BS EN IEC 62488-3:2021

BSI Standards Publication

Power line communication systems for power utility applications

Part 3: Digital Power Line Carrier (DPLC) terminals and hybrid ADPLC terminals

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National foreword

This British Standard is the UK implementation of EN IEC 62488-3:2021. It is identical to IEC 62488-3:2021.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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Date	Text affected

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NORME EUROPÉENNE

EUROPÄISCHE NORM

EN IEC 62488-3

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ICS 33.200

English Version

Power line communication systems for power utility applications - Part 3: Digital Power Line Carrier (DPLC) terminals and hybrid ADPLC terminals (IEC 62488-3:2021)

Systèmes de communication sur lignes d'énergie pour les applications des compagnies d'électricité - Partie 3: Équipements terminaux à courants porteurs sur lignes d'énergie numériques ou DPLC et équipements terminaux hybrides ADPLC
(IEC 62488-3:2021)

Systeme zur Kommunikation über Hochspannungsleitungen für Anwendungen der elektrischen Energieversorgung - Teil 3: Endgeräte für digitale Trägerfrequenzübertragung über Hochspannungsleitungen (DTFH) oder hybride ADTFH-Endgeräte
(IEC 62488-3:2021)

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

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Comité Européen de Normalisation Electrotechnique
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European foreword

The text of document 57/2355/FDIS, future edition 1 of IEC 62488-3, prepared by IEC/TC 57 "Power systems management and associated information exchange" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 62488-3:2021.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-02-28
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2024-05-31

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Endorsement notice

The text of the International Standard IEC 62488-3:2021 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 60358	NOTE	Harmonized as HD 597 S1

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Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC 60038	-	IEC standard voltages	EN 60038	-
IEC 60050-151	2001	International Electrotechnical Vocabulary - Part 151: Electrical and magnetic devices	-	-
IEC 60255-27	2013	Measuring relays and protection equipment - Part 27: Product safety requirements	EN 60255-27	2014
IEC 60529	1989	Degrees of protection provided by enclosures (IP Code)	EN 60529	1991
-	-		+ corrigendum May	1993
IEC 61000-4-2	-	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	-
IEC 61000-4-3	-	Electromagnetic compatibility (EMC) - Part 4-3 : Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN IEC 61000-4-3	-
IEC 61000-4-4	-	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	-
IEC 61000-4-5	-	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	-
IEC 61000-6-2	-	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments	EN IEC 61000-6-2	-
IEC 60721-3-1	1997	Classification of environmental conditions - - Part 3: Classification of groups of environmental parameters and their severities -- Section 1: Storage	-	-

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Publication	Year	Title	EN/HD	Year
IEC 60721-3-3	2002	Classification of environmental conditions - Part 3-3: Classification of groups of environmental parameters and their severities - Stationary use at weatherprotected locations	-	-
IEC 60834-1	1999	Teleprotection equipment of power systems - Performance and testing - Part 1: Command systems	EN 60834-1	1999
IEC 61000-6-4	2018	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments	EN IEC 61000-6-4	2019
IEC 61000-6-5	2015	Electromagnetic compatibility (EMC) - Part 6-5: Generic standards - Immunity for equipment used in power station and substation environment	EN 61000-6-5	2015
IEC 62488-1	2012	Power line communication systems for power utility applications - Part 1: Planning of analogue and digital power line carrier systems operating over EHV/HV/MV electricity grids	EN 62488-1	2013
IEC/TS 62351-1	2007	Power systems management and associated information exchange - Data and communications security - Part 1: Communication network and system security - Introduction to security issues	-	-
IEC/TS 62351-8	2011	Power systems management and associated information exchange - Data and communications security - Part 8: Role-based access control	-	-
IEC 62488-2	2017	Power line communication systems for power utility applications – Part 2: Analogue power line carrier terminals or APLC	EN 62488-2	2017
CISPR 32:2015/A1	2019	Electromagnetic compatibility of multimedia equipment – Emission requirements	EN 55032/A1	2020

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POWER LINE COMMUNICATION SYSTEMS FOR POWER UTILITY APPLICATIONS –

Part 3: Digital Power Line Carrier (DPLC) Terminals and hybrid ADPLC Terminals

FOREWORD

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This International Standard has been prepared by IEC technical committee 57: Power systems management and associated information exchange.

This first edition of IEC 62488-3 cancels and replaces the relevant parts of IEC TR 60663 and IEC 60495, which will be withdrawn at a later date.

The text of this standard is based on the following documents:

FDIS	Report on voting
57/2355/FDIS	57/2372/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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A list of all the parts in the IEC 62488 series, published under the general title *Power line communication systems for power utility applications* can be found on the IEC website

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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INTRODUCTION

Since the first introduction of power line carrier communications in the power systems industry this form of communication has become widely spread throughout the world. This worldwide development will be covered by new standards reflecting the current state of the art in digital PLC communications.

The communication services offered by modern digital power line carrier links and networks enable a high efficiency of data transmission and therefore a low level of operational costs of automation equipment especially for long high-voltage power transmission lines.

Analogue and digital PLC terminals may co-exist using principles of frequency division multiplexing, allowing a successive digitalization of PLC based communications.

Digital PLC terminals may also be combined with traditional analogue PLC transmission paths as hybrid analog & digital PLC equipment, offering reliable and seamless communication for control and/or protection operating at extra high-, high- and medium-voltage levels of the electrical transmission networks and at high-voltage electrical distribution networks.

IEC 62488 consists of four parts dealing with all aspects of power line communication systems operating over electricity power lines.

IEC 62488 applies to power line carrier terminals and systems (PLC) used to transmit information over power networks including extra high, high and medium voltage (EHV/HV/MV) power lines.

Currently this standard series is organised as follows:

- IEC 62488-1, *Planning of analogue and digital power line carrier systems operating over EHV/HV/MV electricity grids*
- IEC 62488-2, *Analogue Power Line Carrier terminals or APLC*
- IEC 62488-3, *Digital Power Line Carrier terminals or DPLC and hybrid ADPLC Terminals*
- IEC 62488-4, *Broadband Power Line systems or BPL*

NOTE IEC 62488-4 has not yet been published.

This document is the third part of IEC 62488 and is composed of the following Clauses**:**

- Clause 1 – Scope of IEC 62488-3
- Clause 2 – Normative references
- Clause 3 – Terms, definitions and abbreviation contains newly introduce in this document additionally to IEC 62488-1 and IEC 62488-2
- Clause 4 – Introduces generic architectures of DPLC and hybrid ADPLC terminals.
- Clause 5 – Defines access side interfaces of DPLC and hybrid ADPLC terminals.
- Clause 6 – Describes transmission line side high frequency interface and defines related parameters
- Clause 7 – Gives several requirements concerning quality and performance of a single or a couple of interconnected DPLC terminals
- Clause 8 – Defines test setup and describes testing methodology
- Clause 9 – Describes configuration and management requirements for DPLC terminals
- Clause 10 – Describes general requirements regarding cyber security
- Clause 11 – Specifies safety requirements
- Clause 12 – Specifies requirements for storage and transportation, operating conditions, power supply
- Clause 13 – Specifies EMC requirements

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POWER LINE COMMUNICATION SYSTEMS FOR POWER UTILITY APPLICATIONS –

Part 3: Digital Power Line Carrier (DPLC) Terminals and hybrid ADPLC Terminals

1 Scope

This part of IEC 62488 applies to power line carrier terminals and networks used to transmit information over power networks including extra high, high and medium voltage (EHV/HV/MV) power lines using both digital and optionally analogue modulation systems in a frequency range between 16 kHz and 1 MHz (see also IEC 62488-1).

In many countries, power line carrier (PLC) channels represent a significant part of the utility-owned telecommunication system. A circuit normally routed via a PLC channel can also be routed via a channel using a different transmission medium such as point to point radio, optical fibre or open wire circuit.

It is therefore important that the input and output interfaces that are used between terminals in the communication system are standardised.

The issues requiring consideration of DPLC and/or APLC devices as parts of a telecommunication network can be found in IEC 62488-1.

Figure 1 shows the correspondence between the elements needed to implement PLC systems and the related International Standards.

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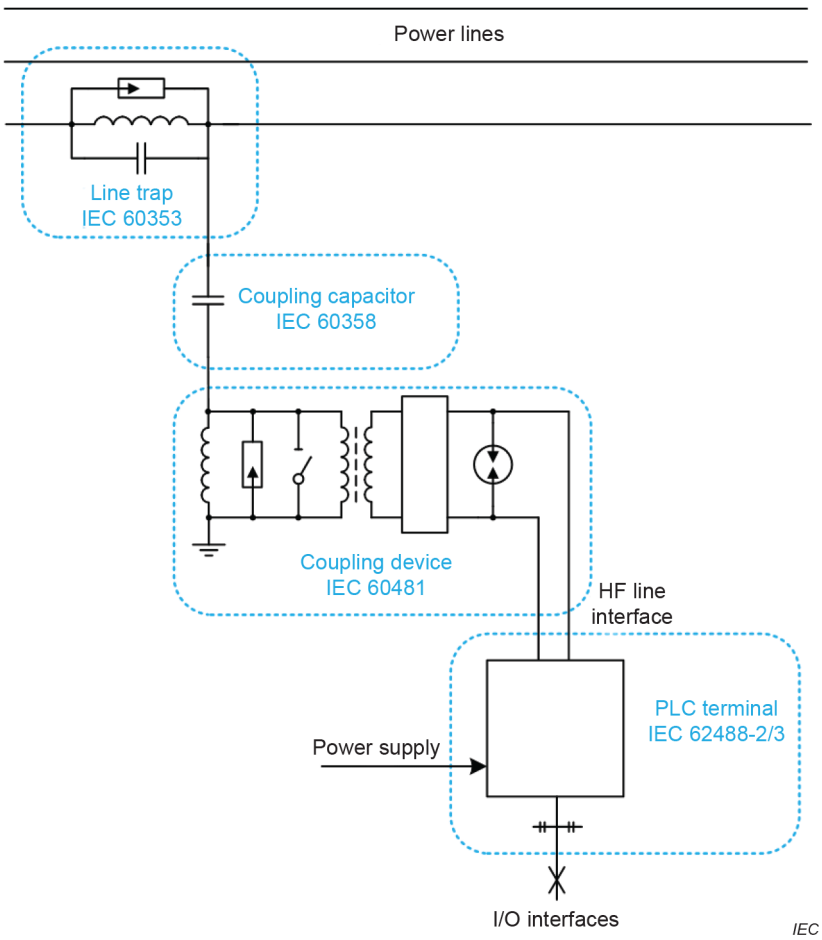

Figure 1 – Schematic representation of the elements needed to implement a PLC system

The scope of this document also includes the description of I/O interfaces and test set-ups that are necessary to qualify characteristics of DPLC or ADPLC terminal at link level.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

IEC 60255-27:2013, *Measuring relays and protection equipment – Part 27: Product safety requirements*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

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IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 60721-3-1:1997, *Classification of environmental conditions – Part 3-1: Classification of groups of environmental parameters and their severities – Storage*

IEC 60721-3-3:2002, *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Stationary use at weather protected locations*

IEC 60834-1:1999, *Teleprotection equipment of power systems – Performance and testing – Part 1: Command systems*

IEC 61000-6-4:2018, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61000-6-5:2015, *Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment*

IEC TS 62351-1:2007, *Power systems management and associated information exchange – Data and communications security – Part 1: Communication network and system security – Introduction to security issues*

IEC TS 62351-8:2011, *Power systems management and associated information exchange – Data and communications security – Part 8: Role-based access control*

IEC 62488-1:2012, *Power line communication systems for power utility applications – Part 1: Planning of analogue and digital power line carrier systems operating over EHV/HV/MV electricity grids*

IEC 62488-2:2017, *Power line communication systems for power utility applications – Part 2: Analogue power line carrier terminals or APLC*

CISPR 32:2015/AMD1:2019, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62488-1, IEC 62488-2 and the following apply.

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ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
DPLC equipment
PLC equipment transmitting information such as digital data or digitized analog signals over the power line using digital modulation techniques

3.1.2
HPLC
any combination of APLC, DPLC and BPLC elements in a single device

3.1.3
ADPLC
PLC equipment containing elements of APLC and DPLC. ADPLC is a sub-class of HPLC

3.1.4
nominal high frequency band for DPLC or HPLC
frequency band in which a particular DPLC or HPLC transmitter or receiver is operating within the carrier frequency range

3.1.5
nominal output power in the high frequency band for DPLC or HPLC
output power of an DPLC or HPLC terminal in the nominal high frequency band (L_{nom}) expressed as PEP for which the terminal has been designed, compatible with the requirements for spurious emissions and inter-channel interference (for multi-channel PLC terminals), available at the high frequency interface output across a resistive load equal to the nominal impedance

3.2 Abbreviated terms

AC	alternating current
AGC	automatic gain control
APLC	analogue PLC
ADPLC	analogue and digital PLC
AWGN	additive white Gaussian noise
BPLC	broadband PLC
BLER	block error rate
BER	bit error rate
B_{nom}	nominal high frequency band for DPLC or HPLC
CDF	cumulative distribution function
CPF	composite peak factor
DC	direct current
DPLC	digital PLC
DSP	digital signal processing
HF	high frequency
HPLC	hybrid PLC
LAN	local area network
LCL	longitudinal conversion loss

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LED	light-emitting diode
LF	low frequency
L_{nom}	Output power of an DPLC or HPLC terminal in the nominal high frequency band
L_{DPLC}	Output power of an DPLC terminal in the nominal high frequency band
MIB	management information base
OFDM	orthogonal frequency division multiplexing
OSB	output signal balance
PEP	peak envelope power
PDF	probability density function
PLC	power line carrier
QAM	quadrature amplitude modulation
RMS	root-mean-square
Rx	receiver, receive
SNMP	Simple Network Management Protocol
SNR	signal-to-noise ratio
SSB	single side band
TP	twisted pair
Tx	transmitter, transmit
UDP	User Datagram Protocol
WAN	wide area network

4 Generic structure of DPLC and ADPLC terminals

The generic structure describes the main building blocks of DPLC and ADPLC terminals. All other building blocks which are necessary for proper functioning (e.g. power supply, device control units) are not considered in Clause 4.

Figure 2 shows the block diagram of a DPLC terminal with the digital and analog interfaces on the left side and the HF line interface on the right side. If only one interface is available, the function of the time division multiplexer / demultiplexer and optional Ethernet switch may be replaced by a simple direct connection to the digital PLC modem. The resulting pass band signal is amplified and matched to the coupling device using the power line interface.

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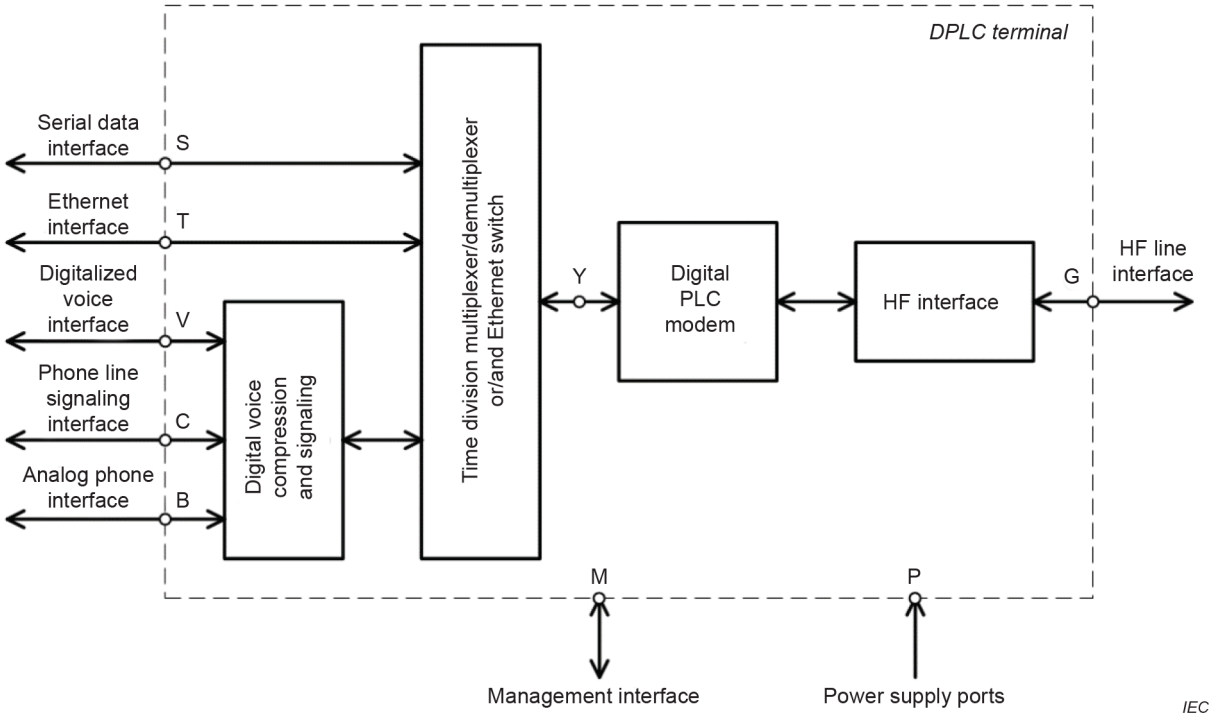

Figure 2 – Generic architecture of a DPLC terminal

Figure 3 shows the block diagram of an ADPLC terminal, which contains both a digital PLC modem as well as an analogue SSB modem, compliant with IEC 62488-2, that shall be used to convey signals coming from teleprotection or analogue I/O interfaces, with the digital and analogue interfaces on the left side and the HF line interface on the right side. An ADPLC terminal contains a digital PLC path, that was introduced above and shown in Figure 2, and may contain a teleprotection path and/or an APLC path according to IEC 62488-2. The output pass band signal of the digital PLC modem may be combined in the frequency domain with the output pass band signals of the optional teleprotection and/or APLC paths. The resulting pass band signal is amplified and matched to the coupling device using the power line interface.

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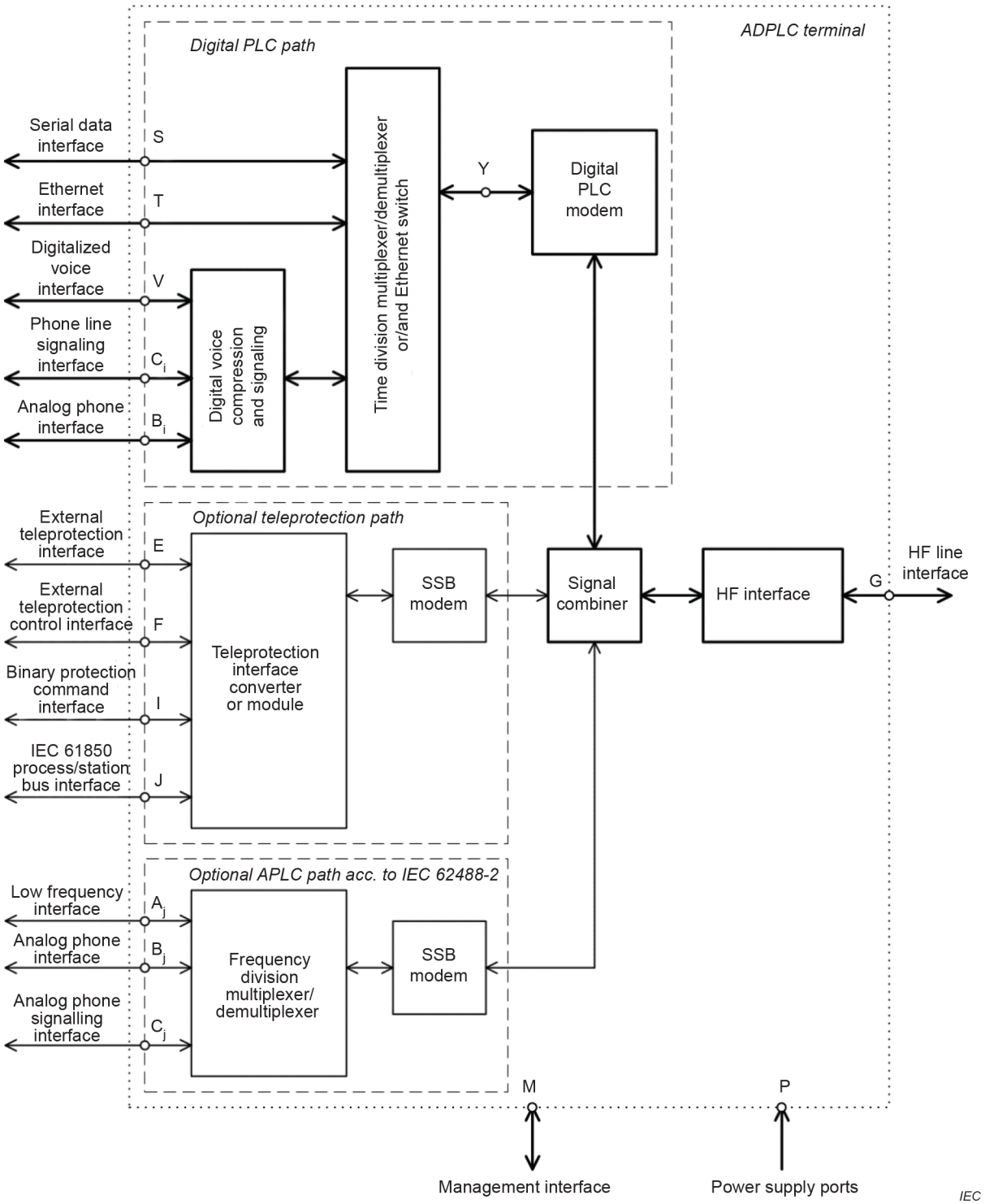

Figure 3 – Generic structure of an ADPLC terminal

NOTE Digital PLC modems use QAM-, OFDM-based digital modulation schemes or other types of digital modulation methods. IEC 62488-1 contains more details.

For planning of a point-to-point DPLC links the manufacturer of the DPLC terminals shall specify the following characteristic of the DPLC terminal:

- Set of transmission efficiency levels in bit/s/Hz under condition of equal bit-loading for all used carriers in a transmission scheme (e. g. OFDM);
- A typical dependence of BER or BLER from SNR for each transmission efficiency level;

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- Possible RMS output power of the DPLC terminal;
- Typical time delay of a point-to-point DPLC link.
- If applicable, a typical delay of the voice signal on interfaces B_i and/or V in a point-to-point DPLC link.

5 Access side interfaces

5.1 General

Access side interfaces related to DPLC equipment are described in Clause 5.

5.2 Digital interfaces

5.2.1 Ethernet IEEE 802.3 interface

5.2.1.1 General

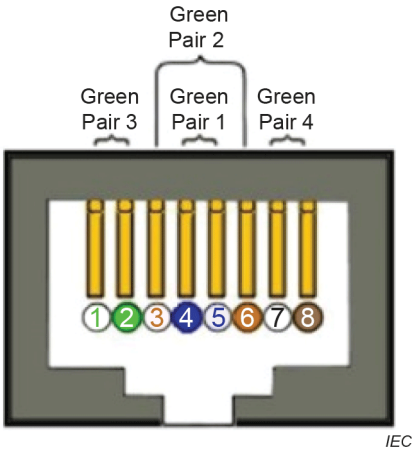
In some cases, it is required to interface DPLC links with local area networks in order to implement switching or bridging functionalities.

This integrated interface often implements both the Ethernet 10/100BaseT (copper) as well as 100FX (optical) standard interfaces.

Ethernet frames are first serialized, elaborated and then transmitted through an internal integrated high-speed data serial modem connected to the DPLC terminal.

5.2.1.2 Physical layer

For Ethernet interfaces, TP (twisted pair copper) or optical connectors are commonly used. Possible examples of these connectors are given in Figure 4 and Figure 5.



Key

1	TX +	2	TX –	3	RX +	4	NC
5	NC	6	RX –	7	NC	8	NC

Figure 4 – ETH IEEE 802.3 RJ45 type connector

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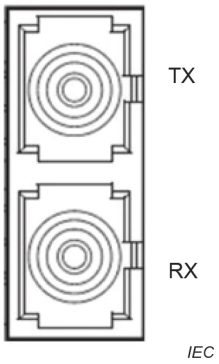

Figure 5 – ETH IEEE 802.3 SC type connector

For the physical characteristics (voltage, connector form factor, insulation, and pinout) of these interfaces, the relative reference standard shall be applied.

An electrical Ethernet interface may optionally provide power over Ethernet of power level 1 or higher, according to IEEE 802.3.

5.2.1.3 Data link layer

For this application the link layer should be compliant with the Ethernet standard IEEE 802.3.

Normally for practical reasons more than one Ethernet port should be made available to implement switching functionalities for local network connection.

Remote Ethernet connectivity may contain an implementation of the basic transparent WAN bridging functionalities, according to IEEE 802.1d.

5.2.2 Serial interface

The following serial data interfaces may be optionally supported by a DPLC terminal:

– TIA-232;
– TIA-422;
– TIA-485;
ITU-T V.11 / ITU-T X.24;
– ITU-T G.703 (64kBit).

It is recommended for the DPLC part to have a flow control mechanism implemented to be able to deal with the possible differences of the bit rate on both sides of a DPLC link.

If necessary, DPLC equipment shall be able to generate or deal with the serial data clock signals required for or generated by an external equipment.

5.3 Analogue interfaces

The description and specification of the Analogue Phone Interface and all possible interfaces of an optional APLC path are given in IEC 62488-2.

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5.4 Teleprotection system interface

5.4.1 Description

A typical goal of a selective teleprotection device consists of accelerating, delaying, locking or conditioning the protection relay (line distance protection, SF6 low pressure protection) installed in the field at both sides of an ADPLC link.

This is achieved by transmitting a command from one teleprotection device to the other by a suitable transmission system, fast, secure and dependable in order to control the way the protection relay at the other end of the line section behaves.

ADPLC terminals optionally may have on board an integrated selective teleprotection device with its interface enabling communication with protection devices.

Another possible option includes an interface enabling the communication between an external teleprotection device and an ADPLC terminal.

In the first case the interface processes signals/commands directly exchanged with the field protection relay. This means no low frequency signals are exchanged but simply logic criteria/commands are processed. This may be done using GOOSE messages defined in IEC 61850 or digital input or output signals according to IEC 60834-1.

The inputs and outputs should preferably be decoupled from the other signal/command input/output.

In the second case the interface connected to an external selective teleprotection device. Therefore the interface is a voice frequency input/output or fiber optic tranceiver with control circuit, which convert the teleprotection commands into base band signals, which are transmitted to the remote ADPLC terminal and an external teleprotection.

5.4.2 Integrated teleprotection

In case of integrated teleprotection or external selective teleprotection the functional requirements of teleprotection command systems, as defined in IEC 60834-1, shall be applied.

5.4.3 Teleprotection interface frequency band

The nominal frequency band used for the teleprotection service shall be specified within the frequency range of the nominal high-frequency band.

This may be a fully dedicated and pre-allocated frequency band or an alternative one which is allocated when the terminals switch to the teleprotection mode.

For this second operational mode, to avoid the risk of interference and optimize command transmission, the other signals present at the low frequency interface may be inhibited, while the commands signal is boosted.

In the same way, in order to get the best possible signal to noise ratio for transmitting a command, the signal resulting from the digital modulation may also be inhibited.

5.4.4 Teleprotection interface impedance

- Input/output impedance 600 Ω

5.4.5 Teleprotection interface reflection

- Return loss ≥ 14 dB

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5.4.6 Teleprotection interface signal levels

- The minimum range of the transmit input level shall be -20 dBm to 0 dBm
- The minimum range of the received output level shall be -20 dBm to 0 dBm

5.4.7 Teleprotection interface control circuits

Control inputs may be provided to accomplish boosting of the teleprotection signal to a maximum specified high frequency PEP output power, and to interrupt the other signals for a short time of typically less than 500 ms, during teleprotection transmission.

ADPLC terminals shall include control circuits to shift the terminals from communication mode to teleprotection mode if the temporary band is allocated for transmitting the teleprotection signal.

The control inputs shall operate with a loop resistance of up to 500 Ω.

Control outputs are often provided to give an alarm to the teleprotection terminal in case of failure or degradation of the ADPLC link.

6 HF line interface

6.1 DPLC high frequency band & channeling

The typical high frequency ranges used in Europe span from 40 kHz to 500 kHz (up to 1 000 kHz in some countries and for special application (e.g. cables) ranges down to 16 kHz may be used). Parts of this range may be barred by national regulations.

The used nominal high frequency band for one direction is divided into a digital PLC band (DPLC band), that may be fragmented by other APLC bands or bands reserved for radio services, and optionally into a number of analogue PLC bands (APLC bands) with a bandwidth of 4 kHz or 2,5 kHz typically as described in IEC 62488-2.

A DPLC terminal usually operates in different high frequency bands for each direction of the transmission. The transmit and receive high frequency bands may be non-adjacent, adjacent or superimposed.

The nominal high frequency band of the ADPLC terminal has a bandwidth equal to

$$B_{\mathrm{nom}} = B_{\mathrm{D}} + \sum_{\mathrm{i}} B_{\mathrm{A}}\,(i) \tag{1.1}$$

where:

B_{D} = bandwidth of DPLC band,

$B_{\mathrm{A}}(i)$ = bandwidth of the i-th APLC band.

The nominal high frequency band of the DPLC terminal has a bandwidth equal to

$$B_{\mathrm{nom}} = B_{\mathrm{D}} \tag{1.2}$$

where: B_{D} = bandwidth of DPLC band.

For each DPLC terminal the possible set of nominal high frequency channel bandwidths and the set of nominal carrier frequencies, for which the recommended values are maintained, shall be stated.

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