IDV

Transformer Differential Protection and Control IED

Instructions Manual for **IDV** Models
M0IDVA1810Iv04

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Chapter 1.

Description and Start-Up

1.1 Functions

The IED generically called **IDV** integrates protection, control and metering functions for a great variety of applications of transformers and autotransformers. These IEDs use the most advanced digital technology based on a potent microprocessor and DSPs that incorporate differential protection, overcurrent protection, voltage protection, frequency protection, overexcitation protection and others.

Protection and control IEDs model **IDV** have all the necessary functions to protect, control and meter a transformer, autotransformer or reactance bay.

1.1.1 Three-Phase Differential Protection (3x87 + 3x87/50)

All IEDs include three-phase differential protection for detecting internal faults of the protected machine, as well as faults occurring within its CTs' zone of influence. The **IDV-A/G/J** models include a protection for machines with two windings, while the **IDV-B/D/F/H/K/L** models provide protection for three windings.

The **87T** unit (**Differential with Restraint**) considers the level of the circulating currents and their harmonic content (2nd, 3rd, 4th and 5th harmonic), and can restrain unit operation avoiding undue operations due to CT measurement errors and to harmonics generated during inrush from the machine itself or from a nearby machine, as well as line voltage changes that cause overexcitation. **IDV-D/F** relay restraint differential element is provided with up to four three phase current channels, which allow for higher restraint current on external faults in dual breaker (breaker-and-a-half or ring) positions and, thus, increased stability.

The **87I** unit (**Instantaneous Differential** or **Differential without Restraint**) acts against extremely severe faults within the CTs' zone of influence, performing no restraint.

1.1.2 External Fault Detector

IDV-D/F/G** relays incorporate an external fault detection element, on the one hand, to handle the ratio between instantaneous differential and restraint current and, on the other hand, for the directional comparison of all the currents measured by the relays.

1.1.3 Three-Phase and Calculated Ground Overcurrent for each of the Windings (3x 50/51 + 50N/51N)

All the models have four overcurrent measuring units for each machine winding (three phase and one ground unit). Each phase unit contains two time elements and three instantaneous elements with an additional adjustable timer. The calculated ground units contain two time elements and two instantaneous elements with an additional adjustable timer.

The time elements have a wide range of selectable time-current curves per IEC, IEEE and US standards: Fixed Time, Moderately Inverse, Inverse, Very inverse, Extremely Inverse, Long-Time Inverse, Short-Time Inverse, RI Inverse as well as any of them configured with a Time Limit, and one User-Defined Curve.

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

1.1.4 Ground Overcurrent Protection (50G/51G)

Additionally, **IDV-A/B/D/H/K/L** models feature two ground measurement units with direct measurement of machine grounding (IG-1 and IG-2), each comprising two time and two instantaneous elements with additional adjustable timing. **IDV-G/J** models include only one grounding channel (IG1). With reference to model **IDV-L**, three additional analog ground channels could be added, each consisting of two time elements and another two instantaneous elements, provided the setting **Number of windings** is set to **Two windings**.

The time element features are identical to those indicated in the previous case.

1.1.5 Directional Units (67+67N+67Q+67P)

In all the models, except for the **IDV-F** model, you can set any of the previously mentioned calculated ground units as directional units. The grounding currents of the machine (IG-1 and IG-2) are used for polarization of the ground directional unit, and can be assigned for this function to any of the existing windings.

Those models with three phase voltage channels (**IDV-/K/J**) with spare digit **D** have the following directional units:

- **Phase Directional Unit**: it will work with the phase currents of the reference winding and the phase-phase voltages.
- **Neutral Directional Unit**: it will work with the neutral currents of the reference winding and the neutral voltage (which can be measured or calculated, depending on the setting **Origin of the neutral voltage**).
- **Negative-Sequence Directional Unit**: it will work with the negative-sequence current of the reference winding and the negative-sequence voltage.
- **Positive-Sequence Directional Unit**: it will work with the positive-sequence current of the reference winding and the positive-sequence voltage.

1.1.6 Negative Sequence Overcurrent Protection for each of the Windings (50Q/51Q)

All the models, except for the **IDV-F** model**,** have independent negative sequence overcurrent measuring units for each machine winding. These units contain two time elements and two instantaneous elements with an additional adjustable timer.

1.1.7 Instantaneous One-Phase Overcurrent (50FA)

The **IDV-B/H** model for three windings features an overcurrent measuring unit that circulates through the machine’s tertiary. Its operation can be subordinated to restraint by 2nd and 5th harmonics. There is another overcurrent measuring unit similar to the one above but without restraint possibilities, and for higher pickup settings. There are settings for enabling or disabling both overcurrent units with and without restraint.

1.1.8 Voltage Dependent Phase Overcurrent Protection (3x51V)

IDV-J/K/L models have three Voltage Dependent Overcurrent units (three phases) each with a definite time delay element and an instantaneous element. Operation can be set as **Voltage Restrained Units** or **Voltage Controlled Units**.

1.1.9 Distance Protection (21/21N)

IDV-F relays incorporate four distance protection zones to be applied as back up protection on network faults, being in this way more selective than the above described overcurrent elements. Said distance zones may be assigned, through a setting, to the primary or secondary winding.

Zones are reversible and are provided with six separate measuring elements; incorporates own settings for reach (Z1) and zero sequence compensation (K0=Z0/Z1, applied to ground elements), both in magnitude and phase angle, separate from other zones, which provides better measuring element accuracy in compound line applications. On the other hand, every zone is provided with separate reach and resistive limit settings (if selecting quadrilateral characteristic) for phase and ground elements.

Mho or **Quadrilateral** distance characteristic can be set separately for phase-to-phase and ground faults.

1.1.10 Elements complementary to Distance Elements

IDV-F relays incorporate a number of elements complementary to distance zones, namely:

- Supervision Elements.
- Phase Selector.
- Fuse Failure Detector.
- Load Limiter.
- Power Swing Detector.

1.1.10.a Overcurrent Supervision for Distance Protection (50SUP)

IDV-F 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.

1.1.10.b Phase Selector

IDV-D/F relays count on a Phase Selector. This enables the generation of ground-fault and two-phase fault signals from **IDV-D** relays which will be used by the Fault Detector. For **IDV-F** relays, the phase selector enables the determination of the type of fault in order to decide which distance elements must operate.

1.1.10.c VT Fuse Failure Detector

IDV-F/J/K/L relays include a fuse failure detector. This element can block the operation of distance elements or any other voltage based element if absence of any secondary voltage of a voltage transformer is detected.

1.1.10.d 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.

1.1.10.e Power Swing Detector (68/78)

IDV-F 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.

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

1.1.11 Phase Undervoltage Protection (1x27)

IDV-A/B models have an undervoltage unit comprising two instantaneous elements with an additional adjustable timer. The user can select the voltage as Line or Phase, as well as their corresponding phases, by using the proper setting. There are status contact inputs for blocking undervoltage trip. **IDV-G/H/J/K/L** models include three-phase undervoltage units.

1.1.12 Phase Overvoltage Protection (1x59)

IDV-A/B models include an overvoltage unit comprising two instantaneous elements with an additional adjustable timer. The user can select the voltage as Line-to-neutral or Phase-to-phase, as well as their corresponding phases, by using the proper setting. There are status contact inputs for blocking overvoltage trip. **IDV-G/H/J/K/L** models include three-phase overvoltage units

1.1.13 Neutral Overvoltage Protection (64 / 59)

IDV-A/B models have a ground overvoltage measuring unit that takes the measurement from a voltage transformer connected to the IED in open DELTA (64). **IDV-G/H/J/K** models take the ground overvoltage measurement by calculating the three phase voltages available in the IED.

Models **IDV-L** are provided with a setting with which the operating magnitude is determined: measurements of voltage transformer connected in open delta to the equipment or ground voltage calculated from the three measured phase voltages.

The measurement unit contains two instantaneous elements with an additional adjustable timer. There are status contact inputs for blocking ground overvoltage trip.

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

IDV-A/B/G/H/J/K/L relays are provided with an analog phase voltage input (Vph or VA depending on the model) to obtain the frequency. **IDV-A/B/G/H** relays, models with code number **X12=C** and **IDV-L** models with code number **X12=C** include twelve measurement elements (4 underfrequency, 4 overfrequency and 4 frequency derivative), whereas **IDV-J/K/L** relays include 6 (2 underfrequency, 2 overfrequency and 2 frequency derivative). These elements consist of a settable fix timer element, which can also be set as instantaneous.

There are status contact inputs for blocking trips induced by any of these frequency units.

For **IDV-B/H/K/L** models, Underfrequency / Rate of Change and Overfrequency units 1 can be programmed to perform a load shedding and reset step. For more steps, it is necessary to use the programmable logic and configure it using the signals generated by the rest of the frequency units.

1.1.15 Breaker Failure Units (for the Breakers of Windings 1, 2 and 3) (50/62BF)

IDV-A/B/D/G/H/J/K/L models has four breaker failure detection measurement units (three phase and one calculated ground) for the three-phase trip of each breaker, which sends trip commands to one or more breakers whenever required.

The breaker failure protection on **IDV-D** relays enable the supervision of four different breakers.

IDV-J/K/L models include retrip function and detection of breaker failure with no phase overcurrent.

1.1.16 Thermal Image Units for each of the Windings (49/49G)

IDV models provide independent thermal protection for each machine winding that, by squaring the current running through the winding, estimates the thermal status to produce a trip when dangerous temperature levels are reached.

IDV-D model includes a Thermal Image protection for each machine ground channel (IG-1 and IG-2).

This IED also features thermal memory, keeping the thermal image of the machine in case of loss of power to the equipment.

The IED provides independent alarm and trip indication for each winding, and both of these can be routed to the equipment's configurable logic.

1.1.17 Hot Spot Thermal Image Unit (26)

IDV-L models and/or with code number **X12=C** include a Hot Spot thermal image unit applicable to oil immersed power transformers based on the IEC 60076-7 loading guide. The operation of the unit is based on both the temperature measurement of the top oil layer in the transformer tank (via a thermal sensor), and on the transformer load (ratio between the circulating current and the transformer nominal current). The top oil layer temperature and the transformer load are used to estimate the temperature of the hottest point in the winding (Hot Spot) to cause a trip if a Hot Spot temperature is reached. Exceeding the Hot Spot temperature degrades the transformer and accelerates transformer aging.

The unit has two alarm levels (oil temperature and Hot Spot temperature) and two trip levels (oil temperature and Hot Spot temperature) that can be disabled by a setting.

Additionally, the unit includes a function for calculating transformer loss of life (starting from the Hot Spot temperature), and a function to control the efficiency of the cooling system. Therefore, a second thermal sensor is required to obtain the ambient temperature measurement.

The unit monitors the following magnitudes: top oil layer temperature, Hot Spot temperature, ambient temperature, cooling efficiency, and transformer loss of life.

The Hot Spot thermal image unit is designed to protect the transformer during long term emergency load conditions. The overload unit covers short term emergency load conditions.

1.1.18 Overload Units (50/51OL)

IDV-L models and/or with code number **X12=C** include an instantaneous overload unit and timer to protect the transformer during situations of excessive loads, which need to be disconnected for a short time (short term emergency load conditions). These units are independent of the Hot Spot thermal image unit, and can be used for other applications.

The characteristics of these units are identical to those of the instantaneous units and phase timers. The only exceptions are the fixed time setting of up to 1 hour, and the lack of a directional characteristic.

1.1.19 Restricted Earth Fault Units (87N)

IDV-A/B/D/H/K/L models have two Restricted Earth Fault measuring units, each comprising two independent time elements. Each of the described measuring units is made using the measurement of the two analog machine grounding current inputs (IG-1 and IG-2) and assigning the inputs to any of the existing windings through the corresponding settings. **IDV-G/J** model has only one Restricted Earth Fault measuring unit.

The idea is to detect faults within the WYE or ZIGZAG windings under grounded, DELTA or grounded through reactance connection, where the value of the fault current produced can be very small depending on the ground impedance and the location of the fault within the winding itself.

1.1.20 Overexcitation Protection (24) (69V/Hz or 59/81)

IDV-A/B/G/H/J/K models are equipped with a unit to determine the overexcitation level of the protected machine. Models **IDV-L** and/or models with code number **X12=B/C** are provided with four overexcitation elements with separate levels. These units have an element for determining the voltage/frequency ratio; the units take action if this value exceeds a certain setting.

Trip outputs of any element can be delayed by a settable time (fixed or inverse).

1.1.21 Cold-Load Pick-Up

The purpose of this function is to avoid undesired trips when reconnecting some of the breakers controlled by the IED when feeding a large set of loads. After selecting the breaker to be controlled there will be an automatic change for the current settings group to the fourth one (Table 4).

This is achieved by selecting the breaker whose shutoff the user wishes to supervise; the timed switch to table 4 of settings occurs automatically.

1.1.22 Current Measurement Supervision (60CT)

System for the supervision of the set of elements that make up the system for measuring phase currents, ranging from external current transformers to the copper cables that connect elements to the relay, to internal magnetic modules for the **IDV-L** equipment and/or models with code number **X12=B/C**.

1.2 Additional Functions

1.2.1 Local Control

You have seven buttons (six totally user-definable and one for lockout relay reset) on the front of the IED for operating on the system's configurable elements in the equipment (Lockout, Breakers, Sectionalizers, 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 captured or equipment-calculated 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 **IDV** and the exterior: auxiliary output contacts, display, communications, LEDs, HMI…

1.2.3 Ports and Communications Protocols

IDV relays are provided with different types of communications ports (depending on 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) or electrical interface RS232 / RS232 FULL MODEM.
  - Remote Port 2: optical fiber interface (glass ST or plastic 1mm) or electrical interface RS232 / RS485.
  - Remote Port 3: electrical interface RS232 / RS485.
- Up to **2 LAN Ports** with RJ45 connector or glass optical fiber MT-RJ for ETHERNET type communications.
- **1 Remote Port** with CAN protocol BUS connection.

The IED also has the following communications protocols: PROCOME 3.0, DNP 3.0 and MODBUS. You can assign any one of them to both remote ports. For PROCOME it can be also assigned to the LAN ports; IEC-61850 (LAN ports) and CAN (electric BUS CAN). The local port supports the PROCOME 3.0 Protocol. It is for parameter setting, configuration and retrieval of information about the IED.

Protocol changeover trailers are completely independent for each port, but several instances of the same protocol can be maintained in both remote ports.

1.2.4 Zero Sequence Filter

The equipment includes a Zero Sequence Filter (adjustable) to compensate the zero sequence current that can flow through the windings in certain circumstances. Some models include a setting through which the type of zero sequence current extracted by the zero sequence filter can be selected: by phase channels or by ground channels.

1.2.5 Adapting the Connection Group

The phase displacement, introduced by the connection group of the machine to be protected between the primary and secondary/tertiary currents, is compensated through the proper setting.

1.2.6 Tap Compensation

Since the current transformers used to measure the winding currents use different transformer ratios, they do not allow direct comparison of the measured currents. The equipment makes up for this difference through the tap settings of each winding.

1.2.7 Adapting to CTs with Different Nominal Currents

By simply setting the value of the nominal current of each winding, the **IDV** equipment is capable of providing proper protection to machines where CTs with different nominal values in the windings are being used.

1.2.8 Own Protections

Eight logic inputs, assignable to digital inputs or logic outputs programmed in the equipment, are available. These inputs automatically trip the breakers associated with the machine.

The purpose of these inputs is to be associated with the machine's own protections.

1.2.9 Lockout Module (86)

IDV IEDs are equipped with a Lockout function, whose goal is to activate a signal whenever one of the units protecting the machine is tripped. Through the corresponding settings the user can select which units can activate this signal, as well as the close command blocking that can be programmed in the equipment.

This signal remains active until a reset command is received through the HMI, communications or a digital input.

1.2.10 Breakers Trip Logic

For those protection units that do not specifically operate in case of a fault or danger due to thermal overload in the machine, users can select whether the activation causes only the trip of the winding breaker assigned to the winding under fault or the trip of all breakers in the machine.

Differential, Restricted Earth Fault, Thermal Image and Overexcitation units, as well as the actions of the machine's own protections, are excluded from this logic. In model **IDV-D**, the thermal image of the ground channels (IG-1 and IG-2) enables the selection of either its own, or all the breakers to be tripped.

1.2.11 Supervision of the Switching Circuits

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.

1.2.12 Selecting the Phase Sequence

It is necessary to know the power system's phase sequence (ABC or ACB) in order to properly calculate the sequence components and power values. In addition, in a differential relay where the windings can have different connection groups, it is indispensable to take into account this sequence in order to make the relevant compensation.

The **Phase Sequence** setting reports the system's actual rotation to the equipment; all equipment functions operate correctly by keeping the same analog current and voltage input connections indicated for phases A, B and C in the external connections diagram.

1.2.13 Breaker Monitoring

To have information for maintaining the breakers all the models, except for **IDV-F** model have a unit that sums and accumulates the kA^n values each time it trips.

1.2.14 Integrated Simulator

The equipment features (depending on the model) 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.

1.2.15 LED Targets

The **IDV** unit is equipped with five optical indicators (LEDs) for the 2U and 3U height models and 17 for the 6U height models, located on the left and right sides of the front panel. All of them are user-definable, except one which indicates that the equipment 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.

1.2.16 Digital Inputs

The number of digital inputs available will depend on each particular model (see 1.5, Model Selection) and may vary from 8 up to 44.

1.2.17 Supervision of Digital Inputs

IDV relays incorporate a Supervision function for digital inputs. When applying a setting, you can select the input to be used for enabling digital inputs. Should the minimum voltage threshold not be exceeded, the other digital inputs will lose the validity of the signals received, and will thus be disabled.

1.2.18 Auxiliary Outputs

The number of auxiliary outputs available will also depend on each particular model (see 1.5, Model Selection) and may vary from 10 up to 44. One of these outputs is not configurable as it is assigned to the relay “In Service” indication.

Some models can also incorporate 6 fast solid state outputs and 4 fast solid state outputs with make and break capacity lower than the rest.

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

1.2.19 Trip and Close Outputs

Two winding models **IDV** can include 4 preset trip output contacts, whereas three winding models can include 6 contacts.

Also, **IDV** relays may not incorporate preset outputs in the tripping function. Any of their auxiliary outputs can be configured with said function always depending on the specific model (refer to 1.5, Model selection).

1.2.20 Virtual Inputs/Outputs

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

1.2.21 Time Synchronization

The IEDs include an internal clock with a resolution of 1 ms. 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.

1.2.22 Event Recording and Programmable Metering Data Logging

Storage capacity of 1000 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.

1.2.23 Fault Reporting

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

1.2.24 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 (captured or calculated) 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.

1.2.25 Oscillographic Register

The Oscillographic Recording function is composed of two different sub functions: **capture** and **display**. Both analog magnitudes and internal signals as well as digital equipment inputs and outputs 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 seconds of total storage.

Sampling and storing frequency can be selected in **IDV-D** relays: 32 or 16 samples per cycle, with 29.5 and 59 seconds for total storage, respectively.

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

1.2.26 DC Power Monitoring

Some models include a function for monitoring the voltage supplied by the substation's DC battery and used to power the equipment.

This monitoring allows overvoltage and undervoltage alarms to be generated, also making it possible to generate a log of voltage values and store them in the ocillographic records that can accompany each use of the equipment.

To perform the monitoring, the equipment includes an input transducer specifically designed to measure the prevailing direct current values in the substations.

1.2.27 Alphanumeric Display and Keypad

- Changing and displaying settings.
- Protection operations:
  - Last trip.
  - Units picked up.
  - Tripped units.
  - Contact input and output status.
- Protection records (displayed via communication):
  - Event recording.
  - Fault report.
  - Log file of currents, voltages, powers, power factor and energies or other calculated values.
- Control records
- Metering values used by protection:
  - Phase, ground and calculated ground currents and their angles for each winding.
  - Differential currents, restraint currents and harmonic differential currents (2^{nd} to 5^{th} order) for each phase and ground differential currents of each grounding channel.
  - Voltages of the three phases and ground and their angles.
  - Thermal image value of each winding.
  - Thermal image value of each grounding channel.
  - Maximum and minimum current.
  - Maximum and minimum voltage.
  - Positive, negative and zero sequence currents of each winding.
  - Active, reactive, apparent powers and power factor.
  - Maximum and minimum powers.
  - Frequency, Rate-of-Change.
  - Energies.
  - Hot Spot temperature, ambient temperature, Oil and Refrigeration.
  - Overexcitation magnitude.
  - Cumulated squared current.
  - Transducer inputs.
  - 2^{nd} to 8^{th} order harmonics of the current of phase A.

1.2.28 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: Alphanumeric Display and Keypad

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.

The display resolution talking about meterings depends on the measurement which is going to be shown (defined inside Chapter 2.1, measurement accuracy or in the control logic side of the relay).

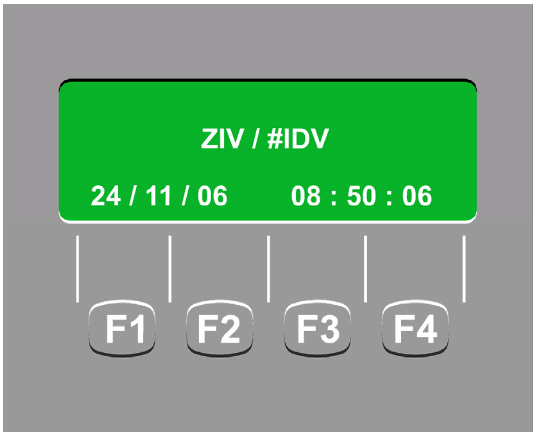


Figure 1.3.1: Alphanumeric Display.

- **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)

- **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.

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

1.3.2 Command Buttons (only 8IDV Models)

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 86 selection button (button for resetting function 86 - Lockout -). This button is accompanied by 1 LED (red / green) indicating the blocking relay 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 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.

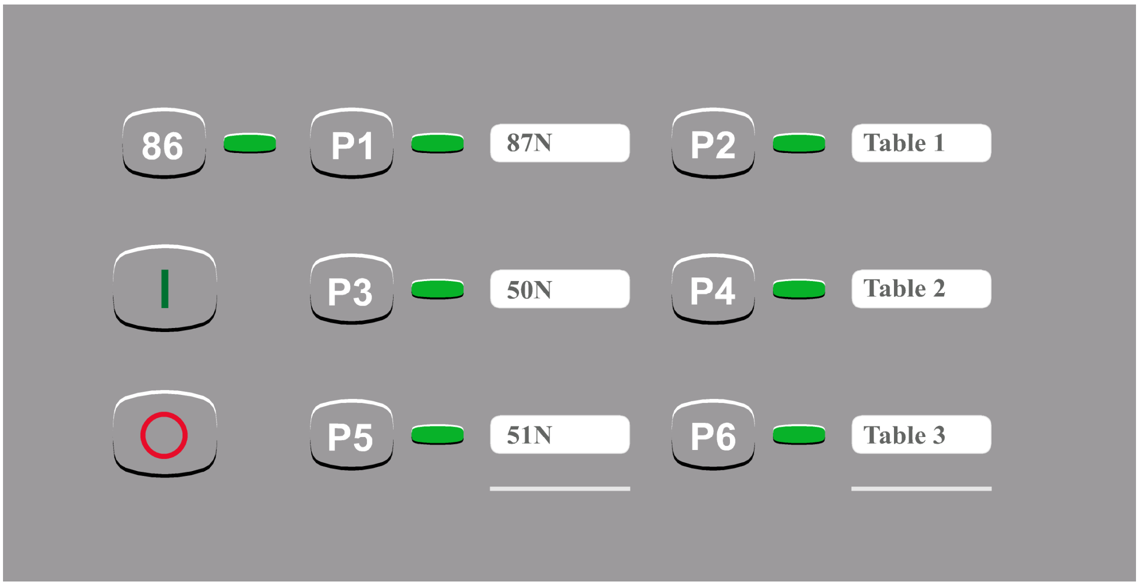


Figure 1.3.3: Control Buttons and Programmable Buttons.

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

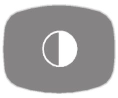
The ESC key is used to exit a screen if the setting is not to be changed or simply to exit an information screen. In any case, pressing this key, system returns the display to the immediately preceding screen.

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

F1 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.

F2 The F2 key is used to consult the relay for information relative to measurements of current, voltage, power, as well as user defined values and counters, and to reset the last trip indication and LEDs.

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

F4 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.

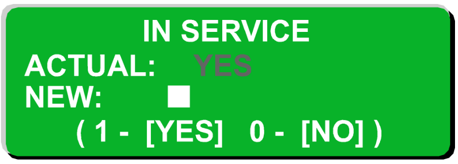
1.3.3.d Operation

- **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.

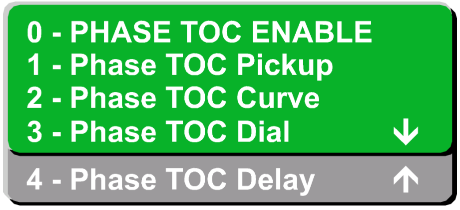
The digit keys are used to edit the new value, which must agree with the range specified in the last line of the display. If an error occurs upon inputting a value, the ▼ key will erase it. Once the new value has been edited, pressing ENT confirms it and exits to the preceding menu.

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 elements 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.

To reset any Last Trip indication on the HMI, F2 key should be pressed for a while and follow the instructions on the display.

1.4 Local Interface: Graphic Display

1.4.1 Introduction

The graphical display is only mounted in models **7IDV** and this chapter is only about its operation as well as the operation of the associated function keys (figure 1.4.1). The examples depicted are intended to explain display operation.

Please note that the graphic display operates in the same manner for both the horizontal and vertical **7IDV** models.

1.4.2 General

Graphical displays are LCD 114 x 64 mm (240 x 128 pixels). They are provided with own illumination and include five keys with following functions:

Functions	Designation	Color
Configurable	O	Red
Configurable	I	Green
Configurable	TAG	Blue
Selection	NXT	Gray
Information	INF	Gray

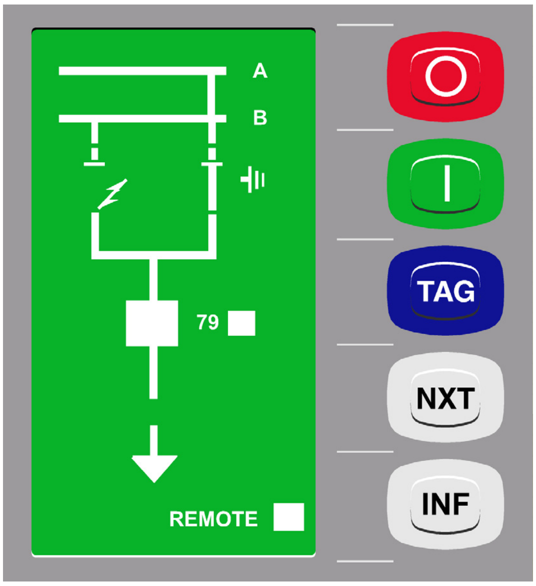


Figure 1.4.1: Local Control Graphic Display.

As shown in table, the first three keys (**O**, **I** and **TAG**) are configurable thus their function must be defined through the programmable logic. That is not so for **NXT** and **INF** keys that already have a function assigned to them.

Two options are available to operate the graphical displays: press function key **INF** to display the information screens or press **NXT** function key to display the different mimic objects and operate on them. Information screens and objects are displayed in sequence. Starting from any information screen, if the **INF** key is not pressed again within an adjustable time the system returns to the default screen. Also, if **NXT** key is not pressed within 10 seconds the system returns to the screen with no element selected.

Press **NXT** within the time-out period to select mimic objects one after the other until the situation of no element selected is reached again. Selected elements are represented graphically by a flashing symbol. This symbol may be created by the user or taken from the databases of the program, as described in figure 1.4.2 (as a function of their state).

Screen sequence can be selected, and a position mimic can be defined indicating the state of the different elements. Elements depicted in the single line diagram depend on the information associated to each of them. All this information is defined in the user configuration loaded into the relay.

1.4.3 Symbols associated to the Graphical Display

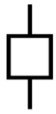
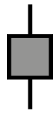
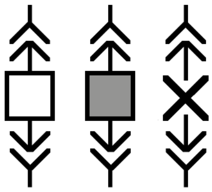
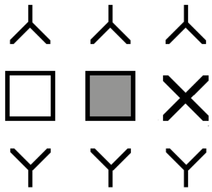
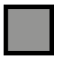
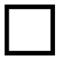
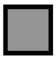
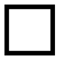
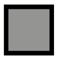
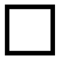
Element	State 1	State 2
Breaker	 Open	 Closed
Breaker	 Unknown (0-0)*	 Unknown (1-1)*
Switch	 Open	 Closed
Position of the Breaker mechanism	 Plugged	 Unplugged
Position of the Breaker mechanism	 Pulled out closed	 Pulled out open
Recloser	**79**  In Service	**79**  Out of Service
Capacitor Bank Control	**AUT**  Automatic	**AUT**  Manual
Voltage Regulator	**90**  Automatic	**90**  Manual

Figure 1.4.2: Device Representation Symbols.

Device representation on display will depend on the state of one or several digital signals, the following representation objects being possible:

- Base.
- Command object.
- 2 state object.
- Magnitude object.
- Text object.

- **Base**

This object is the starting point for screen design. It can be created by the user or it can be taken from the program database.

Static parts (Busbars or ground connections) or the different alarm display boxes are base examples.

- **Command Object**

Command objects represent objects able to adopt a number of states varying from 1 to 16. Furthermore they can be operated from graphical HMI provided object attributes are configured as selectable.

Multi-state (Open, Closed and Unknown) breakers able to perform opening or closing operations are examples of command objects.

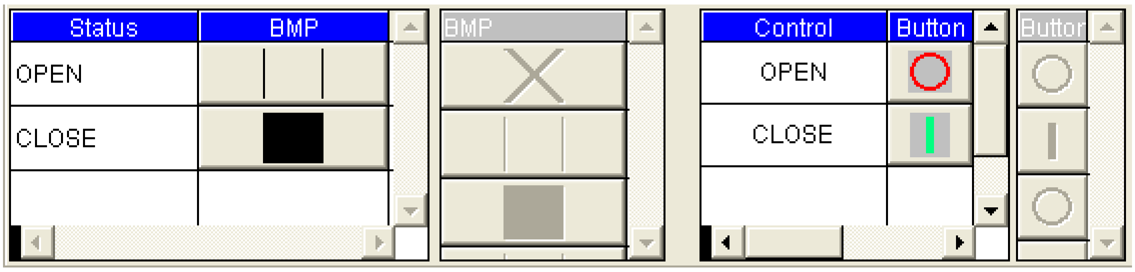


Figure 1.4.3: Example of Breaker State and Operations.

- **2 State Object**

2 state objects represent objects able to adopt one of two states as a function of the value of the digital signal to which it is associated (Deactivated= signal to 0; Activated = signal to 1). Objects may not be operated from graphical HMI their state only being modified when changing the signal value.

Examples of 2 state objects are voltage presence indicators or alarm display signals.

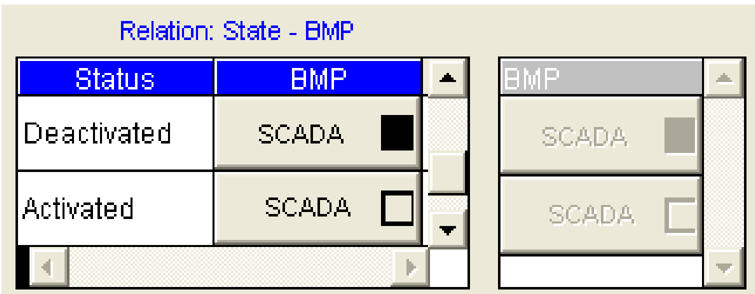


Figure 1.4.4: Example of 2 State Element.

- **Magnitude Object**

Magnitude objects allow displaying both Static (relay default) and User (created through programmable logic) magnitudes.

- **Text Object**

Text objects allow displaying text fields. Maximum number of characters allowed is 16.

It is worth mentioning that all types of objects can be displayed in the same screen, allowing this way for more freedom in screen design.

1.4.4 Access to Information

Press **INF** key for sequential display of accessible information screens on the graphical display.

It is worth highlighting that starting from any information screen, if **INF** is not pressed again within an adjustable time, the system returns to the default screen.

This time setting can only be displayed from the **Configuration** - **Graphical HMI Conf.** its range being from 0 to 60 seconds. A setting of 0 seconds disables the automatic return to the default screen. A **Contrast** setting, within the same option, is available, which affects only the graphical display.

The only default screens are **Digital Output** and **Digital Input** state screens. All other screens and the display sequence are defined through programmable logic.

1.4.4.a Alarm Display

Alarm display appearance as well as the number of screens and alarms to be shown can be designed through programmable logic. Also, digital signals associated to each alarm must be specified as well as the text to be shown on the graphical display.

It is worth mentioning that there are no definite type of screens for alarm display function. Said screens are created in a similar manner than for the rest of graphical display screens, using same objects described in paragraph 1.4.2. This allows maximum flexibility for screen design adapting screens to user needs.

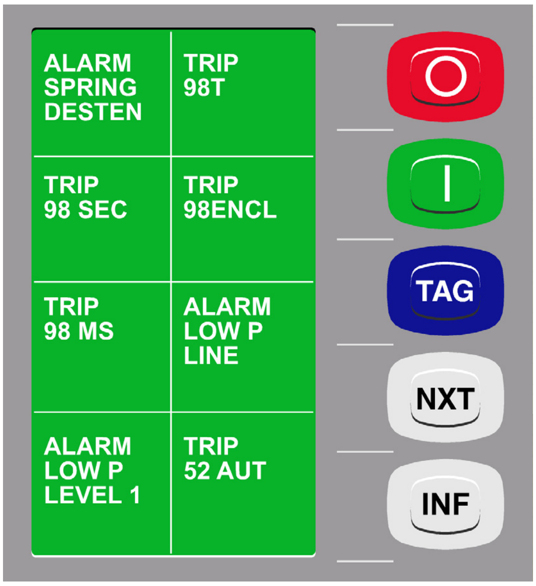


Figure 1.4.5: Example of Alarm Display.

Alarm acknowledgement functions are also defined through programmable logic, which must actuate on the digital signals associated to each alarm.

1.4.4.b I/O State Information

As mentioned in paragraph 1.4.3, **Digital Outputs** and **Digital Inputs** state screens are the only relay default screens. Said screens are not configurable and will thus be different for each model.

New screens can nevertheless be created, in which the state of any digital relay signal whether definite or created through programmable logic is shown.

Digital inputs or outputs are represented by a full rectangle (simulating a LED) if active, whereas the rectangle will be empty if inactive.

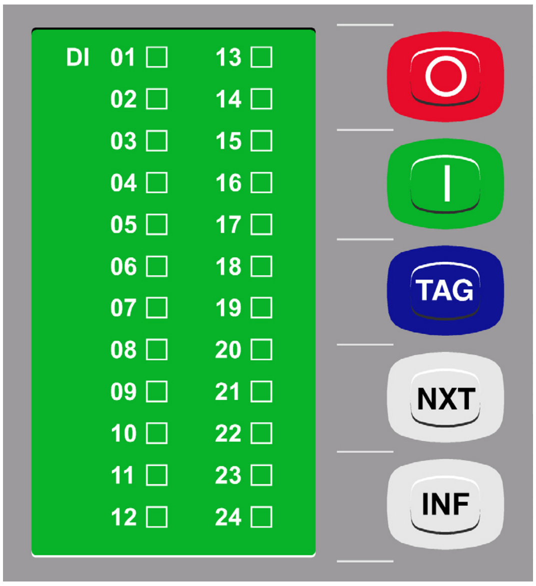


Figure 1.4.6: I/O Display.

1.4.4.c Measurements Information

A screen can be designed for representing relay measurements. As for digital signals, both definite relay measurements (static) and created through programmable logic can be used. No difference exists at the time of using them into the graphical display.

Time is a special measurement. Said static magnitude designated **Present Time** allows representing separately relay date and time.

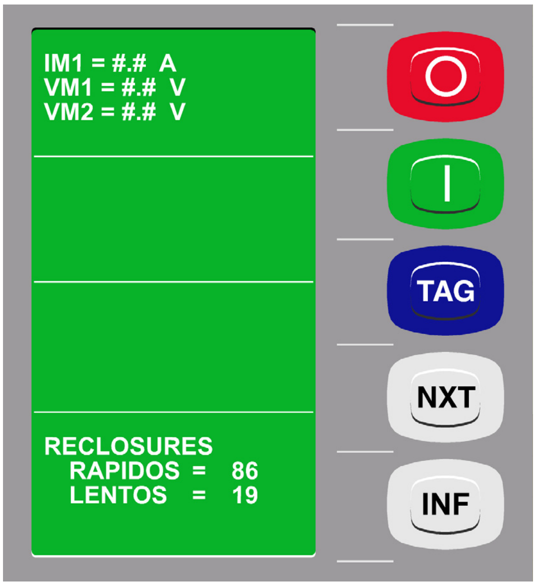


Figure 1.4.7: Example of Display with Measurements.

1.4.5 Control Function Operations

Control functions are mainly performed through graphical displays with the help of the 5 above described control keys.

Action on position elements is conditional on programming a **Command** within the programmable logic and the analysis of said logic on whether said action is feasible or not

1.4.5.a General Procedure for Command Execution

Command execution always follows the same sequential steps no matter the type of the operated device, allowing for easier relay operation.

Every time after pressing the **NXT** key, existing devices are highlighted in sequence and periodically in the position on which commands can be executed. Said highlighting consists in the device image flashing with a 1 second cadence. If after selecting an image no command is received within ten (10) seconds, the module will automatically cancel the selection, returning to the default state corresponding to no element selected. The image part flashing during the selection corresponds to the entire symbol except associated texts.

The established selection sequence can be configured at the time of performing the programmable logic. For a specific position the following sequence could be taken as an example:

- LOCAL / REMOTE Status.
- Panel CONNECTED / DISCONNECTED Status.
- Busbars sectionalizing switch.
- Breaker.
- Associated devices (automatic device recloser etc..).
- Busbars side grounding breakers.
- Line side grounding breakers.
- By pass breakers and finally nothing.

After selecting the element to be commanded press the command key. As a general rule configurable close (**I**) or open (**O**) keys will be used.

If by any reason the command cannot be executed, two text lines will be shown on the relay display stating that execution is impossible as well as the reasons why said command cannot be executed. The following can be some examples:

LINE 1: COMMAND NOT-EXECUTABLE
LINE 2: TAGGED
INTERLOCK
POSITION IN REMOTE CONTROL

These statements are automatically erased after 5 seconds. No operation may be performed within this time.

The possible causes for a COMMAND NOT EXECUTABLE are defined through programmable logic. To this end, at the time of defining a new command, possible digital signals disabling command execution must also be defined. This way, when trying the command a message is displayed with the name of said signal.

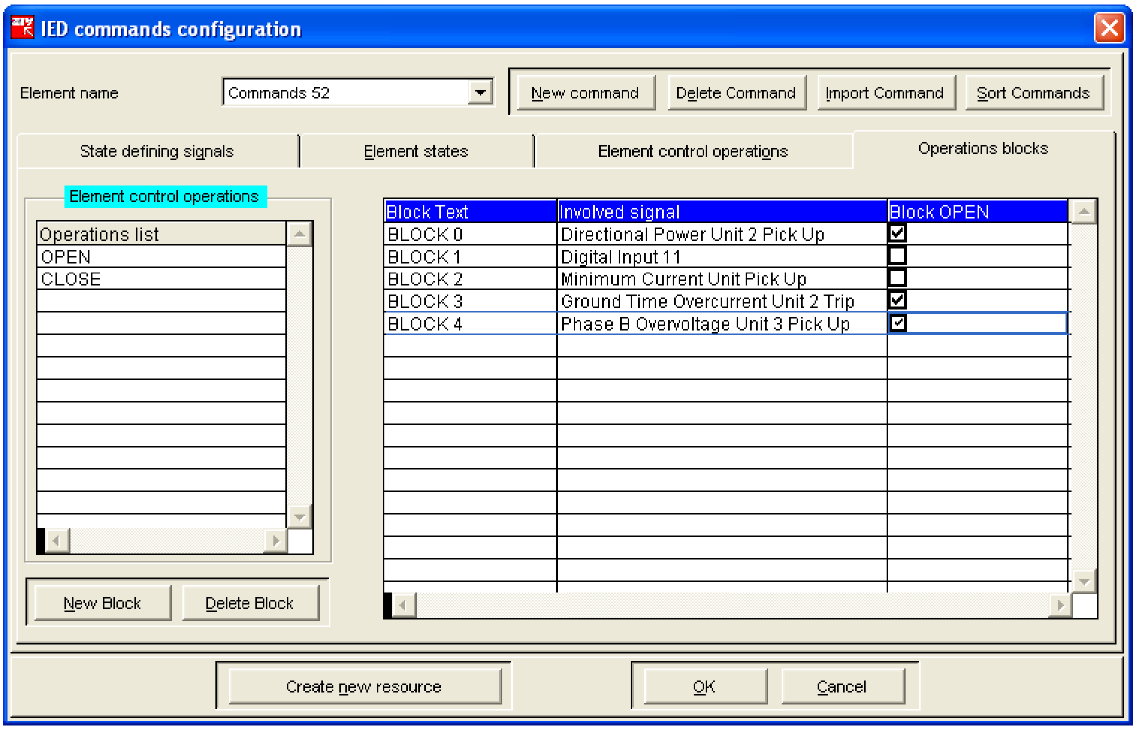


Figure 1.4.8: Example of Command Definition Screen.

This blocking signal can be any digital relay signal. That is, both definite (e.g. Digital inputs or Protection unit outputs) and created through programmable logic and as a result of the supervision of a set of data.

After verifying that the command can be executed, the relay checks the correct command execution through digital inputs or internal logic signal monitoring. If after an established time (selectable for each control) the command is detected to have failed, a screen message is displayed corresponding to COMMAND FAILURE of the same characteristics than above mentioned. If the command has been executed correctly, no external statement is displayed.

1.5 Model Selection

1.5.1 Model Selection

	IDV												
1		2	3	4	5	6	7	8	9	10	11	12	13

1	**Selection**			
	7[(1)]	With Graphic Display.	**8**	Horizontal Format and Programmable Buttons.
	3	Vertical Format and Programmable Buttons.		
2	**Functions**			
	D	Model for two / three winding transformer with breaker and a half.	**L**	Model for two / three winding transformer with four voltage channels
	F	Model for two / three winding transformer with breaker and a half including distance protection.		
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	**Hardware Options**			
	F	External Fault Detector Model + Fault Reports on HMI	**G**	F + 64 samples / cycle
5	**Power Supply Voltage**			
	1	24 VDC / VAC (±20%)	**2**	48 - 250 VDC / VAC (±20%)
6	**Digital Inputs**			
	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]**			
	0	[RS232 + 2xUSB*] [--] [--] [--] [--]	**J**	[RS232+USB] [ETHERNET] [ETHERNET] [RS232/RS485] [ELECTRIC CAN]
	1	[RS232+USB] [PFO] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]	**K**	[RS232+USB] [RS232 F.M.] [RS232/RS485] [ETHERNET] [ELECTRIC CAN][
	2	[RS232+USB] [GFO ST] [GFO ST] [GFO ST] [ELECTRIC CAN]	**M**	[RS232+2xUSB*] [GFO ST] [GFO ST] [--] [ELECTRIC CAN]
	3	[RS232+USB [GFO ST] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]	**P**	[RS232 + 2XUSB*] [PFO] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	9	[RS232+USB] [PFO] [PFO] [--] [ELECTRIC CAN]	**Q**	RS232 + 2XUSB*] [ETHERNET] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]
	C	[RS232+USB] [GFO ST] [GFO 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*] [GFO ST] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	E	[RS232+USB] [GFO ST] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]	**T**	[RS232+USB] [PFO] [GFO ST] [RS232/RS485] [ELECTRIC CAN]
	F	[RS232+USB] [[DOUBLE RING PFO]] [RS232/RS485] [ELECTRIC CAN]	**U**	[RS232+2xUSB*] [PFO] [GFO ST] [RS232/RS485] [ELECTRIC CAN]
	G	[RS232+USB] [PFO] [GFO ST] [GFO ST] [ELECTRIC CAN]	**Y**	[RS232+2xUSB*] [RS232] [RS232/RS485] [ETHERNET] [ELECTRIC CAN]
	H	[RS232+USB] [PFO] [RS232/RS485] [RS232/RS485] [ELECTRIC CAN]	**W**	[RS232+2xUSB*] [GFO ST] [ETHERNET] [ETHERNET] [ELECTRIC CAN]
	I	[RS232+USB] [ETHERNET] [GFO 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 11 digit (Enclosure/Chassis 2U and 3U).

	IDV											
1		2	3	4	5	6	7	8	9	10	11	12	13

8	**Inputs / Outputs**			
	0	8DI + 6DO + 4 Trip Outputs + 1 Alarm Output + 4 LEDs (Model for two winding transformer)	**A**	28DI + 24DO + 1 Alarm Output + 2 Input Transducers (4-20 mA) + 16 LEDs (Model for breaker and a half; all outputs are configurable; supervision for 3 coils).
	1	11DI + 12DO + 6 Trip Outputs + 1 Alarm Output + 4 LEDs (Model for three winding transformer).	**B**	44DI + 18DO + 4 Trip Outputs + 1 Alarm Output + 1 Input Transducers (4-20mA) + 1 Input Transducer for VDC Supervision (0-300VDC) + 16 LEDs (Model for two winding transformer).
	2	25DI + 12DO + 4 Trip Outputs + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2.5mA) + 4 LEDs (Model for two winding transformer).	**C(1)**	13DI + 18DO + 1 Alarm Output + 4 LEDs (Only Model L: Hot Spot unit not included; Model for two/three winding transformer)
	3	28DI + 18DO + 6 Trip Outputs + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2.5mA) + 16 LEDs (Model for three winding transformer).	**D(1)**	30DI + 24DO + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2,5mA) + 16 LEDs (Only Model L; Model for two/three winding transformer).
	4	25DI + 12DO + 4 Trip Outputs + 1 Alarm Output + 1 Input Transducers (0-5mA or ±2.5mA) + 1 Input Transducer for VDC Supervision (0-300VDC) + 4 LEDs (Model for two winding transformer).	**E(1)**	30DI + 24DO + 1 Alarm Output + 2 Input Transducers (4-20mA) + 16 LEDs (Only Model L; Model for two/three winding transformer).
	5	28DI + 18DO + 6 Trip Outputs + 1 Alarm Output + 1 Input Transducers (0-5mA or ±2.5mA) + 1 Input Transducer for VDC Supervision (0-300VDC) + 16 LEDs (Model for three winding transformer).	**F(2)**	27DI + 16DO + 1 Alarm Output + 2 Input Transducers (4-20mA) + 4 LEDs - Only IDV-A with B option in digit 9 (Spare).
	6	25DI + 12DO + 4 Trip Outputs + 1 Alarm Output + 2 Input Transducers (4-20 mA) + 4 LEDs (Model for two winding transformer).	**G**	42DI + 18DO + 4 Trip Outputs + 1 Alarm Output + 4 Input Transducers (4-20mA) + 16 LEDs (Model for two winding transformer).
	7	28DI + 18DO + 6 Trip Outputs + 1 Alarm Output + 2 Input Transducers (4-20mA) + 16 LEDs (Model for three winding transformer).	**H(1)**	47DI + 30DO + 1 Alarm Output + 4 Input Transducers (4-20mA) + 16 LEDs (Only Model L; Model for two/three winding transformer).
	8	11DI + 18DO + 1 Alarm Output + 4 LEDs (Model for breaker and a half; all outputs are configurable; supervision for 3 coils).	**Z**	25DI + 12DO + 4 Trip Outputs + 1 Alarm Output + 2 Input Transducers (0-5mA or ±2,5mA) + 16 LEDs (Model for two winding transformer).
	9	37DI + 44DO + 1 Alarm Output + 16 LEDs (Model for breaker and a half; all outputs are configurable; supervision for 6 coils).		
	(1) All outputs are configurable. Only available with "High Speed and High Duty" in option 6 (Digital Inputs Voltage). (2) All inputs are VDC. Only available with "High Speed and High Duty" in option 6 (Digital Inputs Voltage).			

	IDV											
1		2	3	4	5	6	7	8	9	10	11	12	13

9/10	**Spare (to be defined in the factory)**			
	F0	Standard Model + selectable application of zero sequence filter from phase or ground current channels + Inhibition of 3rd and 5th Harmonic blocking / restrain based on V/f ratio" + polarity inversion + 59 or 64 unit + 4 overflux units + fault detector elimination by setting + Three Phase SUM type in cross blocking + harmonic blocking and inhibition improved (paralell transformer) + change in threshold to show angles + TI supervision + change in ranges the pick-up step for overflux units and the setting for "Inhibition time for harmonic" + 67F, 67P, 67Q units (Not apply in models with X5= A o B) + Hot Spot unit (see notes and rules) + binary input synchronization by pulse per second or pulse per minute + 4 Frequency units (81M, 81m and 81D) + directional comparison unit with angle and logic configurable (External Fault Detector) + third winding configurable for IG or winding units (Only IDV-L model) + New settings for REF unit (directional comparison unit with angle and timer, Minimum level IG Current and Blocking level configurable).	**F6**	F0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP Redundancy.
			F8	F0 + 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	F0 + New management of disturbance recorder files + interrelation between dial and curve settings + new management of IRIG-B alarm.
			G6	G0 + IEC61850 (MMS services and GOOSE service) v.4 (SBO) with Non-Redundancy, Bonding Redundancy or PRP 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.
			GB	G8 + number of XSWI and CSWI logical nodes increased to 24 and 30 respectively.
11	**Enclosure**			
	M	2U x 1 19" Rack (DI / DO types 0 and N).	**0**	2U x 1 19" Rack with cover (DI / DO types 0 and N).
	S	3U x 1 19" Rack (DI / DO types 1, 2, 4, 6, 8, C, F and Z and type 0 in vertical format).	**1**	3U x 1 19" Rack with cover (DI / DO types 1, 2, 4, 6, 8, C, F and Z and type 0 in vertical format).
	Q	4U x 1 19" Rack (DI / DO types 3, 5, 7, A, B, D, E and G).	**2**	4U x 1 19" Rack with cover (DI / DO types 3, 5, 7, A, B, D, E and G).
	V	6U x 1 19" Rack (ED / SD type 9 and H).	**4**	6U x 1 19" Rack with cover (ED / SD type 9 and H).
12	**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).			
13	**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).		

Model	Analog Channels
IDV-A	VPH, VN, IA1, IB1, IC1, IA2, IB2, IC2, IG1, IG2
IDV-B	VPH, VN, IA1, IB1, IC1, IA2, IB2, IC2, IG1, IG2, IA3, IB3, IC3
IDV-D	IA1, IB1, IC1, IA2, IB2, IC2, IA3, IB3, IC3, IG1, IA4, IB4, IC4, IG2
IDV-F	VA, VB, VC, IA1, IB1, IC1, IA2, IB2, IC2, IA3, IB3, IC3, IA4, IB4, IC4
IDV-J	VA, VB, VC, IA1, IB1, IC1, IA2, IB2, IC2, IG1
IDV-K	VA, VB, VC, IA1, IB1, IC1, IA2, IB2, IC2, IG1, IA3, IB3, IC3, IG2
IDV-L	VA, VB, VC, VC, IA1, IB1, IC1, IA2, IB2, IC2, IA3-IG3, IB3-IG4, IC3-IG5, IG1, IG2

ANSI	Functions	Number of Units (*)						
		IDV-A	IDV-B	IDV-D	IDV-F	IDV-J	IDV-K	IDV-L
87	Three-Phase Differential with Percentage and Harmonic Restraint	1	1	1	1	1	1	1
87/50	Instantaneous Three-Phase Differential without Restraint	1	1	1	1	1	1	1
87/50FD	Fault Detector	1	1	1	1	1	1	1
	External Fault Detector	1	1	1	1	1	1	1
87N	Restricted Earth Faults	2 (1)	2 (1)	2 (1)	0	2 (6)	2 (1)	2 (1)
50	Phase Instantaneous Overcurrent	3 (2)	3 (2)	3 (2)	2 (2)	2 (2)	2 (2)	2 (2)
51	Phase Time Overcurrent	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)
50N	Ground Instantaneous Overcurrent	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)
51N	Ground Time Overcurrent	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)	2 (2)
50Q	Negative Sequence Instantaneous Overcurrent	2 (2)	2 (2)	2 (2)	0	2 (2)	2 (2)	2 (2)
51Q	Negative Sequence Time Overcurrent	2 (2)	2 (2)	2 (2)	0	2 (2)	2 (2)	2 (2)
50G	Ground Instantaneous Overcurrent (measurement ground channel)	2 (3)	2 (3)	2 (3)	0	2 (3)	2 (3)	2 (3)
51G	Ground Time Overcurrent (measurement ground channel)	2 (3)	2 (3)	2 (3)	0	2 (3)	2 (3)	2 (3)
50HR	Phase Instantaneous Overcurrent with Harmonics Restraint for the Tertiary	0	1	0	0	0	0	0
50V	Voltage Dependent Inst. Overcurrent	0	0	0	0	1	1	1
51V	Voltage Dependent Time Overcurrent	0	0	0	0	1	1	1
67	Phase Directional Overcurrent	0	0	0	0	3 2)(9)	3 2)(9)	3 2)(9)
67Q	Negative Sequence Directional Overcurrent	0	0	0	0	2 (2)(9)	2 (2))(9)	2 (2)(9)
67N	Ground Directional Overcurrent polarized by current	1 (3)	1 (3)	1 (3)	0	1 (3)	1 (3)	1 (3)
49W	Winding Thermal Image	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)	1 (2)
49G	Ground Thermal Image	0	0	1 (3)	0	0	0	0
26	Hot Spot Thermal Image	0	0	0	0	0	0	1 (8)
50OL	Overload Instantaneous Overcurrent	0	0	0	0	0	0	1
51OL	Overload Time Overcurrent	0	0	0	0	0	0	1
27	Phase Undervoltage	2	2	0	0	2	2	2
59	Phase Overvoltage	2	2	0	0	2	2	2
64	Ground Overvoltage (measured VN)	2	2	0	0	0	0	2
81M	Overfrequency	4	4	0	0	2	2	2
81m	Underfrequency	4	4	0	0	2	2	2
81D	Frequency Rate of Change	4	4	0	0	2	2	2
	Load Shedding	0	1	0	0	0	1	1
59V/Hz	Overexcitation	1	1	0	0	1	1	4
50BF	Breaker Failure	1 (2)	1 (2)	1 (4)	0	1 (7)	1 (7)	1 (7)
	Cold Load	1	1	1	1	1	1	1

ANSI	Functions	Number of Units (*)						
		IDV-A	IDV-B	IDV-D	IDV-F	IDV-J	IDV-K	IDV-L
21N	Ground Distance Protection	0	0	0	4	0	0	0
21P	Phase Distance Protection	0	0	0	4	0	0	0
50SUP	Phase Overcurrent for Distance Supervision	0	0	0	1	0	0	0
	Load Encroachment	0	0	0	1	0	0	0
60VT	Fuse Failure Detector	1	1	1	1	1	1	1
68/78	Power Swing Detector / Out-of-Step	0	0	0	1	0	0	0
60CT	CT Supervision	0	0	0	0	0	0	1(2)
3	Coil Circuit Supervision	3/6(5)	3/6(5)	3/6(5)	3/6(5)	3/6(5)	3/6(5)	3/6(5)
	Breaker Supervision	2	3	4	0	2	3	3

(1) For Windings 1 and 2 (respectively).
(2) By Winding.
(3) By Ground Channel.
(4) By Breaker.
(5) Depending on the number of DIs.
(6) For Winding 1 or 2.
(7) By Breaker (Retrip).
(8) Only available with the converter option in digit 8.
(9) Only available for D options or higher in digit 9.

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

	IDV											
1		2	3	4	5	6	7	8	9	10	11	12	13

2	**Functions(1)**			
	A	Model for two winding transformer with two voltage channels	**H**	Model for three windings transformers with three voltage channels.
	B	Model for three winding transformer with two voltage channel.	**J**	Model for two winding transformer with three voltage channels.
	G	Model for two windings transformers with three voltage channels.	**K**	Model for three winding transformer with three voltage channels.
3	**Options**			
	2	Ports 100FX and 100TX - Ethernet F.O. (MT-RJ) and RJ45 (IEC 61850 / UCA 2.0)		
4	**Hardware Options**			
	D	External Fault Detector Model	**S**	Integrated Simulator
	N	Standard Model	**T**	Integrated Simulator + External Fault Detector
7	**Communications Ports [COM1-LOC] [COM 2-REMP1] [COM3-REMP2] [COM4-REMP3] [COM5-REMP4]**			
		Not available now. (Please contact the Application Department).		
	5	[RS232 + USB] [RS232 F.M.] [RS232 / RS485] [--] [ELECTRIC CAN]	**A**	[RS232+USB] [PFO] [RS232/RS485] [--] [ELECTRIC CAN]
	6	[RS232 + USB] [--] [--] [--] [--]	**B**	[RS232+USB] [ETHERNET] [RS232/RS485] [--] [ELECTRIC CAN]
	7	[RS232+USB] [GFO ST] [GFO ST] [--] [ELECTRIC CAN]	**L**	[RS232+2xUSB] [ETHERNET] [RS232/RS485] [GFO ST] [ELECTRIC CAN]
	8	[RS232+USB] [GFO ST] [RS232/RS485] [--] [ELECTRIC CAN]	**N**	[RS232+2xUSB] [RS232 F.M.] [RS232/RS485] [--] [ELECTRIC CAN]
			Z	[RS232+2xUSB] [GFO ST] [RS232/RS485] [--] [ELECTRIC CAN]
8	**Inputs / Outputs**			
	N	8DI (1DI special alternate + without Coil Supervision) + 6DO + 1TI Sup. VDC (0-300Vcc) + 4DO Trip (2 Windings model)	**P**	11DI (1DI special alternate + without Coil Supervision) + 12DO + 1TISup. VDC (0-300Vcc) + 6DO Trip (3 Windings model)

	IDV											
1		2	3	4	5	6	7	8	9	10	11	12	13

9/10	**Spare (to be defined in the factory)**[3]

00 Standard Model.

01 Data Profile Rev.01.

02 Data Profile Rev.02.

03 Data Profile Rev.03.

04 Data Profile Rev.04.

A0 Standard Model + Selectable application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 - 10000) // RTT_F and RTT_N (0 - 11000) Range + Cross Blocking type SUM.

A3 IEC61850 (services MMS and GOOSE) v.3 + Application of Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 – 11000) Range + Cross Blocking type SUM.

A4 IEC61850 (services MMS and GOOSE) v.3 with Bonding Type Redundancy + Application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 – 11000) Range + Cross Blocking type SUM.

A6 IEC61850 (services MMS and GOOSE), v.4 (SBO) without Redundancy, with Bonding Type Redundancy or with PRP Type Redundancy + Application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio.

B0 Standard Model + Selectable application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 – 11000) range + Cross Blocking type SUM and THREE-PHASE SUM + 4 Overexcitation Units +Polarity selection of analog channels + Fast Outputs.

B6 IEC61850 (services MMS and GOOSE) v.4 (SBO) without Redundancy, with Bonding Type Redundancy or with PRP Type Redundancy + Selectable application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 –11000) Range + Cross Blocking type SUM and THREE-PHASE SUM + 4 Overexcitation Units + Polarity selection of analog channels + Fast Outputs.

C0 Standard Model + Selectable application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 – 11000) Range + Cross Blocking type SUM and THREE-PHASE SUM + 4 Overexcitation Units + Polarity selection of analog channels + Fast Outputs + Extended inhibition time by harmonics + 0,01 p.u steps in Overexcitation Unit + Hot Spot and Overload Unit + Extended range in 50N/51N units.

C3 C0 + IEC61850 (services MMS and GOOSE) v.3

C4 C0 +IEC61850 (services MMS and GOOSE), v.3 with Redundancy type

C6 C0 + IEC61850 (services MMS and GOOSE), v.4 (SBO) without Redundancy, with Bonding Type Redundancy or with PRP Type Redundancy.

D0 Standard Model + Selectable application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 – 11000) Range + Cross Blocking type SUM and THREE-PHASE SUM + 4 Overexcitation Units + Polarity selection of analog channels + Fast Outputs + Extended inhibition time by harmonics + 0,01 p.u steps in Overexcitation Unit + 4 Underfrequency / Overfrequency and Rate of Change (with negative / positive settings) units + Hot Spot and Overload Unit + Extended range in 50N/51N units + Directional units 67, 67P, 67Q + PPS/PPM binary input synchronization.

D6 D0 + IEC61850 (services MMS and GOOSE), v.4 (SBO) without Redundancy, with Bonding Type Redundancy or with PRP Type Redundancy.

E0 Standard Model + Selectable application for Zero Sequence Filtering by phase channels or by ground channels + Inhibition of 3rd and 5th Harmonic blocking / restraint based on V/f ratio + RTI_F and RTI_N (0 – 10000) // RTT_F and RTT_N (0 – 11000) Range + Cross Blocking type SUM and THREE-PHASE SUM + 4 Overexcitation Units + Polarity selection of analog channels + Fast Outputs + Extended inhibition time by harmonics + 0,01 p.u steps in Overexcitation Unit + 4 Underfrequency / Overfrequency and Rate of Change (with negative / positive settings) units + Hot Spot and Overload Unit + Extended range in 50N/51N units + Directional units 67, 67P, 67Q + PPS/PPM binary input synchronization + Directional comparison unit with configurable angle and logic (External Fault Detector) + Channel Selection setting for the third winding, Ground or Phase (Only IDV-L).

E6 E0 + IEC61850 (services MMS and GOOSE), v.4 (SBO) without Redundancy, with Bonding Type Redundancy or with PRP Type Redundancy.

F7 F6 + RSTP Type Redundancy.

	IDV											
1		2	3	4	5	6	7	8	9	10	11	12	13

11	**Communications Protocols [COM1-LOC] [COM 2-REMP1 and COM3-REMP2] [COM4-REMP3] [COM5-REMP4]**			
	B	[PROCOME 3.0] [--] [--] [CAN]	**G**	[PROCOME 3.0] [PROCOME 3.0 / DNP 3.0 (Profile II) / MODBUS (2)] [PROCOME 3.0 / DNP 3.0 (Profile II) / MODBUS (2)] [--]
	C	[PROCOME 3.0] [PROCOME 3.0 / DNP 3.0 / MODBUS (2)] [PROCOME 3.0/DNP 3.0 / MODBUS (2)] [--]	**M**	[PROCOME 3.0] [PROCOME 3.0/DNP 3.0 (Profile II) / MODBUS (2) / Virtual Inputs / Outputs v.2] [PROCOME 3.0/DNP 3.0 (Profile II) / MODBUS (2), SERIE and ETHERNET] [--]
	F	[PROCOME 3.0] [PROCOME 3.0 / DNP 3.0 / MODBUS (2)] [PROCOME 3.0/DNP 3.0 / MODBUS (2)] [CAN MULTIMASTER]	**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 option in 10 digit (Spare).			

(1) Models G and H are replaced by models J and K respectively.
(2) Selectable independently for COM2 and COM3.
(3) The B0 model replaces A0, and the B6 model replaces A3, A4 and A6.

Model	Analog Channels
IDV-G	VA, VB, VC, IA1, IB1, IC1, IA2, IB2, IC2, IG1
IDV-H	VA, VB, VC, IA1, IB1, IC1, IA2, IB2, IC2, IG1, IA3, IB3, IC3, IG2

ANSI	Functions	Number of Units	
		IDV-G	IDV-H
87	Three-Phase Differential with Percentage and Harmonic Restraint	1	1
87/50	Instantaneous Three-Phase Differential without Restraint	1	1
87/50FD	Fault Detector	1	1
	External Fault Detector	1	1
87N	Restricted Earth Faults	2(6)	2(1)
50	Phase Instantaneous Overcurrent	3(2)	3(2)
51	Phase Time Overcurrent	2(2)	2(2)
50N	Ground Instantaneous Overcurrent	2(2)	2(2)
51N	Ground Time Overcurrent	2(2)	2(2)
50Q	Negative Sequence Instantaneous Overcurrent	2(2)	2(2)
51Q	Negative Sequence Time Overcurrent	2(2)	2(2)
50G	Ground Instantaneous Overcurrent (measurement ground channel)	2(3)	2(3)
51G	Ground Time Overcurrent (measurement ground channel)	2(3)	2(3)
67N	Ground Directional Overcurrent polarized by current	1(3)	1(3)
49W	Winding Thermal Image	1(2)	1(2)
27	Phase Undervoltage	2	2
59	Phase Overvoltage	2	2
81M	Overfrequency	4	4
81m	Underfrequency	4	4
81D	Frequency Rate of Change	4	4
	Load Shedding	0	1
59V/Hz	Overexcitation	1	1
50BF	Breaker Failure	1(2)	1(2)
	Cold Load	1	1
3	Coil Circuit Supervision	3/6(5)	3/6(5)
	Breaker Supervision	2	3

(1) For Windings 1 and 2 (respectively).
(2) By Winding.
(3) By Ground Channel.
(4) By Breaker.
(5) Depending on the number of DIs.
(6) For Winding 1 or 2.

1.6 Installation and Commissioning

1.6.1 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 (power supply voltage, current, etc.).**
- **The power supply voltage 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 an **IDV** 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.

1.6.2 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.

1.6.3 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 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.

1.6.4 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.

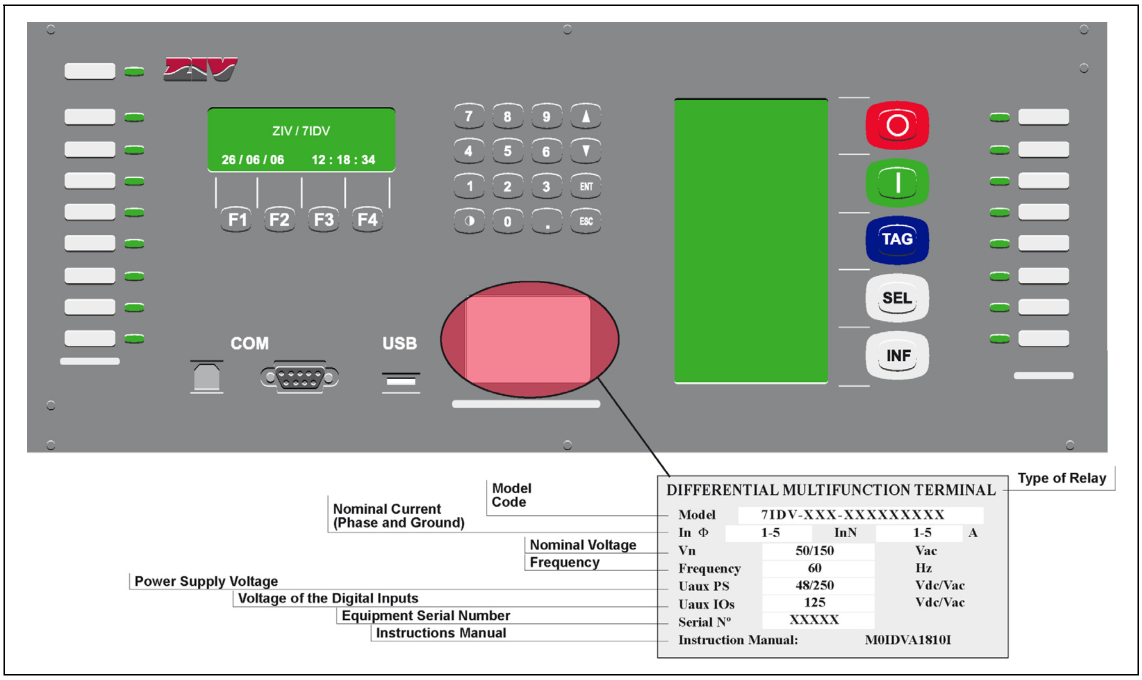


Figure 1.6.1: Name Plate (7IDV).

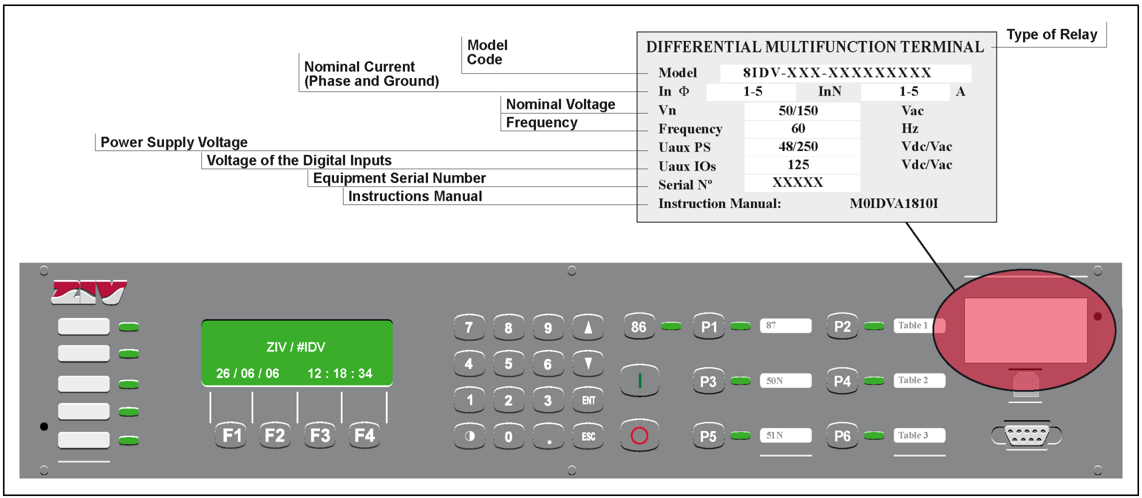


Figure 1.6.2: Name Plate (8IDV).

1.6.5 Tests

1.6.5.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. When the IED has the inputs, outputs and transducers expansion card, terminals of the transducers do not need to be short-circuited (See External Connection Schemes).

- **Between groups**

The isolation groups are made up of the current and voltage inputs (independent channels), digital inputs, auxiliary outputs, transducer inputs, trip and close contacts and power supply. Refer 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.

1.6.5.b Power Supply Test

In models **IDV-A/B/F/G/J/K/H**, connect the power supply as indicated in following table.

VDC PROT	CON1P	CON2P
G3(+) - G2(-)	H12 - H13	H12 - H14

In **IDV-D** model, connect the power supply as indicated in following table.

VDC PROT	CON1P	CON2P
G3(+) - G2(-)	G4 - G5	G4 - G6

In **IDV-L** model, 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.

1.6.5.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 units should be disabled and the cutoff of the injection of current and/or voltage by the breaker avoided. Subsequently, the currents (phase current of each winding and ground current) and voltages (phase and ground voltage) 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 1 (Models IDV-A/B): to check high current values, they should be applied during the shortest possible time; for example, for 20 A, less than 8 seconds. To be able to view the angles, the phase voltage must be applied if the Angle Reference selected is VPH or the Winding 1 phase A current if the Angle Reference is IAWnd1. For measuring the frequency, phase voltage (VPH) must be applied for at least 10 cycles.

Note 2 (Models IDV-F): to check high current values, they should be 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 if the Angle Reference selected is VA or the Channel 1 phase A current if the Angle Reference is IA-1. For measuring the frequency, any phase voltage (VA, VB or VC) must be applied for at least 10 cycles.

Note 3 (Models IDV-D): to check high current values, they should be applied during the shortest possible time; for example, for 20 A, less than 8 seconds. To be able to view the angles, the Breaker 1 phase A current must be applied (IA-1). For measuring the frequency, IA-1 or IA2 phase current must be applied for at least 10 cycles.

Note 4 (Models IDV-G/H/J/K/L): to check high current values, they should be applied during the shortest possible time; for example, for 20 A, less than 8 seconds. To be able to view the angles, the phase voltage must be applied if the Angle Reference selected is VA or the Winding 1 phase A current if the Angle Reference is IAWnd1. For measuring the frequency, a phase voltage (VA) must be applied for at least 10 cycles.

1.7 Onload Test

1.7.1 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).

1.7.2 Voltage Connections

In those models with voltage analog inpus, check that the secondary voltage measurements are correctly rated using a multimeter, 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.

1.7.3 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 MMI 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 of the phase channels is the correct one. With the connection group and tap value settings taking into account the transformer protected and the zero sequence filter disabled, inject nominal currents in the primary and secondary winding of the power transformer and check that the differential current is zero or almost zero (currents should be connected so that in load conditions the relay is reading an angle of 180º between the primary and secondary windings). In case of having differential current in any of the phases, modify the wiring or change the corresponding polarity setting.

Ensure the current polarity of the ground channels is the correct one. Inject the same current value in the ground channel and just in one phase analog input of the corresponding winding (according to the setting located inside the connection group) 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 ground channel or change the corresponding polarity setting.

In those models with power measurements, 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.

Chapter 2.

Technical Specifications and Physical Description

2.1 Technical Data

2.1.1 Power Supply Voltage

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

24 VDC (±20%)
48 - 250 VDC/VAC (±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

8IDV	**15.5W (±20%)** Quiescent
7IDV	**17.5W (±20%)** Quiescent

Standard consumption for **IDV** models with 25 DI and 12 DO IEC61850 option.
Consumption increases in **0.5W** per each additional digital output.

2.1.3 Current Analog Inputs

Phase and Ground Currents

Nominal value	**In=5A** or **1A** (selectable in the IED)
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

Nominal value	**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

Measured currents (phases)	**±0.15%** or **±2 mA** (the greater) for 0.1*Inom≤I<2*Inom **±0.2%** for 2*Inom≤I≤5*Inom
Measured currents (ground)	**±0.15%** or **±1 mA** (the greater) for 0.1*Inom≤I<2*Inom **±0.3%** for 2*Inom≤I≤5*Inom
Differential currents	**±1%** or **±10 mA** (the greater) for In = 1A and 5A
Currents of 2nd, 3rd, 4th and 5th harmonics	**±1%** or **±20 mA** (the greater) for In = 1A and 5A
Calculated currents Ground, I_1, I_2 and I_0	**±0.3%** or **±8 mA** (the greater) for 0.1*Inom≤I<5*Inom
Measured voltages	**±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	**±0.3%** or **±75 mV** (the greater)
VGround, V1, V2 and V0	**±0.3%** or **±100 mV** (the greater) for 0.2 V≤V<250 V
Active and reactive powers (In = 1A and 5A e I_{phases}>1A calculated as 3 times the single-phase powers A)	**±0.33% W/Var** (**0º** or **±90º** or **180º**) **±1.6% W/Var** (**±45º** or **±135º**) **±5%** / **0.65% W** (**±75º** / **±115º**)
Angles	**±0.5º**
Power factor	**±0.013**
Frequency	**±0.005 Hz**

Note1: Signal processing

The sampling function of the analog input signals is set by identifying the times one of the measured signals passes by zero. It works by detecting the change in the period of this analog signal. The value of the calculated frequency is used to modify the sampling frequency used by the metering module to obtain a constant sampling frequency of 32 samples per cycle. The value of the frequency is stored for use by the protection and control tasks.

For IDV-A/B models, zero crossing is detected by the voltage channel VPH ($V_{PHASE-GROUND}$ or $V_{PHASE-PHASE}$). For IDV-H/K/L models is used voltage channel VA. When the value of this voltage goes below certain adjustable level the frequency is no longer calculated but considered as 0Hz. In the situation, the frequency will be the one corresponding to the sampling rate available for the nominal frequency of the system.

For IDV-F relays, zero crossing detection is carried out with VA, VB or VC channel measurements. If the voltage to neutral value VA drops below 2V, VB will be used and if this, in turn, drops also below 2V, VC will be used. If the measured voltage of all phases drop below 2 V, the sampling frequency corresponding to the adjusted rated frequency will be used.

In IDV-D models, detection of zero crossings is carried out with the current of the IA-1 and IA-2 measuring channels. If there is insufficient level of current in IA-1and IA-2, check if any of the other two phase currents corresponding to the last channel used as reference for zero crossings exceed the Inhibition Current setting value. That is, if IA-1 has been the last channel to be used, check the level in (IB-1, IC-1). If IA-2 has been the last channel, check in (IB-2, IC-2). If this is the case, maintain the sampling rate to the last value recorded before the current dropped. Should the current measured in all the phases be lower than the frequency Inhibition Current setting, then the sampling frequency corresponding to the nominal frequency will be used.

For IDV-G/H/K/L relays, zero crossing detection is carried out with VA (Line or Phase Voltage) channel measurement. When the value of this voltage goes below certain adjustable level the frequency is no longer calculated but considered as 0Hz. In the situation, the frequency will be the one corresponding to the sampling rate available for the nominal frequency of the system.

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 Accuracy of the Pickup and Reset of the Differential Units

Differential Units	
Pickup and reset	**±3 %** or **±50mA**
(for In = 1A and 5A)	of the theoretical value (the greater)

2.1.8 Measuring Times of the Differential Unit with Restraint

Blocking Type	Enable	Times I0 (Sensitivity)	Measuring Times 50Hz	Measuring Times 60Hz
Blocking or Harmonic Restraint	YES	1.5	±32 ms	±28 ms
		5	±31 ms	±28 ms
		15	±31 ms	±28 ms
Blocking / Harmonic Restraint	NO*	1.5	±28 ms	±27 ms
		5	±17 ms	±16 ms
		15	±15 ms	±14 ms

(*) When the *Blocking Type / Harmonics Restraint* setting is in Dynamic mode, Harmonics Blocking / Restraint will be disabled in internal fault conditions.

2.1.9 Measuring Times of the Differential Unit without Restraint

Times Pickup	Measuring Times	
	50Hz	60Hz
1.5	±35 ms	±23 ms
5	±15 ms	±15 ms
10	±14 ms	±23 ms

2.1.10 Accuracy of the Pickup and Reset of the Overcurrent Units

Overcurrent Units

Phase, Ground and Negative Sequence pickup and reset (for In = 1A and 5A) (static test): **±3 %** or **±10mA** of the theoretical value (the greater)

2.1.11 Measuring Times of the Overcurrent Units

Mode	Time	Times	Measuring Times	
	Setting	Pickup	50Hz	60Hz
Fixed Time	0 s	1.5	±22 ms	±21 ms
		5	±13 ms	±13 ms
		15	±12 ms	±12 ms
Fixed Time	> 0 s		±1 % of the setting or ±30 ms (the greater)	
Inverse Time			Class 2 (E=2) or ±35ms (the greater) (UNE 21-136, IEC 255-4) (for measured currents of 100 mA or greater)	

2.1.12 Accuracy of the Pickup and Reset of the Voltage Units

Overvoltage and Undervoltage Units	
Pickup and reset (static test)	**±2 %** or **±250 mV** of the theoretical value (the greater)

2.1.13 Measuring Times of the Voltage Units

Mode	Time Setting	Measuring Times	
		50Hz	**60Hz**
Fixed Time	0 s	±32 ms	±28 ms
Fixed Time	> 0 s	±1% of the setting or ±32 ms (the greater)	

2.1.14 Accuracy of the Pickup and Reset of the Frequency Units

Overfrequency Units	
Pickup and reset	**±0.01 Hz** of the theoretical value
Underfrequency Units	
Pickup and reset	**±0.01 Hz** of the theoretical value

2.1.15 Measuring Times of the Frequency Units

Measuring Times	
Fixed Time	**1.5 cycles**

Note: It must be added to this time the adjusted value in Activation Half-time corresponding to Frequency Units (see paragraph 3.9).

2.1.16 Accuracy of the Pickup of the Distance Units (IDV-F)

Distance Units	
Pickup in Line Angle (static test)	**±5 %** or **±0.01** Ω **(V>0.5 V)** of the theoretical value (the greater)

2.1.17 Measuring Times of the Distance Units (IDV-F)

Measuring Times	
Fixed Time	**±1%** of the setting or **±35 ms** (the greater)

2.1.18 Repeatability

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

2.1.19 Transient Overreach

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

<10% for totally inductive lines
<5% for lines with an impedance angle of 70º

I_A = Pickup value for a current with no DC component
I_T = Pickup value for a current with maximum DC offset

2.1.20 Digital Inputs

Configurable inputs (depending on model) with polarity

Nominal Voltage	Maximum Voltage	Burden	V on	V off
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	75 Vdc	60 Vdc
125 Vdc (Act. >65%)	300 Vdc	800mW	93 Vdc	83 Vdc
250 Vdc	500 Vdc	1 W	130 Vdc	96 Vdc
250 Vdc (Von=158Vdc/Voff=132Vdc)	500 Vdc	1 W	130 Vdc	96 Vdc

IN3 to **IN8** inputs can be programmed to monitor the switching circuits. 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**, 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.

2.1.21 Breaker Trip and Close Outputs and Auxiliary Outputs

Contacts (depending on model) N.O. for each switching, 2 or 3 of them (depending on model) internally configurable to closed and auxiliary contacts N.O. (depending on the model).

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**

2.1.22 Solid State Trip Outputs

In **IDV-***-*A********, **IDV-***-*B******, IDV-***-*C******, IDV-***-*D****** and IDV-***-*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).

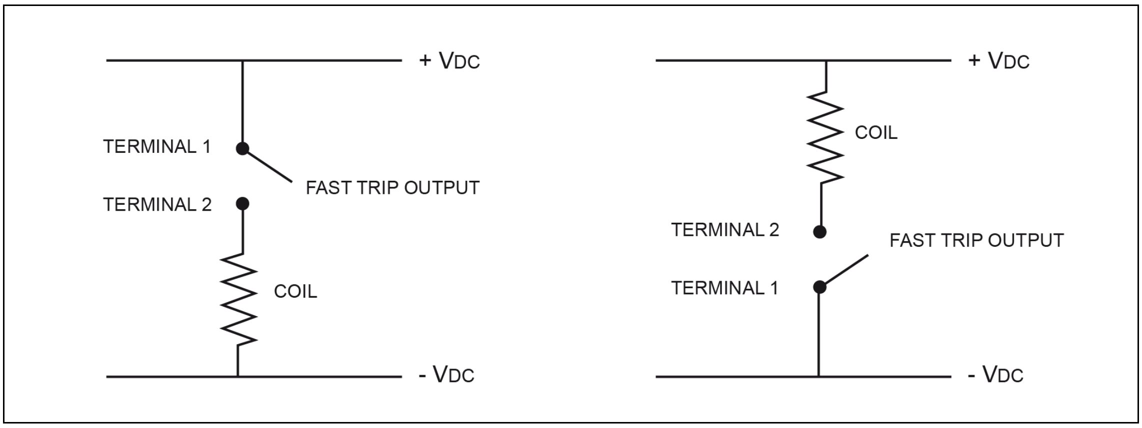


Figure 2.1: Fast Trip Output Wiring Diagram.

2.1.23 Solid State Auxiliary Outputs

Models **IDV-***-*A******, IDV-***-*B******, IDV-***-*C******, IDV-***-*D****** and IDV-***-*G****** are** provided with 4 auxiliary output contacts with make and break capacity lower than the rest of the available relay outputs:

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.

2.1.24 Input Transducers

0-5mA and ±2.5mA Input Transducers	
Input impedance	**511Ω**
Measurement accuracy	**±0.2 %** or **±8μA** (the greater)
4-20mA Input Transducers	
Input impedance	**220Ω**
Measurement accuracy	**±0.2 %** or **±8μA** (the greater)
Voltage transducers	
Input impedance	**<410kΩ**
Measurement accuracy	**±0.2 %** or **±0.2 V** (the greater)

2.1.25 Communications Link

Local Communications Port (RS232C and USB).
Remote Communications Ports (GFO, PFO, RS232C, RS232-Full MODEM or RS485).
Ports LAN (RJ45).
Electric Bus.

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**

Glass Fiber Optics (Ports LAN)	
Type	**Multimode**
Wavelength	**1300 nm**
Connector	**MT-RJ**
Transmitter Minimum Power	
50/125 Fiber	**- 23.5 dBm**
62.5/125 Fiber	**- 20 dBm**
Receiver Sensitivity	**- 34.5 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

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

RS232 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

RJ45 Port Signals	
Used signals	**Pin 1 - TX+**
	Pin 2 - TX-
	Pin 3 - RX+
	Pin 4 - N/C
	Pin 5 - N/C
	Pin 6 - RX-
	Pin 7 - N/C
	Pin 8 - N/C

Electric Bus (CAN)	
Used signals	**Pin 1 - High**
	Pin 2 - Low
	Pin 3 - GND

IRIG-B 123 and 003B: 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 / 211Ω / 330 Ω**
Default impedance	**211 Ω**
Maximum input voltage	**10 V**
Synchronization Accuracy	**± 1ms**

When the IED is receiving an IRIG-B signal for synchronization both Date and Time settings will not be available through the HMI.

It is possible to configure one of the auxiliary outputs to check the IRIG-B signal status. This output will remain active as long as the IRIG-B signal reception is correct.

All the devices are also designed to give an indication for both the loss and recovery of such IRIG-B signal by generating the particular event.

* Internally selectable by 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 equipments are made up of the following boards:

- Power supply.
- Processor module and analog inputs.
- Digital inputs, outputs and transducer inputs.
- 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 **8IDV**.

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

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

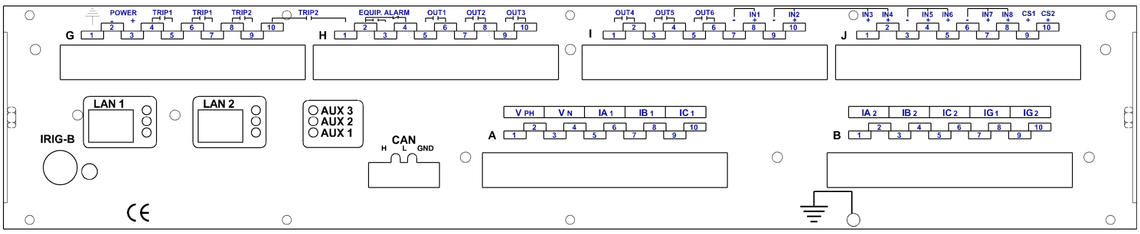


Figure 2.3.2: Rear of a 2-Unit High 8IDV.

Figures 2.3.3 and 2.3.4 represent the external appearance of the 3-unit high **8IDV** models.

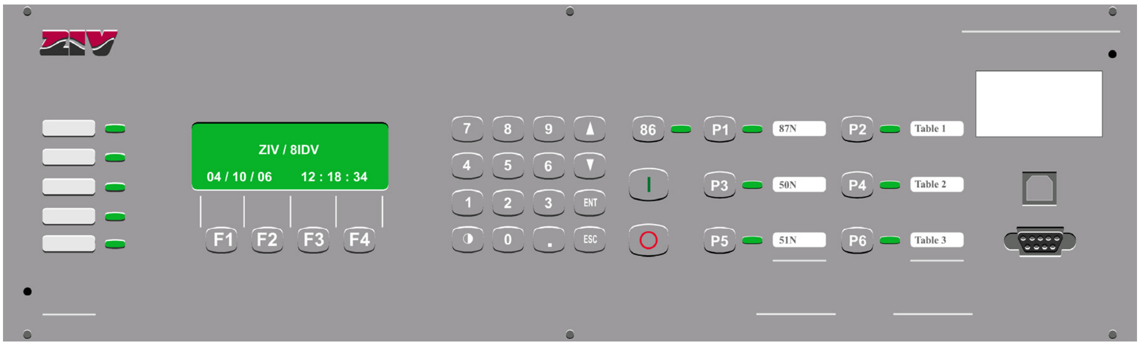


Figure 2.3.3: Front of a 3-Unit High 8IDV.

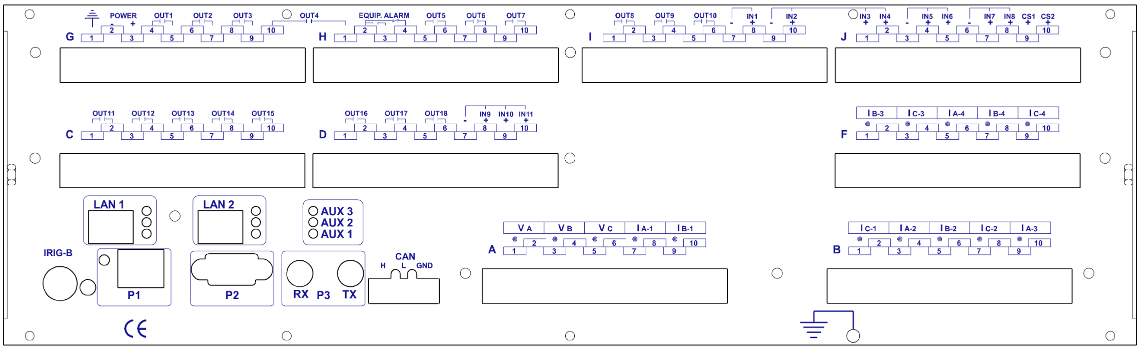


Figure 2.3.4: Rear of a 3-Unit High 8IDV.

Figures 2.3.5 and 2.3.6 represent the external appearance of the 3-unit high (19”-rack) **3IDV** model. **3IDV** Model features a front panel of same characteristics than horizontal format models.

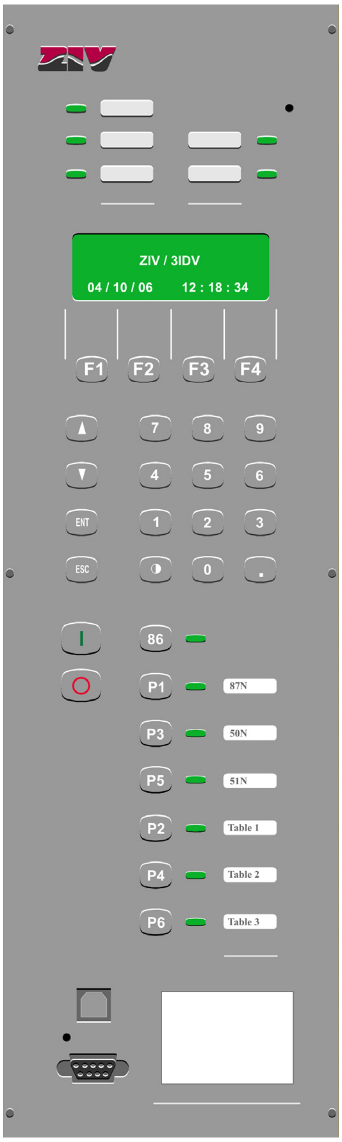


Figure 2.3.5: Front of a 3IDV.

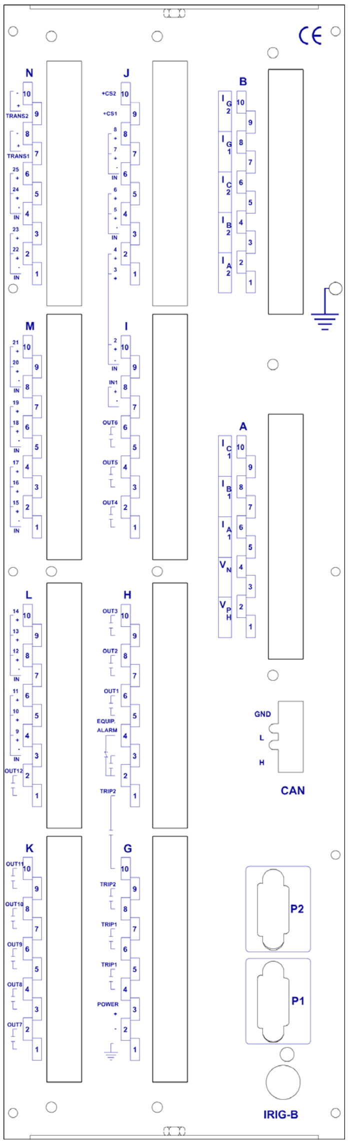


Figure 2.3.6: Rear of a 3IDV.

External appearance of the 4-unit high (19”-rack) **8IDV** model is represented in Figure 2.3.7, with similar characteristics than previous models.

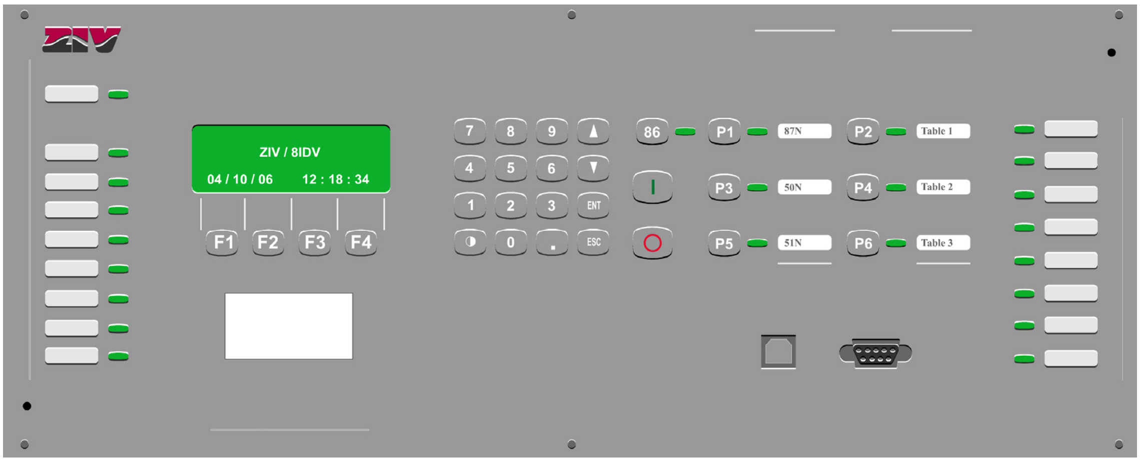


Figure 2.3.7: Front of a 4-Unit High 8IDV.

For **7IDV** models Figure 2.3.8 represents the external appearance of the 4-unit high models. Mounted on the front are the alphanumeric keypad and display, the local communication ports (RS232C and USB), the graphic display and the LED targets.

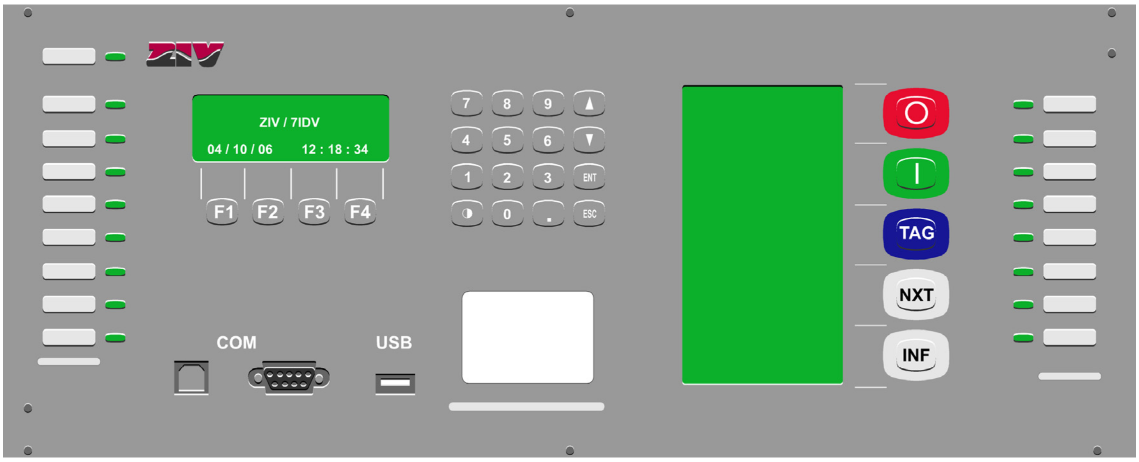


Figure 2.3.8: Front of a 4-Unit High 7IDV.

4- unit high **IDV** models feature a rear panel with the same characteristics than the previous, with additional terminals in order to be able to expand the number of inputs, outputs and transducers, as depicted in figure 2.3.9.

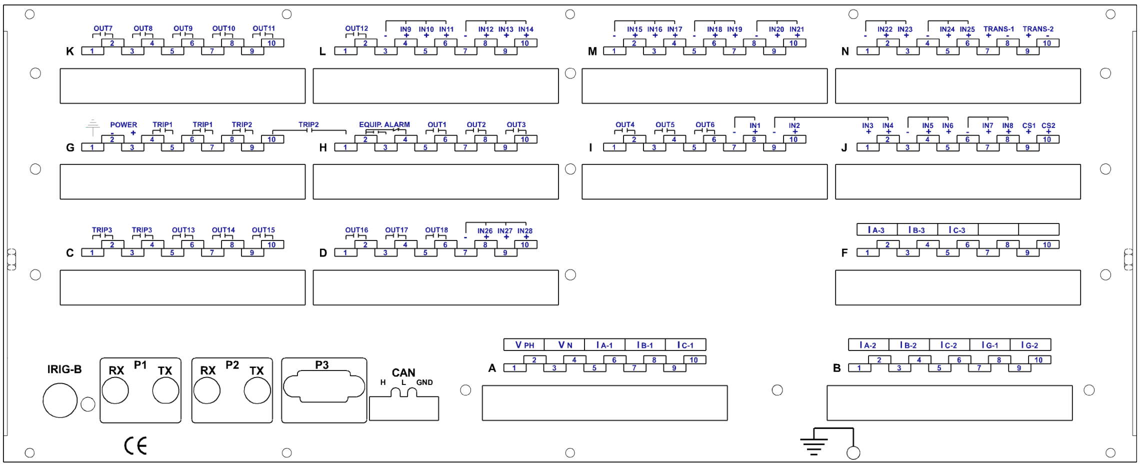


Figure 2.3.9: Rear of a 4-Unit High IDV.

7IDV models can also be installed vertically, 4U high with a 19" wide rack, with special features on the front and a rear plate with additional terminals to increase the number of inputs, outputs and transducers. Figures 2.3.10 and 2.3.11 represent the external appearance of this equipment.

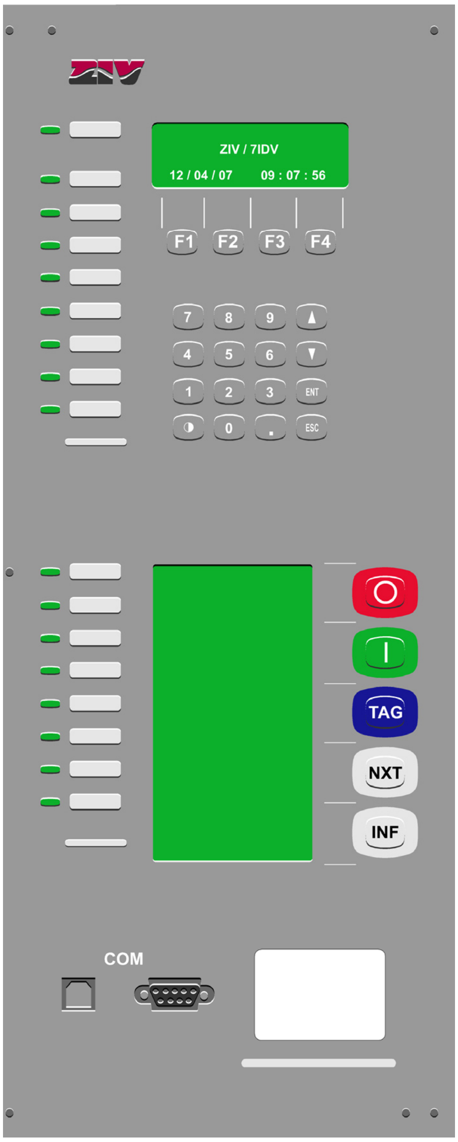


Figure 2.3.10: Front of a 4- Unit High 7IDV (Vertical Format).

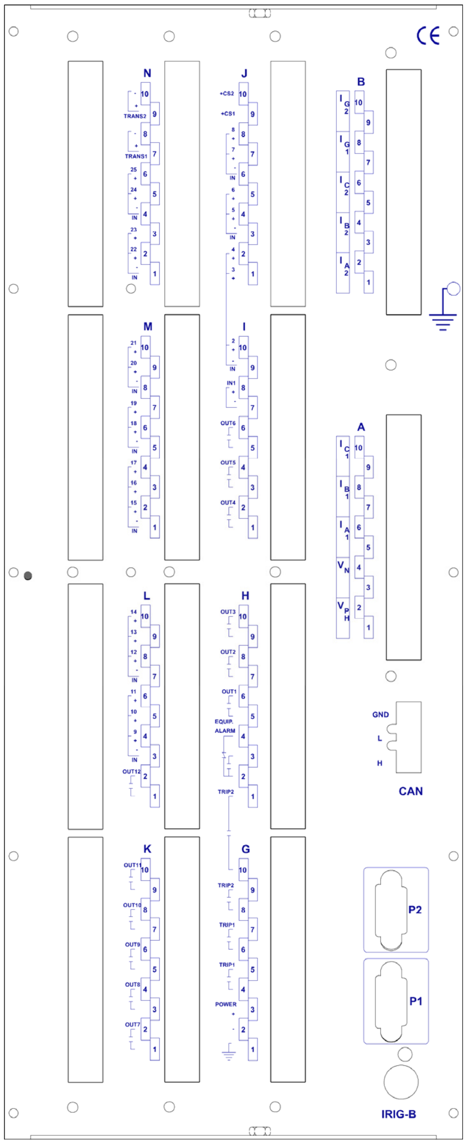


Figure 2.3.11: Rear of a 4- Unit High 7IDV (Vertical Format).

There are available too **IDV** models of 6U high and 19” rack width with a front panel of same characteristics and a rear panel with additional terminals for expansion of digital inputs and auxiliary outputs. Figures 2.3.12, 2.3.13 and 2.3.14 represent the external appearance of this equipment.

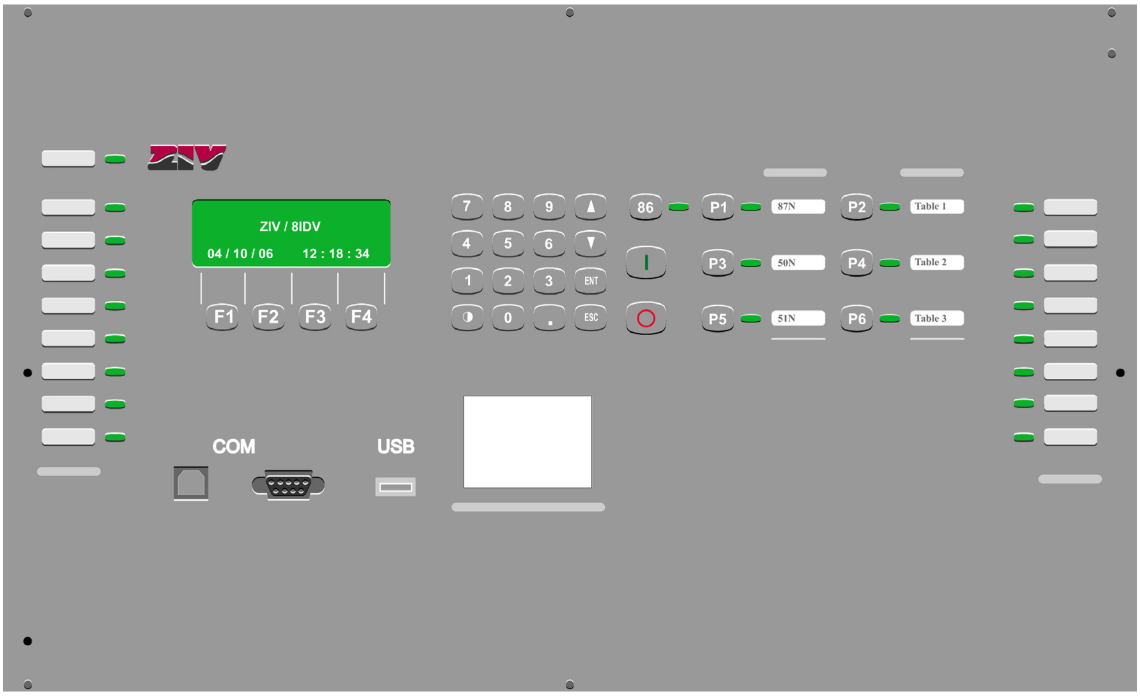


Figure 2.3.12: Front of a 6-Unit High 8IDV.

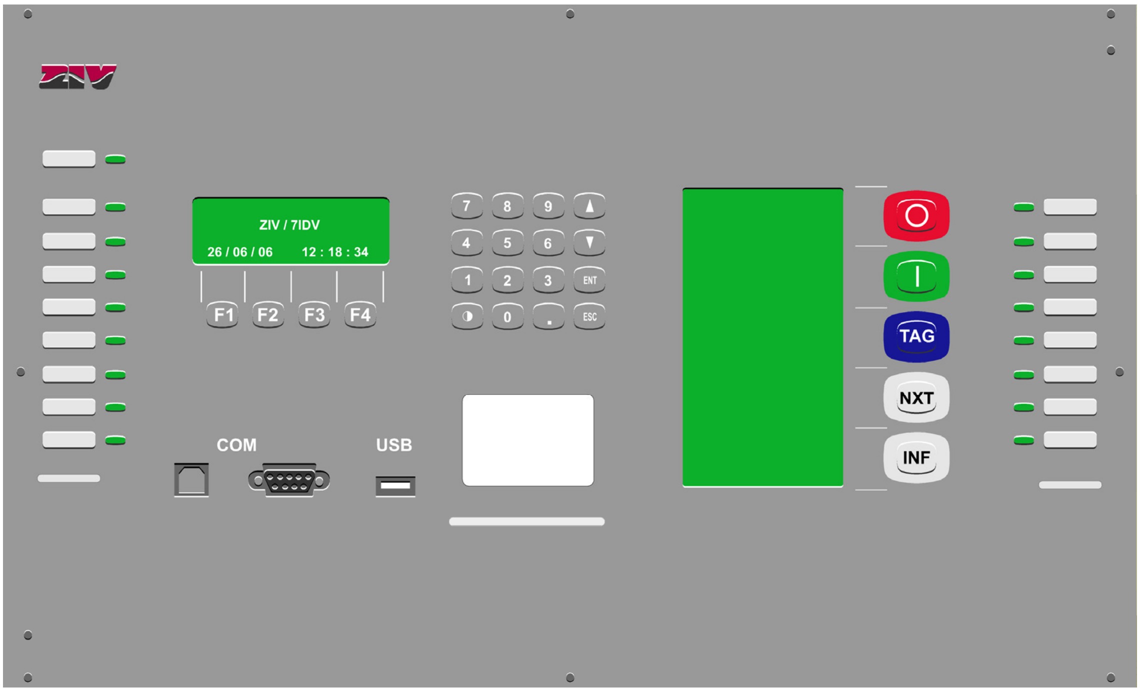


Figure 2.3.13: Front of a 6-Unit High 7IDV.

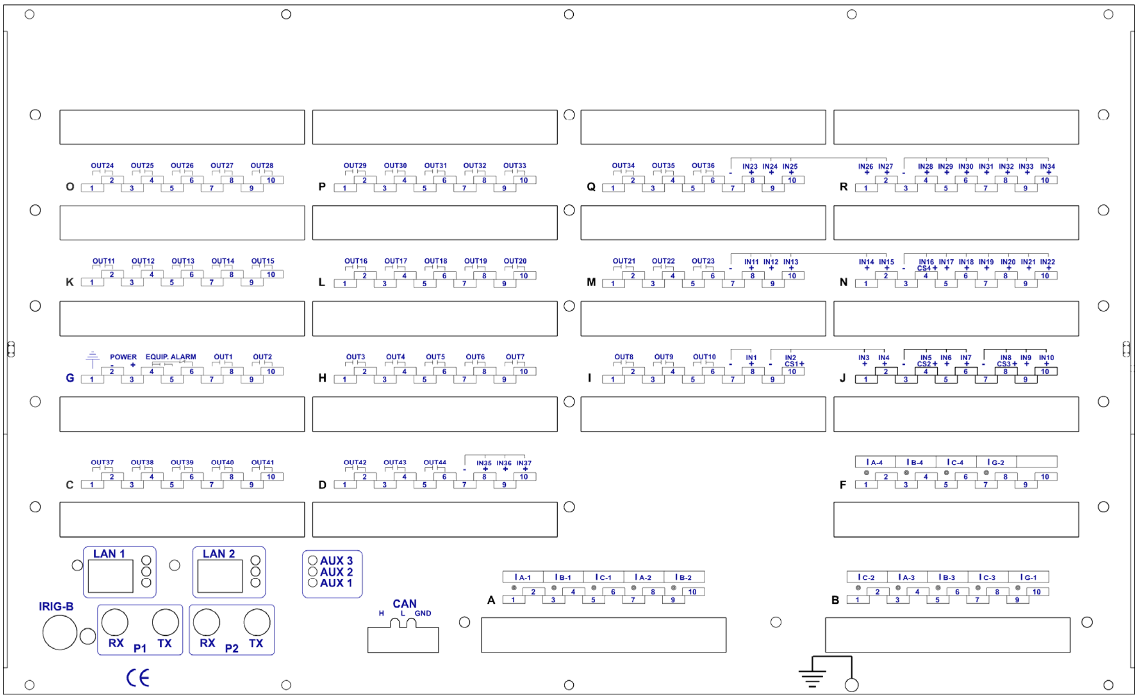


Figure 2.3.14: Rear of a 6-Unit High IDV.

All **8IDV** relay models (enclosure: 2U, 3U, 4U and 6U) can include, as an option, a front cover with a pushbutton to access the key **F2**. Relay models **7IDV** (enclosure: 4U and 6U) can include the same front cover with 5 additional pushbuttons to control the bay through the graphical HMI. Figures 2.3.15 and 2.3.16 show the front cover and pushbuttons supplied, as an option, with relay models **8IDV** (enclosure: 3U) and **7IDV** (enclosure: 4U) respectively.

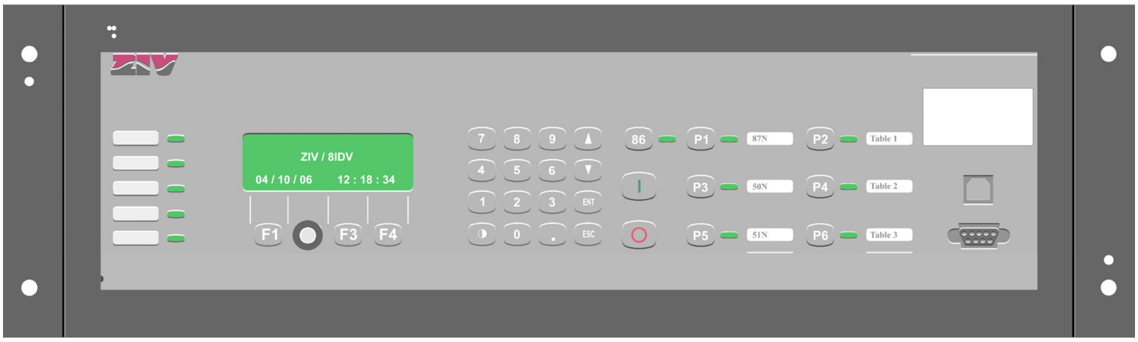


Figure 2.3.15: Front of 3- Unit High 8IDV with Protection Cover.

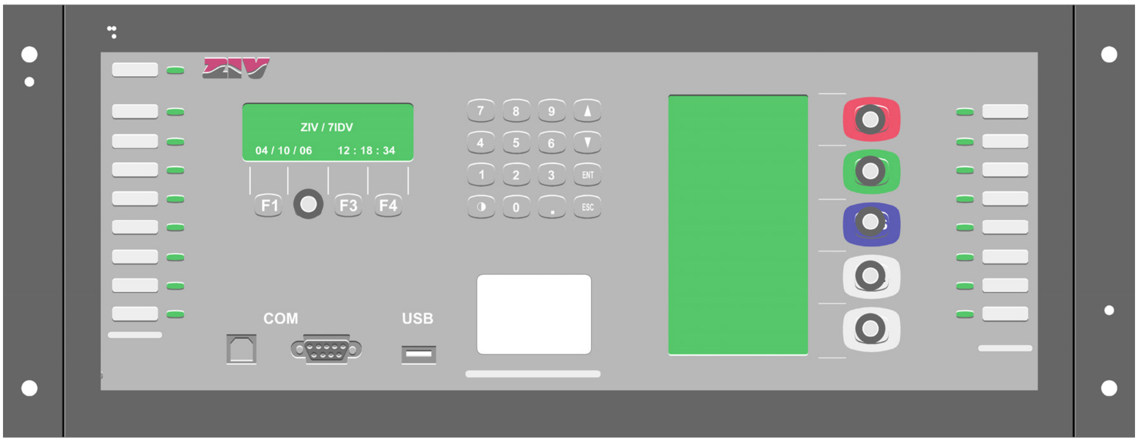


Figure 2.3.16: Front of 4- Unit High 7IDV with Protection Cover.

2.3.2 Dimensions

Depending on the model, the IEDs are mounted as follows:

- Models in enclosures of 1 19"-, 2 standard units high.
- Models in enclosures of 1 19"-, 3 standard units high.
- Models in enclosures of 1 19"-, 4 standard units high.
- Models in enclosures of 1 19"-, 6 standard units high.

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 or 6-units high).

Terminal blocks are horizontal or vertical (depending on the model) as shown in the figures 2.3.2, 2.3.4, 2.3.6, 2.3.9, 2.3.11 and 2.3.14. 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 auxiliary outputs and two transducer inputs by adding one more row with 4 terminal blocks of 10 terminals each one (40 terminals). To accommodate the extra hardware the unit is 3-Unit high (see figure 2.3.4).

The terminal arrangement for the 3-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 3 terminal blocks of 10 inputs each (30 terminals) to expand analog current and voltage inputs, digital inputs, auxiliary outputs and trip and close contacts.
- 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.

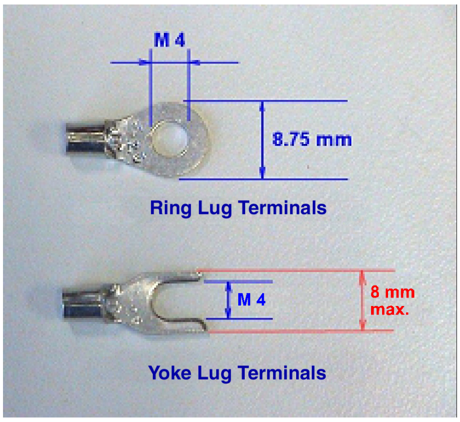
The terminal arrangement for the 4-units high model is as follows:

- 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 3 terminal blocks of 10 inputs each (30 terminals) to expand analog current inputs, digital inputs, auxiliary outputs and trip and close contacts.
- 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.
- 1 row with 4 terminal blocks of 10 terminals each (40 terminals) to expand digital inputs, auxiliary outputs and include two transducer inputs.

The terminal arrangement for the 6-units high model is as follows:

- 1 row with 2 terminal blocks of 10 inputs each (20 terminals) for analog currents / voltages plus all the communication and synchronization connectors.
- 1 row with 3 terminal blocks of 10 inputs each (30 terminals) to expand analog current inputs, digital inputs, auxiliary outputs and trip and close contacts.
- 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.
- 3 rows with 4 terminal blocks of 10 terminals each (40 terminals) to expand digital inputs, auxiliary outputs and include two transducer inputs.

When the expansion board is not included, the corresponding terminal blocks are not mounted. The resulting gaps are covered with blank plates.



Terminals are the same for both analog inputs (voltage / current) and digital inputs and outputs. Ring lug terminals are recommended for connection of the analog inputs while ring or yoke lug terminals are for digital inputs and outputs connections.

Ring lug terminals take wires up to #10 AWG (6 mm^2) and yoke lug terminals up to #13 AWG (2.5 mm^2).

Connectors provided are plug-in type but not self-shorting. Current inputs capability is up to 20A (continuously).

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

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 Differential Units

3.1.1 Introduction

The single-phase differential units implemented in the **IDV** IED are composed of a set of signal processing, measurement and decision elements that operate at a wide range of fault levels, maintaining a high degree of safety for external faults.

The relay consists of two types of differential units, Restraint Differential Units and Instantaneous or Unrestrained Differential Units. Every Restraint Differential Unit provides an output with percentage restraint response characteristic and every Instantaneous Differential Unit another output with high differential current detection setting, not subject to any restraint, for detecting high-magnitude faults.

IDV-A/B/G/H/J/K/L relays differential element operates with measured currents I_{nA}, I_{nB}, I_{nC}, (n=1,2 for **IDV-A/G/J** and n=1,2,3 for **IDV-B/H/K**), which are adequately compensated through **Vector Group**, **Tap** and **Zero Sequence Filter** settings corresponding to Winding n (see section 3.1.4, 3.1.5 and 3.1.6). The differential element of **IDV-D/F** relays, featuring up to 4 channels per phase, compensates the measured currents I_{nA}, I_{nB}, I_{nC} (n=1,2,3,4) to protect two or three winding machines installed in dual breaker (breaker-and-a-half or ring configurations) positions, based on **Vector Group**, **Tap** and **Zero Sequence Filter** settings corresponding to the winding associated to said channels. For this purpose, **Winding 1 current, Winding 2 current, Winding 3 current** configuration settings will be taken into account (see section 3.16.7). If, e.g., **Winding 1 current** setting value is I1+I2 and **Winding 2 current** setting value is I3, **Vector Group**, **Tap** and **Zero Sequence Filter** settings for channels I1 and I2 will be Winding 1 settings and for channel I3 will be Winding 2 settings.

Note: for models IDV-L and IDV-K with option E or higher in digit 9 (see 3.18, General Settings), depending on the setting *Number of windings*, for operation with the differential element, the measured currents InA, InB, InC will be:

- **With Two windings option n=1,2.**
- **With Three windings option n=1,2,3.**

3.1.2 Differential Current

Differential current is defined as the algebraic sum of the instantaneous values of the currents circulating in the phases of the same name as those windings supported by the relay (as the polarity of all winding CTs is the same when current flows towards the transformer; for more information, please refer to the appendix with Schemes and Drawings). From this, the differential element operating magnitude is obtained. This magnitude can be viewed in 2 different ways, as times the reference tap or amps multiplied by the reference tap (see "Differential current measure" setting, within the general settings group).

- Times reference tap: $$\bar{I}_{diffA} = \frac{\bar{I}_{1A}}{t_1} + \frac{\bar{I}_{2A}}{t_2} + \frac{\bar{I}_{3A}}{t_3}$$

- x reference tap: $$\bar{I}_{diffA} = \left(\frac{\bar{I}_{1A}}{t_1} + \frac{\bar{I}_{2A}}{t_2} + \frac{\bar{I}_{3A}}{t_3} \right) .t_{ref}$$

where:

$\bar{I}_{diffA}$	is the phase A differential current
$\bar{I}_{1A}$, $\bar{I}_{2A}$, $\bar{I}_{3A}$	(is the current for phase A for windings 1, 2, and 3 respectively
t_1 , t_2 , t_3	is the tap value of windings 1, 2, and 3 respectively
t_{ref}	is the tap value of the reference winding

Phases B and C are calculated in the same manner:

- Times reference tap:

$$\bar{I}_{diffB} = \frac{\bar{I}_{1B}}{t_1} + \frac{\bar{I}_{2B}}{t_2} + \frac{\bar{I}_{3B}}{t_3}$$

$$\bar{I}_{diffC} = \frac{\bar{I}_{1C}}{t_1} + \frac{\bar{I}_{2C}}{t_2} + \frac{\bar{I}_{3C}}{t_3}$$

- x reference tap:

$$\bar{I}_{diffB} = \left(\frac{\bar{I}_{1B}}{t_1} + \frac{\bar{I}_{2B}}{t_2} + \frac{\bar{I}_{3B}}{t_3} \right) .t_{ref}$$

$$\bar{I}_{diffC} = \left(\frac{\bar{I}_{1C}}{t_1} + \frac{\bar{I}_{2C}}{t_2} + \frac{\bar{I}_{3C}}{t_3} \right) t_{ref}$$

The above equations show a general case of equipment with three windings. When looking at a model with two windings, do not consider the third winding:

- Times reference tap:

$$\overline{I}_{diffA} = \frac{\overline{I}_{1A}}{t_1} + \frac{\overline{I}_{2A}}{t_2} \qquad \overline{I}_{diffB} = \frac{\overline{I}_{1B}}{t_1} + \frac{\overline{I}_{2B}}{t_2} \qquad \overline{I}_{diffC} = \frac{\overline{I}_{1C}}{t_1} + \frac{\overline{I}_{2C}}{t_2}$$

- x reference tap:

$$\overline{I}_{diffA} = \left(\frac{\overline{I}_{1A}}{t_1} + \frac{\overline{I}_{2A}}{t_2}\right) t_{ref} \qquad \overline{I}_{diffB} = \left(\frac{\overline{I}_{1B}}{t_1} + \frac{\overline{I}_{2B}}{t_2}\right) t_{ref} \qquad \overline{I}_{diffC} = \left(\frac{\overline{I}_{1C}}{t_1} + \frac{\overline{I}_{2C}}{t_2}\right) t_{ref}$$

Equations for **IDV-D/F** relays will be:

- Times reference tap:

$$\overline{I}_{diffA} = \frac{\overline{I}_{1A}}{t_1} + \frac{\overline{I}_{2A}}{t_2} + \frac{\overline{I}_{3A}}{t_3} + \frac{\overline{I}_{4A}}{t_4} \qquad \overline{I}_{diffB} = \frac{\overline{I}_{1B}}{t_1} + \frac{\overline{I}_{2B}}{t_2} + \frac{\overline{I}_{1B}}{t_3} + \frac{\overline{I}_{2B}}{t_4} \qquad \overline{I}_{diffC} = \frac{\overline{I}_{1C}}{t_1} + \frac{\overline{I}_{2C}}{t_2} + \frac{\overline{I}_{3C}}{t_3} + \frac{\overline{I}_{4C}}{t_4}$$

- x reference tap:

$$\overline{I}_{diffA} = \left(\frac{\overline{I}_{1A}}{t_1} + \frac{\overline{I}_{2A}}{t_2} + \frac{\overline{I}_{3A}}{t_3} + \frac{\overline{I}_{4A}}{t_4}\right) t_{ref} \qquad \overline{I}_{diffB} = \left(\frac{\overline{I}_{1B}}{t_1} + \frac{\overline{I}_{2B}}{t_2} + \frac{\overline{I}_{3B}}{t_3} + \frac{\overline{I}_{4B}}{t_4}\right) t_{ref} \qquad \overline{I}_{diffC} = \left(\frac{\overline{I}_{1C}}{t_1} + \frac{\overline{I}_{2C}}{t_2} + \frac{\overline{I}_{3C}}{t_3} + \frac{\overline{I}_{4C}}{t_4}\right) t_{ref}$$

where:

$\overline{I}_{diffA}$, $\overline{I}_{diffB}$, $\overline{I}_{diffC}$	are phase A, phase B and phase C residual currents
$\overline{I}_{jA}$, $\overline{I}_{jB}$, $\overline{I}_{jC}$	for j=1, 2, 3, 4) are phase A, phase B and phase C currents measured by channel j
t_j	(for j=1, 2, 3, 4) is the tap value associated to channel j (it need not be winding j tap value).
t_{ref}	is the reference winding tap value

3.1.3 Percentage Restraint Current

Restraint current can be defined as the smallest sum of currents entering or leaving the machine (**Restraint Current Type** setting: 1-Ifr: (I1+I2-Id)/2, within the differential element trip settings group). This current gets through without being by-passed by the fault; this is why it is called sometimes through current. The same as for differential current, this magnitude can be viewed in 2 different ways, as times the reference tap or amps multiplied by the reference tap (see “Differential current measure” setting, within the general settings group).

- Times reference tap: $I_{restA} = \dfrac{\sum_{j=1}^{3} \dfrac{|I_{jA}|}{t_j} \cdot -|I_{diffA}(times.tap)|}{2}$

- x reference tap: $I_{restA} = \dfrac{\sum_{j=1}^{3} \dfrac{|I_{jA}|}{t_j} t_{ref} \cdot -|I_{diffA}(x.t_{ref})|}{2}$

where:

I_{restA}	is the restraint current for phase A
$\|I_{jA}\|$	(for j = 1, 2 or 3) phase A current magnitude of winding 1, 2 or 3
t_j	(for j = 1, 2 or 3) is the tap value for windings 1,2 or 3
$\|I_{diffA}\|$	is the differential current magnitude for phase A
t_{ref}	is the tap value of the reference winding

Phases B and C are calculated in the same manner:

- Times reference tap:

$$I_{restB} = \frac{\sum_{j=1}^{3} \frac{|I_{jB}|}{t_j} - |I_{diffB}(times.tap)|}{2} \qquad I_{restC} = \frac{\sum_{j=1}^{3} \frac{|I_{jC}|}{t_j} - |I_{diffC}(times.tap)|}{2}$$

- x reference tap:

$$I_{restB} = \frac{\sum_{j=1}^{3} \frac{|I_{jB}|}{t_j} t_{ref} - |I_{diffB}(x.t_{ref})|}{2} \qquad I_{restC} = \frac{\sum_{j=1}^{3} \frac{|I_{jC}|}{t_j} t_{ref} - |I_{diffC}(x.t_{ref})|}{2}$$

The equations above represent a general case with three windings. When using a model with two windings, do not take into consideration the third winding, that is, j takes on values 1 and 2.

IDV-D/F relay restraint current will be the current through the protection zone defined by all relay feeding CTs. Said current is defined by the following equations:

- Times reference tap:

$$I_{restA}=\frac{\sum_{j-1}^{4}\frac{|I_{jA}|}{t_j}-|I_{diffA}\,(times.tap)|}{2}\quad I_{restB}=\frac{\sum_{j-1}^{4}\frac{|I_{jB}|}{t_j}-|I_{diffB}\,(times.tap)|}{2}\quad I_{restC}=\frac{\sum_{j-1}^{4}\frac{|I_{jC}|}{t_j}-|I_{diffC}\,(times.tap)|}{2}$$

- x reference tap:

$$I_{restA}=\frac{\sum_{j=1}^{4}\frac{|I_{jA}|}{t_j}t_{ref}-|I_{diffA}(x.t_{ref})|}{2}\quad I_{restB}=\frac{\sum_{j=1}^{4}\frac{|I_{jB}|}{t_j}t_{ref}-|I_{diffB}(x.t_{ref})|}{2}\quad I_{restC}=\frac{\sum_{j=1}^{4}\frac{|I_{jC}|}{t_j}t_{ref}-|I_{diffC}(x.t_{ref})|}{2}$$

where:

I_{restA}, I_{restB}, I_{restC}	are phase A, phase B and phase C restraint currents, respectively
$\|I_{jA}\|$, $\|I_{jB}\|$, $\|I_{jC}\|$	(for j = 1, 2, 3 or 4) are phase A, phase B and phase C current magnitudes, respectively, measured by channel j
t_j	(for j=1, 2, 3, 4) is the tap value associated to channel j (it need not be winding j tap value)
$\|I_{diffA}\|$, $\|I_{diffB}\|$, $\|I_{diffC}\|$	are phase A, phase B and phase C residual current magnitudes
t_{ref}	is the reference winding tap value

It is possible to select a different restraint current calculation criterion by setting the unit (**Restraint Current Type**: 1 - Ires: (I1+I2)/2 within the differential element trip settings group). The expression for calculation purposes is:

- Times reference tap:

$$I_{restA} = \frac{\sum_{j=1}^{3} \frac{|I_{jA}|}{t_j}}{2}$$

- x reference tap:

$$I_{restA} = \frac{\sum_{j=1}^{3} \frac{|I_{jA}|}{t_j}}{2} t_{ref}$$

where:

I_{restA}	is the restraint current for phase A
$\lvert I_{jA} \rvert$	(for j = 1, 2 or 3) is the current magnitude for phase A in windings 1,2 or 3
t_j	(for j = 1, 2 or 3) is the tap value for windings 1,2 or 3
t_{ref}	is the tap value of the reference winding

Phases B and C are calculated in the same manner:

- Times reference tap:

$$I_{restB} = \frac{\sum_{j=1}^{3} \frac{|I_{jB}|}{t_j}}{2} \qquad I_{restC} = \frac{\sum_{j=1}^{3} \frac{|I_{jC}|}{t_j}}{2}$$

- x reference tap:

$$I_{restB} = \frac{\sum_{j=1}^{3} \frac{|I_{jB}|}{t_j}}{2} t_{ref} \qquad I_{restC} = \frac{\sum_{j=1}^{3} \frac{|I_{jC}|}{t_j}}{2} t_{ref}$$

The equations above represent a general case with three windings. When using a model with two windings, do not take into consideration the third winding, that is, j takes on values 1 and 2.

IDV-D/F relay equations defining restraint current second calculation are:

- Times reference tap:

$$I_{restA} = \frac{\sum_{j=1}^{4} \frac{|I_{jA}|}{t_j}}{2} \qquad I_{restB} = \frac{\sum_{j=1}^{4} \frac{|I_{jB}|}{t_j}}{2} \qquad I_{restC} = \frac{\sum_{j=1}^{4} \frac{|I_{jC}|}{t_j}}{2}$$

- x reference tap:

$$I_{restA} = \frac{\sum_{j=1}^{4} \frac{|I_{jA}|}{t_j}}{2} t_{ref} \qquad I_{restB} = \frac{\sum_{j=1}^{4} \frac{|I_{jB}|}{t_j}}{2} t_{ref} \qquad I_{restC} = \frac{\sum_{j=1}^{4} \frac{|I_{jC}|}{t_j}}{2} t_{ref}$$

where:

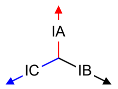
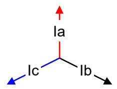
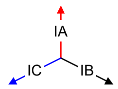
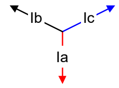
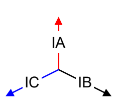
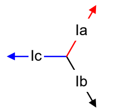
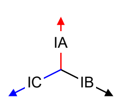
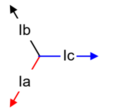
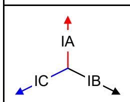
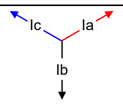
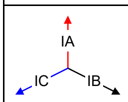
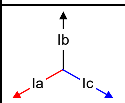
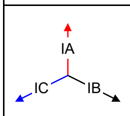
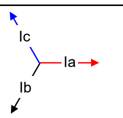
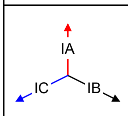
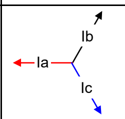
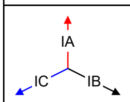
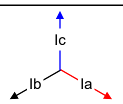
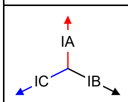
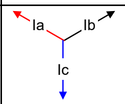
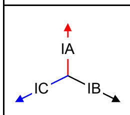
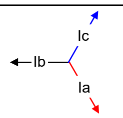
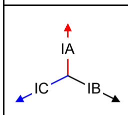
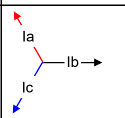
I_{restA} , I_{restB} , I_{restC}	are phase A, phase B and phase C restraint currents, respectively
$\lvert I_{jA} \rvert$, $\lvert I_{jB} \rvert$, $\lvert I_{jC} \rvert$	(for j = 1, 2, 3 or 4) are phase A, phase B and phase C current magnitudes, respectively, measured by channel j
t_j	(for j=1, 2, 3, 4) is the tap value associated to channel j (it need not be winding j tap value)
t_{ref}	is the reference winding tap value

3.1.4 Compensation of the Connection Group

The connection group of the protected machine introduces a number of transformations (phase-angle shifts and magnitude multipliers) which prevent from directly comparing currents, phase to phase, between the different windings. The simple sum of these currents introduces a strong differential current even under no fault conditions. Therefore, a compensation element with a transfer function set as a function of the connection group is required to compensate for the transformations introduced.

This element eliminates the need for groups of intermediate transformers for compensation.

The following table contains information about the transformations made by the equipment depending on the machine's **Connection Group**:

Input Phasors	Output Phasors	Connection Group	Phasor Transformation	Input Phasors	Output Phasors	Connection Group	Phasor Transformation
		0 (0º)	a = A b = B c = C			6 (180º)	a = -A b = -B c = -C
		1 (30º)	a = (A - C) / √3 b = (B - A) / √3 c = (C - B) / √3			7 (210º)	a = (C - A) / √3 b = (A - B) / √3 c = (B - C) / √3
		2 (60º)	a = -C b = -A c = -B			8 (240º)	a = C b = A c = B
		3 (90º)	a = (B - C) / √3 b = (C - A) / √3 c = (A - B) / √3			9 (270º)	a = (C - B) / √3 b = (A - C) / √3 c = (B - A) / √3
		4 (120º)	a = B b = C c = A			10 (300º)	a = -B b = -C c = -A
		5 (150º)	a = (B - A) / √3 b = (C - B) / √3 c = (A - C) / √3			11 (330º)	a = (A - B) / √3 b = (B - C) / √3 c = (C - A) / √3

These transformations assume a system with ABC phase rotation. If the rotation is ACB, then all B (b) and C (c) designations must be exchanged. For more information about "system rotation", see 3.16.4, Phase Sequence.

3.1.5 Tap Compensation Value

Power transformer ratios and possible differences in CT ratios introduce a further unbalance in current measurements at both sides of the transformer. This effect is corrected by tap setting for each winding. Said setting allows for the adjustment of currents so that internal calculations are made on the same current base (refer to section 3.1.12 Examples of vector group adjustment calculations).

3.1.6 Zero Sequence Filter

Zero sequence currents can flow through WYE or ZIGZAG windings and therefore will be present in line currents corresponding to said windings. On the contrary, the same currents may not flow through DELTA windings and therefore will not be present in line currents corresponding to these windings.

When a ground fault occurs at the grounded WYE winding side of the machine, line currents will have a zero sequence component. If any of the other windings is DELTA connected, the corresponding line currents lack the zero sequence component, and a net differential current will result if adequate measures are not taken.

The same problem occurs with grounding reactances within the relay protection areas associated to DELTA windings, to obtain zero sequence sources. Under this situation, a mere compensation of the connection group is not enough and specific measures must be taken to remove the zero sequence component present in the input current. To solve the above cases without additional intermediate transformers, a **Zero Sequence Filter** is added to the protection, which could be disabled by the user through a setting.

IDV Models with option **A** or higher in digit **9** (see 1.5, Model Selection) include a setting through which the type of zero sequence current extracted by the zero sequence filter can be selected:

- **Phase channels**: the zero sequence current is calculated from the phase currents measured in the applicable winding. This option implies a reduction of the differential current on internal ground faults. In order to reduce the loss of sensitivity that this reduction of the differential current implies, **IDV** relays also subtract the zero sequence current in the restraint current. The application of the zero sequence filter from phase currents can cause, on the other hand, the operation of the differential current elements associated to the healthy phases on single phase faults. In order to correctly ascertain the type of fault, **IDV** relays include a Phase Selector separate from the Phase Differential elements (see section 3.5.2). When the zero sequence filter is applied from phase currents, the phase directional comparison element (see section 3.3.3) can use a type **2 of 3** cross-blocking logic, which implies increased safety on external faults with severe saturation of a CT.
- **Ground channels**: the zero sequence current is calculated from the current measured by the ground channel associated to the winding in question. In this case a reduction of the differential current on internal ground faults will not be produced, so no loss of sensitivity will take place. On the other hand, the differential current in healthy phases will be theoretically zero, so the phase differential element will correctly ascertain the type of fault. The drawback of this method is that the phase directional comparison element (see section 3.3.3) will not be able to use **2 of** 3 cross-blocking logic, which will reduce the stability on external faults with very severe saturation of a CT.

When the zero sequence filter is applied from the ground current, this is escalated taking into account the different transformation ratio between the ground CT and the phase CTs of the applicable winding.

It is worth mentioning that in an autotransformer the ground current contains the ground current of both primary and secondary windings. Taking into account that the zero sequence current to be subtracted from each winding must be divided by its tapping (secondary rated current of that winding) the exact fraction of the ground current corresponding to each winding must be known. Since this current distribution is not known, the zero sequence filter cannot be applied with the ground current of an autotransformer.

3.1.7 Reference Winding

IDV equipment have a setting, **Reference Winding** (within the differential element trip settings group), for selecting a machine winding and displaying the differential and restraint currents, both on the HMI display and when retrieved via communications, multiplied by the adjusted tap for that winding (if within the general settings group, the “x reference tap” is selected for “Differential Current Measure” setting).

Setting **Reference winding** is also used to determine the winding associated to the measured voltage. Thus, it is used both for calculating power and voltage and for the restraint overcurrent element (refer to 3.6).

This setting effects only the display and in no case does it effect internal calculations of the Differential unit.

3.1.8 Operating Current Magnitude Calculation

After all disturbances have been compensated (Connection Group, Tap Setting and Zero Sequence Filter), a set of magnitude-normalized and phase-adjusted currents are obtained for each winding and phase, so that their algebraic sum can be obtained without incurring into false differential values.

The operation magnitude (I_{diff}) is obtained by extracting the fundamental component of the calculated differential current and calculating its effective value based on the phasors that define them.

3.1.9 Restraint Current Magnitude Calculation

The restraint magnitude (I_{rest}) is obtained by first calculating the RMS value of the restraint current (depending on the selected criterion – see 3.1.3, Percentage Restraint Current) and, depending on the value for this current, it is multiplied by a different coefficient to obtain the final restraint magnitude. The purpose of these coefficients is to obtain a characteristic like that appearing in Figure 3.1.1.

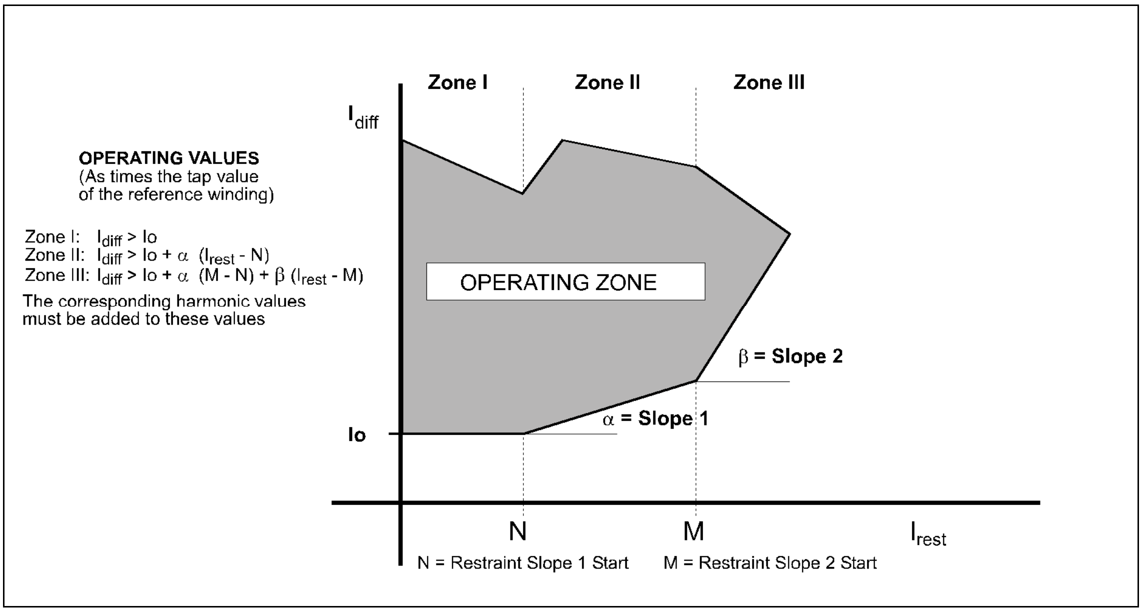


Figure 3.1.1: Operation Characteristics of the Differential Unit with Restraint.

For the larger restraint currents there are larger inequalities, and an increased quantity of differential current is needed to obtain the operation of the unit. Slope 1 is normally used to compensate for CT measurement errors and tap setting errors. Slope 2 provides safety on CT saturation caused by high-magnitude external faults.

The α and β, multiplication coefficients of the restraint current, defined between the values **N** and **M** and from **M** onward, are user-definable and are known as **Percentage Restraint Coefficients** (Restraint Slope 1 and Restraint Slope 2).

The parameter **Io** establishes the **Differential Sensitivity** of the unit, and determines the minimum value of differential current necessary to obtain operation of the unit. This sensitivity setting must be configured as times the reference tap.

3.1.10 Harmonic Restraint

This restraint is only applicable to transformers and autotransformers, and not to the rest of the machines.

Energization of a transformer causes magnetizing inrush currents with high content of even harmonics (mainly, second and fourth harmonics). This phenomenon is aggravated by the possible residual magnetism in the transformer. During such process, the current is much greater at the energization side as magnetizing energy must be provided to the transformer core. This results into a strong differential current for up to several tens of cycles. If proper measures are not taken, the Differential Unit can operate. To prevent this, the second and fourth harmonics present in the differential current are extracted and used to desensitize the measurement element, such that the greater the second-harmonic content the greater the differential current required for element operation.

Also, operation of the transformer in overexciting conditions (overvoltage and underfrequency) has similar characteristics with the appearance of differential current and high odd harmonic content (third and fifth harmonics). This condition is used to detect the overexcitation and desensitize the unit to avoid trips under such circumstances.

There are four settings for activating or deactivating restraint by the 2nd, 3rd, 4th and 5th harmonic. The slopes for restraining the unit's operation are also definable. Therefore, the harmonic restraint graph is a straight line.

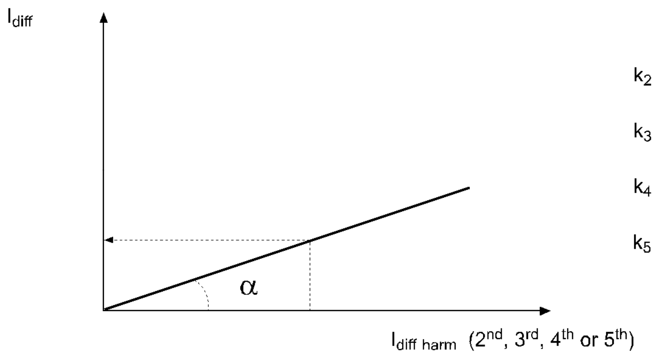


Figure 3.1.2: Characteristics of Harmonic Restraint.

The differential current calculated using the current with harmonic content (2nd,3rd, 4th or 5th) is added to the differential current obtained from the percentage restraint characteristic, i.e.:

$$I_{diff} = I_{\substack{diff\\percentage\\restraint}} + I_{\substack{diff\\harmonic\\restraint}} = I_{\substack{diff\\percentage\\restraint}} + \frac{I_{diff.harm}}{k}$$

The instantaneous unit is not subjected to restraint by the harmonic content in order to avoid an actual fault from being restrained for an unnecessary interval of time, thus damaging the transformer.

3.1.10.a Harmonic Blocking and “Cross Blocking”

It is possible to completely block operation of the Differential Unit with Restraint when the 2nd, 3rd, 4th and/or 5th harmonic levels exceed definable percentages of the nominal frequency current value.

There are four independent settings to enable or disable the 2nd, 3rd, 4th and 5th harmonic blocking, and four percentage settings for the 2nd, 3rd, 4th and 5th harmonics that must be exceeded to block the differential unit. These percentage settings represent the RMS harmonic value in the differential current versus the RMS value of the fundamental component of the differential current. The differential unit is blocked at the setting value and reset at 0.95 times the setting.

There is another setting available (**Harmonics Blocking Type**) to block just the phases containing a certain harmonic distortion (logic **AND**) or to block all phases when:

- The harmonic content in some of the phases is higher than the setting value (logic **OR**)
- The harmonic content in two of the phases is higher than the setting value (logic **2 out of 3**; only **IDV******D/F/G** models).
- Allows blocking only the phases with harmonic content, but taking into account the harmonics of the rest of the phases (**SUM** setting; only for models with option **A** or higher in digit **9** -see 1.5, Model Selection-).
- Allows to generate a three phase blocking taking into account not only the harmonic differential current level but also the fundamental differential current level of the three phases (setting to **Three Phase SUM**; models with option **B** or higher in digit **9** -see 1.5, Model Selection-).

The logic scheme that extends the harmonic blocking along all phases is known as “Cross Blocking”. Such scheme provides better security during the energization of power transformers where the harmonic content of some of the phase currents may be very low. Also, provides the differential unit with better stability under external faults with saturation of some of the CTs during the energization of the machine. In this case the harmonic content is some of the phases can be reduced considerably. The logic **Two Out of Three** provides better obedience than the logic **OR**. The logic **2 out of 3** is not applicable for internal faults.

If it is a two phase or three phase fault, two or three phases without high harmonic content will exist. If it is a single phase fault, whenever the zero sequence filter is applied from the phase channels (**Type of Zero Sequence Filter** set to **Phase Currents**), the harmonic content of healthy phases will be reduced. It is worth mentioning that, if the zero sequence filter is applied from the ground channels, the **2 out of 3** logic will operate a close on to single phase fault as it provides a high harmonic content in the healthy phases.

Models with option **A** or higher in digit **9** include a forth option for the cross-blocking logic, known as **Sum**. This option replaces the harmonic level of each phase by the sum of the harmonic levels of the three phases. The ratio between the harmonic differential current and the fundamental differential current will be:

In phase A: $(IDIFA_{harmonic\ n} + IDIFB_{harmonic\ n} + IDIFC_{harmonic\ n})/IDIFA_{fundamental}$
In phase B: $(IDIFA_{harmonic\ n} + IDIFB_{harmonic\ n} + IDIFC_{harmonic\ n})/IDIFB_{fundamental}$
In phase C: $(IDIFA_{harmonic\ n} + IDIFB_{harmonic\ n} + IDIFC_{harmonic\ n})/IDIFC_{fundamental}$

Where n=2, 3, 4 or 5.

The option **Sum** provides good safety on *inrush* situations and, on the other hand, allows tripping on close on to fault conditions. In this latter case, faulty phases will have a high fundamental component that will reduce the ratio ($IDIFA_{harmonic\ n}$+ $IDIFB_{harmonic\ n}$+ $IDIFC_{harmonic\ n}$) / $IDIFX_{fundamental}$, where n=2, 3, 4 or 5 and X is the faulty phase (A, B or C). The **Sum** logic increases the response of the **2 out of 3** logic under situations in which the zero sequence filter is not enabled (since the transformer configuration does not require it) or it is applied from ground currents.

Models **IDV-L** and models with option **B** or higher in digit **9** include a fifth option for cross blocking logic, designated as **Three Phase SUM**. This option uses, for the three phases, the following ratio between the harmonic differential current and the fundamental differential current:

2nd harmonic ratio for the three phases:

$$(IDIFA_{2^{nd} harmonic\ n} + IDIFB_{2^{nd} harmonic\ n} + IDIFC_{2^{nd} harmonic\ n}) / (IDIFA_{fundamental} + IDIFB_{fundamental} + IDIFC_{fundamental})$$

3rd harmonic ratio for the three phases:

$$(IDIFA_{3^{rd} harmonic\ n} + IDIFB_{3^{rd} harmonic\ n} + IDIFC_{3^{rd} harmonic\ n}) / (IDIFA_{fundamental} + IDIFB_{fundamental} + IDIFC_{fundamental})$$

4th harmonic ratio for the three phases:

$$(IDIFA_{4^{th} harmonic\ n} + IDIFB_{4^{th} harmonic\ n} + IDIFC_{4^{th} harmonic\ n}) / (IDIFA_{fundamental} + IDIFB_{fundamental} + IDIFC_{fundamental})$$

5th harmonic ratio for the three phases:

$$(IDIFA_{5^{th} harmonic\ n} + IDIFB_{5^{th} harmonic\ n} + IDIFC_{5^{th} harmonic\ n}) / (IDIFA_{fundamental} + IDIFB_{fundamental} + IDIFC_{fundamental})$$

Where n=2, 3, 4 or 5.

Option **Three Phase SUM** provides a better balance between safety and response than option **SUM**. During energization, the level of second harmonic differential current in one phase ensures a high three phase second harmonic percentage. On the other hand, during an internal fault the level of the fundamental differential current of the faulted phases will reduce significantly the three phase second harmonic percentage.

It is worth highlighting that, contrary to option **SUM**, by selecting **Three Phase SUM,** increasing the set harmonic pickup level is not required.

In any case the cross blocking duration operating with logic **2 out of 3** or **OR** can be limited by means of an additional configurable timer. After such time the blocking will affect only the phase with a harmonic content higher than the set value.

Harmonic blocking is applied to the Differential Unit with Restraint before pickup and does not reset the unit once is picked up.

3.1.10.b Restraint Inhibition and Harmonics Blocking (IDV-**D/F/G Models)

Restraint or harmonics blocking could delay the tripping of the Differential Unit in the event of internal faults involving the saturation of some CT, due to the harmonic contamination caused by the differential current wave in that case. In order not to cause unnecessary delays, there is the possibility of not having to apply restraint or harmonics blocking. To this avail, settings for **Restraint** and **Harmonics Blocking** must be configured to **Dynamic** mode.

Models **IDV-**D-****0**** and **IDV-**F-****0**** only use measured currents for restraint and blocking inhibition by harmonics, operating exclusively based on restraint and blocking by 2nd and 4th harmonics (blocking or restraint by 3rd and 5th harmonics is always operative if enabled) that will only be applied during transformer energization and inrush situations generated as a consequence of external fault clearance. Restraint and blocking by even harmonics is used under the following conditions:

- The transformer is **de-energized**; this situation is detected when no current flows through any of the windings (current in all the channels is below the setting for **Open Breaker Current**). From the moment the energized transformer is detected (current in any of the windings exceeding the threshold value) the **Harmonics Inhibition Time** will be counted to disable restraint / blocking from the 2nd and 4th harmonics. This setting must exceed the maximum time that transformer energization can last.
- Once the transformer has been **energized**, an external fault condition is detected, whether this is due to the differential instantaneous elements, or else to the phase direction comparison elements, or positive sequence elements. As from the deactivation of the external fault condition, restraint / blocking from harmonics will be continue to be enabled for 5 seconds.
- 2.5 cycles after the activation of fault inception for 5 seconds.

Relays **IDV-**D/F/G** with option **A** or higher in digit **9** use, for restraint and blocking by harmonics disable, both the currents (for 2nd and 4th harmonic) and one voltage (VPH for **IDV-A/B** relays and VA for **IDV-J/K/L** relays). Currents will be used for blocking / restraint by 2nd and 4th harmonic disable in the same way as for relays **IDV-**D-****0**** and **IDV-**F-****0****, except that the time for restraint / blocking by 2nd and 4th harmonic enable, after deactivating the external fault detector or after two and a half cycles from the activation of fault inception, will equal **Harmonic Disable Time** instead of 5 seconds. Voltages will be used to disable blocking / restraint by 3rd and 5th harmonic provided the ratio voltage / frequency is below 1.05 times the ratio (Vrated / PHrated), which indicates that the transformer is not under over excitation condition. When there is no voltage information, these relays will operate as **IDV-**D-****0**** and **IDV-**F-****0**** relays.

Models incorporating three voltage channels (VA, VB and VC), relays **IDV-F/G/H/J/K/L**, will include the blocking / restraint by any harmonic (2nd, 3rd, 4th and 5th) disable function based on voltage and restraint current change. This function operates taking into account that, from the time when a voltage change is produced, some time elapses until the saturation of the power transformer (*inrush* or over excitation situation) and, thereby, until the differential current increases. On an internal fault, however, a voltage change will be instantly accompanied by a differential current increase. Therefore, if during a number of consecutive samples from the time a voltage change occurs (detected based on instantaneous values), the differential current is very small, the internal fault condition is discarded, applying restraint an blocking by all harmonics during the **Harmonic Disable Time**. In order to detect over excitation situations occurring very slowly, the relay will continually check the ratio between voltage and frequency. When it is above 1.05 times the ratio (Vrated / Frated), the restraint by 3rd and 5th harmonic will cease to be disabled. When there is no voltage information, these models operate as **IDV-**D-****0**** and **IDV-**F-****0**** models.

If the **Restraint** and **Harmonics Blocking** is set to **Continuous** mode, both restraint and blocking from these harmonics will always be enabled.

Change to Continuous Restraint and Blocking input enables the activation of continuous mode for blocking and restraint from harmonics, independently from the values adopted by the respective settings.

The blocking / restraint by 2nd harmonic disable method based on currents does not allow discerning close on to fault energizing. During transformer energizing, the blocking / restraint by harmonics will always be present. The blocking / restraint by 2nd harmonic disable method based on voltage and differential current change does allow discerning close on to fault energizing. For this, the measured voltage must be taken from the transformer side and not from the busbar side, so as to detect the voltage change at the time of closing the breaker. If wiring the voltages VA, VB and VC should be required, they not being sourced from the adequate point (transformer side of the winding by which energizing takes place), the restraint / blocking by harmonics disable algorithm will not operate correctly during transformer energizing. Thus it is necessary to set **Restraint** and **Harmonics Blocking** to **Continuous** mode or else to **Dynamic** mode and perform a programmable logic through ***ZIVerlog***® software in order for the **Continuous** mode to remain active during the energizing (through the **Switch to Continuous Restraint and Blocking** input).

IDV-J/K/L relays do not required any programmable logic. They include a setting **Blocking / Restraint by Harmonics with Voltage Inhibition** which indicates whether the restraint / blocking by harmonics disable through voltage is to be used. When the hard wired voltage does not come from the adequate side, this setting must be set to **NO**. In this case, the blocking / restraint by harmonics will be disabled in the same way as for **IDV-**D/F/G** Models with option **A** or higher in digit **9**: blocking / restraint by 2nd and 4th harmonic disable based on measured currents and blocking / restraint by 3rd and 5th harmonic disable based on VPH voltage or measured VA (depending on model). If voltage is hard wired from the adequate side (voltage from the transformer side), in order for the restraint / blocking by harmonics disable algorithm to operate based on voltage measurement, the setting **Blocking / Restraint by Harmonics with Voltage Inhibition** must be set to **Yes**. In this case the relay will operate exactly the same as for **IDV-F/G/H** relays.

As current-based restraint and blocking inhibition by harmonics is based on External Fault Detector activation, restraint and blocking by harmonics will continuously be applied when said detector is disabled.

3.1.11 Fault Detector Supervision

Models **IDV-L** and models with option **B** or higher in digit **9** include a setting, **Fault Detector Supervision** (within the group of settings of the Differential Unit Protection), which allows disabling the trip supervision by the Fault Start Detector (refer to 3.2.3 and 3.2.4).

This setting is of application under given test conditions in which the differential characteristic is tested by means of current ramps, without injecting step values into this magnitude. Current ramps do not activate the fault inception detector, preventing the Differential element from tripping if the setting **Fault Detector Supervision** is set to **YES**. In order to allow testing the differential element under such conditions, said setting must be set to **NO**.

3.1.12 Parallel Transformer

Models **IDV-L** and models with option **B** or higher in digit **9** include a setting, **Parallel Transformer** (within the group of protection settings of the Differential Unit with Restraint), which increases the safety of the dynamic harmonic restraint / blocking (refer to section 3.1.10.b) upon the energization of a transformer connected in parallel (*sympathetic inrush*).

3.1.12.a 2nd and 4th Harmonic Restraint and Blocking Disable with the Transformer in Parallel Setting set to YES

Setting transformers in parallel to **Yes** will prevent disabling, enabling harmonic restraint / blocking, under any of the following conditions:

- AND of the differential element external fault with instantaneous values of the three phases, during 8 ms, if the zero sequence filter is set to Yes and the source of the same are the phase channels. If the zero sequence filter is set to NO or the source are the ground channels, an OR of the differential element external fault with instantaneous values of the three phases will be used.
- AND of the directional comparison external fault during 1.5 cycles if the zero sequence filter is set to Yes and the source of the same are the phase channels. If the zero sequence filter is set to NO or the source are the ground channels, an OR of the directional comparison external fault of the three phases will be used.
- External fault by positive sequence directional comparison during 1.5 cycles.

Also, the 2nd and 4th harmonic restraint / blocking will remain enabled if during the 2.5 cycles after **FS** (Fault Inception) the disabled condition of the harmonic restraint / blocking is not validated within the **Harmonic Disable Time** setting value.

In any case, once this time window (2.5 cycles from fault inception) has elapsed, the disabled condition will deactivate (activating the corresponding blocking) and may not be activated until the **Harmonic Disable Time** setting value times out, even on a new fault inception.

3.1.12.b 3rd and 5th Harmonic Restraint and Blocking Disable with the Transformer in Parallel Setting set to YES

When the **Transformer in Parallel** setting is set to **NO**, so as to detect overexcitation situations produced very slowly, the relay checks continually the voltage-to-frequency ratio. When this exceeds 1.05 times the rated ratio (Vrated / Frated), the 3rd and 5th harmonic restraint will cease to be disabled. Namely, the disabled condition remains whenever the V/f ratio is complied with.

When the **Transformer in Parallel** setting is set to **YES**, the 3rd and 5th harmonic restraint and blocking disable will remain active for 2.5 cycles after fault inception provided certain conditions depending of the type of zero sequence current filter are complied with. Once this 2.5 cycles time window times out, the disabled condition will deactivate (activating the corresponding blocking), and a new 2.5 cycles time window can be activated upon a new fault inception detection.

3.1.13 Operation

3.1.13.a Unrestrained Differential Unit (Instantaneous) Output

It is used for high-magnitude internal faults when fast fault clearance is required.

This output is obtained by comparing the differential current with the level setting (instantaneous differential current pickup setting, which must be configured as times the reference tap), without calculating the percentage restraint characteristic. This output is known as **Instantaneous Output**; its operating level is set to several times the transformer rated current to guarantee unrestrained operation for high differential current levels. Element picks up at 100% of setting and resets at 95% of the calculated pick up value.

Output is activated when the timer times out provided the element is picked up. Any reset brings the integrator to initial conditions, so that a new operation starts timing from zero.

This relay has the option to program a **Trip Blocking** input to prevent operation if the input activates before the trip is generated. If the input activates after tripping, the trip resets. To use this blocking logic the **Unrestrained Differential Element Trip Blocking** input must be programmed. For **IDV-**D/F/G** models, activation of the External Fault Detector can block the unrestrained differential element if the **Instantaneous Differential Element Blocking Enable** on External Fault Detector setting is set to **YES**. On the other hand, tripping the instantaneous differential element of one phase needs the activation of said phase fault detector.

3.1.13.b Restraint Differential Unit Output

Output from this element is obtained calculating the percentage restraint and harmonic restraint characteristic after differential, restraint and harmonic currents have been obtained. This is known as **Restraint Differential Output**.

The element picks up at 100% and resets at $0.8I_0$ if there is no harmonic restraint. If there is harmonic restraint, reset occurs at the largest of the following values:

- 0,8*Io
- $0{,}5 * I_{harmonic}/K_{harmonic}$,

where this last division can be $I_{2nd.harmonic}/k_2$, $I_{3rd.harmonic}/k_3$, $I_{4th.harmonic}/k_4$ or $I_{5th.harmonic}/k_5$, where k is the setting of the harmonic restraint slope.

An adjustable timer can provide delayed trips if required.

A **Trip Blocking** input can be programmed to prevent relay operation if this input activates before trip generation. If input activates after tripping, the trip resets. To use this blocking logic the **Restraint Differential Element Trip Blocking** input must be programmed. For **IDV-**D/F/G** models, activation of the external fault detector can block the restrained differential element if the Instantaneous Restrained Differential Element Blocking Enable on External Fault Detector setting is set to YES. On the other hand, tripping the restraint differential element of one phase needs the activation of said phase fault detector.

3.1.14 Recommended Settings

Some Differential Unit recommended settings are given below.

3.1.14.a Type of Restraint Current

IDV relays incorporate two formulas for restraint current calculation, selected by a setting: **Ifre1 = (I1+I2-Id)/2** and **Ifre2 = (I1+I2)/2**. While the residual current on a fault external to the transformer is small, the first restraint current is similar to the second restraint current. However, on internal faults, the first restraint magnitude will be much lower than the second (if the influence of the load is negligible, as currents flowing through the windings are in phase, the first restraint current is zero). In this way, the compromise between safety and response given by the first formula is better than the second. However, if high residual currents are generated on external fault as a result, for example, of a saturated CT, the first restraint current will be smaller than the second, which means a reduction in safety. In any case, if the External Fault Detector is enabled (see section 3.3), which provides great differential Unit stability on external fault with saturated CTs, the first restraint current formula is recommended, as this improves the response on internal faults.

3.1.14.b Sensitivity

The setting **Sensitivity** defines the minimum residual current required by the Differential Element to operate. It must take into account the residual current generated on minimum load conditions. In this case, the residual current will be given mainly by the magnetizing current in normal operation (with no inrush or over excitation). Typical setting is 0.3 times the tap.

3.1.14.c First Restraint Slope

The **First Restraint Slope** has the purpose to compensate for percent errors, dependent on the flowing current. Said errors will be introduced by the tap change operation, the CTs (on no-saturated condition) and the relay itself. Examples for settings calculations in section 3.1.13 show typical errors generated by the above elements. If the sensitivity has been set only for magnetizing current compensation, **First Restraint Slope Start** must be set at the minimum value.

3.1.14.d Second Restraint Slope

Second Restraint Slope Start must be calculated taking into account the minimum current, on external fault condition, that leads to the saturation of a CT. The restraint slope shall be set to compensate for the residual current generated in this condition. A value of 80% is usually adequate, as the External Fault Detector gives high safety on external faults with saturation of a CT.

3.1.14.e Restraint or Blocking by Harmonics

A value of 20% both for the restraint and blocking by 2^{nd} and 5^{th} harmonics is usually sufficient to detect inrush and over excitation conditions respectively. However, the 2^{nd} harmonic of the magnetizing current of new power transformers on inrush condition can be below 20%. In this case, **Blocking** or **Restraint** settings for said harmonic must be reduced. Other option, only applicable to restraint, is to enable the **4^{th} Harmonic Restraint**, also present in the residual current during inrush condition. In this way total restraint by harmonics will be increased.

The **Cross Blocking** feature (see point 3.1.10.a) also provides the differential unit with more security. The logic **Two Out of Three** is here the most recommended keeping the obedience at acceptable levels.

Restraint or blocking by 3^{rd} harmonic is not applicable when the transformer is delta connected, as this acts as filter for said harmonic.

3.1.14.f Pickup Value of Instantaneous Differential Unit

As Instantaneous Differential Units do not exhibit restraint or blocking by harmonics, their pickup setting value must be above the maximum residual current generated when the power transformer is saturated. The worst situation arises during transformer energization. Maximum magnetizing current under this situation takes place at maximum flux. Taking into account a maximum flux DC component ($2*\Phi_{nominal}$: close at zero crossing) and maximum residual flux ($0.8*\Phi_{nominal}$), maximum operating flux can reach $2.8*\Phi_{nominal}$. If the machine magnetizing curve is known, the magnetizing current corresponding to said flux value can be obtained. The pickup setting of the Instantaneous Differential Unit must be above said current. A value of 8 pu is normally used.

3.1.14.g Zero Sequence Filter

The Zero Sequence Filter must be enabled in all star windings connected to ground, provided there is a delta winding. If on a delta winding side there is an artificial ground connection within the **IDV** relay protection area, the zero sequence filter on the delta side must be enabled.

In general, for star-star transformers enabling the zero sequence filter is not required, except in the case of a three core three phase transformer. In this case, as a consequence of the small zero sequence magnetising reactance (due to the high reluctance of the zero sequence flux), a significant zero sequence differential current can be generated.

3.1.15 Examples of Settings Calculations

- **Example 1**

Consider a power transformer with 2 windings of 60MVA and a transformer ratio of 130kV / 46 kV ± 1150 V (5 taps), YY0 configuration.

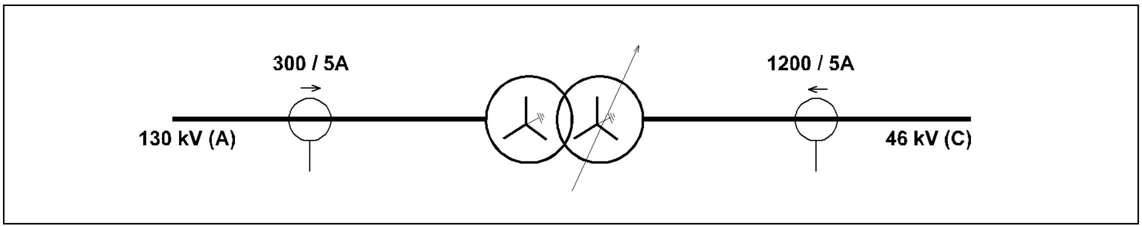


Figure 3.1.3: Example 1 of Settings Calculations for Connection Groups.

Tap Calculations

To determine the tap of the relay, calculate the primary currents corresponding to the maximum power of the machine, for each winding, using the following formula:

$$Current = \frac{MaxPower(kVA)}{Voltage(kV) \cdot \sqrt{3}}$$

Calculate the current of each winding and tap:

HV side (130 kV) (A): $IA = \frac{60{,}000\ kVA}{130\ kV\ .\sqrt{3}} = 266.8\ A$

MV side: For this case we take the minimum, middle and maximum values.

Extreme minimum tap position: 43.7 kV (B): $IB = \frac{60{,}000\ kVA}{43.7\ kV\ .\sqrt{3}} = 793.6\ A$

Middle tap position: 46 kV (C): $IC = \frac{60{,}000\ kVA}{46\ kV\ .\sqrt{3}} = 754\ A$

Extreme maximum tap position: 48.3 kV (D): $ID = \frac{60{,}000\ kVA}{4.3\ kV\ .\sqrt{3}} = 718\ A$

The ratio of the current transformers is:

HV side (130 kV):	300 / 5 A ;	CT Ratio = 60
MV side (46 kV) :	1200 / 5 A ;	CT Ratio = 240

The currents viewed by the relay, for the different taps, are the following:

$$Is\,(A) = \frac{266,8}{60} = 4.45\ A \qquad Is\,(C) = \frac{750}{240} = 3.14\ A$$

$$Is\,(B) = \frac{793.6}{240} = 3.30\ A \qquad Is\,(D) = \frac{718}{240} = 2.99\ A$$

Relay Tap Setting

130 kV (A) side: 4.45 A
46 kV (C) side: 3.14 A. In the tap positions for: 43.7 kV and 48.3 kV: 3.14 A

Differential Current

The difference between the setting and the value of the differential current is:

H.V. side 130 kV (A): Differential current = 4.45 - 4.45 = 0

M.V. side:

Minimum tap position: 43.7 kV (B): Differential current = 3.30 - 3.14 = 0.16 A

Middle tap position: 46 kV (C): Differential current = 3.14 - 3.14 = 0 A

Maximum tap position: 48.3 kV (D): Differential current = 3.14 - 2.99 = 0.15 A

Restraint Current

Defined as the smallest of the currents (if **Restraint current type** setting is: 1 - IRest: (I1+I2-Id)/2, within the differential element trip settings group), when they circulate in the same direction:

Minimum tap: 43.7 kV (B): 3.30 A
Middle tap: 46 kV (C): 3.14 A
Maximum tap: 48.3 kV (D): 2.99 A

Error Setting

We define this error as the quotient of the differential current and the restraint current:

Minimum tap: 43,7 kV (B): $\frac{0.16}{3.30} = 0.048\ ;\ 4.8\,\%$

Middle tap: 46 kV (C): $\frac{0}{3.14} = 0$

Maximum tap: 48.3 kV (D): $\frac{0.15}{2.99} = 0.05\ ;\ 5\,\%$

Calculating the Slope 1

To determine the Slope we should consider: current transformer errors, the error in the different taps (due to the voltage regulation), and the drain current.

C.T. errors: 10% (assuming errors of 5% in each winding and opposite sign)
Drain Current: 2%
Setting error: 5%
Equipment error: 5%

Total: 22%

Recommended Setting: **25%**

Calculating the Slope 2

The Second Slope must be set based on the maximum residual current on external fault, as a result of saturation of a CT and the corresponding restraint current. A setting value of 75% is recommended.

The slope initiation will be determined by the minimum restraint current for which CTs can be saturated.

Sensitivity

It is recommended that the differential sensitivity be adjusted to 30% of the tap value of the reference winding. In the example it would be 30% of the primary winding:

This setting must be entered as times the reference tap, thus the value of said setting is directly **0.3**. This value is equivalent to a value in amps 0.3 x 4.45 A = 1.34 A.

Instantaneous Unit

An adjustment of **5** to **10 times the tap value** (of the reference winding) and an operation time of **20ms** are recommended.

2nd, 3rd, 4th and 5th Harmonic Restraint / Blocking

Recommended setting for 2nd, 3rd, 4th and 5th Harmonic: **20%**

Zero Sequence Filter

Based on the recommendations of section 3.1.12.g, enabling the Zero Sequence Filter would only be required if it is a three core transformer.

In case that the Zero Sequence Filter is active in both windings, the operation of the IED is not affected and will not operate under external faults.

Connection Group

The **IDV** equipment performs angle compensation internally. To do this, the connection group for each winding, the hour index and the zero sequence filter are entered using the HMI:

Winding # 1		Winding # 2	
WYE Connection	**Y**	WYE Connection	**Y**
Zero Sequence Filter	**NO**	Hour Index	**0**
Zero Sequence Filter Type*	**0: Phase Channels**	Zero Sequence Filter	**NO**
		Zero Sequence Filter Type*	**0: Phase Channels**

(*) IDV models with option A or higher in digit 9 (see 1.5, Model Selection).

- **Example 2**

A power transformer with two windings of 40MVA and transformer ratio of 132kV / 20kV, connection group YD11 and extreme tap of high side of 13.2kV:

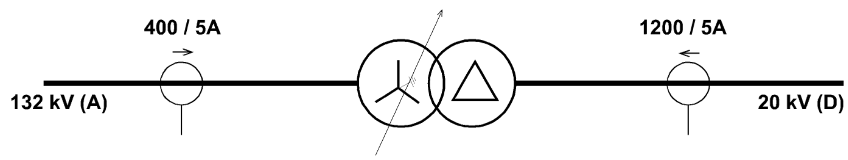


Figure 3.1.4: Example 2 of Settings Calculations for Connection Groups.

Tap Calculations

To determine the tap of the relay, calculate the primary currents corresponding to the maximum power of the machine, for each winding, using the following formula:

$$Current = \frac{MaxPower(kVA)}{Voltage(kV) \cdot \sqrt{3}}$$

In this case we take the minimum, middle, and maximum tap values:

HV side (132 kV) (A):

Middle tap position: 132 kV (A): $IA = \frac{40{,}000\ kVA}{132\ kV \, . \sqrt{3}} = 175.16\ A$

Maximum tap position: 145.2 kV (B): $IB = \frac{40{,}000\ kVA}{145.2\ kV \, . \sqrt{3}} = 159.23\ A$

Minimum tap position: 118.8 kV (C): $IC = \frac{40{,}000\ kVA}{118.8\ kV \, . \sqrt{3}} = 194.24\ A$

MV side: Calculate the tap value: $ID = \frac{40{,}000\ kVA}{20\ kV \, . \sqrt{3}} = 1154.70\ A$

The ratio of the current transformers is:

HV side (132 kV): 400 / 5 A ; CT Ratio = 80
MV side (20 kV) : 1200 / 5 A ; CT Ratio = 240

The currents viewed by the relay, for the different taps, are the following:

$Is\,(A) = \frac{175.16}{80} = 2.1895\ A$ (Middle tap value) $Is\,(C) = \frac{194.24}{80} = 2.428\ A$ (Minimum tap value)

$Is\,(B) = \frac{159.23}{80} = 1.9903\ A$ (Maximum tap value) $Is\,(D) = \frac{1154{,}70}{240} = 4.81\ A$ (M.V. side)

Relay Tap Setting

132 kV (A) side: 2.19 A. In the tap positions for: 118.8 kV and 145.2 kV :2.19 A
20 kV (D) side: 4.81 A.

Differential Current

The difference between the setting and the value of the differential current is:

H.V. side 130 kV (A): Differential current = 4.45 - 4.45 = 0

Minimum tap position: 118.8 kV (C): Differential current = 2.428 - 2.19 = 0.238 A
Middle tap position: 132 kV (A): Differential current = 2.19 - 2.1895 = 0.0005 A
Maximum tap position: 145.2 kV (B): Differential current = 2.19 - 1.9903 = 0.197 A

M.V. side: Differential current = 4.81 - 4.81 = 0 A

Restraint Current

Defined as the smallest of the currents, when they circulate in the same direction (if **Restraint current type** setting is: 1 - IRest: (I1+I2-Id)/2, within the differential element trip settings group):

Minimum tap: 118.8 kV (C): 2.42 A
Middle tap: 132 kV (A): 2.19 A
Maximum tap: 145.2 kV (B): 1.99 A

Error Setting

We define this error as the quotient of the differential current and the restraint current:

Minimum tap: 118.8 kV (C): $\frac{0.238}{2.42} = 0.098\ ;\ 9.8\,\%$

Middle tap: 132 kV (A): $\frac{0}{2.19} = 0$

Maximum tap: 145.2 kV (B): $\frac{0.197}{1.99} = 0.099\ ;\ 9.9\,\%$

Calculating the Slope 1

To determine the Slope we should consider: current transformer errors, the error in the different taps (due to the voltage regulation) and the drain current.

C.T. errors:	10%
Drain Current:	2%
Setting error:	9.9%
Equipment error:	5%
Total:	26.9%

Recommended Setting: **30%**

Calculating the Slope 2

The Second Slope must be set based on the maximum residual current on external fault, as a result of saturation of a CT and the corresponding restraint current. A setting value of 75% is recommended.

The slope initiation will be determined by the minimum restraint current for which CTs can be saturated.

Sensitivity

It is recommended that the differential sensitivity be adjusted to 30% of the tap value of the reference winding. In the example it would be 30% of the primary winding:

This setting must be entered as times the reference tap, thus the value of said setting is directly **0.3**. This value is equivalent to a value in amps 0.3 x 2.19 A = 0.657 A

Instantaneous Unit

An adjustment of **5** to **10 times the tap value** (of the reference winding) and an operation time of **20ms** are recommended. For example 5.8 times the tap:

5.8 times (reference winding in WYE configuration) = (5.8) × 2.19 = 12.7 A (operating value)
5.8 times (reference winding in DELTA configuration) = (5.8) × 4.81 = 23.78 A (operating value)

2nd, 3rd, 4th and 5th Harmonic Restraint / Blocking

Recommended setting for 2nd, 3rd, 4th and 5th Harmonic: **20%**

Zero Sequence Filter

Under a situation of a grounded winding connection in the HV side and a DELTA winding connection in the MV side, any external fault to ground would cause zero sequence currents circulating on the WYE winding but not in the DELTA side. This is the reason why the Zero Sequence Filter should be enabled to avoid false trips due to this situation.

In case that the Zero Sequence Filter is active in both windings, the operation of the IED is not affected and will not operate under external faults.

Connection Group

The **IDV** equipment performs angle compensation internally. To do this, the connection group for each winding, the hour index and the zero sequence filter are entered using the HMI:

Winding # 1		Winding # 2	
WYE Connection	**Y**	DELTA Connection	**D**
Zero Sequence Filter	**YES**	Hour Index	**11**
Zero Sequence Filter Type*	**0: Phase Channels**	Zero Sequence Filter	**NO**
		Zero Sequence Filter Type*	**0: Phase Channels**

(*) IDV models with option B or higher in digit 9 (see 1.5, Model Selection).

- ### Example 3

Consider a three-winding power transformer with the following transformation ratio 220 kV / 132 / 45 kV ± 1150 V (9 taps), with the following powers associated to each winding 50 MVA / 50 MVA / 25 MVA, vector group YYY0.

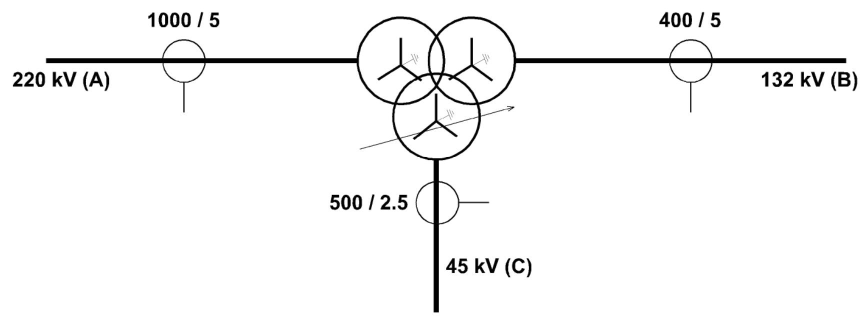


Figure 3.1.5: Example 3 of Settings Calculations for Connection Groups.

Tap Calculations

Relay taps are base secondary currents, allowing the differential unit to operate with element currents comparable to each other. Although the power of the third winding is smaller than for the other windings, calculation of the tap corresponding to said winding must be carried out using the base power considered for the tap calculation of the other windings. As a general rule, tap calculation, for any winding, must be based on the maximum power of the machine.

To determine the tap of the relay, calculate the primary currents corresponding to the maximum power of the machine, for each winding, using the following formula:

$$Current = \frac{MaxPower(kVA)}{Voltage(kV) \cdot \sqrt{3}}$$

Current calculations for each winding and tap:

220 kV Side (A): $IA = \frac{50{,}000\ kVA}{220\ kV \cdot \sqrt{3}} = 131.2\ A$

132 kV Side (B): $IB = \frac{50{,}000\ kVA}{132\ kV \cdot \sqrt{3}} = 218.7\ A$

45 kV Side (C): For this case, minimum, medium and maximum tap values will be taken:

Minimum end tap: 40.4 kV (D): $ID = \frac{50{,}000\ kVA}{40.4\ kV \cdot \sqrt{3}} = 714.5\ A$

Medium tap: 45 kV (C): $IC = \frac{50{,}000\ kVA}{45\ kV \cdot \sqrt{3}} = 641.5\ A$

Maximum end tap: 49.6 kV (E): $IE = \frac{50{,}000\ kVA}{49.6\ kV \cdot \sqrt{3}} = 582\ A$

The ratio of the current transformers is:

220 kV Side:	1000 / 5 A ; CT Ratio = 200
132 kV Side:	400 / 5 A ; CT Ratio = 80
45 kV Side:	500 / 2.5 A ; RT.I. = 200

The currents viewed by the relay, for the different taps, are the following:

$Is\,(A) = \frac{131.2}{200} = 0.66\ A$

$Is\,(C) = \frac{641.5}{200} = 3.20\ A$

$Is\,(B) = \frac{218.7}{80} = 2.73\ A$

$Is\,(D) = \frac{714.5}{200} = 3.57\ A$

$Is\,(E) = \frac{582}{200} = 2.91\ A$

Relay Tap Setting

220 kV Side (A):	0.66 A
132 kV Side (B):	2.73 A
46 kV Side (C):	3.20 A (Minimum tap position)

Differential Current

The difference between the setting and the value of the differential current is:

220 kV Side (A):	Differential Current = 0.66 - 0.66 = 0
132 kV Side (B):	Differential Current = 2.73 -2.73 = 0

45 kV Side (B):

Minimum tap position:	40.4 kV (D)	Differential current = 3.57 - 3.20 = 0.37 A
Middle tap position:	45 kV (C):	Differential current = 3.20 - 3.20 = 0 A
Maximum tap position:	145.2 kV (E):	Differential current = 3.20 - 2.91 = 0.29 A

Restraint Current

Defined as the smallest of the currents, when they circulate in the same direction (if **Restraint current type** setting is: 1 - IRest: (I1+I2-Id)/2, within the differential element trip settings group):

Minimum tap: 40.4 kV (D): 3.57 A
Middle tap: 45 kV (C): 3.20 A
Maximum tap: 49.6 kV (D): 2.91 A

Error Setting

We define this error as the quotient of the differential current and the restraint current:

Minimum tap: 40.4 kV (B): $\frac{0.37}{3.57} = 0.103\ ;\ 10.3\,\%$

Middle tap: 45 kV (C): $\frac{0}{3.20} = 0$

Maximum tap: 49.6 kV (D): $\frac{0.29}{2.91} = 0.099\ ;\ 9.9\,\%$

Calculating the Slope 1

To determine the Slope we should consider: current transformer errors, the error in the different taps (due to the voltage regulation) and the drain current.

C.T. errors: 10%
Drain Current: 2%
Setting error: 10.3%
Equipment error: 5%

Total: 27.3%

Recommended Setting: **30%**

Calculating the Slope 2

The second slope must be set based on the maximum residual current on external fault, as a result of saturation of a CT and the corresponding restraint current. A setting value of 75% is recommended.

The slope initiation will be determined by the minimum restraint current for which CTs can be saturated.

Sensitivity

It is recommended that the differential sensitivity be adjusted to 30% of the tap value of the reference winding. In the example it would be 30% of the primary winding:

This setting must be entered as times the reference tap, thus the value of said setting is directly **0.3**. This value is equivalent to a value in amps 0.3 x 0.66 A = 0.198 A.

Instantaneous Unit

An adjustment of **5** to **10 times the tap value** (of the reference winding) and an operation time of **20ms** are recommended.

2nd, 3rd, 4th and 5th Harmonic Restraint / Blocking

Recommended setting for 2nd, 3rd, 4th and 5th Harmonic: **20%**

Zero Sequence Filter

The Zero Sequence Filter need not be activated as, on ground faults external to the machine, both windings being grounded Y, zero sequence current will flow through both windings. Therefore, the Differential Unit will not measure false residual current that would have caused a trip on external fault.

In any case, if zero sequence filters are active in both windings, the device operation will still be correct, and it does not trip on external fault.

Connection Group

The **IDV** equipment performs angle compensation internally. To do this, the connection group for each winding, the hour index and the zero sequence filter are entered using the HMI:

Winding # 1		**Winding # 2**	
WYE Connection	**Y**	WYE Connection	**Y**
Zero Sequence Filter	**NO**	Hour Index	**0**
		Zero Sequence Filter	**NO**

Winding # 3	
WYE Connection	**Y**
Hour Index	**0**
Zero Sequence Filter	**NO**
Zero Sequence Filter Type*	**0: Phase Channels**

(*) IDV models with option A or higher in digit 9 (see 1.5, Model Selection).

3.1.16 Differential Unit Settings

Differential Unit			
Setting	**Range**	**Step**	**By Default**
Restraint Type	0 - (I1+I2-Id)/2 1 - (I1+I2)/2		0 - (I1+I2-Id)/2
Reference Winding	1 to 3 (*)	1	1
Tap Winding 1	(0.02 - 2.5) In	0.01 A	1 In
Tap Winding 2	(0.02 - 2.5) In	0.01 A	1 In
Tap Winding 3	(0.02 - 2.5) In	0.01 A	1 In
Fault Detector Supervision (2)	YES / NO		YES

Differential Unit (with Restraint)			
Setting	**Range**	**Step**	**By Default**
Differential Enable	YES / NO		NO
Sensitivity	(0.15 - 1) (times the tap)	0.01	0.3
Restraint Slope 1	5 - 100%	0.01%	40%
Restraint Slope 1 Start	(0 - 2) (times the tap)	0.01	1
Restraint Slope 2	(25 - 200%)	0.01%	40%
Restraint Slope 2 Start	(2 - 20) (times the tap)	0.01	10
2nd Restraint Enable	YES / NO		YES
2nd Restraint PU	0.05 - 0.80	0.01	0.4
3rd Restraint Enable	YES / NO		YES
3rd Restraint PU	0.05 - 0.80	0.01	0.4
4th Restraint Enable	YES / NO		YES
4th Restraint PU	0.05 - 0.80	0.01	0.4
5th Restraint Enable	YES / NO		YES
5th Restraint PU	0.05 - 0.80	0.01	0.4
Differential Time Delay	0 - 300 s	0.01 s	0
Harmonics Blocking Logic	0: OR 1: AND 2: 2 out of 3 (IDV-**D-****10***) 3: SUM (1) 4: THREE PHASE SUM (2)		0: OR
OR Blocking Time	0.05 - 300 s	0.01 s	0.1s
2nd Blocking Enable	YES / NO		NO
2nd Blocking PU	5 - 100%	1%	20%
3rd Blocking Enable	YES / NO		NO
3rd Blocking PU	5 - 100%	1%	20%
4th Blocking Enable	YES / NO		NO
4th Blocking PU	5 - 100%	1%	20%
5th Blocking Enable	YES / NO		NO
5th Blocking PU	5 - 100%	1%	20%
Harmonics Restraint (IDV-**D)	0: Continuous 1: Dynamic		0: Continuous
Harmonics Blocking (IDV-**D)	0: Continuous 1: Dynamic		0: Continuous

(1) Models IDV with option A or higher in digit 9 (see 1.5).
(2) Models IDV-L and models with option B or higher in digit 9 (see 1.5).

Differential Unit (with Restraint)			
Setting	**Range**	**Step**	**By Default**
Harmonics Blocking / Restraint Inhibition Time IDV-**D Models IDV-***-****C*** Models	 5 - 300 1 - 300s	0.01 s	80 s
External Fault Detector Blocking Enable (IDV-**D)	YES / NO		YES
Blocking Inhibition / Harmonics Restraint with Voltage (IDV-J/K/L)	YES / NO		NO
Parallel Transformer (2)	YES / NO		NO

(3) Models IDV with option A or higher in digit 9 (see 1.5).
(4) Models IDV-L and models with option B or higher in digit 9 (see 1.5).

Instantaneous Differential Unit (without Restraint)			
Setting	**Range**	**Step**	**By Default**
Instantaneous Differential Enable	YES / NO		NO
Instantaneous Differential Pickup	(1 - 20) (times the tap)	0.01	1
Instantaneous Differential Delay	0 - 300s	0.01s	0s
External Fault Detector Blocking Enable (IDV-**D)	YES / NO		YES

- **Differential Unit: HMI Access IDV-A/B/D Models**

0 - CONFIGURATION	0 - GENERAL	**0 - DIFFERENTIAL**
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	1 - EXT FAULT DETECTOR
2 - CHANGE SETTINGS	**2 - PROTECTION**	2 - WINDING 1
3 - INFORMATION	3 - TRIP PERMISIONS	3 - WINDING 2
	4 - LOCKOUT PERM	4 - WINDING 3
	5 - TRIP OUTPUTS.	5 - DIRECTIONAL
	6 - LOGIC.	6 - GND OVERCURRENT
	7 - BREAKER SUPERV.	7 - TERTIARY
	8 - CIRCUIT COIL SUPERV	8 - VOLTAGE
	9 - HISTORY	9 - FREQUENCY
	10 - OSCILLOGRAPHY	10 - COLD LOAD
	11 - DIGITAL PLL	11 - RESTRICTED EARTH
		12 - OVEREXCITATION

0 - DIFFERENTIAL	**0 - RESTRAINT TYPE**
1 - EXT FAULT DETECTOR	**1 - REFERENCE WNDG**
2 - WINDING 1	**2 - TAP WINDING 1**
3 - WINDING 2	**3 - TAP WINDING 2**
4 - WINDING 3	**4 - TAP WINDING 3**
5 - DIRECTIONAL	**5 - DIFFERENTIAL**
6 - GND OVERCURRENT	**6 - INST DIFFERENTIAL**
7 - TERTIARY	
8 - VOLTAGE	
9 - FREQUENCY	
10 - COLD LOAD	
11 - RESTRICTED EARTH	
12 - OVEREXCITATION	

0 - RESTRAINT TYPE	**0 - DIFF ENABLE**
1 - REFERENCE WNDG	**1 - SENSITIVITY**
2 - TAP WINDING 1	**2 - RESTRAINT SLOPE 1**
3 - TAP WINDING 2	**3 - R SLOPE 1 START**
4 - TAP WINDING 3	**4 - RESTRAINT SLOPE 2**
5 - DIFFERENTIAL	**5 - R SLOPE 2 START**
6 - INST DIFFERENTIAL	**6 - EXT FAULT BLOCK**
	7 - 2ND RESTR. ENAB.
	8 - 2ND RESTRAINT PU
	9 - 3RD RESTR. ENAB.
	10 - 3RD RESTRAINT PU
	11 - 4TH RESTR. ENAB.
	12 - 4TH RESTRAINT PU
	13 - 5TH RESTR. ENAB.
	14 - 5TH RESTRAINT PU
	15 - DIFF TIME DELAY
	16 - REST. 2 AND 4 HARM
	17 - H BLOCKING LOGIC
	18 - OR BLOCKING TIME
	19 - 2ND BLOCK. ENAB.
	20 - 2ND BLOCKING PU
	21 - 3RD BLOCK. ENAB.
	22 - 3RD BLOCKING PU
	23 - 4TH BLOCK. ENAB.
	24 - 4TH BLOCKING PU
	25 - 5TH BLOCK. ENAB.
	26 - 5TH BLOCKING PU
	27 - BLOCK 2 AND 4 HARM
	28 - INH TIME

0 - RESTRAINT TYPE	
1 - REFERENCE WNDG	
2 - TAP WINDING 1	
3 - TAP WINDING 2	
4 - TAP WINDING 3	**0 - INST DIFF ENABLE**
5 - DIFFERENTIAL	**1 - INST DIFF PICKUP**
6 - INST DIFFERENTIAL	**2 - INST DIFF DELAY**
	3 - EXT FAULT BLOCK

- **Differential Unit: HMI Access IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	**7 - DIFFERENTIAL**
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	**0 - RESTRAINT TYPE**
1 - PHASE SELECTOR	**1 - REFERENCE WNDG**
2 - DIST SUPERVISION	**2 - TAP WINDING 1**
3 - FUSE FAILURE	**3 - TAP WINDING 2**
4 - LOAD ENCROACHMENT	**4 - TAP WINDING 3**
5 - POWER SWING DETECTOR	**5 - DIFFERENTIAL**
6 - OPEN BREAKER DET	**6 - INST DIFFERENTIAL**
7 - DIFFERENTIAL	
8 - EXT FAULT DETECTOR	
9 - WINDING 1	
10 - WINDING 2	
11 - WINDING 3	
12 - COLD LOAD	

0 - RESTRAINT TYPE	**0 - DIFF ENABLE**
1 - REFERENCE WNDG	**1 - SENSITIVITY**
2 - TAP WINDING 1	**2 - RESTRAINT SLOPE 1**
3 - TAP WINDING 2	**3 - R SLOPE 1 START**
4 - TAP WINDING 3	**4 - RESTRAINT SLOPE 2**
5 - DIFFERENTIAL	**5 - R SLOPE 2 START**
6 - INST DIFFERENTIAL	**6- EXT FAULT BLOCK**
	7 - 2ND RESTR. ENAB.
	8 - 2ND RESTRAINT PU
	9 - 3RD RESTR. ENAB.
	10 - 3RD RESTRAINT PU
	11 - 4TH RESTR. ENAB.
	12 - 4TH RESTRAINT PU
	13 - 5TH RESTR. ENAB.
	14 - 5TH RESTRAINT PU
	15 - DIFF TIME DELAY
	16 - REST. 2 AND 4 HARM
	17 - H BLOCKING LOGIC
	18 - OR BLOCKING TIME
	19 - 2ND BLOCK. ENAB.
	20 - 2ND BLOCKING PU
	21 - 3RD BLOCK. ENAB.
	22 - 3RD BLOCKING PU
	23 - 4TH BLOCK. ENAB.
	24 - 4TH BLOCKING PU
	25 - 5TH BLOCK. ENAB.
	26 - 5TH BLOCKING PU
	27 - BLOCK 2 AND 4 HARM
	28 - INH TIME

0 - RESTRAINT TYPE	
1 - REFERENCE WNDG	
2 - TAP WINDING 1	
3 - TAP WINDING 2	**0 - INST DIFF ENABLE**
4 - TAP WINDING 3	**1 - INST DIFF PICKUP**
5 - DIFFERENTIAL	**2 - INST DIFF DELAY**
6 - INST DIFFERENTIAL	**3 - EXT FAULT BLOCK**

Differential Unit: HMI Access IDV-G/H/J/K/L Models

0 - CONFIGURATION	0 - GENERAL	0 - FUSE FAILURE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - DIFFERENTIAL**
2 - CHANGE SETTINGS	**2 - PROTECTION**	...
3 - INFORMATION	3 - TRIP PERMISIONS	
	4 - LOCKOUT PERM	
	5 - TRIP OUTPUTS	
	6 - LOGIC	
	7 - BREAKER SUPERV.	
	8 - CIRCUIT COIL SUPERV	
	9 - HISTORY	
	10 - OSCILLOGRAPHY	
	11 - DIGITAL PPL	
	12 - CONTROL	

0 - FALLO FUSIBLE	**0 - RESTRAINT TYPE**
1 - DIFERENCIAL	**1 - REFERENCE WNDG**
...	**2 - TAP WINDIN 1**
	3 - TAP WINDIN 2
	4 - TAP WINDIN 3
	5 - FAULT DETEC SUPERV
	6 - DIFFERENTIAL
	7 - INST DIFFERENTIAL

0 - RESTRAINT TYPE	**0 - DIFF ENABLE**
1 - REFERENCE WNDG	**1 - SENSITIVITY**
2 - TAP WINDIN 1	**2 - RESTRAINT SLOPE 1**
3 - TAP WINDIN 2	**3 - R SLOPE 1 START**
4 - TAP WINDIN 3	**4 - RESTRAINT SLOPE 2**
5 - DIFFERENTIAL	**5 - R SLOPE 2 START**
6 - INST DIFFERENTIAL	**6 - EXT FAULT BLOCK**
	7 - 2ND RESTR. ENAB.
	8 - 2ND RESTRAINT PU
	9 - 3RD RESTR. ENAB.
	10 - 3RD RESTRAINT PU
	11 - 4TH RESTR. ENAB.
	12 - 4TH RESTRAINT PU
	13 - 5TH RESTR. ENAB.
	14 - 5TH RESTRAINT PU
	15 - DIFF TIME DELAY
	16 - HARMONIC RESTRAIN
	17 - H BLOCKING LOGIC
	18 - CROSS BLOQ TIME
	19 - 2ND BLOCK. ENAB.
	20 - 2ND BLOCKING PU
	21 - 3RD BLOCK. ENAB.
	22 - 3RD BLOCKING PU
	23 - 4TH BLOCK. ENAB.
	24 - 4TH BLOCKING PU
	25 - 5TH BLOCK. ENAB.
	26 - 5TH BLOCKING PU
	27 - HARMONIC BLOCKING
	28 - INHIBITION TIME
	29 - INH B/R ARM WITH V
	30 - PARALLEL TRANSFOR.

0 - RESTRAINT TYPE	
1 - REFERENCE WNDG	
2 - TAP WINDIN 1	
3 - TAP WINDIN 2	**0 - INST DIFF ENABLE**
4 - TAP WINDIN 3	**1 - INST DIFF PICKUP**
5 - DIFFERENTIAL	**2 - INST DIFF DELAY**
6 - INST DIFFERENTIAL	**3 - EXT FAULT BLOCK**

3.1.17 Digital Inputs of the Differential Module

Table 3.1-1: Digital Inputs of the Differential Module

Name	Description	Function
ENBL_87R	Differential with restraint unit enable input	Activation of this input puts the Differential Units into service. It can be assigned to digital inputs by level or to a commands from the communications protocol or from the HMI. The default value of this logic input signals is a "1."
ENBL_87U	Differential without restraint unit enable input	
INBLK_87R	Differential with restraint unit block trip input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_87U	Differential without restraint unit block trip input	
IN_HAR_CON	Input of activation in continuous mode for harmonics restraint / blocking (IDV-**D)	Activation of this input enables continuous mode of harmonics restraint and blocking, independently from the mode selected by setting.
IN_INH_2_4_RST	Input of inhibition of 2nd and 4th harmonics restraint (IDV-**D)	Activation of this input inhibits the restraint by 2^{nd} and 4^{th} harmonics.
IN_INH_3_5_RST	Input of inhibition of 3rd and 5th harmonics restraint (IDV-**D)	Activation of this input inhibits the restraint by 3^{rd} and 5^{th} harmonics.
IN_INH_2_4_BLK	Input of inhibition of 2nd and 4th harmonics blocking (IDV-**D)	Activation of this input inhibits the blocking by 2^{nd} and 4^{th} harmonics.
IN_INH_3_5_BLK	Input of inhibition of 3rd and 5th harmonics blocking (IDV-**D)	Activation of this input inhibits the blocking by 3^{rd} and 5^{th} harmonics.

3.1.18 Auxiliary Outputs and Events of the Differential Module

Table 3.1-2: Auxiliary Outputs and Events of the Differential Module

Name	Description	Function
PU_87R_A	Phase A differential with restraint unit pickup	Pickup of the Differential Units and start of the time count.
PU_87R_B	Phase B differential with restraint unit pickup	
PU_87R_C	Phase B differential with restraint unit pickup	
PU_87U_A	Phase A differential without restraint unit pickup	
PU_87U_B	Phase B differential without restraint unit pickup	
PU_87U_C	Phase B differential without restraint unit pickup	
OUT_87R_A	Phase A differential with restraint unit trip	Trip of the Differential Units.
OUT_87R_B	Phase B differential with restraint unit trip	
OUT_87R_C	Phase B differential with restraint unit trip	
OUT_87U_A	Phase A differential without restraint unit trip	
OUT_87U_B	Phase B differential without restraint unit trip	
OUT_87U_C	Phase B differential without restraint unit trip	
OUT_87R_AM	Phase A differential with restraint unit masked trip	Trip of the Differential Units affected by their corresponding trip mask.
OUT_87R_BM	Phase B differential with restraint unit masked trip	
OUT_87R_CM	Phase B differential with restraint unit masked trip	
OUT_87U_AM	Phase A differential without restraint unit masked trip	
OUT_87U_BM	Phase B differential without restraint unit masked trip	
OUT_87U_CM	Phase B differential without restraint unit masked trip	
INH_2_4_RST	Inhibition of 2nd and 4th harmonics restraint (IDV-**D)	Signals showing restraint or blocking inhibition of the corresponding harmonics.
INH_3_5_RST	Inhibition of 3rd and 5th harmonics restraint (IDV-**D)	
INH_2_4_BLK	Inhibition of 2nd and 4th harmonics blocking (IDV-**D)	
INH_3_5_BLK	Inhibition of 3rd and 5th harmonics blocking (IDV-**D)	
BLK_HARM_A	Phase A differential harmonics blocking	This signal is activated when the Differential Unit with restraint is blocked due to excess harmonics.
BLK_HARM_B	Phase B differential harmonics blocking	
BLK_HARM_C	Phase C differential harmonics blocking	
2_4_INH_RST	Inhibition of 2nd and 4th harmonics restraint (IDV-**D)	Activation of this signal indicates inhibition of 2nd and 4th harmonics restraint.
2_4_INH_BLK	Inhibition of 2nd and 4th harmonics blocking (IDV-**D)	Activation of this signal indicates inhibition of 2nd and 4th harmonics blocking.
ENBL_87R	Differential with restraint unit enable input	The same as for the Digital Inputs.
ENBL_87U	Differential without restraint unit enable input	
INBLK_87R	Differential with restraint unit block trip input	The same as for the Digital Inputs.
INBLK_87U	Differential without restraint unit block trip input	
87R_ENBLD	Differential with restraint unit enabled	Indication of enabled or disabled status of the units.
87U_ENBLD	Differential without restraint unit enabled	

3.1.19 Differential Unit Tests

3.1.19.a Differential Unit with Restraint

For testing this element, disabling the rest of elements is recommended, including external fault detector (see explanatory note in paragraph 3.1.1), and set the primary – secondary and primary – tertiary (if there is a tertiary winding) connection group to YY0, with the **Restraint Type** set to 0 [(I1+I2-Id)/2] and without **Zero Sequence Filter**. For **IDV-D/F** relays, currents associated to windings must set as follows:

IDEV1=I-1; IDEV2=I-2; IDEV3=NONE

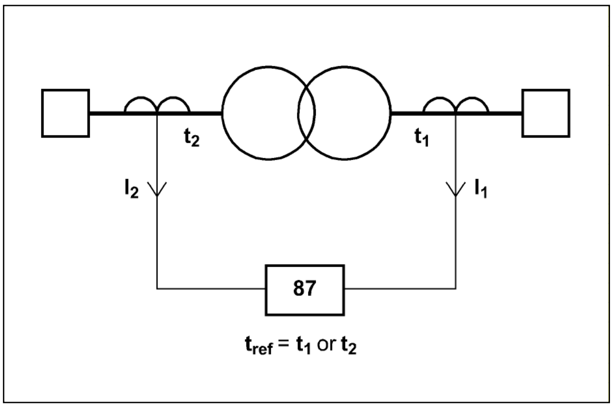


Figure 3.1.6: Diagram for the Differential Unit with Restraint Test.

When current ramps are used instead of current steps, setting **Fault Detector Supervision** (models **IDV-L** and models with option **B** or higher in digit 9) to **NO** is recommended (refer to 3.1.11).

- **Sensitivity**

Apply current in phase A of winding #1 and check that the differential unit of phase A picks up, for a sensitivity setting of X, when the current is within the margin indicated in table 3.1-3.

Table 3.1-3: Sensitivity of the Differential Unit with Restraint

Sensitivity (times the tap)	Pickup	Reset
x	$x \cdot t \pm 3\%$	$0.77 \cdot x \cdot t - 0.83 \cdot x \cdot t$

Where ***t*** is the tap value of the winding where current is applied.

Check that the activation of the Differential Unit causes a trip by the activation of the trip contacts corresponding to all the windings. Repeat the test for phases B and C of the first winding. Repeat the test for each winding.

- **Percentage Restraint Characteristic**

Apply current through phase A of winding #1 and through phase A of winding #2, with a phase displacement of 180º in relation to the prior.

$$I_{rest} = \frac{(\frac{I_1}{t_1}+\frac{I_2}{t_2})-(\frac{I_1}{t_1}-\frac{I_2}{t_2})}{2} = \frac{I_2}{t_2} \text{ (times reference tap)}$$

$$I_{rest} = \frac{(\frac{I_1}{t_1}+\frac{I_2}{t_2}).t_{ref}-(\frac{I_1}{t_1}-\frac{I_2}{t_2}).t_{ref}}{2} = \frac{I_2}{t_2}.t_{ref} \text{ (x reference tap)}$$

$$I_{diff} = (\frac{I_1}{t_1}-\frac{I_2}{t_2}) \text{ (times reference tap)}$$

$$I_{diff} = (\frac{I_1}{t_1}-\frac{I_2}{t_2}).t_{ref} \text{ (x reference tap)}$$

The current through winding #2 will be constant while the current applied through winding #1 is measured in order to operate the unit. To avoid a premature trip based on zero differential current (Idiff=0) so that the value of the initial current through winding #1 should be proportional to that through winding #2 following this formula:

$$I_{diff} = \frac{I_1}{t_1}-\frac{I_2}{t_2} = 0 \rightarrow \frac{I_1}{t_1} = \frac{I_2}{t_2}$$

From this initial value ($I_{diff} = 0$), the current through winding #1 is slowly increased and the unit's pickup value is confirmed.

The value of the current running through winding #2 can be calculated for each zone of the graph (finding the 2 winding current from the following above-explained formula: $I_{rest} = \frac{I_2}{t_2}$), and will remain constant throughout the test (with N=0.5 times tap; M=10 times tap and slope 2 =100%-> β=100%):

zone I: $I_2 < \frac{t_2}{2}$	zone II: $\frac{t_2}{2} < I_2 < 10t_2$	zone III: $10t_2 < I_2$

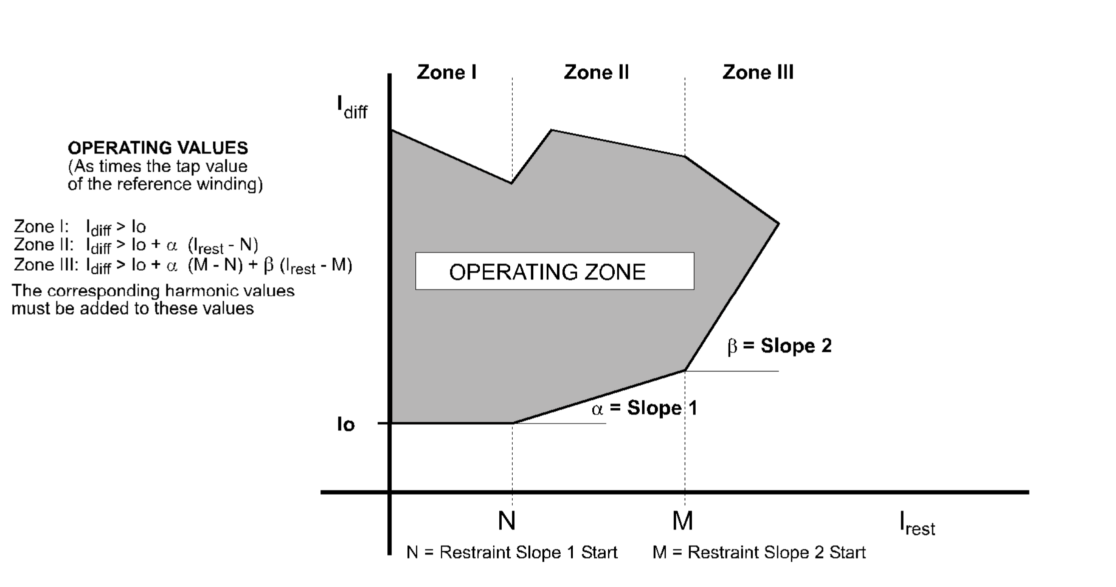


Figure 3.1.7: Operation Characteristics of the Differential Unit with Percentage Restraint.

Check that the operating current is within the margin indicated in table 3.1-4.

Table 3.1-4: Operating Current

Winding #2 Applied Current	Pickup (x t ref) (Irest in times the tap value of the reference winding)		Reset (x t ref)
$I_2 < t_2/2$	$I_{diff} > I_0$, t_{ref} (x reference tap) Note: I_0 is a setting configured in the **IDV** as times the reference tap.	Min: $I_1 = 0{,}95 \cdot (I_0 + \frac{0{,}95 \cdot I_2}{t_2}).t_1$ Max: $I_1 = 1{,}05 \cdot (I_0 + \frac{1{,}05 \cdot I_2}{t_2}).t_1$	$I_{diff} < 0{,}8\ I_0\ t_{ref}$
$t_2/2 < I_2 < 10t_2$	$I_{diff} > I_0$, $t_{ref} + (I_{rest} - 0{,}5t_{ref})\alpha$ (x reference tap) Note: I_0 is a setting configured in the **IDV** as times the reference tap.	Min: $I_1 = 0{,}95 \cdot (I_0 + \frac{0{,}95 \cdot I_2}{t_2} \cdot (1+\alpha) - 0{,}5\alpha)\, t_1$ Max: $I_1 = 1{,}05 \cdot (I_0 + \frac{1{,}05 \cdot I_2}{t_2} \cdot (1{,}05+\alpha) - 0{,}5\alpha)\, t_1$	$I_{diff} < 0{,}8\ I_0\ t_{ref}$
$10t_2 < I_2$	$I_{diff} > I_0$, $t_{ref} + (10\,t_{ref} - 0{,}5\,t_{ref})\alpha + (I_{rest} - 10t_{ref})$ (x reference tap) Note: I_0 is a setting configured in the **IDV** as times the reference tap.	Min: $I_1 = 0{,}95 \cdot (I_0 + 9{,}5\alpha - 10 + 1{,}9 \cdot \frac{I_2}{t_2}).t_1$ Max: $I_1 = 1{,}05 \cdot (I_0 + 9{,}5\alpha - 10 + 2{,}1 \cdot \frac{I_2}{t_2}).t_1$	$I_{diff} < 0{,}8\ I_0\ t_{ref}$

For example, if we consider the following settings:

$t_1 = t_2 = 1$ $I_0 = 0.5$
$t_{rest} = t_1$ $\alpha = 0.2$

For these settings and a current of I_2 (with phase displacement of 180º in relation to I_1) the restraint current will be:

$I_{rest} = I_2$

The unit will pick up when I_1 reaches the values indicated in table 3.1-5.

Table 3.1-5: Pickup Values

Winding #2 Applied Current	Pickup (x t ref)	I_1 Min Pickup	I_1 Max Pickup
$I_2 < 0.5\,A$	$I_{diff} > 0.5\,A$	$I_1 = (0.5 + 0.95 \cdot I_2) \cdot 0.95$	$I_1 = (0.5 + 1.05 \cdot I_2) \cdot 1.05$
$0.5\,A < I_2 < 10\,A$	$I_{diff} > 0.4 + 0.2\,I_2$	$I_1 = (0.4 + 1.14 \cdot I_2) \cdot 0.95$	$I_1 = (0.4 + 1.26 \cdot I_2) \cdot 1.05$
$10\,A < I_2$	$I_{diff} > I_2 - 7.6$	$I_1 = (1.9 \cdot I_2 - 7.6) \cdot 0.95$	$I_1 = (2,1 \cdot I_2 - 7,6) \cdot 1,05$

With the **Restraint Type** setting in mode **1** (**Restraint Current Type**: 1-Ifr: (I1+I2)/2), the expression for the calculation of the restraint current is:

- Times reference tap:

$$I_{rest} = \frac{(\frac{I_1}{t_1} + \frac{I_2}{t_2})}{2}$$

- x reference tap:

$$I_{rest} = \frac{(\frac{I_1}{t_1} + \frac{I_2}{t_2})}{2} . t_{ref}$$

Using this expression, the same tests are performed recalculating the restraint current.

- **Harmonic Restraint**

Apply a current with a second harmonic component through one of the three phases of a winding (corresponding to a restraint current in zone I). The harmonic component is kept constant and the fundamental component, applied to the same winding in parallel with the 2nd harmonic component, is increased until the pickup occurs. Verify that the pickup occurs for the differential current value indicated in the following table. The current is then reduced until the unit is reset.

Verify that the reset occurs for the differential current value indicated in the table.

Table 3.1-6: Pickup and Reset for the Harmonic Restraint

I_{diff} Minimum Pickup (x t ref)	I_{diff} Maximum Pickup (x t ref)	Reset (x t ref)
$\frac{I}{t} t_{ref} \geq (I_0 . t_{ref} + \frac{0,95 \cdot I_{2^o}}{k_2} \cdot \frac{t_{ref}}{t})$	$\frac{I}{t} t_{ref} \geq (I_0 . t_{ref} + \frac{1,05 \cdot I_{2^o}}{k_2}) \cdot \frac{t_{ref}}{t}$	$\frac{I}{t} . t_{ref} < 0,8 \cdot I_0 . t_{ref}$ or $0,5 \cdot \frac{I_{2^o}}{k_2} \cdot \frac{t_{ref}}{t}$ (whichever is greater)

where:

- t : setting of value of the tap winding where current is applied
- t_{ref} : is the tap setting value of the reference winding
- I_{2nd} : 2nd harmonic current
- I: fundamental current applied
- k_2 : setting of 2nd harmonic restraint slope
- I_0: setting if sensitivity (times reference tap)

- **Differential Unit Time Test**

To perform this test, use trip terminals (G4-G5-G6-G7) (G8-G9-G10-H1) (C1-C2-C3-C4), depending on the model.

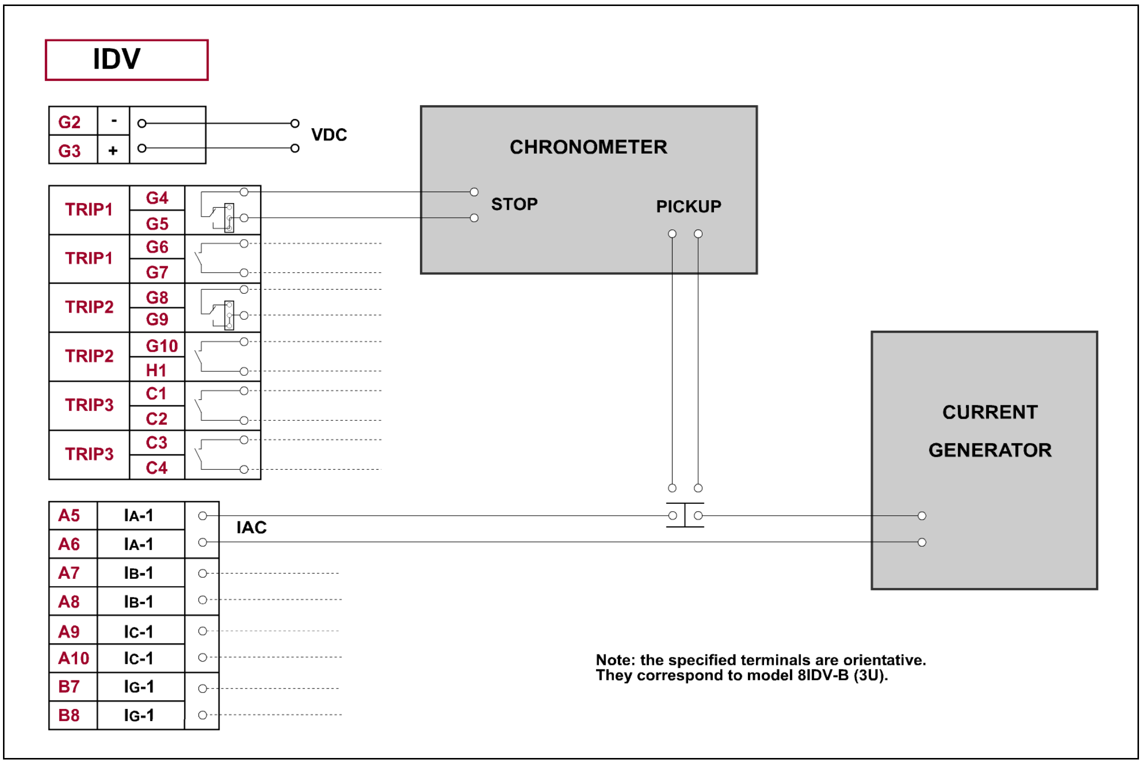


Figure 3.1.8: Time Test Wiring Diagram (Differential Unit).

Apply a current 20% higher than the **Sensitivity** setting to the phase A inputs of winding #1. The operating time should be the selected time setting ±35ms (for 50Hz) or 30ms (for 60Hz). Note that a setting of 0ms will have an operating time of approximately 30 ms.

3.1.19.b Differential Unit without Restraint (Instantaneous)

It is recommended to disable the remainder of the units when testing this unit.

- **Pickup**

The test can be performed applying current to one of the phases (A, B or C) of the first winding. Check that the unit picks up and resets within the margin indicated in table 3.1-7.

Table 3.1-7: Pickup and Reset (Differential Unit without Restraint)

Setting	I_{diff}	Pickup	Reset
X (times t ref)	*X*	$x = \frac{I_1}{t_1} \rightarrow I_1 = x \cdot t_1 \pm 5\%$	$0.95 \cdot x \cdot t_1$

This test can be done the same way for the rest of the windings.

- **Time Test**

Note the wiring diagram in figure 3.1.7. Apply a current 20% higher than the calculated pickup value to the phase A inputs of winding #1. The operating time should correspond with 30ms (for 50 Hz) or 25ms (for 60Hz) of the selected **Time** setting. Note that a setting of 0ms will have an operating time of approximately 30 ms.

3.2 Fault Detector

3.2.1 Fault Detector associated to Differential Element

IDV-D/F/G** models Differential Unit incorporate a Fault Detector for the supervision of their operation. The conditions which activate the Fault Detector for phase n (n=A, B and C) are the following:

- A per cent increase of the **restraint current of said phase**, with respect to two previous cycles above 20%, provided that said phase restraint current exceeds the differential element sensitivity setting.
- A per cent increase of the **differential current of said phase**, with respect to two previous cycles above 20%, provided that said phase differential current exceeds the differential element sensitivity setting.

The fault detector resets when the above conditions remain deactivated for two cycles and the residual current is below the 80% of the Sensitivity setting.

The logic of the fault detector associated to the differential unit for phase A is shown in the following logic diagram:

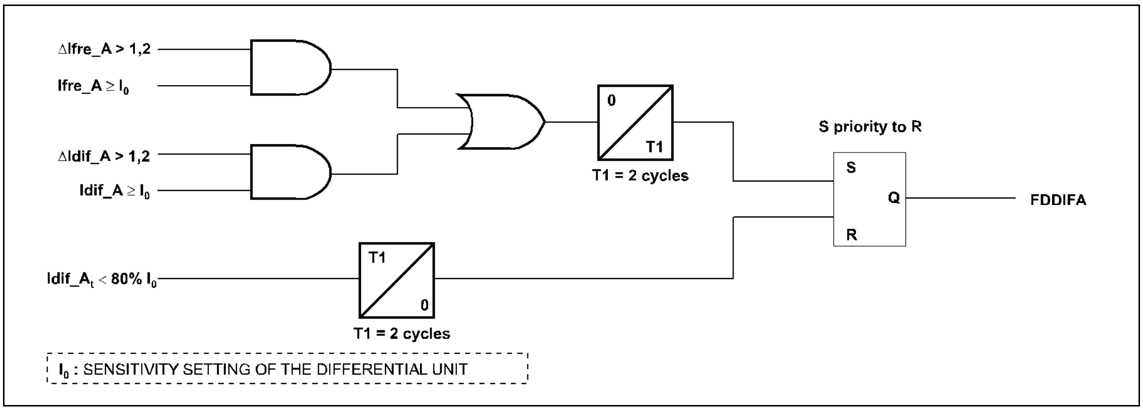


Figure 3.2.1: Fault Detector for Phase A Differential Unit Diagram.

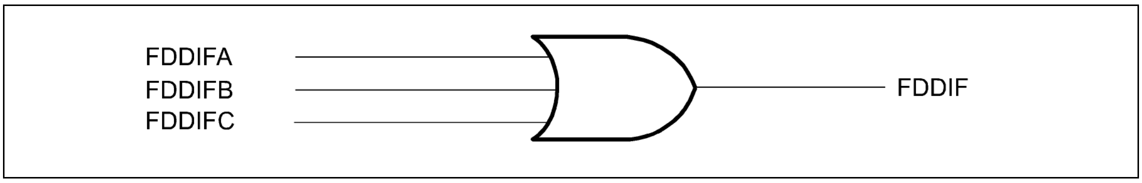


Figure 3.2.2: Fault Detector for Differential Unit Diagram.

3.2.2 Fault Detector associated to Distance Elements

IDV-F relay Distance Elements incorporate a Fault Detector for the supervision of their operation (see paragraph 3.5.8, Stepped Distance). Said element uses the sequence current components of the winding selected to incorporate the distance protection (see chapter 3.4) as operating magnitudes, according to two algorithms.

3.2.2.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** (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** (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).

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 is included.

3.2.2.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 (see paragraph 3.5.2).
- **Two-phase fault output** activation originating from the phase selector.

The above two algorithms require, in addition, that at least one of the following conditions occur:

- Positive sequence current above 0.1 A.
- Zero sequence current above 0.05*In A

Zero sequence threshold supervision allows the Fault Detector to be operative at high zero sequence fault current.

The activation of the Fault Detector generated by either of the two previously-mentioned algorithms is kept sealed with the activation of any of the **Distance** (**PU_ZIG**, **PU_ZIPH**, **PU_ZIIG**, **PU_ZIIPH**, **PU_ZIIIG**, **PU_ZIIIPH**, **PU_ZIVG, PU_ZIVPH),** and **Overcurrent** (**PU_IOC_A/B/Cnm**, **PU_TOC_A/B/Cnm**, **PU_IOC_Nnm**, **PU_TOC_Nnm**, **PU_IOC_NSnm**, **PU_TOC_NSnm)** elements, where n=1, 2 is the number of the element associated to a given winding and m=1, 2, 3 is the winding number; see chapter 3.6, Overcurrent elements.

The operation diagram of the Fault Detector unit is shown in Figures 3.2.3, 3.2.4 and 3.2.5.

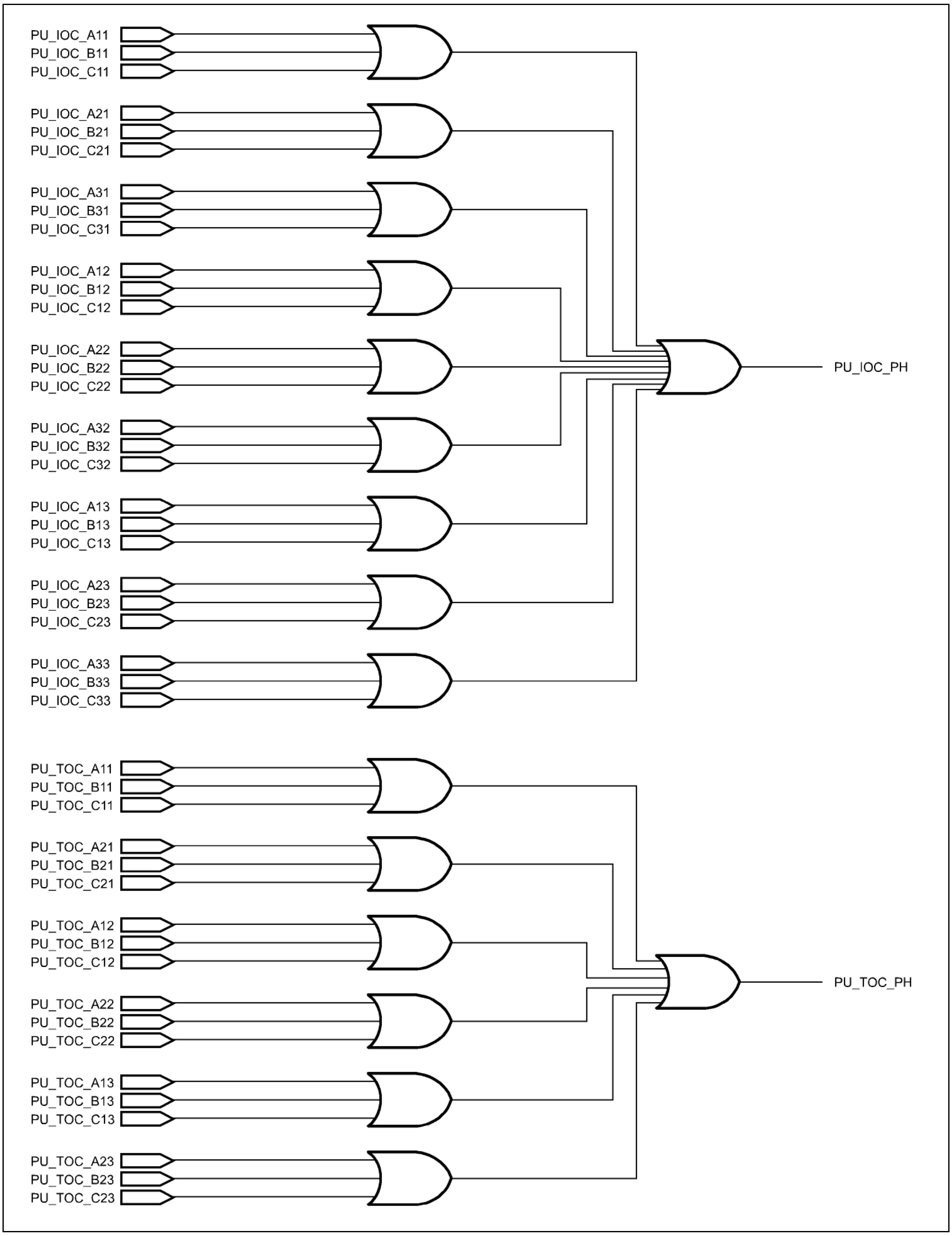


Figure 3.2.3: Activation Logic of Phase Overcurrent Elements Used by the Fault Detector.

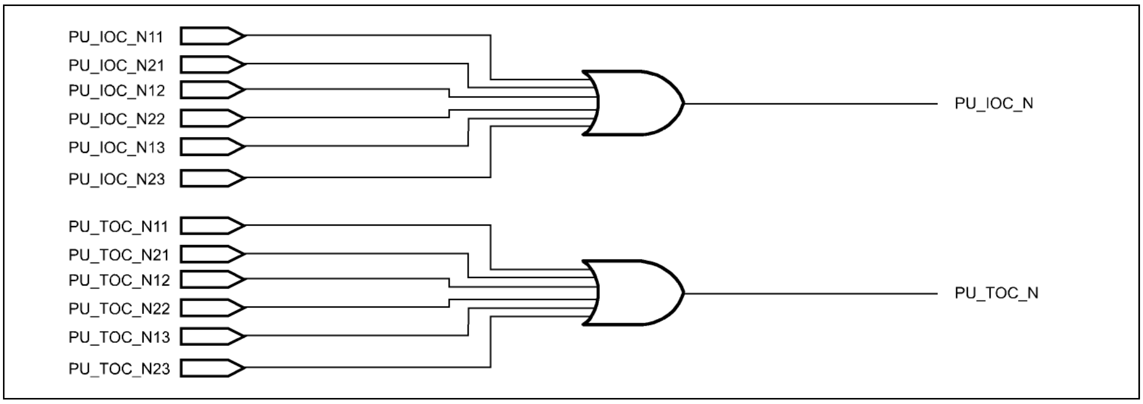


Figure 3.2.4: Activation Logic of Ground Overcurrent Elements Used by the Fault Detector.

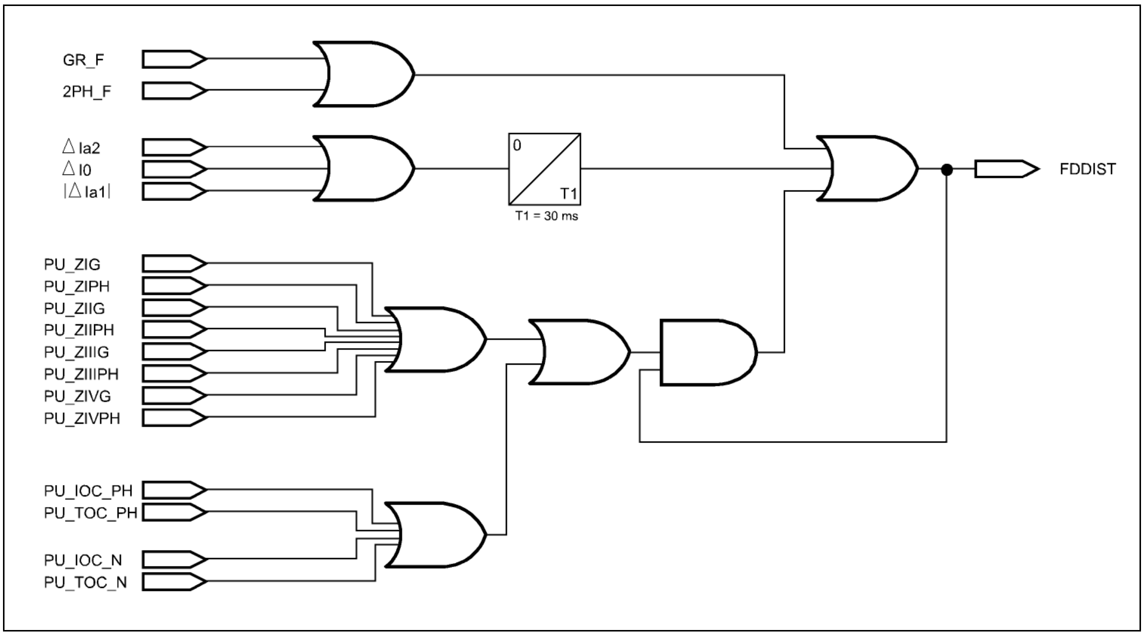


Figure 3.2.5: Fault Detector Block Diagram.

3.2.3 Fault Detector associated to Overcurrent Elements

Overcurrent elements in models **IDV-**D/F/G** without Distance Units present a fault Detector in charge of supervising its field of action. This element employs the sequence currents associated to the first winding as magnitudes for operation, according to the same two algorithms employed in the distance Fault Detector in the **IDV-F**. These algorithms entail the detection of increase in sequence currents and the detection of levels exceeded during the sequence currents.

The logic of the Fault Detector associated to the overcurrent elements is described in the following logic diagram:

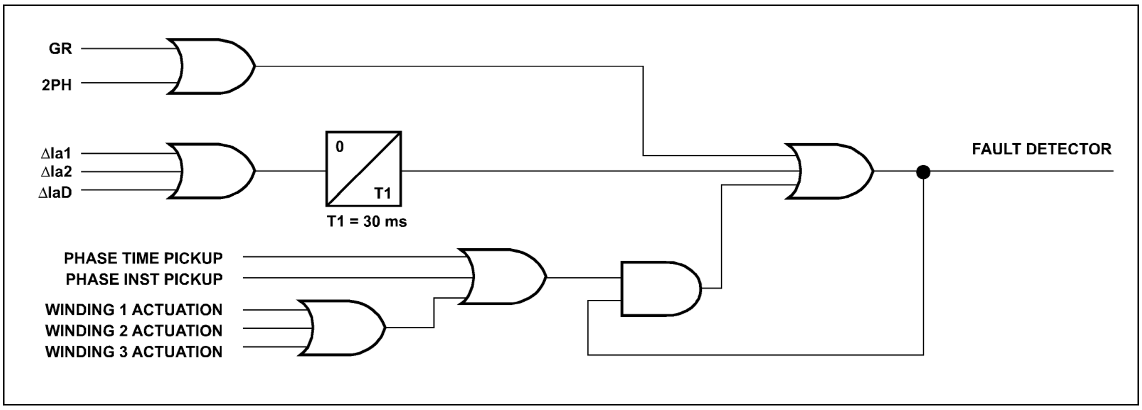


Figure 3.2.6: IDV-D Fault Detector Block Diagram.

3.2.3.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** (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** (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).

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 is included.

3.2.3.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(see paragraph 3.5.2).
- **Two-phase fault output** activation originating from the phase selector.

The above two algorithms require, in addition, that at least one of the following conditions occur:

- Positive sequence current above **0.1 A** (Inom=5A) / **0.03A** (Inom=1A).
- Zero sequence current above **0.25 A** (Inom=5A) / **0.065A** (Inom=1A).

The zero sequence supervisory current level detection allows the fault Detector to operate on faults with mainly zero sequence current flow.

The fault Detector activation generated by any of the two above mentioned algorithms is sealed-in via the activation of any of the relay **Overcurrent Elements**; see chapter 3.6, Overcurrent Elements.

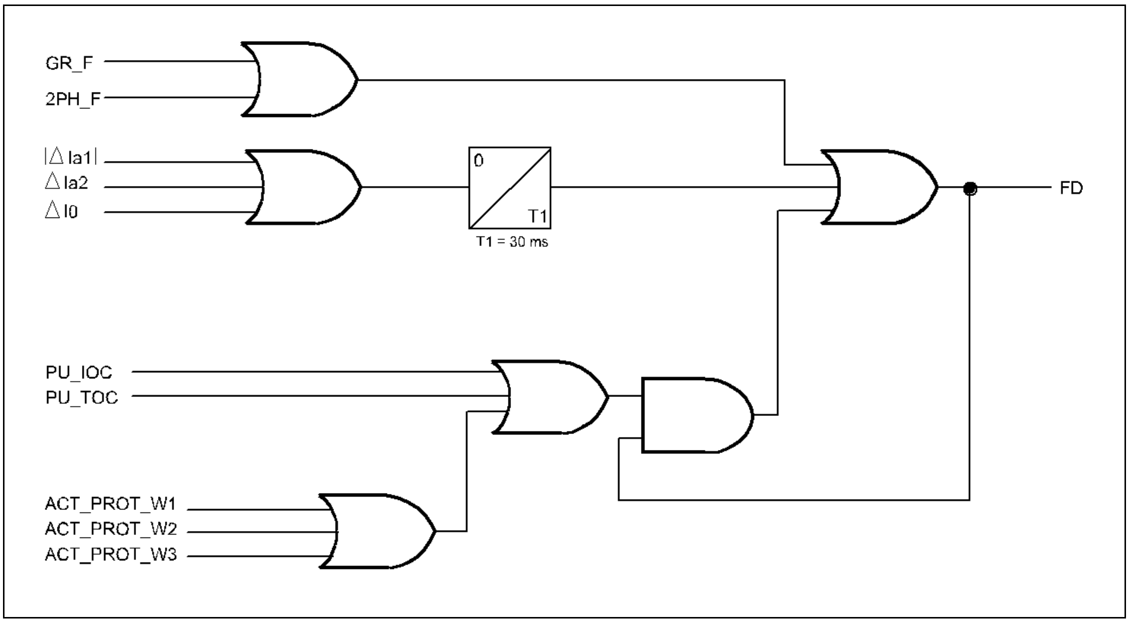


Figure 3.2.7: Overcurrent Fault Detector Bock Diagram.

3.2.4 Fault Start

The **Fault Inception** signal is generated by the activation of any of the above described Fault Detectors. Said signal defines the storage time of prefault currents used by the External Fault Detector (see Chapter 3.3).

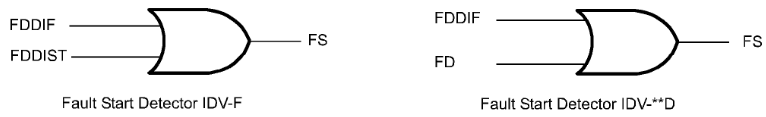


Figure 3.2.8: Fault Start Detector Block Diagram.

For models **IDV-L**, depending on the value of setting **Fault Detector Supervision** (refer to 3.1.11), the operation of differential elements will not depend on the activation of **Fault Start** signal.

3.2.5 Digital Inputs and Events of the Fault Detector

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

3.2.6 Auxiliary Outputs and Events of the Fault Detector

Table 3.2-1: Auxiliary Outputs and Events of the Fault Detector

Name	Description	Function
FDDIFA	Activation of Fault Detector of Differential Element phase A (IDV-**D/F/G)	Activation of Fault Detector associated to differential element phase A.
FDDIFB	Activation of Fault Detector of Differential Element phase B (IDV-**D/F/G)	Activation of Fault Detector associated to differential element phase B.
FDDIFC	Activation of Fault Detector of Differential Element phase C (IDV-**D/F/G)	Activation of Fault Detector associated to differential element phase C.
FDDIF	Activation of Fault Detector of Differential Element (IDV-**D/F/G)	Activation of Fault Detector associated to differential element (OR for activation in three phases).
FDDIST	Activation of Fault Detector of Distance Elements (IDV-F)	Activation of Fault Detector associated to distance elements.
FD	Fault Detector activated (IDV-**D/F/G)	Activation of Fault Detector associated to overcurrent elements.
FS	Fault Start activated (IDV-**D/F/G)	Signal that indicates the Fault Start.

3.3 External Fault Detector

3.3.1 Operating Principles

A very severe saturation of a current transformer can generate, in the event of an external fault, differential and restraint values that onset the tripping of the Differential Unit, despite the fact that this incorporates a double gradient percentage characteristic. In order to increase the security of the same, **IDV-**D/F/G** models incorporate an External Fault Detection element that enables blocking of differential units. This element comprises three sub-elements, as follows:

- Differential Instantaneous elements.
- Directional Phase Comparison element.
- Directional Positive Sequence Comparison element.

3.3.2 Differential Unit with Instantaneous Values

This element compares both differential and restraint instantaneous currents. When the fault is external, and no CT is saturated, instantaneous differential current will be practically non-existent. As a consequence of CT errors, the tap changer operation, magnetization current, relay errors, etc., the geometrical position of the point (*idiff*, *irest*), where *idiff* and *irest* represent differential and restraint instantaneous currents respectively, will not be abscissa axis, but rather a gradient line equal to the error percentage introduced by the above-mentioned factors: *idiff<k*irest*, where **k** is an internal parameter (non-settable) that represents this error percentage.

When a fault takes place that saturates a CT, time will lapse, from the moment this takes place, until the CT is saturated. During this period of time, if the fault is external, the *idiff<k*irest* ratio will apply. Activation of this condition during a consecutive sampling number, will activate the signal **External Fault by Differential Unit with Instantaneous Values**. If, on the other hand, the fault is internal, the *idiff<k*irest* condition will not apply, even in the non-saturated wave section, hence the above-mentioned signal will never be activated.

The Differential Unit with Instantaneous Values will only check the *idiff<k*irest* condition when the **Fault Start** signal is activated (see 3.2). On the other hand, it will only take into account those restraint current values that exceed the **Sensitivity** setting, when they are increasing.

If the fault is multi-phase and the non-saturated periods of the CTs associated to the three phases do not coincide exactly, a false zero sequence current will be generated even during such periods. The application of the zero sequence filter generates, during such periods, an important differential current, hence the *idiff<k*Irest* condition ceases to apply. The Differential Unit with Instantaneous Values must operate with the available information from the moment the fault is detected, until the first saturation of a CT takes place. Once the **External Fault** signal is activated, this will remain sealed while the fault remains active. Under external-internal evolved fault situations, the directional comparison elements described below will be in charge of detecting the fault is internal.

The Differential Unit with instantaneous values will operate on a phase-to-phase basis.

Figure 3.3.1: shows an example of an external fault on a two-winding transformer where a very high saturation of the CT associated to the second winding is produced. Only phase A is shown. It can be noticed that, prior to saturation of this CT, the differential current is zero so the ratio idif/ires is less than the internal constant k.

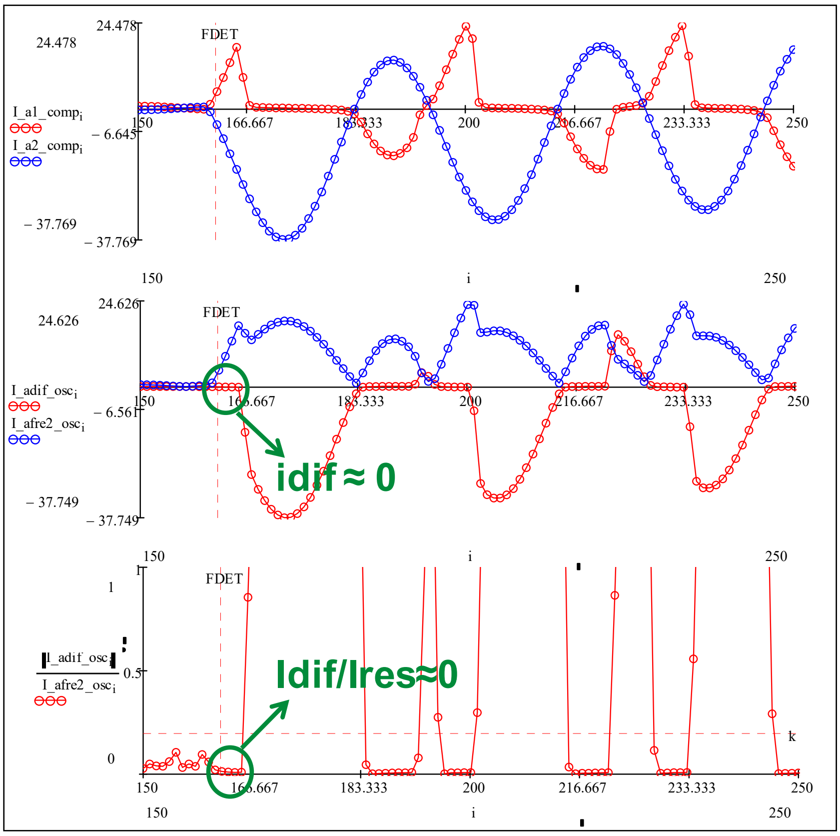


Figure 3.3.1: Example of external fault with saturation of the input current 2 CT: phase A currents; phase A differential and restraint currents; ratio between phase A differential and restraint current.

3.3.3 Phase Directional Comparison Unit

This unit compares the angle of each phase current with the angle obtained from the addition of the rest of the currents from the same phase. That is, it compares the IX-n (X=A, B, C; n=1, 2, 3, 4) angle with the angle $\sum_{i=1}^{4} IX\text{-}i$ with i≠n.

When the fault is external, both currents compared will be phase angle difference, whereas if the fault is internal, both currents will tend to be in phase. The directional phase comparison element will present the following algorithm:

External fault phase X: some IX-n current complies: $ANG\_DC\_PH < \arg(IX\text{-}n) - \arg(\sum_{i=1\ (i\neq n)}^{6} IX\text{-}i) < 360º\text{-}ANG\_DC\_PH$
Internal fault phase X: some IX-n current complies: $360º - ANG\_DC\_PH < \arg(IX\text{-}n) - \arg(\sum_{i=1\ (i\neq n)}^{6} IX\text{-}i) < ANG\_DC\_PH$

Where **ANG_DC_PH** equals 90º for relays **IDV-*******A/B/C/D*** and **Angle for Phase Directional Comparison Unit** setting for **IDV** relays with **E** option or above digit **9** (refer to 1.5, Relay Selection).

Figure 3.3.2: shows the angular ratio between the three power transformer currents on an external fault. These three currents can represent the currents of each three-winding transformer winding or the currents of a two-winding transformer where one winding is connected to a breaker and a half bay. As can be seen, I1 is at 180º with respect I2+I3.

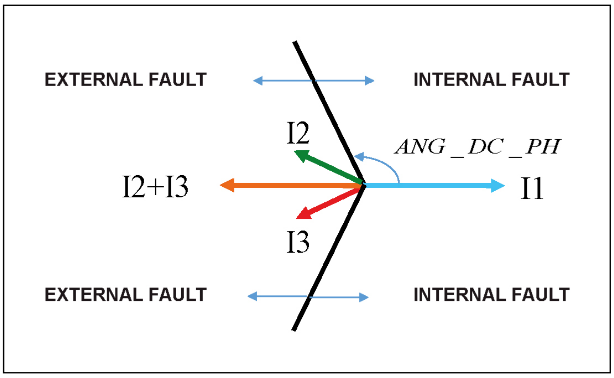


Figure 3.3.2: Angular relationship of the differential element input currents (three-winding transformer or two-winding transformer with breaker and a half in one of them) for an external fault.

The above algorithm could activate the **External Fault** signal in the event of internal faults with outfeed (faults with a lot of load and weak infeed at the end load receiver). In order to avoid the above situation, there is a minimum threshold for a current to be considered in the directional criteria. This threshold is set up by applying settings to the **Current Level** which must take values that exceed the maximum load that can circulate on the transformer.

The Phase Directional Comparison Unit will only operate when the signal **Fault Start** is activated.

For external faults with severe saturation of a CT, the Directional Comparison Element associated to any healthy phase could activate the **Internal Fault** signal as a consequence of enabling the zero sequence filters. In order to prevent this condition, when a zero sequence filter is enabled, applied from phase currents (**Type of Zero Sequence Filter** set to **Phase Channels**), the directional comparison element operates with a **2 out of 3** logic: if two phases activate the **External Fault** signal, the third phase will also activate it, even if the angle comparison indicates otherwise. It is worth mentioning that, in internal single phase faults, the zero sequence filters applied from phase currents will result in the activation of the internal fault signal in any of the healthy phases, which will prevent the **2 out of 3** logic from being applied. If the zero sequence filter is applied from the ground currents, the **2 out of 3** logic will be disabled, as it could be complied with upon an internal fault, causing, in that case, the activation of the **External Fault** signal in the faulty phase.

The Phase Directional Comparison Unit will obviously operate with compensated currents, based on the settings made on **Tap**, **Connection Group** and **Zero Sequence Filter**.

3.3.4 Positive Sequence Directional Comparison Unit

This unit compares the angles of direct pure fault positive sequence currents measured by all the three-phase channels in the relay (I1-1, I1-2, I1-3 and I1-4, for models **IDV-D/F**, and I1WNDG1, I1 WNDG 2 and I1 WNDG 3, for models **IDV-A/B/G/H/J/K/L**). To obtain the pure fault component for this current, the relays eliminate the pre-fault current, stored two cycles before the activation of the fault start (see 3.2, Fault Detectors). The use of pure fault currents eliminates the influence of the load, which enables the generation of correct directional decisions in the event of internal faults involving outfeed.

In order to obtain the pure fault positive sequence, storage of the pre-fault current is required and this magnitude is not available in situations involving close-onto-fault. The External Fault Detector will supervise the module of all saved pre-fault currents. If all modules should be below the **Open Breaker Current** setting, used by the Open Breaker Detector (see 3.18), the directional comparison will be carried out with negative sequence currents. This last algorithm has limitations as it cannot act in the event of three-phase faults.

Of all the currents taken into account by the Positive Sequence Directional Comparison Unit (pure fault positive sequence or negative sequence, depending on the conditions), all those whose magnitude does not exceed a minimum threshold will be ruled out.

The Positive Sequence Directional Comparison Unit will activate the **External Fault** signal when any of the currents taken into account by the algorithm happen to be in a phase angle difference situation as regards the rest. For that, it must be at an angle greater than **90º** for relays **IDV-*******A/B/C/D***** or **Angle for Positive Sequence Directional Comparison Unit** setting for **IDV** relays with **E** option or above digit **9**; and less than **270º** for **IDV-*******A/B/C/D***** relays or **360º - Angle for Positive Sequence Directional Comparison Unit** for **IDV** relays with **E** option or above digit **9.**

If all currents considered in the directional criterion tend to be in phase (phase difference between each other greater than **270º** or **360º - Angle for Positive Sequence Directional Comparison Unit** (as a function of the relay model) and less than **90º** or **Angle for Positive Sequence Directional Comparison Unit**), the element will activate the internal fault condition.

The Positive Sequence Directional Comparison Unit will obviously operate with compensated currents, based on the settings made on **Tap**, **Connection Group** and **Zero Sequence Filter**.

3.3.5 Differential Unit Blocking Logic

For **IDV-*******A/B/C/D*** ** relays, the activation of the external fault condition by at least two of the three above described elements, enables to block the restraint and instantaneous differential element operation.

For **IDV** relays with **E** option or above digit **9**, the **Blocking Logic** setting indicates the blocking signal generation logic of the differential elements with or without restraint. If the setting value is **2 out of 3,** two out of the three above described elements must activate their **External Fault** condition to generate the differential element input blocking signal. If the setting value is **3 out of 3**, the three elements must activate their **External Fault** condition for the above blocking signal.

After the External Fault blocking output signal has been generated, it will only block the differential elements if the corresponding **External Fault Detector Blocking Enable** settings are set to **Yes**.

Note: The majority of the automatic tests carried out by injection relays to test the performance of a differential characteristic with restraint, apply currents in two of the windings with 180º phase angle difference between them. This test would continuously activate external fault signals generated by directional comparison elements, hence, if YES is applied to the blocking setting in the differential unit by the external fault detector, this could never be triggered. Faults injected by the test relays correspond to internal faults (since they generate differential current) with outfeed effect. The phase directional comparison element would not detect an external fault condition if the adequate current threshold is selected. Nevertheless, the positive sequence directional comparison element would continuously activate the external fault signal. This would not take place if the test injected a pre-fault value that was coherent with the fault current (that which generated pure fault currents in both windings practically in phase). If pre-fault was not injected, or should an unreal pre-fault value be injected for an internal fault, as regards the fault value, *Block Enable* must be disabled by the external fault detector for the differential unit.

3.3.6 External Fault Detector Settings

External Fault Detector			
Setting	**Range**	**Step**	**Default**
Unit Enable	YES / NO		YES
Minimum Current Level	0.1 - 20 times the tap	0.01	1
Angle for Phase Directional Comparison Unit (*)	1 - 180º	1º	110º
Angle for Positive Sequence Directional Comparison Unit (*)	1 - 180º	1º	110º
Blocking Logic (*)	2 out of 3 3 out of 3		3 de 3

(*) For IDV Models with option E or higher in digit 9 (see 1.5, Model Selection).

- **External Fault Detector: HMI Access (IDV-*******A/B/C/D*** Models)**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTING	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	**8 - EXT FAULT DETECTOR**
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	
...	
8 - EXT FAULT DETECTOR	**0 - ENABLE**
...	**1 - MIN. CURR. LEVEL**

- **External Fault Detector: HMI Access (IDV Models with option E or higher in digit 9)**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTING	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	**8 - EXT FAULT DETECTOR**
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 – COLD LOAD

0 - DISTANCE	**0 - ENABLE**
...	**1 - MIN. CURR. LEVEL**
8 - EXT FAULT DETECTOR	**2 - ANGLE FOR PHASE DC**
...	**3 - ANGLE FOR PHASE PS**
	4 - BLOCKING LOGIC

3.3.7 Digital Inputs of the External Fault Detector Module

Table 3.3-1: Digital Inputs of the External Fault Detector Module

Name	Description	Function
ENBL_EXTFLT	Enable External Fault Detector Input	Activation of this input puts the external fault detector into service. It can be assigned to digital inputs by level or to a command from the communications protocol or from the HMI. The default value of this logic input signals is a "1."

3.3.8 Auxiliary Outputs of the External Fault Detector Module

Table 3.3-2: Auxiliary Outputs of the External Fault Detector Module

Name	Description	Function
EXT_DIFI_A	External Fault by Differential Unit with phase A instantaneous values	External Fault condition in phase A detected by Differential Unit with instantaneous values.
EXT_DIFI_B	External Fault by Differential Unit with phase B instantaneous values	External Fault condition in phase B detected by Differential Unit with instantaneous values.
EXT_DIFI_C	External Fault by Differential Unit with phase C instantaneous values	External Fault condition in phase C detected by Differential Unit with instantaneous values.
EXT_CDIR_PS	External Fault by Positive Sequence Directional Comparison Unit	External Fault condition detected by Positive Sequence Directional Comparison Unit.
INT_CDIR_PS	Internal Fault by Positive Sequence Directional Comparison Unit	Internal Fault condition detected by Positive Sequence Directional Comparison Unit.
EXT_CDIR_A	External Fault by phase A Directional Comparison Unit	External Fault condition in phase A detected by Phase Directional Comparison Unit.
EXT_CDIR_B	External Fault by phase B Directional Comparison Unit	External Fault condition in phase B detected by Phase Directional Comparison Unit.
EXT_CDIR_C	External Fault by phase C Directional Comparison Unit	External Fault condition in phase C detected by Phase Directional Comparison Unit.
INT_CDIR_A	Internal Fault by phase A Directional Comparison Unit	Internal Fault condition in phase A detected by Phase Directional Comparison Unit.
INT_CDIR_B	Internal Fault by phase B Directional Comparison Unit	Internal Fault condition in phase B detected by Phase Directional Comparison Unit.
INT_CDIR_C	Internal Fault by phase C Directional Comparison Unit	Internal Fault condition in phase C detected by Phase Directional Comparison Unit.

3.4 Distance Elements

3.4.1 Introduction

IDV-F relays incorporate four distance protection zones that can be applied as back up protection on network faults, contributing with greater selectivity than conventional overcurrent elements. Distance elements will operate based on measured voltages VA, VB and VC and currents obtained for winding 1 (IAWNDG1, IBWNDG1, ICWNDG1) or for winding 2 (IAWNDG2, IBWNDG2, ICWNDG2) as a function of the general Distance Winding setting (options Winding 1 or Winding 2). Thus, for said elements to operate correctly the measured voltages must belong to the winding selected to incorporate the distance protection. Currents associated to each winding are obtained from the currents measured by channels IAm, IBm, ICm (m=1, 2, 3, 4), based on configuration settings Winding 1 Current, Winding 2 Current and Winding 3 Current (see paragraph 3.1.7).

The direction of operation of each distance zone can be individually adjusted through the Direction setting that has the following options:

- **Forward** (default option): supervision outside the machine.
- **Reverse**: supervision inside the machine.

As the **Forward** value of the **Direction** setting implies supervision outside the machine, distance elements operate with the currents associated to the winding selected to incorporate said function but with opposite sign.

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.

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:

$K0 = Z0 / Z1$where 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, one zone is provided at the same time with separate distance and resistive limit settings (in case of selecting quadrilateral characteristic) for phase and ground elements.

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.

3.4.2 Quadrilateral Characteristic

Quadrilateral characteristics comprise three elements:

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

3.4.2.a Reactance Element

IDV-F 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.

System differences introduce additional phase angle differences 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 **IDV-F** relay incorporates compensation of the phase comparator of zone 1 reactance characteristic, calculated from system impedances. 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 activation of the fault detector associated to distance elements (see paragraph 3.2.2); 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 3.4-1: Reactance Characteristic

Unit	Fop	Fpol	Criteria
AG	$\left[Ia + I0 \cdot \left(K0n - 1\right)\right] \cdot ZnF - Va$	$Ia2$ ó $Ia - Iapf$	$0° \leq \left[\arg\left(Fop\right) - \arg\left(Fpol\right)\right] \leq 180°$
BG	$\left[Ib + I0 \cdot \left(K0n - 1\right)\right] \cdot ZnF - Vb$	$Ib2$ ó $Ib - Ibpf$	
CG	$\left[Ic + I0 \cdot \left(K0n - 1\right)\right] \cdot ZnF - Vc$	$Ic2$ ó $Ic - Icpf$	
AB	$Iab \cdot ZnF - Vab$	$Iab - Iabpf$	
BC	$Ibc \cdot ZnF - Vbc$	$Ibc - Ibcpf$	
CA	$Ica \cdot ZnF - Vca$	$Ica - Icapf$	

Where:

Ia, Ib, Ic	Phase currents of the winding incorporating distance protection.
$Iapf, Ibpf, Icpf$	Phase currents during prefault (load) of the winding incorporating distance protection.
Iab, Ibc, Ica	Current between phases (Ia-Ib), (Ib-Ic), (Ic-Ia) of the winding incorporating distance protection.
$Iabpf, Ibcpf, Icapf$	Phase currents during prefault (Iapf-Ibpf), (Ibpf-Icpf), (Icpf-Iapf) of the winding incorporating distance protection.
$Ia2, Ib2, Ic2$	Negative sequence phase currents referred to each phase of the winding incorporating distance protection.
$I0$	Zero sequence current of the winding incorporating distance protection.
Va, Vb, Vc	Phase voltages.
Vab, Vbc, Vca	Phase 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.

Pre-fault currents are stored two cycles before the time of activation of the fault detector associated to distance units (see paragraph 3.2.2). 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 associated to distance units is activated and the **Power Swing Blocking** signal is not active (see paragraph 3.5.5).

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 evolution of a single phase into a two phase ground fault (while the phase selector has not yet indicated two phase ground fault) or two-phase ground faults (when the activation of the single-phase element has been enabled, both because the **Lagging Phase**setting has been set to **YES** or because some of the AG, BG or CG element activation enable inputs has been activated (see paragraph 3.4.7, 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 3.4.1 and 3.4.2 show a voltage diagram where a ground fault Reactance line associated to zone 1 has been included.

Figure 3.4.1 shows a **Reactance** line for an 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**.

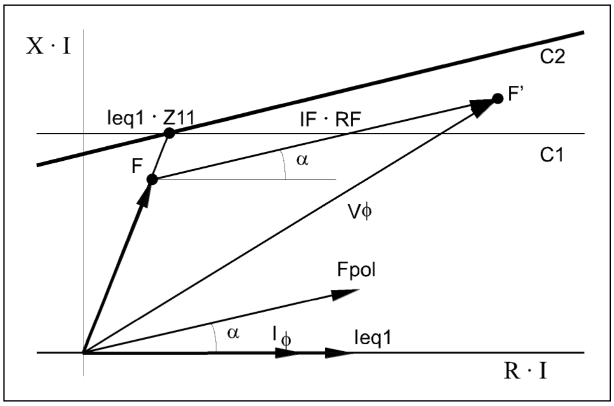


Figure 3.4.1: Reactance Characteristic Diagram for Ground Faults (I).

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 3.4.2 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 **IDV-F** from the line, source and equivalent parallel impedances.

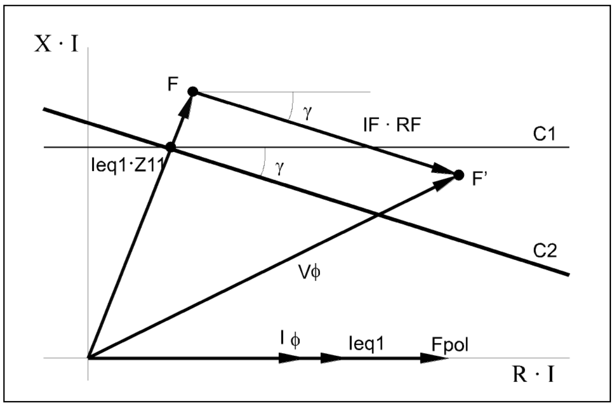


Figure 3.4.2: Reactance Characteristic Diagram for Ground Faults (II).

$I\phi$	Phase current of the winding incorporating distance protection
$Ieq1$	Equivalent current associated to zone 1 of the winding incorporating distance protection: $Ieq1 = I\phi + I0 \cdot (K01 - 1)$
$V\phi$	Phase voltage
RF	Ground fault resistance
IF	Current through ground fault resistance
$Fpol$	Polarization phasor for single-phase reactance $Fpol = I\phi 2$ or $I\phi - I\phi pf$ (currents corresponding to the winding incorporating distance protection)
$Z11$	Zone 1 reach impedance

Figures 3.4.3 and 3.4.4 show a voltage diagram where a **Reactance** line for faults between phases associated to zone 1 has been included.

Figure 3.4.3 shows the **Reactance** line for an 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.

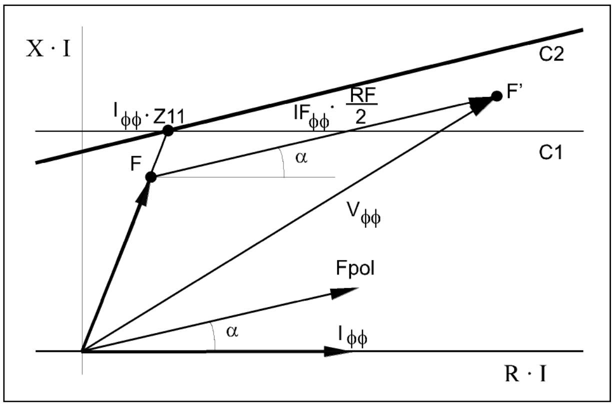


Figure 3.4.3: Reactance Characteristic Diagram for Faults between Phases (I).

Figure 3.4.4 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.

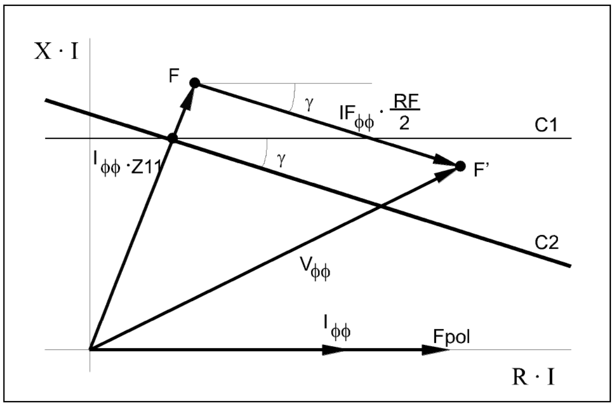


Figure 3.4.4: Reactance Characteristic Diagram for Faults between Phases (II).

Where:

$I\phi\phi$	Phase-to-phase current (Ia-Ib, Ib-Ic, Ic-Ia) of the winding incorporating distance protection
$V\phi\phi$	Phase-to-phase voltage (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 (currents corresponding to the winding incorporating distance protection)
$Z11$	Zone 1 reach impedance

3.4.2.b Directional Element

IDV-F equipment features directional elements for each type of fault, common to the four 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 3.4.5).

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

Table 3.4-2: Directional Unit

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

Where:

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

Figures 3.4.5 and 3.4.6 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 3.4.7 shows said displacement.

Figure 3.4.5 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.

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

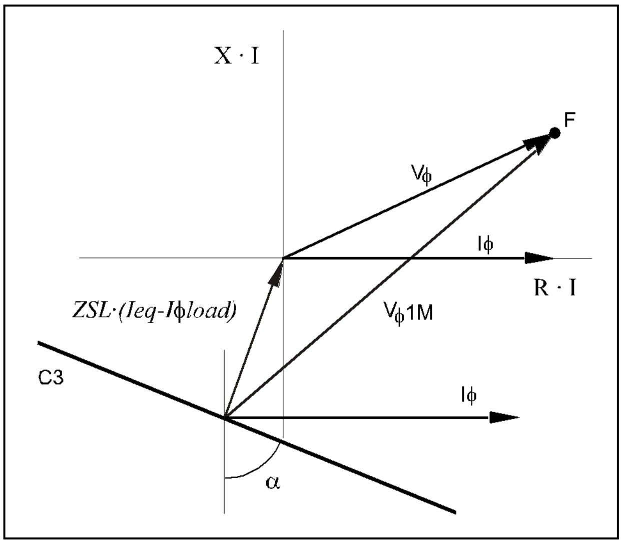


Figure 3.4.5: Directional Element Diagram for Ground Faults (I).

Figure 3.4.6 shows the Directional Element after memory update under a stationary fault state. Said element undergoes a displacement given by the vector:

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

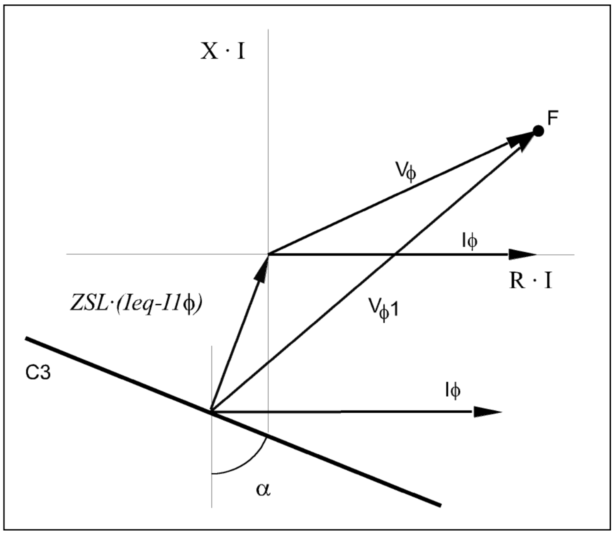


Figure 3.4.6: Directional Element Diagram for Ground Faults (II).

Figure 3.4.7 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:

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

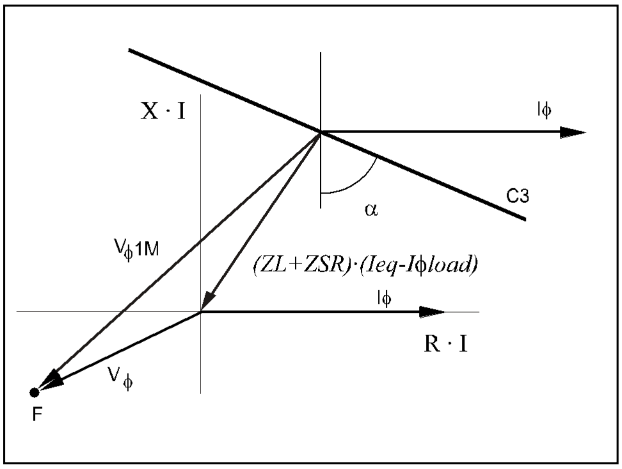


Figure 3.4.7: Directional Element Diagram for Ground Faults (III).

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)* of the winding incorporating distance protection
$I\phi(Ia, Ib, Ic)$	Phase current of the winding incorporating distance protection
$I1\phi$	Fault positive sequence current of the winding incorporating distance protection
$I\phi load$	Load current, previous to the fault of the winding incorporating distance protection
$V\phi$	Phase voltage
$V\phi 1$	Positive sequence voltage

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

Figures 3.4.8 and 3.4.9, 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 3.4.8 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:

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

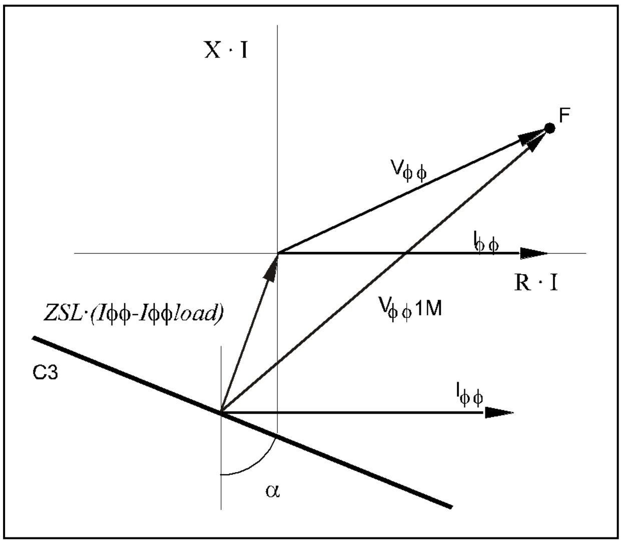


Figure 3.4.8: Directional Element Diagram for Phase-to-Phase Faults (I).

Figure 3.4.9 shows the Directional Element after memory update. Under steady state fault condition, the displacement of said element is given by the vector:

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

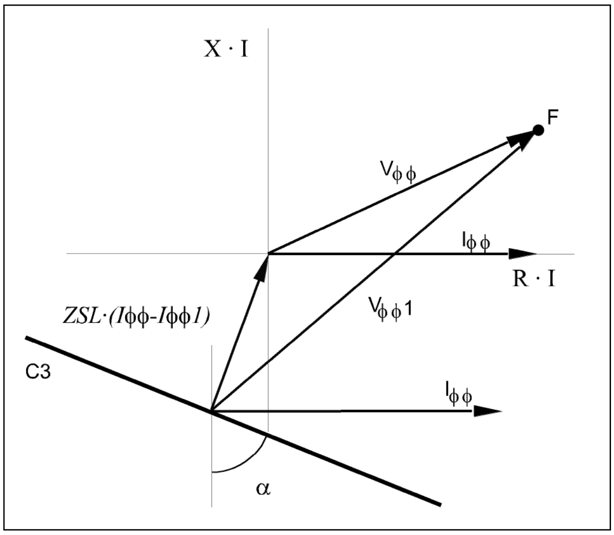


Figure 3.4.9: Directional Element Diagram for Phase-to-Phase Faults (II).

Where:

ZSL	Local source positive sequence impedance
$I\phi\phi(Iab, Ibc, Ica)$	Phase-to-phase current (fault) of the winding incorporating distance protection
$I1\phi\phi$	Positive sequence fault current (phase-to-phase) of the winding incorporating distance protection
$I\phi\phi carga$	Load current (phase-to-phase), previous to fault of the winding incorporating distance protection
$V\phi\phi$	Phase-to-phase voltage
$V\phi\phi 1$	Positive sequence voltage (phase-to-phase)

3.4.2.c Resistive Limiter

The **IDV-F** 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 3.4-3: Resistive Limiter

Axis R>0 Characteristic			
Unit	**Fop**	**Fpol**	**Criteria**
AG	$Ia \cdot RGn - Va$	$Ia \cdot RGn$	$-(90 + \theta bucn) \leq [\arg(Fop) - \arg(Fpol)] \leq \theta bucn$
BG	$Ib \cdot RGn - Vb$	$Ib \cdot RGn$	
CG	$Ic \cdot RGn - Vc$	$Ic \cdot RGn$	
Axis R<0 Characteristic			
AG	$-Ia \cdot RGn - Va$	$-Ia \cdot RGn$	$-(90 + \theta bucn) \leq [\arg(Fop) - \arg(Fpol)] \leq \theta bucn$
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	$Iab \cdot RPn - Vab$	$Iab \cdot RPn$	$-(90^{o} + \theta n) \leq [\arg(Fop) - \arg(Fpol)] \leq \theta n$
BC	$Ibc \cdot RPn - Vbc$	$Ibc \cdot RPn$	
CA	$Ica \cdot RPn - Vca$	$Ica \cdot RPn$	
Axis R<0 Characteristic			
AB	$-Iab \cdot RPn - Vab$	$-Iab \cdot RPn$	$-(90^{o} + \theta n) \leq [\arg(Fop) - \arg(Fpol)] \leq \theta n$
BC	$-Ibc \cdot RPn - Vbc$	$-Ibc \cdot RPn$	
CA	$-Ica \cdot RPn - Vca$	$-Ica \cdot RPn$	

Where:

Ia, Ib, Ic	Phase currents of the winding incorporating distance protection
Iab, Ibc, Ica	Phase-to-phase currents (Ia-Ib), (Ib-Ic), (Ic-Ia) of the winding incorporating distance protection
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 3.4.10 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.

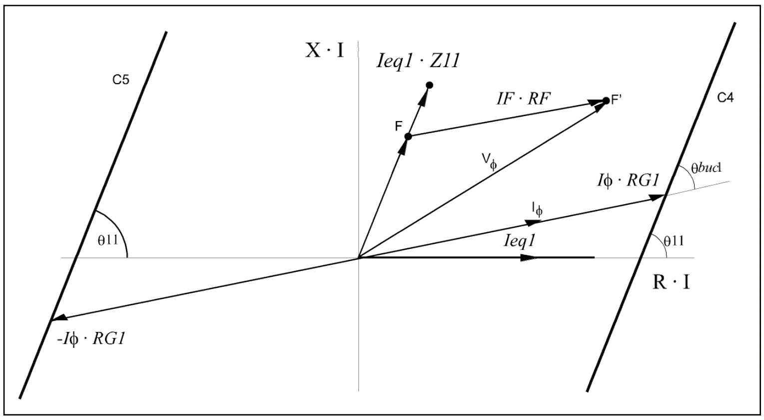


Figure 3.4.10: Resistive Limiters Diagram for Ground Faults.

In Figure 3.4.10 the voltage drop through the fault resistance has been considered parallel to the phase current.

Figure 3.4.11 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.

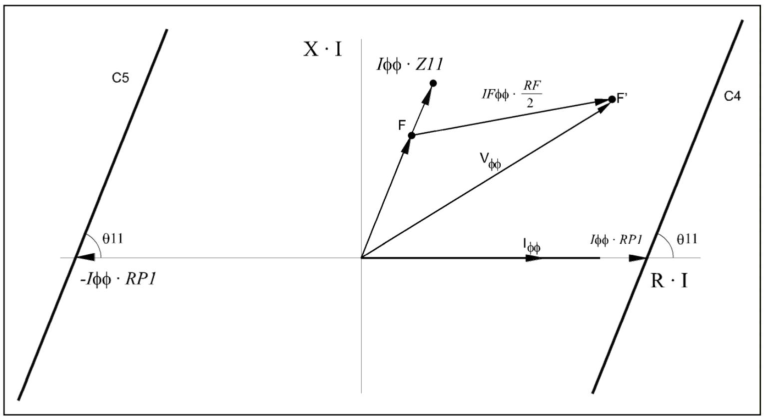


Figure 3.4.11: Resistive Limiter Diagrams for Phase-to-Phase Faults.

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

3.4.2.d Graphic Representation

Figure 3.4.12 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.

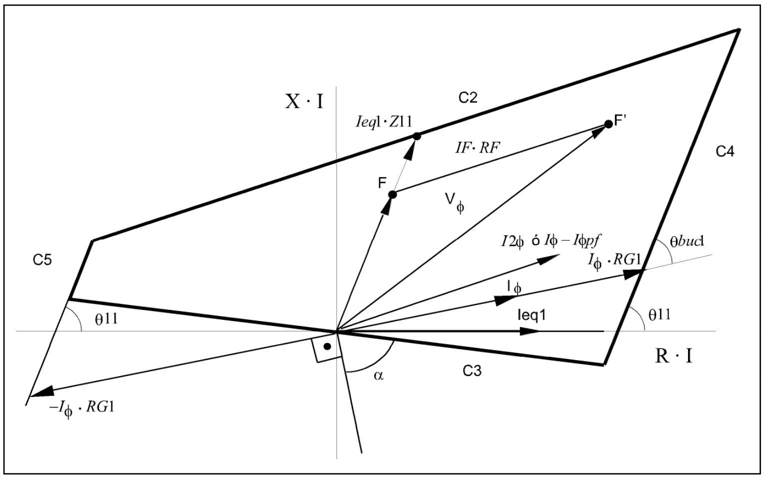


Figure 3.4.12: Quadrilateral Characteristic Diagram for Ground Faults.

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.

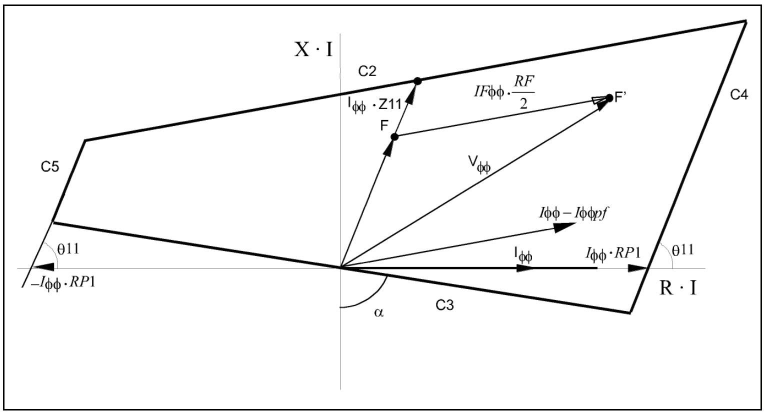


Figure 3.4.13: Quadrilateral Characteristic Diagram for Phase-to-Phase Faults.

3.4.3 Mho Characteristic

The **IDV-F 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 3.4.5).

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

Table 3.4-4: Mho Characteristic

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

Where:

Ia, Ib, Ic	Phase currents of the winding incorporating distance protection
Iab, Ibc, Ica	Line currents (Ia-Ib), (Ib-Ic), (Ic-Ia) of the winding incorporating distance protection
$I0$	Zero sequence currents of the winding incorporating distance protection
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

Figures 3.4.14 and 3.4.15 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 3.4.16.

Figure 3.4.14 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:

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

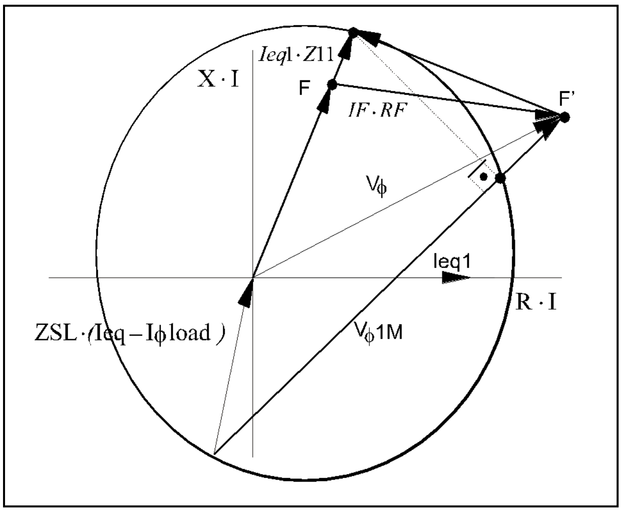


Figure 3.4.14: Phase-to-Ground Fault Mho Characteristic (I).

Figure 3.4.15 shows the **Mho** characteristic after memory update during a stationary state fault. Said characteristic undergoes a displacement given by the vector:

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

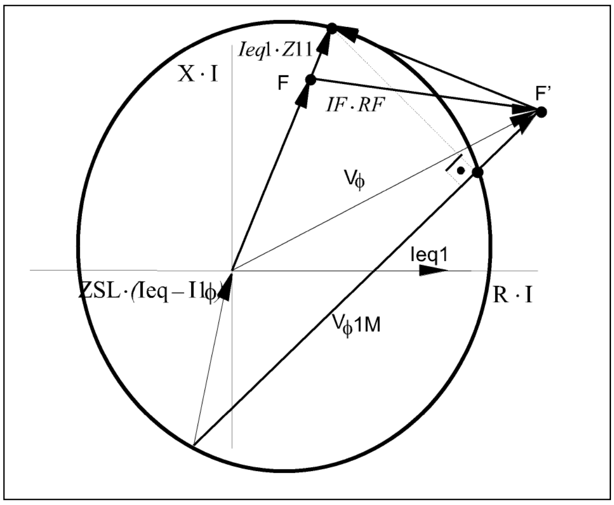


Figure 3.4.15: Phase-to-Ground Fault Mho Characteristic (II).

Figure 3.4.16 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:

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

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:

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

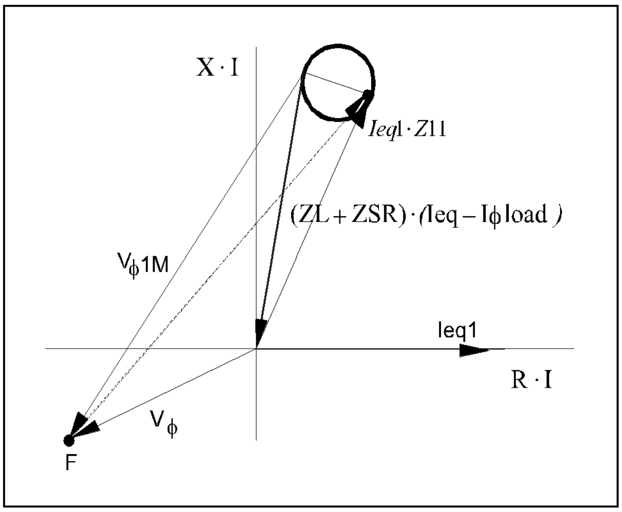


Figure 3.4.16: Phase-to-Ground Fault Mho Characteristic (III).

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)* of the winding incorporating distance protection
$I\phi(Ia, Ib, Ic)$	Phase current of the winding incorporating distance protection
$I1\phi$	Positive sequence fault current of the winding incorporating distance protection
$I\phi load$	Load current, previous to fault of the winding incorporating distance protection
$V\phi$	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 3.4.17 and 3.4.18 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 3.4.16, corresponding to a single-phase fault.

Figure 3.4.17 shows a characteristic at the instant of a fault. The expansion by the effect of the memory is given by vector:

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

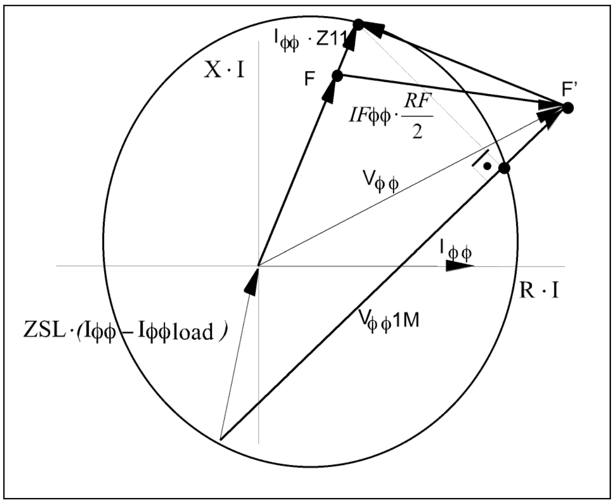


Figure 3.4.17: Mho Characteristic Diagram for Phase-to-Phase Faults (I).

Figure 3.4.18 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:

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

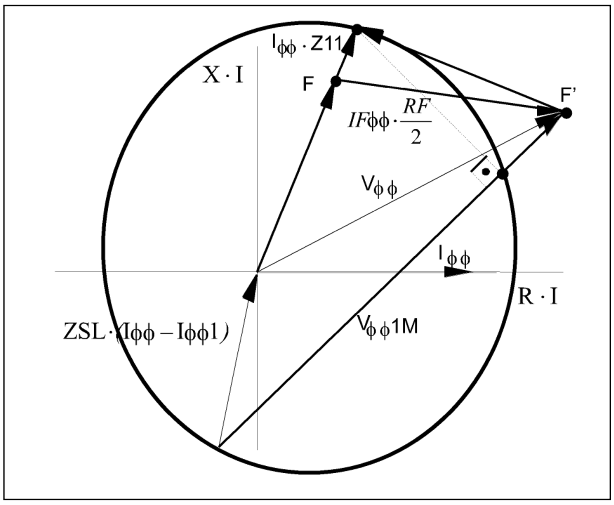


Figure 3.4.18: Mho Characteristic Diagram for Phase-to-Phase Faults (II).

Where:

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

3.4.4 Distance Characteristic Activation

Figures 3.4.19 and 3.4.20 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 3.4.7).

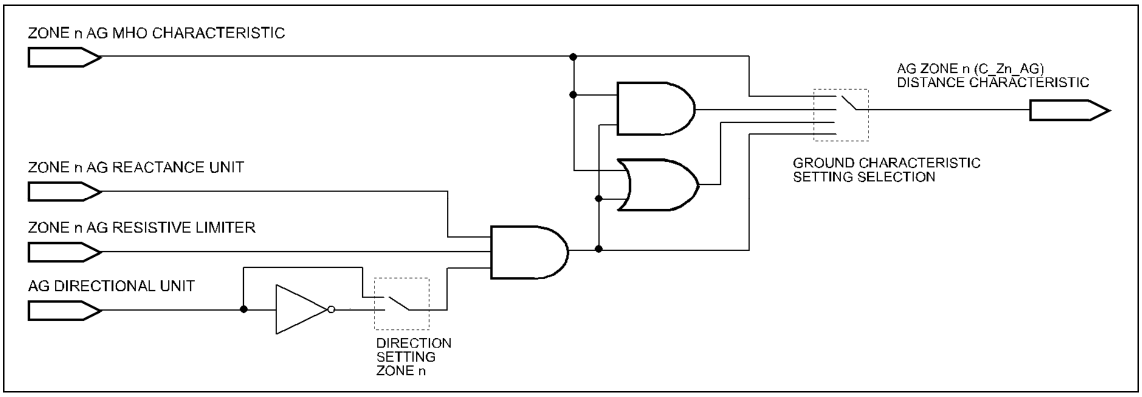


Figure 3.4.19: AG Distance Characteristic Activation Logic.

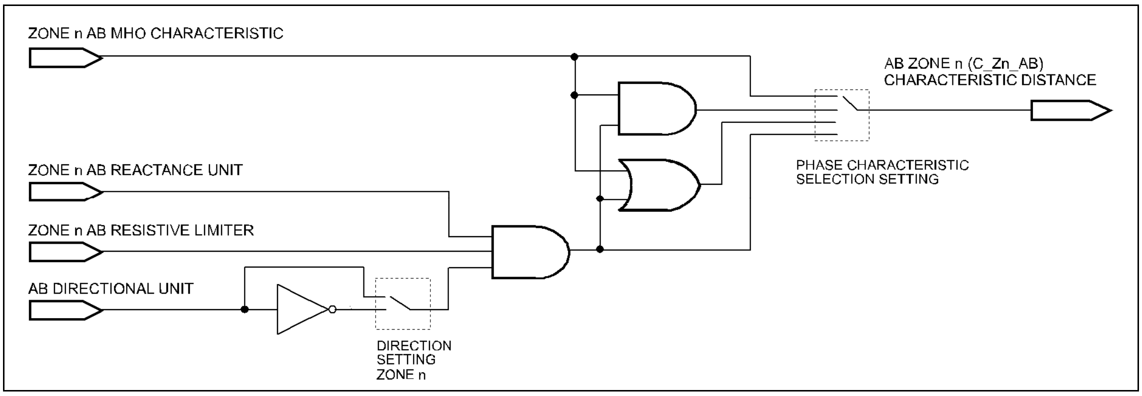


Figure 3.4.20: AB Distance Characteristic Activation Logic.

3.4.5 Voltage Memory Logic

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

The use of the voltage memory will depend on the **Series Compensation** setting. However, no matter said setting, the memorised positive sequence voltage is only used if its value is above 20 V (to prevent use of memory at the time when the breaker is closed in a position with the voltage transformer on the line side, which will prevent tripping) and while the fault detector is active. Said memory duration from the time it is latched, will be given by the Memory duration setting.

If series **Compensation Logic** enable setting is set to NO, voltage memory would only be necessary for clearing three phase faults with voltage below the minimum threshold to polarize distance elements (**Voltage Threshold** setting, within the field of distance elements). In this case, voltage memory is only used if positive sequence voltage (corresponding to the phase or phases considered) is below 50 V. Voltage memory is used even if the actual positive sequence voltage is above the **Voltage Threshold** setting, in order for the Mho characteristic to operate dynamically, increasing its resistive coverage.

If the series **Compensation Setting** is set to YES, one or other protected line incorporates series compensation. Faults associated to voltage reversal can occur in these type of lines, which happens when the impedance from the voltage transformer to the fault position is capacitive. Said voltage reversals lead to wrong directional decisions, as all directional elements are designed assuming inductive interaction between operating current and polarization voltage. Distance characteristics determine the fault direction using the positive sequence voltage as polarization phasor. In most cases, said voltage reversal cannot occur on single or two phase faults, but can on three phase faults, so that using said voltage memory is required. When series **Compensation Setting** is set to YES, the memorised positive sequence voltage is used whenever the fault detector is active, no matter the actual positive sequence voltage level, as reversal of said voltage can occur with relatively high values of the same.

Memory Duration setting can take the maximum value (80 cycles) if faults with positive sequence voltage below the minimum to polarize distance elements are expected (provided the time delay associated to said zones is below 80 cycles).

Voltage memory duration in lines with series compensation must be above the clearance time of a fault with voltage reversal, to sustain all this time a correct directional decision.

No matter the above, voltage memory will never be used when the signal **Power Swing Blocking Condition** is active (see paragraph 3.5.5).

3.4.6 Forward and Reverse Supervision Elements

IDV-F 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 operate with the current of the winding associated to the distance protection (IDEV1 or IDEV2 as a function of the **Distance Winding** setting); they are segregated into two main groups of elements:

- **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 3.4-5: 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 of the winding incorporating distance protection
Iab, Ibc, Ica	Phase-to-phase currents (Ia-Ib), (Ib-Ic), (Ic-Ia) of the winding incorporating distance protection

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.

3.4.7 Distance Elements Activation

Distance elements AG, BG, CG, AB, BC and CA pickup outputs of zone 1, 2, 3 and 4, 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 3.5.2).
- Fuse Failure Detector (see 3.5.3).
- Load Encroachment (see 3.5.4)

3.4.7.a Single-Phase Elements Activation

Figure 3.4.21 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 on the following conditions:

1) When any of the permissive trip inputs for AG, BG or CG elements is activated. At the time of using said inputs, underreach and overreach effects on single phase elements associated to lagging and leading phases respectively on two phase ground faults must be taken into account.

2) If **Lagging Phase**setting is set to YES, allowing only 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 **Lagging Phase** to **YES** will only be justified when a quadrilateral characteristic for ground faults has been selected

Single phase elements assigned to a given zone will only operate when the **Enable Input of the Ground Elements** corresponding to said area is activated, default value being 1.

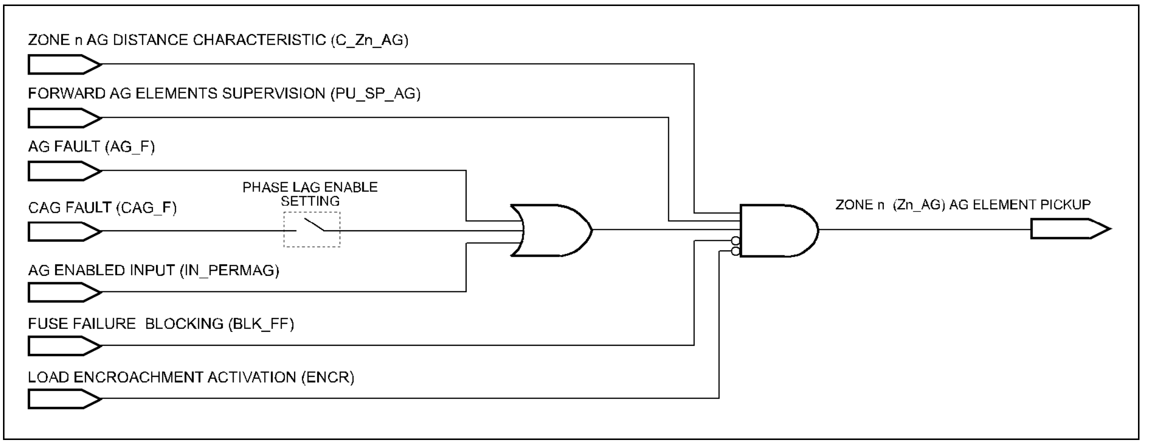


Figure 3.4.21: Pickup Logic of AG Elements.

3.4.7.b Two-Phase Elements Activation

Figure 3.4.22 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.

Two phase elements associated to a given area will only operate when the **Enable Input of Phase Units** corresponding to said area is activated, default value being 1.

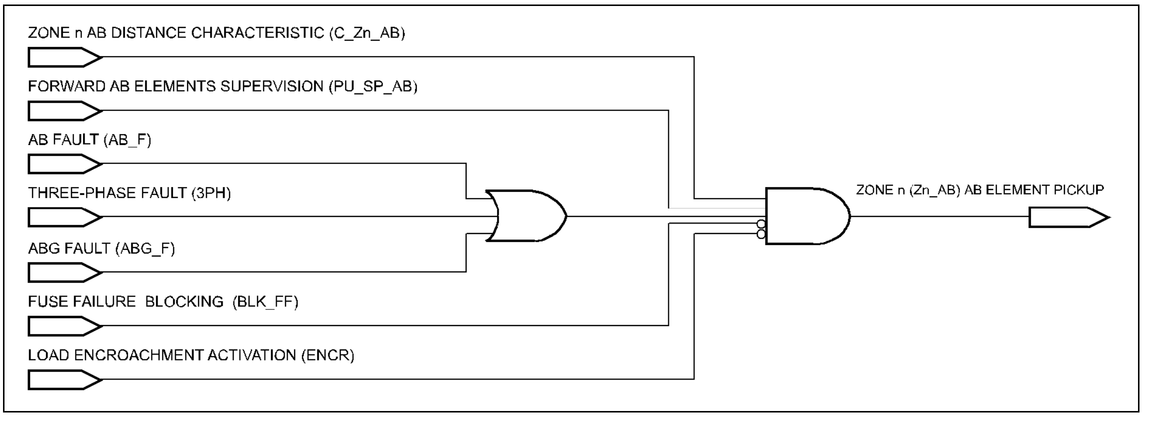


Figure 3.4.22: Pickup Logic of AB Elements.

3.4.8 Step Distance

Distance zones operate on a Step Distance scheme, applying an adjustable timing to each zone to generate trip signals, separate for ground faults and phase-to-phase faults.

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 3.4.23, step distance logic generates the **Pickup** signals of the phase and ground elements for zones 1, 2, 3, and 4 (signals PU_ZIG, PU_ZIPH, PU_ZIIG, PU_ZIIPH, PU_ZIIIG, PU_ZIIIPH, PU_ZIVG and PU_ZIVPH), using the distance elements outputs, previously described.

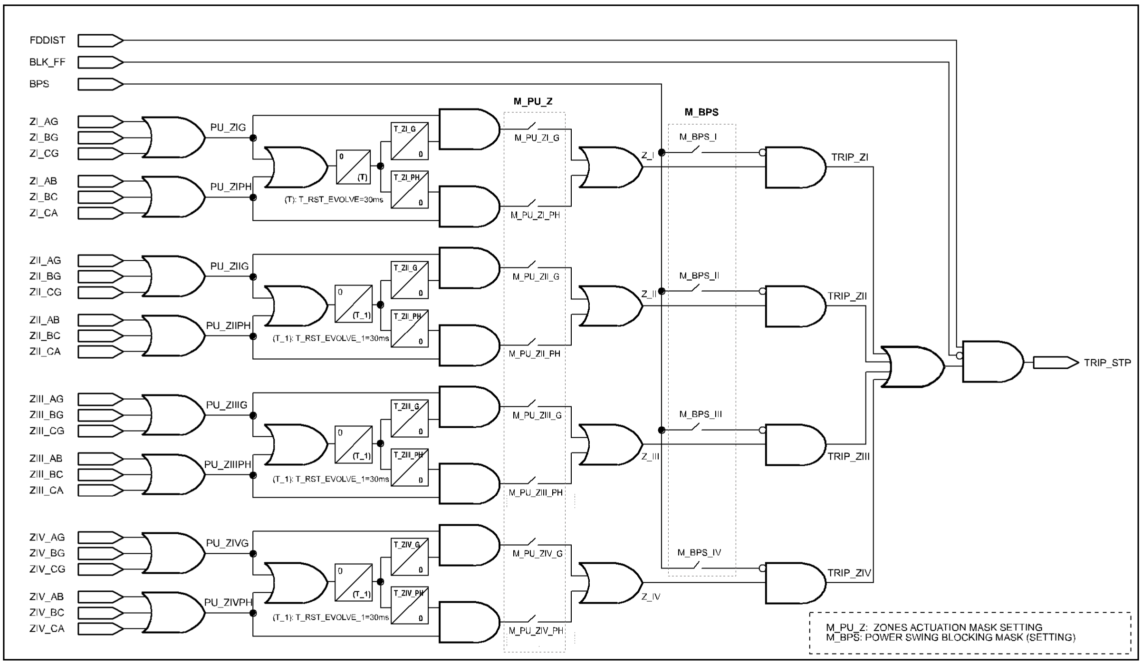


Figure 3.4.23: Step Distance Scheme Block Diagram.

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**).

ATENCIÓN!

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. On the other hand, it must be taken into account that, apart from the zone operation mask, there also exist a general stepped distance trip enable (see chapter 3.22, trip enable). If said trip enable is deactivated, the stepped distance trip will not generate a final trip.

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 3.5.3).On the other hand, the stepped distance trip will be subject to the activation of the fault detector associated to distance elements.

3.4.9 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 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
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
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
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

- **System Impedances: HMI Access**

0 - CONFIGURATION	0 - GENERAL	**0 - LINE IMPEDANCE**
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	**1 - PARALELL EQUIV. IMP.**
2 - CHANGE SETTINGS	**2 - SYSTEM IMPEDANCES**	**2 - LOCAL SOURCE IMP.**
3 - INFORMATION	3 - PROTECTION	**3 - REMOTE SOURCE IMP.**
	4 - TRIP PERMISIONS	
	5 - LOCKOUT PERM	
	6 - TRIP OUTPUTS	
	7 - LOGIC	
	8 - CIRCUIT COIL SUPERV	
	9 - HISTORY	
	10 - OSCILLOGRAPHY	
	11 - DIGITAL PLL	
	12- CONTROL	

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUDE**
1 - PARALELL EQUIV. IMP.	**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 KO FACTOR
	7 - ZERO SEQ. ANGLE 2
	8 - Z2 KO FACTOR
	9 - ZERO SEQ. ANGLE 3
	10 – Z3 KO FACTOR
	11 - ZERO SEQ. ANGLE 4
	12 - Z4 KO FACTOR

0 - LINE IMPEDANCE	**0 - POS. SEQ. MAGNITUDE**
1 - PARALELL EQUIV. IMP.	**1 - POS. SEQ. ANGLE**
2 - LOCAL SOURCE IMP.	
3 - REMOTE SOURCE IMP.	

0 - LINE IMPEDANCE	
1 - PARALELL EQUIV. IMP.	**0 - POS. SEQ. MAGNITUDE**
2 - LOCAL SOURCE IMP.	**1 - POS. SEQ. ANGLE**
3 - REMOTE SOURCE IMP.	

0 - LINE IMPEDANCE	
1 - PARALELL EQUIV. IMP.	
2 - LOCAL SOURCE IMP.	**0 - POS. SEQ. MAGNITUDE**
3 - REMOTE SOURCE IMP.	**1 - POS. SEQ. ANGLE**

Distance Protection			
Zone 1 units			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		YES
Direction	Reverse / Forward		Forward
Ground Reach	(0.05 - 500) / In Ω	0.01 Ω	5 / In
Phase 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 - 0.50 s	0.01 s	0 s
Elements Zones 2, 3 and 4 (independent settings for each zone)			
Setting	**Range**	**Step**	**By default**
Enable	YES / NO		YES
Direction	Reverse / Forward		Forward
Ground Reach	(0.05 - 500) / In Ω	0.01 Ω	
Phase Reach	(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
Lagging Phase Enable			
Setting	**Range**	**Step**	**By default**
Lagging Phase Enable (Two-phase-to-ground fault)	YES / NO		NO
Voltage Memory Duration			
Setting	**Range**	**Step**	**By default**
Memory duration	2 - 80 cycles	1 cycle	2 cycles
Compensation Serial	YES / NO		NO
Positive Sequence Voltage Threshold			
Setting	**Range**	**Step**	**By default**
Voltage threshold	0.1 - 5 V	0.1 V	1 V

Note: when the directional element is set to "Forward", the distance zones supervise outwards of the machine so that they operate via the currents associated to the winding selected to incorporate said function with opposite sign.

Zone Mask Trips			
Setting	**Range**	**Step**	**By default**
Controlled trip elements (YES / NO):			
Zone 1 Ground	YES / NO		
Zone 1 Phases	YES / NO		
Zone 2 Ground	YES / NO		
Zone 2 Phases	YES / NO		
Zone 3 Ground	YES / NO		
Zone 3 Phases	YES / NO		
Zone 4 Ground	YES / NO		
Zone 4 Phases	YES / NO		

- **Distance Protection: HMI Access**

0 - CONFIGURATION	0 - GENERAL	**0 - DISTANCE**
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	**0 - ZONE 1 UNITS**	**0 - ZONE 1 ENABLE**
1 - PHASE SELECTOR	1 - ZONE 2 UNITS	**1 - DIRECTION**
2 - DIST SUPERVISION	2 - ZONE 3 UNITS	**2 - GROUND REACH**
3 - FUSE FAILURE	3 - ZONE 4 UNITS	**3 - PHASE REACH**
...	4 - GND CHARACTERISTIC	**4 - GRND RESIST LIMIT**
	5 - PH CHARACTERISTIC	**5 - PHASE RESIST LIMIT**
	6 - DIREC CHARAC ANGLE	**6 - GROUND TIME**
	7 - LAGGING PHASE	**7 - PHASE TIME**
	8 - SERIES COMP	**8 - TILT TIME**
	9 - MEMORY DURATION	
	10 - VOLTAGE TRESHOLD	
	11 - ZONE MASK	

0 - DISTANCE	0 - ZONE 1 UNITS	**0 - ZONE * ENABLE**
1 - PHASE SELECTOR	**1 - ZONE 2 UNITS**	**1 - DIRECTION**
2 - DIST SUPERVISION	**2 - ZONE 3 UNITS**	**2 - GROUND REACH**
3 - FUSE FAILURE	**3 - ZONE 4 UNITS**	**3 - PHASE REACH**
...	4 - GND CHARACTERISTIC	**4 - GRND RESIST LIMIT**
	5 - PH CHARACTERISTIC	**5 - PHASE RESIST LIMIT**
	6 - DIREC CHARAC ANGLE	**6 - GROUND TIME**
	7 - LAGGING PHASE	**7 - PHASE TIME**
	8 - SERIES COMP	
	9 - MEMORY DURATION	
	10 - VOLTAGE TRESHOLD	
	11 - ZONE MASK	

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

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 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	**2 - DIST SUPERVISION**
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	**0 - FORWARD SUP. 1-PH**
1 - PHASE SELECTOR	**1 - FORWARD SUP. 2-PH**
2 - DIST SUPERVISION	**2 - REVERSE SUP. 1-PH**
3 - FUSE FAILURE	**3 - REVERSE SUP. 2-PH**
...	

3.4.10 Digital Inputs and Events of the Distance Elements

Table 3.4-6: Digital Inputs and Events of the Distance Elements

Name	Description	Function
ENBL_ZIG	Ground element zone 1 enable input	Activating this input enables the ground elements. These can be assigned to digital level inputs or commands from the communications protocol or HMI. Default value is “1”.
ENBL_ZIIG	Ground element zone 2 enable input	
ENBL_ZIIIG	Ground element zone 3 enable input	
ENBL_ZIVG	Ground element zone 4 enable input	
ENBL_ZIP	Phase element zone 1 enable input	Activating this input enables the phase elements. These can be assigned to digital level inputs or commands from the communications protocol or HMI. Default value is “1”.
ENBL_ZIIP	Phase element zone 2 enable input	
ENBL_ZIIIP	Phase element zone 3 enable input	
ENBL_ZIVP	Phase element zone 4 enable input	
IN_PERMAG	AG Unit enable input	Activating this input allows single phase unit operation no matter phase selector output.
IN_PERMBG	BG Unit enable input	
IN_PERMCG	CG Unit enable input	

3.4.11 Auxiliary Outputs and Events of the Distance Elements

Table 3.4-7: Auxiliary 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	

Table 3.4-7: Auxiliary 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	
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	
ZIG_ENBLD	Zone 1 Ground Elements Enabled	Indication of the enabled or disabled status of the zone ground elements.
ZIIG_ENBLD	Zone 2 Ground Elements Enabled	
ZIIIG_ENBLD	Zone 3 Ground Elements Enabled	
ZIVG_ENBLD	Zone 4 Ground Elements Enabled	
ZIP_ENBLD	Zone 1 Phase Elements Enabled	Indication of the enabled or disabled status of the zone phase elements.
ZIIP_ENBLD	Zone 2 Phase Elements Enabled	
ZIIIP_ENBLD	Zone 3 Phase Elements Enabled	
ZIVP_ENBLD	Zone 4 Phase Elements Enabled	
PU_ZIG	Zone 1 Ground Elements Pickup	Pickup of phase and ground distance elements for all 4 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	
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	

Table 3.4-7: Auxiliary Outputs and Events of the Distance Elements		
Name	**Description**	**Function**
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_STP	Step distance trip	Stepped distance trip.
TRIP_STP_M	Step distance trip mask	Stepped distance trip after checking its trip mask.
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	
ENBL_ZIG	Ground element zone 1 enable input	The same as for the Digital Inputs.
ENBL_ZIIG	Ground element zone 2 enable input	
ENBL_ZIIIG	Ground element zone 3 enable input	
ENBL_ZIVG	Ground element zone 4 enable input	
ENBL_ZIP	Phase element zone 1 enable input	The same as for the Digital Inputs.
ENBL_ZIIP	Phase element zone 2 enable input	
ENBL_ZIIIP	Phase element zone 3 enable input	
ENBL_ZIVP	Phase element zone 4 enable input	
IN_PERMAG	AG unit enable input	The same as for the Digital Inputs.
IN_PERMBG	BG unit enable input	
IN_PERMCG	CG unit enable input	

3.4.12 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 3.4-8: Test Settings for the Distance Unit*	
System Impedances	
Positive sequence magnitude. Line impedance	1.20 Ω
Positive sequence angles. Zones 1, 2, 3 and 4 line impedance	75º
Zero sequence angles. Zones 1, 2, 3 and 4 line impedance	75º
K0, K02, K03 and K04 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 1 reach	1.00 Ω
Zone 2 reach	2.00 Ω
Zone 3 reach	4.00 Ω
Zone 4 reach	5.00 Ω
Zone 1 ground resistive limit	2.00 Ω
Zone 2 ground resistive limit	4.00 Ω
Zone 3 ground resistive limit	8.00 Ω
Zone 4 ground resistive limit	10.00 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

Distance Elements	
Zone 1 ground elements time	0 s
Zone 2 ground elements time	0.5 s
Zone 3 ground elements time	1 s
Zone 4 ground elements time	1.5 s
Zone 1 phase elements time	0 s
Zone 2 phase elements time	0.5 s
Zone 3 phase elements time	1 s
Zone 4 phase elements time	1.5 s
Compensation time	0 s
Directional element characteristic angle. Reactance characteristic	75º
Lagging Phaseenable. (Two-phase-to-ground fault)	No
Voltage memory duration	2 cycles

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

3.4.12.a Single-Phase Fault Characteristics

- **Quadrilateral 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 3.4-9.

Slowly decrease the voltage of the phase under test. Each zone should activate within the voltage ranges indicated in Table 3.4-9.

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 3.4-9: 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

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 A ac. 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
$K0n = \frac{\|Z0n\|}{\|Z1n\|}$	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 3.4-10: 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

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 of the winding incorporating distance protection
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 3.4-11.

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 3.4-11 also indicates the ranges of trip times for each zone.

Table 3.4-11: 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

3.4.12.b Characteristic for Faults between Phases

- **Quadrilateral Characteristic**

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 3.4-12. 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 3.4-12.

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 3.4-12: 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

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 (of the winding incorporating distance protection)
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 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 3.4-13. 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 3.4-13.

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 3.4-13: 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

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 (of the winding incorporating distance protection)
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 3.4-14.

Table 3.4-14 also indicates the resulting ranges of the trip times for each zone.

Table 3.4-14: 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

3.5 Protection Schemes for Distance Elements

3.5.1 Introduction

IDV-F relay distance elements incorporate a number of additional elements operating, the same as for the former, based on the measured voltages VA, VB and VC and currents obtained for the winding selected to incorporate the distance protection. That is why, all phase, phase-to-phase or sequence currents referred to in this paragraph will be associated to the winding with the distance function.

By other hand, **IDV-**D** relays only incorporate one of these elements, the Phase Selector, using by the External Fault Detector.

3.5.2 Phase Selector

3.5.2.a Operating Principles

The **IDV-F** 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 3.4.7) to decide which distance units should act.

The **IDV-**D** is provided too with a Phase Selector, but in this case is used to activate the Initiated Fault Detector, used by the External Fault Detector.

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 component**: Negative sequence current value is below 0.05 In A, and below 10% of the positive sequence current value.
2. **Low zero sequence current component**: Zero sequence current value is below 0.05 In A, and below 8% of the positive sequence current value.

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.

In **IDV-F** relays and in power swing conditions (CBPS = 1), the value of these percentages rises to 20 % to avoid selecting different types of erroneous faults also due to the possible imbalances derived from the power swing.

It is worth mentioning that three-phase fault indication is associated to a balanced condition, thus it will also be given under a load condition. The task of discerning between fault and load condition will rest on fault detectors (see section 3.2) associated to differential and distance elements.

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**).

In **IDV-F** models and 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.

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

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

where:

$Ia2$	Negative sequence current of the winding incorporating distance protection referred to phase A.
$Ia1\_f$	Fault positive sequence current (load component removed) of the winding incorporating distance protection referred to phase A.

The angle diagrams, used to determine the phases under fault as a function of the angle ϕ, are represented in following figures.

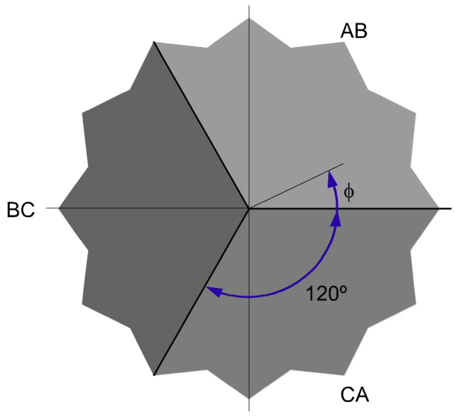


Figure 3.5.1: Two-Phase Fault Angle Diagram.

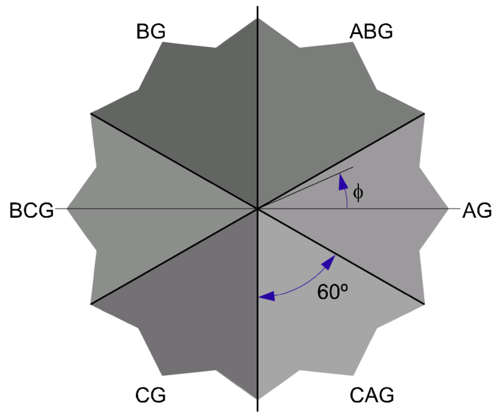


Figure 3.5.2: Single-Phase and Two-Phase- to-Ground Fault Angle Diagram.

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

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

3.5.2.b Phase Selection on Faults where the Current is predominantly Zero Sequence

Power transformers with WYE connected windings and grounded neutral generate, in weak feed faults, predominantly zero sequence currents. In this case, the positive sequence current can be below 0.02*In A, whereas the zero sequence current will be above the threshold of 0.05*In A. If these conditions are met, the phase selector will consider the fault as a ground fault but will not discern the faulted phases from the angle between positive and negative sequence currents, but from the activation of the three undervoltage elements (one per phase), the pickup level of which is given by the **Weak Voltage Supply Threshold** setting.

3.5.3 VT Fuse Failure Detector

3.5.3.a Operating Principles

IDV-F relays include a fuse failure detector designed to operate directly on distance elements. **IDV-J/K** relays also include said detector, the outputs of which can be configured, through programmable logic, to block any voltage based element.

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. Currents not being involved, a fault detection will not occur, thus the output of the fault detector associated to distance elements will be used in the **IDV-F** models (see paragraph 3.2.2) or the Fault Start in **IDV-J/K** models (see paragraph 3.24) as discriminator.

The opening of the breaker or breakers associated to the winding incorporating distance protection (or to the reference winding in IDV-J/K models) would generate a fuse failure condition if the voltage transformer is downstream said breakers. The fuse failure detector is blocked if **Breaker/s Winding n** signal (**BRK_Wn_OP**) is active, where **n** stands for the winding selected for distance protection (or to the reference winding in IDV-J/K models).

By other hand, VT Fuse Failure Detector will not operate if the positive sequence current not exceeding 0.02*In A.

VT Fuse Failure Detection operation is shown in Figure 3.5.3.

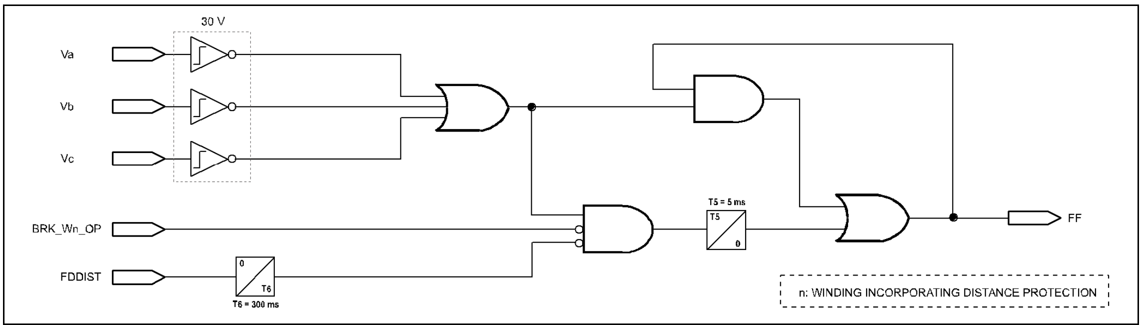


Figure 3.5.3: VT Fuse Failure Detector Block Diagram.

The undervoltage detectors pickup when this voltage is less than 95% of 30 V and resets when it is higher than 30 V.

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.

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.

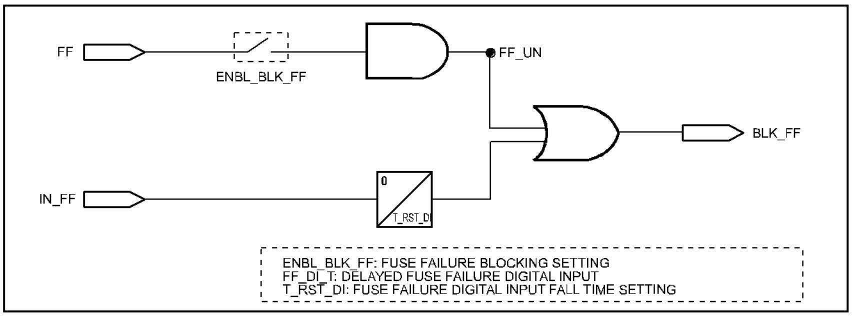


Figure 3.5.4: Logic Diagram of Blocking Due to Fuse Failure.

3.5.4 Load Encroachment

3.5.4.a Operating Principles

IDV-F relays incorporate load encroachment elements to avoid trips on high load conditions. Said elements, as their name suggests, define the load zone in the R-X plane, according to the two characteristics shown in figure 3.5.5, such that if the impedance calculated by each distance element remains within this zone, their operation is blocked.

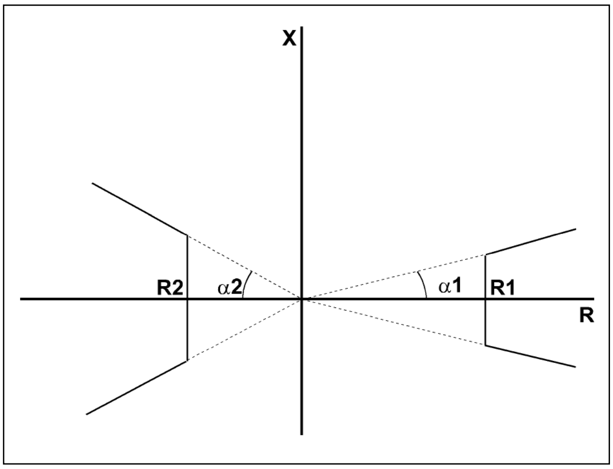


Figure 3.5.5: Characteristics of Load Encroachment Elements.

The impedance calculated by the load encroachment element depends on 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	$Z = \frac{Vc}{Ic + I0 \cdot (K0 - 1)}$

Where:

Ia, Ib, Ic	Phase currents of the winding incorporating distance protection
Iab, Ibc, Ica	Phase-to-phase currents (Ia-Ib), (Ib-Ic), (Ic-Ia) of the winding incorporating distance protection
$I0$	Zero-sequence current of the winding incorporating distance protection
Va, Vb, Vc	Phase voltages
Vab, Vbc, Vca	Phase-to-phase voltages (Va-Vb), (Vb-Vc), (Vc-Va)
$K0 = \frac{\lvert Z0 \rvert}{\lvert Z1 \rvert}$	Zone 1 zero sequence compensation factor

Adjustment of the calculated impedance to the fault type prevents the wrong activation of the load encroachment characteristics under 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:

$$[Re(Z) > R1] \otimes [(360 - \alpha 1) < Arg(Z) < \alpha 1]$$
$$\oplus$$
$$[Re(Z) < -R2] \otimes [(180 - \alpha 2) < Arg(Z) < (180 + \alpha 2)]$$

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

Load encroachment elements block when both positive sequence current and voltage associated to distance elements are below 0.02*In A and **Voltage Threshold** setting, respectively.

3.5.5 Power Swing Detector

3.5.5.a 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.

IDV-F 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 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.

In order to check the above, given the symmetry of the power swing, **IDV-F** relays use one AB impedance measurement element per zone.

Each quadrilateral zone of those mentioned above is formed of the following elements:

- Two resistive limiters.
- Two reactive limiters.

3.5.5.b Resistive Limiters

The **IDV-F** 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 3.5-1: Resistive Limiters			
Right Resistive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$Iab \cdot Rdcho - Vab$	$Iab \cdot Rdcho$	$-(90^{o}+A\lim) \leq [\arg(Fop) - \arg(Fpol)] \leq A\lim$
Left Resistive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$-Iab \cdot Rizdo - Vab$	$-Iab \cdot Rizdo$	$-(90^{o}+A\lim) \leq [\arg(Fop) - \arg(Fpol)] \leq A\lim$

Where:

Iab, Ibc, Ica	Phase currents (Ia-Ib) of the winding incorporating distance protection
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 3.5.6 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 **IDV-F**, given that theoretically the path of the impedance during a power swing is perpendicular to this impedance.

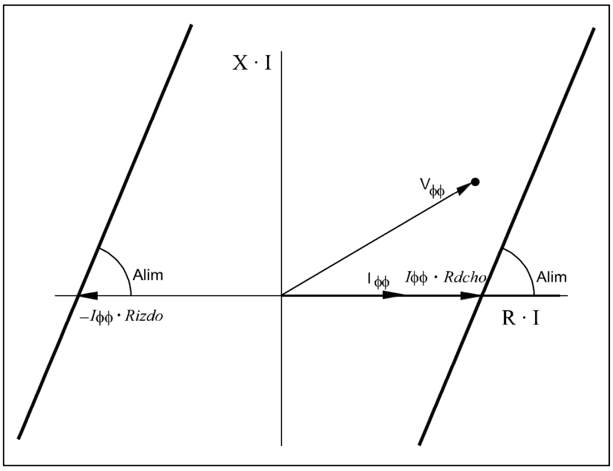


Figure 3.5.6: Diagram of Resistive Limiters of the Power Swing Detection Zones.

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.

3.5.5.c Reactive Limiters

The **IDV-F** 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 3.5-2: Reactive Limiters			
Upper Reactive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$Iab \cdot Z\,sup - Vab$	$Iab \cdot Z\,sup$	$-90^{o} \le \left[\arg(Fop) - \arg(Fpol)\right] \le 90^{o}$
Lower Reactive Limiter			
Unit	**Fop**	**Fpol**	**Criteria**
AB	$-Iab \cdot Z\,inf - Vab$	$-Iab \cdot Z\,inf$	$-90^{o} \le \left[\arg(Fop) - \arg(Fpol)\right] \le 90^{o}$

Where:

Iab, Ibc, Ica	Currents between phases (Ia-Ib) of the winding incorporating distance protection
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 3.5.7 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.

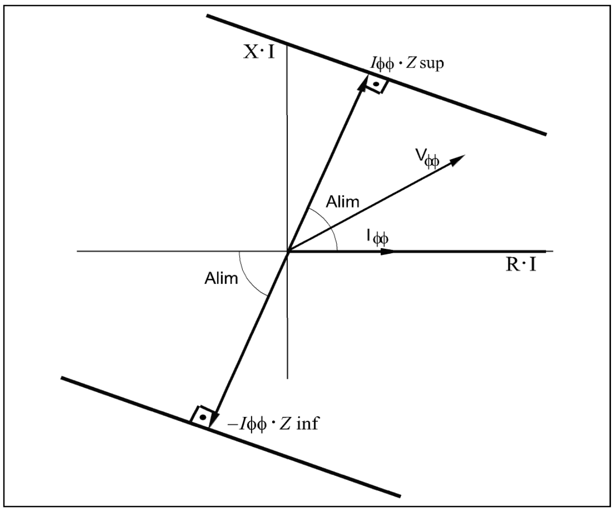


Figure 3.5.7: Diagram of Reactive Limiters of the Power Swing Detection Zones.

The activation of the internal zone will only be considered when the **Power Swing Trip is Enabled** (**ENBL_TRIP_PS**).

On the other hand, there is an adjustable positive sequence current threshold setting for the activation of the three zones (**I1 supervision**).

3.5.5.d Definition of the Zones

Figure 3.5.8 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.

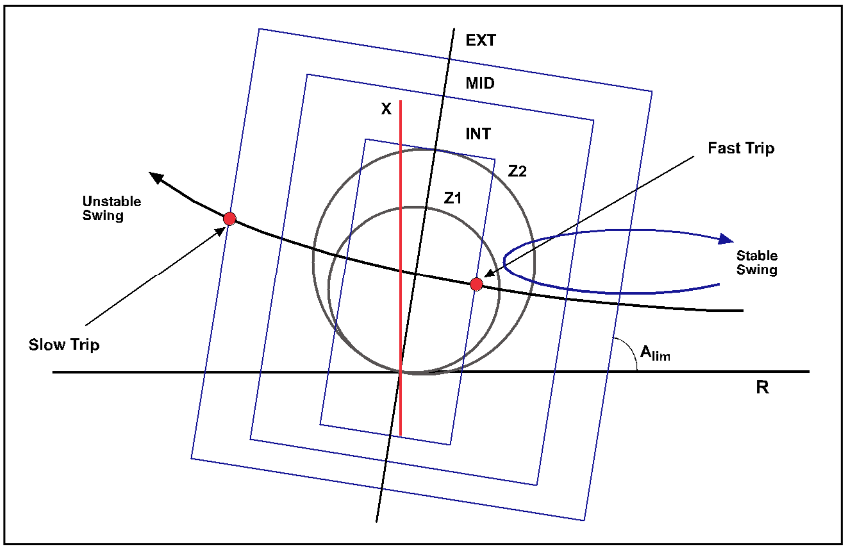


Figure 3.5.8: Power Swing Detector Zones.

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, this zone cannot, under any circumstances, be activated in case of a load condition, given that a blocking condition may arise in this situation, impeding tripping in case of fault. 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:

a. **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.
b. **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 center 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 **IDV-F** installed at one end of a line is in charge of tripping only unstable power swings viewed in a forward direction and whose electric center 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 center is in a remote line. In case of not having other protection which trips in case of swings with an electric center in adjacent lines, it will be necessary to extend these impedance reaches.

3.5.5.e Operation

The operation of the Power Swing Detector is shown in Figure 3.5.9:

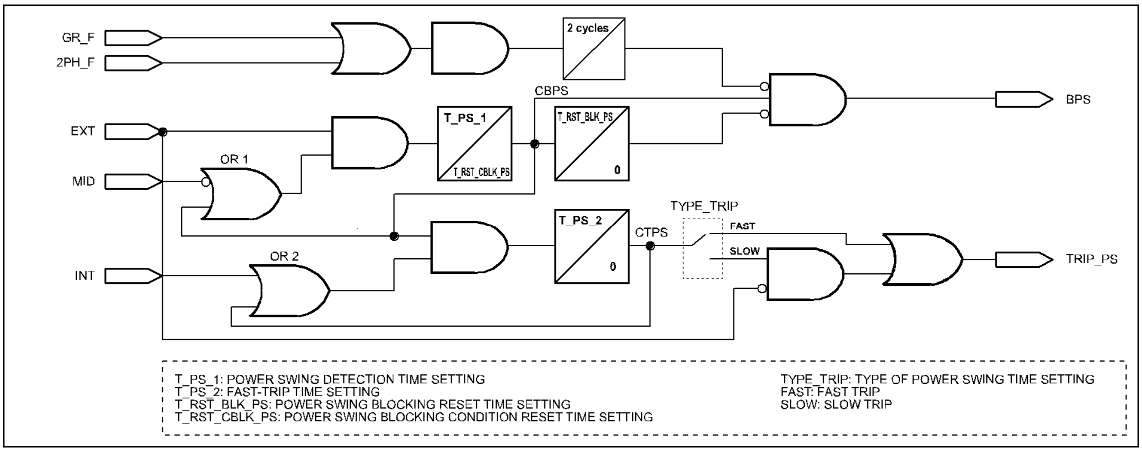


Figure 3.5.9: Block Diagram of the Power Swing Detector.

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 **Ground Fault** (**GR_F**) or **Two-Phase Fault** (**2PH_F**) signals originating from the phase selector is activated. 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 **2PH_F** or the **GR_F** signals are activated, the **BPS** signal will be deactivated after two cycles, avoiding zone 1 trips since the impedance zone was passing that zone in the moment the asymmetry was detected (**Ground Fault** or **Two-Phase Fault**).
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.

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 3.5.8 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** (**Power Swing Reset Time**), 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 favorable 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 four 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.

3.5.6 Setting Ranges for the Protection Schemes for Distance Elements

Phase Selector			
Setting	**Range**	**Step**	**By default**
Weak feed undervoltage level	15 - 70 V	0.01 V	45 V

VT Fuse Failure Detector			
Setting	**Range**	**Step**	**By default**
Permissive fuse failure detector	YES / NO		
Permissive fuse failure block	YES / NO		
Block input reset time	0 - 1000 ms	50 ms	

Load Encroachment			
Setting	**Range**	**Step**	**By default**
Permissive load limiter	YES / NO		NO
Right area resistive limit	(0.5 - 500)/In Ω	0.01 Ω	325 In
Left area resistive limit	(0.5 - 500)/In Ω	0.01 Ω	325 In
Right area angle	0 - 90º	1º	20º
Left area angle	0 - 90º	1º	20º

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 - 1.00 s	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 - 1.00 s	0.002 s	0.05 s
Power Swing Condition Reset Time	0.02 - 1.00 s	0.002 s	0.05 s

- **Protection Schemes for Distance Elements: HMI Access**

Phase Selector

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	**1 - PHASE SELECTOR**
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	
1 - PHASE SELECTOR	**0 - WI UNDERVOLT LEVEL**
...	

VT Fuse Failure Detector

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	**3 - FUSE FAILURE**
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	**0 - FF DET ENABLE**
1 - PHASE SELECTOR	**1 - FF BLOCK ENABLE**
2 - DIST SUPERVISION	**2 - FF INPUT DO DLY**
3 - FUSE FAILURE	
...	

Load Encroachment

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	**4 - LOAD ENCROACHMENT**
	5 - LOCKOUT PERM	5 - POWER SWING DETECTOR
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	**0 - LOAD ENCROACH ENAB**
...	**1 - RIGHT AREA RES LIM**
4 - LOAD ENCROACHMENT	**2 - LEFT AREA RES LIM**
...	**3 - RIGHT AREA ANGLE**
	4 - LEFT AREA ANGLE

Power Swing Detector

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	4 - TRIP PERMISIONS	4 - LOAD ENCROACHMENT
	5 - LOCKOUT PERM	**5 - POWER SWING DETECTOR**
	6 - TRIP OUTPUTS	6 - OPEN BREAKER DET
	7 - LOGIC	7 - DIFFERENTIAL
	8 - CIRCUIT COIL SUPERV	8 - EXT FAULT DETECTOR
	9 - HISTORY	9 - WINDING 1
	10 - OSCILLOGRAPHY	10 - WINDING 2
	11 - DIGITAL PLL	11 - WINDING 3
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE	**0 - PS DETEC ENABLE**
...	**1 - PS TRIP ENABLE**
5 - 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
	21 - POW. SWING BLOCK MSK

0 - PS DETEC ENABLE	**0 - Z1 BLOCK**
...	**1 - Z2 BLOCK**
21 - POW. SWING BLOCK MSK	**2 - Z3 BLOCK**
...	**3 - Z4 BLOCK**

3.5.7 Digital Inputs for the Protection Schemes for Distance Elements

Table 3.5-3: 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.

Table 3.5-4: 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.”

Table 3.5-5: 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.”

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

3.5.8 Auxiliary Outputs and Events of the Protection Schemes for Distance Elements

Table 3.5-6: Auxiliary 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	Multi-Phase fault	

Table 3.5-7:Auxiliary Outputs and Events for the Final Selection of Fault Type (IDV-D)**

Name	Description	Function
GR_F	Ground fault	Indication of type of fault.
2PH_F	Two-phase fault	
MULTIPH_F	Multi-Phase fault	

Table 3.5-8: Auxiliary 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.
ENBL_FF	VT fuse failure detector enable input	The same as for the digital input.
IN_FF	VT fuse failure detector input	The same as for the digital input.

Table 3.5-9: Auxiliary 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.
ENBL_ENCR	Load encroachment elements enable input	The same as for the digital input.

Table 3.5-10: Auxiliary 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.
ENBL_PS	Power swing detector enable input	The same as for the digital input.

3.5.9 Tests of the Protection Schemes for Distance Elements

3.5.9.a VT Fuse Failure Detector Test

Enable the Fuse Failure detector and disable all of the other Auxiliary Units. Configure the auxiliary output as indicated in Table 3.511.

Table 3.5-11: 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:

In the display on the **Information** - **Status** - **Measuring Elements** - **VT Fuse Failure Detector** screen, or on the status screen of the ***ZivercomPlus***® (**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.

3.5.9.b 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 Vac 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 Vac 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.

3.5.9.c Power Swing Detector Test

Enable the Power Swing Detector by adjusting and disable the other Units.

During the test, consult the following indicators:

In the display on the **Information** - **Status** - **Metering Units** - **Power Swing Detector** screen, or on the status screen of the ***ZivercomPlus***® (**Status** - **Elements** - **Power Swing Detector**).

- **Activation Test of the Characteristics**

Configure the unit as indicated in Table 3.5-12 (for In = 5 A):

Table 3.5-12: 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.

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 3.5-13.

Table 3.5-13: Pickup Ranges for the Zones

Zone	Activation Voltage (V)			
	Phase I=0º	**Phase I=45º**	**Phase I=90º**	**Phase I=135º**
EXT	38.8 – 41.2	56 – 59.47	50.21 – 53.32	43.28 – 45.95
MID	29.1 – 30.9	44.8 – 47.57	40.17 – 42.65	32.46 – 34.46
INT	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**
EXT	38.8 – 41.2	56 – 59.47	50.21 – 53.32	43.28 – 45.95
MID	29.1 – 30.9	44.8 – 47.57	40.17 – 42.65	32.46 – 34.46
INT	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 pick up 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

- **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 Vac 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 Vac 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.

- **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 Vac 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 **Activation Test of the Characteristics**, 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).

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 Vac 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 **Activation Test of the Characteristics**, 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).

3.6 Overcurrent Units

- Three Phase Instantaneous Overcurrent elements for each winding (50F_1D1, 50F_1D2, 50F_1D3, 50F_2D1, 50F_2D2, 50F_2D3, 50F_3D1, 50F_3D2, 50F_3D3).
- Two Calculated Ground Instantaneous Overcurrent elements for each winding (50N_1D1, 50N_1D2, 50N_2D1, 50N_2D2, 50N_3D1, 50N_3D2).
- Two Negative Sequence Instantaneous Overcurrent elements for each winding (50Q_1D1, 50Q_1D2, 50Q_2D1, 50Q_2D2, 50Q_3D1, 50Q_3D2).
- Two Ground Instantaneous Overcurrent elements for each metering channel (50G_11, 50G_12, 50G_21, 50G_22).
- Two additional ground instantaneous overcurrent elements per each phase intended for the third winding (50G_13, 50G_14, 50G_15, 50G_23, 50G_24, 50G_25) (models **IDV-L** with setting **Number of Windings** set to **Two Windings** and **Third Winding Current Channels** setting in **Ground Currents**).
- One Tertiary Instantaneous Overcurrent element (without restraint) (50SFA).
- One Tertiary Instantaneous Overcurrent element (with restraint) (50FA).
- Two Phase Time Overcurrent elements for each winding (51F_1D1, 51F_1D2, 51F_1D3, 51F_2D1, 51F_2D2, 51F_2D3, 51F_3D1, 51F_3D2, 51F_3D3).
- Two Calculated Ground Time Overcurrent elements for each winding (51N_1D1, 51N_1D2, 51N_2D1, 51N_2D2, 51N_3D1, 51N_3D2).
- Two Negative Sequence Time Overcurrent elements for each winding (51Q_1D1, 51Q_1D2, 51Q_2D1, 51Q_2D2, 51Q_3D1, 51Q_3D2).
- Two Ground Time Overcurrent elements for each metering channel (51G_11, 51G_12, 51G_21, 51G_22).
- Two additional ground time overcurrent elements per phase intended for the third winding (51G_13, 51G_14, 51G_15, 51G_23, 51G_24, 51G_25), (models **IDV-L** with setting **Number of Windings** set to **Two Windings** and **Third Winding Current Channels** setting in **Ground Currents**).
- One Voltage dependent Phase Instantaneous Overcurrent Element (50V).
- One Voltage dependent Phase Time Overcurrent Element (51V).

Note: the number of overcurrent units depends on the number of windings for protecting the equipment (two windings for IDV-A/G/J/L and three windings for IDV-B/D/F/H/K/L).

Note: Voltage Dependent Overcurrent Units are only available for IDV-J/K/L Models.

Note: IDV-F relays do not incorporate ground overcurrent or negative sequence elements.

Note: Models IDV-L and IDV-K with option E or higher in digit 9 (see 1.5, Model Selection) may contemplate two or three windings as a function of the setting *Number of Windings* (see, 3.18, General Settings).

3.6.1 Obtaining Winding Currents

In **IDV-A/B/G/H** relays, channel currents IAn, IBn, ICn are directly related to phase currents of winding n (n=1, 2 in **IDV-A/G** and n=1, 2, 3 in **IDV-B/H**). However, in **IDV-D/F** relays, winding n phase currents (n=1, 2, 3) are obtained from currents measured by channels IAm, IBm, ICm (m=1, 2, 3, 4) based on **Winding Current** configuration settings **n**, n=1, 2, 3 (see 3.18). Also, for models **IDV-L** and **IDV-K** with option **E** or higher in digit **9** (see 1.5, Model Selection), the phase currents of the winding n (n=1, 2 or 3) are obtained from the currents measured by channels I_{Am}, I_{Bm}, I_{Cm}, based on the configuration setting **Number of Windings** (refer to 3.18, General Settings).

3.6.2 Phase Instantaneous Elements

Phase Instantaneous elements work according to the RMS value of the input currents of each winding. Elements activate when RMS values exceed 1.05 times the pickup setting, and reset at 1 time the pickup setting.

Elements are provided with adjustable timers that allow for optional timing of instantaneous elements.

3.6.3 Calculated Ground Instantaneous Elements

Instantaneous Calculated Ground elements operate according to the effective value of the ground current of each winding, calculated internally as the phasor sum of the three phase currents.

$$\overline{I}_{N1} = \overline{I}_{A1} + \overline{I}_{B1} + \overline{I}_{C1}$$
$$\overline{I}_{N2} = \overline{I}_{A2} + \overline{I}_{B2} + \overline{I}_{C2}$$
$$\overline{I}_{N3} = \overline{I}_{A3} + \overline{I}_{B3} + \overline{I}_{C3}$$

Operation occurs when the effective value exceeds the set pickup value by 1.05 times and resets at 1 time the pickup setting. Additionally, it can be controlled by the directional unit, with having a Torque Control setting.

Each of these elements has an adjustable timer at the output that allows the optional delay of the instantaneous elements.

3.6.4 Negative Sequence Instantaneous Element

Negative sequence instantaneous element algorithm is the same as for phase. The algorithm uses only the criteria of negative sequence current RMS value calculated from phase currents of each winding.

$$\left|I_{2_1}\right| = \left|\frac{I_{A1} + I_{B1} \cdot 1\angle 240^\circ + I_{C1} \cdot 1\angle 120^\circ}{3}\right|$$
$$\left|I_{2_2}\right| = \left|\frac{I_{A2} + I_{B2} \cdot 1\angle 240^\circ + I_{C2} \cdot 1\angle 120^\circ}{3}\right|$$
$$\left|I_{2_3}\right| = \left|\frac{I_{A3} + I_{B3} \cdot 1\angle 240^\circ + I_{C3} \cdot 1\angle 120^\circ}{3}\right|$$

3.6.5 Ground Instantaneous Elements (IDV-A/B/D/G/H/J/K/L Models)

The **IDV-A/B/D/H/K** equipments have two analog input channels (IG-1 and- IG-2) to measure currents that can flow through the machine grounding (if there are any). Each of these analog channels can be assigned to the corresponding machine winding via the proper setting. **IDV-G/J** model has one analog input channel (IG1) to measure currents that can flow through the machine grounding (if there are any). This channel can be assigned to the corresponding machine winding via the proper setting. For **IDV-L** relays, three additional analog ground channels can be obtained provided the **Number of Windings** setting is set to **Two-Windings** and the **Third Winding Current Channels** setting is set to **Ground Currents** (refer to 3.18, General Settings).

For each analog ground input there are two non-directional instantaneous elements. Their algorithms are the same as in previous overcurrent elements, acting only by the RMS value criteria when the measured value exceeds the set pickup by 1.05 times, with reset occurring at 1 time the set value.

3.6.6 Phase, Calculated Ground, Negative Sequence and Ground Time Elements

In the phase, calculated ground, negative sequence and ground elements, the time overcurrent element operates on the input current RMS value:

- Phase: Measured phase winding current. For **IDV-L** relays, third winding currents can be used as phase currents when the **Number of windings** setting is set to **Two windings** and the **Third Winding Current Channels** setting is set to **Phase Currents**, or when the **Number of Windings** setting is set to **Three windings**. For **IDV-K** relays with the **E** option or above digit **9**, third winding currents can be used as phase currents when the **Number of Windings** setting is set to **Two Windings**. (refer to 3.18. General Settings).
- Calculated ground: Calculated currents based on phase currents for each of the windings (I_{N1}, I_{N2} and I_{N3}).
- Negative sequence: Negative sequence currents of each winding ($I2_1$, $I2_2$ and $I2_3$).
- Ground: Currents measured through the two dedicated ground current channels. For model **IDV-L**, three additional ground analog channels could be obtained provided the setting **Number of windings** is set to **Two Windings** and the **Third Winding Current Channels** setting is set to **Ground Currents** (refer to 3.18, General Settings).

Element picks up when the measured value exceeds 1.05 times the setting value, and resets at 1 time the setting value.

Calculated ground elements can be controlled by the directional unit, with having a torque control setting.

Element pickup enables the time delay function, which will make an integration of the measured values. This is carried out applying input current-dependant increments over a meter, the end of count of which governs the operation of the time overcurrent element.

Drop of the measured RMS value below the pickup setting value results in a quick integrator reset. For output activation, pickup must be active during the entire integration time; any integrator reset brings the integrator back to initial conditions, so that new activations start timing from zero.

Time characteristics can be selected among the various types of curves according to **IEC**, **IEEE** (Standard IEEE 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 time inverse curve	Long time inverse curve + time limit
Short time inverse curve	Short time 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 time inverse curve	Short time inverse curve + time limit

The **RI Inverse Curve** may be added to the above curves, mainly used with electromechanical relays.

Time Dial setting is the same as for **IEC**, **IEEE**, **US** and **RI Inverse** curves: range is 0.05 to 10 times.

Nevertheless, effective range for **IEC** curves is 0.05 to 1; for settings above 1, the maximum value of 1 is used. Effective range for the other curves (**IEEE**, **US** and **RI**) starts from 0.1 times; settings below this value operate as if they were set to the minimum value (0.1 times). Furthermore, although setting vary in steps of 0.01, the effective step for these three types of curve is 0.1; any setting other than a multiple of 0.1 will be rounded to the nearest tenth, namely, a setting of 2.37 will be applied as if it were 2.40 and a setting of 2.33 will be applied as if it were 2.30 (the setting 2.35 will be applied as if it were 2.40).

Time Multiplier and **Curve Type** settings are interrelated so that the IED will accept just those combinations which are valid.

A **User-Defined** time characteristic may be added to the above characteristics, downloading it into the relay through the communications system. For inverse-time characteristics, delay time settings are composed of two values: **Curve Type** and **Time Multiplier** (**Dial**) within the family.

Curve types with **Time Limit** are regular time delayed functions with a time threshold, so that no trip takes place before the specified time. This results in that beyond a specified time the tripping curve turns into a horizontal straight line. This operate time limit coincides with the time setting used in the **Definite Time** option.

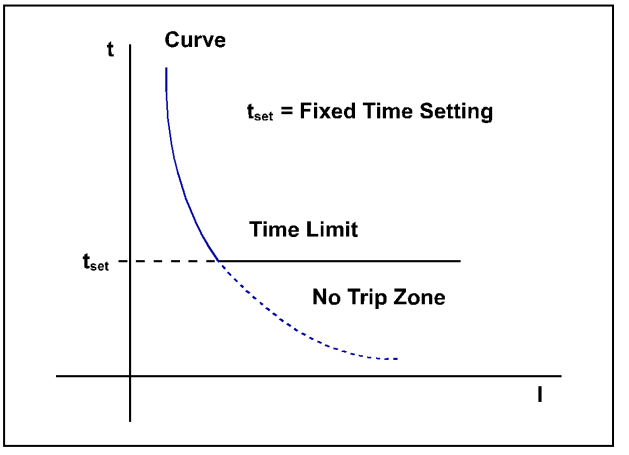


Figure 3.6.1: Diagram of a Curve with a Time Limit for a Time Overcurrent Element.

Definite Time setting range might be excessive compared with curve times. If this should be the case, if curve time (for the dial setting and a current 1.5 times greater than the setting) is less than the **Definite Time** setting, a time delay corresponding to 1.5 times the current is used as a limit line for element operation.

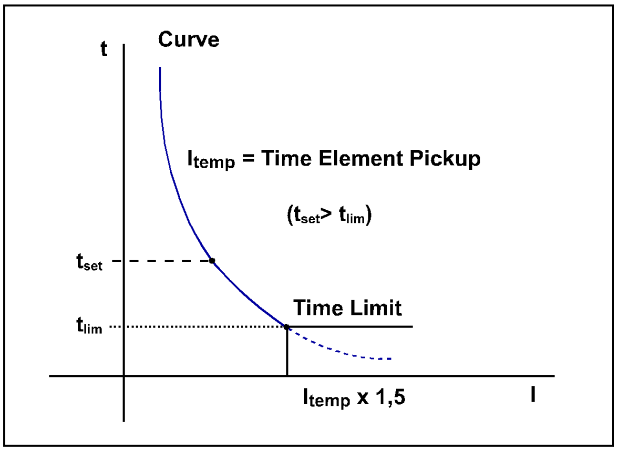


Figure 3.6.2: Time Limit of the Element when the Definite Time is greater than the Curve Time (in pickup x 1.5).

Note: it is worth highlighting that although curves are defined for an input value of up to 20 times the tap, which is the pickup setting of each of the time overcurrent elements, said range cannot always be guaranteed.

Bear in mind that current channel saturation limits are 160 A for phases and calculated ground and 60 A for grounding analog inputs. Based on these limits, the "times the tap" for which curves are effective is a function of the setting:

If $\frac{Saturation\ Limit}{Element\ Setting} > 20$ **, curve operation is guaranteed for elements with said setting over the entire tap range (up to 20 times the setting).**

If $\frac{Saturation\ Limit}{Element\ setting} < 20$ **, curve operation is guaranteed for elements with said setting up to a number of times the tap equal to the result of dividing the saturation limit by the applicable setting. Namely, for a Ground element set to 12A, curves will be effective up to** $\frac{60}{12} = 5$ **times the setting.**

If the current at said Ground channel exceeds 60A, the relay measures said 60A and trip time corresponds to 5 times the tap.

When a current above 20 times the setting is injected, trip time will be the same as for said 20 times.

3.6.6.a Current / Time Curve: Inverse Functions

Figures 3.6.3, 3.6.4, 3.6.5, 3.6.6 and 3.6.7 present the inverse curves according to the IEC standards.

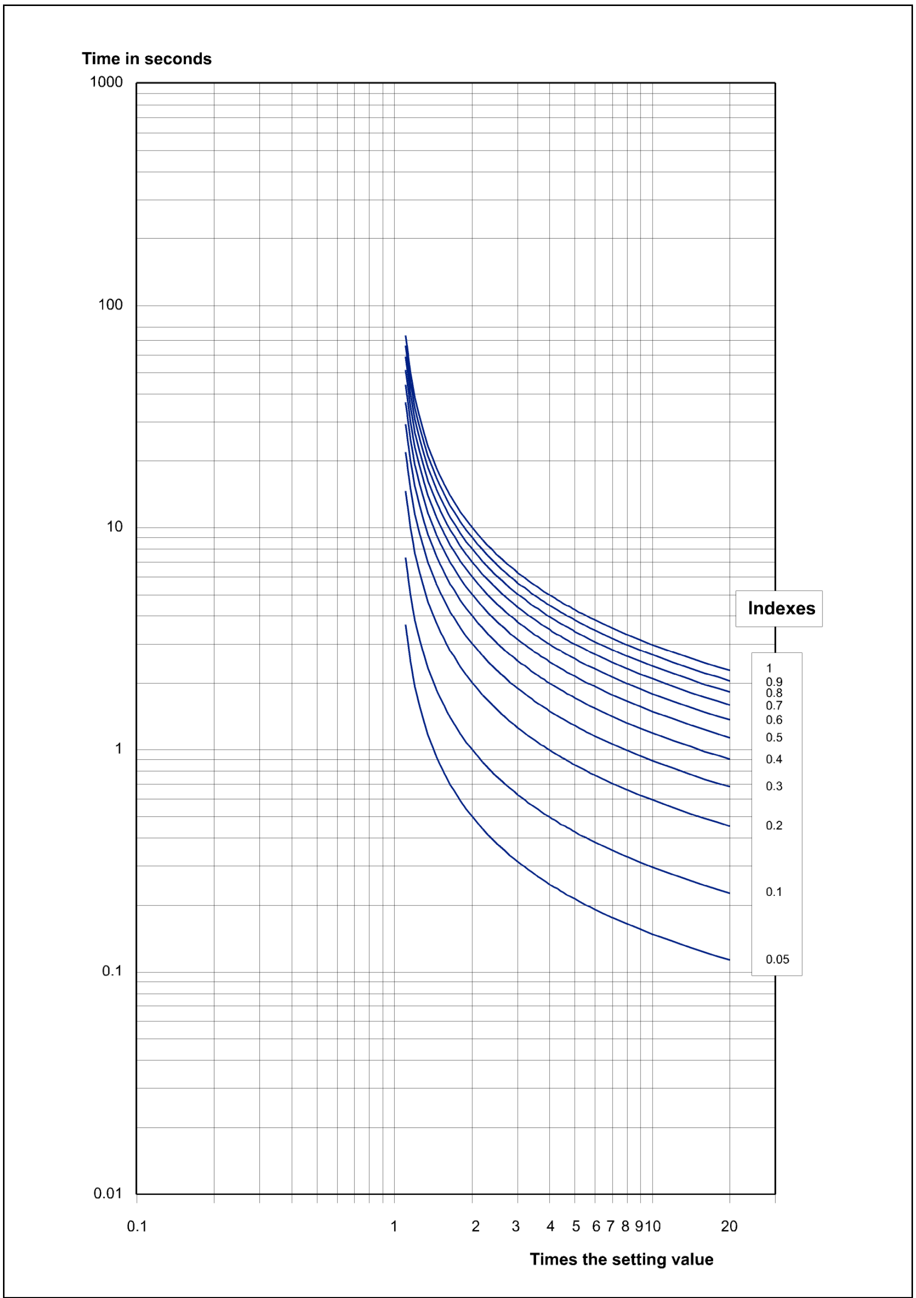


Figure 3.6.3: INVERSE Time Curve (IEC).

$t = \dfrac{0.14}{I_S^{\,0.02} - 1} \times \text{Index}$	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

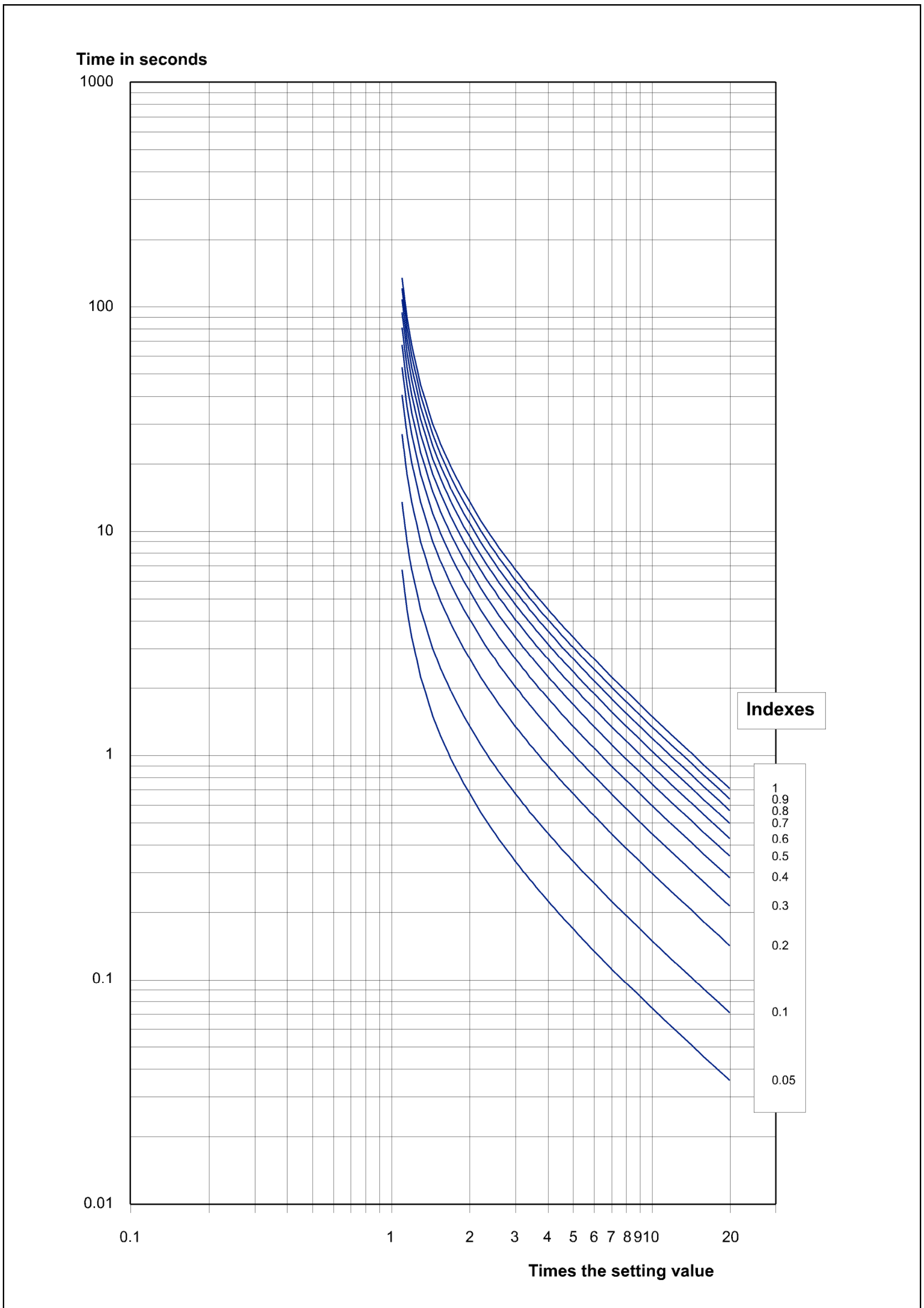


Figure 3.6.4: VERY INVERSE Time Curve (IEC).

$t = \frac{13.5}{I_S - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

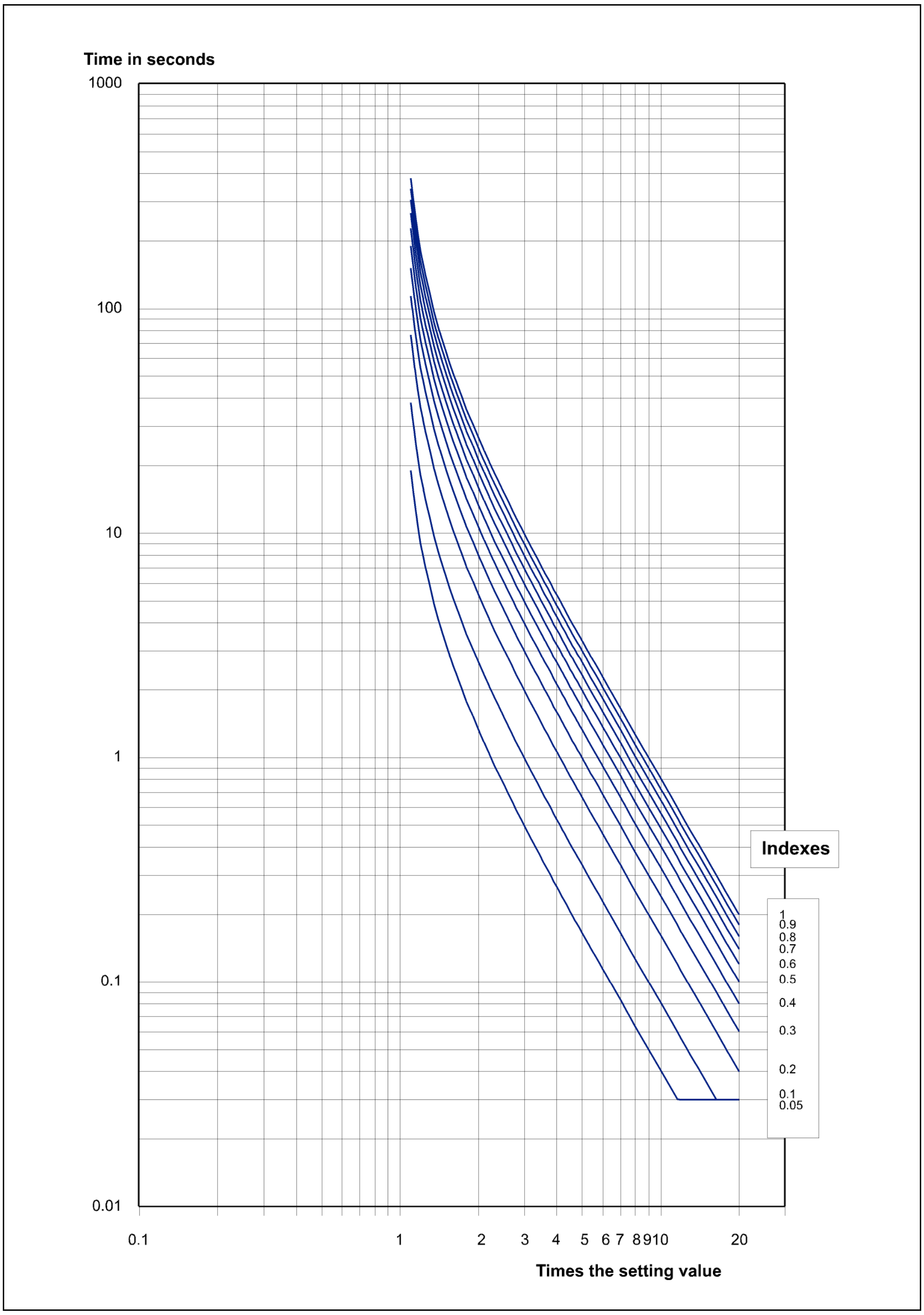


Figure 3.6.5: EXTREMELY INVERSE Time Curve (IEC).

$t = \frac{80}{I_S^2 - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

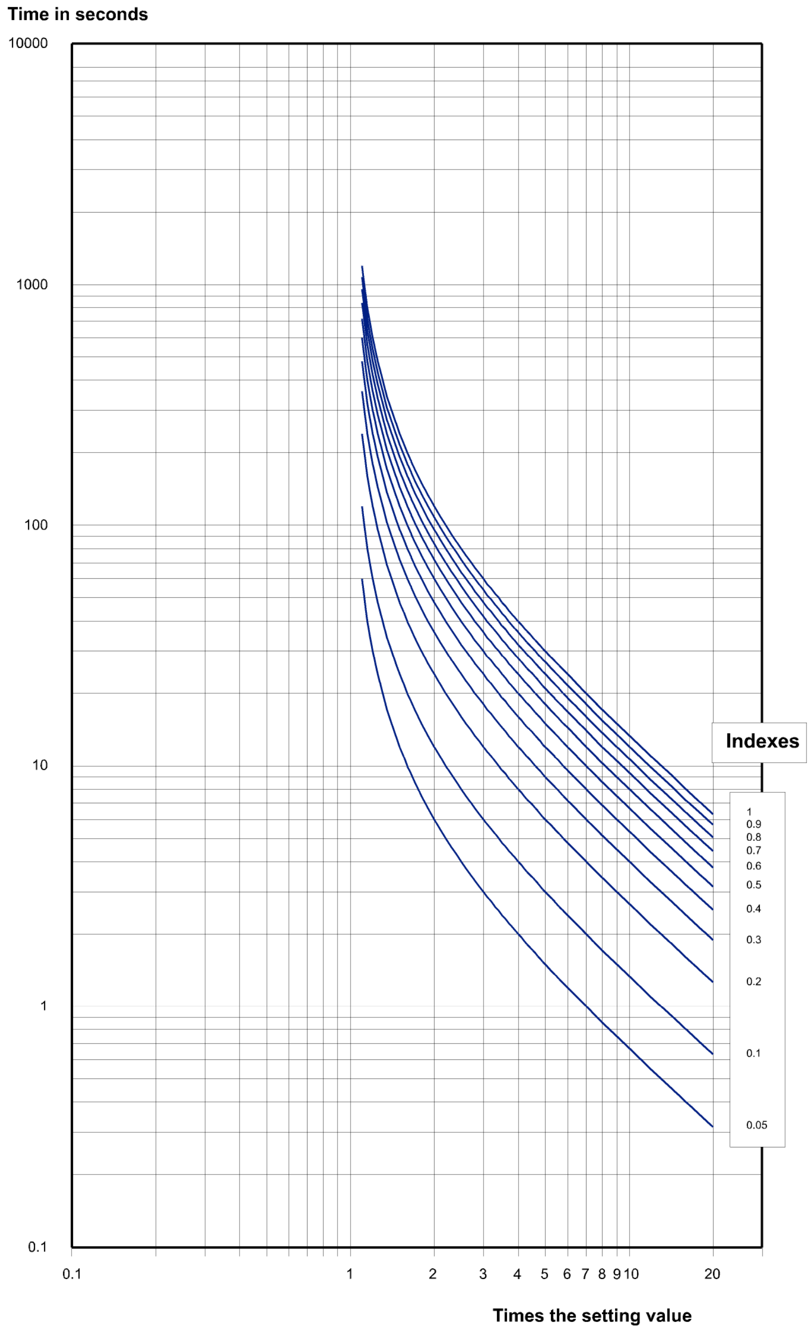


Figure 3.6.6: LONG TIME-INVERSE Curve (IEC).

$t = \frac{120}{I_S - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

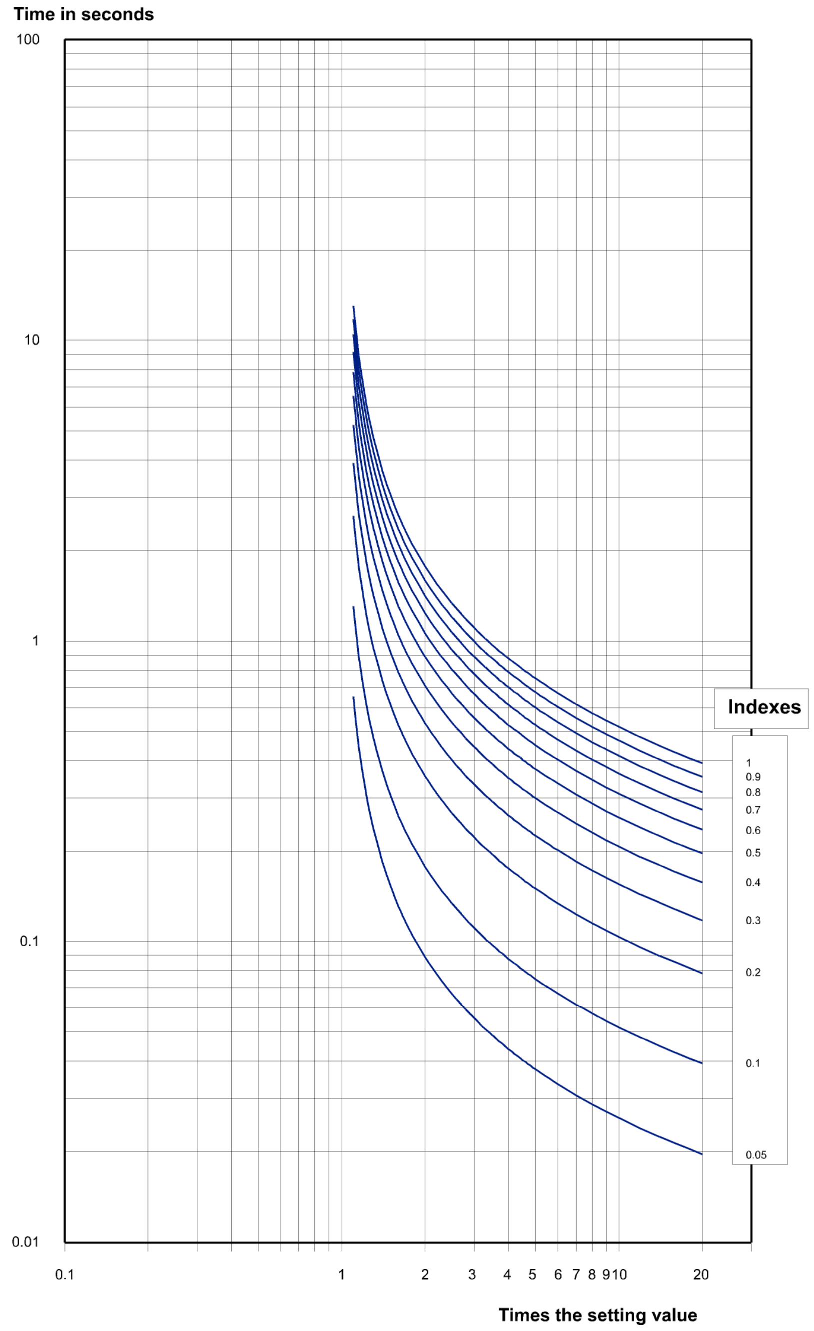


Figure 3.6.7: SHORT TIME-INVERSE Curve (IEC).

$t = \frac{0.05}{I_S^{0.04} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

Figures 3.6.8, 3.6.9, 3.6.10, 3.6.11, 3.6.12, 3.6.13, 3.6.14 and 3.6.15 present the inverse curves according to the IEEE and US standards.

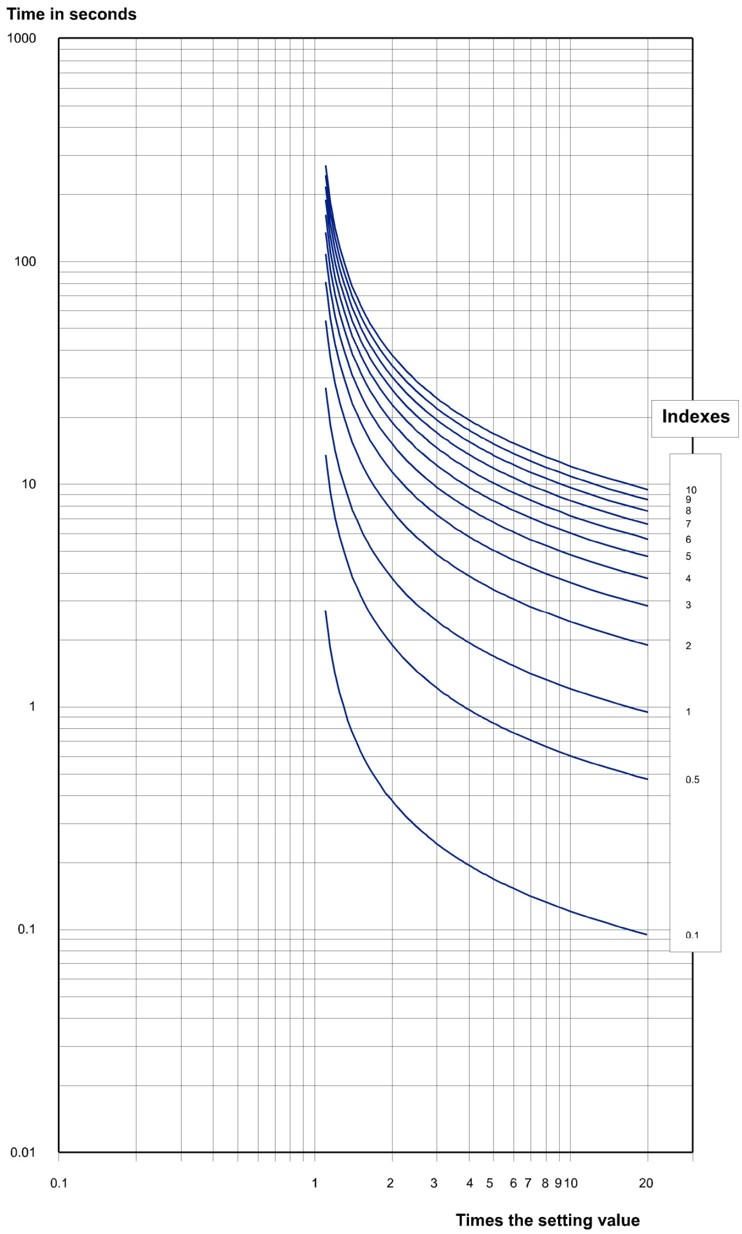


Figure 3.6.8: MODERATELY INVERSE Time Curve (IEEE).

$t = 0.114 + \frac{0.0515}{I_S^{0.02} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

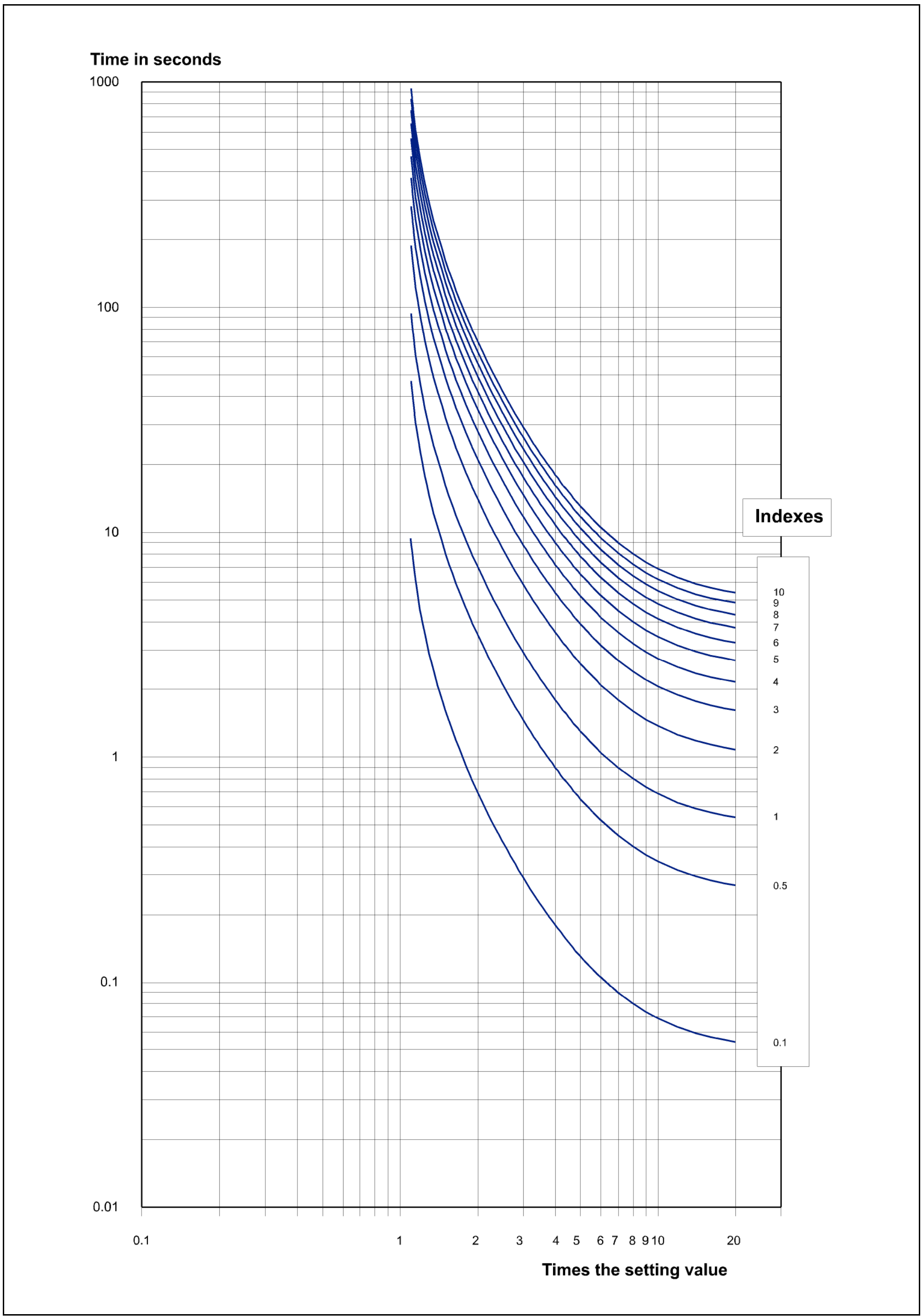


Figure 3.6.9: VERY INVERSE Time Curve (IEEE).

$t = 0.491 + \frac{19.61}{I_S^{\,2} - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

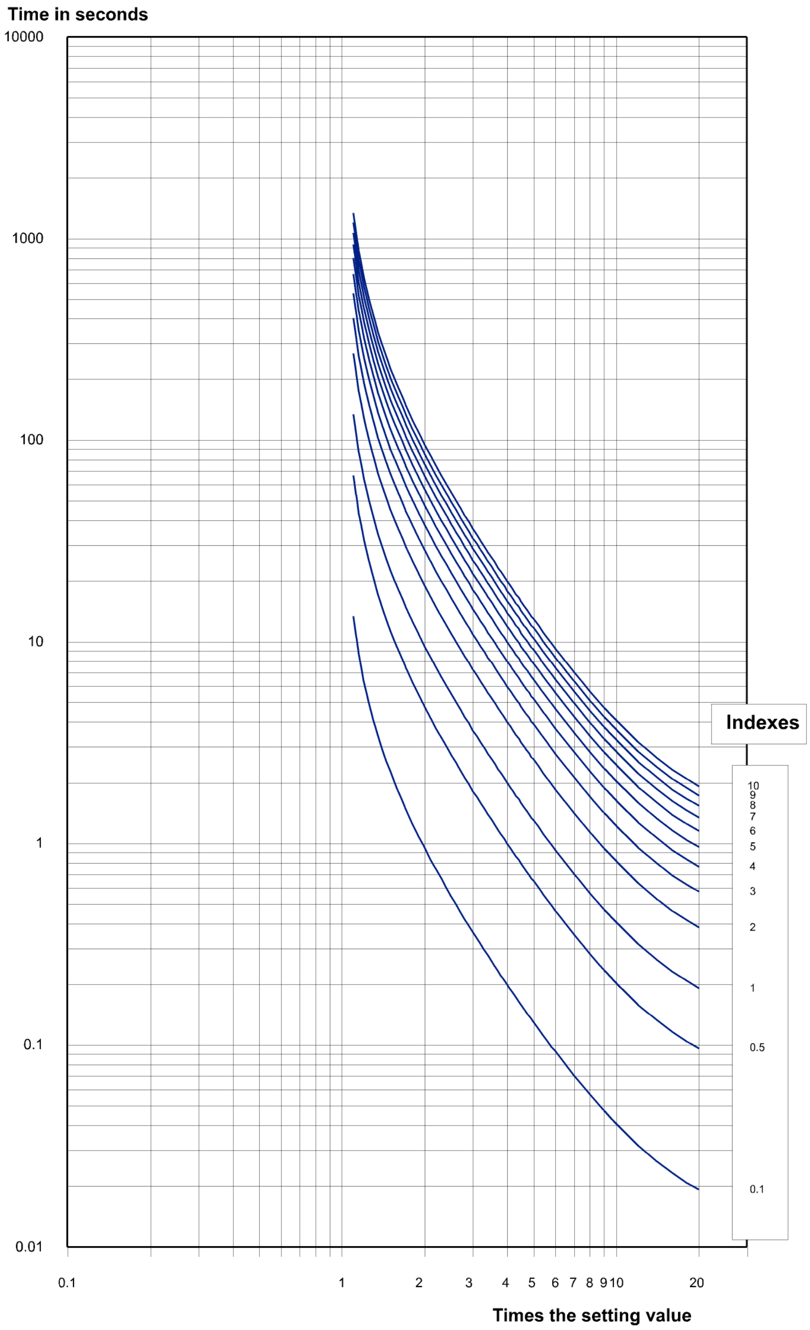


Figure 3.6.10: EXTREMELY INVERSE Time Curve (IEEE).

$t = 0.1217 + \dfrac{28.2}{I_S^{\,2} - 1}$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

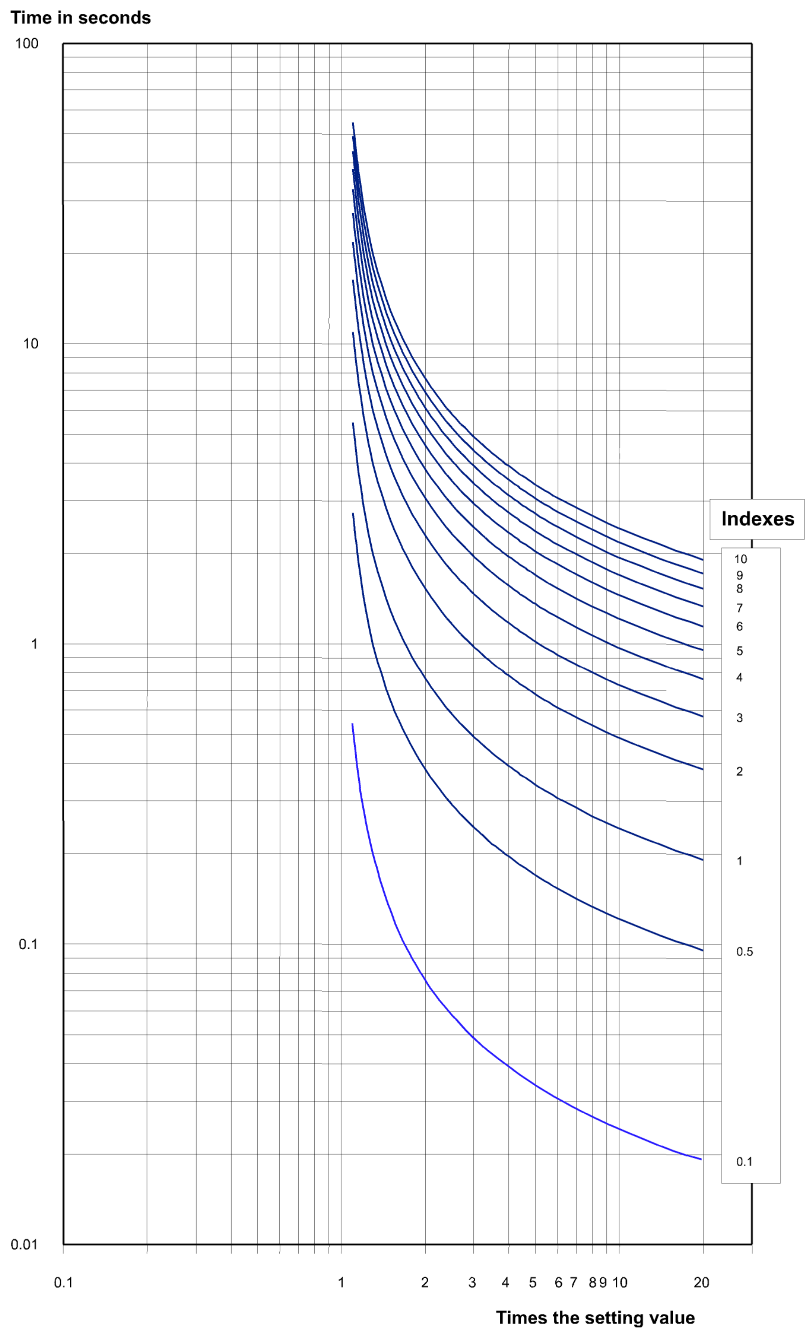


Figure 3.6.11: MODERATELY INVERSE Time Curve (U.S.)

$t = 0.0226 + \dfrac{0.0104}{I_S^{\,0.02} - 1}$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

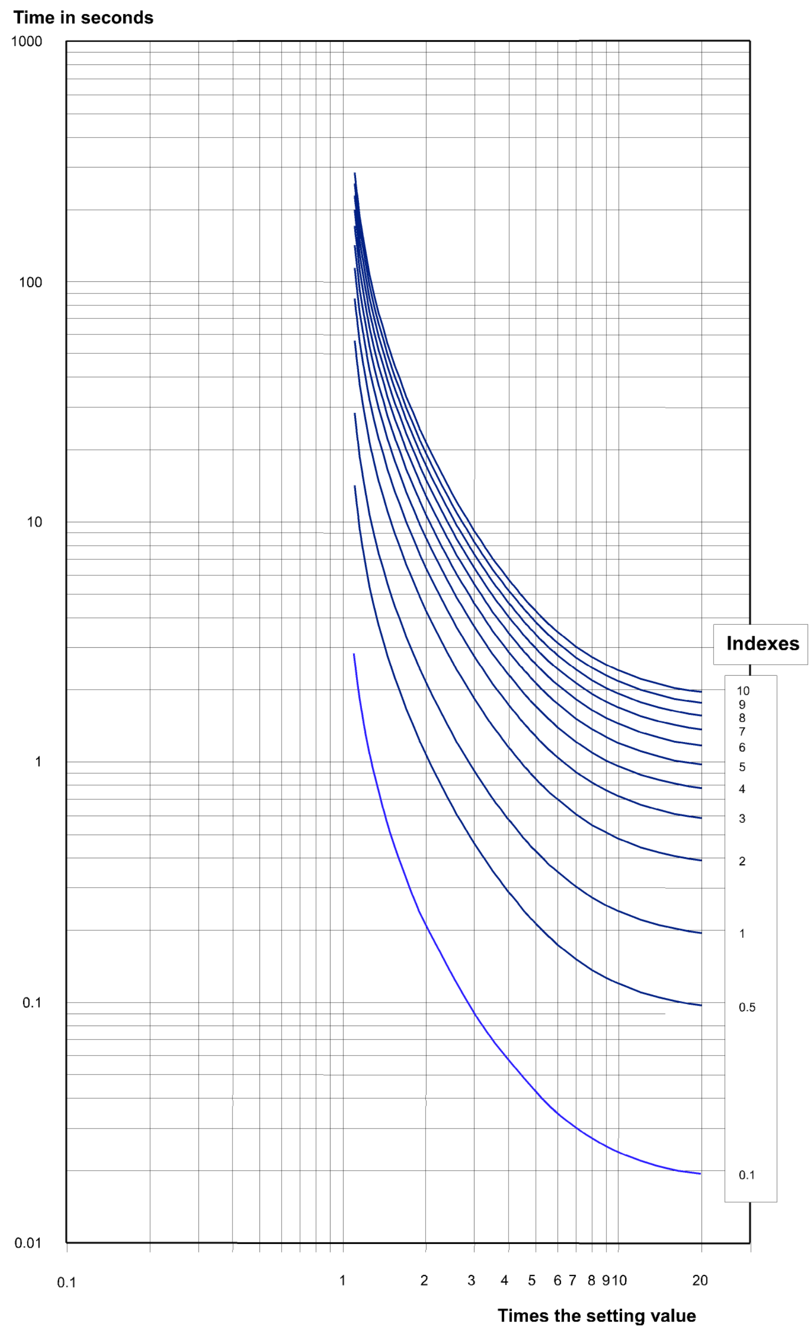


Figure 3.6.12: INVERSE Time Curve (U.S.).

$t = 0.180 + \frac{5.95}{I_S^2 - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

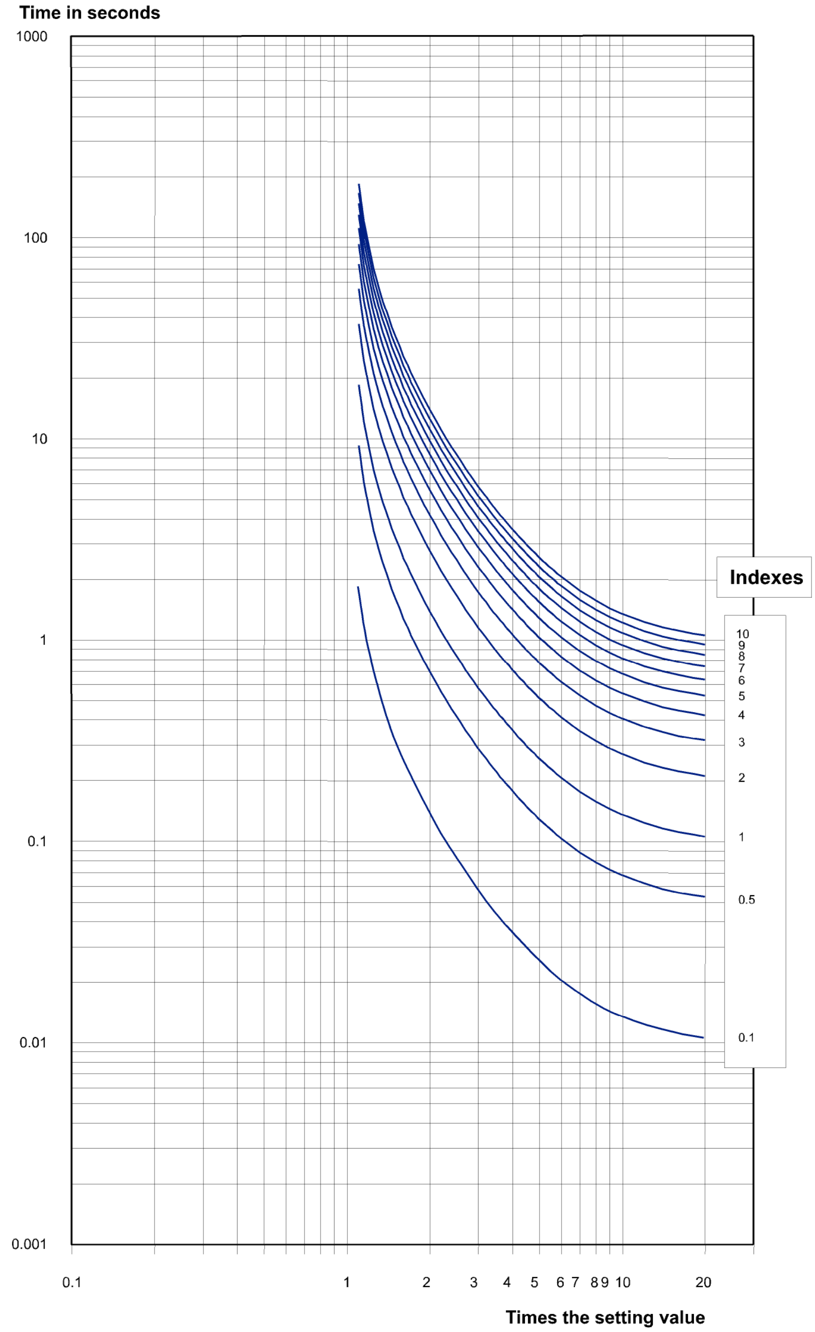


Figure 3.6.13: VERY INVERSE Time Curve (U.S.).

$t = 0.0963 + \frac{3.88}{I_S^2 - 1}$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

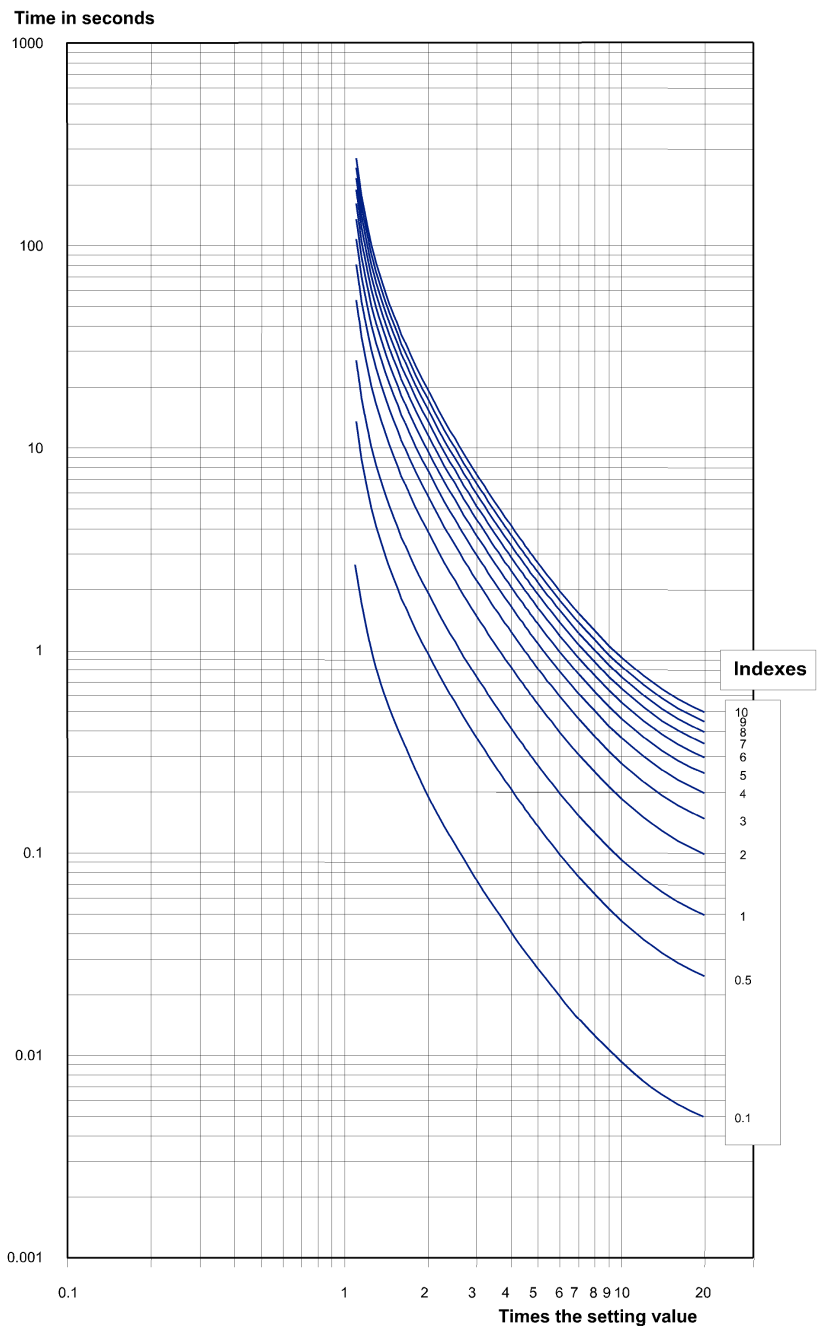


Figure 3.6.14: EXTREMELY INVERSE Time Curve (U.S.).

$t = (0.0352 + \frac{5.67}{I_S^2 - 1})$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

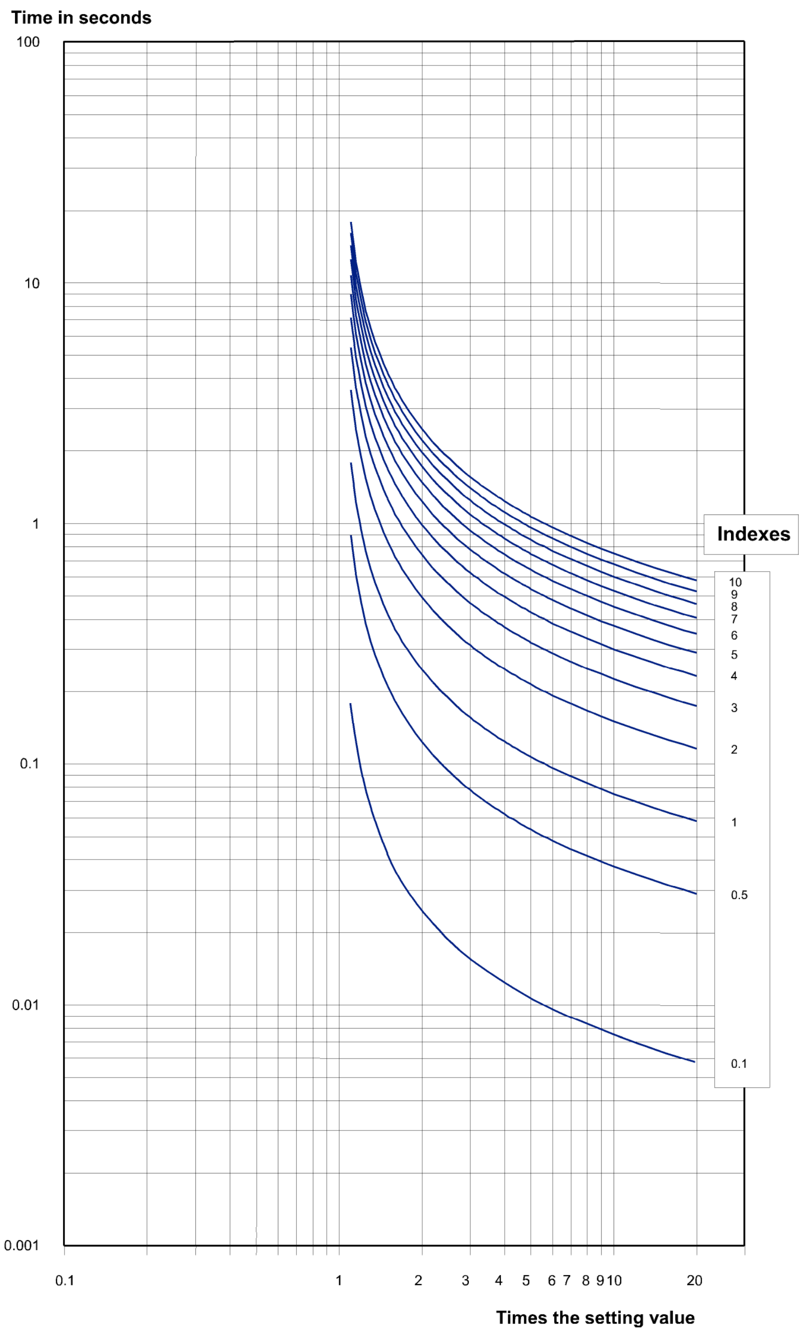


Figure 3.6.15: SHORT INVERSE Time Curve (U.S.).

$t = (0.00262 + \frac{0.00342}{I_S^{0.02} - 1})$ x Index	$I_S = \frac{I_{measured}}{I_{pickup}}$

And figure 3.6.16 presents the RI inverse curve.

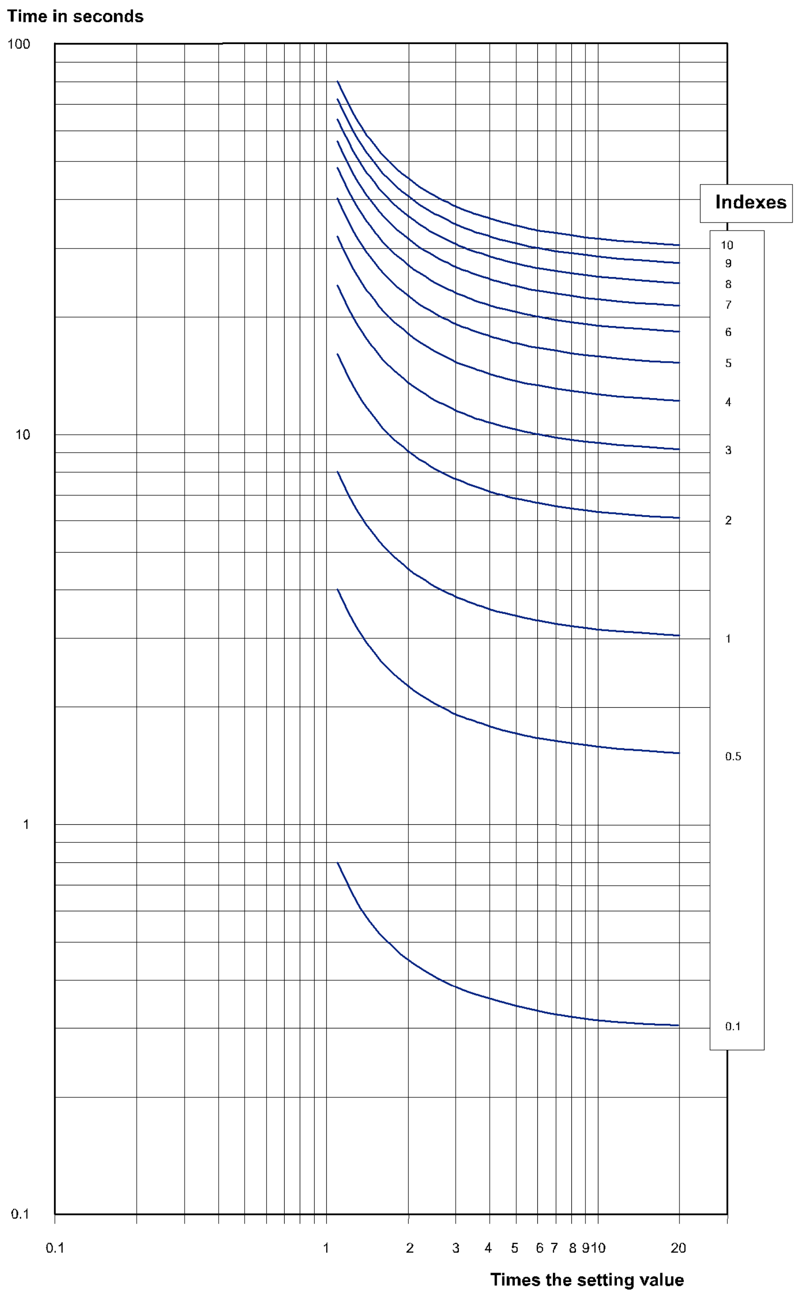


Figure 3.6.16: RI INVERSE Time Curve.

$t = \dfrac{1}{0.339 - 0.236 \cdot \left(\dfrac{1}{I_S}\right)}$ x Index	$I_S = \dfrac{I_{measured}}{I_{pickup}}$

3.6.7 Overcurrent Elements Block Diagrams

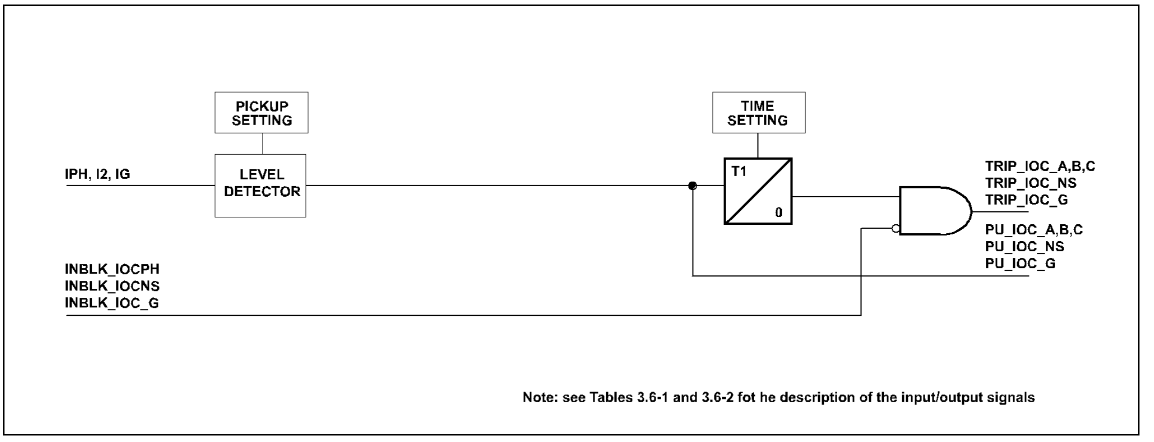


Figure 3.6.17: Block Diagram of a Phase, Negative Sequence or Ground Instantaneous Overcurrent Element.

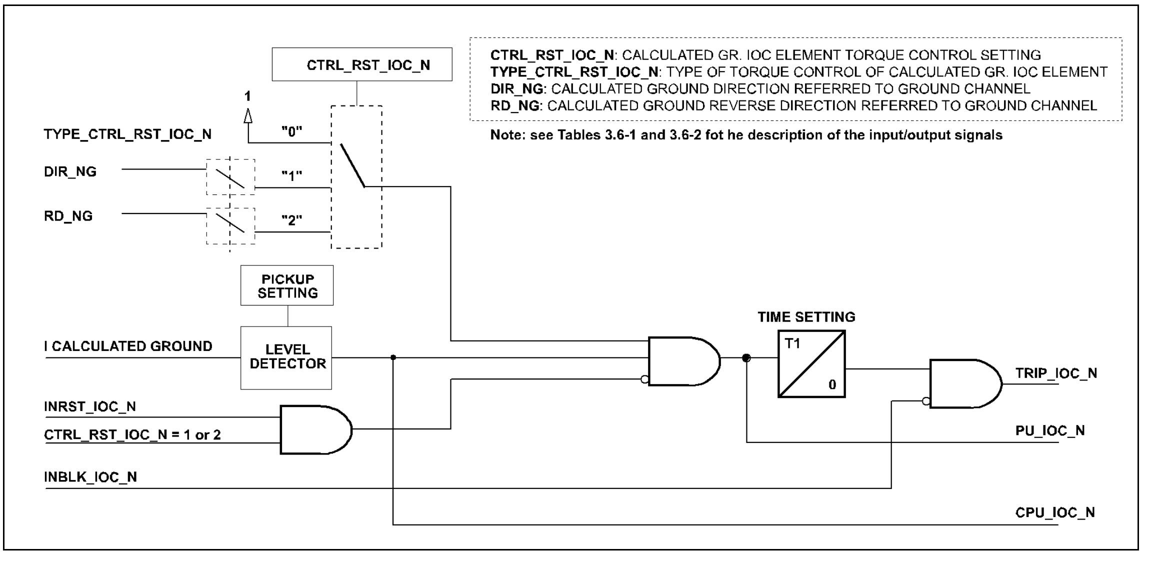


Figure 3.6.18: Block Diagram of a Calculated Ground Instantaneous Overcurrent Element.

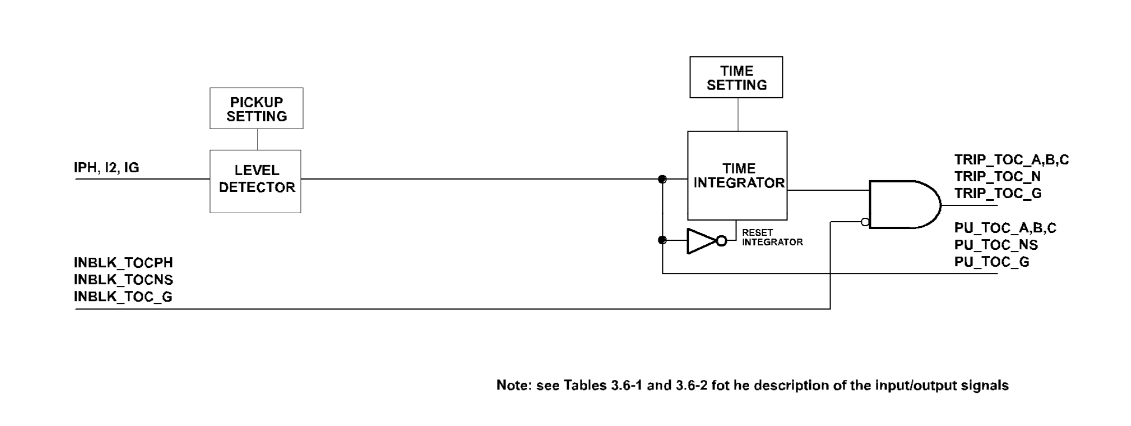


Figure 3.6.19: Block Diagram of a Phase, Negative Sequence or Ground Time Overcurrent Element.

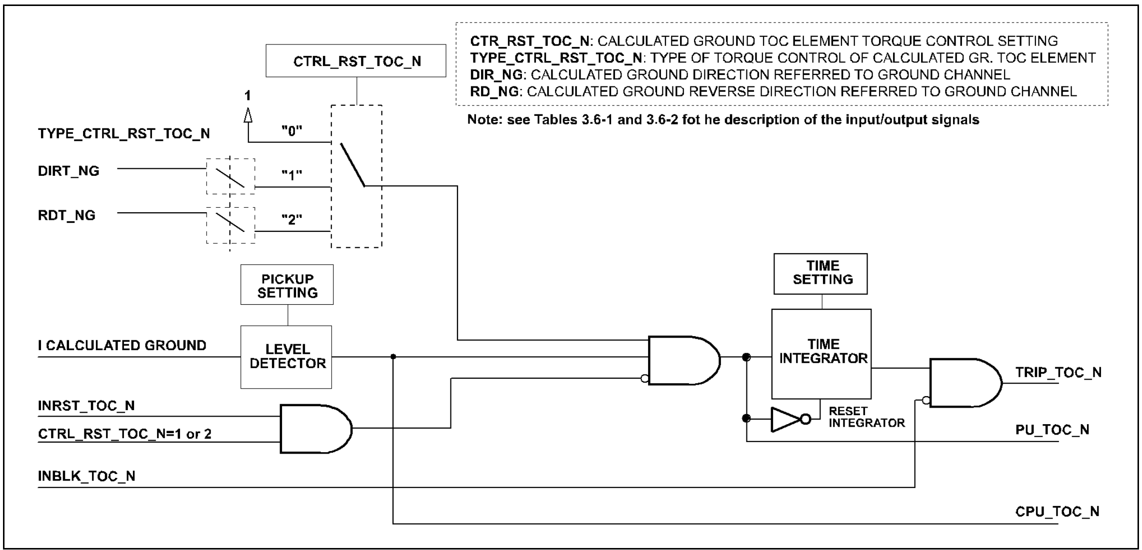


Figure 3.6.20: Block Diagram of a Calculated Ground Time Overcurrent Element.

Direction (**DIR_NG1, DIR_NG2**) and **Reverse Direction** (**RD_NG1, RD_NG2**) signals included in the above diagrams come from the directional units. For more information see 3.7, Directional Units.

3.6.8 Voltage Dependant Elements (IDV-J/K/L)

Voltage Dependant elements are phase overvoltage elements whose pickup level is reset based on a minimum voltage element. They can operate in two modes: Voltage restraint or voltage controlled. **IDV-J/K/L** relays include an instantaneous element (fixed time being possible) and a time element (selectable time characteristic), both elements being able to operate on the above mentioned modes.

The Voltage Dependant Overcurrent protection can be applied, on the one hand, as backup protection in generators. A change in the generator synchronous reactance causes a reduction in fault current time. If this drops below the maximum load current, minimum pickup value of a phase overcurrent element, said element will be reset. Voltage dependence contributes to a greater sensitivity, which guarantees correct discrimination between overload and fault situations.

Voltage Dependant Overcurrent Protection is also applied in very long feeders for which discrimination, based only on current, between a remote two phase and three phase fault and an overload is rather complex.

The change in the pickup level of elements with time characteristic will cause a change of curve. The element computes the trip time corresponding to the new characteristic curve and subtracts the time elapsed from element pickup.

Voltage Dependant Overcurrent elements will use wired phase voltages and phase currents of the reference winding (refer to setting **Reference Winding**, Chapter 3.1).

Note: when the setting *Number of Windings* is set to 2, the setting *Reference Winding* must not ever be set to 3.

3.6.8.a Voltage Restraint Element

The pickup value of the voltage restraint element varies as a function of the measured voltages, and gets more sensitive when voltage decreases. There is one per phase and current depends on phase to phase voltage as shown below.

Table 3.6-1: Voltage Restraint Element

Phase Current	Control Voltage (Phase Sequence ABC)	Control Voltage (Phase Sequence ACB)
IA	UAB	UAC
IB	UBC	UBA
IC	UCA	UCB

The phase to phase voltage is used to increase the sensitivity mainly for phase to phase faults for which the phase voltage may not present a significant drop.

As a consequence of this variable characteristic, coordination with the downstream devices becomes more difficult.

The value by which the pickup setting is multiplied depends on the voltage as shown in figure 3.6.21 and in the table below.

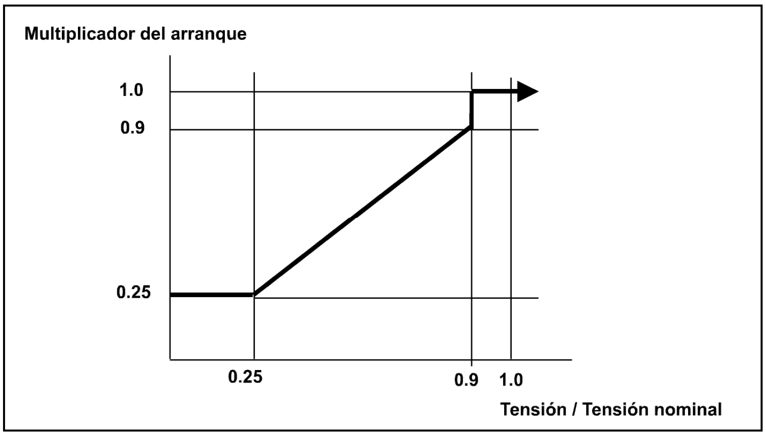


Figure 3.6.21: Voltage Restraint Element.

The voltage ratio is allowed to reach 90% without changing the pickup value. This is due to the fact that measurement errors may appear induced by the accuracy of transformers, etc. If the voltage ratio drops to 25% the setting remains fixed at 25%.

% Nominal Voltage	Pickup Current % Pickup Setting
100	100
90	100
75	75
50	50
25	25
0	25

3.6.8.b Voltage Controlled Element

This element does not pick up until the voltage drops below the voltage setting; a fixed pickup current and operating voltage setting is therefore provided. There is one per phase and each current depends on phase to phase voltages in the same way as indicated for the voltage Restraint mode.

In this mode, coordination with downstream protections is easier.

3.6.8.c Setting and Operating Criteria

The pickup current of these elements is typically defined as 125% of the full load current at normal voltage.

The selection of the trip time must take into account the coordination with downstream devices.

The percentage of the nominal voltage is computed based on nominal Voltage setting (Vn) incorporated in **IDV** relays. AS this element operates using phase to phase voltages, 100% of nominal voltage is deemed to be reached when control voltages read Vn.

Current elements pick up at 105 % of the pickup current value and reset at 100%.

In voltage controlled mode, the pickup enable operating voltage is 100% of its setting and resets at 105%.

3.6.9 Torque Control (Pickup Blocking Enable) (IDV-A/B/D/G/H/J/K/L)

IDV-A/B/D/G/H/J/K/L relays incorporate a torque Control, or pickup blocking enable setting, associated to the directionality of a given ground overcurrent element.

Directional or non-directional control of the calculated ground instantaneous or time overcurrent elements can be selected through this setting, which is incorporated into the element protection group. Possible setting values are:

0 - Directional control disabled.
1 - Forward Direction monitoring enabled.
2 - Reverse direction monitoring enabled.

Elements with **Torque Control** setting or **Pickup Blocking Enable** set to **0** turns into non-directional.

On the other hand those models with three voltage channels and D spare digit (or bigger) **IDV-J/K/L** models with option **D** or higher in digit **9**, will have the **Torque Control** settings in all the overcurrent units and they will also have the **Torque Control Type** setting in the phase and ground overcurrent units. This setting allows select the directional unit in charge of supervising the overcurrent unit. The posible values for each overcurrent units are as follows:

- **Phase Overcurrent** (instantaneous and time overcurrent).
  67F (phase directional element).
  67P (positive sequence directional element). Said option has been designed for series compensated lines. Positive sequence directional element polarization (positive sequence voltage memory) allows generating correct directional decisions on voltage reversal.
  67PQ (negative sequence directional element during non three-phase faults and positive sequence directional element in three-phase faults). The benefit of this option vs. the **67P** option is that for non three-phase faults, the directional element operates correctly even with no voltage memory (close-on-to-fault conditions) or when, even with adequate prefault voltage, current reversals are generated. This last situation will be given, for a forward fault, with the VT on capacitor bank busbar side, when line capacitive reactance is higher than the inductive reactance of the local source. In that case, the use of voltage memory does not solve the directionality problem, as the faulted circuit impedance, measured from the local source will be capacitive. With the VT on capacitor bank busbar side, the negative sequence directional element will operate correctly even with the **Negative Sequence Voltage Compensation Factor** set to zero.
- **Ground and Sensitive Ground Overcurrent** (instantaneous and time overcurrent).
  67N (ground directional element)
  67Q (negative sequence directional element). Option **67Q** may be interesting compared with option **67N** when very low V0 levels are expected, lower than the minimum threshold to polarize the ground directional element. This condition may be present in systems with very high zero sequence sources (low local source zero sequence impedance).
- **Negative Sequence Overcurrent** (instantaneous and time-overcurrent). They are not provided with this setting as they are only monitored by Negative Sequence Directional element (**67NS**).

3.6.10 Trip Blocking and Time Delay Disable

Trip Blocking inputs can be programmed into time and instantaneous overcurrent elements, which disable element trip if input is activated before trip is generated. If input is activated after tripping, trip is reset. Trip blocking inputs must be programmed before this blocking logic can be used.

Another programmable input exists that can turn a given time overcurrent element into instantaneous. Said input is called **Timer Disable** and is available for all time-delayed elements.

3.6.11 Application of the Overcurrent Units

In machine protection, it is necessary to be careful choosing the proper protection elements when facing faults that occur during the clearing of external faults.

External faults can cause thermal or dynamic damage, even for systems with restrictions in the fault current or for remote substation faults. The fault current is usually low – from 0.5 to 5 times the transformer’s nominal current, while maintaining normally high voltages. The fault current is added to the load current, and this represents a strong thermal load for the machine.

3.6.11.a Application of the Phase, Calculated Ground and Ground Overcurrent Units

Overcurrent units are used primarily for:

- Small machines: as a primary protection, including internal faults.
- Large machines: as backup for the differential protection.

In the case of Phase and Calculated Ground overcurrent units, limitations to their application are, primarily:

- Their settings are less sensitive than desired, because they must be above the maximum load current. In this regard, having phase and neutral/ground units somewhat improves sensitivity for some ground faults.

  When used, for example, in the high voltage winding of a transformer with three or more windings, their pickups should let the machine overload to a certain percentage; if used in low voltage windings, a certain degree of sensitivity is gained as only the maximum load of that individual winding has to be considered.

  When used in parallel set transformers, the settings have to take into account overload periods on one of the transformers when one of the transformers set in parallel is out of service.

- Operation times must be longer to coordinate with other protections.

Ground Overcurrent units are more sensitive in detecting ground faults, as they usually employ CTs with a lower transformation ratio than in phases. Their major features include:

- For grounded WYE windings.
- Excellent protection for ground faults.

They have two main purposes:

- Detection of faults close to the transformer ground.
- Backup protection for external ground faults.

The main limitation for their use is their high sensitivity, as they can detect false zero sequence (Io) currents:

- Due to imbalanced grounding.
- Due to very big external faults that are not grounded faults.
- Due to inrush currents.

3.6.11.b Application of the Negative Sequence Overcurrent Units

Since these types of protection units are insensitive to balanced load situations and three-phase faults, they are specially indicated for DELTA-WYE transformers with neutral grounded. The explanation is that only 58% of the secondary current (p.u.) for a single-phase ground fault appears in any one of the primary phases. The backup protection is more complicated when the WYE is grounded by means of an impedance.

A negative sequence protection in the primary winding can be set as sensitive as required for ground or phase-to-phase faults.

In addition, this protection works better than phase overcurrent protections against internal machine faults. The reason is that phase overcurrents have to be set in coordination with the low voltage phase overcurrents, and higher than the negative sequence phase overcurrents, so as not to have problems with unbalanced loads.

3.6.12 Tertiary Overcurrent Units (IDV-B/H Models)

There are two single-phase non-directional overcurrent units that use the current measured through the grounded current measurement channel 2 (**IG-2**). These units are only available in differential equipments for three windings.

3.6.12.a Overcurrent Protection with Harmonic Restraint

This unit contains an Instantaneous Overcurrent Element with an additional adjustable timer.

The unit operates according to the RMS value of the fundamental tertiary current component and of its second and fifth harmonic components.

Once the fundamental (**IT_1**), second harmonic (**IT_2**) and fifth harmonic (**IT_5**) components have been obtained (by the application of the **DFT** - **Discrete Fourier Transformation**), the operating value (**OP_1**) is calculated as the difference between the measurement of the fundamental component and of the second and/or fifth harmonic components multiplied by their restraint constants (**Kf2** and **Kf5**).

$$OP\_1 = IT\_1 - Kf2 \cdot IT\_2 - Kf5 \cdot IT\_5$$

The restraint constants are user-definable values.

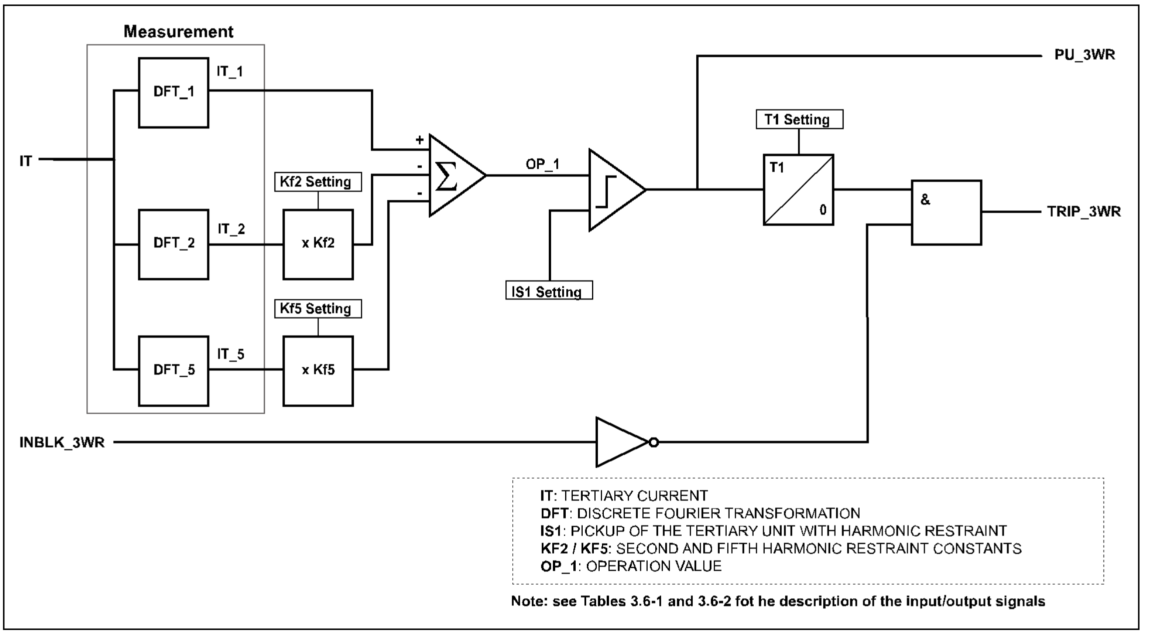


Figure 3.6.22: Logic Diagram of the Tertiary Unit with Harmonic Restraint.

The pickup of the unit (**PU_3WR**) takes place when the measured operating value (**OP_1**) exceeds the 105% of the set value, resetting when the value drops below the 100% setting.

The pickup of the unit activates a user-definable timer, such that the Tertiary Unit without Restraint Activation Output signal (**TRIP_3WR**) is launched when the timer reaches the set value, provided the Harmonic Restraint Unit Blocking Signal (**INBLK_3WR**) is not activated. The unit's output is deactivated when the pickup is reset.

3.6.12.b Overcurrent Protection without Harmonic Restraint

This unit contains an Instantaneous Overcurrent Element with an additional adjustable timer.

The unit operates according to the RMS value of the fundamental component of the tertiary current, that is, it is an overcurrent unit where harmonics are not taken into account.

The pickup of the unit takes place when the fundamental component value (**IT_1**), obtained by the application of the **Discrete Fourier Transformation** to the **IT** (tertiary current measured through the analog channel IG-2), exceeds the set value by 1.05 times, resetting when the value drops below the set value.

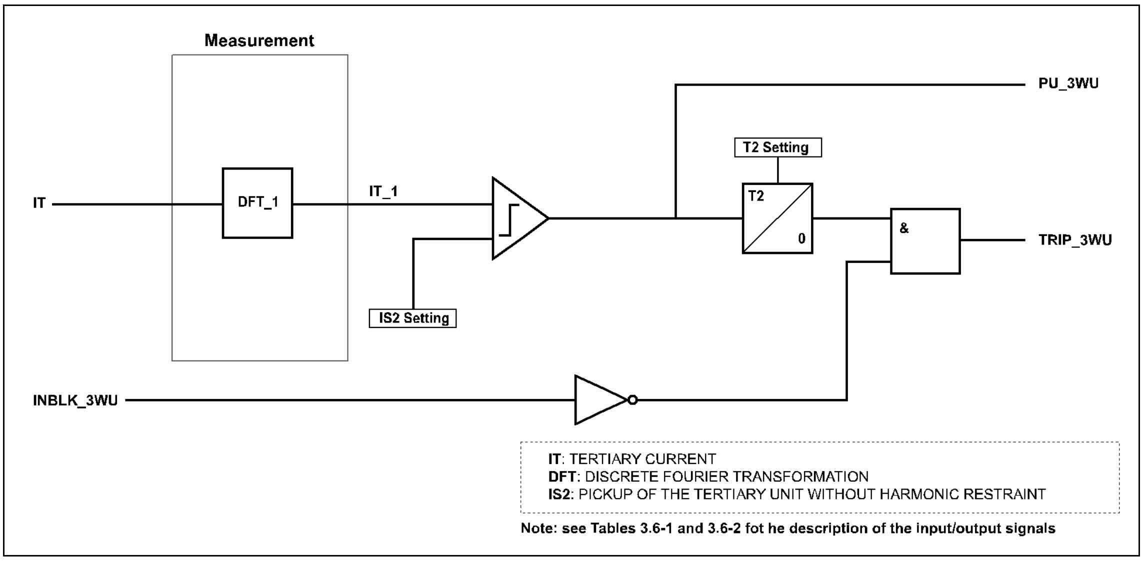


Figure 3.6.23: Logic Diagram of the Tertiary Unit without Harmonic Restraint.

The pickup of the unit (**PU_3WU**) activates a user-definable timer, such that the Tertiary Unit without Restraint Activation Output signal (**TRIP_3WU**) is launched when the timer reaches the set value, provided the Output Blocking signal (**INBLK_3WU**) is not activated. The unit's output is deactivated when the pickup is reset.

It is advisable to adjust this Overcurrent Unit without Harmonic restraint to a far higher pickup value than for the unit "with restraint" (10-20 times higher).

3.6.12.c Operating Conditions of the Tertiary Units

As indicated earlier, the Tertiary Overcurrent Units use the magnitude measured through the analog input number 2, available to measure the grounded current (IG-2).

When any of the two Tertiary Overcurrent Units is “in service”, the equipment puts the Restricted Earth Fault Units for the IG-2 channel (87N_21 and 87N_22) out of service and sets the Calculated Ground Units of the winding to which the measurement channel is assigned as “non-directional”.

3.6.12.d Application of Tertiary Overcurrent Units

The tertiary winding of an autotransformer or a three-winding transformer usually has a great deal less power (kVA) than the rest of the windings. For this reason, the overcurrent protections used to protect other windings are not applicable to the tertiary windings. During system ground faults, high currents can run through the tertiary windings. To support the primary protection for external ground faults, it is advisable to have specific tertiary overcurrent protection.

If the tertiary winding is not used to feed loads, a single-phase protection is utilized, connected to a CT in series with one of the delta windings.

If, on the contrary, it will feed loads, the same single-phase protection powered by three CTs, one in each winding delta connected in parallel to the relay, provides partial protection. It protects against overloads generating zero sequence (ground faults) but not against overloads that only generate positive and negative sequence (faults between phases).

3.6.13 Overcurrent Units Settings

Phase Time Overcurrent; Windings 1, 2 and 3* (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
Phase TOC Enable	YES / NO		NO
Phase TOC Pickup	(0.02 - 25) In	0.01 A	0.4 In
Phase TOC Curve	See list of curves		
Phase TOC 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/RI curves	0.1 - 10	0.01	1
Phase TOC Definite Time	0.05 - 300 s	0.01 s	0.05 s

(*) See 3.18, General Settings.

Negative Sequence Time Overcurrent; Windings 1, 2 and 3* (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
N.S. TOC Enable	YES / NO		NO
N.S. TOC Pickup	(0,1 - 5,0) In	0.1 A	0.4 In
N.S. TOC Curve	See list of curves		
N.S. TOC 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/RI curves	0.1 - 10	0.01	1
N.S. TOC Definite Time	0.05 - 300 s	0.01 s	0.05 s

(*) See 3.18, General Settings.

Calculated Ground Time Overcurrent; Windings 1, 2 and 3* (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
Calculated Ground TOC Enable	YES / NO		NO
Calculated Ground TOC Pickup			
Standard Model	(0.1 - 25) In	0.01 A	0.2 In
IDV-***-****C** Models	(0.02 - 25) In	0.01 A	0.2 In
Calculated Ground TOC Curve	See list of curves		
Calculated Ground TOC 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/RI curves	0.1 - 10	0.01	1
Calculated Ground TOC Definite Time	0.05 - 300 s	0.01 s	0.05 s
Calculated Ground TOC Direction	0: None 1: Direction 2: Reverse		0: None

(*) See 3.18, General Settings.

Ground Time Overcurrent; Channels 1 and 2 (Elements 1 and 2 for each channel)			
Setting	**Range**	**Step**	**By Default**
Ground TOC Enable	YES / NO		NO
Ground TOC Pickup	0.01 - 12 A	0.01 A	1 A
Ground TOC Curve	See list of curves		
Ground TOC 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/RI curves	0.1 - 10	0.01	1
Ground TOC Definite Time	0.05 - 1800 s	0.01 s	0.05 s

Additionals Ground Time Overcurrent (IDV-L); Channels 3, 4 and 5 (Elements 1 and 2 for each channel)*			
Ajuste	**Rango**	**Paso**	**Por defecto**
Ground TOC Enable	YES / NO		NO
Ground TOC Pickup	0.01 - 12 A	0.01 A	1 A
Ground TOC Curve	See list of curves		
Ground TOC 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/RI curves	0.1 - 10	0.01	1
Ground TOC Definite Time	0.05 - 1800 s	0.01 s	0.05 s

(*) See 3.18, General Settings.

Voltage Dependent Time Overcurrent Element (IDV-J/K/L)			
Setting	**Range**	**Step**	**By Default**
V Dependent Enable	YES / NO		NO
V Dependent Pickup	(0.02 - 25) In	0.01 A	0.4 In
V Dependent Curve	See list of curves		
V Dependent 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/RI curves	0.1 - 10	0.01	1
V Dependent Mode	0: Restraint V 1: Controlled V		0: Restraint V
Operating Voltage (V Controlled Mode)	(10- 100) % Un	1%	50 %
V Dependent Time	0.05 - 300 s	0.01 s	0.05 s

Phase Instantaneous Overcurrent; Windings 1, 2 and 3* (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
Phase IOC Enable	YES / NO		NO
Phase IOC Pickup	(0.02 - 30) In	0.01 A	1 In
Phase IOC Delay	0 - 300 s	0.01 s	0 s

(*) See 3.18, General Settings.

Negative Sequence Instantaneous Overcurrent; Windings 1, 2 and 3* (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
N.S. IOC Enable	YES / NO		NO
N.S. IOC Pickup	(0.05 - 30.00) In	0.001 A	2 In
N.S. IOC Delay	0 - 300 s	0.01 s	0 s

(*) See 3.18, General Settings.

Calculated Ground Instantaneous Overcurrent; Windings 1, 2 and 3* (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
Calculated Gnd IOC Enable	YES / NO		NO
Calculated Gnd IOC Pickup			
Standard Model	(0.1 - 25) In	0.01 A	1 In
IDV-***-****C** Models	(0.02 - 30) In	0.01 A	1 In
Calculated Gnd IOC Delay	0 - 300 s	0.01 s	0 s
Calculated Gnd IOC Direction	0: None 1: Direction 2: Reverse		0: None

(*) See 3.18, General Settings.

Ground Instantaneous Overcurrent; Channels 1 and 2 (Elements 1 and 2 for each channel)			
Setting	**Range**	**Step**	**By Default**
Gnd IOC Enable	YES / NO		NO
Gnd IOC Pickup	0.01 - 50 A	0.01 A	1 A
Gnd IOC Delay	0 - 600 s	0.01 s	0 s

Additionals Ground Instantaneous Overcurrent (IDV-L); Channels 3, 4 and 5 (Elements 1 and 2 for each channel)*			
Setting	**Range**	**Step**	**By Default**
Habilitación de la unidad (permiso)	SÍ / NO		NO
Arranque de la unidad	0,01 - 50 A	0,01 A	1 A
Temporización de la unidad	0 - 600 s	0,01 s	0 s

(*) See 3.18, General Settings.

Voltage Dependent Instantaneous Overcurrent Element (IDV-J/K/L)			
Setting	**Range**	**Step**	**By Default**
V Dependent Enable	YES / NO		NO
V Dependent Pickup	(0.2- 20) In	0.1 A	5.0 0 A
V Dependent Mode	0: Restraint V 1: Controlled V		0: Restraint V
Operating Voltage (V Controlled Mode)	(10- 100) % Un	1%	50 %
V Dependent Delay	0.05 - 300 s	0.01 s	1 s

Tertiary Overcurrent Unit with Harmonic Restraint (IDV-B/H Models)			
Setting	**Range**	**Step**	**By Default**
Tertiary 50HR Enable	YES / NO		NO
Tertiary 50HR Pickup	0.05 - 50 A	0.01 A	1 A
Tertiary 50HR Delay	0.00 - 300 s	0.01 s	0 s
2nd Harmonic Restraint	0 - 1	0.01	0
5th Harmonic Restraint	0 - 1	0.01	0 s

Tertiary Overcurrent Unit without Harmonic Restraint (IDV-B/H Models)			
Setting	**Range**	**Step**	**By Default**
Tertiary Enable	YES / NO		NO
Tertiary Pickup	0.05 - 6 A	0.01 A	1 A
Tertiary Delay	0.00 - 300 s	0.01 s	0

Note: Models IDV-L include, at the same time, a function to check the relation between settings in order to prevent enabling all time and instantaneous elements related to the third winding if *Number of Windings* is 2 and to prevent enabling ground time and instantaneous elements Channel 3, Channel 4 and Channel 5 if the setting *Number of Windings* is 3 (see 3.18, General Settings).

- **Instantaneous Overcurrent Units: HMI Access · IDV-A/B/G/H/J/K/L**

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1**
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 2**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 3**
	...	...

0 - DIFFERENTIAL	**0 - OVERCURRENT**	0 - TIME OVERCURRENT
1 - WINDING 1	1 - BREAKER FAILURE	**1 - INSTANTANEOUS**
2 - WINDING 2	2 - THERMAL IMAGE	
3 - WINDING 3		
...		...

0 - TIME OVERCURRENT	**0 - PHASE IOC**
1 - INSTANTANEOUS	**1 - NEG SEQ IOC**
	2 - NEUTRAL IOC

0 - PHASE IOC	**0 - UNIT 1**	**0 - PHASE IOC ENABLE**
1 - NEG SEQ IOC	**1 - UNIT 2**	**1 - PHASE IOC PICKUP**
2 - NEUTRAL IOC	**2 - UNIT 3**	**2 - PHASE IOC DELAY**

0 - PHASE IOC	**0 - UNIT 1**	**0 - N.S. IOC ENABLE**
1 - NEG SEQ IOC	**1 - UNIT 2**	**1 - N.S. IOC PICKUP**
2 - NEUTRAL IOC		**2 - N.S. IOC DELAY**

0 - PHASE IOC	**0 - UNIT 1**	**0 - NTRL IOC ENABLE**
1 - NEG SEQ IOC	**1 - UNIT 2**	**1 - NTRL IOC PICKUP**
2 - NEUTRAL IOC		**2 - NTRL IOC DELAY**
		3 - NTRL IOC DIRECTION

Ground Instantaneous Overcurrent

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**5 - GND OVERCURRENT**
3 - INFORMATION	3 - TRIP PERMISIONS	...
	...	

0 - DIFFERENTIAL	0 - GROUND TIME OVERC	**0 - CHANNEL 1**
...	**1 - GROUND INSTANT.**	**1 - CHANNEL 2**
5 - GND OVERCURRENT		**2 - CHANNEL 3 (*)**
...		**3 - CHANNEL 4 (*)**
		4 - CHANNEL 5 (*)

0 - CHANNEL 1	**0 - UNIT 1**	**0 - GND IOC ENABLE**
1 - CHANNEL 2	**1 - UNIT 2**	**1 - GND IOC PICKUP**
2 - CHANNEL 3 (*)		**2 - GND IOC DELAY**
3 - CHANNEL 4 (*)		
4 - CHANNEL 5 (*)		

(*) Models IDV-L: only available with the setting *Number of Windings* set to *Two Windings*. In this case, the channels corresponding to the third winding become ground channels (see 3.18, General Settings).

- ## Instantaneous Overcurrent Units: HMI Access · IDV-D

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	1 - EXT FAULT DETECTOR
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 1**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 2**
	...	**4 - WINDING 3**
		...

0 - DIFFERENTIAL	**0 - OVERCURRENT**	0 - TIME OVERCURRENT
1 - EXT FAULT DETECTOR	1 - THERMAL IMAGE	**1 - INSTANTANEOUS**
2 - WINDING 1		
3 - WINDING 2		
4 - WINDING 3		...
...		

0 - TIME OVERCURRENT	**0 - PHASE IOC**
1 - INSTANTANEOUS	**1 - NEG SEQ IOC**
	2 - NEUTRAL IOC

0 - PHASE IOC	**0 - UNIT 1**	**0 - PHASE IOC ENABLE**
1 - NEG SEQ IOC	**1 - UNIT 2**	**1 - PHASE IOC PICKUP**
2 - NEUTRAL IOC	**2 - UNIT 3**	**2 - PHASE IOC DELAY**

0 - PHASE IOC	**0 - UNIT 1**	**0 - N.S. IOC ENABLE**
1 - NEG SEQ IOC	**1 - UNIT 2**	**1 - N.S. IOC PICKUP**
2 - NEUTRAL IOC		**2 - N.S. IOC DELAY**

0 - PHASE IOC	**0 - UNIT 1**	**0 - NTRL IOC ENABLE**
1 - NEG SEQ IOC	**1 - UNIT 2**	**1 - NTRL IOC PICKUP**
2 - NEUTRAL IOC		**2 - NTRL IOC DELAY**
		3 - NTRL IOC DIRECTION

Ground Instantaneous Overcurrent

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**7 - GND OVERCURRENT**
3 - INFORMATION	3 - TRIP PERMISIONS	...
	...	

0 - DIFFERENTIAL	0 - GROUND TIME OVERC	**0 - CHANNEL 1**
...	**1 - GROUND INSTANT.**	**1 - CHANNEL 2**
7 - GND OVERCURRENT		
...		

0 - CHANNEL 1	**0 - UNIT 1**	**0 - GND IOC ENABLE**
1 - CHANNEL 2	**1 - UNIT 2**	**1 - GND IOC PICKUP**
		2 - GND IOC DELAY

- **Instantaneous Overcurrent Units: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	**9 - WINDING 1**
3 - INFORMATION	**3 - PROTECTION**	**10 - WINDING 2**
	...	**11 - WINDING 3**
	12- CONTROL	...

0 - DISTANCE		
...		
9 - WINDING 1	**0 - OVERCURRENT**	0 - TIME OVERCURRENT
10 - WINDING 2		**1 - INSTANTANEOUS**
11 - WINDING 3		
...		

0 - TIME OVERCURRENT	**0 - PHASE IOC**
1 - INSTANTANEOUS	**1 - NEUTRAL IOC**

0 - PHASE IOC	**0 - UNIT 1**	**0 - PHASE IOC ENABLE**
1 - NEUTRAL IOC	**1 - UNIT 2**	**1 - PHASE IOC PICKUP**
	2 - UNIT 3	**2 - PHASE IOC DELAY**

0 - PHASE IOC	**0 - UNIT 1**	**0 - NTRL IOC ENABLE**
1 - NEUTRAL IOC	**1 - UNIT 2**	**1 - NTRL IOC PICKUP**
		2 - NTRL IOC DELAY

- **Time Overcurrent Units: HMI Access · IDV-A/B/G/H/J/K/L Models**

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1**
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 2**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 3**
	...	...

0 - DIFFERENTIAL	**0 - OVERCURRENT**	**0 - TIME OVERCURRENT**
1 - WINDING 1	1 - BREAKER FAILURE	1 - INSTANTANEOUS
2 - WINDING 2	2 - THERMAL IMAGE	
3 - WINDING 3		
...		...

0 - TIME OVERCURRENT	**0 - PHASE TOC**
1 - INSTANTANEOUS	**1 - NEG SEQ TOC**
	2 - NEUTRAL TOC

0 - PHASE TOC	**0 - UNIT 1**	**0 - PHASE TOC ENABLE**
1 - NEG SEQ TOC	**1 - UNIT 2**	**1 - PHASE TOC PICKUP**
2 - NEUTRAL TOC		**2 - PHASE TOC CURVE**
		3 - PHASE TOC DIAL
		4 - PHASE TOC DELAY

0 - PHASE TOC	**0 - UNIT 1**	**0 - N.S. TOC ENABLE**
1 - NEG SEQ TOC	**1 - UNIT 2**	**1 - N.S. TOC PICKUP**
2 - NEUTRAL TOC		**2 - N.S. TOC CURVE**
		3 - N.S. TOC DIAL
		4 - N.S. TOC DELAY

0 - PHASE TOC	**0 - UNIT 1**	**0 - NTRL TOC ENABLE**
1 - NEG SEQ TOC	**1 - UNIT 2**	**1 - NTRL TOC PICKUP**
2 - NEUTRAL TOC		**2 - NTRL TOC CURVE**
		3 - NTRL TOC DIAL
		4 - NTRL TOC DELAY
		5 - NTRL TOC DIRECTION

Ground Time Overcurrent

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**5 - GND OVERCURRENT**
3 - INFORMATION	3 - TRIP PERMISIONS	...
	...	

0 - DIFFERENTIAL	**0 - GROUND TIME OVERC**	**0 - CHANNEL 1**
...	1 - GROUND INSTANT.	**1 - CHANNEL 2**
5 - GND OVERCURRENT		**2 - CHANNEL 3 (*)**
...		**3 - CHANNEL 4 (*)**
		4 - CHANNEL 5 (*)

0 - CHANNEL 1	**0 - UNIT 1**	**0 - GROUND TOC ENABLE**
1 - CHANNEL 2	**1 - UNIT 2**	**1 - GROUND TOC PICKUP**
2 - CHANNEL 3 (*)		**2 - GROUND TOC CURVE**
3 - CHANNEL 4 (*)		**3 - GROUND TOC DIAL**
4 - CHANNEL 5 (*)		**4 - GROUND TOC DELAY**

(*) Models IDV-L: only available with the setting *Number of Windings* set to *Two Windings*. In this case, the channels corresponding to the third winding become ground channels (see 3.18, General Settings).

- ### Time Overcurrent Units: HMI Access · IDV-D Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	1 - EXT FAULT DETECTOR
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 1**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 2**
	...	**4 - WINDING 3**
		...

0 - DIFFERENTIAL	**0 - OVERCURRENT**	**0 - TIME OVERCURRENT**
1 - EXT FAULT DETECTOR	1 - THERMAL IMAGE	1 - INSTANTANEOUS
2 - WINDING 1		
3 - WINDING 2		
4 - WINDING 3		
...		

0 - TIME OVERCURRENT	**0 - PHASE TOC**
1 - INSTANTANEOUS	**1 - NEG SEQ TOC**
	2 - NEUTRAL TOC

0 - PHASE TOC	**0 - UNIT 1**	**0 - PHASE TOC ENABLE**
1 - NEG SEQ TOC	**1 - UNIT 2**	**1 - PHASE TOC PICKUP**
2 - NEUTRAL TOC		**2 - PHASE TOC CURVE**
		3 - PHASE TOC DIAL
		4 - PHASE TOC DELAY

0 - PHASE TOC	**0 - UNIT 1**	**0 - N.S. TOC ENABLE**
1 - NEG SEQ TOC	**1 - UNIT 2**	**1 - N.S. TOC PICKUP**
2 - NEUTRAL TOC		**2 - N.S. TOC CURVE**
		3 - N.S. TOC DIAL
		4 - N.S. TOC DELAY

0 - PHASE TOC	**0 - UNIT 1**	**0 - NTRL TOC ENABLE**
1 - NEG SEQ TOC	**1 - UNIT 2**	**1 - NTRL TOC PICKUP**
2 - NEUTRAL TOC		**2 - NTRL TOC CURVE**
		3 - NTRL TOC DIAL
		4 - NTRL TOC DELAY
		5 - NTRL TOC DIRECTION

Ground Time Overcurrent

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**7 - GND OVERCURRENT**
3 - INFORMATION	3 - TRIP PERMISIONS	...
	...	

0 - DIFFERENTIAL	**0 - GROUND TIME OVERC**	**0 - CHANNEL 1**
...	1 - GROUND INSTANT.	**1 - CHANNEL 2**
7 - GND OVERCURRENT		
...		

0 - CHANNEL 1	**0 - UNIT 1**	**0 - GROUND TOC ENABLE**
1 - CHANNEL 2	**1 - UNIT 2**	**1 - GROUND TOC PICKUP**
		2 - GROUND TOC CURVE
		3 - GROUND TOC DIAL
		4 - GROUND TOC DELAY

- **Time Overcurrent Units: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	**9 - WINDING 1**
3 - INFORMATION	**3 - PROTECTION**	**10 - WINDING 2**
	...	**11 - WINDING 3**
	12- CONTROL	12 - COLD LOAD

0 - DISTANCE		
...		
9 - WINDING 1	**0 - OVERCURRENT**	**0 - TIME OVERCURRENT**
10 - WINDING 2		1 - INSTANTANEOUS
11 - WINDING 3		
12 - COLD LOAD		

0 - TIME OVERCURRENT	**0 - PHASE TOC**
1 - INSTANTANEOUS	**1 - NEUTRAL TOC**

0 - PHASE TOC	**0 - UNIT 1**	**0 - PHASE TOC ENABLE**
1 -NEUTRAL TOC	**1 - UNIT 2**	**1 - PHASE TOC PICKUP**
		2 - PHASE TOC CURVE
		3 - PHASE TOC DIAL
		4 - PHASE TOC DELAY

0 - PHASE TOC	**0 - UNIT 1**	**0 - NEUTRAL TOC ENABLE**
1 - NEUTRAL TOC	**1 - UNIT 2**	**1 - NEUTRAL TOC PICKUP**
		2 - NEUTRAL TOC CURVE
		3 - NEUTRAL TOC DIAL
		4 - NEUTRAL TOC DELAY

- **Tertiary Overcurrent: HMI Access · IDV-B Models**

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**6 - TERTIARY**
3 - INFORMATION	3 - TRIP PERMISIONS	...
	...	

0 - DIFFERENTIAL	**0 - TERTIARY H RESTR.**	**0 - TERT. 50HR ENABLE**
...	1 - TERTIARY W/O RESTR	**1 - TERT. 50HR PICKUP**
6 - TERTIARY		**2 - TERT. 50HR DELAY**
...		**3 - 2ND HARM RESTR.**
		4 - 5TH HARM RESTR.

0 - DIFFERENTIAL	0 - TERTIARY H RESTR.	**0 - TERTIARY ENABLE**
...	**1 - TERTIARY W/O RESTR**	**1 - TERTIARY PICKUP**
6 - TERTIARY		**2 - TERTIARY DELAY**
...		

Voltage Dependent Unit: HMI Access · IDV-J/K/L Models

0 - CONFIGURATION	0 - GENERAL	0 - FUSE FAILURE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**2 - PROTECTION**	**8 - V DEPENDENT TIME**
3 - INFORMATION	...	…

0 - FUSE FAILURE		**0 - V DEPENDENT ENABLE**
...	**0 - INSTANTANEOUS**	**1 - V DEPENDENT MODE**
8 - V DEPENDENT TIME	1 - TIME	**2 - V DEPENDENT PICKUP**
		3 - OPERATING VOLTAGE
		4 - V DEPENDENT TIME

0 - FUSE FAILURE		**0 - V DEPENDENT ENABLE**
...	0 - INSTANTANEOUS	**1 - V DEPENDENT MODE**
8 - V DEPENDENT TIME	**1 - TIME**	**2 - V DEPENDENT PICKUP**
		3 - PHASE TOC CURVE
		4 - PHASE TOC DIAL
		5 - OPERATING VOLTAGE
		6 - PHASE TOC DELAY

3.6.14 Digital Inputs of the Overcurrent Modules

Table 3.6-2: Digital Inputs of the Overcurrent Modules

Name	Description	Function
INBLK_IOCPH11	Phase instantaneous element 1 winding 1 block trip input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_IOCPH21	Phase instantaneous element 2 winding 1 block trip input	
INBLK_IOCPH31	Phase instantaneous element 3 winding 1 block trip input	
INBLK_IOCPH12	Phase instantaneous element 1 winding 2 block trip input	
INBLK_IOCPH22	Phase instantaneous element 2 winding 2 block trip input	
INBLK_IOCPH32	Phase instantaneous element 3 winding 2 block trip input	
INBLK_IOCPH13	Phase instantaneous element 1 winding 3 block trip input	
INBLK_IOCPH23	Phase instantaneous element 2 winding 3 block trip input	
INBLK_IOCPH33	Phase instantaneous element 3 winding 3 block trip input	
INBLK_IOC_N11	Calculated ground instantaneous element 1 winding 1 block trip input	
INBLK_IOC_N21	Calculated ground instantaneous element 2 winding 1 block trip input	
INBLK_IOC_N12	Calculated ground instantaneous element 1 winding 2 block trip input	
INBLK_IOC_N22	Calculated ground instantaneous element 2 winding 2 block trip input	
INBLK_IOC_N13	Calculated ground instantaneous element 1 winding 3 block trip input	
INBLK_IOC_N23	Calculated ground instantaneous element 2 winding 3 block trip input	
INBLK_IOCNS11	Negative sequence instantaneous element 1 winding 1 block trip input	
INBLK_IOCNS21	Negative sequence instantaneous element 2 winding 1 block trip input	
INBLK_IOCNS12	Negative sequence instantaneous element 1 winding 2 block trip input	
INBLK_IOCNS22	Negative sequence instantaneous element 2 winding 2 block trip input	
INBLK_IOCNS13	Negative sequence instantaneous element 1 winding 3 block trip input	
INBLK_IOCNS23	Negative sequence instantaneous element 2 winding 3 block trip input	
INBLK_IOC_G11	Ground instantaneous element 1 channel 1 block trip input	
INBLK_IOC_G21	Ground instantaneous element 2 channel 1 block trip input	
INBLK_IOC_G12	Ground instantaneous element 1 channel 2 block trip input	
INBLK_IOC_G22	Ground instantaneous element 2 channel 2 block trip input	

Table 3.6-2: Digital Inputs of the Overcurrent Modules		
Name	**Description**	**Function**
INBLK_IOC_G13	Ground instantaneous element 1 channel 3 block trip input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_IOC_G23	Ground instantaneous element 2 channel 3 block trip input	
INBLK_IOC_G14	Ground instantaneous element 1 channel 4 block trip input	
INBLK_IOC_G24	Ground instantaneous element 2 channel 4 block trip input	
INBLK_IOC_G15	Ground instantaneous element 2 channel 5 block trip input	
INBLK_IOC_G25	Ground instantaneous element 2 channel 5 block trip input	
IN_BLK_VIOC	Voltage dependent instantaneous element block trip input	
INBLK_TOCPH11	Phase time element 1 winding 1 block trip input	
INBLK_TOCPH21	Phase time element 2 winding 1 block trip input	
INBLK_TOCPH12	Phase time element 1 winding 2 block trip input	
INBLK_TOCPH22	Phase time element 2 winding 2 block trip input	
INBLK_TOCPH13	Phase time element 1 winding 3 block trip input	
INBLK_TOCPH23	Phase time element 2 winding 3 block trip input	
INBLK_TOC_N11	Calculated ground time element 1 winding 1 block trip input	
INBLK_TOC_N21	Calculated ground time element 2 winding 1 block trip input	
INBLK_TOC_N12	Calculated ground time element 1 winding 2 block trip input	
INBLK_TOC_N22	Calculated ground time element 2 winding 2 block trip input	
INBLK_TOC_N13	Calculated ground time element 1 winding 3 block trip input	
INBLK_TOC_N23	Calculated ground time element 2 winding 3 block trip input	
INBLK_TOCNS11	Negative sequence time element 1 winding 1 block trip input	
INBLK_TOCNS21	Negative sequence time element 2 winding 1 block trip input	
INBLK_TOCNS12	Negative sequence time element 1 winding 2 block trip input	
INBLK_TOCNS22	Negative sequence time element 2 winding 2 block trip input	
INBLK_TOCNS13	Negative sequence time element 1 winding 3 block trip input	
INBLK_TOCNS23	Negative sequence time element 2 winding 3 block trip input	

Table 3.6-2: Digital Inputs of the Overcurrent Modules

Name	Description	Function
INBLK_TOC_G11	Ground time element 1 channel 1 block trip input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_TOC_G21	Ground time element 2 channel 1 block trip input	
INBLK_TOC_G12	Ground time element 1 channel 2 block trip input	
INBLK_TOC_G22	Ground time element 2 channel 2 block trip input	
INBLK_TOC_G13	Ground time element 1 channel 3 block trip input	
INBLK_TOC_G23	Ground time element 2 channel 3 block trip input	
INBLK_TOC_G14	Ground time element 1 channel 4 block trip input	
INBLK_TOC_G24	Ground time element 2 channel 4 block trip input	
INBLK_TOC_G15	Ground time element 1 channel 5 block trip input	
INBLK_TOC_G25	Ground time element 2 channel 5 block trip input	
IN_BLK_VTOC	Voltage dependent time element block trip input	
INRST_IOC_N11	Calculated ground instantaneous element 1 winding 1 torque annulment input	It resets the instantaneous functions of the elements 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.
INRST_IOC_N21	Calculated ground instantaneous element 2 winding 1 torque annulment input	
INRST_IOC_N12	Calculated ground instantaneous element 1 winding 2 torque annulment input	
INRST_IOC_N22	Calculated ground instantaneous element 2 winding 2 torque annulment input	
INRST_TOC_N11	Calculated ground time element 1 winding 1 torque annulment input	
INRST_TOC_N21	Calculated ground time element 2 winding 1 torque annulment input	
INRST_TOC_N12	Calculated ground time element 1 winding 2 torque annulment input	
INRST_TOC_N22	Calculated ground time element 2 winding 2 torque annulment input	
INRST_TOC_N13	Calculated ground time element 1 winding 3 torque annulment input	
INRST_TOC_N23	Calculated ground time element 2 winding 3 torque annulment input	
IN_BPT_PH11	Phase time element 1 winding 1 bypass time input	It converts the set timing sequence of a given element to instantaneous.
IN_BPT_PH21	Phase time element 2 winding 1 bypass time input	
IN_BPT_PH12	Phase time element 1 winding 2 bypass time input	
IN_BPT_PH22	Phase time element 2 winding 2 bypass time input	
IN_BPT_PH13	Phase time element 1 winding 3 bypass time input	
IN_BPT_PH23	Phase time element 2 winding 3 bypass time input	

Table 3.6-2: Digital Inputs of the Overcurrent Modules

Name	Description	Function
IN_BPT_N11	Calculated ground time element 1 winding 1 bypass time input	It converts the set timing sequence of a given element to instantaneous.
IN_BPT_N21	Calculated ground time element 2 winding 1 bypass time input	
IN_BPT_N12	Calculated ground time element 1 winding 2 bypass time input	
IN_BPT_N22	Calculated ground time element 2 winding 2 bypass time input	
IN_BPT_N13	Calculated ground time element 1 winding 3 bypass time input	
IN_BPT_N23	Calculated ground time element 2 winding 3 bypass time input	
IN_BPT_NS11	Negative sequence time element 1 winding 1 bypass time input	
IN_BPT_NS21	Negative sequence time element 2 winding 1 bypass time input	
IN_BPT_NS12	Negative sequence time element 1 winding 2 bypass time input	
IN_BPT_NS22	Negative sequence time element 2 winding 2 bypass time input	
IN_BPT_NS13	Negative sequence time element 1 winding 3 bypass time input	
IN_BPT_NS23	Negative sequence time element 2 winding 3 bypass time input	
IN_BPT_G11	Ground time element 1 channel 1 bypass time input	
IN_BPT_G21	Ground time element 2 channel 1 bypass time input	
IN_BPT_G12	Ground time element 1 channel 2 bypass time input	
IN_BPT_G22	Ground time element 2 channel 2 bypass time input	
IN_BPT_G13	Ground time element 1 channel 3 bypass time input	
IN_BPT_G23	Ground time element 2 channel 3 bypass time input	
IN_BPT_G14	Ground time element 1 channel 4 bypass time input	
IN_BPT_G24	Ground time element 2 channel 4 bypass time input	
IN_BPT_G15	Ground time element 1 channel 5 bypass time input	
IN_BPT_G25	Ground time element 2 channel 5 bypass time input	

Table 3.6-2: Digital Inputs of the Overcurrent Modules		
Name	**Description**	**Function**
ENBL_IOC_PH11	Phase instantaneous element 1 winding 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_PH21	Phase instantaneous element 2 winding 1 enable input	
ENBL_IOC_PH31	Phase instantaneous element 3 winding 1 enable input	
ENBL_IOC_PH12	Phase instantaneous element 1 winding 2 enable input	
ENBL_IOC_PH22	Phase instantaneous element 2 winding 2 enable input	
ENBL_IOC_PH32	Phase instantaneous element 3 winding 2 enable input	
ENBL_IOC_PH13	Phase instantaneous element 1 winding 3 enable input	
ENBL_IOC_PH23	Phase instantaneous element 2 winding 3 enable input	
ENBL_IOC_PH33	Phase instantaneous element 3 winding 3 enable input	
ENBL_IOC_N11	Calculated ground instantaneous element 1 winding 1 enable input	
ENBL_IOC_N21	Calculated ground instantaneous element 2 winding 1 enable input	
ENBL_IOC_N12	Calculated ground instantaneous element 1 winding 2 enable input	
ENBL_IOC_N22	Calculated ground instantaneous element 2 winding 2 enable input	
ENBL_IOC_N13	Calculated ground instantaneous element 1 winding 3 enable input	
ENBL_IOC_N23	Calculated ground instantaneous element 2 winding 3 enable input	
ENBL_IOC_NS11	Negative sequence instantaneous element 1 winding 1 enable input	
ENBL_IOC_NS21	Negative sequence instantaneous element 2 winding 1 enable input	
ENBL_IOC_NS12	Negative sequence instantaneous element 1 winding 2 enable input	
ENBL_IOC_NS22	Negative sequence instantaneous element 2 winding 2 enable input	

Table 3.6-2: Digital Inputs of the Overcurrent Modules

Name	Description	Function
ENBL_IOC_NS13	Negative sequence instantaneous element 1 winding 3 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_NS23	Negative sequence instantaneous element 2 winding 3 enable input	
ENBL_IOC_G11	Ground instantaneous element 1 channel 1 enable input	
ENBL_IOC_G21	Ground instantaneous element 2 channel 1 enable input	
ENBL_IOC_G12	Ground instantaneous element 1 channel 2 enable input	
ENBL_IOC_G22	Ground instantaneous element 2 channel 2 enable input	
ENBL_VIOC	Voltage dependent instantaneous element enable input	
ENBL_TOC_PH11	Phase time element 1 winding 1 enable input	
ENBL_TOC_PH21	Phase time element 2 winding 1 enable input	
ENBL_TOC_PH12	Phase time element 1 winding 2 enable input	
ENBL_TOC_PH22	Phase time element 2 winding 2 enable input	
ENBL_TOC_PH13	Phase time element 1 winding 3 enable input	
ENBL_TOC_PH23	Phase time element 2 winding 3 enable input	
ENBL_TOC_N11	Calculated ground time element 1 winding 1 enable input	
ENBL_TOC_N21	Calculated ground time element 2 winding 1 enable input	
ENBL_TOC_N12	Calculated ground time element 1 winding 2 enable input	
ENBL_TOC_N22	Calculated ground time element 2 winding 2 enable input	
ENBL_TOC_N13	Calculated ground time element 1 winding 3 enable input	
ENBL_TOC_N23	Calculated ground time element 2 winding 3 enable input	
ENBL_TOC_NS11	Negative sequence time element 1 winding 1 enable input	
ENBL_TOC_NS21	Negative sequence time element 2 winding 1 enable input	
ENBL_TOC_NS12	Negative sequence time element 1 winding 2 enable input	
ENBL_TOC_NS22	Negative sequence time element 2 winding 2 enable input	
ENBL_TOC_NS13	Negative sequence time element 1 winding 3 enable input	
ENBL_TOC_NS23	Negative sequence time element 2 winding 3 enable input	

Table 3.6-2: Digital Inputs of the Overcurrent Modules		
Name	**Description**	**Function**
ENBL_TOC_G11	Ground time element 1 channel 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_TOC_G21	Ground time element 2 channel 1 enable input	
ENBL_TOC_G12	Ground time element 1 channel 2 enable input	
ENBL_TOC_G22	Ground time element 2 channel 2 enable input	
ENBL_TOC_G13	Ground time element 1 channel 3 enable input	
ENBL_TOC_G23	Ground time element 2 channel 3 enable input	
ENBL_TOC_G14	Ground time element 1 channel 4 enable input	
ENBL_TOC_G24	Ground time element 2 channel 4 enable input	
ENBL_TOC_G15	Ground time element 1 channel 5 enable input	
ENBL_TOC_G25	Ground time element 2 channel 5 enable input	
ENBL_VTOC	Voltage dependent time element enable input	
INBLK_3WR	Tertiary unit with restraint blocking input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_3WU	Tertiary unit without restraint blocking input	
ENBL_3WR	Tertiary unit with restraint enable input	Activation of this input puts the unit into service. It can be assigned to status contact inputs by level or to commands.
ENBL_3WU	Tertiary unit without restraint enable input	

3.6.15 Auxiliary Outputs and Events of the Overcurrent Modules

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules

Name	Description	Function
PU_IOC_A11	Phase A instantaneous element 1 wind. 1 pickup	Pickup of the current elements. For the Calculated Ground elements, with the corresponding torque control input.
PU_IOC_B11	Phase B instantaneous element 1 wind. 1 pickup	
PU_IOC_C11	Phase C instantaneous element 1 wind. 1 pickup	
PU_IOC_A12	Phase A instantaneous element 1 wind. 2 pickup	
PU_IOC_B12	Phase B instantaneous element 1 wind. 2 pickup	
PU_IOC_C12	Phase C instantaneous element 1 wind. 2 pickup	
PU_IOC_A13	Phase A instantaneous element 1 wind. 3 pickup	
PU_IOC_B13	Phase B instantaneous element 1 wind. 3 pickup	
PU_IOC_C13	Phase C instantaneous element 2 wind. 3 pickup	
PU_IOC_A21	Phase A instantaneous element 2 wind. 1 pickup	
PU_IOC_B21	Phase B instantaneous element 2 wind. 1 pickup	
PU_IOC_C21	Phase C instantaneous element 2 wind. 1 pickup	
PU_IOC_A22	Phase A instantaneous element 2 wind. 2 pickup	
PU_IOC_B22	Phase B instantaneous element 2 wind. 2 pickup	
PU_IOC_C22	Phase C instantaneous element 2 wind. 2 pickup	
PU_IOC_A23	Phase A instantaneous element 2 wind. 3 pickup	
PU_IOC_B23	Phase B instantaneous element 2 wind. 3 pickup	
PU_IOC_C23	Phase C instantaneous element 2 wind. 3 pickup	
PU_IOC_A31	Phase A instantaneous element 3 wind. 1 pickup	
PU_IOC_B31	Phase B instantaneous element 3 wind. 1 pickup	
PU_IOC_C31	Phase C instantaneous element 3 wind. 1 pickup	
PU_IOC_A32	Phase A instantaneous element 3 wind. 2 pickup	
PU_IOC_B32	Phase B instantaneous element 3 wind. 2 pickup	
PU_IOC_C32	Phase C instantaneous element 3 wind. 2 pickup	
PU_IOC_A33	Phase A instantaneous element 3 winding 3 pickup	
PU_IOC_B33	Phase B instantaneous element 3 winding 3 pickup	
PU_IOC_C33	Phase C instantaneous element 3 winding 3 pickup	
PU_IOC_N11	Calculated ground instantaneous element 1 winding 1 pickup	
PU_IOC_N12	Calculated ground instantaneous element 1 winding 2 pickup	
PU_IOC_N13	Calculated ground instantaneous element 1 winding 3 pickup	
PU_IOC_N21	Calculated ground instantaneous element 2 winding 1 pickup	
PU_IOC_N22	Calculated ground instantaneous element 2 winding 2 pickup	
PU_IOC_N23	Calculated ground instantaneous element 2 winding 3 pickup	
PU_IOC_NS11	Negative sequence instantaneous element 1 winding 1 pickup	
PU_IOC_NS12	Negative sequence instantaneous element 1 winding 2 pickup	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules

Name	Description	Function
PU_IOC_NS14	Negative sequence instantaneous element 1 winding 3 pickup	Pickup of the current elements. For the Calculated Ground elements, with the corresponding torque control input.
PU_IOC_NS21	Negative sequence instantaneous element 2 winding 1 pickup	
PU_IOC_NS22	Negative sequence instantaneous element 2 winding 2 pickup	
PU_IOC_NS23	Negative sequence instantaneous element 2 winding 3 pickup	
PU_IOC_G11	Ground instantaneous element 1 channel 1 pickup	
PU_IOC_G12	Ground instantaneous element 1 channel 2 pickup	
PU_IOC_G21	Ground instantaneous element 2 channel 1 pickup	
PU_IOC_G22	Ground instantaneous element 2 channel 2 pickup	
PU_IOC_G13	Ground instantaneous element 1 channel 3 pickup	
PU_IOC_G14	Ground instantaneous element 1 channel 4 pickup	
PU_IOC_G15	Ground instantaneous element 1 channel 5 pickup	
PU_IOC_G23	Ground instantaneous element 2 channel 3 pickup	
PU_IOC_G24	Ground instantaneous element 2 channel 4 pickup	
PU_IOC_G25	Ground instantaneous element 2 channel 5 pickup	
PU_VIOC_A	Phase A voltage dependent instantaneous overcurrent pickup	
PU_VIOC_B	Phase B voltage dependent instantaneous overcurrent pickup	
PU_VIOC_C	Phase C voltage dependent instantaneous overcurrent pickup	
PU_TOC_A11	Phase A time element 1 winding 1 pickup	
PU_TOC_B11	Phase B time element 1 winding 1 pickup	
PU_TOC_C11	Phase C time element 1 winding 1 pickup	
PU_TOC_A12	Phase A time element 1 winding 2 pickup	
PU_TOC_B12	Phase B time element 1 winding 2 pickup	
PU_TOC_C12	Phase C time element 1 winding 2 pickup	
PU_TOC_A13	Phase A time element 1 winding 3 pickup	
PU_TOC_B13	Phase B time element 1 winding 3 pickup	
PU_TOC_C13	Phase C time element 1 winding 3 pickup	
PU_TOC_A21	Phase A time element 2 winding 1 pickup	
PU_TOC_B21	Phase B time element 2 winding 1 pickup	
PU_TOC_C21	Phase C time element 2 winding 1 pickup	
PU_TOC_A22	Phase A time element 2 winding 2 pickup	
PU_TOC_B22	Phase B time element 2 winding 2 pickup	
PU_TOC_C22	Phase C time element 2 winding 2 pickup	
PU_TOC_A23	Phase A time element 2 winding 3 pickup	
PU_TOC_B23	Phase B time element 2 winding 3 pickup	
PU_TOC_C23	Phase C time element 2 winding 3 pickup	
PU_TOC_N11	Calculated ground time element 1 winding 1 pickup	
PU_TOC_N12	Calculated ground time element 1 winding 2 pickup	
PU_TOC_N13	Calculated ground time element 1 winding 3 pickup	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
PU_TOC_N21	Calculated ground time element 2 winding 1 pickup	Pickup of the current elements. For the Calculated Ground elements, with the corresponding torque control input.
PU_TOC_N22	Calculated ground time element 2 winding 2 pickup	
PU_TOC_N23	Calculated ground time element 2 winding 3 pickup	
PU_TOC_NS11	Negative sequence time element 1 winding 1 pickup	
PU_TOC_NS12	Negative sequence time element 1 winding 2 pickup	
PU_TOC_NS13	Negative sequence time element 1 winding 3 pickup	
PU_TOC_NS21	Negative sequence time element 2 winding 1 pickup	
PU_TOC_NS22	Negative sequence time element 2 winding 2 pickup	
PU_TOC_NS23	Negative sequence time element 2 winding 3 pickup	
PU_TOC_G11	Ground time element 1 channel 1 pickup	
PU_TOC_G12	Ground time element 1 channel 2 pickup	
PU_TOC_G21	Ground time element 2 channel 1 pickup	
PU_TOC_G22	Ground time element 2 channel 2 pickup	
PU_TOC_G13	Ground time element 1 channel 3 pickup	
PU_TOC_G14	Ground time element 1 channel 4 pickup	
PU_TOC_G15	Ground time element 1 channel 5 pickup	
PU_TOC_G23	Ground time element 2 channel 3 pickup	
PU_TOC_G24	Ground time element 2 channel 4 pickup	
PU_TOC_G25	Ground time element 2 channel 5 pickup	
PU_VTOC_A	Phase A voltage dependent time overcurrent pickup	
PU_VTOC_B	Phase B voltage dependent time overcurrent pickup	
PU_VTOC_C	Phase C voltage dependent time overcurrent 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)	
CPU_IOC_N11	Calculated ground instantaneous element 1 winding 1 pickup conditions	Pickup of the Calculated Ground elements, unaffected by the torque control.
CPU_IOC_N12	Calculated ground instantaneous element 1 winding 2 pickup conditions	
CPU_IOC_N13	Calculated ground instantaneous element 1 winding 3 pickup conditions	
CPU_IOC_N21	Calculated ground instantaneous element 2 winding 1 pickup conditions	
CPU_IOC_N22	Calculated ground instantaneous element 2 winding 2 pickup conditions	
CPU_IOC_N23	Calculated ground instantaneous element 2 winding 3 pickup conditions	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
CPU_TOC_N11	Calculated ground time element 1 winding 1 pickup conditions	Pickup of the Calculated Ground elements, unaffected by the torque control.
CPU_TOC_N12	Calculated ground time element 1 winding 2 pickup conditions	
CPU_TOC_N13	Calculated ground time element 1 winding 3 pickup conditions	
CPU_TOC_N21	Calculated ground time element 2 winding 1 pickup conditions	
CPU_TOC_N22	Calculated ground time element 2 winding 2 pickup conditions	
CPU_TOC_N23	Calculated ground time element 2 winding 3 pickup conditions	
TRIP_IOC_A11	Phase A instantaneous element 1 winding 1 trip	Trip of the current elements.
TRIP_IOC_B11	Phase B instantaneous element 1 winding 1 trip	
TRIP_IOC_C11	Phase C instantaneous element 1 winding 1 trip	
TRIP_IOC_A12	Phase A instantaneous element 1 winding 2 trip	
TRIP_IOC_B12	Phase B instantaneous element 1 winding 2 trip	
TRIP_IOC_C12	Phase C instantaneous element 1 winding 2 trip	
TRIP_IOC_A13	Phase A instantaneous element 1 winding 3 trip	
TRIP_IOC_B13	Phase B instantaneous element 1 winding 3 trip	
TRIP_IOC_C13	Phase C instantaneous element 1 winding 3 trip	
TRIP_IOC_A21	Phase A instantaneous element 2 winding 1 trip	
TRIP_IOC_B21	Phase B instantaneous element 2 winding 1 trip	
TRIP_IOC_C21	Phase C instantaneous element 2 winding 1 trip	
TRIP_IOC_A22	Phase A instantaneous element 2 winding 2 trip	
TRIP_IOC_B22	Phase B instantaneous element 2 winding 2 trip	
TRIP_IOC_C22	Phase C instantaneous element 2 winding 2 trip	
TRIP_IOC_A23	Phase A instantaneous element 2 winding 3 trip	
TRIP_IOC_B23	Phase B instantaneous element 2 winding 3 trip	
TRIP_IOC_C23	Phase C instantaneous element 2 winding 3 trip	
TRIP_IOC_A31	Phase A instantaneous element 3 winding 1 trip	
TRIP_IOC_B31	Phase B instantaneous element 3 winding 1 trip	
TRIP_IOC_C31	Phase C instantaneous element 3 winding 1 trip	
TRIP_IOC_A32	Phase A instantaneous element 3 winding 2 trip	
TRIP_IOC_B32	Phase B instantaneous element 3 winding 2 trip	
TRIP_IOC_C32	Phase C instantaneous element 3 winding 2 trip	
TRIP_IOC_A33	Phase A instantaneous element 3 winding 3 trip	
TRIP_IOC_B33	Phase B instantaneous element 3 winding 3 trip	
TRIP_IOC_C33	Phase C instantaneous element 3 winding 3 trip	
TRIP_IOC_N11	Calculated ground instantaneous element 1 winding 1 trip	
TRIP_IOC_N12	Calculated ground instantaneous element 1 winding 2 trip	
TRIP_IOC_N13	Calculated ground instantaneous element 1 winding 3 trip	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
TRIP_IOC_N21	Calculated ground instantaneous element 2 winding 1 trip	Trip of the current elements.
TRIP_IOC_N22	Calculated ground instantaneous element 2 winding 2 trip	
TRIP_IOC_N23	Calculated ground instantaneous element 2 winding 3 trip	
TRIP_IOC_NS11	Negative sequence instantaneous element 1 winding 1 trip	
TRIP_IOC_NS12	Negative sequence instantaneous element 1 winding 2 trip	
TRIP_IOC_NS13	Negative sequence instantaneous element 1 winding 3 trip	
TRIP_IOC_NS21	Negative sequence instantaneous element 2 winding 1 trip	
TRIP_IOC_NS22	Negative sequence instantaneous element 2 winding 2 trip	
TRIP_IOC_NS23	Negative sequence instantaneous element 2 winding 3 trip	
TRIP_IOC_G11	Ground instantaneous element 1 channel 1 trip	
TRIP_IOC_G12	Ground instantaneous element 1 channel 2 trip	
TRIP_IOC_G21	Ground instantaneous element 2 channel 1 trip	
TRIP_IOC_G22	Ground instantaneous element 2 channel 2 trip	
TRIP_IOC_G13	Ground instantaneous element 1 channel 3 trip	
TRIP_IOC_G14	Ground instantaneous element 1 channel 4 trip	
TRIP_IOC_G15	Ground instantaneous element 1 channel 5 trip	
TRIP_IOC_G23	Ground instantaneous element 2 channel 3 trip	
TRIP_IOC_G24	Ground instantaneous element 2 channel 4 trip	
TRIP_IOC_G25	Ground instantaneous element 2 channel 5 trip	
TRIP_VIOC_A	Phase A voltage dependent instantaneous overcurrent trip	
TRIP_VIOC_B	Phase B voltage dependent instantaneous overcurrent trip	
TRIP_VIOC_C	Phase C voltage dependent instantaneous overcurrent trip	
TRIP_TOC_A11	Phase A time element 1 winding 1 trip	
TRIP_TOC_B11	Phase B time element 1 winding 1 trip	
TRIP_TOC_C11	Phase C time element 1 winding 1 trip	
TRIP_TOC_A12	Phase A time element 1 winding 2 trip	
TRIP_TOC_B12	Phase B time element 1 winding 2 trip	
TRIP_TOC_C12	Phase C time element 1 winding 2 trip	
TRIP_TOC_A13	Phase A time element 1 winding 3 trip	
TRIP_TOC_B13	Phase B time element 1 winding 3 trip	
TRIP_TOC_C13	Phase C time element 1 winding 3 trip	
TRIP_TOC_A21	Phase A time element 2 winding 1 trip	
TRIP_TOC_B21	Phase B time element 2 winding 1 trip	
TRIP_TOC_C21	Phase C time element 2 winding 1 trip	
TRIP_TOC_A22	Phase A time element 2 winding 2 trip	
TRIP_TOC_B22	Phase B time element 2 winding 2 trip	
TRIP_TOC_C22	Phase C time element 2 winding 2 trip	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
TRIP_TOC_A23	Phase A time element 2 winding 3 trip	Trip of the current elements.
TRIP_TOC_B23	Phase B time element 2 winding 3 trip	
TRIP_TOC_C23	Phase C time element 2 winding 3 trip	
TRIP_TOC_N11	Calculated Ground time element 1 winding 1 trip	
TRIP_TOC_N12	Calculated Ground time element 1 winding 2 trip	
TRIP_TOC_N13	Calculated Ground time element 1 winding 3 trip	
TRIP_TOC_N21	Calculated Ground time element 2 winding 1 trip	
TRIP_TOC_N22	Calculated Ground time element 2 winding 2 trip	
TRIP_TOC_N23	Calculated ground time element 2 winding 3 trip	
TRIP_TOC_NS11	Negative sequence time element 1 winding 1 trip	
TRIP_TOC_NS12	Negative sequence time element 1 winding 2 trip	
TRIP_TOC_NS13	Negative sequence time element 1 winding 3 trip	
TRIP_TOC_NS21	Negative sequence time element 2 winding 1 trip	
TRIP_TOC_NS22	Negative sequence time element 2 winding 2 trip	
TRIP_TOC_NS23	Negative sequence time element 2 winding 3 trip	
TRIP_TOC_G11	Ground time element 1 channel 1 trip	
TRIP_TOC_G12	Ground time element 1 channel 2 trip	
TRIP_TOC_G21	Ground time element 2 channel 1 trip	
TRIP_TOC_G22	Ground time element 2 channel 2 trip	
TRIP_TOC_G13	Ground time element 1 channel 3 trip	
TRIP_TOC_G14	Ground time element 1 channel 4 trip	
TRIP_TOC_G13	Ground time element 1 channel 5 trip	
TRIP_TOC_G23	Ground time element 2 channel 3 trip	
TRIP_TOC_G24	Ground time element 2 channel 4 trip	
TRIP_TOC_G25	Ground time element 2 channel 5 trip	
TRIP_VTOC_A	Phase A voltage dependent time overcurrent trip	
TRIP_VTOC_B	Phase B voltage dependent time overcurrent trip	
TRIP_VTOC_C	Phase C voltage dependent time overcurrent 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 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules

Name	Description	Function
TRIP_IOC_A11M	Phase A instantaneous element 1 winding 1 masked trip	Trip of the elements affected by their corresponding trip mask.
TRIP_IOC_B11M	Phase B instantaneous element 1 winding 1 masked trip	
TRIP_IOC_C11M	Phase C instantaneous element 1 winding 1 masked trip	
TRIP_IOC_A12M	Phase A instantaneous element 1 winding 2 masked trip	
TRIP_IOC_B12M	Phase B instantaneous element 1 winding 2 masked trip	
TRIP_IOC_C12M	Phase C instantaneous element 1 winding 2 masked trip	
TRIP_IOC_A13M	Phase A instantaneous element 1 winding 3 masked trip	
TRIP_IOC_B13M	Phase B instantaneous element 1 winding 3 masked trip	
TRIP_IOC_C13M	Phase C instantaneous element 1 winding 3 masked trip	
TRIP_IOC_A21M	Phase A instantaneous element 2 winding 1 masked trip	
TRIP_IOC_B21M	Phase B instantaneous element 2 winding 1 masked trip	
TRIP_IOC_C21M	Phase C instantaneous element 2 winding 1 masked trip	
TRIP_IOC_A22M	Phase A instantaneous element 2 winding 2 masked trip	
TRIP_IOC_B22M	Phase B instantaneous element 2 winding 2 masked trip	
TRIP_IOC_C22M	Phase C instantaneous element 2 winding 2 masked trip	
TRIP_IOC_A23M	Phase A instantaneous element 2 winding 3 masked trip	
TRIP_IOC_B23M	Phase B instantaneous element 2 winding 3 masked trip	
TRIP_IOC_C23M	Phase C instantaneous element 2 winding 3 masked trip	
TRIP_IOC_A31M	Phase A instantaneous element 3 winding 1 masked trip	
TRIP_IOC_B31M	Phase B instantaneous element 3 winding 1 masked trip	
TRIP_IOC_C31M	Phase C instantaneous element 3 winding 1 masked trip	
TRIP_IOC_A32M	Phase A instantaneous element 3 winding 2 masked trip	
TRIP_IOC_B32M	Phase B instantaneous element 3 winding 2 masked trip	
TRIP_IOC_C32M	Phase C instantaneous element 3 winding 2 masked trip	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
TRIP_IOC_A33M	Phase A instantaneous element 3 winding 3 masked trip	Trip of the elements affected by their corresponding trip mask.
TRIP_IOC_B33M	Phase B instantaneous element 3 winding 3 masked trip	
TRIP_IOC_C33M	Phase C instantaneous element 3 winding 3 masked trip	
TRIP_IOC_N11M	Calculated ground instantaneous element 1 winding 1 masked trip	
TRIP_IOC_N12M	Calculated ground instantaneous element 1 winding 2 masked trip	
TRIP_IOC_N13M	Calculated ground instantaneous element 1 winding 3 masked trip	
TRIP_IOC_N21M	Calculated ground instantaneous element 2 winding 1 masked trip	
TRIP_IOC_N22M	Calculated ground instantaneous element 2 winding 2 masked trip	
TRIP_IOC_N23M	Calculated ground instantaneous element 2 winding 3 masked trip	
TRIP_IOCNS11M	Negative sequence instantaneous element 1 winding 1 masked trip	
TRIP_IOCNS12M	Negative sequence instantaneous element 1 winding 2 masked trip	
TRIP_IOCNS13M	Negative sequence instantaneous element 1 winding 3 masked trip	
TRIP_IOCNS21M	Negative sequence instantaneous element 2 winding 1 masked trip	
TRIP_IOCNS22M	Negative sequence instantaneous element 2 winding 2 masked trip	
TRIP_IOCNS23M	Negative sequence instantaneous element 2 winding 3 masked trip	
TRIP_IOC_G11M	Ground instantaneous element 1 channel 1 masked trip	
TRIP_IOC_G12M	Ground instantaneous element 1 channel 2 masked trip	
TRIP_IOC_G21M	Ground instantaneous element 2 channel 1 masked trip	
TRIP_IOC_G22M	Ground instantaneous element 2 channel 2 masked trip	
TRIP_IOC_G13M	Ground instantaneous element 1 channel 3 masked trip	
TRIP_IOC_G14M	Ground instantaneous element 1 channel 4 masked trip	
TRIP_IOC_G15M	Ground instantaneous element 1 channel 5 masked trip	
TRIP_IOC_G23M	Ground instantaneous element 2 channel 3 masked trip	
TRIP_IOC_G24M	Ground instantaneous element 2 channel 4 masked trip	
TRIP_IOC_G25M	Ground instantaneous element 2 channel 5 masked trip	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
TRIP_VIOC_AM	Phase A voltage dependent instantaneous overcurrent masked trip	Trip of the elements affected by their corresponding trip mask.
TRIP_VIOC_BM	Phase B voltage dependent instantaneous overcurrent masked trip	
TRIP_VIOC_CM	Phase C voltage dependent instantaneous overcurrent masked trip	
TRIP_TOC_A11M	Phase A time element 1 winding 1 masked trip	
TRIP_TOC_B11M	Phase B time element 1 winding 1 masked trip	
TRIP_TOC_C11M	Phase C time element 1 winding 1 masked trip	
TRIP_TOC_A12M	Phase A time element 1 winding 2 masked trip	
TRIP_TOC_B12M	Phase B time element 1 winding 2 masked trip	
TRIP_TOC_C12M	Phase C time element 1 winding 2 masked trip	
TRIP_TOC_A13M	Phase A time element 1 winding 3 masked trip	
TRIP_TOC_B13M	Phase B time element 1 winding 3 masked trip	
TRIP_TOC_C13M	Phase C time element 1 winding 3 masked trip	
TRIP_TOC_A21M	Phase A time element 2 winding 1 masked trip	
TRIP_TOC_B21M	Phase B time element 2 winding 1 masked trip	
TRIP_TOC_C21M	Phase C time element 2 winding 1 masked trip	
TRIP_TOC_A22M	Phase A time element 2 winding 2 masked trip	
TRIP_TOC_B22M	Phase B time element 2 winding 2 masked trip	
TRIP_TOC_C22M	Phase C time element 2 winding 2 masked trip	
TRIP_TOC_A23M	Phase A time element 2 winding 3 masked trip	
TRIP_TOC_B23M	Phase B time element 2 winding 3 masked trip	
TRIP_TOC_C23M	Phase C time element 2 winding 3 masked trip	
TRIP_TOC_N11M	Calculated ground time element 1 winding 1 masked trip	
TRIP_TOC_N12M	Calculated ground time element 1 winding 2 masked trip	
TRIP_TOC_N13M	Calculated ground time element 1 winding 3 masked trip	
TRIP_TOC_N21M	Calculated ground time element 2 winding 1 masked trip	
TRIP_TOC_N22M	Calculated ground time element 2 winding 2 masked trip	
TRIP_TOC_N23M	Calculated ground time element 2 winding 3 masked trip	
TRIP_TOCNS11M	Negative sequence time element 1 winding 1 masked trip	
TRIP_TOCNS12M	Negative sequence time element 1 winding 2 masked trip	
TRIP_TOCNS13M	Negative sequence time element 1 winding 3 masked trip	
TRIP_TOCNS21M	Negative sequence time element 2 winding 1 masked trip	
TRIP_TOCNS22M	Negative sequence time element 2 winding 2 masked trip	
TRIP_TOCNS23M	Negative sequence time element 2 winding 3 masked trip	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
TRIP_TOC_G11M	Ground time element 1 channel 1 masked trip	Trip of the elements affected by their corresponding trip mask.
TRIP_TOC_G12M	Ground time element 1 channel 2 masked trip	
TRIP_TOC_G21M	Ground time element 2 channel 1 masked trip	
TRIP_TOC_G22M	Ground time element 2 channel 2 masked trip	
TRIP_TOC_G13M	Ground time element 1 channel 3 masked trip	
TRIP_TOC_G14M	Ground time element 1 channel 4 masked trip	
TRIP_TOC_G15M	Ground time element 1 channel 5 masked trip	
TRIP_TOC_G23M	Ground time element 2 channel 3 masked trip	
TRIP_TOC_G24M	Ground time element 2 channel 4 masked trip	
TRIP_TOC_G25M	Ground time element 2 channel 5 masked trip	
TRIP_VTOC_AM	Phase A voltage dependent time overcurrent masked trip	
TRIP_VTOC_BM	Phase B voltage dependent time overcurrent masked trip	
TRIP_VTOC_CM	Phase C voltage dependent time overcurrent masked trip	
INBLK_IOCPH11	Phase instantaneous element 1 winding 1 block trip input	The same as for the Digital Inputs.
INBLK_IOCPH21	Phase instantaneous element 2 winding 1 block trip input	
INBLK_IOCPH31	Phase instantaneous element 3 winding 1 block trip input	
INBLK_IOCPH12	Phase instantaneous element 1 winding 2 block trip input	
INBLK_IOCPH22	Phase instantaneous element 2 winding 2 block trip input	
INBLK_IOCPH32	Phase instantaneous element 3 winding 2 block trip input	
INBLK_IOCPH13	Phase instantaneous element 1 winding 3 block trip input	
INBLK_IOCPH23	Phase instantaneous element 2 winding 3 block trip input	
INBLK_IOCPH33	Phase instantaneous element 3 winding 3 block trip input	
INBLK_IOC_N11	Calculated ground instantaneous element 1 winding 1 block trip input	
INBLK_IOC_N21	Calculated ground instantaneous element 2 winding 1 block trip input	
INBLK_IOC_N12	Calculated ground instantaneous element 1 winding 2 block trip input	
INBLK_IOC_N22	Calculated ground instantaneous element 2 winding 2 block trip input	
INBLK_IOC_N13	Calculated ground instantaneous element 1 winding 3 block trip input	
INBLK_IOC_N23	Calculated ground instantaneous element 2 winding 3 block trip input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules

Name	Description	Function
INBLK_IOCNS11	Negative sequence instantaneous element 1 winding 1 block trip input	The same as for the Digital Inputs.
INBLK_IOCNS21	Negative sequence instantaneous element 2 winding 1 block trip input	
INBLK_IOCNS12	Negative sequence instantaneous element 1 winding 2 block trip input	
INBLK_IOCNS22	Negative sequence instantaneous element 2 winding 2 block trip input	
INBLK_IOCNS13	Negative sequence instantaneous element 1 winding 3 block trip input	
INBLK_IOCNS23	Negative sequence instantaneous element 2 winding 3 block trip input	
INBLK_IOC_G11	Ground instantaneous element 1 channel 1 block trip input	
INBLK_IOC_G21	Ground instantaneous element 2 channel 1 block trip input	
INBLK_IOC_G12	Ground instantaneous element 1 channel 2 block trip input	
INBLK_IOC_G22	Ground instantaneous element 2 channel 2 block trip input	
INBLK_IOC_G13	Ground instantaneous element 1 channel 3 block trip input	
INBLK_IOC_G23	Ground instantaneous element 2 channel 3 block trip input	
INBLK_IOC_G14	Ground instantaneous element 1 channel 4 block trip input	
INBLK_IOC_G24	Ground instantaneous element 2 channel 4 block trip input	
INBLK_IOC_G15	Ground instantaneous element 1 channel 5 block trip input	
INBLK_IOC_G25	Ground instantaneous element 2 channel 5 block trip input	
IN_BLK_VIOC	Voltage dependent instantaneous element block trip input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
INBLK_TOCPH11	Phase time element 1 winding 1 block trip input	The same as for the Digital Inputs.
INBLK_TOCPH21	Phase time element 2 winding 1 block trip input	
INBLK_TOCPH12	Phase time element 1 winding 2 block trip input	
INBLK_TOCPH22	Phase time element 2 winding 2 block trip input	
INBLK_TOCPH13	Phase time element 1 winding 3 block trip input	
INBLK_TOCPH23	Phase time element 2 winding 3 block trip input	
INBLK_TOC_N11	Calculated ground time element 1 winding 1 block trip input	
INBLK_TOC_N21	Calculated ground time element 2 winding 1 block trip input	
INBLK_TOC_N12	Calculated ground time element 1 winding 2 block trip input	
INBLK_TOC_N22	Calculated ground time element 2 winding 2 block trip input	
INBLK_TOC_N13	Calculated ground time element 1 winding 3 block trip input	
INBLK_TOC_N23	Calculated ground time element 2 winding 3 block trip input	
INBLK_TOCNS11	Negative sequence time element 1 winding 1 block trip input	
INBLK_TOCNS21	Negative sequence time element 2 winding 1 block trip input	
INBLK_TOCNS12	Negative sequence time element 1 winding 2 block trip input	
INBLK_TOCNS22	Negative sequence time element 2 winding 2 block trip input	
INBLK_TOCNS13	Negative sequence time element 1 winding 3 block trip input	
INBLK_TOCNS23	Negative sequence time element 2 winding 3 block trip input	
INBLK_TOC_G11	Ground time element 1 channel 1 block trip input	
INBLK_TOC_G21	Ground time element 2 channel 1 block trip input	
INBLK_TOC_G12	Ground time element 1 channel 2 block trip input	
INBLK_TOC_G22	Ground time element 2 channel 2 block trip input	
INBLK_TOC_G13	Ground time element 1 channel 3 block trip input	
INBLK_TOC_G23	Ground time element 2 channel 3 block trip input	
INBLK_TOC_G14	Ground time element 1 channel 4 block trip input	
INBLK_TOC_G24	Ground time element 2 channel 4 block trip input	
INBLK_TOC_G15	Ground time element 1 channel 5 block trip input	
INBLK_TOC_G25	Ground time element 2 channel 5 block trip input	
IN_BLK_VTOC	Voltage dependent time element block trip input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
INRST_IOC_N11	Calculated ground instantaneous element 1 winding 1 torque annulment input	The same as for the Digital Inputs.
INRST_IOC_N21	Calculated ground instantaneous element 2 winding 1 torque annulment input	
INRST_IOC_N12	Calculated ground instantaneous element 1 winding 2 torque annulment input	
INRST_IOC_N22	Calculated ground instantaneous element 2 winding 2 torque annulment input	
INRST_TOC_N11	Calculated ground time element 1 winding 1 torque annulment input	
INRST_TOC_N21	Calculated ground time element 2 winding 1 torque annulment input	
INRST_TOC_N12	Calculated ground time element 1 winding 2 torque annulment input	
INRST_TOC_N22	Calculated ground time element 2 winding 2 torque annulment input	
INRST_TOC_N13	Calculated ground time element 1 winding 3 torque annulment input	
INRST_TOC_N23	Calculated ground time element 2 winding 3 torque annulment input	
IN_BPT_PH11	Phase time element 1 winding 1 bypass time input	
IN_BPT_PH21	Phase time element 2 winding 1 bypass time input	
IN_BPT_PH12	Phase time element 1 winding 2 bypass time input	
IN_BPT_PH22	Phase time element 2 winding 2 bypass time input	
IN_BPT_PH13	Phase time element 1 winding 3 bypass time input	
IN_BPT_PH23	Phase time element 2 winding 3 bypass time input	
IN_BPT_N11	Calculated ground time element 1 winding 1 bypass time input	
IN_BPT_N21	Calculated ground time element 2 winding 1 bypass time input	
IN_BPT_N12	Calculated ground time element 1 winding 2 bypass time input	
IN_BPT_N22	Calculated ground time element 2 winding 2 bypass time input	
IN_BPT_N13	Calculated ground time element 1 winding 3 bypass time input	
IN_BPT_N23	Calculated ground time element 2 winding 3 bypass time input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
IN_BPT_NS11	Negative sequence time element 1 winding 1 bypass time input	The same as for the Digital Inputs.
IN_BPT_NS21	Negative sequence time element 2 winding 1 bypass time input	
IN_BPT_NS12	Negative sequence time element 1 winding 2 bypass time input	
IN_BPT_NS22	Negative sequence time element 2 winding 2 bypass time input	
IN_BPT_NS13	Negative sequence time element 1 winding 3 bypass time input	
IN_BPT_NS23	Negative sequence time element 2 winding 3 bypass time input	
IN_BPT_G11	Ground time element 1 channel 1 bypass time input	
IN_BPT_G21	Ground time element 2 channel 1 bypass time input	
IN_BPT_G12	Ground time element 1 channel 2 bypass time input	
IN_BPT_G22	Ground time element 2 channel 2 bypass time input	
ENBL_IOC_PH11	Phase instantaneous element 1 winding 1 enable input	
ENBL_IOC_PH21	Phase instantaneous element 2 winding 1 enable input	
ENBL_IOC_PH31	Phase instantaneous element 3 winding 1 enable input	
ENBL_IOC_PH12	Phase instantaneous element 1 winding 2 enable input	
ENBL_IOC_PH22	Phase instantaneous element 2 winding 2 enable input	
ENBL_IOC_PH32	Phase instantaneous element 3 winding 2 enable input	
ENBL_IOC_PH13	Phase instantaneous element 1 winding 3 enable input	
ENBL_IOC_PH23	Phase instantaneous element 2 winding 3 enable input	
ENBL_IOC_PH33	Phase instantaneous element 3 winding 3 enable input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
ENBL_IOC_N11	Calculated ground instantaneous element 1 winding 1 enable input	The same as for the Digital Inputs.
ENBL_IOC_N21	Calculated ground instantaneous element 2 winding 1 enable input	
ENBL_IOC_N12	Calculated ground instantaneous element 1 winding 2 enable input	
ENBL_IOC_N22	Calculated ground instantaneous element 2 winding 2 enable input	
ENBL_IOC_N13	Calculated ground instantaneous element 1 winding 3 enable input	
ENBL_IOC_N23	Calculated ground instantaneous element 2 winding 3 enable input	
ENBL_IOC_NS11	Negative sequence instantaneous element 1 winding 1 enable input	
ENBL_IOC_NS21	Negative sequence instantaneous element 2 winding 1 enable input	
ENBL_IOC_NS12	Negative sequence instantaneous element 1 winding 2 enable input	
ENBL_IOC_NS22	Negative sequence instantaneous element 2 winding 2 enable input	
ENBL_IOC_NS13	Negative sequence instantaneous element 1 winding 3 enable input	
ENBL_IOC_NS23	Negative sequence instantaneous element 2 winding 3 enable input	
ENBL_IOC_G11	Ground instantaneous element 1 channel 1 enable input	
ENBL_IOC_G21	Ground instantaneous element 2 channel 1 enable input	
ENBL_IOC_G12	Ground instantaneous element 1 channel 2 enable input	
ENBL_IOC_G22	Ground instantaneous element 2 channel 2 enable input	
ENBL_VIOC	Voltage dependent instantaneous element enable input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
ENBL_TOC_PH11	Phase time element 1 winding 1 enable input	The same as for the Digital Inputs.
ENBL_TOC_PH21	Phase time element 2 winding 1 enable input	
ENBL_TOC_PH12	Phase time element 1 winding 2 enable input	
ENBL_TOC_PH22	Phase time element 2 winding 2 enable input	
ENBL_TOC_PH13	Phase time element 1 winding 3 enable input	
ENBL_TOC_PH23	Phase time element 2 winding 3 enable input	
ENBL_TOC_N11	Calculated ground time element 1 winding 1 enable input	
ENBL_TOC_N21	Calculated ground time element 2 winding 1 enable input	
ENBL_TOC_N12	Calculated ground time element 1 winding 2 enable input	
ENBL_TOC_N22	Calculated ground time element 2 winding 2 enable input	
ENBL_TOC_N13	Calculated ground time element 1 winding 3 enable input	
ENBL_TOC_N23	Calculated ground time element 2 winding 3 enable input	
ENBL_TOC_NS11	Negative sequence time element 1 winding 1 enable input	
ENBL_TOC_NS21	Negative sequence time element 2 winding 1 enable input	
ENBL_TOC_NS12	Negative sequence time element 1 winding 2 enable input	
ENBL_TOC_NS22	Negative sequence time element 2 winding 2 enable input	
ENBL_TOC_NS13	Negative sequence time element 1 winding 3 enable input	
ENBL_TOC_NS23	Negative sequence time element 2 winding 3 enable input	
ENBL_TOC_G11	Ground time element 1 channel 1 enable input	
ENBL_TOC_G21	Ground time element 2 channel 1 enable input	
ENBL_TOC_G12	Ground time element 1 channel 2 enable input	
ENBL_TOC_G22	Ground time element 2 channel 2 enable input	
ENBL_VTOC	Voltage dependent time element enable input	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules

Name	Description	Function
IOCPH11_ENBLD	Phase instantaneous element 1 wind. 1 enabled	Indication of enabled or disabled status of the current elements.
IOCPH12_ENBLD	Phase instantaneous element 1 wind. 2 enabled	
IOCPH13_ENBLD	Phase instantaneous element 1 wind. 3 enabled	
IOCPH21_ENBLD	Phase instantaneous element 2 wind. 1 enabled	
IOCPH22_ENBLD	Phase instantaneous element 2 wind. 2 enabled	
IOCPH23_ENBLD	Phase instantaneous element 2 wind. 3 enabled	
IOCPH31_ENBLD	Phase instantaneous element 3 wind. 1 enabled	
IOCPH32_ENBLD	Phase instantaneous element 3 wind. 2 enabled	
IOCPH33_ENBLD	Phase instantaneous element 3 wind. 3 enabled	
IOC_N11_ENBLD	Calculated ground instantaneous element 1 winding 1 enabled	
IOC_N12_ENBLD	Calculated ground instantaneous element 1 winding 2 enabled	
IOC_N13_ENBLD	Calculated ground instantaneous element 1 winding 3 enabled	
IOC_N21_ENBLD	Calculated ground instantaneous element 2 winding 1 enabled	
IOC_N22_ENBLD	Calculated ground instantaneous element 2 winding 2 enabled	
IOC_N23_ENBLD	Calculated ground instantaneous element 2 winding 3 enabled	
IOCNS11_ENBLD	Negative sequence instantaneous element 1 winding 1 enabled	
IOCNS12_ENBLD	Negative sequence instantaneous element 1 winding 2 enabled	
IOCNS13_ENBLD	Negative sequence instantaneous element 1 winding 3 enabled	
IOCNS21_ENBLD	Negative sequence instantaneous element 2 winding 1 enabled	
IOCNS22_ENBLD	Negative sequence instantaneous element 2 winding 2 enabled	
IOCNS23_ENBLD	Negative sequence instantaneous element 2 winding 3 enabled	
IOC_G11_ENBLD	Ground inst. element 1 channel 1 enabled	
IOC_G12_ENBLD	Ground inst. element 2 channel 1 enabled	
IOC_G21_ENBLD	Ground inst. element 1 channel 2 enabled	
IOC_G22_ENBLD	Ground inst. element 2 channel 2 enabled	
VIOC_ENBLD	Voltage dependent instantaneous element enabled	
TOCPH11_ENBLD	Phase time element 1 winding 1 enabled	

Table 3.6-3: Auxiliary Outputs and Events of the Overcurrent Modules		
Name	**Description**	**Function**
TOCPH12_ENBLD	Phase time element 1 winding 2 enabled	Indication of enabled or disabled status of the current elements.
TOCPH13_ENBLD	Phase time element 1 winding 3 enabled	
TOCPH21_ENBLD	Phase time element 2 winding 1 enabled	
TOCPH22_ENBLD	Phase time element 2 winding 2 enabled	
TOCPH23_ENBLD	Phase time element 2 winding 3 enabled	
TOC_N11_ENBLD	Calculated ground time element 1 winding 1 enabled	
TOC_N12_ENBLD	Calculated ground time element 1 winding 2 enabled	
TOC_N13_ENBLD	Calculated ground time element 1 winding 3 enabled	
TOC_N21_ENBLD	Calculated ground time element 2 winding 1 enabled	
TOC_N22_ENBLD	Calculated ground time element 2 winding 2 enabled	
TOC_N23_ENBLD	Calculated ground time element 2 winding 3 enabled	
TOCNS11_ENBLD	Negative sequence time element 1 winding 1 enabled	
TOCNS12_ENBLD	Negative sequence time element 1 winding 2 enabled	
TOCNS13_ENBLD	Negative sequence time element 1 winding 3 enabled	
TOCNS21_ENBLD	Negative sequence time element 2 winding 1 enabled	
TOCNS22_ENBLD	Negative sequence time element 2 winding 2 enabled	
TOCNS23_ENBLD	Negative sequence time element 2 winding 3 enabled	
TOC_G11_ENBLD	Ground time element 1 channel 1 enabled	
TOC_G12_ENBLD	Ground time element 2 channel 1 enabled	
TOC_G21_ENBLD	Ground time element 1 channel 2 enabled	
TOC_G22_ENBLD	Ground time element 2 channel 2 enabled	
VTOC_ENBLD	Voltage dependent time element enabled	
PU_3WR	Tertiary unit with restraint detector pickup	Pickup of the unit and start of the time count.
PU_3WU	Tertiary unit without restraint detector pickup	
TRIP_3WR	Tertiary unit with restraint detector trip	Trip of the unit.
TRIP_3WU	Tertiary unit without restraint detector trip	
TRIP_3WRM	Tertiary unit with restraint masked trip	Trip of the unit affected by their corresponding trip mask.
TRIP_3WUM	Tertiary unit without restraint masked trip	
INBLK_3WR	Tertiary unit with restraint blocking input	The same as for the Digital Inputs.
INBLK_3WU	Tertiary unit without restraint blocking input	
ENBL_3WR	Tertiary unit with restraint enable input	The same as for the Digital Inputs.
ENBL_3WU	Tertiary unit without restraint enable input	
3WR_ENBLD	Tertiary unit with restraint enabled	Indication of enabled or disabled status of the unit.
3WU_ENBLD	Tertiary unit without restraint enabled	

3.6.16 Overcurrent Units Test

3.6.16.a Phase, Calculated Ground, Negative Sequence and Ground Current Units Test

One–by-one unit testing is recommended and all elements not being tested at that moment must be disabled. For this test the IED shall be nondirectional to not depend on the voltages (**Pickup Blocking Enable** or **Torque Control** set to NO). Otherwise they must be injected, in order for the elements to be in the trip enable zone.

- **Pickup and Reset**

Set pickup setting values of the corresponding unit and check pickup by activating any output configured to this end. It may also be verified by checking the pickup flags in **Information** - **Status** - **Units** menu. Likewise, it may also be checked that the trip flag in said menu activates when element trips.

Table 3.6-4: Overcurrent Units Pickup and Reset				
Element Setting	Pickup		Reset	
	Maximum	Minimum	Maximum	Minimum
X	1.08 **x** X	1.02 **x** X	1.03 **x** X	0.97 **x** X

In low ranges pickup and reset interval can be extended up to X ± (5% x In) mA.

- **Operating Times**

This is checked through trip terminals (G4-G5-G6-G7) (G8-G9-G10-H1) (C1-C2-C3-C4), depending on the model.

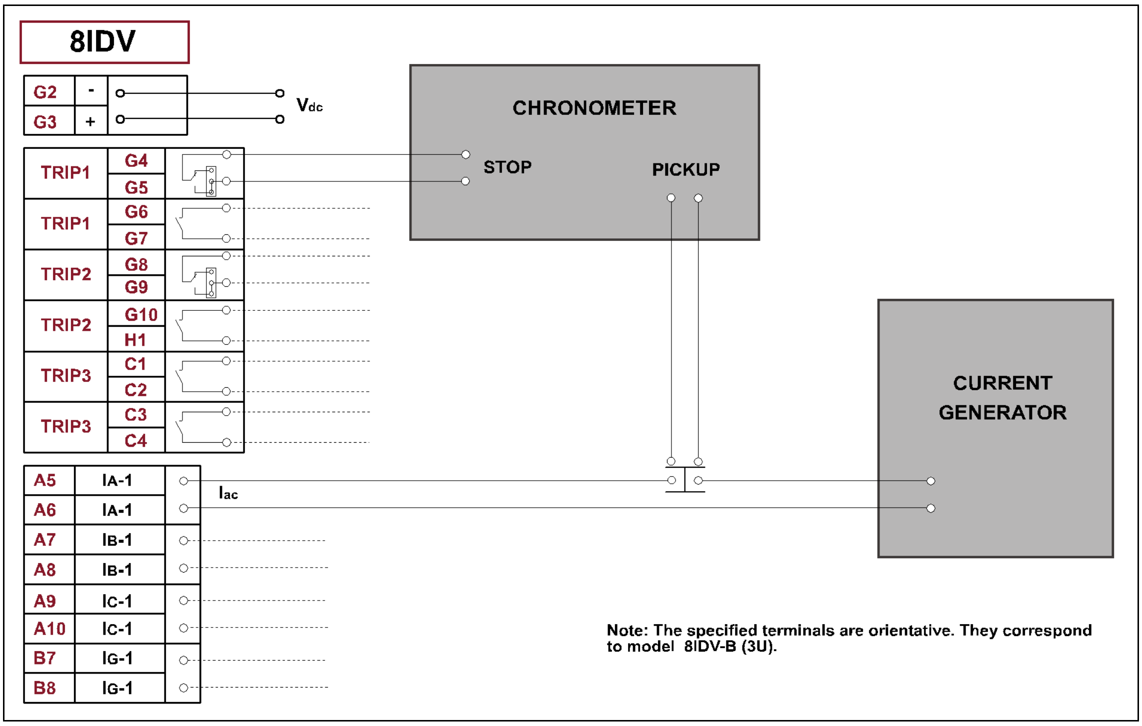


Figure 3.6.24: Operating Time Test Setup (Overcurrent Units).

Definite or Instantaneous Time

A current 20% above the selected pickup setting value shall be applied. Time delay must be 30ms (for 50Hz) or 25ms (for 60Hz) of the selected time delay setting value. Bear in mind that time delay for 0 ms setting will be between 20 and 30 ms (for 50Hz) or between 15 and 25 ms (for 60Hz).

Inverse Time

For a given curve, time delay will be a function of the selected dial and the applied current (times pickup setting value). Tolerance will be given by the result obtained after applying ±1% offset to current measurement. This will result into ±2% or ±35ms (whichever is greater) offset in time measurement.

Operating times for model **IDV** can be checked for curves shown in paragraph 3.6.5 according to **IEC**, **IEEE** and **US** standards. RI Inverse Curve characteristic is added to these curves, mainly used in combination with electromechanical relays. **IEC**, **IEEE**, **US**.

3.6.16.b Tertiary Unit without Harmonic Restraint Test (IDV-A/B/G/H)

Put the units not being tested **Out of Service** and set the Tertiary Unit without Harmonic Restraint to **In Service**.

Repeat the same testing process used for testing the Phase Instantaneous Element.

3.6.16.c Tertiary Unit with Harmonic Restraint Test (IDV-A/B/G/H)

Put the units not being tested **Out of Service** and enable the Tertiary Unit with Harmonic Restraint.

- **Pickup**

Set the pickup of the Tertiary Unit with Harmonic Restraint to 0.5A and the restraint constant to 0.2. Apply a current to the tertiary input (IG-2) whose 2nd harmonic component is zero.

Check that the pickup status indicator of the Tertiary Unit with Harmonic Restraint is set to "1" and remains stable when the fundamental component of the current reaches a value between 0.509A and 0.541A. The Harmonic Restraint Unit output indicator will also activate eventually, and the trip contacts will close simultaneously. Verify that the pickup indicator resets for current values between 0.485A and 0.515A. The output indicator resets when the pickup indicator resets.

Repeat the same process but apply to the tertiary input a current whose 2nd harmonic component is 5 A.

Check that the pickup status indicator of the Tertiary Unit with Harmonic Restraint is set to "1" and remains stable when the fundamental component of the current reaches a value between 1.479A and 1.571A. The Harmonic Restraint Unit output indicator will also activate eventually, and the trip contacts will close simultaneously. Verify that the pickup indicator resets for current values between 1.455A and 1.545A. The output indicator resets when the pickup indicator resets.

- **Times**

Set the pickup of the Tertiary Unit with Restraint to 0.5 Aac and the trip time to 0s. Apply a current with a fundamental component of 3A and 2nd harmonic of 1A, making sure the trip occurs in 30ms (for 50Hz) or in 25ms (for 60Hz). Set the instantaneous trip time to 10 s. Apply 2 Aac and make sure the trip occurs between 9.9s and 10.1s.

3.6.16.d Voltage Restraint Time Element Test (IDV-J/K/L)

Element is set as follows:

Element enable	YES
Mode	0: V Restraint
Element pickup	1A
Operate voltage (Voltage Controlled mode)	50% Un
Element time delay	0.05 s

- **Pickup and Reset**

With nominal voltage setting at 110 Vac, a voltage of 22Vac is applied to phase A; that represents 20% of nominal voltage.

Under these conditions, check that applying current through phase A element pickup takes place at (1.05 * 0.25A) ± 3%, and resets at 0.25A ± 3%.

Disconnect phase A voltage and apply 55Vac through phase B; that represents 50% of nominal voltage.

Under these conditions, check that applying current through phase B element pickup takes place at (1.05 * 0.5A) ± 3%, and resets at 0.5A ± 3%.

Finally, disconnect phase B voltage and apply 104.5Vac through phase C; that represents 95% of nominal voltage.

Under these conditions, check that applying current through phase C element pickup takes place at (1.05 * 1A) ± 3%, and resets at 1A ± 3%.

- **Operating Times**

Apply the currents and voltages stated in paragraph for pickup and reset and check that tripping takes place within 30ms (for 50Hz) or 25ms (for 60Hz) of the selected time setting value. Bear in mind that time delay for 0 ms setting will be between 20 and 30 ms (for 50Hz) or between 15 and 25 ms (for 60Hz).

3.7 Directional Units

3.7.1 Introduction

IDV-A/B/D/G/H/J/K/L relays include one Calculated Ground Directional Unit (**67N**). The task of Directional Unit is to determine the operate current flow direction to control the associated overcurrent unit. Direction is figured out by comparing its phase with that of a reference magnitude, the phase of which remains regardless the operate current flow direction.

The Directional Unit has control over the corresponding Calculated Ground Overcurrent elements provided the **Torque Control** setting is different from **zero**. If it should be **zero**, directional control is inhibited enabling trip in both directions.

If direction forward is asserted, reverse direction instantaneous and time overcurrent are blocked and direction forward instantaneous and time are enabled. If reverse direction is asserted, direction forward instantaneous and time overcurrent are blocked and reverse direction instantaneous and time are enabled.

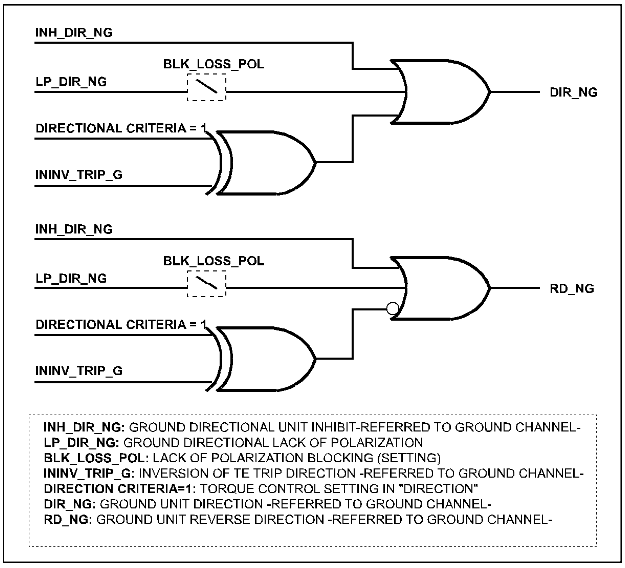


Figure 3.7.1: Calculated Ground Directional Unit Block Diagram.

For Calculated Ground Overcurrent Unit to operate directional elements must pickup and then a current level higher than the overcurrent element setting value must be detected. If the directional unit disables overcurrent unit operation, the time delay function will not initiate. If the operation is disabled after timer pickup, this will be reset so that if element operation should be enabled timer will start again from zero. In any case, for a trip to take place, the time function must run uninterrupted.

In all cases, Directional Unit can enable or block in both directions (direction and reverse direction) as a function of the **Torque Control** setting (**1** for Direction trips and **2** for Reverse Direction trips). If **Torque Disable** input is activated, pickup of the corresponding directional element is blocked.

The operation of the Calculated Ground Directional Unit is based on the use of grounded currents. The operating value magnitude is the **Calculated Ground Current** in each winding, using one of the two **ground currents** available in the equipment as the polarization value (**F_POL**).

Since there may be up to three windings when there are only two available ground channels, these can be assigned to any of the windings through the proper setting. If the ground channels are not assigned to any winding, the Calculated Ground Units will always operate as **non-directional** units, regardless of the Torque Control setting. In this case, windings that do not have the ground channel will not be directional. For this reason there are two directional units. The first is polarized with ground current 1 (**IG-1**), while the second is polarized with ground current 2 (**IG-2**). Its operation is as follows:

If the directional element is inhibited, it enables trip in both directions. In this case, it permits the instantaneous and the time elements to trip. If it is not inhibited, check that the current exceeds a minimum value.

- If it doesn't exceed a minimum value, check the **Lack of Polarization Blocking** setting, and if set to **NO**, proceed as with the case of directional inhibition. If set to **YES**, trips in both directions are blocked.
- If it is exceeded, check that the polarization current assigned via the proper setting exceeds a set value. If so, both currents are multiplied in scalar fashion, and if the **Inversion of the Trip Direction** input is activated, the sign of the result is changed. A positive sign indicates Direction, while a negative sign indicates Reverse Direction.

Determining the phase displacement between the calculated ground current (**IN**) and the current circulating through the grounding (**IG**) 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. In the figure **F_POL** is equal to **IG** 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 Unit in the opposite semiplane.

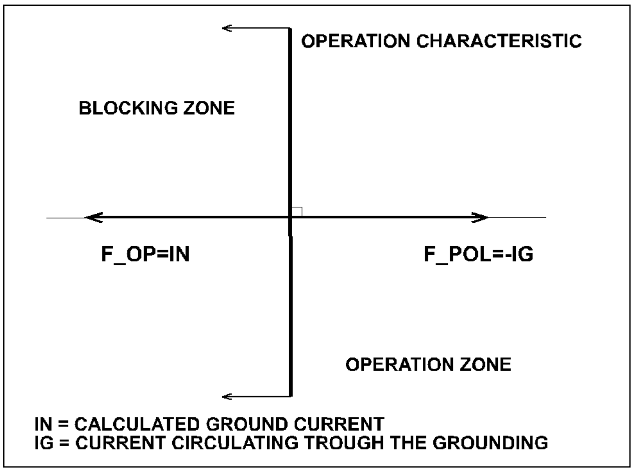


Figure 3.7.2: Vector Diagram of the Ground Directional Unit with Polarization by Current.

On the other hand, those models with three voltage channels and spare digit **D** or greater **IDV-J/K/L**-****D****, are provided with the following directional elements for overcurrent element control:

- One directional phase element (67).
- One directional ground element (67N).
- One directional negative sequence element (67Q).
- One directional positive sequence element (67P).

They will be described down below.

3.7.2 Phase Directional Element (IDV-J/K/L with option D or higher in digit 9)

There is one directional element per phase. Phase operate magnitude is phase current and polarization magnitude is phase-to-phase voltage corresponding to the other two phases memorized 2 cycles before pickup.

Table 3.7-3 shows operation and polarization magnitudes applied to each of three phases.

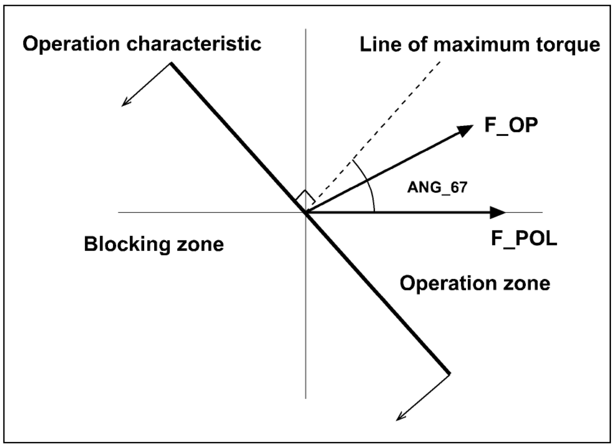


Figure 3.7.3: Vector Diagram of the Directional Phase Element.

The aim of directional phase elements is to check whether phase currents and voltages exceed a given value. This value is settable for voltage and has 60 mA setting for current. If current or voltage do not exceed the threshold values the **Lack of Polarization Blocking** setting is checked. If set to **NO** proceed as for the case of directional inhibition, but if set to **YES** indicates lack of polarization blocking and trips in both directions are blocked.

Following table shows the operating and polarization values applied to each of the three phases.

Table 3.7-1: Phase Sequence (IDV-J/K/L with option D or higher in digit 9)

ABC Phase Sequence			
Phase	**F_OP (*)**	**F_POL (*)**	**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 Phase Sequence			
Phase	**F_OP (*)**	**F_POL (*)**	**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	$U_{BAM} = (V_B - V_A)_M$	

(*) Operate magnitude.

The operate characteristic, drawn on a polar diagram, is a straight line, the perpendicular of which (maximum torque line) is rotated a given angle counter clockwise, known as phase characteristic angle, with respect to polarization magnitude. Said straight line divides the plane into two half planes. It is worth highlighting that said characteristic angle is complementary to the angle of the line positive sequence impedance (see the following application example).

When the directional element is set **Direction**, the overcurrent element is enabled 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 mentioned above, directional control is made phase after phase.

The logic diagram of operation of the phase directional element is shown in Figure 3.7.4.

The activation of the **Phase Directional Element Inhibition** (**INH_DIR_IN**) input converts the element to **Non-directional**.

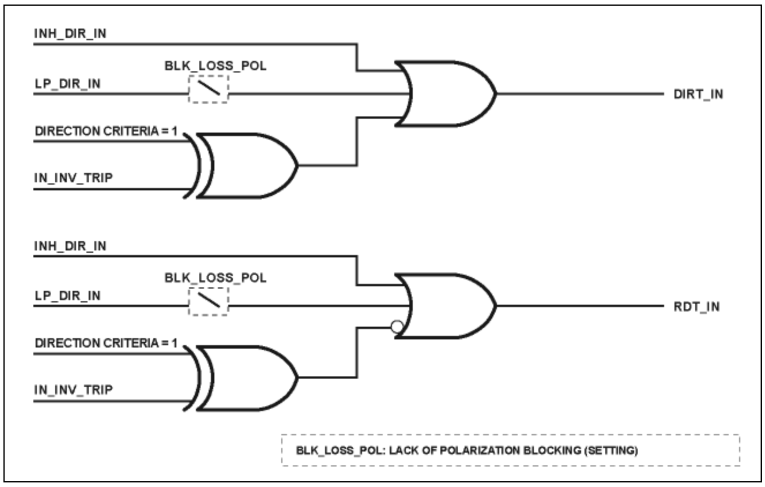


Figure 3.7.4: Block Diagram of a Directional Phase Element.

The **Inversion of the Trip Direction** (**IN_INV_TRIP**) input changes, if activated, the direction of operation of the directional element. **LP_DIR_IN** shows **Lack of Phase Directional Polarization**.

3.7.2.a Application Example

An analysis of the phase **Characteristic Angle**, with respect to the **Polarization Magnitude**, used by the relay to establish **Maximum Torque Line** dividing the plane into enable and disable zones of phase differential elements set **Direction** and with **ABC Phase Sequence** is made in this paragraph.

Let us assume the simple case of a single A- phase to ground fault with no fault impedance in a three phase line opened at one end. If $\mathbf{Z_{la}}$ is line impedance, fault current $\mathbf{I_A}$ will be produced by voltage $\mathbf{V_A}$ with phase lag angle α.

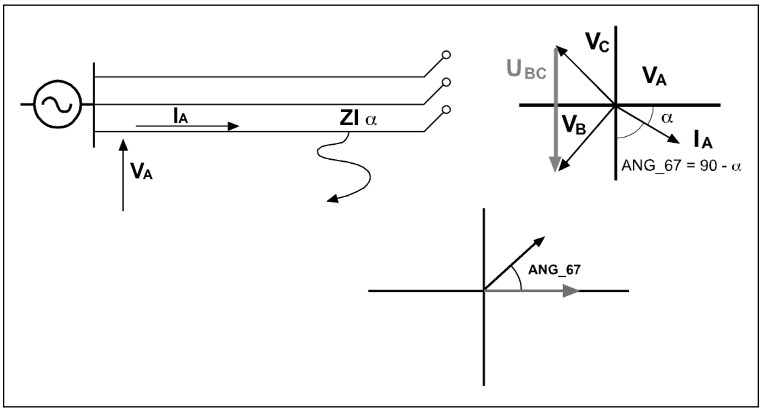


Figure 3.7.5: Graphics for the Application Example.

IDV relay with phase directional elements do not use phase-to-neutral voltages as polarization magnitudes for the corresponding operate magnitudes (phase currents). They use phase-to-phase voltages of the other phases not involved with the possible single phase to ground fault as **Polarization Magnitudes** (see Table 3.7-1).

As shown in the above graphics, for an A-phase to ground fault as described above, the polarization magnitude used by the relay in order to decide tripping or not, is voltage $U_{BC} = V_B - V_C$, with a phase lag of 90º with respect to the phase to neutral voltage of the faulted phase V_A .

As the **Phase Characteristic Angle** (**ANG_67**) set at the relay is the angle between **Operate Magnitude** and **Polarization Magnitude** (see Figure 3.7.1), the value to be assigned is the complementary angle to the “line impedance” angle.

All comments made so far for phase A can be directly extrapolated to phases B and C.

Summarizing, if $\mathbf{Z_{l\theta}}$ is line impedance, phase characteristic angle (**ANG_67**) setting is:

$$\mathbf{ANG\_67 = 90 -} \alpha$$

3.7.3 Ground Directional Element (IDV-J/K/L with option D or higher in digit 9)

Ground Directional element operation is based on zero-sequence and ground magnitudes. Zero-sequence current is taken as operate magnitude (calculated taken into account the phase currents.

Polarization magnitudes to be considered could be the following ones:

- **Compensated Zero-sequence voltage.** Depending on the model it could be the wired voltage (VN input channel) or the calculated one with the phase voltages:

$$\overline{V_N} = \frac{\overline{V_A} + \overline{V_B} + \overline{V_C}}{3}$$

- **Negative sequence voltage.**

Figure 3.7.6 shows the vector diagram associated to the directional ground element. In this case the ground directional unit is polarized with zero-sequence voltage which is compensated through the setting called as **Zero Sequence Voltage Compensation Factor** (K_{COMP_67N}):

$-V0 + I0 \cdot K_{COMP\_67N} \angle ANG\_67N$

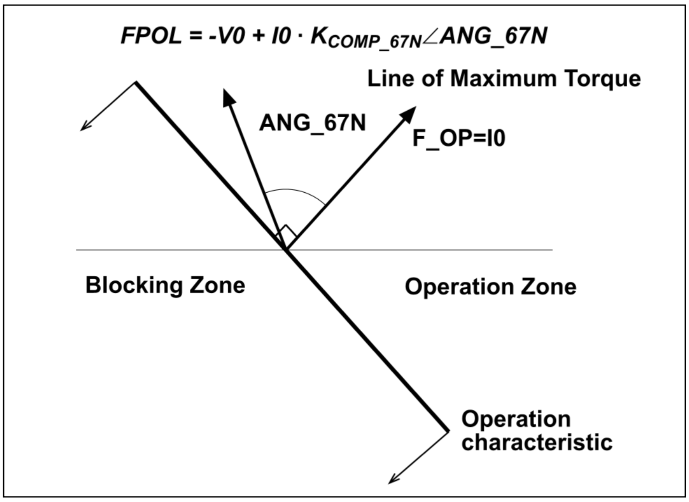


Figure 3.7.6: Vector Diagram of the Ground Directional Element (Polarization by Zero-Sequence Voltage). IDV-J/K/L with option D or higher in digit 9.

The following table shows the operation and polarization phasors which intervene in the ground directional element, as well as the operation criteria applied.

Table 3.7-2: Directional Ground Element (Polarization by Zero-Sequence Voltage) (IDV-J/K/L with option D or higher in digit 9)

F_OP	F_POL	Criteria
I0	$-V0 + I0 \cdot K_{COMP\_67N} \angle ANG\_67N$	$-(90^{o} + ANG\_67N) \le [\arg(Fop) - \arg(Fpol)] \le (90^{o} - ANG\_67N)$

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).

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 3.7.7.

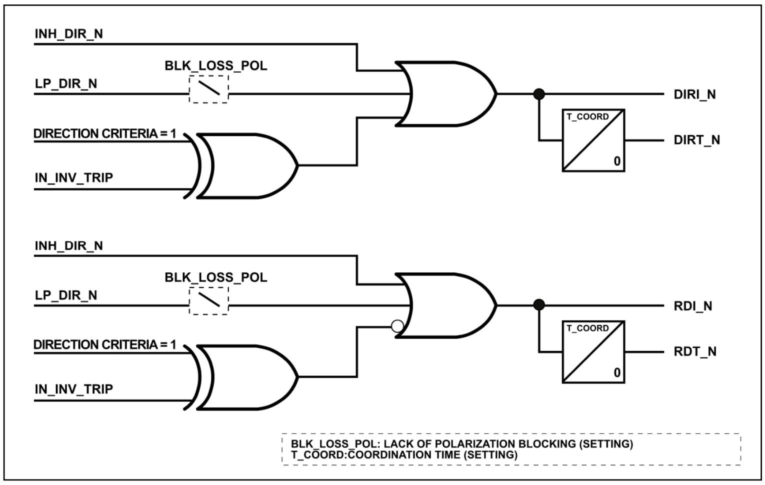


Figure 3.7.7: Block Diagram of a Directional Ground Element.

LP_DIR_N and **LP_DIR_SG** signals show **Lack of Ground Directional Polarization** and **Lack of Residual Ground Directional Polarization**, respectively.

3.7.4 Directional Negative Sequence Polarization (IDV-J/K/L with option D or higher in digit 9)

IDV Models can use as polarization phasor of the negative sequence directional element the compensated zero sequence voltage through setting **Zero Sequence Voltage Compensation Factor** (K_{COMP_67Q}): $-V2 + I2 \cdot K_{COMP\_67Q} \angle ANG\_67Q$

Figure 3.7.8 shows the phasor diagram associated to a Directional Negative Sequence of the **IDV-J/K/L******C**** models.

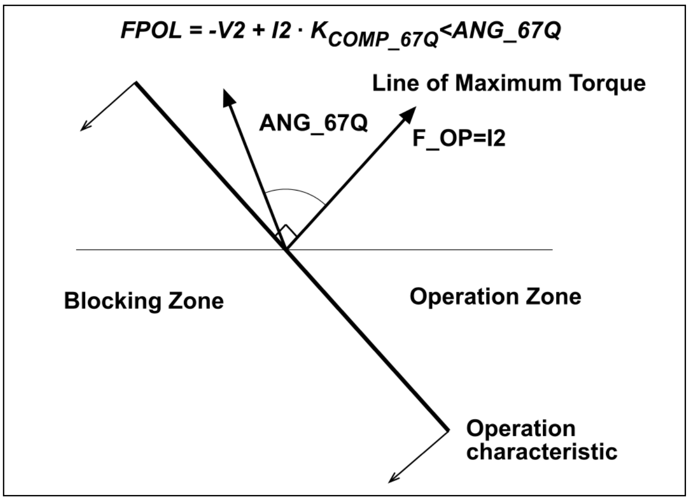


Figure 3.7.8: Vector Diagram of the Directional Negative Sequence Polarization (IDV-J/K/L with option D or higher in digit 9).

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 3.7-3: Directional Negative Sequence Element (IDV-J/K/L with option D or higher in digit 9)

F_OP	F_POL	Criteria
I2	$-V2 + I2 \cdot K_{COMP\_67Q} \angle ANG\_67Q$	$-(90^{o} + ANG\_67Q) \le [\arg(Fop) - \arg(Fpol)] \le (90^{o} - ANG\_67Q)$

Everything said for **Zero sequence compensation factor** is applicable to **Sequence voltage compensation factor**, if the negative sequence network is taken into account instead of the zero sequence network. The purpose of factor K_{COMP_67Q} is as follows:

- **Increase the polarization phasor magnitude**, in order that this exceeds the **Minimum Zero Sequence Voltage**.
- **Compensate the inversion that the V2 voltage** may undergo in lines with series compensation.

3.7.5 Positive Sequence Directional Element (IDV-J/K/L with option D or higher in digit 9)

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 3.2). Figure 3.7.9 shows the phasor diagram associated to the positive sequence directional element.

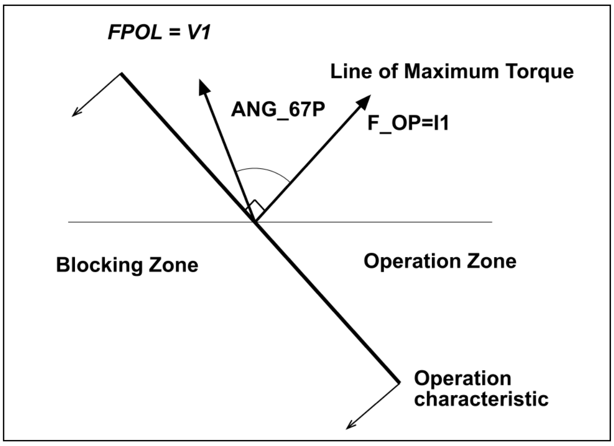


Figure 3.7.9: Vector Diagram of the Positive Sequence Directional Element.

The Negative 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 set to **NO** proceed as for the case of directional inhibition, but if set to **YES** indicates lack of polarization blocking and 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 3.7-4: Directional Negative Sequence Element (IDV-J/K/L with option D or higher in digit 9)

Fop	Fpol	Criteria
I1	V1	$-\left(90^{o}+ANG\_67P\right)\leq\left[\arg\left(Fop\right)-\arg\left(Fpol\right)\right]\leq\left(90^{o}-ANG\_67P\right)$

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 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 3.7.10.

If the **Direction Inversion Input** (**IN_INV_TRIP**) is active, the calculated direction is changed.

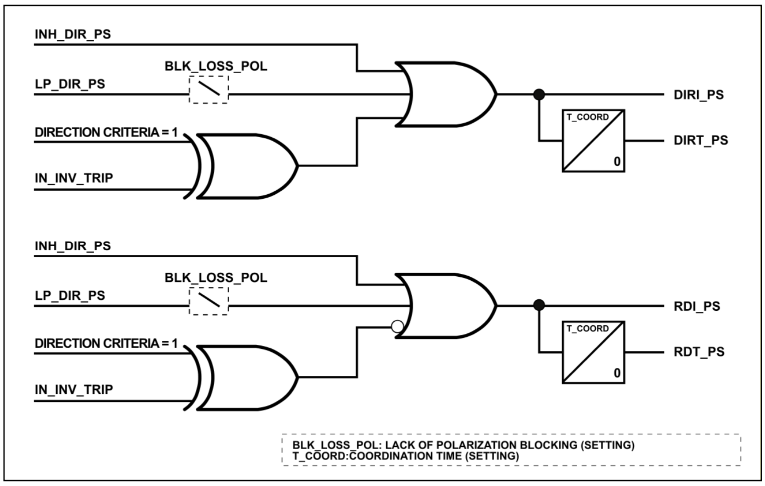


Figure 3.7.10: Block Diagram of a Directional Positive Sequence Element.

The activation of the **Inhibit of the Directional Negative Sequence** (**INH_DIR_NS**) input converts the element to non-directional.

3.7.6 Inversion of the Trip Direction

Directional Units are provided with a logic input that can be connected to some of the digital inputs using the programming capability of the same, the function of which is to change trip direction. When this input is deactivated the trip direction is that of the previous schemes. If said input is activated, trip direction changes to the opposite direction.

3.7.7 Directional Units Settings

Calculated Ground Directional Units			
Setting	**Range**	**Step**	**By Default**
Lack of direction blocking	YES / NO		NO

Directional Units (IDV-J/K/L with option D or higher in digit 9)			
Setting	**Range**	**Step**	**By Default**
Phase Characteristic Angle	-90º - +90º	1º	45º
Neutral Characteristic Angle	-90º - +90º	1º	45º
Negative Sequence Characteristic Angle	-90º - +90º	1º	45º
Positive Sequence Characteristic Angle	0 - 90º	1º	45º
Lack of Direction Blocking	YES / NO		NO
Minimum Phase Voltage	0.05 - 10 V	0.01 V	0.2 V
Minimum Neutral Voltage	0.05 - 10 V	0.01 V	0.2 V
Minimum Negative Sequence Voltage	0.05 - 10 V	0.01 V	0.2 V
Minimum Positive Sequence Voltage	0.05 - 10 V	0.01 V	0.2 V
Coordination Time	0 - 30 ms	1 ms	0 ms

- **Directional Units: HMI Access**

IDV-A/B/G/H/K/L MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**4 - DIRECTIONAL**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - LACK POLARIZ BLOCK**
...	
4 - DIRECTIONAL	
...	

IDV-D MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**6 - DIRECTIONAL**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - LACK POLARIZ BLOCK**
...	
6 - DIRECTIONAL	
...	

3.7.8 Digital Inputs of the Directional Modules

Table 3.7-5: Digital Inputs of the Directional Modules

Name	Description	Function
INH_DIR_NG1	Ground directional inhibit referred to ground channel 1	The activation of these inputs converts the directional elements into non-directional.
INH_DIR_NG2	Ground directional inhibit referred to ground channel 2	
ININV_TRIP_G1	Inversion of the ground trip direction referred to ground channel 1	When the input is quiescent, the operation zones are those indicated in this section 3.3. If it is activated, the operation zone is inverted.
ININV_TRIP_G2	Inversion of the ground trip direction referred to ground channel 2	
INH_DIR_PH	Phase directional element inhibit	The activation of these inputs converts the directional elements into non-directional.
INH_DIR_N	Ground directional element inhibit	
INH_DIR_NS	Negative sequence directional element inhibit	
INH_DIR_PS	Positive sequence directional element inhibit	

3.7.9 Auxiliary Outputs and Events of the Directional Modules

Table 3.7-6: Auxiliary Outputs and Events of the Directional Modules

Name	Description	Function
INH_DIR_NG1	Ground directional inhibit referred to ground channel 1	The same as for the Digital Inputs.
INH_DIR_NG2	Ground directional inhibit referred to ground channel 2	
ININV_TRIP_G1	Inversion of the ground trip direction referred to ground channel 1	
ININV_TRIP_G2	Inversion of the ground trip direction referred to ground channel 2	
RD_NG1	Ground reverse direction referred to ground channel 1	Indication that the current flows in the direction opposite to that of the trip.
RD_NG2	Ground reverse direction referred to ground channel 2	
DIR_NG1	Ground direction referred to ground channel 1	Indication that the current flows in the direction of the trip.
DIR_NG2	Ground direction referred to ground channel 2	
RDI_A	Phase A instantaneous element 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 element reverse direction	
RDI_C	Phase C instantaneous element reverse direction	
RDI_G	Ground instantaneous element reverse direction	
RDI_NS	Negative sequence instantaneous element reverse direction	
RDI_PS	Positive sequence instantaneous element reverse direction	
RDT_A	Phase A time element reverse direction	
RDT_B	Phase B time element reverse direction	
RDT_C	Phase C time element reverse direction	
RDT_G	Ground time element reverse direction	
RDT_NS	Negative sequence time element reverse direction	
RDT_PS	Positive sequence time element reverse direction	

3.7.10 Ground Directional Units Test

This test uses both ground channels. Each channel has to be assigned to each winding, and perform the following tests. Check that the unit is enabled, the **Torque Control** is set to Direction and the inversion of Trip Direction input must not be operational before running the test.

Test can be performing with phase current **Ia** from one winding and the **IG** of the same winding. Next table describes the cases where relay directional control is enabled. To verify if the directional unit is active check the Menu **Information** - **Status** - **Metering Units** - **Overcurrent** - **Directional OC** - locating the corresponding flags for the tested phase.

Table 3.7-7: Ground Directional Control by IG	
I APPLIED	**I APPLIED**
Ia=1A⌊180º	IG=1A⌊0º

In case of **IDV-J/K/L** models with option **D** or higher in digit **9**, prior to testing check that **Pickup Blocking Enable** setting or **Torque Control** setting are set **Direction**, and that **Direction Reversal** input is disabled.

In **IDV-J/K/**L models with option **D** or higher in digit **9** models testing can be carried out: Ia with Vb, Ib with Vc, Ic with Va, In with Va and Ins with Va. Following Tables show the angles between which relay directional control is enabled. To check if the relay directional control is enabled or not go to menu **Information** - **Status** - **Measuring Elements** - **Overcurrent** - **Directional Overcurrent** and check the state of flags corresponding to the tested phase.

Table 3.7-8: Phase Directional Control (IDV-J/K/L with option D or higher in digit 9)	
V APPLIED	**I APPLIED**
Vb = 64V⌊0º	Ia = 1A⌊(270º+α charact to 90º + α charact) ± 2º
Vc = 64V⌊0º	Ib = 1A⌊(270º+α charact to 90º + α charact) ± 2º
Va = 64V⌊0º	Ic = 1A⌊(270º+α charact to 90º + α charact) ± 2º

Table 3.7-9: Ground Directional Control (IDV-J/K/L with option D or higher in digit 9)			
Ground Directional and Sensitive Ground Directional by Vpol		**Ground Directional by Ipol**	
V APPLIED	**I APPLIED**	**I APPLIED**	
Va = 64V⌊0º	In = 1A⌊ (90º - α charact to 270º - α charact) ± 2º	Ip = 1A⌊180º	In = 1A⌊-90º to 90º

Table 3.7-10: Negative Sequence Directional Control (IDV-J/K/L with option D or higher in digit 9)	
V APPLIED	**I APPLIED**
Va = 64V⌊180º	Ia = 1A Î(270º - α charact to 90º - α charact) ± 2º

Table 3.7-11: Positive Sequence Directional Control (IDV-J/K/L with option D or higher in digit 9)	
V APPLIED	**I APPLIED**
Va = 64V⌊0º	Ia = 1A Î(270º - a charact a 90º - a charact) ± 2º

3.8 Voltage Units

IDV-A/B/G/H/J/K/L relays incorporate the following voltage elements:

- **Two Phase Undervoltage Units (27F1 and 27F2)**
- **Two Phase Overvoltage Units (59F1 and 59F2)**
- **Two Ground Overvoltage Units (64_1 and 64_2)**

3.8.1 Undervoltage Units

IDV-A/B models have single-phase voltage units associated with the available analog phase voltage input (**VPH**). **IDV-G/H/J/K/L** models have three-phase voltage units operating with the VA, VB and VC analog voltage channels. All the **IDV** models have a setting, **Voltage Type**, to select between working with **Phase-Ground** or **Phase-Phase** voltages. In **IDV-A/B/J/K** models you can select, through **Voltage Type** setting, the phase for the VPH voltage (Va, Vb, Vc, Vab, Vbc, Vca). In turn, for calculating certain magnitudes (P, Q,...) as ratios with some machine breakers, it's considered that the analog phase voltage input belongs to the winding configured as **Reference Winding**. The **Voltage type** setting for **IDV-A/B** relays is shown within the **General settings** field (refer to section 3.16), whereas for **IDV-G/H/J/K** relays it is shown as setting of the voltage element itself.

The undervoltage elements od the **IDV-G/H/J/K/L** models 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 3.8.2):

- 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 (1) 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 value 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 time. 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.

3.8.1.a Application of the Undervoltage Elements

Undervoltage protection is used in machines to detect low voltage conditions caused by a system fault or by an anomalous operating situation. The reasons for such undervoltage situations can be:

- Faulty operation of voltage regulators (normally a symmetric fault).
- Incorrect manual control of the voltage regulator (normally a symmetric fault).
- Overloads (normally a symmetric fault).
- System faults, primarily single-phase (normally an asymmetric fault).

Some applications of these functions include:

- Combination with AND logics of overcurrent unit outputs and undervoltage unit outputs.
- Automatic tripping of breakers in case of a blackout.
- Automatic capacitor bank connection for voltage support.
- Disconnecting equipment from the network that can be damaged when operating in low voltage conditions.

3.8.2 Overvoltage Units

3.8.2.a Phase Overvoltage Units (59F1 and 59F2)

Like Phase Undervoltage Units, these units are associated with the available analog phase voltage input **VPH** (**IDV-A/B** models) or to the VA, VB and VB analog voltage inputs (**IDV-G/H/J/K/L** models). For a specific overvoltage unit, the pickup takes place when the RMS value is equal to or greater than one (1) time the set value; the reset occurs at a selectable percentage value (lower) with respect to the setting.

IDV-G/H/J/K/L 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 3.8.2):

- **AND**: the (59F) element trips when the three associated overvoltage elements (V1, V2 and V3) comply with the trip condition.
- **OR**: the (59F) element trips when one or more of the three associated overvoltage elements (V1, V2 or V3) comply with the trip condition.

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 time. 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.

3.8.2.b Ground Overvoltage Units

- **Elements 59N1 and 59N2 (IDV-G/H/J/K/L Models)**

Ground overvoltage elements 59N1 and 59N2 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.

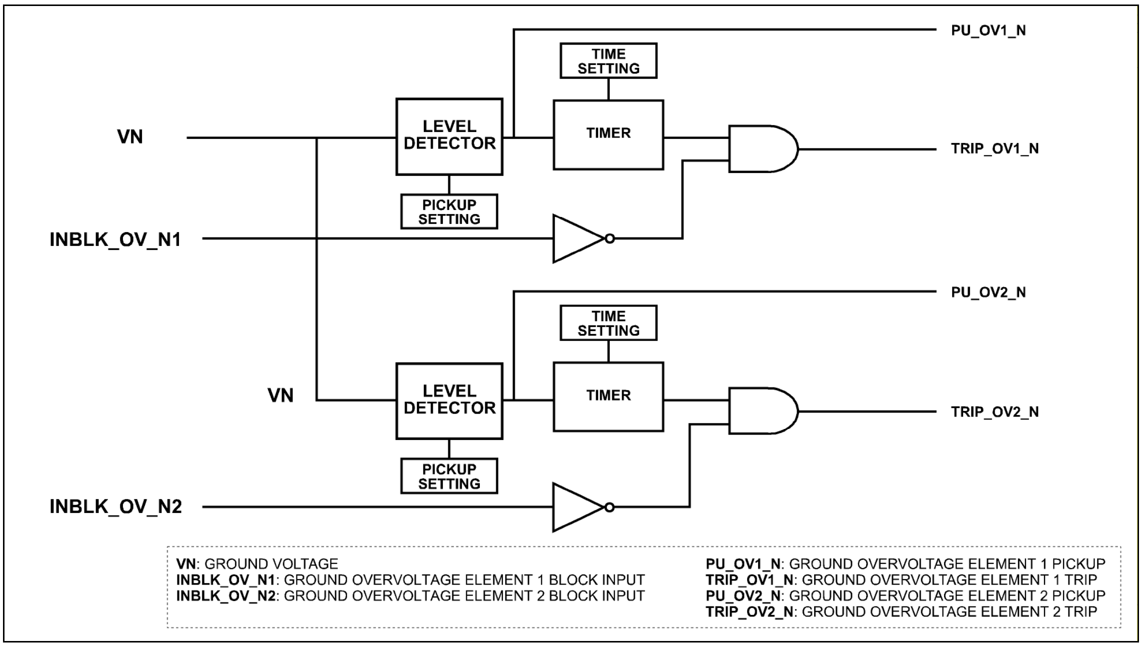


Figure 3.8.1: Block Diagram of Ground Overvoltage Elements 59N1 and 59N2

Each unit picks up when the RMS value of the zero sequence voltage exceeds one (1) times the set pickup value and resets with a selectable value percentage (lower) of the setting.

Elements **64_1** and **64_2** can program **Block Trip** inputs, which prevents the operation of the unit 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**.

- **Elements 64_1 and 64_2 (IDV-A/B/L)**

The characteristics of these elements are identical to those of elements 59N1 and 59N2, except that the neutral voltage is obtained directly through a TT connection in open delta. This is why the IED has a specific voltage analog input. For models **IDV-L** and **IDV-*******B******, the element to be used will be determined by the setting **Ground Voltage Source** (refer to 3.16.14).

3.8.2.c Application of the Overvoltage Units

Phase overvoltage protection is used in machines primarily to avoid damage to insulators when excessively high voltage situations occur. It also protects machines in overexcitation situations.

The reasons for which an overvoltage may occur with normal system frequency values include:

- Faulty operation of voltage regulators (normally a symmetric fault).
- Incorrect manual control of the voltage regulator (normally a symmetric fault).
- Sudden load loss.
- In power lines, low active power transmitted versus high ground capacity.
- Excessive acceleration of generators when disconnected from the network due to a control system malfunction.
- Ground faults in non-grounded systems or high-impedance grounded systems.

Ground overvoltage protection is used as a backup protection for ground faults in isolated ground or high impedance systems.

3.8.3 Block Diagram of the Voltage Units

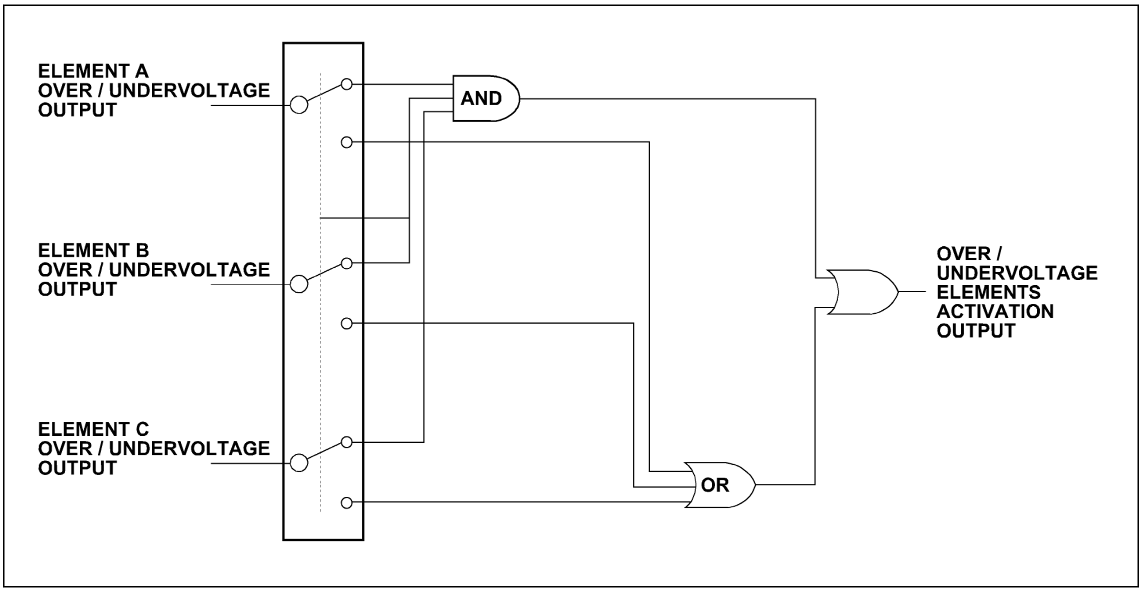


Figure 3.8.2: Block Diagram of the AND/OR Operation for the Voltage Elements

The output that enables overvoltage/undervoltage elements in the diagram of figure 3.6.2 corresponds to the outputs of **three-phase masked trip of undervoltage and overvoltage elements 1, 2 and 3**. This means that their corresponding trip masks affect these signals, which are directional to the protection trip.

Next figure depicts the block diagram of Overvoltage and Undervoltage Units 1. This diagram is also representative of phase Overvoltage and Undervoltage Units 2 and of the Ground Overvoltage Units. In the **IDV-G/H/J/K/L** models is represented the unit associated to the phase voltage VPH.

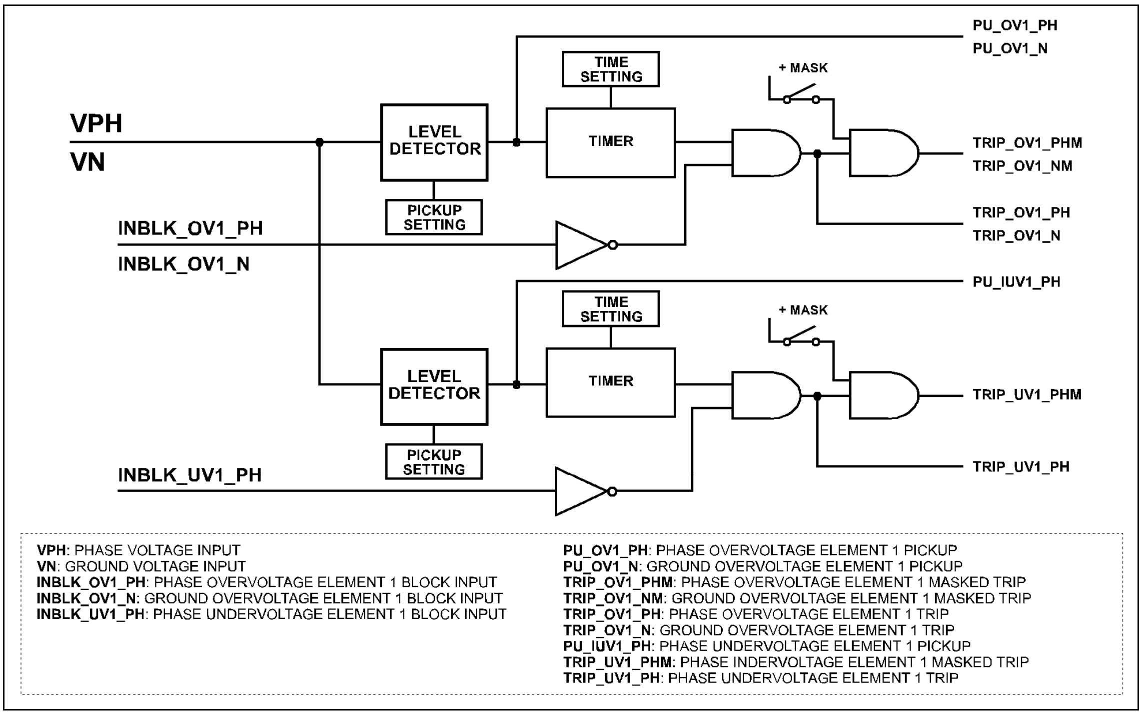


Figure 3.8.3: Block Diagram of the Voltage Units.

3.8.4 Voltage Units Settings

Voltage Restoration			
Setting	**Range**	**Step**	**By Default**
Phase Undervoltage Reset	101 - 150% of setting	1	105 %
Phase Overvoltage Reset	50 - 99% of setting	1	95 %
Ground Overvoltage Reset	50 - 99% of setting	1	95 %

Phase Overvoltage (Elements 1, and 2)			
Setting	**Range**	**Step**	**By Default**
Phase Overvoltage Enable	YES / NO		NO
Voltage Type (IDV-G/H/J/K/L)	Line Voltage Phase Voltage		Line Voltage
Phase Overvoltage Pickup	20 - 300 V	0.01 V	70 V
Phase Overvoltage Delay	0 - 300 s	0.01 s	0 s
Tripping Logic (IDV-G/H/J/K/L)	OR / AND		OR

Ground Overvoltage (Elements 1 and 2)			
Setting	**Range**	**Step**	**By Default**
Ground Overvoltage Enable	YES / NO		NO
Ground Overvoltage Pickup	2 - 150 V	0.01 V	10 V
Ground Overvoltage Delay	0 - 300 s	0.01 s	0 s

Phase Undervoltage (Units 1 and 2)			
Setting	**Range**	**Step**	**By Default**
Phase Undervoltage Enable	YES / NO		NO
Voltage Type (IDV-G/H/J/K/L)	Line Voltage Phase Voltage		Line Voltage
Phase Undervoltage Pickup	10 - 300 V	0.01 V	40 V
Phase Undervoltage Delay	0 - 300 s	0.01 s	0 s
Tripping Logic (IDV-G/H/J/K/L)	OR / AND		OR

- **Voltage Units: HMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**3 - PROTECTION**	**7 - VOLTAGE**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - VOLTAGE RESET**
...	**1 - PHASE OVERVOLTAGE**
7 - VOLTAGE	**2 - GROUND OVERVOLTAGE**
...	**3 - PHASE UNDERVOLTAGE**

Voltage Reset

0 - VOLTAGE RESET	**0 - PH. UNDERV. DROP.**
1 - PHASE OVERVOLTAGE	**1 - PH OVERV. DROP.**
2 - GROUND OVERVOLTAGE	**2 - GND OV RESET**
3 - PHASE UNDERVOLTAGE	

Phase Overvoltage (IDV-A/B)

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH OVERV. ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - PH. OVERV PICKUP**
2 - GROUND OVERVOLTAGE		**2 - PH. OVERV. DELAY**
3 - PHASE UNDERVOLTAGE		

Phase Overvoltage (IDV-G/H/J/K/L)

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH OVERV. ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - VOLTAGE TYPE**
2 - GROUND OVERVOLTAGE		**2 - PH. OVERV PICKUP**
3 - PHASE UNDERVOLTAGE		**3 - PH. OVERV. DELAY**
		4 - OUTP. LOGIC PH OVERV

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 (IDV-A/B)

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH. UNDERV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - PH. UNDERV PICKUP**
2 - GROUND OVERVOLTAGE		**2 - PH. UNDERV DELAY**
3 - PHASE UNDERVOLTAGE		

Phase Undervoltage (IDV-G/H/J/K/L)

0 - VOLTAGE RESET	**0 - UNIT 1**	**0 - PH. UNDERV ENABLE**
1 - PHASE OVERVOLTAGE	**1 - UNIT 2**	**1 - VOLTAGE TYPE**
2 - GROUND OVERVOLTAGE		**2 - PH. UNDERV PICKUP**
3 - PHASE UNDERVOLTAGE		**3 - PH. UNDERV DELAY**
		4 - OUTP LOGIC PH UNDERV

3.8.5 Digital Inputs of the Voltage Modules

Table 3.8-1: Digital Inputs of the Voltage Modules

Name	Description	Function
INBLK_UV1_PH	Phase undervoltage unit 1 block input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_UV2_PH	Phase undervoltage unit 2 block input	
INBLK_OV1_PH	Phase overvoltage unit 1 block input	
INBLK_OV2_PH	Phase overvoltage unit 2 block input	
INBLK_OV1_N	Ground overvoltage unit 1 block input	
INBLK_OV2_N	Ground overvoltage unit 2 block input	
ENBL_UV1_PH	Phase undervoltage unit 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_UV2_PH	Phase undervoltage unit 2 enable input	
ENBL_OV1_PH	Phase overvoltage unit 1 enable input	
ENBL_OV2_PH	Phase overvoltage unit 2 enable input	
ENBL_OV1_N	Ground overvoltage unit 1 enable input	
ENBL_OV2_N	Ground overvoltage unit 2 enable input	

3.8.6 Auxiliary Outputs and Events of the Voltage Modules

Table 3.8-2: Auxiliary Outputs and Events of the Voltage Modules

Name	Description	Function
PU_IUV1_A	Phase A undervoltage unit 1 pickup (IDV-G/H/J/K/L)	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 unit 2 pickup (IDV-G/H/J/K/L)	
PU_IUV1_B	Phase B undervoltage unit 1 pickup (IDV-G/H/J/K/L)	
PU_IUV2_B	Phase B undervoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_IUV1_C	Phase C undervoltage unit 1 pickup (IDV-G/H/J/K/L)	
PU_IUV2_C	Phase C undervoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_IUV1_3PH	Three-phase undervoltage unit 1 pickup (IDV-G/H/J/K/L)	
PU_IUV2_3PH	Three-phase undervoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_IUV1_PH	Phase undervoltage unit 1 pickup (IDV-A/B)	
PU_IUV2_PH	Phase undervoltage unit 2 pickup (IDV-A/B)	
PU_OV1_A	Phase A overvoltage unit 1 pickup (IDV-G/H/J/K/L)	
PU_OV2_A	Phase A overvoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_OV1_B	Phase B overvoltage unit 1 pickup (IDV-G/H/J/K/L)	
PU_OV2_B	Phase B overvoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_OV1_C	Phase C overvoltage unit 1 pickup (IDV-G/H/J/K/L)	
PU_OV2_C	Phase C overvoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_OV1_3PH	Three-phase overvoltage unit 1 pickup (IDV-G/H/J/K/L)	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_OV2_3PH	Three-phase overvoltage unit 2 pickup (IDV-G/H/J/K/L)	
PU_OV1_PH	Phase overvoltage unit 1 pickup (IDV-A/B)	
PU_OV2_PH	Phase overvoltage unit 2 pickup (IDV-A/B)	
PU_OV1_N	Ground overvoltage unit 1 pickup	
PU_OV2_N	Ground overvoltage unit 2 pickup	

Table 3.8-2: Auxiliary Outputs and Events of the Voltage Modules

Name	Description	Function
TRIP_UV1_A	Phase A undervoltage unit 1 trip (IDV-G/H/J/K/L)	Trip of the undervoltage and overvoltage units. The three-phase trips are those that are generated after the chosen AND or OR algorithm.
TRIP_UV2_A	Phase A undervoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_UV1_B	Phase B undervoltage unit 1 trip (IDV-G/H/J/K/L)	
TRIP_UV2_B	Phase B undervoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_UV1_C	Phase C undervoltage unit 1 trip (IDV-G/H/J/K/L)	
TRIP_UV2_C	Phase C undervoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_UV1_3PH	Three-phase undervoltage unit 1 trip (IDV-G/H/J/K)	
TRIP_UV2_3PH	Three-phase undervoltage unit 2 trip (IDV-G/H/J/K)	
TRIP_UV1_PH	Phase undervoltage unit 1 trip (IDV-A/B)	
TRIP_UV2_PH	Phase undervoltage unit 2 trip (IDV-A/B)	
TRIP_OV1_A	Phase A overvoltage unit 1 trip (IDV-G/H/J/K/L)	
TRIP_OV2_A	Phase A overvoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_OV1_B	Phase B overvoltage unit 1 trip (IDV-G/H/J/K/L)	
TRIP_OV2_B	Phase B overvoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_OV1_C	Phase C overvoltage unit 1 trip (IDV-G/H/J/K/L)	
TRIP_OV2_C	Phase C overvoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_OV1_3PH	Three-phase overvoltage unit 1 trip (IDV-G/H/J/K/L)	
TRIP_OV2_3PH	Three-phase overvoltage unit 2 trip (IDV-G/H/J/K/L)	
TRIP_OV1_PH	Phase overvoltage unit 1 trip (IDV-A/B)	
TRIP_OV2_PH	Phase overvoltage unit 2 trip (IDV-A/B)	
TRIP_OV1_N	Ground overvoltage unit 1 trip	
TRIP_OV2_N	Ground overvoltage unit 2 trip	
TRIP_UV1_3PHM	Three-phase undervoltage unit 1 masked trip (IDV-G/H/J/K/L)	Trip of the undervoltage and overvoltage units affected by their corresponding mask. Three-phase trips are those that are generated after the chosen AND or OR algorithm and are the outputs that go to the trip contacts.
TRIP_UV2_3PHM	Three-phase undervoltage unit 2 masked trip (IDV-G/H/J/K/L)	
TRIP_UV1_PHM	Phase undervoltage unit 1 masked trip (IDV-A/B)	
TRIP_UV2_PHM	Phase undervoltage unit 2 masked trip (IDV-A/B)	

<table>
<tr><th colspan="3">Table 3.8-2: Auxiliary Outputs and Events of the Voltage Modules</th></tr>
<tr><th>Name</th><th>Description</th><th>Function</th></tr>
<tr><td>TRIP_OV1_3PHM</td><td>Three-phase overvoltage unit 1 masked trip (IDV-G/H/J/K/L)</td><td rowspan="6">Trip of the undervoltage and overvoltage units affected by their corresponding mask. Three-phase trips are those that are generated after the chosen AND or OR algorithm and are the outputs that go to the trip contacts.</td></tr>
<tr><td>TRIP_OV2_3PHM</td><td>Three-phase overvoltage unit 2 masked trip (IDV-G/H/J/K/L)</td></tr>
<tr><td>TRIP_OV1_PHM</td><td>Phase overvoltage unit 1 masked trip (IDV-A/B)</td></tr>
<tr><td>TRIP_OV2_PHM</td><td>Phase overvoltage unit 2 masked trip (IDV-A/B)</td></tr>
<tr><td>TRIP_OV1_NM</td><td>Ground overvoltage unit 1 masked trip</td></tr>
<tr><td>TRIP_OV2_NM</td><td>Ground overvoltage unit 2 masked trip</td></tr>
<tr><td>UV_PH1_ENBLD</td><td>Phase undervoltage unit 1 enabled</td><td rowspan="6">Indication of enabled or disabled status of the undervoltage and overvoltage units.</td></tr>
<tr><td>UV_PH2_ENBLD</td><td>Phase undervoltage unit 2 enabled</td></tr>
<tr><td>OV_PH1_ENBLD</td><td>Phase overvoltage unit 1 enabled</td></tr>
<tr><td>OV_PH2_ENBLD</td><td>Phase overvoltage unit 2 enabled</td></tr>
<tr><td>OV_N1_ENBLD</td><td>Ground overvoltage unit 1 enabled</td></tr>
<tr><td>OV_N1_ENBLD</td><td>Ground overvoltage unit 2 enabled</td></tr>
<tr><td>INBLK_UV1_PH</td><td>Phase undervoltage unit 1 block input</td><td rowspan="6">The same as for the Digital Inputs.</td></tr>
<tr><td>INBLK_UV2_PH</td><td>Phase undervoltage unit 2 block input</td></tr>
<tr><td>INBLK_OV1_PH</td><td>Phase overvoltage unit 1 block input</td></tr>
<tr><td>INBLK_OV2_PH</td><td>Phase overvoltage unit 2 block input</td></tr>
<tr><td>INBLK_OV1_N</td><td>Ground overvoltage unit 1 block input</td></tr>
<tr><td>INBLK_OV2_N</td><td>Ground overvoltage unit 2 block input</td></tr>
<tr><td>ENBL_UV1_PH</td><td>Phase undervoltage unit 1 enable input</td><td rowspan="6">The same as for the Digital Inputs.</td></tr>
<tr><td>ENBL_UV2_PH</td><td>Phase undervoltage unit 2 enable input</td></tr>
<tr><td>ENBL_OV1_PH</td><td>Phase overvoltage unit 1 enable input</td></tr>
<tr><td>ENBL_OV2_PH</td><td>Phase overvoltage unit 2 enable input</td></tr>
<tr><td>ENBL_OV1_N</td><td>Ground overvoltage unit 1 enable input</td></tr>
<tr><td>ENBL_OV2_N</td><td>Ground overvoltage unit 2 enable input</td></tr>
</table>

3.8.7 Voltage Units Test

3.8.7.a Overvoltage Units Test

Before testing the Overvoltage Units, 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 3.8-3:·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 Unit.

- **Operating Times**

Outputs (G4-G5-G6-G7) (G8-G9-G10-H1) (C1-C2-C3-C4) are used to verify them, depending on the model. [See figure 3.8.2].

Fixed Time or Instantaneous

The pickup setting is increased 20%. Operating time should be the selected time setting ±1% or 32 ms (for 50Hz) or 28ms (for 60Hz). A setting of 0 ms will have an operating time between 20 and 32 ms (for 50Hz) or between 15 and 28 ms (for 60Hz).

3.8.7.b Undervoltage Units Test

Before testing the Undervoltage Units, all the voltage units that are not being tested must be disabled and the phase voltage channel must be configured as V_{AB}.

- **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 3.8-4: 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” corresponds to the setting in per unit of the unit **Reset** for the Undervoltage Unit.

- **Operating Times**

Outputs (G4-G5-G6-G7) (G8-G9-G10-H1) (C1-C2-C3-C4) are used to verify them, depending on the model. [See figure 3.8.2].

Fixed Time or Instantaneous

The pickup setting is increased 20%. Operating time should be the selected time setting ±1% or 32 ms (for 50Hz) or 28ms (for 60Hz). A setting of 0 ms will have an operating time between 20 and 32 ms (for 50Hz) or between 15 and 28 ms (for 60Hz).

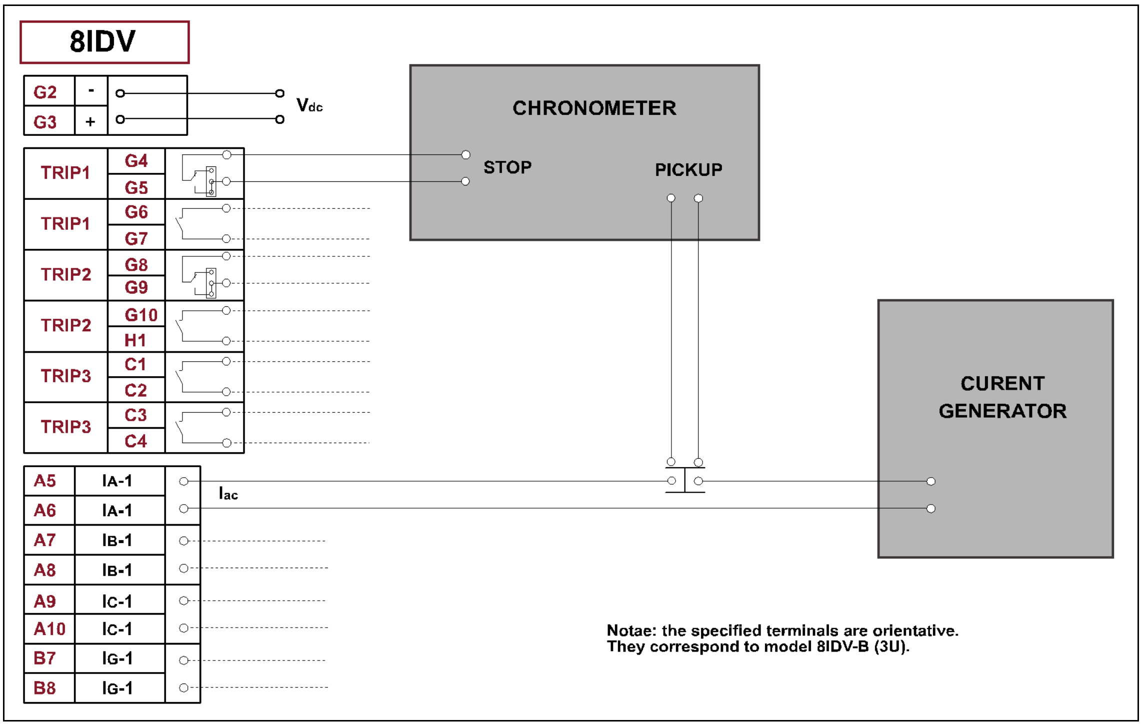


Figure 3.8.4: Operating Time Test Setup (Voltage Units).

3.9 Frequency Units

IDV-A/B/G/H and/or **IDV-***-****C**** relays incorporate the following frequency elements:

- **Four Overfrequency Units (81M1, 81M2, 81M3 and 81M4)**
- **Four Underfrequency Units (81m1, 81m2, 81m3 and 81m4)**
- **Four Frequency Rate of Change Units (81D1, 81D2, 81D3 and 81D4)**

IDV-J/K/L relays incorporate the following frequency elements:

- **Two Overfrequency Units (81M1, 81M2, 81M3 and 81M4)**
- **Two Underfrequency Units (81m1, 81m2, 81m3 and 81m4)**
- **Two Frequency Rate of Change Units (81D1, 81D2, 81D3 and 81D4)**

3.9.1 Introduction

The Underfrequency, Overfrequency and Rate of Change Units 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 Units to meter and to operate. Otherwise, it gives a frequency value of zero and the Frequency Units are inhibited.
- **Activation half-waves**. This is the number of half-waves that must meet the fault conditions for the Frequency Units to pick up.
- **Reset cycles**. This is the number of cycles during which there may not exist fault conditions so that the Frequency Units already picked up will reset. When the Frequency Units 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 unit. 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.
- **Load Shedding Slgorithm**. There is an option to have the Frequency Units 1 operate in pairs, an Underfrequency or Rate of Change element with an Overfrequency Unit, to perform a load shedding scheme. This operation mode permits 1 load shedding level. For more than one level, programmable logic should be configured using the signals from the rest of Frequency Units. Since the frequency is measured based on the phase voltage, and the latter is assigned to the reference winding, the breaker of this winding will be taken into account in the unit's logic.
- **Load Shedding Type**. Either the Underfrequency or the Rate of Change Unit can be selected to initiate the load shedding.
- **Load Shedding Winding**. Selectable between Winding 2 or Winding 3.

Load Shedding function and the corresponding settings are only available for **IDV-B/H/K/L** Models (3 windings).

All the units 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 units have a time module that can be set to instantaneous. It has the following settings: **Pickup** and **Delay**.

Figure 3.9.1 is the block diagram of one of the Frequency Units.

Associated with the level detection block, there is a setting for the pickup value: if the unit is the Overfrequency Unit, and the value measured exceeds the setting value a given quantity, the unit picks up. On the contrary, if it is the Underfrequency Unit, it picks up when the value measured is a given quantity less than the setting value.

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.

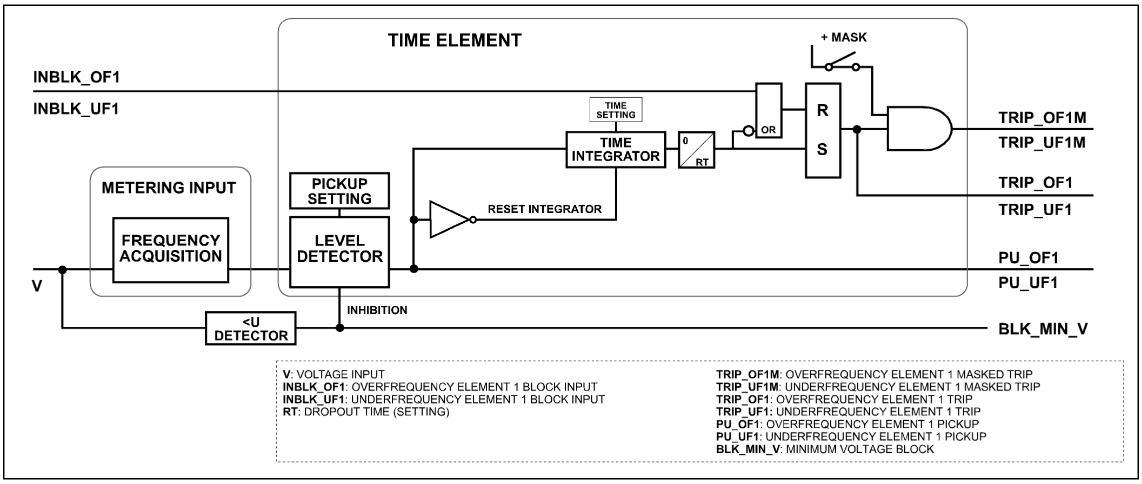


Figure 3.9.1: Block Diagram of a Frequency Unit.

3.9.2 Overfrequency Units

Overfrequency Units operate on the measured frequency value of phase voltage input **VPH** (**VA** for the **IDV-G/H/J/K/L** models).

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 10mHz of this setting for a time equal to or greater than the **Dropout Time** setting. This **Dropout Time** setting indicates how long the fault conditions must disappear after a fault for the trip to reset.

3.9.3 Underfrequency Units

Underfrequency Units operate on the measured frequency value of phase voltage input **VPH** (**VA** for the **IDV-G/H/J/K/L** models).

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 10mHz of this setting for a time equal to or greater than the **Dropout Time** setting. The same as in the Overfrequency Unit, this **Dropout Time** setting indicates how long the fault conditions must disappear after a fault for the trip to reset.

3.9.4 Frequency Rate of Change Units

Frequency Rate of Change Units operate on the measured frequency value of phase voltage input **VPH** (**VA** phase voltage for the **IDV-G/H/J/K/L** models).

The algorithm of these units 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 unit is to pick up.
- **Delay**. Time during which the fault condition must remain for the unit to activate.
- **Dropout Time**. Time during which the fault conditions must disappear after a fault for the unit to reset.

dF/dT value is calculated every time that the voltage analog input Va makes itself zero by obtaining the variation of the frequency between the current value and the one available 5 half-waves before.

The unit will pick-up only when the value of dF/dT is higher than the one set as **Rate of Change Pickup** (setting value + 0.05Hz/s in absolute value) for a selected period of time equal to the “**Activation half-waves**” setting value minus 7 half-waves. In detail, taking into account that the relay requires 2 half-waves to calculate the frequency value accurately and 5 half-waves to calculate the dF/dT value, the time period from the frequency variation to the pickup of the unit is that called as **“Activation half-waves**”. If the value of the **Activation Half-Waves** setting is less than 10 half-waves, then the Frequency Rate of Change unit will always consider a value equal to 10. Refer to the example regarding the operation of the unit pick-up.

In the algorithm, the Rate of Change must be equal to or less than a given adjustable value (frequency unit pickup) for a time equal to or greater than the **Activation Half-Waves** setting before the rate of change is taken into account. This algorithm checks the frequency and the rate of change of the frequency separately. For the element to operate, the pick-up conditions must exist for both. See figure 3.9.2.

The figure below depicts the operation mode for the Frequency Rate of Change function:

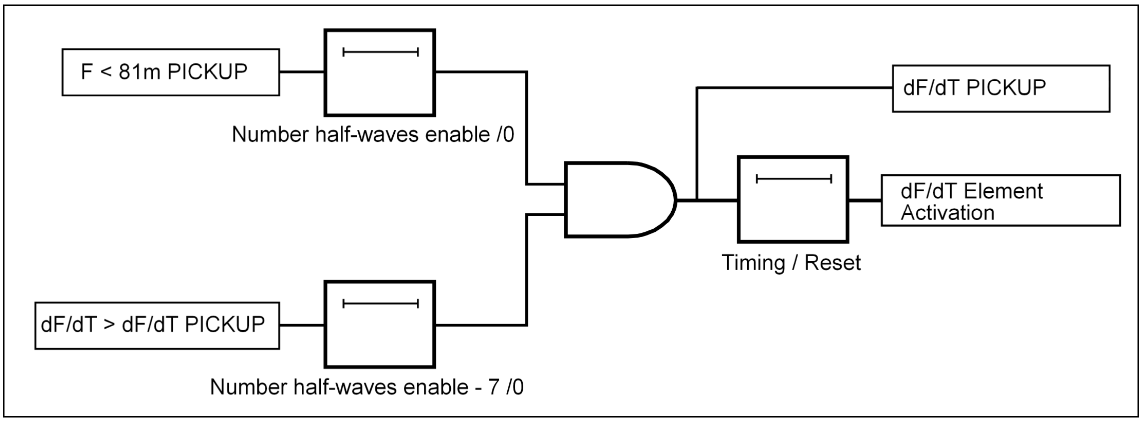


Figure 3.9.2: Logic Diagram of a Frequency Rate of Change Unit.

- **Example regarding the operation of the unit pickup**

Activation half-waves = 3
Frequency unit pickup = 49.8 Hz
dF/dT unit pickup = -1 Hz/s
Time delay = 0.1 s

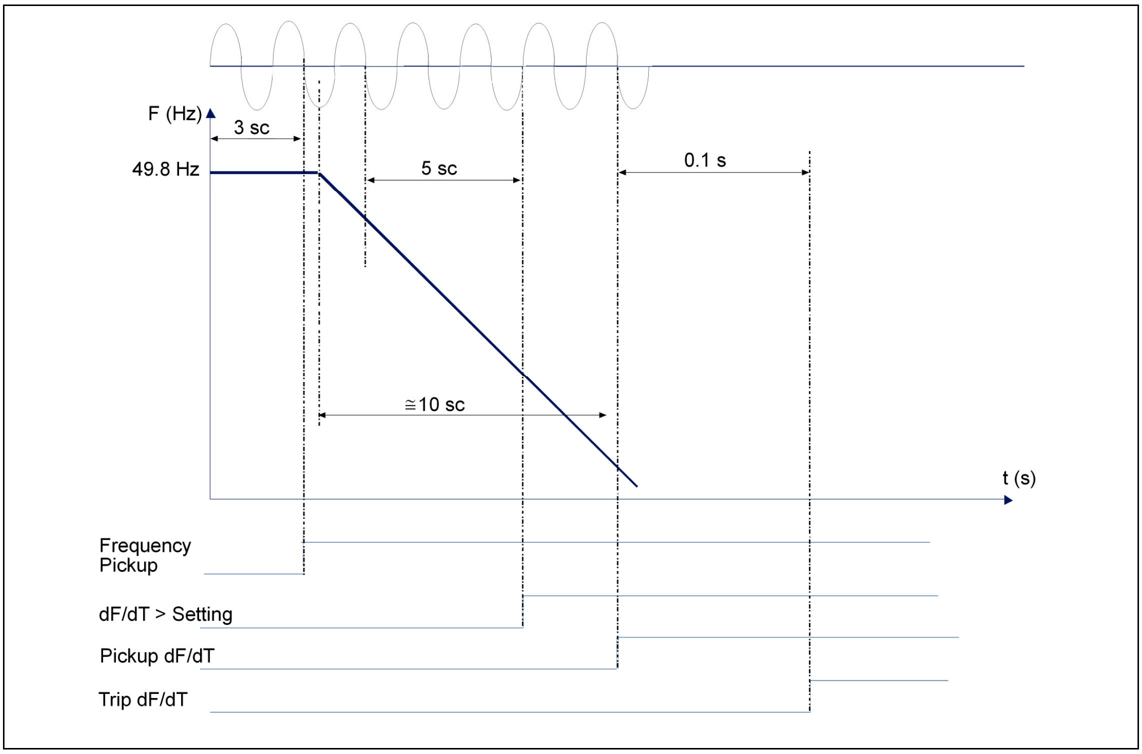


Figure 3.9.3: Example Regarding the Operation of the unit Pickup.

3.9.5 Units Blocking Logic

Each of the Frequency Units has a **Blocking Logic Input**. Activating this input prevents the activation of the output of the corresponding Frequency Unit, as shown in figure 3.9.1. These logic input signals can be associated to the relay's status contact inputs by configuring the inputs (**Configuration** option).

3.9.6 Undervoltage Unit for Blocking

This unit supervises the functioning of the Frequency Units, impeding their operation for measured voltage values below the set value.

The unit 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 10 volts. Therefore, in these conditions, the Frequency Units do not work.

3.9.7 Load Shedding Algorithm

The **IDV** model provides a control function for performing 1 load shedding and reset step. Frequency Units 1 can be set to operate in pairs, with Underfrequency 1 or Rate of Change 1 Unit paired with the Overfrequency 1 Unit, to perform a load shedding and reset control function. Load shading is available only in the 3 winding relays as although loads are shaded in one winding (2 or 3) 2 windings will still operate.

For more steps, it is necessary to use the programmable logic and configure it using the signals generated by the rest of the Frequency Units. The reason for this is that the designed control function takes into account the position of the breaker associated to the configured Load Shedding Winding. If more steps are configured, the user can choose to follow a similar operating scheme by requiring information about the position of other breakers, or choose a completely different logic. The control function logic for Frequency Units 1 is described below:

Close Command (**CLOSE**) and **Open Command** (**OPEN**) can be given as long as **Load Shedding Enable** (**Mslr**) is set to **YES** and the Frequency Units are not blocked (**INBLK**). The operation of the Overfrequency Unit is conditioned by the prior operation of the Underfrequency or Frequency Rate of Change Unit (**TRIP_U**) and the Open Breaker (**IN_BKR**) status, as indicated in the logic diagram of figure 3.9.3.

The **TRIP_U** signal is not a logic output of the Load Shedding module nor does it generate an event. To make it available, it must be generated in the programmable logic.

After the equipment generates the **Close Command**, either because underfrequency has existed or the rate of change has acted and the breaker has opened, it restores the condition of another possible close.

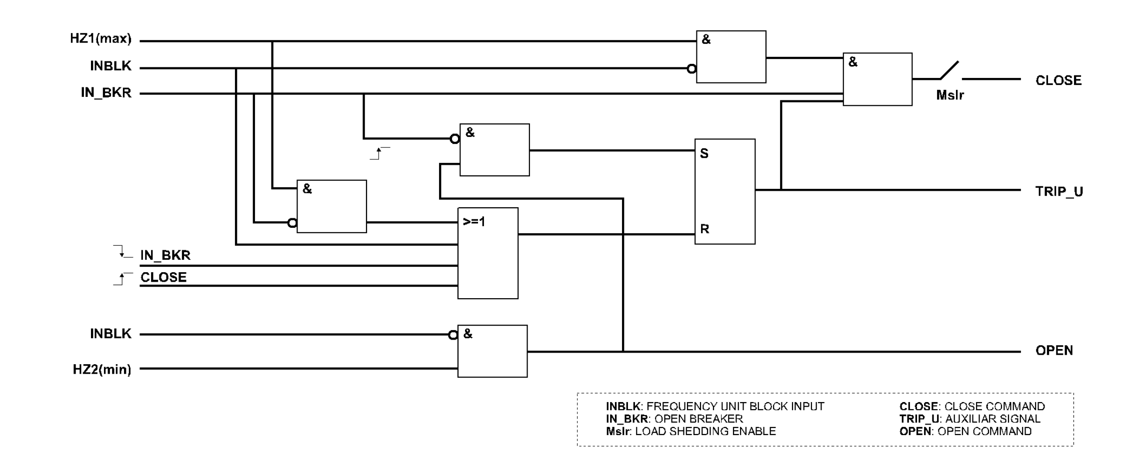


Figure 3.9.4: Logic Diagram of the Load Shedding Algorithm for the Under-Overfrequency Load Shedding Type.

For **IDV-L** models, when the setting **Number of Windings** is set to **2**, the setting **Reference Winding** must not ever be set to **3**.

3.9.8 Application of the Frequency Elements

The frequency variations are caused by an incorrect balance between generation and load, which is generally due to the following reasons:

- Division of the system into parts.
- Imbalance between load and generation due to lack of foresight or deficient programming.
- Loss of generation, trip of busses or important interconnection lines.

Frequency is a reliable indicator of an overload condition. Any decrease in frequency is caused by an excess load. With this condition, underfrequency relays must be used to shed load and thus balance generation with consumption and avoid a major collapse of the system. When frequency recovers its rated value and the electricity system stabilizes, the loads that have been shed are restored. This restoration operation is performed by the overfrequency relay.

A decrease in frequency produces instability in the electricity system and can damage the generators. The greatest danger, however, lies in steam turbines. Variations in the rotational speed of the turbine produce vibrations and consequently the blades suffer mechanical fatigue. Since this is cumulative deterioration, the problem will increase whenever the turbine is in an underfrequency condition.

When the variation in the frequency is small, the imbalance can be corrected by regulating the generators. With large frequency variations, however, the generator cannot correct it. As a result, the frequency starts decreasing, risking a trip of the generation sets. If this frequency drop is not corrected, an irreversible process begins and leads to a general blackout.

In situations of strong generation deficit, the only way to restore balance is to selectively disconnect loads. The loads are usually disconnected when the frequency has fallen below fixed values to give the generation sets time to react to frequency drops with speed regulators. When the frequency drop is very quick, this action is not effective enough. Loads have to be disconnected according to the variation in the frequency in respect of time, that is, by basing calculations and operation on the rate of change in respect of time.

Underfrequency relays are usually installed in substations and industrial plants that require a load shedding system, where the loads are fed exclusively by local generation or by a combination of its own generators and a transmission line derivation. In this second case [part (A) of figure 3.9.4], if a fault occurs in the transmission line, the system's own generators will be overloaded, and the frequency will drop quickly. This plant needs a fast load shedding system controlled by frequency relays.

If the transmission line supplies more than one plant and is disconnected at a remote end [part (B) of figure 3.9.4], the plant, with its own generation, is in a situation to supply power to the line while its own frequency is decreasing. This power flow output can be avoided with protection relays against power inversion but, unless the whole overload is eliminated, the frequency relay must disconnect the lower priority local loads.

Independently of generation, frequency protections are also used in distribution substations that require a load shedding system with a disconnection priority scale. Priorities are also taken into account as frequency is recovered while restoring the loads.

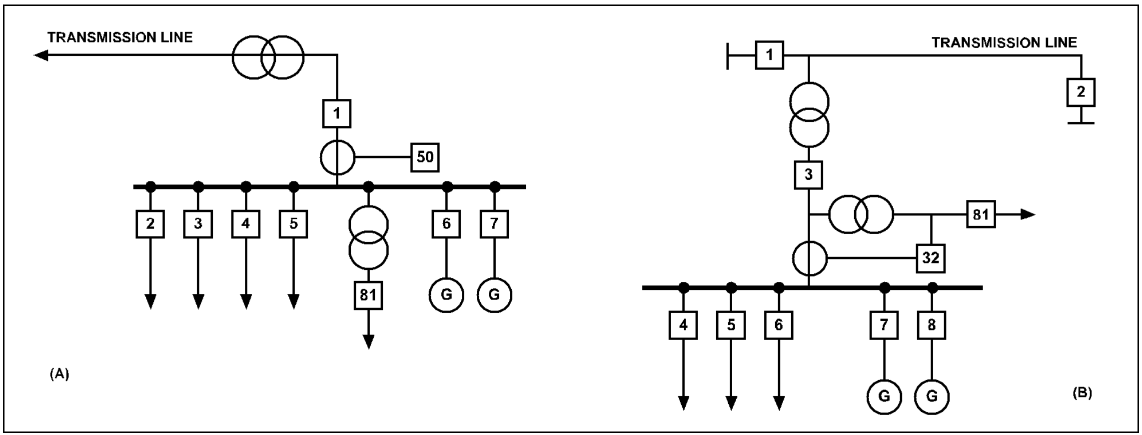


Figure 3.9.5: Load Shedding System in an Industrial Plant.

3.9.9 Frequency Units Settings

Common Settings			
Setting	**Range**	**Step**	**By Default**
Inhibit Voltage	2 - 150 V	1 V	40 or 5 V (*)
Pickup Activation Timer	3 - 30 half cycles	1 half cycles	6 half cycles
Reset Time	0 - 10 cycles	1 cycle	0 cycle
Load Shedding 1 Enable (IDV-B/H/K/L model)	YES / NO		NO
Load Shedding Type (IDV-B/H/K/L model)	0 - Underfrequency 1 - Rate of Change		0 - Underfreq.
Load Shedding Winding (IDV-B/H/K/L model)	2 - 3	1	2

(*) Depending on the model.

Overfrequency Units 1, 2, 3 and 4			
Setting	**Range**	**Step**	**By Default**
Overfrequency Enable	YES / NO		NO
Overfrequency Pickup	40 - 70 Hz	0.01 Hz	70 Hz
Overfrequency Delay	0.00 - 300 s	0.01 s	0 s
Reset Time	0.00 - 300 s	0.01 s	2 s

Underfrequency Units 1, 2, 3 and 4			
Setting	**Range**	**Step**	**By Default**
Underfrequency Enable	YES / NO		NO
Underfrequency Pickup	40 - 70 Hz	0.01 Hz	40 Hz
Underfrequency Delay	0.00 - 300 s	0.01 s	0 s
Reset Time	0.00 - 300 s	0.01 s	2 s

Frequency Rate of Change Units 1, 2, 3 and 4			
Setting	**Range**	**Step**	**By Default**
ROC Frequency Enable	YES / NO		NO
ROC Type (IDV-***-****C***)	Negative / Positive		Negative
Underfrequency Pickup	40 - 70 Hz	0.01 Hz	40 Hz
ROC Frequency Pickup Standard Model IDV-***-****C*** Model	 (-10) - (-0,1) Hz/s (0.1) - (10) Hz/s	 0.01 Hz/s 0.1 Hz/s	 -1 Hz/s 1 Hz/s
ROC Frequency Delay	0.00 - 300 s	0.01 s	0 s
Reset Time	0.00 - 300 s	0.01 s	2 s

- **Frequency Protection: HMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**3 - PROTECTION**	**8 - FREQUENCY**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - INHIBIT VOLTAGE**
…	**1 - PICK UP TIME**
8 - FREQUENCY	**2 - DROPOUT TIME**
…	**3 - LOAD SHEDD. 1 ENA.**
	4 - LOAD SHEDDNG TYPE
	5 - L. SHEDDING WNDG
	6 - OVERFREQUENCY
	7 - UNDERFREQUENCY
	8 - RATE OF CHANGE F.

Overfrequency

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - OVERFREQ. ENABLE**
1 - PICK UP TIME	**1 - UNIT 2**	**1 - OVERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3 (*)**	**2 - OVERFREQ. DELAY**
3 - LOAD SHEDD. 1 ENA.	**3 - UNIT 4 (*)**	**3 - DROPOUT TIME**
4 - LOAD SHEDDNG TYPE		
5 - L. SHEDDING WNDG		
6 - OVERFREQUENCY		
7 - UNDERFREQUENCY		
8 - RATE OF CHANGE F.		

Underfrequency

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - UNDERFREQ. ENABLE**
1 - PICK UP TIME	**1 - UNIT 2**	**1 - UNDERFREQ. PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3 (*)**	**2 - UNDERFREQ. DELAY**
3 - LOAD SHEDD. 1 ENA.	**3 - UNIT 4 (*)**	**3 - DROPOUT TIME**
4 - LOAD SHEDDNG TYPE		
5 - L. SHEDDING WNDG		
6 - OVERFREQUENCY		
7 - UNDERFREQUENCY		
8 - RATE OF CHANGE F.		

Frequency Rate of Change

0 - INHIBIT VOLTAGE	**0 - UNIT 1**	**0 - ROC FREQ. ENABLE**
1 - PICK UP TIME	**1 - UNIT 2**	**1 - UNDERFREC PICKUP**
2 - DROPOUT TIME	**2 - UNIT 3 (*)**	**2 - ROC FREQ. PICKUP**
3 - LOAD SHEDD. 1 ENA.	**3 - UNIT 4 (*)**	**3 - ROC FREQ. DELAY**
4 - LOAD SHEDDNG TYPE		**4 - DROPOUT TIME**
5 - L. SHEDDING WNDG		
6 - OVERFREQUENCY		
7 - UNDERFREQUENCY		
8 - RATE OF CHANGE F.		

(*) Except for the IDV-J/K/L models when they not include Model code X12=C.

3.9.10 Digital Inputs of the Frequency Modules

Table 3.9-1: Digital Inputs 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_OF4	Overfrequency element 4 block input	
INBLK_UF1	Underfrequency element 1 block input	
INBLK_UF2	Underfrequency element 2 block input	
INBLK_UF3	Underfrequency element 3 block input	
INBLK_UF4	Underfrequency element 4 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	
INBLK_ROC4	Rate of Change element 4 block input	
ENBL_OF1	Overfrequency 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_OF2	Overfrequency element 2 enable input	
ENBL_OF3	Overfrequency element 3 enable input	
ENBL_OF4	Overfrequency element 4 enable input	
ENBL_UF1	Underfrequency element 1 enable input	
ENBL_UF2	Underfrequency element 2 enable input	
ENBL_UF3	Underfrequency element 3 enable input	
ENBL_UF4	Underfrequency element 4 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	
ENBL_ROC4	Rate of Change element 4 enable input	

3.9.11 Auxiliary Outputs and Events of the Frequency Modules

Table 3.9-2: Auxiliary 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_OF4	Overfrequency element 4 pickup	
PU_UF1	Underfrequency element 1 pickup	
PU_UF2	Underfrequency element 2 pickup	
PU_UF3	Underfrequency element 3 pickup	
PU_UF4	Underfrequency element 4 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	
PU_ROC4	Rate of Change element 4 pickup	

Table 3.9-2: Auxiliary Outputs and Events of the Frequency Modules

Name	Description	Function
TRIP_OF1	Overfrequency element 1 trip	Trip of the Frequency Elements.
TRIP_OF2	Overfrequency element 2 trip	
TRIP_OF3	Overfrequency element 3 trip	
TRIP_OF4	Overfrequency element 4 trip	
TRIP_UF1	Underfrequency element 1 trip	
TRIP_UF2	Underfrequency element 2 trip	
TRIP_UF3	Underfrequency element 3 trip	
TRIP_UF4	Underfrequency element 4 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	
TRIP_ROC4	Rate of Change element 4 trip	
CLS_LS1	Close of Load Shedding element 1	Close of the overfrequency element 1 when it is configured for load shedding.
TRIP_OF1M	Overfrequency element 1 masked trip	Trip of the frequency elements affected by their corresponding trip masks.
TRIP_OF2M	Overfrequency element 2 masked trip	
TRIP_OF3M	Overfrequency element 3 masked trip	
TRIP_OF4M	Overfrequency element 4 masked trip	
TRIP_UF1M	Underfrequency element 1 masked trip	
TRIP_UF2M	Underfrequency element 2 masked trip	
TRIP_UF3M	Underfrequency element 3 masked trip	
TRIP_UF4M	Underfrequency element 4 masked trip	
TRIP_ROC1M	Rate of Change element 1 masked trip	
TRIP_ROC2M	Rate of Change element 2 masked trip	
TRIP_ROC3M	Rate of Change element 3 masked trip	
TRIP_ROC4M	Rate of Change element 4 masked trip	
CLS_LS1M	Masked close of Load Shedding element 1	Close of the overfrequency element 1 when it is configured for load shedding affected by their corresponding mask.
INBLK_OF1	Overfrequency element 1 block input	The same as for the Digital Inputs.
INBLK_OF2	Overfrequency element 2 block input	
INBLK_OF3	Overfrequency element 3 block input	
INBLK_OF4	Overfrequency element 4 block input	
INBLK_UF1	Underfrequency element 1 block input	
INBLK_UF2	Underfrequency element 2 block input	
INBLK_UF3	Underfrequency element 3 block input	
INBLK_UF4	Underfrequency element 4 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	
INBLK_ROC4	Rate of Change element 4 block input	

Table 3.9-2: Auxiliary Outputs and Events of the Frequency Modules		
Name	**Description**	**Function**
ENBL_OF1	Overfrequency element 1 enable input	The same as for the Digital Inputs.
ENBL_OF2	Overfrequency element 2 enable input	
ENBL_OF3	Overfrequency element 3 enable input	
ENBL_OF4	Overfrequency element 4 enable input	
ENBL_UF1	Underfrequency element 1 enable input	
ENBL_UF2	Underfrequency element 2 enable input	
ENBL_UF3	Underfrequency element 3 enable input	
ENBL_UF4	Underfrequency element 4 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	
ENBL_ROC4	Rate of Change element 4 enable input	
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	
OF4_ENBLD	Overfrequency element 4 enabled	
UF1_ENBLD	Underfrequency element 1 enabled	
UF2_ENBLD	Underfrequency element 2 enabled	
UF3_ENBLD	Underfrequency element 3 enabled	
UF4_ENBLD	Underfrequency element 4 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	
ROC4_ENBLD	Rate of Change element 4 enabled	
BLK_MIN_V	Minimum voltage block	Blocking of Frequency and Phase Angle Measuring Units.

3.9.12 Frequency Elements Test

Before testing these elements, the voltage elements that are not being tested must be disabled and the phase voltage channel must be configured as V_{AB}.

- **Pickup and Reset of the Overfrequency and Underfrequency Units**

Depending on the settings of the Frequency Units (Overfrequency / Underfrequency), the pickups and resets must be within the margins indicated in tables 3.9-3 and 3.9-4 for their nominal voltage.

Table 3.9-3: Pickup and Reset of the Overfrequency Elements				
Setting	Pickup		Reset	
XHz	ΦA_MIN	ΦA_MAX	ΦR_MIN	ΦR_MAX
	X - 0.005Hz	X + 0.005Hz	(X - 0.01Hz) + 0.005Hz	(X - 0.01Hz) - 0.005Hz

Table 3.9-4: Pickup and Reset of the Underfrequency Elements				
Setting	Pickup		Reset	
XHz	ΦA_MIN	ΦA_MAX	ΦR_MIN	ΦR_MAX
	X + 0.005Hz	X - 0.005Hz	(X + 0.01Hz) - 0.005Hz	(X + 0.01Hz) + 0.005Hz

- **Voltage Reset**

The Frequency Units must reset within the margin indicated in table 3.9-5 for set voltage value X.

Table 3.9-5:·Voltage Reset				
Setting	Pickup		Reset	
X	MAX	MIN	MAX	MIN
	1.03 x X	0.97 x X	1.08 x X	1.02 x X

- **Operating Times**

They are verified with trip outputs (G4-G5-G6-G7) (G8-G9-G10-H1) (C1-C2-C3-C4), depending on the model.

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 comply with 1.5 cycles + **Activation Half Cycles** setting. If the setting value is 0, the operating time will also be close to 1.5 cycles + **Activation Half Cycles** setting.

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 Overfrequency Unit can be tested. Going from no voltage applied to applying voltage above the Inhibit Voltage and the Overfrequency settings will yield a time value somewhat greater than with a frequency ramp.

- **Pickup and Reset of the Frequency Rate of Change Units**

The Rate of Change units are configured with the following operation values:

81D1 Unit:	**0.5 Hz/s**
81D2 Unit:	**0.7 Hz/s**
81D3 Unit:	**0.9 Hz/s**
81D4 Unit:	**1 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.

3.10 Breaker Failure Unit

3.10.1 Introduction

The **Breaker Failure** unit detects malfunctions following trip commands and generates a signal to trip other breakers to clear the fault. **IDV-A/B/G/H/J/K/L** models have a Breaker Failure Unit per winding (for **IDV-L** models see Chapter 3.18, General Settings). In models **IDV-D** the element is applied to each breaker. The operation of this function is outlined in the block diagram of figure 3.10.1.

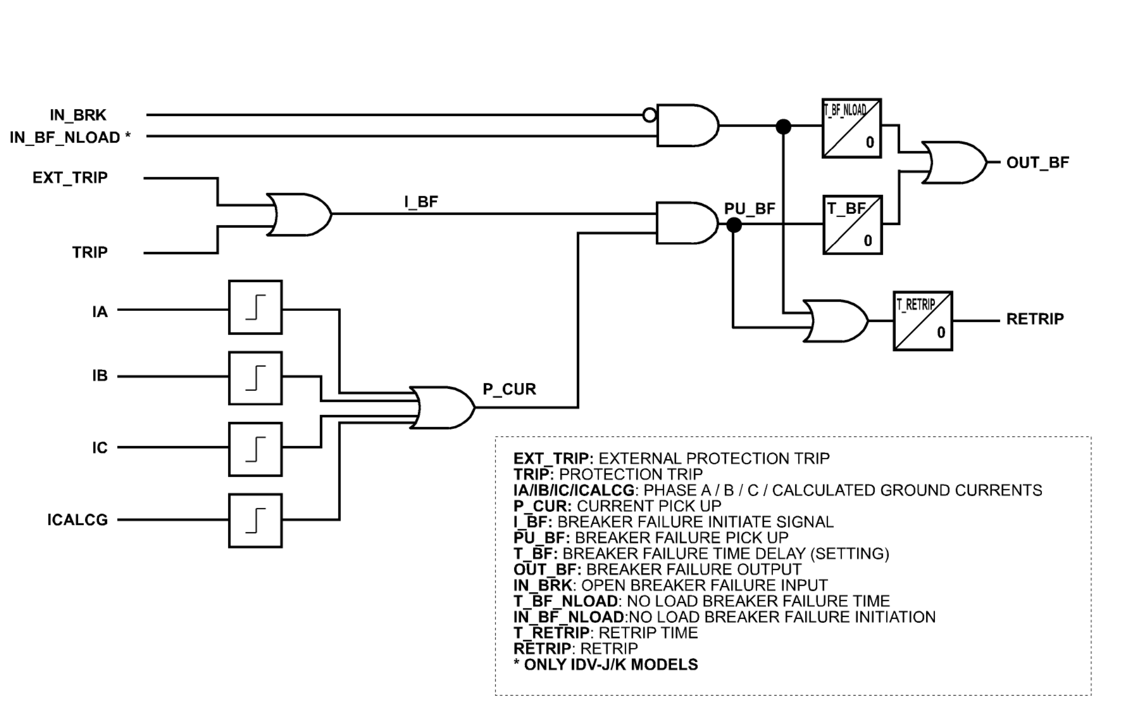


Figure 3.10.1: Block Diagram of the Breaker Failure Function (one Unit for each Winding).

A trip command generated by the IED's internal protection elements (**TRIP**) or an external protection device (**EXT_TRIP**) activates the **breaker failure initiate** signal (**I_BF**). When the **I_BF** signal is activated and the current is equal or higher than the set value (**P_CUR** signal), the counter for the breaker failure time delay starts-up (**T_BF**). If **T_BF** times out before **I_BF** resets, indicating that the initial breaker failure conditions are no longer present, or **P_CUR** resets, indicating that the unit no longer detects current, the **OUT_BF** output will activate

IDV-J/K/L relays include retrip function. In these, signal **PU_BF** not only starts timer **T_BF** but also starts timer **T_RETRIP**. Once this last timer times out, signal **RETRIP** activates aiming at issuing a new trip command to the failed breaker before generating a **Breaker Failure** command (**OUT_BF**). Obviously, the retrip time setting must be less than the breaker failure time. **IDV-J/K/L** relays include, also, detection of breaker failure with no phase overcurrent. Trip signals, whether from the same relay or external relay, which would produce the initiation of the breaker failure, can be activated without the pickup of the phase current detection elements. This situation can take place, in general, upon any type of disturbance tripped by elements independent from the measured current, such as voltage elements, frequency elements, transformer own protection elements etc. In this case, breaker failure detection is made based on breaker contact position: when logic input **No Load Breaker Failure Initiation** (**IN_BF_NLOAD**) activates, the breaker remaining closed, the timer **T_BF_NLOAD** will start. When said timer times out, signal **OUT_BF** activates. The **No Load Breaker Failure Input** can be configured with the trip of the transformer own protection elements, frequency elements, voltage elements, etc. The pickup of the no load breaker failure element also causes a breaker to retrip (see figure 3.10.1).

Signal P**_CUR** will be activated while the value of any current is above the pick-up level set for any of the phases or calculated ground currents. The most important characteristic of these current detectors is their fast reset time to stop the timer as soon as the breaker has opened and made the current disappear, not allowing the erroneous activation of **OUT_BF**. The operating principle is based not only on the measurement of the rms value but on the measurement of instantaneous values. This last principle significantly reduces the reset time. If reset time would be too long there would be high risk of non-stopping duly on time the counter and then cause false trips on other circuit breakers different from the one on the faulty circuit, even when the current went to zero.

In order to detect as fast as possible that the current value is going down to zero, the device will not check the RMS value but will check if at least 3 instantaneous and consecutive sampled values are under the **phases and calculated ground breaker failure pick-up** value.

To be able to use the external operation signal (**EXT_TRIP**) as part of this function, you must program one of the IED's status contact inputs to be connected to this signal. Otherwise, the **EXT_TRIP** signal will default to a logic "0". The same applies to the **No Load Breaker Failure Initiation Input** (**IN_BF_NLOAD**). Likewise, the external use of the logic output of **Breaker Failure** (**OUT_BF**) requires programming the connection between it and one of the auxiliary contact outputs.

3.10.2 Breaker Failure Settings

Breaker Failure Unit: Windings 1, 2 and 3* (IDV-A/B/G/H/J/K/L Models)			
Setting	**Range**	**Step**	**By Default**
Breaker Failure Enable	YES / NO		NO
Breaker Failure Phase Pickup	(0.02 - 2) In	0.01 A	0.05 In
Breaker Failure Ground Pickup	(0.02 - 2) In	0.01 A	0.05 In
Breaker Failure Time Delay	0.00 - 2.00 s	0.01 s	0 s
Retrip delay (IDV-J/K/L relays)	0.00 - 2.00 s	0.01 s	0 s
No load breaker failure delay (IDV-J/K/L relays)	0.00 - 2.00 s	0.01 s	0 s

(*) See 3.18, General Settings.

Breaker Failure Unit: Breakers 1, 2, 3 and 4 (IDV-D Models)			
Setting	**Range**	**Step**	**By Default**
Breaker Failure Enable	YES / NO		NO
Breaker Failure Phase Pickup	0.02 – 5 A	0.01 A	0.25 A
Breaker Failure Ground Pickup	0.02 – 5 A	0.01 A	0.25 A
Breaker Failure Delay	0.00 - 2.00 s	0.01 s	0 s

- **Breaker Failure: HMI Access**

IDV-A/B/G/H MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1**
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 2**
3 - INFORMATION	...	**3 - WINDING 3**
		...

0 - DIFFERENTIAL	0 - OVERCURRENT	**0 - BF ENABLE**
1 - WINDING 1	**1 - BREAKER FAILURE**	**1 - BF PHASE PICKUP**
2 - WINDING 2	2 - THERMAL IMAGE	**2 - BF GROUND PICKUP**
3 - WINDING 3		**3 - BF DELAY**
...		

IDV-D MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**5 - BREAKER FAILURE**
3 - INFORMATION	...	...

0 - DIFFERENTIAL	**0 - I1**	**0 - BF ENABLE**
...	**1 - I2**	**1 - BF PHASE PICKUP**
5 - BREAKER FAILURE	**2 - I3**	**2 - BF GROUND PICKUP**
...	**3 - I4**	**3 - BF DELAY**

IDV-J/K/L MODELS

0 - CONFIGURATION	0 - GENERAL	0 - FUSE FAILURE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**2 - PROTECTION**	**3 - WINDING 1**
3 - INFORMATION	…	**4 - WINDING 2**
		5 - WINDING 3
		…

0 - FUSE FAILURE	0 - OVERCURRENT	**0 - BF ENABLE**
…	**1 - BREAKER FAILURE**	**1 - BF PHASE PICKUP**
3 - WINDING 1	2 - THERMAL IMAGE	**2 - BF GROUND PICKU**
4 - WINDING 2		**3 - BF DELAY**
5 - WINDING 3		**4 - RETRIP DELAY**
…		**5 - NO LOAD BF TIME**

3.10.3 Digital Inputs of the Breaker Failure Module

Table 3.10-1: Digital Inputs of the Breaker Failure Module

Name	Description	Function
ENBL_BF_W1	Winding 1 breaker failure unit enable input (IDV-A/B/G/H)	Activation of this input puts the breaker failure unit of each winding 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_BF_W2	Winding 2 breaker failure unit enable input (IDV-A/B/G/H)	
ENBL_BF_W3	Winding 3 breaker failure unit enable input (IDV-A/B/H/G)	
ENBL_BF1	Breaker 1 breaker failure unit enable input (IDV-D)	
ENBL_BF2	Breaker 2 breaker failure unit enable input (IDV-D)	
ENBL_BF3	Breaker 3 breaker failure unit enable input (IDV-D)	
ENBL_BF4	Breaker 4 breaker failure unit enable input (IDV-D)	
EXT_TRIP1	External protection 1 trip input	Activation of this input indicates to the Breaker Failure unit of each winding that an external protection has an active trip and in case enough current is available, it has to start the breaker failure time.
EXT_TRIP2	External protection 2 trip input	
EXT_TRIP3	External protection 3 trip input	
IN_BF_NLD_W1	No load breaker failure initiation input winding 1 (IDV-J/K/L relays)	The activation of this input initiates the no load or no overcurrent breaker failure. The timer of this breaker failure will only start when said input activates, and the applicable breaker contacts indicate it is closed.
IN_BF_NLD_W2	No load breaker failure initiation input winding 2 (IDV-J/K/L relays)	
IN_BF_NLD_W3	No load breaker failure initiation input winding 3 (IDV-J/K/L relays)	

3.10.4 Auxiliary Outputs and Events of the Breaker Failure Module

Table 3.10-2: Auxiliary Outputs and Events of the Breaker Failure Module

Name	Description	Function
OUT_BF1	Breaker failure 1 operation output	Signal for alarm or trip initiation of other breakers.
OUT_BF2	Breaker failure 2 operation output	
OUT_BF3	Breaker failure 3 operation output	
OUT_BF4	Breaker failure 4 operation output	
OUT_BF_W1	Breaker failure operation output winding 1	
OUT_BF_W2	Breaker failure operation output winding 2	
OUT_BF_W3	Breaker failure operation output winding 3	
RETRIP_W1	Retrip winding 1 (IDV-J/K/L)	Breaker retrip output
RETRIP_W2	Retrip winding 2 (IDV-J/K/L)	
RETRIP_W3	Retrip winding 3 (IDV-J/K/L)	
ENBL_BF_W1	Winding 1 breaker failure unit enable input (IDV-A/B/G/H)	The same as for the Digital Inputs.
ENBL_BF_W2	Winding 2 breaker failure unit enable input (IDV-A/B/G/H)	
ENBL_BF_W3	Winding 3 breaker failure unit enable input (IDV-A/B/G/H)	
ENBL_BF1	Breaker 1 breaker failure unit enable input (IDV-D)	
ENBL_BF2	Breaker 2 breaker failure unit enable input (IDV-D)	
ENBL_BF3	Breaker 3 breaker failure unit enable input (IDV-D)	
ENBL_BF4	Breaker 4 breaker failure unit enable input (IDV-D)	
BF_ENBLD1	Breaker failure unit 1 enabled	Indication of enabled or disabled status of each unit.
BF_ENBLD2	Breaker failure unit 2 enabled	
BF_ENBLD3	Breaker failure unit 3 enabled	
BF_ENBLD4	Breaker failure unit 4 enabled	
BF_ENBLD1	Winding 1 breaker failure unit enable input	The same as for the Digital Inputs.
BF_ENBLD2	Winding 2 breaker failure unit enable input	
BF_ENBLD3	Winding 3 breaker failure unit enable input	
EXT_TRIP1	External protection 1 trip input	The same as for the Digital Inputs.
EXT_TRIP2	External protection 2 trip input	
EXT_TRIP3	External protection 3 trip input	

3.10.5 Breaker Failure Units Test

The test is performed for each of the windings available in the relay. The test is identical for each of the windings.

To test the units, one of the auxiliary contact outputs is configured for the Breaker Failure function of each winding. All the units are disabled except the Phase and Ground Instantaneous Overcurrent and Breaker Failure units.

The phase and ground instantaneous overcurrent pickups are set to 0.5 A and their time delay to zero. The reset levels of the Breaker Failure units are set to the desired current reset and operating time values. A trip is provoked by applying a 1A phase and ground current and maintaining the current after the trip. The Breaker Failure Unit will operate in a period of time between ±1% and ±30 ms of the set value. To verify the operation of this unit, an auxiliary output is configured as Breaker Failure.

The current is gradually reduced until the Breaker Failure Unit reaches a stable reset. This must occur for a value between ±1% of the set value.

3.11 Thermal Image Unit

3.11.1 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.

IDV terminals have a Thermal Image protection unit per winding (this is, 2 for **IDV-A/G** model and 3 for **IDV-B/D/F/G/H/K/L** Models) 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 **IDV-D** relays include two Thermal Image units that enable checking of grounding impedance if the thermal characteristic is exceeded. A Thermal Image unit is available for each of the grounding channels which are associated in the same way as its corresponding unit, to the winding set according to **Connection Groups**.

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 nominal value 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 in phase A for each winding.
- τ: Is the time constant. Adjustable parameter.
- θ: Thermal image. Refers to ITERM_1D for winding 1, ITERM_2D for winding 2 and ITERM_3D for winding 3; ITERM_G1 in grounding channel 1 and ITERM_G2 in grounding channel 2.
- $d\theta/dt$: Thermal image rate of change.

The **Time Constant** (τ) 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:

$\theta_i = \theta_0 + (\theta_\infty - \theta_0) * 0.63$

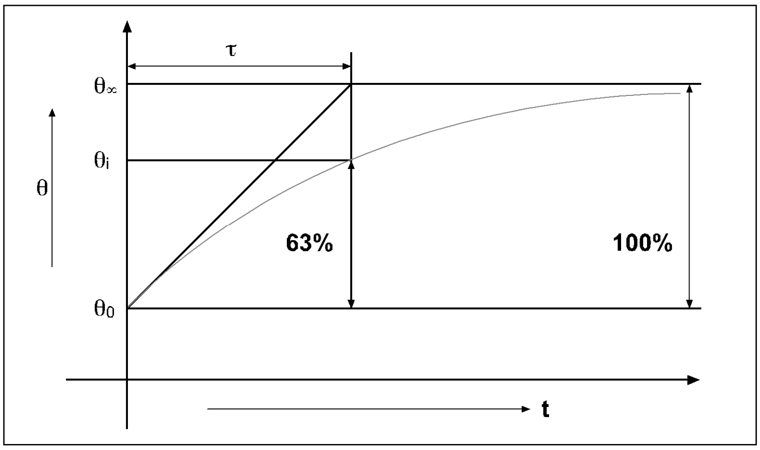


Figure 3.11.1: Time Constant (Thermal Image).

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.

The Thermal Image Unit is prepared to protect machines from overheating. The square of the current flowing through each winding is used as the measuring current ($IA\text{-}1^2$ for winding 1 thermal image element, $IA\text{-}2^2$ for winding 2 thermal image element and $IA\text{-}3^2$ for winding 3 thermal image element). It has two time constants (**Constant τ_1** and **Constant τ_2**), one for when the equipment is ventilated, one for when it is not ventilated. A digital input is used to toggle between the two. The default time constant is "with ventilation" (τ_1). To change this setting, the **Constant Change** input has to be configured (there is a **Constant Change** digital input per winding or grounding channel, depending on the model). If this input is activated, the constant then becomes "without ventilation" (τ_2); if this input is deactivated, the constant then becomes "with ventilation" (τ_1).

Apart from the digital input for changing the time constant, there are also other digital inputs for blocking (**Blocking Input**), for resetting (**Reset Input**) and for enabling (**Enable Input**).

The Thermal Image unit estimates the thermal status and, when it reaches a certain value it trips unless the blocking input is activated. In addition to the trip level, the unit has an adjustable alarm level. Herein it is described in detail the way for the calculation of the thermal status and both levels mentioned (trip and alarm):

- 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 actual: θ = θ + 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:

$$\theta_{TRIP} = \mathbf{Imax\ (A)^2}$$

Where **Imax** is the value of the maximum admissible sustained current. Adjustable parameter.

The **Thermal Image Trip** signal resets when θ descends below:

$$\theta_{RST\_TRIP} = \theta_{TRIP} * \mathbf{Reset.Threshold\ (\%) / 100}$$

Where **Reset.Threshold** is an adjustable parameter.

The **Thermal Image Alarm** output is activated when the θ value reaches the value:

$$\theta_{ALARM} = \theta_{TRIP} * \mathbf{AlarmSetting\ (\%) / 100}$$

Where **AlarmSetting** is an adjustable parameter.

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:

$$t = \tau \cdot Ln \frac{I^2}{I^2 - I_{max}{}^2}$$

If you start with a preliminary **Ip** current level, the operating time is:

$$t = \tau \cdot Ln \frac{I^2 - I_p{}^2}{I^2 - I_{max}{}^2}$$

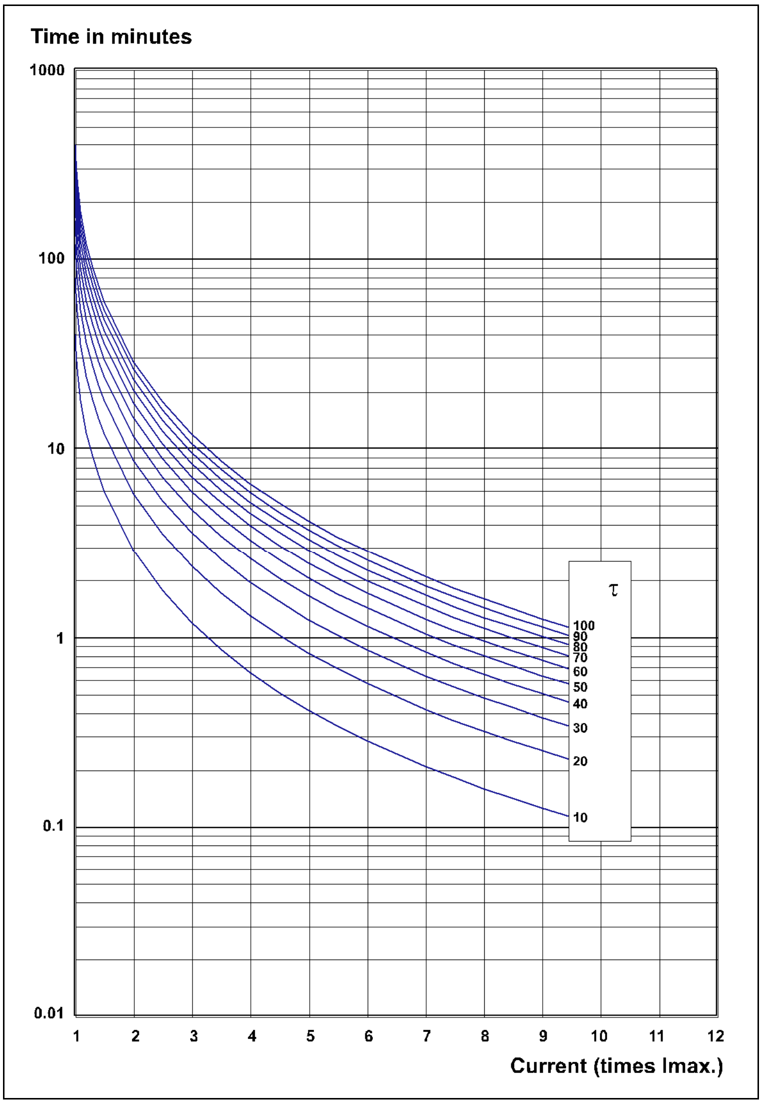


Figure 3.11.2: Operating Time Curves of the Thermal Image Unit.

3.11.2 Applying the Thermal Image Function

Mostly faults on electrical system cause currents higher than the rated current of the system's elements. In these cases the thermal effects can quickly produce damages in such elements. Also, situations where a machine is running above its nominal values cause dangerous overheating that can shorten the life span of the machine's insulations.

The protections that are regularly used in these cases use overcurrent, causing trips both instantly and after a timed sequence using inverse "current / time" characteristics or set fixed times. However, in some applications, this protection system presents certain limitations.

An example might be a system with two transformers set in parallel powering the same bus, each of them running at loads below the nominal load. If one of the transformers is out of service, the other transformer steps in and takes on the full load, very likely running at a load above its nominal load.

With an overcurrent protection it can be disconnected in a very short period of time even when power transformers are designed to run with excess loads for several minutes without suffering any damage. During this period of time, there is no possibility of performing any action to reset the situation.

Given its operating principle, the Thermal Image Unit is highly indicated in these types of situations. In general, it can be said that this function is complementary to other protection types for cables or all kinds of machines (transformers, generators, etc.).

Overload situations can arise primarily as a result of:

- Overload due to power > rated transfer.
- External faults not cleared quickly enough.
- Cooling system fault.
- High ambient temperature.
- Others: underfrequency, overvoltage, phase voltage unbalance.

3.11.3 Thermal Image Unit Settings

Thermal Image Unit: Windings 1, 2 and 3*			
Setting	**Range**	**Step**	**By Default**
Thermal Image Enable	YES / NO		NO
Constant 1	0.5 - 300 min	0.01 min	0.5 min
Constant 2	0.5 - 300 min	0.01 min	0.5 min
Max. Operating Current	(0.20 - 2.5) In	0.01A	1 In
Alarm Level	50 - 100 %	1 %	50 %
Reset Threshold	50 - 100 %	1 %	80 %
Thermal Memory Enable	YES / NO		NO

(*) See 3.18, General Settings.

Thermal Image Unit: Ground Channels 1 and 2 (IDV-D Models)			
Setting	**Range**	**Step**	**By Default**
Thermal Image Enable	YES / NO		NO
Minimum Current for Heating Condition	0.04 - 4 A	0.01 A	0.1 A
Constant 1	0.5 - 300 min	0.01 min	0.5 min
Constant 2	0.5 - 300 min	0.01 min	0.5 min
Max. Operating Current	(0.20 - 2.5) In	0.01A	1 In
Alarm Level	50 - 100 %	1 %	50 %
Reset Threshold	50 - 100 %	1 %	80 %
Thermal Memory Enable	YES / NO		NO
Trip and Thermal Level Automatic Reset	YES / NO		NO

- **Thermal Image Unit: HMI Access**

IDV-A/B/G/H/J/K/L Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1**
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 2**
3 - INFORMATION	...	**3 - WINDING 3**
		...

0 - DIFFERENTIAL	0 - OVERCURRENT	**0 - THERMAL IMG. ENA**
1 - WINDING 1	1 - BREAKER FAILURE	**1 - CONSTANT 1**
2 - WINDING 2	**2 - THERMAL IMAGE**	**2 - CONSTANT 2**
3 - WINDING 3		**3 - MAX. SUST. CURR.**
...		**4 - ALARM LEVEL**
		5 - RESET THRESHOLD
		6 - THERMAL MEMORY

IDV-D Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	1 - EXT FAULT DETECTOR
2 - CHANGE SETTINGS	**2 - PROTECTION**	**2 - WINDING 1**
3 - INFORMATION	...	**3 - WINDING 2**
		4 - WINDING 3
		...

0 - DIFFERENTIAL	0 - OVERCURRENT	**0 - THERMAL IMG. ENA**
1 - EXT FAULT DETECTOR	**1 - THERMAL IMAGE**	**1 - CONSTANT 1**
2 - WINDING 1		**2 - CONSTANT 2**
3 - WINDING 2		**3 - MAX. SUST. CURR.**
4 - WINDING 3		**4 - ALARM LEVEL**
...		**5 - RESET THRESHOLD**
		6 - THERMAL MEMORY

3.11.4 Digital Inputs of the Thermal Image Module

Table 3.11-1: Digital Inputs of the Thermal Image Module		
Name	**Description**	**Function**
C_CONST_T1	Change thermal constant winding 1	Its activation changes the constant in the Thermal Image Unit.
C_CONST_T2	Change thermal constant winding 2	
C_CONST_T3	Change thermal constant winding 2	
C_CONST_G1	Change thermal constant Ground Channel 1 (IDV-D)	
C_CONST_G2	Change thermal constant Ground Channel 2 (IDV-D)	
RST_MEM_T1	Winding 1 Thermal Image reset	Its activation resets the memorized value.
RST_MEM_T2	Winding 2 Thermal Image reset	
RST_MEM_T3	Winding 3 Thermal Image reset	
RST_MEM_G1	Ground Channel 1 Thermal Image reset (IDV-D)	
RST_MEM_G2	Ground Channel 2 Thermal Image reset (IDV-D)	
INBLK_THERM1	Winding 1 Thermal Image blocking input	Activation of the input before the trip is generated prevents the unit from operating. If activated after the trip, it resets.
INBLK_THERM2	Winding 2 Thermal Image blocking input	
INBLK_THERM3	Winding 3 Thermal Image blocking input	
INBLK_THERMG1	Ground Channel 1 Thermal Image blocking input (IDV-D)	
INBLK_THERMG2	Ground Channel 2 Thermal Image blocking input (IDV-D)	
ENBL_THERM1	Winding 1 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.”
ENBL_THERM2	Winding 2 Thermal Image enable input	
ENBL_THERM3	Winding 3 Thermal Image enable input	
ENBL_THERMG1	Ground Channel 1 Thermal Image enable input (IDV-D)	
ENBL_THERMG2	Ground Channel 2 Thermal Image enable input (IDV-D)	

3.11.5 Auxiliary Outputs and Events of the Thermal Image Module

Table 3.11-2: Auxiliary Outputs and Events of the Thermal Image Module

Name	Description	Function
AL_THERM1	Winding 1 Thermal Image alarm	Alarm of the Thermal Image Unit.
AL_THERM2	Winding 2 Thermal Image alarm	
AL_THERM3	Winding 3 Thermal Image alarm	
AL_THERMG1	Ground Channel 1 Thermal Image alarm (IDV-D)	
AL_THERMG2	Ground Channel 2 Thermal Image alarm (IDV-D)	
TRIP_THERM1	Winding 1 Thermal Image trip	Trip of the Thermal Image Unit.
TRIP_THERM2	Winding 2 Thermal Image trip	
TRIP_THERM3	Winding 3 Thermal Image trip	
TRIP_THERMG1	Ground Channel 1 Thermal Image trip (IDV-D)	
TRIP_THERMG2	Ground Channel 2 Thermal Image trip (IDV-D)	
TRIP_THERM1M	Winding 1 Thermal Image masked trip	Trip of the Thermal Image Unit affected by its trip mask.
TRIP_THERM2M	Winding 2 Thermal Image masked trip	
TRIP_THERM3M	Winding 3 Thermal Image masked trip	
TRIP_THERMG1M	Ground Channel 1 Thermal Image masked trip (IDV-D)	
TRIP_THERMG2M	Ground Channel 2 Thermal Image masked trip (IDV-D)	
THERM_ENBLD1	Winding 1 Thermal Image enabled	Indication of enabled or disabled status of the Thermal Image Unit.
THERM_ENBLD2	Winding 2 Thermal Image enabled	
THERM_ENBLD3	Winding 3 Thermal Image enabled	
THERM_ENBLDG1	Ground Channel 1 Thermal Image enabled (IDV-D)	
THERM_ENBLDG2	Ground Channel 2 Thermal Image enabled (IDV-D)	
C_CONST_T1	Change thermal constant winding 1	The same as for the Digital Inputs.
C_CONST_T2	Change thermal constant winding 2	
C_CONST_T3	Change thermal constant winding 2	
C_CONST_G1	Change thermal constant Ground Channel 1 (IDV-D)	
C_CONST_G2	Change thermal constant Ground Channel 2 (IDV-D)	
RST_MEM_T1	Winding 1 Thermal Image reset	The same as for the Digital Inputs.
RST_MEM_T2	Winding 2 Thermal Image reset	
RST_MEM_T3	Winding 3 Thermal Image reset	
RST_MEM_G1	Ground Channel 1 Thermal Image reset (IDV-D)	
RST_MEM_G2	Ground Channel 2 Thermal Image reset (IDV-D)	

Table 3.11-2: Auxiliary Outputs and Events of the Thermal Image Module		
Name	**Description**	**Function**
INBLK_THERM1	Winding 1 Thermal Image blocking input	The same as for the Digital Inputs.
INBLK_THERM2	Winding 2 Thermal Image blocking input	
INBLK_THERM3	Winding 3 Thermal Image blocking input	
INBLK_THERMG1	Ground Channel 1 Thermal Image blocking input (IDV-D)	
INBLK_THERMG2	Ground Channel 2 Thermal Image blocking input (IDV-D)	
ENBL_THERM1	Winding 1 Thermal Image enable input	The same as for the Digital Inputs.
ENBL_THERM2	Winding 2 Thermal Image enable input	
ENBL_THERM3	Winding 3 Thermal Image enable input	
ENBL_THERMG1	Ground Channel 1 Thermal Image enable input (IDV-D)	
ENBL_THERMG2	Ground Channel 2 Thermal Image enable input (IDV-D)	

3.11.6 Thermal Image Units Test

The test is performed for each of the windings available in the relay. The test is identical for each of the windings.

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 Operating Current** (Imax) is applied through phase A. The trip time must be:

$$t = \tau \cdot Ln \frac{(I \pm 1\%)^2}{(I \pm 1\%)^2 - I_{max}{}^2}$$

where τ is the set time constant ζ1.

An example: a time constant without ventilation 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 unit trips must be between 33.05 s and 38.18 s.

3.12 Restricted Earth Fault

3.12.1 Description

The Restricted Earth Fault unit is used to detect ground faults in transformers, reactances and rotating machines (generators and motors). This detection requires star-connected windings and with the neutral grounded or delta-connected windings with an artificial grounding (i.e zig-zag transformer).

The Restricted Earth Fault unit provides higher sensibility than the Phase Differential unit, mainly when the neutral point is connected to ground through an impedance.

The Restricted Earth Fault unit is a neutral differential unit that calculates the differential current as the vector sum of the neutral current, calculated from the phase currents (IA, IB, IC: phase currents of the winding related to the ground current channel) and the ground current (IG-1 ó IG-2, related to the corresponding winding by means of the settings **Winding IG1** and **Winding IG2**). The Restricted Earth Fault unit operates with the RMS value of the differential current, obtained with the following formula:

$$\bar{I}_{diffN} = \frac{\bar{I}_A + \bar{I}_B + \bar{I}_C}{t_N} + \bar{I}G = \frac{3\bar{I}_0}{t_N} + \bar{I}G$$

Where:

$\bar{I}_{diffN}$ is the neutral differential current of the corresponding winding. For the winding assigned to ground current 1 (IG-1) it is called IGN1 and for the winding and assigned to ground current 2 (IG-2) it is called IGN2.

$\bar{I}_A$, $\bar{I}_B$, $\bar{I}_C$ are the phase A, B and C currents of the corresponding winding, respectively

$\bar{I}G$ Is the current measured in the neutral grounding CT.

tN is the quotient of the ground CT ratio and phase CT ratio of the winding assigned to the ground channel.

$$t_N = \frac{CTIG}{CTPhase}$$

CTIG: Ground CT Ratio:
- **Gnd 1 CT Ratio**for ground channel 1.
- **Gnd 2 CT Ratio**for ground channel 2.

CTPhase: Phase CT Ratio of the corresponding winding:
- **Winding 1 Ratio** for winding 1 phase currents.
- **Winding 2 Ratio** for winding 2 phase currents.
- **Winding 3 Ratio** for winding 3 phase currents.

Figure 3.12.1 shows external and internal faults to a wye-connected winding in the two winding wye-delta transformer included. For the external fault, due to the phase and ground CTs polarity (both CTs looking towards the protected winding), the secondary currents, neutral and ground, already scaled, in ideal conditions, will be equal and 180º phase-shifted. Therefore $\text{IdifN=IGs+}\frac{\text{(IAs+IBs+ICs)}}{t_N}\text{=0}$. In an internal fault, the mentioned currents will be 0º phase-shifted, therefore $\text{IdifN=IGs+}\frac{\text{(IAs+IBs+ICs)}}{t_N} \neq 0$

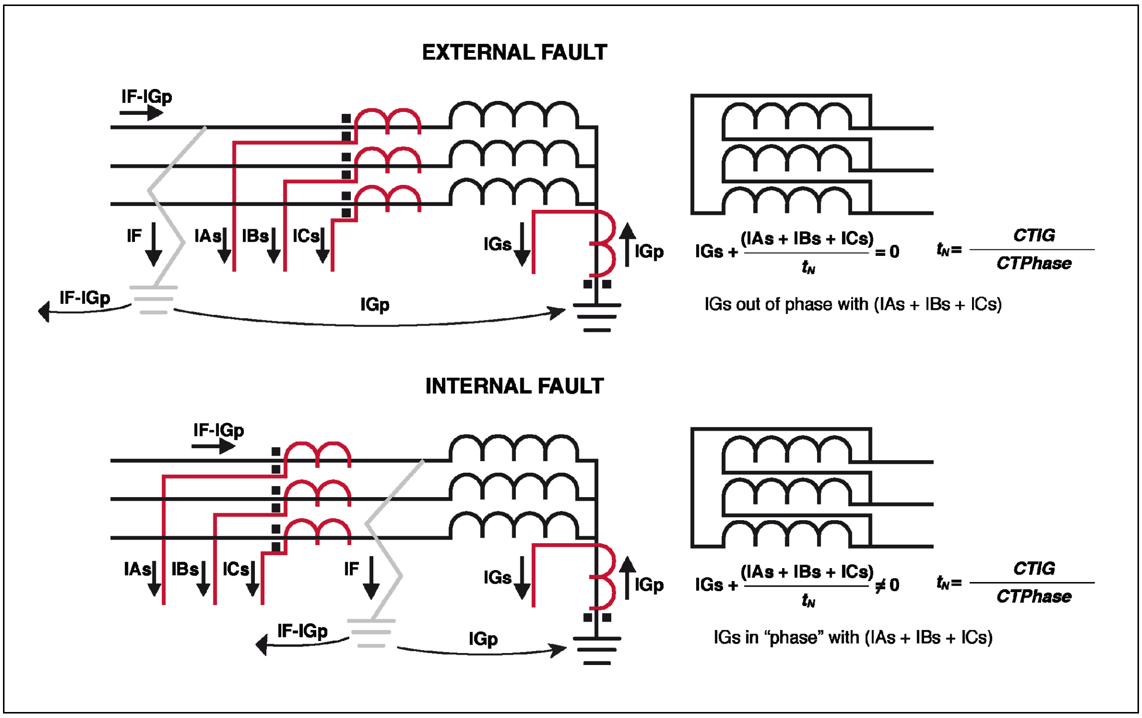


Figure 3.12.1: External and Internal Faults to a Power Transformer.

The Restricted Earth Fault Unit provides higher sensibility than the Phase Differential unit because the relation between the differential current and the distance from the fault location to the neutral point is linear; whereas for the phase differential unit this relation is quadratic. Figure 3.12.2 shows a fault located in a wye winding at a distance to the neutral point given by “n”, value in per unit with regard to the total winding turns. In order to simplify the explanation, the breaker of the wye winding is supposed open, therefore **IGDIFF=IG** and **IPHDIFF=IPH**.

The neutral differential current will be equal to:

$$\text{IG}=\frac{n\cdot V_r}{Zn},$$

where Vr represents the rated voltage of the wye winding.

While the phase differential current will be equal to:

$$\text{IPH}=\frac{IG\cdot n\cdot N2}{N1}=\frac{n^2\cdot V_r\cdot N2}{Zn\cdot N1}\cdot\frac{1}{\sqrt{3}}$$

The variation of the mentioned differential currents as a function of the distance from the fault location to the neutral point, “n”, is shown in the plot of Figure 3.12.3. As it can be observed, the magnitude of the phase differential current is lower than the corresponding magnitude of the neutral differential current. Even by removing the √3 factor, derived from the transformation between the wye and delta windings, the phase differential current would be lower than the neutral differential current.

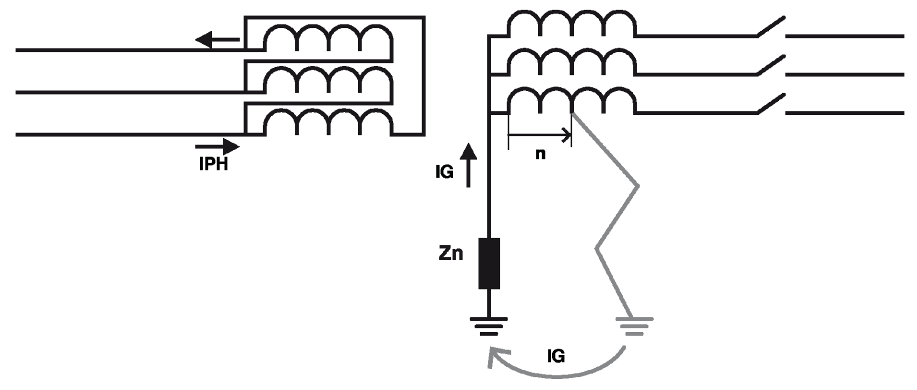


Figure 3.12.2: Ground Fault in a Wye Winding Located at a Distance “n” from the Neutral Point.

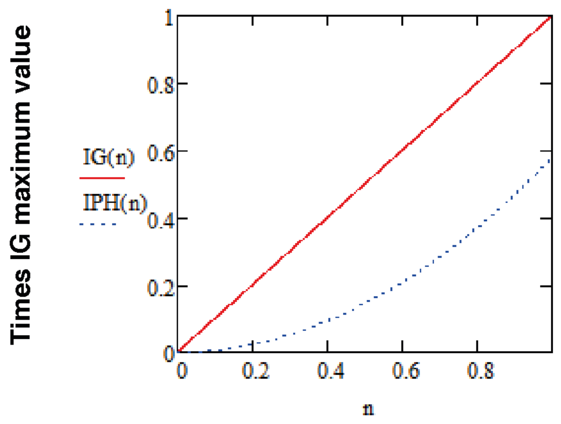


Figure 3.12.3: Variation of the Neutral and Phase Differential Currents with the Distance “N” from the Fault Location to the Neutral Point.

When the neutral point of the wye winding is solidly grounded, the magnitude of the ground current mainly depends on the winding leakage reactance. As such reactance is very low for faults close to the neutral point, the ground current will be high for these faults. Therefore, in solidly grounded neutrals, the Restricted Earth Fault unit will practically cover faults in the 100% of the winding.

3.12.2 Percentage Restraint Characteristic

In order to take into account the CT errors, the Restricted Earth Fault unit includes a percentage restraint characteristic. The restraint current is calculated as:

$$I_{restN} = \frac{\max(I_A, I_B, I_C)}{t_N}$$

$$t_N = \frac{CTIG}{CTPhase}$$

The restraint based on the maximum phase current allows the stabilization of the Restricted Earth Fault unit during non-grounded faults which generate a false neutral current due to CT saturation. This false neutral current will directly create a false differential current.

Restricted Earth Fault unit is provided with a settable timer for time delayed trips if required.

The unit pickup takes place at 100% of the operate characteristic value and resets at 80% of this value.

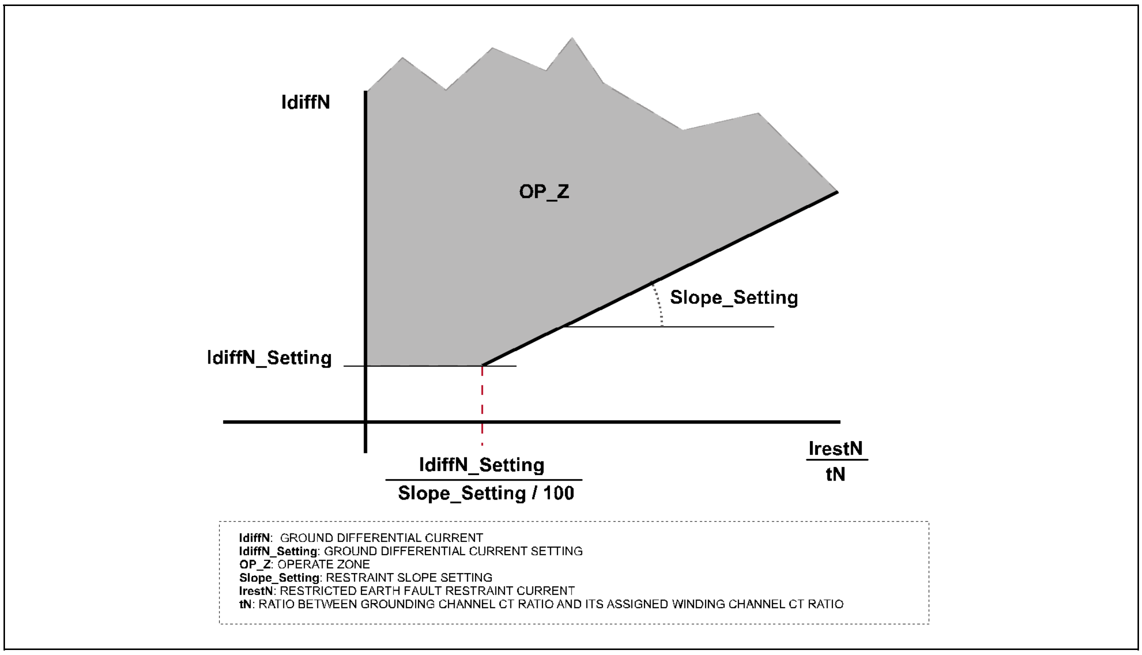


Figure 3.12.4: Percentage Restraint Characteristic for Differential Unit.

3.12.3 Blocking by Directional Comparison Unit

To increase the security during external faults with CT saturation, the Restricted Earth Fault unit includes a Directional Comparison unit, which compares the angle between the ground current (IG) and the neutral current (IN). When this angle, in absolute value, is higher than 120º (models **IDV*******0/A/B/C/D/E*****) or higher than the setting **Angle for Directional Comparison REF Channel n** (n=1, 2) (models **IDV** with option **F** or higher in digit **9**) the directional comparison unit will activate the external fault condition (signal **External Fault Restricted Earth Fault channel n** (n=1, 2)),. If the angle, in absolute value, is lower or equal than 120º or the mentioned setting, depending on the model, the directional comparison unit will activate the internal fault condition (signal **External Fault Restricted Earth Fault channel n** (n=1, 2)). The Restricted Earth Fault unit will only operate when the directional comparison unit activates the internal fault condition.

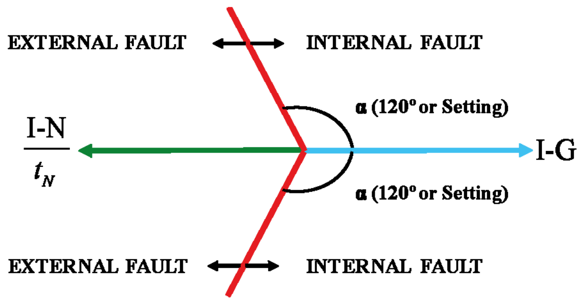


Figure 3.12.5: Directional Comparison Unit.

For the directional comparison unit to operate it is necessary that both the neutral and ground currents are above a minimum threshold:

In models **IDV*******0/A/B/C/D/E*****:**

- IG must be higher than **50 mA**
  AND
- Any winding phase current must be higher **10 mA**

In models **IDV** with option **F** or higher in digit **9**:

- IG must be higher than the setting **Minimum Level IG Current Channel** n (n=1, 2)
  AND
- IN / t_N must be higher than 90% of the setting **Minimum Level IG Current Channel n (n=1, 2)** AND Ia, Ib or Ic are higher than **14 mA**

The latter condition will avoid the operation of the Restricted Earth Fault unit during non-grounded external faults which generate a false neutral current (which will result in a false differential current) due to CT saturation. In this type of faults there will not be any ground current, therefore IG will be lower than the corresponding threshold.

However, the need for the ground and neutral current to exceed a minimum threshold may block the Restricted Earth Fault unit trip for internal faults with no neutral current, as it is the case of figure 2. This condition could occur during close onto faults with the winding 2 breaker open (it is supposed that energization is done from winding 1) or during internal faults with the power transformer unloaded. In order to allow the trip in the latter conditions, in model **IDV** with option **F** or higher in digit **9**, the directional comparison unit will activate the internal fault condition when:

- IG magnitude is higher than the setting **Minimum Level IG Current Channel n**
  AND
- IN / t_N magnitude is lower than 90% of the setting **Minimum Level IG Current Channel n** OR the magnitude of the three phase currents is below **14 mA.**

As a summary, in models **IDV** with option **F** or higher in digit **9**, the internal fault condition, output **Internal Fault Restricted Earth Fault channel n** (n=1, 2), will activate when any of the following two conditions is fulfilled:

- Absolute angle between IG and IN currents is lower than the setting **Angle for Directional Comparison REF Channel n** (n=1, 2), OR
  OR
- IG> **Minimum Level IG Current Channel n (n=1, 2)** AND (IN / tN < 0.9 * **Minimum Level IG Current Channel n** (n=1, 2) OR **Ia<14 mA; Ib<14 mA and Ic<14 mA)**.

The Restricted Earth Fault unit will have permission to trip if the signal **Internal Fault Restricted Earth Fault channel n** is activated during one cycle. This time-delay is included to filter transient activations of the internal fault condition.

The setting **Minimum Level IG Current Channel n** must be higher than the maximum ground current flowing under load conditions, as a result of system unbalances. A value between 5% and 10% of the transformer rated current is recommended.

When the three-phase currents of the corresponding winding are below **14 mA**, the neutral current considered for the calculation of the neutral differential current will be 0 A.

In models **IDV*******0/A/B/C/D/E***,** in order to allow the Restricted Earth Fault unit to trip during internal faults with no neutral current, it is necessary to carry out the following programmable logic:

[**NOT** (Neutral overcurrent unit n (n=1, 2) winding X (X=1, 2, 3) pick-up)] **AND** (Ground overcurrent unit m (m=1, 2) channel Y (Y=1, 2, 3, 4, 5))→ **TIME DELAY** →Programmable Trip.

Where the pick-up setting of the ground overcurrent unit must follow the same recommendations mentioned for the setting **Minimum Level IG Current Channel n.** On the other hand, the pick-up setting of the neutral overcurrent unit must be equal to the pick-up setting of the ground overcurrent unit multiplied by t_N

The directional comparison unit allows distinguishing internal and external faults with CT saturation whenever the saturation free time is higher than 3.5 ms.

3.12.4 Blocking by Neutral Current Level

The Restricted Earth Fault unit is designed to detect internal faults to the winding that generate a reduced current, for which the phase differential current does not provide enough sensitivity. For this reason the restricted ground fault unit can be blocked in faults with high current. In this way, the operation with external faults with CT saturation is avoided.

In models **IDV*******0/A/B/C/D/E*****, if IN / t_N is higher than 30 A the Restricted Earth Fault unit is blocked.

In models **IDV** with option **F** or higher in digit **9**, if IN / t_N is higher than the setting **Blocking Level IN REF Channel n** (n=1, 2), the Restricted Earth Fault unit will be blocked. This setting must be above the maximum neutral current for an internal fault divided by t_N.

When the Restricted Earth Fault unit is blocked by Neutral current level, the signal **External Fault Restricted Earth Fault Channel n** is activated.

3.12.5 Restricted Earth Fault with Autotransformers

The application of Restricted Earth Fault Unit in the case of autotransformers requires different calculations. These are applied when the setting **Autotransformer**, inside the field **Connection Groups** is set to **YES**.

Consider the electric diagram for an autotransformer shown in Figure 3.12.6 Due to the CT polarity, in secondary values, if the CT ratios were equal, we would have IN1s+IN2s+IGs=0.

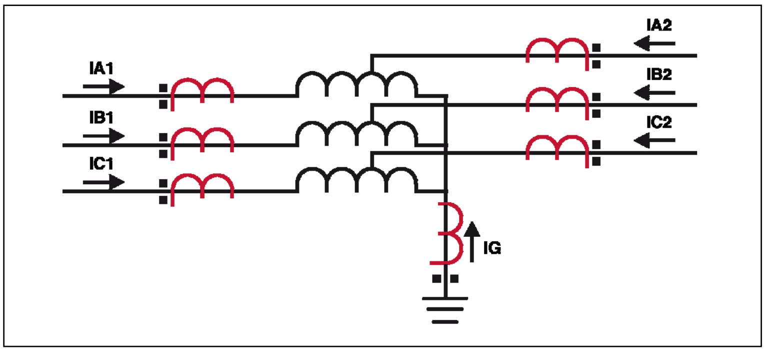


Figure 3.12.6: Electric Diagram of an Autotransformer.

The Restricted Earth Fault Unit adds the neutral current (IN) and the ground current (IG). In the case of autotransformers, the IN value used is as follows:

$$IN_{\text{AUTOTRANSFORMER}} = \frac{IN_1}{t_{N1}} + \frac{IN_2}{t_{N2}}$$

where IN_1 is the neutral current of winding 1 and IN_2 is the neutral current of winding 2.

$$t_{N1} = \frac{CTIG1}{CTPhase1} \quad \text{and} \quad t_{N2} = \frac{CTIG2}{CTPhase2}$$

When the **Autotransformer** setting is set to **YES**, the IG-1 and IG-2 analog inputs are automatically assigned to windings 1 and 2, respectively.

3.12.6 Blocking Inputs

These units have the possibility to program **Trip Blocking** inputs, which prevents the operation of these units if the corresponding inputs are activated before the trip is generated. If they are activated after the trip, it is reset. In order to use this blocking logic, the inputs defined as Restricted Earth Fault Trip Blocking must be programmed for each of the four available units.

3.12.7 Example of Calculating the Restricted Earth Fault Unit Settings

This example considers a 60 MVA two winding power transformer, transformation ratio of 130 kV / 46 kV, connection group ΔY1. The ground CT ratio in the 2nd winding is 300/1A. Earth resistor is 15 Ω.

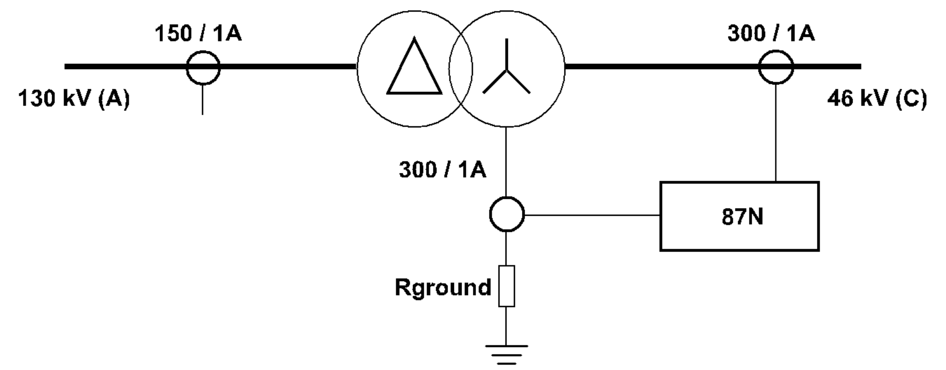


Figure 3.12.7: Example of Calculating the Restricted Earth Fault Unit Settings.

- **Calculating the maximum grounding current, fault current and zero sequence current**

Nominal current on winding 2 for the maximum power value:

$$Current = \frac{MaximumPower(kVA)}{Voltage(kV)\cdot\sqrt{3}} = \frac{60000kVA}{46\cdot\sqrt{3}} = 753.06A$$

The current flowing through the grounding of the transformer is limited with a resistance in that ground. The magnitude of this resistance permits knowing the position of the fault in the winding with respect to ground, based on the measured current value.

Maximum current is:

$$MaxGroundCurrent = \frac{Voltage\,(V)}{EarthResistor(\Omega)\cdot\sqrt{3}} = \frac{46000}{15\cdot\sqrt{3}} = 1770.54A$$

This means that ground current in transformer will be maximum 1770.54A; or 5.901A as secondary value for a CT ratio of 300/1A. Under this situation, a fault located at 7% from the neutral would cause:

$$Fault\ Current = 7\% \cdot Max\ Ground\ Current\ (A) = 0.07 \cdot 1770.54\ \ A = 123.94\ A$$

The increasing of the phase currents is near zero and therefore the calculated ground current will also be considered as zero.

IN=3Io=0A

- **Calculating Settings**

1- **Pickup** setting in secondary values will be:

$$Diff.\ Current = |3 \cdot I0 + IG| = |0 + Fault\ Current/CTIG| = |0 + 123.94 / 300| = 0.4131\ A$$

2- **Slope** setting is obtained from the minimum ratio between the differential current for the fault to be detected and the nominal current:

$$Slope = \frac{123.94\,A}{753.06\,A} \cdot 100 = 16.46 \rightarrow 16.46\%$$

3- **Time Delay**: a time-delay of half-cycle is recommended in order to filter transient activations

3.12.8 Restricted Earth Fault Units Settings

Restricted Earth Fault Units (Units 1 and 2 for each Ground Channel)			
Setting	**Range**	**Step**	**By Default**
REF Enable	YES / NO		NO
REF Pickup	0.05 - 50 A	0.01 A	0.05 A
REF Restraint Slope	0 - 100 %	1 %	20 %
REF Delay	0.00 - 300 s	0.01 s	0.01 s
Minimum level IG Current Channel 1 / 2	0.02A - 10A	0.01A	0.05A
Blocking level IN REF Channel 1 / 2	10A - 160A	1A	30A
Angle for Directional Comparison REF Channel 1 / 2	0º - 180º	1º	120º

- **Restricted Earth Fault Units: HMI Access**

IDV-A/B/G/H/K/L Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**3 - PROTECTION**	**10 - RESTRICTED EARTH**
3 - INFORMATION	….	…

0 - DIFFERENTIAL	**0 - CHANNEL 1**	**0 - UNIT 1**
…	**1 - CHANNEL 2**	**1 - UNIT 2**
10 - RESTRICTED EARTH		
…		

0 - UNIT 1	**0 - R EARTH ENABLE**
1 - UNIT 2	**1 - R EARTH PICKUP**
	2 - R EARTH RESTRAINT
	2 - R EARTH DELAY

IDV-D Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**3 - PROTECTION**	**9 - RESTRICTED EARTH**
3 - INFORMATION	….	…

0 - DIFFERENTIAL	**0 - CHANNEL 1**	**0 - UNIT 1**
…	**1 - CHANNEL 2**	**1 - UNIT 2**
9 - RESTRICTED EARTH		
…		

0 - UNIT 1	**0 - R EARTH ENABLE**
1 - UNIT 2	**1 - R EARTH PICKUP**
	2 - R EARTH RESTRAINT
	3 - R EARTH DELAY

IDV Models with option F or higher in digit 9

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**3 - PROTECTION**	**16 - RESTRICTED EARTH**
3 - INFORMATION	….	…

0 - DIFFERENTIAL	**0 - CHANNEL 1**	**0 - MINIMUM IG CURR C1**
…	**1 - CHANNEL 2**	**1 - BLOCK LEVEL IN REF**
9 - RESTRICTED EARTH		**2 - ANGLE DIR COM C1**
…		**3 - UNIT 1**
		4 - UNIT 2

0 - MINIMUM IG CURR C1	
1 - BLOCK LEVEL IN REF	**0 - R EARTH ENABLE**
2 - ANGLE DIR COM C1	**1 - R EARTH PICKUP**
3 - UNIT 1	**2 - R EARTH RESTRAINT**
4 - UNIT 2	**3 - R EARTH DELAY**

3.12.9 Digital Inputs of the Restricted Earth Fault Module

Table 3.12-1: Digital Inputs of the Restricted Earth Fault Module

Name	Description	Function
INBLK_REF_11	Restricted Earth Fault IG-1 unit 1 blocking input	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.
INBLK_REF_12	Restricted Earth Fault IG-1 unit 2 blocking input	
INBLK_REF_21	Restricted Earth Fault IG-2 unit 1 blocking input	
INBLK_REF_22	Restricted Earth Fault IG-2 unit 2 blocking input	
ENBL_REF_11	Restricted Earth Fault IG-1 unit 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_REF_12	Restricted Earth Fault IG-1 unit 2 enable input	
ENBL_REF_21	Restricted Earth Fault IG-2 unit 1 enable input	
ENBL_REF_22	Restricted Earth Fault IG-2 unit 2 enable input	

3.12.10 Auxiliary Outputs and Events of the Restricted Earth Fault Module

Table 3.12-2: Auxiliary Outputs and Events of the Restricted Earth Fault Module

Name	Description	Function
PU_REF_11	Restricted Earth Fault IG-1 unit 1 pickup	Unit pickup and timing start.
PU_REF_12	Restricted Earth Fault IG-1 unit 2 pickup	
PU_REF_21	Restricted Earth Fault IG-2 unit 1 pickup	
PU_REF_22	Restricted Earth Fault IG-2 unit 2 pickup	
TRIP_REF_11	Restricted Earth Fault IG-1 unit 1 trip	Trip of the unit.
TRIP_REF_12	Restricted Earth Fault IG-1 unit 2 trip	
TRIP_REF_21	Restricted Earth Fault IG-2 unit 1 trip	
TRIP_REF_22	Restricted Earth Fault IG-2 unit 2 trip	
TRIP_REFM_11	Restricted Earth Fault IG-1 unit 1 masked trip	Unit trip affected by trip mask.
TRIP_REFM_12	Restricted Earth Fault IG-1 unit 2 masked trip	
TRIP_REFM_21	Restricted Earth Fault IG-2 unit 1 masked trip	
TRIP_REFM_22	Restricted Earth Fault IG-2 unit 2 masked trip	
EXTFLT_REF_C1	External Fault Restricted Earth Fault Channel 1	Internal and external fault condition generated by the REF directional comparison unit
INTFLT_REF_C1	Internal Fault Restricted Earth Fault Channel 1	
EXTFLT_REF_C2	External Fault Restricted Earth Fault Channel 2	
INTFLT_REF_C2	Internal Fault Restricted Earth Fault Channel 2	
REF_ENBLD_11	Restricted Earth Fault IG-1 unit 1 enabled	Indication of enabled or disabled status of the unit.
REF_ENBLD_12	Restricted Earth Fault IG-1 unit 2 enabled	
REF_ENBLD_21	Restricted Earth Fault IG-2 unit 1 enabled	
REF_ENBLD_22	Restricted Earth Fault IG-2 unit 2 enabled	
INBLK_REF_11	Restricted Earth Fault IG-1 unit 1 blocking input	The same as for the Digital Inputs.
INBLK_REF_12	Restricted Earth Fault IG-1 unit 2 blocking input	
INBLK_REF_21	Restricted Earth Fault IG-2 unit 1 blocking input	
INBLK_REF_22	Restricted Earth Fault IG-2 unit 2 blocking input	
ENBL_REF_11	Restricted Earth Fault IG-1 unit 1 enable input	The same as for the Digital Inputs.
ENBL_REF_12	Restricted Earth Fault IG-1 unit 2 enable input	
ENBL_REF_21	Restricted Earth Fault IG-2 unit 1 enable input	
ENBL_REF_22	Restricted Earth Fault IG-2 unit 2 enable input	

3.12.11 Restricted Earth Fault Units Test

The test is performed to each of the four Restricted Earth Fault Units. Each ground channels have to be assigned to each winding, and perform the following tests.

- **Settings**

Relay settings to be as per Table 3.12-3 below:

Table 3.12-3: Restricted Earth Fault Units Test (Settings)	
Setting Label	**Value**
Windings Ratio	300
Ground CT Ratio	300
REF Enable	YES
REF Pickup	2 A
REF Restraint Slope	2 %
REF Delay	5 s
Unit Trip Mask	YES
Rest of Units Enable	NO

- **Unit Sensitivity**

Apply current to one ground channel and one winding phase only (at 0º) and check that Restricted Earth Fault Unit picks up and resets, for all pickup settings, when said current is within the margin indicated in Table 3.12-4.

Table 3.12-4: Restricted Earth Fault Element Test (Element Sensitivity)		
Pickup setting	Pickup	Reset
2 A	0.97 - 1.03 A	0.776 - 0.824 A
1 A	0.485 - 0.515 A	0.3288 - 412 A
0.04 A	0.0194 - 0.0206 A	0.014 - 0.017 A

Check that upon unit activation a trip occurs activating all trip contacts.

- **Element Timer**

Apply a current 2.5 A to ground channel and check that trip occurs within the margin ±2% or ±30ms (whichever is greater) of the timer setting value. Bear in mind that operate time for a 0 ms setting is between 1 and 2 cycles.

- **Unit Characteristic**

One of the Restricted Earth Fault units should be set as:

Setting Label	Value
Unit Pickup	0.2 A
Unit Restraint Slope	20 %
Unit Delay	0 s

Apply currents on phase A, B and the corresponding ground channel of such winding. Phase current will be constant and current to be injected to grounding channel for the element to operate shall be measured.

When opposite polarity sign, test will be started with ground channel value equal to phase value and then step down. For 0º out of phase, test will start with ground channel to 0 A and then step up.

Check that operate current is within the margin stated in Table 3.12-5.

Table 3.12-5: Restricted Earth Fault Element Test (Element Characteristic)

A-Phase	B-Phase	Ground Channel - Pickup	
1 A (0º)	-	180º	Never
1 A (0º)	-	0º	0.048 A - 0.052 A
2 A (0º)	-2 A (180º)	0º	0.388 A - 0.412 A
3.2 A (0º)	3.2 A (180º)	0º	0.621 - 0.659 A

Repeat the test using B and C phases.

3.13 Hot Spot Thermal Image Unit

3.13.1 Operating Principles

The operation of this unit is based on the IEC 60076-7 loading guide.

The degradation or aging of an oil immersed power transformer is dependent on the thermal condition of its components, mainly the temperature of the hottest point on the winding (called the Hot Spot) and the oil temperature (coolant). Operating a transformer above the nominal conditions can cause excessive temperatures within the components. This causes accelerated aging of the machine (premature degradation of the insulation material, temporary loss of dielectric strength through the formation of gas bubbles, increase of losses, etc.). These conditions brought to the extreme will cause a fault in the transformer. Depending on the temperature level reached, it is preferable to maintain the transformer overloaded and to assume an allowable loss of life, than to cause a failure in the electrical supply.

Therefore, three operating conditions are defined below according to load and Hot Spot temperature:

- Normal conditions: Nominal conditions, or temporarily high, that throughout time does not cause considerable transformer loss of life.
- Long term emergency conditions: Overload and Hot Spot high temperature conditions that cause considerable loss of life, but can persist over long periods of time (weeks, months).
- Short term emergency conditions: Overload and Hot Spot high temperature conditions that must be reduced in a short period of time (trip in 30 minutes).

IDV-L and **IDV-***-****C*****[1] models include a Hot Spot thermal image unit that measures the transformer load (ratio between circulating current and transformer nominal current), and the temperature of the top oil layer using a thermal sensor. The units have the capability to determine Hot Spot temperature with greater accuracy than thermal image units based solely on transformer load measurements.

Hot Spot thermal image units are designed for long term emergency conditions, whereas short term emergency conditions are handled by the overload unit.

3.13.1.a Temperature Measurement

The unit operates according to both the top oil layer temperature measurement (to calculate the Hot Spot) and the ambient temperature measurement (to calculate the efficiency of the cooling system). These temperature measurements are obtained using PT100 sensors installed in the transformer, connected to the device by two converter inputs (configurable as -2.5 to 2.5 mA or 0 to 5 mA converters). The temperature is set for the top oil layer and the ambient temperature at each converter input by adjusting the **Sensor Input Selection**.

The sensor temperature ranges are related to the converter input ranges by settings, assigning the sensor temperature maximum and minimum values to the maximum and minimum values for each converter input. Therefore, different sensors can be used by simply modifying the unit settings.

[1] **IDV-***-****C***** models will include the Hot Spot Thermal Image Unit with X9 code equal to 2, 3, 5, 7, A, E, F, G, H or Z.

3.13.1.b Hot Spot Temperature Calculation

The Hot Spot calculation (HS_TEMP) is performed by direct measurement of the top oil layer temperature (TopOilProbe) at each instant, taking into account the increase in the Hot Spot temperature (ΔThs) that occurs between the actual instant and the previous instant, according to the following expression:

$HS\_TEMP_i = TopOilProbe_i + \Delta Ths_i$,

where: $\Delta Ths_i = \Delta Ths1_i - \Delta Ths2_i$

and:

$$\Delta Ths1_i := \frac{\Delta t}{k22 \cdot \tau w}\left[k21 \cdot HS\_Grad \cdot (k_i)^{Win\_Exp} - \Delta Ths1_{i-1}\right] + \Delta Ths1_{i-1}$$

$$\Delta Ths2_i := \frac{\Delta t \cdot k22}{\tau o}\left[(k21 - 1) \cdot HS\_Grad \cdot (k_i)^{Win\_Exp} - \Delta Ths2_{i-1}\right] + \Delta Ths2_{i-1}$$

The parameters used in the above expressions are described below:

TopOilProbe: Top oil layer temperature.
HS_TEMP: Actual Hot Spot temperature.
i : Number of samples at the actual instant of the calculation.
i-1: Number of samples at the instant of the previous calculation.
Δt : Time interval between the actual instant and the previous instant (1 minute).
K11, K21, K22: Transformer thermal model constants.
τo : Oil thermal constant.
τw : Winding thermal constant.
Wind_Exp: Winding exponent.
HS_Grad: Temperature gradient between the oil and the winding, measured under nominal load conditions.
K: load (IWngX/Inom_XF). ratio between the mean current through the channel selected in **Current channel** setting and transformer rated current.

The initial conditions for the Hot Spot calculation are defined assuming that the temperature and the transformer load are maintained stable (steady state), following the equations:

$$\Delta Ths1_0 := k21 \cdot HS\_Grad \cdot (k_0)^{Win\_Exp}$$

$$\Delta Ths2_0 := (k21 - 1) \cdot HS\_Grad \cdot (k_0)^{Win\_Exp}$$

Initializing the unit before reaching steady state could cause a transient in the thermal image unit that calculates the relay. This could (if initialized at no load) generate an unwanted trip after a certain time. To prevent an unwanted trip, the unit includes the **Hot Spot Start Threshold Current** setting. This setting prevents the unit from initializing until the load (winding n phase X current, where n = 1, 2 or 3) exceeds the setting value. This setting is only valid during unit initialization.

One possible case is as follows: During startup of the relay, the transformer is unloaded and in steady state (cold transformer) or the transformer is loaded in steady state, but the relay thermal image unit has not reached steady state (due to initialization in non-steady state conditions). In this case, activating the **Hot Spot Initiate Order** signal (configurable using programmable logic) initializes the unit in any situation. Therefore, the user is responsible for activating the signal when the transformer reaches steady state in regard to temperature and load.

It is also worth mentioning that changing the setting **Current channel** (hot/cold) may also required to change the rated current (as the magnitude considered is the load **K= IDevX/Inom**, where **Inom** is the rated current set in the thermal image element), that can generate untimely trips after a certain time. To this end, after changing this setting (**Current channel**), the user must be able to find the right moment (if the situation requires) to activate the signal **Hot Spot start command** adapting in this way the algorithm to the actual situation.

One specific case pertaining to the Hot Spot calculation is as follows: In fault conditions where the current may exceed the nominal current various times over short periods (ms), the Hot Spot temperature may increase considerably, possibly causing the unit to trip even after the fault has been cleared. A similar situation could arise during a short term emergency condition where the Hot Spot thermal unit could trip before the overload unit. This would cause a fault in the supply before anticipated. The Hot Spot unit is immune to these situations since the Hot Spot temperature calculation adapts while winding n (where n = 1, 2 or 3) phase X, by means of **Current Channel** setting, is equal or higher than the **Fault Detection Current** setting. Fault conditions are finished when phase X current value is less than **Fault Detection Current** setting value.

3.13.1.c Hot Spot Temperature Trip and Top Oil Layer Temperature Trip

Once the Hot Spot temperature is calculated, it is compared to the trip level setting. If the level is reached, it causes a trip. The Hot Spot trip reset value is adjustable. The user can define the Hot Spot temperature value at which the transformer will reconnect (this setting is expressed as a % of the Hot Spot temperature trip value).

In addition to the Hot Spot trip level, the unit includes a Hot Spot alarm level that activates an alarm signal when the level is reached. The alarm is reset when the Hot Spot temperature lowers below 95% of the alarm level setting.

In addition to the Hot Spot temperature alarm and trip levels, the unit has a top oil layer temperature alarm and trip level. The signals are activated when the top oil layer temperature (measured directly by the sensor) reaches the respective level settings. The trip reset is adjustable (expressed as a % of the top oil layer temperature trip value). The alarm resets when the top oil layer temperature lowers below 95% of the alarm level setting.

Both the oil temperature trip and the Hot Spot temperature trip can be disabled using the corresponding trip mask setting.

The unit trip logic includes both a Hot Spot trip block signal and a top oil layer temperature trip block signal. Activating the block signals prevents the corresponding trip, if it has not already occurred, or resets the trip in case the signal is still activated. These two blocks apply to situations in which after a trip, the transformer needs to be reconnected before the temperature lowers below the trip reset level.

3.13.1.d Accumulated Loss of Life

With the Hot Spot temperature calculated as a reference (HS_TEMP), and depending on the thermal treatment of the winding insulation (cellulose), the loss of life or accelerated aging of the transformer (Acc_L) can be estimated according to the following expressions:

$$Acc\_L_i := \left(\Delta t \cdot 2^{\frac{HS\_TEMP_i - 98}{6}}\right) + Acc\_L_{i-1}$$ if the cellulose is not thermally treated, or

$$Acc\_L_i := \left(\Delta t \cdot e^{\frac{15000}{110+273} - \frac{15000}{HS\_TEMP_i + 273}}\right) + Acc\_L_{i-1}$$ if the cellulose is thermally treated.

Therefore, a day of operating at the Hot Spot temperature limit (98ºC or 110ºC, according to the case) assumes a day of aging. An increase in the Hot Spot temperature accelerates transformer aging, while operating at temperatures lower than the Hot Spot reduces the degree of transformer aging.

There are many situations in which transformer startup does not coincide with the protection device startup (protection renovations, replacement of faulty devices). The **Initial Loss of Life** setting initiates the accumulated loss of life calculation using the value setting. The initialization is made effective when the **Accumulated Loss of Life Initialization Order** signal is activated (this signal must be configured in the programmable logic).

The accumulated loss of life is a magnitude that is saved in the non-volatile memory and remains immune to power faults in the device. The maximum value of this magnitude is 432000 hours (an unattainable limit for any transformer).

3.13.1.e Cooling System Efficiency

The cooling system efficiency measurement is based on comparing the top oil layer temperature measured directly by the sensor (TopOilProbe) with the estimated top oil layer temperature. This temperature is calculated from the load current and from the ambient temperature (Topoil_cal). Therefore a second thermal sensor is required to obtain the ambient temperature measurement (AmbientProbe).

When a fault is produced in the cooling system, the direct measurement of the top oil layer increases. The calculated measurement remains constant, since it can be assumed that the load and the ambient temperature will remain constant. The device activates the **Cooling System Alarm** signal when the difference between the direct measurement of the oil temperature (TopOilProbe) and the calculated temperature (Topoil_cal) exceed the value setting for the **Cooling System Alarm Level**. The alarm resets at 95% of the set value.

The calculation of the top oil layer temperature using the ambient temperature follows the expression:

$$Topoil\_cal_i := \frac{\Delta t}{k11 \cdot \tau o} \cdot \left[\left[\frac{1 + (k_i)^2 \cdot R}{1 + R} \right]^{Oil\_Exp} \cdot Oil\_Grad + AmbientProbe_i - Topoil\_cal_{i-1} \right] + Topoil\_cal_{i-1}$$

Where the following parameters are defined in addition to the ones above:

R: Ratio between the nominal load losses and the unloaded losses.
Oil_Exp: Oil exponent.
Oil_Grad: Temperature gradient between the air and the oil, measured under nominal load conditions

The initial conditions assume a steady state temperature and load according to the expression:

$$Topoil\_cal_0 := \left[\left[\frac{1 + (k_0)^2 \cdot R}{1 + R} \right]^{Oil\_Exp} \cdot Oil\_Grad + AmbientProbe_0 \right]$$

The initialization of the calculated oil temperature occurs at the same instant as the initialization of the Hot Spot calculation.

The following magnitudes are monitored by the Hot Spot thermal image unit: top oil layer temperature, Hot Spot temperature, ambient temperature, cooling efficiency, and transformer accumulated loss of life. All of these magnitudes (similar to other device magnitudes) can be configured in the events log or in the history log. They are also available for the device programmable logic where they can be configured as measurements for a SCADA system, or as user defined algorithms (control logic for commands, blocks, etc.)

3.13.2 Thermal Image Unit Settings

Thermal Image Unit			
Setting	**Range**	**Step**	**By Default**
Current Channel	0 - IA Winding1 1 - IB Winding1 2 - IC Winding1 3 - IA Winding2 4 - IB Winding2 5 - IC Winding2 6 - IA Winding3 7 - IB Winding3 8 - IC Winding3		IA Winding1
Enable	YES / NO		NO
Sensor input selection 0- TR-IN1 Oil / TR-IN2 Ambient 1- TR-IN1 Ambient / TR-IN2 Oil 2- TR-IN1 Oil 3- TR-IN2 Oil	0- 3	1	0
Minimum oil sensor temp	-20 - 20 ºC	0.01	-20 ºC
Maximum oil sensor temp	95 - 200 ºC	0.01	140ºC
Minimum ambient sensor temp	-50 - 10 ºC	0.01	-20ºC
Maximum ambient sensor temp	30 - 85 ºC	0.01	50 ºC
Transformer nominal current	0.5 - 10 A	0.01	5 A
Transformer thermal model k11 constant	0.1 - 3	0.01	0.5
Transformer thermal model k21 constant	0.1 - 3	0.01	2
Transformer thermal model k22 constant	0.1 - 3	0.01	2
Oil heating time constant	20 - 250 min	0.1	150 min
Winding heating time constant	2 - 20 min	0.1	7 min
Winding exponent	1 - 3	0.01	1.3
Winding temperature gradient for oil at nominal load	10 - 60 ºC	0.1	20 ºC
Hot spot start threshold current	0.05 - 5 A	0.01	0.1 A
Hot spot temperature alarm level	80 - 200 ºC	1	100 ºC
Hot spot temperature trip level	80 - 200 ºC	1	120 ºC
Winding temp trip reset level	50 - 100 **%**	1	79 **%**
Oil layer temp alarm level	50 - 200 ºC	1	90 ºC
Oil layer temp trip level	50 - 200 ºC	1	105 ºC
Oil layer temp trip reset level	50 - 100 **%**	1	90 **%**
Cooling control alarm level	5 - 100 ºC	1	30 ºC
Oil exponent	0.5 - 1.5	0.01	0.8
Top oil layer temp gradient for ambient at nominal load	10 - 100 ºC	0.1	60 ºC
Loss ratio at nominal load and no load	1 - 20	0.1	6
Paper thermal treatment	YES / NO		NO
Initial loss of life	0 - 131400 hours	1	0 hours

Recommended settings according to the IEC 60076-7 loading guide:

	Distribution Transformers	Medium and High Power Transformers						
	ONANd	**ONANr(*)**	**ONAN**	**ONAFr(*)**	**ONAF**	**OFr(*)**	**OF**	**OD**
Oil_Exp	0.8	0.8	0.8	0.8	0.8	1	1	1
Wind_Exp	1.6	1.3	1.3	1.3	1.3	1.3	1.3	2
K11	1	0.5	0.5	0.5	0.5	1	1	1
K21	1	3	2	3	2	1.45	1.3	1
K22	2	2	2	2	2	1	1	1
τo	180	210	210	150	150	90	90	90
τw	4	10	10	7	7	7	7	7

(*) Applicable to zig-zag windings where oil circulation may be limited due to radial separators less than 3 mm.

- ### Hot Spot Thermal Image Unit: HMI Access

0 - CONFIGURATION	0 - GENERAL	0 - OVERCURRENT
1 - OPERATIONS	**1 - PROTECTION**	...
2 - CHANGE SETTIINGS	2 - RECLOSER	**12 - HOT SPOT THERMAL**
3 - INFORMATION	3 - LOGIC	...
	...	

0 - OVERCURRENT	**0 - CURRENT CHANNEL**
...	**1 - GENERAL**
12 - HOT SPOT THERMAL	**2 - THERMAL PROBES**
...	**3 - TRANSFORMER**

0 - CURRENT CHANNEL	**0 - IADEV1**
1 - GENERAL	**1 - IBDEV1**
2 - THERMAL PROBES	**2 - ICDEV1**
3 - TRANSFORMER	**3 - IADEV2**
	4 - IBDEV2
	5 - ICDEV2
	6 - IADEV3
	7 - IBDEV3
	8 - ICDEV3

0 - CURRENT CHANNEL	**0 - ENABLE**
1 - GENERAL	**1 - HOT SPOT ALARM**
2 - THERMAL PROBES	**2- HOT SPOT TRIP**
3 - TRANSFORMER	**3 - HOT SPOT RESET**
	4 - OIL ALARM
	5 - OIL TRIP
	6 - OIL RESET
	7 - COOLING ALARM
	8 - HS CURRENT THRESH
	9 - FAULT CURRENT

0 - CURRENT CHANNEL	**0 - PROBE SELECTION**
1 - GENERAL	**1 - MIN TEMP OIL**
2 - THERMAL PROBES	**2 - MAX TEMP OIL**
3 - TRANSFORMER	**3 - MIN TEMP AMBIENT**
	4 - MAX TEMP AMBIENT

0 - CURRENT CHANNEL	**0 - NOMINAL CURRENT**
1 - GENERAL	**1 - TH CONSTANT K11**
2 - THERMAL PROBES	**2 - TH CONSTANT K21**
3 - TRANSFORMER	**3 - TH CONSTANT K22**
	4 - OIL TIME CONSTANT
	5 - WINDING TIME CONST
	6 - WINDING EXP
	7 - HOT SPOT-OIL GRAD
	8 - OIL EXP
	9 - OIL-AMBIENT GRAD
	10 - LOSSES RATIO
	11 - UPGRADED PAPER
	12 - INITIAL LIFE

3.13.3 Digital Inputs of the Hot Spot Thermal Image Module

Table 3.13-1: Digital Inputs of the Hot Spot Thermal Image Module

Name	Description	Function
ENBL_HotSpot	Hot Spot Thermal Unit Enabling Input	Activating this input places the unit in service. Digital inputs can be assigned by level or to commands from the communications protocol or from the HMI. The default value for the logic inputs is "1".
HotSpot_BL	Hot Spot Trip Block Input	Activating the input before the trip is generated impedes activation of the unit. If activated after the trip, it resets.
TopOil_BL	Oil Temperature Trip Block Input	
RST_Acc_L	Accumulated Loss of Life Initialization Order	Initializes loss of life using the setting value. This command must be configured in the programmable logic.
RST_HS	Hot Spot Initiate Order	Initializes the Hot Spot calculation.

3.13.4 Auxiliary Outputs and Events of the Hot Spot Thermal Image Module

Table 3.13-2: Auxiliary Outputs and Events of the Hot Spot Thermal Image Module		
Name	**Description**	**Function**
HS_ALR	Hot Spot temperature alarm	Unit high temperature alarms.
L1_Oil	Oil temperature alarm	
HS_TRIP	Hot Spot temperature trip	Unit high temperature trips.
L2_ Oil_TRIP	Oil temperature trip	
HS_TRIPM	Hot Spot temperature masked trip	Unit trips conditioned by masked trips.
L2_ Oil_TRIPM	Oil temperature masked trip	
Cool_Ef_ALR	Cooling system alarm	Indicates a cooling problem due to the difference between the measured and calculated oil temperature.
HotSpot_ ENBLD	Enabled Hot Spot thermal unit	Indicates the status of the unit, enabled or disabled.
ENBL_HotSpot	Hot Spot thermal unit input enabling	The same as for the digital inputs.
HotSpot_BL	Hot Spot trip block input	
TopOil_BL	Oil temperature trip block input	
RST_Acc_L	Accumulated loss of life initialization order	
RST_HS	Hot Spot initiate order	

3.13.5 Hot Spot Thermal Image Unit Test

As a recommendation, disable the units that are not being tested when testing the unit.

Set the converter inputs as 0 to 5 mA converters.

Set the Hot Spot thermal image unit according to the following table:

Enabling the Unit (Permission)	YES
Sensor Input Selection	0
Minimum Oil Sensor Temperature	-20 ºC
Maximum Oil Sensor Temperature	140ºC
Transformer Nominal Current (I_nomXF)	5 A
Transformer Thermal Model k11 Constant	0.5
Transformer Thermal Model k21 Constant	2
Transformer Thermal Model k22 Constant	2
Oil heating Time Constant	150 min
Winding Heating Time Constant	7 min
Winding Exponent	1.3
Winding Temperature Gradient for Oil at Nominal Load	35 ºC
Hot Spot Start Threshold Current	0.1 A
Fault Detection Current	25 A
Hot Spot Temperature Alarm Level	110 ºC
Hot Spot Temperature Trip Level	130 ºC
Winding temp trip reset level	96 **%**
Oil Layer Temp Alarm Level	100 ºC
Oil Layer Temp Trip Level	120 ºC
Oil Layer Temp Trip Reset Level	95 **%**

The ratio between the sensor temperature and the equivalent in the mA converter is:

$$\frac{T - Tmin}{Tmax - Tmin} := \frac{mA - Cmin}{Cmax - Cmin}$$

For this case (settings from the table above):

Cmin = 0 mA. Cmax = 5 mA. Tmin = -20ºC Tmax = 140ºC

The ratio between the phase A current and the load is as follows:

K = IA / I_nomXF

In our case, according to the settings in the table above, the transformer nominal current is:

I_nomXF = 5 A

3.13.5.a Top Oil Layer Temperature Alarm and Trip

Injected by converter 1 (TR-IN1), a DC current increase from 3 mA to 4.5 mA, and from 4.5 mA to 3 mA (*):

- The top oil layer temperature alarm activates at 3.75 mA ± 0.2% and resets at 3.594 mA ± 0.2%.
- The top oil layer temperature trip activates at 4.375 mA ± 0.2% and resets at 4.188 mA ± 0.2%.

(*) Note that the unit performs the calculations every minute.

3.13.5.b Hot Spot Temperature Alarm and Trip

Disable the unit and inject 2.82 mA (dc) by TR-IN1 and 5 A (ac) by channel IADEV1. Enable the unit (at the moment when the initial conditions are calculated) and vary the values injected according to the following table at a rate of 1 minute:

TR-IN1	2.82 mA cc	2.82 mA cc	2.82 mA cc	2.82 mA cc	2.82 mA cc	2.34 mA cc
IA	5 A ac	7.5 A ac	7.5 A ac	18.5 A ac	0 A	0 A
Hot Spot	105.24 ºC	108.39 ºC	111.29 ºC	131.12 ºC	124.58 ºC	103.3 ºC

Verify the activation and reset of the Hot Spot alarm and trip according to the value settings.

3.14 Overexcitation Protection Unit

3.14.1 Operating Principles

The effective value of the input phase voltage (measured through **VPH** channel for the **IDV-A/B** models and **VA** channel for the **IDV-G/H/J/K/L** models) and the frequency of the signal are calculated. These values are plotted on a voltage/frequency comparison curve where it is determined if the average values exceed the value set ratio value.

The ratio between the adjusted nominal voltage and adjusted nominal frequency is taken as the unit value (V/Hz=1). The function's pickup setting depends on this unit value. The function is activated when the ratio between the measured voltage and frequency exceeds this value. Note that the voltage measured can be a line-to-line or line-to-neutral voltage, while the Nominal Voltage setting is a value between phases; consequently, if line-to-neutral voltage is used, the V/Hz ratio should be multiplied by √3.

The pickup of the unit takes place when the measured value of the voltage/frequency ratio exceeds the set V/Hz value by 1.05 times, resetting when the measurement drops below the set pickup value.

The same setting used for Frequency Units (**Inhibit Voltage**) is used to disable trips in this unit when the measured voltage is below a certain value.

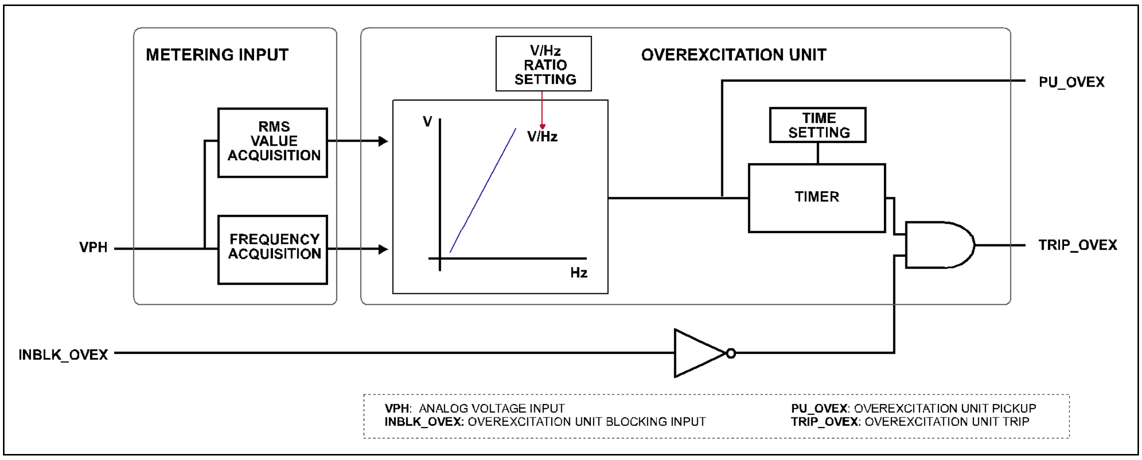


Figure 3.14.1: Overexcitation Unit Block Diagram.

Pickup activation enables the timing function to determine the performance of the time element. The activation of the output requires the pickup to remain activated throughout the entire time elapse set in the timer. The resetting of the pickup signal means that the output timer will start counting from zero when pickup conditions are present once again.

The user can choose between **Fixed Time** and **Inverse Curve** timing types. The equation for the **Inverse Curve** is as follows:

$$t = 0.8 + \frac{2 \cdot Overex.Dial}{\left(\frac{V/f}{(V_N/f_N)\ setting} - 1 \right)^2}$$

where V and f are the measured voltage between phases and the measured frequency.

3.14.2 Application Description

The purpose of an overexcitation protection is to protect the machine against overvoltage and underfrequency situations. Based on the equation that defines the voltage induced in a coil: $E = 4{,}44 \cdot f \cdot A \cdot N \cdot B_{MAX}$; the "maximum flow" (B_{MAX}) fulfills the following expression:

$$B_{MAX} = K \cdot \frac{E}{f}$$

and, therefore, the magnetic flow in the machine's core is directly proportional to the voltage and inversely proportional to the frequency.

The measurement of the V/Hz ratio is an indicator of the existing excitation. The magnetic core is saturated when this V/Hz ratio exceeds a permissible value, which gives rise to increased voltage between the strips that form the core, causing damage to the iron. When this happens, the magnetic path for which the machine was designed cannot accommodate the increased flow, thus generating "leakage currents" that cause thermal damage.

Under normal conditions, the voltage regulators of generators and other power system control elements maintain voltage within proper margins. However, anomalous conditions like those described below can occur:

- **Overvoltages**: When starting or stopping generators, with load losses in "island" configurations or load shedding. In addition, if the control system is not functioning properly, overvoltage situations can extend themselves over time.
- **Underfrequency**: For isolated or poorly meshed systems under overload conditions and for malfunction operations in load shedding schemes.

3.14.3 Overexcitation Protection Unit Settings

Overexcitation Protection Unit Settings			
Setting	**Range**	**Step**	**By Default**
Overexcitation Enable	YES / NO		NO
Overexcitation Pickup	1 - 3 V/Hz	0,1 V/Hz 0,01 V/Hz (*)	1,1
Overexcitation Curve	0: Definite Time 1: Inverse		0: Definite Time
Overexcitation Dial	0.01 - 10	0.1	1
Overexcitation Delay	0.00 - 600 s	0.01 s	1 s

(*)IDV-*-****C** Models.**

- **Overexcitation Protection Unit: HMI Access**

IDV-A/B/G/H/J/K Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**3 - PROTECTION**	**11 - OVEREXCITATION**
3 - INFORMATION	….	…

0 - DIFFERENTIAL	**0 - OVEREX. ENABLE**
…	**1 - OVEREX. PICKUP**
11 - OVEREXCITATION	**2 - OVEREX. CURVE**
…	**3 - OVEREX. DIAL**
	4 - OVEREX. DELAY

IDV-L / IDV-***-****B/C**** Models

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	…
2 - CHANGE SETTINGS	**3 - PROTECTION**	**16 - OVEREXCITATION**
3 - INFORMATION	….	…

0 - DIFFERENTIAL	**0 - UNIT 1**	**0 - OVEREX. ENABLE**
…	**1 - UNIT 2**	**1 - OVEREX. PICKUP**
16 - OVEREXCITATION	**2 - UNIT 3**	**2 - OVEREX. CURVE**
…	**3 - UNIT 4**	**3 - OVEREX. DIAL**
		4 - OVEREX. DELAY

3.14.4 Digital Inputs of the Overexcitation Module

Table 3.14-1: Digital Inputs of the Overexcitation Module

Name	Description	Function
INBLK_OVEX 1	Overexcitation unit 1 blocking input	Activation of input before trip generation blocks unit operation. If activated after tripping, trip resets.
INBLK_OVEX 2	Overexcitation unit 2 blocking input	
INBLK_OVEX 3	Overexcitation unit 3 blocking input	
INBLK_OVEX 4	Overexcitation unit 4 blocking input	
ENBL_OVEX 1	Overexcitation unit 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_OVEX 2	Overexcitation unit 2 enable input	
ENBL_OVEX 3	Overexcitation unit 3 enable input	
ENBL_OVEX 4	Overexcitation unit 4 enable input	

3.14.5 Auxiliary Outputs and Events of the Overexcitation Module

Table 3.14-2: Auxiliary Outputs and Events of the Overexcitation Module

Name	Description	Function
PU_OVEX 1	Overexcitation unit 1 pickup	Unit pickup and timing start.
PU_OVEX 2	Overexcitation unit 2 pickup	
PU_OVEX 3	Overexcitation unit 3 pickup	
PU_OVEX 4	Overexcitation unit 4 pickup	
TRIP_OVEX 1	Overexcitation unit 1 trip	Trip of the unit.
TRIP_OVEX 2	Overexcitation unit 2 trip	
TRIP_OVEX 3	Overexcitation unit 3 trip	
TRIP_OVEX 4	Overexcitation unit 4 trip	
TRIP_OVEX 1 M	Overexcitation unit 1 masked trip	Unit trip affected by trip mask.
TRIP_OVEX 2 M	Overexcitation unit 2 masked trip	
TRIP_OVEX 3 M	Overexcitation unit 3 masked trip	
TRIP_OVEX 4 M	Overexcitation unit 4 masked trip	
OVEX 1_ENBLD	Overexcitation unit 1 enabled	Indication of enabled or disabled status of the unit.
OVEX 2_ENBLD	Overexcitation unit 2 enabled	
OVEX 3_ENBLD	Overexcitation unit 3 enabled	
OVEX 4_ENBLD	Overexcitation unit 4 enabled	
INBLK_OVEX 1	Overexcitation unit 1 blocking input	The same as for the Digital Inputs.
INBLK_OVEX 2	Overexcitation unit 2 blocking input	
INBLK_OVEX 3	Overexcitation unit 3 blocking input	
INBLK_OVEX 4	Overexcitation unit 4 blocking input	
ENBL_OVEX 1	Overexcitation unit 1 enable input	The same as for the Digital Inputs.
ENBL_OVEX 2	Overexcitation unit 2 enable input	
ENBL_OVEX 3	Overexcitation unit 3 enable input	
ENBL_OVEX 4	Overexcitation unit 4 enable input	

3.14.6 Overexcitation Unit Test

Set the transformer Overexcitation Unit (V/Hz) to 1.0 V/Hz, trip time to 5 seconds, the nominal values being 110Vac and 50Hz and the voltage type U_{AB}.

Apply 30V at 50Hz through the phase voltage channel for 300ms (as 10 complete voltage cycles are initially needed for frequency calculation) being Inhibit Voltage value below 30V (for example 5V).

Apply 110Vac at 50.00Hz through the phase voltage channel for 300ms and check that the unit is activated.

After unplugging the test voltage check that time recorder is within the range 4.85 - 5.25 s.

3.15 Cold Load Unit

3.15.1 Application Description

If a breaker has been open for a long time after line recloser failure, problems may occur when closing. When breaker is closed, large motors may start demanding high current peaks. Overcurrent protection may activate as a result of this. Pickup levels must be increased to prevent the above, and Table 4 can be used to this end as a second group with higher calibration settings.

IDV IEDs, by definition of their application, operate on more than one breaker. When applying the “cold load” function, it is necessary to select, via a setting (**Cold Load Breaker**), which breaker position will be supervised, i.e. which winding it corresponds to. In **IDV-D/F** relays, the cold load breaker setting supervises winding n open breaker/s (n=1, 2, 3), so that, in case one winding has two associated breakers, the cold load function will only activate when both breakers open.

Assuming the relay works using Table 1 and the supervised breaker opens, a timer starts timing and if breaker remains open after time-out, settings in Table 4 apply. Table 4 will be the active table while breaker remains open.

When breaker closes, the IED will be working with higher settings, and trips caused by starting motors will not take place.

A timer starts timing after closing, and if breaker remains closed after time-out, Table 1 activates. If this function is disabled, Table 4 can be used in the same way as other tables.

It could happen that with the Cold Load Unit enabled, the breaker changes state while the equipment is switched off. In this case, the unit works as follows:

- **If equipment is switched off when breaker is closed and breaker is open when switched on**, Cold Load Unit activates 100 milliseconds after equipment is switched on, and Table 4 will apply.
- **If equipment is switched off with Cold Load Unit activated (Table 4 applies after breaker trips) and breaker is closed when switched on**, Cold Load Unit remains activated during 100 milliseconds (Table 4 active) after pickup. When time expires the unit resets and the last relay operate table before activation of Cold Load Unit will apply.
- **If equipment is switched off with Cold Load Unit activated and unit disable digital signal is active when switched on**, unit output remains active during 100 milliseconds after pickup. When time expires output resets and the original table will apply.
- **If equipment is switched on with Cold Load Unit deactivated and breaker opens within 100 milliseconds wait time for unit pickup**, unit output will activate instantaneously after said time.
- **If equipment is switched off with Cold Load Unit activated and breaker remains open when switched on**, unit continuous its normal operation as if nothing had happened.

3.15.2 Cold Load Unit Settings

Cold Load Unit			
Setting	**Range**	**Step**	**By Default**
Cold Load Enable	YES / NO		NO
Cold Load Breaker	1 - 3	1	1
Timer for Group 4 Activation after Trip	0 - 1800 s	0.1 s	120 s
Timer for Previous Group Activation after Closing	0 - 1800 s	0.1 s	120 s

- **Cold Load Unit: HMI Access**

IDV-A/B/G/H/J/K/L MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**3 - PROTECTION**	**9 - COLD LOAD**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - COLD LOAD ENABLE**
...	**1 - COLD LOAD BREAKER**
9 - COLD LOAD	**2 - GROUP 4 ACT. TIME**
...	**3 - PREV GRP ACT TIME**

IDV-D MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**3 - PROTECTION**	**8 - COLD LOAD**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - COLD LOAD ENABLE**
...	**1 - COLD LOAD BREAKER**
8 - COLD LOAD	**2 - GROUP 4 ACT. TIME**
	3 - PREV GRP ACT TIME

IDV-F MODELS

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**3 - PROTECTION**	**12 - COLD LOAD**
3 - INFORMATION	....	...

0 - DIFFERENTIAL	**0 - COLD LOAD ENABLE**
...	**1 - COLD LOAD BREAKER**
12 - COLD LOAD	**2 - GROUP 4 ACT. TIME**
	3 - PREV GRP ACT TIME

3.15.3 Digital Inputs of the Cold Load Module

Table 3.15-1: Digital Inputs of the Cold Load Module		
Name	**Description**	**Function**
ENBL_CLPU	Cold Load 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 Auxiliary Outputs and Events of the Cold Load Module

Table 3.15-2: Auxiliary Outputs and Events of the Cold Load Module		
Name	**Description**	**Function**
ACT_CLPU	Cold Load activation (Table 4)	This signal indicates that cold load logic is activated so that settings in Table 4 apply. Or is deactivated so that settings in the original Table apply.
CLPU_ENBLD	Cold Load enabled	Indication of enabled or disabled status of the element.
ENBL_CLPU	Cold Load enable input	The same as for the Digital Inputs.

3.16 Overload Units

3.16.1 Overload Units (50/51OL)

IDV-L models are equipped with two overload units (one instantaneous and one timer). The main application of these units is to protect the transformer during short term emergency load conditions, as described in the IEC 60076-7 loading guide.

Power transformer operations can be classified into three operating conditions (normal, long term emergency and short term emergency) according to the loading and heat conditions.

- The normal condition assumes transformer operations under the nominal conditions for which it was designed.
- The long term emergency condition assumes transformer accelerated aging (this situation can be prolonged for days, weeks or months) and is covered by the hot spot thermal image unit that trips the transformer if the risk values for the machine are reached.
- The short term emergency load condition assumes overload and heat values that cause a loss of dielectric strength that can cause the transformer to fail. However, it is preferable to assume the risk of a fault for a short period of time (30 minutes) before a supply fault occurs. The overload unit applies to this case.

These units are independent of the hot spot thermal image unit, and can be used for other applications. The operating principles of overload elements are the same as for instantaneous and time phase overcurrent elements (operating only by the phase selected in setting **Current Channel** located in the Hot Spot element), with the distinction that it includes a **Fixed Time** setting up to 2 hours.

3.16.2 Overload Units Settings

Timer Overload			
Setting	**Range**	**Step**	**By Default**
Enable	YES / NO		NO
Unit Pickup	(0.02 - 25) In	0.01 A	6.50 A
Time Curve	See list of curves		Fixed Time
Negative Curve Time 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/RI curves	0.1 - 10	0.01	1
Fixed Time	0 - 7200 s	0.01 s	1800 s

Instantaneous Overload			
Setting	**Range**	**Step**	**By Default**
Enable	YES / NO		NO
Unit Pickup	(0.02 - 25) In	0.01 A	7.50 A
Unit Time	0.05 - 7200 s	0.01 s	5 s

- **Overload Unit: MMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - FUSE FAILURE
1 - OPERATIONS	1 - CONNECTION GROUPS	1 - DIFFERENTIAL
2 - CHANGE SETTINGS	**2 - PROTECTION**	...
3 - INFORMATION	3 - TRIP PERMISIONS	**13 - OVERLOAD**
	...	...

0 - FUSE FAILURE	**0 - TIME OVERCURRENT**	**0 - TOL ENABLE**
1 - DIFFERENTIAL	1 - INSTANTANEOUS	**1 - TOL PICKUP**
...		**2 - OVERLOAD CURVE**
13 - OVERLOAD		**3 - OVERLOAD DIAL**
...		**4 - TOL DELAY**

0 - FUSE FAILURE	0 - TIME OVERCURRENT	**0 - IOL ENABLE**
1 - DIFFERENTIAL	**1 - INSTANTANEOUS**	**1 - IOL PICKUP**
...		**2 - IOL DELAY**
13 - OVERLOAD		
...		

3.16.3 Digital Inputs of the Overload Module

Tabla 3.16-1: Digital Inputs of the Overload Module

Name	Description	Function
IN_BLK_TOL	Overload Timer Unit Block Input	Activating the input before the trip is generated impedes activation of the unit. If activated after the trip, it resets.
IN_BLK_IOL	Overload Instantaneous Unit Block Input	
IN_BPT_TOL	Overload Timing Cancellation Input	Converts the timer setting in the unit to instantaneous. Only affects the timer unit.
ENBL_TOL	Overload Timer Unit Enable Input	Activating this input places the unit in service. Digital inputs can be assigned by level or to commands from the communications protocol or from the MMI. The default value for the logic inputs is "1".
ENBL_IOL	Overload Instantaneous Unit Enable Input	

3.16.4 Auxiliary Outputs and Events of the Overload Module

Tabla 3.16-2: Auxiliary Outputs and Events of the Overload Module		
Name	**Description**	**Function**
PU_TOL	Overload Timer Unit Startup	Overload unit start-up logic.
PU_IOL	Overload Instantaneous Unit Startup	
TRIP_TOL	Overload Timer Unit Trip	Overload unit trip.
TRIP_IOL	Overload Instantaneous Unit Trip	
TRIP_TOL_M	Overload Timer Unit Masked Trip	Unit trip conditioned by corresponding masked trips.
TRIP_IOL_M	Overload Instantaneous Unit Masked Trip	
IN_BLK_TOL	Overload Timer Unit Block Input	Identical to digital inputs.
IN_BLK_IOL	Overload Instantaneous Unit Block Input	
ENBL_OL	Overload Unit Enable Input	Identical to digital inputs.
ENBL_IOL	Overload Instantaneous Unit Enable Input	
OL_ENBLD	Overload Unit Enabled	Indicates the status of the current units, enabled or disabled.
IOL_ENBLD	Overload Instantaneous Unit Enabled	

3.16.5 Overload Unit Test

As a recommendation, disable the units that are not being tested when testing each unit.

- **Startup and Reset**

Set the startup values desired for the unit. Check unit activation by actuating an output configured for this purpose. The unit can also be checked by checking the startup flags from the **Information - Status - Units** menu, or by ensuring the trip flag on the menu mentioned above activates if the unit trips.

Tabla 3.16-3: Overload Unit Startup and Reset

Unit Setting	Pickup		Reset	
	maximum	minimum	maximum	minimum
X	1.08 **x** X	1.02 **x** X	1.03 **x** X	0.97 **x** X

The ranges below the startup and reset interval can be extended up to X ± (5% x In) mA.

- **Activation Times**

Use trip terminals (G4-G5-G6-G7) (G8-G9-G10-H1) (C1-C2-C3-C4), depending on the model, for testing.

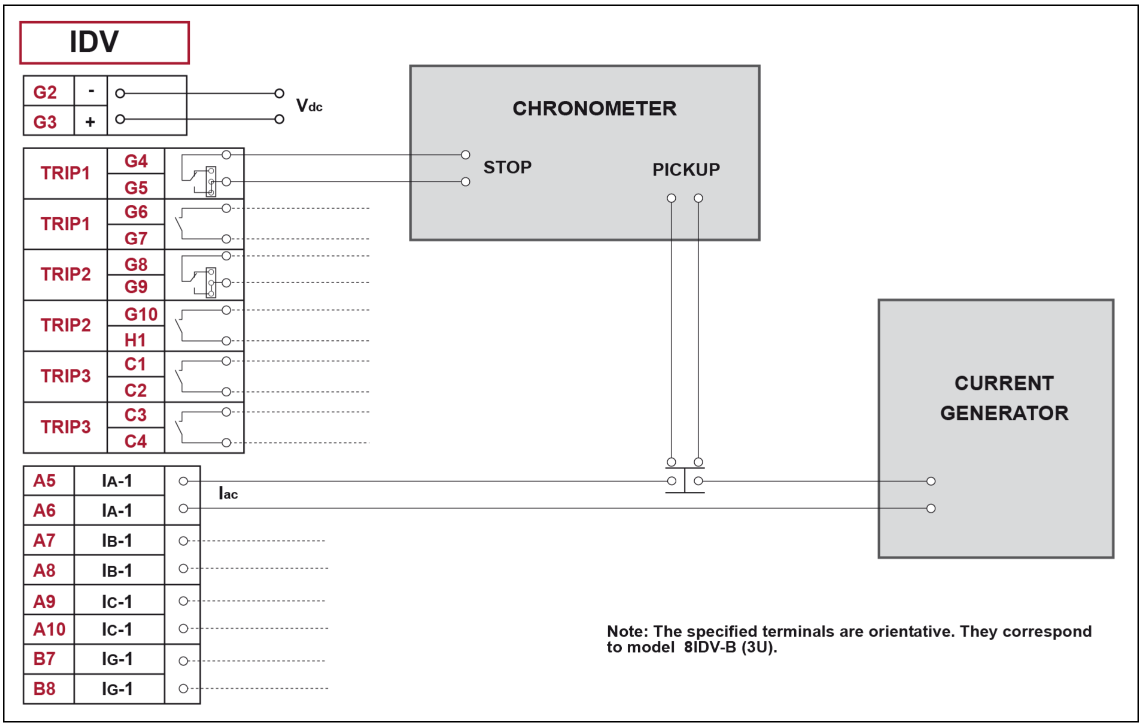


Figure 3.16.1: Operating Time Test Setup.

Fixed time

20% over the setpoint value selected for startup will be applied. The activation time will correspond to ±1% or ±30ms (whichever is greater) of the value setting for the selected time.

Inverse time

For a determined curve, the activation time is given by the dial selected and by the applied current (number of times for the start value setting). The tolerance is given by the result of applying a margin of error of ±1% to the current measurement. This translates into an error of ±2% or ±35ms (whichever is greater) for the time measurements.

3.17 Configuration Settings

3.17.1 Introduction

The following setting groups are included into the **Configuration** group: **Nominal Values**, access **Passwords**, **Communications**, **Date and Time**, **Contrast** adjustment and **Command Buttons**.

ZivercomPlus® communications program only allows access to **Rated Values** settings (only modifiable from the HMI but also viewed from the ***ZivercomPlus®***), **Date and Time** settings and **Communications** settings.

3.17.2 Nominal Values

Nominal operating values can be selected through following parameters:

- **Nominal Current of each Winding.**
- **Voltage**: Nominal phase-to-phase voltage setting is the reference value for all settings expressed in times or % nominal voltage. Applied both to phase and ground voltage. For **IDV-G/H** models, voltage nominal value must be set in Phase-Ground value, that is, at 63.5 Vac.
- **Nominal Frequency**: To select system nominal frequency, regardless whether the frequency adaptation system is later capable of adjusting to changes produced in this magnitude.

After modification of any of the settings above, accessible from HMI display and via communications, relay resets the same as if it were switched off and then switched on; no setting or information is lost.

Note: from *ZivercomPlus®*, the rated currents associated to each breaker can be displayed on the IDV-D. Nevertheless, in order to proceed to change its value, the rated value of the winding currents they belong to must be changed.

3.17.2.a Machine Protection with Different Nominal Currents at each Winding

IDV IEDs only requires the **Nominal Current** setting for each winding. Any difference is compensated internally to be used in all the protection functions using winding measured currents.

3.17.3 Access Passwords

The **Passwords** option allows changing access passwords for options: **Configuration**, **Operations** and **Settings**.

Select the **Configuration** option, to change access password for **Configuration** group options. Also, different passwords can be configured for **Operations** and **Settings** modification options. These settings are only accessible from HMI display.

3.17.4 Communications

See paragraph 3.38 on Communications.

3.17.5 Date and Time

Selecting **Date and Time** in the **Configuration** menu displays this setting to configure relay date and time.

3.17.5.a Local Time Zone Setting

If **Time Zone IRIG-B** is set to **UTC**, a time correction must be introduced to adapt the relay to the local time zone. Setting **Local Time Zone** allows putting UTC time forward or back as required.

3.17.5.b Summer Time / Winter Time Change

Relay allows configuring the dates when summer time / winter time change takes place. In the first case the relay clock is put one hour forward **(+1 Hour**). In the second case the relay clock is put one hour back (**-1 Hour**) for the winter season.

To configure a change of season the following must be specified:

- **Begin Time**: time when change of season takes place. Range 0 to 23 h.
- **Begin Day Type**: type of day when change of season takes place. It can take the following values **First Sunday**, **Second Sunday**, **Third Sunday**, **Fourth Sunday**, **Last Sunday** of the month and **Specific Day**.
- **Begin Day**: in case **Specific Day** is selected, state in which specific day of the month the change of season takes place.
- **Begin Month**: state the month in which the change of season takes place.

These settings are independent for the summer and winter seasons.

Note: if the Begin Day setting value is higher than the number of days of a given month, the last valid day of said month is taken as the day for the change of season.

The change of season function can be activated or deactivated through **Summer Time / Winter Time Change Enable** setting.

3.17.6 Command Buttons

Enables or disables front pushbuttons for performing operations associated to them through the relay programmable logic.

3.17.7 Contrast Adjustment

This setting modifies the display contrast value (high value = more contrast).

3.17.8 Configuration Settings

Nominal Values			
Setting	**Range**	**Step**	**By Default**
Nominal Winding 1	1 A / 5 A	5 A	5 A
Nominal Winding 2	1 A / 5 A	5 A	5 A
Nominal Winding 3	1 A / 5 A	5 A	5 A
Nominal VABC	50 - 230 V	1V	115 V
Nominal Freq.	50 Hz / 60 Hz	10 Hz	50 Hz
Nominal Breaker 1 (IDV-D)	1 A - 5 A	1 A	5 A
Nominal Breaker 2 (IDV-D)	1 A - 5 A	1 A	5 A
Nominal Breaker 3 (IDV-D)	1 A - 5 A	1 A	5 A
Nominal Breaker 4 (IDV-D)	1 A - 5 A	1 A	5 A

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 3.38

Contrast
Adjustable from the keypad

Date and Time			
Setting	**Range**	**Step**	**By Default**
Local Time Zone	GMT+(0, 1, 2, 3, 3:30, 4, 4:30, 5, 5:30, 5:45, 6, 6:30, 7, 8, 9, 9:30, 10, 11, 12) GMT-(1, 2, 3, 3:30, 4, 5, 6, 7, 8, 9, 9:30, 10, 11)		GMT+01:00
Summer Time / Winter Time Change Enable	YES / NO		NO
Summer Begin Time	0 - 23 Hours	1	2
Summer Begin Day Type	0 = Specific day 1 = First Sunday of the month 2 = Second Sunday of the month 3 = Third Sunday of the month 4 = Fourth Sunday of the month 5 = Last Sunday of the month		Last Sunday of the month
Summer Begin Day	1 - 31	1	1
Summer Begin Month	January, February, March, ...	1	March
Winter Begin Time	0 - 23 Hours	1	3
Winter Begin Day Type	0 = Specific day 1 = First Sunday of the month 2 = Second Sunday of the month 3 = Third Sunday of the month 4 = Fourth Sunday of the month 5 = Last Sunday of the month		Last Sunday of the month
Winter Begin Day	1 - 31	1	1
Winter Begin Month	January, February, March, ...	1	October

- **Configuration Settings: HMI Access**

0 - CONFIGURATION	**0 - NOMINAL VALUES**	**0 - NOMINAL WNDG 1**
1 - ACTIVATE GROUP	1 - PASSWORDS	**1 - NOMINAL WNDG 2**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - NOMINAL WNDG 3**
3 - INFORMATION	3 - TIME AND DATE	**3 - NOMINAL VABC**
	4 - CONTRAST	**4 - NOMINAL FREQ.**
	5 - COMMAND BUTTONS	

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - CONFIGURATION**
1 - ACTIVATE GROUP	**1 - PASSWORDS**	**1 - OPERATIONS**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - SETTINGS**
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	
	5 - COMMAND BUTTONS	

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - PORTS**
1 - ACTIVATE GROUP	1 - PASSWORDS	**1 - PROTOCOLS**
2 - CHANGE SETTINGS	**2 - COMMUNICATIONS**	
3 - INFORMATION	3 - TIME AND DATE	
	4 - CONTRAST	
	5 - COMMAND BUTTONS	

0 - CONFIGURATION	0 - NOMINAL VALUES	**0 - TIME AND DATE**
1 - ACTIVATE GROUP	1 - PASSWORDS	**1 - LOCAL TIME ZONE**
2 - CHANGE SETTINGS	2 - COMMUNICATIONS	**2 - SUMMER/WINTER ENAB**
3 - INFORMATION	**3 - TIME AND DATE**	**3 - SUMMER START HOUR**
	4 - CONTRAST	**4 - TYPE OF SUMMER DAY**
	5 - COMMAND BUTTONS	**5 - SUMMER STARTINGDAY**
		6 - SUMMER START MONTH
		7 - WINTER START HOUR
		8 - TYPE OF WINTER DAY
		9 - WINTER STARTINGDAY
		10 - WINTER START MONTH

0 - CONFIGURATION	0 - NOMINAL VALUES
1 - ACTIVATE GROUP	1 - PASSWORDS
2 - CHANGE SETTINGS	2 - COMMUNICATIONS
3 - INFORMATION	3 - TIME AND DATE
	4 - CONTRAST
	5 - COMMAND BUTTONS

0 - CONFIGURATION	0 - NOMINAL VALUES
1 - ACTIVATE GROUP	1 - PASSWORDS
2 - CHANGE SETTINGS	2 - COMMUNICATIONS
3 - INFORMATION	3 - TIME AND DATE
	4 - CONTRAST
	5 - COMMAND BUTTONS

3.18 General Settings

3.18.1 Introduction

The following settings are included within the **General Settings** group: **Unit in Service**, **Transformer Ratios**, **Phase Sequence**, **Capacitive Voltage Transformer**, **Distance Winding**, **Winding 1 Current**, **Winding 2 Current**, **Winding 3 Current**, **Phase Voltage Type**, **Ground Voltage Origin**, **Differential and Slope Current Measure**, **Number of Windings**, **Reference Angle**, **Transducer Inputs** and **Invert Polarity**.

Note: The program *ZivercomPlus®* makes two other settings available to the user; i.e. Name of the Transformer and Name of the Circuit Breaker (usually from primary side).

Note: Distance winding, winding 1 current, winding 2 current and winding 3 current settings are accessible only through HMI.

3.18.2 Unit in Service

Relay enabled (**YES**), means that all relay functions work normally (as programmed in the corresponding settings).

If relay is disabled (**NO**), all functions are restricted to measurement operations only. Measurements are visualized on display and through local and remote communications.

3.18.3 Transformer Ratios

Transformer Ratio defines how analog values are displayed on the protection display. If Transformer Ratio is set to 1, secondary values are displayed. If, on the other hand, the Transformer Ratio corresponding to analog input adapter transformer is selected, primary values are displayed. Settable turn ratios are:

- Phase current of each winding. These currents also affect the calculated neutral currents. For **IDV-L** they also affect the measurements of grounds 3, 4 and 5.
- Current for each ground analog input (IG-1 and IG-2) (**IDV-A/B/D/H/K/L** Models).
- Current for the ground analog input (IG-1) (**IDV-G/J** Model).
- Phase and ground voltage.

In all cases, all overcurrent and overvoltage protection element settings are referred to secondary values. Programmable logic analog settings could refer both to secondary and primary values.

Note: all Event Record and Metering History Log magnitudes are stored in secondary values; except for energy magnitudes that are always recorded in primary values.

***ZivercomPlus®* status screen may display all the measurements in primary or secondary values depending on the button ( ), being pushed or not respectively. Energy measurements are an exception as will always be displayed on primary values.**

3.18.4 Phase Sequence

It is necessary to know the power system's sequence of phases (ABC or ACB) in order to properly calculate the sequence components and power values. In addition, in a differential relay where the windings can have different connection groups, it is essential to take into account this sequence in order to make the relevant compensation.

The **Phase Sequence** setting reports the system's actual rotation to the equipment, and all equipment functions operate correctly by keeping the same analog current and voltage input connections indicated for phases A, B and C in the external connections diagram.

The information provided in section 3.1.4 on Compensation of the Connection Group is indicated for a system with an **ABC** phase sequence; for machines connected in an **ACB** system, it is only necessary to switch the B (b) phases with the C(c) phases. This can be seen in the following example:

1. If a system with an ABC phase sequence is applied to the WYE winding terminals of a Y/Δ30º transformer, the currents in the coils of the DELTA winding are set back 30º with respect to the currents in the WYE winding coils.

   If the measuring CTs are placed in both windings with their polarities facing outward or inward with regard to the transformer, and their secondary polarities are connected to the relay terminals maintaining the same polarity, the angle seen in the relay between the currents of the WYE and DELTA windings is 210º (180º+30º).

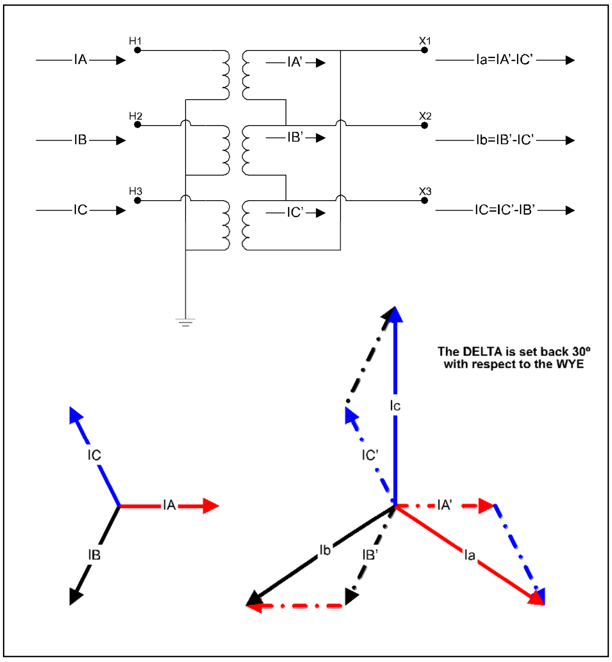


Figure 3.18.1: System with an ABC Phase Sequence (Example).

2. If a system with an ACB phase sequence is applied to the same WYE winding terminals of the Y/Δ30º transformer, the direction of the currents in the coils changes. In this case, the currents in the DELTA winding are set back 330º in relation to the currents in the WYE winding coils.

   Assuming the same connection, regarding the polarities as in the previous case, the angle between currents reaching the relay is 150º. If the WYE currents are used as a reference, the DELTA currents are set back 150º. This phase displacement equals a connection of an Y/Δ330º transformer in an ABC system.

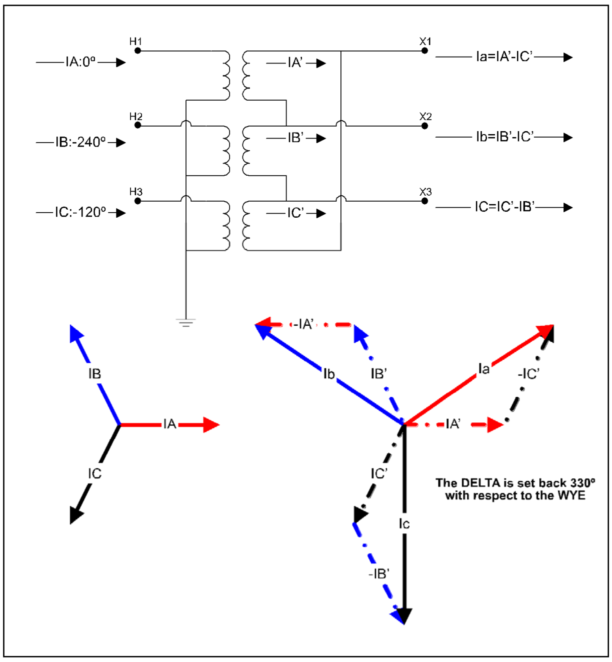


Figure 3.18.2: System with an ACB Phase Sequence (Example).

It should be noted that there is no need for changing the transformer vector group if the phase sequence is ACB. Necessary compensation is carried out internally by the relay.

3.18.5 Capacitive Voltage Transformer (IDV-F Model)

IDV-F relays incorporate an algorithm to filter voltage wave transients originated in capacitive voltage transformers, to reduce the overreach produced by distance units. Said filtering can be enabled or disabled through the general Capacitive VT setting.

It is worth mentioning that enabling this filter can delay distance element operation up to half cycle.

3.18.6 Winding Incorporating the Distance Element (IDV-F Model)

IDV-F distance elements operate based on measured voltages VA, VB and VC and currents obtained for winding 1 (IADEV1, IBDEV1, ICDEV1) or winding 2 (IADEV2, IBDEV2, ICDEV2) as a function of **Distance winding** setting (**Winding 1** or **Winding 2** options). Currents associated to each winding are obtained from the currents measured by channels IAm, IBm, ICm (m=1, 2, 3, 4), based on **Winding 1 Current**, **Winding 2 Current** and **Winding 3 Current** configuration settings (see 3.18.7).

After modifying said setting, only accessible from the HMI display, the relay resets in the same way as switching it off and on again; no setting or information is lost.

3.18.7 Currents Associated to each Winding (IDV-D/F Model)

IDV-D/F relays are designed to protect two or three winding transformers, installed in dual breaker positions (breaker-and-a-half or ring configuration). Their 4 phase current channels (IA1, IB1, IC1, IA2, IB2, IC2, IA3, IB3, IC3, IA4, IB4, IC4) allow measurement of currents from all CTs used into the configurations shown in figures 3.18.5 and 3.18.6. All these currents will be used for the calculation of the differential element restraint currents (see 3.1), which will increase its stability on external faults.

Current channels associated to each machine winding are selected through **Winding 1 Current**, **Winding 2 Current** and **Winding 3 Current** settings, as a function of machine configuration. When any of these settings, accessible only through the HMI, is modified, the relay resets in the same way than switching it off and on again; no setting or information is lost.

Following figures show the different configurations where **IDV-F** relays can be applied:

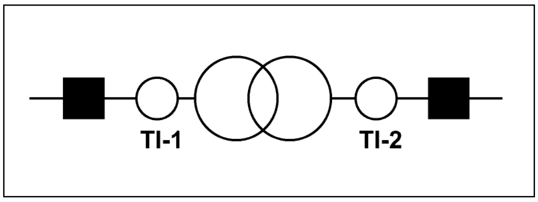


Figure 3.18.3: Two Winding Machine Connected to Two Single Breaker Positions (Winding 1 Current = I-1 Winding 2 Current = I-2; Winding 3 Current 3 = None).

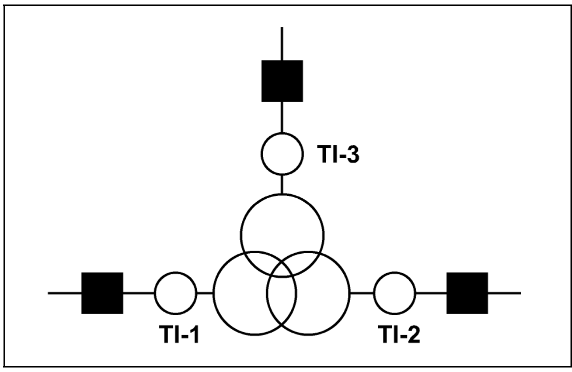


Figure 3.18.4: Three Winding Machine Connected to Three Single Breaker Positions (Winding 1 Current = I-1; Winding 2 Current = I-2; Winding 3 Current = I-3).

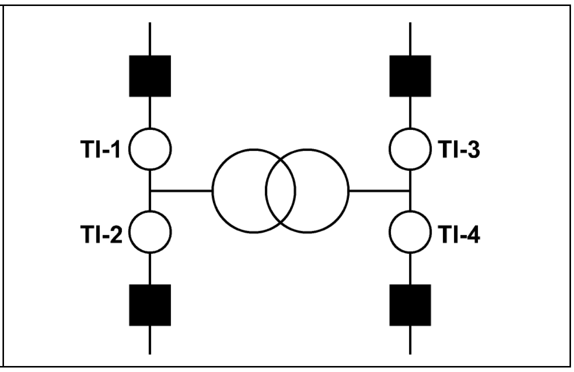


Figure 3.18.5: Two Winding Machine Connected to Two Dual Breaker Positions (Winding 1 Current = I-1 + I-2 Winding 2 Current =I-3+I-4; Winding 3 Current 3 = None).

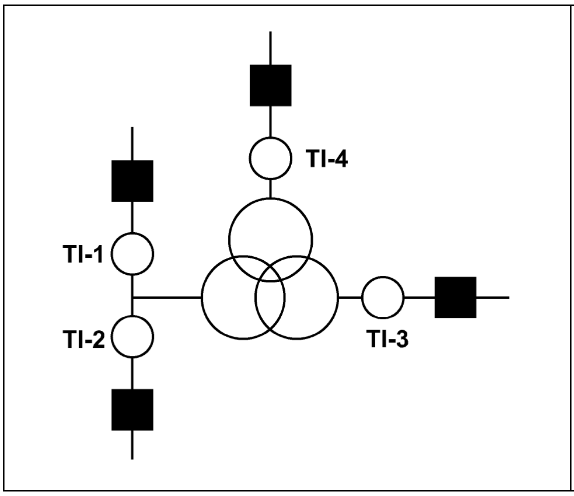


Figure 3.18.6: Three Winding Machine Connected to Two Single Breaker Positions and One Dual Breaker Position (Winding 1 Current = I-1+I-2; Winding 2 Current = I-3; Winding 3 Current = I-4).

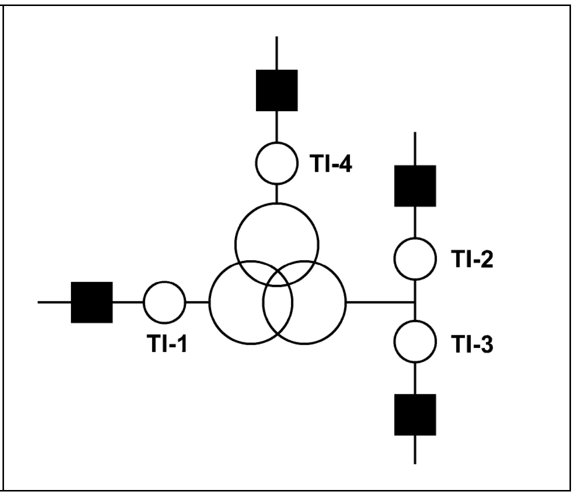


Figure 3.18.7: Three Winding Machine Connected to Two Single Breaker Positions and One Dual Breaker Position (Winding 1 Current = I-1; Winding 2 Current = I-2+I-3; Winding 3 Current = I-4).

Note: Configurations that associate the same current channel to more than one winding will generate an error indication and cannot be sent to the equipment.

Note: Channels not associated to any winding always measure nil current value, even with current circulating through them.

Note: en los modelos IDV-D sólo está disponible la configuración de interruptor y medio para el primer devanado. El resto de devanados sólo permite la asociación de un canal de intensidad por devanado. Por ello, sólo se podrá aplicar en las configuraciones de las figuras 3.18.3, 3.18.4 y 3.18.6.

Note: for IDV-D relays only the breaker and a half configuration is available for the first winding. All other windings only allow the allocation of one current channel per winding. Therefore, it can only be applied in the configurations shown in figures 3.18.3, 3.18.4 and 3.18.6.

3.18.8 Type of Phase Voltage (IDV-A/B/G/H/J/K/L)

The type of voltage measured through the phase voltage analog input can be configured. The user can select whether the voltage line-to-ground or line-to-line, as well as their corresponding phases (V_A, V_B, V_C, V_{AB}, V_{BC} or V_{CA}).

All units using this magnitude and its phase-shift to other magnitudes will take this into account. Also, it is important to calculate all power magnitudes corresponding to the winding defined as "**Reference Winding**" as the voltage considered for the calculation will be the one associated to such winding.

8IDV-F relays incorporate 3 analog voltage channels always considered as voltages VA, VB and VC; so that specifying the type of voltage measured through said channels is not required.

3.18.9 Viewing Differential and Restraint Currents

The user can choose whether to display the differential and restraint currents in times the reference tap or in amps multiplied by the reference tap.

This setting affects the values presented in the HMI display and the values obtained by communications through the ***ZivercomPlus®***.

3.18.10 Angle Reference

Angle reference in **IDV** models is adjustable.

- In **IDV-A/B/G/H/J/K/L** models this reference can be taken as the one obtained from the phase voltage or from the phase A current in winding 1 (IA Wndg1).
- For **IDV-D** models, the angle reference is the measurement carried out by the first analog channel of phase A current (IA-1) pertaining to winding 1.
- For **IDV-F** relays the phase reference can be Phase A voltage (VA) measured by the analog voltage channel or phase A current (IA-1) measured by the first analog current channel.

3.18.11 Transducer Inputs (IDV-A/B/G/H/J/K/L)

In **IDV-A/G/J** models (2 windings) and **IDV-B/H/K/L** (3 windings) with input / output extension (3U and 4U high), up to 2 input current transducers are included. For the same HW, the following converter options can be selected: **0 to 5mA**, **-2.5 to +2.5 mA** and **4 to 20 mA**.

It is through the programmable logic that the converter can be allocated with a magnitude and a constant to represent the true reading (current, voltage, power...) and the transformation ratio. The measured current in mA is turned into the actual measured magnitude and shown on the display (V, A, W...).

Note: if range -2.5 to +2.5mA is selected, transducer measurement reaches +/-3mA. For a setting 0 to 5mA measurement reaches +5.587mA.

3.18.11.a Models with Power Supply Voltage Monitoring

In models incorporating Power Supply Voltage Monitoring function, **Transducer 2** is provided with a specific HW that allows direct current measurements. Two types of transducers exist depending on nominal voltage of the digital inputs:

- For 24Vdc and 48Vdc digital input relays.
- For 125Vdc and 250Vdc digital input relays.

The measured magnitude is available for display and recording in all functions using “user magnitudes” (HMI, ***ZivercomPlus***®, Oscillograms, Events, Logs, Programmable Logic, Protocols,...).

Transducer 1 has the same characteristics as in paragraph 3.18.11.

3.18.12 Inhibition Current

Models **IDV-D** count on an Inhibition Current level to calculate the frequency. This level has been set at 200 mA. Should current in channels IA-x (x=1.2) exceed this level, then the frequency is calculated. If this level of current is not exceeded in any of the measurement channels, the frequency calculated shall be zero.

In principle, the A-level in channels IA-x (x=1,2) is checked to see if it exceeds the level of **Inhibition Current** starting with IA-1. Should any of these be below this value, the current is checked via the IA-2 channel. Should the current exceed this level, this new channel is used as referential to calculate the frequency.

3.18.13 Number of Windings (IDV-L and IDV-K with option E or higher in digit 9)

In **IDV-L** Models**,** the number of available windings can be configured, namely, two windings or three windings, by means of the setting **Number of Windings**. It also includes a function to check the ratio between settings to ensure that, depending on the setting value, all time and instantaneous elements related to the third winding or ground elements 3, 4 and 5 can be enabled.

The analog channels used for the third winding or for the three additional ground elements will be the same, used as required as a function of the selected setting.

For **IDV-K** relays with **E** option or above digit **9** (refer to 1.5, Relay model selection), when two-winding option is selected, the analog channels used for the third winding will not have any effect on the differential element, and third winding time and instantaneous elements may be used.

3.18.13.a Third winding current channels (IDV-L)

Third winding channels may be allocated to different protection functions through the **Third winding current channels** setting:

- **With *Number of windings* set to Two windings**.

  In case it has been configured as **Ground currents**, ground elements 3, 4 and 5 may be enabled, third winding time and instantaneous elements being disabled.

  In case it has been configured as **Phase currents**, the operation will be the same as for the three-winding option, but they will have no effect on the differential calculation. In this case, all phase ground elements (3, 4 and 5) will be disabled.

  In these cases, with the **Number of windings** set to two, the differential element will never operate with third winding measured currents.

- **With *Number of windings* set to Three windings**.

  The **Third winding current channels** setting will not have any effect on third winding channels.

For both cases, there will exist a settings relationship check function to ensure that, as a function of this setting value, both the ground elements 3, 4 and 5 and the third winding elements (time and instantaneous elements) cannot be enabled.

3.18.14 Source of Ground Voltage (IDV-L and IDV with option B or higher in digit 9)

With this setting the source of the working ground voltage, namely, the physical measurement captured by the channel dedicated to this avail (VN) or the one calculated through the three phase channels (VA, VB and VC).

3.18.15 Polarity Reversal (IDV-L and IDV with option B or higher in digit 9)

With this setting, a wrong wiring of the relay analog channels can be corrected, avoiding in this way doing it physically.

If the polarity reversal setting is set to **YES**, the polarity of the corresponding analog channel will be opposite to the polarity depicted on the relay external connection diagram.

3.18.16 General Settings

Unit In Service			
Setting	**Range**	**Step**	**By Default**
Unit In Service	YES / NO		NO

Transformation Ratio			
Setting	**Range**	**Step**	**By Default**
Winding 1 Ratio	1 - 3000	1	1
Winding 2 Ratio	1 - 3000	1	1
Winding 3 Ratio	1 - 3000	1	1
Ground 1 CT Ratio	1 - 3000	1	1
Ground 2 CT Ratio	1 - 3000	1	1
Phase VT Ratio	1 - 4000	1	1
Neutral VT Ratio	1 - 4000	1	1

Transformation Ratio (IDV with option A or higher in digit 9)			
Setting	**Range**	**Step**	**By Default**
Winding 1 Ratio	1 - 10000	1	1
Winding 2 Ratio	1 - 10000	1	1
Winding 3 Ratio	1 - 10000	1	1
Ground 1 CT Ratio	1 - 10000	1	1
Ground 2 CT Ratio	1 - 10000	1	1
Phase VT Ratio	1 - 11000	1	1
Neutral VT Ratio	1 - 11000	1	1

Phase Sequence			
Setting	**Range**	**Step**	**By Default**
Phase Sequence	0: ABC 1: ACB		0: ABC

Capacitive Voltage Transformer			
Setting	**Range**	**Step**	**By Default**
TT Capacitive	YES / NO		NO

Winding Incorporating the Distance Element			
Setting	**Range**	**Step**	**By Default**
Distance Winding	0: Winding 1 1: Winding 2		0: Winding 1

Currents Associated to each Winding			
Setting	**Range**	**Step**	**By Default**
Winding 1 Current	I-1 I-1+I-2		I-1
Winding 2 Current	I-2 I-3 I-2+I-3 (IDV-A/B/F Mod.) I-3+I-4 (IDV-A/B/F Mod.)		I-2
Winding 3 Current	None I-3 I-4		I-3

Voltage Type			
Setting	**Range**	**Step**	**By Default**
Voltage Type	V_A, V_B, V_C, V_{AB}, V_{BC} V_{CA}		V_A

Number of Windings			
Setting	**Range**	**Step**	**By Default**
Number of windings	Two Windings Three Windings		Two Windings

Differential Current Measure			
Setting	**Range**	**Step**	**By Default**
Differential Current Measure	0: Times Tap 1: x Ref Tap		0: Times Tap

Reference Angle			
Setting	**Range**	**Step**	**By Default**
Reference Angle	0: VPh / VA (depending on the model) 1: IA Wndg1 / IA-1 (depending on the model)		1: IA Wndg 1

Polarity Reversal			
Setting	**Range**	**Step**	**By Default**
VA	YES / NO		NO
VB	YES / NO		NO
VC	YES / NO		NO
VN	YES / NO		NO
IA WNDG1	YES / NO		NO
IB WNDG1	YES / NO		NO
IC WNDG1	YES / NO		NO
IA WNDG2	YES / NO		NO
IB WNDG2	YES / NO		NO
IC WNDG2	YES / NO		NO
IA WNDG3	YES / NO		NO
IB WNDG3	YES / NO		NO
IC WNDG3	YES / NO		NO
IG1	YES / NO		NO
IG2	YES / NO		NO

Source of Ground Voltage			
Setting	**Range**	**Step**	**By Default**
Source of Ground Voltage	Trafo Calculated		Trafo

Transducer Inputs			
Setting	**Range**	**Step**	**By Default**
Transducer Type	0: -2.5 ÷ +2.5 mA 1: 0 - 5 mA		0: -2.5 ÷ +2.5 mA

- **General Settings: HMI Access**

IDV-A/B/G/H/J/K Models

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1 RATIO**
2 - CHANGE SETTINGS	2 - PROTECTION	**2 - WINDING 2 RATIO**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 3 RATIO**
	...	**4 - GND 1 CT RATIO**
		5 - GND 2 CT RATIO
		6 - PHASE VT RATIO
		7 - NEUTRAL VT RATIO
		8 - PHASE SEQUENCE
		9 - VOLTAGE TYPE
		10 - DIFF CURR MEASURE
		11 - REFERENCE ANGLE
		12 - CONVERTERS

IDV-L Model

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1 RATIO**
2 - CHANGE SETTINGS	2 - PROTECTION	**2 - WINDING 2 RATIO**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 3 RATIO**
	....	**4 - GND 1 CT RATIO**
		5 - GND 2 CT RATIO
		6 - PHASE VT RATIO
		7 - NEUTRAL VT RATIO
		8 - PHASE SEQUENCE
		9 - NUMBER OF WINDINGS
		10 - DIFF CURR MEASURE
		11 - REFERENCE ANGLE
		12 - VN ORIGIN
		13 - TRANSDUCERS
		14 - INVERT POLARITY

IDV-D Models

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1 RATIO**
2 - CHANGE SETTINGS	2 - PROTECTION	**2 - WINDING 2 RATIO**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WINDING 3 RATIO**
	...	**4 - GND 1 CT RATIO**
		5 - GND 2 CT RATIO
		6 - PHASE SEQUENCE
		7 - DIFF CURR MEASURE
		8 - WINDING INT 1
		9 - WINDING INT 2
		10 - WINDING INT 3

IDV-F Models

0 - CONFIGURATION	**0 - GENERAL**	**0 - UNIT IN SERVICE**
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	**1 - WINDING 1 RATIO**
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	**2 - WINDING 2 RATIO**
3 - INFORMATION	3 - PROTECTION	**3 - WINDING 3 RATIO**
	...	**4 - PHASE VT RATIO**
		5 - PHASE SEQUENCE
		6 - CAPACITIVE VT
		7 - DIFF CURR MEASURE
		8 - REFERENCE ANGLE
		9 - WINDING 1 CURR
		10 - WINDING 2 CURR
		11 - WINDING 3 CURR
		12 - WINDING DIST

3.18.17 Auxiliary Outputs and Events (Protection in Service)

Table 3.18-1: Auxiliary Outputs and Events (Protection in Service)

Name	Description	Function
PROT_INSRV	Protection in service	Indicates that the IED is working with all the functions available.
U_FREC_FaltaIA1	Frequency measurement: IA-1 Fault (IDV-D)	It indicates the current measured by IA-1 is lower than that selected for the setting.
U_FREC_FaltaIA2	Frequency measurement: IA-2 Fault (IDV-D)	It indicates the current measured by IA-2 is lower than that selected for the setting.

3.19 Connection Groups Settings

3.19.1 Introduction

The **Connection Groups** settings include the following settings: **Connection Group** of each winding, **Zero Sequence Filter**, **Winding assigned to ground currents** and **Autotransformer**.

3.19.2 Connection Group of each winding

The phase displacement, introduced by the connection group of the machine to be protected between the primary and secondary/tertiary currents, is compensated through the proper setting. There is a **Connection Group** setting per winding with the following options: **WYE**, **DELTA** or **ZIGZAG**. (More detailed information in section 3.1.4).

3.19.3 Zero Sequence Filter

The equipment includes a **Zero Sequence Filter** (adjustable) to compensate the zero sequence current that can flow through the windings in certain circumstances. It can be selected independently for each winding.

Models **IDV** with option **A** or higher in digit **9** include a setting through which the type of zero sequence current extracted by the zero sequence filter can be selected: by phase channels or by ground channels.

3.19.4 Winding Assigned to Ground Currents (IDV-A/B/D/G/H/J/K/L)

The **IDV-A/B/D/H/K/L** IEDs have two analog inputs (IG-1, IG-2) for measuring the machine's grounding currents. **IDV-G/J** models have one analog input (IG1) for this purpose.

These two analog inputs can be freely assigned to any of the machine's windings; in this way they can serve as polarization magnitudes for the calculated ground units of the windings to which they are associated, as well as for the their restricted earth fault functions.

When not used for the functions described above, either because they are not going to be connected to the secondary of any measurement transformer or because they will only be used for ground overcurrent units, it is advisable not to assign them to any winding (setting = 0).

For analog input no. 2 (IG-2), when it is enabled for tertiary overcurrent units, it is disabled for directional and restricted earth faults functions.

Also, **IDV-L** relays may have three additional ground channels (refer to 3.18, General Settings) that can be used as ground overcurrent elements.

3.19.5 Autotransformer (IDV-A/B/D/G/H/J/K/L)

By setting the **Autotransformer** to **YES**, the protection for applying restricted earth fault units in autotransformers is configured properly. (More detailed information in section 3.8).

3.19.6 Connection Groups Settings

Connection Groups			
Setting	**Range**	**Step**	**By Default**
Winding 1 Connection	0: (WYE) 1: (DELTA) 2: (ZIGZAG)		0
Zero Sequence Filter Winding 1	0: NO 1: YES		0: NO
Winding 2 Connection	0: (WYE) 1: (DELTA) 2: (ZIGZAG)		0
Winding 2 Phase Angle	**0 - 2 - 4 - 6 - 8 - 10** if W 1 / W 2 is: DELTA/DELTA (D/D) DELTA / ZIGZAG (D/Z) ZIGZAG / DELTA (Z/D) WYE / WYE (Y/Y) **1 - 3 - 5 - 7 - 9 - 11** if W 1 / W 2 is: DELTA / WYE (D/Y) ZIGZAG / WYE (Z/Y) WYE / DELTA (Y/D) WYE / ZIGZAG (Y/Z)		0
Zero Sequence Filter Winding 2	0: NO 1: YES		0: NO
Winding 3 Connection	0: (WYE) 1: (DELTA) 2: (ZIGZAG)		0: WYE
Winding 3 Phase Angle	**0 - 2 - 4 - 6 - 8 - 10** if W 1 / W 3 is: DELTA/DELTA (D/D) DELTA / ZIGZAG (D/Z) ZIGZAG / DELTA (Z/D) WYE / WYE (Y/Y) **1 - 3 - 5 - 7 - 9 - 11** if W 1 / W 3 is: DELTA / WYE (D/Y) ZIGZAG / WYE (Z/Y) WYE / DELTA (Y/D) WYE / ZIGZAG (Y/Z)		0
Zero Sequence Filter Winding 3	0: NO 1: YES		0: NO
Zero Sequence Filter Type (IDV with option A or higher in digit 9)	0: Phase Channels 1: Ground Channels		0
Ground C1 Winding	0 - 3	1	1
Ground C2 Winding	0 - 3	1	2
Autotransformer	NO / YES		NO

- **Connection Groups Settings: HMI Access · IDV-A/B/D/H/K/L Models**

0 - CONFIGURATION	0 - GENERAL	**0 - WNDG 1 CONNECTION**
1 - ACTIVATE GROUP	**1 - CONNECTION GROUPS**	**1 - ZS FILTER WNDG 1**
2 - CHANGE SETTINGS	2 - PROTECTION	**2 - WNDG 2 CONNECTION**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WNDG 2 PHASE ANG**
	...	**4 - ZS FILTER WNDG 2**
		5 - WNDG 3 CONNECTIO
		6 - WNDG 3 PHASE ANG
		7 - ZS FILTER TYPE*
		8 - ZS FILTER WNDG 3
		9 - GND C1 WINDING
		10 - GND C2 WINDING
		11 - AUTOTRANSFORMER

(*) IDV with option A or higher in digit 9

- **Connection Groups Settings: HMI Access · IDV-G/J Models**

0 - CONFIGURATION	0 - GENERAL	**0 - WNDG 1 CONNECTION**
1 - ACTIVATE GROUP	**1 - CONNECTION GROUPS**	**1 - ZS FILTER WNDG 1**
2 - CHANGE SETTINGS	2 - PROTECTION	**2 - WNDG 2 CONNECTION**
3 - INFORMATION	3 - TRIP PERMISIONS	**3 - WNDG 2 PHASE ANG**
	...	**4 - ZS FILTER WNDG 2**
		5 - ZS FILTER TYPE*
		6 - GND C1 WINDING
		7 - AUTOTRANSFORMER

(*) IDV with option A or higher in digit 9

- **Connection Groups Settings: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	**0 - WNDG 1 CONNECTION**
1 - ACTIVATE GROUP	**1 - CONNECTION GROUPS**	**1 - ZS FILTER WNDG 1**
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	**2 - WNDG 2 CONNECTION**
3 - INFORMATION	3 - PROTECTION	**3 - WNDG 2 PHASE ANG**
	….	**4 - ZS FILTER WNDG 2**
		5 - WNDG 3 CONNECTION
		6 - WNDG 3 PHASE ANG
		7 - ZS FILTER WNDG 3

3.20 Current Measurement Supervision

3.20.1 Introduction

IDV-L and **IDV-*******B****** models 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 relay itself.

3.20.2 Operation Principles

This supervision function is exclusively based on the measurement of phase currents of each winding. Measurement of the **Three** Phase currents per winding 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** Winding n, where n = 1, 2 or 3) below 2% of its rated value is detected, other phase currents are checked (phases **Y** and **Z** Winding n, where n = 1, 2 or 3) 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** of the Winding n, the phase **X** Winding n current circuit failure alarm is activated.

Figure 3.20.1 shows the supervision algorithm used for current measurement in phase A of Winding 1.

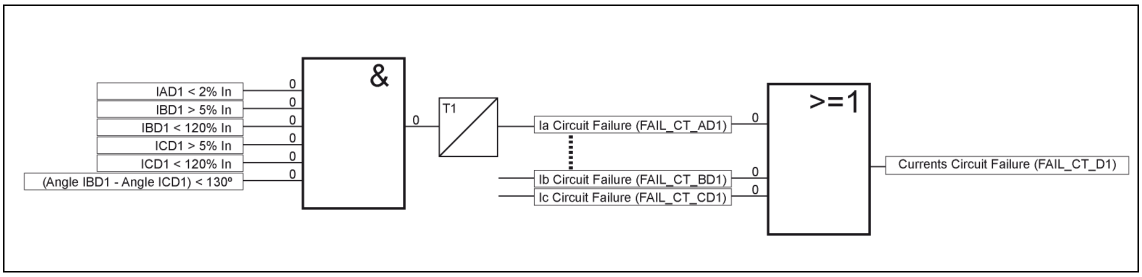


Figure 3.20.1: Supervision Algorithm for Current Measurement in Phase A Winding 1.

Failure detection in any of the measuring circuits only generates the activation of the following signals: **FAIL_CT_AD1**, **FAIL_CT_BD1**, **FAIL_CT_CD1** and **FAIL_CT_D1**. Blocking the operation of protection elements that are affected by measurement unbalance of phase currents must be programmed in ***ZIVerComPlus***® logic.

3.20.3 Current Measurement Supervision Settings

Current Transformers Supervision (per each Winding)			
Setting	**Range**	**Step**	**By Default**
CT Supervision Enable	YES / NO		NO
CT Supervision Time	0.15 - 300 s		0.5 s

- **Restricted Earth Faults Element: HMI Access**

IDV-L / IDV-*****B***** Models**

0 - CONFIGURATION	0 - GENERAL	0 - DIFFERENTIAL
1 - ACTIVATE GROUP	1 – CONNECTION GROUPS	...
2 - CHANGE SETTINGS	**2 - PROTECTION**	**8 - CT SUPERVISION**
3 - INFORMATION	3 - TRIP PERMISIONS	...
	4 - LOCKOUT PERM	
	...	

0 - DIFFERENTIAL	
...	**0 - WINDING 1**
8 - CT SUPERVISION	**1 - WINDING 2**
...	**2 - WINDING 3**

0 - WINDING 1	**0 - CT SUPERV ENABLE**
1 - WINDING 2	**1 - CT SUPERV TIME**
2 - WINDING 3	

3.20.4 Digital Inputs of Current Measurement Supervision Module

Table 3.20-1: Digital Inputs of the Current Measurement Supervision Module		
Name	**Description**	**Function**
IN_ENBL_SUPCT_D1	Winding 1 CT Supervision enable input	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”.
IN_ENBL_SUPCT_D2	Winding 2 CT Supervision enable input	
IN_ENBL_SUPCT_D3	Winding 3 CT Supervision enable input	
IN_BLK_SUPCT_D1	Winding 1 CT Supervision block input	Activation of this input generates the blocking of the supervision.
IN_BLK_SUPCT_D2	Winding 2 CT Supervision block input	
IN_BLK_SUPCT_D3	Winding 3 CT Supervision block input	

3.20.5 Auxiliary Outputs and Events of the Current Measurement Supervision Module

Table 3.20-2: Auxiliary Outputs and Events of the Current Measurement Supervision Module

Name	Description	Function
FAIL_CT_AD1	Activation of CT Supervision Element for Phase A Winding 1	Its activation indicates the existence of a failure in the measuring system of one of the phases
FAIL_CT_BD1	Activation of CT Supervision Element for Phase B Winding 1	
FAIL_CT_CD1	Activation of CT Supervision Element for Phase C Winding 1	
FAIL_CT_AD2	Activation of CT Supervision Element for Phase A Winding 2	
FAIL_CT_BD2	Activation of CT Supervision Element for Phase B Winding 2	
FAIL_CT_CD2	Activation of CT Supervision Element for Phase C Winding 2	
FAIL_CT_AD3	Activation of CT Supervision Element for Phase A Winding 2	
FAIL_CT_BD3	Activation of CT Supervision Element for Phase B Winding 2	
FAIL_CT_CD3	Activation of CT Supervision Element for Phase C Winding 2	
FAIL_CT_D1	Activation of Winding 1 CT Supervision Element	
FAIL_CT_D2	Activation of Winding 2 CT Supervision Element	
FAIL_CT_D3	Activation of Winding 3 CT Supervision Element	
ENBL_SUPCT_D1	Activation of Winding 1 CT Supervision enabled	Block output due to condition of fuse failure detected by the element in question.
ENBL_SUPCT_D2	Activation of Winding 2 CT Supervision enabled	
ENBL_SUPCT_D3	Activation of Winding 3 CT Supervision enabled	
EB_SUPCT_D1	Activation of Winding 1 CT Supervision block Input	Block output due to condition of fuse failure (either detected by the element itself, or else by digital input).
EB_SUPCT_D2	Activation of Winding 2 CT Supervision block Input	
EB_SUPCT_D3	Activation of Winding 3 CT Supervision block Input	

3.21 Open Breaker Detector

3.21.1 Operating principle

IDV-D/F relays incorporate a specific element to detect the opening of any breaker associated to the machine, generating the corresponding signals (**Open Breaker m**; m=1, 2, 3, 4). Detection of open breaker m is carried out based both on the breaker position status (**Open Breaker m Input**) and the output of three undercurrent detectors, one per phase, that operate on the current measured by channels I_{Am}, I_{Bm} and I_{Cm}. Pickup levels for said detectors are given by the setting: **Current level of open breaker**.

From each open breaker indicator output, the open breaker detector generates, at the same time, **open winding n breaker outputs** (n=1, 2, 3). Said outputs are obtained from the **winding n current** configuration settings (n=1, 2, 3), (see paragraph 3.17.6), which indicate the breakers associated to each winding. If winding n has two associated breakers x and y, the open winding n breaker output will only be activated when the two Breaker x and Breaker y outputs are activated.

The outputs of this element are used by another element, which carry out modifications in their operating logic to adapt to the new situation of opened breaker.

Model **IDV-D** enables the possibility of generating the **m Breaker Open** input signals via the ***Ziverlog***® logic, stemming from the **m Breaker Open Pole n** input (n= A, B, C). Signals from **m Breaker Open Pole n** input are used for breaker supervision logic.

3.21.2 Open Breaker Detector Settings

Open Breaker Detector			
Setting	**Range**	**Step**	**By Default**
Open Breaker Current	0.04 - 4 A	0.01 A	0.1 A

- **Open Breaker Detector: HMI Access**

0 - CONFIGURATION	0 - GENERAL	0 - DISTANCE
1 - ACTIVATE GROUP	1 - CONNECTION GROUPS	1 - PHASE SELECTOR
2 - CHANGE SETTINGS	2 - SYSTEM IMPEDANCES	2 - DIST SUPERVISION
3 - INFORMATION	**3 - PROTECTION**	3 - FUSE FAILURE
	...	4 - LOAD ENCROACHMENT
		5 - POWER SWING DETECTOR
		6 - OPEN BREAKER DET
		7 - DIFFERENTIAL
		8 - EXT FAULT DETECTOR
		9 - WINDING 1
		10 - WINDING 2
		11 - WINDING 3
		12 - COLD LOAD

0 - DISTANCE	
...	
6 - OPEN BREAKER DET	**0 - OPEN BREAKER CURR**
...	

3.21.3 Digital Inputs of Open Breaker Detector

Table 3.21-1: Digital Inputs of Open Breaker Detector

Name	Description	Function
IN_BKR1	Open breaker 1 Input	Activation of this input indicates that the corresponding breaker is open (closed 52b contact or open 52a contact).
IN_BKR2	Open breaker 2 Input	
IN_BKR3	Open breaker 3 Input	
IN_BKR4	Open breaker 4 Input	
IN_52bA1	Breaker 1 Pole A Open Position Input	
IN_52bB1	Breaker 1 Pole B Open Position Input	
IN_52bC1	Breaker 1 Pole C Open Position Input	
IN_52Ba2	Breaker 2 Pole A Open Position Input	
IN_52bB2	Breaker 2 Pole B Open Position Input	
IN_52bC2	Breaker 2 Pole C Open Position Input	
IN_52BA3	Breaker 3 Pole A Open Position Input	
IN_52bB3	Breaker 3 Pole B Open Position Input	
IN_52bC3	Breaker 3 Pole C Open Position Input	
IN_52BA4	Breaker 4 Pole A Open Position Input	
IN_52bB4	Breaker 4 Pole B Open Position Input	
IN_52bC4	Breaker 4 Pole C Open Position Input	

3.21.4 Auxiliary Outputs and Events of Open Breaker Detector

Table 3.21-2: Auxiliary Outputs and Events of Open Breaker Detector

Name	Description	Function
BKR1_OP	Open breaker 1	Corresponding open breaker indication.
BKR2_OP	Open breaker 2	
BKR3_OP	Open breaker 3	
BKR4_OP	Open breaker 4	
IN_BKR1	Open breaker 1 Input	The same as for the Digital Inputs.
IN_BKR2	Open breaker 2 Input	
IN_BKR3	Open breaker 3 Input	
IN_BKR4	Open breaker 4 Input	
IN_52bA1	Breaker 1 Pole A Open Position Input	
IN_52bB1	Breaker 1 Pole B Open Position Input	
IN_52bC1	Breaker 1 Pole C Open Position Input	
IN_52Ba2	Breaker 2 Pole A Open Position Input	
IN_52bB2	Breaker 2 Pole B Open Position Input	
IN_52bC2	Breaker 2 Pole C Open Position Input	
IN_52BA3	Breaker 3 Pole A Open Position Input	
IN_52bB3	Breaker 3 Pole B Open Position Input	
IN_52bC3	Breaker 3 Pole C Open Position Input	
IN_52BA4	Breaker 4 Pole A Open Position Input	
IN_52bB4	Breaker 4 Pole B Open Position Input	
IN_52bC4	Breaker 4 Pole C Open Position Input	
BKR_W1_OP	Winding 1 breaker/s open	Breaker associated to a winding open indication.
BKR_W2_OP	Winding 2 breaker/s open	
BKR_W3_OP	Winding 3 breaker/s open	

3.22 Logic

3.22.1 Introduction

The Logic group provides the following functions: Trip Output Seal-In, Breakers Minimum Open Command Reset Time, Open / Close Failure Time and Pickup Reports.

3.22.2 Trip Seal-In

To enable the seal-in function the setting **Trip Seal-In** must be set to **YES**. Under these circumstances, once an opening or trip command and the corresponding breaker operate command has been generated; the command is active until open breaker is detected through the auxiliary contact.

If setting **Trip Seal-In** is set to **NO**, the trip command resets when protection measuring elements or logic signals that generated trip activation reset.

This setting is of application when the breaker associated to the protection fails or is very slow (very slow auxiliary contacts 52/a for breaking the current of the trip circuit), and an upstream breaker clears the fault, the trip contact would be compelled to open the trip circuit causing its destruction.

The failed or slow breaker, once the function that caused the trip is reset, makes the relay contact to open before the breaker auxiliary contact 52/a, even after the overrun time of the first. An active open or trip command prevents the relay contact from breaking the current of the trip circuit (mainly inductive and high), and related damage to same circuit as normally these currents exceed circuit rated current breaking capability.

On the **IDV** units capable of operating more than one breaker, the seal-in setting is common for every trip command over any of the breakers. In cases where breaker status change is not received for one of the breakers, the seal-in is only applied to that particular breaker.

3.22.3 Breaker Trip and Close Commands. Breaker Open and Close Failure Time

For manual operations as well as those generated by the protection elements, the guaranteed time of an open command is at least 100 ms. For this purpose the setting **Minimum Open Command Activation Time** is used the range of which is from 100ms to 5s.

If it is generated by the activation of some protection element, when that activation lasts less than the setting value, the open command is active during the setting value; in case units are active during a longer period of time, the open command will be active until unit deactivate.

If open command is manual, duration is always the setting value.

The open command will be active until an open breaker is confirmed only if setting **Trip Seal-In** is set to YES.

Regarding Close Commands (to be configured in the Logic settings of **IDV**) a setting **Minimum Close Command Activation Time** is provided that allows setting the minimum activation time for a close command. Range is from 0s to 5s. The value 0 indicates that close commands will be active until closed breaker is detected or a Close Command Failure is given.

Both for manual and protection element-generated operations, if a breaker state change signal is not received, after an operate command is sent, within the operate failure time (settable separately for open and close operations), **Open Command Failure** or **Close Command Failure** signals are activated. **Close Command Failure** indication is always active for 80ms, no matter the status of the CB, however the **Open Command Failure** indication will remain active until the CB is effectively open.

Open and close commands are active during the reset time setting even if Open or Close Command Failure is produced.

3.22.4 Pickup Reports

Fault reports are set up following the scheme below: they initiate upon a pickup and terminate when units are reset. Fault report files are written only if a trip occurs during a fault condition.

The duration of the fault report can be picked up by the Oscillograph, by means of the **Short circuit time (T_Cortocir)** user magnitude, or else through the HMI as a magnitude.

Setting **Pickup Reports** allows selecting the option to write the report file when no trip has occurred. When setting is set to **YES**, the corresponding report is written to the Fault Report file with no need for the trip to occur.

3.22.5 Logic Settings

Logic Settings			
Setting	**Range**	**Step**	**By Default**
Trip Seal-In	YES / NO		NO
Minimum Open Command Reset Time	0.1 - 5 s	0.1 s	0.2 s
Fail to Open Time	0.02 - 2 s	0.01 s	0.02
Minimum Close Command Reset Time	0.1 - 5 s	0.1 s	0.2 s
Fail to Close Time	0.02 - 2 s	0.01 s	0.02 s
Pickup Reports	YES / NO		NO

- **Logic: HMI Access · IDV-A/B/D/G/H/J/K/L Models**

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP SEAL-IN**
1 - ACTIVATE GROUP	...	**1 - MIN OPENING RES T**
2 - CHANGE SETTINGS	**6 - LOGIC**	**2 - FAIL TO OPEN TIME**
3 - INFORMATION	...	**3 - MIN CLOSING RES T**
		4 - FAIL TO CLOSE TIME
		5 - PICK UP REPORT

- **Logic: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP SEAL-IN**
1 - ACTIVATE GROUP	...	**1 - MIN OPENING RES T**
2 - CHANGE SETTINGS	**7 - LOGIC**	**2 - FAIL TO OPEN TIME**
3 - INFORMATION	...	**3 - MIN CLOSING RES T**
		4 - FAIL TO CLOSE TIME
		5 - PICK UP REPORT

3.22.6 Auxiliary Outputs and Events of the Logic (Command Failure Module)

Table 3.22-1: Auxiliary Outputs and Events of the Command Failure Module

Name	Description	Function
FAIL_CLOSE_W1	Close command failure winding 1 (IDV-A/B/G/H/J/K/L Models)	Activate when set times expire after sending open or close commands, but do not operate. They are independents for each breaker.
FAIL_CLOSE_W2	Close command failure winding 2 (IDV-A/B/G/H/J/K/L Models)	
FAIL_CLOSE_W3	Close command failure winding 3 (IDV-A/B/H/J/K/L Models)	
FAIL_OPEN_W1	Open command failure winding 1 (IDV-A/B/G/H/J/K/L Models)	
FAIL_OPEN_W2	Open command failure winding 2 (IDV-A/B/G/H/J/K/L Models)	
FAIL_OPEN_W3	Open command failure winding 3 (IDV-A/B/H/J/K/L Models)	
FAIL_CLOSE1	Close command failure 1 (IDV-D/F Models)	Activate when set times expire after sending open or close commands, but do not operate. They are independents for each breaker.
FAIL_CLOSE2	Close command failure 2 (IDV-D/F Models)	
FAIL_CLOSE3	Close command failure 3 (IDV-D/F Models)	
FAIL_CLOSE4	Close command failure 4 (IDV-D/F Models)	
FAIL_OPEN1	Open command failure 1 (IDV-D/F Models)	
FAIL_OPEN2	Open command failure 2 (IDV-D/F Models)	
FAIL_OPEN3	Open command failure 3 (IDV-D/F Models)	
FAIL_OPEN4	Open command failure 4 (IDV-D/F Models)	

3.23 Lockout Function

3.23.1 Operation Principles

The **IDV** IED features a **Lockout** function, whose goal is to activate a signal whenever one of the units protecting the machine trips. Through the corresponding settings the user can select, which units can activate this signal. This signal remains active until a reset command is received (available to be programmed on the relay) through the HMI, communications, or a digital input.

The **Lockout** function resides in non-volatile memory, so a power supply loss will not cause any loss of data.

3.23.2 Lockout Function Settings

Lockout Settings
Elements tripping Lockout function (86): (YES / NO)
Differential with Restraint (87T) Differential without Restraint (87I) Phase Instantaneous Overcurrent; Winding 1 (50F_1D1, 50F_1D2 and 50F_1D3) Phase Instantaneous Overcurrent; Winding 2 (50F_2D1, 50F_2D2 and 50F_2D3) Phase Instantaneous Overcurrent; Winding 3 (50F_3D1, 50F_3D2 and 50F_3D3) Phase time Overcurrent; Winding 1 (51F_1D1 and 51F_1D2) Phase time Overcurrent; Winding 2 (51F_2D1 and 51F_2D2) Phase time Overcurrent; Winding 3 (51F_3D1 and 51F_3D2) Calculated Ground Instantaneous Overcurrent; Winding 1 (50N_1D1 and 50N_1D2) Calculated Ground Instantaneous Overcurrent; Winding 2 (50N_2D1 and 50N_2D2) Calculated Ground Instantaneous Overcurrent; Winding 3 (50N_3D1 and 50N_3D2) Calculated Ground Time Overcurrent; Winding 1 (51N_1D1 and 51N_1D2) Calculated Ground Time Overcurrent; Winding 2 (51N_2D1 and 51N_2D2) Calculated Ground Time Overcurrent; Winding 3 (51N_3D1 and 51N_3D2) Ground Instantaneous Overcurrent; Channel 1 (50G_11 and 50G_12) Ground Instantaneous Overcurrent; Channel 2 (50G_21 and 50G_22) Ground Instantaneous Overcurrent; Channel 3 (50G_31 and 50G_32) Ground Instantaneous Overcurrent; Channel 4 (50G_41 and 50G_42) Ground Instantaneous Overcurrent; Channel 5 (50G_51 and 50G_52) Ground Time Overcurrent; Channel 1 (51G_11 and 51G_12) Ground Time Overcurrent; Channel 2 (51G_21 and 51G_22) Ground Time Overcurrent; Channel 3 (51G_31 and 51G_32) Ground Time Overcurrent; Channel 4 (51G_41 and 51G_43) Ground Time Overcurrent; Channel 5 (51G_51 and 51G_52) Negative Sequence Instantaneous Overcurrent; Winding 1 (50Q_1D1 and 50Q_1D2) Negative Sequence Instantaneous Overcurrent; Winding 2 (50Q_2D1 and 50Q_2D2) Negative Sequence Instantaneous Overcurrent; Winding 3 (50Q_3D1 and 50Q_3D2) Negative Sequence Time Overcurrent; Winding 1 (51Q_1D1 and 51Q_1D2) Negative Sequence Time Overcurrent; Winding 2 (51Q_2D1 and 51Q_2D2) Negative Sequence Time Overcurrent; Winding 3 (51Q_3D1 and 51Q_3D2) Tertiary Instantaneous Overcurrent (without Restraint) (50SFA) Tertiary Instantaneous Overcurrent (with Restraint) (50FA) Phase Overcurrent (59F1 and 59F2) Phase Undervoltage (27F1 and 27F2) Ground Overvoltage (64_1 and 64_2)

Lockout Settings
Elements tripping Lockout function (86): (YES / NO)
Overfrequency (81M1, 81M2, 81M3 and 81M4) Underfrequency (81m1, 81m2, 81m3 and 81m4) Frequency Rate of Change (81D1, 81D2, 81D3 and 81D4) Thermal Image; Winding 1 (49_1D) Thermal Image; Winding 2 (49_2D) Thermal Image; Winding 3 (49_3D) Thermal Image; Ground Channel 1 (49_G1) Thermal Image; Ground Channel 2 (49_G2) Restricted Earth Faults; Channel 1 (87N_11 and 87N_12) Restricted Earth Faults; Channel 2 (87N_21 and 87N_22) Overexcitation (24) Hot Sopt Thermal Image (26) Instantaneous Overload Unit (50OL) Time Overload Unit (51OL) Programmable Trip (configurable in the programmable logic) Transformer Protections Trips (DSPP01, DSPP02, DSPP03, DSPP04, DSPP05, DSPP06, DSPP07, DSPP08)

- **Lockout: HMI Access · IDV-A/B/D/G/H/J/K/L**

0 - CONFIGURATION	0 - GENERAL	**0 - LOCKOUT PERM**
1 - ACTIVATE GROUP	...	
2 - CHANGE SETTINGS	**4 - LOCKOUT PERM**	
3 - INFORMATION	...	

- **Lockout: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	**0 - LOCKOUT PERM**
1 - ACTIVATE GROUP	...	
2 - CHANGE SETTINGS	**5 - LOCKOUT PERM**	
3 - INFORMATION	...	

3.23.3 Digital Inputs of the Lockout Module

Table 3.23-1: Digital Inputs of the Lockout Module

Name	Description	Function
RST_LO	Lockout reset input	Activation of this input resets the lockout function. They can be assigned to digital inputs by levels or to commands from the communications protocol or from the HMI.

3.23.4 Auxiliary Outputs and Events of the Lockout Module

Table 3.23-2: Auxiliary Outputs and Events of the Lockout Module

Name	Description	Function
LOCKOUT	Lockout	Activated after a trip configured to prevent a subsequent direct closure, and not deactivated until a reset command is received.
RST_LO	Lockout reset input	The same as for the Digital Inputs.

3.24 Breakers Trip Logic

3.24.1 Operation Principles

For those protection units that do not specifically act in case of a fault or danger of thermal overload in the machine, users can select whether the activation causes only the breaker of the winding to which it is assigned to trip or whether it causes all machine-associated breakers to trip. Then, when setting **Trip Outputs** it is needed to assign for each unit the kind of trip to be performed, i.e.: trip of all CB or trip of winding 1 BC, or winding 2 CB or winding 3 CB (winding 3 only available in case of **IDV-B/H/K**). For **IDV-D/F** relays, the options come down to **All** breakers or **Breakers Specific to each Winding**. Distance units will trip breakers associated to the winding configured to incorporate said elements.

Differential, Restricted Earth Fault, Thermal Image and Overexcitation units, as well as the actions of the machine's own protections, are excluded from this logic. These units will cause the trip of all winding CB in the transformer as they indicate a problem within the machine. The use of this logic is enabled for models **IDV-D** for the Thermal Image elements of grounding channels.

3.24.2 Breakers Trip Logic Settings

Trip Outputs
Elements to trip one or all breakers (ALL BREAKERS/WINDING1/ WINDING2/ WINDING3):
Stepped Distance (21) Phase Instantaneous Overcurrent; Winding 1 (50F_1D1, 50F_1D2 and 50F_1D3) Phase Instantaneous Overcurrent; Winding 2 (50F_2D1, 50F_2D2 and 50F_2D3) Phase Instantaneous Overcurrent; Winding 3 (50F_3D1, 50F_3D2 and 50F_3D3) Phase Time Overcurrent; Winding 1 (51F_1D1 and 51F_1D2) Phase Time Overcurrent; Winding 2 (51F_2D1 and 51F_2D2) Phase Time Overcurrent; Winding 3 (51F_3D1 and 51F_3D2) Calculated Ground Instantaneous Overcurrent; Winding 1 (50N_1D1 and 50N_1D2) Calculated Ground Instantaneous Overcurrent; Winding 2 (50N_2D1 and 50N_2D2) Calculated Ground Instantaneous Overcurrent; Winding 3 (50N_3D1 and 50N_3D2) Calculated Ground Time Overcurrent; Winding 1 (51N_1D1 and 51N_1D2) Calculated Ground Time Overcurrent; Winding 2 (51N_2D1 and 51N_2D2) Calculated Ground Time Overcurrent; Winding 3 (51N_3D1 and 51N_3D2) Ground Instantaneous Overcurrent; Channel 1 (50G_11 and 50G_12) Ground Instantaneous Overcurrent; Channel 2 (50G_21 and 50G_22) Ground Instantaneous Overcurrent; Channel 3 (50G_31 and 50G_32) Ground Instantaneous Overcurrent; Channel 4 (50G_41 and 50G_42) Ground Instantaneous Overcurrent; Channel 5 (50G_51 and 50G_52) Ground Time Overcurrent; Channel 1 (51G_11 and 51G_12) Ground Time Overcurrent; Channel 2 (51G_21 and 51G_22) Ground Time Overcurrent; Channel 3 (51G_31 and 51G_32) Ground Time Overcurrent; Channel 4 (51G_41 and 51G_43) Ground Time Overcurrent; Channel 5 (51G_51 and 51G_52) Negative Sequence Instantaneous Overcurrent; Winding 1 (50Q_1D1 and 50Q_1D2) Negative Sequence Instantaneous Overcurrent; Winding 2 (50Q_2D1 and 50Q_2D2) Negative Sequence Instantaneous Overcurrent; Winding 3 (50Q_3D1 and 50Q_3D2) Negative Sequence Time Overcurrent; Winding 1 (51Q_1D1 and 51Q_1D2) Negative Sequence Time Overcurrent; Winding 2 (51Q_2D1 and 51Q_2D2) Negative Sequence Time Overcurrent; Winding 3 (51Q_3D1 and 51Q_3D2) Tertiary Instantaneous Overcurrent (without Restraint) (50SFA) Tertiary Instantaneous Overcurrent (with Restraint) (50FA)

Trip Outputs
Elements to trip one or all breakers (ALL BREAKERS/WINDING1/ WINDING2/ WINDING3):
Phase Overvoltage (59F1 and 59F2) Phase Undervoltage (27F1 and 27F2) Ground Overvoltage (64_1 and 64_2) Overfrequency (81M1, 81M2, 81M3 and 81M4) Underfrequency (81m1, 81m2, 81m3 and 81m4) Frequency Rate of Change (81D1, 81D2, 81D3 and 81D4) Thermal Image; Ground Channel 1 (49_G1) (IDV-D) Thermal Image; Ground Channel 2 (49_G2) (IDV-D) Programmable Trip (configurable in the programmable logic)

- **Trip Outputs: HMI Access · IDV-A/B/D/G/H/J/K/L Models**

0 - CONFIGURATION	0 - GENERAL
1 - ACTIVATE GROUP	...
2 - CHANGE SETTINGS	**5 - TRIP OUTPUTS**
3 - INFORMATION	...

- **Trip Outputs: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL
1 - ACTIVATE GROUP	...
2 - CHANGE SETTINGS	**6 - TRIP OUTPUTS**
3 - INFORMATION	...

3.25 Trip Enable

3.25.1 Operation Principles

A number of settings control which trips are allowed or selectively blocked. When these settings are set to **YES**, the relevant unit is allowed to trip.

The action of the trip masks is subordinated to the enabling of the relevant unit within its own protection settings because, if the unit is disabled, it will not pick up. The trip mask corresponding to the **NO** setting prevents the activation of the trip output signal and/or of the output configured as a mask, but the element performs the entire process from its pickup up to its decision to generate a trip. The output signal configured to enable the output of the unit is also activated.

This can be interesting when, even though one or more of the units does not require the trip, the user is interested in a chronological record of their activity or in using them as alarm units.

3.25.2 Trip Enable Settings

Trip Enable
Trip elements controlled. YES/NO for:
Differential with Restraint (87T) Differential without Restraint (87I) Stepped Distance (21) Phase Instantaneous Overcurrent; Winding 1 (50F_1D1, 50F_1D2 and 50F_1D3) Phase Instantaneous Overcurrent; Winding 2 (50F_2D1, 50F_2D2 and 50F_2D3) Phase Instantaneous Overcurrent; Winding 3 (50F_3D1, 50F_3D2 and 50F_3D3) Phase Time Overcurrent; Winding 1 (51F_1D1 and 51F_1D2) Phase Time Overcurrent; Winding 2 (51F_2D1 and 51F_2D2) Phase Time Overcurrent; Winding 3 (51F_3D1 and 51F_3D2) Calculated Ground Instantaneous Overcurrent; Winding 1 (50N_1D1 and 50N_1D2) Calculated Ground Instantaneous Overcurrent; Winding 2 (50N_2D1 and 50N_2D2) Calculated Ground Instantaneous Overcurrent; Winding 3 (50N_3D1 and 50N_3D2) Calculated Ground Time Overcurrent; Winding 1 (51N_1D1 and 51N_1D2) Calculated Ground Time Overcurrent; Winding 2 (51N_2D1 and 51N_2D2) Calculated Ground Time Overcurrent; Winding 3 (51N_3D1 and 51N_3D2) Ground Instantaneous Overcurrent; Channel 1 (50G_11 and 50G_12) Ground Instantaneous Overcurrent; Channel 2 (50G_21 and 50G_22) Ground Instantaneous Overcurrent; Channel 3 (50G_31 and 50G_32) Ground Instantaneous Overcurrent; Channel 4 (50G_41 and 50G_42) Ground Instantaneous Overcurrent; Channel 5 (50G_51 and 50G_52) Ground Time Overcurrent; Channel 1 (51G_11 and 51G_12) Ground Time Overcurrent; Channel 2 (51G_21 and 51G_22) Ground Time Overcurrent; Channel 3 (51G_31 and 51G_32) Ground Time Overcurrent; Channel 4 (51G_41 and 51G_43) Ground Time Overcurrent; Channel 5 (51G_51 and 51G_52) Negative Sequence Instantaneous Overcurrent; Winding 1 (50Q_1D1 and 50Q_1D2) Negative Sequence Instantaneous Overcurrent; Winding 2 (50Q_2D1 and 50Q_2D2) Negative Sequence Instantaneous Overcurrent; Winding 3 (50Q_3D1 and 50Q_3D2) Negative Sequence Time Overcurrent; Winding 1 (51Q_1D1 and 51Q_1D2) Negative Sequence Time Overcurrent; Winding 2 (51Q_2D1 and 51Q_2D2) Negative Sequence Time Overcurrent; Winding 3 (51Q_3D1 and 51Q_3D2) Tertiary Instantaneous Overcurrent (without Restraint) (50SFA) Tertiary Instantaneous Overcurrent (with Restraint) (50FA)

Trip Enable
Trip elements controlled. YES/NO for:
Phase Overvoltage (59F1 and 59F2) Phase Undervoltage (27F1 and 27F2) Ground Overvoltage (64_1 and 64_2) Overfrequency (81M1, 81M2, 81M3 and 81M4) Underfrequency (81m1, 81m2, 81m3 and 81m4) Frequency Rate of Change (81D1, 81D2, 81D3 and 81D4) Thermal Image; Winding 1 (49_1D) Thermal Image; Winding 2 (49_2D) Thermal Image; Winding 3 (49_3D) Thermal Image; Ground Channel 1 (49_G1) Thermal Image; Ground Channel 2 (49_G2) Restricted Earth Faults; Channel 1 (87N_11 and 87N_12) Restricted Earth Faults; Channel 2 (87N_21 and 87N_22) Overexcitation (24) Hot Sopt Thermal Image (26) Instantaneous Overload Unit (50OL) Time Overload Unit (51OL) Programmable Trip (configurable in the programmable logic) Transformer Protections Trips (DSPP01, DSPP02, DSPP03, DSPP04, DSPP05, DSPP06, DSPP07, DSPP08)

Load Restoration Enable
Load Restoration Enable (LOAD REST1)

- **Trip Enable: HMI Access · IDV-A/B/G/H/J/K/L Models**

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP PERMISIONS**
1 - ACTIVATE GROUP	...	**1 - LOAD RESTORATION ENA**
2 - CHANGE SETTINGS	**3 - TRIP PERMISIONS**	
3 - INFORMATION	...	

0 - TRIP PERMISIONS	
1 - LOAD RESTORATION ENA	**0- LOAD REST1**

- **Trip Enable: HMI Access · IDV-D Models**

0 - CONFIGURATION	0 - GENERAL	
1 - ACTIVATE GROUP	...	
2 - CHANGE SETTINGS	**3 - TRIP PERMISIONS**	**0 - TRIP PERMISIONS**
3 - INFORMATION	...	

- **Trip Enable: HMI Access · IDV-F Models**

0 - CONFIGURATION	0 - GENERAL	
1 - ACTIVATE GROUP	...	
2 - CHANGE SETTINGS	**4 - TRIP PERMISIONS**	**0 - TRIP PERMISIONS**
3 - INFORMATION	...	

3.26 Machine's Own Protections

3.26.1 Description

Machines usually have their own protections (Buchholz, coolant level, overpressure, etc.) that can be routed to the **IDV** IED so that the **IDV** equipment is in charge, after activation, of ensuring that the relay executes the trip command for all breakers associated with the machine.

Eight logic inputs, assignable to digital inputs or logic outputs programmed in the equipment, are available. These inputs automatically trip the breakers associated with the machine.

3.26.2 Digital Inputs of the Machine's Own Protections Module

Table 3.26-1: Digital Inputs of the Machine's Own Protections Module

Name	Description	Function
TRIP_EXT1	External trip input 1	The activation of these inputs causes all breakers associated with the machine to trip immediately.
TRIP_EXT2	External trip input 2	
TRIP_EXT3	External trip input 3	
TRIP_EXT4	External trip input 4	
TRIP_EXT5	External trip input 5	
TRIP_EXT6	External trip input 6	
TRIP_EXT7	External trip input 7	
TRIP_EXT8	External trip input 8	

3.26.3 Auxiliary Outputs and Events of the Machine's Own Protections Module

Table 3.26-2: Auxiliary Outputs and Events of the Machine's Own Protections Module

Name	Description	Function
TRIP_EXT1M	External masked trip input 1	Masked trip output of all breakers associated with the machine due to a Machine's own protection.
TRIP_EXT2M	External masked trip input 2	
TRIP_EXT3M	External masked trip input 3	
TRIP_EXT4M	External masked trip input 4	
TRIP_EXT5M	External masked trip input 5	
TRIP_EXT6M	External masked trip input 6	
TRIP_EXT7M	External masked trip input 7	
TRIP_EXT8M	External masked trip input 8	
TRIP_EXT1	External trip input 1	The same as for the Digital Inputs.
TRIP_EXT2	External trip input 2	
TRIP_EXT3	External trip input 3	
TRIP_EXT4	External trip input 4	
TRIP_EXT5	External trip input 5	
TRIP_EXT6	External trip input 6	
TRIP_EXT7	External trip input 7	
TRIP_EXT8	External trip input 8	

3.27 Programmable Trip

3.27.1 Description

Its activation is equivalent to the activation of any protection output but it is intended to be assigned to the output of any particular protection unit previously defined in the Programmable Logic module by the user.

3.27.2 Digital Inputs of the Programmable Trip

Table 3.27-1: Digital Inputs of the Programmable Trip

Name	Description	Function
TRIP_PROG	Programmable trip	Activation is equivalent to activation of protection unit output.

3.27.3 Auxiliary Outputs and Events of the Programmable Trip

Table 3.27-2: Auxiliary Outputs and Events of the Programmable Trip

Name	Description	Function
TRIP_PROG	Programmable trip	The same as for the Digital Input.
TRIP_PROGM	Programmable masked trip	Activation of programmable trip supervised by the corresponding trip mask.

3.28 Trip and Close Coil Circuit Supervision

3.28.1 Description

This function 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 the 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.

This monitor function can generate six outputs: **Switching Circuit Failure 1** (**FAIL_CIR1**) (or **Trip Circuit Supervision Failure FAIL_SUPR**), **Switching Circuit Failure 2** (**FAIL_CIR2**), **Switching Circuit Failure 3** (**FAIL_CIR3**), **Switching Circuit Failure 4** (**FAIL_CIR4**), **Switching Circuit Failure 5** (**FAIL_CIR5**) and **Switching Circuit Failure 6** (**FAIL_CIR6**), which the programmable logic can use to activate any of the IED's auxiliary contact outputs, also generating the corresponding events.

The three supervisions are treated separately as independent functions that can be independently set and enabled by means of a setting. Figure 3.28.1 is the block diagram showing the application in the situation of open breaker for two circuits with open and closed monitoring.

3.28.2 Operation Mode

There are settings for supervising the state of three or six coils: **Trip Coil**, **Coil 2**, **Coil 3**, **Coil 4**, **Coil 5**, **and Coil 6**. All of the Coils may be trip or close. Hence their generic name. 6 coil supervision is only available for **IDV-###-###9##** relays**.**

Each of the coils has an associated pair of configurable digital inputs for monitoring. They can be paired to **Supervision in 2 States**, which is explained next, or individually to **Supervision 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 3.28-1 identifies the status contact inputs that must be used to monitor each of the circuits:

Table 3.28-1: Configuration of Digital Inputs for Supervision

Monitored Circuit	Supervision in 2 states	Supervision in one state
Coil 1	IN3	IN3
	IN4	-
Coil 2	IN5 (IN6*)	IN5 (IN6*)
	IN6 (IN7*)	-
Coil 3	IN7 (IN9*)	IN7 (IN9*)
	IN8 (IN10*)	-
Coil 4	IN17	IN17
	IN18	-
Coil 5	IN19	IN19
	IN20	-
Coil 6	IN21	IN21
	IN22	-

(*)IDV-L Models.

All these digital inputs do not need to be configured in advance to perform the coils supervision function. By enabling any of the coils supervision, each pair of digital inputs will be automatically configured as per the table above. The IED needs no physical intervention to be able to assign status contact inputs for the Supervision function; they simply need to be set for this purpose.

Moreover, to monitor the **Coil 1**, a positive must be entered through terminal **IN2/CS1+**; to monitor **Coil 2**, a positive must be entered through terminal **IN5/CS2+**; to monitor **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+**.

Each of the 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 3.28.1 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, IN5 or IN7). 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 Failure is activated.

Trip and Close Coil Circuit Supervision 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

3.28.3 Trip Coil Circuit

In the conditions of figure 3.28.1 (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. This current flowing means that the voltage on **IN3** (+) will correspond to the drop of voltage in the coil and then, a too low value to get it activated. Then, **IN3** will not be activated.

There is no current flowing through **IN4** as the contact **52/a** is open. Then, the voltage on **IN4** (+) will almost be the one available on the open circuit and therefore **IN4** will be activated.

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 deactivated and **IN4** is activated.

If the trip coil opens, the input that was deactivated, **IN3**, will activate and **IN4** will remain activated. After the configured Reset Time for Trip Circuit Failure, the **Circuit Failure 1** (**FAIL_CIR1**) signal will be given.

If a close 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 reset time 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 (**FAIL_CIR1, FAIL_SUPR**) 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 through the use of programmable logic from the equipment.

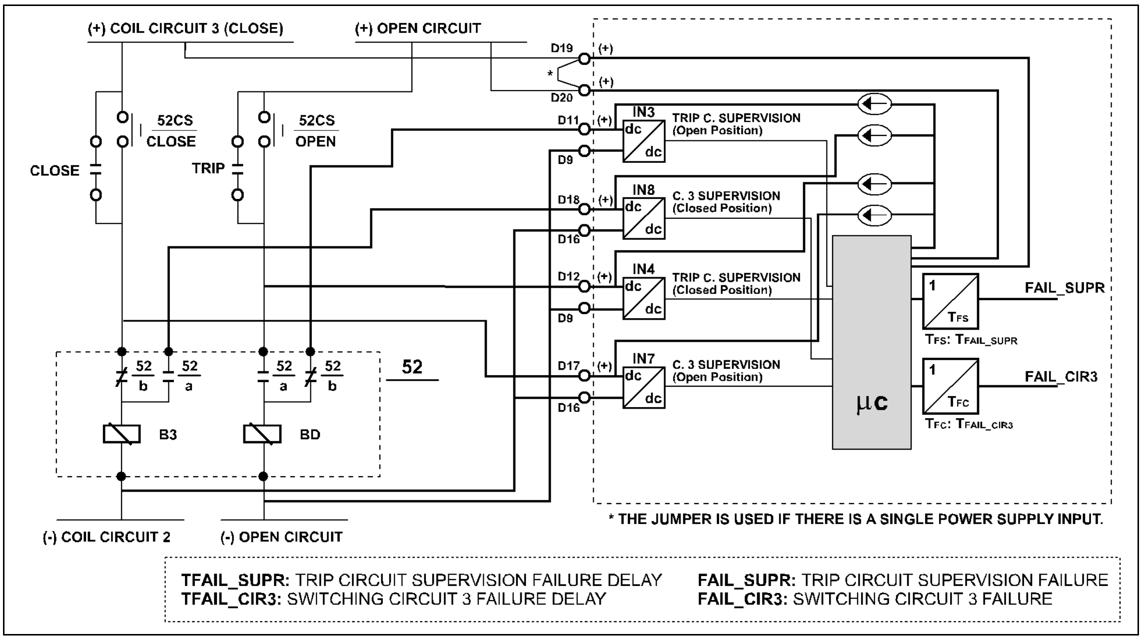


Figure 3.28.1: Trip/Close Coil Circuit Supervision Block Diagram.

3.28.4 Coil Circuits 2, 3, 4, 5 and 6

The explanation given for the open circuit 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**.

3.28.5 Trip and Close Coil Circuit Supervision Settings

Trip and Close Coil Circuit Supervision			
Setting	**Range**	**Step**	**By Default**
Coil 1 Circuit	0: NO 1: One State 2: Two States		0: NO
Coil 1 Failure Delay	1 - 50 s	0.01 s	0.2 s
Coil 2 Circuit	0: NO 1: One State 2: Two States		0: NO
Coil 2 Failure Delay	1 - 50 s	0.01 s	0.2 s
Coil 3 Circuit	0: NO 1: One State 2: Two States		0: NO
Coil 3 Failure Delay	1 - 50 s	0.01 s	0.2 s
Coil 4 Circuit	0: NO 1: One State 2: Two States		0: NO
Coil 4 Failure Delay	1 - 50 s	0.01 s	0.2 s
Coil 5 Circuit	0: NO 1: One State 2: Two States		0: NO
Coil 5 Failure Delay	1 - 50 s	0.01 s	0.2 s
Coil 6 Circuit	0: NO 1: One State 2: Two States		0: NO
Coil 6 Failure 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**
2 - ACTIVATE GROUP	...	**1 - CIR. 1 COIL FAIL.DLY**
3 - CHANGE SETTINGS	**8 - CIRCUIT COIL SUPERV**	**2 - CIRCUIT 2 COIL**
4 - INFORMATION	...	**3 - CIR. 2 COIL FAIL.DLY**
		4 - CIRCUIT 3 COIL
		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

3.28.6 Auxiliary Outputs and Events of the Trip/Close Coil Circuit Supervision Module

Table 3.28-2: Auxiliary Outputs and Events of the Trip/Close Coil Circuit Supervision Module

Name	Description	Function
FAIL_CIR1	Switching circuit 1 failure	They activate when an anomaly is detected in one or more of the switching circuits.
FAIL_CIR2	Switching circuit 2 failure	
FAIL_CIR3	Switching circuit 3 failure	
FAIL_CIR4	Switching circuit 4 failure	
FAIL_CIR5	Switching circuit 5 failure	
FAIL_CIR6	Switching circuit 6 failure	

3.29 Breaker Monitoring

3.29.1 IDV-A/B/G/H/J/K/L Models Breaker Monitoring

In order to have adequate information for carrying out maintenance operations, the current interrupted by the breaker associated to the relay **IDV-A/B/G/H/J/K/L** is recorded and saved as Amps squared. The sum so obtained is proportional to the total accumulated power interrupted by the breaker.

There exists a magnitude "breaker opening current" for each winding, which is saved by the relay measured as the maximum phase current between the time the trip or manual open command is issued and the time the breaker opens. This magnitude is updated each time a trip or manual open command is issued; in case an Open Command Failure occurs, the magnitude is updated with the value 0. This magnitude is stored individually for each circuit breaker (see values ACC C W1, ACC C W2 and for models **IDV-B/H/K/L** see also ACC C W3).

When a trip occurs the square of the maximum phase current measured between the time the trip or manual open command is issued and the time the breaker opens multiplied by the transformation ratio is saved. When a manual open command is issued, whether through the relay or through external means, the square of the maximum phase current measured between the time the open command is issued and the time the breaker opens multiplied by the transformation ratio is also saved.

This function is controlled and monitored through two settings independent for each circuit breaker in the machine:

- Alarm level for accumulated squared amps.
- Actual accumulated squared amps.

Once the **Alarm** setting value is reached, the function activates an alarm signal that can be used through the programmable output function to activate an output; also a record is written into the event record.

Accumulated squared amps value is updated by the protection relay each time a trip occurs or the breaker opens, and can be modified manually through the **Reset Command** Input. By the activation of this digital input, the value of **I2 Dropout Value** set in the relay will be added to the actual value of current stored. The last setting represents the starting value for the accumulated sum on top of which successive values corresponding to later openings will be summed. This manual modification allows taking into account the history of breaker openings before relay installation and is also used to reset the sum following a maintenance operation.

Manual modification is not made through a change in settings, as it is not a setting as such; the modification requires creating a command through the programmable logic.

3.29.2 IDV-D Model Breaker Monitoring

The breaker supervision function incorporated into **IDV-D** relays 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. **IDV-D** 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 $I_{RMS}^2*T_{frame}$, where T_{frame}, 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, 3 ,4) **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).

IDV-D Models generate the magnitude **Breaker n** (n = 1, 2, 3, 4) **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).
- 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: $n1 * I1^N = n2 * I2^N$. **IDV-D** Models have the possibility to select the exponent N through a setting.

IDV-D Models generate other magnitude, **Breaker n** (n = 1, 2, 3, 4) **X Pole** (X = A, B, C) **Sum Current**, which stores the following value, every time the **Breaker n X Pole Open Current** updates:

$$\left(I_{RMS\_Xn} \times R_{TIABC}\right)^N \times T_{frame}$$

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_{frame} represents the selected calculation time frame.

The total stored value is obtained as percentage of the **I2 Sum Alarm** setting (expressed as ***kA^N*cycle***). When the **Breaker n X Pole Sum Current** magnitude reaches 100%, the function activates the **Breaker n X Pole I2 Sum Alarm** 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 I2 Dropout Command** input activation. In that case the latter magnitude will take the value of the **Breaker n X Pole Sum kA Dropout 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.

3.29.2.a Breaker Operating Time

The models **IDV-D** record the operating time of each breaker pole [magnitude **Pole X Fault Clearance Time** (X = A, B, C) **Breaker n** (n = 1, 2, 3, 4)] 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 pick up 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.

3.29.3 Breaker Monitoring Settings

Breaker Monitoring (Breakers of Windings 1, 2, 3) (IDV-A/B/G/H/J/K/L)			
Setting	**Range**	**Step**	**By Default**
I2 Sum Alarm	0 - 99,999.992188 kA	0.01 kA	99,999.992188 kA
I2 Dropout Value	0 - 99,999.992188 kA	0.01 kA	99.999,992188 kA

Breaker Monitoring (Breakers of Windings 1, 2, 3) (IDV-D)			
Setting	**Range**	**Step**	**By default**
I2 sum alarm	0 - 99,999.99 kA^2	0.01	99,999.99
A pole cumulative preset value I2	0 - 99,999.99 kA^2	0.01	0 kA^2
B pole cumulative preset value I2	0 - 99,999.99 kA^2	0.01	0 kA^2
C pole cumulative preset value I2	0 - 99,999.99 kA^2	0.01	0 kA^2
kA index	1 - 2	0.1	2
Arc initiate delay	(-1) - 50 cycles	¼ cycle	0 cycles
Calculation frame duration	0 / 1 / 2 cycles	0.01	2 cycles

- **Breaker Monitoring: HMI Access · IDV-A/B/G/H/J/K/L Models**

0 - CONFIGURATION	0 - GENERAL	**0 - I² W1 SUM ALARM**
1 - ACTIVATE GROUP	...	**1 - I² W1 DROPOUT**
2 - CHANGE SETTINGS	**7 - BREAKER SUPERV.**	**2 - I² W2 SUM ALARM**
3 - INFORMATION	...	**3 - I² W2 DROPOUT**
		4 - I² W3 SUM ALARM
		5 - I² W3 DROPOUT

- **Breaker Monitoring: HMI Access · IDV-D Models**

0 - CONFIGURATION	0 - GENERAL	**0 - I1**
1 - ACTIVATE GROUP	...	**1 - I2**
2 - CHANGE SETTINGS	**7 - BREAKER SUPERV.**	**2 - I3**
3 - INFORMATION	...	**3 - I4**

0 - I1	**0 - I² SUM ALARM**
1 - I2	**1 - I POLE A DROPOUT**
2 - I3	**2 - I POLE B DROPOUT**
3 - I4	**3 - I POLE C DROPOUT**
	4 - KA INDEX
	5 - ARC START DELAY
	6 - WINDOW LENGTH

3.29.4 Digital Inputs of Breaker Monitoring Module

Table 3.29-1: Digital Inputs of Breaker Monitoring Module

Name	Description	Function
IN_BLK_KA1	Breaker 1 kA Counter Blocking Input (IDV-D)	Activating this input blocks breaker 1 kA store
IN_BLK_KA2	Breaker 2 kA Counter Blocking Input (IDV-D)	Activating this input blocks breaker 1 kA store
IN_BLK_KA3	Breaker 3 kA Counter Blocking Input (IDV-D)	Activating this input blocks breaker 1 kA store
IN_BLK_KA4	Breaker 4 kA Counter Blocking Input (IDV-D)	Activating this input blocks breaker 1 kA store
RST_CUMI2_1	Accumulated I^2 reset command winding 1	When activated, the set value is added to the actual I^2.
RST_CUMI2_2	Accumulated I^2 reset command winding 2	
RST_CUMI2_3	Accumulated I^2 reset command winding 3	

Table 3.29-1: Digital Inputs of Breaker Monitoring Module		
Name	**Description**	**Function**
RST_CUMIA1	Pole A Breaker 1 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 1 A Pole Stored Current magnitude to the “Breaker 1 A Pole stored kA reset value” setting.
RST_CUMIB1	Pole B Breaker 1 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 1 B Pole Stored Current magnitude to the “Breaker 1 B Pole stored kA reset value” setting.
RST_CUMIC1	Pole C Breaker 1 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 1 C Pole Stored Current magnitude to the “Breaker 1 C Pole stored kA reset value” setting.
RST_CUMIA2	Pole A Breaker 2 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 2 A Pole Stored Current magnitude to the “Breaker 1 A Pole stored kA reset value” setting.
RST_CUMIB2	Pole B Breaker 2 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 2 B Pole Stored Current magnitude to the “Breaker 1 B Pole stored kA reset value” setting.
RST_CUMIC2	Pole C Breaker 2 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 2 C Pole Stored Current magnitude to the “Breaker 1 C Pole stored kA reset value” setting.

Table 3.29-1: Digital Inputs of Breaker Monitoring Module		
Name	**Description**	**Function**
RST_CUMIA3	Pole A Breaker 3 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 3 A Pole Stored Current magnitude to the “Breaker 1 A Pole stored kA reset value” setting.
RST_CUMIB3	Pole B Breaker 3 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 3 B Pole Stored Current magnitude to the “Breaker 1 B Pole stored kA reset value” setting.
RST_CUMIC3	Pole C Breaker 3 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 3 C Pole Stored Current magnitude to the “Breaker 1 C Pole stored kA reset value” setting.
RST_CUMIA4	Pole A Breaker 4 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 4 A Pole Stored Current magnitude to the “Breaker 1 A Pole stored kA reset value” setting.
RST_CUMIB4	Pole B Breaker 4 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 4 B Pole Stored Current magnitude to the “Breaker 1 B Pole stored kA reset value” setting.
RST_CUMIC4	Pole C Breaker 4 kA Counter Reset Input (IDV-D)	Activating this input resets breaker 4 C Pole Stored Current magnitude to the “Breaker 1 C Pole stored kA reset value” setting.
IN_KA_STR_A1	Breaker 1 Pole A Arc Start Input (IDV-D)	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 Pole B Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 1.
IN_KA_STR_C1	Breaker 1 Pole C Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 1.

Table 3.29-1: Digital Inputs of Breaker Monitoring Module

Name	Description	Function
IN_KA_STR_A1	Breaker 1 Pole A Arc Start Input (IDV-D)	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 Pole B Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 1.
IN_KA_STR_C1	Breaker 1 Pole C Arc Start Input (IDV-D)	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 Pole A Arc Start Input (IDV-D)	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 Pole B Arc Start Input (IDV-D)	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 Pole C Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 2.
IN_KA_STR_A3	Breaker 3 Pole A Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker 3.
IN_KA_STR_B3	Breaker 3 Pole B Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 3.
IN_KA_STR_C3	Breaker 3 Pole C Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 3.
IN_KA_STR_A4	Breaker 4 Pole A Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the A pole of the breaker 4.
IN_KA_STR_B4	Breaker 4 Pole B Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the B pole of the breaker 4.
IN_KA_STR_C4	Breaker 4 Pole C Arc Start Input (IDV-D)	The activation of this input starts the window calculating the RMS current value open by the C pole of the breaker 4.

3.29.5 Auxiliary Outputs and Events of Breaker Monitoring Module

Table 3.29-2: Auxiliary Outputs and Events of Breaker Monitoring Module		
Name	**Description**	**Function**
AL_KA2_1	Winding 1 breaker accumulated I^2 alarm	Causes the activation of I^2 alarm for each winding.
AL_KA2_2	Winding 2 breaker accumulated I^2 alarm	
AL_KA2_3	Winding 3 breaker accumulated I^2 alarm	
AL_KA_A1	Breaker 1 Pole A accumulated Amps Alarm (IDV-D)	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 (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 1 have reached the alarm level.
AL_KA_C1	Breaker 1 Pole C accumulated Amps Alarm (IDV-D)	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 (IDV-D)	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 (IDV-D)	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 (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 2 have reached the alarm level.
AL_KA_A3	Breaker 3 Pole A accumulated Amps Alarm (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker 3 have reached the alarm level.
AL_KA_B3	Breaker 3 Pole B accumulated Amps Alarm (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 3 have reached the alarm level.
AL_KA_C3	Breaker 3 Pole C accumulated Amps Alarm (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 3 have reached the alarm level.
AL_KA_A4	Breaker 4 Pole A accumulated Amps Alarm (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole A of the breaker 4 have reached the alarm level.
AL_KA_B4	Breaker 4 Pole B accumulated Amps Alarm (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole B of the breaker 4 have reached the alarm level.
AL_KA_C4	Breaker 4 Pole C accumulated Amps Alarm (IDV-D)	Indication that the kA^{N*} cycles accumulated by pole C of the breaker 4 have reached the alarm level.

Table 3.29-2: Auxiliary Outputs and Events of Breaker Monitoring Module		
Name	**Description**	**Function**
IN_BLK_KA1	Breaker 1 kA Counter Blocking Input (IDV-D)	The same as for the Digital Inputs.
IN_BLK_KA2	Breaker 2 kA Counter Blocking Input (IDV-D)	
IN_BLK_KA3	Breaker 3 kA Counter Blocking Input (IDV-D)	
IN_BLK_KA4	Breaker 4 kA Counter Blocking Input (IDV-D)	
RST_CUMI2_1	Accumulated I^2 Reset Command Winding 1	The same as for the Digital Inputs.
RST_CUMI2_2	Accumulated I^2 Reset Command Winding 2	
RST_CUMI2_3	Accumulated I^2 Reset Command Winding 3	
RST_CUMIA1	Pole A Breaker 1 kA Counter Reset Input (IDV-D)	The same as for the Digital Inputs.
RST_CUMIB1	Pole B Breaker 1 kA Counter Reset Input (IDV-D)	
RST_CUMIC1	Pole C Breaker 1 kA Counter Reset Input (IDV-D)	
RST_CUMIA2	Pole A Breaker 2 kA Counter Reset Input (IDV-D)	
RST_CUMIB2	Pole B Breaker 2 kA Counter Reset Input (IDV-D)	
RST_CUMIC2	Pole C Breaker 2 kA Counter Reset Input (IDV-D)	
RST_CUMIA3	Pole A Breaker 3kA Counter Reset Input (IDV-D)	
RST_CUMIB3	Pole B Breaker 3 kA Counter Reset Input (IDV-D)	
RST_CUMIC3	Pole C Breaker 3 kA Counter Reset Input (IDV-D)	
RST_CUMIA4	Pole A Breaker 4 kA Counter Reset Input (IDV-D)	
RST_CUMIB4	Pole B Breaker 4 kA Counter Reset Input (IDV-D)	
RST_CUMIC4	Pole C Breaker 4 kA Counter Reset Input (IDV-D)	
IN_KA_STR_A1	Breaker 1 Pole A Arc Start Input (IDV-D)	The same as for the Digital Inputs.
IN_KA_STR_B1	Breaker 1 Pole B Arc Start Input (IDV-D)	
IN_KA_STR_C1	Breaker 1 Pole C Arc Start Input (IDV-D)	
IN_KA_STR_A2	Breaker 2 Pole A Arc Start Input (IDV-D)	
IN_KA_STR_B2	Breaker 2 Pole B Arc Start Input (IDV-D)	
IN_KA_STR_C2	Breaker 2 Pole C Arc Start Input (IDV-D)	
IN_KA_STR_A3	Breaker 3 Pole A Arc Start Input (IDV-D)	
IN_KA_STR_B3	Breaker 3 Pole B Arc Start Input (IDV-D)	
IN_KA_STR_C3	Breaker 3 Pole C Arc Start Input (IDV-D)	
IN_KA_STR_A4	Breaker 4 Pole A Arc Start Input (IDV-D)	
IN_KA_STR_B4	Breaker 4 Pole B Arc Start Input (IDV-D)	
IN_KA_STR_C4	Breaker 4 Pole C Arc Start Input (IDV-D)	

3.30 Power Supply Voltage Monitoring

3.30.1 Introduction

Models where the Input / Output digit for Model Selection shows that the relay is provided with an input voltage transducer (Sup. VDC), feature a DC Voltage Monitoring function for substation batteries.

Overvoltage and undervoltage condition alarms can be generated through said monitoring function, also allowing recording the evolution of said voltage when trips, closing and other control operations requiring power supply from the monitored batteries take place.

3.30.2 Operating Principle

As the measured battery voltage is relay power supply voltage, measurement is obtained through hard connection of said supply voltage to the **input transducer arranged for voltage measurement**, in parallel with the relay power supply voltage.

Two measurement units are available, one overvoltage and the other undervoltage, which compare voltage measured through the transducer with pickup settings.

Units pickup at 100% of setting and reset at 95% in case of overvoltage and 105% in case of undervoltage.

These units are not provided with output timers; their activation / deactivation log the events and activate / deactivate the signals shown in table 3.30-1.

Output timers can be incorporated through the programmable logic in order to get the necessary logic function, such as obtaining a new signal as a result of gates AND or OR.

Signals obtained through this logic functions can generate their own events and trigger new actions (LED activation, oscillograph starting...).

When measured voltage is below 10Vdc, transducer power supply is considered unconnected and the oscillograph will not start on undervoltage nor will the event and signal activation corresponding to this undervoltage be generated.

No matter the model (power supply and digital input voltage range), Overvoltage and Undervoltage units have only one setting (15Vdc to 300Vdc). Nevertheless, 24 Vdc and 48Vdc models will have a common measurement range and 125Vdc and 250Vdc models will have another. Measurement ranges for each of them are shown in Section 2.1.

A Log of said voltages can be saved into oscillographic records attached to each relay operation, logged into the events record, visualized locally or through communications channel and used for the generation of user logic functions in the “programmable logic”.

Note: this monitoring is only valid for direct current power supply, and if the relay works with alternating current power supply, the transducer shall not be connected to said power supply.

3.30.3 Power Supply Voltage Monitoring Settings

DC Power Monitoring			
Setting	**Range**	**Step**	**By Default**
DC_OV Pickup	15 - 300 Vdc	0.1 V	300 V
DC_UV Pickup	15 - 300 Vdc	0.1 V	15 V

- **Power Supply Voltage Monitoring: HMI Access**

0 - CONFIGURATION	0 - GENERAL	**0 - DC_OV PICKUP**
1 - ACTIVATE GROUP	...	**1 - DC_UV PICKUP**
2 - CHANGE SETTINGS	**12 - DC POWER MONIT.**	
3 - INFORMATION	...	

3.30.4 Auxiliary Outputs and Events of the Power Supply Voltage Monitoring

Table 3.30-1: Auxiliary Outputs and Events of the Power Supply Voltage Monitoring		
Name	**Description**	**Function**
OVDC	Power supply overvoltage	These signals activate when relay power supply voltage exceeds battery voltage monitoring overvoltage or undervoltage element settings respectively.
UVDC	Power supply undervoltage	

3.31 Change Settings Groups

3.31.1 Description

There are up to four alternative setting 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 digital 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_MMI** are active, groups can not be changed with commands via communications nor through the HMI.

If the digital inputs are used to change groups, up to four digital inputs may need to be configured through the programmable digital 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**).
- Command to activate Settings Group 4 by digital input (**CMD_GRP4_DI**).

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, T3 and T4 only if the display is in the default screen.

3.31.2 Digital Inputs to Change Settings Groups

Table 3.31-1: Digital Inputs 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	

3.31.3 Auxiliary Outputs and Events to Change Settings Groups

Table 3.31-2: Auxiliary Outputs and Events to Change Settings Groups

Name	Description	Function
INH_CGRP_COM	Inhibit group change via communications	The same as for the Digital Input.
INH_CGRP_HMI	Inhibit group change via HMI	The same as for the Digital Input.
CMD_GRP1_COM	Command to activate Settings Group 1 via communications	The same as for the Digital Inputs.
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	
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	

3.32 Event Record

3.32.1 Description

The capacity of the recorder is 1000 notations in non-volatile memory. The signals that generate the events are user-selectable and are recorded with a resolution of 1ms together with a maximum of 12 values also selectable from all the available metering values measured or calculated by the IED ("user defined values", including VDC in models with power supply voltage monitoring).

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 3.32-1 -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 3.32-1: Event Record

Name	Description
HMI access	See the description in Auxiliary Outputs.
Clock synchronization	
IRIGB Active	
External oscillography trigger	
Oscillography picked up	
Deletion of oscillographs	
Open command winding 1 (IDV-A/B/H/J/K/L)	
Open command winding 2 (IDV-A/B/H/J/K/L)	
Open command winding 3 (IDV-A/B/H/J/K/L)	
Close command winding 1 (IDV-A/B/H/J/K/L)	
Close command winding 2 (IDV-A/B/H/J/K/L)	
Close command winding 3 (IDV-A/B/H/K/L)	
Open command breaker 1 (IDV-D/F)	
Open command breaker 2 (IDV-D/F)	
Open command breaker 3 (IDV-D/F)	
Open command breaker 4 (IDV-D/F)	
Close command breaker 1 (IDV-D/F)	
Close command breaker 2 (IDV-D/F)	
Close command breaker 3 (IDV-D/F)	
Close command breaker 4 (IDV-D/F)	
External trip control	
Trip by Protection	
Lockout Function Reset Button (86 Open)	
Open Button P1	
Open Button P2	
Open Button P3	
Open Button P4	
Open Button P5	
Open Button P6	

Table 3.32-1: Event Record

Name	Description
Close Button P1	See the description in Auxiliary Outputs.
Close Button P2	
Close Button P3	
Close Button P4	
Close Button P5	
Close Button P6	
Digital Input 1	
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	

Table 3.32-1: Event Record

Name	Description
Validity of Digital Input 1	See the description in Auxiliary Outputs.
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	
Validity of Digital Input 11	
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	

Table 3.32-1: Event Record	
Name	**Description**
Auxiliary Output 12	See the description in Auxiliary Outputs.
Auxiliary Output 13	
Auxiliary Output 14	
Auxiliary Output 15	
Auxiliary Output 16	
Auxiliary Output 17	
Auxiliary Output 18	
Auxiliary Output 19	
Auxiliary Output 20	
Auxiliary Output 21	
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	
Input of breaker position winding 1: Open (1) / Closed (0) (IDV-A/B/G/H/J/K/L)	
Input of breaker position winding 2: Open (1) / Closed (0) (IDV-A/B/G/H/J/K/L)	
Input of breaker position winding 3: Open (1) / Closed (0) (IDV-A/B/H/K/L)	
Input of breaker 1 position open (IDV-D/F)	
Input of breaker 2 position open (IDV-D/F)	
Input of breaker 3 position open (IDV-D/F)	
Input of breaker 4 position open (IDV-D/F)	
LEDs reset input	
Power meters reset input	
Maximeters reset command	
Trip indication reset command	
Current detected with open breaker status	

Table 3.32-1: Event Record	
Name	**Description**
Cold load pickup of IED	See the description in Auxiliary Outputs.
Warm start up of IED	
Manual reinitialization of the IED	
Change of settings initialization	
Port 0 communication failure	
Port 1 communication failure	
Port 2 communication failure	
Port 3 communication failure	
Remote	
Local Control	
Panel-controlled	
Critical system error	
Non-critical system error	
System event	
Reset pending reconfiguration (*)	
Write to flash in progress (*)	
SNTP not synchronized (*)	
Status of communications port LAN1 (*)	
Status of communications port LAN2 (*)	
Communications port LAN active (bonding) (*)	
Network congestion detected in LAN1 (*)	
Network congestion detected in LAN2 (*)	

(*) IDV-*-*****6*** Models.**

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.

3.32.2 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. Taking this feature into account and the fact that normally simultaneous events are generated when a fault occurs, it could be said that the capacity of events is around one thousand events. The relay will store as many events as take place with a resolution of 1ms, for example forty events in ten miliseconds.

3.32.3 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 (1000 events) and erase more important previous events.

3.32.4 Consulting the Record

The communications and remote management program ***ZivercomPlus®*** has a completely decoded system for consulting the Event Record.

3.32.5 Event Record Settings (via communications)

Events Mask
IED events may be masked separately

Event Magnitudes (IDV-A/B Models)				
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:				
Null	H8A CAW1	CWNDG3N	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW2	CDIF H2A	CMINW3	RMSWNDG1CB
ACC C W2	H8A CAW2	CDIF H2B	NSC_W1	RMSWNDG1CC
ACC C W3	CNV1	CDIF H2C	NSC_W2	RMSWNDG2CA
ALARMS	DFREQ	CDIF H3A	NSC_W3	RMSWNDG2CB
H2A CAW1	PF	CDIF H3B	PSC_W1	RMSWNDG2CC
H2A CAW2	FREQ	CDIF H3C	PSC_W2	RMSWNDG3CA
H2A CAW3	CABI D1	CDIF H4A	PSC_W3	RMSWNDG3CB
H2A CG2	CABI D2	CDIF H4B	ZSC_W1	RMSWNDG3CC
H3A CAW2	CABI D3	CDIF H4C	ZSC_W2	RMSIG1
H3A CAW3	CADIF	CDIF H5A	ZSC_W 3	RMSIG2
H4A CAW1	CBDIF	CDIF H5B	THERM W1	S
H4A CAW2	CCDIF	CDIF H5C	THERM W2	SMAX
H4A CAW3	CWNDG1A	CRESTR A	THERM W3	SMIN
H5A CAW1	CWNDG1B	CRESTR B	N.A.ENGY	ACTGRP
H5A CAW2	CWNDG1C	CRESTR C	N.R.ENGY	VDC
H5A CAW3	CWNDG1N	CG1	P	VMAX
H5A CG2	CWNDG2A	CG2	P.Active Energy	VMIN
H6A CAW1	CWNDG2B	CGN1	PMAX	VG
H6A CAW2	CWNDG2C	CGN2	PMIN	VPH
H6A CAW3	CWNDG2N	CMAXW1	P.Reactive Energy	V/HZ
H7A CAW1	CWNDG3A	CMAXW2	Q	
H7A CAW2	CWNDG3B	CMAXW3	QMAX	
H7A CAW3	CWNDG3C	CMINW1	QMIN	
Note: all magnitudes for each event are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.				

Event Magnitudes (IDV-D Models)				
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:				
Null	ANGIC4	H8AIAW2	IWNDG2N	THERM W1
CUMIOPEN_A1	ANGIG1	H8AIAW3	IWNDG3A	THERM W2
CUMIOPEN_A2	ANGIG2	FREQ	IWNDG3B	THERM W3
CUMIOPEN_A3	ANGIN1	IA1	IWNDG3C	THERM 49G1
CUMIOPEN_A4	ANGIN2	IB1	IWNDG3N	THERM 49G2
CUMIOPEN_B1	ANGIN3	IC1	IDIF H2A	N_OPEN_1
CUMIOPEN_B2	ANGIN4	IA2	IDIF H3A	N_OPEN_2
CUMIOPEN_B3	ANG PS W1	IB2	IDIF H4A	N_OPEN_3
CUMIOPEN_B4	ANG PS W2	IC2	IDIF H5A	N_OPEN_4
CUMIOPEN_C1	ANG PS W3	IA3	IDIF H2B	COLDSTART
CUMIOPEN_C2	ANG ZS W1	IB3	IDIF H3B	N_CLOSING_1
CUMIOPEN_C3	ANG ZS W2	IC3	IDIF H4B	N_CLOSING_2
CUMIOPEN_C4	ANG ZS W3	IA4	IDIF H5B	N_CLOSING_3
ALARMS	ANG NS W1	IB4	IDIF H2C	N_CLOSING_4
ANG W1A	ANG NS W2	IC4	IDIF H3C	WARMSTART
ANG W1B	ANG NS W3	OPENI_A1	IDIF H4C	NTRAPS
ANG W1C	H2AIAW1	OPENI_A2	IDIF H5C	Null
ANG W1N	H2AIAW2	OPENI_A3	IRESTR A	RMSWNDG1IA
ANG W2A	H2AIAW3	OPENI_A4	IRESTR B	RMSWNDG2IA
ANG W2B	H2 IG2	OPENI_B1	IRESTR C	RMSWNDG3IA
ANG W2C	H3AIAW1	OPENI_B2	IG1	RMS_IG1
ANG W2N	H3AIAW2	OPENI_B3	IG2	RMS_IG2
ANG W3A	H3AIAW3	OPENI_B4	IGN1	FAULTIME
ANG W3B	H4AIAW1	OPENI_C1	IGN2	ACTGR
ANG W3C	H4AIAW2	OPENI_C2	IN1	T_FLTCLEAR_A1
ANG W3N	H4AIAW3	OPENI_C3	IN2	T_FLTCLEAR_A2
ANGIA1	H5AIAW1	OPENI_C4	IN3	T_FLTCLEAR_A3
ANGIA2	H5AIAW2	IDIFFA	IN4	T_FLTCLEAR_A4
ANGIA3	H5AIAW3	IDIFFB	PSC_W1	T_FLTCLEAR_B1
ANGIA4	H5 IG2	IDIFFC	PSC_W2	T_FLTCLEAR_B2
ANGIB1	H6AIAW1	IWNDG1A	PSC_W3	T_FLTCLEAR_B3
ANGIB2	H6AIAW2	IWNDG1B	ZSC_W1	T_FLTCLEAR_B4
ANGIB3	H6AIAW3	IWNDG1C	ZSC_W2	T_FLTCLEAR_C1
ANGIB4	H7AIAW1	IWNDG1N	ZSC_W3	T_FLTCLEAR_C2
ANGIC1	H7AIAW2	IWNDG2A	NSC_W1	T_FLTCLEAR_C3
ANGIC2	H7AIAW3	IWNDG2B	NSC_W2	T_FLTCLEAR_C4
ANGIC3	H8AIAW1	IWNDG2C	NSC_W3	
Note: all magnitudes for each event are stored in secondary values; therefore not affected by any primary-to-secondary ratio.				

Event Magnitudes (IDV-F Models)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

Null	CSDCOMP1	CWNDG1A	CDIF C2A	NSV
DFREQ	CSDCOMP2	CWNDG1B	CDIF C3A	PSV
FREQ	CSDCOMP3	CWNDG1C	CDIF C4A	TACTIVE
CA1	CSDCOMP4	CWNDG2A	CDIF C5A	VA
CB1	CSHCOMP1	CWNDG2B	CRESTR A	VB
CC1	CSHCOMP2	CWNDG2C	CRESTR B	VC
CA2	CSHCOMP3	CWNDG3A	CRESTR C	ZSV
CB2	CSHCOMP4	CWNDG3B	DSC_D1	
CC2	CSICOMP1	CWNDG3C	DSC_D2	
CA3	CSICOMP2	CDIF A2A	DSC_D3	
CB3	CSICOMP3	CDIF A3A	HSC_D1	
CC3	CSICOMP4	CDIF A4A	HSC_D2	
CA4	CADIF	CDIF A5A	HSC_D3	
CB4	CBDIF	CDIF B2A	ISC_D1	
CC4	CCDIF	CDIF B3A	ISC_D2	
		CDIF B4A	ISC_D3	
		CDIF B5A		

Note: all magnitudes for each event are stored in secondary values; therefore not affected by any primary-to-secondary ratio.

Event Magnitudes (IDV-G/J Models)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

Null	H8A CAW1	CDIF A2A	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW1	CDIF A3A	PSC_W1	RMSWNDG1CB
ACC C W2	CNV1	CDIF A4A	PSC_W2	RMSWNDG1CC
ALARMS	DFREQ	CDIF A5A	ZSC_W1	RMSWNDG2CA
H2A CAW1	PF	CDIF B2A	ZSC_W2	RMSWNDG2CB
H2A CAW2	FREQ	CDIF B3A	NSC_W1	RMSWNDG2CC
H2A CG2	CABI D1	CDIF B4A	NSC_W2	RMSIG1
H3A CAW2	CABI D2	CDIF B5A	THERM W1	S
H3A CAW1	CADIF	CDIF C2A	THERM W2	SMAX
H4A CAW2	CBDIF	CDIF C3A	N.A.ENGY	SMIN
H5A CAW1	CCDIF	CDIF C4A	N.R.ENGY	ACTGRP
H5A CAW2	CWNDG1A	CDIF C5A	P	VDC
H5A CG2	CWNDG1B	CRESTR A	P.Active Energy	VMAX
H6A CAW1	CWNDG1C	CRESTR B	PMAX	VMIN
H6A CAW2	CWNDG1N	CRESTR C	PMIN	VA
H7A CAW1	CWNDG2A	IG1	P.Reactive Energy	VB
H7A CAW2	CWNDG2B	IGN1	Q	VC
	CWNDG2C	CMAXW1	QMAX	PSV
	CWNDG2N	CMAXW2	QMIN	NSV
		CMINW1		ZSV
				V/HZ

Note: all magnitudes for each event are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.

Event Magnitudes (IDV-H/K Models)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

Null	H8A CAW1	CWNDG3N	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW2	CDIF A2A	CMINW3	RMSWNDG1CB
ACC C W2	H8A CAW3	CDIF A3A	PSC_W1	RMSWNDG1CC
ACC C W3	CNV1	CDIF A4A	PSC_W2	RMSWNDG2CA
ALARMS	DFREQ	CDIF A5A	PSC_W3	RMSWNDG2CB
H2A CAW1	PF	CDIF B2A	ZSC_W1	RMSWNDG2CC
H2A CAW2	FREQ	CDIF B3A	ZSC_W2	RMSWNDG3CA
H2A CAW3	CABI D1	CDIF B4A	ZSC_W3	RMSWNDG3CB
H2A CG2	CABI D2	CDIF B5A	NSC_W1	RMSWNDG3CC
H3A CAW2	CABI D3	CDIF C2A	NSC_W2	RMS_IG1
H3A CAW3	CADIF	CDIF C3A	NSC_W3	RMS_IG2
H4A CAW1	CBDIF	CDIF C4A	THERM W1	S
H4A CAW2	CCDIF	CDIF C5A	THERM W2	SMAX
H4A CAW2	CWNDG1A	CRESTR A	THERM W3	SMIN
H5A CAW1	CWNDG1B	CRESTR B	N.A.ENGY	ACTGRP
H5A CAW2	CWNDG1C	CRESTR C	N.R.ENGY	VDC
H5A CAW3	CWNDG1N	IG1	P	VMAX
H5A CG2	CWNDG2A	IG2	P.Active Energy	VMIN
H6A CAW1	CWNDG2B	IGN1	PMAX	VA
H6A CAW2	CWNDG2C	IGN2	PMIN	VB
H6A CAW3	CWNDG2N	CMAXW1	P.Reactive Energy	VC
H7A CAW1	CWNDG3A	CMAXW2	Q	PSV
H7A CAW2	CWNDG3B	CMAXW3	QMAX	NSV
H7A CAW3	CWNDG3C	CMINW1	QMIN	ZSV
				V/HZ

Note: all magnitudes for each event are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.

Event Magnitudes (IDV-L Models)

Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:

ACC C W1	ANG W2C	H6A IAW1	IRESTR A	M V2 12	RMSWNDG1IB
ACC C W2	ANG W2N	H6A IAW2	IRESTR B	M V2 13	RMSWNDG1IC
ACC C W3	ANG W3A	H6A IAW3	IRESTR C	M V2 14	RMSWNDG2IA
ACT TIME	ANG W3B	H7A IAW1	IWNDG1A	M V2 15	RMSWNDG2IB
ACTGRP	ANG W3C	H7A IAW2	IWNDG1B	M V2 16	RMSWNDG2IC
ALARMS	ANG W3N	H7A IAW3	IWNDG1C	N E AF 1	RMSWNDG3IA
ANG IA	ANG ZSW1	H8A IAW1	IWNDG1N	N E AF 2	RMSWNDG3IB
ANG IACOMP_1	ANG ZSW2	H8A IAW2	IWNDG2A	N E DF 1	RMSWNDG3IC
ANG IACOMP_2	ANG ZSW3	H8A IAW3	IWNDG2B	N E DF 2	ROC FREQ
ANG IACOMP_3	CMAXW1	I_EFD1	IWNDG2C	N Er AC 1	S
ANG IBCOMP_1	CMAXW2	I_EFD2	IWNDG2N	N Er AC 2	SMAX
ANG IBCOMP_2	CMAXW3	I_EFD3	IWNDG3A	N.A.ENGY	SMIN
ANG IBCOMP_3	CMINW1	IA	IWNDG3B	N.R.ENGY	T Act 1
ANG ICCOMP_1	CMINW2	IACP1	IWNDG3C	NSC_W1	T Act 2
ANG ICCOMP_2	CMINW3	IACP2	IWNDG3N	NSC_W2	T AMBIENT
ANG ICCOMP_3	COLDSTARTS	IACP3	M V1 01	NSC_W3	T HOT SPOT
ANG IG1	COOLING EFFICIENCY	IBCP1	M V1 02	NSCCP1	T OIL
ANG IG2	CUMULATIVE LOSS LIFE	IBCP2	M V1 03	NSCCP2	THERM W1
ANG NSCCOMP_1	D_I1MAX	IBCP3	M V1 04	NSCCP3	THERM W2
ANG NSCCOMP_2	D_I2MAX	ICCP1	M V1 05	NTRAPS	THERM W3
ANG NSCCOMP_3	D_I3MAX	ICCP2	M V1 06	Null	TRANSDUCER C1
ANG NSW1	D_PMAX	ICCP3	M V1 07	OPENC W1	TRANSDUCER C2
ANG NSW2	D_QMAX	IDIF H2A	M V1 08	OPENC W2	V/Hz
ANG NSW3	D_SMAX	IDIF H2B	M V1 09	OPENC W3	VA
ANG PSCCOMP_1	D_VMAX	IDIF H2C	M V1 10	P	VAB
ANG PSCCOMP_2	FAULTT	IDIF H3A	M V1 11	P.Active Energy	VB
ANG PSCCOMP_3	FAULTT	IDIF H3B	M V1 12	P.React. Energy	VBC
ANG PSW1	FREQ	IDIF H3C	M V1 13	PF	VC
ANG PSW2	H2A IAW1	IDIF H4A	M V1 14	PMAX	VCA
ANG PSW3	H2A IAW2	IDIF H4B	M V1 15	PMIN	VMAX
ANG VA	H2A IAW3	IDIF H4C	M V1 16	PSC_W1	VMIN
ANG VAAB	H2A IG2	IDIF H5A	M V2 01	PSC_W2	VN
ANG VB	H3A IAW1	IDIF H5B	M V2 02	PSC_W3	WARMSTARTS
ANG VC	H3A IAW2	IDIF H5C	M V2 03	PSCCP1	ZSC_W1
ANG VN	H3A IAW3	IDIFFA	M V2 04	PSCCP2	ZSC_W2
ANG W1A	H4A IAW1	IDIFFB	M V2 05	PSCCP3	ZSC_W3
ANG W1B	H4A IAW2	IDIFFC	M V2 06	Q	
ANG W1C	H4A IAW3	IG1	M V2 07	QMAX	
ANG W1N	H5A IAW1	IG2	M V2 08	QMIN	
ANG W2A	H5A IAW2	IGN1	M V2 09	RMSIG1	
ANG W2B	H5A IAW3	IGN2	M V2 10	RMSIG2	

Note: all magnitudes for each event are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.

3.33 Fault Reports

3.33.1 Introduction

The terminal incorporates **Fault Reports** register, which stores the most relevant information about last 15 faults cleared by the IED. Access to this information is available through the communication ports. The information stored in each fault report is listed below.

3.33.2 Fault Start Time Tag

It presents the date and time of the pickup of the first element involved in the fault. It also includes:

- **Pre-fault currents and voltages**. They are the values of the phase and calculated ground of each winding, differential currents and restraint currents (through current and harmonic) ground and of the measured voltages (phase and ground) two cycles before the onset of the fault; that is, before the pickup of the element generating this fault report.

  The values of the negative and zero sequence currents of each winding are also registered. The currents (except for the differential, restraint and sequence magnitudes) as well as the voltages are recorded with their arguments.

  For **IDV-D/F** relays, prefault magnitudes are the phase currents measured by the four three phase current channels, residual and restraint currents (through pass current and harmonics) and phase currents measured two cycles in advance of fault commencement.

- **Elements picked up** (depending on the model) for full fault duration.

3.33.3 Trip Command Time Tag

It presents the date and time of the trip command. It also presents:

- **Fault currents and voltages**. They are the values of the phase and calculated ground of each winding, differential currents and restraint currents (through current and harmonic) ground and of the measured voltages (phase and ground) two and a half sequences after the onset of the fault; that is, after the pickup of the element generating this fault report.

  The values of the negative and zero sequence currents of each winding are also registered. The currents (except for the differential, restraint and sequence magnitudes) as well as the voltages are recorded with their arguments.

  For **IDV-D/F** relays, fault magnitudes are the phase currents measured by the four three phase current channels, differential and restraint currents (through pass current and harmonics) and phase currents measured two cycles in advance of fault commencement.

- **Elements tripped** (depending on the model).

3.33.4 End of Fault Time Tag

It is the date and time of the reset of the last element involved in the fault.

For **IDV-A/B/G/H/K/L** Models angle values included in the report use as reference the pre-fault phase A voltage or phase A pre-fault current in winding 1 (IA - Wndg 1 pre-fault) depending on the **Angle Reference** setting. For **IDV-F/H** Models, the angle reference, as per the setting above, can be prefault phase A voltage (VA) or channel 1 prefault phase A current (IA-1). For **IDV-D** Models, the angle reference, as per the setting above, can be prefault phase A current (IA-1) or channel 2 prefault phase A current (IA-2).

Each annotation of the fault report shows the following information at the time of the trip.

- **Frequency**.
- **Setting Group** activated at time of trip.
- **Thermal Image Value** (of each winding) (**IDV-A/B/G/H/K/L** Models).
- **Thermal Image Value** (of each ground channel) (**IDV-D** Models).
- **Ground Differential Current** corresponding to each ground channel (**IDV-A/B/G/H/K/L** Models).
- **Ground Current** of each ground channel (**IDV-D** Models).
- **Overexcitation** value (V/Hz) (**IDV-A/B/G/H/K/L** Models).
- **Hot Spot Thermal Image** value (**IDV-L** and **IDV-*******B****** Models).

3.33.5 Fault Report on HMI

IDV-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.

3.34 Metering History Log

3.34.1 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 **Sampling Interval**. This time interval is adjustable between 1 and 15 minutes.

The **Recording 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 3.34.1 shows how the Metering History Log works.

-**SI**: Sampling Interval; the figure shows an SI value of one minute.

-**RI**: Recording Interval; the figure shows a RI of 15 minutes.

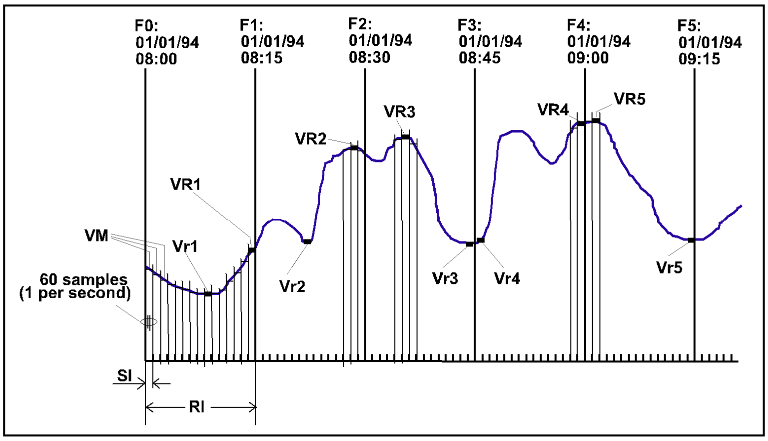


Figure 3.34.1: Explanatory Diagram of the Metering Log.

There are 12 Log Groups. Up to **4 different magnitudes** may be defined within each group for historical record calculations.

Each **SI** yields two **MV** values: the maximum and minimum averages. If only one magnitude is configured in one group, its mean value coincides with its maximum and its minimum values (see figure 3.34.1). Each **RI** interval takes the maximum and minimum values of all the **MV**s computed. The profile of figure 3.34.1 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 Sampling 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 SI, the value recorded is: 0A / 0V.

As already indicated, twelve (12) values can be configured among all the direct or calculated metering values (“user defined values”, including VDC in models with power supply voltage monitoring) 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 **Sampling Interval** are found. See figure 3.34.2.

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 **Week Mask** (the same hour range for all the days). No values outside the mask will be recorded.

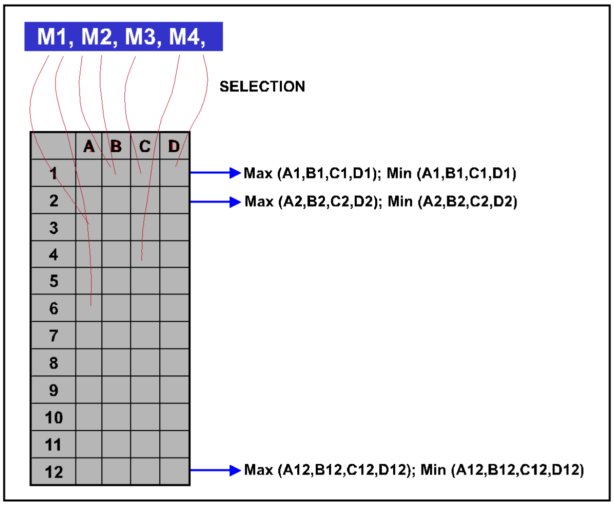


Figure 3.34.2: Metering History Log Logic.

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®***.

3.34.2 Metering History Log Settings

Metering History Log			
Setting	**Range**	**Step**	**By Default**
Sampling Interval	1 - 15 min	1	1 min
Recording Interval	00.00 to 24:00		00:01
Week Mask	Monday to Sunday	YES / NO	YES
Recording Start Time	00.00 to 24:00		00.00
Recording End Time	00.00 to 24:00		24:00

Log Groups (IDV-A/B Models)				
There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:				
Null	H8A CAW1	CWNDG3N	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW2	CDIF H2A	CMINW3	RMSWNDG1CB
ACC C W2	H8A CAW2	CDIF H2B	NSC_W1	RMSWNDG1CC
ACC C W3	CNV1	CDIF H2C	NSC_W2	RMSWNDG2CA
ALARMS	DFREQ	CDIF H3A	NSC_W3	RMSWNDG2CB
H2A CAW1	PF	CDIF H3B	PSC_W1	RMSWNDG2CC
H2A CAW2	FREQ	CDIF H3C	PSC_W2	RMSWNDG3CA
H2A CAW3	CABI D1	CDIF H4A	PSC_W3	RMSWNDG3CB
H2A CG2	CABI D2	CDIF H4B	ZSC_W1	RMSWNDG3CC
H3A CAW2	CABI D3	CDIF H4C	ZSC_W2	RMSIG1
H3A CAW3	CADIF	CDIF H5A	ZSC_W 3	RMSIG2
H4A CAW1	CBDIF	CDIF H5B	THERM W1	S
H4A CAW2	CCDIF	CDIF H5C	THERM W2	SMAX
H4A CAW3	CWNDG1A	CRESTR A	THERM W3	SMIN
H5A CAW1	CWNDG1B	CRESTR B	N.A.ENGY	TACTIVE
H5A CAW2	CWNDG1C	CRESTR C	N.R.ENGY	VDC
H5A CAW3	CWNDG1N	CG1	P	VMAX
H5A CG2	CWNDG2A	CG2	P.Active Energy	VMIN
H6A CAW1	CWNDG2B	CGN1	PMAX	VG
H6A CAW2	CWNDG2C	CGN2	PMIN	VPH
H6A CAW3	CWNDG2N	CMAXW1	P.Reactive Energy	V/HZ
H7A CAW1	CWNDG3A	CMAXW2	Q	
H7A CAW2	CWNDG3B	CMAXW3	QMAX	
H7A CAW3	CWNDG3C	CMINW1	QMIN	
Note: all magnitudes for history log are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.				

Log Groups (IDV-D Models)				
Up to 12 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:				
Null	ANGIC4	H8AIAW2	IWNDG2N	THERM W1
CUMIOPEN_A1	ANGIG1	H8AIAW3	IWNDG3A	THERM W2
CUMIOPEN_A2	ANGIG2	FREQ	IWNDG3B	THERM W3
CUMIOPEN_A3	ANGIN1	IA1	IWNDG3C	THERM 49G1
CUMIOPEN_A4	ANGIN2	IB1	IWNDG3N	THERM 49G2
CUMIOPEN_B1	ANGIN3	IC1	IDIF H2A	N_OPEN_1
CUMIOPEN_B2	ANGIN4	IA2	IDIF H3A	N_OPEN_2
CUMIOPEN_B3	ANG PS W1	IB2	IDIF H4A	N_OPEN_3
CUMIOPEN_B4	ANG PS W2	IC2	IDIF H5A	N_OPEN_4
CUMIOPEN_C1	ANG PS W3	IA3	IDIF H2B	COLDSTART
CUMIOPEN_C2	ANG ZS W1	IB3	IDIF H3B	N_CLOSING_1
CUMIOPEN_C3	ANG ZS W2	IC3	IDIF H4B	N_CLOSING_2
CUMIOPEN_C4	ANG ZS W3	IA4	IDIF H5B	N_CLOSING_3
ALARMS	ANG NS W1	IB4	IDIF H2C	N_CLOSING_4
ANG W1A	ANG NS W2	IC4	IDIF H3C	WARMSTART
ANG W1B	ANG NS W3	OPENI_A1	IDIF H4C	NTRAPS
ANG W1C	H2AIAW1	OPENI_A2	IDIF H5C	Null
ANG W1N	H2AIAW2	OPENI_A3	IRESTR A	RMSWNDG1IA
ANG W2A	H2AIAW3	OPENI_A4	IRESTR B	RMSWNDG2IA
ANG W2B	H2 IG2	OPENI_B1	IRESTR C	RMSWNDG3IA
ANG W2C	H3AIAW1	OPENI_B2	IG1	RMS_IG1
ANG W2N	H3AIAW2	OPENI_B3	IG2	RMS_IG2
ANG W3A	H3AIAW3	OPENI_B4	IGN1	FAULTIME
ANG W3B	H4AIAW1	OPENI_C1	IGN2	ACTGR
ANG W3C	H4AIAW2	OPENI_C2	IN1	T_FLTCLEAR_A1
ANG W3N	H4AIAW3	OPENI_C3	IN2	T_FLTCLEAR_A2
ANGIA1	H5AIAW1	OPENI_C4	IN3	T_FLTCLEAR_A3
ANGIA2	H5AIAW2	IDIFFA	IN4	T_FLTCLEAR_A4
ANGIA3	H5AIAW3	IDIFFB	PSC_W1	T_FLTCLEAR_B1
ANGIA4	H5 IG2	IDIFFC	PSC_W2	T_FLTCLEAR_B2
ANGIB1	H6AIAW1	IWNDG1A	PSC_W3	T_FLTCLEAR_B3
ANGIB2	H6AIAW2	IWNDG1B	ZSC_W1	T_FLTCLEAR_B4
ANGIB3	H6AIAW3	IWNDG1C	ZSC_W2	T_FLTCLEAR_C1
ANGIB4	H7AIAW1	IWNDG1N	ZSC_W3	T_FLTCLEAR_C2
ANGIC1	H7AIAW2	IWNDG2A	NSC_W1	T_FLTCLEAR_C3
ANGIC2	H7AIAW3	IWNDG2B	NSC_W2	T_FLTCLEAR_C4
ANGIC3	H8AIAW1	IWNDG2C	NSC_W3	
Note: all magnitudes for history log are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.				

Log Groups (IDV-F Models)

There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:

NulL	CSDCOMP1	CWNDG1A	CDIF C2A	NSV
DFREQ	CSDCOMP2	CWNDG1B	CDIF C3A	PSV
FREQ	CSDCOMP3	CWNDG1C	CDIF C4A	TACTIVE
CA1	CSDCOMP4	CWNDG2A	CDIF C5A	VA
CB1	CSHCOMP1	CWNDG2B	CRESTR A	VB
CC1	CSHCOMP2	CWNDG2C	CRESTR B	VC
CA2	CSHCOMP3	CWNDG3A	CRESTR C	ZSV
CB2	CSHCOMP4	CWNDG3B	DSC_D1	
CC2	CSICOMP1	CWNDG3C	DSC_D2	
CA3	CSICOMP2	CDIF A2A	DSC_D3	
CB3	CSICOMP3	CDIF A3A	HSC_D1	
CC3	CSICOMP4	CDIF A4A	HSC_D2	
CA4	CADIF	CDIF A5A	HSC_D3	
CB4	CBDIF	CDIF B2A	ISC_D1	
CC4	CCDIF	CDIF B3A	ISC_D2	
		CDIF B4A	ISC_D3	
		CDIF B5A		

Note: all magnitudes for history log are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.

Log Groups (IDV-G/J Models)

There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:

Null	H8A CAW1	CDIF A2A	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW1	CDIF A3A	PSC_W1	RMSWNDG1CB
ACC C W2	CNV1	CDIF A4A	PSC_W2	RMSWNDG1CC
ALARMS	DFREQ	CDIF A5A	ZSC_W1	RMSWNDG2CA
H2A CAW1	PF	CDIF B2A	ZSC_W2	RMSWNDG2CB
H2A CAW2	FREQ	CDIF B3A	NSC_W1	RMSWNDG2CC
H2A CG2	CABI D1	CDIF B4A	NSC_W2	RMSIG1
H3A CAW2	CABI D2	CDIF B5A	THERM W1	S
H3A CAW1	CADIF	CDIF C2A	THERM W2	SMAX
H4A CAW2	CBDIF	CDIF C3A	N.A.ENGY	SMIN
H5A CAW1	CCDIF	CDIF C4A	N.R.ENGY	ACTGRP
H5A CAW2	CWNDG1A	CDIF C5A	P	VDC
H5A CG2	CWNDG1B	CRESTR A	P.Active Energy	VMAX
H6A CAW1	CWNDG1C	CRESTR B	PMAX	VMIN
H6A CAW2	CWNDG1N	CRESTR C	PMIN	VA
H7A CAW1	CWNDG2A	IG1	P.Reactive Energy	VB
H7A CAW2	CWNDG2B	IGN1	Q	VC
	CWNDG2C	CMAXW1	QMAX	PSV
	CWNDG2N	CMAXW2	QMIN	NSV
		CMINW1		ZSV
				V/HZ

Note: all magnitudes for history log are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.

Log Groups (IDV-H/K Models)				
There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:				
Null	H8A CAW1	CWNDG3N	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW2	CDIF A2A	CMINW3	RMSWNDG1CB
ACC C W2	H8A CAW3	CDIF A3A	PSC_W1	RMSWNDG1CC
ACC C W3	CNV1	CDIF A4A	PSC_W2	RMSWNDG2CA
ALARMS	DFREQ	CDIF A5A	PSC_W3	RMSWNDG2CB
H2A CAW1	PF	CDIF B2A	ZSC_W1	RMSWNDG2CC
H2A CAW2	FREQ	CDIF B3A	ZSC_W2	RMSWNDG3CA
H2A CAW3	CABI D1	CDIF B4A	ZSC_W3	RMSWNDG3CB
H2A CG2	CABI D2	CDIF B5A	NSC_W1	RMSWNDG3CC
H3A CAW2	CABI D3	CDIF C2A	NSC_W2	RMS_IG1
H3A CAW3	CADIF	CDIF C3A	NSC_W3	RMS_IG2
H4A CAW1	CBDIF	CDIF C4A	THERM W1	S
H4A CAW2	CCDIF	CDIF C5A	THERM W2	SMAX
H4A CAW2	CWNDG1A	CRESTR A	THERM W3	SMIN
H5A CAW1	CWNDG1B	CRESTR B	N.A.ENGY	ACTGRP
H5A CAW2	CWNDG1C	CRESTR C	N.R.ENGY	VDC
H5A CAW3	CWNDG1N	IG1	P	VMAX
H5A CG2	CWNDG2A	IG2	P.Active Energy	VMIN
H6A CAW1	CWNDG2B	IGN1	PMAX	VA
H6A CAW2	CWNDG2C	IGN2	PMIN	VB
H6A CAW3	CWNDG2N	CMAXW1	P.Reactive Energy	VC
H7A CAW1	CWNDG3A	CMAXW2	Q	PSV
H7A CAW2	CWNDG3B	CMAXW3	QMAX	NSV
H7A CAW3	CWNDG3C	CMINW1	QMIN	ZSV
				V/HZ
Note: all magnitudes for history log are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.				

Event Magnitudes (IDV-L Models)					
There are 12 Log Groups. Up to 4 different magnitudes may be defined within each group for historical record calculations. Said magnitudes are:					
ACC C W1	ANG W2C	H6A IAW1	IRESTR A	M V2 12	RMSWNDG1IB
ACC C W2	ANG W2N	H6A IAW2	IRESTR B	M V2 13	RMSWNDG1IC
ACC C W3	ANG W3A	H6A IAW3	IRESTR C	M V2 14	RMSWNDG2IA
ACT TIME	ANG W3B	H7A IAW1	IWNDG1A	M V2 15	RMSWNDG2IB
ACTGRP	ANG W3C	H7A IAW2	IWNDG1B	M V2 16	RMSWNDG2IC
ALARMS	ANG W3N	H7A IAW3	IWNDG1C	N E AF 1	RMSWNDG3IA
ANG IA	ANG ZSW1	H8A IAW1	IWNDG1N	N E AF 2	RMSWNDG3IB
ANG IACOMP_1	ANG ZSW2	H8A IAW2	IWNDG2A	N E DF 1	RMSWNDG3IC
ANG IACOMP_2	ANG ZSW3	H8A IAW3	IWNDG2B	N E DF 2	ROC FREQ
ANG IACOMP_3	CMAXW1	I_EFD1	IWNDG2C	N Er AC 1	S
ANG IBCOMP_1	CMAXW2	I_EFD2	IWNDG2N	N Er AC 2	SMAX
ANG IBCOMP_2	CMAXW3	I_EFD3	IWNDG3A	N.A.ENGY	SMIN
ANG IBCOMP_3	CMINW1	IA	IWNDG3B	N.R.ENGY	T Act 1
ANG ICCOMP_1	CMINW2	IACP1	IWNDG3C	NSC_W1	T Act 2
ANG ICCOMP_2	CMINW3	IACP2	IWNDG3N	NSC_W2	T AMBIENT
ANG ICCOMP_3	COLDSTARTS	IACP3	M V1 01	NSC_W3	T HOT SPOT
ANG IG1	COOLING EFFICIENCY	IBCP1	M V1 02	NSCCP1	T OIL
ANG IG2	CUMULATIVE LOSS LIFE	IBCP2	M V1 03	NSCCP2	THERM W1
ANG NSCCOMP_1	D_I1MAX	IBCP3	M V1 04	NSCCP3	THERM W2
ANG NSCCOMP_2	D_I2MAX	ICCP1	M V1 05	NTRAPS	THERM W3
ANG NSCCOMP_3	D_I3MAX	ICCP2	M V1 06	Null	TRANSDUCER C1
ANG NSW1	D_PMAX	ICCP3	M V1 07	OPENC W1	TRANSDUCER C2
ANG NSW2	D_QMAX	IDIF H2A	M V1 08	OPENC W2	V/Hz
ANG NSW3	D_SMAX	IDIF H2B	M V1 09	OPENC W3	VA
ANG PSCCOMP_1	D_VMAX	IDIF H2C	M V1 10	P	VAB
ANG PSCCOMP_2	FAULTT	IDIF H3A	M V1 11	P.Active Energy	VB
ANG PSCCOMP_3	FAULTT	IDIF H3B	M V1 12	P.React. Energy	VBC
ANG PSW1	FREQ	IDIF H3C	M V1 13	PF	VC
ANG PSW2	H2A IAW1	IDIF H4A	M V1 14	PMAX	VCA
ANG PSW3	H2A IAW2	IDIF H4B	M V1 15	PMIN	VMAX
ANG VA	H2A IAW3	IDIF H4C	M V1 16	PSC_W1	VMIN
ANG VAAB	H2A IG2	IDIF H5A	M V2 01	PSC_W2	VN
ANG VB	H3A IAW1	IDIF H5B	M V2 02	PSC_W3	WARMSTARTS
ANG VC	H3A IAW2	IDIF H5C	M V2 03	PSCCP1	ZSC_W1
ANG VN	H3A IAW3	IDIFFA	M V2 04	PSCCP2	ZSC_W2
ANG W1A	H4A IAW1	IDIFFB	M V2 05	PSCCP3	ZSC_W3
ANG W1B	H4A IAW2	IDIFFC	M V2 06	Q	
ANG W1C	H4A IAW3	IG1	M V2 07	QMAX	
ANG W1N	H5A IAW1	IG2	M V2 08	QMIN	
ANG W2A	H5A IAW2	IGN1	M V2 09	RMSIG1	
ANG W2B	H5A IAW3	IGN2	M V2 10	RMSIG2	
Note: all magnitudes for history log are stored in secondary values; therefore not affected by any primary-to-secondary ratio except for energy magnitudes that are always recorded in primary values.					

- ## Metering History Log: HMI Access

0 - CONFIGURATION	0 - GENERAL	**0 - SAMPLE INTERVAL**
1 - ACTIVATE GROUP	...	**1 - LOG REC. INTERVAL**
2 - CHANGE SETTINGS	**9 - HISTORY**	**2 - HIST. START TIME**
3 - INFORMATION	...	**3 - HIST. END TIME**

3.35 Oscillographic Recording

3.35.1 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.

The sampling and storage frequency is **32 samples per cycle** with **750 cycles of total storage** (up to 555 cycles for the **IDV-F** model). The storage frequency can be selected in model **IDV-D**, by means of setting (32 or 16 samples per cycle). If a frequency of 16 samples per cycle is selected, total storage time will be 2975 cycles. Permanence of the information, with the IED disconnected from the power supply, is guaranteed during 28 days at 25º.

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.

3.35.2 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.

In a system with a frequency between 16Hz and 81Hz, the IED can capture signals with a frequency range between 3Hz and 500Hz. The response in the higher side could be better when working with 64 samples per cycle; in any case this limit can be reached when the signal duration is greater than one millisecond.

3.35.3 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.

3.35.4 Number of Channels and Digital Signals

Depending on the model is possible to record up to 20 or 23 analog values (up to15 analog channels and 5 or 8 values*), 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.

Models with Power Supply Voltage Monitoring measure the voltage via a transducer input. This value is considered an user-defined value.

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. The power supply voltage is stored with the label **VDC**.

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.

3.35.5 Start Function

The start function is determined by a programmable mask applied to certain internal signals (unit 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**.

3.35.6 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.).

3.35.7 Trip Required

Data are stored only if a trip occurs within the time configured as Oscillography record length.

3.35.8 Concatenation Stream Mode

The **YES** / **NO** setting allow extending the oscillography record length if new pickups of units occur while one is being recorded. The recording system restarts the count of sequences to store if any other unit picks up before the unit generating the oscillography pickup resets.

It is possible for multiple pickups to occur during a fault. Sometimes these pickups 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, pickups occurring during adjusted interval after the first pickup do not extend the length of the oscillography.

3.35.9 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.

3.35.10 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 (FIFO memory).

The maximum number of waveform records is 64, and the maximum number of cycles that can be stored in memory is 725 (**IDV-A**), 2950 (**IDV-D**) or 530 (**IDV-B/F/G/H/J/K/L**). Depending on the length selected, the maximum number varies.

Set number of cycles	Max. number of oscillographs
725	1
350	2
175	3
...	...
22	32
11	64

Note 1: 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.
Note 2: modifying settings belonging to the oscillography recording or loading a programmable logic configuration will erase all the oscillography files recorded in the IED.

3.35.11 Recording Frequency

IDV-D Models count on a setting that enables the selection of sample storage inside the oscillograph. The two options included are 32 and 16 samples per cycle, which count on a total storage time of 30 and 60 seconds, respectively.

3.35.12 Interval between Triggers

This setting is used to discriminate whether consecutive elements pick-ups correspond to the same fault or not. This way, all activations during that interval would be considered as belonging to the same fault and, therefore, the record is not enlarged

However, for activations after that time, and as long as the **Continuous Mode** setting is enabled, the record will be enlarged as per the **Length of the Oscillograph** setting.

3.35.13 Oscillography Settings

Oscillography			
Setting	**Range**	**Step**	**By Default**
Trip Required	YES / NO		YES
Continuous Mode	YES / NO		NO
Pre-Fault Recording Length	0 - 25 cycles	1 cycle	5 cycles
Post-Fault Recording Length (2 windings)	5 - 725 cycles	1 cycle	5 cycles
Post-Fault Recording Length (3 windings)	5 - 530 cycles	1 cycle	5 cycles
Post-Fault Recording Length (3 windings) (IDV-D)	5 - 2950 cycles	1 cycle	5 cycles
Interval between Triggers (2 windings models)	1 - 725 cycles	1 cycle	4 cycles
Interval between Triggers (3 windings models)	1 - 530 cycles	1 cycle	4 cycles
Recording Frequency (IDV-D)	32 s/c 16 s/c		32 s/c

Trigger Mask		
Setting	**Setting**	**Setting**
Differential with Restraint (87T)	YES / NO	NO
Instantaneous Differential without Restraint (87I)	YES / NO	NO
Zone 1 Ground	YES / NO	NO
Zone 1 Phases	YES / NO	NO
Zone 2 Ground	YES / NO	NO
Zone 2 Phases	YES / NO	NO
Zone 3 Ground	YES / NO	NO
Zone 3 Phases	YES / NO	NO
Zone 4 Ground	YES / NO	NO
Zone 4 Phases	YES / NO	NO
Phase Instantaneous Overcurrent; W1 (50F_1D1, 50F_1D2 and 50F_1D3)	YES / NO	NO
Phase Instantaneous Overcurrent; W2 (50F_2D1, 50F_2D2 and 50F_2D3)	YES / NO	NO
Phase Instantaneous Overcurrent; W3 (50F_3D1, 50F_3D2 and 50F_3D3)	YES / NO	NO
Phase Time Overcurrent; W1 (51F_1D1 and 51F_1D2)	YES / NO	NO
Phase Time Overcurrent; W2 (51F_2D1 and 51F_2D2)	YES / NO	NO
Phase Time Overcurrent; W3 (51F_3D1 and 51F_3D2)	YES / NO	NO
Calculated Gr. Instantaneous Overcurrent; W1 (50N_1D1 and 50N_1D2)	YES / NO	NO
Calculated Gr. Instantaneous Overcurrent; W2 (50N_2D1 and 50N_2D2)	YES / NO	NO
Calculated Gr. Instantaneous Overcurrent; W3 (50N_3D1 and 50N_3D2)	YES / NO	NO
Calculated Ground Time Overcurrent; W1 (51N_1D1 and 51N_1D2)	YES / NO	NO
Calculated Ground Time Overcurrent; W2 (51N_2D1 and 51N_2D2)	YES / NO	NO
Calculated Ground Time Overcurrent; W3 (51N_3D1 and 51N_3D2)	YES / NO	NO
Ground Instantaneous Overcurrent; channel 1 (50G_11 and 50G_12)	YES / NO	NO
Ground Instantaneous Overcurrent; channel 2 (50G_21 and 50G_22)	YES / NO	NO
Ground Instantaneous Overcurrent; channel 3 (50G_31 and 50G_32)	YES / NO	NO
Ground Instantaneous Overcurrent; channel 4 (50G_41 and 50G_42)	YES / NO	NO
Ground Instantaneous Overcurrent; channel 5 (50G_51 and 50G_52)	YES / NO	NO
Ground Time Overcurrent; channel 1 (51G_11 and 51G_12)	YES / NO	NO
Ground Time Overcurrent; channel 2 (51G_21 and 51G_22)	YES / NO	NO
Ground Time Overcurrent; channel 3 (51G_31 and 51G_32)	YES / NO	NO
Ground Time Overcurrent; channel 4 (51G_41 and 51G_42)	YES / NO	NO
Ground Time Overcurrent; channel 5 (51G_51 and 51G_52)	YES / NO	NO
Negative Seq. Instantaneous Overcurrent; W1 (50Q_1D1 and 50Q_1D2)	YES / NO	NO
Negative Seq. Instantaneous Overcurrent; W2 (50Q_2D1 and 50Q_2D2)	YES / NO	NO
Negative Seq. Instantaneous Overcurrent; W3 (50Q_3D1 and 50Q_3D2)	YES / NO	NO
Negative Seq. Time Overcurrent; W1 (51Q_1D1 and 51Q_1D2)	YES / NO	NO
Negative Seq. Time Overcurrent; W2 (51Q_2D1 and 51Q_2D2)	YES / NO	NO
Negative Seq. Time Overcurrent; W3 (51Q_3D1 and 51Q_3D2)	YES / NO	NO
Tertiary Instantaneous Overcurrent (without Restraint) (50SFA)	YES / NO	NO
Tertiary Instantaneous Overcurrent (with Restraint) (50FA)	YES / NO	NO

Trigger Mask		
Setting	**Setting**	**Setting**
Phase Overvoltage (59F1 and 59F2)	YES / NO	NO
Phase Undervoltage (27F1 and 27F2)	YES / NO	NO
Ground Overvoltage (64_1 and 64_2)	YES / NO	NO
Overfrequency (81M1, 81M2, 81M3 and 81M4)	YES / NO	NO
Underfrequency (81m1, 81m2, 81m3 and 81m4)	YES / NO	NO
Frequency Rate of Change (81D1, 81D2, 81D3 and 81D4)	YES / NO	NO
Thermal Image; W1 (49_1D)	YES / NO	NO
Thermal Image; W2 (49_2D)	YES / NO	NO
Thermal Image; W3 (49_3D)	YES / NO	NO
Restricted Earth Faults; Channel 1 (87N_11 and 87N_12)	YES / NO	NO
Restricted Earth Faults; Channel 2 (87N_21 and 87N_22)	YES / NO	NO
Overexcitation (24)	YES / NO	NO
Hot Spot Thermal Image	YES / NO	NO
Oil Temperature level	YES / NO	NO
Instantaneous Overload (50OL)	YES / NO	NO
Time Overload (51OL)	YES / NO	NO
Programmable Trip (configurable in the programmable logic)	YES / NO	NO
Transformer Protections Trips (EX_1, EX_2, EX_3, EX_4, EX_5, EX_6, EX_7, EX_8)	YES / NO	NO
External Trigger	YES / NO	NO
Power Supply Undervoltage	YES / NO	NO
Power Supply Overvoltage	YES / NO	NO

Analog Channel Mask (maximum 13 channels) (IDV-A/B Model)		
1 - Phase Voltage	2 - Ground Voltage	3 - Phase A Current (Winding 1)
4 - Phase B Current (Winding 1)	5 - Phase C Current (Winding 1)	6 - Phase A Current (Winding 2)
7 - Phase B Current (Winding 2)	8 - Phase C Current (Winding 2)	9 - Ground Current 1
10 - Ground Current 2	11 - Phase A Current (Winding 3)	12 - Phase B Current (Winding 3)
13 - Phase C Current (Winding 3)		

Analog Channel Mask (maximum 14 channels) (IDV-D Model)		
1 - Channel 1 Phase A Current	2 - Channel 1 Phase B Current	3 - Channel 1 Phase C Current
4 - Channel 2 Phase A Current	5 - Channel 2 Phase B Current	6 - Channel 2 Phase C Current
7 - Channel 3 Phase A Current	8 - Channel 3 Phase B Current	9 - Channel 3 Phase C Current
10 - Ground Current 1	11 - Channel 4 Phase A Current	12 - Channel 4 Phase B Current
13 - Channel 4 Phase C Current	14 - Ground Current 2	

Analog Channel Mask (maximum 15 channels) (IDV-F Model)		
1 - Phase A Voltage	2 - Phase B Voltage	3 - Phase C Voltage
4 - Phase A Current Channel 1	5 - Phase B Current Channel 1	6 - Phase C Current Channel 1
7 - Phase A Current Channel 2	8 - Phase B Current Channel 2	9 - Phase C Current Channel 2
10 - Phase A Current Channel 3	11 - Phase B Current Channel 3	12 - Phase C Current Channel 3
13 - Phase A Current Channel 4	14 - Phase B Current Channel 4	15 - Phase C Current Channel 4

Analog Channel Mask (maximum 10 channels) (IDV-G/J Model)		
1 - Phase A Voltage	2 - Phase B Voltage	3 - Phase C Voltage
4 - Phase A Current (Winding 1)	5 - Phase B Current (Winding 1)	6 - Phase C Current (Winding 1)
7 - Phase A Current (Winding 2)	8 - Phase B Current (Winding 2)	9 - Phase C Current (Winding 2)
10 - Ground Current		

Analog Channel Mask (maximum 14 channels) (IDV-H/K Model)		
1 - Phase A Voltage	2 - Phase B Voltage	3 - Phase C Voltage
4 - Phase A Current (Winding 1)	5 - Phase B Current (Winding 1)	6 - Phase C Current (Winding 1)
7 - Phase A Current (Winding 2)	8 - Phase B Current (Winding 2)	9 - Phase C Current (Winding 2)
10 - Ground Current 1	11 - Ground Current 2	12 - Phase A Current (Winding 3)
13 - Phase B Current (Winding 3)	14 - Phase C Current (Winding 3)	

Analog Channel Mask (maximum 14 channels) (IDV-L Model)		
1 – Phase A Voltage A	2 - Phase B Voltage	3 - Phase C Voltage
4 – Ground Voltage	5 - Phase A Current (Winding 1)	6 - Phase B Current (Winding 1)
7 - Phase C Current (Winding 1)	8 - Phase A Current (Winding 2)	9 - Phase B Current (Winding 2)
10 - Phase C Current (Winding 2)	11 - Phase A Current (Winding 3)	12 - Phase B Current (Winding 3)
13 - Phase C Current (Winding 3)	14 – Ground Current 1	15 – Ground Current 2

User Defined Values (Up to 5 Values) (IDV-A/B Models)				
Null	H8A CAW1	CWNDG3N	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW2	CDIF H2A	CMINW3	RMSWNDG1CB
ACC C W2	H8A CAW2	CDIF H2B	NSC_W1	RMSWNDG1CC
ACC C W3	CNV1	CDIF H2C	NSC_W2	RMSWNDG2CA
ALARMS	DFREQ	CDIF H3A	NSC_W3	RMSWNDG2CB
H2A CAW1	PF	CDIF H3B	PSC_W1	RMSWNDG2CC
H2A CAW2	FREQ	CDIF H3C	PSC_W2	RMSWNDG3CA
H2A CAW3	CABI D1	CDIF H4A	PSC_W3	RMSWNDG3CB
H2A CG2	CABI D2	CDIF H4B	ZSC_W1	RMSWNDG3CC
H3A CAW2	CABI D3	CDIF H4C	ZSC_W2	RMSIG1
H3A CAW3	CADIF	CDIF H5A	ZSC_W 3	RMSIG2
H4A CAW1	CBDIF	CDIF H5B	THERM W1	S
H4A CAW2	CCDIF	CDIF H5C	THERM W2	SMAX
H4A CAW3	CWNDG1A	CRESTR A	THERM W3	SMIN
H5A CAW1	CWNDG1B	CRESTR B	N.A.ENGY	TACTIVE
H5A CAW2	CWNDG1C	CRESTR C	N.R.ENGY	VDC
H5A CAW3	CWNDG1N	CG1	P	VMAX
H5A CG2	CWNDG2A	CG2	P.Active Energy	VMIN
H6A CAW1	CWNDG2B	CGN1	PMAX	VG
H6A CAW2	CWNDG2C	CGN2	PMIN	VPH
H6A CAW3	CWNDG2N	CMAXW1	P.Reactive Energy	V/HZ
H7A CAW1	CWNDG3A	CMAXW2	Q	
H7A CAW2	CWNDG3B	CMAXW3	QMAX	
H7A CAW3	CWNDG3C	CMINW1	QMIN	

User Defined Values (Up to 5 Values) (IDV-D Models)				
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:				
Null	ANGIC4	H8AIAW2	IWNDG2N	THERM W1
CUMIOPEN_A1	ANGIG1	H8AIAW3	IWNDG3A	THERM W2
CUMIOPEN_A2	ANGIG2	FREQ	IWNDG3B	THERM W3
CUMIOPEN_A3	ANGIN1	IA1	IWNDG3C	THERM 49G1
CUMIOPEN_A4	ANGIN2	IB1	IWNDG3N	THERM 49G2
CUMIOPEN_B1	ANGIN3	IC1	IDIF H2A	N_OPEN_1
CUMIOPEN_B2	ANGIN4	IA2	IDIF H3A	N_OPEN_2
CUMIOPEN_B3	ANG PS W1	IB2	IDIF H4A	N_OPEN_3
CUMIOPEN_B4	ANG PS W2	IC2	IDIF H5A	N_OPEN_4
CUMIOPEN_C1	ANG PS W3	IA3	IDIF H2B	COLDSTART
CUMIOPEN_C2	ANG ZS W1	IB3	IDIF H3B	N_CLOSING_1
CUMIOPEN_C3	ANG ZS W2	IC3	IDIF H4B	N_CLOSING_2
CUMIOPEN_C4	ANG ZS W3	IA4	IDIF H5B	N_CLOSING_3
ALARMS	ANG NS W1	IB4	IDIF H2C	N_CLOSING_4
ANG W1A	ANG NS W2	IC4	IDIF H3C	WARMSTART
ANG W1B	ANG NS W3	OPENI_A1	IDIF H4C	NTRAPS
ANG W1C	H2AIAW1	OPENI_A2	IDIF H5C	Null
ANG W1N	H2AIAW2	OPENI_A3	IRESTR A	RMSWNDG1IA
ANG W2A	H2AIAW3	OPENI_A4	IRESTR B	RMSWNDG2IA
ANG W2B	H2 IG2	OPENI_B1	IRESTR C	RMSWNDG3IA
ANG W2C	H3AIAW1	OPENI_B2	IG1	RMS_IG1
ANG W2N	H3AIAW2	OPENI_B3	IG2	RMS_IG2
ANG W3A	H3AIAW3	OPENI_B4	IGN1	FAULTIME
ANG W3B	H4AIAW1	OPENI_C1	IGN2	ACTGR
ANG W3C	H4AIAW2	OPENI_C2	IN1	T_FLTCLEAR_A1
ANG W3N	H4AIAW3	OPENI_C3	IN2	T_FLTCLEAR_A2
ANGIA1	H5AIAW1	OPENI_C4	IN3	T_FLTCLEAR_A3
ANGIA2	H5AIAW2	IDIFFA	IN4	T_FLTCLEAR_A4
ANGIA3	H5AIAW3	IDIFFB	PSC_W1	T_FLTCLEAR_B1
ANGIA4	H5 IG2	IDIFFC	PSC_W2	T_FLTCLEAR_B2
ANGIB1	H6AIAW1	IWNDG1A	PSC_W3	T_FLTCLEAR_B3
ANGIB2	H6AIAW2	IWNDG1B	ZSC_W1	T_FLTCLEAR_B4
ANGIB3	H6AIAW3	IWNDG1C	ZSC_W2	T_FLTCLEAR_C1
ANGIB4	H7AIAW1	IWNDG1N	ZSC_W3	T_FLTCLEAR_C2
ANGIC1	H7AIAW2	IWNDG2A	NSC_W1	T_FLTCLEAR_C3
ANGIC2	H7AIAW3	IWNDG2B	NSC_W2	T_FLTCLEAR_C4
ANGIC3	H8AIAW1	IWNDG2C	NSC_W3	

User Defined Values (Up to 5 Values) (IDV-F Models)				
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:				
NulL	CSDCOMP1	CWNDG1A	CDIF C2A	NSV
DFREQ	CSDCOMP2	CWNDG1B	CDIF C3A	PSV
FREQ	CSDCOMP3	CWNDG1C	CDIF C4A	TACTIVE
CA1	CSDCOMP4	CWNDG2A	CDIF C5A	VA
CB1	CSHCOMP1	CWNDG2B	CRESTR A	VB
CC1	CSHCOMP2	CWNDG2C	CRESTR B	VC
CA2	CSHCOMP3	CWNDG3A	CRESTR C	ZSV
CB2	CSHCOMP4	CWNDG3B	DSC_D1	
CC2	CSICOMP1	CWNDG3C	DSC_D2	
CA3	CSICOMP2	CDIF A2A	DSC_D3	
CB3	CSICOMP3	CDIF A3A	HSC_D1	
CC3	CSICOMP4	CDIF A4A	HSC_D2	
CA4	CADIF	CDIF A5A	HSC_D3	
CB4	CBDIF	CDIF B2A	ISC_D1	
CC4	CCDIF	CDIF B3A	ISC_D2	
		CDIF B4A	ISC_D3	
		CDIF B5A		

User Defined Values (Up to 5 Values) (IDV-G/J Models)				
Up to 12 different magnitudes may be selected to be annotated with each equipment event. Said magnitudes are:				
Null	H8A CAW1	CDIF A2A	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW1	CDIF A3A	PSC_W1	RMSWNDG1CB
ACC C W2	CNV1	CDIF A4A	PSC_W2	RMSWNDG1CC
ALARMS	DFREQ	CDIF A5A	ZSC_W1	RMSWNDG2CA
H2A CAW1	PF	CDIF B2A	ZSC_W2	RMSWNDG2CB
H2A CAW2	FREQ	CDIF B3A	NSC_W1	RMSWNDG2CC
H2A CG2	CABI D1	CDIF B4A	NSC_W2	RMSIG1
H3A CAW2	CABI D2	CDIF B5A	THERM W1	S
H3A CAW1	CADIF	CDIF C2A	THERM W2	SMAX
H4A CAW2	CBDIF	CDIF C3A	N.A.ENGY	SMIN
H5A CAW1	CCDIF	CDIF C4A	N.R.ENGY	ACTGRP
H5A CAW2	CWNDG1A	CDIF C5A	P	VDC
H5A CG2	CWNDG1B	CRESTR A	P.Active Energy	VMAX
H6A CAW1	CWNDG1C	CRESTR B	PMAX	VMIN
H6A CAW2	CWNDG1N	CRESTR C	PMIN	VA
H7A CAW1	CWNDG2A	IG1	P.Reactive Energy	VB
H7A CAW2	CWNDG2B	IGN1	Q	VC
	CWNDG2C	CMAXW1	QMAX	PSV
	CWNDG2N	CMAXW2	QMIN	NSV
		CMINW1		ZSV
				V/HZ

User Defined Values (Up to 5 Values) (IDV-H/K Models)				
Null	H8A CAW1	CWNDG3N	CMINW2	RMSWNDG1CA
ACC C W1	H8A CAW2	CDIF A2A	CMINW3	RMSWNDG1CB
ACC C W2	H8A CAW3	CDIF A3A	PSC_W1	RMSWNDG1CC
ACC C W3	CNV1	CDIF A4A	PSC_W2	RMSWNDG2CA
ALARMS	DFREQ	CDIF A5A	PSC_W3	RMSWNDG2CB
H2A CAW1	PF	CDIF B2A	ZSC_W1	RMSWNDG2CC
H2A CAW2	FREQ	CDIF B3A	ZSC_W2	RMSWNDG3CA
H2A CAW3	CABI D1	CDIF B4A	ZSC_W3	RMSWNDG3CB
H2A CG2	CABI D2	CDIF B5A	NSC_W1	RMSWNDG3CC
H3A CAW2	CABI D3	CDIF C2A	NSC_W2	RMS_IG1
H3A CAW3	CADIF	CDIF C3A	NSC_W3	RMS_IG2
H4A CAW1	CBDIF	CDIF C4A	THERM W1	S
H4A CAW2	CCDIF	CDIF C5A	THERM W2	SMAX
H4A CAW2	CWNDG1A	CRESTR A	THERM W3	SMIN
H5A CAW1	CWNDG1B	CRESTR B	N.A.ENGY	ACTGRP
H5A CAW2	CWNDG1C	CRESTR C	N.R.ENGY	VDC
H5A CAW3	CWNDG1N	IG1	P	VMAX
H5A CG2	CWNDG2A	IG2	P.Active Energy	VMIN
H6A CAW1	CWNDG2B	IGN1	PMAX	VA
H6A CAW2	CWNDG2C	IGN2	PMIN	VB
H6A CAW3	CWNDG2N	CMAXW1	P.Reactive Energy	VC
H7A CAW1	CWNDG3A	CMAXW2	Q	PSV
H7A CAW2	CWNDG3B	CMAXW3	QMAX	NSV
H7A CAW3	CWNDG3C	CMINW1	QMIN	ZSV
				V/HZ

User Defined Values (IDV-L Models)					
ACC C W1	ANG W2C	H6A IAW1	IRESTR A	M V2 12	RMSWNDG1IB
ACC C W2	ANG W2N	H6A IAW2	IRESTR B	M V2 13	RMSWNDG1IC
ACC C W3	ANG W3A	H6A IAW3	IRESTR C	M V2 14	RMSWNDG2IA
ACT TIME	ANG W3B	H7A IAW1	IWNDG1A	M V2 15	RMSWNDG2IB
ACTGRP	ANG W3C	H7A IAW2	IWNDG1B	M V2 16	RMSWNDG2IC
ALARMS	ANG W3N	H7A IAW3	IWNDG1C	N E AF 1	RMSWNDG3IA
ANG IA	ANG ZSW1	H8A IAW1	IWNDG1N	N E AF 2	RMSWNDG3IB
ANG IACOMP_1	ANG ZSW2	H8A IAW2	IWNDG2A	N E DF 1	RMSWNDG3IC
ANG IACOMP_2	ANG ZSW3	H8A IAW3	IWNDG2B	N E DF 2	ROC FREQ
ANG IACOMP_3	CMAXW1	I_EFD1	IWNDG2C	N Er AC 1	S
ANG IBCOMP_1	CMAXW2	I_EFD2	IWNDG2N	N Er AC 2	SMAX
ANG IBCOMP_2	CMAXW3	I_EFD3	IWNDG3A	N.A.ENGY	SMIN
ANG IBCOMP_3	CMINW1	IA	IWNDG3B	N.R.ENGY	T Act 1
ANG ICCOMP_1	CMINW2	IACP1	IWNDG3C	NSC_W1	T Act 2
ANG ICCOMP_2	CMINW3	IACP2	IWNDG3N	NSC_W2	T AMBIENT
ANG ICCOMP_3	COLDSTARTS	IACP3	M V1 01	NSC_W3	T HOT SPOT
ANG IG1	COOLING EFFICIENCY	IBCP1	M V1 02	NSCCP1	T OIL
ANG IG2	CUMULATIVE LOSS LIFE	IBCP2	M V1 03	NSCCP2	THERM W1
ANG NSCCOMP_1	D_I1MAX	IBCP3	M V1 04	NSCCP3	THERM W2
ANG NSCCOMP_2	D_I2MAX	ICCP1	M V1 05	NTRAPS	THERM W3
ANG NSCCOMP_3	D_I3MAX	ICCP2	M V1 06	Null	TRANSDUCER C1
ANG NSW1	D_PMAX	ICCP3	M V1 07	OPENC W1	TRANSDUCER C2
ANG NSW2	D_QMAX	IDIF H2A	M V1 08	OPENC W2	V/Hz
ANG NSW3	D_SMAX	IDIF H2B	M V1 09	OPENC W3	VA
ANG PSCCOMP_1	D_VMAX	IDIF H2C	M V1 10	P	VAB
ANG PSCCOMP_2	FAULTT	IDIF H3A	M V1 11	P.Active Energy	VB
ANG PSCCOMP_3	FAULTT	IDIF H3B	M V1 12	P.React. Energy	VBC
ANG PSW1	FREQ	IDIF H3C	M V1 13	PF	VC
ANG PSW2	H2A IAW1	IDIF H4A	M V1 14	PMAX	VCA
ANG PSW3	H2A IAW2	IDIF H4B	M V1 15	PMIN	VMAX
ANG VA	H2A IAW3	IDIF H4C	M V1 16	PSC_W1	VMIN
ANG VAAB	H2A IG2	IDIF H5A	M V2 01	PSC_W2	VN
ANG VB	H3A IAW1	IDIF H5B	M V2 02	PSC_W3	WARMSTARTS
ANG VC	H3A IAW2	IDIF H5C	M V2 03	PSCCP1	ZSC_W1
ANG VN	H3A IAW3	IDIFFA	M V2 04	PSCCP2	ZSC_W2
ANG W1A	H4A IAW1	IDIFFB	M V2 05	PSCCP3	ZSC_W3
ANG W1B	H4A IAW2	IDIFFC	M V2 06	Q	
ANG W1C	H4A IAW3	IG1	M V2 07	QMAX	
ANG W1N	H5A IAW1	IG2	M V2 08	QMIN	
ANG W2A	H5A IAW2	IGN1	M V2 09	RMSIG1	
ANG W2B	H5A IAW3	IGN2	M V2 10	RMSIG2	

Digital Channel Selection (via communications)
Selectable from all configurable Digital Inputs and Digital Signals

- **Oscillographic Recording: HMI Access · IDV-A/B/F/G/H/J/K/L Models**

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP REQUIRED**
1 - ACTIVATE GROUP	...	**1 - CONTINUOUS MODE**
2 - CHANGE SETTINGS	**10 - OSCILLOGRAPHY**	**2 - PRETRIG. LENGTH**
3 - INFORMATION	...	**3 - LENGTH**
		4 - TRIGGERS INTERVAL
		5 - OSCILLO CHANN. MASK

- **Oscillographic Recording: HMI Access · IDV-D Models**

0 - CONFIGURATION	0 - GENERAL	**0 - TRIP REQUIRED**
1 - ACTIVATE GROUP	...	**1 - CONTINUOUS MODE**
2 - CHANGE SETTINGS	**10 - OSCILLOGRAPHY**	**2 - PRETRIG. LENGTH**
3 - INFORMATION	...	**3 - LENGTH**
		4 - TRIGGERS INTERVAL
		5 - RECORDING FREQ
		6 - OSCILLO CHANN. MASK

3.35.14 Digital Inputs of the Oscillographic Recording

Table 3.35-1: Digital Inputs of the Oscillographic Recording

Name	Description	Function
TRIG_EXT_OSC	External oscillography trigger	Input intended for external triggering.
DEL_OSC	Deletion of oscillographs	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.”

3.35.15 Auxiliary Outputs and Events of the Oscillographic Recording

Table 3.35-2: Auxiliary Outputs and Events of the Oscillographic Recording

Name	Description	Function
TRIG_EXT_OSC	External oscillography trigger	The same as for the digital input.
DEL_OSC	Deletion of oscillographs	The same as for the digital input.
PU_OSC	Oscillography picked up	This output indicates that the oscillographic recording is on process.

3.36 Inputs, Outputs & LED Targets

3.36.1 Introduction

The **IDV** has a flexible, user-definable structure of **Inputs / Outputs / LEDs**. It is described in the following sections. Factory programming included default values. Settings can be changed using the software package ***ZivercomPlus®***.

3.36.2 Digital Inputs

The number of digital inputs available will depend on each particular model. 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 Filter 1**: 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** (**1-10**): 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.
- **Time between Samplings Filter 2**: 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-2 Input** (**1-10**): 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.
- **Filter Assignation** (**Filter 1 / Filter 2**): Each configurable digital input can be assigned to "filter 1" or to "filter 2." The settings previously 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 (2-60/1-30s)**: 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 **IDV-***-****01**** model, 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**).

On the other hand, model **IDV-***-****02*****, counts on the following settings related to Digital Inputs:

- **Supervision of ED Input Voltage**: this indicates the input used to supervise the voltage level of digital inputs. By default, the setting is 0 and does not supervise Digital Inputs, which remain enabled. By selecting an input, this supervises the validity of the remaining inputs, which are deemed valid should this ED be activated having exceeded the input voltage threshold.

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 cannot be assigned to more than one status contact input.

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).

3.36.2.a Enable Input

Each protection element module of the **IDV** relay 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.

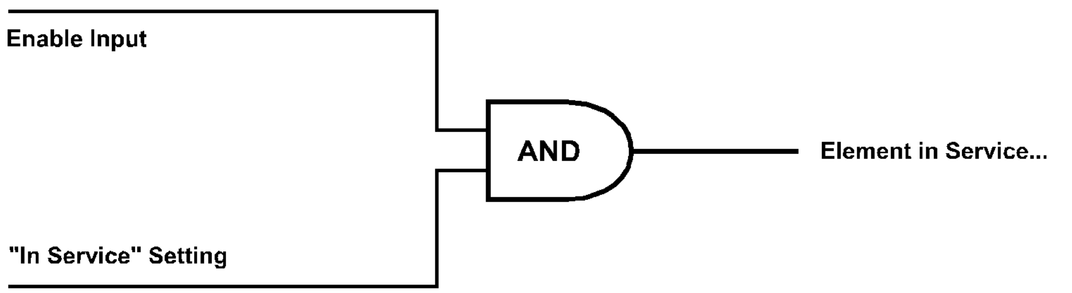


Figure 3.36.1: Element Enable Logic.

The default value of the logic input signal **Element Enable Input**... 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.

3.36.2.b Digital Inputs Table

Table 3.36-1: Digital Inputs

Name	Description	Function
CEXT_TRIP	External trip control	It blocks all trips.
IN_BKR_W1	Input of breaker position winding 1: Open (1) / Closed (0) (IDV-A/B/G/H/J/K/L)	It monitors breakers status.
IN_BKR_W2	Input of breaker position winding 2: Open (1) / Closed (0) (IDV-A/B/G/H/J/K/L)	
IN_BKR_W3	Input of breaker position winding 3: Open (1) / Closed (0) (IDV-A/B/H/K/L)	
IN_BKR1	Input of Open Breaker 1 (IDV-D/F)	
IN_BKR2	Input of Open Breaker 2 (IDV-D/F)	
IN_BKR3	Input of Open Breaker 3 (IDV-D/F)	
IN_BKR4	Input of Open Breaker 4 (IDV-D/F)	
IN_RST_MAX	Maximeters reset	Its activation sets the content of the current, voltage and power demand elements to zero.
IN_PMTR_RST	Power meters reset	Its activation sets the content of the power meters to zero.
ENBL_PLL	Digital PLL input enable	Enables the operation of the automatic system to adapt to the frequency. By default, when not configured, it is a logic “1.”
IN_CLS_CMD_W1	Manual open command winding 1 (IDV-A/B/G/H/J/K/L)	Activation performs manual open and close commands respectively. They can be assigned to the HMI, to communications signals, digital inputs or to any other signal from the programmable logic. Mainly they will be assigned to COMMANDS.
IN_CLS_CMD_W2	Manual open command winding 2 (IDV-A/B/G/H/J/K/L)	
IN_CLS_CMD_W3	Manual open command winding 3 (IDV-A/B/H/K/L)	
IN_OP_CMD_W1	Manual close command winding 1 (IDV-A/B/G/H/J/K/L)	
IN_OP_CMD_W2	Manual close command winding 2 (IDV-A/B/G/H/J/K/L)	
IN_OP_CMD_W3	Manual close command winding 3 (IDV-A/B/H/K/L)	
IN_CLS_CMD1	Manual open command breaker 1 (IDV-D/F)	
IN_CLS_CMD2	Manual open command breaker 2 (IDV-D/F)	
IN_CLS_CMD3	Manual open command breaker 3 (IDV-D/F)	
IN_CLS_CMD4	Manual open command breaker 4 (IDV-D/F)	
IN_OP_CMD1	Manual close command breaker 1 (IDV-D/F)	
IN_OP_CMD2	Manual close command breaker 2 (IDV-D/F)	
IN_OP_CMD3	Manual close command breaker 3 (IDV-D/F)	
IN_OP_CMD4	Manual close command breaker 4 (IDV-D/F)	
LED_1	LED 1	They activate their corresponding LEDs.
LED_2	LED 2	
LED_3	LED 3	
LED_4	LED 4	
LED_5	LED 5 (7IDV)	
LED_6	LED 6 (7IDV)	

Table 3.36-1: Digital Inputs

Name	Description	Function
LED_7	LED 7 (7IDV)	They activate their corresponding LEDs.
LED_8	LED 8 (7IDV)	
LED_9	LED 9 (7IDV)	
LED_10	LED 10 (7IDV)	
LED_11	LED 11 (7IDV)	
LED_12	LED 12 (7IDV)	
LED_13	LED 13 (7IDV)	
LED_14	LED 14 (7IDV)	
LED_15	LED 15 (7IDV)	
LED_16	LED 16 (7IDV)	
LED_86R	LED 86 red (IDV)	
LED_86G	LED 86 green (IDV)	
LED_P1R	LED P1 red (IDV)	
LED_P1G	LED P1 green (IDV)	
LED_P2R	LED P2 red (IDV)	
LED_P2G	LED P2 green (IDV)	
LED_P3R	LED P3 red (IDV)	
LED_P3G	LED P3 green (IDV)	
LED_P4R	LED P4 red (IDV)	
LED_P4G	LED P4 green (IDV)	
LED_P5R	LED P5 red (IDV)	
LED_P5G	LED P5 green (IDV)	
LED_P6R	LED P6 red (IDV)	
LED_P6G	LED P6 green (IDV)	
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 al 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	

Table 3.36-1: Digital Inputs		
Name	**Description**	**Function**
CMD_DIS_DI23	Command to disable digital input 23	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
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	
REMOTE	Remote	Sets the relay in remote mode.
LOCAL	Local Control	Means 'Local Commands' enabled, whose performance is defined in user's logic module.
CONTROL_PANEL	Operation Desk control	Means 'Operation Desk Commands' enabled, whose performance is defined in user's logic module.
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	

Table 3.36-1: Digital Inputs		
Name	**Description**	**Function**
CMD_ENBL_DI23	Command to enable digital input 23	Inputs to the module of digital inputs that activate and deactivate each of the digital inputs.
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 3.36-2: Digital Outputs		
Name	**Description**	**Function**
DO_1	Digital output 1	They activate their corresponding outputs.
DO_2	Digital output 2	
DO_3	Digital output 3	
DO_4	Digital output 4	
DO_5	Digital output 5	
DO_6	Digital output 6	
DO_7	Digital output 7	
DO_8	Digital output 8	
DO_9	Digital output 9	
DO_10	Digital output 10	
DO_11	Digital output 11	
DO_12	Digital output 12	
DO_13	Digital output 13	
DO_14	Digital output 14	
DO_15	Digital output 15	
DO_16	Digital output 16	
DO_17	Digital output 17	
DO_18	Digital output 18	
DO_19	Digital output 19	
DO_20	Digital output 20	
DO_21	Digital output 21	
DO_22	Digital output 22	
DO_23	Digital output 23	
DO_24	Digital output 24	
DO_25	Digital output 25	
DO_26	Digital output 26	
DO_27	Digital output 27	
DO_28	Digital output 28	

Table 3.36-2: Digital Outputs		
Name	**Description**	**Function**
DO_29	Digital output 29	They activate their corresponding outputs.
DO_30	Digital output 30	
DO_31	Digital output 31	
DO_32	Digital output 32	
DO_33	Digital output 33	
DO_34	Digital output 34	
DO_35	Digital output 35	
DO_36	Digital output 36	
DO_37	Digital output 37	
DO_38	Digital output 38	
DO_39	Digital output 39	
DO_40	Digital output 40	
DO_41	Digital output 41	
DO_42	Digital output 42	
DO_43	Digital output 43	
DO_44	Digital output 44	

3.36.3 Auxiliary Outputs

The number of digital outputs available will depend on each particular model. 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.

For models **IDV-***-*A********, **IDV-***-*B********, **IDV-***-*C********, **IDV-***-*D******** and **IDV-***-*G********, the outputs **OUT_7, OUT _8, OUT _9** and **OUT _10** can be configured by means of a setting as fast outputs (solid state), with make and break capacity lower than the rest of outputs.

However, outputs **OUT_1, OUT_2, OUT_3, OUT_4, OUT_5** and **OUT_6** are solid state command outputs that operate in parallel with a electromechanical relay. These outputs are approximately 6ms faster than conventional outputs and have the same make and break capacity characteristics, so that they are very suitable for use as trip outputs.

The IED's metering units 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 3.36.2. 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 3.36.2 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**.

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.

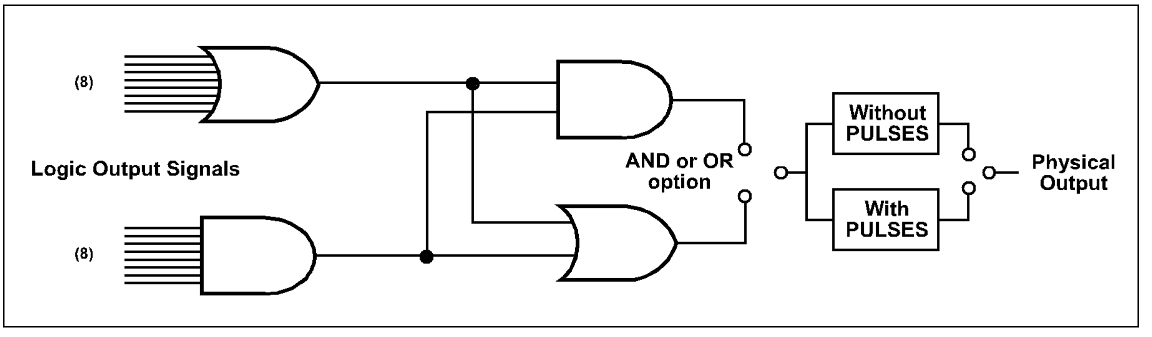


Figure 3.36.2: Auxiliary Contact Output Logic Cell Block Diagram.

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 3.36-2, 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).

3.36.3.a Auxiliary Outputs Table

Table 3.36-3: Auxiliary 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 indicates that IRIG-B signal is being received.
UN_ACT	Any element activated	They indicate that any protection element is activated.
UN_PU	Any element picked up	They indicate that any protection element is picked up.
OPEN_CMD_W1	Open command winding 1	Commands that go to the relay's trip and close contacts.
OPEN_CMD_W2	Open command winding 2	
OPEN_CMD_W3	Open command winding 3	
CLOSE_CMD_W1	Close command winding 1	
CLOSE_CMD_W2	Close command winding 2	
CLOSE_CMD_W3	Close command winding 3	
OPEN_CMD_BR1	Open command beaker 1	Trip and close commands for each breaker associated to the machine.
OPEN_CMD_BR2	Open command beaker 2	
OPEN_CMD_BR3	Open command beaker 3	
OPEN_CMD_BR4	Open command beaker 4	
CLOSE_CMD_BR1	Close command beaker 1	
CLOSE_CMD_BR2	Close command beaker 2	
CLOSE_CMD_BR3	Close command beaker 3	
CLOSE_CMD_BR4	Close command beaker 4	
CCR	Close command canceled	To indicate that the close command has been cancelled.
RST_IND_TRIP	Reset command of trip indication	When activated, it deletes the information about the last trip the relay has stored, thus also cleaning the display.
CEXT_TRIP	External trip control	The same as for the digital input.
ACT_PROT	Activation of any protection unit associated to any winding	Signal indicating that the open / close command issued by the IED comes from the trip / close of some protection element.
ACT_PROT_W1	Activation of any protection unit associated to winding 1	
ACT_PROT_W2	Activation of any protection unit associated to winding 2	
ACT_PROT_W3	Activation of any protection unit associated to winding 3	
ACT_PROT_BR1	Activation of any protection unit associated to breaker 1	
ACT_PROT_BR2	Activation of any protection unit associated to breaker 2	
ACT_PROT_BR3	Activation of any protection unit associated to breaker 3	
ACT_PROT_BR4	Activation of any protection unit associated to breaker 4	

Table 3.36-3: Auxiliary Outputs		
Name	Description	Function
B_OPEN_86	Open button 86. Lockout function reset	They indicate that the corresponding button has been pressed.
B_OPEN _P1	Open button P1	
B_OPEN_P2	Open button P2	
B_OPEN_P3	Open button P3	
B_OPEN_P4	Open button P4	
B_OPEN_P5	Open button P5	
B_OPEN_P6	Open button P6	
B_CLS_P1	Close button P1	
B_CLS_P2	Close button P2	
B_CLS_P3	Close button P3	
B_CLS_P4	Close button P4	
B_CLS_P5	Close button P5	
B_CLS_P6	Close button P6	
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	
IN_24	Digital input 24	
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	

Table 3.36-3: Auxiliary Outputs

Name	Description	Function
IN_34	Digital input 34	They indicate that the corresponding input has been activated.
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	
VAL_DI_30	Validity of digital input 30	
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	
CMD_DIS_DI1	Command to disable digital input 1	The same as for 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	

Table 3.36-3: Auxiliary Outputs		
Name	**Description**	**Function**
CMD_DIS_DI6	Command to disable digital input 6	The same as for the digital inputs.
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	
CMD_ENBL_DI1	Command to enable digital input 1	The same as for 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	

Table 3.36-3: Auxiliary Outputs		
Name	**Description**	**Function**
CMD_ENBL_DI16	Command to enable digital input 16	The same as for the digital inputs.
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	
DO_1	Digital output 1	The same as for the digital inputs.
DO_2	Digital output 2	
DO_3	Digital output 3	
DO_4	Digital output 4	
DO_5	Digital output 5	
DO_6	Digital output 6	
DO_7	Digital output 7	
DO_8	Digital output 8	
DO_9	Digital output 9	
DO_10	Digital output 10	
DO_11	Digital output 11	
DO_12	Digital output 12	
DO_13	Digital output 13	
DO_14	Digital output 14	
DO_15	Digital output 15	
DO_16	Digital output 16	
DO_17	Digital output 17	
DO_18	Digital output 18	
DO_19	Digital output 19	
DO_20	Digital output 20	
DO_21	Digital output 21	
DO_22	Digital output 22	
DO_23	Digital output 23	

Table 3.36-3: Auxiliary Outputs		
Name	**Description**	**Function**
DO_24	Digital output 24	The same as for the digital inputs.
DO_25	Digital output 25	
DO_26	Digital output 26	
DO_27	Digital output 27	
DO_28	Digital output 28	
DO_29	Digital output 29	
DO_30	Digital output 30	
DO_31	Digital output 31	
DO_32	Digital output 32	
DO_33	Digital output 33	
DO_34	Digital output 34	
DO_35	Digital output 35	
DO_36	Digital output 36	
DO_37	Digital output 37	
DO_38	Digital output 38	
DO_39	Digital output 39	
DO_40	Digital output 40	
DO_41	Digital output 41	
DO_42	Digital output 42	
DO_43	Digital output 43	
DO_44	Digital output 44	
LED_1	LED 1	The same as for the digital inputs.
LED_2	LED 2	
LED_3	LED 3	
LED_4	LED 4	
LED_5	LED 5	
LED_6	LED 6	
LED_7	LED 7	
LED_8	LED 8	
LED_9	LED 9	
LED_10	LED 10	
LED_11	LED 11	
LED_12	LED 12	
LED_13	LED 13	
LED_14	LED 14	
LED_15	LED 15	
LED_16	LED 16	
LED_86R	LED 86 red	
LED_86G	LED 86 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	

Table 3.36-3: Auxiliary Outputs		
Name	**Description**	**Function**
LED_P5R	LED P5 red	The same as for the digital inputs.
LED_P5G	LED P5 green	
LED_P6R	LED P6 red	
LED_P6G	LED P6 green	
IN_BKR_W1	Input of breaker position winding 1: Open (1) / Closed (0) (IDV-A/B/G/H/J/K/L)	The same as for the digital inputs.
IN_BKR_W2	Input of breaker position winding 2: Open (1) / Closed (0) (IDV-A/B/G/H/J/K/L)	
IN_BKR_W3	Input of breaker position winding 3: Open (1) / Closed (0) (IDV-A/B/H/K/L)	
IN_BKR1	Input open breaker 1 (IDV-D/F)	
IN_BKR2	Input open breaker 2 (IDV-D/F)	
IN_BKR3	Input open breaker 3 (IDV-D/F)	
IN_BKR4	Input open breaker 4 (IDV-D/F)	
IN_RST_LED	LEDs reset input	Resets the LEDs that are active because they are memorized.
IN_PMTR_RST	Power meters reset input	The same as for the digital input.
IN_RST_MAX	Maximeters reset	The same as for the digital input.
CUR_LINE_W1	Indicator of current in winding 1	It is activated when some of the phase currents of a winding is higher than 0.1 A.
CUR_LINE_W2	Indicator of current in winding 2	
CUR_LINE_W3	Indicator of current in winding 3	
ENBL_PLL	Digital PLL input enable	The same as for the digital input.
PU_CLPU	Cold load pickup of relay	It is marked whenever the IED is energized.
PU_WLPU	Warm pickup of relay	It is activated after any reset (configuration loading, manual reset…), while remaining the device powered-up.
EDIG_VF	DIs Voltage Failure Input	This is activated when there is no voltage in the digital input selected for supervision of EDs.
RST_MAN	Manual reinitialization of the relay	It is marked whenever the IED is reset manually.
INIT_CH_SET	Change of settings initialization	It is indicated when some setting is modified.
FAIL_COM_L	Port 0 communication failure	They activate when no communication port activity is detected during the set time.
FAIL_COM_R1	Port 1 communication failure	
FAIL_COM_R2	Port 2 communication failure	
FAIL_COM_R3	Port 3 communication failure	
REMOTE	Remote	Indicates that the relay is in remote mode.

Table 3.36-2: Auxiliary Outputs		
Name	**Description**	**Function**
LOCAL	Local Control	The same as for the digital input.
CONTROL_PANEL	Operation Desk control	The same as for the digital input.
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).

3.36.3.b Trip and Close Outputs

Models **IDV-A/G/J/L** for 2 winding machines have 4 trip/close contacts, 2 NO contacts and 2 configurable NO or NC contacts. Models **IDV-B/H/K/L** for 3 winding machines have 6 trip/close contacts, 3 NO contacts and 3 configurable, via jumper, as NO or NC contacts. Depending on the model, said outputs are assigned, in a fixed manner (without the possibility to change the configuration), to winding n open command digital outputs (n=1, 2 for **IDV-A/G/J/L** and n=1, 2, 3 for **IDV-B/H/K/L**). **IDV-D/F** relays do not have outputs configured as fixed, but all are programmable. Because of the robustness of all digital auxiliary outputs, any of them can actuate as a trip output. For **IDV-D/F** relays, breaker m open digital command signals (m=1, 2, 3, 4) should be configured as trip signals.

Breaker trip and close operations can be made using the same trip contacts. The operating mode, through the button frame on the front of the IED, is designed to always request confirmation of maneuvers before executing them.

Both for manual and protection element-generated operations, if a breaker state change signal is not received, after an operate command is sent, within the operate failure time (settable separately for open and close operations), **Open Command Failure** signals are activated.

Note: Relays IDV-L may contemplate two or three windings as a function of the setting *Number of Windings*.

3.36.4 LED Targets

The **IDV** IED has 5 (2 and 3 units height models) or 17 (4 and 6U units height models) optical indicators (LEDs) on the front panel. 4 / 16 are user-definable and the remainder indicates whether the IED is **Ready**.

Each of the user-definable optical indicators is associated to a combinatorial function. These are diagramed in figure 3.36.3. 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.

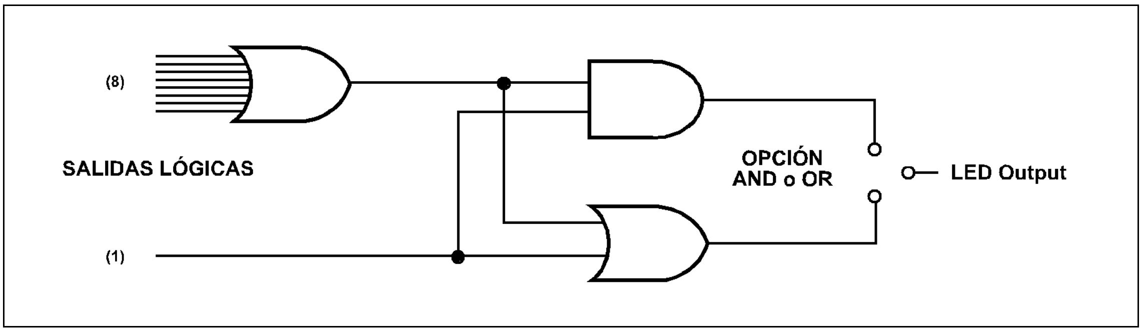


Figure 3.36.3: Target Output Logic Cell Block Diagram.

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 **Reset LEDs** digital input. Since it is defined as a command it will be available in the operations display menu. 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 3.36-2. 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.

3.36.5 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.

3.36.5.a Synchronization by Binary Input Digital OutputsTable

Table 3.36-4: 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.

3.36.6 Setting Ranges

Digital Inputs			
Setting	**Range**	**Step**	**By Default**
Time Between Samples (Filter 1)	2 - 10 ms	2 ms	6 ms
Time Between Samples (Filter 2)	2 - 10 ms	2 ms	6 ms
Number of Samples to Validate Changes (Filter 1)	1 - 10 samples	1 sample	2 samples
Number of Samples to Validate Changes (Filter 2)	1 - 10 samples	1 sample	2 samples
Filter Assignation (independent setting for each DI)	0 = Filter 1 1 = Filter 2		0 = filter 1
Number of Changes to Disable	2 - 60 changes	1 change	60 changes
Number of Changes to Enable	2 - 60 changes	1 change	2 changes
Disable Window	1 - 30 s	1 s	5 s
Enable Window	1 - 30 s	1 s	2 s
EDs Supply Voltage Control	0 = NO 1 = YES	1	0
EDs Supply Voltage Level	0 = 24 1= 48 2 = 125 3 = 125(>65%) 4 = 250	1	24
Automatic ED Disable (independently for each ED of the relay)	0 = NO 1 = YES	1	1
Digital Inputs Voltage Supervisory Input (IDV-***-****02*** Model)	0 - 37		0
Synchronization Input (IDV with option D or higher in digit 9)	0 - max number of DIs (*)	1	0
Synchronization Type (IDV with option D or higher in digit 9)	0: PPS 1: PPM		PPS
Synchronization Edge (IDV with option D or higher in digit 9)	0: Rising edge 1: Falling edge		Rising edge

(*) DI number 1 cannot be selected.

Digital Inputs Special Ranges (IDV-***-****10-**)			
Setting	**Range**	**Step**	**By Default**
Time between Samplings Filter 1	1 - 10 ms	1 ms	6 ms
Time between Samplings Filter 2	1 - 10 ms	1 ms	6 ms

Digital Outputs (IDV-***-*A******, IDV-***-*B******, IDV-***-*C******, IDV-***-*D******, IDV-***-*G******)			
Setting	**Range**	**Step**	**By Default**
Output 7 Type	Normal Fast Both		Normal
Output 8 Type	Normal Fast Both		Normal
Output 9 Type	Normal Fast Both		Normal
Output 10 Type	Normal Fast Both		Normal

3.36.7 Digital Inputs, Auxiliary Outputs and LED's Test

Apply nominal voltage, appropriate for the model. At this time, the **Ready** 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").

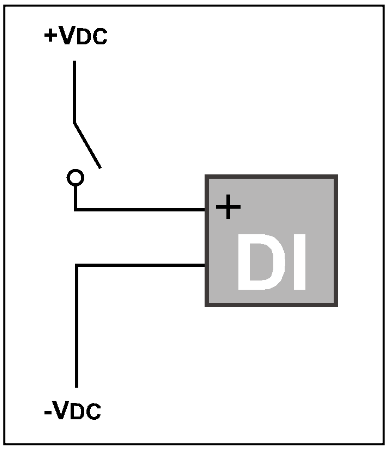


Figure 3.36.4: Digital Inputs Test.

- **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.

- **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.

Press the **86** key and the corresponding LED will blink. Next, press the **O** key to deactivate the lockout contacts if an output was programmed with such signal, and the tripped unit was programmed with the lockout function enabled.

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.

3.37 Programmable Logic

3.37.1 Description

One of the functions of **IDV** 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, oscillograph records, digital inputs and outputs, HMI and communications according to how their programmable logic has been configured.

From the signals or readings generated by any of the functions of the relay (Protection units, Digital inputs, Communications, Command functions and 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 IED and the exterior: auxiliary output contacts, display, LEDs, communications, HMI, etc.

Maximum size for the programmable logic will be 64kb; i.e. around 1000 primitive logic gates.

3.37.2 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.

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. These 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 logic. These settings can be consulted afterwards from the HMI or communications.

In addition, the logic configurations 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 or logic units.

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.

3.37.3 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 output signal.

- **Cable**

Moves to a digital signal the value of another.

Operands:
Digital input signal.

Results:
Digital output 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).

- **FFD**

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.

- **FFRS**

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.

Resultados:
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.

3.37.3.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 3.37-1: 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.

3.38 Communications

3.38.1 Communications Ports

IDV 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	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).

3.38.2 Communication with *ZivercomPlus*®

Protection, loading or reading programmable logic configuration and reading out protection data (events, fault reports, oscillograms, ...) can be configured through communications ports set for PROCOME protocol. The local port is always assigned this protocol, whereas for remote ports it depends on settings.

Communications are established through ***ZivercomPlus***® communications program, which allows dialog between the **IDV** family and other relays, whether locally (via a PC connected to front port) or remotely (via rear serial ports with PROCOME protocol), covering all needs regarding programming, settings, recording, reports, etc..

Local and remote communications ports are configured through HMI.

IDV model features three controllers, one for each communications port, so that communications can be established through all of them at the same time.

The ***ZivercomPlus***® communications program that involves the application of the model involved is protected against non-authorized users through access passwords. The ***ZivercomPlus***®, that runs in WINDOWS™ environment is easy to operate and uses buttons or keys to display the different submenus.

3.38.3 Synchronization by IRIG-B 123 and 003

IDV relays are provided with a BNC type input for IRIG-B 123 or 003 standard time synchronization signals. Said input is located at the relay rear panel. Synchronization accuracy is ±1ms.

In case the relay is receiving an IRIG-B synchronization signal, access from HMI to **Date and Time** settings is denied.

An output can be configured to show IRIG-B signal received status. This output remains active while the relay receives correctly said signal.

Relays are also prepared for indication of both the loss and recovery of IRIG-B signal by generating events associated to each of these circumstances.

3.38.3.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.

3.38.3.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

3.38.3.c Auxiliary Outputs of the IRIG-B Function

Table 3.38-1: Auxiliary Outputs of the IRIG-B Function		
Name	**Description**	**Function**
SIGNAL_IRIGB	IRIGB Active	Signal indicates that IRIG-B signal is being received.

3.38.4 Communications Protocol

All **IDV** 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:

- **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-MAESTRO are available.
- **Ports LAN 1** and **2**: can communicate through IEC61850.

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.

3.38.4.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 **IDV** 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.

3.38.5 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 MMI.
- **Remote port CAN**: **[P4]** code.

These codes, in case of PROCOME 3.0 protocol, remain displayed during **Communications Password TimeOut** setting indicated in paragraph 3.38.5.f 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**.

3.38.5.a Local Port

The setting options of the local communications port are:

- **Baud Rate**: a value from 300 bauds to 38400 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.

3.38.5.b Remote Port 1

Remote port 1 has fiber optic and electrical access RS232 / RS232 FULL MODEM. Access through RS232 FULL MODEM has all the MODEM lines in format DB9. The settings available for configuring this port are:

- **Baud Rate, Stop Bits, Parity** and **Character Reception Time**, the same as the local port.
- **Protocol**: depending on model, PROCOME 3.0, DNP 3.0, MODBUS Protocols and Virtual Inputs Outputs can be selected. The default protocol is PROCOME.
- **·Advanced settings**:

  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, 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.

  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 / DCD):

  NO: Collision detection disabled.

  ECHO: A collision is considered to have occurred when the characters received do not coincide with the characters 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 on collision detection.

  Maximum Time Between Retries (0-60000 ms): Maximum time between retries on collision detection.

3.38.5.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.

3.38.5.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 - 65535): 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.

3.38.5.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 - 10sg).

3.38.5.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 **IDV** 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.

3.38.5.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 **IDV** 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 **IDV** sends a message requesting the master to confirm the Application layer (Level 7), until this confirmation is considered lost. The **IDV** 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 **IDV** 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** (YESI/NO): enables (YES) or disables (NO) sending spontaneous messages (Unsolicited); it is used in combination with the MTU Number parameter. For the **IDV** 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 **IDV** 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): enables (YES) or disables (NO) sending Forced Unsolicited messages (for compatibility with versions pre DNP3-1998). When Unsolicited Start is activated, the **IDV** 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): 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.

3.38.5.h MODBUS Protocol Setting

The only configuration setting of the MODBUS protocol is the **Relay Number** (0-254), which the same as for the other protocols specifies the **IDV** relay address (acting as RTU or Remote Terminal Unit) with reference to the rest of relays communicating with the same master station (MTU or Master Terminal Unit).

3.38.5.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).

Models **IDV** with option **4** or higher in digit **10** include a setting **Detection Time** that detects the loss of the communications link.

Models **IDV** with option **6** or higher in digit **10** include a group of settings related to the Ethernet Redundancy:

- **Redundancy mode** (No Redundancy / Bondng Redund / PRP Redund.).
- **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).

3.38.6 IEC61850 Communications Protocol

3.38.6.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.

3.38.6.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** **_IDVP4N403B.CID**
Equipment home screen that indicates the equipment is fully booted and ready for communications.	**ZIV/IDV** **17/04/10 22:49:02**

3.38.6.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.

IDVP4N*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)
[IDV-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)
[IDV -9836]
Ver SO(2.99)
IEC [6.0R][RUN]
CRC:[4720E6D0]
BLD[Sep 28 2011]
BLD[08:46:05]
MMS<->IEC<->IDV
IDVP4N***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.

3.38.6.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[IDV-9836]
Version NK	2.99
Version IEC	[6.2R][RUN]
Build EXE	[Sep 28 2011][4720E6D0]
Model IDV	IDVP4N***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.

3.38.6.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.

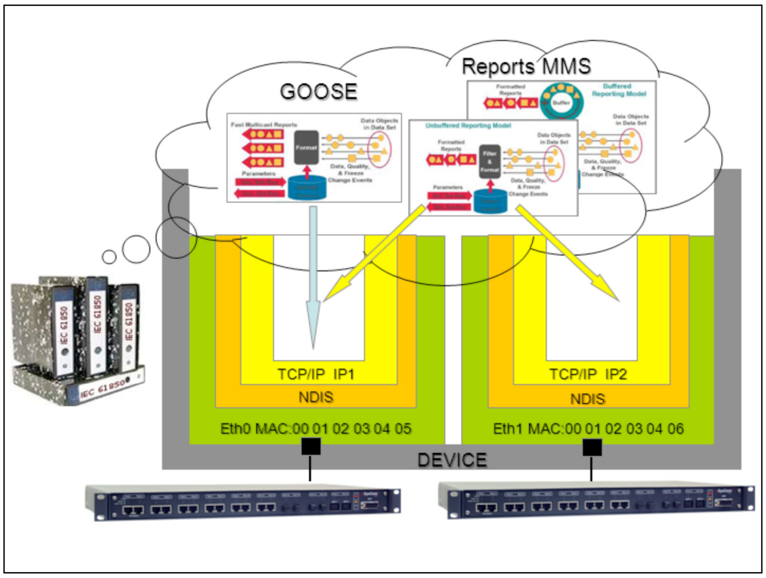


Figure 3.38.1: Configuration of Communications Ports for Relays without Ethernet Redundancy.

- **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.

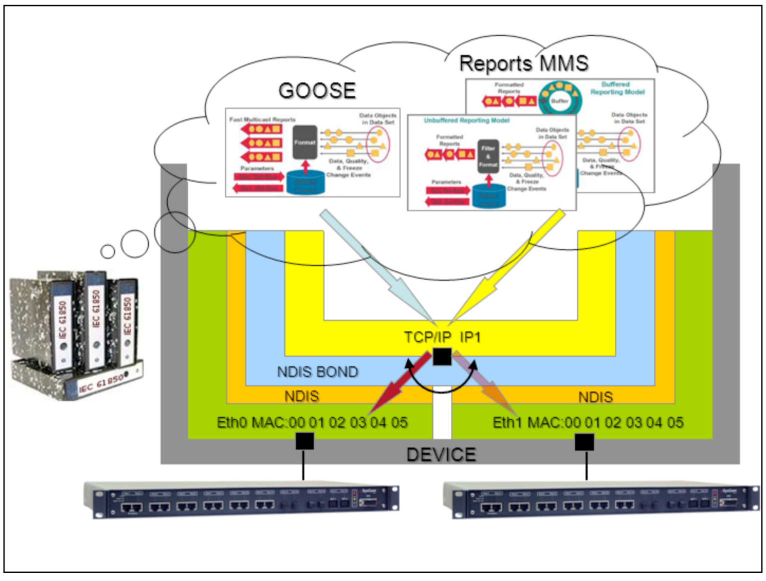


Figure 3.38.2: Configuration of Communications Ports for Relays with Bonding Type Redundancy.

- **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).

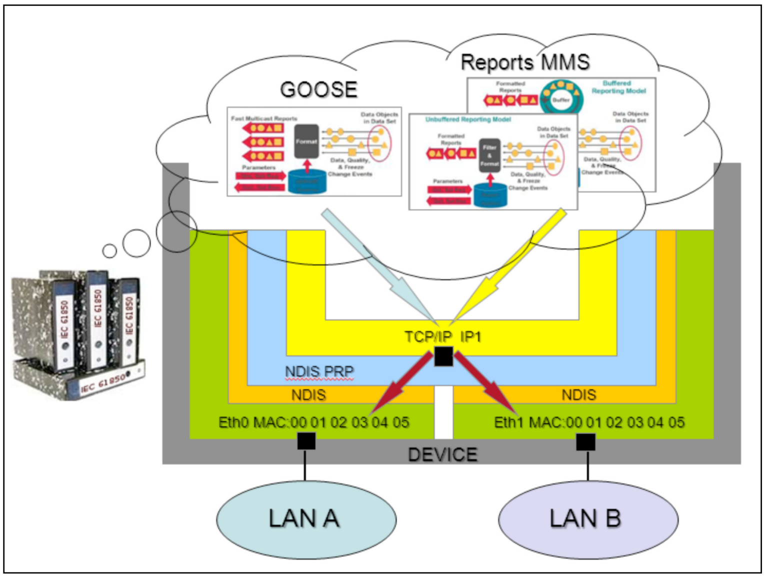


Figure 3.38.3: Configuration of Communications Ports for the Relay with PRP Type Redundancy.

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.

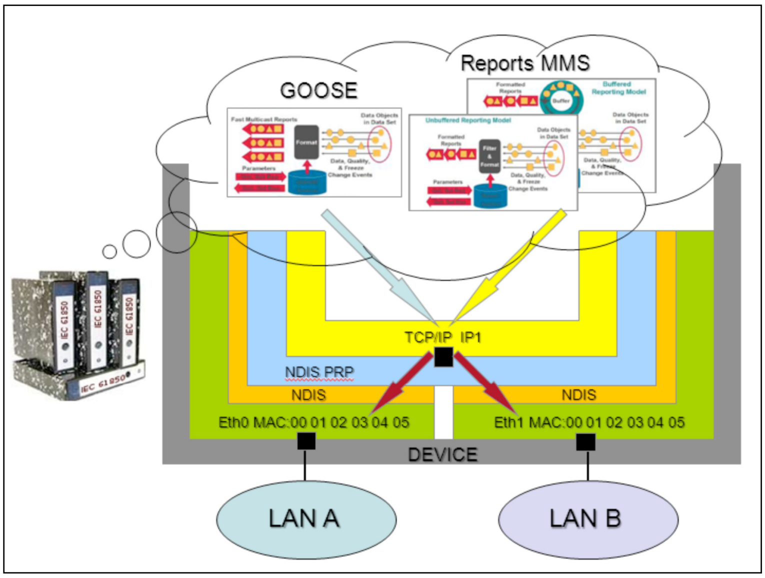


Figure 3.38.4: Configuration of Communications Ports for Relays with RSTP Type Redundancy

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.

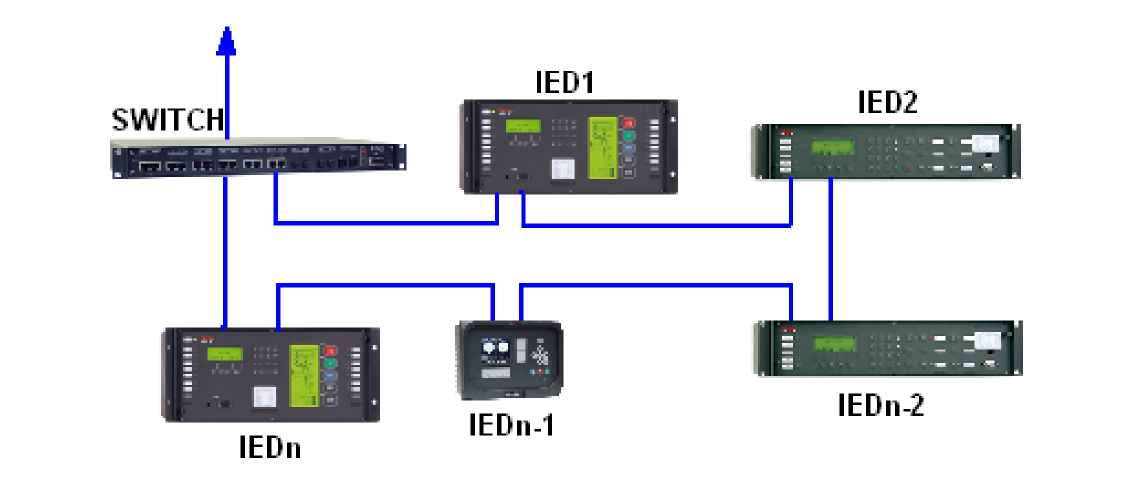


Figure 3.38.5: Example of Connecting Relays with RSTP Redundancy with Simple Ring

Relays **IDV-***-*****1*****, **IDV-***-*****2***** y **IDV-***-*****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.

IDV-*-*****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).

IDV-*-*****2***** and **IDV-***-*****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 **IDV-***-*****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 **IDV** with option **6** or higher in digit **10** 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.

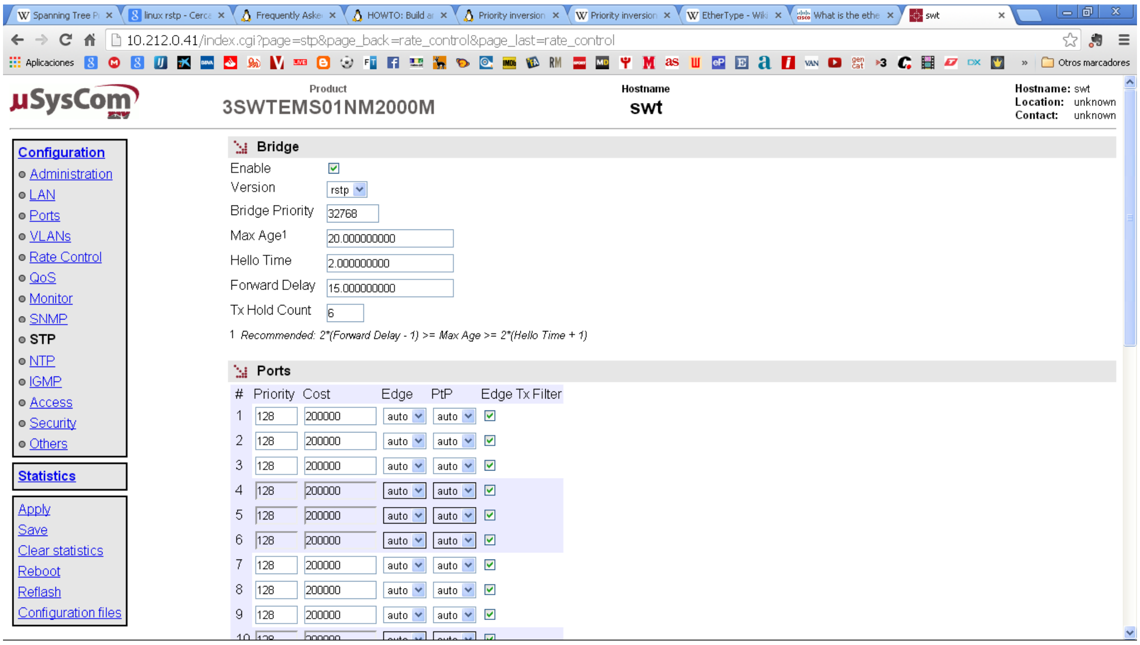


Figure 3.38.6: Image of the RSTP Settings available in the Web Server.

3.38.6.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:

Logging in as user: *info* and password: *info*, a directory structure similar to the one on the right will be displayed.

These are read-only folders and can be downloaded.

Directories will contain the same data provided by the web server: Boot data, active CID, oscillogram files, etc.

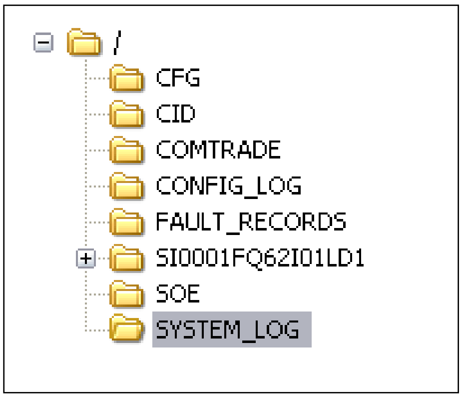


Figure 3.38.7: Directory Structure.

3.38.6.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:

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.

The equipment will validate the **CID** (checks it is a correct SCL and the CID IP coincide with the IP configured in the equipment).

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
_IDVP4N104K.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

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, **_IDVP4N104K.CID** being the active **CID** file.

IEC [6.0R]
!ERROR!:[0100]
_IDVP4N104K.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/IDV
[ALARMS:00100000]
17/04/10 22:49:02

3.38.6.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_IDV_RD_CID	Error when reading protection settings.
ERROR_IDV_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

3.38.7 CAN Communications Protocol

3.38.7.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.

3.38.7.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.

3.38.7.c Digital Inputs of the CAN Function

Table 3.38-2: 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	

3.38.7.d Auxiliary Outputs of the CAN Function

Table 3.38-3: 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	
RIN_24	Remote digital input 24	
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	

Table 3.38-3: Auxiliary Outputs of the CAN Function		
Name	**Description**	**Function**
VAL_RIN_14	Validity of remote digital input 14	Activates said validity of remote digital input.
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	
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	

3.38.8 Virtual Inputs / Outputs

Virtual inputs / outputs function allows the bidirectional transmission of up to 16 digital signals and 16 analog magnitudes between two **IDV** 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.

3.38.8.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.

3.38.8.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.

3.38.8.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.

3.38.8.d Digital Inputs of the Virtual Inputs / Outputs Function

Table 3.38-4: 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	

3.38.8.e Auxiliary Outputs of the Virtual Inputs / Outputs Function

Table 3.38-5: 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 3.38-5: 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	

3.38.8.f Magnitudes of the Virtual Inputs / Outputs Function

Table 3.38-6: 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 3.38-6: 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	

3.38.9 Communications Settings

Local Port Communications			
Setting	**Range**	**Step**	**By 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**	**By 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**	**By 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**	**By 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**	**By 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**	**By 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**	**By 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.		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

(*) Models IDV with option 6 or higher in digit 10.

- **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 (Models IDV with option 6 or higher in digit 10)

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

3.38.10 Outputs and Events of the Communications Module (Models IDV with option 6 or higher in digit 10)

Table 3.38-7: Outputs and Events of the Communications Module (Models IDV with option 6 or higher in digit 10)

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	

3.38.11 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.

3.38.11.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.

3.38.11.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.

3.39 Integrated Simulator

3.39.1 Description

The **IDV** 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.

3.39.2 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

3.39.3 Digital Inputs of the Integrated Simulator

Table 3.39-1: Digital Inputs of the Integrated Simulator

Name	Description	Function
INST_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.
INCNCL_SIMOSC	Oscillogram simulation cancellation input	Activation of this input removes the equipment from the oscillogram simulation mode state.

3.39.4 Auxiliary Outputs of the Integrated Simulator

Table 3.39-2: Auxiliary Outputs 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.

3.40 Adaptive Sampling Frequency

3.40.1 Description

IDV 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**.

3.40.2 Digital PLL Settings

Digital PLL			
Setting	**Range**	**Step**	**By Default**
Enable	YES / NO		NO

3.40.3 Digital Inputs and Events of the Digital PLL

Table 3.40-1: Digital Inputs and Events of the Digital PLL		
Name	**Description**	**Function**
ENBL_PLL	Digital PLL Enable Input	It enables the operation of the automatic frequency adaptation system. It is set to logic “1” by default.

3.41 Current Transformers Dimensioning

3.41.1 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

3.41.2 CT Dimensioning According to Different Standards

3.41.2.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:

$$Ktf = \frac{w \cdot T1 \cdot T2}{T1 - T2} \cdot \cos\theta \cdot (e^{\frac{-t}{T1}} - e^{\frac{-t}{T2}}) + \sin\theta \cdot e^{\frac{-t}{T2}} - \sin(wt + \theta) \qquad (3.41.1)$$

, 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).

3.41.2.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.

3.41.2.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 3.41.1).

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.

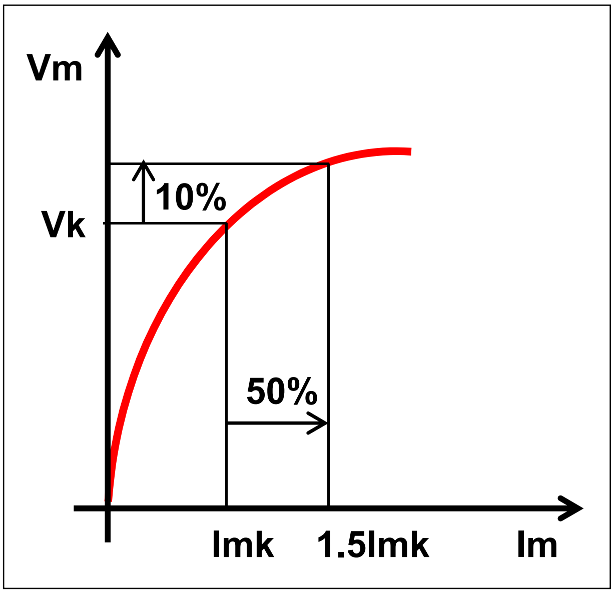


Figure 3.41.1: Knee Point Voltage Definition.

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

3.41.3 CT Dimensioning for Different Protection Functions

Table 3.41-1 includes general parameters to be considered for the calculation of CT dimensioning factors.

Table 3.41-2 includes the saturation free times (for Ktf calculation) and current values (for Kssc calculation) that must be used for CT dimensioning.

Table 3.41-1: 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 3.41-2	(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 ($mm^2*\Omega/m$) 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 3.41-2)	(s)

Table 3.41-2: 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. f = 50 Hz	t (s) f = 60 Hz	IF (fault current to calculate Kssc)
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 = $IF_{80\%}$

3.41.3.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

3.41.3.b Ktf Factor

The following tables include different ktf values calculated according to the formula (3.41.1). The saturation free times included in Table 3.41-2 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

8IDV 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 **IDV** with **IEC61850** are also provided with a fourth route:

- General alarm counter.

4.1.2 Activation of Signal and Alarm Generation 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.

Following Table 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 reading settings	0x00000001	CRITICAL
Loss of calibration values	0x00000002	NON-CRITICAL
Protection operation error	0x00000020	CRITICAL
Error writing settings	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
Error on Virtual Inputs channel 1	0x00010000	NON-CRITICAL
Error on Virtual Inputs channel 2	0x00020000	NON-CRITICAL
Error lack of VCC	0x00080000	CRITICAL
Error IEC 61850	0x00100000	NON-CRITICAL
Error signals	0x00200000	CRITICAL
Error in configuration	0x00800000	NON-CRITICAL
Program error	0x01000000	CRITICAL
Communications failure between the C167 and the DSP0.	0x02000000	NON-CRITICAL
Communications failure between the C167 and the DSP1.	0x04000000	NON-CRITICAL
Failure in remote port 1.	0x08000000	NON-CRITICAL
Failure in remote port 2.	0x10000000	NON-CRITICAL
Failure in remote port 3.	0x20000000	NON-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.

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 HMI 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 HMI 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, differential, restraint and sequence currents and harmonics: **Rated value I_{PHASE} + 20**% sends 4095 counts.
- Ground currents: **Rated value I_{GROUND} + 20%** sends 4095 counts.
- Line-to-ground and sequence voltages and harmonics: **(Rated value V / √3) + 20%** sends 4095 counts.
- Line-to-line 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

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

Basic Profile

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IDV

☐ ☒

Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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MMI

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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 (IDV will parse)		RESPONSE (IDV 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 (IDV will parse)		RESPONSE (IDV 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*⑧:

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0.	
Index	**Description**
16	***Configure by ZIVercomPlus⑧ 512 points***
17	***Configure by ZIVercomPlus⑧ 512 points***
18	***Configure by ZIVercomPlus⑧ 512 points***
19	***Configure by ZIVercomPlus⑧ 512 points***
20	***Configure by ZIVercomPlus⑧ 512 points***
21	***Configure by ZIVercomPlus⑧ 512 points***
22	***Configure by ZIVercomPlus⑧ 512 points***
23	***Configure by ZIVercomPlus⑧ 512 points***
24	***Configure by ZIVercomPlus⑧ 512 points***
25	***Configure by ZIVercomPlus⑧ 512 points***
26	***Configure by ZIVercomPlus⑧ 512 points***
27	***Configure by ZIVercomPlus⑧ 512 points***
....	***Configure by ZIVercomPlus⑧ 512 points***
254	***Configure by ZIVercomPlus⑧ 512 points***
255	***Configure by ZIVercomPlus⑧ 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, differential, restraint, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	◊ Deadband
Currents (Ground)	0 to 1,2 x In_{GROUND} A	0 to 32767	◊ Deadband
Voltages (Phase to ground, ground, harmonics)	0 to 1,2 x Vn/√3 V	0 to 32767	◊ Deadband
Voltages(Phase to phase)	0 to 1,2 x Vn V	0 to 32767	◊ Deadband
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	◊ Deadband
Power factor	-1 to 1	-32768 to 32767	◊ Deadband
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	◊ Deadband
Thermal value	0 to 200%	0 to 32767	◊ Deadband

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

- <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)

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)

Basic Extended Profile

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IDV

☐ ☒

Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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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 (IDV will parse)		RESPONSE (IDV 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 (IDV will parse)		RESPONSE (IDV 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, differential, restraint, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**◊ Deadband**
Currents (Ground)	0 to 1,2 x In_{GROUND} A	0 to 32767	**◊ Deadband**
Voltages (Phase to ground, ground, harmonics)	0 to 1,2 x Vn/√3 V	0 to 32767	**◊ Deadband**
Voltages(Phase to phase)	0 to 1,2 x Vn V	0 to 32767	**◊ Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	**◊ Deadband**
Power factor	-1 to 1	-32768 to 32767	**◊ Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**◊ Deadband**
Thermal value	0 to 200%	0 to 32767	**◊ Deadband**

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)

Profile II

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IDV

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Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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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 (IDV parse)		RESPONSE (IDV 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 (IDV parse)		RESPONSE (IDV 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*⑧ 256 points	
15	*Configure by ZIVercomPlus*⑧ 256 points	
16	*Configure by ZIVercomPlus*⑧ 256 points	
17	*Configure by ZIVercomPlus*⑧ 256 points	
...	*Configure by ZIVercomPlus*⑧ 256 points	
253	*Configure by ZIVercomPlus*⑧ 256 points	
254	*Configure by ZIVercomPlus*⑧ 256 points	
255	*Configure by ZIVercomPlus*⑧ 256 points	

ANALOG INPUT (OBJECT 30) -> Assigned to Class 0. ANALOG INPUT CHANGE (OBJECT 32) -> Assign to Class		
Index	**Description**	**Deadband**
0	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_1.
1	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_2.
2	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_3.
3	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_4.
4	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_5.
5	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_6.
6	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_7.
7	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_8.
8	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_9.
9	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_10.
10	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_11.
11	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_12.
12	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_13.
13	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_14.
14	*Configure by ZIVercomPlus*⑧ 256 points	() Deadband_15.
15	*Configure by ZIVercomPlus*⑧ 256 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, differential, restraint, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**() Deadband**
Currents (Ground)	0 to 1,2 x In_{GROUND} A	0 to 32767	**() Deadband**
Voltages (Phase to ground, ground, harmonics)	0 to 1,2 x $Vn/\sqrt{3}$ V	0 to 32767	**() Deadband**
Voltages(Phase to phase)	0 to 1,2 x Vn V	0 to 32767	**() Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x $Vn/\sqrt{3}$ W	-32768 to 32767	**() Deadband**
Power factor	-1 to 1	-32768 to 32767	**() Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**() Deadband**
Thermal value	0 to 200%	0 to 32767	**() Deadband**

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

- 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.
  election to send Binary Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Analog Changes CLASS.
  election to send Analog Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Counter Changes CLASS.
  election to send Counter Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Binary Status .
  end Binary with status otherwise without status
- 32 Bits Analog Input .

end 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)

Dnp3 Profile II Ethernet

Implementation Table **Point List**

ZIV Aplicaciones y Tecnología S.A.

IDV

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Unsolicited after Restart (for compatibility with terminals whose revision is before DNP3-1998)

synchronization in time.

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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 (IDV parse)		RESPONSE (IDV 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 (IDV parse)		RESPONSE (IDV 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, differential, restraint, sequences, harmonics)	0 to 1,2 x In_{PHASE} A	0 to 32767	**Deadband**
Currents (Ground)	0 to 1,2 x In_{GROUND} A	0 to 32767	**Deadband**
Voltages (Phase to ground, ground, harmonics)	0 to 1,2 x Vn/√3 V	0 to 32767	**Deadband**
Voltages(Phase to phase)	0 to 1,2 x Vn V	0 to 32767	**Deadband**
Power (Real, reactive, apparent)	0 to 3 x 1,4 x In_{PHASE} x Vn/√3 W	-32768 to 32767	**Deadband**
Power factor	-1 to 1	-32768 to 32767	**Deadband**
Frequency	0 to 1,2 x Rated frequency (50/60 Hz)	0 to 32767	**Deadband**
Thermal value	0 to 200%	0 to 32767	**Deadband**

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.
  election to send Binary Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Analog Changes CLASS.
  election to send Analog Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Counter Changes CLASS.
  election to send Counter Changes as CLASS 1 CLASS 2 CLASS 3 or None.
- Binary Status .
  end Binary with status otherwise without status
- 32 Bits Analog Input .
  end 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 **IDV** IED.

This document provides a detailed MODBUS address map (input status, coil status, input registers and force single coil) and their equivalent in the **IDV** 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 IDV

The MODBUS coil status address map for the **IDV** 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 IDV

The MODBUS input status address map for the **IDV** 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 IDV

The MODBUS read holding registers address map for the **IDV** 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 IDV

The MODBUS read input registers address map for the **8IDV** 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, differential, restraint and sequence currents and harmonics: **Rated value I_{PHASE} + 20**% sends 32767 counts.
- Ground currents: **Rated value I_{GROUND} + 20%** sends 32767 counts.
- Line-to-ground and sequence voltages and harmonics: **(Rated value V / √3) + 20%** sends 32767 counts.
- Line-to-line 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.

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 IDV

The MODBUS force single coil address map of the **IDV** 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

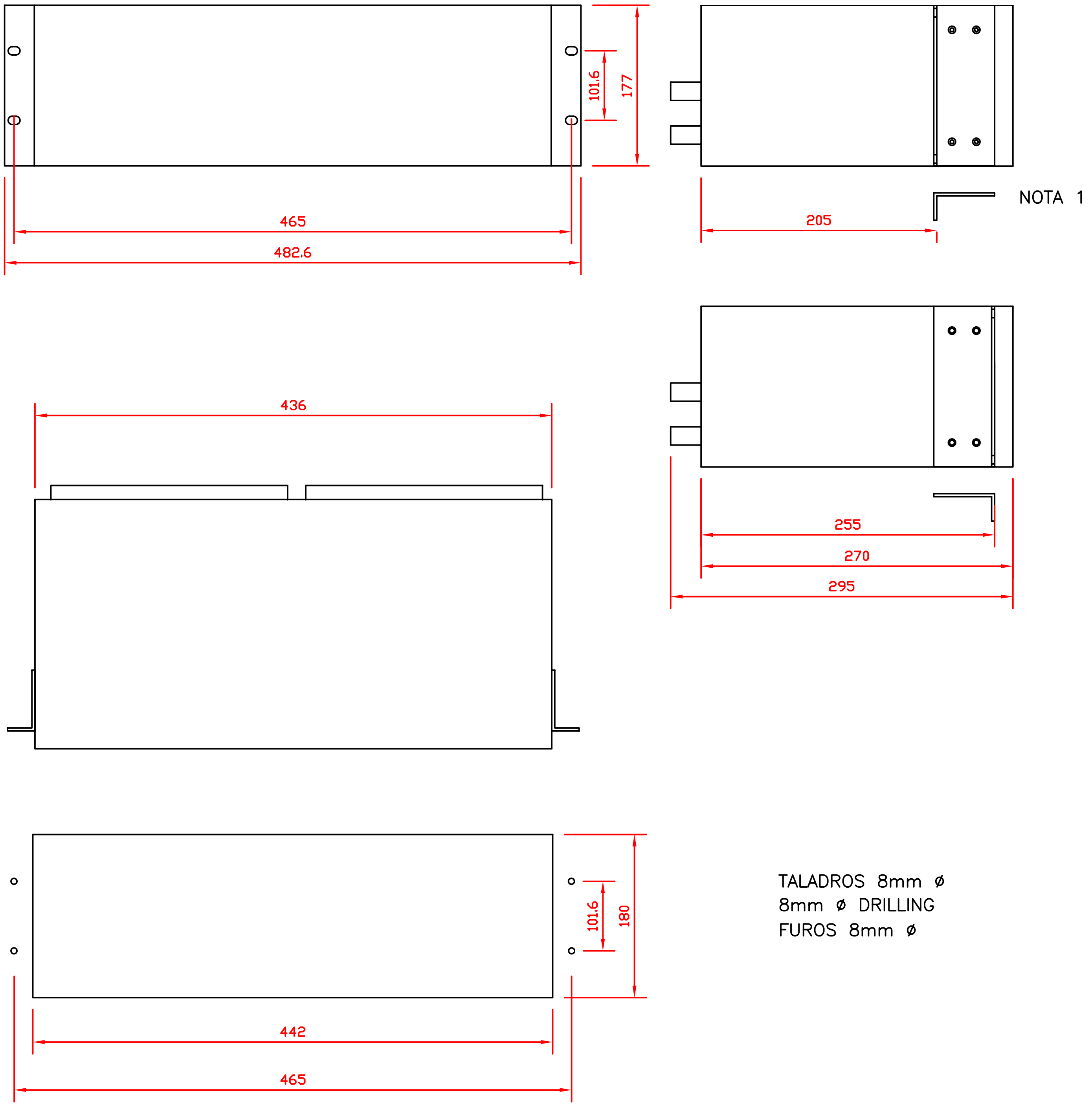
Dimension and Drill Hole Schemes

4U x 1 19” rack	>>4BF0100/0037
2U x 1 19” rack	>>4BF0100/0040
3U x 1 19” rack	>>4BF0100/0041
6U x 1 19” rack	>>4BF0100/0043

External Connection Schemes

7IDV-B (4 U)	>>3RX0187/0033 (generic)
8IDV-A (2 U)	>>3RX0187/0018 (generic)
8IDV-B (3 U)	>>3RX0187/0020 (generic)
8IDV-A (3 U)	>>3RX0187/0019 (generic)
8IDV-B (4 U)	>>3RX0187/0021 (generic)
8IDV-D (6 U)	>>3RX0187/0038 (generic)
8IDV-F (3 U)	>>3RX0187/0036 (generic)
8IDV-H (4 U)	>>3RX0187/0048 (generic)
8IDV-G (2 U	>>3RX0187/0046 (generic)
8IDV-K (4 U)	>>3RX0187/0057 (generic)
8IDV-L (4 U)	>>3RX0187/0071 (generic)

CAJA TIPO "Q"
ENCLOSURE TYPE "Q"
CAIXA TIPO "Q"



NOTA 1:
LA PIEZA ADMITE LAS 2 POSICIONES MOSTRADAS PARA FACILITAR UN MONTAJE DEL EQUIPO MÁS Ó MENOS SALIENTE

Z I V Aplicaciones y Tecnologia S.A.

TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "Q" 4U 1RACK (IDV)

REVISIONES	0	CD0407129	1	CD0504115	
2	3		4		
5	6		7		
8	9		10		
11	12		13		
14	15		16		

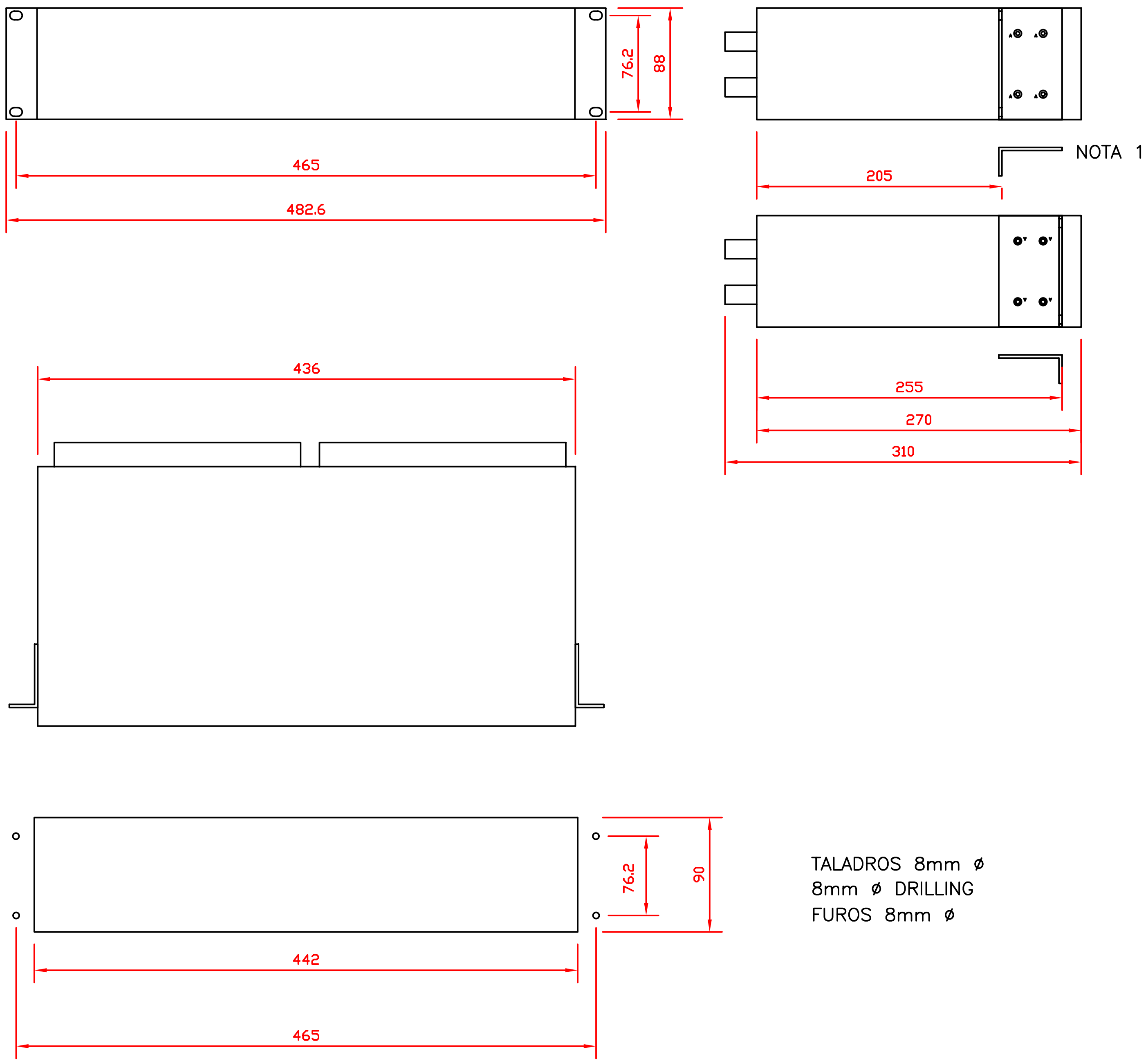
Rev.0
Rev.1 12/4/05

NUMERO: 4BF0100/0037

	Fecha	Nombre
Dibujado	07/09/04	J.C.S.
Aprobado	07/09/04	J.M.Y.

Hoja: 1
Continua en Hoja:

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	

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TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "M" 2U 1RACK

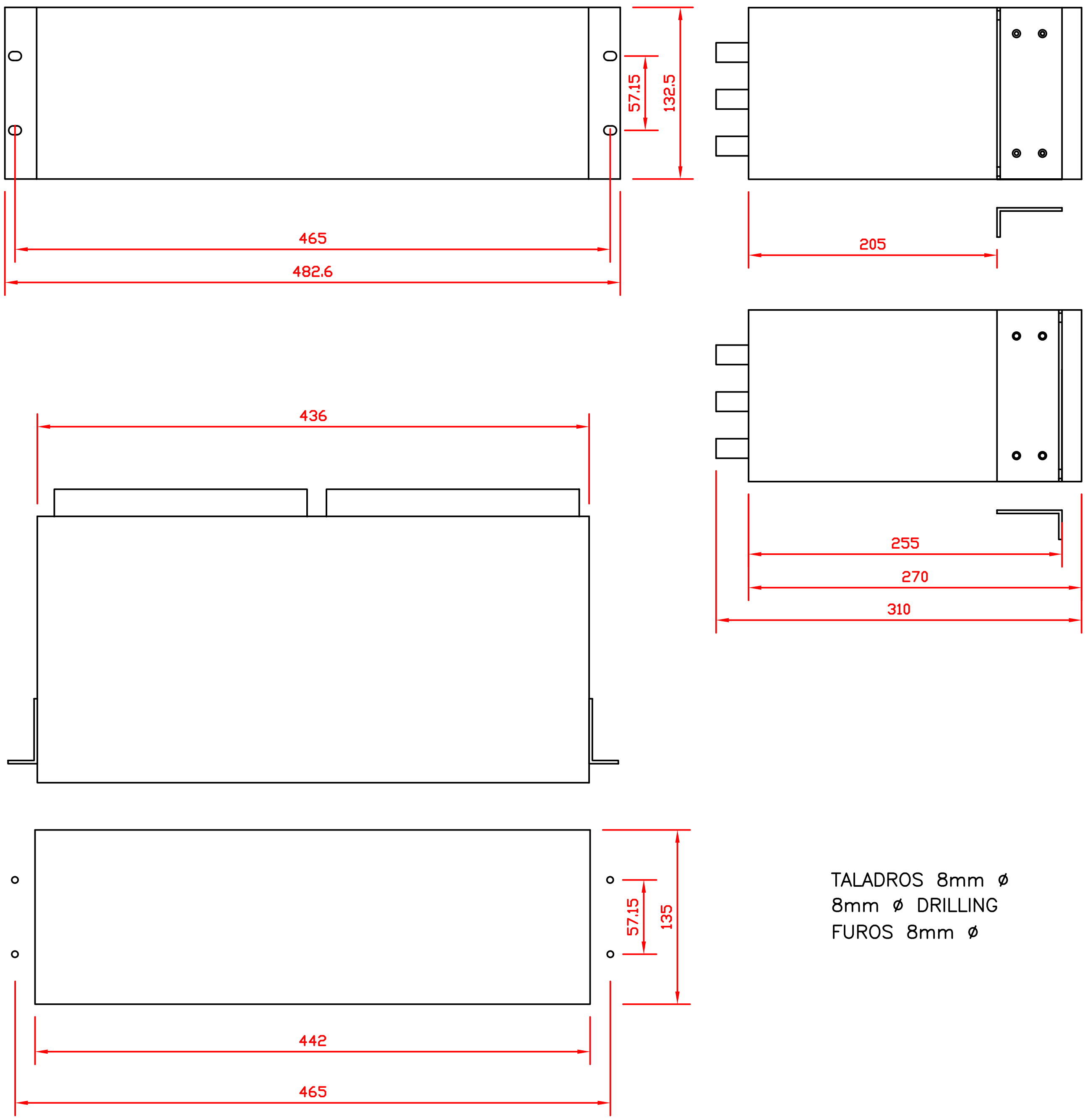
Rev.0

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

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.

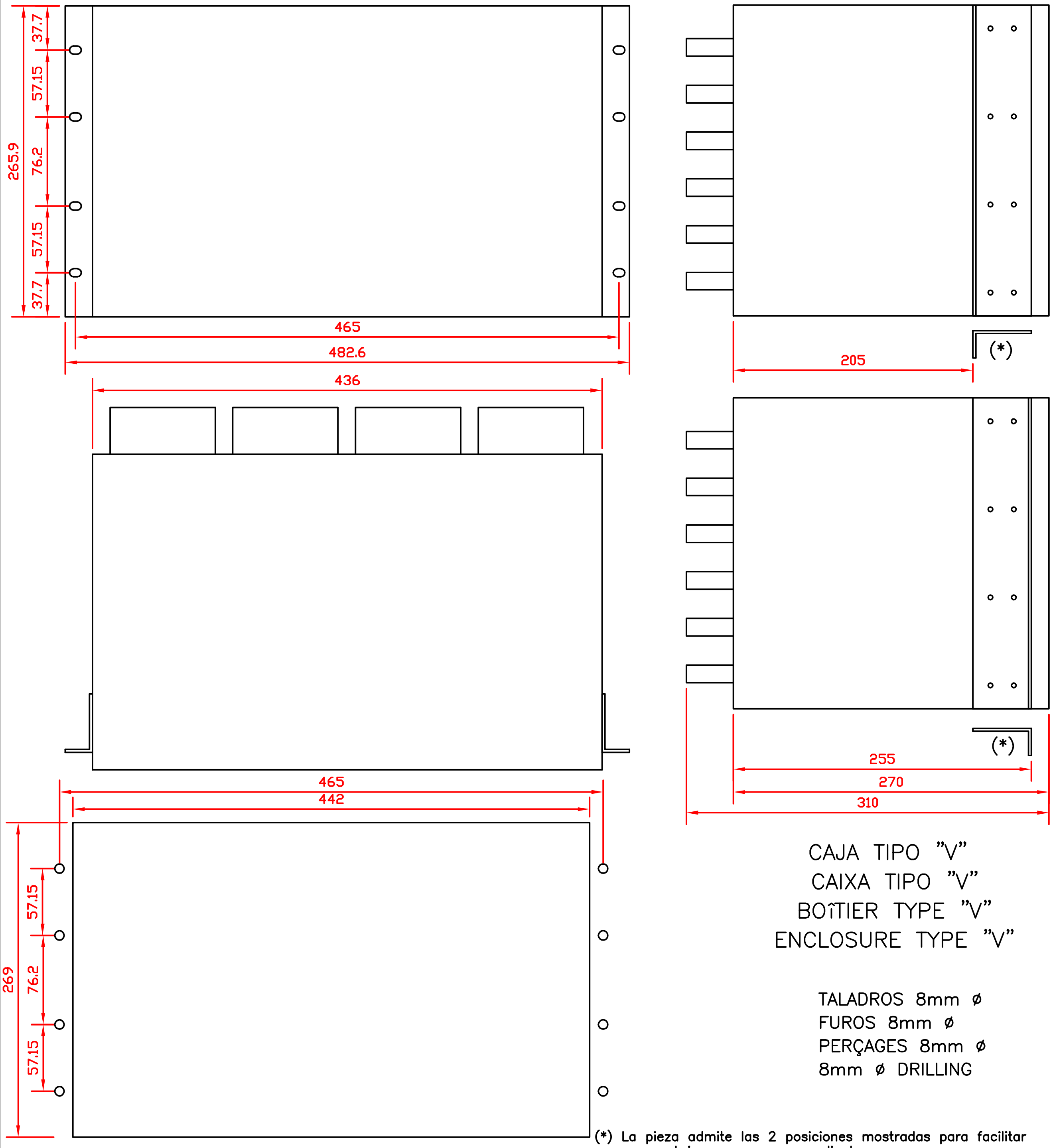
TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "S" 3U 1RACK

Rev.0

NUMERO: 4BF0100/0041

	Fecha	Nombre	
Dibujado	28/04/05	U.G.	Hoja: 1
Aprobado	28/04/05	C.G.G.	Continua en Hoja:



CAJA TIPO "V"
CAIXA TIPO "V"
BOîTIER TYPE "V"
ENCLOSURE TYPE "V"

TALADROS 8mm ø
FUROS 8mm ø
PERÇAGES 8mm ø
8mm ø DRILLING

(*) La pieza admite las 2 posiciones mostradas para facilitar un montaje mas o menos saliente.

A peça admite as 2 posições mostradas para facilitar uma montagem do equipamento mais ou menos saliente.

La piéce peut être montée dans une des deux positions indiquées afin de faciliter le montage de l'equipement plus ou moinx proéminent.

Two mounting positions are posible, as shown, to vary the depth of the unit with respect to the cabinet.

REVISIONES	0	CD0504145	1	CD0901130
2	3		4	
5	6		7	
8	9		10	
11	12		13	
14	15		16	

Z I V Aplicaciones y Tecnologia S.A.

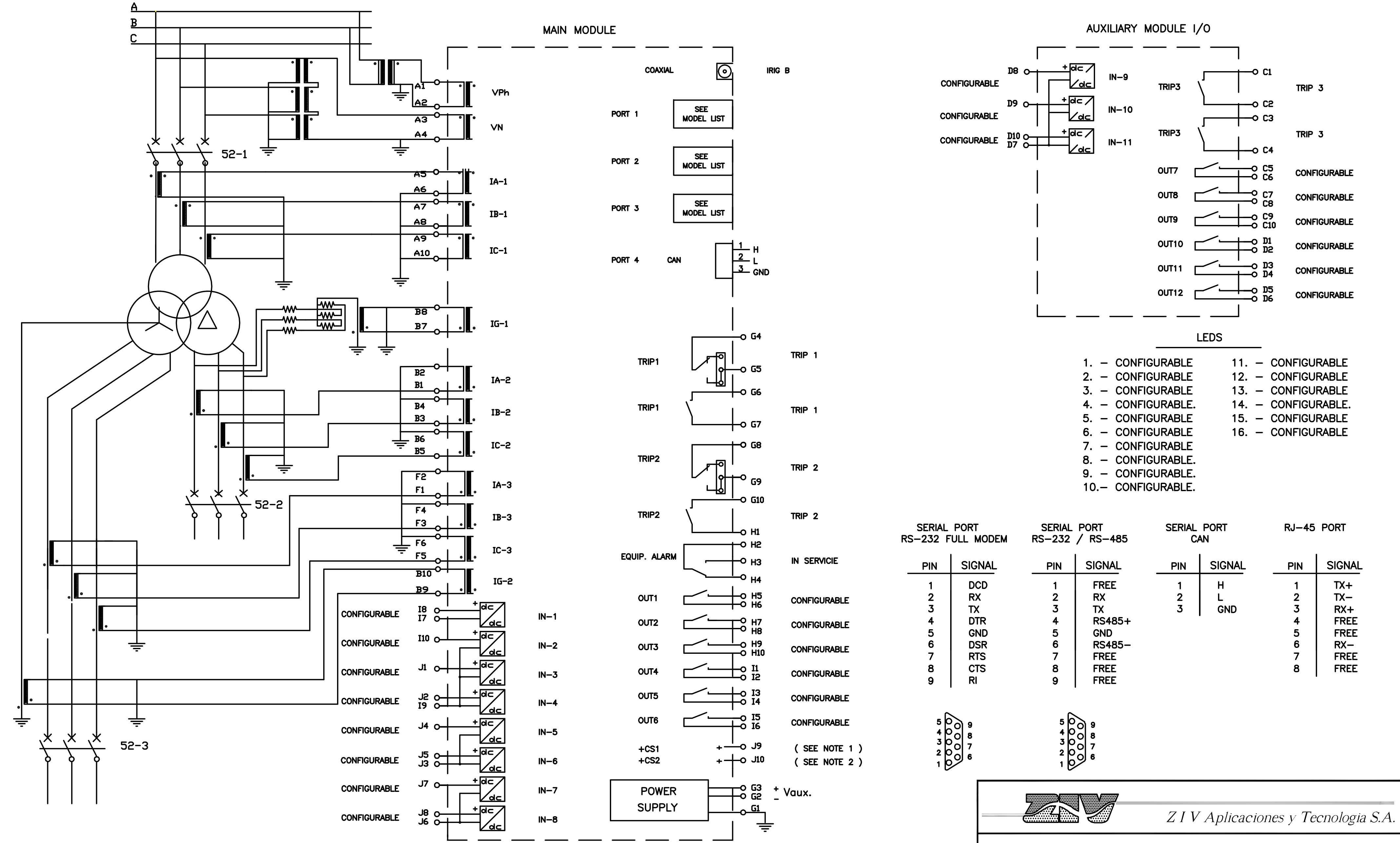
TITULO: DIMENSIONES Y TALADRADO

PROYECTO: CAJA TIPO "V" 6U 1RACK

Rev.0
Rev. 1 10/2/09

NUMERO: 4BF0100/0043

	Fecha	Nombre	
Dibujado	27/04/05	U.G.	Hoja: 1
Aprobado	27/04/05	C.G.G.	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

SERIAL PORT RS-232 FULL MODEM

PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485-
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND

RJ-45 PORT

PIN	SIGNAL
1	TX+
2	TX-
3	RX+
4	FREE
5	FREE
6	RX-
7	FREE
8	FREE

NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 2: TERMINAL J10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN7 OR IN8 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 3: VPh AND VN ANALOG INPUTS CAN BE CONNECTED TO ANY OF THE WINDINGS. CONNECTION SHOWN IS ONLY ONE EXAMPLE. VPh CAN BE CONNECTED AS A L-L OR L-N VOLTAGE.
NOTE 4: CONFIGURATION SHOWN (WYE AND OPEN-DELTA) IS ONE CONNECTION EXAMPLE, A REFERENCE FOR OTHER POSSIBLE CONFIGURATIONS.
NOTE 5: NEUTRAL CONNECTION OF EACH WINDING DEPENDS ON GROUP CONNECTION AND IT IS POSSIBLE TO ASSIGN IG-1 AND IG-2 ANALOG INPUTS TO ANY OF THE WINDINGS.

REVISIONS	0	CD0808113	1		2		3		4	
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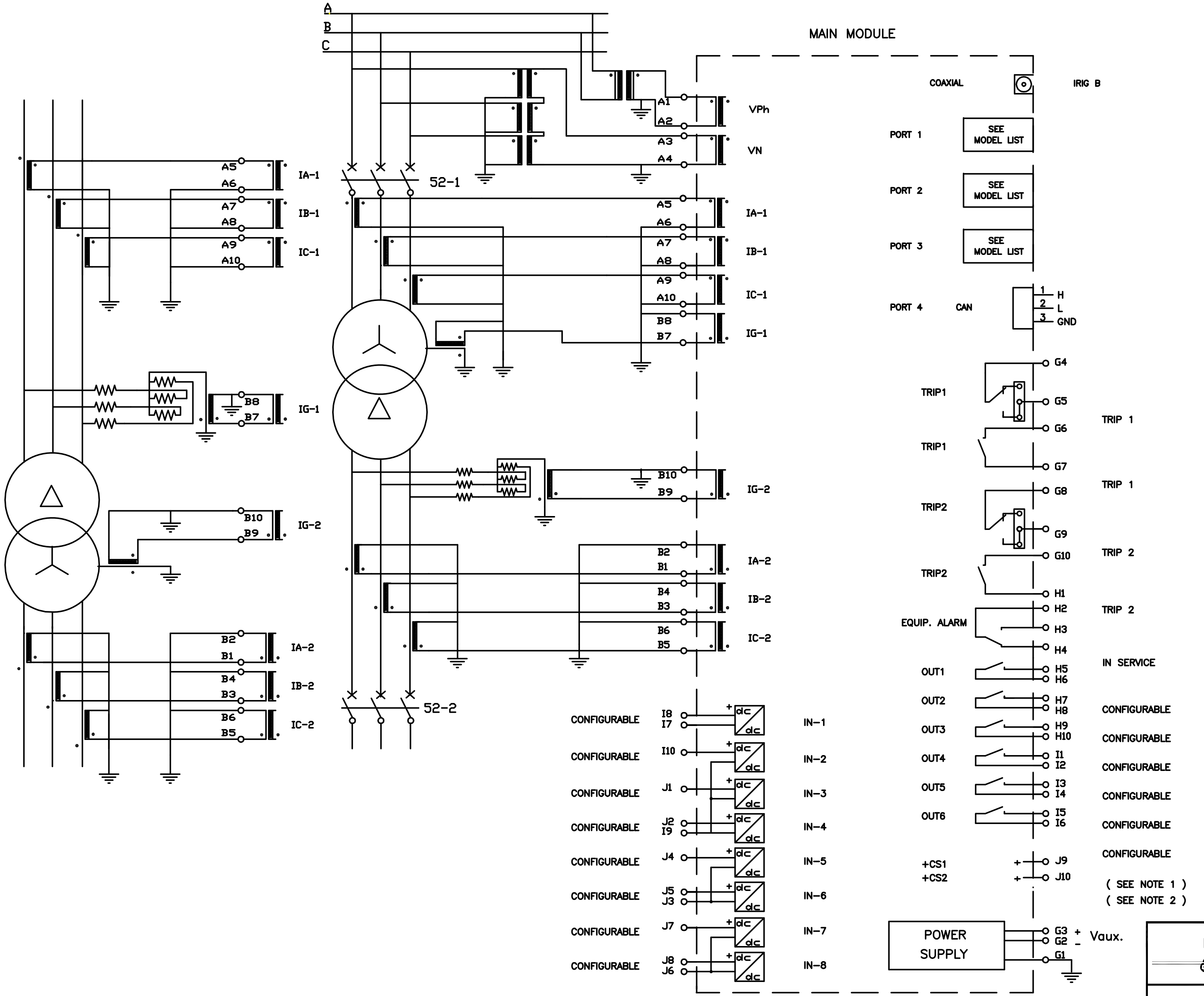
11	12		13		14		15		16	

Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNECTIONS 7IDV-B (100)
PROJECT: IDV (BORNAS W.)
Rev.0
NUMBER: 3RX0187/0033

	Date	Name
Drawn	27/08/08	J.C.S.
Approved	27/08/08	J.M.Y.

Sheet: 1
Continued on Sheed:



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10.– CONFIGURABLE.

SERIAL PORT RS-232 FULL MODEM

PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND

NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
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NOTE 5: NEUTRAL CONNECTION OF EACH WINDING DEPENDS ON GROUP CONNECTION AND IT IS POSSIBLE TO ASSIGN IG-1 AND IG-2 ANALOG INPUTS TO ANY OF THE WINDINGS.

REVISIONS	0	CD0608100	1		2		3		4	
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Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNECTIONS IDV 2U

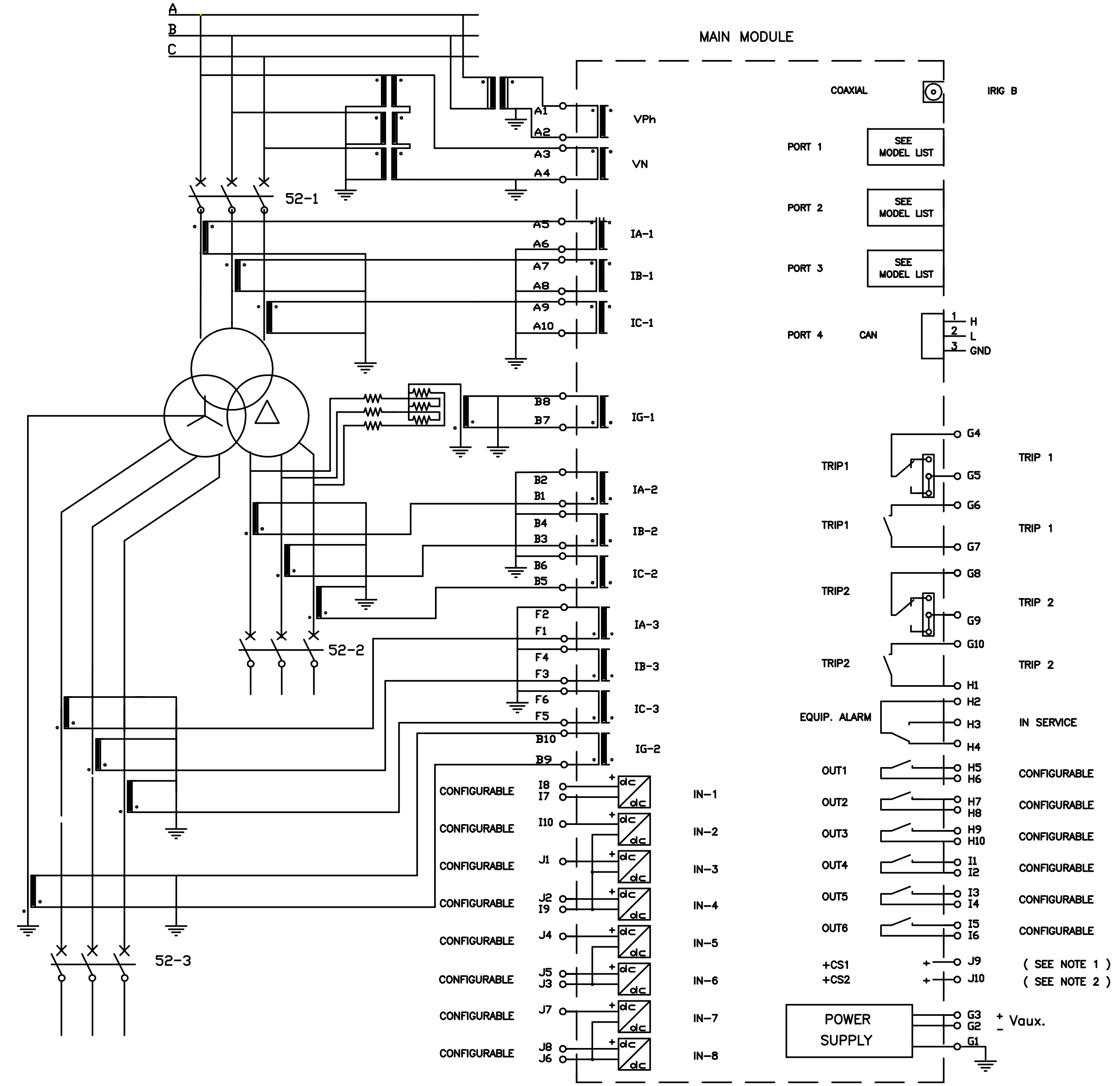
PROJECT: IDV (BORNAS W.)

Rev.0 NUMBER: 3RX0187/0018

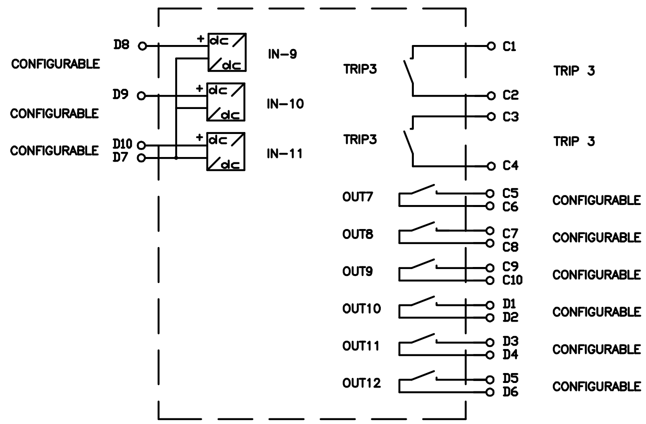
	Date	Name
Drawn	02/08/06	J.C.S
Approved	02/08/06	J.M.Y.

Sheet: 1

Continued on Sheed:



AUXILIARY MODULE I/O



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10.– CONFIGURABLE.

SERIAL PORT RS-232 FULL MODEM

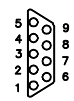
PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

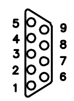
SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485-
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND





NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 2: TERMINAL J10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN7 OR IN8 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
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REVISIONS	0	CD0608100	1		2		3		4	
5	6		7		8		9		10	
11	12		13		14		15		16	

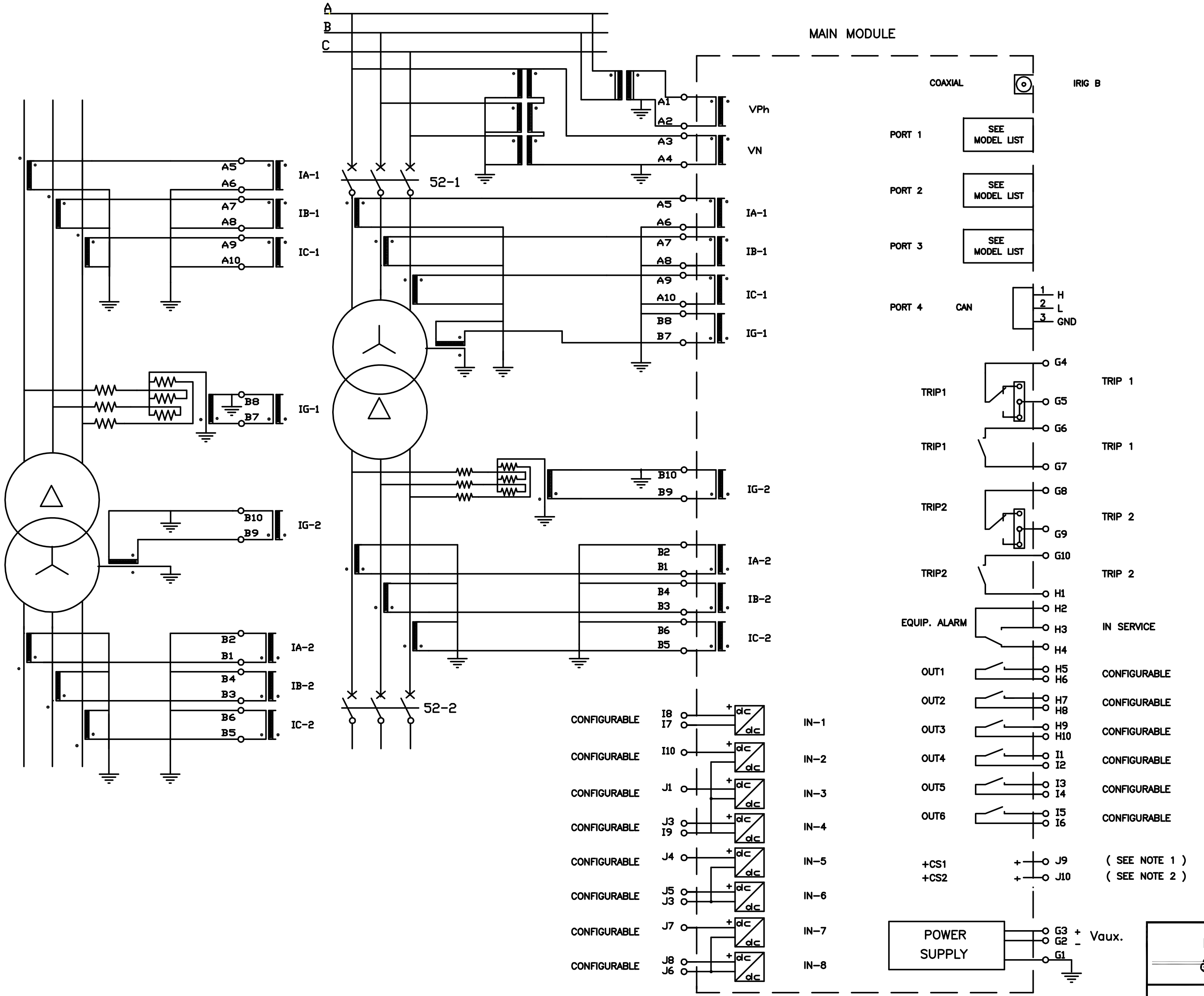
Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNECTIONS IDV-B 3U

PROJECT: IDV (BORNAS W.)

Rev.0 NUMBER: 3RX0187/0020

	Date	Name	Sheet:1
Drawn	02/08/06	J.C.S.	Continued on Sheed:
Approved	02/08/06	J.M.Y.	



LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10.– CONFIGURABLE.

SERIAL PORT RS–232 FULL MODEM

PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT RS–232 / RS–485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND

NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
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NOTE 5: NEUTRAL CONNECTION OF EACH WINDING DEPENDS ON GROUP CONNECTION AND IT IS POSSIBLE TO ASSIGN IG–1 AND IG–2 ANALOG INPUTS TO ANY OF THE WINDINGS.

REVISIONS	0	CD0608100	1		2		3		4	
5	6		7		8		9		10	
11	12		13		14		15		16	

Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNECTIONS IDV–A 3U

PROJECT: IDV–A (BORNAS W)

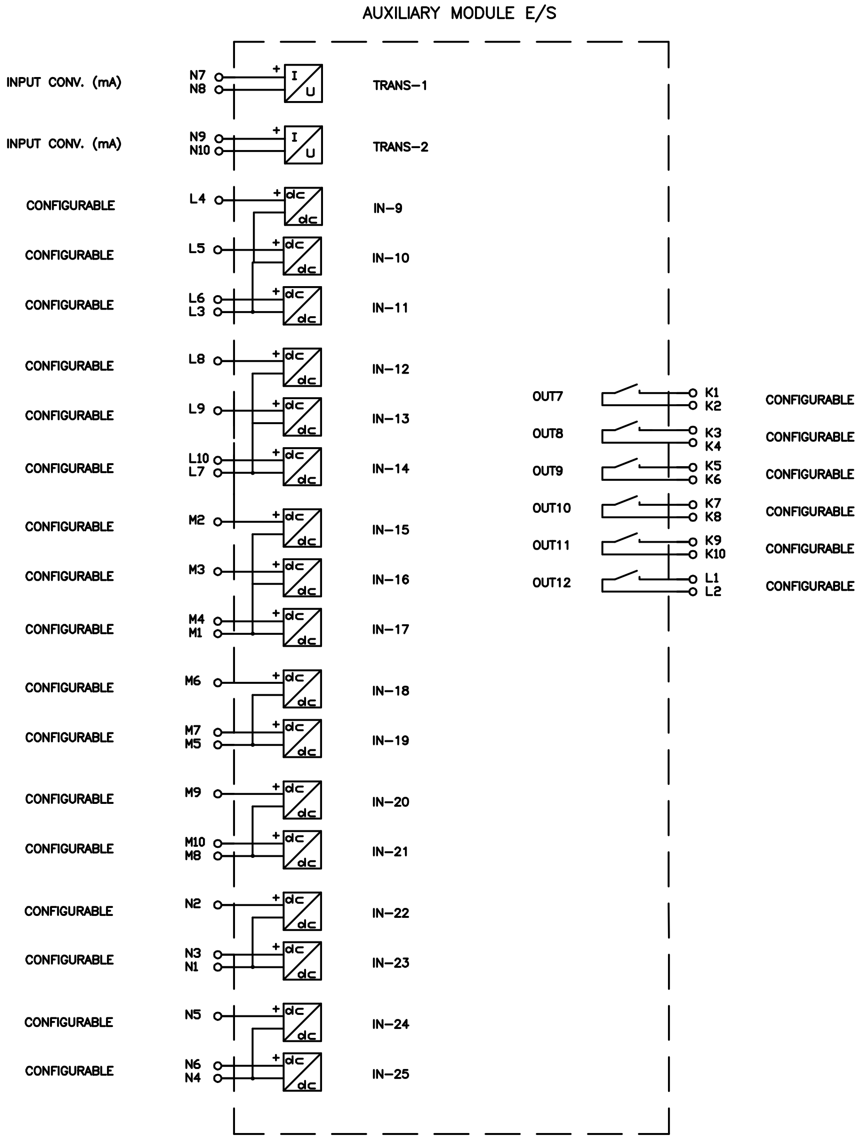
Rev.0

NUMBER: 3RX0187/0019

	Date	Name
Drawn	02/08/06	J.C.S.
Approved	02/08/06	J.M.Y.

Sheet: 1

Continued on Sheed: 2



"WARNING"
This document contains trade secret information of Z I V S.A. Unauthorized disclosure is strictly prohibited and may result in serious legal consequences.

REVISIONS	0	CD0608100	1		2		3		4	
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11	12		13		14		15		16	

Z I V Aplicaciones y Tecnologia S.A.

TITLE: EXTERNAL CONNECTIONS IDV-A 3U

PROJECT: IDV-A (BORNAS W.)

Rev.0

NUMBER: 3RX0187/0019

	Date	Name	
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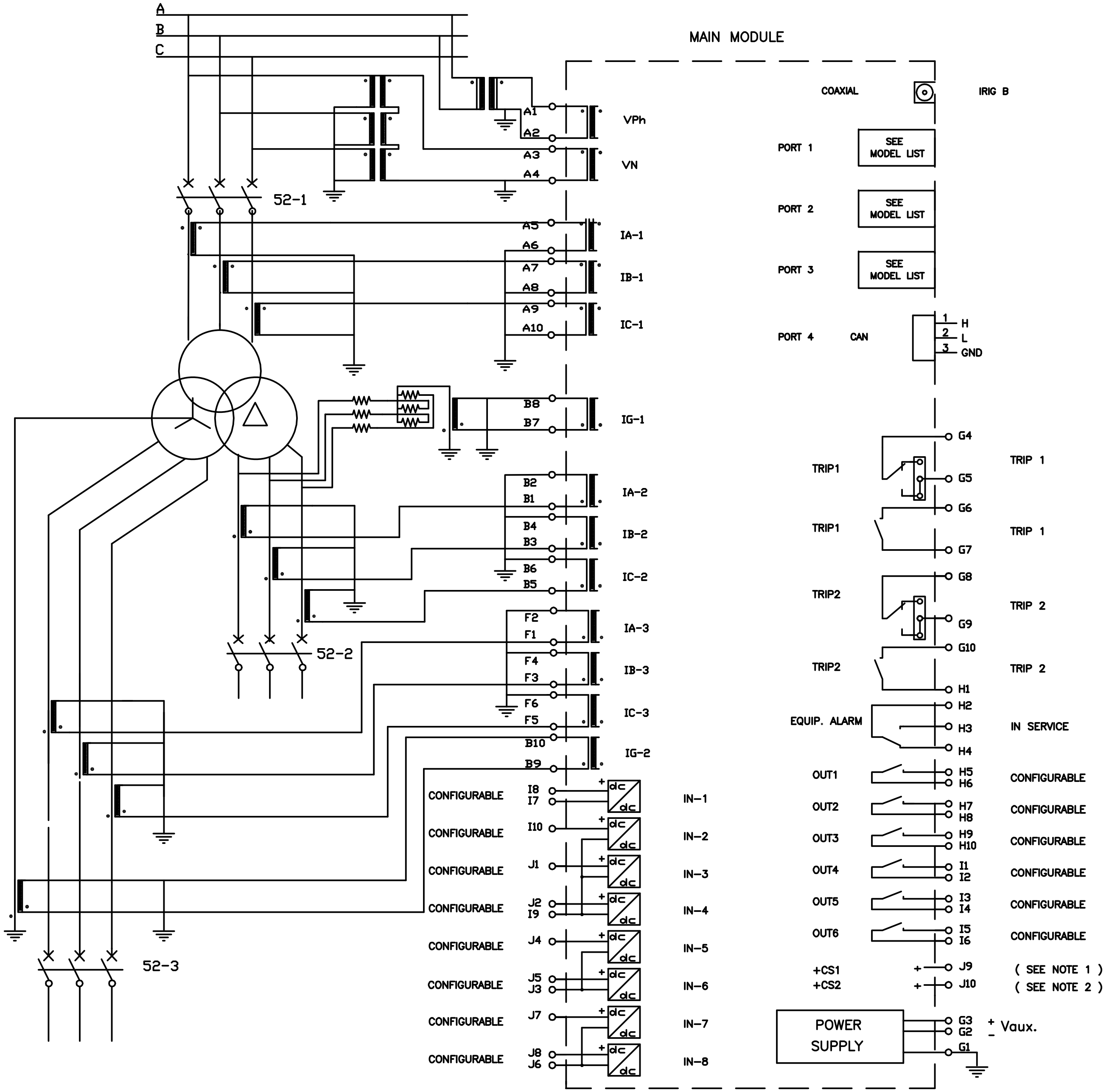
Approved	02/08/06	J.M.Y.	



LEDS

1. – CONFIGURABLE	12. – CONFIGURABLE
2. – CONFIGURABLE	13. – CONFIGURABLE
3. – CONFIGURABLE	14. – CONFIGURABLE.
4. – CONFIGURABLE.	15. – CONFIGURABLE
5. – CONFIGURABLE	16. – CONFIGURABLE
6. – CONFIGURABLE	17. – CONFIGURABLE
7. – CONFIGURABLE	18. – CONFIGURABLE.
8. – CONFIGURABLE.	19. – CONFIGURABLE.
9. – CONFIGURABLE.	20.– CONFIGURABLE.
10.– CONFIGURABLE.	21.– CONFIGURABLE.
11.– CONFIGURABLE.	22.– CONFIGURABLE.

SERIAL PORT RS-232 FULL MODEM

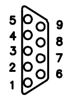
PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

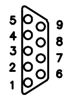
SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND





NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 2: TERMINAL J10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN7 OR IN8 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
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REVISIONS	0	CD0608100	1		2		3		4	
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11	12		13		14		15		16	

Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNECTIONS IDV-B 4U

PROJECT: IDV (BORNAS W.)

Rev.0

NUMBER: 3RX0187/0021

	Date	Name
Drawn	02/08/06	J.C.S.
Approved	02/08/06	J.M.Y.

Sheet: 1

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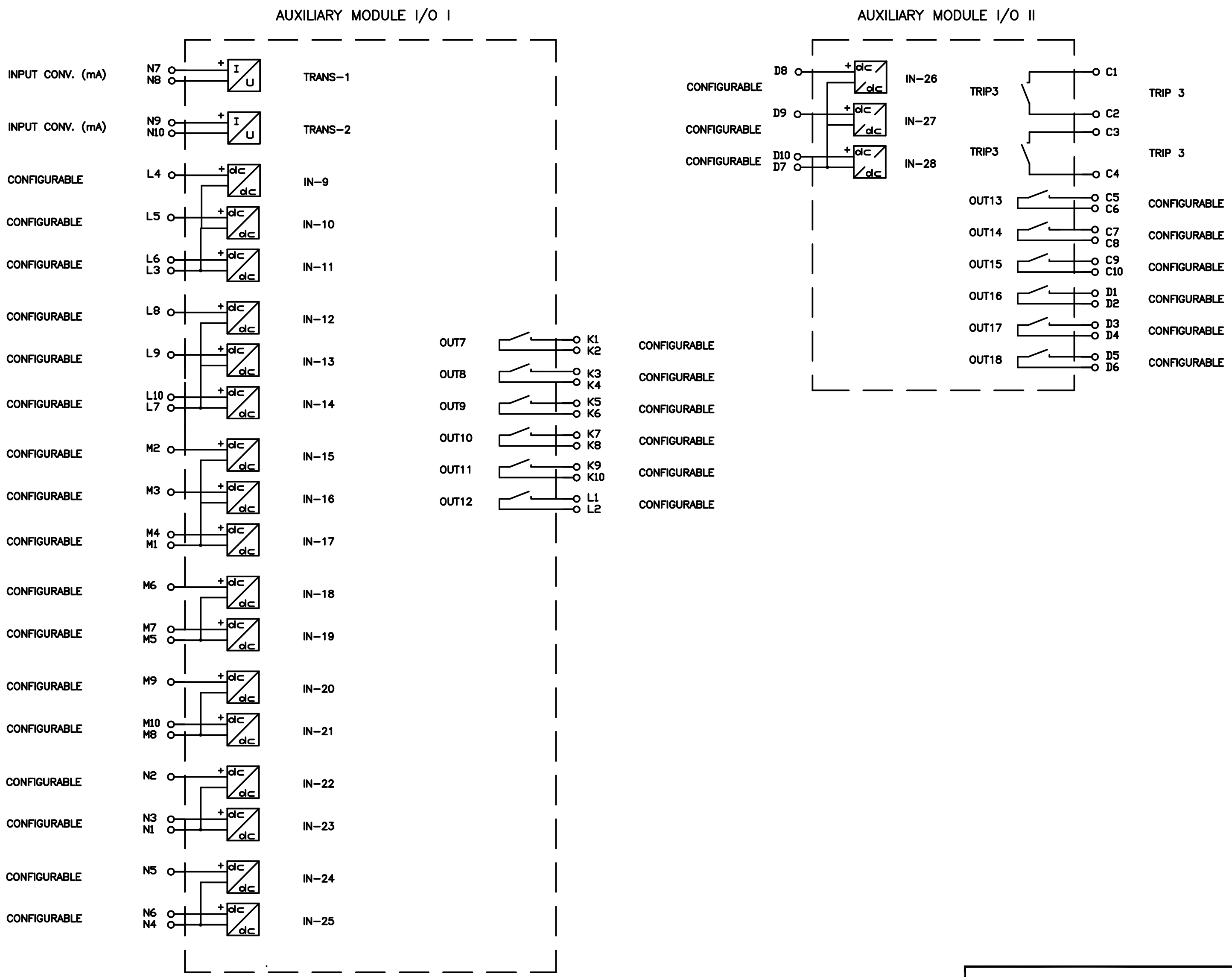

"WARNING"
This document contains trade secret information of Z I V S.A. Unauthorized disclosure is strictly prohibited and may result in serious legal consequences.

REVISIONS	0	CD0608100	1		2		3		4	
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Z I V Aplicaciones y Tecnologia S.A.

TITLE: EXTERNAL CONNECTIONS IDV-B 4U

PROJECT: IDV (BORNAS W.)

Rev.0

NUMBER: 3RX0187/0021

	Date	Name	
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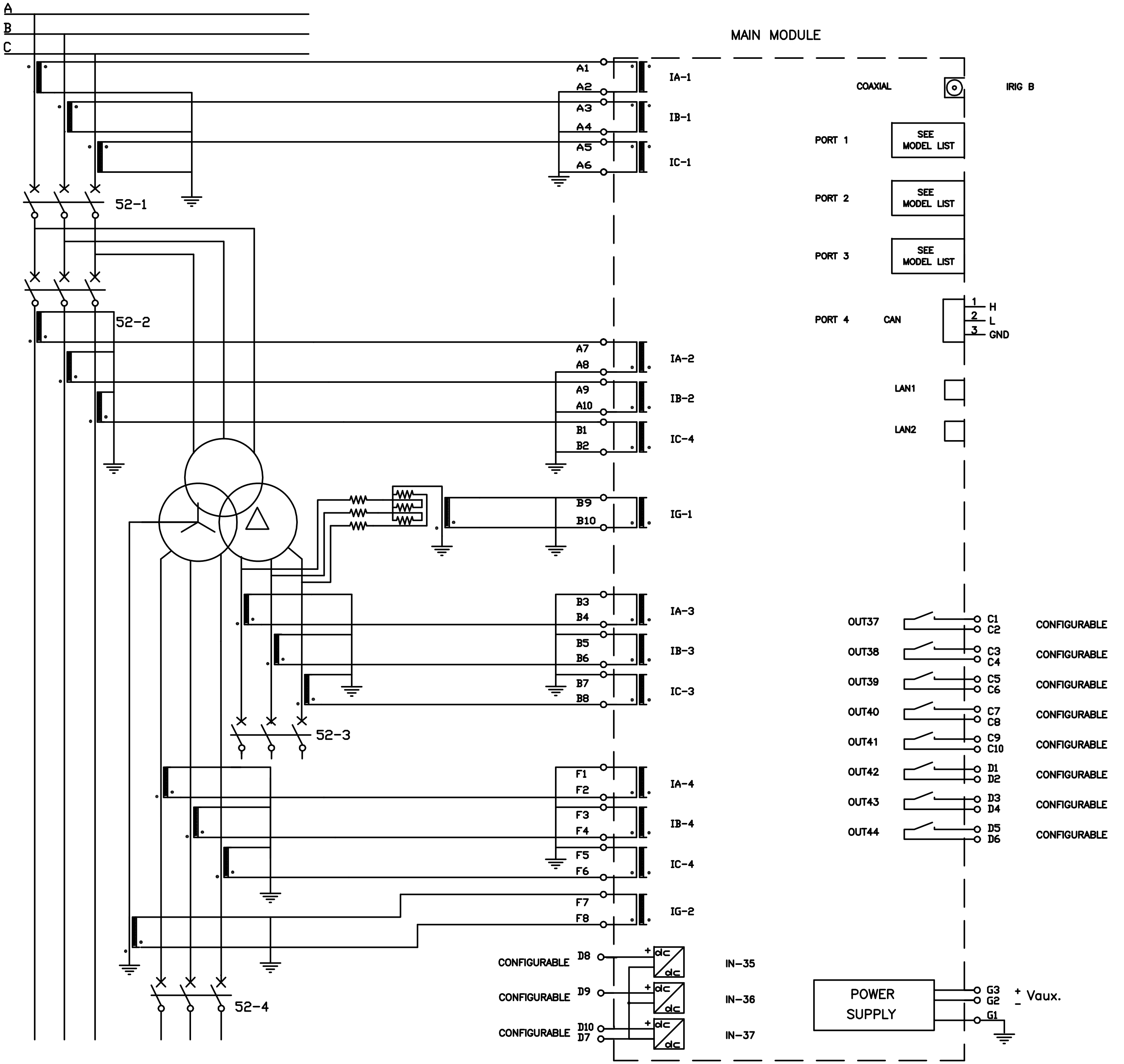
Approved	02/08/06	J.M.Y.	Continued on Sheed:



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.

SERIAL PORT RS-232 FULL MODEM

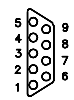
PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

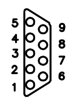
SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND





NOTE 1: CONFIGURATION SHOWN (WYE AND OPEN-DELTA) IS ONE CONNECTION EXAMPLE, A REFERENCE FOR OTHER POSSIBLE CONFIGURATIONS.
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REVISIONS	0	CD0906124	1		2		3		4	
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Z I V Aplicaciones y Tecnología S.L.

TITLE: EXTERNAL CONNECTIONS IDV–D

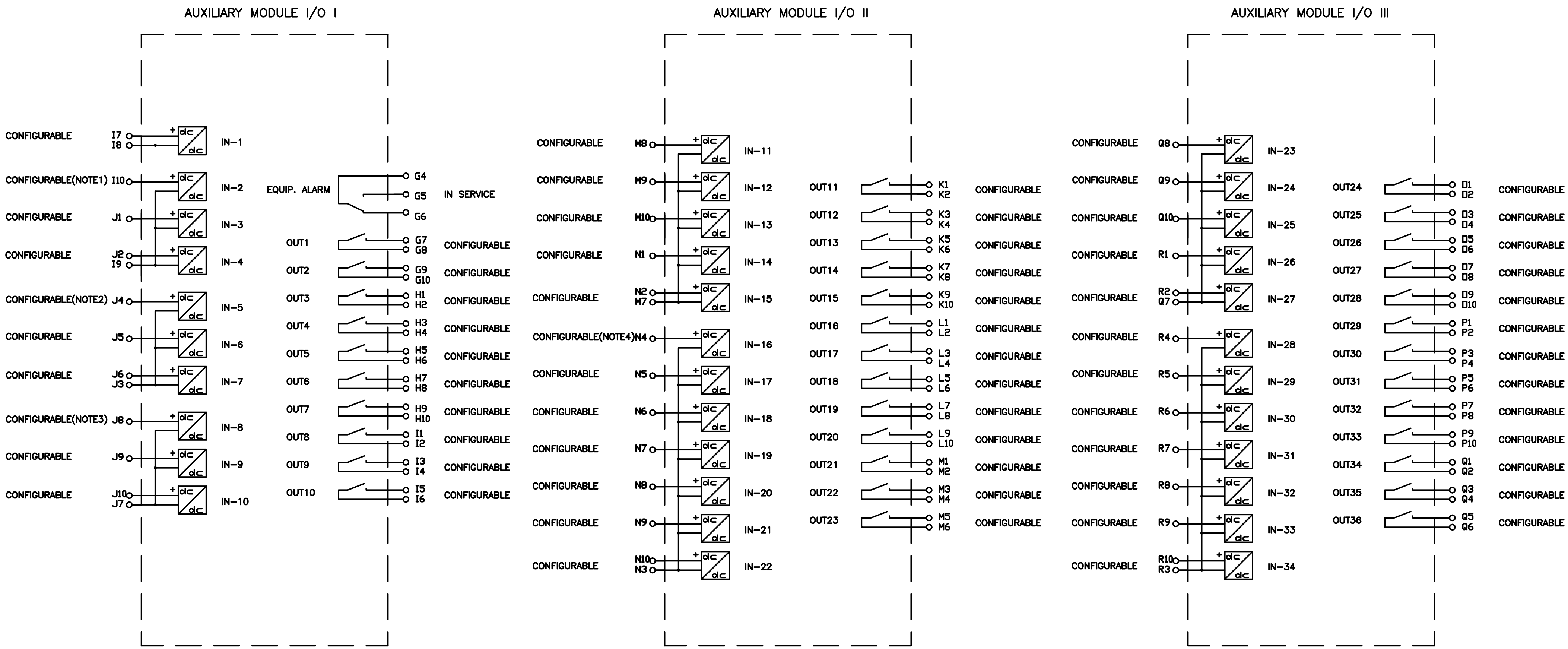
PROJECT: IDV (BORNAS W.)

Rev.0 NUMBER: 3RX0187/0038

	Date	Name
Drawn	24/06/09	J.C.S.
Approved	24/06/09	J.M.Y.

Sheet: 1

Continued on Sheed: 2



NOTE 1: TERMINAL I10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 2: TERMINAL J4 HOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN6, IN7 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 3: TERMINAL J8 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN9, IN10 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 4: TERMINAL N4 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN17, IN18, IN19, IN20, IN21, IN22 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

REVISIONS	0	CD0906124	1	2	3	4
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11	12		13	14	15	16

Z I V Aplicaciones y Tecnología S.L.

TITLE: EXTERNAL CONNECTIONS IDV-D
PROJECT: IDV (BORNAS W.)
Rev.0
NUMBER: 3RX0187/0038

	Date	Name
Drawn	24/06/09	J.C.S.
Approved	24/06/09	J.M.Y.

Sheet: 2
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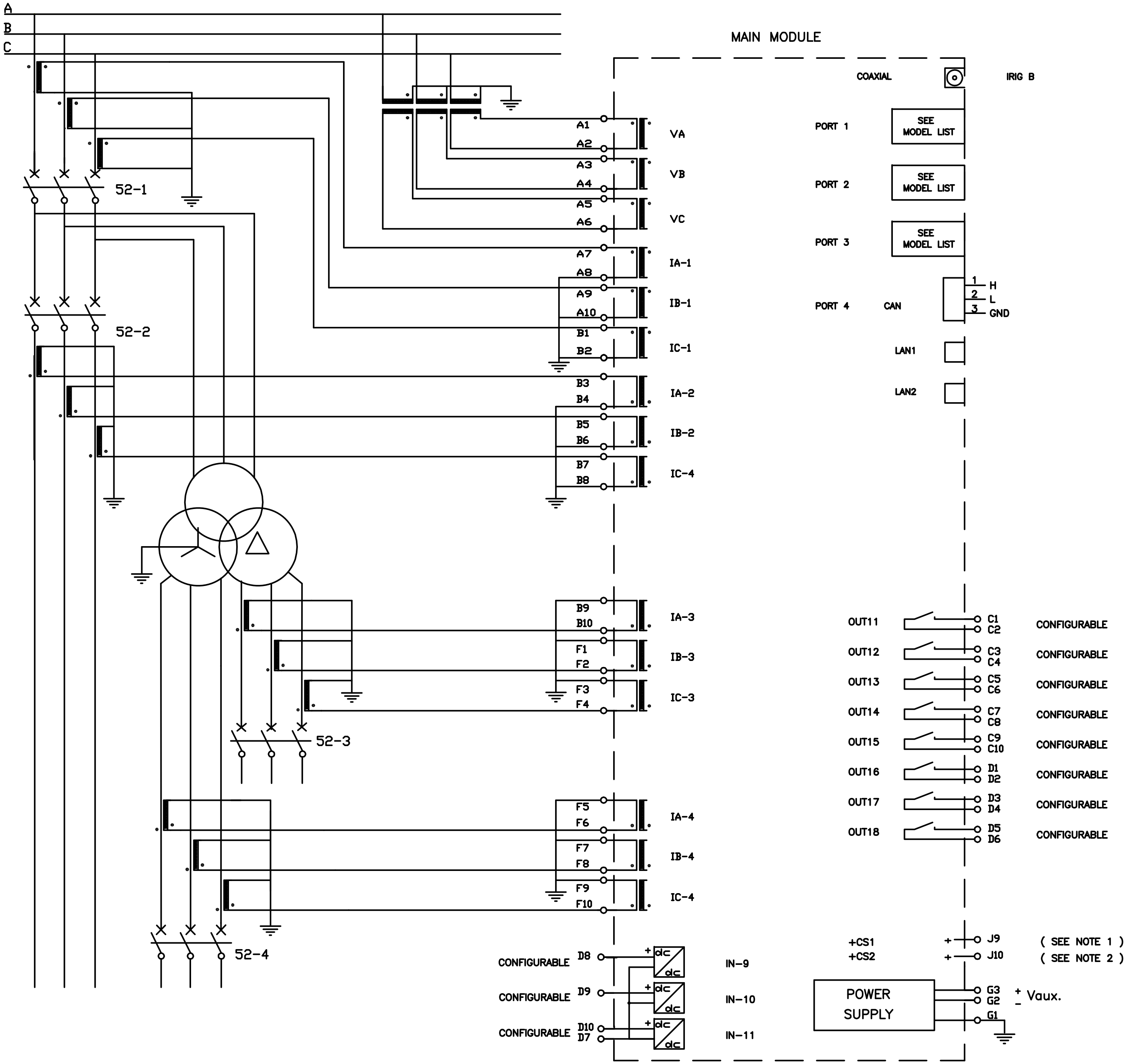


LEDS

1. – CONFIGURABLE
2. – CONFIGURABLE
3. – CONFIGURABLE
4. – CONFIGURABLE.
5. – CONFIGURABLE
6. – CONFIGURABLE
7. – CONFIGURABLE
8. – CONFIGURABLE.
9. – CONFIGURABLE.
10.– CONFIGURABLE.

SERIAL PORT RS-232 FULL MODEM

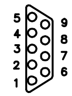
PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

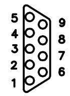
SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485−
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND





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REVISIONS	0	CD0810138	1		2		3		4	
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11	12		13		14		15		16	

Z I V Aplicaciones y Tecnología S.A.

TITLE: EXTERNAL CONNECTIONS IDV-F 3U

PROJECT: IDV (BORNAS W.)

Rev.0

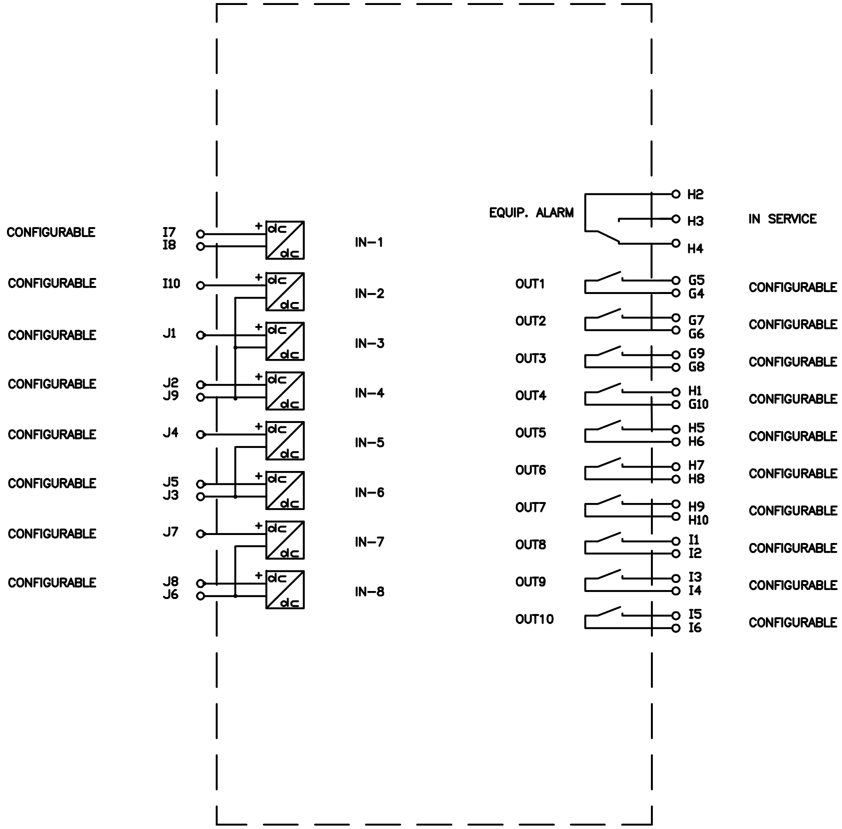
NUMBER: 3RX0187/0036

	Date	Name
Drawn	16/10/08	J.C.S.
Approved	16/10/08	J.M.Y.

Sheet: 1

Continued on Sheed: 2

AUXILIARY MODULE I/O



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11	12		13		14		15		16	

Z I V Aplicaciones y Tecnologia S.A.

TITLE: EXTERNAL CONNECTIONS IDV-F 3U

PROJECT: IDV (BORNAS W.)

Rev.0

NUMBER: 3RX0187/0036

	Date	Name
Drawn	16/10/08	J.C.S.
Approved	16/10/08	J.M.Y.

Sheet: 2

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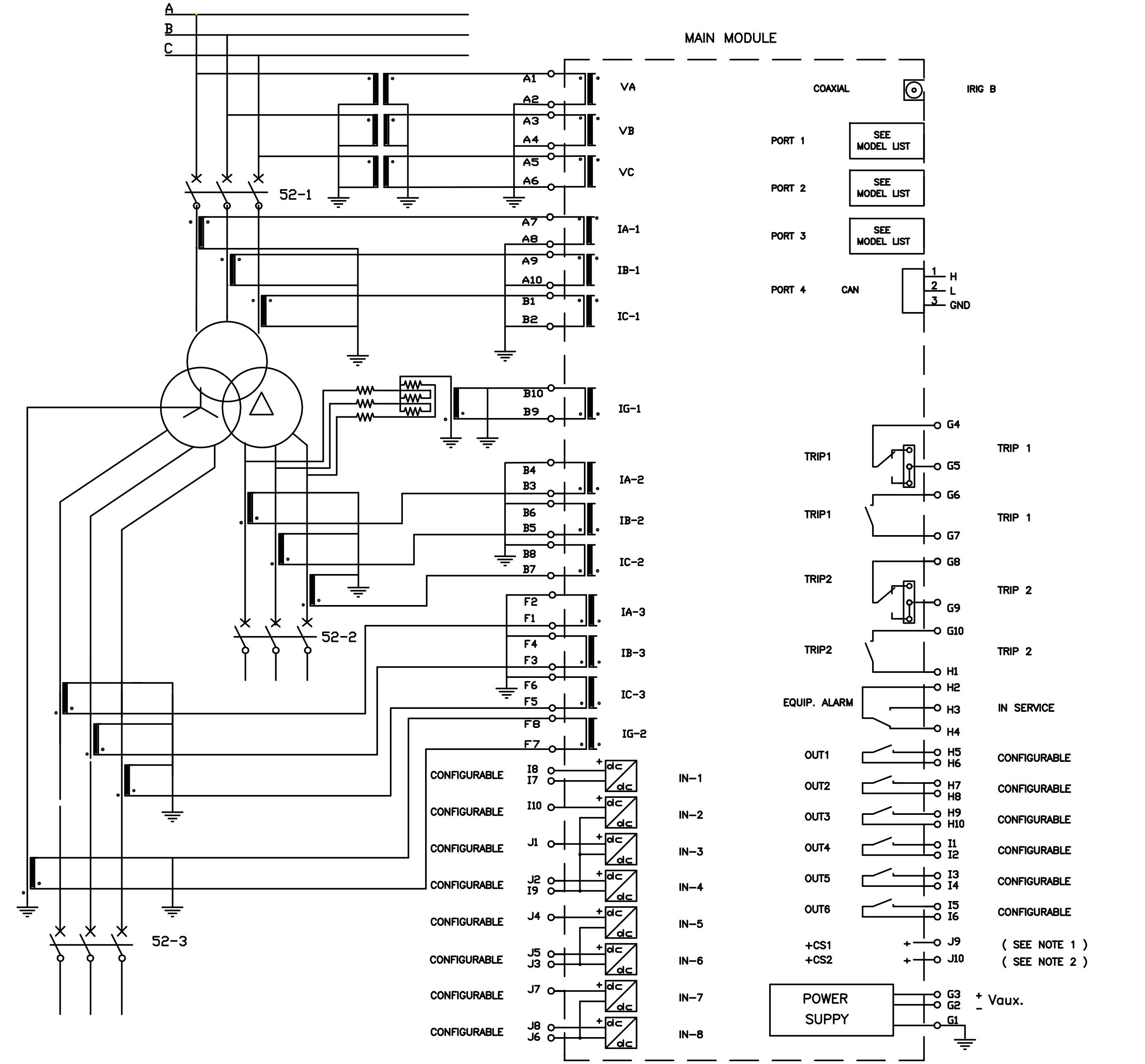

LEDS

1. – CONFIGURABLE	12. – CONFIGURABLE
2. – CONFIGURABLE	13. – CONFIGURABLE
3. – CONFIGURABLE	14. – CONFIGURABLE.
4. – CONFIGURABLE.	15. – CONFIGURABLE
5. – CONFIGURABLE	16. – CONFIGURABLE
6. – CONFIGURABLE	17. – CONFIGURABLE
7. – CONFIGURABLE	18. – CONFIGURABLE.
8. – CONFIGURABLE.	19. – CONFIGURABLE.
9. – CONFIGURABLE.	20.– CONFIGURABLE.
10.– CONFIGURABLE.	21.– CONFIGURABLE.
11.– CONFIGURABLE.	22.– CONFIGURABLE.

SERIAL PORT RS-232 FULL MODEM

PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	FREE
8	FREE
9	FREE

SERIAL PORT CAN

PIN	SIGNAL
1	H
2	L
3	GND

NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 2: TERMINAL J10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN7 OR IN8 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 3: VA, VB, AND VC ANALOG INPUTS CAN BE CONNECTED TO ANY OF THE WINDINGS. CONNECTION SHOWN IS ONLY ONE EXAMPLE. VA, VB, AND VC CAN BE CONNECTED AS A L-L OR L-N VOLTAGE.
NOTE 4: CONFIGURATION SHOWN (WYE AND OPEN-DELTA) IS ONE CONNECTION EXAMPLE, A REFERENCE FOR OTHER POSSIBLE CONFIGURATIONS.
NOTE 5: NEUTRAL CONNECTION OF EACH WINDING DEPENDS ON GROUP CONNECTION AND IT IS POSSIBLE TO ASSIGN IG-1 AND IG-2 ANALOG INPUTS TO ANY OF THE WINDINGS.

REVISIONS	0	CD1005128	1		2		3		4	
5	6		7		8		9		10	
11	12		13		14		15		16	

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TITLE: CONEXIONES EXTERNAS 8IDV-H 4U

PROJECT: IDV (BORNAS W.)

Rev.0 NUMBER: 3RX0187/0048

	Date	Name
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Approved	02/06/10	J.M.Y.

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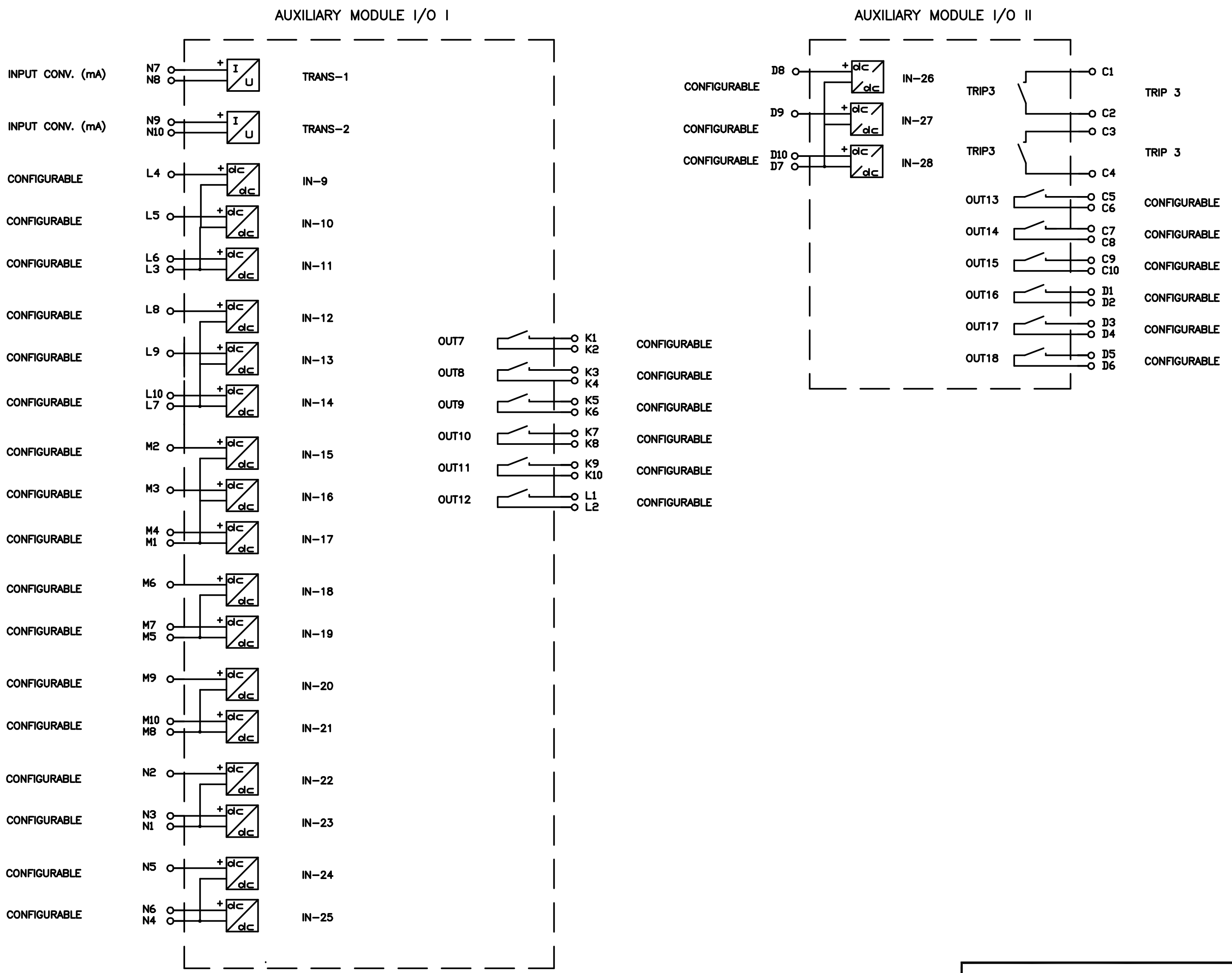
Continued on Sheed: 2



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Z I V Aplicaciones y Tecnología S.L.

TITLE: EXTERNAL CONNECTIONS IDV-H 4U

PROJECT: IDV (BORNAS W.)

Rev.0 NUMBER: 3RX0187/0048

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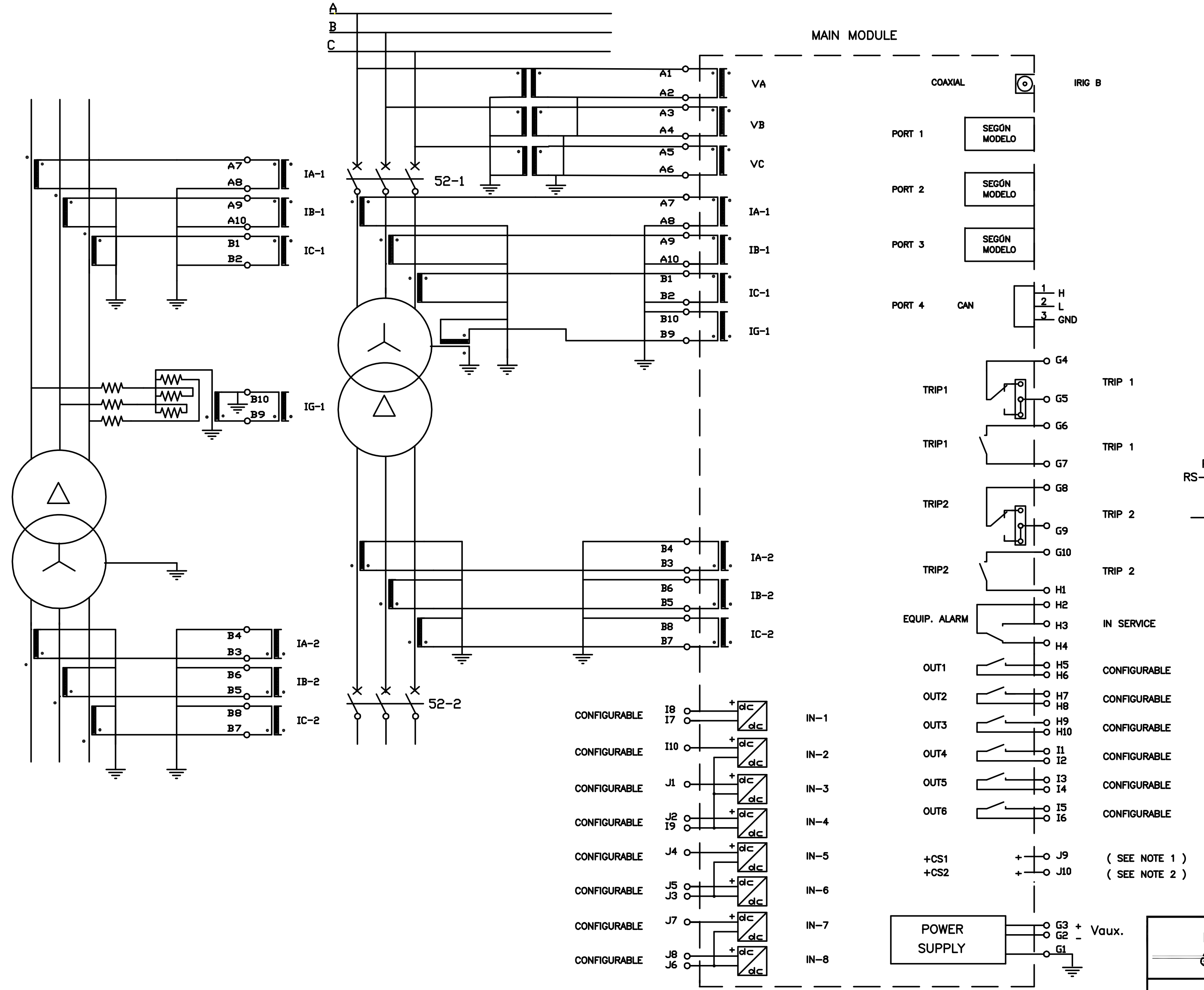
Drawn	01/06/10	J.C.S.	Sheet: 2
Approved	01/06/10	J.M.Y.	Continued on Sheed:



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

PORT SERIE RS-232 FULL MODEM

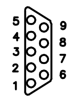
PIN	SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

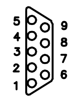
PORT SERIE RS-232 / RS-485

PIN	SIGNAL
1	FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485−
7	FREE
8	FREE
9	FREE

PORT SERIE CAN

PIN	SIGNAL
1	H
2	L
3	GND





NOTE 1: TERMINAL J9 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4, IN5 OR IN6 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 2: TERMINAL J10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN7 OR IN8 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.
NOTE 3: VA, VB, AND VC ANALOG INPUTS CAN BE CONNECTED TO ANY OF THE WINDINGS. CONNECTION SHOWN IS ONLY ONE EXAMPLE. VA, VB, AND VC CAN BE CONNECTED AS A L-L OR L-N VOLTAGE.
NOTE 4: CONFIGURATION SHOWN (WYE AND OPEN-DELTA) IS ONE CONNECTION EXAMPLE, A REFERENCE FOR OTHER POSSIBLE CONFIGURATIONS.
NOTE 5: NEUTRAL CONNECTION OF EACH WINDING DEPENDS ON GROUP CONNECTION AND IT IS POSSIBLE TO ASSIGN IG-1 ANALOG INPUT TO ANY OF THE WINDINGS.

REVISIONS	0	CD1005128	1		2		3		4	
5	6		7		8		9		10	
11	12		13		14		15		16	

Z I V Aplicaciones y Tecnología S.L.

TITLE: EXTERNAL CONNECTIONS IDV-G 2U

PROJECT: IDV-G (BORNAS W)

Rev.0 NUMBER: 3RX0187/0046

	Date	Name
Drawn	02/06/10	J.C.S.
Approved	02/06/10	J.M.Y.

Sheet: 1

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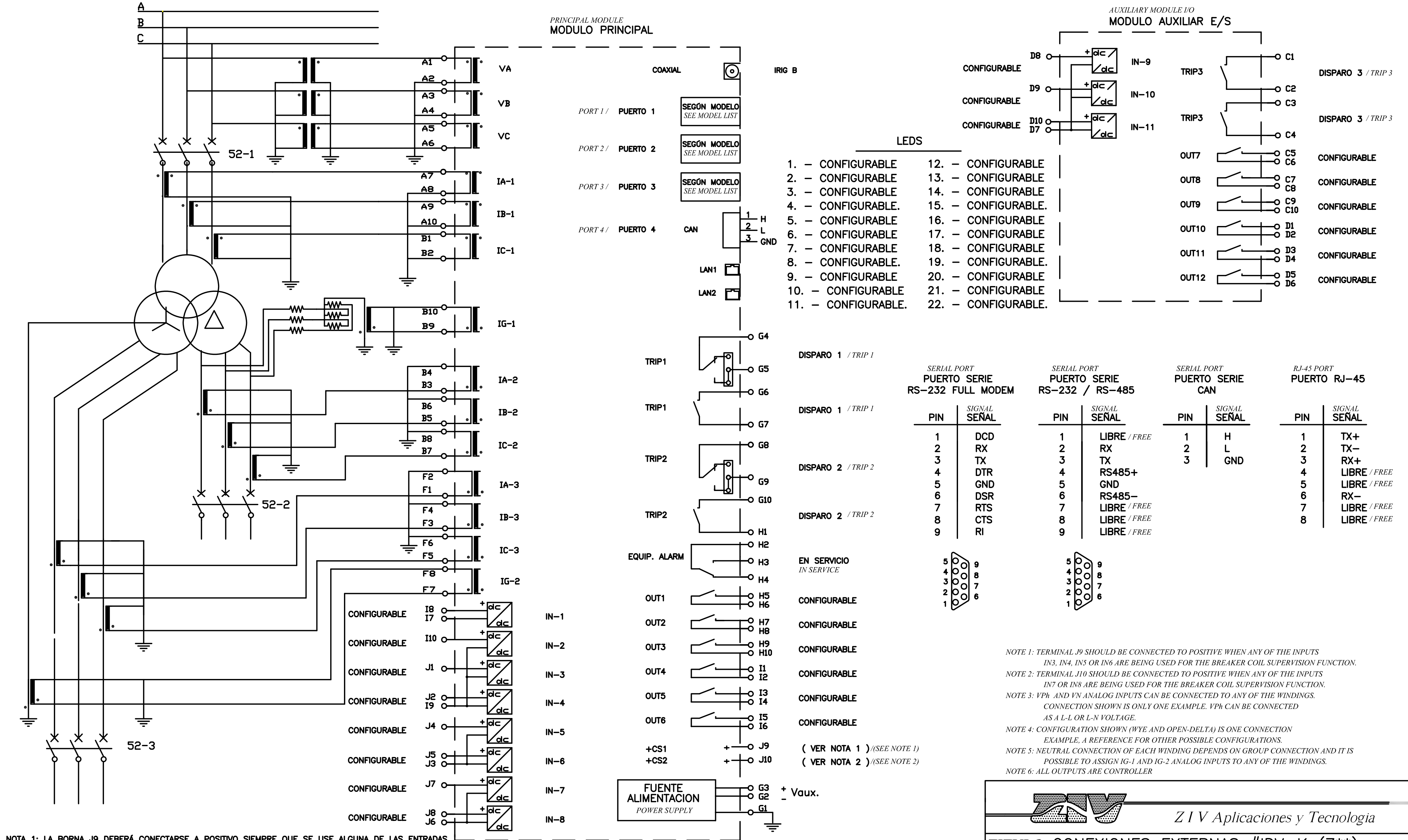

NOTA 1: LA BORNA J9 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN3, IN4, IN5 o IN6 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 2: LA BORNA J10 DEBERÁ CONECTARSE A POSITIVO SIEMPRE QUE SE USE ALGUNA DE LAS ENTRADAS IN7, IN8 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 3: LOS CANALES DE TENSIÓN VA, VB Y VC PUEDEN CONECTARSE EN CUALQUIERA DE LOS TRES DEVANADOS. LA CONEXIÓN REPRESENTADA ES ÚNICAMENTE UN EJEMPLO DE APLICACIÓN. VA, VB Y VC PUEDEN CONECTARSE A CUALQUIER TENSIÓN FASE-FASE Ó FASE-TIERRA.

NOTA 4: LA CONFIGURACIÓN REPRESENTADA (ESTRELLA Y TRIANGULO PARA LOS DEVANADOS 2 Y 3) ES ÚNICAMENTE UN EJEMPLO DE CONEXIÓN, REFERENCIA PARA EL RESTO DE CONFIGURACIONES POSIBLES.

NOTA 5: LA CONEXIÓN DEL NEUTRO DE CADA DEVANADO DEPENDE DEL GRUPO DE CONEXIÓN, PUDIENDO ASIGNARSE LOS CANALES IG-1 E IG-2 A CUALQUIERA DE LOS TRES DEVANADOS.

NOTA 6: TODAS LAS SALIDAS SON DE MANIOBRA.

REV.	0	CD1107105	1	2	3	4
5	6		7	8	9	10
11	12		13	14	15	16

ZIV *Aplicaciones y Tecnologia*

TITULO: CONEXIONES EXTERNAS #IDV-K (7**)
TITLE: EXTERNAL CONNECTIONS #IDV-K (7**)

PROYECTO / *PROJECT:* IDV (BORNAS W.) / IDV (TERMINALS W.)

Rev.0

NUM.: 3RX0187/0057

	Fecha / *Date*	Nombre / *Name*
Dibujado / *Drawn*	14/07/11	D.A.R.
Aprobado / *Approved*	14/07/11	P.A.

Hoja / *Sheet:* 1
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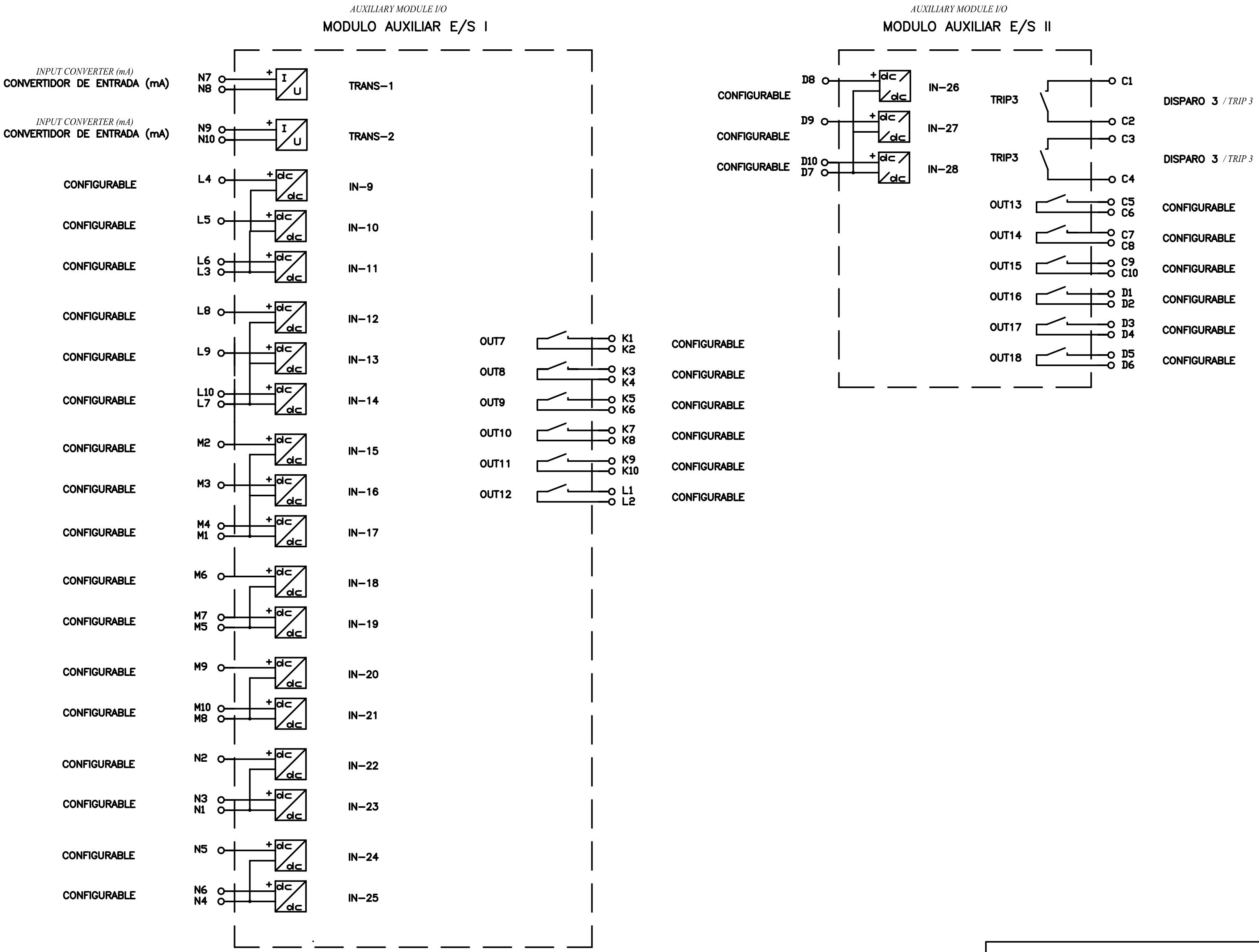

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Z I V Aplicaciones y Tecnologia

TITULO: CONEXIONES EXTERNAS #IDV-K (7**)
TITLE: EXTERNAL CONNECTIONS #IDV-K (7**)

PROYECTO / *PROJECT:* IDV (BORNAS W.) / IDV (TERMINALS W.)

Rev.0

NUM.: 3RX0187/0057

	Fecha / *Date*	Nombre / *Name*
Dibujado / *Drawn*	14/07/11	D.A.R.
Aprobado / *Approved*	14/07/11	P.A.

Hoja / *Sheet:* 2
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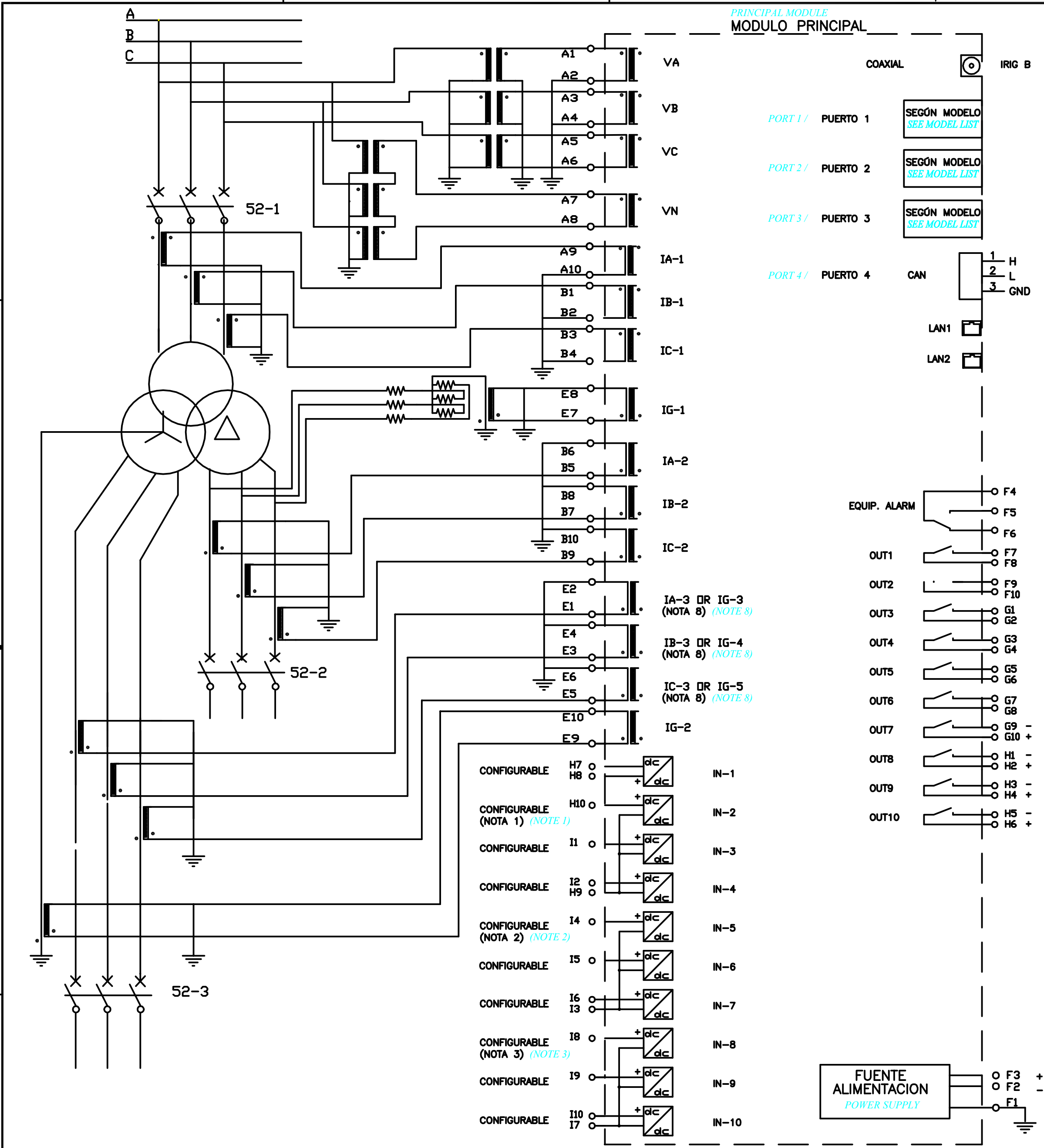

BUTTONS LEDS / BOTONES LEDS

ROJO (RED) 86 – CONFIGURABLE	VERDE (GREEN) 86 – CONFIGURABLE
ROJO (RED) P1 – CONFIGURABLE	VERDE (GREEN) P1 – CONFIGURABLE
ROJO (RED) P2 – CONFIGURABLE	VERDE (GREEN) P2 – CONFIGURABLE
ROJO (RED) P3 – CONFIGURABLE	VERDE (GREEN) P3 – CONFIGURABLE
ROJO (RED) P4 – CONFIGURABLE	VERDE (GREEN) P4 – CONFIGURABLE
ROJO (RED) P5 – CONFIGURABLE	VERDE (GREEN) P5 – CONFIGURABLE
ROJO (RED) P6 – CONFIGURABLE	VERDE (GREEN) P6 – CONFIGURABLE

LEDS

1. – CONFIGURABLE	9. – CONFIGURABLE
2. – CONFIGURABLE	10. – CONFIGURABLE
3. – CONFIGURABLE	11. – CONFIGURABLE.
4. – CONFIGURABLE.	12. – CONFIGURABLE
5. – CONFIGURABLE	13. – CONFIGURABLE
6. – CONFIGURABLE	14. – CONFIGURABLE
7. – CONFIGURABLE	15. – CONFIGURABLE
8. – CONFIGURABLE.	16. – CONFIGURABLE

SERIAL PORT / PUERTO SERIE RS-232 FULL MODEM

PIN	SEÑAL / SIGNAL
1	DCD
2	RX
3	TX
4	DTR
5	GND
6	DSR
7	RTS
8	CTS
9	RI

SERIAL PORT / PUERTO SERIE RS-232 / RS-485

PIN	SEÑAL / SIGNAL
1	LIBRE / FREE
2	RX
3	TX
4	RS485+
5	GND
6	RS485–
7	LIBRE / FREE
8	LIBRE / FREE
9	LIBRE / FREE

SERIAL PORT / PUERTO SERIE CAN

PIN	SEÑAL / SIGNAL
1	H
2	L
3	GND

RJ-45 PORT / PUERTO RJ-45

PIN	SEÑAL / SIGNAL
1	TX+
2	TX–
3	RX+
4	LIBRE / FREE
5	LIBRE / FREE
6	RX–
7	LIBRE / FREE
8	LIBRE / FREE

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 IN8, IN9 PARA LA FUNCIÓN DE VIGILANCIA DE BOBINAS DE INTERRUPTOR.

NOTA 4: LOS CANALES DE TENSIÓN VA, VB, VC Y VN PUEDEN CONECTARSE EN CUALQUIERA DE LOS TRES DEVANADOS. LA CONEXIÓN REPRESENTADA ES ÚNICAMENTE UN EJEMPLO DE APLICACIÓN. VA, VB, VC Y VN PUEDEN CONECTARSE A CUALQUIER TENSIÓN FASE-FASE Ó FASE-TIERRA.

NOTA 5: LA CONFIGURACIÓN REPRESENTADA (ESTRELLA Y TRIANGULO PARA LOS DEVANADOS 2 Y 3) ES ÚNICAMENTE UN EJEMPLO DE CONEXIÓN, REFERENCIA PARA EL RESTO DE CONFIGURACIONES POSIBLES.

NOTA 6: LA CONEXIÓN DEL NEUTRO DE CADA DEVANADO DEPENDE DEL GRUPO DE CONEXIÓN, PUDIENDO ASIGNARSE LOS CANALES IG-1 E IG-2 A CUALQUIERA DE LOS TRES DEVANADOS.

NOTA 7: LAS SALIDAS OUT7 A OUT10 PUEDEN SER CONFIGURADAS COMO SALIDAS RÁPIDAS (RELÉ DE ESTADO SÓLIDO)

NOTA 8: SEGUN AJUSTE Nº DE DEVANADOS.

NOTE 1: TERMINAL H10 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN3, IN4 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

NOTE 2: TERMINAL I4 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN6 OR IN7 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

NOTE 3: TERMINAL I8 SHOULD BE CONNECTED TO POSITIVE WHEN ANY OF THE INPUTS IN8 OR IN9 ARE BEING USED FOR THE BREAKER COIL SUPERVISION FUNCTION.

NOTE 4: VA, VB, VC AND VN ANALOG INPUTS CAN BE CONNECTED TO ANY OF THE WINDINGS. CONNECTION SHOWN IS ONLY ONE EXAMPLE. VA, VB, VC AND VN CAN BE CONNECTED AS A L-L OR L-N VOLTAGE.

NOTE 5: CONFIGURATION SHOWN (WYE AND OPEN-DELTA) IS ONE CONNECTION EXAMPLE. A REFERENCE FOR OTHER POSSIBLE CONFIGURATIONS.

NOTE 6: NEUTRAL CONNECTION OF EACH WINDING DEPENDS ON GROUP CONNECTION AND IT IS POSSIBLE TO ASSIGN IG-1 AND IG-2 ANALOG INPUTS TO ANY OF THE WINDINGS.

NOTE 7: THE OUT7 TO OUT10 OUTPUTS CAN BE CONFIGURED AS FAST OUTPUTS (SOLID STATE RELAY)

NOTE 8: NUMBER OF WINDINGS SETTING

REV.	0	CD1307100	1	CD1312111	2	3	4
5		6	7	8	9	10	
11		12	13	14	15	16	

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TITULO: CONEXIONES EXTERNAS 8IDV-L (D**), 4U
TITLE: EXTERNAL CONNECTIONS 8IDV-L (D**), 4U

PROYECTO / *PROJECT:* IDV (BORNAS W.) / IDV (TERMINALS W.)

Rev.0
Rev.1 16/12/13

NUM.: 3RX0187/0071

	Fecha / *Date*	Nombre / *Name*
Dibujado / *Drawn*	30/10/13	J.M.S.
Aprobado / *Approved*	30/10/13	P.A.

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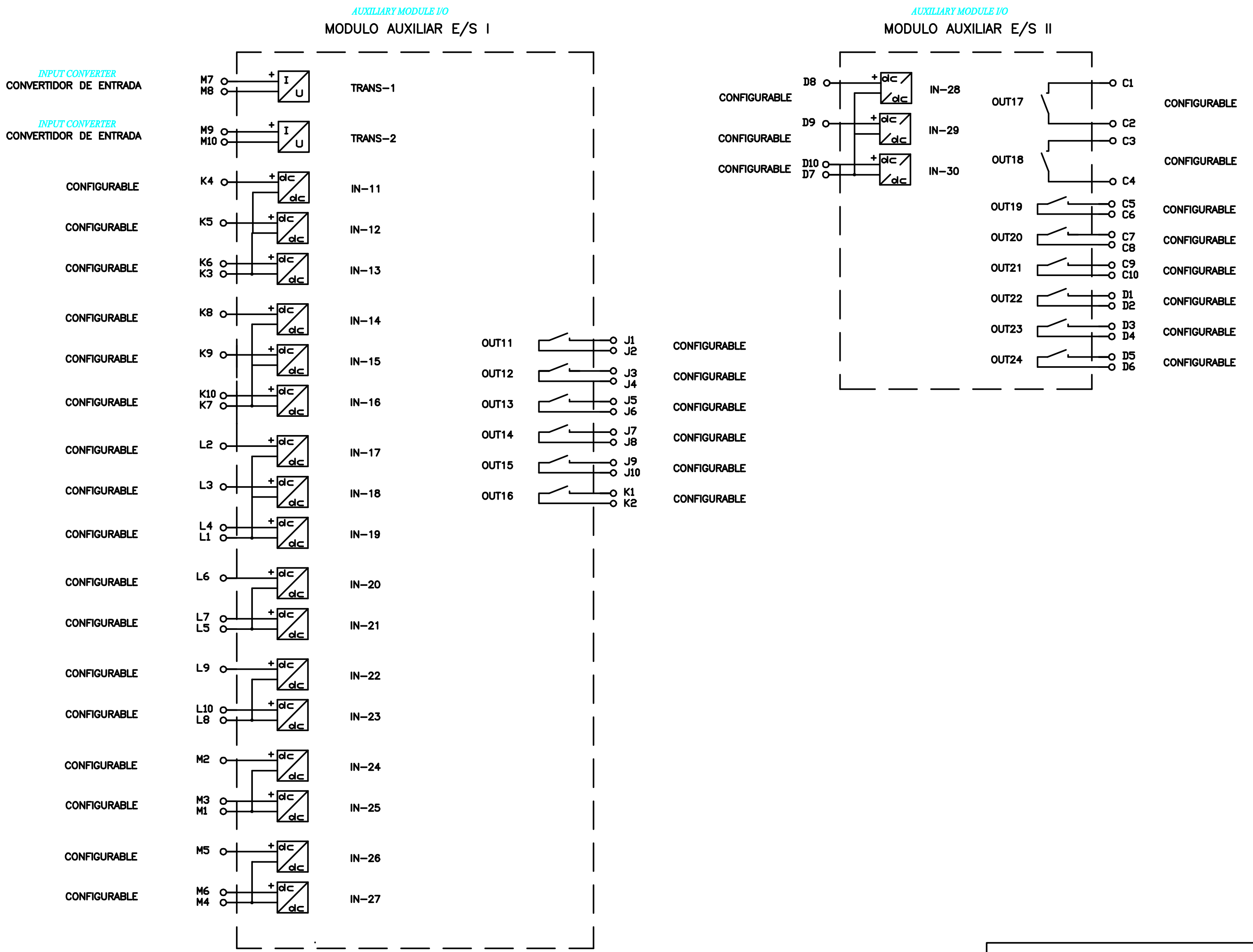

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TITULO: CONEXIONES EXTERNAS 8IDV-L (D**), 4U
TITLE: EXTERNAL CONNECTIONS 8IDV-L (D**), 4U

PROYECTO / *PROJECT:* IDV (BORNAS W.) / IDV (TERMINALS W.)

Rev.0
Rev.1 17/09/14

NUM.: 3RX0187/0071

	Fecha / *Date*	Nombre / *Name*
Dibujado / *Drawn*	30/10/13	J.M.S.
Aprobado / *Approved*	30/10/13	P.A.

Hoja / *Sheet:* 2

Continua en Hoja: / *Continued on sheet:* -

E. List of Illustrations and Tables

Annex E. List of Illustrations and Tables

E.1 List of Figures

E.2 List of Tables

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