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North American Broadcasters Association (NABA)

ADDITIONAL STUDIES OF PLT SYSTEMS

The North American Broadcasters Association (NABA, *www.nabanet.com*) is an association of broadcasters in Canada, Mexico, and the United States, and the NABA Technical Committee is its standing technical body. NABA is thus in a position to present the technical viewpoints of the most authoritative association of professional North American Broadcasters in television and sound programme production, post-production, and distribution for terrestrial, satellite, and cable broadcasting.

NABA is a Sector Member of ITU-R and a long-time participant in ITU-R Study Groups, Working Parties, Task Groups, Rapporteur Groups, etc. NABA numbers among its members Chairmen, Vice-Chairmen and members of the above groups. NABA also participates widely in the ITU work on radio, television and multimedia services and has a strong interest in spectrum management studies including spectrum engineering techniques, spectrum management fundamentals, spectrum monitoring, and inter-service sharing, interference and compatibility.

NABA notes that while satisfactory progress has been already made with some ITU-R Recommendations on the subject of interference, an adequate criterion for protection of the broadcasting services from harmful interference caused by PLT technology is needed. NABA further notes that it has submitted a study on PLT emissions in Annex 19 of Document 1A/62. NABA strongly supports the inclusion of these studies in its entirely into the "Working document towards a preliminary draft new Report – Impact of power line telecommunications systems on radiocommunication systems operating in the LF, MF, HF and VHF bands below 80 MHz" (Annex 4 of Document 1A/62).

The Report of the Working Party 1A Chairman in Document 1A/62 states that the "The Administration of Japan strongly objected to the inclusion of material from Document 1A/35 for technical reasons, noting that additional material is required to provide context and adequate technical background for the study." Consequently, NABA has repeated the tests in North America, outside of Japan, in order to confirm the test results and conclusions. NABA repeated the tests under the direction of one of the most world-renowned laboratories for radiocommunications, the Communications Research Centre (Canada).

The Communications Research Centre (CRC) is the Canadian Government's primary laboratory for research and development (R&D) in advanced telecommunications, with a critical mass and expertise in four major platforms that form the basic transport mechanism for information delivery around the world: wireless, broadcasting, satellite and fibre optics. The CRC has been committed to applied and basic research in communications and related technologies since the late 1940s.

Over the last 50 years many scientific and engineering milestones have been achieved at the CRC, contributing advancements in wireless and satellite communications and broadcast technologies. An institute of Industry Canada since 1993, the CRC has maintained its tradition of excellence in managing technical issues concerning the radio spectrum, the deployment of wireless communications and broadcast services, and the development of new technologies and knowledge for exploitation by Canadian industry. CRC is Canada's main research centre for radiocommunications technology R&D. The CRC mission is to be the centre of excellence for communications R&D, ensuring an independent source of advice for public policy purposes.

The results of these tests on PLT emissions at the CRC confirm the need for protection to the Broadcasting Service (BS) from PLT systems operating at frequencies up to 80 MHz. The impact on the BS is not insignificant since 34 percent of the spectrum below 80 MHz is allocated in the Radio Regulations to the BS. It must be noted that planning for the BS is often done on a noise-limited basis. Consequently, the BS is particularly vulnerable to interference from PLT systems. Recommendation ITU-R BT.1786 provides a criterion to protect the BS from interference caused by emissions of non-broadcasting radiocommunication devices in the bands allocated to the BS. The criterion states the total interference to systems operating in the broadcasting service, from all sources of interference should at no time exceed one per cent of the total receiving system noise power. Interference from PLT devices is more than a national issue. As revealed in the CRC tests, PLT devices are readily available internationally without respect for national borders.

NABA continues to support the investigation of the impact of PLT on the BS. To this end, NABA presents a synopsis of the CRC test results in Annex 1 that illustrates the need for protection to the BS from PLT systems operating in the BS bands below 80 MHz. NABA provides this important study for inclusion in Section 5, “Analyses of potential interference,” of the working document (Annex 4 of Document 1A/62). The complete CRC laboratory PLT test Report is also provided in the document as a pdf electronic Attachment to Annex 1.

Annex 1

Further measurements of the radiated emissions from in-house power line telecommunications devices into the residential environment

1 Introduction

Subsequent to the measurements made by Kitagawa and Ohishi[1], the North American Broadcasters Association (NABA) contracted the Communications Research Centre, Canada (CRC) to carry out similar measurements from Power Line Telecommunications (PLT) devices operating in a residential environment. This Annex describes the test procedures and results of field strength measurements of PLT emissions to determine the extent of potential interference from PLT devices. The measurements clearly demonstrate the need to provide interference protection to the broadcasting service (BS). Since PLT devices operate without a frequency allocation in the ITU Radio Regulations, the appropriate protection criterion for the broadcasting service can be found in Recommendation ITU-R BT.1786.

2 Conducted power measurement – Test procedure and results

A total of eight (8) commercially-available PLT devices representing the various PLT standards were considered for testing. These devices were readily available in the United States, Canada, and Japan. The PLT devices, shown in the table below, were evaluated in the CRC laboratory prior to the field tests.

TABLE 1

List of PLT devices evaluated for the field tests

Device #	Manufacturer	Model	PLT Standard	Manufacturer specification		
				Data rate (Mbps)	Operating frequency range (MHz)	Region
1	TrendNet	TPL-202E	HomePlug 1.0 Turbo	85	4.5-21.0	North America
2	Panasonic	BL-PA100	HD-PLC	190	4.0-28.0	North America
3	Linksys	PLK200	HomePlug AV	100	Not Specified	North America
4	NetGear	XE102GNA	HomePlug 1.0	14	4.3-20.9	North America
5	NetGear	XE103G-100NAS	HomePlug 1.0	85	4.3-20.9	North America
6	NetGear	HDX101-100NAS	UPA	200	2.0-30.0	North America
7	Logitec	LPL-TX/S	UPA	200	2.0-30.0	Japan
8	CNC	CNC-1000	HomePlug 1.0	85	4.3-20.9	Japan

[1] Masahiro Kitagawa and Masatoshi Ohishi, "Measurements of the radiated electric field and the common mode current from the in-house broadband power line communications in residential environment I", IEICE Tech. Rep., vol. 107, no. 533, EMCJ2007-117, pp. 1-6, March 2008.

As can be seen in Table 1, many of the PLT devices use the same standard or different versions of the same standard. Following the laboratory evaluation, it was decided to limit the number of PLT devices at one per standard for the field test. PLT devices 2, 3, and 6 were chosen for field tests.

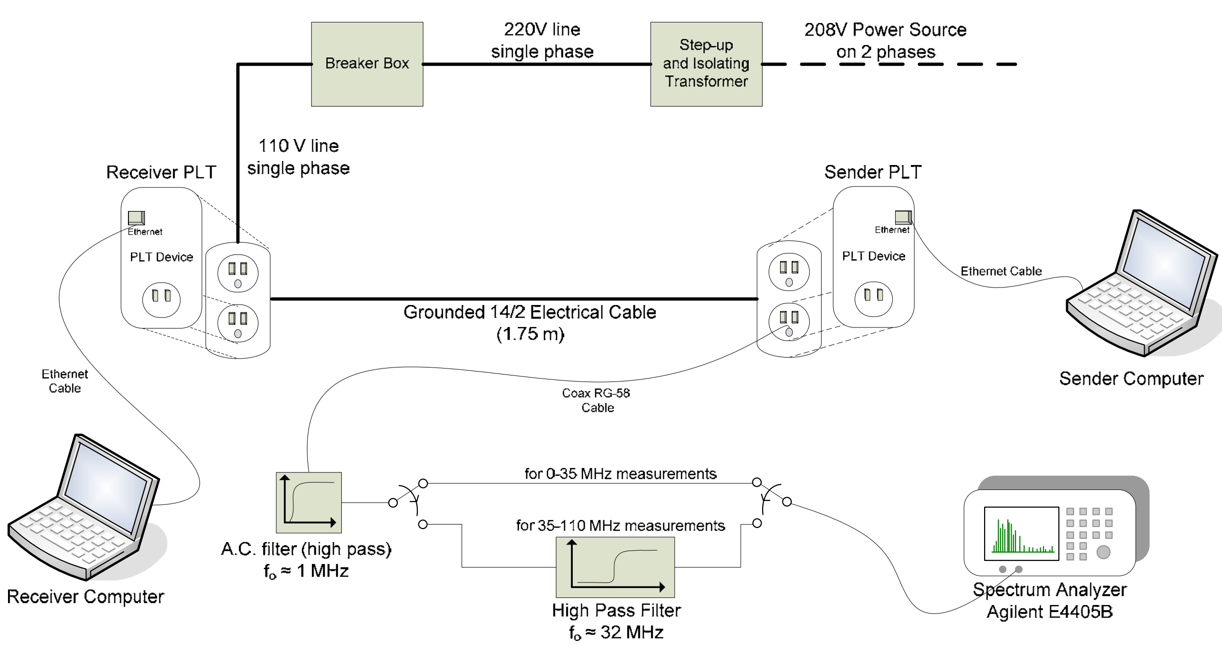
The laboratory setup for the conducted power measurement is presented in Figure 3-1. The AC electrical source came from the CRC main power through a step up transformer and a breaker box to isolate and convert the AC to 110 to 120 volts, 60 Hz single phase voltage. Two outlets, used to plug in the PLT device pairs, were linked with a grounded 14/2 electrical cable of 1.75 meters typical of residential construction. A computer was assigned to each PLT device for the transfer of data. One computer sent a large file to a receiving computer.

The power measurements for signals below 30 MHz were made using an Agilent E4405B spectrum analyzer, set with a resolution bandwidth of 9 kHz and using peak detection and a maximum hold trace of 10 seconds. In order to measure the conducted signal from the PLT devices with the spectrum analyzer, an AC filter was required to remove the 60 Hz, 110 to 120 volt component. The AC filter was a 2nd order LC filter with a cut-off frequency of 1 MHz.

In order to measure low signal levels above 30 MHz with better precision, a high-pass filter was used to attenuate the main PLT signal carriers present in the operating frequency range. This was necessary to measure the emissions up to 110 MHz without overloading the spectrum analyzer. As shown in Figure 1, two laboratory setups were used; one without and one with the high-pass filter. The high-pass filter was supplied by Tin Lee Electronics Ltd., model number HP7 30/33(40) B50, with a –3 dB cut-off frequency of 32 MHz. Only measurements above 35 MHz were done and recorded using this high-pass filter. The resolution bandwidth for these measurements was 120 kHz.

FIGURE 1

PLT Devices conducted power measurements test setup



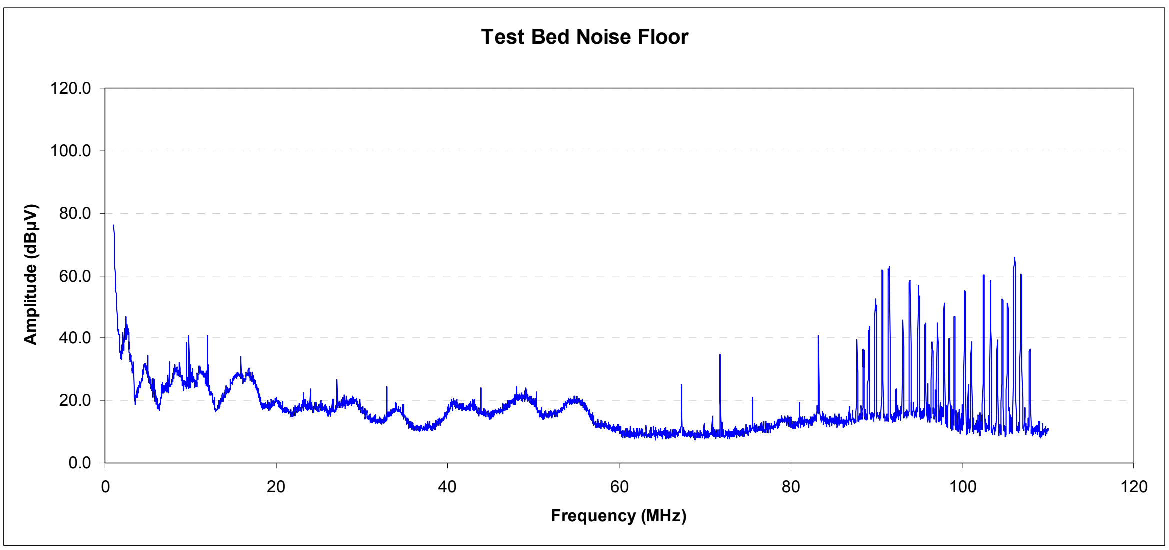
The conducted power measurements were made over the frequency range from 0 to 110 MHz using two modes of operation: Data Transfer mode and Idle mode (no active data transfer). The goal of the tests was to determine the output level injected into electrical lines up to 110 MHz in both modes and the bandwidth and spectral shape of the PLT devices.

In order to achieve good precision, the measurements were made from 0 to 110 MHz in consecutive frequency spans of 10 MHz wide with the spectrum analyzer set to a resolution bandwidth of 9 kHz and using peak detection. In general, the reference level of the spectrum analyzer was adjusted as low as possible without creating spectral overload. Since a high-pass filter was used to obtain improved measurement precision for frequencies above 35 MHz, a discontinuity in the noise floor can be observed in the results at 35 MHz.

The measurement of the test bed noise floor is shown in Figure 2. The Figure illustrates that the electrical line test setup acted as an antenna that captured signals from other radiocommunication systems. The spikes between 85 MHz and 108 MHz are from local FM radio stations, while other spikes at other frequencies were intermittent and probably caused by other radiocommunication systems. It was necessary to take this into account when looking at the conducted emission results.

FIGURE 2

Conducted measurements test setup noise floor



The results for PLT devices 2, 3 and 6 are shown in Figures 3, 4, and 5, respectively. The blue curve shows the conducted signal during data transfer and the green curve (generally, the lower trace) shows the conducted signal in the idle mode. As can be seen in the figures, the signal level in idle mode does not exceed the signal level in data transfer mode. Additionally, the devices tested don’t operate identically in idle mode. PLT devices 2 and 3 were transmitting occasional carriers to keep the channel open and synchronized, while device 6 was constantly transmitting its full signal bandwidth. The results of conducted measurements for the other PLT devices are shown in Appendix A of the CRC Report contained in the Attachment.

FIGURE 3

Conducted power from Device 2 (HD-PLC standard)

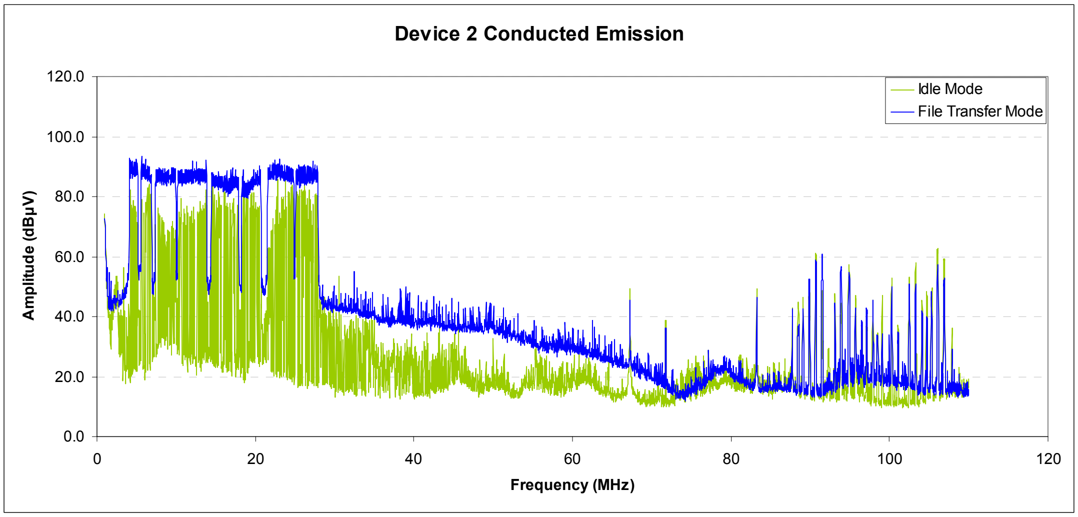


FIGURE 4

Conducted power from Device 3 (Homeplug AV standard)

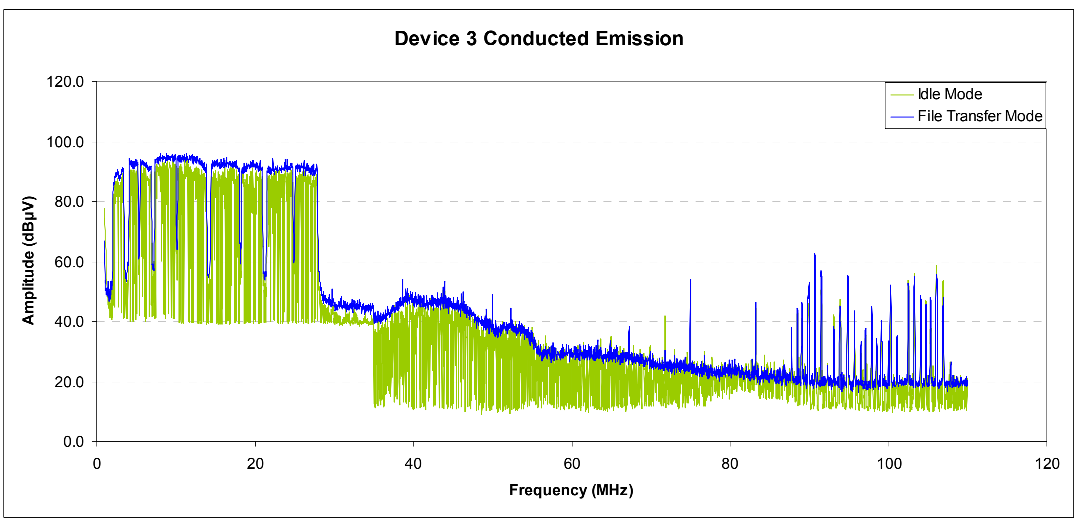
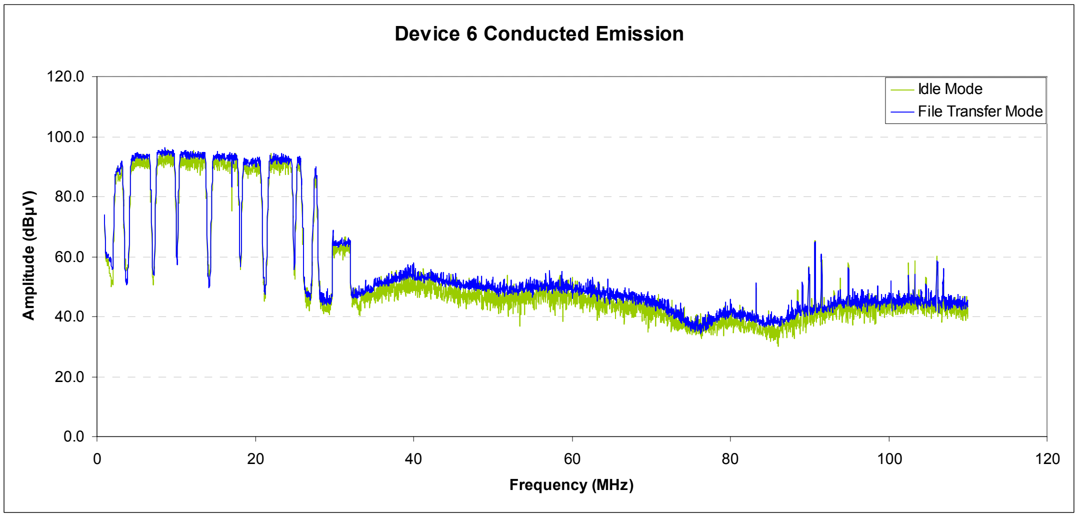


FIGURE 5

Conducted power from Device 6 (UPA standard)



These results illustrate that the potential for interference is pervasive and continuous from a PLT device. Even if the PLT device is not transmitting data, the device is actively generating emissions. It is also observed that even if the PLT device operates below 30 MHz, the device significantly raises the noise floor up to at least 80 MHz.

3 Field strength measurements – Procedure and results

RF field strength measurements were made using one and two-story residential houses near Ottawa, Canada. Most of the houses are connected to the electricity distribution grid (220 volts single phase) through underground lines, but some were connected using overhead lines. The front and the back of the houses had enough clearance to make field strength measurements at three and ten meters from the outer walls, thus these orientations were selected for the measurements.

A total of 17 houses were selected for the field tests as shown in Table 2 representing various layouts and construction materials. The table summarises each test site, including the type of house, the material of the outer walls and the type of electrical line used to connect the house to the electricity grid of the neighbourhood (underground or overhead lines). Appendix B of the CRC Report contained in the Attachment provides the full description of all 17 test sites, including pictures and a diagram of each house.

TABLE 2

Description of the field test sites

Site #	Type of House	Exterior Wall Material				Electrical Line
		Front Wall		Back Wall		
		1st Floor	2nd Floor	1st Floor	2nd Floor	
1	Two-story single-detached	Brick	Vinyl	Vinyl	Vinyl	Underground
2	Two-story semi-detached	Brick	Brick/Canaxel	Brick	Canaxel	Underground
3*	Two-story single-detached	Brick	Brick/Vinyl	Vinyl	Vinyl	Underground
4	Two-story single-detached	Brick	Brick	Brick	Aluminum	Underground
5	Two-story single-detached	Brick	Brick	Brick	Aluminum	Underground
6	Two-story townhouse	Brick	Brick/Vinyl	Vinyl	Vinyl	Underground
7	Two-story single-detached	Brick	Brick	Vinyl	Vinyl	Underground
8	Two-story single-detached	Brick	Brick	Vinyl	Vinyl	Underground
9	Bungalow single-detached	Brick	N/A	Vinyl	N/A	Underground
10	Two-story townhouse	Brick	Aluminum	Aluminum	Aluminum	Underground
11	Bungalow single-detached	Stucco	N/A	Stucco	N/A	Underground
12	Two-story single-detached	Brick	Vinyl	Vinyl	Vinyl	Overhead
13	Sides split single-detached	Brick	Brick	Brick	Vinyl	Underground
14	Two-story single-detached	Brick	Shingle	Brick	Shingle	Overhead
15	Two-story single-detached	Brick	Aluminum	Brick	Aluminum	Overhead
16	Two-story single-detached	Brick	Brick/Shingle	Vinyl	Vinyl	Underground
17	Two-story single-detached with loft	Brick	Brick/Vinyl	Vinyl	Vinyl	Underground

* The data from Test site 3 was not used in the analysis. It was found that PLT devices in use in an adjacent house during the tests interfered with the results.

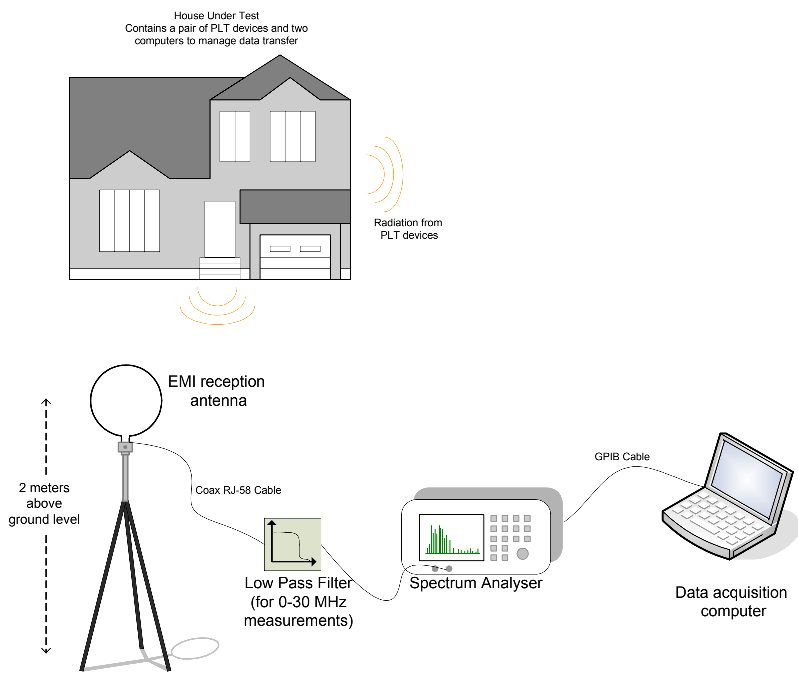
The PLT devices (2, 3, and 6) were tested in pairs of the same model, connected to AC outlets inside the houses. The devices were positioned inside the house to be far apart from each other, representing a realistic home network. The devices were positioned as to have one device from a PLT pair in a room near the front of the house and the other device near the back of the house. In the case of two-story homes, one PLT device was on the first floor and one was on the second floor. Each PLT device was connected to a personal computer. Two modes of PLT operation were tested: Data Transfer mode for all the houses and the Idle mode for a few selected houses. For the data transfer mode, measurements were made while a large file was transferred between the two computers. Reference measurements of the ambient noise were also performed at each measurement location.

The RF field strength was measured using a calibrated passive loop antenna for the frequency range of 0 to 30 MHz (EMC Test Systems, Model 6512) and a calibrated passive dipole antenna for the frequencies of 30 to 108 MHz (A.H. Systems Inc. Model SAS-530 balun and SAS-542 folding elements). The antenna factor of these antennas was precisely calibrated to yield RF field strength measurements in dBµV/m. The antennas were positioned at two meters above ground level. The measurements were made at three meters and ten meters from the front and back outer walls of the houses.

Figure 6 shows the test setup for RF field strength measurements. A low pass filter (Tin Lee Electronics Ltd. Model LP7E-30-37 B50, –1 dB Cut-off at 31 MHz, –40 dB Cut-off at 35 MHz) connected between the antenna and the spectrum analyser was used to remove high-powered VHF signals (FM and TV stations) when measuring below 30 MHz, so as not to overload the spectrum analyser.

FIGURE 6

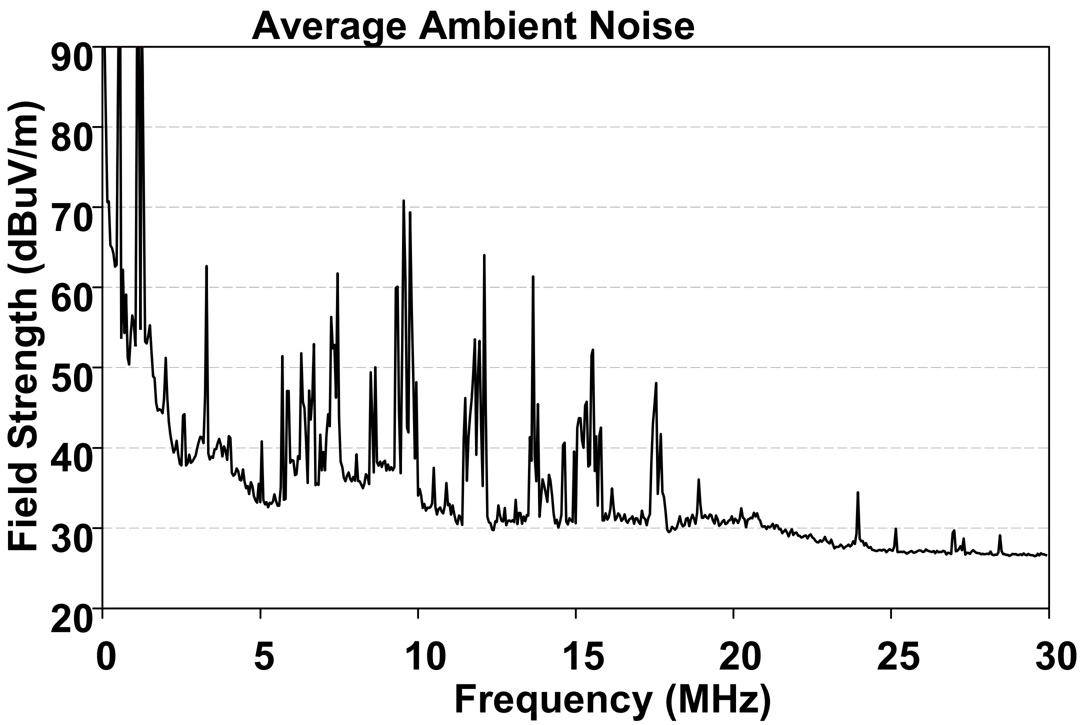
RF Field strength measurement test setup



The average ambient noise measurement (linear voltage average converted back to a dB scale) for 16 test sites is shown in Figure 7. The contribution of the ambient noise in the field strength measurement was not negligible at certain frequencies. Most of the strong signal spikes were believed to be from amateur or short wave band stations. Other noise sources such as electric motors (furnace, refrigerator and other appliances) may have contributed in raising the ambient noise.

FIGURE 7

Average ambient noise distribution at 3 and 10 meters for 16 test sites



For the purpose of analysing the measured RF field strength, all measurements done on the 16 houses were grouped by their respective devices and distance from the houses. Note that Test Site 3 is not included in this statistical analysis because of interference from neighbouring PLT devices. Figure 8 through Figure 13 show the statistical analyses for the three devices. Each Figure shows the maximum RF field strength measured for each device. Furthermore, the study used the measurements from the 16 houses to calculate a confidence interval that should represent the expected maximum field strength from PLT devices radiated from typical houses. A 95 % confidence interval of the RF field strength is calculated from the standard deviation of the 16 houses sampled, given a normal distribution. The upper bound of this 95 % confidence interval is shown. The calculations in this statistical analysis were done with linear values. As explained above, the contribution of interference from sources other than PLT devices was not negligible and can not be removed from the statistical analysis.

FIGURE 8

RF field strength distribution, PLT Device 2 (HD-PLC) at 3 meters

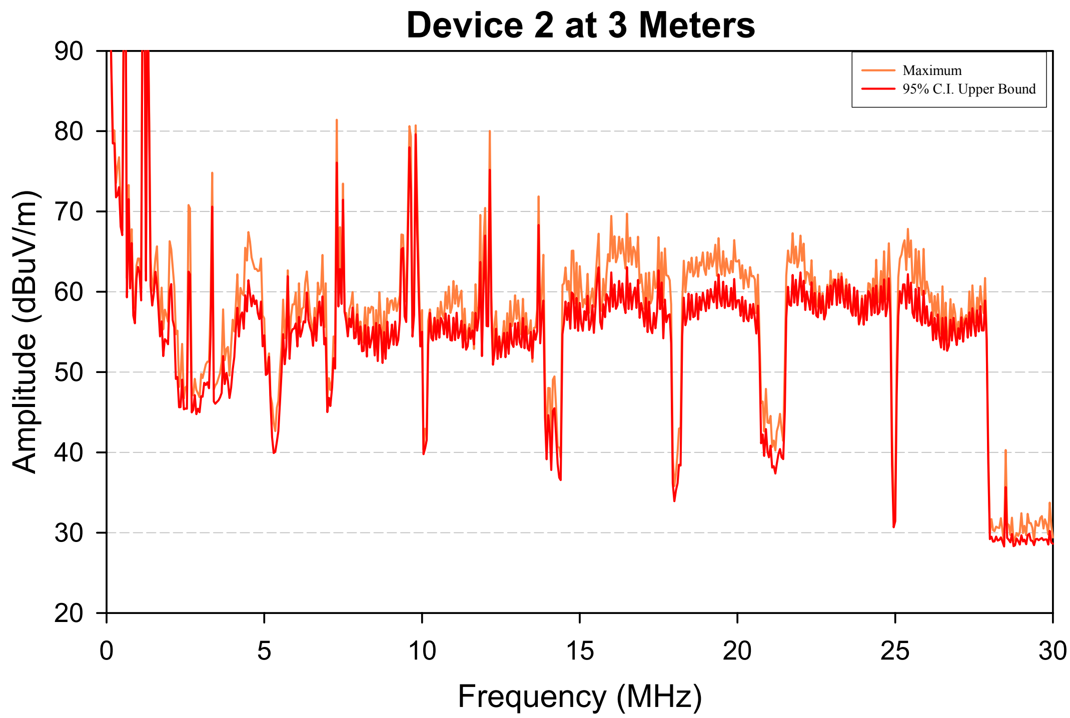


FIGURE 9

RF field strength distribution, PLT Device 2 (HD-PLC) at 10 meters

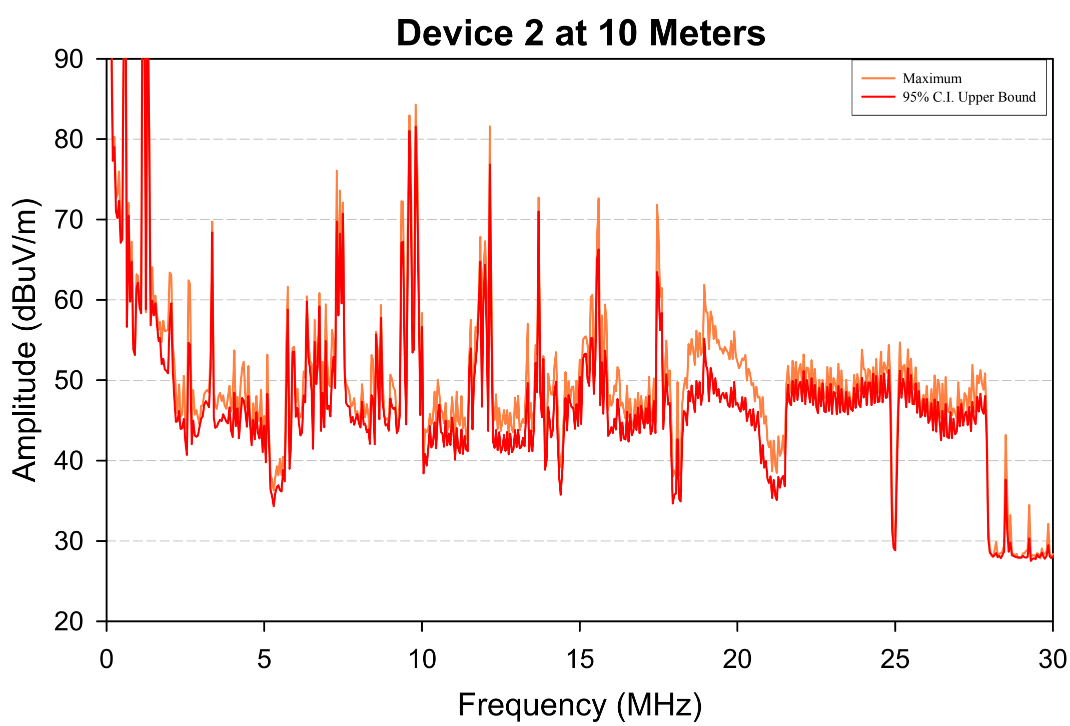


FIGURE 10

RF field strength distribution, PLT Device 3 (Homeplug AV) at 3 meters

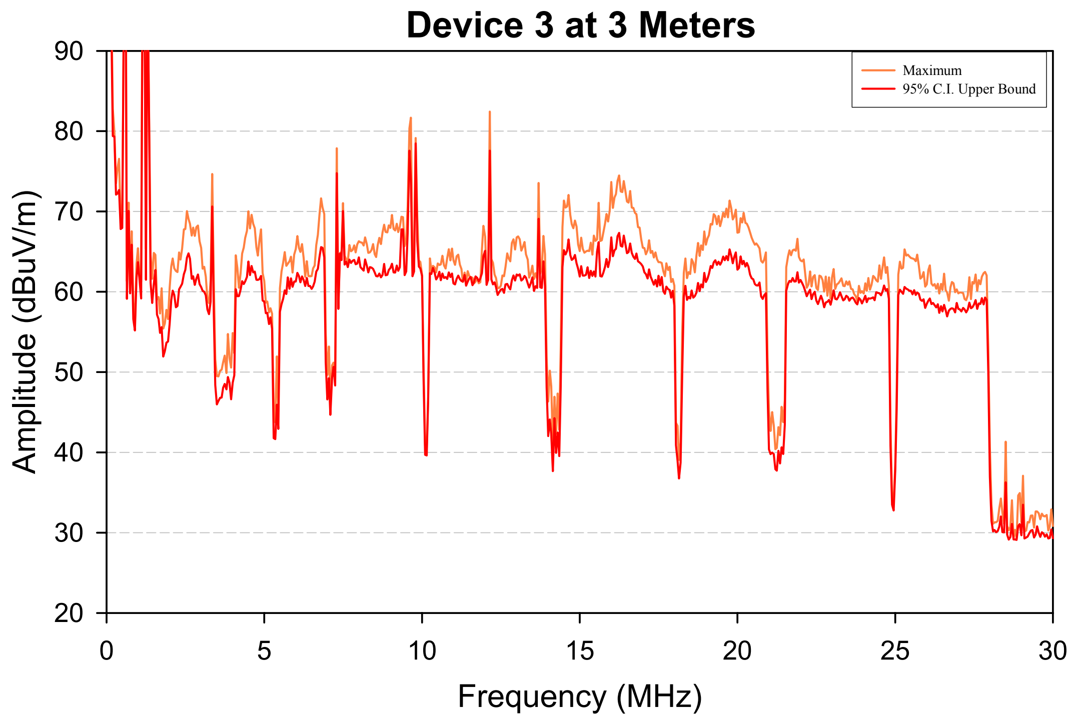


FIGURE 11

RF field strength distribution, PLT Device 3 (Homeplug AV) at 10 meters

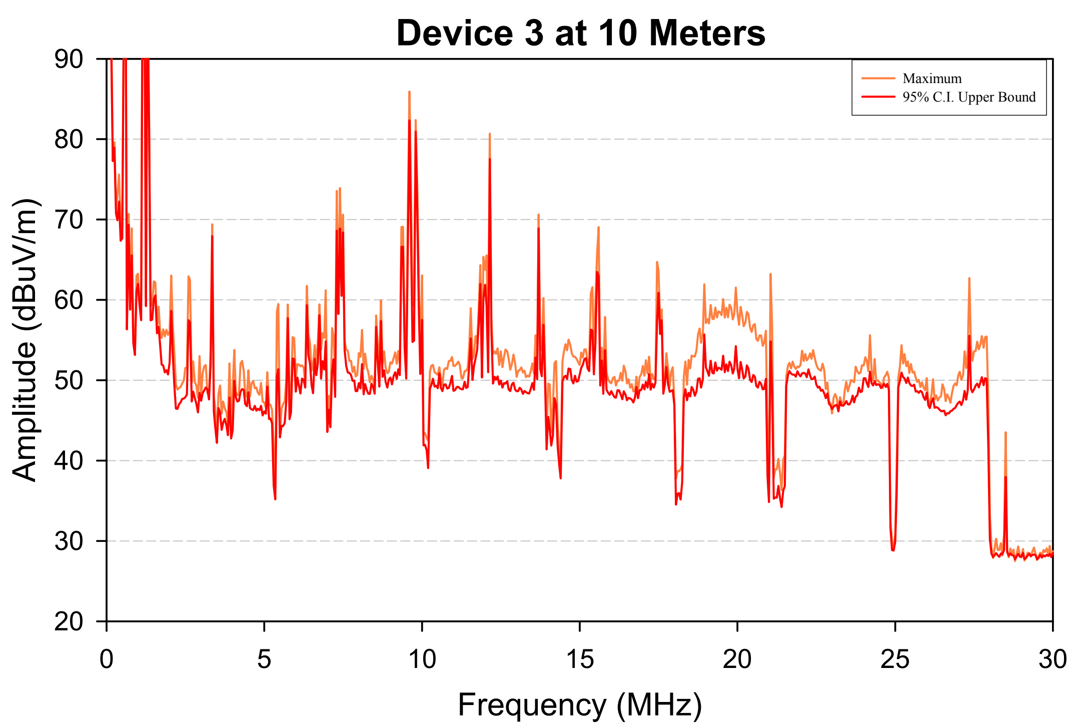


FIGURE 12

RF field strength distribution, PLT Device 6 (UPA) at 3 meters

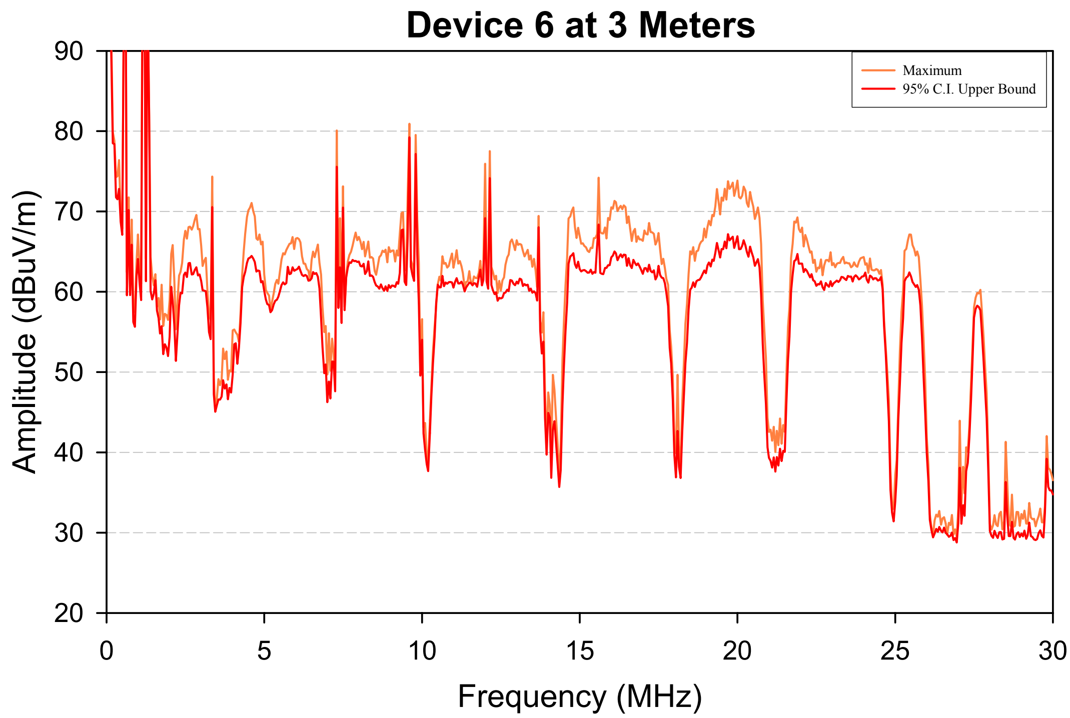
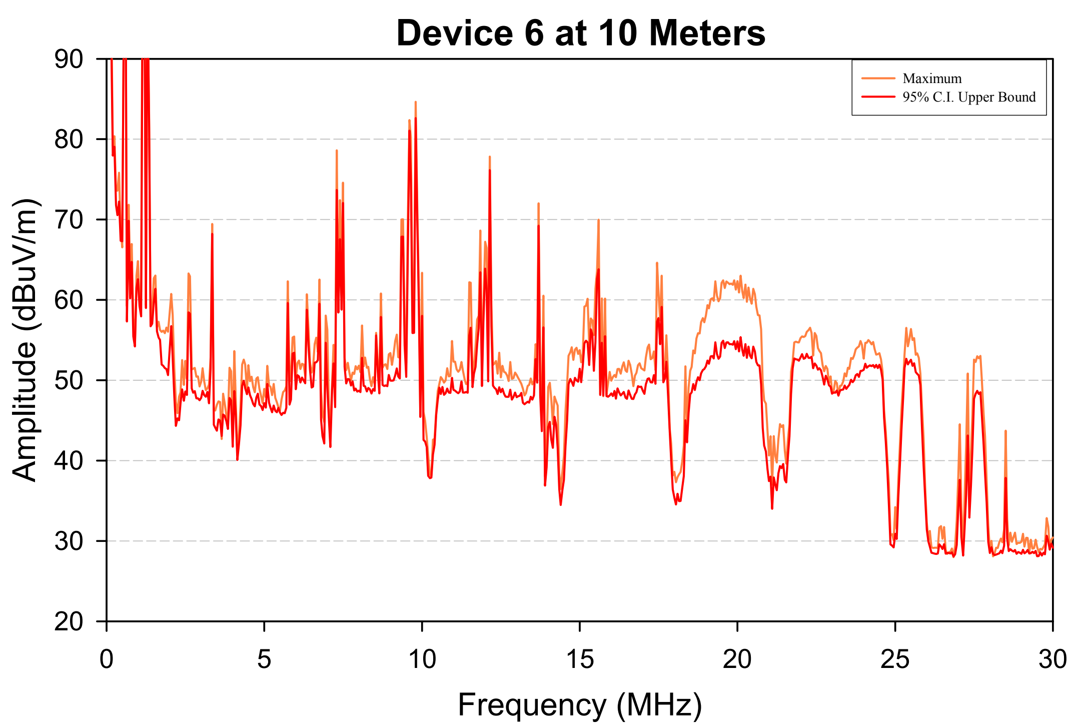


FIGURE 13

RF field strength distribution, PLT Device 6 (UPA) at 10 meters



4 Conclusions

The results of laboratory and field testing by the CRC clearly show that emissions from PLT devices in a typical residential house easily exceeded the ambient noise levels by more than 30 to 40 dB at a distance of 10 to 3 meters, respectively, from the outer wall of the house. Thus, as observed by the CRC, PLT devices will interfere with radiocommunication services, especially those services operating on a noise-limited basis. The Broadcasting Service is particularly vulnerable to interference from PLT devices. The planning factors for the BS require reception at much lower field strengths then are possible in the presence of emissions from PLT devices. For example, Recommendation ITU-R BS.703 sets the minimum useable field strength for an average HF broadcast receiver at 40 dBµV/m. The CRC test results presented here clearly show that PLT devices will generate interference levels 20 to 30 dB higher than the signal levels for which an HF broadcast receiver is expected to receive.

Recommendation ITU-R BT.1786 provides a criterion to protect the BS from interference caused by emissions of PLT devices in the bands allocated to the BS. This Recommendation should be applied to PLT devices for all frequencies utilized by the broadcasting service to ensure protection from interference. The criterion specifies that the total interference to systems operating in the broadcasting service, from all sources of interference (PLT devices included) should at no time exceed one per cent of the total receiving system noise power

Attachment to the Annex

"Measurements of EM radiation from in-house Power Line Telecommunication (PLT) devices operating in a residential environment – Field Test Report", Communications Research Centre (Canada), 28 January 2009

CRC PLT Test Report

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