CURRENT Technologies, LLC
Report of Measurements
CT OTP™ URD 5000

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1. General Information

Applicant:	CURRENT Technologies, LLC
Applicant Address:	20420 Century Boulevard Germantown, MD 20874 301-944-2700
Equipment:	CT OTP™ URD 5000
Equipment Description:	The CT OTP URD 5000 is part of an Access BPL system. It operates on public utility power lines over medium-voltage wires and is installed at utility riser poles where overhead wires are used to feed underground systems. The CT OTP is the primary device that connects the BPL system to a local point of presence; aggregating and forwarding the data traffic from its downstream CT Bridges®. Each CT OTP has four interfaces: a backhaul interface to a fiber-optic connection and three medium-voltage interfaces through CT Couplers® to the MV primary URD cables. Each medium-voltage interface operates in a different frequency band or channel.
Test Operator:	Steve Seymour
Dates of Testing:	October 27, 2005 to August 3, 2006
Test Locations:	▪ CURRENT Technologies Orchard Hills Test Area – Riser Pole (North Potomac, Maryland) ▪ CURRENT Technologies Urbana Test Area – Riser 1 (Urbana, Maryland) ▪ CURRENT Technologies Urbana Test Area – Riser 2 (Urbana, Maryland) ▪ Washington Laboratories Open Area Test Site (Gaithersburg, Maryland)
Modes of Operation:	▪ Downstream MV1 (transmitting high-density QAM signal on MV wire, 29.7 MHz to 35.7 MHz), ▪ Downstream MV2 (transmitting high-density QAM signal on MV wire, 36.85 MHz to 42.85 MHz), ▪ Downstream MV3 (transmitting high-density QAM signal on MV wire, 44.0 MHz to 50.0 MHz), ▪ Lab Normal (powered up)
Applicable EMC Specification:	FCC Part 15, Subpart G
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 15.109	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 OTP.

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: 29.7 MHz to 50 MHz, and 50 MHz to 1000 MHz. The CT OTP was set and operated in a manner representative of actual use.

4.2.1. Radiated Emissions Measurement – 29.7 MHz to 50 MHz

In the frequency band 29.7 MHz to 50 MHz, the CT OTP functions as an Access BPL device as described in FCC Rules, Sections 15.3(ff). The radiated emissions were measured at three separate, representative installation sites, as required under the rules. Measurements were made with the transmit power set to its maximum output power level.

The CT OTP was installed on a utility riser pole with overhead wires extending in two directions away from the pole, and a medium-voltage feeder wire extending down the pole and traveling underground to a URD system. The CT OTP low-voltage wires were connected to low-voltage power lines on the pole. The CT OTP medium-voltage connectors were connected to a CURRENT Technologies URD medium-voltage coupler, model number CT Coupler® URD 5000r, which was installed on the medium-voltage URD feeder wire, extending down the pole.

The CT OTP was operated remotely using Access BPL services. The Access BPL control equipment is described in Section 5. Control equipment was connected to the CT OTP through a fiber optic link. For measurements of radiated emissions associated with the downstream signals (29.7 MHz to 50.0 MHz), the CT OTP was configured to continuously transmit simulated high-density data traffic over the medium-voltage power-line at its maximum output power level.

The test antenna was placed on the ground at a distance of approximately 10 meters, measured horizontally, from the CT OTP and its associated overhead power lines. Where placing the antenna at this distance was impractical due to interference from conductive objects, or where placing it at that distance created a hazardous situation (e.g., traffic hazard due to the antenna being in the middle of a residential street), it was moved to an alternate position. The antenna height during this initial sweep was kept at a fixed height of 1 meter. The antenna was moved to the left and right of the OTP's location, parallel to the medium-voltage power line, a distance of 7.6 meters. This distance corresponds to one wavelength of the OTP's downstream signal center frequency. The antenna was moved along this 7.6-meter distance in 1.9-meter (¼-wavelength) increments. The downstream signal radiated emissions were measured at frequencies from 29.7 MHz to 50.0 MHz. All significant emissions were recorded.

At each test location during this initial sweep, the antenna polarity was changed to find the orientation that resulted in maximum emissions. Small frequency ranges (typically 8 MHz or less) were spanned in order to increase resolution and to make it easier to identify emissions emanating from the CT OTP. The spectrum analyzer was set to peak detection mode with the resolution bandwidth set to 120 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 zero-hertz 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 OTP and associated medium-voltage power lines were measured, and horizontal distances from the antenna to the OTP or power-line were measured at each test location. The slant-range distance from the antenna to the closer of either the OTP or medium-voltage power wire was then calculated for each test location and used to determine the distance correction fact 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.

4.2.2. Radiated Emissions Measurement – 50 MHz to 1000 MHz

Because of the nature of this equipment, radiated emissions above 50 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 OTP. The controlled conditions in the laboratory environment allowed any and all frequencies, from 50 MHz to 1000 MHz, radiating from the CT OTP to be observed and measured. The second stage was to measure emissions from the CT OTP in actual installations. Since ambient conditions at the actual installation sites prevented being able to perform a complete frequency sweep, measurements were made only at the specific radiating frequencies discovered in stage one testing.

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

The CT OTP 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 1 meter. The power leads from the device were connected to the laboratory power source. The device's medium-voltage connections were terminated with standard 3' coaxial cables and 75-ohm resistors. Preliminary testing showed that identical results were obtained at frequencies above 50 MHz regardless of the operating state of the DUT. For simplicity, the operating state of the device during lab testing was to be powered up and operated normally with no actual data transmission.

The DUT was placed on a turntable at the Open Area Test Site. The test antenna was placed at a distance of 3 meters from the DUT and the radiated emissions were measured. The DUT 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 or less) were spanned in order to increase resolution and aid in the identification of emissions emanating from the DUT. 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 DUT 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 – 50 MHz to 1000 MHz – Stage Two

The CT OTP was installed on a utility riser pole with overhead wires extending in two directions away from the pole, and a medium-voltage feeder wire extending down the pole and traveling underground to a URD system. The CT OTP low-voltage wires were connected to low-voltage power lines on the pole. The CT OTP medium-voltage connectors were connected to a CURRENT Technologies URD medium-voltage coupler, model number CT Coupler® URD 5000r, which was installed on the medium-voltage URD feeder wire, extending down the pole. Preliminary testing showed that identical results were obtained at frequencies above 50 MHz regardless of the operating state of the CT OTP. For simplicity, the operating state of the CT OTP during field testing was to be powered up and transmitting continuous downstream data traffic over the MV wire.

The CT OTP was operated remotely using Access BPL services. The Access BPL control equipment is described in Section 5. Control equipment was connected to the CT OTP through a fiber optic link. For measurements of radiated emissions above 50 MHz, the CT OTP was configured to continuously transmit simulated high-density data traffic over the medium-voltage power-line at its maximum output power level.

The test antenna was placed on the ground at a distance of 3 meters, measured horizontally, from the CT OTP. 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 DUT 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 200 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 OTP was measured, and the slant-range distance from the antenna to CT OTP was then calculated for each test location and used to determine the distance correction fact 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

Figure 1 shows the system configuration that was used for testing. Data signals from the CMTS are converted into three separate downstream channels, MV1 (29.7 MHz to 35.7 MHz), MV2 (36.85 MHz to 42.85 MHz), and MV3 (44.0 MHz to 50.0 MHz), and coupled onto the URD medium-voltage feeder wire as continuous high-density QAM signals. The downstream signals have the same amplitude and duty cycle regardless of actual data content.

In the laboratory, where a CMTS was not available, the CT OTP was powered up through a laboratory power supply and operated in its normal mode with no actual data transmissions. Also, since medium-voltage power lines could not be properly simulated in the lab, the MV1, MV2 and MV3 cables were terminated with 75-ohm resistors.

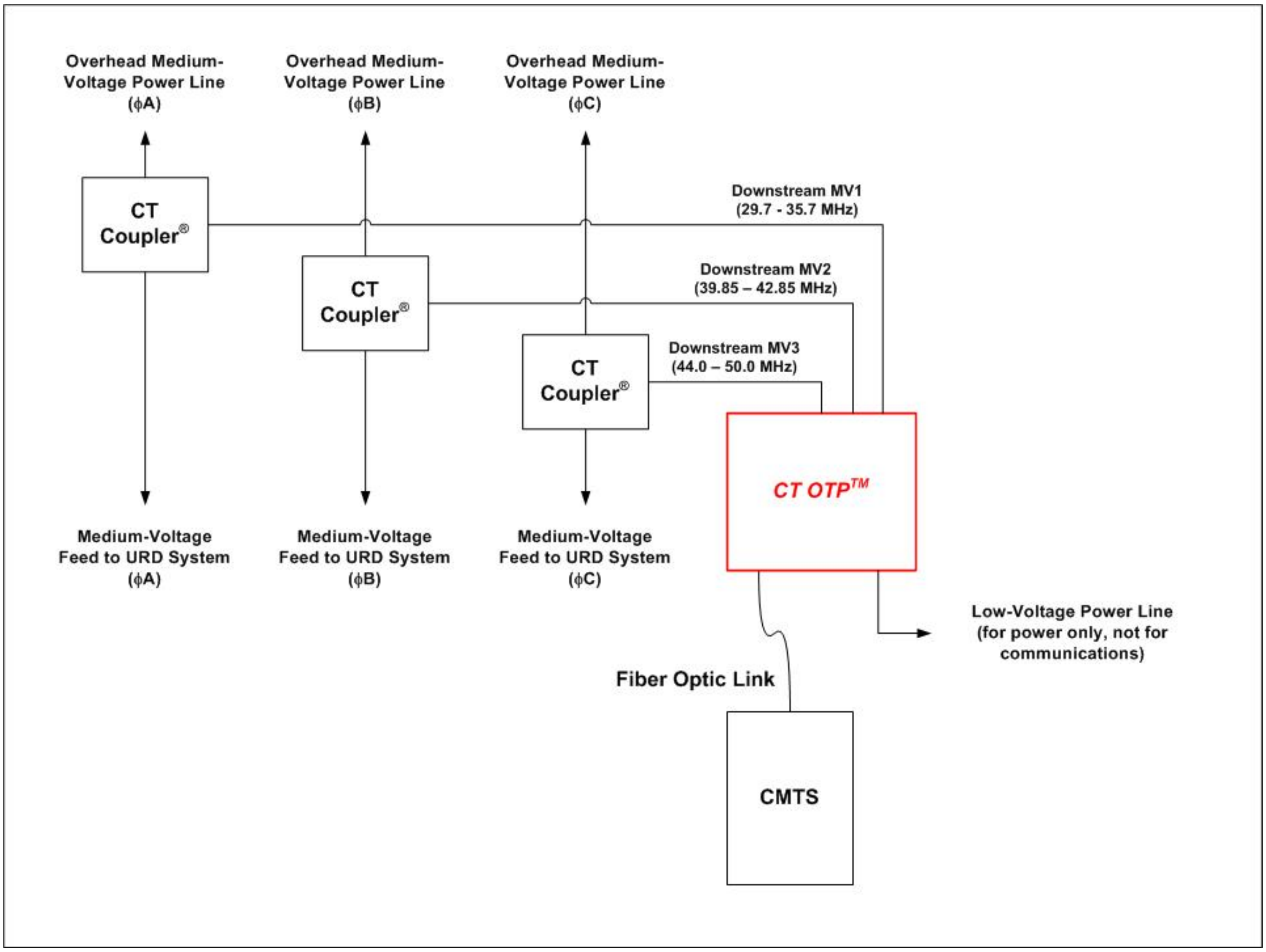

Figure 1: System Test Configuration

6. Equipment Modifications

The equipment tested was the latest version as of the date it was tested. All firmware modifications necessary for compliance were incorporated into the devices at the time of test and will be incorporated into the design at the time of manufacture. Transmit levels are not adjustable by the user beyond the maximum levels used during testing.

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

CURRENT Technologies Orchard Hills Test Area – Riser Pole

Location:	Quince Orchard Drive, McDonald Chapel Drive North Potomac, MD
Site Description:	System installation on a utility pole in a residential neighborhood. The pole is located next to a city street and is equipped with overhead low-voltage wires and medium-voltage wires, as well as a medium-voltage feeder wire that goes down the pole and travels underground to a URD system.
Site Diagrams:	See Figure 2, below.
Site Photos:	See Photographs B-1 and B-2 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 29.7 MHz to 50 MHz, on July 31, 2006 ▪ Radiated Emissions, 50 MHz to 1000 MHz, on January 5, 2006

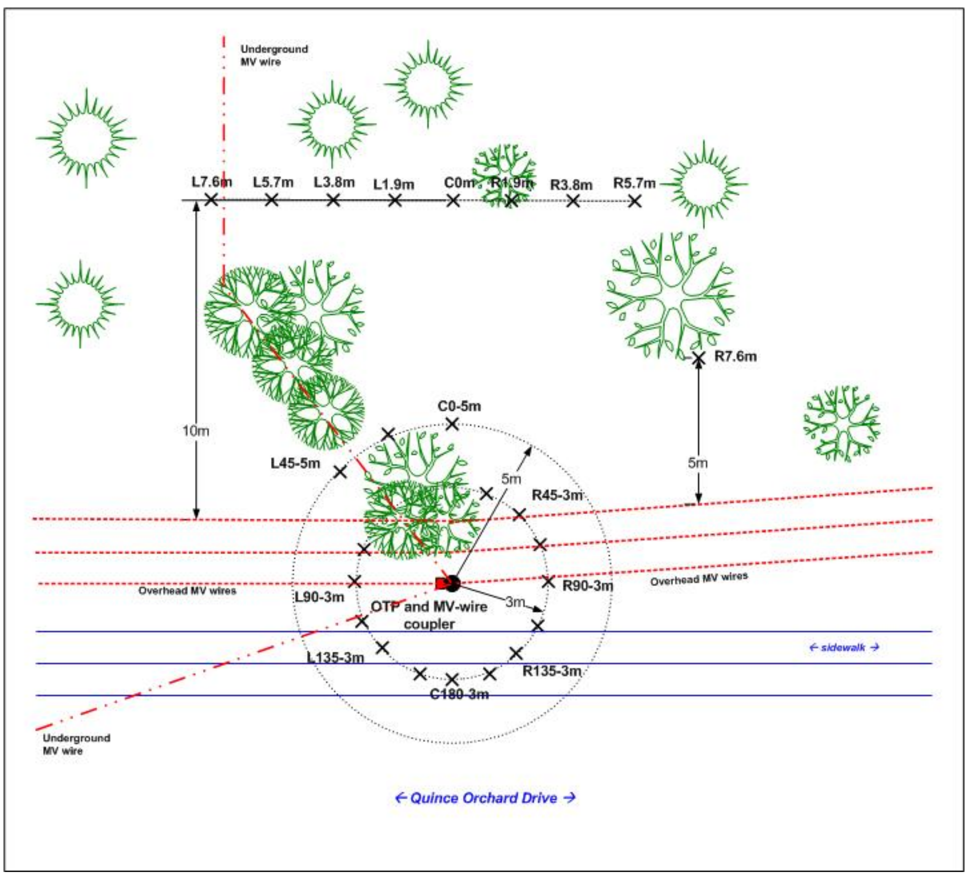

Figure 2: Test Site Diagram – CURRENT Technologies Orchard Hills Test Area – Riser Pole

CURRENT Technologies Urbana Test Area – Riser 1

Location:	3280 Urbana Pike Urbana, MD
Site Description:	System installation on a utility pole in a residential neighborhood. The pole is located in a field and is equipped with overhead low-voltage wires and medium-voltage wires, as well as a medium-voltage feeder wire that goes down the pole and travels underground to a URD system.
Site Diagrams:	See Figure 3, below.
Site Photos:	See Photographs B-3 and B-4 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 29.7 MHz to 50 MHz, on August 2, 2006 ▪ Radiated Emissions, 50 MHz to 1000 MHz, on August 2, 2006

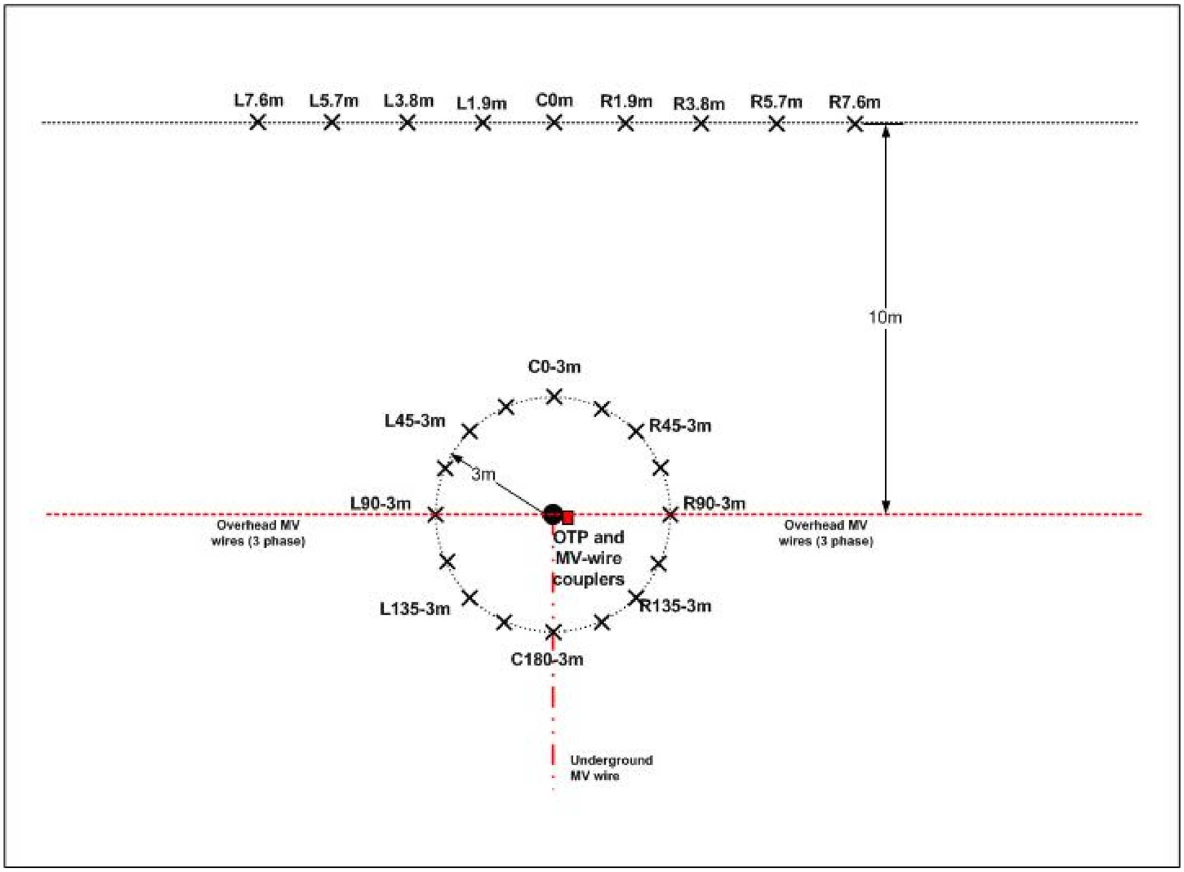

Figure 3: Test Site Diagram – CURRENT Technologies Urbana Test Area – Riser 1

CURRENT Technologies Urbana Test Area – Riser 2

Location:	3280 Urbana Pike Urbana, MD
Site Description:	System installation on a utility pole in a residential neighborhood. The pole is located in a field and is equipped with overhead low-voltage wires and medium-voltage wires, as well as a medium-voltage feeder wire that goes down the pole and travels underground to a URD system.
Site Diagrams:	See Figure 4, below.
Site Photos:	See Photographs B-5 and B-6 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 29.7 MHz to 50 MHz, on August 3, 2006

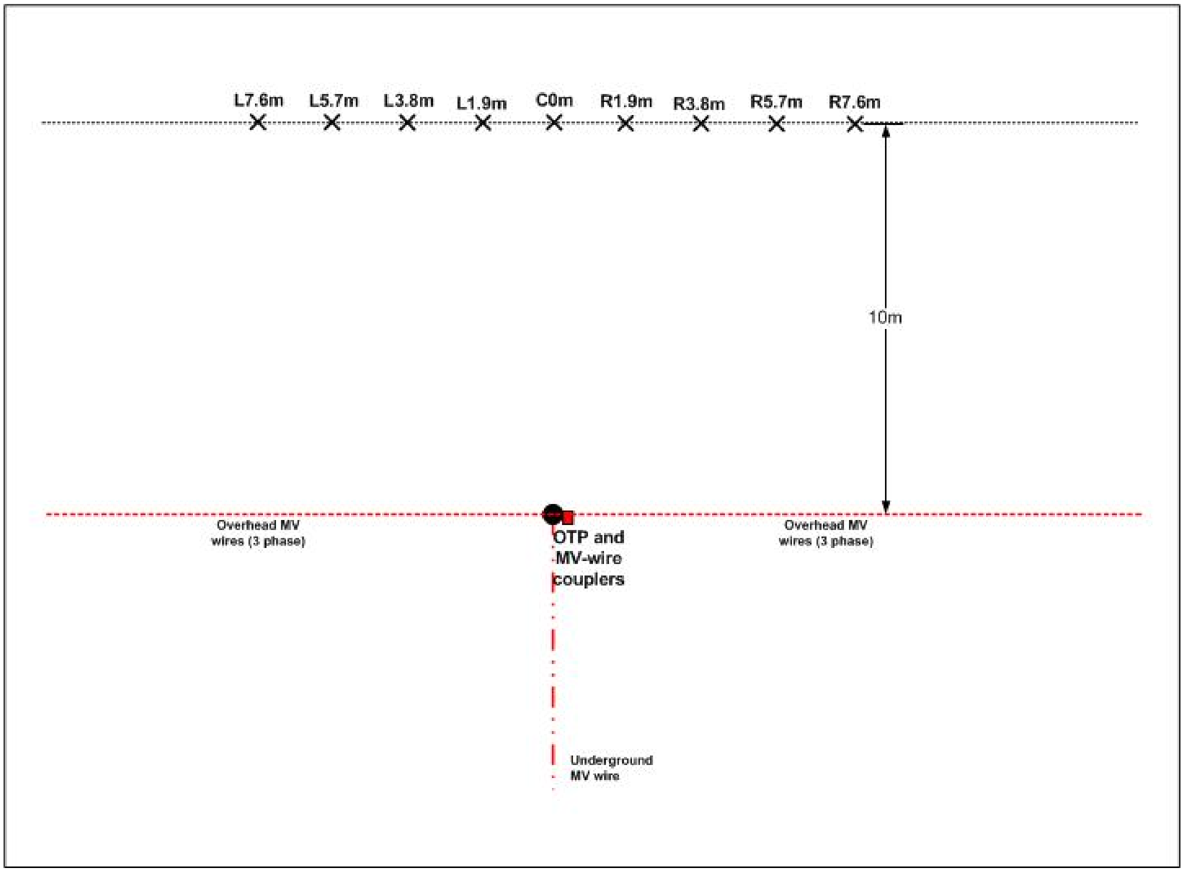

Figure 4: Test Site Diagram – CURRENT Technologies Urbana Test Area – Riser 2

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 OTP was mounted on a wooden platform in approximately the same position in which it would be mounted in the field, at a height of approximately 1 meter above the floor. The medium-voltage connections were terminated with 3' coaxial cables and 75-ohm resistors. The cables were arranged in a way that was representative of the way they would be arranged in an actual installation.
Site Diagram:	See Figure 5, below.
Site Photos:	See Photographs B-7 and B-8 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 50 MHz to 1000 MHz, on October 27, 2005

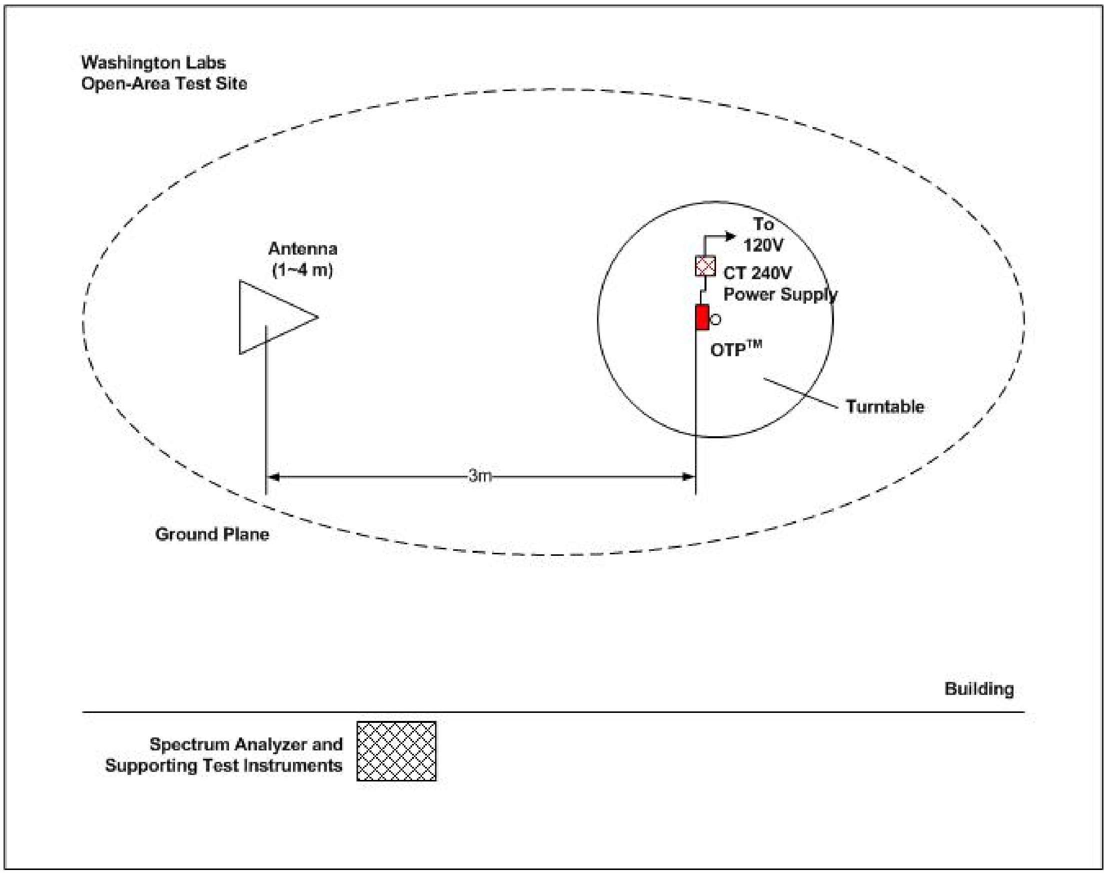

Figure 8: Test Site Diagram – Washington Laboratories Open Area Test Site

8. List of Test Equipment Used

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

Radiated Emissions Measurement – 29.7 MHz to 50 MHz

Description	Manufacturer and Model Number	Serial Number and Identification Number	Calibration Due Date
EMC Analyzer	HP E7402A	MY44212893	May 31, 2007
Antenna, Biconical (20 MHz to 330 MHz)	A.H. Systems SAS-200/540	573	December 6, 2006
RF Cable, 100'	RG-58	CT #100A	January 12, 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 5, 2006
Quasi-Peak Adapter	HP 85650A	WL #00068	July 5, 2006
RF Preselector (w/ OPT 8ZE)	HP 85685A	WL #00070	July 5, 2006
Antenna, Biconlog	Sunol JB1	WL #00382	January 25, 2007
Coaxial cable	WLL RG214	WL #00544	October 4, 2006

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 31, 2007
Antenna, Log-Periodic (290 MHz to 2000 MHz)	A.H. Systems SAS-200/510	784	December 6, 2006
Antenna, Biconical (20 MHz to 330 MHz)	A.H. Systems SAS-200/540	573	December 6, 2006
RF Cable, 50'	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 adding the appropriate correction factors (antenna, cable loss, external pre-amplifier, filter, etc.) to a voltage reading made by a spectrum analyzer. In some cases, the spectrum analyzer adds the correction factors automatically, producing a reading in dBµV/m. In other cases, the correction factors are added in afterward using a computer spreadsheet. 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.

<u>Conclusion</u>: The CT OTP meets the FCC limits for radiated emissions from Access BPL devices in the frequency range 29.7 MHz to 50 MHz when actively transmitting Downstream signals (29.7 MHz to 50.0 MHz). In this operation mode, and over this frequency range, the minimum passing margin was 0.3 dB.

The CT OTP meets the Part 15 Class A radiated emission requirements over the frequency range 50 MHz to 1000 MHz. Over this frequency range, the minimum passing margin was 11.2 dB.