EMC aspects of Power Line Telecommunication

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ABSTRACT
The rapid and important growth of the Internet has resulted in the requirement for a new range of broadband access technologies to residential premises. Low Voltage Electricity Distribution Networks have become potential fruitful media in order to offer Power Line Telecommunication (PLT). Currently there are a lot of regulatory efforts within the relevant EMC standardisation committees, leading to specify for PLT systems, the frequency ranges, signal levels and the EMC limits (electromagnetic emission and immunity). After a brief description of access and in-house networks, the paper outlines electromagnetic compatibility aspects of PLT.

INTRODUCTION

The demand for bandwidth, by Internet users, led to seek new ways to facilitate this requirement. Beside the Telco Local Loop infrastructure delivering services such as Asymmetric Digital Subscriber Loop (ADSL) and Very High Speed Digital Subscriber Loop (VDSL), Low Voltage Electricity Distribution Networks have become potential fruitful media in order to offer Power Line Telecommunication (PLT). Two kinds of applications for the PLT are being developed: access media and in-house distribution systems. PLT systems will be used as a result of competitive market situations and are expected to be a major growth factor in the next years.
The introduction of PLT is based on the fact that in-house electric-power lines can function as high-speed transmission lines for home networking. However the radio community is mainly worried about interference to radio services caused by PLT systems.
Currently there are a lot of regulatory efforts within the relevant EMC standardisation committees, leading to specify for PLT systems, the frequency ranges, signal levels and the EMC limits (electromagnetic emission and immunity).
In this newly deregulated environment, France Telecom is interested on this new technology in order to re-use the existing low voltage network inside residential houses as an extension of broadband services. However this media was not originally designated for supporting such application.
The first part of the paper outlines the EMC activities, related to xDSL and PLT technologies, in the standardisation committees and the second part will be devoted to the presentation of the work carried on by France Telecom in order to address the EMC characterization of a PLT transmission operating within home.

EVOLUTION OF EMC STANDARDS

In Europe, the work that is nowadays undertaken in the different EMC standardisation committees has as a main goal to ensure that a widespread PLT system will not interfere with electrical appliances or radio frequencies needed for emergency services and military transmissions in the HF band. This leads to the following considerations:

- Identify the frequency ranges over which PLT and cable transmission are likely to operate now and for the future;
- Identify those services that are likely to be affected by PLT and cable transmissions in general (broadcasting, maritime, radionavigation, radio amateurs…) and evaluate their protection needs;
- Investigate methods of measuring the emissions from PLT and cable transmissions;
- Perform compatibility studies to derive limiting values for emissions from PLT and cable transmissions to protect primary services;
- Propose a harmonised European approach for PLT systems and cable transmissions in general;

Each member nation within the European Community will have its own regulatory infrastructure of which radio regulation and EMC will probably have the most immediate impact on the future development of broadband access technologies.
It's interesting to give a summary of the evolution of EMC requirements, related to telecommunication networks [1]:

- On August 2001 the European commission issued a standardization mandate addressed to CEN, CENELEC and ETSI concerning EMC for telecommunication networks.

This European commission EMC mandate states:

Until now, no harmonized standards covering the EMC of fixed installations, such as for instance, telecommunication networks have been developed.

- The mandate concerns the preparation of harmonised standards covering EMC aspects of wire-line telecommunication networks including their in-house extensions.
- That the mandate does not concern the preparation of harmonized standards relating to the EMC of equipment to be connected to the networks.

CENELEC and ETSI accepted this mandate and an ETSI /CENELEC joint working group plans to issue a harmonized standard.

- In the mean time the national regulators in the UK and in Germany issued also limits for the radiation emission. The UK issued MPT 1570 [2] and Germany issued NB30 [3]
- In CEPT the SE35 project team started already from April 2000 on the emission standards for power line telecommunication networks (PLT) and this was later extended to cable transmission networks in general.

CEPT SE plans to make a recommendation to the CENELEC/ETSI joint working group for the radiation limits. The ETSI/CENELEC joint working group plans a new EMC standard defining radiation limits for extensive wire-bound telecommunication networks. The draft proposal made by this joint working group is indicated in table 1 [1].

Table 1 : Joint working group CENELEC/ETSI draft proposal

Frequency range (MHz)	Disturbance field strength quasi –peak values in dB microV/m at 3 meter	Measurement bandwidth
0.009 to 0.15	37 - 20 log F	200 Hz
0.15 to 1	37 - 20 log F	9 KHz
1 to 30	37 - 8.8 log F	9 KHz
30 to 230	30 - 8.8 log F	120 KHz
230 to 1000	30	120 KHz

This table is equivalent to the NB30 proposal with conversion of the peak values in quasi peak values.
The table 2 gives a comparison of the limits indicated by some standards

Table 2. Comparison of some limits

Frequency (Mhz)	EN 550222 class B	FCC part 15 class B	BBC white paper	NB30	MPT1570
0.009				90.9	74.4
0.15				66.5	50
> 0.15			28.5	66.5	66.5
1			21.8	50	50
>1			21.8	50	50
1.6			20.1	48.2	45.9
30	50	50	9.8	37	
>30	50	50		37	
88	50	50		37	
>88	50	53.5		37	
216	50	53.5		37	
>216	50	56.4		37	
230	50	56.4		37	
>230	57	56.4		37	
960	57	56.4		37	
>960	57	64		37	
1000	57	64		37	

To allow comparison all values have been converted to 1m peak values of electrical fieldstrength dB microV/m
From above table it can be concluded:

- EN555022 and FC part 15 are very similar but do not specify fieldstrength below 30MHz. Below 30 MHz they specify only conducted limits. Preliminary analysis, based on only one in-situ measurement, identified that the NB30 limits below 30 MHz are 10 to 15 dB more severe than the EN55022 limits.
- The BBC WHP013 limits are 27 to 38 dB more severe than the NB30 limits.
- NB30 limits and MP1750 limits are similar but MP1750 specifies only to 1.6 MHz

EMC CHARACTERISATION OF PLT TRANSMISSION

This part addresses the EMC characterization of a PLT transmission operating within home. The EMC issues of PLT systems are evaluated in a realistic environment, namely the electrical installation in home.
The goal of this evaluation is to define different processes that can be used for large-scale field trials of power-line communications technology and also to provide some qualitative results in order to contribute to the work of the EMC standardisation bodies.
An EMC evaluation as well as radiated and conducted emission, will allow to characterize the cabling inside individual homes in order to obtain some indications on the electromagnetic interference levels and the possibility to use the electrical installation for data transmission in home.
The objective is to find a correlation between the injected power and the emitted electromagnetic field. It is very important to characterize the radiated emission inside and also outside the home. By considering several points of measurement in each room of the house, it is possible to establish a map of the radiated field and to determine also the coupling factor K(f) which is the link between the injected power and the radiated field. This coupling factor will allow the calculation of the radiated field from the injected power of an arbitrary PLT signal.
Regarding the electromagnetic immunity the characterisation of the impulsive noise measured at the entry of the customer modem is also an important step for the study of the impact of impulse noise on the PLT transmission quality.
This EMC evaluation is performed according the following steps:

- Measurement of the attenuation between electrical outlets from 10 KHz to 30 MHZ;
- Measurement of the conducted emission (noise and PLT signal) until 30MHz;
- Measurement of the radiated magnetic field H from 10 KHZ to 30 MHZ inside and outside the building when the PLT signal is successively switched on and switched off;
- Measurement and statistical analysis of the impulsive noise.

A measurement campaign was performed on an apartment located on the first floor of a building which includes three stages. The parts of the model apartment break up as indicated in figure 1.

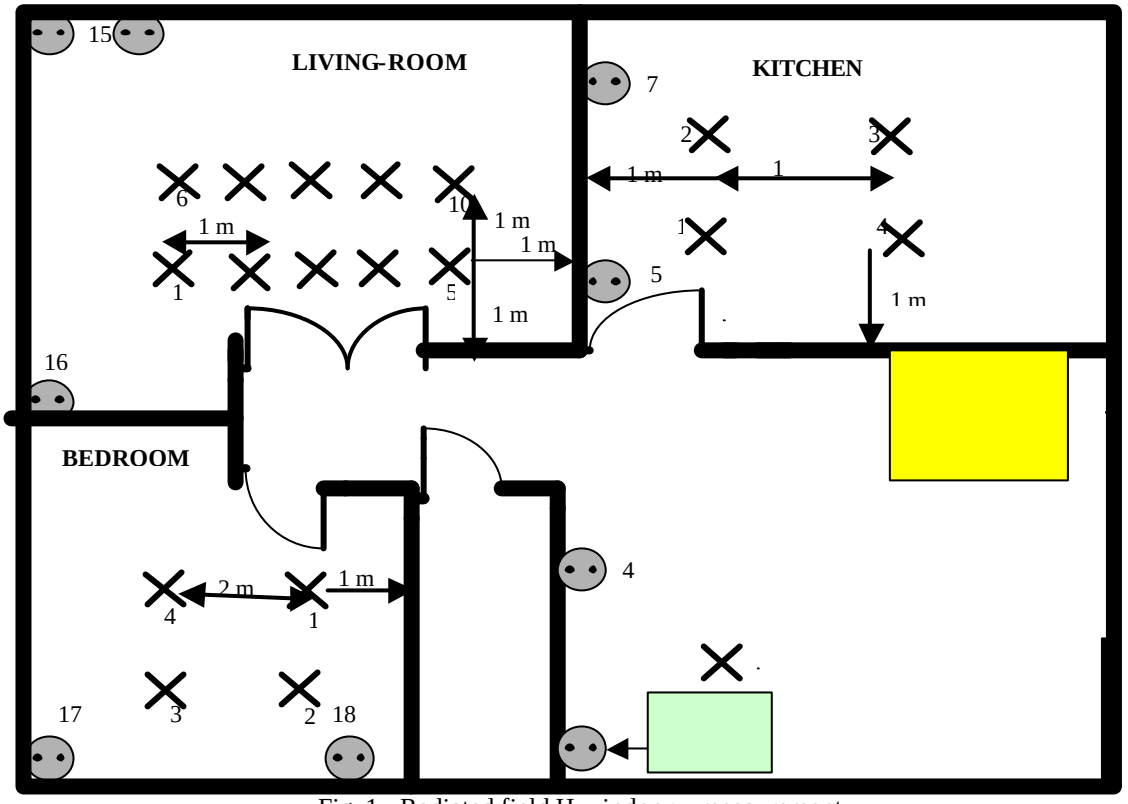

Fig. 1. Radiated field H « indoor » measurement

Electricity is provided from the differential transformer and the fuse box, the whole being located in the hall. The electrical power is distributed in three rooms; the kitchen, the living-room and the bedroom. The sockets of each rooms

are indicated by a number and the crosses in each room indicate the position of the field H loop antenna. PLT signal is injected on the socket 3.
A parking and a park surround the building. The radiated field measurements are done respectively at 3m and 10m.
It is necessary to know the insertion loss between the outlets in order to establish a correlation between the conducted emission and the radiated field H (K factor). Therefore, the EMC evaluation was performed by :

- Measuring the attenuation between the outlets up to 30 MHz;
- Measuring the conducted emission (noise and PLT signal) until 30 MHz;
- Measuring the radiated field H from 10 KHz to 30 MHz inside and outside the apartment, with and without PLT signal.

As a summary of the obtained results [4], the figure 2 shows different values of the K factor, which represents the correlation between a conducted emission and radiated H field. The diagram of figure 2 which summarizes the main elements of this study, represents two scales of level related by these K factors: the one in conducted emission and the other in radiated H field. The standards EN55022, NB30 and specifications " Home Plug Alliance" are also indicated in each scales.

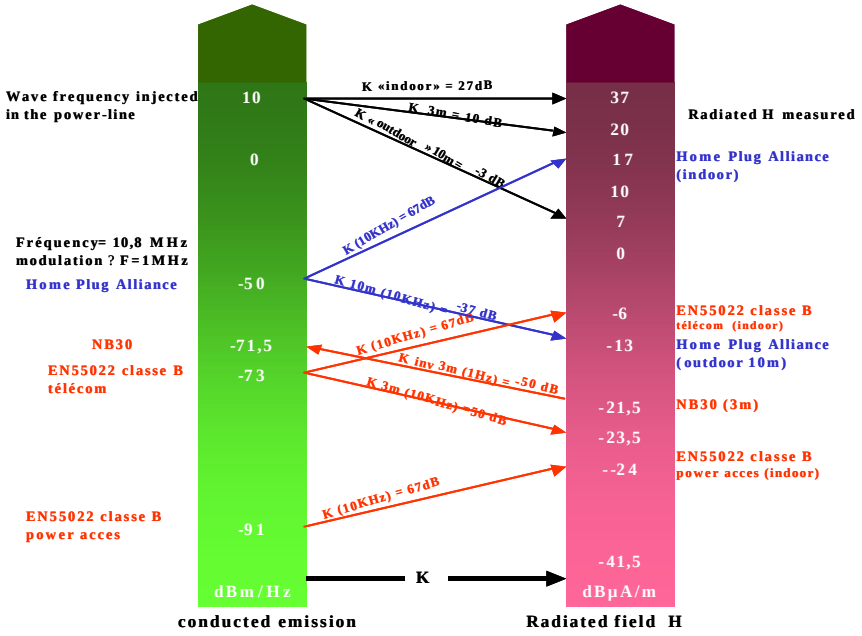

Fig. 2. **Correlation between the conducted emission and the radiated field H of the apartment**

First of all, the “outdoor 3m” K factor shows a good coherence between the standard EN55022 Telecom access and NB30 standard. A PSD injected in power-line at -50 dBm/Hz will disturb the SW radio receiver located into or near the apartment (no more longer than 10m).

CNCLUSION

In the field of standardization, a new EMC standard defining radiation limits for extensive wire-bound telecommunication networks is under preparation. For “in house” PLT architecture it will be essential to adapt the emission of PLT modems in order to avoid EM disturbances.

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