main.net Communications

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Inquiry Regarding Carrier Current Systems	)	ET Docket No. 03-104
Including Broadband over Power Line	)	
Systems	)	
	)	

COMMENTS
OF
MAIN.NET COMMUNICATIONS LTD.

Pursuant to Section 1.415 of the Federal Communications Commission ("FCC") Rules, Main.net Communications Ltd. ("Main.net") hereby submits its comments in response to the *Notice of Inquiry* in the above referenced proceeding.[1] Main.net applauds the FCC for initiating this NOI and provides the following information on Broadband over Power Line ("BPL") and suggestions for encouraging its development.

Main.net and Its Technology. Main.net, a private company founded in 1999, is the leader in the BPL Access market. Main.net and its subsidiaries develop and market a complete, flexible, and cost-effective broadband communication solution over power lines. Main.net's PLUS (Power Line Ultimate System) technology and product line provide power utilities and operators with a cost-effective solution to provide communication services over their existing infrastructure of low and medium voltage

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1 *Inquiry Regarding Carrier Current Systems, including Broadband over Power Line Systems*, Notice of Inquiry, *ET Docket No. 03-104* (April 28, 2003) *("FCC NOI")*.

power lines as well as their communication backbone. PLUS combines both Access and In-home networks in one single, efficient system. Main.net has successfully implemented its technology in trials and commercial operations with some of the largest power companies in the world in over 60 locations in 25 countries in the United States, Europe, the Latin America, Africa, and the Middle and Far East. Today, over 150,000 homes are passed by Main.net technology and over 10,000 households are using the technology. Main.net has installed and has in operation over 20,000 BPL devices over 10,000 are Access BPL devices.

PLUS' main applications include Broadband Internet, Telephony, home networking, power management and control, and in-home advanced services (i.e. home automation, advanced on demand and multimedia applications) provided from every electrical outlet in the home without new wiring. Main.net provides fully integrated solutions that are remotely managed and controlled. Main.net's technology can be installed and operated on any type of electric grid architecture.

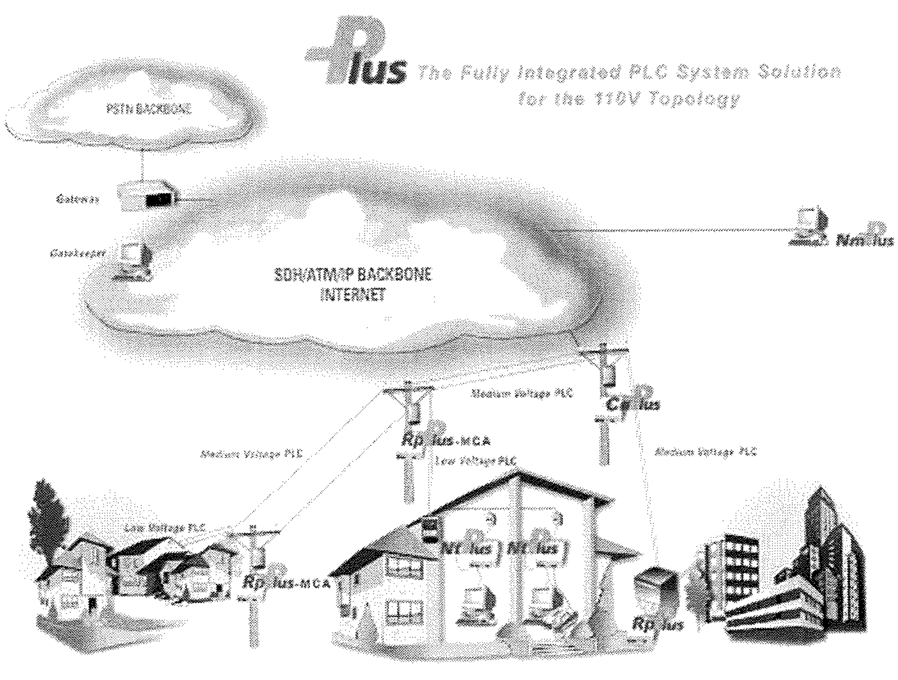
The PLUS technology is self-provisioning, allowing for fast, simple deployment. The units are remotely accessible, providing for superior customer service provisioning and upgrades. Main.net BPL devices (both Access and In-home) are remotely controlled and configurable allowing for, among other things, adjustment of the power levels and the frequencies in which they operate.

Main.net BPL system uses several types of devices:

- Medium voltage modems (PLUS-MCA™) that are coupled to the medium voltage lines using couplers.

Location	Company	Status
Cape Girardeau, Missouri, USA	Ameren UE	Three-stage evaluation of PLUS. Successful pilot project was followed by current pre-commercial deployment as preparation for mass deployment
Allentown, Pennsylvania, USA	PPL Electric Utilities Corporation	Successful pilot in Emmaus, PA was followed by current pre-commercial deployment n Allentown, PA as preparation for mass deployment
Manassas, Virginia, USA	City of Manassas	Pre-commercial rollout in the framework of a technology evaluation grant from the APPA. PLUS has proven itself as a non-intrusive, low cost, last mile solution over the city power grid
Atlanta, Georgia, USA	Southern Co.	Main.net entered into a PLC evaluation agreement with Southern Telecom, a subsidiary of Southern Co.
Mannheim, Germany	MVV Energie AG (via PPC)	Full commercial under the brandname "Vype". Reference: www.vype.de
Hameln, Germany	GWS Stadtwerke Hameln	Full commercial under the brandname "Piper-Net" Reference: www.piper-net.de
Offenbach, Germany	Energieversorgung Offenbach	Successful pilot was followed by current pre-commercial rollout under the brandname "EVO*powerline*". Reference: www.evo-ag.de
Solingen, Germany	Stadtwerke Solingen	Successful pilot was followed by current pre-commercial rollout
Dresden, Germany	Stadtwerke Dresden (DREWAG)	Full commercial under the brandname "PowerKom". Reference: www.drewag.de
Linz, Austria	Linz Strom AG (via Speed-web Consulting)	Full commercial under the brandname "Speed-Web". Reference: www.linzag.net
Gotland, Sweden	GEAB/Vattenfall	Full commercial under the brandname "ENkom". Reference: www.enkom.nu
Grosseto, Italy	ENEL	Successful pilot in Florence was followed by a large-scale advanced market test in Grosseto.
Crieff and Campbeltown, Scotland	Southern Energy (SSE)	After a successful pilot project with SSET, the telecom subsidiary of SSE, in Maidenhead and Poole, the service is presently offered to end users in Crieff and Campbeltown under the name "Broadband". Reference: www.hydro.co.uk/broadband
Paris, France	EDF	Several successful advances projects at various locations were followed by current pr-commercial rollout in Paris.
Moscow, Russia	Electrocom (partner)	Successful pilot project was followed by present evaluation for full commercial rollout.
Sao Paulo, Brazil	AES Eletropaulo	Two successful pilot projects were conducted.

- Low voltage modems (PLUS™) that include both low voltage devices that are installed outside the house over the low voltage network and In-home units that are installed inside the premises.
- Management system (NmPLUS™) which enable remote management and control of the devices that installed in the network (both Access and In-home).



Main.net's current technology (G2) provides users with an effective maximum bandwidth of 10 Mbps, with a sustainable service level of 1.5-10 Mbps. These speeds are sustainable in the network which controls the load balancing and the service fairness between users. Main.net's next-generation (G3) system will enable users to transmit and receive more than 100Mbps of shared bandwidth.

The electric wires and the PLUS technology support symmetric and asymmetric transmit and receive functions. Thus, if an end user needs all the bandwidth for upstream use and none for downstream use, the system will permit the user to allocate all of his or her capacity in the upstream direction.

Main.net's equipment operates in the spectrum portion of 2-30 MHz. Main.net has observed that operation of BPL in the spectrum above 30 MHz is less efficient, because of the greater attenuation among other factors, but Main.net is not opposed to the use of frequencies above 30 MHz (in addition to 1.75 – 30 MHz) for additional capacity. All Main.net's units are independent of the physical layer, and have the ability to integrate different physical layer/chipsets into the system. The transport and data link which is used in Main.net's system is fully transparent IP (TCP/IP, UDP/IP, PPPoE), thus enabling use of any standard application.

Main.net's current technology implements two types of physical layers: one that is based on Direct Sequence Spread Spectrum ("DSSS") and another that is based on Orthogonal Frequency Division Multiplexing ("OFDM"). In the future, Main.net may implement other chipsets using these and other modulation techniques.

Regardless of the modulation used, Main.net's PLUS system will always retain the capability to remotely configure the devices including their power level and operational frequencies.

Signals are coupled to the power line using one of two methods: coupling a voltage on the line conductors using magnetic induction; and coupling a current into the line using capacitive (electric field) induction. On a medium voltage segment one can find a varying number of conductors. Typically, the main feeder has four conductors: three phases and one neutral. The minimum number of conductors on a segment is two: one phase and one neutral. An RF signal is injected into one or more of the available conductors (including the neutral) at the location of injection.

Security in Main.net PLUS BPL is primarily performed at the MAC (Media Access Control) layer. The system is built using several levels so it can protect the network from internal hacking as well as secure the in-home device and the end-user's PC using standard DES56 encryption as well as other mechanisms. The end-user's privacy and security are ensured using different mechanisms. As the traffic is going to the Internet, we recommend that both the end user and the service provider add application layer security (as in any other broadband technology).

Interference. Main.net supports the establishment of different emission limits for Access and In-home BPL based on the difference in each one's typical proximity to broadcast receivers. This is the same rationale presently used by the FCC and other regulatory bodies to differentiate digital devices as either Class A or Class B. Typical operation of an In-House BPL could place the unit within 10 feet of a residential broadcast receiver. The typical operation of an Access Medium Voltage BPL would normally never place the unit closer than 30 feet from a residential broadcast receiver. On this basis, Main.net recommends that BPL systems be divided into two parts: Medium voltage should be defined as Class A and Low voltage (which include residential and the low voltage wiring near and inside the home) should be defined as Class B.

If we assume that the above estimated separations between BPL and broadcast receivers are reasonable, then even using a (20 log D1/D2) extrapolation, we have shown a reasonable case for a (9.5) dB difference in limits between Access and In-House BPL.

Main.net's technology works in such a way that, even if hundreds of units are installed, only one unit is transmitting on any given frequency at any given time in an area. Therefore, the measured emission of one unit is equivalent to that of the entire system.

There have been no interference issues with ADSL or cable service. ADSL operates below 1.1 MHz, which is below the frequency the Main.net's BPL product. In some cases, cable systems operate on frequencies that overlap with BPL service, but interference is prevented because cable and electrical wiring is always installed with sufficient physical separation for safety reasons. In addition, cable wiring is shielded and insulated.

Although there is some theoretical concern regarding interference to Amateur Radio operations below 30 MHz, Main.net's experience, including operation in the homes of active Amateur Radio licensees, has been that there is no interference. Part of the reason for this is likely that Amateurs typically install their antenna outside.

Testing for FCC Part 15 compliance of Main.net BPL products has been performed by a third-party test laboratory for both Access BPL and In-House BPL products. This testing was completed at 3 typical residences for the In-House BPL products and repeated at 3 typical medium voltage locations for the Access BPL products. The following is a brief description of those tested systems and the corresponding conclusions:

The In-house BPL units were tested in 3 homes. *See* test report 02F247. The test homes were chosen such that the electrical service feeds were a mixture of both overhead and underground. Emissions data was collected between 2-500 MHz at a minimum of 14 equidistant azimuths at a 10 meter distance around the periphery of the home under test. One In-house unit was communicating via an AC outlet located on an exterior wall and the second unit was communicating via an AC outlet separated by at least 20 feet. The test units were communicating at their maximum data rate.

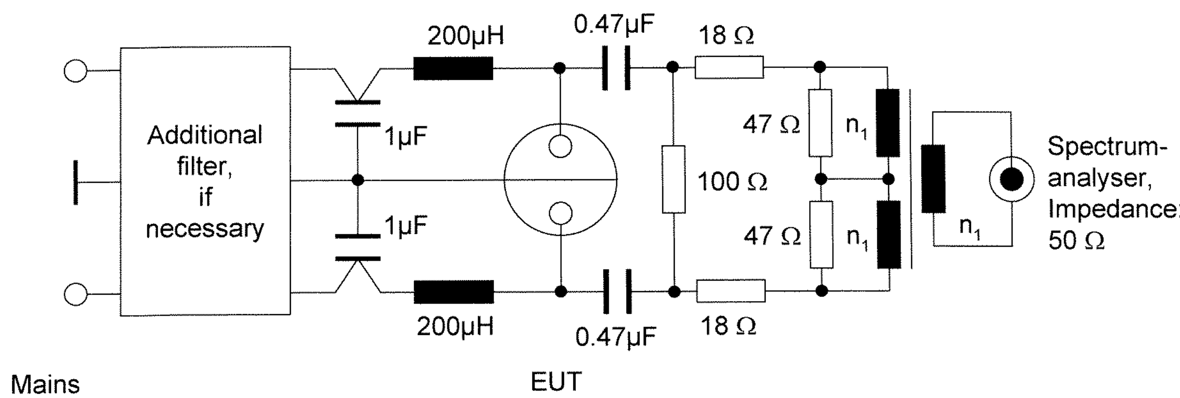
The Access BPL units were tested while installed in a mixture of both overhead and underground installations resulting in 3 distinctly different distribution environments. *See* test report 02F409S. Emissions data was collected between 2-500 MHz at a minimum of 14 equidistant azimuths/spacing at 10 meter distance from the electrical wires under test. One unit was communicating via a secondary electrical service drop and the second unit was communicating via various locations of the medium voltage system. The test units were communicating at their maximum data rate.

Main.net's technology does not require the use of any band pass filter, so there are none of the interference concerns associated with using band pass filters.

In the currently installed equipment (which is based on spread spectrum modulation) under the experimental license as well as in Main.net's next generation technology (which is based on OFDM modulation), notches can be defined remotely, so that the system will not transmit in any frequencies where there is an official request regarding interference. This notching is controlled by software and can be done remotely.

Interference measurement methods. Main.net recommends different measurement methods for low voltage and medium voltage BPL systems. Main.net recommends that conducted emission tests provide sufficient data for low voltage BPL equipment. For medium voltage equipment, the radiated emission measurement should be used. The Access BPL measurement method shall be an open-area test site using a characteristic wiring assembly. The testing should include the complete set of BPL device, coupling device and the wiring.

For low voltage BPL systems, conducted emission limits should be measured by LISN as described below:

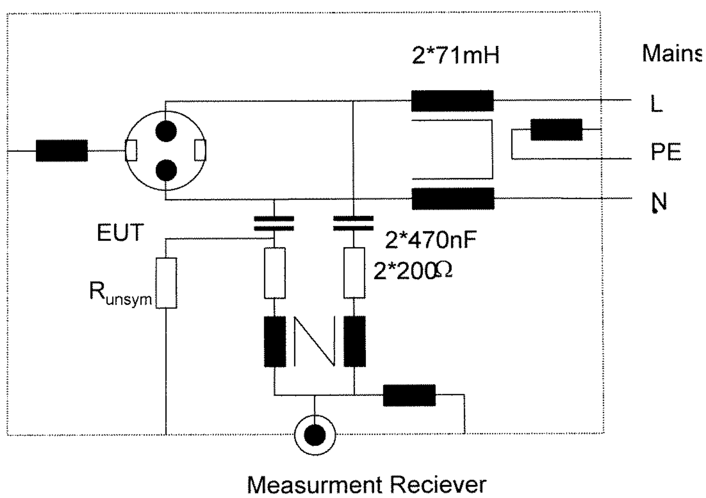


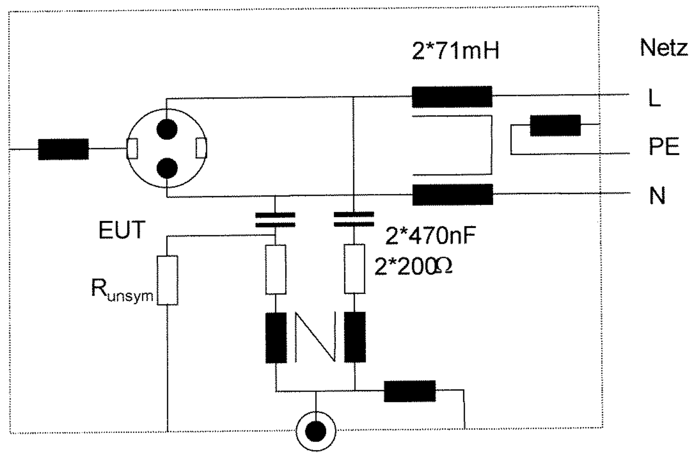
Line impedance stabilization network (LISN) for measurement of conducted emission

The conducted emission limits should be –40dBm/Hz measured using quasi-peak detector at a bandwidth of 9 KHz. As explained in a technical paper by Prof. Hirsch (attached as Appendix A), - 40 dBm/Hz is the typical level of background noise produced by Ethernet cabling, which is widely deployed in the home and office indoor environment and has not produced any known interference problems. The Hirsch paper describes measurements of BPL that are consistent with the results Main.net measured in its U.S.

deployments. The Hirsch paper provided key inputs to the most current draft CISPR standards (attached as Appendix B) which provides further useful information regarding measurement techniques.

In addition, for low voltage network, Main.net recommends using the T-ISN mode of measurement, which simultaneously measures the total effect of the common-mode and differential-mode contributions in proportion to their expected respective contributions to radiated emissions. In the T-ISN, we assume, based on measured data, that the common mode rejection ratio of the low voltage line is greater than 30dB. *See* Appendices A and B.





Together with the 50 Ohms input impedance, an asymmetric impedance of 150 Ohms is reached. However, this impedance is decreased by the R_{unsym}. A common mode choke (to optimize the frequency characteristics some chokes are placed in series) builds the high frequency differential mode necessary for an effective decoupling system between the EUT- and the electricity input (mains). The resistor R_{unsym} value should be fixed in order to create an LCL value of 30dB. A symmetric termination is solely reached by the connection to the electricity input (mains) and the connected consumers. The measurements are performed in a shielded with net filters equipped cabin, so that the net lines do only have a few branch outs of short length.

Medium voltage should be tested in an open area test site with characterized pole wire assembly including at least two poles and two wires at list (Neutral, Phase), coupling devices, modem, and all the equipment which is part of the installation, as the measurement can be done only for the complete set of devices and not only for the BPL unit itself.

Intramodal, intersystem interference and standardization issues.

The FCC also should impose out-of-band emissions limits on power line carrier systems that operate below 1.7 MHz, to prevent these systems from causing interference to BPL systems in the future. The same out of band limits that apply to other unlicensed device would be appropriate.

In Europe there is an official procedure for CE-marking of PLC-equipment referring to this committee-draft. This procedure has high support of the European Commission. According to this procedure, different Access BPL product (e.g.. Main.net) and In-home BPL product (e.g. HomePlug) are being CE-marked and sold commercially in the European market. IEEE (Institute of Electrical and Electronics Engineers) is an organization that deals with developing standards and bench-marks of electrical and electronics systems. IEEE is currently engaged in the study of PLC and BPL systems under the jurisdiction of the Power Systems Communication committee (a group under the Power Engineering Society of IEEE). Based on the current information available to us, this committee is aware of developments by CISPR and is working for the adaptation of these standards to the U.S. systems.

Conclusion

Based on the foregoing, Main.net urges the Commission to continue to take actions that support the rapid deployment of BPL technology.

Respectfully submitted,

Main.net Communications Ltd.

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July 7, 2003

Appendix A

The degree of difference in radiated emissions from houses and buildings when In-House PLC signals are injected in common mode (phase/neutral to an RF ground) versus differential mode (phase to neutral)

Author: Prof. Hirsch, University of Dortmund, Germany

Introduction

Due to the installation practise of low voltage distribution networks (LVDN) within the users' premises, the HF characteristics of these networks are not well defined. Therefore possible radiation when used for Powerline Communications (PLC) is often object of controversial discussions. This article depicts the development of the standardization activities at CISPR dealing with the EMC related issues of PLC. The general understanding of standardisation aims and procedures are taken into account.

I. PROCEDURE FOR THE EVALUATION OF THE DISTURBANCE POTENTIAL OF ELECTRICAL PRODUCTS

In principle, the field strength (electric and/or magnetic) can be measured at a well defined test site for the evaluation of the radiation produced by any electrical product. Common standards published by CISPR follow this approach for frequencies above 30 MHz. Below 30 MHz the disturbance field normally is not produced by the equipment itself, but by the lines attached to the equipment. The structures of the connected lines influence strongly the radiation characteristic. On a test site a nearly realistic radiation is established only, when the length of the connected lines are sufficient for the observed wave length. Due to the finite dimensions of test sites the cables can not lay out as straight lines, which result in a lack of reproducibility. Therfore CISPR follows another approach for frequencies below 30 MHz.

If the connected lines can be characterised in a sufficient manner, the disturbance voltage, disturbance current or disturbance power at every connection port of the equipment can be used as measure for radiation. In the beginning of EMC-standardisation different artificial mains networks have been defined. In newer standards usually a V-shaped network is used. With this the unsymmetric voltage can be measured and compared to corresponding limits. Beside this unsymmetrical signal a symmetrical and asymmetrical signal can be measured in a two-wire-system. Figure 1 shows the relationship between the three signals.

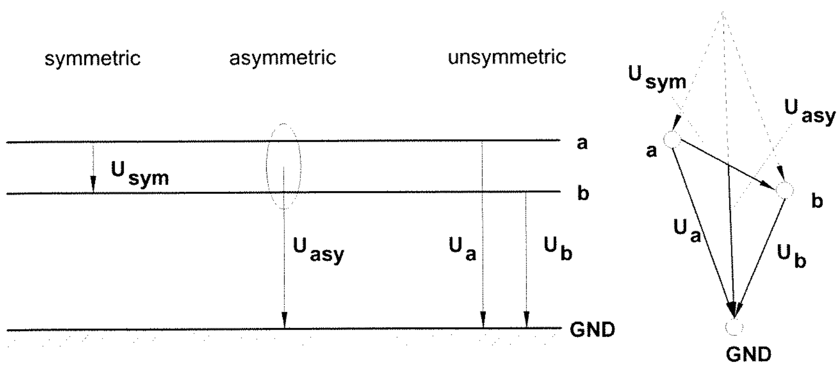


Figure 1 relationship between unsymmetric, symmetric and asymmetric voltages in a two-wire-system

Due to the compensation of the fields generated by symmetrical signals, the radiation is mainly represented by the asymmetric signal. Consequently the asymmetric disturbance voltage is measured in the case of telecommunication ports with a T-shaped network.

The unsymmetry within networks partly transforms energy from the symmetric to the asymmetric mode. Therefore the magnitude of the symmetric mode together with a measure for the asymmetry of the network is also relevant for radiation. A common used measure for asymmetry is the longitudinal conversion loss (LCL) defined by ITU G.117. Consequently a T-shaped network representing the network has also a defined LCL.

II. NECESSITY OF STANDARDISATION

A product which is to be put on the EU market must fulfil the EMC directive 89/336/EC, which is adopted by national law in each member state. The directive defines the legal frame only. The technical requirements are deemed to be fulfilled, if harmonised EMC standards are fulfilled. For information technology equipment the emission aspects are covered by EN 55022 (mostly identical to CISPR-22). Therefore this standard gets nearly legal importance.

CISPR-22 does not cover the special demands of PLC-systems. It only defines methods and limits for the mains port (port that is used for power supply) as well as methods and limits for telecommunications ports.

Intended and unintended PLC signals

PLC technology uses the same line (here: mains line) both as power supply as well as for IT transmission. This technology is operating with its principles since many decades in several systems as e.g.:

- ripple control
- home automation e.g. temperature control, shutters control, electrical load management
- 2-wire-interface for sensors in industrial environment
- in-house audio transmission (e.g. baby phones)
- signalling on low voltage installations IEC 61000-3-8

All these systems have in common that there are existing product standards defining the intended signal. In most cases, these standards include also measures for radio protection. But there is always a clear distinction between intended and unintended signal.

Back to PLC, the proposal to use the V-NETWORK, in CISPR named artificial mains network (AMN), would mix the symmetrical and the asymmetrical signal components when measuring. The symmetrical signal components are less relevant for radiation whereas the asymmetrical signal components are highly relevant.

For a "standard" device (e.g. washing machine), that is only connected for power supply to the mains, measuring with V-NETWORK is appropriate, as both signal components, symmetric and asymmetric, are not intended and are therefore categorized as interference, whereas usually the symmetrical signal component of ITE products is intended for transmitting the signal via the connected line (please refer to figure 2).

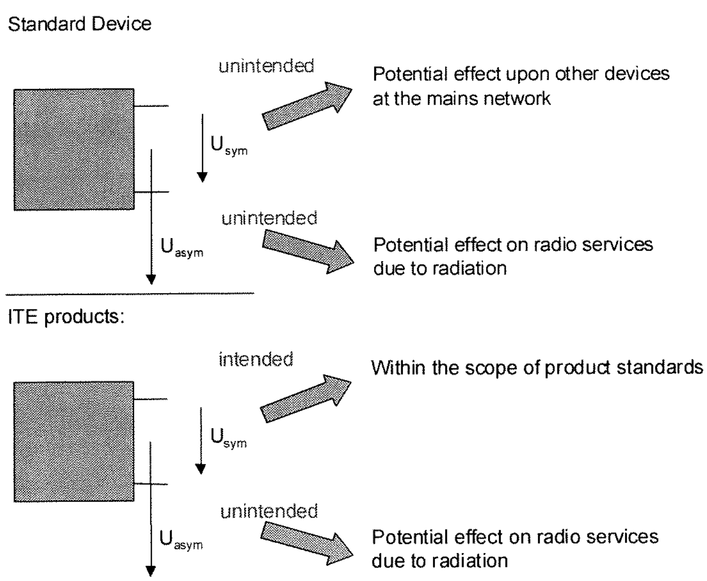


Figure 2: Different consideration of symmetrical and asymmetrical signal components

The resulting radiation by a symmetrical signal at an arbitrarily chosen measuring point is very low due to obliteration of its components. In distinction, the resulting radiation by an asymmetrical signal is much higher (please refer to figure 3).

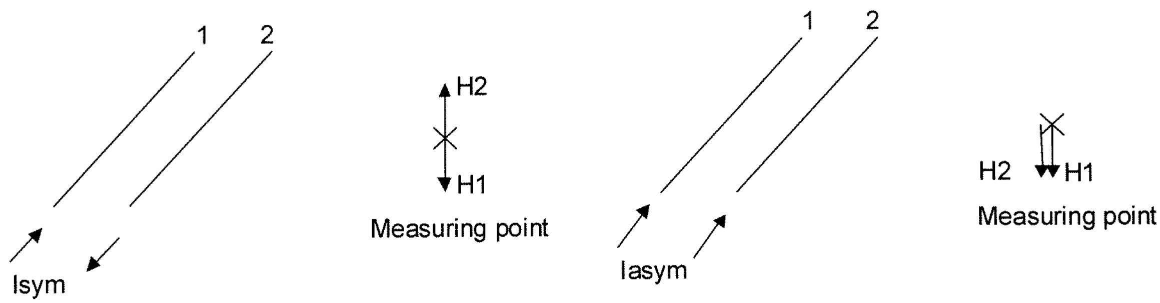


Figure 3: Resulting radiated field strengths causes by symmetric and asymmetric signals

In conclusion, to achieve the aim of radio interference protection, PLC systems shall be regulated by limits for asymmetrical signals. This approach, radio protection and fair competition, was followed when putting forward the actual standardisation activities at CISPR.

There are many other examples within IEC and CENELEC that follow the same approach. E.g. IEC 61000-6-3:1996 (prEN 61000-6-3:2001) defines limits for asymmetrical, unintended signals generally for signal and control ports, including connection to networks. These limits are identical with CISPR 22 class B telecom port limits.

III. RADIO PROTECTION BY LIMITING THE RADIATION

The key for this consideration is the coupling factor. The PLCforum defined the measuring method and performed lots of measurements at different locations. This was coordinated by University of Karlsruhe. The results were evaluated statistically (please refer to figure 4).

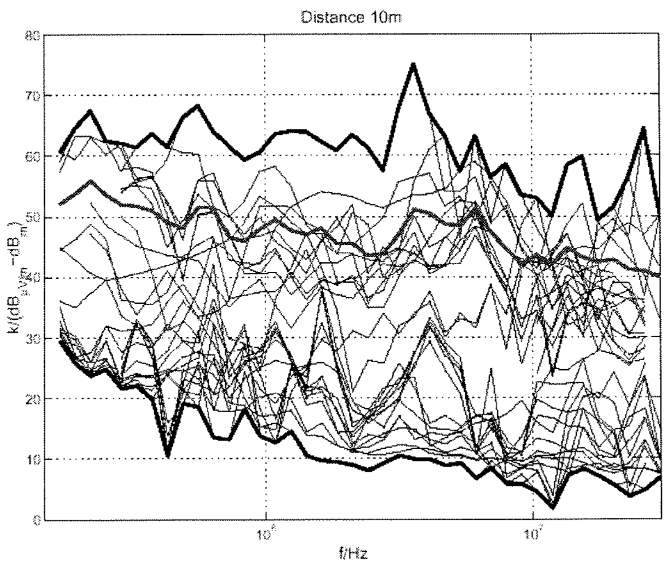


Figure 4: Coupling factor at a 10m distance to the PLC installation

In figure 4, the blue curves are individual measurements. The black are minimum and maximum. The red curve is the statistical evaluation based on the non-centralized t-spreading. With a probability of 80%, 80% of the coupling factors of all installation are below this red curve. For compliance testing of serial IT products according to CISPR 22, the same statistical approach is used.

In Europe, the general limits for radiation caused by communication networks are currently discussed in the ETSI/CENELEC Joint Working Group. This process was initiated by the European Commission with their mandate M313/2001. The so called NB30 limits, according to a former German by-law, are only one proposal within this discussion. As the mandate requires also harmonisation with existing product standards, the basic question is:

Will products, which have been tested to be compliant with CISPR22, at the same time meet the proposed radiation limits according to the former NB30?

This question can be answered with “yes” for products which use the mains for power supply only. For products using the telecom port, the answer is a clear “no,” as also shown in a paper by the German RegTP (please refer to figure 5).

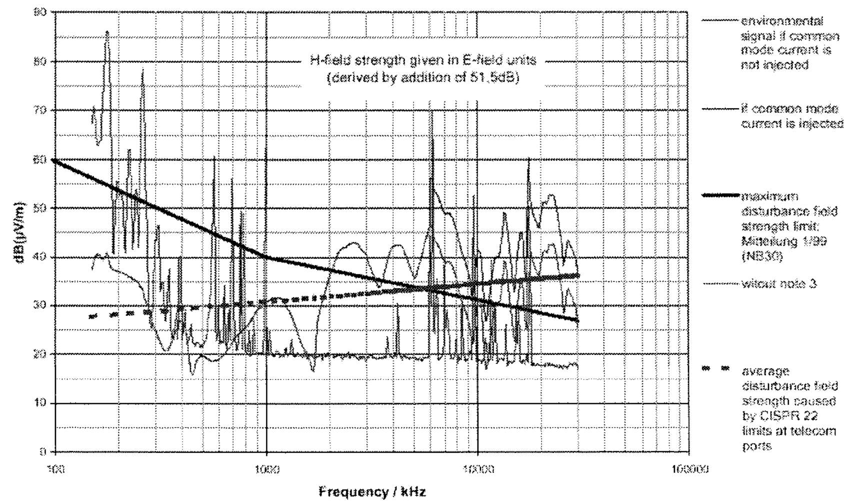


Figure 4: Magnetical field strength 8 m from office building of RegTP (Kolberg, room 17) if the injected asymmetrical current level is equal the limit of CISPR 22:11/97

Figure 5: Measuring results performed by RegTP at telecom lines (contribution CISPR/G/WG1(TFxDSL)2000-10)

These measuring results show e.g. that at 30 MHz the actual radiation of IT systems, tested in compliance to CISPR 22, is 17dB above NB30 limits. These results also show that obviously the resulting radiation is different when devices are compliant to CISPR 22 radio protection aims on mains and on telecom port (please refer to figure 5).

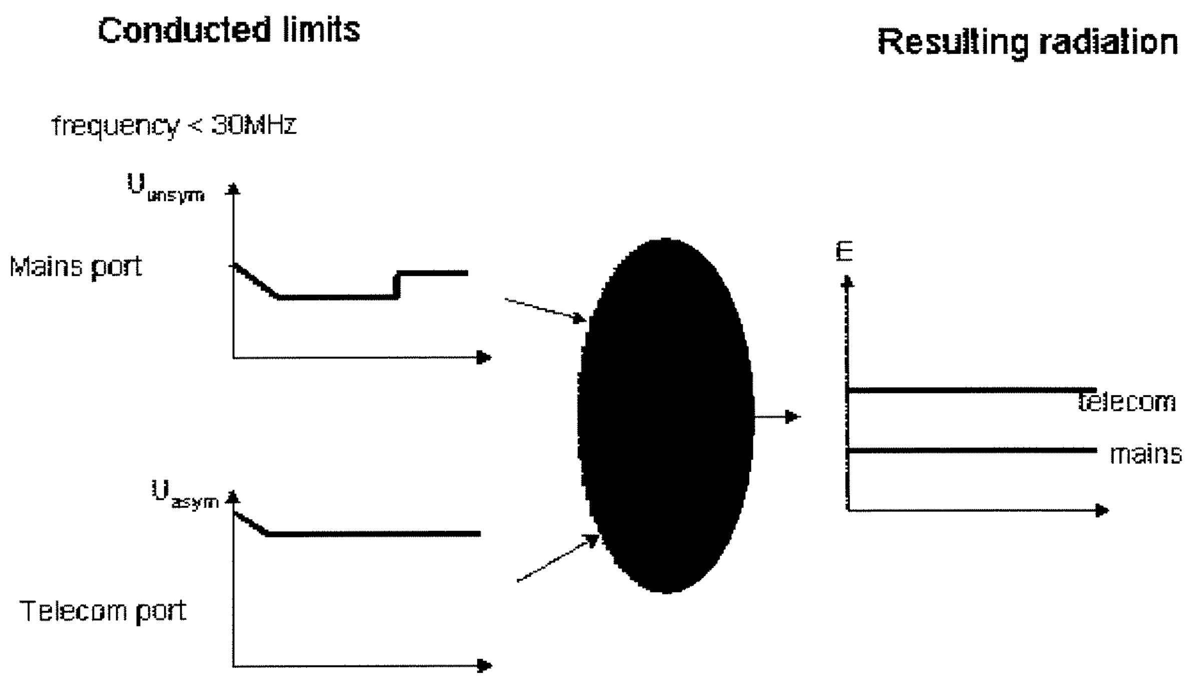


Figure 5: Limits for conducted emissions due to CISPR-22 actually result in different radiation caused by devices on mains or on telecom port

Adopting the principle of equal and fair treatment for PLC systems within the telecommunication sector, it hence appears appropriate to implement the same radio protection aims for PLC as for other telecommunication systems. This approach is the background of the actual standardisation process at CISPR.

IV. IMPEDANCE AND SYMMETRY OF LOW VOLTAGE DISTRIBUTION NETWORKS

CISPR 22 defines to use a T-ISN to model the asymmetric impedances as well as the symmetry behaviour of telecommunication lines. The asymmetric impedances actually are about the same in LVDN and telecommunication networks (please refer to the measuring results shown in figure 7).

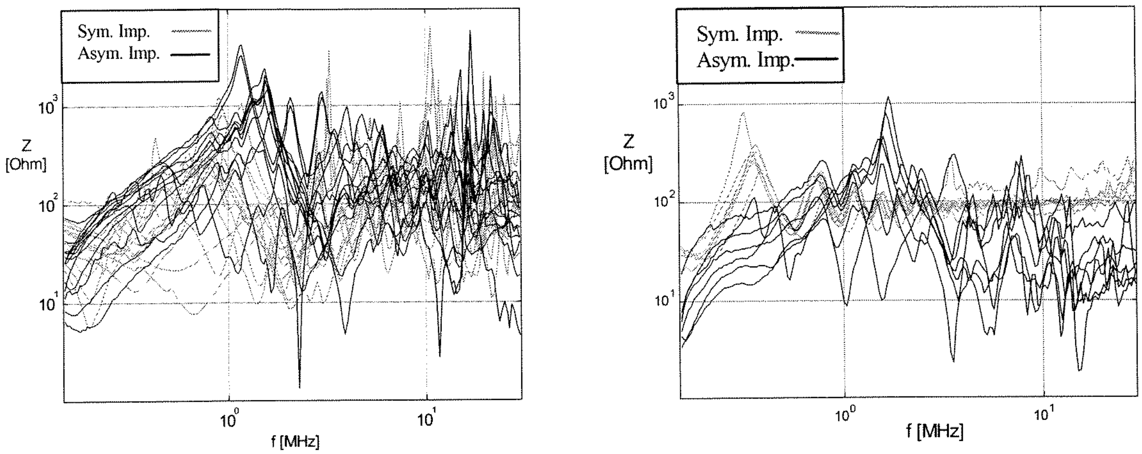
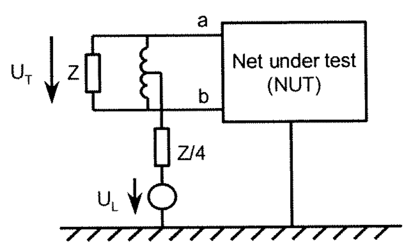


Figure 7: Impedance measured at low voltage distribution networks (left side) and at telecommunication networks (right side).

The symmetry of telecommunication networks is measured using the LCL (Longitudinal Conversion Loss) approach according to ITU-G117 (please refer to figure 8).



$$LCL = 20 \cdot \log\left(\frac{U_L}{U_T}\right)$$

Figure 8: Definition of the LCL

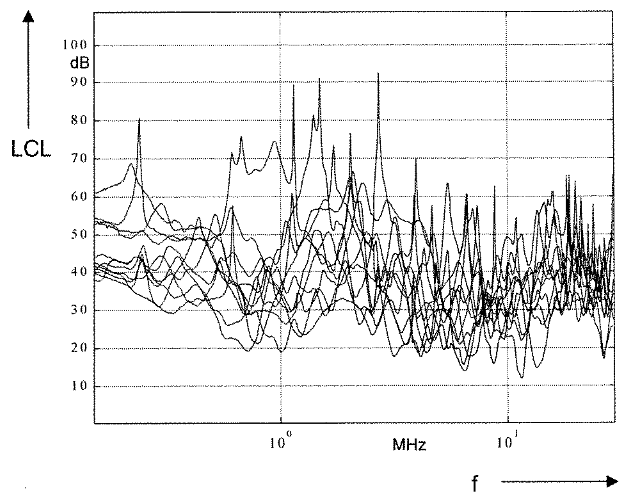


Figure 9: LCL-measuring results in a building of University of Dortmund

The LCL measuring results were done at many different sites in different countries. Figure 9 shows one example measured at University of Dortmund. The results were evaluated statistically which led to the proposal of 30 dB by University of Dortmund and of 36 dB after evaluating the increased database with results from other countries.

Conclusion

The principle of having technology neutral regulation in the telecommunication sector requires the same radio protection aims for all telecommunication systems, independent whether they operate on telecom wiring or on power lines. A CISPR Working Group proposed in February 2002 an amendment to CISPR 22 following this principle and using identical methods for all networks to define the parameters (impedance, symmetry). Therefore, operation of PLC systems will cause the same resulting radiation with the same probability as IT systems operation on telecommunication lines, which are compliant to CISPR 22. Details of the amendment are discussed with passion but the illustrated principles of the approach are widely accepted.

Appendix B

DKE Deutsche Kommission
Elektrotechnik Elektronik Informationstechnik
im DIN und VDE

Deutsches Mitglied in IEC und CENELEC

DKE
VDE DIN

VDE – DKE · Stresemannallee 15 · 60596 Frankfurt am Main

767.15_0168-2002

Rundschreiben Nr. **767.17_0223-2002**

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IEC-Schriftstück **Projekt: IEC CISPR 22 Amd.2 f9 Ed.3.0**
IEC CIS/I/44/CD
"Amendment to CISPR 22: Clarification of its application to telecommunication system on the method of disturbance measurement at ports used for PLC (Power Line Communication)"

Sehr geehrte Damen und Herren,

als Anlage übersenden wir Ihnen den im Betreff genannten Committee Draft, zu dem das Central Office der IEC um Stellungnahme bis zum **18.10.2002** gebeten hat.

Bitte senden Sie Ihre Beantwortungsvorschläge und Hinweise in englischer Sprache zu dem genannten Schriftstück unter Verwendung des Formulars DKEF08C.Doc bis spätestens **20.09.2002** an den Deutschen Sprecher

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Den Deutschen Sprecher bitten wir, uns bis spätestens **04.10.2002** eine gesammelte, zur Weitergabe an die IEC geeignete Stellungnahme in englischer Sprache unter Verwendung des Formulars DKEF08C.Doc möglichst über E-Mail oder auf Diskette zu übermitteln.

Hinweis: Das Formular DKEF08C.Doc kann von der DKE-Homepage www.dke.de unter der Adresse: "http://www.dke.de/de/gstelle/mitteilungen/schriftstuecke.htm" heruntergeladen werden.

Mit freundlichen Grüßen

DKE Deutsche Kommission
Elektrotechnik Elektronik Informationstechnik
im DIN und VDE
Referat UK 767.17
für Herrn Klaus-Peter Bretz

gez. Delia Pätzold, Sekretärin

Anlage

CISPR/I/44/CD

COMMITTEE DRAFT (CD)

IEC/TC or SC: CISPR/I	Project number CISPR 22 Amd.2 f9 Ed.3	
Title of TC/SC: EMC of Information technology, multimedia equipment and receivers	Date of circulation **2002-07-12**	Closing date for comments **2002-10-18**
Also of interest to the following committees CISPR/A, CISPR/H	Supersedes document CISPR/G/218/CDV, CISPR/I/1/INF CISPR/I/26/DC, CISPR/I/33/INF	

Functions concerned:
☐ Safety ☒ EMC ☐ Environment ☐ Quality assurance

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Title:
Amendment to CISPR 22: Clarification of its application to telecommunication system on the method of disturbance measurement at ports used for PLC (Power Line Communication)
(Titre) :

Introductory note
In CISPR 22, conducted disturbances of ITE are measured at the mains port and at the telecom port. PLC modems however use one port only for both purposes (mains power supply and telecom). This leads to the definition of the **Multi Purpose Port**[1] for PLC.

The current document is based on the principle that PLC equipment is required to meet the same radio protection limits as any other wire bound communication system. The interference potential at the multi purpose port is thus measured twice:

1) in its function as a power consumer (i.e. communication function disabled) using the familiar V-network and limits in tables 1 and 2 of CISPR 22 and;
2) in its function as telecom device using the T-network specified within this document and applying the limits in tables 3 and 4 of CISPR 22.

National committees are advised that this application of separate limits for the different functions is a new approach in CISPR/I and are asked to comment on this approach.

The test methods proposed are based on the principle that:

- A consumer appliance power supply is an unsymmetrical source of disturbance in which case a V-network (AMN) is suited to determine the interference potential.
- In contrast a telecom device is engineered to be a symmetrical source where the common mode signal, which is the cause for radiation, is much smaller than the differential mode signal. A T-ISN is suited to measure the common mode voltage, accounting for the conversion of differential to common mode due to a defined unbalance (LCL) representative of the appropriate network performance.

National committees are advised that this document includes some specific test methods and CISPR/I is looking for guidance as whether this work (which is specific to PLC) should be transferred to CISPR/A.

A Task Force of CISPR/I/ WG3 is mandated to determine the LCL function suitable for low voltage power distribution networks.

This CD is based on CISPR/I/33/INF (compilation of comments on CISPR/I/26/DC) and decisions at the CISPR/I WG3 meeting held on 27 - 28 June 2002 in Red Bank.

[1] not defined in CISPR 22:1997 but defined in this CD

Amendment to CISPR 22: Clarification of its application to telecommunication system on the method of disturbance measurement at ports used for PLC

Change the following paragraphs as follows (changes/additions underlined):

Add new paragraph 3.7 to read as follows
3.7 Multi Purpose Port
A port, connecting to low voltage distribution networks supporting data transfer and telecommunications, which combines the functions of the telecommunication port and the mains port.

Change paragraph 5 to read as follows:
5 Limits for conducted disturbance at mains ports, multi purpose ports and telecommunication ports

The equipment under test (EUT) shall meet the limits in tables 1 and 3 or 2 and 4, as applicable. Multi purpose ports have to be measured twice:

a) with the communication functions inactive using an AMN in conjunction with the limits of tables 1 or 2 and
b) with the communication functions active using a T-ISN in conjunction with the limits of tables 3 or 4.

Meeting the limits shall include the average limit and the quasi-peak limit when using, respectively, an average detector receiver and quasi-peak detector receiver and measured in accordance with the methods described in clause 9. Either the voltage limits or the current limits in table 3 or 4, as applicable, shall be met except for the measurement method of C.1.3 where both limits shall be met. If the average limit is met when using a quasi-peak detector receiver, the EUT shall be deemed to meet both limits and measurement with the average detector receiver is unnecessary.
If the reading of the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the higher reading shall be recorded with the exception of any brief isolated high reading, which shall be ignored.

Change Headline of paragraph 5.1 to read as follows:
Limits of disturbance voltage of mains terminals and multi purpose ports with communication functions inactive.

Change Headline of table 1, paragraph 5.1 to read as follows:
Table 1 – Limits for conducted disturbance at the mains ports and at multi purpose ports with communication functions inactive of class A ITE.

Change Headline of table 2, paragraph 5.1 to read as follows:
Table 2 – Limits for conducted disturbance at the mains ports and at multi purpose ports with communication functions inactive of class B ITE.

Change Headline of paragraph 5.2 to read as follows:
5.2 Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports and multi purpose ports with communications functions active.

Change Headline of table 3, paragraph 5.2 to read as follows:
Table 3 – Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports and multi purpose ports with communications functions active in the frequency range 0,15 MHz to 30 MHz for class A equipment.

Change Headline of table 4, paragraph 5.2 to read as follows:
Table 4 – Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports and multi purpose ports with communications functions active in the frequency range 0,15 MHz to 30 MHz for class B equipment.

Change Headline of paragraph 9 to read as follows:
9 Method of measurement of conducted disturbance at mains ports, multi purpose ports and telecommunication ports

Change the last sentence of 9.4 to read as follows:

A telecommunication port or a multi purpose port is connected by its signal cable to a T-ISN

Change the headline and the first paragraph of 9.5 to read as follows:
9.5 Measurement of disturbances at telecommunication ports and multi purpose ports

The purpose of these tests is to measure the common mode disturbance emitted at the telecommunication ports and multi purpose ports of an EUT.

Change the last sentence of paragraph 9.5.1.1 to read as follows:
9.5.1.1 Alternative 1

...

In cases of dispute the method of conformance in 9.5.1.2 takes precedence for telecommunication ports intended to be connected to category 3 and category 5 cables (see ISO/IEC 11801) or for multi purpose ports connected to low voltage distribution networks.

Add to paragraph 9.5.1.2 following the last sentence:
9.5.1.2 Alternative 2

...

For multi purpose ports intended to be connected to low voltage distribution networks the measurement is made using a T-ISN with an LCL as defined in c) 4) of 9.5.2.

Add to paragraph 9.5.2 an option c)4) to specify a T-shaped ISN for PLC equipment:
9.5.2 Impedance stabilisation network (ISN)

...

c)4) T-ISN for method of conformance alternative 2, multi purpose ports for low voltage distribution networks

The longitudinal conversion loss (LCL) shall be:

- 150 kHz to 30 MHz: 36 dB +/- 3dB

Change the headline of 9.5.3 to read as follows:
9.5.3 Measurement at telecommunication ports and multi purpose ports

Add a new paragraph 9.5.3.6:
Measurement at multi purpose ports intended for connection to low voltage distribution networks

The measurement method of C.1.5 shall be used.

Contributions of AE equipment to the measured levels of EUT mains disturbances shall be minimised. Therefore, PLT terminal adapter or PLC network simulator transmissions shall be adjusted to the minimum levels necessary to exercise the normal PLT transmission functions of the EUT. Bonding to the metal reference plane, or insulation from it, shall duplicate normal usage.
EUT mains supply ports that are NOT used for PLC shall not be measured for disturbances in the way illustrated above but shall be measured, and shall comply with the relevant mains disturbance limits, using an AMN as specified in clause 9.2.
The terminals of the T-ISN will be, in general, at mains potential. For operator safety they shall be insulated or otherwise made inaccessible.

Change first sentence of paragraph C.1 in Annex C to read as follows:
These test methods and test set-ups are used for multi purpose ports (C.1.5) or for cases where ISNs specified in 9.5.2 are not applicable.

Add C.1.5 to paragraph C.1 of Annex C to read as follows:
C.1.5 shall be applied to low voltage power distribution networks.

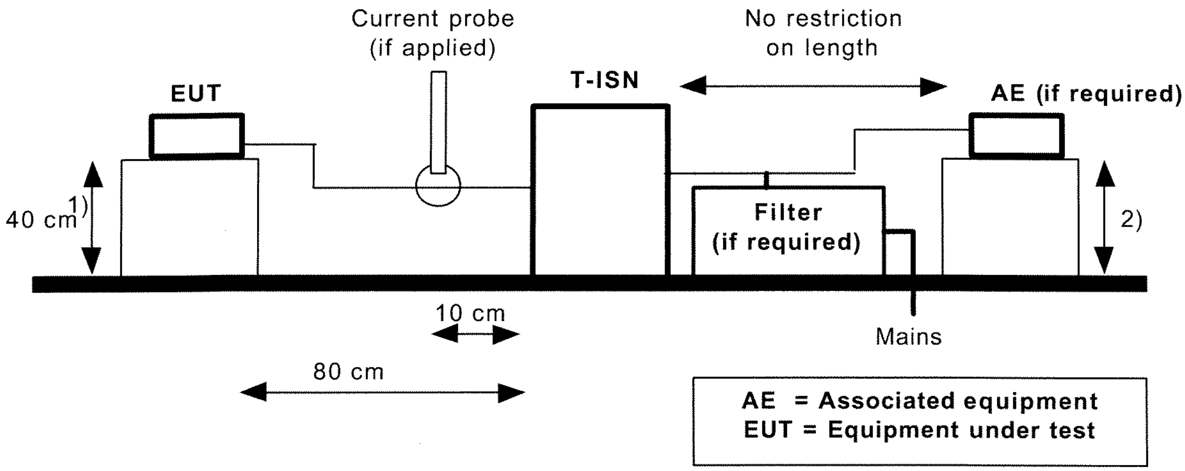
Add title and text of subclause C.1.5 to read as follows:

C.1.5 Using T-ISN

- Connect T-ISN directly to reference groundplane.
- If voltage measurement is used, measure voltage at the measurement port of the T-ISN, correct the reading by adding the voltage division factor of the T-ISN, and compare to the voltage limit.

- If current measurement is used, measure current with the current probe and compare to the current limit.
- It is not necessary to apply both, the voltage and the current limit if a T-ISN is used.
- A 50 Ω load has to be connected to the measurement port of the T-ISN during the current measurement.

Add figure C.5 to look as follows:



1) Distance to the reference groundplate (vertical or horizontal)
2) Distance to the reference groundplate is not critical

Figure C.5: Compliance test set-up

Add the following paragraph after figure C5.

To ensure that at any test frequency unwanted signals existing on the supply mains do not affect the measurement, an additional RF low-pass filter may be required, inserted between the T-ISN to AE connection and the supply mains. The recommended attenuation of this filter is at least 40 dB over the frequency range from 150 kHz to 30 MHz for both the differential-mode and the common-mode voltages. With this filter inserted, the impedance requirements given below shall be met. The components forming this filter shall be enclosed in a metallic screen directly connected to the reference earth of the measuring system. The voltage drop of the RF low-pass filter shall comply with clause 5.1.8 of CISPR 16-1:99.

The differential-mode impedance presented by the RF low-pass filter to the T-ISN and to the AE, from 1.6 to 30 MHz, has to be at least 20 times the differential-mode impedance of the EUT in transmit mode or the AE in receive mode, whichever is the largest.

The T-ISN shall have the following properties:

a) The common mode termination impedance in the frequency range 0,15 MHz to 30 MHz shall be 150 Ω ± 20 Ω, phase angle $0^0 \pm 20^0$.

b) The T-ISN shall provide sufficient isolation against disturbances from an AE. The attenuation of the T-ISN, for common mode current or voltage disturbances originating from the AE, shall be such that the measured level of these disturbances at the measuring receiver input shall be at least 10 dB below the relevant disturbance limit.

The required isolation is at least:

- 150 kHz to 1,5 MHz > 35 dB to 55 dB, increasing linearly with the logarithm of the frequency
- 1,5 MHz to 30 MHz > 55 dB.

Note – Isolation means the decoupling of common mode disturbance originating in an AE and subsequently appearing at the EUT port of the T-ISN.

c) The T-ISN implements an LCL of 36 dB ± 3 dB in the whole frequency range.

NOTE 1 – The above specification of LCL versus the frequency (c) is an approximate representation of the LCL between phase and neutral of typical mains networks as installed in representative environments. Such specifications are under continuing study and open to future modification.
NOTE 2 – The LCL is defined in accordance with the ITU-T Recommendation G.117: 1996.

d) The attenuation distortion or other deterioration of the signal quality in the wanted signal frequency band caused by the presence of the T-ISN shall not significantly affect the normal operation of the EUT.
e) If a voltage port on the T-ISN is available then the accuracy of the voltage division factor shall be within ±1,0 dB. The voltage division factor is the difference between the voltage appearing across the common mode impedance presented to the EUT by the T-ISN and the resulting voltage appearing across a receiver input attached to the measuring port of the ISN, expressed in decibels. For example, for a 150 O common mode impedance and a 50 O receiver input, the voltage division factor is given by 20 $\log_{10}$ (50/150) = -9,5 dB

Change title of figure C.5 to read as follows:

Figure C.6 – Calibration fixture

Add Figure D.5 with note to annex D as follows:

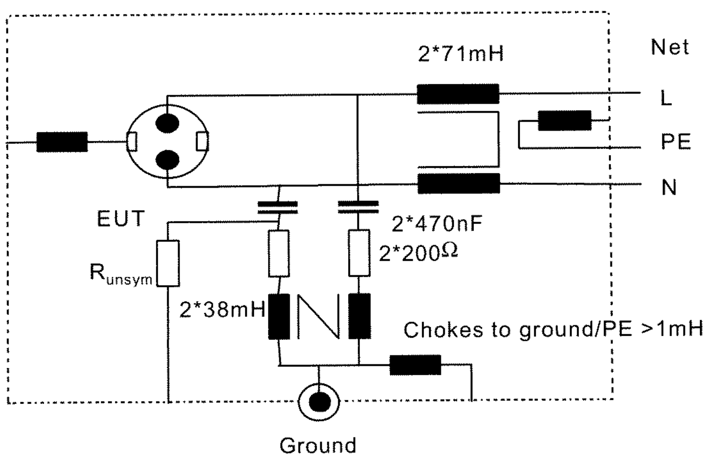


Figure D.5 T-ISN for use with power distribution networks

Note: By calibrating the resistor Runsym, the desired LCL can be achieved. This calibrating is necessary due to tolerances within the characteristics of the used chokes. The method for calibrating the ISN is to adjust the resistor while measuring the LCL of the ISN with the same method as used for the power network. If the desired LCL is reached, the value of Runsym is frozen.

Annex A
(informative)

Justification of LCL figure quoted

A.1 Documented data on LCL measurements for national committees to make an informed decision on the proposed LCL value

A measurement campaign is being performed in various countries, in order to determine the LCL of real electricity networks.
Figure A.1 shows results obtained up to the date for in-home electricity networks. The basic theory of LCL measurements can be found in the ITU-T Recommendations G.117 (02.96) and O.9 (03.99). The practical measurements are carried out according to the method described by Ian P. Macfarlane in IEEE Transactions on electromagnetic compatibility, Vol. 41, No. 1, February 1999. This method is by no means new. It was first described by Macfarlane in 1988 to CISPR Subcommittee G Working Group 2. It was developed to assist that WG's consideration of measuring methods at balanced signal ports of Information Technology Equipment for a revision of CISPR Publication 22. Since then it is considered a well proven method by the EMC community. According to the experience of the contributors to this paper, the Macfarlane methodology is also well suited to LCL measurement on low voltage distribution networks.

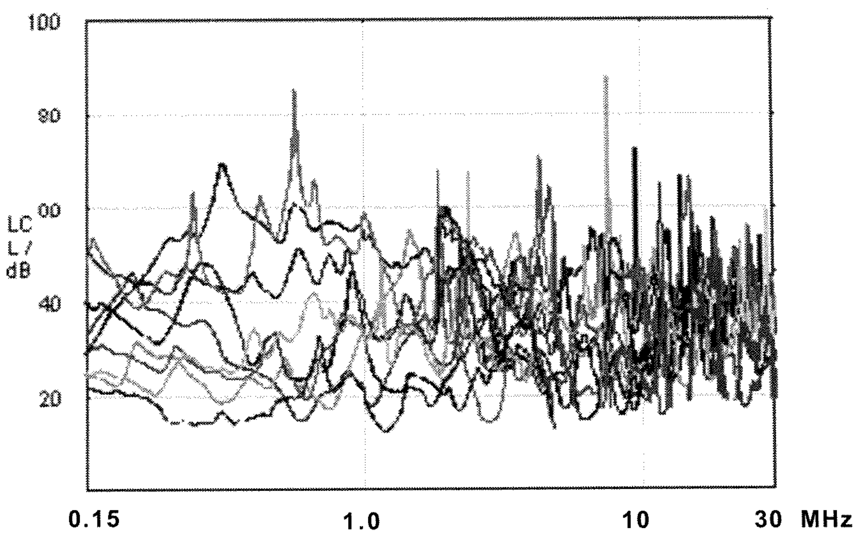


Figure A. 1. LCL - In-home electricity networks phase-neutral

Some measurements were also made on access lines. Their number is somewhat smaller and not sufficient for statistical analysis. Considering the available data it appears that the LCL of access lines is somewhat higher than the LCL on in-home lines.

A.2 Test method and apparatus used for measurements presented in A.1

A.2.1 The test adapter and formulas used.

The test method described below Figure A.2 shall allow any expert to collect additional data under comparable test conditions

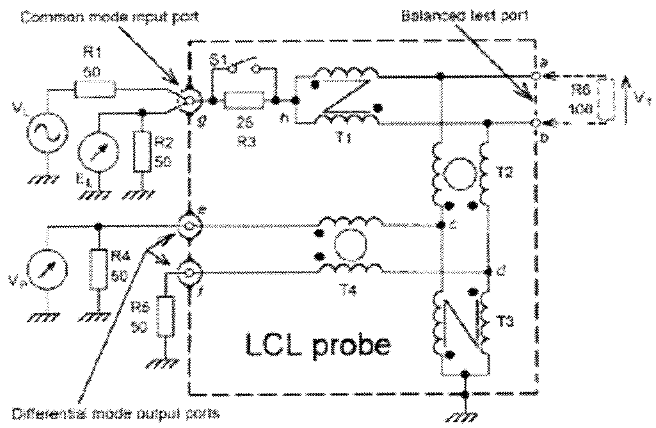


Figure A.2 Universal LCL measurement adapter according to Macfarlane IEEE Trans. on EMC, Vol. 41, No. 1, pp 3-14.

The measurements were made by connecting the terminals a/b of the balanced test port via safety capacitors of 100 nF each to the phase respectively to the neutral of low voltage distribution networks. The differential mode impedance is 100 O (R4 + R5). The common mode generator impedance is 100 O/4 = 25 O. For this purpose EL is maintained constant and the switch S1 is open. LCL is calculated as follows:

LCL = 20 log (EL / VT) or

LCL = 20 log (EL / 2 VP)

A.2.2 An example of a test equipment set-up

The measurements can be performed with 4-port test equipment like a network analyser or with a spectrum analyser-tracking generator combination. If both the generator output impedance and the analyser input impedance is 50 O, the impedance requirements of R1 through R3 of the LCL test adapter are met by simply connecting the measuring equipment to the probe. Other equipment needed is an amplifier if the output of the test-generator is not sufficiently high and surge limiters to protect the input.

Additionally, commercially available adapters, which are designed for telephone line measurements, need to be modified for use with the mains supply voltage. At the test-terminals 'a' and 'b' of the LCL test adapter two safety capacitors (Cy) have to be added. In order to keep the measuring uncertainty low at 150 kHz, the value of the capacitor should be not smaller than 100 nF.

Due to the modification of the LCL adapter with the capacitors, the 'self' LCL of the adapter shall be measured and calibrated and the adapter must be re-calibrated according to the procedures described in Macfarlane IEEE Trans. On EMC, Vol. 41, No 1,pp 3-14. The self-LCL should be at any frequency at least 10 dB higher than the actual LCL values to be measured.

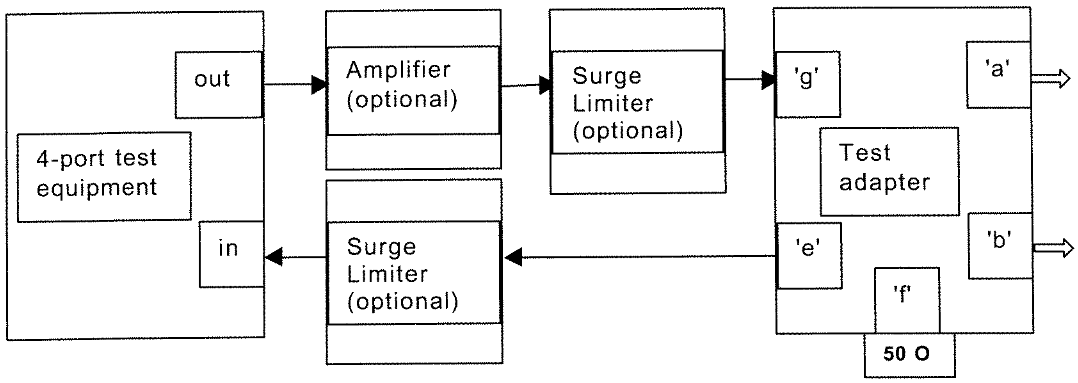


Figure A. 3 The measurement equipment set-up

The reference of the measuring set-up is ground. A virtual connection to the Ground is made by means of the large capacitance between a metal plane on which the measuring equipment - inclusive the test adapter - is placed and the environment. A trolley covered with e.g. copper or aluminium foil is a perfect measuring station. The surface of the metal plane should be at least 1 m^2. For safety reasons, the metal plate - and the measuring equipment on the metal plate - must be grounded. The safety ground point shall be isolated form the test set-up for frequencies above 150 kHz by means of common mode chokes in the ground wire. The value of the coil is at least 280 µH. This inductance value is taken form IEC61000-4-6, where it is used for the construction of CDN's. CDN's also can be used for the isolation of measurement set-equipment, e.g. a CDN M3 for the equipment power supply. An AMN with the earth connection switched 'on' also can be used.

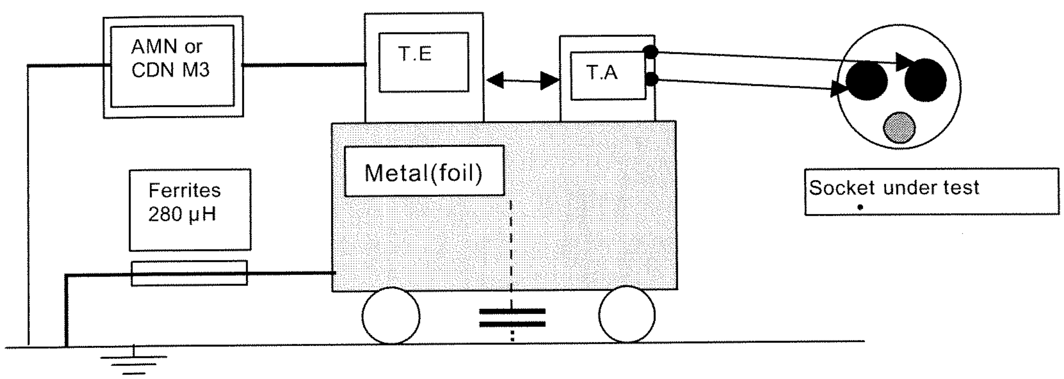


Figure A.4 The measurement equipment layout

T.E. = test equipment, connected to metal foil
T.A. = test adapter, bonded to metal foil
AMN = artificial mains network, earth coil switched 'on'
CDN-M3, defined in IEC 61000-4-6
Ferrite's on safety earth connection, value defined in IEC 61000-4-6

Note: If battery powered equipment is used, the AMN or the CDN-M3 are not present.

A.2.3 The test procedure

In this description of the test procedure it is assumed that there is only one voltage measuring device available, e.g. the input of a network analyser. This means that the voltage measurements at the ports 'g' and 'e' of the test adapter - see figure A.2 - can't be done simultaneously. If two voltage measuring devices are available, then the measuring procedure is slightly simpler. On the other hand, with two separate voltage measuring devices the tracking with the source can be a problem.

1. Connect the output of the voltage source to port 'g' of the test adapter. A coaxial T-piece is needed on port 'g'
2. Connect the input of the voltage measuring device also to port 'g' of the test adapter. Ports 'e' and ' f' are terminated with 50O. Record the injected voltage EL.
3. Connect the input of the voltage measuring device to port 'e' of the test adapter. T-piece port 'g' and port ' f' are terminated with 50O. Record the voltage VP.
4. Calculate LCL according to: LCL = 20 log (EL / 2 VP)

As an alternative, using modern spectrum analysers which keep VL constant versus frequency: If one closes S1 and one calculates LCL = 20 log VL / 4 VP there is no need to calibrate EL.

Note: The noise voltage at test adapter terminal 'e' with the test generator switched 'off' should be sufficiently low in order to get a minimum average signal to noise ratio of 10 dB. If this requirement is not met, the optional amplifier must be used.

A.3 Statistical Analysis of LCL-Measurement

The limit-value of LCL was derived by statistical analysis of all available LCL-measurement-results. The following analysis method was used:

The frequencies at which the sample values were either individually measured or selected out of frequency sweep measurements were chosen at random.
The limit value of LCL was chosen in such a way that 80% of the sample-values of LCL were equal or superior to the limit-value of LCL.

The result of this analysis showed a LCL-limit value of 36 dB.