CURRENT Technologies, LLC
Report of Measurements
CT AMR Meter

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1. General Information

Applicant: CURRENT Technologies, LLC

Applicant Address: 20420 Century Boulevard
Germantown, MD 20874
301-944-2700

Equipment: CT AMR Meter

Equipment Description: The CT AMR Meter is part of an Access BPL system. It combines traditional power meter functions with BPL signaling capability over the low-voltage wires.

Test Operator: Steve Seymour and Bob McKay

Dates of Testing: May 16, 2006 to August 22, 2006

Test Locations:

- Washington Laboratories Laboratory (Gaithersburg, Maryland),
- Washington Laboratories Open Area Test Site (Gaithersburg, Maryland),
- 16116 Orchard Grove Road (North Potomac, Maryland)
- 12109 Sheets Farm Road (North Potomac, Maryland)
- 17907 Coachmans Road (Germantown, Maryland)
- 12028 Coldstream Drive (Potomac, Maryland)

Modes of Operation:

- Active: transmitting high-density OFDM signal on Low-Voltage power line (4.4 MHz to 20.8 MHz);
- Idle: powered up and transmitting low-density (800 μs bursts of data repeated at 0.25 second to 1.25 second intervals) channel-estimation signals on LV power line

Applicable EMC Specification: FCC Part 15

Class of Service:

- Class B

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 apply to the low-voltage power connector on the CT AMR Meter.

Equipment Operating Mode	Applicable Specification Reference	Frequency Range (MHz)	Conducted Limit	
			Quasi-Peak	Average
Idle	FCC 15.107(a)	0.15 to 0.50 0.5 to 5.0 5 to 30	66 to 56 *(note 2)* 56 60	56 to 46 *(note 2)* 46 50
Active	FCC 15.107(c)(2)	0.535 to 1.705	60	-

Notes:

1. *Measurements are made across a 50 Ω/μH Line Impedance Stabilization Network (LISN)*
2. *Decreases with the logarithm of the frequency*

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	B	100	40.0	3
	88 to 216	B	150	43.5	3
	216 to 960	B	200	46.0	3
	960 and Above	B	500	54.0	3

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 AMR Meter.

4.1. AC Power Line Conducted Emissions Measurements

Measurements were made to determine the line-to-ground radio noise voltages. Measurements were conducted on CT AMR Meter input power terminals that are directly connected to the public utility AC power lines.

The CT AMR Meter was connected to the public utility power lines through a standard Line Impedance Stabilization Network (LISN). Both phases of the power leads were tested. The LISN provides a 50 Ω / 50 µH coupling impedance for the measuring equipment. AMR Meter control equipment, as described in Section 5, was connected to the meter through the LISN. See the conducted emissions measurement block diagram in Figure 1 below.

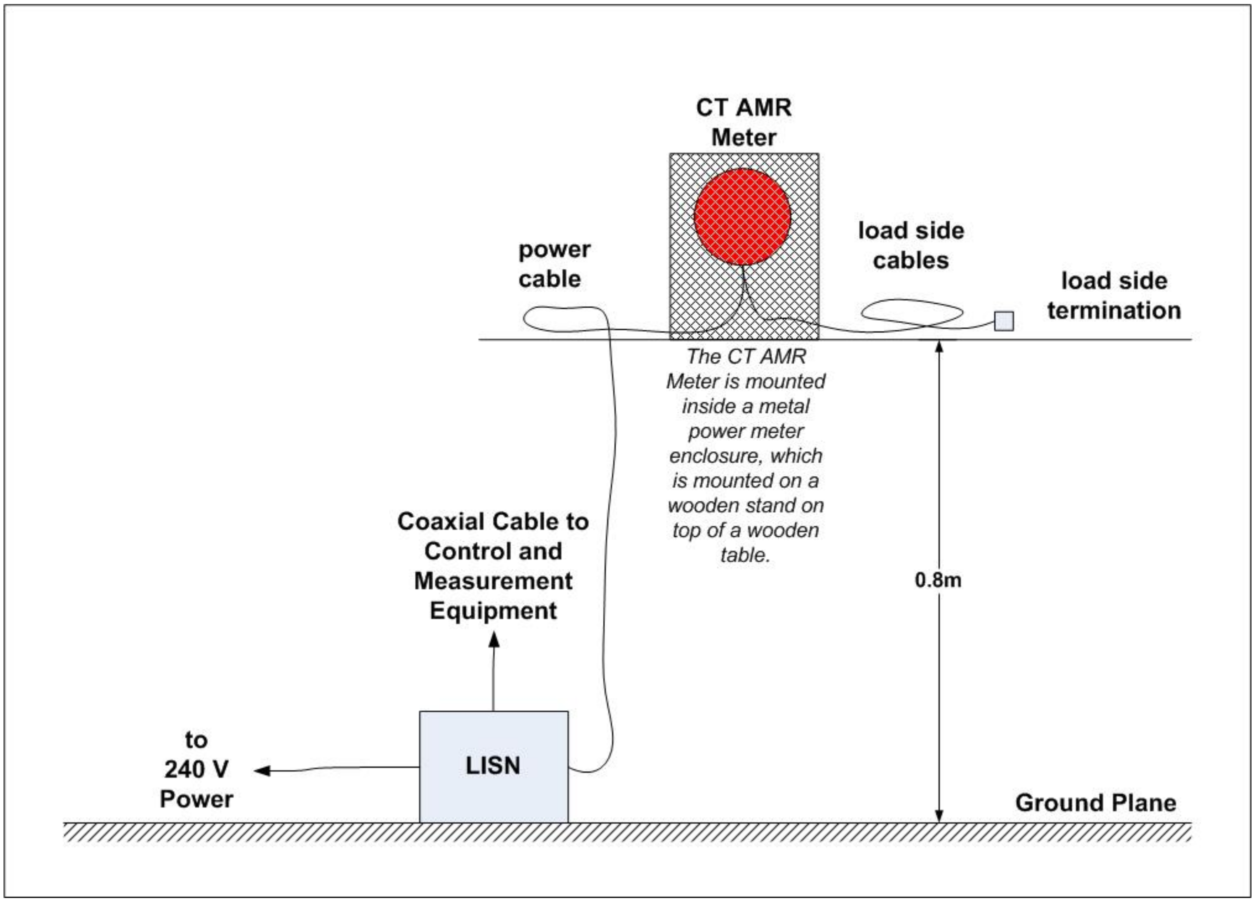

Figure 1: Conducted Emissions Measurement Block Diagram

During the tests, the CT AMR Meter was mounted inside a metal power meter enclosure, which was then mounted on a wooden stand in the same position in which it would be mounted in an actual home installation. The stand positions the CT AMR Meter at a height above the floor of approximately 0.8 meter. The CT AMR Meter load-side cables were terminated with a load that represents the typical impedance that would be present in a standard home installation. The CT AMR Meter's load and source cables were positioned in a way that maximized emissions.

Both sides of the AC line were checked for the maximum conducted emission interference. In order to find the maximum emissions, the relating positions of equipment and all of the interference cables must be changed according to CISPR 22: 1997 regulation: The Measurement Procedure on Conducted Emission Interference. Conducted emissions measurements were made with the CT AMR Meter in its idle mode over the frequency range 0.150 MHz to 30 MHz. Conducted emissions measurements were made with the CT AMR Meter in its active mode over the frequency range 0.535 MHz to 1.705 MHz.

The resolution bandwidth of the field strength meter is set at 9 kHz.

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

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 AMR Meter 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 AMR Meter 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 AMR Meter was installed in a residential home inside a metal power meter enclosure. The CT AMR Meter low-voltage wires were connected to the power utility's low-voltage power lines. The CT AMR Meter would normally communicate with a CURRENT Technologies Access BPL device located outside the home on public power utility wiring. Since this supporting equipment was not available at the three test locations, it was simulated using a BPL device located within the home. The CT AMR Meter control equipment is described in Section 5. AMR Meter control equipment was connected to the meter through house wiring.

For measurements of radiated emissions associated with the LV-signal (4.4 MHz to 20.8 MHz), the CT AMR Meter was configured to continuously transmit as described in Section 5.1.

The test antenna was placed on the ground at a distance of 10 meters from the home's exterior walls. Where placing the antenna at this distance was impractical due to space limitations or interference from other structures, it was moved closer. The antenna height was kept at a fixed height of 1 meter. The antenna was moved to various locations around the home with radial spacings of approximately 22.5° - sixteen points in all. The LV-signal radiated emissions were measured at frequencies from 4.4 MHz to 20.8 MHz. All significant emissions were recorded.

At each location during this initial sweep, the test antenna was rotated to find the orientation that resulted in maximum emissions. This antenna orientation was used for the remainder of emissions measurements at that antenna location. 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 AMR Meter. 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 narrow frequency span.

The horizontal distance from the antenna to the nearest point on the home's exterior walls was used as the measurement distance. 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 AMR Meter. The controlled conditions in the laboratory environment allowed any and all of the CT AMR Meter's radiating frequencies from 30 MHz to 1000 MHz to be observed and measured. The second stage was to measure emissions from the CT AMR Meter 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 AMR Meter'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 AMR Meter was installed in a metal power meter enclosure, which was then mounted on a wooden stand in the same position in which it would be mounted in an actual installation. The stand positions the CT AMR Meter at a height above the ground plane of 0.8 meter. The CT AMR Meter power leads were connected to the laboratory power source through a LISN. The CT AMR Meter's load-side cables were terminated with a load that represents the typical impedance that would be present in a standard home installation. Radiated emissions measurements were made with the CT AMR Meter in its active mode. AMR Meter control equipment, as described in Section 5, was connected to the meter through the LISN.

The CT AMR Meter 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 AMR Meter and the radiated emissions were measured. The CT AMR Meter was rotated in a complete circle while the spectrum analyzer performed a maximum-hold of measured emissions. All significant emissions were recorded.

At each location 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 AMR Meter. 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 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 AMR Meter 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 AMR Meter was installed in its typical configuration in a residential home inside a metal power meter enclosure. The CT AMR Meter low-voltage connectors were connected to the power utility's low-voltage power lines. The CT AMR Meter would normally communicate with a CURRENT Technologies Access BPL device located outside the home on public power utility wiring. Since this supporting equipment was not available at the three test locations, it was simulated using a BPL device located within the home. The CT AMR Meter control equipment is described in Section 5. AMR Meter control equipment was connected to the meter through house wiring. Measurements were made with the CT AMR Meter in its active mode.

The test antenna was placed on the ground at a distance of 3 meters from the CT AMR Meter, 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 AMR Meter 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.

At each location 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 horizontal distance from the antenna to the CT AMR Meter was used as the measurement distance. Measurements were compared to the limits given in Section 3.2.

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

5. System Test Configuration

During each of the emissions tests, the CT AMR Meter was installed inside a metal power meter enclosure. The low-voltage connectors were connected to the power utility's low-voltage power lines. The CT AMR Meter would normally communicate with a CURRENT Technologies Access BPL device located outside the home on public power utility wiring. Since this supporting equipment was not available at the test locations, it was simulated using the configuration shown in Figure 2.

A DHCP router was used to provide IP addresses to both the controlling laptop and the CT AMR Meter. A commercially available HomePlug BPL modem was used to provide a connection between the DHCP Router and the AMR Meter. The effect of radiated emissions coming from the HomePlug modem was reduced by placing it inside a metal enclosure, and then connecting it to the power line through a coaxial cable and an AC balun circuit.

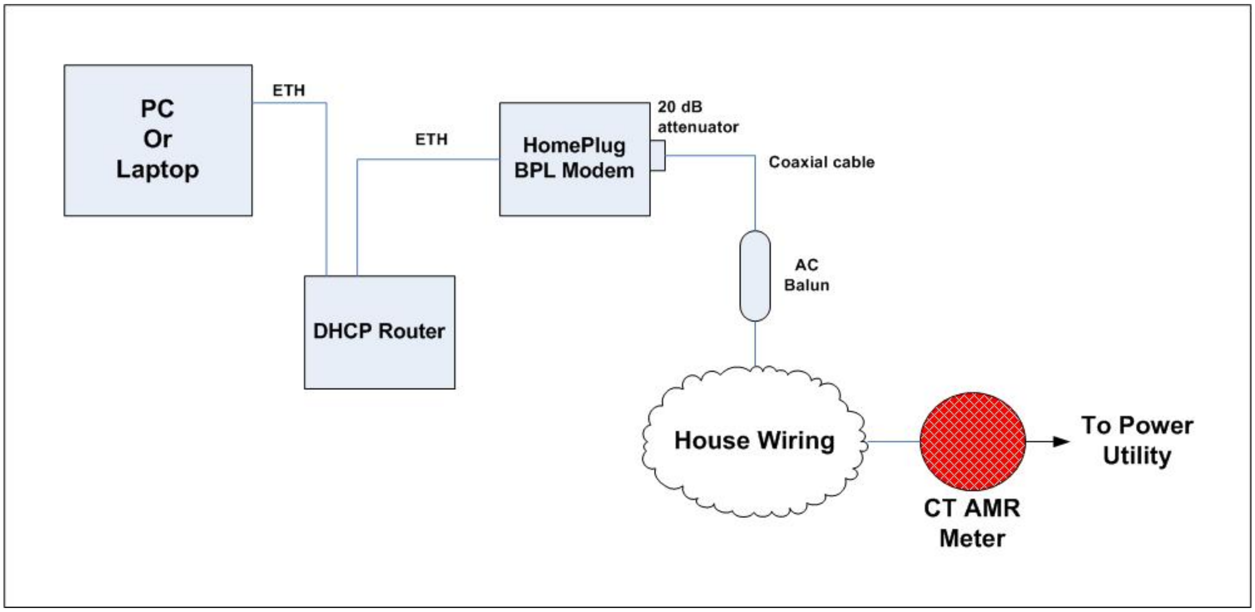

Figure 2: System Test Configuration

5.1. Description of Test Signal and Power Levels

For all testing, traffic was generated using the software application 'nuttcp' to ensure that signal levels consistently generated the maximum possible duty factor. This application was originally designed for network performance and is ideal for emissions testing since it generates a continuous stream of data from the unit under test to a receiving unit. The '-u' parameter was used to provide UDP traffic from the unit under test, since that eliminates the need for the receiving device to generate IP layer acknowledgement packets and increases the duty factor. Both lab and field testing show that the achieved duty factors exceed 80% with this application, and all in situ tests included a verification that this duty factor is achieved.

Additionally, for all testing the power level was set at maximum output on the low voltage output. The operator does have the ability to reduce power outputs from the levels set in the factory firmware, but can not increase them.

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 five 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

<u>Washington Laboratories Open Area Test Site</u>

Location:	Washington Laboratories 7560 Lindbergh Drive Gaithersburg, MD
Site Description:	Simulated system installation at an Open Area Test Site. The CT AMR Meter was installed in a metal power meter enclosure which was mounted on a wooden stand approximately 0.8 meter above the floor. The load-side cables were terminated with a load that represents the typical impedance that would be present in a standard home installation.
Site Diagram:	See Figure 3 below.
Site Photo:	See Photographs B-1 and B-2 in Appendix B.
Tests Performed at this Location:	▪ Conducted Emissions on May 18, 2006 ▪ Radiated Emissions, 30 MHz to 1000 MHz, on May 18, 2006

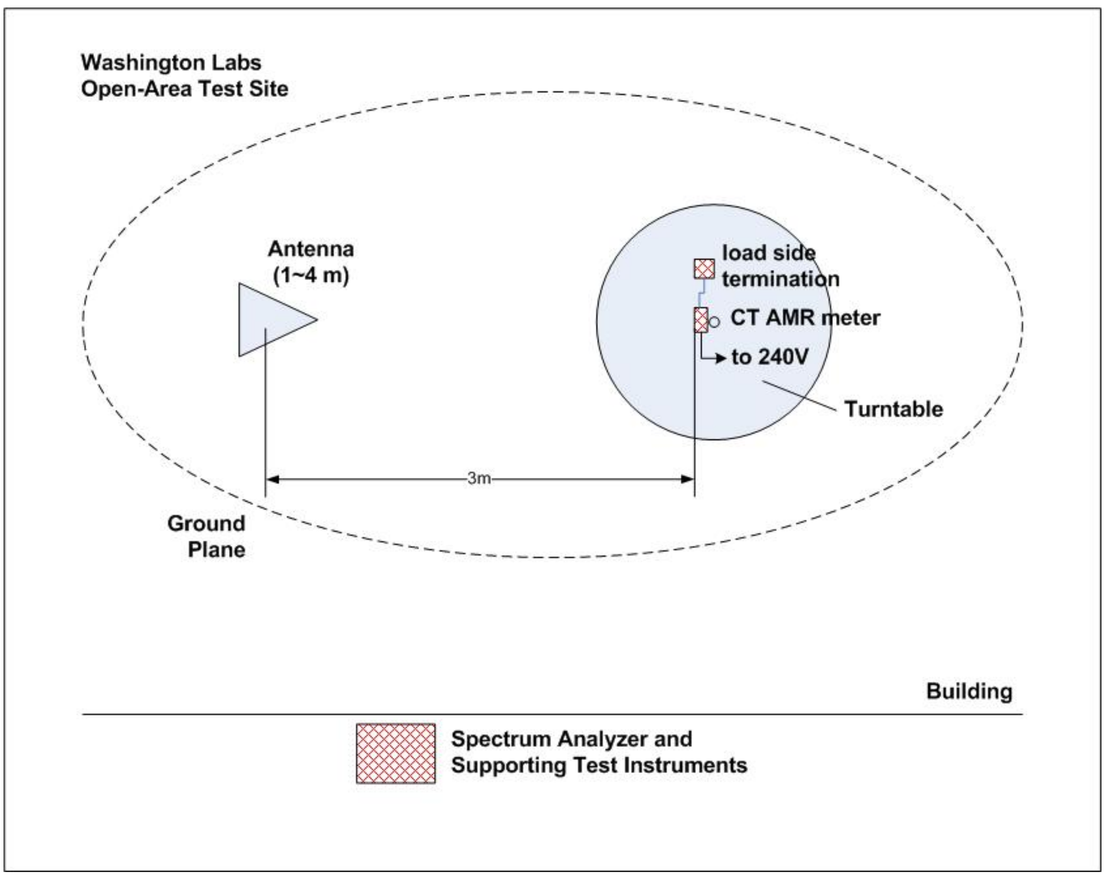

Figure 3: Test Site Diagram – Washington Laboratories Open Area Test Site

16116 Orchard Grove Road

Location:	16116 Orchard Grove Road North Potomac, MD
Site Description:	System installation inside a metal power meter enclosure inside a residential home with underground feed.
Site Diagram:	See Figure 4, below.
Site Photo:	See Photographs B-3 and B-4 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 30 MHz to 1000 MHz, on May 24, 2006

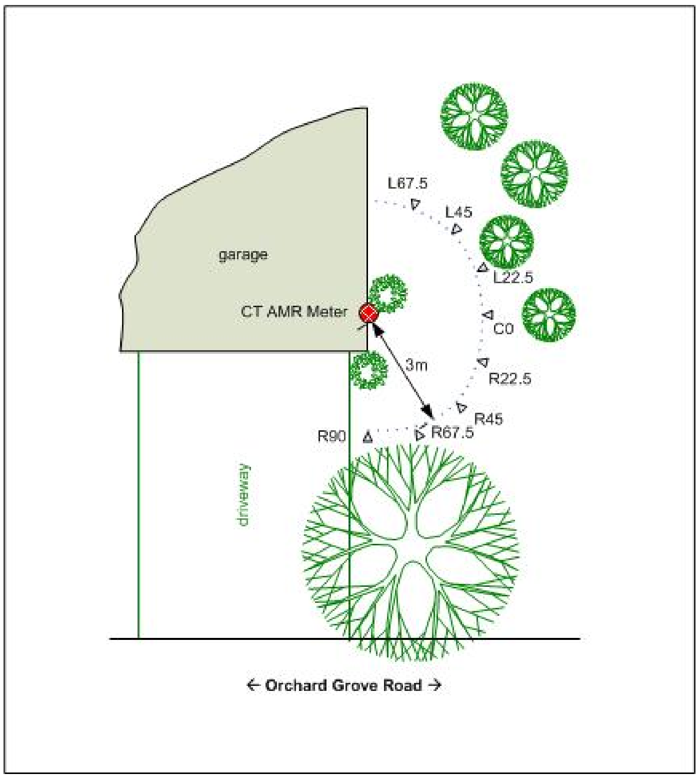

Figure 4: Test Site Diagram – 16116 Orchard Grove Road

12028 Coldstream Drive

Location:	12028 Coldstream Drive Potomac, MD
Site Description:	System installation inside a metal power meter enclosure inside a residential home with overhead feed.
Site Diagram:	See Figure 5, below.
Site Photo:	See Photographs B-5, B-6 and B-7 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 1.705 MHz to 30 MHz, on August 22, 2006

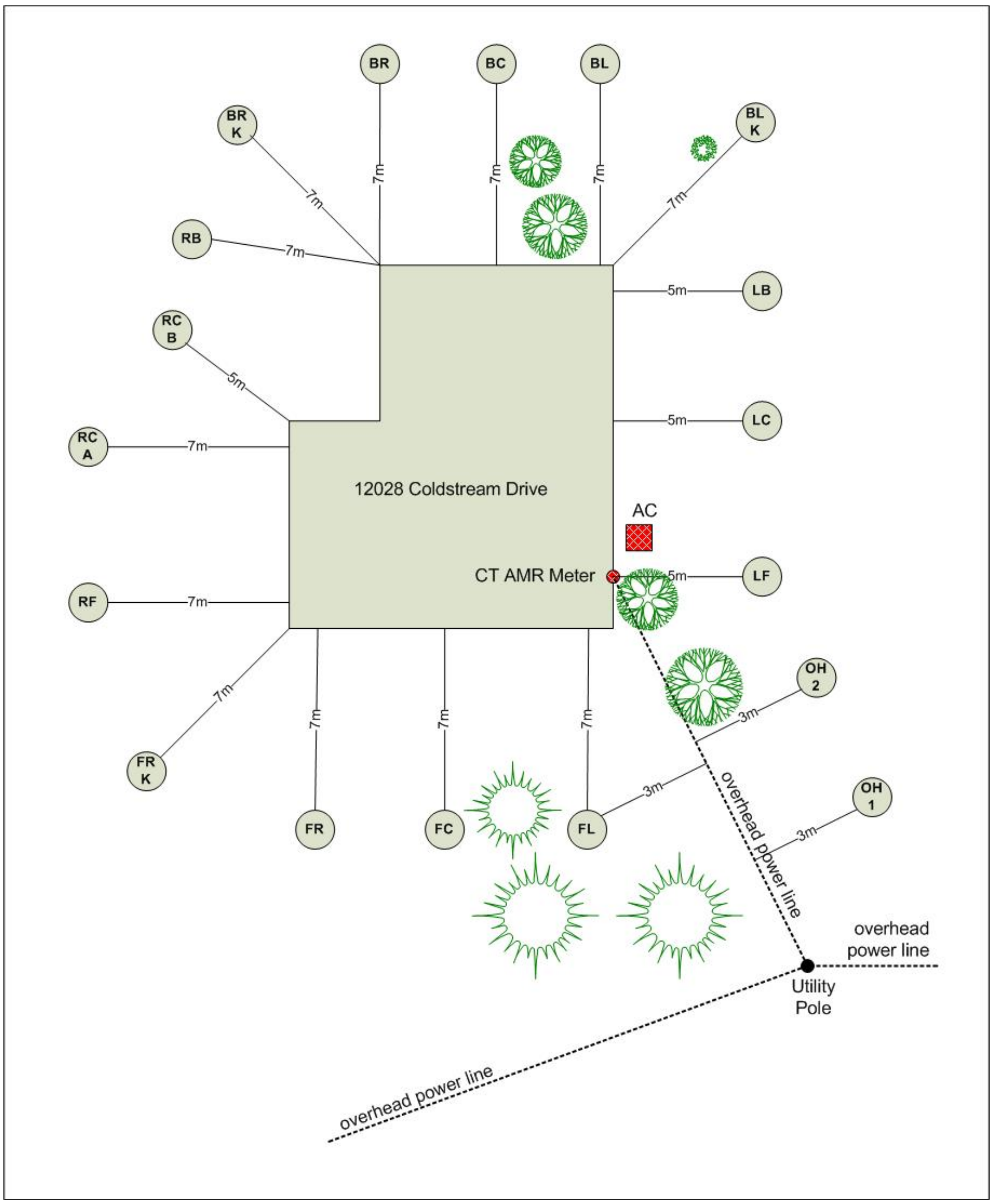

Figure 5: Test Site Diagram – 12028 Coldstream Drive

12109 Sheets Farm Road

Location:	12109 Sheets Farm Road North Potomac, MD
Site Description:	System installation inside a metal power meter enclosure inside a residential home with underground feed.
Site Diagram:	See Figure 6, below.
Site Photo:	See Photographs B-8 and B-9 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 1.705 MHz to 30 MHz, on August 22, 2006

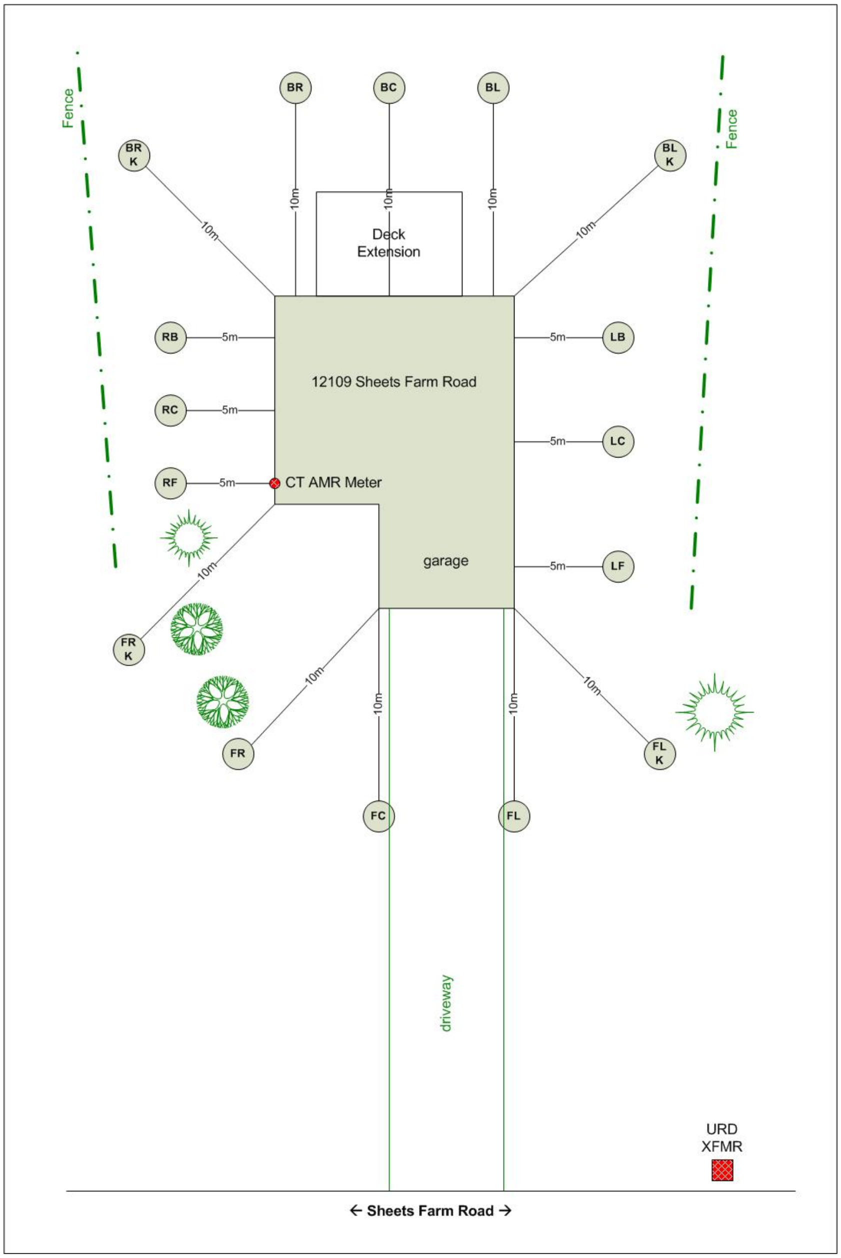

Figure 6: Test Site Diagram –12109 Sheets Farm Road

17907 Coachmans Road

Location:	17907 Coachmans Road Germantown, MD
Site Description:	System installation inside a metal power meter enclosure inside a residential home with underground feed.
Site Diagram:	See Figures 7 and 8, below.
Site Photo:	See Photographs B-10 and B-11 in Appendix B.
Tests Performed at this Location:	▪ Radiated Emissions, 1.705 MHz to 30 MHz, on August 22, 2006 ▪ Radiated Emissions, 30 MHz to 1000 MHz, on May 22, 2006

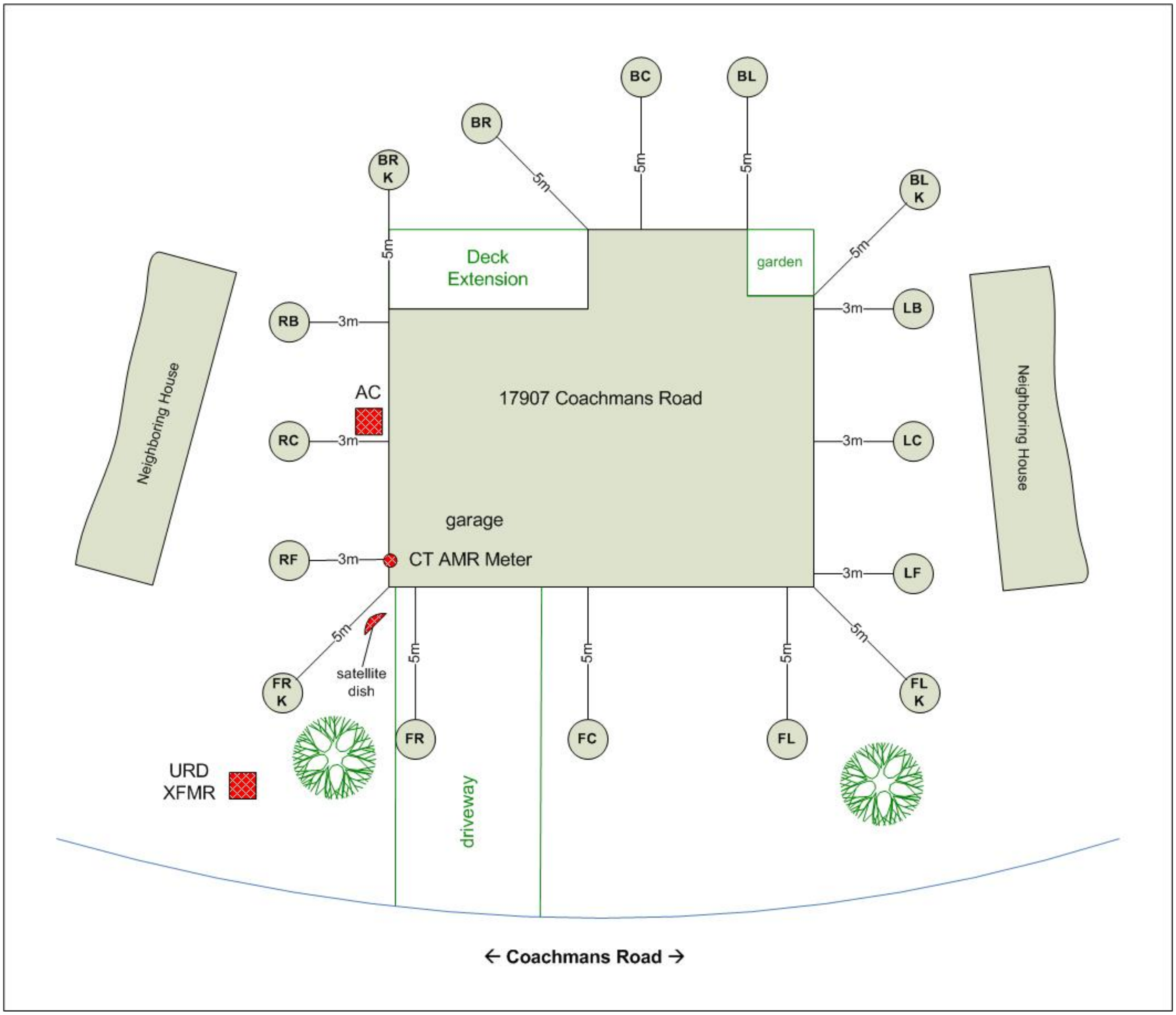

Figure 7: Test Site Diagram – 17907 Coachmans Road – 1.705 MHz to 30 MHz

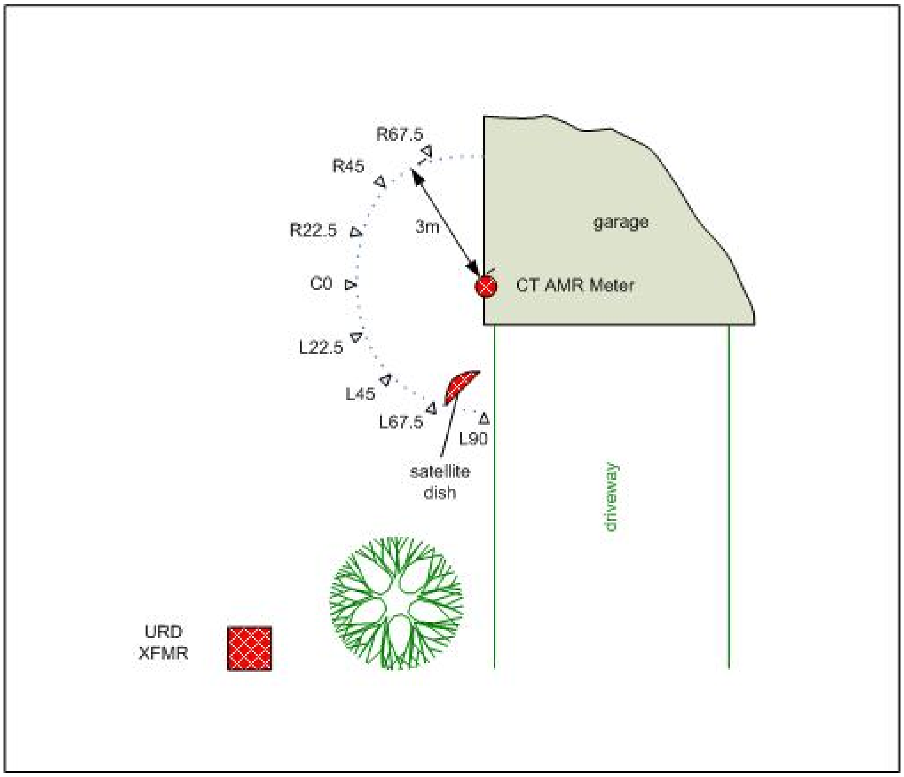

Figure 8: Test Site Diagram – 17907 Coachmans Road – 30 MHz to 1000 MHz

8. List of Test Equipment Used

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

Conducted Emissions Measurement

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
LISN	Solar 8028-50-TS-24-BNC	WL #00125	January 31, 2007
LISN	Solar 8028-50-TS-24-BNC	WL #00126	January 31, 2007

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	00051987	December 7, 2006
RF Cable, 100′	RG-58	CT #100A	January 12, 2007
RF Cable, 100′	RG-58	CT #100B	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 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 #30A	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

The final level of the conducted emission, in dBµV, is calculated by taking the reading from the spectrum analyzer and taking into account the LISN correction factor and the cable loss. More detailed information is given in tabular form in Appendix A.

Conclusion: The CT AMR Meter meets the FCC Part 15 Class B conducted emission requirements. With the CT AMR Meter idle, the minimum passing margin in the frequency range 0.150 MHz to 30.0 MHz was 21.2 dB at 0.289 MHz. With the CT AMR Meter actively transmitting, the minimum passing margin in the frequency range 0.535 MHz to 1.705 MHz was 36.0 dB at 0.567 MHz.

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 AMR Meter meets the FCC limits for radiated emissions from a carrier-current 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 2.3 dB at 4.49 MHz.

The CT AMR Meter 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 3.2 dB at 400.00 MHz.