Radiocommunication Study Groups

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North American Broadcasters Association (NABA)

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT NEW REPORT

On measurement techniques for power line high data rate telecommunication 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 in Annex 5 to Document 1C/35 that Working Party 1C has developed a "Working Document towards a Preliminary Draft New Report" entitled "On measurement techniques for power line high data rate telecommunication systems." NABA notes further that Working Party 7D, in Document 1C/41, has raised concerns with the measurement methods proposed in the working document. NABA agrees with the view of WP 7D that the radiated emission measurement should be used for the case of Power Line Telecommunication (PLT) systems. NABA has recently completed a field study of PLT emissions at the laboratories of the Canadian Communications

Research Centre (CRC)1. The CRC report of the study is attached in Annex 1 of this document for inclusion in the Preliminary Draft New Report.

The CRC field measurements address the relationship between common-mode and differential-mode currents and radiated emissions from residential dwellings using in-house PLT devices. The results of these measurements are summarized in Annex 2 below for inclusion in the Preliminary Draft New Report.

Annex 1

"Measurements of EM radiation from in-house Power Line Telecommunication (PLT) devices operating in a residential environment – Field Test Report", Communications Research Centre (Canada), 24 March 2009


CRC PLT Test Report

Annex 2

1 CMI and DMI Field Test

Common Mode Current (CMI) and Differential Mode Current (DMI) measurements were made in two residential dwellings (see CRC Report in Annex 1, Sites 1 and 4). The purpose of measuring CMI and DMI was to determine if there is a relationship between these two measurements and EMI caused by PLT devices.

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[1] The 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.

1.1 CMI and DMI Field Test Setup

The measurements were made at four electrical outlets in each house. Two of these outlets were the same outlets that were used to connect the PLT devices during EMI field tests. The CMI and DMI were measured at these two outlets by inserting a short extension cable between the PLT device and the outlet. Two additional outlets were tested, one on each floor of the houses. An open ended extension cable was used to measure the CMI and DMI at these outlets. Consequently, there were two different test setup used for these measurements, as is described below.

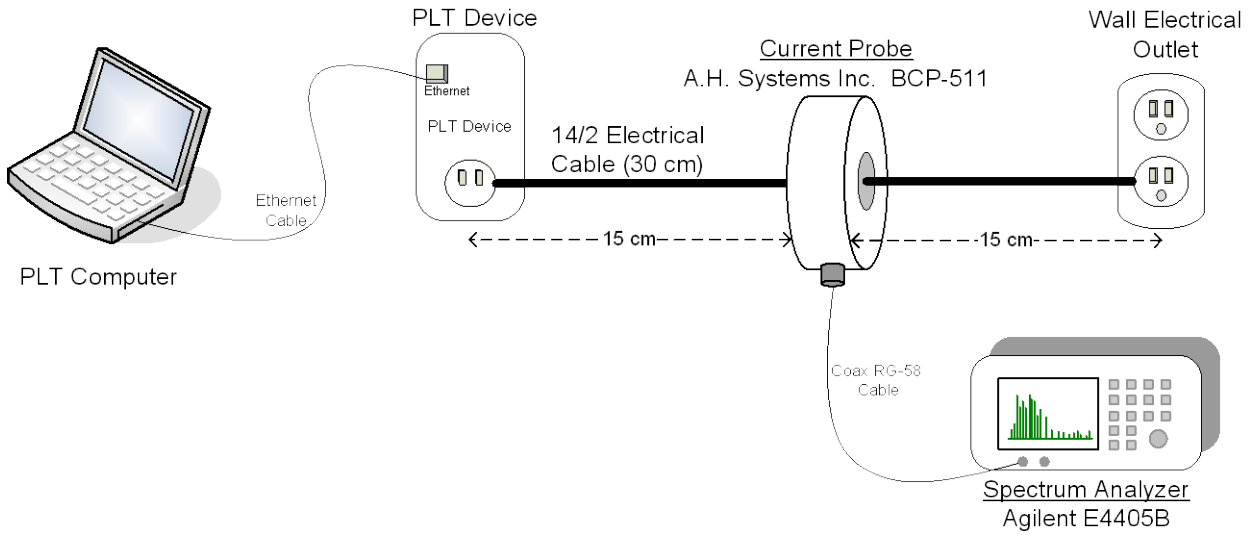
CMI and DMI measurements required the following equipment:

- Agilent E4405B spectrum analyzer
- Current Probe
  - Brand: A.H. Systems Inc.
  - Model number: BCP-511
  - Operating Range: 20 kHz – 100 MHz
- 2 x 14/2 grounded electrical cable (30 cm and 3 meters cables)
- PLT device pairs 2, 3 and 6 (see CRC Report in Annex 1)
- Two computers used to transfer data over the PLT network

Figures 1 and 2 show the configuration for the test setups and the equipment used. Figure 1 shows the test setup when testing on an outlet that had a PLT device connected, while Figure 2 is the setup that was used to test at other outlets in the houses (no PLT device connected).

FIGURE 1

CMI and DMI Test Setup at PLT Outlet



As shown in Figure 1, an electrical cable extension of 30 cm was inserted between the PLT device and its respective outlet. A current probe was placed halfway on the extension cable to measure the current with the spectrum analyzer. Measurements were made while the pair of PLT devices present on the electrical network was in data transfer mode.

During CMI measurements, the current probe encircles all the wires in the electrical cable (Live, Neutral and Ground). For DMI measurements, the electrical cable sheath was removed and only the Live wire is placed in the current probe, while the Neutral and Ground are looped outside the probe.

FIGURE 2

CMI and DMI Test Setup at Other Outlet

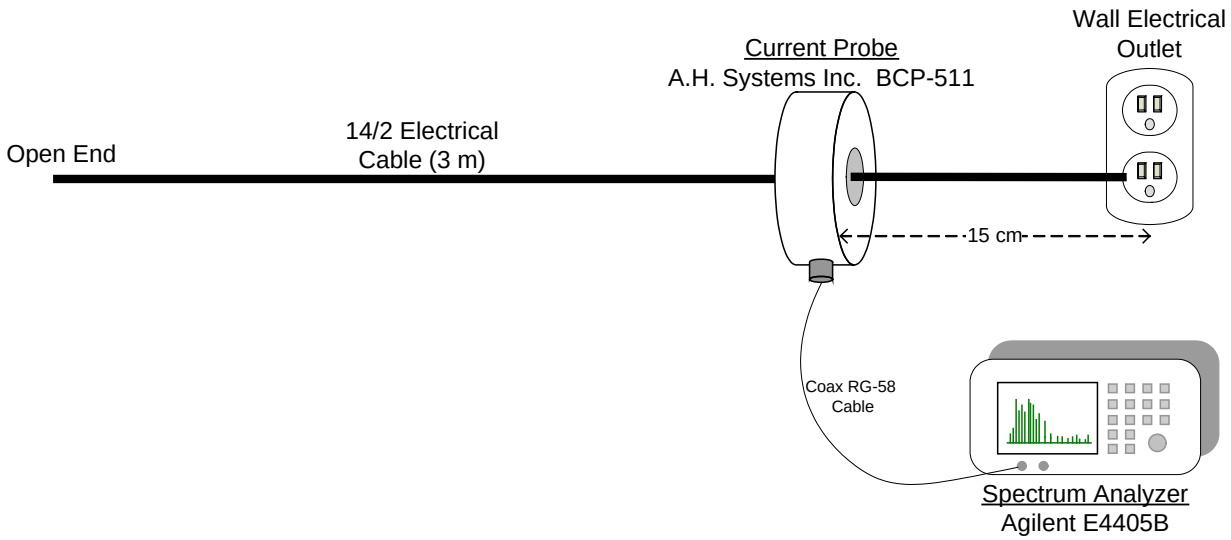


Figure 2 shows the test setup when testing on outlets that had no PLT devices connected. As can be seen in the figure, an open ended extension cable of 3 meters was used to place the current probe. The pair of PLT devices was still connected to their original outlets in the house, and the data transfer was initiated.

The measurements were done over the frequency range of 0-30 MHz for configurations. The following settings were used for the spectrum analyzer:

- Resolution Bandwidth = 10 kHz
- Average Detector
- Max Hold Trace (10 seconds)
- One trace point every 50 kHz (601 points total)

1.2 CMI & DMI Field Test Measurements

The results for CMI and DMI field test measurements are presented in this section. Only the results from one of the two sites (Site 4) are presented here since the observations and conclusions are the same for both sites. The results for Site 1 are available in the CRC report (Annex 1).

1.2.1 CMI Measurements and Observations

The CMI measurements made on the four electrical outlets for the measurement site and the three PLT devices are shown in Figure 3 through Figure 6.

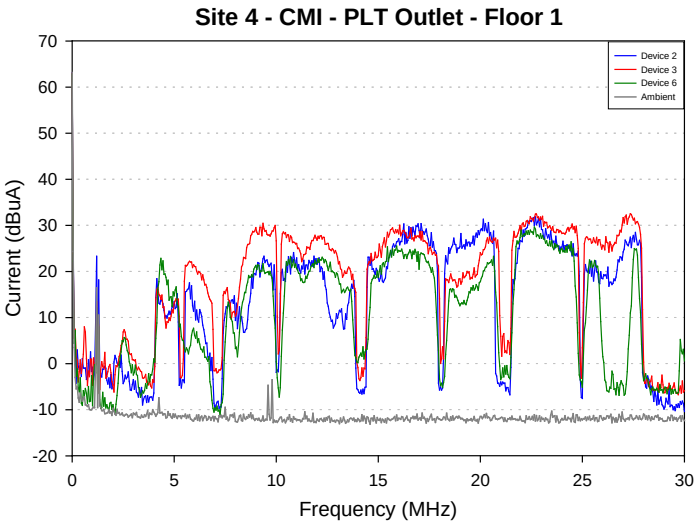


FIGURE 3

CMI at PLT Outlet on Floor 1

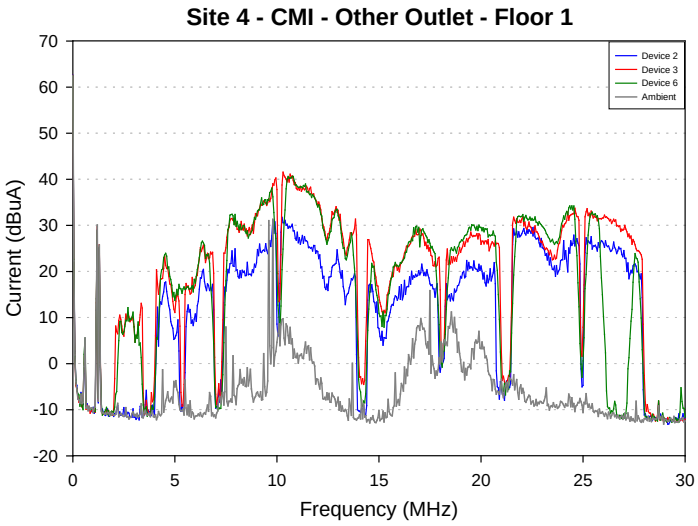


FIGURE 4

CMI at Other Outlet on Floor 1

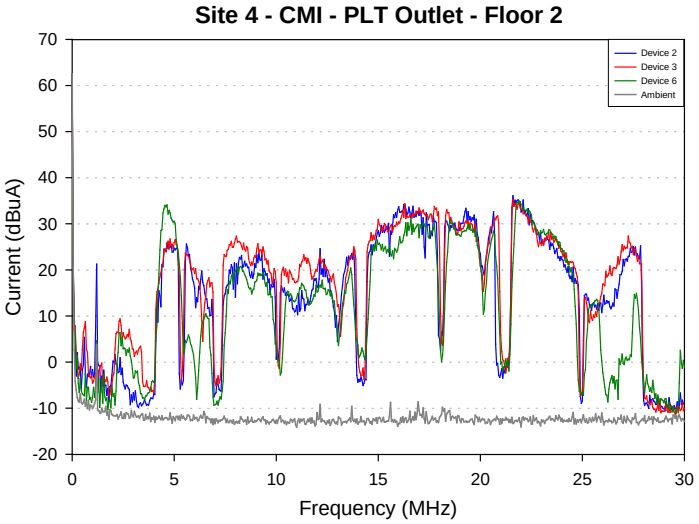


FIGURE 5

CMI at PLT Outlet on Floor 2

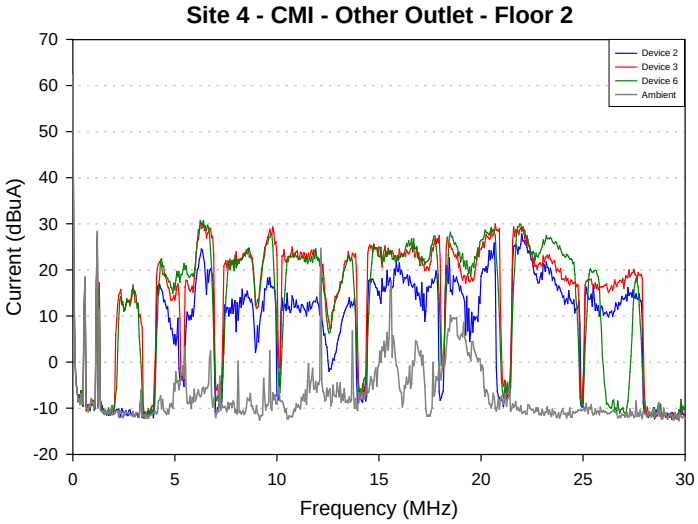


FIGURE 6

CMI at Other Outlet on Floor 2

In the figures above, the term “PLT Outlet” refers to an electrical outlet that had a PLT device connected to it, while the term “Other Outlet” refers to an outlet that didn’t have a PLT outlet, as explained in the test setup description of Section 1.1 above.

Figure 7 shows a comparison of CMI between the four electrical outlets under test, but only for a single PLT device (Device 3).

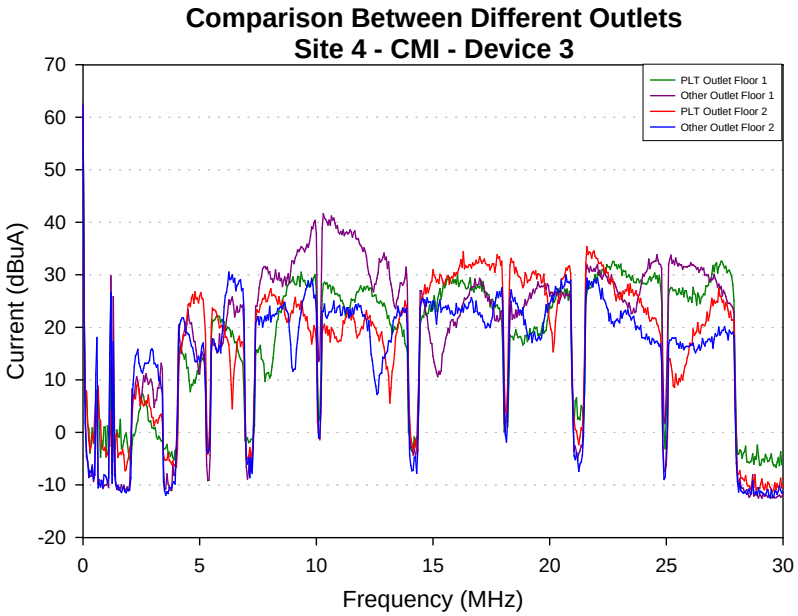


FIGURE 7

Comparison of CMI for a Single Device on the Four Electrical Outlets

From the CMI measurements presented in this section, the following observations were made:

- For a single device and outlet, CMI level vary greatly depending on the frequency range (it's not flat over the frequency range).
- When comparing different devices on a single outlet, devices that transmit stronger conducted power don't necessarily have stronger CMI over all the frequency range. Devices that transmit lower conducted power can have higher CMI than other devices at certain frequencies.
- From outlet to outlet, the CMI is completely different.
- **There is no discernable relationship between EMI and CMI.** A CMI measured is only valid for a single point on the electrical network. The EMI would be a summation of CMI over the whole house network as seen from the EMI antenna point of view. Because of this, the in-house EMI might be different from room to room. This is similar to the near field effect of an antenna. Being further away would stabilize that effect.

1.2.2 DMI Measurements and Observations

The DMI measurements were done on the same conditions as CMI. The DMI was measured only on the Live wire. Figures 8 through 11 show the DMI for the four electrical outlets under test.

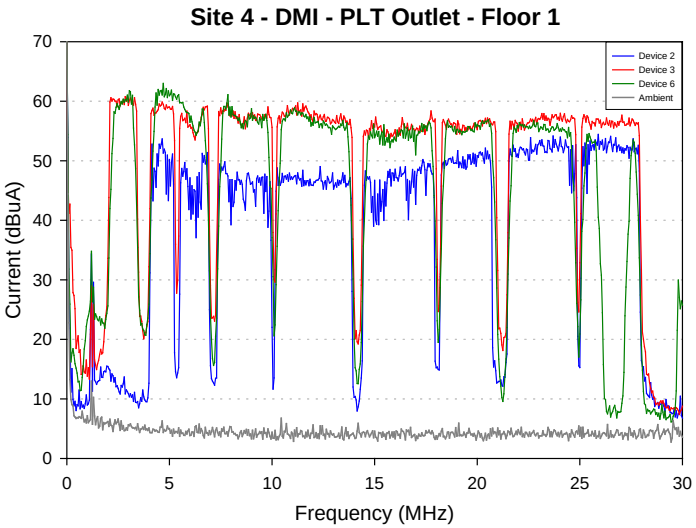


FIGURE 8

DMI at PLT Outlet on Floor 1

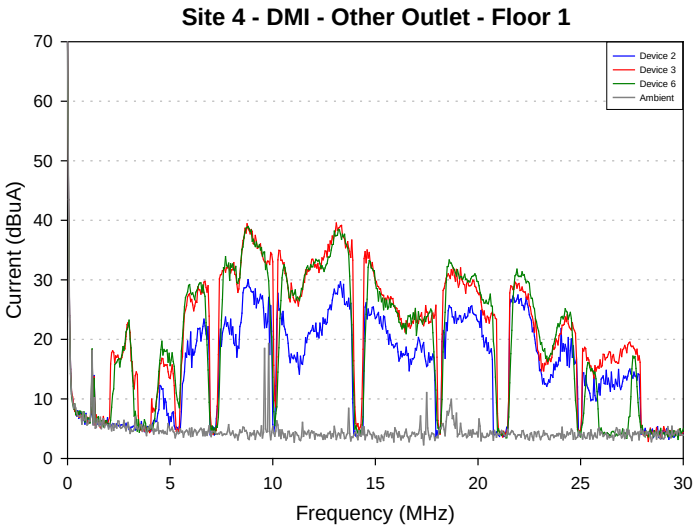


FIGURE 9

DMI at Other Outlet on Floor 1

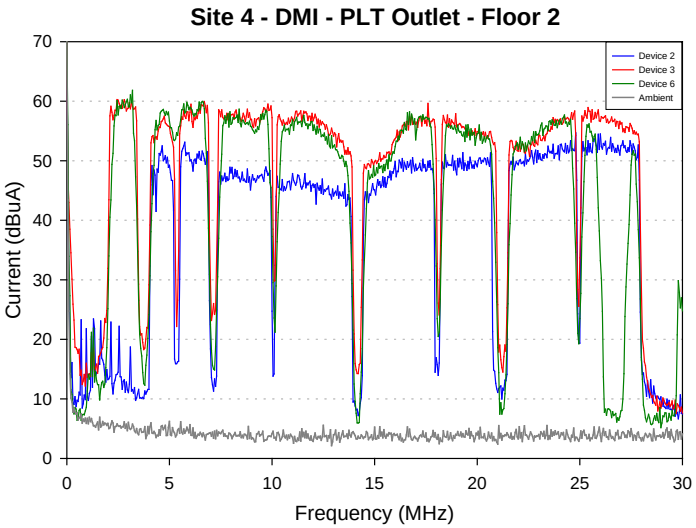


FIGURE 10

DMI at PLT Outlet on Floor 2

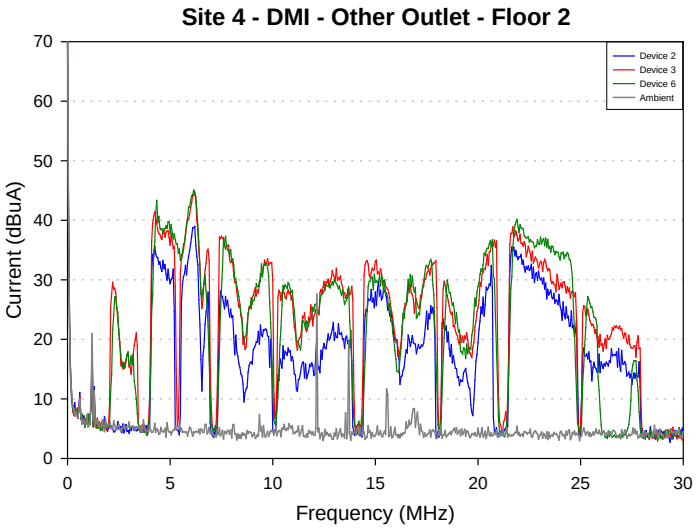


FIGURE 11

DMI at Other Outlet on Floor 2

The DMI measurements done during field trials can be summarized by the following points:

- In contrast to CMI, DMI measured at PLT outlets show more consistent results with the devices' conducted power. So devices with stronger output power show stronger current readings.
- The DMI measured at other outlets (where no PLT is connected) exhibit wide amplitude differences over the frequency range. This is good to show what a PLT signal looks like when received from another device. It shows that the home electrical network has a very severe frequency response.

- Some DMI measured at other outlets (non-PLT outlets) show much lower current level probably due to the outlet being connected to a different live wire than the PLT devices are using (e.g., in North America, most houses have two phase AC power).
- There is no observable relationship between CMI and DMI

2 LCL Field Test Results

The longitudinal conversion loss (LCL) is a parameter that measures the balance of a line. It defines the conversion ratio of differential mode signal to common mode signal in a communication network. The LCL was measured at the same houses and electrical outlets where CMI and DMI were measured in the previous section. The purpose of these tests is to obtain LCL in typical household electrical outlets and see if there is an observable correlation with the CMI and DMI measurements.

2.1 LCL Measurements Tests Setup and Methodology

The LCL measurements were done in conjunction with the CMI and DMI measurements described above. At each of the four PLT outlets used to measure the CMI and DMI (see section 1), the LCL was measured over the frequency range of 0-30 MHz. Performing the LCL measurements required the following list of equipment:

- Hewlett Packard 8753D Network Analyser
- LCL Probe (Longitudinal Balance Bridge)
    - Brand: North Bridge
    - Model number: 52100LBB
    - Operating Range: 0.1 – 100 MHz
- 14/2 grounded electrical cable (1 m)
- High-Pass AC filter (built into the 30 cm electrical cable connector)
    - Brand: CRC custom made
    - -1dB Cut-off frequency: 1 MHz

Figure 12 shows the test setup for the LCL measurements. The Network Analyser ports 1 and 2 were connected to their respective ports 1 and 2 on the LCL probe, while the 1 meter electrical cable was connected to the LCL probe's test port and into the wall outlet. To protect the equipment from the main 60Hz AC voltage, an AC high pass filter was placed between the LCL probe and the electrical cable.

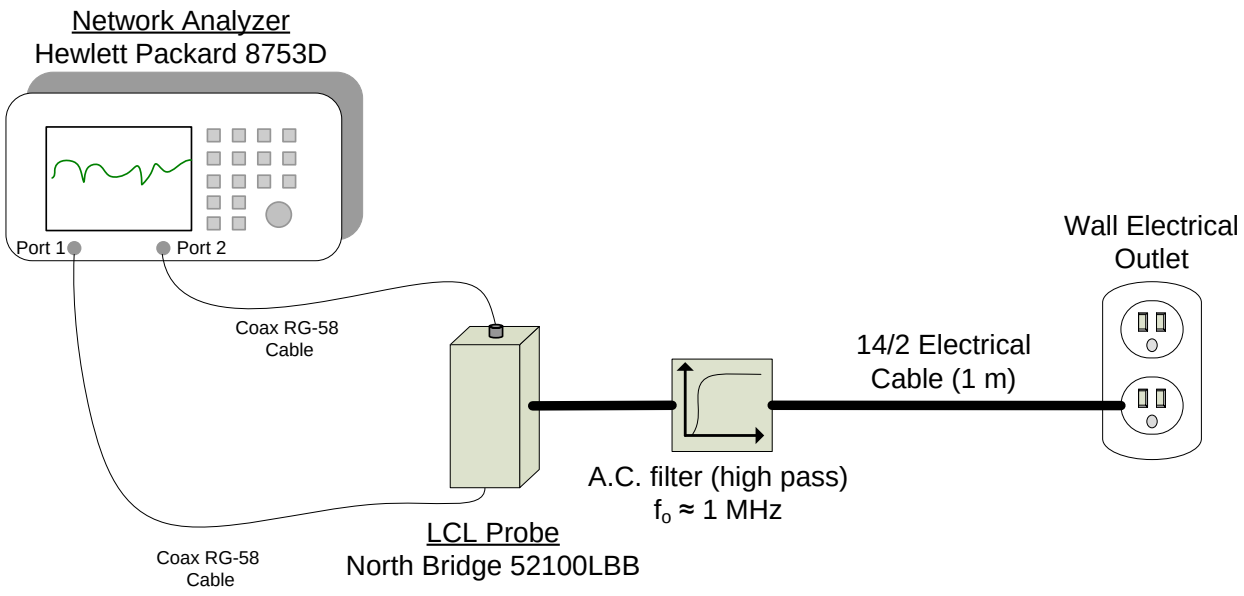


FIGURE 12

LCL Field Test Setup

Prior to doing a measurement, calibration was performed on the network analyzer for a S_{21} measurement with a calibration load that was supplied with the LCL probe. Afterwards, the LCL probe was connected as in Figure 12 and the LCL was measured.

2.2 LCL Field Tests Measurements and Observations

The LCL measurements for Site 4 are presented in this section. Full results for Site 1 are available in the CRC report (Annex 1). Figure 13 through 16 show the LCL measurements for each individual outlet, while Figure 17 shows the LCL for the four outlets on the same figure.

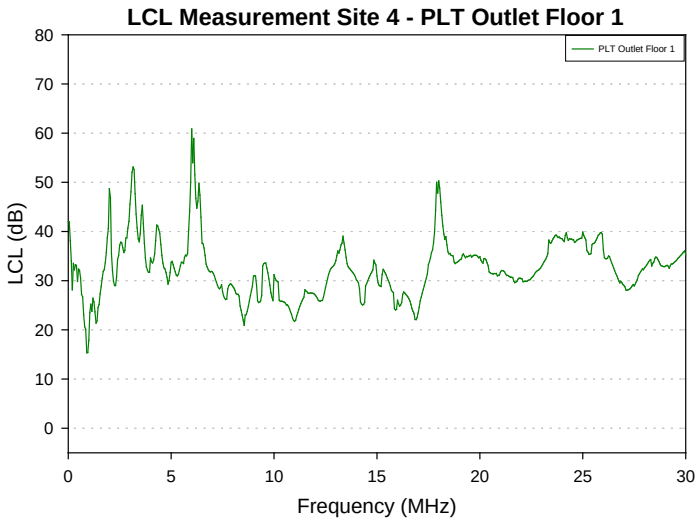


FIGURE 13

LCL at PLT Outlet on Floor 1

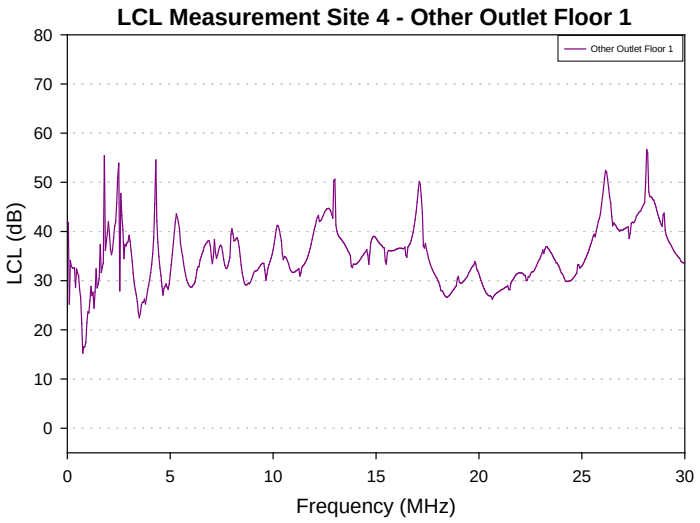


FIGURE 14

LCL at Other Outlet on Floor 1

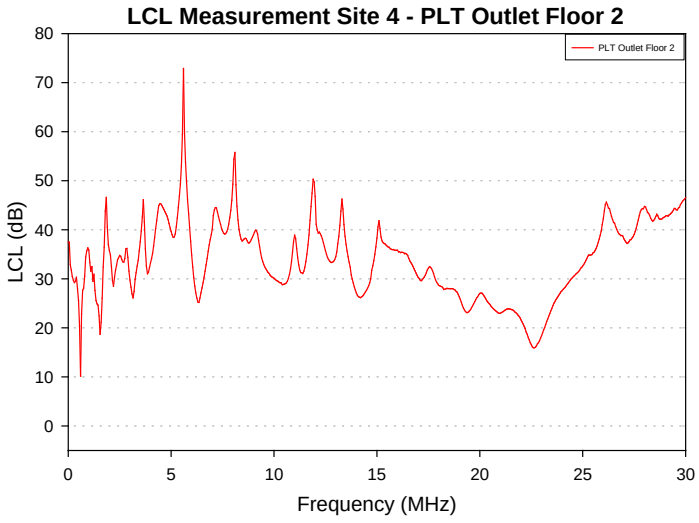


FIGURE 15

LCL at PLT Outlet on Floor 2

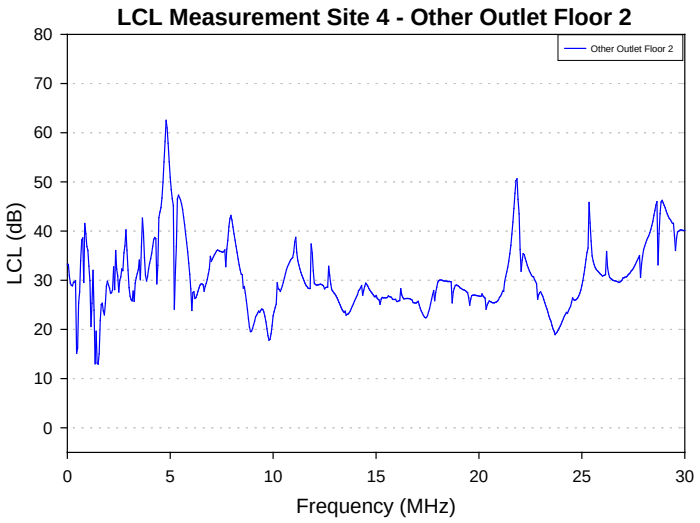


FIGURE 16

LCL at Other Outlet on Floor 2

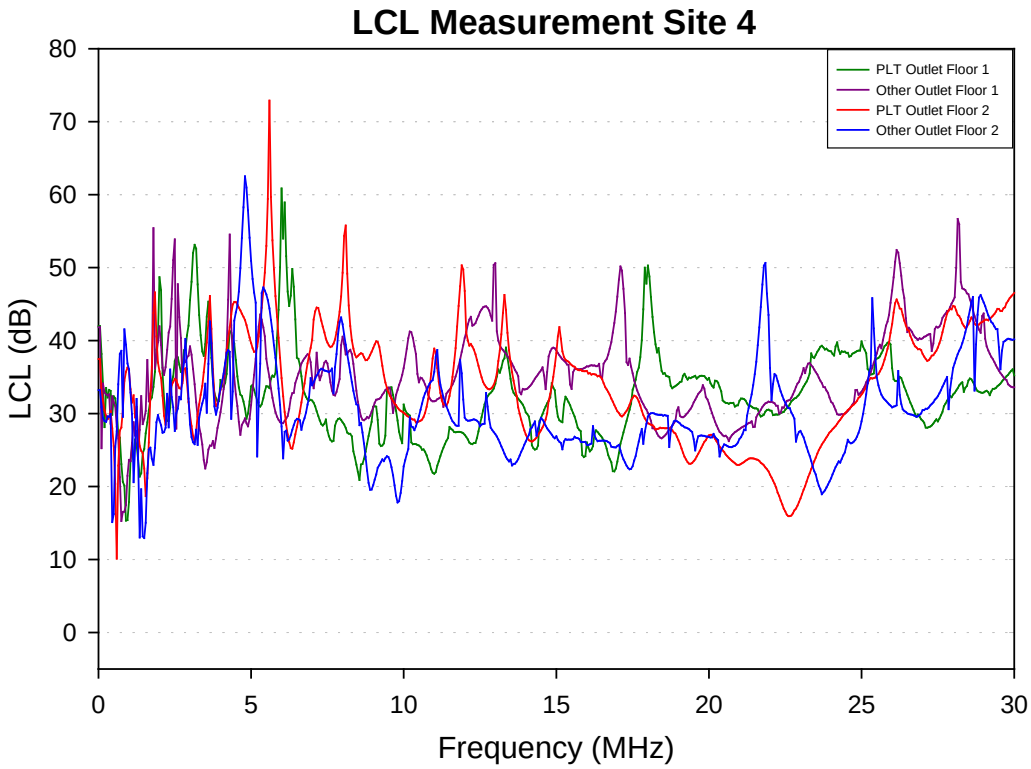


FIGURE 17

Comparison of LCL on the Four Electrical Outlets

From the figures above and the additional results for Site 1 (see Appendix C of the CRC Report), the following observations were made on LCL at the electrical outlets of typical houses:

- LCL is generally 20 dB or greater, which is consistent with the Japanese ITU-R submission 2007[2] which assumed a value of 16 dB for the test bed.
- The LCL varies greatly over the frequency range. There are differences of more than 40 dB depending on frequency.
- LCL is very different between different outlets of a single home.
- There is no observable relationship between CMI/DMI and LCL.
- It was observed during field tests that LCL is very sensitive to house appliances and electric devices depending on whether these appliances and devices are powered on or not.

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[2] ITU-R study group 1A/154-E document, "Proposed Modification to the Working Document Toward a Preliminary Draft New Recommendation – Power Line High Data Rate Telecommunications Systems (Japan)", June 5 2007