CURRENT Technologies, LLC
Report of Measurements
CT LVR™ OH 5000

Table of Contents

1. General Information

Applicant:	CURRENT Technologies, LLC
Applicant Address:	20420 Century Boulevard Germantown, MD 20874 301-944-2700
Equipment:	CT LVR™ OH 5000
Equipment Description:	The CT LVR OH 5000 is part of an Access BPL system. It operates on overhead public utility power lines over the low-voltage wires. The CT LVR OH 5000 is used to repeat proprietary low-voltage signals between a subscriber link and a CT Bridge® OH 5000ml.
Test Operator:	Steve Seymour
Dates of Testing:	November 3, 2006 to November 21, 2006
Test Locations:	▪ Washington Laboratories Open Area Test Site (Gaithersburg, Maryland), ▪ CURRENT Technologies Field Research and Test Area (Urbana, Maryland) ▪ CURRENT Technologies Rockville Test Area (Rockville, Maryland)
Modes of Operation:	▪ Active: transmitting high-density OFDM signal on Low-Voltage power line (4.4 MHz to 20.8 MHz);
Applicable EMC Specification:	FCC Part 15
Class of Service:	▪ Class A

2. Applicable Documents

Testing of emissions was performed in accordance with FCC requirements.

2.1. Federal Communication Commission (FCC), code of Federal Regulations 47, FCC docket 89-103, Part 15: Radio Frequency Devices, Subpart G, October 2005.

2.2. Federal Communication Commission (FCC), code of Federal Regulations 47, FCC docket 89-103, Part 15: Radio Frequency Devices, Section 15.109(b) and 15.209, October 2001.

2.3. FCC/OET, "FCC Procedure for Measuring Electromagnetic Emissions for Digital Devices", TP-5, March 1989.

2.4. Federal Communication Commission (FCC), Report and Order, FCC-04-245, Appendix C, Measurement Guidelines for Broadband Over Power Line (BPL) Devices or Carrier Current Systems (CCS) and Certification Requirements for Access BPL Devices, October 2004.

2.5. International Special committee on Radio Interference (CISPR) Publication 16, First Edition 1977, "CISPR Specification for Radio Interference Measuring, Apparatus and Measurement Methods".

2.6. American National Standard, "Interim Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz", ANSI C63.4, 2000.

3. Detailed Applicable EMC Requirements and Limits

The equipment was evaluated to Federal Communications Commission (FCC) requirements.

3.1. Conducted Limits

Conducted emissions limits do not apply to this Access BPL equipment.

3.2. Radiated Limits

The following radiated emissions limits apply:

Applicable Specification Reference	Frequency Range (MHz)	Class	Limit of Radiated Emissions		Measurement Distance (m)
			(µV/m)	(dBµV/m)	
FCC 15.107(c)(3), 15.109(c), 15.209	1.705 to 30	-	30	29.5	30
FCC 15.109	30 to 88	A	90	39.1	10
	88 to 216	A	150	43.5	10
	216 to 960	A	210	46.4	10
	960 and Above	A	300	49.5	10

Notes:

1. *The tighter limit shall apply at the edge between two frequency bands*
2. *Distance refers to the distance in meters from measuring instrument antenna to the closest point of any part of the equipment under test.*

4. Procedures for Measuring RF Emissions

The following test procedures were used to measure RF emissions from the CT LVR OH 5000.

4.1. AC Power Line Conducted Emissions Measurements

Conducted emissions limits do not apply to this Access BPL equipment.

4.2. Radiated Emissions Measurements

Measurements of radiated emissions were made using a spectrum analyzer and calibrated broadband antennas. Tests were performed in the following frequency ranges: 1.705 MHz to 30 MHZ, and 30 MHz to 1000 MHz. The CT LVR OH 5000 was set and operated in a manner representative of actual use.

4.2.1. Radiated Emissions Measurement – 1.705 MHz to 30 MHz

In the frequency band 1.705 MHz to 30 MHz, the CT LVR OH 5000 functions as an Access BPL device as described in FCC Rules, Sections 15.3(ff). The radiated emissions were measured at three separate installation sites, as required under the rules. Measurements were made with the transmit power set to its maximum output power level.

The CT LVR OH 5000 was installed in a residential neighborhood on a utility pole, approximately 6-8 meters above the ground. The CT LVR OH 5000 low-voltage wires were connected to the power utility's low-voltage power lines. The CT LVR OH 5000 would normally be used to repeat proprietary low-voltage signals between a subscriber link and a CT Bridge, each of which would be located some distance away from the pole on which the CT LVR OH 5000 is mounted. For convenience during testing, this supporting equipment was simulated using BPL devices located at the base of the utility pole on which the CT LVR was installed. Test signals from the simulating equipment were attenuated sufficiently that they had no effect on measurements. The CT LVR OH 5000 control equipment is described in Section 5.

For measurements of radiated emissions associated with the LV-signal (4.4 MHz to 20.8 MHz), the CT LVR OH 5000 was configured to continuously transmit the test signal described in Section 5.

The test antenna was placed on the ground at a distance of approximately 10 meters, measured horizontally, from the CT LVR OH 5000 and its associated overhead power lines. Where placing the antenna at this distance was impractical due to interference from conductive objects within the test area, (for example, parked cars), the antenna was moved to an alternate location near the intended location. The antenna height was kept at a fixed height of 1 meter. The antenna was moved to the left and right of the CT LVR's location, parallel to the low-voltage power line, a distance of 36 meters. This distance corresponds to 1.5 wavelengths of the CT LVR's LV-signal center frequency. The antenna was moved along this 36-meter distance in 6-mter (¼-wavelength) increments. The LV-signal radiated emissions were measured at frequencies from 4.4 MHz to 20.8 MHz. All significant emissions were recorded.

At each test location during this initial sweep, the test antenna was rotated to find the orientation that resulted in maximum emissions. Small frequency ranges, (typically 5 MHz), were spanned in order to increase resolution and to make it easier to identify emissions emanating from the CT LVR OH 5000. The spectrum analyzer was set to peak detection mode with the resolution bandwidth set to 9 kHz.

Quasi-peak measurements were made at each significant emission recorded during the initial sweep. For the quasi-peak measurements, the spectrum analyzer was set to quasi-peak detection and tuned to the recorded emission frequency using a 0-Hz frequency span.

The height of the CT LVR and associated low-voltage power lines were measured, and horizontal distances from the antenna to the nearest power-line were measured at each test location. The slant-range distance from the antenna to the nearest power-line was then calculated for each test location and used to determine the distance correction factor to be used for measurements at that location. Measurements were compared to the limits given in Section 3.2, after correcting them for distance using an extrapolation factor of 40 dB/decade.

All significant emissions are reported in Appendix A of this report.

4.2.2. Radiated Emissions Measurement – 30 MHz to 1000 MHz

Because of the nature of this equipment, radiated emissions above 30 MHz were measured in two stages. The first stage was to measure emissions at an Open Area Test Site using a simulated installation of the CT LVR OH 5000. The controlled conditions in the laboratory environment allowed any and all of the CT LVR OH 5000's radiating frequencies from 30 MHz to 1000 MHz to be observed and measured. The second stage was to measure emissions from the CT LVR OH 5000 in an actual installation. Since ambient conditions at the actual installation sites prevented being able to perform a complete frequency sweep, measurements were made only at the CT LVR OH 5000's specific radiating frequencies, as discovered in stage one testing.

4.2.2.1. Radiated Emissions Measurement – 30 MHz to 1000 MHz – Stage One

The CT LVR OH 5000 was mounted on a wooden table or stand in the same position in which it would be mounted in an actual installation. The stand positions the device under test (DUT) at a height above the ground plane of 0.8 meter. The DUT power leads were connected to the laboratory power source through a LISN. Radiated emissions measurements were made with the CT LVR OH 5000 in its active mode. Control equipment, as described in Section 5, was connected to the CT LVR OH 5000 through the LISN.

The CT LVR OH 5000 was placed on a turntable at the Open Area Test Site. The test antenna was placed at a distance of 3 meters from the CT LVR OH 5000 and the radiated emissions were measured. The CT LVR OH 5000 was rotated in a complete circle while the spectrum analyzer performed a maximum-hold of measured emissions. All significant emissions were recorded.

During this initial sweep, the test antenna was installed on the antenna mast in the horizontal polarity at a height of 1 meter. Small frequency ranges (typically 100 MHz) were spanned in order to increase resolution and aid in the identification of emissions emanating from the CT LVR OH 5000. The spectrum analyzer was set to peak detection mode with the resolution bandwidth set to 120 kHz.

Quasi-peak measurements were made at each emission recorded in the initial sweep. For the quasi-peak measurements, the spectrum analyzer was set to quasi-peak detection and tuned to the recorded emission frequency using a large frequency span. The frequency span was then reduced while keeping the spectrum analyzer's center frequency tuned to the emission's peak. The CT LVR OH 5000 was then rotated in a full circle to determine the direction of maximum emission. Further maximization of the emission was done by changing the height of the antenna from 1 meter to 4 meters.

The initial sweep to identify frequencies with significant emissions and the subsequent quasi-peak measurement process was repeated with the antenna in the vertical polarity.

All significant emissions are reported in Appendix A of this report.

4.2.2.2. Radiated Emissions Measurement – 30 MHz to 1000 MHz – Stage Two

The CT LVR OH 5000 was installed in a residential neighborhood on a utility pole, approximately 6-8 meters above the ground. The CT LVR OH 5000 low-voltage wires were connected to the power utility's low-voltage power lines. The CT LVR OH 5000 would normally be used to repeat proprietary low-voltage signals between a subscriber link and a CT Bridge, each of which would be located some distance away from the pole on which the CT LVR OH 5000 is mounted. For convenience during testing, this supporting equipment was simulated using BPL devices located at the base of the utility pole on which the LVR was installed. Test signals from the simulating equipment were attenuated sufficiently that they had no effect on measurements. The CT LVR OH 5000 control equipment is described in Section 5.

The test antenna was placed on the ground at a distance of 3 meters from the CT LVR OH 5000, measured horizontally. The antenna height during this initial sweep was kept at a fixed height of 1 meter. The antenna was moved to various locations around the CT LVR OH 5000 with radial spacings of approximately 22.5°. The radiated emissions were measured at the frequencies discovered in stage one testing. All significant emissions were recorded.

During this initial sweep, the test antenna was installed on the antenna mast in the horizontal polarity. The analyzer was tuned to the desired frequency with a small frequency span (typically 500 kHz or less). The spectrum analyzer was set to peak detection mode with the resolution bandwidth set to 120 kHz. The sweep was repeated with the antenna set to the vertical polarity.

Quasi-peak measurements were made at each significant emission recorded during the initial sweep. For the quasi-peak measurements, the spectrum analyzer was set to quasi-peak detection and tuned to the recorded emission frequency using a narrow frequency span. Maximization of the emission was done by changing the height of the antenna from 1 meter to 4 meters in 0.5 meter increments.

The height of the CT LVR™ OH 5000 was measured, and the slant-range distance from the antenna to the DUT was then calculated for teach test location. This distance was used to determine the distance correction factor to be used for measurements at that location. Measurements were compared to the limits given in Section 3.2, after correcting them for distance using an extrapolation factor of 20 dB/decade.

All significant emissions are reported in Appendix A of this report.

5. System Test Configuration

During each of the emissions tests, the CT LVR OH 5000 was installed in a residential neighborhood on a utility pole, approximately 6-8 meters above the ground. The CT LVR OH 5000 low-voltage wires were connected to the power utility's low-voltage power lines. The CT LVR OH 5000 would normally be used to repeat proprietary low-voltage signals between a subscriber link and a CT Bridge, each of which would be located some distance away from the pole on which the CT LVR OH 5000 is mounted. For convenience during testing, this supporting equipment was simulated using BPL devices located at the base of the utility pole on which the LVR was installed. Test signals from the simulating equipment were attenuated sufficiently that they had no effect on measurements. The system test configuration is shown in Figure 1.

Two laptop computers with power-line interface devices (PLIDs) were configured for a standard throughput test with the CT LVR OH 5000 functioning as a repeater for the two devices. The two PCs, a subscriber PC and a PC simulating a CT Bridge, were configured to communicate only if the CT LVR acted as a repeater. The test time was configured to be long enough to allow measurement of radiated emissions. The effect of radiated emissions coming from the PLIDs was reduced by placing them inside metal enclosures, and then attenuating their signals before connecting them to the power line through coaxial cables attached to AC baluns. The throughput test was configured to simulate high-density data traffic over the power line using an *nuttcp* command. The command line for data traffic simulation is:

nuttcp –t –u –l1472 –T30M –R40M [IP address of receiving device]

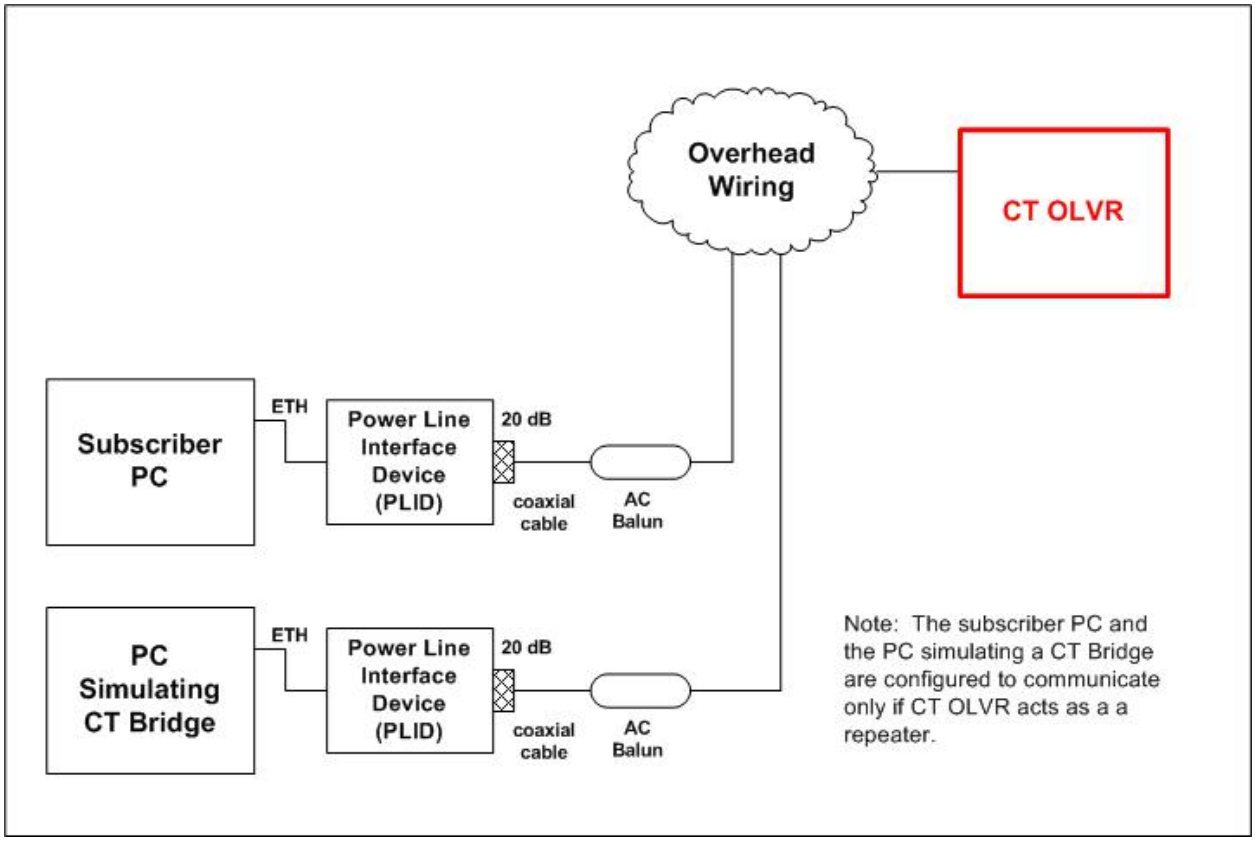

Figure 1: System Test Configuration

6. Equipment Modifications

The equipment tested was the latest version as of the date it was tested. All modifications necessary for compliance were incorporated into the design at the time of manufacture. Additional modifications were not needed.

7. Description of the Test Sites

Radiated emissions testing was performed at four different locations. Not all testing was performed at each location. A description of each location is given below. A list of the testing performed at each location is included in the descriptive information for that location

Washington Laboratories Open Area Test Site

Location:	Washington Laboratories 7560 Lindbergh Drive Gaithersburg, MD
Site Description:	Simulated system installation at an Open Area Test Site. The CT LVR OH 5000 was mounted on a wooden platform in approximately the sameposition in shich it would be mounted in the field, at a height of approximately 0.8 meter above the floor.
Site Diagram:	See Figure 2 below.
Site Photo:	See Photographs B-1, and B-2 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 30 MHz to 1000 MHz, on November 15, 2006

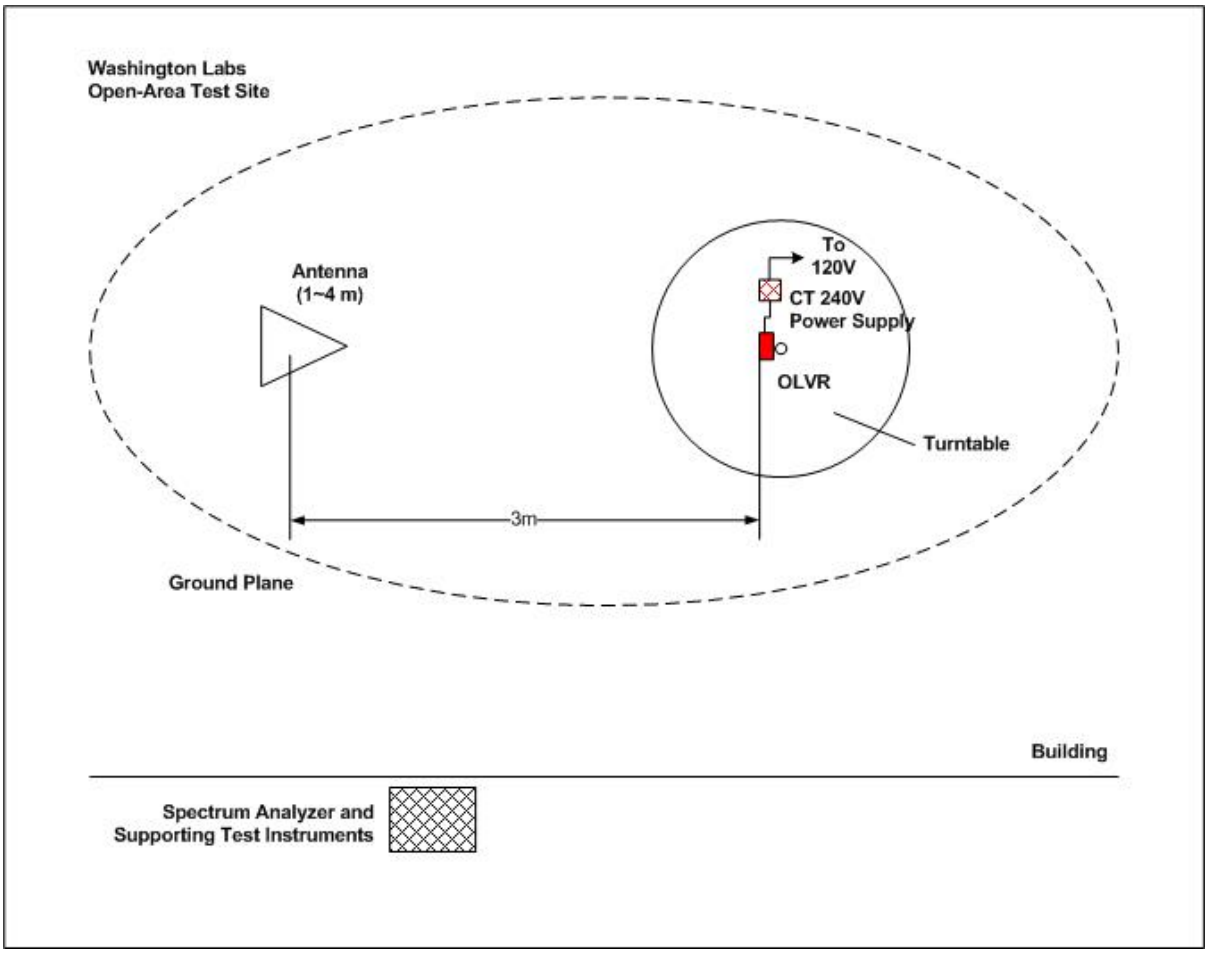

Figure 2: Test Site Diagram – Washington Laboratories Open Area Test Site

CURRENT Technologies Field Research and Test Area – Pole P4

Location:	Urbana Pike Urbana, MD
Site Description:	System installation on a utility pole in a BPL system test area. The pole is located in an open field and is equipped with low-voltage wires and medium-voltage wires. CT LVR Height: 6.6m LV-wire Height: 6.4m
Site Diagram:	See Figure 3, below.
Site Photo:	See Photographs B-3, and B-4 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 1.705 MHz to 30 MHz, on November 3, 2006

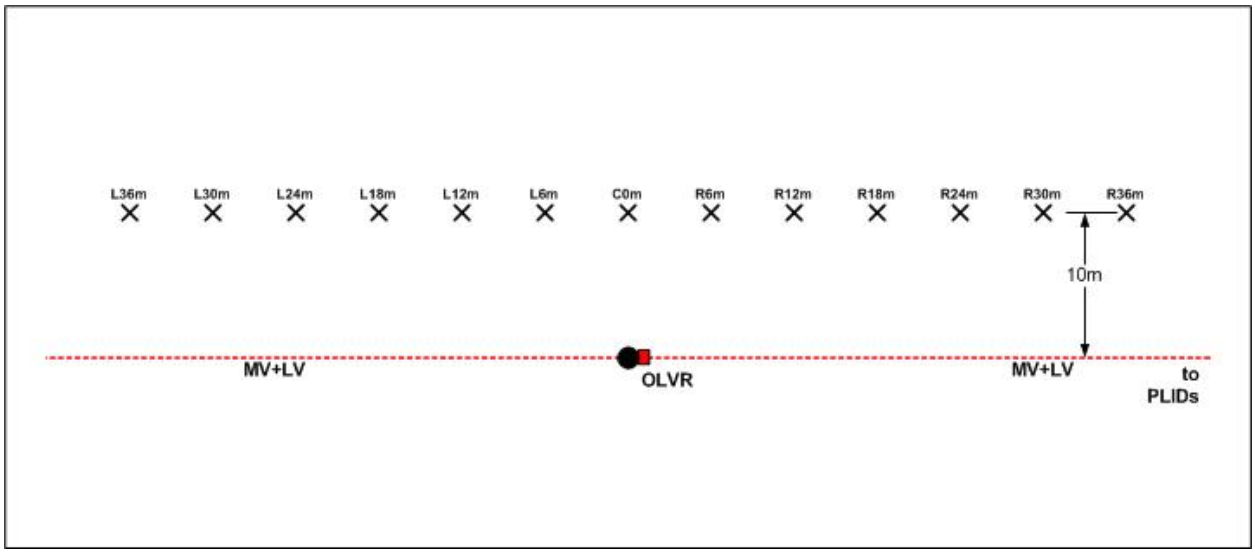

Figure 3: Test Site Diagram – CURRENT Technologies Field Research and Test Area – Pole P4

CURRENT Technologies Rockville Test Area – Macon Road

Location:	Macon Road Rockville, MD
Site Description:	System installation on a utility pole in a residential neighborhood. The pole is located next to a residential street and is equipped with a transformer, low-voltage wires and medium-voltage wires. CT LVR Height: 7.9m LV-wire Height: 7.8m
Site Diagram:	See Figure 4, below.
Site Photo:	See Photographs B-5, and B-6 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 1.705 MHz to 30 MHz, on November 14, 2006 ▪ Radiated Emissions, 30 MHz to 1000 MHz, on November 21, 2006

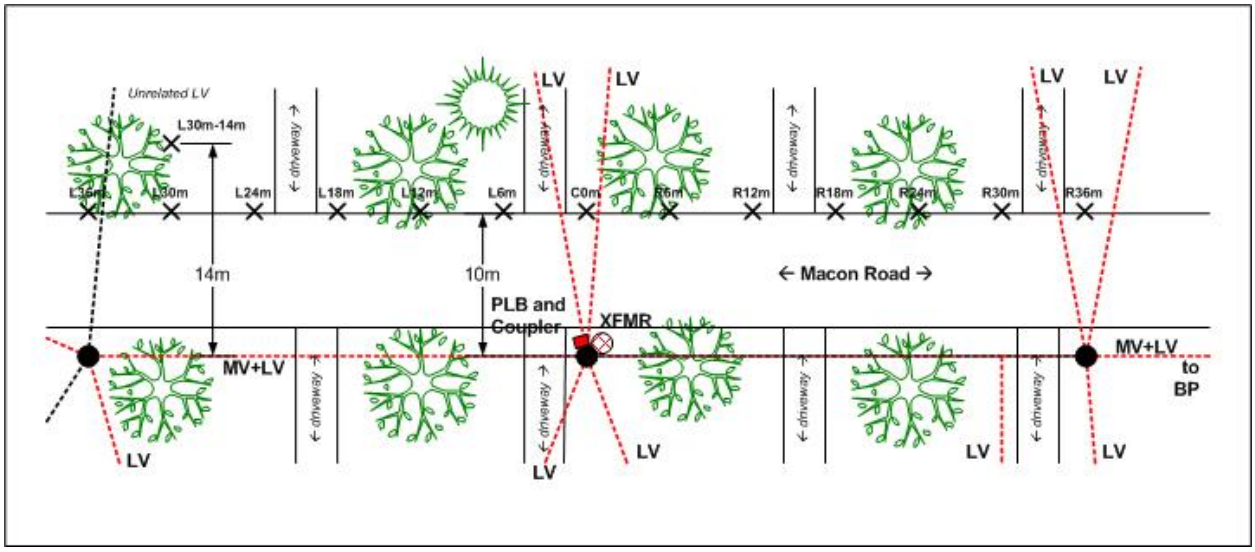

Figure 4: Test Site Diagram – CURRENT Technologies Rockville Test Area – Macon Road

CURRENT Technologies Rockville Test Area – Old Drovers Way

Location:	Old Drovers Way Rockville, MD
Site Description:	System installation on a utility pole in a residential neighborhood. The pole is located next to a residential street and is equipped with a transformer, low-voltage wires and medium-voltage wires. CT LVR Height: 7.3m LV-wire Height: 7.1m
Site Diagram:	See Figure 5, below.
Site Photo:	See Photographs B-7, and B-8 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 1.705 MHz to 30 MHz, on November 20, 2006 ▪ Radiated Emissions, 30 MHz to 1000 MHz, on November 21, 2006

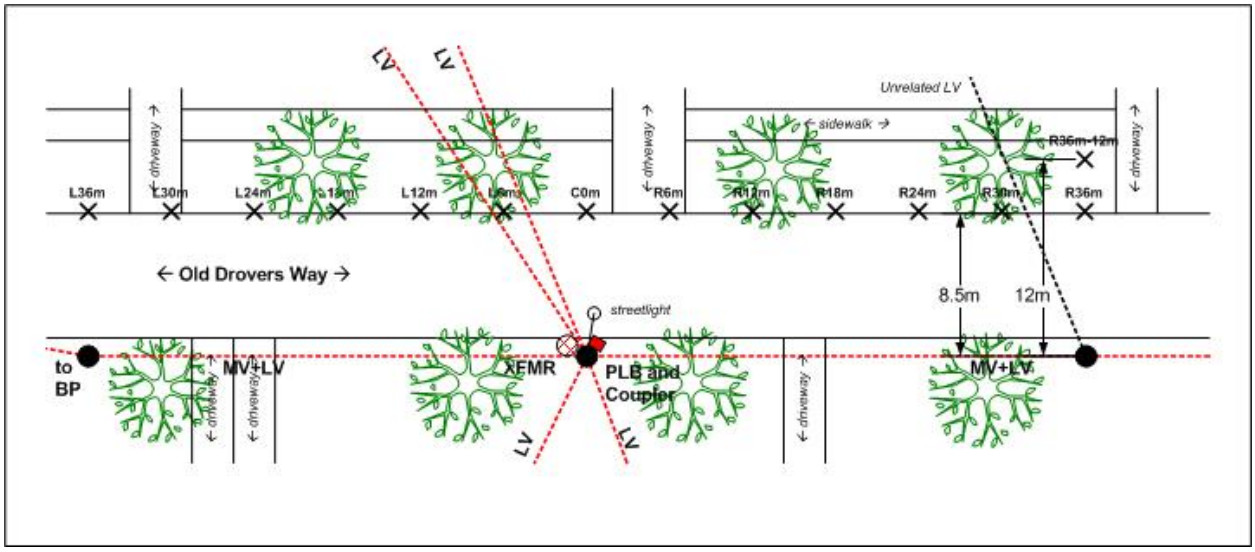

Figure 5: Test Site Diagram – CURRENT Technologies Rockville Test Area – Macon Road

8. List of Test Equipment Used

The following is a list of test equipment used during testing.

Radiated Emissions Measurement – 1.705 MHz to 30 MHz

Description	Manufacturer and Model Number	Serial Number and Identification Number	Calibration Due Date
EMC Analyzer	HP E7402A	MY44212893	May 30, 2007
Antenna, Active Loop (10 kHz to 30 MHz)	EMCO 6507	9007-1226	December 6, 2006
Antenna, Passive Loop (10 kHz to 30 MHz)	EMCO 6512	00051987	December 6, 2006
RF Cable, 100'	RG-58	CT #125	November 2, 2007

Radiated Emissions Measurement – 50 MHz to 1000 MHz – Stage One

Description	Manufacturer and Model Number	Serial Number and Identification Number	Calibration Due Date
Spectrum Analyzer	HP 8568B	WL #00072	July 3, 2007
Quasi-Peak Adapter	HP 85650A	WL #00068	July 3, 2007
Transient Limiter	HP 11947A	WL #00078	August 23, 2007
Antenna, Biconlog	Sunol JB1	WL #00382	January 25, 2007

Radiated Emissions Measurement – 50 MHz to 1000 MHz – Stage Two

Description	Manufacturer and Model Number	Serial Number and Identification Number	Calibration Due Date
EMC Analyzer	HP E7402A	MY44212893	May 30, 2007
Antenna, Log-Periodic (290 MHz to 2000 MHz)	A.H. Systems SAS-200/510	784	December 6, 2007
Antenna, Biconical (20 MHz to 330 MHz)	A.H. Systems SAS-200/540	573	December 6, 2007
RF Cable, 30'	RG-58	CT #50A	January 12, 2007

9. EMI Test Results

EMI test results for both conducted and radiated emissions measurements are summarized below.

9.1. Conducted Emission Data

Conducted emissions limits do not apply to this Access BPL equipment.

9.2. Radiated Emission Data

The final level of the radiated emission, in dBµV/m, is calculated by taking the reading from the spectrum analyzer (in dBµV) and adding the appropriate correction factors (antenna, cable loss, external pre-amplifier, filter, etc.). A distance correction factor is then added to compensate for the actual measurement distance being different from the specified measurement distance. The difference between this result and the FCC limit is calculated, giving the margin of compliance, as shown in Appendix A.

The field strength was calculated using the formula:

$$E(dB\mu V/m) = Vrec(dB\mu V) + AF(dB/m) + CL(dB)$$

Where Vrec is the voltage detected voltage by the spectrum analyzer, AF is the antenna factor at the specified frequency, and CL is the insertion loss on the RF cable which is connected between the antenna and the spectrum analyzer.

Conclusion: The CT LVR OH 5000 meets the FCC limits for radiated emissions from an Access BPL device in the frequency range 1.705 MHz to 30 MHz when actively transmitting LV signals (4.4 MHz to 20.8 MHz). In this operation mode, and over this frequency range, the minimum passing margin was 1.2 dB.

The CT LVR OH 5000 meets the Part 15 Class B radiated emission requirements over the frequency range 30 MHz to 1000 MHz. Over this frequency range, the minimum passing margin was 7.3 dB.