Telecommunications Standards Advisory Committee (TSAC)

# Technical Specification

# Powerline Communications (PLC) Home Networking

**IMDA TS PLC**
**Issue 1, 1 October 2016**

Info-communications Media Development Authority
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# Acknowledgement

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| | |
|---|---|
| **IDA TS PLC Issue 1 (August 2012) re-issued as IMDA TS PLC Issue 1 (1 October 2016)** | Technical Specification for Powerline Communications (PLC) Home Networking |
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# Content

# Technical Specification for Powerline Communications (PLC) Home Networking

## 1 Preamble

1.1 Powerline Communications (PLC) is a technology which allows the transmission of voice, video and data through the low voltage electrical distribution network and premises electrical cables/wires. Since the electrical distribution network is not meant for telecommunications purposes, any users or service providers and providers of PLC equipment, as the case may be, have a responsibility to ensure that they obtain the necessary approval from the relevant authorities that have jurisdiction over the use of electrical distribution cables.

1.2 This Specification does not in any way, constitute an approval to transmit telecommunications signal over the power cables. Reference to this Specification should only be made after prior approval from the relevant authorities (as mentioned in the preceding paragraph) has been obtained.

1.3 This Specification is intended for facilitating the use of PLC for home networking, and service providers/users are required to:

(a) Ensure that the in-home PLC devices operate within the frequency range of 2 to 80 MHz, the Power Spectral Density (PSD) mask defined in § 5 and have suppressed the use of frequency bands listed in § 9 and § 10 of this Specification.

(b) Ensure that the level of the PLC device output power is reduced to a minimum value for communication with the dynamic power control function implemented (§ 5), and that the conducted and radiated disturbances are within the limits defined in § 7 and § 8 of this Specification.

1.4 Service providers who offer the PLC home networking option and suppliers of PLC devices are required to:

(a) Provide information to customers and users on how to resolve interference problems.

(b) Advise their customers that:

i. The operation of PLC devices is allowed under the condition that no interference is caused to other authorised telecommunications services, and that any interference caused by an authorised radio station, electrical or electronic equipment must be tolerated.

ii. Operation of the PLC devices may have to cease if it is found causing interference to other telecommunications services.

iii. Compliance with requirements defined in this Specification does not imply a guarantee of a certain level of performance quality or multi-vendor equipment interoperability.

## 2 Scope

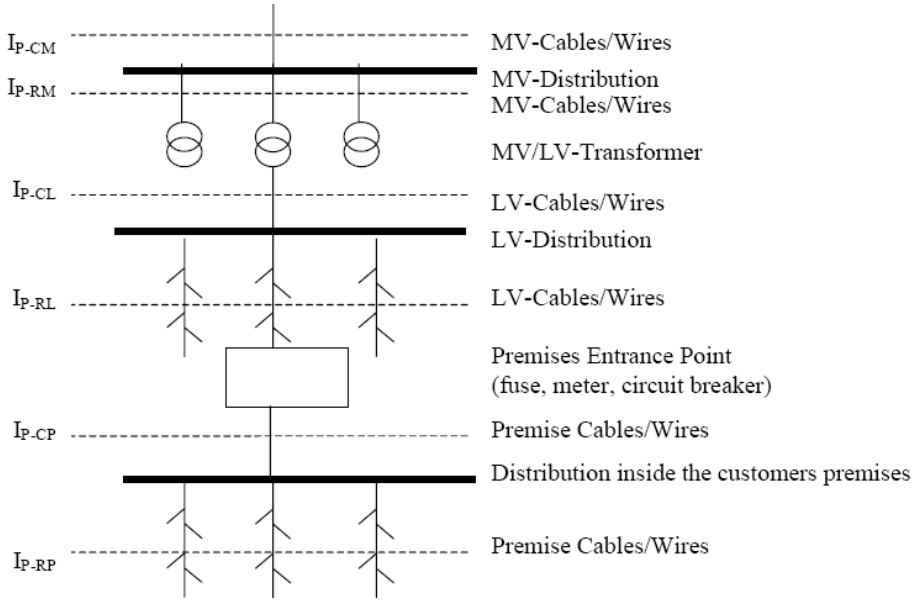
2.1 This Specification defines the minimum technical requirements for the connection of PLC devices to the mains network for the purpose of data transfer and telecommunications and also possibly, for the supply of electrical energy to the devices. The Specification is applicable to PLC home networking equipment or in-home PLC devices connected at the same premises that can comply with the Power Spectral Density (PSD) mask as shown in Figure 2.

2.2 The support for PSD reduction and power management can be implemented independently of the PLC technology.

2.3 The Specification also outlines 2 possible system reference models (refer to §6 of this Specification) which may be adopted to complement the PSD mask with logical interface between the PLC home networking transceivers and the power line medium.

2.4 The PSD levels are further assured by the Electromagnetic Compatibility (EMC) requirements defined for limiting the transmitted signal from the PLC port according to the CENELEC EN 50561-1 [1] and the IEC CISPR 32 [2] standards.

2.5 PLC devices are connected at the powerline interfaces $I_{P-RP}$ of the network architecture model as shown in Figure 1, after the Low Voltage (LV) distribution in the customer premises. Figure 1 shows a schematic of an Electrical Distribution Network (EDN) substation up to the level of the Medium Voltage/Low Voltage (MV/LV) transformer, LV distribution and premises cables/wires. It shows a star configuration although ring configuration is also possible on each power level.




Note: $I_{P-YX}$ Interface Powerline – Y may be C denoting Central or R denoting Remote
X may be L denoting Low Voltage Outdoor or P denoting Premises

**Figure 1 (Figure 3/ETSI TS 101 896 [3]): Physical Interfaces ($I_{P-YX}$) in the EDN**

2.6 The PLC device shall be tested for compliance with the IEC 60950-1 [4] or IEC 62368-1 [5] safety standard. The requirements in IEC 60950-1 or IEC 62368-1 that are applicable to the equipment (e.g. class of equipment, type of TNV circuit and types of components) shall be identified and complied with.

2.7 Figure A-1/Annex A (Informative) of this Specification gives the generic building block for powerline telecommunications, $PLT_X$. It shows how PLT device or functionality may be inserted into the different levels of the power network architecture (refer to Figure 1). It also shows how the PLT networks may be connected to the telecommunications networks at the $I_{T-CX}$ interface for interworking, and the customer premises equipment (CPE) may be connected to the $I_{T-RX}$ interface.

# 3 References

For the technical requirements captured in this Specification, reference has been made to the following standards. Where versions are not indicated, implementation of this Specification shall be based on current and valid versions of these standards published by the respective Standards Development Organisations.


[1] CENELEC EN 50561-1, Power line communication apparatus used in low-voltage installations – Radio disturbance characteristics – Limits and methods of measurement – Part 1: Apparatus for in-home use

[2] IEC CISPR 32, Electromagnetic compatibility of multimedia equipment – Emission requirements

Note: Validity of the IEC CISPR 22, EMC standard for information technology equipment, will lapse by 31 March 2017, in sync with IEC's timeline for withdrawing this CISPR standard, and replacing it with the CISPR 32 standard.

[3] ETSI TR 102 324, Power-line Telecommunications (PLT); Radiated emissions' characteristics and measurement method of state of the art power-line communication networks

[4] IEC 60950-1, Information Technology Equipment – Safety

[5] IEC 62368-1, Audio/video, information and communication technology equipment – Part 1: Safety requirements

[6] ITU-T Recommendation G.9964, Unified high-speed wire-line based home networking transceivers – Power Spectral Density (PSD) Specification

[7] ITU-T Recommendation G.9960, Unified high-speed wire-line based home networking transceivers – system architecture and physical layer specification

[8] IEEE Standard P1901, IEEE standard for Broadband over Power Line Networks: Medium Access Control and Physical Layer Specifications

[9] ETSI TR 102 324, Powerline Telecommunications (PLT); Radiated emissions' characteristics and measurement method of state of the art powerline communication networks

[10] IEC CISPR 16-1, Specification for radio disturbance and immunity measuring apparatus and methods

# 4 Abbreviations

| | |
|---|---|
| BS | British Standard |
| CENELEC | European Committee for Electrotechnical Standaridisation |
| CISPR | International Special Committee on Radio Interference |
| CPE | Customer Premises Equipment |
| DM | Differential Mode |
| EDN | Electrical Distribution Network |
| EMC | Electromagnetic Compatibility |
| EN | European Standard (or European Norm) |
| ETSI | European Telecommunications Standards Institute |
| ETSI PLT | ETSI Powerline Telecommunications project |
| HF | High Frequency |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronics Engineers |
| ITE | Information Technology Equipment |
| ITU | International Telecommunication Union |
| LCM | Launched Common Mode |
| LPM | Limit PSD Mask |
| LV | Low Voltage |
| MV | Medium Voltage |
| PB | Power-line Baseband |
| PLC | Power-Line Communications |
| PLT | Power-Line Telecommunications |
| PSD | Power Spectral Density |
| PSDC | PSD Ceiling |
| PSM | PSD Shaping Mask |
| SM | Sub-carrier Mask |

# 5 Power Spectral Density (PSD) Specification

## 5.1 Transmit PSD Mask

5.1.1 The PLC device shall have the capability to limit the transmit Power Spectral Density (PSD) mask with the presence of a dynamic power control function.

5.1.2 The limit PSD mask for operation over power lines shall be as presented in Figure 2 (ITU-T Rec. G.9964 [6] Figure 6-2) with the values of frequencies $f_L$ - $f_H$ as presented in Table 1 (ITU-T Rec. G.9964 Table 6-5).

5.1.3 Sub-carriers with frequencies (80 MHz - $F_{SC}$) ≤ $f$ ≤ (100 MHz + $F_{SC}$) shall be masked (zero power transmitted).

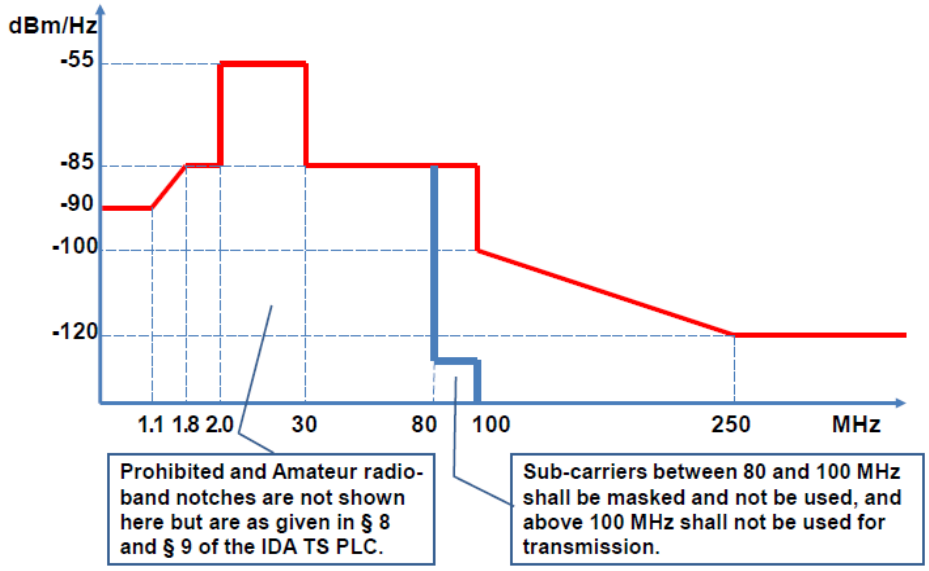



**Figure 2 (Figure 6.2/ ITU-T Rec. G.9964): Limit PSD mask for baseband transmission (Amateur radio-band notches are not shown)**

**Table 1 (Table 6-5/ITU-T Rec. G.9964): Parameters of Limit PSD mask for the 25MHz-PB, 50MHz-PB, and 100MHz-PB band plans**

| Parameters | Frequency (MHz) | PSD (dBm/Hz) | Note/Description |
|---|---|---|---|
| $f_{L1}$ | 1.1 | - 90 | Additional reduction below 1.1 MHz is to reduce crosstalk into ADSL |
| $f_{L2}$ | 1.8 | - 85 | Coincides with the Amateur radio band |
| $f_{L3}$ | 2.0 | | |
| $f_{L3}$ + Δf | 2.0 + Δf | - 55 | Δf is an arbitrary small positive value |
| $f_{H1}$ - Δf | 30 - Δf | - 55 | Δf is an arbitrary small positive value |
| $f_{H1}$ | 30 | - 85 | Δf is an arbitrary small positive value |
| $f_{H2}$ - Δf | 100 - Δf | | |
| $f_{H2}$ | 100 | - 100 | |
| $f_{H3}$ | 250 | - 120 | |
| Note: All sub-carriers above $f_{H2}$ - Δf shall not be used for transmission (neither data nor any auxiliary information). | | | |

5.2 Dynamic Power or PSD Control

5.2.1 PLC devices shall be able to transmit at a low output power with PSD reduction tools or dynamic power control implemented.

5.2.2 The transmit PSD shall be a function of the channel attenuation between 2 communicating PLC devices. Typically, PLC devices transmit at a PSD of less than -80 dBm/Hz in power circuits of 10 dB insertion loss.

5.3 Measurement of Maximum Transmit Signal Levels

5.3.1 The transmit signal from the PLC port shall not exceed the maximum values given in Table 2 (Table 2/EN 50561-1) measured using methods and procedures given in § 9.2 of the EN 50561-1 [1]; or any equivalent methods for measuring the transmitted symmetrical signal from the PLC port. This demonstrates that there is a dynamic power or PSD control function.

**Table 2 (Table 2/EN 50561-1): Maximum PLC Transmit Signal Level between 1.6065 MHz and 30 MHz**

| | | | |
|---|---|---|---|
| Symmetrical mode insertion loss EUT to AE in dB | 10 | 20 | ≥ 40 |
| Maximum transmit signal level in dB(µV) (Average) | 65 Note 1 | 75 | 95 |
| Maximum transmit signal level in dB(µV) (Peak) | 75 | 85 | 105 |
| Note: The transmit power management function of an AE should operate in the same way as the EUT otherwise the signal of the AE may dominate and cause erroneous results during measurement. | | | |

## 6 System Reference Models for PLC Networking Transceivers

5.1 Specification of the transmit PSD and tools for supporting the reduction of the transmit PSD should be complemented by a system architecture and reference model as defined in the ITU-T Recommendation G.9960 [7] or the IEEE Standard 1901 [8].

[1] dBW = dBV – 20 (R, the differential input impedance for the PLC port, is 100 Ω.)
dBm = dBW + 30
dBm = dBV + 10 = (dBµV – 120) + 10 = dBµV – 110
As the transmit PSD or maximum transmit signal is measured as a function of frequency, and scanned for all PLC transmission frequencies below 30 MHz, using a resolution bandwidth of 9 kHz,
dBm/Hz = dBµV – 110 – (10log9x10$^3$) = dBµV – 110 – 39.5
65 dBµV = 65 – 149.5 = – 84.5 dBm/Hz

# 7 Requirements for Asymmetric Conducted Disturbances

7.1 The PLC device shall either be tested for conducted disturbances below 30 MHz, following methods and procedures given in § 7.2 of this Specification; or be tested for radiated disturbances below 30 MHz, following methods and procedures given in § 8.1 of this Specification.

7.2 To ensure the inherent symmetry of the PLC port, in all operating conditions, the PLC device should be tested for compliance with disturbance limits given in Table 3 (Table 1/EN 50561-1 or Table 10/CISPR 32), using methods and procedures given in § 9.4 of the EN 50561-1 [2] for measuring conducted asymmetric disturbances.

**Table 3 (Table 1/EN 50561-1 or Table A.10/CISPR 32): Limits for Asymmetric Conducted Disturbances**

| **Frequency range MHz** | **Limits dB(µV)** | |
|---|---|---|
| | **Quasi-peak** | **Average** |
| 0.15 to 0.50 | 66 to 56 | 56 to 46 |
| 0.50 to 5 | 56 | 46 |
| 5 to 30 | 60 | 50 |
| Note 1: The lower limit applies at the transition frequencies.<br>Note 2: The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz. | | |

# 8 Requirements for Radiated Disturbances

8.1 Radiated Disturbances below 30 MHz

8.1.1 Radiated emissions from the PLC device below 30 MHz should be measured according to the ETSI TR 102 324 [9] and shall be less than the value given in Table 4 (Table 1/ ETSI TR 102 324).

**Table 4 (Table 1/ETSI TR 102 324): Radiated Emissions from PLC Networks below 30 MHz**

| Frequency Range (MHz) | Field Strength (dBµA/m quasi-peak) | Reference Measurement Distance (m) | Measurement Bandwidth (kHz) |
|---|---|---|---|
| 1.605 to 30 | 14 | 3 | 9 |

8.1.2 In the frequency range 1.605 to 30 MHz, the magnetic component of the radiated emission shall be measured. A calibrated measuring system according to IEC CISPR 16-1 [9] consisting of a radio disturbance measuring receiver, an associated loop antenna for measurement of magnetic field components and a tripod is required. Other specialised equipment such as resonant loop antennas can also be used. A measuring bandwidth of 9 kHz and a Quasi-peak detector shall be used.

8.2 Radiated Disturbances above 30 MHz

8.2.1 Radiated disturbances from the PLC device above 30 MHz shall be measured according to the IEC CISPR 32 [2] and shall meet the limits of Table 5 (Table A.4/CISPR 32).

**Table 5 (Table A.4/CISPR 32): Limits for Radiated Disturbance of class B ITE at a measuring distance of 10 m**

| Frequency range<br>MHz | Quasi-peak limits<br>dBµV/m |
|---|---|
| 30 to 230 | 30 |
| 230 to 1000 | 37 |
| Note 1 The lower limit shall apply at the transition frequency.<br>Note 2 Additional provisions may be required for cases where interference occurs. | |

## 9 Prohibited Frequencies

PLC transmission in the following frequency bands is prohibited and shall be suppressed by PSD reduction of at least 30 dB with respect to the transmit level outside of the PSD reduction with widths encompassing the suppressed frequency bands.

(a) 2.850 – 3.025 MHz

(b) 5.480 – 5.730 MHz

(c) 6.525 – 6.685 MHz

(d) 8.815 – 8.965 MHz

(e) 10.005 – 10.100 MHz

(f) 10.7 MHz

(g) 11.275 – 11.400 MHz

(h) 74.800 – 75.200 Mhz

## 10 Amateur Radio Frequency Bands

PLC transmission in the following amateur radio frequency bands shall be suppressed by PSD reduction of at least 30 dB with respect to the transmit level outside of the PSD reduction with widths encompassing the suppressed frequency bands.

(a) 3.500 – 3.900 MHz

(b) 7.000 – 7.100 MHz

(c) 10.100 – 10.1500 MHz

(d) 14.000 – 14.350 MHz

(e) 18.068 – 18.168 MHz

(f) 21.000 – 21.450 MHz

(g) 28.000 – 29.700 Mhz

# Annex A
(Informative)

# Interfaces of PLC Equipment for connection to Telecommunications Network

Interworking between PLT and telecommunications networks is demarcated by the $I_{T-CX}$ as shown in the PLT building block of Figure A-1 (Figure 1/ETSI TS 101 896).

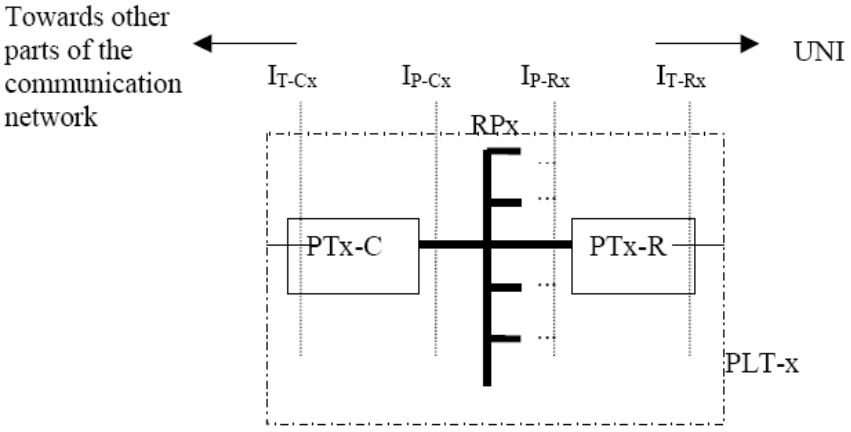



**Figure A-1 (Figure 1/ETSI TS 101 896): Generic Building Block $PLT_X$**

| | |
|---|---|
| X | X may be L denoting Low Voltage Outdoor or P denoting Premises |
| $I_{T-CX}$ | Interface Telecommunication Central connection point to a core backbone network or to $I_{T-RX}$ of another $PLT_X$ in a layered PLT structure |
| $I_{P-CX}$ | Interface Powerline Central connection point to the Electrical Distribution Network (EDN) |
| $I_{P-RX}$ | Interface Powerline Remote connection point to the Electrical Distribution Network (EDN) |
| $I_{T-RX}$ | Interface Telecommunication Remote connection point to either customer equipment or to $I_{T-CX}$ of another $PLT_X$ in a layered PLT structure |
| $RP_X$ | Reference Point to the respective section of the EDN |
| $PT_{X-C}$ | Powerline Transmission Central modem unit, which modulates information from $I_{T-CX}$ in downstream direction into RF signal on the $I_{P-CX}$, and demodulates an upstream RF signal from the $I_{P-CX}$ into the $I_{T-CX}$. |
| $PT_{X-R}$ | Powerline Transmission Remote modem unit, which modulates information from $I_{T-RX}$ in upstream direction into RF signal on the $I_{P-RX}$, and demodulates a downstream RF signal from the $I_{P-RX}$ into the $I_{T-RX}$. |
| $PLT_X$ | Powerline Telecommunications building block |

# Annex B

# Conformity Assessment Checklist

| IMDA TS PLC | Description | CR | Yes/No | Remarks |
|---|---|---|---|---|
| 2.6 | IEC 60950-1 or IEC 62368-1 safety standard | M | | |
| 5.1.1 | Limit transmit PSD with a dynamic power control function | M | | |
| 5.1.2 | Limit PSD Mask as shown in Figure 2 with parameters as given in Table 1. | M | | |
| 5.1.3 | Sub-carriers with frequencies (80 MHz - $F_{SC}$) ≤ $f$ ≤ (100 MHz + $F_{SC}$) shall be masked. | M | | |
| 5.2.1 | Transmit at minimum power with PSD reduction or dynamic power control implemented. | M | | |
| 5.2.2 | Typically, transmit at a PSD of less than – 80 dBm/Hz in power circuits of 10 dB insertion loss. | M | | |
| 5.3 | Comply with maximum transmit signal levels given in Table 2 when measured with methods and procedures given in § 9.2 of the EN 50561-1 or equivalent. | M | | |
| 6 | System Reference Models for PLC networking transceivers | O | | |
| 7.2 | Comply with Table 3 on requirements for conducted asymmetric disturbances below 30 MHz when measured with methods and procedures given in § 9.4 of the EN 50561-1. | O Note 1 | | |
| 8.1 | Comply with Table 4 on requirements for radiated disturbances below 30 MHz when measured according to ETSI TR 102 324. | O Note 1 | | |
| 8.2 | Comply with Table 5 on requirements for radiated disturbances above 30 MHz (IEC CISPR 22) | M | | |
| 9 | Suppress listed prohibited frequency bands. | M | | |
| 10 | Suppress listed amateur radio frequency bands. | M | | |

CR : Compliance Requirement
M : Mandatory
O : Optional
Note 1 : PLC devices shall either be tested for conducted asymmetric disturbances below 30 MHz, according to § 7.2; or be tested for radiated disturbances below 30 MHz, according to § 8.1.

# Annex C

# Corrigendum & Addendum

| Changes to the IDA TS PLC Issue 1 (August 2012) | | | |
|---|---|---|---|
| **Page** | **IDA TS Ref.** | **Items Changed** | **Date of Issue** |
| | | The IMDA TS PLC Issue 1 (October 2016) has superseded the IDA TS PLC Issue 1 (August 2012).<br><br>Changes are largely editorial to provide clarity of requirements and updates for measurements of conducted and radiated emissions from the power-line, based on standards development that has taken place in CENELEC and IEC. There is no change to the technical requirements for conformity assessment. | 1 Oct 2016 |
| 3<br>6 | § 2.3<br>§ 5.1 | The "*3 possible system reference models"* has been replaced with "2 possible system reference models" in the IMDA TS PLC, as reference to the Universal Powerline Association – Digital Home Standard (UPA-DHS) in § 5.1 is no longer available. The UPA had suspended its activities and discontinued its website. | 1 Oct 2016 |
| 5 | § 4.1.1 | The capability to limit the transmit Power Spectral Density (PSD) mask "*with tools that support power reduction or mechanisms that perform dynamic power control*" has been replaced "with the presence of a dynamic power control function". | 1 Oct 2016 |
| 5<br><br>5<br>6<br><br>6 | § 4.2<br><br>§ 4.2.1<br>§ 4.2.2<br><br>§ 4.2.3 | The sub-title "*Reduction of the Transmit PSD*" has been replaced with "Dynamic Power or PSD Control" in the IMDA TS PLC.<br><br>Deleted from the IMDA TS PLC.<br>The phrase "*transmit at minimum power*" has been replaced with "to transmit at a low output power" in § 5.2.1 of the IMDA TS PLC.<br><br>"*Typical PSD of -80 dBm/Hz in power cable length < 30m*" has been replaced by "Typically, PLC devices transmit at a PSD of less than -80 dBm/Hz in power circuits of 10 dB insertion loss" in § 5.2.2 of the IMDA TS PLC. | 1 Oct 2016 |
| 6 | § 4.3 | The sub-title "*Measurements of Limit PSD Mask and Total Transmit Power*" has been replaced with "Measurement of Maximum Transmit Signal Levels" in the IMDA TS PLC.<br><br>The "methods and procedures given in § 9.2 of the EN 50561-1 or any equivalent methods for measuring the transmitted symmetrical signal from the PLC port" has replaced the measurement methods taken from ITU-T G.9964. | 1 Oct 2016 |

| Changes to the IDA TS PLC Issue 1 (August 2012) | | | |
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| **Page** | **TS Ref.** | **Items Changed** | **Date of Issue** |
| 7 | § 6 | The sub-title "*Conducted Emission Characteristics of PLC Networks*" has been replaced with "Requirements for Asymmetric Conducted Disturbances" in § 7 of IMDA TS PLC, with measurement methods and procedures according to EN 50561-1 and limits based on CISPR 32. | 1 Oct 2016 |
| 7 | § 7 | The title "*Radiated Emission Characteristics of PLC Networks*" has been replaced with "Requirements for Radiated Disturbances" under § 8 of IMDA TS PLC, and sub-titles "Radiated Disturbances below 30 MHz" (§ 8.1) and "Radiated Disturbances above 30 MHz" (§ 8.2) added. | 1 Oct 2016 |

| Changes to the IDA RS PLC Issue 1 (August 2003) | | | |
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| | | The IDA TS PLC Issue 1 (August 2012) has superseded the IDA RS PLC Issue 1(August 2003). | 27 August 2012 |