

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Power line communication systems for power utility applications –
Part 3: Digital Power Line Carrier (DPLC) Terminals and hybrid ADPLC Terminals**

**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 (DPLC) et équipements terminaux hybrides ADPLC**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2021 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC online collection - oc.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC online collection - oc.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Power line communication systems for power utility applications –
Part 3: Digital Power Line Carrier (DPLC) Terminals and hybrid ADPLC Terminals**

**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 (DPLC) et équipements terminaux hybrides ADPLC**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.200

ISBN 978-2-8322-1034-2

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
1 Scope.....	10
2 Normative references	11
3 Terms, definitions and abbreviated terms	12
3.1 Terms and definitions.....	12
3.2 Abbreviated terms.....	13
4 Generic structure of DPLC and ADPLC terminals	14
5 Access side interfaces.....	17
5.1 General.....	17
5.2 Digital interfaces.....	17
5.2.1 Ethernet IEEE 802.3 interface.....	17
5.2.2 Serial interface	18
5.3 Analogue interfaces	18
5.4 Teleprotection system interface	19
5.4.1 Description	19
5.4.2 Integrated teleprotection.....	19
5.4.3 Teleprotection interface frequency band	19
5.4.4 Teleprotection interface impedance	19
5.4.5 Teleprotection interface reflection.....	19
5.4.6 Teleprotection interface signal levels.....	20
5.4.7 Teleprotection interface control circuits.....	20
6 HF line interface	20
6.1 DPLC high frequency band & channeling	20
6.2 Frequency accuracy.....	21
6.3 Signal levels	21
6.4 In-band emissions.....	21
6.5 Nominal impedance	21
6.6 Return loss	21
6.7 Degree of unbalance to earth.....	21
6.8 Tapping loss	21
6.9 Spurious emissions.....	22
6.10 Nominal output power in the high frequency band	23
7 Quality and performance.....	23
7.1 General.....	23
7.2 Dynamic range of the DPLC receiver	24
7.3 Bit rate.....	24
7.4 Start-up time	25
7.5 Recovery time after synchronization loss	25
7.6 Sensitivity	25
7.7 Selectivity	25
7.8 Adaptability to line conditions.....	25
7.9 Quality of voice channels	25
7.10 Telephone signalling transmission	26

7.11	Quality on the serial DATA channels	26
7.11.1	General	26
7.11.2	Bit rate	26
7.11.3	BER.....	26
7.11.4	Nominal transmission link delay.....	27
7.12	Quality of the frame transmission using Ethernet interfaces	27
7.12.1	General	27
7.12.2	LAN to LAN Speed	27
7.12.3	LAN to LAN latency	27
7.12.4	Packet loss on the LAN transfer.....	27
8	Testing	27
8.1	General.....	27
8.2	Test setup for DPLC link tests.....	28
8.3	Signal to noise ratio	28
8.4	Return loss	28
8.5	Degree of unbalance to earth.....	30
8.5.1	General	30
8.5.2	Longitudinal conversion loss.....	30
8.5.3	Output signal balance	31
8.6	Tapping loss	31
8.7	Spurious and in-band emissions	32
8.8	Selectivity	33
8.9	Bit error rate	35
8.10	Serial data transmission delay	37
8.11	Dynamic range of the DPLC receiver	38
8.12	LAN to LAN testing	38
8.12.1	General	38
8.12.2	Maximum LAN to LAN throughput.....	39
8.12.3	LAN to LAN latency	39
8.13	Start-up time	39
8.14	Recovery time after synchronization loss	39
9	Configuration and management	40
9.1	General.....	40
9.2	Configuration	40
9.3	Network management system	40
9.4	Local terminal alarms.....	40
9.5	Event logging.....	41
10	Cyber security	41
10.1	General.....	41
10.2	Transmitted payload	41
10.3	Management interface	41
10.3.1	General	41
10.3.2	Legacy-style management interfaces / Manufacturer-specific management interfaces	42
10.3.3	LAN/WAN connected management interfaces	42
10.3.4	Authentication and role-base model.....	42

10.4	Network management system interface	42
10.5	Security-related event logging.....	43
11	DPLC safety	43
11.1	General.....	43
11.2	Safety reference standard	43
11.3	Classification of DPLC terminals	43
11.4	Ingress protection	44
11.5	Type and routine tests	45
12	Storage and transportation, operating conditions, power supply.....	47
12.1	Storage and transportation.....	47
12.1.1	Climatic conditions	47
12.1.2	Mechanical	48
12.2	Operating conditions	50
12.2.1	Climatic conditions	50
12.2.2	Mechanical	51
12.2.3	Operating conditions set of tests.....	51
12.3	Power supply	52
12.3.1	AC supply	52
12.3.2	DC supply.....	52
13	EMC	53
13.1	Emission and immunity reference standards	53
13.2	Emission	53
13.2.1	Radiated and conducted emission	53
13.2.2	Low frequency disturbance emission	58
13.3	Immunity	58
13.3.1	EMC environment	58
13.3.2	Functional requirements	60
13.3.3	Immunity test list	60
Annex A (informative)	HF modulated power signal for ADPLC.....	63
A.1	General.....	63
A.2	Computation model of ADPLC.....	63
A.3	Distribution of E/U ratio of voice channels.....	65
A.4	Distribution of E/U ratio of sinusoidal waves.....	67
A.5	Example of E/U ratio of a digital signal.....	68
A.6	Composite distribution of E/U ratios	69
A.7	RMS power and load capacity of voice signals	71
A.8	Comprehensive load capacity for ADPLC	73
A.9	Simplified computation method for comprehensive load capacity	74
Bibliography	75
Figure 1	– Schematic representation of the elements needed to implement a PLC system.....	11
Figure 2	– Generic architecture of a DPLC terminal	15
Figure 3	– Generic structure of an ADPLC terminal.....	16
Figure 4	– ETH IEEE 802.3 RJ45 type connector	17
Figure 5	– ETH IEEE 802.3 SC type connector	18

Figure 6 – Tapping loss limits for DPLC terminals	22
Figure 7 – Max level of spurious emissions outside the high frequency band	23
Figure 8 – Reference points for measuring DPLC parameters	24
Figure 9 – Block diagram of a serial data channel	26
Figure 10 – Test circuit for return loss measurement.....	29
Figure 11 – Test circuit for LCL measurement (transmission port).....	30
Figure 12 – Test circuit for OSB measurement (Rx port)	31
Figure 13 – Test circuit for tapping loss measurement	32
Figure 14 – Test circuit for spurious and in-band emissions measurement	33
Figure 15 – Test circuit for selectivity measurement.....	34
Figure 16 – Test circuit for bit error rate measurement.....	36
Figure 17 – Test circuit for serial data transmission delay measurement with a data tester	37
Figure 18 – Test circuit for serial data transmission delay measurement.....	37
Figure 19 – Test circuit for maximal throughput and latency measurement.....	38
Figure 20 – LF disturbances measurement setup	58
Figure A.1 – Calculation model of load capacity for ADPLC	64
Figure A.2 – Cumulative distributions of E/U ratio of voice channels for positive half	66
Figure A.3 – Probability density of combined sine waves	67
Figure A.4 – Constellation diagram of 64 QAM.....	68
Figure A.5 – Amplitude spectra of unmodulated OFDM sub-carriers.....	68
Figure A.6 – Probability of constellation point power in 64 QAM.....	69
Figure A.7 – Cumulative distribution of comprehensive E/U ratios.....	70
Figure A.8 – Cumulative distribution of equivalent volume for N system channel.....	72
Table 1 – Dependence of voice channel quality vs. DPLC capacity	26
Table 2 – Basic insulation (Table C.6 of IEC 60255-27:2013).....	43
Table 3 – Double or reinforced insulation (Table C.10 of IEC 60255-27:2013)	44
Table 4 – List of Type and Routine Tests (Table 12 of IEC 60255-27:2013)	46
Table 5 – Classification of climatic conditions (Table 1 of IEC 60721-3-1:1997)	47
Table 6 – Climatic tests for storage and transportation.....	48
Table 7 – Classification of mechanical conditions for transportation (Table 5 of IEC 60721-3-2:1997)	49
Table 8 – Classification of climatic conditions from Table 1 of IEC 60721-3-3:2002	50
Table 9 – Classification of mechanical conditions from Table 6 of IEC 60721-3-3:2002.....	51
Table 10 – Climatic Tests	51
Table 11 – Sinusoidal vibration test	52
Table 12 – Non-repetitive shock test.....	52
Table 13 – Emission – Enclosure port (Table 1 of IEC 61000-6-4:2011).....	54
Table 14 – Emission – Low voltage AC and DC mains port (Table 2 of IEC 61000-6-4:2011).....	56
Table 15 – Emission – Telecommunications/network port (Table 3 of IEC 61000-6-4:2011).....	57
Table 16 – Characterization of the electromagnetic phenomena (Table 1 of IEC 61000-6-5:2015).....	59
Table 17 – Port classification	59

Table 18 – Performance criteria	60
Table 19 – Immunity test list	61
Table A.1 – Approximation formula for E/U cumulative distribution of speech.....	66
Table A.2 – PDF of constellation point power in 64 QAM constellation diagram	69
Table A.3 – Calculation of $P_{RMS}(1\%)$ and load capacity.....	73

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**POWER LINE COMMUNICATION SYSTEMS
FOR POWER UTILITY APPLICATIONS –**
**Part 3: Digital Power Line Carrier (DPLC) Terminals
and hybrid ADPLC Terminals**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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.

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.

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

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.