLVA1810Iv08

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Chapter 1.

Description and Start-Up

1.1 Functions

The IED generically designated as **ZLV** combines all the necessary functions required for full protection of line positions. These IEDs use the most advanced digital technology based on powerful microprocessors and DSP's, and incorporates **Distance**, **Overcurrent**, **Over / Undervoltage** and **Over / Underfrequency** protection, **Recloser**, **Synchronism Detection**, **Control** and **Metering** functions.

ZLV systems are of application in high and medium voltage lines, no matter whether overhead, underground or a combination of both, and no matter whether they incorporate series compensation or not.

ZLV IEDs combine **Distance** metering device (and complementary units such as **Close-onto-Fault**, **Dead-Line**, **Remote Breaker Open Detector**, **VT Fuse Failure**, **Power Swing** and **Load Encroachment** detectors), with **Voltage** metering device (Phase Over / Undervoltage and Ground Overvoltage), **Current** metering device (Phase, Ground and Negative Sequence Instantaneous and Time Overcurrent, Stub Bus Protection, Thermal Image Protection, Breaker Failure Protection and Open Phase Detector) and **Frequency** metering device (Over / Underfrequency and Frequency Rate of Change).

Protection Schemes can be added to both distance and overcurrent elements for instantaneous tripping along the entire length of the line.

The **ZLV-B/F/G/J** relay allows for **Single-Phase** or **Three-Phase** tripping (it can be set to three phase tripping only) using Single/three-phase tripping logic. Tripping of **ZLV-A/E/H** models is always **Three-phase**.

The **ZLV-B/F/G/J Recloser** allows for reclosing either single-phase or three-phase trips or both; four different modes of reclosing operation being possible in order to do so. Furthermore, prior to a reclosing command, it will optionally check synchronism, and this information can be supplied by the equipment **Synchronism Unit**. **ZLV-A/B/E** relays can perform 3 reclosing attempts. In some **ZLV-F/G/H/J** models it is possible to perform up to 4 reclosing attempts. The **ZLV-G/J** relays recloser controls two breakers.

ZLV relays also include **Command Logic** to perform breaking and closing operations and generate from these operations as well as from tripping and reclosing commands, trip and close failure information.

Also, **Breaker Monitoring** functions are provided to detect an excessive number of tripping operations. The terminal units are also equipped with **up to six trip and close circuit supervision elements** to detect breaker trip coil and close coil circuit failure (depending on model).

Finally, the equipment includes functions for **Oscillography Records** (analog and digital channels), **Fault Reports** (with **Fault Location**), **Event Recording** and **Historical Metering Data Logging**, **Programmable Logic** and **Integrated Simulator** (depending on the model).

The **ZLV-E** model is a reduced version of the **ZLV-A** model. The following functions are excluded in this model: **Remote Breaker Open Detector**, **Stub Bus Protection**, **Breaker Failure**, **Open Phase Detector**, **Frequency Elements**, **Teleprotection Schemes** (except for the Step Distance and the Zone 1 Extension) and **Supervision of the Trip and Close Coils**.

1.1.1 Distance Protection (21/21N)

ZLV relays include up to 6 reversible distance zones, each provided with six separate metering elements.

Each zone includes own settings for reach (Z1) and zero sequence compensation (K0=Z0/Z1, applied to ground elements), both in magnitude and angle, independent from the other zones, which gives metering devices a greater accuracy in mixed line applications.

The distance units have independently selectable Mho and/or Quadrilateral characteristics for phase and ground faults.

In double circuits, some relays enable, in distance elements, a zero sequence mutual coupling compensation. This compensation takes place through the measurement of the residual current in the parallel line.

1.1.2 Overcurrent Supervision for Distance Protection (50SUP)

ZLV terminal units contain overcurrent elements to supervise the operation of the distance measuring elements. These overcurrent elements are used to establish a minimum current level of operation for the distance elements. Supervision elements are divided into two groups:

- Forward supervision.
- Reverse supervision.

1.1.3 Distance Protection Schemes (85-21)*

Seven protection schemes can be selected in **ZLV** IEDs for the management of trip signals generated in the different zones.

1.1.3.a Basic Scheme

- **Step Distance Tripping (Default)**

This scheme does not include tele-protection and works basically applying an adjustable timing to each zone (separately for ground and between-phase faults) to generate trip signals. Said logic is always active and, in case a teleprotection scheme is used, it will back up the operation of the same.

Under this scheme, the tripping action of any of these zones can be monitored through VT Fuse Failure, Power Swing and Load Encroachment Detectors, so that, if none of these events are present, tripping takes place.

The rest of the protection schemes, the purpose of which is to speed up the tripping action in line areas not covered by the first zone, are described below:

* The Step Distance Scheme and the Extension of Zone 1 are available for the ZLV-E models.

1.1.3.b Schemes not requiring Communication Channel

- **Zone 1 Extension**

By activating this scheme, overreach zone instantaneous trips are generated, adjusted to more than 100% of the line.

As said scheme can generate trips on lines adjacent to the remote end, zone 1 extension is blocked when reclosing, in order to prevent second tripping on permanent faults external to the line.

1.1.3.c Schemes requiring Communication Channel

All these schemes are based on using signals transferred through a communication channel linking terminals at both line ends, so that decision logic operates on local and remote information.

- **Permissive Underreach Tripping**

The operation of this scheme is based on the fact that if one terminal sees a fault in zone 1 (adjusted below 100% of line) and the other terminal sees the fault in the overreach zone (adjusted above 100% of line), then the fault can be considered as internal.

By activating the underreach zone (zone 1), a local end instantaneous trip is generated and a permissive trip signal is sent to the remote end so as to speed up the tripping. The remote terminal will trip instantaneously upon receiving the permissive trip signal and if some unit in the overreach zone is picked up.

- **Direct Transfer Tripping**

This scheme is similar to the Permissive Underreach Tripping, except that upon receiving the trip signal form the other end, an instantaneous trip is generated with no additional monitoring.

- **Permissive Overreach Tripping**

This scheme is based on the fact that if both terminals see the fault in the overreach zone (adjusted above 100% of the line, overreaching), the fault can be considered as internal to the line.

The permissive trip signal is sent by the activation of overreach zone. Reception of said signal by the remote end generates an instantaneous trip only if the overreach zone at this end is picked up.

- **Directional Comparison Unblocking**

This scheme is an extension of the Permissive Overreach Tripping Scheme, which allows for instantaneous tripping of faults internal to the line when no permissive trip signal is received from the other end. It is mainly used as a permissive scheme when using carrier wave communications, so as to avoid delayed tripping on losing the trip signal as a consequence of the large attenuation caused by the fault.

- **Directional Comparison Blocking**

This scheme basically differs from the two previous schemes in that the signal sent through the channel is used to block the tripping of the remote end, instead of speeding it up. There are two elements for the activation of this blocking signal:

- Reverse direction distance elements: indicating that the fault is behind, in the adjacent line.
- Non-directional overcurrent elements (fast transmission): as the blocking signal can be activated upon forward direction faults, it must be disabled by the operation of the overreach zone in this end.

Apart from the available protection schemes, any other scheme can be set up using the built-in relay programmable logic.

1.1.3.d Additional Logics for Distance Protection Schemes

These logics, if enabled, can work in parallel with all the permissive schemes.

- **Weak Infeed Logic (27WI)**

Echo Logic: the echo function allows one end under a weak infeed condition to send back a permissive trip signal received from the other end in order to speed up the tripping from the “strong” end.

Tripping Logic: said logic, which will operate together with the echo function, allows for instantaneous tripping of the weak end based on undervoltage conditions.

- **Reverse Current Blocking Logic**

This logic prevents the overreach zone from generating wrong trips on current reversals occurring during sequential trips from a fault in a line parallel to the protected line. The overreach zone is only blocked, for an adjustable time, when a fault is detected in the parallel line.

1.1.4 Load Encroachment

The purpose of these elements is to prevent tripping upon high load conditions. They block the operation of distance elements as long as the calculated positive sequence impedance remains within their associated characteristic.

1.1.5 Fault Locator (FL)

The **ZLV** comes with a built in fault locator to obtain the distance to the fault, either in line length units (kilometers or miles) or in percentage of total line length.

In case of double circuits, it is possible to have a zero sequence mutual coupling compensation that takes place thanks to the measurement of the residual current in the parallel line.

1.1.6 Power Swing Detector (68/78)

ZLV IEDs include a Power Swing Detector, in order to avoid undue tripping of the distance elements on stable power swing (power swing blocking) and allow controlled tripping on unstable power swing (tripping on loss of stability) as required. Power Swing detection is not available for the **ZLV-E** models.

Also, **ZLV** IEDs can detect faults originated during power swings, so as to unblock distance elements.

1.1.7 Close-Onto-Fault Detector (50SOF)

The Close-Onto-Fault Detector allows for instant tripping on faults occurring at the moment of breaker closing. It is activated on manual closing or reclosing commands whether internal or external. It incorporates non-directional phase overcurrent elements with second harmonic restraint (for prevention of unwanted operations on transformer energization) operating in parallel with Zone 1 Extension function.

1.1.8 Dead-Line Detector (ZLV-F/G/H/J Models)

The **ZLV-F/G/H/J** relay incorporates a Dead-Line detection element, which allows detecting deenergized lines based on the operation of two elements, undercurrent and undervoltage. The Dead-Line detector allows detecting the closing of the breaker (one line energized), so that can be used to activate the switch-onto-fault element with the benefit of not requiring external contacts for said activation.

1.1.9 Remote Breaker Open Detector [*]

The purpose of the Remote Breaker Open Detector is to produce an instant trip of the local end breaker upon the pick up of any of the units on the second zone, provided adequate conditions indicating the opening of the remote end breaker have been detected. Said function can be considered as a protection scheme for speeding up the tripping with no need for a communication channel.

1.1.10 VT Fuse Failure Detector

This element can block the trips based on voltage measurement (Distance Protection, Phase Undervoltage, Ground Overvoltage, Synchronism and Weak Infeed Trip Logic) when loss of any secondary voltage of a voltage transformer is detected.

[*] Not available for the ZLV-E models.

1.1.11 Phase, Ground and Negative Sequence Overcurrent Protection (3x 50/51 + 50N/51N + 50Q/51Q)

All models are provided with five overcurrent metering units (three for phase currents, one for ground and one for negative sequence current). Each unit is composed of three time delay elements and three instantaneous elements, with additional adjustable timer.

Time elements can be selected with the following types of characteristics, in accordance with IEC and IEEE/ANSI standards: Definite Time, Moderately Inverse, Inverse, Very Inverse, Extremely Inverse, Long-Term Inverse, Short-Term Inverse, RI Inverse, as well as any of them set up with Time Limit, and one User Definable curve.

These models have independent LED targets for each unit for the pickup and trip of the phase and neutral time and instantaneous elements. They can be directed to any logic signal.

All overcurrent elements can be adjusted as directional, and the directional unit in charge of taking the directional decision can be selected by setting (including Distance Zone 2).

1.1.12 Directional Units (3x67 + 67N + 67Q)

Phase Directional Units. One directional element is associated with each phase. Polarization is done by between-phase voltage with memory.

Ground Directional Unit. Includes double polarization

- By ground voltage.
- By grounding current.

Negative Sequence Directional Unit. Polarized by negative sequence voltage.

1.1.13 Ground Overcurrent Protection Schemes [*] (85-67N/67Q)

The following protection schemes can complement the directional elements of ground or negative sequence overcurrent.

- Permissive Underreach Trip.
- Direct Transfer Trip.
- Permissive Overreach Trip.
- Directional Comparison Unblocking.
- Directional Comparison Blocking.

All these schemes are independent from the schemes associated with the distance elements, so that separate communication channels can be used.

Similar to distance elements, thanks to programmable logic, protection schemes can be created at users will.

Additional transient unblocking by current reversal and weak infeed logic functions are also available to work in parallel with these protection schemes.

Overcurrent elements assigned for underreach and overreach can be adjusted for single-phase tripping thanks to the **ZLV** phase selector.

1.1.14 Stub Bus Protection (50STUB)[*]

Said element is applied to one-and-a-half-breaker scheme or ring substations. Its purpose is protecting the area between the two current transformers and the line sectionalizer when the latter is open. This time phase overcurrent element is activated when the line sectionalizer opens. The **ZLV-G/J** relays Stub Bus protection incorporates a restraint algorithm that gives more stability on external faults.

1.1.15 Logic for Lines with Series Compensation [*]

In lines with series compensation, a reverse directional fault can cause false directional decisions when voltage memory times out. In order to avoid undue tripping of timed cleared reverse faults, the **ZLV** incorporates logic functions for transient blocking of forward directional elements. This blocking signal is generated by the activation of the distance and directional overcurrent elements that monitor the reverse directional current.

1.1.16 Undervoltage Units (3x27 / 1x27)

ZLV models are provided with three undervoltage units (three phases) that can be separately selected as phase or line voltage, each composed of three instantaneous elements with additional adjustable timers.

Element tripping can be set up as single-phase or three-phase undervoltage.

1.1.17 Overvoltage Units (3x59 / 1x59)

ZLV models are provided with three overvoltage units (three phases) that can be separately selected as phase or line voltage, each composed of three instantaneous elements with additional adjustable timers.

Element tripping can be set up as single-phase or three-phase overvoltage.

[*] Not available for the ZLV-E models.

1.1.18 Ground Overvoltage Unit (1x59N)

All models are provided with two residual overvoltage metering elements. They take the measurement obtained by calculating the three phase voltages available in the IED.

Said metering units are composed of two instantaneous elements with additional adjustable timer.

1.1.19 Underfrequency (81m), Overfrequency (81M) and Rate of Change (81D) Protection*

All the models have an analog voltage input for obtaining the frequency and six metering units: 2 underfrequency, 2 overfrequency and 2 rate of change. Each of these units contains one element with an adjustable timer. You can set it as instantaneous.

1.1.20 Open Phase Unit (46)*

All the models have an Open Phase unit to detect the opening or unbalance of one or more phases. When this is detected, the unit trips and eliminates the unbalance.

1.1.21 Thermal Image Unit (49)

The **ZLV** has a thermal image unit that uses the current circulating through the cables to estimate their thermal status in order to trigger a trip when they have reached high temperatures.

The unit provides separate alarm and tripping indications. You can direct both to the IED's configurable logic.

* Not available for the ZLV-E models.

1.1.22 Breaker Failure (50BF)*

The **ZLV** incorporates Breaker Failure protection with two time steps so that retripping (single or three-phase) of failed breaker can be produced, if required, prior to the tripping command of adjacent breakers.

Breaker Failure protection incorporates separate timers and overcurrent levels for single-phase and three-phase tripping. Pick ups generated by single-phase tripping incorporate overcurrent detectors and phase segregated timers in order to act correctly in the event of evolving faults. All overcurrent detectors have very fast resetting characteristics.

Also, this unit allows protection against breaker failure with no overcurrent and detects the presence of active internal arcing.

The **ZLV-G/J** relays Breaker Failure protection supervises two breakers.

1.1.23 Open Pole and Pole Discordance Detector (2)

The equipment incorporates Open Pole detection logic, which operates based on the position of the breaker contacts this being backed up by phase segregated current detectors. Said logic output is taken into account for the operation of a number of protection devices, due to various conditions generated by an open pole.

On the other hand, the equipment allows for the detection of breaker pole discordance condition, which could cause a trip if the condition remains unchanged for an adjustable time.

The **ZLV-G/J** relays Open Pole and Pole Discrepancy Detector supervise two breakers.

1.1.24 Synchronism Unit (25)

Several elements are included in this unit: **Line Voltage and Bus Voltage** (with selectable energizing mask), **Voltage Difference**, **Phase Difference**, and **Frequency Difference**.

This unit can be set to supervise the reclosing function and block breaker closing when synchronous conditions are not satisfied.

The **ZLV-G/J** relays Synchronism Element supervises two breakers.

1.1.25 Monitoring of the Switching Circuits (3)*

The IED has units for verifying the proper operation of the switching circuits of the breaker. They can monitor up to six coils. You can monitor both breaker positions (open and closed) or either one of them.

* Not available for the ZLV-E models.

1.1.26 Recloser (ZLV-A/E/H Models) (79)

The recloser can be coordinated with external protection as well as with the protection contained in the IED.

A maximum of three attempts can selected, with independent settings for reclosing times. The reclosing sequence is controlled by the breaker position and by the reclose initiate signal.

Some **ZLV-H** models can perform 4 reclosing attempts.

The reclosing sequence after Zone 1, 2, 3, 4, 5 and 6 tripping; and after overcurrent, open phase and remote open breaker units tripping will be determined according to the settings.

1.1.27 Single / Three-Phase Recloser (ZLV-B/F/G/J Models) (79)

Apart from the above described points, the **ZLV-B/F/G/J** recloser features separate cycles for different tripping modes: single and three-phase, and the following operation modes can be selected:

- 1p Mode: Reclosing for single-phase trips only.
- 3p Mode: Reclosing for three-phase trips only.
- 1p/3p Mode: Reclosing for both types of trips.
- Dependent Mode: Only one reclosing attempt for three-phase tripping, and as programmed by the number of reclosing attempts setting for single-phase tripping.

The **ZLV-G/J** relay recloser controls two breakers.

Some **ZLV-F/G/J** models can perform 4 reclosing attempts.

1.2 Additional Functions

1.2.1 Local Control

You have eight buttons (six totally user-definable and two for opening/resetting the breaker) on the front of the relay for operating on the system's configurable units in the relay (breaker, sectionalizers, recloser function, programmable control functions, protection units, local/remote, active group of settings, etc.) and for resetting the operation LEDs.

1.2.2 Programmable Logic

An operational logic can be programmed in order to set up blockings, automatic controls, control and trip logic functions, command hierarchy, etc through logic gates combined with any acquired or equipment-computed signal.

All the signals generated by the equipment will be available to the events, fault reports, oscillograph records, digital inputs and outputs, HMI and communications according to how their programmable logic has been configured.

The processing of the input signals produces logical outputs that can be assigned to existing connections between the **ZLV** and the exterior: auxiliary output contacts, display, communications, LEDs, HMI…

1.2.3 Ports and Communications Protocols

The **ZLV** can have up to four communication ports: one local (RS323/USB) and three remote (RS232, RS485 or FO).

The **ZLV** includes three communications protocols: PROCOME 3.0, DNP 3.0 and MODBUS. It is possible to assign any of the protocols to each of the remote ports. The local port supports PROCOME 3.0, and it is used for setting programming, configuration and retrieval of information.

In addition, two of the remote ports can be configured as Virtual Inputs / Outputs.

Protocol changeover trailers are totally independent for each port, and two same-protocol instances can be maintained in both remote ports.

1.2.4 Integrated Simulator

Some models feature a special mode for testing and simulating the operation of implemented units by means of loading an external oscillogram into the device through the front communication port.

1.2.5 Breaker Monitoring

In order that information for breaker maintenance is available, the equipment features a unit for adding up and totaling the kA^2 values at every breaker opening operation.

1.2.6 Excessive Number of Trips

This function prevents the breaker from performing more than a specified number of operations during a set up period of time, which may result in breaker damage. The recloser is blocked upon exceeding the maximum allowed number of tripping operations.

1.2.7 Phase Sequence Selection

Relay connection to the sequence network may be configured when phase sequence is ABC or ACB.

1.2.8 LED Targets

Models 2U and 3U have five LEDs and models 4U and 6U have seventeen LEDs located on the left and right sides of the front panel. All LEDs are configurable, except for one that indicates if the relay is **Ready** and light in red when are activated. Those models with command buttons are provided also with other configurable LEDs, as explained in the Local Interface Chapter.

1.2.9 Digital Inputs

Basic equipment is provided with 10 digital inputs, all of them configurable. The number of inputs can be extended up to 37 by means of expansion modules.

1.2.10 Auxiliary Outputs

Basic equipment is provided with ten output contacts. The number of outputs can be extended up to 44 by means of extension boards. But for the tripping and closing contacts (included in some **ZLV-F/H** models), all outputs are configurable. All models incorporate 4 fast outputs to operate over teleprotection equipment.

All auxiliary outputs are robust enough to be used as operating outputs (trip and close).

1.2.11 Time Synchronization

The **ZLV** features an internal clock accurate to 1 millisecond. The clock can be synchronized through GPS (protocol IRIG-B 003 and 123) or by communications: Protocol PROCOME 3.0, DNP 3.0 or SNTP.

Devices with spare digit “**D**” can also be synchronized by binary input with a pulse per second signal or pulse per minute signal.

1.2.12 Event Recording and Programmable Metering Data Logging

Storage capacity of 400 annotations in a non-volatile memory. Event-generated signals can be selected by the user and are annotated with 1ms resolution and a maximum of 12 measurements also user-selected.

1.2.13 Fault Reporting

Storage capacity of up to 15 fault reports with relevant information, such as units picked up, units tripped, prefault values, fault values, current interrupted by breaker, etc.

1.2.14 Historical Metering Data Logging

Historical metering data logging allows for obtaining twelve maximum and twelve minimum values from a group of four magnitudes selected out of all available measurements (acquired or calculated), except meters, for each time window. This window can be adapted to the application by adjustment of day and interval masks. Up to 168 records can be saved.

1.2.15 Oscillographic Register (OSC)

The oscillographic recording function is composed of two different sub functions: acquisition function and display function. Both analog magnitudes and internal signals as well as digital equipment inputs will be recorded, up to a total of 64 oscillograms in a circular memory. Sampling and storing frequency is 32 samples per cycle with 15 sec total storage. The **ZLV-***-****E/F/G/H**** and **ZLV-G/J** relays allow selecting a recording frequency of 16 samples per cycle, which allows for increasing the total storage time up to 30 seconds.

Oscillograms are delivered in format COMTRADE 99. A program for the display and analysis of the acquired oscillograms is supplied with the equipment.

1.2.16 Virtual Inputs / Outputs

The virtual inputs / outputs allow the bi-directional transmission of up to 16 digital signals and 16 analog magnitudes between the two **ZLV** units connected through a digital communications system. This function allows to program logics, which contain local and remote information, analog as well as digital.

1.2.17 Local information (Alphanumerical Display and Keypad)

- Changing and displaying settings.
- Protection operations:
  - Last trip and recloser status.
  - Units picked up.
  - Tripped units.
  - Input and output status.
  - Distance to the fault.
  - Counters status (reclosing and kA^2).
- Protection records (displayed via communication):
  - Event recording.
  - Fault report.
  - Log file of currents, voltages, powers, power factor or other calculated values.
- Control records.
- Measurements used by the protection:
  - Phase and ground currents and angles.
  - Line currents.
  - Parallel line ground current.
  - Polarization current.
  - Voltage of three phases and ground (and their angles).
  - Line voltages.
  - Synchronism voltage.
  - Positive, negative and zero-sequence currents.
  - Positive, negative and zero-sequence voltages.
  - Active, reactive and apparent powers and power factor.
  - Energies.
  - Frequency.
  - Thermal value.

1.2.18 Self-Test Program

A continuously running diagnostic self-test program verifies the correct operation of the terminal unit and alerts the user of potential problems.

1.3 Local Interface

1.3.1 Alphanumeric Display & Keypad

The liquid crystal alphanumeric display has a 4-row by 20-character matrix. It displays information about relay alarms, settings, metering, states, etc. There are 4 function keys (F1, F2, F3 and F4) under the display. The next section explains their functions. Figure 1.3.1 shows the default graphic display and the function keys.

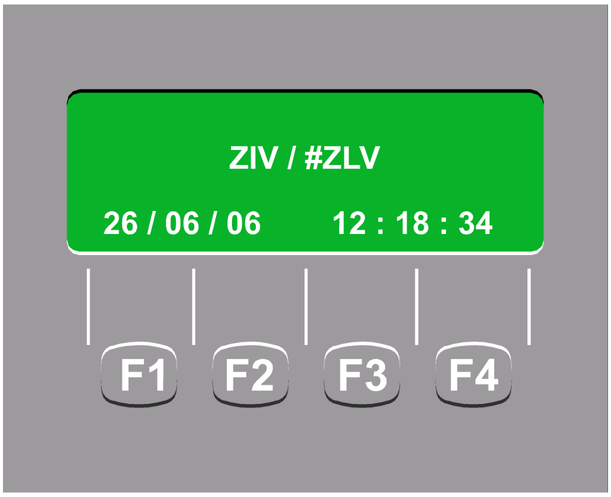


Figure 1.3.1: Alphanumeric Display.

- **Default Display**

Figure 1.3.1 depicts the default display showing the relay model, the date and the time. The upper left corner also indicates the connection mode (if communication has been established):

[PL] Local connection (communication through the front port).
[P1] Remote connection (communication through rear port 1).
[P2] Remote connection (communication through rear port 2).
[P3] Remote connection (communication through rear port 3).

- **Keypad Associated with the Display**

The keypad consists of 16 keys arranged in a 4 x 4 matrix. Their properties are specified next. Figure 1.3.2 shows the layout of this keypad.

In addition to the keys corresponding to the digits (keys from 0 to 9), there are the selection keys (↑ and ↓), the confirmation key (ENT), the escape key (ESC) and the contrast key (◑).

Figure 1.3.2: Keypad Layout.

Starting with the default screen, operations can be performed on **ZLV** system functions in two different ways: using one single key (F2) or using the whole keypad.

1.3.2 Control Buttons

There are three columns of buttons for operating on the system units, settings groups and protection elements configured in the relay.

The first column contains the **I** and **O** buttons (close and open commands respectively), as well as the breaker selection button. This button is accompanied by 1 LED (red=open / green=closed) indicating the breaker status.

1.3.2.a Programmable Buttons

The next 2 columns are made up of six programmable buttons (P1 to P6) for operating on the elements / units that the user determines using the communications program, together with a space for displaying the description of that button's function. Each of these six buttons in turn has a configurable LED that indicates the state of the object / function associated with that button. The function of these buttons is to select the unit to be operated upon. The command is sent to the unit with the (I) and (O) buttons.

The push-button group has a general interlock that can be configured from the HMI or via the communications ports providing the security required for proper operation.

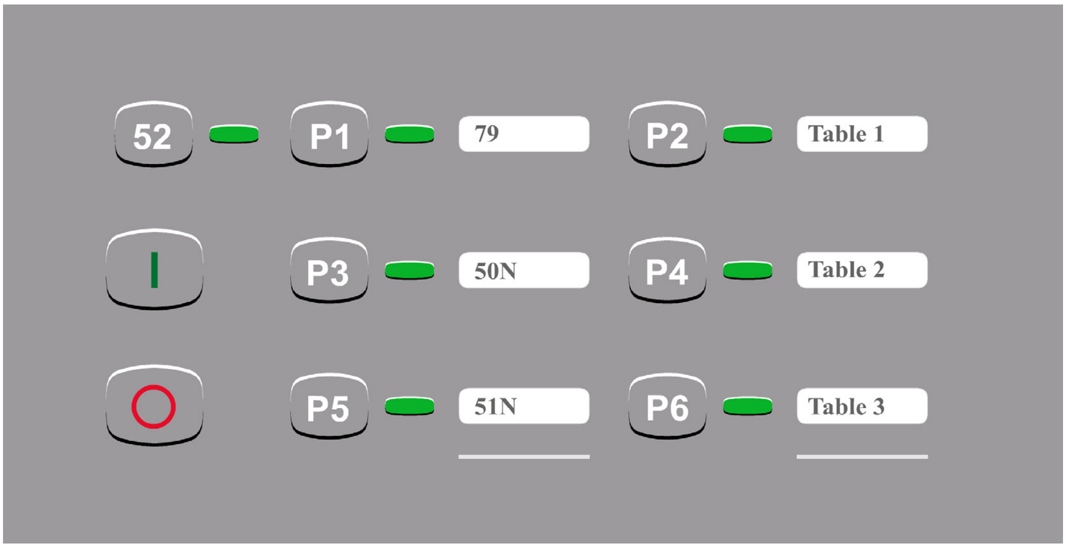


Figure 1.3.3: Control Buttons and Programmable Buttons.

1.3.3 Keys, Functions and Operation Modes

This section explains the alphanumeric display's function keys and the keypad's digit keys.

1.3.3.a Keypad

Confirmation Key

The ENT key is used to confirm an action: after making a selection or after editing a setting and to advance to view all the records. After any operation (selection, change of settings, information, etc.), pressing ENT again accesses the immediately preceding level.

Escape Key

The ESC key is used to exit a screen if the setting is not to be changed or simply to exit an information screen. In any case, pressing this key returns the display to the immediately preceding screen.

Display Selection Keys

The selection keys are for advancing or returning, in correlative order, to any of the options of a menu or a submenu. When a menu has more than four options, an arrow (↓) will appear in the lower right corner of the display indicating that there are more. The ∇ key brings up the second set of options.

An arrow (↑) will appear in the upper right corner of the display to indicate the existence of the first set of options.

The ∇ key is also used to delete digits within a setting that is being modified. It only has this function when a setting is being entered.

Contrast Key and Minus (-) Sign

Pressing this key brings up the screen for adjusting the contrast of the display. The selection keys modify this contrast value: greater value = less contrast. Also, when setting floating point values, it permits entering a negative sign (-).

1.3.3.b Function Keys

Pressing F1 confirms changes in settings (when the relay requests such confirmation) and confirms the activation of a settings group (when the relay requests this confirmation).

When pressed from the stand-by screen, it provides access to the information provided by the sequential events recorder.

The F2 key is used to consult the relay for information relative to measurements of current, voltage, power, etc. and to lock / unlock the recloser function, to reset the last trip indication and to reset LEDs and reclose counter among others.

Pressing F3 displays the state of the relay's digital inputs and outputs.

Pressing the F4 key rejects changes in settings (when the relay requests confirmation of the changes) and rejects the activation of a reserve settings group (likewise when such confirmation is requested).

1.3.3.c Accessing the Options

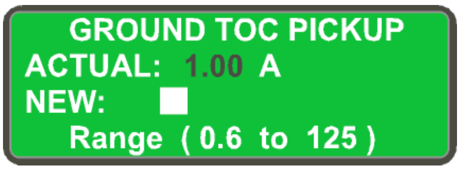
The digit keys (0 to 9) are used to directly access the options (settings, data, measurements, etc.). This direct access consists in successively pressing the identification numbers that the screen displays prior to each setting or option within the corresponding setting.

Another way to access the options consists in navigating the menus with the selection keys and then confirming the option selected with ENT.

1.3.3.d Operation

- **Change of Settings (Range)**

The change of settings (Range) presents the following arrangement: the operational value of the setting appears in the place indicated by the word ACTUAL. The new value is entered where a blinking cursor indicates the place in the next line indicated by the word NEW.

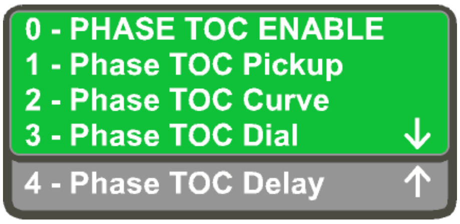


The digit keys are used to edit the new value, which must agree with the range specified in the last line of the display. If an error occurs upon inputting a value, the ∇ key will erase it. Once the new value has been edited, pressing ENT confirms it and exits to the preceding menu.

There is a type of setting that follows this outline but with a range limited to the options, YES and NO. In this case, the 1 and 0 keys correspond to the values YES and NO. Then pressing ENT confirms the setting and returns to the preceding screen.

- **Change of Settings (Options)**

These settings are presented in an options menu which is selected by either of two already known procedures: with the direct access number associated with the option or by using the selection keys and confirming with ENT. In both cases, the system returns to the preceding screen.



- **Settings of Masks**

Every option is listed in vertical order. Next to each option the setting is displayed by the box: full (■) for enable and empty (□) for disable.

The mask can be modified (in the line between brackets) using the key 1 (enable) or 0 (disable).

If there are more options than lines in the screen a down arrow (↓) will be included at the end of the last line. The second screen will be displayed after adjusting the last setting in the first screen.

- **Exit Menus and Settings**

Pressing the ESC key exits a menu or a setting without changing it. Pressing either ENT or ESC indistinctly exit an information screen. In either case, the display returns to the preceding menu.

1.3.4 Last Trip Indication

If there has been a trip, the relay will present its data first. This information is presented as follows:

As the various types of elements generate trip, additional screens are created. The format is always similar: a header line indicating the type of unit tripped (for example, Time current) and, below that, all the operated units and phases (Time1 A, Time1 B, etc.). If several functions trip and they do not fit on one screen, the selection keys allow accessing all that are generated.

If there have been no trips since the last reset, this screen is not presented.

1.4 Model Selection

1.4.1 Model Selection

	ZLV											
1		2	3	4	5	6	7	8	9	10	11	12

1	**Selection**			
	3	Vertical Format	**8**	Horizontal Format
	7	With Graphic Display (1).		
2	**Functions**			
	F	Three / single pole tripping model for single breaker positions	**J**	Three / single pole tripping model for double breaker positions with three Vsync channels.
	H	Three pole tripping model for single breaker positions		
3	**Communication Interfaces for IEC 61850**			
	1	None.	**5**	Two 100BASE-FX Connectors (Multimode FOC LC).
	3	Two 100BASE-TX Connectors (RJ45).	**6**	One 100BASE-TX Connector (RJ 45) + One 100BASE-FX Connector (Multimode FOC LC).
	4	Two 100BASE-FX Connectors (Multimode FOC ST).		
4	**Additional Functions**			
	F	Fault Reports on HMI		
5	**Power Supply Voltage**			
	1	24 VDC / VAC (±20%)	**2**	48 - 250 VDC / VAC (±20%)
6	**Digital Inputs Voltage**			
	0	24 VDC	**A**	24 VDC (DIs) + 6 DO HSHD
	1	48 VDC	**B**	48 VDC (DIs) + 6 DO HSHD
	2	125 VDC	**C**	125 VDC (DIs) + 6 DO HSHD
	3	250 VDC	**D**	250 VDC (DIs) + 6 DO HSHD
	6	125 VDC (ACTIVATION >65%)	**G**	125 VDC (ACTIVATION >65%) (DIs) + 6 DO HSHD
	7	250 VDC (VON=158VDC / VOFF = 132VDC)		
7	**Communications Ports [COM1-LOC] [COM 2-REMP1] [COM3-REMP2] [COM4-REMP3] [COM5-REMP4] (3)**			
	0	[RS232+2xUSB*] [--] [--] [--] [ELECTRIC CAN]	**J**	[RS232+USB] [ETHERNET] [ETHERNET] [RS232 / RS485] [ELECTRIC CAN]
	1	[RS232+USB] [FOP] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]	**K**	[RS232+USB] [RS232 F.M] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	2	[RS232+USB] [FOC ST] [FOC ST] [FOC ST] [ELECTRIC CAN]	**M**	[RS232+2xUSB*] [FOC ST] [FOC ST] [--] [ELECTRIC CAN]
	3	[RS232+USB] [FOC ST] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]	**P**	[RS232+2xUSB*] [FOP] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	9	[RS232+USB] [FOP] [FOP] [--] [ELECTRIC CAN]	**Q**	[RS232+2xUSB*] [ETHERNET] [RS232 / RS485] [RS232 / RS485] [ELECTRIC CAN]
	C	[RS232+USB] [FOC ST] [FOC ST] [RS232 / RS485] [ELECTRIC CAN]	**R**	[RS232+USB] [RS232 F.M] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]
	D	[RS232+USB] [ETHERNET] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]	**S**	[RS232+2xUSB*] [FOC ST] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	E	[RS232+USB] [FOC ST] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]	**T**	[RS232+USB] [FOP] [FOC ST] [RS232 / RS485] [ELECTRIC CAN]
	F	[RS232+USB] [[DOUBLE RING FOP]] [RS232/RS485] [ELECTRIC CAN]	**U**	[RS232+2xUSB*] [FOP] [FOC ST] [RS232 / RS485] [ELECTRIC CAN]
	G	[RS232+USB] [FOP] [FOC ST] [FOC ST] [ELECTRIC CAN]	**Y**	[RS232+2xUSB*] [RS232] [RS232 / RS485] [ETHERNET] [ELECTRIC CAN]
	H	[RS232+USB] [FOP] [RS232 / RS485] [RS232/RS485] [ELECTRIC CAN]	**W**	[RS232+2xUSB*] [FOC ST] [ETHERNET] [ETHERNET] [ELECTRIC CAN]
	I	[RS232+USB] [ETHERNET] [FOC ST] [RS232/RS485] [ELECTRIC CAN]		
	(*) Includes an additional USB FRONT PORT for management of IEC 61850 system.			

(1) Non-compatible with Type M,S, 0 and 1 in 10 digit (Enclosure/Chassis 2U and 3U).

1.4 Model Selection

	ZLV											
1		2	3	4	5	6	7	8	9		10	11	12

8	**Inputs / Outputs**

- **0** 10DI + 10DO + 1 Alarm Output + 4 LEDs
  First Input for VAC / VDC
  ZLV-F Models: DO1=CLOSE, DO2=TRIP-A, DO3=TRIP-B, DO4=TRIP-C.
  ZLV-H Models: DO1=CLOSE, DO2=TRIP.
- **1** 22DI + 23DO + 1 Alarm Output + 4 LEDs
  First Input for VAC / VDC.
  ZLV-F Models: DO1=CLOSE, DO2=TRIP-A, DO3=TRIP-B, DO4=TRIP-C;
  ZLV-H Models: DO1=CLOSE, DO2=TRIP.
- **2** 34DI + 36DO + 1 Alarm Output + 16 LEDs
  First Input for VAC / VDC.
  ZLV-F Models: DO1=CLOSE, DO2=TRIP-A, DO3=TRIP-B, DO4=TRIP-C.
  ZLV-H Models: DO1=CLOSE, DO2=TRIP.
- **3** 25DI + 31DO + 1 Alarm Output + 16 LEDs
  Only **ZLV-G/J Models**. All Inputs for VDC.
  All outputs are configurable.
- **4** 39DI + 29DO + 1 Alarm Output + 2 Input Transducers (4-20 mA) + 16 LEDs
  First Input for VAC / VDC.
  ZLV-F Models: DO1=CLOSE, DO2=TRIP-A, DO3=TRIP-B, DO4=TRIP-C.
  ZLV-H Models: DO1=CLOSE, DO2=TRIP.
- **5** 34DI + 36DO + 1 Alarm Output + 16 LEDs
  Only **ZLV-F/H Models**. First Input for VDC.
  All outputs are configurable.
- **6** 22DI + 23DO + 1 Alarm Output + 16 LEDs
  Only **ZLV-F/H Models**. First Input for VDC.
  All outputs are configurable.
- **9** 37DI + 44DO + 1 Alarm Output + 16 LEDs
  Only **ZLV-G/J Models** All Inputs for VDC.
  All outputs are configurable.
- **A** 33DI + 33DO + 1 Alarm Output + 1 Input Transducers (0-5mA or ±2,5mA) + 1 Output Transducer (0-5mA) + 16 LEDs
  First Input for VAC / VDC. All outputs are configurable.
- **N** 22DI + 23DO + 1 Alarm Output + (DO22 and DO23 as NC) + 4 LEDs
  First Input for VAC / VDC.
  ZLV-F Models: DO1=CLOSE, DO2=TRIP-A, DO3=TRIP-B, DO4=TRIP-C.
  ZLV-H Models: DO1=CLOSE, DO2=TRIP.

9	**Spare**

- **N0** CT Supervision + Mutual coupling compensation for distance units (parallel lines) + Phase Selector with settable thresholds + 60VT with settable threshold + Improved fault locator + 79 with 4 reclose cycles + Improved Close-Onto-a-Fault Detector + Zone 6 + Harmonic blocking + 79 with positive sequence supervision + Extended range in Power Swing unit + Saturation Detector + Binary input synchronization by pulse per second or pulse per minute + Disturbance recorder configurable for 16/32 samples per cycle + Zone start timer is selected by setting (Zone pick up + Distance pick up) + Increased CT ratio range (1-10000) + Improvements in 25 unit + Fast Distance + Increased CT & VT ratio + Directional block/disable setting due to lack of polarization.
- **N8** N0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy + 8 Goose Control Blocks.
- **NB** N8 + Number of XSWI and CSWI logical nodes increased to 24 and 30 respectively.
- **O0** M0 + Directional block/disable setting due to lack of polarization
- **O8** O0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy + 8 Goose Control Blocks
- **OB** O8 + Number of XSWI and CSWI logical nodes increased to 24 and 30 respectively.

10	**Enclosure**

- **M** 2U x 1 19” Rack (DI / DO type 0)
- **S** 3U x 1 19” Rack (DI / DO types 1 and N)
- **Q** 4U x 1 19” Rack (DI / DO types 2, 3, 5 and 6)
- **V** 6U x 1 19” Rack (DI / DO type 9)
- **0** 2U x 1 19” Rack with cover (DI / DO type 0)
- **1** 3U x 1 19” Rack with cover (DI / DO types 1 and N)
- **2** 4U x 1 19” Rack with cover (DI / DO types 2, 3, 5 and 6)
- **4** 6U x 1 19” Rack with cover (DI / DO type 9)

	ZLV											
1		2	3	4	5	6	7	8	9		10	11	12

11	**Protocols for Remote Communication**			
	K	Standard [PROCOME 3.0/DNP 3.0 (Profile v.2)/MODBUS RTU - SERIAL and over ETHERNET for Remote Ports 1, 2 & 3]	**N***	Standard plus Virtual I/O Protocol for Remote Ports 1 & 2 + [DNP3 and MODBUS RTU over the IEC61850 ports]
	M	Standard plus Virtual I/O Protocol for Remote Ports 1 & 2		
	(*) Not available when the selection in digit 3 (Communication Interfaces for IEC 61850) is 1 (None).			
12	**Finishing**			
	--	Horizontal Rack Mount + [O] Red / [I] Green.	**Q**	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + For both User Interfaces (with texts in english).
	A	Vertical Rack Mount + [O] Red / [I] Green.	**R**	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + Texts in Spanish/Portuguese (only for Models with graphic display).
	L	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green.	**S**	Vertical Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + For both User Interfaces (with texts in english).
	M	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green + Texts in English (only for Models with graphic display).	**T**	Horizontal Rack Mount + Conformal Coated Circuit Boards + [O] Green / [I] Red + Texts in Spanish/Portuguese (only for Models with graphic display) + Box with front IP51.
	N	Vertical Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green.		
	P	Vertical Rack Mount + Conformal Coated Circuit Boards + [O] Red / [I] Green + Texts in English (only for Models with graphic display).		

- **Functions**

21/21N	Distance Protection for Ground and Phase Faults.
79	Recloser.
25	Synchrocheck.
27	Phase Undervoltage.
59	Phase Overvoltage.
59N	Ground Overvoltage.
67	Directional Phase Unit.
50	Instantaneous Phase Overcurrent.
51	Time Phase Overcurrent (Inverse / Definite).
67N	Directional Ground Unit.
50N	Instantaneous Ground Overcurrent.
51N	Time Ground Overcurrent (Inverse / Definite).
67Q	Directional Negative Sequence Unit.
50Q	Instantaneous Negative Sequence Overcurrent (I2).
51Q	Time Negative Sequence Overcurrent (Inverse / Definite) (I2).
67P	Positive Sequence Directional Unit.
27WI	Weak Infeed Protection.
81M	Overfrequency.
81m	Underfrequency.
81D	Frequency Rate of Change.
49	Thermal Image.
68/78	Power Swing Blocking / Trip due to Power Oscillation.
46	Open Phase Unit: I2/I1 (Current Unbalance).
50SUP	Overcurrent Supervision for Distance Protection.
50STUB	Stub Bus Protection.
85-21	Protection Schemes for Distance Elements.
85-67N/67Q	Protection Schemes for Overcurrent Elements.
50BF	Breaker Failure.
3	Trip and Close Coil Circuit Supervision.
2	Pole Discordance Detector.
60VT	Fuse Failure Detector.
50SOF	Switch-on-to-Fault Detector.
FL	Fault Locator.
OSC	Oscillographic Recording.

1.4.2 Models Replaced by others with Higher Functionality and Not Available Options

	ZLV											
1		2	3	4	5	6	7	8	9	10	11	12

2	**Functions**			
	A	21(3F) + 79 + 25 + 3x(3x27) + 3x(3x59) + 2x59N + 3x(3x67-3x50/51) + 3x(67N-50N/51N) + 3x(67Q-50Q/51Q) + 27WI + 3x81M + 3x81m + 3x81D + 49 + 68/78 + 46 + 50SOF + 50Sup + 50STUB + 85 + 50FI + 6x3 + 2 + 60VT + FL + OSC	**E**	21(3F) + 79 + 25 + 3x(3x27) + 3x(3x59) + 2x59N +3x(3x67-3x50/51) + 3x(67N-50N/51N) + 3x(67Q-50Q/51Q) + 49 + 68 + 50SOF + 50Sup + 2 + 60VT + FL+ OSC
	B	21(1F/3F) + 79 + 25 + 3x(3x27) + 3x(3x59) + 2x59N + 3x(3x67-3x50/51) + 3x(67N-50N/51N) + 3x(67Q-50Q/51Q) + 27WI + 3x81M + 3x81m + 3x81D + 49 + 68/78 + 46 + 50SOF + 50Sup + 50STUB + 85 + 50FI(1F/3F) + 6x3 + 2 + 60VT + FL+ OSC	**G**	Models with Single-Phase / Three-Phase trip for double breaker bays.
3	**IEC 61850 Communications Interface**			
	2	Ports 100FX and 100TX - Ethernet F.O. (MT-RJ) and RJ45 (IEC 61850 / PROCOME 3.0)		
4	**Additional Functions**			
	N	Standard Model	**S**	Integrated Simulator
7	**Communications Ports [COM1-LOC] [COM 2-REMP1] [COM3-REMP2] [COM4-REMP3] [COM5-REMP4] (1)**			
	5	[RS232 + USB] [RS232 F.M] [RS232 / RS485] [--] [ELECTRIC CAN]	**B**	[RS232 + USB] [ETHERNET] [RS232 / RS485] [--] [ELECTRIC CAN]
	6	[RS232 + USB] [--] [--] [--] [--]	**L**	[RS232 + USB] [ETHERNET] [RS232 / RS485] [GFO ST] [ELECTRIC CAN]
	7	[RS232 + USB] [GFO ST] [GFO ST] [--] [ELECTRIC CAN]	**N**	[RS232 + USB] [RS232 F.M] [RS232 / RS485] [--] [ELECTRIC CAN]
	8	[RS232 + USB] [GFO ST] [RS232 / RS485] [--] [ELECTRIC CAN]	**Z**	[RS232 + USB] [GFO ST] [RS232 / RS485] [--] [ELECTRIC CAN]
	A	[RS232 + USB] [PFO] [RS232 / RS485] [--] [ELECTRIC CAN]		
9	**Spare**			
	00	Standard Model	**E0**	CT Supervision + Mutual coupling compensation for distance units (parallel lines) + Phase Selector with settable thresholds + 60VT with settable threshold + Improved fault locator + 79 with 4 reclose cycles + Improved Close-Onto-a-Fault Detector + Zone 6 + harmonic blocking + 79 with positive sequence supervision + Extended range in Power Swing unit + Saturation Detector + binary input synchronization by pulse per second or pulse per minute + disturbance recorder configurable for 16/32 samples per cycle.
	01	Data Profile Revision 01		
	02	Data Profile Revision 02		
	03	Data Profile Revision 03		
	04	Data Profile Revision 04		
	11	01 + CTs Supervision		
	A0	CTs Supervision + Mutual Coupling Compensation for 21 Function + Adjustable Phase Selector + 60VT with Adjustable Voltage Level.		
	A2	02 + CTs Supervision + Mutual Coupling Compensation for 21 Function + Adjustable Phase Selector + 60VT with Adjustable Voltage Level.	**E6**	E0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy.
	A3	A0 + IEC61850 (MMS and GOOSE Services) v.3.		
	A4	A0 + IEC61850 (MMS and GOOSE Services) v.3 with Bonding Redundancy.	**E7**	E0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy.
	A6	A0 + IEC61850 (MMS and GOOSE Services) v.4 (SBO) without Redundancy, with Bonding Redundancy or with PRP Redundancy.		
	B0	A0 + Improved Fault Locator + 79 Function with 4 reclosing attempts.	**E8**	E7 + 8 Goose Control Blocks.
			F0	E0 + Fast Distance.
	B3	B0 + IEC61850 (MMS and GOOSE Services) v.3.	**F6**	F0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy.
	B4	B0 + IEC61850 (MMS and GOOSE Services) v.3 with Bonding Redundancy.		
	B6	B0 + IEC61850 (MMS and GOOSE Services) v.4 (SBO) without Redundancy, with Bonding Redundancy.	**F7**	F0 +IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy.
	C0	B0 + Improved Close-Onto-a-Fault Detector + Fast Distance + Zone 6 + Harmonics Blocking + Recloser with Positive Sequence Voltage Supervision +Extended Range in Power Swing Unit.	**F8**	F7 + 8 Goose Control Blocks.

	ZLV											
1		2	3	4	5	6	7	8	9		10	11	12

9	**Spare**			
	C3	C0 + IEC61850 (MMS and GOOSE Services) v.3. Fast + Zone 6 + Harmonics Blocking +	**G6**	G0 + IEC61850 (MMS and GOOSE Services) v.4 (SBO) without Redundancy, with Bonding Redundancy or PRP Redundancy.
	C4	C0 + IEC61850 (servicios MMS y GOOSE) v.3 with Bonding Redundancy.	**G8**	G0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy + 8 Goose Control Blocks.
	C6	C0 + IEC61850 (MMS and GOOSE Services) v.4 (SBO) without Redundancy, with Bonding Redundancy.		
	D0	CT Supervision + Mutual coupling compensation for distance units (parallel lines) + Phase Selector with settable thresholds + 60VT with settable threshold + Improved fault locator + 79 with 4 reclose cycles + Improved Close-Onto-a-Fault Detector + Fast Distance + Zone 6 + harmonic blocking + 79 with positive sequence supervision + Extended range in Power Swing unit + Saturation Detector + binary input synchronization by pulse per second or pulse per minute + Fast Distance.	**H0**	G0 + Fast Distance.
			H6	H0 + IEC61850 (MMS and GOOSE Services) v.4 (SBO) without Redundancy, with Bonding Redundancy or PRP Redundancy.
			H8	H0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy + 8 Goose Control Blocks.
			I0	G0 + Increased CT ratio range (1-10000).
	D6	D0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy.	**I8**	I0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP Redundancy + 8 Goose Control Blocks.
	D7	D0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy.	**J0**	I0 + Fast Distance.
			J8	J0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP Redundancy + 8 Goose Control Blocks.
	G0	CTs Supervision + Mutual Coupling Compensation for 21 Function + Adjustable Phase Selector + 60VT with Adjustable Voltage + Improved Fault Locator + 79 Function with 4 reclosing attempts + Improved Close-Onto-a-Fault Detector + Zone 6 + Harmonics Blocking +Recloser with Positive Sequence Voltage Supervision + Extended Range in Power Swing Unit + Saturation detector + Binary input Synchronization by PPS/PPM + Adjustable Zone Timer pickup.	**K9**	K8 + CID load by frontal port.
			K0	I0 + Improvements in 25 unit + Increased CT & VT ratio.
			K8	K0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy or RSTP redundancy + 8 Goose Control Blocks.
			KB	K8 + number of XSWI and CSWI logical nodes increased to 24 and 30 respectively.
11	**Communications Protocol [COM1-LOC] [COM 2-REMP1 and COM3-REMP2] [COM4-REMP3] [COM5-REMP4]**			
	B	[PROCOME 3.0] [--] [--] [--]	**P***	Standard + Virtual I/O Protocol by Remote Ports 1 & 2 + [5 instances by the IEC61850 ports, 1 PROCOME and 4 configurable DNP3 or MODBUS]
	(*) Just when the selection of the Communication interfaces for IEC61850, digit 3, all options except 1 option. Only available with *6 options in 9 digit (Spare).			
12	**Finishing**			
	J	Stainless Steel + Tropicalized Printed Circuit Board + Standard Colors [O] Red / [I] Green + Horizontal (self-shorting pin connectors)		

1.5 Installation and Commissioning

1.5.1 General

Improper handling of electrical equipment is extremely dangerous, therefore, only skilled and qualified personnel familiar with appropriate safety procedures and precautions should work with this equipment. Damage to equipment and injury to personnel can result when proper safety precautions are not followed.

The following general safety precautions are provided as a reminder:

- **High magnitude voltages are present in Power Supply and metering circuits even after equipment has been disconnected.**
- **Equipment should be solidly grounded before handling or operating.**
- **Under no circumstances should the operating limits of the equipment be exceeded (voltage, current, etc.).**
- **The Power Supply Voltage (ac or dc) should be disconnected from the equipment before extracting or inserting any module; otherwise damage may result.**

The tests defined next are those indicated for the start-up of a **ZLV** IED. They do not necessarily coincide with the final manufacturing tests to which each manufactured IED is subjected. The number, the type and the specific characteristics of the acceptance tests are model dependent.

1.5.2 Accuracy

The accuracy of the measuring instruments and test source signals (auxiliary power supply voltage, AC currents and AC voltages) is key in electrical testing. Therefore, the information specified in the Technical Data section (2.1) of this manual can only be reasonably verified with test equipment under normal reference conditions and with the tolerances indicated in the UNE 21-136 and IEC 255 standards in addition to using precision instruments.

It is extremely important that there be little or no distortion (<2%) in the test source signals as harmonics can affect internal measuring of the equipment. For example, distortions will affect this IED, made up of non-linear elements, differently from an AC ammeter, because the measurement is made differently in both cases.

It must be emphasized that the accuracy of the test will depend on the instruments used for measuring as well as the source signals used. Therefore, tests performed with secondary equipment should focus on operation verification and not on measuring accuracy.

1.5.3 Installation

- **Location**

The place where the equipment is installed must fulfill some minimum requirements, not only to guarantee correct operation and the maximum duration of useful life, but also to facilitate placing the unit in service and performing necessary maintenance. These minimum requirements are the following:

- Absence of dust.
- Absence of humidity.
- Absence of vibration.
- Good lighting.
- Easy access.
- Horizontal or vertical mounting.

Installation should be accomplished in accordance with the dimension diagrams.

- **Connections**

The first terminal of the terminal block corresponding to the auxiliary power supply must be connected to ground so that the filter circuits can operate. The cable used for this connection should be 14 AWG stranded wire, with a minimum cross section of 2.5 mm^2. The length of the connection to ground should be as short as possible, but not more than 75 inches (30 cm). In addition, the ground terminal of the case, located on the rear of the unit, should be connected to ground.

1.5.4 Preliminary Inspection

The following equipment aspects should be examined:

- The unit is in good physical condition, mechanical parts are securely attached and no assembly screws are missing.
- The unit model number and specifications agree with the equipment order.

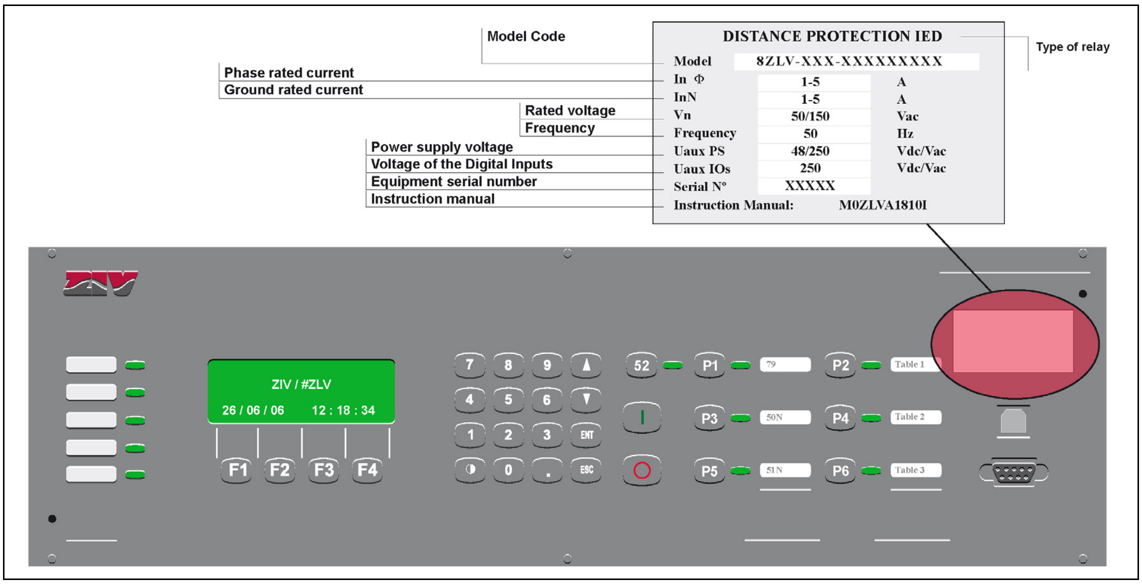


Figure 1.5.1: Name Plate.

1.5.5 Tests

1.5.5.a Isolation Test

While testing for isolation of switchgear and external wiring, the IED must be disconnected to avoid damage in case the test is not performed properly or if there are shorts in the harness, since the manufacturer has performed isolation testing on 100% of the units.

- **Common Mode**

All the terminals of the IED must be short-circuited, except those that relate to the power supply. The enclosure ground terminal must also be disconnected. Then 2000 Vac are applied between the interconnected terminals and the metal case for 1 min or 2500 Vac during 1s between the terminal group and the metal enclosure.

- **Transverse Mode**

The isolation groups are comprised of the current and voltage inputs (independent channels), digital inputs, auxiliary outputs, trip contacts and power supply. Reffer to the connection's schematic to identify the terminals to group for performing the test. Then 2500 VAC are applied during 1 sec. between each pair of groups.

WARNING!

There are internal capacitors that can generate high voltage if the test points are removed for the insulation test without reducing the test voltage.

1.5.5.b Power Supply Test

Connect the power supply as indicated in following table.

VDC PROT	CON1P	CON2P
F3(+) - F2(-)	F4-F5	F4-F6

It is important to verify that, when the IED is not energized, the contacts designated CON2P in the table mentioned previously are closed, and those designated CON1P are open. Then it is fed its rated voltage and the contacts designated CON1P and CON2P must change state and the "**Ready**" LED must light up.

1.5.5.c Metering Tests

For this test it should be considered that, if it is required to avoid trips while this is being carried out, the elements should be disabled and the cutoff of the injection of current and/or voltage by the breaker avoided. Subsequently, the currents and voltages which, as an example, are indicated in the following Table, will be applied to each of the channels and the following measures will be verified:

Applied Current or Voltage	Measured Current or Voltage	Phase of I or V applied	Phase of I or V measured	Freq. Applied (V > 20 Vac)	Freq. Measured (V > 20 Vac)
X	X ±1%	Y	Y ±1º	Z	Z ±5 mHz

Note: to check high current values, they are applied during the shortest possible time; for example, for 20 A, less than 8 seconds. To be able to view the angles, the phase A voltage must be applied the same as for measuring the frequency.

1.6 Onload Test

1.6.1 Introduction

The objectives of Onload Test are the following ones:

- Confirm that the external wiring of the voltage and current analog input channels is correct.
- Check the polarity of the current tranformers.
- Check the voltage and current measurements (module and angle).

In order to proceed with the test, primary injections will be done to check the polarity and transformation ratios. These tests can only be carried out if there are no restrictions related to the energization of the bay and all the other devices of the bay where the protection relay is located have already been commissioned.

Before starting the tests, check that all the test leads have been removed and ensure that the external wiring is properly connected (it is possible that during the commissioning tests external wirings have been disconnected).

1.6.2 Voltage Connections

Using a multimeter check that the secondary voltage measurements are correctly rated, and by means of a phase rotation meter confirm that the system phase rotation is the correct one.

Compare the secondary multimeter values with the measurements the relay shows in the measurement screen when the transformation ratio is set to 1. Check not only the module but also the angle. Modify the setting in order to show the measurements in primary values. The measurements that are displays in the HMI of the device or in the communication program should comply with the values which are specified in the Measurement Accuracy paragraph in Chapter 2.1, Technical Data.

1.6.3 Current Connections

Place a multimeter in series with each of the analog current inputs of the relay in order to test the secondary values of each phase. This test will be carried out comparing the value of the multimeter with the value displayed in the HMI of the relay when the transformation ratio is set to 1. Check not only the module but also the angle. Modify the setting in order to show the measurements in primary values. The measurements that are displays in the HMI of the device or in the communication program should comply with the values which are specified in the Measurement Accuracy paragraph in Chapter 2.1, Technical Data.

Check that when inyecting a balanced system, the current which is flowing through the neutral circuit of the transformer is negligible.

Ensure the current polarity is the correct one measuring the phase angle between the current and the voltage which are being injected.

Check that for load current flowing outside the bay (forward direction) the active power measurement is positive while for load current flowing inside the bay (reverse direction) the active power measurement is negative.

In those models with ground differential current measurement, check that the current polarity of the polarization channels is the correct one. Inject the same current value in the polarization channel and just in one phase analog input lagging 180º and check that the ground differential current (IGN) is zero or almost zero. In case of having ground differential current, modify the wiring of the polarization channel.

Chapter 2.

Technical Specifications and Physical Description

2.1 Technical Data

2.1.1 Power Supply Voltage

ZLV IEDs have two types of auxiliary power supplies. Depending on the model, their values are selectable:

24 VDC (+20% / -15%)
48 - 250 VAC/VDC (±20%)

Note: In case of power supply failure, a maximum interruption of 100 ms is allowed for 110 Vdc input.

2.1.2 Power Supply Burden

Quiescent	**7 W**
Maximum	**<20 W**

2.1.3 Current Analog Inputs

Rated current (selectable in the IED)	In = **5 A** or **1 A**
Thermal withstand capability	**20 A** (continuously)
Standard connectors	**250 A** (for 1s)
Self-Shorting connectors	**500 A** (for 1s)
Dynamic limit	**1250 A**
Current circuit burden (connector perfectly screwed and measured in equipment terminals)	**<0.2 VA** (In = **5 A** or **1 A**)

2.1.4 Voltage Analog Inputs

Rated voltage	Un = **50** to **230 VAC**
Thermal withstand capability	**300 VAC** (continuously)
	400 VAC (for 10s)
Voltage circuit burden	**0.1 VA** (110/120 VAC)

2.1.5 Frequency

Operating range	**16 - 81 Hz**

2.1.6 Measurement Accuracy at Environment Temperature (25ºC)

Measured currents Phase and Ground	**±0.15%** or **±2 mA** (the greater) for 0.1*Inom≤I<2*Inom **±0.2%** for 2*Inom≤I≤5*Inom
Measured currents Ungrounded and Sensitive Ground	**±0.15%** or **±1 mA** (the greater) for 0.005 A≤I<1.5 A **±0.2%** for I>=1.5 A
Calculated currents Phase - Phase I_1, I_2 and I_0	**±0.2%** or **±6 mA** (the greater) **±0.3%** or **±8 mA** (the greater) for 0.1*Inom<I≤5*Inom
Measured voltages Phase-Ground, Phase-Phase, Ground and Synchronism	**±0.2%** or **±50 mV** (the greater) for 0.2 V≤V<130 V **±0.25%** for 130 V≤V≤250 V
Calculated voltages Phase-Phase (0 to 300V) VGround , V_1, V_2 and V_0	**±0.3%** or **±75 mV** (the greater) **±0.3%** or **±100 mV** (the greater) for 0.2 V≤V≤250 V
Active and reactive powers (In = 5A and I_{phases}>1A) Angles 0º or ±90º or 180º Angles ±45º or ±135º Angles ±75º / ±115º	 **±0.33% W/var** **±1.6% W/var** **±5% W / ±0.65 % var**
Angles	**±0.5º**
Power factor	**±0.013**
Frequency	**±0.005 Hz**

Note: Signal processing.

Sampling function adjustment of analog input signals is made by means of zero pass count of one of the measured signals, and works detecting the change in said signal period. The value of the calculated frequency is used to modify the sampling frequency used by the metering device attaining a constant sampling frequency of 32 samples per cycle. The frequency value is saved for later use in Protection and Control tasks.

The zero crossings are detected by the voltage inputs VA, VB or VC; when the value of the line-to-neutral phase A voltage descends below 2V, the VB will be used; if VA and VB are below 2V, then VC is used.

For loss of voltage in three phases, the sampling rate corresponding to the adjusted nominal frequency is used.

- **If measured value of voltage for all phases is lower than 2V, the sampling frequency corresponding to the adjusted nominal frequency is used.**

When Protection and Control tasks are readjusted in accordance with the sampling function, phasor real and imaginary components of analog signals are calculated by means of the Fourier transform. Fourier components are calculated by means of said Discrete Fourier Transform (DFT) using 32 sample/cycle. Using DFT this way the magnitude and phase angle of the fundamental component at power system frequency of every analog input signal is obtained. The rest of measurements and calculations of Protection functions is obtained based on the fundamental components calculated by the Fourier method. DFT gives a precise measurement of the fundamental frequency component and it is an efficient filter for harmonics and noise.

Harmonics are not completely damped for frequencies other than the nominal frequency. This is not a problem for small deviations of ±1Hz but, in order that a greater deviation from the working frequency can be allowed, the above-mentioned automatic adjustment of the sampling frequency is included. On lack of an adequate signal for sampling frequency adjustment, said frequency is adjusted to the corresponding nominal frequency (50/60Hz).

2.1.7 Effect of Temperature in Measurement Accuracy

Temperature range	**-25ºC** to **70ºC** (operating range)
Measured currents	for 0.1*Inom≤I<2*Inom
Any current channels	**±0.85%**
	for -25ºC ≤x≤5ºC and 30ºC ≤x≤70ºC
	for 2*Inom≤I≤5*Inom
	±0.35%
	for -25ºC ≤x≤5ºC and 50ºC ≤x≤70ºC
Measured voltages	for V<1 V
Any voltage channel	**±0.75%**
	for -25ºC ≤x≤5ºC and 30ºC ≤x≤70ºC
	for 1 V≤V≤250 V
	±0.25%
	for -25ºC ≤x≤-5ºC and 50ºC ≤x≤70ºC
	for 1 V≤V≤250 V
	±0.35%
	for -25ºC ≤x≤-15ºC and 30ºC ≤x≤70ºC

Note: these error margins will be added to the measurement accuracy at environment temperature ones. In the temperature range which is not defined, the measurement accuracy is not affected.

2.1.8 Accuracy of the Pickup and Reset of the Overcurrent Units

Overcurrent units	
Pickups and resettings of phases and ground (for In = 1A and 5A) (static test)	**±3%** or **±10mA** of the theoretical value (the greater)

Measuring times	
Fixed time characteristic	**±1%** of the setting or **±35 ms** (the greater)
Inverse Time (UNE 21-136, IEC 255-4) (for measured currents of 100 mA or greater)	**Class 2** (E=2) or **±35ms** (the greater)

2.1.9 Accuracy of the Pickup and Reset of the Voltage Units

Overvoltage and Undervoltage Elements	
Pickup and reset (static test)	**±2%** or **±250 mV** of the theoretical value (the greater)
Measuring times	
Fixed Time	**±1%** of the setting or **±35 ms** (the greater)

2.1.10 Accuracy of the Pickup of the Distance Units

Distance Units	
Pickup in Line Angle (static test)	**±5%** or **±0,01 Ω** (**V>0.5 V**) of the theoretical value (the greater)
Measuring times	
Fixed Time	**±1** of the setting or **±35 ms** (the greater)

2.1.11 Accuracy of the Directional Units

Pickup	**±2º** of the theoretical value

2.1.12 Trip Time of Distance Elements

The following diagrams show the operating times of distance elements for different SIR (**System Impedance Ratio**) and different fault percentage with respect to the zone reach.

$SIR = \frac{ZS}{ZL}$ Where ZS represents the local source impedance and ZL the line impedance.

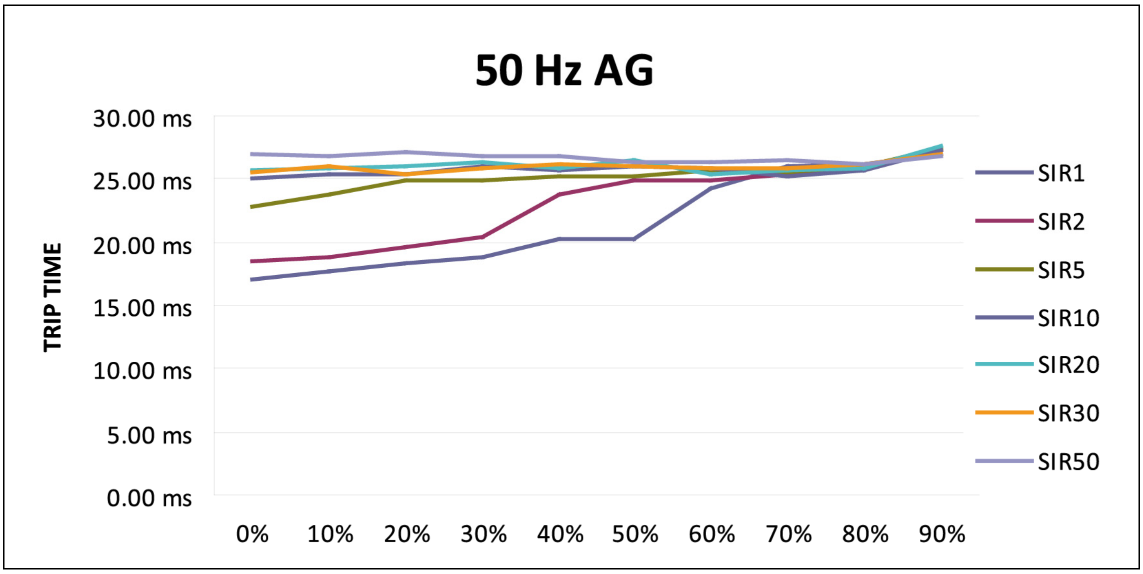


Figure 2.1.1: Trip Times for 50Hz Single-Phase Fault.

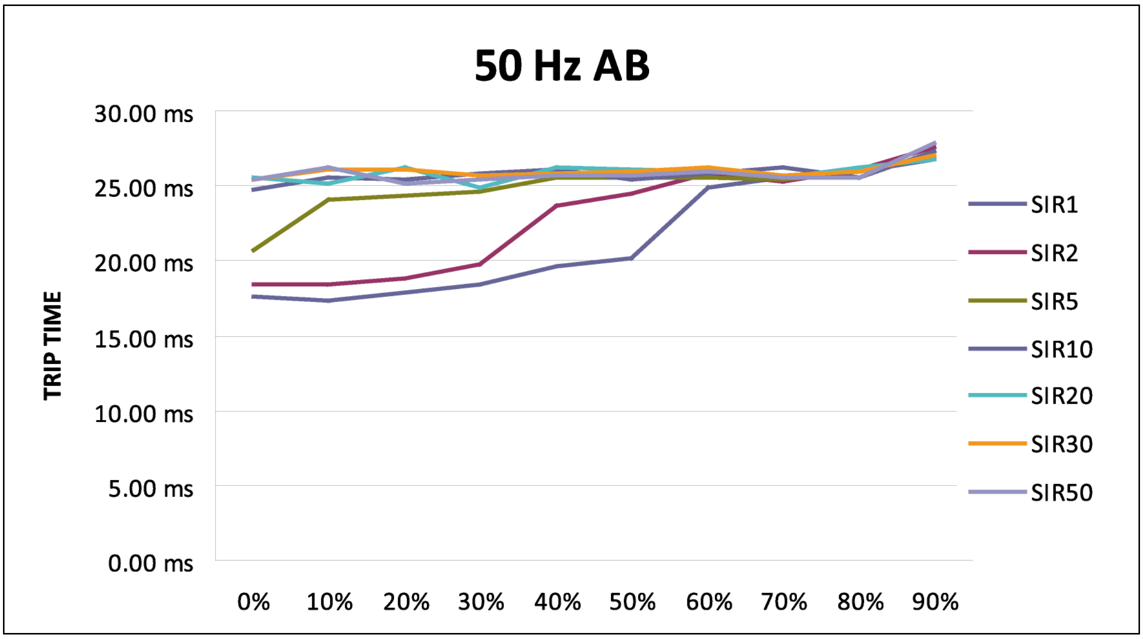


Figure 2.1.2: Trip Times for 50Hz Two-Phase Fault.

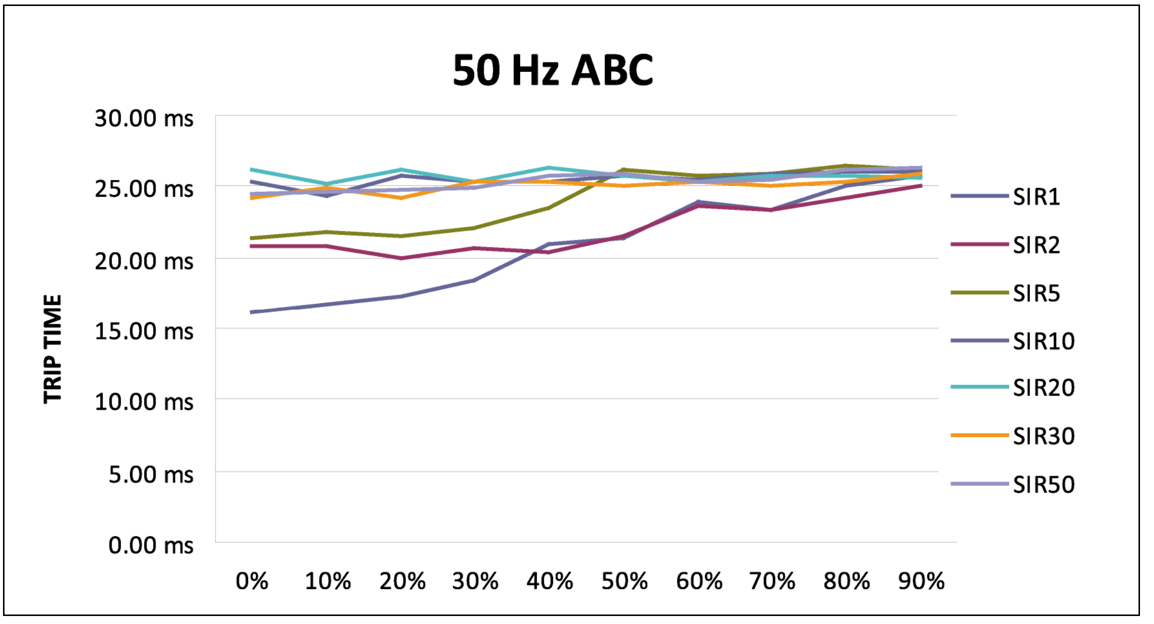


Figure 2.1.3: Trip Times for 50Hz Three-Phase Fault.

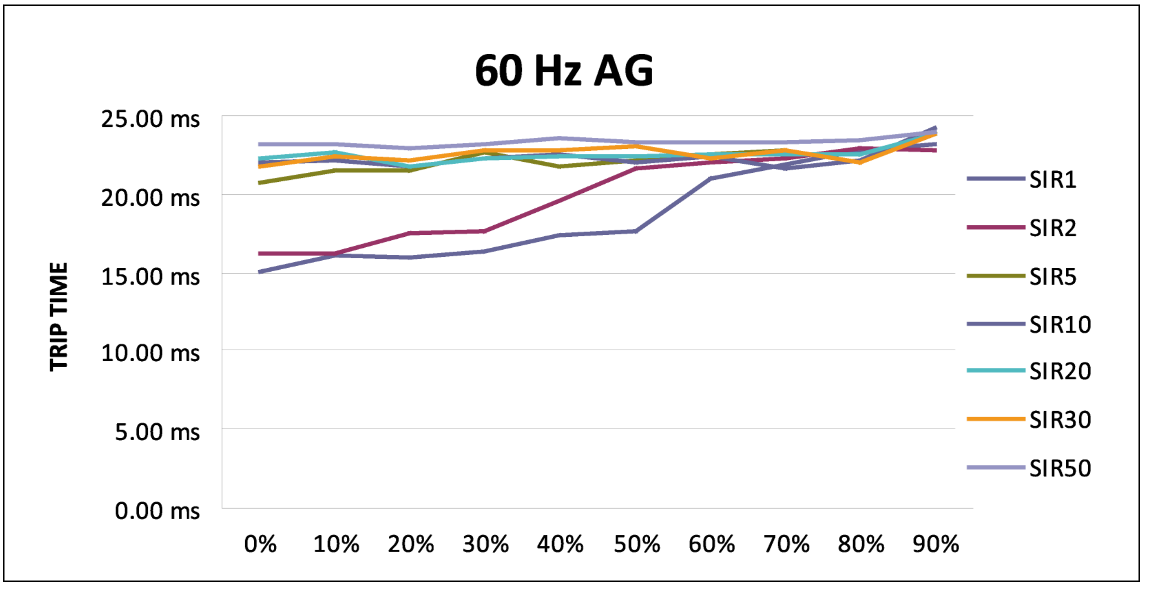


Figure 2.1.4: Trip Times for 60Hz Single-Phase Fault.

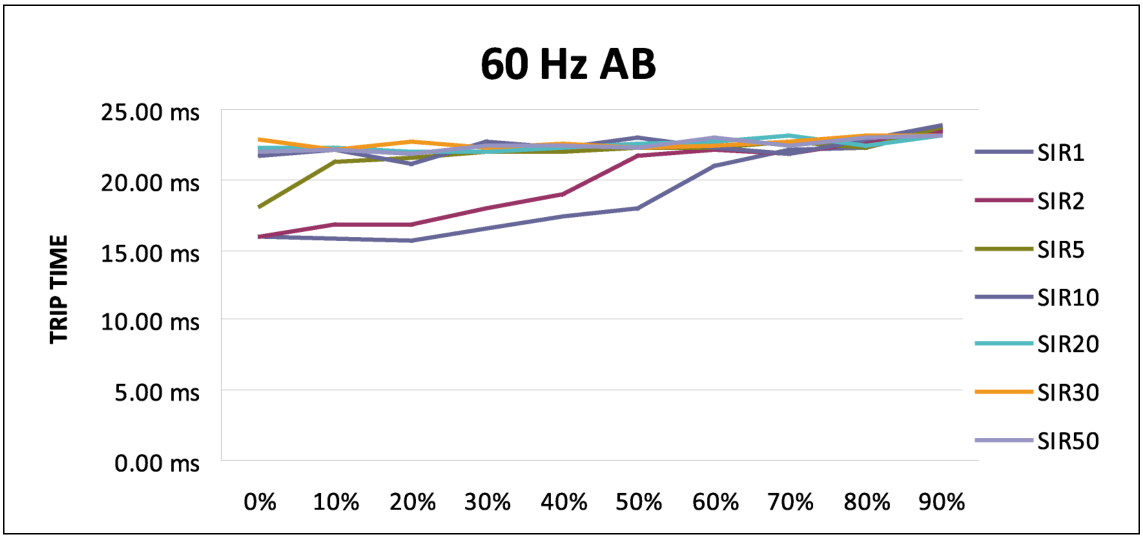


Figure 2.1.5: Trip Times for 60Hz Two-Phase Fault.

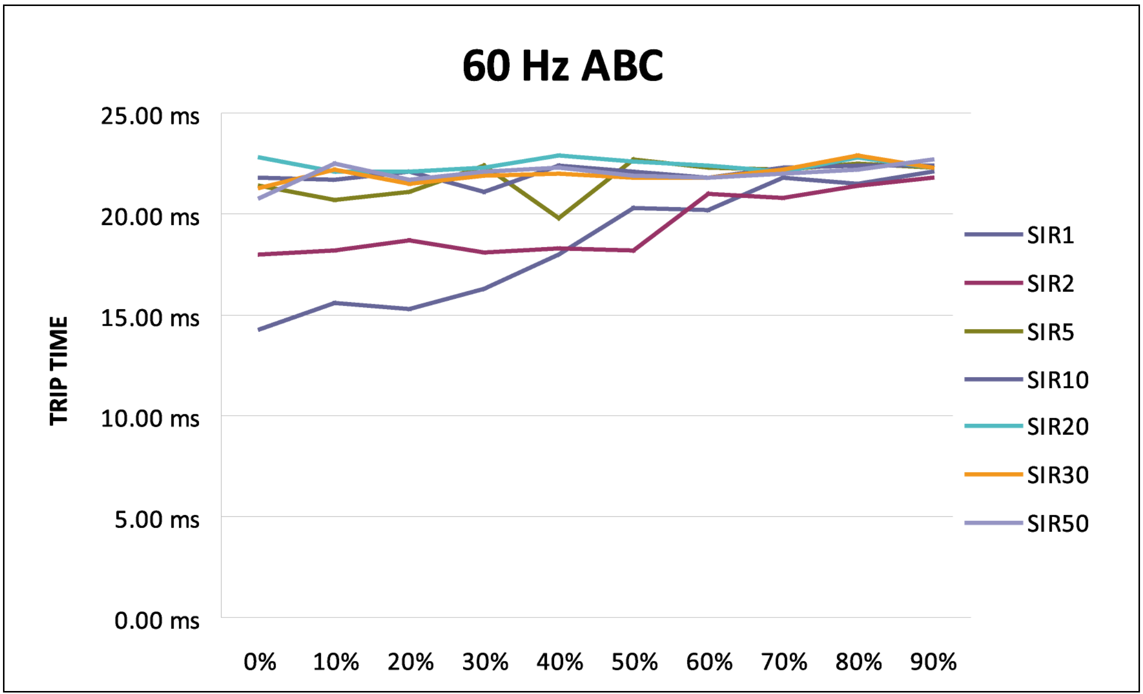


Figure 2.1.6: Trip Times for 60Hz Three-Phase Fault.

Note: Trip Times have been obtained with fast trip outputs (see section 2.1.16).

The **ZLV-***-****F/H**** and **ZLV-G/J**-****D**** models have a Fast Distance Unit that can reach operation times below the cycle. The following diagrams show the operating times of distance elements for different SIR (**System Impedance Ratio**) and different fault percentage with respect to the zone reach.

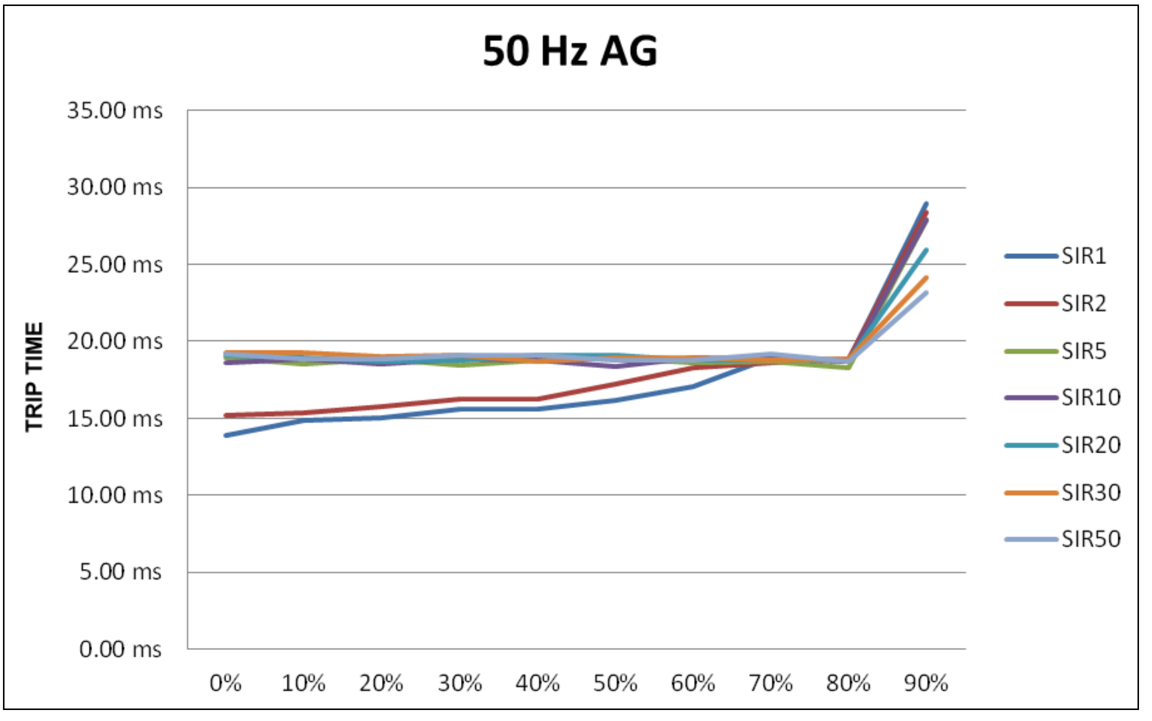


Figure 2.1.7: Trip Times for 50Hz Single-Phase Fault. ZLV-*-****F/H** Models.**

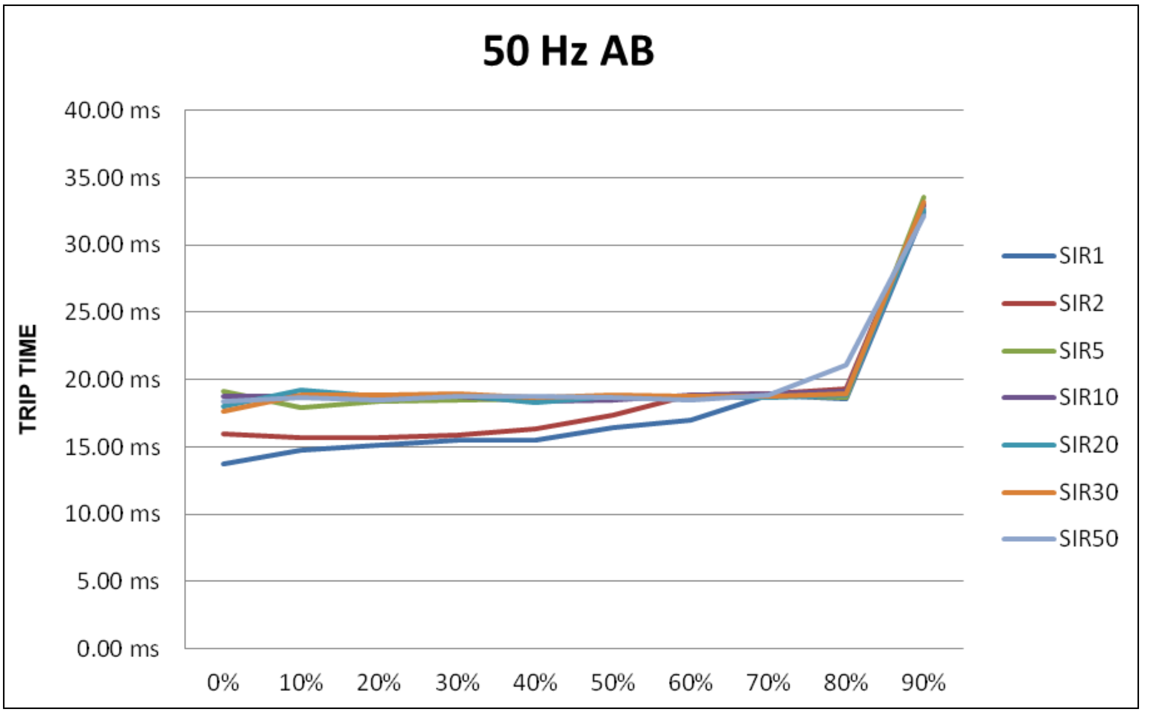


Figure 2.1.8: Trip Times for 50Hz Two-Phase Fault. ZLV-*-****F/H**Models.**

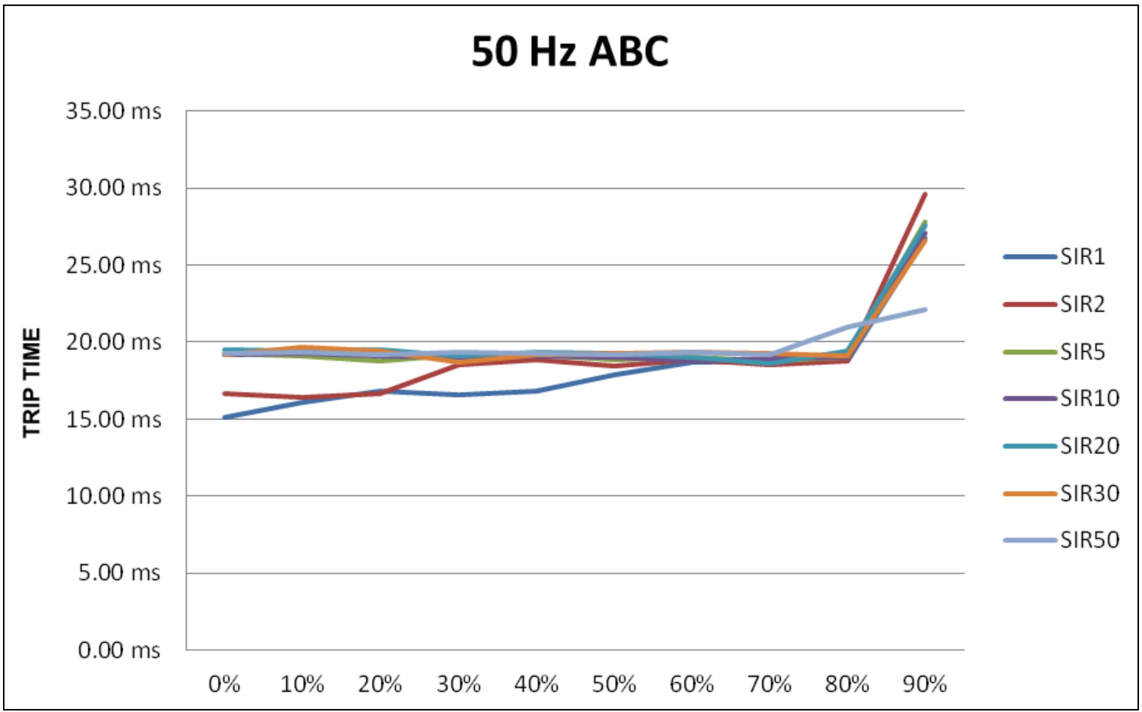


Figure 2.1.9: Trip Times for 50Hz Three-Phase Fault. ZLV-*-****F/H** Models.**

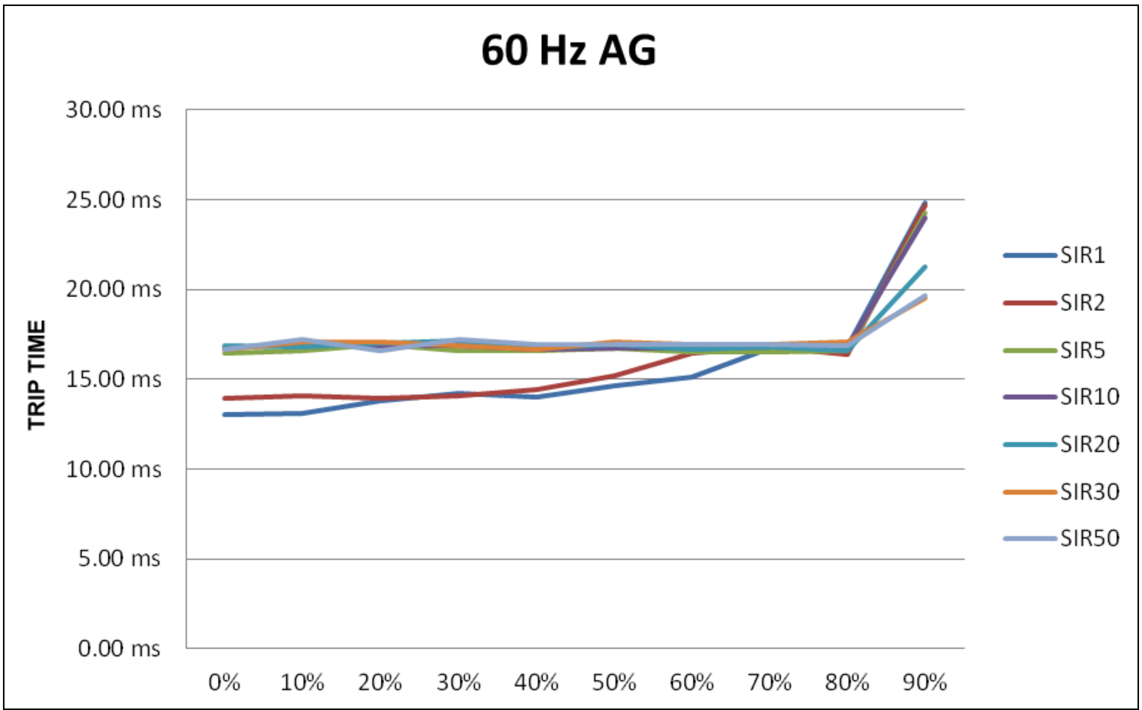


Figure 2.1.10: Trip Times for 60Hz Single-Phase Fault. ZLV-*-****F/H** Models.**

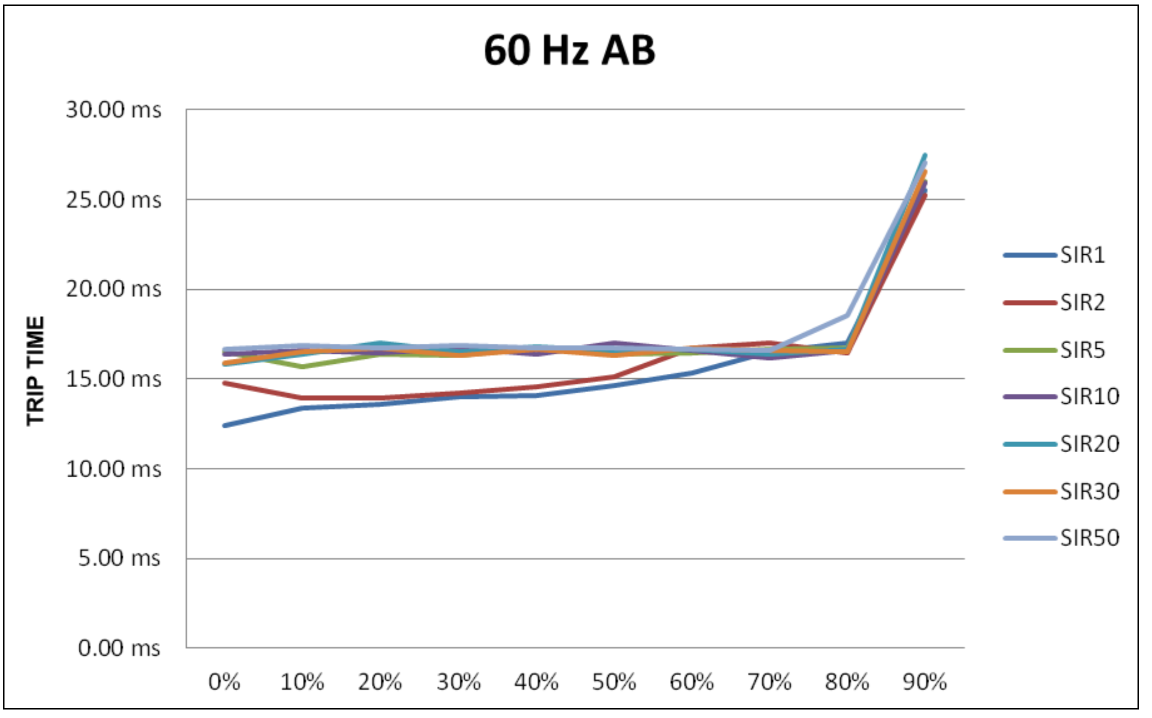


Figure 2.1.11: Trip Times for 60Hz Two-Phase Fault. ZLV-*-****F/H** Models.**

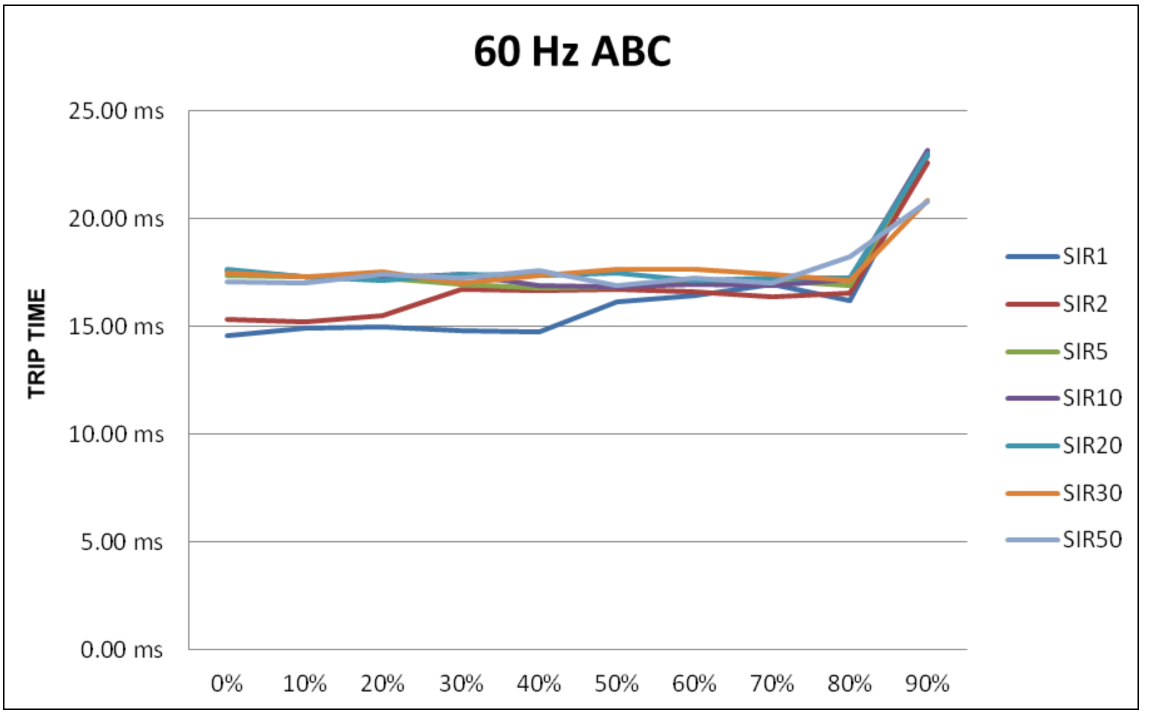


Figure 2.1.12: Trip Times for 60Hz Three-Phase Fault. ZLV-*-****F/H** Models.**

Note: Trip Times have been obtained with fast trip outputs (see section 2.1.16).

2.1.13 Accuracy of the Pickup and Reset of the Frequency Elements

Overfrequency Elements	
Pickup and reset	**±0.01 Hz** of the theoretical value
Underfrequency Elements	
Pickup and reset	**±0.01 Hz** of the theoretical value
Measuring times	
Fixed Time	**±1%** of the setting or **±25 ms** (the greater)

2.1.14 Repeatability

Operating time	**2%** or **25 ms** (the greater)

2.1.15 Transient Overreach

Expressed as: $$ST = \frac{I_A - I_T}{I_A} x100$$

<5%

IA = Pick up value for a current with no dc component.
IT = Pick up value for a current with maximum dc offset.

2.1.16 Breaker Trip and Close Outputs and Auxiliary Outputs

Normally open contacts for switching and auxiliary outputs.

I DC maximum limit (with resistive load)	**60 A** (1 s)
I DC continuous service (with resistive load)	**16 A**
Close	**5000 W**
Breaking capability (with resistive load)	**240 W** - max. **5 A** - (**48 Vdc**) **110 W** (**80 Vdc** - **250 Vdc**) **2500 VA**
Break (L/R = 0.04 s)	**120 W** at **125 Vdc**
Switching voltage	**250 Vdc**
Momentary close time trip contacts remain closed	**100 ms**
Break delay	**<150 ms**

2.1.17 Solid State Operating Outputs

In **ZLV-***-*A*****, ZLV-***-*B*****, ZLV-***-*C*****, ZLV-***-*D***** and **ZLV-***-*G***** relays, **OUT1**, **OUT2**, **OUT3**, **OUT4**, **OUT5** and **OUT6** are solid state outputs operating in parallel with an electromechanical relay. These outputs are approximately 6 ms faster than normal outputs and have the same close and open current capacity, so they are very suitable for being used as trip outputs. In order for the solid state output to operate it must be connected to a circuit at a voltage Vdc>20 V (see Figure).

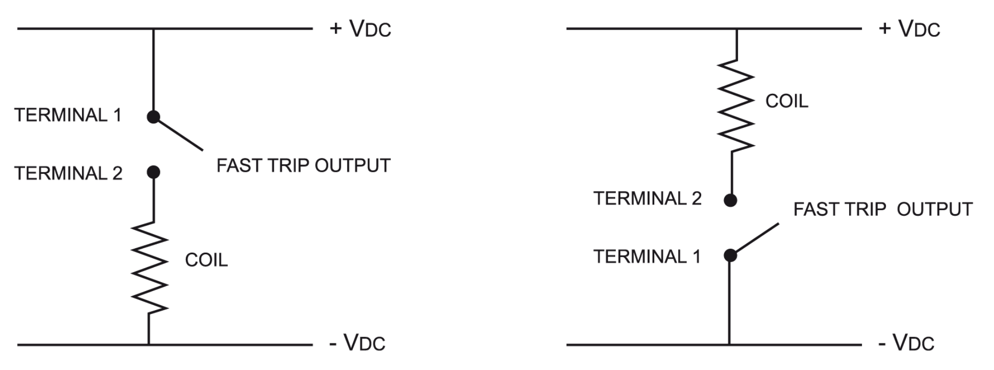


Figure 2.1.13: Fast Trip Output Wiring Diagram.

2.1.18 Solid State Auxiliary Outputs

Models **ZLV** are provided with 4 auxiliary output contacts with a close and breaking capability lower than the remaining outputs and can be dedicated to activating / deactivating signal transmission through the teleprotection communication channel:

OUT7, **OUT8**, **OUT9** and **OUT10**

These 4 outputs can be programmed to close their contact by means of a solid-state relay, an electromechanical relay or both at the same time. Solid-state relay characteristics are:

Continuous	**300 mA**
Switching voltage	**400 Vdc**
Maximum operating and resetting time	**1 ms**

Warning: these outputs are internally protected by diodes and therefore have a specific polarity, which has to be respected. See external connection diagrams.

2.1.19 Digital Inputs

Configurable inputs with polarity (IN1 is alternating current, the rest are direct current)

Rated Voltage	Maximum Voltage	Burden	V on	V off
110/125 Vac	250 Vac	350 mW	85 Vac	51 Vac
24 Vdc	48 Vdc	50 mW	12 Vdc	9 Vdc
48 Vdc	90 Vdc	500 mW	30 Vdc	25 Vdc
125 Vdc	300 Vdc	800 mW	70 Vdc	65 Vdc
125 Vdc (65%)	300 Vdc	800 mW	89 Vdc	84 Vdc
250 Vdc	500 Vdc	1 W	120 Vdc	115 Vdc

IN2 to IN10 and IN16 to IN22 inputs can be programmed to monitor the switching circuits, and two different ranges are available:

For IEDs with **24 Vdc** digital inputs: monitoring voltage of 24 Vdc

For IEDs with **48 Vdc**, **125 Vdc** or **250 Vdc** digital inputs: monitoring voltage of 48 Vdc to 250 Vdc.

In IEDs with spare digit **D/E/F/G/H**, any of the inputs except IN1 can be configured to be used for the binary input PPS or PPM synchronization.

Note: In those cases in which input IN1 can be feeded also with Vac, it has an approximated activation and deactivation time of 150 ms and therefore it is not suitable for applications that require fast detection times.

2.1.20 Communications Link

Local Communications Port (RS232C and USB)

Remote Communications Ports (GFO, PFO, RS232C, RS232-Full Modem or RS485)

Glass Fiber Optics

Type	**Multimode**
Wavelength	**820 nm**
Connector	**ST**
Transmitter Minimum Power:	
50/125 Fiber	**- 20 dBm**
62.5/125 Fiber	**- 17 dBm**
100/140 Fiber	**- 7 dBm**
Receiver Sensitivity:	**- 25.4 dBm**

Plastic Fiber Optics (1 mm)

Wavelength	**660 nm**
Transmitter Minimum Power	**- 16 dBm**
Receiver Sensitivity	**- 39 dBm**

RS232C Port Signals	
Terminal unit DB-9 (9-pin) connectors	**Pin 5 - GND** **Pin 2 - RXD** **Pin 3 - TXD**

RS232C Full MODEM Port Signals	
Terminal unit DB-9 (9-pin) connectors	Pin 1 - DCD Pin 2 - RXD Pin 3 - TXD Pin 4 - DTR Pin 5 - GND Pin 6 - DSR Pin 7 - RTS Pin 8 - CTS Pin 9 - RI

RS485 Port Signals	
Used signals	**Pin 4 - (A) TX+ / RX+** **Pin 6 - (B) TX- / RX-**

IRIG-B 123 and 003	B: 100pps	
	1: Amplitude modulated wave	0: By pulse width
	2: 1kHz/1ms	0: Without carrier
	3: BCD, SBS	3: BCD, SBS
Type BNC connector		
Input impedance	**41 Ω**, **211 Ω** or **330 Ω** (*)	
Default impedance	**211 Ω**	
Maximum input voltage	**10 V**	

(*) Selectable internally by the manufacturer.

2.2 Standards and Type Tests

The equipment satisfies the standards indicated below. When not specified, the standard is UNE 21-136 (IEC-60255).

2.2.1 Insulation

Insulation Test (Dielectric Strength)	*IEC-60255-5*
Between all circuit terminals and ground	**2 kV**, **50/60 Hz**, for **1 min**; or **2.5 kV**, **50/60 Hz**, for **1s**
Between all circuit terminals	**2 kV**, **50/60 Hz**, for **1min**; or **2.5 kV**, **50/60 Hz**, for **1s**
Measurement of Insulation Resistance	*IEC-60255-5*
Common mode	**R** ≥ **100 MΩ** or **5μA**
Differential mode	**R** ≥ **100 kΩ** or **5mA**
Voltage Impulse Test	*IEC-60255-5* (*UNE 21-136-83/5*)
Common mode (analog inputs, DIs, AOs and PS)	**5 kV**; **1.2/50 μs**; **0.5 J**
Differential mode (AOs)	**1 kV**; **1.2/50 μs**
Differential mode (Power Supply)	**3 kV**; **1.2/50 μs**

2.2.2 Electromagnetic Compatibility

1 MHz Burst Test	*IEC-60255-22-1 Class III* (*UNE 21-136-92/22-1*)
Common mode	**2.5kV**
Differential mode	**2.5kV**
Fast Transient Disturbance Test	*IEC-60255-22-4 Class IV* (*UNE 21-136-92/22-4*) (**IEC 61000-4-4**) **4 kV ±10 %**
Radiated Electromagnetic Field Disturbance	*IEC 61000-4-3 Class III*
Amplitude modulated (*EN 50140*)	**10 V/m**
Pulse modulated (*EN 50204*)	**10 V/m**
Conducted Electromagnetic Field Disturbance	*IEC 61000-4-6 Class III* (*EN 50141*)
Amplitude modulated	**10 V**
Electrostatic Discharge	*IEC 60255-22-2 Class IV* (*UNE 21-136-92/22-2*) (*IEC 61000-4-2*)
On contacts	**±8 kV ±10 %**
In air	**±15 kV ±10 %**

Surge Immunity Test	*IEC-61000-4-5* (*UNE 61000-4-5*)
	(1.2/50µs - 8/20µs)
Between conductors	4 kV
Between conductors and ground	4 kV

Radiated Electromagnetic Field Disturbance at Industrial Frequency (50/60 Hz)	*IEC61000-4-8*

Radio Frequency Emissivity	*EN55022* (Radiated) *EN55011* (Conducted)

2.2.3 Environmental Test

Temperature	*IEC 60068-2*
Cold work	*IEC 60068-2-1* **-5º C**, **2 hours**
Cold work limit conditions	*IEC 60068-2-1* **-10º C**, **2 hours**
Dry heat	*IEC 60068-2-2* **+45º C**, **2 hours**
Dry heat limit conditions	*IEC 60068-2-2* **+55º C**, **2 hours**
Humid heat	*IEC 60068-2-78* **+40º C**, **93% relative humidity**, **4 days**
Quick temperature changes	*IEC 60068-2-14 / IEC 61131-2* IED open, **-25º C** for **3h** and **+70º C** for **3h** (**5 cycles**)
Changes in humidity	*IEC 60068-2-30 / IEC 61131-2* **+55º C** for **12h** and **+25º C** for **12h** (**6 cycles**)
Endurance test	**+55º C** for **1000 hours**

Operating range	From **-40ºC** to **+85ºC** (standard model) From **-40ºC** to **+70ºC** (model with IEC61850 communications interface)
Storage range	From **-40ºC** to **+85ºC** (standard model) From **-40ºC** to **+70ºC** (model with IEC61850 communications interface)
Humidity	**95 %** (non-condensing)

Climate Test (55º, 99% humidity, 72 hours)

Time / Current Characteristic	*ANSI C37.60 Class II*

2.2.4 Power Supply

Power Supply Interference and Ripple	*IEC 60255-11 / UNE 21-136-83 (11)* **< 20 %** and **100 ms**
Inverse Polarity of the Power Supply	*IEC 61131-2*
Resistance of Ground Connection	*IEC 61131-2* **< 0.1 Ω**
Gradual Stop / Start Test	*IEC 61131-2 (Test A)*
Surge Capacity	*IEC 60044-1*

2.2.5 Mechanical Test

Vibration (sinusoidal)	*IEC-60255-21-1 Class I*
Mechanical Shock and Bump Test	*IEC-60255-21-2 Class I*
External Protection Levels	*IEC-60529 / IEC 60068-2-75*
Front	*IP31* (without protection cover) *IP51* (with protection cover)
Rear Protection	*IP10*
Mechanical Protection	*IK07*

The models comply with the EEC 89/336 standard of electromagnetic compatibility.

2.3 Physical Architecture

2.3.1 General

The **ZLV** is made up of the following boards:

- Power Supply.
- Processor module and analog inputs.
- Digital inputs, outputs and transducers input.
- Communications module.

The boards, or modules, are mounted horizontally and can be extracted by removing the front panel. External connections use plug-in terminal blocks on the rear panel of the enclosure, with ring lug connectors.

Depending on the terminal configuration, all the contact inputs / outputs may be used or some may remain as spare signals.

Figures 2.3.1 and 2.3.2 represent the external appearance of the 2-unit high models (horizontal format) of the **ZLV** family.

Mounted on the front are the alphanumeric keypad and display, the local communication ports (RS232C and USB), the local control buttons and the LED targets.

Figure 2.3.1: Front of a 2-Unit High 8ZLV.

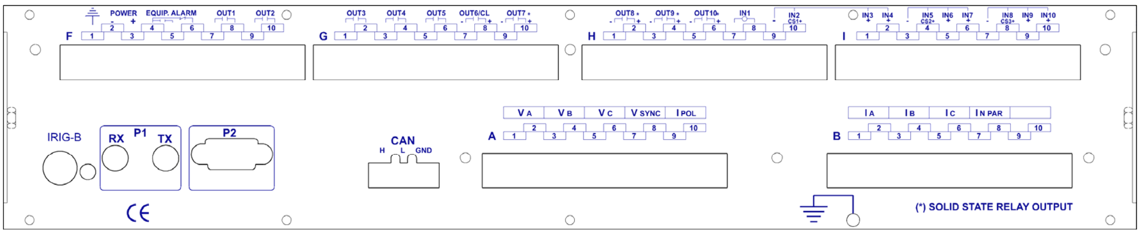


Figure 2.3.2: Rear of a 2-Unit High 8ZLV.

Another **ZLV** horizontal models are available with 3U, 4U and 6U high and 19” rack width with a front panel with that same control functions and a rear panel with additional terminals for expansion of digital inputs and outputs. These units are depicted in figures 2.3.3, 2.3.4, 2.3.5 2.3.6, 2.3.7 and 2.3.8.

Figure 2.3.3: Front of a 3-Unit High 8ZLV.

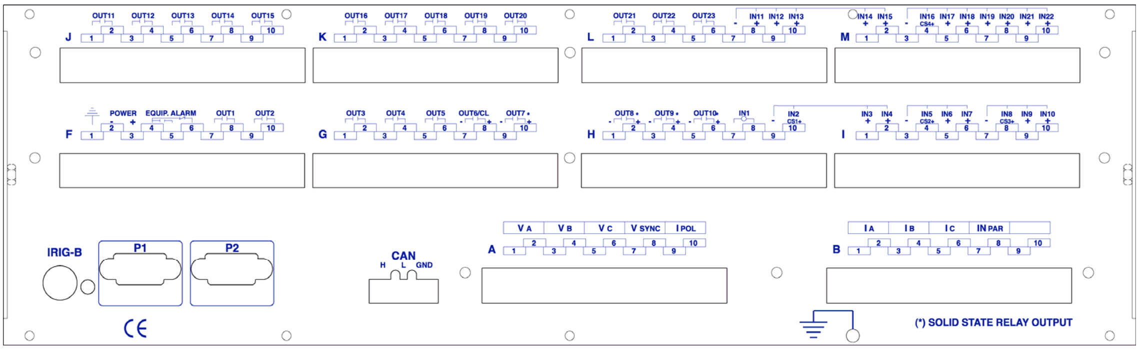


Figure 2.3.4: Rear of a 3-Unit High 8ZLV.

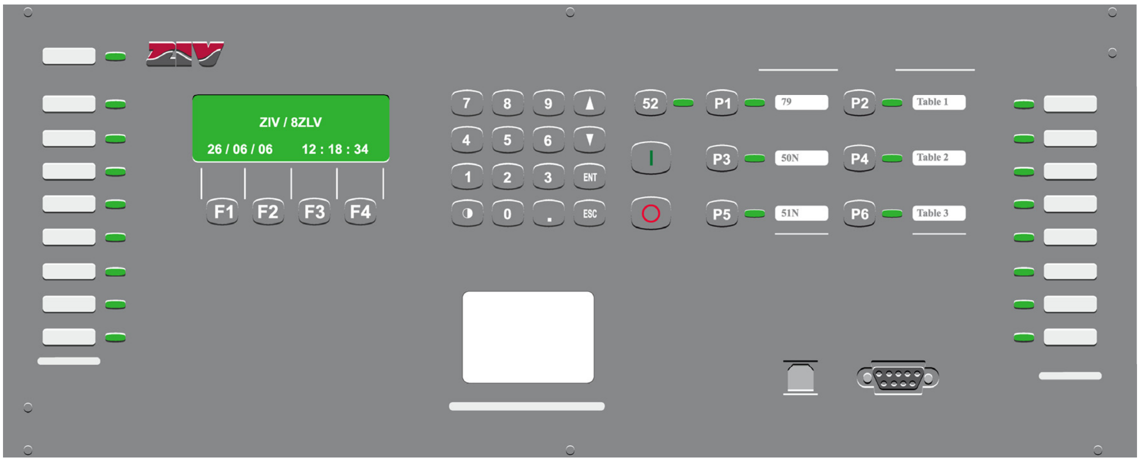


Figure 2.3.5: Front of a 4-Unit High 8ZLV.

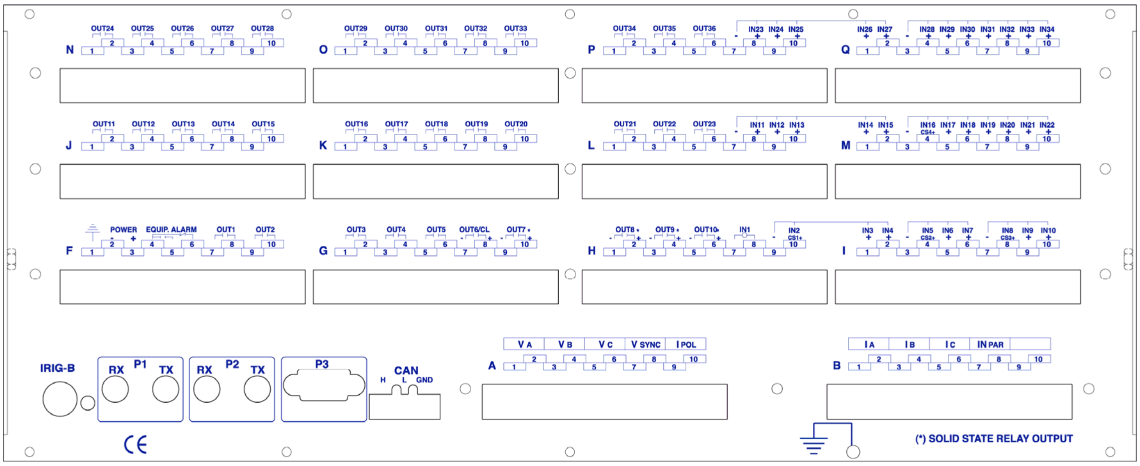


Figure 2.3.6: Rear of a 4-Unit High 8ZLV.

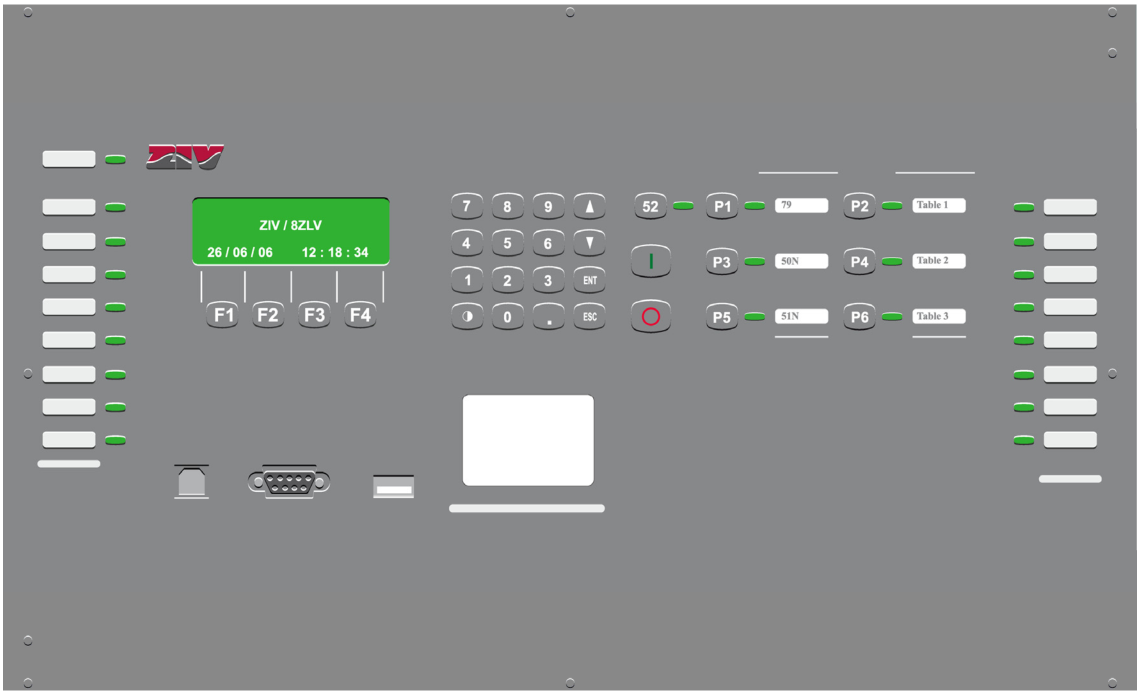


Figure 2.3.7: Front of a 6-Unit High 8ZLV.

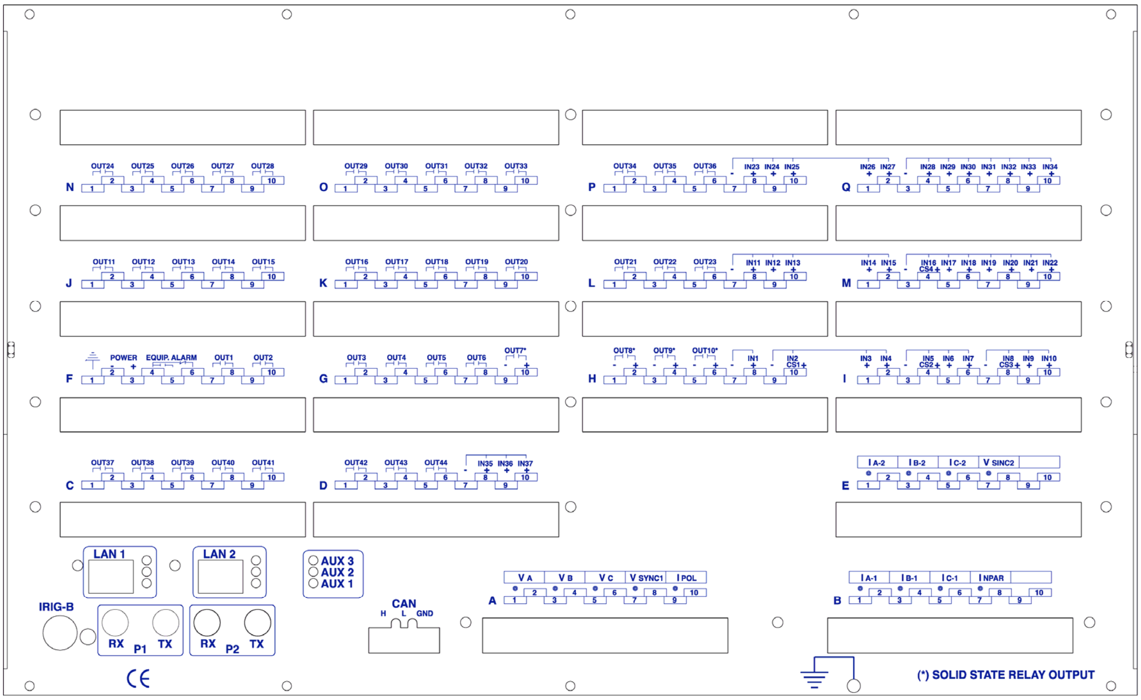


Figure 2.3.8: Rear of a 6-Unit High 8ZLV.

All **ZLV** relay models (enclosure: 2U, 3U, 4U and 6U) can include, as an option, a front cover with a pushbutton to access the key **F2**.

Figures 2.3.9, 2.3.10, 2.3.11 and 2.3.12 represent the external appearance of the vertical format models. The dimensions of the enclosure are identical to those of the 3-unit high and 4-unit high (19"-rack) horizontal models, respectively.

Figure 2.3.9: Front of the 3-Unit High Vertical Model.

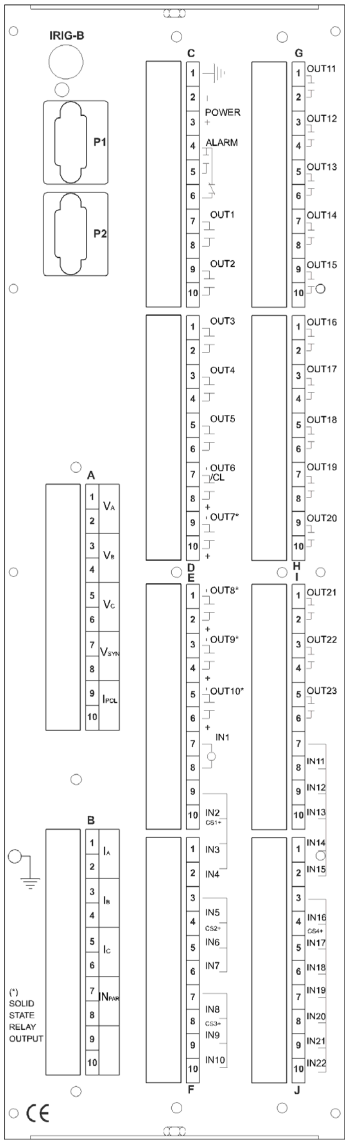


Figure 2.3.10: Rear of the 3-Unit High Vertical Model.

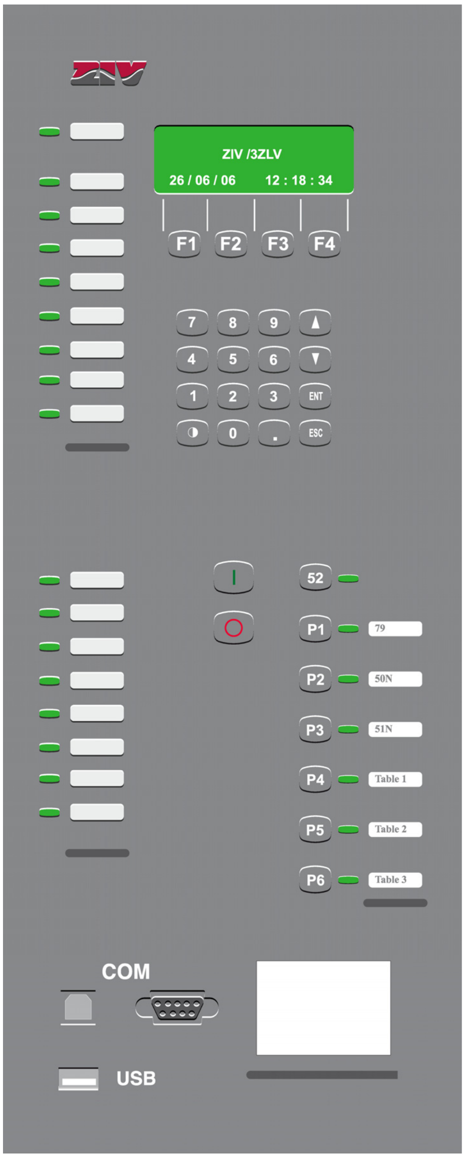


Figure 2.3.11: Front of the 4-Unit High Vertical Model.

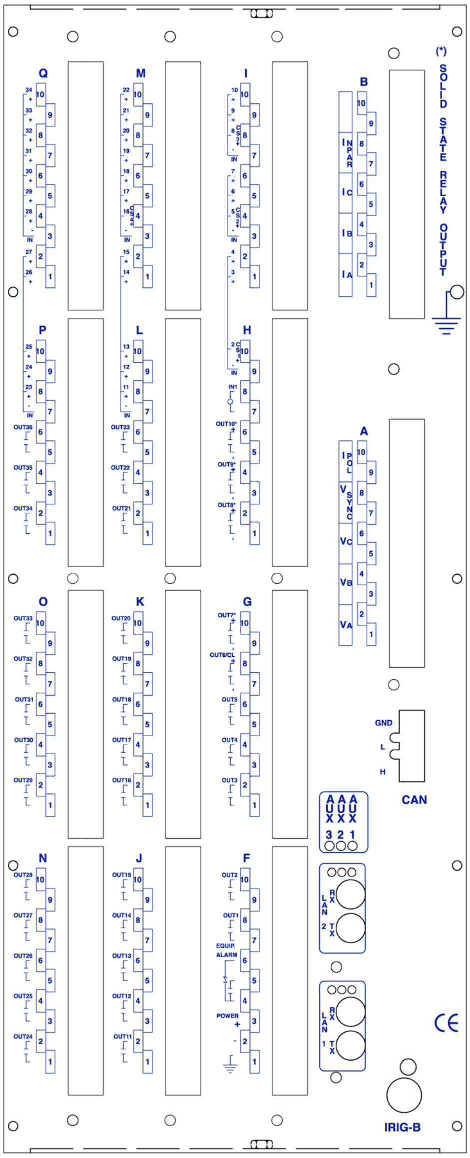


Figure 2.3.12: Rear of the 4-Unit High Vertical Model.

2.3.2 Dimensions

Depending on the model, **ZLV** relays are mounted as follows:

- Models in enclosures of 1 19"-, 2 standard units high, in horizontal format.
- Models in enclosures of 1 19"-, 3 standard units high, in horizontal and vertical formats.
- Models in enclosures of 1 19"-, 4 standard units high, in horizontal and vertical formats.
- Models in enclosures of 1 19"-, 6 standard units high, in horizontal format.

The equipment is intended to be installed either semi-flush mounted on panels or inside a 19" rack. The enclosure is graphite gray.

2.3.3 Connection Elements

2.3.3.a Terminal Blocks

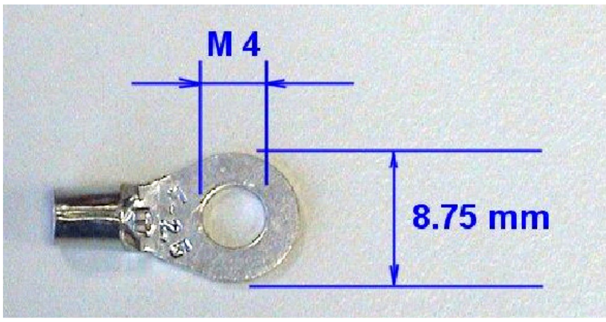
The number of connectors depends on the number of the model's contact inputs and outputs. Moreover, the terminal blocks are arranged differently depending on the model (2-units, 3-units, 4-units high or 6-units high).

Terminal blocks are horizontal as shown in the figures. The terminal arrangement for the 2-units high model is as follows:

- 1 row with 2 terminal blocks of 10 inputs each (20 terminals) for analog currents and voltages plus all the communication and synchronization connectors.
- 1 row with 4 terminal blocks of 10 terminals each (40 terminals) for digital inputs, auxiliary outputs, trip and close contacts and power supply input.

As an option is possible to expand the number of digital inputs and outputs by adding one or two more rows with 4 terminal blocks of 10 terminals each one (40, 80 or 150 terminals). To accommodate the extra hardware the unit is 3U, 4U or 6U high (see figures 2.3.4, 2.3.6 and 2.3.8).

The vertical format models have a rear plate with the same number and type of terminal blocks as the 3-unit and 4-unit models. See their layouts in figures 2.3.10 and 2.3.12. When the expansion board is not included, the corresponding terminal blocks are not mounted. The resulting gaps are covered with blank plates.



The terminals take wires up to #10 AWG (6 mm^2). We recommend ring lug terminals for these connections.

The connectors are plug-in and not self-shorting. They can be assigned to the current circuits supporting a current of 20 A continuously.

2.3.3.b Removing Printed Circuit Boards (Non Self-Shorting)

WARNING!

The IED's printed circuit board can be taken out. **WARNING: the current connector is non self-shorting. Consequently, the CT secondaries must be short-circuited externally before board removal.**

The printed circuit board is attached to the case with self-tapping screws. These screws must be removed before the board is withdrawn. This operation always requires the protection to be **not in service**.

2.3.3.c Internal Wiring

The equipment uses traditional printed circuit board connections and internal buses to minimize internal wiring.

Chapter 3.

Functions and Description of Operation

3.1 Distance Metering Elements

3.1.1 Introduction

ZLV relays are provided with four, five o six independent protection zones. The direction of operation for each zone is selected using the Zone Direction setting.

The direction of the zone designated as direction reverse zone (**Zone 4** in **ZLV-A/B/E** relays and **Zone 4** or **Zone 5** as a function of **Direction Reverse Zone** setting value -see 3.2- in **ZLV-F/G/H/J** relays) behaves differently than the other zones. When the selected protection scheme is either **Directional Comparison Blocking** or if **Weak Infeed** logic ("echo" or "echo + trip" signals) and **Transient Reverse Overcurrent Blocking** is enabled, Zone 4 will operate as **Reverse looking** even if the setting is forward-looking. Therefore, when either of these schemes is in use, it is not necessary to adjust the Zone 4 (in **ZLV-A/B/E** relays) or Zone 5 (in **ZLV-F/G/J** relays) direction.

Each zone is provided with six independent metering elements (one for each fault type), which comprise one operation phasor and one polarization phasor derived from the elemental voltage and current phasors and the settings specific to the characteristics of the line to be protected.

In **ZLV-G/J** relays, designed for dual breaker bay protection (breaker-and-a-half or ring substations), phase currents (IA, IB, IC) are obtained from relay measured phase currents (IA-1, IB-1, IC-1, IA-2, IB-2, IC-2), based on **Line Current** setting (see paragraph 3.29.6).

Ground fault metering elements make reverse-looking impedance compensation so as to assess an impedance directly proportional to the line positive sequence impedance. Said compensation is made based on factor K0 defined as:

K0 = Z0 / Z1where Z0 and Z1 are the zero sequence and positive sequence impedances respectively, associated to each distance zone.

Each zone is provided with **Reach** settings (positive sequence impedance) and **Zero sequence compensation** (K0 = Z0 / Z1), both in modulus and argument, independent from the other zones. Said independence provides higher precision of metering elements for mixed lines. On the other hand, zones have **Separate Reach** and **Resistive Limit** settings for phase and ground elements (in case quadrilateral characteristic is selected).

In **ZLV-***-****A/B/C/D/E/F/G/H**** relays, ground fault measurement elements can compensate the zero sequence mutual coupling in parallel lines. To this avail, the setting **Distance Mutual Coupling Enable**, corresponding to distance elements (there is a separate setting for the fault locator, see section 3.37), must be set to **YES**. The mutual coupling compensation is made through the term **K0M*(INPAR/3)** where:

> **K0M=Z0M/Z1** is the mutual coupling factor (**Z0M** is the zero sequence mutual impedance and **Z1** is the positive sequence impedance of the line).
> **INPAR** is the ground current of the parallel line.

Zero sequence mutual coupling compensation will only be made if the ratio I0/I0PAR (zero sequence current of the protected line / zero sequence current of the parallel line) exceeds the setting **Factor I0/I0PAR**. The purpose of this setting is to prevent the mutual coupling compensation from being enabled for faults in the parallel line with a high I0PAR value. In that case, this compensation will produce a great overreach that might cause the relay to trip on said external fault. Provided both parallel lines share the same source, a fault in the parallel line will generate an I0PAR greater than I0 so that **I0/I0PAR<Factor I0/I0PAR**.

Distance characteristic can be adjusted separately for between-phase and earth faults, through **Ground Characteristic** and **Phase Characteristic** settings respectively, which have the following options:

- Quadrilateral characteristic.
- Mho characteristic.
- Mho and Quadrilateral.
- Mho or Quadrilateral.

3.1.2 Quadrilateral Characteristic

Quadrilateral characteristics comprise three elements:

- Reactance Element.
- Directional Element.
- Resistive Limiter.

3.1.2.a Reactance Element

ZLV Reactance elements are polarized by a phasor that, in homogeneous systems, is parallel to the current through the fault impedance. This type of polarization compensates for the influence of the load, avoiding the overreach and underreach of the relay produced by the load on resistive faults with remote-end feeding of the fault, by introducing a phase difference between local and remote currents.

A system that is not homogeneous introduces an additional phase difference between local and remote currents, and may also lead to overreach and underreach that cannot be compensated by the use of the polarization phasor. To avoid this situation, the **ZLV** introduces compensation in the phase comparator of zone 1 reactance characteristic, based on the impedances of the system. This compensation is equivalent to a tilt in the characteristic, which is defined as tilt angle, and is only applied when the characteristic is set to forward looking and during an adjustable time (**Tilt time**) after the fault occurs; when the time is out, the characteristic returns to the original position.

Next table shows the operation and polarization phasors involved in each of the **Reactance** metering elements, as well as the applied operation criteria.

Table 3.1-1: Reactance Characteristic

Unit	Fop	Fpol	Criteria
AG	$\left[Ia + I0 \cdot \left(K0n - 1\right) + (I0PAR \cdot K0M)^{*}\right] \cdot Z1n - Va$	$Ia2$ or $Ia - Iapf$	$0^\circ \le \left[\arg\left(\mathrm{Fop}\right) - \arg\left(\mathrm{Fpol}\right)\right] \le 180^\circ$
BG	$\left[Ib + I0 \cdot \left(K0n - 1\right) + (I0PAR \cdot K0M)^{*}\right] \cdot Z1n - Vb$	$Ib2$ or $Ib - Ibpf$	
CG	$\left[Ic + I0 \cdot \left(K0n - 1\right) + (I0PAR \cdot K0M)^{*}\right] \cdot Z1n - Vc$	$Ic2$ or $Ic - Icpf$	
AB	$Iab \cdot Z1n - Vab$	$Iab - Iabpf$	
BC	$Ibc \cdot Z1n - Vbc$	$Ibc - Ibcpf$	
CA	$Ica \cdot Z1n - Vca$	$Ica - Icapf$	

*** Only for ZLV-***-****A/B/C/D/E/F/G/H** relays. The term is only applied if the distance element setting “Distance Mutual Coupling Enable” is set to YES and I0/I0PAR> I0/I0PAR factor.**

Where:

Ia, Ib, Ic	Phase currents
$Iapf, Ibpf, Icpf$	Phase current during pre-fault (load)
Iab, Ibc, Ica	Line currents (Ia-Ib), (Ib-Ic), (Ic-Ia)
$Iabpf, Ibcpf, Icapf$	Line currents during pre-fault (Iapf-Ibpf), (Ibpf-Icpf), (Icpf-Iapf)
$Ia2, Ib2, Ic2$	Negative sequence phase currents
$I0$	Zero sequence currents
$I0PAR$	Zero sequence current of the parallel line (ground current INPAR divided by 3).
Va, Vb, Vc	Phase voltages
Vab, Vbc, Vca	Line voltages (Va-Vb), (Vb-Vc), (Vc-Va)
$Z1n$	Positive sequence reach impedance associated to zone n
$Z0n$	Zero sequence reach impedance associated to zone n
$K0n = \frac{\lvert Z0n \rvert}{\lvert Z1n \rvert}$	Zero sequence compensation factor for zone n
$K0M = \frac{Z0M}{Z1L}$	Negative Sequence Mutual Coupling Factor
$Z0M$	Negative Sequence Mutual Impedance
$Z1L$	Line Positive Sequence Impedance

Pre-fault currents are stored two cycles before the time of activation of the fault detector (see 3.4). The values of said currents are compared percentage wise with the values of fault currents, to ascertain that the stored magnitudes come from a load condition. Pre-fault magnitudes are only considered as long as the **Fault Detector** is activated and the **Power Swing Blocking** signal is not active (see 3.9).

Ground fault **Reactance** metering elements are normally polarized by negative sequence current it being parallel to the current through the fault resistance. Nevertheless, said parallelism may not be guaranteed under certain conditions, such as the opening of one pole (single-phase reclosing cycle), or two-phase ground faults (when a single-phase element has been allowed to operate, whether **Phase lag** setting is set to **Yes** or any AG, BG or CG element enable input has been activated -only **ZLV-F/G/H/J** relays-. See section 3.1.7, Distance element activation). In those cases, the negative sequence current is replaced by fault phase current (load component removed), which will be in phase with the voltage drop through the fault resistance.

Figures 3.1.1 and 3.1.2 show a voltage diagram where a ground fault **Reactance** line associated to zone 1 has been included.

Figure 3.1.1 shows a **Reactance** line for a homogeneous system with load. The point **F** indicates where the fault occurs, and point **F’** indicates where the relay locates the fault. As shown, both points do not coincide due to **IF·RF** vector, which represents the voltage drop in the fault impedance. Under no load conditions, this vector would be horizontal, and **F’** would be located on the horizontal line passing through **F**.

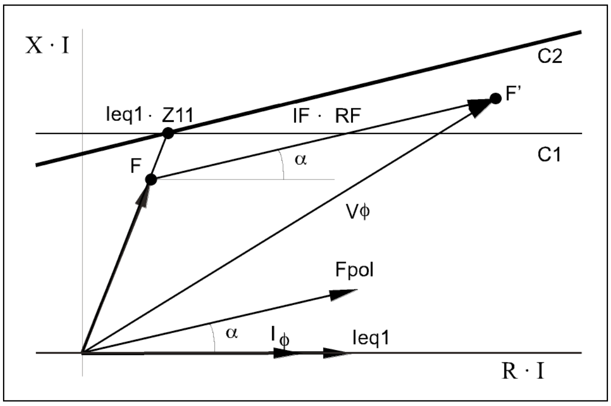


Figure 3.1.1: Reactance Characteristic Diagram for Ground Faults (I).

However, the remote end feeding creates a rotation α moving the point **F’** to the place shown in the figure (a load feed from the remote end has been considered).

C1 characteristic (represented under the condition of no feed from the other end) turns into **C2**, with a rotation by an angle α that keeps **F’** within the operation zone. The tilt of the **Reactance** characteristic tends to compensate for the voltage drop through the fault impedance, as seen by the relay, avoiding both overreach and underreach.

Figure 3.1.2 shows a **Reactance** characteristic under a no load but not homogeneous system (no phase difference between local and remote sources).

In this case the voltage drop at the fault is seen by the relay to be rotated an angle γ due to the lack of homogeneity on the system. The tilt angle changes the characteristic from C1 to C2, avoiding the overreach of the relay during the preset tilt time (starting from the activation of the fault detector), allowing adjacent protection elements to clear the fault. Angle γ is calculated by the **ZLV** from the line, source and equivalent parallel impedances.

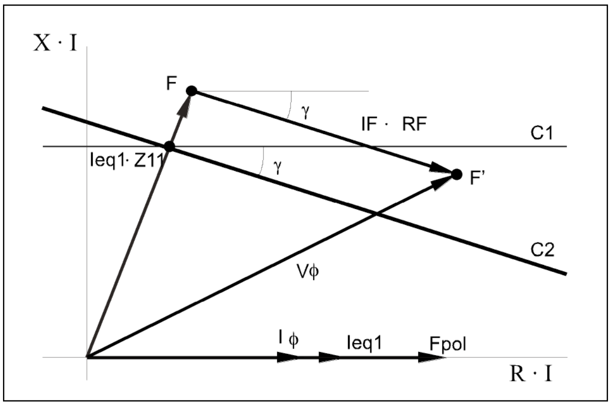


Figure 3.1.2: Reactance Characteristic Diagram for Ground Faults (II).

The value of the tilt angle γ is calculated from the impedances of the line, the source and the equivalent parallel circuit. In **ZLV-***-****A/B/C/D/E/F/G/H**** relays, this angle depends on the setting **Compensation Angle Type**. If this setting takes the value **Direct**, γ equals the setting **Compensation Angle**. If the setting **Compensation Angle Type** takes the value **Calculated**, the value of γ will be calculated from the impedances of the equivalent system.

$I\phi$	Phase current
$Ieq1$	Equivalent current associated to zone 1: $Ieq1 = I\phi + I0 \cdot (K01 - 1) + (I0PAR \cdot K0M)^{*}$
$V\phi$	Phase voltage
RF	Ground fault resistance
IF	Current through ground fault resistance
$Fpol$	Polarization phasor for single-phase reactance $Fpol = I\phi 2$ or $I\phi - I\phi pf$
$Z11$	Zone 1 reach impedance

*** Only for ZLV-***-****A/B/C/D/E/F/G/H** relays. The term is only applied if the distance element setting "Distance Mutual Coupling Enable" is set to YES and I0/I0PAR> I0/I0PAR factor.**

Figures 3.1.3 and 3.1.4 show a voltage diagram where a **Reactance** line for faults between phases associated to zone 1 has been included.

Figure 3.1.3 shows the **Reactance** line for a homogeneous system with load. Similarly to the case above, for single-phase ground faults, the reactance line undergoes an angle of rotation to compensate for the underreach as a consequence of remote end feeding.

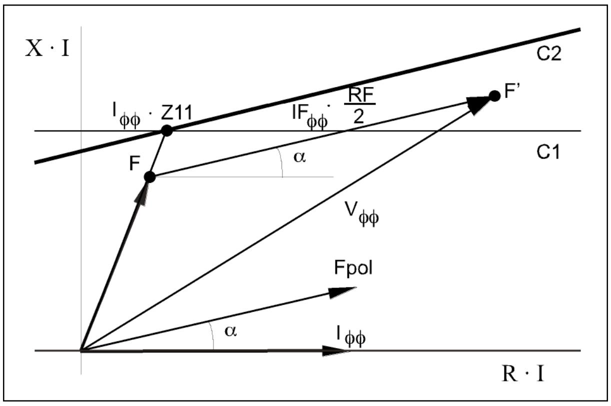


Figure 3.1.3: Reactance Characteristic Diagram for Faults between Phases (I).

Figure 3.1.4 shows a **Reactance** characteristic under a no load system that is not homogeneous. Similarly to single-phase ground faults, it can be seen the rotation of the reactance line by a tilt angle calculated internally, this way avoiding the overreach of the relay during the preset tilt time.

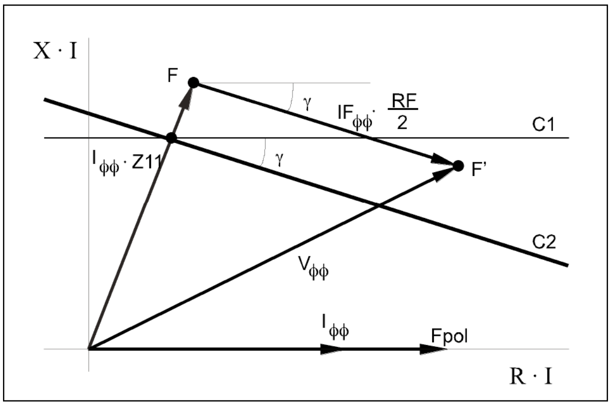


Figure 3.1.4: Reactance Characteristic Diagram for Faults between Phases (II).

Where:

$I\phi\phi$	Current phase-to-phase (Ia-Ib, Ib-Ic, Ic-Ia)
$V\phi\phi$	Voltage phase-to-phase (Va-Vb, Vb-Vc, Vc-Va)
RF	Phase-to-phase fault resistance
$IF\phi\phi$	Phase-to-phase current through fault resistance (IFa-IFb, IFb-IFc, IFc-IFa)
$Fpol$	Polarization phasor for two-phase reactance $Fpol = I\phi\phi - I\phi\phi pf$
$Z11$	Zone 1 reach impedance

3.1.2.b Directional Element

ZLV equipment features directional elements for each type of fault, common to the four, five or six zones. Said directional elements are polarized by the positive sequence voltage (with memory, when required) of the corresponding phase or phases, producing a behavior with the following characteristics:

- **Variable**: the use of the positive sequence voltage produces a reverse displacement of the directional element, when the fault is forward looking, proportional to the local source impedance value. The reason for said behavior is that positive sequence voltage involves the unimpaired phase or phases.
- **Dynamic**: the use of voltage memory produces a temporary reverse displacement (depending on the duration of said memory) of the directional element, when the fault is forward looking, also proportional to the local source impedance value.

Both characteristics allow the directional element to determine the correct direction under very near faults (with very low voltage) and under likely voltage reversals in lines with series compensation.

Voltage memory is used when so dictated by the memory logic (see 3.1.5).

The following table shows the operation and polarization phasors of the directional elements, as well as the applied operating criteria.

Table 3.1-2: Directional unit

Unit	Fop	Fpol	Criteria
AG	Ia	$Va1M$	$-(90^{o}+\alpha) \leq [\arg(Fop)-\arg(Fpol)] \leq (90^{o}-\alpha)$
BG	Ib	$Vb1M$	
CG	Ic	$Vc1M$	
AB	Iab	$Vab1M$	
BC	Ibc	$Vbc1M$	
CA	Ica	$Vca1M$	

Where:

Ia, Ib, Ic	Phase currents
Iab, Ibc, Ica	Line currents (Ia-Ib), (Ib-Ic), (Ic-Ia)
$Va1M, Vb1M, Vc1M$	Stored positive sequence voltages corresponding to each phase
$Vab1M, Vbc1M, Vca1M$	Stored positive sequence voltages corresponding to each pair of phases

Figures 3.1.5 and 3.1.6 show the **Directional element** for ground faults (characteristic C3). By the effect of the polarization system used, said directional element does not go through the origin being moved down by a vector dependant of the local source impedance. This effect allows that very close forward looking faults, with very low voltage values (located very near the origin) are seen in the trip direction. The directional element will keep indicating the trip direction even for forward looking faults in lines with series compensation appearing on the third quadrant by the effect of negative capacitive reactance.

It is worth mentioning that the above effect does not imply a loss of directional capability, as for reverse direction faults, the directional element undergoes a forward displacement, following a vector proportional to the sum of line and remote source impedances. Figure 3.1.7 shows said displacement.

Figure 3.1.5 shows the directional element at moment when a forward looking fault occurs, to which, as a result of the memory, positive sequence voltage previous to the fault is applied. It is apparent that said element displacement is represented by the vector:

$$ZSL \cdot (Ieq - I\phi load)$$

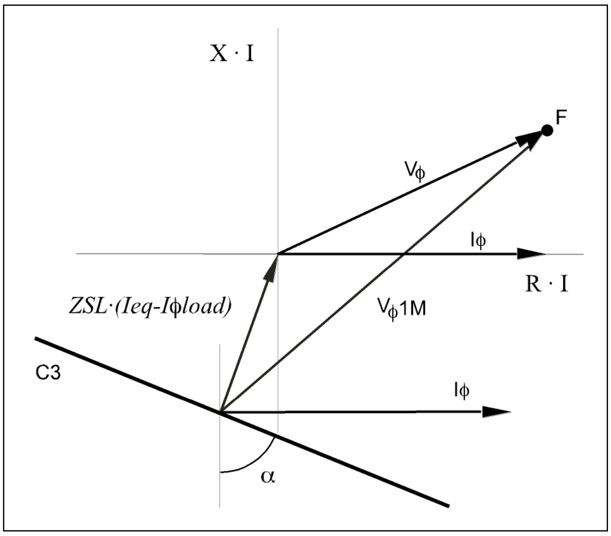


Figure 3.1.5: Directional Element Diagram for Ground Faults (I).

Figure 3.1.6 shows the directional element after memory update under a stationary fault state. Said element undergoes a displacement given by the vector:

$$ZSL \cdot (Ieq - I1\phi)$$

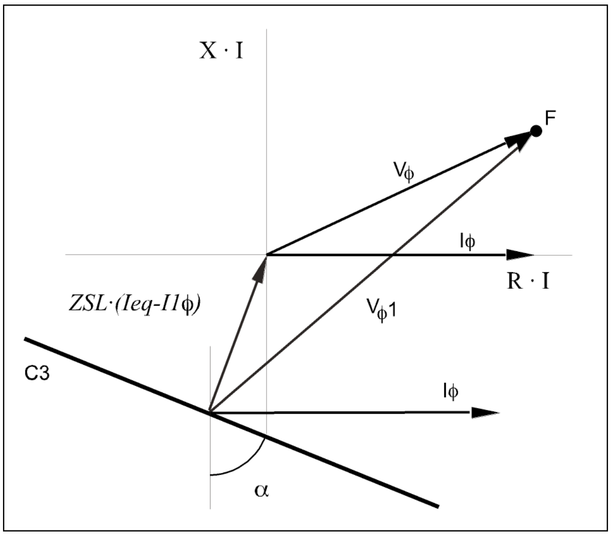


Figure 3.1.6: Directional Element Diagram for Ground Faults (II).

Figure 3.1.7 shows the directional element at the moment when a reverse looking fault occurs. As a result of the memory, the element undergoes an upward displacement given by the vector:

$$(ZL + ZSR)\cdot(Ieq - I\phi load)$$

When the memory is updated, by the effect of the positive sequence voltage, during the duration of the fault, the element will keep an upward displacement given by the vector:

$$(ZL + ZSR)\cdot(Ieq - I1\phi)$$

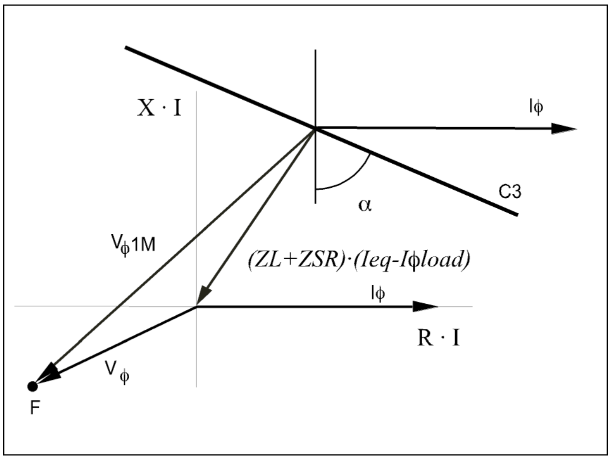


Figure 3.1.7: Directional Element Diagram for Ground Faults (III).

Where:

ZSL	Positive sequence impedance of the local source (located behind the relay)
ZL	Positive sequence impedance of the line
ZSR	Positive sequence impedance of the remote source
Ieq	Equivalent current (common to the line, local source and remote source)*
$I\phi(Ia, Ib, Ic)$	Phase current
$I1\phi$	Fault positive sequence current
$I\phi load$	Load current, previous to the fault
$V\phi$	Phase voltage
$V\phi 1$	Positive sequence voltage

(*) Above described displacement vectors have been figured out on the bases that zero sequence compensation factors associated to the line, local source and remote source are equal.

Figures 3.1.8 and 3.1.9, shows the **Directional element** for phase-to-phase faults (characteristic C3). Said figures are drawn for a forward looking fault. For a reverse looking fault, the directional element would be displaced upwards, and the arrangement would be similar to figure 3.1.7, corresponding to a single-phase fault.

Figure 3.1.8 shows the directional element at the moment when the fault occurs. The displacement undergone by the element by effect of the memory is given by the vector:

$$ZSL \cdot (I\phi\phi - I\phi\phi load)$$

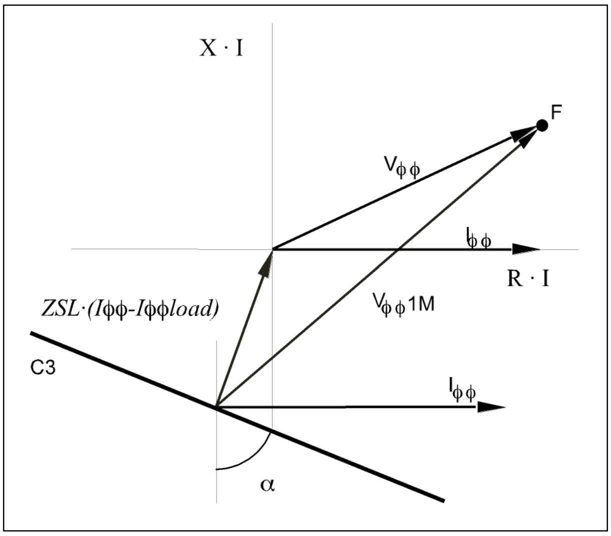


Figure 3.1.8: Directional Element Diagram for Phase-to-Phase Faults (I).

Figure 6.9 shows the directional element after memory update. Under steady state fault condition, the displacement of said element is given by the vector:

$$ZSL \cdot (I\phi\phi - I\phi\phi 1)$$

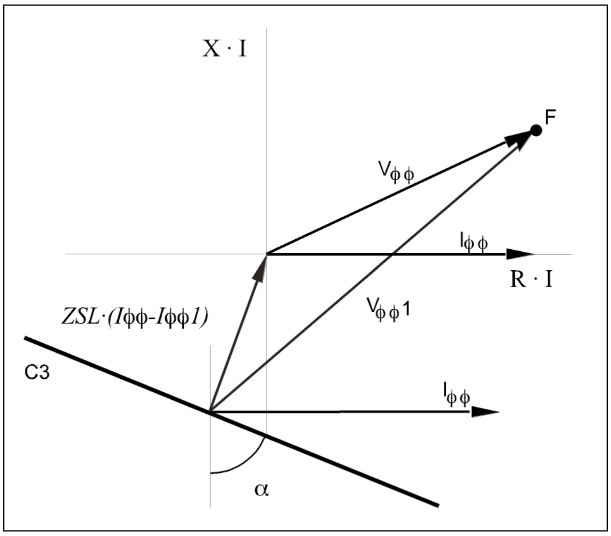


Figure 3.1.9: Directional Element Diagram for Phase-to-Phase Faults (II).

Where:

ZSL	Local source positive sequence impedance
$I\phi\phi(Iab, Ibc, Ica)$	Phase-to-phase current (fault)
$I1\phi\phi$	Positive sequence fault current (phase-to-phase)
$I\phi\phi load$	Load current (phase-to-phase), previous to fault
$V\phi\phi$	Phase-to-phase voltage
$V\phi\phi 1$	Positive sequence voltage (phase-to-phase)

3.1.2.c Resistive Limiter

The **ZLV** features six resistive limiter elements (one for each type of fault) per zone. The reach of resistive limiters for ground faults and phase-to-phase faults are independent from each other, each zone having its own adjustment. The following table shows the operation and polarization phasors of the resistive limiters, as well as the applied operating criteria.

Table 3.1-3: Resistive Limiter

Axis R>0 Characteristic			
Unit	**Fop**	**Fpol**	**Criteria**
AG	$Ia \cdot RGn - Va$	$Ia \cdot RGn$	$-(180-\theta bucn) \le [\arg(Fop)-\arg(Fpol)] \le \theta bucn$
BG	$Ib \cdot RGn - Vb$	$Ib \cdot RGn$	
CG	$Ic \cdot RGn - Vc$	$Ic \cdot RGn$	
Axis R<0 Characteristic			
AG	$-Ia \cdot RGn - Va$	$-Ia \cdot RGn$	$-(180-\theta bucn) \le [\arg(Fop)-\arg(Fpol)] \le \theta bucn$
BG	$-Ib \cdot RGn - Vb$	$-Ib \cdot RGn$	
CG	$-Ic \cdot RGn - Vc$	$-Ic \cdot RGn$	

Axis R>0 Characteristic			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$Iab \cdot RPn - Vab$	$Iab \cdot RPn$	$-(180^{o}-\theta n) \le [\arg(Fop)-\arg(Fpol)] \le \theta n$
BC	$Ibc \cdot RPn - Vbc$	$Ibc \cdot RPn$	
CA	$Ica \cdot RPn - Vca$	$Ica \cdot RPn$	
Axis R<0 Characteristic			
AB	$-Iab \cdot RPn - Vab$	$-Iab \cdot RPn$	$-(180^{o}-\theta n) \le [\arg(\mathrm{Fop})-\arg(\mathrm{Fpol})] \le \theta n$
BC	$-Ibc \cdot RPn - Vbc$	$-Ibc \cdot RPn$	
CA	$-Ica \cdot RPn - Vca$	$-Ica \cdot RPn$	

Where:

Ia, Ib, Ic	Phase currents
Iab, Ibc, Ica	Phase-to-phase currents (Ia-Ib), (Ib-Ic), (Ic-Ia)
Va, Vb, Vc	Phase voltages
Vab, Vbc, Vca	Phase-to-phase voltages
RGn	Resistive reach for ground faults corresponding to zone n
RPn	Resistive reach for phase-to-phase faults corresponding to zone n
θn	Positive sequence reach impedance angle corresponding to zone n
$\theta bucn$	Loop impedance angle for zone n: $\theta bucn = \theta n - [\arg(Ia) - \arg(Ieqn)]$

Resistive limiters for ground faults use phase current as polarization phasor, as it is normally closer to the current going through the fault resistance than the equivalent current.

Figure 3.1.10 represents **Resistive limiters** for ground faults associated to zone 1.

Both C4 and C5 characteristics are at an angle to the phase current axis equal to the loop impedance for zone 1, so that they will be at an angle to the equivalent current axis equal to the positive sequence reach impedance for said zone.

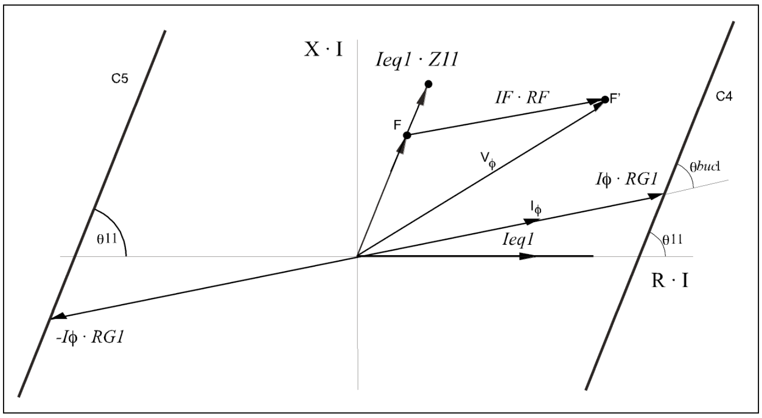


Figure 3.1.10: Resistive Limiters Diagram for Ground Faults.

In Figure 3.1.10 the voltage drop through the fault resistance has been considered parallel to the phase current.

Figure 3.1.11 shows **Resistive limiters** for phase-to-phase faults associated to zone 1.

Both C4 and C5 characteristics are at an angle to the phase-to-phase current axis equal to the positive sequence reach impedance for zone 1.

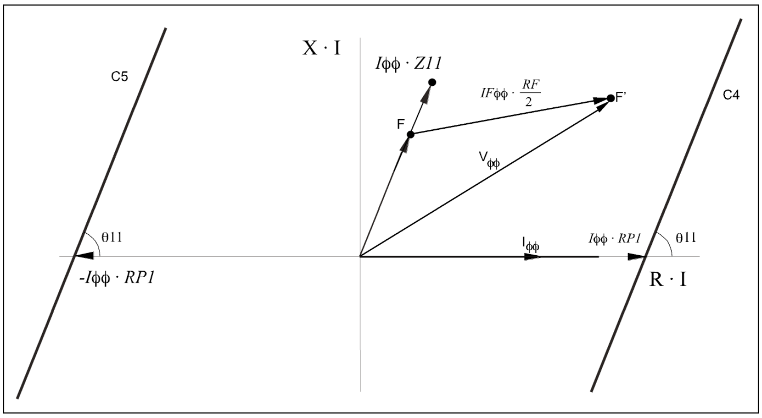


Figure 3.1.11: Resistive Limiter Diagrams for Phase-to-Phase Faults.

The resistive limiter tilt provides the same resistive coverage along the whole line length included in each zone.

3.1.2.d Graphic Representation

Figure 3.1.12 shows the quadrilateral characteristic for ground faults in the voltage plane referred to the equivalent current. In order to change to the impedance plane, all vectors must be divided by said current value.

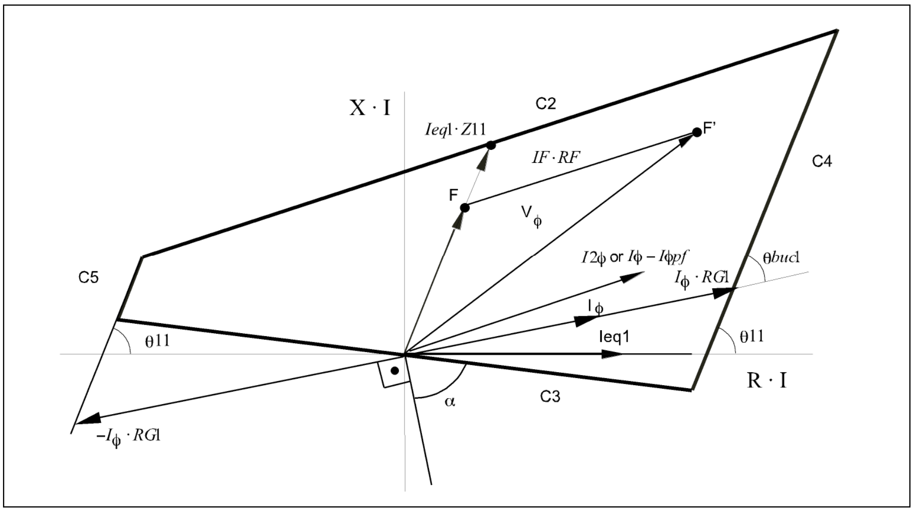


Figure 3.1.12: Quadrilateral Characteristic Diagram for Ground Faults.

An homogeneous system has been considered (thus, the tilt effect has not been included), although, on the other hand, one case has been selected where none of the vectors $I\phi$, Ieq and $I2\phi$ (or $I\phi - I\phi pf$) are parallel. The phase difference between $I\phi$ and $I2\phi$ is a function of the load flow, whereas the possible phase difference between $I\phi$ and Ieq will be a function of the zero sequence current (which will be greatly affected by the type of fault: single-phase or two-phase ground fault) as well as the zero sequence compensation factor. The phase difference between the phase current and the equivalent current in cables is normally high because of the angle difference between positive sequence and zero sequence impedances.

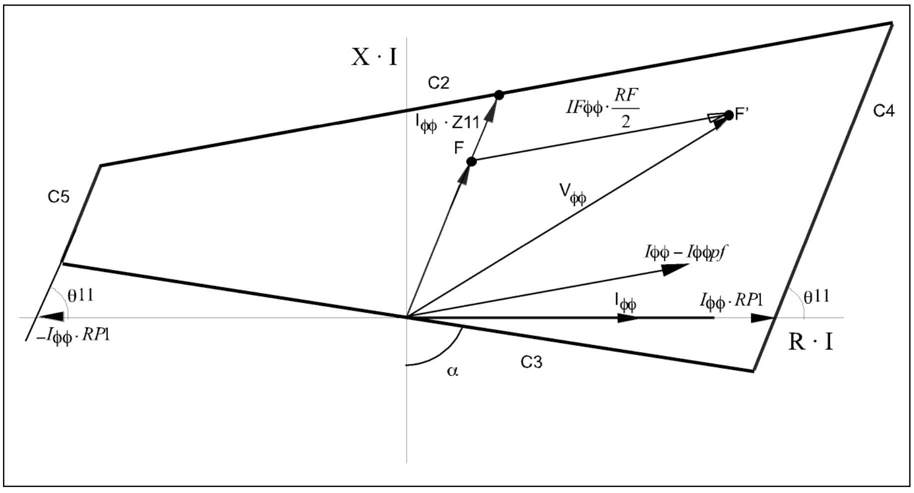


Figure 3.1.13: Quadrilateral Characteristic Diagram for Phase-to-Phase Faults.

3.1.3 Mho Characteristic

The **ZLV Mho** characteristic is polarized by the positive sequence voltage (with memory, when required) of the corresponding phase or phases. This polarization produces a behavior with the following characteristics:

- **Variable**: the use of positive sequence voltage makes the characteristic to expand backwards, when the fault is forward looking, proportional to the local source impedance value. The reason for said behavior is that positive sequence voltage involves the undamaged phase or phases.

- **Dynamic**: the use of voltage memory makes a temporary backwards expansion (as a function of said memory duration) of the characteristic, when the fault is forward looking, also proportional to the local source impedance value.

Said behavior allows the **Mho** characteristic for a correct operation under very close faults (with very low voltage) and under voltage reversals likely to occur in lines with series compensation.

The memorized voltage is used when voltage memory logic so dictates (see 3.1.5).

The following table shows the operation and polarization phasors of the **Mho** characteristic measuring elements, as well as the applied operational criteria.

Table 3.1-4:Mho Characteristic

Unit	Fop	Fpol	Criteria
AG	$\left[Ia + I0 \cdot \left(K0n - 1\right) + (I0PAR \cdot K0M)^{*}\right] \cdot Z1n - Va$	$Va1M$	$-90^{\circ} \leq \left[\arg\left(Fop\right) - \arg\left(Fpol\right)\right] \leq 90^{\circ}$
BG	$\left[Ib + I0 \cdot \left(K0n - 1\right) + (I0PAR \cdot K0M)^{*}\right] \cdot Z1n - Vb$	$Vb1M$	
CG	$\left[Ic + I0 \cdot \left(K0n - 1\right) + (I0PAR \cdot K0M)^{*}\right] \cdot Z1n - Vc$	$Vc1M$	
AB	$Iab \cdot Z1n - Vab$	$Vab1M$	
BC	$Ibc \cdot Z1n - Vbc$	$Vbc1M$	
CA	$Ica \cdot Z1n - Vca$	$Vca1M$	

*** Only for ZLV-***-****A/B/C/D/E/F/G/H** relays. The term is only applied if the distance element setting "Distance Mutual Coupling Enable" is set to YES and I0/I0PAR> I0/I0PAR factor.**

Where:

Ia, Ib, Ic	Phase currents
Iab, Ibc, Ica	Line currents (Ia-Ib), (Ib-Ic), (Ic-Ia)
$I0$	Zero sequence currents
$I0PAR$	Zero sequence current of the parallel line (ground current INPAR divided by 3).
Va, Vb, Vc	Phase voltages
Vab, Vbc, Vca	Line voltages (Va - Vb), (Vb - Vc), (Vc - Va)
$Va1M, Vb1M, Vc1M$	Positive sequence voltages referred to each phase
$Vab1M, Vbc1M, Vca1M$	Positive sequence voltages referred to each phase pair
$Z1n$	Positive sequence reach impedance associated to zone n
$Z0n$	Zero sequence reach impedance associated to zone n
$K0n = \frac{\lvert Z0n \rvert}{\lvert Z1n \rvert}$	Zero sequence compensation factor for zone n
$K0M = \frac{Z0M}{Z1L}$	Negative Sequence Mutual Coupling Factor
$Z0M$	Negative Sequence Mutual Impedance
$Z1L$	Line Positive Sequence Impedance

Figures 3.1.14 and 3.1.15 show the phase-to-ground fault **Mho** characteristics. Due to the polarization used, the diameter of the characteristic is the vector addition of the adjusted reach and a vector function of the local source impedance. This effect allows tripping under very close forward looking faults, with very low voltage values (located very close to the origin) or even under forward looking faults in lines with series compensation appearing in the third quadrant by the effect of the capacitors negative reactance.

It is again important to highlight that the above going effect does not imply loss of directionality, as for reverse direction faults the **Mho** characteristic is displaced forward, following a vector proportional to the sum of line and remote source impedances. Said displacement is shown in figure 3.1.16.

Figure 3.1.14 shows the **Mho** characteristic at the moment when a forward looking fault occurs, the positive sequence voltage previous to the fault being applied as polarization voltage by effect of the memory. It is apparent that the expansion undergone by said characteristic is given by the vector:

$$ZSL \cdot (Ieq - I\phi load)$$

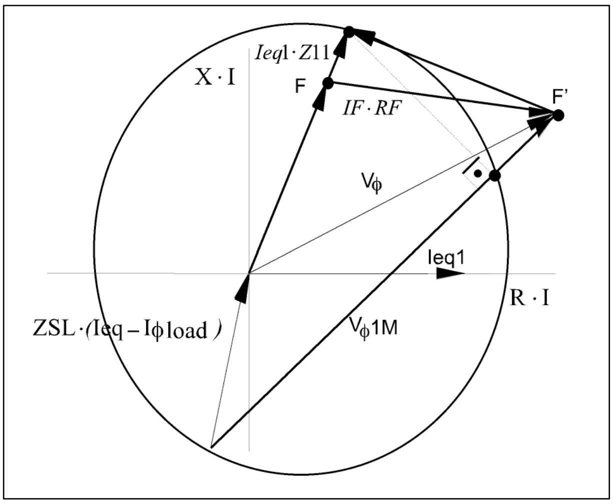


Figure 3.1.14: Phase-to-Ground Fault Mho Characteristic (I).

Figure 3.1.15 shows the **Mho** characteristic after memory update during a stationary state fault. Said characteristic undergoes a displacement given by the vector:

$$ZSL \cdot (Ieq - I1\phi)$$

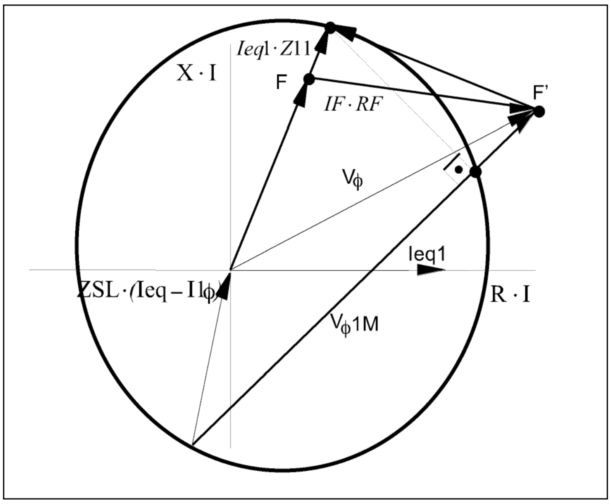


Figure 3.1.15: Phase-to-Ground Fault Mho Characteristic (II).

Figure 3.1.16 shows the **Mho** characteristic at the moment when a reverse looking fault occurs. By effect of the memory said characteristic undergoes a displacement upwards given by the vector:

$$\left(ZL + ZSR\right) \cdot (Ieq - I\phi load)$$

After memory update by the effect of the positive sequence voltage, during the duration of the fault, the **Mho** characteristic will keep an upward displacement given by the vector:

$$\left(ZL + ZSR\right) \cdot (Ieq - I1\phi)$$

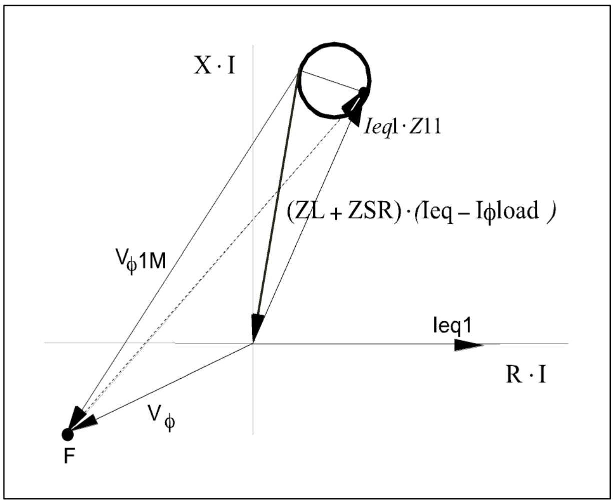


Figure 3.1.16: Phase-to-Ground Fault Mho Characteristic (III).

Where:

ZSL	Local source positive sequence impedance (located behind the relay)
ZL	Line positive sequence impedance
ZSR	Remote source positive sequence impedance
$Z11$	Reach impedance for zone 1
Ieq	Equivalent current (common to line, local source and remote source)*
$I\phi(Ia, Ib, Ic)$	Phase current
$I1\phi$	Positive sequence fault current
$I\phi load$	Load current, previous to fault
$V\phi$	Phase voltage
$V\phi 1$	Positive sequence voltage

(*) Above described displacement vectors have been figured out considering that compensation factors associated to the line, local source and remote source are equal.

Figures 3.1.17 and 3.1.18 show the phase-to-phase fault Mho characteristics. These figures have been drawn for a forward-looking fault current. In the case of a reverse-looking fault current, the **Mho** characteristic would be displaced upwards, with an arrangement similar to that drawn in figure 3.1.16, corresponding to a single-phase fault.

Figure 3.1.17 shows a characteristic at the instant of a fault. The expansion by the effect of the memory is given by vector:

$$ZSL \cdot (I\phi\phi - I\phi\phi load)$$

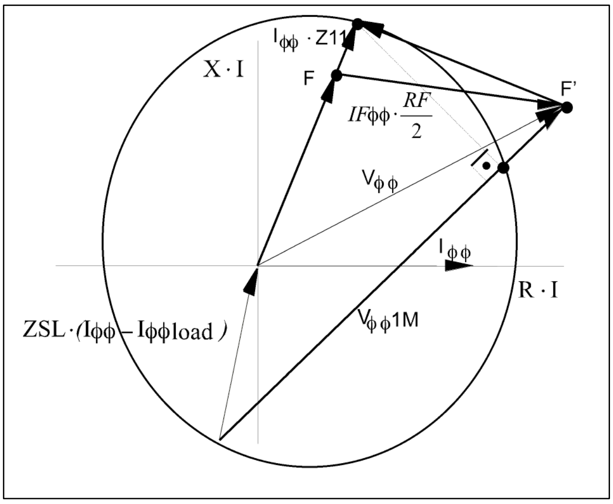


Figure 3.1.17: Mho Characteristic Diagram for Phase-to-Phase Faults (I).

Figure 3.1.18 shows the characteristic once the buffer for the voltage memory effect has been updated. The expansion undergone by said characteristic under a steady state of the fault is given by the vector:

$$ZSL \cdot (I\phi\phi - I\phi\phi 1)$$

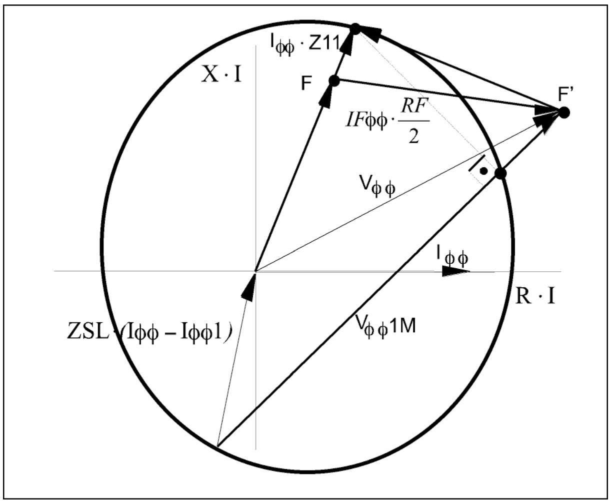


Figure 3.1.18: Mho Characteristic Diagram for Phase-to-Phase Faults (II).

Where:

ZSL	Local source positive sequence impedance
$I\phi\phi(Iab, Ibc, Ica)$	Phase-to-phase current (fault)
$I1\phi\phi$	Positive sequence fault current (phase-to-phase)
$I\phi\phi load$	Load current (phase-to-phase), previous to fault
$V\phi\phi$	Phase-to-phase voltage
$V\phi\phi 1$	Positive sequence voltage (phase-to-phase)

3.1.4 Distance Characteristic Activation

Figures 3.1.19 and 3.1.20 show the activation logic of distance characteristics AG and AB, respectively, for a zone n, as a function of outputs generated by the elements hitherto described and selected characteristic setting.

When a zone is set as backward looking, **Mho** and **Reactance** elements will reverse the direction of the current used in their operation algorithm, whereas the directional element, which always watch forward looking faults, will disable its output.

If the **Characteristic** selection setting, either for **ground faults** or **phase-to-phase faults**, is set with the **Mho and Quadrilateral** option, both characteristics need to be active in order to pickup the distance function. However, if this setting has the **Mho or Quadrilateral** option, the activation of only one of these characteristics will be enough to pickup the distance function.

Distance characteristic outputs will be introduced into the distance element activation logic (see 3.1.7).

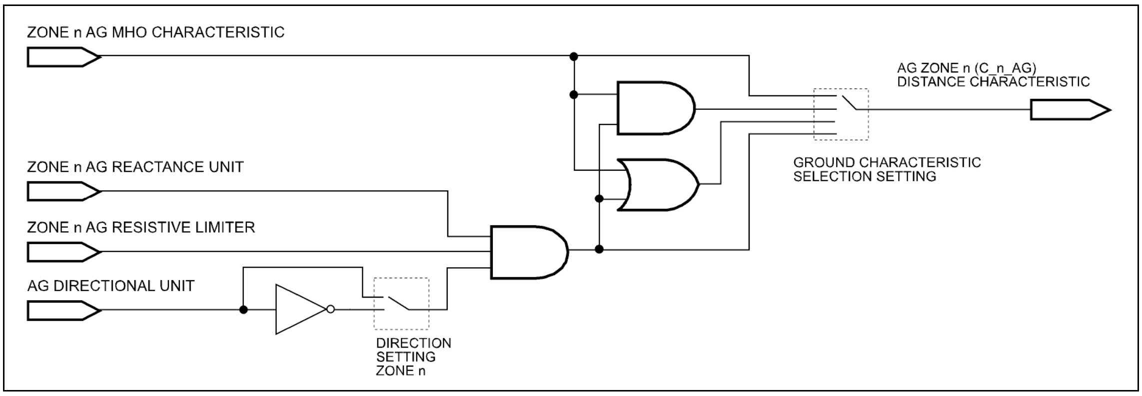


Figure 3.1.19: AG Distance Characteristic Activation Logic.

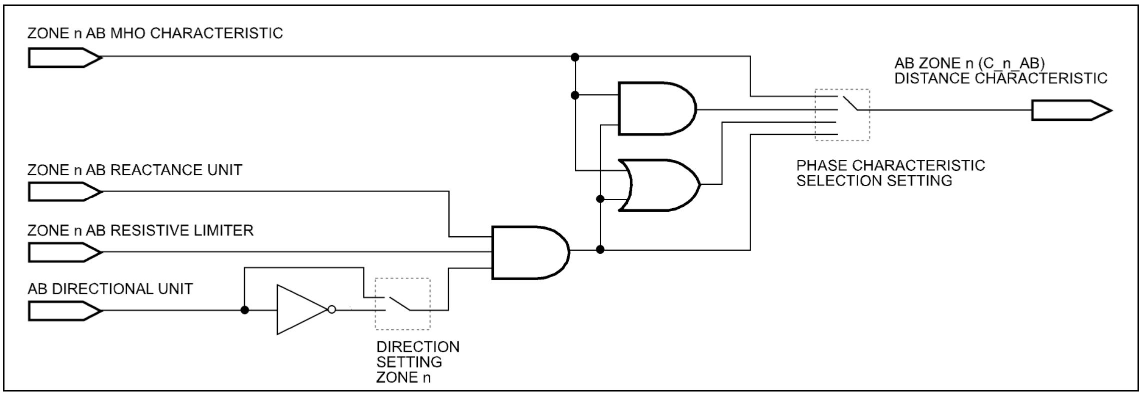


Figure 3.1.20: AB Distance Characteristic Activation Logic.

3.1.5 Voltage Memory Logic

Storage of positive sequence voltage memory takes place two cycles before the moment the fault detector activates.

The use of the voltage memory will depend on the **Series compensation logic** enable setting (see 3.15). However, no matter said setting, the positive sequence voltage with memory is only used if its value is above 20 V (with the purpose of preventing using it at the moment when the switch is closed in a position with the voltage transformer on the line side, which will not allow the trip) and while the fault detector is active. Said memory duration, from the moment it is latched, will be given by the setting **Memory duration**.

If **Series compensation logic** enable setting is **NO** (which means that **ZLV** is not applied to a line with series compensation), voltage memory would only be necessary for clearing three-phase faults with voltage below the minimum threshold to polarize distance elements (**Voltage threshold** configuration setting). Thus, voltage memory is only used if positive sequence voltage (corresponding to the phase or phases considered) is below **50 V**.

If **Series compensation logic** enable is set to **YES** no threshold is supervised, as the purpose of voltage memory is to allow correct actions not only under near zero voltage faults but also under voltage reversal, which can take place with relatively high fault voltage.

Memory duration setting can take the maximum value (100 cycles) if faults with positive sequence voltage below the minimum to polarize distance elements in zone 2 or zone 3 are expected (provided the time delay associated to said zones is below 80 cycles). This situation could take place under three-phase faults in very short lines, with very high SIR (ratio between the source impedance and line impedance).

Regarding lines with series compensation, voltage reversal is unlikely for faults in zone 2, as the existing inductive reactance from the relay to zone 1 reach is normally greater than the introduced capacitive reactance (however, the comparison ought to be done). Thus, voltage memory during zone 2 times is not required for clearing correctly forward looking faults. On the other hand, **Series compensation logic** enable allows acting correctly under reverse looking faults using a minimum voltage memory time.

If the line features series compensation, the voltage reversal problem, as previously stated, is solved with small voltage memory time, although the possibility of positive sequence voltage reversal or very low values of said voltage for faults in zone 2 ought to be studied. However, voltage memory is used whenever the fault detector is activated, thus avoiding its continuous use under no fault conditions.

No matter the above, the memory voltage will be used for a maximum of 4 cycles when the signal **Power Swing Blocking Condition** is active (see 3.10).

3.1.6 Forward and Reverse Supervision Elements

ZLV relays contain overcurrent elements to supervise the operation of the distance measuring elements. These overcurrent elements are used to establish a minimum current level of operation for the distance elements. Supervision elements are divided into two groups:

- **Forward** supervision.
- **Reverse** supervision.

Each one includes supervision of phase currents (A, B, C) and line currents (AB, BC, CA).

Forward and reverse supervision elements are non-directional overcurrent elements; i.e., they do not detect fault direction, but calculate the true RMS value of the phase or line current when the preset value is exceeded. The purpose of these elements is to supervise the operation of the distance element for each zone according to the corresponding directional setting.

The following table lists supervision elements with their operation current and pickup settings. The output signal generated is also included.

Table 3.1-5: Supervision Elements

Direction	Unit	Iop	Pickup Setting	Output	
Forward	Phase A	Ia	Single-Phase Forward	Forward AG elements supervision	(PU_SP_AG)
	Phase B	Ib		Forward BG elements supervision	(PU_SP_BG)
	Phase C	Ic		Forward CG elements supervision	(PU_SP_CG)
	Phases AB	Iab	Two Phases Forward	Forward AB elements supervision	(PU_SP_AB)
	Phases BC	Ibc		Forward BC elements supervision	(PU_SP_BC)
	Phases CA	Ica		Forward CA elements supervision	(PU_SP_CA)
Reverse	Phase A	Ia	Single-Phase Reverse	Reverse AG elements supervision	(PU_R_SP_AG)
	Phase B	Ib		Reverse BG elements supervision	(PU_R_SP_BG)
	Phase C	Ic		Reverse CG elements supervision	(PU_R_SP_CG)
	Phases AB	Iab	Two Phases Reverse	Reverse AB elements supervision	(PU_R_SP_AB)
	Phases BC	Ibc		Reverse BC elements supervision	(PU_R_SP_BC)
	Phases CA	Ica		Reverse CA elements supervision	(PU_R_SP_CA)

Where:

Ia, Ib, Ic	Phase currents
Iab, Ibc, Ica	Line currents (Ia-Ib), (Ib-Ic), (Ic-Ia)

The forward or reverse supervision element will pick up when the true RMS value of the corresponding phase or line current exceeds 105% of the pickup value, and resets below the preset value.

Single-phase forward supervision elements (outputs PU_SP_AG, PU_SP_BG and PU_SP_CG) also activate trip output latching, which keeps the contact closed until the measured value falls below the adjusted value (see 3.25, Tripping Logic).

3.1.7 Distance Elements Combinations

Distance elements AG, BG, CG, AB, BC and CA pickup outputs of zone 1, 2, 3, 4, 5 and 6, which are used in step distance logic (see section 3.2.1), are obtained combining outputs generated by the already described Mho and Quadrilateral characteristics with outputs from the following elements:

- Supervision Elements.
- Phase Selector (see 3.3).
- Open Pole Detector (see 3.6).
- Fuse Failure Detector (see 3.5).
- Load Encroachment (see 3.9).

The **Start Timers** setting (**ZLV-***-****G/H****** Models) indicates whether the start of the timer for each zone starts with the start of the zone in question or with the start of any zone.

3.1.7.a Single-Phase Elements Activation

Figure 3.1.21 shows the logic diagram associated to the pickup of elements AG, for a zone n set as forward looking. If said zone were set to “Reverse looking” direction the diagram would be similar but using the element reverse looking supervision output.

Apart from single-phase faults, single-phase elements can operate on two phase ground faults provided the following conditions are met:

1) When any of the **AG, BG or CG Element Enable** inputs is activated (only **ZLV-F/G/H/J** relays). Said inputs are of application in dual circuits, when a two phase ground fault occurs affecting both circuits in different phases (faults known as “cross-country”).

   Figure 3.1.21 shows one fault of this type affecting phases A and B. The ZLV-2 phase selector, at the line end closest to the fault, will indicate **AG Fault**, whereas the ZLV-1 phase selector, at the other end, will indicate **ABG Fault**. If a protection scheme via communications has been configured, the ZLV-1 high speed tripping will always be three-phase, as a two phase element will be operating (AB in this case). To prevent said **ZLV** tripping three-phase (provided single-phase tripping on single-phase fault philosophy has been selected), the relay must receive from the remote end, apart from the signal **Transmission distance channel**, the **Type of fault** signal (AG in this case). This last signal could be used, on the one hand, to allow the operation of the single-phase element associated to the faulted phase of the protected line, by means of the above mentioned single-phase element enable inputs, and, on the other hand, to block the two phase element. In this way, the trip generated will always be single-phase.

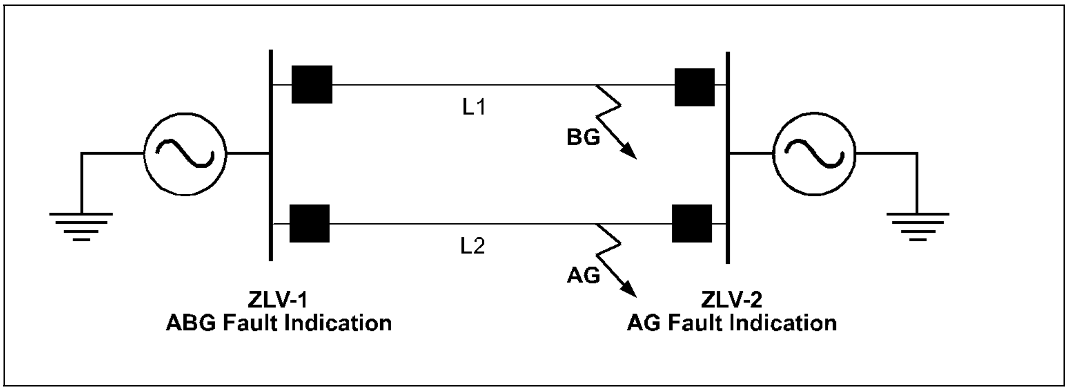


Figure 3.1.21: Simultaneous Single-Phase Faults AG and BG in Dual Circuit.

However, it must be born in mind that a cross-country fault is a two phase ground fault, generally with a resistance between the common point of the two faulted phases and ground, which will produce underreach and overreach effects on the single-phase elements associated to the lagging and leading phases respectively. If the faulted phase of the protected line is the leading phase, the operation of the single-phase element will not have negative results, as the indication of single-phase fault coming from the other end will only be given if the fault is internal to the line. The overreach effect of the single-phase element will ensure, in this case, an instant trip (high speed tripping by overreach zone or even direct by zone 1). However, if the faulted phase of the protected line is the lagging phase, the above mentioned underreach effect can disable the pickup of the single-phase element associated to the overreach zone (as a function of the reach of this zone and the ground fault resistance). In that case blocking the two phase element might not be recommended. In order for the trip generated to be still single-phase, using single breaker pole block inputs and three-phase trip preparation block input, as described in paragraph 3.25 Single-phase / Three-phase Trip Logic.

2) When **Phase Lag** setting is set to **YES**, which allows, for any two phase fault, the operation of the single-phase element associated to the lagging phase.

   Under a two-phase ground fault, the single-phase lagging element will undergo an underreach provided a fault resistance exists between the junction of the two phases and ground. The greater the ground resistance the greater said underreach. In this case, the two-phase element will be in charge of tripping the fault correctly. However, for two-phase ground faults with zero resistance between the junction of the two phases and ground, as is the case for simultaneous single-phase faults, the lagging single-phase element will actuate correctly, supporting the two-phase element clearing the fault.

   When high resistance ground faults are expected (compared to line impedance) and the Quadrilateral characteristic is selected only for single-phase faults, it is advisable to adjust said setting to **YES**. The two-phase **Mho** characteristic will operate correctly under most of two-phase ground faults, as normally the resistance between phases is not high (electric arc resistance). However, underreach may be obtained under simultaneous single-phase faults in view of the high resistance between phases. In this case, the single-phase quadrilateral characteristic will be in charge of clearing the fault.

   In accordance with the above considerations, setting **Phase Lag Enable** to **YES** will only be justified when a quadrilateral characteristic for ground faults has been selected.

Single-phase elements will produce single-phase trips provided a preparation for a three-phase trip is not generated (see 3.25, Single-Phase / Three-Phase Tripping Logic).

With one pole open (single phase trip), the operation of any unit (single-phase or double-phase) containing the open pole phase will be disabled.

Single-phase elements associated to a given zone can only operate when the **Ground Element Enable Input** corresponding to said zone is active, default value being 1 (only **ZLV-F/G/H/J** relays).

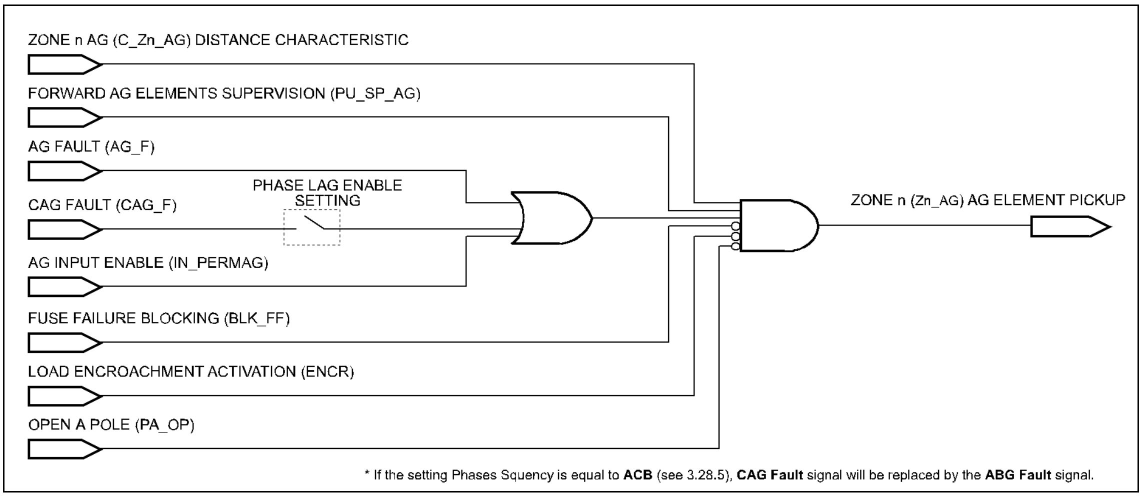


Figure 3.1.22: Pickup Logic of AG Elements.

3.1.7.b Two-phase Elements Activation

Figure 3.1.23 shows the logic diagram associated to the pickup of elements AB, for a zone n set as “Forward” looking. If said zone were set to “Reverse” looking direction the diagram would be similar but using the element reverse looking supervision output.

Two-phase elements will never activate under single-phase faults in view of the preparation to three-phase trip always generated by said elements (see 3.25, Single-Phase / Three-Phase Tripping Logic).

With one pole open (single phase trip), the operation of any unit (single-phase or two-phase) containing the open pole phase will be disabled.

Two-phase elements associated to a given zone can only operate when the **Phase Element Enable Input** corresponding to said zone is active, default value being 1 (only **ZLV-F/G/H/J** relays).

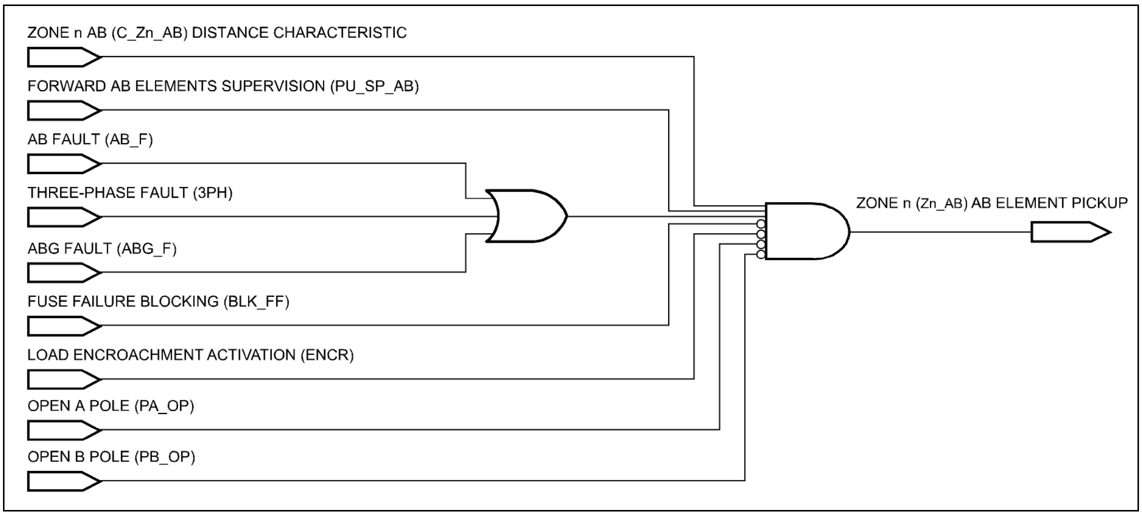


Figure 3.1.23: Pickup Logic of AB Elements.

3.1.8 Saturation Detector (ZLV-***-****D/E/F/G/H**)

The saturation of a CT causes a reduction of the magnitude of the current, obtained based on the DFT. With severe saturation, the current RMS might not exceed the set threshold. In order to avoid this situation, the magnitude of the current will be calculated based on the maximum value of the rate of change with time. The equation for the current in sample ***i*** is:

$I_i = A \cdot \cos(\frac{2\pi i}{N} + \varphi) + B \cdot e^{\lambda i}$, where ***N*** represents the number of samples per cycle.

Taking into account that the high value of the damping constant ***λ***, the equation of the rate of change of the current for sample ***i***, will be approximately:

$$I_i' = A \cdot \frac{2\pi}{N} \cdot \sin(\frac{2\pi i}{N} + \varphi)$$

A, the maximum value of the current, will be easily obtained from the maximum value of the rate of change of the current. When the current is not saturated, the calculated value of ***A*** will match the wave maximum value. When the current saturates, the value of the rate of change will increase considerably during the saturation of the CT, which will make the calculated value of ***A*** to be considerably higher than the actual wave maximum value, ensuring that the minimum threshold is exceeded. Since the maximum value is obtained every half cycle, the condition of exceeding the threshold will include one cycle reset time.

The Saturation Detector is based on calculating the rate of change of the measured current. At the time when saturation of a CT occurs, the rate of change undergoes a sharp increase. Taking into account that the maximum value of the rate of change of the current is $A \cdot \frac{2\pi}{N}$, (where A is the maximum value of the current and ***N*** the number of samples per cycle), saturation will be detected when $I_i' > k \cdot A \cdot \frac{2\pi}{N}$ (where ***k*** is a constant). ***A*** will be calculated as the maximum value of two consecutive peaks. The Saturation Detector will only operate when ***A*** is greater than the local phase rated current, in peak value, when the fault detector is active. One cycle reset time is included.

Activation of the Saturation Detector blocks the actuation of the Fast Distance units in the **ZLV-***-****D/F/H**** models.

3.1.9 Distance Elements Settings

System Impedances			
Line Impedance			
Setting	**Range**	**Step**	**By default**
Zone 1 positive sequence magnitude	(0.05 - 500) / In Ω	0.01 Ω	6.25 In
Zone 1 positive sequence angle	5 - 90º	1º	75º
Zone 2 positive sequence angle	5 - 90º	1º	75º
Zone 3 positive sequence angle	5 - 90º	1º	75º
Zone 4 positive sequence angle	5 - 90º	1º	75º
Zone 5 positive sequence angle (ZLV-F/G/H/J)	5 - 90º	1º	75º
Zone 6 positive sequence angle (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	5 - 90º	1º	75º
Zone 1 zero sequence angle	5 - 90º	1º	75º
Zone 2 zero sequence angle	5 - 90º	1º	75º
Zone 3 zero sequence angle	5 - 90º	1º	75º
Zone 4 zero sequence angle	5 - 90º	1º	75º
Zone 5 zero sequence angle (ZLV-F/G/H/J)	5 - 90º	1º	75º
Zone 6 zero sequence angle (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	5 - 90º	1º	75º
K0 Factor (Zone 1) (*) (zero sequence comp.)	0.50 - 10.00	0.01	2
Zone 2 K0 Factor	0.50 - 10.00	0.01	2
Zone 3 K0 Factor	0.50 - 10.00	0.01	2
Zone 4 K0 Factor	0.50 - 10.00	0.01	2
Zone 5 K0 Factor (ZLV-F/G/H/J)	0.50 - 10.00	0.01	2
Zone 6 K0 Factor (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	0,50 - 10,00	0,01	2
Parallel Line Impedance (ZLV-*-****A/B/C/D/E/F/G/H**)**			
Setting	**Range**	**Step**	**By default**
Mutual coupling factor (**)	0 - 10	0.01	0
Mutual coupling angle (angle of Z0M)	5 - 90º	1º	25º
I0/I0PAR factor	0.3 - 1	0.01	0.95
Equivalent Parallel Impedance			
Setting	**Range**	**Step**	**By default**
Positive sequence magnitude	(0.05 - 50,000) / In Ω	0.01 Ω	6.25 In
Positive sequence angle	5 - 90º	1º	75º
Zero sequence magnitude	(0.05 - 50,000) / In Ω	0.01 Ω	6.25 In
Zero sequence angle	5 - 90º	1º	75º

System Impedances			
Local Source Impedance			
Setting	**Range**	**Step**	**By default**
Positive sequence magnitude	(0.05 - 500) / In Ω	0.01 Ω	6.25 In
Positive sequence angle	5 - 90º	1º	75º
Zero sequence magnitude	(0.05 - 500) / In Ω	0.01 Ω	6.25 In
Zero sequence angle	5 - 90º	1º	75º
Remote Source Impedance			
Setting	**Range**	**Step**	**By default**
Positive sequence magnitude	(0.05 - 500) / In Ω	0.01 Ω	6.25 In
Positive sequence angle	5 - 90º	1º	75º
Zero sequence magnitude	(0.05 - 500) / In Ω	0.01 Ω	6.25 In
Zero sequence angle	5 - 90º	1º	75º

(*)K0 = zero sequence magnitude / positive sequence magnitude
(**) K0M = Z0M / Z1L (module of the zero sequence mutual impedance / module of the positive sequence impedance of the line).

- ## System Impedances: HMI access

0 - CONFIGURATION	0 - GENERAL	**0 - LINE IMPEDANCE**
1 - OPERATIONS	**1 - SYSTEM IMPEDANCES**	**1 - PARALELL EQUIV. IM**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - LOCAL SOURCE IMP.**
3 - INFORMATION	3 - PROTECTION	**3 - REMOTE SOURCE IMP.**
	4 - RECLOSER	**4 - PAR.LINE COUPLING (*)**
	5 - LOGIC	
	6 - BREAKER SUPERV.	
	7 - CIRCUIT COIL SUPER	
	8 - HISTORY	
	9 - OCILLOGRAPHY	
	10 - DIGITAL PLL	

(*) ZLV-*-****A/B/C/D/E/F/G/H** Models.**

ZLV-A/B/E Models

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUD**
1 - PARALELL EQUIV. IM	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	**2 - POS. SEQ. ANGLE 2**
3 - REMOTE SOURCE IMP.	**3 - POS. SEQ. ANGLE 3**
	4 - POS. SEQ. ANGLE 4
	5 - ZERO SEQ. ANGLE
	6 - Z1 K0 FACTOR
	7 - ZERO SEQ. ANGLE 2
	8 - Z2 K0 FACTOR
	9 - ZERO SEQ. ANGLE 3
	10 - Z3 K0 FACTOR
	11 - ZERO SEQ. ANGLE 4
	12 - Z4 K0 FACTOR

ZLV-F/G/H/J Models

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUD**
1 - PARALELL EQUIV. IM	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	**2 - POS. SEQ. ANGLE 2**
3 - REMOTE SOURCE IMP.	**3 - POS. SEQ. ANGLE 3**
	4 - POS. SEQ. ANGLE 4
	5 - POS. SEQ. ANGLE 5
	6 - ZERO SEQ. ANGLE
	7 - Z1 K0 FACTOR
	8 - ZERO SEQ. ANGLE 2
	9 - Z2 K0 FACTOR
	10 - ZERO SEQ. ANGLE 3
	11 - Z3 K0 FACTOR
	12 - ZERO SEQ. ANGLE 4
	13 - Z4 K0 FACTOR
	14 - ZERO SEQ. ANGLE 5
	15 - Z5 K0 FACTOR

ZLV-F/G/H/J**-****C/D/E/F/G/H** Models

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUD**
1 - PARALELL EQUIV. IM	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	**2 - POS. SEQ. ANGLE 2**
3 - REMOTE SOURCE IMP.	**3 - POS. SEQ. ANGLE 3**
	4 - POS. SEQ. ANGLE 4
	5- POS. SEQ. ANGLE 5
	6- POS. SEQ. ANGLE 6
	7 - ZERO SEQ. ANGLE
	8 - Z1 K0 FACTOR
	9 - ZERO SEQ. ANGLE 2
	10 - Z2 K0 FACTOR
	11 - ZERO SEQ. ANGLE 3
	12 - Z3 K0 FACTOR
	13 - ZERO SEQ. ANGLE 4
	14 - Z4 K0 FACTOR
	15 - ZERO SEQ. ANGLE 5
	16 - Z5 K0 FACTOR
	15 - ZERO SEQ. ANGLE 6
	16 – Z6 K0 FACTOR

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUD**
1 - PARALELL EQUIV. IM	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	**2 - ZERO SEQ. MAGNITUD**
3 - REMOTE SOURCE IMP.	**3 - ZERO SEQ. ANGLE**
4 - PAR.LINE COUPLING (*)	

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUD**
1 - PARALELL EQUIV. IM	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	**2 - ZERO SEQ. MAGNITUD**
3 - REMOTE SOURCE IMP.	**3 - ZERO SEQ. ANGLE**
4 - PAR.LINE COUPLING (*)	

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUD**
1 - PARALELL EQUIV. IM	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	**2 - ZERO SEQ. MAGNITUD**
3 - REMOTE SOURCE IMP.	**3 - ZERO SEQ. ANGLE**
4 - PAR.LINE COUPLING (*)	

0 - LINE IMPEDANCE	
1 - PARALELL EQUIV. IM	
2 - LOCAL SOURCE IMP.	**2 - MUTUAL COUPL. FACTOR**
3 - REMOTE SOURCE IMP.	**3 - MUTUAL COUPL. ANGLE**
4 - PAR.LINE COUPLING (*)	**4 - FACTOR I0/I0PAR**

(*) ZLV-*-****A/B/C/D/E/F/G/H** Models.**

Distance Protection			
Zone 1 units			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		YES
Direction	Reverse / Forward		Forward
Reach	(0.05 - 500) / In Ω	0.01 Ω	5 In
Ground fault resistive limit	(0.05 - 500) / In Ω	0.01 Ω	20 In
Phase-to-phase fault resistive limit	(0.05 - 500) / In Ω	0.01 Ω	20 In
Ground fault time delay	0.00 - 300.00 s	0.01 s	0 s
Phase-to-phase fault time delay	0.00 - 300.00 s	0.01 s	0 s
Compensation time	0.00 - 0.50s 0.0- 2.00s (ZLV-***-****A/B/C/D/E/F/G/H**)	0.01 s	0 s
Compensation angle type (ZLV-***-****A/B/C/D/E/F/G/H**)	Calculated / Direct		Calculated
Compensation angle (ZLV-***-****A/B/C/D/E/F/G/H**)	-90º - 90º	1	0º

Elements Zones 2, 3, 4, 5 and 6 (independent settings for each zone)			
Setting	**Range**	**Step**	**By default**
Enable Zone 2 / 3 / 4 / 5 / 6	YES / NO		YES
Direction	Reverse / Forward		Forward
Reach (ZLV-A/B/E)	(0.05 - 500) / In Ω	0.01 Ω	
Ground fault reach (ZLV-F/G/H/J)	(0.05 - 500) / In Ω	0.01 Ω	
Phase-to-phase fault reach (ZLV-F/G/H/J)	(0.05 - 500) / In Ω	0.01 Ω	
Ground fault resistive limit	(0.05 - 500) / In Ω	0.01 Ω	20 In
Phase-to-phase fault resistive limit	(0.05 - 500) / In Ω	0.01 Ω	20 In
Ground fault time delay	0.00 - 300.00 s	0.01 s	
Phase-to-phase fault time delay	0.00 - 300.00 s	0.01 s	
Ground Fault Characteristics			
Setting	**Range**	**Step**	**By default**
Element type	Quadrilateral Mho Quadrilateral and Mho Quadrilateral or Mho		Mho
Phase-to-Phase Characteristics			
Setting	**Range**	**Step**	**By default**
Element type	Quadrilateral Mho Quadrilateral and Mho Quadrilateral or Mho		Mho
Directional Element Characteristic Angle			
Setting	**Range**	**Step**	**By default**
Directional element characteristic angle Quadrilateral characteristic	0 - 90º	1º	75º
Start Timers (ZLV-*-****G/H**)**			
Setting	**Range**	**Step**	**By default**
Start Type	Zone Pick Up Distance Pick Up		Zone Pick Up
Phase Lag Enable			
Setting	**Range**	**Step**	**By default**
Phase Lag Enable (Two-phase-to-ground fault)	YES / NO		NO
Voltage Memory Duration			
Setting	**Range**	**Step**	**By default**
Memory duration	2 - 80 cycles 2 - 100 cycles (ZLV-***-****A/B/C/D/E/F/G/H**)	1 cycle	2 cycles
Positive Sequence Voltage Threshold			
Setting	**Range**	**Step**	**By default**
Voltage threshold	0.1 - 5 V	0.1 V	1 V
Parallel Line Coupling (ZLV-*-****A/B/C/D/E/F/G/H**)**			
Setting	**Range**	**Step**	**By default**
Mutual Coupling Enable	YES / NO		NO

- **Distance Protection: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	**0 - DISTANCE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	2 - CLOSE ONTO FAULT
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	...	...

0 - DISTANCE	**0 - ZONE 1 UNITS**
1 - DIST SUPERVISION	**1 - ZONE 2 UNITS**
2 - CLOSE ONTO FAULT	**2 - ZONE 3 UNITS**
3 - FUSE FAILURE	**3 - ZONE 4 UNITS**
...	**4 - GND CHARACTERISTIC**
	5 - PH CHARACTERISTIC
	6 - DIREC CHARAC ANGLE
	7 - LAGGING PHASE
	8 - MEMORY DURACTION
	9 - VOLTAGE THRESHOLD

Zone 1 Units

0 - DISTANCE	**0 - ZONE 1 UNITS**	**0 - ZONE 1 ENABLE**
1 - DIST SUPERVISION	**...**	**1 - FORWARD**
2 - CLOSE ONTO FAULT		**2 - REACH**
3 - FUSE FAILURE		**3 - GRND RESIST LIMIT**
...		**4 - PHASE RESIST LIMIT**
		5 - GROUND TIME
		6 - PHASE TIME
		7 - TILT TIME

Zones 2, 3 and 4 Units

0 - DISTANCE	0 - ZONE 1 UNITS	**0 - ZONE * ENABLE**
1 - DIST SUPERVISION	**1 - ZONE 2 UNITS**	**1 - FORWARD**
2 - CLOSE ONTO FAULT	**2 - ZONE 3 UNITS**	**2 - REACH**
3 - FUSE FAILURE	**3 - ZONE 4 UNITS**	**3 - GRND RESIST LIMIT**
......	...	**4 - PHASE RESIST LIMIT**
		5 - GROUND TIME
		6 - PHASE TIME

(*) Corresponding zone according to the previous selection: zone 2, 3 or 4.

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	**0 - DISTANCE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	2 - CLOSE ONTO FAULT
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	…	…

0 - DISTANCE	**0 - ZONE 1 UNITS**
1 - DIST SUPERVISION	**1 - ZONE 2 UNITS**
2 - CLOSE ONTO FAULT	**2 - ZONE 3 UNITS**
3 - FUSE FAILURE	**3 - ZONE 4 UNITS**
…	**4 - ZONE 5 UNITS**
	5 - GND CHARACTERISTIC
	6 - PH CHARACTERISTIC
	7 - DIREC CHARAC ANGLE
	8 - LAGGING PHASE
	9 - MEMORY DURACTION
	10 - VOLTAGE THRESHOLD

ZLV-F/G/H/J**-****C/D/E/F/G/H**

0 - CONFIGURATION	0 - GENERAL	**0 - DISTANCE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	2 - CLOSE ONTO FAULT
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	…	…

0 - DISTANCE	**0 - ZONE 1 UNITS**
1 - DIST SUPERVISION	**1 - ZONE 2 UNITS**
2 - CLOSE ONTO FAULT	**2 - ZONE 3 UNITS**
3 - FUSE FAILURE	**3 - ZONE 4 UNITS**
…	**4 - ZONE 5 UNITS**
	5 - ZONE 6 UNITS
	6 - GND CHARACTERISTIC
	7 - PH CHARACTERISTIC
	8 - DIREC CHARAC ANGLE
	9 - LAGGING PHASE
	10 - MEMORY DURACTION
	11 - VOLTAGE THRESHOLD

Zone 1 Units

0 - DISTANCE	**0 - ZONE 1 UNITS**	**0 - ZONE 1 ENABLE**
1 - DIST SUPERVISION	…	**1 - DIRECTION**
2 - CLOSE ONTO FAULT		**2 - GROUND REACH**
3 - FUSE FAILURE		**3 - PHASE REACH**
…		**4 - GRND RESIST LIMIT**
		5 - PHASE RESIST LIMIT
		6 - GROUND TIME
		7 - PHASE TIME
		8 - TILT TIME

Zones 2, 3, 4, 5 and 6 Units

0 - DISTANCE	0 - ZONE 1 UNITS	**0 - ZONE * ENABLE**
1 - DIST SUPERVISION	**1 - ZONE 2 UNITS**	**1 - DIRECTION**
2 - CLOSE ONTO FAULT	**2 - ZONE 3 UNITS**	**2 - GROUND REACH**
3 - FUSE FAILURE	**3 - ZONE 4 UNITS**	**3 - PHASE REACH**
…	**4 - ZONE 5 UNITS**	**4 - GRND RESIST LIMIT**
	5 - ZONE 6 UNITS	**5 - PHASE RESIST LIMIT**
	…	**6 - GROUND TIME**
		7 - PHASE TIME

(*) Corresponding zone according to the previous selection: zone 2, 3, 4, 5 or 6.
(**)ZLV-F/G/H/J-****C/D/E/F/G/H** Models.**

Zone 1 Units. ZLV-***-****A/B/C/D/E/F/G/H** Models

0 - DISTANCE	**0 - ZONE 1 UNITS**	**0 - ZONE 1 ENABLE**
1 - DIST SUPERVISION	…	**1 - DIRECTION**
2 - CLOSE ONTO FAULT		**2 - GROUND REACH**
3 - FUSE FAILURE		**3 - PHASE REACH**
…		**4 - GRND RESIST LIMIT**
		5 - PHASE RESIST LIMIT
		6 - GROUND TIME
		7 - PHASE TIME
		8 - TILT TIME
		9 - TILT ANGLE TYPE
		10 - TILT ANGLE

Distance Supervision			
Elements Supervision			
Setting	**Range**	**Step**	**By default**
Single-phase forward current	(0.04 - 1.50) In	0.01 A	0.2 A
Two-phase forward current	(0.04 - 1.50) In	0.01 A	0.2 A
Single-phase reverse current	(0.04 - 1.50) In	0.01 A	0.2 A
Two-phase reverse current	(0.04 - 1.50) In	0.01 A	0.2 A

- ### Distance Supervision: HMI Access

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - DIST SUPERVISION**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	2 - CLOSE ONTO FAULT
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	…	…

0 - DISTANCE	**0 - FORWARD SUP. 1-PH**
1 - DIST SUPERVSISION	**1 - FORWARD SUP. 2-PH**
2 - CLOSE ONTO FAULT	**2 - REVERSE SUP. 1-PH**
3 - FUSE FAILURE	**3 - REVERSE SUP. 2-PH**
	…

3.1.10 Digital Inputs and Events of the Distance Elements

Table 3.1-6: Digital Inputs and Events of the Distance Elements

Name	Description	Function
ENBL_ZI	Zone 1 Enable Input (ZLV-A/B/E)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_ZII	Zone 2 Enable Input (ZLV-A/B/E)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_ZIII	Zone 3 Enable Input (ZLV-A/B/E)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_ZIV	Zone 4 Enable Input (ZLV-A/B/E)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_ZIG	Ground element enable input zone 1 (ZLV-F/G/H/J)	Its activation puts ground elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZIIG	Ground element enable input zone 2 (ZLV-F/G/H/J)	Its activation puts ground elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZIIIG	Ground element enable input zone 3 (ZLV-F/G/H/J)	Its activation puts ground elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZIVG	Ground element enable input zone 4 (ZLV-F/G/H/J)	Its activation puts ground elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZVG	Ground element enable input zone 5 (ZLV-F/G/H/J)	Its activation puts ground elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZVIG	Ground element enable input zone 6 (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	Its activation puts ground elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZIP	Phase element enable input zone 1 (ZLV-F/G/H/J)	Its activation puts phase elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZIIP	Phase element enable input zone 2 (ZLV-F/G/H/J)	Its activation puts phase elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZIIIP	Phase element enable input zone 3 (ZLV-F/G/H/J)	Its activation puts phase elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBLZIVP	Phase element enable input zone 4 (ZLV-F/G/H/J)	Its activation puts phase elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZVP	Phase element enable input zone 5 (ZLV-F/G/H/J)	Its activation puts phase elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
ENBL_ZVIP	Phase element enable input zone 6 (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	Its activation puts phase elements into operation. They can be assigned to digital inputs on level or commands from the communications protocol or from the HMI. Default value is “1”.
IN_PERMAG	AG element enable input (ZLV-F/G/H/J)	Its activation puts single-phase elements into operation no matter phase selector outputs
IN_PERMBG	BG element enable input (ZLV-F/G/H/J)	Its activation puts single-phase elements into operation no matter phase selector outputs
IN_PERMCG	CG element enable input (ZLV-F/G/H/J)	Its activation puts single-phase elements into operation no matter phase selector outputs

3.1.11 Digital Outputs and Events of the Distance Elements

Table 3.1-7: Digital Outputs and Events of the Distance Elements

Name	Description	Function
C_ZI_AG	Zone 1 AG Characteristic	Distance characteristic activation for different zones.
C_ZI_BG	Zone 1 BG Characteristic	
C_ZI_CG	Zone 1 CG Characteristic	
C_ZI_AB	Zone 1 AB Characteristic	
C_ZI_BC	Zone 1 BC Characteristic	
C_ZI_CA	Zone 1 CA Characteristic	
C_ZII_AG	Zone 2 AG Characteristic	
C_ZII_BG	Zone 2 BG Characteristic	
C_ZII_CG	Zone 2 CG Characteristic	
C_ZII_AB	Zone 2 AB Characteristic	
C_ZII_BC	Zone 2 BC Characteristic	
C_ZII_CA	Zone 2 CA Characteristic	
C_ZIII_AG	Zone 3 AG Characteristic	
C_ZIII_BG	Zone 3 BG Characteristic	
C_ZIII_CG	Zone 3 CG Characteristic	
C_ZIII_AB	Zone 3 AB Characteristic	
C_ZIII_BC	Zone 3 BC Characteristic	
C_ZIII_CA	Zone 3 CA Characteristic	
C_ZIV_AG	Zone 4 AG Characteristic	
C_ZIV_BG	Zone 4 BG Characteristic	
C_ZIV_CG	Zone 4 CG Characteristic	
C_ZIV_AB	Zone 4 AB Characteristic	
C_ZIV_BC	Zone 4 BC Characteristic	
C_ZIV_CA	Zone 4 CA Characteristic	
C_ZV_AG	Zone 5 AG Characteristic (ZLV-F/G/H/J)	
C_ZV_BG	Zone 5 BG Characteristic (ZLV-F/G/H/J)	
C_ZV_CG	Zone 5 CG Characteristic (ZLV-F/G/H/J)	
C_ZV_AB	Zone 5 AB Characteristic (ZLV-F/G/H/J)	
C_ZV_BC	Zone 5 BC Characteristic (ZLV-F/G/H/J)	
C_ZV_CA	Zone 5 CA Characteristic (ZLV-F/G/H/J)	
C_ZVI_AG	Zone 6 AG Characteristic (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
C_ZVI_BG	Zone 6 BG Characteristic (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
C_ZVI_CG	Zone 6 CG Characteristic (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
C_ZVI_AB	Zone 6 AB Characteristic (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
C_ZVI_BC	Zone 6 BC Characteristic (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
C_ZVI_CA	Zone 6 CA Characteristic (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	

Table 3.1-7: Digital Outputs and Events of the Distance Elements		
Name	**Description**	**Function**
ZI_AG	Zone 1 AG Element Pickup	Pickup of the distance elements for each Zone.
ZI_BG	Zone 1 BG Element Pickup	
ZI_CG	Zone 1 CG Element Pickup	
ZII_AG	Zone 2 AG Element Pickup	
ZII_BG	Zone 2 BG Element Pickup	
ZII_CG	Zone 2 CG Element Pickup	
ZIII_AG	Zone 3 AG Element Pickup	
ZIII_BG	Zone 3 BG Element Pickup	
ZIII_CG	Zone 3 CG Element Pickup	
ZIV_AG	Zone 4 AG Element Pickup	
ZIV_BG	Zone 4 BG Element Pickup	
ZIV_CG	Zone 4 CG Element Pickup	
ZV_AG	Zone 5 AG Element Pickup (ZLV-F/G/H/J)	
ZV_BG	Zone 5 BG Element Pickup (ZLV-F/G/H/J)	
ZV_CG	Zone 5 CG Element Pickup (ZLV-F/G/H/J)	
ZVI_AG	Zone 6 AG Element Pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZVI_BG	Zone 6BG Element Pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZVI_CG	Zone 6CG Element Pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZI_AB	Zone 1 AB Element Pickup	
ZI_BC	Zone 1 BC Element Pickup	
ZI_CA	Zone 1 CA Element Pickup	
ZII_AB	Zone 2 AB Element Pickup	
ZII_BC	Zone 2 BC Element Pickup	
ZII_CA	Zone 2 CA Element Pickup	
ZIII_AB	Zone 3 AB Element Pickup	
ZIII_BC	Zone 3 BC Element Pickup	
ZIII_CA	Zone 3 CA Element Pickup	
ZIV_AB	Zone 4 AB Element Pickup	
ZIV_BC	Zone 4 BC Element Pickup	
ZIV_CA	Zone 4 CA Element Pickup	
ZV_AB	Zone 5 AB Element Pickup (ZLV-F/G/H/J)	
ZV_BC	Zone 5 BC Element Pickup (ZLV-F/G/H/J)	
ZV_CA	Zone 5 CA Element Pickup (ZLV-F/G/H/J)	
ZVI_AB	Zone 6 AB Element Pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZVI_BC	Zone 6 BC Element Pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZVI_CA	Zone 6 CA Element Pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZI_ENBLD	Zone 1 Enabled (ZLV-A/B/E)	Indication of enabled or disabled status of the Zone.
ZII_ENBLD	Zone 2 Enabled (ZLV-A/B/E)	
ZIII_ENBLD	Zone 3 Enabled (ZLV-A/B/E)	
ZIV_ENBLD	Zone 4 Enabled (ZLV-A/B/E)	

Table 3.1-7: Digital Outputs and Events of the Distance Elements

Name	Description	Function
ZIG_ENBLD	Ground elements zone 1 enabled (ZLV-F/G/H/J)	Indication of the enabled or disabled condition of the corresponding zone ground elements.
ZIIG_ENBLD	Ground elements zone 2 enabled (ZLV-F/G/H/J)	
ZIIIG_ENBLD	Ground elements zone 3 enabled (ZLV-F/G/H/J)	
ZIVG_ENBLD	Ground elements zone 4 enabled (ZLV-F/G/H/J)	
ZVG_ENBLD	Ground elements zone 5 enabled (ZLV-F/G/H/J)	
ZVIG_ENBLD	Ground elements zone 6 enabled (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
ZIP_ENBLD	Phase elements zone 1 enabled (ZLV-F/G/H/J)	Indication of the enabled or disabled condition of the corresponding zone phase elements.
ZIIP_ENBLD	Phase elements zone 2 enabled (ZLV-F/G/H/J)	
ZIIIP_ENBLD	Phase elements zone 3 enabled (ZLV-F/G/H/J)	
ZIVP_ENBLD	Phase elements zone 4 enabled (ZLV-F/G/H/J)	
ZVP_ENBLD	Phase elements zone 5 enabled (ZLV-F/G/H/J)	
ZVIP_ENBLD	Phase elements zone 6 enabled (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
PU_SP_AG	Supervision units AG forward	Supervision unit pickup for different types of forward and reverse faults.
PU_SP_BG	Supervision units BG forward	
PU_SP_CG	Supervision units CG forward	
PU_SP_AB	Supervision units AB forward	
PU_SP_BC	Supervision units BC forward	
PU_SP_CA	Supervision units CA forward	
PU_R_SP_AG	Supervision units AG reverse	
PU_R_SP_BG	Supervision units BG reverse	
PU_R_SP_CG	Supervision units CG reverse	
PU_R_SP_AB	Supervision units AB reverse	
PU_R_SP_BC	Supervision units BC reverse	
PU_R_SP_CA	Supervision units CA reverse	
UD_A	Direction of AG distance elements	Operation of the directional elements associated to the quadrilateral characteristic. Their activation is produced in forward faults.
UD_B	Direction of BG distance elements	
UD_C	Direction of CG distance elements	
UD_AB	Direction of AB distance elements	
UD_BC	Direction of BC distance elements	
UD_CA	Direction of CA distance elements	

3.1.12 Distance Elements Test

Before running the test, those elements that are not being tested must be deactivated and the distance element activated with the following settings:

Table 3.1-8:Test Settings for the Distance Unit*	
System Impedances	
Positive sequence magnitude. Line impedance	1.20 Ω
Positive sequence angles. Zones 1, 2, 3, 4 and 5 line impedance	75º
Zero sequence angles. Zones 1, 2, 3, 4 and 5 line impedance	75º
K0, K02, K03, K04 and K05 factors	3.00
Positive sequence magnitude. Local source impedance	1.00 Ω
Positive sequence angle. Local source impedance	75º
Zero sequence magnitude. Local source impedance	1.00 Ω
Zero sequence angle. Local source impedance	75º
Positive sequence magnitude. Remote source impedance	1.00 Ω
Positive sequence angle. Remote source impedance	75º
Zero sequence magnitude. Remote source impedance	1.00 Ω
Zero sequence angle. Remote source impedance	75º
Positive sequence magnitude. Equivalent parallel impedance	1.00 Ω
Positive sequence angle. Equivalent parallel impedance	75º
Zero sequence magnitude. Equivalent parallel impedance	1.00 Ω
Zero sequence angle. Equivalent parallel impedance	75º
Distance Elements	
Ground distance characteristic	Quadrilateral
Phase-to-phase characteristic	Quadrilateral
Zone 1 direction	Forward
Zone 2 direction	Forward
Zone 3 direction	Forward
Zone 4 direction	Forward
Zone 5 direction	Forward
Zone 1 reach	1.00 Ω
Zone 2 reach	2.00 Ω
Zone 3 reach	4.00 Ω
Zone 4 reach	5.00 Ω
Zone 5 reach	6.00 Ω
Zone 1 resistive limit	2.00 Ω
Zone 2 resistive limit	4.00 Ω
Zone 3 resistive limit	8.00 Ω
Zone 4 resistive limit	10.00 Ω
Zone 5 resistive limit	12.00 Ω
Zone 1 phase-to-phase resistive limit	2.00 Ω
Zone 2 phase-to-phase resistive limit	4.00 Ω
Zone 3 phase-to-phase resistive limit	8.00 Ω
Zone 4 phase-to-phase resistive limit	10.00 Ω
Zone 5 phase-to-phase resistive limit	12.00 Ω

Distance Elements (cont.)	
Ground element zone 1 pickup time	0 s
Ground element zone 2 pickup time	0.5 s
Ground element zone 3 pickup time	1 s
Ground element zone 4 pickup time	1.5 s
Ground element zone 5 pickup time	2 s
Phase element zone 1 pickup time	0 s
Phase element zone 2 pickup time	0.5 s
Phase element zone 3 pickup time	1 s
Phase element zone 4 pickup time	1.5 s
Phase element zone 5 pickup time	2 s
Compensation time	0 s
Directional element characteristic angle. Reactance characteristic	75º
Phase lag enable. (Two-phase-to-ground fault)	No
Voltage memory duration	2 cycles

*** For an In = 5 A.**

3.1.12.a Ground Fault Characteristics

- **Reactance Characteristic**

This test will check the reactance element, as well as the resistive limiter.

Apply a three-phase balanced input of voltages, with an input of 65 Vac and inductive angles of 0º, 120º and 240º to phases A, B and C, respectively.

In the phase under test, apply a current of 5 A, with the inductive angles (related to the voltage of the same phase) shown in Table 3.1-9.

Slowly decrease the voltage of the phase under test. Each zone should activate within the voltage ranges indicated in Table 3.1-9.

Activation of each zone will be displayed in the **Information** - **Status** - **Measuring Elements** - **Step Distance** screen, or in the **Status** (**Status** - **Elements** - **Step Distance**) screen of the ***ZIVercomPlus***® software. Also, the verification can be made configuring the activation in auxiliary outputs and verifying the status.

Table 3.1-9: Reactance Characteristic Test for Single Phase Faults

Zone	Voltage Trip (V)						
	Res. Limit R>0		Reactance			Res. Limit R<0	
	Phase I=0º	Phase I=15º	Phase I=45º	Phase I=75º	Phase I=105º	Phase I=150º	Phase I=165º
1	9.7-10.3	10.82-11.49	11.04-11.73	8.08-8.58	8.08-8.58	9.7-10.3	9.37-9.95
2	19.4-20.6	21.64-22.98	22.08-23.45	16.17-17.17	16.17-17.17	19.4-20.6	18.74-19.9
3	38.8-41.2	43.28-45.95	44.17-46.9	32.33-34.33	32.33-34.33	38.8-41.2	37.48-39.8
4	48.5-51.5	54.09-57.44	55.21-58.63	40.42-42.92	40.42-42.92	48.5-51.5	46.85-49.74
5	58.2-61.8	64.91-68.93	66.25-70.35	48.50-51.50	48.50-51.50	58.20-61.80	56.22-56.69

This test uses the relationship between the voltage **V**, which trips the unit by the **Reactance** characteristic, for a given current **I** in the test phase; provided the current difference of the other phases to that of the test phase current yields 0 Aac. This relationship is given by the following equation:

$$V = \frac{1}{3} \cdot I \cdot Z1n \cdot \frac{sen(a + \theta 1n)}{sen(\alpha)} \cdot \left| 2 + K0n \cdot e^{j \cdot (\theta 0n - \theta 1n)} \right|$$

Use the following equation to determine the operating points of the **Resistive limiter** (R>0):

$$V = \frac{I \cdot RGn \cdot sen(\theta bn)}{sen(\theta bn - \alpha)}$$

And the following equation to determine the operating points of the **Resistive limiter** (R<0):

$$V = \frac{I \cdot RGn \cdot sen(\theta bn)}{sen(\alpha - \theta bn)}$$

Where:

$Z1n$	Positive sequence reach impedance of the zone n
RGn	Resistive limiter reach impedance in Ω, for ground faults of the zone n
$\theta 1n$	Positive sequence reach impedance angle of the zone n
$\theta 0n$	Zero sequence reach impedance angle of the zone n
θbn	Impedance angle of the loop for zone n In case that the sound phases are null θbn = θ1n+a
$K0n = \frac{\lvert Z0n \rvert}{\lvert Z1n \rvert}$	Zero sequence compensation factor of the zone n
I	Effective value of the phase current
α	Inductive angle of the phase current with respect to the phase voltage
a	Phase shift between the equivalent current and the phase current, i.e., $a = \arg\left(2 + K0n \cdot e^{j \cdot (\theta 0n - \theta 1n)}\right)$ in case that the sound phases are null

- **MHO Characteristic**

The test will be carried out in the same manner as previously, on adjusting the **Characteristic for Ground Fault** as **MHO**. The results obtained will be the following:

Table 3.1-10: Mho Characteristic Test for Single Phase Faults

Zone	Voltage Trip (V)					
	Phase I=0º	Phase I=30º	Phase I=60º	Phase I=75º	Phase I=90º	Phase I=120º
1	2.09-2.22	5.72-6.07	7.81-8.29	8.08-8.58	7.81-8.29	5.72-6.07
2	4.18-4.44	11.43-12.14	15.62-16.58	16.17-17.17	15.62-16.58	11.43-12.14
3	8.37-8.89	22.86-24.28	31.23-33.16	32.33-34.33	31.23-33.16	22.86-24.28
4	10.46-11.11	28.58-30.35	39.04-41.45	40.42-42.92	39.04-41.45	28.58-30.35
5	12.55-13.33	34.29-36.41	46.84-49.74	48.5-51.5	46.84-49.74	34.29-36.41

This test uses the relationship between the voltage **V**, which trips the unit by the Mho characteristic, for a given a current **I** in the test phase; provided the current difference of the other phases to that of the test phase current yields 0 A ac. This relationship is given by the following equation:

$$V = \frac{1}{3} \cdot I \cdot Z1n \cdot \cos(\theta 1n - \alpha + a) \cdot \left| 2 + K0n \cdot e^{j \cdot (\theta 0n - \theta 1n)} \right|$$

Where:

$Z1n$	Positive sequence reach impedance of the zone n
$\theta 1n$	Positive sequence reach impedance angle of the zone n
$\theta 0n$	Zero sequence reach impedance angle of the zone n
$K0n = \frac{\lvert Z0n \rvert}{\lvert Z1n \rvert}$	Zero sequence compensation factor of the zone n
I	Effective value of the phase current
α	Inductive angle of the phase current with respect to the phase voltage
a	Phase shift between the equivalent current and the phase current, i.e., $a = \arg\left(2 + K0n \cdot e^{j \cdot (\theta 0n - \theta 1n)}\right)$ in case that the sound phases are null

- **Zone Times**

Prepare the system to measure the time between the application of current to the test phase and the close of the corresponding trip contact.

Begin with a three-phase balanced voltage system, with an input of 65 Vac and inductive angles of 0º, 120º and 240º in the A, B and C phases, respectively; and a balanced three-phase current, with an input of 0 Vac and inductive angles of 75º, 195º and 315º in the A, B and C phases, respectively.

The voltage of the phase under test will be reduced to the values for each zone, as indicated in Table 3.1-11.

Raise the effective value of the current of the phase under test until it reaches 5 A ac, measuring the time between the application of the current and the close of the trip contact of the phase under test.

Table 3.1-11 also indicates the ranges of trip times for each zone.

Table 3.1-11: Zone Times (single-phase faults)

Zone	Applied Voltage (V)	Minimum Time (s)	Maximum Time (s)
1	5.00	-	0.045
2	12.00	0.475	0.525
3	20.00	0.950	1.050
4	36.00	1.425	1.575
5	42.00	1.9	2.1

3.1.12.b Characteristic for Faults between Phases

- **Reactance Characteristic for Faults between Phases**

This test will check the **Reactance element**, as well as the **Resistive limiter**.

For this test, two phases will be used (pairs AB, BC or CA). Initially, 65 Vac will be applied with 0º to the first phase, and a voltage of 65 Vac and 180º to the second phase and a voltage of 65 Vca and 90º to the third.

A current of 5 A ac will be applied to the first phase, with an angle (inductive) as indicated in Table 3.1-12. A current of 5 A ac will be applied to the second phase and an angle 180º out of phase to that of the first phase.

The voltages of the phases under test should be gradually and simultaneously reduced, and the characteristics of the different zones should activate within the voltage ranges that are shown in Table 3.1-12.

The activation of each zone can be viewed on the display (**Information** - **Status** - **Measuring Units** - **Step Distance**), or in the status screen of the ***ZIVercomPlus***® software program (**Status** - **Elements** - **Step Distance**). The verification can also be made configuring the activations in auxiliary outputs and verifying the status.

Table 3.1-12: Reactance Characteristic Test for Faults Between Phases							
Zone	**Voltage Trip (V)**						
	Res. Limit R>0		**Reactance**			**Res. Limit R<0**	
	Phase I=0º	**Phase I=15º**	**Phase I=45º**	**Phase I=75º**	**Phase I=105º**	**Phase I=150º**	**Phase I=165º**
1	9.7-10.3	10.82-11.49	6.63-7.03	4.85-5.15	4.85-5.15	9.7-10.3	9.37-9.95
2	19.4-20.6	21.64-22.98	13.25-14.07	9.7-10.3	9.7-10.3	19.4-20.6	18.74-19.9
3	38.8-41.2	43.28-45.95	26.5-28.14	19.4-20.6	19.4-20.6	38.8-41.2	37.48-39.8
4	48.5-51.5	54.09-57.44	33.13-35.18	24.25-25.75	24.25-25.75	48.5-51.5	46.85-49.74
5	58.2-61.8	64.91-68.92	39.75-42.21	29.1-30.9	29.1-30.9	Reactance breaking	46.84-49.74

This test uses the relationship between the value of the phase voltage **V** (with angles of 0° and 180º), which trips the unit by the Reactance characteristic for faults between phases and the corresponding phase current, for a given current **I** (with angles of 0° and 180º plus a phase difference with respect to the voltage). This relationship is given by the following equation:

$$V = \left(I \cdot Z1n\right) \cdot \frac{sen\left(\theta 1n\right)}{sen\left(\alpha\right)}$$

Use the following equation to determine the operating points of the **Resistive limiter** (R>0):

$$V = \frac{I \cdot RPn \cdot sen(\theta 1n)}{sen(\theta 1n - \alpha)}$$

And the following equation to determine the operating points of the **Resistive limiter** (R<0):

$$V = \frac{I \cdot RPn \cdot sen(\theta 1n)}{sen(\alpha - \theta 1n)}$$

Where:

$Z1n$	Positive sequence reach impedance of the zone n
$\theta 1n$	Positive sequence reach impedance angle of the zone n
I	Effective value of the phase current
α	Inductive angle of the currents with respect to the voltages
RPn	Resistive limiter reach impedance in Ω, for faults between phases of the zone n

In general, this equation shows the relationship between the voltage and current equivalents for a given pair of phases that establishes the corresponding point of the Reactance characteristic for a fault between phases.

- **Mho Characteristic for Faults between Phases**

For this test, two phases will be used (pairs AB, BC or CA). Initially, 65 Vac will be applied with 0º to the first phase, a voltage of 65 Vac and 180º to the second phase and a voltage of 65 Vca and 90º to the phase not involved in the fault.

A current of 5 A ac will be applied to the first phase, with an angle as indicated in Table 3.1-13. A current of 5 A ac will be applied to the second phase and an angle 180º out of phase to that of the first phase.

The voltages of the phases under test should be gradually and simultaneously reduced, and the characteristics of the different zones should activate within the voltage ranges that are shown in Table 3.1-13.

The activation of each zone can be viewed on the display (**Information** - **Status** - **Measuring Units** - **Step Distance**) or in the status screen of the ***ZIVercomPlus***® software program (**Status** - **Elements** - **Step Distance**). The verification can also be made configuring the activations in auxiliary outputs and verifying its status.

Table 3.1-13: Mho Characteristic Test for Faults Between Phases

Zone	Voltage Trip (V)					
	Phase I=0º	Phase I=30º	Phase I=60º	Phase I=75º	Phase I=90º	Phase I=120º
1	1.26-1.33	3.43-3.64	4.69-4.97	4.85-5.15	4.69-4.97	3.43-3.64
2	2.51-2.67	6.86-7.28	9.37-9.95	9.7-10.3	9.37-9.95	6.86-7.28
3	5.02-5.33	13.72-14.57	18.74-19.9	19.4-20.6	18.74-19.9	13.72-14.57
4	6.28-6.66	17.15-18.21	23.42-24.87	24.25-25.75	23.42-24.87	17.15-18.21
5	7.53-7.99	20.57-21.85	28.10-29.85	29.1-30.9	27.93-29.66	20.57-21.84

This test uses the relationship between the value of the phase voltage **V** (with angles of 0° and 180º), which trips the unit by the MHO characteristic for faults between phases and the corresponding phase current, for a given current **I** (with angles of 0° and 180º plus a phase difference with respect to the voltage). This relationship is given by the following equation:

$$V = I \cdot Z1n \cdot \cos(\theta 1n - \alpha)$$

Where:

$Z1n$	Positive sequence reach impedance of the zone n
$\theta 1n$	Positive sequence reach impedance angle of the zone n
I	Effective value of the phase current
α	Inductive angle of the currents with respect to the voltages

In general, this equation shows the relationship between the voltage and current equivalents for a given pair of phases that establishes the corresponding point of the MHO characteristic for a fault between phases.

- **Zone Times**

Prepare the system to measure the time between the application of current and the close of the corresponding trip contact.

Two phases will be used for this test. A voltage of 65 Vac and 0º will be applied to one phase, a voltage of 65 Vac and 180º will be applied to the second and in the voltage not involved in the fault 65 Vca and 90º.

A current of 7.5 A ac and an angle of 75º will be applied to the first phase. To the second phase, a current of 7.5 A ac and an angle 180º out of phase to that of the first phase will be applied.

The effective values of the voltages of the phases under test will be reduced to a different value for each zone, according to the values shown in Table 3.1-14.

Table 3.1-14 also indicates the resulting ranges of the trip times for each zone.

Table 3.1-14: Zone Times (Faults between Phases)

Zone	Applied Voltage (V)	Minimum Time (s)	Maximum Time (s)
1	5.00	-	0.045
2	12.00	0.475	0.525
3	20.00	0.950	1.050
4	36.00	1.425	1.575
5	42.00	1.9	2.1

3.2 Protection Schemes for Distance Elements

3.2.1 Introduction

ZLV terminal units include different protection schemes as a complement to the distance elements (zones 1 to 6). These schemes are intended to accelerate tripping for faults occurring outside Zone 1. These systems are known as **Distance Protection Schemes** and are based on the use of signals transmitted through communication channels between terminals at both line ends, so that the decision logic operates both with local and remote information. Said protection schemes are independent from **Overcurrent Protection Schemes** (see 3.14), so that they may use separate communication channels.

Note: all inputs and outputs on distance protection scheme logic diagrams will be identified with the word "Distance", so as to distinguish them from inputs and outputs in overcurrent protection schemes logic, which will be identified with the word "Overcurrent".

Seven protection schemes can be selected in **ZLV** relays *:

1. Step Distance
2. Zone 1 Extension
3. Permissive Underreach
4. Directional Comparison Blocking
5. Direct Transfer Trip
6. Permissive Overreach
7. Directional Comparison Unblocking

The **Stepped Distance** scheme does not include teleprotection and works basically applying an adjustable timing to each zone to generate trip signals. Said logic is always active. In case any teleprotection scheme has been selected (schemes 2 to 7, mutually excluded), will supplement the operation of the same.

Zone 1 Extension scheme only works with local information, so that a communication channel between both line ends is not required. However, it may not always accelerate the tripping in parts of the line not covered by the first zone.

Schemes 3 to 7 work with both local and remote information, so that they need a communication channel between line ends. Under the schemes 3 to 6, the signal transmitted from one equipment to another through the communication channel is deemed as a trip permissive signal, whereas the function of scheme 7 is preventing the other equipment from tripping.

But for schemes 1 to 4, all schemes use an underreach zone (set below 100% of the line), coinciding with zone 1, and an overreach zone (set above 100% of the line), which can be zone 2 or zone 3 as a function of the **Overreach Zone** setting.

ZLV relay comprises **Weak Infeed Logic** ** (see 3.2.9) and **Reverse Current Blocking Logic** ** (see 3.2.10), which, if enabled, could supplement those protection schemes that so require. Said logics are independent from logics associated to **Overcurrent Protection Schemes**.

Scheme 7 and weak Feed and reverse current lockout logic use a reverse looking zone, zone 4 for **ZLV-A/B** relays and **Zone 4 or Zone 5,** as a function of the **Reverse looking Zone** setting, for **ZLV-F/G/H/J** relays.

The **Distance Protection Scheme** setting selects which of the seven options is active.

* Only the step distance scheme and the extension of zone 1 are available for the ZLV-E models.
** Not available for the ZLV-E models.

3.2.2 Step Distance

As discussed previously, this scheme is always activated, independent of the selected protection scheme. If **Step Distance** is selected as the **Protection Scheme** setting, this will be the only scheme activated.

As seen in Figure 3.2.1, step distance logic generates the **Pickup** signals of the phase and ground elements for zones 1, 2, 3, 4, 5 and 6 (signals PU_ZIG, PU_ZIPH, PU_ZIIG, PU_ZIIPH, PU_ZIIIG, PU_ZIIIPH, PU_ZIVG, PU_ZIVPH, PU_ZVG, PU_ZVPH, PU_ZVIG and PU_ZVIPH), using the distance elements outputs, previously described in 3.1.

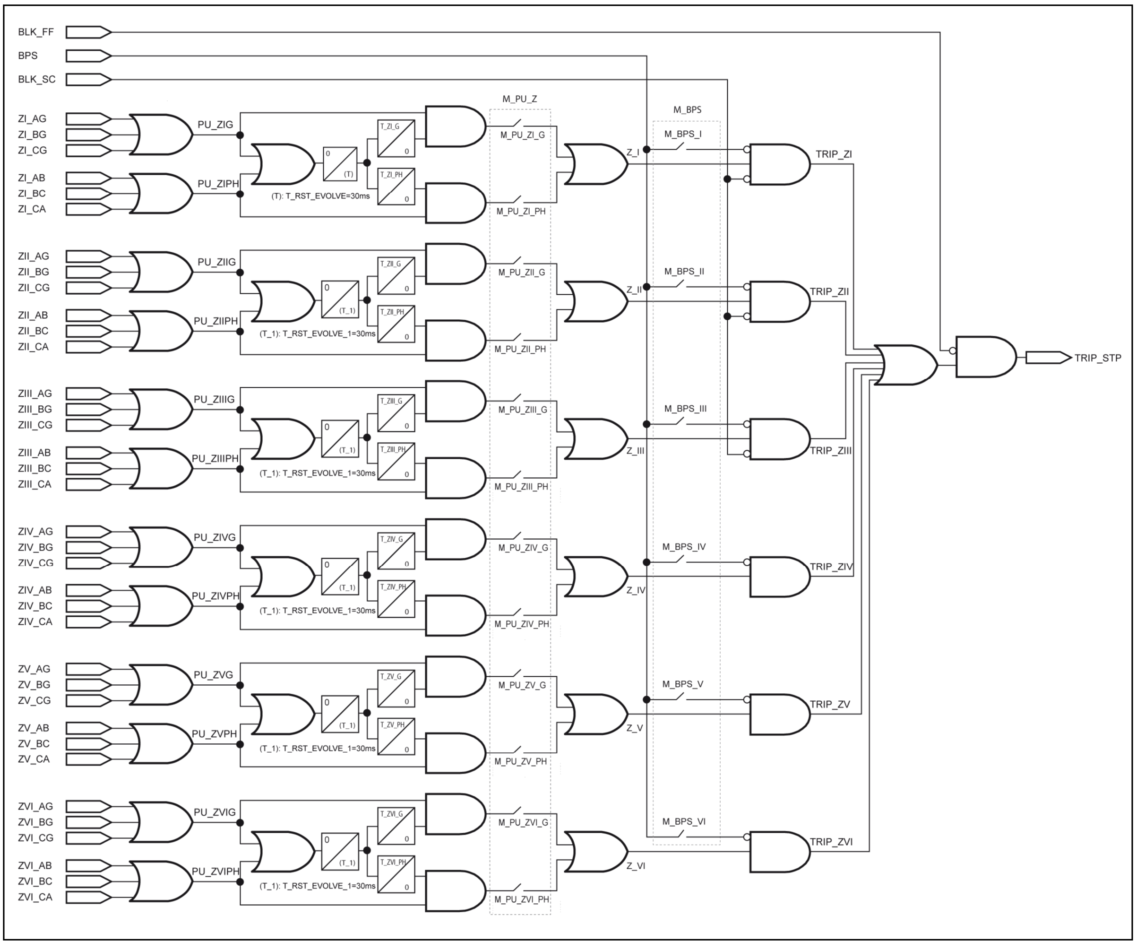


Figure 3.2.1: Step Distance Scheme Block Diagram.

Legend	
M_PU_Z: Zone Trip Mask (Setting).	Zn_XX: Zone n Unit X Pickup.
M_BPS: Power Swing Blocking Mask (Setting)	PU_ZnX: Zone n Groung/Phase Units Pickup.
BLK_FF: Fuse Failure Blocking.	T_Zn_X: Zone n Ground/Phase Time Delay.
TRIP_STP: Step Distance Trip.	Z_n: Zone n Fault.
BPS: Power Swing Blocking.	Trip_Zn: Zone n Trip.
BLK_SC: Series Compensation Blocking.	

Once the **Phase Time Delay (T_Z**n**_G)** and **Ground Time Delay (T_Z**n**_PH)** settings have been adjusted for each zone, the elements will be ready for a trip operation, as long as the bits related to the **Zone Trip Mask** are set to **1** (**YES**).

CAUTION!

Since the Zone Trip Mask settings allow the user to enable or disable tripping of phase and ground zone elements, the user must check these settings carefully. If every setting is selected as NO (0), the step distance protection scheme would be disabled.

Times **T_RST_EVOLVE** and **T_RST_EVOLVE_1** prevent zone timers from resetting under developing faults. If **Ground Time** and **Phase Time** set values corresponding to zone 1 are 0, **T_RST_EVOLVE_1** is disabled.

Activation of a zone element can be blocked for Power Swing conditions (**BPS** signal activated). This is achieved when the bits related to the **Power Swing Blocking** setting are set to **1** (**YES**). If this value is set to **0** (**NO**), the zone elements will activate independently of the Power Swing Detector status.

Step distance tripping can be blocked in case of a voltage circuit failure. To select this feature, the **VT Fuse Failure Blocking** (**BLK_FF**) must be enabled. VT fuse failure may be detected by the **VT Fuse Failure Detector** (see 3.5).

Signal **Series Compensation Blocking** (**BLK_SC**), coming from **Logic for Series compensation** (see 3.15), will block, for the time it is active, forward looking distance elements (zones 1, 2 and 3 in case **ZLV** is used in lines with series compensation).

3.2.3 Zone 1 Extension

Zone 1 Extension is activated when selected in the **Protection Scheme** setting. It functions as a complement to the Step Distance scheme.

This scheme is useful in lines without any communication channel between line ends. Selecting Zone 1 Extension allows the overreach zone to trip instantaneously, which is equivalent to extending the reach of zone 1 up to the overreach zone. As this scheme is likely to produce instantaneous trips under faults external to the line, it must be supplemented with very quick reclosers for restoring the supply as soon as possible. The operation logic of said scheme is represented in the diagram of figure 3.2.2.

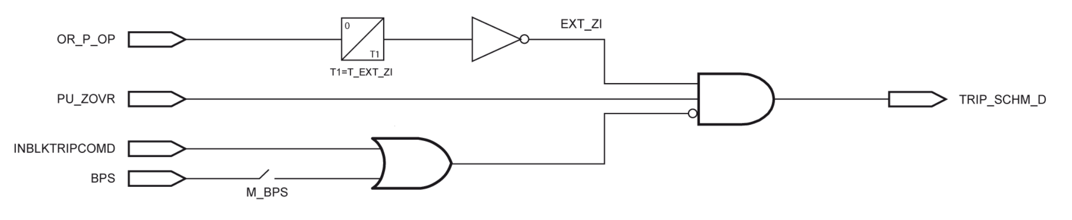


Figure 3.2.2: Zone 1 Extension Scheme Block Diagram.

Legend	
OR_P_OP: Any Pole Open.	T_EXT_ZI: Z1 Extension Blocking Time (setting).
PU_ZOVR: Overreach Zone Pickup.	
INBLKTRIPCOMD: Distance Channel Trip Blocking Input.	M_BPS: Power Swing Blocking Mask (setting).
	TRIP_SCHM_D: Distance Protection Scheme Trip.
BPS: Power Swing Blocking.	
EXT_ZI: Zone 1 Extension 1.	

After selecting this protection scheme, signal **Zone 1 Extension** (**EXT_ZI**) will be activated if the breaker has remained closed during **Z1 Extension Blocking Time** setting (**T_EXT_ZI**). **Zone 1 Extension** signal will activate the **Distance Channel Trip** signal provided the overreach zone is picked up. Although no communication channel between line ends is required for this scheme, the designation "channel trip" is maintained to refer to trips (instantaneous) by protection scheme.

The purpose of signal **EXT_ZI** reset after the break of any breaker pole (**OR_P_OP**) keeping it at zero for the time **T_EXT_ZI** from the moment the breaker is closed, is preventing second instantaneous trips under permanent faults external to the line. This way, after a reclosing and for the time **T_EXT_ZI** (time required to discern if two consecutive trips belong to the same fault), the equipment will operate following the Step Distance scheme.

The channel trip and activation may be blocked by digital input **Distance Channel Trip Blocking** (**INBLKTRIPCOMD**) activation or by the signal **Power Swing Blocking** (if said event is allowed to block the operation of the schemes through the corresponding bit of **Power Swing Blocking Mask**).

3.2.4 Permissive Underreach

Permissive Underreach is activated when selected in the **Protection Scheme** setting. It functions as a complement to the Step Distance scheme.

With this scheme, if a terminal locates the fault inside Zone 1 (adjusted below 100% of the line), and the other terminal locates the fault inside overreach zone (adjusted over 100% of the line), the fault is considered internal to the transmission line; closer to the terminal that initially detects the fault.

The terminal detecting the fault inside Zone 1 will generate an instantaneous tripping signal and transmit this channel signal to the remote end to allow tripping (in case of lines with more than two terminals, the signal will be sent to all of them). The remote terminal will trip instantaneously when the channel signal is received if any overreach measuring element has picked up. In case of more than two terminals, only a permissive signal from one of them is sufficient to activate an immediate trip by the overreach zone in any of the other terminals (because of this the channel reception input should be configured as an OR of the received permissive signals).

If weak or zero infeed conditions exist at one of the line ends and the overreach zone is not activated, this end could be tripped in an instantaneous mode, by means of Weak Infeed tripping logic, provided the “strong” end has seen the fault in zone 1 and has therefore sent a permissive tripping signal towards the “weak” end. To this end, **Distance Weak Infeed Output** (**WI_DM**) should be set to **Echo + Trip**, even if the echo signal is not used in the Permissive Underreach scheme, it being considered useless.

If, because of weak or zero infeed conditions at one of the line ends, no end sees the fault in zone 1, it is preferable to select a Permissive Overreach scheme together with the Weak Infeed logic.

3.2.4.a Channel Activation Conditions (“Distance Channel Transmission”)

The communications channel will be activated by any of the following conditions:

1. Any of Zone 1 elements picked up.
2. Activation of the overreach zone, provided the Channel Reception input is activated.
3. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.

3.2.4.b Tripping Conditions (“Distance Protection Scheme Trip”)

The channel trip will take place upon channel reception and the activation of the overreach zone or else signal **Distance Weak Infeed Trip** is activated, (**TRIP_WI_D**), for which **Distance Weak Infeed Output** (**WI_DM**) must be set to **Echo + Trip**.

3.2.4.c Operation

Channel activation and trip command generation are shown in the following block diagram.

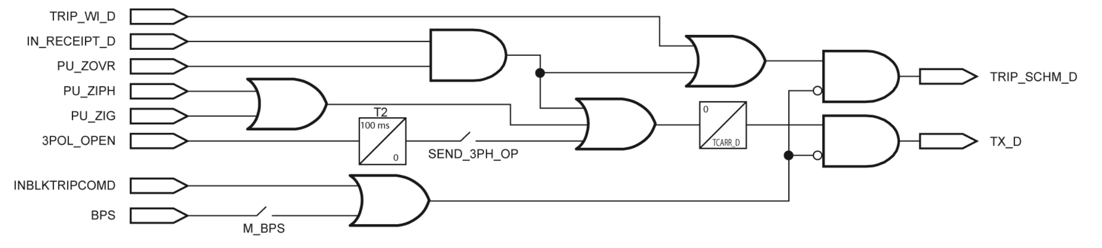


Figure 3.2.3: Permissive Underreach Scheme Block Diagram.

Legend	
TRIP_WI_D: Distance Weak Infeed Trip.	BPS: Power Swing Blocking.
IN_RECEIPT_D: Distance Channel Reception Input.	TX_D: Distance Channel Transmission.
PU_ZOVR: Overreach Zone Pickup.	TRIP_SCHM_D: Distance Protection Scheme Trip.
PU_ZI x: Zone 1 Ground/Phase Units Pickup.	SEND_3PH_OPEN: Open Breaker Transmission (setting).
3POL_OPEN: Three Pole Open.	
INBLKTRIPCOMD: Distance Channel Trip Blocking Input.	TCARR_D: Distance Carrier Time (setting).
	M_BPS: Power Swing Blocking Mask (setting).

The purpose of **Distance Carrier Time** (**TCARR_D**) setting on the diagram is guaranteeing a minimum time for **Channel Activation** (**TX_D**).

Open Breaker Transmission (**SEND_3PH_OP**) setting allows activating the channel upon the opening of the three breaker poles. The purpose of **T2** time delay of 100ms is delaying carrier transmission when this is produced by breaker trip.

Channel tripping and channel activation can be disabled using the status contact input **Distance Channel Trip Blocking** (**INBLKTRIPCOMD**) activation or by the signal **Power Swing Blocking** (if said event is allowed to block the operation of the schemes through the corresponding bit of **Power Swing Blocking Mask**).

3.2.5 Direct Transfer Trip

Direct Transfer Trip scheme is activated when selected in the **Protection Scheme** setting. It functions as a complement to the Step Distance scheme.

This scheme is similar to the Permissive Underreach, except that upon receiving the trip signal form the other end, an instantaneous trip is generated with no additional monitoring.

3.2.5.a Channel Activation Conditions (“Distance Channel Transmission”)

The communications channel will be activated by any of the following conditions:

1. Any of Zone 1 elements picked up
2. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.

3.2.5.b Tripping Conditions (“Distance Protection Scheme Trip”)

Channel tripping will always take place whenever channel reception takes place.

Since this scheme produces trips without supervising any protection unit, the trips must always be three-phase. In this case, it is necessary to connect, by means of the programmable logic, the **Distance Protection Scheme Trip** output to the **Three-Phase Trip Enable** input.

3.2.5.c Operation

Channel activation and trip command generation are shown in the following block diagram.

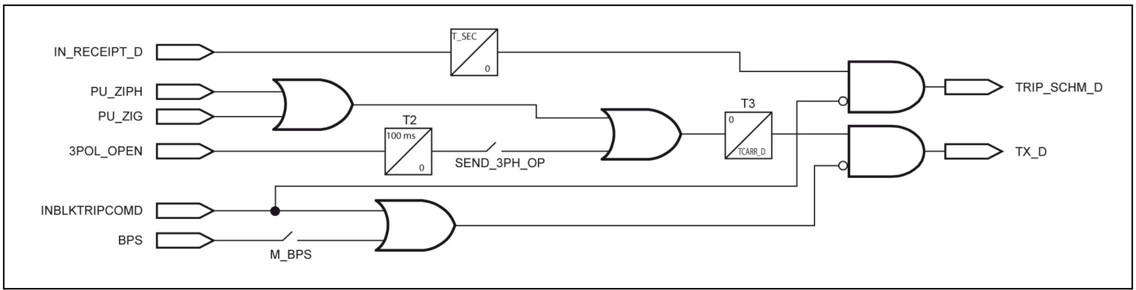


Figure 3.2.4: Direct Transfer Trip Scheme Block Diagram.

Legend	
IN_RECEIPT_D: Distance Channel Reception Input.	TRIP_SCHM_D: Distance Protection Scheme Trip.
PU_ZI x: Zone 1 Ground/Phase Units Pickup.	T_SEC: Security Time (setting)
3POL_OPEN: Three Open Pole.	SEND_3PH_OPEN: Open Breaker Transmission (setting).
INBLKTRIPCOMD: Distance Channel Trip Blocking Input.	TCARR_D: Distance Carrier Time (setting).
BPS: Power Swing Blocking.	M_BPS: Power Swing Blocking Mask (setting).
TX_D: Distance Channel Transmission.	

The purpose of **Distance Carrier Time** (**TCARR_D**) setting on the diagram is guaranteeing a minimum **Channel Activation** (**TX_D**) time.

Open Breaker Transmission (**SEND_3PH_OP**) setting allows channel activation when the three breaker poles open. The purpose of **T2** timing of 100 ms is delaying the carrier transmission when it is caused by breaker trip.

The purpose of **Security Time** (**T_SEC**) setting is guaranteeing a minimum duration of the received signal, thus avoiding undue operations upon channel noise.

Channel tripping and channel activation may be blocked by digital input **Distance Channel Trip Blocking** (**INBLKTRIPCOMD**) activation. **Power Swing Blocking (BPS)** activation can disable channel activation; however the option of channel trip blocking is not given, as no protection element activation is checked at the end receiving the transferred trip signal.

3.2.6 Permissive Overreach

Permissive Overreach is activated when selected in the **Protection Scheme** setting. It will function as a complement to the Step Distance scheme.

This scheme is based on the fact that if both terminals see the fault in the overreach zone (adjusted above 100% of the line, overreaching), the fault can be considered as internal to the line. The terminal detecting the fault inside the overreach zone sends the permissive trip signal to the other end (in case of lines with more than two terminals, the signal is sent to all of them).

At the other terminal, the reception of the permissive signal coming from the first terminal produces an instantaneous trip if any of the metering elements of the overreach-designated zone has been picked up. In case of more than two terminals, receiving permissive signals from the rest of the terminals is required to allow immediate trip activation by the overreach zone of any of them, so that the channel reception input should be setup as an AND of the signals received.

Signal **Distance Reverse Current Blocking** (**BLK_INV_A_D**), coming from **Reverse Current Blocking Logic** (for distance), blocks, provided it is activated, the input coming from the overreach zone pickup, to prevent wrong trips upon current reversal produced as a consequence of the sequential clearance of faults in a parallel line.

If weak or zero infeed conditions exist in one of the line ends, so that none of the elements associated to the overreach zone are picked up, neither end may trip under this scheme (they will trip under the Step Distance scheme). In this case, the Permissive Overreach scheme should be supplemented by the Weak Infeed logic, which allows sending a trip permissive signal to the “strong” end (as an echo of the signal sent by said end) to achieve its tripping (**Distance Weak Infeed Output** (**WI_DM**) must be set to **Echo** or **Echo + Trip**), apart from giving the option for tripping the “weak” end (**Distance Weak Infeed Output** (**WI_DM**) must set to **Echo + Trip**).

3.2.6.a Channel Activation Conditions (“Distance Channel Transmission”)

In order that the communication channel activation is produced at a terminal (permissive signal transmission), any of the following conditions must be met:

1. Any of the elements associated to zone 1 or overreach zone picked up.
2. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.
3. **Distance Echo** (**ECHO_D**) activated, output of Weak Infeed logic, for which **Distance Weak Infeed Output** (**WI_DM**) setting of said logic must be set to **Echo** or **Echo + Trip**.

3.2.6.b Tripping Conditions (“Distance Protection Scheme Trip”)

Channel trip will take place upon channel reception and pickup of any of the elements associated to the Overreach Zone or if **Distance Weak Infeed Trip** (**TRIP_WI_D**) is activated, for which **Distance Weak Infeed Output** (**WI_DM**) of the Weak Infeed logic (for distance elements) must be set to **Echo + Trip**.

3.2.6.c Operation

Channel activation and generation of a trip command are shown in the following block diagram:

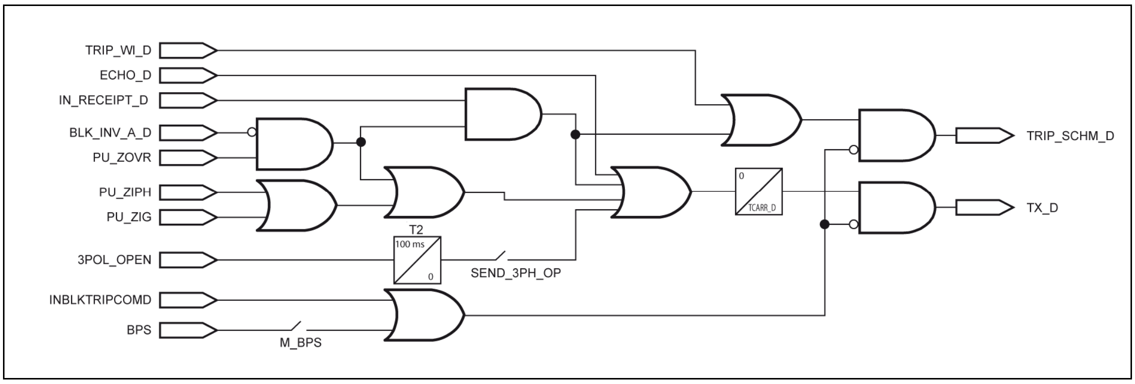


Figure 3.2.5: Permissive Overreach Scheme Block Diagram.

Legend	
TRIP_WI_D: Distance Weak Infeed Trip.	INBLKTRIPCOMD: Distance Channel Trip Blocking Input.
ECHO_D: Distance echo transmission.	
IN_RECEIPT_D: Distance Channel Reception Input.	BPS: Power Swing Blocking.
	TX_D: Distance Channel Transmission.
BLK_INV_A_D: Distance Reverse Current Blocking.	TRIP_SCHM_D: Distance Protection Scheme Trip.
PU_ZOVR: Overreach Zone Pickup.	SEND_3PH_OPEN: Open Breaker Transmission (setting).
PU_ZI x: Zone 1 Ground/Phase Units Pickup.	
3POL_OPEN: Three Pole Open.	TCARR_D: Distance Carrier Time (setting).
	M_BPS: Power Swing Blocking Mask (setting).

The purpose of setting **Distance Carrier Time** (**TCARR_D**) on the diagram is guaranteeing a minimum time for **Channel Activation** (**TX_D**).

Open Breaker Transmission (**SEND_3PH_OP**) setting allows channel activation when all three breaker poles have tripped. The purpose of **T2** timing of 100 ms is to delay carrier transmission when it is produced by breaker tripping.

Channel tripping and channel activation can be disabled using the status contact input **Distance Channel Trip Blocking** (**INBLKTRIPCOMD**) activation or by the signal **Power Swing Blocking** (if said event is allowed to block the operation of the schemes through the corresponding bit of **Power Swing Blocking Mask**).

3.2.7 Directional Comparison Unblocking

Directional Comparison Unblocking is activated when selected in the **Protection Scheme** setting. It will function as a complement to the Step Distance scheme.

In permissive schemes using carrier wave channels, the trip permissive signal is frequently transmitted through the faulted phase/s, and the signal is attenuated, in a number of cases, to such a low level that the signal does not reach the other end. The end not receiving the trip permissive signal will not be able to trip following the Permissive Overreach scheme (it will trip following the Step Distance scheme). In order to avoid timed trips upon this type of situations, the Directional Comparison Unblocking scheme is used, which is an extension of the Permissive Overreach tripping scheme.

The Directional Comparison Unblocking scheme has been introduced to be used with switched frequency carrier wave equipment. When no fault is present in the line, this equipment continuously sends a signal at a “guard” frequency (guard signal) for channel supervision. Upon detecting a fault, the relay commands the carrier wave equipment to switch the guard frequency to other frequency known as “trip frequency” (trip signal). Thus, but for the time elapsed in the switching process, the teleprotection equipment will never send both signals at the same time.

Upon receipt of the trip signal and non-receipt of the guard signal at one end, said end will trip following the same criteria set up in a Permissive Overreach scheme (provided the overreach zone is picked up). On the contrary, upon non-receipt of the trip signal and non-receipt of the guard signal, the Directional Comparison Unblocking scheme will allow, during a time window, the instantaneous tripping of the overreaching zone.

Distance Reverse Current Blocking (**BLK_INV_A_D**) signal coming from the Reverse Current Blocking logic (associated to distance schemes), blocks, while activated, the input coming from the pickup of the overreaching zone, with the purpose of preventing wrong trips upon current reversals as a consequence of clearing faults in a parallel line in case of double circuits.

The same as for the Permissive Overreach scheme, if weak or zero infeed conditions exist at one of the line ends, so that no elements associated to the overreaching zone of said terminal pickup, none of the ends can trip with this scheme (it would trip following the Step Distance scheme). In this case, the Directional Comparison Unblocking scheme should be supplemented by the Weak Infeed logic, which allows the transmission of a trip permissive signal to the "strong" end (as echo of the signal transmitted by said end) in order to achieve its trip (**Distance Weak Infeed Output** (**WI_DM**) must be set to **Echo** or **Echo + Trip**), apart from giving the option to trip the "weak" end (**Distance Weak Infeed Output** (**WI_DM**) must be set to **Echo + Trip**).

3.2.7.a Channel Activation Conditions ("Distance Channel Transmission")

For communication channel activation at a terminal (transmission of the permissive signal), any of the following conditions must be present:

1. Pickup of any of the elements associated to Zone 1 or overreach zone.
2. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.
3. Activation of **Distance Echo** (**ECHO_D**) signal, Weak Infeed logic output, for which **Distance Weak Infeed Output** (**WI_DM**) of said logic must be set to **Echo** or **Echo + Trip**.

3.2.7.b Tripping Conditions ("Distance Protection Scheme Trip")

Tripping by channel signal reception will occur under the following conditions:

1. Channel reception and loss of guard and any of the elements associated to the overreach zone picked up.
2. Loss of guard, without channel activation, and any of the elements associated to the overreach zone picked up before **T_TRIP** times out.
3. **Distance Weak Infeed Trip** (**TRIP_WI_D**) activated, for which **Distance Weak Infeed Output** (**WI_DM**) of Weak Infeed logic (for distance elements) must be set to **Echo + trip**.

3.2.7.c Operation

Activation of a channel and generation of a trip command are shown in the following block diagram:

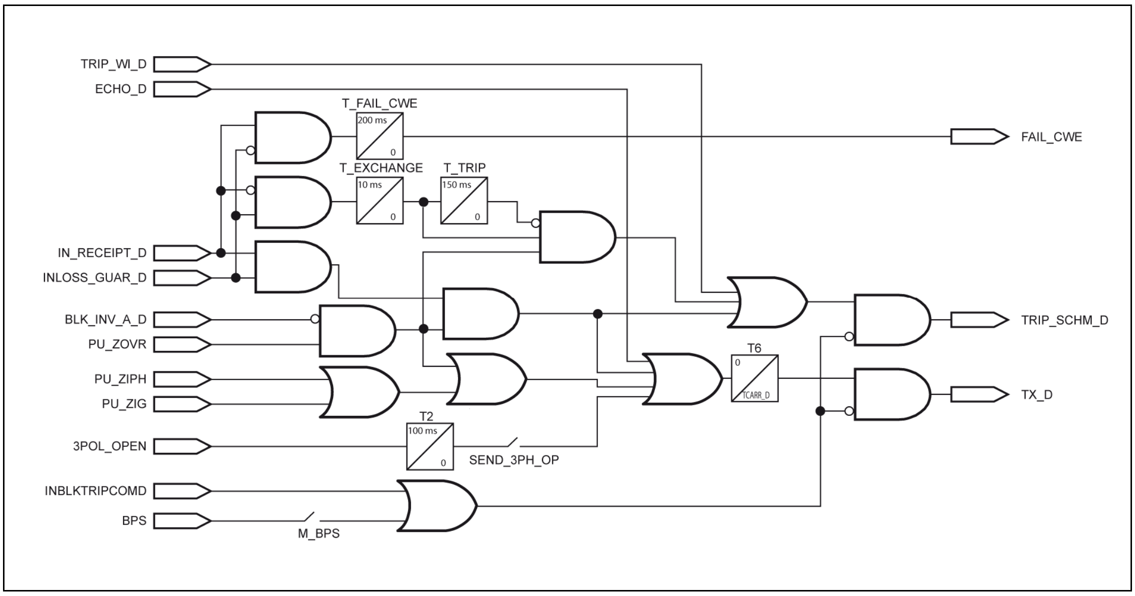


Figure 3.2.6: Directional Comparison Unblocking Scheme Block Diagram.

Legend	
TRIP_WI_D: Distance Weak Infeed Trip.	TX_D: Distance Channel Transmission.
ECHO_D: Distance echo transmission.	FAIL_CWE: Carrier Wave Equipment Failure.
IN_RECEIPT_D: Distance Channel Reception Input.	TRIP_SCHM_D: Distance Protection Scheme Trip.
INLOSS_GUARD_D: Distance Guard Loss Input.	T_EXCHANGE: Switching Time.
BLK_INV_A_D: Distance Reverse Current Blocking.	T_FAIL_CWE: Carrier Wave Equipment Failure Time.
PU_ZOVR: Overreach Zone Pickup.	T_TRIP: Trip Time.
PU_ZI x: Zone 1 Ground/Phase Units Pickup.	SEND_3PH_OPEN: Open Breaker Transmission (setting).
3POL_OPEN: Three Pole Open.	
INBLKTRIPCOMD: Distance Channel Trip Blocking Input.	TCARR_D: Distance Carrier Time (setting).
	M_BPS: Power Swing Blocking Mask (setting).
BPS: Power Swing Blocking.	

The purpose of **Distance Carrier Time** (**TCARR_D**) on the diagram is guaranteeing a minimum time for **Channel Activation** (**TX_D**).

The purpose of **Open Breaker Transmission** (**SEND_3PH_OP**) setting is activating the channel when the three breaker poles trip. The purpose of **T2** timing of 100 ms is delaying the carrier transmission caused by breaker tripping.

The carrier wave equipment features the following output contacts: one normally closed (hereafter called **Guard**), which remains open when the guard signal is being received, and other normally open (hereafter called **Trip**) which closes upon the reception of the trip signal from the other end. The **Guard** contact must be wired to the **#ZLV INLOSS_GUAR_D** (**Distance Guard Loss**) input, whereas the contact **Trip** will be wired to the **IN_RECEIPT_D** (**Distance Channel Reception**) input. On the other hand the **TX_D** (**Distance Channel Transmission**) output **(#ZLV** output) must be wired to the wave carrier equipment input, which will give the command for frequency switching.

When both **INLOSS_GUAR_D** and **IN_RECEIPT_D** inputs are activated, the response is exactly equal to a Permissive Overreach scheme, an instantaneous tripping being produced provided the overreaching zone is picked up.

In case only **INLOSS_GUAR_D** input is activated, which might indicate a complete attenuation of the trip permissive signal from the other end, if this situation remains during the switching time **T_EXCHANGE**=10 ms (enough for the carrier wave equipment to switch from guard frequency to trip frequency), the overreaching zone will be allowed to trip instantaneously during the time **T_TRIP** =150 ms.

If only **IN_RECEIPT_D** input has been activated, after time **T_FAIL_CWE** =200 ms, the signal **FAIL_CWE** will be activated, which indicates Failure in the Carrier Wave Equipment.

Channel tripping and channel activation can be disabled using the status contact input **Distance Channel Trip Blocking** (**INBLKTRIPCOMD**) activation or by the signal **Power Swing Blocking** (**BPS**) (if said event is allowed to block the operation of the schemes through the corresponding bit of **Power Swing Blocking Mask**).

3.2.8 Directional Comparison Blocking

Directional Comparison Blocking is activated when selected in the **Protection Scheme** setting. It will function as a complement to the Step Distance scheme.

The main difference between this scheme and the others is that the channel signal is transmitted to avoid remote tripping instead of accelerating it.

Proper operation of this scheme requires that the measuring element used to activate the channel be selected as reverse-looking. Said zone will be **Zone 4** for **ZLV-A/B** relays and **Zone 4 or Zone 5,** as a function of **Reverse looking Zone** setting for **ZLV-F/G/H/J** relays**.** When selecting the **Directional Comparison Lockout** scheme, the zone designated as reverse looking zone will operate as reverse looking, even though the direction setting indicates otherwise.

When a terminal unit on the transmission line detects a reverse-direction fault, a channel signal will be transmitted to avoid remote-end tripping by overreach elements. This way, the trip is only produced upon non-receipt of the blocking signal from the remote end terminal of the line.

The terminal detecting the fault in the reverse direction zone sends the trip blocking signal to the other end (in case of lines with more than two terminals, the signal is sent to all of them). At the other terminal, the receipt of the blocking signal from the first terminal immediately disables the tripping of any of the metering elements of the zone designated as overreaching. In case of more than two terminals, the receipt of the blocking signal from one of the terminals is enough to block the immediate overreaching zone trip in any of the other terminals, so that the channel receipt input should be setup as one OR of the received signals.

Correct application of this scheme requires that the following conditions be satisfied:

1. The distance covered by the reverse direction zone must be greater than the distance covered by any of the overreaching zones in the rest of terminals (not in absolute value, but the measurement from the terminal considered), so as to guaranteeing the blocking of any fault within the overreaching zone and outside the line.
2. An overreaching zone trip delay time must be considered to allow the communication equipment to transmit the blocking signal from the remote to the local terminal. Said delay is given by **Distance Delay Time** setting.

With this scheme, if the fault current seen through one of the ends is low enough so that the reverse unit does not pickup, the rest of the terminals will be able to trip due to faults seen by the overreach unit (with the risk that those faults being outside the protected line). The same happens if the communications fail and the blocking signal can not be sent.

There exists the possibility to produce the channel activation (transmission of blocking signal) through the non-directional pickup (**Pickup Condition**, **CPU_IOC** signal) of Overcurrent Elements: Phase and Ground Instantaneous Elements nº1. This possibility is obtained by setting **Quick Transmission** to **YES**. The pickup condition of said Overcurrent Elements not only will activate the channel for backward looking faults but also for forward looking faults, so that the pickup of the overreaching zone and Zone 1 will be in charge of deactivating the channel. The advantage of the **Quick Transmission** is based on the smaller **Delay Time** (which can even be zero) that must be introduced into the operation of the overreaching zone, owing to an earlier blocking signal generation (the operation of a non-directional overreaching element is quicker than the operation of a distance element). This allows producing quicker trips.

Echo and Weak Infeed trip logic is purposeless under this scheme. On the other hand, this scheme needs not be supplemented by the Reverse Current Blocking logic because this scheme can detect the current reversal thanks to the use of Zone 4 setup to reverse direction.

3.2.8.a Channel Activation Conditions (“Distance Channel Transmission”)

The communications channel (trip blocking) will activate under the following condition:

1. Pickup of the reverse direction zone or the non-directional overcurrent elements, provided **Quick Transmission** is set to **YES**, with no activation of the overreaching zone and non-existence of any conditions for transmission disable.
2. Channel trip blocking input activated and non-existence of any conditions for transmission disable. In this case, as it is a blocking system, channel activation means trip blocking.

3.2.8.b Channel Stop Conditions (“Distance Channel Disable”)

The communications channel (trip blocking) will deactivate (trip blocking deactivated) under any of the following conditions:

1. Activation of the Channel Stop status contact input.
2. Overreach element activation without channel signal reception, reverse supervision zone activation or activation of the Channel Trip Blocking input.
3. Activation of Zone 1 elements.

3.2.8.c Tripping Conditions (“Distance Protection Scheme Trip”)

A trip using this protection scheme will occur provided the following conditions are satisfied at the same time:

1. Overreach elements activation.
2. No blocking signal is received through the communications channel.
3. Reverse supervision elements are not activated.

3.2.8.d Operation

Activation of a channel and generation of a trip command are shown in the following block diagram:

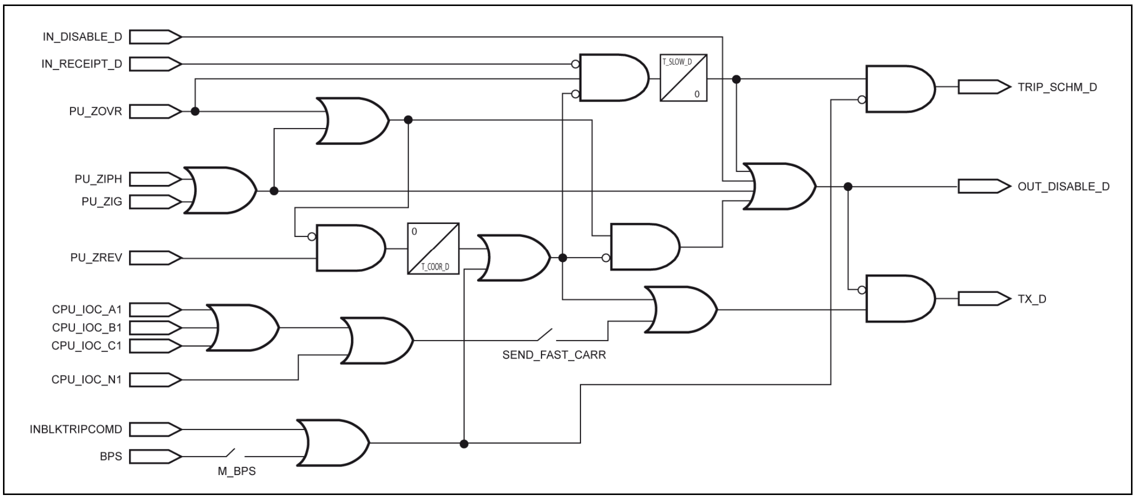


Figure 3.2.7: Directional Comparison Blocking Scheme Block Diagram.

Legend	
IN_DISABLE_D: Distance Channel Disable Input.	BPS: Power Swing Blocking.
IN_RECEIPT_D: Distance Channel Reception Input.	TX_D: Distance Channel Transmission. OUT_DISABLE_D: Distance Channel Disable.
PU_ZOVR: Overreach Zone Pickup. PU_ZI x: Zone 1 Ground/Phase Units Pickup.	TRIP_SCHM_D: Distance Protection Scheme Trip.
PU_ZREV: Reverse Looking Zone Pickup.	T_SLOW_D: Distance Delay Time (setting)
CPU_IOC_ x1: Phase/Ground X Instantaneous Element 1 Pickup Conditions.	SEND_FAST_CARR: Carrier Quick Transmission (setting).
BLK_INV_A_D: Distance Reverse Current Blocking.	T_COORD_D: Distance Coordination Time (setting)
INBLKTRIPCOMD: Distance Channel Trip Blocking Input.	M_BPS: Power Swing Blocking Mask (setting).

The purpose of **Distance Delay Time** (**T_SLOW_D**) setting, as previously mentioned, is to allow, for external faults, a time lapse for the receipt of the trip signal from the remote end terminal.

Distance Coordination Time (**TCOOR_D**) sets a reset time for the reverse direction zone pickup signal, so as to prevent channel disable upon current reversal in double circuits, as a consequence of sequential parallel line breaker trips on a fault in the same. It is worth mentioning that zone 1 and the instantaneous directional overcurrent element may block the trip transmission, no matter the pickup of the reverse direction zone, as said elements are only picked up upon internal line faults.

The purpose of **ZLV** channel disable output is to be wired to the teleprotection equipment **PARADA_CANAL** input so as to disable the channel. However, said output also disables the channel activation output as a prevention measure, in case **PARADA_CANAL** input has not been setup in the teleprotection equipment as a priority against **ACTIVACION_CANAL** input, when both are active.

Channel tripping and channel activation can be disabled using the status contact input **Distance Channel Trip Blocking** (**INBLKTRIPCOMD**). It also can be disabled for power swing conditions by adjusting the **Power Swing Blocking** setting. Said **Distance Channel Trip Blocking** generates, at the same time, channel activation.

Signal **PU_ZREV**, in **ZLV-A/B** relays, will be one OR of signals **PU_IVG** and **PU_IVF**.

3.2.9 Weak Infeed Logic

The **Weak Infeed Logic**, if enable, can work in parallel with all permissive teleprotection schemes.

As mentioned before, if a Permissive Overreach scheme has been selected (or Directional Comparison Unblocking) and one of the line ends is in a weak infeed condition, so that overreaching elements are not picked up at said end, none of the line terminals can trip instantaneously. To this end, the Teleprotection scheme must be supplemented by the Weak Infeed logic, which presents two options: **Echo Transmission** and **Weak Infeed Tripping**.

3.2.9.a Echo Logic

This function is enabled by setting **Distance Weak Infeed Output** (**WI_DM**) to **Echo**.

The Echo function allows sending a permissive trip signal to the “strong” end (as echo of the signal transmitted by said end).

The echo signal will activate whenever a signal from the other end is received, none of the elements associated to the reverse looking zone having been picked up.

3.2.9.b Weak Infeed Tripping

This function is enabled by setting **Distance Weak Infeed Output** (**WI_DM**) to **Echo + Trip**.

The echo transmission allows the trip (instantaneous) of the “strong” end, but not the “weak” end trip. The Weak Infeed trip allows tripping this latter end when undervoltage conditions are detected, a trip permissive signal has been received and none of the elements associated to the reverse direction zone and the overreaching zone are picked up.

The Weak Infeed function is always associated to echo transmission.

In view of the need for one of the zones monitors in reverse direction for correct logic operation, when setting **Distance Weak Infeed Output** takes the value **Echo** or **Echo + Trip**, the zone designated direction reverse zone will operate as if it is set backwards, even if its setting indicates otherwise.

3.2.9.c Operation

Figure 3.2.8 shows the logic operating diagram.

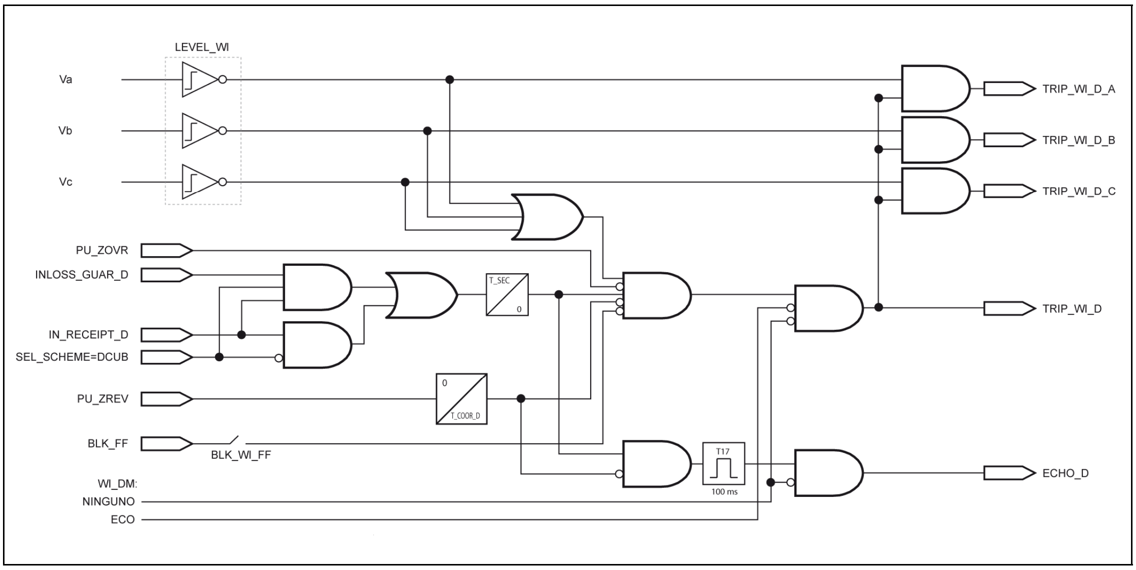


Figure 3.2.8: Weak Infeed Logic Block Diagram.

Legend	
PU_ZOVR: Overreach Zone Pickup.	TRIP_WI_D: Distance weak infeed trip.
INLOSS_GUARD_D: Distance Guard Loss Input.	LEVEL_WI: Weak Infeed Voltage Threshold (setting).
IN_RECEIPT_D: Distance Channel Reception Input.	BLK_WI_FF: Fuse Failure Weak Infeed Blocking (setting).
PU_ZREV: Reverse Looking Zone Pickup.	
BLK_FF: Fuse Failure Blocking.	SEL_SCHEME: Teleprotection Schemne Selection (setting).
WI_DM: Distance Weak Infeed Output.	
ECHO_D: Distance Echo Transmission.	T_SEC Security Time (setting).
TRIP_WI_D_X: Phase X Distance Weak Infeed Trip.	T_COORD_D: Distance Coordination Time (setting)

Undervoltage detectors (represented as negated overvoltage detectors) pickup and reset with only one value, equal to **Weak Infeed Voltage Threshold** (**LEVEL_WI**) setting.

The purpose of **Security Time** (**T_SEC**) setting is guaranteeing a channel receipt time to avoid echo transmission upon channel noise. On the other hand, it leaves time for the pickup of reverse direction elements (in case the fault is backward looking); although it is normal that said elements pickup before channel receipt, as upon an external fault the overreaching elements of the remote end (the ones activating the channel) will take longer to pickup than reverse direction elements of the local end.

If a **Directional Comparison Unblocking** has been selected, the **Channel Receipt** (**IN_RECEIPT_D**) must be supplemented with **Guard Loss** (**INLOSS_GUAR_D**) input activation.

The setting **Distance Coordination Time** (**TCOOR_D**) is used to prevent weak infeed trips upon current reversal in double circuits.

The weak infeed trip can be blocked by **Fuse Failure Blocking** (**BLK_FF**) signal activation, provided **Fuse Failure Weak Infeed Blocking** (**BLK_WI_FF**) is set to **YES**, as the indication of undervoltage detectors is not reliable upon a fuse failure.

TRIP_WI_D_A, **TRIP_WI_D_B** and **TRIP_WI_D_C** outputs act as phase selectors (as will be seen in single-phase / three-phase trip logic) as under weak infeed conditions the phase selector may generate no outputs, the positive sequence current being very small.

Signal **PU_ZREV**, in **ZLV-A/B** relays, will be one OR of signals **PU_IVG** and **PU_IVF**.

3.2.10 Transient Blocking by Current Reversal Logic

In double circuits, the sequential trips of the breakers associated to one of the lines, as a consequence of the clearance of a fault in the same, can produce a current reversal in the parallel line. Said current reversal will cause the pickup of the overreaching zone hitherto deactivated at one end and the reset of said zone at the opposite end. As these events do not occur at the same time, overreaching teleprotection schemes can give way to wrong trips in the unimpaired line.

Figure 3.2.9 represents a current reversal event.

In case of a Permissive Overreaching scheme, a current reversal in line 2 takes place upon the trip of the breaker in B1, and the B2 relay overreaching zone picks up. If the trip permissive signal coming from the relay in A2 has not yet reset a channel trip will be produced in B2. In order to avoid these types of wrong trips the B2 relay overreaching zone should be temporarily blocked.

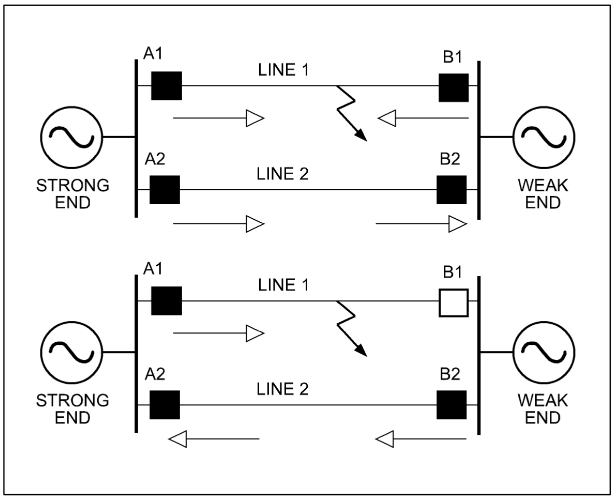


Figure 3.2.9: Current Reversal Event.

3.2.10.a Operation

Transient current reversal lockout logic generates the signal **Distance current reversal lockout** (**BLK_INV_A_D**) when the zone is activated by reverse looking (reverse looking zone) Said signal will be active during the **Distance coordination time** (**T_COOR_D**) from the reset of the reverse looking zone setting.

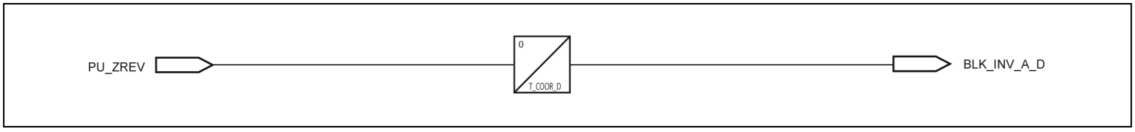


Figure 3.2.10: Block Diagram for Distance Reverse Current Blocking Logic.

Legend	
PU_ZREV: Reverse Looking Zone Pickup.	T_COORD_D: Distance Coordination Time (setting).
BLK_INV_A_D: Distance Reverse Current Blocking.	

Given the need for one of the zones supervising in reverse direction for the correct operation of this logic, enabling it will make Zone 4 to operate as if it were set backward looking, even if its directional setting indicates otherwise.

Signal **PU_ZREV**, in **ZLV-A/B** relays, will be one OR of signals **PU_IVG** and **PU_IVF**.

3.2.11 Programmable Schemes

Apart from the available protection schemes, any other protection scheme can be setup by means of the programmable logic incorporated into the equipment. In this case, teleprotection schemes can be generated, which need the transmission of several signals between both line ends (indication of the faulted phase, single-phase and three-phase permissive signals, etc), for which a digital network may be the communication media.

3.2.12 Distance Elements Protection Schemes Settings

Protection Scheme (*)			
Setting	**Range**	**Step**	**By default**
Carrier Transmission Enable By 52 Open	YES / NO		YES
Carrier Reception Security Time	0 - 50 ms	1 ms	0 ms
Weak Infeed Voltage Level	15.00 - 70.00 V	0.01 V	45 V
Weak Infeed Trip Blocking Due To Fuse Failure	YES / NO		NO

Distance Protection Schemes			
Setting	**Range**	**Step**	**By default**
Protection Scheme	Step Distance. Zone 1 Extension. Permissive Underreach. Direct Transfer Trip. Permissive Overreach. Directional Comparison Unblocking. Directional Comparison Blocking.		Step distance.
Carrier Time	0 - 200 ms	10 ms	50 ms 0 ms (**)
Coordination Time (Reverse Current Blocking Logic)	0 - 50 ms 0 - 300 ms (**)	1 ms	25 ms
Time Delay For ZSOB In Blocking Schemes	0 - 200 ms	10 ms	50 ms
Zone 1 Extension Inhibit Time	0.05 - 300.00 s	0.01 s	10 s
Overreach Zone	Zone 2 / Zone 3		Zone 2
Reverse Zone (ZLV-F/G/H/J)	Zone 4 / Zone 5		Zone 4
Logic Output	NONE ECHO ECHO + TRIP		NONE
Carrier Fast Transmission Enable (Blocking Schemes)	YES / NO		NO
Reverse Current Blocking Logic Enable	YES / NO		NO
Distance Protection Scheme Time (ZLV-***-****D/E/F/G/H**)	0.0 - 100.00 s	0,01 s	0 s

(*) Common to distance and overcurrent schemes.
(**) ZLV-*-****C/D/E/F/G/H** Models.**

Remark: if Directional Comparison Blocking scheme is selected, or if Weak Infeed or Reverse Current Blocking Logic are enabled, the zone designated as reverse looking zone (zone 4 for ZLV-A/B relays and Zone 4 or Zone 5, as a function of Reverse looking Zone setting, for ZLV-F/G/H/J relays) will actuate as if it were set to Reverse, even if it has been set to Forward.

- **Distance Elements Protection Schemes: HMI access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	...
3 - INFORMATION	**3 - PROTECTION**	**15 - PROTECTION SCHEM**
	...	...

0 - DISTANCE	**0 - CARRIER BY OPEN BR**
1 - DIST SUPERVISION	**1 - SECURITY TIME**
...	**2 - WI UNDERVOLT LEVEL**
15 - PROTECTION SCHEM	**3 - FF WI BLOCK**
...	**4 - DISTANCE PILOT PRO**
	5 - O/C PROTEC SCHEME

0 - CARRIER BY OPEN BR	**0 - DIST PROTEC SCHEME**
1 - SECURITY TIME	**1 - DIST CARRIER TIME**
2 - WI UNDERVOLT LEVEL	**2 - DIST COORD TIME**
3 - FF WI BLOCK	**3 - DIST DELAY DCB**
4 - DISTANCE PILOT PRO	**4 - Z1 EXT. BLOCK TIME**
5 - O/C PROTEC SCHEME	**5 - OVERREACHING ZONE**
	6 - DIST WI LOGIC OUTP
	7 - DIST CURV INV BLOCK
	8 - CARRIER FAST SENDS

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	...
3 - INFORMATION	**3 - PROTECTION**	**15 - PROTECTION SCHEM**
	...	...

0 - DISTANCE	**0 - CARRIER BY OPEN BRKR**
1 - DIST SUPERVISION	**1 - SECURITY TIME**
...	**2 - WI UNDERVOLT LEVEL**
15 - PROTECTION SCHEM	**3 - FF WI BLOCK**
...	**4 - DISTANCE PILOT PROT.**
	5 - O/C PROTEC SCHEME

0 - CARRIER BY OPEN BR	**0 - DIST PROTEC SCHEME**
1 - SECURITY TIME	**1 - DIST CARRIER TIME**
2 - WI UNDERVOLT LEVEL	**2 - DIST COORD TIME**
3 - FF WI BLOCK	**3 - DIST DELAY DCB**
4 - DISTANCE PILOT PRO	**4 - Z1 EXT. BLOCK TIME**
5 - O/C PROTEC SCHEME	**5 - OVERREACHING ZONE**
	6 - REVERSE ZONE
	7 - DIST WI LOGIC OUTP
	8 - DIST CURV INV BLOCK
	9 - CARRIER FAST SENDING
	10 - DIST SCHEME DELAY (*)

(*) ZLV-*-**** D/E/F/G/H** Models**

3.2.13 Digital Inputs and Events of the Distance Protection Schemes Module

Table 3.2-1: Digital Inputs and Events of the Distance Protection Schemes Module		
Name	**Description**	**Function**
IN_RECEIPT_D	Distance channel receipt input	The activation of this input means a signal receipt (trip permissive or blocking, as a function of the selected scheme) from the other end.
INBLKTRIPCOMD	Distance channel trip blocking input	The activation of this input blocks the trip of any distance protection scheme.
INLOSS_GUAR_D	Distance guard signal loss input	The activation of this input means that the guard signal receipt has ceased. It is used in the Directional Comparison Unblocking scheme.
IN_DISABLE_D	Distance channel disable input	The activation of this input generates Channel Disable output. It is used in the Directional Comparison Blocking scheme.

3.2.14 Digital Outputs and Events of the Distance Protection Schemes Module

Table 3.2-2: Digital Outputs and Events of the Distance Protection Schemes Module		
Name	**Description**	**Function**
PU_ZIG	Zone 1 ground elements pickup	Pickup of phase and ground distance elements for all 6 zones.
PU_ZIPH	Zone 1 phase elements pickup	
PU_ZIIG	Zone 2 ground elements pickup	
PU_ZIIPH	Zone 2 phase elements pickup	
PU_ZIIIG	Zone 3 ground elements pickup	
PU_ZIIIPH	Zone 3 phase elements pickup	
PU_ZIVG	Zone 4 ground elements pickup	
PU_ZIVPH	Zone 4 phase elements pickup	
PU_ZVG	Zone 5 ground elements pickup (ZLV-F/G/H/J)	
PU_ZVPH	Zone 5 phase elements pickup (ZLV-F/G/H/J)	
PU_ZVIG	Zone 6 ground elements pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
PU_ZVIPH	Zone 6 phase elements pickup (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
Z_I	Zone 1 fault	Pickup output for the different zones, after time out, but before the Power Swing Detector Blocking has been applied.
Z_II	Zone 2 fault	
Z_III	Zone 3 fault	
Z_IV	Zone 4 fault	
Z_V	Zone 5 fault (ZLV-F/G/H/J)	
Z_VI	Zone 6 fault (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	

Table 3.2-2: Digital Outputs and Events of the Distance Protection Schemes Module		
Name	**Name**	**Name**
TRIP_ZI	Zone 1 trip	Trip by distance zones.
TRIP_ZII	Zone 2 trip	
TRIP_ZIII	Zone 3 trip	
TRIP_ZIV	Zone 4 trip	
TRIP_ZV	Zone 5 trip (ZLV-F/G/H/J)	
TRIP_ZVI	Zone 6 trip (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
TRIP_STP	Step distance trip	Step distance trip.
TRIP_SCHM_D	Distance protection scheme trip	Selected distance protection scheme trip.
TX_D	Distance channel transmission	Channel activation by the selected distance protection scheme.
PU_ZOVR	Overreach protection zone pickup	Pickup output for the overreach protection zone.
PU_ZREV	Reverse looking zone pickup (ZLV-F/G/H/J)	Reverse looking zone pickup. In ZLV-A/B relays, said signal is replaced by OR of PU_ZIVG and PU_ZIVPH)
FAIL_CWE	Carrier wave equipment failure	Carrier wave equipment failure.
OUT_DISABLE_D	Distance channel disable	Output for channel disabling used in Directional Comparison Blocking scheme.
TRIP_WI_D	Distance weak infeed trip	Weak infeed condition trip in distance protection scheme.
TRIP_WI_D_A	Phase A distance weak infeed trip	Trip by weak infeed condition in phase (A, B, C) in distance protection scheme
TRIP_WI_D_B	Phase B distance weak infeed trip	
TRIP_WI_D_C	Phase C distance weak infeed trip	
ECHO_D	Distance echo transmission	Echo transmission in distance protection scheme
BLK_INV_A_D	Distance reverse current blocking	Overreaching zone blocking in distance protection scheme by current reversal detection.

3.3 Phase Selector

3.3.1 Operating Principles

The **ZLV** is provided with a Phase Selector unit whose function is to determine the type of failure to generate the outputs which include this information. These outputs will be used in the actuation logic of the distance units (as was seen in 3.1) to decide which distance units should act. On the other hand, the phase selector outputs are used in the **Single / Three-phase Trip Logic** (**ZLV-B/F/G/J** models) to determine the type of tripping to be carried out, in case that this information is not already implicit in started distance units: when the single-phase unit operates on a delayed basis in a two-phase ground fault (since this should generate a three-phase trip) or when it is attempted to render single-phase trips through ground or negative sequence overcurrent (if the **67G Single-Phase Trip** has been adjusted to **YES** -**ZLV-B/F/G/J** models-).

The information on the faulted phases is developed using two algorithms. The first algorithm determines that a three-phase (**3PH_F**) fault is generated if the following conditions are met:

1. **Low negative sequence current**: the presence of a negative sequence current not greater than 0.05*In A (or setting **I2 Level** in **ZLV-***-****A/B/C/D/E/F/G/H**** relays) and a ratio of negative sequence current / positive sequence current no greater than 8% (or the setting **I2/I1 Factor** in **ZLV-***-****A/B/C/D/E/F/G/H**** relays).
2. **Low zero sequence current**: the presence of a zero sequence current no greater than 0.05*In A (or setting **I0 Level** in **ZLV-***-****A/B/C/D/E/F/G/H**** relays) and a ratio of zero sequence current / positive sequence current no greater than 8% (or the setting **I0/I1 Factor** in **ZLV-***-****A/B/C/D/E/F/G/H**** relays).

The percentages of negative and zero sequence current with respect to the positive sequence current avoid erroneous phase selections due to imbalance deriving from a different degree of saturation presented by the current transformers in case of three-phase faults.

Under power swing conditions (CBPS = 1), higher I2/I1 and I0/I1 ratios are used with the purpose of preventing the selection of wrong fault types as a consequence of unbalances derived from the power swing itself. The I2/I1 and I0/I1 ratio will take a value of 20% or the value determined by settings **I2/I1 Power Swing** and **I0/I1 Power swing**, respectively, in **ZLV-***-****A/B/C/D/E/F/G/H**** relays.

It is important to point out that the three-phase indication is associated with a balanced condition, for which it would also arise in a load situation. The Fault Detector (see 3.4) will be in charge of distinguishing the fault condition of a load.

When the detected fault does not satisfy the conditions to be considered a three-phase fault, the second algorithm will be executed, based on the comparison between positive and negative sequence current magnitudes.

When the fault is not three-phase, but the second condition for three-phase faults is satisfied (low zero sequence current component), the fault involves two phases (**2PH_F**). If the second condition is not met (low zero sequence current component), a ground fault has occurred, which could be single-phase or two phases to ground (**GR_F**).

To determine the phases involved, the angle will be examined:

$$\phi = \arg(Ia2) - \arg(Ia1\_f)$$

Where:

$Ia2$	Phase A negative sequence current component.
$Ia1\_f$	Phase A positive sequence fault current component (without the load component).

The angle diagrams, used to determine the phases under fault as a function of the angle ϕ, are represented in Figures 3.3.1 and 3.3.2.

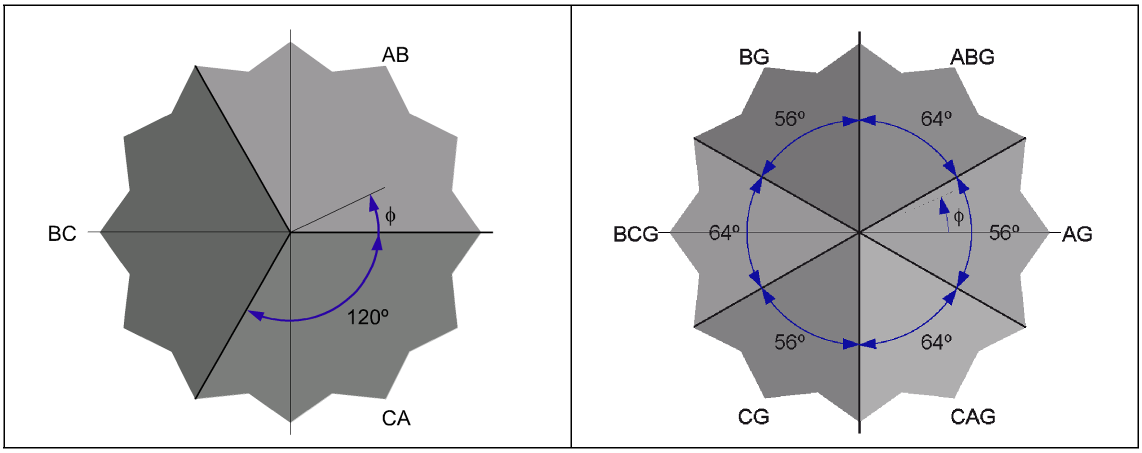


Figure 3.3.1: Two-Phase Fault Angle Diagram.

Figure 3.3.2: Single-Phase and Two-Phase- to-Ground Fault Angle Diagram.

The phase selector will not operate if the following two conditions are simultaneously complied with:

1. Presence of positive sequence current not above 0.02*In A.
2. Presence of zero sequence current not above 0.05*In A.

3.3.2 Phase Selection upon Faults with Mainly Zero Sequence Current Flow

The presence of power transformers with grounded wye connected windings, generate, upon weak infeed faults, mainly zero sequence fault current flow. In this case, the positive sequence current can be below 0.02*In A, whereas the zero sequence current will be above the 0.05*In A threshold (or **Level I0** for **ZLV-***-****A/B/C/D/E/F/G/H**** Models). If these conditions are met, the phase selector will consider it a ground fault but will not determine the faulted phases from the angle between positive and negative sequence currents but based on the activation of three undervoltage elements (one per phase), the pickup level of which is given by the **Weak infeed voltage threshold** setting, also used by the Weak Infeed Logic (see 3.2.9).

3.3.3 Phase Selection in Open-Pole or Power Oscillation Conditions

The opening of a breaker pole, detected through the Open-Pole Detector (see 3.6), creates an imbalance which generates negative and zero sequence components in load conditions. The Phase Selector will remove pre-fault currents in order to operate with fundamental fault currents.

To determine the fault phases the following angle is studied:

$$\phi = \arg\left(Ia2\_f\right) - \arg\left(Ia0\_f\right)$$

Where:

$Ia2\_f$	Phase A Negative Sequence fault current (load component removed).
$Ia0\_f$	Phase A Zero Sequence fault current (load component removed).

The figure shows the angle diagrams used for the determination of the fault phases as a function of the ϕ angle.

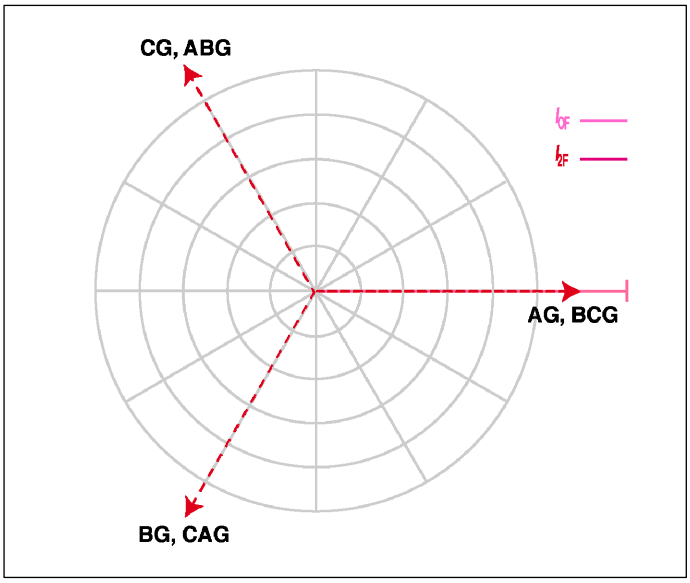


Figure 3.3.3: Angle Diagram for Single-Phase and Two-Phase to Ground Faults.

To differentiate the faults AG and BCG, CG and ABG, BG and CAG, the I0/I2 quotient is used:

If Ia0_f / Ia2_f > 0.62, we will have a single-phase fault (AG, BG or CG).
If Ia0_f / Ia2_f < 0.62, we will have a two-phase to ground fault (BCG, ABG and CAG).

In Power Swing conditions (CBPS = 1) and during the 500 ms after its deactivation this same criterion is also used.

3.3.4 Phase Selector Settings (ZLV-***-****A/B/C/D/E/F/G/H**)

Phase Selector			
Setting	**Range**	**Step**	**By Default**
Level I0	0.1 - 5 A	0.01 A	0.25 A
Level I2	0.1 - 5 A	0.01 A	0.25 A
I0/I1 Factor	5 - 30	0,1	8
I2/I1 Factor	5 - 30	0,1	10
I0/I1 Factor for Power Swing	5 - 30	0,1	20
I2/I1 Factor for Power Swing	5 - 30	0,1	20

- **Phase Selector: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**20 - PHASE SELECTOR**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**21 - PHASE SELECTOR**
3 - INFORMATION	...	...

0 - DISTANCE	**0 - I0 LEVEL**
...	**1 - I2 LEVEL**
*** - PHASE SELECTOR**	**2 - I0/I1 FACTOR**
...	**3 - I2/I1 FACTOR**
	4 - I0/I1 FACT POW SWI
	5 - I0/I1 FACT POW SWI

(*) Option 20 or 21, depending on the model.

3.3.5 Digital Inputs and Events of the Phase Selector

The phase selector does not present any digital input, not even enable, remaining always in operation.

3.3.6 Digital Outputs and Events for the Final Selection of Fault Type

Table 3.3-1: Digital Outputs and Events for the Final Selection of Fault Type

Name	Description	Function
AG_F	AG Fault	Indication of type of fault.
BG_F	BG Fault	
CG_F	CG Fault	
AB_F	AB Fault	
BC_F	BC Fault	
CA_F	CA Fault	
ABG_F	ABG Fault	
BCG_F	BCG Fault	
CAG_F	CAG Fault	
3PH_F	ABC fault	
GR_F	Ground fault	
2PH_F	Two-phase fault	
MULTIPH_F	Polyphase fault	

3.4 Fault Detector

3.4.1 Operating Principles

ZLV terminal units are provided with a Fault Detector to supervise element operation (see 3.25 Tripping Logic). Operation of the Fault Detector is based on:

3.4.1.a Detection of Increases in the Sequence Currents

The conditions which activate the Fault Detector are the following:

- An increase in the effective value of the **zero sequence current** with respect to the value of two cycles previously higher than **0.04*In A** or than **Delta I0** setting in **ZLV-***-****D/E/F/G/H**** Models (ground fault indicative).
- An increase in the effective value of the **negative sequence current** with respect to the two cycle value previously higher than **0.04*In A** or than **Delta I2** setting in **ZLV-***-****D/E/F/G/H**** Models (phase fault indicative).
- A percentual increase in the effective value of the **positive sequence current** with respect to the two-cycle value previously higher than 25% (indicative of any fault).

Under Power Swing Conditions (CBPS = 1), is used the value determined by settings **Delta I0 Power Swing** and **Delta I2 Power Swing**, respectively, in **ZLV-***-****D/E/F/G/H**** Models. In addition, the Fault Detector activation based on the increase of positive sequence current is disabled.

The activation of the Fault Detector based on previously mentioned increases will remain sealed for the duration of two cycles, given that the comparison is made with magnitudes memorized two cycles previously. Notwithstanding, an additional reset time of 30 ms included which. In Power Swing conditions, this reset time is replaced by a time equal to the **Memory Duration** setting (see 3.1.5, Voltage Memory Logic).

3.4.1.b Detection of Levels Exceeded in the Sequence Current

The following are the conditions which activate the Fault Detector:

- **Ground fault output** activation originating from the phase selector.
- **Two-phase fault output** activation originating from the phase selector.

An open pole condition excludes the **Ground Fault** and **Two Phase Fault** signals from the fault detector. Otherwise, this situation would activate the detector as long as the pole remains open.

The above algorithms further need at least one of the following conditions to be met:

- Positive sequence current above 0.02*In A.
- Zero sequence current above 0.05*In A.

Zero sequence threshold current supervision allows the fault detector to be operative upon faults associated to mainly zero sequence current flow.

The activation of the fault detector generated by either of the two previously-mentioned algorithms is kept sealed (except under Power Swing conditions) with the activation of any of the **Distance Units** (**PU_ZIG**, **PU_ZIPH**, **PU_ZIIG**, **PU_ZIIPH**, **PU_ZIIIG**, **PU_ZIIIPH**, **PU_ZIVG**, **PU_ZIVPH**, **PU_ZVG**, **PU_ZVPH**, **PU_ZVIG** or **PU_ZVIPH**), **Overcurrent** (**PU_IOC_PHn**, **PU_TOC_PHn**, **PU_IOC_Nn**, **PU_TOC_Nn**, **PU_IOC_NSn**, **PU_TOC_NSn**, see overcurrent units), **Stub Bus Protection** (**PU_STUB**) or **Close-onto-Fault** (**COF**).

The operation diagram of the fault detector unit is shown in Figures 3.4.1, 3.4.2 and 3.4.3.

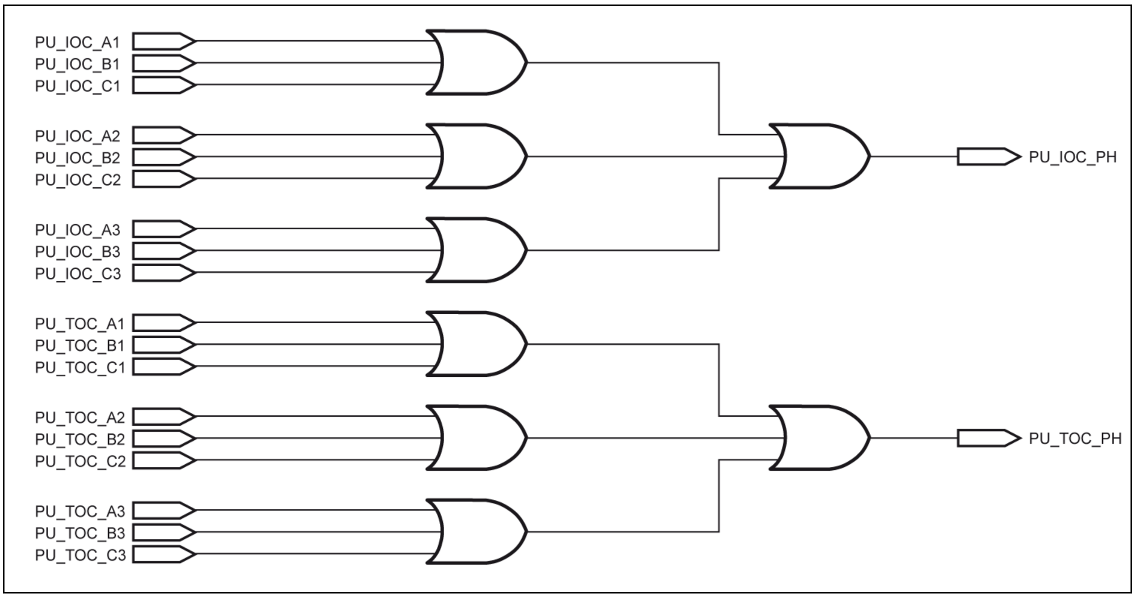


Figure 3.4.1: Activation Logic of Phase Overcurrent Elements Used by the Fault Detector.

Legend
PU_IOC_Xn: Phase X Instantaneous Element n Pickup.
PU_TOC_Xn: Phase X Time Element n Pickup.
PU_IOC_PH: Any Phase Instantaneous Element Pickup.
PU_TOC_PH: Any Phase Time Element Pickup.

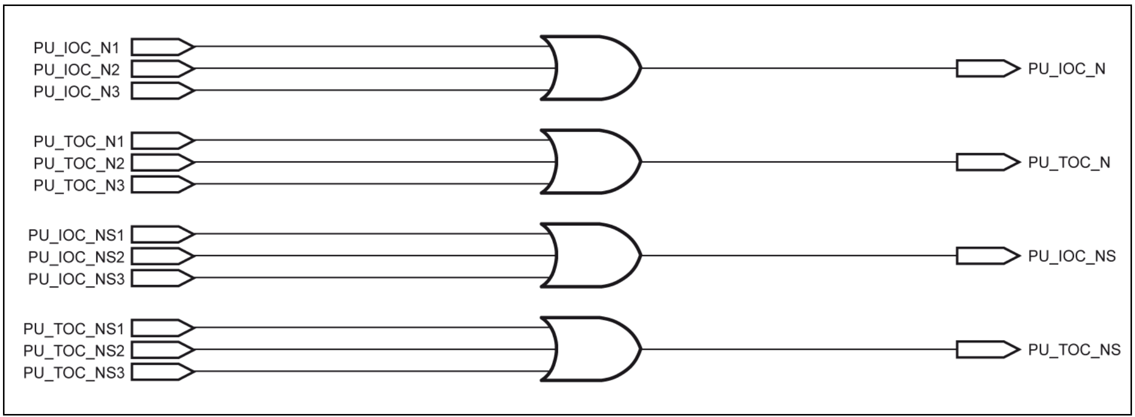


Figure 3.4.2: Activation Logic of Ground and Negative Sequence Overcurrent Elements Used by the Fault Detector.

Legend
PU_IOC_Nn: Ground Instantaneous Element n Pickup.
PU_TOC_Nn: Ground Time Element n Pickup.
PU_IOC_Nsn: Negative Sequence Instantaneous Element n Pickup.
PU_TOC_Nsn: Negative Sequence Time Element n Pickup.
PU_IOC_N: Any Ground Instantaneous Element Pickup.
PU_TOC_N: Any Ground Time Element Pickup.
PU_IOC_Ns: Any Negative Sequence Instantaneous Element Pickup.
PU_TOC_Ns: Any Negative Sequence Time Element Pickup.

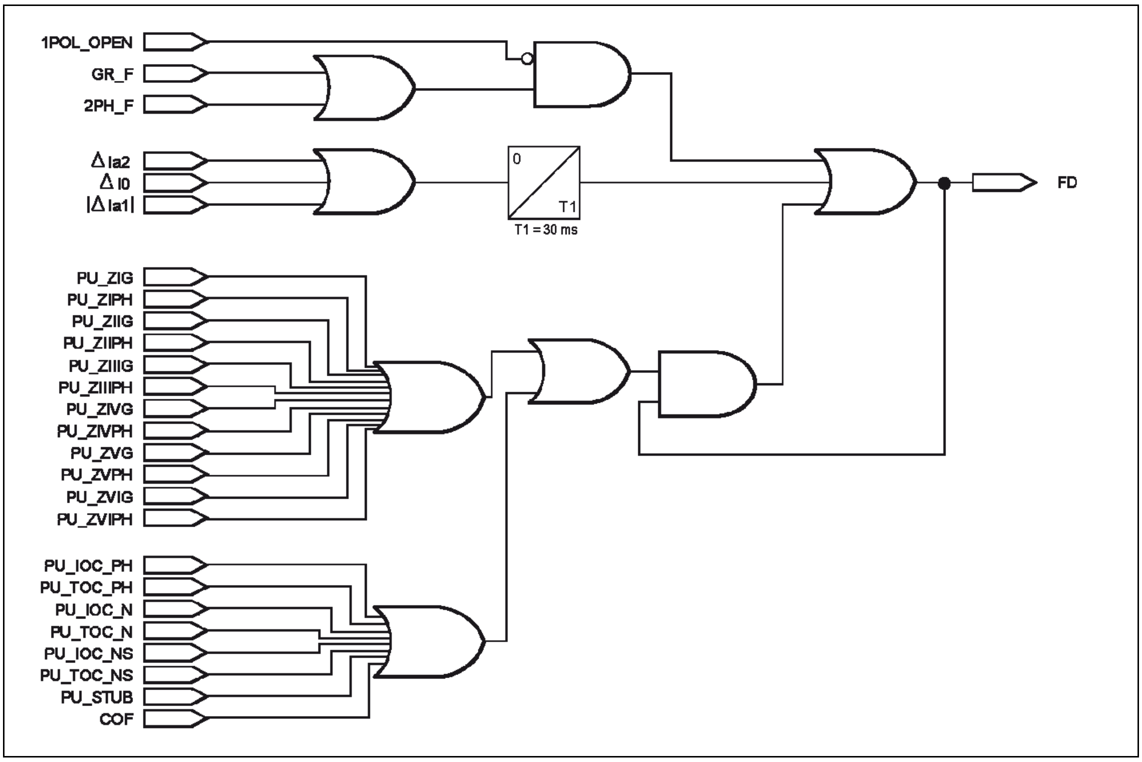


Figure 3.4.3: Fault Detector Block Diagram (without Power Swing Conditions).

Legend	
1POL_OPEN: One pole open.	PU_IOC_PH: Any Phase Instantaneous Element Pickup.
GR_F: Ground Fault.	
2PH_F: Two-phase fault.	PU_IOC_N: Any Ground Instantaneous Element Pickup.
PU_ZnG: Zone n Ground Units Pickup.	
PU_ZnPH: Zone n Phase Units Pickup.	PU_TOC_N: Any Ground Time Element Pickup.
PU_STUB: Stub Bus Pickup.	PU_IOC_Ns: Any Negative Sequence Instantaneous Element Pickup.
COF: Close-on-to-Fault.	
FD: Fault Detector.	PU_TOC_Ns: Any Negative Sequence Time Element Pickup.
PU_TOC_PH: Any Phase Time Element Pickup.	

3.4.2 Fault Detector Settings (ZLV-***-****D/E/F/G/H**)

Fault Detector			
Setting	**Range**	**Step**	**By Default**
Delta I0	0.1 - 5 A	0.01 A	0.25 A
Delta I2	0.1 - 5 A	0.01 A	0.25 A
Delta I0 Power Swing	0.1 - 5 A	0.01 A	0.25 A
Delta I2 Power Swing	0.1 - 5 A	0.01 A	0.25 A

- **Fault Detector: HMI Access**

ZLV-***-****D/E/F/G/H**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	**2 - PROTECTION**	**x – FAULT DETECTOR**
3 - INFORMATION	…	…

0 - DISTANCE	**0 - DELTA I0**
…	**1 - DELTA I2**
*** - FAULT DETECTOR**	**2 - DELTA I0 P. SWING**
…	**3 - DELTA I2 P. SWING**

3.4.3 Digital Inputs and Events of the Fault Detector

The fault detector does not present any digital input, not even enable, remaining always in operation.

3.4.4 Digital Outputs and Events of the Fault Detector

Table 3-4-1: Digital Outputs and Events of the Fault Detector		
Name	**Description**	**Function**
FD	Fault detector activated	Detection of the existence of a fault.

3.5 VT Fuse Failure Detector

3.5.1 Operating Principles

If the VT secondary circuit fuses blow, the terminal unit will lose the corresponding voltage analog input. This situation may cause unwanted operation of the distance elements. Therefore, this condition must be detected and the measuring elements must be blocked before undesired tripping occurs.

The fuse failure condition is detected when one of the three phase voltages drops below 30 V (or below of the **Voltage Level** setting value in **ZLV-***-****A/B/C/D/E/F/G/H**** Models). On not involving this phenomenon at the currents, there will not be a fault detection, for which the output of this detector (**FD**) is used (see 3.4, Fault Detector) as discriminator.

The opening of any pole of the breaker will generate a fuse failure condition if the voltage transformer is on the line side, for which the output of **Any Open Pole** (**OR_P_OP**) originating from the Open Pole Detector blocks the activation of the Fuse Failure Detector. In **ZLV-***-****N/O**** models, the **Fuse Failure Det Delay** setting allows to set the time required for these conditions to be met in order to activate the detector output.

On the other hand, the Fuse Failure unit is disabled if the value of the positive sequence current is below 0.1A for In = 5A and 0.03A for IN = 1A.

VT Fuse Failure Detection operation is shown in Figure 3.5.1.

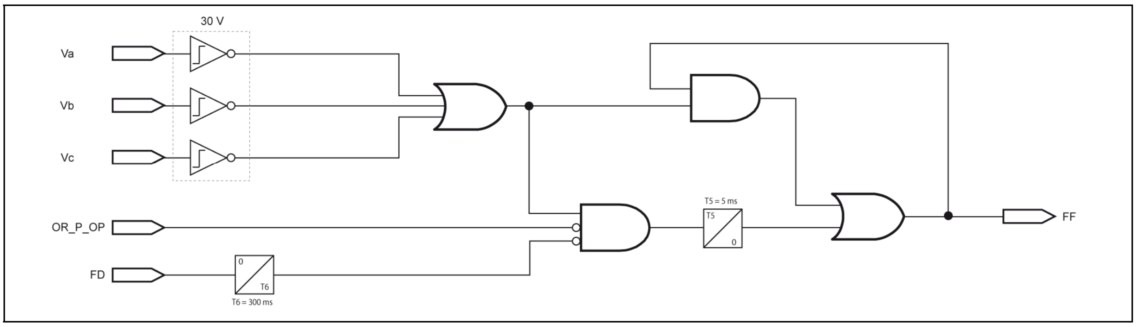


Figure 3.5.1: VT Fuse Failure Detector Block Diagram.

Legend	
OR_P_OP: Any Open Pole.	FF: Fuse Failure.
FD: Fault Detector.	

Undervoltage detectors pick up when this voltage is lower than 95% of 30 V (or the setting **Voltage Level** in **ZLV-***-****A/B/C/D/E/F/G/H**** relays) and reset when it is greater than 100% of said voltage.

The output of the Fuse Failure unit will generate **Blocking due to Fuse Failure** (**BLK_FF**) output if **Blocking Due to Fuse Failure** is set at **YES**. This last output will always block the activation of all the distance units and may block the activation of other units based on the voltage measurement, such as Undervoltage Units, Weak Infeed logic (for distance as well as overcurrent units) or Synchronism Unit, if the corresponding blocking settings are enabled.

The **Fuse Failure** (**IN_FF**) digital input, originating from the contact position of a voltage thermalmagnetic circuit breaker, is another possibility which exists to detect the fuse failure condition. The activation of this input will always generate **Blocking due to Fuse Failure** output, originating from the enable and/or blocking adjustments of the Fuse Failure unit. The activation of the **Fuse Failure** digital input presents a fall time adjustment (**Fuse Failure Input Time**), in order to maintain the blocking of the units on which acting during the voltage reset transient.

The logic scheme encompasses the two possibilities of blocking due to fuse failure:

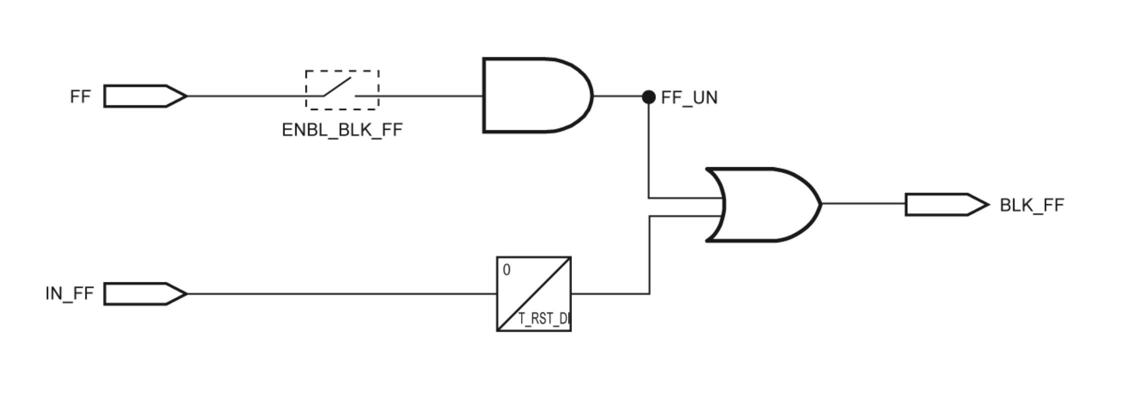


Figure 3.5.2: Logic Diagram of Blocking due to Fuse Failure.

Legend	
FF: Fuse Failure.	ENBL_BLK_FF: Fuse Failure Blocking Enable (setting)
IN_FF: Fuse Failure Input.	
FF_UN: Fuse Failure Unit Blocking.	T_RST_DI: Fuse Failure Digital Input Fall Time (setting).
BLK_FF: Fuse Failure Blocking.	

When a fuse failure condition arises, the distance units as well as directional units, supervisors of the overcurrent elements without **Torque Control** setting at **NO**, they do not have the necessary voltage to be polarized, for which they cannot act if there is a failure in this situation. In order to have an emergency non-directional overcurrent element, provided one does not already exist, the directional units present the **Blocking due to Lack of Polarization** setting. If this adjustment is set at **NO**, when the necessary voltage to polarize these is not available, they go on to issue actuation permission to the overcurrent units on which they depend, consequently converting these into non-directional.

3.5.2 VT Fuse Failure Detector Settings

VT Fuse Failure Detector			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Input DropOut Time	0 - 1000 ms	50 ms	150 ms
Block Enable	YES / NO		NO
Voltage Level (ZLV-***-****A/B/C/D/E/F/G/H**)	5 - 70 V	0.01 V	30 V
Detection Time (ZLV-***-****O/N**)	0 - 6 s	0.001 s	0 s

- **VT Fuse Failure Detector: HMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	2 - CLOSE ONTO FAULT
3 - INFORMATION	**3 - PROTECTION**	**3 - FUSE FAILURE**
	...	...

0 - DISTANCE	**0 - FF DET ENABLE**
1 - DIST SUPERVISION	**1 - FF BLOCK ENABLE**
2 - CLOSE ONTO FAULT	**2 - FF INPUT DO DLY**
3 - FUSE FAILURE	**3 - VOLTAGE LEVEL (*)**
...	**4 - FF DETEC TIME (**)**

(*) ZLV-*-****A/B/C/D/E/F/G/H** Models.**
(**) ZLV-*-****O/N** Models.**

3.5.3 Digital Inputs and Events of the VT Fuse Failure Detector

Table 3.5-1: Digital Inputs and Events of the VT Fuse Failure Detector		
Name	**Description**	**Function**
ENBL_FF	VT fuse failure detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
IN_FF	VT fuse failure detector input	The activation of this input directly generates the blocking output due to fuse failure.

3.5.4 Digital Outputs and Events of the VT Fuse Failure Detector

Table 3.5-2: Digital Outputs and Events of the VT Fuse Failure Detector		
Name	**Description**	**Function**
FF	VT fuse failure detector activated	Output of the VT fuse failure detector.
FF_UN	Fuse failure unit blocking	Blocking output due to fuse failure condition detected by the unit itself.
BLK_FF	Fuse failure blocking	Blocking output due to fuse failure condition (detected by the unit itself or by the digital input).
FF_ENBLD	VT fuse failure detector enabled	Indication of enabled or disabled status of the unit.

3.5.5 VT Fuse Failure Detector Test

Enable the Fuse Failure detector and disable all of the other Auxiliary Units. The setting **Voltage Level** in **ZLV-***-****A/B/C/D/E/F/G/H**** relays will take the default value (30 V).

Table 3.5-3: Output Configuration for the Fuse Failure Detector Test	
AUX-5	Activation of the VT fuse failure detector
AUX-6	VT fuse failure detector blocking

During the test, consult the indicators:

Display In the **Information** - **Status** - **Measuring Elements** - **VT Fuse Failure Detector** screen,
ZIVercomPlus® In the **Status** screen (**Status** - **Elements**- **VT Fuse Failure Detector**).

For this test, apply a three-phase balanced system of voltages and current of 65 Vac with angles of 0º, 120º and 240º; and 1 A ac with inductive angles of 25º, 145º and 265º, respectively for phases A, B and C. The current will reflect a shift phase with respect to the voltage of 25º inductive.

Simultaneously reduce the voltages of the three-phases to 28.5 Vac (27.64 Vac to 29.35 Vac). The contacts of the outputs AUX-5 and AUX-6 should close and the indicators mentioned previously should activate.

3.6 Open Pole Detector

3.6.1 Operating Principles

This unit detects the opening of any pole of the breaker, generating the corresponding outputs (**A Pole Open**, **B Pole Open** and **C Pole Open**), based not only on the condition of the breaker position contacts but also on the output of the three undercurrent detectors, one for each pole, whose levels are given by the following adjustments: **A Pole Open Current Level**, **B Pole Open Current Level** and **C Pole Open Current Level**. With the aperture indication outputs of each pole, the open pole detector also generates the following outputs: **One Open Pole**, **Three Open Poles** or **Any Open Pole**.

The outputs of this unit are used by other units which carry out modifications in the operating logic to adapt to the new situation which causes the opening of any pole of the breaker.

The Open Pole Detector can operate based on two operating logics, exclusive within themselves, each of which can be selected through the **Number of Inputs for Breaker Position** setting. If this setting takes the value **3 Inputs**, the operating logic will be the following:

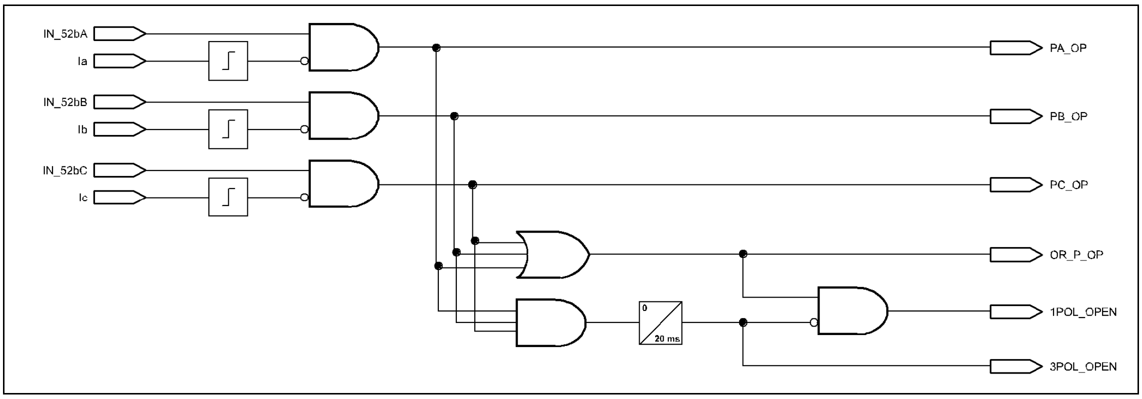


Figure 3.6.1: Logic Diagram of the Open Pole Detector for ZLV-A/B/E/F/H Relays (I).

Legend	
IN_52bX: Open X Pole Position Input.	1POL_OPEN: One Pole Open.
PX_OP: Open X Pole.	3POL_OPEN: Three Poles Open.
OR_P_OP: Any Pole Open.	

IN_52bA, **IN_52bB** e **IN_52bC** inputs are designed to receive breaker **52b** normally closed contact state. However, using programmable logic, said logic inputs could receive breaker 52a contact (use operator NOT) or both **52b** and **52a** contacts (use operators NOT and AND) state.

The reset time of 20 ms associated with the **Three Pole Open** (**3POL_OPEN**) signal will be used to avoid transient activation of the **One Pole Open** (**1POL_OPEN**) signal in case of imbalances which arise in a three-phase reclose.

If the **Number of Inputs for Breaker Position** setting takes the value **2 Inputs**, the operating logic used becomes the following:

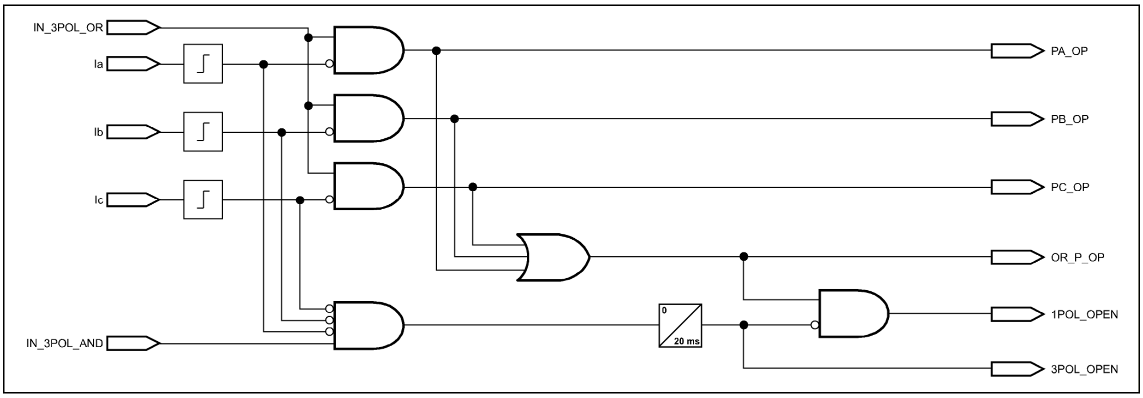


Figure 3.6.2: Logic Diagram of the Open Pole Detector for ZLV-A/B/E/F/H Relays (II).

Legend	
IN_3POL_OR: One Pole Open Input.	OR_P_OP: Any Pole Open.
IN_3POL_AND: Three Poles Open Input.	1POL_OPEN: One Pole Open.
PX_OP: Open X Pole.	3POL_OPEN: Three Poles Open.

This logic allows using one less input than the logic above. Inputs **IN_3POL_OR** and **IN_3POL_AND** are designed to receive one **OR** and one **AND,** respectively, from the breaker **52b** normally closed contacts. However, using programmable logic, one OR and one AND from the **52 a** normally open contacts or both **52b** and **52a** contacts can also be assigned.

The reset time of 20 ms associated with the **Three Pole Open** (**3POL_OPEN**) signal is used, as in the previous logic, to avoid transient activation of the **One Pole Open** (**1POL_OPEN**) signal in case of imbalances which occur in a three-phase reclose.

The outputs of the Open Pole Detector are used by the following units or logics: Phase Selector, Distance Measuring Units (Single-Phase Quadrilateral Characteristic), Distance Units Activation Logic, Ground and Negative Sequence Overcurrent Units, Power Swing Detector, Fuse Failure Detector and Recloser.

3.6.2 Open Pole Detector in ZLV-G/J Relays

ZLV-G/J relays Open Pole Detector allows supervising two breakers (applicable to breaker-and-a-half, ring or two bus and dual breaker configurations) when **Supervised Breakers** setting is set to **Breaker 1+Breaker 2**. Option **Breaker 1** must be selected in single breaker bays or when in a dual breaker bay, the breaker selected as “Breaker 2” is out of operation. Similarly, option **Breaker 2** must be selected in dual breaker bays when the breaker selected as “Breaker 1” is out of operation. When the **Supervised Breakers** setting is set to **ED Selection**, the breaker or breakers to be supervised will be determined by the relay through the logic inputs **IN_SUP1 (Breaker 1 Open Pole Supervision Input)** and **IN_SUP2 (Breaker 2 Open Pole Supervision Input)** based on the following table:

IN_SUP1	IN_SUP2	Result
0	0	Breaker 1 (default value): activation of **Breaker 1 Open Pole Supervision** output
0	1	Breaker 2: activation of **Breaker 2 Open Pole Supervision** output
1	0	Breaker 1: activation of **Breaker 1 Open Pole Supervision** output
1	1	Breaker 1+Breaker 2: activation of **Breaker 1 and Breaker 2 Open Pole Supervision** output

If **Nº of Breaker State Inputs** setting takes the value **3 Inputs** the operating logic will be as follows:

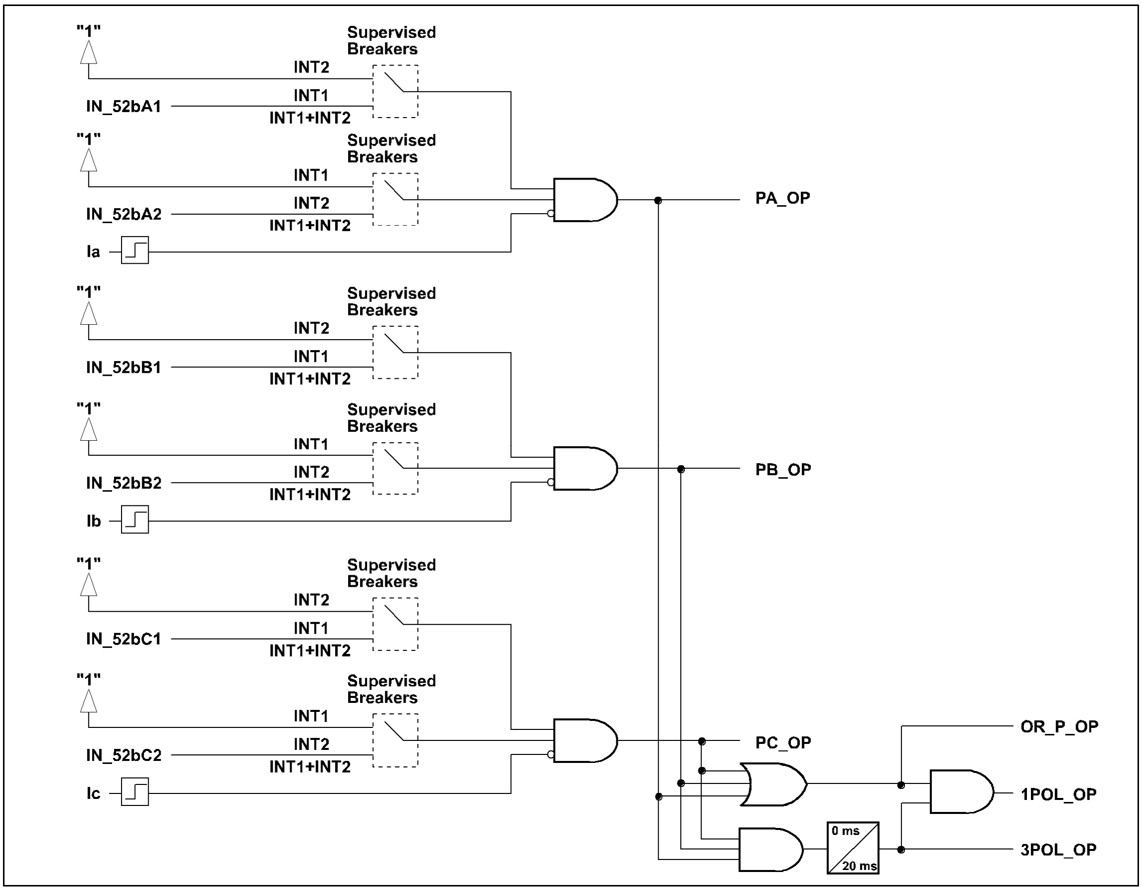


Figure 3.6.3: Logic Diagram of Open Pole Detector for ZLV-G/J Models (I).

Legend	
IN_52bXn: Open X Pole Position Breaker n Input	OR_P_OP: Any Pole Open.
PX_OP: Open X Pole.	1POL_OPEN: One Pole Open.
	3POL_OPEN: Three Poles Open.

If **Nº of Breaker State Inputs** setting takes the value **2 Inputs** the operating logic will be as follows:

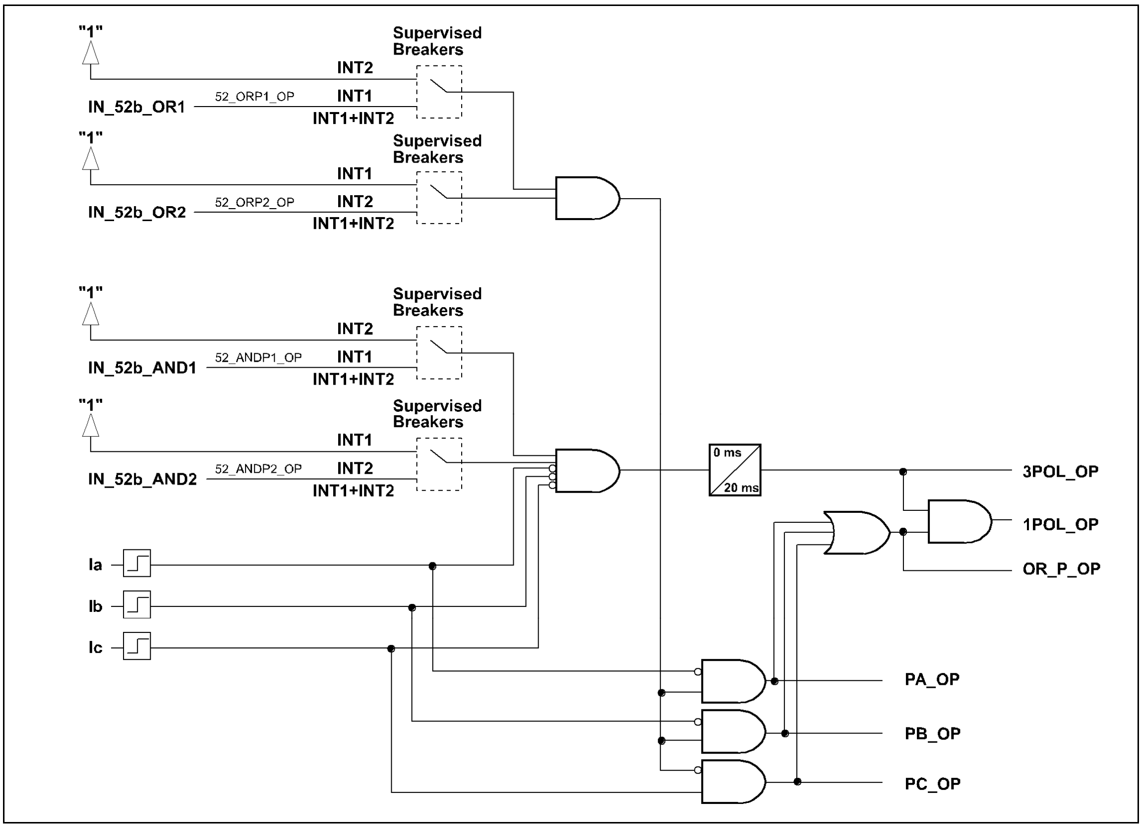


Figure 3.6.4: Logic Diagram of Open Pole Detector for ZLV-G/J Models (II).

Legend	
IN_52b_ORn: Breaker n Any Pole Open State Input.	PX_OP: Open X Pole. OR_P_OP: Any Pole Open.
IN_52b_ANDn: Breaker n Three Pole Open State Input.	1POL_OPEN: One Pole Open. 3POL_OPEN: Three Poles Open.

3.6.3 Open Pole Detector Settings

Open Pole Detector			
Setting	**Range**	**Step**	**By default**
Number of Inputs for Breaker Position	3 / 2		3
Supervised Breakers (ZLV-G/J)	Breaker 1 Breaker 2 Breaker 1 + Breaker 2 Selection by DI		Breaker 1
Phase A Current Level	(0.04 - 0.8) In A	0.01 A	0.04 In
Phase B Current Level	(0.04 - 0.8) In A	0.01 A	0.04 In
Phase C Current Level	(0.04 - 0.8) In A	0.01 A	0.04 In

- **Open Pole Detector: HMI Access**

ZLV-A/B/E/F/H

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	…
3 - INFORMATION	**3 - PROTECTION**	**5 - OPEN POLE LOGIC**
	….	…

0 - DISTANCE	**0 - OPEN POLE SELECTIO**
1 - DIST SUPERVISION	**1 - A POLE OPEN CURREN**
…	**2 - B POLE OPEN CURREN**
5 - OPEN POLE LOGIC	**3 - C POLE OPEN CURREN**
…	

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	…
3 - INFORMATION	**3 - PROTECTION**	**6 - OPEN POLE LOGIC**
	….	…

0 - DISTANCE	**0 - OPEN POLE SELECTIO**
1 - DIST SUPERVISION	**1 - BREAKERS NUMBER**
…	**2 - A POLE OPEN CURREN**
6 - OPEN POLE LOGIC	**3 - B POLE OPEN CURREN**
…	**4 - C POLE OPEN CURREN**

3.6.4 Digital Inputs and Events of the Open Pole Detector

Table 3.6-1: Digital Inputs and Events of the Open Pole Detector

Name	Description	Function
IN_52bA	Open A pole position input (ZLV-A/B/E/F/H)	Activation of this input indicates that 52b contact of A pole position of the breaker is closed.
IN_52bB	Open B pole position input (ZLV-A/B/E/F/H)	Activation of this input indicates that 52b contact of B pole position of the breaker is closed.
IN_52bC	Open C pole position input (ZLV-A/B/E/F/H)	Activation of this input indicates that 52b contact of C pole position of the breaker is closed.
IN_3POL_AND	Open three pole input (ZLV-A/B/E/F/H)	The activation of this input indicates that the three 52b contacts of the pole position of the breaker are closed.
IN_3POL_OR	Any pole open input (ZLV-A/B/E/F/H)	The activation of this input indicates that any 52b contact of the pole position of the breaker is closed.

Table 3.6-1: Digital Inputs and Events of the Open Pole Detector		
Name	**Description**	**Function**
IN_52bA1	Breaker 1 A pole open state input (ZLV-G/J)	Its activation indicates that breaker 1 A pole 52b contact state is closed.
IN_52bB1	Breaker 1 B pole open state input (ZLV-G/J)	Its activation indicates that breaker 1 B pole 52b contact state is closed.
IN_52bC1	Breaker 1 C pole open state input (ZLV-G/J)	Its activation indicates that breaker 1 C pole 52b contact state is closed.
IN_52bA2	Breaker 2 A pole open state input (ZLV-G/J)	Its activation indicates that breaker 2 A pole 52b contact state is closed.
IN_52bB2	Breaker 2 B pole open state input (ZLV-G/J)	Its activation indicates that breaker 2 B pole 52b contact state is closed.
IN_52bC2	Breaker 2 C pole open state input (ZLV-G/J)	Its activation indicates that breaker 2 C pole 52b contact state is closed.
IN_52b_AND1	Breaker 1 three pole open state input (ZLV-G/J)	Its activation indicates that the breaker 1 three pole 52b contacts state is closed.
IN_52b_OR1	Any breaker 1 pole open state input (ZLV-G/J)	Its activation indicates that breaker 1 any pole 52b contact state is closed.
IN_52b_AND2	Breaker 2 three pole open state input (ZLV-G/J)	Its activation indicates that the breaker 2 three pole 52b contacts state is closed.
IN_52b_OR2	Any breaker 2 pole open state input (ZLV-G/J)	Its activation indicates that breaker 2 any pole 52b contact state is closed.
IN_SUP1	Breaker 1 open pole supervision input (ZLV-G/J)	Its activation indicates that breaker 1 is to be supervised (it is taken into account only if Supervised Breakers setting is set to ED Selection).
IN_SUP2	Breaker 2 open pole supervision input (ZLV-G/J)	Its activation indicates that breaker 2 is to be supervised (it is taken into account only if Supervised Breakers setting is set to ED Selection).

3.6.5 Digital Outputs and Events of the Open Pole Detector

Table 3.6-2: Digital Outputs and Events of the Open Pole Detector

Name	Description	Function
PA_OP	Open A pole	Open A pole indication
PB_OP	Open B pole	Open B pole indication
PC_OP	Open C pole	Open C pole indication
OR_P_OP	Any pole open	Any pole open indication.
1POL_OPEN	One pole open	One pole open indication. It is also activated when 2 poles open.
3POL_OPEN	Three poles open	Three poles open indication.
52_ORP1_OP	Any breaker 1 pole open by contact indication (ZLV-G/J)	Indication of any breaker 1 pole open based only on said breaker state contacts.
52_ORP2_OP	Any breaker 2 pole open by contact indication (ZLV-G/J)	Indication of any breaker 2 pole open based only on said breaker state contacts.
52_ANDP1_OP	Three breaker 1 poles open by contact indication (ZLV-G/J)	Indication of three breaker 1 poles open based only on said breaker state contacts.
52_ANDP2_OP	Three breaker 2 poles open by contact indication (ZLV-G/J)	Indication of three breaker 2 poles open based only on said breaker state contacts.
SUP1	Breaker 1 open pole supervision (ZLV-G/J)	Its activation indicates that only the breaker 1 is being supervised
SUP2	Breaker 2 open pole supervision (ZLV-G/J)	Its activation indicates that only the breaker 2 is being supervised.

3.7 Close-Onto-a-Fault Detector

3.7.1 Operating Principles

ZLV terminal units are provided with a Close-Onto-a-Fault Detector, which generates instantaneous tripping when a fault is detected at the time a breaker close command is generated.

The unit will enter into operation with orders for manual closing as well as for reclose, since these are internal (activation of the **Manual Closing Order** (**IN_CLOSE_MAN**) output, of the control logic, or activation of the **Reclose Command** (**RCLS_CMD**) output, from the recloser) or external (activation of the **External Manual Closing** (**IN_CLOSE_EXT**) input or activation of the **External Reclose** (**IN_EXT_RCLS**) input). The generation of any of the above mentioned commands keeps the element in operation during one fixed duration pulse (300 ms) for **ZLV-A/B/E** relays and adjustable duration pulse, based on **COF Time** setting**,** for **ZLV-F/G/H/J** relays.

No matter whether the breaker manual reset or reclose commands are external, the switch onto fault detector can be put into operation with no need for supervising the state of any digital input. To this end, in **ZLV-F/G/H/J** relays, the outputs generated by the dead line detector can be used. In order for the switch onto fault detector to activate when the breaker closes, namely, when the line is energised, the deactivation of the signal **Any Phase Dead** (switching from 1 to 0, obtained applying the leading edge function, incorporated into the programmable logic, to the negation of said signal) can be assigned to both **External Manual reset** and **External Reclosing** inputs. In order to discern between manual reset and reclose (the switch onto fault detector operation may differ whether manual reset or reclose: zone 1 extension, etc), the time during which the line has remained deenergised can be taken into account. To this end, the logic input **External Manual reset** must be activated only if the signal **Any Phase Dead** has remained active for a time sufficiently greater than that of any reclose cycle. A time of 50 s may be advisable.

In **ZLV-***-****C/D/E/F/G/H**** relays, signals to activate the operation of the relay can be selected. This can be done through the **Close-onto-Fault Detector Initiate Mask** setting. The relay can operate both with manual close commands and reclose commands, whether:

Internal
Activation of control logic's **Manual Close Command** output (**IN_CLOSE_MAN**)..
Activation of **Manual Close by Dead Line Deactivation** output (**CLOSE_DL**).
Activation of **Manual Close by Open Pole Deactivation** output (**CLOSE_OP**).
Activation of recloser **Reclose Command** output (**RCLS_CMD**).
Activation of **Reclose by Dead Line Deactivation** output (**RCLS_DL**).
Activation of **Reclose by Open Pole Deactivation** output (**RCLS_OP**).
External
Activation of **External Manual Close** input (**IN_CLOSE_EXT**).
Activation of **External Reclose** input (**IN_EXT_RCLS**).

Manual Close by Dead Line Deactivation (**CLOSE_DL**) activates when **Any Dead Line** (**DL_OR**) signal deactivates, after having been active for at least the **Manual close delay** setting value.

Manual Close by Open Pole Deactivation (**CLOSE_OP**) activates when **Any Open Pole** (**OR_P_OP**) signal deactivates, after having been active for at least the **Manual close delay** setting value.

Reclose by Dead Line Deactivation (**RCLS_DL**) activates when **Any Dead Line** (**DL_OR**) signal deactivates, after having been active for at least the **Reclose delay** setting value.

Reclose by Open Pole Deactivation (**RCLS_OP**) activates when **Any Pole Open** (**OR_P_OP**) signal deactivates, after having been active for at least the **Reclose Delay** setting value.

When the Close-Onto-a-Fault unit enters into operation with a manual closing order, its activation will always produce non-resetting three-phase tripping. However, if the unit begins to operate with a reclose command, its activation will also permit three-phase tripping but will generate a new reclose sequence (which will result in a new reclose command or a definite trip according to the decisions made by the recloser).

The Close-Onto-a-Fault unit presents, on the one part, non-directional phase overcurrent units with adjustable pickup levels (**COF Current Pickup** setting). These units are for the purpose of clearing faults with voltage less than the minimum to polarize the distance units, when there is no voltage memory. They can only operate when the positive sequence voltage has dropped below 50 V.

The operation of the Close-Onto-a-Fault Detector is shown in Figure 3.7.1.

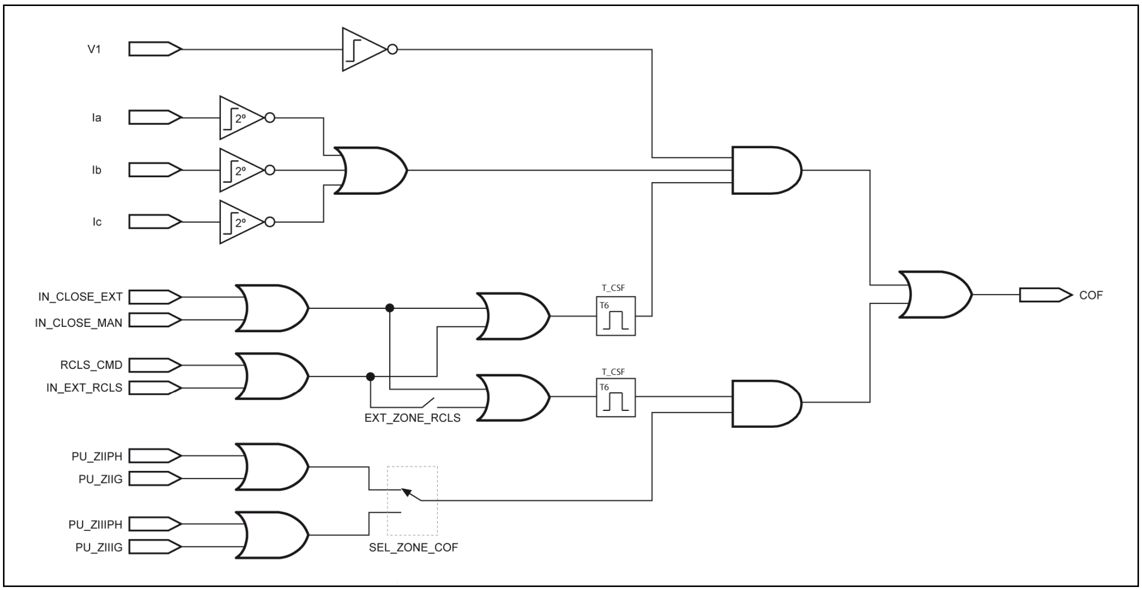


Figure 3.7.1: Close-Onto-a-Fault Detector Block Diagram.

Legend	
V1: Positive Sequence Voltage.	EXT_ZONE_RCLS: Zone 1 Extension for Reclosing (setting)
IN_CLOSE_EXT: External Manual Closing Input.	
IN_CLOSE_MAN: Manual Closing Command.	SEL_ZONE_COF: Close-on-to-Fault Supervision Zone (setting)
RCLS_CMD: Reclose Command.	
IN_EXT_RCLS: External Reclose Input.	T_CSF: Close-on-to-Fault Operation Time (setting)
PU_ZnX: Zone n Phase / Ground Units Pickup	
COF: Close-on-to-Fault.	

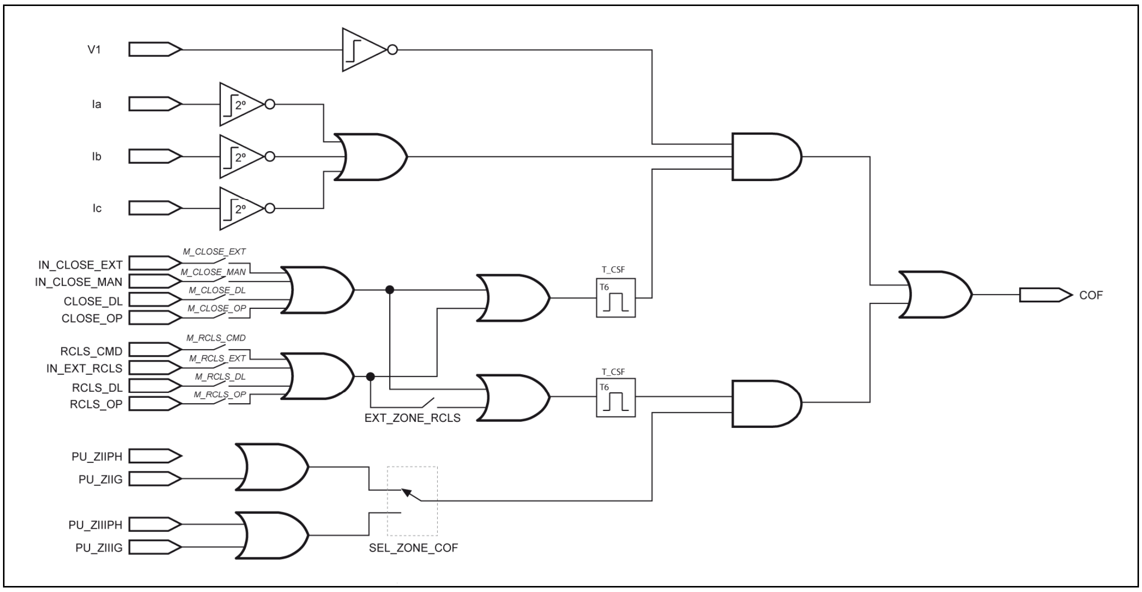


Figure 3.7.2: Close-Onto-a-Fault Detector Block Diagram (ZLV-*-****C/D/E/F/G/H**).**

Legend	
V1: Positive Sequence Voltage.	PU_ZnX: Zone n Phase / Ground Units Pickup
IN_CLOSE_EXT: External Manual Closing Input.	COF: Close-on-to-Fault.
IN_CLOSE_MAN: Manual Closing Command.	EXT_ZONE_RCLS: Zone 1 Extension for Reclosing (setting)
RCLS_CMD: Reclose Command.	
IN_EXT_RCLS: External Reclose Input.	SEL_ZONE_COF: Close-on-to-Fault Supervision Zone (setting)
CLOSE_DL: Manual Close by dead line.	
CLOSE_OP: Manual close by open pole.	T_CSF: Close-on-to-Fault Operation Time (setting)
RCLS_DL: Reclose by dead line.	
RCLS_OP: Reclose by open pole.	

The phase overcurrent units indicated previously present second harmonic restraint in order to prevent actuation in case of transformer energization. The restraint percentage is set by the **2nd Harmonic Restraint** (**tg**α **x 100**) setting. The operating characteristic of these units is represented in Figure 3.7.2.

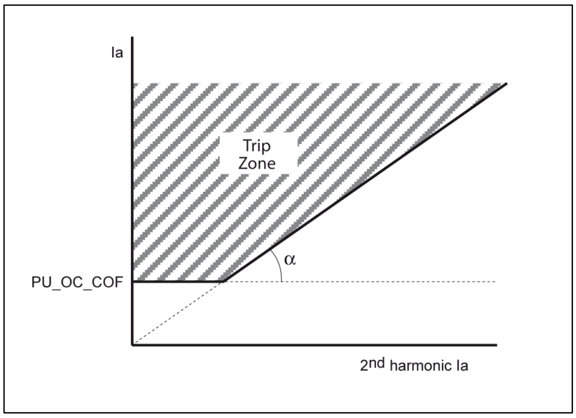


Figure 3.7.3: Operating Characteristic of the Close-Onto-a-Fault Overcurrent Units.

Legend
PU_OC_COF: Close-on-to-Fault Current Pickup (setting)

On the other hand, the Close-Onto-a-Fault unit permits the area selected through the **COF Supervision Zone** setting (zone 2 or 3) to generate an instantaneous tripping. Consequently, it permits to make an extension of zone 1. This will always occur in case of manual closings, with it being optional with reclose commands, according to the **Z1 Extension for Reclosing** setting.

ZLV-G/J relays can select through the **Switch Onto Fault Breaker** setting, in dual breaker bays, whether the switch onto fault element activates with the closing of the first breaker or both breakers. It is worth mentioning that in breaker and a half or ring bays the current circulating through each CT may vary greatly. If the closing of the first breaker connects the line to a very weak source, the above mentioned phase overcurrent elements might not pickup upon a switch onto fault condition.

The following figure show logic diagrams generating inputs **IN_CLOSE_MAN** and **RCLS_MAN** in **ZLV-G/J** relays.

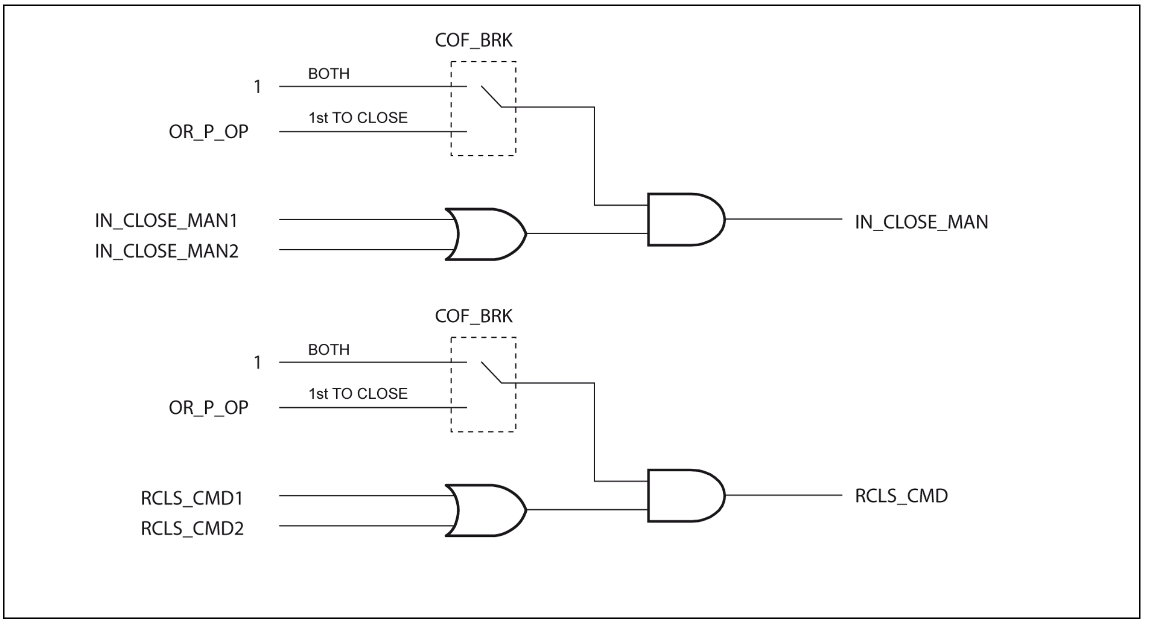


Figure 3.7.4: Logic Diagram that Generate IN_CLOSE_MAN and RCLS_MAN Signals (ZLV-G/J Models).

Legend	
OR_P_OP: Any Open Pole.	IN_CLOSE_MAN: Manual Close Command
IN_CLOSE_MANn: Breaker n Manual Close Command Input	RCLS_CMD: Reclose Command.
RCLS_CMDn: Breaker n Reclose Command.	COF_BRK: Breaker that activate the Close-onto-Fault.

3.7.2 Close-Onto-Fault Detector Magnitudes

Table 3.7-1: Close-Onto-Fault Detector Magnitudes		
Name	**Description**	**Units**
ARM2 IA	IA current second harmonic	A
ARM2 IB	IC current second harmonic	A
ARM2 IC	IB current second harmonic	A

3.7.3 Close-Onto-Fault Detector Settings

Close-Onto-Fault Detector			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
COF Supervision Zone	Zone 2 / Zone 3		Zone 2
Current Pickup	(0.2 - 6) In A	0.05 A	2 In
Zone 1 Extension for Reclosing	YES / NO		NO
Second Harmonic Restraint	0 - 50%	1%	0 %
Switch onto fault operating time (ZLV-F/G/H/J)	100 - 2000 ms	2 ms	300 ms
Breaker that initiate the close-onto-fault (ZLV-G/J)	1st to close Both		1st to close
Manual Close Delay (ZLV-***-****C/D/E/F/G/H**)	0.05 s - 300 s	0.01 s	50 s
Reclose Delay (ZLV-***-****C/D/E/F/G/H**)	0.05 s - 300 s	0.01 s	0.2 s
Close-onto-Fault Detector Initiate Mask (ZLV-***-****C/D/E/F/G/H**)			
Manual Close by Dead Line Deactivation	YES / NO		NO
Manual Close by Open Pole Deactivation	YES / NO		NO
External Manual Close	YES / NO		NO
Manual Close Command	YES / NO		NO
Reclose by Dead Line Deactivation	YES / NO		NO
Reclose by Open Pole Deactivation	YES / NO		NO
External Reclose	YES / NO		NO
Reclose Command	YES / NO		NO

- **Close-Onto-Fault Detector: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - CLOSE ONTO FAULT**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	**0 - COF ENABLE**
1 - DIST SUPERVISION	**1 - COF SUP. ZONE**
2 - CLOSE ONTO FAULT	**2 - I COF PICK UP**
...	**3 - Z1 EXT. AFTER RECL**
	4 - 2ND HARM. RESTRAIN

ZLV-F/H

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - CLOSE ONTO FAULT**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	**0 - COF ENABLE**
1 - DIST SUPERVISION	**1 - COF SUP. ZONE**
2 - CLOSE ONTO FAULT	**2 - I COF PICK UP**
...	**3 - Z1 EXT. AFTER RECL**
	4 - 2ND HARM. RESTRAIN
	5 - COF TIME
	6 - CLOSE WAITING TIME (*)
	7 - RECLO WAITING TIME (*)
	8 - COF INIT MASK (*)

(*) ZLV-*-****C/D/E/F/G/H** Models.**

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - CLOSE ONTO FAULT**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	**0 - COF ENABLE**
1 - DIST SUPERVISION	**1 - COF SUP. ZONE**
2 - CLOSE ONTO FAULT	**2 - I COF PICK UP**
...	**3 - Z1 EXT. AFTER RECL**
	4 - 2ND HARM. RESTRAIN
	5 - COF TIME
	6 - COF BREAKER

3.7.4 Digital Inputs and Events of the Close-Onto-a-Fault Detector

Table 3.7-2: Digital Inputs and Events of the Close-Onto-a-Fault Detector

Name	Description	Function
ENBL_COF	Close-onto-a-fault detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
IN_CLOSE_EXT	External manual closing input	The activation of this input indicates that an external manual closing has been carried out; this input puts into operation the close-onto-a-fault detector.
IN_EXT_RCLS	External reclose input	The activation of this input indicates that a reclose has been carried out through an external unit; this input puts into operation the close-onto-a-fault detector.

3.7.5 Digital Outputs and Events of the Close-Onto-a-Fault Detector

Table 3.7-3: Digital Outputs and Events of the Close-Onto-a-Fault Detector

Name	Description	Function
COF	Tripping due to close onto a fault	Trip of the unit
COF_ENBLD	Close-onto-a-fault detector enabled	Indication of enabled or disabled status of the unit.

3.7.6 Close-Onto-Fault Detector Test

During the test, consult the following indicators:

Display In the **Information** - **Status** - **Measuring Elements** - **Close-Onto-Fault**.
ZIVercomPlus® In the status screen (**Status** - **Elements** - **Close-Onto-Fault**).

Introduce an undervoltage and overcurrent condition, as high as would be seen on a balanced three-phase system of 25 Vac with inductive angles of 0º, 120º and 240º in the A, B and C phases, respectively for the voltages; and of 15 A ac with identical angles for the currents.

The input **External Manual Closing** (**IN_CLOSE_EXT**) should activate. The state of each metering element indicator should activate for the switch onto fault time (fixed time of 300 ms for **ZLV-A/B/E** relays or time setting for **ZLV-F/G/H/J** relays) and the equipment should trip. The last trip indicator in the display, as well as in the ***ZIVercomPlus***® program, should show a three-phase fault with a close-onto-fault detector trip (**COF**).

It will be verified that the performance of the relay is the same if instead of activating the **External Manual Closing** (**IN_CLOSE_EXT**) input we carry out a close command under the same conditions.

It will be verified that the close onto a fault also operates after a reclosing (close-onto-fault reclosing) that is, a trip due to close-onto-fault reclosing will be obtained in case that under the same conditions mentioned previously the reclosing is carried out or the **External Reclosing (IN_EXT_RCLS)** input is activated. In case of close-onto-fault reclosing, in addition, it is possible to disable the extension of zone 1.

All the zones will be adjusted in reverse (in order that the close/reclose onto a fault does not act by the extension of zone 1) and fault conditions with second harmonic content will be applied to the relay. It will be verified that the close/reclose onto fault acts (inasmuch as any of the signals mentioned previously are activated) or not according to the settings **CSF Current Pick Up** and **2nd Harmonic Restraint** (provided that the positive sequence voltage is below 50 V).

3.8 Dead Line Detector

3.8.1 Operating principles

ZLV-F/G/H/J relays incorporate a dead line detection element to detect deenergised line condition with no need for supervising any physical digital input. This is based on the operation of one undercurrent and one undervoltage elements the pickup values of which are given by the **Current level** and **Voltage level** settings respectively. Said elements activate at 95% of the pickup setting and reset at 100% of said setting.

The dead line detector can be applied only when the voltage transformer is on the line side and has been designed to support the switch onto fault detector (see 3.7), in order for it to activate with no need for digital inputs, when both manual reset and reclose are operated externally to the relay.

The dead line detector blocks when the **Fuse Fail Block** signal (**BLK_FF**) activates, given the lack of reliability of undervoltage detectors on fuse failure conditions.

Figure 3.8.1 Logic diagram of the Dead Line Detector, shows the operation of this element.

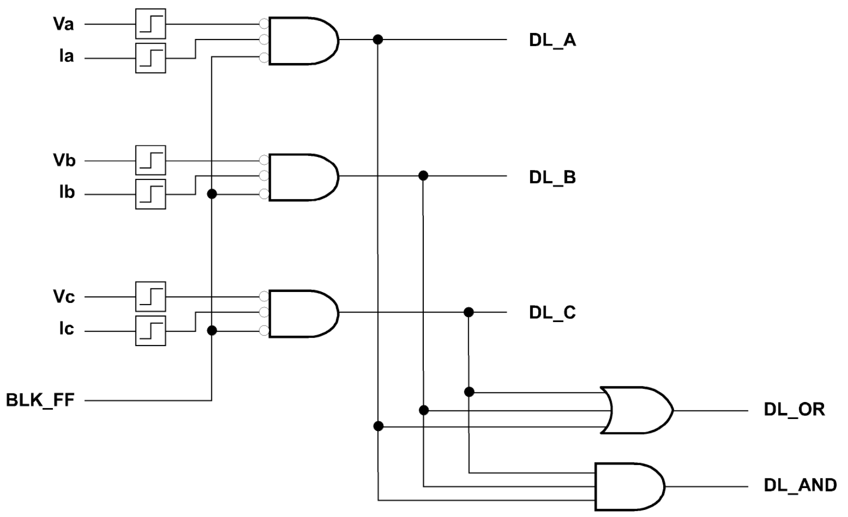


Figure 3.8.1: Logic Diagram of the Dead Line Detector.

Legend	
BLK_FF: Fuse Failure Blocking.	DL_OR: Any Dead Phase.
DL_X: Dead Phase X.	DL_AND: Three Dead Phases.

3.8.2 Dead Line Detector Settings

Dead Line Detector			
Setting	**Range**	**Step**	**By default**
Dead line detector enable signal	YES / NO		NO
Dead line current level	0.2 - 4 A	0.01 A	0,2 A
Dead line voltage level	2 - 70 V	0.01 V	45 V

- **Dead Line Detector: HMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**4 - DEAD LINE DETECTOR**
3 - INFORMATION	**3 - PROTECTION**	…
	…	

0 - DISTANCE	**0 - DL DETEC ENABLE**
…	**1 - CURRENT LEVEL**
4 - DEAD LINE DETECTOR	**2 - VOLTAGE LEVEL**
…	

3.8.3 Digital Inputs and Events of the Dead Line Detector

Table 3.8-1: Digital Inputs and Events of the Dead Line Detector		
Name	**Description**	**Function**
ENBL_DL	Dead line detector enable input	Its activation sets the element into operation. It can be assigned to a level digital input or communications protocol or HMI command. Default value of this logic input is "1".

3.8.4 Digital Outputs and Events of the Dead Line Detector

Table 3.8-2: Digital Outputs and Events of the Dead Line Detector		
Name	**Description**	**Function**
DL_A	Dead Phase A	Indication of phase A deenergised.
DL_B	Dead Phase B	Indication of phase B deenergised.
DL_C	Dead Phase C	Indication of phase C deenergised.
DL_OR	Any Dead Phase	Indication of any phase deenergised
DL_AND	Three Dead Phases	Indications of three-phases deenergised
DL_ENBLD	Dead line detector enabled	Indication of element enabled or disabled state.

3.9 Load Encroachment

3.9.1 Operating Principles

ZLV terminal units incorporate Load Encroachment elements to avoid trips in highload conditions. These units delimit the load zone in the R-X plane, according to the two characteristics shown in Figure 3.9.1, such that if the impedance calculated by the distance element remains within said area its operation is blocked.

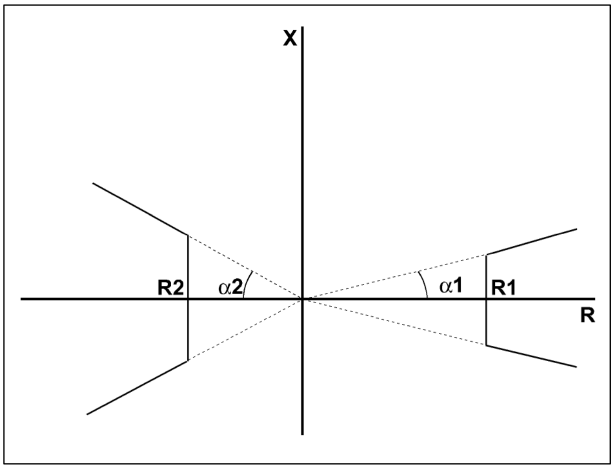


Figure 3.9.1: Characteristics of Load Encroachment Elements.

The impedance calculated by the load encroachment element is a function of the type of fault indicated by the phase selector:

Fault type	Calculated impedance
3-Ph or AB	$Z = \frac{Vab}{Iab}$
BC	$Z = \frac{Vbc}{Ibc}$
CA	$Z = \frac{Vca}{Ica}$
AG	$Z = \frac{Va}{Ia + I0 \cdot (K0 - 1)}$
BG	$Z = \frac{Vb}{Ib + I0 \cdot (K0 - 1)}$
CG	$Z = \frac{Vc}{Ic + I0 \cdot (K0 - 1)}$

The meaning of the variables used in the table above is as follows:

Ia, Ib, Ic	Phase currents
Iab, Ibc, Ica	Phase to phase currents (Ia-Ib), (Ib-Ic), (Ic-Ia)
$I0$	Zero sequence current
Va, Vb, Vc	Phase voltages
Vab, Vbc, Vca	Phase to phase voltages (Va-Vb), (Vb-Vc), (Vc-Va)
$K0 = \frac{\lvert Z0 \rvert}{\lvert Z1 \rvert}$	Zero sequence compensation factor for zone 1

Adjusting the calculated impedance to the type of fault prevents the wrong activation of load encroachment characteristics upon fault conditions.

Load Encroachment elements present two independent characteristics, one for forward load streams and the other for backward load streams. Each of these characteristics is defined by a resistive reach setting (R) and an angle setting (α).

The operating criteria of the Load Encroachment elements is indicated in the following:

$$[Re(Z1) > R1] \otimes [(360 - \alpha 1) < Arg(Z1) < \alpha 1]$$
$$\oplus$$
$$[Re(Z1) < -R2] \otimes [(180 - \alpha 2) < Arg(Z1) < (180 + \alpha 2)]$$

The meaning of the variables used in the above equations is the following:

$R1$	Right area resistive limit
$\alpha 1$	Right area angle
$R2$	Left area resistive limit
$\alpha 2$	Left area angle

3.9.2 Load Encroachment Settings

Load Encroachment			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Right Zone Resistive Limit	(0.5 - 500)/In Ω	0.01 Ω	325 In
Left Zone Resistive Limit	(0.5 - 500)/In Ω	0.01 Ω	325 In
Right Zone Angle	0 - 90º	1º	20º
Left Zone Angle	0 - 90º	1º	20º

- **Load Encroachment: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**4 - LOAD ECNCROACHMENT**
3 - INFORMATION	**3 - PROTECTION**	…
	…	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**4 - LOAD ECNCROACHMENT**
3 - INFORMATION	**3 - PROTECTION**	…
	…	

0 - DISTANCE	**0 - LOAD ENCROACH ENAB**
…	**1 - RIGTH AREA RES LIM**
*** - LOAD ECNCROACHMENT**	**2 - LEFT AREA RES LIM**
…	**3 - RIGTH AREA ANGLE**
	4 - LEFT AREA ANGLE

(*) 4 or 5 option, depending on the model.

3.9.3 Digital Inputs and Events of the Load Encroachment Elements

Table 3.9-1: Digital Inputs and Events of the Load Encroachment Elements		
Name	**Description**	**Function**
ENBL_ENCR	Load encroachment elements enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."

3.9.4 Digital Outputs and Events of the Load Encroachment Elements

Table 3.9-2: Digital Outputs and Events of the Load Encroachment Elements		
Name	**Description**	**Function**
ENCR	Activation of load encroachment elements	Activation output of load encroachment elements.
ENCR_ENBLD	Load encroachment enabled	Indication of enabled or disabled status of the unit.

3.9.5 Load Encroachment Elements Test

Enable the load encroachment element and the distance elements. Disable the remaining elements.

Consult the following indicators during the test:

In the display on the **Information** - **Status** - **Measuring elements** - **Load Encroachment** screen, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Load Encroachment**).

Adjust the distance elements according to the settings of the tests of the distance element. Define a load encroachment area which enters up to zone 1, setting, for example, the positive and negative load limiters at 0.5 Ohms and the load angles at 45º (positive as well as negative).

A three-phase balanced voltage and current system of 65 Vca and 0º, 120º and 240º and 5 Aac and 0º, 120º and 240º, respectively will be departed from (the latter angles are inductive values). Verify that the load encroachment element is active.

The voltages of the three phases will be reduced gradually and simultaneously, until the load encroachment element is deactivated. Verify that this deactivation occurs for an impedance of 0.5 Ohms.

A three-phase balanced voltage and current system of 10 Vca and 0º, 120º and 240º and 5 Aac and 0º, 120º and 240º, respectively, will again be departed from (the latter angles are inductive values). Verify that the load encroachment element is active.

Continue to increase the angle (inductive) of the phase currents gradually and simultaneously. Verify that the load encroachment element is deactivated when the angle exceeds 45º. Carry out the same verification but with capacitive angles. The load encroachment element should also be deactivated for 45º (capacitive).

The tests for the negative area of the load encroachment element will be similar to these but with inverted currents.

Test, applying prefault-fault type faults to the relay, which when the fault point is simultaneously within a zone and within the load encroachment element, the trip (or pick up of the zone) is blocked.

3.10 Power Swing Detector

3.10.1 Description

Power swings are disturbances basically produced by imbalances between generation and demand, which may be originated by changes in the topology of the network, load variations, failures, etc. These disturbances produce speed slip between generators, which no longer turn at the synchronism speed, but which accelerate and decelerate to adapt to the new situation, producing swings in the power transferred between different parts of the system.

During a power swing, variations are produced in the current and in the voltage, in the magnitude as well as in angle, which originates change in the impedance seen by the distance relays, which may come to see tripping conditions. Power swings may be stable (dampened until reaching a new balance situation) or unstable (balance not recovered). In case of unstable power swings, it is necessary to make separations in the system, creating islands in which there is balance between generation and demand.

In case of any type of power swing, it is necessary to block the trip of the distance units: if the swing is stable, because a trip may convert this to unstable and if the swing is unstable, because it tends to follow a strategy at the time of creating islands, opening breakers only in determined positions of the system.

ZLV relays include a Power Swing Detector, in order to avoid undue tripping of the distance elements on stable power swing (power swing blocking) and allow controlled tripping (not available for the **ZLV-E** models) on unstable power swing.

The Power Swing Detector unit bases its operation on the analysis of the transfer speed of the impedance point through the R-X diagram. In case of failure, the transfer between the situation of no failure and that of failure presents a very high transfer speed of the impedance point (since this involves an electromagnetic phenomenon) while the transfer of this same point in case of a power swing involves a much lower speed (given that this is an electromechanical phenomenon), which depends on the condition of the initial load, the out-of-square magnitude between generation and demand, generator inertia, etc.

The principle of operation of the Power Swing Detector is based on the time measurement that the viewed impedance takes to travel the strip defined between two quadrilateral zones, **External** and **Intermediate**, such that if this time is longer than a threshold (set by the **Power Swing Detection Time** adjustment), it can be considered that there is no failure but rather a power swing. Once the existence of a power swing has been detected, if the **PS Trip Enable**[*] (**ENBL_TRIP_PS**) adjustment has been set to **YES**, it is determined if the swing is stable or unstable. For this, it is verified if the viewed impedance reaches an internal quadrilateral zone, similar to the two above. In this case, the swing is considered unstable, thus being able to generate a trip, as will be seen in the following.

To carry out the above verifications, the **ZLV** incorporates three units of phase-to-phase impedance measurement per zone. When the three poles of the breaker are closed, it is sufficient to verify one of these measuring units, for example, AB, given the symmetry of the power swing phenomenon. The opening of a pole disables the measuring units related to the open phase due to the lack of reliability of these.

Each quadrilateral zone of those mentioned above is formed of the following elements:

- Two resistive limiters.
- Two reactive limiters.

[*] Not available for the ZLV-E models.

3.10.2 Resistive Limiters

The **ZLV** incorporates three resistive limit units per zone (external, intermediate and internal). Each resistive limit unit is formed of a pair of limiters, left and right, with independent reach settings.

The following table shows the operation and polarization phasors of the resistive limiters, as well as the applied operating criteria.

Table 3.10-1: Resistive Limiters

Right Resistive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$Iab \cdot Rdcho - Vab$	$Iab \cdot Rdcho$	$-(180º - A\lim) \leq [\arg(Fop) - \arg(Fpol)] \leq A\lim$
BC	$Ibc \cdot Rdcho - Vbc$	$Ibc \cdot Rdcho$	
CA	$Ica \cdot Rdcho - Vca$	$Ica \cdot Rdcho$	
Left Resistive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$-Iab \cdot Rizdo - Vab$	$-Iab \cdot Rizdo$	$-(180º - A\lim) \leq [\arg(Fop) - \arg(Fpol)] \leq A\lim$
BC	$-Ibc \cdot Rizdo - Vbc$	$-Ibc \cdot Rizdo$	
CA	$-Ica \cdot Rizdo - Vca$	$-Ica \cdot Rizdo$	

Where:

Iab, Ibc, Ica	Current between phases (Ia-Ib), (Ib-Ic), (Ic-Ia)
Vab, Vbc, Vca	Voltages between phases (Va-Vb), (Vb-Vc), (Vc-Va)
$Rdcho$	Right limiter resistive reach setting (internal, intermediate and external)
$Rizdo$	Left limiter resistive reach setting (internal, intermediate and external)
$A\lim$	Resistive limiters angle setting

Figure 3.10.1 represents the resistive limiters in a voltage plane.

To pass to an impedance plane, it is only necessary to divide this by the phase-to-phase current. The angle formed with the horizontal axis (defined by the phase-to-phase current) is given by **Alim** (**Resistive Limiter Angle**) setting. This angle should be equal to the angle of transfer impedance between the two systems which interconnect the line protected by the **ZLV**, given that theoretically the path of the impedance during a power swing is perpendicular to this impedance.

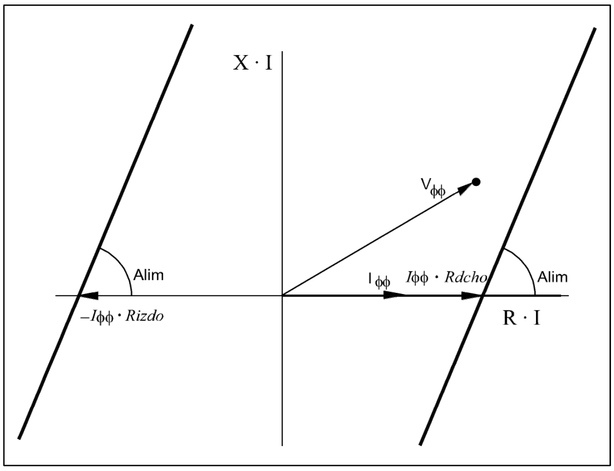


Figure 3.10.1: Diagram of Resistive Limiters of the Power Swing Detection Zones.

The transfer impedance is equal to the sum of the positive sequence impedance of a local source, line and remote source. In general, the angle of this impedance is very similar to the angle of positive sequence impedance of the line, for which it tends to be adjusted in a similar manner.

3.10.3 Reactive Limiters

The **ZLV** incorporates three reactive limit units per zone (external, intermediate and internal). Each reactive limit unit is formed of a pair of limiters, upper and lower, with independent reach settings.

The following table shows the operation and polarization phasors which intervene in each of the reactance units, as well as the operating criteria applied.

Table 3.10-2: Reactive Limiters			
Upper Reactive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$Iab \cdot Z\,sup - Vab$	$Iab \cdot Z\,sup$	$-90^\circ \le [\arg(Fop) - \arg(Fpol)] \le 90^\circ$
BC	$Ibc \cdot Z\,sup - Vbc$	$Ibc \cdot Z\,sup$	
CA	$Ica \cdot Z\,sup - Vca$	$Ica \cdot Z\,sup$	
Lower Reactive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$-Iab \cdot Z\,inf - Vab$	$-Iab \cdot Z\,inf$	$-90^\circ \le [\arg(Fop) - \arg(Fpol)] \le 90^\circ$
BC	$-Ibc \cdot Z\,inf - Vbc$	$-Ibc \cdot Z\,inf$	
CA	$-Ica \cdot Z\,inf - Vca$	$-Ica \cdot Z\,inf$	

Where:

Iab, Ibc, Ica	Currents between phases (Ia-Ib), (Ib-Ic), (Ic-Ia)
Vab, Vbc, Vca	Voltages between phases (Va-Vb), (Vb-Vc), (Vc-Va)
$Z\ sup$	Upper reactive limiter reach impedance setting (internal, intermediate an external)
$Z\ inf$	Lower reactive limiter reach impedance setting (internal, intermediate and external)

Figure 3.10.2 represents the reactive limiters in a voltage plane. To pass to an impedance plane, it is only necessary to divide this by the phase-to-phase current. The reactive limiters are straight, perpendicular to the resistive limiters, for which the angle of **Zsup** (external, intermediate and internal) and **Zinf** (external, intermediate and internal) impedances is equal to the **Alim** (**Resistive Limiter Angle**) setting.

The external, intermediate and internal zones will be activated provided that the corresponding resistive and reactive limiters are activated simultaneously.

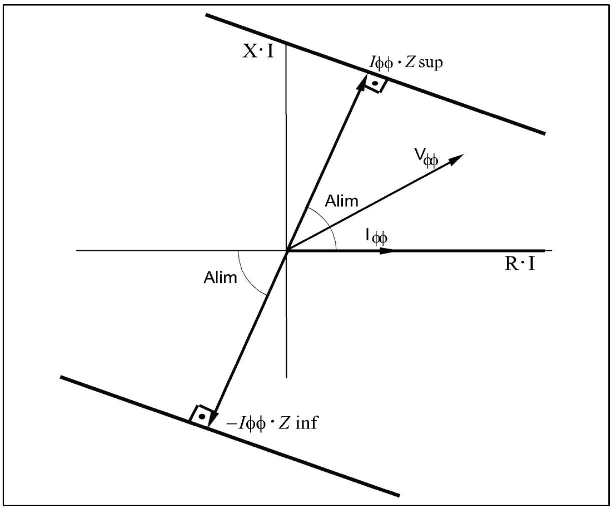


Figure 3.10.2: Diagram of Reactive Limiters of the Power Swing Detection Zones.

3.10.4 Zone Activation Logic

Figures 3.10.3, 3.10.4 and 3.10.5 show the activation logic of the external, intermediate and internal zones according to the outputs of the open-pole logic:

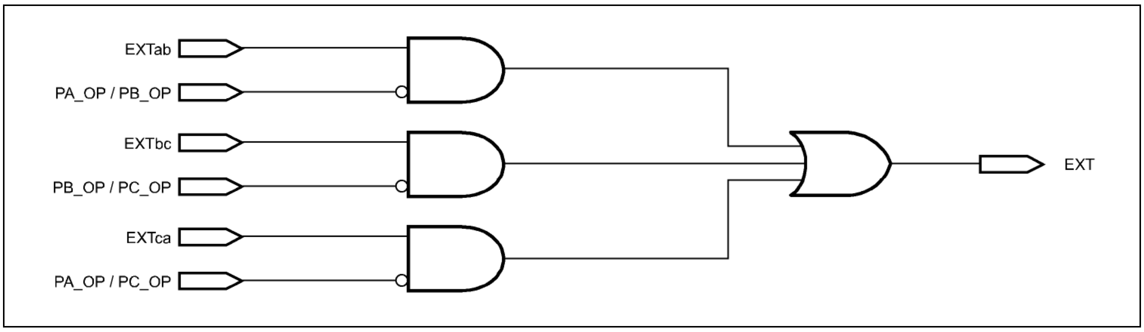


Figure 3.10.3: Activation Logic of the External Zone.

Legend	
PX_OP: Open X Pole.	EXT: External Zone Activation.

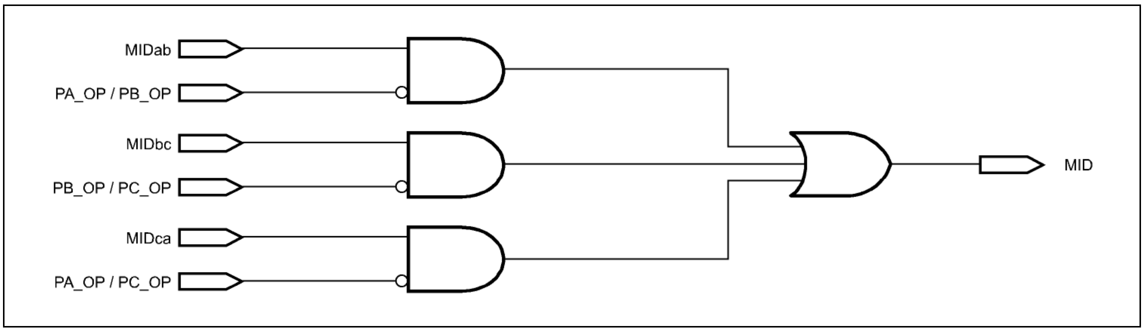


Figure 3.10.4: Activation Logic of the Intermediate Zone.

Legend	
PX_OP: Open X Pole.	MID: Intermediate Zone Activation.

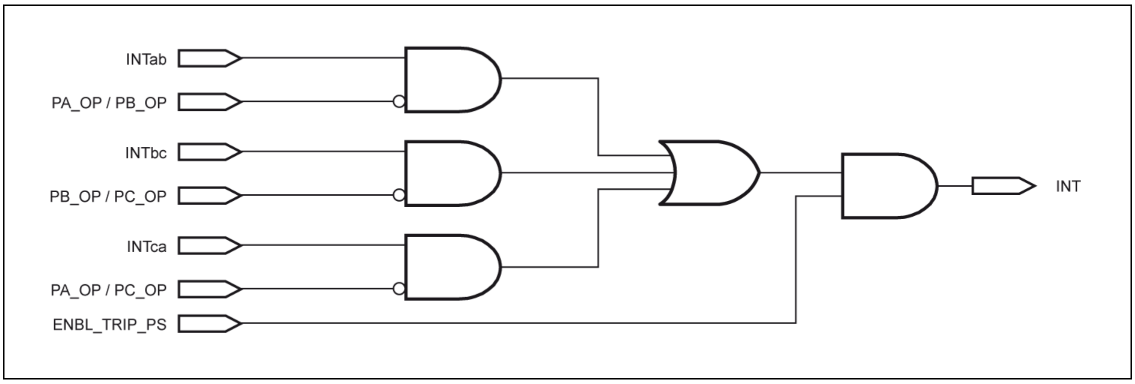


Figure 3.10.5: Activation Logic of the Internal Zone.

Legend	
PX_OP: Open X Pole.	INT: Internal Zone Activation.

The activation of the internal zone is subordinate on the **PS Trip Enable** (**ENBL_TRIP_PS**)*.

On the other hand, there is a minimum adjustable level of positive sequence current for the activation of the three zones (**I1 Supervision**).

* Not available for the ZLV-E models.

3.10.5 Definition of the Zones

Figure 3.10.6 represents, in an R-X plane, the three quadrilateral zones used by the Power Swing Detector together with the two distance zones with Mho characteristic.

The two types of tripping due to power swing indicated are commented on in the following point.

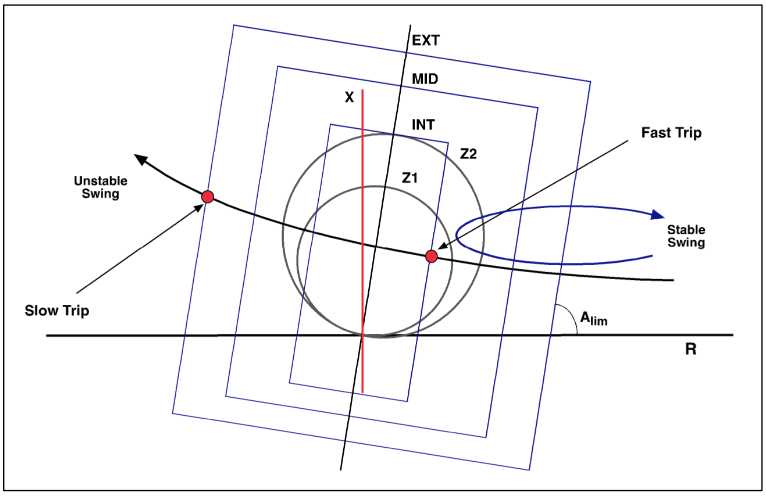


Figure 3.10.6: Power Swing Detector Zones.

The **Intermediate Zone** should be configured in order that it surrounds the most external tripping characteristic to block it before the impedance reaches it.

The **External Zone** will be configured based on the strip which defines, in respect to the intermediate zone, and the anticipated time of the impedance remaining in this strip during a power swing (**Power Swing Detection Time** setting, commented on below). On the other hand, said zone could never be activated on load conditions, as a lockout condition could occur already on this condition, by trip delay upon later three-phase faults (see zone reset upon faults during power swing). In case of very high load conditions on the line, it will be necessary to limit the range of the external resistive limiter. This may require the intermediate resistive limiter to cut the most external tripping characteristic. In this case, a start of this characteristic would be produced if, during a power swing, the impedance reaches this without having yet reached the intermediate zone. This pickup will be reset when the **Power Swing Detection Time** elapses. In general, the most external tripping zone presents a longer timing than this last setting. Still, it is possible to avoid distance pickup for the most overreaching zone by conditioning this pickup to the intermediate zone pickup using the Programmable Logic (use the disable distance zones input).

In respect to the **Internal Zone***, which will only be considered when tripping due to power swing is enabled, following the meaning of the adjustments which define this is explained:

- **Resistive reach** (right or left): this setting should be selected based on the maximum phase difference between the voltages of the two systems which interconnect the protected line which ensures the stability of the system. This angle will be obtained through a stability study. The right resistive reach refers to the power swings which start from a forward load situation, while the left resistive reach is for swings which originate from backward load streams.
- **Impedance reach** (higher and lower): an unstable power swing will cross the transfer impedance between two systems linked through the protected line by a point designated as the electric centre of the system. This point will be the most appropriate for making the separation between the two systems and will theoretically coincide with the intermediate point of the transfer impedance. It is usual that an **ZLV** installed at one end of a line is in charge of tripping only unstable power swings viewed in a forward direction and whose electric centre is located in the line itself. This philosophy would be applied taking into consideration that the lines adjacent to the local and remote points already have protection for tripping in case of unstable power swings which pass through it. In this case, the lower reach of the internal zone could be adjusted to the minimum value and the upper reach equal to the line impedance, or a little lower, in order not to overreach power swings whose electric centre is in a remote line. In case of not having other protection which trips in case of swings with an electric centre in adjacent lines, it will be necessary to extend these impedance reaches.

* Not available for the ZLV-E models.

3.10.6 Operation

The operation of the Power Swing Detector is shown in Figure 3.10.7:

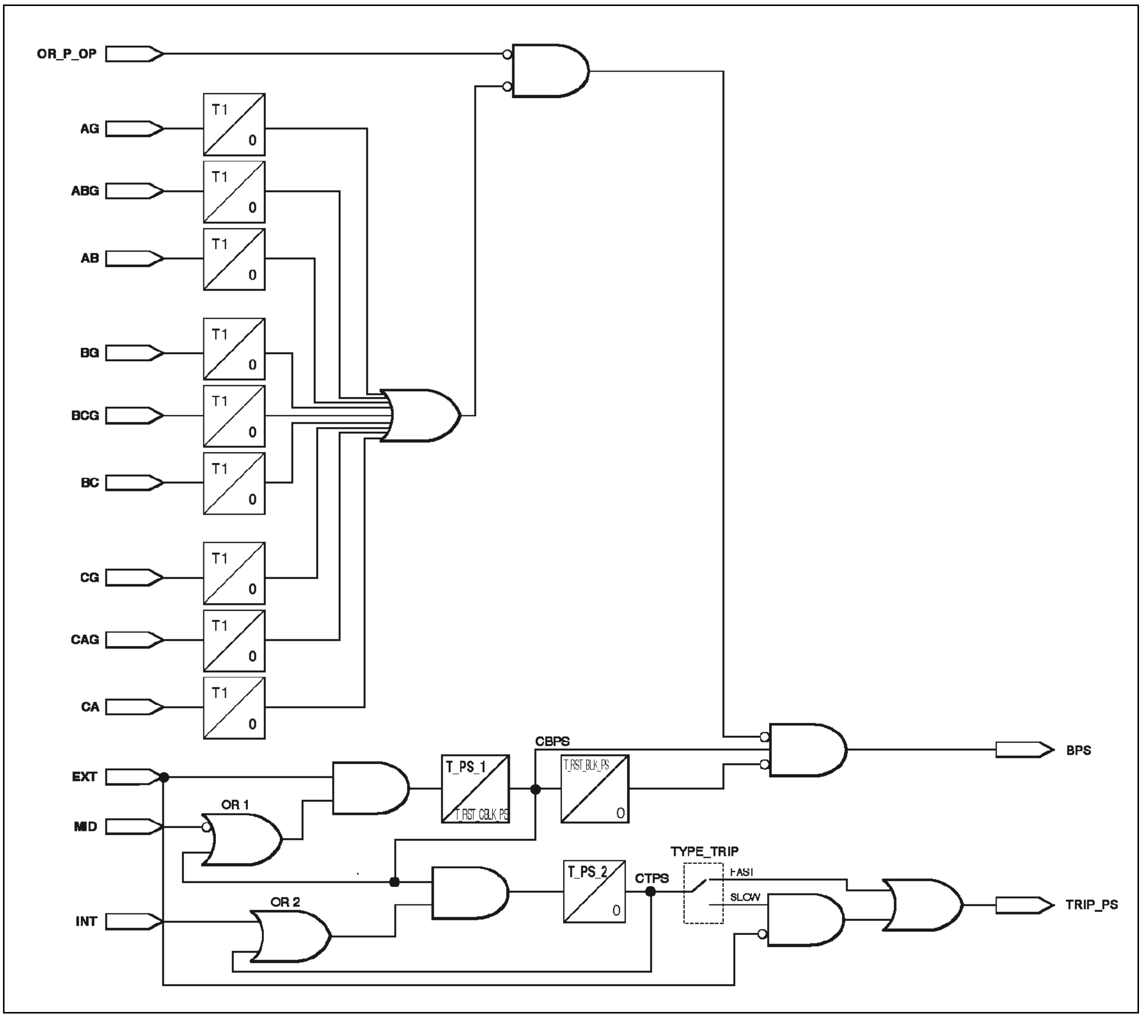


Figure 3.10.7: Block Diagram of the Power Swing Detector.

Legend	
OR_P_OP: Any Pole Open.	T_PS_1: Power Swing Detection Time (setting)
EXT: External Zone Activation.	T_PS_2: Fast Trip Time (setting)
MID: Intermediate Zone Activation.	T_RST_BLK_PS: Power Swing Blocking Reset Time (setting)
INT: Internal Zone Activation.	
CBPS: Power Swing Blocking Condition.	T_RST_CBLK_PS: Power Swing Blocking Condition Reset Time (setting)
CTPS: Power Swing Tripping Condition.	
BPS: Power Swing Blocking..	TYPE_TRIP: Power Swing Trip Type (setting)
TRIP_PS: Power Swing Trip.	FAST: Fast Trip.
	SLOW: Slow Trip.

When the impedance enters the strip between the external and intermediate zone, the **T_PS_1** (**Power Swing Detection Time**) timer starts. Once this expires, the **Power Swing Blocking Condition** signal (**CBPS**) is activated. To prevent its deactivation in case of activation of the intermediate zone, a feedback is carried out through the **OR1** port, in order that **CBPS** remains active whenever it is in the external zone. **T_PS_1** should be adjusted with a lower value than the transition through the above-mentioned strip of the fastest power swing.

The **CBPS** signal will generate the **BPS** (**Power Swing Blocking**) signal provided that:

1. None of the **AG/BG/CG/ABG/BCG/CAG/AB/BC/CA** fault signals originating from the Phase Selector are activated longer than **Time Delay for Ground Fault Detection** setting. These signals should never activate during a power swing, given the symmetry of this phenomenon. Its activation, consequently, permits to unblock the distance zones, blocked by the detection of a power swing, in case of unbalanced faults. Once the **BPS** signal has been activated, if the **AG/BG/CG/ABG/BCG/CAG/AB/BC/CA** signals are activated, the **BPS** signal will be deactivated after the time setting, avoiding zone 1 trips since the impedance zone was passing that zone in the moment the asymmetry was detected.
2. The **T_RST_BLK_PS** (**Power Swing Blocking Reset Time**) setting has not elapsed, which commences with the activation of the **CBPS** signal. During a power swing, the impedance of this is moving continuously, such that if it enters an external zone, it should again exit from this. The time which exists from the activation of the external zone until its deactivation depends on the speed of the power swing. If the impedance remains within the external characteristic longer than expected, it can be concluded that the power swing has developed into a failure. The **T_RST_BLK_PS** time setting should be longer than the time of duration of the slowest power swing in entering and exiting the external characteristic (on the other hand, it is necessary to add the **T_PS_1** time, which is the time it takes to activate the **CBPS** signal from the activation of the external characteristic). The objective of the **T_RST_BLK_PS** setting is to unblock the distance zones, blocked by the detection of a power swing, in case of a three-phase fault, given that the **Ground Fault** or **Two-Phase Fault** signals will not be activated. Similarly, it permits the unblocking of the distance zones in case of faults which occur from a power swing detected in an open-pole condition, since the Phase Selector's previous signals are not taken into account in this condition.

In both cases, there will be an increase in the positive sequence current, for which the failure detector will be activated, ensuring tripping.

As long as the **CBPS** signal is active, the distance units will not consider prefault currents or memory voltage, given that these magnitudes do not correspond to a load situation and will lack reliability.

Once the **CBPS** signal is activated and the **Power Swing Trip**[*], option has been selected, the activation of the internal zone commences the counting of the **T_PS_2** (**Fast-Trip Time**) timer; if this reaches its end, the **CTPS** (**Power Swing Tripping Condition**) signal is activated. In case of **TYPE_TRIP** (**Type of Power Swing Trip**) setting is **Fast Trip**, the **CTPS** signal will directly activate **TRIP_PS** (**Power Swing Trip**). In case of selecting **Fast Trip**, the **T_PS_2** timer leaves a time margin to produce this tripping. Notwithstanding, the timer will reset when the internal zone is deactivated, for which this time cannot be longer than the time it takes the impedance to cross this zone. The **T_PS_2** time serves as additional verification that the movement of the impedance is due to a power swing.

Figure 3.10.6 shows the two possible tripping points in case of an unstable power swing.

If, on the contrary, **Slow Trip** is selected, the tripping will be produced on deactivating the external zone. In this case, the **CTPS** signal should continue active although the internal zone is deactivated, for which it is resupplied through the **OR 2**. The **CBPS** signal is kept active in case of deactivation of the external zone during reset time of the **T_PS_1**, **T_RST_BLK_PS** (**Lockout Condition Reset Time by Power Swing**), which will quantify the duration of the slow tripping due to power swing (for this reason, it is necessary to establish a minimum value of this time, if this type of tripping is selected). The slow tripping has the advantage of generating an open command of the breaker under far more favourable conditions in that referring to effort, given that the output voltages of the external zone present a difference in phase much less than at the internal zone entrance, which results in smaller currents.

The **Power Swing Blocking** (**BPS**) signal permits to block the activation of the distance zones and tripping through the distance protection scheme through the **Power Swing Blocking Mask**.

On the other hand, it is possible to block other units which may act in case of power swings, such as overcurrent units. For this, it will be necessary to "wire" the **Power Swing Blocking** (**BPS**) output to the blocking inputs of these units through the use of programmable logic incorporated in the equipment.

The Power Swing Detector is enabled only if there is an open pole, if the Phase Selector indicates three-phase fault or if Power Swing Conditions are present (CBPS signal).

[*] Not available for the ZLV-E models.

3.10.7 Power Swing Detector Settings

Power Swing Detector			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Power Swing Tripping Enable	YES / NO		NO
Right External Resistive Limit	(0.5 - 500)/In Ω	0.01 Ω	50 In
Right Middle Resistive Limit	(0.5 - 500)/In Ω	0.01 Ω	25 In
Right Internal Resistive Limit (Tripping Only)	(0.5 - 500)/In Ω	0.01 Ω	5 In
Left External Resistive Limit	(0.5 - 500)/In Ω	0.01 Ω	50 In
Left Middle Resistive Limit	(0.5 - 500)/In Ω	0.01 Ω	25 In
Left Internal Resistive Limit (Tripping Only)	(0.5 - 500)/In Ω	0.01 Ω	5 In
Resistive Limiters Angle	0 - 90º	1º	75º
Upper External Reach	(0.5 - 500)/In Ω	0.01 Ω	50 In
Upper Middle Reach	(0.5 - 500)/In Ω	0.01 Ω	25 In
Upper Internal Reach	(0.5 - 500)/In Ω	0.01 Ω	5 In
Lower External Reach	(0.5 - 500)/In Ω	0.01 Ω	50 In
Lower Middle Reach	(0.5 - 500)/In Ω	0.01 Ω	25 In
Lower Internal Reach	(0.5 - 500)/In Ω	0.01 Ω	5 In
Supervision Positive Sequence Current	(0.04 - 10) In A	0.01 A	0.2 In
Power Swing Detection Time	0 - 1.00s 0 - 2.00s (*)	0.002 s	0.03 s
Power Swing Blocking Reset Time	0.1 - 5 s	0.1 s	1 s
Power Swing Trip Type	Fast / Slow		Slow
Fast Trip Time Delay	0 - 1.00s 0 - 2.00s (*)	0.002 s	0.05 s
Power Swing Condition Reset Time	0,02 - 1.00s 0,02 - 2.00s (*)	0.002 s	0.05 s
Time Delay for Ground Fault Detection (*)	0 - 200 ms	1 ms	40 ms

(*) ZLV-*-****C/D/E/F/G/H*** Models.**

- **Power Swing Detector: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**6 - POWER SWING DETECTOR**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**7 - POWER SWING DETECTOR**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	**0 - PS DETEC ENABLE**
...	**1 - PS TRIP ENABLE**
*** - POWER SWING DETECTOR**	**2 - RIGHT EXT RES LIM**
...	**3 - RIGHT MED RES LIM**
	4 - RIGHT INT RES LIM
	5 - LEFT EXT RES LIM
	6 - LEFT MED RES LIM
	7 - LEFT INT RES LIM
	8 - RESIST LIMIT ANGLE
	9 - FORWARD EXT REACH
	10 - FORWARD MED REACH
	11 - FORWARD INT REACH
	12 - REVERSE EXT REACH
	13 - REVERSE MED REACH
	14 - REVERSE INT REACH
	15 - I1 SUPERVISION
	16 - PS DET TIME
	17 - PS BLOC RESET TIME
	18 - PS TRIP TYPE
	19 - FAST TRIP TIME
	20 - PS COND RESET TIME

(*) 6 or 7 options, depending on the model.

3.10.8 Digital Inputs and Events of the Power Swing Detector

Table 3.10-3: Digital Inputs and Events of the Power Swing Detector		
Name	**Description**	**Function**
ENBL_PS	Power swing detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

3.10.9 Digital Outputs and Events of the Power Swing Detector

Table 3.10-4: Digital Outputs and Events of the Power Swing Detector		
Name	**Description**	**Function**
EXT	External zone activation	Activation of the external zone.
MID	Intermediate zone activation	Activation of intermediate zone.
INT	Internal zone activation	Activation of the internal zone.
BPS	Power swing blocking	Power swing blocking
TRIP_PS	Power swing trip	Power swing trip
CBPS	Power swing blocking condition	Existence of blocking condition due to power swing
CTPS	Power swing tripping condition	Existence of tripping conditions due to power swing
PS_ENBLD	Power swing detector enabled	Indication of enabled or disabled status of the unit.

3.10.10 Power Swing Detector Test

Enable the Power Swing Detector by adjusting and disable the other Units. During the test, consult the following indicators:

Display In the **Information** – **Status** – **Metering Units** – **Power Swing Detector** screen.
ZIVercomPlus® In the status screen (**Status** – **Elements** – **Power Swing Detector**).

3.10.10.a Activation Test of the Characteristics

Configure the unit as indicated in Table 3.10-5 (for In = 5 A):

Table 3.10-5: Test Settings for the Power Swing Detector

Trip Enable*	YES
Right External Resistive Limit	8 Ω
Right Middle Resistive Limit	6 Ω
Right Internal Resistive Limit*	3 Ω
Left External Resistive Limit	8 Ω
Left Middle Resistive Limit	6 Ω
Left Internal Resistive Limit*	3 Ω
Resistive Limiter Angle	75º
Upper External Reach	10 Ω
Upper Middle Reach	8 Ω
Upper Internal Reach*	7 Ω
Lower External Reach	10 Ω
Lower Middle Reach	8 Ω
Lower Internal Reach*	7 Ω
I1 Supervision	0.2 A
Power Swing Detection Time	0.2 s
Power Swing Blocking Reset Time	5 s
Power Swing Trip Type*	Fast
“Fast Trip” Time Delay*	0.1 s
Power Swing Condition Reset Time	0.1 s

Although the trip is enabled, it will remain masked for this test (actuation masks of auxiliary elements in protection logic).

For this test, apply a balanced three-phase system of voltages and current of 65 Vac with inductive angles of 0º, 120º and 240º and 5 Aac and phase difference (inductive) with respect to each voltage, according to the test table.

* Not available for the ZLV-E models.

Gradually and simultaneously reduce the voltages of the three phases. **External Zone Activation**, **Middle Zone Activation** and **Internal Zone Activation** flags should activate within the voltage ranges indicated in Table 3.10-6.

Table 3.10-6: Pickup Ranges for the Zones

Zone	Activation Voltage (V)			
	Phase I=0º	Phase I=45º	Phase I=90º	Phase I=135º
External	38.8 – 41.2	56 – 59.47	50.21 – 53.32	43.28 – 45.95
Middle	29.1 – 30.9	44.8 – 47.57	40.17 – 42.65	32.46 – 34.46
Internal	14.55 – 15.45	28.11 – 29.85	35.15 – 37.32	16.23 – 17.23

Zone	Activation Voltage (V)			
	Phase I=180º	Phase I=225º	Phase I=270º	Phase I=315º
External	38.8 – 41.2	56 – 59.47	50.21 – 53.32	43.28 – 45.95
Middle	29.1 – 30.9	44.8 – 47.57	40.17 – 42.65	32.46 – 34.46
Internal	14.55 – 15.45	28.11 – 29.85	35.15 – 37.32	16.23 – 17.23

The following expressions have been used to obtain the pickup values of the different characteristics:

For the right resistive limiter:

$$V = I \cdot \frac{sen(\theta) \cdot Rdcho}{sen(\theta - \alpha)}$$

For the higher reach:

$$V = I \cdot \frac{Z\sup}{\cos(\theta - \alpha)}$$

For the left resistive limiter:

$$V = I \cdot \frac{sen(\theta) \cdot Rizdo}{sen(\alpha - \theta)}$$

For the lower reach:

$$V = I \cdot \frac{Z\inf}{\cos(\theta - \alpha + 180^o)}$$

Where:

$Z\sup$	Impedance reach setting for upper limit (Internal, intermediate and external)
$Z\inf$	Impedance reach setting for lower limit (Internal, intermediate and external)
$Rdcho$	Resistive reach setting of right limiter (Internal, intermediate and external)
$Rizdo$	Resistive reach setting of left limiter (Internal, intermediate and external)
θ	Limiters angle (setting)
α	Inductive angle of the current with respect to the voltage

3.10.10.b Power Swing Blocking Test

To carry out this test we will enable the distance elements and disable the trip due to Power Swing.

We will depart from a situation of balanced voltages and currents of 65 Vca and inductive angles of 0º, 120º and 240º and 5 Aac and different phase differences (inductive), as the case may be.

In this situation and taking the values obtained in the previous test, we will cause the voltages to drop (simultaneously) up to a value between the limit voltage values of intermediate and external zone, for the intensity angle being used in each case (see values in table of the previous test).

Maintaining this situation, it will be verified that the **Power Swing Blocking** flag is activated on expiration of the power swing detection time.

Immediately after, the voltages will be reduced and the currents increased in order that the impedance enters into zone 1. It will then be verified that the power swing blocking is maintained until the expiration of the power swing blocking reset time (time which begins at the time when the external characteristic is entered).

To verify that the blocking does not act in case of three-phase faults, we will again depart from the initial situation: Balanced voltages and currents of 65 Vca and inductive angles of 0º, 120º and 240º and 5 Aac and a different phase difference (inductive) as the case may be.

In this situation, we will go directly to a situation of fault in zone 1 (this time without going through the intermediate state). It will be verified that there is a trip by zone 1 and that there is no power swing blocking.

3.10.10.c Power Swing Trip Test[*]

To carry out this test we will disable the distance elements and enable the trip due to Power Swing.

- **Power Swing Fast Trip**

We will depart from a situation of balanced voltages and currents of 65 Vca and inductive angles of 0º, 120º and 240º and 5 Aac and a different phase difference (inductive), as the case may be.

In this situation and taking the values obtained in test 3.10.10.a, we will cause the voltages to drop (simultaneously) up to a value between the limit voltage values of the intermediate and external zones, for the intensity angle being used in each case (see values in the table of the previous test).

Maintaining this situation, it will be verified that the **Power Swing Blocking** flag is activated on expiration of the power swing detection time.

Immediately after, the voltages will be reduced to a value which makes the impedance enter the internal characteristic of the power swing. It will then be verified that a trip is produced due to power swing on expiration of the timing of the fast trip (although previously entering into a blocking situation).

[*] Not applicable for the ZLV-E models.

- **Power Swing Slow Trip**

To carry out this test we will adjust the **Power Swing Trip Type** to **Slow** and we will adjust the **Fast Trip Time** to 0 s.

We will start from a situation of balanced voltages and currents of 65 Vca and inductive angles of 0º, 120º and 240º and 5 Aac and angles 0º, 120º and 240º.

Being in this situation and taking the values obtained in test 3.10.10.a, we will cause the voltages to drop (simultaneously) up to a value between the limit voltage values of the intermediate and external zones (between 29.1 and 41.2 V).

Maintaining this situation, it will be verified that the **Power Swing Blocking** flag is activated on expiration of the **Power Swing Time**. Immediately after, the voltages will be reduced to a value which makes the impedance enter the internal characteristic of the Power Swing.

Once this situation has been maintained for a period longer than **Fast Trip Time** (which in this case is set at 0 s), the currents will be inverted and the voltages increased up to a value which makes the impedance go outside the left external resistive limiter (V>41.2 V).

It will then be verified that a trip is produced due to power swing once the reset time of the power swing condition has expired (provided that the blocking has not previously dropped as a result of the expiration of the power swing blocking reset time, since if this happens there would not be any trip).

3.11 Remote Breaker Open Detector

3.11.1 Operating Principles

ZLV terminal units, except for the **ZLV-E** model, are provided with a Remote Breaker Open Detector, which generates a signal to instantaneously open the local breaker when the Zone 2 element activates and the remote-end three-phase breaker opens. Under these conditions, the trip is instantaneous, since the fault is located inside the line (Zone 2 elements adjusted over 100% of the length of the protected line).

Detector operation is blocked under the following conditions:

1. The fault is detected by the Zone 1 element at the local end; therefore, tripping is instantaneous.
2. The trip signal is activated. If this signal is activated before the detector output signal becomes activated, the trip signal will initiate tripping the breaker.
3. A three-phase fault occurs, since it is not possible to see beyond the fault.

If the circumstances described do not arise and it is detected that the remote breaker is open, the operation of the detector will only be permitted when zone 2 is activated without the activation of zone 1. Given that in a failure in zone 1, zone 2 will also be activated (even before zone 1 itself); a timeout is applied to the pickup signal of zone 2.

The Remote Breaker Open Detector is based on if there is a three-phase aperture at the remote end during a non-three-phase fault, the current through any of the phases (one if the fault is two phase and two if single phase) will be very small (capacitive current), while in the remaining phase(s) it will continue to detect the fault in zone 2. For this, the unit has an undercurrent unit whose level is given by the **Minimum Current Level** setting.

In case of long lines, the current which circulates through the phases without fault once the remote end is open may be higher than the **Minimum Current Level** setting, due to the ground capacities. For this reason, it is also possible to detect the aperture of the remote breaker through the presence of capacitive current if the **Capacitive Current Detection** (**D_CAP_CUR**) adjustment is set at **YES**.

3.11.2 Capacitive Current Detectors

There are three capacitive current detectors, one per phase. Each one activates when the phase current leads the phase voltage by $90º \pm \delta\_DIRA$ (under ideal conditions, pure capacitive current leads phase voltage by 90º). The following table shows capacitive current detector operation and polarization phasors, as well as the applied operation criteria.

Table 3.11-1: Capacitive Current Detection

Phase	Fop	Fpol	Criteria
A	Ia	Va	$90º - \delta\_DIRA \leq [arg(Fop) - arg(Fpol)] \leq 90º + \delta\_DIRA$
B	Ib	Vb	
C	Ic	Vc	

Where:

Ia, Ib, Ic	Phase currents
Va, Vb, Vc	Phase voltages
δ_DIRA	Capacitive current drift angle (15º)

The block diagram of Figure 3.11.1 shows the operation of the Remote Breaker Open Detector logic.

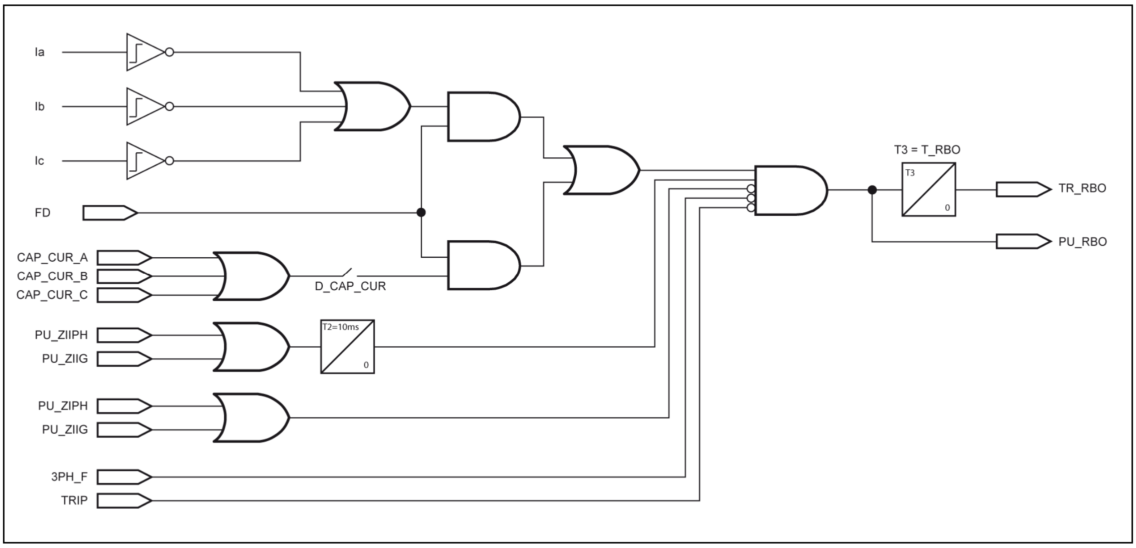


Figure 3.11.1: Remote Breaker Open Detector Block Diagram.

Legend	
CAP_CUR_X: Phase X Capacitive Current Detection Unit Activation.	PU_RBO: Remote Breaker Open Detector Pickup. FD: Fault Detector Activated.
PU_ZnX: Zone n Phase / Ground unit Pickup.	D_CAP_CUR: Capacitive Current Detection (setting).
3PH_F: ABC Fault.	
TRIP: Trip	T_RBO: Remote Open Breaker Detector Delay (setting)
TR_RBO: Remote Breaker Open Detector Trip.	

3.11.3 Remote Breaker Open Detector Settings

Remote Breaker Open Detector			
Setting	**Range**	**Step**	**By default**
Enable Remote Open Breaker Detector	YES / NO		YES NO (*)
Remote Open Breaker Detector Delay	0.00 - 2000 ms	5 ms	0 ms
Detection By Capacitive Current	YES / NO		NO
Minimum Current Level	(0 - 1) In A	0.01 A	0.15 In

(*) ZLV-*-****A/B/C/D/E/F/G/H**.**

- **Remote Breaker Open Detector: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**7 - REM BREAKR OPEN DET.**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**8 - REM BREAKR OPEN DET.**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	**0 - REM BRK OP DET ENA**
...	**1 - REM OPEN BRK TIME**
*** - REM BREAKR OPEN DET.**	**2 - DET. BY CAP. CURRE**
...	**3 - MIN. CURR. LEVEL**

(*) 7 or 8 option, depending on the model.

3.11.4 Digital Inputs and Events of the Remote Breaker Open Detector

Table 3.11-2: Digital Inputs and Events of the Remote Breaker Open Detector		
Name	**Description**	**Function**
ENBL_RBO	Remote breaker open detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."

3.11.5 Digital Outputs and Events of the Remote Breaker Open Detector

Table 3.11-3: Digital Outputs and Events of the Remote Breaker Open Detector		
Name	**Description**	**Function**
PU_RBO	Remote breaker open detector pickup	Pickup of the unit.
TR_RBO	Remote breaker open detector trip	Trip of the unit.
RBO_ENBLD	Remote breaker open detector enabled	Indication of enabled or disabled status of the unit.

3.11.6 Remote Breaker Open Detector Test

Prepare the system to measure the time between the application of the current and the close of any of the trip contacts. The Remote Breaker Open Detector should be enabled, and the remaining Auxiliary Units should be disabled. During the test, consult the following indicators:

Display	In the **Information** – **Status** – **Measuring Elements** – **Remote Breaker Open Detector** screen,
ZIVercomPlus®	In the status screen (**Status** - **Elements**- **Remote Breaker Open Detector**).

Introduce a fault in Zone 2, which won't be tripped by the distance elements. For this test, apply a three-phase balanced system of voltages set at 12 Vac with inductive angles of 0º, 120º and 240º in phases A, B and C, respectively.

Apply a current of 5 A ac with phase A at 50º, and simultaneously apply 1 A ac at 170º and 290º for phases B and C, respectively.

Remove the current to phases B and C (or lower the value below the **Minimum I** setting). The state of the metering element indicator should activate and the equipment should trip. The last trip indicator in the display, as well as in the ***ZIVercomPlus®***, program, should show a fault AG with a trip by Remote Breaker Open Detector (RA). The measured time should be less than 45 ms.

The test should be repeated with an adjusted time of 2000 ms. The measured time should then be between 1900 ms and 2100 ms.

The timing will again be adjusted to 0 s and the **Capacitive Current Detection** setting enabled. The fault in zone 2 of the previous test will be introduced and the intensity angle of phase B or C modified, in order that this takes a capacitive value (between 75º and 105º) with respect to the voltage of the same phase.

As in the previous case, the last trip indicator in the display, as well as in the ***ZIVercomPlus®*** program, should show a fault AG with a trip by Remote Breaker Open Detector (**RBO**). The measured time should be less than 45 ms.

3.12 Overcurrent Elements

Overcurrent Protection Elements
Three phase instantaneous overcurrent elements (50F1, 50F2 and 50F3)
Three ground instantaneous overcurrent elements (50N1, 50N2 and 50N3)
Three negative sequence instantaneous overcurrent elements (50Q1, 50Q2 and 50Q3)
Three phase time overcurrent elements (51F1, 51F2 and 51F3)
Three ground time overcurrent elements (51N1, 51N2 and 51N3)
Three negative sequence time overcurrent elements (51Q1, 51Q2 and 51Q3)

3.12.1 Phase, Ground and Negative Sequence Instantaneous Elements

The phase, ground and negative sequence instantaneous overcurrent elements work according to the RMS value of the input currents. They operate when the RMS value exceeds a value 1.05 times the pickup setting and reset at 1 times the set value.

Each of these elements has an adjustable timer at the output that allows the optional delay of the instantaneous elements.

3.12.2 Phase, Ground and Negative Sequence Time Elements

In the phase, ground and negative sequence time overcurrent elements, the overcurrent time delay function operates on the RMS of the input current. Pickup occurs when the value measured exceeds 1.05 times the pickup setting and resets at the pickup setting.

The pickup activates the timer, which integrates the measured values. The algorithm increases a counter depending on the input current. The counter limit determines the timer element activation.

When the RMS falls below the pickup setting, a rapid reset of the integrator occurs. The activation of the output requires that the pickup continue throughout the integration time; any reset returns the integrator to its initial conditions so that a new operation initiates the time count from zero.

The time curve can be selected from among several types of curves according to **IEC**, **IEEE** (IEEE Standard C37.112-1996) and **US** standards:

IEC CURVES	
Inverse curve	Inverse curve + time limit
Very inverse curve	Very inverse curve + time limit
Extremely inverse curve	Extremely inverse curve + time limit
Long-term inverse curve	Long-term inverse curve + time limit
Short-term inverse curve	Short-term inverse curve + time limit
IEEE CURVES	
Moderately inverse curve	Moderately inverse curve + time limit
Very inverse curve	Very inverse curve + time limit
Extremely inverse curve	Extremely inverse curve + time limit
US CURVES	
Moderately inverse curve	Moderately inverse curve + time limit
Inverse curve	Inverse curve + time limit
Very inverse curve	Very inverse curve + time limit
Extremely inverse curve	Extremely inverse curve + time limit
Short-term inverse curve	Short-term inverse curve + time limit

In addition to these curves, there is the **RI Inverse** curve, used primarily to coordinate with electromechanical relays.

The curve index setting is the same for the **IEC** curves, the **IEEE** curves, the **US** curves and the **RI Inverse** curve: their range is from 0.05 to 10 times the set current.

However, the effective range for the **IEC** curves is from 0.05 to 1. Settings above 1 use the maximum value, which is 1. In the case of the other curves (**IEEE**, **US** and **RI**), the effective range starts at 0.1 times the setting. Lower settings act as if they were set to the minimum (0.1 times the setting). Moreover, although the setting step is 0.01, the effective step for these three types of curve is 0.1. Any setting that is not a multiple of 0.1 is rounded off; that is, a setting of 2.37 is applied as if it were 2.40 and a setting of 2.33 is applied as if it were 2.30 (the setting 2.35 is applied as if it were 2.40).

You can add a **User-Defined** time curve to these and load it on the relay via the communications system. The time setting, in the inverse time curves, is composed of two values: **Curve Type** and **Index** within the family.

Time Limit curves have a classical delay function with a time threshold, so that no trip will occur sooner than specified. This amounts to changing the trip curve into a horizontal straight line at a given moment. This limit on the operation of the element coincides with the time setting in the **Fixed Time** option.

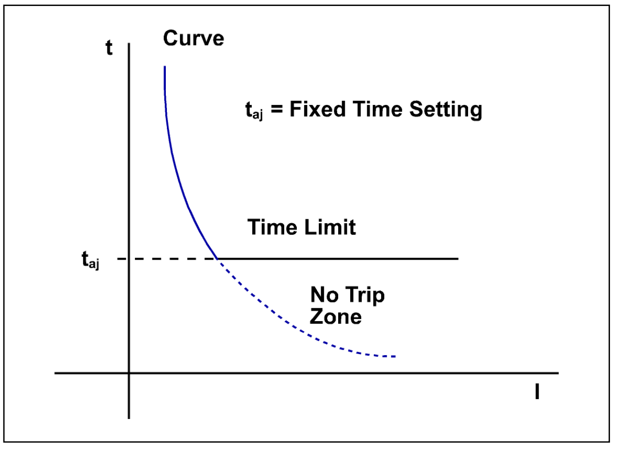


Figure 3.12.1 Diagram of a Curve with a Time Limit for a Time Overcurrent Element.

The **Fixed Time** setting ranges may be excessive for the times of the curve. If the time of the curve (for the dial set and for a current 1.5 times greater than the set current) is less than the fixed time setting, the operation of the element uses 1.5 times the set current as the straight line limit.

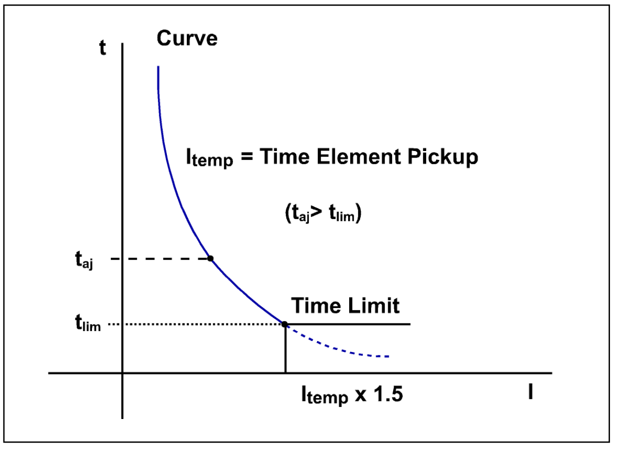


Figure 3.12.2 Time Limit of the Element when the Fixed Time is Greater than the Curve Time (in pickup x 1.5).

Note: although the curves are defined for an input value of up to 20 times the tap, which is the set pickup value in each of the time overcurrent elements, this range can not always be guaranteed. It is important to consider that the saturation limit of the current channels is 160A. Based on these limits, the "number of times the tap" for which the curves are effective depends on the setting:

- **If** $\frac{SaturationLimit}{ElementSetting} > 20$, **the curve is guaranteed to work for the element with this setting throughout its range of taps (up to 20 times the setting).**

- **If** $\frac{SaturationLimit}{ElementSetting} < 20$, **the curve is guaranteed to work for the element with this setting up to a number of times the tap equal to the value of this limit divided by the corresponding setting.**

When a current greater than 20 times the setting is injected, the trip time will be the same as that corresponding to these 20 times.

3.12.2.a Current / Time Curve: Inverse Functions

Figures 3.12.3, 3.12.4, 3.12.5, 3.12.6 and 3.12.7 present the inverse curves according to the **IEC** standards available for **ZLV** models.

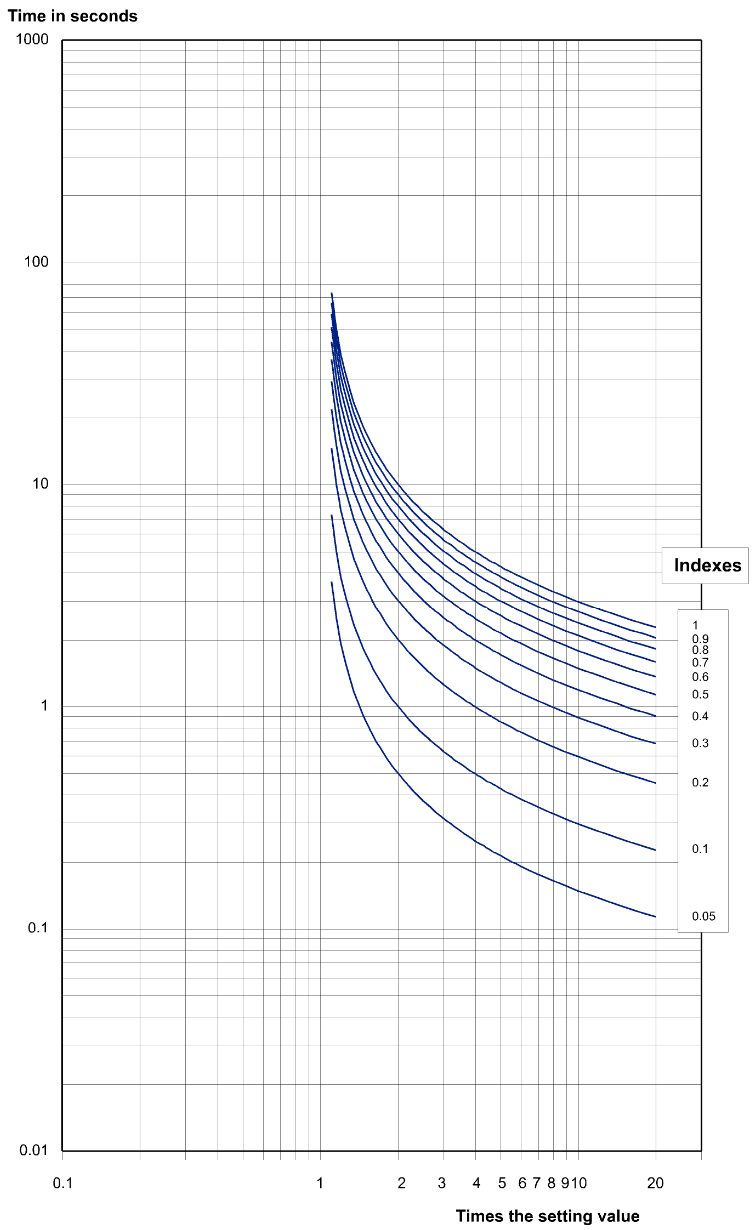


Figure 3.12.3 INVERSE Time Curve (IEC).

$t = \dfrac{0.14}{I_S^{\,0.02} - 1} \times \text{Index}$	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

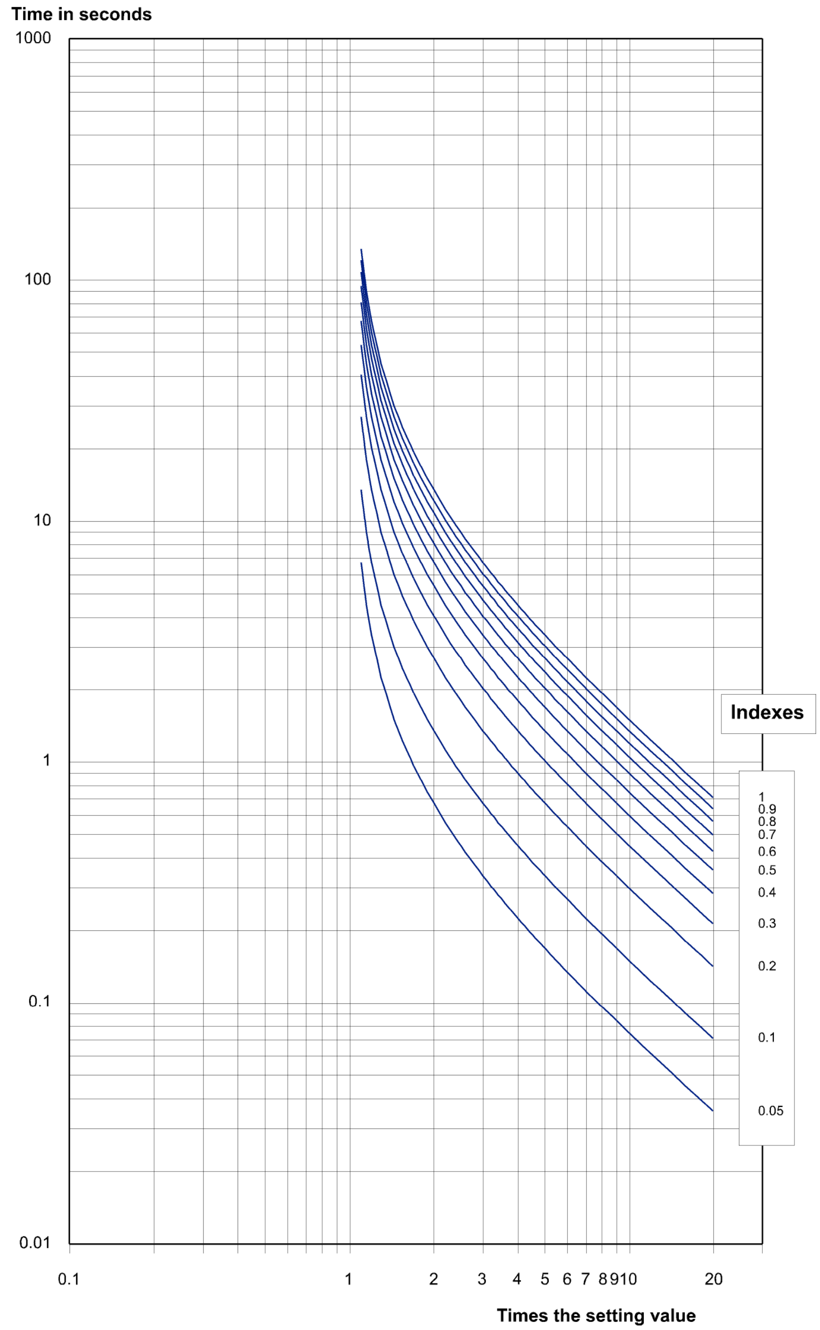


Figure 3.12.4 VERY INVERSE Time Curve (IEC).

$t = \frac{13.5}{I_S - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

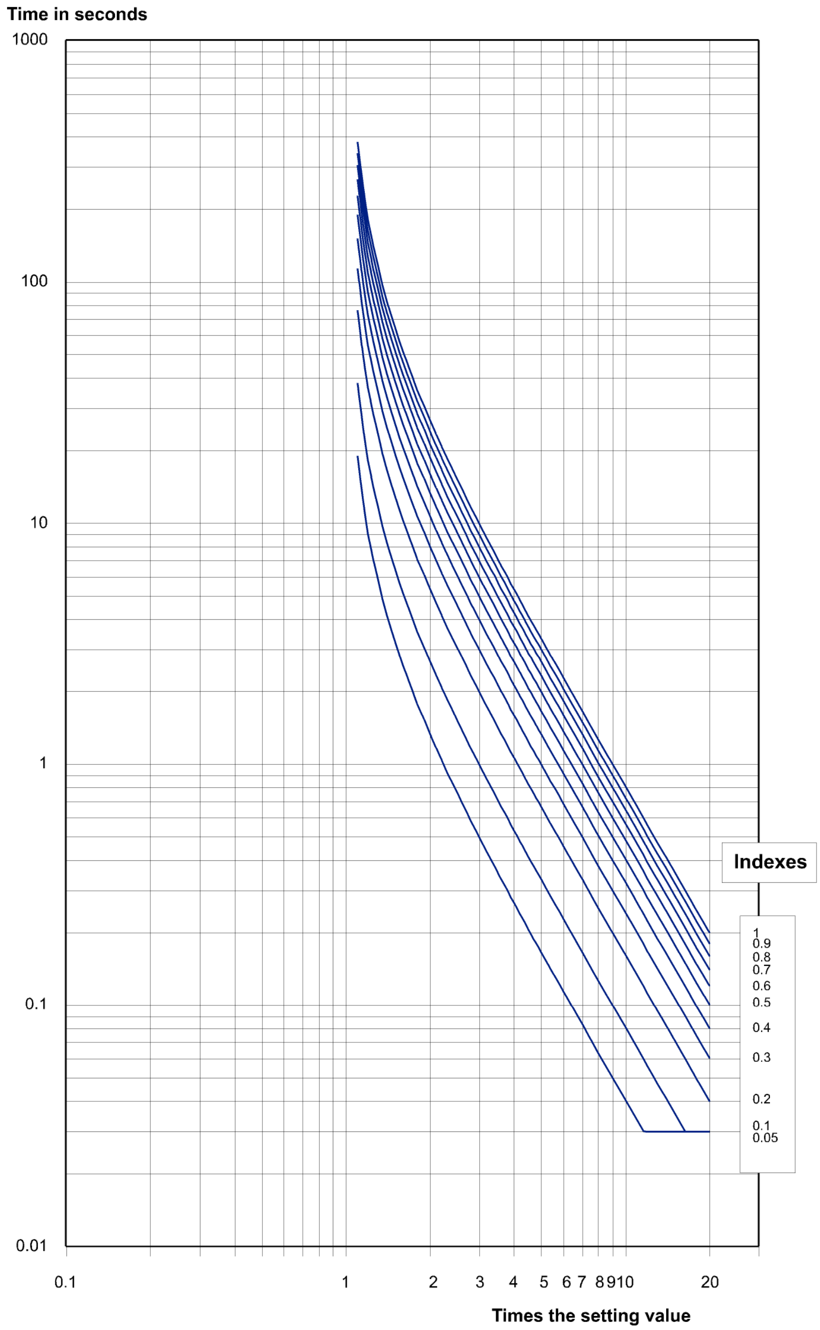


Figure 3.12.5 EXTREMELY INVERSE Time Curve (IEC).

$t = \frac{80}{I_S^{2} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

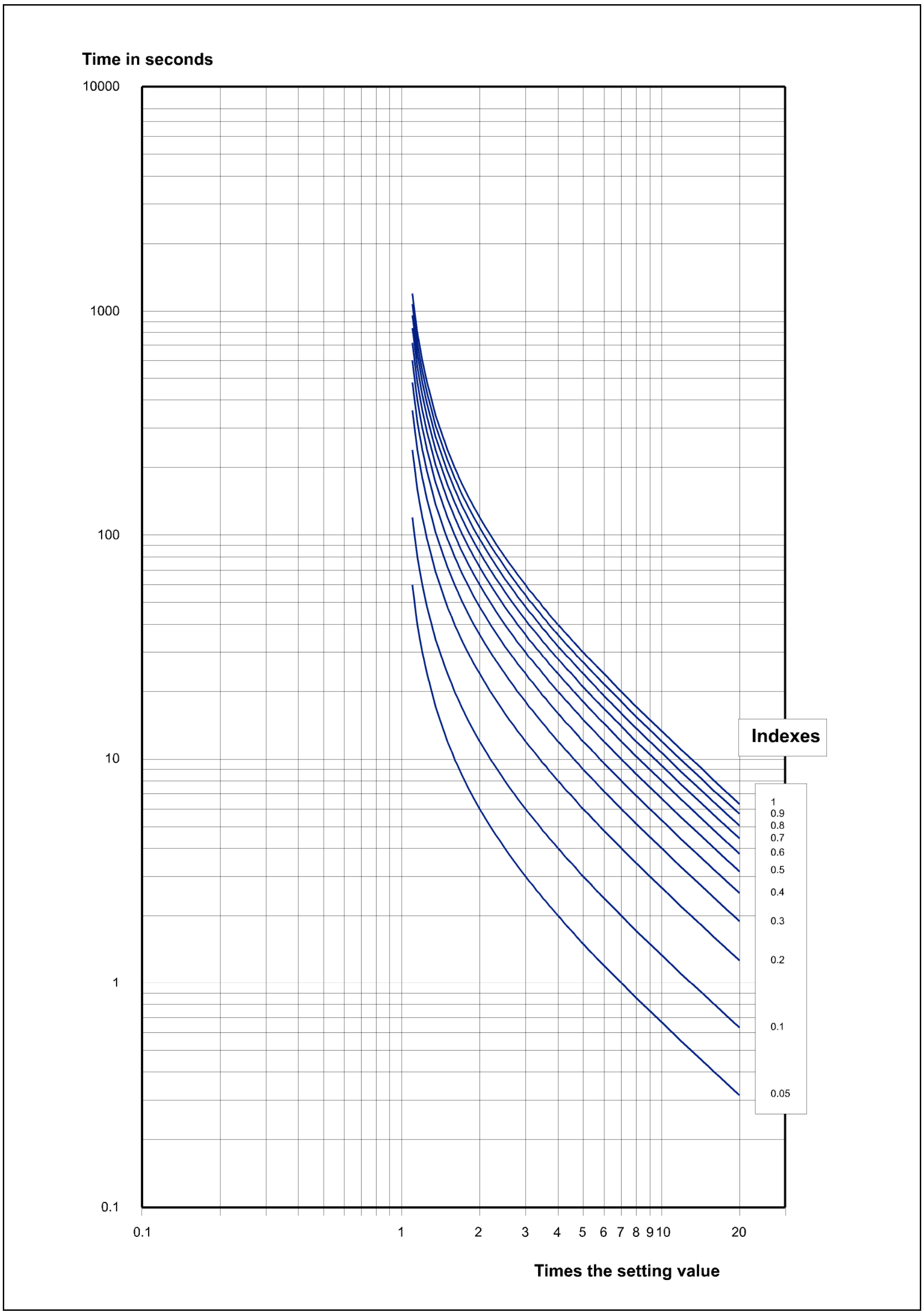


Figure 3.12.6 LONG TIME-INVERSE Curve (IEC).

$t = \frac{120}{I_S - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

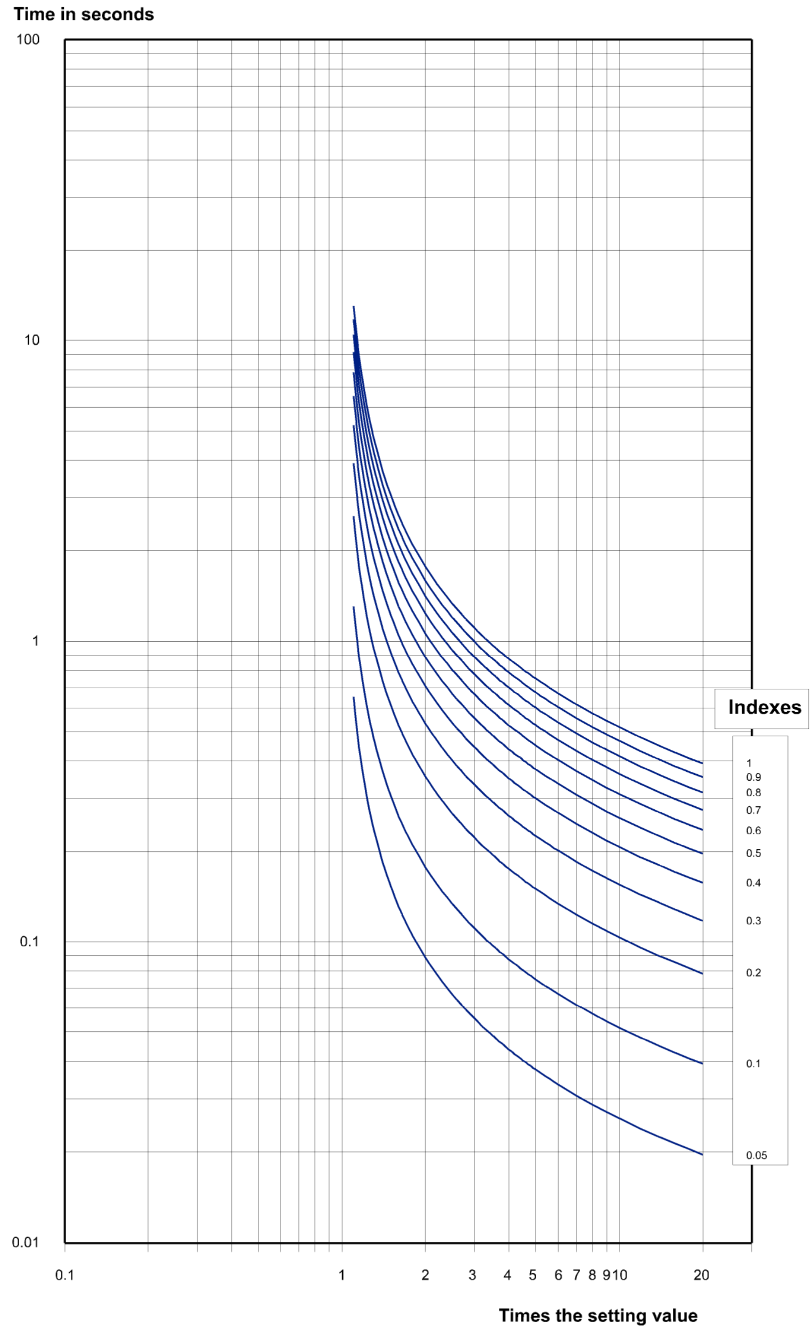


Figure 3.12.7 SHORT TIME-INVERSE Curve (IEC).

$t = \frac{0.05}{I_S^{0.04} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

Figures 3.12.8, 3.12.9, 3.12.10, 3.12.11, 3.12.12, 3.12.13, 3.12.14 and 3.12.15 present the inverse curves according to the **IEEE** and **US** standards available for the **ZLV** models.

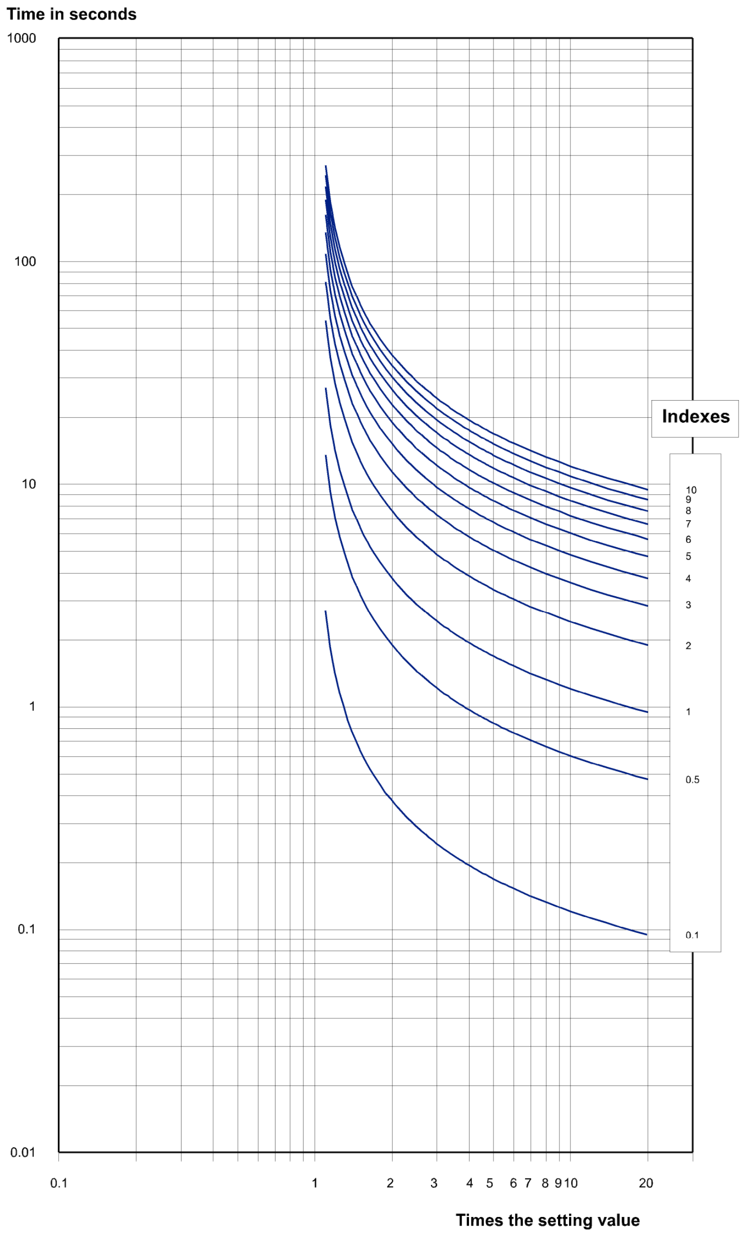


Figure 3.12.8 MODERATELY INVERSE Time Curve (IEEE).

$t = \left(0.114 + \dfrac{0.0515}{I_S^{0.02} - 1}\right)$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

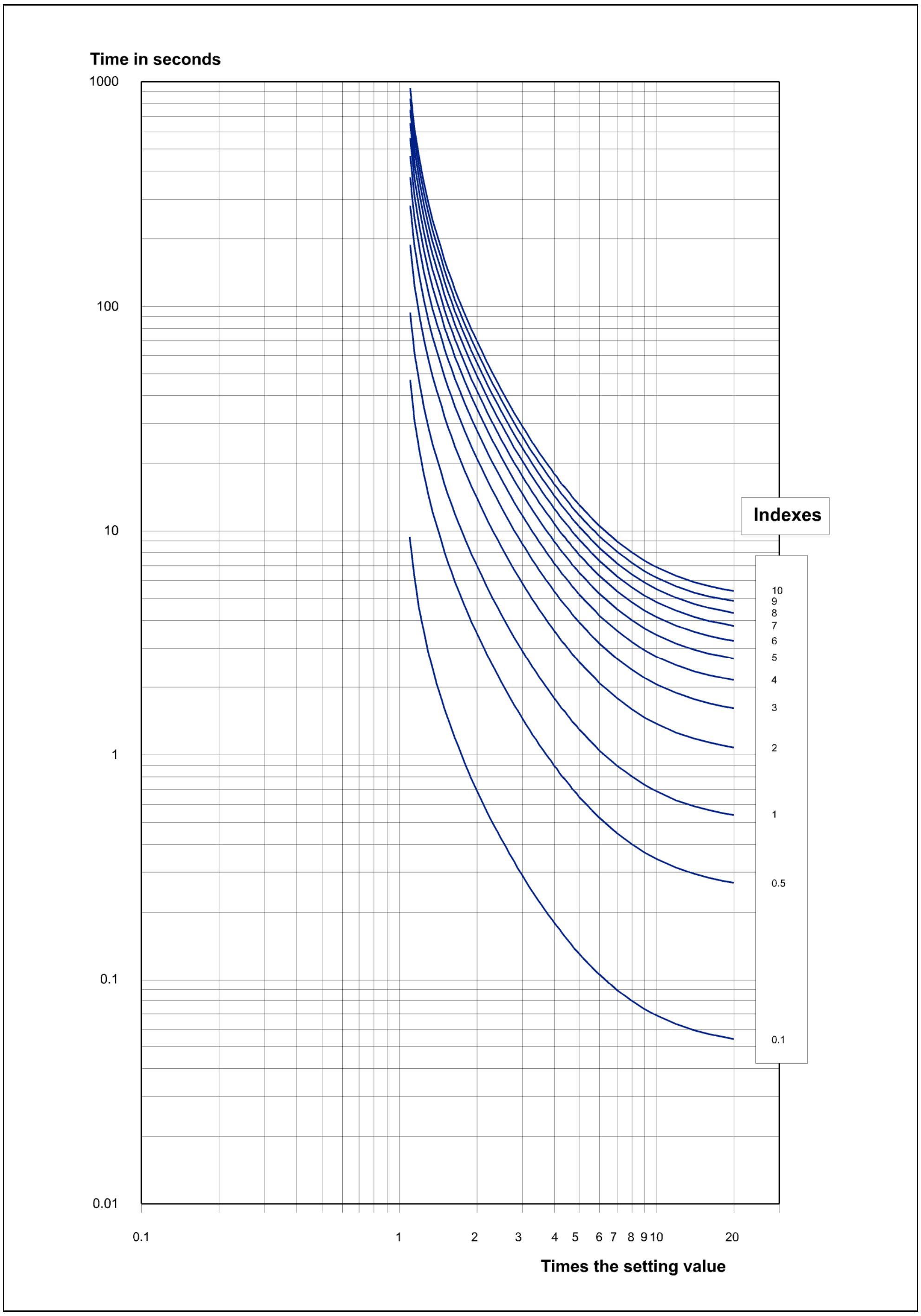


Figure 3.12.9 VERY INVERSE Time Curve (IEEE).

$t = \left(0.491 + \frac{19.61}{I_S^{2} - 1}\right)$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

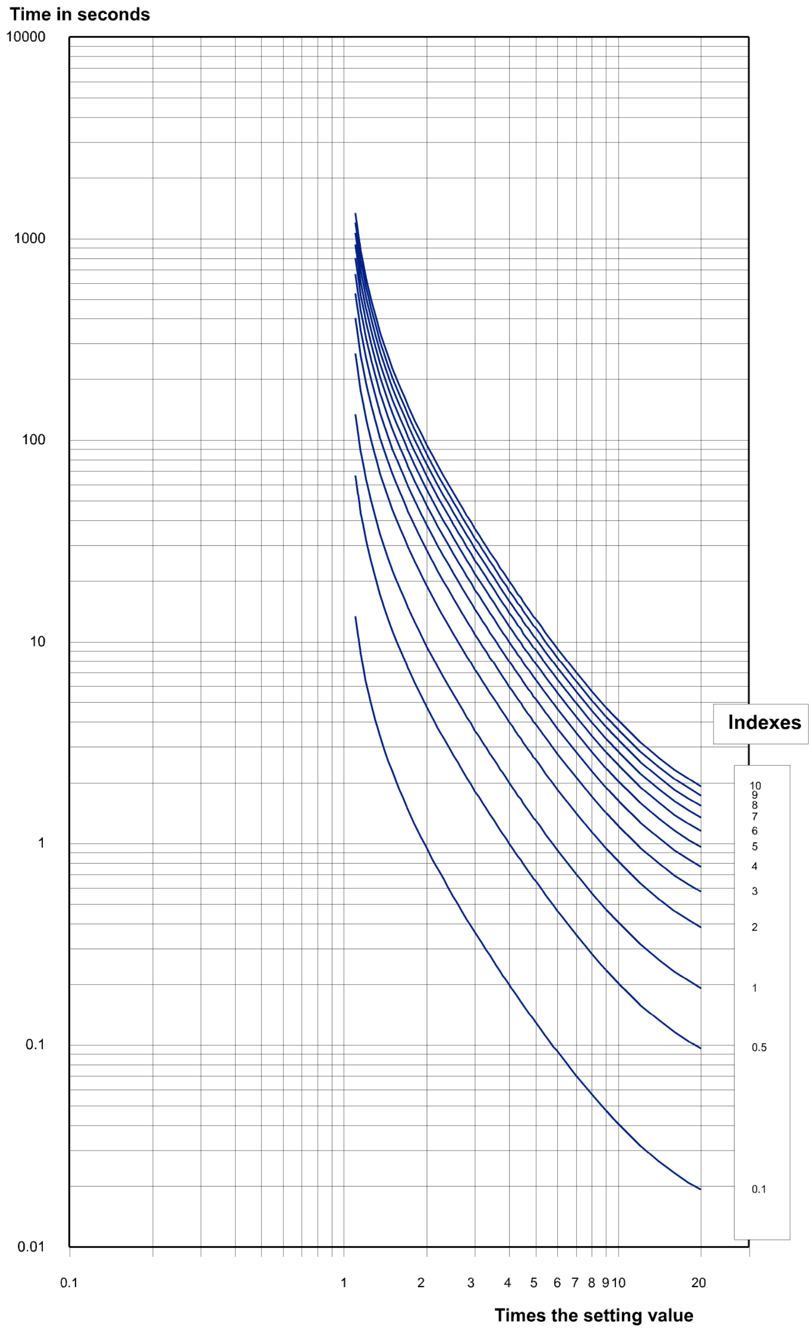


Figure 3.12.10 EXTREMELY INVERSE Time Curve (IEEE).

$t = \left(0.1217 + \frac{28.2}{I_S^2 - 1}\right)$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

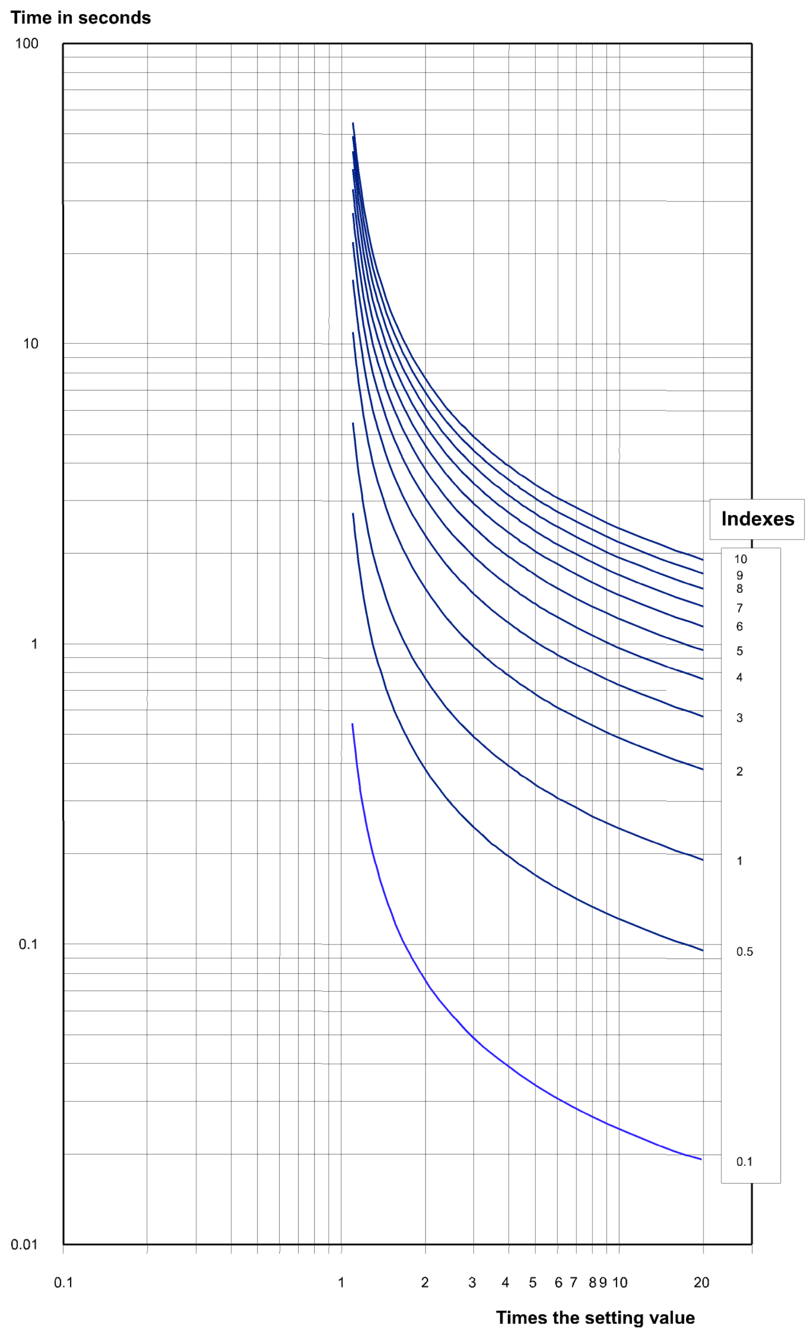


Figure 3.12.11 MODERATELY INVERSE Time Curve (U.S.)

$t = \left(0.0226 + \frac{0.0104}{I_S^{0.02} - 1}\right)$ x Index	$I_S = \frac{I\ measured}{I\ pickup}$

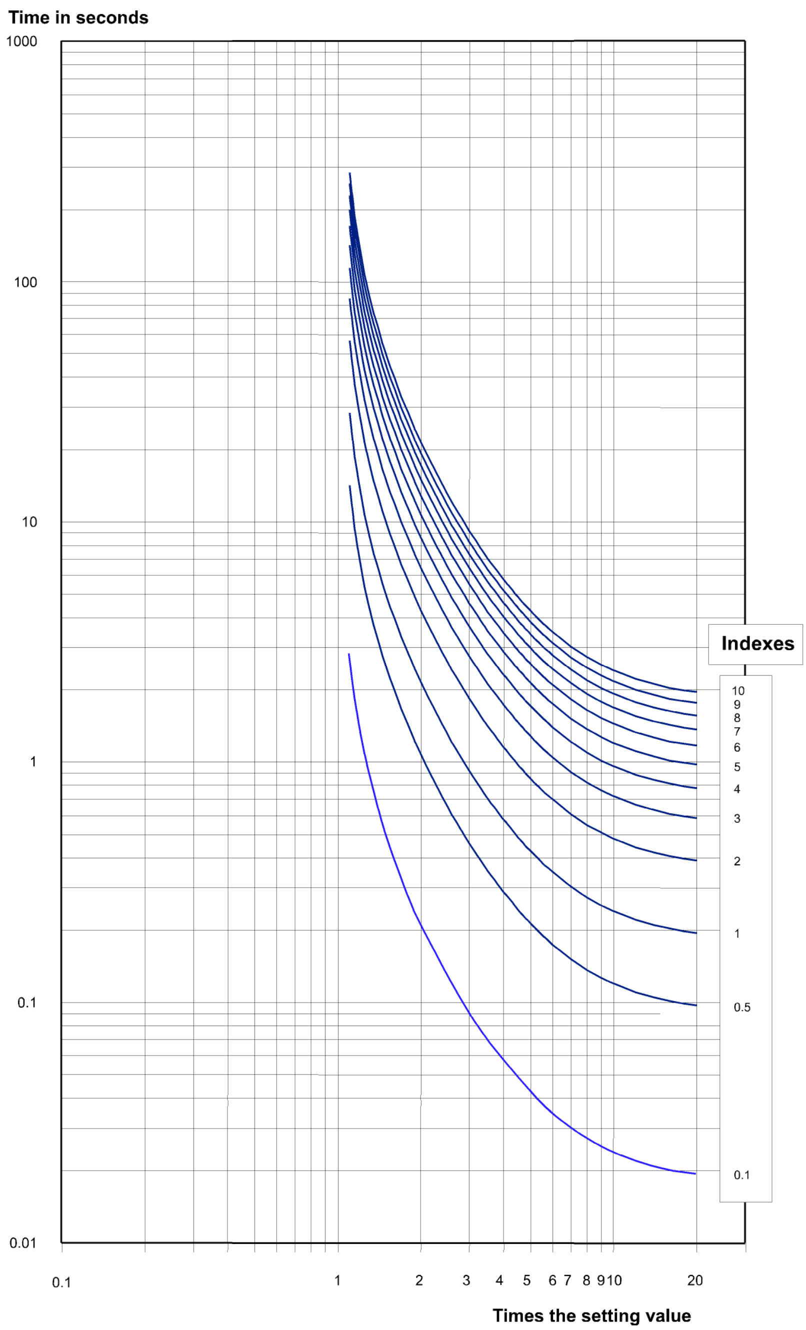


Figure 3.12.12 INVERSE Time Curve (U.S.).

$t = \left(0.180 + \frac{5.95}{I_S^2 - 1}\right)$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

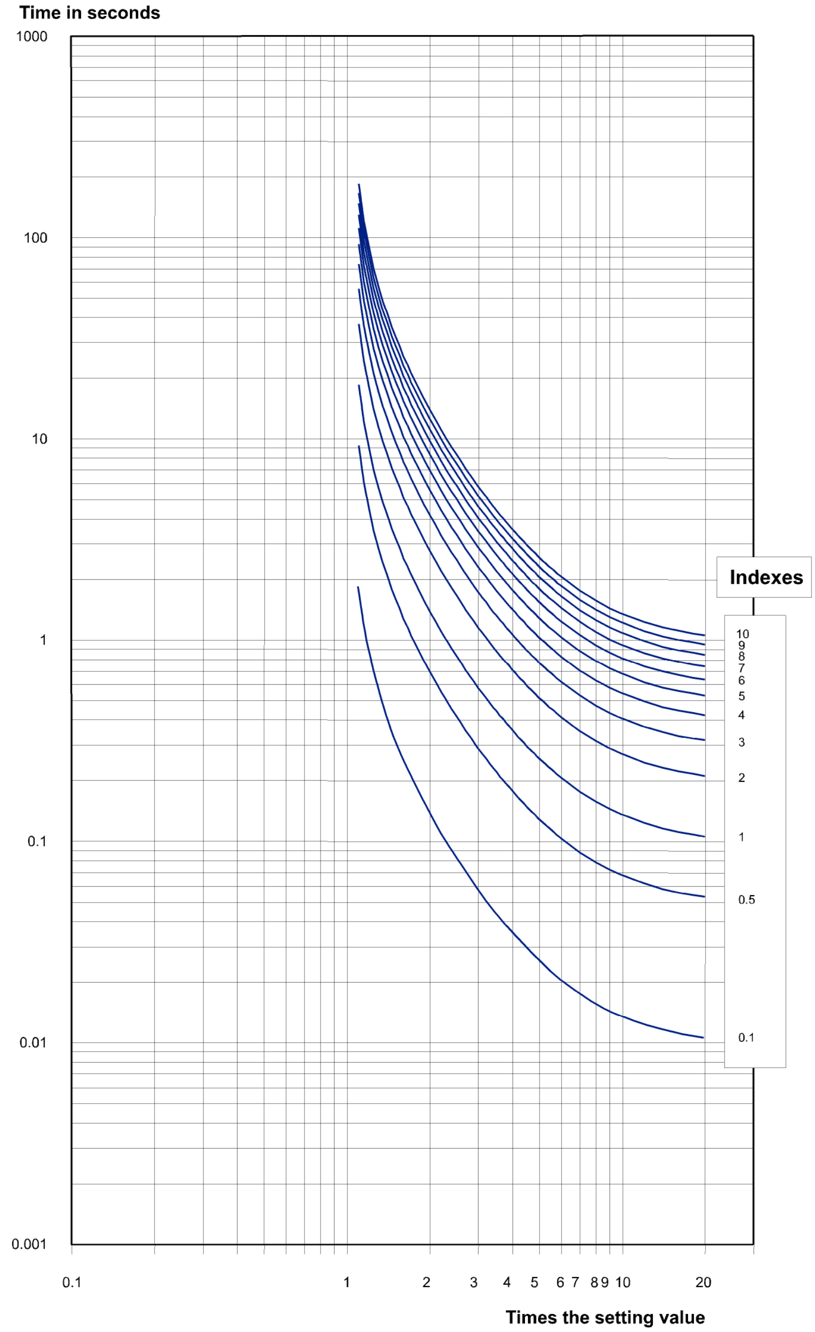


Figure 3.12.13 VERY INVERSE Time Curve (U.S.).

$t = \left(0.0963 + \frac{3.88}{I_S^2 - 1}\right)$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

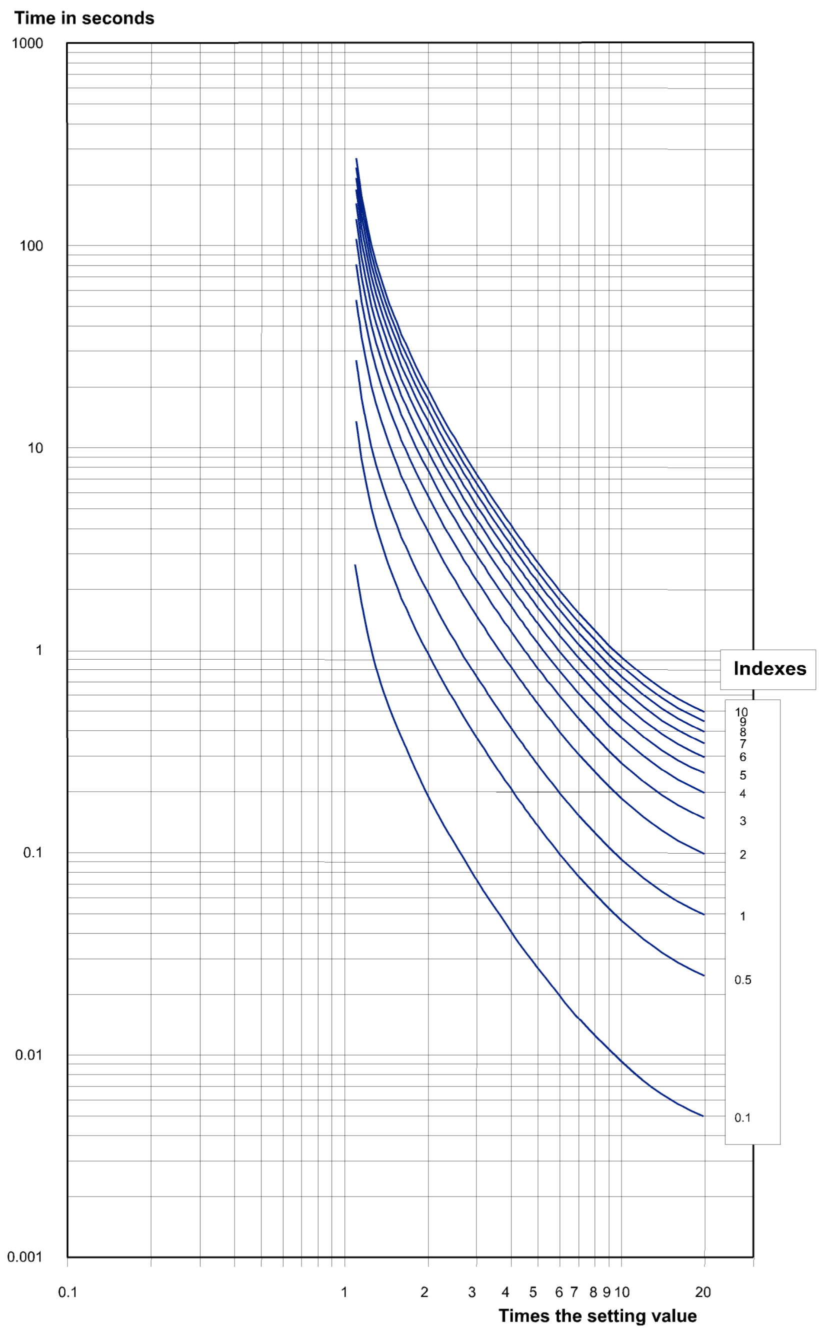


Figure 3.12.14 EXTREMELY INVERSE Time Curve (U.S.).

$t = \left(0.0352 + \frac{5.67}{I_S^2 - 1}\right)$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

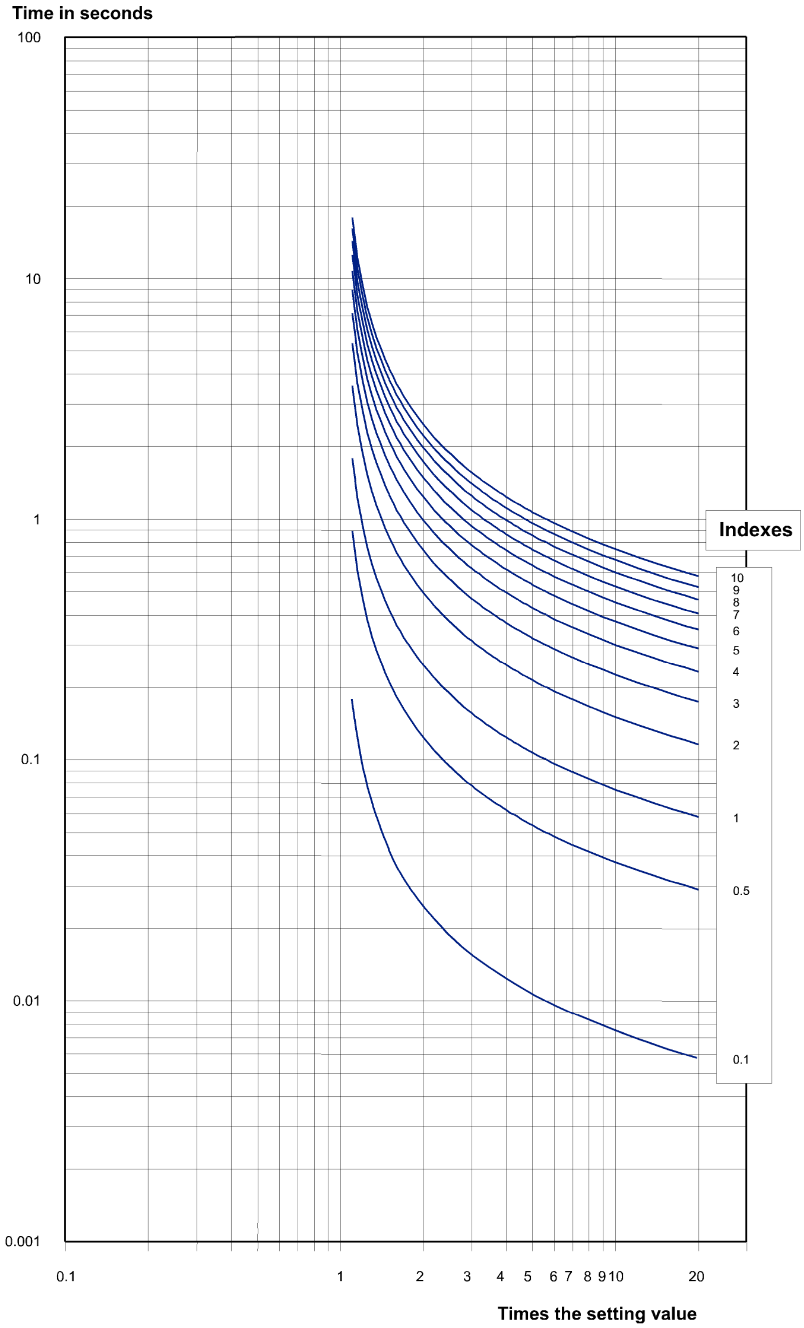


Figure 3.12.15 SHORT INVERSE Time Curve (U.S.).

$t = (0.00262 + \frac{0.00342}{I_S^{0.02} - 1})$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

And figure 3.12.16 presents the **RI Inverse** curve available for the **ZLV** models.

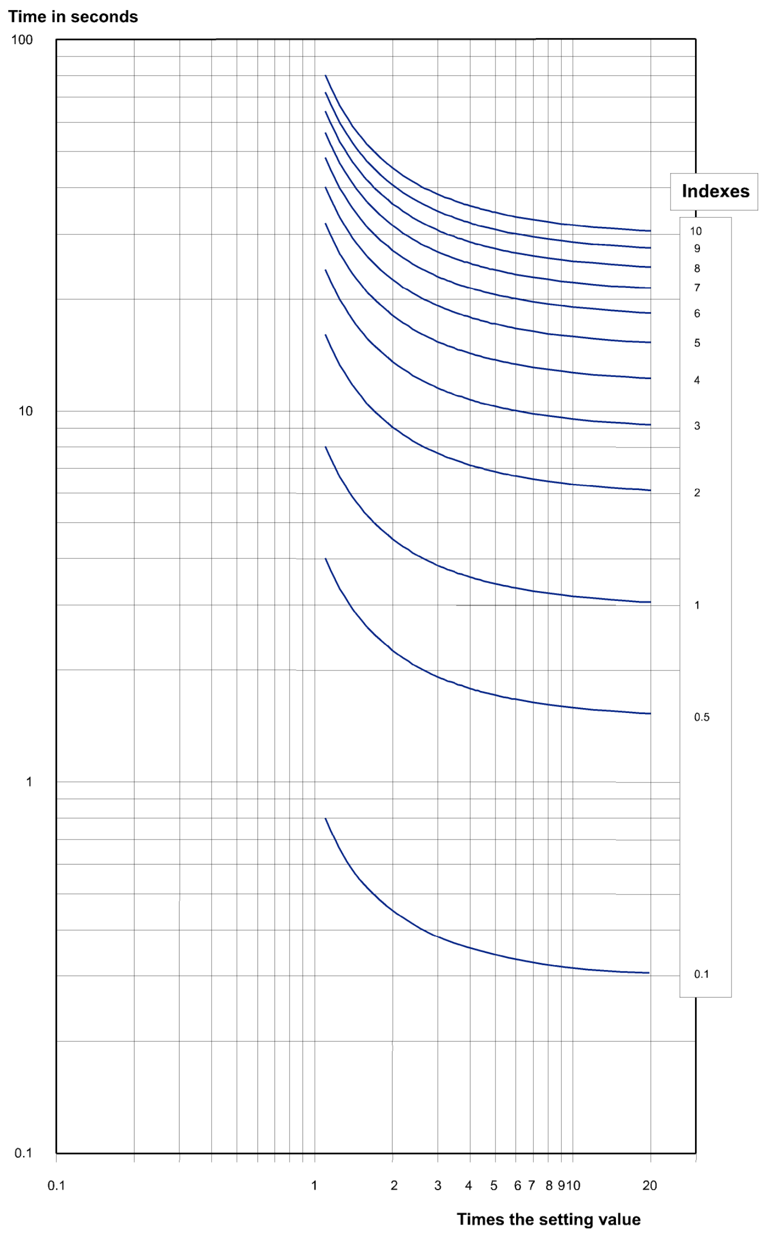


Figure 3.12.16 RI INVERSE Time Curve.

$t = \dfrac{1}{0.339 - 0.236 \cdot \left(\dfrac{1}{I_S}\right)}$ x Index	$I_S = \dfrac{I\ measured}{I\ pickup}$

3.12.3 Torque Control

The **Torque Control** setting associated with an overcurrent unit allows selecting the directionality of this unit. Possible setting values are:

1. There is no permission to use directionality.
2. Permission to use the indications in the co-direction current.
3. Permission to use the indications in the reverse current.

An element with **Torque Control** set to zero becomes non-directional.

On the other hand, the **Torque Control Type** setting corresponding to an overcurrent unit allows to select the type of directional unit in charge of subordinating it. The possible values that this setting can take for the different types of overcurrent units are indicated in the following.

3.12.3.a Torque Control In ZLV-***-****N/O** Models

The **Lack of Direction Blocking 60FF** settings allows to select the operation of the directional element for each overcurrent unit when a **Lack of Polarization by 60FF** is detected. This function is used to avoid the incorrect operation of the overcurrent units supervised by a directional unit in those cases where there is a lack of polarization, or it is not reliable, debt to a VT Fuse Failure or any other condition that may activate the Fuse Failure Detector. To activate this condition, the VT Fuse Failure unit (60FF) must be activated.

The **Lack of Direction Blocking 60FF** settings can be set as:

- **Directional Unit Setting**: the overcurrent unit will operate according to the directional unit. The directional elements will operate depending on its settings **Lack of Direction Blocking** and **Lack of Direction Blocking by 60FF**(*).
- **Yes**: the overcurrent unit will be blocked anytime the **Lack of Polarization by 60FF** is detected.
- **No**: the overcurrent unit will have trip permission anytime the **Lack of Polarization by 60FF** is detected.

**Note: the Lack of Direction settings of the directional elements affect the activation of the Direction and Reverse signals, and so, it affects to all the overcurrent units supervised by that directional element.*

Phase Overcurrent (Instantaneous or Time Elements)

67F (phase directional element).
67P (positive sequence directional element; only available in **ZLV-***-****A/B/C/D/E/F/G/H**** relays). This option has been designed for series compensation lines. The polarization of the positive sequence directional element (positive sequence voltage with memory) enables generating correct directional decisions on voltage reversal.
ZII (phase or ground zone 2 directionality).

The ZII option has the advantages already mentioned of the directionality of the distance characteristics (see 3.1). Similarly, if ZII is selected in a time overcurrent unit, a time activation output of zone 2 can be obtained based on an inverse curve, which may be used to carry out coordinations with electromechanical relays.

Ground Overcurrent (Instantaneous or Time Elements)

67N (ground directional element).
67Q (negative sequence directional element).
ZIIG (ground zone 2 directionality).

The 67Q option may be interesting vs. the 67N option when very low V0 voltage levels are anticipated, less than the minimum threshold to polarize the ground directional unit. This condition may arise in very strong zero-sequence source systems (low impedance of zero-sequence local source). On the other hand, the 67Q option may be of interest when there are large mutual couplings (zero sequence) with a parallel line, which could distort the V0 voltage.

Negative Sequence Overcurrent (Instantaneous or Time Elements)

67Q (negative sequence directional element).
ZII (phase or ground zone 2 directionality).

3.12.4 Block Trip and Bypass Time

Both instantaneous and time overcurrent elements can program **Block Trip** inputs, which prevents the operation of the element if this input is activated before the trip is generated. If activated after the trip, it resets. To be able to use these logic input signals, it is necessary to program the status contact inputs defined as block trip.

Another programmable input can change a time overcurrent element into an instantaneous element. This input is called **Bypass Time** and is available for all the time overcurrent elements.

3.12.5 Harmonics Blocking (ZLV-***-****C/D/E/F/G/H**)

The energising of a transformer causes transient saturation as a consequence of the dc component generated in the magnetic flux. This results in high magnetising currents (*inrush*), which can be several times the machine rated current.

In order to avoid the operation of overcurrent elements under the mentioned magnetising currents, **ZLV-***-****C/D/E/F/G/H**** models include the Harmonics Blocking function.

In order to differentiate between a fault current and an *inrush* current, both with high fundamental component, the 2nd harmonic component is analysed. Energising currents have a high 2nd harmonic content. Blocking by 2nd harmonics is enabled through the settings **2nd Blocking Enable**. The 2nd harmonic content is calculated for the three phase currents and ground current. When the ratio between the 2nd harmonic current and the fundamental current exceeds, in percentage, the setting **2nd Blocking Pickup**, the signals **Phase A Blocking by 2nd Harmonic**, **Phase B Blocking by 2nd Harmonic**, **Phase C Blocking by 2nd Harmonic**, **Ground Blocking by 2nd Harmonic** and **Sensitive Ground Blocking by 2nd Harmonic** will activate, as a function of the type of current analysed.

The calculation of the ratio *harmonic current / fundamental current* will only be carried out when the fundamental current exceeds the setting **MInimum Current** (phase or ground). This setting must equal the minimum pickup level setting of the applicable overcurrent element (phase or ground).

For phase overcurrent elements, there is the possibility to enable a cross-blocking logic. This logic allows for extending the blocking by harmonics to the rest of phases when at least in one phase (**OR** option) or in two phases (**2 out of 3** option) the harmonic level is high. The **AND** option of the setting **Harmonics Blocking Logic** disables the crossed-blocking logic.

The setting **Cross Blocking Time** limits the duration of the cross-blocking logic.

The signal **Cross Blocking by Harmonics** indicates the cross-blocking logic setting: **OR** or **2 out of 3** is met.

3.12.6 Operation of the Overcurrent Elements

3.12.6.a Instantaneous Elements

Operation of the instantaneous elements is shown in the block diagrams of Figures 3.12.17, 3.12.18 and 3.12.19.

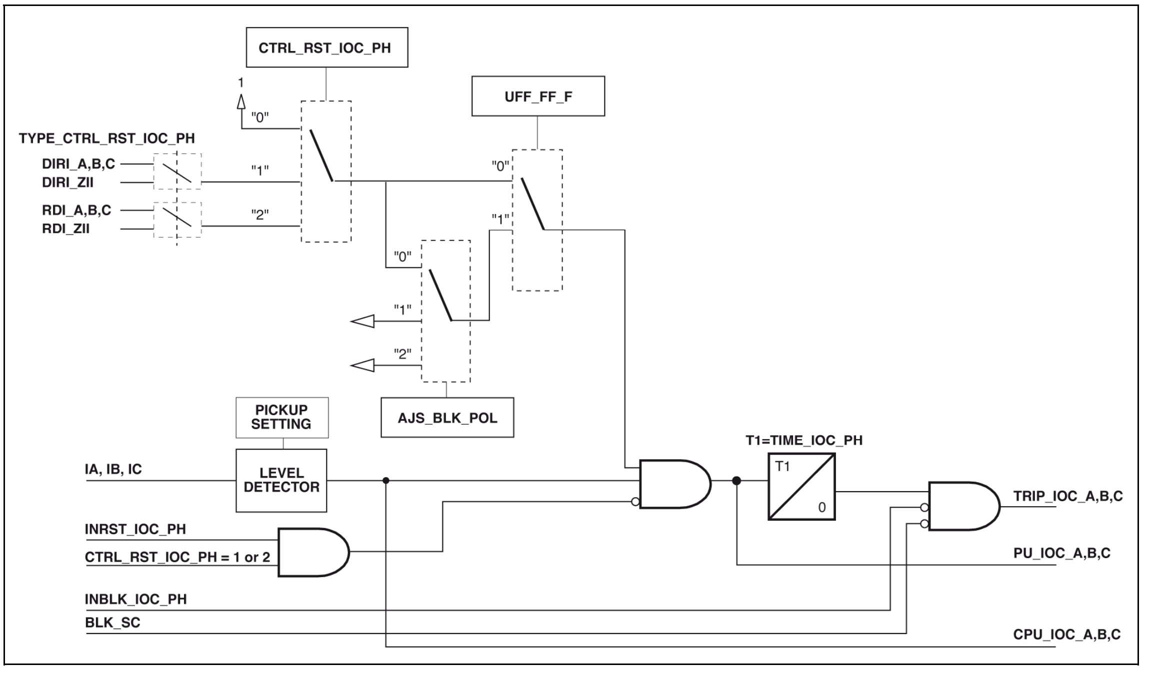


Figure 3.12.17 Block Diagram of a Phase Instantaneous Overcurrent Element.

Legend
INRST_IOC_PH: Phase Instantaneous Torque Annulment Input.
BLK_SC: Series Compensation Logic Blocking.
INBLK_IOC_PH: Phase Instantaneous Block Trip Input.
TRIP_IOC_A,B,C: Instantaneous A, B, C Unit Trip.
PU_IOC_A,B,C: Instantaneous A, B, C Unit Pickup.
CPU_IOC_A,B,C: Phase A, B, C Instantaneous Unit Pickup Conditions.
DIRI_A,B,C / RDI_A,B,C: Phase A, B, C Instantaneous Direction / Reverse Direction.
DIRI_ZII / RDI_ZII: Zone 2 Instantaneous Direction / Reverse Direction.
TYPE_CTRL_RST_IOC_PH: Phase IOC Torque Control Type (setting).
CTRL_RST_IOC_PH: Phase IOC Torque Control (setting).
TIME_IOC_PH: Phase IOC Time Delay (setting).

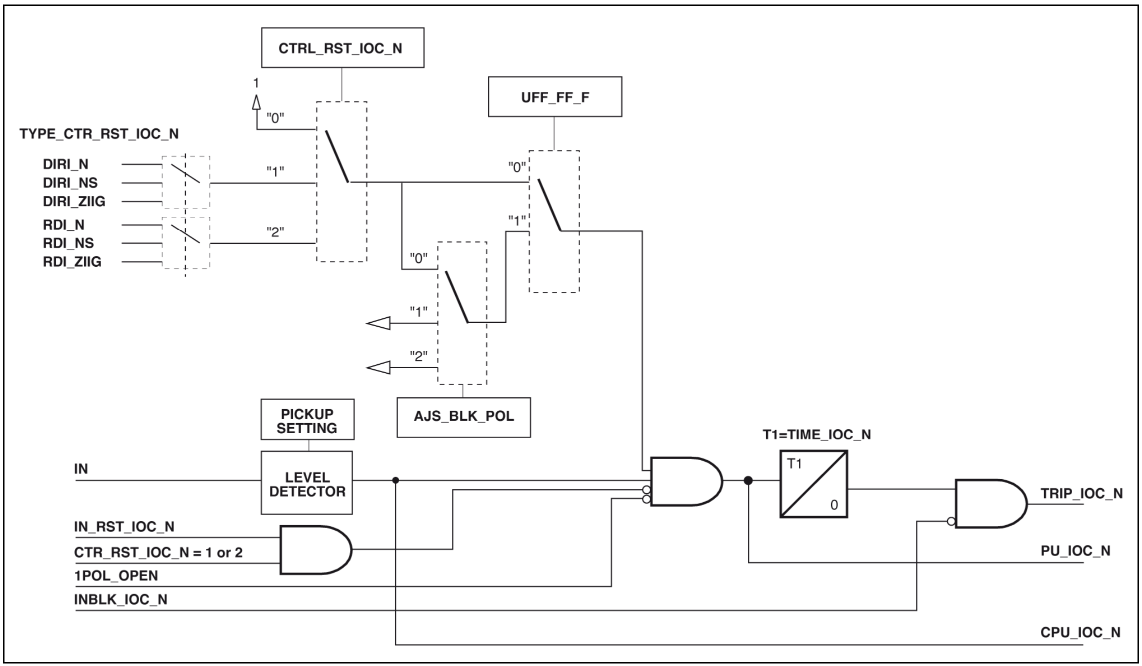


Figure 3.12.18 Block Diagram of a Ground Instantaneous Overcurrent Element.

Legend
IN_RST_IOC_N: Ground Instantaneous Torque Annulment Input.
1POL_OPEN: One Open Pole.
INBLK_IOC_N: Ground Instantaneous Block Trip Input.
TRIP_IOC_N: Ground Instantaneous Unit Trip.
PU_IOC_N: Ground Instantaneous Unit Pickup.
CPU_IOC_N: Ground Instantaneous Unit Pickup Conditions.
DIRI_N / RDI_N: Ground Instantaneous Direction / Reverse Direction.
DIRI_NS / RDI_NS: Negative Sequence Instantaneous Direction / Reverse Direction.
DIRI_ZIIG / RDI_ZIIG: Zone 2 Ground Instantaneous Direction / Reverse Direction.
TYPE_CTR_RST_IOC_N: Ground IOC Torque Control Type (setting).
CTR_RST_IOC_N: Ground IOC Torque Control (setting).
TIME_IOC_N: Ground IOC Time Delay (setting).

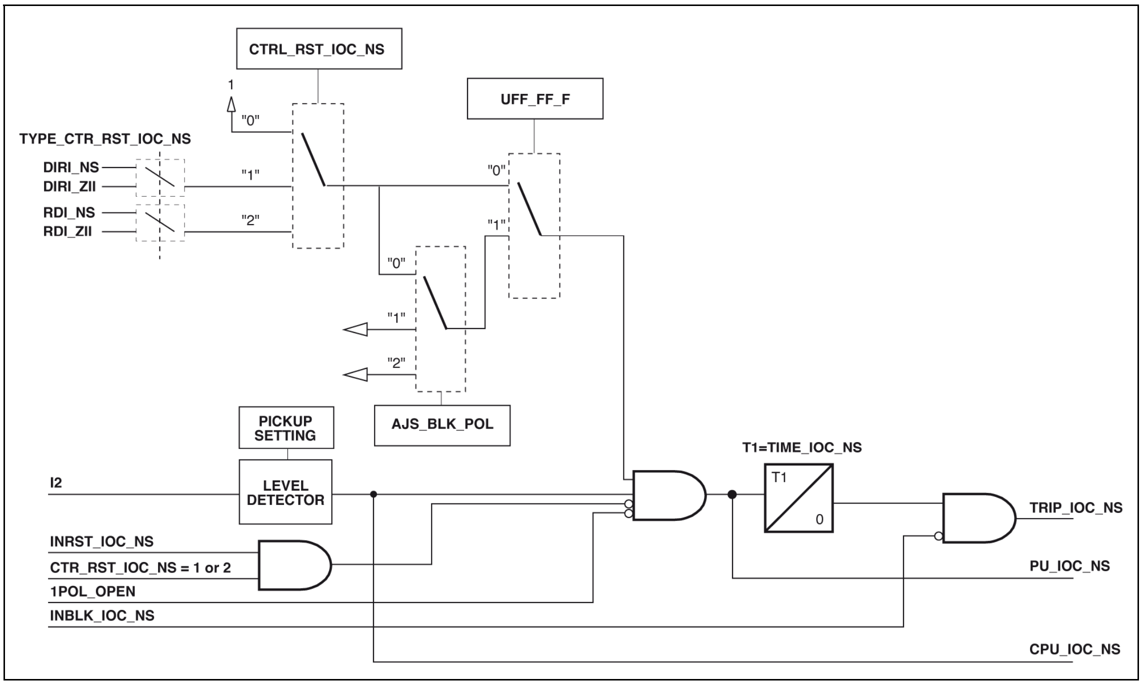


Figure 3.12.19 Block Diagram of a Negative Sequence Instantaneous Overcurrent Element.

Legend
IN_RST_IOC_NS: Negative Sequence Instantaneous Torque Annulment Input.
1POL_OPEN: One Open Pole.
INBLK_IOC_NS: Negative Sequence Instantaneous Block Trip Input.
TRIP_IOC_NS: Negative Sequence Instantaneous Trip.
PU_IOC_NS: Negative Sequence Instantaneous Pickup.
CPU_IOC_NS: Negative Sequence Instantaneous Pickup Conditions.
DIRI_NS / RDI_NS: Negative Sequence Instantaneous Direction / Reverse Direction.
DIRI_ZII / RDI_ZII: Zone 2 Instantaneous Direction / Reverse Direction.
TYPE_CTR_RST_IOC_NS: Negative Sequence IOC Torque Control Type (setting).
CTR_RST_IOC_NS: Negative Sequence IOC Torque Control (setting).
TIME_IOC_NS: Negative Sequence IOC Time Delay (setting).

Figure 3.12.17 shows how the **Series Compensation Blocking** (**BLK_SC**) signal, originating from the **Series Compensation Logic*** (see 3.14), blocks, during the time it remains active, the phase overcurrent units which supervise in a forward looking direction (units 1 and 2 in case of using **ZLV** in lines with series compensation). The ground and negative sequence units do not need to be blocked by the **BLK_SC** signal, as is indicated in the **Series Compensation Logic**.

Figures 3.12.18 and 3.12.19 show the blocking that the **One Open Pole** (**1POL_OPEN**) signal carries out on the ground and negative sequence overcurrent units, in order to prevent its pickup in case of a new situation originated by the aperture of a pole.

The **Torque Disable** input associated with each instantaneous overcurrent unit (**INRST_IOC**) blocks the pickup of the unit, provided that this includes directionality (torque control = 1 or 2).

The **Directional** (**DIRI**) and **Counter Directional** (**RDI**) signals included in the previous diagrams originate from the directional units described in 3.13.

* Not available for the ZLV-E models.

3.12.6.b Time-Delayed Elements

Operation of the time delayed elements is also shown in the block diagrams of Figures 3.12.20, 3.12.21 and 3.12.22.

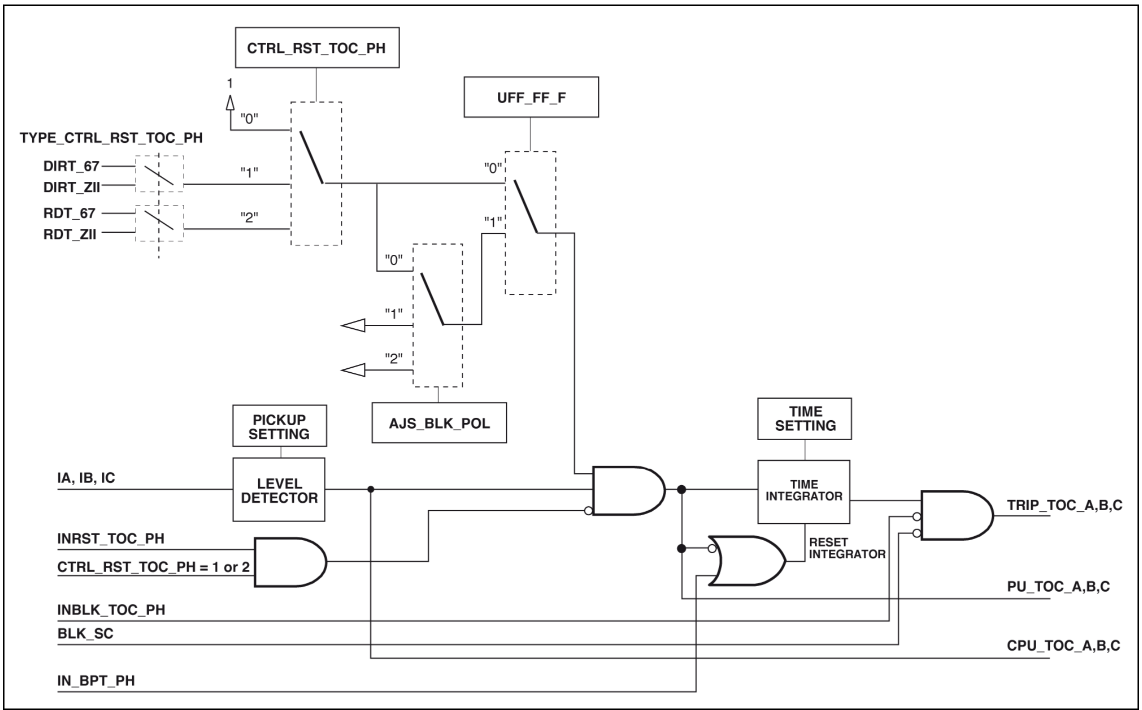


Figure 3.12.20 Block Diagram of a Phase Time Overcurrent Element.

Legend
INRST_TOC_PH: Phase Time Torque Annulment Input.
BLK_SC: Series Compensation Logic Blocking.
INBLK_TOC_PH: Phase Time Block Trip Input.
IN_BPT_PH: Phase Time Unit Bypass Time Input.
TRIP_TOC_A,B,C: Time A, B, C Unit Trip.
PU_TOC_A,B,C Time A, B, C Unit Pickup.
CPU_TOC_A,B,C: Phase A, B, C Time Unit Pickup Conditions.
DIRT_A,B,C / RDT_A,B,C: Phase A, B, C Time Direction / Reverse Direction.
DIRT_ZII / RDT_ZII: Zone 2 Time Direction / Reverse Direction.
TYPE_CTRL_RST_TOC_PH: Phase TOC Torque Control Type (setting).
CTRL_RST_TOC_PH: Phase TOC Torque Control (setting)

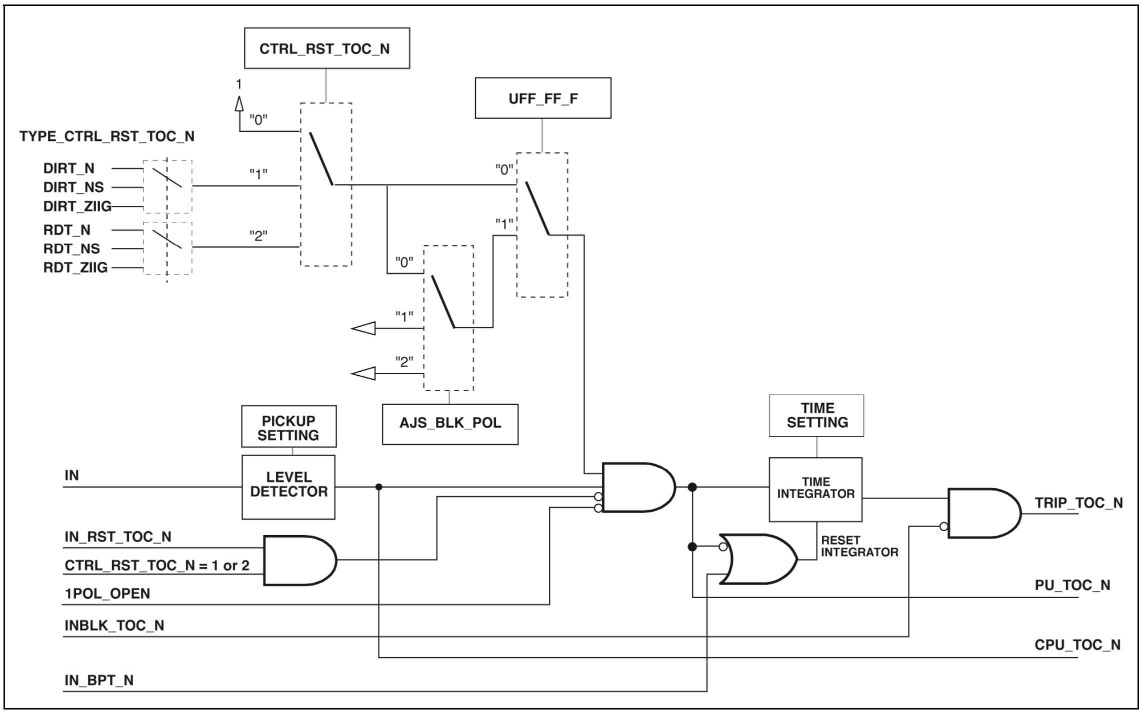


Figure 3.12.21 Block Diagram of a Ground Time Overcurrent Element.

Legend
IN_RST_TOC_N: Ground Time Torque Annulment Input.
1POL_OPEN: One Open Pole.
INBLK_TOC_N: Ground Time Block Trip Input.
IN_BPT_N: Ground Time Unit Bypass Time Input.
TRIP_TOC_N: Ground Time Unit Trip.
PU_TOC_N: Ground Time Unikt Pickup.
CPU_TOC_N: Ground Time Unit Trip Conditions.
DIRT_N / RDT_N: Ground Time Direction / Reverse Direction
DIRT_NS / RDT_NS: Negative Sequence Time Direction / Reverse Direction.
DIRT_ZIIG / RDT_ZIIG: Zone 2 Ground Time Direction / Reverse Direction.
TYPE_CTRL_RST_TOC_N: Ground TOC Torque Control Type (setting).
CTRL_RST_TOC_N: Ground TOC Torque Control (setting).

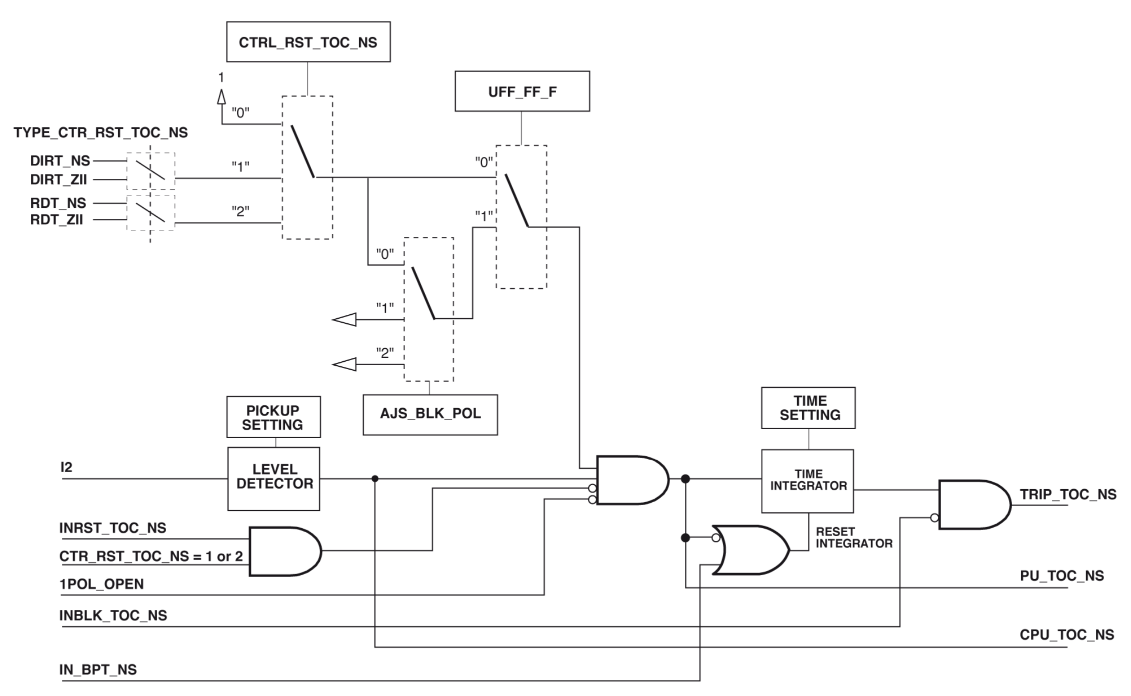


Figure 3.12.22 Block Diagram of a Negative Sequence Time Overcurrent Element.

Legend
IN_RST_TOC_NS: Negative Sequence Time Torque Annulment Input.
1POL_OPEN: One Open Pole.
INBLK_TOC_NS: Negative Sequence Time Block Trip Input.
TRIP_TOC_NS: Negative Sequence Time Trip.
PU_TOC_NS: Negative Sequence Time Pickup.
CPU_TOC_NS: Negative Sequence Time Pickup Conditions.
DIRT_NS / RDT_NS: Negative Sequence Time Direction / Reverse Direction.
DIRT_ZII / RDT_ZII: Zone 2 Time Direction / Reverse Direction.
TYPE_CTR_RST_TOC_NS: Negative Sequence.
TOC Torque Control Type (setting).
CTR_RST_TOC_NS: Negative Sequence TOC Torque Control (setting).

Figure 3.12.20 shows how the **Series Compensation Blocking** (**BLK_SC**), originating from the **Series Compensation Logic**[*] (see 3.15), blocks, during the time it remains active, the phase overcurrent units which supervise in a forward looking direction (units 1 and 2 in case of using **ZLV** in lines with series compensation). The ground and negative sequence units do not need to be blocked by the **BLK_SC** signal, as was indicated in **Series Compensation Logic**.

Figures 3.12.21 y 3.12.22 show the blocking that the **Open Pole** (**1POL_OPEN**) signal carries out on ground and negative sequence overcurrent units, in order to prevent its pickup in case of a new situation arising as a result of the aperture of a pole.

The **Torque Disable** input associated with each time overcurrent unit (**INRST_TOC**) blocks the pickup of the unit provided that this includes directionality (torque control =1 or 2).

The **Directional** (**DIRT**) and **Counter Directional** (**RDT**) signals included in the previous diagrams originate from the directional units, described in 3.13.

[*] Not available for the ZLV-E models.

3.12.7 Overcurrent Elements Settings

Phase Instantaneous Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Pickup	(0.01 - 30) In	0.01 A	In
Time Delay	0 - 300 s	0.01 s	0 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Phase directional element (67F) 1: Zone 2 (Z2) 2: Positive sequence directional unit (67P) (ZLV-***-****A/B/C/D/E/F/G/H**)		0: Phase dir. element
Lack of Direction Blocking 60FF (ZLV-***-****O/N**)	0: Directional Setting 1: YES 2: NO		0: Directional Setting

Ground Instantaneous Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Pickup	(0.12 - 30) In (0.01- 30) In (ZLV-***-****A/B/C/D/E/F/G/H**)	0.01 A	In
Time Delay	0 - 300 s	0.01 s	0 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Ground directional element (67N) 1: Negative sequence direct. Element (67Q) 2: Ground Zone 2 (Z2G)		0: Ground directional element
Lack of Direction Blocking 60FF (ZLV-***-****O/N**)	0: Directional Setting 1: YES 2: NO		0: Directional Setting

Negative Sequence Instantaneous Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Pickup	(0.01 - 30) In (0,05 - 30) In (ZLV-***-****A/B/C/D/E/F/G/H**)	0.01 A	2 In
Time Delay	0 - 300 s	0.01 s	0 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Negative sequence direct. element (67Q) 1: Zone 2 (Z2)		0: Neg. seq. dir. element
Lack of Direction Blocking 60FF (ZLV-***-****O/N**)	0: Directional Setting 1: YES 2: NO		0: Directional Setting

Phase Time Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Pickup	(0.02 - 25) In	0.01 A	0.4 In
Time Curve	See curve list		Fixed Time
Inverse Time Curve Dial	0.05 - 10	0.01	1
Effective Range for the IEC Curves	0.05 - 1	0.01	1
Effective Range for the IEEE/US Curves	0.1 - 10	0.01	1
Time Delay	0.05 - 300 s	0.01 s	0.05 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Phase directional element (67F) 1: Zone 2 (Z2) 2: Positive sequence directional unit (67P) (ZLV-***-****A/B/C/D/E/F/G/H**)		0: Phase dir. element
Lack of Direction Blocking 60FF (ZLV-***-****O/N**)	0: Directional Setting 1: YES 2: NO		0: Directional Setting

Ground Time Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Pickup	(0.12 - 25) In (0.02- 25) In (ZLV-***-****A/B/C/D/E/F/G/H**)	0.01 A	0.4 In
Time Curve	See curve list		Fixed Time
Inverse Time Curve Dial	0.05 - 10	0.01	1
Effective Range for the IEC Curves	0.05 - 1	0.01	1
Effective Range for the IEEE/US Curves	0.1 - 10	0.01	1
Time Delay	0.05 - 300 s	0.01 s	0.05 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Ground directional element (67N) 1: Negative sequence dir. element (67Q) 2: Ground Zone 2 (Z2G)		0: Ground dir. element
Lack of Direction Blocking 60FF (ZLV-***-****O/N**)	0: Directional Setting 1: YES 2: NO		0: Directional Setting

Negative Sequence Time Overcurrent (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**Default**
Enable	YES / NO		NO
Pickup	(0.1- 5.0) In	0.01 A	0.4 In
Time Curve	See curve list		Fixed Time
Inverse Time Curve Dial	0.05 - 10	0.01	1
Effective Range for the IEC Curves	0.05 - 1	0.01	1
Effective Range for the IEEE/US Curves	0.1 - 10	0.01	1
Time Delay	0.05 - 300 s	0.01 s	0.05 s
Torque Control (Pickup Blocking Enable)	0: Non-directional 1: Directional 2: Reverse direction		0: Non-directional
Torque Control Type	0: Negative sequence direct. element (67Q) 1: Zone 2 (Z2)		0: Neg. seq. dir. element
Lack of Direction Blocking 60FF (ZLV-***-****O/N**)	0: Directional Setting 1: YES 2: NO		0: Directional Setting

Harmonics Blocking (ZLV-***-****C/D/E/F/G/H**)			
Setting	**Range**	**Step**	**Default**
2nd Blocking Enable	YES / NO		NO
2nd Blocking Pickup	5% - 100%	0.01%	20%
Harmonics Blocking Logic	0 - OR 1 - AND 2 - 2 out of 3		0 - OR
Cross Bloking Time	0.05 s - 300 s	0.01 s	0.1 s
Phase Minimum Current	0.01 - 120 A	0.01 A	0.2 A

List of Available Curves

IEC CURVES

Inverse Curve	Inverse Curve + Time Limit
Very Inverse Curve	Very Inverse Curve + Time Limit
Extremely Inverse Curve	Extremely Inverse Curve + Time Limit
Long-Term Inverse Curve	Long-Term Inverse Curve + Time Limit
Short-Term Inverse Curve	Short-Term Inverse Curve + Time Limit

IEEE CURVES

Moderately Inverse Curve	Moderately Inverse Curve + Time Limit
Very Inverse Curve	Very Inverse Curve + Time Limit
Extremely Inverse Curve	Extremely Inverse Curve + Time Limit

US CURVES

Moderately Inverse Curve	Moderately Inverse Curve + Time Limit
Inverse Curve	Inverse Curve + Time Limit
Very Inverse Curve	Very Inverse Curve + Time Limit
Extremely Inverse Curve	Extremely Inverse Curve + Time Limit
Short-Term Inverse Curve	Short-Term Inverse Curve + Time Limit

RI Inverse Curve
User-Defined Curve
Fixed Time Characteristic

- **Overcurrent Elements: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**8 - OVERCURRENT**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**9 - OVERCURRENT**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

Time Overcurrent elements

0 - DISTANCE	0 - DIRECTIONAL	**0 - PHASE TOC**
…	**1 - TIME OVERCURRENT**	**1 - NEGSEQ TOC**
*** - OVERCURRENT**	2 - INSTANTANEOUS	**2 - GROUND TOC**
…		

(*) 8 or 9 option, depending on the model

0 - PHASE TOC	**0 - UNIT 1**	**0 - PHASE TOC ENABLE**
1 - NEGSEQ TOC	**1 - UNIT 2**	**1 - PHASE TOC PICKUP**
2 - GROUND TOC	**2 - UNIT 3**	**2 - PHASE TOC CURVE**
		3 - PHASE TOC DIAL
		4 - PHASE TOC DELAY
		5 - PH TOC DIRECTION
		6 - PH TOC DIR UNT
		7 - PH TOC LACK POL BLOCK*

(*) (ZLV-*-****O/N**)**

0 - PHASE TOC	**0 - UNIT 1**	**0 - N.S. TOC ENABLE**
1 - NEGSEQ TIME OVERC	**1 - UNIT 2**	**1 - N.S. TOC PICKUP**
2 - GROUND TOC	**2 - UNIT 3**	**2 - N.S. TOC CURVE**
		3 - N.S. TOC DIAL
		4 - N.S. TOC DELAY
		5 - N.S. TOC DIRECTION
		6 - N.S. TOC DIR UNT
		7 - N.S. TOC LACK POL BLOCK*

(*) (ZLV-*-****O/N**)**

0 - PHASE TOC	**0 - UNIT 1**	**0 - GROUND TOC ENABLE**
1 - NEGSEQ TOC	**1 - UNIT 2**	**1 - GROUND TOC PICKUP**
2 - GROUND TOC	**2 - UNIT 3**	**2 - GROUND TOC CURVE**
		3 - GROUND TOC DIAL
		4 - GROUND TOC DELAY
		5 - GROUND TOC DIRECTION
		6 - GROUND TOC DIR UNT
		7 - GROUND TOC LACK POL BLOCK*

(*) (ZLV-*-****O/N**)**

Instantaneous Phase Overcurrent

0 - DISTANCE	0 - DIRECTIONAL	**0 - PHASE IOC**
…	1 - TIME OVERCURRENT	**1 - NEGSEQ IOC**
*** - OVERCURRENT**	**2 - INSTANTANEOUS**	**2 - GROUND IOC**
…		

(*) 8 or 9 option, depending on the model

0 - PHASE IOC	**0 - UNIT 1**	**0 - PHASE IOC ENABLE**
1 - NEGSEQ IOC	**1 - UNIT 2**	**1 - PHASE IOC PICKUP**
2 - GROUND IOC	**2 - UNIT 3**	**2 - PHASE IOC DELAY**
		3 - PHASE IOC DIRECTION
		4 - PHASE IOC DIR UNT
		5 - PHASE IOC LACK POL BLOCK*

(*) (ZLV-*-****O/N**)**

0 - PHASE IOC	**0 - UNIT 1**	**0 - N.S. IOC ENABLE**
1 - NEGSEQ IOC.	**1 - UNIT 2**	**1 - N.S. IOC PICKUP**
2 - GROUND IOC	**2 - UNIT 3**	**2 - N.S. IOC DELAY**
		3 - N.S. IOC DIRECTION
		4 - N.S. IOC DIR UNT
		5 - N.S. IOC LACK POL BLOCK*

(*) (ZLV-*-****O/N**)**

0 - PHASE IOC	**0 - UNIT 1**	**0 - GND IOC ENABLE**
1 - NEGSEQ IOC	**1 - UNIT 2**	**1 - GND IOC PICKUP**
2 - GROUND IOC	**2 - UNIT 3**	**2 - GND IOC DELAY**
		3 - GND IOC DIRECTION
		4 - GND IOC DIREC UNIT
		5 - GND IOC LACK POL BLOCK**

(*) (ZLV-*-****O/N**)**

Harmonic Blocking (ZLV-***-****C/D/E/F/G/H**)

0 - DISTANCE	0 - DIRECTIONAL	**0 - 2ND BLOCK. ENAB.**
…	**1 - HARMONIC BLOCKING**	**1 - 2ND BLOCKING PU**
*** - OVERCURRENT**	2 - TIME OVERCURRENT	**2 - H BLOCKING LOGIC**
…		**3 - CROSS BLOQ TIME**
		4 - PHASE MIN CURRENT

(*) 8 or 9 option, depending on the model.

3.12.8 Digital Inputs and Events of the Overcurrent Modules

Table 3.12-1: Digital Inputs and Events of the Overcurrent Modules

Name	Description	Function
INBLK_IOC_PH1	Phase instantaneous element 1 block trip input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
INBLK_IOC_N1	Ground instantaneous element 1 block trip input	
INBLK_IOC_NS1	Neg. sequence inst. element 1 block trip input	
INBLK_IOC_PH2	Phase instantaneous element 2 block trip input	
INBLK_IOC_N2	Ground instantaneous element 2 block trip input	
INBLK_IOC_NS2	Neg. sequence inst. element 2 block trip input	
INBLK_IOC_PH3	Phase instantaneous element 3 block trip input	
INBLK_IOC_N3	Ground instantaneous element 3 block trip input	
INBLK_IOC_NS3	Neg. sequence inst. element 3 block trip input	
INBLK_TOC_PH1	Phase time element 1 block trip input	
INBLK_TOC_N1	Ground time element 1 block trip input	
INBLK_TOC_NS1	Neg. sequence time element 1 block trip input	
INBLK_TOC_PH2	Phase time element 2 block trip input	
INBLK_TOC_N2	Ground time element 2 block trip input	
INBLK_TOC_NS2	Neg. sequence time element 2 block trip input	
INBLK_TOC_PH3	Phase time element 3 block trip input	
INBLK_TOC_N3	Ground time element 3 block trip input	
INBLK_TOC_NS3	Neg. sequence time element 3 block trip input	
INRST_IOC_PH1	Phase inst. element 1 torque annulment input	It resets the element's timing functions and keeps them at 0 as long as it is active. With the element configured in directional mode, if the corresponding monitoring setting and the input are active, trip is blocked for lack of determining the direction.
IN_RST_IOC_N1	Ground inst. element 1 torque annulment input	
INRST_IOC_NS1	Neg. seq. inst. element 1 torque annulment input	
INRST_IOC_PH2	Phase inst. element 2 torque annulment input	
IN_RST_IOC_N2	Ground inst. element 2 torque annulment input	
INRST_IOC_NS2	Neg. seq. inst. element 2 torque annulment input	
INRST_IOC_PH3	Phase inst. element 3 torque annulment input	
IN_RST_IOC_N3	Ground inst. element 3 torque annulment input	
INRST_IOC_NS3	Neg. seq. inst. element 3 torque annulment input	
INRST_TOC_PH1	Phase time element 1 torque annulment input	
IN_RST_TOC_N1	Ground time element 1 torque annulment input	
INRST_TOC_NS1	Neg. seq. time element 1 torque annulment input	
INRST_TOC_PH2	Phase time element 2 torque annulment input	
IN_RST_TOC_N2	Ground time element 2 torque annulment input	
INRST_TOC_NS2	Neg. seq. time element 2 torque annulment input	
INRST_TOC_PH3	Phase time element 3 torque annulment input	
IN_RST_TOC_N3	Ground time element 3 torque annulment input	
INRST_TOC_NS3	Neg. seq. time element 3 torque annulment input	

Table 3.12-1: Digital Inputs and Events of the Overcurrent Modules

Name	Description	Function
IN_BPT_PH1	Phase time element 1 bypass time input	It converts the set timing sequence of a given element to instantaneous.
IN_BPT_N1	Ground time element 1 bypass time input	
IN_BPT_NS1	Neg. sequence time element 1 bypass time input	
IN_BPT_PH2	Phase time element 2 bypass time input	
IN_BPT_N2	Ground time element 2 bypass time input	
IN_BPT_NS2	Neg. sequence time element 2 bypass time input	
IN_BPT_PH3	Phase time element 3 bypass time input	
IN_BPT_N3	Ground time element 3 bypass time input	
IN_BPT_NS3	Neg. sequence time element 3 bypass time input	
ENBL_IOC_PH1	Phase instantaneous element 1 enable input	Activation of this input puts the element into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_IOC_N1	Ground instantaneous element 1 enable input	
ENBL_IOC_NS1	Negative sequence inst. element 1 enable input	
ENBL_IOC_PH2	Phase instantaneous element 2 enable input	
ENBL_IOC_N2	Ground instantaneous element 2 enable input	
ENBL_IOC_NS2	Negative sequence inst. element 2 enable input	
ENBL_IOC_PH3	Phase instantaneous element 3 enable input	
ENBL_IOC_N3	Ground instantaneous element 3 enable input	
ENBL_IOC_NS3	Negative sequence inst. element 3 enable input	
ENBL_TOC_PH1	Phase time element 1 enable input	
ENBL_TOC_N1	Ground time element 1 enable input	
ENBL_TOC_NS1	Negative sequence time element 1 enable input	
ENBL_TOC_PH2	Phase time element 2 enable input	
ENBL_TOC_N2	Ground time element 2 enable input	
ENBL_TOC_NS2	Negative sequence time element 2 enable input	
ENBL_TOC_PH3	Phase time element 3 enable input	
ENBL_TOC_N3	Ground time element 3 enable input	
ENBL_TOC_NS3	Negative sequence time element 3 enable input	

3.12.9 Digital Outputs and Events of the Overcurrent Modules

Table 3.12-2: Digital Outputs and Events of the Overcurrent Modules

Name	Description	Function
PU_IOC_A1	Phase A instantaneous element 1 pickup	AND logic of the pickup of the current elements with the corresponding torque control input.
PU_IOC_B1	Phase B instantaneous element 1 pickup	
PU_IOC_C1	Phase C instantaneous element 1 pickup	
PU_IOC_N1	Ground instantaneous element 1 pickup	
PU_IOC_NS1	Negative sequence inst. element 1 pickup	
PU_IOC_A2	Phase A instantaneous element 2 pickup	
PU_IOC_B2	Phase B instantaneous element 2 pickup	
PU_IOC_C2	Phase C instantaneous element 2 pickup	
PU_IOC_N2	Ground instantaneous element 2 pickup	
PU_IOC_NS2	Negative sequence inst. element 2 pickup	
PU_IOC_A3	Phase A instantaneous element 3 pickup	
PU_IOC_B3	Phase B instantaneous element 3 pickup	
PU_IOC_C3	Phase C instantaneous element 3 pickup	
PU_IOC_N3	Ground instantaneous element 3 pickup	
PU_IOC_NS3	Negative sequence inst. element 3 pickup	
PU_TOC_A1	Phase A time element 1 pickup	
PU_TOC_B1	Phase B time element 1 pickup	
PU_TOC_C1	Phase C time element 1 pickup	
PU_TOC_N1	Ground time element 1 pickup	
PU_TOC_NS1	Negative sequence time element 1 pickup	
PU_TOC_A2	Phase A time element 2 pickup	
PU_TOC_B2	Phase B time element 2 pickup	
PU_TOC_C2	Phase C time element 2 pickup	
PU_TOC_N2	Ground time element 2 pickup	
PU_TOC_NS2	Negative sequence time element 2 pickup	
PU_TOC_A3	Phase A time element 3 pickup	
PU_TOC_B3	Phase B time element 3 pickup	
PU_TOC_C3	Phase C time element 3 pickup	
PU_TOC_N3	Ground time element 3 pickup	
PU_TOC_NS3	Negative sequence time element 3 pickup	
PU_IOC	Instantaneous elements pickup (does not generate an event)	Pickup of the grouped current elements.
PU_TOC	Time elements pickup (does not generate an event)	

Table 3.12-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
CPU_IOC_A1	Phase A inst. element 1 pickup conditions	Pickup of the current elements, unaffected by the torque control.
CPU_IOC_B1	Phase B inst. element 1 pickup conditions	
CPU_IOC_C1	Phase C inst. element 1 pickup conditions	
CPU_IOC_N1	Ground inst. element 1 pickup conditions	
CPU_IOC_NS1	Neg. sequence inst. element 1 pickup conditions	
CPU_IOC_A2	Phase A inst. element 2 pickup conditions	
CPU_IOC_B2	Phase B inst. element 2 pickup conditions	
CPU_IOC_C2	Phase C inst. element 2 pickup conditions	
CPU_IOC_N2	Ground inst. element 2 pickup conditions	
CPU_IOC_NS2	Neg. sequence inst. element 2 pickup conditions	
CPU_IOC_A3	Phase A inst. element 3 pickup conditions	
CPU_IOC_B3	Phase B inst. element 3 pickup conditions	
CPU_IOC_C3	Phase C inst. element 3 pickup conditions	
CPU_IOC_N3	Ground inst. element 3 pickup conditions	
CPU_IOC_NS3	Neg. sequence inst. element 3 pickup conditions	
CPU_TOC_A1	Phase A time element 1 pickup conditions	
CPU_TOC_B1	Phase B time element 1 pickup conditions	
CPU_TOC_C1	Phase C time element 1 pickup conditions	
CPU_TOC_N1	Ground time element 1 pickup conditions	
CPU_TOC_NS1	Neg. sequence time element 1 pickup conditions	
CPU_TOC_A2	Phase A time element 2 pickup conditions	
CPU_TOC_B2	Phase B time element 2 pickup conditions	
CPU_TOC_C2	Phase C time element 2 pickup conditions	
CPU_TOC_N2	Ground time element 2 pickup conditions	
CPU_TOC_NS2	Neg. sequence time element 2 pickup conditions	
CPU_TOC_A3	Phase A time element 3 pickup conditions	
CPU_TOC_B3	Phase B time element 3 pickup conditions	
CPU_TOC_C3	Phase C time element 3 pickup conditions	
CPU_TOC_N3	Ground time element 3 pickup conditions	
CPU_TOC_NS3	Neg. sequence time element 3 pickup conditions	

Table 3.12-2: Digital Outputs and Events of the Overcurrent Modules

Name	Description	Function
TRIP_IOC_A1	Phase A instantaneous element 1 trip	Trip of the current elements.
TRIP_IOC_B1	Phase B instantaneous element 1 trip	
TRIP_IOC_C1	Phase C instantaneous element 1 trip	
TRIP_IOC_N1	Ground instantaneous element 1 trip	
TRIP_IOC_NS1	Negative sequence instantaneous element 1 trip	
TRIP_IOC_A2	Phase A instantaneous element 2 trip	
TRIP_IOC_B2	Phase B instantaneous element 2 trip	
TRIP_IOC_C2	Phase C instantaneous element 2 trip	
TRIP_IOC_N2	Ground instantaneous element 2 trip	
TRIP_IOC_NS2	Negative sequence instantaneous element 2 trip	
TRIP_IOC_A3	Phase A instantaneous element 3 trip	
TRIP_IOC_B3	Phase B instantaneous element 3 trip	
TRIP_IOC_C3	Phase C instantaneous element 3 trip	
TRIP_IOC_N3	Ground instantaneous element 3 trip	
TRIP_IOC_NS3	Negative sequence instantaneous element 3 trip	
TRIP_TOC_A1	Phase A time element 1 trip	
TRIP_TOC_B1	Phase B time element 1 trip	
TRIP_TOC_C1	Phase C time element 1 trip	
TRIP_TOC_N1	Ground time element 1 trip	
TRIP_TOC_NS1	Negative sequence time element 1 trip	
TRIP_TOC_A2	Phase A time element 2 trip	
TRIP_TOC_B2	Phase B time element 2 trip	
TRIP_TOC_C2	Phase C time element 2 trip	
TRIP_TOC_N2	Ground time element 2 trip	
TRIP_TOC_NS2	Negative sequence time element 2 trip	
TRIP_TOC_A3	Phase A time element 3 trip	
TRIP_TOC_B3	Phase B time element 3 trip	
TRIP_TOC_C3	Phase C time element 3 trip	
TRIP_TOC_N3	Ground time element 3 trip	
TRIP_TOC_NS3	Negative sequence time element 3 trip	
TRIP_IOC	Instantaneous elements trips (does not generate an event)	Trip of the grouped current elements.
TRIP_TOC	Time elements trips (does not generate an event)	

Table 3.12-2: Digital Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
IOC_PH1_ENBLD	Phase instantaneous element 1 enabled	Indication of enabled or disabled status of the current elements.
IOC_N1_ENBLD	Ground instantaneous element 1 enabled	
IOC_NS1_ENBLD	Negative sequence inst. element 1 enabled	
IOC_PH2_ENBLD	Phase instantaneous element 2 enabled	
IOC_N2_ENBLD	Ground instantaneous element 2 enabled	
IOC_NS2_ENBLD	Negative sequence inst. element 2 enabled	
IOC_PH3_ENBLD	Phase instantaneous element 3 enabled	
IOC_N3_ENBLD	Ground instantaneous element 3 enabled	
IOC_NS3_ENBLD	Negative sequence inst. element 3 enabled	
TOC_PH1_ENBLD	Phase time element 1 enabled	
TOC_N1_ENBLD	Ground time element 1 enabled	
TOC_NS1_ENBLD	Negative sequence time element 1 enabled	
TOC_PH2_ENBLD	Phase time element 2 enabled	
TOC_N2_ENBLD	Ground time element 2 enabled	
TOC_NS2_ENBLD	Negative sequence time element 2 enabled	
TOC_PH3_ENBLD	Phase time element 3 enabled	
TOC_N3_ENBLD	Ground time element 3 enabled	
TOC_NS3_ENBLD	Negative sequence time element 3 enabled	
HARM_2_BLK_A	Phase A Blocking by 2nd Harmonic (ZLV-***-****C/D/E/F/G/H**)	Phase Harmonics Blocking.
HARM_2_BLK_B	Phase B Blocking by 2nd Harmonic (ZLV-***-****C/D/E/F/G/H**)	
HARM_2_BLK_C	Phase C Blocking by 2nd Harmonic (ZLV-***-****C/D/E/F/G/H**)	
HARM_BLK_CROSS	Cross Blocking by Harmonics (ZLV-***-****C/D/E/F/G/H**)	

3.12.10 Overcurrent Elements Test

It is recommended that the overcurrent units be tested one by one, disabling those that are not being tested at any given time. For this test, the directionality of the IED should be annulled to not depend on the voltages (setting **Enable Pickup Blocking** or **Torque Control** to **NO**). Otherwise, they must be injected so the units will be in the trip enable zone.

- **Pickup and Reset**

The desired pickup values for the relevant unit must be set and its activation checked by operating any output configured for this purpose. This can also be verified by checking the pickup flags of the menu **Information** - **Status** - **Measuring Elements** - **Overcurrent**. It can also be checked that the trip flag of this menu is activated if the unit trips.

Table 3.12-3: Pickup and Reset of the Overcurrent Elements

Setting of the unit	Pickup		Reset	
	Maximum	Minimum	Maximum	Minimum
X	1.08 **x** X	1.02 **x** X	1.03 **x** X	0.97 **x** X

In the low ranges, the pickup and reset interval can be extended up to X ± (5% x In) mA.

- **Operating Times**

They are verified with trip outputs F9-F10, F11-F12 and F13-F14 (Pole A, B and C trips). For **ZLV-A/E/H** units, use the F9-F10 terminals (trip). In **ZLV-G/J** relays, bear in mind that there are no fixed trip outputs configured.

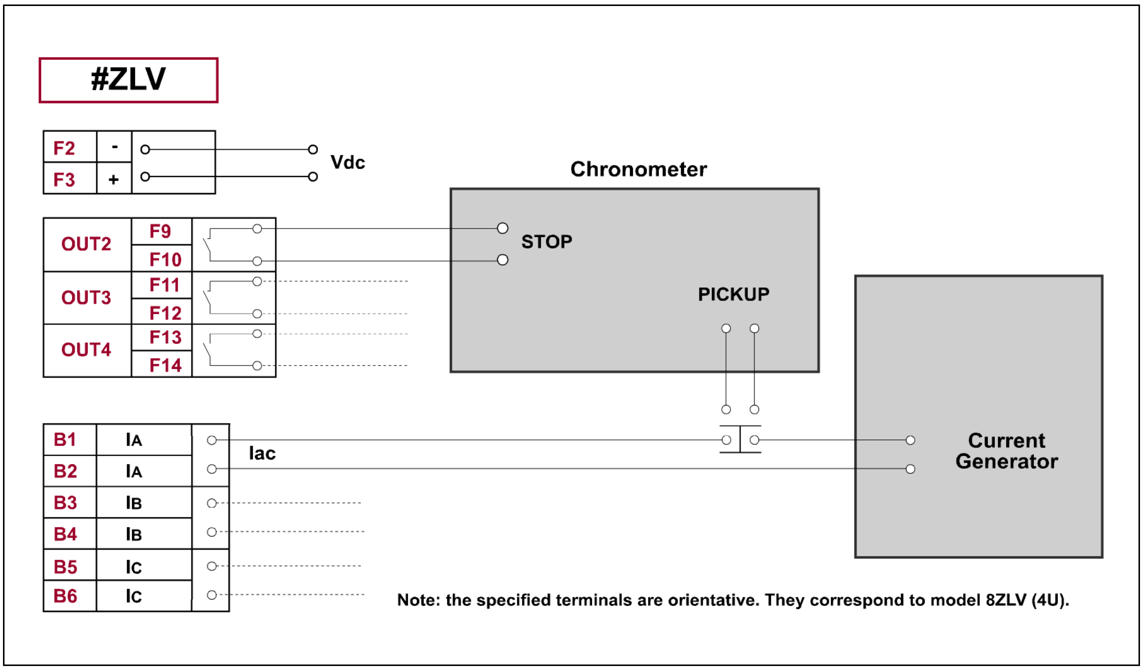


Figure 3.12.23 Operating Time Test Setup.

Fixed Time or Instantaneous

The pickup setting is increased 20%. Operating time should be the selected time setting ±1% or ±20 ms (whichever is greater). A setting of 0 ms will have an operating time between 20 and 25 ms.

Inverse Time

For a given curve, the operating time is determined by the time dial setting and the current applied (number of times of the pickup setting value). The tolerance is determined by applying a margin of error of ±1% in the current measurement. This means an error of ±2% or ±20 ms (whichever is greater) in the measuring times.

The operating times for the marked curves can be verified in the **ZLV** model in section 3.12.2.

3.13 Directional Elements

3.13.1 Introduction

- Directional Elements.
- One Directional Phase Element (67).
- One Directional Ground Element (67N).
- One Directional Negative Sequence Element (67Q).
- One Directional Positive Sequence Element (67P) (ZLV-***-****A/B/C/D/E/F/G/H**).
- One Zone 2 Directional Distance Element.

The mission of the directional element is to determine the direction in which the operating current is flowing in order to control its associated overcurrent element. The direction is determined by comparing its phase with that of a reference value, the phase of which is maintained irrespective of the direction of the flow of the operating current.

Each directional element controls the corresponding overcurrent elements as long as the **Torque Control** setting is other than **zero**. The control over the overcurrent element is carried out inhibiting the operation of the pickup elements in case the current flows in the reverse direction to that selected. If the directional element inhibits the operation of the overcurrent element, the timing function will not start. If the inhibition occurs once the timing has started, it will reset so that the timing will start again from zero if the inhibition disappears. In any case, a trip requires the timing function to be uninterrupted.

If the **Torque Control** is equal to **zero**, the directional control is inhibited and allows the pickup of the overcurrent elements for current flows in both directions: direction and reverse direction.

In all cases, the directional element can enable and block trips in both directions (direction and reverse direction) with the **Torque Control** setting (**1** for the direction and **2** for the reverse direction). With **Torque Annulment** input activated, the corresponding directional element is not allowed to pick up.

In ZLV-*-****N/O** models:**

The **Lack of Direction Blocking by 60FF** setting allows to select the possibility to block or not the directional units when the VT Fuse Failure Detector is activated. This function is used to avoid the overcurrent units supervised by the directional units of wrong operations when there is an unreliable Polarization Voltage (V_POL) debt to any condition that could activate the VT Fuse Failure Detector.

In the case of the Neutral Directional unit (67N), the loss of any of the Phase Voltages could make the Neutral Voltage to be higher than **Minimum Neutral Tension** setting, preventing the **Loss of Polarization** signal to be activated in a situation where the polarization voltage is not reliable. Thus, it is necessary the **Lack of Direction Blocking by 60FF** as secondary criteria to detect the lack of polarization.

The directional unit will give permission to trip due to lack of polarization by activating both Direction and Reverse signals, if the conditions of one of these two criteria are met.

The **Trip Direction Reversal** input (**IN_INV_TRIP**) changes, if activated, the direction of operation of all the directional elements.

All the directional elements generate direction and reverse direction outputs, instantaneous as well as timed, which exercise directional control over the instantaneous and time overcurrent elements, respectively. The timing of the timed outputs of the directional elements is given by the **Coordination Time** setting.

The **Coordination Time** setting is applicable when teleprotection schemes are used in permissive overreach, created through the **Timing Annulment** input associated with these elements. The following wiring should be carried out for this: pickup output of the time elements to the channel activation input of the teleprotection equipment and channel reception output of the teleprotection equipment to the timer annulment input of the time element.

The coordination time avoids erroneous trips in case of current reversal produced in double circuits. We consider the case of two parallel lines; the detection of a fault and its subsequent sequential trip in one of these may cause current reversal of one of the terminals of the parallel line, started as a result of this fault. In this case, the directional element will reverse its status and will go on not to allow the trip. If because of the Permissive overreach the timer is annulled, an instantaneous trip will be produced, since the channel reception signal has a reset time other than zero. To prevent this possibility, the Coordination time may be used, which delays the application of the directional permission until the channel reception signal has disappeared. This delay only affects the time elements, provided that they are configured as directional.

Note: protection schemes associated to overcurrent elements (see 3.14) already include a coordination Time setting separate from the one commented in this paragraph. In case of ZLV-A/B relays, said protection schemes are associated to ground and negative sequence instantaneous overcurrent elements, the directional elements of which do not include any coordination time; however, in ZLV-F/G/H/J relays, the protection schemes can be associated to any overcurrent element whether instantaneous or time delayed. If time delayed elements are used the coordination times must be considered (directional element setting and protection scheme setting).

3.13.2 Directional Phase Element

There is a directional element for each of the phases. In any one of them, the operating value is the phase current and the polarization value is the line voltage corresponding to the other two phases memorized 2 cycles before the pickup.

Figure 3.13.1 presents the vector diagram which shows the operating principle of the directional phase elements.

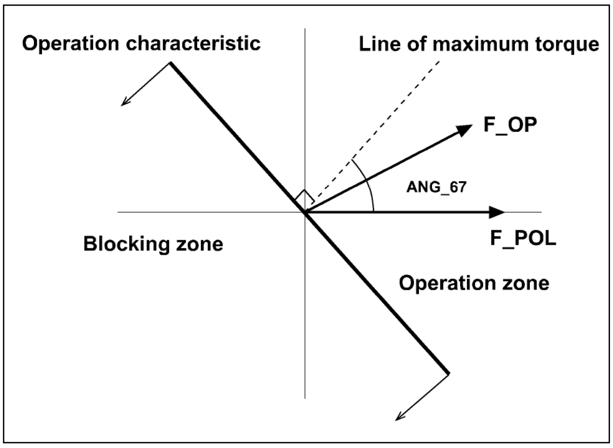


Figure 3.13.1: Vector Diagram of the Directional Phase Element.

The phase directional elements check that the current and the voltages of the phases are above certain values. This value is adjustable for the voltage (**Minimum Phase Voltage** setting) and 0.02 In (with In being the rated current of the IED) for the current. If currents and voltages do not exceed their threshold values the above mentioned checking criterion is discontinued, signal **No Phase Polarization** (**LP_DIR_PH**) is activated and the **No Polarization Lockout** setting is checked. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates blocking by lack of polarization, trips in both directions are blocked.

Following table shows the operating and polarization values applied to each of the three phases.

Table 3.13-1: Phase Directional Element			
ABC Phases Sequence			
Phase	**Fop**	**Fpol**	**Criteria**
A	I_A	$U_{BCM} = (V_B - V_C)_M$	$-(90^o - ANG\_67) \le [\arg(Fop) - \arg(Fpol)] \le (90^o + ANG\_67)$
B	I_B	$U_{CAM} = (V_C - V_A)_M$	
C	I_C	$U_{ABM} = (V_A - V_B)_M$	
ACB Phases Sequence			
Phase	**Fop**	**Fpol**	**Criteria**
A	I_A	$U_{CBM} = (V_C - V_B)_M$	$-(90^o - ANG\_67) \le [\arg(Fop) - \arg(Fpol)] \le (90^o + ANG\_67)$
B	I_B	$U_{ACM} = (V_A - V_C)_M$	
C	I_C	$U_{BAM} = (V_B - V_A)_M$	

Drawn on a polar plot, the operation characteristic is a straight line the perpendicular of which (line of maximum torque) is rotated a certain angle counter clockwise, called characteristic angle, with respect to the polarization value. This straight line divides the plane into two semiplanes. This characteristic angle is the complementary to the argument of the positive sequence line impedance (see 3.13.2.a, Example of Application).

The directional element, if configured in direction, enables the overcurrent element when the above criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram). As already mentioned, directional control is phase by phase.

The logic diagram of operation of the phase directional element is shown in Figure 3.13.2

The activation of the **Phase Directional Element Inhibition** (**INH_DIR_PH**) input converts the element to **Non-directional**.

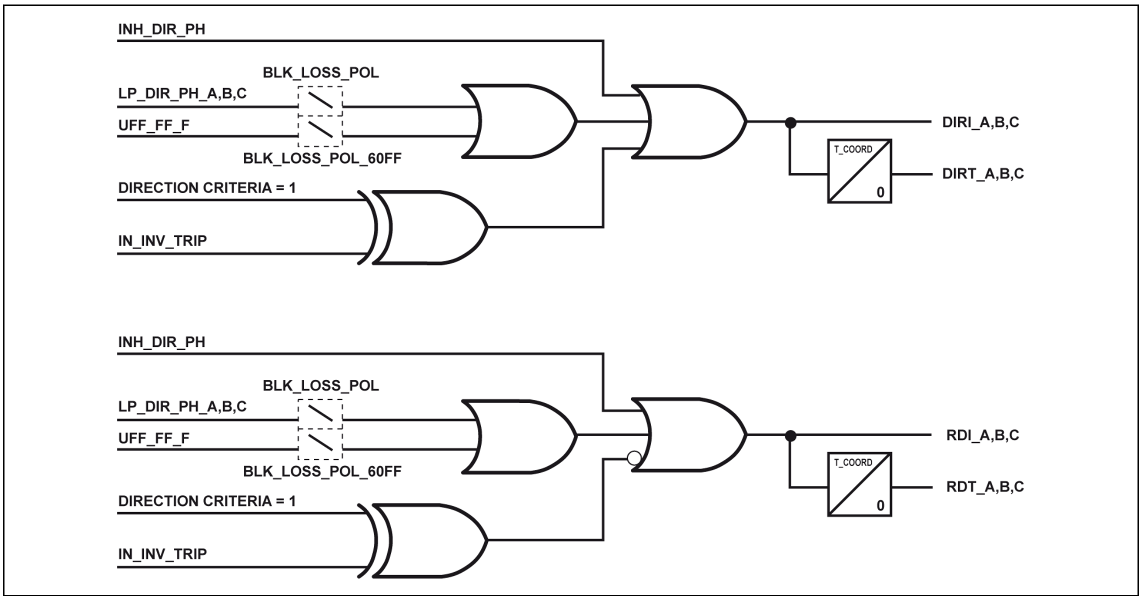


Figure 3.13.2: Block Diagram of a Directional Phase Element.

Legend
INH_DIR_PH: Phase Directional Element Inhibition
LP_DIR_PH: No Phase Polarization.
IN_INV_TRIP: Inversion of the Trip Direction Input.
DIRI / DIRT: Instantaneous / Time Direction
RDI / RDT: Instantaneous / Time Reverse Direction.
BLK_LOSS_POL: Lack of Polarization Blocking (setting).
T_COORD: Coordination Time (setting).

The **Inversion of the Trip Direction** (**IN_INV_TRIP**) input changes, if activated, the direction of operation of the directional element.

3.13.2.a Example of Application

This section will analyze the setting value of the characteristic angle for the phases with respect to the polarization magnitude that the IED uses to establish the line of maximum torque. This gives rise to the operation and blocking zones of the phase differential elements in **Direction** mode.

The simplest case is a three-phase line open at one of its ends. Suppose a single-phase fault of phase A to ground and without default impedance. If the impedance of the line is **Z**Iα, the current **I**$_A$ that will flow through the fault will be generated by the presence of voltage **V**$_A$ and delayed with respect to it, an angle α.

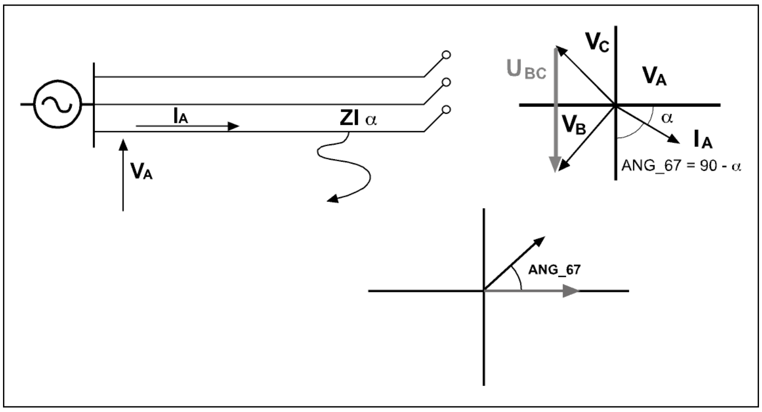


Figure 3.13.3: Graphics for the Example of Application.

ZLV IEDs with directional elements for the phases do not use the simple phase currents as polarization value for each of their corresponding operating values (the currents of each phase). The polarization values used are the phase-to-phase voltages between the other two phases not involved in the possible single-phase fault.

As the graphics show, for a fault in phase A like the one described initially, the polarization value that the IED uses to decide whether or not there is a trip is voltage $U_{BC} = V_B - V_C$, which is delayed in quadrature with respect to the simple voltage of faulted phase V_A.

Given that the characteristic angle (**ANG_67**) that adjusts to the IED is that which is between the operation value and the polarization value (see figure 3.13.1), the value assigned to it must be the angle complementary to the argument of the “impedance of the line”. Everything said so far for phase A can be extrapolated directly for phases B and C.

In conclusion, if the impedance of the line is **Z**Iα, the characteristic angle (**ANG_67**) that must be adjusted for the phases is: **ANG_67 = 90 -** α

3.13.3 Directional Ground Element

To operate, the directional ground element uses zero sequence and ground magnitudes. The operating magnitude is the zero sequence current, using two source signals to obtain the polarization magnitude:

- Zero sequence voltage: The zero sequence voltage (V0) is calculated with the phase voltages as follows:

$$\overline{V_0} = \frac{\overline{V_A} + \overline{V_B} + \overline{V_C}}{3}$$

- Circulating current through grounding.

In this case, there are two operation characteristics, one corresponding to each of the two modes, which, when drawn on a polar plot, are straight lines, each of which divides the plane into two semiplanes. The location of the operating value determines the output of the directional element and its action on the overcurrent element.

3.13.3.a Polarization by Voltage

In this case, the operating principle of the ground directional element rests on the determination of the phase difference between the zero sequence current and a "compensated" zero sequence voltage based on **the Zero Sequence Voltage Compensation Factor** (K_{COMP_67N}).setting. Figure 3.13.4 diagrams the elements used to explain how polarization by voltage works.

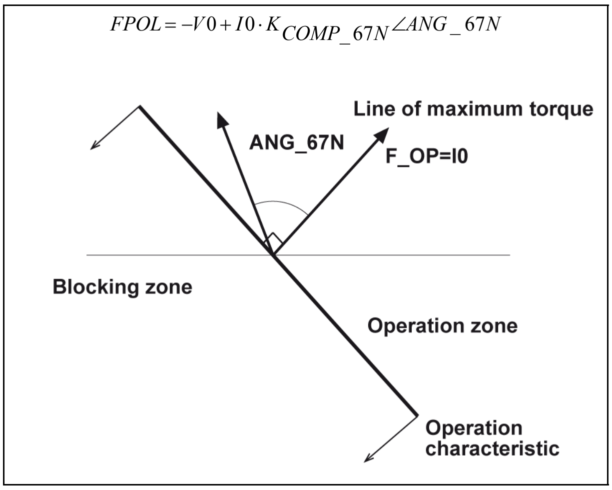


Figure 3.13.4: Vector Diagram of the Directional Ground Element (Polarization by Voltage).

The directional ground element checks that the polarization currents are above a certain value. This value is adjustable for the polarization phasor (**Minimum Zero Sequence Voltage** setting) and **0.02 In** (with **In** being the rated current of the IED) for the operation phasor. If the operation or polarization phasors do not exceed the threshold values, the **No Ground Polarization** (**LP_DIR_N**) signal will be activated and **Blocking due to Lack of Polarization** setting is shown. If this setting indicates that there is NO blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates blocking due to lack of polarization, trips in both directions are blocked.

The following table shows the operation and polarization phasors which intervene in the ground directional element, as well as the operation criteria applied.

Table 3.13-2: Directional Ground Element (polarization by voltage)

Fop	Fpol	Criteria
I0	$-V0 + I0 \cdot K_{COMP\_67N} \angle ANG\_67N$	$-(90^{\circ} + ANG\_67N) \leq [\arg(Fop) - \arg(Fpol)] \leq (90^{\circ} - ANG\_67N)$

The directional element, if configured in direction, enables the overcurrent element when the previous criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

Figures 3.13.5 and 3.13.6 show the zero sequence network for a ground fault (single phase or two phase) in a forward and reverse direction, respectively.

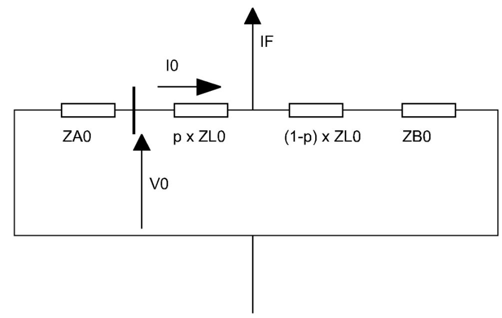


Figure 3.13.5: Zero Sequence Network for Forward Fault.

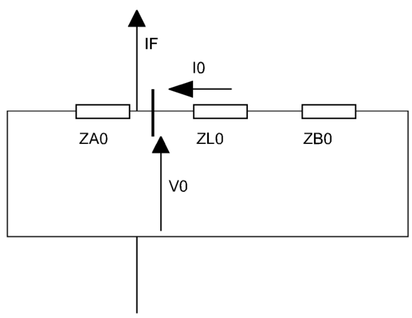


Figure 3.13.6: Zero Sequence Network for Reverse Fault.

If the fault is in forward direction, it can be deduced that $V0 = ZA0 \cdot (-I0)$, where $ZA0$ is the zero sequence impedance of the local source. It is seen, consequently, that the angle between $-V0$ and $I0$ will be that corresponding to this impedance. For this reason, this should be the characteristic angle of the ground directional element (**ANG_67N** setting).

If the fault is in the reverse direction, the following expression will be obtained: $V0 = (ZL0 + ZB0) \cdot I0$, where $ZL0$ and $ZB0$ are the zero sequence impedance of the line and the remote source, respectively. Consequently, the angle between $-V0$ and $I0$ will be supplementary of the angle of $ZL0 + ZB0$ impedance (which will be similar to the $ZA0$ angle).

Through the relative phase difference between $-V0$ and $I0$, the directionality of the fault can be deduced. However, the K_{COMP_67N} factor is used for the following two reasons:

Increase the polarization phasor magnitude, in order that this exceeds the **Minimum Zero Sequence Voltage**:

When the zero sequence impedance of the local source is small, in case of forward fault, the $V0$ voltage which measures the relay may present values under the **Minimum Zero Sequence Voltage** setting [it was previously deduced that $V0 = ZA0 \cdot (-I0)$]. In order to have sufficient voltage to polarize the ground directional element, a new voltage with the same phase is added to the $-V0$ phasor, which will correspond to the voltage drop in an impedance with **ANG_67N** angle (it is assumed that this adjustment will be equal to the $ZA0$ angle) and with a magnitude equal to K_{COMP_67N}. The effect of the new polarization phasor is that of expanding the zero sequence impedance magnitude of the local source with a value equal to K_{COMP_67N}.

The K_{COMP_67N} value should be restricted in order that the ground directional element does not take any erroneous directional decisions in case of faults in the reverse direction. When the fault is in the reverse direction $V0 = (ZL0 + ZB0) \cdot I0$, as was deduced previously. If we assume that the $ZL0 + ZB0$ angle is similar to the **ANG_67N** setting (assumption equal to $ZA0$ angle), $-V0$ and $I0 \cdot K_{COMP\_67N}$ will be in anti-phase, for which the sum of $I0 \cdot K_{COMP\_67N}$ reduces the polarization phasor value, with it being possible to even reverse its direction. The latter would occur if $K_{COMP\_67N} > (ZL0 + ZB0)$; in this case, the directional element would consider that the fault is in forward direction. For this reason, the K_{COMP_67N} value is restricted by the $ZL0 + ZB0$ value.

Compensate the inversion that the V0 voltage may undergo in lines with series compensation:

In case of faults in a forward direction, in a line with series compensation, $V0$ will be reversed (approximately 180º considering that the angle of source impedance is close to 90º), provided that the zero sequence impedance existing between the voltage transformer and the local source is capacitive. In this case, the directional element will act erroneously since it will consider that the fault is in the reverse direction. In order to rotate the reversed $-V0$ voltage 180º, such that the directional element can see the fault in a forward direction, a K_{COMP_67N} factor should be applied whose value exceeds the capacitive reactance value introduced. Notwithstanding, and in order to avoid erroneous directional decisions in case of reverse directional faults, as was indicated previously, K_{COMP_67N} should be less than $ZL0 + ZB0$ (impedance existing between the voltage transformer and the remote source).

- **Polarization by Current**

Determining the phase displacement between the residual current and the current circulating through the grounding is simple because the phase displacements between the two magnitudes can only be 0º and 180º or, what is the same, the characteristic angle must always be 0º.

When it is configured in direction, the operation zone is the zone in which the fault or operating current **In** is rotated 180º with respect to the current flowing through the grounding. As in the figure, **F_POL** is equal to the current flowing through the grounding rotated 180º. Therefore, **F_POL** and **In** must be in phase to be in the operation zone. When it is configured in reverse direction, it enables the overcurrent element in the opposite semiplane. Figure 3.13.7 shows the vector diagram associated with the ground directional element when the polarization by current is used.

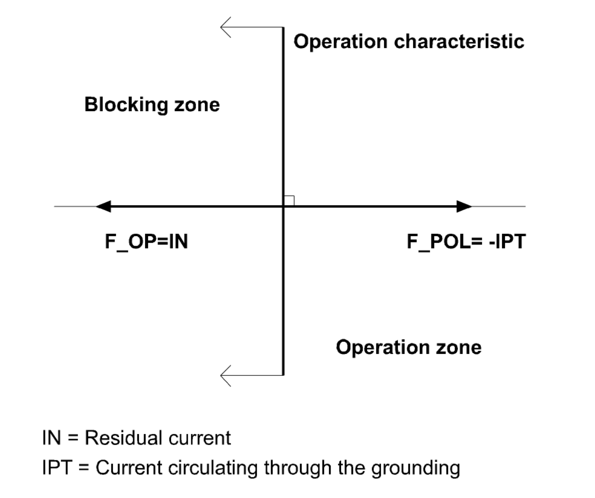


Figure 3.13.7: Vector Diagram of the Directional Ground Element (Polarization by Current).

The following table shows the operation and polarization phasors which intervenes in the ground directional element, as well as the operation criteria applied.

Table 3.13-3: Directional Ground Element (Polarization by Current)

Fop	Fpol	Criteria
I0	-IPT	$-90° \leq \arg(F\_OP) - \arg(F\_POL) \leq 90°$

The directional element, if configured in direction, enables the overcurrent element when the previous criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

- **Polarization by Voltage and Current**

If both polarizations coexist, the criterion is the following: If the directional ground element is not inhibited, it checks that the current is above a minimum value. If it does not exceed this, the **No Ground Polarization** (**LP_DIR_N**) signal is activated and the **Blocking due to Lack of Polarization Voltage** setting is shown. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates trip blocking, trips in both directions are blocked.

If it is above the minimum value, it checks that the polarization current is above a given value. If it is, it determines whether or not there is trip direction. If the **Direction Inversion Input** (**IN_INV_TRIP**) is active, the calculated direction is changed.

If the polarization by current solves the directionality (enables trip), the element does not check polarization by voltage.

If the polarization by current does not solve the directionality, the element verifies that the polarization voltage is above a given adjustable value (**Ground Minimum Voltage**). If this is not the case, the **No Ground Polarization** (**LP_DIR_N**) signal is activated and the **Blocking due to Lack of Polarization Voltage** setting is shown. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates trip blocking, trips in both directions are blocked.

If the voltage level is correct, it is determined if there is trip direction according to the criteria indicated. If the **Direction Inversion Input** (**IN_INV_TRIP**) input is active, the direction of the calculated direction is changed.

The activation of the **Directional Ground Element Inhibit** (**INH_DIR_N**) input converts the element to non-directional.

The logic diagram of operation of the ground directional element is shown in Figure 3.13.8.

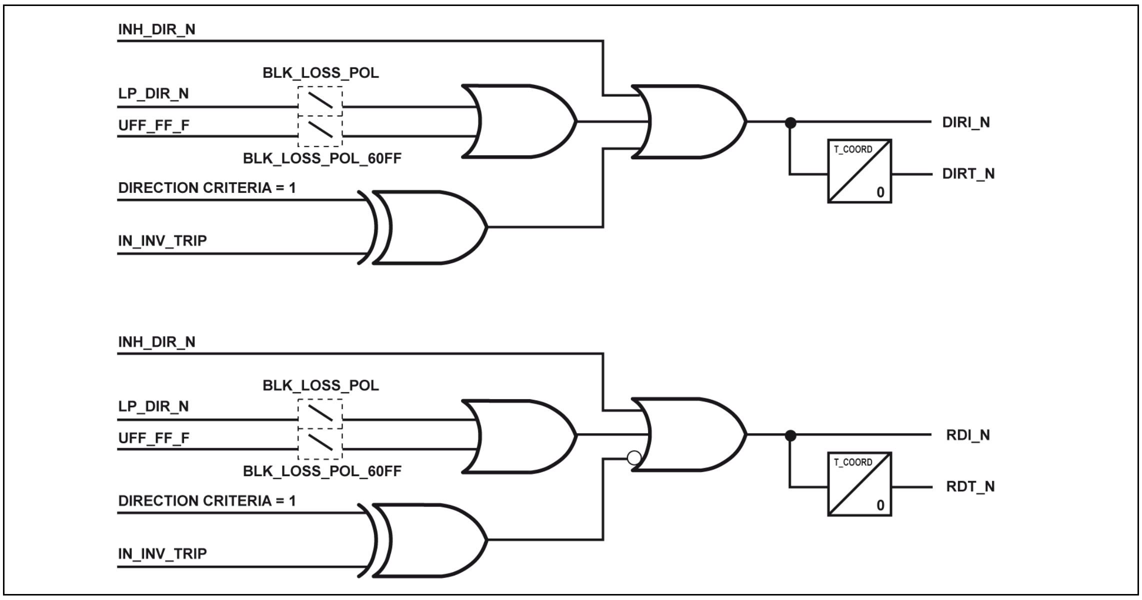


Figure 3.13.8: Block Diagram of a Directional Ground Element.

Legend
INH_DIR_N: Ground Directional Element Inhibition
LP_DIR_N: No Ground Polarization.
IN_INV_TRIP: Inversion of the Trip Direction Input.
DIRI_N / DIRT_N: Ground Instantaneous / Time Direction
RDI_N / RDT_N: Ground Instantaneous / Time Reverse Direction.
BLK_LOSS_POL: Lack of Polarization Blocking (setting).
T_COORD: Coordination Time (setting).

3.13.4 Directional Negative Sequence Element

The operating principle of a directional negative sequence element rests on the determination of the relative phase difference between the negative sequence current and a "compensated" negative sequence voltage based on the **Negative Sequence Voltage Compensation Factor** (K_{COMP_67Q}) setting. Figure 3.13.9 presents the vector diagram associated with the directional negative sequence element.

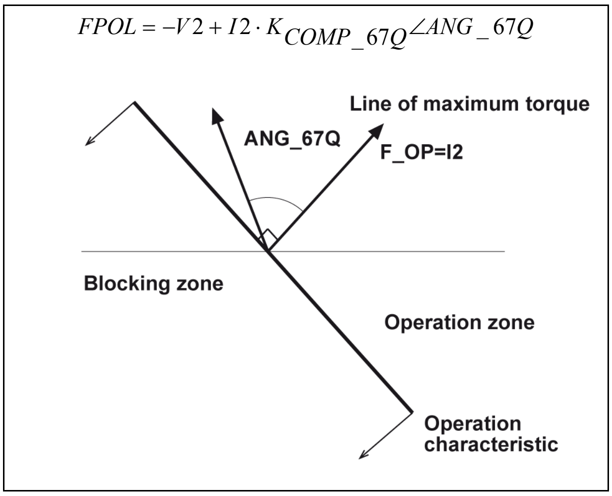


Figure 3.13.9: Vector Diagram of the Directional Negative Sequence Element.

The directional negative sequence element verifies that the operation and polarization phasors exceed certain determined values. This value is adjustable for the polarization phasor (**Minimum Negative Sequence Voltage** setting) and **0.02 In** (with **In** being the rated current of the IED) for the operation phasor. If the operation or polarization phasors do not exceed the threshold values, the **No Negative Sequence Polarization** (**LP_DIR_NS**) signal will be activated and the **Blocking due to Lack of Polarization** setting is shown. If this setting indicates that there is **NO** blocking, the same procedure as in case of directional inhibition is carried out; but if it indicates blocking due to lack of polarization, the trips in both directions are blocked.

The following table shows the operation and polarization phasors which intervene in the directional negative sequence element, as well as the operation criteria applied.

Table 3.13-4: Directional Negative Sequence Element		
Fop	**Fpol**	**Criteria**
I2	$-V2 + I2 \cdot K_{COMP\_67Q} \angle ANG\_67Q$	$-(90^{\circ} + ANG\_67Q) \leq [\arg(Fop) - \arg(Fpol)] \leq (90^{\circ} - ANG\_67Q)$

The directional element, if configured in direction, enables the overcurrent element when the above criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

All that stated for the **Zero Sequence Voltage Compensation Factor** is applicable to the **Sequence Voltage Compensation Factor**, if the negative sequence network is considered instead of the zero sequence network.

Figures 3.13.10 and 3.13.11 show the negative sequence network for a forward and reverse unbalanced fault (single phase or two phase), respectively.

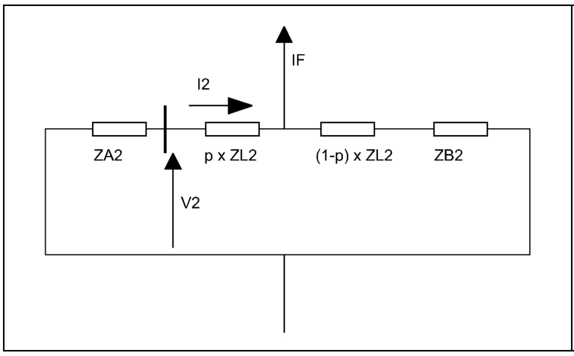


Figure 3.13.10: Negative Sequence Network for Forward Fault.

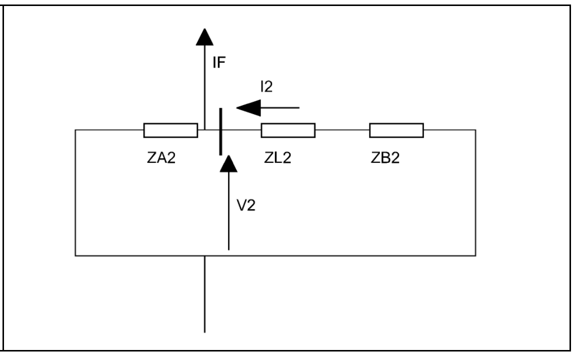


Figure 3.13.11: Negative Sequence Network for Reverse Fault.

If a forward fault, it can be deduced that $-V2 = ZA2 \cdot (-I2)$, where $ZA2$ is the negative sequence impedance of the local source. Consequently, it can be seen that the angle between $-V2$ and $I2$ will be that corresponding to this impedance. For this reason, this should be the characteristic angle of the directional negative sequence element (**ANG_67Q** setting).

The objective of the K_{COMP_67Q} factor is similar to that indicated for the K_{COMP_67N} factor in the ground directional element:

- Increase the polarization phasor magnitude, in order that this exceeds the Minimum negative sequence voltage setting.
- Compensate the inversion that the V2 voltage may undergo in lines with series compensation:

The logic diagram of operation of the directional negative sequence element is shown in Figure 3.13.12.

If the **Inversion of Directionality** (**IN_INV_TRIP D**) input is active, the direction of calculated direction is changed.

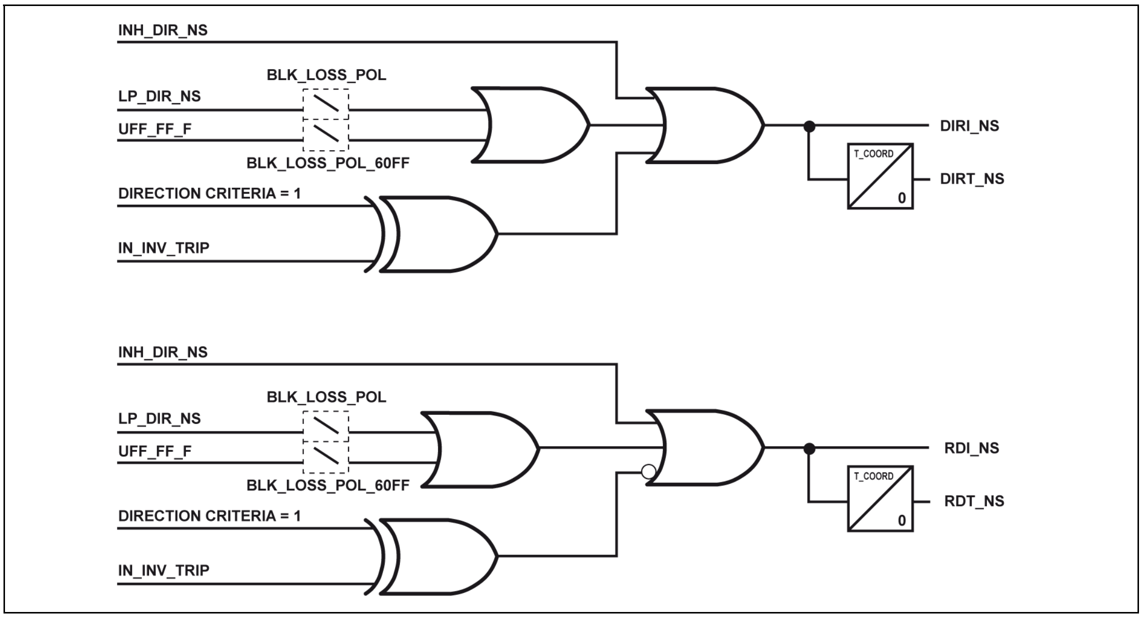


Figure 3.13.12: Block Diagram of a Directional Negative Sequence Element.

The activation of the **Ground Directional Element Inhibit** (**INH_DIR_NS**) input converts the element into non-directional.

Legend
INH_DIR_NS: Negative Sequence Directional Element Inhibition
LP_DIR_NS: No Negative Sequence Polarization.
IN_INV_TRIP: Inversion of the Trip Direction Input.
DIRI_NS / DIRT_NS: Negative Sequence Instantaneous / Time Direction
RDI_NS / RDT_NS: Negative Sequence Instantaneous / Time Reverse Direction.
BLK_LOSS_POL: Lack of Polarization Blocking (setting).
T_COORD: Coordination Time (setting).

3.13.5 Positive Sequence Directional Unit (ZLV-***-****A/B/C/D/E/F/G/H**)

The operation of the Positive Sequence directional element is based on determining the phase difference between positive sequence current and positive sequence voltage memorized two cycles in advance of fault detector activation (see 3.4). Figure 3.13.3 shows the phasor diagram associated to the positive sequence directional element.

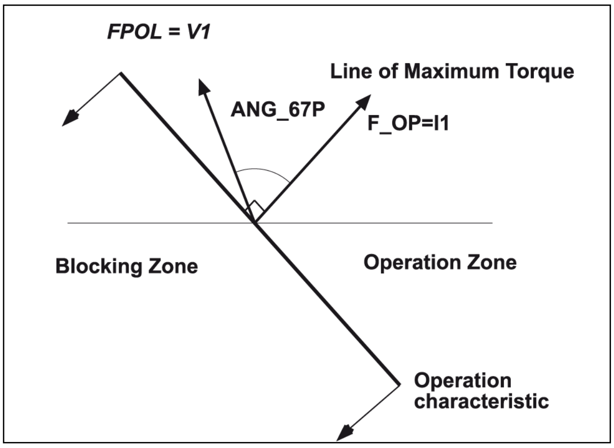


Figure 3.13.13: Vector Diagram of the Positive Sequence Directional Element.

The Positive Sequence directional element checks that operation and polarization phasors exceed given values. This value is adjustable for the polarization phasor (**Minimum Zero Sequence Voltage** setting) and **0.02 In** (with **In** being the rated current of the IED) for the operation phasor. If the operation or polarization phasors do not exceed the threshold values the **Lack of Polarization of Positive Sequence** (**LP_DIR_PS**) signal will be activated and **Blocking due to Lack of Polarization** setting is shown. If this setting indicates that there is **NO** blocking, the procedure is the same as for inhibiting the directional element. If, however, it indicates blocking due to lack of polarization, trips in both directions are blocked.

The following table shows the operation and polarization phasors which intervene in the ground directional element, as well as the operation criteria applied.

Table 3.13-5: Directional Positive Sequence Element		
Fop	**Fpol**	**Criteria**
I1	V1	$-\left(90^{\circ}+ANG\_67P\right) \leq \left[\arg\left(Fop\right)-\arg\left(Fpol\right)\right] \leq \left(90^{\circ}-ANG\_67P\right)$

The directional element, if configured in direction, enables the overcurrent element when the previous criteria is fulfilled (operation zone indicated in the diagram), while if configured in reverse direction, it enables the overcurrent element when this criteria is not fulfilled (blocking zone indicated in the diagram).

The positive sequence directional element can supervise the operation of phase overcurrent elements, if their Torque Control Type setting is set to **67P**. Thanks to the type of polarization used (Positive Sequence Voltage with Memory), the positive sequence directional element operates correctly on voltage reversals produced in series compensated lines.

The logic diagram of operation of the directional positive sequence element is shown in Figure 3.13.14.

If the **Direction Inversion Input** (**IN_INV_TRIP**) is active, the calculated direction is changed.

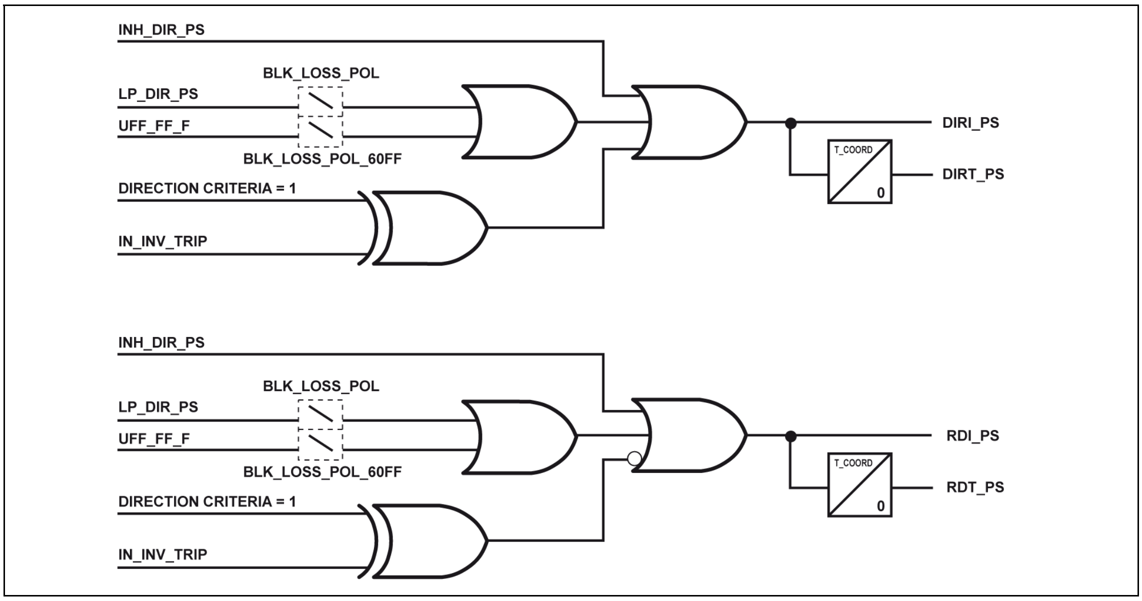


Figure 3.13.14: Block Diagram of a Directional Positive Sequence Element.

Legend
INH_DIR_PS: Positive Sequence Directional Element Inhibition
LP_DIR_PS: No Positive Sequence Polarization.
IN_INV_TRIP: Inversion of the Trip Direction Input.
DIRI_PS / DIRT_PS: Positive Sequence Instantaneous / Time Direction
RDI_PS / RDT_PS: Positive Sequence Instantaneous / Time Reverse Direction.
BLK_LOSS_POL: Lack of Polarization Blocking (setting).
T_COORD: Coordination Time (setting).

The activation of the **Inhibit of the Directional Negative Sequence** (**INH_DIR_NS**) input converts the element to non-directional.

3.13.6 Distance Zone 2 Directional Element

The Distance Zone 2 can carry out the control of the overcurrent elements, instantaneous or timed, of phases, ground and negative sequence, if indicated through the **Torque Control Type** setting (**ZII** option for phase and negative sequence overcurrent elements and **ZIIG** option for ground overcurrent elements).

Figures 3.13.15 and 3.13.16 include the logic diagrams of operation which generate the direction and reverse direction outputs for zone 2, from the pickups of this zone.

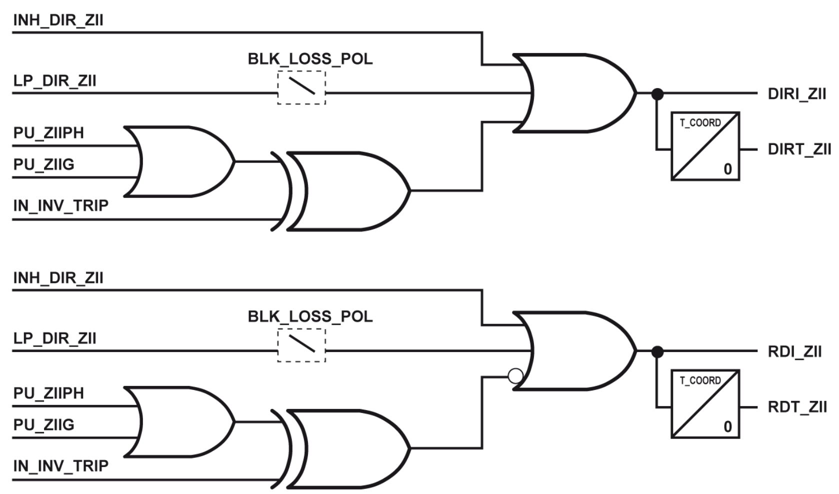


Figure 3.13.15: Zone 2 Directional Element Operation Diagram (Phases and Ground).

Legend
INH_DIR_ZII: Zone 2 Directional Element Inhibition
LP_DIR_ZII: No Zone 2 Polarization.
PU_ZIIX: Zone 2 Phase / Ground Unit Pickup
IN_INV_TRIP: Inversion of the Trip Direction Input.
DIRI_ZII / DIRT_ZII: Zone 2 Instantaneous / Time Direction
RDI_ZII / RDT_ZII: Zone 2 Instantaneous / Time Reverse Direction.
BLK_LOSS_POL: Lack of Polarization Blocking (setting).
T_COORD: Coordination Time (setting).

If the **Inversion of Directionality** (**IN_INV_TRIP**) input is active, the direction of the calculated direction is changed.

The activation of the **Inhibition of the Neutral Directional Element** (**INH_DIR_ZII**) input converts the element to non-directional.

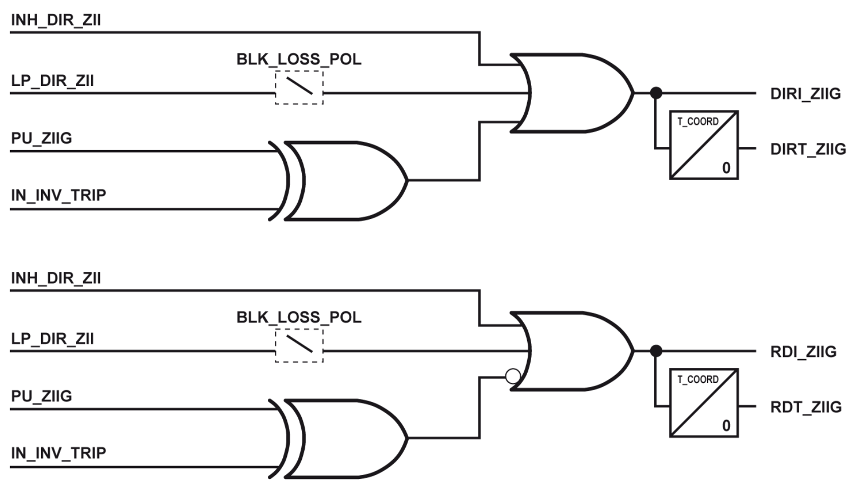


Figure 3.13.16: Zone 2 Directional Element Operation Diagram (Ground).

Legend
INH_DIR_ZII: Zone 2 Directional Element Inhibition
LP_DIR_ZII: No Zone 2 Polarization.
PU_ZIIG: Zone 2 Ground Unit Pickup
IN_INV_TRIP: Inversion of the Trip Direction Input.
DIRI_ZIIG / DIRT_ZIIG: Zone 2 Ground Instantaneous / Time Direction
RDI_ZIIG / RDT_ZIIG: Zone 2 Ground Instantaneous / Time Reverse Direction.
BLK_LOSS_POL: Lack of Polarization Blocking (setting).
T_COORD: Coordination Time (setting).

3.13.7 Directional Elements Settings

Directional Elements			
Setting	**Range**	**Step**	**Default**
Phase Characteristic Angle	0º - 90º	1º	45º 15º (*)
Zero Sequence Characteristic Angle	0º - 90º	1º	45º 75º (*)
Negative Sequence Characteristic Angle	0º - 90º	1º	45º 75º (*)
Positive Sequence Characteristic Angle (ZLV-***-****A/B/C/D/E/F/G/H**)	0º - 90º	1º	45º 75º (*)
Lack of Polarization Blocking	YES / NO		NO
Lack of Polarization Blocking 60FF (ZLV-***-****N/O**)	YES / NO		NO
Minimum Phase Voltage	0.05 - 10 V	0.01 V	0.2 V 1 V (*)
Minimum Zero Sequence Voltage	0.05 - 10 V	0.01 V	0.2 V 1 V (*)
Minimum Negative Sequence Voltage	0.05 - 10 V	0.01 V	0.2 V 1 V (*)
Minimum Positive Sequence Voltage (ZLV-***-****A/B/C/D/E/F/G/H**)	0.05 - 10 V	0,01 V	0.2 V 1 V (*)
Coordination Time	0 - 30 ms	1 ms	0 ms
Zero Sequence Voltage Compensation Factor	0.00 - 50	0.01	0
Negative Sequence Voltage Compensation Factor	0.00 - 50	0.01	0

(*) ZLV-*-****C/D/E/F/G/H** Models.**

- **Directional Elements: HMI Access**

ZLV-***-****A/B/C/D/E/F/G/H**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**8 - OVERCURRENT**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**9 - OVERCURRENT**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - DIRECTIONAL**	**0 - PHASE CHARAC ANGLE**
...	1 - TIME OVERCURRENT	**1 - GND. CHARACT. ANGLE**
*** - OVERCURRENT**	2 - INSTANTANEOUS	**2- NEGSEQ CHARACT ANGLE**
...		**3 - LACK POLARIZ BLOCK**
		4 - COORD TIME
		5 - MIN. PHASE VOLTAGE
		6 - MIN. GND VOLTAGE
		7 - MIN NEG SEQ VOLTAGE
		8 - RESID. VOLT. COMP.
		9 - NEGSEQ VOLT. COMP.

ZLV-***-****A/B/C/D/E/F/G/H**

0 - DISTANCE	**0 - DIRECTIONAL**	**0 - PHASE CHARACT ANGLE**
...	1 - TIME OVERCURRENT	**1 - GND. CHARACT. ANGLE**
*** - OVERCURRENT**	2 - INSTANTANEOUS	**2 -NEGSEQ CHARACT ANGLE**
...		**3 - POSSEQ CHARACT ANGLE**
		4 - LACK POLARIZ BLOCK
		5 - COORD. TIME
		6 - MIN. PHASE VOLTAGE
		7 - MIN. GND VOLTAGE
		8 - MIN. NEG SEQ VOLTAGE
		9 - MIN POS SEQ VOLTAGE
		10 - RESID.VOLT. COMP.
		11 - NEGSEQ VOLT.COMP.
		12 - LACK POLARIZ BLOCK 60FF**

(*) 8 or 9 option, depending on the model.
(**) ZLV-*-****N/O** Models.**

3.13.8 Digital Inputs and Events of the Directional Modules

Table 3.13-6: Digital Inputs and Events of the Directional Modules

Name	Description	Function
INH_DIR_PH	Directional phase element inhibit	The activation of these inputs converts the directional elements into non-directional.
INH_DIR_N	Directional ground element inhibit	
INH_DIR_NS	Directional negative sequence element inhibit	
INH_DIR_PS	Directional positive sequence element inhibit (ZLV-***-****A/B/C/D/E/F/G/H**)	
INH_DIR_ZII	Zone 2 directional element inhibit	
INV_TRIP	Inversion of the trip direction	When the input is quiescent, the operation zones are those indicated in this section. If it is activated, the operation zone of all the directional elements is inverted.

3.13.9 Digital Outputs and Events of the Directional Modules

Table 3.13-7: Digital Outputs and Events of the Directional Modules

Name	Description	Function
RDI_A	Phase A instantaneous reverse direction	Indication that the current flows in the direction opposite to that of the trip. The signals of time overcurrent elements are activated when the "coordination time" is up.
RDI_B	Phase B instantaneous reverse direction	
RDI_C	Phase C instantaneous reverse direction	
RDI_N	Ground instantaneous reverse direction	
RDI_NS	Negative sequence instantaneous reverse direction	
RDI_PS	Positive sequence inst. reverse direction (ZLV-***-****A/B/C/D/E/F/G/H**)	
RDI_ZII	Zone 2 instantaneous reverse direction	
RDI_ZIIG	Ground zone 2 instantaneous reverse direction	
RDT_A	Phase A time reverse direction	
RDT_B	Phase B time reverse direction	
RDT_C	Phase C time reverse direction	
RDT_N	Ground time reverse direction	
RDT_NS	Negative sequence time reverse direction	
RDT_PS	Positive sequence time reverse direction (ZLV-***-****A/B/C/D/E/F/G/H**)	
RDT_ZII	Zone 2 time reverse direction	
RDT_ZIIG	Ground zone 2 time reverse direction	
DIRI_A	Phase A instantaneous direction	Indication that the current flows in the direction of the trip. The signals of time overcurrent elements are activated when the "coordination time" is up.
DIRI_B	Phase B instantaneous direction	
DIRI_C	Phase C instantaneous direction	
DIRI_N	Ground instantaneous direction	
DIRI_NS	Negative sequence instantaneous direction	
DIRI_PS	Positive sequence instantaneous direction (ZLV-***-****A/B/C/D/EF/G/H**)	
DIRI_ZII	Zone 2 instantaneous direction	
DIRI_ZIIG	Ground zone 2 instantaneous direction	

Table 3.13-6: Digital Outputs and Events of the Directional Modules		
Name	**Description**	**Function**
DIRT_A	Phase A time direction	Indication that the current flows in the direction of the trip. The signals of time overcurrent elements are activated when the “coordination time” is up.
DIRT_B	Phase B time direction	
DIRT_C	Phase C time direction	
DIRT_N	Ground time direction	
DIRT_NS	Negative sequence time direction	
DIRT_PS	Positive sequence time direction (ZLV-***-****A/B/C/D/E/F/G/H**)	
DIRT_ZII	Zone 2 time direction	
DIRT_ZIIG	Ground zone 2 time direction	
LP_DIR_PH_A	Loss of polarization for phase A	Indication for loss of polarization from the corresponding directional unit.
LP_DIR_PH_B	Loss of polarization for phase B	
LP_DIR_PH_C	Loss of polarization for phase C	
LP_DIR_N	Loss of polarization for ground	
LP_DIR_NS	Loss of polarization for negative sequence	
LP_DIR_PS	Loss of polarization for positive sequence (ZLV-***-****A/B/C/D/E/F/G/H**)	
LP_DIR_ZII	Loss of polarization for distance	

3.13.10 Directional Elements Test

The enable **Pickup Blocking** or the **Torque Control** must be set to **Direction** and the inversion of directionality input must not be operational before running the test.

The test can be performed phase by phase: Ia with Vb, Ib with Vc, Ic with Va. Tables 3.13-7, 3.13-8, 3.13-9 and 3.13-10 present the angles between which the IED must enable direction. Whether or not the IED is seeing direction can be checked with the menu **Information** - **Status** - **Measuring Elements** - **Overcurrent** - **Directional Element** or in the ***ZIVercomPlus***® to **Status** – **Elements** - **Overcurrent** - **Directional** and the states of the flags of the phase being tested must be verified.

Table 3.13-8: Phase Directionality	
V APPLIED	I APPLIED
Vb = 64V⌊0º	Ia = 1A⌊(α phase char. -90º to α phase char. +90º) ± 2º
Vc = 64V⌊0º	Ib = 1A⌊(α phase char. -90º to α phase char. + 90º) ± 2º
Va = 64V⌊0º	Ic = 1A⌊(α phase char. -90º to α phase char. + 90º) ± 2º

Table 3.13-9: Directional Ground by Vpol	
V APPLIED	I APPLIED
Va = 64V⌊180º	In = 1A⌊ (-(90º+ α ground char.) to 90º - α ground char.) ± 2º

Table 3.13-10: Directional Ground by Ipol	
I APPLIED	I APPLIED
Ip = 1A ⌊180º	In = 1A ⌊(-90º to 90º)

Table 3.13-11: Negative Sequence Directionality	
V APPLIED	I APPLIED
Va = 64V ⌊180º	In = 1A ⌊ (-(90º+ α negative char.) to 90º - α negative char.) ± 2º

Table 3.13-12:Positive Sequence Directionality	
V APPLIED	I APPLIED
Va = 64V ⌊0º	Ia = 1A ⌊ (-(90º+ α positive char.) to 90º - α positive char.) ± 2º

For all overcurrent elements there is the possibility of subordinating these to a directional element based on the pickup of zone 2, such that if zone 2 does not pick up it will be considered that there is no trip direction.

To test this type of directionality, the distance elements will be enabled but the trip will be masked.

A phase overcurrent element will be enabled and the directionality will be adjusted in Z2 mode. We will verify that the trip is produced provided the pickup value of the element is exceeded and zones 2 of ground and phases are picked up. The phase overcurrent will be disabled.

Now a ground overcurrent element will be enabled and its directionality will be adjusted in Z2G mode. We will verify that the trip is produced provided the pickup value of the element is exceeded and zone 2 of ground is picked up. The ground overcurrent will be disabled.

Now a negative sequence overcurrent element will be enabled and its directionality adjusted in Z2 mode. We will verify that a trip is produced provided the pickup value of the element is exceeded and zones 2 of ground or phases are picked up. The negative sequence overcurrent element will be disabled.

3.14 Protection Schemes for Overcurrent Elements

3.14.1 Introduction

ZLV terminal units, except for the **ZLV-E** models, include different protection schemes to complement the instantaneous (with settable time delay) directional elements of ground or negative sequence overcurrent

All schemes will use two elements, one **Underreach** and one **Overreach**. The first element will coincide, in all **ZLV** relays including overcurrent protection schemes, with the ground or negative sequence instantaneous overcurrent element 1 (OR both). The overreach element will coincide, in **ZLV-A/B** relays**,** with the ground or negative sequence (OR both) instantaneous overcurrent (with the possibility for time delayed) element 2. The **ZLV-F/G/H/J** relays overreach element will pickup when the logic input **Overreach Element Pickup** activates, to which the pickup signal of any overcurrent element could be assigned through the programmable logic.

Underreach and overreach elements must be forward looking. The underreach element must only operate with faults internal to the line, so that time delay must be zero, whereas the overreach element will also cover faults external to the line and must be time delayed.

The underreach and overreach instantaneous tripping may be performed as single-phase trip just by setting the value **Single-phase Trip 67G** to **YES**.

The setting value for **Protection schemes** for **Overcurrent** may be configured as:

1. None.
2. Permissive Underreach Transfer Trip.
3. Direct Transfer Trip.
4. Permissive Overreach Transfer Trip.
5. Directional Comparison Unblocking.
6. Directional Comparison Blocking.

Protection schemes for overcurrent are independent of those associated with the distance elements. Therefore, they can use different communication channels. In this situation the kind of scheme selected for distance and overcurrent elements may be different. However, when the communication channels to be used are the same for both cases the protection scheme selected should be the same for both, distance and overcurrent units.

ZLV IED comprises **Weak Infeed** logic and **Reverse Current Blocking** logic, which, if enabled, could supplement those protection schemes that so require. Said logics are independent from logics associated to **Distance Protection Schemes**.

Note: all inputs and outputs on overcurrent protection scheme logic diagrams will be identified with the word “Overcurrent”, so as to distinguish them from inputs and outputs in distance protection schemes logic, which will be identified with the word ”Distance”.

3.14.2 Permissive Underreach

Permissive Underreach is activated when selected in the **Overcurrent Protection Scheme** setting.

With this scheme, the pickup of the Underreach unit at one of the line ends will generate an instantaneous trip and transmit this channel signal to the other end to allow tripping. The remote terminal will trip instantaneously when the channel signal is received if the overreach unit has picked up.

If weak or zero infeed conditions exist at one of the line ends and the overreach unit is not activated, this end could be tripped in an instantaneous mode, by means of **Weak Infeed Tripping Logic**, if the Underreach unit has picked up at the “strong” end and has therefore sent a permissive tripping signal towards the “weak” end. To this end, **Overcurrent Weak Infeed Output** (**WI_OCM**) should be set to **Echo** + **Trip**, even if the echo signal is not used in the permissive underreach scheme, it being considered useless.

If, because of weak or zero infeed conditions at one of the line ends, underreach unit does not pick up at no end, it is preferable to select a **Permissive Overreach** scheme together with the **Weak Infeed** logic.

3.14.2.a Channel Activation Conditions (“Overcurrent Channel Transmission”)

The communications channel will be activated by any of the following conditions:

1. Pick up of the Underreach unit.
2. Pick up of the Overreach unit, provided the channel reception input is activated.
3. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.

3.14.2.b Tripping Conditions (“Overcurrent Protection Scheme Trip”)

The channel trip will take place upon channel reception and the pick up of the overreach unit or else signal **Overcurrent Weak Infeed Trip** is activated, (**TRIP_WI_OC**), for which **Overcurrent Weak Infeed Output** (**WI_OCM**) must be set to **Echo + Trip**.

3.14.2.c Operation

Channel activation and trip command generation are shown in the block diagram.

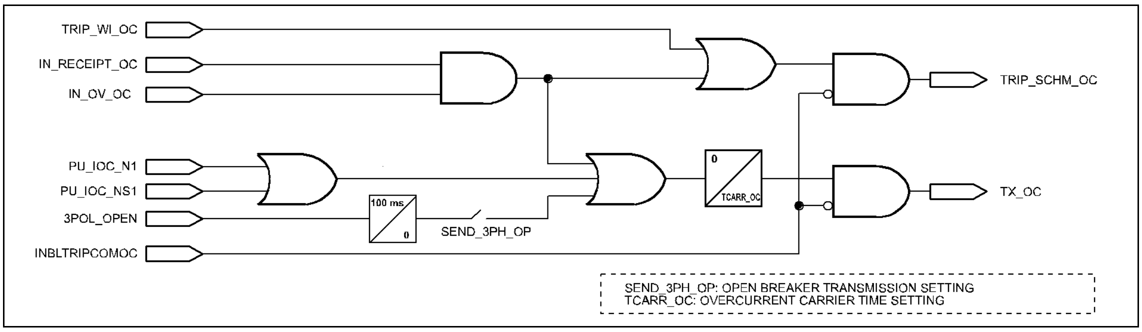


Figure 3.14.1: Permissive Underreach Scheme Block Diagram (Overcurrent).

The purpose of **Overcurrent Carrier Time** (**TCARR_OC**) setting on the diagram is guaranteeing a minimum time for channel activation (**TX_OC**).

Open Breaker Transmission (**SEND_3PH_OP**) setting allows activating the channel upon the opening of the three breaker poles. The purpose of **T2** time delay of 100ms is delaying carrier transmission when this is produced by breaker trip.

Channel tripping and channel activation can be disabled using the status contact input **Overcurrent Channel Trip Blocking** (**INBLTRIPCOMOC**).

The **ZLV-A/B** relay signal **IN_OV_OC** will coincide with **PU_IOC_N2** and **PU_IOC_NS2** OR signal.

3.14.3 Direct Transfer Trip

Direct Transfer Trip scheme is activated when selected in the **Overcurrent Protection Scheme** setting.

This scheme is similar to the Permissive Underreach, except that upon receiving the trip signal form the other end, a direct trip is generated with no additional monitoring.

3.14.3.a Channel Activation Conditions ("Overcurrent Channel Transmission")

The communications channel will be activated by any of the following conditions:

1. Pick up of the Underreach unit.
2. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.

3.14.3.b Tripping Conditions ("Overcurrent Protection Scheme Trip")

Transfer trip will always take place whenever channel reception takes place. For this to occur, the **Overcurrent Protection Scheme Trip** output must be *connected*, by means of the Programmable Logic, to the **Three-Phase Trip Enable** input.

3.14.3.c Operation

Channel activation and trip command generation are shown in the block diagram.

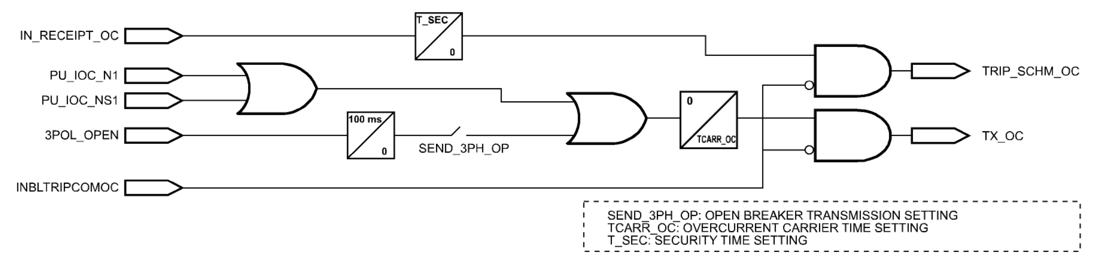


Figure 3.14.2: Direct Transfer Trip Scheme Block Diagram (Overcurrent).

The purpose of **Overcurrent Carrier Time** (**TCARR_OC**) setting on the diagram is guaranteeing a minimum time for channel activation (**TX_OC**).

Open Breaker Transmission (**SEND_3PH_OP**) setting allows activating the channel upon the opening of the three breaker poles. The purpose of **T2** time delay of 100ms is delaying carrier transmission when this is produced by breaker trip.

The purpose of **Safety Time** (**T_SEC**) setting is guaranteeing a minimum duration of the received signal, thus avoiding undue operations upon channel noise.

Channel tripping and channel activation can be disabled using the status contact input **Overcurrent Channel Trip Blocking** (**INBLTRIPCOMOC**).

3.14.4 Permissive Overreach

Permissive Overreach is activated when selected in the **Overcurrent Protection Scheme** setting.

In this scheme, the pickup of the Overreach unit at one of the line ends sends the permissive trip signal to the other end. The reception of the permissive signal produces an instantaneous trip if the Overreach unit has pick up.

Overcurrent Reverse Current Blocking (**BLK_INV_A_OC**) signal, coming from **Reverse Current Logic** (for overcurrent), blocks, provided it is activated, the input coming from the Overreach unit, to prevent wrong trips upon current reversal produced as a consequence of the sequential clearance of faults in a parallel line.

If weak or zero infeed conditions exist in one of the line ends, so that the Overreach unit is not picked up, neither end may trip under this scheme (they will trip under time delayed conditions). In this case, the permissive overreach scheme should be supplemented by the Weak Infeed logic, which allows sending a trip permissive signal to the “strong” end (as an echo of the signal sent by said end) to achieve its tripping (**Overcurrent Weak Infeed Output** (**WI_OCM**) must be set to **Echo** or **Echo + Trip**), apart from giving the option for tripping the “weak” end (**Overcurrent Weak Infeed Output** (**WI_OCM**) must set to **Echo + Trip**).

3.14.4.a Channel Activation Conditions (“Overcurrent Channel Transmission”)

In order that the communication channel activation is produced at a terminal (permissive signal transmission), any of the following conditions must be met:

1. Pick up of the Underreach or Overreach unit.
2. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.
3. **Overcurrent Echo** (**ECHO_OC**) activated, output of **Weak Infeed Logic**, for which **Overcurrent Weak Infeed Output** (**WI_OCM**) setting of said logic must be set to **Echo** or **Echo + Trip**.

3.14.4.b Tripping Conditions (“Overcurrent Protection Scheme Trip”)

Channel trip will take place upon channel reception and pickup of the overreach unit or if **Overcurrent Weak Infeed Trip** (**TRIP_WI_OC**) is activated, for which **Overcurrent Weak Infeed Output** (**WI_OCM**) of the **Weak Infeed Logic** (for overcurrent elements) must be set to **Echo + Trip**.

3.14.4.c Operation

Channel activation and generation of a trip command are shown in the following block diagram:

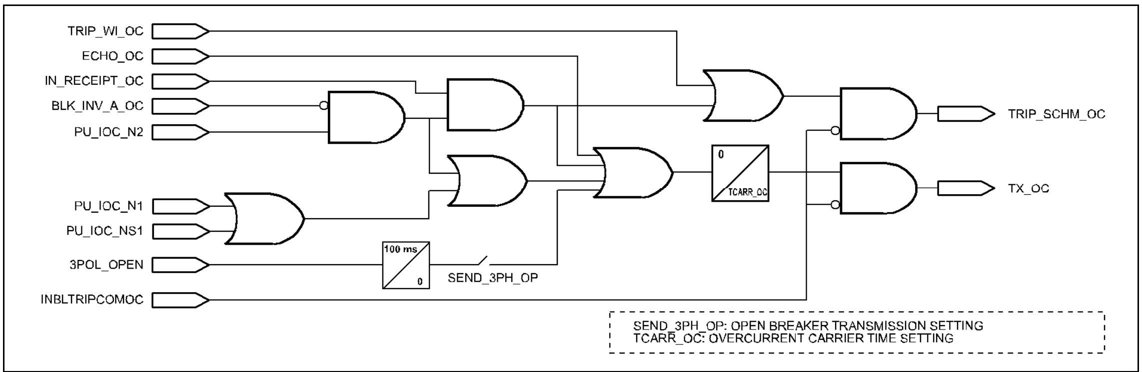


Figure 3.14.3: Permissive Overreach Scheme Block Diagram (Overcurrent).

The purpose of **Overcurrent Carrier Time** (**TCARR_OC**) setting on the diagram is guaranteeing a minimum time for channel activation (**TX_OC**).

Open Breaker Transmission (**SEND_3PH_OP**) setting allows channel activation when all three breaker poles have tripped. The purpose of **T2** timing of 100 ms is to delay carrier transmission when it is produced by breaker tripping.

Channel tripping and channel activation can be disabled using the status contact input **Overcurrent Channel Trip Blocking** (**INBLTRIPCOMOC**).

The **ZLV-A/B** relay signal **IN_OV_OC** will coincide with **PU_IOC_N2** and **PU_IOC_NS2** OR signal.

3.14.5 Directional Comparison Unblocking

Directional Comparison Unblocking is activated when selected in the **Overcurrent Protection Scheme** setting.

In permissive schemes using carrier wave channels, the trip permissive signal is frequently transmitted through the faulted phase/s, and the signal is attenuated, in a number of cases, to such a low level that the signal does not reach the other end. The end not receiving the trip permissive signal will not be able to trip following the Permissive Overreach Scheme (it will produce time delayed trip). In order to avoid timed trips upon this type of situations, the Directional Comparison Unblocking Scheme is used, which is an extension of the Permissive Overreach Tripping Scheme.

The Directional Comparison Unblocking Scheme has been introduced to be used with switched frequency carrier wave equipment. When no fault is present in the line, this equipment continuously sends a signal at a "guard" frequency (guard signal) for channel supervision. Upon detecting a fault, the relay commands the carrier wave equipment to switch the guard frequency to other frequency known as "trip frequency" (trip signal). Thus, but for the time elapsed in the switching process, the teleprotection equipment will never send both signals at the same time.

Upon receipt of the trip signal and non-receipt of the guard signal at one end, said end will trip following the same criteria set up in a Permissive Overreach Scheme (provided the overreach unit is picked up). On the contrary, upon non-receipt of the trip signal and non-receipt of the guard signal, the Directional Comparison Unblocking Scheme will allow, during a time window, the instantaneous tripping of the overreaching unit.

Overcurrent Reverse Current Blocking (**BLK_INV_A_OC**) signal coming from the **Reverse Current Blocking Logic** (associated to overcurrent schemes), blocks, while activated, the input coming from the pickup of the overreaching unit, with the purpose of preventing wrong trips upon current reversals as a consequence of clearing faults in a parallel line in case of double circuits.

The same as for the Permissive Overreach Scheme, if weak or zero infeed conditions exist at one of the line ends, so that the overreaching unit of said end does not pick up, none of the ends can trip with this scheme (it would produce time delayed trip). In this case, the Directional Comparison Unblocking Scheme should be supplemented by the Weak Infeed Logic, which allows the transmission of a trip permissive signal to the "strong" end (as echo of the signal transmitted by said end) in order to achieve its trip (**Overcurrent Weak Infeed Output** (**WI_OCM**) must be set to **Echo** or **Echo + Trip**), apart from giving the option to trip the "weak" end (**Overcurrent Weak Infeed Output** (**WI_OCM**) must be set to **Echo + Trip**).

3.14.5.a Channel Activation Conditions ("Overcurrent Channel Transmission")

For communication channel activation at a terminal (transmission of the permissive signal), any of the following conditions must be present:

1. Pick up of the Underreach or Overreach unit.
2. The three breaker poles tripped if **Open Breaker Transmission** is set to **YES**.
3. Activation of **Overcurrent Echo** (**ECHO_OC**) signal, **Weak Infeed Logic** output, for which **Overcurrent Weak Infeed Output** (**WI_OCM**) of said logic must be set to **Echo** or **Echo + Trip**.

3.14.5.b Tripping Conditions ("Overcurrent Protection Scheme Trip")

Tripping by channel signal reception will occur under the following conditions:

1. Channel reception and loss of guard and Overreach unit picked up.
2. Loss of guard, without channel activation, and Overreach unit picked up before **T_TRIP** times out.
3. **Overcurrent Weak Infeed Trip** (**TRIP_WI_OC**) activated, for which **Overcurrent Weak Infeed Output** (**WI_OCM**) of **Weak Infeed Logic** (for Overcurrent elements) must be set to **Echo + Trip**.

3.14.5.c Operation

Activation of a channel and generation of a trip command are shown in the following block diagram:

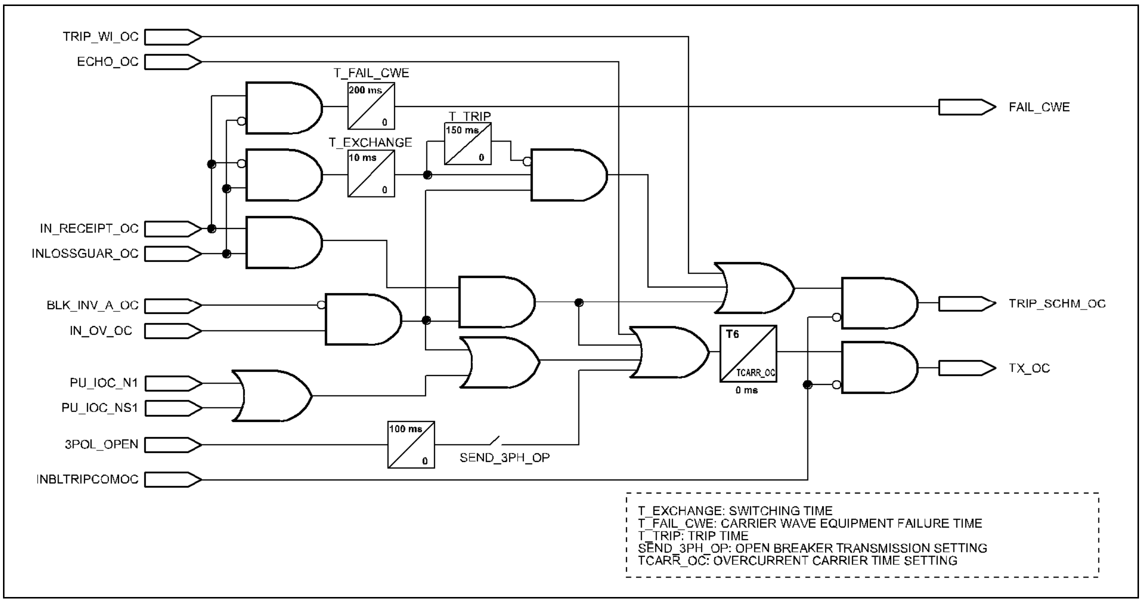


Figure 3.14.4: Directional Comparison Unblocking Scheme Block Diagram (Overcurrent).

The purpose of **Overcurrent Carrier Time** (**TCARR_OC**) on the diagram is guaranteeing a minimum time for channel activation (**TX_OC**).

The purpose of **Open Breaker Transmission** (**SEND_3PH_OP**) setting is activating the channel when the three breaker poles trip. The purpose of **T2** timing of 100 ms is delaying the carrier transmission caused by breaker tripping.

The carrier wave equipment features the following output contacts: one normally closed (hereafter called **Guard**), which remains open when the guard signal is being received, and other normally open (hereafter called **Trip**) which closes upon the reception of the trip signal from the other end. The guard contact must be wired to the **ZLV Overcurrent Guard Loss** input - **INLOSSGUAR_OC**-, whereas the contact trip will be wired to the **IN_RECEIPT_OC** (**Overcurrent Channel Reception**) input. On the other hand the **TX_OC** (**Overcurrent Channel Activation**) output (**ZLV** IED output) must be wired to the wave carrier equipment input, which will give the command for frequency switching.

When both **INLOSSGUAR_OC** and **IN_RECEIPT_OC** inputs are activated, the response is exactly equal to a Permissive Overreach Scheme, an instantaneous tripping being produced provided the overreaching unit is picked up.

In case only **INLOSSGUAR_OC** input is activated, which might indicate a complete attenuation of the trip permissive signal from the other end, if this situation remains during the switching time **T_EXCHANGE**=10 ms (enough for the carrier wave equipment to switch from guard frequency to trip frequency), the overreaching unit will be allowed to trip instantaneously during the time **T_TRIP**=150 ms.

If only **IN_RECEIPT_OC** input has been activated, after time **T_FAIL_CWE**, the signal **FAIL_CWE**=200 ms will be activated, which indicates failure in the carrier wave equipment.

Channel tripping and channel activation can be disabled using the status contact input **Overcurrent Channel Trip Blocking** (**INBLTRIPCOMOC**).

The **ZLV-A/B** relay signal **IN_OV_OC** will coincide with **PU_IOC_N2** and **PU_IOC_NS2** OR signal.

3.14.6 Directional Comparison Blocking

Directional Comparison Blocking is activated when selected in the **Overcurrent Protection Scheme** setting.

The main difference between this scheme and the others is that the channel signal is transmitted to avoid remote tripping instead of accelerating it.

Proper operation of this scheme requires that the ground or negative sequence element, used to activate the channel, be selected as reverse looking. This element will be the ground or negative sequence instantaneous overcurrent element 3 (OR logic of these elements) in **ZLV-A/B** relays. Therefore, in said relays, when this protection scheme is selected, element 3 will have a reverse direction torque control, even though its setting indicates otherwise. The **ZLV-F/G/H/J** relays reverse looking element will pickup when the logic input **Reverse Direction element** activates, to which the pickup signal of any overcurrent element could be assigned. In **ZLV-F/G/H/J** relays the torque control of the overcurrent element selected as reverse looking will always be as indicated by the setting.

The pickup of the reverse direction unit at a line end will send the trip blocking signal to the remote-end to avoid tripping by overreach unit. This way, the trip is only produced upon non-receipt of the blocking signal from the remote end terminal of the line.

Correct application of this scheme requires that the following conditions be satisfied:

1. The pickup setting of the reverse direction unit must be lower than the setting of the overreaching unit in the rest of terminals, so as to guaranteeing the blocking of any external fault outside the line for which the overreaching unit/s picked up.
2. An overreaching unit trip delay time must be considered to allow the communication equipment to transmit the blocking signal from the remote to the local terminal. Said delay is given by **Overcurrent Delay Time** setting.

Echo and **Weak Infeed Trip Logic** is purposeless under this scheme. On the other hand, this scheme needs not be supplemented by the **Reverse Current Blocking Logic** because this scheme can detect the current reversal thanks to the use of the reverse direction unit.

3.14.6.a Channel Activation Conditions (“Overcurrent Channel Transmission”)

The communications channel (trip blocking) will activate under the following condition:

1. Pickup of the reverse direction unit, with no activation of the Overreaching unit and non-existence of any conditions for transmission disable.
2. Channel trip blocking input activated and non-existence of any conditions for transmission disable. In this case, as it is a blocking system, channel activation means trip blocking.

3.14.6.b Channel Stop Conditions (“Overcurrent Channel Disable”)

The communications channel (trip blocking) will deactivate (trip blocking signal deactivated) under any of the following conditions:

1. Activation of the **Channel Stop** status contact input.
2. Overreach unit activation without channel signal reception, reverse direction activation or activation of the **Channel Tripping Blocking** input.
3. Underreach unit activation.

3.14.6.c Tripping Conditions (“Overcurrent Protection Scheme Trip”)

A trip using this protection scheme will occur provided the following conditions are satisfied at the same time:

1. Overreach unit activation.
2. No channel signal is received (blocking signal, from the other terminal).
3. Reverse direction unit is not activated.

3.14.6.d Operation

Activation of a channel and generation of a trip command are shown in the following block diagram:

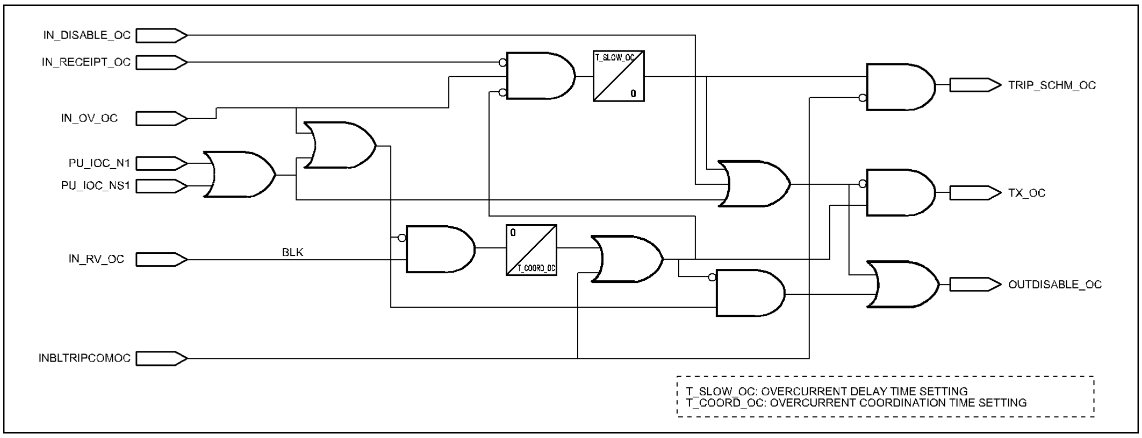


Figure 3.14.5: Directional Comparison Blocking Scheme Block Diagram (Overcurrent).

The purpose of **Overcurrent Delay Time** (**T_SLOW_OC**) setting, as previously mentioned, is to allow, for external faults, a time lapse for the receipt of the blocking signal from the remote end terminal.

Overcurrent Coordination Time (**T_COORD_OC**) sets a reset time for the reverse direction unit pickup signal, so as to prevent channel disable upon current reversal in double circuits, as a consequence of sequential parallel line breaker trips on a fault in the same. It is worth mentioning that the underreach unit may disable the blocking transmission, no matter the pickup of the reverse direction unit, as said underreach unit is only picked up upon internal line faults.

The purpose of **ZLV** Channel Disable output is to be wired to the teleprotection equipment **PARADA_CANAL** input so as to disable the channel. However, said output also disables the channel activation output as a prevention measure, in case **PARADA_CANAL** input has not been setup in the teleprotection equipment as a priority against **ACTIVACION_CANAL** input, when both are active.

Channel tripping and channel activation can be disabled using the status contact input **Overcurrent Channel Trip Blocking** (**INBLTRIPCOMOC**).

The **ZLV-A/B** relay signals **IN_OV_OC** and **IN_RV_OC** will coincide with **PU_IOC_N2** and **PU_IOC_NS2** OR signal and **PU_IOC_N3** and **PU_IOC_NS3** OR signal, respectively.

3.14.7 Weak Infeed Logic

The **Weak Infeed Logic**, if enable, can work in parallel with all permissive teleprotection schemes.

As mentioned before, if a Permissive Overreaching Scheme has been selected (or Directional Comparison Unblocking) and one of the line ends is in a weak infeed condition, so that overreaching unit is not picked up at said end, none of the line terminals can trip instantaneously. To this end, the teleprotection scheme must be supplemented by the **Weak Infeed Logic**, which presents two options: **Echo Transmission** and **Weak Infeed Tripping**.

3.14.7.a Echo Logic

This function is enabled by setting **Overcurrent Weak Infeed Output** (**WI_OCM**) to **Echo**.

The Echo function allows sending a permissive trip signal to the “strong” end (as echo of the signal transmitted by said end).

The echo signal will be activated provided a signal from the other end has been received and the reverse direction unit has not picked up.

3.14.7.b Weak Infeed Tripping

This function is enabled by setting **Overcurrent Weak Infeed Output** (**WI_OCM**) to **Echo + Trip**.

The echo transmission allows the trip (instantaneous) of the “strong” end, but not the “weak” end trip. The weak infeed trip allows tripping this latter end when undervoltage conditions are detected, a permissive trip signal has been received and the reverse direction unit or the Overreaching unit is not picked up.

The weak infeed function is always associated to echo transmission.

In view of the need for one of the units monitors in reverse direction for correct logic operation, when setting **Overcurrent Weak Infeed Output** takes the value **Echo** or **Echo + Trip**, unit 3 will present a reverse direction torque control, even if its setting indicates otherwise (**ZLV-A/B** relays only).

3.14.7.c Operation

Figure 3.14.6 shows the logic operating diagram.

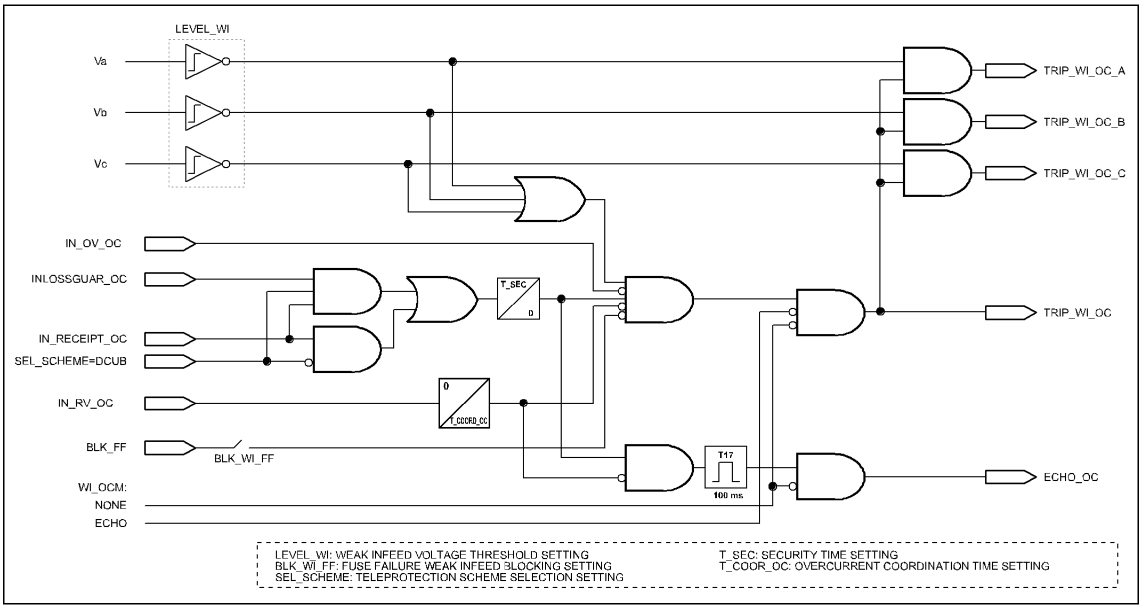


Figure 3.14.6: Weak Infeed Logic Block Diagram (Overcurrent).

Undervoltage detectors (represented as negated overvoltage detectors) pickup and reset with only one value, equal to **Weak Infeed Voltage Threshold** (**LEVEL_WI**) setting.

The purpose of **Safety Time** (**T_SEC**) setting is guaranteeing a channel receipt time to avoid echo transmission upon channel noise.

If a **Directional Comparison Unblocking** scheme has been selected, the **Channel Receipt** (**IN_RECEIPT_OC**) must be supplemented with **Guard Loss** (**INLOSSGUAR_OC**) input activation.

The setting **Overcurrent Coordination Time** (**T_COORD_OC**) is used to prevent weak infeed trips upon current reversal in double circuits.

The Weak Infeed trip can be blocked by **Fuse Failure Blocking** (**BLK_FF**) signal activation, provided **Fuse Failure Weak Infeed Blocking** (**BLK_WI_FF**) is set to **YES**, as the indication of undervoltage detectors is not reliable upon a fuse failure.

TRIP_WI_OC_A, **TRIP_WI_OC_B** and **TRIP_WI_OC_C** outputs act as phase selectors (as will be seen in Single-Phase / Three-Phase Trip Logic) when the setting **67G Single-Phase Trip** is set to **YES**, as under weak infeed conditions the phase selector may generate no outputs, the positive sequence current being very small.

The **ZLV-A/B** relay signals **IN_OV_OC** and **IN_RV_OC** will coincide with **PU_IOC_N2** and **PU_IOC_NS2** OR signal and **PU_IOC_N3** and **PU_IOC_NS3** OR signal, respectively.

3.14.8 Transient Blocking by Current Reversal Logic

In double circuits, the sequential trips of the breakers associated to one of the lines, as a consequence of the clearance of a fault in the same, can produce a current reversal in the parallel line. Said current reversal will cause the activation of the overreaching unit hitherto deactivated at one end and the reset of said unit at the opposite end. As these events do not occur at the same time, overreaching teleprotection schemes can give way to wrong trips in the unimpaired line.

Figure 3.14.7 represents a current reversal event.

In case of a Permissive Overreaching Scheme, a current reversal in line 2 takes place upon the trip of the breaker in B1, and the B2 relay overreaching unit picks up. If the trip permissive signal coming from the relay in A2 has not yet reset a channel trip will be produced in B2. In order to avoid these types of wrong trips the B2 relay overreaching unit should be temporarily blocked.

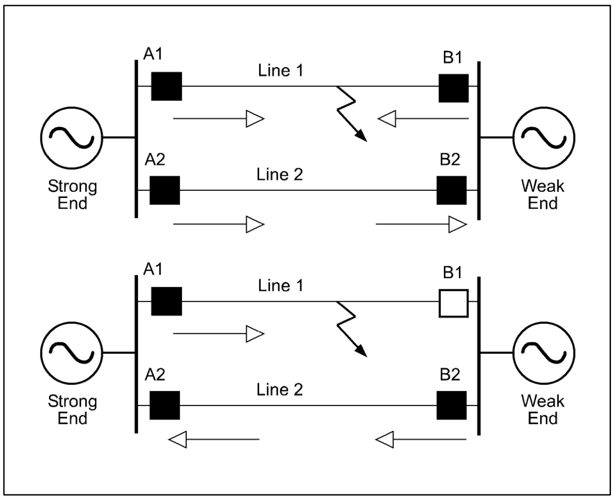


Figure 3.14.7: Current Reversal Event.

3.14.8.a Operation

The **Transient Blocking by Current Reversal Logic** generates **Overcurrent Reverse Current Blocking** (**BLK_INV_A_OC**) signal when the reverse direction unit picks up. Said signal **BLK_INV_A_OC** will stay active during **Overcurrent Coordination Time** (**T_COORD_OC**) setting, from the reset of the reverse direction unit.

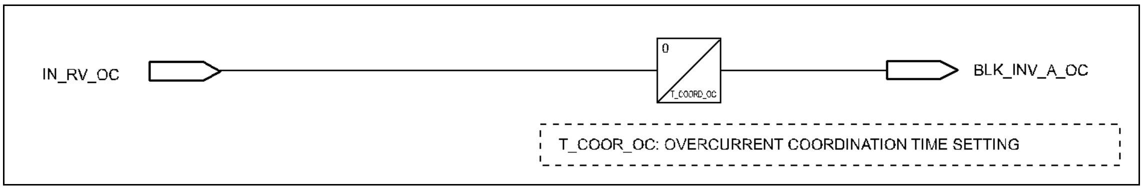


Figure 3.14.8: Block Diagram for Reverse Current Blocking Logic (Overcurrent).

Given the need for one of the units supervising in reverse direction for the correct operation of this logic, enabling it will make unit 3 presents a reverse direction torque control, even if its setting indicates otherwise (**ZLV-A/B** relays only).

The **ZLV-A/B** relay signal **IN_RV_OC** will coincide with **PU_IOC_N3** and **PU_IOC_NS3** OR signal.

3.14.9 Programmable Schemes

Apart from the available protection schemes, any other protection scheme can be setup by means of the programmable logic incorporated into the equipment. In this case, teleprotection schemes can be generated, which need the transmission of several signals between both line ends (indication of the faulted phase, single-phase and three-phase permissive signals, etc), for which a digital network may be the communication media.

3.14.10 Overcurrent Elements Protection Schemes Settings

Protection Scheme (*)			
Setting	**Range**	**Step**	**By default**
Carrier Transmission Enable by 52 Open	YES / NO		YES
Carrier Reception Safety Time	0 - 50 ms	1 ms	0 ms
Weak Infeed Voltage Level	15.00 - 70.00 V	0.01 V	45 V
Weak Infeed Trip Blocking due to Fuse Failure	YES / NO		NO

Overcurrent Protection Schemes			
Setting	**Range**	**Step**	**By default**
Protection Scheme	None Permissive Underreach. Direct Transfer Trip. Permissive Overreach. Directional Comparison Unblocking. Directional Comparison Blocking.		None
Carrier Time	0 - 200 ms	10 ms	50 ms 0 ms (**)
Coordination Time (Reverse Current Blocking Logic)	0 - 50 ms 0 - 300 ms (**)	1 ms	25 ms
Blocking Scheme Level 2 Time Delay	0 - 200 ms	10 ms	50 ms
Weak Infeed Logic Output	NONE ECHO ECHO + TRIP		None
Reverse Current Blocking Logic for Overcurrent Elements	YES / NO		NO
Overcurrent Protection Scheme Delay (ZLV-***-****D/E/F/G/H**)	0.0 - 100.00 s	0.01 s	0 s

(*) Common to Distance and Overcurrent Schemes.
(**) ZLV-*-****C/D/E/F/G/H** Models.**

Remark: on ZLV-A/B relays if selected protection scheme is Directional Comparison Blocking, or if Weak Infeed and Reverse Current Blocking Logic are enabled, ground overcurrent and negative sequence elements 3 will actuate as if were set to Reverse Direction, even if Torque Control setting is Direction.

- **Overcurrent Elements Protection Schemes: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	…
3 - INFORMATION	**3 - PROTECTION**	**15 - PROTECTION SCHEME**
	….	…

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	1 - DIST SUPERVISION
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	…
3 - INFORMATION	**3 - PROTECTION**	**16 - PROTECTION SCHEME**
	….	…

0 - DISTANCE	**0 - CARRIER BY OPEN BRKR**
1 - DIST SUPERVISION	**1 - SECURITY TIME**
…	**2 - WI UNDERVOLT LEVEL**
*** - PROTECTION SCHEME**	**3 - FF WI BLOCK**
…	**4 - DISTANCE PILOT PROT.**
	5 - O/C PROTEC SCHEME

(*) 15 or 16 option, depending on the model

0 - CARRIER BY OPEN BR	**0 - O/C PROTEC SCHEME**
1 - SECURITY TIME	**1 - O/C CARRIER TIME**
2 - WI UNDERVOLT LEVEL	**2 - O/C COORD TIME**
3 - FF WI BLOCK	**3 - O/C DELAY DCB**
4 - DISTANCE PILOT PRO	**4 - O/C WI LOGIC OUTP**
5 - O/C PROTEC SCHEME	**5 - O/C CUR INV BLOCK**
	6 - O/C SCHEME DELAY (*)

(*) ZLV-*-**** D/E/F/G/H** Models.**

3.14.11 Digital Inputs and Events of the Overcurrent Protection Schemes Module

Table 3.14-1: Digital Inputs and Events of the Overcurrent Protection Schemes Module

Name	Description	Function
IN_RECEIPT_OC	Overcurrent channel receipt input	The activation of this input means a signal receipt (trip permissive or blocking, as a function of the selected scheme) from the other end.
INBLTRIPCOMOC	Overcurrent channel trip blocking input	The activation of this input blocks the trip of any overcurrent protection scheme.
INLOSSGUAR_OC	Overcurrent guard signal loss input	The activation of this input means that the guard signal receipt has ceased. It is used in the Directional Comparison Unblocking scheme.
IN_DISABLE_OC	Overcurrent channel disable input	The activation of this input generates Channel Disable output. It is used in the Directional Comparison Blocking scheme.
IN_OV_OC	Overreach element pickup input (ZLV-F/G/H/J)	Overreach overcurrent element pickup
IN_RV_OC	Reverse looking element pickup input (ZLV-F/G/H/J)	Reverse looking overcurrent element pickup

3.14.12 Digital Outputs and Events of the Overcurrent Protection Schemes Module

Table 3.14-2: Digital Outputs and Events of the Overcurrent Protection Schemes Module		
Name	**Description**	**Function**
TRIP_SCHM_OC	Overcurrent protection scheme trip	Selected overcurrent protection scheme trip.
TX_OC	Overcurrent channel transmission	Channel activation by the selected overcurrent protection scheme.
FAIL_CWE	Carrier wave equipment failure	Carrier wave equipment failure.
OUTDISABLE_OC	Overcurrent channel disable	Output for channel disabling used in Directional Comparison Blocking scheme.
TRIP_WI_OC	Overcurrent weak infeed trip	Weak infeed condition trip in overcurrent protection scheme.
TRIP_WI_OC_A	Phase A overcurrent weak infeed trip	Trip by weak infeed condition in phase A in overcurrent protection scheme.
TRIP_WI_OC_B	Phase B overcurrent weak infeed trip	Trip by weak infeed condition in phase B in overcurrent protection scheme.
TRIP_WI_OC_C	Phase C overcurrent weak infeed trip	Trip by weak infeed condition in phase C in overcurrent protection scheme.
ECHO_OC	Overcurrent echo transmission	Echo transmission in overcurrent protection scheme.
BLK_INV_A_OC	Overcurrent reverse current blocking	Overreaching unit blocking in overcurrent protection scheme by current reversal detection.

3.15 Lines with Series Compensation

3.15.1 Operating Principles

Faults which involve voltage reversal can be produced in a line with Series Compensation, which occurs when the impedance existing from the voltage transformer position up to the fault point is capacitive. This voltage reversal results in erroneous directional decisions, given that all the directional units are designed assuming inductive relations between the operating current and the polarization voltage.

The distance characteristics determine the direction of the fault, using positive sequence voltage as a polarization phasor. In most cases this voltage is not reversed in case of single-phase or two-phase faults, but may be in case of three-phase faults, for which the use of memory of this voltage is necessary. When the Series Compensation Logic is enabled, the positive sequence voltage with memory is always used whenever the fault detector is active, independent of the positive sequence voltage level at the time, given that a reversal of this voltage can be given with relatively high values of this. The duration of the voltage memory will be given by the **Memory Duration** setting.

In general, to correctly clear faults in a forward direction it is not necessary to use high voltage memory times, because the voltage reversal do not tend to arise for faults in Zone 2 (it would be necessary to verify that the inductive reactance existing from the voltage transformer up to the reach of Zone 1 is higher than the capacitive reactance introduced). The correct actuation in case of reverse direction faults may, however, require very high voltage memory times, which will depend on the actuation times of the protections (of other lines) in charge of clearing these faults. In order to avoid incorrect trips at the end of the voltage memory time, the **ZLV** IED incorporates a logic which allows to transiently blocking all directional units which supervise in a forward direction, once it is detected that the fault is in a reverse direction. This logic is not included in the **ZLV-E** models.

Figure 3.15.1 presents the diagram of the operation of this logic.

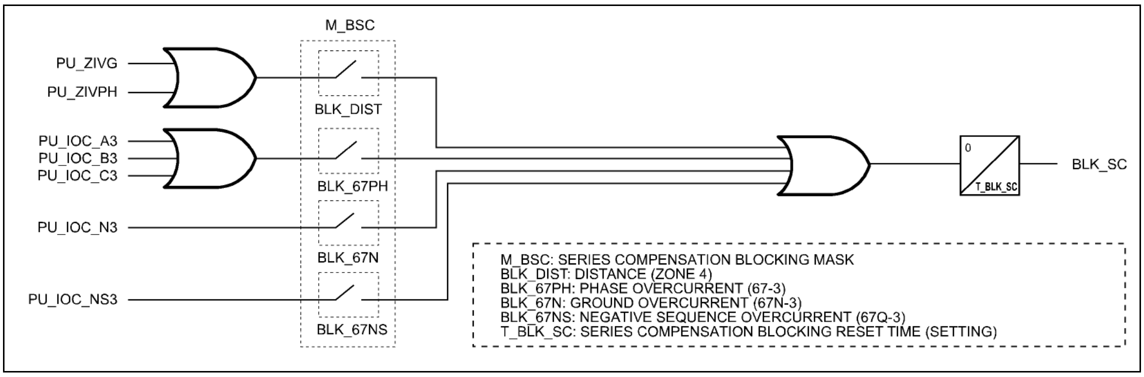


Figure 3.15.1: Block Diagram of the Logic for Lines with Series Compensation.

The **Series Compensation Blocking** signal can be activated by any of the following elements, which should supervise in the reverse direction, according to the **Series Compensation Blocking Mask**:

- Distance: Zone 4.
- Ground overcurrent: Level 3, instantaneous.
- Negative sequence overcurrent: Level 3, instantaneous.
- Phase overcurrent: Level 3, instantaneous.

The **Series Compensation Blocking** signal will block the activation of distance zones 1, 2 and 3 (see Step Distance 3.2.2), and the activation of levels 1 and 2, instantaneous as well as timed, of phase overcurrent (see Overcurrent Elements, 3.12). Levels 1 and 2 (instantaneous or timed) of ground and negative sequence overcurrent do not require to be blocked given that the directional elements which can subordinate these either solve the voltage reversal problem without using voltage memory (see Ground and Negative Sequence Directional Units, 3.13.3 and 3.13.4) or otherwise have already been blocked (in case of selecting zone 2 as the directional element).

The **Series Compensation Blocking** signal has a reset time which is given by the **Series Compensation Blocking Time** setting. This time allows to maintain the blocking of the units on which it acts, when the voltage memory times out.

ZLV-*-****A/B/C/D/E/F/G/H**** relays do not feature **Series Compensation Blocking** mask setting or **Series Compensation Blocking Time** setting. These relays enable setting voltage memory times of up to 100 cycles so generating the signal **Series Compensation Blocking** is not required. The logic enable setting for series compensation lines results in using the voltage memory for all types of faults, irrespective of positive sequence voltage level of the fault.

3.15.2 Lines with Series Compensation Logic Settings

Lines with Series Compensation Logic			
Setting	**Range**	**Step**	**By default**
Logic enable	YES / NO		NO
Transient blocking time delay (*)	0 - 100 s	0.01 s	1 s
Mask of blocking elements	Distance (Zone 4)		NO
(Reverse direction supervision elements) (*)	Ground Overcurrent (67N-3)		NO
	Neg. Sequence Overcurrent (67Q-3)		NO
	Phase Overcurrent (67-3)		NO

(*) No available for ZLV-*-****A/B/C/D/E/F/G/H** Models.**

- **Lines with Series Compensation Logic: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**17 - SERIES COMP. LOGIC**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**18 - SERIES COMP. LOGIC**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	**0 - SERIES COMP ENABLE**
...	**1 - SER COMP BLOCK DLY (**)**
*** - SERIES COMP. LOGIC**	**2 - SC BLQ DIST (**)**
...	**3 - SC GND O/C BLQ (**)**
	4 - SC NS O/C BLQ (**)
	5 - SC PH O/C BLQ (**)

(*) 17 or 18 option, depending on the model.
(**) Not available for ZLV-*-****A/B/C/D/E/F/G/H** Models.**

3.15.3 Digital Inputs and Events of the Lines with Series Compensation Logic

Table 3.15-1: Digital Inputs and Events of the Lines with Series Compensation Logic

Name	Description	Function
ENBL_SC	Series compensation logic enable input	Activation of this input puts the element into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."

3.15.4 Digital Outputs and Events of the Lines with Series Compensation Logic

Table 3.15-2: Digital Outputs and Events of the Lines with Series Compensation Logic

Name	Description	Function
BLK_SC	Series compensation logic blocking	Transient blocking output for series compensation lines.
SC_ENBLD	Series compensation logic enabled	Indication of enabled or disabled status of the logic.

3.16 Stub Bus Protection

3.16.1 Operating Principles

Stub bus protection is usually used in breaker-and-a-half or ring configurations and its purpose is to protect the section between the two current transformers and the line sectionalizer (this zone is called "stub bus" or "heel") when the latter is open. In this case, and if the voltage transformer is on the line side, the distance elements cannot trip since they do not have sufficient voltage to polarize. This function is not included in the **ZLV-E** models.

When the line sectionalizer is open and, in case of a fault outside the "heel," the current which arrives to the relay is practically null (given that the same current value circulates through the secondaries of the current transformers, but in the opposite direction).

However, in case that the fault is situated in the stub bus, the current going through the secondaries of both current transformers is added, such that a fault current arrives to the relay.

Figure 3.16.1 represents a breaker-and-a-half substation with a fault in the Stub Bus.

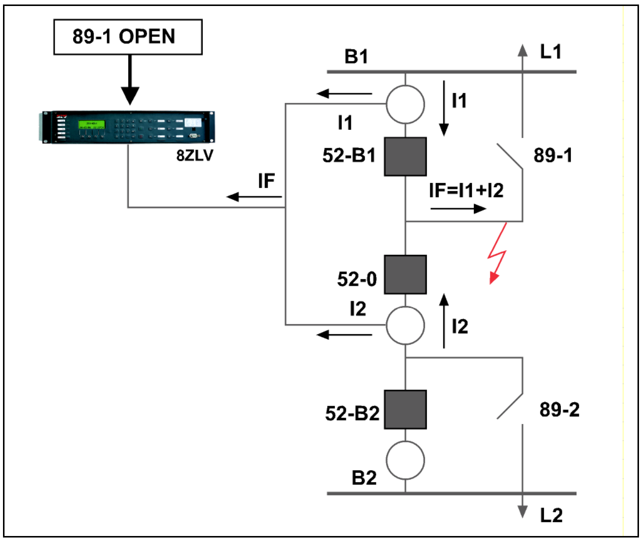


Figure 3.16.1: Breaker-and-a-Half Substation with Stub Bus Fault.

The Stub Bus protection operates only with the aperture of the line sectionalizer (activation of the **Open Line Sectionalizer** (**IN_89L_A**) input, to which the normally closed contact of the line sectionalizer position should be wired) and this involves a non-directional overcurrent element with a defined time.

STUB Bus protection pickup is normally set at a high level, to prevent trips on external faults that cause saturation of any CT (thus leading to residual current).

Figure 3.16.2 represents the operation diagram of stub bus protection.

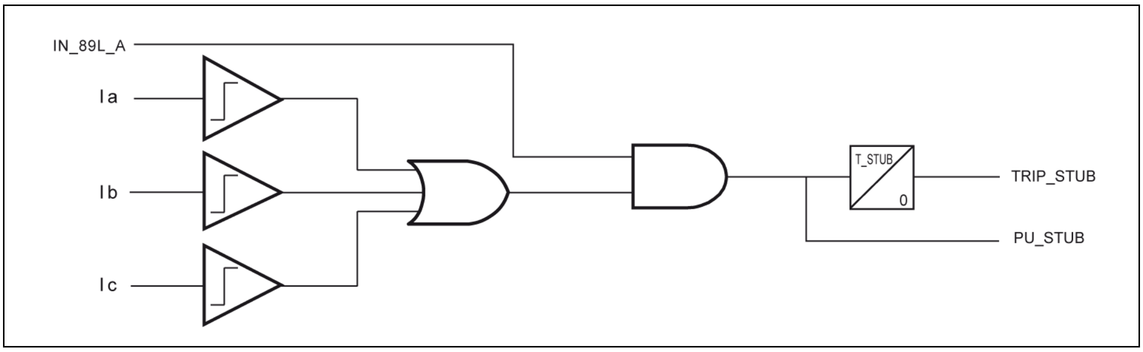


Figure 3.16.2: Block Diagram of the Stub Bus Protection.

Legend	
IN_89L_A: Open Line Sectionalizer Input.	T_STUB: Stub Bus Protection Time Delay (setting).
TRIP_STUB: Stub Bus Protection Trip.	
PU_STUB: Stub Bus Protection Pickup.	

The Stub Bus protection operates when the phase current equals 1.05 times the pickup value and resets when said current equals the pickup value.

3.16.2 ZLV-G/J Relays STUB Bus Protection

ZLV-G/J relays are designed for the protection of a dual breaker bay and measure the currents from the two CTs associated to said bay (I1 and I2 in figure 3.16.1). The line current I is calculated internally by the sum of I1 and I2. The saturation of a CT on a fault external to the Stub Bus generates a line current that can operate the Stub Bus protection.

In order to increase the stability of said protection on external faults, the **ZLV-G/J** relay Stub Bus protection incorporates a percent restraint characteristic with adjustable slope. Figure 3.16.3 shows the characteristic associated to phase A. The straight line of adjustable slope, α, goes through the origin. The IAMIN current is the element pickup setting. A similar characteristic applies to phases B and C.

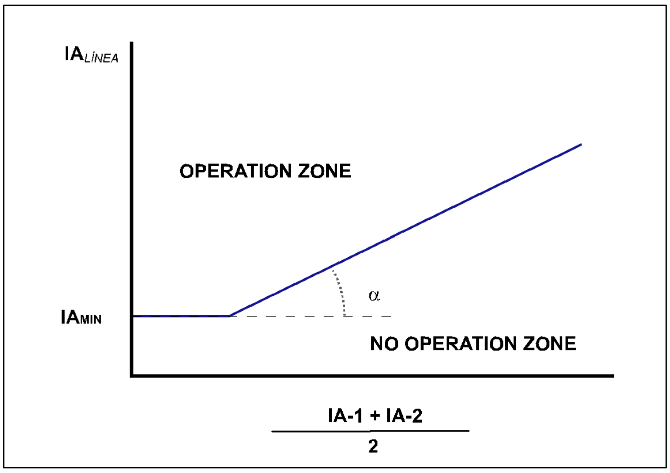


Figure 3.16.3: Operating Characteristic of ZLV-G/J Relay Stub Bus Protection.

Phase A restraint current is calculated as $IA_{rest} = \frac{IA-1+IA-2}{2}$, where IA-1 and IA-2 are currents measured by relay channels IA-1 and IA-2.

3.16.3 Stub Bus Protection Settings

Stub Bus			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	(0.02 - 30) In A	0.01 A	2 In
Time delay	0 - 100 s	0.01 s	0 s
Restraint slope (ZLV-G/J)	0 200%	1%	20%

- **Stub Bus: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**14 - STUB BUS PROTECION**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - STUB BUS PROT. ENA**
...	**1 - STUB BUS PROT. PU**
14 - STUB BUS PROTECION	**2 - STUB BUS PROT. DLY.**
...	

ZLV-F/H

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**15 - STUB BUS PROTECION**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - STUB BUS PROT. ENA**
...	**1 - STUB BUS PROT. PU**
15 - STUB BUS PROTECION	**2 - STUB BUS PROT. DLY.**
...	

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**15 - STUB BUS PROTECION**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - STUB BUS PROT. ENA**
...	**1 - STUB BUS PROT. PU**
15 - STUB BUS PROTECION	**2 - STUB BUS PROT. DLY.**
...	**3- RESTRAINT SLOPE**

3.16.4 Digital Inputs and Events of the Stub Bus Protection

Table 3.16-1: Digital Inputs and Events of the Stub Bus Protection		
Name	**Description**	**Function**
ENBL_STUB	Stub Bus protection enable input	Activation of this input puts the element into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
IN_89L_A	Open line sectionalizer input	Activation of this input indicates that the normally closed contact of the line sectionalizer is closed.

3.16.5 Digital Outputs and Events of the Stub Bus Protection

Table 3.16-2: Digital Outputs and Events of the Stub Bus Protection		
Name	**Description**	**Function**
PU_STUB	Stub Bus protection pickup	Pickup of the unit
TRIP_STUB	Stub Bus protection trip	Trip of the unit
STUB_ENBLD	Stub Bus protection enabled	Indication of enabled or disabled status of the unit.

3.16.6 Stub Bus Protection Element Test

The Stub Bus protection will be enabled and the remaining elements disabled.

The following indicators will be monitored during the test: In the display on the **Information** - **Status** - **Measuring Elements** - **Stub Bus Protection** screen, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Stub Bus Protection**).

- **ZLV-A/B/F/H Models**

Set the start-up to 5 A and the timing to 0.5 s.

Apply a current of 6 A through any of the three phases. Activate the **Open Line Sectionalizer** position input. Verify that a Stub Bus protection trip is produced at 0.5 s.

- **ZLV-G/J Models**

The percentage characteristic of the **ZLV-G/J** relays STUB Bus protection is tested phase by phase, setting a restraint current and increasing the current until the element pickup value is determined. For testing, it is recommended to inject currents **I**-1 and **I**-2 in opposite phase (180º phase angle difference). The restraint current will be equal to the sum of the magnitudes of both currents divided by 2, whereas line current will be equal to the difference of the two magnitudes.

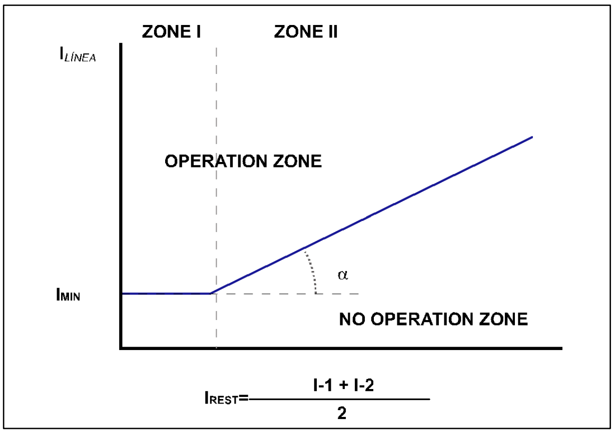


Figure 3.16.4: Graphic for the STUB bus Protection Percentage Characteristic.

The difference of the two magnitudes can be increased, while keeping constant the sum of the two magnitudes, until the STUB bus protection picks up.

The following table shows the values of currents **I**-1 and **I**-2 that make the STUB Bus protection to pickup, for the following settings: pickup (IMIN)=1 A, slope (α)=20%. Said table is obtained by solving the following system of equations:

$\frac{\lvert I-1\rvert+\lvert I-2\rvert}{2}=I_{RESTRAINT}$	$\lvert I-1\rvert-\lvert I-2\rvert=I_{LINE}$

ZONE I

$I_{RESTRAINT}$ / I_{LINE}	0.525 A	1 A	3 A	5 A
1*1.05 A	I-1=1.05 $_{0°}$ I-2=0 $_{0°}$	I-1=1.525 $_{0°}$ I-2=0.475 $_{180°}$	I-1=3.525 $_{0°}$ I-2=2.475 $_{180°}$	I-1=5.525 $_{0°}$ I-2=4.475 $_{180°}$

ZONE II

$I_{RESTRAINT}$ / I_{LINE}	6 A	7 A	8 A	9 A
1.2*1.05 A	I-1=6.63 $_{0°}$ I-2=5.37 $_{0°}$			
1.4*1.05 A		I-1=7.73 $_{0°}$ I-2=6.26 $_{180°}$		
1.6*1.05 A			I-1=8.84 $_{0°}$ I-2=7.16 $_{180°}$	
1.8*1.05 A				I-1=9.94 $_{0°}$ I-2=8.05 $_{180°}$

3.17 Open Phase Unit

3.17.1 Operating Principles

The Open Phase unit is for the purpose of detecting series faults, which may occur due to the rupture of an overhead line conductor. A series fault generates an unbalanced condition which can be detected by measuring the negative sequence current (I2). The overcurrent units incorporated in the **ZLV** which use this magnitude should present pick up levels above the maximum unbalance which may arise in the line under normal conditions (without fault). This unbalance will be greater the more unbalanced the line, such that, in a maximum load condition, the negative sequence current may come to be in the neighborhood of that corresponding to a series fault. This would impede the negative sequence overcurrent units from detecting this type of fault. The open-phase unit uses the negative sequence (I2) as well as the positive sequence (I1) current and operates based on the (I2/I1) ratio, thus making its operation independent from the line load. The Open-Phase unit is not included in the **ZLV-E** models.

The pick up of the unit occurs when this ratio exceeds the setting startup value. Figures 3.17.1, 3.17.2, 3.17.3 and 3.17.4 represent the block diagram of this unit.

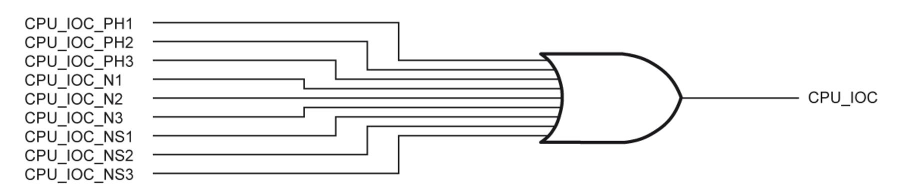


Figure 3.17.1: Activation Logic of the Pick Up Condition Signal of the Instantaneous Overcurrent Elements Used by the Open Phase.

Legend	
PH: Phase.	NS: Negative Sequence.
N: Ground.	CPU_IOC: Instantaneous Overcurrent Pickup Conditions.

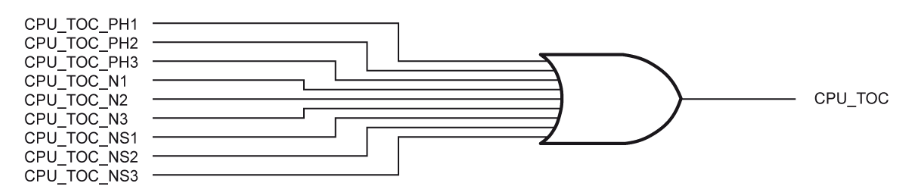


Figure 3.17.2: Activation Logic of the Pick Up Condition Signal of the Time Overcurrent Elements Used by the Open Phase.

Legend	
PH: Phase.	NS: Negative Sequence.
N: Ground.	CPU_IOC: Time Overcurrent Pickup Conditions.

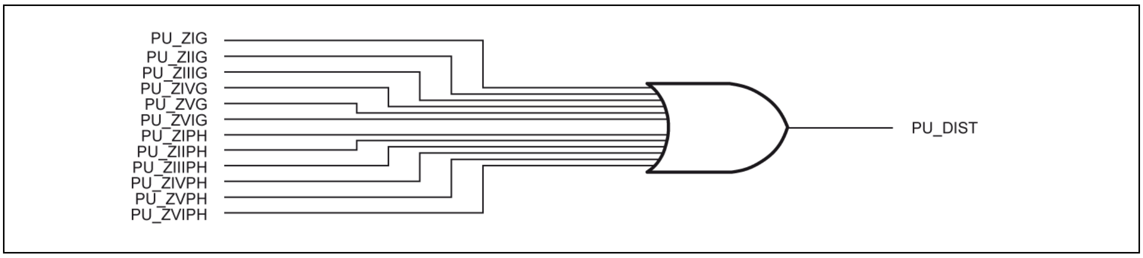


Figure 3.17.3: Activation Logic of the Pick Up Signal of Distance Units Used by the Open Phase.

Legend	
PU_Z: Zone Pickup.	PU_DIST: Distance Units Pickup.

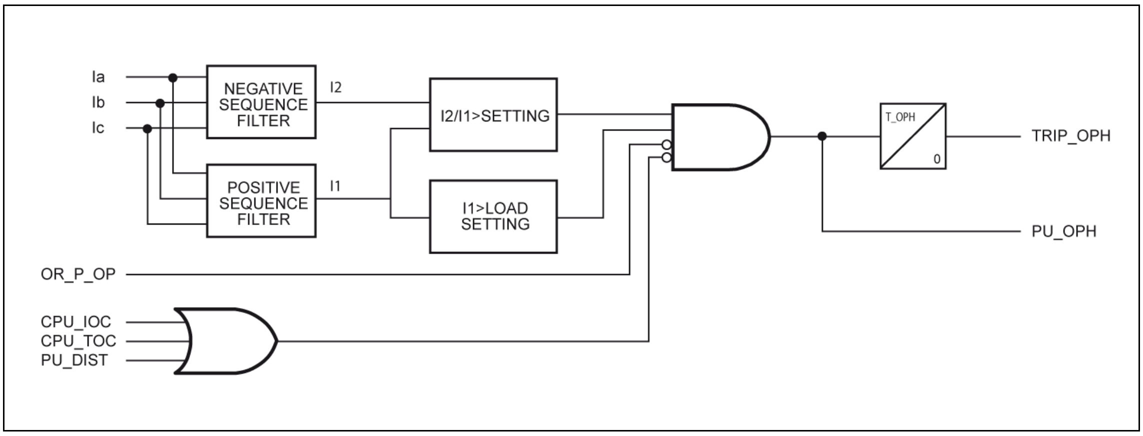


Figure 3.17.4: Block Diagram of the Open-Phase Unit.

Legend	
OR_P_OP: Any Open Pole.	CPU_TOC: Time Overcurrent Pickup Conditions.
TRIP_OPH: Open Phase Detector Trip.	PU_DIST: Distance Units Pickup.
PU_OPH: Open Phase Detector Pickup.	T_OPH: Open Phase Unit Time Delay (setting).
CPU_IOC: Instantaneous Overcurrent Pickup Conditions.	

Once picked up, the element acts if the pickup is maintained for a period of time equal to or greater than the set value.

The operation of this function is conditioned to the position of the breaker and to the level of the positive sequence current: if any breaker pole (**OR_P_OP**) is open or the positive sequence current is less than the **Positive Sequence Sensitivity** setting, the unit will be disabled. Similarly, the function will be cancelled when there is a pick up of any of the distance elements or a pick up condition (without considering the directionality) of any of the overcurrent elements: phase, ground or sequence time or instantaneous. In this manner, the actuation of the open phase unit is only ensured in case of series faults.

When the aperture of a single pole of the breaker is produced (single-phase or transient reclose sequence in a three-phase trip in which the three poles do not open at the same time), an unbalanced condition similar to that of a series fault will be originated. The **Any Pole Open** (**OR_P_OP**) signal allows to detect the previous condition and blocks the open phase unit. Notwithstanding, the relay will always measure a negative sequence current before activating the **OR_P_OP** signal. This measured current may cause the open phase unit to pick up before it receives the blocking signal, for which it is necessary to establish a minimum timing.

Pick up occurs when the value measured exceeds 1.02 times the pickup setting and resets at 0.97 times the pickup setting.

3.17.2 Open Phase Unit Settings

Open Phase Unit			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup I2 = negative sequence current I1 = positive sequence current	0.05 - 0.4 I2/I1	0.01	0.05
Minimum load	(0.02 - 1) In	0.01 A	0.1 In
Time delay	0.05 - 300 s	0.01 s	0.05

- **Open Phase Unit: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**11 - OPEN PHASE DETECTOR**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**12 - OPEN PHASE DETECTOR**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - OPEN PHASE ENABLE**
...	**1 - OPEN PHASE PU**
*** - OPEN PHASE DETECTOR**	**2 - OPEN PHASE WAIT TIME**
...	**3 - MIN. LOAD OPEN PHASE**

(*) 11 or 12 option, depending on the model

3.17.3 Digital Inputs and Events of the Open Phase Module

Table 3.17-1: Digital Inputs and Events of the Open Phase Module		
Name	**Description**	**Function**
ENBL_OPH	Open phase detector enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

3.17.4 Digital Outputs and Events of the Open Phase Module

Table 3.17-2: Digital Outputs and Events of the Open Phase Module		
Name	**Description**	**Function**
PU_OPH	Open phase detector pickup	Pickup of the time count element.
TRIP_OPH	Open phase detector trip	Trip of the element.
OPH_ENBLD	Open phase detector element enabled	Indication of enabled or disabled status of the detector.

3.17.5 Open Phase Element Test

After putting all the phase and ground units out of service, this two-current system is applied:

Ia = 1/0º and Ib = 1/60º (it is understood that these angles are inductive).

After setting the element to 0.2 I2/I1, it must not be picked up. After increasing the phase B current, the element must pick up (the pickup flag at "1") with a current value in phase B between 1.493 Aac and 1.348 Aac.

With the trip time set to 10 s, a current of 2 A / 60º is applied in phase B. A trip must be initiated between 10.1 s and 9.9 s. Also the trip contacts must close.

In model **ZLV**, the unit is set to 0.2 I1/I1.2 and the **Minimum Load** in the line to 1.2 A. Applying Ia = 1/0º and Ib = 2/60º, the unit should not operate. If, under the same conditions, the **Minimum Load** in the line is set to 0.8 A, the unit should pick up.

3.18 Thermal Image Unit

3.18.1 Operating Principles

Thermal relays, which directly measure the temperatures of the machine to be protected, have very serious problems in accomplishing their function in more sensitive areas (windings), having to take measurements in nearby areas (oil, insulators, etc.). This indirect measurement involves drawbacks because the points where the direct temperature measurements are made belong to elements with significant thermal inertia.

For this reason, instead of using thermal relays, thermal image protections are commonly used. Using mathematical algorithms based on the material's physics, they estimate the temperature of the machine to be protected using the currents that flow through the machine.

It is assumed that when machine overloads occur, the main cause for deterioration is the thermal phenomenon; possible dynamic effects are not considered.

ZLV protection terminals have a thermal image protection unit that estimates the thermal state by measuring the current flow and resolving the thermal differential equation in order to generate a trip when high temperature levels are reached.

The algorithms are based on modeling the heating of a resistive element when running an electric current through it. The effect of radiation is not considered (since the impact is considered negligible given the temperatures reached by the elements to be protected, less than 400 ºC), nor are heat dissipation sources other than that deriving from the Joule effect.

Cooling of the equipment is also simulated if the current value returns to the rated range after a relatively short overload period.

The thermal image unit does not have a threshold at which pickup starts: it is always "picked up". The trip time depends on the current flowing from a given instant up to when the temperature limit is reached and the temperature value at a specific instant. The prior temperature depends on what has happened before, the measured current and the time applied.

The differential equation that controls any thermal phenomenon is the following:

$$I^2 = \theta + \tau \cdot \frac{d\theta}{dt}$$

Where:

- I: Is the RMS value of the measured current.
- τ: Is the time constant. Adjustable parameter.
- Imax: Value of the maximum admissible sustained current. Adjustable parameter.

The Time Constant is represented by τ and it represents the time needed for a body that will go from an initial temperature θ_0 to a final temperature θ_∞ to reach 63% of the temperature increase necessary for θ_∞; that is, the time it will take to reach the intermediate temperature θ_i starting from θ_0, where:

$\theta_i = \theta_0 + (\theta_\infty - \theta_0) * 0.63$

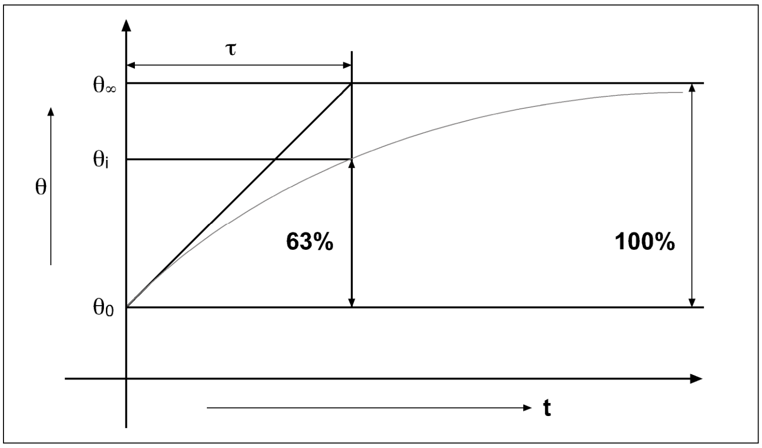


Figure 3.18.1: Time Constant (Thermal Image).

Temperature values (θ) are always stored in case there is a failure in the IED's power supply. There is a **Thermal Memory** setting that you can set to **YES** so that the initial temperature value will be the stored one whenever the IED is reinitialized.

This unit is prepared to protect lines from overheating. For lines, the rated voltage used is the sum of the square of phase A. It has two time constants, one for heating (while there is current) and one for cooling (when the positive sequence current is under 0.1 amperes).

The thermal image unit estimates the thermal state and, when it reaches the level equivalent to that obtained by the constant flow of Imax, it provides a trip output.

In addition to the trip level, the unit has an adjustable alarm level.

The thermal state is estimated thus:

- The initial value is $\theta = 0$ or $\theta \neq 0$ depending on the initial thermal state.
- The thermal image unit is activated every 500 milliseconds. Each time, it subtracts the θ value of the preceding sample from the current value squared:
  A = I^2 - θ
- The value obtained is divided by the time constant and multiplied by 500 milliseconds:
  B = A * (0.5 sec / τ (in sec))
- This value is added to the preceding θ to obtain the current.
  $\theta = \theta + B$

The value of θ is calculated as a % of the maximum value.

The **Thermal Image Trip** output is activated when the corresponding θ value reaches the value:

$$\theta_{TRIP} = Imax^2$$

The **Thermal Image Trip** signal resets when θ descends below:

$$\theta_{RST\_TRIP} = \theta_{TRIP} * PermissionSetting\_Connection\ (\%) / 100$$

The **Thermal Image Alarm** output is activated when the θ value reaches the value:

$$\theta_{ALARM} = \theta_{TRIP} * AlarmSetting\ (\%) / 100$$

The **Thermal Image Alarm** signal resets when θ descends below:

$$\theta_{RST\_ALARM} = 0.95 * \theta_{ALARM}$$

After applying a current **I** and starting with a current value of zero, the trip time is:

$$t = \tau \cdot Ln \frac{I^2}{I^2 - Imax^2}$$

If you start with a preliminary **Ip** current level, the operating time is:

$$t = \tau \cdot Ln \frac{I^2 - Ip^2}{I^2 - Imax^2}$$

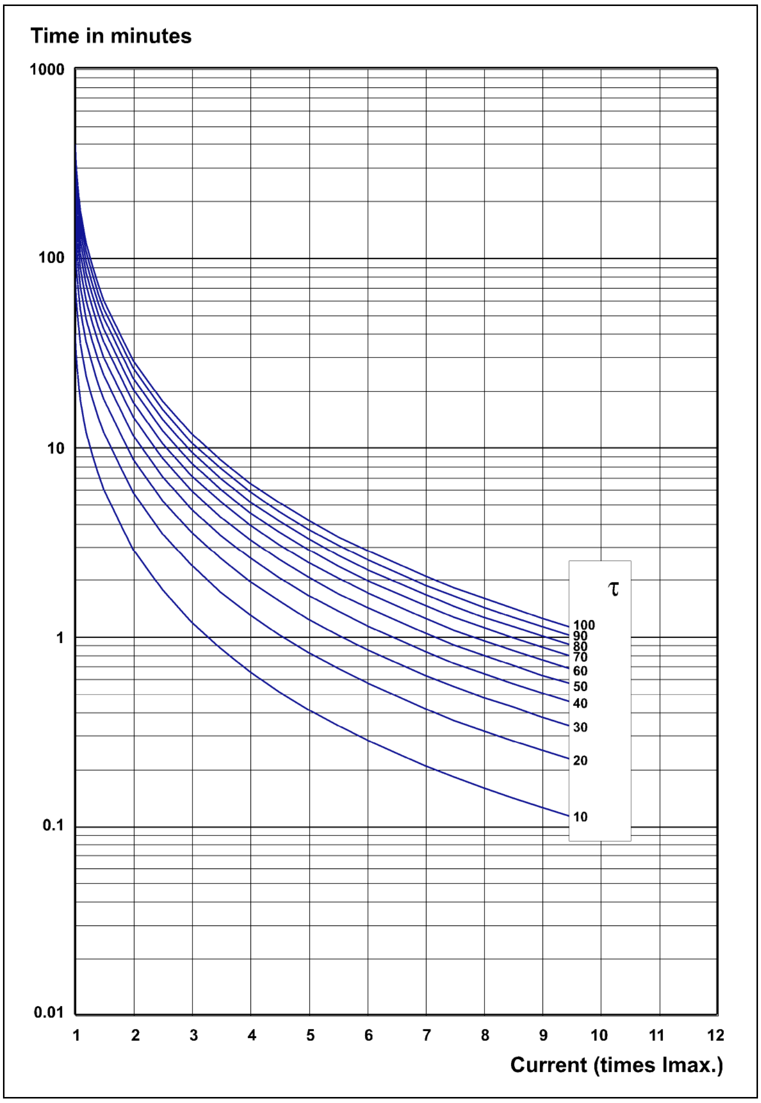


Figure 3.18.2: Operating Time Curves of the Thermal Image Unit.

3.18.2 Thermal Image Unit Settings

Thermal Image Unit			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Heating constant ζ 1	0.5 - 300 min	0.01 min	0.5 min
Cooling constant ζ 2	0.5 - 300 min	0.01 min	0.5 min
Maximum sustained current	(0.2 - 2.5) In	0.01A	In
Alarm activation level	50 - 100%	1%	50%
Reset threshold	5 - 100%	1%	80%
Thermal memory enable	YES / NO		NO

- **Thermal Image Unit: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**13 - THERMAL IMAGE**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**14 - THERMAL IMAGE**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	**0 - THERMAL IMG. ENA**
...	**1 - CONSTANT 1**
*** - THERMAL IMAGE**	**2 - CONSTANT 2**
...	**3 - MAX. SUST. CURR.**
	4 - ALARM LEVEL
	5 - RESET THRESHOLD
	6 - THERMAL MEMORY

(*) 13 or 14 option, depending on the model.

3.18.3 Digital Inputs and Events of the Thermal Image Module

Table 3.18-1: Digital Inputs and Events of the Thermal Image Module		
Name	**Description**	**Function**
RST_MEM_T	Thermal image reset	Its activation resets the memorized value.
INBLK_THERM	Thermal image blocking input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
ENBL_THERM	Thermal image enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

3.18.4 Digital Outputs and Events of the Thermal Image Module

Table 3.18-2: Digital Outputs and Events of the Thermal Image Module		
Name	**Description**	**Function**
AL_THER	Thermal image alarm	Alarm of the thermal image unit.
TRIP_THERM	Thermal image trip	Trip of the thermal image unit.
THERM_ENBLD	Thermal image enabled	Indication of enabled or disabled status of the unit.

3.18.5 Thermal Image Unit Test

Before performing this test, the protection should be turned off and then back on to reset the thermal level. A current greater than the set maximum sustained current (I_{max}) is applied through phase A. The trip time must be:

$$t = \tau \cdot Ln \frac{(I \pm 1\%)^2}{(I \pm 1\%)^2 - Imax^2}$$

where τ is the set time constant ζ1.

An example: a time constant of 0.5 minutes and a maximum current of 5 A. A current of 6 A is injected in phase A of the first winding. The time transpired until the thermal unit trips must be between 33.05 s and 38.18 s.

3.19 Voltage Elements

3.19.1 Undervoltage Elements

ZLV IEDs have three phase undervoltage elements (27F1, 27F2 and 27F3). They operate when the RMS values of the voltages measured (phase-ground voltages) reach a given value. This value is set simultaneously for the three voltages in each unit.

The undervoltage elements have an associated logic which can be controlled with a setting in which you select between the following two possible types of operation (see figure 3.19.2):

- **AND**: the (27F) element trips when the three associated undervoltage elements (V1, V2 and V3) comply with the trip condition.
- **OR**: the (27F) element trips when one or more of the three associated undervoltage elements (V1, V2 or V3) comply with the trip condition.

Pickup occurs for a given undervoltage element when the value measured is equal to or less than one times the set value, and resets at a selectable percentage (greater) above the setting.

The undervoltage element pickup enables the timing function. This is done by applying increments on a meter that picks up the element when it times out. The time setting included allows selecting a **Fixed Time** timing sequence.

When the RMS exceeds the set pickup, a rapid reset of the integrator occurs. The activation of the output requires the pickup to continue operating throughout the integration. Any reset leads the integrator to its initial conditions so that a new operation initiates the time count from zero.

An analog input can be assigned to the logic signal that blocks the trip signaling of the undervoltage phase elements, thus disabling the output if this signal is activated.

The undervoltage elements will be blocked whenever the **Any Pole Open** (**OR_P_OP**) or **Blocking Due to Fuse Failure** (**BLK_FF**) signals, originating from the Open Pole Logic and Fuse Failure Detector, respectively, are activated.

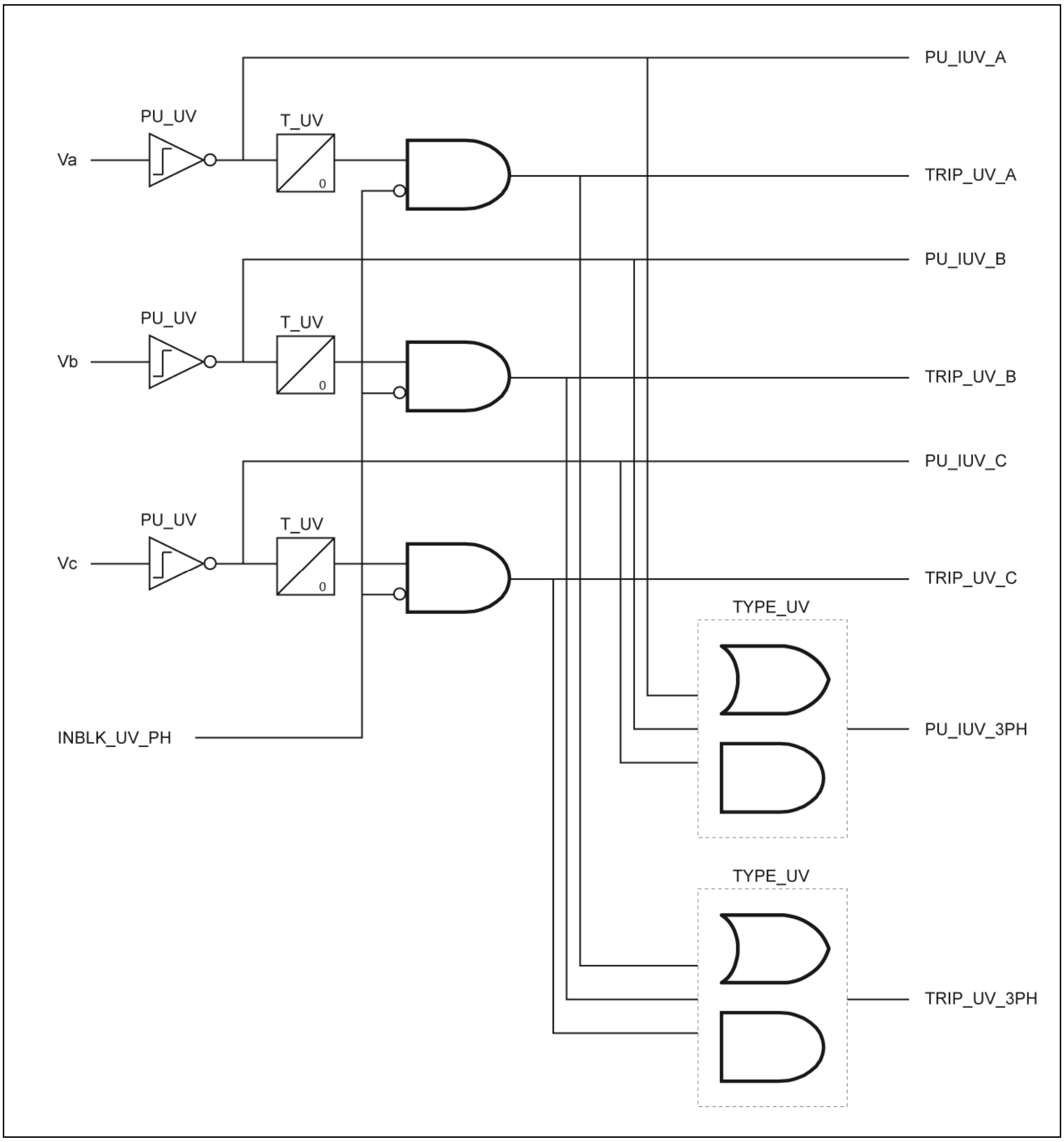


Figure 3.19.1: Block Diagram of Undervoltage Elements.

Legend
INBLK_UV_PH: Undervoltage Unit Block Input.
PU_IUV: Undervoltage Unit Pickup.
TRIP_UV: Undervoltage Unit Trip.
PU_UV: Undervoltage Elements Pickup (setting)
T_UV: Undervoltage Elements Time Delay (setting)
TYPE_UV: Undervoltage Logic (setting)

3.19.2 Overvoltage Elements

ZLV IEDs have the following overvoltage elements:

- Three phase overvoltage elements (59F1, 59F2 and 59F3).
- Two ground overvoltage elements (59N1 and 59N2).

3.19.2.a Phase Overvoltage Elements

They operate when the RMS values of the voltages measured (phase-ground voltages) reach a given value. This value is set simultaneously for the three voltages in each unit.

The overvoltage elements have an associated logic which can be controlled with a setting in which you select between the following two possible types of operation (see figure 3.19.2):

- **AND**: the (59F) element trips when the three associated undervoltage elements (V1, V2 and V3) comply with the trip condition.
- **OR**: the (59F) element trips when one or more of the three associated undervoltage elements (V1, V2 or V3) comply with the trip condition.

Pickup occurs for a given overvoltage element when the value measured is greater than one times the set value, and resets at a selectable percentage (less) of the setting.

The overvoltage element pickup enables the timing function. This is done by applying increments on a meter that picks up the element when it times out. The time setting included allows selecting a fixed time timing sequence.

When the RMS falls below the pickup setting, a rapid reset of the integrator occurs. The activation of the output requires the pickup to continue operating throughout the integration. Any reset leads the integrator to its initial conditions so that a new operation initiates the time count from zero.

You can assign an analog input to the logic signal that blocks the trip signaling of the overvoltage phase elements, thus disabling the output if this signal is activated.

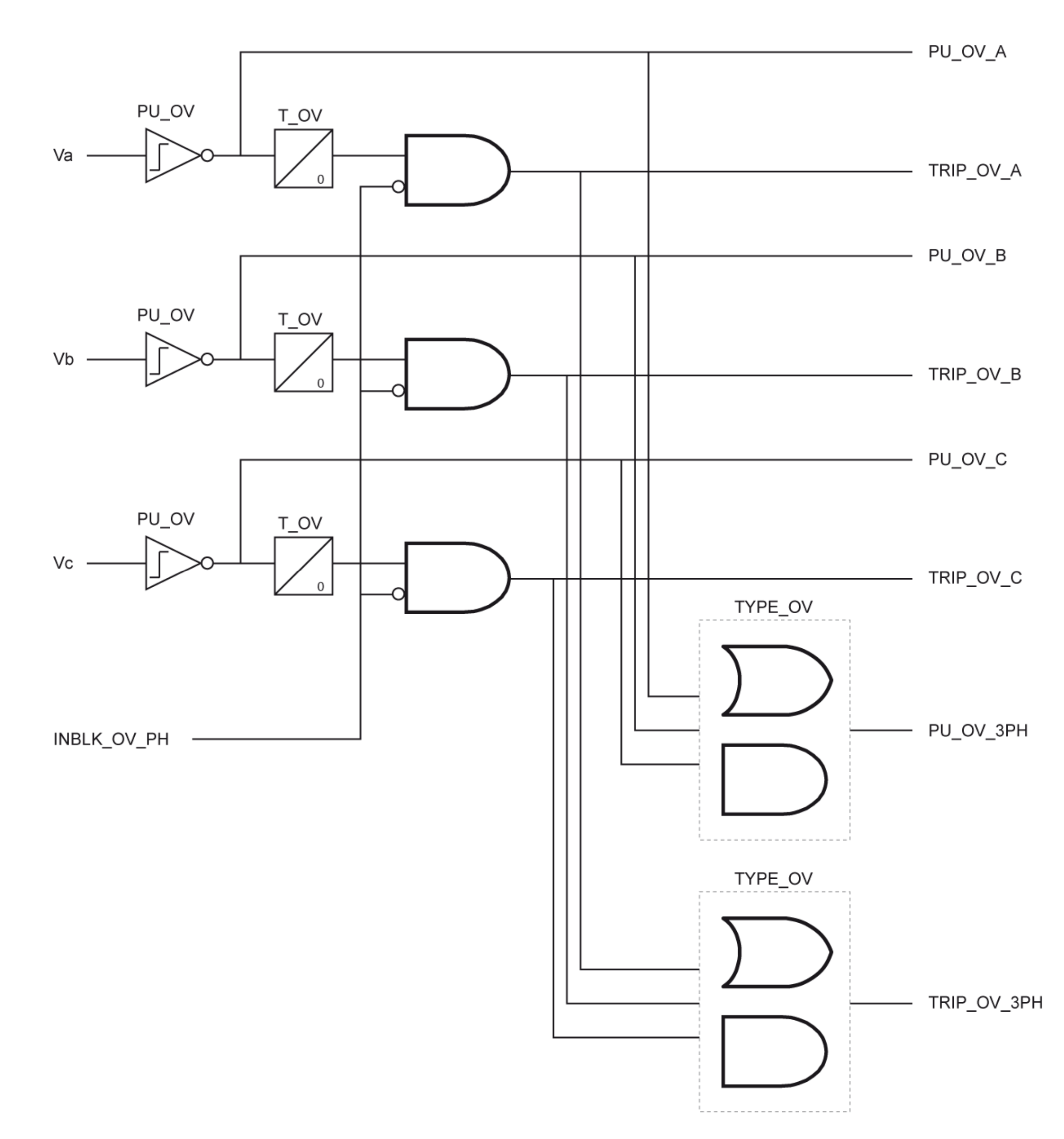


Figure 3.19.2: Block Diagram of Overvoltage Elements.

Legend
INBLK_OV_PH: Overvoltage Unit Block Input.
PU_OV_X: Overvoltage Unit Pickup.
TRIP_OV: Overvoltage Unit Trip.
PU_OV: Overvoltage Elements Pickup (setting)
T_OV: Overvoltage Elements Time Delay (setting)
TYPE_OV: Overvoltage Logic (setting)

3.19.2.b Ground Overvoltage Elements

Ground overvoltage elements are made up of an instantaneous overvoltage element with an additional independent adjustable timer.

The ground voltage is calculated using data from the three phase voltages. The RMS value of this ground voltage, which is the operating magnitude of the level detector, is calculated with the phase voltages as follows:

$$\overline{V_N} = \overline{V_A} + \overline{V_B} + \overline{V_C}$$

The adjustable output of this detector is the pickup signal of elements 59N1 and 59N2. It initializes an adjustable timer, whose output, combined with the blocking signal of the unit, in the AND gate is taken as the element's output. See figure 3.19.3.

The ground overvoltage elements will be blocked whenever the **Any Pole Open** (**OR_P_OP**) or **Blocking Due to Fuse Failure** (**BLK_FF**) signals, originating from the **Open Pole Logic** and from the **Fuse Failure Detector**, respectively, are activated.

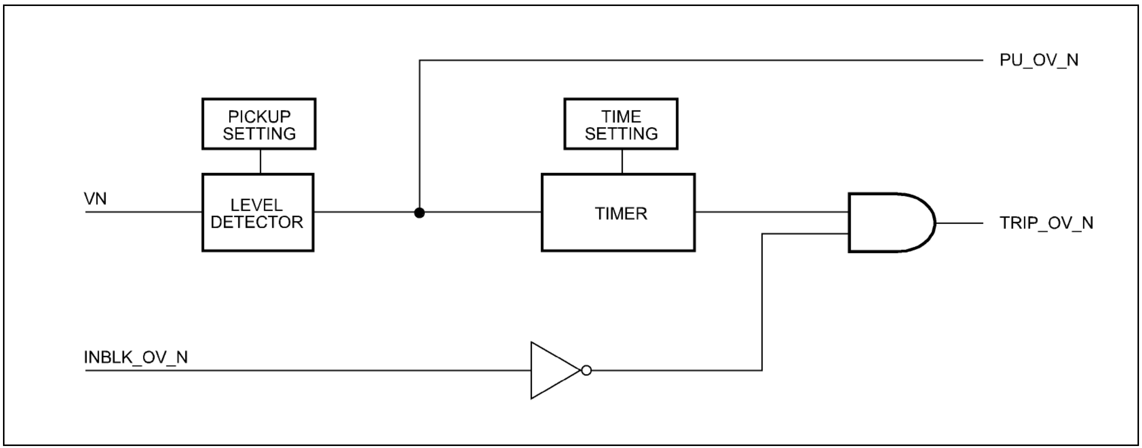


Figure 3.19.3: Block Diagram of a Ground Overvoltage Element.

Legend	
INBLK_OV_N: Ground Overvoltage Unit Block Input.	PU_OV_N: Ground Overvoltage Unit Pickup.
	TRIP_OV_N: Ground Overvoltage Unit Trip.

Each element picks up when the RMS value of the zero sequence voltage exceeds 1 times the set pickup value and resets with a selectable value percentage (lower) of the setting.

Elements 59N1 and 59N2 can program **Block Trip** inputs, which prevents the operation of the element if this input is activated before the trip is generated. If activated after the trip, it resets. To be able to use these logic input signals, it is necessary to program the status contact inputs defined as **Block Trip**.

3.19.3 Voltage Elements Settings

Voltage Dropout			
Setting	**Range**	**Step**	**By default**
Phase overvoltage elements dropout	50 - 99% of setting	1%	95%
Ground overvoltage elements dropout	50 - 99% of setting	1%	95%
Phase undervoltage elements dropout	101 - 150% of setting	1%	105%

Phase Overvoltage (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	20 - 300 V	0.01 V	70 V
Time delay	0 - 300 s	0.01 s	0 s
Tripping logic	OR / AND		OR

Phase Undervoltage (Elements 1, 2 and 3)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	10 - 300 V	0.01 V	40 V
Time delay	0 - 300 s	0.01 s	0 s
Tripping logic	OR / AND		OR

Ground Overvoltage (Elements 1 and 2)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	2 - 150 V	0.01 V	10 V
Time delay	0 - 300 s	0.01 s	0 s

- **Voltage Elements: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**9 - VOLTAGE**
3 - INFORMATION	**3 - PROTECTION**	…
	…	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**10 - VOLTAGE**
3 - INFORMATION	**3 - PROTECTION**	…
	…	

0 - DISTANCE	**0 - VOLTAGE RESET**
…	**1 - PHASE OVERVOLTAGE**
*** - VOLTAGE**	**2 - GROUND OVERVOLTAGE**
…	**3 - PHASE UNDERVOLTAGE**

(*) 9 or 10 option, depending on the model

Voltage Reset

0 - VOLTAGE RESET	**0 - PH. UV RESET**
1 - PHASE OVERVOLTAGE	**1 - PH. OV RESET**
2 - GROUND OVERVOLTAGE	**2 - GND. OV RESET**
3 - PHASE UNDERVOLTAGE	

Phase Overvoltage

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH OV. ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - PH. OV PICKUP**
2 - GROUND OVERVOLTAGE	**2 - UNIT 3**	**2 - PH. OV. DELAY**
3 - PHASE UNDERVOLTAGE		**3 - OUTPUT LOGIC PH OV**

Ground Overvoltage

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - GND OV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - GND OV PICKUP**
2 - GROUND OVERVOLTAGE		**2 - GND OV DELAY**
3 - PHASE UNDERVOLTAGE		

Phase Undervoltage

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH. UV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - PH. UV PICKUP**
2 - GROUND OVERVOLTAGE	**2 - UNIT 3**	**2 - PH. UV DELAY**
3 - PHASE UNDERVOLTAGE		**3 - OUTPUT LOGIC PH UV**

3.19.4 Digital Inputs and Events of the Voltage Modules

Table 3.19-1: Digital Inputs and Events of the Voltage Modules

Name	Description	Function
INBLK_UV1_PH	Phase undervoltage element 1 block input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
INBLK_UV2_PH	Phase undervoltage element 2 block input	
INBLK_UV3_PH	Phase undervoltage element 3 block input	
INBLK_OV_PH1	Phase overvoltage element 1 block input	
INBLK_OV_PH2	Phase overvoltage element 2 block input	
INBLK_OV_PH3	Phase overvoltage element 3 block input	
INBLK_OV_N1	Ground overvoltage element 1 block input	
INBLK_OV_N2	Ground overvoltage element 2 block input	
ENBL_UV_PH1	Phase undervoltage element 1 enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_UV_PH2	Phase undervoltage element 2 enable input	
ENBL_UV_PH3	Phase undervoltage element 3 enable input	
ENBL_OV_PH1	Phase overvoltage element 1 enable input	
ENBL_OV_PH2	Phase overvoltage element 2 enable input	
ENBL_OV_PH3	Phase overvoltage element 3 enable input	
ENBL_OV_N1	Ground overvoltage element 1 enable input	
ENBL_OV_N2	Ground overvoltage element 2 enable input	

3.19.5 Digital Outputs and Events of the Voltage Modules

Table 3.19-2: Digital Outputs and Events of the Voltage Modules

Name	Description	Function
PU_IUV1_A	Phase A undervoltage element 1 pickup	Pickup of the undervoltage and overvoltage elements and start of the time count. Three-phase pickups are those that are generated after the chosen AND or OR algorithm.
PU_IUV2_A	Phase A undervoltage element 2 pickup	
PU_IUV3_A	Phase A undervoltage element 3 pickup	
PU_IUV1_B	Phase B undervoltage element 1 pickup	
PU_IUV2_B	Phase B undervoltage element 2 pickup	
PU_IUV3_B	Phase B undervoltage element 3 pickup	
PU_IUV1_C	Phase C undervoltage element 1 pickup	
PU_IUV2_C	Phase C undervoltage element 2 pickup	
PU_IUV3_C	Phase C undervoltage element 3 pickup	
PU_IUV1_3PH	Three-phase undervoltage element 1 pickup	
PU_IUV2_3PH	Three-phase undervoltage element 2 pickup	
PU_IUV3_3PH	Three-phase undervoltage element 3 pickup	
PU_OV1_A	Phase A overvoltage element 1 pickup	
PU_OV2_A	Phase A overvoltage element 2 pickup	
PU_OV3_A	Phase A overvoltage element 3 pickup	
PU_OV1_B	Phase B overvoltage element 1 pickup	
PU_OV2_B	Phase B overvoltage element 2 pickup	
PU_OV3_B	Phase B overvoltage element 3 pickup	
PU_OV1_C	Phase C overvoltage element 1 pickup	
PU_OV2_C	Phase C overvoltage element 2 pickup	
PU_OV3_C	Phase C overvoltage element 3 pickup	
PU_OV1_N	Ground overvoltage element 1 pickup	
PU_OV2_N	Ground overvoltage element 2 pickup	
PU_OV1_3PH	Three-phase overvoltage element 1 pickup	
PU_OV2_3PH	Three-phase overvoltage element 2 pickup	
PU_OV3_3PH	Three-phase overvoltage element 3 pickup	
TRIP_UV1_A	Phase A undervoltage element 1 trip	Trip of the undervoltage and overvoltage elements. The three-phase trips are those that are generated after the chosen AND or OR algorithm.
TRIP_UV2_A	Phase A undervoltage element 2 trip	
TRIP_UV3_A	Phase A undervoltage element 3 trip	
TRIP_UV1_B	Phase B undervoltage element 1 trip	
TRIP_UV2_B	Phase B undervoltage element 2 trip	
TRIP_UV3_B	Phase B undervoltage element 3 trip	
TRIP_UV1_C	Phase C undervoltage element 1 trip	
TRIP_UV2_C	Phase C undervoltage element 2 trip	
TRIP_UV3_C	Phase C undervoltage element 3 trip	
TRIP_UV1_3PH	Three-phase undervoltage element 1 trip	
TRIP_UV2_3PH	Three-phase undervoltage element 2 trip	
TRIP_UV3_3PH	Three-phase undervoltage element 3 trip	
TRIP_OV1_A	Phase A overvoltage element 1 trip	
TRIP_OV2_A	Phase A overvoltage element 2 trip	
TRIP_OV3_A	Phase A overvoltage element 3 trip	
TRIP_OV1_B	Phase B overvoltage element 1 trip	
TRIP_OV2_B	Phase B overvoltage element 2 trip	
TRIP_OV3_B	Phase B overvoltage element 3 trip	

Table 3.19-2: Digital Outputs and Events of the Voltage Modules		
Name	**Description**	**Function**
TRIP_OV1_C	Phase C overvoltage element 1 trip	Trip of the undervoltage and overvoltage elements. The three-phase trips are those that are generated after the chosen AND or OR algorithm.
TRIP_OV2_C	Phase C overvoltage element 2 trip	
TRIP_OV3_C	Phase C overvoltage element 3 trip	
TRIP_OV1_N	Ground overvoltage element 1 trip	
TRIP_OV2_N	Ground overvoltage element 2 trip	
TRIP_OV1_3PH	Three-phase overvoltage element 1 trip	
TRIP_OV2_3PH	Three-phase overvoltage element 2 trip	
TRIP_OV3_3PH	Three-phase overvoltage element 3 trip	
UV_PH1_ENBLD	Phase undervoltage element 1 enabled	Indication of enabled or disabled status of the voltage elements.
UV_PH2_ENBLD	Phase undervoltage element 2 enabled	
UV_PH3_ENBLD	Phase undervoltage element 3 enabled	
OV_PH1_ENBLD	Phase overvoltage element 1 enabled	
OV_PH2_ENBLD	Phase overvoltage element 2 enabled	
OV_PH3_ENBLD	Phase overvoltage element 3 enabled	
OV_N1_ENBLD	Ground overvoltage element 1 enabled	
OV_N2_ENBLD	Ground overvoltage element 2 enabled	

3.19.6 Voltage Elements Test

3.19.6.a Overvoltage Elements Test

Before testing the overvoltage unit, all the voltage units that are not being tested must be disabled.

- **Pickup and Reset**

The desired pickup values for the relevant unit are set and their activation is checked by operating any output configured for this purpose. This can also be verified by checking the pickup flags of the menu **Information** - **Status** - **Units**. This verification can also be made by checking that the trip flag of this menu is activated if the unit trips.

Table 3.19-3: Pickup and Reset of the Overvoltage Elements				
Setting of the unit	Pickup		Reset	
X	Maximum	Minimum	Maximum	Minimum
	1.03 x X	0.97 x X	(RST setting + 0.03) x X	(RST setting - 0.03) x X

Where the value "RST setting" corresponds to the setting in per unit of the **Unit Reset** for the overvoltage units.

- **Operating Times**

Outputs F9-F10, F11-F12 and F13-F14 are used to verify them [See figure 3.18.4]. F9-F10 for **ZLV-A/E/H** models. For **ZLV-G/J** relays, bear in mind that no fixed trip output configuration is available.

Fixed Time or Instantaneous

The pickup setting is increased 20%. Operating time should be the selected time setting ±1% or ±20 ms (whichever is greater). A setting of 0 ms will have an operating time between 20 and 25 ms.

3.19.6.b Undervoltage Elements Test

Before testing the undervoltage unit, all the voltage units that are not being tested must be disabled.

- **Pickup and Reset**

The desired pickup values for the relevant unit are set and their activation is checked by operating any output configured for this purpose. This can also be verified by checking the pickup flags of the menu **Information** - **Status** - **Units**. This verification can also be made by checking that the trip flag of this menu is activated if the unit trips.

Table 3.19-4:Pickup and Reset of the Undervoltage Elements				
Setting of the unit	Pickup		Reset	
X	Maximum	Minimum	Maximum	Minimum
	1.03 x X	0.97 x X	(RST setting + 0.03) x X	(RST setting - 0.03) x X

Where the value "RST setting" is the setting in per unit of the **Unit Reset** for the undervoltage units.

- **Operating Times**

Outputs F9-F10, F11-F12 and F13-F14 are used to verify them [See figure 3.19.4]. F9-F10 for **ZLV-A/E/H** models. For **ZLV-G/J** relays, bear in mind that no fixed trip output configuration is available.

Fixed time or instantaneous

The pickup setting is decreased 20%. Operating time should be the selected time setting ±1% or ±20 ms (whichever is greater). A setting of 0 ms will have an operating time between 20 and 25 ms.

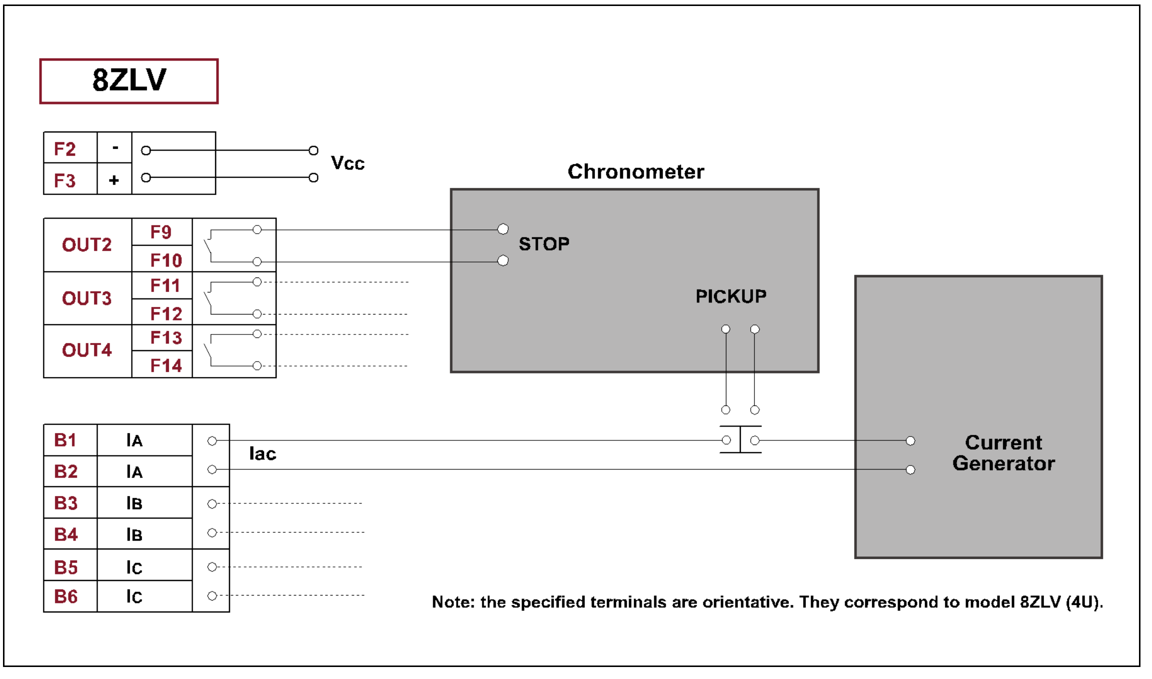


Figure 3.19.4: Operating Time Test Setup.

3.20 Frequency Elements

3.20.1 Introduction

ZLV IEDs (except for the **ZLV-E** Model) have the following frequency elements:

- Two or three overfrequency elements (81M1, 81M2 and 81M3).
- Two or three underfrequency elements (81m1, 81m2 and 81m3).
- Two or three rate of change elements (81D1, 81D2 and 81D3).

The underfrequency, overfrequency and rate of change elements have their own settings for each function and a set of settings common to all of them. The shared settings are:

- **Inhibition Voltage**. This setting checks that the voltage is above a set value. If so, it allows the frequency elements to operate. Otherwise, the frequency elements are inhibited.
- **Activation Half-waves**. This is the number of half-waves that must meet the fault conditions for the frequency elements to pick up.
- **Reset Cycles**. This is the number of cycles during which there may not exist fault conditions so that the frequency elements already picked up will reset. When the frequency elements have been picked up and have not yet operated, the fault conditions may disappear during a brief instant. This setting indicates how long these conditions may disappear without resetting the element. For example, if the rate of change should be falling below -0.5 Hz/s and during an instant it only goes down to -0.45 Hz/s; it may not be desirable that the protection function reset if the time the fault condition disappears is very short.

All the elements have a disabling counter. This counter, of approximately 50 milliseconds, operates when, while the element is tripped, the function is deactivated either by the inhibition voltage, by setting or because the breaker opens.

All the elements have a time module that can be set to instantaneous. It has the following settings: **Pickup** and **Time**.

Figure 3.20.1 is the block diagram of one of the frequency elements.

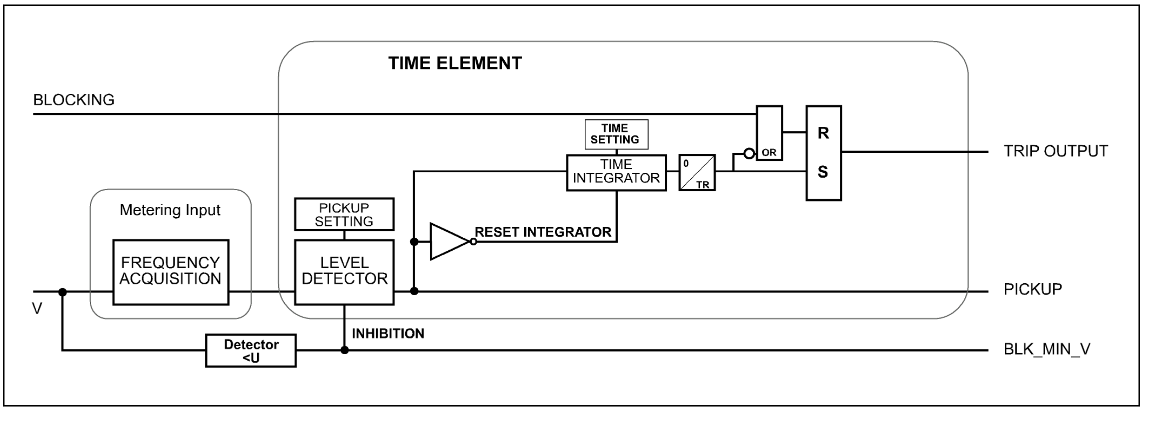


Figure 3.20.1: Block Diagram of a Frequency Element.

Associated with the level detection block, there is a setting for the pickup value: if the element is the overfrequency element, and the value measured exceeds the setting value a given quantity, the element picks up; if it is the underfrequency element, it picks up whether or not the value measured is less than the setting value a given quantity.

Activation of the pickup enables the timing function. This is done by applying increments on a meter that picks up the element when it times out.

3.20.2 Overfrequency Elements

The Overfrequency elements operate on the measured frequency value of voltages **Va**, **Vb** or **Vc**.

Pickup occurs when the value measured coincides with or surpasses the pickup value (100% of the setting) during a number of half-waves equal to or greater than the **Activation Half-Waves** setting, and resets when the frequency falls below 99.9% of this setting for a time equal to or greater than the **Reset Time** setting. This **Reset Time** setting indicates how long the fault conditions must disappear after a fault for the trip to reset.

3.20.3 Underfrequency Elements

Underfrequency elements operate on the measured frequency value of input voltages **Va**, **Vb** or **Vc**.

Pickup occurs when the value measured coincides with or is below the pickup value (100% of the setting) during a number of half-waves equal to or greater than the setting of **Activation Half-Waves**, and resets when the frequency goes up above 100.1% of this setting for a time equal to or greater than the **Reset Time** setting. The same as in the overfrequency element, this **Reset Time** setting indicates how long the fault conditions must disappear after a fault for the trip to reset.

3.20.4 Rate of Change Elements

Rate of Change elements operate on the measured frequency value of input voltage **Va**.

The algorithm of these elements uses the following specific settings for the Rate of Change function (in addition to the enabling permission of each of them):

- **Frequency Pickup**. Frequency value below which this magnitude must be to consider the rate of its change.
- **Rate of Change Pickup**. Instantaneous value of the rate of change in respect of the time for which the element is to pick up.
- **Timing**. Time during which the fault condition must remain for the element to activate.
- **Reset Time**. Time during which the fault conditions must disappear after a fault for the element to reset.

In the algorithm, the rate of change must be below a given adjustable value for a time equal to or greater than the **Activation Half-Waves** setting before the rate of change is taken into account. It is activated when the frequency is the same as or below the pickup setting, and resets when the frequency goes above 100.1% of this setting. This algorithm checks the frequency and the rate of change of the frequency separately. For the element to operate, the fault conditions must exist for both. See figure 3.20.2.

For the element to pick up, the dF/dT value has to be greater (setting + 0.05 Hz/s in absolute value) than the value of the **Rate of Change Pickup** setting during five cycles minus the set number of **Activation Half-Waves**. The five cycles are subtracted because, just as a complete cycle is needed to calculate the frequency, to calculate the rate of change, at least 5 cycles are needed.

If the value of the **Activation Half-Waves** setting is less than ten half-waves, five cycles will be used to generate the pickup of the rate of change element.

The following figure depicts the operation mode for the rate of change function:

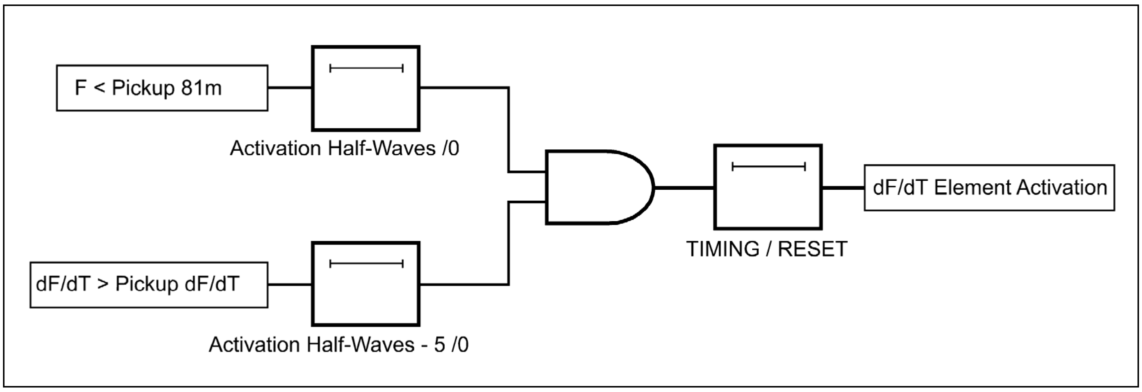


Figure 3.20.2: Algorithm of a Rate of Change Element.

3.20.5 Elements Blocking Logic

Each of the frequency elements has a **Blocking** logic input. Activating this input prevents the activation of the output of the corresponding frequency element, as shown in figure 3.20.1.

These logic input signals can be associated to the relay's status contact inputs by configuring the input settings.

3.20.6 Undervoltage Unit for Blocking

This element supervises the functioning of the frequency elements, impeding their operation for measured voltage below the set value.

The element picks up when the measured voltage value coincides with or is less than the pickup value (100% of the setting), and resets with a value greater than or equal to 105% of the setting, provided this condition is maintained for at least 10 consecutive cycles. These 10 verification cycles provide assurance that the voltage is stable.

In any case, the relay cannot measure frequency for voltage less than 2 volts. Therefore, in these conditions, the frequency elements do not work.

3.20.7 Frequency Elements Settings

Common Settings			
Setting	**Range**	**Step**	**By default**
Inhibition for minimum voltage	2 - 150 V	1 V	40 V
Pickup time	3 - 30 half cycles	1 half cycle	6 half cycles
Dropout time	0 - 10 cycles	1 cycle	0 cycles

Overfrequency Elements 1, 2 and 3			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	40 - 70 Hz	0.01 Hz	70 Hz
Time delay	0.00 - 300 s	0.001 s	0 s
Dropout time	0.00 - 300 s	0.001 s	2 s

Underfrequency Elements 1, 2 and 3			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Pickup	40 - 70 Hz	0.01 Hz	40 Hz
Time delay	0.00 - 300 s	0.001 s	0 s
Dropout time	0.00 - 300 s	0.001 s	2 s

Rate of Change Elements 1, 2 and 3			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Frequency pickup	40 - 70 Hz	0.01 Hz	40 Hz
Rate of change pickup	(-10,00) - (-0,5) Hz/s	0.01 Hz/s	-1 Hz
Time delay	0.00 - 300 s	0.01 s	0 s
Dropout time	0.00 - 300 s	0.001 s	2 s

- **Frequency Protection: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**10 - FREQUENCY**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**11 - FREQUENCY**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - INHIBIT VOLTAGE**
...	**1 - PICKUP TIME**
11 - FREQUENCY	**2 - DROPOUT TIME**
...	**3 - OVERFREQUENCY**
	4 - UNDERFREQUENCY
	5 - FREQ RATEOFCHANGE

(*) Option 10 or 11, depending on the model.

Overfrequency Protection

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - OVERFREQ. ENABLE**
1 - PICKUP TIME	**1 - UNIT 2**	**1 - OVERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3**	**2 - OVERFREQ. DELAY**
3 - OVERFREQUENCY		**3 - DROPOUT TIME**
4 - UNDERFREQUENCY		
5 - FREQ RATEOFCHANGE		

Underfrequency Protection

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - UNDERFREQ. ENABLE**
1 - PICKUP TIME	**1 - UNIT 2**	**1 - UNDERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3**	**2 - UNDERFREQ. DELAY**
3 - OVERFREQUENCY		**3 - DROPOUT TIME**
4 - UNDERFREQUENCY		
5 - FREQ RATEOFCHANGE		

Frequency Rate of Change

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - ROC. FREQ. ENABLE**
1 - PICKUP TIME	**1 - UNIT 2**	**1 - UNDERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3**	**2 - ROC FREQ. PICKUP**
3 - OVERFREQUENCY		**3 - ROC FREQ. DELAY**
4 - UNDERFREQUENCY		**4 - DROPOUT TIME**
5 - FREQ RATEOFCHANGE		

3.20.8 Digital Inputs and Events of the Frequency Modules

Table 3.20-1: Digital Inputs and Events of the Frequency Modules

Name	Description	Function
INBLK_OF1	Overfrequency element 1 block input	Activation of the input before the trip is generated prevents the element from operating. If activated after the trip, it resets.
INBLK_OF2	Overfrequency element 2 block input	
INBLK_OF3	Overfrequency element 3 block input	
INBLK_UF1	Underfrequency element 1 block input	
INBLK_UF2	Underfrequency element 2 block input	
INBLK_UF3	Underfrequency element 3 block input	
INBLK_ROC1	Rate of Change element 1 block input	
INBLK_ROC2	Rate of Change element 2 block input	
INBLK_ROC3	Rate of Change element 3 block input	
ENBL_OF1	Overfrequency element 1 enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_OF2	Overfrequency element 2 enable input	
ENBL_OF3	Overfrequency element 3 enable input	
ENBL_UF1	Underfrequency element 1 enable input	
ENBL_UF2	Underfrequency element 2 enable input	
ENBL_UF3	Underfrequency element 3 enable input	
ENBL_ROC1	Rate of Change element 1 enable input	
ENBL_ROC2	Rate of Change element 2 enable input	
ENBL_ROC3	Rate of Change element 3 enable input	

3.20.9 Digital Outputs and Events of the Frequency Modules

Table 3.20-2: Digital Outputs and Events of the Frequency Modules

Name	Description	Function
PU_OF1	Overfrequency element 1 pickup	Pickup of the frequency elements and start of the time count.
PU_OF2	Overfrequency element 2 pickup	
PU_OF3	Overfrequency element 3 pickup	
PU_UF1	Underfrequency element 1 pickup	
PU_UF2	Underfrequency element 2 pickup	
PU_UF3	Underfrequency element 3 pickup	
PU_ROC1	Rate of Change element 1 pickup	
PU_ROC2	Rate of Change element 2 pickup	
PU_ROC3	Rate of Change element 3 pickup	
TRIP_OF1	Overfrequency element 1 trip	Trip of the frequency elements.
TRIP_OF2	Overfrequency element 2 trip	
TRIP_OF3	Overfrequency element 3 trip	
TRIP_UF1	Underfrequency element 1 trip	
TRIP_UF2	Underfrequency element 2 trip	
TRIP_UF3	Underfrequency element 3 trip	
TRIP_ROC1	Rate of Change element 1 trip	
TRIP_ROC2	Rate of Change element 2 trip	
TRIP_ROC3	Rate of Change element 3 trip	
OF1_ENBLD	Overfrequency element 1 enabled	Enable or disable status indication of the frequency elements.
OF2_ENBLD	Overfrequency element 2 enabled	
OF3_ENBLD	Overfrequency element 3 enabled	
UF1_ENBLD	Underfrequency element 1 enabled	
UF2_ENBLD	Underfrequency element 2 enabled	
UF3_ENBLD	Underfrequency element 3 enabled	
ROC1_ENBLD	Rate of Change element 1 enabled	
ROC2_ENBLD	Rate of Change element 2 enabled	
ROC3_ENBLD	Rate of Change element 3 enabled	
BLK_MIN_V	Minimum voltage block	Blocking of frequency and phase angle measuring units.

3.20.10 Frequency Elements Test

Before testing these units, the voltage units that are not being tested must be disabled.

- **Pickup and Reset of the Overfrequency and Underfrequency Elements**

Depending on the settings of the frequency units (overfrequency / underfrequency), the pickups and resets must be within the margins indicated in table 3.20-3 for their rated voltage.

Table 3.20-3: Pickup and Reset of the Overfrequency and Underfrequency Elements

Setting	Pickup		Reset	
	ΦA_MIN	ΦA_MAX	ΦR_MIN	ΦR_MAX
XHz	X±0.005Hz	(Xx0.999)±0.005Hz	X±0.005Hz	(Xx1.001)±0.005Hz

- **Voltage Reset**

The frequency units must reset within the margin indicated in Table 3.20-4 for set voltage value X.

Table 3.20-4: Voltage Reset

Min. Voltage Setting	Reset	
	VR_MIN	VR_MAX
X	0.95 • X	1.05 • X

- **Operating Times**

They are verified with trip outputs F9-F10, F11-F12 and F13-F14 (F9-F10 for **ZLV-A/E/H** models). For **ZLV-G/J** relays, bear in mind that no fixed trip output configuration is available.

To measure times, the voltage generator must be able to generate an up or down frequency ramp depending on the unit to be tested as well as to provide an output to initiate a chronometer when it gets to the pickup frequency.

Operating times for a setting of Xs must be between (1.01 × X – 0.99 × X) or between (X+20 ms - X-20 ms). If the setting is 0, the operating time will be close to 60 ms.

In operating times, it is important how the frequency ramp is generated and when the chronometer starts. The frequency value of the signal generated should be very close to the threshold to test and generate the broadest step possible.

Without a frequency ramp generator, only the maximum frequency unit can be tested. Going from no voltage applied to applying voltage above the disable and the maximum frequency settings will yield a time value somewhat greater than with a frequency ramp.

- **Pickup and Reset of the Rate of Change Elements**

The Rate of Change elements are configured with the following operation values:

81D1 Element:	**0.5 Hz/s**
81D2 Element:	**0.7 Hz/s**
81D3 Element:	**0.9 Hz/s**

They are all set to the same frequency value.

Frequency ramps are generated below the set frequency value and each ramp must operate with a margin of error not greater than 0.05 Hz/s.

3.21 Breaker Failure Unit

3.21.1 Introduction

The **ZLV** (except for the **ZLV-E** models) incorporate one or two Breaker Failure elements (depending on the model). The Breaker Failure unit detects malfunction of the breaker after a trip command is issued. A signal is generated to allow closing of other breakers contributing to the fault (those adjacent to that protected line and at the remote end).

The Breaker Failure unit incorporates a retrip function whose objective is to send a new tripping command to the failed breaker before the open command directed toward the remaining breakers which may continue to feed the fault is generated. In order for the failed breaker to open with the retripping command before being actuated over the breakers of the adjacent lines, the timing of the breaker failure unit should be longer than that adjusted in the retrip function.

The Breaker Failure protection is provided with six phase current metering units, two for each of the phases, and one ground current metering unit. The two groups of phase metering units and the ground metering unit have independent pick up levels, with the following settings: **Phase Single-Phase Pick Up** (1 phase pick up), **Phase Three-Phase Pick Up** (2 phase pick up) and **Ground Pick Up**. The main characteristic of the pick up detectors is its rapid reset time (5 ms).

The diagrams corresponding to the measuring units are those represented in Figures 3.21.1 and 3.21.2 and give the breaker failure pick up signals as the output.

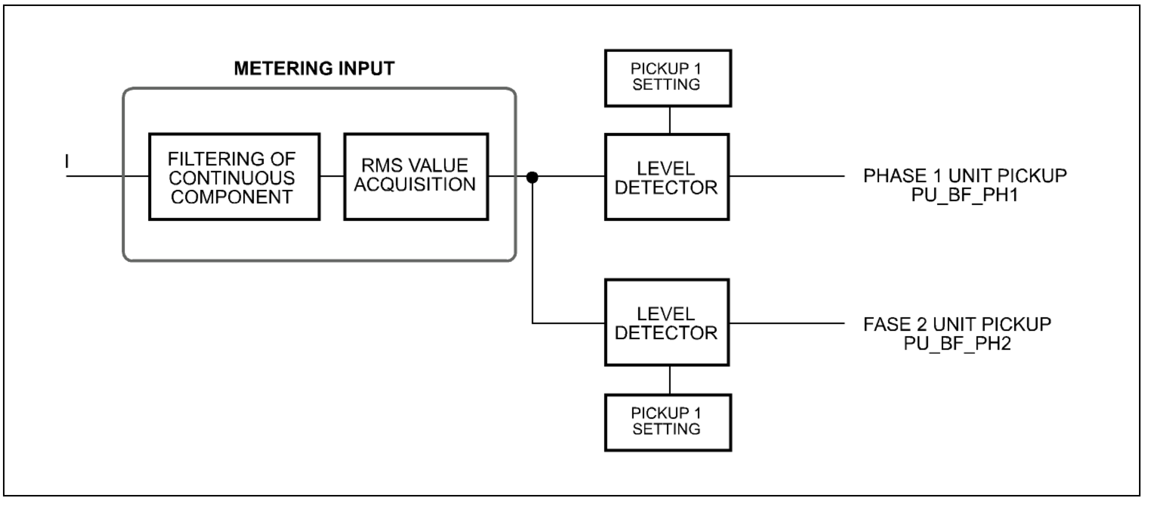


Figure 3.21.1: Block Diagram of the Phase Current Metering Units of the Breaker Failure.

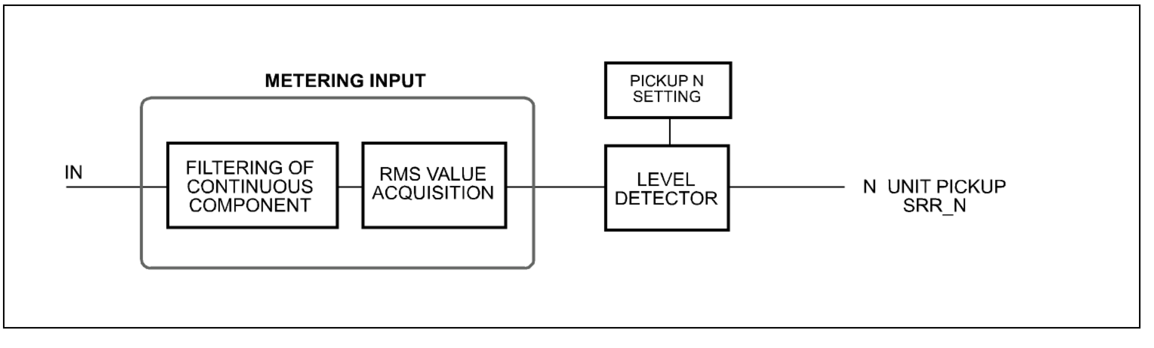


Figure 3.21.2: Block Diagram of the Ground Current Metering Unit of the Breaker Failure.

3.21.2 Operation Logic of the Breaker Failure Unit. ZLV-B/F Model

The operation logic of the Breaker Failure unit for **ZLV-B/F** models is described in the following. This logic is controlled by the pick up of the above-mentioned phase and ground overcurrent units together with a series of logic signals originating from other protection modules.

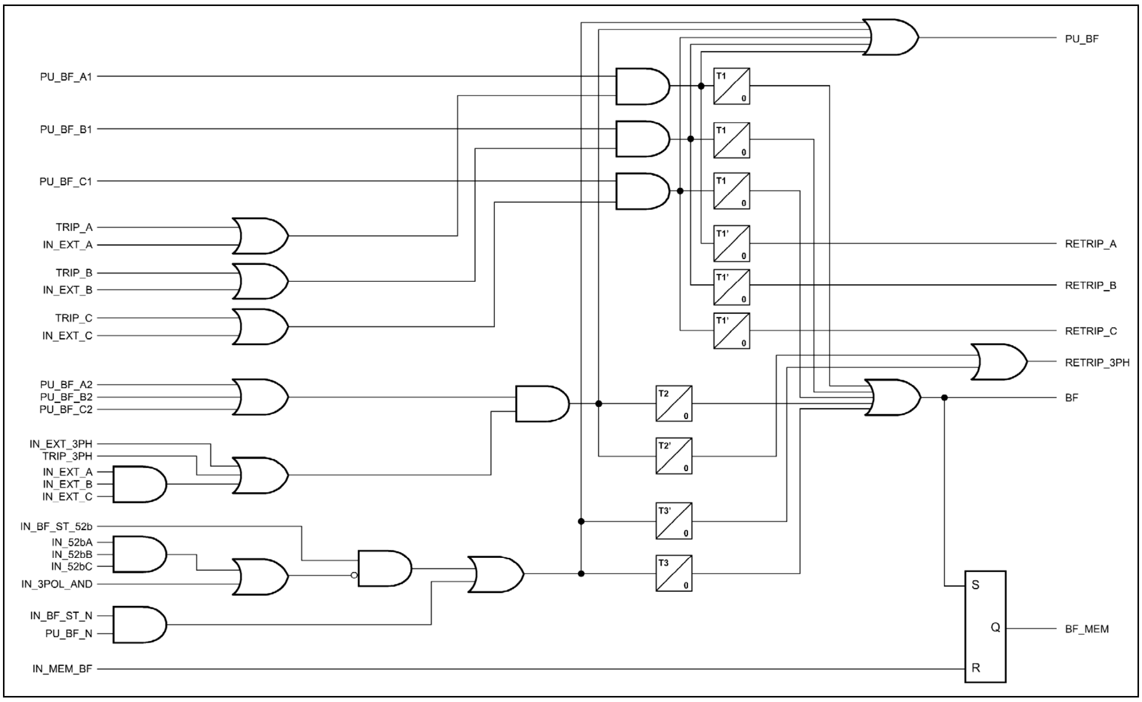


Figure 3.21.3: Logic Diagram of the Breaker Failure Unit (ZLV-B Model).

The actuation of the Breaker Failure unit (activation of the **BF** output) is memorized in a bistable element, activating the **BF_MEM** output. This signal will remain active even when **BF** is reset and only disappears through a reset command which will be issued through the activation of the **IN_MEM_BF** logic input.

The actuation process of the breaker failure unit can be divided into three groups: **Single-Phase Tripping**, **Three-Phase Tripping with Phase Overcurrent** and **Three-Phase Tripping without Phase Overcurrent**.

3.21.2.a Single-Phase Tripping

The commencement of the single-phase breaker failure is produce by the activation of a single-phase tripping signal together with the pick up of the single-phase current detector associated with the tripped phase (faulted phase). The single-phase trip signals may be generated by the **ZLV** itself (**A Pole Trip** (**TRIP_A**), **B Pole Trip** (**TRIP_B**) and **C Pole Trip** (**TRIP_C** signals), originating from the Single/Three-Phase Trip Logic, see 2.23) or originate from an external unit (**A Pole External Trip** (**IN_EXT_A**), **B Pole External Trip** (**IN_EXT_B**) and **C Pole External Trip** (**IN_EXT_C**) logic inputs).

The starting of the single-phase breaker failure starts the **T1** timers (**Single-Phase Breaker Failure Time**) and **T1'** (**Single-Phase Retripping Time**). The **T1'** timer output generates the retripping signal associated with the faulted phase (**A Pole Retripping** (**RETRIP_A**), **B Pole Retripping** (**RETRIP_B**), **C Pole Retripping** (**RETRIP_C**)), in order to send a new tripping command to the failed breaker pole, before generating the **Breaker Failure** (**BF**) command. If the retripping command does not produce the aperture of the pole already tripped, the **T1** timer will reach the end, activating the **BF** (**Breaker Failure**) and **BF_MEM** (**Memorized Breaker Failure**) signals. The use of timers segregated by phase ensures the expiration of the T1 time before the activation of the breaker failure output in the event of evolving faults.

As was indicated previously, the most important characteristic of the current detectors is their rapid reset time, in order to stop the timer count as soon as the breaker opens and make the current disappear, not allowing the erroneous activation of **BF**. If the reset time is long, there is a risk of not stopping the timer in time, in spite of the disappearance of current, and cause the undue tripping of other breakers not belonging to the protected line.

3.21.2.b Three-Phase Tripping with Phase Overcurrent

The starting of the three-phase trip failure with overcurrent is produced by the activation of a three-phase trip signal together with the pick up of any of the three-phase current detectors. The three-phase trip signal can be generated by the equipment itself (**Three-Phase Tripping** (**TRIP_3PH**), originating from the Single/Three-Phase Trip Logic, see 3.24) or by an external unit (AND logic output of **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C** or activation of **IN_EXT_3PH**).

The starting of the three-phase breaker failure with overcurrent starts the **T2** (**Three-Phase Breaker Failure Time**) and **T2'** (**Three-Phase Retripping Time**) timers. The **T2'** timer output generates the **Three-Phase Retripping** (**RETRIP_3PH**) signal in order to send a new trip command to the failed breaker, before generating the **Breaker Failure** (**BF**) command. If the retrip command does not produce the breaker aperture, the **T2** timer will reach the end, activating the **BF** (**Breaker Failure**) and **BF_MEM** (**Memorized Breaker Failure**) signals.

Given that polyphase faults require to be cleared more quickly than single-phase faults, in order to ensure the stability of the system, the **T2** time will be adjusted to a lower value than the **T1** time. Thus, when the trip is three phase, the breaker failure signal will always be activated on expiration of **T2** instead of **T1**.

The rapid reset time of the current detectors should again be pointed out.

3.21.2.c Three-Phase Tripping without Phase Overcurrent

The trip signals, of the equipment itself or of an external unit, which produce the commencement of a breaker failure, can be activated without the pick up of the phase current detection units. This situation may arise, in general, in case of any type of disturbance tripped by units which do not depend on the current metering, such as Voltage units, Frequency, etc., or in case of faults in which the local contribution is very weak, as a result of the fault resistance being very high or the local source being weak.

There are two alternative routes to detect a breaker failure without overcurrent:

- **Detection Based on the Position of the Breaker Contacts**

The start of the breaker failure is produced with the activation of the **Contact Position Breaker Failure Start** (**IN_BF_ST_52b**) whenever any breaker pole remains closed (it is checked either that the AND of the three breaker position inputs is open (**IN_52bA**, **IN_52bB** and **IN_52bC**), deactivated or that the input of three open poles (**IN_3POL_AND**) is set at zero). The input can be configured with the trip outputs of the Frequency units, Overvoltage, Weak Infeed logic, etc.

- **Detection Based on a Ground Current Metering Unit**

The start of breaker failure is produced with the activation of the **IN_BF_ST_N** (**Ground Unit Breaker Failure Start** input) input together with the starting of the ground current detector. The **IN_BF_ST_N** input can be configured with the general tripping output of the equipment (**TRIP**) or with an external general tripping output (**IN_EXT** or OR of **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C**).

The start of the three-phase breaker failure without phase overcurrent starts the **T3** (**Three-Phase Breaker Failure Time without Overcurrent**) and **T3’** (**Three-Phase Retripping Time without Overcurrent**) timers. The **T3’** timer generates the **Three-Phase Retripping** (**RETRIP_3PH**) signal in order to send a new trip command to the failed breaker, before generating the **Breaker Failure** (**BF**) command. If the retrip command does not produce the aperture of the breaker, the **T3** timer will reach the end, activating the **BF** (**Breaker Failure**) and **BF_MEM** (**Memorized Breaker Failure**) signals.

3.21.3 Breaker Failure Element Operation Logic. ZLV-G/J Models

In breaker and a half or ring configurations, it must be discerned which of the breakers associated to a given bay has failed, as the actions to be taken differ as a function of the failed breaker. Thus, two breaker failure elements are necessary, which will operate based on the current circulating through each breaker and not through the line (sum of both currents).

ZLV-G/J relays incorporate two breaker failure elements, designated element 1 and element 2, to supervise breakers 1 and 2 respectively. Phase and ground elements associated to breaker 1 will operate based on currents measured by channels IA-1, IB-1, IC-1 and the calculated current IN-1, respectively, while elements associated to breaker 2 will operate based on currents measured by channels IA-2, IB-2, IC-2 and calculated current IN-2. **ZLV-G/J** relay operation logic associated to element n (n=1,2), similar to the only element included into the **ZLV-B** relay, is shown below.

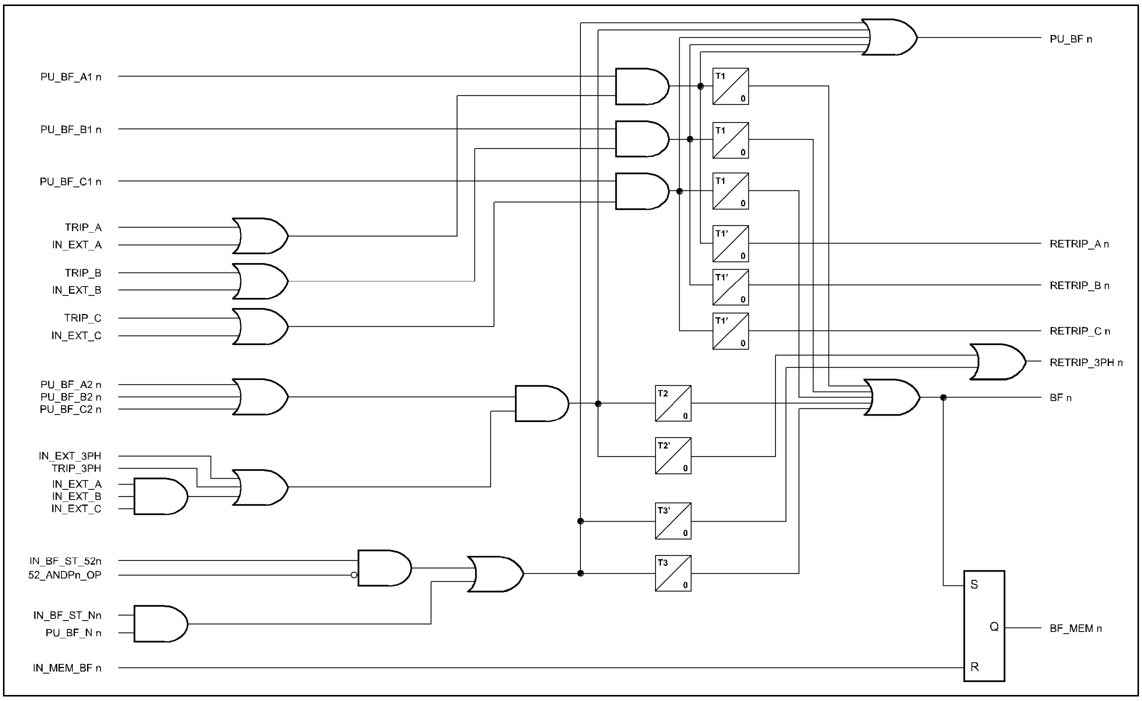


Figure 3.21.4: Logic Diagram of Breaker Failure Element (ZLV-G/J Models).

3.21.4 Operation Logic of the Breaker Failure Unit. ZLV-A/H Model

The operation logic of the breaker failure unit for **ZLV-A** models is controlled by the pick up of the above-mentioned phase and ground overcurrent units together with a series of logic signals originating from other protection modules.

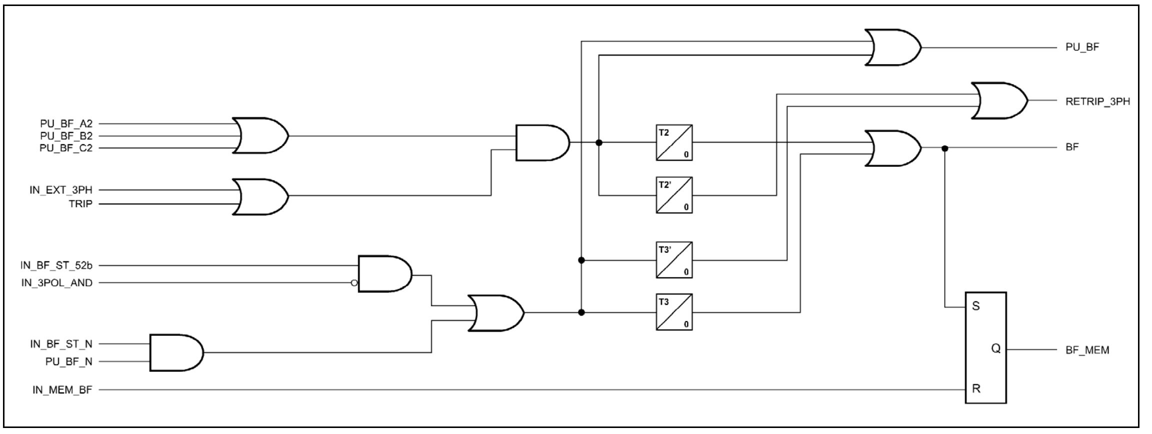


Figure 3.21.5: Logic Diagram of the Breaker Failure Unit (ZLV-A/H Model).

The actuation process of the breaker failure unit in the **ZLV-A/H** model will be similar to that corresponding to the **ZLV-B/F** model, with the exception that the start of the single-phase breaker failure will not exist.

3.21.5 Internal Arc Detector

As a complement to the above-mentioned Breaker Failure unit, the **ZLV** equipment incorporates a logic which allows to detect the existence of an unextinguished internal arc. **ZLV-G/J** relays incorporate two internal arc detectors, one per breaker, which will use the supervised breaker pole state inputs.

If a breaker begins to open but remains jammed, the electric arc between the contacts may not be extinguished. The arc resistance may greatly reduce the fault current to the point of resetting the protection units and the trip signal. In this case, the Breaker Failure unit would also be reset.

The presence of an unextinguished electric arc in a phase can be detected if the pole position contacts associated with that phase indicate that this is open and notwithstanding the current in this phase exceeds a determined threshold (**Internal Arc Detector Pick Up** setting).

The pick up of the Internal Arc Detector tends to adjust to below the pick up values of the current metering units used by the Breaker Failure function. The operation diagram of the Internal Arc Detector is shown to the right.

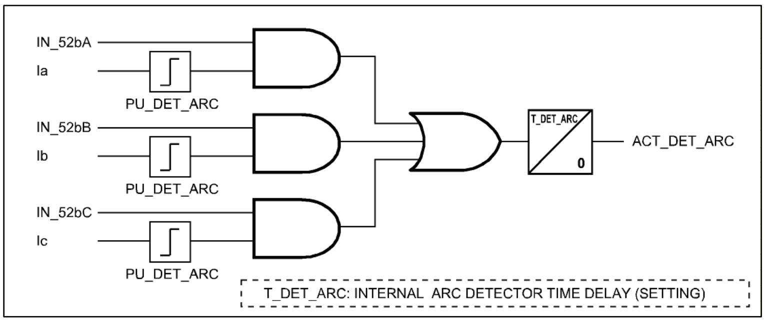


Figure 3.21.6: Logic Diagram of the Internal Arc Detector.

3.21.6 Breaker Failure Unit Settings

Breaker Failure Unit			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Single-phase pickup	(0.02 - 2.4) In A	0.01 A	0.2 In
Three-phase pickup	(0.02 - 2.4) In A	0.01 A	0.2 In
Ground pickup	(0.02 - 1.2) In A	0.01 A	0.1 In
Single-phase breaker failure time delay	0.05 - 2 s	0.01 s	0.5 s
Three phase breaker failure time delay with overcurrent	0.05 - 2 s	0.01 s	0.5 s
Three phase breaker failure time delay without overcurrent	0.05 - 2 s	0.01 s	0.5 s
Single-phase breaker failure retripping time delay	0.05 - 2 s	0.01 s	0.5 s
Three-phase breaker failure retripping time delay with overcurrent	0.05 - 2 s	0.01 s	0.5 s
Three-phase breaker failure retripping time delay without overcurrent	0.05 - 2 s	0.01 s	0.5 s
Internal arc detector enable	YES / NO		NO
Internal arc detector pickup	(0.01 - 0.2) In A	0.01 A	0.01 In
Internal arc detector time delay	0.1 - 2 s	0.01 s	0.1 s

- **Breaker Failure Unit: HMI Access**

ZLV-A/B

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**16 - BREAKER FAILURE**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	**0 - BF ENABLE**
…	**1 - SINGLE PHASE PU**
16 - BREAKER FAILURE	**2 - THREE PHASE PU**
…	**3 - BF GROUND PICKUP**
	4 - 1 POLE BF DELAY
	5 - 3 POLE BF DELAY
	6 - 3POLE NOOC BF DELAY
	7 - 1 POLE RETRIP DELA
	8 - 3 POLE RETRIP DELA
	9 - 3POLE RETRP NOOC
	10 - ARC DET ENABLE
	11 - ARR DETEC PICK UP
	12 - ARR DETECTOR TIME

ZLV-F/H

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**17 - BREAKER FAILURE**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	**0 - BF ENABLE**
…	**1 - SINGLE PHASE PU**
17 - BREAKER FAILURE	**2 - THREE PHASE PU**
…	**3 - BF GROUND PICKUP**
	4 - 1 POLE BF DELAY
	5 - 3 POLE BF DELAY
	6 - 3POLE NOOC BF DELAY
	7 - 1 POLE RETRIP DELA
	8 - 3 POLE RETRIP DELA
	9 - 3POLE RETRP NOOC
	10 - ARC DET ENABLE
	11 - ARR DETEC PICK UP
	12 - ARR DETECTOR TIME

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**17 - BREAKER FAILURE**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	**0 - BREAKER 1**	**0 - BF ENABLE**
…	**1 - BREAKER 2**	**1 - SINGLE PHASE PU**
17 - BREAKER FAILURE		**2 - THREE PHASE PU**
…		**3 - BF GROUND PICKUP**
		4 - 1 POLE BF DELAY
		5 - 3 POLE BF DELAY
		6 - 3POLE NOOC BF DLY
		7 - 1 POLE RETRIP DELAY
		8 - 3 POLE RETRIP DELAY
		9 - 3POLE RETRP NOOC DLY
		10 - ARC DET ENABLE
		11 - ARC DETEC PICK UP
		12 - ARC DETECTOR TIME

3.21.7 Digital Inputs and Events of the Breaker Failure Module

Table 3.21-1: Digital Inputs and Events of the Breaker Failure Module		
Name	**Description**	**Function**
ENBL_BF	Breaker Failure element enable input (ZLV-A/B/F/H)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_BF1	Breaker Failure 1 element enable input (ZLV-G/J)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_BF2	Breaker Failure 2 element enable input (ZLV-G/J)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
IN_EXT_A	A pole external trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of a trip of A pole of the breaker generated by an external protection.
IN_EXT_B	B pole external trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of a trip of B pole of the breaker generated by an external protection.
IN_EXT_C	C pole external trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of a trip of C pole of the breaker generated by an external protection.
IN_EXT_3PH	Three-phase external trip input	Activation of this input indicates the existence of a three-phase trip of the breaker generated by an external protection.
IN_EXT	External trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of a trip of the breaker generated by an external protection.
IN_MEM_BF	Memorized Breaker Failure reset input (ZLV-A/B/F/H)	Activation of this input resets the memorized output of the breaker failure.
IN_MEM_BF1	Memorized Breaker Failure 1 reset input (ZLV-G/J)	Activation of this input resets the memorized output of the breaker failure 1.
IN_MEM_BF2	Memorized Breaker Failure 2 reset input (ZLV-G/J)	Activation of this input resets the memorized output of the breaker failure 2.

Table 3.21-1: Digital Inputs and Events of the Breaker Failure Module		
Name	**Name**	**Name**
IN_BF_ST_52b	Contact position Breaker Failure start input (ZLV-A/B/F/H)	Activation of this input produces the start of the breaker failure without overcurrent, whenever there is a breaker pole closed.
IN_BF1_ST_52b	Contact position Breaker Failure 1 start input (ZLV-G/J)	Activation of this input produces the start of the breaker failure without overcurrent, whenever there is a breaker pole closed.
IN_BF2_ST_52b	Contact position Breaker Failure 2 start input (ZLV-G/J)	Activation of this input produces the start of the breaker failure without overcurrent, whenever there is a breaker pole closed.
IN_BF_ST_N	Ground unit Breaker Failure start input (ZLV-A/B/F/H)	Activation of this input produces the start of the breaker failure without overcurrent, provided that the neutral current detection unit is picked up.
IN_BF1_ST_N	Ground unit Breaker Failure start input (ZLV-G/J)	Activation of this input produces the start of the breaker failure without overcurrent, provided that the neutral current detection unit is picked up.
IN_BF2_ST_N	Ground unit Breaker Failure start input (ZLV-G/J)	Activation of this input produces the start of the breaker failure without overcurrent, provided that the neutral current detection unit is picked up.
ENBL_ARC	Internal arc detector enable input (ZLV-A/B/F/H)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_ARC1	Internal arc 1 detector enable input (ZLV-G/J)	
ENBL_ARC2	Internal arc 2 detector enable input (ZLV-G/J)	

3.21.8 Digital Outputs and Events of the Breaker Failure Module

Table 3.21-2: Digital Outputs and Events of the Breaker Failure Module		
Name	**Description**	**Function**
PU_BF_A1	A phase single-phase B.F. unit pick up (ZLV-B/F)	Pick up of the current metering unit for single-phase breaker failure detection in the corresponding phase.
PU_BF_B1	B phase single-phase B.F. unit pick up (ZLV-B/F)	
PU_BF_C1	C phase single-phase B.F. unit pick up (ZLV-B/F)	
PU_BF1_A1	A phase single-phase B.F. unit 1 pick up (ZLV-G/J)	Pick up of the current metering unit for single-phase breaker failure 1 detection in the corresponding phase.
PU_BF1_B1	B phase single-phase B.F. unit 1 pick up (ZLV-G/J)	
PU_BF1_C1	C phase single-phase B.F. unit 1 pick up (ZLV-G/J)	
PU_BF1_A2	A phase single-phase B.F. unit 2 pick up (ZLV-G/J)	Pick up of the current metering unit for single-phase breaker failure 2 detection in the corresponding phase.
PU_BF1_B2	B phase single-phase B.F. unit 2 pick up (ZLV-G/J)	
PU_BF1_C2	C phase single-phase B.F. unit 2 pick up (ZLV-G/J)	
PU_BF_A2	A phase three-phase B.F. unit pick up (ZLV-A/B/F/H)	Pick up of the current metering unit for three-phase breaker failure detection in the corresponding phase.
PU_BF_B2	B phase three-phase B.F. unit pick up (ZLV-A/B/F/H)	
PU_BF_C2	C phase three-phase B.F. unit pick up (ZLV-A/B/F/H)	
PU_BF1_A2	A phase three-phase B.F. unit 1 pick up (ZLV-G/J)	Pick up of the current metering unit for three-phase breaker failure 1 detection in the corresponding phase.
PU_BF1_B2	B phase three-phase B.F. unit 1 pick up (ZLV-G/J)	
PU_BF1_C2	C phase three-phase B.F. unit 1 pick up (ZLV-G/J)	
PU_BF2_A2	A phase three-phase B.F. unit 2 pick up (ZLV-G/J)	Pick up of the current metering unit for three-phase breaker failure 2 detection in the corresponding phase.
PU_BF2_B2	B phase three-phase B.F. unit 2 pick up (ZLV-G/J)	
PU_B2_C2	C phase three-phase B.F. unit 2 pick up (ZLV-G/J)	
PU_BF_N	Ground B.F. unit pick up (ZLV-A/B/F/H)	Pick up of the ground current metering unit for breaker failure detection without phase overcurrent.
PU_BF1_N	Ground B.F. unit 1 pick up (ZLV-G/J)	Pick up of the ground current metering unit for breaker failure 1 detection without phase overcurrent.
PU_BF2_N	Ground B.F. unit 2 pick up (ZLV-G/J)	Pick up of the ground current metering unit for breaker failure 2 detection without phase overcurrent.

Table 3.21-2: Digital Outputs and Events of the Breaker Failure Module		
Name	**Name**	**Name**
PU_BF	Breaker Failure pick up (ZLV-A/B/F/H)	Pick up of the Breaker Failure.
PU_BF1	Breaker Failure 1 pick up (ZLV-G/J)	Pick up of the Breaker Failure 1.
PU_BF2	Breaker Failure 2 pick up (ZLV-G/J)	Pick up of the Breaker Failure 2.
RETRIP_A	A pole retrip (ZLV-B/F)	Retrip output of A pole of the breaker.
RETRIP_B	B pole retrip (ZLV-B/F)	Retrip output of B pole of the breaker.
RETRIP_C	C pole retrip (ZLV-B/F)	Retrip output of C pole of the breaker.
RETRIP_3PH	Three-phase retrip (ZLV-A/B/F/H)	Three-phase retrip output of the breaker.
RETRIP_A1	Breaker 1 A pole retrip (ZLV-G/J)	Retrip output of A pole of the breaker 1.
RETRIP_B1	Breaker 1 B pole retrip (ZLV-G/J)	Retrip output of B pole of the breaker 1.
RETRIP_C1	Breaker 1 C pole retrip (ZLV-G/J)	Retrip output of C pole of the breaker 1.
RETRIP_3PH1	Breaker 1 Three-phase retrip (ZLV-G/J)	Three-phase retrip output of the breaker 1.
RETRIP_A2	Breaker 2 A pole retrip (ZLV-G/J)	Retrip output of A pole of the breaker 2.
RETRIP_B2	Breaker 2 B pole retrip (ZLV-G/J)	Retrip output of B pole of the breaker 2.
RETRIP_C2	Breaker 2 C pole retrip (ZLV-G/J)	Retrip output of C pole of the breaker 2.
RETRIP_3PH2	Breaker 2 Three-phase retrip (ZLV-G/J)	Three-phase retrip output of the breaker 2.
BF	Breaker failure (ZLV-A/B/F)	Activation of breaker failure.
BF1	Breaker failure 1 (ZLV-G/J)	Activation of breaker failure 1.
BF2	Breaker failure 2 (ZLV-G/J)	Activation of breaker failure 2.
BF_MEM	Memorized breaker failure (ZLV-A/B/F/H)	Activation of memorized breaker failure.
BF_MEM1	Memorized breaker failure 1 (ZLV-G/J)	Activation of memorized breaker failure 1.
BF_MEM2	Memorized breaker failure 2 (ZLV-G/J)	Activation of memorized breaker failure 2.
BF_ENBLD	Breaker Failure unit enabled (ZLV-A/B)	Indication of enabled or disabled status of the unit.
BF_ENBLD1	Breaker Failure 1 unit enabled (ZLV-G/J)	Indication of enabled or disabled status of the unit.
BF_ENBLD2	Breaker Failure 2 unit enabled (ZLV-G/J)	Indication of enabled or disabled status of the unit.
ACT_DET_ARC	Arc Detector activation (ZLV-A/B/F/H)	Activation of the unit.
ACT_DET_ARC1	Arc Detector 1 activation (ZLV-G/J)	Activation of the unit.
ACT_DET_ARC2	Arc Detector 2 activation (ZLV-G/J)	Activation of the unit.
ARC_ENBLD	Internal arc detector unit enabled (ZLV-A/B/F/H)	Indication of enabled or disabled status of the unit.
ARC_ENBLD1	Internal arc detector 1unit enabled (ZLV-G/J)	Indication of enabled or disabled status of the unit.
ARC_ENBLD2	Internal arc detector 2 unit enabled (ZLV-G/J)	Indication of enabled or disabled status of the unit.

3.21.9 Breaker Failure Unit Test

To verify the activation of the breaker failure element the **Information** - **Status** - **Measuring Elements** - **Breaker Failure** menu or in the ***ZIVercomPlus***® to **Status** - **Elements** - **Breaker Failure** should be accessed and the statuses of the breaker failure and memorized breaker failure flags should be contrasted.

To carry out the tests, in addition to the breaker failure element itself, the distance elements should be enabled (the remaining disabled elements).

The pick up levels of the breaker failure elements should be adjusted (single-phase, three-phase and ground pick up) at 0.5 A. Similarly, the single-phase, three-phase and three-phase without load breaker failure times should be adjusted to 0.5 s.

3.21.9.a Single-Phase Breaker Failure

Apply a single-phase fault in zone 1, such that the trip does not disconnect the current (with this being higher than 0.5 A). Verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the current and verify that, although the breaker failure signal resets, the memorized breaker failure output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

Adjust distance elements as reverse direction and apply a current of 1 A to phase A. Activate the **IN_EXT_A** (**A Phase External Protection Actuation**) input and verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the current and verify that, although the breaker failure signal resets, the memorized breaker failure output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

3.21.9.b Three-Phase Breaker Failure

Readjust the distance elements as forward direction.

Apply a two-phase fault in zone 1, such that the trip does not disconnect the currents (with these being higher than 0.5 A). Verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the currents and verify that although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

Adjust the distance elements as reverse direction and apply a current of 1 A to A and B phases. Activate the **IN_EXT_3PH** (**External Three-Phase Trip**) input or the **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C** inputs simultaneously (**A Phase**, **B Phase** and **C Phase External Protection Actuation**) and verify that the **Breaker Failure** and **Memorized Breaker Failure** flags activate at 0.5 s.

Disconnect the current and verify that, although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

3.21.9.c Three-Phase Breaker Failure without Load

Disable the distance elements.

Activate the **IN_BF_ST_52b** (**Contact Position Breaker Failure Start** input) input without activating the **IN_3POL_AND** (**Three Open Pole**) input or the **IN_52bA**, **IN_52bB**, **IN_52bC** inputs (simultaneously). Verify that **Breaker Failure** and **Memorized Breaker Failure** flags are activated at 0.5 s.

Deactivate the **IN_BF_ST_52b** input and verify that, although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

Apply a current of 3 A to phase C and activate the **IN_BF_ST_N** (**Ground Element Breaker Failure Start**) input. Verify that **Breaker Failure** and **Memorized Breaker Failure** flags are activated at 0.5 s.

Disconnect the current and verify that, although the **Breaker Failure** signal resets, the **Memorized Breaker Failure** output does not reset until the **Memorized Breaker Failure Reset** signal is activated.

3.21.9.d Internal Arc Detector

Since this is considered a complement to the Breaker Failure element, the tests of this element are included in the same section

Consult the following indicators during the test: In the display on the **Information** - **Status** - **Measuring Elements** - **Breaker Failure** - **Internal Arc** menu, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Breaker Failure** - **Internal Arc**).

Disable the Breaker Failure element and enable that of Internal Arc detection. Adjust the pick up to 0.1 A and the timing to 0.5 s. Apply a current of 0.5 A to phase B and activate the **IN_52bB** input. Verify that the **Internal Arc Detector** flag is activated at 0.5 s.

Note: ZLV-G/J relays phase currents used for testing breaker 1 failure element will be IA-1, IB-1 and IC-1 and IA-2, IB-2, IC-2 for breaker 2 failure element.

3.22 Synchronism Unit

3.22.1 Description

ZLV relays incorporate one or two synchronism check elements (depending on model) the function of which is to check whether the conditions at both ends of the supervised breaker are suitable to closing it (either by reclose or manual reset) and that there will be no oscillations.

The functioning of the synchronism unit is based, on one hand, on comparing the module, phase and/or frequency of the voltages on **Side A** (**Line**) and **Side B** (**Busbar**) to check if the two voltages are the same. On the other hand, the element can detect synchronism according to the energization on both sides of the breaker, that is, in terms of the possible combinations of presence/absence of voltage on sides A and B.

ZLV-A/B/E/F/H relays include one single synchronism element that uses the voltage measure by channel VSYNC as **side B** voltage. However, in order to supervise the synchronism of the two breakers associated to a breaker and a half or ring bay, **ZLV-G** relays incorporate two synchronism elements to supervise breakers 1 and 2, designated element 1 and element 2 respectively, which will use the voltages measured by channels VSYNC1 and VSYNC2, respectively, as **side B** voltage. However, if the **Dual Busbar** setting is set to **YES**, both synchronism elements will use the same voltage (VSYNC1 or VSYNC2), selected as a function of **IN_89B1_OP** (**Tie Breaker 1 Open**) and **IN_89B2_OP** (**Tie Breaker 2 Open**) state, as per Table.3.22-1 Said option prevents, in dual bus with single breaker bays, the use of external devices for selecting the adequate busbar voltage.

Table 3.22-1: Voltage Channel used by Synchronism Elements in a Dual Bus Configuration

E_89B1_A	E_89B2_A	Result
0	0	VSINC1
0	1	VSINC1
1	0	VSINC2
1	1	VSINC1

The voltage on **Side B** may correspond to phase A, B or C or phase-to-phase AB, BC or CA voltage as a function of the situation of the transformer on the busbar side. In order to compare said voltage with that of **Side A**, the **Side B** voltage setting must be adequately configured. This setting will be used for angle compensation so that voltage on **Side B** may be compensated, as far as angle is concerned, through voltage on **Side A**.

In case phase-to-phase voltage is used on **Side B** for synchronism check, model compensation is required besides angle compensation, in order to compare voltages on both sides. To this end, **Side B Voltage Compensation Factor** (**K_{LB}**) setting must be set properly. As for magnitudes, the measured values are standardized, considering line-to-neutral voltages on both sides. As for angles, they are compensated according to the values shown in table 3.22-1. Magnitude standardization and angle compensation is made through the following settings:

- **Voltage on Side B**: through this setting, the measured value of the voltage on **side B** of the breaker is selected and the angle compensation to be used established. This setting is not considered for magnitude standardization.
- **Side B Voltage Compensation Factor B** (**K_{LB}**): based on the rated voltage on **side A**, the rated voltage on **side B** is compensated through multiplication by parameter **K_{LB}** for standardization so that voltage difference criterion may be used for synchronism. Parameter **K_{LB}** is calculated as:

$$K_{LB} = \frac{V_{nominal\,SIDE\_A}}{V_{nominal\,SIDE\_B}}$$

The synchronism unit also takes into account the system's phase sequence (ABC or ACB). Appropriate angle compensation depends on **Phase Sequence** (ABC / ACB) setting.

For example, if the voltage of side A is **A Phase** voltage and the voltage of side B is **B Phase** voltage, angle compensation for ABC sequence systems will be 120º; if system sequence is ACB, compensation will be 240º. Table 3.22-1 lists all angle compensation possibilities:

Table 3.22-2: Angle Compensation (Phase Sequence)

Side A	Side B voltage setting	ABC Sequence	ACB Sequence
V_A	V_A	0º	0º
V_A	V_B	120º	240º
V_A	V_C	240º	120º
V_A	V_{AB}	330º	30º
V_A	V_{BC}	90º	270º
V_A	V_{CA}	210º	150º

All angles measured with respect to V_A.

See the block diagram of the synchronism unit in figure 3.22.1.

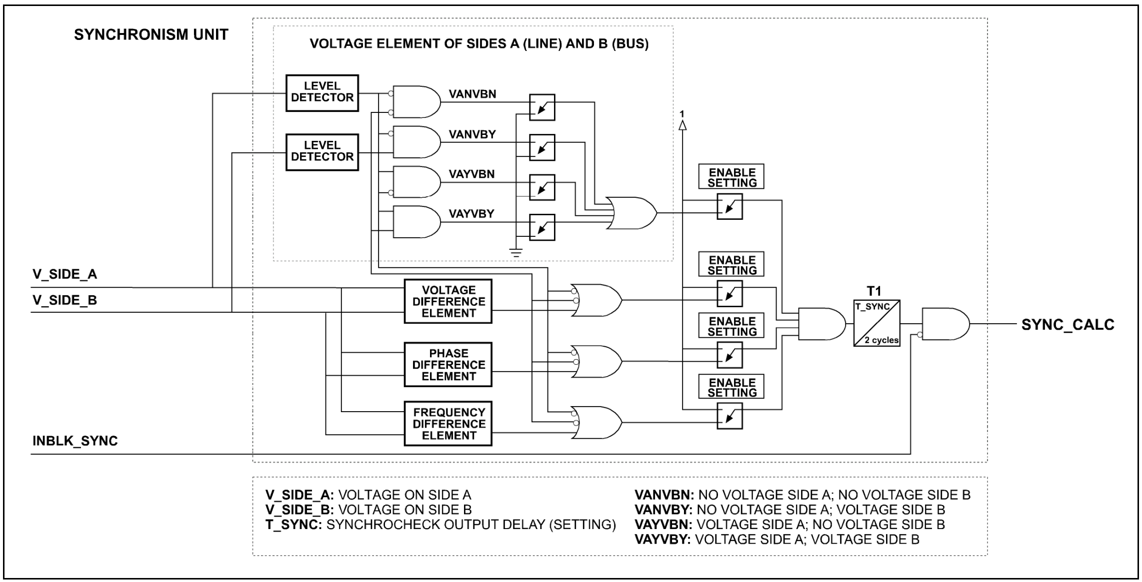


Figure 3.22.1: Block Diagram of the Synchronism Unit.

Note: the diagram shows that, if a permission value is 0 (element disabled), the input of the AND gate corresponding to this element will be at 1 as if this element were picked up. Therefore, if all the elements are disabled, the synchronism unit will be activated (unless it is blocked externally).

Note: the diagram shows that, if the bay overvoltage element and/or the bus overvoltage element are reset, the inputs to the AND gate corresponding to the voltage difference, angle difference and frequency difference elements are always at 1.

The Synchronism Unit output (**SYNC_CALC**) can be blocked with the **Block Synchronism Check** (**INBLK_SYNC**) digital input.

The Synchronism Unit is comprised of four elements (voltage elements of sides A and B, voltage, phase and frequency difference elements). Each has a permission (**Enable**) setting. Details of its operation are explained next.

3.22.2 Voltage Difference Element

This element picks up when the voltage difference between the signals of sides A and B is less than or equal to the set value (in percentage), and resets when the ratio between the voltages of sides A and B is equal to or greater than 105% of the set value.

$$\text{(Startup value)} \left| \frac{\text{V sideA}}{\text{V sideB}} - 1 \right| \leq \text{setting}$$

$$\text{(Reset value)} \left| \frac{\text{V line}}{\text{V bus}} - 1 \right| \geq \text{setting} \times 1{,}05$$

3.22.3 Phase Difference Element

This element picks up when the phase displacement between the signals of sides A and B is less than or equal to the setting and resets when the phase displacement angle is greater than 105% of the set value or greater than the set value +2º.

In **ZLV-F/G/H** relays, if the **Breaker Closing Time Compensation** is set to **YES**, the phase difference element will consider the phase angle difference between side A y B voltages at the time of closing the breaker, taking into account its operating time through the **Breaker Closing Time** setting and the phase shift angle between sides A and B. Thus, the following phase difference will be added to the phase shift angle between side A and B voltages:

$$\frac{Tclosing(ms)}{1000} \cdot 360 \cdot \left(f_A - f_B\right)$$

where *Tclosing* is the breaker closing time, f_A is the frequency of side A voltage and f_B is the frequency of side B voltage.

In this way, if side A voltage rotates faster than side B ($f_A > f_B$), the above phase shift will be positive, whereas if side A voltage rotates slower than side B ($f_A < f_B$) the phase angle correction to take into account will be negative.

3.22.4 Frequency Difference Element

This element picks up when the frequency difference between the signals of sides A and B is less than the pickup (100% of the setting), and resets when this difference is greater than the setting + 0.01 Hz.

A and **B side** signal angles are already compensated values according to Table 3.22.1.

3.22.5 Voltage Element of Sides A and B

This element is comprised of two overvoltage elements (for **Sides A** and **B** respectively). Each overvoltage element picks up when the RMS value of the input voltage exceeds 105% of the pickup value (set value) and resets when it is below 100% of this value. The voltages used are values standardized as line-to-neutral voltages.

The voltage element of **sides A** and **B** has two outputs that indicate the presence of voltage on each of the sides.

These outputs are generated whether they have been selected or not with the **Energization** setting, whose only function is to set the combinations to detect synchronism.

3.22.6 Selection of Type of Synchronism

The recloser as well as the command algorithm (for closing maneuvers of the breaker) use the **SYNC_R** signal, which indicates the presence or absence of synchronism prior to resetting the breaker.

This information can be supplied to the **ZLV** by the output of the IED's own synchronism unit (**SYNC_CALC** signal) or by the digital input of **External Synchronism** (**IN_SYNC_EXT** signal). The setting that determines the origin of the synchronization signal is the **Type of Synchronism** (**SEL_SYNC**).

The activation of the **Blocking Due to Fuse Failure** (**BLK_FF**) signal can cancel the **SYNC_R** signal if the **Synchronism Blocking Due to Fuse Failure** setting (**BLK_SYNC_FF**) is set to **YES**. Thus, closures which could occur without conditions of synchronism are avoided, since the fuse failure would generate a dead-line condition, which could automatically activate the **SYNC_R** signal (if the synchronism is external as well as if calculated) according to the **Energization** setting. The logic diagram which defines the synchronism signal (**SYNC_R**) is shown in Figure 3.22.2.

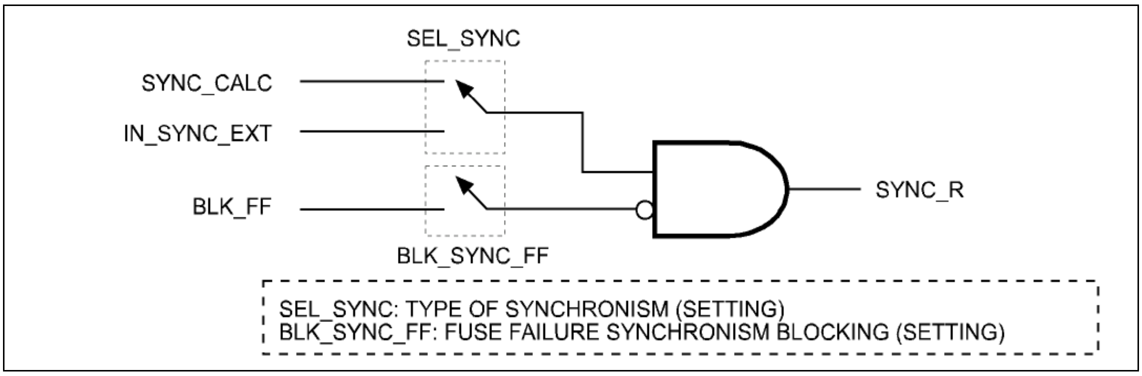


Figure 3.22.2: Block Diagram to Obtain the Synchronism Signal.

3.22.7 Synchronism Elements (ZLV-J)

ZLV-J relays incorporate two synchronism check elements, for each breaker, the function of which is to verify whether the conditions at both ends of the supervised breaker are suitable to closing it (either by reclose or manual reset) and that there will be no oscillations.

The functioning of the synchronism unit is based, on one hand, on comparing the module, phase and/or frequency of the voltages on **Side A** (**Line**) and **Side B** (**Busbar**) to check if the two voltages are the same. On the other hand, the element can detect synchronism according to the energization on both sides of the breaker, that is, in terms of the possible combinations of presence/absence of voltage on sides A and B.

In order to be able to supervise that the two breaker-and-a-half or ring circuit breakers are synchronized, **ZLV-J** relays include two synchronism elements designated as element 1 and element 2, intended to supervise breakers 1 and 2 respectively, which will use as side B voltage the voltages measured through channels VSYNC1, VSYNC2 and VSYNC3 respectively. However, as shown in the following tables, the disconnect switches used in the system topology will be selected according to the **VSINC Selection DI Supervision** setting, so that SIDE A and SIDE B voltages used to synchronize the breakers in question will be selected as a function of this setting and the status of each breaker. These options prevent, in double busbar with single breaker bays, the use of external devices intended to select the adequate busbar voltage.

- **VSINC Selection DI Supervision = NO:** For single busbar or double busbar with double breaker. The two **BREAKER 1** elements will use **VSYNC1** voltage as **Side B** and the two **BREAKER 2** elements will use **VSYNC2** voltage as **Side B**.

Table 3.22-3: Breaker 1

89B1_NC	89B2_NC	VX (SIDE A)	VSYNC1	VSYNC2	VSYNC3	Single Breaker Configuration	SETTING: VSINC Selection DI Supervision
Not used	Not used	√	√	Not used	Not used	Single or double busbar with double breaker	NO

Table 3.22-4: Breaker 2

89B1_NC	89B2_NC	VX (LADO A)	VSINC1	VSINC2	VSINC3	Single Breaker Configuration	SETTING: VSINC Selection DI Supervision
Not used	Not used	√	Not used	√	Not used	Single or double busbar with double breaker	NO

- **VSINC Selection DI Supervision = 89B:** For double busbar with single breaker. Synchronism elements will use the corresponding input voltages as a function of the status of input signals **IN_89B1_NC** (Busbar disconnect switch 1 open) and **IN_89B2_NC** (Busbar disconnect switch 2 open).

Table 3.22-5: Breaker 1

89B1_NC	89B2_NC	VX (SIDE A)	VSYNC1	VSYNC2	VSYNC3	Single Breaker Configuration	SETTING: VSINC Selection DI Supervision
0	0	√	√	Not used	Not used	Double busbar with single breaker	89B
0	1	√	√	Not used	Not used		
1	0	√	Not used	√	Not used		
1	1	√	√	Not used	Not used		

Table 3.22-6: Breaker 2

89B1_NC	89B2_NC	VX (SIDE A)	VSYNC1	VSYNC2	VSYNC3	Single Breaker Configuration	SETTING: VSINC Selection DI Supervision
0	0	√	√	Not used	Not used	Double busbar with single breaker	89B
0	1	√	√	Not used	Not used		
1	0	√	Not used	√	Not used		
1	1	√	√	Not used	Not used		

When single breaker and single with double bar configuration is selected (89B option):

- 89B1_NC: Busbar 1 disconnect switch open (*).
- 89B2_NC: Busbar 2 disconnect switch open.
- Vx: Side A voltage (where x=A, B or C).
- VSINC1: Side B voltage (busbar 1).
- VSINC2: Side B voltage (busbar 2).

(*)The element automatically selects the double busbar logic when configuring input signals "Busbar 1 disconnect switch open" and "Busbar 2 disconnect switch open".

- **VSINC Selection DI Supervision = 89L:** For Breaker-and-a-half. Synchronism elements will use the corresponding input voltages as a function of the status of input signals **IN_89L1_NC** (Busbar disconnect switch 1 open) and **IN_89L2_NC** (Busbar disconnect switch 2 open)

Table 3.22-7: Breaker 1

89L1_NC	89L2_NC	VX (SIDE A)	VSYNC1	VSYNC2	VSYNC3	Breaker and-a-half Configuration	VSINC Selection DI Supervision
0	0	√	√	Not used	Not used	Breaker 1 (side) 89L1 and 89L2 independent	89L
0	1	√	√	Not used	Not used		
1	0	Not used (2)	√	Not used	√		
1	1	Not used (2)	√	√	Not used		
0	Not used	√	√	Not used	Not used	Breaker 1 (side) 89L1 and 89L2 switched	
1	Not used	Not used (2)	√	√	Not used		

Table 3.22-8: Breaker 2

89L1_NC	89L2_NC	VX (SIDE A)	VSYNC1	VSYNC2	VSYNC3	Breaker and-a-half Configuration	VSINC Selection DI Supervision
0	0	√	Not used	Not used	√	Breaker 2 (central) 89L1 and 89L2 independent	89L
0	1	√	Not used	√	Not used		
1	0	Not used (2)	√	Not used	√		
1	1	Not used (2)	√	√	Not used		
0	Not used (1)	√	Not used	√	Not used	Breaker 2 (central) 89L1 and 89L2 switched	
1	Not used (1)	Not used (2)	√	√	Not used		

Note (1): External wired voltage according to 89L2.
Note (2): When the selected option does not use the Vx (Side A) voltage, the VSINC1 voltage, will be represented as side A, using both side A status and settings (Live / Dead voltage thresholds). So that, in case side A and side B settings are different, no angular compensation will be used.

When **breaker-and-a-half** configuration **(option 89L)** is selected:

- 89L1_NC: Line 1 disconnect switch 1 open (**)
- 89L2_NC: Line 2 disconnect switch 2 open
- Vx: Side A voltage (where x=A, B or C)
- VSINC1: Side B voltage (busbar 1)
- VSINC2: Side B voltage (busbar 2)
- VSINC3: Side B voltage (line 2)

Note (**): The element automatically selects the breaker-and-a-half logic when configuring input signals "Line 1 disconnect switch open" and "Line 2 disconnect switch open".

Figures 3.22.2 and 3.22.3 show single breaker with double busbar and breaker-and-a-half configurations respectively.

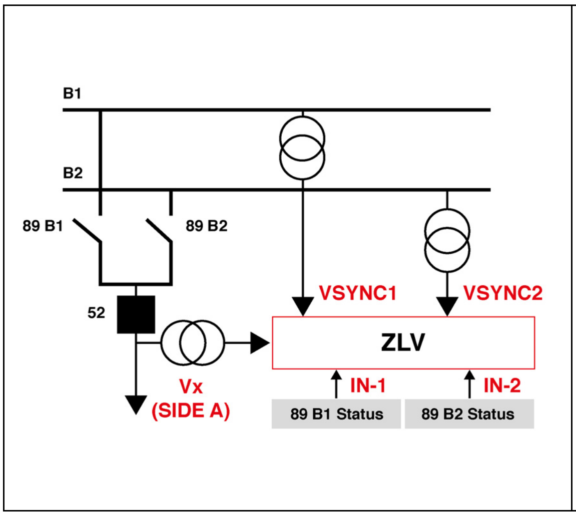


Figure 3.22.3: Double Busbar Substation Configuration.

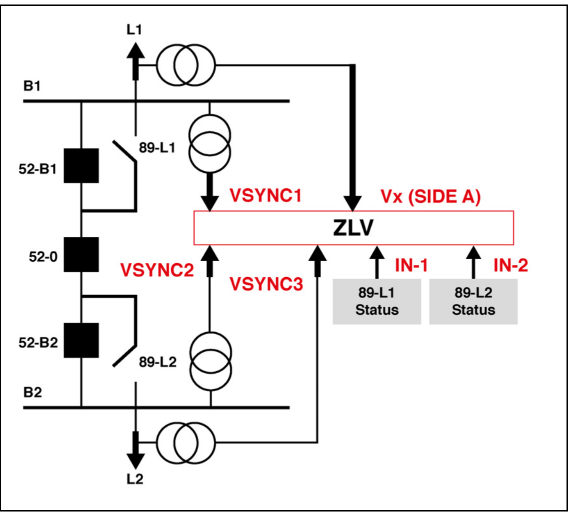


Figure 3.22.4: Breaker-and-a-half Substation Configuration.

Side A voltage may correspond to A, B or C phases as a function of the line side transformer state. On the other hand, also, **side B** voltage can correspond with A, B or C phase voltages or AB, BC or CA phase to phase voltages as a function of the busbar side transformer state. In order to compare this voltage with **side A** voltage, both **Side A Voltage** and **Side B** voltage configuration settings must adequately be specified. This latter setting, **Side B** setting, will be taken into account to make an angular compensation so that **Side B** voltage can be compensated, as far as the angle is concerned, with **Side A** voltage.

In case phase-to-phase voltage is used on **Side B** for synchronism check, model compensation is required besides angle compensation, in order to compare voltages on both sides. To this end, **Side B Voltage Compensation Factor** (**K_{LB}**) setting must be set properly. As for magnitudes, the measured values are standardized, considering line-to-neutral voltages on both sides. As for angles, they are compensated according to the values shown in Table 3.22-9. Magnitude standardization and angle compensation is made through the following settings:

- **Voltage on Side B**: through this setting, the measured value of the voltage on **side B** of the breaker is selected and the angle compensation to be used established. This setting is not considered for magnitude standardization. Since this setting will be common for all **B Side** voltages (VSYNC1, VSYNC2 and VSYNC3), they must be coincident in their wiring.
- **Side B Voltage Compensation Factor B** (**K_{LB}**): based on the rated voltage on **side A**, the rated voltage on **side B** is compensated through multiplication by parameter **K_{LB}** for standardization so that voltage difference criterion may be used for synchronism. Parameter **K_{LB}** is calculated as:

$$K_{LB} = \frac{V_{nominal\,SIDE\_A}}{V_{nominal\,SIDE\_B}}$$

The synchronism unit also takes into account the system's phase sequence (ABC or ACB). Appropriate angle compensation depends on **Phase Sequence** (ABC / ACB) setting.

For example, if the voltage of side A is **A Phase** voltage and the voltage of side B is **B Phase** voltage, angle compensation for ABC sequence systems will be 120º; if system sequence is ACB, compensation will be 240º. Table 3.22-9 lists all angle compensation possibilities:

Table 3.22-9:Angle Compensation (Phase Sequence)

Side A	Side B voltage setting	ABC Sequence	ACB Sequence
V_A	V_A	0º	0º
V_A	V_B	120º	240º
V_A	V_C	240º	120º
V_A	V_{AB}	330º	30º
V_A	V_{BC}	90º	270º
V_A	V_{CA}	210º	150º
V_B	V_A	240º	120º
V_B	V_B	0º	0º
V_B	V_C	120º	240º
V_B	V_{AB}	210º	150º
V_B	V_{BC}	330º	30º
V_B	V_{CA}	90º	270º
V_C	V_A	120º	240º
V_C	V_B	240º	120º
V_C	V_C	0º	0º
V_C	V_{AB}	90º	270º
V_C	V_{BC}	210º	150º
V_C	V_{CA}	330º	30º

All angles measured with respect to V_A.

See the block diagram of the synchronism unit in figure 3.22.4.

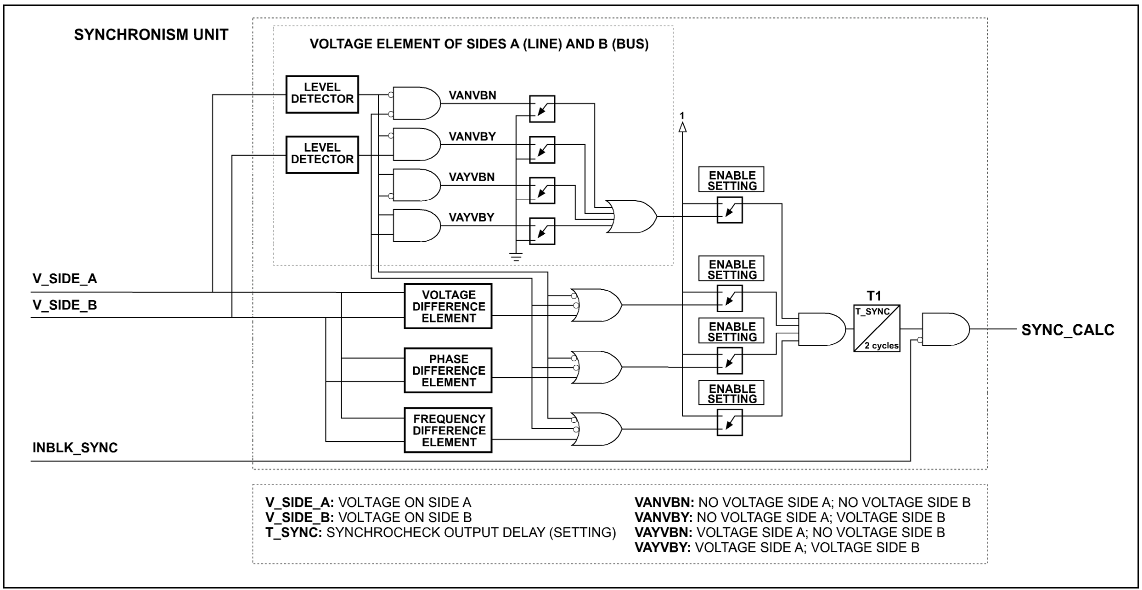


Figure 3.22.5: Block Diagram of the Synchronism Unit.

Legend	
V_SIDE_A: VOLTAGE ON SIDE A.	VANVBN: No Voltage Side A; No Voltage Side B.
V_SIDE_B: VOLTAGE ON SIDE B.	VANVBS: No Voltage Side A; Voltage Side B.
T_SYNC: Synchrocheck Output Delay (Setting).	VASVBN: Voltage Side A; No Voltage Side B.
	VASVBS: Voltage Side A; Voltage Side B.

Note: the diagram shows that, if a permission value is 0 (element disabled), the input of the AND gate corresponding to this element will be at 1 as if this element were picked up. Therefore, if all the elements are disabled, the synchronism unit will be activated (unless it is blocked externally).

Note: the diagram shows that, if the bay overvoltage element and/or the bus overvoltage element are reset, the inputs to the AND gate corresponding to the voltage difference, angle difference and frequency difference elements are always at 1.

The Synchronism Unit output (**SYNC_CALC**) can be blocked with the **Block Synchronism Check** (**INBLK_SYNC**) digital input.

The Synchronism Unit is comprised of four elements (voltage elements of sides A and B, voltage, phase and frequency difference elements). Each has a permission (**Enable**) setting. Details of its operation are explained next.

3.22.7.a Voltage Difference Element

This element picks up when the voltage difference between the signals of sides A and B is less than or equal to the set value (in percentage), and resets when the ratio between the voltages of sides A and B is equal to or greater than 105% of the set value.

Pickup: If $100 \times \left| \frac{V\ sideA}{V\ sideB} - 1 \right| \leq setting$

Reset: If $100 \times \left| \frac{V\ line}{V\ bus} - 1 \right| \geq setting \times 1.05$

3.22.7.b Phase Difference Element

This element picks up when the phase displacement between the signals of sides A and B is less than or equal to the setting and resets when the phase displacement angle is greater than 105% of the set value or greater than the set value +2º.

If the **Breaker Closing Time Compensation** is set to **YES**, the phase difference element will consider the phase angle difference between side A y B voltages at the time of closing the breaker, taking into account its operating time through the **Breaker Closing Time** setting and the phase shift angle between sides A and B. Thus, the following phase difference will be added to the phase shift angle between side A and B voltages:

$$\frac{Tclosing(ms)}{1000} \cdot 360 \cdot \left(f_A - f_B\right)$$

where *Tclosing* is the breaker closing time, f_A is the frequency of side A voltage and f_B is the frequency of side B voltage.

In this way, if side A voltage rotates faster than side B ($f_A > f_B$), the above phase shift will be positive, whereas if side A voltage rotates slower than side B ($f_A < f_B$) the phase angle correction to take into account will be negative.

3.22.7.c Frequency Difference Element

This element picks up when the frequency difference between the signals of sides A and B is less than the pickup (100% of the setting), and resets when this difference is greater than the setting + 0.01 Hz.

A and **B side** signal angles are already compensated values according to Table 3.22-9.

3.22.7.d Sides A and B Voltage Elements

These elements consist of two overvoltage elements for each breaker (one element for each side of the breaker) and two undervoltage elements for each breaker (one element for each side of the breaker). Based on these four settings, three different voltage bands will be determined, three for Side A (Line) and three for Side B (Busbar).

For live line or busbar detection, each overvoltage element, picks up when the rms of the input voltage exceeds 100% of the pickup value (setting value) and resets when it is below 95% of this value. The voltages used are standard phase voltages.

For dead line or busbar detection, each undervoltage element picks up when the rms of the input voltage is below 100% of the pickup value (setting value) and resets when it exceeds 95% of this value. The voltages used are standard phase voltages.

The voltage elements intended to detect whether **Sides A** and **B** are live or dead are provided with 4 outputs that show the following signals for each side of each breaker.

- **Live line**: This signal will activate when the line voltage (SIDE A) ≥ Live line setting set to live.
- **Dead line**: This signal will activate when the line voltage (SIDE A) < Dead line setting.
- **Live bus**: This signal will activate when the busbar voltage (SIDE B) ≥ Live bus setting.
- **Dead bus**: This signal will activate when the busbar voltage (SIDE B) < Dead bus setting.

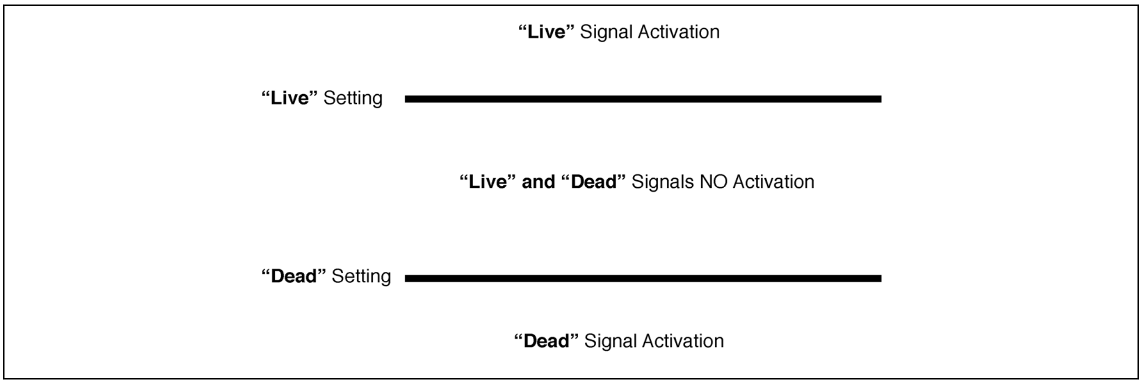


Figure 3.22.6: Activation thresholds to determine Live Line / Dead Line and Live Bus / Dead Bus.

These outputs are generated whether they have of have not been selected through the **Energization** setting, whose sole function is to set the combinations to be used to detect synchronism. This will occur provided we are in the live or dead zone, since if the voltage at any side of the breaker is in the **No activation of "Live" and "Dead" Signals** zone, shown in figure 3.22.5, the outputs of the side involved will not be calculated independently from the rest of the synchronism element settings.

3.22.7.e Selection of Type of Synchronism

The recloser as well as the command algorithm (for closing maneuvers of the breaker) use the **SYNC_R** signal, which indicates the presence or absence of synchronism prior to resetting the breaker.

This information can be supplied to the **ZLV** by the output of the IED's own synchronism unit (**SYNC_CALC** signal) or by the digital input of **External Synchronism** (**IN_SYNC_EXT** signal). The setting that determines the origin of the synchronization signal is the **Type of Synchronism** (**SEL_SYNC**).

The activation of the **Blocking Due to Fuse Failure** (**BLK_FF**) signal can cancel the **SYNC_R** signal if the **Synchronism Blocking Due to Fuse Failure** setting (**BLK_SYNC_FF**) is set to **YES**. Thus, closures which could occur without conditions of synchronism are avoided, since the fuse failure would generate a dead-line condition, which could automatically activate the **SYNC_R** signal (if the synchronism is external as well as if calculated) according to the **Energization** setting. The logic diagram which defines the synchronism signal (**SYNC_R**) is shown in Figure 3.22.6.

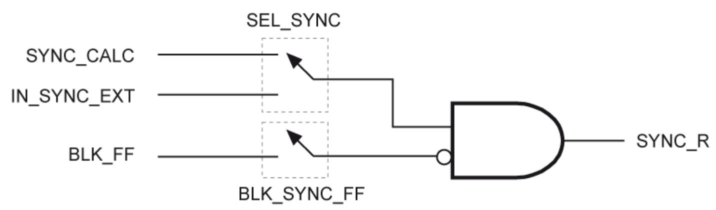


Figure 3.22.7: Block Diagram to Obtain the Synchronism Signal.

Legend
SEL_SYNC: Type of Synchronism (Setting)
BLK_SYNC_FF: Fuse Failure Synchronism Blocking (Setting)
SYNC_CAL: Synchronism Unit Activation
IN_SYNC_EXT: External synchronism input
BCK_FF: Synchronism Blocking due to Fuse Failure
SYNC_R: Close by Synchronism Enabled

3.22.8 Synchronism Elements (ZLV-F/H**-*****K/M* or Higher)

Models **ZLV-F/H** with digit **X9=K** or **M** or higher incorporate two synchronism check elements, the function of which is to verify whether the conditions at both ends of the supervised breaker are suitable to closing it (either by reclose or manual reset) and that there will be no oscillations.

In order to be able to supervise that the breaker is synchronized, **ZLV-F/H**-*****K/M*** or higher relays include two synchronism elements designated as element 1 and element 2, intended to supervise the closures through the recloser and the manual closing of the breaker respectively.

3.22.8.a Configurating the Voltage of the two Voltage Sides (A and B)

Side A voltage may correspond to A, B or C phases as a function of the line side transformer state. On the other hand, also, **side B** voltage can correspond with A, B or C phase voltages or AB, BC or CA phase to phase voltages as a function of the busbar side transformer state. In order to compare this voltage with **side A** voltage, both **Side A Voltage** and **Side B** voltage configuration settings must adequately be specified. This latter setting, **Side B** setting, will be taken into account to make an angular compensation so that **Side B** voltage can be compensated, as far as the angle is concerned, with **Side A** voltage.

The angle compensation of the **Side B** voltage will continue to be applied in the same way as that mentioned above, but the standardization of modules and compensation of angles is done according to the following table.

For example, if the voltage of side A is **A Phase** voltage and the voltage of side B is **B Phase** voltage, angle compensation for ABC sequence systems will be 120º; if system sequence is ACB, compensation will be 240º. Table 3.22-10 lists all angle compensation possibilities:

Table 3.22-10:Angle Compensation (Phase Sequence)

Side A	Side B voltage setting	ABC Sequence	ACB Sequence
V_A	V_A	0º	0º
V_A	V_B	120º	240º
V_A	V_C	240º	120º
V_A	V_{AB}	330º	30º
V_A	V_{BC}	90º	270º
V_A	V_{CA}	210º	150º
V_B	V_A	240º	120º
V_B	V_B	0º	0º
V_B	V_C	120º	240º
V_B	V_{AB}	210º	150º
V_B	V_{BC}	330º	30º
V_B	V_{CA}	90º	270º
V_C	V_A	120º	240º
V_C	V_B	240º	120º
V_C	V_C	0º	0º
V_C	V_{AB}	90º	270º
V_C	V_{BC}	210º	150º
V_C	V_{CA}	330º	30º

3.22.8.b Sides A and B Voltage Elements

These elements consist of two overvoltage elements and two undervoltage elements. Based on these four settings, three different voltage bands will be determined, three for Side A (Line) and three for Side B (Busbar).

For live line or busbar detection, each overvoltage element, picks up when the rms of the input voltage exceeds 100% of the pickup value (setting value) and resets when it is below 95% of this value. The voltages used are standard phase voltages.

For dead line or busbar detection, each undervoltage element picks up when the rms of the input voltage is below 100% of the pickup value (setting value) and resets when it exceeds 95% of this value. The voltages used are standard phase voltages.

The voltage elements intended to detect whether **Sides A** and **B** are live or dead are provided with 4 outputs that show the following signals for each side of each breaker.

- **Live line**: This signal will activate when the line voltage (SIDE A) ≥ Live line setting set to live.
- **Dead line**: This signal will activate when the line voltage (SIDE A) < Dead line setting.
- **Live bus**: This signal will activate when the busbar voltage (SIDE B) ≥ Live bus setting.
- **Dead bus**: This signal will activate when the busbar voltage (SIDE B) < Dead bus setting.

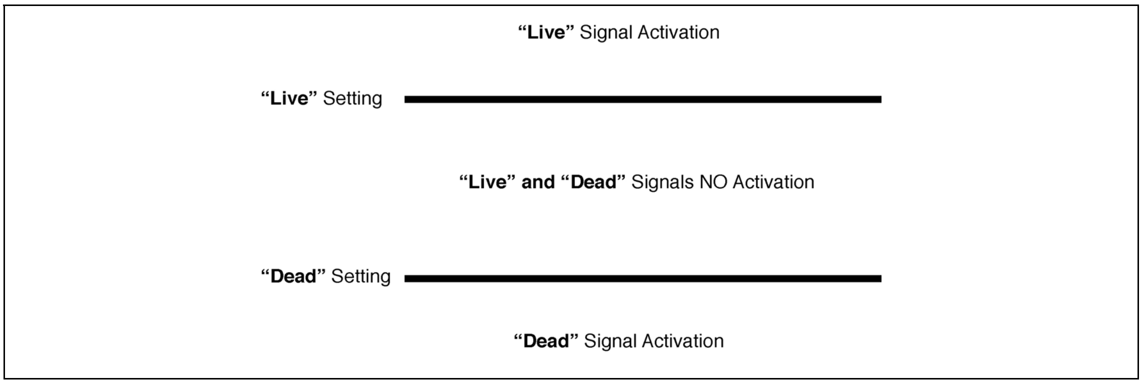


Figure 3.22.8: Activation thresholds to determine Live Line / Dead Line and Live Bus / Dead Bus.

These outputs are generated whether they have of have not been selected through the **Energization** setting, whose sole function is to set the combinations to be used to detect synchronism. This will occur provided we are in the live or dead zone, since if the voltage at any side of the breaker is in the **No activation of "Live" and "Dead" Signals** zone, shown in Figure 3.22.8, the outputs of the side involved will not be calculated independently from the rest of the synchronism element settings.

3.22.9 Application of the Synchronism Function

The synchronism function is used to monitor the connection of the two parts of the circuit by the reset of a breaker. It verifies that the voltages on both sides of the breaker ($V_{SIDE\ A}$ and $V_{SIDE\ B}$) are within the magnitude, angle and frequency limits established in the settings.

Verification of synchronism is defined as the comparison of the voltage difference of two circuits with different sources to be joined through an impedance (transmission line, feeder, etc.), or connected with parallel circuits of defined impedances. The voltages on both sides of a breaker are compared before executing its reset so as to minimize possible internal damage due to the voltage difference in phase, as well as magnitude and angle. This is very important in steam-powered power plants where the reclosings of the output lines with considerable angle differences can cause very serious damage to the shaft of the turbine.

The difference in voltage level and phase angle at a given point in time is the result of the load existing between remote sources connected through parallel circuits (load flow). It is also a consequence of the impedance of the elements that join them (even when there is no load flow in the parallel circuits or because the sources to connect to each other are totally independent and isolated from each other).

In meshed systems, the angle difference between two ends of an open breaker is not normally significant since their sources are joined remotely by other elements (equivalent or parallel circuits). Nevertheless, in isolated circuits, as in the case of an independent generator, the angle difference, the voltage levels and the relative phase shift of the voltage phasors can be very considerable. The relative phase shift of their voltages can even be very small or null in such a way that they will be in phase very infrequently. Due to the changing conditions of an electricity system (connection-disconnection of loads, sources and new inductive-capacitive elements) the relative phase shift of one phasor in respect of the other is not null, making synchronization necessary.

In the first case, although the length of the line whose ends (sources) will be connected to determine the angle difference between them should be considered, this is not sufficient to set the synchronism conditions before closing the breaker. Experience indicates that the angle difference window between voltage phasors must be set to 15º-20º.

3.22.10 Synchronism Unit Settings

Synchronism Unit			
Setting	**Range**	**Step**	**By default**
Dual Bus configuration (ZLV-G)	YES / NO		NO
Enable	YES / NO		NO
Synchronism type	0: External 1: Internal (Calculated)		0: External
Side B Voltage (busbars)	V_A / V_B / V_C / V_{AB} / V_{BC} / V_{CA}		V_A
Side B voltage compensation factor (K_{LB})	0.1 - 4	0.01	1
Fuse failure synchronism blocking	YES / NO		NO
Breaker closing time compensation (ZLV-F/G/H)	YES / NO		NO
Breaker closing time (ZLV-F/G/H)	5 - 1000 ms	5 ms	100 ms
Synchronism output time delay	0.00 - 300 s	0.01 s	0 s
Voltage supervision elements enable	YES / NO		NO
Side A voltage elements pickup	20 - 200 V	1 V	20 V
Side B voltage elements pickup	20 - 200 V	1 V	20 V
Energization mask No voltage side A, No voltage side B No voltage side A, Voltage side B Voltage side A, No voltage side B Voltage side A, Voltage side B	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz

- **Synchronism Unit: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**12 - SYNCROCHECK**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	**0 - SYNC ENABLE**
…	**1 - TYPE OF SYNC**
12 - SYNCROCHECK	**2 - BUSBAR SELECTION**
…	**3 - VOLTAGE SUPRV. ENBL**
	4 - SIDE A VOLT. PU
	5 - SIDE B VOLT. PU
	6 - ENERGIZATION MASK
	7 - VOLT. DIFF. ENABLE
	8 - MAX. VOLTAGE DIFF.
	9 - PHASE DIFF. ENABLE
	10 - MAX. PHASE DIFF.
	11 - FREQ. DIFF. ENABLE
	12 - MAX. FREQ. DIFF.
	13 - SYNC. DELAY
	14 - FF SYNC. BLOCK

ZLV-F/H

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**13 - SYNCROCHECK**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	**0 - SYNC ENABLE**
…	**1 - TYPE OF SYNC**
13 - SYNCROCHECK	**2 - BUSBAR SELECTION**
…	**3 - BUS VOLT. COMPENS.**
	4 - VOLTAGE SUPRV. ENBL
	5 - SIDE A VOLT. PU
	6 - SIDE B VOLT. PU
	7 - ENERGIZATION MASK
	8 - VOLT. DIFF. ENABLE
	9 - MAX. VOLTAGE DIFF.
	10 - PHASE DIFF. ENABLE
	11 - MAX. PHASE DIFF.
	12 - FREQ. DIFF. ENABLE
	13 - MAX. FREQ. DIFF.
	14 - SYNC. DELAY
	15 - FF SYNC. BLOCK
	16 - BRK CLOSE T COMP
	17 - BRK CLOSE T

ZLV-G

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**13 - SYNCROCHECK**
3 - INFORMATION	**3 - PROTECTION**	…
	….	

0 - DISTANCE	
…	**0 - DUAL BUS**
13 - SYNCROCHECK	**1 - BREAKER 1**
…	**2 - BREAKER 2**

0 - DUAL BUS	**0 - SYNC ENABLE**
1 - BREAKER 1	**1 - TYPE OF SYNC**
2 - BREAKER 2	**2 - BUSBAR SELECTION**
	3 - BUS VOLT. COMPENS.
	4 - VOLTAGE SUPRV. ENBL
	5 - SIDE A VOLT. PU
	6 - SIDE B VOLT. PU
	7 - ENERGIZATION MASK
	8 - VOLT. DIFF. ENABLE
	9 - MAX. VOLTAGE DIFF.
	10 - PHASE DIFF. ENABLE
	11 - MAX. PHASE DIFF.
	12 - FREQ. DIFF. ENABLE
	13 - MAX. FREQ. DIFF.
	14 - SYNC. DELAY
	15 - FF SYNC. BLOCK
	16 - BRK CLOSE T COMP
	17 - BRK CLOSE T

3.22.11 Synchronism Units Settings (ZLV-J)

Synchronism Unit			
Setting	**Range**	**Step**	**By default**
VSYNC Selection DI Supervision	NO / 89B / 89L		NO
Breaker 1			
Synchronism Type	0: External 1: Internal (Calculated)		0: Internal
Line Selection	V_A / V_B / V_C		V_A
Busbar Selection	V_A / V_B / V_C / V_{AB} / V_{BC} / V_{CA}		V_A
Side B Voltage Compensation Factor (K_{LB})	0.1 - 4	0.01	1
Voltage supervision elements enable	YES / NO		NO
Live Line	0 - 200 V	1 V	51 V
Dead Line	0 - 200 V	1 V	19 V
Live Bus	0 - 200 V	1 V	51 V
Dead Bus	0 - 200 V	1 V	19 V
Breaker Close Time Compensation	YES / NO		NO
Breaker Close Time	5 - 1000 ms	5 ms	100 ms
Unit 1			
Synchronism Enable	YES / NO		NO
Energization mask D BUS / D LINE H BUS / D LINE D BUS / H LINE H BUS / H LINE	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz
Synchronism Delay	0.00 - 300 s	0.01 s	0 s
Fuse Failure Synchronism Blocking	YES / NO		NO
Unit 2			
Synchronism Enable	YES / NO		No
Energization mask D BUS / D LINE H BUS / D LINE D BUS / H LINE H BUS / H LINE	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz
Synchronism Delay	0.00 - 300 s	0.01 s	0 s
Fuse Failure Synchronism Blocking	YES / NO		NO

Synchronism Unit			
Setting	**Range**	**Step**	**By default**
Breaker 2			
Synchronism Type	0: External 1: Internal (Calculated)		0: Internal
Line Selection	V_A / V_B / V_C		V_A
Busbar Selection	V_A / V_B / V_C / V_{AB} / V_{BC} / V_{CA}		V_A
Side B Voltage Compensation Factor (K_{LB})	0.1 - 4	0.01	1
Voltage supervision elements enable	YES / NO		NO
Live Line	0 - 200 V	1 V	51 V
Dead Line	0 - 200 V	1 V	19 V
Live Bus	0 - 200 V	1 V	51 V
Dead Bus	0 - 200 V	1 V	19 V
Breaker Close Time Compensation	YES / NO		NO
Breaker Close Time	5 - 1000 ms	5 ms	100 ms
Unit 1			
Synchronism Enable	YES / NO		NO
Energization mask D BUS / D LINE H BUS / D LINE D BUS / H LINE H BUS / H LINE	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz
Synchronism Delay	0.00 - 300 s	0.01 s	0 s
Fuse Failure Synchronism Blocking	YES / NO		NO
Unit 2			
Synchronism Enable	YES / NO		No
Energization mask D BUS / D LINE H BUS / D LINE D BUS / H LINE H BUS / H LINE	 YES / NO YES / NO YES / NO YES / NO		 NO YES NO YES
Voltage difference element enable	YES / NO		NO
Maximum voltage difference	2% - 30%	1%	2%
Phase difference element enable	YES / NO		NO
Maximum phase difference	2 - 80º	1º	2º
Frequency difference element enable	YES / NO		NO
Maximum frequency difference	0.005 - 2.00Hz	0.01 Hz	0.01 Hz
Synchronism Delay	0.00 - 300 s	0.01 s	0 s
Fuse Failure Synchronism Blocking	YES / NO		NO

- **Synchronism Unit: HMI Access (ZLV-J)**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**15 - SYNCROCHECK**
3 - INFORMATION	**3 - PROTECTION**	...
	...	

0 - DISTANCE	
...	**0 - DI SUPERV VSYN SEL**
15 - SYNCROCHECK	**1 - BREAKER 1**
...	**2 - BREAKER 2**

0 - DI SUPERV VSYN SEL	**0 - TYPE OF SYNC**
1 - BREAKER 1	**1 - LINE SELECTION**
2 - BREAKER 2	**2- BUSBAR SELECTION**
	3 - BUS VOLT. COMPENS.
	4 - VOLTAGE SUPRV ENBL
	5 - LIVE LINE
	6 - DEAD LINE
	7 - LIVE BUS
	8 - DEAD BUS
	9 - BRK CLOSE T COMP
	10 - BRK CLOSE T
	11 - UNIT 1
	12 - UNIT 2

10 - BRK CLOSE T	**0 - SYNC ENABLE**
11 - UNIT 1	**1 - ENERGIZATION MASK**
12 - UNIT 2	**2 - VOLT. DIFF. ENABLE**
	3 - MAX. VOLTAGE DIFF.
	4 - PHASE DIFF. ENABLE
	5 - MAX. PHASE DIFF.
	6 - FREQ. DIFF. ENABLE
	7 - MAX. FREQ. DIFF.
	8 - SYNC DELAY
	9- FF SYNC. BLOCK

3.22.12 Digital Inputs and Events of the Synchronism Module

Table 3.22-11: Digital Inputs and Events of the Synchronism Module		
Name	**Description**	**Function**
INBLK_SYNC	Close synchronism block input (ZLV-A/B/E/F/H)	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
INBLK_SYNC1	Close 1 synchronism block input (ZLV-G)	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
INBLK_SYNC2	Close 2 synchronism block input (ZLV-G)	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
ENBL_SYNC	Close synchronism enable input (ZLV-A/B/E/F/H)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_SYNC1	Close 1 synchronism enable input (ZLV-G)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_SYNC2	Close 2 synchronism enable input (ZLV-G)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”

Table 3.22-11: Digital Inputs and Events of the Synchronism Module		
Name	**Name**	**Name**
IN_SYNC_EXT	External synchronism input (ZLV-A/B/E/F/H)	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_SYNC_EXT1	External 1 synchronism input (ZLV-G)	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_SYNC_EXT2	External 2 synchronism input (ZLV-G)	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_89B1_OP	Tie Breaker 1 Open (ZLV-G)	Its activation means that the normally closed tie breaker 1 state contact is closed
IN_89B2_OP	Tie Breaker 2 Open (ZLV-G)	Its activation means that the normally closed tie breaker 2 state contact is closed

3.22.13 Digital Inputs and Events of the Synchronism Modules (ZLV-J)

Table 3.22-12:Digital Inputs and Events of the Synchronism Modules (ZLV-J)		
Name	**Description**	**Function**
INBLK_SYNC1	Close 1 synchronism block input	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
INBLK_SYNC2	Close 2 synchronism block input	Activation of the input blocks the activation of the synchronism unit output (calculated synchronism).
ENBL_SYNCn1	Close 1 Unit n (n=1,2) synchronism enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
ENBL_SYNCn2	Close 2 Unit n (n=1,2) synchronism enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a “1.”
IN_SYNC_EXT1	External 1 synchronism input	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_SYNC_EXT2	External 2 synchronism input	Activation of the input is necessary to permit the recloser to generate a close command if the supervision by synchronism setting is enabled and the synchronism mode chosen is “external.”
IN_89L1_NC	Line 1 disconnect switch open	Its activation indicates that Line 1 disconnect switch normally closed contact is closed.
IN_89L2_NC	Line 2 disconnect switch open	Its activation indicates that Line 2 disconnect switch normally closed contact is closed.
IN_89B1_NC	Tie Breaker 1 Open	Its activation means that the normally closed tie breaker 1 state contact is closed
IN_89B2_NC	Tie Breaker 2 Open	Its activation means that the normally closed tie breaker 2 state contact is closed

3.22.14 Digital Outputs and Events of the Synchronism Module

Table 3.22-13: Digital Outputs and Events of the Synchronism Module		
Name	**Description**	**Function**
SYNC_CALC	Synchronism unit activation (ZLV-A/B/E/F/H)	The synchronism unit determines that there are overall close conditions.
SYNC1_CALC	Synchronism 1 unit activation (ZLV-G)	The synchronism 1 unit determines that there are overall close conditions.
SYNC2_CALC	Synchronism 2 unit activation (ZLV-G)	The synchronism 2 unit determines that there are overall close conditions.
P_SYNC_DPH	Permission to close by phase difference (ZLV-A/B/E/F/H)	The synchronism unit determines that there are close conditions by the phase difference criterion.
P_SYNC1_DPH	Permission to close Breaker 1 by phase difference (ZLV-G)	The synchronism 1 unit determines that there are close conditions by the phase difference criterion.
P_SYNC2_DPH	Permission to close Breaker 2 by phase difference (ZLV-G)	The synchronism 2 unit determines that there are close conditions by the phase difference criterion.
P_SYNC_DF	Permission to close by frequency difference (ZLV-A/B/E/F/H)	The synchronism unit determines that there are close conditions by the frequency difference criterion.
P_SYNC1_DF	Permission to close Breaker 1 by frequency difference (ZLV-G)	The synchronism 1 unit determines that there are close conditions by the frequency difference criterion.
P_SYNC2_DF	Permission to close Breaker 2 by frequency difference (ZLV-G)	The synchronism 2 unit determines that there are close conditions by the frequency difference criterion.
P_SYNC_DV	Permission to close by voltage difference (ZLV-A/B/E/F/H)	The synchronism unit determines that there are close conditions by the voltage difference criterion.
P_SYNC1_DV	Permission to close Breaker 1 by voltage difference (ZLV-G)	The synchronism 1 unit determines that there are close conditions by the voltage difference criterion.
P_SYNC2_DV	Permission to close Breaker 2 by voltage difference (ZLV-G)	The synchronism 2 unit determines that there are close conditions by the voltage difference criterion.

Table 3.22-13: Digital Outputs and Events of the Synchronism Module		
Name	**Name**	**Name**
P_SYNC_EL	Permission to close by energization on the sides (ZLV-A/B/E/F/H)	The synchronism unit determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
P_SYNC1_EL	Breaker 1 permission to close by energization on the sides (ZLV-G)	The synchronism 1 unit determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
P_SYNC2_EL	Breaker 2 permission to close 2 by energization on the sides (ZLV-G)	The synchronism 2 unit determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
SYNC_R	Close by synchronism enabled (ZLV-A/B/E/F/H)	It is the signal that the recloser receives to monitor the close by synchronism. Its activation indicates that there is permission, and depending on how the selector is set, it will be external or calculated synchronism.
SYNC1_R	Breaker 1 close by synchronism enabled (ZLV-G)	It is the signal that the recloser receives to monitor the breaker 1 close by synchronism. Its activation indicates that there is permission, and depending on how the selector is set, it will be external or calculated synchronism.
SYNC2_R	Breaker 2 close by synchronism enabled (ZLV-G)	It is the signal that the recloser receives to monitor the breaker 2 close by synchronism. Its activation indicates that there is permission, and depending on how the selector is set, it will be external or calculated synchronism.
SYNC_ENBLD	Close synchronism enabled (ZLV-A/B/E/F/H)	Indication of enabled or disabled status of the unit.
SYNC1_ENBLD	Breaker 1 close synchronism enabled (ZLV-G)	Indication of enabled or disabled status of the unit.
SYNC2_ENBLD	Breaker 2 close synchronism 2 enabled (ZLV-G)	Indication of enabled or disabled status of the unit.
V_SIDE_A	Voltage on side A (ZLV-A/B/E/F/H)	It indicates presence of voltage on side A.
V_SIDE_A1	Voltage on side A breaker 1 (ZLV-G)	It indicates presence of voltage on side A of breaker 1.
V_SIDE_A2	Voltage on side A breaker 2 (ZLV-G)	It indicates presence of voltage on side A of breaker 2.

Table 3.22-13: Digital Outputs and Events of the Synchronism Module		
Name	**Name**	**Name**
V_SIDE_B	Voltage on side B (ZLV-A/B/E/F/H)	It indicates presence of voltage on side B.
V_SIDE_B1	Voltage on side B breaker 1 (ZLV-G)	It indicates presence of voltage on side B of breaker 1.
V_SIDE_B2	Voltage on side B breaker 2 (ZLV-G)	It indicates presence of voltage on side B of breaker 2.

CAUTION!

If, while the Permission (Enable) setting is YES, the four bits of the energization mask are set to NO, the voltage element is deactivated and, consequently, the synchronism unit. Therefore, if you want to disable the voltage element of sides A and B, set that element's Permission to NO and not the four bits of the energization mask.

3.22.15 Digital Outputs and Events of the Synchronism Modules (ZLV-J)

Table 3.22-14:Digital Outputs and Events of the Synchronism Modules (ZLV-J)		
Name	**Description**	**Function**
SYNC_Rn1	Breaker 1 Synchronism unit n (n=1, 2) Close Enable	The synchronism element n determines that there are global breaker 1 close conditions. (Internal or External synchronism). Element 1 signal is sent to the recloser for breaker 1 close synchronism check. Its activation implies authorization, and it will be external or calculated synchronism as a function of the selector setting.
SYNC_Rn2	Breaker 2 Synchronism unit n (n=1, 2) Close Enable	The synchronism element n determines that there are global breaker 2 close conditions. (Internal or External synchronism). Element 1 signal is sent to the recloser for breaker 2 close synchronism check. Its activation implies authorization, and it will be external or calculated synchronism as a function of the selector setting.
SYNC_CALC n1	Breaker 1 Synchronism unit n (n=1, 2) Activation	The synchronism 1 unit n determines that there are overall close conditions (internal synchronism).
SYNC_CALC n2	Breaker 2 Synchronism unit n (n=1, 2) Activation	The synchronism 2 unit n determines that there are overall close conditions (internal synchronism).
P_SYNC_DOn1	Breaker 1 Unit n (n=1, 2) Permission to close by phase difference	The synchronism 1 unit n determines that there are close conditions by the phase difference criterion.

Table 3.22-14: Digital Outputs and Events of the Synchronism Module		
Name	**Description**	**Function**
P_SYNC_DOn2	Breaker 2 Unit n (n=1, 2) Permission to close by phase difference	The synchronism 2 unit n determines that there are close conditions by the phase difference criterion.
P_SYNCn1_DF	Breaker 1 Unit n (n=1, 2) Permission to close by frequency difference	The synchronism 1 unit n determines that there are close conditions by the frequency difference criterion.
P_SYNCn2_DF	Breaker 2 Unit n (n=1, 2) Permission to close by frequency difference	The synchronism 2 unit n determines that there are close conditions by the frequency difference criterion.
P_SYNCn1_DV	Breaker 1 Unit n (n=1, 2) Permission to close by voltage difference	The synchronism 1 unit n determines that there are close conditions by the voltage difference criterion.
P_SYNCn2_DV	Breaker 2 Unit n (n=1, 2) Permission to close by voltage difference	The synchronism 2 unit n determines that there are close conditions by the voltage difference criterion.
P_SYNCn1_EL	Breaker 1 Unit n (n=1, 2) Permission to close by energization on the sides	The synchronism 1 unit n determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
P_SYNCn2_EL	Breaker 2 Unit n (n=1, 2) Permission to close by energization on the sides	The synchronism 2 unit n determines that there are close conditions by the criterion of presence/absence of voltages on sides A and B.
LIVELINE1	Voltage on side A of breaker 1	It indicates presence of voltage on side A of breaker 1.
DEADLINE1	No Voltage on side A of breaker 1	Indicates absence of voltage on side A of breaker 1.
LIVEBUS1	Voltage on side B of breaker 1	It indicates presence of voltage on side B of breaker 1.
DEADBUS1	No Voltage on side B of breaker 1	Indicates absence of voltage on side B of breaker 1.
LIVELINE2	Voltage on side A of breaker 2	It indicates presence of voltage on side A of breaker 2.
DEADLINE2	No Voltage on side A of breaker 2	Indicates absence of voltage on side A of breaker 2.
LIVEBUS2	Voltage on side B of breaker 2	It indicates presence of voltage on side B of breaker 2.
DEADBUS2	No Voltage on side B of breaker 2	Indicates absence of voltage on side B of breaker 2.

CAUTION!

If, while the Permission (Enable) setting is YES, the four bits of the energization mask are set to NO, the voltage element is deactivated and, consequently, the synchronism unit. Therefore, if you want to disable the voltage element of sides A and B, set that element's Permission to NO and not the four bits of the energization mask.

3.22.16 Synchronism Unit Test

To verify this unit, first the protection units are disabled. Then, the system is prepared to measure the time between the injection of the voltage and the activation of the Synchronism Unit. Lastly, the signals indicated in Table 3.22-15 are checked.

Table 3.22-15:Output Configuration

Logic signal	Description of logic signal
SINC_CALC	Activation of the synchronism unit
Side A Voltage	Voltage on side A detected
Side B Voltage	Voltage on side B detected

3.22.16.a Voltage Elements Test

Disable the Voltage Difference, Phase Difference and Frequency Difference elements. The Synchronism Unit is set as follows:

Synchronism enable	**YES**
Type of synchronism	**1: Internal**
Side B voltage	**1: VB**
Fuse failure synchronism blocking	**NO**
Side B voltage compensation factor (KLB)	**1**

Voltage Supervision Element

Enable	**YES**
Side A detection pickup	**25 V**
Side B detection pickup	**25 V**
Energization masks	
No voltage side A; No voltage side B	**NO**
No voltage side A; Voltage side B	**YES**
Voltage side A; No voltage side B	**YES**
Voltage side A; Voltage side B	**NO**

Voltage Difference Element

Enable	**YES**
Maximum voltage difference	**10%**

Phase Difference Element

Enable	**YES**
Maximum phase difference	**20º**

Frequency Difference Element

Enable	**YES / NO**
Maximum frequency difference	**0.20 Hz**
Synchronism output time delay	**0.00s**

Pickups

Three tests should be performed for each of the three different pickup settings.

Apply a voltage of 15 Vac with a phase angle of 0º to phase A, and apply 65 Vac with a phase angle of 0º to voltage side B (bus voltage). Synchronism Unit should activate.

Increase the voltage of phase A until the synchronism unit is deactivated. The voltage at which it is deactivated should be within the ranges shown in Table 3.22-16 for the corresponding pickup setting.

Table 3.22-16: Pickup and Reset of the Voltage Units

Pickup Setting (V)	Pickup Value (V)		Dropout Value (V)	
	Minimum	Maximum	Minimum	Maximum
25	24.25	25.75	23.04	24.46
45	43.65	46.35	41.47	44.03
60	58.20	61.80	55.29	58.71

The dropout should take place instantaneously within the ranges shown in Table 3.22-16, corresponding to the setting used.

3.22.16.b Voltage Difference Element Test

Enable the Voltage Difference element, and disable the Voltage, Phase Difference and Frequency Difference elements.

- **Pickup**

Three tests should be performed for each of the three different pickup settings.

A voltage of 30 Vac and phase 0º is applied to phase A and of 65 Vac and phase 0º to the voltage channel of side B. All the outputs must deactivate.

Increase the voltage of phase A until Synchronism element is activated and stable. The voltage where this activation occurs should be within the ranges shown in Table 3.22-17 for the corresponding pickup setting.

The dropout should take place instantaneously within the ranges shown in Table 3.22-17, corresponding to the setting used.

Table 3.22-17: Pickup and Reset of The Voltage Difference Unit				
Pickup Setting (p.u.)	**Pickup Value (V)**		**Dropout Value (V)**	
	Minimum	Maximum	Minimum	Maximum
10%	56.75	60.26	56.42	59.92
20%	50.44	53.56	49.81	52.89
30%	44.14	46.87	43.19	45.87

3.22.16.c Phase Difference Element Test

Enable the Phase Difference element, and disable the Voltage, Voltage Difference and Frequency Difference elements.

- **Pickup**

Three tests should be performed for each of the three different pickup settings.

Apply a voltage of 65 Vac with a phase angle of 50º to phase A, and apply 65 Vac with a phase angle of 0º to the voltage side B (bus voltage).

Reduce the angle of the voltage of phase A, until Synchronism element is activated and stable. The angle where this activation occurs should be within the ranges shown in Table 3.22-18 for the corresponding pickup setting.

The dropout should take place instantaneously within the ranges shown in Table 3.22-18, corresponding to the setting used.

Table 3.22-18: Pickup and Reset of The Phase Difference Unit				
Pickup Setting (º)	**Pickup Value (º)**		**Dropout Value (º)**	
	Minimum	Maximum	Minimum	Maximum
20	19	21	21	23
30	29	31	31	33
40	39	41	41	43

- **Breaker closing time compensation (ZLV-G/F/H relays)**

Set the phase angle difference element to 20º. Set to YES the **Breaker Closing Time Compensation Enable** setting. Set the **Breaker Closing Time** to 50 ms.

Inject VA=65 $_{0°}$ and VSINC=65 $_{30°}$, both at 50 Hz. Change VSINC voltage frequency to 51 Hz. Given the frequency difference between the voltages at both sides of the breaker, during its closing time, voltage VSINC, rotating faster than voltage VA, will have a shift of 18º

$$\frac{Tclosing(ms)}{1000} \cdot 360 \cdot \left(f_A - f_B\right)$$

where $T_{closing}$ is breaker closing time, f_A is VA frequency and f_B is VB frequency). Thus, check that the phase difference element picks up when VSINC lags 37º to 39º relative to VA and resets when VSINC leads 1º to 3º relative to VA.

3.22.16.d Frequency Difference Element Test

Enable the Frequency Difference element and disable the remaining elements.

- **Pickup**

Three tests should be performed for each of the pickup settings indicated in Table 3.22-19.

Apply a voltage of 65 Vac with a phase angle of 0º and a frequency of 53 Hz to phase A, and apply 65 Vac with a phase angle of 0º and a frequency of 50 Hz to voltage side B (bus voltage). All the outputs must deactivate.

Reduce the frequency of the voltage to phase A until Synchronism element is active and stable. The frequency where this occurs should be within the ranges shown in Table 3.22-19 for the corresponding pickup setting. The dropout should take place instantaneously within the ranges shown in Table 3.22-18, corresponding to the setting used.

Table 3.22-19: Pickup and Reset of the Frequency Difference Unit

Pickup Setting (Hz)	Pickup Difference (Hz)		Dropout Difference (Hz)	
	Minimum	Maximum	Minimum	Maximum
0.20	0.19	0.21	0.20	0.22
1.00	0.97	1.03	0.98	1.04
2.00	1.94	2.06	1.95	2.07

3.22.16.e Time Settings Test

Three tests should be performed for three different pickup settings (0.10s, 1s and 10s).

Prepare the system to measure the time between the application of voltage and the close of the contact of the Synchronism element.

Only the voltage difference unit is enabled between **Sides A** and **B**.

A voltage of 65 V and 0º is applied to phase A and to the voltage channel of side B. The synchronism unit must activate within the margin of ±1% of the setting or ±20ms.

The angle to add to the phase displacement between VA and VSINC is -1.8 º. Verify that the pick up of this element is at an angle of VSINC of 356.8 º.

Note: in the model ZLV-G, the B side voltage of the Synchronism Units of circuit breakers 1 and 2 will be VSINC and VSINC2 respectively.

3.22.17 Synchronism Units Test (ZLV-J)

To verify this unit, first the protection units are disabled. Then, the system is prepared to measure the time between the injection of the voltage and the activation of the Synchronism Unit. Lastly, the signals indicated in Table 3.22-20 are checked.

Table 3.22-20:Output Configuration

Logic signal	Description of logic signal
SYNC_CALC	Activation of the synchronism unit
Side A Voltage	Voltage on side A detected
Side B Voltage	Voltage on side B detected

3.22.17.a Voltage Elements Test

Disable the Voltage Difference, Phase Difference and Frequency Difference elements. The Synchronism Unit is set as follows:

VSINC Selection DI Supervision	**NO**
Breaker 1	
Type of Synchronism	**1: Internal**
Side A Voltage	**1: V_A**
Side B Voltage	**1: V_A**
Fuse Failure Synchronism Blocking	**NO**
Side B Voltage Compensation Factor (K_{LB})	**1**
Synchronism Enable (Unit 1)	**YES**

- **Voltage Supervision Elements**

Enable	**YES**
Live Line	**51 V**
Dead Line	**25 V**
Live Bus	**51 V**
Dead Bus	**25 V**
Energization Mask	
D BUS / D LINE	**NO**
H BUS / D LINE	**YES**
D BUS / H LINE	**YES**
H BUS / H LINE	**NO**

- **Voltage Difference Element**

Enable	**YES**
Maximum Voltage Difference	**10%**

- **Phase Difference Element**

Enable	**YES**
Maximum Phase Difference	**20º**

- **Frequency Difference Element**

Enable	**YES / NO**
Maximum Frequency Difference	**0.20Hz**
Synchronism Output Time Delay	**0.00s**

- **Pickups**

Three tests should be performed for each of the three different Line Dead pickup settings. Apply a voltage of 15 Vac with a phase angle of 0º to phase A (**Side A**), and apply 65 Vac with a phase angle of 0º to voltage channel Vsync1 (**Side B**). Synchronism Unit should activate.

Increase the voltage of phase A (**Side A**) until the synchronism unit is deactivated. The voltage at which it is deactivated should be within the ranges shown in Table 3.22-21 for the corresponding pickup setting.

Table 3.22-21:Pickup and Reset of the Voltage Units

Dead Line Setting (V)	Pickup Value (V)		Dropout Value (V)	
	Minimum	Maximum	Minimum	Maximum
25	24.25	25.75	23.04	24.46
45	43.65	46.35	41.47	44.03
60	58.20	61.80	55.29	58.71

The dropout should take place instantaneously within the ranges shown in Table 3.22-21, corresponding to the setting used.

3.22.17.b Voltage Difference Element Test

Enable the Voltage Difference element, and disable the Voltage, Phase Difference and Frequency Difference elements.

- **Pickup**

Three tests should be performed for each of the three different pickup settings.

A voltage of 30 Vac and phase 0º is applied to phase A (**Side A**) and of 65 Vac and phase 0º to the voltage channel Vsync1 (**Side B**). All the outputs must deactivate.

Increase the voltage of phase A (**Side A**) until Synchronism element is activated and stable. The voltage where this activation occurs should be within the ranges shown in Table 3.22-22 for the corresponding pickup setting.

The dropout should take place instantaneously within the ranges shown in Table 3.22-22, corresponding to the setting used.

Table 3.22-22:Pickup and Reset Of The Voltage Difference Unit

Pickup Setting (p.u.)	Pickup Value (V)		Dropout Value (V)	
	Minimum	Maximum	Minimum	Maximum
10%	56.75	60.26	56.42	59.92
20%	50.44	53.56	49.81	52.89
30%	44.14	46.87	43.19	45.87

3.22.17.c Phase Difference Element Test

Enable the Phase Difference element, and disable the Voltage, Voltage Difference and Frequency Difference elements.

- **Pickup**

Three tests should be performed for each of the three different pickup settings.

Apply a voltage of 65 Vac with a phase angle of 50º to phase A (**Side A**), and apply 65 Vac with a phase angle of 0º to the voltage channel Vsync1 (**Side B**).

Reduce the angle of the voltage of phase A, until Synchronism element is activated and stable. The angle where this activation occurs should be within the ranges shown in Table 3.22-23 for the corresponding pickup setting.

The dropout should take place instantaneously within the ranges shown in Table 3.22-23, corresponding to the setting used.

Table 3.22-23:Pickup and Reset of The Phase Difference Unit

Pickup Setting (º)	Pickup Value (º)		Dropout Value (º)	
	Minimum	Maximum	Minimum	Maximum
20	19	21	21	23
30	29	31	31	33
40	39	41	41	43

- **Breaker Closing Time Compensation**

Set the phase angle difference element to 20º. Set to YES the **Breaker Closing Time Compensation Enable** setting. Set the **Breaker Closing Time** to 50 ms.

Inject VA=65 $_{0º}$ and VSYNC1=65 $_{30º}$, both at 50 Hz. Change VSINC voltage frequency to 51 Hz. Given the frequency difference between the voltages at both sides of the breaker, during its closing time, voltage VSINC, rotating faster than voltage VA, will have a shift of 18º

$$\frac{Tclosing(ms)}{1000} \cdot 360 \cdot \left(f_A - f_B\right)$$

where $T_{closing}$ is breaker closing time, f_A is VA frequency and f_B is VB frequency). Thus, check that the phase difference element picks up when VSINC lags 37º to 39º relative to VA and resets when VSYNC1 leads 1º to 3º relative to VA.

3.22.17.d Frequency Difference Element Test

Enable the Frequency Difference element and disable the remaining elements.

- **Pickup**

Three tests should be performed for each of the three pickup settings.

Apply a voltage of 65 Vac with a phase angle of 0º and a frequency of 53 Hz to phase A, and apply 65 Vac with a phase angle of 0º and a frequency of 50 Hz to voltage channel Vsync1 (**Side B)**. All the outputs must deactivate.

Reduce the frequency of the voltage to phase A until Synchronism element is active and stable. The frequency where this occurs should be within the ranges shown in Table 3.22-24 for the corresponding pickup setting. The dropout should take place instantaneously within the ranges shown in Table 3.22-24, corresponding to the setting used.

Table 3.22-24: Pickup and Reset of the Frequency Difference Unit

Pickup Setting (Hz)	Pickup Difference (Hz)		Dropout Difference (Hz)	
	Minimum	Maximum	Minimum	Maximum
0.20	0.19	0.21	0.20	0.22
1.00	0.97	1.03	0.98	1.04
2.00	1.94	2.06	1.95	2.07

3.22.17.e Time Settings Test

Three tests should be performed for three different pickup settings (0.10s, 1s and 10s).

Prepare the system to measure the time between the application of voltage and the close of the contact of the Synchronism element.

Only the voltage difference unit is enabled between **Sides A** and **B**.

A voltage of 65 V and 0º is applied to phase A (**Side A**) and to the voltage channel Vsync1 (**Side B**). The synchronism unit must activate within the margin of ±1% of the setting or ±20ms.

The angle to add to the phase displacement between VA and VSYNC1 is -1.8 º. Verify that the pick up of this element is at an angle of VSYNC1 of 356.8 º.

ATTENTION: based on how the ZLV-J is configured for these tests, the side B voltage of breakers 1 and 2 synchronism check elements will be VSINC1 and VSINC2 respectively.

3.23 Current Measurement Supervision

3.23.1 Introduction

Models **ZLV-***-****A/B/C/D/E/F/G/H**** count on a supervision system for the set of elements that make up the phase current measurement system, from external current transformers, to copper cables that connect them to the relay, up to the internal magnetic modules on the **ZLV** relay itself.

3.23.2 Operation Principles

This supervision function is exclusively based on the measurement of phase currents. Measurement of the **three** phase currents is required for its application, otherwise it must be disabled.

Due to the unlikely simultaneous failure of more than one phase, a simple algorithm is used to enable the detection of failures in a single phase each time. Simultaneous failures are not detected.

When a phase current (phase **X**) below 2% of its rated value is detected, other phase currents are checked (phases **Y** and **Z**) to see if they exceed 5% and are below 120% of their rated value. The angular difference between these currents is also calculated, which, under normal operating conditions, must be within the 120º±10º range.

If "normal" operating conditions are detected in phases **Y** and **Z**, the phase **X** current circuit failure alarm is activated.

Figure 3.23.1 shows the supervision algorithm used for current measurement in phase A.

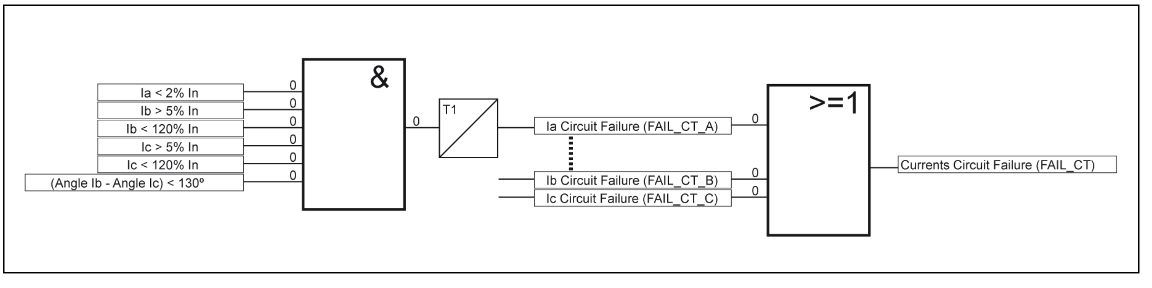


Figure 3.23.1: Supervision Algorithm for Current Measurement in Phase A.

Failure detection in any of the measuring circuits only generates the activation of the following signals: **FAIL_CT_A**, **FAIL_CT_B**, **FAIL_CT_C** and **FAIL_CT**. Blocking the operation of protection elements that are affected by measurement unbalance of phase currents must be programmed in ***ZIVerComPlus***® logic.

3.23.3 Current Measurement Supervision Settings

Current Measurement Supervision			
Setting	**Range**	**Step**	**By Default**
CT Supervision Enable	YES / NO		NO
CT Supervision Time	0.15 - 300 s		0.5 s

- **Current Measurement Supervision: HMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	…
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**13 - CT SUPERVISION**
3 - INFORMATION	**3 - PROTECTION**	…
	…	

0 - DISTANCE	
...	**0 - CT SUPERV ENABLE**
*** - CT SUPERVISION**	**1 - CT SUPERV TIME**
...	

(*) Option 11 or 12, depending on the model.

3.23.4 Digital Inputs of Current Measurement Supervision Module

<table>
<tr><th colspan="3">Table 3.23-1:Digital Inputs of the Current Measurement Supervision Module</th></tr>
<tr><th>Name</th><th>Description</th><th>Function</th></tr>
<tr><td>IN_ENBL_SUPCT</td><td>CT Supervision enable input</td><td rowspan="3">Activation of this input brings the element into operation. It can be assigned to a digital input by level or to a command from the communications protocol, or from the HMI: The default value for this logic input is “1”.</td></tr>
<tr><td>IN_ENBL_SUPCT1</td><td>CT 1 Supervision enable input (ZLV-G/J)</td></tr>
<tr><td>IN_ENBL_SUPCT2</td><td>CT2 Supervision enable input (ZLV-G/J)</td></tr>
<tr><td>IN_BLK_SUPCT</td><td>CT Supervision block input</td><td>Activation of this input generates the blocking of the supervision.</td></tr>
<tr><td>IN_BLK_SUPCT1</td><td>CT 1 Supervision block input (ZLV-G/J)</td><td></td></tr>
<tr><td>IN_BLK_SUPCT2</td><td>CT 2 Supervision block input (ZLV-G/J)</td><td></td></tr>
</table>

3.23.5 Auxiliary Outputs and Events of the Current Measurement Supervision Module

<table>
<tr><th colspan="3">Table 3.23-2:Auxiliary Outputs and Events of the Current Measurement Supervision Module</th></tr>
<tr><th>Name</th><th>Description</th><th>Function</th></tr>
<tr><td>FAIL_CT_A</td><td>Activation of CT Supervision Element for Phase A</td><td rowspan="12">Its activation indicates the existence of a failure in the measuring system of one of the phases.</td></tr>
<tr><td>FAIL_CT_B</td><td>Activation of CT Supervision Element for Phase B</td></tr>
<tr><td>FAIL_CT_C</td><td>Activation of CT Supervision Element for Phase C</td></tr>
<tr><td>FAIL_CT</td><td>Activation of CT Supervision Element</td></tr>
<tr><td>FAIL_CT_A1</td><td>Activation of CT 1 Supervision Element for Phase A</td></tr>
<tr><td>FAIL_CT_B1</td><td>Activation of CT 1 Supervision Element for Phase B</td></tr>
<tr><td>FAIL_CT_C1</td><td>Activation of CT 1 Supervision Element for Phase C</td></tr>
<tr><td>FAIL_CT1</td><td>Activation of CT 1 Supervision Element</td></tr>
<tr><td>FAIL_CT_A2</td><td>Activation of CT 2 Supervision Element for Phase A</td></tr>
<tr><td>FAIL_CT_B2</td><td>Activation of CT 2 Supervision Element for Phase B</td></tr>
<tr><td>FAIL_CT_C2</td><td>Activation of CT 2 Supervision Element for Phase C</td></tr>
<tr><td>FAIL_CT2</td><td>Activation of CT 2 Supervision Element</td></tr>
<tr><td>ENBL_SUPCT</td><td>Activation of CT Supervision enabled</td><td rowspan="3">Block output due to condition of fuse failure detected by the element in question.</td></tr>
<tr><td>ENBL_SUPCT1</td><td>Activation of CT 1 Supervision enabled (ZLV-G/J)</td></tr>
<tr><td>ENBL_SUPCT2</td><td>Activation of CT 2 Supervision enabled (ZLV-G/J)</td></tr>
<tr><td>EB_SUPCT</td><td>Activation of CT Supervision block Input</td><td rowspan="3">Block output due to condition of fuse failure (either detected by the element itself, or else by digital input).</td></tr>
<tr><td>EB_SUPCT1</td><td>Activation of CT 1 Supervision block Input</td></tr>
<tr><td>EB_SUPCT2</td><td>Activation of CT 2 Supervision block Input</td></tr>
</table>

3.24 Pole Discordance Detector

3.24.1 Operating Principles

This unit is for the purpose of detecting a discordance in the position of the three breaker poles. If this condition is maintained during the **T_PD** (**Discordance Time**) time setting, the **TRIP_PD** (**Pole Discordance Detector Trip**) trip signal is generated. Given that the single-phase reclose cycles will produce a pole discordance condition, the **T_PD** time setting should be longer than the single-phase reclose time.

Figure 3.24.1 shows the operation diagram of the Pole Discordance Detector.

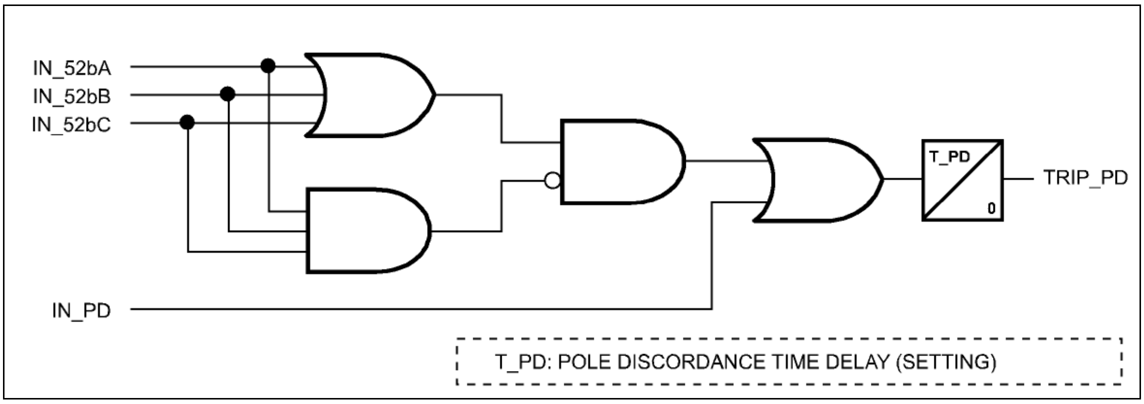


Figure 3.24.1: Diagram of the Pole Discordance Detector.

It will be possible to detect the existence of pole discordance from the status of the three digital inputs associated with the status of the three poles of the breaker (activated if the corresponding pole is open). Notwithstanding, many breakers incorporate a wiring logic in their control cabinets, which detects the pole discordance (based on the status of the **52aA/B/C** and **52bA/B/C** contacts), generating a signal in this case. For this reason, the **ZLV** IED incorporates a digital input, **IN_PD**, to receive this signal, which will directly activate the **TRIP_PD** output.

3.24.2 ZLV-G/J Models Pole Discordance

For applications in breaker and a half and ring substations, **ZLV-G/J** relays incorporate two pole discordance elements, designated element 1 and element 2, respectively, to supervise the breakers 1 and 2, respectively.

Each element discerns a discordance situation on one pole open, two poles open or any pole open, including separate timers for each situation. The pole discordance logic n (n=1,2) is shown below.

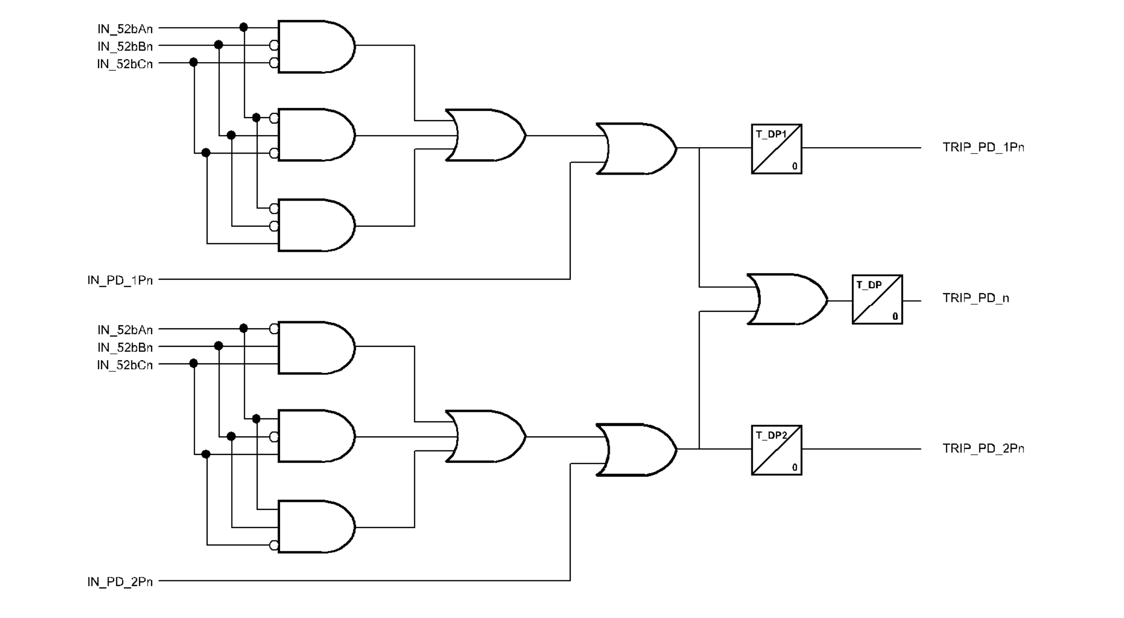


Figure 3.24.2: ZLV-G/J Relay Pole Discordance Detector Diagram.

The single/three phase trip logic (see paragraph 3.24) uses the **TRIP_PDn** (**Breaker n any Pole Open Discordance Trip**) signal; however, **ZLV-G/J** relays Logic is provided with a programmable trip input, which can be assigned through the programmable logic to any of the signals **TRIP_PD_1Pn** (**Breaker n Single Pole Open Discordance Trip**) or **TRIP_PD_2Pn** (**Breaker n Two Poles Open Discordance Trip**) in order to produce, based on them, a three-phase trip.

3.24.3 Pole Discordance Detector Settings

Pole Discordance Detector			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		NO
Poles Discordance Time delay (ZLV-A/B/E/F/H)	0 - 50 s	0.01 s	2 s
Single Pole Open Discordance Time delay (ZLV-G/J)	0 - 50 s	0.01 s	2 s
Two Pole Open Discordance Time delay (ZLV-G/J)	0 - 50 s	0.01 s	2 s
Any Pole Open Discordance Time delay (ZLV-G/J)	0 - 50 s	0.01 s	2 s

- **Pole Discordance Detector: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**18 - POLE DISCREPANCY**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - POLE DISCR ENABLE**
...	**1 - POLE DISCREP. DELAY**
18 - POLE DISCREPANCY	
...	

ZLV-F/H

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**19 - POLE DISCREPANCY**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - POLE DISCR ENABLE**
...	**1 - POLE DISCREP. DELAY**
19 - POLE DISCREPANCY	
...	

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**19 - POLE DISCREPANCY**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - BREAKER 1**	**0 - POLE DISCR ENABLE**
...	**1 - BREAKER 2**	**1 - TIME 1 POLE OPEN**
19 - POLE DISCREPANCY		**2 - TIME 2 POLE OPEN**
...		**3 - TIME ANY POLE OPEN**

3.24.4 Digital Inputs and Events of the Pole Discordance Detector

Table 3.24-1: Digital Inputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
ENBL_PD	Pole discordance detector enable input (ZLV-A/B/E/F/H)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_PD1	Pole discordance detector enable input breaker 1 (ZLV-G/J)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
ENBL_PD2	Pole discordance detector enable input breaker 2 (ZLV-G/J)	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signal is a "1."
IN_52bA	Open A pole position input (ZLV-A/B/E/F/H)	Activation of this input indicates that the 52b contact of A pole position of the breaker is closed.
IN_52bB	Open B pole position input (ZLV-A/B/E/F/H)	Activation of this input indicates that the 52b contact of B pole position of the breaker is closed.
IN_52bC	Open C pole position input (ZLV-A/B/E/F/H)	Activation of this input indicates that the 52b contact of C pole position of the breaker is closed.
IN_52bA1	Open A pole position input breaker 1 (ZLV-G/J)	Activation of this input indicates that the 52b contact of A pole position of the breaker 1 is closed.
IN_52bB1	Open B pole position input breaker 1 (ZLV-G/J)	Activation of this input indicates that the 52b contact of B pole position of the breaker 1 is closed.
IN_52bC1	Open C pole position input breaker 1 (ZLV-G/J)	Activation of this input indicates that the 52b contact of C pole position of the breaker 1 is closed.

Table 3.24-1: Digital Inputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
IN_52bA2	Open A pole position input breaker 2 (ZLV-G/J)	Activation of this input indicates that the 52b contact of A pole position of the breaker 2 is closed.
IN_52bB2	Open B pole position input breaker 2 (ZLV-G/J)	Activation of this input indicates that the 52b contact of B pole position of the breaker 2 is closed.
IN_52bC2	Open C pole position input breaker 2 (ZLV-G/J)	Activation of this input indicates that the 52b contact of C pole position of the breaker 2 is closed.
IN_PD	Pole discordance detector input (ZLV-A/B/E/F/H)	Activation of this input directly generates the startup of the timer associated with the pole discordance detector.
IN_PD_1P1	Single open pole discordance detector input breaker 1 (ZLV-G/J)	Activation of this input directly generates the startup of the timer associated with the breaker 1 single open pole discordance detector.
IN_PD_1P2	Single open pole discordance detector input breaker 2 (ZLV-G/J)	Activation of this input directly generates the startup of the timer associated with the breaker 2 single open pole discordance detector.
IN_PD_2P1	Two open poles discordance detector input breaker 1 (ZLV-G/J)	Activation of this input directly generates the startup of the timer associated with the breaker 1 two open poles discordance detector.
IN_PD_2P2	Two open poles discordance detector input breaker 2 (ZLV-G/J)	Activation of this input directly generates the startup of the timer associated with the breaker 2 two open poles discordance detector.

3.24.5 Digital Outputs and Events of the Pole Discordance Detector

Table 3.24-2: Digital Outputs and Events of the Pole Discordance Detector		
Name	**Description**	**Function**
TRIP_PD	Pole discordance detector trip (ZLV-A/B/E/F/H)	Trip of the unit.
TRIP_PD1	Pole discordance detector trip breaker 1 (ZLV-G/J)	Trip of the unit.
TRIP_PD2	Pole discordance detector trip breaker 2 (ZLV-G/J)	Trip of the unit.
TRIP_PD_1P1	Single pole open discordance detector trip breaker 1 (ZLV-G/J)	Trip of the unit by a single pole open.
TRIP_PD_1P2	Single pole open discordance detector trip breaker 2 (ZLV-G/J)	Trip of the unit by a single pole open.
TRIP_PD_2P1	Two poles open discordance detector trip breaker 1 (ZLV-G/J)	Trip of the unit by two poles open.
TRIP_PD_2P2	Two poles open discordance detector trip breaker 2 (ZLV-G/J)	Trip of the unit by two poles open.
PD_ENBLD	Pole discordance detector enabled (ZLV-A/B/E/F/H)	Indication of enabled or disabled status of the unit.
PD1_ENBLD	Pole discordance detector enabled breaker 1 (ZLV-G/J)	Indication of enabled or disabled status of the unit.
PD2_ENBLD	Pole discordance detector enabled breaker 2 (ZLV-G/J)	Indication of enabled or disabled status of the unit.

3.24.6 Pole Discordance Detector Test

The following indicators will be monitored during the test:

In the display on the **Information** - **Status** - **Measuring elements** - **Pole Discordance** screen, or on the status screen of the ***ZIVercomPlus***® (**Status** - **Elements** - **Pole Discordance**).

- **ZLV-A/B/E/F/H Models**

The pole discordance element will be enabled and the remaining elements disabled.

Adjust the timing to 10 s.

Activate the **Open A Pole Position** input, without the **Open B Pole Position** and **Open C Pole Position** inputs being active. Verify that a three-phase trip due to pole discordance is produced after 10 s.

Repeat the test with the **Open A Pole Position** and **Open B Pole Position** inputs active without the **Open C Pole Position** input active. Verify that a three-phase trip due to pole discordance is produced after 10 s.

Activate the **Pole Discordance** input and verify that a three-phase trip due to pole discordance is produced after 10 s.

- **ZLV-G/J Models**

ZLV-G/J relays incorporate two pole discordance elements. Below are described the tests to be carried out on element 1:

Single Pole Open Discordance Test

Activate the **Breaker 1 pole A open state** input. Check that **Breaker 1 single pole open discordance trip** and **Breaker 1 pole discordance trip** signals activate after the proper time delays.

Check the activation of the above signals after the proper time delay when **Breaker 1 pole B open state** and **Breaker 1 pole C open state** inputs are activated separately**.**

Activate **Breaker 1 single pole open discordance input.** Check the above signals activate after the proper time delay.

Two Pole Open Discordance Test

Activate the **Breaker 1 pole A open state** and **Breaker 1 pole B open state** inputs**.** Check that **Breaker 1 two pole open discordance trip** and **Breaker 1 pole discordance trip** signals activate after the proper time delays.

Activate **Breaker 1 pole B open state** and **Breaker 1 pole C open state** inputs**.** Check the above signals activate after the proper time delay.

Activate **Breaker 1 pole C open state** and **Breaker 1 pole A open state** inputs**.** Check the above signals activate after the proper time delay.

Activate **Breaker 1 two pole open discordance input.** Check the above signals activate after the proper time delay.

3.25 Single / Three-Phase Tripping Logic

3.25.1 Single / Three-Phase Tripping Logic. Model ZLV-B/F/G/J

ZLV-B/F/G/J terminal units are provided with a single- or three-phase Tripping Logic. Trip commands are generated for phase A, B, and C according to activation of protection elements, blocking status contact inputs, element masks, recloser status, etc. The Tripping Logic comprises the following sub-logics:

1. **Trip Command Generation Logic**, in charge of processing the activation of the different protection elements responsible for trips to generate a general trip command.
2. **Three-Phase Trip Logic**, in charge of indicating to the phase trip logic if the trip must be a three-phase trip.
3. **Phase Trip Logic**, in charge of generating independent tripping signals for phases A, B, and C (outputs **TRIP_A**, **TRIP_B** and **TRIP_C**), which will be used by the command module (see 3.26) to generate the open outputs of each pole.

The block diagram of Figure 3.25.8 shows the complete Single / Three-Phase Tripping Logic.

3.25.2 Trip Logic. Models ZLV-A/E/H

The **ZLV-A/E/H** IEDs are provided with a tripping logic which generates a breaker trip signal according to the activation of the protection units, blocking digital inputs, actuation masks of the units, recloser status, etc. Consequently, it is in charge of the trip generation. The Tripping Logic comprises the following sub-logics:

1. **Trip Command Generation Logic**, in charge of processing the activation of the different protection elements responsible for trips to generate a general trip command.
2. **Three-Phase Trip Logic**, in charge of generating the tripping output, which will be used by the command module to generate the open command.

3.25.3 Trip Command Generation Logic

This logic generates a trip command according to activation of the protection elements. The settings to enable or the elements involved are (depending on model):

- Distance Elements.
- Protection Schemes (Distance and Overcurrent).
- Auxiliary Units:
  - Close-Onto-Fault Detector.
  - Power-Swing Detector (power-swing trip enabled).
  - Remote Breaker Open Detector.
  - Phase Instantaneous Overcurrent Elements.
  - Ground Instantaneous Overcurrent Elements.
  - Negative Sequence Instantaneous Overcurrent Elements.
  - Phase Time Overcurrent Elements.
  - Ground Time Overcurrent Elements.
  - Negative Sequence Time Overcurrent Elements.
  - Stub Bus Protection.
  - Thermal Image Protection.
  - Open Phase Detector.
  - Phase Undervoltage Elements.
  - Phase Overvoltage Elements.
  - Ground Overvoltage Elements.
  - Underfrequency Elements.
  - Overfrequency Elements.
  - Rate Of Change Elements.
  - Pole Discordance Detector.
  - Programmable Trip.
  - External Trip (**ZLV-***-****A/B/C/D/E/F/G/H**** Models).

Enabling the **Step Distance** scheme (signal **TRIP_STP**) activates the protection elements for ground fault and phase-to-phase faults in Zones 1, 2, 3, 4, 5 and 6. The **Zone Trip Mask** setting (see 3.2.2 Step Distance) allows the user to independently enable or disable tripping by each of these elements.

Distance trips (by step or by channel) can be blocked by using the Status Contact Input **Distance Protection Blocking** (**INBLK_DIST**), which presents an adjustable reset time (**Distance Blocking Time**).

Trips by auxiliary units and trips by ground and phase elements for Zones 1 to 6 can be independently enabled or disabled in the **Auxiliary Units Mask** setting. Setting any of these elements to **0** (disabled) will disable the element from tripping.

The trips due to the protection scheme, either Distance or Overcurrent (**TRIP_SCHM_D** and **TRIP_SCHM_OC** signals, respectively) are non-maskable, for which if it is not wanted to produce these trips, the distance and overcurrent protection schemes should be adjusted as **Step Distance** and **None**, respectively.

CAUTION!

Given that the setting of the Auxiliary Unit Mask allows to inhibit the trip by the auxiliary units (not distance), if it is required that any of these produce a trip, it should be ensured that this setting has an unmasked measuring unit. Otherwise, the protection will be unable to trip units other than distance.

As shown in Figures 3.25.8 and 3.25.9, the Trip Command will be generated if any of the following occurs:

1. A trip by Step Distance (**TRIP_STP**) or by Distance Protection Scheme (**TRIP_SCHM_D**) not blocked by digital input (**INBLK_DIST**).
2. A trip by an Overcurrent Protection Scheme (**TRIP_SCHM_OC**).
3. A trip of any of the auxiliary units.
4. Activation of **Programmable Trip** (**INPROGTRIP**).
5. In **ZLV-***-****A/B/C/D/E/F/G/H**** relays**,** the activation of the input **Three-Phase External Trip (IN_EXT_3PH)** or the inputs **Pole A External Trip (IN_EXT_A)**, **Pole B External Trip B (IN_EXT_B)** and **Pole C External Trip (IN_EXT_C)**.
6. In **ZLV-A/B** Models, the prior existence of a trip.

In addition, the **Trip Blocking** (**INBLK_TRIP**) digital input should not be activated and the **Fault Detector** (**FD**) should be activated, provided that there are no conditions of power swing and the trip does not originate from Voltage, Frequency, Thermal Image, Pole Discordance and Power Swing Detector (trip by power swing: **TRIP_PS**), or due to Weak Infeed Logic (either distance or overcurrent) or **Programmable trip** input or **External Three-Phase Trip** input **(IN_EXT_3PH)**. In **ZLV-F/G/J** relays, it must also be taken into account that the activation of **Three-phase Trip Preparation Block** input (**INBLK_3PHPREP)** will disable any three-phase-only trip (see conditions in following paragraph).

Also, trip blocking inputs for each pole (**INBLK_TRIP_A**, **INBLK_TRIP_B**, **INBLK_TRIP_C**) will cancel the trip of the corresponding pole, except if the trip is produced through the inputs **Pole A External Trip (IN_EXT_A), Pole B External Trip (IN_EXT_B)** and **Pole C External Trip (IN_EXT_C)**. Trip blocking inputs per pole are applied to enable single phase trips by two-phase elements on “cross-country” faults (see section 3.1.7.a, Operation of single phase elements).

3.25.4 Three-Phase Trip Logic. Models ZLV-B/F/G/J

The Three-Phase Trip Logic function detects if the trip generated by the previous logic will be a three-phase trip. In the case of a three-phase trip, the logic will generate the **Three-Phase Trip Ready** signal (**3PH_PREP**).

Whenever the detected fault is a fault between phases (two or three phases, signals **PU_ZIPH**, **PU_ZIIPH**, **PU_ZIIIPH**, **PU_ZIVPH, PU_ZVPH** and **PU_ZVIPH**), the trip will be a three-phase trip. Also, there are a series of conditions where a three-phase trip will be generated independent of the fault detected. These conditions are:

1. The **Three-Phase Trip** setting is set to **YES**.
2. The status contact input **Three-Phase Trip Enable** is activated (signal **3POL_OPEN**).
3. If the Recloser is in **Blocking Command** (**RCLS_CMD_LO** signal activated) or in **Internal Blocking** (**RCLS_LO** signal activated).
4. The Recloser is set to three-phase mode (**3P Mode**).
5. The **Recloser Sequence** is activated (signal **RECLOSING**). (Therefore, a three-phase trip will always follow any reclosing operation.)
6. If Zone 2, 3, 4, 5 or 6 is activated, that is, if in the Step Distance scheme the **Fault in Zone 2** (**Z_II**), **Fault in Zone 3** (**Z_III**), **Fault in Zone 4** (**Z_IV**), **Fault in Zone 5** (**Z_V**) or **Fault in Zone 6** (**Z_VI**) outputs are activated, as long as **Zone 2 Three-Phase Trip Blocking** (**INBLK_3PH_ZII**), **Zone 3 Three-Phase Trip Blocking** (**INBLK_3PH_ZIII**), **Zone 4 Three-Phase Trip Blocking** (**INBLK_3PH_ZIV**), **Zone 5 Three-Phase Trip Blocking** (**INBLK_3PH_ZV**) or **Zone 6 Three-Phase Trip Blocking** (**INBLK_3PH_ZVI**) outputs remain deactivated, respectively.
7. If the trip of any of the auxiliary units is produced, except in case of unit 1 of ground or negative sequence overcurrent and the **Single-Phase Trip 67G** (**1P_67G_ON**) setting is at **YES** and the fault is single phase (**AG_F**, **BG_F** and **CG_F**).
8. If the **Programmable Trip** (**INPROGTRIP**) input has been activated.
9. If the input **Three-Phase External Trip (IN_EXT_3PH)** has been activated in **ZLV-***-****A/B/C/D/E/F/G/H**** relays.
10. If at least two breaker poles have tripped (**3PH_PREP_TRIP** signal).
11. If the phase selector indicates two-phase to ground fault and the two single-phase units associated with this fault are picked up (**PREP_3PH_PH-PH-G** signal).

In **ZLV-F/G/J** relays, no matter the above conditions, activating the **Three-phase Trip Preparation Block** input (**INBLK_3PHPREP)** disables all three-phase trip preparations.

Under any of the above conditions, the trip will be three-phase, even if a single-phase fault is detected. Consequently, single-phase trips can only occur when the following trip:

1. **Zone 1** units and the fault is single phase (**AG_F**, **BG_F** and **CG_F**).
2. The distance protection scheme in operation, with the fault also being single phase (**AG_F**, **BG_F** and **CG_F** outputs or **TRIP_WI_D_A**, **TRIP_WI_D_B** and **TRIP_WI_D_C** outputs), provided this is carried out prior to the timing of the units of Zone 2 and none of the above conditions are fulfilled.
3. **Unit 1** of **Ground** or **Negative Sequence Overcurrent** provided that the **Single-Phase Trip 67G** (**1P_67G_ON**) setting is set at **YES** and the fault is single phase (**AG**, **BG** and **CG**).
4. The overcurrent protection scheme is in operation, with the fault also being single phase (**AG_F**, **BG_F** and **CG_F** outputs or **TRIP_WI_I_A**, **TRIP_WI_I_B** and **TRIP_WI_I_C** outputs), provided this is carried out prior to the timing of unit 2 of ground or negative sequence overcurrent.
5. In **ZLV-F/G/J** relays, when zone 1 to 6 distance elements, ground overcurrent or negative sequence element 1 pickup or **Overreach Element Pickup** input is activated, provided it is a single-phase fault and **Three-phase Trip Preparation Block** input (**INBLK_3PHPREP)** activates or **pole trip block** inputs (**INBLK_TRIP_A, INBLK_TRIP_B, INBLK_TRIP_C)** associated to unfaulted phases activate**.** In this way, single-phase time delayed trips would be allowed.
6. In **ZLV-***-****A/B/C/D/E/F/G/H**** relays when only one of the inputs **Pole A External Trip (IN_EXT_A)**, **Pole B External Trip (IN_EXT_B)** or **Pole C External Trip (IN_EXT_C)** has been activated.

All provided that the above-mentioned **Three-Phase Trip Ready** signal has not been activated, except for the case of external trip inputs per pole **(IN_EXT_A, IN_EXT_B** and **IN_EXT_C)**.

3.25.5 Trip Logic Operation

3.25.5.a Phase Trip Logic. Models ZLV-B/F/G/J

The phase trip logic function generates the independent trip command for each of the phases (signals **TRIP_A**, **TRIP_B** and **TRIP_C**), the **Trip** signal (**TRIP**) and the **Three-Phase Trip** signal (**TRIP_3PH**). To generate these signals, the logic uses the **Trip Command** signal and the **Three-Phase Trip Ready** signal (**3PH_PREP**), described in the previous sections.

The tripping logic of the poles is formed of three single-phase sub-logics corresponding to phases A, B and C. The trip command is common to the three logics. However, in case that three-phase trip conditions present themselves (for example, if the recloser is blocked), on activating the **3PH_PREP** signal, the trip is produced in the three phases even though the single-phase sub-logics indicate otherwise. On the other side, in **ZLV-F/G/J** relays, pole trips can be disabled by means of **INBLK_TRIP_A**, **INBLK_TRIP_B**, **INBLK_TRIP_C** inputs.

It is worth noting that external trip inputs per pole **(IN_EXT_A, IN_EXT_B** and **IN_EXT_C)** do not depend on any intermediate logic. Their operation translates into tripping only the pole involved, regardless of the status of the signal **3PH_PREP** and the signals **INBLK_TRIP_A**, **INBLK_TRIP_B**, **INBLK_TRIP_C.**

Once the trip generating signals are deactivated, the trip contacts remain latched until:

1. The current in the tripped phase is zero (for single-phase trips), therefore the corresponding forward-looking supervision element is deactivated, and
2. The fault detector is deactivated or the logic input signal **Trip Blocking** (**INBLK_TRIP**) is activated.
3. In **ZLV-F/G/J** relays, the applicable pole trip block input is activated.

When the trip is produced by one of the external trip inputs per pole **(IN_EXT_A, IN_EXT_B** and **IN_EXT_C)**, it will be released when the corresponding input is deactivated.

3.25.5.b Tripping Logic of the Breaker. Models ZLV-A/E/H

The function of this logic is to generate the direct trip (**TRIP**) output.

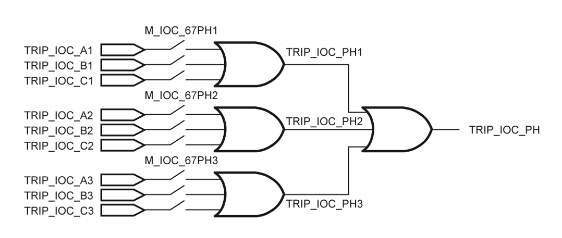


Figure 3.25.1: Activation Logic of Phase Instantaneous Overcurrent Units for Tripping Logic.

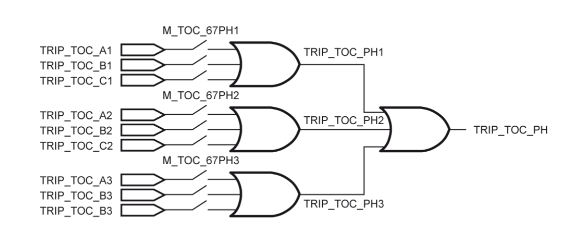


Figure 3.25.2: Activation Logic of Phase Time Overcurrent Units for Tripping Logic.

Legend
M_IOC_67PH(1/2/3): Phase IOC Unit (1/2/3) Trip Mask.
M_TOC_67PH(1/2/3): Phase TOC Unit (1/2/3) Trip Mask

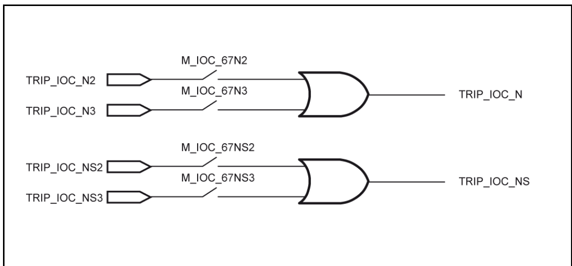


Figure 3.25.3: Activation Logic of Ground and Negative Sequence Instantaneous Overcurrent Units for Tripping Logic.

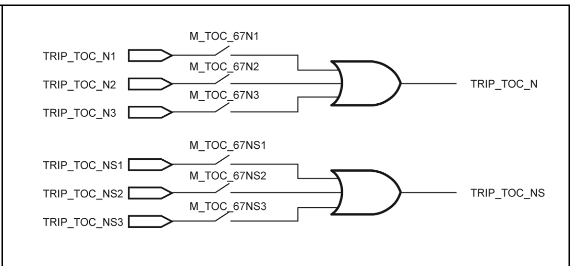


Figure 3.25.4: Activation Logic of Ground and Negative Sequence Time Overcurrent Units for Tripping Logic.

Legend
M_IOC_67N(2/3): Ground IOC Unit (2/3) Trip Mask.
M_IOC_67NS(2/3): Negative Sequence IOC Unit (2/3) Trip Mask.
M_TOC_67N(1/2/3): Ground TOC Unit (1/2/3) Trip Mask.
M_TOC_67NS(1/2/3): Negative Sequence TOC Unit (1/2/3) Trip Mask.

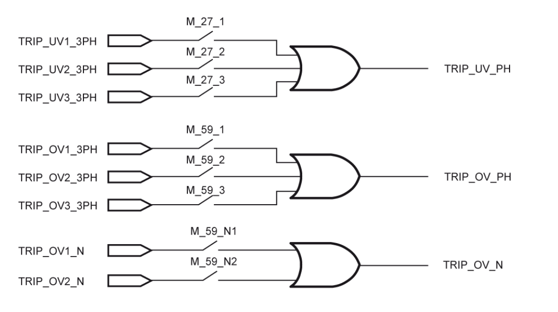


Figure 3.25.5: Activation Logic of Voltage Units for Tripping Logic.

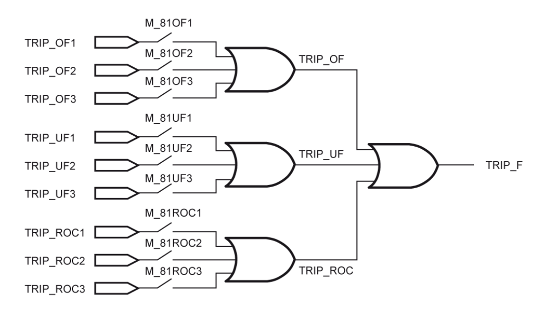


Figure 3.25.6: Activation Logic of Frequency Units for Tripping Logic.

Legend
M_27_(1/2/3): Phase Undervoltage Unit (1/2/3) Trip Mask.
M_59_(1/2/3): Phase Overvoltage Unit (1/2/3) Trip Mask.
M_59_N(1/2): Ground Overvoltage Unit (1/2) Trip Mask.
M_81OF(1/2/3): Overfrequency Unit (1/2/3) Trip Mask.
M_81UF(1/2/3): Underfrequency Unit (1/2/3) Trip Mask.
M_81ROC(1/2/3): Frequency Rate of Change Unit (1/2/3) Trip Mask.

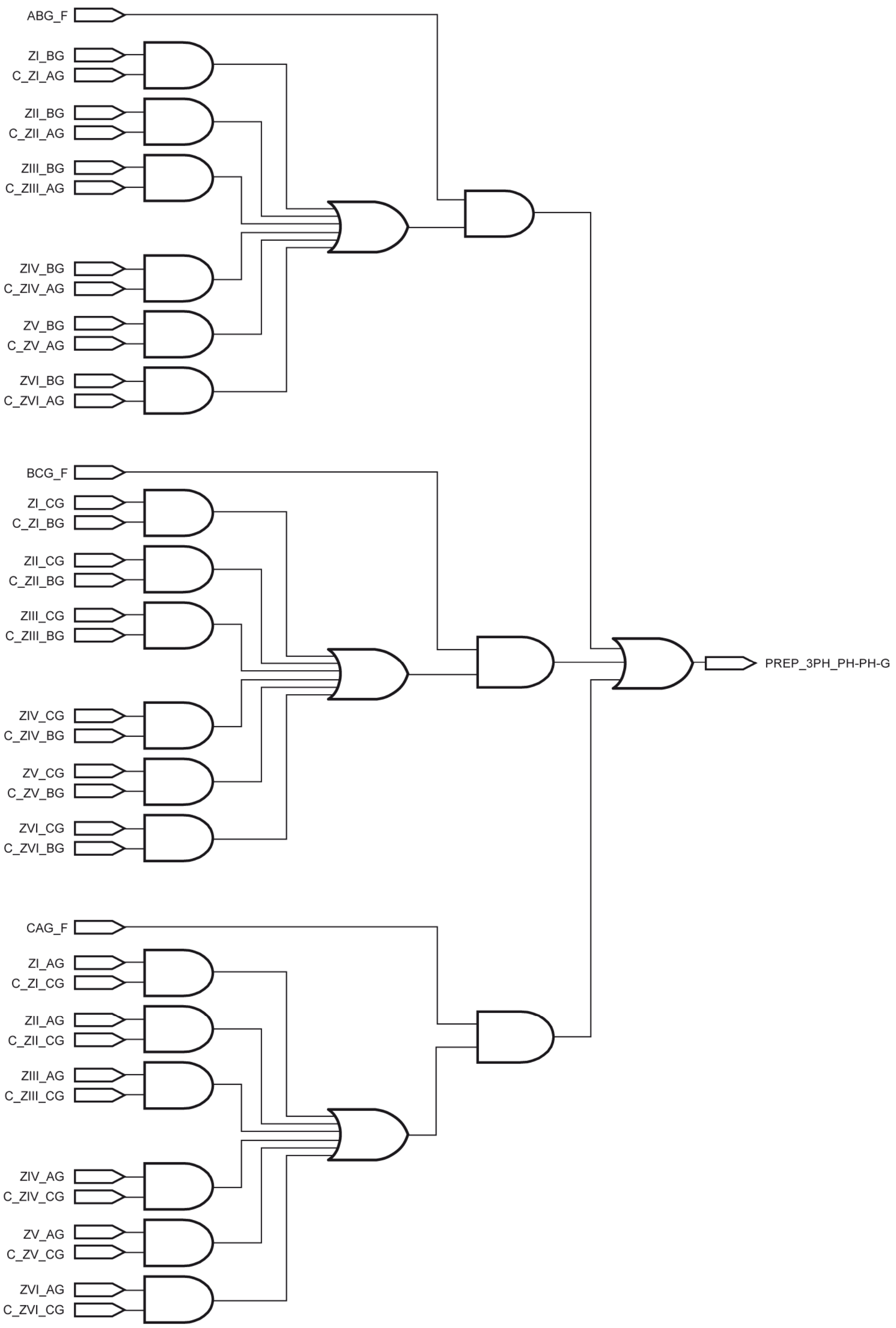


Figure 3.25.7:Generation Logic of the Three-Phase Trip Ready Signal in Case of a Two-Phase Fault to Ground (Model ZLV-B/F/G/J).

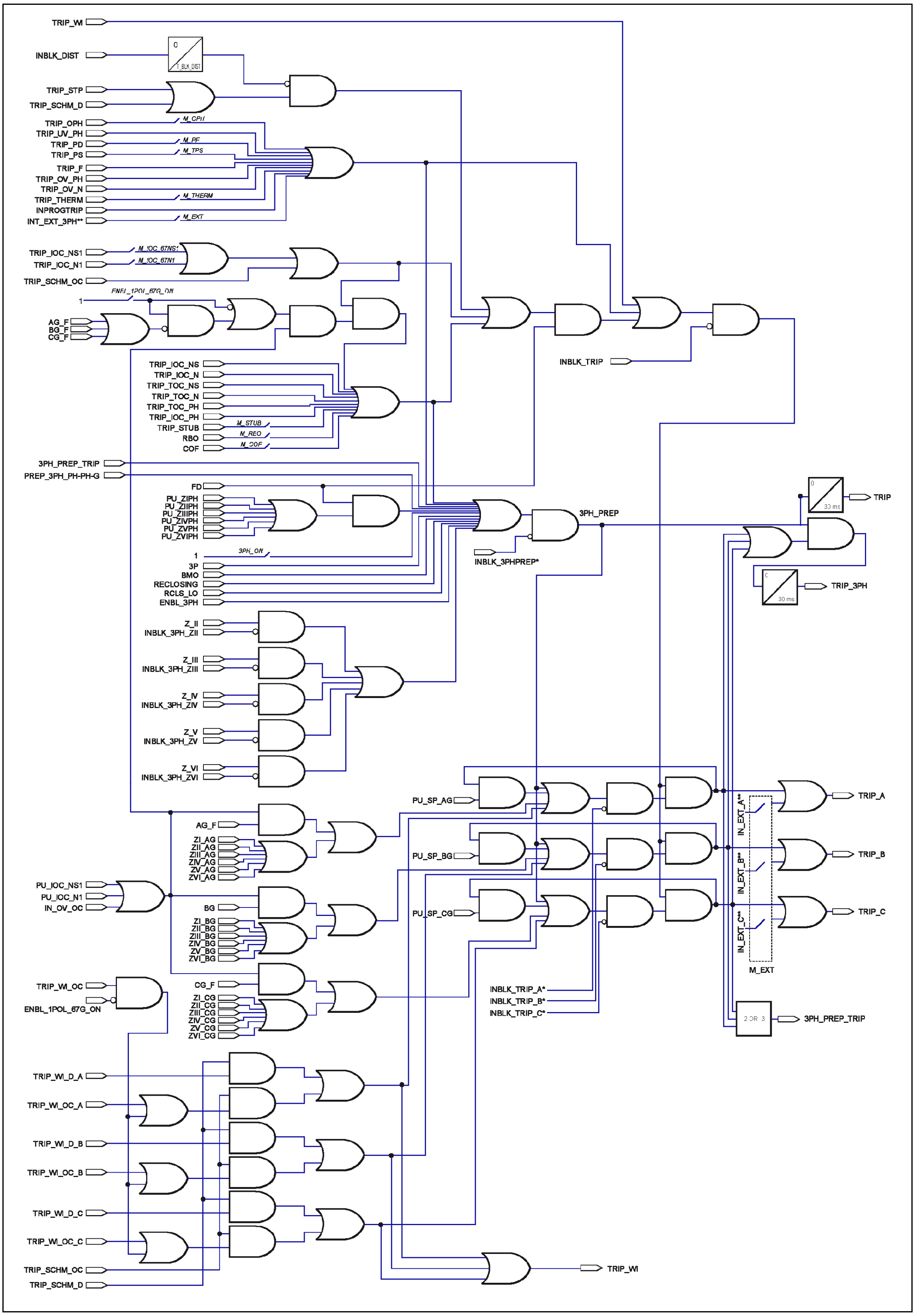


Figure 3.25.8: Block Diagram of the Single-Three-Phase Trip Logic (Model ZLV-B/F/G/J).

Legend
T_BLK_DIST: Distance Blocking Input Reset Time Delay (setting).
M_OPH: Open Phase Element Trip Mask (setting).
M_PF: Pole Discordance Element Trip Mask (setting).
M_TPS: Power Swing Element Trip Mask (setting).
M_THERM: Thermal Image Element Trip Mask (setting).
M_IOC_67NS1: Negative Sequence IOC Element 1 Trip Mask (setting).
M_IOC_67N1: Ground IOC Element 1 Trip Mask.
ENBL_1POL_67G_ON: Ground Overcurrent Single-Phase Trip Enable (setting).
M_STUB: Stub Bus Element Trip Mask (setting).
M_RBO: Remote Breaker Open Element Trip Mask (setting).
M_COF: Close-onto-Fault Element Trip Mask (setting).
M_EXT: Mask for External Trip (setting). ZLV-*******A/B/C/D/E* Models.
MR=3POL: Recloser 3-P Mode (setting).

(*) Only ZLV-F/G/J Models.
(**) Only ZLV-*-****A/B/C/D/E/F/G/H** Models.**

In **ZLV-A/B** relays, the **IN_OV_OC** signal (**Overreach Element Pickup Input**) will be an OR of **PU_IOC_N2** (**Ground Instantaneous Element 2 Pickup**) and **PU_IOC_NS2** (**Negative Sequence Instantaneous Element 2 Pickup**) signals

In **ZLV-G/J** relays:

- Signal **TRIP_PD** will be an OR of **TRIP_PD1** and **TRIP_PD2** signals.
- Signal **RECLOSING** will be an OR of the signals **RECLOSING1** and **RECLOSING2**.
- Signal RCLS_LO will follow the logic included in figure 3.25.9.
- Signal BMO will follow the logic included in figure 3.25.10.

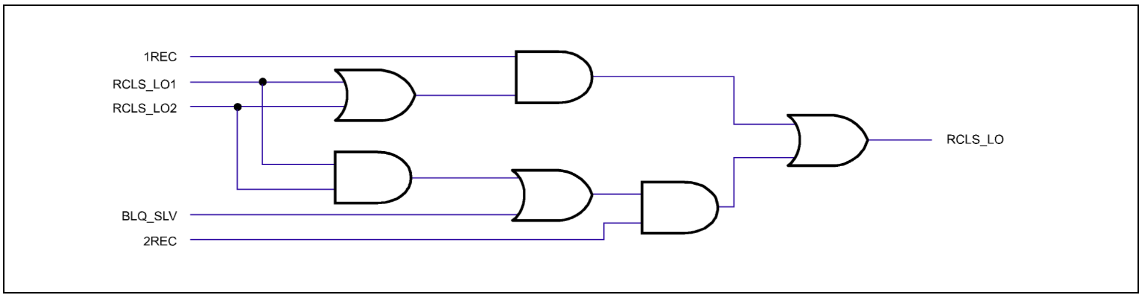


Figure 3.25.9: Logic of Recloser Internal Block Signal Generation (ZLV-G/J).

Legend	
1REC: 1 1 Recloser in Operation.	BLK_SLV: Slave Recloser Lockout.
RCLS_LO: Recloser Lockout.	2REC: 2 Reclosers in Operation.

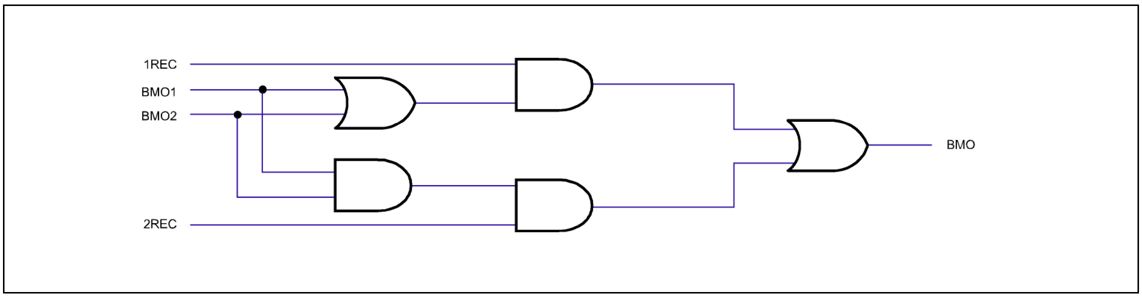


Figure 3.25.10:Logic of Recloser Command Block Signal Generation (ZLV-G/J).

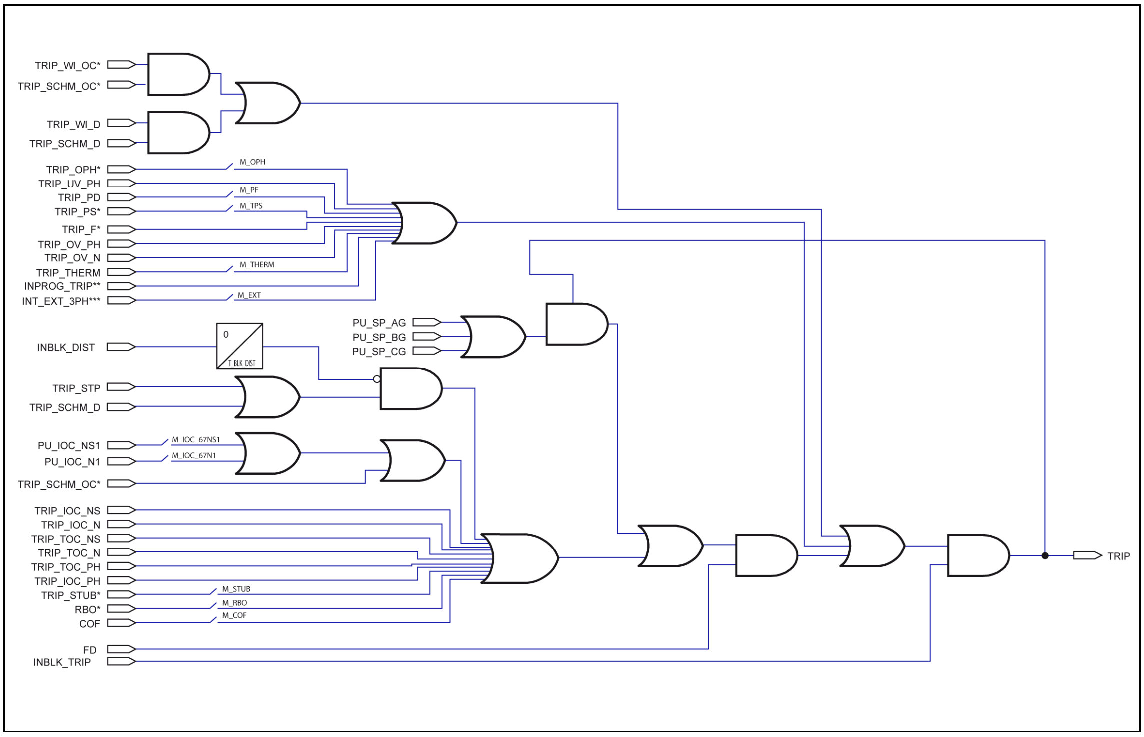


Figure 3.25.11:Block Diagram of the Tripping Logic (Models ZLV-A/E/H).

Legend
T_BLK_DIST: Distance Blocking Input Reset Time Delay (setting)
M_OPH: Open Phase Element Trip Mask (setting)
M_PF: Pole Discordance Element Trip Mask (setting)
M_TPS: Power Swing Element Trip Mask (setting)
M_THERM: Thermal Image Element Trip Mask (setting)
M_IOC_67NS1: Negative Sequence IOC Element 1 Trip Mask (setting)
M_IOC_67N1: Ground IOC Element 1 Trip Mask
M_STUB: Stub Bus Element Trip Mask (setting)
M_RBO: Remote Breaker Open Element Trip Mask (setting)
M_COF: Close-Onto-Fault Element Trip Mask (setting)
M_EXT: Mask For External Trip (setting). ZLV-***-****A/B/C/D/E/F/G/H**.Models.

(*) Signals not included in ZLV-E Models. **(**)ZLV-H Models.** **(**) ZLV-H**-****A/B/C/D/E/F/G/H**.**

3.25.6 Tripping Logic Settings

Tripping Logic			
Setting	**Range**	**Step**	**By default**
Three-phase trip (Model ZLV-B/F/G/J)*	YES / NO		NO
Ground overcurrent single-phase trip (ZLV-B/F/G/J)*	YES / NO		NO
Distance blocking input reset time delay	0 - 1000 ms	50 ms	150 ms
Trip Reset Time (ZLV-***-****D/E/F/G/H**)	0 - 10 s	10 ms	30 ms
Zones Mask:			
Z1 Ground faults	YES / NO		NO
Z1 Phase-to-phase faults	YES / NO		NO
Z2 Ground faults	YES / NO		NO
Z2 Phase-to-phase faults	YES / NO		NO
Z3 Ground faults	YES / NO		NO
Z3 Phase-to-phase faults	YES / NO		NO
Z4 Ground faults	YES / NO		NO
Z4 Phase-to-phase faults	YES / NO		NO
Z5 Ground faults (ZLV-F/G/H/J)	YES / NO		NO
Z5 Phase-to-phase faults (ZLV-F/G/H/J)	YES / NO		NO
Z6 Ground faults (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	YES / NO		NO
Z6 Phase-to-phase faults (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	YES / NO		NO

*** Enabling the first setting disables the second**

Tripping Logic			
Setting	**In Display**	**Range**	**By default**
Auxiliary Units Activation Mask			
Remote breaker open detector	REM OP BRK	YES / NO	NO
Close-onto-fault detector	CO FAULT	YES / NO	NO
Stub Bus protection	STUB BUS	YES / NO	NO
Thermal image	THERMAL IMG	YES / NO	NO
Open phase	OPEN PHASE	YES / NO	NO
Pole discordance detector (ZLV-A/B/E/F/H)	POLE DISCREP	YES / NO	NO
Pole discordance detector breaker 1 (ZLV-G/J)	POLE DISCREP1	YES / NO	NO
Pole discordance detector breaker 2 (ZLV-G/J)	POLE DISCREP2	YES / NO	NO
Power swing detector	PS TRIP	YES / NO	NO
Phase time overcurrent (51-1)	TOC PH1	YES / NO	NO
Phase time overcurrent (51-2)	TOC PH2	YES / NO	NO
Phase time overcurrent (51-3)	TOC PH3	YES / NO	NO
Phase instantaneous overcurrent (50-1)	IOC PH1	YES / NO	NO
Phase instantaneous overcurrent (50-2)	IOC PH2	YES / NO	NO
Phase instantaneous overcurrent (50-3)	IOC PH3	YES / NO	NO
Ground time overcurrent (51N-1)	TOC GND1	YES / NO	NO
Ground time overcurrent (51N-2)	TOC GND2	YES / NO	NO
Ground time overcurrent (51N-3)	TOC GND3	YES / NO	NO
Ground instantaneous overcurrent (50N-1)	IOC GND1	YES / NO	NO
Ground instantaneous overcurrent (50N-2)	IOC GND2	YES / NO	NO
Ground instantaneous overcurrent (50N-3)	IOC GND3	YES / NO	NO

Tripping Logic			
Setting	**In Display**	**Range**	**By default**
Auxiliary Units Activation Mask			
Negative Sequence time overcurrent (51Q-1)	TOC NEG SEQ1	YES / NO	NO
Negative Sequence time overcurrent (51Q-2)	TOC NEG SEQ2	YES / NO	NO
Negative Sequence time overcurrent (51Q-3)	TOC NEG SEQ3	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-1)	IOC NEG SEQ1	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-2)	IOC NEG SEQ2	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-3)	IOC NEG SEQ3	YES / NO	NO
Phase undervoltage (27-1)	UNDERVOLT PH1	YES / NO	NO
Phase undervoltage (27-2)	UNDERVOLT PH2	YES / NO	NO
Phase undervoltage (27-3)	UNDERVOLT PH3	YES / NO	NO
Phase overvoltage (59-1)	OVERVOLT PH1	YES / NO	NO
Phase overvoltage (59-2)	OVERVOLT PH2	YES / NO	NO
Phase overvoltage (59-3)	OVERVOLT PH3	YES / NO	NO
Ground overvoltage (59N-1)	OVERVOLT G1	YES / NO	NO
Ground overvoltage (59N-2)	OVERVOLT G2	YES / NO	NO
Underfrequency (81m-1)	UNDFREQ1	YES / NO	NO
Underfrequency (81m-2)	UNDFREQ2	YES / NO	NO
Underfrequency (81m-3)	UNDFREQ3	YES / NO	NO
Overfrequency (81M-1)	OVERFREQ1	YES / NO	NO
Overfrequency (81M-2)	OVERFREQ2	YES / NO	NO
Overfrequency (81M-3)	OVERFREQ3	YES / NO	NO
Rate of Change (81D-1)	ROC FREQ1	YES / NO	NO
Rate of Change (81D-2)	ROC FREQ2	YES / NO	NO
Rate of Change (81D-3)	ROC FREQ3	YES / NO	NO
External Trip (DISP EXT) (ZLV-***-****A/B/C/D/E/F/G/H**)		YES / NO	NO
Power Swing detector trip blocking mask			
Zone 1	YES / NO		NO
Zone 2	YES / NO		NO
Zone 3	YES / NO		NO
Zone 4	YES / NO		NO
Zone 5 (ZLV-F/G/H/J)	YES / NO		NO
Zone 6 (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	YES / NO		NO
Protection Scheme	YES / NO		NO

- **Tripping Logic: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**19 - PROTECTION LOGIC**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

ZLV-F/G/H/J

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	...
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**20 - PROTECTION LOGIC**
3 - INFORMATION	**3 - PROTECTION**	...
	....	

0 - DISTANCE	**0 - THREE PHASE TRIP**
...	**1 - 1 PHASE TRIP 67G**
*** - PROTECTION LOGIC**	**2 - DISTANCE BLOCK TIMER**
...	**3 - ZONE MASK**
	4 - AUX UNITS MASK
	5 - POW. SWING BLOCK MSK

ZLV-***-****D/E/F/G/H*

0 - DISTANCE	**0 - THREE PHASE TRIP**
...	**1 - 1 PHASE TRIP 67G**
*** - PROTECTION LOGIC**	**2 - DISTANCE BLOCK TIMER**
...	**3 - TRIP DROP OUT TIME**
	4 - ZONE MASK
	5 - AUX UNITS MASK
	6 - POW. SWING BLOCK MSK

(*) 19 or 20 option, depending on the model.

3.25.7 Digital Inputs and Events of the Tripping Logic

Table 3.25-1: Digital Inputs and Events of the Tripping Logic		
Name	**Description**	**Function**
INBLK_TRIP	Trip Blocking Input	Activation of this input produces a block of any trip.
INBLK_DIST	Distance Trip Blocking Input	Activation of this input inhibits trips by distance units, either due to step distance or protection scheme.
ENBL_3PH	Three-phase Trip Enable Input	Activation of this input produces a three-phase trip ready.
INPROGTRIP	Programmable Trip Input (ZLV-F/G/J)	Activating this input causes a direct three-phase trip.
INBLK_3PHPREP	Three-phase Trip Preparation Block Input (ZLV-F/G/H/J)	Activating this input disables the three-phase trip preparation.
INBLK_TRIP_A	Pole A Trip Block Input (ZLV-F/G/J)	Activating this input disables pole A tripping.
INBLK_TRIP_B	Pole B Trip Block Input (ZLV-F/G/J)	Activating this input disables pole B tripping.
INBLK_TRIP_C	Pole C Trip Block Input (ZLV-F/G/J)	Activating this input disables pole C tripping.
INBLK_3P_ZII	Zone 2 Three-Phase Trip Blocking Input (ZLV-F/G/H/J)	The activation of this input permits the performance of single-phase tripping according to the corresponding protection zone (as long as it is a single-phase fault and there is not any other condition to initiate a three-phase trip).
INBLK_3P_ZIII	Zone 3 Three-Phase Trip Blocking Input (ZLV-F/G/H/J)	
INBLK_3P_ZIV	Zone 4 Three-Phase Trip Blocking Input (ZLV-F/G/H/J)	
INBLK_3P_ZV	Zone 5 Three-Phase Trip Blocking Input (ZLV-F/G/H/J)	
INBLK_3P_ZVI	Zone 6 Three-Phase Trip Blocking Input (ZLV-F/G/H/J**-****C/D/E/F/G/H**)	
IN_EXT_A	Pole A external trip input (ZLV-B/F/G/J)	The activation of this input indicates the existence of a trip of the A pole of the breaker caused by an external protection.
IN_EXT_B	Pole B external trip input (ZLV-B/F/G/J)	The activation of this input indicates the existence of a trip of the B pole of the breaker caused by an external protection.
IN_EXT_C	Pole C external trip input (ZLV-B/F/G/J)	The activation of this input indicates the existence of a trip of the C pole of the breaker caused by an external protection.
IN_EXT_3PH	Three-phase external trip input	The activation of this input indicates the existence of a three-phase trip of the breaker caused by an external protection.

3.25.8 Digital Outputs and Events of the Tripping Logic

Table 3.25-2: Digital Outputs and Events of the Tripping Logic

Name	Description	Function
TRIP_A	Phase A trip output activated (ZLV-B/F/G/J)	Trip of A pole of the breaker.
TRIP_B	Phase B trip output activated (ZLV-B/F/G/J)	Trip of B pole of the breaker.
TRIP_C	Phase C trip output activated (ZLV-B/F/G/J)	Trip of C pole of the breaker.
TRIP_3PH	Three-phase trip (ZLV-B/F/G/J)	Three-phase trip of the breaker.
TRIP	Trip	Trip of the breaker.
3PH_PREP	Three-phase trip ready	Three-Phase trip condition

3.26 Recloser

3.26.1 Description

Model ZLV-B/F

ZLV-B/F terminal unit Recloser allows up to three reclosing attempts, with independent reclosing timers (dead time delays) for the:

- First single-phase reclosing attempt.
- First three-phase reclosing attempt.
- Second reclosing attempt (always 3-Phase).
- Third reclosing attempt (always 3-Phase).

Second and third attempts are always three-phase reclosing.

Also, the recloser is able to operate in any of the following four modes:

1P Mode	Only single-phase reclosing is allowed. The recloser will lockout after a three-phase trip. Therefore, this mode has a single reclosing attempt, independent of the number of attempts.
3P Mode	Only three-phase reclosing is allowed, forcing the tripping logic to make all the trips of this type.
1P / 3P Mode	Both single- and three-phase reclosing is allowed. The first attempt will be either single-phase or three-phase. The remaining attempts (depending on the **Reclosing Attempts** setting) will always be three-phase.
Dependent Mode	Only one reclosing will be attempted after a three-phase trip. For single-phase trips, the recloser will operate according to the number of attempts selected in the **Reclosing Attempts** setting.

Figures 3.26.3, 3.26.4, 3.26.5, 3.26.6 and 3.26.7 show the recloser operation flow diagrams with the details for each reclosing mode. In these diagrams, the signal **RCLS** (**Recloser Start Element Activated**) corresponds to the logic output in charge of generating the trips that are allowed to be reclosed by the associated Recloser Start Masks.

Models ZLV-G/J

ZLV-G/J relay automatic reclose function comprises two reclosers, coordinated with each other, designated **Recloser 1** and **Recloser 2**, associated to breakers 1 and 2 respectively. The **Number of reclosers** setting defines whether there are one or two reclosers in operation. When said setting is set to **Selection by DI**, the number of reclosers in operation will be defined by logic input **IN_2REC** (**Two reclosers in operation input**) state based on the following table:

IN_2REC	Result
0	1 Recloser in operation
1	2 Recloser in operation

Whenever two reclosers are in operation, reclose will take place in sequence, so that one of the reclosers must operate before the other. This recloser will be designated as master recloser whereas the other will be the slave recloser. Said selection is made through the setting **Master Recloser**. If said setting is set to **Selection by DI** the selection of the master recloser will be made by logic input **IN_1MAS** (**Master Recloser 1 input**) state based on the following table:

IN_1MAS	Result
0	Master recloser 2
1	Master recloser 1

When there is only one recloser in operation, the selection of the master recloser (through setting or digital input) allows selecting the operating recloser, as there will not be a slave recloser.

The **ZLV-F/G/J** relay automatic reclose function has the same reclose modes than **ZLV-B** relays. If the "reclose mode" of the former relay is set to **Selection by DI**, the reclose mode will be defined by logic inputs **IN_1P** (**1P Mode Input**) and **IN_3P** (**3P Mode input**) state based on the following table:

E_1P	E_3P	Result
0	0	Dependent Mode
0	1	3P Mode
1	0	1P Mode
1	1	1P/3P Mode

Figures 3.26.9, 3.26.10, 3.26.11, 3.26.12, 3.26.13, 3.26.14, 3.26.15, 3.26.16, 3.26.17 and 3.26.18, show the flow diagrams describing the recloser operation and the features of the four reclose modes. In said figures, signal **RCLS** (**Recloser initiate**) corresponds to the output of a logic processing the reclosable trips and their reclose initiate mask settings.

Models ZLV-A/E/H

ZLV-A/E/H terminal units Recloser allows up to three reclosing attempts, with independent reclosing timers (dead time delays).

Figure 3.26.8 shows the recloser operation flow diagram with the details for each reclosing mode. In the diagram, the signal **RCLS** (**Recloser Start Element Activated**) corresponds to the logic output in charge of generating the trips that are allowed to be reclosed by the associated Recloser Start Masks.

3.26.2 External Trips

Model ZLV-B/F

The recloser operates in the same manner for trips generated by the **ZLV-B/F** terminal unit or by external protection. Therefore, the four modes of operation are available to reclose trips generated by other protection terminals. To take advantage of this feature, the logic input signals **External A Pole Trip** (**IN_EXT_A**), **External B Pole Trip** (**IN_EXT_B**), **External C Pole Trip** (**IN_EXT_C**) or **External Protection Trip** (**IN_EXT**) and **External Protection Three-Phase Trip** (**IN_EXT_3PH**) must be used as follows:

1. When the external device only generates three-phase trips, the recloser can operate connecting the **IN_EXT** and **IN_EXT_3PH** inputs or otherwise using only the **IN_EXT_3PH** input.
2. When the external device generates both single-phase and three-phase trips, the three **IN_EXT_A**, **IN_EXT_B** and **IN_EXT_C** inputs or otherwise the two **IN_EXT** and **IN_EXT_3PH** inputs should be connected.

Models ZLV-A/E/H

The Recloser operates in the same manner for trips generated by the **ZLV-A/E/H** terminal units or by external protection. To take advantage of this feature, the logic input signal **External Protection Three-Phase Trip** (**IN_EXT_3PH**) must be used.

Models ZLV-G/J

All comments for the **ZLV-B/F** relay are applicable to the **ZLV-G/J** relays, as the above mentioned external trip inputs will actuate on both reclosers incorporated into the automatic reclose function.

3.26.3 Recloser Start Logic

Model ZLV-B/F/G/J

The recloser start logic is depicted in Figure 3.26.1. As can be seen in this figure, the recloser start can be produced when any distance zone, any of the phase, ground or negative sequence overcurrent elements, the open phase unit or the remote breaker open detector, distance or overcurrent protection scheme is tripped, provided the **Recloser Start Mask** allows it.

Recloser start is also produced if there is a channel trip when the close onto fault detector trips, provided it has done so in a fault reclose [**COF** is activated without resetting the recloser sequence signal, (the **RECLOSING** signal, OR of the signals **RECLOSING1** and **RECLOSING2** for **ZLV-G/J** relays) which will be carried out after the reset time, see Reclosing Logic], or otherwise an external trip is detected (if the **A Pole External Trip**, **B Pole External Trip**, **C Pole External Trip** inputs or otherwise the **External Trip** and **External Three-Phase Trip** inputs are programmed). Under all circumstances, the recloser start is equal to the **RCLS** signal activation. The remaining elements generate non-reclosable trips.

The recloser will not start its close sequence if it detects that the number of trips has exceeded the set limit (see 3.30.2, Excessive Number of Trips) or, in **ZLV-F/G/J** relays, if **IN_BLKRCLS (Recloser Initiate Block input**) has been activated.

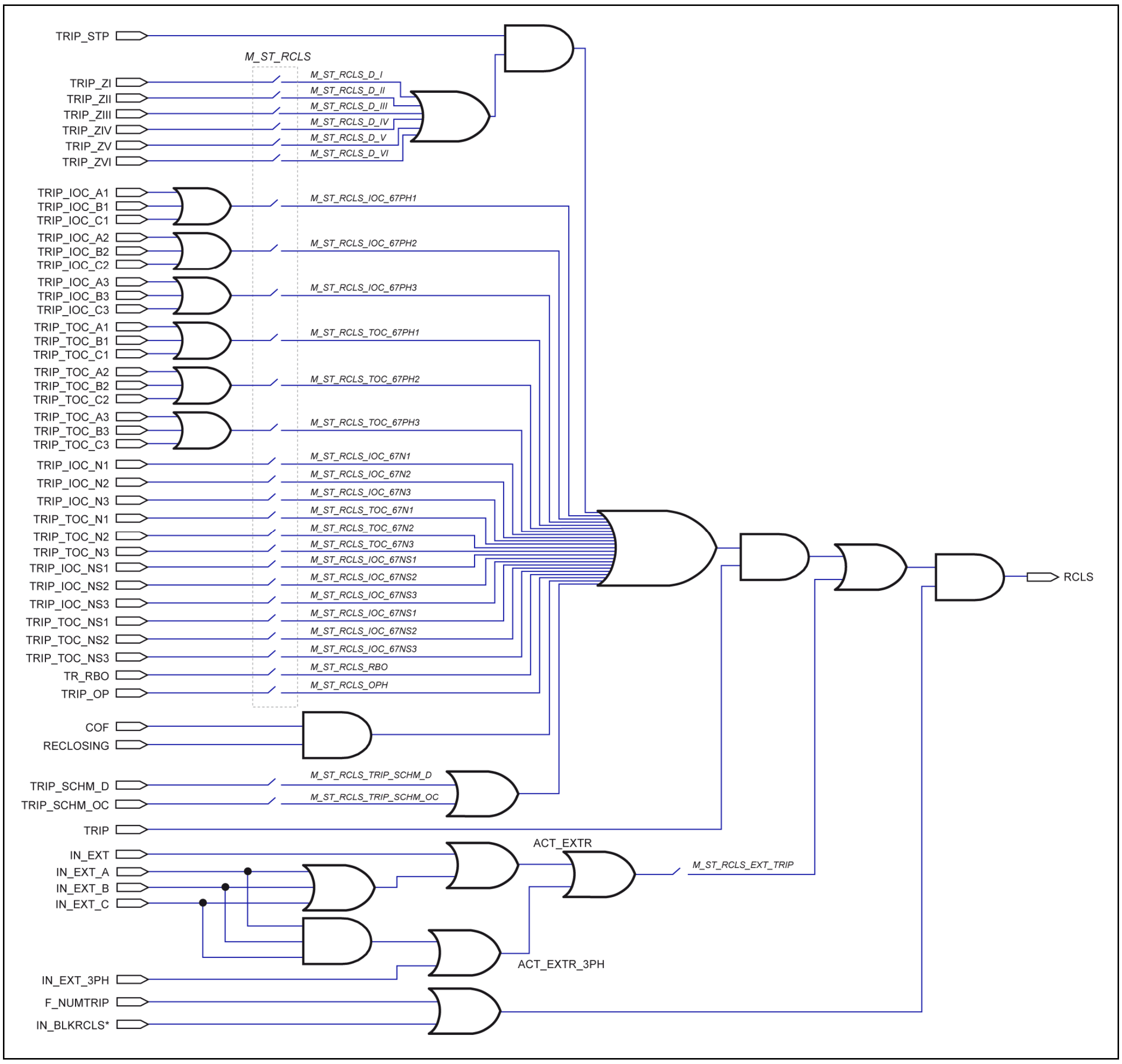


Figure 3.26.1: Recloser Sequence Start Logic Diagram (Model ZLV-B/F/G).

Legend
M_ST_RCLS: Recloser Start Mask.
M_ST_RCLS_D_I: Zone 1 Elements.
M_ST_RCLS_D_II: Zone 2 Elements.
M_ST_RCLS_D_III: Zone 3 Elements.
M_ST_RCLS_D_IV: Zone 4 Elements.
M_ST_RCLS_D_V: Zone 5 Elements.
M_ST_RCLS_D_VI: Zone 6 Elements.
M_ST_RCLS_IOC_67PH1: Phase Instantaneous Overcurrent 1.
M_ST_RCLS_IOC_67PH2: Phase Instantaneous Overcurrent 2.
M_ST_RCLS_IOC_67PH3: Phase Instantaneous Overcurrent 3.

Legend
M_ST_RCLS_TOC_67PH1: Phase Time Overcurrent 1
M_ST_RCLS_TOC_67PH2: Phase Time Overcurrent 2
M_ST_RCLS_TOC_67PH3: Phase Time Overcurrent 3
M_ST_RCLS_IOC_67N1: Ground Instantaneous Overcurrent 1
M_ST_RCLS_IOC_67N2: Ground Instantaneous Overcurrent 2
M_ST_RCLS_IOC_67N3: Ground Instantaneous Overcurrent 3
M_ST_RCLS_TOC_67N1: Ground Time Overcurrent 1
M_ST_RCLS_TOC_67N2: Ground Time Overcurrent 2
M_ST_RCLS_TOC_67N3: Ground Time Overcurrent 3
M_ST_RCLS_IOC_67NS1: Negative Sequence Instantaneous Overcurrent 1
M_ST_RCLS_IOC_67NS2: Negative Sequence Instantaneous Overcurrent 2
M_ST_RCLS_IOC_67NS3: Negative Sequence Instantaneous Overcurrent 3
M_ST_RCLS_TOC_67NS1: Negative Sequence Time Overcurrent 1
M_ST_RCLS_TOC_67NS2: Negative Sequence Time Overcurrent 2
M_ST_RCLS_TOC_67NS3: Negative Sequence Time Overcurrent 3
M_ST_RCLS_RBO: Remote Breaker Open Detector
M_ST_RCLS_OPH: Open Phase Element
M_ST_RCLS_TRIP_SCHM_D: Distance Protection Scheme Trip**
M_ST_RCLS_TRIP_SCHM_OC: Overcurrent Protection Scheme Trip**
M_ST_RCLS_EXT_TRIP: External Trip**
F_NUMTRIP: Excessive Number Of Trips

(*) ZLV-F/G/J Models.
(**) ZLV-*-****A/B/C/D/E/F/G/H** Models.**

Models ZLV-A/E/H

The recloser start logic is depicted in Figure 3.26.2. As can be seen in this figure, the recloser start can be produced when any distance zone trips any of the phase, ground or negative sequence overcurrent elements, open phase unit or the remote breaker open detector, distance or overcurrent protection scheme, provided the **Recloser Start Mask** setting allows it.

Recloser start is also produced when the close onto fault detector trips, provided that it has done so in a fault reclose or otherwise an external trip is detected. In all cases, the recloser start is equivalent to the activation of the **RCLS** signal.

The remaining elements generate non-reclosable trips.

The recloser will not initiate the closing cycle in case the number of trips is bigger than the setting value (see 3.30.2; Excessive Number of Trips) or, for models **ZLV-H**, if **IN_BLKRCLS (Recloser Initiate Block Input**) has been activated.

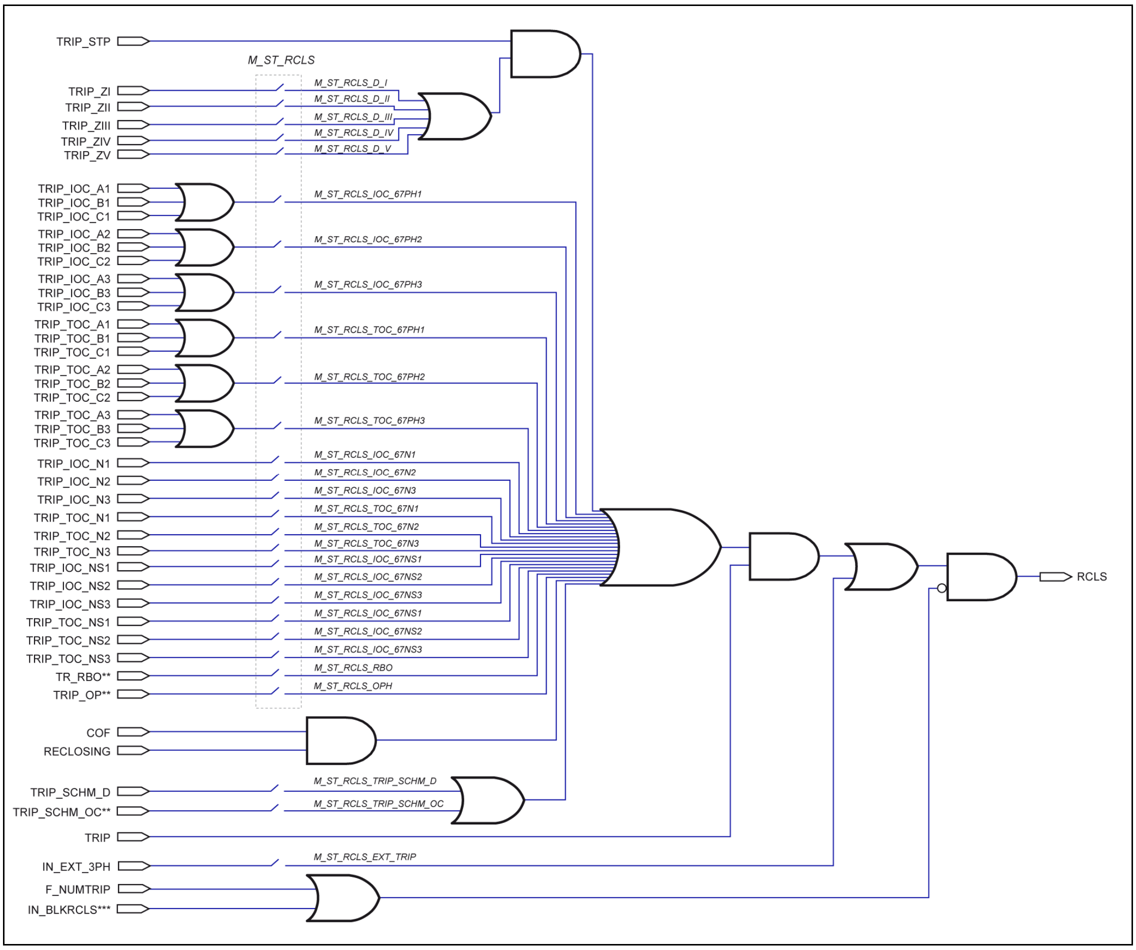


Figure 3.26.2: Recloser Sequence Start Logic Diagram (Models ZLV-A/E/H).

Legend
M_ST_RCLS: Recloser Start Mask.
M_ST_RCLS_D_I: Zone 1 Elements.
M_ST_RCLS_D_II: Zone 2 Elements.
M_ST_RCLS_D_III: Zone 3 Elements.
M_ST_RCLS_D_IV: Zone 4 Elements.
M_ST_RCLS_D_V: Zone 5 Elements.
M_ST_RCLS_IOC_67PH1: Phase Instantaneous Overcurrent 1.
M_ST_RCLS_IOC_67PH2: Phase Instantaneous Overcurrent 2.
M_ST_RCLS_IOC_67PH3: Phase Instantaneous Overcurrent 3.
M_ST_RCLS_TOC_67PH1: Phase Time Overcurrent 1
M_ST_RCLS_TOC_67PH2: Phase Time Overcurrent 2
M_ST_RCLS_TOC_67PH3: Phase Time Overcurrent 3
M_ST_RCLS_IOC_67N1: Ground Instantaneous Overcurrent 1
M_ST_RCLS_IOC_67N2: Ground Instantaneous Overcurrent 2
M_ST_RCLS_IOC_67N3: Ground Instantaneous Overcurrent 3

Legend
M_ST_RCLS_TOC_67N1: Ground Time Overcurrent 1
M_ST_RCLS_TOC_67N2: Ground Time Overcurrent 2
M_ST_RCLS_TOC_67N3: Ground Time Overcurrent 3
M_ST_RCLS_IOC_67NS1: Negative Sequence Instantaneous Overcurrent 1
M_ST_RCLS_IOC_67NS2: Negative Sequence Instantaneous Overcurrent 2
M_ST_RCLS_IOC_67NS3: Negative Sequence Instantaneous Overcurrent 3
M_ST_RCLS_TOC_67NS1: Negative Sequence Time Overcurrent 1
M_ST_RCLS_TOC_67NS2: Negative Sequence Time Overcurrent 2
M_ST_RCLS_TOC_67NS3: Negative Sequence Time Overcurrent 3
M_ST_RCLS_RBO: Remote Breaker Open Detector
M_ST_RCLS_OPH: Open Phase Element
M_ST_RCLS_TRIP_SCHM_D: Distance Protection Scheme Trip
M_ST_RCLS_TRIP_SCHM_OC: Overcurrent Protection Scheme Trip**
M_ST_RCLS_EXT_TRIP: External Trip *
F_NUMTRIP: Excessive Number Of Trips

(*) ZLV-H-****A/B/C/D/E/F/G/H** Models.**
(**) Signals not included in ZLV-E Models.
(***) ZLV-H Model.

3.26.4 Reclosing Logic

3.26.4.a Automatic Reclose with One Recloser

Model ZLV-B/F/G/J

Figures 3.26.3, 3.26.4, 3.26.5 and 3.26.6 depict the flow diagrams for the four different recloser operation modes. Figure 3.26.7 shows the block diagram of the recloser lockout. This last block diagram is common for each of the four reclosing modes.

The flow diagrams of Automatic reclose with two reclosers (**ZLV-G/J** relays only) consider subscripts m (m=1,2) and s (s=1,2; s≠m) for master and slave reclosers respectively. The flow diagrams of the Automatic reclose with one recloser consider the subscript m (m=1,2). Said subscript is only applicable to the **ZLV-G/J** relay as the operative recloser (recloser 1 or 2) can be selected in this relay. For **ZLV-B/F** relays said subscript should not be considered.

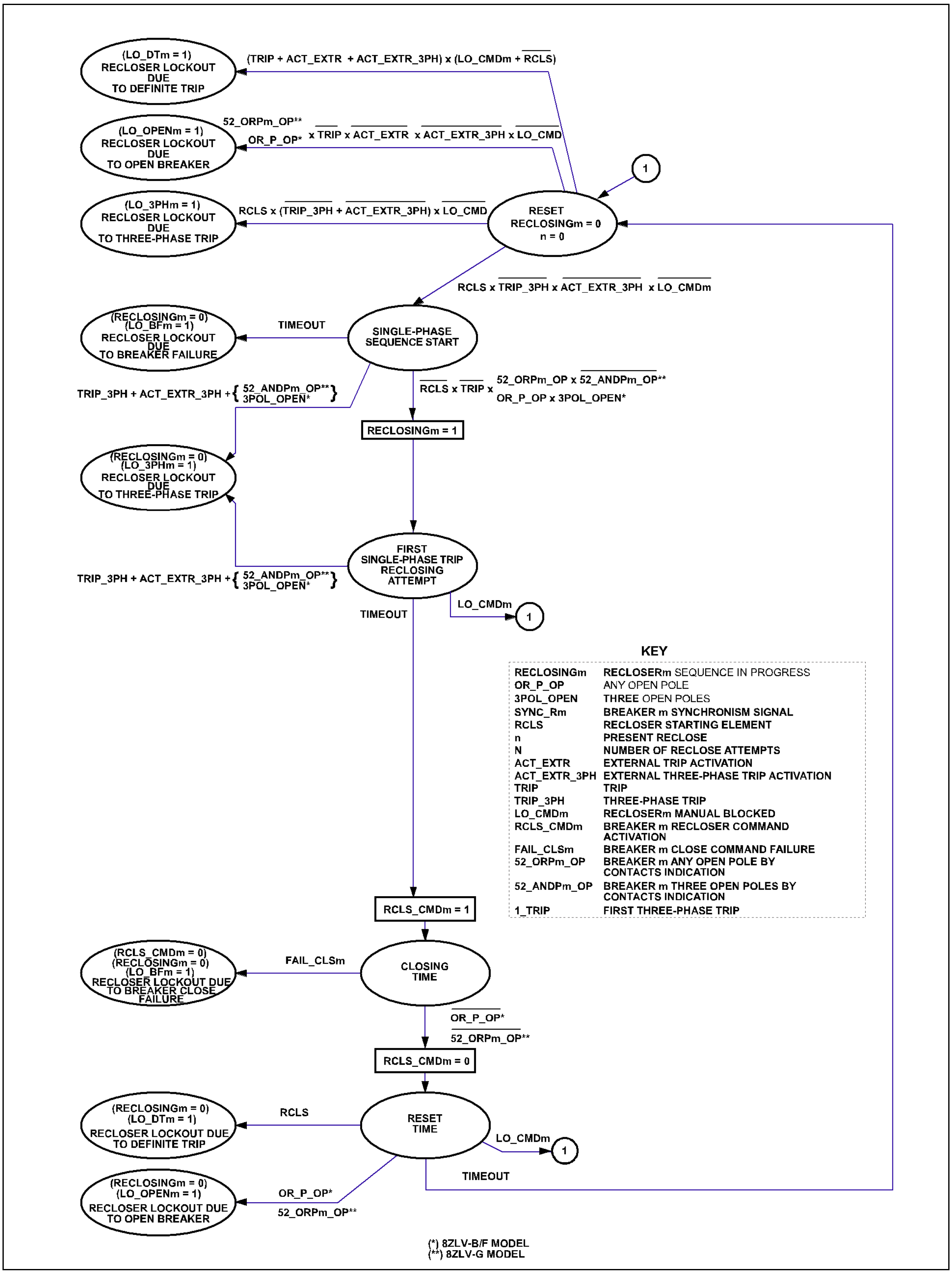


Figure 3.26.3: Recloser 1-P Mode 0peration Flow Diagram (I) (ZLV-B/F/G/J Models with One Recloser in Operation).

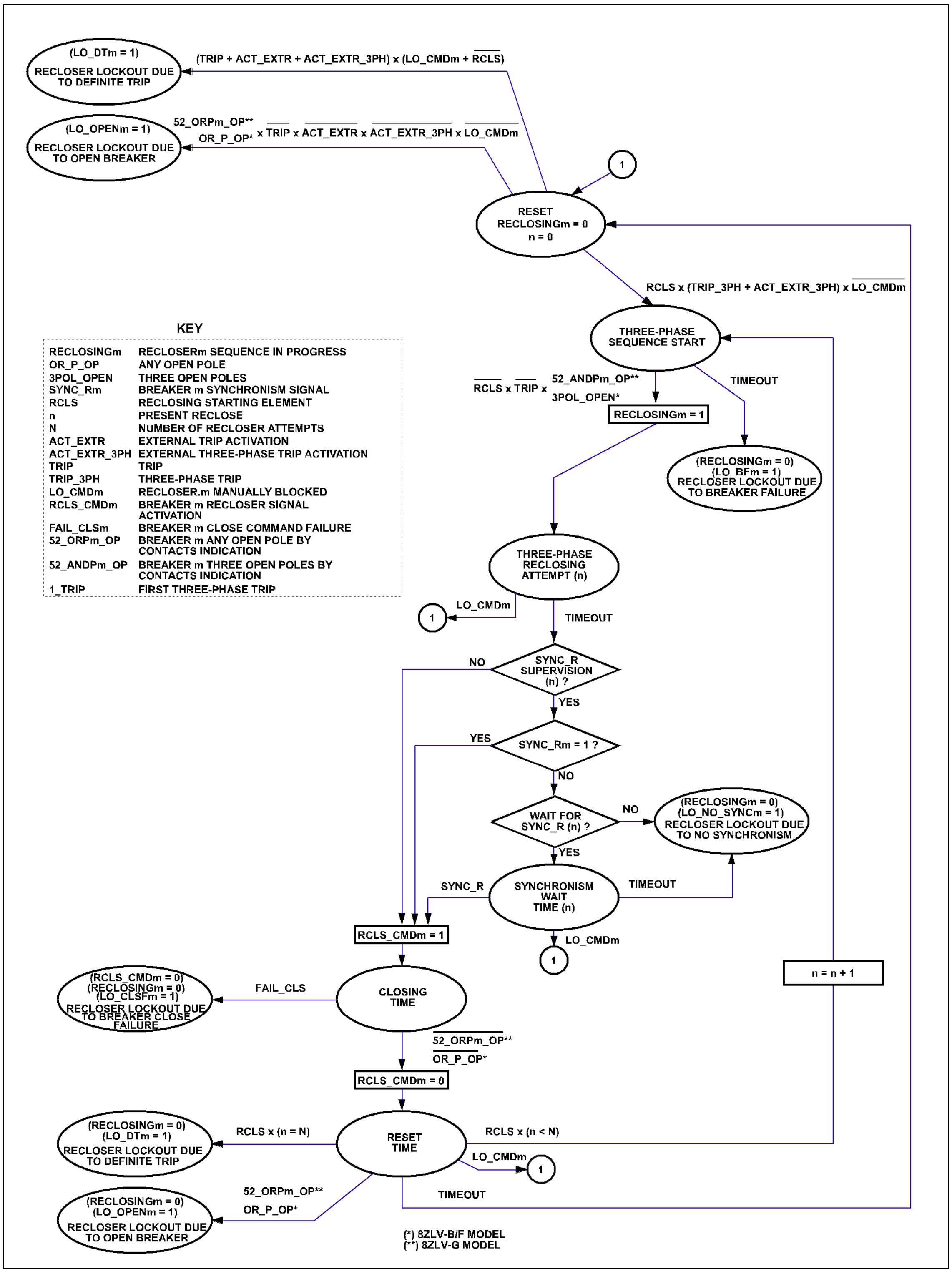


Figure 3.26.4: Recloser 3-P Mode Operation Flow Diagram (I) (ZLV-B/F/G/J Models with One Recloser in Operation).

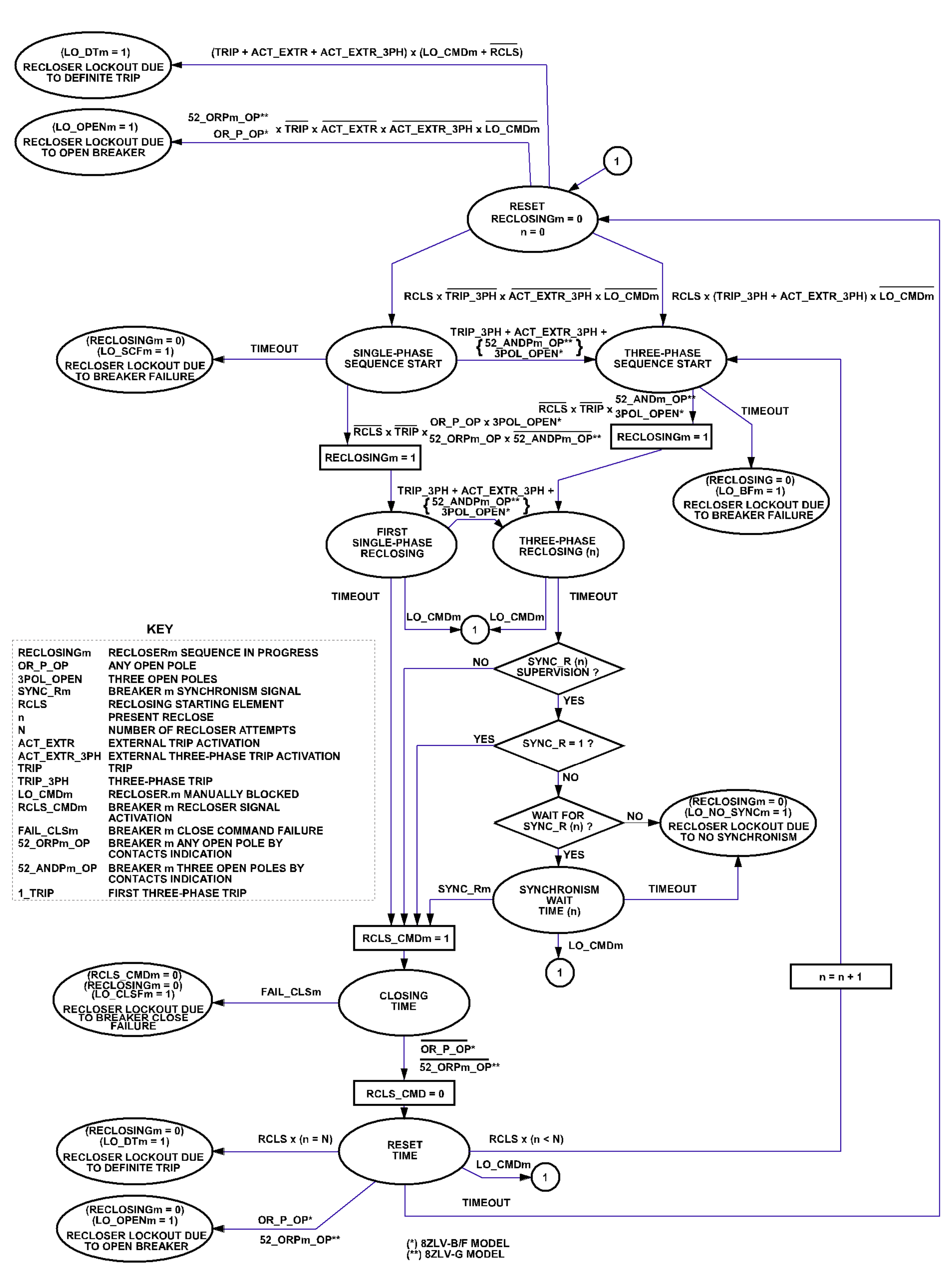


Figure 3.26.5: Recloser 1P / 3P Mode Operation Flow Diagram (I) (ZLV-B/F/G/J Models with One Recloser in Operation).

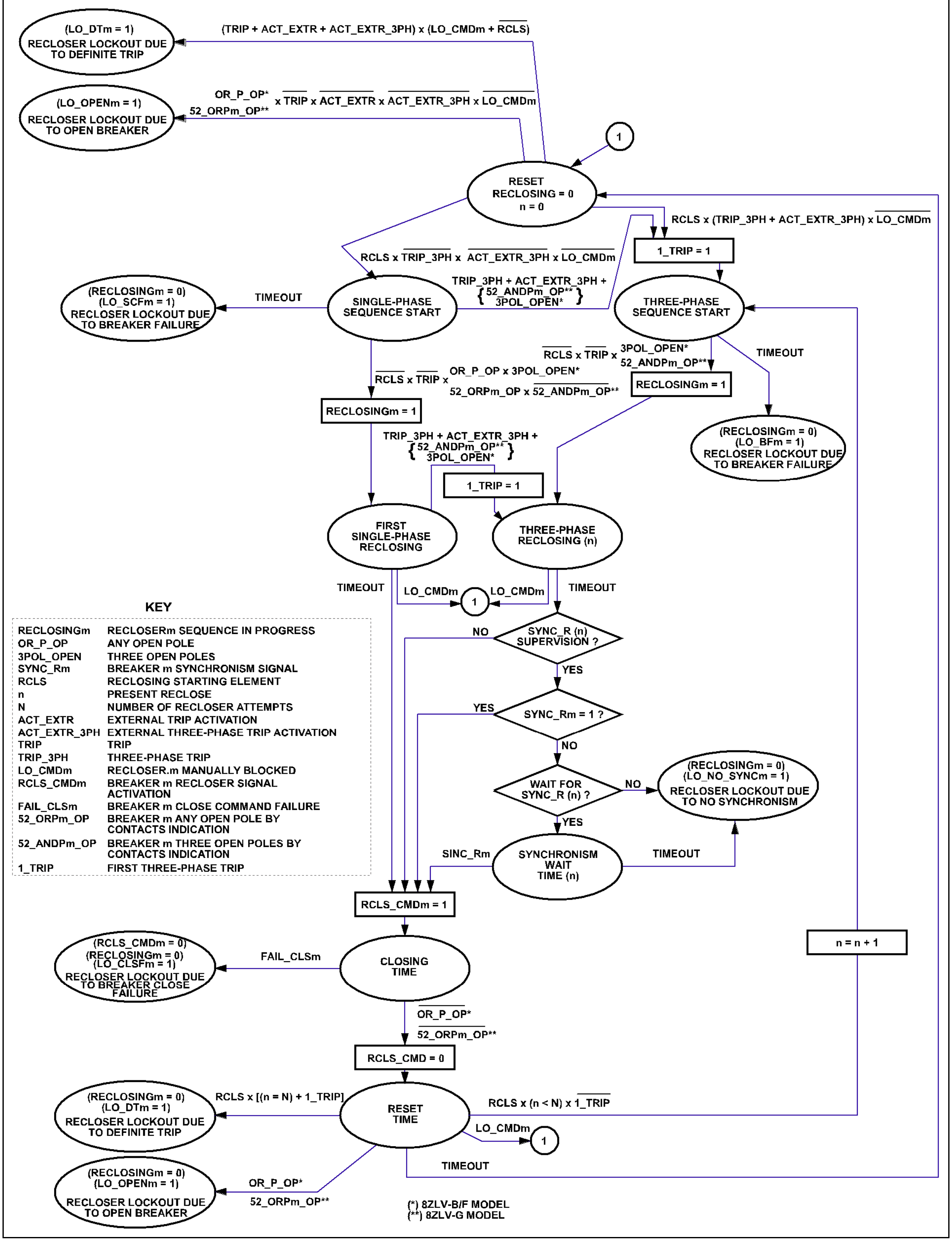


Figure 3.26.6: Recloser Dependent Mode Operation Flow Diagram (I) (ZLV-B/F/G/J Models with One Recloser in Operation).

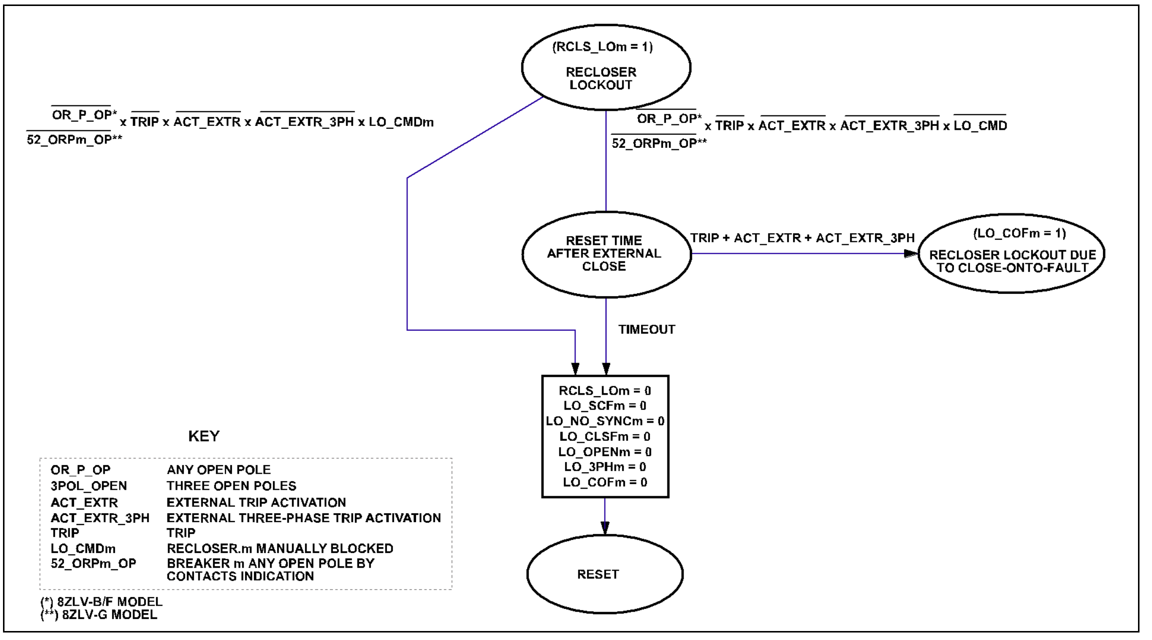


Figure 3.26.7: Recloser Operation Flow Diagram (II) (ZLV-B/F/G/J Models with One Recloser in Operation).

Models ZLV-A/E

Figure 3.26.8 depicts the recloser operation flow diagrams.

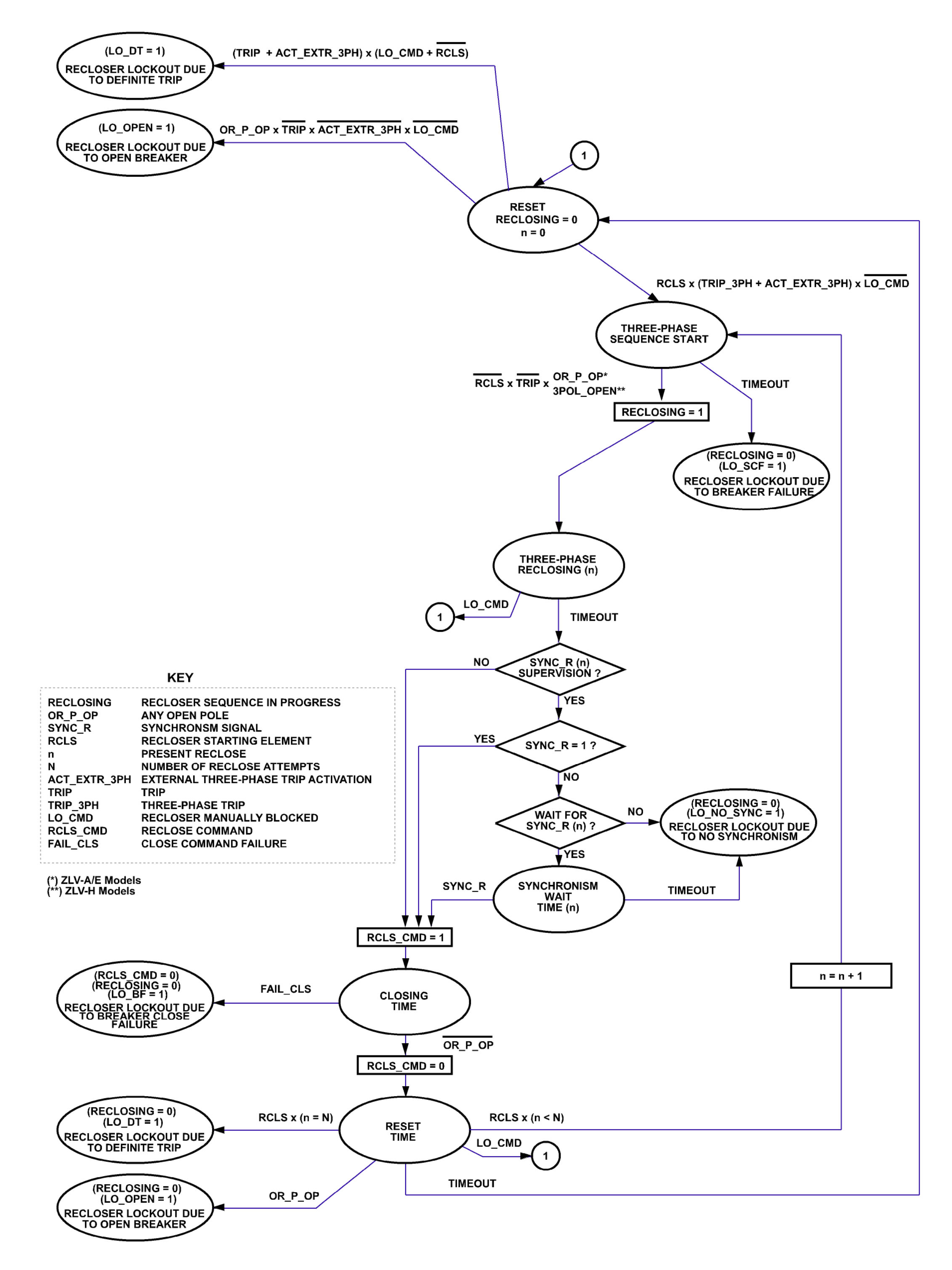


Figure 3.26.8: Recloser Operation Flow Diagram (Models ZLV-A/E/H).

3.26.4.b Automatic Reclose with Two Reclosers. ZLV-G/J Models

Figures 3.26.9 to 3.26.16 show the flow diagrams of the four reclose or operating modes for both reclosers, master and slave, respectively. Figures 3.26.17 and 3.26.18 shows the flow diagram of the internal lockout state also for both reclosers, master and slave. This last diagram is common for the four reclose modes.

The flow diagrams of Automatic reclose with two reclosers (**ZLV-G/J** relays only) consider subscripts m (m=1,2) and s (s=1,2; s≠m) for master and slave reclosers respectively.

Key for figures 3.26-9 to 3.26-18:

RECLOSINGm	Recloser m in Sequence in Progress
LO_OPENm/s	Recloser m/s Internal Lockout on Open Breaker
LO_3PHm/s	Recloser m/s Internal Lockout on Three-phase Trip
LO_BFm/s	Recloser m/s Internal Lockout on Initialization Failure
LO_CLSFm/s	Recloser m/s Internal Lockout on Closing Failure
LO_DTm/s	Recloser m/s Internal Lockout on Final Trip
LO_NO_SYNCm/s	Recloser m/s Internal Lockout on Lack of Synchronism
LO_CFm/s	Recloser m/s Internal Lockout on Switch Onto Fault
LO_MASs	Recloser s Internal Lockout on Master Command
RCLS_LOm/s	Any Recloser m/s Internal Lockout State
RCLS_CMDm/s	Breaker m/s Reclose Command
SLV_PERM	Slave Recloser Enable
SLV_BLK	Slave Recloser Lockout
RCLSm/s_STANBY	Recloser m/s Reset
REPm/s	Reset
E_TINIMm/s	Single-Phase Initation Time
E_TINITm/s	Three-Phase Initation Time
E_TRMm/s	Single-Phase Reclose Time
E_TRTnm/s	Three-Phase Reclose n Time
E_ESP_SINCm/s	Synchronism Waiting Time
E_ESP_CIERm/s	Closing Waiting Time
E_TSEG1m/s	Security Time 1
E_TSEG2m/s	Security Time 2
E_SEG_CMm/s	Security Time after Manual Closing
E_ESP_CESCm	Waiting for Slave Closing
E_MAES_CMs	Waiting for Master after Single-Phase Sequence
E_MAES_CTs	Waiting for Master after Three-Phase Sequence
$\mathbf{n_m}$	Reclose Sequence Recloser m
$\mathbf{n_s}$	Reclose Sequence Recloser s
N	Adjust Sequence Recloser Number

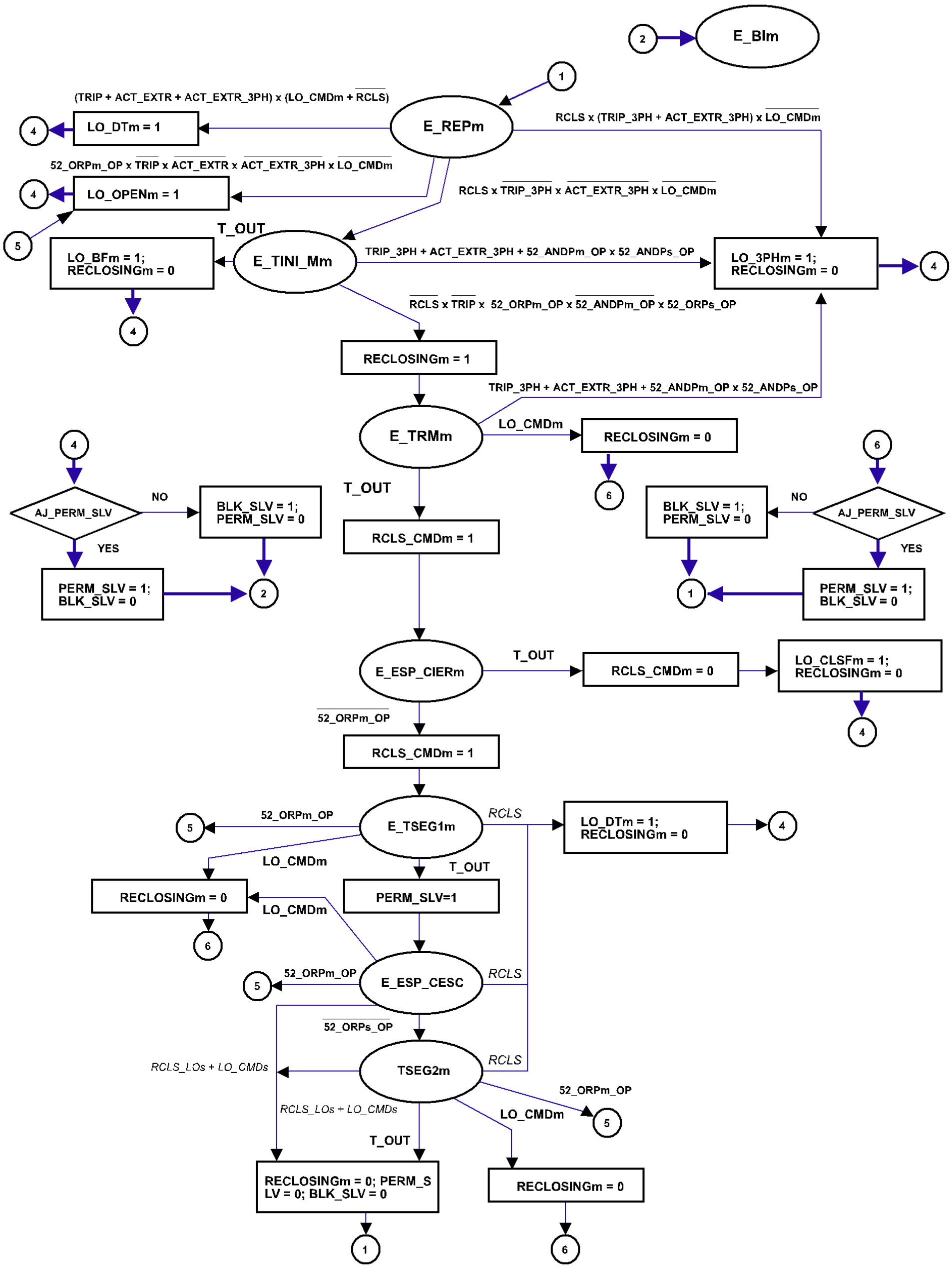


Figure 3.26.9: 1P Mode Master Recloser (ZLV-G/J).

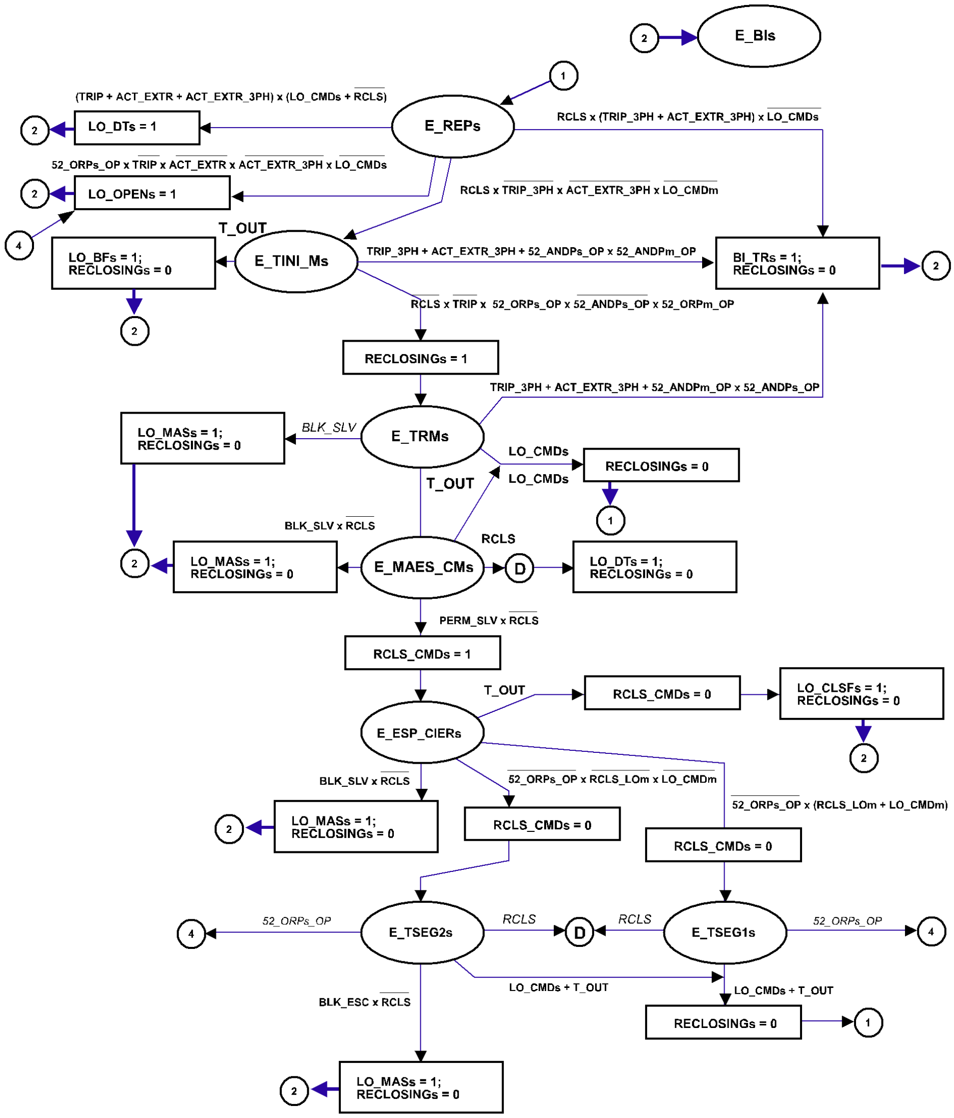


Figure 3.26.10: 1P Mode Slave Recloser (ZLV-G/J).

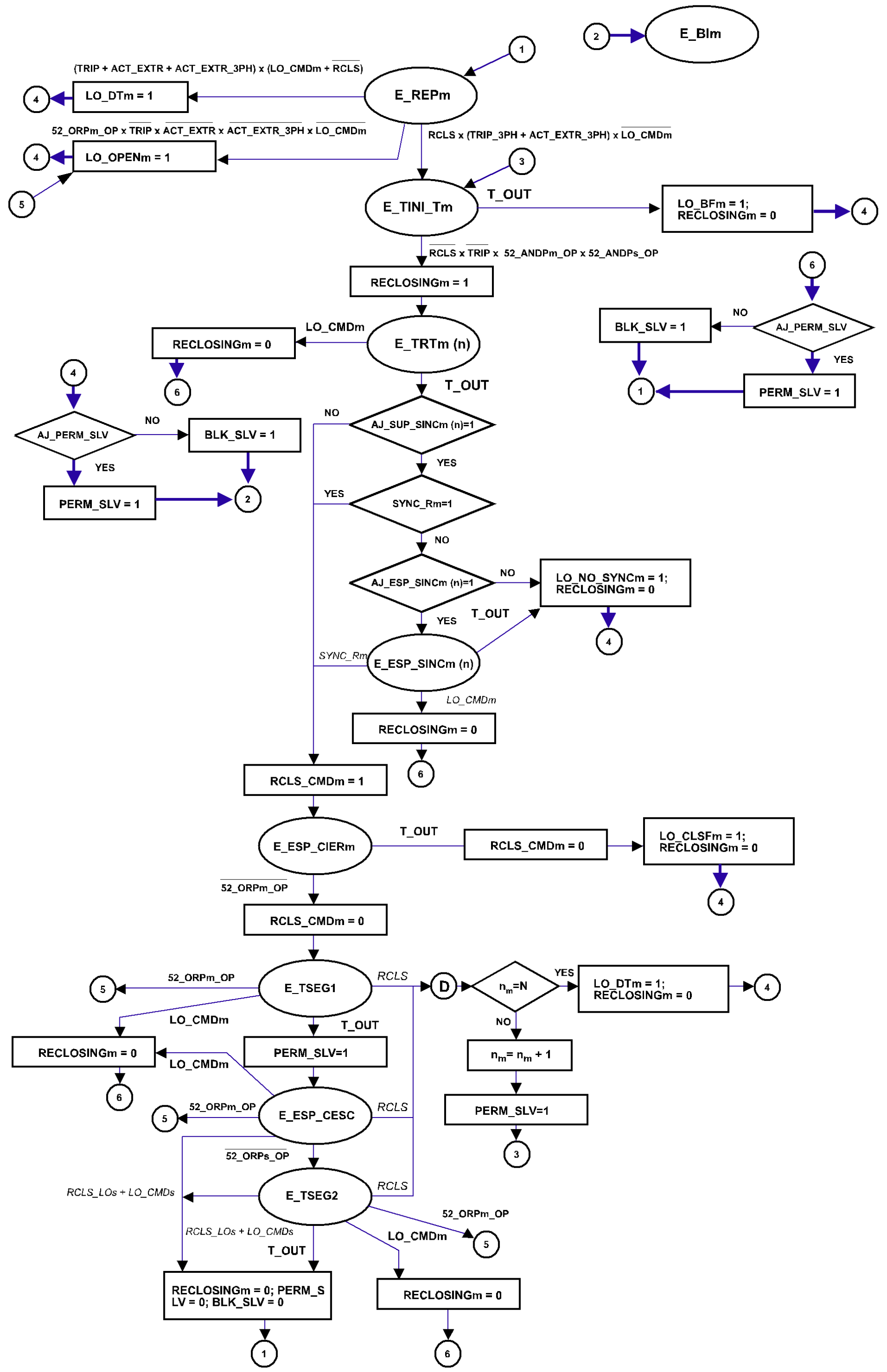


Figure 3.26.11: 3P Mode Master Recloser (ZLV-G/J).

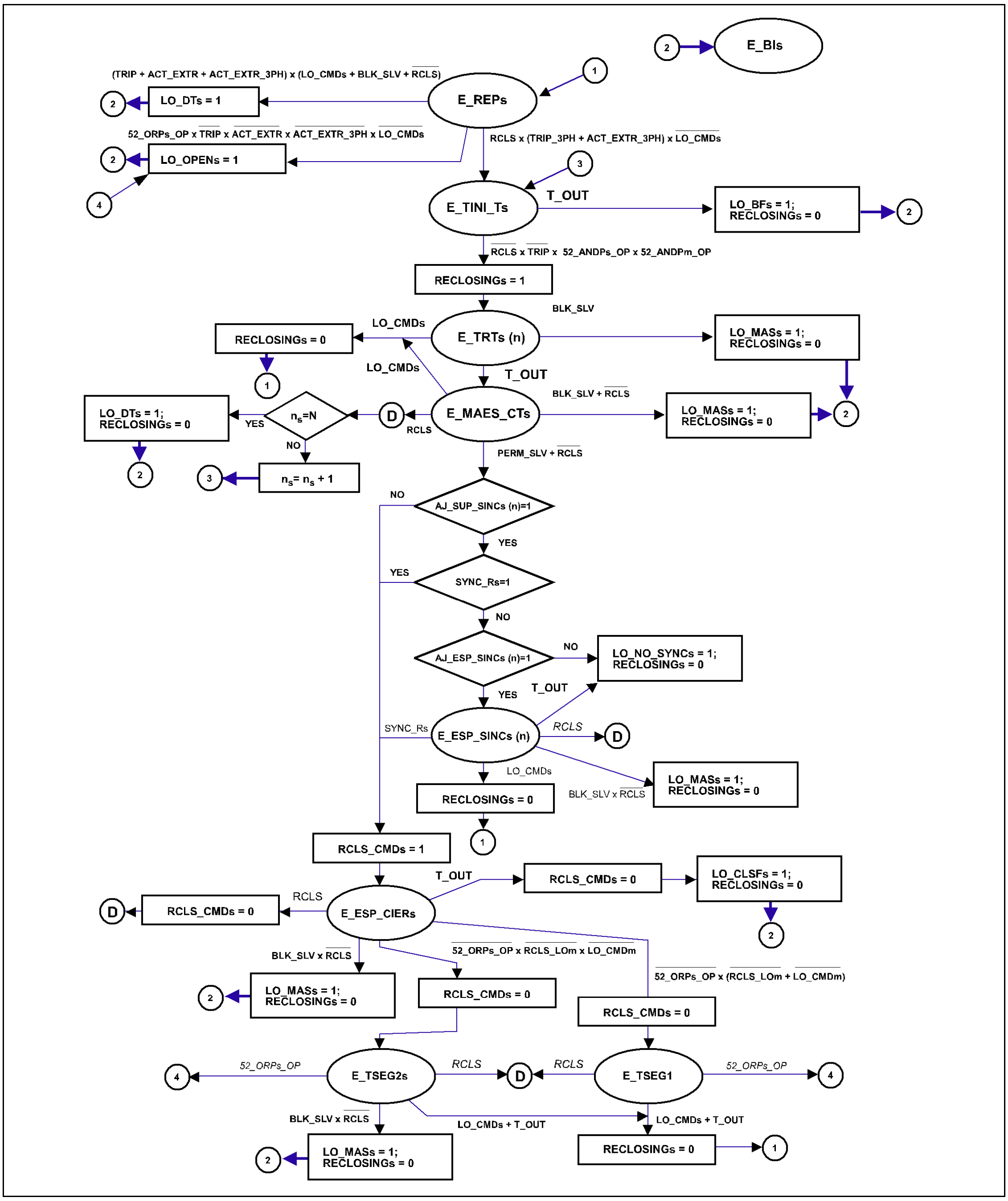


Figure 3.26.12: 3P Mode Slave Recloser (ZLV-G/J).

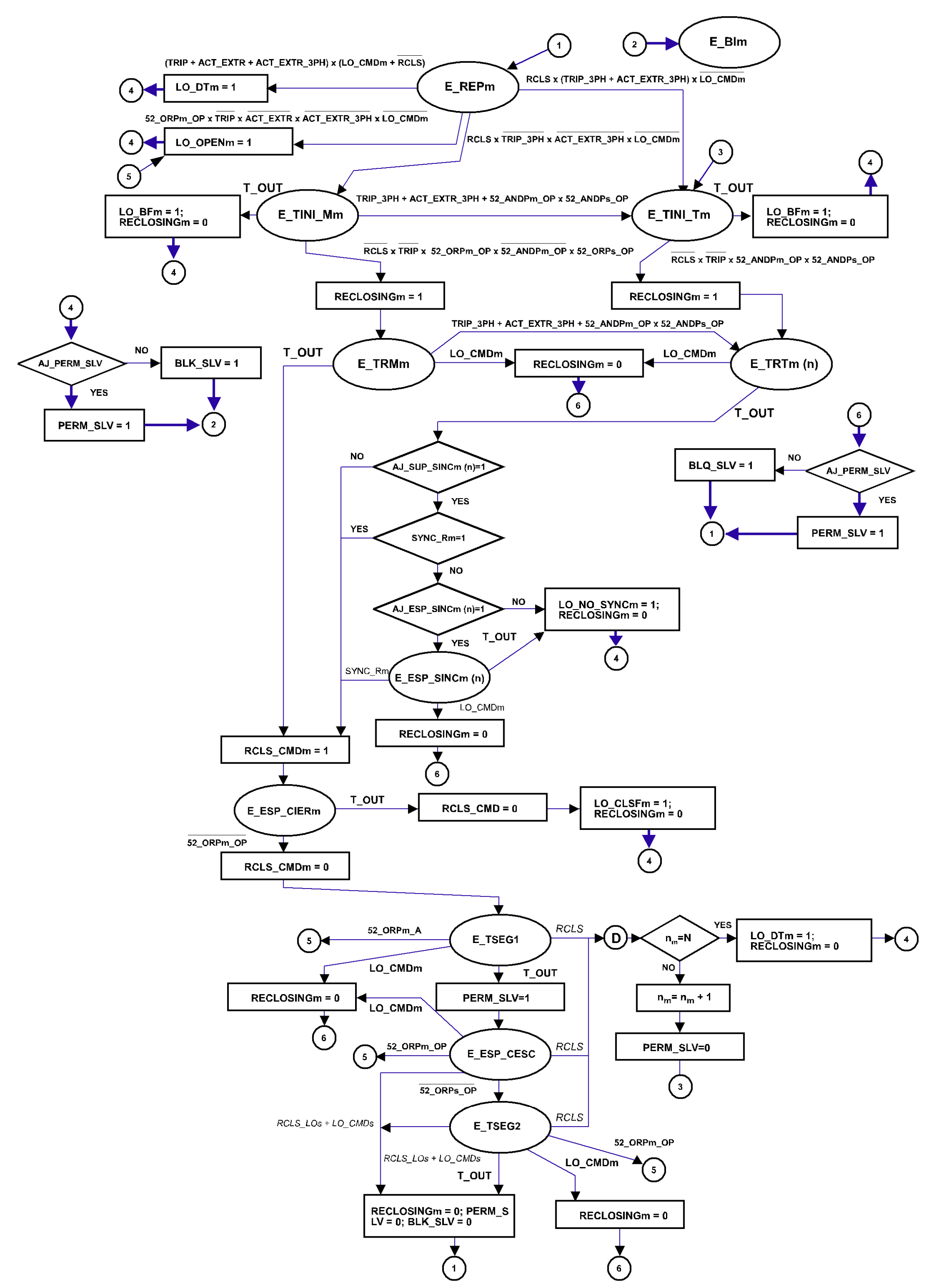


Figure 3.26.13: 1P/3P Mode Master Recloser (ZLV-G/J).

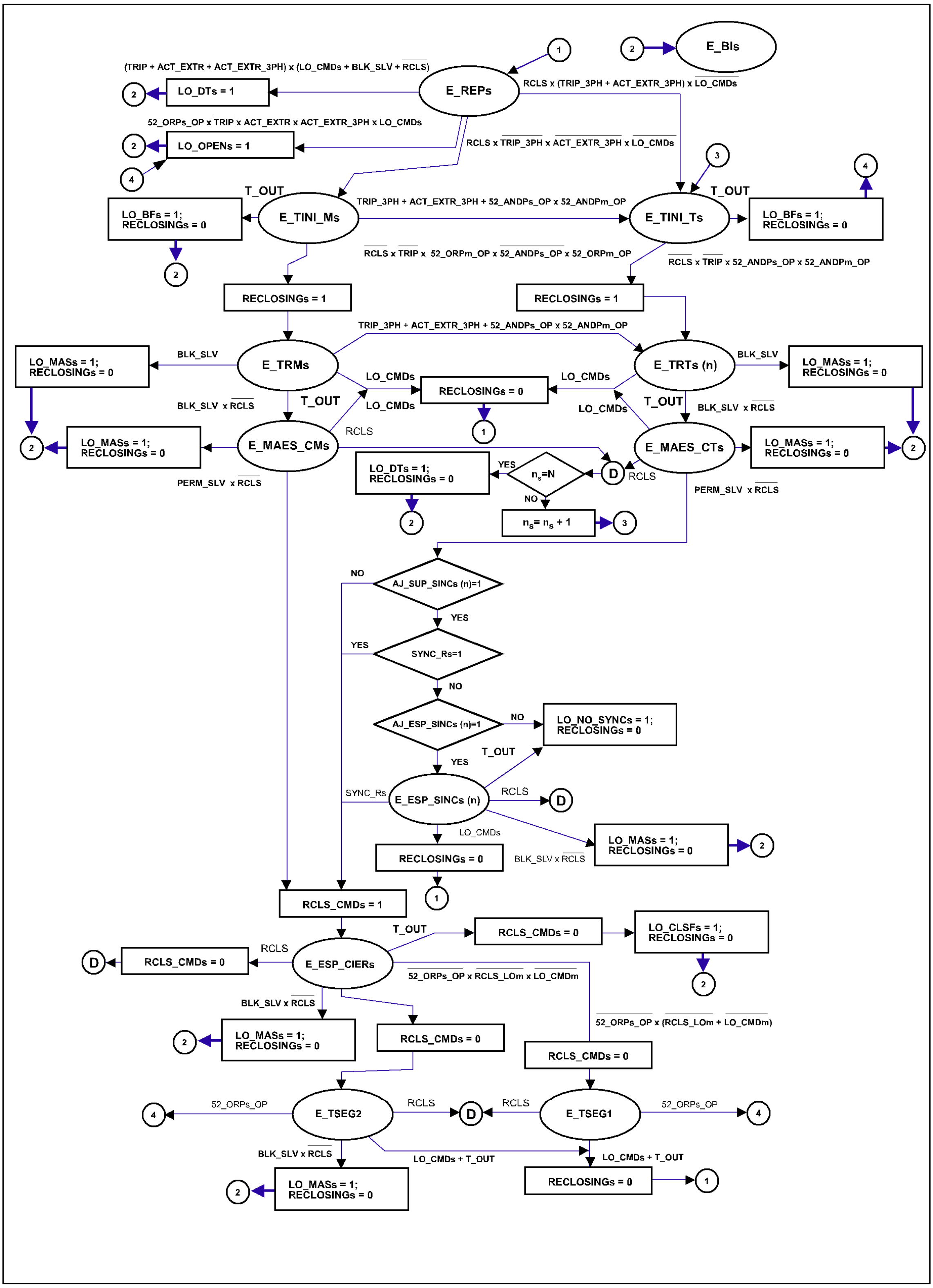


Figure 3.26.14: 1P/3P Mode Slave Recloser (ZLV-G/J).

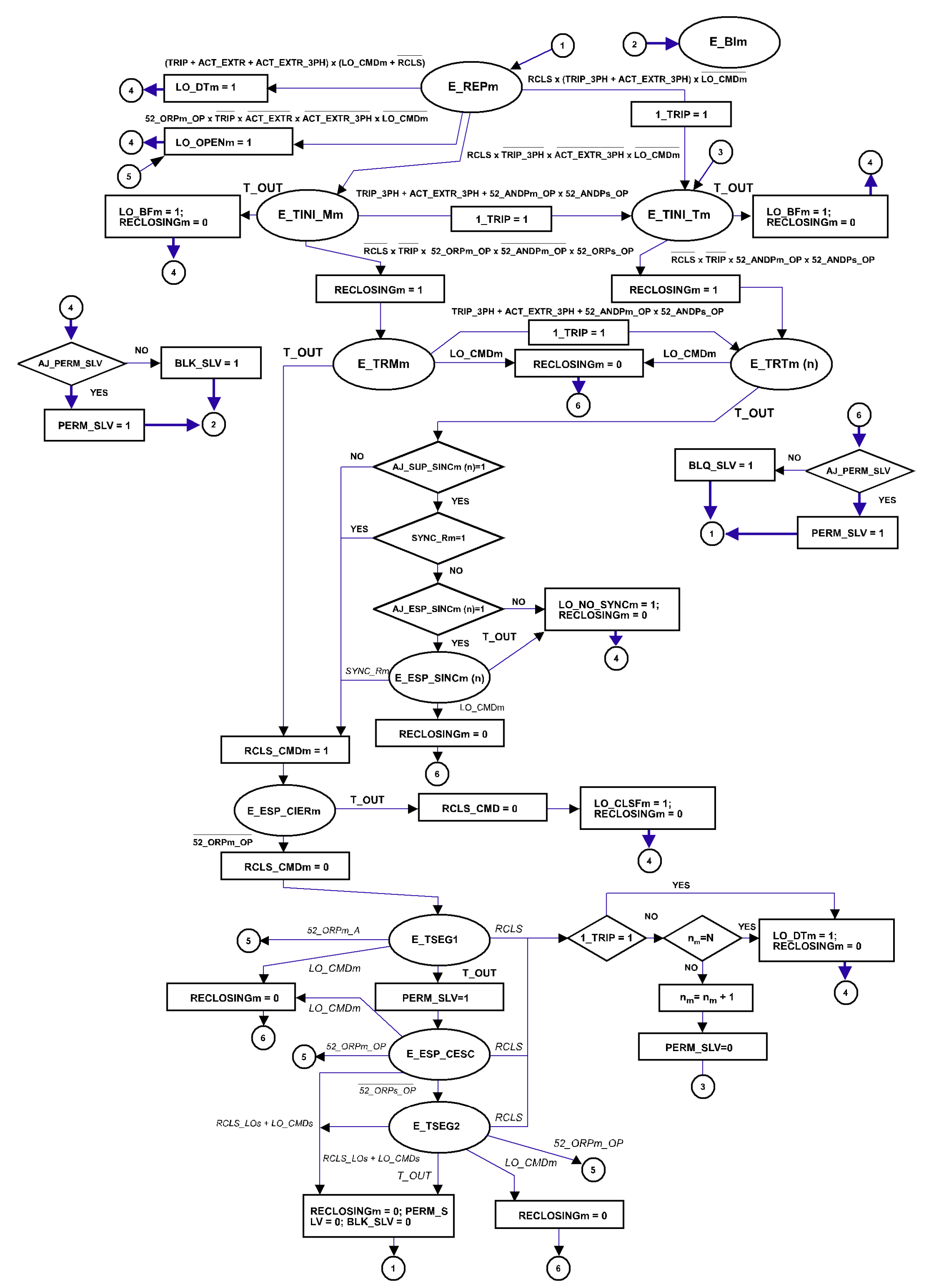


Figure 3.26.15: Dependent Mode Master Recloser (ZLV-G/J).

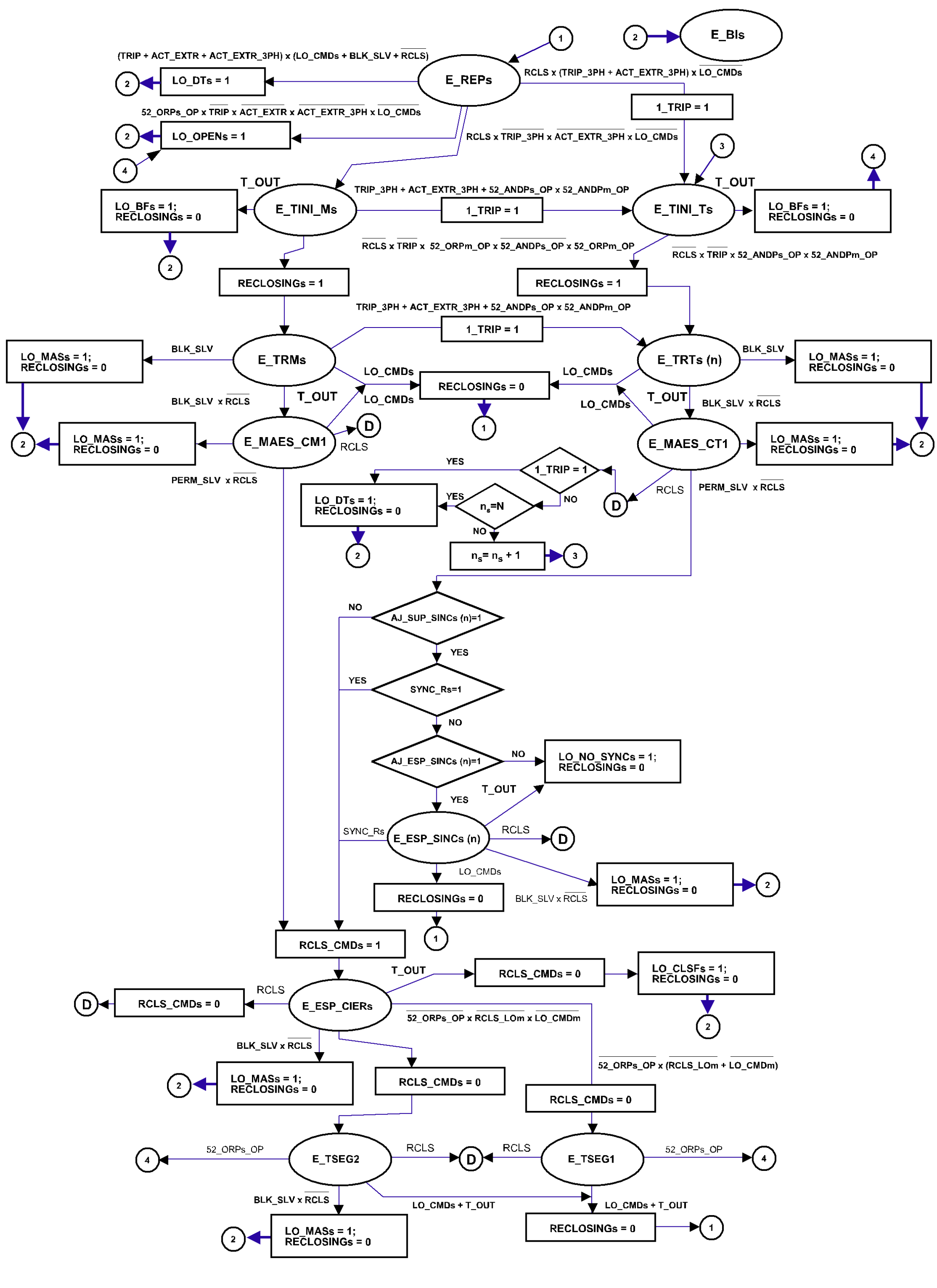


Figure 3.26.16: Dependent Mode Slave Recloser (ZLV-G/J).

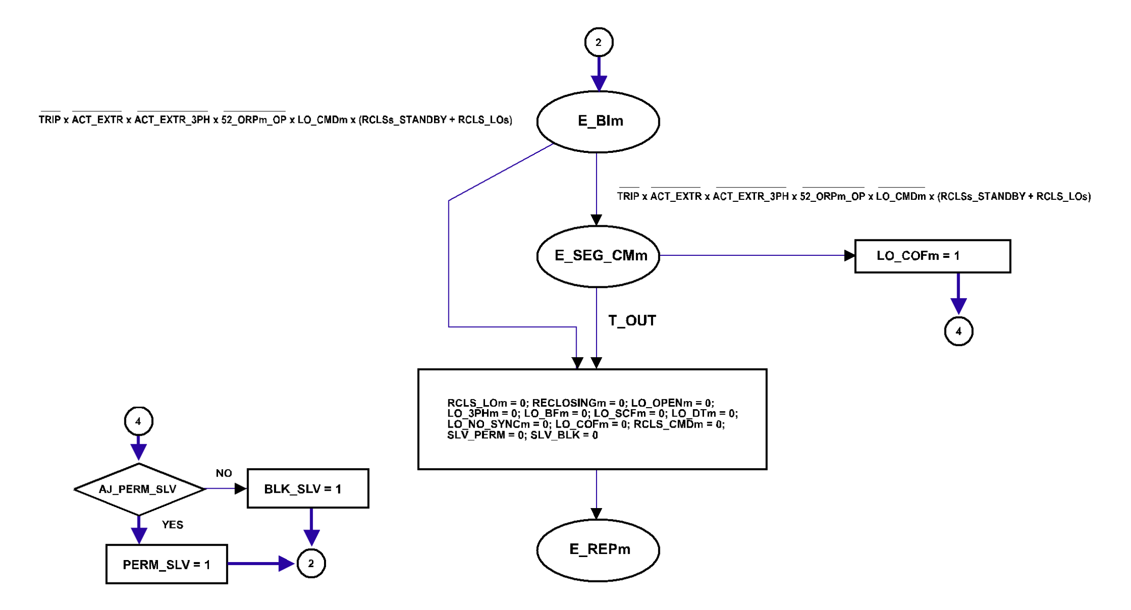


Figure 3.26.17: Internal Recloser Master Recloser (ZLV-G/J).

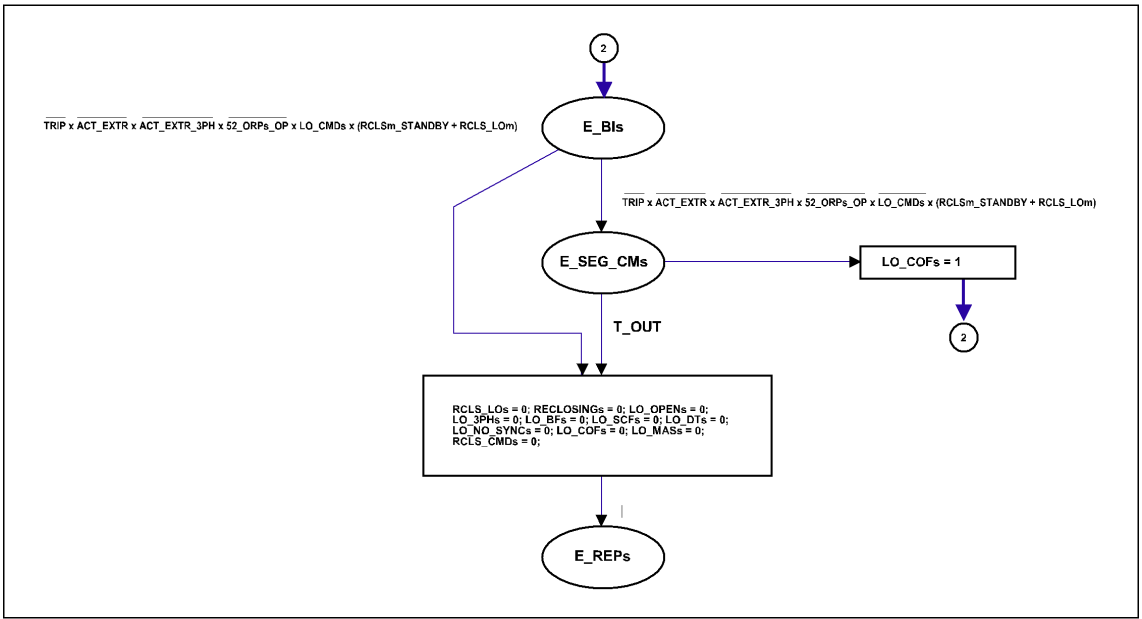


Figure 3.26.18: Internal Recloser Slave Recloser (ZLV-G/J).

3.26.5 Reclose Sequence

Up to three reclose attempts can be programmed in the reclose sequence. A sequence of operations takes place during each of these close attempts which is controlled by the recloser settings and by certain external events, detected through the digital input system or received from the protection units contained in the **ZLV** IED itself.

Below are represented the different states of the automatic reclose function, with only one recloser (**ZLV-A/B/E/F/H** and **ZLV-G/J** relays when selecting **1 Recloser** option through the **Reclosers in operation** setting) or two reclosers (**ZLV-G/J** relays when selecting **2 Reclosers** through the **Reclosers in operation** setting).

3.26.5.a Sequence Start

- **Automatic Recloser with 1 Recloser. ZLV-B/F/G/J Models**

The **ZLV-B/F/G/J** Recloser presents two start time states (**Single-Phase Start Time** state and **Three-Phase Start Time** state).

When the recloser is in the Recloser Reset state, reclosing is initiated as follows:

- In **1P Mode**, the operation starts on a single-phase trip being produced by any of the enable protection units or by the **External Trip Activation** (**ACT_EXTR**) signal, with the **External Three-Phase Activation Trip** (**ACT_EXTR_3PH**) deactivated.

  In either of the two cases, the **RCLS** signal will be activated, which will remove the Recloser from its Reset state to change it to the Single-Phase Start Time state provided the recloser is not blocked by command (see 3.26.7).

  If the **RCLS** activation is due to **Three-Phase Trip** (**TRIP_3PH** or **ACT_EXTR_3PH**), the Recloser evolves the Internal **Blocking due to Three-Phase Trip** state instead of starting a reclose sequence.

- In **3P Mode**, the operation starts on one of the enabled protection units producing a three-phase trip or by the **External Three-Phase Activation Trip** (**ACT_EXTR_3PH**) signal.

  In either of the two cases, the **RCLS** signal will be activated, which will remove the Recloser from its Reset State to change it to the **Three-Phase Start Time** state provided the recloser is not blocked by command (see 3.26.7).

- In **1p/3p** and **Dependent** modes, the operation of the Recloser is based on the combination of the two previous modes (**1p** for single-phase trips and **3p** for three-phase trips).

Single-Phase Sequence Start

In the **Single-Phase Start Time** state, a time counter with **Start Time** setting is put into operation. If this time ends before detecting the fault reset (**RCLS** reset), the opening of the breaker ($OR\_P\_OP \times \overline{AND\_P\_OP}$ in **ZLV-B/F** relays or $52\_ORPm\_OP \times \overline{52\_ANDPm\_A}$ in **ZLV-G/J** relays) and the trip drop (**TRIP**), the system evolves to the **Internal Blocking Due to Breaker Failure** state, from which it can only leave through a close command to the breaker. Otherwise, the single-phase sequence starts activating the **RECLOSINGm** (Sequence in Progress) signal and generating the Recloser Sequence Start. The activation of **RECLOSING** produces the activation of **3PH_PREP** (**Three-Phase Trip Ready** signal), as is indicated in the single-phase/three-phase Tripping Logic, with which the following trips will be three phase up to the deactivation of **RECLOSINGm**.

Note: The RECLOSINGm signal will remain activated during the entire recloser m sequence, since the first attempt sequence will continue until the recloser switches to the Reset or the Lockout state.

If the single-phase trip evolves to three-phase before the initiate timer times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip**, in **1p Mode**.
- **Three-Phase Initiate Time**, in **1p/3p** and **Dependent Modes**.

Three-Phase Sequence Start

In the **Three-Phase Start Time** state, a time counter is put into operation with the **Start Time** setting. As in the single-phase case, if this time ends before the fault reset is detected (**RCLS** reset), the opening of the breaker (**OR_P_OP** in **ZLV-B/F** relays or **52_AND_OPm** in **ZLV-G/J** relays) and trip drop (**TRIP**), the system evolves to the Internal Blocking Due to Breaker Failure state, from which it can only leave through a close command to the breaker. Otherwise, the three-phase sequence commences activating the **RECLOSINGm** (Sequence in Progress) signal and generating the Recloser Sequence Start. The activation of **RECLOSING** produces the activation of **3PH_PREP** (**Three-Phase Trip Ready** signal), as is indicated in the single-phase/three-phase Tripping Logic, with which the following trips will be three phase up to the deactivation of **RECLOSINGm**.

Note: The RECLOSINGm signal will remain activated during the entire recloser m sequence, since the first attempt sequence will continue until the recloser switches to the Reset or the Lockout state.

If the single-phase trip evolves to three-phase (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or if the breaker opens its three poles (activation of **AND_P_OP** in **ZLV-A/B/F** relays or **52_ANDPm_OP** in **ZLV-G/J** relays only) before the initiate timer times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip**, in **1p Mode**.
- **Three-Phase Initiate Time**, in **1p/3p** and **Dependent Modes**.

• Automatic Recloser with 1 Recloser. ZLV-A/E/H Models

From a Recloser Reset state, the operation of the recloser commences on producing a Three-Phase Trip by any of the protection units enabled or by the **External Three-Phase Trip Activation** (**ACT_EXTR_3PH**) signal.

In either of the two cases, the **RCLS** signal will be activated, which will remove the Recloser from its Reset state to change it to the Start Time state provided that the Recloser is not in manual block.

In the **Start Time** state, a time counter with **Start Time** setting is put into operation. If this time ends before detecting the fault reset (**RCLS** reset), the opening of the breaker (**OR_P_OP**) and the trip drop (**TRIP**), the system evolves into the Internal **Blocking Due to Breaker Failure** state, from which it can only leave through a **Close Command** to the breaker. Otherwise, the sequence commences activating the **RECLOSING** (**Sequence in Progress**) signal and generating the Recloser Sequence start.

Note: The RECLOSING signal will remain activated during the entire recloser sequence, since the first attempt sequence will continue until the recloser switches to the Reset or the Lockout state.

- **Automatic Reclose with Two Reclosers: Master Recloser (m) and Slave Recloser (s). ZLV-G/J Models**

Both **ZLV-G/J** relays reclosers, whether master or slave, has two initiate time states (**Single-phase Start Time** state and **Three-phase Start Time** state).

Starting from a reset situation, the recloser operation initiates as follows:

- In **1p Mode**, the operation initiates upon a single-phase trip by any enabled protection element or by the **External Trip Activation** (**ACT_EXTR**) signal, the **External Three-phase Trip Activation** (**ACT_EXTR_3PH**) being deactivated. In either case, signal **RCLS** will be activated, bringing each recloser to the **Single-phase Start Time**, provided they are not blocked by command (see paragraph 3.26.7). If **RCLS** is activated by a three-phase trip (**TRIP_3PH** or **ACT_EXTR_3PH**), the recloser evolves to **Internal Lockout on Three-phase Trip** state instead of initiating a reclose sequence.

- In **3p Mode**, the operation initiates upon a three-phase trip by any enabled protection element or by the **External Three-phase Trip Activation** (**ACT_EXTR_3PH**) signal. In either case, signal **RCLS** will be activated, which will bring each recloser out of the reset state into the **Three-phase Start Time** state, provided they are not blocked by command (see paragraph 3.26.7).

- In **1p/3p** and **Dependent Modes**, recloser operation is based on the combination of the two modes above (**1p** for single-phase trips and **3p** for three-phase trips).

The above conditions, initiating the recloser operation (switching from the **Reset** state into the **Initiate Time** state), are the same for both reclosers, whether master or slave, so that, if neither is blocked by command, both will switch into the same **Start Time** state (single-phase or three-phase) and this will happen at the same time.

Single-phase Sequence Start for the Master Recloser (m)

At **Single-phase Start Time** state a timer set to **Start Time** setting starts timing. If the timer times out before detecting the reclose initiate signal reset (**RCLS**), the single-phase opening of the breaker associated to the master recloser ($52\_ORPm\_OP \times \overline{52\_ANDPm\_A}$), the opening of any pole of the other breaker (**52_ORPs_OP**) and the trip (**TRIP**), the recloser evolves to the **Internal Lockout on Start Failure** state, which can only be reset under the conditions stated in paragraph 3.26.6. Otherwise, the single-phase sequence initiates and the **RECLOSINGm** (**Recloser m in Sequence in Progress**) signal activates. The **RECLOSINGm** activation causes the activation of **3PH_PREP** (**Three-phase Trip Preparation** signal), as shown in the single / three-phase trip logic, so that the following trips are three-phase until **RECLOSINGm** is deactivated.

Note: the RECLOSINGm signal remains active for the complete recloser m sequence (from the start of the first sequence until the recloser resets or switches to internal lockout).

If the single-phase trip evolves to three-phase (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or both breakers open their three poles (**52_ANDPm_OP x 52_ANDPs_OP**) before the **Start Time** times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**.
- **Three-Phase Start Time** state, in **1p/3p** and **Dependent Modes**.

The activation of any of the above mentioned **Master Recloser Internal Block** signals, **LO_BFm** (**Recloser m Internal Lockout on Start Failure**) or **LO_3PHm** (**Recloser m Internal Lockout on Three-phase Trip)** generates the **Block** or **Slave Recloser Enable** signals (**BLK_SLV** and **PERM_SLV** respectively) as a function of the **Slave Recloser Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

Single-phase Sequence Start for the Slave Recloser (s)

The above comments on the master recloser are applicable to the slave recloser (swapping the variables m and s), except with regard to **Block** and **Slave Reclose Enable** signal generation, which are characteristic of the master recloser.

As mentioned above, in order for a recloser **Single-phase Start Time** state to reset, apart from **Recloser Start** signal reset, **Trip** and **Single-phase Opening** of the breaker associated to said recloser, the opening of any pole of the breaker associated to the second recloser is required. If said opening has been single-phase, the **Single-phase Start Time** state of both reclosers, master and slave, will reset simultaneously. If the opening has been three-phase, the second recloser will switch to **Internal Lockout on Start Failure**, so that only the first recloser will initiate the reclose sequence.

Three-phase Sequence Start for the Master recloser (m)

At **Three-phase Start Time** state a timer set to **Start Time** setting starts timing. If the timer times out before detecting the **Reclose Start** signal reset (**RCLS**), the three-phase opening of the two breakers (**52_ANDPm_OP** and **52_ANDPs_OP**) and the trip (**TRIP**), the master recloser evolves to the **Internal Lockout on Start Failure** state, which can only be reset under the conditions stated in paragraph 3.26.6. Otherwise, the three-phase sequence initiates and the **RECLOSINGm** (**Recloser m in Sequence in Progress**) signal activates. The **RECLOSINGm** activation causes the activation of **3PH_PREP** (**Three-phase Trip Preparation** signal), as shown in the single / three-phase trip logic, so that the following trips are three-phase until **RECLOSINGm** is deactivated.

Note: the RECLOSINGm signal remains active for the complete recloser m sequence (from the start of the first sequence until the recloser resets or switches to internal lockout).

The activation of any of the above mentioned master recloser **Internal Block** signals, **LO_BFm** (**Recloser m Internal Lockout on Start Failure**) or **LO_3PHm** (**Recloser m Internal Lockout on Three-phase Trip)** generates the **Block** or **Slave Recloser Enable** signals (**BLK_SLV** and **PERM_SLV** respectively) as a function of the **Slave Recloser Enable** setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

Three-phase Sequence Start for the Slave Recloser (s)

The above comments on the master recloser are applicable to the slave recloser (swapping the variables m and s), except with regard to **Block** and slave recloser **Enable** signal generation, which are characteristic of the master recloser.

Inasmuch as the condition to reset the **Three-phase Start Time** state is the same for both reclosers, in case it is complied with, both reclosers will reset at the same time. Otherwise both will switch, also at the same time, to the **Internal Lockout on Start Failure** state.

3.26.5.b Reclosing Timer (Dead Time)

- **Automatic Recloser with 1 Recloser. ZLV-B/F/G/J Models**

There are two different reclosing timers, according to the single-phase or three-phase character of the Reclose start. In both cases, the activation of the **Reclose Command** (**RCLS_CMDm**) will produce the activation of the **Command CLOSEm** output, with the latter giving a **Close Command** to the breaker.

Single-Phase Reclosing Timer

On entering this state (which only occurs in the first sequence of the **1P** and **1P/3P** modes), the adjusted **First Single-Phase Reclosing Time** will commence to be counted.

If a recloser block command is issued (activation of **LO_CMDm**) before the timer times out, the recloser resets without reclosing. On the other hand, if the single-phase trip evolves to three-phase (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or if the breaker opens the three poles (activation of signals **AND_P_OP** in **ZLV-B/F** relays or **52_ANDPm_OP** in **ZLV-G/J** relays) before the single-phase reclose time times out, the recloser m switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**
- **Three-Phase Initiate Time** state, in **1p/3p** and **Dependent Modes**

Otherwise, if the counted timer times out the **Reclose Command** signal (**RCLS_CMD**) is generated and the **Closing Time** state is achieved.

Three-Phase Reclosing Timer

When the Three-Phase Reclosing Timer state is achieved, the corresponding timer will be started:

- The **First Three-Phase Reclosing Timer** will start for the first reclosing attempt after a three-phase trip.
- The **Second or Third Reclosing Timer** will start for a second or third reclosing sequence (as previously noted, only three-phase reclosing is possible after the first recloser sequence).

As in the single phase wait status, if the recloser is manually blocked (activation of **LO_CMDm**) before time-out, the recloser resets without reclosing. However, if the timer times-out, synchronism conditions are checked and then **RCLS_CMDm** (**Reclose Command**) activates if synchronism conditions and positive sequence voltage are complied with (**ZLV-***-****C/D/E/F/G/H**** relays).

First, the **Synchronism Supervision Enable** setting, adjustable separately for each of the three possible reclose cycles, is checked. If the setting of the current cycle is set to **NO**, **RCLS_CMDm** (**Reclose Command**) is generated and the **Close Delay** status is entered (in **ZLV-H**-****A/B/C/D/E/F/G/H**** relays, the **Positive Sequence Voltage Supervision Enable** setting is first checked).

However, if the enable setting is set to **YES**, **SYNC_Rm** (**SYNC_Rm1** for **ZLV-J** relays), that indicates the presence of synchronism, is checked. If this signal is active, **RCLS_CMDm** is generated and the **Close delay** status is entered (in **ZLV-***-****C/D/E/F/G/H**** relays, the **Positive Sequence Voltage Supervision Enable** setting is first checked).

When synchronous conditions are not reached (**SYNC_Rm** -or **SYNC_Rm1** for **ZLV-J** relays- deactivated), the **Synchronism Timer Enable** setting, independently adjustable for each of the three possible sequences of the recloser function, is checked. If this setting is set to **NO**, the recloser changes to the **Internal Lockout Due to Lack of Synchronism** state. If the setting is set to **YES**, the **Synchronism Wait Timer** starts to count down the adjusted time.

The activation of **SYNC_Rm** (**SYNC_Rm1** for **ZLV-J** relays) before delay time-out generates **RCLS_CMDm** (**Reclose Command**) and the **Close Delay** status is entered (in **ZLV-***-****C/D/E/F/G/H**** relays the **Positive Sequence Voltage Supervision Enable** setting is first checked). Otherwise, the recloser enters the **Internal Blocking by Lack of Synchronism** status.

In **ZLV-***-****C/D/E/F/G/H**** relays, once synchronism has been checked, the **Positive Sequence Voltage Supervision Enable** setting value is checked. If the setting is set to **NO**, **RCLS_CMDm** (**Reclose Command**) is generated and **Close Delay** status is entered.

However, if the enable setting is set to **YES**, the status of **59_VSDm,** that indicates that the positive sequence voltage exceeds the setting value, is checked. If this signal is active, **RCLS_CMDm** is generated and **Close Delay** status is entered.

If the positive sequence voltage does not exceed the setting value (**59_VSDm** deactivated), the **Positive Sequence Voltage Delay Enable** setting value is checked. If the setting value is set to **NO**, the recloser switches to **Internal Blocking by Lack of Positive Sequence Voltage** status. Instead, if the delay setting is set to **YES**, the **Positive Sequence Voltage Delay Time** status is entered, and the **Positive Sequence Voltage Delay Time** starts counting (settable).

The activation of **59_VSDm** before delay time-out generates **RCLS_CMDm** (**Reclose Command**) and **Close Delay** status is entered. Otherwise, the recloser switches to **Internal Blocking by Lack Of Positive Sequence Voltage** status.

- **Automatic Recloser with 1 Recloser. ZLV-A/E/H Models**

On entering this state it will commence to count the corresponding **Reclosing Time** (first, second or third reclosing).

If the recloser is manually blocked (**LO_CMD** activation) before the count ends, the Recloser returns to Reset state without reclosing. On the other hand, if the count ends, it is verified if synchronism conditions exist and then **RCLS_CMD** (Reclose Command) is activated if the synchronism conditions have been previously fulfilled.

The **Synchronism Supervision** setting may be adjusted independently for each recloser sequence. If the **Synchronism Supervision** setting for the corresponding sequence is set to **NO**, the **Reclose Command** signal (**RCLS_CMD**) is generated and the **Closing Time** state is achieved. If the **Synchronism Supervision** setting is set to **YES**, the next step is to check the **SYNC_R** signal, which indicates the presence of synchronous conditions. If this signal is activated, the **Reclose Command** signal (**RCLS_CMD**) is generated and the **Closing Time** state is achieved.

When synchronous conditions are not reached (**SYNC_R** deactivated), the **Synchronism Timer Enable** setting, independently adjustable for each of the three possible sequences of the recloser function, is checked. If this setting, for the corresponding sequence, is set to **NO**, the Recloser changes to the **Internal Lockout Due to Lack of Synchronism** state. If the setting is set to **YES**, the **Synchronism Wait Timer** starts to count down the adjusted time.

Activation of the **SYNC_R** signal before timeout generates activation of the **Reclose Command** signal (**RCLS_CMD**), and the **Closing Time** state is achieved. If the **SYNC_R** signal is not activated before timeout, the Recloser changes to the **Internal Lockout Due to Lack of Synchronism** state.

The activation of the **Reclose Command** (**RCLS_CMD**) will produce the activation of the **Command CLOSE** output, with the latter giving a close command to the breaker.

- **Automatic Reclose with Two Reclosers. ZLV-G/J Models**

For both reclosers, master and slave, there exist two reclose time waiting states, as a function of the single-phase or three-phase character of the reclose initiation. In both cases, the activation of the **Reclose command** (**RCLS_CMDm/s**) will cause the activation of the **CLOSEm/s Command** output, the latter issuing a **Close command** to the corresponding breaker.

Master Recloser (m) Single-Phase Reclose Time

When this state is reached (which only occurs on the first sequence of **1p** and **1p/3p Modes**) the **First single-phase reclose time** setting starts timing.

If a **Recloser Block Command** is issued (activation of **LO_CMDm**) before the timer times out, the master recloser resets without reclosing. On the other hand, if a three-phase trip occurs (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or both breakers open their three poles (**52_ANDPm_OP and 52_ANDPs_OP**) before the single-phase reclose time times out, the master recloser switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**.
- **Three-Phase Reclose Time** state, in **1p/3p** and **Dependent Modes**.

But, if the single-phase reclose time times out, **RCLS_CMDm** (**Breaker m Reclose Command**) activates and **Close waiting time** state is reached.

Activating **LO_3PHm** (**Recloser m Internal Lockout on Three-phase Trip**) or **LO_CMDm** (**Recloser m Lockout on Command)** signals generates the **Block** or **Slave Recloser Enable** signals (**BLK_SLV** and **PERM_SLV** respectively) as a function of the "**Slave Recloser Enable**" setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

Slave Recloser (s) Single-Phase Reclose Time

When this state is reached (which occurs only in the first sequence of **1p** and **1p/3p Modes**) the **First Single-phase Reclose Time** setting starts timing.

If a **Recloser Block Command** is issued (activation of **LO_CMDm**) before the timer times out, the slave recloser resets without reclosing. On the other hand, if a **Three-phase Trip** occurs (activation of **TRIP_3PH** or **ACT_EXTR_3PH** signals) or both breakers open the three poles (**52_ANDPm_OP** and **52_ANDPs_OP**) before the **Single-phase Reclose Time** times out, the master recloser switches to:

- **Internal Lockout on Three-Phase Trip** state, in **1p Mode**.
- **Three-Phase Reclose Time** state, in **1p/3p** and **Dependent Modes**.

Similarly, if the master recloser activates the **Slave Recloser Block Command**, this will go into **Internal Lockout on Master Command** state, which will reset only if the conditions stated in paragraph 3.26.6 are complied with.

If the **Single-phase Reclose Time** times out, the slave recloser switches to **Waiting for Master Recloser after Single-phase Sequence** state.

Master Recloser (m) Three-Phase Reclose Time

When going into this state the corresponding set time starts timing:

- **First Three-phase Reclose Time**, when it refers to the first reclose due to a three-phase trip.
- **Second or Third Reclose Time**, when it refers to a second or third retry (as mentioned above, recloses other than the first will always be three-phase).

Similarly than for the single-phase sequence, if a **Recloser Block Command** is issued (activation of **LO_CMDm**) before the timer times out, the recloser **Resets** without reclosing. On the other hand, if the timer times out, synchronism conditions are checked.

First, the **Synchronism Supervision Enable** setting, adjustable separately for each of the three possible reclose cycles and each breaker, is checked. If the setting of the current cycle is set to **NO**, **RCLS_CMDm** (**Breaker m Reclose Command**) is generated and the **Close Delay** status is entered (in **ZLV-***-****C/D/E/F/G/H**** relays, the **Positive Sequence Voltage Supervision Enable** setting is first checked).

However, if the **Enable** setting is set to **YES**, **SYNC_Rm** (**SYNC_Rm1** for **ZLV-J** relays), that indicates the presence of synchronism for breaker m, is checked. If this signal is active, **RCLS_CMDm** is generated and the **Close Delay** status is entered (in **ZLV-***-****C/D/E/F/G/H**** relays, the **Positive Sequence Voltage Supervision Enable** setting is first checked).

If there is no synchronism (**SYNC_Rm** -**SYNC_Rm1** for **ZLV-J** relays- deactivated), **Synchronism Waiting Enable** setting value, adjustable separately for each of the three possible sequences and for each breaker, is checked. If the setting corresponding to the present sequence is set to **NO**, the recloser goes into **Internal Lockout on Lack of Synchronism** state. If, on the other hand, the waiting setting is set to **YES**, **Synchronism Waiting Time** state is reached, at which **Synchronism Waiting Time** (adjustable) starts timing.

The activation of **SYNC_Rm** (**SYNC_Rm1** for **ZLV-J** relays) before delay time-out generates **RCLS_CMDm** (**Breaker m Reclose command**) and the **Close Delay** status is entered (in **ZLV-***-****C/D/E/F/G/H**** relays the **Positive Sequence Voltage Supervision Enable** setting is first checked). Otherwise, the recloser enters the **Internal Blocking by Lack of Synchronism** status.

In **ZLV-***-****C/D/E/F/G/H**** relays, once synchronism has been checked, the **Positive Sequence Voltage Supervision Enable** setting value is checked. If the setting is set to **NO**, **RCLS_CMDm** (**Reclose command**) is generated and **Close Delay** status is entered.

However, if the enable setting is set to **YES**, the status of **59_VSDm,** that indicates that the positive sequence voltage exceeds the setting value, is checked. If this signal is active, **RCLS_CMDm** is generated and **Close Delay** status is entered.

If the positive sequence voltage does not exceed the setting value (**59_VSDm** deactivated), the **Positive Sequence Voltage Delay Enable** setting value is checked. If the setting value is set to **NO**, the recloser switches to **Internal Blocking by Lack of Positive Sequence Voltage** status. Instead, if the delay setting is set to **YES**, the **Positive Sequence Voltage Delay Time** status is entered, in which the **Positive Sequence Voltage Delay Time** starts counting (settable).

The activation of **59_VSDm** before delay time-out generates **RCLS_CMDm** (**Reclose Command**) and **Close Delay** status is entered. Otherwise, the recloser switches to **Internal Blocking by Lack of Positive Sequence Voltage** status.

The activation of **LO_NO_SYNCm** (**Recloser m Internal Blocking by Lack of Synchronism**) or **LO_NO_VSDm** (**Recloser m Internal Blocking by Lack of Positive Sequence Voltage**) or **LO_CMDm** (**Recloser m internal blocking by command**) signals will generate the **Blocking** or **Slave Recloser Enable** signals as a function of the **Slave Enable** setting. The purpose of this setting is to allow the slave recloser to continue the reclose cycle when the master recloser reaches a **Blocking** situation.

Slave Recloser (s) Three-Phase Reclose Time

When this state is reached, the corresponding set time starts timing:

- **First Three-phase Reclose Time**, when it refers to the first reclose due to a three-phase trip.
- **Second or Third Reclose Time**, when it refers to a second or third retry (as mentioned above, recloses other than the first will always be three-phase).

Similarly than for the single-phase sequence, if a **Recloser Block Command** is issued (activation of **LO_CMDs**) before the timer times out, the recloser **Resets** without reclosing. On the other hand, if the master recloser activates the **Slave Recloser Block Command**, it will go into **Internal Lockout on Master Command** state, which will reset only if the conditions stated in paragraph 3.26.6 are complied with.

If the corresponding **Three-phase Reclose Time** times out, the slave recloser switches to **Waiting for Master Recloser after Three-phase Sequence** state.

3.26.5.c Waiting for Master Recloser. ZLV-G/J Models

When the slave recloser **Reclose Time** times out (single-phase or three-phase) the **Waiting for Master Recloser** state is reached (after single-phase or three-phase sequence). In said state, the slave recloser will be waiting for the master recloser to complete the reclose sequence, supervising the following signals:

- **Slave Recloser Enable**: this signal activates when the master recloser successfully completes one reclose (transient fault: **Security Time 1** times out without a new trip, see paragraph 3.26.6.e) or when it goes into **Internal Lockout** and **Slave Recloser Enable** is set to **YES**. Activating this signal allows the slave recloser to carry on its reclose sequence, activating directly the **RCLS_CMDs (Breaker s Reclose Command)** signal and switching to **Waiting Reclose** state if the reclose sequence has been single-phase or checking whether synchronism conditions exist if the reclose sequence has been three-phase. In the latter case all comments on the supervision of synchronism in the three-phase reclose sequence for the master recloser are applicable to the slave recloser, swapping variables m and s. In **Synchronism Waiting Time** state, as the breaker associated to the master recloser might already be closed (master recloser in **Waiting for Slave Recloser Closing** state**,** see paragraph 3.26.5.d), a fault can occur (transient, as the master recloser **Security Time 1** has timed out). Thus, during the **Synchronism Waiting Time** state**,** the slave recloser will be supervising the reclose initiate **(RCLS)** signal, in order to start the new three-phase reclose sequence or go into **Internal Lockout on Final Trip** depending on conditions.
- **Slave Recloser Block**: this signal activates when the master recloser goes into internal lockout, the "**Slave Recloser Enable**" setting being set to **NO**. Activating this signal brings the slave recloser into the **Internal Lockout on Master Command** state.
- **Reclose Initiate Signal (RCLS)**: if the fault is permanent, when the breaker associated to the master recloser closes, a new trip will occur, and the **Reclose Initiate** (**RCLS**) signal will activate before **Security Time 1** times out. If the conditions for a new reclose sequence are met (see paragraph 3.26.5.e) both reclosers, master and slave, will switch to the **Three-phase Initiate Time** state, otherwise, both will go into the **Internal Lockout on Final Trip** state.
- **Slave Recloser Block Command (LO_CMDs)**: activating this signal resets the slave recloser without reclosing.

The purpose of the waiting for master recloser state is to prevent both breakers from closing and opening on permanent faults, to avoid unnecessary wear.

3.26.5.d Closing Time

- **Automatic Reclose with One Recloser**

After issuing the **Reclose Command**, the recloser switches to the **Waiting for closing** state, in which setting **Close Command Failure Time** set via the **Command** module (see paragraph 3.26) starts timing. If the timer times out before the three poles of the breaker close (deactivation of the **Any Pole Open**, **OR_P_OP** signal, in **ZLV-A/B/E/F/H** relays or deactivation of **Any Pole Open by Contact State, 52_ORPm_OP**, in **ZLV-G/J** relays) the **FAIL_CLSm** output (**Close Command Failure**) activates and the recloser switches to **Internal Lockout on Close Failure** state. If during the **Command Failure** time the three breaker poles are closed, the recloser will switch to **Security Time** state.

In both cases, the **RCLS_CMD** output will be deactivated.

- **Automatic Reclose with Two Reclosers ZLV-G/J (Model)**

Waiting for Master Recloser (m) to Close

After issuing the **Reclose Command**, the master recloser switches to the **Waiting for Closing** state, in which setting **Close Command Failure Time** set via the **Command** module (see paragraph 3.26) starts timing. If the timer times out before **52_ORPm_OP** (**Any Breaker m Pole Open by Contact State**) signal deactivates, output **FAIL_CLSm** (**Breaker m Close Command Failure**) activates and the recloser switches to **Internal Lockout on Close Failure** state. If during the close command failure time, the signal **52_ORPm_OP** deactivates, which implies breaker m is closed, the master recloser switches to **Security Time 1**.

In both cases output **RCLS_CMDm** deactivates.

Waiting for Slave Recloser (s) to Close

After issuing the reclose command, the slave recloser switches to the **Waiting for Closing** state, in which setting **Close Command Failure Time** set via the **Command** module (see paragraph 3.26) starts timing. During said time the slave recloser will supervise the following conditions:

- **Master Recloser Block**: this signal activates when the master recloser switches to **Lockout** (internal or on command) while in **Slave Recloser Waiting Time** state, "**Slave enable**" being set to **NO**. Activating this signal brings the slave recloser into the **Internal Lockout on Master Command** state.
- **Closing of Three Breaker Poles** (signal **51_ORPs_OP** negated), the master recloser ($\overline{RCLS\_LOm} \times \overline{LO\_CMDm}$) not being blocked: if at the time of closing the breaker associated to the slave recloser the master recloser is not blocked, this must have gone through **Security Time 1** with no trips (activating the **Slave Recloser Enable Signal**), therefore the fault being transient. In this case, as the slave recloser will not have to discern the nature of the fault, it will switch to **Security Time 2** (see paragraph...) state.
- Closing of three breaker poles (signal **51_ORPs_OP** negated), the master recloser being blocked (**RCLS_LOm or LO_CMDm**): in this case, the **slave recloser enable signal** activates when the master recloser reaches a blocked situation. Said blocked situation generates before the master recloser goes through **Security Time 1**. Therefore, the slave recloser switches to **Security Time 1** state, in order to discern whether it is a transient or permanent fault.
- Reclose initiate signal (**RCLS**): if activated, the slave recloser, together with the master recloser, initiate a new three-phase reclose sequence or switch to **Lockout on Final Trip** depending on conditions.

If **Close Command Failure Time** times out, the signals above not being activated, **FAIL_CLSm** (**Breaker m Close Command Failure**) output activates and the recloser switches to **Internal Lockout on Close Failure** state.

In all cases, the **RCLS_CMDm** output deactivates.

3.26.5.e Security Time

ZLV-B/F Models

When this state is achieved, an adjustable **Security Time** timer is started. This setting is common for all the three reclosing sequences. The **Security Time** setting is used to determine whether two consecutive trips correspond to the same fault that has not been successfully cleared, or to two consecutive faults. If the **Security Time** is completed without a trip being initiated, the recloser switches to the recloser **Reset** state, and the reclose attempt is completed.

If a trip occurs (**RCLS** signal activated) before the **Security Time** is completed, the next step in the reclose sequence is determined by the number of **Reclose Attempts** setting. If a trip occurs after the last reclose attempt permitted by this setting, or if the recloser operates in **Dependent Mode** and the first trip has been three-phase (see consultation of **1_TRIP** signal in Figure 3.26.6), the Recloser switches to **Recloser Lockout Due to Definite Trip**. At this point, the reclose sequence ends. If the Recloser has not reached the last permitted reclose attempt, the trip signal that occurs before the **Reset Time** is completed will initiate a new reclose attempt. The recloser will then switch to the **Three-Phase Sequence Start** state.

Opening any breaker pole before **Security Time** times out switches the recloser to **Lockout due to Open Breaker** state. Also, if a recloser block command is issued before **Security Time** times out, it switches to **Reset** state.

ZLV-A/E/H Models

When the Reset Time state is achieved, an adjustable **Security Time** timer is started. This setting is common for all the three reclosing sequences. The **Security Time** setting is used to determine whether two consecutive trips correspond to the same fault that has not been successfully cleared, or to two consecutive faults. If the **Security Time** is completed without a trip being initiated, the recloser switches to the Recloser **Reset** state, and the reclose attempt is completed.

If a trip occurs (**RCLS** signal activated) before the **Security Time** is completed, the next step in the reclose sequence is determined by the number of **Reclose Attempts** setting. If a trip occurs after the last reclose attempt permitted by this setting, or if the Recloser operates in **Dependent Mode** and the first trip has been three-phase (see consultation of **1_TRIP** signal in Figure 3.26.8), the Recloser switches to **Recloser Lockout Due to Definite Trip**. At this point, the reclose sequence ends. If the Recloser has not reached the last permitted reclose attempt, the trip signal that occurs before the **Security Time** is completed will initiate a new reclose attempt. The recloser will then switch to the **Sequence Start** state.

Opening any breaker pole before **Security Time** times out switches the recloser to **Lockout due to Open Breaker** state. Also, if a recloser block command is issued before **Security Time** times out, it switches to **Reset** state.

3.26.5.f Security Time 1. ZLV-G/J Models

- **Master Recloser**

When reaching this state, a timer with the setting **Security Time 1**, common for the three recloser sequences, starts timing. Said time is used to discern whether two consecutive trips correspond to the same fault, which has not successfully been cleared, or to two consecutive faults. If **Security Time** times out with no trip occurring, the master recloser switches to **Waiting for Slave Recloser** state.

If a trip occurs (**RCLS** signal activated) before **Security Time 1** times out, the next step depends on whether the number of programmed reclose attempts has been reached or not. If this limit has been reached or if the recloser operates in dependent mode the first trip being three-phase (see consultation of **1_TRIP** signal in figure 3.26.15), both reclosers switch to **Internal Lockout on Final Trip**, the sequence being completed. Otherwise, a new trip initiates a new close sequence, both reclosers switching to **Three-phase Initiate Time** state.

Opening any breaker **m** pole before **Security Time 1** times out switches the recloser to **Lockout on Breaker m Open** state. It switches to the **Reset** state if the master recloser is blocked manually before **Security Time 1** times out.

Activating **LO_OPENm** (**Recloser m Internal Lockout on Open Breaker**) or **LO_CMDm** (**Recloser m Lockout on Command)** generates **Block** or **Slave Recloser Enable** (**BLK_SLV** and **PERM_SLV** respectively) signals as a function of "**Slave Recloser Enable**" setting.

- **Slave Recloser**

The slave recloser will go through **Security Time 1** state only if the master recloser does not, namely when the latter has been blocked before said state is reached, enabling the slave recloser.

The above comments on the master recloser are applicable to the slave recloser (swapping the variables m and s), except with regard to **Block** and **Slave Recloser Enable** signal generation, which are characteristic of the master recloser. On the other hand, if **Security Time** times out with no trips occurring, the slave recloser switches to **Reset** state.

3.26.5.g Slave Close Waiting Time. ZLV-G/J Models

At this state, the master recloser waits for the breaker associated to the slave recloser to close, in order for both reclosers switch simultaneously to **Security Time 2** state. In slave close waiting time state, the master recloser supervises the following conditions:

- Deactivation of **52_ORPs_OP (Any Breaker s Pole Open by Contact State)** signal: if this occurs, both reclosers, master and slave, switch to **Security Time 2** state.
- Activation of **Reclose Initiate** signal (**RCLS**): both reclosers initiate a new three-phase reclose sequence or switch to **Internal Lockout on Final Trip** (see paragraph 3.26.9) depending on conditions.
- Activation of **RCLS_LOs (Recloser s Internal Block)** or **LO_CMDs (Recloser s Block on Command)** signals: this condition switches the master recloser to **Reset** state.

3.26.5.h Slave Close Waiting Time. ZLV-G/J Models

If the master recloser goes through **Security Time 1**, and the slave recloser completes its reclose sequence correctly, both reclosers switch to **Security Time 2** state, and this timer starts timing. The purpose of said timer is to allow time to reset the breaker associated to the slave recloser, in case a new trip-reclose sequence occurs the time for the next reclose sequence not being enough for said reset.

During **Security Time 2** both reclosers supervise the following signals:

- **Reclose Start** signal (**RCLS**): its activation will cause both reclosers to initiate a new three-phase reclose sequence or switch to **Internal Lockout on Final Trip** (see paragraph 3.26.9) depending on conditions.
- **Recloser Lockout** on command signal (**LO_CMDm/s**): its activation will switch the applicable recloser to **Reset** state.
- Opening of any pole of the breaker associated to the recloser signal (**52_ORPm/s_OP**): activation of said signal will switch the applicable recloser to **Internal Lockout on Open Breaker**.

The master recloser will also supervise the activation of **RCLS_LOs (Recloser s Internal Block)** or **LO_CMDs (Recloser s Block on Command)** signals; said condition switches the recloser to **Reset** state.

On the other hand, the slave recloser will also supervise the activation of the signal form the master recloser (**BLK_SLV**), which will switch the recloser to **Internal Lockout on Master Command** state.

If **Security Time 2** times out and none of these signals activate, both reclosers switch to **Reset** state.

3.26.6 Recloser Lockout

- **Automatic Reclose with One Recloser**

The **Internal Lockout** states correspond to situations in which the Recloser will not initiate its sequence in case of a trip and, consequently, all those produced under these circumstances are definite.

In the previous statement, the Internal Lockout states to which the recloser can arrive once the recloser abandons the reset state as a result of a fault and its corresponding trip are defined. However, there are other circumstances which may result in the internal lockout of the recloser and this is the opening of the breaker not associated with a fault. Under these circumstances, the recloser will change to the **Internal Lockout Due to Open Breaker** state, remaining unable to carry out the closing.

The Recloser will remain in any of the Internal Lockout states reached until it detects the closing of the breaker. When this situation is detected, the Recloser will abandon the **Internal Lockout** state reached and will change to the **Reset Time after an External Closing** state. On entering this state, the count of the **Reset Time after an External Closing** setting commences. If the count ends without any trip having been produced (from the equipment or external), the Recloser will change to Reset state. If, on the other hand, a trip is produced before the time ends, the Recloser will change to the Internal **Blocking Due to Close onto a Fault** state and the trip will be definite, without subsequent reclosing.

- **Automatic Reclose with Two Reclosers. ZLV-G/J Models**

To reset a recloser, master or slave, reaching an **Internal Lockout** state, apart from the controlled breaker to close, the other recloser must be in **Internal Lockout** or **Reset** state. If this situation is detected, the applicable recloser will reset from **Internal lockout** switching to **Security Time on External Closing** state. At this state, **Security Time on External Closing** timer starts timing. If the timer times out with no trips occurring (by own or external relay), the recloser switches to **Reset** state. If, otherwise, a trip occurs before the timer times out, the recloser switches to **Internal Lockout on Switch onto Fault (LO_COF**) state and the trip will be final, with no later reclose.

Any internal lockout of the master recloser will activate one of the **Block** or **Slave Recloser Enable** (**BLK_SLV** and **PERM_SLV** respectively) signals as a function of "**Slave Recloser Enable**" setting. The purpose of said setting is to allow the slave recloser to continue the reclose sequence when the master recloser reaches a blocked situation.

3.26.7 Recloser Block Command (Manual or External)

- **ZLV-A/B/E/F/H Models**

The recloser is provided with two types of blocking commands which take it to the Block Command state: **Manual Command** and **External Command**.

The **Manual** and **External Blocking Commands** are produced through the activation of the **INBLK_MAN** (**Recloser Manual Block Command**) and **INBLK_EXT** (**Recloser External Block**) logic inputs, respectively. The objective of the **INBLK_MAN** logic input is to receive signals originating from the HMI or communications (in local or remote mode), while the **INBLK_EXT** logic input is for the purpose of receiving external signals, which will arrive through the digital inputs of the equipment.

Manual Blocking Command is always by pulse; entering into the **Block Command** state will occur with an activation pulse from the **INBLK_MAN** (**Recloser Manual Block Command**), while the exiting of this state requires a complementary unblocking command, which will be issued by an activation pulse of the **IN_UNBLK_MAN** (**Recloser Manual Unblock Command**) input or **IN_UNBLK_EXT** (**Recloser External Unblock Command**) input, provided that the **External Blocking Type** setting is in Pulse.

External Blocking Command may be a pulse or level, according to the **External Blocking Type** setting. When this setting is in **Pulse**, the entry into Block Command state will occur with an activation pulse of the **INBLK_EXT** (**Recloser External Block**) input, while the output of this state will be produced with an activation pulse of the **IN_UNBLK_EXT** (**External Unblocking**) or **IN_UNBLK_MAN** (**Manual Unblocking**) inputs. However, if the **External Blocking Type** setting is **Level**, the blocking as well as the unblocking of the Recloser will be produced through the **INBLK_EXT** input. If this input is at **1**, the Recloser will be blocked; if it is at **0**, it will be unblocked. In this case, while the **INBLK_EXT** input is activated, the state of the **IN_UNBLK_EXT** and **IN_UNBLK_MAN** inputs will not be considered; even if these inputs are at **1**, the Recloser will continue to be blocked.

If the Recloser is in a reclose sequence, it will be stopped on receiving the Block Command, changing to the Reset state. In this state, no reclosing attempt will be made after tripping, which would be, in all cases, definite, generating the **Internal Lockout Due to Definite Trip** event.

If with the recloser blocked and in a reset state, an Unblocking Command is received and the breaker is open, the Recloser would change to **Internal Lockout Due to Open Breaker** state from which it leaves on the breaker closing. If, on the other hand, the breaker is closed, the Recloser will remain in the Reset state.

- **ZLV-G/J Models**

Each recloser, master and slave, has two types of block commands, which will switch the reclosers to **lockout on command** state: **Manual Command** and **External Command**.

Manual and **External Block** commands occur activating logic inputs **INBLK_MANm/s** (**Recloser m/s Manual Block Command**) and **INBLK_EXT** (**Recloser m/s External Block**) respectively. The function of logic input **INBLK_MANm/s** is to receive signals from the *MMI* or through communications (in local and remote modes), whereas logic input **INBLK_EXTm/s** has the function of receiving external signals through relay digital inputs.

Manual Block commands are always by pulse; a recloser is switched to **Block on Command** state via an activation pulse of **INBLK_MANm/s** (**Recloser m/s Manual Block Command**) input, whereas resetting from this state needs an additional unblock command via activation pulse of **IN_UNBLK_MANm/s** (**Recloser m/s Manual Unblock Command**) input or **IN_UNBLK_EXT** (**Recloser m/s External Unblock**) input, provided **Type of External Block** is set to **Pulse**. In order for the recloser to reset from **Lockout on Command** state, apart from the applicable unblock command, the other recloser must be in **Reset** or **Internal Lockout** state.

The **External Block** command can be on pulse or level, as a function of **Type of External Block** setting. When said setting is set to **Pulse**, switching a recloser to **Lockout on Command** state will be via activation pulse of **INBLK_EXT** (**Recloser External Block**) input, whereas said state will be reset via activation pulse of **IN_UNBLK_EXT** (**External Unblock**) or **IN_UNBLK_MAN** (**Manual Unblock**) inputs, provided the other recloser is in **Reset** or **Internal Lockout** state. If **Type of External Block** setting is set to **Level**, both recloser lockout and reset will occur via **INBLK_EXT** input. If said input is set to **1**, the recloser will be blocked; if it is set to **0**, the other recloser being in reset or internal lockout state, it will be unblocked. In this case, the state of **IN_UNBLK_EXT** and **IN_UNBLK_MAN** inputs will not be taken into account while input **INBLK_EXT** remains activated; the recloser remains blocked even if said inputs are set to **1**.

3.26.8 Definite Trip

- **ZLV-A/B/E/F/H Models**

The Recloser will generate a **Recloser in Internal Lockout Due to Definite Trip** (**LO_DT** output) signal when a trip is produced with the **Recloser in Manual Block** or in circumstances such that the Recloser Start Element Activated signal (**RCLS**) is not activated. In this case, the recloser changes to the Internal **Lockout Due to Definite Trip** state.

Although not expressed in the flow diagrams, each time that the **LO_3PH** (**Internal Lockout Due to Three-Phase Trip** -**ZLV-B/F** Model-), **LO_SCF** (**Internal Lockout Due to Breaker Failure**), **LO_BF** (**Internal Lockout Due to Close Failure**) and **LO_NO_SYNC** (**Internal Lockout Due to Synchronism Failure**) signals are activated, the **LO_DT** (**Internal Lockout Due to Definite Trip**) signal should also be activated.

- **ZLV-G/J Models**

What has been said for **ZLV-A/B/E/F/H** relays applies to **ZLV-G/J** relays, bearing in mind that each recloser will have an associated **Internal Block on Final Trip** signal.

3.26.9 Recloser Not in Service

The Recloser is placed in the Not in Service state whenever the Recloser **Enable** setting is **NO**.

If it is required to use an external Recloser with the model **ZLV-B/F/G**, in order to guarantee that all the trips are three phase after a single-phase reclosing, it is necessary to wire the **Sequence in Progress** output of the external Recloser to the **Three-Phase Trip Enable** (**ENBL_3PH**) input.

3.26.10 Reclose Counter

- **ZLV-A/E/H Models**

There is one counter accessible from the operator interface display, which indicate the number of reclose attempts completed. The counter can be reset from the operator interface.

- **ZLV-B/F Models**

There are two counters accessible from the operator interface display, which indicate the number of reclose attempts completed. The counters can be reset from the operator interface. One counter records the number of single-phase reclose attempts, and the second counts the three-phase reclose attempts. For example, when the number of reclose attempts is set to three, and a fault has been successfully cleared after the third trip, the first counter is incremented one count and two counts in the second.

- **ZLV-G/J Models**

ZLV-G/J relays reclosers have two shot counters, one for single-phase and one for three-phase reclosing, similar to the ones described for **ZLV-B/F** relays.

3.26.11 Recloser Settings

Recloser In Service			
Setting	**Range**	**Step**	**By default**
Recloser In Service	YES / NO		NO

Recloser Timers			
Setting	**Range**	**Step**	**By default**
First Single-Phase Reclosing Attempt Delay (ZLV-B/G/J)	0,05 - 300 s	0,01 s	0,1 s
			1 s (*)
First Three-Phase Reclosing Attempt Delay	0,05 - 300 s	0,01 s	0,05 s
			0,5 s (*)
Second Reclosing Attempt Delay	0,05 - 300 s	0,01 s	0,2 s
			1 s (*)
Third Reclosing Attempt Delay	0,05 - 300 s	0,01 s	0,3 s
			1 s (*)
Fourth Reclosing Attempt Delay (ZLV-***-****B/C/D/E/F/G/H**)	0.05 - 300 s	0.01 s	0.4 s
			1 s (*)

(*) ZLV-*-****C/D/E/F/G/H**.**

Sequence Control Time			
Setting	**Range**	**Step**	**By default**
Sequence Check (Start) Time	0.07 - 0.60 s	0.01 s	0.2 s
Security Time (ZLV-A/B/E/F/H)	0.05 - 300 s	0.01 s	10 s
Security Time 1 (ZLV-G/J)	0.05 - 300 s	0.01 s	10 s
Security Time 2 (ZLV-G/J)	0.05 - 300 s	0.01 s	0.5 s
Manual Close Reset Time	0.05 - 300 s	0.01 s	5 s
Synchronism Check Time Delay	0.05 - 300 s	0.01 s	5 s
Positive Sequence Voltage Time Delay (ZLV-***-****C/D/E/F/G/H**)	0.05 - 300 s	0.01 s	5 s

Sequence Control			
Setting	**Range**	**Step**	**By default**
Reclosing Mode (ZLV-B/F/G/J)	1P Mode 3P Mode 1P / 3P Mode Dependent Mode Selection by DI (ZLV-F/G)		1P Mode
Number of Reclose Attempts	1 - 3		3
Number of Reclose Attempts (ZLV-***-****B/C/D/E/F/G/H**)	1 - 4		4
Number of Reclosers in Operation (ZLV-G/J)	1, 2, Selection by DI		1
Master Recloser (ZLV-G/J)	1, 2, Selection by DI		1
Slave Recloser (ZLV-G/J)	YES / NO		YES
External Blocking	Level / Pulse		Level

Recloser Start Mask			
Setting	**In Display**	**Range**	**By default**
Zone 1 Elements	ZONE 1	YES / NO	NO
Zone 2 Elements	ZONE 2	YES / NO	NO
Zone 3 Elements	ZONE 3	YES / NO	NO
Zone 4 Elements	ZONE 4	YES / NO	NO
Zone 5 Elements (ZLV-F/G/H/J)	ZONE 5	YES / NO	NO
Zone 6 Elements (ZLV-***-****C/D/E/F/G/H**)	ZONE 6	YES / NO	NO
Open phase detector	OPEN PHASE	YES / NO	NO
Remote breaker open detector	REM OP BRK	YES / NO	NO
Phase time overcurrent (51-1)	TOC PH1	YES / NO	NO
Phase time overcurrent (51-2)	TOC PH2	YES / NO	NO
Phase time overcurrent (51-3)	TOC PH3	YES / NO	NO
Phase instantaneous overcurrent (50-1)	IOC PH1	YES / NO	NO
Phase instantaneous overcurrent (50-2)	IOC PH2	YES / NO	NO
Phase instantaneous overcurrent (50-3)	IOC PH3	YES / NO	NO
Ground time overcurrent (51N-1)	TOC GND1	YES / NO	NO
Ground time overcurrent (51N-2)	TOC GND2	YES / NO	NO
Ground time overcurrent (51N-3)	TOC GND3	YES / NO	NO
Ground instantaneous overcurrent (50N-1)	IOC GND1	YES / NO	NO
Ground instantaneous overcurrent (50N-2)	IOC GND2	YES / NO	NO
Ground instantaneous overcurrent (50N-3)	IOC GND3	YES / NO	NO
Negative Sequence time overcurrent (51Q-1)	TOC NEG SEQ1	YES / NO	NO
Negative Sequence time overcurrent (51Q-2)	TOC NEG SEQ2	YES / NO	NO
Negative Sequence time overcurrent (51Q-3)	TOC NEG SEQ3	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-1)	IOC NEG SEQ1	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-2)	IOC NEG SEQ2	YES / NO	NO
Negative Sequence inst. overcurrent (50Q-3)	IOC NEG SEQ3	YES / NO	NO
Programmable trip (ZLV- F/G/H/J)	Prog Trip	YES / NO	NO

Synchronism Check Supervision*			
Setting	**Range**	**Step**	**By default**
Synchronism Check supervision enable			
1st reclosing supervision	YES / NO		NO
2nd reclosing supervision	YES / NO		NO
3rd reclosing supervision	YES / NO		NO
4th reclosing supervision (ZLV*******B/C/D/E/F/G/H**)	YES / NO		NO
Synchronism Check wait enable			
1st reclosing wait time	YES / NO		NO
2nd reclosing wait time	YES / NO		NO
3rd reclosing wait time	YES / NO		NO
4th reclosing wait time (ZLV-***-****B/C/D/E/F/G/H**)	YES / NO		NO

(*) Separate for each recloser in ZLV-G/J relays.

Positive Sequence Voltage Supervision (ZLV-***-****C/D/E/F/G/H**)			
Setting	**Range**	**Step**	**By default**
Positive Sequence Voltage Supervision	YES / NO		NO
Positive Sequence Voltage Supervision Waiting	YES / NO		NO
Positive Sequence Voltage Level	0 V - 200 V	1 V	20 V

- Recloser: HMI Access. ZLV-A/B/E/F/H Models

0 - CONFIGURATION	0 - GENERAL	**0 - IN SERVICE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - RECLOSER TIMERS**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - SEQ CONTROL TIMER**
3 - INFORMATION	3 - PROTECTION	**3 - SEQUENCE CONTROL**
	4 - RECLOSER	**4 - RECLOSER INIT MASK**
	…	**5 - SYNCROCHECK SUPERV.**

Recloser Timers (ZLV-B)

0 - IN SERVICE	**0 - 1ST 1PH RECL ATTEMPT**
1 - RECLOSER TIMERS	**1 - 1ST 3PH RECL ATTEMPT**
2 - SEQ CONTROL TIMER	**2 - 2ND RECLOS ATTEMPT**
3 - SEQUENCE CONTROL	**3 - 3RD RECL. ATTEMPT**
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

Recloser Timers (ZLV-A/H)

0 - IN SERVICE	**1 - 1ST RECL ATTEM**
1 - RECLOSER TIMERS	**2 - 2ND RECLOS ATTEMPT**
2 - SEQ CONTROL TIMER	**3 - 3RD RECL. ATTEMPT**
3 - SEQUENCE CONTROL	**4 - 4TH RECL. ATTEMPT (*)**
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

(*) ZLV-*-****B/C/D/E/F/G/H**.**

Sequence Control Timers

0 - IN SERVICE	**0 - START TIME**
1 - RECLOSER TIMERS	**1 - SECURITY TIME**
2 - SEQ CONTROL TIMER	**2 - MC RESET TIME**
3 - SEQUENCE CONTROL	**3 - SYNC WAIT TIME**
4 - RECLOSER INIT MASK	**4 - V1 SUP. WAIT TIME (*)**
5 - SYNCROCHECK SUPERV	

(*) ZLV-*-****C/D/E/F/G/H**.**

Sequence Control (ZLV-B/F)

0 - IN SERVICE	**0 - RECLOSING MODE**
1 - RECLOSER TIMERS	**1 - RECLOSE ATTEMPTS**
2 - SEQ CONTROL TIMER	**2 - EXTERNAL BLOCKING**
3 - SEQUENCE CONTROL	
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

Sequence Control (ZLV-A/H)

0 - IN SERVICE	**0 - RECLOSE ATTEMPTS**
1 - RECLOSER TIMERS	**1 - EXTERNAL BLOCKING**
2 - SEQ CONTROL TIMER	
3 - SEQUENCE CONTROL	
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

Synchronism Check Supervision

0 - IN SERVICE	**0 - SYNC. SUPERV. ENABLE**
1 - RECLOSER TIMERS	**1 - SYNC WAIT ENABLE**
2 - SEQ CONTROL TIME	
3 - SEQUENCE CONTROL	
4 - RECLOSER INIT MASK	
5 - SYNCROCHECK SUPERV	

Positive Sequence Voltage Supervision (ZLV-***-****C/D/E/F/G/H**)

0 - IN SERVICE	
1 - RECLOSER TIMERS	
2 - SEQ CONTROL TIME	
3 - SEQUENCE CONTROL	
4 - RECLOSER INIT MASK	**0 - V1 LEVEL**
5 - SYNCROCHECK SUPERV	**0 - SUPERV ENABLE**
6 - V1 SUPERVISION	**2 - SUP. WAIT ENA**

- **Recloser: HMI access. ZLV-G/J Models**

0 - CONFIGURATION	0 - GENERAL	**0 - IN SERVICE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - RECLOSER NUMBER**
2 - CHANGE SETTINGS	2 - PROTECTION	**2 - MASTER RECLOSER**
3 - INFORMATION	**3 - RECLOSER**	**3 - SLAVE RECLOSER**
	...	**4 - RECLOSER TIMERS**
		5 - SEQ CONTROL TIMER
		6 - SEQUENCE CONTROL
		7 - RECLOSER INIT MASK

Recloser Timers

0 - IN SERVICE	
1 - RECLOSER NUMBER	
2 - MASTER RECLOSER	
3 - SLAVE RECLOSER	**0 - 1ST 1PH RECL ATTEMPT**
4 - RECLOSER TIMERS	**1 - 1ST 3PH RECL ATTEMPT**
5 - SEQ CONTROL TIMER	**2 - 2ND RECLOS ATTEMPT**
6 - SEQUENCE CONTROL	**3 - 3RD RECL. ATTEMPT**
7 - RECLOSER INIT MASK	**4 - 4TH RECL. ATTEMPT (*)**

(*) ZLV-*-****B/C/D/E/F/G/H**.**

Sequence Control Timers

0 - IN SERVICE	
1 - RECLOSER NUMBER	
2 - MASTER RECLOSER	
3 - SLAVE RECLOSER	**0 - START TIME**
4 - RECLOSER TIMERS	**1 - SECURITY TIME**
5 - SEQ CONTROL TIMER	**2 - SECURITY TIME 2**
6 - SEQUENCE CONTROL	**3 - MC RESET TIME**
7 - RECLOSER INIT MASK	**4 - SYNC WAIT TIME**

Sequence Control

0 - IN SERVICE	
1 - RECLOSER NUMBER	
2 - MASTER RECLOSER	
3 - SLAVE RECLOSER	
4 - RECLOSER TIMERS	
5 - SEQ CONTROL TIMER	**0 - RECLOSING MODE**
6 - SEQUENCE CONTROL	**1 - RECLOSE ATTEMPTS**
7 - RECLOSER INIT MASK	**2 - EXTERNAL BLOCKING**

3.26.12 Digital Inputs and Events of the Recloser

Table 3.26-1: Digital Inputs and Events of the Recloser		
Name	**Description**	**Function**
IN_EXT_A	A pole external trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of an A pole trip of the breaker generated by an external protection.
IN_EXT_B	B pole external trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of an B pole trip of the breaker generated by an external protection.
IN_EXT_C	C pole external trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of an C pole trip of the breaker generated by an external protection.
IN_EXT_3PH	Three-phase external trip input	Activation of this input indicates the existence of a three-phase trip of the breaker generated by an external protection.
IN_EXT	External trip input (ZLV-B/F/G/J)	Activation of this input indicates the existence of a trip of the breaker generated by an external protection.
INBLK_MAN	Recloser manual block command (ZLV-A/B/E/F/H)	An activation pulse of this input sends the recloser to the Block Command state.
IN_UNBLK_MAN	Recloser manual unblock command (ZLV-A/B/E/F/H)	An activation pulse of this input removes the recloser from the Block Command state (provided that the External Blocking Type setting is not at level and the BE input is active).
INBLK_MAN1	Recloser 1 manual block command (ZLV-G/J)	An activation pulse of this input sends the recloser 1 to the Block Command state.
IN_UNBLK_MAN1	Recloser 1 manual unblock command (ZLV-G/J)	An activation pulse of this input removes the recloser 1 from the Block Command state (provided that the External Blocking Type setting is not at level and the BE input is active).
INBLK_MAN2	Recloser 2 manual block command (ZLV-G/J)	An activation pulse of this input sends the recloser 2 to the Block Command state.
IN_UNBLK_MAN2	Recloser 2 manual unblock command (ZLV-G/J)	An activation pulse of this input removes the recloser 2 from the Block Command state (provided that the External Blocking Type setting is not at level and the BE input is active).

Table 3.26-1: Digital Inputs and Events of the Recloser		
Name	**Description**	**Function**
INBLK_EXT	Recloser external block command (ZLV-A/B/E/F/H)	An activation pulse of this input sends the recloser to the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_UNBLK_EXT	Recloser external unblock command (ZLV-A/B/E/F/H)	An activation pulse of this input removes the recloser from the Block Command state (provided that the External Blocking Type setting is at Pulse).
INBLK_EXT1	Recloser 1 external block command (ZLV-G/J)	An activation pulse of this input sends the recloser 1 to the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_UNBLK_EXT1	Recloser 1 external unblock command (ZLV-G/J)	An activation pulse of this input removes the recloser 1 from the Block Command state (provided that the External Blocking Type setting is at Pulse).
INBLK_EXT2	Recloser 2 external block command (ZLV-G/J)	An activation pulse of this input sends the recloser 2 to the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_UNBLK_EXT2	Recloser 2 external unblock command (ZLV-G/J)	An activation pulse of this input removes the recloser 2 from the Block Command state (provided that the External Blocking Type setting is at Pulse).
IN_BLKRCLS	Reclose Initiate Block Input (ZLV-F/G/H/J)	Activating said input prevents reclose initiate
RST_NUMREC	Shot counter reset command (ZLV-A/B/E/F/H)	Said input resets the two breaker shot counters (single-phase and three-phase)
RST_NUMREC1	Shot counter reset command breaker 1 (ZLV-G/J)	Said input resets the two breaker 1 shot counters (single-phase and three-phase)

Table 3.26-1: Digital Inputs and Events of the Recloser		
Name	**Description**	**Function**
RST_NUMREC2	Shot counter reset command breaker 2 (ZLV-G/J)	Said input resets the two breaker 2 shot counters (single-phase and three-phase)
ENBL_REC	Recloser Enable Input (ZLV-F/G/H/J)	Activating this input puts the automatic recloser in operation. They can be assigned to level digital inputs or commands from the communications protocol or the HMI. Default value is “1”.
IN_1P	1P Mode Input (ZLV-F/G/J)	Together with input IN_3P, it defines the reclose mode, provided Reclose Mode is set to ED Selection.
IN_3P	3P Mode Input (ZLV-F/G/J)	Together with input IN_1P, it defines the reclose mode, provided Reclose Mode is set to ED Selection.
IN_2REC	2 Reclosers in Operation Input (ZLV-G/J)	Allows selecting the number of reclosers in operation, provided Number of Reclosers in Operation is set to ED selection
IN_1MAS	Master Recloser 1 Input (ZLV-G/J)	Allows selecting the master recloser provided Master recloser is set to ED selection

3.26.13 Digital Outputs and Events of the Recloser

Table 3.26-2: Digital Outputs and Events of the Recloser

Name	Description	Function
RCLS	Recloser start	Recloser start.
RECLOSING	Reclose sequence in progress (ZLV-A/B/E/F/H)	Reclose sequence in progress.
RECLOSING1	Reclose 1 sequence in progress (ZLV-G/J)	Reclose 1 sequence in progress.
RECLOSING2	Reclose 2 sequence in progress (ZLV-G/J)	Reclose 2 sequence in progress.
RCLS_CMD	Recloser command (ZLV-A/B/E/F/H)	Recloser command.
RCLS_CMD1	Recloser command breaker 1 (ZLV-G/J)	Recloser command breaker 1.
RCLS_CMD2	Recloser command breaker 2 (ZLV-G/J)	Recloser command breaker 2.
RCLS_LO	Recloser lockout (ZLV-A/B/E/F/H)	LO_NO_SYNC + LO_DT + LO_CLSF + LO_COF + LO_BF + LO_3PH + LO_OPEN
RCLS_LO1	Recloser 1 lockout (ZLV-G/J)	LO_NO_SYNC1 + LO_DT1 + LO_CLSF1 + LO_COF1 + LO_BF1 + LO_3PH1 + LO_OPEN1 + LO_MAS1
RCLS_LO2	Recloser 2 lockout (ZLV-G/J)	LO_NO_SYNC2 + LO_DT2 + LO_CLSF2 + LO_COF2 + LO_BF2 + LO_3PH2 + LO_OPEN2 + LO_MAS2
LO_NO_SYNC	Recloser lockout due to lack of synchronism (ZLV-A/B/E/F/H)	Recloser lockouts.
LO_NO_SYNC1	Recloser 1 lockout due to lack of synchronism (ZLV-G/J)	
LO_NO_SYNC2	Recloser 2 lockout due to lack of synchronism (ZLV-G/J)	
LO_NO_VSD	Recloser lockout due to positive sequence voltage (ZLV-F**-****C/D/E**)	
LO_NO_VSD1	Recloser 1 lockout due to positive sequence voltage (ZLV-G**-****C/D/E**)	
LO_NO_VSD2	Recloser 2 lockout due to positive sequence voltage (ZLV-G**-****C/D/E**)	
LO_DT	Recloser lockout due to definite trip (ZLV-A/B/E/F/H)	
LO_DT1	Recloser 1 lockout due to definite trip (ZLV-G/J)	
LO_DT2	Recloser 2 lockout due to definite trip (ZLV-G/J)	
LO_BF	Recloser lockout due to breaker close failure (ZLV-A/B/E/F/H)	
LO_BF1	Recloser lockout due to breaker close failure (ZLV-G/J)	
LO_BF2	Recloser lockout due to breaker close failure (ZLV-G/J)	
LO_COF	Recloser lockout due to close-onto-a-fault (ZLV-A/B/E/F/H)	
LO_COF1	Recloser 1 lockout due to close-onto-a-fault (ZLV-G/J)	
LO_COF2	Recloser 2 lockout due to close-onto-a-fault (ZLV-G/J)	

Table 3.26-2: Digital Outputs and Events of the Recloser		
Name	**Description**	**Function**
LO_BF	Recloser lockout due to breaker failure (ZLV-A/B/E/F/H)	Recloser lockouts.
LO_BF1	Recloser 1 lockout due to breaker failure (ZLV-G/J)	
LO_BF2	Recloser 2 lockout due to breaker failure (ZLV-G/J)	
LO_3PH	Recloser lockout due to three-phase trip (ZLV-B/F)	
LO_3PH1	Recloser 1 lockout due to three-phase trip (ZLV-G/J)	
LO_3PH2	Recloser 2 lockout due to three-phase trip (ZLV-G/J)	
LO_OPEN	Recloser lockout due to open breaker (ZLV-A/B/E/F/H)	
LO_OPEN1	Recloser 1 lockout due to open breaker (ZLV-G/J)	
LO_OPEN2	Recloser 2 lockout due to open breaker (ZLV-G/J)	
LO_CMD	Recloser lockout command (ZLV-A/B/E/F/H)	
LO_CMD1	Recloser 1 lockout command (ZLV-G/J)	
LO_CMD2	Recloser 2 lockout command (ZLV-G/J)	
LO_MAS1	Recloser 1 lockout master command (ZLV-G/J)	
LO_MAS2	Recloser 2 lockout master command (ZLV-G/J)	
RESET_C_RNG	Recloser counters reset (ZLV-A/B/E/F/H)	Reset of reclose counter.
RESET_C_RNG1	Recloser breaker 1 counters reset (ZLV-G/J)	
RESET_C_RNG2	Recloser breaker 2 counters reset (ZLV-G/J)	
BLK_CMD	Recloser Block Command (ZLV-A/B/E/F/H)	Recloser block command generated through manual or external block command
BLK_CMD1	Recloser 1 Block Command (ZLV-G/J)	Recloser 1 block command generated through manual or external block command
BLK_CMD2	Recloser 2 Block Command (ZLV-G/J)	Recloser 2 block command generated through manual or external block command

Table 3.26-2: Digital Outputs and Events of the Recloser

Name	Description	Function
UNBLK_CMD	Recloser Unblock Command (ZLV-A/B/E/F/H)	Recloser unblock command generated through manual or external block command
UNBLK_CMD1	Recloser 1 Unblock Command (ZLV-G/J)	Recloser 1 unblock command generated through manual or external block command
UNBLK_CMD2	Recloser 2 Unblock Command (ZLV-G/J)	Recloser 2 unblock command generated through manual or external block command
ACT_EXTR	External trip activation (ZLV-B/F)	Trip indication of any pole of the breaker by external protection.
ACT_EXTR_3PH	External three-phase trip activation	Trip indication of the three poles of the breaker by external protection.
REC_ENBLD	Recloser Enabled (ZLV-F/G/H/J)	Automatic reclose function enabled or disabled state signal.
PERM_SLV	Slave Recloser Enable (ZLV-G/J)	Enable signal for the slave recloser to resume the reclose sequence.
BLK_SLV	Slave recloser lockout (ZLV-G/J)	Signal for the slave recloser to finalize the reclose sequence switching to lockout.
1P	1P Mode Active (ZLV-F/G/J)	Active 1P reclose mode signal.
3P	3P Mode Active (ZLV-F/G/J)	Active 3P reclose mode signal.
1P/3P	1P/3P Mode Active (ZLV-F/G/J)	Active 1P/3P reclose mode signal.
DEP	DEP Mode Active (ZLV-F/G/J)	Active dependent reclose mode signal.
1REC	1 Recloser in Operation (ZLV-G/J)	Single recloser in operation signal.
2REC	2 Reclosers in Operation(ZLV-G/J)	Two reclosers in operation signal.
1MAS	Master Recloser 1 (ZLV-G/J)	Signal states recloser 1 is master.
2MAS	Master Recloser 2 (ZLV-G/J)	Signal states recloser 2 is master.
RCLS1_INSERV	Recloser 1 in Operation (ZLV-G/J)	Signal states recloser 1 is in operation.
RCLS2_INSERV	Recloser 2 in Operation (ZLV-G/J)	Signal states recloser 2 is in operation.
RCLS1_STANDBY	Recloser 1 reset (ZLV-G/J)	Signal states recloser 1 is reset.
RCLS2_STANDBY	Recloser 2reset (ZLV-G/J)	Signal states recloser 2 is reset.

3.26.14 Recloser Parameters

Table 3.26-3: Recloser Parameters		
Name	**Description**	**Function**
C REENG1	Breaker 1 actual reclose sequence (ZLV-G/J)	
C REENG2	Breaker 2 actual reclose sequence (ZLV-G/J)	
REE MONO	Single-phase shot counter (ZLV-B/F)	
REE TRIF	Three-phase shot counter (ZLV-A/B/E/F/H)	
REE MONO 1	Breaker 1 single-phase shot counter (ZLV-G/J)	
REE MONO 2	Breaker 2 single-phase shot counter (ZLV-G/J)	
REE TRIF 1	Breaker 1 three-phase shot counter (ZLV-G/J)	
REE TRIF 2	Breaker 2 three-phase shot counter (ZLV-G/J)	

3.26.15 Recloser Test

3.26.15.a ZLV-A/B/E/F/H Relays

For testing the recloser function, the following is important:

- After a manual closing, the reset time after a manual close should be awaited. If this time is not allowed to expire before generating the trip, the Recloser will become blocked.
- In order to start the reclose sequence, the protection should detect that the breaker is open and that current does not circulate through the phases before concluding the **Sequence Start Time** (setting situated in the **Recloser** - **Sequence Control Time**).
- In order that the recloser carries out the entire sequence up to the definite trip, the trips should be carried out with a time interval between them shorter than the adjusted **Reset Time**.
- The trip and reclose masks should be considered.

Figure 3.26.19 shows how to perform the Recloser test. If the current generator does not cut off the injection before the sequence check times out, the test can be performed either by opening the current circuit (with the breaker itself or by simulating it), or by causing an instantaneous unit trip with a simple pulse. This may be enough for the instantaneous unit to operate and, at the same time, to cease detecting current before the sequence check times out.

In case that three bistables are available to carry out the test, a trip should be wired to each bistable (A pole, B pole, C pole). Similarly, we will obtain one output from each bistable, which we will wire to the **Open A Pole**, **Open B Pole** and **Open C Pole** inputs (instead of wiring the three to **Any Open Pole**).

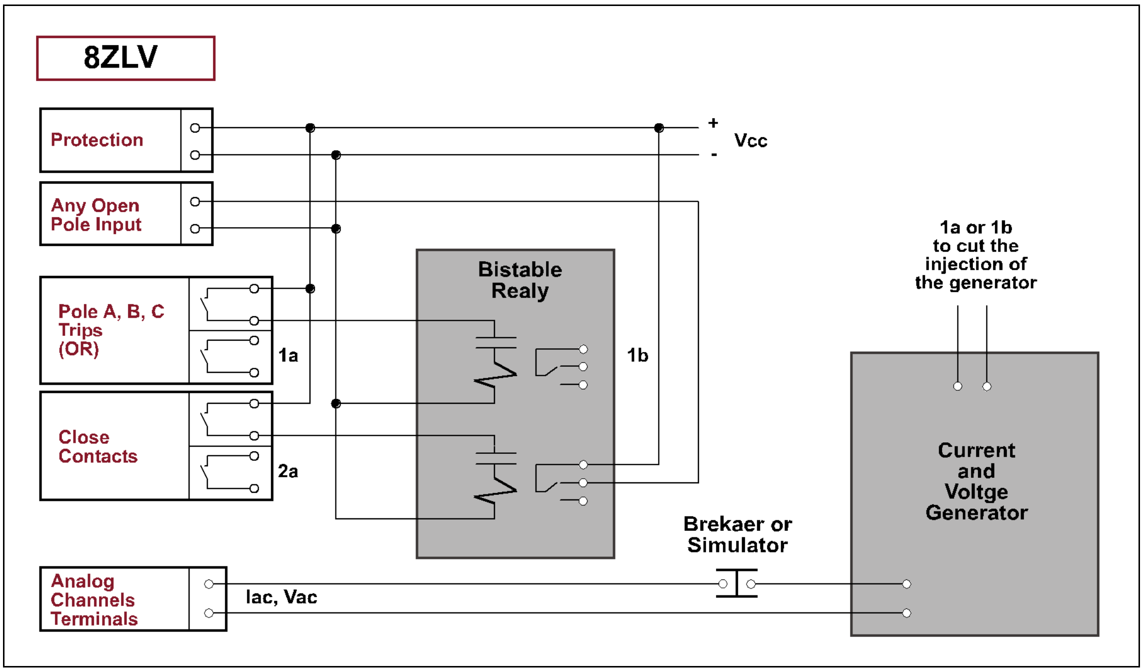


Figure 3.26.19:Connection Diagram for the Recloser Test.

Once we have the scheme of Figure 3.26.19 prepared, the following auxiliary outputs will be configured in the manner indicated:

Table 3.26-4: Output Configuration for the Recloser Test

Output	Description of Logic Signal
AUX5	Recloser lockout
AUX6	Recloser lockout due to lack of synchronism
AUX7	Recloser lockout due to definite trip
AUX8	Recloser lockout due to breaker close failure
AUX9	Recloser lockout due to close-onto-a-fault
AUX10	Recloser lockout due to breaker failure
AUX11	Recloser lockout due to three-phase trip
AUX12	Recloser lockout due to open breaker
AUX13	Recloser sequence in progress
AUX14	Recloser blocked
AUX15	Reclose signal activation

During the entire recloser test, an attempt will be made for there to be synchronism conditions in order that this is not internally lockout due to lack of synchronism.

The breaker will close, waiting longer than the reset time after external closing to continue.

Disable all the auxiliary units not associated with the distance elements, and adjust all the bits of the **Zone Trip Mask** to **NO**, except those corresponding to **Zone 1**.

Note: The test corresponding to the 3P Mode will be used to test the ZLV-A/E/H recloser function models.

- **1P Mode**

Two tests should be performed, corresponding to a first single-phase trip and to a first three-phase trip.

First Single-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A and a current of 5 A ac with a phase angle of 50º inductive to phase A. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the single-phase reclose time) and a short activation of the output **AUX15**.

The current will be reapplied prior to the expiration of the reset time. The following contacts should be closed: the **Recloser Lockout** (**AUX5**), the **Recloser Lockout Due to Definite Trip** (**AUX7**) and the **Recloser Lockout Due to Three-Phase Trip** (**AUX11**). The **Recloser Sequence in Progress** contact should be open (**AUX13** deactivated). Once this state has been reached, no subsequent reclose signal should be produced.

Close the breaker. The **Recloser Lockout** (**AUX5**), the **Recloser Lockout Due to Definite Trip** (**AUX7**) and **Recloser Lockout Due to Three-Phase Trip** (**AUX11**) outputs should deactivate after Reset Time.

The Recloser Counter should indicate that the number of single-phase recloses equals **1** and the number of three-phase recloses equals **0**. After viewing the display, reset the counters.

First Three-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A, and 1 Vac with a phase angle of 180º to phase B. Apply a current of 5 A ac with 50º inductive to phase A and 5 A ac and 230º to phase B.

Produce a trip, closing the **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Three-Phase Trip** (**AUX11**) contacts.

Close the breaker. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Three-Phase Trip** (**AUX11**) outputs should deactivate after Reset Time.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **0**.

- **3P Mode**

Set the unit to **3P Mode**. Trips in this mode should always be three-phase. A single test should be performed, corresponding to a first three-phase trip (the fault should be single-phase to ground).

First Three-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A and a current of 5 A ac with a phase angle of 50º inductive to phase A. The following events will occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the reclose time) and a short activation of the output **AUX15**.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Reset Time expires, the current will be reapplied, producing a trip. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state is reached, a subsequent reclosing will not take place.

Close the breaker. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate after the Reset Time.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **3**. After viewing the display, reset the counters.

- **1P / 3P Mode**

Set the unit to **1P / 3P Mode**. Two tests should be performed, corresponding to a first single-phase trip and to a first three-phase trip. After each trip, the fault report should contain information regarding the conditions surrounding the trip.

First Single-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A and a current of 5 A ac with a phase angle of 50º inductive to phase A. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the single-phase reclose time) and a short activation of the output **AUX15**.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Reset Time expires, the current will be reapplied. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state is reached, a subsequent reclosing will not take place.

Close the breaker. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should open after the reset time.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **1** and the number of three-phase reclose attempts equals **2**. After viewing the display, reset the counters.

First Three-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A, and 1 Vac with a phase angle of 180º to phase B. Apply a current of 5 A ac with 50º inductive to phase A and 5 A ac and 230º to phase B. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the first three-phase reclose time) and a short activation of the output **AUX15**.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

The current will be reapplied before the reset time expires. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state reached, a subsequent reclosing will not take place.

Close the breaker. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate once the Reset Time has expired.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **3**. After viewing, reset the counters.

- ## Dependent Mode

Set the unit to the **Dependent Mode**. Two tests should be performed, corresponding to a first single-phase trip and to a first three-phase trip. After each trip, the fault report should contain information regarding the conditions surrounding the trip.

First Single-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A and a current of 5 A ac with a phase angle of 50º inductive to phase A. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the single-phase reclose time) and a short activation of the output **AUX15**.

Before the reset time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 2nd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

Before the Reset Time expires, the current will be reapplied, producing a trip and, on expiration of the time of the 3rd reclosing attempt, a reclosing (**AUX15**). The **Sequence in Progress** contact will remain closed, that is, the **AUX13** output will continue activated.

The current will be reapplied before the Reset Time expires. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close; the **Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state reached, a subsequent reclosing will not take place.

The breaker will close. The **Recloser Lockout** (**AUX5**) and **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate once the Reset Time has expired.

First Three-Phase Trip

Apply a voltage of 1 Vac with a phase angle of 0º to phase A, and 1 Vac with a phase angle of 180º to phase B. Apply a current of 5 A ac with 50º inductive to phase A and 5 A ac and 230º to phase B. The following events should occur:

1. Trip and activation of the **Recloser Sequence in Progress** signal (output **AUX13**).
2. Reclosing (on expiration of the first three-phase reclose time) and a short activation of the output **AUX15**.

Before the Reset Time expires, the current will be reapplied. The **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) contacts should close. **The Recloser Sequence in Progress** contact should open (**AUX13** deactivated). Once this state reached, a subsequent reclosing will not take place. Close the breaker.

The breaker will close. **Recloser Lockout** (**AUX5**) and the **Recloser Lockout Due to Definite Trip** (**AUX7**) outputs should deactivate 3 seconds later.

The Recloser Counter should indicate that the number of single-phase reclose attempts equals **0** and the number of three-phase reclose attempts equals **1**. Reset the counters.

3.26.15.b ZLV-G/J Relays

ZLV-G/J relay automatic reclose function consists of two reclosers coordinated with each other. When only one recloser is enabled (number of reclosers in operation setting = 1), checks will be similar to the checks described for **ZLV-B** relays. When two reclosers are enabled, the coordination with each other shall be checked. The check, in this case, must be made with six flip-flops, which will simulate all poles of breakers 1 and 2 (hard wire to the applicable inputs). A Pole trip signals will be hard wired to the two flip-flops simulating the A poles of breakers 1 and 2. B and C pole trip signals will be hard wired in like manner.

Synchronism through both breakers is recommended during automatic reclose check to prevent one breaker switching to **Internal Lockout on Lack of Synchronism**.

Breakers will be closed, waiting for the safety time to time out after external closing to continue.

All auxiliary elements other than distance elements will be disabled and all **Zone Mask** bits will be set to **NO**, except **Zone 1** bit.

- **1P Mode**

Two checks will be made, corresponding to one first single-phase trip and one first three-phase trip.

First Single-phase Trip

A voltage of 1 Vca and 0º phase shift and a current of 5 Aac and 50º inductive phase shift will be applied to phase A.

The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after **Single-phase** reclose time times out (slave recloser will be in **Waiting for Master Recloser** state).

Current will be applied again before **Security Time 1** times out. Following signals for both reclosers, master and slave, will activate: **Internal Block, Internal Block on Final Trip** and **Internal Block on Three-phase Trip**, deactivating **Sequence in progress** signal**.** No further retries will take place in said states.

Both breakers will close, and **Internal Block, Internal Block on Final Trip** and **Internal Block on Three-phase Trip** signals deactivate when the safety time after a manual reclose times out**.**

Shot counters of both reclosers will be checked, the number of master recloser single-phase shots must be 1, the number of slave recloser single-phase shots must be 0 and the number of three-phase shots for both reclosers must be 0. Then, the counters will be reset.

The check can be repeated injecting the fault when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser shot counter that must now be **1**.

First Three-Phase Trip

A voltage of 1 Vca and 0º phase shift will be applied to phase A and 1 Vca and 180º will be applied to phase B. Then, a current of 5 Aac and 50º inductive phase shift will be applied to phase A and 5 Aac and 230º to phase B.

A trip will occur and **Internal Block** and **Internal Block on Three-phase Trip** signals of both reclosers will activate.

Both breakers will close, and **Internal Block** and **Internal Block on Three-phase Trip** signals of both reclosers will deactivate when the safety time after a manual reclose times out.

Shot counters of both reclosers will be checked, the Number of single-phase shots must be 0 and the Number of three-phase shots must be **0** for both reclosers.

- **3P Mode**

The **Reclose mode** must be set to **3P Mode**. Shots on this reclose mode will always be three-phase, so that only one check is made, corresponding to a first three-phase trip (single-phase fault).

First Three-Phase Trip

A voltage of 1 Vca and 0º phase shift and a current of 5 Aac and 50º inductive phase shift will be applied to phase A. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the reclose time times out (slave recloser will be in waiting for master recloser state).

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **second** shot time. **Sequence in progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **third** shot time. **Sequence in progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Internal Block** and **Internal Block on Final Trip** signals activate**,** and **Sequence in progress** of both reclosers deactivate. Later reclose shots will not occur from this state.

Both breakers will close, and **Internal block** and **Internal Block on Three-phase Trip** signals of both reclosers will deactivate when the safety time after a manual reclose times out.

Shot counters will be checked, the number of **Single-phase shots** must be **0** for both reclosers, the number of **Three-phase shots** must be **3** for the master recloser and the number of **Three-phase shots** must be **0** for the slave recloser. Then, shot counters reset.

The above check can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser three-phase shot counter that must now be 3.

- **1P/3P Mode**

The **Reclose mode** must be set to **1P/3P Mode**. Two checks will be made, corresponding to a first single-phase trip and a first three-phase trip. Fault reports will be collected after each check.

First single-phase trip

A voltage of 1 Vca and 0º phase shift and a current of 5 Aac and 50º inductive phase shift will be applied to phase A. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the **Single-phase Reclose** time times out (slave recloser will be in waiting for master recloser state).

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **second** shot time. **Sequence in Progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **third** shot time. **Sequence in Progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Internal Block, Internal Block on Final Trip** signals activate**,** and **Sequence in progress** of both reclosers will deactivate. No further retries will take place in said states.

Both breakers will close, and **Internal Block, Internal Block on Final Trip** signals deactivate when the safety time after a manual reclose times out.

Shot counters of both reclosers will be checked, the number of master recloser **Single-phase shots** must be **1**, the number of master recloser **Three-phase Shots** must be **2** and the number of slave recloser **Three-phase and Single-phase Shots** must be **0**. Then, the counters will be reset.

The check above can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser single-phase and three-phase shot counters that must now be **1** and **2** respectively.

First Three-Phase Trip

A voltage of 1 Vca and 0º phase shift will be applied to phase A and 1 Vca and 180º will be applied to phase B. Then, a current of 5 Aac and 50º inductive phase shift will be applied to phase A and 5 Aac and 230º to phase B. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the **First Three-phase Reclose** time times out (slave recloser will be in waiting for master recloser state).

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **second** shot time. **Sequence in Progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **third** shot time. **Sequence in Progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Internal Block, Internal Block on Final Trip** signals activate**,** and **Sequence in Progress** of both reclosers will deactivate. No further retries will take place in said states.

Both breakers will close, and **Internal Block, Internal Block on Final Trip** signals deactivate when the safety time after a manual reclose times out.

Shot counters will be checked, the number of **Single-phase Shots** must be **0** for both reclosers, the number of **Three-phase Shots** must be **3** for the master recloser and the number of **Three-phase Shots** must be **0** for the slave recloser. Then, shot counters reset.

The above check can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser three-phase shot counter that must now be 3.

- **Dependent Mode**

Reclose Mode will be set to **Dependent Mode**. Two checks will be made, corresponding to a first single-phase trip and a first three-phase trip. Fault reports will be collected after each check.

First Single-Phase Trip

A voltage of 1 Vca and 0º phase shift and a current of 5 Aac and 50º inductive phase shift will be applied to phase A. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the **Single-phase Reclose Time** times out (slave recloser will be in waiting for master recloser state).

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **second** shot time. **Sequence in Progress** signal of both reclosers will remain active.

Current will be applied again before **Security Time 1** times out, a trip will occur and a new master reclose after the **third** shot time. **Sequence in Progress** signal of both reclosers will remain active.

Current will be applied again before safety time 1 times out, and a trip will occur. **Internal Block, Internal Block on Final Trip** signals activate**,** and **Sequence in Progress** of both reclosers will deactivate. No further retries will take place in said states.

Both breakers will close, and **Internal Block, Internal Block on Final Trip** signals deactivate when the safety time after a manual reclose times out.

Shot counters will be checked, the number of master recloser **Single-phase Shots** must be **1**, the number of master recloser **Three-phase shots** must be **2** and the number of slave recloser **Three-phase and Single-phase Shots** must be **0**. Then, the counters will be reset.

The check above can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser single-phase and three-phase shot counters that must now be **1** and **2** respectively**.**

First Three-Phase Trip

A voltage of 1 Vca and 0º phase shift will be applied to phase A and 1 Vca and 180º will be applied to phase B. Then, a current of 5 Aac and 50º inductive phase shift will be applied to phase A and 5 Aac and 230º to phase B. The following events will happen:

- Trip and activation of **Sequence in Progress** signal for both reclosers (master and slave).
- Master reclose after the first **Three-phase Reclose Time** times out (slave recloser will be in waiting for master recloser state).

Current will be applied again before **Security Time 1** times out, and a trip will occur. **Internal Block, Internal Block on Final Trip** signals activate**,** and **Sequence in progress** of both reclosers will deactivate. No further retries will take place in said states.

Both breakers will close, and **Internal Block, Internal Block on Final Trip** signals deactivate when the safety time after a manual reclose times out.

Shot counters will be checked, the number of **Single-phase Shots** must be **0** for both reclosers, the number of master recloser **Three-phase Shots** must be **1** and the number of slave recloser **Three-phase Shots** must be **0**. Then, shot counters reset.

The above check can be repeated injecting the faults when the master recloser **Security Time 1** times out both reclosers switching to **Security Time 2**. The result will be the same as the above but for the slave recloser three-phase shot counter that must now be **1**.

3.27 Command Logic

3.27.1 Introduction

The **ZLV** IED presents a command logic in charge of generating the open command outputs of each pole of the breaker (**OPEN_A**, **OPEN_B** and **OPEN_C**), in addition to the open outputs (**OPEN**) and three-phase open (**OPEN_3PH**), from the trip commands (originating from the Tripping Logic) and manual open (**Manual Open Command** input: **IN_OPEN_CMD**). Similarly, the command module is in charge of generating the close output of the breaker (**CLOSE**) from the reclose (**RCLS_CMD**) and manual close (**Manual Close Command** input: **IN_CLOSE_MAN**) commands.

On the other hand, the command module allows to generate the **Open Command Failure** signals of each pole of the breaker (**FAIL_OPEN_A**, **FAIL_OPEN_B** and **FAIL_OPEN_C**) and **Close Command Failure** (**FAIL_CLS**), from the previously-mentioned open / close outputs

The following functions exist within the Command Logic group: **Trip Seal-in Enable**, **Breaker Opening / Closing Failure Time Delay**, **Close supervision by Synchronism Check** and **Pickup Report**.

3.27.2 Opening Command

3.27.2.a Opening Command Logic. Model ZLV-B/F

The opening command generation logic is shown in Figures 3.27.1 and 3.27.2.

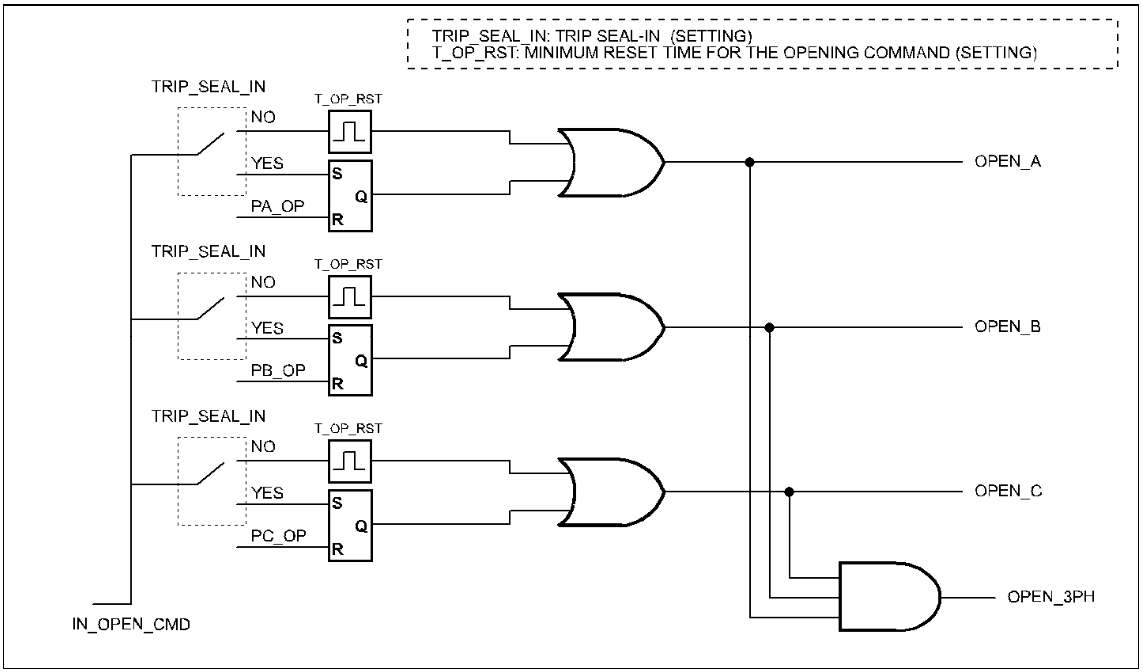


Figure 3.27.1: Logic Diagram of Generation of Opening Commands from a Manual Command (ZLV-B/F).

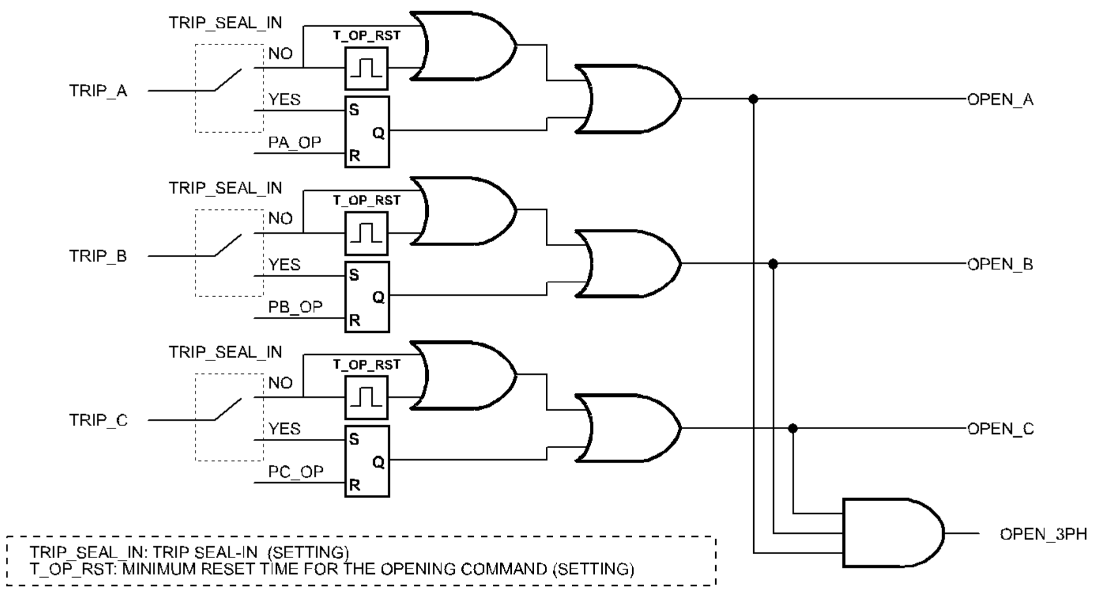


Figure 3.27.2: Logic Diagram of Generation of Opening Commands from Trip Commands (ZLV-B/F).

The trip seal-in function is enabled by providing the **Seal-In Enable** setting with the **YES** value. Under these circumstances, the opening command over a pole of the breaker (**OPEN_A**, **OPEN_B** and **OPEN_C**) will be kept activated as long as the opening of this is not detected (**PA_OP**, **PB_OP** and **PC_OP** open pole detector outputs). The objective of this setting is to ensure that the break contacts of the relay do not cut the current of the trip circuit of the breaker poles, given that this operation will be carried out by the corresponding 52/a auxiliary contact of the breaker. The relay contacts may be damaged on cutting the trip circuit current, since this current (basically inductive and of a high value) tends to exceed the rated break characteristics of these contacts.

Although the **NO** value is assigned to the **Seal-in Enable** setting, if the opening command originates from trip outputs, it should be considered that these outputs remain activated until the supervision units are reset, which already produces a seal. On the other hand, in the command logic, for manual operations as well as trip commands, a time is guaranteed for the opening command, configurable according to the **T_OP_RST** setting (**Minimum Reset Time From The Open Command**):

- If the activation of the opening command is preceded by a trip signal that is deactivated before the **T_OP_RST** time, the opening command will last during the set time. If the activation of the trip signal lasts longer than the **T_OP_RST** setting, the opening command will stay until the trip condition clears.
- If the activation of the opening command precedes a manual opening command, its duration is always a pulse defined by the **T_OP_RST** time.

Only if the trip **Seal-in Enable** setting is set at **YES** will the opening command be maintained for the necessary time until the breaker open is shown.

Once the opening command of a pole of the breaker is generated, if the **Opening Command Failure Time** setting elapses without detecting the open status of the pole, the **Opening Command Failure** output of this pole (**FAIL_OPEN_A**, **FAIL_OPEN_B** and **FAIL_OPEN_C**) is activated, in addition to the **Opening Command Failure** (**FAIL_OPEN**) generic output.

3.27.2.b Opening Command Logic. ZLV-G/J Models

ZLV-G/J relays can operate two breakers, so they incorporate open command generation logic similar to the logic described in the paragraph above for each breaker. Said logics are shown in figures 3.27.3, 3.27.4, 3.27.5 and 3.27.6.

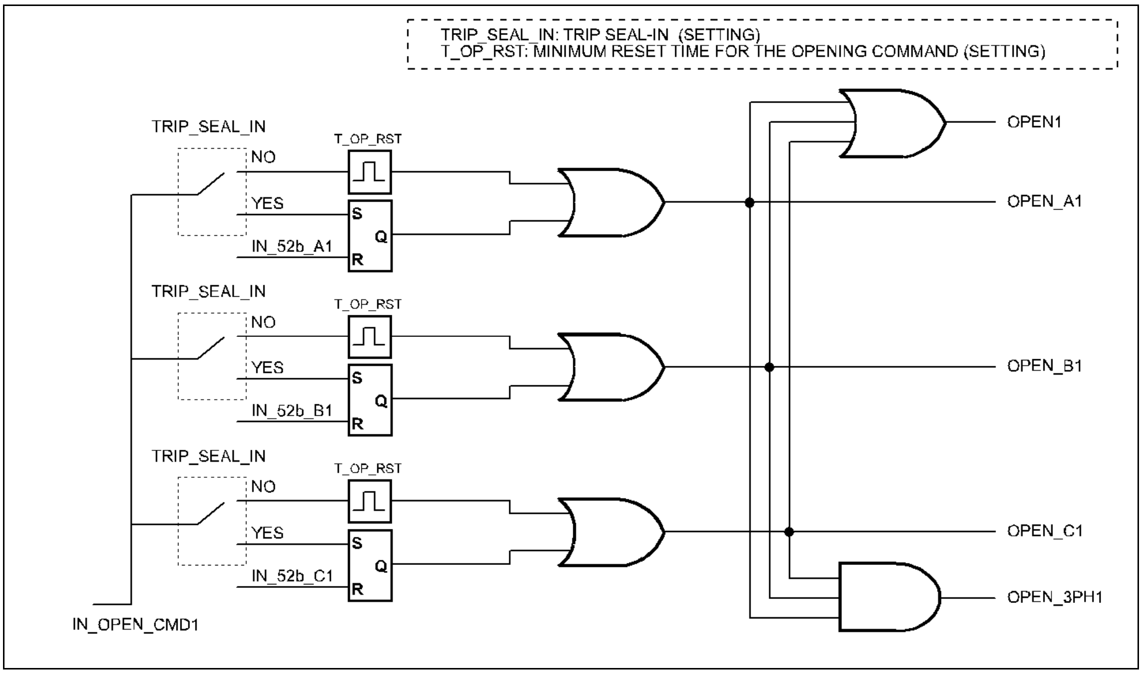


Figure 3.27.3: Breaker 1 Open Command Generation Logic Diagram from Manual command (ZLV-G/J).

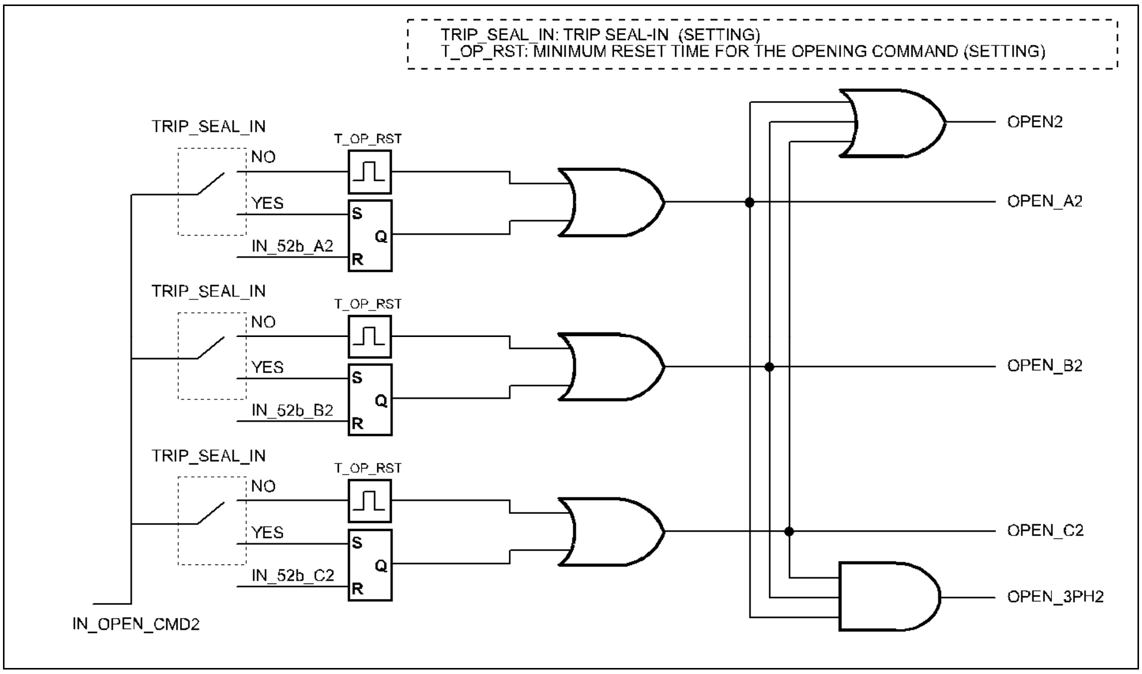


Figure 3.27.4: Breaker 2 Open Command Generation Logic Diagram from Manual Command (ZLV-G/J).

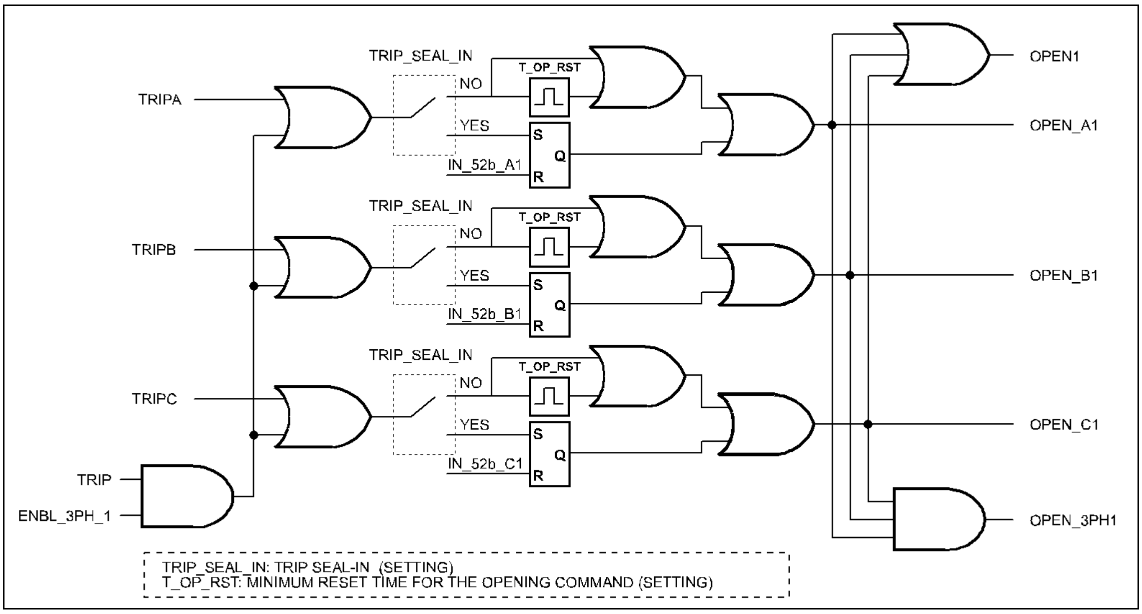


Figure 3.27.5: Breaker 1 Open Command Generation Logic Diagram from Trip Command (ZLV-G/J).

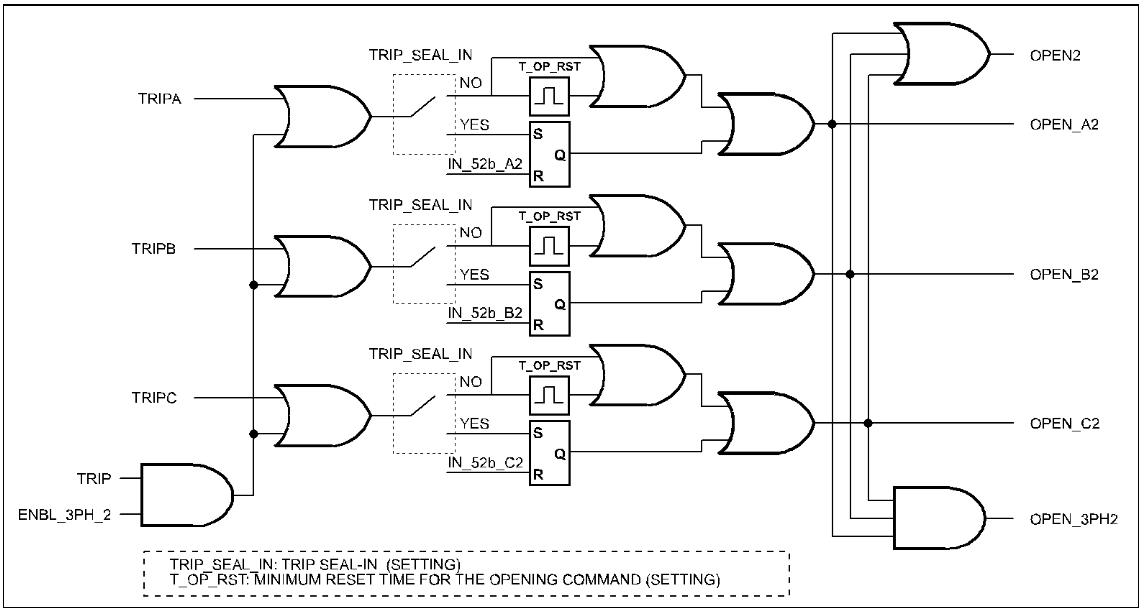


Figure 3.27.6: Breaker 1 Open Command Generation Logic Diagram from Trip Command (ZLV-G/J).

In **ZLV-G/J** relays, the signals **OPEN, OPEN_3PH, OPEN_A, OPEN_B and OPEN_C** are obtained as an OR of signals **OPEN1** y **OPEN2**, **OPEN_3PH1** and **OPEN_3PH2 OPEN_A1** and **OPEN_A2**, **OPEN_B1** and **OPEN_B2**, **OPEN_C1** and **OPEN_C2** respectively.

Breaker 1 and 2 three-phase open enable inputs, **ENBL_3PH_1** and **ENBL_3PH_2,** respectively, allow generating three-phase open commands separately for each breaker. As the preparation for three-phase trip, generated in the trip logic (see paragraph 3.24), occurs when both reclosers are in **Internal Blocking** state (**RCLS_LO1** and **RCLS_LO2**) or **Blocking on Command** state (**LO_CMD1** and **LO_CMD2**), if only one recloser has reached a lockout state with its associated breaker closed, said breaker trips might be one pole trips if appropriate measures are not taken. In order to generate always three-phase open enable inputs on a breaker with a lockout associated recloser, the logic inputs **ENBL_3PH_1** and **ENBL_3PH_2** must be configured with an OR of **RCLS_LO1** and **LO_CMD1** signals and with an OR of **RCLS_LO2** and **LO_CMD2** signals respectively.

3.27.2.c Opening Command Logic. Models ZLV-A/E/H

The opening command generation logic is shown in Figures 3.25.7 and 3.25.8:

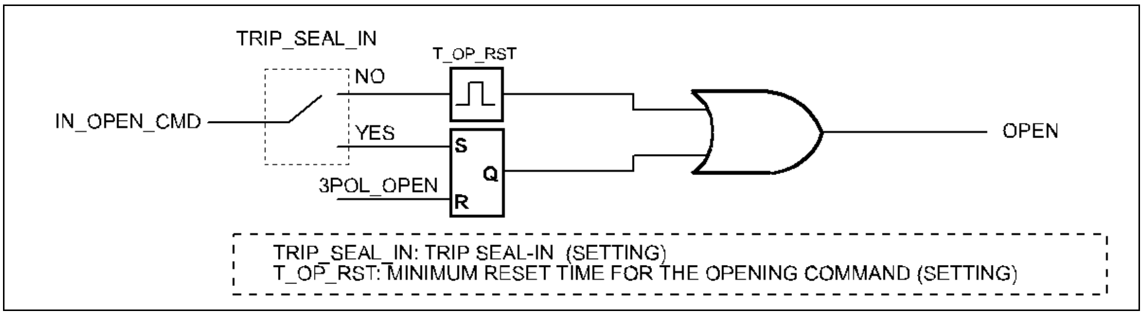


Figure 3.27.7: Logic Diagram of Generation of Opening Commands from Manual Command (ZLV-A/E/H).

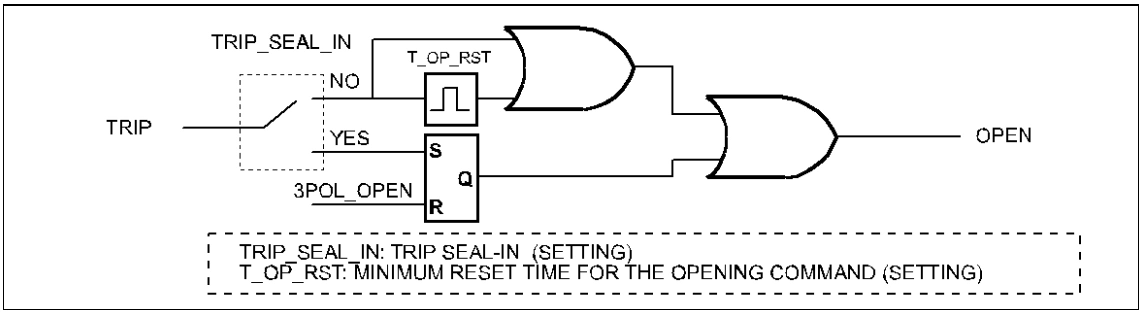


Figure 3.27.8: Logic Diagram of Generation of Opening Commands from Trip Commands (ZLV-A/E/H).

Once the opening command of the breaker is generated, if the **Opening Command Failure Time** setting elapses without detecting the opening of the breaker, the **Opening Command Failure** output is activated.

3.27.3 Closing Commands

3.27.3.a ZLV-A/B/F/H Relays

The **Close** output (**CLOSE**) will be generated by the **Reclose Command** (**RCLS_CMD**) or by the **Manual Close Command** (**IN_CLOSE_MAN**). The latter close command may be supervised by the existence of synchronism. For this, it is necessary that the close **Supervision Due to Synchronism** setting (**SUP_C_SINC**) be set at **YES**.

The **Close Command** output will be disabled on the following conditions:

- **Close Block** input activation.
- **Open Command** output activation.
- All breaker poles closed.

Once the close command of the breaker is generated, if the **Closing Command Failure** time setting elapses without detecting the closing of the breaker (no pole open: **OR_P_OP** at zero) the **Closing Command Failure** (**FAIL_CLS**) output is activated.

The **Close** output will be maintained until it is detected that the breaker has closed or until the **Close Command Failure** is issued.

The **Close** output will remain active at least the **Minimum Reset Time for Closing** (**T_CL_RST** setting). In addition, if the breaker fails to close, this time could be prolonged until the Failure of the **Closing Command** is given (provided that this time is longer than the **T_CL_RST** setting).

In case of protection trips, the **Opening Command** will remain as long as the reason for which this originated continues, even if the **Opening Failure Time** is exceeded.

3.27.3.b ZLV-G/J Relays

ZLV-G/J relays can operate two breakers and thus they include a close command generation logic similar to the logic explained in the paragraph above for each breaker.

In **ZLV-G/J** relays, the signal to close the breaker used to generate Breaker n (n=1,2) close command output will be the negation of **52_ORPn_OP** (**Any breaker n pole open by contact indication**).

ZLV-G/J relays control module incorporates a shot counter for each breaker. Said shot counters can be reset through a digital input.

3.27.3.c Close Synchronism Check

The **Close Command** output (**CLOSEm**) will be generated by **Manual Close Command** (**IN_CLOSE_MANm**). This close command can be supervised through whether synchronism exists or not. To this end, the **Synchronism Close Supervision** (**SUP_C_SINCm**) setting must be set to **YES**.

For **ZLV-G/J** relays, the signal to be supervised in order to issue the manual close command (**IN_CLOSE_MANm**) will be **SYNC_Rm** (**SYNC_Rm2** for **ZLV-J** relays). If so, the close command (**CLOSEm**) will run properly.

3.27.4 Command Logic Settings

Command Logic Settings			
Setting	**Range**	**Step**	**By default**
Trip seal-in enable	YES / NO		NO
Minimum reset time for the opening command	0.1 - 5 s	0.1 s	0.2 s
Breaker opening failure time delay	0.02 - 5 s	0.01 s	0.02 s 0.1 s (*)
Minimum reset time for the closing command	0 - 5 s	0.1 s	0.2 s
Breaker closing failure time delay	0.02 - 5 s	0.01 s	0.02 s 0,1 s (*)
Breaker closing Synchrocheck Supervision (ZLV-A/B/E/F/H)	YES / NO		NO
Breaker 1 closing Synchrocheck Supervision (ZLV-G/J)	YES / NO		NO
Breaker 2 closing Synchrocheck Supervision (ZLV-G/J)	YES / NO		NO
Pickup report	YES / NO		NO

(*) ZLV-*-****C/D/E/F/G/H**.**

- **Command Logic Settings: HMI Access**

ZLV-A/B/E/F/H

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP SEAL-IN**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - MIN OPENING RES T**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - FAIL TO OPEN TIME**
3 - INFORMATION	3 - PROTECTION	**3 - MIN CLOSING RES T**
	4 - RECLOSER	**4 - FAIL TO CLOSE TIME**
	5 - LOGIC	**5 - PICK UP REPORT**
	...	**6 - SINCR. SUPERVISION**

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP SEAL-IN**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - MIN OPENING RES T**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - FAIL TO OPEN TIME**
3 - INFORMATION	3 - PROTECTION	**3 - MIN CLOSING RES T**
	4 - RECLOSER	**4 - FAIL TO CLOSE TIME**
	5 - LOGIC	**5 - PICK UP REPORT**
	...	**6 - SINCR. SUPERVISION 1**
		7 - SINCR. SUPERVISION 2

3.27.5 Digital Inputs and Events of the Command Logic Module

Table 3.27-1: Digital Inputs and Events of the Command Logic Module		
Name	**Description**	**Function**
IN_BLK_CLS	Breaker close blocking input (ZLV-A/B/E/F/H)	Its activation blocks close output.
IN_OPEN_CMD	Manual opening command (ZLV-A/B/E/F/H)	Its activation generates manual open and close commands, respectively; these can be assigned to HMI, to communications, to digital inputs or to any signal of the programmable logic. Its application is directed toward being assigned to COMMANDS.
IN_CLOSE_CMD	Manual closing command (ZLV-A/B/E/F/H)	
IN_BLK_CLS1	Breaker 1 close blocking input (ZLV-G/J)	Its activation blocks close output of the breaker 1.
IN_BLK_CLS2	Breaker 2 close blocking input (ZLV-G/J)	Its activation blocks close output of the breaker 2.
IN_OPEN_CMD1	Breaker 1 manual opening command (ZLV-G/J)	Its activation generates manual open and close commands, respectively; these can be assigned to HMI, to communications, to digital inputs or to any signal of the programmable logic. Its application is directed toward being assigned to COMMANDS.
IN_CLOSE_CMD1	Breaker 1 manual closing command (ZLV-G/J)	
IN_OPEN_CMD2	Breaker 2 manual opening command (ZLV-G/J)	Its activation generates manual open and close commands, respectively; these can be assigned to HMI, to communications, to digital inputs or to any signal of the programmable logic. Its application is directed toward being assigned to COMMANDS.
IN_CLOSE_CMD2	Breaker 2 manual closing command (ZLV-G/J)	
ENBL_3PH_1	Breaker 1 three-phase open enable input (ZLV-G/J)	Activating this input makes breaker 1 open commands always three-phase
ENBL_3PH_2	Breaker 2 three-phase open enable input (ZLV-G/J)	Activating this input makes breaker 2 open commands always three-phase
ORD_REP_CAPER1_A	Breaker 1 A pole open counter reset input (ZLV-G/J)	Activating this input resets breaker 1 A pole open counter
ORD_REP_CAPER1_B	Breaker 1 B pole open counter reset input (ZLV-G/J)	Activating this input resets breaker 1 B pole open counter
ORD_REP_CAPER1_C	Breaker 1 C pole open counter reset input (ZLV-G/J)	Activating this input resets breaker 1 C pole open counter

Table 3.27-1: Digital Inputs and Events of the Command Logic Module		
Name	**Description**	**Function**
ORD_REP_CAPER2_A	Breaker 2 A pole open counter reset input (ZLV-G/J)	Activating this input resets breaker 2 A pole open counter
ORD_REP_CAPER2_B	Breaker 2 B pole open counter reset input (ZLV-G/J)	Activating this input resets breaker 2 B pole open counter
ORD_REP_CAPER2_C	Breaker 2 C pole open counter reset input (ZLV-G/J)	Activating this input resets breaker 2 C pole open counter
ORD_REP_CCIER1	Breaker 1 reclose shot counter reset input (ZLV-G/J)	Activating this input resets breaker 1 reclose shot counter
ORD_REP_CCIER2	Breaker 2 reclose shot counter reset input (ZLV-G/J)	Activating this input resets breaker 2 reclose shot counter

3.27.6 Digital Outputs and Events of the Command Logic Module

Table 3.27-2: Digital Outputs and Events of the Command Logic Module		
Name	**Description**	**Function**
OPEN	Open command (ZLV-A/B/E/F/H)	Open
OPEN_A	A pole open command (ZLV-B/F)	A pole open output of the breaker.
OPEN_B	B pole open command (ZLV-B/F)	B pole open output of the breaker.
OPEN_C	C pole open command (ZLV-B/F)	C pole open output of the breaker.
OPEN_3PH	Three-phase open command (ZLV-B/F)	Three-phase open output of the breaker.
CLOSE	Close (ZLV-A/B/E/F/H)	Close output of the breaker.
FAIL_OPEN	Open command failure (ZLV-A/B/E/F/H)	Activated from when the open or close commands are issued, the adjusted times elapse, but these are not carried out.
FAIL_OPEN_A	A pole open command failure (ZLV-A/B/E/F)	
FAIL_OPEN_B	B pole open command failure (ZLV-A/B/E/F)	
FAIL_OPEN_C	C pole open command failure (ZLV-A/B/E/F)	
FAIL_CLS	Close command failure (ZLV-A/B/E/F/H)	
OPEN1	Breaker 1 open command (ZLV-G/J)	Breaker 1 open output.
OPEN_A1	Breaker 1 A pole open command (ZLV-G/J)	Breaker 1 A pole open output.
OPEN_B1	Breaker 1 B pole open command (ZLV-G/J)	Breaker 1 B pole open output.
OPEN_C1	Breaker 1 C pole open command (ZLV-G/J)	Breaker 1 C pole open output.
OPEN_3PH1	Breaker 1 three-phase open command (ZLV-G/J)	Breaker 1 three-phase open output.
CLOSE1	Breaker 1 reclose command (ZLV-G/J)	Breaker 1 reclose output.

Table 3.27-2: Digital Outputs and Events of the Command Logic Module		
Name	**Description**	**Function**
FAIL_OPEN1	Breaker 1 open command failure (ZLV-G/J)	These signals activate when breaker 1 open and reclose commands are not executed before the timer settings time out.
FAIL_OPEN_A1	Breaker 1 A pole open command failure (ZLV-G/J)	
FAIL_OPEN_B1	Breaker 1 B pole open command failure (ZLV-G/J)	
FAIL_OPEN_C1	Breaker 1 C pole open command failure (ZLV-G/J)	
FAIL_CLS1	Breaker 1 reclose command failure (ZLV-G/J)	
OPEN2	Breaker 2 open command (ZLV-G/J)	Breaker 2 open output.
OPEN_A2	Breaker 2 A pole open command (ZLV-G/J)	Breaker 2 A pole open output.
OPEN_B2	Breaker 2 B pole open command (ZLV-G/J)	Breaker 2 B pole open output.
OPEN_C2	Breaker 2 C pole open command (ZLV-G/J)	Breaker 2 C pole open output.
OPEN_3PH2	Breaker 2 three-phase open command (ZLV-G/J)	Breaker 2 three-phase open output.
CLOSE2	Breaker 2 reclose command (ZLV-G/J)	Breaker 2 reclose output.
FAIL_OPEN2	Breaker 2 open command failure (ZLV-G/J)	These signals activate when breaker 2 open and reclose commands are not executed before the timer settings time out.
FAIL_OPEN_A2	Breaker 2 A pole open command failure (ZLV-G/J)	
FAIL_OPEN_B2	Breaker 2 B pole open command failure (ZLV-G/J)	
FAIL_OPEN_C2	Breaker 2 C pole open command failure (ZLV-G/J)	
FAIL_CLS2	Breaker 2 reclose command failure (ZLV-G/J)	

3.27.7 Control Logic Parameters

Table 3.27-3:Control Logic Parameters		
Name	**Description**	**Units**
NAPERINT1_A	Number of breaker 1 A pole openings (ZLV-G/J)	
NAPERINT1_B	Number of breaker 1 B pole openings (ZLV-G/J)	
NAPERINT1_C	Number of breaker 1 C pole openings (ZLV-G/J)	
NAPERINT2_A	Number of breaker 2 A pole openings (ZLV-G/J)	
NAPERINT2_B	Number of breaker 2 B pole openings (ZLV-G/J)	
NAPERINT2_C	Number of breaker 2 C pole openings (ZLV-G/J)	
NCIERREINT1	Number of breaker 1 reclose shots (ZLV-G/J)	
NCIERREINT2	Number of breaker 1 reclose shots (ZLV-G/J)	
NAPER_A	Number of breaker 1 A pole openings (ZLV-F)	
NAPER_B	Number of breaker 1 B pole openings (ZLV-F)	
NAPER_C	Number of breaker 1 C pole openings (ZLV-F)	
NCIERRE	Number of breaker 1 reclose shots (ZLV-F/H)	

3.28 Configuration Settings

3.28.1 Introduction

The Configuration settings group has the following groups of settings: Nominal Values, Passwords, Communications, Operations, Date and time and Contrast setting.

3.28.2 Nominal Values (Operation Mode)

The **Nominal Values** settings serve to select the rated operating values for both currents and voltages. The selectable parameters are:

- Nominal phase current.
- Nominal polarization current.
- Voltage: the rated value of the voltage is set in phase-phase value. This is the reference for all settings expressed in times or % of the nominal voltage. It is applied to the phase voltages as well as to the synchronism voltage.
- Nominal frequency: permits choosing the rated frequency of the network, independently of whether or not the system for adapting to the frequency can later adapt to the changes that occur in this magnitude.

After modifying any of these settings, which are only accessible from the HMI display, the relay restarts the same way as if its power supply were turned off and then back on; no setting or information is lost.

3.28.3 Passwords

The Passwords option allows changing the access password for the options: **Configuration**, **Operations** and **Settings**.

Selecting the Configuration option allows varying the access password for the options of the **Configuration** group. Likewise, it is possible to configure different passwords for the **Operations** options and for modifying **Settings**.

3.28.4 Communications

See section 3.40 of Communications.

3.28.5 Date and Time

Selecting **Date and Time** from the **Configuration** menu provides access to this setting to configure the date and the time.

3.28.6 Contrast Setting

This setting serves to modify the contrast value of the display (higher value = greater contrast).

3.28.7 Configuration Settings

Nominal Values			
Setting	**Range**	**Step**	**By default**
Nominal IABC	1 A / 5 A		5 A
Nominal IGPAR	1 A / 5 A		5 A
Nominal Ipol	1 A / 5 A		5 A
Nominal Voltage	50 - 230 V		110 V
Nominal Frequency	50 Hz / 60 Hz		50 Hz

Passwords
The factory-specified access password (full access) is 2140. Nevertheless, you can change the password to access the following options with the keypad: **Configuration**, **Operations** and **Settings**.

Communications
See section 3.40

Date and Time
Update from keyboard

Contrast
Adjustable from keyboard

- **Configuration Settings: HMI Access**

0 - CONFIGURATION	**0 - NOMINAL VALUES**
1 - OPERATIONS	**1 - PASSWORDS**
2 - CHANGE SETTINGS	**2 - COMMUNICATIONS**
3 - INFORMATION	**3 - TIME AND DATE**
	4 - CONTRAST

Nominal Values

0 - CONFIGURATION	**0 - NOMINAL VALUES**	**0 - NOMINAL IABC**
1 - OPERATIONS	1 - PASSWORDS	**1 - NOMINAL IPOL**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - NOMINAL IGPAR**
3 - INFORMATION	3 - TIME AND DATE	**3 - NOMINAL VABC**
	4 - CONTRAST	**4 - NOMINAL FREC.**

Passwords

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - CONFIGURATION**
1 - OPERATIONS	**1 - PASSWORDS**	**1 - OPERATIONS**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - SETTINGS**
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	

3.29 General Settings

3.29.1 Introduction

The following settings are available in the General settings group: IED in service, Transformer ratios and Capacitive TT.

3.29.2 Unit in Service

IED enabled (**YES**) allows every function in the system to be executed (as programmed in the corresponding settings).

IED disabled (**NO**) only leaves the system metering functional. Metering values will be displayed in the HMI and via communications.

3.29.2.a Digital Outputs and Events (Unit in Service)

Table 3.29-1: Digital Outputs and Events (Unit in Service)

Name	Description	Function
PROT_INSRV	Protection in service	Indicates that the IED is working with all the functions available.

3.29.3 Transformer Ratios

The transformation ratio defines the mode in which the analog values are viewed in the protection display. If the transformation ratio is set to **1**, the display will present secondary values. If, on the contrary, the transformation ratio corresponding to the analog input of the matching transformers is selected, the display will present primary values.

The adjustable transformer ratios are:

- Phase, ground, polarization and parallel line ground currents.
- Phase and synchronism voltage.

In any case, all the settings of the current and voltage protection elements refer to secondary values. The analog settings defined in the programmable logic can refer to both secondary as well as primary values.

3.29.4 Capacitive Transformers

ZLV relays include an algorithm to reduce the overreach of distance elements derived from transients generated by capacitive voltage transformers. When the measured source impedance / line impedance ratio (SIR - System impedance ratio) exceeds a given threshold a temporary compression of the distance characteristics is produced. This algorithm can be enabled or disabled through the general setting **Capacitive VT**.

It must be noted that enabling the above algorithm may delay for up to a quarter of a cycle the operation of the distance elements, for faults close to the limit of the operation characteristic.

3.29.5 Phase Sequence

Power system's phase sequence (**ABC** or **ACB**) may be selected through **Phase sequence** setting.

This setting tells the relay the actual system's phase sequence and, if the same analog current and voltage input connections for phases A, B and C are kept in the external connections diagram, all functions will work properly.

3.29.6 Line Current. ZLV-G/J Models

ZLV-G relays, designed for dual breaker bay protection (Breaker and a half or ring substations), incorporate a setting to allow defining line phase currents (IA, IB, IC) from phase currents measured by the relay (IA-1, IB-1, IC-1, IA-2, IB-2, IC-2). Possible setting values are: **I**-1, **I**-2 and **I**-1+**I**-2. The first two values must be applied when the **ZLV-G/J** relays are installed in a single breaker bay, whereas the last value must be used when said relay is protecting a dual breaker bay.

It is worth highlighting that currents not considered by the **Line Current** setting will be cancelled by the relay. If the setting is for example **I**-1, the samples measured by current channels **I**-2 will be 0, even if current is circulating through said channels.

3.29.7 General Settings

General Settings			
Setting	**Range**	**Step**	**By default**
Unit in service	YES / NO		YES
Phase C.T. ratio	1 – 3000 1 - 10.000 (*)	1	1
Phase V.T. ratio	1 - 10.000 1 - 11.000 (*)	1	1
Synchronism 1 V.T. ratio	1 - 10.000 1 - 11.000 (*)	1	1
Parallel line ground C.T. ratio	1 – 3000 1 - 10.000 (*)	1	1
Earth connection C.T. ratio	1 – 3000 1 - 10.000 (*)	1	1
Capacitive V.T.	YES / NO		NO
Line current (ZLV-G/J)	I-1 / I-2 / I-1+I-2		I-1

(*) Models ZLV-*-*****K/M* or higher.**

Event Mask (only via communications)			
Event Mask	YES / NO		

- **General Settings: HMI Access**

ZLV-A/B/E/F/H

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - PHASE CT RATIO**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - POL. CT RATIO**
3 - INFORMATION	3 - PROTECTION	**3 - GND PARAL CT RATIO**
	4 - RECLOSER	**4 - PHASE VT RATIO**
	...	**5 - BUSBAR VT RATIO**
		6 - PHASE SEQUENCE
		7 - CAPACITIVE VT

ZLV-G/J

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - PHASE CT RATIO**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - POL. CT RATIO**
3 - INFORMATION	3 - PROTECTION	**3 - GND PARAL CT RATIO**
	4 - RECLOSER	**4 - PHASE VT RATIO**
	...	**5 - SYNC VT RATIO**
		6 - SYNC 2 VT RATIO
		7 - PHASE SEQUENCE
		8 - CAPACITIVE VT
		9 - LINE CURRENT

3.30 Trip and Close Coil Circuit Supervision

3.30.1 Description

The Trip and Close Coil Circuit Supervision function (not included in the **ZLV-E** model) permits an alarm when an anomalous situation occurs in the breaker's switching circuits: losses of the auxiliary switching power supply voltage or openings in the open and close circuits themselves. Up to three or six (depending on model) switching circuits can be monitored. Each of them can be set to both breaker positions (open and closed) or only to one of them.

The supervision function generates three or six outputs: **Circuit 1 Failure** (**FAIL_CIR1**), **Circuit 2 Failure** (**FAIL_CIR2**), **Circuit 3 Failure** (**FAIL_CIR3**), **Circuit 4 Failure** (**FAIL_CIR4**), **Circuit 5 Failure** (**FAIL_CIR5**) and **Circuit 6 Failure** (**FAIL_CIR1**), which the programmable logic can use to activate any of the IED's auxiliary contact outputs, also generating the corresponding events.

The six supervisions are treated separately as independent functions that can be independently set to enabled by means of a setting. Figure 3.30.1 is the block diagram showing the application in the situation of open breaker for two circuits with open and closed monitoring.

3.30.2 Operation Mode

There are settings for supervising the state of six coils: Trip Coil, Coil 2, Coil 3, Coil 4, Coil 5 and Coil 6. All of them may be trip or close. Hence their generic name. The activation of the **Trip/Close Circuit Failure** (**FAIL_CIRn**) of the coil or coils corresponding to the trip circuits may be used to, through the adequate programmable logic, impede the recloser from going on to initiate reclosing.

Each of the coils has an associated pair of configurable digital inputs for monitoring. They can be paired to **Monitor in 2 States**, which is explained next, or individually to **Monitor in 1 State**. In any case, both modes can be combined for different coils (for example, to monitor the trip coil in open and closed, and coil two only in open).

Table 3.30-1 identifies the status contact inputs that must be configured and used to monitor each of the circuits.

Table 3.30-1: Input Configuration for the Coil Circuit Supervision

Monitored Circuit	Supervision in 2 States	Supervision in 1 State
Coil 1	IN3	IN3
	IN4	-
Coil 2	IN6	IN6
	IN7	-
Coil 3	IN9	IN9
	IN10	-
Coil 4	IN17	IN17
	IN18	-
Coil 5	IN19	IN19
	IN20	-
Coil 6	IN21	IN21
	IN22	-

Moreover, to monitor the **Coil 1**, a positive must be entered through terminal **IN2/CS1+**, to monitor the **Coil 2**, a positive must be entered through terminal **IN5/CS2+**, to monitor the **Coil 3**, a positive must be entered through terminal **IN8/CS3+**, and to monitor **Coils 4**, **5** and **6** a positive must be entered through terminal **IN6/CS4+**.

The IED needs no physical intervention to be able to assign status contact inputs for the monitor function; they simply need to be set for this purpose.

Each of the three or six coils can be configured as:

1. **No Supervision**. The supervision algorithm is not executed and the status contact inputs associated with the supervision of each of the coils are treated as standard status contact inputs.
2. **Supervision in 2 States**. The algorithm is the one indicated by way of example in figure 3.19.1 and explained in section 3.28.3. Basically, an XOR algorithm supervises the state of the switching circuit in open as well as in closed.
3. **Supervision in 1 State**. The algorithm only takes into account the supervision of the coil in the breaker's position configured in the input used for this purpose (IN3, IN7, IN9, IN17, IN19 or IN21). It does not monitor in the other position and therefore can never detect a fault in the coil.

For each of the monitored coils, it is possible to set a time after which, if there is discordance, the fault is activated.

Trip and close coil circuit monitoring is not sensitive to the impedance of the circuits seen from the relay. Its operating principle is based on an injection of current pulses that allows detecting continuity in those circuits. Every second a pulse of 100ms is sent, monitoring that the current circulates though the circuit. Current will not circulate if the auxiliary contact is open or the coil circuit is open.

3.30.3 Trip Coil Circuit

In the conditions of figure 3.30.1 (open breaker), current pulses are injected through inputs **IN3** and **IN4**. Because **IN3** is connected to contact **52/b**, which is closed, current flows through it and this is detected. No current flows through **IN4** and this fact is also detected. Given that the supervision has been programmed for **Supervision in 2 States**, the μController in charge of the management of this supervisory function will send a “0” logic to the main μProcessor and this will set the **FAIL_CIR1** (**Circuit Failure 1**) signal to “0” logic. In this situation it will be detected that the **IN3** digital input is activated and **IN4** is deactivated.

If the trip coil opens, the input that was activated, **IN3**, will deactivate and **IN4** will remain deactivated. After the configured **Trip Circuit Failure Reset Time**, the **Trip Circuit Failure 1** (**FAIL_CIR1**) signal will be given.

If a close or a reclosure occurs while the switching circuit is intact, once the command is executed, the state of the breaker and that of its **52/a** and **52/b** contacts changes. Consequently, the activation or deactivation of inputs **IN3** and **IN4** will invert and the **FAIL_CIR1** output will remain deactivated.

The purpose of the time delay is to compensate for the time gap between the closing of contact **52/a** and the opening of **52/b**. Generally, the **IN3** and **IN4** digital contacts do not change state simultaneously and, therefore, there will be a discordance between the two contacts. This will not modify the state of the **FAIL_CIR1** output as long as its duration is less than the set time.

If a trip occurs with the breaker closed and the breaker opens, inverting the state of contacts **52/a** and **52/b**, the **FAIL_CIR1** signal will not activate regardless of the duration of the trip command. If the breaker does not execute the command and the open command persists longer than the established reset time, the **FAIL_CIR1** signal will activate.

If the switching voltage disappears, the inputs that are energized will de-energize and this will activate both switching circuit failure outputs (**FAIL_CIR1** and **FAIL_CIR2**).

When the supervisory function of the trip coil detects the rupture of the circuit and, consequently, the impossibility of tripping, the sending of close commands to the breaker through the equipment should be impeded, manual as well as from the recloser, through the use of programmable logic from the equipment.

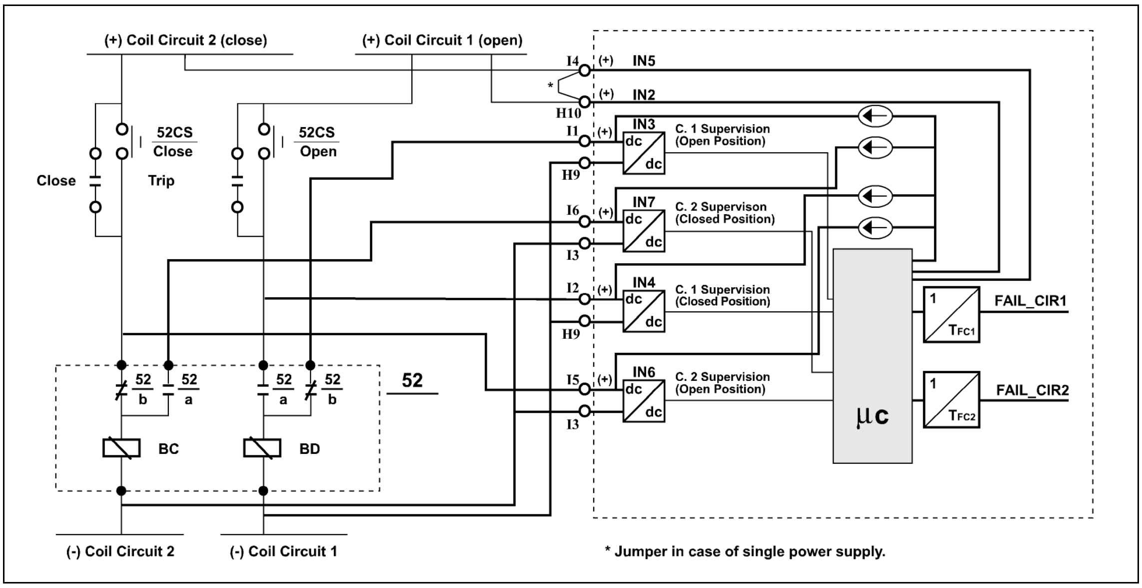


Figure 3.30.1: Trip/Close Coil Circuit Supervision Block Diagram.

3.30.4 Coil Circuits 2, 3, 4, 5 and 6

The explanation given for the open Circuit 1 is valid for the circuits of Coils 2, 3, 4, 5 and 6, referring to a possible close coil and to the corresponding operating circuit and changing the open commands for close commands, or to a second trip coil. Moreover, for coils 2, 3, 4, 5 and 6, the reset times for activating the failure output are independent of that indicated for the open circuit. The failure signal in the switching circuit is called **FAIL_CIR2**, **FAIL_CIR3**, **FAIL_CIR4**, **FAIL_CIR5** and **FAIL_CIR6**.

3.30.5 Trip and Close Coil Circuit Supervision Settings

Trip and Close Coil Circuit Supervision			
Setting	**Range**	**Step**	**By default**
Coil 1 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 1 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 2 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 2 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 3 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 3 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 4 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 4 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 5 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 5 failure time delay	1 - 50 s	0.01 s	0.2 s
Coil 6 Monitoring	0: Do not monitor 1: Monitor one state 2: Monitor both states		0: Do not monitor
Coil 6 failure time delay	1 - 50 s	0.01 s	0.2 s

- **Trip and Close Coil Circuit Supervision: HMI Access**

0 - CONFIGURATION	0 - GENERAL	**0 - CIRCUIT 1 COIL**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - CIR. 1 COIL FAIL. DLY**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - CIRCUIT 2 COIL**
3 - INFORMATION	3 - PROTECTION	**3 - CIR. 2 COIL FAIL. DLY**
	...	**4 - CIRCUIT 3 COIL**
	*** - CIRCUIT COIL SUPERV**	**5 - CIR. 3 COIL FAIL. DLY**
	...	**6 - CIRCUIT 4 COIL**
		7 - CIR. 4 COIL FAIL. DLY
		8 - CIRCUIT 5 COIL
		9 - CIR. 5 COIL FAIL. DLY
		10 - CIRCUIT 6 COIL
		11 - CIR. 6 COIL FAIL. DLY

(*) Option 6 or 7, depending on the model.

3.30.6 Digital Outputs and Events of the Trip/Close Coil Circuit Supervision Module

Table 3.30-2: Digital Outputs and Events of the Trip/Close Coil Circuit Supervision Module

Name	Description	Function
FAIL_CIR1	Circuit #1 failure activated	They activate when an anomaly is detected in one or more of the switching circuits.
FAIL_CIR2	Circuit #2 failure activated	
FAIL_CIR3	Circuit #3 failure activated	
FAIL_CIR4	Circuit #4 failure activated	
FAIL_CIR5	Circuit #5 failure activated	
FAIL_CIR6	Circuit #6 failure activated	

3.31 Breaker Monitoring

3.31.1 ZLV-A/B/E Relays Breaker Supervision

To have suitable information for performing maintenance operations on the breaker, the **ZLV-A/B/E** IED records the interrupting current for each trip of the associated breaker and accumulates it as amperes squared. This number is proportional to the accumulated power actually interrupted by the breaker.

There is a magnitude called “interrupting current” that stores the value of the largest phase current measurement between a trip or manual open command and the opening of the breaker. The value of this magnitude updates whenever a trip or manual open command occurs. If there is an “open command failure, the value of the magnitude updates with the value 0.

When a trip is initiated, it accumulates the square of the largest phase current measured between the trip command and the opening of the breaker, multiplied by the transformation ratio. When it is a manual open, either through the IED itself or by external means, the element also saves the square of the largest phase current measured between the open command and the opening of the breaker, multiplied by the transformation ratio.

Once the value established for the alarm level is reached, the function activates an alarm signal that can be used by the programmable output function to activate an auxiliary contact output. When activated, the events recorder stores this output.

This function is controlled and consulted by means of two settings:

- Alarm Value of Cumulative Square Amps.
- Actual Value of Cumulative Square Amps.

This value is updated by protection whenever a trip or opening operation of the breaker is initiated, and can be modified manually. In the latter case, it represents the baseline value of accumulation to which successive interruption values are added. Manual modification allows setting an initial value corresponding to the breaker's interruption log upon installation of the IED and resetting it to zero after a maintenance operation.

The manual modification is not made by changing settings, since this value is not a proper setting; its modification requires a command through the programmable logic.

3.31.2 ZLV-F/G/H/J Relay Breaker Supervision

The breaker supervision function incorporated into **ZLV-F/G/J** relays is more sophisticated than other models, as it makes a more precise calculation of the arc energy dissipated by the breaker contacts. On the other hand, said calculation is made for all breaker poles.

The theoretical formula for the energy of the arc generated during the contact opening process will be: $E_{arc}=\int(I_{arc}*V_{arc})dt$, where I_{arc} and V_{arc} represent arc current and voltage. As $V_{arc}=I_{arc}*R_{arc}$, where R_{arc} is arc resistance, the above formula can be expressed as $E_{arc}=\int(I_{arc}^2*R_{arc})dt$. If a constant arc resistance is assumed, arc energy will be proportional to $I_{RMS}^2*T_{arc}$, where I_{RMS} is the calculated current RMS value during a time frame coinciding exactly with the arc duration and T_{arc} is the duration of the arc between the breaker contacts. **ZLV-F/G/H/J** relays calculate the above expression, with no need for using variable frames (T_{arc} varies from one opening to another), based on the following formula $I_{RMS}^2*T_{ventana}$, where $T_{ventana}$, representing the calculation time frame, is fixed and high enough to cover for arc duration. Based on typical arc durations included in Standard IEC T100a (from 4 to 25 ms), a calculation time frame of 2 cycles has been considered. Said time frame must start at the time when the arc is established between contacts, which can be determined in two ways:

- Taking into account the time when the corresponding breaker pole open signal (whether external or internal to the relay) activates, after adding said pole contact opening time (device operating time: breakers with 2, 3, 5 and 8 cycle operating time have typical contact opening times of 1.5, 2, 3 and 4 cycles).
- Taking into account breaker pole state contact (52b or 52a) operate time after subtracting said contact delay time with respect to the main contacts.

In order to select the most convenient way, based on breaker available information, the arc initiate signal (**breaker n** (n=1, 2 in **ZLV-G/J** relays) **pole X** (X=A, B, C) **Arc Initiate** input) can be configured through the programmable logic (opening signal or breaker state contacts). At the time of activation of said signal, a settable time (**Arc Initiate Delay**: from -1 to 50 cycles in ¼ cycle steps) is added or subtracted.

If neither the contact opening time nor the secondary contact (52b/52a) delay time with respect to the main contacts is known, neither the arc initiate time nor its duration can be calculated. In that case, the best choice is to consider an arc duration of 1 cycle letting the relay store the current RMS value with calculation time frames of equal duration (just setting **Calculation Time Frame** to 1 cycle), starting at the time of breaker pole open signal activation (set **Arc Initiate Delay** to 0 cycles).

ZLV-F/G/H/J relays generate the magnitude **Breaker n** (n=1, 2 in **ZLV-G/J** relays) **X Pole** (X=A, B, C) **open current**. Said magnitude equals the RMS value of the current circulating through breaker n X pole, calculated during the above defined frame. The value of this magnitude updates every time the **Breaker n X Pole Arc Initiate Input** activates, the calculation frame being completed and the **breaker n X Pole Open Input** activated. The magnitude resets to 0 under various conditions:

- When, after completing the calculation frame, a **Breaker n X Pole Open Command Failure** occurs (in this case the **Breaker n X Pole Open Input** will not activate). The model **ZLV-H** generates internally the Open Command Failure signals per pole.
- When the **Calculation Frame Duration** setting sets to 0
- When the **Breaker n Current Buffer Block** input is activated**.** Said input prevents current buffers from increasing (see below) when relays are being checked with secondary injection equipment (during which the breaker current is zero).

Arc energy has been previously considered proportional to $I_{RMS}{}^{2}*T_{arc}$, assuming constant arc resistance. Actually, arc resistance depends on the arc current value, thus arc energy will be proportional to $I_{RMS}{}^{N}*T_{arc}$, where N has a value between 1 and 2. The breaker manufacturer as a rule gives two figures of the number of operations at a given current: n1 operations at I1 kA and n2 operations at I2 kA. In order for the energy calculated for both current levels to be the same, an exponent N other than 2 must be used for the current: $n1*I1^{N}=n2*I2^{N}$. **ZLV-F/G/H/J** relays have the possibility to select the exponent N through a setting.

ZLV-F/G/H/J relays generate other magnitude, **Breaker n** (n=1, 2) **X** (X=A, B, C) **Pole Opened Current**, which stores the following value, every time the **Breaker n X Pole Open Current** updates:

$$\left(I_{RMS\_Xn} \times R_{TIABC}\right)^{N} \times T_{ventana}$$

where I_{RMS_Xn} represents the breaker n X pole opened current, R_{TIABC} represents the phase current transformation ratio, N represents the exponent selected and $T_{ventana}$ represents the selected calculation time frame.

The total stored value is obtained as percentage of the **Stored Current Alarm** setting. When the **Breaker n X Pole Stored Current** magnitude reaches 100%, the function activates the **Breaker n X pole Stored Current** signal that can be used to activate one output through the programmable output function; also a write is added to the event recorder.

The stored current magnitude is updated every time the arc initiate input is activated, nevertheless said magnitude can be modified manually, via **Breaker n X Pole Stored Current Reset Command** input activation. In that case the latter magnitude will take the value of the **Breaker n X Pole Stored kA Reset Value** setting. Said setting represents the base stored value above which successive values corresponding to later openings will be added. Manual modification allows taking into account the breaker pole opening history when installing the relay and the updated value after a maintenance operation.

3.31.3 Excessive Number of Trips

The Excessive Number of Trips function is intended to interrupt an uncontrolled sequence of openings and closings that could damage the breaker. When a certain number of trips have occurred, adjustable between 1 and 40 in a definite time period (30 minutes), an output signal is generated and it can be connected to any of the IED's physical auxiliary contact outputs.

The activation of the Excessive Number of Trips output function disables any further reclose initiation by placing the recloser function in the state of Recloser Lockout Due to Open Breaker status. This condition will reset only after a manual close command or a loss of auxiliary supply.

3.31.4 Breaker Operating Time (Models ZLV-G/J)

The models **ZLV-G/J** record the operating time of each breaker pole [magnitude **Pole X Fault Clearance Time** (X = A, B, C) **Breaker n** (n = 1, 2)] every time there is an open command. For this purpose the time is measured between the open command (signal **Pole X Breaker n Trip Command**) and the joint activation (**AND** operator) of the input **Pole X Breaker n Opened** and the pickup of the undercurrent unit, which operates with the current IX-n and takes as its pick up value the setting of **Phase X Opened Pole Current Level.** If a breaker pole open command has been issued, and an opening failure of this pole is detected, the clearance time of the fault will not be updated.

3.31.5 Breaker Monitoring Settings

Breaker Monitoring			
Setting	**Range**	**Step**	**By default**
Excessive number of trips	1 - 40	1	40
I2 sum alarm	0 - 99,999.99 kA^2	0.01	99,999.99
Cumulative preset value I2 (ZLV-A/B/E)	0 - 99,999.99 kA^2	0.01	0 kA^2
A pole cumulative preset value I2 (ZLV-F/G/H/J)	0 - 99,999.99 kA^2	0.01	0 kA^2
B pole cumulative preset value I2 (ZLV-F/G/H/J)	0 - 99,999.99 kA^2	0.01	0 kA^2
C pole cumulative preset value I2 (ZLV-F/G/H/J)	0 - 99,999.99 kA^2	0.01	0 kA^2
kA index (ZLV-F/G/H/J)	1 - 2	0.1	2
Arc Initiate Delay (ZLV-F/G/H/J)	(-1) - 50 cycles	¼ cycle	0 cycles
Calculation frame duration (ZLV-F/G/H/J)	0 / 1 / 2 cycles	0.01	2 cycles

- **Breaker Monitoring: HMI Access**

ZLV-A/B/E

0 - CONFIGURATION	0 - GENERAL	
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	
3 - INFORMATION	3 - PROTECTION	
	…	**0 - EXCESSIVE TRIPS**
	6 - BREAKER SUPERV.	**1 - I^2 SUM ALARM**
	…	**2 - I^2 DROPOUT VALUE**

ZLV-F/H

0 - CONFIGURATION	0 - GENERAL	
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	
3 - INFORMATION	3 - PROTECTION	
	…	**0 - EXCESSIVE TRIPS**
	6 - BREAKER SUPERV.	**1 - I^2 SUM ALARM**
	…	**2 - I DROPOUT VALUE P A**
		3 - I DROPOUT VALUE P B
		4 - I DROPOUT VALUE P C
		5 - INDEX KA
		6 - ARC INITIATE DELAY
		7 - CALC FRAME DURATION

ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	
3 - INFORMATION	3 - PROTECTION	
	…	**0 - EXCESSIVE TRIPS**
	6 - BREAKER SUPERV.	**1 - BREAKER 1**
	…	**2 - BREAKER 2**

0 - GENERAL		**1 - I^2 SUM ALARM**
1 - SYSTEM IMPEDANCES		**2 - I DROPOUT VALUE P A**
2 - FAULT LOCATOR		**3 - I DROPOUT VALUE P B**
3 - PROTECTION		**4 - I DROPOUT VALUE P C**
…	**0 - EXCESSIVE TRIPS**	**5 - INDEX KA**
6 - BREAKER SUPERV.	**1 - BREAKER 1**	**6 - ARC INITIATE DELAY**
…	**2 - BREAKER 2**	**7 - CALC FRAME DURATION**

3.31.6 Digital Inputs and Events of the Breaker Monitoring Module

Table 3.31-1: Digital Inputs and Events of the Breaker Monitoring Module

Name	Description	Function
IN_BLK_KA	Current Store Block input (ZLV-F/H)	Activating this input blocks current store.
IN_BLK_KA1	Breaker 1 Current Store Block input (ZLV-G/J)	Activating this input blocks breaker 1 current store
IN_BLK_KA2	Breaker 2 Current Store Block input (ZLV-G/J)	Activating this input blocks breaker 2 current store.
RST_CUMI	Stored Current Reset command (ZLV-A/B/E)	Activating this input resets stored current magnitude to the “Stored kA reset value” setting.
RST_CUMIA	A Pole Stored Current Reset Command (ZLV-F/H)	Activating this input resets A Pole Stored Current magnitude to the “A Pole stored kA reset value” setting.
RST_CUMIB	B Pole Stored Current Reset Command (ZLV-F/H)	Activating this input resets B Pole Stored Current magnitude to the “B Pole stored kA reset value” setting.
RST_CUMIC	C Pole Stored Current Reset Command (ZLV-F/H)	Activating this input resets C Pole Stored Current magnitude to the “C Pole stored kA reset value” setting.
RST_CUMIA1	Breaker 1 A Pole Stored Current Reset Command (ZLV-G/J)	Activating this input resets breaker 1 A Pole Stored Current magnitude to the “Breaker 1 A Pole stored kA reset value” setting.
RST_CUMIB1	Breaker 1 B Pole Stored Current Reset Command (ZLV-G/J)	Activating this input resets breaker 1 B Pole Stored Current magnitude to the “Breaker 1 B Pole stored kA reset value” setting.
RST_CUMIC1	Breaker 1 C Pole Stored Current Reset Command (ZLV-G/J)	Activating this input resets breaker 1 C Pole Stored Current magnitude to the “Breaker 1 C Pole stored kA reset value” setting.

Table 3.31-1: Digital Inputs and Events of the Breaker Monitoring Module		
Name	**Description**	**Function**
RST_CUMIA2	Breaker 2 A Pole Stored Current Reset Command (ZLV-G/J)	Activating this input resets breaker 2 A Pole Stored Current magnitude to the "Breaker 2 A Pole stored kA reset value" setting.
RST_CUMIB2	Breaker 2 B Pole Stored Current Reset Command (ZLV-G/J)	Activating this input resets breaker 2 B Pole Stored Current magnitude to the "Breaker 2 B Pole stored kA reset value" setting.
RST_CUMIC2	Breaker 2 C Pole Stored Current Reset Command (ZLV-G/J)	Activating this input resets breaker 2 C Pole Stored Current magnitude to the "Breaker 2 C Pole stored kA reset value" setting.
IN_KA_STR_A	Arc pole A start input (ZLV-F/H)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker.
IN_KA_STR_B	Arc pole B start input (ZLV-F/H)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker.
IN_KA_STR_C	Arc pole C start input (ZLV-F/H)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker.
IN_KA_STR_A1	Breaker 1 Arc pole A start input (ZLV-F)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker 1.
IN_KA_STR_B1	Breaker 1 Arc pole B start input (ZLV-F)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 1.

Table 3.31-1: Digital Inputs and Events of the Breaker Monitoring Module		
Name	**Description**	**Function**
IN_KA_STR_C1	Breaker 1 Arc pole C start input (ZLV-F)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 1.
IN_KA_STR_A2	Breaker 2 Arc pole A start input (ZLV-F)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker 2.
IN_KA_STR_B2	Breaker 2 Arc pole B start input (ZLV-F)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 2.
IN_KA_STR_C2	Breaker 2 Arc pole C start input (ZLV-F)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 2.

3.31.7 Digital Outputs and Events of the Breaker Monitoring Module

Table 3.31-2: Digital Outputs and Events of the Breaker Monitoring Module		
Name	**Description**	**Function**
EXC_NTRIP	Excessive number of trips	Indication that the maximum number of trips set has been reached.
AL_KA2	Accumulated KA^2 alarm (ZLV-A/B/E)	Indication that the summed kA^2 values accumulated by the breaker have reached the alarm level.
AL_KA_A	Pole A accumulated Amps alarm (ZLV-F/H)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker have reached the alarm level.
AL_KA_B	Pole B accumulated Amps alarm (ZLV-F/H)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker have reached the alarm level.
AL_KA_C	Pole C accumulated Amps alarm (ZLV-F/H)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker have reached the alarm level.
AL_KA_A1	Breaker 1 Pole A accumulated Amps alarm (ZLV-G/J)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker 1 have reached the alarm level.
AL_KA_B1	Breaker 1 Pole B accumulated Amps alarm (ZLV-G/J)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 1 have reached the alarm level.

Table 3.31-2: Digital Outputs and Events of the Breaker Monitoring Module		
Name	**Description**	**Function**
AL_KA_C1	Breaker 1 Pole C accumulated Amps alarm (ZLV-G/J)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 1 have reached the alarm level.
AL_KA_A2	Breaker 2 Pole A accumulated Amps alarm (ZLV-G/J)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker 2 have reached the alarm level.
AL_KA_B2	Breaker 2 Pole B accumulated Amps alarm (ZLV-G/J)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 2 have reached the alarm level.
AL_KA_C2	Breaker 2 Pole C accumulated Amps alarm (ZLV-G/J)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 2 have reached the alarm level.

3.31.8 Breaker Supervision Module Magnitudes

Table 3.31-3: Breaker Supervision Module Magnitudes		
Name	**Description**	**Function**
IABI_A	Pole A Opened Current (ZLV-F/H)	
IABI_B	Pole B Opened Current (ZLV-F/H)	
IABI_C	Pole C Opened Current (ZLV-F/H)	
ACUMIAB_A	Pole A Stored Current (ZLV-F/H)	
ACUMIAB_B	Pole B Stored Current (ZLV-F/H)	
ACUMIAB_C	Pole C Stored Current (ZLV-F/H)	
IABI_A1	Breaker 1 Pole A Opened Current (ZLV-G/J)	A
IABI_B1	Breaker 1 Pole B Opened Current (ZLV-G/J)	A
IABI_C1	Breaker 1 Pole C Opened Current (ZLV-G/J)	A
IABI_A2	Breaker 2 Pole A Opened Current (ZLV-G/J)	A
IABI_B2	Breaker 2 Pole B Opened Current (ZLV-G/J)	A
IABI_C2	Breaker 2 Pole C Opened Current (ZLV-G/J)	A
ACUMIAB_A1	Breaker 1 Pole A Stored Current (ZLV-G/J)	% of breaker 1 stored kA Alarm Value
ACUMIAB_B1	Breaker 1 Pole B Stored Current (ZLV-G/J)	% of breaker 1 stored kA Alarm Value.
ACUMIAB_C1	Breaker 1 Pole C Stored Current (ZLV-G/J)	% of breaker 1 stored kA Alarm Value.
ACUMIAB_A2	Breaker 2 Pole A Stored Current (ZLV-G/J)	% of breaker 2 stored kA Alarm Value.
ACUMIAB_B2	Breaker 2 Pole B Stored Current (ZLV-G/J)	% of breaker 2 stored kA Alarm Value.
ACUMIAB_C2	Breaker 2 Pole C Stored Current (ZLV-G/J)	% of breaker 2 stored kA Alarm Value.

Table 3.31-3: Breaker Supervision Module Magnitudes		
Name	**Description**	**Function**
TFALTA_A1	Breaker 1 Pole A Operating Time (ZLV-G/J)	ms
TFALTA_B1	Breaker 1 Pole B Operating Time (ZLV-G/J)	ms
TFALTA_C1	Breaker 1 Pole C Operating Time (ZLV-G/J)	ms
TFALTA_A2	Breaker 2 Pole A Operating Time (ZLV-G/J)	ms
TFALTA_B2	Breaker 2 Pole B Operating Time (ZLV-G/J)	ms
TFALTA_C2	Breaker 2 Pole C Operating Time (ZLV-G/J)	ms

3.32 Change Settings Groups

3.32.1 Description

The **Protection**, **Logic** and **Recloser** settings include four alternative groups (GROUP 1, GROUP 2, GROUP 3 and GROUP 4), which can be activated or deactivated from the keypad, through the communication ports, by using external status contact inputs or with signals generated in the programmable logic.

This function permits modifying the active setting groups and, thereby, the response of the protection. This way, the behavior of the IED can adapt to changes in the external circumstances.

Two logic input signals can block changes in the active group from the HMI as well as via communications. When inputs **INH_CGRP_COM** and **INH_CGRP_HMI** are active, groups cannot be changed with commands via communications nor through the HMI.

If the status contact inputs are used to change groups, up to four status contact inputs may need to be configured through the programmable status contact inputs: **Command to Activate Settings Group 1 by Digital Input** (**CMD_GRP1_DI**), **Command to Activate Settings Group 2 by Digital Input** (**CMD_GRP2_DI**), **Command to Activate Settings Group 3 by Digital Input** (**CMD_GRP3_DI**) and **Command to Activate Settings Group 4 by Digital Input** (**T CMD_GRP4_DI**). There is another possible input whose function is to disallow group changes: **Inhibit Setting Group Control** (**INH_C_DE**).

Activating inputs **CMD_GRP1_DI**, **CMD_GRP2_DI**, **CMD_GRP3_DI** and **CMD_GRP4_DI** will activate GROUP 1, GROUP 2, GROUP 3 and GROUP 4 respectively.

If, while one of the inputs is active, either of the other three or several of them are activated, no group change will take place. The status contact settings group control logic will recognize a single input only. If all four inputs are deactivated, however, the IED will remain in the last active settings group.

Note: Groups can be changed by activating T1, T2 and T3 only if the display is in the default screen.

3.32.2 Digital Inputs and Events to Change Settings Groups

Table 3.32-1:Digital Inputs and Events to Change Settings Groups		
Name	**Description**	**Function**
INH_CGRP_COM	Inhibit group change via communications	It blocks any change of the active group by the PROCOME procedure.
INH_CGRP_HMI	Inhibit group change via HMI	It blocks any change of the active group through the HMI menu.
CMD_GRP1_COM	Command to activate settings group 1 via communications	Commands to change the active group.
CMD_GRP1_DI	Command to activate settings group 1 via DI	
CMD_GRP1_HMI	Command to activate settings group 1 via HMI	
CMD_GRP2_COM	Command to activate settings group 2 via communications	
CMD_GRP2_DI	Command to activate settings group 2 via DI	
CMD_GRP2_HMI	Command to activate settings group 2 via HMI	
CMD_GRP3_COM	Command to activate settings group 3 via communications	
CMD_GRP3_DI	Command to activate settings group 3 via DI	
CMD_GRP3_HMI	Command to activate settings group 3 via HMI	
CMD_GRP4_COM	Command to activate settings group 4 via communications	
CMD_GRP4_DI	Command to activate settings group 4 via DI	
CMD_GRP4_HMI	Command to activate settings group 4 via HMI	

3.32.3 Digital Outputs and Events to Change Settings Groups

Table 3.32-2: Digital Outputs and Events to Change Settings Groups		
Name	**Description**	**Function**
T1_ACTIVATED	Settings group 1 activated	Indication of the active group.
T2_ACTIVATED	Settings group 2 activated	
T3_ACTIVATED	Settings group 3 activated	
T4_ACTIVATED	Settings group 4 activated	

3.33 Event Record

3.33.1 Description

The capacity of the recorder is 400 notations in non-volatile memory. The signals that generate the events are user-selectable and are recorded with a resolution of 1 ms together with a maximum of 12 values also selectable from all the available metering values measured or calculated by the IED ("user defined values").

Each of the functions that the system uses records an event in the Event Record when any of the situations listed in the tables nested in the description of each function occur. Moreover, the events listed in table 3.33-1 -the IED's general services- are also recorded. The tables mentioned above only list the events available with the default configuration. The list of signals can be expanded with those that the user configures in the programmable logic (any signal existing in the programmable logic can be configured to generate an event with the description that the user defines).

Table 3.33-1: Event Record

Name	Description
HMI access	See the description in Digital Outputs.
Clock synchronization	
IRIG-B active	
Oscillography picked up	
Deletion of oscillographs command	
Pole A open command (ZLV-B/F)	
Pole B open command (ZLV-B/F)	
Pole C open command (ZLV-B/F)	
Open command (ZLV-A/E/F/H)	
Open command pole A breaker 1 (ZLV-G/J)	
Open command pole B breaker 1 (ZLV-G/J)	
Open command pole C breaker 1 (ZLV-G/J)	
Open command pole A breaker 2 (ZLV-G/J)	
Open command pole B breaker 2 (ZLV-G/J)	
Open command pole C breaker 2 (ZLV-G/J)	
Open command breaker 1 (ZLV-G/J)	
Open command breaker 2 (ZLV-G/J)	
Open 52 button	
Open P1 button	
Open P2 button	
Open P3 button	
Open P4 button	
Open P5 button	
Open P6 button	
Close 52 button	
Close P1 button	
Close P2 button	
Close P3 button	
Close P4 button	
Close P5 button	
Close P6 button	

Table 3.33-1: Event Record	
Name	**Description**
Digital Input 1	See the description in Digital Outputs.
Digital Input 2	
Digital Input 3	
Digital Input 4	
Digital Input 5	
Digital Input 6	
Digital Input 7	
Digital Input 8	
Digital Input 9	
Digital Input 10	
Digital Input 11	
Digital Input 12	
Digital Input 13	
Digital Input 14	
Digital Input 15	
Digital Input 16	
Digital Input 17	
Digital Input 18	
Digital Input 19	
Digital Input 10	
Digital Input 21	
Digital Input 22	
Digital Input 23	
Digital Input 24	
Digital Input 25	
Digital Input 26	
Digital Input 27	
Digital Input 28	
Digital Input 29	
Digital Input 30	
Digital Input 31	
Digital Input 32	
Digital Input 33	
Digital Input 34	
Digital Input 35	
Digital Input 36	
Digital Input 37	
Validity of Digital Input 1	
Validity of Digital Input 2	
Validity of Digital Input 3	
Validity of Digital Input 4	
Validity of Digital Input 5	
Validity of Digital Input 6	
Validity of Digital Input 7	
Validity of Digital Input 8	
Validity of Digital Input 9	
Validity of Digital Input 10	

Table 3.33-1: Event Record	
Name	**Description**
Validity of Digital Input 11	See the description in Digital Outputs.
Validity of Digital Input 12	
Validity of Digital Input 13	
Validity of Digital Input 14	
Validity of Digital Input 15	
Validity of Digital Input 16	
Validity of Digital Input 17	
Validity of Digital Input 18	
Validity of Digital Input 19	
Validity of Digital Input 20	
Validity of Digital Input 21	
Validity of Digital Input 22	
Validity of Digital Input 23	
Validity of Digital Input 24	
Validity of Digital Input 25	
Validity of Digital Input 26	
Validity of Digital Input 27	
Validity of Digital Input 28	
Validity of Digital Input 29	
Validity of Digital Input 30	
Validity of Digital Input 31	
Validity of Digital Input 32	
Validity of Digital Input 33	
Validity of Digital Input 34	
Validity of Digital Input 35	
Validity of Digital Input 36	
Validity of Digital Input 37	
Auxiliary Output 1	
Auxiliary Output 2	
Auxiliary Output 3	
Auxiliary Output 4	
Auxiliary Output 5	
Auxiliary Output 6	
Auxiliary Output 7	
Auxiliary Output 8	
Auxiliary Output 9	
Auxiliary Output 10	
Auxiliary Output 11	
Auxiliary Output 12	
Auxiliary Output 13	
Auxiliary Output 14	
Auxiliary Output 15	
Auxiliary Output 16	
Auxiliary Output 17	
Auxiliary Output 18	
Auxiliary Output 19	
Auxiliary Output 20	

Table 3.33-1: Event Record	
Name	**Description**
Auxiliary Output 21	See the description in Digital Outputs.
Auxiliary Output 22	
Auxiliary Output 23	
Auxiliary Output 24	
Auxiliary Output 25	
Auxiliary Output 26	
Auxiliary Output 27	
Auxiliary Output 28	
Auxiliary Output 29	
Auxiliary Output 30	
Auxiliary Output 31	
Auxiliary Output 32	
Auxiliary Output 33	
Auxiliary Output 34	
Auxiliary Output 35	
Auxiliary Output 36	
Auxiliary Output 37	
Auxiliary Output 38	
Auxiliary Output 39	
Auxiliary Output 40	
Auxiliary Output 41	
Auxiliary Output 42	
Auxiliary Output 43	
Auxiliary Output 44	
LEDs reset input	
Power meters reset input	
Cold load pickup of IED	
Manual reinitialization of the IED	
Change of settings initialization	
Critical system error	
Non-critical system error	
System event	

All the configured events as well as the pre-existing ones in the default configuration can be masked.

The text indicated in the events tables is expanded with the message **Activation of...** when the event is generated by activation of any of the signals or **Deactivation of...** when the event is generated by deactivation of the signal.

3.33.2 Organization of the Event Record

The event record capacity is four hundred events. When the record is full, a new event displaces the oldest one. The following information is stored in each event register:

- Values of the 12 magnitudes selected at the time the event is generated.
- Event date and time.

Event recorder management is optimized so that simultaneous operations generated by the same event occupy a single position in the event memory. For example, the simultaneous occurrence of the phase A and neutral time overcurrent pickups are recorded in the same memory position. However, if the occurrences are not simultaneous, two separate events are generated. Simultaneous events are those operations occurring within a 1 ms interval, the resolution time of the recorder.

3.33.3 Event Mask

Use the general settings in communications to mask unneeded or unused events for system behavior analysis. Events are masked by communications within the General settings.

Important: Events that can be generated in excess should be masked since they could fill the memory (400 events) and erase more important previous events.

3.33.4 Consulting the Record

The communications and remote management program, ***ZIVercomPlus***®, has a completely decoded system for consulting the event record.

3.33.5 Event Record Settings (Via Communications)

Event Mask
Equipment events may be masked separately

Event Magnitudes (ZLV-A/B/E)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

IA	VA	P	P.Active Energy	M V1 01	M V2 01
IB	VB	PMIN	N.A.ENGY	M V1 02	M V2 02
IC	VC	PMAX	P.React.Energy	M V1 03	M V2 03
IAB	VN	Q	N.R.ENGY	M V1 04	M V2 04
IBC	VAB	QMIN	DIST	M V1 05	M V2 05
ICA	VBC	QMAX	C RECLO	M V1 06	M V2 06
IG	VCA	S	RECL MONO	M V1 07	M V2 07
IGPAR	VG	SMIN	RECL TRIF	M V1 08	M V2 08
IPOL	VSYNC	SMAX	TRANSDUCER C1	M V1 09	M V2 09
POS SEQ	POS SEQ	PF	N E AF 1	M V1 10	MV2 10
NEG SEQ	NEG SEQ	FREQ	N E AF 2	M V1 11	M V2 11
ZERO SEQ I	ZERO SEQ V	FREQ SYNC	N E DF 1	M V1 12	M V2 12
IMIN	IMIN	ROC FREQ	N E DF 2	M V1 13	M V2 13
IMAX	IMAX	CUMULATIVE kA^2	N Er C 1	M V1 14	M V2 14
		FAULTT	N Er C 2	M V1 15	M V2 15
		ACTGRP	T Act 1	M V1 16	M V2 16
		THERMAL IMG	T Act 2		
		TRIPTYPE	N Er AC 1		
			N Er AC 2		

Event Magnitudes (ZLV-F/H)					
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:					
IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VN	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ SYNC	N.A.ENGY	M V1 06	M V2 06
IG	VCA	ROC FREQ	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	CUMULATIVE kA^2_A	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMULATIVE kA^2_B	DIST	M V1 09	M V2 09
POS SEQ	IMIN	CUMULATIVE kA^2_C	C RECLOSER	M V1 10	MV2 10
NEG SEQ	IMAX	IABI_A	RECL MONO	M V1 11	M V2 11
ZERO SEQ I	VMIN	IABI_B	RECL TRIF	M V1 12	M V2 12
HARM2 IA	VMAX	IABI_C	NOPEN_A	M V1 13	M V2 13
HARM2 IB	PMIN	FAULTT	NOPEN_B	M V1 14	M V2 14
HARM2 IC	PMAX	ACTGRP	NOPEN_C	M V1 15	M V2 15
	QMIN	THERMAL IMG	NCLOSE	M V1 16	M V2 16
	QMAX	TRIPTYPE		N E AF 1	NPICKUPS
	SMIN	TRANSDUCER C1		N E AF 2	NRPICKUS
	SMAX			N E DF 1	NTRAPS
				N E DF 2	FECHTRIP
				N Er C 1	T_CORTO
				N Er C 2	

Event Magnitudes (ZLV-G/J)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VN	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ SYNC	N.A.ENGY	M V1 06	M V2 06
IG	VCA	FREQ SYNC2	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	ROC FREQ	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMULATIVE kA^2_A1	DIST	M V1 09	M V2 09
POS SEQ	VSYNC2	CUMULATIVE kA^2_B1	C RECLOSER1	M V1 10	MV2 10
NEG SEQ	POS SEQ	CUMULATIVE kA^2_C1	C RECLOSER2	M V1 11	M V2 11
ZERO SEQ I	NEG SEQ	CUMULATIVE kA^2_A2	RECL MONO1	M V1 12	M V2 12
IA1	ZERO SEQ V	CUMULATIVE kA^2_B2	RECL MONO2	M V1 13	M V2 13
IB1	IMIN	CUMULATIVE kA^2_C2	RECL TRIF1	M V1 14	M V2 14
IC1	IMAX	IABI_A1	RECL TRIF2	M V1 15	M V2 15
IA2	VMIN	IABI_B1	NOPENINT1_A	M V1 16	M V2 16
IB2	VMAX	IABI_C1	NOPENINT1_B	N E AF 1	NPICKUPS
IC2	PMIN	IABI_A2	NOPENINT1_C	N E AF 2	NRPICKUS
IN1	PMAX	IABI_B2	NOPENINT2_A	N E DF 1	NTRAPS
IN2	QMIN	IABI_C2	NOPENINT2_B	N E DF 2	FECHTRIP
HARM2 IA	QMAX	FAULTT	NOPENINT2_C	N Er C 1	T_CORTO
HARM2 IB	SMIN	ACTGRP	NCLOSEINT1	N Er C 2	T_FAULT_A1
HARM2 IC	SMAX	THERMAL IMG	NCLOSEINT2		T_FAULT_B1
		TRIPTYPE			T_FAULT_C1
		TRANSDUCER C1			T_FAULT_A2
					T_FAULT_B2
					T_FAULT_C2

3.34 Fault Reports

3.34.1 Introduction

The terminal incorporates Fault reports register, which stores the most relevant information about faults cleared by the IED. Access to this information is available through the communication ports. The information stored in each fault report is distributed in three tags: **Fault Initiation Time Tag**, **Open Command Time Tag** and **Fault End Time Tag**.

3.34.2 Fault Initiation Time Tag

Presents the date and time of the moment when the activation of the fault detector was produced or, if not activated, the start of the first element involved in the fault. Also included:

- **Pre-fault currents and voltages**. These are the values of the phase, ground, polarization and ground of the parallel line currents, and of the phase voltages (phase and line) and synchronism, two cycles prior to the commencement of the fault (activation of the fault detector or pick up of the first element involved in the fault). The values of the positive, negative and zero sequence currents and voltages are also noted. The currents as well as voltages (phase) are accompanied by their arguments.
- **Elements picked up** for full fault duration.

3.34.3 Open Command Time Tag

It presents the date and time of the trip command and also displays:

- **Fault currents and voltages.** These are the values of the phase, ground, polarization and ground of the parallel line currents, and of the phase voltages (phase and line) and synchronism, one and one-half cycles after the pick up of the first element involved in the fault. The values of the positive, negative and zero sequence currents and voltages are also noted. The currents as well as voltages (phase) are accompanied by their arguments.
- **Trip generator units**, that is, those elements activated at the instant of the trip.
- **Fault Type**.
- **Trip Zone**. Indicates zones involved in the fault.
- **Trip Mode**. Indicates single-phase or three-phase trip.

3.34.4 Fault End Time Tag

It is the date and time of the reset of the last element involved in the fault. Also displays:

- **Fault currents and voltages**.
- **Frequency**.
- **Current Interrupted by Breaker**.
- **Thermal State**.
- **Distance to the fault.**

A magnitude, **Fault Duration** is generated from fault initiate and clearance labels, which is also included into the fault report.

Each record in the fault report includes the setting group active during the trip, and the number of single phase and three phase recloser attempts previous to the fault.

It should be pointed out that the indication of the type of fault will be UNKNOWN FAULT (DES) when all the elements and the trip are reset before the elapse of 1.5 cycles after the first pick up.

3.34.5 Fault Report on HMI

ZLV-F** relays include the possibility to display fault reports on the HMI. To gain access to these records, enter the field **3- Information → 6- Fault Reports**. Once the above field has been accessed, a list with the date and time of the last fault records will be displayed that will include the following information:

- Pick up and trip signals activated during the duration time of the fault: the short name of the signal will be used (refer to tables of digital outputs corresponding to each protection element). E.g. trip and pick up of the ground instantaneous overcurrent element 1 will be displayed as: **PU_IOC_N1** and **TRIP_IOC_N1**.
- Type of fault, type of trip, zone tripped, distance to fault, duration time of fault, active table, frequency, status of temperature switch and reclose counter.
- Fault voltages and currents.

3.35 Metering Log

3.35.1 Operation

This function records the evolution of the values monitored at the point where the IED is installed. It samples each of the 12 values programmed for this purpose and calculates their average over the interval defined as **Averaging Calculation Time Interval**. This time interval is adjustable between 1 and 15 minutes. Each interval yields two values: the highest and the lowest of these magnitude averages.

The **Data Record Interval** is an adjustable period of time between 1 minute and 24 hours. The maximum and minimum averages recorded in the whole interval are recorded with their final time stamp. Figure 3.35.1 shows how the history record works.

- **AT** average calculation time interval; the figure shows an AT value of one minute.

- **RI**: data record interval; the figure shows a RI of 15 minutes.

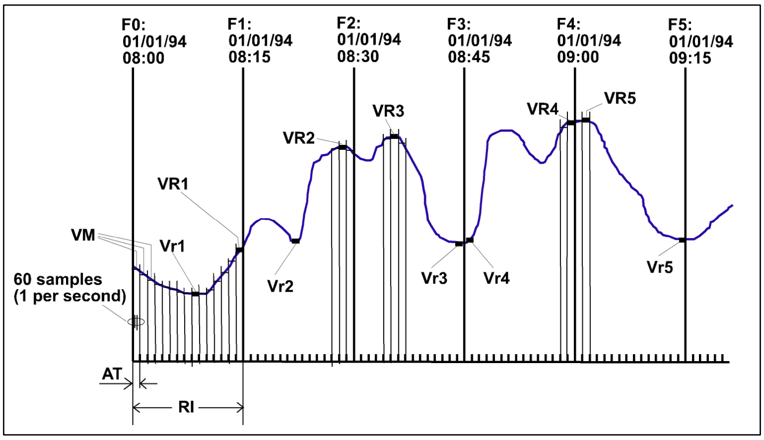


Figure 3.35.1: Explanatory Diagram of the Metering Log.

Each **AT** yields two **MV** values: the maximum and minimum averages. Each **RI** interval takes the maximum and minimum values of all the **MV**s computed. The profile of figure 3.35.1 yields the following values: VR1 - Vr1; VR2 - Vr2; VR3 - Vr3; VR4 - Vr4 and VR5 - Vr5.

Note: if phase or ground elements pick up during the average calculation time interval, the average of the measurements made while the elements were not picked up is recorded. Otherwise, if the elements remain picked up throughout the AT, the value recorded is: 0A / 0V.

As already indicated, twelve values can be configured among all the direct or calculated metering values ("user defined values") available in the IED (M_i). For each of the 12 values, up to four different metering values can be selected. For each of them, the greatest and the smallest of the three averages calculated along the **Averaging Calculation Time Interval** are found. See figure 3.35.2.

Thus, the greatest and the smallest value of all those calculated for each of the metering values that comprise each magnitude M_i are recorded.

The memory available for the metering log is RAM, large enough for 168 values. The memory can be customized by defining an **Hour Range** and **Day Calendar Mask** (the same hour range for all the days). No values outside the mask will be recorded.

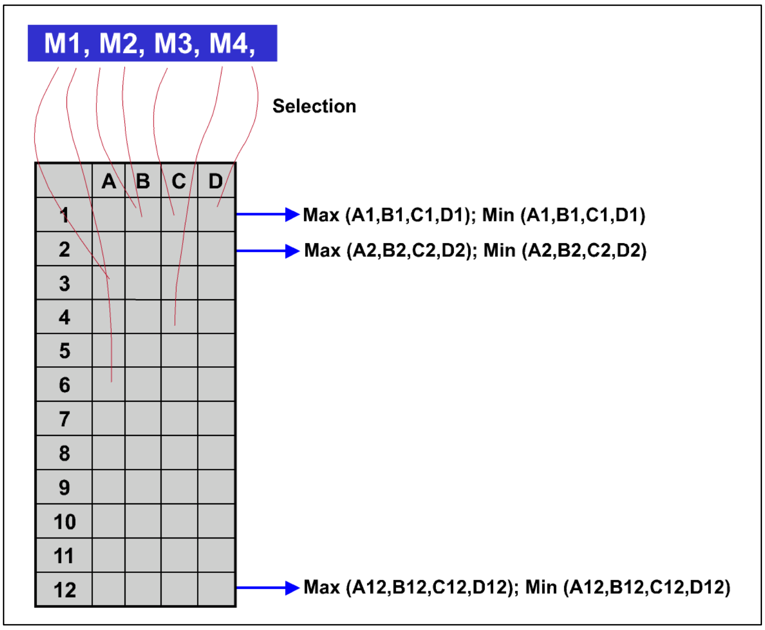


Figure 3.35.2: Metering Log Algorithm.

Likewise, the phase currents and voltages as well as the powers are constantly sampled. The sampled values are compared with those already stored. This keeps a maximum/minimum demand metering of the phase currents and voltages and of the active, reactive and apparent powers up to date.

These maximum and minimum values are stored in non-volatile memory, so they are reset by the logic input signal **Maximum Demand Element Reset**.

All this information is only available via communications through the communications and remote management program ***ZIVercomPlus***®.

3.35.2 Metering Log Settings

Metering Log			
Setting	**Range**	**Step**	**By default**
Sample interval	1 - 15 min		1 min
Historical data record interval	From 1 min to 24.00 h.		1 min
Day calendar mask	Monday to Sunday	YES / NO	YES
Calendar time mask	0 to 24.00 h		0 - 24 h

Log Groups (ZLV-A/B/E)

There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:

IA	VA	P	P.Active Energy	M V1 01	M V2 01
IB	VB	PMIN	N.A.ENGY	M V1 02	M V2 02
IC	VC	PMAX	P.React.Energy	M V1 03	M V2 03
IAB	VN	Q	N.R.ENGY	M V1 04	M V2 04
IBC	VAB	QMIN	DIST	M V1 05	M V2 05
ICA	VBC	QMAX	C RECLO	M V1 06	M V2 06
IG	VCA	S	RECL MONO	M V1 07	M V2 07
IGPAR	VG	SMIN	RECL TRIF	M V1 08	M V2 08
IPOL	VSYNC	SMAX	TRANSDUCER C1	M V1 09	M V2 09
POS SEQ	POS SEQ	PF	N E AF 1	M V1 10	MV2 10
NEG SEQ	NEG SEQ	FREQ	N E AF 2	M V1 11	M V2 11
ZERO SEQ I	ZERO SEQ V	FREQ SYNC	N E DF 1	M V1 12	M V2 12
IMIN	IMIN	ROC FREQ	N E DF 2	M V1 13	M V2 13
IMAX	IMAX	CUMULATIVE kA^2	N Er C 1	M V1 14	M V2 14
		FAULTT	N Er C 2	M V1 15	M V2 15
		ACTGRP	T Act 1	M V1 16	M V2 16
		THERMAL IMG	T Act 2		
		TRIPTYPE	N Er AC 1		
			N Er AC 2		

Log Groups (ZLV-F/H)					
There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:					
IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VN	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ SYNC	N.A.ENGY	M V1 06	M V2 06
IG	VCA	ROC FREQ	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	CUMULATIVE kA^2_A	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMULATIVE kA^2_B	DIST	M V1 09	M V2 09
POS SEQ	IMIN	CUMULATIVE kA^2_C	C RECLOSER	M V1 10	MV2 10
NEG SEQ	IMAX	IABI_A	RECL MONO	M V1 11	M V2 11
ZERO SEQ I	VMIN	IABI_B	RECL TRIF	M V1 12	M V2 12
HARM2 IA	VMAX	IABI_C	NOPEN_A	M V1 13	M V2 13
HARM2 IB	PMIN	FAULTT	NOPEN_B	M V1 14	M V2 14
HARM2 IC	PMAX	ACTGRP	NOPEN_C	M V1 15	M V2 15
	QMIN	THERMAL IMG	NCLOSE	M V1 16	M V2 16
	QMAX	TRIPTYPE		N E AF 1	NPICKUPS
	SMIN	TRANSDUCER C1		N E AF 2	NRPICKUS
	SMAX			N E DF 1	NTRAPS
				N E DF 2	FECHTRIP
				N Er C 1	T_CORTO
				N Er C 2	

Log Groups (ZLV-G/J)					
There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:					
IA	VA	P	T Act 1	M V1 01	M V2 01
IB	VB	Q	T Act 2	M V1 02	M V2 02
IC	VC	S	N Er AC 1	M V1 03	M V2 03
IAB	VN	PF	N Er AC 2	M V1 04	M V2 04
IBC	VAB	FREQ	P.Active Energy	M V1 05	M V2 05
ICA	VBC	FREQ SYNC	N.A.ENGY	M V1 06	M V2 06
IG	VCA	FREQ SYNC2	P.React.Energy	M V1 07	M V2 07
IGPAR	VG	ROC FREQ	N.R.ENGY	M V1 08	M V2 08
IPOL	VSYNC	CUMULATIVE kA^2_A1	DIST	M V1 09	M V2 09
POS SEQ	VSYNC2	CUMULATIVE kA^2_B1	C RECLOSER1	M V1 10	MV2 10
NEG SEQ	POS SEQ	CUMULATIVE kA^2_C1	C RECLOSER2	M V1 11	M V2 11
ZERO SEQ I	NEG SEQ	CUMULATIVE kA^2_A2	RECL MONO1	M V1 12	M V2 12
IA1	ZERO SEQ V	CUMULATIVE kA^2_B2	RECL MONO2	M V1 13	M V2 13
IB1	IMIN	CUMULATIVE kA^2_C2	RECL TRIF1	M V1 14	M V2 14
IC1	IMAX	IABI_A1	RECL TRIF2	M V1 15	M V2 15
IA2	VMIN	IABI_B1	NOPENINT1_A	M V1 16	M V2 16
IB2	VMAX	IABI_C1	NOPENINT1_B	N E AF 1	NPICKUPS
IC2	PMIN	IABI_A2	NOPENINT1_C	N E AF 2	NRPICKUS
IN1	PMAX	IABI_B2	NOPENINT2_A	N E DF 1	NTRAPS
IN2	QMIN	IABI_C2	NOPENINT2_B	N E DF 2	FECHTRIP
HARM2 IA	QMAX	FAULTT	NOPENINT2_C	N Er C 1	T_CORTO
HARM2 IB	SMIN	ACTGRP	NCLOSEINT1	N Er C 2	T_FAULT_A1
HARM2 IC	SMAX	THERMAL IMG	NCLOSEINT2		T_FAULT_B1
		TRIPTYPE			T_FAULT_C1
		TRANSDUCER C1			T_FAULT_A2
					T_FAULT_B2
					T_FAULT_C2

- **Metering Log: HMI Access**

0 - CONFIGURATION	0 - GENERAL	
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	
3 - INFORMATION	3 - PROTECTION	**0 - SAMPLE INTERVAL**
	...	**1 - LOG REC. INTERVAL**
	*** - HISTORY**	**2 - HIST. START TIME**
	...	**3 - HIST. END TIME**

(*) Option 7 or 8, depending on the model.

3.36 Oscillographic Recording

3.36.1 Introduction

The oscillography function is composed of two different sub functions: **Capture** and **Display**. The first captures and stores protection data inside the IED and is part of the relay's software; the second retrieves and presents the stored data graphically with one or more programs running on a PC connected to the protection.

In **ZLV-***-****E/F/G/H**** and **ZLV-G/J** relays, the storage frequency is selected through a setting (32 or 16 samples per cycle). If 16 samples per cycle is selected, total storage time is 30 seconds. In the rest of models, the sampling and storage frequency is fixed, 32 samples per cycle and 15 seconds total storage. Permanence of the information, with the IED disconnected from the power supply, is guaranteed for all relays during 28 days in 25º C.

The IEDs come with a display and analysis program, because the waveform records are in binary COMTRADE format according to IEEE standard C37.111-1999. The COMTRADE file generated considers the changes in frequency that can occur in the system, so that the analog magnitudes are stored with complete fidelity to how they have evolved on the system.

3.36.2 Capture Function

It is possible to record measured analog values, user defined values, digital inputs to the IED, internal logic signals generated by the protection and the programmable logic up to a total of 64 oscillographs in cyclical memory.

3.36.3 Stored Data

The following data are stored with a resolution time equal to the sampling rate:

- Value of the samples of the selected parameters (measured and user defined) and of the digital signals programmed for this purpose.
- Time stamp of the oscillography startup.

Any changes to the settings of the Oscillographic Recorder will erase all oscillographs.

3.36.4 Number of Channels and Digital Signals

It is possible to record up to 15 analog values, depending in the model, enabling or disabling them via independent settings.

It is possible to include up to 5 user defined values. User defined values are every calculated value including those values calculated by the programmable logic via ***ZIVercomPlus***® software.

User defined values include any type of parameters. If sine waves are recorded the oscillography records the changes of the RMS value. Values are stored in the COMTRADE oscillography format with the label assigned in the programmable logic.

It is also possible to assign direct metering from the analog channels as an user defined value. Being waveforms the RMS value is stored. COMTRADE label is VALUE_u (ie. VA_u).

The maximum number of recorded digital signals is 80. Each user defined value configured in the oscillography counts as 16 digital signals.

3.36.5 Start Function

The Start Function is determined by a programmable mask applied to certain internal signals (element pickups, open command, etc.) and to an **External Pickup Signal** (which, if it is to be used, must be connected to any of the physical status contact inputs, to a programmable button of the HMI, to a command via communications or to a signal configured for this purpose in the programmable logic).

If the start function mask setting is **YES**, this signal activates the oscillography startup. This signal will not start the oscillography function if its mask setting is **NO**.

3.36.6 Oscillograph Deletion Function

Since the oscillograph records are stored in non-volatile memory, there is a mechanism that allows deleting all the content of this memory externally.

The oscillograph deletion function can operate by activating the **Deletion of Oscillographs** signal, which can be assigned by the programmable logic to any of the physical inputs, to a programmable button of the HMI, to a command via communications, etc.).

3.36.7 Trip Required

Data are stored only if a trip occurs within the time configured as oscillography record length.

3.36.8 Concatenation Stream Mode

The **YES** / **NO** setting allows extending the oscillography record length if new pickups of elements occur while one is being recorded. The recording system restarts the count of sequences to store if any other element picks up before the element generating the oscillography pickup resets.

It is possible for multiple triggers to occur during a fault. Sometimes these triggers are not simultaneous but they are staged in the early moments of a fault. The available memory to store oscillography is divided in zones, depending on the oscillography length setting. To optimize the memory management, for subsequent triggers (occurring after the first trigger), the length of the oscillograph will not be extended beyond the number of defined cycles by means of the **Interval Between Triggers** setting.

3.36.9 Interval Between Triggers

Interval between Triggers defines the minimum time required between different triggers, to extend the length of the oscillography record when the **Continuous Mode** setting is set to **YES**.

3.36.10 Pre-Fault Time

This is the length of pre-fault data that must be stored before the start function initiates a record. The setting range is from 0 to 25 pre-fault cycles.

3.36.11 Length of the Oscillograph

It is the fault record duration. The number of records stored in memory varies and depends on the number of channels recorded and the length of the fault records. Once the recording memory is full, the next event will overwrite the oldest one stored.

The maximum number of waveform records is 64, and the maximum number of cycles that can be stored in memory is 725. Depending on the length selected, the maximum number varies

Set number of cycles	Maximum number of oscillographs
725	1
350	2
175	3
...	...
22	32
11	64

Note: when selecting the length of each oscillograph, it is important to take into account that if, for example, an oscillography record length greater than 350 cycles is selected, only one oscillograph can be stored.

3.36.12 Recording Frequency

ZLV-*-****E/F/G/H**** and **ZLV-G/J** relays incorporate a setting to select the sample storage frequency into the oscillograph. Two options of 32 and 16 samples per cycle are included, with total storage time of 15 and 30 seconds, respectively.

3.36.13 Oscillographic Recording Settings

Oscillographic Recording			
Setting	**Range**	**Step**	**By default**
Trip required	YES / NO		YES
Continuous mode	YES / NO		NO
Pretrigger length	0 - 25 cycles	1	5 cycles
Length	5 - 725 cycles	1	5 cycles
Interval Between Triggers	4 - 725 cycles	1	4 cycles
Recording Frequency) (ZLV-***-****E/F/G/H** and ZLV-G/J)	32 m/c 16 m/c		32 m/c

Start Function		
Setting	**Step**	**By Default**
Remote breaker open detector	YES / NO	NO
Close-onto-fault detector	YES / NO	NO
Stub Bus protection	YES / NO	NO
Thermal image unit	YES / NO	NO
Open phase unit	YES / NO	NO
Pole discordance detector (ZLV-A/B/E/F/H)	YES / NO	NO
Pole discordance detector breaker 1 (ZLV-G/J)	YES / NO	NO
Pole discordance detector breaker 2 (ZLV-G/J)	YES / NO	NO
Power swing detector	YES / NO	NO
Phase time overcurrent (51-1)	YES / NO	NO
Phase time overcurrent (51-2)	YES / NO	NO
Phase time overcurrent (51-3)	YES / NO	NO
Phase instantaneous overcurrent (50-1)	YES / NO	NO
Phase instantaneous overcurrent (50-2)	YES / NO	NO
Phase instantaneous overcurrent (50-3)	YES / NO	NO

Start Function (Cont.)		
Setting	**Step**	**By Default**
Ground time overcurrent (51N-1)	YES / NO	NO
Ground time overcurrent (51N-2)	YES / NO	NO
Ground time overcurrent (51N-3)	YES / NO	NO
Ground instantaneous overcurrent (50N-1)	YES / NO	NO
Ground instantaneous overcurrent (50N-2)	YES / NO	NO
Ground instantaneous overcurrent (50N-3)	YES / NO	NO
Negative Sequence time overcurrent (51Q-1)	YES / NO	NO
Negative Sequence time overcurrent (51Q-2)	YES / NO	NO
Negative Sequence time overcurrent (51Q-3)	YES / NO	NO
Negative Sequence instantaneous overcurrent (50Q-1)	YES / NO	NO
Negative Sequence instantaneous overcurrent (50Q-2)	YES / NO	NO
Negative Sequence instantaneous overcurrent (50Q-3)	YES / NO	NO
Phase undervoltage (27-1)	YES / NO	NO
Phase undervoltage (27-2)	YES / NO	NO
Phase undervoltage (27-3)	YES / NO	NO
Phase overvoltage (59-1)	YES / NO	NO
Phase overvoltage (59-2)	YES / NO	NO
Phase overvoltage (59-3)	YES / NO	NO
Ground overvoltage (59N-1)	YES / NO	NO
Ground overvoltage (59N-2)	YES / NO	NO
Underfrequency (81m-1)	YES / NO	NO
Underfrequency (81m-2)	YES / NO	NO
Underfrequency (81m-3)	YES / NO	NO
Overfrequency (81M-1)	YES / NO	NO
Overfrequency (81M-2)	YES / NO	NO
Overfrequency (81M-3)	YES / NO	NO
Rate of Change (81D-1)	YES / NO	NO
Rate of Change (81D-2)	YES / NO	NO
Rate of Change (81D-3)	YES / NO	NO
Breaker failure (configurable in the programmable logic)	YES / NO	NO
Retripping (A, B, C or 3Ph) (configurable in the programmable logic)	YES / NO	NO
External pickup	YES / NO	YES
Closing (manual or reclosing) (configurable in the programmable logic)	YES / NO	NO
Open command (configurable in the programmable logic)	YES / NO	NO
Zone 1 Phase-to-phase fault	YES / NO	NO
Zone 1 Ground fault	YES / NO	NO
Zone 2 Phase-to-phase fault	YES / NO	NO
Zone 2 Ground fault	YES / NO	NO
Zone 3 Phase-to-phase fault	YES / NO	NO
Zone 3 Ground fault	YES / NO	NO
Zone 4 Phase-to-phase fault	YES / NO	NO
Zone 4 Ground fault	YES / NO	NO
Zone 5 Phase-to-phase fault (ZLV-F/G/H/J)	YES / NO	NO
Zone 5 Ground fault (ZLV-F/G/H/J)	YES / NO	NO
Zone 6 Phase-to-phase fault (ZLV-F/G/J**-****C/D/E/F/G/H**)	YES / NO	NO
Zone 6 Ground fault (ZLV-F/G/J**-****C/D/E/F/G/H**)	YES / NO	NO
Programmable Trip (ZLV-F/G/H/J)	YES / NO	NO

Analog Channels (ZLV-A/B/E/F/H)	
1 - Phase A Voltage	5 - Phase A Current
2 - Phase B Voltage	6 - Phase B Current
3 - Phase C Voltage	7 - Phase C Current
4 - Synchronism Voltage	8 - Polarization Current
	9 - Parallel Line Ground Current

Analog Channels (ZLV-G/J)	
1 - Phase A Voltage	8 - Phase A Current 1
2 - Phase B Voltage	9 - Phase B Current 1
3 - Phase C Voltage	10 - Phase C Current 1
4 - Ground Voltage	11 - Phase A Current 2
5 - Synchronism 1 Voltage	12 - Phase B Current 2
6 - Synchronism 2 Voltage	13 - Phase C Current 2
7 - Ground Current	14 - Polarization Current
	15 - Parallel Line Ground Current

Digital Channel Selection
Selectable from all configurable Digital Inputs and Digital Signals

- **Oscillographic Recording: HMI Access**

ZLV-A/B/E/F/H

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP REQUIRED**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - CONTINUOUS MODE**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - PRETRIG. LENGTH**
3 - INFORMATION	3 - PROTECTION	**3 - LENGTH**
	...	**4 - TRIGGERS INTERVAL**
	9 - OSCILLOGRAPHY	**5 - OSCILLO CHANN. MAS**

ZLV-***-****E/F/G/H** and ZLV-G/J

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP REQUIRED**
1 - OPERATIONS	1 - SYSTEM IMPEDANCES	**1 - CONTINUOUS MODE**
2 - CHANGE SETTINGS	2 - FAULT LOCATOR	**2 - PRETRIG. LENGTH**
3 - INFORMATION	3 - PROTECTION	**3 - LENGTH**
	...	**4 - TRIGGERS INTERVAL**
	9 - OSCILLOGRAPHY	**5 - RECORDING FREQ**
	...	**6 - S OSCILLO CHANN. MAS**

3.36.14 Digital Inputs and Events of the Oscillographic Recording

Table 3.36-1:Digital Inputs and Events of the Oscillographic Recording		
Name	**Description**	**Function**
TRIG_EXT_OSC	External oscillography trigger	Input intended for external triggering.
DEL_OSC	Deletion of oscillographs command	The activation of this input deletes all the oscillographs stored.
ENBL_OSC	Oscillographic recording enable input	Activation of this input puts the element into service. The default value of this logic input signal is a “1.”

3.36.15 Digital Outputs and Events of the Oscillographic Recording

Table 3.36-2: Digital Outputs and Events of the Oscillographic Recording		
Name	**Description**	**Function**
PU_OSC	Oscillography picked up	This output indicates that the oscillographic recording is on process.
OSC_ENBLD	Oscillographic recording enabled	Indication of enabled or disabled status of the element.

3.37 Fault Locator

3.37.1 Fault Locator Settings

The **ZLV** IED is provided with a fault locator which determines the distance to the fault. The locator algorithm makes use of the settings which appear in the **System Impedances** section, which define the Line Impedances, Parallel Line in **ZLV-***-****A/B/C/D/E/F/G/H**** Models, Local Source, Remote Source and Equivalent Parallel Circuit. These settings are also used by the distance elements. However, there are settings which exclusively belong to the locator. **Length and Units**, **Mutual Coupling of a Parallel Line**, **Non-Homogeneity Compensation (ZLV-***-****B/C/D/E/F/G/H**)**, **Permanent Indication and Indication Duration** and **Indication Zone (ZLV-***-****C/D/E/F/G/H**)**.

3.37.1.a Length and Units

- **Line Length**

This setting corresponds to the length of the line that the locator is going to operate on. It is a dimensionless value.

- **Length Units**

The Line Length Units setting allows selecting the unit of length, kilometers or miles, for the preceding setting.

- **Locator Units**

The Locator Units setting can be a unit of length or a percentage of the line length. When there is a fault, the locator will express the measurements according to this setting.

3.37.1.b Mutual Coupling of a Parallel Line

- **Mutual Coupling Correction**

If this setting is set to **YES**, it is possible to carry out a compensation of the zero sequence mutual coupling with the parallel line. For this, the **ZLV** IED has an analog channel to measure the residual current of the parallel line. This setting is independent from the one corresponding to Distance Elements (see 3.1.1).

- **Mutual Coupling Factor**

This involves the following quotient: ZM0=ZM0/ZL1, where ZM0 is the zero sequence mutual coupling impedance between the two lines and ZL1 is the positive sequence impedance of the protected line. In **ZLV-***-****A/B/C/D/E/F/G/H**** relays, this factor is defined by the setting **Parallel Line Impedance**, within the menu **System Impedances**. In all other relays, the mutual coupling factor is included within the menu **Fault Locator**.

- **Mutual Coupling Impedance Angle**

This is the ZM0 angle. In **ZLV-***-****A/B/C/D/E/F/G/H**** relays, this factor is defined by the setting **Parallel Line Impedance**, within the menu **System Impedances**. In all other relays, the mutual coupling factor is included within the menu **Fault Locator**.

3.37.1.c Non-Homogeneity Compensation (ZLV-***-****B/C/D/E/F/G/H**)

If this setting is set at YES, the relay compensates a possible non-homogeneity on the system.

3.37.1.d Permanent Indication and Indication Duration

Once the distance to the fault is calculated, the location measurement variable will maintain the value calculated for some time. This time depends on the **Permanent Indication and Indication Duration** settings.

If the **Permanent Indication** setting is **YES**, the value of the variable will not change until a new fault report is stored. Then it will change to the new value. In this operation mode, the location measurement will always be the value calculated for the last fault report stored.

If, on the contrary, the **Permanent Indication** setting is **NO**, the measurement variable will maintain the value for the time defined in the **Duration of the Indication** setting. If another fault report is stored meanwhile, the corresponding distance to the fault is not stored in the location measurement variable, although it is stored in its corresponding fault report record.

This operating mode is the same for the fault distance indication in the display as well as for the distance value which can be configured to be sent by communications through any of the available protocols.

3.37.1.e Indication Zone (ZLV-***-****C/D/E/F/G/H**)

The setting **Indication Zone** selects if the fault locator calculates distance to the fault for faults inside the protected line of for any fault detected by the relay.

With the option **Inside Line**, information is available for faults located inside the defined length for the protected line.

With the option **Inside and Outside**, information is available for any fault independent of the location being inside or outside of the defined length.

3.37.2 Configuration of the Fault Locator

The fault locator has two settings for sending the distance through remote communications (in the control profile):

Permanent Indication: YES / NO
Duration of the Indication: 1 - 120min

If the **Permanent Indication** setting is **NO**, the locator takes the **Duration of the Indication** setting into account for sending the distance through the communications profile. When a fault report occurs, the indication of the distance through the control profile lasts the time set. If a new fault occurs meanwhile, the distance sent by communications is still that of the first fault. When the set time transpires, an **invalid** value for the distance is sent. Now if a new fault occurs the distance to this last fault is sent. In contrast, the last trip indication in the display and the fault report always show the locator's distance for the last trip produced.

If the **Permanent Indication** setting is **YES**, communications always sends the distance of the last fault registered. If the relay has not registered a fault, it will be sending an **invalid** value.

3.37.3 Location Information

3.37.3.a From Display

The indication of the distance to the fault can be set to be offered either in line length units (kilometers or miles) or in percentage of the line length. It is always accompanied by the type of fault (**AG_F**, **BG_F**, **CG_F**, **AB_F**, **BC_F**, **CA_F**, **ABG_F**, **BCG_F**, **CAG_F** and **3PH_F**). The default screen will indicate this distance when there is a fault.

The fault locator will display the distance to the fault provided information on the type of fault is available and the result is between 0 and 100% of the line length. Otherwise ***** will be displayed.

For **ZLV-***-****C/D/E/F/G/H**** relays, if the **Indication Zone** setting is set to **Inside and Outside**, data on the location of any fault detected by the relay is given, regardless of whether it is within the length of the line configured or not.

3.37.3.b Fault Report

The information about the **Distance to the Fault** that can appear in the report is the same as that shown in the display, that is, the elements are the same as those chosen to be presented in it. When the fault is unknown, however, the distance will be filled in with asterisks and the type of fault will be UNKNOWN FAULT.

3.37.3.c Information Via Remote Communications

The **Distance to the Fault** value sent via communications by the protocol selected is fully configurable; that is, its full-scale value and the type of elements in which it is sent can be chosen.

The options for configuring it in the programmable logic so that it will be sent are: **Percentage Value**, the **Value in Kilometers** or the **Value in Miles**. The selection is totally independent of the magnitude used for presenting it on the display and in the fault reports.

With the ***ZIVercomPlus***®, it is possible to define the **Full-Scale** value to be used to transmit this magnitude in **counts**, the unit that all the protocols use. There are three definable parameters that determine the range of distance covered:

- **Offset Value**: the minimum value of the magnitude for which 0 counts are sent.
- **Limit**: the length of the range of the magnitude on which it is interpolated to calculate the number of counts to send. If the offset value is 0, it coincides with the value of the magnitude for which the maximum defined counts are sent for each protocol (4095 counts for PROCOME and MODBUS and 32767 counts for DNP 3.0).
- **Nominal Flag**: this flag allows determining whether the limit set is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user in the programmable logic can be configured, while the rest of the existing magnitudes are fixed.

The expression that allows defining this **Full-Scale** value is the following:

When the **Nominal Flag** is enabled,

$$CommunicationsMeasurement = \frac{Measurement - Offset}{Nominal} \times \frac{4095}{Limit}$$ for PROCOME and MODBUS

$$CommunicationsMeasurement = \frac{Measurement - Offset}{Nominal} \times \frac{32767}{Limit}$$ for DNP 3.0

When the **Nominal Flag** is NOT enabled,

$$CommunicationsMeasurement = (Measurement - Offset) \times \frac{4095}{Limit}$$ for PROCOME and MODBUS

$$CommunicationsMeasurement = (Measurement - Offset) \times \frac{32767}{Limit}$$ for DNP 3.0

Taking into account this system for sending values, if the **Distance** is to be sent so that 0 counts are sent in 0% and the maximum number of counts allowed by the protocol are sent in 100%, the settings must be:

The **Percentage Value** of the distance is selected. The following settings are made:

Offset value = 0
Limit = 100
Nominal Flag = NO

To create a profile like that of figure 3.37.1, the following configuration is required:

The **Percentage Value** of the distance is selected. The following settings are made:

Offset value = -20
Limit = 120
Nominal Flag = NO

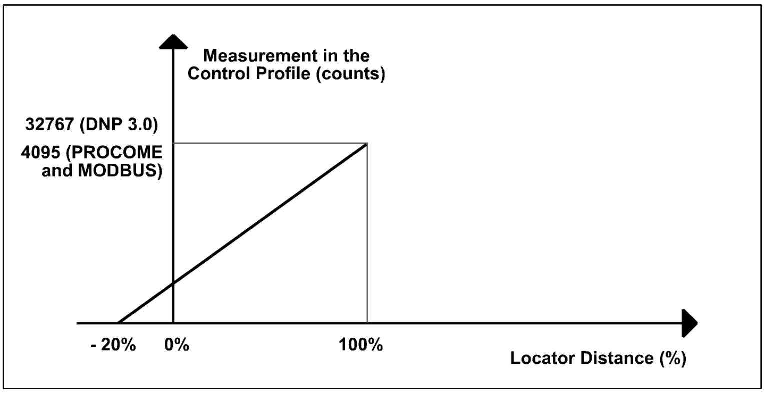


Figure 3.37.1: Scale of the Locator Measurements in the Control Profile.

Moreover, if between -20% and 0%, 0 counts should be sent, all that is needed is an algorithm in the programmable logic generating a user magnitude that is the **User Percentage Value**. This new magnitude is the one that will be sent via communications. It is generated as follows:

- An **Analog Selector** is configured. Its inputs are the **Percentage Value** and a **Zero**; its output is the **User Percentage Value**.
- A **Comparator** is configured to activate its output of **Greater than (>)** when the **Percentage Value** is greater than **0**, and subsequently *denies* this output.
- This *denied output* is used as a signal to control the **Analog Selector**.

Thus, the following is received via communications:

Distance: -20% → 0 counts
Distance: 100% → 32767 counts (DNP 3.0) or 4095 counts (PROCOME and MODBUS)

This way, if the distance that the locator calculates is greater than 100% or is less than or equal to 0%, the measurement sent in the control profile is **0** counts. However, the information presented in the display and in the report will be: **>100%** and **<0%**.

If the idea is to send the distance in kilometers or miles, sending the same number of counts as kilometers or miles shown on the display and the fault report will require the following configuration:

The value in **Kilometers** or **Miles** of the distance is selected. The following settings are made:

Offset value = 0
Limit = 4095 for PROCOME and MODBUS and 32767 for DNP 3.0
Nominal Flag = NO

As indicated previously, there are two locator settings in protection related to the transmission of the distance to control protocol: **Permanent Indication** and **Indication Duration**.

There is another input to the fault locator module, the **Restore the Distance to the Fault** input. Its function is to set the value of the distance to the fault and the type of fault that can be sent via communications to zero.

3.37.4 Fault Locator Settings

Length and Units			
Setting	**Range**	**Step**	**By default**
Line length	0.00 - 400.00	0.01	100
Line length unit	Km / Miles		Km
Locator unit	Length / % line length		Length

Parallel Line Coupling			
Setting	**Range**	**Step**	**By default**
Mutual coupling factor (*)	0 - 10	0.01	0
Mutual coupling angle	5 - 90º	1º	25º
Mutual coupling compensation	YES / NO		NO

*** K0 = mutual coupling impedance zero sequence magnitude / positive sequence magnitude**

Non-Homogeneity Compensation (ZLV-***-****B/C/D/E/F/G/H**)			
Setting	**Range**	**Step**	**By default**
Non-Homogeneity Compensation	YES / NO		NO

Indication			
Setting	**Range**	**Step**	**By default**
Permanent indication	YES / NO		NO
Indication duration	1 - 120 min	5 min	5 min
Indication Zone (ZLV-***-****C/D/E/F/G/H**)	0 (Inside Line) 1 (Inside and Outside)		0 (Inside Line)

- **Fault Locator: HMI Access**

0 - CONFIGURATION	0 - GENERAL	
1 - ACTIVATE GROUP	1 - SYSTEM IMPEDANCES	
2 - CHANGE SETTINGS	**2 - FAULT LOCATOR**	**0 - LENGTH AND UNITS**
3 - INFORMATION	3 - PROTECTION	**1 - PAR. LINE COUPLING**
	…	**2 - INDICATION**

ZLV-***-****A/B/C/D/E/F/G/H**

0 - CONFIGURATION	0 - GENERAL	**0 - LENGTH AND UNITS**
1 - ACTIVATE GROUP	1 - SYSTEM IMPEDANCES	**1 - PAR. LINE COUPLING**
2 - CHANGE SETTINGS	**2 - FAULT LOCATOR**	**2 - NON-HOMOG. COMP.**
3 - INFORMATION	3 - PROTECTION	**3 - INDICATION**

Length and Units

0 - LENGTH AND UNITS	**0 - LINE LENGTH**
1 - PAR. LINE COUPLING	**1 - LENGTH UNITS**
	2 - LOCATOR UNITS

Parallel Line Coupling

0 - LENGTH AND UNITS	**0 - MUTUAL COUPL. FACT**
1 - PAR. LINE COUPLING	**1 - MUTUAL COUPL. ANGL**
	2 - MUTUAL COUPL. COMP E

0 - LENGTH AND UNITS	ZLV-***-****A/B/C/D/E/F/G/H**
1 - PAR. LINE COUPLING	**0 - MUT COUPL. COMP. ENA**

Non-Homogeneity Compensation (ZLV-***-****B/C/D/E/F/G/H*)

1 - PAR. LINE COUPLING	
2 - NON-HOMOG. COMP.	**0 - NON-HOMOG. COMP.**
3 - INDICATION	

Indication

0 - LENGTH AND UNITS	
1 - PAR. LINE COUPLING	**0 - PERMANENT INDICATI**
2 - INDICATION	**1 - TIME INDICATION**

0 - LENGTH AND UNITS	ZLV-***-****A/B**
1 - PAR. LINE COUPLING	
2 - NON-HOMOG. COMP.	**0 - PERMANENT INDICATI**
3 - INDICATION	**1 - TIME INDICATION**

0 - LENGTH AND UNITS	ZLV-***-****C/D/E/F/G/H**
1 - PAR. LINE COUPLING	**0 - PERMANENT INDICATI**
2 - NON-HOMOG. COMP.	**1 - TIME INDICATION**
3 - INDICATION	**2 - INDICATION ZONE**

3.38 Inputs, Outputs & LED Targets

3.38.1 Introduction

The **ZLV** has a flexible, user-definable structure of inputs / outputs and LEDs. It is described in the following sections. Factory programming included default values. Settings can be changed using the software package ***ZIVercomPlus***®.

3.38.2 Digital Inputs

The number of digital inputs depend on the model:

- **ZLV-A/H** relays: include 10 or 22 physical digital inputs (2U and 3U enclosures respectively).
- **ZLV-B/F** relays: include 22 or 34 physical digital inputs (3U and 4U enclosures respectively).
- **ZLV-E** relays: include 10 physical digital inputs (only in 2U enclosures).
- **ZLV-G/J** relays: include 25 or 37 physical digital inputs (4U and 6U enclosures respectively).

All these inputs can be configured with any input signal to the pre-existing protection and control modules or defined by the user in the programmable logic.

The **Filtering** of the digital inputs can be configured with the following options:

- **Time Between Samplings** (**2-10 ms**): to establish the periodicity with which samples of the state of a digital input are taken.
- **Number of Samples with the same Value to Validate a Filter-1 Input** (**2-10**): the number of samples that must be detected consecutively to consider an input deactivated or activated can be set to logical "0" or "1" respectively.
- **Number of Samples with the same Value to Validate a Filter-2 Input** (**2-10**): The number of samples that must be detected consecutively to consider an input deactivated or activated can be set to logical "0" or "1" respectively.
  Note: Each configurable digital input can be assigned to "filter 1" or to "filter 2." The last two settings defined allow constructing filters 1 and 2 to create *fast* and *slow* detection inputs.
- **Number of Changes to Deactivate an Input and its Time Slot** (**2-60/1-30s**): an adjustable time slot is established to keep a digital input in which there is an external or internal malfunction to the relay from generating problems. This time slot monitors the number of times that this digital input changes condition. If this number of changes in state exceeds a set value, the input is disabled. Once an input is disabled, it will be enabled again when the enabling conditions are met or by an enabling command.
- **Number of Changes to Enable an Input and its Time Slot**: as for disabling, to enable an input again, there is also a time slot and a user-definable number of changes within that slot.

In the **ZLV-***-****01**** and **ZLV-***-****02**** models, the following settings related to Digital Inputs also exist:

- **EDs Supply Voltage Control** (YES / NO): Allows Digital Input validation control enable as a function of relay Supply voltage.
- **EDs Supply Voltage Level** (**24 / 48 / 125 / 125(>65%Vn) / 250 Vdc**): States relay rated supply voltage. When latter setting is set to YES, and relay supply voltage drops below EDs activation threshold, all validation signals are deactivated and the EDs disabled. Validation is reset when relay supply voltage exceeds EDs activation threshold. The supply voltage level is obtained through an input Vdc converter connected in parallel with the relay supply voltage. For EDs activation and deactivation thresholds as appropriate refer to chapter 2.1.
- **Automatic ED disable** (YES / NO): There is a separate setting for each Digital Input. If set to YES, allows for Automatic ED Disable on excessive number of changes (see in this same chapter the settings **Number of Changes for Disable** an input and **Time Window**).
- **Number of Digital Inputs for Supply Voltage supervision** (0 - 25) (*): Allows using a Digital Input as Supply Voltage reference. If the selected Digital Input is energized, Digital Inputs will remain active, otherwise, Digital Inputs will be deactivated and will reflect their last valid status. Selecting Digital Input 0, means this function is not used.

(*) The total number of Digital Inputs depends on model.

The IED's metering elements and logic functions use **Logic Input Signals** in their operation. They are enumerated in the tables nested in the description of each of them. Those corresponding to the IED's general services are listed in table 3.36-1 and can be assigned to the **Physical Digital Inputs** or to logic output signals of opcodes configured in the programmable logic. More than one **Logic Input Signal** can be assigned to a **Single Status Contact Input**, but the same logic input signal can not be assigned to more than one status contact input.
It is possible to disable the physical inputs with the **Input Enabling** setting. If they are disabled the input status will be ignored by the IED.

The tables mentioned above only list the inputs available with the default configuration. The list of inputs can be expanded with those that are configured in the programmable logic (any logic input signal created in the programmable logic can be used with the description that the user creates).

Note: The ED-1 digital input, which can be supplied with alternating- or direct-current, presents a greater filtering than the remainder, for which it cannot be used to receive external signals involved in protection logic with critical times.

3.38.2.a Enable Input

The protection element module of each **ZLV** family IED has a special "logic input signal" to put it "into service" or "out of service" from the HMI (buttons on the front), with a digital input by level and with the communications protocol configured in each port (control command).

This logic input signal is called **Enable Input ….** It combines with the **In Service** setting in this algorithm.

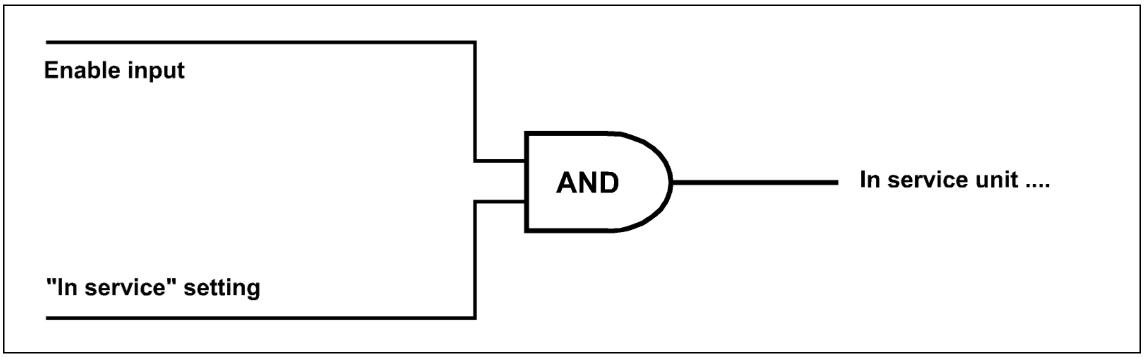


Figure 3.38.1: Unit Enabling Logic

The default value of the logic input signal **Enable input IED...** is a "1." Therefore, when you do not configure the programmable logic at all, putting the protection elements into service depends only on the value of the **In Service** setting of each of them. The logic configuration to activate or switch off the enabling logic input signal will be as complicated or simple as you wish, from assigning it to a status contact input to building logical schemas with the various logic gates available (flip-flop's, etc.).

Those protection functions that are put "out of service" by any of these methods will not generate or activate any of their associated logic signals, not even those that may be configured in the programmable logic and are directly related to these functions.

3.38.2.b Digital Inputs Table

Table 3.38-1: Digital Inputs		
Name	**Description**	**Function**
IN_RST_LED	LEDs reset input	Resets the LEDs that are active because they are memorized.
IN_RST_MAX	Maximeters reset input	Its activation sets the content of the current, voltage and power demand elements to zero.
IN_RST_DIS	Distance to the fault reset input	Its activation sets the value of the distance to the fault sent via communications to zero.
IN_PMTR_RST	Power meters reset input	Its activation sets the content of the power meters to zero.
ENBL_PLL	Digital PLL enable input	Enables the operation of the automatic system to adapt to the frequency. By default, when not configured, it is a logic “1.”
LED_1	LED 1	They activate their corresponding LEDs.
LED_2	LED 2	
LED_3	LED 3	
LED_4	LED 4	
LED_52R	LED 52 red	
LED_52G	LED 52 green	
LED_P1R	LED P1 red	
LED_P1G	LED P1 green	
LED_P2R	LED P2 red	
LED_P2G	LED P2 green	
LED_P3R	LED P3 red	
LED_P3G	LED P3 green	
LED_P4R	LED P4 red	
LED_P4G	LED P4 green	
LED_P5R	LED P5 red	
LED_P5G	LED P5 green	

Table 3.38-1: Digital Inputs

Name	Description	Function
LED_P6R	LED P6 red	
LED_P6G	LED P6 green	
RST_IND_TRIP	Trip indication reset command	When activated, it deletes the information about the last trip the relay has stored, thus also cleaning the display.
CMD_DIS_DI1	Command to disable digital input 1	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
CMD_DIS_DI2	Command to disable digital input 2	
CMD_DIS_DI3	Command to disable digital input 3	
CMD_DIS_DI4	Command to disable digital input 4	
CMD_DIS_DI5	Command to disable digital input 5	
CMD_DIS_DI6	Command to disable digital input 6	
CMD_DIS_DI7	Command to disable digital input 7	
CMD_DIS_DI8	Command to disable digital input 8	
CMD_DIS_DI9	Command to disable digital input 9	
CMD_DIS_DI10	Command to disable digital input 10	
CMD_DIS_DI11	Command to disable digital input 11	
CMD_DIS_DI12	Command to disable digital input 12	
CMD_DIS_DI13	Command to disable digital input 13	
CMD_DIS_DI14	Command to disable digital input 14	
CMD_DIS_DI15	Command to disable digital input 15	
CMD_DIS_DI16	Command to disable digital input 16	
CMD_DIS_DI17	Command to disable digital input 17	
CMD_DIS_DI18	Command to disable digital input 18	
CMD_DIS_DI19	Command to disable digital input 19	
CMD_DIS_DI20	Command to disable digital input 20	
CMD_DIS_DI21	Command to disable digital input 21	
CMD_DIS_DI22	Command to disable digital input 22	
CMD_DIS_DI23	Command to disable digital input 23	
CMD_DIS_DI24	Command to disable digital input 24	
CMD_DIS_DI25	Command to disable digital input 25	
CMD_DIS_DI26	Command to disable digital input 26	
CMD_DIS_DI27	Command to disable digital input 27	
CMD_DIS_DI28	Command to disable digital input 28	
CMD_DIS_DI29	Command to disable digital input 29	
CMD_DIS_DI30	Command to disable digital input 30	
CMD_DIS_DI31	Command to disable digital input 31	
CMD_DIS_DI32	Command to disable digital input 32	
CMD_DIS_DI33	Command to disable digital input 33	
CMD_DIS_DI34	Command to disable digital input 34	
CMD_DIS_DI35	Command to disable digital input 35	
CMD_DIS_DI36	Command to disable digital input 36	
CMD_DIS_DI37	Command to disable digital input 37	

Table 3.38-1: Digital Inputs

Name	Description	Function
CMD_ENBL_DI1	Command to enable digital input 1	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
CMD_ENBL_DI2	Command to enable digital input 2	
CMD_ENBL_DI3	Command to enable digital input 3	
CMD_ENBL_DI4	Command to enable digital input 4	
CMD_ENBL_DI5	Command to enable digital input 5	
CMD_ENBL_DI6	Command to enable digital input 6	
CMD_ENBL_DI7	Command to enable digital input 7	
CMD_ENBL_DI8	Command to enable digital input 8	
CMD_ENBL_DI9	Command to enable digital input 9	
CMD_ENBL_DI10	Command to enable digital input 10	
CMD_ENBL_DI11	Command to enable digital input 11	
CMD_ENBL_DI12	Command to enable digital input 12	
CMD_ENBL_DI13	Command to enable digital input 13	
CMD_ENBL_DI14	Command to enable digital input 14	
CMD_ENBL_DI15	Command to enable digital input 15	
CMD_ENBL_DI16	Command to enable digital input 16	
CMD_ENBL_DI17	Command to enable digital input 17	
CMD_ENBL_DI18	Command to enable digital input 18	
CMD_ENBL_DI19	Command to enable digital input 19	
CMD_ENBL_DI20	Command to enable digital input 20	
CMD_ENBL_DI21	Command to enable digital input 21	
CMD_ENBL_DI22	Command to enable digital input 22	
CMD_ENBL_DI23	Command to enable digital input 23	
CMD_ENBL_DI24	Command to enable digital input 24	
CMD_ENBL_DI25	Command to enable digital input 25	
CMD_ENBL_DI26	Command to enable digital input 26	
CMD_ENBL_DI27	Command to enable digital input 27	
CMD_ENBL_DI28	Command to enable digital input 28	
CMD_ENBL_DI29	Command to enable digital input 29	
CMD_ENBL_DI30	Command to enable digital input 30	
CMD_ENBL_DI31	Command to enable digital input 31	
CMD_ENBL_DI32	Command to enable digital input 32	
CMD_ENBL_DI33	Command to enable digital input 33	
CMD_ENBL_DI34	Command to enable digital input 34	
CMD_ENBL_DI35	Command to enable digital input 35	
CMD_ENBL_DI36	Command to enable digital input 36	
CMD_ENBL_DI37	Command to enable digital input 37	

Table 3.38-1: Digital Inputs		
Name	Description	Function
DO_3	Auxiliary output 3	They activate their corresponding outputs.
DO_4	Auxiliary output 4	
DO_5	Auxiliary output 5	
DO_6	Auxiliary output 6	
DO_7	Auxiliary output 7	
DO_8	Auxiliary output 8	
DO_9	Auxiliary output 9	
DO_10	Auxiliary output 10	
DO_11	Auxiliary output 11	
DO_12	Auxiliary output 12	
DO_13	Auxiliary output 13	
DO_14	Auxiliary output 14	
DO_15	Auxiliary output 15	
DO_16	Auxiliary output 16	
DO_17	Auxiliary output 17	
DO_18	Auxiliary output 18	
DO_19	Auxiliary output 19	
DO_20	Auxiliary output 20	
DO_21	Auxiliary output 21	
DO_22	Auxiliary output 22	
DO_23	Auxiliary output 23	
DO_24	Auxiliary output 24	
DO_25	Auxiliary output 25	
DO_26	Auxiliary output 26	
DO_27	Auxiliary output 27	
DO_28	Auxiliary output 28	
DO_29	Auxiliary output 29	
DO_30	Auxiliary output 30	
DO_31	Auxiliary output 31	
DO_32	Auxiliary output 32	
DO_33	Auxiliary output 33	
DO_34	Auxiliary output 34	
DO_35	Auxiliary output 35	
DO_36	Auxiliary output 36	
DO_37	Auxiliary output 37	
DO_38	Auxiliary output 38	
DO_39	Auxiliary output 39	
DO_40	Auxiliary output 40	
DO_41	Auxiliary output 41	
DO_42	Auxiliary output 42	
DO_43	Auxiliary output 43	
DO_44	Auxiliary output 44	

3.38.3 Auxiliary Outputs

Depending on the model, you can have from 10 to 44 Digital Outputs. The number, as well as the configuration of these outputs, is specified in Chapter 1.4, Model Selection (see box 8, of Inputs and Outputs).

In all models, the **DO_7**, **DO_8**, **DO_9** and **DO_10** outputs can be configured through setting as fast outputs (solid state), in order to be used to act on teleprotection equipment.

They can all be configured with any input or output signal of the pre-existing protection and control modules or defined by the user in the programmable logic.

The IED's metering elements and logic functions generate a series of logic output signals. Each of these signals has either a “true” or “false” value and this status can be used as an input to either of the combinational logic gates shown in figure 3.38.2. The use of the combinational logic gates described in figure is optional. Its purpose is to facilitate the simplest configurations. To develop more complex algorithms and be able to assign the resulting outputs to auxiliary contact outputs, the necessary opcodes must be programmed in the programmable logic.

The outputs from the blocks described in figure 3.38.2 can be connected to one of the programmable auxiliary contact outputs in the IED. There is an additional, non-programmable auxiliary output contact corresponding to relay **In Service**.

It is possible to disable the auxiliary and trip/close contacts by means of the **Auxiliary Output Operation Enable** and the **Trip and Close Contact Operation Enable**. If they are disabled, the mechanical operation of the contacts will not occur but the logic output may activate. This can be a useful option for field testing to avoid interferences between the test and the associated equipment.

Two blocks of eight inputs are available. One of the blocks performs an **OR** operation with the selected signals (any signal activates the logic gate output). The other block performs an **AND** operation with the selected signals (all signals need to be active to activate the logic gate output). The result of these two blocks is then operated through either an **AND** or an **OR** gate. The pulse option can be added to the result of this operation. It works as follows:

- **Without Pulses**: by adjusting the pulse timer to 0, the output signal remains active as long as the signal that activated it lasts.
- **With Pulses**: once the output signal is activated, it remains the set time whether or not the signal that generated it is deactivated before or remains active.

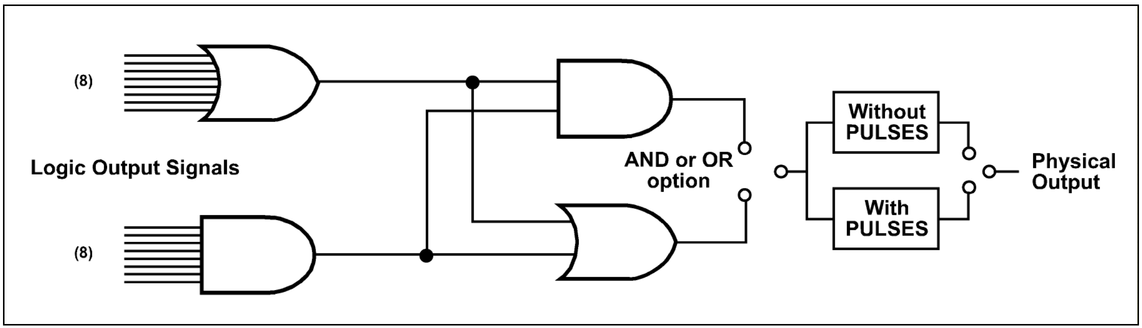


Figure 3.38.2: Auxiliary Contact Output Logic Cell Block Diagram.

All the logic output signals listed in the tables nested in the description of each of the elements are user-definable. Moreover, the signals indicated in Table 3.38-2, all corresponding to the IED's general services, can also be assigned.

The tables mentioned only list the logical outputs available with the default configuration. The list of signals can be expanded with those configured in the programmable logic (any logic signal created in the programmable logic can be used with the description that the user creates).

3.38.3.a Digital Outputs Table

Table 3.38-2: Digital Outputs

Name	Description	Function
ACCESS_HMI	HMI access	Indication that the HMI has been accessed.
SYNC_CLK	Clock synchronization	Indication of having received a date/time change.
SIGNAL_IRIGB	IRIGB active	Signal that indicates that the IRIG-B signal is being received.
B_OPEN_52	Open 52 button	They indicate that the corresponding button has been pressed.
B_OPEN_P1	Open P1 button	
B_OPEN_P2	Open P2 button	
B_OPEN_P3	Open P3 button	
B_OPEN_P4	Open P4 button	
B_OPEN_P5	Open P5 button	
B_OPEN_P6	Open P6 button	
B_CLS_52	Close 52 button	
B_CLS_P1	Close P1 button	
B_CLS_P2	Close P2 button	
B_CLS_P3	Close P3 button	
B_CLS_P4	Close P4 button	
B_CLS_P5	Close P5 button	
B_CLS_P6	Close P6 button	
IN_1	Digital input 1	They indicate that the corresponding input has been activated.
IN_2	Digital input 2	
IN_3	Digital input 3	
IN_4	Digital input 4	
IN_5	Digital input 5	
IN_6	Digital input 6	
IN_7	Digital input 7	
IN_8	Digital input 8	
IN_9	Digital input 9	
IN_10	Digital input 10	
IN_11	Digital input 11	
IN_12	Digital input 12	
IN_13	Digital input 13	
IN_14	Digital input 14	
IN_15	Digital input 15	
IN_16	Digital input 16	
IN_17	Digital input 17	
IN_18	Digital input 18	
IN_19	Digital input 19	
IN_20	Digital input 20	
IN_21	Digital input 21	
IN_22	Digital input 22	
IN_23	Digital input 23	

Table 3.38-2: Digital Outputs		
Name	**Description**	**Function**
IN_24	Digital input 24	They indicate that the corresponding input has been activated.
IN_25	Digital input 25	
IN_26	Digital input 26	
IN_27	Digital input 27	
IN_28	Digital input 28	
IN_29	Digital input 29	
IN_30	Digital input 30	
IN_31	Digital input 31	
IN_32	Digital input 32	
IN_33	Digital input 33	
IN_34	Digital input 34	
IN_35	Digital input 35	
IN_36	Digital input 36	
IN_37	Digital input 37	
VAL_DI_1	Validity of digital input 1	They indicate whether the input has been enabled or disabled.
VAL_DI_2	Validity of digital input 2	
VAL_DI_3	Validity of digital input 3	
VAL_DI_4	Validity of digital input 4	
VAL_DI_5	Validity of digital input 5	
VAL_DI_6	Validity of digital input 6	
VAL_DI_7	Validity of digital input 7	
VAL_DI_8	Validity of digital input 8	
VAL_DI_9	Validity of digital input 9	
VAL_DI_10	Validity of digital input 10	
VAL_DI_11	Validity of digital input 11	
VAL_DI_12	Validity of digital input 12	
VAL_DI_13	Validity of digital input 13	
VAL_DI_14	Validity of digital input 14	
VAL_DI_15	Validity of digital input 15	
VAL_DI_16	Validity of digital input 16	
VAL_DI_17	Validity of digital input 17	
VAL_DI_18	Validity of digital input 18	
VAL_DI_19	Validity of digital input 19	
VAL_DI_20	Validity of digital input 20	
VAL_DI_21	Validity of digital input 21	
VAL_DI_22	Validity of digital input 22	
VAL_DI_23	Validity of digital input 23	
VAL_DI_24	Validity of digital input 24	
VAL_DI_25	Validity of digital input 25	
VAL_DI_26	Validity of digital input 26	
VAL_DI_27	Validity of digital input 27	
VAL_DI_28	Validity of digital input 28	
VAL_DI_29	Validity of digital input 29	

Table 3.38-2: Digital Outputs		
Name	**Description**	**Function**
VAL_DI_30	Validity of digital input 30	They indicate whether the input has been enabled or disabled.
VAL_DI_31	Validity of digital input 31	
VAL_DI_32	Validity of digital input 32	
VAL_DI_33	Validity of digital input 33	
VAL_DI_34	Validity of digital input 34	
VAL_DI_35	Validity of digital input 35	
VAL_DI_36	Validity of digital input 36	
VAL_DI_37	Validity of digital input 37	
PU_CLPU	Cold load pickup of IED	It is marked whenever the IED is energized.
RST_MAN	Manual reinitialization of the IED	It is marked whenever the IED is reset manually.
INIT_CH_SET	Change of settings initialization	It is indicated when some setting is modified.
ERR_CRIT	Critical system error	They note that some technical problem has cropped up in the IED.
ERR_NONCRIT	Non-critical system error	
EVENT_SYS	System event	Indicates the reset of SW in the IED.

Configuration for outputs can be loaded at the factory. Users can easily program different output configurations using the ***ZIVercomPlus***® software via the local communication ports that have the PROCOME protocol configured (the local port is always assigned this protocol).

3.38.3.b Trip and Close Outputs

All the outputs of the **ZLV** equipment are robust, for which any of these can be configured as a switching output. Notwithstanding, there is a series of permanently programmed outputs with the trip or close functions, which we refer to as switching outputs.

ZLV-B/F Models are provided with four physical switching outputs: **DO_1**, **DO_2**, **DO_3** (assigned to A Pole Trip, B Pole Trip and C Pole Trip logic outputs, respectively) and **DO_4** assigned to the Close logic output.

ZLV-A/E/H Models are provided with two physical switching outputs: **DO_1** (assigned to the Pole Trip logic output) and **DO_2**assigned to the Close logic output.

ZLV-G/J relays are not provided with any output configured as permanent as they can be used for dual and single breaker bays.

Some **ZLV-F** and **ZLV-H** models do not have any output configured in a fixed way.

3.38.4 LED Targets

ZLV terminal units are provided with 5 optical indicators (LEDs), located on the front panel; 4 of them are configurable LEDs and the other one corresponds to equipment **In Service**.

Each of the user-definable optical indicators is associated to a combinatorial function. These are diagramed in figure 3.38.3. They way they function and are configured is similar to the auxiliary contact outputs. One of the two blocks has eight inputs that perform an OR operation (any signal activates the output). The other block has one input. The two blocks together can perform an OR or an AND operation without the subsequent possibility of using pulses.

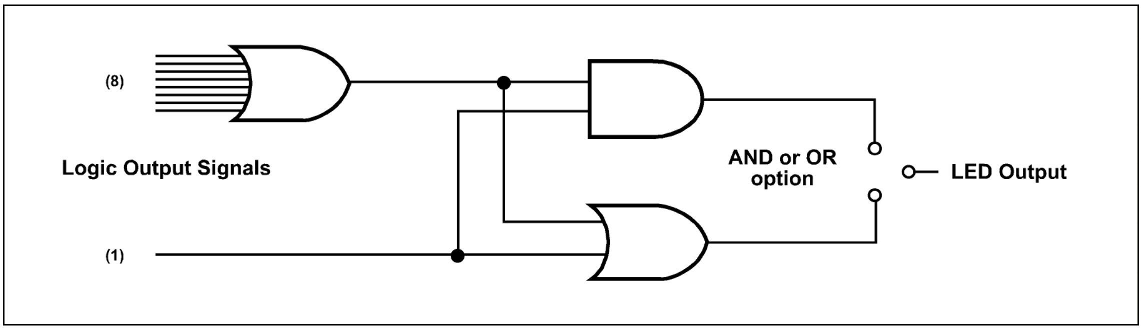


Figure 3.38.3: LED Target Output Logic Cell Block Diagram.

Each LED can be latched or unlatched. If an LED is latched, it will remain illuminated until reset. It is possible to program one of the programmable buttons, communications command, or digital input with the logic signal **Reset LEDs**. The latching function resides in the volatile memory section of the microprocessor. A power supply loss will cause any latched LED to reset.

The LEDs can be associated to any of the available logic output signals indicated in table 3.38-2. Logic equations can be created and modified with the ***ZIVercomPlus***® program via the local communication ports that have the PROCOME protocol configured (the local port is always assigned this protocol).

To develop more complex algorithms and be able to assign the resulting outputs to the LEDs, the necessary opcodes must be programmed in the programmable logic. This, for example, allows configuring latched LEDs that do not lose memory after an auxiliary power supply voltage failure. This requires the use of latched bistable circuits.

The IED has another 7 LEDs associated with each of the operating buttons available on the front of the IED. These indicators show the current state of the element governed by each button by its color (user-configurable). In the process of selecting an element and confirming / executing a command, the associated LED blinks. These LEDs must be configured through the programmable logic.

3.38.5 Binary Input Synchronization

The IED can be synchronized by binary input with a pulse per second signal (**PPS**) or a pulse per minute signal (**PPM**) and any digital input except **DI1** can be configured for this purpose. Once one DI is selected by setting (**Synchronization Input**), the synchronization by binary input is enabled and the IED will start searching or waiting for the pulsed signal through the selected digital input.

The pulse length of the digital input signal does not affect the time synchronization as the IED will work with the positive flank of the received pulse or with the negative flank depending on the settings called as **Synchronization Edge**. Depending on the **Synchronization Type** setting (PPS/PPM) the IED will know the acceptable time range in which the pulses have to arrive. The relay will activate or accept the time synchronization when two pulses arrive in time. Respectively, if the synchronization pulses disappear, the relay takes the time that corresponds to the time range of three pulses before de-activating the binary input synchronization (3 seconds when working with PPS and 3 minutes with PPM).

When the PPS synchronization is selected and a correct PPS signal is connected to the IED, the real-time clock of the relay will be rounded to the nearest whole second when the positive or negative flank of the pulse is received, once the pulse signal has been validated, this is, when two pulses on time have arrived (2 seconds). If the synchronization pulses differ more than ±50ms from the real-time clock of the relay, the synchronization pulse is rejected.

Time in IED when “PPS” arrives	Corrected time in Relay after the PPS
15:32:12.000 to 15:32:12.499	15:32:12.000
15:32:12.500 to 15:32:12.999	15:32:13.000

When the **PPM synchronization** is selected and a correct PPM signal is connected to the IED, the real-time clock of the relay will be rounded to the nearest whole minute when the positive or negative flank of the pulse is received, once the pulse signal has been validated, this is, when two pulses on time have arrived (2 minutes). If the synchronization pulses differ more than ±2s from the real-time clock of the relay, the synchronization pulse is rejected.

Time in IED when PPM arrives	Corrected time in Relay after the PPM
15:32:00.000 to 15:32:29.999	15:32:00.000
15:32:30.000 to 15:32:59.999	15:33:00.000

When the IRIG-B signal is being received none of the other synchronization methods are taken into account, so in this case, no matter the DI is selected and PPS/PPM is set, the relay will just take the time from the IRIG-B rejecting the PPS/PPM signal.

When the time is set via communications (PROCOME, DNP3 or SNTP) and **PPM** is enabled, the year-month-day-hour-minute is written to the real-time clock of the relay and when **PPS** is set the year-month-day-hour-minute-second is written.

When the time is set from the HMI, the entire time is written to the relay's internal clock.

3.38.5.a Synchronization by Binary Input Digital OutputsTable

Table 3.38-3: Digital Outputs of the Synchronization by Binary Input		
Name	**Description**	**Function**
TIME_DI_ENA	Synchronization by digital input enabled	Synchronization enabled by settings.
TIME_DI_ACT	Device synchronized by digital input	PPS/PPM signal accepted and IED synchronized.

3.38.5.b Setting Ranges

Digital Input Filtering			
Setting	**Range**	**Step**	**By default**
Digital input enable	YES / NO		YES
Time between samples. Filter 1	2 - 10	2	6
Time between samples. Filter 2	2 - 10	2	6
No. of same value samples for filter 1 validation	1 - 10 samples	1	2
No. of same value samples for filter 2 validation	1 - 10 samples	1	2
No. of changes for input disabling	2 - 60 changes	1	5
Disabling time	1 - 30 s	1	2 s
Number of Digital Inputs for Supply Voltage Supervision	0 - 25 (*)	1	0
No. of changes for input enabling	2 - 60 changes	1	5
Enabling time	1 - 30 s	1	2 s
Synchronization input (ZLV-***-****D/E/F/G/H**)	0-max numb. DIs (**)	1	0
Synchronization type (ZLV-***-****D/E/F/G/H**)	0: PPS 1: PPM		PPS
Synchronization edge (ZLV-***-****D/E/F/G/H**)	0: Rising Edge 1: Falling Edge		Rising Edge

(*) The total number of Digital Inputs depends on model.
(**) DI1 cannot be selected. When synchronization input is equal to 0, the binary input synchronization is disabled.

Auxiliary Outputs			
Setting	**Range**	**Step**	**By default**
Trip and close contact operation enable	YES / NO		YES
Auxiliary output operation enable	YES / NO		YES
Output type*	Normal Quick Both		Normal

* Not available for the ZLV-E models.

3.38.6 Digital Inputs, Auxiliary Outputs and LED's Test

Apply rated voltage, appropriate for the model. At this time, the **In Service** LED should be lit.

- **Digital Inputs**

For the inputs test, the rated voltage is applied between the terminals corresponding to the inputs (marked in the external connections diagram), always taking the polarity of the contacts into account.

From the inputs screen of the **Information** menu, it is verified that the inputs are activated ("1"). The voltage is removed and the contact inputs must reset ("0").

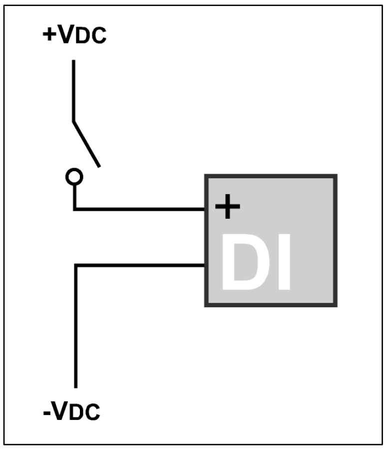


Figure 3.38.4: Digital Inputs Test.

- **Auxiliary Outputs**

To test the auxiliary contact outputs, their operation is provoked according to how they are configured. If they are not configured, they can be configured as activation of the status contact inputs. Part of the inputs test consists in verifying the operation of auxiliary output contacts OUT1 to OUT6.

- **Selection and Command Buttons and Associated LEDs**

To test the definable selection and command buttons on the front of the IED, they are assigned a configuration such that, once they have been selected and the command given, the corresponding auxiliary contact outputs (indicated in the external connections diagram) are activated and deactivated.

Pressing the **52** key causes the associated LED to blink; then pressing the **I** or **O** key enables the **Close** (**CLOSE**) or **Trip** (**TRIP**) contacts as long as the breaker element is in the position contrary to the selected one.

Pressing the **P1** to **P6** keys after the configuration indicated above has been made, causes the LEDs corresponding to each of them to blink. Then, pressing the **I** or **O** key enables the contacts corresponding to the auxiliary contact outputs OUT1 to OUT6.

- **LED Targets**

To check the LED targets, the **F2** key must be pressed from the stand-by screen until the Resetting LEDs screen appears. It is held down until all the LEDs light up. When the push-button is released, they must all go off.

3.39 Programmable Logic

3.39.1 Description

One of the functions of **ZLV** models is a fully configurable one called programmable logic. The user can freely interconnect this logic digitally and analogically by using the ***ZIVercomPlus***® program.

All the signals generated by the equipment will be available to the events, fault reports, oscillograph records, digital inputs and outputs, HMI and communications according to how their programmable logic has been configured.

The inputs to the logic functions can be any of the signals or readings generated by the following functions:

- Protection units.
- Digital inputs.
- Communications.
- Command functions.
- Analog inputs.

The user can define a logical operation using primitive logic functions (AND, OR, XOR, NOT, etc.), bistable circuits (latched or not), timers, comparators, constants, values, etc.

The programming function allows definition of the trip logic, control logic, interlocks, functional modules, local and remote states and control hierarchy required for complete protection and operation of a bay.

Priorities may also be selected in the programmable logic. There are three run cycles, of 2, 10 and 20 milliseconds, and priorities may be allocated placing the logics in either cycle. In this way, control logic can be carried out and use them as protection functions as they can be run with a priority similar to the functions implemented into the equipment firmware itself. For more information, please refer to the ***ZivercomPlus***® manual.

The processing of the input signals produces logical outputs that can be assigned to existing connections between the **ZLV** and the exterior: auxiliary output contacts, display, LEDs, communications, HMI, etc.

3.39.2 Functional Characteristics

The IEDs can execute local programmable control functions associated with the bay as well as the logic associated with internal and external interlockings, treatment and generation of alarms and processing of signals. They are all programmable.

The execution of interlockings towards the external circuits implies being able to execute continuously active outputs depending on the combination of the state of various input signals through logic gates. These interlocking outputs are used for interrupting / continuing an exterior command circuit. These interlockings are the consequence of the logic capacity pointed out in the following sections.

The execution of internal interlockings implies being able to obtain logic outputs of permission / blocking of commands towards the external circuits according to the combination of the state of various input signals through logic gates. These processed logic signals affect the permissions / lockouts of commands generated both from the unit's local control module and from the Central Unit originating in the control display, central programmable control functions and/or remote control.

Logical alarms can be generated with data from the combination of the state of various input signals through logic gates as well as from "timers" of presence / absence of a given signal, either physical or logic.

The processing of analog signals offers the possibility of comparing analog inputs with set points and of generating digital ON/OFF signals as a result of this comparison as well as the possibility of adding and multiplying analog signals. Analog values can be used in primary or secondary values.

Logic configurations can also generate user defined values such as counters. This values are the result of the user defined logic algorithms. User defined values can be displayed on the HMI, sent via communications and retrieved using ***ZIVercomPlus***®.

Likewise, it is also possible to define new user settings in the IED associated with the algorithm. These settings can be consulted afterwards from the HMI or communications.

In addition, the algorithms can disable protection elements of the IED. The disabling of an element allows it to be replaced by another that operates under user-defined algorithms.

Basically, the system takes input signals from various sources, both external to the IED (communications or HMI) and internal; processes these signals according to the configuration that has been loaded and the pre-established settings and activates certain output signals that will be used for sending information messages or measurements to the central unit as well as commands to relays, LEDs and protection.

The **Programmable Logic** and its **Configuration** comprise the engine of this whole system. The logic has a set of *blocks* that encompass a series of logic operations. Each of these blocks determines an *outcome* (state of one or more signals) depending on the state of the inputs of that *block*. The **Configuration** determines the use of one or another block.

The operation chosen to obtain a given output determines the input signals to the *blocks*. The **Input Connection** process is the software process that connects the inputs of the *blocks* with the appropriate inputs to the control subsystem according to the **Configuration**.

Likewise, the output signals from the *blocks* are associated with the appropriate outputs. This is done in the **Output Connecting** process according to the **Configuration**.

If the required input signals are signals that arrive through communications, they arrive encoded according to the PROCOME, MODBUS or DNP 3.0 communications protocol, which forces associating each necessary signal with its corresponding protocol. This process is performed in **Input Tagging** and the associations are made in one form or another according to the configuration. The same happens with the signals sent through communications; the software process is carried out in **Output Tagging** and is also determined by the **Configuration**.

New logic-generated values can be redirected to the IED's different communication protocols as well as to the HMI.

The **Programmable Logic** can be used to generate events with any available digital signal that the IED can capture with the PROCOME communications protocol and the program. It doesn't matter if this signal is a digital input or a signal received via communications from the central unit or, on the contrary, is the outcome of internal operations included in the programmed algorithm itself. Moreover, there is the option of recording the event by the rising edge of the chosen signal, by the falling edge or by both.

Once the event is generated, it can be captured the same as the rest of the events generated by the IED (as, for example, trip events) with the ***ZIVercomPlus***® communications program.

There is an exclusive option to simplify the task of configuring the Digital Inputs, Digital Outputs and LEDs. This voids the need to work with complex algorithms that would make the task unnecessarily difficult.

3.39.3 Primitive Functions (Opcodes)

The following logic operations can be used in the algorithm.

AND	Pulse	Adder	Digital/Analog Converter
OR	Timer A	Subtracter	BCD/Analog Converter
XOR	Timer B	Multiplier	Binary/Analog Converter
NOT	DFF	Divisor	Analog/BCD Converter
Cable	RSFF	Comparator	Analog/Binary Converter
Multifiber Cable	Analog Cable	Level Comparator	Pulse train
Multiplexer	Counter		Rising edge

- **AND**

Performs an AND operation between digital signals.

Operands:

From 2 to 16 digital input signals

Results:

Digital output signal, the outcome of the operation

- **OR**

Performs an OR operation between digital signals.

Operands:

From 2 to 16 digital input signals

Results:

Digital output signal, the outcome of the operation

- **XOR**

Performs an XOR operation between two digital signals.

Operands:

Two digital input signals.

Results:

Digital output signal, the outcome of the operation.

- **NOT**

Moves to a digital signal the outcome of negating another.

Operands:

Digital input signal.

Results:

Digital input signal.

- **Cable**

Moves to a digital signal the value of another.

Operands:

Digital input signal.

Results:

Digital input signal.

- **Multifiber Cable**

Moves to a digital signal the value of another.

Operands:

Digital input signal.

Results:

From 1 to 16 digital output signals.

- **Multiplexer**

Based on a selector, it establishes the value of an output signal with the value of one of the two inputs.

Operands:

Digital input selector signal.
2 digital input signals.

Results:

Digital output signal.

- **Analog Selector**

Based on a selector, it establishes the value of an analog output magnitude with the value of one of the two analog input magnitudes.

Operands:

Digital input selector signal.
2 analog input magnitudes.

Results:

Analog output magnitude.

- **Pulse**

When the input signal goes from 0 to 1, the output signal is activated during the time specified as parameter.

Operands:

Digital input signal.
Setting or pulse time constant in seconds.

Results:

Digital output signal.

Limits:

The maximum time must be set between 0.0 and 2147483.648 seconds (24 days).

- **Timer A**

When the time set since the input signal went from 0 to 1 is up, the output goes to one until the input resets.

Operands:

Digital input signal.
Setting or delay time constant in seconds.

Results:

Digital output signal.

Limits:

The maximum time must be set between 0.0 and 2147483.648 seconds (24 days).

- **Timer B**

The output is activated as long as the input is active or has been deactivated after a time no greater than the time set.

Operands:

Digital input signal.
Setting or delay time constant in seconds.

Results:

Digital output signal.

Limits:

The maximum time must be set between 0.0 and 2147483.648 seconds (24 days).

- **DFF**

Type D bistable. Whenever a rising edge occurs in the clock signal, the bistable takes the value of the input.

Operands:

Digital clock signal.
Digital input signal.

Results:

Digital output signal

- **RSFF**

Type RS bistable. As long as the S signal is active, the bistable takes the value of the input. When the R input is activated, the bistable takes value 0.

Operands:

Digital signal R.
Digital signal S.

Results:

Digital output signal.

- **Analog Cable**

Moves to an analog magnitude the value of another.

Operands:

Input magnitude.

Results:

Output magnitude.

- **Counter**

It manages a counter that increases with each rising edge of the clock signal. When the reset input is activated, the counter resets to 0.

Operands:

Digital reset signal.
Digital clock signal.

Results:

Magnitude of counter value.

Limits:

The counter has a saturation value of 65535. Subsequent increments do not modify the output value of the counter.

- **Adder**

It establishes the value of the output magnitude with the result of the sum of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Subtracter**

It establishes the value of the output magnitude with the result of the subtraction of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Multiplier**

It establishes the value of the output magnitude with the result of the product of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Divisor**

It establishes the value of the output magnitude with the result of the division of the input values.

Operands:

2 input values, settings or constants.

Results:

Output magnitude.

- **Comparator**

Compares two input values and establishes the value of the digital output signal according to the outcome of the comparison.

Operands:

2 input values, settings or constants.
Type of comparison as a constant value inserted in the opcode:
Greater than.
Less than.
Equal to.
Not equal to.
Greater than or equal to.
Less than or equal to.

Results:

Digital output signal.

- **Level Comparator**

It compares the input magnitude with respect to a minimum and maximum reference value and establishes the output according to it. Thus:
The output is 1 if the input is greater than the maximum reference value.
The output is 0 if the input is less than the minimum reference value.
Otherwise, the output keeps the same value.

Operands:

Input magnitude (magnitude, setting or constant).
Minimum reference value (magnitude, setting or constant).
Maximum reference value (magnitude, setting or constant).

Results:

Digital output signal.

- **Digital / Analog Converter**

It converts a digital signal to an analog magnitude with value 0 or 1.

Operands:

Digital input signal.

Results:

Analog output magnitude.

- **BCD / Analog Converter**

With 16 digital inputs, it generates an analog magnitude using BCD code.

Operands:

16 digital input signals.

Results:

Analog output magnitude.

- **Binary / Analog Converter**

With 16 digital inputs, it generates an analog magnitude using binary code.

Operands:

16 digital input signals.

Results:

Analog output magnitude.

- **Analog / BCD Converter**

It converts an analog magnitude into 16 digital signals by converting to BCD code.

Operands:

Analog input magnitude.

Results:

16 digital output signals.

- **Analog / Binary Converter**

It converts an analog magnitude into 16 digital signals by converting to binary code.

Operands:

Analog input magnitude.

Results:

16 digital output signals.

- **Pulse Train**

Logic block produced by a pulse train while the digital input signal is active.

Operands:

Digital signal enabling pulse train.
Magnitude, setting or time constant of active pulse in seconds.
Magnitude, setting or time constant of inactive pulse in seconds.

Results:

Digital output signal.

- **Rising Edge**

The output is activated when a change from 0 to 1 is detected in the input.

Operands:

Digital input signal.

Results:

Digital output signal.

3.39.3.a Logic Operations with Memory

Certain logical functions can be configured to preserve the internal state of the function after a shut down. Not all the logical functions have internal states that require this treatment:

Table 3.39-1: Logic Operations with Memory

Logical function	Can be memorized
AND	-
OR	-
XOR	-
NOT	-
Cable	-
Multifiber cable	-
Pulse	Y
Timer A	Y
Timer B	Y
DFF	Y
RSFF	Y
Analog cable	-
Counter	Y
Adder	-
Subtracter	-
Multiplier	-
Divisor	-
Comparator	-
Level comparator	Y
Digital to analog	-
RSFF with timed reset	Y
Pulse train	Y

Memorization mode is selected by means of a memory field inserted in the opcode when configuring with the ***ZIVercomPlus***® program.

3.40 Communications

3.40.1 Communications Types

ZLV relays are provided with different types of communications ports as a function of the selected model:

- **1** front **Local Port** type RS232C and USB.
- Up to **3 Remote Ports** with following configurations:
  - Remote Port 1: optical fiber interface (glass ST or plastic 1mm), electrical interface RS232 / RS232 FULL MODEM and RJ45 connector for ETHERNET communications.
  - Remote Port 2: optical fiber interface (glass ST or plastic 1mm), electrical interface RS232 / RS485 and RJ45 connector for ETHERNET communications.
  - Remote Port 3: optical fiber interface (glass ST or plastic 1mm), electrical interface RS232 / RS485 and RJ45 connector for ETHERNET communications.
- **2 LAN Ports** with following configurations (ETHERNET type communications):

	LAN 1	**LAN 2**
1st Combination	RJ45	RJ45
2nd Combination	RJ45	MTRJ
3rd Combination	FOC ST	FOC ST

- **1 Remote Port** with CAN protocol BUS connection.

Technical data for these communications links can be found in Chapter 2.1 (Technical Data). Information on model ports can be found in chapter 1.5 (Model selection).

3.40.2 Communication with the *ZIVercomPlus*®

Communication for configuring the protection, for loading or reading the configuration of the programmable logic and for obtaining the data protection (events, fault reports, oscillography, etc.) can be made through the communication ports that have the PROCOME protocol configured. The local port is always assigned this protocol, while the remote ports depend on the settings.

The communication is performed with the ***ZIVercomPlus***® communications program. It dialogs with the **ZLV** family of equipment and other equipment, either locally (through a PC connected to the front port) or remotely (via rear communications ports with PROCOME protocol), about all programming, settings, recording, reports, etc.

The local and remote communication ports are configured through the HMI.

The **ZLV** model has three controllers, one for each remote communication port, to allow establishing communication through all of them at the same time.

The ***ZIVercomPlus***® communications program, which covers the needs of this family of equipment, is password-protected against unauthorized users. The ***ZIVercomPlus***®, which runs under WINDOWS™, is user-friendly. The various submenus are opened with buttons or keys.

3.40.3 IRIG-B 123 and 003 Synchronization

ZLV models come with a **BNC** type input for synchronizing by means of a standard format **IRIG-B 123** or **003** time code signal. This input is located on the rear of the IED. The synchronization accuracy is ±1 ms.

If the **ZLV** IED is receiving **IRIG-B** signal for synchronization, the HMI will deny access to the **Date** and **Time** settings.

An output can be configured to indicate the reception status of the **IRIG-B** signal. This output will stay active as long as the unit receives this signal properly.

ZLV IEDs are also prepared to indicate the loss as well as the recovery of the **IRIG-B** signal by generating the events associated with each of these circumstances.

3.40.3.a UTC / Local Time Configuration

Discerning whether the time received through BNC connector corresponds to **UTC Time** or a given **Time Zone (Local)** is possible through **IRIG-B Time Zone** setting.

In the first case, a correction must be introduced to adapt the UTC time to the time zone of the relay site. The **Local Time Zone** setting within the **Date and Time** settings group is used for this purpose, which allows putting UTC time forward or back as required.

In the second case, the relay receives the time signal already adapted to the local time zone and no correction is needed. In this case local **Local Time Zone** has no effect.

3.40.3.b IRIG-B Function Settings

IRIG-B Function Settings			
Setting	**Range**	**Step**	**By Default**
IRIG-B Time Zone	0 = Local Time 1 = UTC Time	1	0 = Local Time

3.40.3.c Digital Outputs and Events of the IRIG-B Function

Table 3.40-1: Digital Outputs and Events of the IRIG-B Function		
Name	**Description**	**Function**
SIGNAL_IRIGB	IRIG B Active	Signal indicating reception of IRIG-B.

3.40.4 Communications Protocol

All **ZLV** relays are provided with rear communications ports for remote access and one front port for local access. Depending on model, rear ports feature several communications protocols:

- **Local Port**: uses only PROCOME protocol.
- **Remote Ports 1** and **2**: options PROCOME, DNP3.0, MODBUS and Virtual Inputs / Outputs are available.
- **Remote Port 3**: options PROCOME, DNP3.0 and MODBUS are available.
- **Remote Port 4**: options CAN and CAN MULTI-MASTER are available.
- **Ports LAN 1 and 2**: Can communicate with IEC61850 and PROCOME and, DNP3 and Modbus depending on model. Refer to IEC61850 communications section.

It is worth mentioning that communications through all ports can be maintained simultaneously.

PROCOME protocol complies with IEC-870-5 standards and is used, the same as for IEC61850, for both protection and control information management. On the other hand, protocols DNP 3.0, CAN and MODBUS are used for control information management.

For more details on protocols refer to the applicable protocol paragraph.

3.40.4.a Control Change Recording

Depending on signals configured into the programmable logic through the ***ZIVercomPlus***® program, the different system events make changed-state signals to be written.

Different signal lists for PROCOME 3.0 and DNP 3.0 protocols can be configured through the programmable logic, saving changes into different and separate **ZLV** relay files for each of the communications ports. This implies that although the tail of changes of one port is emptied after collecting said information, the same information is available at the other port for collection through the allocated protocol, whether it is the same as for the first port or not.

Also, from the signals configured in PROCOME, DNP 3.0 or both, signals to be displayed through the HMI can be selected. They are also saved into separate files, so that even if tails of control changes of communications ports are emptied, the information is still available through HMI. Between 100 and 115 records are saved depending on their simultaneity.

Information on the Control Change Record is displayed from the HMI or pressing F1 key through **Information** option, the changes list view or delete options being available. If the view option is selected, the last change generated is always displayed (the most recent). Information is presented as follows:

```
AA/MM/DD|HH:MM:SS
000   text1      ☐ or ■
001   text2      ☐ or ■

AA/MM/DD|HH:MM:SS
000   text3      ☐ or ■
001   text4      ☐ or ■
```

Namely, events are grouped by “date” and “time”. Then, in the following line, the milliseconds corresponding to each control change and the label defined through the ***ZIVercomPlus***® (maximum of 13 characters) are shown. And at the end of the line, a filled or blank square indicates ACTIVATION-ON (■) or DEACTIVATION-OFF (□) respectively. Default signal text labels are defined in input and output tables; in case of new signals generated into the programmable logic, said text must be defined. In any case, in order to use the names required by each user, the creation of a logic record card allocating a personalized name to every signal to be displayed is recommended.

The date and time stamp will be generated every time a new event occurs in it.

The MODBUS allows to display the actual value of the configured digital signals but do not record their changes.

3.40.5 Communications Settings

As the below described settings are independent for each port, they are grouped as follows: **Local Port**, **Remote Port 1**, **Remote Port 2**, **Remote Port 3**, **LAN1**, **LAN2** and **CAN**. Finally specific settings for each protocol are described.

Whenever communication is established through one of these ports, the following codes are displayed on relay alphanumeric HMI:

- **Local port**: **[PL]** code.
- **Remote port 1**, **Remote port 2**, **Remote port 3**: **[P1]**, **[P2]** and **[P3]** codes.
- **Remote ports LAN1** and **LAN 2**: no display on HMI.
- **Remote port CAN**: **[P4]** code.

These codes, in case of PROCOME 3.0 protocol, remain displayed during **Communications Password TimeOut** setting indicated in paragraph 3.31.4.d after the last communication carried out; in case of MODBUS, DNP V3.00 and CAN protocols, the message remains displayed for one minute after the last communication.

There are three timer settings, one for each communications port (**Communication Failure Time Indication**), which, no matter the assigned protocol, allow configuring the period without communication activity before generating the alarms (digital signals and events) **Communication Failure Port 0**, **1**, **2**, **3** and **CAN**.

3.40.5.a Local Port

The setting options of the local communications port are:

- **Baud Rate**: a value from **300 bauds** to **57600 bauds** can be chosen, default value being 38400 bauds.
- **Stop Bits**: **one** of two stop **bits** can be selected.
- **Parity**: **even**, **odd** or **no parity** (None) can be selected. No parity is configured by default.
- **Character Reception Time** (**0-60000 ms**): maximum time between characters allowed during the receiving of a message. The current message will be considered cancelled if it exceeds the set time between the reception of two characters.
- **Communication Failure Indication Time** (**0-600 s**.): maximum time between messages without indication of communication channel blocking.

3.40.5.b Remote Port 1

Remote Communications Port 1 has simultaneous fiber optic and electrical access RS232C/RS485. Access through RS232C has all the MODEM lines in format DB9. In light of these characteristics, the settings available for configuring this port are:

- **Baud Rate**, **Stop Bits**, **Parity** and **Character Reception Time**, the same as the local port.
- **Protocol**: protocol options are PROCOME 3.O, DNP 3.0, MODBUS and Virtual Inputs / Outputs. The default protocol is PROCOME.
- **Advanced Settings** to use the port's full-modem characteristics:

  1. Flow Control

  CTS Flow (NO / YES): it specifies whether the **Clear to Send** signal is monitored to control the data transmission flow. If the setting is YES and the CTS signal falls to "0," the transmission is suspended until the CTS signal resets.

  DSR Flow (NO / YES): it specifies whether the **Data Set Ready** signal is monitored to control the data transmission flow. If the setting is YES and the DSR signal falls to "0," the transmission is suspended until the DSR signal resets.

  DSR Sensitive (NO / YES): it specifies whether the communications port is sensitive to the state of the DSR signal. If the setting is YES, the communications driver ignores any byte received unless the DSR line is active.

  DTR Control (INACTIVE / ACTIVE / ENABLE SEND):

  Inactive: It sets the DTR control signal to permanently inactive.

  Active: It sets the DTR control signal to permanently active.

  Enable Send: The DTR signal remains active as long as the receiving of new characters is allowed.

  RTS Control (INACTIVE / ACTIVE / ENABLE SEND / SOL. SEND):

  Inactive: It sets the RTS control signal to permanently inactive.

  Active: It sets the RTS control signal to permanently active.

  Enable Send: The RTS signal remains active as long as the receiving of new characters is allowed.

  Solicit send: The RTS signal remains active as long as there are characters pending transmission.

  2. Time

  Transmission Time Factor (0-100 characters): Per-character time factor that determines when the transmission times out.

  Transmission Time Constant (0-60000 ms): Fixed time in seconds that is added to the per-character time factor and that determines when the transmission times out.

  3. Message modification

  Number of Zeros (0-255): Number of zeros to insert as preamble to each message.

  4. Collisions

  Type of collision (NO / ECHO / DCE):

  NO: Collision detection disabled.

  ECHO: A collision is considered to have occurred when the characters received do not coincide with those transmitted.

  DCD: A collision is considered to have occurred when the DCD line is activated.

  Number of Retries (0-3): Maximum number of retries in the transmission when collisions are detected.

  Minimum Time between Retries (0-60000 ms): Minimum time between retransmissions due to detection of collision.

  Maximum Time between Retries (0-60000 ms): Maximum time between retries due to detection of collision.

3.40.5.c Remote Ports 2 and 3

Remote ports 2 and 3 have fiber optic and electrical access RS232 / RS485. Available configuration settings for these ports are similar to the local port settings, and it is possible to select the communications protocol and a specific parameter for RS485 application. Thus, settings are:

- **Baud Rate, Stop Bits, Parity** and **Character Reception Time**.
- **Protocol**: Depending on model, PROCOME 3.0, DNP 3.0, MODBUS protocols and Virtual Inputs / Outputs (this last option is only available for remote port 2) can be selected. The default protocol is PROCOME.
- **·Advanced settings**:

  1. Operation Mode (RS232 / RS485): This setting allows selecting the operation mode of DB9 interface of remote port 2 or 3 as a RS232 port or RS485 port.

  2. Time

  Transmission Time Factor (0-100 characters): Per-character time factor which determines when the transmission ends by time-out.

  Transmission Time Constant (0-60000 ms): Fixed time in seconds that is added to the per-character time factor, and that determines when the transmission ends by time-out.

  Number of 485 Stop Bytes (0-4 bytes): It specifies the number of stop bytes between transmit and receive when the port is configured as RS485.

  3. Message modification

  Number of Zeros (0-255): Number of zeros to insert as preamble to each message.

  4. Collisions

  Type of Collision (NO / ECHO / DCE):

  NO: Collision detection disabled.

  ECHO: A collision is considered to have occurred when the characters received do not coincide with the characters transmitted.

  Number of Retries (0-3): Maximum number of retries in the transmission when collisions are detected.

  Minimum Time between Retries (0-60000 ms): Minimum time between retransmissions on collision detection.

  Maximum Time between Retries (0-60000 ms): Maximum time between retries on collision detection.

3.40.5.d Ethernet Remote Ports 1, 2 and 3

- **Protocol**: Depending on model, PROCOME 3.0, DNP 3.0, MODBUS protocols and Virtual Inputs / Outputs (this last option is only available for remote port 2) can be selected. The default protocol is PROCOME.
- **Ethernet**
  1. Enabling the Ethernet Port (YES-NO): enables (YES) or disables (NO) the Ethernet Port.
  2. IP Address (ddd.ddd.ddd.ddd): Ethernet device ID number.
  3. Net mask (128.000.000.000 – 255.255.255.254): number that indicates to the device what part of the IP address is the network number, and what part of the IP address corresponds to the device.
  4. Port Number (0 - 62235): number used to indicate the delivery route of the data received, to the destination device.
  5. Max. Time between Messages TCP (0-65 sec.): number of seconds between Keepalive packages - if zero then Keepalive packages were not sent. These Packages inform the server if a client is still present on the Ethernet Network.
  6. RX Car Time (0-60000 milliseconds): maximum time between characters allowed while receiving a message through the Ethernet. The message is timed out if the set time is exceeded between the receipt of two characters.
  7. Communication fault indication time (0-600 sec.): maximum time between messages via the Ethernet port before an indication that communications have stopped.

3.40.5.e Remote Port 4

Remote port 4 of BUS CAN has the following configuration settings available:

- **Baud Rate** (100, 125, 250, 500 and 100 Kbaud).
- **Trip Indication Time** (1 - 10sc).

3.40.5.f PROCOME 3.0 Protocol Settings

The configuration settings of the PROCOME 3.0 protocol are:

- **Relay Number** (**0-254**): it specifies the address of the **ZLV** relay (acting as RTU or Remote Terminal Unit) in relation to the rest of equipment that communicate with the same master station (**MTU** or Master Terminal Unit).
- **Communications Password Enable** (**YES-NO**): this setting allows to enable the access password function to establish communication with the relay through the rear port: YES means enabling the permission and **NO**, disabling.
- **Communications Password TimeOut** (**1-10 minutes**): this setting allows establishing a period of time for activating a communication blocking with the relay (whenever communication is via the rear port): if the set time expires with no activity taking place in the communications program, the system blocks, and the communication must be reinitiated.
- **Communications Password**: the communications password allows establishing a specific password to access communications with the relay through the rear port. This password must have 8 characters, which will be entered using the numerical keys and the key corresponding to a dot.

3.40.5.g DNP 3.0 Protocol Settings

The DNP 3.0 protocol configuration settings include the definition of:

- **Relay Number** (0-65519): it specifies the address of the **ZLV** relay (acting as RTU or Remote Terminal Unit) in relation to the rest of equipment that communicate with the same master station (MTU or Master Terminal Unit). The 0xFFF0 to 0xFFFF addresses are reserved for the Broadcast addresses.
- **T. Confirm TimeOut** (100-65535): it specifies the time lapse (in milliseconds) from the time the **ZLV** sends a message requesting the master to confirm the Application layer (Level 7), until this confirmation is considered lost. The **ZLV** requests confirmation of the Application Layer when it sends spontaneous (Unsolicited) messages or in response to requests for Class 1 or Class 2 Data. When this time expires, the message is retransmitted the number of times specified in the N. Retries parameter.
- **N. Retries** (0-65535): number of retries of the Application Layer (N7). The default value is 0 (zero), indicating that no retransmission will be attempted.
- **Master Number Unsolicited** (0-65535): it specifies the address of the master station (MTU or Master Terminal Unit) to which the **ZLV** relay will send spontaneous (Unsolicited) messages. It is used in combination with Enable Unsolicited parameter. Addresses 0xFFF0 to 0xFFFF are reserved for Broadcast addresses.
- **Enable Unsolicited** (YES/NO): enables (YES) or disables (NO) sending spontaneous messages (Unsolicited); it is used in combination with the MTU Number parameter. For the **ZLV** relay to begin sending spontaneous messages the master must also enable them with the Function Code FC = 20.
- **Unsolicited Start Enable** (YES/NO): enables (YES) or disables (NO) sending spontaneous start messages (Unsolicited after Restart); it is used in combination with the MTU Number parameter. For the **ZLV** relay to begin sending spontaneous start messages there is not need for the master to enable them.
- **Time Grouping Unsolicited** (**100-65535**): it specifies the time interval between the generation of a first event for an unsolicited message and the transmission of the message, with the purpose of grouping several events that may occur within this time interval in a single transmission message, in order not to saturate the communications line with multiple messages.
- **Sync. Interval** (**0-120 minutes**): it specifies the maximum time interval between two synchronizations. If no synchronization occurs within the interval, the need for synchronization is set in Internal Indication (IIN1-4 NEED TIME). This setting has no effect if the Sync. Interval is 0.
- **Unsolicited Start Activation** (YES/NO) (**ZLV-***-**2******* models): enables (YES) or disables (NO) sending Forced Unsolicited messages (for compatibility with versions pre DNP3-1998). When Unsolicited Start is activated, the **ZLV** relay begins to transmit the existing spontaneous messages without additional enabling by the level 2. For this setting to have effect Enable Unsolicited Start must be enabled.
- **DNP3 Revision** (STANDARD ZIV/2003) (**ZLV-***-**2******* models): indicates the DNP3 certification revision to use. STANDARD ZIV or 2003 (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03).
- **Measurement Transmission as Class 1** (YES/NO): enables (YES) or disables (NO) measurement transmission as Class 1.
- **Compression of Multiple Reading Response Messages** (YES/NO): enables (YES) or disables (NO) same fragment multiple object response to multiple request message.

Up to 64 measurements or analog magnitudes can be set for DNP3 transmission. Among them, up to 16 measurements can be set for transmission upon a change request.

To select the measurements to transmit upon a change request, enable the **DNP3 Measurement Change** control configuration option using ***Ziverlog***®.

The measurement change transmission is set through two parameters for each measurement: **Upper Limit** (in profile I relays) or **Maximum Value** (in profile II relays) setting values and the **Band** setting value set for that measurement. Up to 16 band values may be configured through ***ZivercomPlus***®, which will be associated to the measurements enabled for change transmission in the same sequence as they are ordered in ***Ziverlog***®. Namely: band value 000 will be assigned to the first measurement enabled for change transmission, 001 to the second, and so on up to the last measurement enabled, with the limit of 16. The band represents a percentage of the **Maximum Value**, so that when a measurement change exceeds that band, the measurement value is annotated to be sent as change. When the relay receives a measurement change request, it will send all changes annotated.

Analog changes will not be annotated for measurements with option **DNP3 Measurement Change** enabled but with the band set to 100%, or measurements with option **DNP3 Measurement Change** not enabled, they being deemed disabled for change transmission.

Additionally, these are other settings defined for the **DNP3 Profile II and Profile II Ethernet Protocols**:

- **Class for binary changes** (CLASS..., NONE). Assigns the class to the binary changes.
- **Class for analog changes** (CLASS..., NONE). Assigns the class to the analog changes.
- **Class for counter changes** (CLASS..., NONE). Assigns the class to the counter changes.
- **"Status" type binary inputs** (YES-NO). Binary inputs used are according to "status" type inputs (YES) or binary inputs used are not sent according to "status" type inputs (NO).
- **32 bits analog inputs** (YES-NO). Analog inputs used are 32 bits resolution (YES) or analog inputs used are 16 bits resolution (NO).
- Change in DNP3 Counter **(1 to 32767). The setting value shows the minimum increase of counts needed to send a new DNP3 message stating a new change in the counter. 20 counters can be configured as maximum under the DNP3 Profile II and Profile II Ethernet Protocols.**

3.40.5.h MODBUS Protocol Setting

The only configuration setting of the MODBUS protocol is the **IED Address** (0-254), which, as in the other protocols, specifies the address of the acting as RTU or Remote Terminal Unit for the rest of units communicating with the same master station (MTU or Master Terminal Unit).

3.40.5.i TCP/IP Protocol Settings

TCP/IP protocol configuration settings include the definition of:

- **Ethernet Channel 0** (**LAN 1**). The following settings are available within the channel:
  - IP Address (ddd.ddd.ddd.ddd).
  - DHCP Enable (YES/ NO).
  - Default Gateway (ddd.ddd.ddd.ddd).
  - Network Mask (ddd.ddd.ddd.ddd).
  - DNS Address (ddd.ddd.ddd.ddd).
- **Ethernet Channel 1** (**LAN 2**). The following settings are available within the channel:
  - IP Address (ddd.ddd.ddd.ddd).
  - DHCP Enable (YES/ NO).
  - Default Gateway (ddd.ddd.ddd.ddd).
  - Network Mask (ddd.ddd.ddd.ddd).
  - DNS Address (ddd.ddd.ddd.ddd).
- **SNTP** The following settings are available within SNTP:
  - SNTP enable (YES / NO).
  - Broadcast Synchronization Enable (YES / NO).
  - Unicast Synchronization Enable (YES / NO).
  - IP address of Primary SNTP Server (ddd.ddd.ddd.ddd).
  - IP address of Slave SNTP Server (ddd.ddd.ddd.ddd).
  - Unicast Validity Timer (10 - 1000000).
  - Unicast Error Timer (10 - 1000000).
  - Number of Connection Retries (1 - 10).
  - Tuning period (1 - 1000000).
  - Retry Period (1 - 1000000).
  - Broadcast validity Timer (0 - 1000000).
  - Broadcast Error Timer (0 - 1000000).
  - Maximum Synchronism Time Delay (0 - 1000000).
  - Ignore Synchronization Leap Indicator (YES / NO).
  - Synchronism State Calculation (Timing / Leap Indicator).

Settings related to the Ethernet Redundancy (depending on the model):

- **Redundancy mode** (No Redundancy / Bondng Redundancy / PRP Redundancy / RSTP Redundancy).
- **Channel status time** (1 - 60).
- **Bonding Redundancy**
  - Link check interval (25 - 500).
- **PRP Redundancy**
  - Transmission time of supervision frames (0 - 30000).
  - LSB of supervision frame destination MAC address (0 - 255).
- **RSTP Redundancy**: settings are found in the web server. Refer to section Communications Protocol IEC61850.

3.40.6 IEC61850 Communications Protocol

3.40.6.a Introduction

IEC61850 communications equipment of the 'V' family is provided with functions additional to those provided by protection and control equipment.

This equipment may become independent from communications, performing their protection or control functions independently or may be used for data reports, set or receive specific data.

IEC61850 communications provide the following additional services:

- Report device-generated data (Starting, tripping, blocking, etc.) to higher level equipment (Central unit, remote control, HMI, etc.).
- Report prompt data (GOOSE) to other same level equipment (protections, control equipment, auxiliary services) or even to other higher level equipment.
- MMS communications that allows any MMS browser to receive the model of equipment data and be able to operate with it to edit settings and parameters and execute commands to the equipment.
- Handle a single configuration file (CID) that allows having a backup of all parameters whether they are protection, control and communications.
- Web server to provide data about equipment status, errors and state and measurement values.

3.40.6.b Starting Communications

Unlike protection and control functions that start in less than 3 seconds, **IEC61850** communications start in a variable time as a function of the data configured. In a reboot, the main **IEC61850** communications screens are as follows:

Initial moment in which the basic data of the operating system are loaded.

Starting IEC61850
06/08/11 02:98:36

Autorun screen that manages the IP and allows to stop booting or carry out other maintenance tasks.

AUTORUN 1.35 E(3.8)
LN1:192.168.1.81

Screens to create the **IEC61850** model and read **CID**.

READ CID
_ZLVF4F403B.CID

Equipment home screen that indicates the equipment is fully booted and ready for communications.

ZIV/ZLV
17/04/10 22:49:02

3.40.6.c Information Screens

Equipment with **IEC61850** communications include a data Menu, access of which is gained pressing the key combination: Up Scroll Arrow and Dot from the HMI default screen.

This screen displays in the first line the equipment software model, in the second line, versions of the active **IEC61850** application, the third, the equipment IP (if no network cable were connected, it will show 0.0.0.0) and the last line, the MAC of the network adapter.

ZLVF4F*403*B20FC**
V(0.7) [02] [6.0R]
192.168.1.81
00:E0:AB:02:98:36

From this screen more data can be displayed through the function keys F2, F3 and F4.

Pressing F2 displays a screen with Goose message data. This screen displays information on whether Goose message transmission is activated: [ON]GO, if receive is configured [ON]GI, and if so, the message that is not being received: 01??
The arrow → indicates the moment when a Goose message is sent.

[ON]GIe:0000 0000
01?? GIv:0000 0000
[ON]GOe:0000 0000→
GOv:0000 0000

Pressing F3 displays a screen with expanded data.

EBOOT (3.8)
[ZLV-9836]
Ver SO(2.99)
IEC [6.0R][RUN]

It is a screen that can be scrolled down using the scroll arrows, the complete data being: Data on the Eboot, Operating System, application, checksums versions and network adapter data, etc.

```
EBOOT (3.8)
[ZLV -9836]
Ver SO(2.99)
IEC [6.0R][RUN]
CRC:[4720E6D0]
BLD[Sep 28 2011]
BLD[08:46:05]
MMS<->IEC<->ZLV
ZLVF4F***403*K20FC
(0.7)[02]
[BOND_ETHBOND]
192.168.1.81
00:E0:AB:02:98:36
DHCP[0]
Type[6]
GWY[192.168.1.10]
CONNECTIONS 0

[BOND:ETHBOND]
RxERR:[0]
TxERR:[0]

FiFoE:0 Use:1
FiFoM:0 Use:68
NmRtr:0 Mxmed:4
```

Pressing F4 displays the SNTP client data screen. The screen shows the version of the Operating System, the version of the SNTP client, whether the client is switched off, switched on or in Error and the receive time and whether is valid (v) or invalid (i).

Ver S.O.(2.99)
Ver SNTP(2.250)
Sinc SNTP [ON]
10/04/17 22:49:02v

Press ESC to return to the default screen from any screen.

3.40.6.d Web Server

Through the web server access can be gained to firmware versions, boot status and useful relay data. Write the equipment IP address in a web browser for access:

The following data are displayed:

(C) ZIV http://www.ziv.es	
EBOOT	See (3.8) ID[ZLV-9836]
Version NK	2.99
Version IEC	[6.2R][RUN]
Build EXE	[Sep 28 2011][4720E6D0]
Model ZLV	ZLVF4F***403*B20FC
Version API	(0.6)[01]
HTML	APPLICATION
HTML	EXECUTION
HTML	MAPPING
HTML	CIDLOAD
	CONNECTIONS
	LIST DIGITALS
	LIST ANALOGS
	LIST OSCILOS
TXT	APLERROR.LOG
TXT	MAPERROR.LOG
TXT	EXECERROR.LOG
TXT	CIDERROR.LOG
CID ACTIVE	_DBCC1A612P.CID

ETHERNET ADAPTERS						
LAN2	**BOND_ETHBOND**	128.127.50.152	00:E0:AB:02:98:36	DHCP ON	Type[6]	GATEWAY:[128.127.0.102]

That corresponds to firmware versions, network adapter data, boot data, which can be displayed in web page (HTML) format or in downloadable text file (TXT) format.

Also, information on the active MMS connections (MMS clients), a list of internal signals and their value in IEC61850 standard format with their actual description is provided.

Generated oscillograms (DAT and CFG files) can be displayed and downloaded from the link.

Also, the active CID will be available, which can be downloaded from the link.

3.40.6.e Communications Port Configuration

Relays with IEC61850 communications use Ethernet network, using TCP/IP protocol for MMS communications (used to pack network data). Therefore, regardless of the physical medium and the connection (fiber, copper, etc.) the IP used by the relay in the network must be configured. For this, knowing the type of Ethernet redundancy implemented in each relay is vital, there being currently three possibilities:

- **No redundancy**

The relay is provided with 2 separate network adapters with different MAC address and different IP address. Both adapters are independent, it being possible to access the MMS data through both adapters. GOOSE messages will be sent and received only through one of the two adapters.

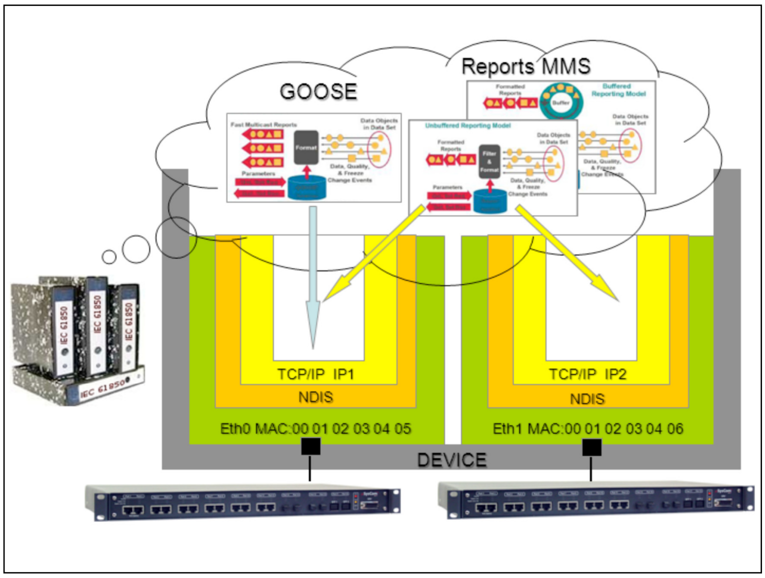


Figure 3.40.1 Configuration of Communications Ports for Relays without Ethernet Redundancy.

- **Bonding Type Redundancy**

The relay is provided with 2 network adapters both operating with the same MAC address and the same IP address, only one of them being active as a function of the medium detection (a broken connection to the adapter results in switching to the other adapter that has a good connection). Both MMS data and GOOSE messages will be sent and received only by the active adapter.

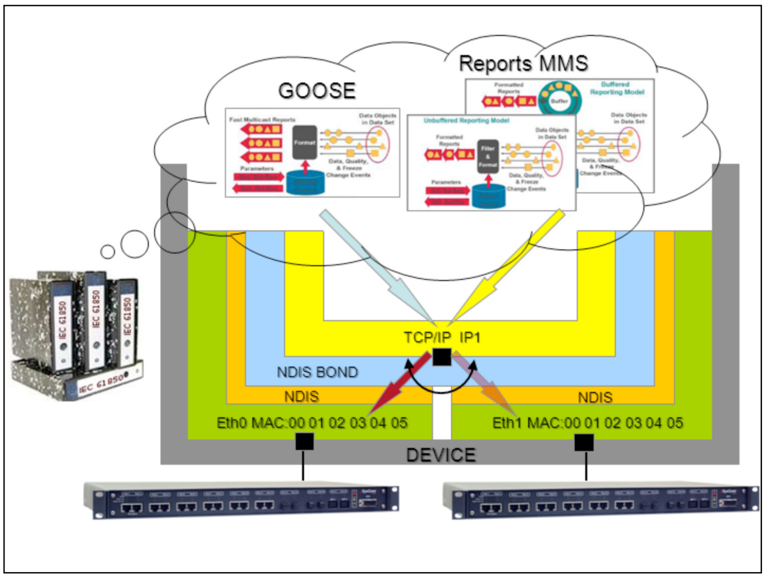


Figure 3.40.2 Configuration of Communications Ports for Relays with Bonding Type Redundancy.

- **PRP Type Redundancy**

The relay is provided with 2 network adapters both operating with the same MAC address and the same IP address, both adapters being active at any time and sending the same data through both adapters using the IEC 62439-3 protocol Parallel Redundancy Protocol (PRP).

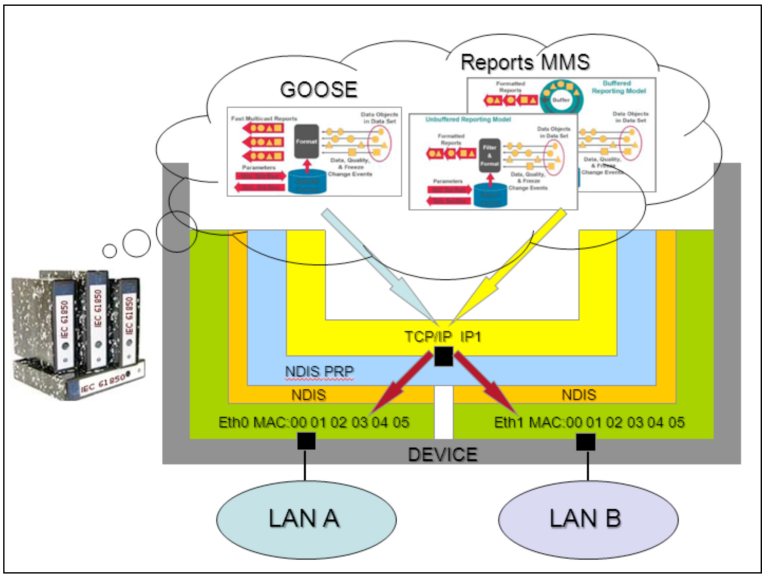


Figure 3.40.3 Configuration of Communications Ports for the Relay with PRP Type Redundancy.

This protocol is based on connecting the relays to two separate Ethernet networks (LAN), not connected to each other. The same data are sent through both adapters at the same time, adding 6 bytes to each Ethernet frame for the PRP protocol. These bytes enable discarding duplicate data, as the same data are received through both adapters and the idea is discarding the duplicate packet at the lowest possible level within the communications stack. The relay will send PRP supervision frames periodically (multicast) to enable system monitoring. Both MMS data and GOOSE messages will be sent through both adapters at the same time.

- **RSTP Type Redundancy**

The relay includes 2 network adapters, both operating with the same MAC address and the same IP address, and both adapters are active at all times. Relays define, together, the optimal path to send messages opening the ring to prevent loop formation. Also, they reconfigure the path when some type of relay or link failure occurs.

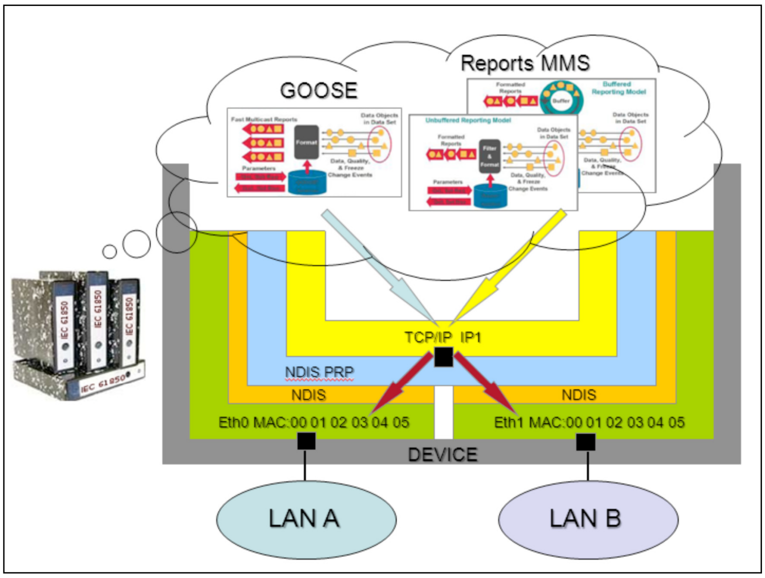


Figure 3.40.4 Configuration of Communications Ports for Relays with RSTP Type Redundancy

RSTP type redundancy is based on connecting relays with each other with single ring, star or star-ring instead of using switches. The relays themselves are in charge of defining and opening the ring, as well as deleting messages from the same preventing their indefinite recirculation.

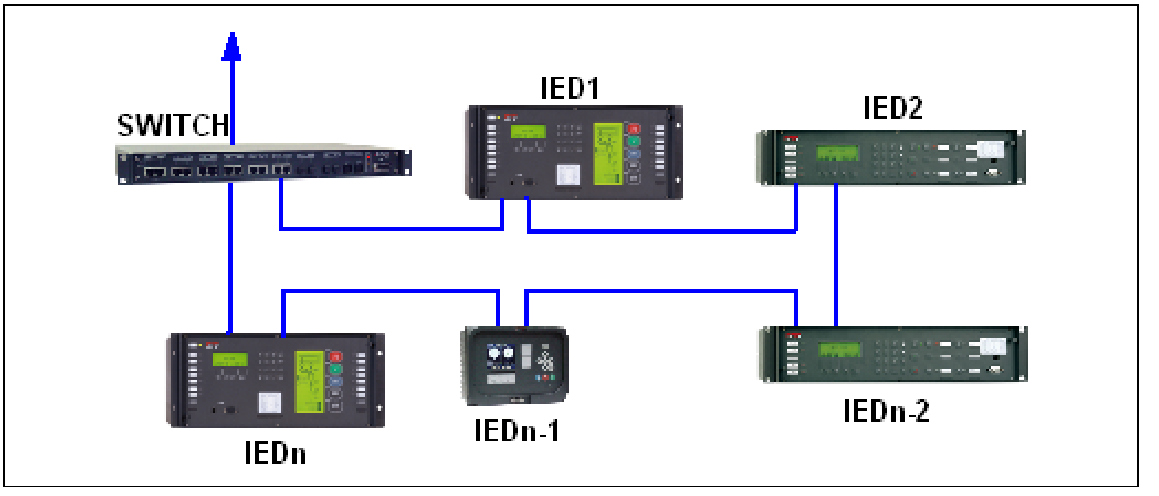


Figure 3.40.5 Example of Connecting Relays with RSTP Redundancy with Simple Ring

Relays **ZLV-***-*****1*****, **ZLV-***-*****2***** and **ZLV-***-*****3***** have no Ethernet redundancy, so they are provided with 2 physical ports with separate IPs, thus separate configuration settings. They will have the following settings per adapter:

- IP Address.
- DHCP Enable.
- Default Gateway.
- Network Mask.
- DNS Address.

ZLV-*-*****0***** Model settings are described below.

- **Goose Channel** (**Ethernet Channel 1** - **Ethernet Channel 2**): it selects the Goose message transmission / reception channel in IEC-61850.
- **Input Gooses**. The following settings are available within each IED:
  - **Subscription data**:
    Input Goose (from **1** to **32**):
    - Goose ID (Up to 65 characters): Input Goose identifier.
    - Goose CB ref (Up to 64 characters).
    - MAC Address (00.00.00.00.00.00 - FF.FF.FF.FF.FF.FF): Ethernet card address.
    - AppID (0 – 16383).
  - **Connections with Logic Inputs**:
    Logic Input Goose (from **1** to **32**):
    - Associated Goose: Input Goose from 1 to 32.
    - Object number (0 - 1024).
  - **Output Goose**.
    Goose Out Enable (YES / NO): it enables output Gooses.
    Goose Out ID (up to 65 characters): output Goose identifier.
    MAC Address (01.0C.CD.01.00.00 - 01.0C.CD.01.01.FF).
    Priority (0 -1).
    VID (0 - 4095).
    App. ID (0 - 16383).
    Revision (0 - 999999999).
    First Retry Timer (1 - 100 ms).
    Retry Time Multiplier (1 - 100).
    Maximum Retry Time (0.1 - 30 s).

ZLV-*-*****2***** and **ZLV-***-*****3***** relays do not include most of these settings, as they are used for Gooses configuration, configuration file IEC 61850 (**CID**).

The following settings can still be defined:

- **Goose Channel** (**Channel Ethernet 1** - **Channel Ethernet 2**): selects Goose message transmission / reception channel according to IEC-61850.
- **Output Goose**.
  - **Goose Out Enable**(YES / NO): enables output Gooses.

Relays **ZLV-***-*****4***** count on Bonding type redundancy, whereby they have 2 physical ports with only one IP with only one set of setting:

- IP Address.
- DHCP Enable.
- Default Gateway.
- Network Mask.
- DNS Address.

Since there is no setting to configure the GOOSE send / receive channel, as it always occurs through the active adapter, it incorporates only the following setting:

- **Output Goose**.
  - **Goose Out Enable** (YES / NO): it enables output Gooses.

It also includes a setting to configure the medium switching time (from 25 to 1000 ms).

Models **ZLV-***-*****6** or higher implement different types of redundancy. They will have a setting to configure this mode of redundancy:

- If no redundancy is selected (**No Redundancy**), they will have 2 physical ports with separate IPs, thus, separate configuration settings. They will have the following settings per adapter:

○ IP Address.	○ Network Mask.
○ DHCP Enable.	○ DNS Address.
○ Default Gateway.	

The following settings can also be defined:

- ○ **Goose Channel** (**Channel Ethernet 1** - **Channel Ethernet 2**): selects Goose message transmission / reception channel according to IEC-61850.
- ○ **Output Goose**.
  - ▪ **Goose Out Enable**(YES / NO): enables output Gooses.

- If Bonding type redundancy is selected (**Bonding Redund.**), they will have 2 physical ports with only one IP and only one set of settings:

○ IP Address.	○ Network Mask.
○ DHCP Enable.	○ DNS Address.
○ Default Gateway.	

As there is no setting to configure the GOOSE send / receive channel, as it always is produced through the active adapter, they incorporate the following settings:

- ○ **Output Goose**.
  - ▪ **Goose Out Enable**(YES / NO): enables output Gooses.
- ○ **Channel Status Time Delay** (1 – 60 s): time without medium detection to indicate the channel is down.
- ○ **Link Check Interval** (25 – 500 ms): time to determine that no medium is available switching to the other adapter.

- If PRP type redundancy is selected (**PRP Redund.**), it will have 2 physical ports with only one IP and only one set of settings:

○ IP Address.	○ Network Mask.
○ DHCP Enable.	○ DNS Address.
○ Default Gateway.	

As there is no setting to configure the GOOSE send / receive channel, as it is always produced through both adapters, they have the following settings:

- ○ **Output Goose**.
  - ▪ **Goose Out Enable**(YES / NO): enables output Gooses.
- ○ **Channel Status Time Delay** (1 - 60 s): time without receiving frames to indicate that the channel is down.
- ○ **Transmission Time of Supervision Frames** (0 - 30000): send interval of PRP supervision frames.
- ○ **LSB of Supervision Frame Destination MAC Address** (0 - 255): last octet of the PRP supervision frame destination MAC (destination MAC address will be 01-15-4E-00-01-XX).

- In case of **RSTP** type redundancy, the relay will be provided with 2 physical ports with only one IP and with only one set of settings as for Bonding type redundancy. All settings related to the switch, VLANes, priorities, etc., will be available through the web server from the moment when the relay setting is selected as **RSTP** and the relay has been booted. In this way, access can be gained to the settings below through the web server:

  - ***Version***: operation with protocol RSTP or STP.
  - ***Bridge Priority***: node priority.
  - ***Max Age***, ***Hello Time***, ***Forward Delay***: timers of the protocol RSTP itself (seconds).
  - ***Tx Hold Count***: maximum burst of messages sent per second.
  - For each port:
    - ***Priority***: priority.
    - ***Cost***: link cost.
    - ***Edge*** (On, Off, Auto): port with a host connected to it.
    - ***PtP*** (On, Off, Auto): point to point.
    - ***Edge Tx Filter***: deletion of Tx in case of an Edge port.

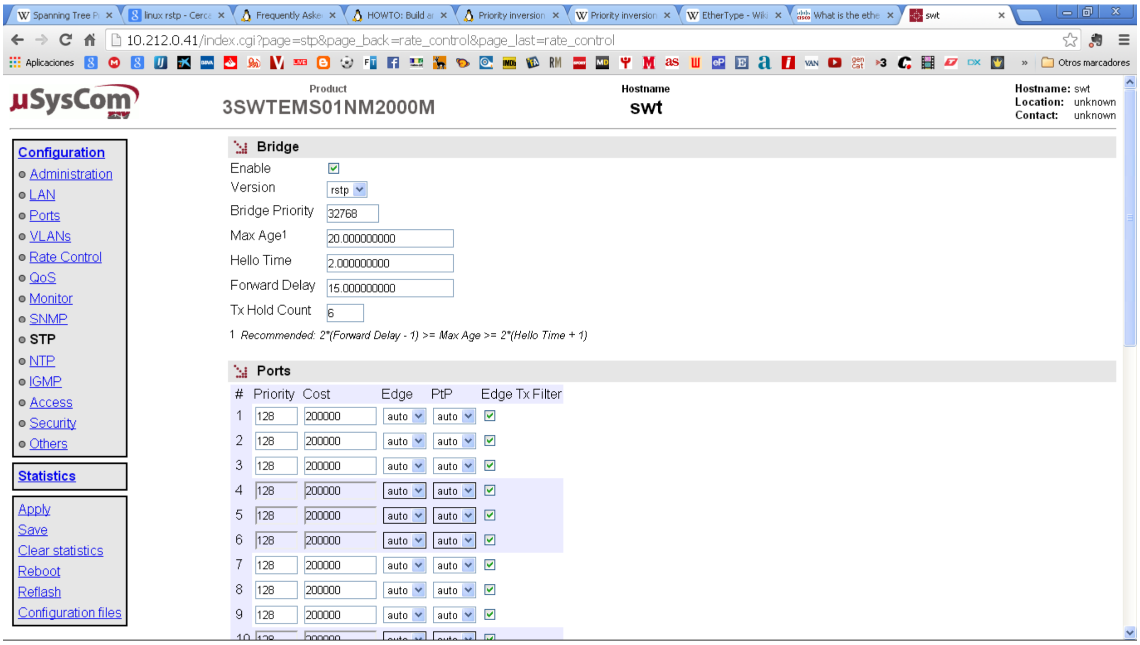


Figure 3.40.6 Image of the RSTP Settings available in the Web Server.

3.40.6.f FTP Access

The FTP access will allow having a number of equipment folders available. There will be different folders as a function of the user and password:

For IEC61850 versions previous tan the 7.7R, logging in as user: *info* and password: *info*, a directory structure similar to the one on the right will be displayed.

For IEC61850 versions equals or higher than the 7.7R the level of security has increased and a username and password to perform the loading of a CID and thus to change the control settings and protection settings will be necessary. In the same way, with the appropriate username and password, you can access to a directory in which you will only be able to copy a new CID (see Changing CID Configuration File section). For the user and password, please contact the manufacturer.

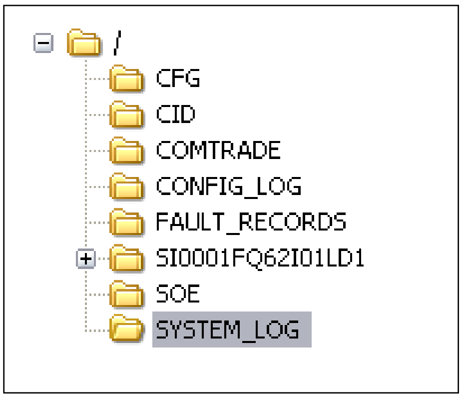


Figure 3.40.7 Directory Structure.

These are read-only folders and the information can be downloaded.

Directories will contain the same data provided by the web server: Boot data, active CID, oscillogram files, etc.

3.40.6.g CID Configuration File

The equipment includes a file (**CID**) in **IEC61850** standard format according to part 6 (SCL). This file allows knowing the equipment data model in node, data and attribute format.

Also, it allows to configure GOOSE message parameters, receive other GOOSES, create datasets and assign them to Reports, edit settings, change the control logic, descriptions, parameters, etc.

This file can be edited through a SCL file editing program, the ***ZiverCID***®.

This program allows configuring this file to be sent later to the equipment through FTP or USB port.

- **Loading the CID trough FTP**

In order to gain access to the equipment through FTP an FTP client program is required. The Windows browser itself allows making an FTP to the equipment address. For this, enter the equipment IP address in the Address bar in the following way:

For IEC61850 versions previous tan the 7.7R, the **CID** configured can be copied to the FTP root directory without entering user and password, as write access is gained only to the directory NotValidated. For IEC61850 versions higher than the 7.7R, the level of security has increased and a username and password to perform the action.

The equipment will validate the **CID**, that is, checks it is a correct SCL and the CID IP coincide with the IP configured in the equipment). After a certain version IEC61850 also checks that the IED matches the relay model that is within the CID.

Once it has been validated, the equipment carries out a backup and reboot process, rebooting communications and using a new **CID**. If the **CID** fails validation it will be rejected and deleted from the directory, and it will continue to operate in the normal way with the already loaded **CID** without ever losing communications.

If problems arise during loading the new **CID** (control reconfiguration process or loading protection settings), the relay will display a screen that will allow recovering the previous **CID** (refer to the errors section).

- **Loading the CID through USB by means of a Pendrive**

To load a new **CID** to the equipment through the HMI USB, an empty Pendrive is needed to copy the new CID to the root directory.

With the equipment fully booted and from the home screen, insert the Pendrive and wait for it to be detected.

Then confirmation to copy is requested.

COPY CID
_ZLVF4F104K.cid
CONFIRM COPY
YES NO

Confirm by pressing F1.

REMOVE PENDRIVE
COPY OK

When removing the Pendrive, the equipment will copy the **CID** to a temporary directory (NotValidated directory) where it will be validated (it will check it is a correct SCL and **CID** IP matches that of the equipment).

VALID CID
VALIDATE CID

For versions higher than the 7.7R the level of security has increased and a password to perform the loading of a new CID will be necessary.

Once it has been validated, the equipment carries out a backup and reboot process, rebooting communications and using the new **CID**. If the **CID** fails validation it will be rejected and deleted from the directory, and it will continue to operate in the normal way with the already loaded **CID** without ever losing communications.

If problems arise during loading the new **CID** (control reconfiguration process or loading protection settings), the relay will display a screen that will allow recovering the previous **CID** (refer to the errors section).

If the USB contains more files or directories apart from the **CID,** the relay will display the message below, refusing to load:

REMOVE PENDRIVE **ONLY ONE FILE IN**

- **Backup**

For a backup protection of the relay data, namely, obtaining the CID, logs, oscillograms and other data, the methods below can be used

- FTP with access as user: *info* and password: **info** (refer to FTP access section)
- Web server (refer to section)
- USB. With the relay booted and with no error messages displayed on the screen, insert an empty USB in the relay to automatically copy the active CID. Then, three screens will be displayed giving the user the option to download the rest of the data:

	COPY OSCILOS **CONFIRM COPY**	
YES		**NO**

	COPY REPORTS **CONFIRM COPY**	
YES		**NO**

	COPY SYSLOGS **CONFIRM COPY**	
YES		**NO**

- **CID Load by Frontal Port**

CID file can be also loaded by the frontal serial port of the IED using the configuration tool ***ZIV e-NET TOOL*** (available depending on model selection).

- **Errors**

During equipment configuration, actions may be carried out resulting in errors that can be identified and corrected.

- **Switching the equipment off during the process of CID write to a Flash memory**: during operation, the equipment writes the CID to Flash type non volatile memory.

  !WRITING CID!
  DO NOT POWER OFF

  If during this process, the equipment is switched off, it is likely that the CID copied to the Flash is lost. In this case, in the next boot up the type of message below will be displayed on the screen, **_ZLVF4F104K.CID** being the active **CID** file.

  IEC [6.0R]
  !ERROR!:[0100]
  _ZLVF4F104K.CID
  YES RESTORE CID? NO

  For a few seconds, it will be possible to recover the backup copy of the **CID** available in the equipment just before the settings were last changed. The equipment will offer the same option after an incomplete attempt to load a new **CID**.

  If F1 is pressed to recover the **CID**, the equipment will use this backup copy to boot up. If F4 or no key is pressed, the equipment will remain waiting for a new CID through any of the **CID** loading methods (FTP or USB).

- **In case of multiple undue shutdowns** (e.g. shutdown after CID recovery), the backup copy of the CID could also be lost. In this case the message on the right will be displayed, waiting for a new **CID** to be introduced by any of the **CID** loading methods (FTP or USB).

  IEC [6.0R]
  !ERROR!:[0100]
  -------.CID

- **100000 Alarm**. This means there is a problem with IEC61850 communications that does not affect the protection and control function.
  In this case, please contact the technical service to identify the nature of the failure.

  ZIV/ZLV
  [ALARMS:00100000]
  17/04/10 22:49:02

3.40.6.h Code Errors

- **HMI of the relay**

ERROR CODE	DESCRIPTION
0x00003010	General error generated while loading the Data Model of the relay. Reasons: the CID file does not match the relay model, the CID version does not match the FW version of the relay…
0x00003020	IDS does not match the relay model. Reason: the IEC 61850 FW relay model and version does not match the protection FW relay model and version.
0x00003060	Error in the GOOSE subscription configuration. Reason: there is any kind of error in the GIGGIO logical node (setRef or intAddr). Check the webser log, it indicates exactly where the problem is.
0x00003070	Error in RFC1006.CFG file. Reason: IEC 61850 FW error, this file belongs to the set of files of the FW and it is loaded to the relay when updating the FW.
0x00003080	Error in the interface version of the relay. Reason: IEC 61850 FW error.
0x00003011	Error when loading a new CID file. Reason: the control logic inside the CID file has any kind of error.
0x00003200	Error in IRQs of DPRAM. Reason: IEC 61850 and/or protection FW error.

- **Webserver**

TEXT	DESCRIPTION
ERROR_SUSGOOSE	Error in the GOOSE subscription configuration.
ERROR_CFGPERFIL	Error while loading the Data Model of the relay.
ERROR_CFGLOG	Error when asking for the information of the control logic which is loaded in the relay.
ERROR_MEMCFGLOG	Error when reserving memory for the control logic configuration.
ERROR_CFGLOGREAD	Error when reading the control logic nodes loaded.
ERROR_VER_PERFIL	Error in the compatibility of the profiles loaded.
ERROR_DB_REFNVL	Error in the generation of Data Sets.
ERROR_CFGERROR	Error while mapping the Data Model.
ERROR_CRC_PERFIL	Error in the CRC.
ERROR_OPENPERFIL	Error when opening the profile.
ERROR_RUN_SRVCOMPRESS	Error when executing the compression server.
ERROR_OPEN_CID	Error when opening or Reading the CID file.
ERROR_HEAD_CID	Error when reading the head of the CID file.
ERROR_IED_NAME_CID	Error when reading the IED name in the CID file.
ERROR_DATASET_ITEM_CID	Error when reading elements of a Data Set.
ERROR_RCB_CID	Error when reading the list of RCBs.
ERROR_GOOSE_ID_CID	Error when reading the elements of a GOOSE.
ERROR_READ_SP_CID	Error when reading the data of a SP.
ERROR_WRITE_SP_CID	Error when writing data of a SP.
ERROR_WRITE_PRM_REV_CID	Error when writing the ParamRev in the CID.
ERROR_ZLV_RD_CID	Error when reading protection settings.
ERROR_ZLV_WR_CID	Error when writing protection settings.
ERROR_HEAD_LOGICA	Error when reading data of the control logic from the CID.

TEXT	DESCRIPTION
ERROR_READ_CF_CID	Error when reading the CF values from CID.
ERROR_CACHE_CID	Error when generating the copy in RAM of the CID once uncompressed.
ERROR_CONNECT_AP_IP	Error when read in the IP address from CID.
ERROR_ATTR_IN_CID	There is one (or more) elements in one Data Set whose reference does not exist (it is located in no logical node).
ERROR_LCB_CID	Error when Reading data of LCB.
ERROR_CREATE_MAPLOG	Error when generating the MAPLOG.BIN file.
ERROR_READ_PRM_REV_CID	Error when Reading the ParamRev of the CID.
ERROR_GEN_LOG_CID	Error when generating the control logic.
ERROR_EXTRACT_LOG_CID	Error when extracting the files of the control logic.
ERROR_CONF_LOG_CID	Error in the control configuration loaded to the relay.
ERROR_APIXML_INIT	Error when initialization the XML library

3.40.6.i PROCOME, DNP3 and MODBUS Protocols on IEC-61850 Ports

ZLV--*******N** relays can communicate through LAN1 and LAN2 ports with IEC61850, PROCOME, MODBUS and DNP v3.0. TCP/IP ports for these communications links are allocated to the following values and cannot be configured:

- PROCOME: port 32001.
- MODBUS: port 502.
- DNP v3.0: port 20000.

This does not affect to the port selection for other physical ports (local port, remote ports 1-3).

ZLV--*******P** relays include five communications instances for other than IEC61850 protocols through LAN IEC61850 ports. One instance is always PROCOME (proprietary protocol) and the other four can be configured to communicate with DNP3.0 or MODBUS simultaneously (the same protocol can be selected for the four instances).

TCP/IP ports for these communications links will be configurable, except the proprietary protocol, PROCOME, which will have fixed TCP/IP port (32001).

This does not affect to the port selection for other physical ports (local port, remote ports 1-3).

3.40.7 CAN Communications Protocol

3.40.7.a Introduction

In view of the large number of signals acquired and controlled in power substations, remote real time device inputs and outputs must be connected via high speed serial communication protocols, so as to reduce the cost and simplify the hard wiring in the power substation environment.

The above is achieved through the communication of **ZIV** Master Relays with other Slave Relays using the CAN protocol, this way increasing the number of inputs and outputs available in **ZIV** Master Relays, said signals behaving as if they were internal to **ZIV** Master Relay.

3.40.7.b General Data

- **Physical Level**

Description	Value
Can Version	2.0b
Baud Rate	125 kbits
Bit Time	8 micro s
Maximum Distance	500 meters
Id Size	11 bits

When CAN 2.0b with 16 bit ID messages are transmitted the following bits corresponding to the extended CAN are sent:

- RTR to 1 (recessive).
- r0 to 1(recessive).
- r1 1 0(dominant).

All transmitted messages are acknowledged by writing one dominant bit of the first of the two recessive bits sent by the transmitter in the acknowledge field.

NRZ bits coding (Non-Return-to-Zero).

In data frames with 5 consecutive bits, a sixth bit with opposite sign is inserted.

CAN bus electrical characteristics are defined in ISO 11898.

- **Link Level**

It uses media access CSMA/CD+CR (Carrier Sense Multiple Access Collision Resolution).

- In Ethernet (CSMA), upon a collision, all messages are lost.
- In CAN (CSMA/CD+CR), upon a collision, the highest priority message survives (defined by dominant bits).

The state of a node can be Active, Passive or Cancelled as a function of errors detected.

- **Application Level**

The Application Layer uses an optimized protocol for power substation Protection and Control applications, with messages of 1 to 8 bytes.

Implemented protocol messages are used to achieve the following functions:

- **LOGIN Message**. Allows the **ZIV** Master Relay to know the availability of Slave Relays.
- **CHANGE Message**. Allows the **ZIV** Master Relay to receive spontaneously the state of Slave Relay inputs and outputs.
- **READ Message**. Allows the **ZIV** Master Relay to request the state of Slave Relay inputs and outputs.
- **TICK Message**. Allows the **ZIV** Master Relay to synchronize with Slave Relays.
- **DIGITAL OUTPUT WRITE Message**. Allows the **ZIV** Master Relay to send the state of digital outputs to Slave Relays.
- **SETTINGS WRITE Message**. Allows the **ZIV** Master Relay to send the Settings value to Slave Relays.

3.40.7.c Digital Inputs of the CAN Function

Table 3.40-2: Digital Inputs of the CAN Function

Name	Description	Function
RDO_1	Remote digital output 1	Activates said remote digital output in the CAN port.
RDO_2	Remote digital output 2	
RDO_3	Remote digital output 3	
RDO_4	Remote digital output 4	
RDO_5	Remote digital output 5	
RDO_6	Remote digital output 6	
RDO_7	Remote digital output 7	
RDO_8	Remote digital output 8	
RDO_9	Remote digital output 9	
RDO_10	Remote digital output 10	
RDO_11	Remote digital output 11	
RDO_12	Remote digital output 12	
RDO_13	Remote digital output 13	
RDO_14	Remote digital output 14	
RDO_15	Remote digital output 15	
RDO_16	Remote digital output 16	

3.40.7.d Auxiliary Outputs of the CAN Function

Table 3.40-3: Auxiliary Outputs of the CAN Function

Name	Description	Function
RIN_1	Remote digital input 1	Activates said remote digital input in the CAN port.
RIN_2	Remote digital input 2	
RIN_3	Remote digital input 3	
RIN_4	Remote digital input 4	
RIN_5	Remote digital input 5	
RIN_6	Remote digital input 6	
RIN_7	Remote digital input 7	
RIN_8	Remote digital input 8	
RIN_9	Remote digital input 9	
RIN_10	Remote digital input 10	
RIN_11	Remote digital input 11	
RIN_12	Remote digital input 12	
RIN_13	Remote digital input 13	
RIN_14	Remote digital input 14	
RIN_15	Remote digital input 15	
RIN_16	Remote digital input 16	
RIN_17	Remote digital input 17	
RIN_18	Remote digital input 18	
RIN_19	Remote digital input 19	
RIN_20	Remote digital input 20	
RIN_21	Remote digital input 21	
RIN_22	Remote digital input 22	
RIN_23	Remote digital input 23	

Table 3.40-3 Auxiliary Outputs of the CAN Function		
Name	**Description**	**Function**
RIN_24	Remote digital input 24	Activates said remote digital input in the CAN port.
RIN_25	Remote digital input 25	
RIN_26	Remote digital input 26	
RIN_27	Remote digital input 27	
RIN_28	Remote digital input 28	
RIN_29	Remote digital input 29	
RIN_30	Remote digital input 30	
RIN_31	Remote digital input 31	
RIN_32	Remote digital input 32	
VAL_RIN_1	Validity of remote digital input 1	Activates said validity of remote digital input.
VAL_RIN_2	Validity of remote digital input 2	
VAL_RIN_3	Validity of remote digital input 3	
VAL_RIN_4	Validity of remote digital input 4	
VAL_RIN_5	Validity of remote digital input 5	
VAL_RIN_6	Validity of remote digital input 6	
VAL_RIN_7	Validity of remote digital input 7	
VAL_RIN_8	Validity of remote digital input 8	
VAL_RIN_9	Validity of remote digital input 9	
VAL_RIN_10	Validity of remote digital input 10	
VAL_RIN_11	Validity of remote digital input 11	
VAL_RIN_12	Validity of remote digital input 12	
VAL_RIN_13	Validity of remote digital input 13	
VAL_RIN_14	Validity of remote digital input 14	
VAL_RIN_15	Validity of remote digital input 15	
VAL_RIN_16	Validity of remote digital input 16	
VAL_RIN_17	Validity of remote digital input 17	
VAL_RIN_18	Validity of remote digital input 18	
VAL_RIN_19	Validity of remote digital input 19	
VAL_RIN_20	Validity of remote digital input 20	
VAL_RIN_21	Validity of remote digital input 21	
VAL_RIN_22	Validity of remote digital input 22	
VAL_RIN_23	Validity of remote digital input 23	
VAL_RIN_24	Validity of remote digital input 24	
VAL_RIN_25	Validity of remote digital input 25	
VAL_RIN_26	Validity of remote digital input 26	
VAL_RIN_27	Validity of remote digital input 27	
VAL_RIN_28	Validity of remote digital input 28	
VAL_RIN_29	Validity of remote digital input 29	
VAL_RIN_30	Validity of remote digital input 30	
VAL_RIN_31	Validity of remote digital input 31	
VAL_RIN_32	Validity of remote digital input 32	

Table 3.40-3 Auxiliary Outputs of the CAN Function

Name	Description	Function
RDO_1	Remote digital output 1	Activates said remote digital output in the CAN port.
RDO_2	Remote digital output 2	
RDO_3	Remote digital output 3	
RDO_4	Remote digital output 4	
RDO_5	Remote digital output 5	
RDO_6	Remote digital output 6	
RDO_7	Remote digital output 7	
RDO_8	Remote digital output 8	
RDO_9	Remote digital output 9	
RDO_10	Remote digital output 10	
RDO_11	Remote digital output 11	
RDO_12	Remote digital output 12	
RDO_13	Remote digital output 13	
RDO_14	Remote digital output 14	
RDO_15	Remote digital output 15	
RDO_16	Remote digital output 16	

3.40.8 Virtual Inputs / Outputs

Virtual inputs / outputs function allows the bidirectional transmission of up to 16 digital signals and 16 analog magnitudes between two **ZLV** relays connected through a digital communications system. Said function allows programming logic functions of local and remote information whether analog or digital.

Among the main applications of virtual inputs / outputs is the optimizing of teleprotection schemes: they reduce digital signal transfer time between terminals, give more security in said transfer, allow exchanging a greater number of signals, etc.

The exchange of information between relays is made through frames sent every 2 ms, which include 16 digital signals and ½ analog magnitude. It is apparent that the transmission speed of the 16 digital signals is very high, as they are considered high priority signals; so that they can be used within teleprotection schemes.

The virtual inputs / outputs function allows detecting communication failure that generate errors in the frame contents (some of which are corrected by using a redundancy code) or errors in the frame reception sequence. The number of errors detected is recorded by a counter that resets after the **Error Detection Period** time setting. There is an input exists to reset this counter.

Depending on the model, relay rear ports Remote 1 and Remote 2 can be configured as virtual inputs / outputs ports. To this end, **Protocol Selection** setting of this port must be set to Virtual Inputs / Outputs.

Once the protocol Virtual Inputs / Outputs has been selected for one of the ports, the relay ignores all settings associated to said port shown in the Communications field, and only the settings introduced into the Inputs / Outputs field are considered as settings of the port selected as virtual.

Virtual inputs and outputs are configured exactly the same as for digital inputs and outputs, through the programmable logic incorporated into the ***ZivercomPlus***® program.

3.40.8.a Virtual Port 1

Virtual Port 1 settings:

- **Enable**: enables virtual inputs / outputs function for this port.
- **Baud Rate**: a value from 9600 to 115200 bauds can be selected, default value being 9600 bauds.
- **Error detection period**: time after which the communications error counter is reset.
- **Time Out**: time without receiving a complete frame before a communications error is generated.
- **CTS flow** (NO / YES): it specifies whether the Clear to Send signal is monitored for data transmission flow control. If it set to YES and the CTS signal falls to “0”, the transmission is interrupted until the CTS signal is reset.
- **DSR flow** (NO / YES): it specifies whether the Data Set Ready signal is monitored for data transmission flow control. If it set to YES and the DSR signal falls to “0”, the transmission is interrupted until the DSR signal is reset.
- **DSR Sensitive** (NO / YES): it specifies whether the communications port is sensitive to DSR signal state. If it is set to YES, the communications driver ignores any bit received unless the DSR line is active.
- **DTR Control** (Inactive/ Active/ Enable Send):
  Inactive: sets DTR control signal to permanent inactive state.
  Active: sets DTR control signal to permanent active state.
  Enable Send: DTR signal remains enabled while receiving new characters is allowed.
- **DTR Control** (INACTIVE / ACTIVE / ENABLE SEND):
  Inactive: It sets the DTR control signal to permanently inactive.
  Active: It sets the DTR control signal to permanently active.
  Enable Send: The DTR signal remains active as long as the receiving of new characters is allowed.
- **RTS Control** (INACTIVE / ACTIVE / ENABLE SEND / SOL. SEND):
  Inactive: It sets the RTS control signal to permanently inactive.
  Active: It sets the RTS control signal to permanently active.
  Enable Send: The RTS signal remains active as long as the receiving of new characters is allowed.
  Solicit Send: The RTS signal remains active as long as there are characters pending transmission.

3.40.8.b Virtual Port 2

Virtual port 2 settings:

- **Enable**: enables virtual inputs / outputs function for this port.
- **Baud Rate**: a value from 9600 to 115200 bauds can be selected, default value being 9600 bauds.
- **Error Detection Period**: time after which the communications error counter is reset.
- **Time Out**: time without receiving a complete frame before a communications error is generated.

3.40.8.c Virtual Measurements

Virtual magnitudes corresponding to rear ports Remote 1 and Remote 2 can also be configured in the Inputs / Outputs field, and any of the magnitudes calculated by the relay can be selected, including the magnitudes calculated into the programmable logic through the ***ZivercomPlus***® program.

3.40.8.d Digital Inputs of the Virtual Inputs / Outputs Function

Table 3.40-4: Digital Inputs of the Virtual Inputs / Outputs Function		
Name	**Description**	**Function**
RST_CO_ERR1	Error counter 1 reset	Activation of this input resets the communications error counter associated to port 1.
RST_CO_ERR2	Error counter 2 reset	Activation of this input resets the communications error counter associated to port 2.
OUT_VIR1_1	Virtual digital output_1 1	Activates said virtual digital output of port 1.
OUT_VIR1_2	Virtual digital output_1 2	
OUT_VIR1_3	Virtual digital output_1 3	
OUT_VIR1_4	Virtual digital output_1 4	
OUT_VIR1_5	Virtual digital output_1 5	
OUT_VIR1_6	Virtual digital output_1 6	
OUT_VIR1_7	Virtual digital output_1 7	
OUT_VIR1_8	Virtual digital output_1 8	
OUT_VIR1_9	Virtual digital output_1 9	
OUT_VIR1_10	Virtual digital output_1 10	
OUT_VIR1_11	Virtual digital output_1 11	
OUT_VIR1_12	Virtual digital output_1 12	
OUT_VIR1_13	Virtual digital output_1 13	
OUT_VIR1_14	Virtual digital output_1 14	
OUT_VIR1_15	Virtual digital output_1 15	
OUT_VIR1_16	Virtual digital output_1 16	
OUT_VIR2_1	Virtual digital output_2 1	Activates said virtual digital output of port 2.
OUT_VIR2_2	Virtual digital output_2 2	
OUT_VIR2_3	Virtual digital output_2 3	
OUT_VIR2_4	Virtual digital output_2 4	
OUT_VIR2_5	Virtual digital output_2 5	
OUT_VIR2_6	Virtual digital output_2 6	
OUT_VIR2_7	Virtual digital output_2 7	
OUT_VIR2_8	Virtual digital output_2 8	
OUT_VIR2_9	Virtual digital output_2 9	
OUT_VIR2_10	Virtual digital output_2 10	
OUT_VIR2_11	Virtual digital output_2 11	
OUT_VIR2_12	Virtual digital output_2 12	
OUT_VIR2_13	Virtual digital output_2 13	
OUT_VIR2_14	Virtual digital output_2 14	
OUT_VIR2_15	Virtual digital output_2 15	
OUT_VIR2_16	Virtual digital output_2 16	

3.40.8.e Auxiliary Outputs of the Virtual Inputs / Outputs Function

Table 3.40-5: Auxiliary Outputs of the Virtual Inputs / Outputs Function

Name	Description	Function
VAL_DI1	Validity of virtual digital inputs 1	
VAL_AI1	Validity of virtual analog inputs 1	
VAL_DI2	Validity of virtual digital inputs 2	
VAL_AI2	Validity of virtual analog inputs 2	
IN_VIR1_1	Virtual Digital Input_1 1	Shows that said virtual input of port 1 is activated.
IN_VIR1_2	Virtual Digital Input_1 2	
IN_VIR1_3	Virtual Digital Input_1 3	
IN_VIR1_4	Virtual Digital Input_1 4	
IN_VIR1_5	Virtual Digital Input_1 5	
IN_VIR1_6	Virtual Digital Input_1 6	
IN_VIR1_7	Virtual Digital Input_1 7	
IN_VIR1_8	Virtual Digital Input_1 8	
IN_VIR1_9	Virtual Digital Input_1 9	
IN_VIR1_10	Virtual Digital Input_1 10	
IN_VIR1_11	Virtual Digital Input_1 11	
IN_VIR1_12	Virtual Digital Input_1 12	
IN_VIR1_13	Virtual Digital Input_1 13	
IN_VIR1_14	Virtual Digital Input_1 14	
IN_VIR1_15	Virtual Digital Input_1 15	
IN_VIR1_16	Virtual Digital Input_1 16	
IN_VIR2_1	Virtual Digital Input_2 1	Shows that said virtual input of port 2 is activated.
IN_VIR2_2	Virtual Digital Input_2 2	
IN_VIR2_3	Virtual Digital Input_2 3	
IN_VIR2_4	Virtual Digital Input_2 4	
IN_VIR2_5	Virtual Digital Input_2 5	
IN_VIR2_6	Virtual Digital Input_2 6	
IN_VIR2_7	Virtual Digital Input_2 7	
IN_VIR2_8	Virtual Digital Input_2 8	
IN_VIR2_9	Virtual Digital Input_2 9	
IN_VIR2_10	Virtual Digital Input_2 10	
IN_VIR2_11	Virtual Digital Input_2 11	
IN_VIR2_12	Virtual Digital Input_2 12	
IN_VIR2_13	Virtual Digital Input_2 13	
IN_VIR2_14	Virtual Digital Input_2 14	
IN_VIR2_15	Virtual Digital Input_2 15	
IN_VIR2_16	Virtual Digital Input_2 16	

Table 3.40-5 Auxiliary Outputs of the Virtual Inputs / Outputs Function

Name	Description	Function
OUT_VIR1_1	Virtual digital output_1 1	Activates said virtual digital output of port 1.
OUT_VIR1_2	Virtual digital output_1 2	
OUT_VIR1_3	Virtual digital output_1 3	
OUT_VIR1_4	Virtual digital output_1 4	
OUT_VIR1_5	Virtual digital output_1 5	
OUT_VIR1_6	Virtual digital output_1 6	
OUT_VIR1_7	Virtual digital output_1 7	
OUT_VIR1_8	Virtual digital output_1 8	
OUT_VIR1_9	Virtual digital output_1 9	
OUT_VIR1_10	Virtual digital output_1 10	
OUT_VIR1_11	Virtual digital output_1 11	
OUT_VIR1_12	Virtual digital output_1 12	
OUT_VIR1_13	Virtual digital output_1 13	
OUT_VIR1_14	Virtual digital output_1 14	
OUT_VIR1_15	Virtual digital output_1 15	
OUT_VIR1_16	Virtual digital output_1 16	
OUT_VIR2_1	Virtual digital output_2 1	Activates said virtual digital output of port 2.
OUT_VIR2_2	Virtual digital output_2 2	
OUT_VIR2_3	Virtual digital output_2 3	
OUT_VIR2_4	Virtual digital output_2 4	
OUT_VIR2_5	Virtual digital output_2 5	
OUT_VIR2_6	Virtual digital output_2 6	
OUT_VIR2_7	Virtual digital output_2 7	
OUT_VIR2_8	Virtual digital output_2 8	
OUT_VIR2_9	Virtual digital output_2 9	
OUT_VIR2_10	Virtual digital output_2 10	
OUT_VIR2_11	Virtual digital output_2 11	
OUT_VIR2_12	Virtual digital output_2 12	
OUT_VIR2_13	Virtual digital output_2 13	
OUT_VIR2_14	Virtual digital output_2 14	
OUT_VIR2_15	Virtual digital output_2 15	
OUT_VIR2_16	Virtual digital output_2 16	

3.40.8.f Magnitudes of the Virtual Inputs / Outputs Function

Table 3.40-6: Magnitudes of the Virtual Inputs / Outputs Function

Name	Description	Units
MV1 01	Virtual Quantity 1 for communication channel 1	Depend on the magnitude configurated
MV2 01	Virtual Quantity 2 for communication channel 1	Depend on the magnitude configurated
MV1 03	Virtual Quantity for communication channel 1	Depend on the magnitude configurated
MV1 04	Virtual Quantity 4 for communication channel 1	Depend on the magnitude configurated
MV1 05	Virtual Quantity 5 for communication channel 1	Depend on the magnitude configurated
MV1 06	Virtual Quantity 6 for communication channel 1	Depend on the magnitude configurated
MV1 07	Virtual Quantity 7 for communication channel 1	Depend on the magnitude configurated
MV1 08	Virtual Quantity for communication channel 1	Depend on the magnitude configurated
MV1 09	Virtual Quantity 9 for communication channel 1	Depend on the magnitude configurated
MV1 10	Virtual Quantity 10 for communication channel 1	Depend on the magnitude configurated
MV1 11	Virtual Quantity 11 for communication channel 1	Depend on the magnitude configurated
MV1 12	Virtual Quantity 12 for communication channel 1	Depend on the magnitude configurated
MV1 13	Virtual Quantity 13 for communication channel 1	Depend on the magnitude configurated
MV1 14	Virtual Quantity 14 for communication channel 1	Depend on the magnitude configurated
MV1 15	Virtual Quantity 15 for communication channel 1	Depend on the magnitude configurated
MV1 16	Virtual Quantity 16 for communication channel 1	Depend on the magnitude configurated
MV2 01	Virtual Quantity 1 for communication channel 2	Depend on the magnitude configurated
MV2 01	Virtual Quantity 2 for communication channel 2	Depend on the magnitude configurated
MV2 03	Virtual Quantity 3 for communication channel 2	Depend on the magnitude configurated
MV2 04	Virtual Quantity 4 for communication channel 2	Depend on the magnitude configurated
MV2 05	Virtual Quantity 5 for communication channel 2	Depend on the magnitude configurated
MV2 06	Virtual Quantity 6 for communication channel 2	Depend on the magnitude configurated
MV2 07	Virtual Quantity 7 for communication channel 2	Depend on the magnitude configurated
MV2 08	Virtual Quantity 8 for communication channel 2	Depend on the magnitude configurated
MV2 09	Virtual Quantity 9 for communication channel 2	Depend on the magnitude configurated

Table 3.40-6 Magnitudes of the Virtual Inputs / Outputs Function

Name	Description	Units
MV2 10	Virtual Quantity 10 for communication channel 2	Depend on the magnitude configurated
MV2 11	Virtual Quantity 11 for communication channel 2	Depend on the magnitude configurated
MV2 12	Virtual Quantity 12 for communication channel 2	Depend on the magnitude configurated
MV2 13	Virtual Quantity 13 for communication channel 2	Depend on the magnitude configurated
MV2 14	Virtual Quantity 14 for communication channel 2	Depend on the magnitude configurated
MV2 15	Virtual Quantity 15 for communication channel 2	Depend on the magnitude configurated
MV2 16	Virtual Quantity 16 for communication channel 2	Depend on the magnitude configurated
N E FA 1	Cumulative number of fatal errors detected in analog frame in communication channel 1	
N E FA 2	Cumulative number of fatal errors detected in analog frame in communication channel 2	
N E FD 1	Cumulative number of fatal errors in communication channel 1	
N E FD 2	Cumulative number of fatal errors in communication channel 2	
N ERR C 1	Cumulative number of fatal errors detected and repaired in communication channel 1	
N ERR C 2	Cumulative number of fatal errors detected and repaired in communication channel 2	
ACUM ERR 1	Cumulative number of fatal errors detected in the last N seconds in communication channel 1	
ACUM ERR 2	Cumulative number of fatal errors detected in the last N seconds in communication channel 2	
T SIN ACT 1	Time without activity in communication channel 1	
T SIN ACT 2	Time without activity in communication channel 2	

3.40.9 Communications Settings

Local Port Communications			
Setting	**Range**	**Step**	**Default**
Baud Rate	300 - 38400 Baud		38400
Stop Bits	1 - 2		1
Parity	0: None 1: Even		0: None
RX Time Between Character	1 - 60000 ms	0.5 ms	40 ms
Communication Failure Indication Time	0 - 600 s	0.1 s	60 s

Remote Communications Port 1			
Setting	**Range**	**Step**	**Default**
Protocol Selection	0: PROCOME 1: DNP 3.0 2: MODBUS		0: PROCOME
Baud Rate	300 - 38400 Baud		38400 Baud
Stop Bits	1 - 2		1
Parity	0: None 1: Even 2: Odd		0: None
RX Time between Character	1 - 60000 ms	0.5 ms	40 ms
Communication Failure Indication Time	0 - 600 s	0.1 s	60 s
Advanced Settings			
Flow Control			
CTS Flow	0 (NO) - 1 (YES)		NO
DSR Flow	0 (NO) - 1 (YES)		NO
DSR Sensitive	0 (NO) - 1 (YES)		NO
DTR Control	0: Inactive 1: Active 2: Permit send		0: Inactive
RTS Control	0: Inactive 1: Active 2: Permit send 3: Solicit send		0: Inactive
Time			
Tx Time Factor	0 -100 characters	0.5	1
Tx Time Constant	0 - 60000 ms	1 ms	0 ms
Message Modification			
Number of Zeros	0 - 255	1	0
Collisions			
Type of Collision	0: NO 1: DCD 2: ECO		NO
Number of Retries	0 - 3	1	0
Minimum Retry Time	0 - 60000 ms	1 ms	0 ms
Maximum Retry Time	0 - 60000 ms	1 ms	0 ms

Remote Communications Port 2			
Setting	**Range**	**Step**	**Default**
Protocol Selection	0: Procome 1: DNP V3.0 2: Modbus		0: Procome
Baud Rate	300 - 38400 Baud		38400 Baud
Stop Bits	1 - 2		1
Parity	0: None 1: Even 2: Odd		0: None
RX Time Between Character	1 - 60000 ms	0.5 ms	40 ms
Communication Failure Indication Time	0 - 600 s	0.1 s	60 s
Advanced Settings			
Operation Mode	0: RS232 1: RS485		0: RS232
Time			
Tx Time Factor	0 -100 characters	0.5	1
Tx Time Constant	0 - 60000 ms	1 ms	0 ms
Number of 485 Stop Bytes	0 - 4 bytes	1 byte	0 bytes
Message Modification			
Number of Zeros	0 - 255	1	0
Collisions			
Type of Collision	0: NO 1: ECO		0: NO
Number of Retries	0 - 3	1	0
Minimum Retry Time	0 - 60000 ms	1 ms	0 ms
Maximum Retry Time	0 - 60000 ms	1 ms	0 ms

Remote Communications Ports 1, 2 and 3 Ethernet			
Setting	**Range**	**Step**	**Default**
Protocol Selection	PROCOME DNP 3.0 MODBUS Virtual Inputs / Outputs (*)		PROCOME
Enabling the Ethernet Port	NO / YES		YES
IP Address	ddd. ddd. ddd. ddd		192.168.1.151(PR1) 192.168.1.61(PR2) 192.168.1.71(PR3)
Net Mask	128.000.000.000 - 255.255.255.254		255.255.255.0
Port Number	0 - 65535	1	20000
Max. Time between Messages TCP	0 - 65 s	1	30
RX Car. Time	0 - 60000 ms	0.5 ms	1 ms
Communication fault indication time	0 - 600 s	0.1 s	60 s

(*) The Virtual Inputs / Outputs function is only for the Remote Port 2.

Communications Protocols			
Setting	**Range**	**Step**	**Default**
PROCOME Protocol			
IED Address	0 - 254	1	0
Communications Password Enable	YES / NO		NO
Communications Password Timeout	1 - 10 min	1	10 min
Communications Password	8 characters		
DNP 3.0 Protocol			
IED Address	0 - 65519	1	1
T. Confirm Timeout	100 - 65535 ms	1	1000 ms
Max. Retries	0 - 65535	1	0
Enable Unsolicited	YES / NO		NO
Unsolicited Start Enable	YES / NO		
Unsolic. Master No.	0 - 65519	1	1
Unsolic. Grouping Time.	100 - 65535 ms	1	1000 ms
Sync Interval	0 - 120 min	1	0 min
Unsolicited Start Activation	YES / NO		
DNP 3.0 Revision	Standard ZIV / 2003		
DNP 3.0 Protocol: Measurements (16 Deadband Measurements Change)	0.01 - 100	0.01	100
DNP 3.0 Profile II Protocol: Measurements (16 Deadband Measurements Change)	0.0001 - 100	0.0001	100
Digital Changes Class (DNP 3.0 Profile II and Profile II Ethernet)	CLASS 1 CLASS 2 CLASS 3 NONE		CLASS 1
Analog Changes Class (DNP 3.0 Profile II and Profile II Ethernet)	CLASS 1 CLASS 2 CLASS 3 NONE		CLASS 2
Counters Changes Class (DNP 3.0 Profile II and Profile II Ethernet)	CLASS 1 CLASS 2 CLASS 3 NONE		CLASS 3
Validity Status for Digital Inputs (DNP 3.0 Profile II and Profile II Ethernet)	YES / NO		YES
32 Bits Measurements (DNP 3.0 Profile II and Profile II Ethernet)	YES / NO		YES
Counters (max. 20) (DNP 3.0 Profile II and Profile II Ethernet)	1 - 32767	1	1
MODBUS Protocol			
IED Address	0 - 247	1	1

Communications Protocols			
Setting	**Range**	**Step**	**Default**
IEC-61850 Protocol			
Goose Channel	Ethernet Channel 1 Ethernet Channel 2		Ethernet Channel 1
Input Gooses			
Subscription data			
Input Goose (from 1 to 32)			
Goose ID	Up to 65 characters		
Goose CB ref	Up to 64 characters		
MAC Address	00.00.00.00.00.00 – FF.FF.FF.FF.FF.FF		00.00.00.00.00.00
AppID	0 - 16383	1	0
Connections with Virtual Input Gooses			
Virtual Input Goose (from 1 to 32):			
Associated Goose	Input Goose from 1 to 32		
Object number	0 - 1024	1	0
Output Goose			
Goose Out Enable	YES / NO		
Goose Out ID	Up to 65 characters		
MAC Address	01.0C.CD.01.00.00 - 01.0C.CD.01.01.FF		01.0C.CD.01.00.C1
Priority	0 - 1	1	0
VID	0 - 4095	1	0
App. D	0 - 16383	1	0
Revision	0 - 999999999	1	0
First Retry Timer	1 - 100 ms	1	4
Retry Time Multiplier	1 - 100	1	2
Maximum Retry Time	0.1 - 30 sc	0.01	10
IP			
IP Address	ddd.ddd.ddd.ddd		
DHCP Enable	YES / NO		YES
Default Gateway	ddd.ddd.ddd.ddd		
Network Mask	ddd.ddd.ddd.ddd		
DNS Address	ddd.ddd.ddd.ddd		

Communications Protocols			
Setting	**Range**	**Step**	**Default**
IEC-61850 Protocol			
SNTP			
SNTP enable	YES / NO		NO
Broadcast Synchronizing Enable	YES / NO		NO
Unicast Synchronizing Enable	YES / NO		NO
IP Address of Main SNTP Server	Ddd.Ddd.Ddd.Ddd		
IP Address of Secondary SNTP Server	Ddd.Ddd.Ddd.Ddd		
Time Delay of Unicast Validation	10 - 1000000 S	1 S	30 S
Time Delay of Unicast Error	10 - 1000000 S	1 S	30 S
Number of Connection Retries	1 - 10	1	3
Synchronizing Period	10 - 1000000 S	1 S	10 S
Period between Retries	10 - 1000000 S	1 S	10 S
Time Delay of Broadcast Validation	0 - 1000000 S	1 S	0 S
Time Delay of Broadcast Error	0 - 1000000 S	1 S	0 S
Maximum Synchronizing Time Difference	0 - 1000000 S	1 S	0 S
Ignore Synchronizing Leap Indicator	YES / NO		NO
Calculation of Synchronizing Status	Time delay Leap Indicator		Time delay
Ethernet			
Redundancy Mode	No Redundancy Bondng Redund. PRP Redund. RSTP Redund.		No Redundancy
Channel Status Time	1 - 60 s	1 s	5 s
Bonding			
Link Check Interval	25 - 500 ms	25 ms	100 ms
PRP			
Supervision Frame Send Interval	0 - 30000 ms	500 ms	2000 ms
LSB of Destination MAC for Supervision Frames	0 - 255	1	0

- **Communications: HMI Access**

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - PORTS**
1 - OPERATIONS	1 - PASSWORDS	**1 - PROTOCOLS**
2 - CHANGE SETTINGS	**2 - COMMUNICATIONS**	
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	
	5 - HMI DIAGRAM CONF.	

Ports / Local Port

0 - PORTS	**0 - LOCAL PORT**	**0 - BAUDRATE**
1 - PROTOCOLS	1 - REMOTE PORT 1	**1 - STOP BITS**
	2 - REMOTE PORT 2	**2 - PARITY**
	3 - REMOTE PORT 3	**3 - RX TIME BTW. CHAR**
	4 - IRIG-B	**4 - COMMS FAIL IND. TIME**

Ports / Remote Port 1

0 - PORTS	0 - LOCAL PORT	**0 - PROTOCOL SELECT.**
1 - PROTOCOLS	**1 - REMOTE PORT 1**	**1 - BAUDRATE**
	2 - REMOTE PORT 2	**2 - STOP BITS**
	3 - REMOTE PORT 3	**3 - PARITY**
	4 - IRIG-B	**4 - RX TIME BTW. CHAR**
		5 - COMMS FAIL IND. TIME
		6 - ADVANCED SETTINGS

0 - PROTOCOL SELECT.	
1 - BAUDRATE	
2 - STOP BITS	
3 - PARITY	**0 - FLOW CONTROL**
4 - RX TIME BTW. CHAR	**1 - TIME**
5 - COMMS FAIL IND. TIME	**2 - MESSAGE MODIF.**
6 - ADVANCED SETTINGS	**3 - COLLITIONS**

Remote Port 2

0 - PORTS	0 - LOCAL PORT	**0 - PROTOCOL SELECT.**
1 - PROTOCOLS	1 - REMOTE PORT 1	**1 - BAUDRATE**
	2 - REMOTE PORT 2	**2 - STOP BITS**
		3 - PARITY
		4 - RX TIME BTW. CHAR
		5 - COMMS FAIL IND. TIME
		6 - STOP BYTES 485
		7 - ADVANCED SETTINGS

0 - PROTOCOL SELECT.	
1 - BAUDRATE	
2 - STOP BITS	
3 - PARITY	**0- FLOW CONTROL**
4 - RX TIME BTW. CHAR	**1 - OPERATING MOD**
5 - COMMS FAIL IND. TIME	**2 - TIME**
6 - STOP BYTES 485	**3 - MESSAGE MODIF.**
7 - ADVANCED SETTINGS	**4 - COLLITIONS**

Ports / Remotes Ports 1, 2 and 3 Ethernet

0 - PORTS	0 - LOCAL PORT	**0 - PROTOCOL SELECT.**
1 - PROTOCOLS	**1 - REMOTE PORT 1**	**1 - UART**
	2 - REMOTE PORT 2	**2 - ETHERNET**
	3 - REMOTE PORT 3	
	4 - IRIG-B	

0 - PROTOCOL SELECT.	**0 - BAUDRATE**
1 - UART	**1 - STOP BITS**
2 - ETHERNET	**2 - PARITY**
	3 - RX TIME BTW. CHAR
	4 - COMMS FAIL IND. TIME
	5 - ADVANCED SETTINGS

0 - BAUDRATE	
1 - STOP BITS	
2 - PARITY	**0 - FLOW CONTROL**
3 - RX TIME BTW CHAR	**1 - TIME**
4 - COMMS FAIL IND. TIME	**2 - MESSAGE MODIF.**
5 - ADVANCED SETTINGS	**3 - COLLITIONS**

0 - PROTOCOL SELECT.	**0 - ENAB. ETHERNET PORT**
1 - UART	**1 - IP ADDRESS**
2 - ETHERNET	**2 - NET MASK**
	3 - PORT NUMBER
	4 - MAX. TIME TCP MESSAG
	5 - RX CAR. TIME
	6 - TPO. IND. FALLO COMS

Protocols / Procome Protocol

0 - PORTS	**0 - PROCOME PROTOCOL**	**0 - UNIT NUMBER**
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	**1 - COMMS PASSW. ENABLE**
	2 - MODBUS PROTOCOL	**2 - COMMS PASSW. TIMEOUT**
	3 - IEC 61850	**3 - COMMS PASSW.**
	4 - TCP/IP	

Protocols / DNP 3.0 Protocol

0 - PORTS	0 - PROCOME PROTOCOL	**0 - RELAY NUMBER**
1 - PROTOCOLS	**1 - DNP 3.0 PROTOCOL**	**1 - T. CONFIRM TIMEOUT**
	2 - MODBUS PROTOCOL	**2 - MAX RETRIES**
	3 - IEC 61850	**3 - HAB. UNSOLICITED**
	4 - TCP/IP	**4 - UNSOL. PICKUP ACT.**
		5 - UNSOLIC. MASTER NO.
		6 - UNSOL. GROUPING TIME
		7 - SYNCR. INTERVAL
		8 - REV DNP 3.0
		9 - MEASURES

Protocols / DNP 3.0 Protocol (Profile II and Profile II Ethernet)

0 - PORTS	0 - PROCOME PROTOCOL	**0 - RELAY NUMBER**
1 - PROTOCOLS	**1 - DNP 3.0 PROTOCOL**	**1 - T. CONFIRM TIMEOUT**
	2 - MODBUS PROTOCOL	**2 - MAX RETRIES**
	3 - IEC 61850	**3 - HAB. UNSOLICITED**
	4 - TCP/IP	**4 - UNSOL. PICKUP ACT.**
		5 - UNSOLIC. MASTER NO.
		6 - UNSOL. GROUPING TIME
		7 - SYNCR. INTERVAL
		8 - REV DNP 3.0
		9 - DIGITAL CHANGES CLASS
		10 - ANAL. CHANGES CLASS
		11 - COUN. CHANGES CLASS
		12 - STATUS VALIDEZ ED
		13 - MEASURES 32 BITS
		14 - MEASURES
		15 - COUNTERS

Protocols / Modbus Protocol

0 - PORTS	0 - PROCOME PROTOCOL	
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	
	2 - MODBUS PROTOCOL	**0 - UNIT NUMBER**
	3 - IEC 61850	
	4 - TCP/IP	

Protocols / IEC 61850 Protocol

0 - PORTS	0 - PROCOME PROTOCOL	
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	
	2 - MODBUS PROTOCOL	**0 - GOOSE CHANNEL**
	3 - IEC 61850	**1 - ENBLGOOSEOUT**
	4 - TCP/IP	

Protocols / TCP/IP Protocol

0 - PORTS	0 - PROCOME PROTOCOL	
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	
	2 - MODBUS PROTOCOL	**0 - LAN 1**
	3 - IEC 61850	**1 - LAN 2**
	4 - TCP/IP	**2 - SNTP**

0 - PROCOME PROTOCOL		**0 - IP ADDRESS**
1 - DNP 3.0 PROTOCOL		**1 - ENABLE DHCP**
2 - MODBUS PROTOCOL	**0 - LAN 1**	**2 - DEFAULT GATEWAY**
3 - IEC 61850	**1 - LAN 2**	**3 - NETWORK MASK**
4 - TCP/IP	2 - SNTP	**4 - DNS ADDRESS**

0 - PROCOME PROTOCOL		**0 - ENABLESNTP**
1 - DNP 3.0 PROTOCOL		**1 - ENBL_BROADCASTSNTP**
2 - MODBUS PROTOCOL	0 - LAN 1	**2 - ENBL_UNICASTSNTP**
3 - IEC 61850	1 - LAN 2	**3 - MAINSNTPSRV**
4 - TCP/IP	**2 - SNTP**	**4 - BACKUPSNTPSRV**
		5 - UNICAST VALID TIME
		6 - UNICAST ERROR TIME
		7 - RETRY ATTEMPTS
		8 - SYNC PERIOD
		9 - RETRY PERIOD
		10 - BRDCST VALID TIME
		11 - BRDCST ERROR TIME
		12 - MAX TIME DIF
		13 - SNTP_IGNORELEAPIND
		14 - SNTP_SYNCSTATECALC

Protocols / IEC 61850 Protocol (ZLV-***-*****6)

0 - PORTS	0 - PROCOME PROTOCOL	**0 - ETHERNET**
1 - PROTOCOLS	1 - DNP 3.0 PROTOCOL	**1 - IP**
	2 - MODBUS PROTOCOL	**2 - GOOSE**
	3 - IEC 61850	**3 - SNTP**

0 - ETHERNET	**0 - REDUNDANCY MODE**
1 - IP	**1 - CHANNEL LIVE TIME**
2 - GOOSE	**2 - BONDING**
3 - SNTP	**3 - PRP**

0 - ETHERNET	0 - REDUNDANCY MODE	
1 - IP	1 - CHANNEL LIVE TIME	
2 - GOOSE	**2 - BONDING**	**0 - LINK CHK INTERVAL**
3 - SNTP	3 - PRP	

0 - ETHERNET	0 - REDUNDANCY MODE	
1 - IP	1 - CHANNEL LIVE TIME	
2 - GOOSE	2 - BONDING	**0 - SUPERV TX INTERVAL**
3 - SNTP	**3 - PRP**	**1 - SUP LSB DEST MAC**

0 - ETHERNET		**0 - IP ADDRESS**
1 - IP	**0 - LAN 1**	**1 - ENABLE DHCP**
2 - GOOSE	**1 - LAN 2**	**2 - DEFAULT GATEWAY**
3 - SNTP		**3 - NETWORK MASK**
		4 - DNS ADDRESS

0 - ETHERNET	
1 - IP	**0 - GOOSE CHANNEL**
2 - GOOSE	**1 - ENBLGOOSEOUT**
3 - SNTP	

0 - ETHERNET	**0 - ENABLESNTP**
1 - IP	**1 - ENBL_BROADCASTSNTP**
2 - GOOSE	**2 - ENBL_UNICASTSNTP**
3 - SNTP	**3 - MAINSNTPSRV**
	4 - BACKUPSNTPSRV
	5 - UNICAST VALID TIME
	6 - UNICAST ERROR TIME
	7 - RETRY ATTEMPTS
	8 - SYNC PERIOD
	9 - RETRY PERIOD
	10 - BRDCST VALID TIME
	11 - BRDCST ERROR TIME
	12 - MAX TIME DIF
	13 - SNTP_IGNORELEAPIND
	14 - SNTP_SYNCSTATECALC

3.40.10 Outputs and Events of the Communications Module (ZLV-***-*****6)

Table 3.40-7: Outputs and Events of the Communications Module (ZLV-***-*****6)		
Name	**Description**	**Function**
RESET REQ	Reset Required for Reconfiguration	Indicates that it is necessary to reset the relay in order for the configuration changes to take effect.
WRITING FLASH	Writing to Flash in Progress	Indicates that a write to FLASH is in progress (ON: In progress / OFF: End).
SNTP NO SYNC	SNTP Not Synchronized	Indicates the synchronizing status of the SNTP module. (ON: Not Synchronized / OFF: Synchronized).
LAN1 STATUS	LAN1 Communications Port Status	Indicates the status of the applicable communications port LAN. It is only used when the relay is redundancy configured, whether bonding or PRP (if there is no redundancy, the value is always OFF): - Bonding: Indicates whether LAN detects medium during a settable time. If medium is not detected during this time, it takes the value OFF. As soon as it detects medium, it switches to ON. - PRP: Indicates whether LAN receives frames during a settable time. If it receives any frame, it takes the value ON. If no frames are received during this time, it takes the value OFF.
LAN2 STATUS	LAN2 Communications Port Status	
BOND ACT LAN	Active LAN Communications Port (bonding)	Indicates the active LAN when the configured redundancy is bonding (OFF: LAN1 active / ON: LAN2 active).
LAN1 NET OVFL	Network Congestion Detected on LAN1	Indicates whether a network congestion is taking place (abnormal network avalanche) in the corresponding LAN (ON: Congestion present / OFF: No congestion present).
LAN2 NET OVFL	Network Congestion Detected on LAN2	

3.40.11 Communications Test

In order to proceed with the communications testing the relay must be supplied with the nominal voltage. Then the “In Service” LED must light up.

3.40.11.a PROCOME Protocol Test

The testing shall be performed through the three communications ports (one front and two rear [P1 and P2] ports), which must be set as follows:

Baud rate	**38,400 bauds**
Stop bits	**1**
Parity	**1** (even)

All ports shall be assigned the PROCOME protocol in order to use the ***ZivercomPlus***® communications program in all of them.

Connect with the relay through the front port via a male DB9 cable. Synchronize the time through the ***ZivercomPlus***® program. Disconnect the relay and wait for two minutes. Then, supply power to the relay again and connect with the relay through both rear ports. Finally set the ***ZivercomPlus***® program to cyclic and check that the time updates properly with both P1 and P2 connected.

3.40.11.b DNP v3.0 Protocol Tests

The main objects to test are:

1	0	Binary Input – All variations
1	1	Binary Input

The relay is asked about the state in that instant of the IED's status contact input signals (digital inputs, digital outputs, logic signals) configured to be sent via DNP v3.0.

2	0	Binary Input Change – All variations
2	1	Binary Input Change without Time
2	2	Binary Input Change with Time
2	3	Binary Input Change with Relative Time

The relay is asked about the control changes generated by the status contact input signals configured to be sent via DNP v3.0. They can be all the changes, without time, with time or with relative time.

10	0	Binary Outputs – All variations

The relay is asked about the state of the writings of outputs configured in the relay.

12	1	Control Relay Output Block

The operations sent through communications are tested on the IED.

20	0	Binary Counter – All variations
20	1	32-bit Binary Counter
21	0	Frozen Counter – All variations
21	1	32-bit Frozen Counter
22	0	Counter Change Event – All variations

A request is made for the value of the counters included in the IED's logic. These counters can be 32-bits binary or frozen counters. A request is also made for the changes generated by the value of these counters.

30	0	Analog Input – All variations
30	2	16-Bit Analog Input

A request is made for the value of the IED's analog inputs at that precise moment.

32	0	Analog Change Event – All variations
32	4	16-Bit Analog Change Event with Time

A request is made for the control changes generated by the variation in the value of the IED's analog channels.

40	0	Analog Output Status – All variations

The relay is asked about the state at that precise moment of the value of the IED's analog outputs.

41	2	16-Bit Analog Output Block

The relay is asked about the state at that precise moment of the value of the IED's 16-bit analog outputs.

50	1	Time and Date

The IED's date and time are synchronized.

52	2	Time Delay Fine

The relay is asked about the communications delay time. It is measured from the time the relay receives the first bit of the first byte of the question until the transmission of the first bit of the first byte of the IED's response.

60	1	Class 0 Data
60	2	Class 1 Data
60	3	Class 2 Data
60	4	Class 3 Data

The relay is asked about the various data defined in the relay as Class 0, Class 1, Class 2 and Class 3.

Within these requests, the IED's generation and sending of Unsolicited Messages for each of the different kinds of data is tested.

80	1	Internal Indications

The IED's Internal Indication bit (IIN1-7 bit Device Restart) is reset.

--	--	No Object (Cold Start)

When the IED receives a “Cold Load Pickup” object, it must answer with a message object “Time Delay Fine” and with a reset of the internal indication bit IIN1-7 (Device Restart).

--	--	No Object (Warm Start)

When the IED receives a “Warm Load Pickup” object, it must answer with a message object “Time Delay Fine” and with a reset of the internal indication bit IIN1-7 (Device Restart).

--	--	No Object (Delay Measurement)

The IED must answer with a communications object “Time Delay Fine.”

The Broadcast addresses are tested and the indications corresponding to “All Stations” with each of them.

3.41 Adaptive Sampling Frequency

3.41.1 Description

ZLV relays include an algorithm that automatically adapts the sampling frequency to the network frequency, varying the time between samples, to ensure that the DFT calculation window comprises exactly one network cycle. If this adaptation should not take place, said window would not comprise one periodic wave, which will result in DFT measurement errors. The greater the deviation between the window time and the period of the sampled wave, the greater the errors.

The algorithm of sampling frequency adaptation is disabled by default. It can only be enabled through the HMI, which is only recommended in those cases in which large variations in the frequency are likely to be produced. For this, go to option **2-Change Settings→10- Digital PLL**.

3.41.2 Digital PLL Settings

Digital PLL			
Setting	**Range**	**Step**	**By Default**
Enable	YES / NO		NO

3.41.3 Digital Inputs and Events of the Digital PLL

Table 3.41-1: Digital Inputs and Events of the Digital PLL		
Nombre	**Descripción**	**Función**
ENBL_PLL	Digital PLL Enable Input	It enables the operation of the automatic frequency adaptation system. It is set to logic “1” by default.

3.42 Integrated Simulator

3.42.1 Description

The **ZLV** IED is provided with a special test and simulation mode of the implemented units which allows to upload an external oscillogram through any of the communication ports used by the PROCOME protocol. Oscillograms captured by the equipment itself or by other equipment can be used. In the latter case, an external program will prepare the oscillogram for this purpose (adaptation of the sampling frequency and scale).

Once an oscillogram is sent through the ***ZIVercomPlus***® program, the equipment enters into **Oscillogram Simulation Mode**, from which it can exit through an activation pulse of the **Oscillogram Simulation Cancellation** input. The simulation will only commence when, with the equipment in oscillogram simulation mode, one of the following two conditions is fulfilled:

- Reception of an activation pulse of the **Oscillogram Simulation Start** input, provided that the **Trigger Enable Via Digital Signal** setting is set at **YES**.
- The time of the IED reaches the time set in the uploaded oscillogram, provided that the **Time Trigger Enable** setting is set at **YES**.

Once the simulation is complete, the equipment exits the oscillography simulation mode after 5 seconds. To return to this mode, without having to upload a new oscillogram, if the relay already has one (it always considers the last oscillogram, either collected by it or previously uploaded through communications), it is only necessary to activate the **Start Oscillogram Simulation Mode** input.

With the start of the simulation, the relay suspends the capture of samples from the analog-digital converter and carries out a reading, from the memory, of the samples contained in the oscillogram, operating with samples read in the same manner as those captured.

The oscillogram storage operates in normal mode, such that the waveforms captured can be compared with those read.

Given that the simulation function is also considered for use with equipment already installed, as part of the maintenance practices, it may be necessary to impede the real actuation of the relay over its physical environment; for this reason, it is possible to disable the following resources through setting:

- **Physical Digital Inputs**: when the **Digital Input Simulation** setting is set at **YES**, the equipment ignores the state of the physical digital inputs, which are substituted by the logical signals of the oscillogram configured as digital inputs.
- **Switching Outputs**: when the **Trip and Close Contact Operation Enable** setting is set at **NO**, the equipment ceases to act on the switching outputs.
- **Auxiliary Outputs**: when the **Auxiliary Output Operation Enable** setting is set at **NO**, the equipment ceases to act on the auxiliary outputs.

3.42.2 Integrated Simulator Settings

Integrated Simulator			
Setting	**Range**	**Step**	**By default**
Trigger enable via digital signal	YES / NO		NO
Time trigger enable	YES / NO		NO
Digital input simulation	YES / NO		NO
Trip and close contact operation enable	YES / NO		NO
Auxiliary output operation enable	YES / NO		NO

3.42.3 Digital Inputs and Events of the Integrated Simulator

Table 3.42-1: Digital Inputs and Events of the Integrated Simulator

Name	Description	Function
IN_ST_MODE_SIM	Oscillogram simulation mode start input	Activation of this input takes the equipment to the oscillogram simulation mode.
IN_ST_SIM_OSC	Oscillogram simulation start input	Activation of this input starts simulation.
IN_CNCL_SIM_OSC	Oscillogram simulation cancellation input	Activation of this input removes the equipment from the oscillogram simulation mode state.

3.42.4 Digital Outputs and Events of the Integrated Simulator

Table 3.42-2: Digital Outputs and Events of the Integrated Simulator

Name	Description	Function
FILE_LOADED	File uploaded	An oscillogram is received to carry out simulation.
MODE_SIM_OSC	Oscillogram simulation mode	The equipment is in oscillogram simulation mode.
PU_SIM_OSC	Simulation picked up	The equipment has started a simulation.

3.43 Current Transformers Dimensioning

3.43.1 Introduction

When dimensioning the Current Transformers (CTs), several factors are taken into account that influence the level of flux generated in the CT itself and, therefore, the tendency of the same to saturate. These include: load, internal resistance, incidence angle of the fault, primary and secondary time constants, remanence, etc.

The following points describe the data provided by different CT standards and the factors that must be calculated for the CT dimensioning

3.43.2 CT Dimensioning According to Different Standards

3.43.2.a Class P of IEC 61869-2 Standard

The CT is specified with the following data:

- Rated transformation ratio: the ratio of the rated primary current to the rated secondary current, e.g 600/5.
- Rated power: power provided by the CT at rated current and rated burden, e.g 10 VA.
- Accuracy class: 5P and 10P defines a maximum composite error of 5% or 10% at the accuracy limit current (accuracy limit factor (ALF) multiplied by the rated current).
- Accuracy limit factor: times the rated current, without DC offset, at which the accuracy class is fulfilled.
- Secondary internal resistance.

The CT will be adequate if K_total=Kssc*Kb*Ktf*Krem<ALF, where

Kssc: symmetrical short-circuit current factor.
Kb: burden factor.
Ktf: overdimensioning factor for DC offset.
Krem: remanence overdimensioning factor.

- **Symmetrical Short-Circuit Current Factor (Kssc)**

It is the ratio between the maximum short circuit current and the rated current.

- **Burden Factor (Kb)**

It is the ratio (Rct+Rburden)/(Rct+Rn), where:

Rn is the rated burden. Rn can be calculated from the CT rated power:

$$Rn = \frac{Pn}{I2n^2}$$

Rct: is the internal secondary resistance of the CT
Rburden: is the burden resistance
I2n: is the rated secondary current

The accuracy limit factor is defined for the rated burden. For a different burden the maximum symmetrical current that assures the fulfillment of the accuracy class will be different than the accuracy limit current (it will be higher than the accuracy limit current if the burden is lower than the rated one and it will be lower if the burden is higher than the rated one). This condition is taken into account by the burden factor.

- **Transient Overdimensioning Factor (Ktf)**

The flux created by a current with DC offset (asymmetrical current) is much higher than the flux generated by a current without any DC component (symmetrical current). As the ALF factor is defined for a symmetrical current, an overdimensioning factor for asymmetrical currents must be considered. This factor will be given by $\frac{\phi_{\text{MAX AC+DC}}}{\phi_{\text{MAX AC}}}$,which represents the ratio between the maximum total flux (sum of DC and AC fluxes) and the maximum AC flux. Ktf is calculated with the following formula:

$$Ktf = \frac{w \cdot T1 \cdot T2}{T1 - T2} \cdot \cos\theta \cdot (e^{\frac{-t}{T1}} - e^{\frac{-t}{T2}}) + \sin\theta \cdot e^{\frac{-t}{T2}} - \sin(wt + \theta) \qquad \text{(3.43.1), where}$$

T1 is the primary time constant.
T2 is the secondary time constant.
t is the saturation free time or time to saturation.
θ is the fault inception angle.

For saturation free times higher than 15 ms, the maximum flux will be obtained with $\theta = 0$, however, for saturation free times lower than 15 ms, the maximum flux will be obtained for other fault inception angles.

For each saturation free time tolerated by the protection function the worst inception angle should be determined.

- **Remanence Overdimensioning Factor (Krem)**

The remanent flux may worsen the CT transient response if it has the same sign of the flux generated by the current magnitude, burden value and DC offset. This is considered by the remanence overdimensioning factor $Krem = \frac{1}{(1 - Kr)}$, where Kr is the remanent factor (maximum remanent flux / saturation flux).

3.43.2.b Class C of IEEE C57.13 Standard

The most common accuracy class in the IEEEC57.13 standard is the C class. The letter C is followed by a number that indicates the secondary voltage rating, which is defined as the CT secondary voltage that the CT will deliver when it is connected to a standard secondary burden at 20 times the rated secondary current, without exceeding a 10% ratio error. The common standard burdens for protection CTs are 1, 2, 4 and 8 ohms, which correspond, at 5 A rated current, to 100, 200, 400 and 800 V secondary rating voltages (for a C100 CT the voltage at the 1 ohm burden will be 20*5*1=100 V).

With the secondary voltage rating (burden voltage - Vb) we can obtain the internal magnetizing voltage by adding the voltage drop in the secondary resistance (Rct):

Emrated=Vb+Rct*20*I2n

The dimensioning of an IEEE CT can be done by calculating Em as:

Emcalc=Ktotal'*I2n*(Rct+Rb),

where Ktotal'=Kssc*Ktf*Krem.

If Emcalc<Emrated= Vb+Rct*20*I2n the CT will be valid

An easier deduction can be made considering that the ALF factor of a C class CT is always 20 (the 10% ratio error cannot be exceeded for a secondary current 20 times the rated current with the rated burden). If Ktotal<ALF the CT will be valid.

3.43.2.c Class X of BS3938 Standard or Class PX of IEC61869-2

Class X CT is defined with:

- Primary and secondary rated currents.
- Transformation ratio.
- Rated knee-point voltage.
- Magnetizing current at rated knee-point voltage.
- Resistance of secondary winding.

The rated knee-point voltage is defined as the minimum voltage, at rated frequency, applied to the CT secondary terminals which increased by a 10% causes an increase in the magnetizing current of 50% (see Figure 3.43.1).

The relationship between the rated knee-point voltage (Vknee) and the magnetizing voltage at the accuracy limit current with rated burden (Emrated) is done by approximation, because the definition of the two voltages has no direct relation (Vknee has to do with the slope of the magnetizing characteristic and Emrated with the current composite error). It is normally considered that Emrated=(1.25 – 1.3)*Vknee.

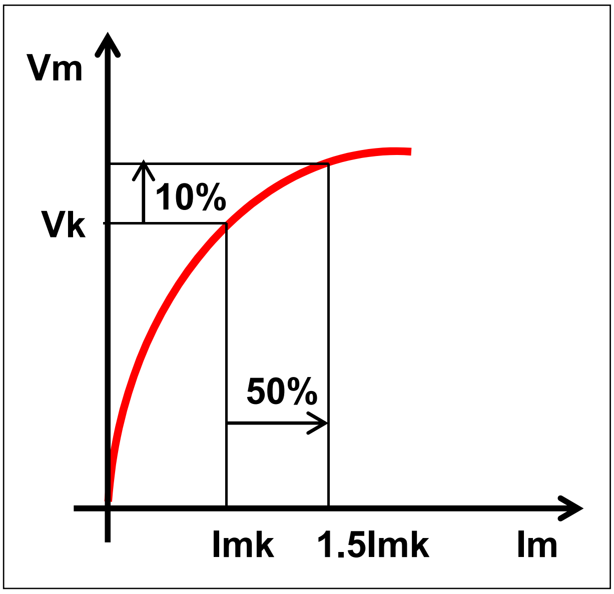


Figure 3.43.1: Knee Point Voltage Definition.

Once Emrated is calculated it can be compared with Emcalc= Ktotal'*I2n*(Rct+Rb). The CT will be valid if Emcalc<Emrated.

where Ktotal'=Kssc*Ktf*Krem

3.43.3 CT Dimensioning for Different Protection Functions

Table 3.43-1 includes general parameters to be considered for the calculation of CT dimensioning factors.

Table 3.43-2 includes the saturation free times (for Ktf calculation) and current values (for Kssc calculation) that must be used for CT dimensioning.

Table 3.43-1: General Parameters

Data	Description	Units
f	Frequency (50 or 60 Hz)	(Hz)
IF	Maximum primary fault current (single phase fault current or three phase fault current, the highest one). It depends on the protection function – see Table 3.43-2	(A)
CT ratio	I1n/I2n	
I1n	Primary nominal current	(A)
I2n	Secondary nominal current	(A)
T1	Primary time constant = L/R (taking into account the total impedance from the source to the fault location).	(s)
T2	Secondary time constant (CT time constant) (Usual value = 3 s)	(s)
Rn	CT nominal resistance	(ohms)
Rct	CT internal resistance For CTs of 5 A nominal current, the Rct is around 0.2 ohms to 0.4 ohms. For the CTs of 1 A nominal current, the Rct is higher (10 ohms for example).	(ohms)
Rb	CT burden resistance = Relay burden + Cable resistance	(ohms)
	Cable resistance = 2·RL (if the maximum primary fault current belongs to a single phase fault). Cable resistance = RL (when the maximum primary fault current belongs to a 3 phase fault). RL = ρ · (L/S) ρ = resistivity (mm^2*Ω/m) S = cable section (m^2) L = cable length (m)	(ohms)
	Relay burden = (0.2 VA) / ($I2n^2$)	(ohms)
t	Required saturation free time (depends of the protection function – see Table 3.43-2)	(s)

Table 3.43-2: Saturation Free Time and Fault Current Values

Protection Function	Fault Scenarios to be considered	t (s) = the time (seconds) from the fault start until the CT becomes saturated.		IF (fault current to calculate Kssc)
		f = 50 Hz	f = 60 Hz	
87	External fault in the busbar (giving maximum fault current)	$3x10^{-3}$ (s)	$2.5x10^{-3}$ (s)	$IF = IF_{max\_external}$ Maximum fault current for external fault
87N	External fault in the busbar (giving maximum fault current)	$4x10^{-3}$ (s)	$3.5x10^{-3}$ (s)	$IF = IF_{max\_external}$ Maximum fault current for external fault
50	Internal fault giving a fault current equal to the pick-up value	It depends on the primary constant, however, it is always lower than $10x10^{-3}$ (s)	It depends on the primary constant, however, it is always lower than $8.3x10^{-3}$ (s)	$IF = IF_{pickup50}$ (instantaneous overcurrent unit pickup in primary value). IFpickup50 ≈ 0.7 · (IF_2) IF_2=the fault current to be detected by 50 overcurrent protection. It is normally the fault current at 50%-80% of the feeder. **Note 1**: The 0.7 factor is introduced to compensate CT errors, relay errors and short circuit calculation errors. **Note 2**: If the current IF_2 is not known, a first approximation could be done taking IF_1 instead of IF_2; Being IF_1= 80% of the fault current at 0% of the feeder (maximum short circuit current) = 80% ($IF_{0\%}$)
	Internal fault at 0% of the line	It depends on the primary constant, however, it is always lower than $7.4x10^{-3}$ (s)	It depends on the primary constant, however, it is always lower than 6 $x10^{-3}$ (s)	$IF = IF_{0\%}$
21	Internal fault at 0% of the line	$8.4x10^{-3}$ (s)	7 $x10^{-3}$ (s)	$IF = IF_{0\%}$
	Internal fault at 100% of the line	$15x10^{-3}$ (s)	$12.5x10^{-3}$ (s)	$IF = IF_{100\%}$
	Internal fault at the limit of zone 1 reach (normally 80% of the line).	$25x10^{-3}$ (s)	$21x10^{-3}$ (s)	$IF = IF_{80\%}$

3.43.3.a Remanence Factor

Remanence factor is not considered for overcurrent and distance protection. For the mentioned functions Krem=1.

For the rest of the functions Kr=75%-->Krem=4

3.43.3.b Ktf Factor

The following tables include different ktf values calculated according to the formula (3.43.1). The saturation free times included in Table 3.43-2 are considered together with the worst inception angles (θ). T2 is considered equal to 3 s.

Function	T1 (s)	K_{tf}
87T	0.01-0.3	0.43

Function	T1 (s)	K_{tf}
87N	0.01-0.3	0.58

Function	T1 (s)	K_{tf_pickup} 60 Hz	K_{tf_pickup} 50 Hz	$K_{tf\_0\%}$ 60 Hz	$K_{tf\_0\%}$ 50 Hz
50	0.01	1	1	1	1
	≤ 0.02	1	1	1	1
	≤ 0.03	1.15	1.15	1	1
	≤ 0.04	1.48	1.48	1	1
	≤ 0.05	1.6	1.6	1	1
	≤ 0.08	1.9	1.9	1	1
	≤ 0.1	2.1	2.1	1	1
	≤ 0.2	2.4	2.4	1	1
	≤ 0.3	2.5	2.5	1	1

Function	T1 (s)	$K_{tf\ zone1}$ 60 Hz	$K_{tf\ zone1}$ 50 Hz	$K_{tf\ 100\%}$ 60 Hz	$K_{tf\ 100\%}$ 50 Hz	$K_{tf\ 0\%}$ 60 Hz	$K_{tf\ 0\%}$ 50 Hz
21	0.01	4.3	3.9	3.8	3.6	2.3	2.3
	≤ 0.02	5.9	5.5	4.6	4.4	2.6	2.5
	≤ 0.03	6.6	6.3	4.9	4.8	2.7	2.6
	≤ 0.04	7.15	6.8	5.1	5	2.7	2.7
	≤ 0.05	7.46	7.2	5.3	5.2	2.7	2.7
	≤ 0.1	8.14	7.9	5.5	5.5	2.8	2.8
	≤ 0.2	8.5	8.4	5.6	5.6	2.8	2.8
	≤ 0.3	8.6	8.5	5.7	5.7	2.8	2.8

NOTE: For overcurrent and distance functions, Ktotal must be calculated for each of the cases considered (fault at 0% and fault with Ifault=Ipick-up for overcurrent; fault at 0%, 80% and 100% of the line for distance). The maximum value of Ktotal must be used to compare against ALF.

Overcurrent

$$Ktotal_{0\%}=Kssc_{0\%}*Kburden*Ktf_{0\%}*Krem$$

$$Ktotal_{pick\text{-}up}=Kssc_{pick\text{-}up}*Kburden*Ktf_{pick\text{-}up}*Krem$$

$$Ktotal=max(Ktotal_{0\%}, Ktotal_{pick\text{-}up})$$

Distance

$$Ktotal_{0\%}=Kssc_{0\%}*Kburden*Ktf_{0\%}*Krem$$

$$Ktotal_{80\%}=Kssc_{80\%}*Kburden*Ktf_{80\%}*Krem$$

$$Ktotal_{100\%}=Kssc_{100\%}*Kburden*Ktf_{100\%}*Krem$$

$$Ktotal=max(Ktotal_{0\%}, Ktotal_{80\%}, Ktotal_{100\%})$$

Chapter 4.

Maintenance and Troubleshooting

4.1 Alarm Codes

4.1.1 Introduction

ZLV models notify the occurrence of alarms by 3 routes:

- Activation of an Alarm Generation Signal and Event
- Update of the Alarm Status Magnitude
- Indication on the HMI Stand-by Screen

Models **ZLV-***-****01***** and **ZLV-***-****02***** are also provided with a fourth route:

- General Alarm Counter

4.1.2 Activation of an Alarm Generation Signal and Event

The IED has 2 status contact input signals to indicate critical and non-critical level alarms:

- Non-critical system error: ERR_NONCRIT
- Critical system error: ERR_CRIT

The activation of any of these signals generates its associated event. These signals can be used as inputs to be processed by the user-developed algorithms. Likewise, these signals can be connected to any of the communications protocols for their remote notification.

4.1.3 Update of the Alarm Status Magnitude

The IED has a magnitude whose value is determined by the combination of active alarms in the IED. This magnitude can be used as input to be processed by the user-developed algorithms. Likewise, a user-developed algorithm can connect this magnitude or the outcome of its processing to any of the communications protocols for transmission.

Table 3.43-1 shows the possible causes of alarm coded by alarm magnitude, together with their level of severity.

Table 4.1-1: Alarm Status Magnitude and Severity Level

Alarm	Value	Severity
Error read/write settings	0x00000001	CRITICAL
Protection operation error	0x00000020	CRITICAL
Error read/write from E2PROM	0x00000040	CRITICAL
Non-critical error in A/D converter	0x00000080	NON-CRITICAL
Critical error in A/D converter	0x00000100	CRITICAL
Loss of content in non-volatile RAM	0x00000200	NON-CRITICAL
Error in internal clock operation	0x00000400	NON-CRITICAL
Error read/write from FLASH	0x00008000	CRITICAL

In the case of more than one alarm at once, the sum of the codes of these alarms is seen in hexadecimal form.

4.1.4 Indication on the HMI Stand-By Screen

The activation of the Critical System Error signal produces the display of the current magnitude of the status of alarms of the IED in hexadecimal format on the stand-by display of the HMI.

4.1.5 General Alarm Counter

The relay is provided with three counters on the HMI to inform on the number of starts, re-starts and Traps:

- **Number of starts** (NARRANQS): Informs on the number of times the relay has been cold restarted (relay power supply failure).
- **Number of restarts** (NREARRAQS): Informs on the number of times the relay has been hot restarted (manually through change in configuration, or change of any nominal setting or relay reset).
- **Number of Traps** (NTRAPS): Number of exceptions produced in the relay followed by a reset.

Warning: contact the manufacturer if the unit displays any of these alarms codes or Traps counter increment.

4.2 Troubleshooting

4.2.1 Introduction

The purpose of this Chapter is to allow identifying error conditions in the device so that the user can carry out the appropriate corrective action in each case.

4.2.2 Software with Self-Checking

The relay performs continuous monitoring and self-checking its hardware and software. If any problem is detected, the device will show an alarm message in the HMI as it is explained in the Chapter 4.1, Alarm Codes.

The alarms generated by the self-checking module are divided in two levels, critical and non-critical alarms (table located in Chapter 4.1, Alarm Codes). When there is a non-critical alarm, the corresponding alarm message is displayed in the HMI and the device keeps on working due to the fact that the error level detected does not prevent the basic protection functionality, while when there is a critical alarm along with the error message in the HMI the alarm or watchdog contact of the relay changes its position because the protection goes out of service.

4.2.3 Power Up

If the relay does not appear to power up, verify the following points in order to determine if the error is located in the external wiring, in the power supply module or in the display.

Table 4.2-1: Power Up

Test	Check	Actions
1	Measure the auxiliary voltage on terminals of the relay, verifying that the voltage level and polarity is the one defined on the front label. Verify the positive and negative terminal in the external connection drawing.	If the auxiliary voltage is correct, proceed to test 2. If the auxiliary voltage is not the expected one, verify the wiring, fuses and/or minicircuit breakers should be checked.
2	Verify the alarm/watchdog contact of the relay taking into account the external connection drawing of the device	In the device is in service status and the “ready” LED and display are not switched on, the problem is located in the frontal card of the relay or in the internal cables. If the device is in alarm status the problem is located in the power supply module or in the internal cables. In both situations contact your supplier and the Quality Department of ZIV.

4.2.4 In Service / Alarm Contact

Table 4.2-2: In Service / Alarm Contact		
Test	**Check**	**Actions**
1	Access through the MMI or with the communication program (*Zivercomplus*®) to the setting called as “Unit In Service” which is inside General. If it is enabled proceed to test 2.	If the setting is disabled, enable it and verify that the alarm/watchdog contact switched from alarm status to in service status. If it does not change, proceed to test 2.
2	Check if there is any alarm message in the MMI and verify if it is a critical alarm taking into account the table located in the Chapter 4.1, Alarm Codes.	Contact your supplier and the Quality Department of ZIV.

4.2.5 Error Messages during Power Up

If the device, once the power up process has finished, is not showing the default screen (model, date and time) verify the following points.

- **IEC61850 Devices**

Table 4.2-3: Error Messages during Power Up - IEC61850 Devices		
Test	**Check**	**Actions**
1	IEC61850 power up stops showing the following message: ---------------.CID	Protection is operating but communications cannot run because the device has no CID file. Load a correct CID file to the relay.
2	IEC61850 power up stops showing the 3010 error	Protection is operating but communications cannot run because there is a problem while loading the IEC61850 profile. Contact your supplier of the Quality Department of ZIV.
3	IEC61850 power up stops showing the 3011 error	Protection is operating but communications cannot run because there is a problem while loading the CID file. Verify in the logs (web server or FTP) the error reason, modify the CID file and load the corrected file.
4	IEC61850 power up stops showing the 3020 error	Protection is operating but communications cannot run because the FW version of the protection and the IEC61850 FW are not matching. Contact your supplier of the Quality Department of ZIV.
5	IEC61850 power up stops showing the 3030 error	Protection is operating but communications cannot run because there is a mistake in the external control logic configuration of the CID (InRefs, LOGGAPC). Verify in the logs (web server or FTP) the error reason, modify the CID file and load the corrected file.

Table 4.2-3: Error Messages during Power Up - IEC61850 Devices		
Test	**Check**	**Actions**
6	IEC61850 power up stops showing the 3060 error	Protection is operating but communications cannot run because there is a mistake in the GOOSE subscription configuration. Verify in the logs (web server or FTP) the error reason, modify the CID file and load the corrected file.
7	IEC61850 power up stops showing the 3070 error	Protection is operating but communications cannot run because there is an error in the internal file that manages the Ethernet connection. Contact your supplier of the Quality Department of ZIV.
8	IEC61850 power up stops showing the 3080 error	Protection is operating but communications cannot run because there is a problem in the interfaces. Contact your supplier of the Quality Department of ZIV.
9	IEC61850 power up stops showing the 3200 error	Protection is operating but communications cannot run because there is a problem with the interruptions of the DPRAM. Contact your supplier of the Quality Department of ZIV.
	If there is a generic non IEC61850 error message in the HMI, check which kind of error it is according to the table that appears in Chapter 4.1, Alarm Codes.	Contact your supplier of the Quality Department of ZIV.

- **Non IEC61850 Devices**

Table 4.2-4: Error Messages during Power Up – Non IEC61850 Devices		
Test	**Check**	**Actions**
1	If there is an error message in the HMI, check which kind of error it is according to the table that appears in Chapter 4.1, Alarm Codes.	Contact your supplier of the Quality Department of ZIV.

4.2.6 Error Messages when the Relay is in Normal Operation

Table 4.2-5: Error Messages when the Relay is in Normal Operation		
Test	**Check**	**Actions**
1	If there is an error message in the MMI, check which kind of error it is according to the table that appears in Chapter 4.1, Alarm Codes.	Contact your supplier of the Quality Department of ZIV.

4.2.7 Errors while Communicating

Table 4.2-6: Errors while Communicating		
Test	**Check**	**Actions**
1	If a communication error takes place when trying to communicate with *Zivercomplus®* program through the frontal port with the following message: Doesn't communicate. Cannot get identifier.	Verify: - That you are using a crossed cable (5-5, 2-3). - That you are using a USB cable and you have all the drivers installed. - That the communication parameters of the device and the ones set in *Zivercomplus®* fit. Click two times in the screen of *Zivercomplus®* and scan the PC port used for the connection with the relay to obtain automatically the suitable parameters. If even with those parameters the message is still appearing, contact your supplier and the Quality Department of ZIV.
2	If a communication error takes place when trying to communicate with *Zivercomplus®* program through the frontal port with the following message: Cannot locate the identifier corresponding profile: XXXX.	Close *Zivercomplus®* program, update the database and run again *Zivercomplus®* in order to communicate with the relay.
3	If a communication error takes place when trying to communicate with *Zivercomplus®* program through the serial rear ports of the relay.	Verify: - That you are using a crossed cable (5-5, 2-3). - That the communication parameters of the device and the ones set in *Zivercomplus®* fit. - That the protocol of the rear port has been set to PROCOME. Click two times in the screen of *Zivercomplus®* and scan the PC port used for the connection with the relay to obtain automatically the suitable parameters. If even with those parameters the message is still appearing, contact your supplier and the Quality Department of ZIV.
4	If a communication error takes place when trying to communicate with *Zivercomplus®* program through the Ethernet serial rear ports or the LAN ports of the relay.	Verify: - The IP address of the relay is the same one set in *Zivercomplus®*. - That the TCP port set in *Zivercomplus®* is 32001. - That the LAN parameter selected in *Zivercomplus®* is transparent. - That the IP address of the PC belongs to the same family address of the one set in the relay and the network masks are correct. If the error is still appearing, contact your supplier and the Quality Department of ZIV.

Table 4.2-6: Errors while Communicating

Test	Check	Actions
5	Errors when communicating in Modbus and DNP3 through the serial remote ports.	Verify: - That you are using a crossed cable. - That the communication parameters of the device and the ones set in Zivercomplus fit. - That the rear port in the relay has been set with the appropriate protocol. - That the control configuration of the relay has the addresses requested by the client. If you cannot communicate, verify the correct behavior of the port trying to communicate in PROCOME with *Zivercomplus*®. If it works, check again the initial points. If it does not work, contact your supplier and the Quality Department of ZIV.
6	Errors when communicating in Modbus and DNP3 through the serial Ethernet ports.	Verify: - The IP address of the relay is the same one set in *Zivercomplus*®. - That the TCP port fits. - The rear port is set with the appropriate protocol. - That the control configuration of the relay has the addresses requested by the client. - That the IP address of the PC/client belongs to the same family address of the one set in the relay and the network masks are correct. If you cannot communicate, verify the correct behavior of the port trying to communicate in PROCOME with *Zivercomplus*®. If it works, check again the initial points. If it does not work, contact your supplier and the Quality Department of ZIV.
7	Errors when communicating in Modbus and DNP3 through the IEC61850 LAN ports.	Verify: - That the model supports DNP3 and MODBUS through the LAN IEC61850 ports as defined in the model selection. - The IP address of the relay is the same one set in the PC/client. - That the TCP port fits. - The rear port is set with the appropriate protocol. - That the control configuration of the relay has the addresses requested by the client. - That the IP address of the PC/client belongs to the same family address of the one set in the relay and the network masks are correct. - That the number of instances of each protocol have not been exceeded. - That there is no IEC61850 error in HMI of the relay (press ♠•). If you cannot communicate, verify the correct behavior of the port trying to communicate in PROCOME with *Zivercomplus*®. If it works, check again the initial points. If it does not work, contact your supplier and the Quality Department of ZIV.

4.2.8 Error in Digital Inputs

Table 4.2-7: Error in Digital Inputs

Test	Check	Actions
1	Verify with a multimeter that the DI is energized (positive and negative as external connection wiring diagram) checking the voltage level and polarity taking into account the indications of the front label of the relay.	If the voltage supply of the DI is correct (positive and negative) skip to step 2. If the auxiliary voltage is not the expected one, check the external wiring, fuses and/or mini circuit breakers of the circuit.
2	If you are using a DI that can be configured for coil supervision, check that the corresponding setting has been set to NO.	Access through HMI or *Zivercomplus®* to the coil supervision settings and disable them. If they were enabled go to step 3.
3	Check the activation/deactivation voltage levels as the table that appears in Digital Inputs inside Chapter 2.1, Technical Data.	If the voltage is located inside the activation margin and the DI is not activating, verify that the FW of the relay matches with the model of the front label of the relay. In any case contact your supplier and the Quality Department of ZIV.

4.2.9 Error in Digital Outputs

Table 4.2-8: Error in Digital Outputs

Test	Check	Actions
1	If the output contacts are not operating.	Verify the control logic and the signals that activate the outputs. If it is correct, make the necessary actions in order to execute the control logic and give the closing command. Verify if the output is changing the status in the HMI of the relay. If any of the outputs are not operating contact your supplier or the Quality Department of ZIV. If you are seeing the DO changing in the HMI, verify the activation of the output contact a multimeter, taking into account the external connection wiring diagram. If the physical output is not activating, contact your supplier and the Quality Department of ZIV.
2	If the TRIP contacts are not operating when there is a trip condition indicated in the HMI.	Verify that the protection unit is not taking into account the status of the breaker or other kind of factors. If the tripping condition is being complied but the trip contacts are not closed after verifying them with a multimeter and the external connection wiring diagram, contact your supplier and the Quality Department of ZIV.
3	If the CLOSE contacts are not operating when the relay gives a reclosing command.	Repeat the action to generate a new reclosing command, verifying that the command is generated in the events of the relay and the close contact is not closing (with a multimeter and the external connection wiring diagram). If the DO is not activating, contact your supplier and the Quality Department of ZIV.

4.2.10 Error in Input Transducers

Table 4.2-9: Error in Input Transducers

Test	Check	Actions
1	Verify that the input transducer has a suitable input signal taking into account the type of input transducer of the relay (front label of the relay and model selection).	If the input signal is not the expected one, check the external wiring, intermediate devices, etc. If the input signal is the correct one, contact your supplier and the Quality Department of ZIV.

4.2.11 Error in Measurements

- Compare the measurements shown in the HMI of the relay with the magnitudes metered with a multimeter in the terminals of the relay.
- Check that the transformation ratios of the CTs and VTs are the correct ones.
- Check that the terminals wired in the relay are the correct ones (external connection wiring diagram).
- Check the angle shift in order to confirm that the inputs are correctly wired.

If all the verifications are correct (external wiring, polarity and measurements in terminals of the relay), contact your supplier and the Quality Department of ZIV.

4.2.12 Fatal Errors

The device can reset itself in order to escape from transient anomalies, whose cause could be internal or external to the relay and which do not imply a damage of the relay itself. When there is an evidence of a malfunctionality of the device and/or a spontaneous reset, access through the HMI to the FW information screen (ENT / Information / Relay Information / Software/) and check if it is appearing a numerical code inside brackets [xx] in the line which is located between the firmware model and the version and checksum. If so, collect the available information of the relay (events, logs, fault reports, disturbance recorder files, etc.) and contact your supplier and the Quality Department of ZIV.

A. PROCOME 3.0 Protocol

A.1 Control Application Layer

- **Application Functions**

☑ **Initialization of the secondary station**
☑ **Clock synchronization**
☑ **Control functions**
  ☑ Control interrogation
  ☑ Refreshing of digital control signals
  ☑ Write outputs
  ☑ Enabling and disabling of inputs
  ☑ Overflow
  ☑ Force single coil

- **Compatible ASDUs in Secondary-to-Primary Direction**

☑	**<5>**	**Identification**
☑	**<6>**	**Clock synchronization**
☑	**<100>**	**Transmission of metering values and digital control signal changes**
☑	**<101>**	**Transmission of counters**
☑	**<103>**	**Transmission of digital control states**
☑	**<110>**	**Write binary outputs**
☑	**<121>**	**Force single coil**

- **Compatible ASDUs in Primary to Secondary Direction**

☑	**<6>**	**Clock synchronization**
☑	**<100>**	**Control data request (Metering values and control changes INF=200)**
☑	**<100>**	**Control data request (Capture of counters INF=202)**
☑	**<100>**	**Control data request (Request for counters INF=201)**
☑	**<103>**	**Request for digital control states**
☑	**<110>**	**Write binary outputs**
☑	**<112>**	**Enable/disable binary inputs**
☑	**<121>**	**Force single coil**

A.2 Control Data

- **Control Metering (MEA-s)**

Configurable through the ***ZIVercomPlus***® any value measured or calculated by the protection or generated by the programmable logic. It is possible to select between primary and secondary values, taking into account the corresponding transformation ratios.

All the full scale values of the magnitudes are definable, and these magnitudes can be used to create **user values**. Some typical values are:

- **Phase**, **ground** and **sequence currents**. Rated value I_{PHASE} + 20% sends 4095 counts.
- **Polarization current**: Rated value I_{POL} + 20% sends 4095 counts.
- **Parallel line ground current**: Rated value I_{NPAR} + 20% sends 4095 counts.
- **Phase** and **sequence voltages**: (Rated value V / √3) + 20% sends 4095 counts.
- **Line** and **synchronization voltages**: Rated value V + 20% sends 4095 counts.
- **Powers**: 3 x 1.4 x rated value I_{PHASE} x rated value / √3 sends 4095 counts.
- **Power factor**: from –1 to 1 sends from –4095 to 4095 counts.
- **Frequency**: from 0 Hz to 1.2 x $Frequency_{RATED}$ (50Hz / 60Hz) sends 4095 counts.
- **Thermal value**: 240% sends 4095 counts
- **Distance to the fault**:
  - Percentage value: ±100% sends ±4095 counts (range from -100% to 100%).
  - Value in kilometers: with the “length of the line,” it sends ±4095 counts (range from 0 km to the length of the line set in km. It can also send negative values).
  - Value in miles: with the “length of the line,” it sends ±4095 counts (range from 0 km to the length of the line set in miles. It can also send negative values).

With the ***ZIVercomPlus***® program, it is possible to define the full-scale value to be used to transmit this magnitude in counts, the unit that all the protocols use. There are three definable parameters that determine the range of distance covered:

- **Offset value**: the minimum value of the magnitude for which 0 counts are sent.
- **Limit**: the length of the range of the magnitude on which it is interpolated to calculate the number of counts to send. If the offset value is 0, it coincides with the value of the magnitude for which the defined maximum of counts (4095) is sent.
- **Nominal flag**: this flag allows determining whether the limit set is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user in the programmable logic can be configured, while the rest of the existing magnitudes are fixed.

The expression that allows defining this full-scale value is the following:

- -When the Nominal flag is enabled,

$$CommunicationsMeasurement = \frac{Measurement - Offset}{Nominal} \times \frac{4095}{Limit}$$

- -When the Nominal flag is NOT enabled,

$$CommunicationsMeasurement = (Measurement - Offset) \times \frac{4095}{Limit}$$

- **Counters**

Configurable through the ***ZIVercomPlus***®: Counters can be created with any signal configured in the programmable logic or from the protection modules. The default counters are those of the real energies (positive and negative) and the reactive energies (capacitive and inductive).

The metering range of energies in primary values is from 100wh/varh to 99999 MWh/Mvarh. The magnitude transmitted via communications is this same primary value; that is, one (1) count represents 100 wh/varh.

- **Force Single Coil (ISE-s)**

Configurable through the ***ZIVercomPlus***®: A command can be made on any input from the protection modules and on any signal configured in the programmable logic.

- **Write Control Outputs (ISS-s)**

Configurable through the ***ZIVercomPlus***®: A writing can be made on any input from the protection modules and on any signal configured in the programmable logic.

- **Digital Control Signals (ISC-s)**

Configurable through the ***ZIVercomPlus***®: Any input or output logic signal from the protection modules or generated by the programmable logic.

B. DNP V3.00 Device Profiles Document

Dnp3 Basic Profile

Version 02.44.00 is the last Software Version that supports this Profile

DNP V3.00 Basic Profile

DEVICE PROFILE DOCUMENT

This document must be accompanied by: **Implementation Table** and **Point List**.

Vendor Name: **ZIV Aplicaciones y Tecnología S.A.**

Device Name: **ZLV**

Highest DNP Level Supported:	Device Function:
For Requests 2 For Responses 2	☐ Master ☒ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

1) **Supports Enable/Disable Unsolicited Responses (FC=20 and 21), for classes 1 and 2.**
2) **Supports Write operations (FC=2) on Time and Date objects.**
3) **Supports Delay measurement Fine (FC=23).**
4) **Supports Warm Start command (FC=14).**
5) **Supports Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)**
6) **Supports selection of DNP3 Revision.**
7) **Supports indication of no synchronization in time.**
8) **Supports simultaneous communications with two different Master devices**

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted **292** Received **292**	Transmitted **2048** (if >2048, must be configurable) Received **249** (must be <= 249)

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☒ None ☐ Fixed at ____ ☐ Configurable, range ___ to ___	☐ None ☒ Configurable, range **0** to **3** (Fixed is not permitted)

Requires Data Link Layer Confirmation:

☒ Never
☐ Always
☐ Sometimes. If 'Sometimes', when? ____________
☐ Configurable. If 'Configurable', how? ____________

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always (not recommended)
- ☒ When reporting Event Data (Slave devices only) **For unsolicited, Class 1 and Class 2 responses that contain Event Data. (If there is no Event Data reported into a Class 1 or 2 response, Application Layer Confirmation is not requested)**
- ☐ When sending multi-fragment responses (Slave devices only)
- ☐ Sometimes. If 'Sometimes', when?
- ☐ Configurable. If 'Configurable', how?

Timeouts while waiting for:

Data Link Confirm	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Complete Appl. Fragment	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable
Complete Appl. Response	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable

Others ____

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout

Application Confirm timeout setting (*MMI*): Range 50 ms. 65.535 ms.

Sends/Executes Control Operations:

- Maximum number of CROB (obj. 12, var. 1) objects supported in a single message **1**
- Maximum number of Analog Output (obj. 41, any var.) supported in a single message **0**

☐ Pattern Control Block and Pattern Mask (obj. 12, var. 2 and 3 respectively) supported.

☐ CROB (obj. 12) and Analog Output (obj. 41) permitted together in a single message.

WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT (3) / OPERATE (4)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE (5)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK (6)	☐ Never	☒Always	☐ Sometimes	☐ Configurable

Count > 1	☐ Never	☐ Always	☒ Sometimes	☐ Configurable
Pulse On	☐ Never	☒Always	☐ Sometimes	☐ Configurable
Pulse Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☒Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☒Always	☐ Sometimes	☐ Configurable

Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation:

- **All points support the same Function Codes: (3) Select, (4) Operate, (5) Direct Operate and (6) Direct Operate - No ACK.**
- **Maximum Select/Operate Delay Time: 60 seconds.**
- **Count can be >1 only for PULSE ON and PULSE OFF**

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:	
Reports Binary Input Change Events when no specific variation requested: ☐ Never ☒ Only time-tagged ☐ Only non-time-tagged ☐ Configurable to send both, one or the other (attach explanation)	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☒ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable (attach explanation)
Sends Unsolicited Responses: ☐ Never ☒ Configurable (**See Note D**) ☒ Only certain objects **(Class 1 and 2)** ☐ Sometimes (attach explanation) ☒ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable (attach explanation) ☒ Default Object 20,21 Default Variation 1 ☐ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☐ 32 Bits ☒ Other Value 31 Bits ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ☒ Yes ☐ No	

QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS

Function Codes

1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
6	Direct Operate-No ACK
7	Immediate Freeze
8	Immediate Freeze no ACK
13	Cold Start
14	Warm Start
20	Enable Unsol. Messages
21	Disable Unsol. Messages
23	Delay Measurement
129	Response
130	Unsolicited Message

7	6	5	4	3	2	1	0
	Index Size			Qualifier Code			

Index Size

0- No Index, Packed
1- 1 byte Index
2- 2 byte Index
3- 4 byte Index
4- 1 byte Object Size
5- 2 byte Object Size
6- 4 byte Object Size

Qualifier Code

0- 8-Bit Start and Stop Indices
1- 16-Bit Start and Stop Indices
2- 32-Bit Start and Stop Indices
3- 8-Bit Absolute address Ident.
4- 16-Bit Absolute address Ident.
5- 32-Bit Absolute address Ident.
6- No Range Field (all)
7- 8-Bit Quantity
8- 16-Bit Quantity
9- 32-Bit Quantity
11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (ZLV will parse)		RESPONSE (ZLV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	**1**	6			
1	1	Binary Input			129	1	Assigned to Class 0.
2	0	Binary Input Change – All variations	1	6,7,8			
2	1	Binary Input Change without Time	1	6,7,8	129		B
2	2	Binary Input Change with Time	1	6,7,8	129,130	28	Assigned to Class 1.
2	3	Binary Input Change with Relative Time	1	6,7,8	129		B
10	0	Binary Outputs – All variations	1	6	129		A
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	
20	0	Binary Counter – All variations	1	6	129		A
20	1	32 Bits Binary Counter			129	1	
21	0	Frozen Counter – All variations	1	6	129		A
21	1	32 Bits Frozen Counter			129	1	
22	0	Counter Change Event – All variations	1	6,7,8	129		B
30	0	Analog Input – All variations	1	6			
30	2	16-Bit Analog Input			129	1	Assigned to Class 0.
32	0	Analog Change Event – All variations	1	6,7,8			
32	4	16-Bit Analog Change Event with Time			129,130	28	Assigned to Class 2.
40	0	Analog Output Status – All variations	1	6	129		A
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129		A
50	1	Time and Date	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (ZLV will parse)		RESPONSE (ZLV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	N/A		B
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

A: Device implementation level does not support this group and variation of object or, for static objects, it has no objects with this group and variation. **OBJECT UNKNOWN** response (IIN2 bit 1 set).

B: No point range was specified, and device has no objects of this type. **NULL response** (no IIN bits set, but no objects of the specified type returned).

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1 and 2) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured “on”, then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as** 50 Binary Input Changes **and** 50 Analog Input Changes**. If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- Configuration ➔ Binary Inputs/Outputs **menu: contains the default configuration (as shipped from factory or after a reset by means of F4 key), but customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assigned to Class 1.		
Index	Description	
0	*Configure by ZIVercomPlus*® 2048 points	
1	*Configure by ZIVercomPlus*® 2048 points	
2	*Configure by ZIVercomPlus*® 2048 points	
3	*Configure by ZIVercomPlus*® 2048 points	
4	*Configure by ZIVercomPlus*® 2048 points	
5	*Configure by ZIVercomPlus*® 2048 points	
6	*Configure by ZIVercomPlus*® 2048 points	
7	*Configure by ZIVercomPlus*® 2048 points	
8	*Configure by ZIVercomPlus*® 2048 points	
9	*Configure by ZIVercomPlus*® 2048 points	
10	*Configure by ZIVercomPlus*® 2048 points	
11	*Configure by ZIVercomPlus*® 2048 points	
12	*Configure by ZIVercomPlus*® 2048 points	
13	*Configure by ZIVercomPlus*® 2048 points	
14	*Configure by ZIVercomPlus*® 2048 points	
15	*Configure by ZIVercomPlus*® 2048 points	
16	*Configure by ZIVercomPlus*® 2048 points	
17	*Configure by ZIVercomPlus*® 2048 points	
...	*Configure by ZIVercomPlus*® 2048 points	
253	*Configure by ZIVercomPlus*® 2048 points	
254	*Configure by ZIVercomPlus*® 2048 points	
255	*Configure by ZIVercomPlus*® 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	Description	
0	***Configure by ZIVercomPlus*® 256 points**	
1	***Configure by ZIVercomPlus*® 256 points**	
2	***Configure by ZIVercomPlus*® 256 points**	
3	***Configure by ZIVercomPlus*® 256 points**	
4	***Configure by ZIVercomPlus*® 256 points**	
5	***Configure by ZIVercomPlus*® 256 points**	
6	***Configure by ZIVercomPlus*® 256 points**	
7	***Configure by ZIVercomPlus*® 256 points**	
8	***Configure by ZIVercomPlus*® 256 points**	
9	***Configure by ZIVercomPlus*® 256 points**	
10	***Configure by ZIVercomPlus*® 256 points**	
11	***Configure by ZIVercomPlus*® 256 points**	
12	***Configure by ZIVercomPlus*® 256 points**	
13	***Configure by ZIVercomPlus*® 256 points**	
14	***Configure by ZIVercomPlus*® 256 points**	
15	***Configure by ZIVercomPlus*® 256 points**	
16	***Configure by ZIVercomPlus*® 256 points**	
17	***Configure by ZIVercomPlus*® 256 points**	
...	***Configure by ZIVercomPlus*® 256 points**	
253	***Configure by ZIVercomPlus*® 256 points**	
254	***Configure by ZIVercomPlus*® 256 points**	
255	***Configure by ZIVercomPlus*® 256 points**	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assigned to Class 2.		
Index	Description	Deadband
0	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_1.
1	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_2.
2	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_3.
3	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_4.
4	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_5.
5	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_6.
6	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_7.
7	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_8.
8	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_9.
9	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_10.
10	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_11.
11	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_12.
12	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_13.
13	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_14.
14	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_15.
15	*Configure by ZIVercomPlus*® 512 points	◊ Deadband_16.

Additional assign with *ZIVercomPlus*Ⓡ:

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0.	
Index	**Description**
16	***Configure by ZIVercomPlus*Ⓡ *512 points***
17	***Configure by ZIVercomPlus*Ⓡ *512 points***
18	***Configure by ZIVercomPlus*Ⓡ *512 points***
19	***Configure by ZIVercomPlus*Ⓡ *512 points***
20	***Configure by ZIVercomPlus*Ⓡ *512 points***
21	***Configure by ZIVercomPlus*Ⓡ *512 points***
22	***Configure by ZIVercomPlus*Ⓡ *512 points***
23	***Configure by ZIVercomPlus*Ⓡ *512 points***
24	***Configure by ZIVercomPlus*Ⓡ *512 points***
25	***Configure by ZIVercomPlus*Ⓡ *512 points***
26	***Configure by ZIVercomPlus*Ⓡ *512 points***
27	***Configure by ZIVercomPlus*Ⓡ *512 points***
....	***Configure by ZIVercomPlus*Ⓡ *512 points***
254	***Configure by ZIVercomPlus*Ⓡ *512 points***
255	***Configure by ZIVercomPlus*Ⓡ *512 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	**Full Scale Range**		
	Engineering units	**Counts**	
Currents (Phases, ground, sequences)	0 to 1,2 x In_{PHASE} A	0 to 32767	Currents (Phases, ground, sequences)
Currents (Polarizing)	0 to 1,2 x In_{POL} A	0 to 32767	Currents (Polarizing)
Currents (Parallel line)	0 to 1,2 x In_{NPAR} A	0 to 32767	Currents (Parallel line)
Voltages (Phase to ground, sequences)	0 to 1,2 x Vn/√3 V	0 to 32767	Voltages (Phase to ground, sequences)
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	Voltages(Phase to phase, synchronizing)
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	Power (Real, reactive, apparent)
Power factor	-1 to 1	-32768 to 32767	Power factor
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	Frequency

With ***ZIVercomPlus®*** program it's possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*, which is the unit used by the protocol. There are three parameters to determine the distance range covered:

- **Offset:** minimum value of each magnitude to transmit 0 counts.
- **Limit:** it's the length of the magnitude range used to calculate the number of counts to transmit. If **offset** is 0, it's the same as the value of the magnitude for which the maximum number of counts defined by the protocol is sent (32767 counts).
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureComm = \frac{Measure - Offset}{RatedValue} \times \frac{32767}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureComm = (Measure - Offset) \times \frac{32767}{Limit}$$

Deadbands

- Deadbands are used for configuring *Analog Input Change* objects (Object 32).
- A Deadband is defined as a percentage over the **Full Scale Range (FSR)**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface), between 0.00% and 100.00%, in steps of 0.01%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Analog Input.

Energy counters

The range for the energy counters in primary values is from 100wh/varh to 99999Mwh/Mvarh, and these are the values transmitted by protocol.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings						
DNP Protocol Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
DNP Port 1 Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Baud rate	**Integer**	**300**	**38400**	**38400**	**300 600 1200 2400 4800 9600 19200 38400**	**baud**
Stop Bits	**Integer**	**1**	**2**	**1**	**1**	
Parity	**Integer**	**None Odd Even**	**None Odd Even**	**None**	**None Odd Even**	
Rx Time btw. Char	**Float**	**1**	**60000**	**0.5**	**40**	**msec.**
Comms Fail Ind. Time	**Float**	**0**	**600**	**0.1**	**60**	**s**

Advaced settings						
Flow control						
CTS Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Sensitive	Bool	No Yes	No Yes	No	No Yes	
DTR Control	Integer	Inactive Active Rec. Req.	Inactive Active Rec. Req.	Inactive	Inactive Active Rec. Req.	
RTS Control	Integer	Inactive Active Rec. Req. Sen. Req.	Inactive Active Rec. Req. Sen. Req.	Inactive	Inactive Active Rec. Req. Sen. Req.	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO DCD	NO ECHO DCD	NO	NO ECHO DCD	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

DNP Port 2 Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Protocol Select	Uinteger	Procome Dnp3 Modbus	Procome Dnp3 Modbus	Procome	Procome Dnp3 Modbus	
Baud rate	Integer	300	38400	38400	300 600 1200 2400 4800 9600 19200 38400	baud
Stop Bits	Integer	1	2	1	1	
Parity	Integer	None Odd Even	None Odd Even	None	None Odd Even	
Rx Time btw. Char	Float	1	60000	0.5	40	msec.
Comms Fail Ind. Time	Float	0	600	0.1	60	s

Advaced settings						
Operating Mode	Integer	RS-232 RS-485	RS-232 RS-485	RS-232	RS-232 RS-485	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Wait N Bytes 485	Integer	0	4	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO	NO ECHO	NO	NO ECHO	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.
Analog Inputs (Deadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband AI#0	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#1	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#2	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#3	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#4	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#5	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#6	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#7	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#8	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#9	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#10	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#11	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#12	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#13	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#14	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#15	Float	0 %	100 %	100 %	0.01 %	

✓ **All settings remain unchanged after a power loss.**

DNP Protocol Configuration

- **Relay Number (RTU Address):**
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- **T Confirm Timeout (N7 Confirm Timeout) :**
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- **Max Retries (N7 Retries) :**
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- **Enable Unsolicited (Enable Unsolicited Reporting) :**
  Enables or disables Unsolicited reporting.
- **Enable Unsol. after Restart :**
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.
- **Unsolic. Master No. (MTU Address) :**
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- **Unsol. Grouping Time (Unsolicited Delay Reporting) :**
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- **Synchronization Interval**
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- **DNP 3.0 Rev.**
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)

DNP Port 1 and Port 2 Configuration

- **Number of Zeros (Advice_Time) :**
  Number of zeros before the message.
- **Max Retries (N1 Retries) :**
  Number of retries of the Physical Layer after collision detection.
- **Min Retry Time (Fixed_delay) :**
  Minimum time to retry of the Physical Layer after collision detection.
- **Max Retry Time :**
  Maximum time to retry of the Physical Layer after collision detection.
- **Collision Type :**

  Port 1:
  NO
  ECHO based on detection of transmitted data (monitoring all data transmitted on the link).

  Port 2:
  NO
  ECHO based on detection of transmitted data (monitoring all data transmitted on the link.
  DCD (Data Carrier Detect) based on detecting out-of-band carrier.

  If the device prepares to transmit and finds the link busy, it waits until is no longer busy, and then waits a backoff_time as follows:
  backoff_time = Min Retry Time + random(Max Retry Time - Max Retry Time)
  and transmit. If the device has a collision in transmission the device tries again,up to a configurable number of retries (Max Retries) if has news collision.

- **Wait N Bytes 485:**
  Number of wait bytes between Reception and transmission Use Port 2 Operate Mode RS-485.

Dnp3 Basic Extended Profile

(Version 02.45.00 is the first Software Version that supports this Profile)

DNP V3.00 Basic Extended Profile

DEVICE PROFILE DOCUMENT

This document must be accompanied by: **Implementation Table** and **Point List**.

Vendor Name: **ZIV Aplicaciones y Tecnología S.A.**

Device Name: **ZLV**

Highest DNP Level Supported:	Device Function:
For Requests 2 For Responses 2	☐ Master ☒ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

1) **Supports Enable/Disable Unsolicited Responses (FC=20 and 21), for classes 1 and 2.**
2) **Supports Write operations (FC=2) on Time and Date objects.**
3) **Supports Delay measurement Fine (FC=23).**
4) **Supports Warm Start command (FC=14).**
5) **Supports Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)**
6) **Supports selection of DNP3 Revision.**
7) **Supports indication of no synchronization in time.**
8) **Supports simultaneous communications with two different Master devices**
9) **Supports respond to Multiple Read Request with multiple object types in the same Application Fragment .**

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted **292** Received **292**	Transmitted **2048** (if >2048, must be configurable) Received **249** (must be <= 249)

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☒ None ☐ Fixed at ____________ ☐ Configurable, range ___ to ______	☐ None ☒ Configurable, range **0** to **3** (Fixed is not permitted)

Requires Data Link Layer Confirmation:

☒ Never
☐ Always
☐ Sometimes. If 'Sometimes', when? ________________________________
☐ Configurable. If 'Configurable', how? ________________________________

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always (not recommended)
- ☒ When reporting Event Data (Slave devices only) **For unsolicited, Class 1 and Class 2 responses that contain Event Data. (If there is no Event Data reported into a Class 1 or 2 response, Application Layer Confirmation is not requested)**
- ☐ When sending multi-fragment responses (Slave devices only)
- ☐ Sometimes. If 'Sometimes', when?
- ☐ Configurable. If 'Configurable', how?

Timeouts while waiting for:

Data Link Confirm	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Complete Appl. Fragment	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable
Complete Appl. Response	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable

Others ____

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout

Application Confirm timeout setting (*MMI*): Range 50 ms. 65.535 ms.

Sends/Executes Control Operations:

- Maximum number of CROB (obj. 12, var. 1) objects supported in a single message **1**
- Maximum number of Analog Output (obj. 41, any var.) supported in a single message **0**

☐ Pattern Control Block and Pattern Mask (obj. 12, var. 2 and 3 respectively) supported.
☐ CROB (obj. 12) and Analog Output (obj. 41) permitted together in a single message.

WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT (3) / OPERATE (4)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE (5)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK (6)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable

Count > 1	☐ Never	☐ Always	☒ Sometimes	☐ Configurable
Pulse On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Pulse Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation:

- **All points support the same Function Codes: (3) Select, (4) Operate, (5) Direct Operate and (6) Direct Operate - No ACK.**
- **Maximum Select/Operate Delay Time: 60 seconds.**
- **Count can be >1 only for PULSE ON and PULSE OFF**

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:	
Reports Binary Input Change Events when no specific variation requested: ☐ Never ☒ Only time-tagged ☐ Only non-time-tagged ☐ Configurable to send both, one or the other (attach explanation)	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☒ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable (attach explanation)
Sends Unsolicited Responses: ☐ Never ☒ Configurable (**See Note D**) ☒ Only certain objects **(Class 1 and 2)** ☐ Sometimes (attach explanation) ☒ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable (attach explanation) ☒ Default Object 20,21 Default Variation 1 ☐ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☐ 32 Bits ☒ Other Value 31 Bits ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ☒ Yes ☐ No	

QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS

Function Codes

1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
9	Direct Operate-No ACK
10	Immediate Freeze
11	Immediate Freeze no ACK
13	Cold Start
14	Warm Start
20	Enable Unsol. Messages
21	Disable Unsol. Messages
23	Delay Measurement
129	Response
130	Unsolicited Message

7	6	5	4	3	2	1	0
	Index Size			Qualifier Code			

Index Size

0- No Index, Packed
1- 1 byte Index
2- 2 byte Index
3- 4 byte Index
4- 1 byte Object Size
5- 2 byte Object Size
6- 4 byte Object Size

Qualifier Code

0- 8-Bit Start and Stop Indices
1- 16-Bit Start and Stop Indices
2- 32-Bit Start and Stop Indices
3- 8-Bit Absolute address Ident.
4- 16-Bit Absolute address Ident.
5- 32-Bit Absolute address Ident.
6- No Range Field (all)
7- 8-Bit Quantity
8- 16-Bit Quantity
9- 32-Bit Quantity
11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (ZLV will parse)		RESPONSE (ZLV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	**1**	6			
1	1	Binary Input			129	1	Assigned to Class 0.
2	0	Binary Input Change – All variations	1	6,7,8			
2	1	Binary Input Change without Time	1	6,7,8	129		B
2	2	Binary Input Change with Time	1	6,7,8	129,130	28	Assigned to Class 1.
2	3	Binary Input Change with Relative Time	1	6,7,8	129		B
10	0	Binary Outputs – All variations	1	6	129		A
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	
20	0	Binary Counter – All variations	1	6	129		~~A~~
20	1	32 Bits Binary Counter			129	1	
21	0	Frozen Counter – All variations	1	6	129		~~A~~
21	1	32 Bits Frozen Counter			129	1	
22	0	Counter Change Event – All variations	1	6,7,8	129		B
30	0	Analog Input – All variations	1	6			
30	2	16-Bit Analog Input			129	1	Assigned to Class 0.
32	0	Analog Change Event – All variations	1	6,7,8			
32	4	16-Bit Analog Change Event with Time			129,130	28	Assigned to Class 2.
40	0	Analog Output Status – All variations	1	6	129		A
41	2	16-Bit Analog Output Block	3,4,5,6	17,28	129		A
50	1	Time and Date	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (ZLV will parse)		RESPONSE (ZLV will respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	N/A		B
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

A: Device implementation level does not support this group and variation of object or, for static objects, it has no objects with this group and variation. **OBJECT UNKNOWN** response (IIN2 bit 1 set).

B: No point range was specified, and device has no objects of this type. **NULL response** (no IIN bits set, but no objects of the specified type returned).

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1 and 2) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured "on", then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as** 50 Binary Input Changes **and** 50 Analog Input Changes**. If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- Configuration ➔ Binary Inputs/Outputs **menu: contains the default configuration (as shipped from factory or after a reset by means of F4 key), but customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assigned to Class 1.		
Index	Description	
0	*Configure by ZIVercomPlus*® 2048 points	
1	*Configure by ZIVercomPlus*® 2048 points	
2	*Configure by ZIVercomPlus*® 2048 points	
3	*Configure by ZIVercomPlus*® 2048 points	
4	*Configure by ZIVercomPlus*® 2048 points	
5	*Configure by ZIVercomPlus*® 2048 points	
6	*Configure by ZIVercomPlus*® 2048 points	
7	*Configure by ZIVercomPlus*® 2048 points	
8	*Configure by ZIVercomPlus*® 2048 points	
9	*Configure by ZIVercomPlus*® 2048 points	
10	*Configure by ZIVercomPlus*® 2048 points	
11	*Configure by ZIVercomPlus*® 2048 points	
12	*Configure by ZIVercomPlus*® 2048 points	
13	*Configure by ZIVercomPlus*® 2048 points	
14	*Configure by ZIVercomPlus*® 2048 points	
15	*Configure by ZIVercomPlus*® 2048 points	
16	*Configure by ZIVercomPlus*® 2048 points	
17	*Configure by ZIVercomPlus*® 2048 points	
...	*Configure by ZIVercomPlus*® 2048 points	
253	*Configure by ZIVercomPlus*® 2048 points	
254	*Configure by ZIVercomPlus*® 2048 points	
255	*Configure by ZIVercomPlus*® 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
0	***Configure by ZIVercomPlus®*** **256 points**	
1	***Configure by ZIVercomPlus®*** **256 points**	
2	***Configure by ZIVercomPlus®*** **256 points**	
3	***Configure by ZIVercomPlus®*** **256 points**	
4	***Configure by ZIVercomPlus®*** **256 points**	
5	***Configure by ZIVercomPlus®*** **256 points**	
6	***Configure by ZIVercomPlus®*** **256 points**	
7	***Configure by ZIVercomPlus®*** **256 points**	
8	***Configure by ZIVercomPlus®*** **256 points**	
9	***Configure by ZIVercomPlus®*** **256 points**	
10	***Configure by ZIVercomPlus®*** **256 points**	
11	***Configure by ZIVercomPlus®*** **256 points**	
12	***Configure by ZIVercomPlus®*** **256 points**	
13	***Configure by ZIVercomPlus®*** **256 points**	
14	***Configure by ZIVercomPlus®*** **256 points**	
15	***Configure by ZIVercomPlus®*** **256 points**	
16	***Configure by ZIVercomPlus®*** **256 points**	
17	***Configure by ZIVercomPlus®*** **256 points**	
...	***Configure by ZIVercomPlus®*** **256 points**	
253	***Configure by ZIVercomPlus®*** **256 points**	
254	***Configure by ZIVercomPlus®*** **256 points**	
255	***Configure by ZIVercomPlus®*** **256 points**	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assigned to Class 2.		
Index	Description	Deadband
0	*Configure by ZIVercomPlus*® 512 points	◊Deadband_1.
1	*Configure by ZIVercomPlus*® 512 points	◊Deadband_2.
2	*Configure by ZIVercomPlus*® 512 points	◊Deadband_3.
3	*Configure by ZIVercomPlus*® 512 points	◊Deadband_4.
4	*Configure by ZIVercomPlus*® 512 points	◊Deadband_5.
5	*Configure by ZIVercomPlus*® 512 points	◊Deadband_6.
6	*Configure by ZIVercomPlus*® 512 points	◊Deadband_7.
7	*Configure by ZIVercomPlus*® 512 points	◊Deadband_8.
8	*Configure by ZIVercomPlus*® 512 points	◊Deadband_9.
9	*Configure by ZIVercomPlus*® 512 points	◊Deadband_10.
10	*Configure by ZIVercomPlus*® 512 points	◊Deadband_11.
11	*Configure by ZIVercomPlus*® 512 points	◊Deadband_12.
12	*Configure by ZIVercomPlus*® 512 points	◊Deadband_13.
13	*Configure by ZIVercomPlus*® 512 points	◊Deadband_14.
14	*Configure by ZIVercomPlus*® 512 points	◊Deadband_15.
15	*Configure by ZIVercomPlus*® 512 points	◊Deadband_16.

Additional assign with *ZIVercomPlus*®:

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0.	
Index	**Description**
16	***Configure by ZIVercomPlus® 512 points***
17	***Configure by ZIVercomPlus® 512 points***
18	***Configure by ZIVercomPlus® 512 points***
19	***Configure by ZIVercomPlus® 512 points***
20	***Configure by ZIVercomPlus® 512 points***
21	***Configure by ZIVercomPlus® 512 points***
22	***Configure by ZIVercomPlus® 512 points***
23	***Configure by ZIVercomPlus® 512 points***
24	***Configure by ZIVercomPlus® 512 points***
25	***Configure by ZIVercomPlus® 512 points***
26	***Configure by ZIVercomPlus® 512 points***
27	***Configure by ZIVercomPlus® 512 points***
....	***Configure by ZIVercomPlus® 512 points***
254	***Configure by ZIVercomPlus® 512 points***
255	***Configure by ZIVercomPlus® 512 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	Full Scale Range		
	Engineering units	Counts	
Currents (Phases, ground, sequences)	0 to 1,2 x In_{PHASE} A	0 to 32767	Currents (Phases, ground, sequences)
Currents (Polarizing)	0 to 1,2 x In_{POL} A	0 to 32767	Currents (Polarizing)
Currents (Parallel line)	0 to 1,2 x In_{NPAR} A	0 to 32767	Currents (Parallel line)
Voltages (Phase to ground, sequences)	0 to 1,2 x Vn/√3 V	0 to 32767	Voltages (Phase to ground, sequences)
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	Voltages(Phase to phase, synchronizing)
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	Power (Real, reactive, apparent)
Power factor	-1 to 1	-32768 to 32767	Power factor
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	Frequency

With ***ZIVercomPlus®*** program it's possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*, which is the unit used by the protocol. There are three parameters to determine the distance range covered:

- **Offset:** minimum value of each magnitude to transmit 0 counts.
- **Limit:** it's the length of the magnitude range used to calculate the number of counts to transmit. If **offset** is 0, it's the same as the value of the magnitude for which the maximum number of counts defined by the protocol is sent (32767 counts).
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureComm = \frac{Measure - Offset}{RatedValue} \times \frac{32767}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureComm = (Measure - Offset) \times \frac{32767}{Limit}$$

Deadbands

- Deadbands are used for configuring *Analog Input Change* objects (Object 32).
- A Deadband is defined as a percentage over the **Full Scale Range (FSR)**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface), between 0.00% and 100.00%, in steps of 0.01%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Analog Input.

Energy counters

The range for the energy counters in primary values is from 100wh/varh to 99999Mwh/Mvarh, and these are the values transmitted by protocol.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings						
DNP Protocol Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
DNP Port 1 Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Baud rate	**Integer**	**300**	**38400**	**38400**	**300 600 1200 2400 4800 9600 19200 38400**	**baud**
Stop Bits	**Integer**	**1**	**2**	**1**	**1**	
Parity	**Integer**	**None Odd Even**	**None Odd Even**	**None**	**None Odd Even**	
Rx Time btw. Char	**Float**	**1**	**60000**	**0.5**	**40**	**msec.**
Comms Fail Ind. Time	**Float**	**0**	**600**	**0.1**	**60**	**s**

Advaced settings						
Flow control						
CTS Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Sensitive	Bool	No Yes	No Yes	No	No Yes	
DTR Control	Integer	Inactive Active Rec. Req.	Inactive Active Rec. Req.	Inactive	Inactive Active Rec. Req.	
RTS Control	Integer	Inactive Active Rec. Req. Sen. Req.	Inactive Active Rec. Req. Sen. Req.	Inactive	Inactive Active Rec. Req. Sen. Req.	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO DCD	NO ECHO DCD	NO	NO ECHO DCD	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

DNP Port 2 Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Protocol Select	Uinteger	Procome Dnp3 Modbus	Procome Dnp3 Modbus	Procome	Procome Dnp3 Modbus	
Baud rate	Integer	300	38400	38400	300 600 1200 2400 4800 9600 19200 38400	baud
Stop Bits	Integer	1	2	1	1	
Parity	Integer	None Odd Even	None Odd Even	None	None Odd Even	
Rx Time btw. Char	Float	1	60000	0.5	40	msec.
Comms Fail Ind. Time	Float	0	600	0.1	60	s

Advaced settings						
Operating Mode	Integer	RS-232 RS-485	RS-232 RS-485	RS-232	RS-232 RS-485	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Wait N Bytes 485	Integer	0	4	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO	NO ECHO	NO	NO ECHO	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

Analog Inputs (Deadbands)

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step	Unit
Deadband AI#0	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#1	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#2	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#3	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#4	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#5	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#6	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#7	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#8	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#9	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#10	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#11	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#12	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#13	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#14	Float	0 %	100 %	100 %	0.01 %	
Deadband AI#15	Float	0 %	100 %	100 %	0.01 %	

✓ **All settings remain unchanged after a power loss.**

DNP Protocol Configuration

- Relay Number (**RTU Address**):
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- T Confirm Timeout **(N7 Confirm Timeout) :**
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- Max Retries **(N7 Retries) :**
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- Enable Unsolicited **(Enable Unsolicited Reporting) :**
  Enables or disables Unsolicited reporting.
- Enable Unsol. after Restart **:**
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.
- Unsolic. Master No. (**MTU Address) :**
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- Unsol. Grouping Time **(Unsolicited Delay Reporting) :**
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- Synchronization Interval
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- DNP 3.0 Rev.
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)

DNP Port 1 and Port 2 Configuration

- **Number of Zeros (Advice_Time) :**
  Number of zeros before the message.
- **Max Retries (N1 Retries) :**
  Number of retries of the Physical Layer after collision detection.
- **Min Retry Time (Fixed_delay) :**
  Minimum time to retry of the Physical Layer after collision detection.
- **Max Retry Time :**
  Maximum time to retry of the Physical Layer after collision detection.
- **Collision Type :**

  Port 1:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link).

  Port 2:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link.

  DCD (Data Carrier Detect) based on detecting out-of-band carrier.

  If the device prepares to transmit and finds the link busy, it waits until is no longer busy, and then waits a backoff_time as follows:

  backoff_time = Min Retry Time + random(Max Retry Time - Max Retry Time)

  and transmit. If the device has a collision in transmission the device tries again,up to a configurable number of retries (Max Retries) if has news collision.

- **Wait N Bytes 485:**
  Number of wait bytes between Reception and transmission Use Port 2 Operate Mode RS-485.

Dnp3 Profile II

(Version 02.46.00 is the first Software Version that supports this Profile)

DNP V3.00 Profile II

DEVICE PROFILE DOCUMENT

This document must be accompanied by: **Implementation Table** and **Point List**.

Vendor Name: **ZIV Aplicaciones y Tecnología S.A.**

Device Name: **ZLV**

Highest DNP Level Supported:	Device Function:
For Requests **2** For Responses **2**	☐ Master ☒ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

1) **Supports Enable/Disable Unsolicited Responses (FC=20 and 21), for classes 1 and 2.**
2) **Supports Write operations (FC=2) on Time and Date objects.**
3) **Supports Delay measurement Fine (FC=23).**
4) **Supports Warm Start command (FC=14).**
5) **Supports Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)**
6) **Supports selection of DNP3 Revision.**
7) **Supports indication of no synchronization in time.**
8) **Supports simultaneous communications with two different Master devices**
9) **Supports assign event Class for Binary, Analog and Counter events: Class 1 , Class 2, Class 3, None**
10) **Supports respond to Multiple Read Request with multiple object types in the same Application Fragment .**

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted **292** Received **292**	Transmitted **2048** (if >2048, must be configurable) Received **249** (must be <= 249)

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☒ None ☐ Fixed at ____ ☐ Configurable, range ___ to ______	☐ None ☒ Configurable, range **0** to **3** (Fixed is not permitted)

Requires Data Link Layer Confirmation:

☒ Never
☐ Always
☐ Sometimes. If 'Sometimes', when? ____________
☐ Configurable. If 'Configurable', how? ____________

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always (not recommended)
- ☒ When reporting Event Data (Slave devices only) **For unsolicited, Class 1 Class 2 and Class 3 responses that contain Event Data. (If there is no Event Data reported into a Class 1 2 or 3 response, Application Layer Confirmation is not requested)**
- ☐ When sending multi-fragment responses (Slave devices only)
- ☐ Sometimes. If 'Sometimes', when?
- ☐ Configurable. If 'Configurable', how?

Timeouts while waiting for:

Data Link Confirm	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Complete Appl. Fragment	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable
Complete Appl. Response	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable

Others

____

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout

Application Confirm timeout setting (*MMI*): Range 50 ms. 65.535 ms.

Sends/Executes Control Operations:

- Maximum number of CROB (obj. 12, var. 1) objects supported in a single message **1**
- Maximum number of Analog Output (obj. 41, any var.) supported in a single message **0**

☐ Pattern Control Block and Pattern Mask (obj. 12, var. 2 and 3 respectively) supported.
☐ CROB (obj. 12) and Analog Output (obj. 41) permitted together in a single message.

WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT (3) / OPERATE (4)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE (5)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK (6)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable

Count > 1	☐ Never	☐ Always	☒ Sometimes	☐ Configurable
Pulse On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Pulse Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation:

- **All points support the same Function Codes: (3) Select, (4) Operate, (5) Direct Operate and (6) Direct Operate - No ACK.**
- **Maximum Select/Operate Delay Time: 60 seconds.**
- **Count can be >1 only for PULSE ON and PULSE OFF**

<table>
<tr><th colspan="2">FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:</th></tr>
<tr><td>Reports Binary Input Change Events when no specific variation requested:

☐ Never
☒ Only time-tagged
☐ Only non-time-tagged
☐ Configurable to send both, one or the other (attach explanation)</td><td>Reports time-tagged Binary Input Change Events when no specific variation requested:

☐ Never
☒ Binary Input Change With Time
☐ Binary Input Change With Relative Time
☐ Configurable (attach explanation)</td></tr>
<tr><td>Sends Unsolicited Responses:

☐ Never
☒ Configurable (See Note D)
☒ Only certain objects (Class 1 2 and 3)
☐ Sometimes (attach explanation)

☒ ENABLE/DISABLE UNSOLICITED Function codes supported</td><td>Sends Static Data in Unsolicited Responses:

☒ Never
☐ When Device Restarts
☐ When Status Flags Change

No other options are permitted.</td></tr>
<tr><td>Default Counter Object/Variation:

☐ No Counters Reported
☐ Configurable (attach explanation)
☒ Default Object 20,21
Default Variation 1
☐ Point-by-point list attached</td><td>Counters Roll Over at:

☐ No Counters Reported
☐ Configurable (attach explanation)
☐ 16 Bits
☐ 32 Bits
☒ Other Value 31 Bits
☐ Point-by-point list attached</td></tr>
<tr><td colspan="2">Sends Multi-Fragment Responses: ☒ Yes ☐ No</td></tr>
</table>

QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS		
Function Codes 1 Read 2 Write 3 Select 4 Operate 5 Direct Operate 6 Direct Operate-No ACK 7 Immediate Freeze 8 Immediate Freeze no ACK 13 Cold Start 14 Warm Start 20 Enable Unsol. Messages 21 Disable Unsol. Messages 23 Delay Measurement 129 Response 130 Unsolicited Message	7 6 5 4 3 2 1 0 [ ] Index Size | Qualifier Code **Index Size** 0- No Index, Packed 1- 1 byte Index 2- 2 byte Index 3- 4 byte Index 4- 1 byte Object Size 5- 2 byte Object Size 6- 4 byte Object Size	**Qualifier Code** 0- 8-Bit Start and Stop Indices 1- 16-Bit Start and Stop Indices 2- 32-Bit Start and Stop Indices 3- 8-Bit Absolute address Ident. 4- 16-Bit Absolute address Ident. 5- 32-Bit Absolute address Ident. 6- No Range Field (all) 7- 8-Bit Quantity 8- 16-Bit Quantity 9- 32-Bit Quantity 11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (ZLV parse)		RESPONSE (ZLV respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
1	1	Binary Input	1	0,1,6,7,8	129	0,1	
2	0	Binary Input with Status	1	0,1,6,7,8	129	0,1	
2	0	Binary Input Change – All variations	1	6,7,8			
2	2	Binary Input Change with Time	1	6,7,8	129,130	17,,28	Assign to Event Class
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	Echo of request
20	0	Binary Counter – All variations	1	0,1,6,7,8			Assigned to Class 0.
20	1	32 Bits Binary Counter			129	0,1	
21	0	Frozen Counter – All variations	1	0,1,6,7,8			
21	1	32 Bits Frozen Counter			129	0,1	
22	0	Counter Change Event – All variations	1	6,7,8			
22	5	32 Bits Counter Change Event With Time			129,130	17,,28	Assign to Event Class
30	0	Analog Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	1	
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	1	
32	0	Analog Change Event – All variations	1	6,7,8			
32	3	32-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
32	4	16-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
50	1	Time and Date	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (ZLV parse)		RESPONSE (ZLV respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	129,130	28	D
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface ***ZIVercomPlus***). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1, 2 and 3) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured “on”, then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as 128** Binary Input Changes**,** 64 Analog Input Changes and 64 Counter Input Change. **If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- **Customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assign to Class.		
Index	Description	
0	*Configure by ZIVercomPlus®* 2048 points	
1	*Configure by ZIVercomPlus®* 2048 points	
2	*Configure by ZIVercomPlus®* 2048 points	
3	*Configure by ZIVercomPlus®* 2048 points	
4	*Configure by ZIVercomPlus®* 2048 points	
5	*Configure by ZIVercomPlus®* 2048 points	
6	*Configure by ZIVercomPlus®* 2048 points	
7	*Configure by ZIVercomPlus®* 2048 points	
8	*Configure by ZIVercomPlus®* 2048 points	
9	*Configure by ZIVercomPlus®* 2048 points	
10	*Configure by ZIVercomPlus®* 2048 points	
11	*Configure by ZIVercomPlus®* 2048 points	
12	*Configure by ZIVercomPlus®* 2048 points	
13	*Configure by ZIVercomPlus®* 2048 points	
14	*Configure by ZIVercomPlus®* 2048 points	
15	*Configure by ZIVercomPlus®* 2048 points	
16	*Configure by ZIVercomPlus®* 2048 points	
17	*Configure by ZIVercomPlus®* 2048 points	
...	*Configure by ZIVercomPlus®* 2048 points	
253	*Configure by ZIVercomPlus®* 2048 points	
254	*Configure by ZIVercomPlus®* 2048 points	
255	*Configure by ZIVercomPlus®* 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	Description	
0	*Configure by ZIVercomPlus®* 256 points	
1	*Configure by ZIVercomPlus®* 256 points	
2	*Configure by ZIVercomPlus®* 256 points	
3	*Configure by ZIVercomPlus®* 256 points	
4	*Configure by ZIVercomPlus®* 256 points	
5	*Configure by ZIVercomPlus®* 256 points	
6	*Configure by ZIVercomPlus®* 256 points	
7	*Configure by ZIVercomPlus®* 256 points	
8	*Configure by ZIVercomPlus®* 256 points	
9	*Configure by ZIVercomPlus®* 256 points	
10	*Configure by ZIVercomPlus®* 256 points	
11	*Configure by ZIVercomPlus®* 256 points	
12	*Configure by ZIVercomPlus®* 256 points	
13	*Configure by ZIVercomPlus®* 256 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
14	***Configure by ZIVercomPlus***® **256 points**	
15	***Configure by ZIVercomPlus***® **256 points**	
16	***Configure by ZIVercomPlus***® **256 points**	
17	***Configure by ZIVercomPlus***® **256 points**	
...	***Configure by ZIVercomPlus***® **256 points**	
253	***Configure by ZIVercomPlus***® **256 points**	
254	***Configure by ZIVercomPlus***® **256 points**	
255	***Configure by ZIVercomPlus***® **256 points**	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assign to Class		
Index	**Description**	**Deadband**
0	***Configure by ZIVercomPlus***® **256 points**	**Deadband_1.**
1	***Configure by ZIVercomPlus***® **256 points**	**Deadband_2.**
2	***Configure by ZIVercomPlus***® **256 points**	**Deadband_3.**
3	***Configure by ZIVercomPlus***® **256 points**	**Deadband_4.**
4	***Configure by ZIVercomPlus***® **256 points**	**Deadband_5.**
5	***Configure by ZIVercomPlus***® **256 points**	**Deadband_6.**
6	***Configure by ZIVercomPlus***® **256 points**	**Deadband_7.**
7	***Configure by ZIVercomPlus***® **256 points**	**Deadband_8.**
8	***Configure by ZIVercomPlus***® **256 points**	**Deadband_9.**
9	***Configure by ZIVercomPlus***® **256 points**	**Deadband_10.**
10	***Configure by ZIVercomPlus***® **256 points**	**Deadband_11.**
11	***Configure by ZIVercomPlus***® **256 points**	**Deadband_12.**
12	***Configure by ZIVercomPlus***® **256 points**	**Deadband_13.**
13	***Configure by ZIVercomPlus***® **256 points**	**Deadband_14.**
14	***Configure by ZIVercomPlus***® **256 points**	**Deadband_15.**
15	***Configure by ZIVercomPlus***® **256 points**	**Deadband_16.**

Additional assign with *ZIVercomPlus*⑧:

Index	Description
16	***Configure by ZIVercomPlus⑧ 256 points***
17	***Configure by ZIVercomPlus⑧ 256 points***
18	***Configure by ZIVercomPlus⑧ 256 points***
19	***Configure by ZIVercomPlus⑧ 256 points***
20	***Configure by ZIVercomPlus⑧ 256 points***
21	***Configure by ZIVercomPlus⑧ 256 points***
22	***Configure by ZIVercomPlus⑧ 256 points***
23	***Configure by ZIVercomPlus⑧ 256 points***
24	***Configure by ZIVercomPlus⑧ 256 points***
25	***Configure by ZIVercomPlus⑧ 256 points***
26	***Configure by ZIVercomPlus⑧ 256 points***
27	***Configure by ZIVercomPlus⑧ 256 points***
....	***Configure by ZIVercomPlus⑧ 256 points***
62	***Configure by ZIVercomPlus⑧ 256 points***
63	***Configure by ZIVercomPlus⑧ 256 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	Full Scale Range		
	Engineering units	Counts	
Currents (Phases, ground, sequences)	0 to 1,2 x In_{PHASE} A	0 to 32767	Currents (Phases, ground, sequences)
Currents (Polarizing)	0 to 1,2 x In_{POL} A	0 to 32767	Currents (Polarizing)
Currents (Parallel line)	0 to 1,2 x In_{NPAR} A	0 to 32767	Currents (Parallel line)
Voltages (Phase to ground, sequences)	0 to 1,2 x Vn/√3 V	0 to 32767	Voltages (Phase to ground, sequences)
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	Voltages(Phase to phase, synchronizing)
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	Power (Real, reactive, apparent)
Power factor	-1 to 1	-32768 to 32767	Power factor
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	Frequency

Communication Measure in Counts

With ***ZIVercomPlus*** program is possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de Magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Max Communication:** it's a constant that depend of the Number Bits of Analog Input.
  Max Communication=2(Number Bits Analog Input - 1)**
  For 16-Bit Analog Input (Obj 30 Var. 2) 2**(15) = 32.767 counts
  For 32-Bit Analog Input (Obj 30 Var. 1) 2**(31) = 2.147.483.647 counts
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** This *flag* defines if the **limit** is proportional to the **rated value** of the magnitude.
- **TR:** Secondary to Primary Transformation Ratio.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times \frac{MaxComunication}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times \frac{MaxComunication}{Limit}$$

Communication Measure in Engineering Units

With ***ZIVercomPlus*** program **also** it's possible to transmit each magnitude in Engineering Units. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the **rated value** of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.
- **TR:** Secondary to Primary Transformation Ratio.
- **Scaling Factor:** Multiply Factor of magnitude.

Mathematical expression to obtain **Measure in Engineering Units** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times ScalingFactor$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times ScalingFactor$$

DeadBands

- Deadband is an area of a magnitude range or band where no generate magnitude change (the magnitude is dead). Meaning that no generation of Analogical Change Events if difference with value of generation of previous change is not equal or greater that DeadBand calculated. There is an independent setting for each 16 Measures with change.
- A Deadband is calculated as a percentage defined in DeadBand Setting over value of **parameter Limit**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 0.0000% and 100.00%, in steps of 0.0001%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Magnitude with change.

BINARY COUNTER (OBJECT 20) -> Assigned to Class 0. FROZEN COUNTER (OBJECT 21) 32 BIT COUNTER CHANGE EVENT (OBJECT 22) -> Assign to Class		
Index	Description	Deadband
0	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_1.
1	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_2.
2	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_3.
3	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_4.
4	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_5.
5	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_6
6	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_7.
7	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_8.
8	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_9.
9	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_10.
10	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_11.
11	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_12.
12	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_13.
13	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_14.
14	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_15.
15	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_16.
16	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_17.
17	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_18.
18	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_19.
19	*Configure by ZIVercomPlus*® 256 points	◊ CounterDeadBand_20.

◊ CounterDeadBands

- CounterDeadband is an area of a counter magnitude range or band, where no generate counter magnitude change (the communication counter magnitude is dead).Meaning that no generation of Counter Change Events if difference with value of generation of previous change is not equal or greater that CounterDeadBand setting. There is an independent setting for each Counter.

- The CounterDeadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 1 and 32767, in steps of 1, default value is 1.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings

DNP Protocol Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
Binary Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 1	None Class 1 Class 2 Class 3	
Analog Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 2	None Class 1 Class 2 Class 3	
Counter Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 3	None Class 1 Class 2 Class 3	
Binary Status Change	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	
32 Bits Analog Input	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	

Analog Inputs (Deadbands)

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step	Unit
Deadband AI#0	Float	0 %	100 %	100 %	0.0001 %	
Deadband AI#1	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#2	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#3	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#4	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#5	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#6	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#7	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#8	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#9	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#10	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#11	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#12	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#13	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#14	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#15	Float	0 %	100 %	100 %	0. 0001 %	

Counter Inputs (CounterDeadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband Cont.I#0	Integer	1	32767	1	1	
Deadband Cont.I#1	Integer	1	32767	1	1	
Deadband Cont.I#2	Integer	1	32767	1	1	
Deadband Cont.I#3	Integer	1	32767	1	1	
Deadband Cont.I#4	Integer	1	32767	1	1	
Deadband Cont.I#5	Integer	1	32767	1	1	
Deadband Cont.I#6	Integer	1	32767	1	1	
Deadband Cont.I#7	Integer	1	32767	1	1	
Deadband Cont.I#8	Integer	1	32767	1	1	
Deadband Cont.I#9	Integer	1	32767	1	1	
Deadband Cont.I#10	Integer	1	32767	1	1	
Deadband Cont.I#11	Integer	1	32767	1	1	
Deadband Cont.I#12	Integer	1	32767	1	1	
Deadband Cont.I#13	Integer	1	32767	1	1	
Deadband Cont.I#14	Integer	1	32767	1	1	
Deadband Cont.I#15	Integer	1	32767	1	1	
Deadband Cont.I#16	Integer	1	32767	1	1	
Deadband Cont.I#17	Integer	1	32767	1	1	
Deadband Cont.I#18	Integer	1	32767	1	1	
Deadband Cont.I#19	Integer	1	32767	1	1	
DNP Port 1 Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step/ Select**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Baud rate	**Integer**	**300**	**38400**	**38400**	**300 600 1200 2400 4800 9600 19200 38400**	**baud**
Stop Bits	**Integer**	**1**	**2**	**1**	**1**	
Parity	**Integer**	**None Odd Even**	**None Odd Even**	**None**	**None Odd Even**	
Rx Time btw. Char	**Float**	**1**	**60000**	**0.5**	**40**	**msec.**
Comms Fail Ind. Time	**Float**	**0**	**600**	**0.1**	**60**	**s**

Advanced Settings						
Flow control						
CTS Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Flow	Bool	No Yes	No Yes	No	No Yes	
DSR Sensitive	Bool	No Yes	No Yes	No	No Yes	
DTR Control	Integer	Inactive Active Rec. Req.	Inactive Active Rec. Req.	Inactive	Inactive Active Rec. Req.	
RTS Control	Integer	Inactive Active Rec. Req. Sen. Req.	Inactive Active Rec. Req. Sen. Req.	Inactive	Inactive Active Rec. Req. Sen. Req.	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO DCD	NO ECHO DCD	NO	NO ECHO DCD	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

DNP Port 2 and 3 Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Protocol Select	Uinteger	Procome Dnp3 Modbus	Procome Dnp3 Modbus	Procome	Procome Dnp3 Modbus	
Baud rate	Integer	300	38400	38400	300 600 1200 2400 4800 9600 19200 38400	baud
Stop Bits	Integer	1	2	1	1	
Parity	Integer	None Odd Even	None Odd Even	None	None Odd Even	
Rx Time btw. Char	Float	1	60000	0.5	40	msec.
Comms Fail Ind. Time	Float	0	600	0.1	60	s

Advanced Settings						
Operating Mode	Integer	RS-232 RS-485	RS-232 RS-485	RS-232	RS-232 RS-485	
Times						
Tx Time Factor	Float	0	100	1	0.5	
Tx Timeout Const	Uinteger	0	60000	0	1	
Wait N Bytes 485	Integer	0	4	0	1	
Message modification						
Number of Zeros	Integer	0	255	0	1	
collision						
Collision Type	Integer	NO ECHO	NO ECHO	NO	NO ECHO	
Max Retries	Integer	0	3	0	1	
Min Retry Time	Uinteger	0	60000	0	1	msec.
Max Retry Time	Uinteger	0	60000	0	1	msec.

✓ **All settings remain unchanged after a power loss.** F4

DNP Protocol Configuration

- <u>Relay Number</u> (**RTU Address**):
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- <u>T Confirm Timeout</u> **(N7 Confirm Timeout) :**
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- <u>Max Retries</u> **(N7 Retries) :**
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- <u>Enable Unsolicited</u> **(Enable Unsolicited Reporting) :**
  Enables or disables Unsolicited reporting.
- <u>Enable Unsol. after Restart</u> **:**
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.
- <u>Unsolic. Master No</u>. (**MTU Address) :**
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- <u>Unsol. Grouping Time</u> **(Unsolicited Delay Reporting) :**
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- <u>Synchronization Interval</u>
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- <u>DNP 3.0 Rev</u>.
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)
- <u>Binary Changes CLASS</u>.
  Selection to send Binary Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- <u>Analog Changes CLASS</u>.
  Selection to send Analog Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- <u>Counter Changes CLASS</u>.
  Selection to send Counter Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- <u>Binary Status</u> .
  Send Binary with status otherwise without status
- <u>32 Bits Analog Input</u> .
  Send Analog All Variations and Analog Change Event Binary Changes with 32 bits otherwise with 16 bits.

DNP Port 1 Port 2 and Port 3 Configuration

- **Number of Zeros (Advice_Time) :**
  Number of zeros before the message.
- **Max Retries (N1 Retries) :**
  Number of retries of the Physical Layer after collision detection.
- **Min Retry Time (Fixed_delay) :**
  Minimum time to retry of the Physical Layer after collision detection.
- **Max Retry Time :**
  Maximum time to retry of the Physical Layer after collision detection.
- **Collision Type :**

  Port 1:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link).

  Port 2:

  NO

  ECHO based on detection of transmitted data (monitoring all data transmitted on the link.

  DCD (Data Carrier Detect) based on detecting out-of-band carrier.

  If the device prepares to transmit and finds the link busy, it waits until is no longer busy, and then waits a backoff_time as follows:

  backoff_time = Min Retry Time + random(Max Retry Time - Max Retry Time)

  and transmit. If the device has a collision in transmission the device tries again ,up to a configurable number of retries (Max Retries) if has news collision.

- **Wait N Bytes 485:**
  Number of wait bytes between Reception and transmission Use Port 2 Operate Mode RS-485 .

Dnp3 Profile II Ethernet

(Version 02.60.00 is the first Software Version that supports this Profile)

DNP V3.00 Dnp3 Profile II Ethernet

DEVICE PROFILE DOCUMENT

This document must be accompanied by: **Implementation Table** and **Point List**.

Vendor Name: **ZIV Aplicaciones y Tecnología S.A.**

Device Name: **ZLV**

Highest DNP Level Supported:	Device Function:
For Requests **2** For Responses **2**	☐ Master ☒ Slave

Notable objects, functions, and/or qualifiers supported in addition to the Highest DNP Levels Supported (the complete list is described in the attached table):

1) **Supports Enable/Disable Unsolicited Responses (FC=20 and 21), for classes 1 and 2.**
2) **Supports Write operations (FC=2) on Time and Date objects.**
3) **Supports Delay measurement Fine (FC=23).**
4) **Supports Warm Start command (FC=14).**
5) **Supports Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)**
6) **Supports selection of DNP3 Revision.**
7) **Supports indication of no synchronization in time.**
8) **Supports simultaneous communications with two different Master devices**
9) **Supports assign event Class for Binary, Analog and Counter events: Class 1 , Class 2, Class 3, None**
10) **Supports respond to Multiple Read Request with multiple object types in the same Application Fragment .**

Maximum Data Link Frame Size (octets):	Maximum Application Fragment Size (octets):
Transmitted **292** Received **292**	Transmitted **2048** (if >2048, must be configurable) Received **249** (must be <= 249)

Maximum Data Link Re-tries:	Maximum Application Layer Re-tries:
☒ None ☐ Fixed at ______ ☐ Configurable, range ___ to ______	☐ None ☒ Configurable, range **0** to **3** (Fixed is not permitted)

Requires Data Link Layer Confirmation:

☒ Never
☐ Always
☐ Sometimes. If 'Sometimes', when? ________________
☐ Configurable. If 'Configurable', how? ________________

Requires Application Layer Confirmation:

- ☐ Never
- ☐ Always (not recommended)
- ☒ When reporting Event Data (Slave devices only) **For unsolicited, Class 1 Class 2 and Class 3 responses that contain Event Data. (If there is no Event Data reported into a Class 1 2 or 3 response, Application Layer Confirmation is not requested)**
- ☐ When sending multi-fragment responses (Slave devices only)
- ☐ Sometimes. If 'Sometimes', when?
- ☐ Configurable. If 'Configurable', how?

Timeouts while waiting for:

Data Link Confirm	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Complete Appl. Fragment	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable
Application Confirm	☐ None	☐ Fixed at ____	☐ Variable	☒ Configurable
Complete Appl. Response	☒ None	☐ Fixed at ____	☐ Variable	☐ Configurable

Others

Attach explanation if 'Variable' or 'Configurable' was checked for any timeout

Application Confirm timeout setting (*MMI*): Range 50 ms. 65.535 ms.

Sends/Executes Control Operations:

- Maximum number of CROB (obj. 12, var. 1) objects supported in a single message **1**
- Maximum number of Analog Output (obj. 41, any var.) supported in a single message **0**

☐ Pattern Control Block and Pattern Mask (obj. 12, var. 2 and 3 respectively) supported.
☐ CROB (obj. 12) and Analog Output (obj. 41) permitted together in a single message.

WRITE Binary Outputs	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
SELECT (3) / OPERATE (4)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE (5)	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
DIRECT OPERATE - NO ACK (6)	☐ Never	☒Always	☐ Sometimes	☐ Configurable

Count > 1	☐ Never	☐ Always	☒ Sometimes	☐ Configurable
Pulse On	☐ Never	☒Always	☐ Sometimes	☐ Configurable
Pulse Off	☐ Never	☒ Always	☐ Sometimes	☐ Configurable
Latch On	☐ Never	☒Always	☐ Sometimes	☐ Configurable
Latch Off	☐ Never	☒Always	☐ Sometimes	☐ Configurable
Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable
Clear Queue	☒ Never	☐ Always	☐ Sometimes	☐ Configurable

Attach explanation:

- **All points support the same Function Codes: (3) Select, (4) Operate, (5) Direct Operate and (6) Direct Operate - No ACK.**
- **Maximum Select/Operate Delay Time: 60 seconds.**
- **Count can be >1 only for PULSE ON and PULSE OFF**

FILL OUT THE FOLLOWING ITEMS FOR SLAVE DEVICES ONLY:	
Reports Binary Input Change Events when no specific variation requested: ☐ Never ☒ Only time-tagged ☐ Only non-time-tagged ☐ Configurable to send both, one or the other (attach explanation)	Reports time-tagged Binary Input Change Events when no specific variation requested: ☐ Never ☒ Binary Input Change With Time ☐ Binary Input Change With Relative Time ☐ Configurable (attach explanation)
Sends Unsolicited Responses: ☐ Never ☒ Configurable (**See Note D**) ☒ Only certain objects **(Class 1 2 and 3)** ☐ Sometimes (attach explanation) ☒ ENABLE/DISABLE UNSOLICITED Function codes supported	Sends Static Data in Unsolicited Responses: ☒ Never ☐ When Device Restarts ☐ When Status Flags Change No other options are permitted.
Default Counter Object/Variation: ☐ No Counters Reported ☐ Configurable (attach explanation) ☒ Default Object 20,21 Default Variation 1 ☐ Point-by-point list attached	Counters Roll Over at: ☐ No Counters Reported ☐ Configurable (attach explanation) ☐ 16 Bits ☐ 32 Bits ☒ Other Value 31 Bits ☐ Point-by-point list attached
Sends Multi-Fragment Responses: ☒ Yes ☐ No	

QUICK REFERENCE FOR DNP3.0 LEVEL 2 FUNCTION CODES & QUALIFIERS

Function Codes

1	Read
2	Write
3	Select
4	Operate
5	Direct Operate
9	Direct Operate-No ACK
10	Immediate Freeze
11	Immediate Freeze no ACK
13	Cold Start
14	Warm Start
20	Enable Unsol. Messages
21	Disable Unsol. Messages
23	Delay Measurement
24	Record Current Time
129	Response
130	Unsolicited Message

7	6	5	4	3	2	1	0
	Index Size			Qualifier Code			

Index Size

0- No Index, Packed
1- 1 byte Index
2- 2 byte Index
3- 4 byte Index
4- 1 byte Object Size
5- 2 byte Object Size
6- 4 byte Object Size

Qualifier Code

0- 8-Bit Start and Stop Indices
1- 16-Bit Start and Stop Indices
2- 32-Bit Start and Stop Indices
3- 8-Bit Absolute address Ident.
4- 16-Bit Absolute address Ident.
5- 32-Bit Absolute address Ident.
6- No Range Field (all)
7- 8-Bit Quantity
8- 16-Bit Quantity
9- 32-Bit Quantity
11-(0xB) Variable array

IMPLEMENTATION TABLE

OBJECT			REQUEST (ZLV parse)		RESPONSE (ZLV respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
1	0	Binary Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
1	1	Binary Input	1	0,1,6,7,8	129	0,1	
2	0	Binary Input with Status	1	0,1,6,7,8	129	0,1	
2	0	Binary Input Change – All variations	1	6,7,8			
2	2	Binary Input Change with Time	1	6,7,8	129,130	17,,28	Assign to Event Class
12	1	Control Relay Output Block	3,4,5,6	17,28	129	17,28	Echo of request
20	0	Binary Counter – All variations	1	0,1,6,7,8			Assigned to Class 0.
20	1	32 Bits Binary Counter			129	0,1	
21	0	Frozen Counter – All variations	1	0,1,6,7,8			
21	1	32 Bits Frozen Counter			129	0,1	
22	0	Counter Change Event – All variations	1	6,7,8			
22	5	32 Bits Counter Change Event With Time			129,130	17,,28	Assign to Event Class
30	0	Analog Input – All variations	1	0,1,6,7,8			Assigned to Class 0.
30	1	32-Bit Analog Input	1	0,1,6,7,8	129	1	
30	2	16-Bit Analog Input	1	0,1,6,7,8	129	1	
32	0	Analog Change Event – All variations	1	6,7,8			
32	3	32-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
32	4	16-Bit Analog Change Event with Time	1	6,7,8	129,130	28	Assign to Event Class
50	1	Time and Date	2	7 count=1	129		C
50	3	Time and Date at Last Recorded Time	2	7 count=1	129		C
52	2	Time Delay Fine	23		129	1	F,G

OBJECT			REQUEST (ZLV parse)		RESPONSE (ZLV respond)		
Obj	Var	Description	Func Codes (dec)	Qual Codes (hex)	Func Codes (dec)	Qual Codes (hex)	Notes
60	1	Class 0 Data	1	6	129	1	
60	2	Class 1 Data	1 20,21	6,7,8 6	129,130	28	D
60	3	Class 2 Data	1 20,21	6,7,8 6	129,130	28	D
60	4	Class 3 Data	1 20,21	6,7,8 6	129,130	28	D
80	1	Internal Indications	2	0 index=7			E
--	--	No Object (Cold Start)	13				F
--	--	No Object (Warm Start)	14				F
--	--	No Object (Delay Measurement)	23				G

NOTES

C: Device supports write operations on Time and Date objects. Time Synchronization-Required Internal Indication bit (IIN1-4) will be cleared on the response.

D: The device can be configured to send or not, unsolicited responses depending on a configuration option by means of ***MMI*** (Man-Machine Interface or front-panel user interface ***ZIVercomPlus***). Then, the Master can Enable or Disable Unsolicited messages (for Classes 1, 2 and 3) by means of requests (FC 20 and 21).
If the unsolicited response mode is configured "on", then upon device restart, the device will transmit an initial Null unsolicited response, requesting an application layer confirmation. While waiting for that application layer confirmation, the device will respond to all function requests, including READ requests.

E: Restart Internal Indication bit (IIN1-7) can be cleared explicitly by the master.

F: The outstation, upon receiving a ***Cold or Warm Start*** request, will respond sending a Time Delay Fine object message (which specifies a time interval until the outstation will be ready for further communications), restarting the DNP process, clearing events stored in its local buffers and setting IIN1-7 bit (Device Restart).

G: Device supports Delay Measurement requests (FC = 23). It responds with the Time Delay Fine object (52-2). This object states the number of milliseconds elapsed between Outstation receiving the first bit of the first byte of the request and the time of transmission of the first bit of the first byte of the response.

DEVICE SPECIFIC FEATURES

- Internal Indication IIN1-6 (Device trouble): **Set to indicate a change in the current DNP configuration in the outstation. Cleared in the next response. Used to let the master station know that DNP settings have changed at the outstation. Note that some erroneous configurations could make impossible to communicate this condition to a master station.**

  This document also states the DNP3.0 settings currently available in the device. If the user changes whatever of these settings, it will set the *Device Trouble Internal Indication* bit on the next response sent.
- Event buffers**: device can hold as much as 128** Binary Input Changes**,** 64 Analog Input Changes and 64 Counter Input Change**. If these limits are reached the device will set the *Event Buffers Overflow Internal Indication* bit on the next response sent. It will be cleared when the master reads the changes, making room for new ones.**
- Configuration ➔ Operation Enable **menu: the device can enable or disable** permissions **for the operations over al Control Relay Output Block. In case permissions are configured off (disabled) the response to a command (issued as Control Relay Output Block) will have the Status code NOT_AUTHORIZED. In case the equipment is** blocked **the commands allowed are the configured when permitted. While blocked, the relay will accept commands over the configured signal. If the equipment is in** operation inhibited state**, the response to all commands over the configured signal will have the Status code NOT_AUTHORIZED.**
- **Customers can configure Inputs/Outputs to suit their needs, by means of** *ZIVercomPlus®* **software.**

POINT LIST

BINARY INPUT (OBJECT 1) -> Assigned to Class 0. BINARY INPUT CHANGE (OBJECT 2) -> Assign to Class.		
Index	Description	
0	*Configure by ZIVercomPlus®* 2048 points	
1	*Configure by ZIVercomPlus®* 2048 points	
2	*Configure by ZIVercomPlus®* 2048 points	
3	*Configure by ZIVercomPlus®* 2048 points	
4	*Configure by ZIVercomPlus®* 2048 points	
5	*Configure by ZIVercomPlus®* 2048 points	
6	*Configure by ZIVercomPlus®* 2048 points	
7	*Configure by ZIVercomPlus®* 2048 points	
8	*Configure by ZIVercomPlus®* 2048 points	
9	*Configure by ZIVercomPlus®* 2048 points	
10	*Configure by ZIVercomPlus®* 2048 points	
11	*Configure by ZIVercomPlus®* 2048 points	
12	*Configure by ZIVercomPlus®* 2048 points	
13	*Configure by ZIVercomPlus®* 2048 points	
14	*Configure by ZIVercomPlus®* 2048 points	
15	*Configure by ZIVercomPlus®* 2048 points	
16	*Configure by ZIVercomPlus®* 2048 points	
17	*Configure by ZIVercomPlus®* 2048 points	
...	*Configure by ZIVercomPlus®* 2048 points	
253	*Configure by ZIVercomPlus®* 2048 points	
254	*Configure by ZIVercomPlus®* 2048 points	
255	*Configure by ZIVercomPlus®* 2048 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	Description	
0	*Configure by ZIVercomPlus®* 256 points	
1	*Configure by ZIVercomPlus®* 256 points	
2	*Configure by ZIVercomPlus®* 256 points	
3	*Configure by ZIVercomPlus®* 256 points	
4	*Configure by ZIVercomPlus®* 256 points	
5	*Configure by ZIVercomPlus®* 256 points	
6	*Configure by ZIVercomPlus®* 256 points	
7	*Configure by ZIVercomPlus®* 256 points	
8	*Configure by ZIVercomPlus®* 256 points	
9	*Configure by ZIVercomPlus®* 256 points	
10	*Configure by ZIVercomPlus®* 256 points	
11	*Configure by ZIVercomPlus®* 256 points	
12	*Configure by ZIVercomPlus®* 256 points	
13	*Configure by ZIVercomPlus®* 256 points	

CONTROL RELAY OUTPUT BLOCK (OBJECT 12)		
Index	**Description**	
14	*Configure by ZIVercomPlus®* 256 points	
15	*Configure by ZIVercomPlus®* 256 points	
16	*Configure by ZIVercomPlus®* 256 points	
17	*Configure by ZIVercomPlus®* 256 points	
...	*Configure by ZIVercomPlus®* 256 points	
253	*Configure by ZIVercomPlus®* 256 points	
254	*Configure by ZIVercomPlus®* 256 points	
255	*Configure by ZIVercomPlus®* 256 points	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assign to Class		
Index	**Description**	**Deadband**
0	*Configure by ZIVercomPlus®* 256 points	() Deadband_1.
1	*Configure by ZIVercomPlus®* 256 points	() Deadband_2.
2	*Configure by ZIVercomPlus®* 256 points	() Deadband_3.
3	*Configure by ZIVercomPlus®* 256 points	() Deadband_4.
4	*Configure by ZIVercomPlus®* 256 points	() Deadband_5.
5	*Configure by ZIVercomPlus®* 256 points	() Deadband_6.
6	*Configure by ZIVercomPlus®* 256 points	() Deadband_7.
7	*Configure by ZIVercomPlus®* 256 points	() Deadband_8.
8	*Configure by ZIVercomPlus®* 256 points	() Deadband_9.
9	*Configure by ZIVercomPlus®* 256 points	() Deadband_10.
10	*Configure by ZIVercomPlus®* 256 points	() Deadband_11.
11	*Configure by ZIVercomPlus®* 256 points	() Deadband_12.
12	*Configure by ZIVercomPlus®* 256 points	() Deadband_13.
13	*Configure by ZIVercomPlus®* 256 points	() Deadband_14.
14	*Configure by ZIVercomPlus®* 256 points	() Deadband_15.
15	*Configure by ZIVercomPlus®* 256 points	() Deadband_16.

Additional assign with ***ZIVercomPlus***⑧:

Index	Description
16	***Configure by ZIVercomPlus⑧ 256 points***
17	***Configure by ZIVercomPlus⑧ 256 points***
18	***Configure by ZIVercomPlus⑧ 256 points***
19	***Configure by ZIVercomPlus⑧ 256 points***
20	***Configure by ZIVercomPlus⑧ 256 points***
21	***Configure by ZIVercomPlus⑧ 256 points***
22	***Configure by ZIVercomPlus⑧ 256 points***
23	***Configure by ZIVercomPlus⑧ 256 points***
24	***Configure by ZIVercomPlus⑧ 256 points***
25	***Configure by ZIVercomPlus⑧ 256 points***
26	***Configure by ZIVercomPlus⑧ 256 points***
27	***Configure by ZIVercomPlus⑧ 256 points***
....	***Configure by ZIVercomPlus⑧ 256 points***
62	***Configure by ZIVercomPlus⑧ 256 points***
63	***Configure by ZIVercomPlus⑧ 256 points***

The full scale ranges are adjustable and user's magnitudes can be created. It's possible to choose between primary and secondary values, considering CT and PT ratios. Typical ranges in secondary values are:

Description	Full Scale Range		
	Engineering units	Counts	
Currents (Phases, ground, sequences)	0 to 1,2 x In_{PHASE} A	0 to 32767	Currents (Phases, ground, sequences)
Currents (Polarizing)	0 to 1,2 x In_{POL} A	0 to 32767	Currents (Polarizing)
Currents (Parallel line)	0 to 1,2 x In_{NPAR} A	0 to 32767	Currents (Parallel line)
Voltages (Phase to ground, sequences)	0 to 1,2 x Vn/√3 V	0 to 32767	Voltages (Phase to ground, sequences)
Voltages(Phase to phase, synchronizing)	0 to 1,2 x Vn V	0 to 32767	Voltages(Phase to phase, synchronizing)
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	Power (Real, reactive, apparent)
Power factor	-1 to 1	-32768 to 32767	Power factor
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	Frequency

Communication Measure in Counts

With ***ZIVercomPlus*** program is possible to define the ***Full Scale Range*** that is desired to transmit each magnitude in *counts*. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de Magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Max Communication:** it's a constant that depend of the Number Bits of Analog Input.
  Max Communication=2(Number Bits Analog Input - 1)**
  For 16-Bit Analog Input (Obj. 30 Var. 2) 2**(15) = 32.767 counts
  For 32-Bit Analog Input (Obj. 30 Var. 1) 2**(31) = 2.147.483.647 counts
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** This *flag* defines if the **limit** is proportional to the **rated value** of the magnitude.
- **TR:** Secondary to Primary Transformation Ratio.

Mathematical expression to describe the ***Full Scale Range*** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times \frac{MaxComunication}{Limit}$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times \frac{MaxComunication}{Limit}$$

Communication Measure in Engineering Units

With ***ZIVercomPlus*** program **also** it's possible to transmit each magnitude in Engineering Units. Parameters necessary to configure the Mathematical expression are:

- **Offset:** A number indicating the compensation of de magnitude.
- **Limit:** it's the Maximum value of magnitude range.
- **Rated value:** Nominal Value of the magnitude.
- **Nominal Flag:** this *flag* defines if the **limit** is proportional to the **rated value** of the magnitude or not. The rated value of the new magnitudes defined by the user is a setting, while for the pre-defined magnitudes is a fix value.
- **TR:** Secondary to Primary Transformation Ratio.
- **Scaling Factor:** Multiply Factor of magnitude.

Mathematical expression to obtain **Measure in Engineering Units** is:

- When **Nominal Flag** is actived,

$$MeasureCom = TR \times \frac{Measure - Offset}{RatedValue} \times ScalingFactor$$

- When **Nominal Flag** is NOT actived,

$$MeasureCom = TR \times (Measure - Offset) \times ScalingFactor$$

DeadBands

- Deadband is an area of a magnitude range or band where no generate magnitude change (the magnitude is dead). Meaning that no generation of Analogical Change Events if difference with value of generation of previous change is not equal or greater that DeadBand calculated. There is an independent setting for each 16 Measures with change.
- A Deadband is calculated as a percentage defined in DeadBand Setting over value of **parameter Limit**.
- The Deadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 0.0000% and 100.00%, in steps of 0.0001%. Default value is 100.00%, meaning that generation of Analog Change Events is **DISABLED** for that input. There is an independent setting for each Magnitude with change.

BINARY COUNTER (OBJECT 20) -> Assigned to Class 0.
FROZEN COUNTER (OBJECT 21)

32 BIT COUNTER CHANGE EVENT (OBJECT 22) -> Assign to Class

Index	Description	Deadband
0	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_1.**
1	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_2.**
2	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_3.**
3	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_4.**
4	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_5.**
5	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_6**
6	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_7.**
7	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_8.**
8	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_9.**
9	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_10.**
10	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_11.**
11	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_12.**
12	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_13.**
13	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_14.**
14	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_15.**
15	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_16.**
16	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_17.**
17	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_18.**
18	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_19.**
19	***Configure by ZIVercomPlus® 256 points***	**CounterDeadBand_20.**

CounterDeadBands

- CounterDeadband is an area of a counter magnitude range or band, where no generate counter magnitude change (the communication counter magnitude is dead).Meaning that no generation of Counter Change Events if difference with value of generation of previous change is not equal or greater that CounterDeadBand setting. There is an independent setting for each Counter.

- The CounterDeadband can be adjusted to the device by means of ***MMI*** (Man-Machine Interface or front-panel user interface *ZIVercomPlus*), between 1 and 32767, in steps of 1, default value is 1.

DNP3 PROTOCOL SETTINGS

DNP3 Protocol Settings

DNP Protocol Configuration

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step/ Select	Unit
Relay Number	Integer	0	65519	1	1	
T Confirm Timeout	Integer	1000	65535	1000	1	msec.
Max Retries	Integer	0	65535	0	1	
Enable Unsolicited.	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Enable Unsol. after Restart	Boolean	0 (No)	1 (Yes)	0 (No)	1	
Unsolic. Master No.	Integer	0	65519	1	1	
Unsol. Grouping Time	Integer	100	65535	1000	1	msec.
Synchronization Interval	Integer	0	120	0	1	min.
DNP 3.0 Rev.	Integer	2003 ST.ZIV	2003 ST.ZIV	2003	2003 ST.ZIV	
Binary Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 1	None Class 1 Class 2 Class 3	
Analog Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 2	None Class 1 Class 2 Class 3	
Counter Changes CLASS	Integer	None Class 1 Class 2 Class 3	None Class 1 Class 2 Class 3	Class 3	None Class 1 Class 2 Class 3	
Binary Status Change	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	
32 Bits Analog Input	Boolean	0 (No)	1 (Yes)	1 (Yes)	1	

Analog Inputs (Deadbands)

Setting Name	Type	Minimum Value	Maximum Value	Default Value	Step	Unit
Deadband AI#0	Float	0 %	100 %	100 %	0.0001 %	
Deadband AI#1	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#2	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#3	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#4	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#5	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#6	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#7	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#8	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#9	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#10	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#11	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#12	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#13	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#14	Float	0 %	100 %	100 %	0. 0001 %	
Deadband AI#15	Float	0 %	100 %	100 %	0. 0001 %	

Counter Inputs (CounterDeadbands)						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Deadband Cont.I#0	Integer	1	32767	1	1	
Deadband Cont.I#1	Integer	1	32767	1	1	
Deadband Cont.I#2	Integer	1	32767	1	1	
Deadband Cont.I#3	Integer	1	32767	1	1	
Deadband Cont.I#4	Integer	1	32767	1	1	
Deadband Cont.I#5	Integer	1	32767	1	1	
Deadband Cont.I#6	Integer	1	32767	1	1	
Deadband Cont.I#7	Integer	1	32767	1	1	
Deadband Cont.I#8	Integer	1	32767	1	1	
Deadband Cont.I#9	Integer	1	32767	1	1	
Deadband Cont.I#10	Integer	1	32767	1	1	
Deadband Cont.I#11	Integer	1	32767	1	1	
Deadband Cont.I#12	Integer	1	32767	1	1	
Deadband Cont.I#13	Integer	1	32767	1	1	
Deadband Cont.I#14	Integer	1	32767	1	1	
Deadband Cont.I#15	Integer	1	32767	1	1	
Deadband Cont.I#16	Integer	1	32767	1	1	
Deadband Cont.I#17	Integer	1	32767	1	1	
Deadband Cont.I#18	Integer	1	32767	1	1	
Deadband Cont.I#19	Integer	1	32767	1	1	
DNP Port 1 Port 2 and 3 DNP 3 Profile II Ethernet Configuration						
Setting Name	**Type**	**Minimum Value**	**Maximum Value**	**Default Value**	**Step**	**Unit**
Protocol Select	**Uinteger**	**Procome Dnp3 Modbus**	**Procome Dnp3 Modbus**	**Procome**	**Procome Dnp3 Modbus**	
Enable Ethernet Port	**Boolean**	**0 (No)**	**1 (Yes)**	**1 (Yes)**	**1**	
IP Address Port 1	**Byte[4]**	**ddd.ddd.ddd.ddd**	**ddd.ddd.ddd.ddd**	**192.168.1.51**	**1**	
IP Address Port 2	**Byte[4]**	**ddd.ddd.ddd.ddd**	**ddd.ddd.ddd.ddd**	**192.168.1.61**	**1**	
IP Address Port 3	**Byte[4]**	**ddd.ddd.ddd.ddd**	**ddd.ddd.ddd.ddd**	**192.168.1.71**	**1**	
Subnet Mask	**Byte[4]**	**128.0.0.0**	**255.255.255.254**	**255.255.255.0**	**1**	
Port Number	**Uinteger**	**0**	**65535**	**20000**	**1**	
Keepalive Time	**Float**	**0**	**65**	**30**	**60**	**s.**
Rx Time Characters	**Float**	**1**	**60000**	**1**	**0.5**	**ms.**
Comms Fail Timer	**Float**	**0**	**600**	**60**	**0.1**	**s.**

- ✓ **All settings remain unchanged after a power loss.**

DNP Protocol Configuration

- **Relay Number (RTU Address):**
  Remote Terminal Unit Address. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*.
- **T Confirm Timeout (N7 Confirm Timeout) :**
  Timeout while waiting for Application Layer Confirmation. It applies to Unsolicited messages and Class 1 and Class 2 responses with event data.
- **Max Retries (N7 Retries) :**
  Number of retries of the Application Layer after timeout while waiting for Confirmation.
- **Enable Unsolicited (Enable Unsolicited Reporting) :**
  Enables or disables Unsolicited reporting.
- **Enable Unsol. after Restart :**
  Enables or disables Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998). It has effect only if Enable Unsolicited after Restart is set.
- **Unsolic. Master No. (MTU Address) :**
  Destination address of the Master device to which the unsolicited responses are to be sent. Addresses 0xFFF0 to 0xFFFF are reserved as *Broadcast Addresses*. It is useful only when Unsolicited Reporting is enabled.
- **Unsol. Grouping Time (Unsolicited Delay Reporting) :**
  Delay between an event being generated and the subsequent transmission of the unsolicited message, in order to group several events in one message and to save bandwidth.
- **Synchronization Interval**
  Max interval time between two synchronization. If no synchronizing inside interval, indication IIN1-4 (NEED TIME). This setting has no effect if Synchronization Interval is zero.
- **DNP 3.0 Rev.**
  Certification revision **STANDARD ZIV** or **2003** (DNP3-2003 Intelligent Electronic Device (IED) Certification Procedure Subset Level 2 Version 2.3 29-Sept-03)
- **Binary Changes CLASS.**
  Selection to send Binary Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- **Analog Changes CLASS.**
  Selection to send Analog Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- **Counter Changes CLASS.**
  Selection to send Counter Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- **Binary Status .**
  Send Binary with status otherwise without status
- **32 Bits Analog Input .**
  Send Analog All Variations and Analog Change Event Binary Changes with 32 bits otherwise with 16 bits

DNP PROFILE II ETHERNET Port 1 Port 2 and Port 3 Configuration

- **Enable Ethernet Port :**
  Enables or disables Ethernet Port.

- **IP Address :**
  Identification Number of Ethernet device.

- **Subnet Mask :**
  Indicate the part of IP Address is the Net Address and the part of IP Address is the Device Number.

- **Port Number :**
  Indicate to Destinatión Device the path to send the recived data.

- **Keepalive Time :**
  Number of second between Keepalive paquets, if zero no send packages Keepalive. These packages allow to Server know if a Client is present in the Net.

- **Rx Time Between Characters :**
  Maximum time between Characters.

- **Comm Fail Timer :**
  Maximum time between Messages without indicate Communication Fail.

C. MODBUS RTU Documentation. Address Map

C.1 Preliminary Information

This a reference document for implementing the MODBUS RTU protocol in the **ZLV** IED.

This document provides a detailed MODBUS address map (input status, coil status, input registers and force single coil) and their equivalent in the **ZLV** relay.

The functions that will be implemented are:

ModBus Function	Meaning
01	Read Coil Status
02	Read Input Status
04	Read Input Registers
05	Force Single Coil

Any other function not among those indicated will be considered illegal and will return exception code 01 (Illegal function).

C.2 Function 01: Read Coil Status

C.2.1 Modbus Address Map for ZLV

The MODBUS coil status address map for the **ZLV** relay will be:

Address	Description
Configurable through the *ZIVercomPlus*®	Any input or output logic signal from the protection modules or generated by the programmable logic.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 1023 and they are assigned automatically by the ***ZIVercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal data address).

C.3 Function 02: Read Input Status

C.3.1 Modbus Address Map for ZLV

The MODBUS input status address map for the **ZLV** relay will be:

Address	Description
Configurable through the *ZIVercomPlus*®	Any input or output logic signal from the protection modules or generated by the programmable logic.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 1023 and they are assigned automatically by the ***ZIVercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal data address).

C.4 Function 03: Read Holding Registers

C.4.1 Modbus Address Map for ZLV

The MODBUS read holding registers address map for the **ZLV** relay will be:

Address	Description
Configurable through the *ZIVercomPlus*®	Any input or output logic signal from the protection modules or generated by the programmable logic whose number of changes is to be measured.

Configurable through the ***ZIVercomPlus***®: Counters can be created with any signal configured in the programmable logic or from the protection modules. The default counters are those of the real energies (positive and negative) and the reactive energies (capacitive and inductive).

The metering range of energies in primary values is from 100wh/varh to 6553.5 kWh/kVArh. This is the magnitude transmitted via communications. That is, one (1) count represents 100 wh/varh.

To obtain an energy counter with a higher maximum value, a “user magnitude” must be created using this counter. For example, dividing the value of the counter by 1000 and making the output of the divider the new magnitude yields an energy counter with a range from 100 kWh/kVArh to 6553.5 MWh/Mvarh; that is, one (1) count represents 100 kWh/varh.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 255 and they are assigned automatically by the ***ZIVercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal data address).

C.5 Function 04: Read Input Registers

C.5.1 Modbus Address Map for ZLV

The MODBUS read input registers address map for the **ZLV** relay will be:

Address	Description
Configurable through the *ZIVercomPlus*®	Any magnitude measured or calculated by the protection or generated by the programmable logic. It is possible to select between primary and secondary values, taking into account the corresponding transformation ratios.

All the full scale values of the magnitudes are definable, and these magnitudes can be used to create **user values**. Some typical values are:

- **Phase**, **ground** and **sequence currents**. Rated value I_{PHASE} + 20% sends 32767 counts.
- **Polarization current**: Rated value I_{POL} + 20% sends 32767 counts.
- **Parallel line ground current**: Rated value I_{NPAR} + 20% sends 32767 counts.
- **Phase** and **sequence voltages**: (Rated value V / √3) + 20% sends 32767 counts.
- **Line** and **synchronization voltages**: Rated value V + 20% sends 32767 counts.
- **Powers**: 3 x 1.4 x rated value I_{PHASE} x rated value / √3 sends 32767 counts.
- **Power factor**: from -1 to 1 sends from -32767 to 32767 counts.
- **Frequency**: from 0 Hz to 1.2 x $Frequency_{RATED}$ (50Hz / 60Hz) sends 32767 counts.
- **Thermal value**: 240% sends 32767 counts
- **Distance to the fault**:
  - Percentage value: ±100% sends ±32767 counts (range from -100% to 100%).
  - Value in kilometers: with the "length of the line," it sends ±32767 counts (range from 0 km to the length of the line set in km. It can also send negative values).
  - Value in miles: with the "length of the line," it sends ±32767 counts (range from 0 km to the length of the line set in miles. It can also send negative values).

With the ***ZIVercomPlus***® program, it is possible to define the full-scale value to be used to transmit this magnitude in counts, the unit that all the protocols use. There are three definable parameters that determine the range of distance covered:

- **Offset value**: the minimum value of the magnitude for which 0 counts are sent.
- **Limit**: the length of the range of the magnitude on which it is interpolated to calculate the number of counts to send. If the offset value is 0, it coincides with the value of the magnitude for which the defined maximum of counts (32767) is sent.
- **Nominal flag**: this flag allows determining whether the limit set is proportional to the rated value of the magnitude or not. The rated value of the new magnitudes defined by the user in the programmable logic can be configured, while the rest of the existing magnitudes are fixed.

The expression that allows defining this full-scale value is the following:

- When the Nominal flag is enabled,

$$CommunicationsMeasurement = \frac{Measurement - Offset}{Nominal} \times \frac{32767}{Limit}$$

- When the Nominal flag is NOT enabled,

$$CommunicationsMeasurement = (Measurement - Offset) \times \frac{32767}{Limit}$$

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 255 and they are assigned automatically by the ***ZIVercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal data address).

C.6 Function 05: Force Single Coil

C.6.1 Modbus Address Map for ZLV

The MODBUS force single coil address map of the **ZLV** relay will be:

Address	Description
Configurable through the *ZIVercomPlus*®	A command can be made on any input from the protection modules and on any signal configured in the programmable logic.

The content of the addresses is variable (reflection of each relay's configuration). The range of addresses is from 0 to 255 and they are assigned automatically by the ***ZIVercomPlus***® program.

Non-configured addresses will be considered illegal and will return exception code 02 (Illegal data address).

Any value other than 00H or FFH will be considered illegal and will return exception code 03 (Illegal data value).

D. Schemes and Drawings

Dimension and drill hole schemes

8ZLV (2U x 1 19” rack)	>>4BF0100/0040
3/8ZLV (3U x 1 19” rack)	>>4BF0100/0041
3/8ZLV (4U x 1 19” rack)	>>4BF0100/0037

External connection schemes

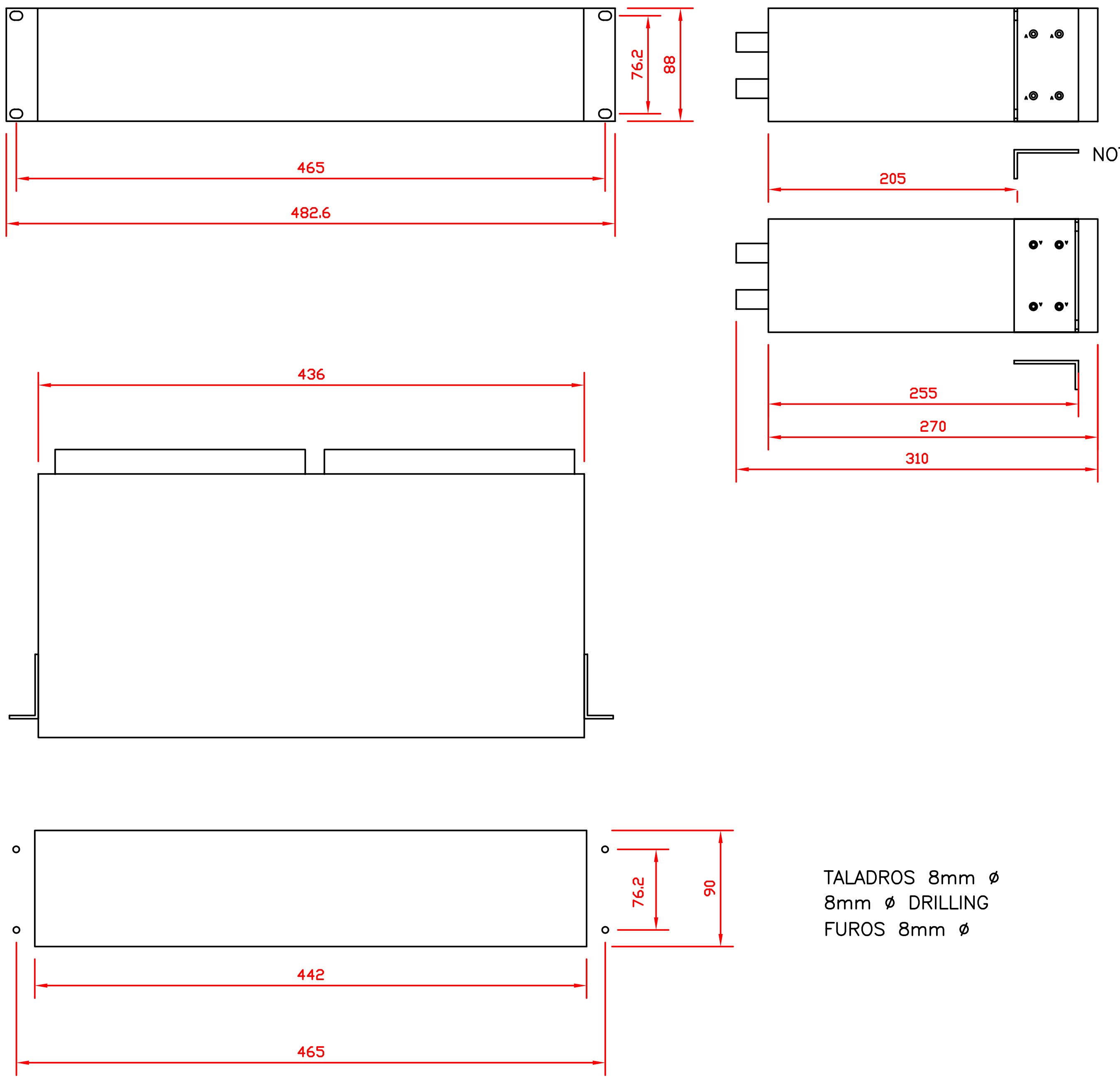
ZLV-A/H (2U)	>>3RX0193/0021 (generic)
ZLV-A (3U)	>>3RX0193/0022 (generic)
ZLV-B/F (3U)	>>3RX0193/0023 (generic)
ZLV-B/F (4U)	>>3RX0193/0024 (generic)
ZLV-B/F (4U)	>>3RX0193/0025 (generic)
ZLV-G (6U)	>>3RX0193/0033 (generic)

CAJA TIPO "M"

BOÎTIER TYPE "M"

ENCLOSURE TYPE "M"

CAIXA TIPO "M"



TALADROS 8mm ø
8mm ø DRILLING
FUROS 8mm ø

NOTA 1:
LA PIEZA ADMITE LAS 2 POSICIONES MOSTRADAS PARA FACILITAR UN MONTAJE DEL EQUIPO MÁS Ó MENOS SALIENTE

REVISIONES		0	CD0504145	1	
2		3		4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

Z I V Aplicaciones y Tecnologia S.A.

TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "M" 2U 1RACK

Rev.0

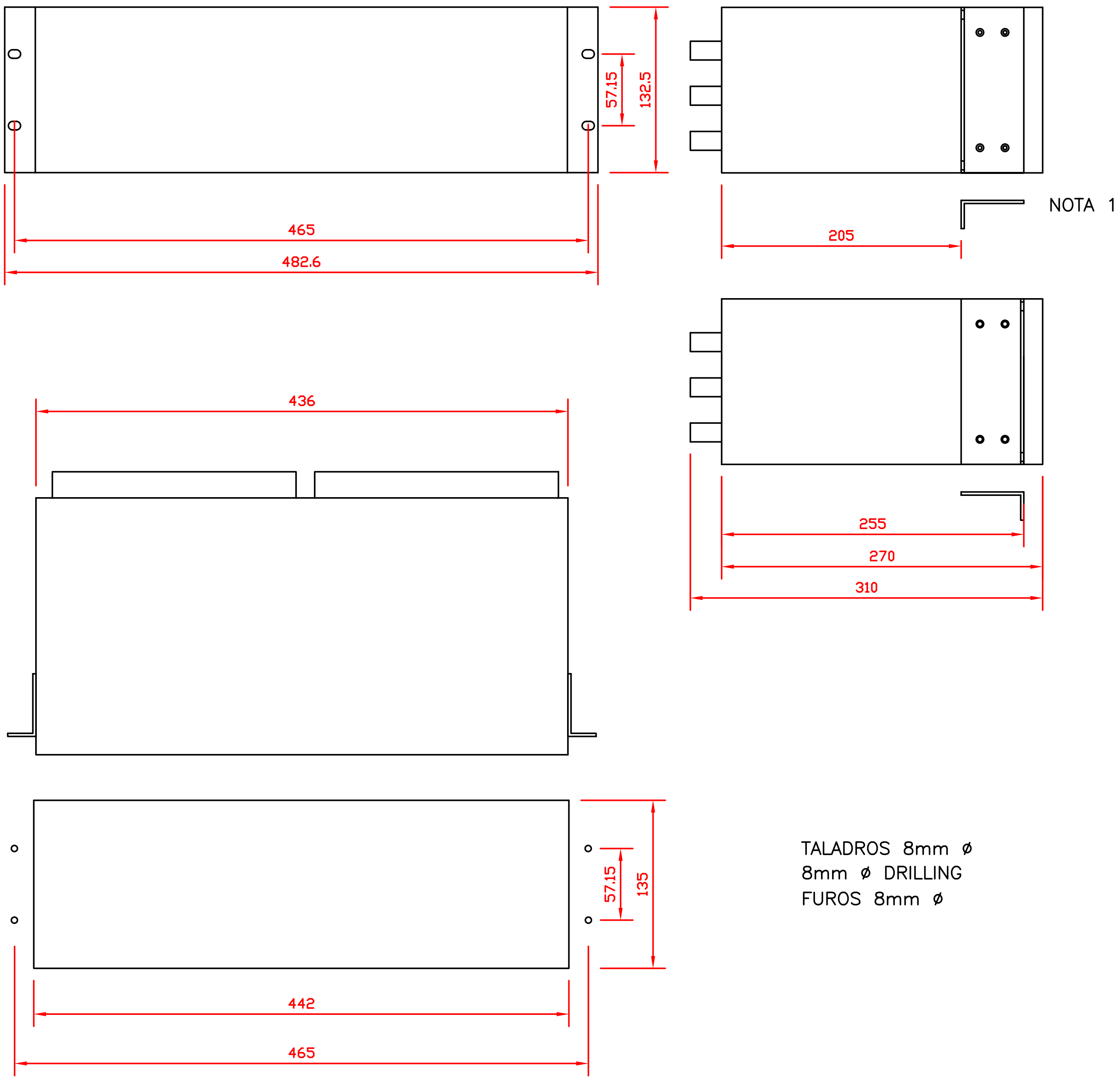
NUMERO: 4BF0100/0040

	Fecha	**Nombre**
Dibujado	28/04/05	U.G.
Aprobado	28/04/05	C.G.G.

Hoja: 1

Continua en Hoja:

CAJA TIPO "S"
BOÎTIER TYPE "S"
ENCLOSURE TYPE "S"
CAIXA TIPO "S"



NOTA 1:
LA PIEZA ADMITE LAS 2 POSICIONES MOSTRADAS PARA FACILITAR UN MONTAJE DEL EQUIPO MÁS Ó MENOS SALIENTE

REVISIONES		0	CD0504145	1	
2		3		4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

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TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "S" 3U 1RACK

Rev.0

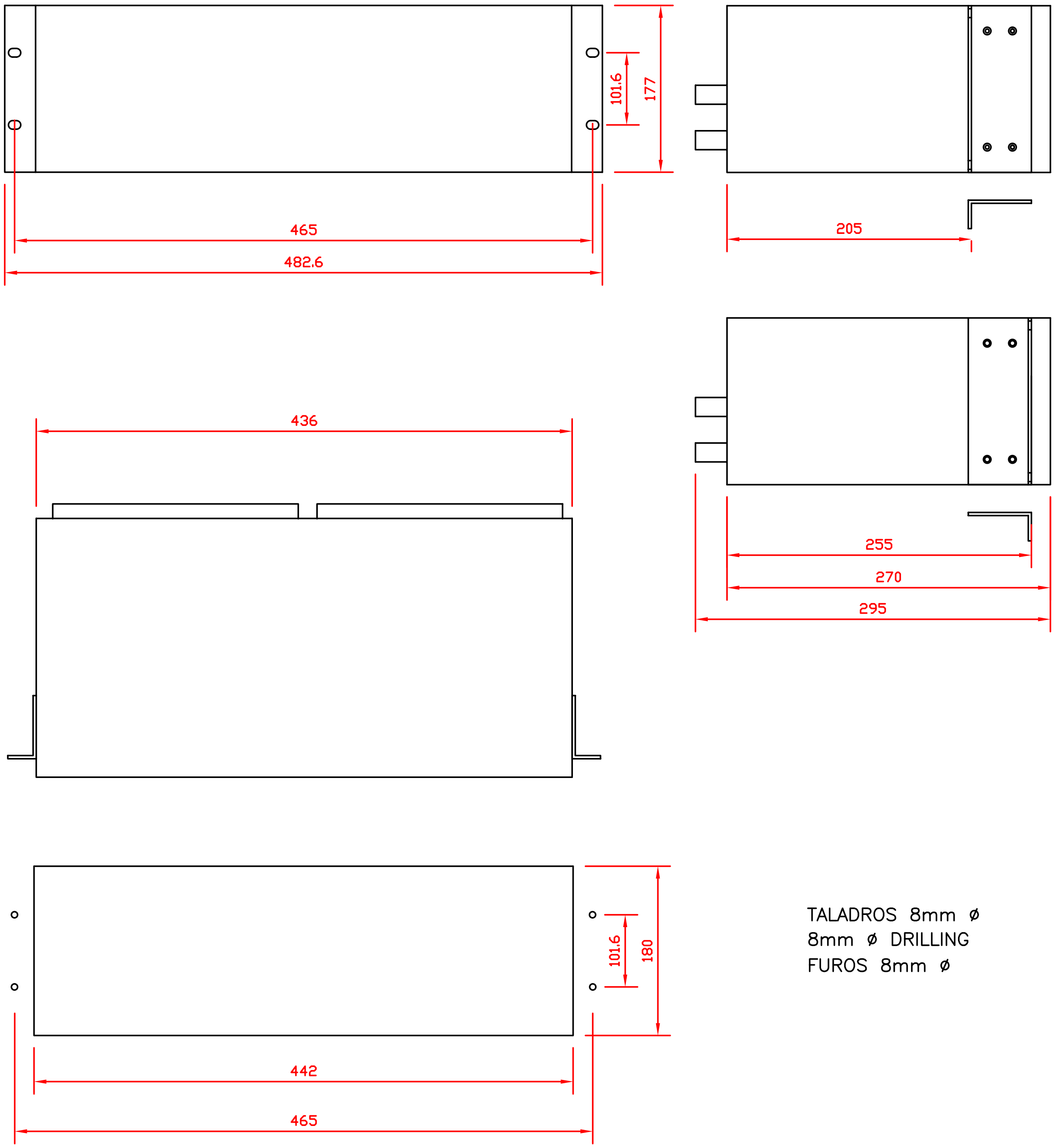
NUMERO: 4BF0100/0041

	Fecha	Nombre
Dibujado	28/04/05	U.G.
Aprobado	28/04/05	C.G.G.

Hoja: 1

Continua en Hoja:

CAJA TIPO "Q"
ENCLOSURE TYPE "Q"
CAIXA TIPO "Q"



TALADROS 8mm ø
8mm ø DRILLING
FUROS 8mm ø

NOTA 1:
LA PIEZA ADMITE LAS 2 POSICIONES MOSTRADAS PARA FACILITAR UN MONTAJE DEL EQUIPO MÁS Ó MENOS SALIENTE

REVISIONES		0	CD0407129	1	CD0504115
2		3		4	
5		6		7	
8		9		10	
11		12		13	
14		15		16	

Z I V Aplicaciones y Tecnologia S.A.

TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "Q" 4U 1RACK (IDV)

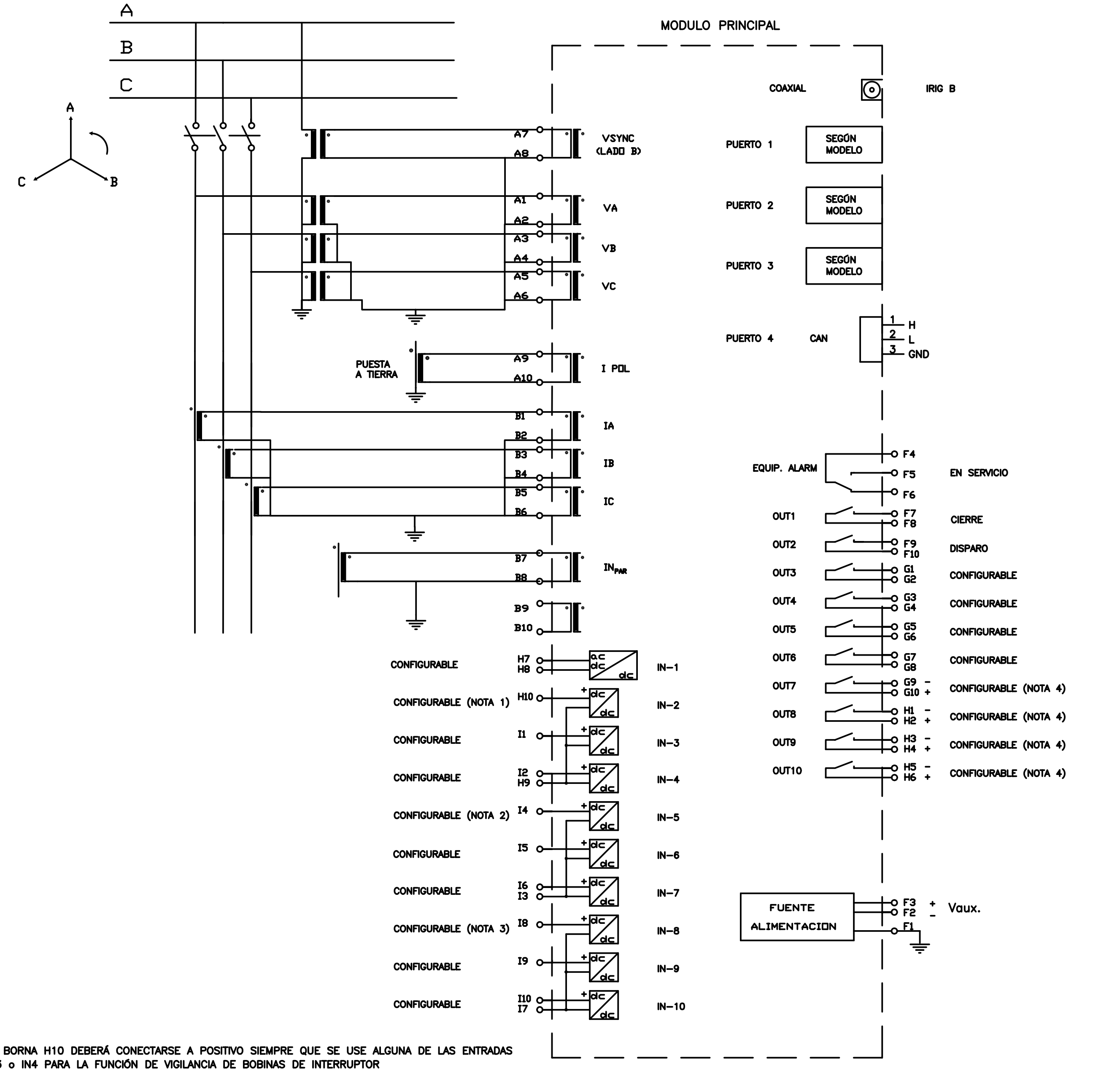
Rev.0
Rev.1 12/4/05

NUMERO: 4BF0100/0037

	Fecha	Nombre
Dibujado	07/09/04	J.C.S.
Aprobado	07/09/04	J.M.Y.

Hoja: 1

Continua en Hoja:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.

PUERTO SERIE RS–232 FULL MODEM

PIN	SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

PUERTO SERIE RS–232 / RS–485

PIN	SEÑAL
1	LIBRE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	LIBRE
8	LIBRE
9	LIBRE

PUERTO SERIE CAN

PIN	SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3 o IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6 o IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9 o IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 4: LAS SALIDAS OUT7 A OUT10 PUEDEN SER CONFIGURADAS COMO SALIDAS RÁPIDAS (RELÉ DE ESTADO SÓLIDO)

REVISIONES	0	CD0602148	1	CD0805153	2	CD0807111	3	CD1112118	4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CONEX. EXTERNAS ZLV–A/H 2U Caja M

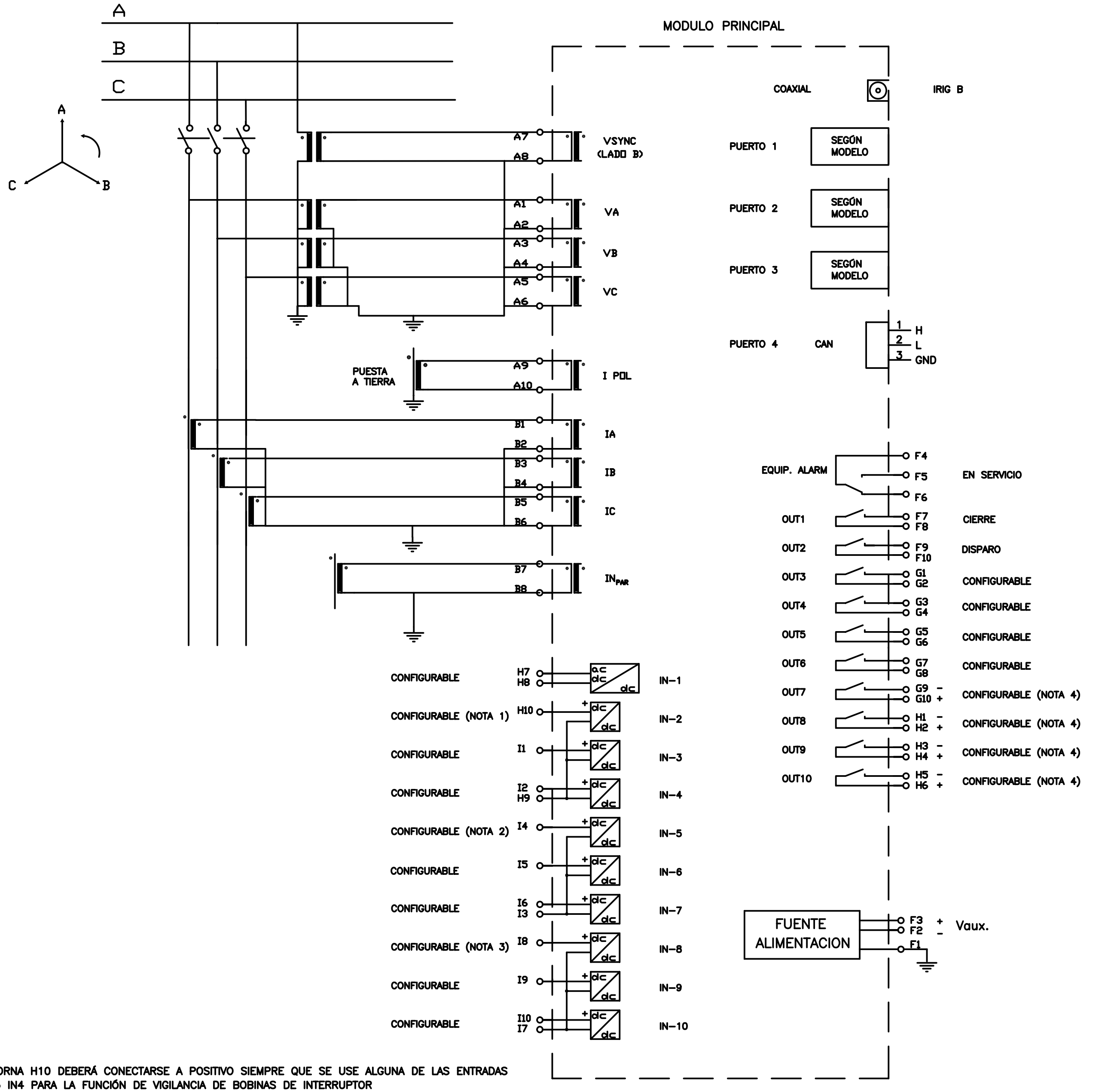
PROYECTO: ZLV

Rev.0
Rev.1 06/06/08
Rev.2 30/07/08
Rev.3 08/02/12

NUMERO: 3RX0193/0016

	Fecha	Nombre
Dibujado	14/02/06	I.L.I.
Aprobado	14/02/06	J.R.S.

Hoja: 1
Continua en Hoja:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.

PUERTO SERIE RS-232 FULL MODEM

PIN	SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

PUERTO SERIE RS-232 / RS-485

PIN	SEÑAL
1	LIBRE
2	RX
3	TX
4	RS485+
5	GND
6	RS485-
7	LIBRE
8	LIBRE
9	LIBRE

PUERTO SERIE CAN

PIN	SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3 o IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6 o IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9 o IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 4: LAS SALIDAS OUT7 A OUT10 PUEDEN SER CONFIGURADAS COMO SALIDAS RÁPIDAS (RELÉ DE ESTADO SÓLIDO)

REVISIONES	0	CD0602148	1	CD0805153	2	CD0807111	3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CONEXIONES EXTERNAS ZLV-A 3U Caja S

PROYECTO: ZLV

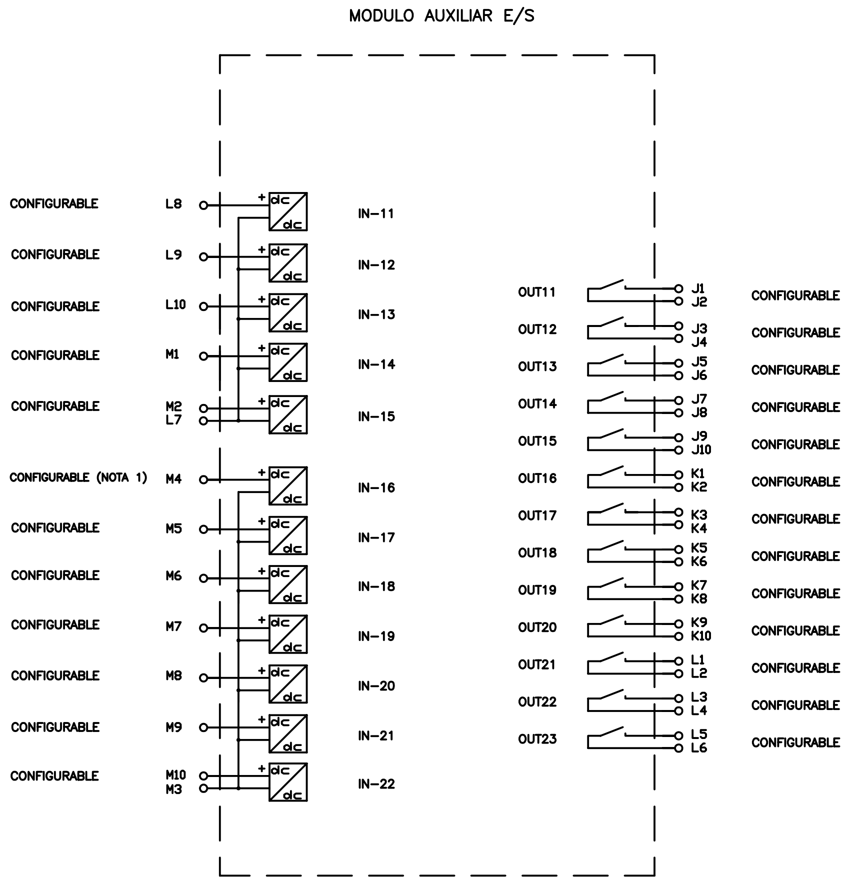
Rev.0
Rev.1 06/06/08
Rev.2 30/07/08

NUMERO: 3RX0193/0017

	Fecha	Nombre
Dibujado	14/02/06	I.L.I.
Aprobado	14/02/06	J.R.S.

Hoja: 1

Continua en Hoja: 2



NOTA 1: LA BORNA M4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN17, IN18, IN19, IN20, IN21 o IN22 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

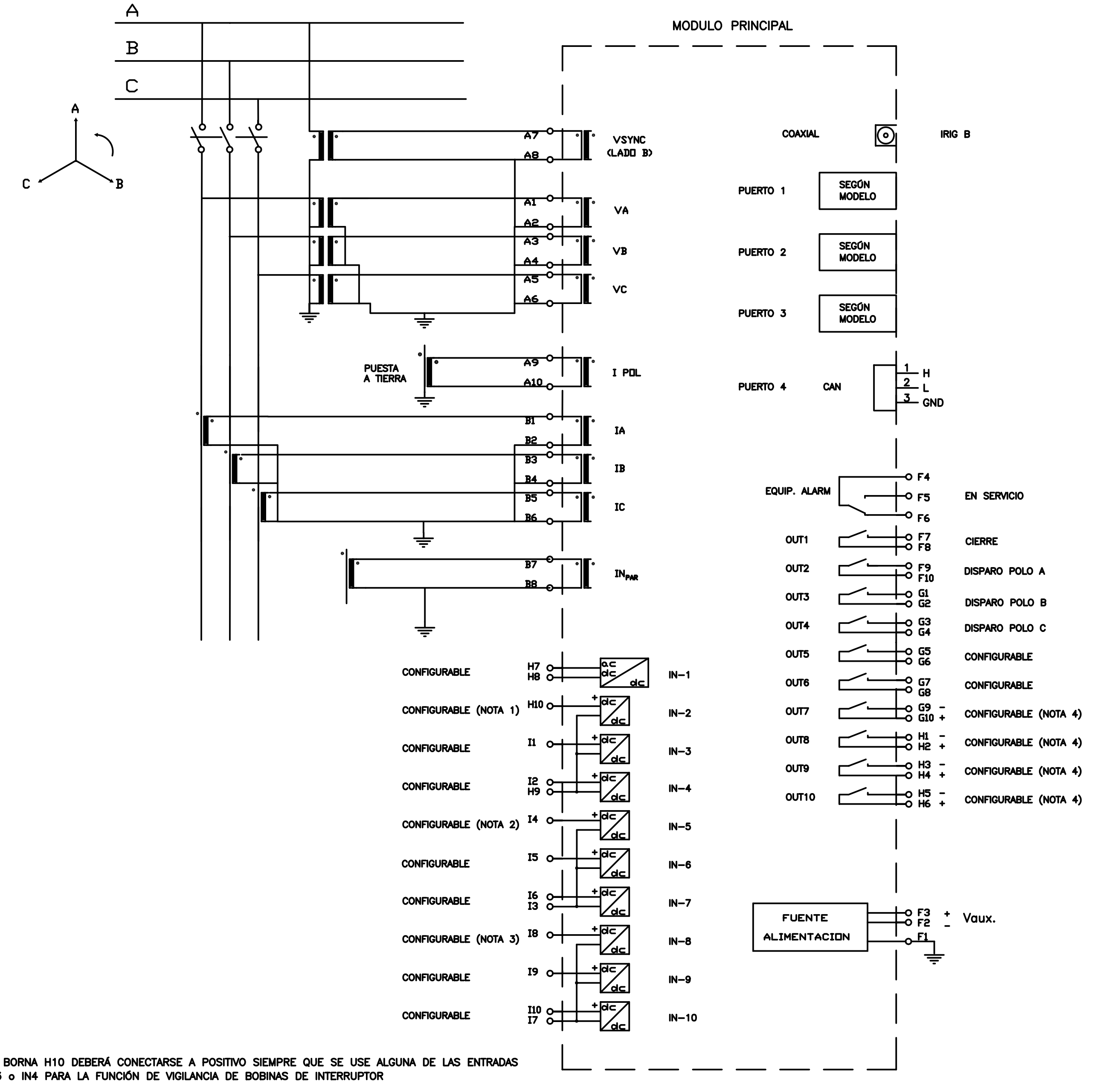
REVISIONES	0	CD0602148	1		2		3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CONEXIONES EXTERNAS ZLV-A 3U Caja S
PROYECTO: ZLV
Rev.0
NUMERO: 3RX0193/0017

	Fecha	Nombre
Dibujado	14/02/06	I.L.I.
Aprobado	14/02/06	J.R.S.

Hoja: 2
Continua en Hoja:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.

PUERTO SERIE RS-232 FULL MODEM

PIN	SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

PUERTO SERIE RS-232 / RS-485

PIN	SEÑAL
1	LIBRE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	LIBRE
8	LIBRE
9	LIBRE

PUERTO SERIE CAN

PIN	SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3 o IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6 o IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9 o IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 4: LAS SALIDAS OUT7 A OUT10 PUEDEN SER CONFIGURADAS COMO SALIDAS RÁPIDAS (RELÉ DE ESTADO SÓLIDO)

REVISIONES	0	CD0602148	1	CD0805153	2	CD0807111	3		4	
5		6		7		8		9		10
11		12		13		14		15		16

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TITULO: CONEX. EXTERNAS ZLV–B/F 3U CAJA S

PROYECTO: ZLV

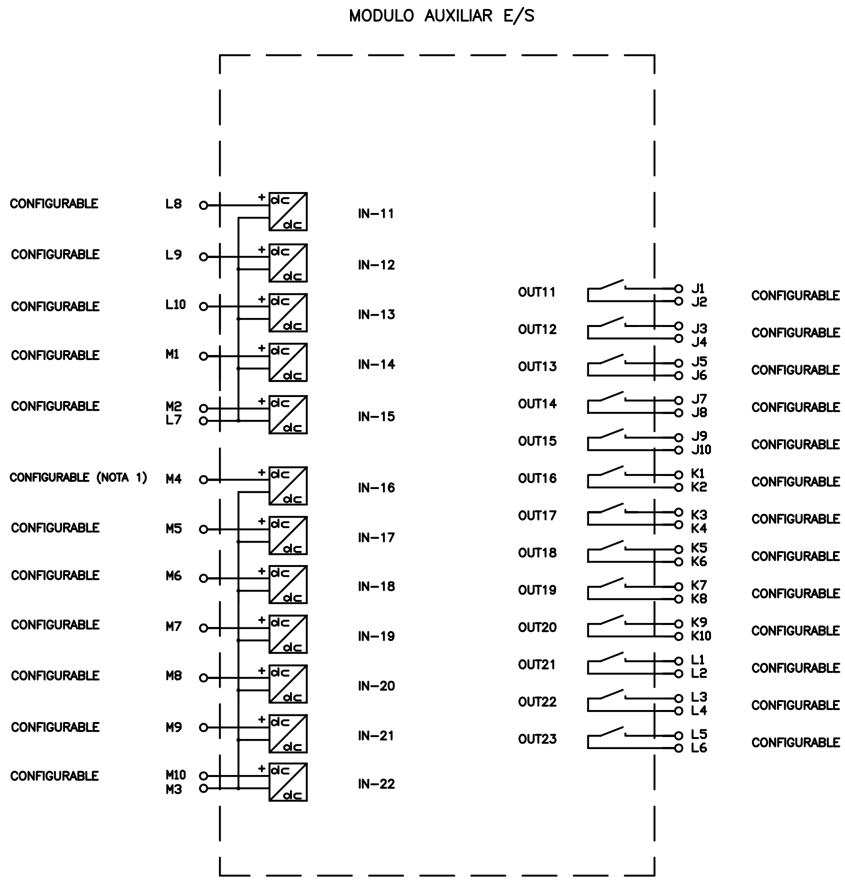
Rev.0
Rev.1 06/06/08
Rev.2 04/07/08

NUMERO: 3RX0193/0018

	Fecha	Nombre
Dibujado	14/02/06	I.L.I.
Aprobado	14/02/06	J.R.S.

Hoja: 1

Continua en Hoja: 2



NOTA 1: LA BORNA M4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN17, IN18, IN19, IN20, IN21 o IN22 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

REVISIONES	0	CD0602148	1	CD0807111	2		3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CONEX. EXTERNAS ZLV-B/F 3U CAJA S

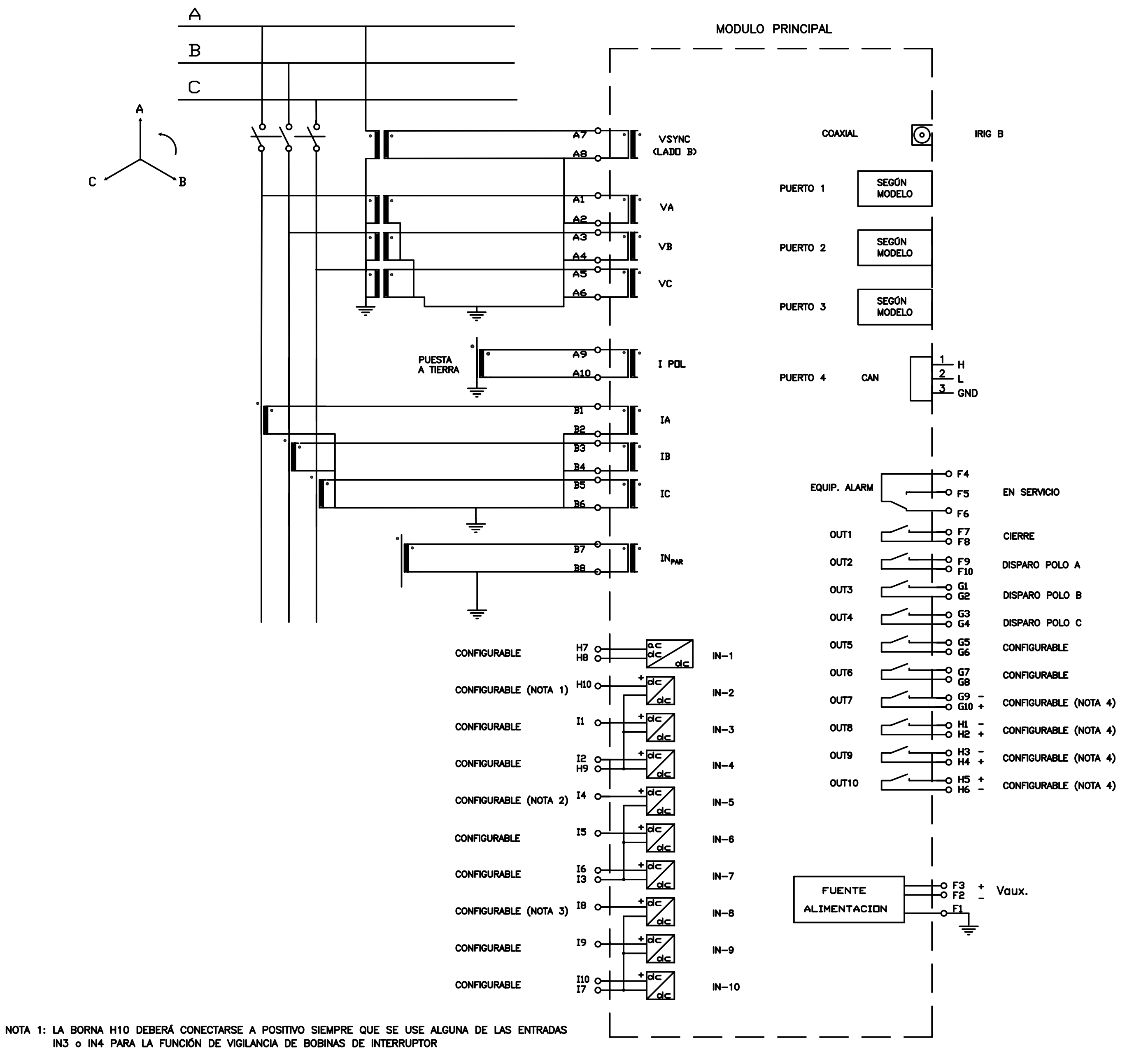
PROYECTO: ZLV

Rev.0
Rev.1 04/07/08

NUMERO: 3RX0193/0018

	Fecha	Nombre
Dibujado	14/02/06	I.L.I.
Aprobado	14/02/06	J.R.S.

Hoja: 2
Continua en Hoja:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10. – CONFIGURABLE.
11. – CONFIGURABLE
12. – CONFIGURABLE
13. – CONFIGURABLE
14. – CONFIGURABLE.
15. – CONFIGURABLE
16. – CONFIGURABLE

PUERTO SERIE RS-232 FULL MODEM

PIN	SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

PUERTO SERIE RS-232 / RS-485

PIN	SEÑAL
1	LIBRE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	LIBRE
8	LIBRE
9	LIBRE

PUERTO SERIE CAN

PIN	SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3 o IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6 o IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9 o IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 4: LAS SALIDAS OUT7 A OUT10 PUEDEN SER CONFIGURADAS COMO SALIDAS RÁPIDAS (RELÉ DE ESTADO SÓLIDO)

REVISIONES	0	CD0602148	1	CD0805153	2	CD0807111	3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CONEX. EXTERNAS ZLV B/F 4U Caja Q

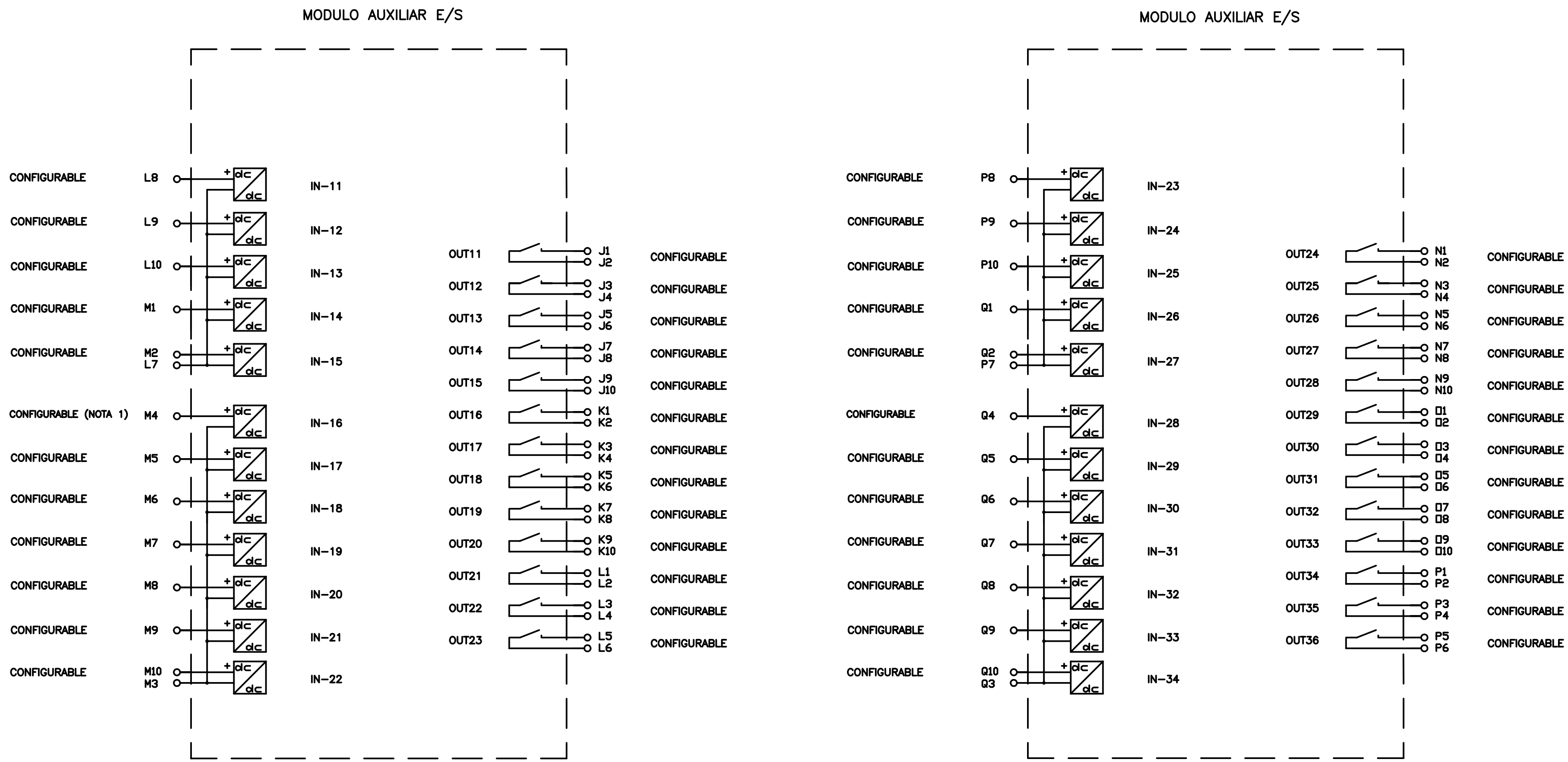
PROYECTO: ZLV

Rev.0
Rev.1 06/06/08
Rev.2 23/07/08

NUMERO: 3RX0193/0019

	Fecha	Nombre
Dibujado	14/02/06	I.L.I.
Aprobado	14/02/06	J.R.S.

Hoja: 1
Continua en Hoja: 2



NOTA 1: LA BORNA M4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN17, IN18, IN19, IN20, IN21 o IN22 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

REVISIONES	0	CD0602148	1	CD0807111	2		3		4		
5		6		7		8		9		10	
11		12		13		14		15		16	

Z I V Aplicaciones y Tecnologia S.A.

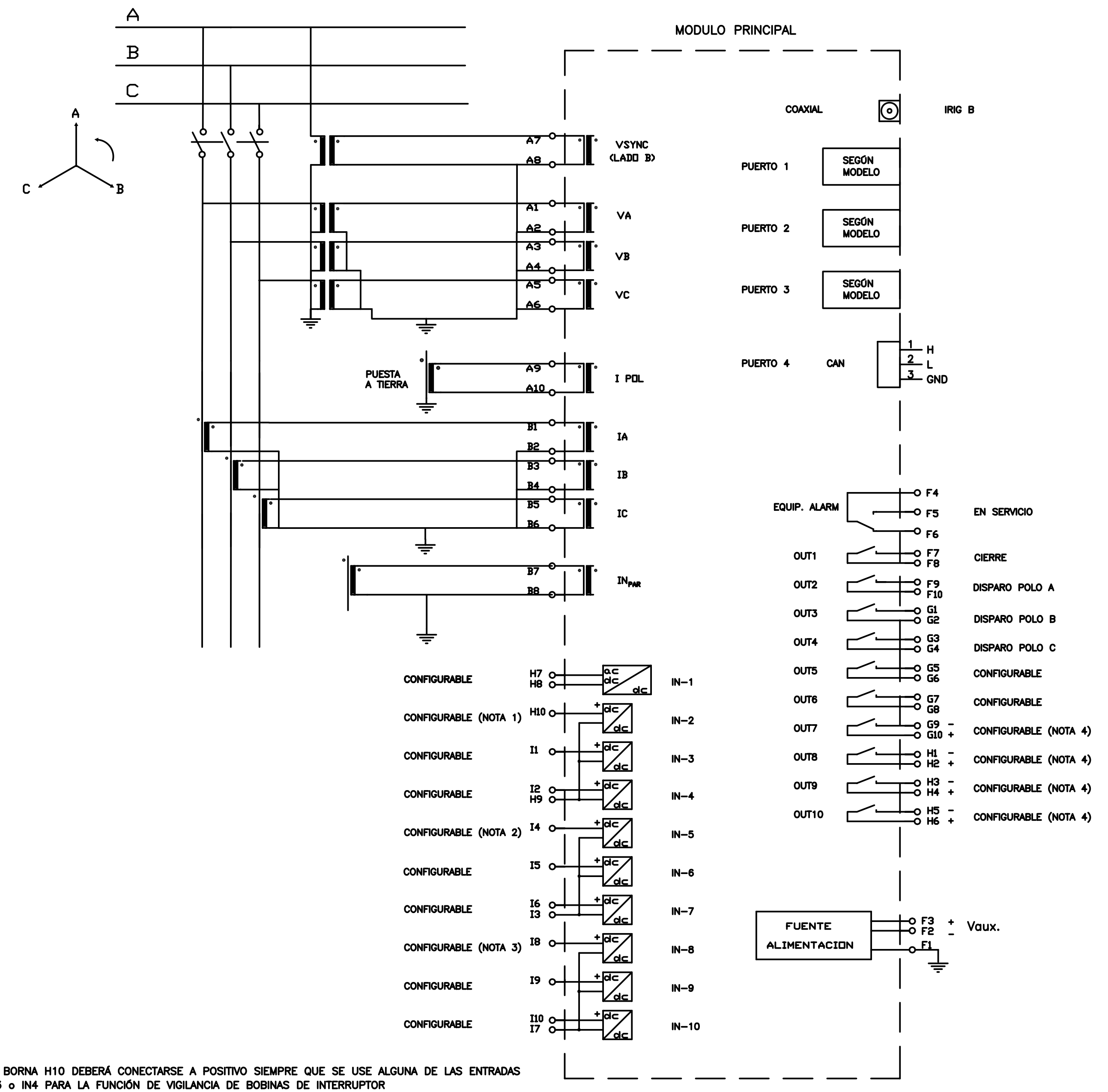
TITULO: CONEX. EXTERNAS ZLV-B/F 4U Caja Q

PROYECTO: ZLV

Rev.0
Rev.1 23/07/08

NUMERO: 3RX0193/0019

	Fecha	Nombre	
Dibujado	13/02/06	I.L.I.	Hoja: 2
Aprobado	13/02/06	J.R.S	Continua en Hoja:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10.– CONFIGURABLE.
11. – CONFIGURABLE
12. – CONFIGURABLE
13. – CONFIGURABLE
14. – CONFIGURABLE.
15. – CONFIGURABLE
16. – CONFIGURABLE

PUERTO SERIE RS-232 FULL MODEM

PIN	SEÑAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

PUERTO SERIE RS-232 / RS-485

PIN	SEÑAL
1	LIBRE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	LIBRE
8	LIBRE
9	LIBRE

PUERTO SERIE CAN

PIN	SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3 o IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6 o IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9 o IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

NOTA 4: LAS SALIDAS OUT7 A OUT10 PUEDEN SER CONFIGURADAS COMO SALIDAS RÁPIDAS (RELÉ DE ESTADO SÓLIDO)

REVISIONES	0	CD0602148	1	CD0805153	2	CD0807111	3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CON EXT ZLV-B/F 4U Caja Q. Entr. mA

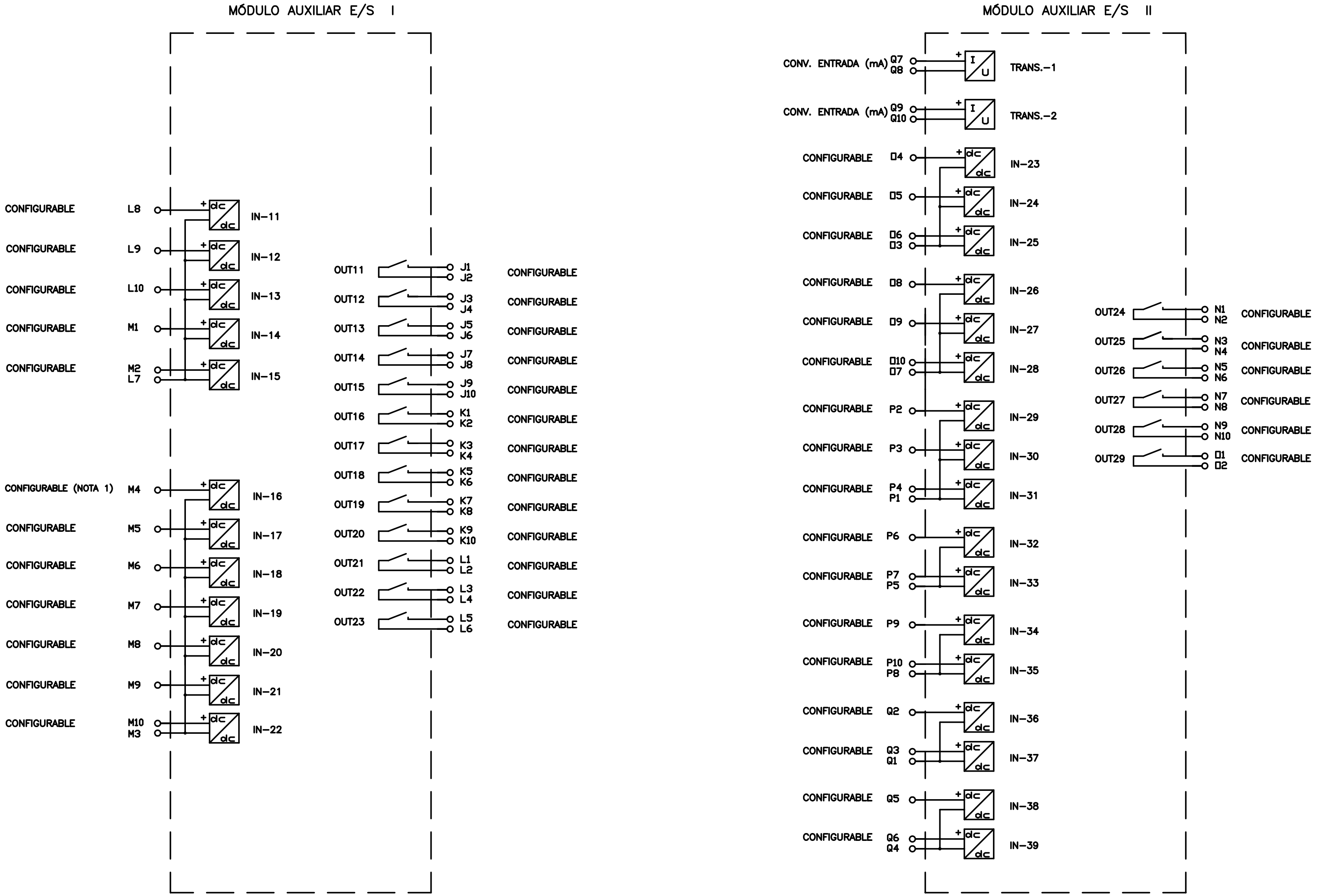
PROYECTO: ZLV

Rev.0
Rev.1 06/06/08
Rev.2 23/07/08

NUMERO: 3RX0193/0020

	Fecha	Nombre
Dibujado	15/02/06	I.L.I.
Aprobado	15/02/06	J.R.S.

Hoja: 1
Continua en Hoja: 2



NOTA 1: LA BORNA M4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN17, IN18, IN19, IN20, IN21 o IN22 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

REVISIONES	0	CD0602148	1	CD0807111	2		3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CON EXT ZLV-B/F 4U Caja Q. Entr. mA

PROYECTO: ZLV

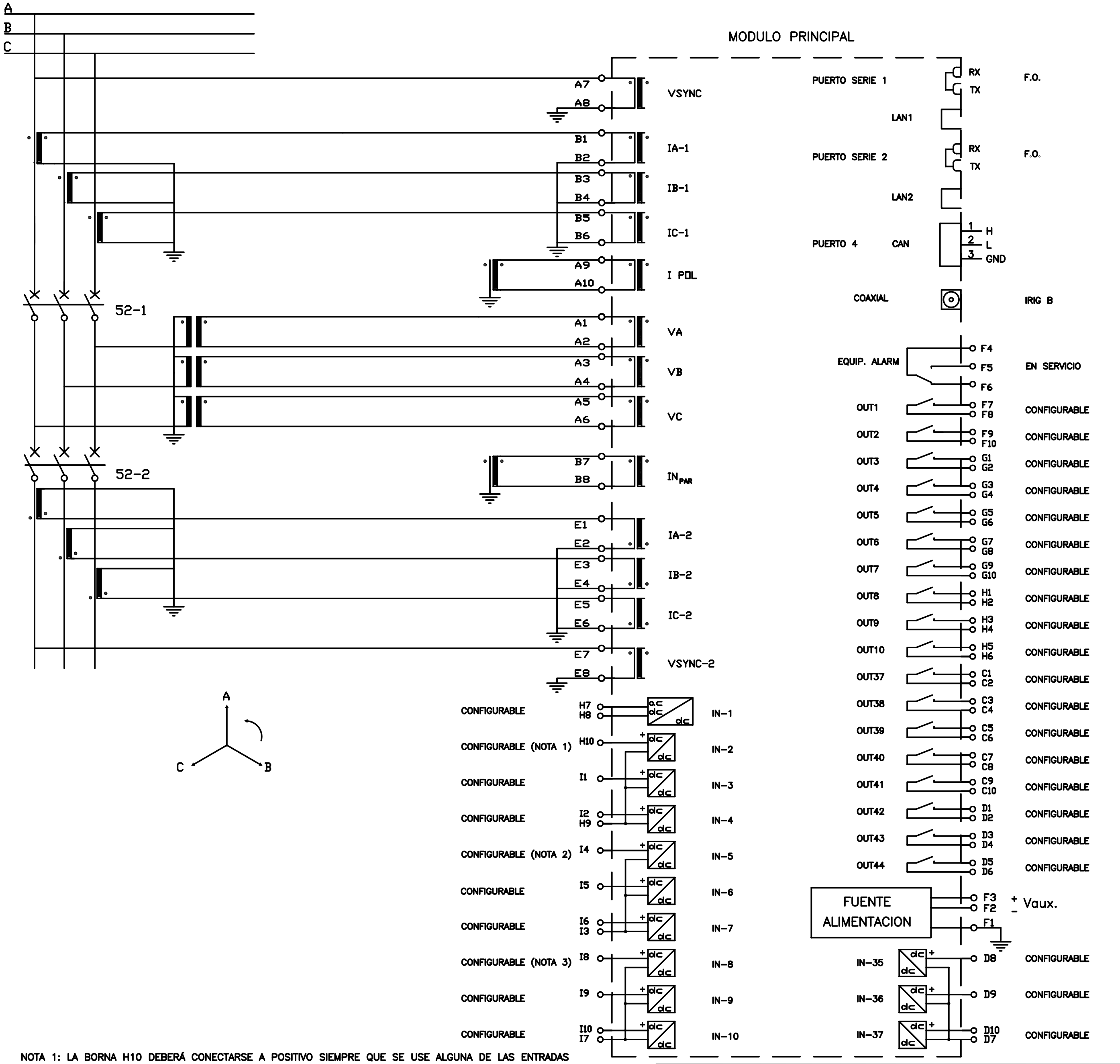
Rev.0
Rev.1 23/07/08

NUMERO: 3RX0193/0020

	Fecha	Nombre
Dibujado	15/02/06	I.L.I.
Aprobado	15/02/06	J.R.S

Hoja: 2

Continua en Hoja:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10. – CONFIGURABLE.
11. – CONFIGURABLE
12. – CONFIGURABLE
13. – CONFIGURABLE
14. – CONFIGURABLE.
15. – CONFIGURABLE
16. – CONFIGURABLE

PUERTO SERIE CAN

PIN	SEÑAL
1	H
2	L
3	GND

NOTA 1: LA BORNA H10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3, IN4 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 2: LA BORNA I4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN6, IN7 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 3: LA BORNA I8 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN9, IN10 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

REVISIONES	0	CD0803104	1	CD0809146	2	CD0809146	3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnología S.A.

TITULO: CONEXIONES EXTERNAS ZLV–G 6U

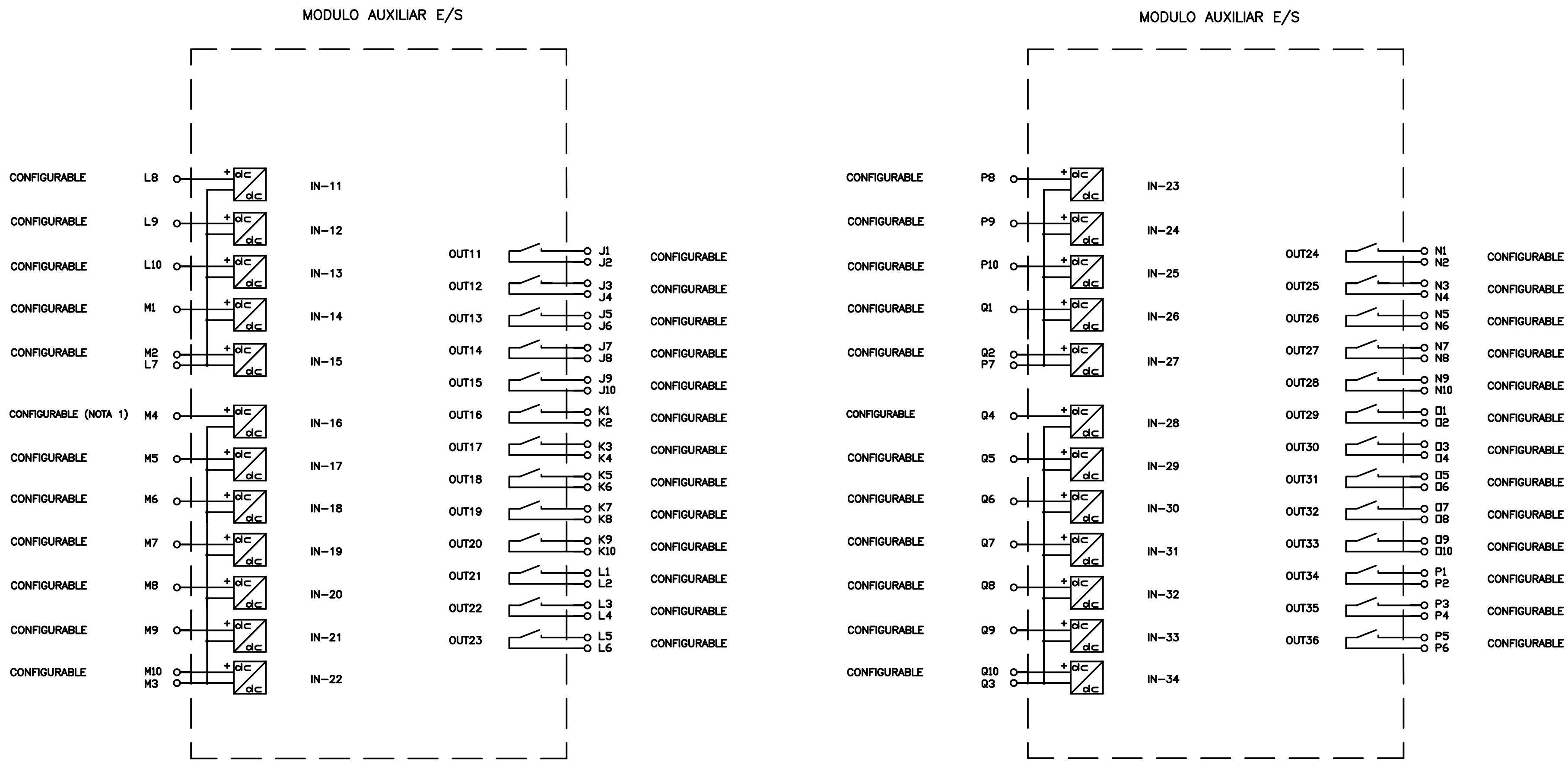
PROYECTO: ZLV–G

Rev.0
Rev.1 02/10/08
Rev.2 19/11/08

NUMERO: 3RX0193/0032

	Fecha	Nombre
Dibujado	06/03/08	J.C.S.
Aprobado	06/03/08	J.M.Y.

Hoja: 1
Continua en Hoja: 2



NOTA 1: LA BORNA M4 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN17, IN18, IN19, IN20, IN21 o IN22 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR

REVISIONES	0	CD0803104	1		2		3		4	
5		6		7		8		9		10
11		12		13		14		15		16

Z I V Aplicaciones y Tecnologia S.A.

TITULO: CONEXIONES EXTERNAS ZLV-G 6U

PROYECTO: ZLV-G

Rev.0

NUMERO: 3RX0193/0032

	Fecha	Nombre
Dibujado	06/03/08	J.C.S.
Aprobado	06/03/08	J.M.Y.

Hoja: 2

Continua en Hoja:

E. List of Illustrations and Tables

Annex E. List of Illustrations and Tables

E.1 List of Figures

Annex E. List of Illustrations and Tables

E.2 List of Tables

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ZIV Aplicaciones y Tecnología S.L.
Parque Tecnológico, 210
48170 Zamudio (Bizkaia)
Apartado 757
48080 Bilbao - Spain
Tel.- (34) 94 452.20.03