DIGITAL POWER-LINE CARRIER SYSTEM

TYPE OPD-1

GENERAL DESCRIPTION
Web External version

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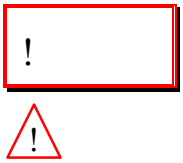
SAFETY SYMBOLS



WARNING OR CAUTION:

This symbol denotes a hazard. Do not follow the indicated procedure, operation or such like, it 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 such like.

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1 INTRODUCTION

1.1 GENERAL

The great development that has taken place in the telecommunication networks of the electrical sector has considerably increased the demand for speech and data communication channels. In the case of Power-Line Carrier (PLC) transmission over high-voltage lines the increase can only be produced by making a better use of the frequency spectrum available.

The important technological advances that have taken place, not only in the field of high-speed modems, but also in the speech compression techniques and data multiplexing makes it possible to increase the amount of information that can be transmitted in a determined bandwidth, and therefore obtain a better use of the frequency spectrum. In order to do this, it is necessary to use the most advanced digital techniques in the field of PLC systems.

Another factor that must be considered in digital PLC terminals is that they are not only capable of multiplexing speech and data channels but also of establishing channels at 64 kbit/s of basic access to digital networks, PLUS service channels of a lower speed, in order to be able to form an integral part of the digital communication systems in the electrical networks, mainly based on the use of fibre optics and digital radio links.

As it is a system directly related to high-voltage lines, it is also necessary for the digital PLC terminal to be able to be equipped with a teleprotection system.

1.2 DIGITAL PLC SYSTEM TYPE OPD-1

The digital Power-Line Carrier (PLC) system for high-voltage lines has been designed to comply with the requirements mentioned previously and is made up of a modem, capable of operating with the noise levels characteristic of high-voltage lines, and a frequency converter. The gross bit rate of the system is of 81 kbit/s, of which 79 kbit/s are available for the user, allowing various speech and data channels to be multiplexed, or alternatively, establish a channel of 64 kbit/s plus other additional channels, up to a total of 15 kbit/s for signalling, telecontrol, etc. An analogue teleprotection system type TPC, either internal or external, can be connected to the OPD-1 terminal.

The basic equipment includes two ports, one for the transmission of synchronous data, capable of working at a maximum speed of 72 kbit/s, and the other for the transmission of asynchronous data for a maximum speed of 14400 bit/s.

The multiplexing of the different services can be carried out by means of an internal or external multiplexer. By using the internal multiplexer it is possible to make the most of the net bit rate of 79 kbit/s. It must be pointed out that it is possible to use both multiplexers simultaneously, which not only allows the number of ports to be increased, but also carry out the insertion of channels, both locally and remotely.

The high-frequency transmission channel occupies a bandwidth of 16 kHz, in each direction, the channelling being compatible with the frequency plan of 4 kHz usually used. Thanks to the use of the built-in echo canceller, the transmission and reception bands can be superimposed, which means the total bandwidth occupied by the link is of 16 kHz. The high-frequency part of the OPD-1 terminals complies with Recommendation IEC 495 making it perfectly compatible with that of the existing analogue PLC systems including the corresponding coupling and line-matching units.

The OPD-1 system uses Trellis Coding Modulation (TCM) which gives a coding gain equivalent to an increase of 4 dB in signal-to-noise ratio present at the input of the receiver.

The transmission rate can be reduced to half or a third of the maximum value if necessary, that is to say, to 40.5 kbit/s and 27 kbit/s respectively, in order to be able to establish the communication when there is unfavourable line noise and signal reflection conditions. In some cases it may be advisable to work with non-adjacent transmission and reception bands, eliminating in this way the effects of the reflections, instead of reducing the transmission rate.

All the operative parameters of the OPD-1 system, such as the central transmission and reception frequencies, gross bit rate, transmit level, and the operation mode are all programmable via interface RS-232C from a standard web browser installed in a compatible personal computer (PC). The only manual adjustment required is that of the transmit and receive line filters, but is easy to carry out thanks to the instructions contained in a help menu of the OPD-1 Management System.

By means of the Management System, it is also possible to supervise from one end of the link, the parameters relative to either the local or remote terminal, to consult the chronological registers of alarms and events, as well as modify the programming of the two terminals. These operations are carried out by means of the internal service channel, the transmission speed being of 1 kbit/s, 500 bit/s and 333 bit/s for the transmission rate of 81 kbit/s 40.5 kbit/s and 27 kbit/s, respectively.

2 CONSTITUTION OF THE TERMINAL

The OPD-1 terminal consists of two shelves for mounting in a 19" rack. One shelf is 6 standard units (s.u.) high and the other is 3 s.u. high. The 6 s.u. shelf houses the base modules of the terminal, that is to say, those of the modem and those of the frequency converter, the optional modules, such as those of the internal multiplexer and of the teleprotection system, as well as a forced draught block. The 3 s.u. shelf contains the high-frequency hybrid, the transmit line filter, the output amplifier and the corresponding power supply.

The terminal can be supplied with a plug-in terminal block or with a terminal block prepared for mounting in a cabinet or wall cabinet.

2.1 BASE MODULES

ACPD.## ALARMS (Power supply and alarms)

This module includes the circuits for the generation and regulation of the internal voltages of +15 V_{DC}, −15 V_{DC}, +12 V_{DC} Aux and +5 V_{DC}. The module also contains the alarm indicators of the terminal itself as well as the collateral terminal, and four relays for the external signalling of the alarms.

Module type depends on the input voltage. The following types are available:

ACPD.48 Input voltage: 48 V_{DC}.

ACPD.24 Input voltage: 24 V_{DC}.

ACPD.10 Input voltage: 110 V_{DC}.

INTF.00 INTERFACE AND CONTROL

This module contains the internal-frame generation and synchronization circuits, the control and management of the multiplexer circuits, and the programming and supervision of the terminal circuits. It also contains the master oscillator for the generation of the carriers needed for frequency conversion. This module also includes the service-telephony circuits and two data ports, one for synchronous data, with interface V.35 or V.11 or G.703, and the other for asynchronous data, with interface V.24/V.28.

EMTR.## ENCODING AND MODULATION

This module carries out the 128-QAM, 16-QAM or 4-QAM modulation of the signal proceeding from module INTF, the Trellis coding and the digital-analogue conversion that gives place to a signal in the band of between 28 kHz and 44 kHz. On the front plate there is an output for the display of the signal space in transmission by means of an external oscilloscope.

It also contains the input circuits for the signals coming from the internal or external teleprotection system type TPC.

Depending on the activation voltage of the external input for boosting control there are the two following types:

EMTR.00 Encoding and modulation for OPD-1 terminal of 48 V_{DC} and 110 V_{DC} (30V to 190V).

EMTR.24 Encoding and modulation for OPD-1 terminal of 24 V_{DC} (15V to 100V).

SYTM.01 HF XMT

In this module a double modulation process is carried out in order to transpose the signals supplied by module EMTR to the desired channel frequency.

PYSD.01 HF RCV

This module comprises the receive-line filter and the first and second-demodulation circuits.

RCDE.00 ECHO CANCELLER

It contains the Automatic Gain Control (AGC) circuits, the band-pass filter that gives the receiver the required selectivity, and the echo canceller which allows the transmission in superimposed bands to be carried out. It also contains the output circuits of the teleprotection signals going towards the TPC system, either internal or external.

RDDT.00 DEMODULATION AND DECODING

Demodulates and decodes the signals proceeding from module RCDE. The module also contains an adaptive equalizer which minimizes the intersymbol interference. On the front plate there is an output for the display of the signal space in reception by means of an external oscilloscope.

2.2 POWER MODULES

FACA.## POWER SUPPLY

This module adapts the input voltage to the power-supply voltage necessary for the output-amplifier module.

Module type depends on the input voltage. The following types are available:

FACA.48 Input voltage: 48 V_{DC}.

FACA.24 Input voltage: 24 V_{DC}.

FACA.10 Input voltage: 110 V_{DC}.

ALPD.01 OUTPUT AMPLIFIER

Block which contains the output amplifier and the alarm circuits for overload of the same amplifier or for low transmitted-signal level.

JFLH.40 LINE FILTER AND HF HYBRID

This is a block which contains the transmit-line filter and the high-frequency hybrid.

2.3 MODULES OF THE INTERNAL MULTIPLEXER

In the base configuration the OPD-1 terminal includes two data ports, housed in the INTF module. By incorporating an optional multiplexer, the number of ports can be increased to a maximum of eleven. This optional multiplexer is made up of up to three MMXA modules, each of which can have three data or speech ports. The characteristics of a port depend on the type of submodule used, which could be one of the following:

KDMX Data submodule.

Supports a communication channel for synchronous, asynchronous or anisochronous data. It is equipped with an interface that complies with Recommendation V.24/V.28 of the ITU-T (RS-232C).

Table 1 indicates the data speed allowed for each type of channel according to the gross bit rate of the system.

	Gross bit rate		
	81 kbit/s	**40.5 kbit/s**	**27 kbit/s**
Synchronous port	Between 600 bit/s and 38400 bit/s	Between 600 bit/s and 38400 bit/s	Between 600 bit/s and 19200 bit/s
Asynchronous port	Between 50 bit/s and 28800 bit/s	Between 50 bit/s and 28800 bit/s	Between 50 bit/s and 19200 bit/s
Anisochronous port	Up to 1440 bit/s	Up to 1440 bit/s	Up to 1440 bit/s

Table 1 Port data speed

KVMX Speech submodule at 16 kbit/s.

For 4-wire or 2-wire exchange-side telephone termination with ADPCM speech encoder at 16 kbit/s.

Depending on the activation voltage of the external input for the 2W/4W operating-mode switch command and M-wire signalling (transmission) there are the two following types:

KVMX.00 Speech submodule at 16 kbit/s for OPD-1 terminal of 48 V_{DC} and 110 V_{DC} (30V to 190V).

KVMX.24 Speech submodule at 16 kbit/s for OPD-1 terminal of 24 V_{DC} (15V to 100V).

KAVX Speech submodule at 4800 bit/s, 6400 bit/s or 8000 bit/s.

Submodule for either 4-wire or 2-wire, 2-wire exchange-side telephone termination, and 2-wire subscriber-side telephone termination with speech encoder at 4800 bit/s, 6400 bit/s or 8000 bit/s based on MP-MLQ multipulse encoding. This termination also allows the transmission of Group 3 fax signals up to 7200 bit/s in accordance with Recommendations V.21, V.27ter and V.29 of the ITU-T, as well as modem signals at 2400 bit/s and 1200 bit/s in accordance with Recommendation V.22bis.

Depending on the activation voltage of the external input for the 2W/4W operating-mode switch command and M-wire signalling (transmission) there are the two following types:

KAVX.00 Speech submodule at 4800 bit/s, 6400 bit/s or 8000 bit/s for OPD-1 terminal of 48 V_{DC} and 110 V_{DC} (30V to 190V).

KAVX.24 Speech submodule at 4800 bit/s, 6400 bit/s or 8000 bit/s for OPD-1 terminal of 24 V_{DC} (15V to 100V).

The transmission speeds of the signals depend on the speed programmed in the OPD-1 service frame. Table 2 shows this speed as a function of the speed programmed in the OPD-1 frame.

Transmission speed	**bit/s**	**bit/s**	**bit/s**
OPD-1 frame	4800	6400	8000
Voice	4700	6300	6300
Fax (max.)	2400	4800	7200
Modem data (max.)	2400	2400	2400

Table 2 Transmission speeds

2.4 ANALOGUE TELEPROTECTION UNIT

As an option, the 6 s.u. shelf of the OPD-1 terminal can incorporate an analogue teleprotection unit, based on the use of digital signal processing. There are two different teleprotection units.

TPC-1 teleprotection unit

The analogue teleprotection unit type TPC-1 is able to transmit and receive up to three commands independently or in any combination.

The unit can be constituted by either one or two different modules according to user requirements. For the transmission of one command, the unit should be equipped with the TPMB.00 module only. If it is necessary to transmit two or three commands, either simultaneously or not, the unit should be equipped with two modules, the TPMB.00 and the TPCB.01.

TPMB.00 It is the base module of the TPC-1 system. This module contains the digital central processing unit (DSP), which carries out the generation of the guard and command tones and the implementation of the filters for the reception of signals. An auxiliary microcontroller makes decisions in command reception, takes charge of the logical management of inputs and outputs, supervises the link and carries out the automatic and manual test. The module also contains the input and output circuits for the transmission and reception of one command.

TPCB.01 This module contains the input and output circuits for the transmission and reception of two additional commands.

TPC-2 teleprotection unit

The analogue teleprotection unit type TPC-2 is able to transmit and receive up to four commands.

The unit can be made up of either one or two different modules according to user requirements. For the transmission of one or two commands, the unit should be equipped with the TPMA.02 module only. Should it be necessary to transmit from three to four commands the terminal should be equipped with two modules, the TPMA.02 and the TPCC.02.

TPMA.02 It is the base module of the TPC-2 system. This module contains the digital central processing unit (DSP), which carries out the generation of the guard and command tones and the implementation of the filters for the reception of signals. An auxiliary microcontroller makes decisions in command reception, takes charge of the logical management of inputs and outputs, supervises the link and carries out the automatic and manual test. The module also contains the input and output circuits for the transmission and reception of two commands.

TPCC.02 This module contains the input and output circuits for the transmission and reception of two additional commands.

2.5 OTHERS

MBTV.00 Forced draught block.

TPSU.00 6 s.u. extension card (supplied as accessory).

3 STRUCTURE OF THE INTERNAL FRAME

The information proceeding from the different multiplexer ports group together in frames of 81 bits, as shown in Figure 1. The first bit of each frame (S) is used for the frame synchronism and the second (C) for the internal service channel.

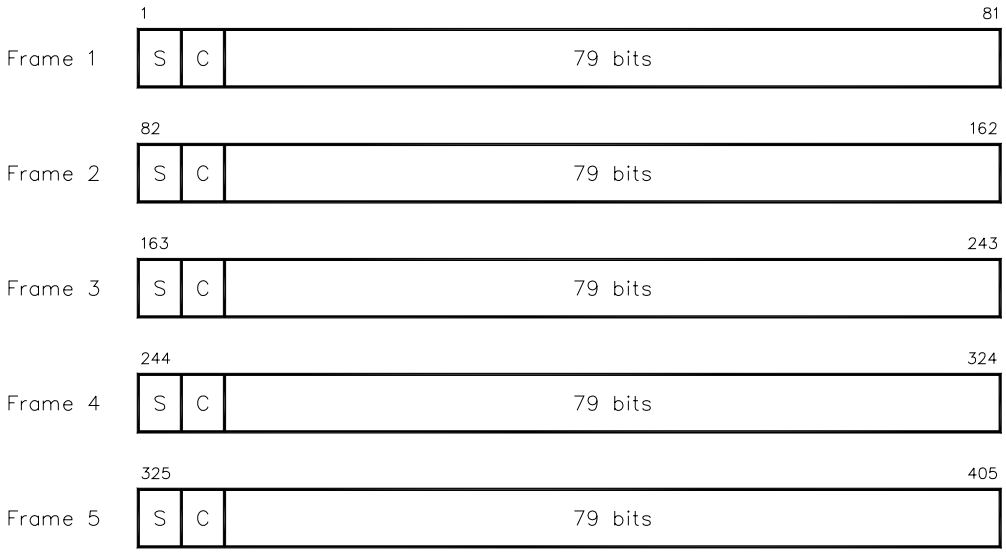


Figure 1 Structure of the internal frame

The frames then group together in fives to form the multiframes, which make up the basic messages of the transmission. In each two multiframes the synchronism bits make up the synchronism sequence.

When the transmission is carried out at the rate of 81 kbit/s, each frame transmits in a millisecond and each multiframe in five milliseconds. Therefore, the synchronism and service channel information transmit at a speed of 1 kbit/s and the system net bit rate is of 79 kbit/s. The minimum speed that can be assigned to a data channel, that is to say, the resolution of the system is of 200 bit/s which corresponds to the use of one bit per multiframe.

At the transmission rates of 40.5 kbit/s and 27 kbit/s the structure of the multiframe is not altered, but the transmission time does vary. In the case of 40.5 kbit/s, the transmission time becomes 10 ms, the speed of the synchronism and service channels is reduced to 500 bit/s, the minimum speed to 100 bit/s and the net bit rate to 39.5 kbit/s. At the transmission rate of 27 kbit/s, these values are 15 ms, 333 bit/s, 66 bit/s and 26.33 kbit/s, respectively.

The service telephony occupies the last sixteen bits of each frame. If these bits are used to transmit speech or data channels, every time service telephony is used the channels should be blocked. During terminal programming it can be decided which channels occupy these bits, that is, the channels that block when service telephony is used.

The distribution of the information in the frame is managed by the INTF module.

4 OPERATIONAL DESCRIPTION

The OPD-1 basically consists of a user interface (module INTF), a high-speed modem (modules EMTR, RCDE and RDDT), a frequency converter (modules SYTM and PYSD) and a power stage. Likewise, it also has a power supply and alarm module (ACPD) which generates, from the input voltage, the internal power-supply voltages and carries out the external signalling of the alarms, in both the local and remote terminal.

To the base equipment up to three multiplexer optional MMXA modules and an analogue teleprotection unit type TPC can be added.

A simplified block diagram of the OPD-1 terminal is shown in Figure 2. The following sections describe the main elements of the OPD-1 terminal.

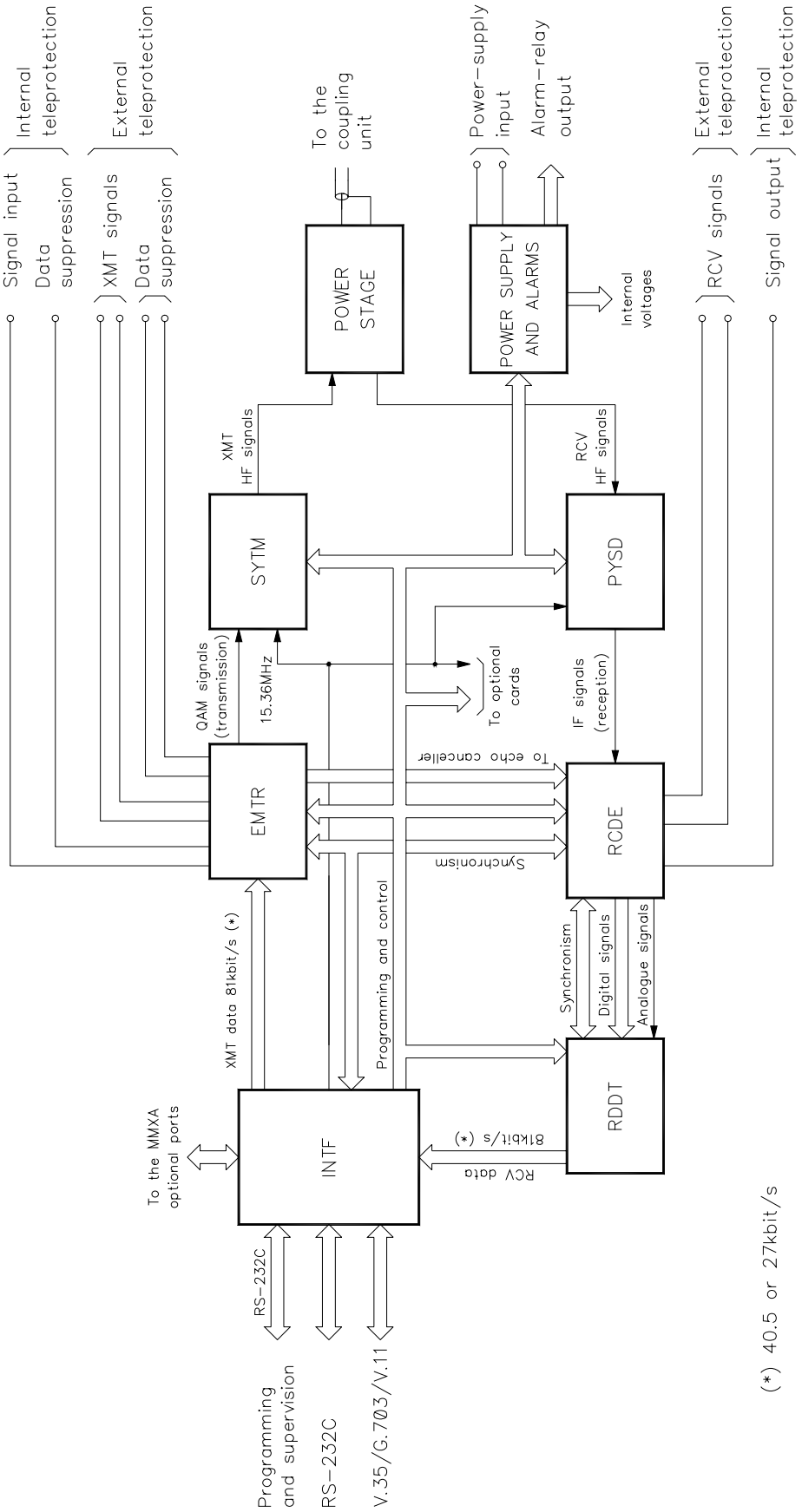


Figure 2 OPD-1 simplified block diagram

4.1 USER INTERFACE

The user interface, INTF module, includes two ports, one for the transmission of synchronous data up to 72 kbit/s, with interface according to Recommendation V.35 or V.11 of the ITU-T or G.703 codirectional or contradirectional, and the other for asynchronous data up to 14400 bit/s, with interface according to V.24/V.28 of the ITU-T. The selection of the type of interface of the synchronous data port is carried out from the programming terminal. In the case of the V.35 and V.11 interfaces it is also necessary to carry out a setting in the module.

The synchronous data port is capable of accepting an external clock signal so that the internal frame can be generated by means of either the internal or external clock.

The INTF module also includes the circuits for the functions described below:

Programming and supervision of the terminal

It comprises the RS-232C interface, with a transmission speed of 600 bit/s to 9600 bit/s, the microprocessor, the real time clock and the memories for the configuration parameter and chronological register data storage.

Frame generation and recovery

This block generates the transmission frame from the data proceeding from the interface circuits, to which the synchronism and the internal service channel bits are added. Furthermore, it recovers frame synchronism from the received data, decodes the data and delivers it to the output circuits.

Service telephony

The INTF module has the necessary elements in order to establish a service communication coded at 16 kbit/s. As the speech and data channels can use all the system capacity, occasionally it may be necessary to block some of the channels when the service telephony is in use.

Frequency synthesizer

It generates the carriers that are necessary for the frequency conversion by means of a highly stable quartz oscillator and the corresponding frequency-division circuits.

Internal process clocks

This block generates the transmit and receive process clocks.

The OPD-1 system works with only one clock, which depending on the programming of port 1, can be either internal or external.

The programming of the terminal configuration automatically determines a *Master-Slave* operating mode for the recovery of synchronisms. The *Master* terminal can generate the transmit synchronisms from the internal oscillator or from an external data source connected to port 1. The *Slave* terminal always uses the clock recovered from the data received from the line to generate the transmit synchronisms.

The receive synchronisms are always generated from the clock recovered from the received data.

Control and management of the multiplexer

This block distributes the different input channels, according to their rates, in the frame and carries out the supervision of the different multiplexer ports.

4.2 HIGH-SPEED MODEM

It comprises the EMTR module, transmit side, and RCDE and RDDT modules, receive side.

Transmit side

The data stream proceeding from the user interface is encoded and then modulated at 128-QAM, 16-QAM or 4-QAM according to whether the gross bit rate is of 81 kbit/s, 40.5 kbit/s or 27 kbit/s, respectively. The data is subjected to the following processes: scrambling, serial-to-parallel conversion, differential encoding, convolutional encoding (Trellis encoding), symbol mapping, pulse-shaping filtering and QAM modulation.

Digital signals obtained in this way are then converted into an analogue signal which occupies a band comprised between 28 kHz and 44 kHz. This signal is then sent to the frequency converter.

The EMTR module has an output for displaying the signal-space point constellation by means of an oscilloscope. This module also contains the input circuits of the teleprotection signal proceeding from an external or internal TPC system.

In rest condition the guard tone of the teleprotection is transmitted together with the QAM signal generated by the EMTR module. When a command has to be sent the guard tone is substituted for a command tone and, through the boosting signal, the EMTR module interrupts the transmission of the QAM signal for a period of time not higher than 500 ms.

Receive side

The analogue signal proceeding from the frequency converter enters the RCDE module where, once subjected to an AGC process, it is converted into a digital signal and passes through a band-pass filter which gives the receiver the selectivity characteristics desired.

In the superimposed-band operation mode, the filtered signal is applied to an echo-canceller device where the transmit signal that superimposes the received signal is cancelled, by means of a signal coming from the transmitter and adequately processed. The obtained signal is sent to the RDDT module where it is demodulated and decoded in order to be sent to the user interface.

In the superimposed-band operation mode, when an echo canceller is not used, the digital filtered signal is sent directly to the RDDT module. As for the transmit side, it is possible to display the signal-space point constellation by means of an oscilloscope. The RDDT module also includes an adaptive equalizer which minimizes the intersymbol interference.

The teleprotection signal is extracted from the digital filtered signal, in the RCDE module, before echo cancellation. When the disappearance of the guard tone is detected the QAM signal generated by the EMTR module blocks, for a period of time not higher than 500 ms, to allow command signal detection.

4.3 MULTIPLEXER

The multiplexer is an optional unit of the OPD-1 terminal which is made up of up to three optional modules, called MMXA, each one of which can be equipped with three speech and data ports. These ports, together with the two data ports of the base equipment can share the system net bit rate of 79 kbit/s, 39.5 kbit/s or 26.3 kbit/s.

Any multiplexer input combination is possible, as long as the total rate of all the channels does not exceed the net bit rates mentioned. The programming and configuration of each one of the services are carried out by means of the programming system of the OPD-1 terminal.

4.4 FREQUENCY CONVERTER AND POWER STAGE

A simplified block diagram of the frequency converter of the OPD-1 terminal is shown in Figure 3.

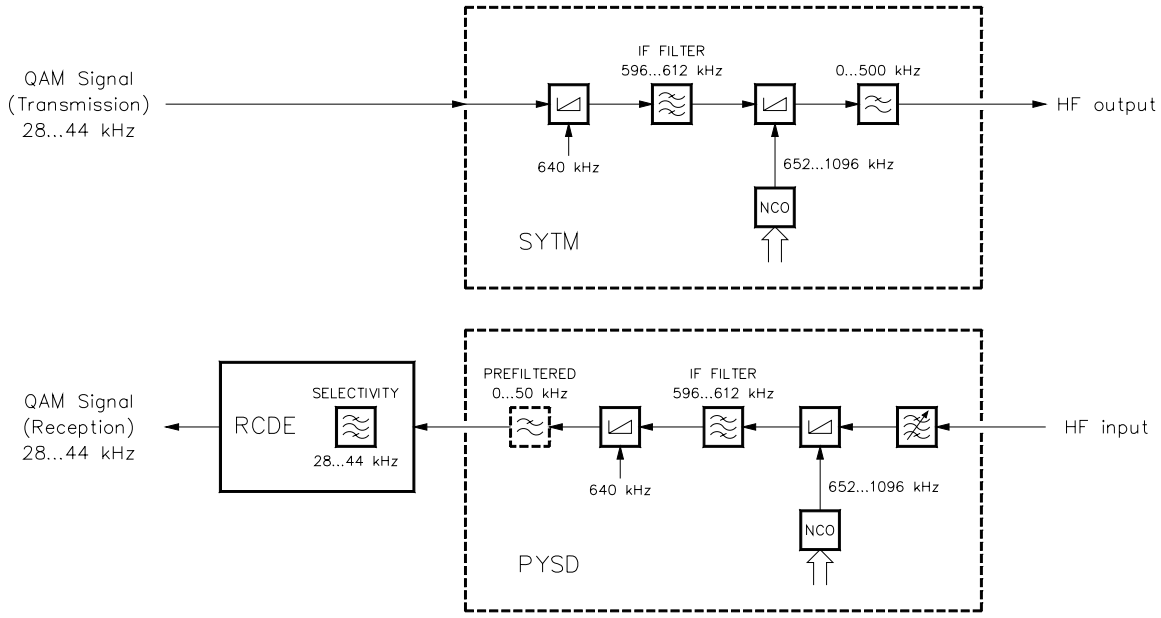


Figure 3 Simplified block diagram of the frequency converter

The signals proceeding from the EMTR module are transposed to the desired frequency band by means of a double modulation. The first-modulation carrier frequency is fixed, whilst the second-modulation carrier frequency is programmable, in 1 Hz steps, and is generated by means of the Direct Digital Synthesis technique (DDS).

The HF signal so obtained is sent to the power circuits where it is amplified in the ALPD module and is sent to the line through module JFLH which contains the transmit line filter and HF hybrid.

The line filter, with a bandwidth of 16 kHz, is adjustable in the range of frequencies comprised between 40 kHz and 500 kHz.

The transmission and reception bands can be superimposed or non-adjacent The high-frequency hybrid is disconnected from the line when the transmit and receive bands are non-adjacent.

The signals proceeding from the line are sent directly to the receive filter in the module PYSD or by means of the high-frequency hybrid in the case of superimposed bands, and are then subjected to a double demodulation process before being sent to the RCDE module.

The first-demodulation carrier frequency is programmable and is generated in the same way as indicated for transmission, that is, by means of the Direct Digital Synthesis technique. The second-demodulation carrier frequency is fixed.

The receive-line filter, the bandwidth of which is 16 kHz, is adjustable in the range of frequencies comprised between 40 kHz and 500 kHz.

Transmission modulation plan

The transmission modulation plan is shown in Figure 4. The first modulation is carried out at a frequency of 640 kHz and the modulation products, after band-pass filtering, are in the intermediate-frequency (IF) band that extends from 596 kHz to 612 kHz.

The second modulation, which transposes the IF band to the desired frequency of between 40 kHz to 500 kHz, is carried out at a programmable frequency, of between 652 kHz and 1096 kHz. The band of undesired frequencies is eliminated by a low-pass filter with a 500 kHz cut-off frequency.

Reception modulation plan

The reception modulation plan is shown in Figure 5. The HF signal is demodulated by means of a selectable frequency of between 652 kHz to 1096 kHz. After 596 kHz to 612 kHz band-pass filtering, the first-demodulation intermediate-frequency (IF) band is achieved.

Then, a second demodulation at a frequency of 640 kHz is carried out. The band of undesired frequencies is eliminated by a low-pass filter with a 50 kHz cut-off frequency. After selective band-pass filtering, carried out in the RCDE module, the QAM signal is recovered in the band of frequencies comprised between 28 kHz and 44 kHz.

4.5 INTERNAL SERVICE CHANNEL

In the OPD-1 links it is possible to establish an internal service channel that permits the following operations to be carried out:

- Transmission of alarms, service-telephony signalling, and internal control messages.
- Supervision of the remote terminal, that is to say, inspection of the alarms, the chronological register, the level of the received signal, etc.
- Modification of the remote terminal programming.

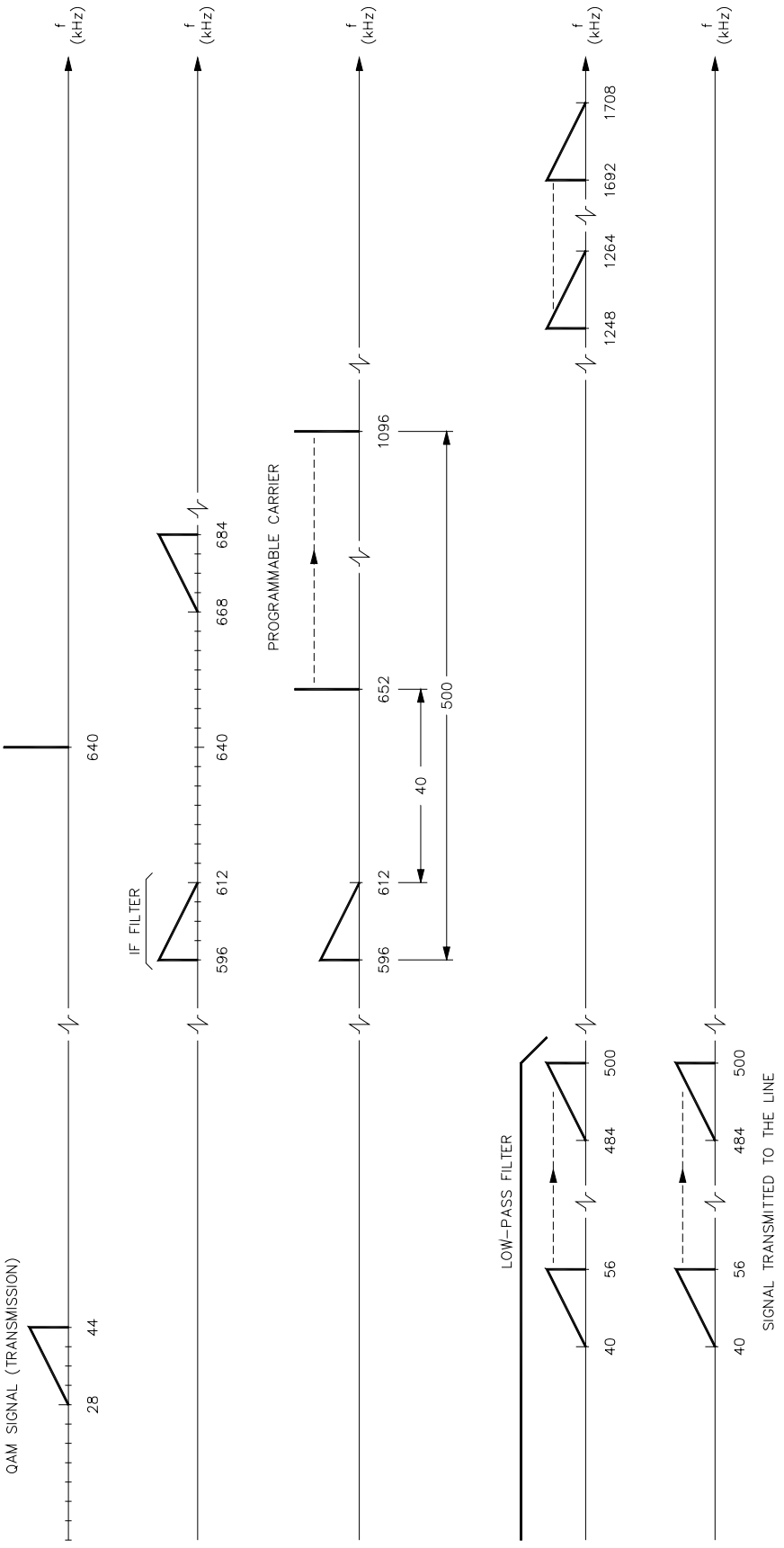


Figure 4 Transmission modulation plan

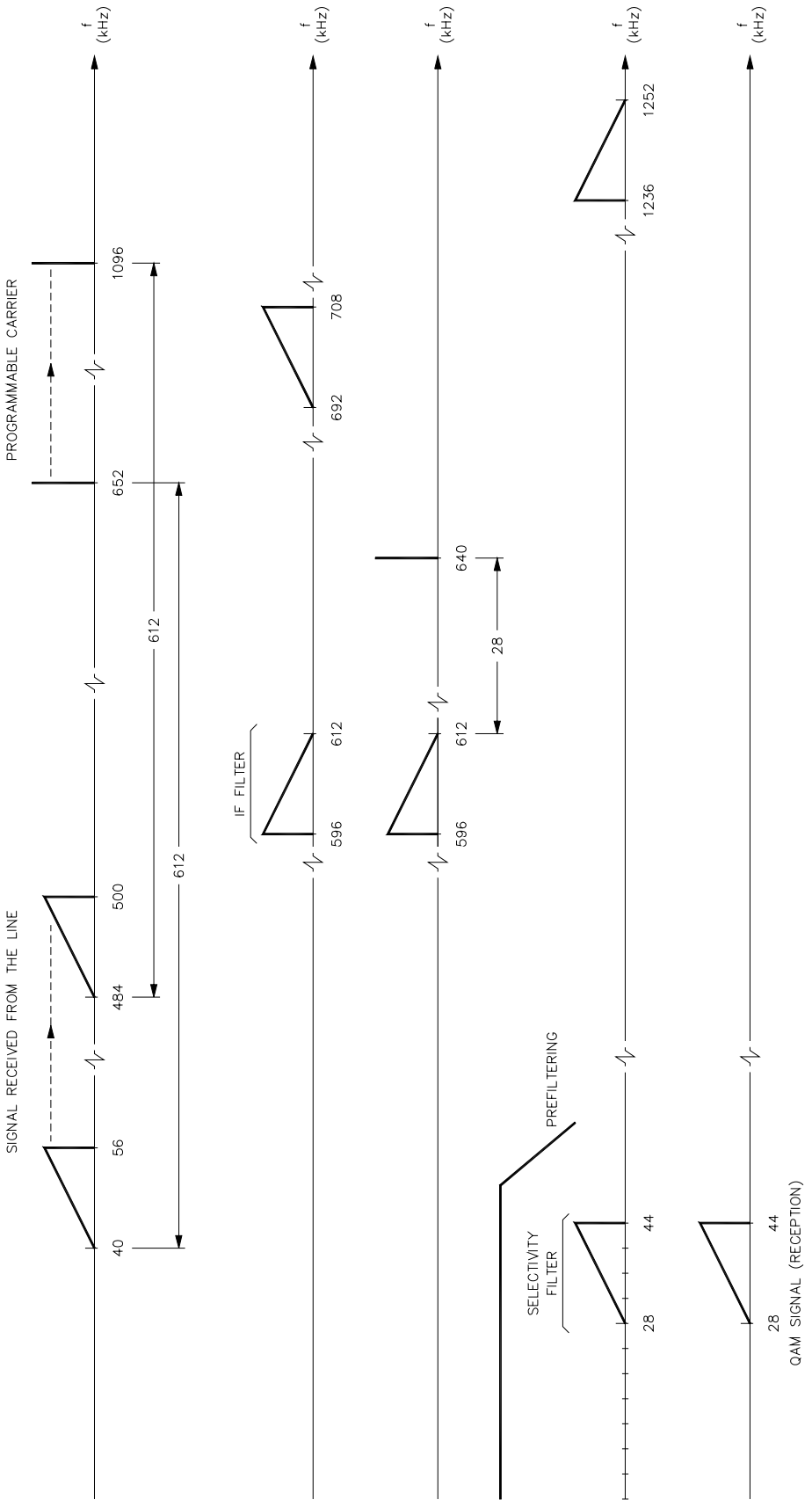


Figure 5 Reception modulation plan

5 MANAGEMENT SYSTEM

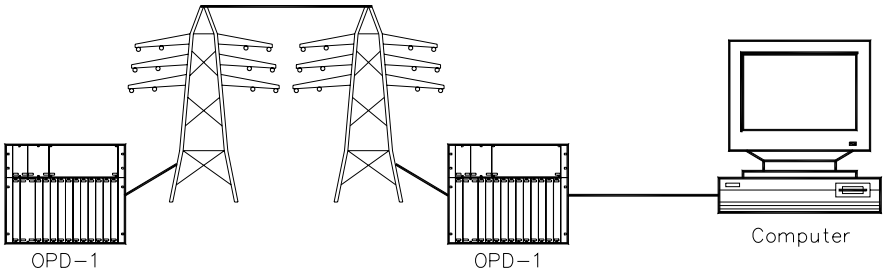
The OPD-1 terminals of a link are managed from a web browser installed in a PC connected to one of the terminals via interface RS-232C.

In order for the web browser to configure and supervise any of the parameters of the OPD-1 terminals of a link it is only necessary to install, in the same management PC, the web server containing all the web pages necessary for the management of the system. The web server is installed in the management PC by means of the CD-ROM supplied with every OPD-1 terminal. The CD-ROM also contains an off-line version of the web server for use in those cases where connection with the terminal is not possible. It allows the configuration of the terminal to be carried out in the computer, save it as a file and load it in the terminal when connection is possible.

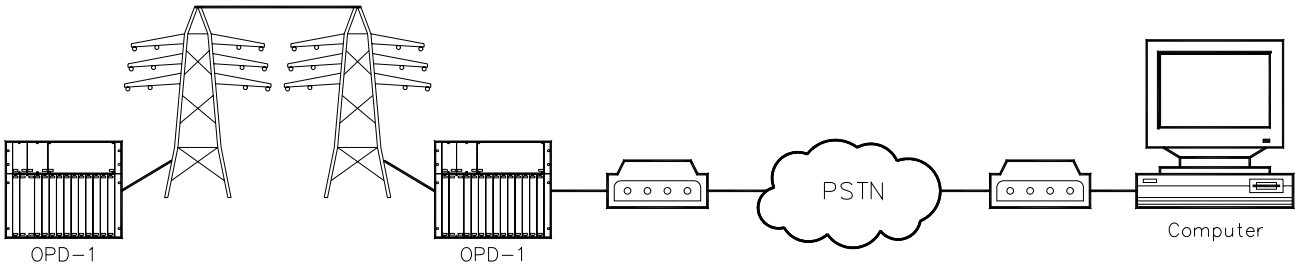
In order to access the OPD-1 terminal and the web server from the browser a user password is required. There are two different user passwords defined for two different user profiles: one as a basic user, that can only display parameters, and the other as an administrator user, that as well as displaying parameters can also program the OPD-1 terminal.

The service interface of the OPD-1 terminals allows the connection with the management computer, via RS-232C, to be carried out directly or at a distance via modem as shown in Figure 6a) and Figure 6b).

When the web server is accessed from the browser, a home page is displayed showing five main menus. The first menu, *Files*, controls the flow of information entering and leaving the Management System. The second, *Programming*, 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 third menu, *Monitoring*, allows supervision of the system to be carried out, whilst the fourth, *Alignment help*, contains guidelines on alignment and maintenance. Finally, the fifth menu, *About...*, gives information on the Management System.



a) Direct connection



b) Connection via modem

Figure 6 Possible connections between an OPD-1 terminal and a PC

5.1 PROGRAMMING MENU

From this menu the identification and configuration of the two OPD-1 terminals of a link are established, and their operative parameters as well as the optional modules they incorporate are programmed.

The programming menu also allows alarms to be assigned to the external signalling relays of the ACPD module.

The options of the menu dedicated to the said functions are the following:

Terminal configuration

This option displays the identification number assigned to the terminal in the factory, which coincides with its serial number. It also shows an additional field where the user can introduce a text of up to 49 characters which caracterize the terminal.

The serial number is essential in order to be able to identify each terminal during supervision and programming, as well as being able to assign the corresponding programming to a terminal when it has been stored on a file.

This option also allows whether the terminal should operate as master or slave to be established, if the terminal incorporates a teleprotection unit, internal or external, and the gross bit rate used. It is also possible to configure the type of each one of the optional internal multiplexer ports.

When there is no teleprotection, this option allows a permanent test tone (pseudopilot) to be generated at 20% modulation (QAM at 80%) and at a frequency of 28150 Hz, if it is a master terminal, or 43850 Hz, if it is slave.

Bands and frequencies

The central-frequency values for transmission and reception are introduced from this option, and whether the transmission and reception bands are superimposed or non-adjacent. It must be taken into account that when programming superimposed bands the echo canceller is activated at the same time.

In the case of superimposed bands, the frequency values in transmission and reception must be the same. If the bands are non-adjacent the said frequency values must be separated by at least 32 kHz.

Multiplexer

Allows the operative parameters of the data ports of the INTF module to be programmed, as well as those of the data and speech ports of the optional MMXA modules that have already been configured. It also makes it possible to de-activate the service associated to a port, activating it again when necessary.

Internal teleprotection

When the terminal is equipped with an internal teleprotection unit, the programming menu allows the operative parameters which are characteristic of the teleprotection option to be programmed.

External teleprotection levels

When the terminal is equipped with an external teleprotection unit, the programming menu allows the nominal level of the teleprotection input and output signals to be programmed.

Alarm conditions

All the alarms of a terminal, as well as those of the collateral terminal are displayed on the front plate of the power supply and alarms module (ACPD). This module has four relays,

three with a simple contact and one with a double contact. From this option, an alarm or a combination of alarms for their external signalling can be assigned to each of these relays.

5.2 MONITORING MENU

The monitoring menu allows the state of the two OPD-1 terminals of a link to be checked.

The information given by the monitoring system about each terminal is the following: the level of the received signal, the signal-to-noise ratio of the channel, the quality of the received signal, established with regard to the bit error rate of the channel, the state of module INTF ports as well as those of the optional MMXA modules of the built-in multiplexer, the state of the alarms of the terminal, and the alarm and events chronological lists. When the terminal is equipped with an internal teleprotection unit, the monitoring system also permits the state of the teleprotection to be checked and the corresponding events and alarms to be displayed.

The OPD-1 system registers in chronological order the appearance and disappearance of the alarms of the terminal as well as the events related to the link service, such as the command transmission, the starting up of the terminal, etc. For each alarm or event there is a brief description, together with the date, with the day, month and year, and the hour, minute and seconds, on which they occurred.

The messages relating to the alarms and events can be displayed, independently or jointly, from the Management System or from a text file, printable from any text editor or spreadsheet.

The register has a maximum capacity of 200 alarms and events; which means that when this limit is reached the first events or alarms introduced are eliminated.

5.3 ALIGNMENT HELP MENU

This menu allows adjustment operations to be carried out that make commissioning of the local terminal easier. It also contains test and measurement facilities that allow maintenance tasks to be carried out in both terminals of the link.

When the terminal is equipped with an internal teleprotection unit, this menu also allows the transmitted and received command counters to be reset, delete the chronological register of the teleprotection, initialize the teleprotection system, and carry out tests as well as send teleprotection commands to the terminal at the other end of the link.

The facilities of the alignment help and maintenance menu that allow the functions associated to the OPD-1 terminals to be carried out are the following:

Level adjustment

This option allows the transmit level to be regulated, once the line filter has been adjusted, in order to guarantee that the output power is the one desired.

On the other hand, it also allows a test signal or tone to be generated, and block the modem and the teleprotection unit incorporated in the terminal. The remote programming of these actions is timed in such a way that, once an action is programmed, it is de-activated by the remote terminal after a prefixed time.

Initializations

This option allows the terminal to be reset without having to use the push-button on the front plate, force the starting up of the training sequence, initialize the chronological register and carry out certain actions related to the Automatic Gain Control (AGC) circuit.

Setting the clock

This option shows the date and time of the real-time clock of the terminal, allowing the values of both parameters to be modified.

Switch configuration

The Management System contains tables with the configuration of the terminal switches, according to whether the bands are superimposed or non-adjacent. It also shows the settings of the optional modules of the terminal.

Transmit-filter adjustment

This option, only available for the local terminal, contains the pages necessary to carry out the transmit line filter adjustment, allowing its resonance circuits to be adjusted and, later, the checking of the whole filter.

Receive-filter adjustment

This option, only available for the local terminal, contains the pages necessary to carry out the receive line filter adjustment, allowing its inductances to be adjusted and, later, the checking of the whole filter.

Generation of HF-signal pulses

This option, only available for the local terminal, allows the quality of the high-voltage line with respect to impedance mismatching to be known, by means of the generation of high-frequency signal pulses.

High-frequency loop

This option, only available for the local terminal, allows a loop to be carried out at high frequency.

Loops

This option allows a data loop to be carried out in the ports.

6 TECHNICAL CHARACTERISTICS

6.1 HIGH-FREQUENCY CHARACTERISTICS

Frequency range	40 kHz to 500 kHz
Transmission and reception bands	Superimposed or non-adjacent
Bandwidth	Superimposed bands: 16 kHz Non-adjacent bands: 16 kHz in each direction (with a minimum band-spacing of 16 kHz)
Line connection	Selectable between balanced and non-balanced
Nominal impedance	Selectable between 50, 75, 125 and 140 Ω
Return loss	Better than 11 dB
Balance to ground	Better than 40 dB at power frequency
Tapping loss	In accordance with IEC 495, Fig. A.1 with n=4
Insulation	2 kV_{rms}/50 Hz/1 min
Impulse-voltage withstanding	5 kV for common mode. 5 kV for differential mode
High-frequency disturbance	1 kV for differential mode
Fast Transient	2 kV, in accordance with IEC 801-4 level III

Transmitter

Maximum power of the QAM signal over resistive load	+40 dBm, corresponding to a Peak Envelope Power of 80 W (+49 dBm)
Nominal power	+37 dBm
Central frequency of the transmit line filter	Programmable in 2 kHz steps

Receiver

Central frequency of the receive line filter	Programmable in 2 kHz steps
Maximum value of input power in non-adjacent bands	+37 dBm in the 16 kHz band
Sensitivity	-10 dBm (received power of QAM signal)
Selectivity	In accordance with IEC 495 cls. 5.3.1.5
Automatic Gain Control (AGC) range	50 dB
Minimum S/N ratio, with white gaussian noise (AWGN) at receiver input and for an error probability better than 10^{-8}	25 dB at 81 kbit/s. 18 dB at 40.5 kbit/s. 14 dB at 27 kbit/s

6.2 GENERAL CHARACTERISTICS OF THE MODEM

Gross bit rate	81 kbit/s, 40.5 kbit/s or 27 kbit/s
Modulation	128 QAM with Trellis coding, 16 QAM with Trellis coding or 4 QAM for the rates of 81 kbit/s, 40.5 kbit/s and 27 kbit/s, respectively
Net bit rate	79 kbit/s, 39.5 kbit/s or 26.3 kbit/s

6.3 FREQUENCY CONVERTER

Modulation	Single sideband
Operating frequency	Programmable in 1 Hz steps

6.4 USER INTERFACE

Basic equipment	One synchronous data port to be chosen between: - Interface in accordance with Rec. V.35 of the ITU-T of 1200, 2400, 3600, 4800, 6400, 7200, 8000, 9600, 14400, 16000, 19200, 28800, 32000, 38400, 64000 and 72000 bit/s. - Interface in accordance with Rec. V.11 of the ITU-T of 1200, 2400, 3600, 4800, 6400, 7200, 8000, 9600, 14400, 16000, 19200, 28800, 32000, 38400, 64000 and 72000 bit/s. - Interface G.703, codirectional or contradirectional, of the ITU-T of 64 kbit/s. One asynchronous data port of 50, 100, 200, 600, 1200, 2400, 3600, 4800, 7200, 9600 and 14400 bit/s with interface in accordance with Rec. V.24/V.28 of the ITU-T (EIA RS-232C)
Built-in multiplexer (optional)	Up to nine additional ports, either speech or data, distributed in three modules (up to three ports per module)
Speech ports	16 kbit/s (ADPCM). 4800 bit/s, 6400 bit/s or 8000 bit/s; group 3 fax signals up to 7200 bit/s in accordance with Recommendations V.21, V.27ter and V.29 of the ITU-T; modem signals at 2400 and 1200 bit/s in accordance with Recommendation V.22bis of the ITU-T (MP-MLQ)
Connection	2-wire and 4-wire with E and M signalling or DTMF

Data ports	Synchronous, of 600, 1200, 2400, 3600, 4800, 6400, 7200, 8000, 9600, 14400, 16000, 19200, 28800, 32000 and 38400 bit/s. (Up to 19200 bit/s at the 27 kbit/s gross bit rate). Asynchronous, of 50, 100, 200, 600, 1200, 2400, 3600, 4800, 7200, 9600, 14400, 19200 and 28800 bit/s. (Up to 19200 bit/s at the 27 kbit/s gross bit rate). Anisochronous, of 60, 120, 240, 360, 480, 640, 720, 800, 960 and 1440 bit/s
Interface	V.24/V.28 of the ITU-T (EIA RS-232C)
Asynchronous data format	1 Start bit. 6 to 9 data bits. 1 or 2 Stop bits

6.5 OTHER CHARACTERISTICS

Data transmission delay	15 ms at 81 kbit/s. 20 ms at 40.5 kbit/s. 25 ms at 27 kbit/s
Service telephony	With ADPCM coding at 16 kbit/s. Only some of the user services may be affected when the service telephony is in use
Alarms and signalling	
Alarms	- Power-supply failure. - Power amplifier failure. - Low RCV level. - Frequency synthesizer failure. - Loss of synchronism. - Card out. - BER $> 10^{-3}$
Signalling	- Maintenance (Tests, loops or de-activation of one port). Both local and remote alarms and signalling are displayed on each terminal

Alarm and signalling indication	By means of LEDs
External signalling of the alarms	By means of four relays, one double changeover contact and three single changeover contact, to which the different alarms, in the combination required by the user, can be assigned from a computer type PC
Contact rating	1 A/250 V_{AC}/150 V_{DC}
Test elements	- Data loop in local and remote terminals. - High-frequency loop (isolated terminal). - Displaying of the XMT and RCV signal space constellation by means of oscilloscope - Permanent pseudopilot - Generation of HF-signal pulses - Test tone
Interface for the Management System	EIA RS-232C. Transmission rate: 600, 1200, 2400, 4800 or 9600 bit/s selectable by the user

6.6 OPERATING CONDITIONS

Temperature and humidity	From −5 °C to +45 °C and relative humidity not greater than 95%, in accordance with IEC 721-3-3 class 3K5 (3K5 climatogram)
Maximum temperature	+55 °C for a period not greater than 24 hours (IEC 495 cls. 3.1)
Power-supply voltage	48 V_{DC} ± 20%. Operating range: from 36 to 72 V_{DC}. 24 V_{DC} ± 20%. 110 V_{DC} ± 20%. Other voltages on request

Maximum consumption	Base equipment:	160 W
	Optional internal multiplexer:	20 W
	Teleprotection system:	15 W
Power-supply insulation	In accordance with IEC 495	
EMI and EMC	In accordance with IEC 870-2-1	
Storage conditions	In accordance with IEC 721-3-1, class 1K5	

6.7 MECHANICAL CHARACTERISTICS

Maximum dimensions	483 x 400 x 346 mm (one 6 s.u. shelf and another of 3 s.u. for 19" rack mounting)
Maximum weight	21 kg
Module arrangement	See Figure 7
Terminal characteristics	
Plug-in terminal block	
Power-supply terminals	Terminals that do not have disconnect devices and that are suitable for 6 mm^2 rigid conductors or 4 mm^2 flexible conductors
The rest of the terminals	Terminals that do not have disconnect devices and that are suitable for 2.5 mm^2 rigid or flexible conductors
Cabinet-mounting terminal block	
Power-supply terminals	Terminals that do not have disconnect devices and that are suitable for 16 mm^2 rigid conductors or 10 mm^2 flexible conductors
The rest of the terminals	Terminals that have disconnect devices and that are suitable for 4 mm^2 rigid conductors or 2.5 mm^2 flexible conductors

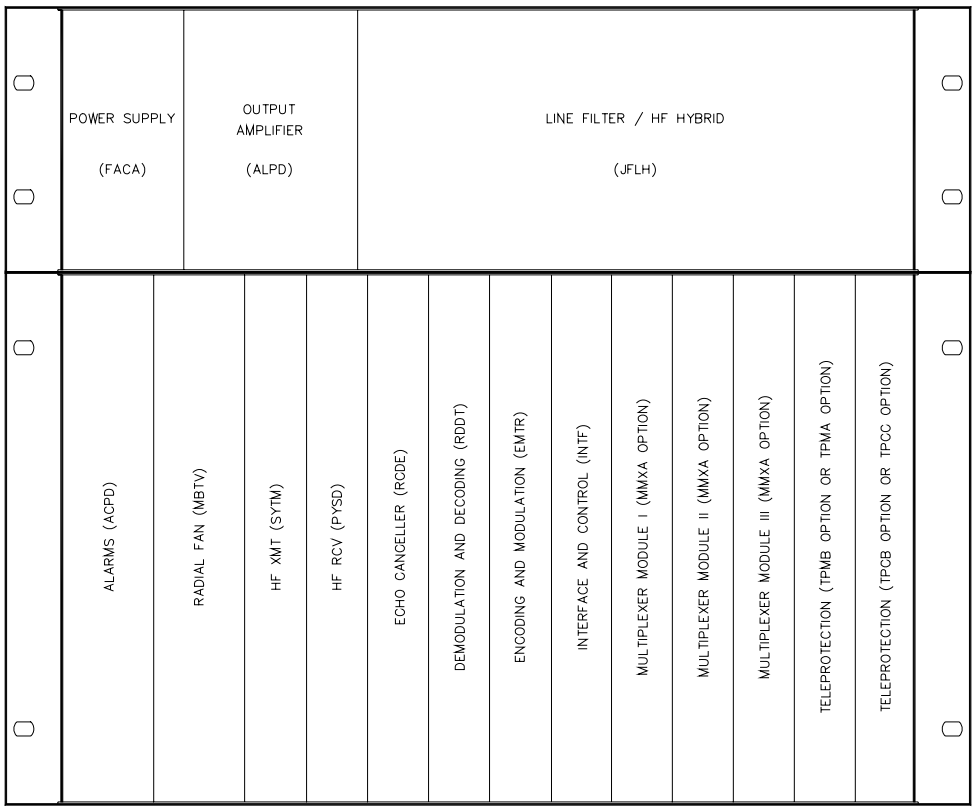


Figure 7 Module arrangement

6.8 CHARACTERISTICS OF THE MANAGEMENT COMPUTER

Type	Compatible personal computer (PC)
Model	Pentium II 350 MHz processor or higher
RAM memory	64 Mbytes
Graphic adapter	1 Mbyte SVGA
Communication	RS-232C serial port
Additional hardware	CD-ROM unit and a mouse
Operating system	Microsoft Windows 98 SE, Microsoft Windows 2000 or Microsoft Windows XP
Web browser	Microsoft Internet Explorer v 5.5 or higher

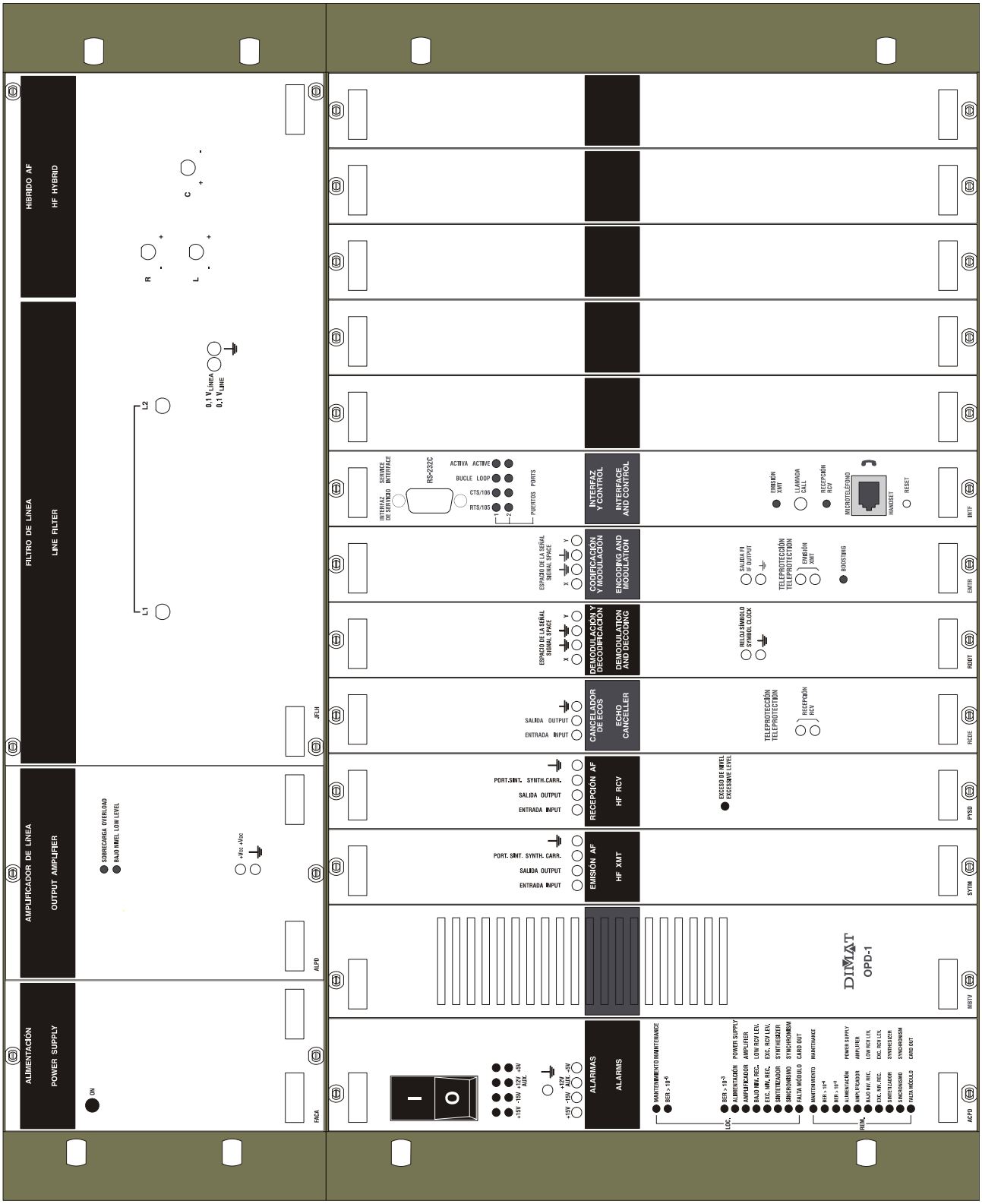


Figure 8 OPD-1 front view