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| **Radiocommunication Study Groups** |  |
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| Received: 18 January 2016Subject: Radiated disturbances from PLT and wired telecommunication systems | **Document 6/7-EDocument 6A/23-E** |
| **19 January 2016** |
| **English only** |
| Study Group 6 Rapporteur on PLT Issues |
| Report on Recent Developments Concerning PLT[[1]](#footnote-1) and wired Telecommunication systems |
| (Question ITU-R 221/1) |

# 1 Introduction

This Report covers developments on relevant issues since the seventh meeting of Radiocommunication Study Group 6 (Geneva, 24 July 2015), notably:

* further developments in CENELEC on standards for PLT devices following on from the concerns brought to the attention of Working Party 6A and Study Group 6 in previous Reports of the Rapporteur (see Section 3 of Document [6/272 – 6A/479](http://www.itu.int/md/R12-SG06-C-0272/en), Section 2 of Document [6/327 – 6A/541](http://www.itu.int/md/R12-SG06-C-0327/en)), Document [6/327(Add.1)](http://www.itu.int/md/R12-SG06-C-0327/en) and Section 2 of Document [6/397– 6A/631](http://www.itu.int/md/R12-SG06-C-0397/en));
* EMC considerations on electronic and electrical equipment relevant to Wireless Power Transfer (WPT);
* considerations on the greater diversity of sources of electromagnetic interference (EMI) now being encountered because of conducted and radiated RF emissions.

As noted in Document [6/397– 6A/631](http://www.itu.int/md/R12-SG06-C-0397/en), a more constructive working relationship between ITU-R and CENELEC has been put in place, under which ITU-R is invited to send a representative to the meetings of CLC/TC 210. The SG6 Rapporteur has attended the two TC 210 meetings held in 2015 (Dublin, 19 – 20 May, and Brussels, 9 – 10 December) in his parallel capacity of Rapporteur of the Working Party 1A Rapporteur Group on the coexistence of wired telecommunication with radiocommunication systems. Further consideration will be given on how best to organize this activity following additional consultations with Study Group Chairmen and Counsellors.

# 2 Developments in CENELEC concerning the EN 50561 standard on PLT apparatus

Sections 2.3 and 2.4 of Document [6/397– 6A/631](http://www.itu.int/md/R12-SG06-C-0397/en) outlined the developments that took place during the May 2015 meeting of the CENELEC CLC/TC 210 group concerning PLT and set out the implications on sound broadcasting in the HF bands and Bands II and III.

The main issue then was the continuing work by CENELEC on the EN 50561 family of standards on PLT equipment. This activity continued during the December 2015 meeting of CLC/TC 210.

The EN 50561 standard is organized as three parts:

* Part 1 covers PLT apparatus for in-home networking operating below 30 MHz – this part is already in force (see: [EN 50561-1:2013](http://www.cenelec.eu/dyn/www/f?p=104:110:651683583081801::::FSP_ORG_ID,FSP_PROJECT,FSP_LANG_ID:1258289,46262,25));
* Part 2 covers Access PLT – the final draft is now being prepared for voting by National Committees[[2]](#footnote-2);
* Part 3 covers PLT apparatus for in-home networking operating above 30 MHz – the final draft has been approved through the National Committee voting procedure.

## 2.1 Developments on Part 1 of EN 50561 (EN 50561-1)

Part 1 of EN 50561 has been in force for Members States of the European Union (EU) since citation in the Official Journal of the European Union on 25 February 2014. Part 1 was offered to CISPR/I but was not adopted for consideration as a future IEC/CISPR standard.

A new CENELEC work item has approved in order to update the present base references to CISPR 22[[3]](#footnote-3) to CISPR 32, entitled *“Electromagnetic compatibility of multimedia equipment – Emission requirements”*. The objective for developing CISPR 32 was to take account of the increasing convergence between information technology and broadcast/multi-media equipment. The requirements of CISPR 32 are predominantly based on CISPR 22 and the structure remains substantially the same at present. However, major changes are planned in subsequent editions.

CISPR 32 defines two equipment classes depending on product intended environment:

* Class A: equipment for installation in non-residential environments;
* Class B: equipment for installation in residential environments.

Broadcast receiving equipment is categorized as Class B only. It should be noted that Class A equipment may not offer protection to broadcasting services in a residential environment.

A possible new work item may arise with EN 50561-1 in respect of whether or how to include Multiple Input/Multiple Output (MIMO) operation. The interest in MIMO operation for PLT equipment results from a perceived need to provide a diversity of communication paths over the mains wiring, by using the Live-Earth and Neutral-Earth wire pairs as well as the Live-Neutral pair. This is considered necessary in order to maintain reliability of throughput over the all the variations in mains wiring and loading found in homes and business premises. However, this is not a particularly new point; a submission to Working Party 6A from the [BBC](http://www.itu.int/md/R07-WP6A-C-0478/en) in 2011 noted considerable variability in the performance of PLT connections under test in real world conditions.

CENELEC is coming under pressure from some manufacturers who intend to include MIMO operation in their products. This would appear to reflect a view that EN 50561-1 is worthless without the inclusion of MIMO. The question of MIMO is examined further in Section 2.4.

## 2.2 Developments on Part 2 of EN 50561 (EN 50561-2)

The final draft of Part 2 of the standard EN 50561 covering PLT access networks has been approved for circulation and was passed for editorial review on 22 September 2015 prior to invoking the CENELEC voting procedure. Considerations on the eventual outcome of the vote were provided in Section 2.4.2 of Document [6/397– 6A/631](http://www.itu.int/md/R12-SG06-C-0397/en). It should be noted that the EU Commission is still interested in PLT for access networking, even though enthusiasm is waning elsewhere in recognition that there are better means of providing broadband access, such as cable and G.fast.

## 2.3 Developments on Part 3 of EN 50561 (EN 50561-3)

Part 3 of the EN 50561 standard covering PLT operating in the range 30-87.5 MHz has passed the formal voting procedure in CENELEC - The final version incorporates measurements of conducted emissions in the range 30-120 MHz and sets a PSD spectrum mask, which together serve to provide better compatibility in respect of VHF sound broadcasting and the G.fast[[4]](#footnote-4) wired broadband link system developed in ITU-T Study Group 15. As with Part 1, a revision will be necessary in order to replace the references to CISPR 22 with reference to CISPR 32. Considerations on the eventual outcome of the vote were provided in Section 2.4.1 of Document [6/397 – 6A/631](http://www.itu.int/md/R12-SG06-C-0397/en). A contentious point, also noted in relation to Parts 1 and 2, was whether or how MIMO operation should be included in a future revision.

## 2.4 Considerations on MIMO operation

The question of whether or how to include MIMO operation in EN 50561-1 is proving highly controversial as MIMO is perceived as potentially more disturbing. The test methods and limits of EN 50561 do not explicitly reference MIMO, and the expectation is that disturbances will be higher with MIMO operation, This expectation is supported by evidence and studies previously presented to CENELEC, and other fora, such as Annex 2 to Document [6/327(Add.1)](http://www.itu.int/md/R12-SG06-C-0327/en). A new work item has been approved in CENELEC in order to progress the MIMO issue, but no work has yet taken place in TC 210 WG11, the responsible working group.

Irrespective of the above concerns, there are other difficulties with MIMO operation to contend with because of the different regulations for low voltage mains wiring in Europe and around the world. In particular, different regulations apply in respect of bonding the protective earth and neutral wires. Some countries allow the bonding of the protective earth and neutral in homes and buildings, while others prohibit this and only allow bonding within electricity sub-stations. In addition some countries allow socket outlets on different phases to be installed in close proximity to each other within domestic premises, while others prohibit this. Moreover some countries use bi-phase supplies and other three-phase. All these variations would affect how MIMO would actually operate how test methods should be set and applied.

One view on MIMO is that its use is definitely not covered in EN 50561 and that attempts incorporate MIMO without defining appropriate test methods and limits are an abuse of procedures. Various instances of abuse of Part 1 have been observed where MIMO operation has been incorporated by going down the route (which exists in EU procedures) of establishing a TF (Technical File) which is then submitted to technical certification bodies.

Another view is that because the present suite of EN 50561 standards are silent on MIMO operation there is nothing to rule out MIMO operation and thereby prevent the current standard from being interpreted as covering MIMO operation. There are other problems over interpretation as well, in that it can be claimed that PLT equipment can pass CIPSR 22/EN 55022 by treating the mains connection as the signal port while with the modem in operation and measuring disturbances on the mains port only while the modem is inoperative.

The CLC/TC 210 group examined various ways of resolving the problems presented by MIMO operation including:

* to develop an information or interpretation sheet explaining that the present editions of EN 50561 do not make provisions for MIMO operation;
* to inform notifying bodies and manufacturers directly that there must be a proper assessment of MIMO operation before treating it as part of EN 50561;
* to modify texts in order to clarify the test method rather than producing new standards;
* to generate a Technical Report on MIMO before taking any further action with respect to EN 50561 (NB: this proposal had also been discussed during the May 2015 CL/TC 210 meeting
* to send all relevant parties the simple statement that MIMO is not included in EN 50561 and that claiming to apply the standard in such a way does not guarantee protection for radio services under CISPR 22 or CISPR 32.

The last idea would go directly to the concerns previously expressed in ITU-R about the impact of PLT on radio services. However, there was no firm consensus on how to resolve the MIMO issue. A particular problem identified with PLT was that circulating information on MIMO would not provide an adequate solution because, in practice, many of the PLT modems on the European market do not use or claim to use EN 50561-1 and its 30 MHz limit. Some PLT equipment on the European market relies instead on an industry specification using MIMO and operating up to
68 MHz. This may be on the basis of a historic draft text on PLT developed in CISPR.

It was eventually decided to produce a proposal for a new work item for MIMO operation under EN 50561-1, EN 50561-2 and EN 50561-3. An alternative could be to develop new Parts 4, 5 & 6 covering MIMO use separately. The situation now is that discussion on the MIMO will continue in TC 210/WG11 working-group.

The CLC/TC 210 group also considered other EMI problems from a wide range of electronic and electrical equipment where access to markets is a concern. The extensive discussion on controlling the market in PLT equipment, considering the potential for non-compliance with MIMO, proved useful in linking into to a more general consideration of the role of market surveillance and legislation in dealing with EMI and non-compliant equipment (see Section 4).

# 3 Increasing EMI observed in the VLF and LF bands

The Brussels meeting of the CLC/TC 210 group also addressed several issues of mutual concern as a result of the increasing number of instances of EMI now being observed in the frequency
range 2-150 kHz. These involve a wide variety of equipment and devices and causes, as detailed in the third edition of the CLC/SC205A Study Report on *Electromagnetic Interference between Electrical Equipment/Systems in the Frequency Range below 150 kHz.* This situation is of particular concern to Working Party 6A because the Region 1 LF broadcasting band is immediately above this frequency range. Other important radiocommunication and radiodetermination services operating within and above this frequency range are also at risk of suffering interference. The wide ranging nature of the interference and the mechanisms involved will also add to concerns previously expressed in Working Party 6A in respect of WPT (see Section 3.2.4 of Document [6A/652](http://www.itu.int/md/R12-WP6A-C-0652/en)).

The information contained in the CLC/SC205A Study Report supports the concerns expressed in the previous Report of the Rapporteur (see Section 5 of Document [6/397 – 6A/631](http://www.itu.int/md/R12-SG06-C-0397/en)) that more attention needs to be given in respect of *“…the impact of leakage of radio frequency energy from an increasing number of disparate sources, in order to ensure that extraneous noise in the environment, particularly within domestic and business premises, does not as degrade the reception of broadcasting services”*.

In fact, the situation appears to be far worse than the limited number of interference sources and the range of radio services at risk from increasing EMI that was previously considered in ITU-R Study Groups. The CENELEC Study Report provides many examples of EMI from all sorts of electronic and electrical equipment in the range 2-150 kHz and also gives examples of harmonics affecting higher frequency ranges.

Many examples of interfering equipment involve the increasing application of high frequency switching techniques in power inverters, converters and chargers which has led to a shift in non-intentional emissions from classical harmonics below 2 kHz to higher frequencies in the
range 2 kHz to 150 kHz. This includes many new types of equipment, now in common use, such as inverters used in conjunction with solar panel arrays, where power levels range from 1 to 100 kVA. Small converters and power supplies for domestic electronic equipment and household appliances from induction cookers to washing machines are also involved. Not only is there a risk to a wide range of radio services from both conducted and radiated emissions, but emissions of RF noise can affect the control circuits of a wide range of electronic equipment connected to the mains. A whole range of equipment malfunctions have been observed, including uncommanded starting or stopping, incorrect or suspended data output or displays, incorrect time signalling from electronic or radio clocks, and false alarm activations/displays.

Of particular concern is the impact on the narrow band PLT equipment used for automatic meter reading under the Smart Grid project (see Report ITU-R [SM.2351](http://www.itu.int/pub/R-REP-SM.2351-2015)). Both CENELEC and ITU-T Study Group 15 have developed standards for narrow-band PLT for use with Smart Grid. For this application ITU-T Study Group 15 has been working in conjunction with the IEC TC57 WG20 group and has developed the ITU-T **G.990x** family of Recommendations (i.e. [G.9901](http://www.itu.int/rec/T-REC-G/recommendation.asp?lang=en&parent=T-REC-G.9901), [G.9902](http://www.itu.int/rec/T-REC-G/recommendation.asp?lang=en&parent=T-REC-G.9902), [G.9903](http://www.itu.int/rec/T-REC-G/recommendation.asp?lang=en&parent=T-REC-G.9903), [G.9904](http://www.itu.int/rec/T-REC-G/recommendation.asp?lang=en&parent=T-REC-G.9904)). The CENELEC Study Report confirms concerns expressed in the ITU-T and IEC groups that excessive RF noise on mains wiring could disrupt the operation of Smart Grid metering. The CENELEC Study Report cites examples of loss of communications affecting 40%, and more, of automatic meters in an area affected by a single item of faulty equipment. Table 1 shows the frequency bands used by narrow-band PLT equipment used in automatic metering systems.

TABLE 1

Frequency bands for narrowband PLT for Smart Grid

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| --- | --- | --- |
| **Band** | **FSTART (kHz)** | **FEND (kHz)** |
|  CENELEC-A | 35.9375 | 90.625 |
|  CENELEC-B | 98.4375 | 123.4375 |
|  CENELEC-C/D | 125 | 143.75 |
| FCC-1 | 34.375 | 137.5 |
| FCC-1 | 150 | 478.125 |

Another major concern with EMI in the frequency range 2-150 kHz is the impact on the standard frequency and time signal service; note that RR No. **5.56** provides for specific protection from harmful interference to the transmissions of standard frequency and time signals operating in the VLF and LF bands. The protected frequency bands for the standard frequency and time signal service are shown in Table 2.

TABLE 2

Frequency bands for the standard frequency and time signal service

|  |  |
| --- | --- |
| Frequency (kHz) | Area of use |
| 14-19.95 kHz | Regions 1, 2 &3 |
| 20.05-70 kHz |
| 72-84 kHz | Region 1 |
| 86-90 kHz |
| 25 kHz | Armenia, Azerbaijan, Belarus, the Russian Federation, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan |
| 50 kHz |

The continuing importance of the VLF and LF bands for radio services is evidenced by several changes to the Table of Frequency Allocations made by WRC-12 relating to the scientific research, meteorological aids, radionavigation, amateur and maritime mobile services (see RR Nos. **5.54A**, **5.54B**, **5.54C**, **5.67B**, **5.77**. **5.80A**, **5.80B** and **5.82**).

A potent source of RF emissions in the range 2-150 kHz turns out to be compact fluorescent lamps and LED lamps. RF emissions far above the general EN 55015/55011 limits and EN 50065 spurious emission limits have been observed.

Although most of the extreme cases of interference noted in the CENELEC Study Report result from faulty equipment or equipment that has come to market without the RF filtering or power factor correction components installed (as would be demanded if in compliance with a claimed standard), ageing effects have now been identified as a major source of EMI, with observed instances of EMI increasing significantly when compared with previous editions of the Study Report.

Ageing particularly affects electrolytic capacitors used in rectifier and power factor correction circuits. The ageing problem can be seen as twofold, as ageing of electronic components causes

* increased RF emissions from concerned electronic and electrical equipment, resulting in an increased potential for EMI to other electrical equipment.
* thermal stress to other electronic and electrical equipment caused by RF voltages superimposed on mains wiring, resulting in a reduction of lifetime of such equipment and often additional RF emissions from the deteriorating equipment

Thus, there is a vicious circle in the ageing process by which superimposed RF voltages on mains lines promote internal degradation and failure of electrolytic capacitors, accompanied by heating of these components as a result of the progressive degradation. Thermal stress then leads to overheating of these components and the equipment as a whole, contributing further to dry-out and failure of electrolytic capacitors. Thus EMI from increasing levels of RF voltages on mains wiring directly induces degradation in other equipment. This then results in further increases in levels of superimposed RF voltages on the mains wiring, resulting in further degradation and higher levels of RF emissions and so on and so forth.

RF voltages superimposed on mains wiring therefore constitute a significant driver of thermal stress, which subsequently has a significant adverse impact on the lifetime of electronic equipment, containing rectifier and power conversion circuitry using electrolytic capacitors, i.e., just about everything. It has been observed that a temperature increase at the DC-link capacitors in the rectifier circuits of equipment under test can amount up to a 1° Kelvin temperature rise per percent of the superimposed RF voltage component, as compared to measurements taken with a pure sinusoidal mains frequency voltage. Besides the additional heating, audible noise has been observed in various examples of equipment under test, even at RF voltage levels of around 1 %.

Examples of compact fluorescent and LED lamps under test have shown temperatures measured at different points rising to ~ 74° C. Because of the different mounting conditions and air streams at the ceiling, the temperature increase may be even higher under real conditions.

From the above observations on the design of electrical power converters and induction units and the adverse impact of attendant thermal stress, it must be expected that WPT equipment will pose a risk of interference to radio services and other electronic and electrical equipment connected to mains wiring including, rather ironically, PLT equipment. This is because WPT equipment of any size from small mobile phone chargers to high power electric vehicle chargers poses a risk of interference to a wide range of electronic and electrical equipment, many of which will be incorporate electronic communications functions. The risk of EMI will not be confined to radio services operating near the frequency ranges proposed for WPT.

The CLC/TC 210 group recognized that there are areas of common interest between ITU and CENELEC in developing standards for WPT equipment. In particular it was suggested that ITU provides a technical analysis of why the frequencies proposed in the preliminary draft new Recommendation ITU-R SM.[WPT], being developed by Working Party 1A, are considered suitable, taking account of the constraints of the physical coupling mechanisms involved and transfer efficiency considerations.

# 4 Considerations on market surveillance

As a result of the extensive discussions on EMI from a variety of electronic and electrical equipment and the particular problems with PLT equipment, the CLC/TC 210 group noted several concerns with the effectiveness of the present EU legislative and market surveillance regime for preventing non-compliant equipment from reaching the market or remaining in operation after it deteriorates to the extent that it produces EMI in violation of the applicable standards.

Part of the problem is that in 2001 the European Commission issued an advice to be relaxed on PLT. Since then, CISPR 22 and the CENELEC mirror standard EN 55022 have changed and now provide for more stringent EMC limits applicable to PLT. During the transition period manufacturers are allowed to use ancient standards and draft standards.

It was noted that, in practice, there are no effective legal tools to remove non-compliant equipment from the EU market. A major defect in the present regime is that if manufacturers do not claim to meet the requirements for a harmonized standard then they cannot be accused of violating the standard. However, even in the case where a manufacturer claims in a CE marking declaration to meet the essential requirements of an EMC standard, but does not, the course of action in dealing with the violation is far from clear. It may be that the determination of violation is a matter only for courts to decide, rather than being a matter where national authorities are able to take immediate direct action.

There was some discussion on how to bring the concerns on poor and ineffective market surveillance to the attention of EU Commission and industry in general, aspects of which have become increasingly evident over the last 10 years. There were views in favour of taking some urgent action in order to highlight the problem, through some sort of campaign, so as to ensure that the whole industry is not discredited. However, it was concluded that the scope for action by CENELEC alone is rather limited; the aim should be to encourage industry to make use of standards, not to penalize them. It was concluded that the main task of CENELEC is to make good standards, even if they are not used; it was acknowledged to be difficult to help the situation where EU enforcement and market surveillance is not effective.

# 5 Conclusions and recommended actions

This Report has concentrated on recent activities in CENELEC and has shown that the improved arrangements for engagement with CENELEC that were initiated by the concerns raised in Study Group 6 a year ago are paying dividends.

Although there are continuing concerns on the PLT work in CENELEC and the potential for increased interference with MIMO operation, there is a growing recognition now of areas of common interest in minimising the amount of RF noise being injected into the environment through conducted and radiated emissions from a wide range of electronic and electrical equipment.

Such concerns have already been expressed in both Study Groups 1 and 6, albeit in rather abstract terms. The CLC/SC205A Study Report on increasing EMI in the range 2-150 kHz shows just how pervasive and disruptive EMI from excessive RF noise can be.

The main concern of Study Group 6 is the impact on the reception of broadcast transmissions. However, ITU as a whole needs to be concerned about the wide range of malfunctions and disruption that can occur to all types of telecommunication and radiocommunication equipment as a result of increasing EMI from a wide range of electronic and electrical equipment. Awareness also needs to be raised outside ITU on the implications of allowing excessive RF noise to permeate the environment. In a world where the main means of ensuring freedom from EMI is the development of effective and appropriate standards, effective legislative regimes and market surveillance are also essential.

In ITU-R, there is a growing reliance on the expectation that equipment will operate in accordance with effective standards when developing solutions for ensuring co-existence between various systems and applications. If the standards, manufacturing quality and market access arrangements for electronic and electrical equipment do not meet the required compatibility requirements in real world use then many of the means of communication underpinning modern society will become increasingly unreliable.

The issues where Working Party 6A, or Study Group 6 as a whole, may wish offer further comments or advice on the pervasive effects of RF interference, while respecting the lead role of Working Party 1A in ITU-R on co-existence issues, are:

* To maintain vigilance in respect of the activities of Standards Developing Organizations s and industry alliances outside ITU in order to ensure that the efforts of ITU-T and ITU-R to achieve interference free operation of wired telecommunication systems and broadcasting systems are not undermined by conflicting standards developed elsewhere.
* To maintain interest and support studies on the design and performance of electronic and electrical equipment in respect of minimizing EMI, so as to ensure that extraneous RF noise in the environment does not degrade the viability of broadcasting services;
* To communicate information within ITU, as appropriate, on particular instances of interference caused to broadcasting reception by any equipment or systems subject to product or immunity standards.

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1. The term PLT – Power Line Telecommunications – is used in this Report in order to align with previous work in Study Group 6 and its Working Parties. However the term PLC – Powerline Communications is also used extensively and interchangeably in ITU-T and ITU-R and in other organizations and fora. [↑](#footnote-ref-1)
2. The national bodies voting in CENELEC. [↑](#footnote-ref-2)
3. The IEC CISPR 22 (edition 6) standard: *“Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement”.* [↑](#footnote-ref-3)
4. The G.fast system is defined through Recommendations ITU G.[9700](http://www.itu.int/rec/T-REC-G.9700/en) and [9701](http://www.itu.int/rec/T-REC-G.9701/en). [↑](#footnote-ref-4)