UNIVERSAL TELEPROTECTION

TPU-1

GENERAL DESCRIPTION
Web version TPU-1R

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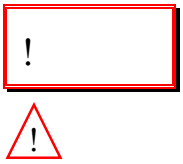
SAFETY SYMBOLS



WARNING OR CAUTION:

This symbol denotes a hazard. Not following the indicated procedure, operation or alike could mean a total or partial breakdown of the equipment or even injury to the personnel handling it.

NOTE:

Information or important aspects to take into account in a procedure, operation or alike.

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1 INTRODUCTION

The TPU-1 universal teleprotection terminal is outstanding in its high level of modularity, allowing each user to obtain the services that best adapt to his requirements. Depending on the modules that make up the TPU-1 terminal, it can be configured to work with one or two transmission channels that can be either analog or digital. Furthermore, when working with two channels the terminal can be programmed to work as two independent teleprotection terminals.

Equipped with a specific communications module, the TPU-1 terminal can transmit the teleprotection information over IP packet networks. Specific tags of the packet, which are added to the teleprotection information, allow the quality of service of the IP network to be monitored and, if it has been configured by the user, the command outputs of the TPU-1 terminal to be blocked when the load of the IP network affects the performance of the teleprotection system.

A TPU-1 terminal configured to work over IP packet networks allows the transmission of up to eight teleprotection commands into one IP packet using an IP communications interface. This IP communications interface consists of either two electrical ports type 10/100Base-Tx with RJ-45 connector or two optical ports 100Base-Fx multimode (1300 nm) with ST connector. The two ports have the same IP address.

A TPU-1 terminal configured to work over analog channels is capable of transmitting and receiving up to four combined (single tone) or independent (dual tone) teleprotection commands or up to thirty two encoded (dual tone) commands.

A TPU-1 terminal configured to work over digital channels allows the two-way transmission of up to eight teleprotection commands using digital lines with electrical or optical interface. The electrical interface can be 2 Mbit/s or 64 kbit/s according to Recommendation G.703 of the ITU-T, as well as 64 kbit/s, 56 kbit/s or 32 kbit/s according to Recommendations V.11 / X.21 and V.35 of the ITU-T. The optical interface of the TPU-1 terminals works at a speed of 64 kbit/s or in accordance with C37.94 standard (2 Mbit/s frame).

Equipped with the corresponding modules, the TPU-1 terminal can also transmit and receive analog measurements and digital signals (states, alarms, etc.) by means of the internal channel of the line interface. In this way, it can be used in intertripping and remote measurements systems related to cogeneration applications.

The TPU-1 terminal can be compatible with the IEC 61850 standard and, therefore, allows the teleprotection-protection communication in a substation to be carried out in accordance with the said standard. The TPU-1 terminal can also be equipped with analog protection interfaces, if desired, which allow it to communicate with protections that are not adapted to the IEC 61850 standard.

The TPU-1 terminals have a web server in which are stored all the HTML pages necessary to carry out programming and monitoring of the system from a web browser installed in a PC. The connection between the PC and the TPU-1 can be direct or by means of an IP network. In the last case it is possible for various computers of the IP network to manage various TPU-1 terminals connected to it.

The TPU-1 terminals, furthermore, include an SNMP agent able to send notifications (unsolicited information spontaneously transmitted) about alarms and events of the terminal to the devices specified by the user, and this makes it possible to monitor the TPU-1 terminal from an SNMP management application, such as, HP Openview.

The TPU-1 terminals chronologically register all the alarms and events produced in a link. This chronological register of alarms and events of the TPU-1 terminals is carried out based on its internal real time clock, being able to synchronize it with the GPS system or by means of the SNTP protocol.

The TPU-1 terminal complies with IEC 60834-1 and IEC 6100-6-5 standards and also with the standards ANSI C37.90.1 and ANSI C37.90.2.

2 CONSTITUTION OF THE EQUIPMENT

The TPU-1 equipment consists of a shelf that is 19" wide and three standard units (s.u.) high, which is prepared for rack mounting. Different types of modules can be housed in the shelf, depending on the operation mode desired.

The modules that can make up a TPU-1 terminal are classified as: basic modules, GOOSE protection interface module, protection interface modules, line interface modules, relay interface modules and modules for telesignalling and remote measurements. In minimum configuration the TPU-1 is made up of the basic modules and a line interface module.

The input and output of signals is carried out by means of the connectors located at the rear of the terminal. If one wishes the external connections to be carried out through a cabinet-mounting terminal block, it can be supplied on request, together with the necessary cables.

2.1 BASIC MODULES

ATPU.## POWER SUPPLY

This module contains the DC/DC converter that generates the internal power-supply voltages from the input voltage, as well as a filter at the input to suppress disturbance caused by fast transient bursts.

The module also contains the power-supply alarm external signalling relay.

The type of module depends on the nominal input voltage. The following types are available:

ATPU.00 Input voltage of 48 V_{DC}.

ATPU.01 Input voltage from 110 V_{DC} to 250 V_{DC} and from 110 V_{AC} to 220 V_{AC}.

ATPU.03 Input voltage of 24 V_{DC}.

Should it be necessary to have redundancy of the power supply, the TPU-1 terminals can be equipped with two ATPU modules.

MWTU.## PROCESSING MODULE

It contains the system programming circuits and manages the information specially associated to teleprotection, whether compatible or not with the IEC 61850 standard, as well as the communication channel (or channels). In telesignalling and remote measurements applications, it manages the two-way transmission of analog measurements and digital signals (states, alarms, etc.) by means of the internal channel of the line interface (analog and/or digital).

It includes a web server, an SNMP agent, a microcontroller, a decoder capable of processing, according to IRIG-B standard, signals coming from an external synchronization equipment and one LAN interface (10/100Base-TX or 100Base-FX) for connection to a PC.

The temporary reference obtained via protocol SNTP, if time synchronization has been programmed via Ethernet, is carried out by means of the LAN interface.

The type of module depends on the type of LAN interface, in this way:

MWTU.01 Has a 100Base-Fx interface.

MWTU.02 Has a 10/100Base-Tx interface.

WFTU.## Interconnection module (back panel) and front plate.

This module allows the modules to be connected and their interconnection. It contains the LEDs for visual indication, an USB connector that is for Pweb management[(1)], and if requested an optional LCD display.

The following types are available:

WFTU.00 Has the ATPU power-supply module. Without LCD display.

WFTU.01 Has the ATPU power-supply module. With LCD display.

WFTU.03 Has the ATPU power-supply module. Without LCD display. RS-232C connector for Pweb[(1)] management.

2.2 GOOSE PROTECTION INTERFACE MODULE

The GOOSE protection interface module allows the TPU-1 terminal to communicate with the protection terminals of a substation according to IEC 61850 standard.

The terminal can house one module of this type.

[(1)] Local management system based on a Web interface. The Pweb management, given that it requires a web server external to the terminal, is known as External Web Management.

IEPT GOOSE PROTECTION INTERFACE

It includes two electrical ports type 10/100Base Tx with RJ-45 connector (IEPT.01). The two ports have the same IP address. The input and output of the GOOSE messages is carried out through these ports. Upon request, instead of the above, the module can be supplied with two optical ports type 100Base-Fx multimode (1300 nm) with ST connector (IEPT.00).

2.3 PROTECTION INTERFACE MODULES

The protection interface module allows the TPU-1 terminal to communicate with the protection terminals of a substation that are not prepared for operation according to IEC 61850 standard.

The terminal can house up to eight IPTU protection interface modules in the shelf.

IPTU PROTECTION SIDE INTERFACE (circuits from one to two commands)

This module contains the input and output circuits from one to two commands, made up of two optocoupled inputs, two command outputs and two auxiliary outputs for signalling and/or alarm, configurable by the user.

2.4 LINE INTERFACE MODULES

The TPU-1 terminal is equipped with one or two line modules depending on whether it manages one or two communication channels. The available line interface modules are divided into digital line interface modules, analog line interface modules and IP communications interface modules.

Digital line-interface modules

IETU ELECTRICAL INTERFACE

This module carries out the transmission and reception of the teleprotection signal. The module is prepared to work as an interface circuit at 64 kbit/s in accordance with Recommendation G.703 and at 64 kbit/s, 56 kbit/s or 32 kbit/s in accordance with Recommendations V.11/X.21 and V.35 of the ITU-T.

IDTU ELECTRICAL INTERFACE

This module carries out the transmission and reception of the teleprotection signal. The module is prepared to work as an interface circuit at 2 Mbit/s in accordance with Recommendation G.703 of the ITU-T with codirectional clock. It has two BNC (75Ω) connectors or a RJ-45 connector (120Ω) for twisted pair. The type of connector and whether the cable shield is connected to earth (output not balanced) or not (output balanced) is configured by internal settings.

In IDTU.00 modules of version 3.1, the type of connector (BNC or RJ-45) is programmed from the TPU-1 Management System.

IOTU.## OPTICAL INTERFACE

This module carries out the transmission and reception of the teleprotection signal. This module is used with a single-mode optical fiber and has a LASER transmitter that transmits at a speed of 64 kbit/s and at a wavelength of 1300 nm (IOTU.00) or 1550 nm (IOTU.01).

IOCT OPTICAL INTERFACE

This module carries out the transmission and reception of the teleprotection signal, complying with the C37.94 standard and at a speed of 2 Mbit/s (occupies 1 slot of 64 kbit/s of the 2 Mbit/s frame). The IOCT.00 module is used with a multimode optical fiber and has a LED transmitter that transmits at a wavelength of 830 nm. The IOCT.01 module is used with a single-mode optical fiber and has a LASER transmitter that transmits at a wavelength of 1300 nm.

Analog line-interface modules

IATU/IBTU ANALOG INTERFACE BY SINGLE TONE (4 COMBINED COMMANDS)

This module is able to transmit and receive up to four commands according to a specific logic, in the 0 to 4 kHz band, by means of 4 wire connections.

It contains a Digital Signal Processor (DSP) that generates the guard and command tones and implements a bank of filters for the reception of commands.

It also contains a power-boosting solid-state relay and an auxiliary electromechanical relay for signalling or alarm, which can be configured by the user.

IBTU ANALOG INTERFACE BY DUAL TONE (ENCODED COMMANDS IN A 4 kHz BAND)

This module is able to transmit and receive up to 32 commands, in the 0 to 4 kHz band, by means of 4 wire connections.

The 32 commands can be divided into two different groups: A and B. Group A consists of a group of up to 4 commands, and any combination of them, which have a higher priority. Group B is made of up to 28 commands, which have a lower priority, the transmission of which is carried out sequentially.

It contains a Digital Signal Processor (DSP) that generates the encoded signals and implements a bank of filters for the reception of all the frequencies used.

Two frequencies are assigned to each signal (guard or command). Ten frequencies are needed for: two types of guard (one type associated to the lower frequencies of the 4 kHz-standard channel and the other to the upper frequencies), 28 commands of Group B, and 4 commands and any combination of them, of Group A, which have a higher priority.

The module also contains a power-boosting solid-state relay and an auxiliary electromechanical relay for signalling or alarm, which can be configured by the user.

IBTU ANALOG INTERFACE BY DUAL TONE (4 ENCODED COMMANDS IN A 2.5 kHz BAND)

This module is able to transmit and receive up to 4 independent commands, and any combination of them, in the 0 to 2.5 kHz band, by means of 4 wire connections.

It contains a Digital Signal Processor (DSP) that generates the encoded signals and implements a bank of filters for the reception of all the frequencies used.

Two frequencies are assigned to each signal (guard or command). Nine frequencies are needed for the guard and 4 independent commands and any combination of them.

The module also contains a power-boosting solid-state relay and an auxiliary electromechanical relay for signalling or alarm, which can be configured by the user.

IP communications interface modules

IPIT IP INTERFACE

This module performs teleprotection signal transmission and reception in packet mode. In transmission, the module collects information on the state of the commands (commands 1 to 8) from the processing MWTU module and adds some specific tags that constitute the teleprotection packet. In reception, the module detects whether the received packets are valid or not and also calculates the quality of service of the IP network. If the values are not satisfactory, the module generates the necessary alarms and, if it has been configured by the user, blocks the command outputs of the TPU-1 terminal.

The module is equipped with either two electrical ports type 10/100Base-Tx with RJ-45 connector (IPIT.01) or two optical ports type 100Base-Fx multimode (1300 nm) with ST connector (IPIT.00). The two ports have the same IP address.

2.5 RELAY INTERFACE MODULES

Provided free positions be available in the shelf, the TPU-1 terminal can incorporate electromechanical relay-interface modules in the shelf thereby increasing the number of auxiliary outputs for signalling and/or alarm.

The number of auxiliary outputs depends on the type of module used, the following being available:

IRTU.02 Has two relays for signalling and/or alarm, configurable by the user.

IRTU.04 Has four relays for signalling and/or alarm, configurable by the user.

IRTU.08 Has eight relays for signalling and/or alarm, configurable by the user.

2.6 MODULES FOR TELESIGNALLING AND REMOTE MEASUREMENTS

Equipped with remote measurements modules, the TPU-1 terminal can transmit and receive analog measurements and digital signals.

The terminal can house up to three MCTU modules and up to two DSTU modules in the shelf.

MCTU CURRENT MEASUREMENT MODULE

It contains four independent analog inputs and their corresponding current measurement hardware circuits. Each value measured is digitized and periodically delivered to the processing module which in turn delivers it to the associated line interface module as information to be transmitted by the internal channel to the remote terminal.

The module also contains four output analog circuits (current loop) which receive the value measured at the analog inputs of the remote terminal from the processing module. The current delivered at output 1 corresponds to the current measured at input 1 of the remote terminal, that of output 2 with the current measured in input 2 of the remote terminal, and so on until output 4 that corresponds with the current measured in input 4 of the remote terminal. In this way, being a point to point transmission/reception.

DSTU DIGITAL SIGNAL I/O INTERFACE

It contains six optocoupled digital inputs. The value of the said signals is periodically delivered to the processing module which in turn delivers it to the associated line interface module as information to be transmitted by the internal channel to the remote terminal.

The module also contains six digital outputs (voltage free, relay type) that receive the value of the digital signals of the remote terminal from the processing module. The value delivered at digital output 1 corresponds with the value of the digital input 1 of the remote terminal, that of the digital output 2 with that of the digital input 2 of the remote terminal, and so on until digital output 6 the value of which corresponds with that of the digital input 6 of the remote terminal. In this way, being a point to point transmission/reception.

3 APPLICATIONS

The TPU-1 terminal, thanks to its modular design, can be used in a multitude of teleprotection, telesignalling and remote measurements applications. This section describes possible applications, highlighting the most relevant facilities of the TPU-1 terminal.

3.1 MIXED PROTECTION INTERFACES

This example shows how a TPU-1 terminal equipped with protection interfaces that are compatible with the IEC 61850 standard can also be equipped, simultaneously, with analog protection interfaces that make migration of the protections to IEC 61850 standard in a substation easier.

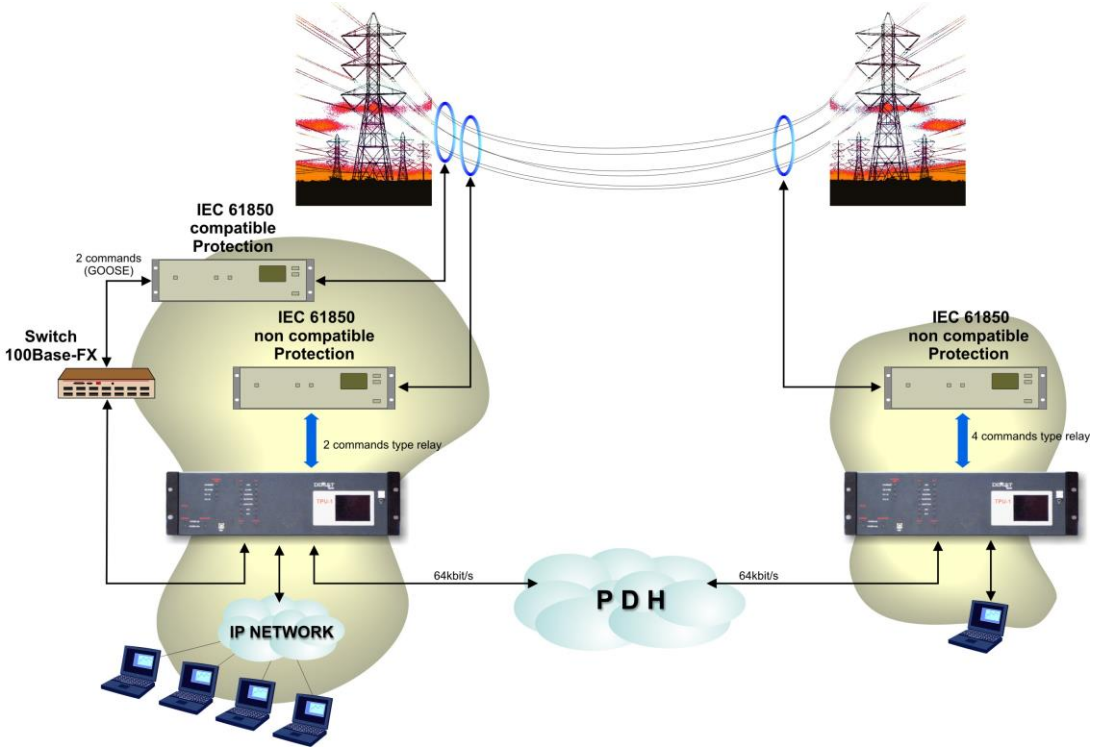


Figure 1 Example of use

The example shows how substation A is equipped with a protection that is compatible with the IEC 61850 standard and with another that is not. The protection of substation B is not compatible with the IEC 61850 standard. It is considered that four commands are transmitted between the TPU-1 terminals although the number of commands could be up to eight.

The two TPU-1 terminals communicate through a PDH network which they access by means of a channel of 64 kbit/s. The TPU-1 terminal of substation A is connected to the corporate network of the Electrical power utility, so that authorized users can access it from any point of the network.

3.2 BACK-UP CHANNEL

This example shows how a TPU-1 terminal can be equipped with two communication interfaces, so that it has a back-up channel that can prevent any possible failure of the main channel.

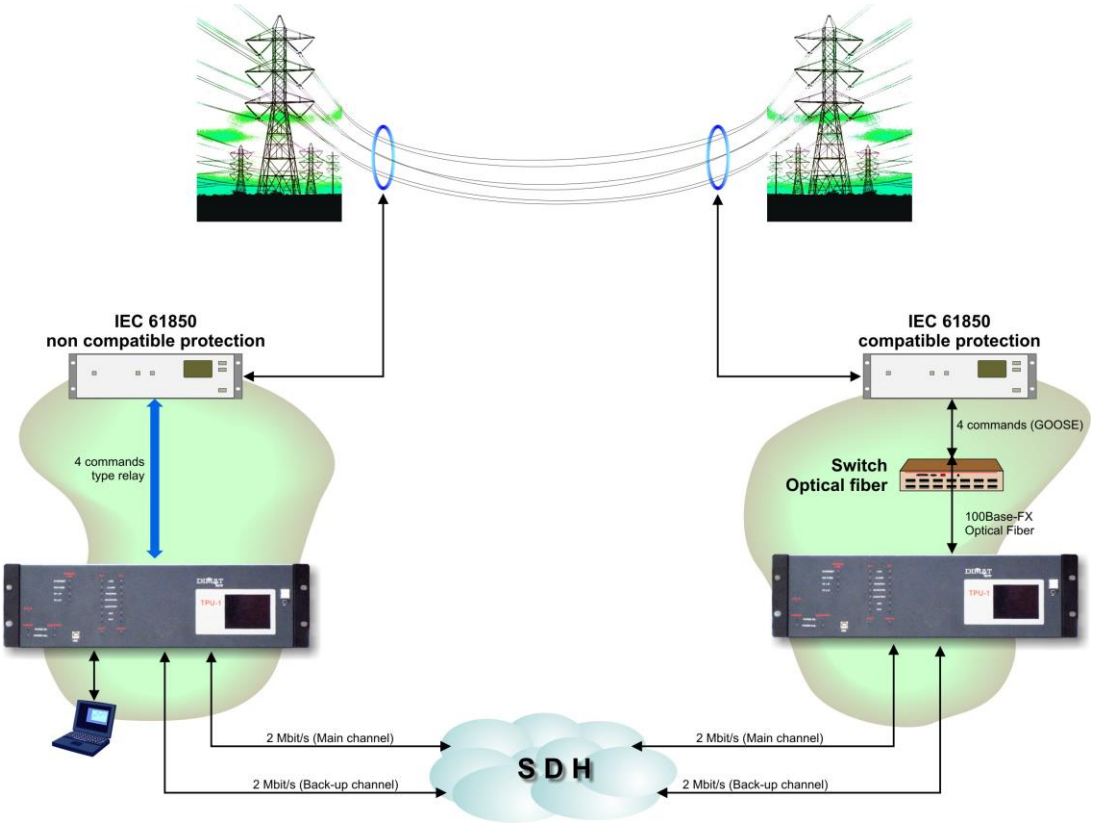


Figure 2 Example of use

As can be seen in the example, substation A is not prepared to work according to IEC 61850 standard, whilst substation B is.

3.3 TWO INDEPENDENT TELEPROTECTION TERMINALS IN A SINGLE SHELF

This example shows how a TPU-1 terminal can be used as two independent teleprotection terminals.

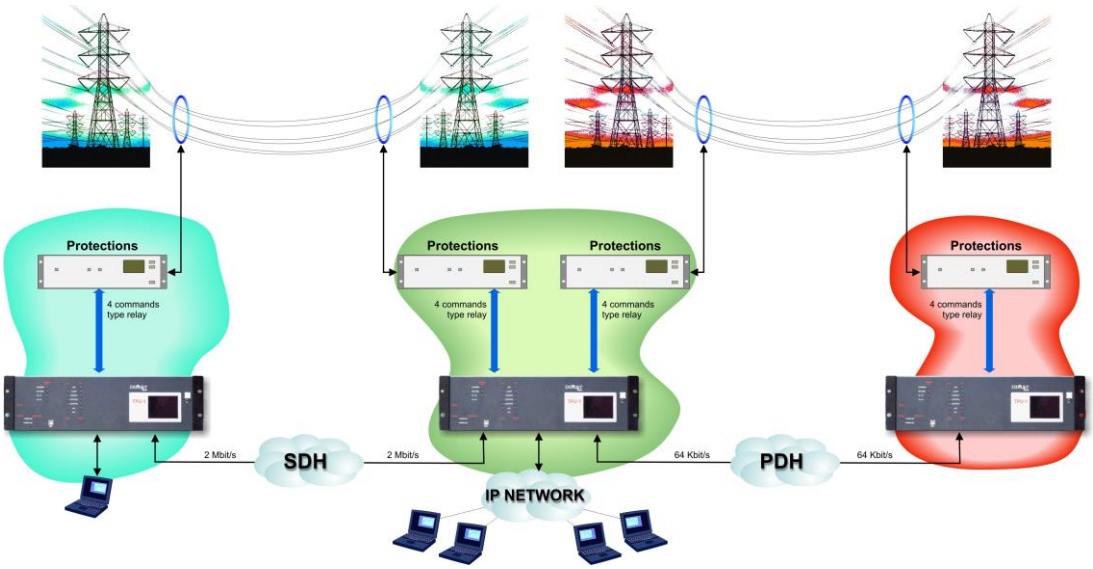


Figure 3 Example of use

In this example, it has been considered that none of the three substations is compatible with IEC 61850 standard. The TPU-1 terminal of substation A is connected to the corporate network of the Electrical power utility, being possible for authorized users to access it from any point of the network.

3.4 TRANSITS

One outstanding feature is that, when the TPU-1 terminal is equipped with two line interfaces, it can transit the received information towards another terminal, being possible to connect three TPU-1 terminals in T (Teed-line), see Figure 4, or connect various TPU-1 terminals in a ring configuration, see Figure 5.

Figure 4 shows how the C terminal transits the information of the link made up of A and B terminals but at the same time maintaining communication with the collateral terminal associated to each of its lines.

Figure 5 shows how the information transits the different terminals until it arrives at its destination. Transit is also carried out in both directions giving the system greater security and reliability.

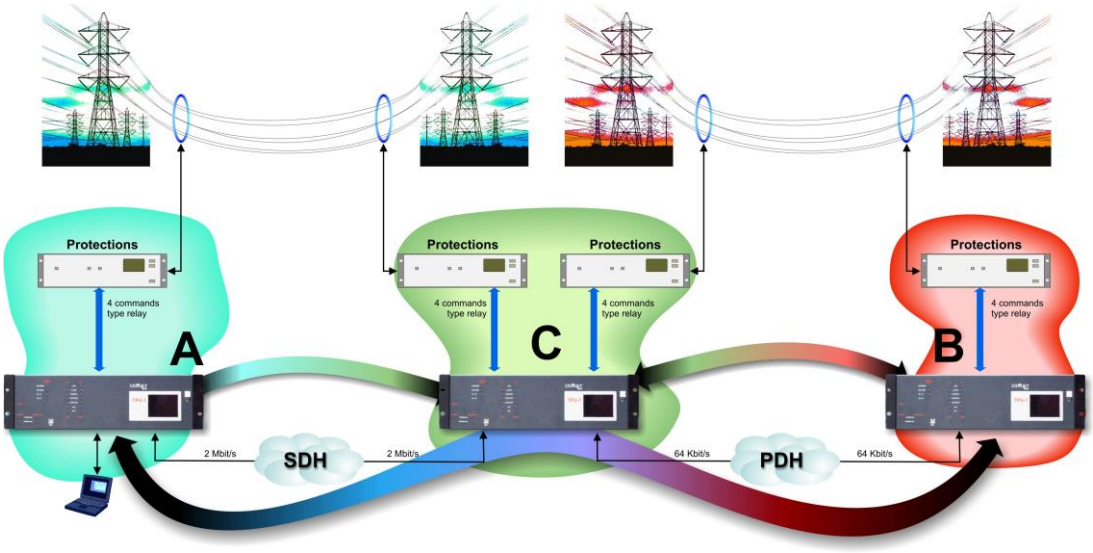


Figure 4 Example of use

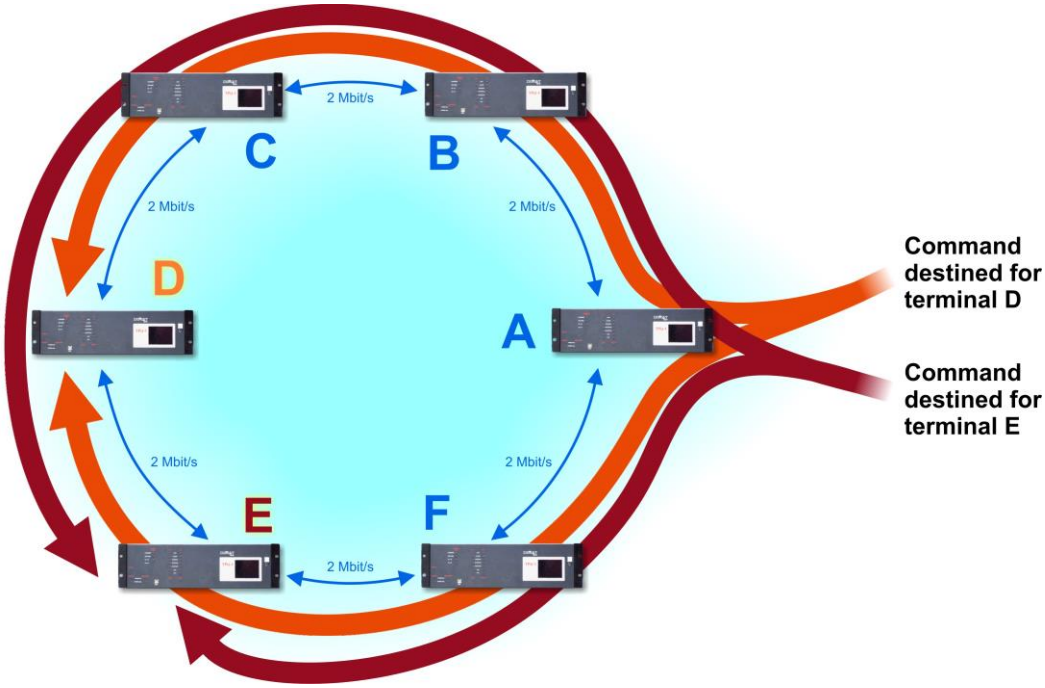


Figure 5 Example of use

3.5 TELESIGNALLING AND REMOTE MEASUREMENTS

The cogeneration plants, including those based on renewable energies (wind, solar, biomass and others), in most cases, require the use of teleprotection terminals to ensure the plant disconnection.

In the example in Figure 6, terminal B transmits commands (controls) from the Utility Substation, to guarantee the cogeneration-plant disconnection and to avoid the plant being reconnected under fault conditions. Terminal A is used as a supervision main breaker by transmitting analog measurements and digital signals (states, alarms) from the cogeneration plant to the Utility Substation.

In the example, each TPU-1 terminal has a current measurement module (MCTU) and a digital signal I/O interface module (DSTU).

The communication of the TPU-1 terminals of the link is carried out by means of the line interface. When digital line interfaces are used, transmission of data through the internal channel is not interrupted when commands (controls) are transmitted. However, when an analog line interface by single tone (IATU/IBTU) or dual tone (IBTU) is used, transmission is interrupted and, in this case, it is possible to decide the state of the outputs, of both the MCTU and DSTU modules, once the channel is re-established, being able to configure a pre-fixed value or establish that the outputs maintain their values, by means of the corresponding programming option.

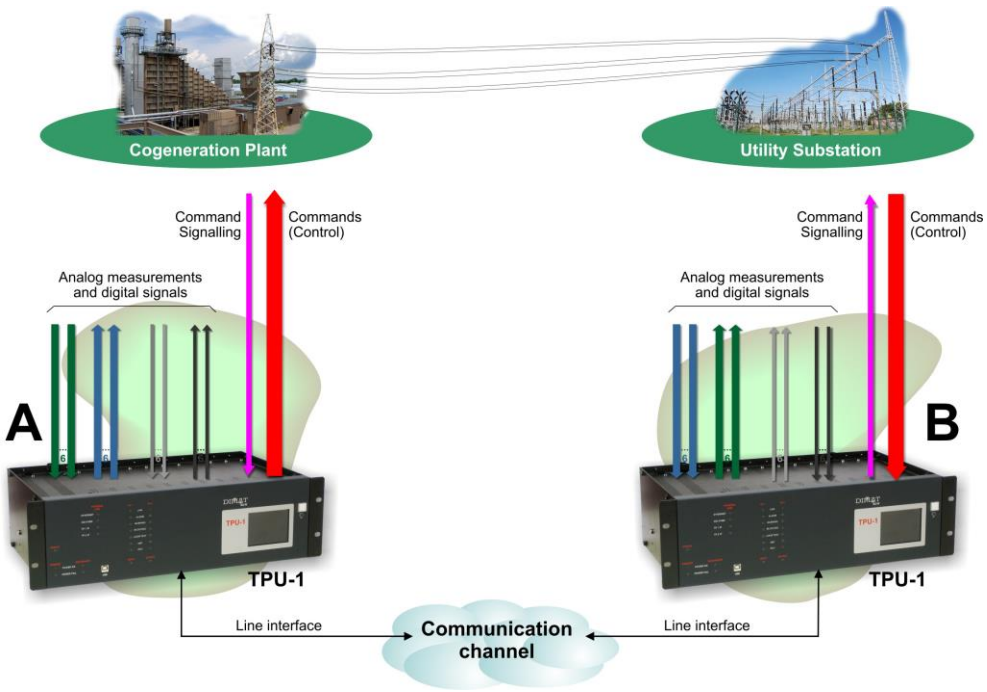


Figure 6 Example of use

3.6 TELEPROTECTION IN A 2.5 kHz BAND

For this application the TPU-1 terminal is equipped with a specific IBTU module by dual tone, for a better use of the frequency spectrum.

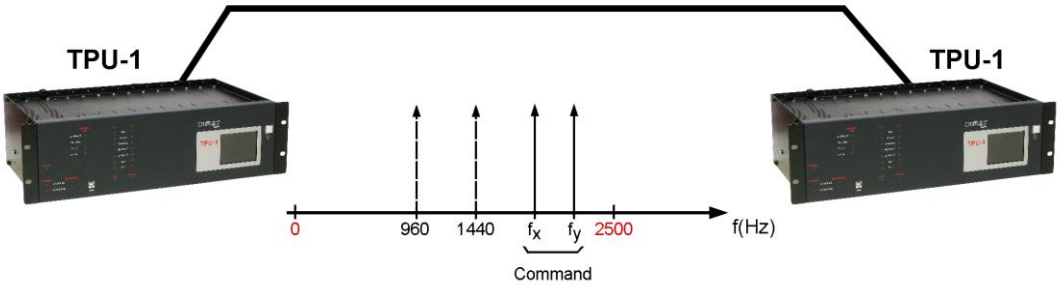


Figure 7 Example of use

3.7 TELEPROTECTION OVER IP PACKET NETWORKS

The vast growth of the Internet has made the Internet Protocol (IP) become the basis of today's telecommunication networks. In this way, power utilities tend to replace traditional analog and digital interfaces by standard interfaces type Ethernet or IP, with the aim of using a single network to transport all types of information including, among other services, teleprotection, one of the most important services in power transmission networks.

In the example of Figure 8, each TPU-1 terminal is equipped with an IP interface, in order to carry out teleprotection signal transmission and reception in packet mode over an IP network. Specific tags of the packet, which are added to the teleprotection information, allow to monitor the quality of service of the IP network and, if it has been configured by the user, the command outputs of the TPU-1 terminal to be blocked when the quality of service of the IP network is not satisfactory.

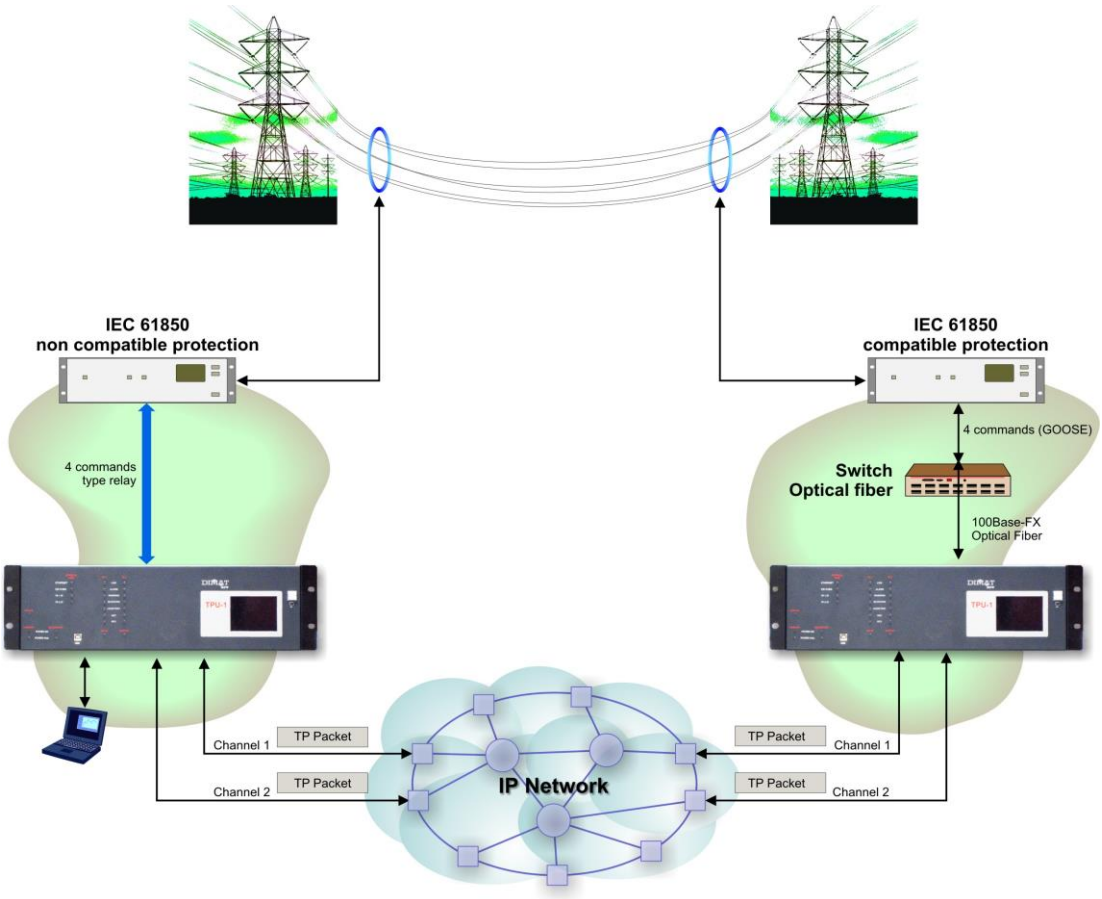


Figure 8 Example of use

4 OPERATIONAL DESCRIPTION

This section describes the main aspects relating to the operation principles of the TPU-1 terminal, it explains the test mechanisms available in the terminal and, lastly, it explains how to carry out the time synchronization.

The operation principle of a TPU-1 terminal is based, on the one hand, on the communication with a protection terminal within the same substation and, on the other hand, on the communication with its collateral TPU-1 terminal, that is to say, the terminal at the other end of the link, to be able to transmit a command signal.

The communication with the protection terminals can be analog or digital according to the IEC 61850 standard. The TPU-1 terminal which receives a command from the TPU-1 terminal at the other end of the link, must activate the corresponding command output relay (or relays) and/or the GOOSE message (or messages) towards the protection terminal (or terminals).

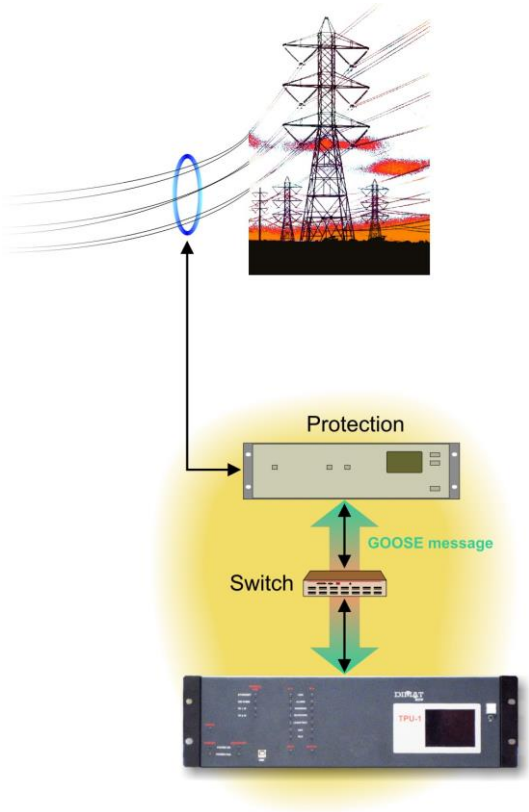


Figure 9 Teleprotection-protection communication by means of IEC 61850 standard

The communication between the TPU-1 terminal and a protection terminal according to IEC 61850 standard is carried out by means of GOOSE messages, which are messages that are transmitted with high priority over the IP network of a substation. These messages access the TPU-1 terminal by means of the GOOSE protection interface module (IEPT).

The communication between a TPU-1 terminal and its collateral can be carried out by means of a digital or an analog channel or over IP packet networks.

4.1 COMMAND TRANSMISSION PROCEDURE

The analog protection interface of the TPU-1 terminal is located in the IPTU modules.

Each IPTU module has two independent command inputs. The nominal activation voltage is configurable by means of jumpers. The user can assign the inputs to any of the possible commands to be transmitted (commands 1 to 8 for a digital channel or IP-based communications, commands 1 to 4 for an analog channel by single tone, and commands 1 to 32 for an analog channel by dual tone) from the Management System. Should more than one input be assigned to the same command, the logic that must be fulfilled in order for the TPU-1 to transmit the command to the TPU-1 terminal at the other side of the link, must be programmed. This logic can be:

- All the inputs active (logic AND).
- One of the inputs active (logic OR).

As far as the digital protection interface is concerned, the GOOSE protection interface (IEPT) module allows the TPU-1 terminals to manage up to 16 different IEC 61850 inputs.

As in the case of the analog protection interfaces, the GOOSE messages can be associated to any of the possible commands to be transmitted (commands 1 to 8) from the Management System. Should more than one message be assigned to the same command, the logic that must be fulfilled in order for the TPU-1 terminal to transmit the command to the terminal at the other side of the link, must be programmed.

When one or more analog inputs are activated and/or one or more GOOSE messages access the terminal, the optical indicator INPUT on the front plate lights up.

When the MWTU detects, according to the programmed logic, that one or various teleprotection commands exist, it manages the information towards the line interface module so that it can transmit the teleprotection signal. The information coming from digital inputs is in turn managed by means of the IEPT module towards the line interface module.

Command transmission is signalled on the front plate by means of LED XMT of the corresponding channel, 1 or 2. Furthermore, the corresponding signalling relay is also activated if it has been programmed.

From the Management System, it is possible to slow down command transmission process by means of an additional timing, as well as program the duration of the transmission of each command.

Digital channel

When the line interface module is for a digital channel it generates a frame with the corresponding information at 64 kbit/s, 56 kbit/s or 32 kbit/s. As can be seen in Figure 10, one of the bytes of the frame contains the teleprotection information (byte COMMANDS).

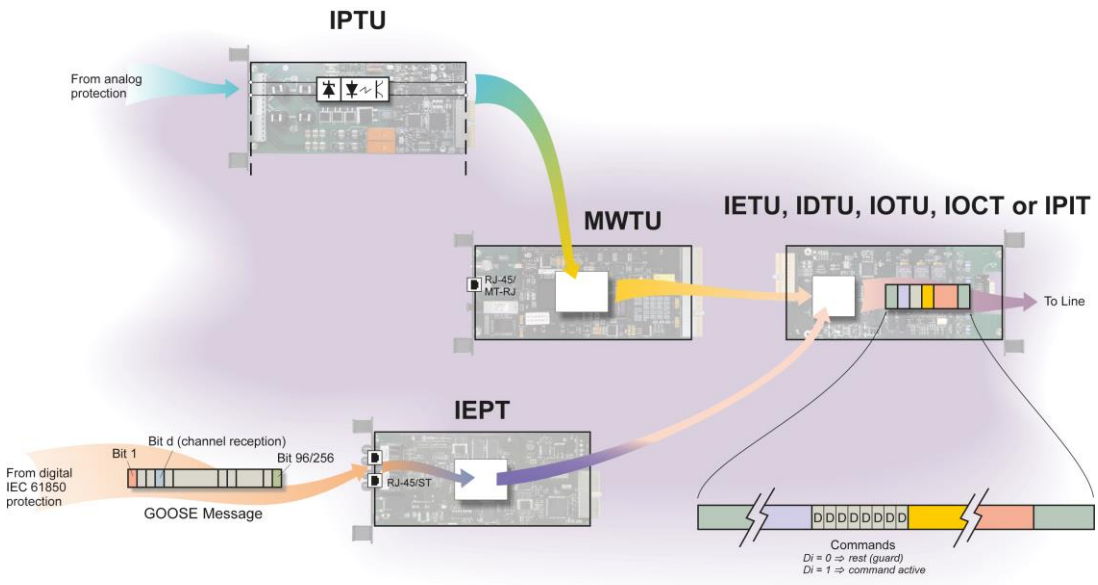


Figure 10 Command transmission procedure for digital channel

Each one of the bits of the COMMANDS byte corresponds to a teleprotection command (commands 1 to 8) in such a way that the presence of the command is transmitted with the corresponding bit in state "1".

As well as the teleprotection information the said frame contains other information such as transmitter identification, internal communication-channel messages, and so on.

The TPU-1 terminal allows the communication through electric lines at 2 Mbit/s or 64 kbit/s according to Recommendation G.703 of the ITU-T and at 64 kbit/s, 56 kbit/s or 32 kbit/s according to Recommendations V.11/X.21 and V.35 of the ITU-T. It also allows the communication through optical fiber links at 64 kbit/s or links according to C37.94 standard (2 Mbit/s frame).

Communications channel over IP

When the line interface module is for a communications channel over IP, the module generates a packet containing the teleprotection information (commands 1 to 8). The presence of the command is transmitted with the corresponding bit in state “1”.

In addition to teleprotection information, the packet contains the sequence information and other informations that monitor the quality of service of the IP network.

Analog channel by single tone

When the line interface module is for an analog channel by single tone, the module transmits the guard and command signals. In quiescent conditions the transmitter continuously transmits a guard signal, which is replaced by a command tone when a command needs to be sent.

The receiver has a maximum of eight filters for all the command frequencies so that, from one to three commands, can be transmitted and received independently or any combination of them. However, with four commands, as there are fifteen possible command combinations, it is necessary to establish a logic in order to determine the command tone that should be transmitted for each of the different input combinations. The logic can be programmed in four different ways named Mode 2+2 (1), Mode 2+2 (2), Mode 3+1 (1) and Mode 3+1 (2).

Mode 2+2 (1) allows the simultaneous protection of two lines by means of two permissive trips (C and D) and two direct trips (A and B) which have priority over the permissive ones.

Mode 2+2 (2) allows the simultaneous protection of two lines by means of two permissive trips (A and B) and two direct trips (C and D) which have priority over the permissive ones.

Mode 3+1 allows the simultaneous protection of the three phases of a line by means of three permissive trips (A, B and C) and a direct trip (D) which has priority. The difference between the two versions of the Mode 3+1 is in the command tone that is transmitted for each of the different input combinations associated to the permissive trips.

On the other hand, the TPU-1 terminal can be programmed to increase the output power above the nominal level during the transmission of a command signal, being the output maximum level of 0 dBm (including the power boosting). Each time a command signal is transmitted, the terminal signals the power-boosting command by means of the contacts of a relay. Power-boosting, therefore, can be effected directly in the TPU-1 terminal, or signalling can be delivered to the transmission equipment, by means of the power-boosting relay, for the transmission equipment to carry out the power-boosting facility. It must be taken into account that the output nominal level of the TPU-1 terminal should be equal to the input nominal level of the transmission equipment.

INPUT COMMANDS	MODE 2+2 (1)	MODE 2+2 (2)	MODE 3+1(1)	MODE 3+1(2)
A	f(A)	f(A)	f(A)	f(A)
B	f(B)	f(B)	f(B)	f(B)
C	f(C)	f(C)	f(C)	f(C)
D	f(D)	f(D)	f(D)	f(D)
A+B	f(A+B)	f(A+B)	f(A+B)	f(D)
A+C	f(A)	f(C)	f(A+C)	f(D)
A+D	f(A+D)	f(A+D)	f(D)	f(D)
B+C	f(B+C)	f(B+C)	f(B+C)	f(D)
B+D	f(B)	f(D)	f(D)	f(D)
C+D	f(C+D)	f(C+D)	f(D)	f(D)
A+B+C	f(A+B)	f(B+C)	f(A+B+C)	f(D)
A+B+D	f(A+B)	f(A+D)	f(D)	f(D)
A+C+D	f(A+D)	f(C+D)	f(D)	f(D)
B+C+D	f(B+C)	f(C+D)	f(D)	f(D)
A+B+C+D	f(A+B)	f(C+D)	f(D)	f(D)

Table 1 Logic of the transmission tones for four commands

Analog channel by dual tone

When the line interface module is for an analog channel by dual tone, the module transmits the encoded guard and command signals. In quiescent conditions the transmitter continuously transmits a guard encoded signal, which is replaced by a command encoded signal when a command needs to be sent.

Two frequencies are assigned to each signal (see Table 2). Ten frequencies are needed for: two types of guard, 28 commands (sequentially) of Group B, and 4 commands and any combination of them, of Group A, which have a higher priority.

The frequencies assigned to the command signals are pre-established. Therefore, from the Management System it is only necessary to configure the type of guard encoded signal. One type is associated to lower frequencies (1200 Hz/1680 Hz) and the other to upper frequencies (2640 Hz/3120 Hz).

Encoded signal			f_1 960Hz	f_2 1200Hz	f_3 1440Hz	f_4 1680Hz	f_5 1920Hz	f_6 2400Hz	f_7 2640Hz	f_8 2880Hz	f_9 3120Hz	f_{10} 3360Hz
Command		**Guard 1**		X		X						
		Guard 2							X		X	
Group A (4)	**C1**	**A**	X		X							
	C2	**B**	X				X					
	C3	**C**	X							X		
	C4	**D**	X									X
	-	A+B	X					X				
	-	A+C			X		X					
	-	A+D			X			X				
	-	B+C			X					X		
	-	B+D			X							X
	-	C+D					X	X				
	-	A+B+C					X			X		
	-	A+B+D					X					X
	-	B+C+D						X		X		
	-	A+C+D						X				X
	-	A+B+C+D								X		X
Group B (28)	**C5**	B1	X	X								
	C6	B2		X	X							
	C7	B3		X			X					
	C8	B4		X				X				
	C9	B5		X					X			
	C10	B6		X						X		
	C11	B7		X							X	
	C12	B8		X								X
	C13	B9	X			X						
	C14	B10			X	X						
	C15	B11				X	X					
	C16	B12				X		X				
	C17	B13				X			X			
	C18	B14				X				X		
	C19	B15				X					X	
	C20	B16				X						X
	C21	B17	X						X			
	C22	B18			X				X			
	C23	B19					X		X			
	C24	B20						X	X			
	C25	B21							X	X		
	C26	B22							X			X
	C27	B23	X								X	
	C28	B24			X						X	
	C29	B25					X				X	
	C30	B26						X			X	
	C31	B27								X	X	
	C32	B28									X	X

Table 2 Frequency assignment to guard and command signals

Figure 11 shows the configuration for the system for 32 commands. As can be seen in the figure, the first four commands (C1 to C4) are for Group A and the remaining 28 commands (C5 to C32) are for Group B.

When the number of commands is lower than 32, as is shown in the examples of Figure 12, commands C1 to C4 can be assigned to Group B if not used for Group A.

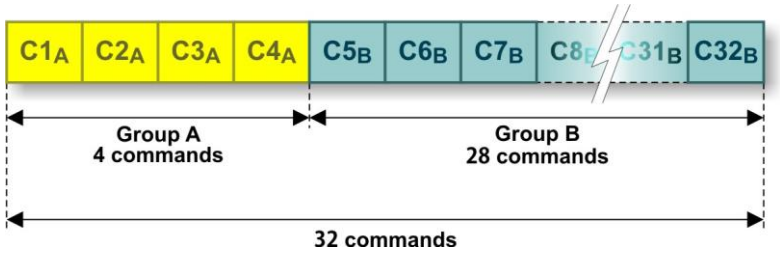


Figure 11 Configuration of the system for 32 commands

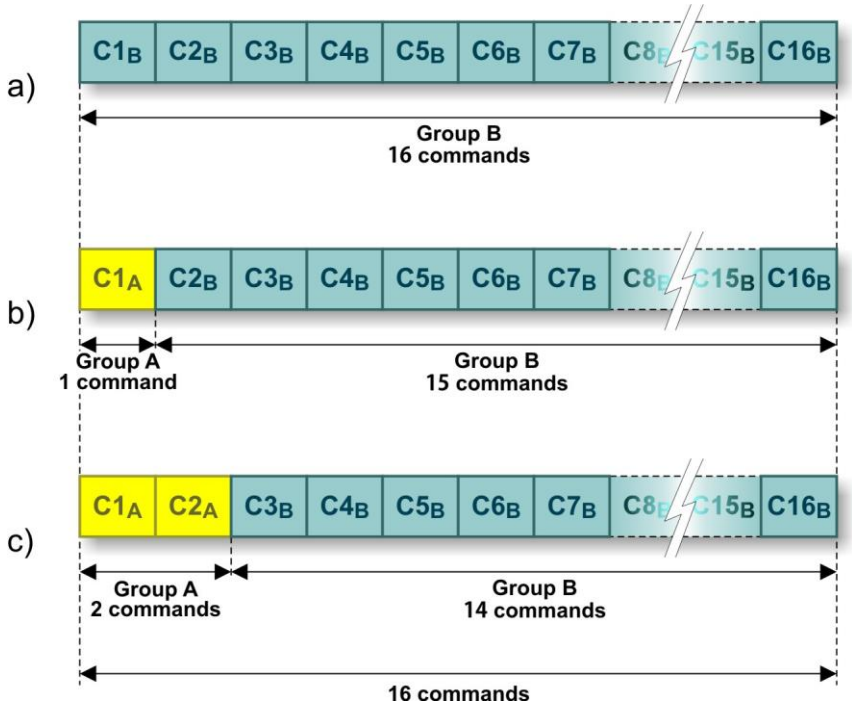


Figure 12 Example of the configuration of the system for 16 commands

Group A commands have a higher priority and are normally used for electrical high-frequency line protection schemes As mentioned previously, this group is made up of up to 4 independent commands (C1 to C4) and any combination of them. As the commands of this group have a higher priority, when an associated command input is activated the command is transmitted immediately. Each of the commands can be configured for blocking, direct tripping and permissive tripping providing that they meet the IEC 60834-1 standard with respect to transmission time, security and dependability.

Group B commands have a lower priority and are used for the control of devices. As mentioned previously, this group is composed of up to 28 independent commands the transmission of which is carried out sequentially. Each of the commands meets the IEC 60834-1 standard with respect to security and dependability of a specific direct tripping.

If a Group A command input is activated during the transmission of a Group B command, the Group B command is temporarily interrupted and the Command A transmitted.

The transmitter memorises the duration of the interruption of the Group B command and once the Group A command is finished the transmission of command B is resumed for its original duration.

This operating mode is summarized in the example in Figure 13. In the example, input I1 is assigned to command C1 of Group A and inputs I5 and I7 are assigned to commands C5 and C7 of Group B, respectively.

O1, O5 and O7 signals are the command outputs of the remote terminal. The reception on the remote terminal is explained in section 4.2, *Command reception procedure*.

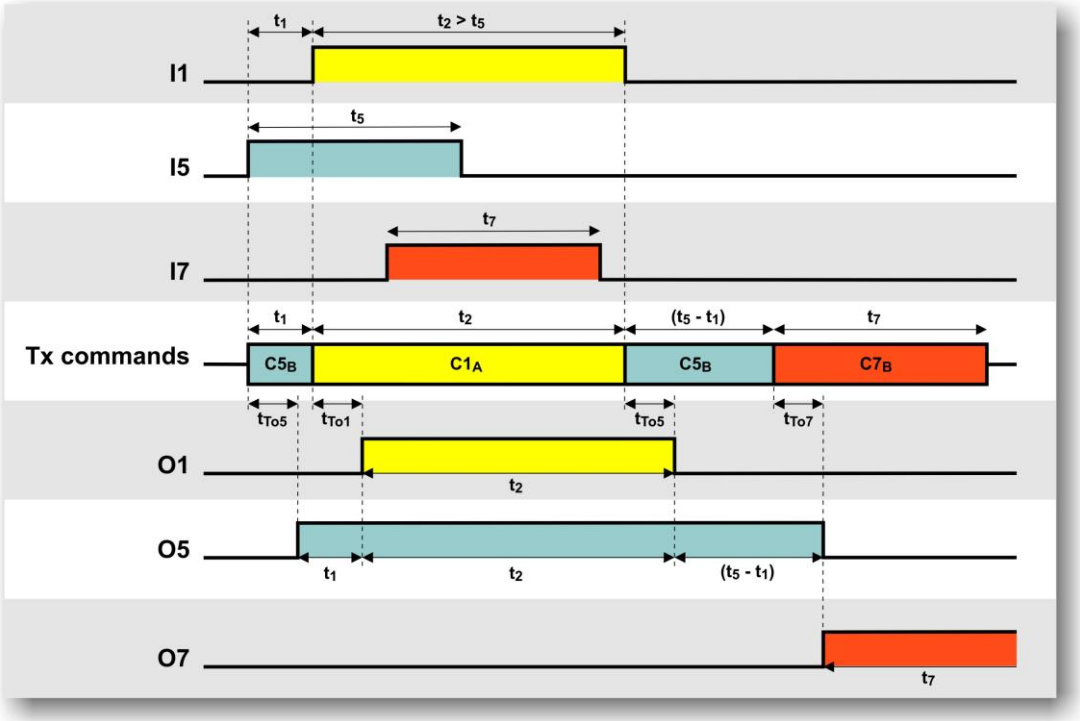


Figure 13 Example of command transmission

When only Group B commands are transmitted, they are transmitted one by one depending on the priority established for them within the group. An activation of a B command input never interrupts another command transmission. For example, if a command input of Group B is activated when another Group B command is being transmitted, the transmitter memorizes the second B-command activation and the time the input command is active. When the transmission of the first B command is finished, the system transmit the signal associated to the second B-command during the memorized time (always in accordance with the priorities).

Priority is established according to the command numbering. The commands with lower numbers have higher priority. For example, if we want input I6 to have more priority than input I2, it is necessary to assign the command with the lowest number to I6, for example C4 for input I6 and C7 for input I2.

Analog channel by dual tone in a 2.5 kHz band

When the line interface module is for an analog channel by dual tone, the module transmits the encoded guard and command signals. In quiescent conditions the transmitter continuously transmits a guard encoded signal, which is replaced by a command encoded signal when a command needs to be sent.

Two frequencies are assigned to each signal (see Table 3). Nine frequencies are needed for the guard and 4 independent commands and any combination of them.

The frequencies assigned to the command signals are pre-established, as well as the guard encoded signal (960 Hz/1440 Hz).

Encoded signal			f_1 480Hz	f_2 720Hz	f_3 960Hz	f_4 1200Hz	f_5 1440Hz	f_6 1680Hz	f_7 1920Hz	f_8 2160Hz	f_9 2400Hz
Command		**Guard**			X		X				
Group	**C1**	**A**		X		X					
	C2	**B**		X				X			
	C3	**C**		X					X		
	C4	**D**		X							X
	-	A+B		X						X	
	-	A+C				X		X			
	-	A+D				X				X	
	-	B+C	X			X					
	-	B+D				X					X
	-	C+D						X		X	
	-	A+B+C	X					X			
	-	A+B+D						X			X
	-	B+C+D	X						X		
	-	A+C+D	X							X	
	-	A+B+C+D							X		X

Table 3 Frequency assignment to guard and command signals

The command group is made up of up to 4 independent commands (C1 to C4) and any combination of them. Each of the commands can be configured for blocking, direct tripping and permissive tripping providing that they meet the IEC 60834-1 standard with respect to transmission time, security and dependability.

4.2 COMMAND RECEPTION PROCEDURE

The teleprotection signal is received in the line interface module.

Command reception is signalled on the front plate by means of LED RCV of the corresponding channel, 1 or 2.

When a command output relay (or relays) is activated and/or a GOOSE message (or messages), the optical indicator OUTPUT on the front plate lights up. Furthermore, the corresponding signalling relay is also activated if it has been programmed.

The time during which the command output relay (or relays) should remain active and/or the repetition strategy of the GOOSE message (or messages) can be established from the Management System.

Digital channel

In reception, see Figure 14, the function of the line module is to decode the frame received in line. Before carrying out the said process, it should be verified that the frame received is correct (length, error-detection code and fixed sequence). If it is detected that the value of the identification code does not coincide with that assigned to the terminal in reception, or de security identification code (SIC) received does not coincide with that expected, the optical indicator ALARM of the corresponding channel, 1 or 2, lights up in red on the front plate.

Each bit of the COMMANDS byte is stored in a shift register, which is given the name ***window***. The length of the window is the number of teleprotection information bytes that must be analyzed to detect a command signal. The length of the register is variable and its value is determined from the Management System independently for each command.

The ***decision threshold*** is the number of teleprotection information bytes, with command signal, that must be received correctly within the length of the window for the command to be executed. As for the window, its value is determined from the Management System, independently for each command.

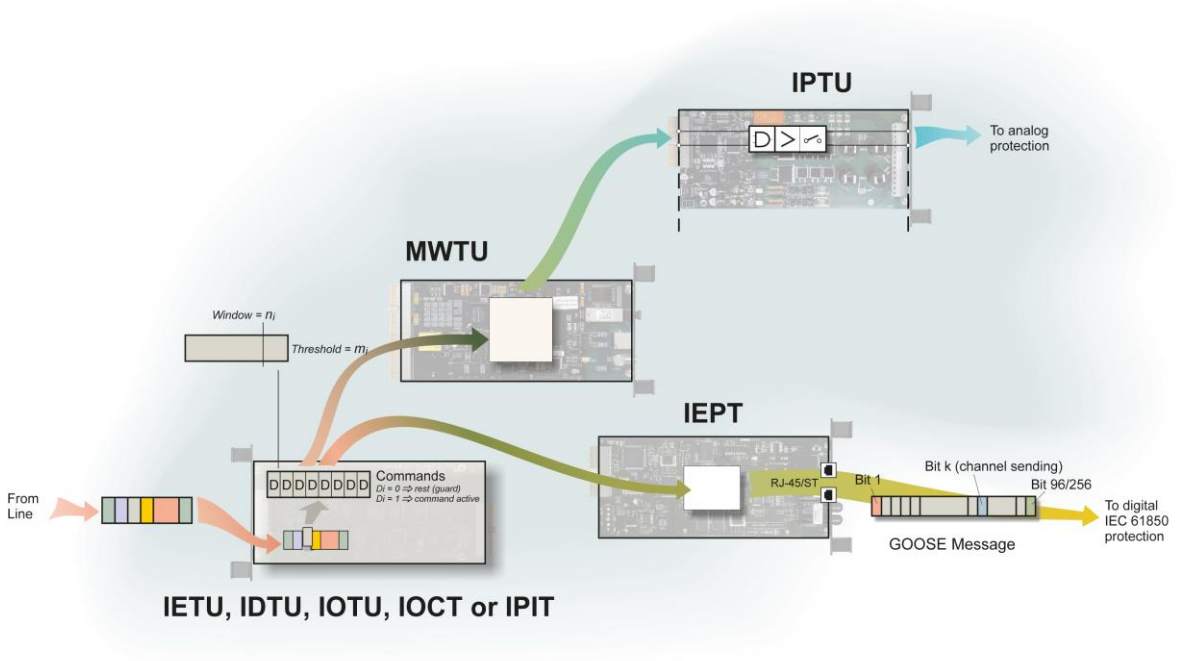


Figure 14 Command reception procedure for digital channel

When the line module detects that the number of "1" bits contained in the ***window*** is the same as that of the prefixed number for the ***threshold***, it manages the information towards the processing module so that it, as long as this situation is not due to a remote test starting locally or the terminal is blocked, can proceed to activate the corresponding output combination, that is to say, command output relay (or relays) and/or GOOSE message (or messages).

The command finishes when the number of "1" bits contained in the window is lower than the threshold and the number of "0" bits is greater. Should there be an equal quantity of "1" bits and "0" bits, the "1" bits have preference and the command therefore remains active.

In order to avoid the execution of a command being interrupted by transmission errors, incorrect messages are not taken into account. In this case, the shift register remains stable.

The quality of the received signal is established with regard to the bit error rate (BER) of the channel. The programming of the BER alarm is carried out by configuring the activation and deactivation thresholds (from $1x10^{-2}$ to $0.5x10^{-9}$ in 0.5 steps) from the Management System.

Communications channel over IP

In reception, the IP communications module decodes the packet received from the IP network. First of all, it should be verified that the received packet is correct (thanks to the control code) and its sequence number (thanks to the sequence field). If the packet is not correct, the LINK LED is turned off.

Then the value of quality of service parameters of the IP network is calculated. If the values are not satisfactory, the ALARM LED lights up on the front plate and, if it has been configured by the user, the command outputs of the terminal are blocked.

Finally, the teleprotection information is processed.

Each bit of the COMMANDS byte is stored in a shift register, which is given the name ***window***. The length of the window is the number of teleprotection information bytes that must be analyzed to detect a command signal. The length of the register is variable and its value is determined from the Management System independently for each command.

The ***decision threshold*** is the number of teleprotection information bytes, with command signal, that must be received correctly within the length of the window for the command to be executed. As for the window, its value is determined from the Management System, independently for each command.

When the line module detects that the number of “1” bits contained in the ***window*** is the same as that of the prefixed number for the ***threshold,*** it manages the information towards the processing module so that it, as long as this situation is not due to a remote test starting locally or the terminal is blocked, can proceed to activate the corresponding output combination, that is to say, command output relay (or relays) and/or GOOSE message (or messages).

The command finishes when the number of “1” bits contained in the window is lower than the threshold and the number of “0” bits is greater. Should there be an equal quantity of “1” bits and “0” bits, the “1” bits have preference and the command therefore remains active.

Analog channel by single tone

The signal coming from the line, in the case of single tone, follows different paths depending on whether it is a guard signal or command signal. The guard signal is digitized, and the command signal is subjected to a non-linear process before being band-limited and digitized.

The digital signal processor (DSP) implements up to nine filters, which correspond to the guard tone and to the eight possible command tones. The central frequency and bandwidth of these filters are defined by the user when carrying out programming of the equipment.

Each command is detected by its corresponding filter and decision logic in order to activate the associated command output or outputs (IPTU modules). Each IPTU module has two independent command outputs.

With respect to the command-reception process, the disappearance of the guard tone initiates a temporary window during which the reception of a command signal is awaited. If the window time expires without a re-established guard signal or a command signal having been received, an internal blocking signalling is generated.

The internal blocking signalling blocks the outputs and generates the blocking alarm and the signal loss alarm. It also activates the relay programmed for receiver blocking alarm, except when there is an additional timing programmed for the relay. On the other hand, it is possible to configure the activation of a signalling relay for *Command Unblocking.* The unblocking signalling relay activates when the internal blocking signalling is generated, except when there is an activation delay programmed for the relay. The activation time of the unblocking relay can also be programmed by the user. When the said time has elapsed, the unblocking relay deactivates although the internal blocking signalling remains active.

Analog channel by dual tone

The signal coming from the line is digitized in the IBTU module.

The Digital Signal Processor (DSP) implements a bank of filters for the reception of all the frequencies used in transmission (see Table 2). The central frequency and bandwidth of these filters are defined by the user when programming the type of command trip.

The frequencies associated to the guard and to the commands of Group A have three types of filters with different bandwidths associated to them: for blocking, for permissive tripping and for direct tripping. The frequencies associated to Group B commands have a type of filter suitable for specific direct tripping associated to them.

Each command is detected by the two filters associated to each one of the frequencies that make up the encoded signal. The central frequency of the filter is the value of the pre-established frequency and the bandwidth is according to the type of command trip.

The disappearance of the guard initiates a temporary window during which the reception of a command is awaited. If the window time expires without a re-established guard or a command having been received, an internal blocking signalling is generated.

Each IPTU module has two independent command outputs. From the Management System, the user can assign the associated command output or outputs.

As can be seen in the example in Figure 13, the command output does not present redundancy. When a Group B command output (O5) is interrupted by a Group A command output (O1), the Group B command output (O5) is kept active until the Group A command deactivates and it is verified that the Group B command is still being received.

If so, the Group B command output remains active whilst the Group B command is being received. If not, it deactivates when Group A command output deactivates.

If the time elapsed between the activation of I5 (B command) and I1 (A command) is lower than 15 ms (the time that the receiver filter needs to be energized), output O1 (A command) is becoming active before output O5 (B command) does. In this way, output O5 deactivates once input I1 (A command) goes to the deactivation state.

In case of two commands of A group, the transmission time of the first A command is the nominal time plus the delay between the activation of the two A commands, provided that the time be lower than 12 ms (in permissive commands). If the time be higher, the transmission time of the first A command is the nominal one, and for the second A command the transmission time is higher (1.5 ms plus, for example, 12+1.5=13.5 ms for permissive commands) but always under the nominal value.

Analog channel by dual tone in a 2.5 kHz band

The signal coming from the line is digitized in the IBTU module.

The Digital Signal Processor (DSP) implements a bank of filters for the reception of all the frequencies used in transmission (see Table 3). The central frequency and bandwidth of these filters are defined by the user when programming the type of command trip.

The frequencies associated to the guard and to the commands have three types of filters with different bandwidths associated to them: for blocking, for permissive tripping and for direct tripping.

Each command is detected by the two filters associated to each one of the frequencies that make up the encoded signal. The central frequency of the filter is the value of the pre-established frequency and the bandwidth is according to the type of command trip.

The disappearance of the guard initiates a temporary window during which the reception of a command is awaited. If the window time expires without a re-established guard or a command having been received, an internal blocking signalling is generated.

Each IPTU module has two independent command outputs. From the Management System, the user can assign the received command to the corresponding command outputs.

4.3 TEST DEVICES

In order to facilitate alignment and maintenance operations, as well as fault finding, the TPU-1 Management System allows different tests and loops to be carried out. These are described below.

The Alignment menu contains an option which allows the terminal to be blocked in order not to allow it to activate any output, whether compatible or not with the IEC 61850 standard, when it receives a command. In this way, depending on the type of test or loop one wishes to carry out, it is first necessary to program a **blocking**.

4.3.1 Command transmission

The TPU-1 Management System contains the options necessary to verify the correct operation of the input logic. In this way, from the Alignment menu, it is possible to force the activation of the corresponding analog and/or digital IEC 61850 inputs and check whether the activation has initiated the transmission of the desired command.

The activation of the inputs can be forced for a determined period or, if desired, permanently. Once the activation is programmed, in the same screen, it is possible to verify whether the input activation has produced the transmission of the desired command.

From the Monitoring menu it is also possible to monitor the state of the inputs and consult the counter of number of activations associated to each one of them, as well as monitor the transmitted commands and consult the command transmission counters.

Before carrying out a test of this type, the command transmission should be suitably treated in order to make sure that no undesired output activation take place in the remote terminal or in the terminal itself if a loop has been established.

4.3.2 Internal loop

The Alignment menu of the TPU-1 Management System contains an option that allows an internal loop to be programmed in the terminal, in such a way that the local transmitter remains connected to the local receiver (see Figure 15).

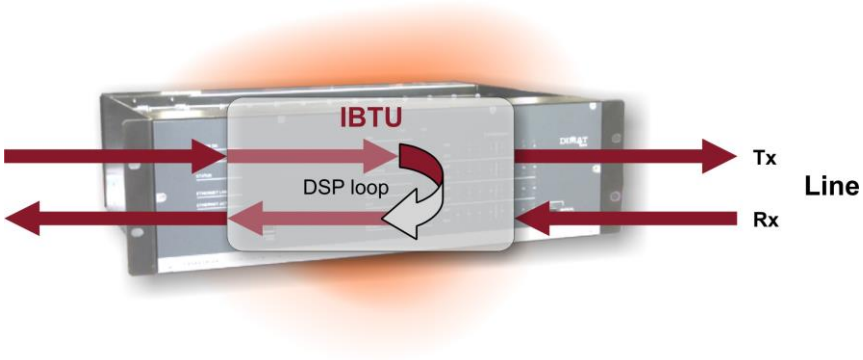


Figure 15 Internal loop

The loop, therefore, allows the correct transmission and reception of the command to be verified, on a local level, and the correct operation of the output logic established for each command received.

When the terminal is in loop, the optical indicator LOOP/TEST of the corresponding channel, TP1 or TP2, on the front plate lights up in amber.

The loop can be programmed for a pre-fixed duration, or can be established permanently until the programming to deactivate is not given. Once the loop is established, the activation of the inputs can be forced by means of the corresponding option of the Alignment menu (see section 4.3.1, *Command transmission*).

The internal loop can also be carried out in the collateral terminal, that is to say, in the terminal at the other side of the link. In this case, from the Management System, it is first necessary to access the remote terminal and then to carry out the internal loop. Unlike the internal loop carried out in the local terminal, the internal loop carried out in the remote terminal can only be programmed for a pre-fixed duration.

Before carrying out the loop, the command outputs of the terminal should be suitably treated in order to make sure that no undesired output activation take place.

4.3.3 Line loop

The Alignment menu of the TPU-1 Management System also contains an option that allows a line loop to be programmed. As can be seen in Figure 16, the loop is established at line interface level, the communication line remaining in loop. The loop, therefore, allows the behaviour of the communication channel to be verified.

When the terminal is in loop, the optical indicator LOOP/TEST of the corresponding channel, TP1 or TP2, on the front plate lights up in amber.

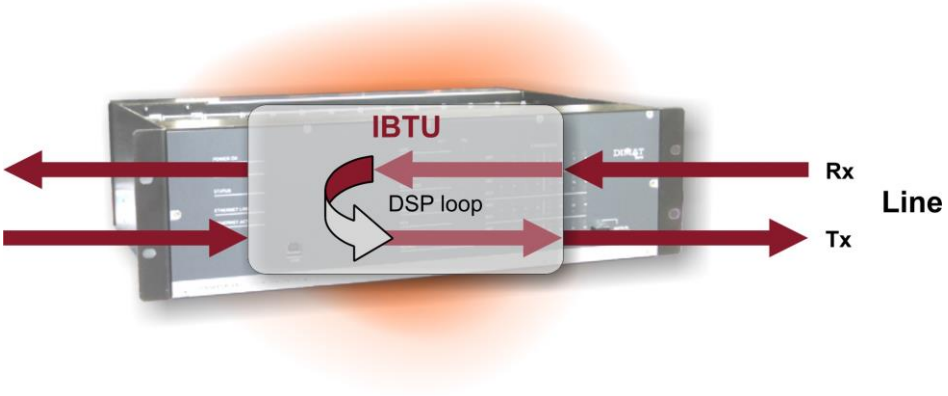


Figure 16 Line loop

When the loop is programmed from the local terminal, it can be established for a pre-fixed duration, or can be established permanently until the programming order to deactivate is not given. To carry out the loop in the remote terminal, from the Management System, it is first necessary to access the remote terminal and then to carry out the line loop. Unlike the line loop carried out in the local terminal, the line loop carried out in the remote terminal can only be programmed for a pre-fixed duration.

Before carrying out the loop, the command outputs of the terminal should be suitably treated in order to make sure that no undesired output activation take place.

4.3.4 Remote test starting locally in digital line interface and IP interface

The TPU-1 Management System allows a remote test in the link to be programmed. This test is also carried out when the terminal is started up. The test can also be automatic when the specified time has elapsed.

The test consists of sending a series of frames from the local terminal to the collateral terminal, with the fixed sequence modified, in which all the bits of the COMMANDS byte contain a command. The remote terminal must identify correctly all the commands and, if so, send a message indicating that the result of the remote test is correct to the local terminal by means of the service channel.

The result of the test is shown by means of the optical indicator LOOP/TEST of the corresponding channel, 1 or 2, on the front plate. When correct it lights up in green and when not, in red.

This test, therefore, allows the quality of the link to be verified periodically.

4.3.5 Local test in analog line interface

The TPU-1 Management System contains an option that allows a local test to be carried out. This test can also be automatic when the specified time has elapsed.

The test consists of the transmitter sequentially sending the command tones programmed in the receiver to its own receiver without being interrupted by the sending of the guard signal to the collateral terminal. The receiver processes the received test tones in the same way that it does when receiving a command tone from the collateral terminal. If the receiver correctly identifies all the test signals, the test is correct.

The result of the test is shown by means of the optical indicator LOOP/ TEST of the corresponding channel, 1 or 2, on the front plate. When correct it lights up in green and when not, in red. A failure in local test is registered in the chronological register.

The terminal under test continuously supervises the reception of the guard signal from the other terminal and awaits the possible input of commands from its protection-side interface. This allows the test to be aborted (LED LOOP/ TEST off) and the transmission or reception of a real command to be attended to if necessary.

4.3.6 Remote test starting locally in analog line interface

The TPU-1 Management System allows a remote test in the link to be programmed. This test can also be automatic when the specified time has elapsed.

The test consists of the transmitter sending a message to the collateral terminal by means of the service channel. The remote terminal must receive correctly the message and, if so, send a confirmation message to the local terminal.

The result of the test is shown by means of the optical indicator LOOP/ TEST of the corresponding channel, 1 or 2, on the front plate. When the confirmation message is received correctly, the LED lights up in green. When not, after two attempts, it lights in red, and a failure in remote test is registered in the chronological register.

The terminal under test continuously supervises the reception of the guard signal from the other terminal and awaits the possible input of commands from its protection-side interface. This allows the test to be aborted (LED LOOP/ TEST off) and the transmission or reception of a real command to be attended to if necessary.

4.3.7 Telesignalling and remote measurements module tests

The TPU-1 Management System also allows tests to be carried out in the telesignalling and remote measurements modules.

In the case of the digital signal I/O interface module (DSTU), it is possible to force the activation of the digital inputs and outputs from either the local or remote terminal. As well as being able to verify that the activations have been carried out in the local terminal, it is also possible to verify that the activations transmitted from the local terminal have been satisfactorily received in the remote terminal and viceversa.

In the case of the current measurement module (MCTU), it is possible to force a fixed current value for the analog inputs and outputs from either the local or remote terminal. As well as being able to verify the values in the local terminal, it is also possible to verify that the values transmitted from the local terminal have been satisfactorily received in the remote terminal and viceversa.

4.4 TIME SYNCHRONIZATION

The TPU-1 terminal chronologically registers all the alarms and events produced in the teleprotection link. In order to establish the date and time the alarms and/or events are produced, the TPU-1 terminal has a real time clock, which can be synchronized either via the GPS system or via Ethernet.

When time synchronization is established in the terminal, the TPU-1 refers its internal real time clock to the UTC[2] system, estimating in this way the UTC time by which it can calculate the time in other zones of the world. In this case, the UTC time will always remain as a model of the internal clock of the terminal, even against any date and time programming carried out by the user.

4.4.1 GPS synchronization

The TPU-1 terminal can synchronize its real time clock with the time reference given by the GPS system, therefore only being necessary to connect it to a GPS receiver that has a timing output, which must be an IRIG-B output. IRIG-B standard establishes the format of signals used to identify specific instants of time.

The standard IRIG-B signals are classified according to the modulation applied to them, their frequency/resolution and codes applied to the words (set of bits) that contain the information. According to this classification, a number is applied to each one of the three parameters mentioned earlier and standards are defined, such as for example, the IRIG-B 120 or the IRIG-B 123.

The TPU-1 terminal is capable of processing standard IRIG-B 123 signals, in which the signal is modulated in amplitude at 1 kHz, and standard IRIG-B 003 signals, in which the signal is modulated by pulses.

4.4.2 Ethernet synchronization

The TPU-1 terminals can also synchronize their real time clock via Ethernet using the SNTP (Simple Network Time Protocol) protocol, which uses UTC as a time base.

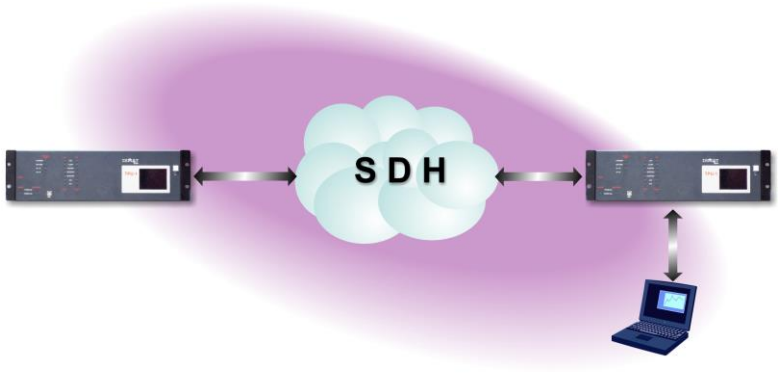
It is possible to configure up to 5 possible addresses of SNTP servers from the TPU-1 Management System.

[2] UTC is not really an abbreviation but a variant of universal time (*UT*) and the C of "coordinated" is added to show that it is another variant of UT.

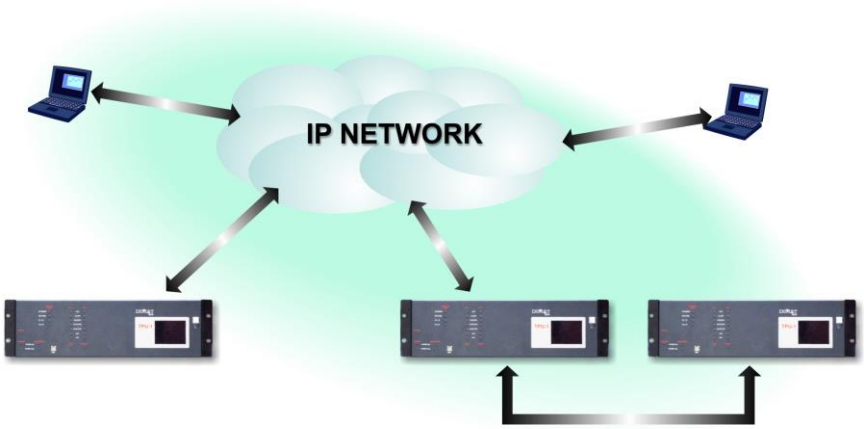
5 SYSTEM MANAGEMENT

The TPU-1 terminals include a web server containing all the pages necessary for the system programming and monitoring, being unnecessary for any software to be supplied with the equipment.

The MWTU module can include two LAN interfaces, which means that the connection between the PC and the TPU-1 terminal can be direct or by means of an IP network (LAN or WAN). In the last case all the computers connected to the IP network can manage any TPU-1 terminal connected to the said IP network.



Direct connection



Connection via IP network

Figure 17 Possible connection between PCs and TPU-1 terminals

The TPU-1 terminals also include an SNMP agent that, when configured, is capable of sending trap (unconfirmed) and inform (confirmed) notifications, about alarms and events of the terminal, to the devices specified by the user, and this makes it possible to monitor the TPU-1 terminal from an SNMP management application, such as, HP Openview.

To configure the terminal or retrieve the chronological register it is necessary to use the Web Management.

5.1 ACCESS CONTROL

Access to the Web Management of the TPU-1 terminal requires a user password, which comprises a user identification and a password.

There are two different user profiles, one basic and the other administrator. Each one has different management capacities so that whereas the administrator user can modify and supervise any parameter of the terminal, the basic user can only retrieve or supervise the parameters of the terminal, and is unable to alter its operation at any time.

By default, the system has two created profiles, one basic and the other administrator, whose user identifications and passwords can be seen in Table 4.

	User identification	Password
Basic User	basic	basic
Administrator User	admin	admin

Table 4 Default user passwords of the system

5.2 OFF-LINE WEB MANAGEMENT

In the Web Management, a distinction must be made between on-line and off-line.

On-line Web Management means that the TPU-1 terminal is managed from a computer connected to it, whilst in Off-line Web Management, the management can be carried out without any need for it to be connected to the terminal.

The off-line Management takes on special meaning when one wishes to configure the terminal from somewhere where there is no connection with it. The terminal configuration can be programmed and stored in the Management computer or in a magnetic support and when the connection is possible, load the configuration in the terminal.

To be able to perform off-line management, it is necessary for the management computer to have been previously connected to the TPU-1 terminal to obtain the pages corresponding to the management from the server.
These pages can only be downloaded by an ADMINISTRATOR user.

5.3 MAIN MANAGEMENT MENUS

The Web Management of the TPU-1 terminals only requires a standard web browser. The user can access the home web page of the Management System by entering the IP address of the web server integrated in the TPU-1 in the browser, once authorisation is gained by means of the user password.

Seven main menus appear in the home web page. The first menu, *Files*, controls the flow of information entering and leaving the Management System. The second, *Updatings*, allows the pages necessary for carrying out off-line Web Management to be downloaded as well as the display of the module software versions. The third, *Server*, gives access to the options which allow the specification of: the web server user passwords, the basic network management parameters (IP address, subnetwork mask and gateway), that must be compatible with those of the management computer. The fourth, *SNMP*; gives access to the options which allow the configuration of the SNMP agent included in the terminal. The fifth, *Equipment*, allows all the operative parameters of the terminal to be configured and those of its collateral, that is to say, those of the terminal at the other side of the link. The sixth menu, *Monitoring,* allows supervision of the system to be carried out, whilst the seventh, *Alignment*, contains guidelines on alignment and maintenance. Some of these menus are described in more detail in the following sections.

5.3.1 Files menu

This menu gives access to the reading functions of the disk or terminal and writing functions to disk or in the terminal.

5.3.2 Equipment menu

This submenu contains the options and submenus that allow the TPU-1 terminal to be configured according to the teleprotection requirements.

The parameters to be programmed are:

- **Clocks and synchronism.** The menu has an option that shows the date and time of the internal real time clock of the terminal and the UTC time allowing, if desired, the date and time values of the internal clock of the terminal to be modified using the UTC clock as a reference.

> The date and time programming of the internal clock of the terminal does not remain when the terminal has an external timing synchronization programmed, via GPS or via Ethernet.

- **Basic configuration of the equipment**. Consists of specifying the number of transmission channels and their operation (two independent channels, transit activation, activation of the remote measurements application), the number of transmission and reception commands, the constitution of the equipment, and whether the terminal should operate with protections according to IEC 61850 standard.
- **Input and output logic**. Configuration of the input and output matrix. Both matrix are independent and widely configurable. The input matrix consists of establishing the input logic, whether compatible or not with the IEC 61850 standard, that allows the command transmission process to begin, as well as command transits if necessary. The output matrix establishes the output logic, whether compatible or not with the IEC 61850 standard, for each command received.
- **Command transmission duration**. Consists of establishing the duration of the command transmission to the TPU-1 terminal at the other end of the link. The transmission can be permanent whilst the input condition is present, or the time can be prolonged, limited, or of fixed duration.
- **Additional timing**. Consists of establishing the time during which the input conditions have to be fulfilled.
- **Command output duration**. Consists of establishing the time during which the command output relay (or relays) should remain active. The time can be the same as that of the command reception, or be prolonged, limited, or of fixed duration.

- **Window length for digital channel and for IP interface.** Consists of establishing the number of teleprotection information bytes that must be examined to detect a command signal.

- **Decision threshold for digital channel and for IP interface.** Consists of establishing the number of teleprotection-information bytes, with command signals, that must be received correctly within the window length. The number should be lower or the same as that of the window length.

- **Digital line interface configuration.** The parameters to be specified vary according to the type of module. For example, in the case of the optical fiber interface, IOTU module, the type of clock (internal or recovered) has to be specified, whilst in the case of the electric interface according to Recommendation V.35 of the ITU-T, IETU module, the speed and operation mode has to be specified.
  The BER alarm is programmed in the page associated to the digital line interface.

- **Configuration of the communications interface over IP.** The parameters to be specified are the security and dependability criteria, the transmitter functionality, the type of line interface (IP or Ethernet), and the configuration of the alarms of quality of service of the IP network.

- **Analog line interface configuration.** The parameters to be specified are different depending on module type. In this way, for example, in the case of the interface by single tone (4 combined commands), IATU/IBTU module, are the transmission and reception frequencies of the guard and command tones, the transmission time, the transmission and reception levels of the guard and command tones and, in the case of the command tones, the power-boosting condition level.

- **Identification codes for digital channel and for IP interface.** They are codes that are configured, in transmission and reception, in each one of the link terminals in order to establish the origin of the received information.

- **Security identification codes for digital channel.** They are codes that are configured in each one of the link terminals in order to guarantee the origin of the received information. The transmission code (own SIC) is programmed at the factory, whilst the reception code (expected SIC) has to be specified by the user according to the SIC of the remote terminal that one wishes to obtain the information from.

- **Periodicity of the test.** Consists of specifying the interval of time, in hours, between remote tests (digital line interface and IP interface) or local and remote tests (analog line interface).

- **Activation condition of the auxiliary relays.** Consists of specifying the use of the auxiliary relays of the protection-side interface modules (IPTU) and, if necessary, the use of the auxiliary relay of the analog line-interface module (IATU or IBTU) and that of the auxiliary relays of the IRTU modules. The auxiliary relays can be programmed for command transmission signalling, command output or alarm and, if be the case, unblocking.

- **Auxiliary relay timing.** Consists of specifying the time during which the programmed alarm conditions must be present in order to activate the corresponding auxiliary relay.

- **IEC 61850 parameters.** Basically consists of configuring basic parameters (IP address, subnetwork mask, gateway and configuration of the GOOSE encoding format in transmission), and of specifying the repetition strategy of the output GOOSE messages, as well as establishing, for each one of the possible 16 outputs, the identification and Multicast address they came from.

- **Remote measurements.** Basically consists of establishing the delivery time of remote measurements information between terminals, of assigning the MCTU and DSTU modules to the communication channels, and of specifying the output values of the analog and digital signals should the communication channel be interrupted.
  If the remote measurements application is activated, the registration of the events associated with remote measurements in the chronological register should be activated.

5.3.3 Monitoring menu

The monitoring menu makes it possible to verify the operation of either of the two TPU-1 terminals in a link.

Data supplied by the monitoring system regarding each terminal are: Alarm signals, Teleprotection state, Input state, Output state and Chronological register. The data relative to Signal/Noise ratio also appear for the analog channel, and the error rate (BER) for the digital channel.

When a communications channel over IP is used, the following data related to the quality of service of the IP network are displayed: average value of the delay (Mean Transfer Delay: MTD), variance of delay (Cell Delay Variation: CDV) and packet loss ratio (Cell Loss Ratio: CLR).

Alarm signals

The terminal alarms that can be monitored from the Management System are the terminal general alarms as well as the specific alarms of each communication channel.

- RTC synchronization failure (general).
- IEC 61850 link failure (general).
- Power-supply 1 and/or 2 failure (general).
- Telemeasuring failure (general).
- Main module failure (general).
- Module failure in slot no. (general).
- Manual blocking in channel 1 and/or 2 (analog and digital).
- Automatic test failure in channel 1 and/or 2 (analog and digital).
- Incorrect identification code in channel 1 and/or 2 (digital).
- Incorrect security identification code (SIC) in channel 1 and/or channel 2 (digital).
- Loss of synchronism in channel 1 and/or 2 (digital).
- BER alarm in channel 1 and/or 2 (digital).
- Remote Alarm Indication (digital IOCT type).
- Loss of signal (digital IOCT type).
- Reception blocking in channel 1 and/or 2 (analog).
- Signal loss in channel 1 and/or 2 (analog).
- Low guard-signal level/Excess guard-signal level in channel 1 and/or 2 (analog).
- Low Signal/Noise ratio in channel 1 and/or 2 (analog).
- Reception error in channel 1 and/or 2 (analog).
- General transmission failure (IEC 61850).
- Failure in synchronization with system clock (IEC 61850).
- GOOSE receive timeout failure (IEC 61850).
- MTD signal out of range in channel 1 and/or 2 (IP interface).
- CDV signal out of range in channel 1 and/or 2 (IP interface).
- CLR signal out of range in channel 1 and/or 2 (IP interface).
- IP link failure in channel 1 and/or 2 (IP interface).

These alarms can be assigned, by means of programming, to the auxiliary relays of the protection-side interface modules (IPTU) or, if be the case, to the auxiliary relay of the IATU or IBTU module and/or the auxiliary relays of the IRTU modules.

When the optional LCD display is included in the TPU-1 terminal, these alarms can be displayed on the front of the terminal by means of the said display.

Tx/Rx commands

The menu makes it possible to monitor, for each channel, which command is being transmitted and which command is being received. It is also possible to monitor the counters of number of command transmissions and the counters of number of command receptions.

When the optional LCD display is included in the TPU-1 terminal, the counters can be displayed on the front of the terminal by means of the said display.

Input state

The menu makes it possible to monitor what inputs have brought about the command transmission, whether compatible with the IEC 61850 standard or not, and the counters of number of input activations.

When the optional LCD display is included in the TPU-1 terminal, the counters can be displayed on the front of the terminal by means of the said display.

Output state

The menu makes it possible to monitor which outputs have been activated, whether they are compatible or not with IEC 61850 standard, and the counters of number of output activations.

When the optional LCD display is included in the TPU-1 terminal, the counters can be displayed on the front of the terminal by means of the said display.

Chronological register

The TPU-1 system stores in a FIFO-based register the appearance and disappearance of the alarms and events which refer to link service, such as: transmission of command, reception of command, modification of programming, carrying out a loop, and if be the case information associated to remote measurements and so on. A brief description is given for each alarm and event, indicating the date, with day, month and year, and the time in minutes, seconds and milliseconds when they occurred.

The messages can be displayed independently or together, that is to say, alarms and events at the same time or for a certain channel or both, in blocks or in total, and in order, that is to say, by date and hour, or chronologically beginning with the last.

The Web Management also includes the possibility of saving the contents of the chronological register on a text file, which can be used to make listings easily printable from standard text-editor applications.

It is possible to specify display filters of alarms and events.

Teleprotection Signal/Noise ratio

This menu displays for an analog channel the Signal/Noise ratio.

For an analog channel by single tone (4 combined commands), the signal-to-noise ratio is referred to a 4 kHz-band signal with the modulation percentage programmed in the guard tone.

For an analog channel by dual tone (encoded commands), the signal-to-noise ratio is referred to a 4 kHz-band or 2.5 kHz-band.

It also indicates whether an alarm for low signal-to-noise ratio or signal loss exists.

State of the IP interface (IPIT) module

When a communications channel over IP is used, this menu displays the state of the alarms related to the quality of service of the IP network. These alarms are the average value of the delay (Mean Transfer Delay: MTD), the variance of delay (Cell Delay Variation: CDV) and the packet loss ratio (Cell Loss Ratio: CLR).

Remote measurements

If the remote measurements application has been activated, the menu makes it possible to monitor which digital inputs and outputs of the DSTU module have been activated, and the counters of number of input and output activations.

In the case of analog inputs and outputs, it is possible to monitor the current value in each input and each output, as well as the maximum and minimum measurement obtained in each one from the last counter reset or from the starting up of the terminal.

It is also possible to scale the values of analog signals to real values of equal or different magnitude.

5.3.4 Alignment menu

The facilities of the Alignment menu are the following:

Loops, blocking and tests

The Alignment menu contains an option which allows the terminal to be blocked for a certain period of time, or permanently, so that it cannot activate any output, whether compatible or not with the IEC 61850 standard. It also contains the options that allow the internal and line loops to be carried out, the remote test starting locally (digital and IP), as well as the local and remote test starting locally (analog).

When the optional LCD display is included in the TPU-1 terminal, blocking is displayed by means of a padlock symbol.

Counter reset

The Alignment menu has an option that sets the transmitted and received command counters to zero together with the input and output activation counters.

Release relays

The Alignment menu has an option that allows the command transmission/reception signalling relays configured for *Manual deactivation* to be deactivated.

Operate relays

The Alignment menu has an option that allows the operation of the local signalling relays to be checked. The activation of the relays can last a timing or be established as permanent.

Reset modules

From the Alignment menu it is possible to force a reset of the processing module and/or of the rest of the modules.

If the remote measurements application has been activated, it is also possible to put the counters of the number of digital input and output activations to zero, as well as the counters of analog input and output measurements (maximum and minimum).

Input activation

The Alignment menu allows the analog and IEC 61850 digital inputs to be activated, by one channel or both and for a prefixed time, and check whether the activation has initiated the transmission of the desired command.

Registry enabling

The Alignment menu has an option that can select the alarms and events to be registered in the chronological register.

Remote measurements

If the remote measurements application has been activated, the menu makes it possible to carry out a test of the analog and digitals inputs and outputs.

6 TECHNICAL CHARACTERISTICS

6.1 GENERAL CHARACTERISTICS

Application

Transmission of teleprotection commands for electrical high-frequency line protection for the following schemes:

- Blocking.
- Direct tripping.
- Permissive tripping.

Telesignalling and Remote measurements in cogeneration applications.

Transmission of teleprotection commands over IP packet networks.

Operating mode

- Mixed protection interfaces (analog and in accordance with IEC 61850 standard).
- IP interface for connection to packet networks.
- Possibility of working with two independent channels.
- Possibility to transit teleprotection commands in configurations in T (Teed-line) or in a ring configuration.
- Integrated Web management system with LAN connection.
- Time synchronization of the chronological register via GPS (IRIG-B) and/or via Ethernet (SNTP protocol).
- SNMP agent.

Number of communication channels	2, analog and/or digital with electric or optic interface and/or with communications interface over IP.
Capacity	- Digital channel or IP communications: From 1 to 8 commands. - Analog channel by single tone: From 1 to 4 commands. - Analog channel by dual tone: From 1 to 32 commands[3].
Digital channel interface	- E1/T1 (G.703). - 64 kbit/s (G.703, V.35 or V.11/X.21). - 64 kbit/s (single-mode 9/125 μm optical fiber, 1300 nm or 1550 nm). - C37.94 (1 slot of 64 kbit/s of the 2 Mbit/s frame, multimode 62,5 μm and 50 μm optical fiber, 830 nm). - 56 kbit/s (V.35 or V.11). - 32 kbit/s (V.35 or V.11)
Interface for communications channel over IP	- 10/100Base-Tx (RJ-45). - 100Base-Fx multimode (1300 nm, ST).
Analog channel interface	By means of 4-wire connections, in the 0 to 4 kHz band, for operation by: - single tone (4 combined commands). - dual tone (32 encoded commands). By means of 4-wire connections, in the 0 to 2.5 kHz band, for operation by: - dual tone (4 independent encoded commands).

(3)The 32 commands are divided as follows: up to 4 commands (and any combination of them) for Group A and up to 28 commands for Group B. When working with two communication channels (TP1 and TP2), the 32 commands can be distributed in this way: up to 4 commands of Group A in TP1 channel, up to 4 commands of the second Group A in TP2, channel and the remaining 24 commands of Group B shared in TP1 and TP2 channels as desired.

Test devices	- Command transmission (permanent or not). - Internal loop (permanent or not). - Line loop (permanent or not). - Remote test starting locally (digital and IP). - Local test (analog). - Remote test starting locally (analog). - Activation of signalling relays. - Test of the analog and digital inputs and outputs (telesignalling and remote measurements).
Capacity of chronological register	4000 alarms and events (FIFO-based register)
Resolution of chronological register	1 ms
GPS time connector	
Connector type	BNC
Standard	IRIG-B 123 and IRIG-B 003

6.2 CHARACTERISTICS OF THE DIGITAL LINE INTERFACES

Communication protocol	HDLC (High-Level Data Link Control) with fixed sequence
Internal channel	Data transmission
Recommended configuration	- Direct tripping. Transmission time less than 6.5 ms (Decision threshold = 3, Window length = 5) - Permissive tripping. Transmission time less than 5 ms (Decision threshold = 3, Window length = 3) - Blocking. Transmission time less than 4 ms (Decision threshold = 2, Window length = 2)

Nominal transmission time
for the indicated configuration values

At 2 Mbit/s (1/2 slots)	
Decision threshold = 1	Between 2.1 ms and 2.6 ms
Decision threshold = 5	Between 3.6 ms and 4.1 ms
Decision threshold = 15	Between 7.3 ms and 7.8 ms
At 64 kbit/s	
Decision threshold = 1	Between 2.1 ms and 3.6 ms
Decision threshold = 5	Between 5.6 ms and 6.7 ms
Decision threshold = 15	Between 14.7 ms and 15.66 ms
At 56 kbit/s	
Decision threshold = 1	Between 2.56 ms and 3.63 ms
Decision threshold = 5	Between 6.51 ms and 7.65 ms
Decision threshold = 15	Between 16.39 ms and 17.7 ms
At 32 kbit/s	
Decision threshold = 1	Between 3.32 ms and 5.16 ms
Decision threshold = 5	Between 10.26 ms and 12.2 ms
Decision threshold = 15	Between 27.6 ms and 29.81 ms

Security and dependability	In accordance with IEC 60834-1 standard
IETU module	
G.703 interface	
Transmission speed	64 kbit/s
Internal-oscillator stability	±50 ppm
Synchronism	Codirectional or contradirectional clock
Output impedance	120 Ω ± 5%, symmetric
Input impedance	120 Ω ± 5%, symmetric
Maximum line attenuation	6 dB at 128 kHz
Type of connector	SUB-D male 15-pin
Electrical characteristics and line coding	In accordance with Recommendation ITU-T G.703
Phase-fluctuation tolerance	In accordance with Recommendation ITU-T G.823
V.11 interface	
Transmission speed	64, 56 or 32 kbit/s
Synchronism	Terminal equipment. Clock from the line terminal
Type of connector	SUB-D male 15-pin
Electrical characteristics	In accordance with Recommendation ITU-T V.11
V.35 interface	
Transmission speed	64, 56 or 32 kbit/s
Internal-oscillator stability	±50 ppm
Synchronism	Internal transmission clock or from the line terminal
Type of connector	SUB-D male 15-pin
Electrical characteristics	In accordance with appendix 2 of Recommendation ITU-T V.35

X.21 interface

Transmission speed	64 kbit/s
Type of connector	SUB-D male 15-pin
Electrical characteristics	In accordance with Recommendation ITU-T X.21

IDTU module

G.703 interface

Transmission speed	2 Mbit/s (5 slots)
Internal-oscillator stability	±50 ppm
Synchronism	Codirectional clock
Output impedance	75 Ω or 120 Ω, by a setting [4]. The connection of the cable shield to earth (output not balanced) or not (output balanced) is also configured by a setting
Input impedance	75 Ω or 120 Ω, by a setting [4]
Maximum line attenuation	6 dB at 1024 kHz
Type of connector	Two BNC connectors or a RJ-45 connector, by a setting
Electrical characteristics and line coding	In accordance with Recommendation ITU-T G.703
Phase-fluctuation tolerance	In accordance with Recommendation ITU-T G.823

IOTU.## module

Optical-fiber interface

Transmission speed	64 kbit/s
Internal-oscillator stability	±50 ppm
Line coding	MANCHESTER

([4]) In IDTU.00 modules of version 3.1, the type of connector (BNC or RJ-45) is programmed from the TPU-1 Management System.

Maximum attenuation permissible	30 dB
Transmitter optical power minimum level	-5 dBm
Type of connector	FC female
Fiber type	Single mode (9/125 μm)
Wavelength	1300 nm (IOTU.00) or 1550 nm (IOTU.01)

IOCT module

Optical-fiber interface according to C37.94 standard

Transmission speed	1 slot of 64 kbit/s of the 2 Mbit/s frame
Maximum attenuation permissible	IOCT.00: 15 dB IOCT.01: 30 dB
Transmitter optical power level	IOCT.00: -15 dBm (average value) IOCT.01: -5 dBm (minimum level)
Type of connector	IOCT.00: ST female IOCT.01: FC female
Fiber type	IOCT.00: Multimode (62,5 μm and 50 μm) IOCT.01: Single mode (9/125 μm)
Wavelength	IOCT.00: 830 ± 35 nm IOCT.01: 1300 nm

IPIT module

Type of connector	IPIT.01: RJ-45 (10/100Base-Tx) IPIT.00: ST (100Base-Fx, multimode, 1300 nm)
Occupation in a 100 Mbit/s link	• With **constant time** interval between packets, and **k=1**: - 1.1 % (***IP*** line interface-UDP socket over IP) - 0.88 % (***Ethernet*** line interface)

6.3 CHARACTERISTICS OF THE ANALOG LINE INTERFACES

IATU/IBTU module (single tone)

- Operation by single tone (combined commands):
  - able to transmit and receive up to 3 commands independently or in any combination
  - able to transmit and receive up to 4 commands according to the following logic:
    - **Mode 2+2**: simultaneous protection of two lines by means of two permissive trips and two direct trips. The difference between the two versions of the Mode 2+2 is the commands associated to the permissive and direct trips.
    - **Mode 3+1**: simultaneous protection of the three phases of a line by means of three permissive trips (A, B and C) and one direct trip (D). The difference between the two versions of the Mode 3+1 is in the command tone that is transmitted for each of the different input combinations associated to the permissive trips

IBTU module (dual tone)

- Operation by dual tone (encoded commands):
  - able to transmit and receive up to 32 commands according to the following: 4 independent commands which have a higher priority and any combination of them (Group A) and 28 commands (Group B) the transmission of which is carried out sequentially

IBTU module (dual tone- 2.5 kHz band)

- Operation by dual tone (encoded commands):
  - able to transmit and receive up to 4 independent commands and any combination of them

Security and dependability	In accordance with IEC 60834-1 standard
AF output	
Nominal impedance	600 Ω
Return loss	>20 dB
Nominal level	Configurable from the Management System between -30 and 0 dBm
Power boosting	- Configurable from the Management System between 0 and +6 dB. - External signalling: By solid-state relay of 120 mA/250 V_{DC}. Non energized (contacts N.C. and C short-circuited) in normal operating conditions
AF input	
Nominal impedance	600 Ω
Return loss	>20 dB
Nominal level	Configurable from the Management System between -40 and 0 dBm
Receiver sensitivity	22 dB
Guard and command frequencies (IATU/IBTU by single tone)	Within audio band and configurable from among those defined in Recs. R.35, R.37 and R.38 of the ITU-T and the frequencies: 3300 Hz, 3360 Hz, 3420 Hz, 3480 Hz, 3540 Hz, 3600 Hz, 3660 Hz, 3780 Hz and 3800 Hz
Frequencies used to conform the encoded signals (IBTU by dual tone)	960 Hz, 1200 Hz, 1440 Hz, 1680 Hz, 1920 Hz, 2400 Hz, 2640 Hz, 2880 Hz, 3120 Hz and 3360 Hz
Frequencies used to conform the encoded signals (IBTU by dual tone - 2.5 kHz band)	480 Hz, 720 Hz, 960 Hz, 1200 Hz, 1440 Hz, 1680 Hz, 1920 Hz, 2160 Hz and 2400 Hz

Nominal transmission time (IATU/IBTU by single tone)	Configurable among 7 ms (intended for blocking), 15 ms (intended for permissive tripping) and 25 ms (intended for direct tripping)
Nominal transmission time (IBTU by dual tone)	Configurable among 8.5 ms (intended for blocking), 15 ms (intended for permissive tripping) and 25 ms (intended for direct tripping)

Internal channel (IATU/IBTU by single tone)

Functions	Data transmission
Central frequency	Guard frequency
Modulation	By frequency-shift keying of ± 15Hz
Maximum rate	25 bit/s

Internal channel (IBTU by dual tone)

Functions	Data transmission
Central frequency	330 Hz
Modulation	By frequency-shift keying of ±15 Hz
Maximum rate	50 bit/s

6.4 COMMAND INPUT AND OUTPUT

Command inputs

Type	Digital or Analog
Digital (IEPT module)	In accordance with IEC 61850 standard. Up to sixteen different inputs
Analog (IPTU module)	
Type	Optocoupled

Number of inputs per command	Configurable. With one IPTU module: 2 With eight IPTU modules: 16
Nominal operating voltage	24, 48, 110 and 220 V_{DC}
Minimum voltage that guarantees activation	-20% of the nominal voltage
Maximum voltage that guarantees NO activation	-40% of the nominal voltage
Maximum operating voltage	+20% of the nominal voltage
Polarity	Indistinct
Consumption	Constant 10 mA to the nominal voltage (in the whole range)
Activation minimum time	700 µs
Activation logic	By presence of voltage
Additional timing for command transmission	Configurable from the Management System between 0 and 31 ms with 1 ms steps
Timing possibilities	- Whilst the analog command input is activated or a GOOSE message is detected - Prolonged to 20÷15000 ms. Configurable in 10 ms steps - Limited between 20÷15000 ms. Configurable in 10 ms steps - Fixed duration of 20÷15000 ms. Configurable in 10 ms steps

Command outputs

Type	Digital or Analog
Digital (IEPT module)	In accordance with IEC 61850 standard. Up to sixteen different outputs

Analog (IPTU module)

Type	Solid-state relay (semiconductor)
Number of outputs per command	Configurable. With one IPTU module: 2 With eight IPTU modules: 16
Contact	Normally open. Voltage free
Maximum connection power	900 W
Maximum current in connection	Permanent: 2 A 3 A for a max. of 20 s
Maximum connection voltage	300 V_{DC}
Residual voltage in connection	4 V
Leakage current	<300 μA
Switching time	<250 μs
Timing possibilities	- Whilst receiving command - Prolonged to 20÷15000 ms. Configurable in 10 ms steps - Limited between 20÷15000 ms. Configurable in 10 ms steps - Fixed duration of 20÷15000 ms. Configurable in 10 ms steps

6.5 GOOSE MESSAGE INPUT AND OUTPUT

Encoding format of the transmission frame	It can be set between *Dynamic Length* or *Fixed Length*. Both criteria are fully compatible with IEC 61850-8-1:2011 standard
GOOSE encoding format (fixed length)	In accordance with IEC 61850-8-1:2011 standard, Tables A.1 & A.2
GOOSE encoding format (dynamic length)	In accordance with IEC 61850-8-1:2011 standard, Annexes A.1 & A.2

6.6 TELESIGNALLING AND REMOTE MEASUREMENTS

Analog inputs

Number of inputs	Floating differential and insulated. With one MCTU module: 4 With two MCTU modules: 8 With three MCTU modules: 12 The MCTU module can be assigned to one or both line channels (TP1/TP2).
Detection range	Bipolar signals: ±20 mA
Resolution	15 bits
Accuracy	0.2%
Acquisition time	100 ms
Polling time	With one MCTU module: programmable between 1 and 60 s With two or three MCTU modules: programmable between 3 and 60 s. The average value of the last 10 samples is delivered (a sample is retrieved each 100 ms)

Analog outputs

Type	In current loop
Number of outputs	Floating differential and insulated. With one MCTU module: 4 With two MCTU modules: 8 With three MCTU modules: 12 The MCTU module can be assigned to one or both line channels (TP1/TP2).
Output range	Bipolar signals: ±20 mA
Resolution	16 bits
Accuracy	0.1%
Acquisition time	100 ms

Digital inputs

Number of inputs	With one DSTU module: 6 With two DSTU modules: 12, being possible to associate the two DSTU modules to the same channel or one DSTU module to a channel (TP1) and the other to a second channel (TP2).
Type	Optocoupled
Input voltage	24, 48 and 110 Vdc
Activation range[5]	±20% of the nominal voltage
Permanent overvoltage	1.4 x Vnominal
Current for the activation	≥ 3 mA
Resolution	better than 10 ms. Changes higher than 20 ms will be admitted

Digital outputs

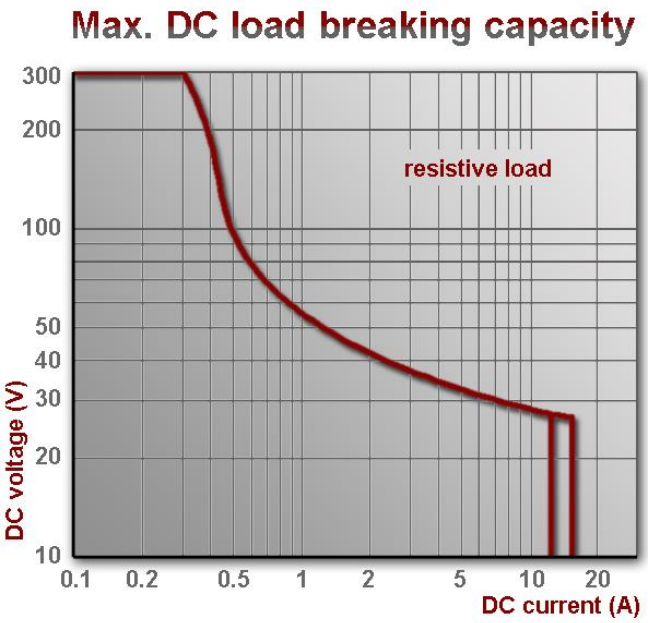
Number of outputs	With one DSTU module: 6 With two DSTU modules: 12, being possible to associate the two DSTU modules to the same channel or one DSTU module to a channel (TP1) and the other to a second channel (TP2).
Type	Voltage-free contacts (electromechanical relay)
Operating voltage	48 and 125 Vdc
Operating current	0.5 A

[5] If the input voltage is 60% lower than the nominal voltage, the inputs are not considered as active.

6.7 EXTERNAL SIGNALLING AND VISUAL INDICATIONS

Power-supply alarm external signalling

Type	By relay. One per power supply. Changeover contact. Contact rating 1 A/250 V_{AC}, see Figure 18 for V_{DC}
Closing/opening times including bounces	5/3 ms
State in normal operating conditions	Energized (N.O. and C contacts short-circuited)



NOTE: 2A is the maximum current

Figure 18 DC voltage/DC current

Auxiliary outputs

Number of relays	- 2 electromechanical relays per IPTU module. - 1 electromechanical relay per IATU / IBTU module. - 2 electromechanical relays per IRTU.02 module. - 4 electromechanical relays per IRTU.04 module. - 8 electromechanical relays per IRTU.08 module. Configurable for signalling of: command transmission, command output or alarm and, if be the case, unblocking
Type	- By electromechanical relay. Changeover contact. Contact rating 1 A/250 V_{AC}, see Figure 18 for V_{DC} (IPTU, IATU/IBTU and IRTU modules)
Closing/opening times including bounces	- 5/3 ms (IPTU, IATU/IBTU and IRTU modules)
State in normal operating conditions	- Relays programmed for signalling of command transmission, command output and unblocking: Non energized (N.C. an C contacts short-circuited). - Relays programmed for alarm signalling: Energized (N.O. and C contacts short-circuited)
Activation timing in case of alarm	Configurable from the Management System between 0 and 60 s
Alarm programmable conditions	- RTC synchronization failure (general). - Telemeasuring failure (general). - IEC 61850 link failure (general). - Main module failure (general). - Module failure in slot no. (general). - Power-supply failure (general).

- Manual blocking (analog and digital).
- Automatic test failure (analog and digital).
- Loss of synchronism (digital).
- Incorrect identification code (digital).
- Incorrect security identification (SIC) code (digital).
- BER alarm (digital).
- Remote Alarm Indication (digital IOCT type).
- Loss of signal (digital IOCT type).
- Reception blocking (analog).
- Reception error (analog).
- Low Signal/Noise ratio (analog).
- Signal loss (analog).
- Low guard-signal level/Excess guard-signal level (analog).
- General failure in IEC 61850 output command.
- Failure synchronization with system clock in IEPT module.
- Timeout IEC 61850 input command.
- MTD alarm (IP interface).
- CDV alarm (IP interface).
- CLR alarm (IP interface).
- IP link failure (IP interface).

Visual indications

Signalling

- Terminal powered by primary and/or secondary power supply.
- System operative.
- Software updating.
- Link correct in LAN interface.
- Link correct in CEI 61850 interface.
- Line interface module operative in channel 1 and/or channel 2.

	- Analog command input active and/or GOOSE message. - Analog command output active and/or GOOSE message. - Command transmission in channel 1 and/or channel 2. - Command reception in channel 1 and/or channel 2. - Terminal in loop in channel 1 and/or channel 2. - Test correct in channel 1 and/or channel 2.
Alarms	- Power-supply failure in primary and/or secondary power supply. - System non operative (terminal starting up, configuration error, module error or RTC error). - Receiver blocking (analog), module error, incorrect identification code or incorrect security code (digital), signal loss (analog) or synchronism loss (digital) in channel 1 and/or channel 2. - Low S/N ratio or guard signal out of range (analog) or BER alarm (digital) in channel 1 and/or channel 2. - Test not correct in channel 1 and/or channel 2. - Manual blocking or the receiver (analog and digital) or receiver blocking (analog) in channel 1 and/or channel 2.
Command transmission and reception counters	Monitored from the Management System. On demand, can be monitored from the front of the terminal by means of the optional LCD display
Input and output activation counters	Monitored from the Management System. On demand, can be monitored from the front of the terminal by means of the optional LCD display

Digital input and output activation counters (DSTU module)	Monitored from the Management System.
Analog input and output measurement counters (MCTU module)	Monitored from the Management System.

6.8 ELECTROMAGNETIC COMPATIBILITY

Standards	Complies with IEC 60834-1, IEC 61000-6-2, ANSI C37.90.1 and ANSI C37.90.2

6.9 OPERATING AND STORAGE CONDITIONS

Temperature and humidity	From –5 °C to +55 °C and relative humidity not greater than 95%, in accordance with IEC 721-3-3 class 3K5 (climatogram 3K5)	
Power supply[6]		
Nominal input voltage	ATPU.00 module:	48 V_{DC}
	ATPU.01 module:	from 110 V_{DC} to 250 V_{DC} and from 110 V_{AC} to 220 V_{AC}
	ATPU.03 module:	24 V_{DC}
	For direct current, protected against polarity inversion	
Operating range	ATPU.00 module:	from 36 to 72 V_{DC}.
	ATPU.01 module:	from 88 V_{DC} to 300 V_{DC} and from 88 V_{AC} to 265 V_{AC}.
	ATPU.03 module:	from 19 to 29 V_{DC}.

[6] Should it be necessary to have redundance of the power supply, the TPU-1 terminals can be equipped with two ATPU modules.

Power supply interruptions	Level 1 of IEC 60870-2-1
Protection against overvoltages	Electronic PTC
Maximum consumption at 48 V_{DC}	With 8 IPTU modules: 1.5 A
Storage conditions	In accordance with IEC 721-3-1, class 1K5

6.10 MECHANICAL CHARACTERISTICS

Dimensions	19” (482 mm) wide and 3 s.u. high (133 mm). Depth of 256 mm
Connections	By means of plug-in connectors at the rear of the terminal. A cabinet-mounting terminal block can be supplied on request, together with the necessary cables.

In disturbed environments it is recommended to use screened cables for the connections. For safety reasons the screen of the connection cables must be grounded, the connection to earth being made at just one end to avoid interference.

Minimum weight	7 kg
IP protection level	IP30 according to IEC 60529
Capacity	13 slots, of which 2 slots for the power-supply modules (primary and secondary) and 1 slot for the processing module are reserved

6.11 MANAGEMENT SYSTEM

Terminal management interfaces

10/100Base-TX LAN interface

Type of interface	IEEE 802.3 (CSMA/CD)
Connector	8-pin RJ-45 female
Type of cable	UTP-5
Transmission rate	10 or 100 Mbit/s

100Base-FX LAN interface (only for MWTU.01)

Type of interface	IEEE 802.3u (CSMA/CD)
Connector	MT-RJ
Type of cable	Multi-mode optical fiber
Wavelength	1300 nm (second window)
Transmission rate	100 Mbit/s

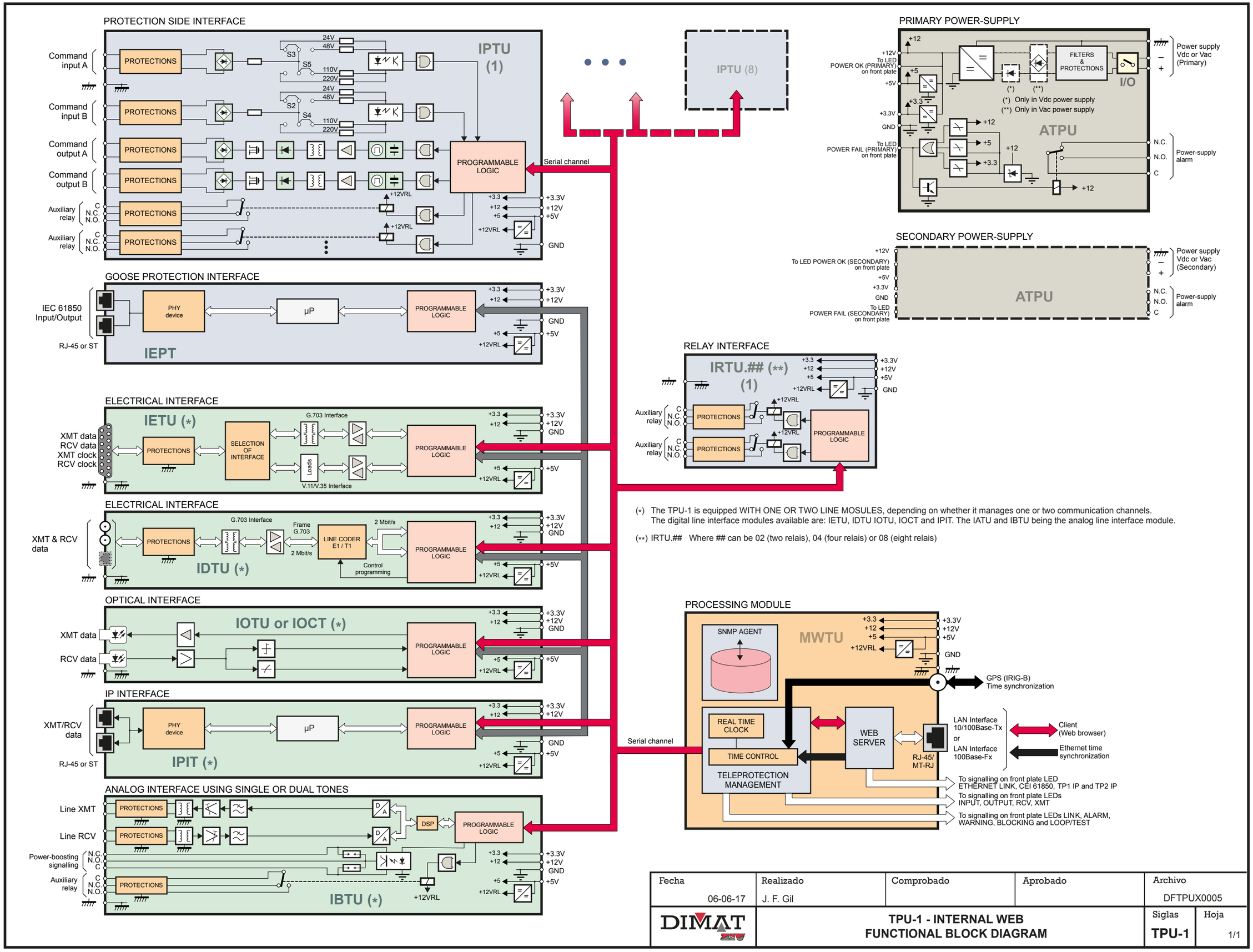
SNMP agent

SNMP protocol	v1, v2c and v3
Functions	• Transmission of both unconfirmed and confirmed notifications (traps and informs) of alarms and events of the terminal. The last type is only accepted for the v2c and v3 protocol versions. • Supervision of certain monitorable parameters of the terminal by means of a GET operation, these being: - Network parameters (IP, subnet mask and gateway). - Internal clock and time synchronization. - State of the transmitted and received command counters and of the input and output activation counters. - Alarm signal state. - Event monitoring.

- Signal/Noise ratio in the analog channel.

- Set to zero of the transmitted and received command counters and of the input and output activation counters by means of a SET operation.
- Modification of the network parameters (IP, subnet mask and gateway) by means of a SET operation.

Supervision by means of SNMP agent	Possible from an SNMP application. Upon request, an optional HP Openview integration kit can be supplied.
Management computer	
Type	Compatible personal computer (PC)
Model	Pentium III 550 MHz processor or higher
RAM memory	512 MBytes
Graphic adapter	1 Mbyte SVGA
Communication	LAN module with 10/100Base-TX or 100Base-FX interface
Operating system	Microsoft Windows XP Service Pack 2 version, Microsoft Windows 7 or Microsoft Windows 10
Web browser	Microsoft Internet Explorer v 6.0 or higher
JAVA virtual machine (Sun Microsystems)	Version 1.7 or higher



(*) The TPU-1 is equipped WITH ONE OR TWO LINE MOSULES, depending on whether it manages one or two communication channels. The digital line interface modules available are: IETU, IDTU IOTU, IOCT and IPIT. The IATU and IBTU being the analog line interface module.

(**) IRTU.## Where ## can be 02 (two relais), 04 (four relais) or 08 (eight relais)

Fecha	Realizado	Comprobado	Aprobado	Archivo
06-06-17	J. F. Gil			DFTPUX0005

DIMAT

TPU-1 - INTERNAL WEB FUNCTIONAL BLOCK DIAGRAM

Siglas: **TPU-1** | Hoja: 1/1