FCC Part 15 Subpart C
Transmitter Certification

Direct Sequence Spread Spectrum Transmitter

Test Report

FCC ID: R7PUWE-PIT

FCC Rule Part: 15.247

ACS Report Number: 05-0412 - 15C

Manufacturer: Cellnet Technology, Inc.
Model: Cellnet Water Endpoint – Pit

Test Begin Date: November 8, 2005
Test End Date: December 22, 2005

Report Issue Date: February 14, 2006

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code 200612

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This report contains 18 pages

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1.0 GENERAL

1.1 Purpose
The purpose of this report is to demonstrate compliance with Part 15, Subpart C of the FCC's Code of Federal Regulations.

1.2 Product Description

1.2.1 General
The Cellnet Water Endpoint (CWE) is a battery-powered radio transmitter operating in the 902-928 MHz unlicensed ISM band. It is designed to be connected to a variety of residential water meters and will periodically transmit water consumption information. This information is gathered by a Cellnet proprietary cellular network infrastructure.

1.2.2 Manufacturer
Cellnet Technology, Inc.
30000 Mill Creek Avenue
Suite 100
Alpharetta, GA 30022
USA

2.0 TEST FACILITIES

2.1 Location

The radiated and conducted emissions test sites are located at the following address:

Advanced Compliance Solutions
5015 B.U. Bowman Drive
Buford, GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598

2.2 Laboratory Accreditations/Recognitions/Certifications

The Semi-Anechoic Chamber Test Site, Open Area Test Site (OATS) and Conducted Emissions Site have been fully described, submitted to, and accepted by the FCC, Industry Canada and the Japanese Voluntary Control Council for Interference by information technology equipment. In addition, ACS is compliant to ISO 17025 as certified by the National Institute of Standards and Technology under their National Voluntary Laboratory Accreditation Program. The following certification numbers have been issued in recognition of these accreditations and certifications:

FCC Registration Number: 89450
Industry Canada Lab Code: IC 4175
VCCI Member Number: 1831

- VCCI OATS Registration Number R-1526
- VCCI Conducted Emissions Site Registration Number: C-1608

NVLAP Lab Code: 200612

2.3 Radiated Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The Semi-Anechoic Chamber Test Site consists of a 20' x 30' x 18' shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 101 x 101 x 19mm thick and weighs approximately 550 grams. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 150cm in diameter and is located 160cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3' x 6' x 4' deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4" PVC chases from the turntable to the pit that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3-1 below:

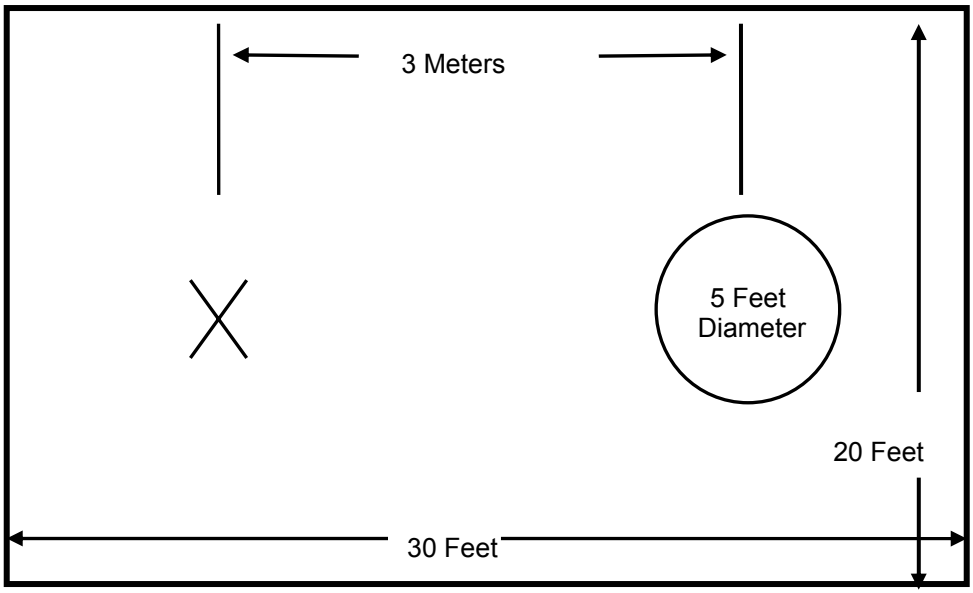


Figure 2.3-1: Semi-Anechoic Chamber Test Site

2.3.2 Open Area Tests Site (OATS)

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 2.3-2 below:

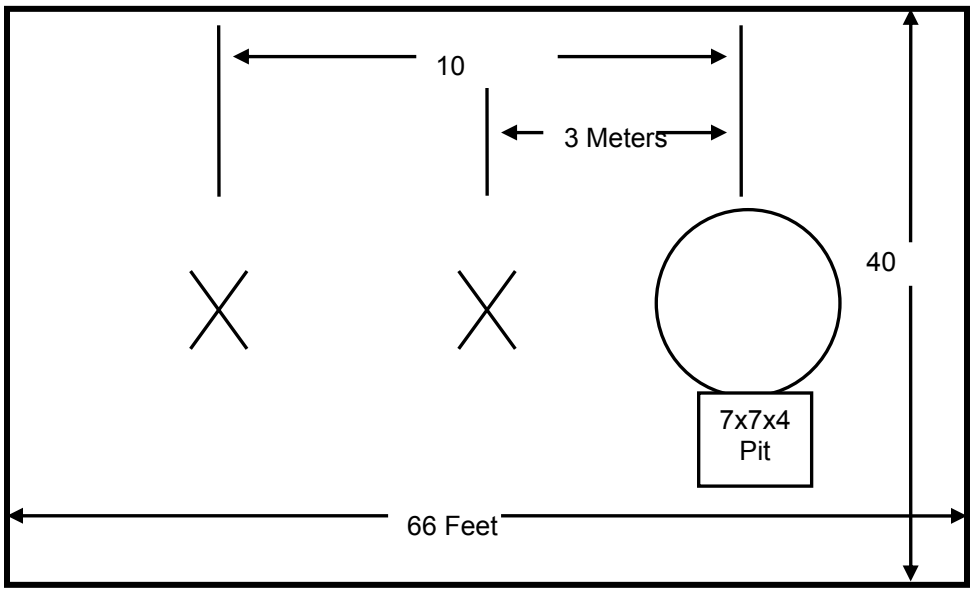


Figure 2.3-2: Open Area Test Site

2.4 Conducted Emissions Test Site Description
The AC mains conducted EMI site is a shielded room with the following dimensions:

- Height: 3.0 Meters
- Width: 3.6 Meters
- Length: 4.9 Meters

The room is manufactured by Rayproof Corporation and installed by Panashield, Inc. Earth ground is provided to the room via an 8' copper ground rod. Each panel of the room is connected electrically at intervals of 4".

Power to the room is filtered to prevent ambient noise from coupling to the EUT and measurement equipment. Filters are models 1B42-60P manufactured by Rayproof Corporation.

The room is of sufficient size to test table top and floor standing equipment in accordance with section 6.1.4 of ANSI C63.4.

A diagram of the room is shown below in figure 2.4-1:

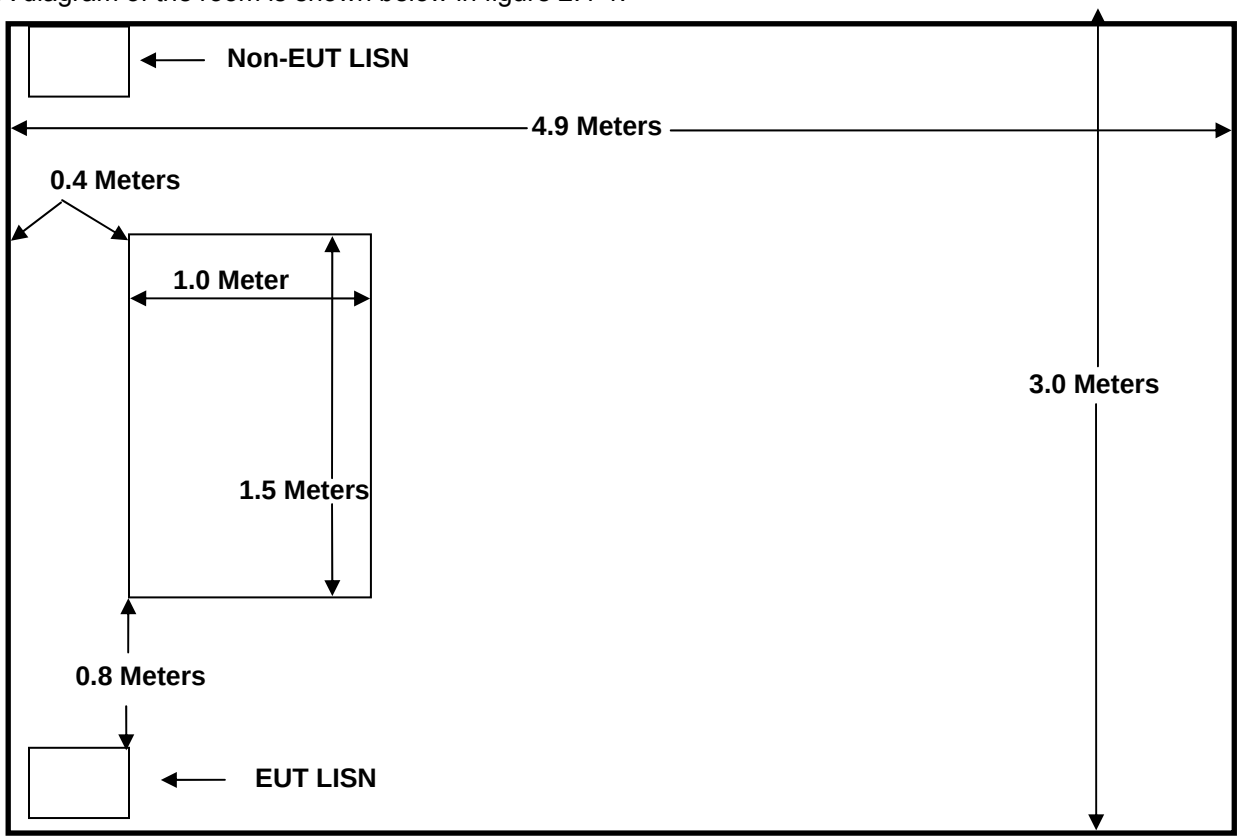


Figure 2.4-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES
The following standards were used:

1 - ANSI C63.4-2003: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the 9 KHz to 40GHz
2 - US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators
3 - FCC OET Bulletin 65 Appendix C - Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

4.0 LIST OF TEST EQUIPMENT

All test equipment used for regulatory testing is calibrated yearly or according to manufacturer's specifications.

Table 4.0-1: Test Equipment

Equipment Calibration Information					
ACS#	**Mfg.**	**Eq. type**	**Model**	**S/N**	**Cal. Due**
☐ 25	Chase	Bi-Log Antenna	CBL6111	1043	5/23/06
☐ 26	Chase	Bi-Log Antenna	CBL6111	1044	6/2/06
☐ 193	ACS	OATS Cable Set	RG8	193	1/07/06
☐ 225	Andrew	OATS RF cable	Heliax	225	1/06/06
☐ 22	Agilent	Pre-Amplifier	8449B	3008A00526	5/06/06
☐ 73	Agilent	Pre-Amplifier	8447D	272A05624	5/18/06
☐ 30	Spectrum Technologies	Horn Antenna	DRH-0118	970102	5/09/06
☐ 105	Microwave Circuits	High Pass Filter	H1G810G1	2123-01 DC0225	9/13/06
☐ 209	Microwave Circuits	High Pass Filter	H3G020G2	4382-01 DC0421	9/20/06
☐ 1	Rohde & Schwarz	Receiver Display	804.8932.52	833771/007	3/07/06
☐ 2	Rohde & Schwarz	ESMI Receiver	1032.5640.53	839587/003	3/07/06
☐ ---	Agilent	Spectrum Analyzer	E7405A	US39110103	6/6/06
☐ 213	Test Equipment Corp.	Pre-Amplifier	PA-102	44927	6/29/06
☐ 211	Eagle	Band Reject Filter	C7RFM3NFNM	n/a	1/06/06
☐ 168	Hewlett Packard	Pulse Limiter	11947A	3107A02268	1/06/06
☐ 6	Harbour Industries	HF RF Cable	LL-335	00006	3/16/06
☐ 7	Harbour Industries	HF RF Cable	LL-335	00007	3/16/06
☐ 208	Harbour Industries	HF RF Cable	LL142	00208	6/24/06
☐ 167	ACS	Chamber EMI Cable Set	RG6	167	12/29/05
☐ 204	ACS	Chamber EMI RF cable	RG8	204	1/07/06

5.0 SUPPORT EQUIPMENT

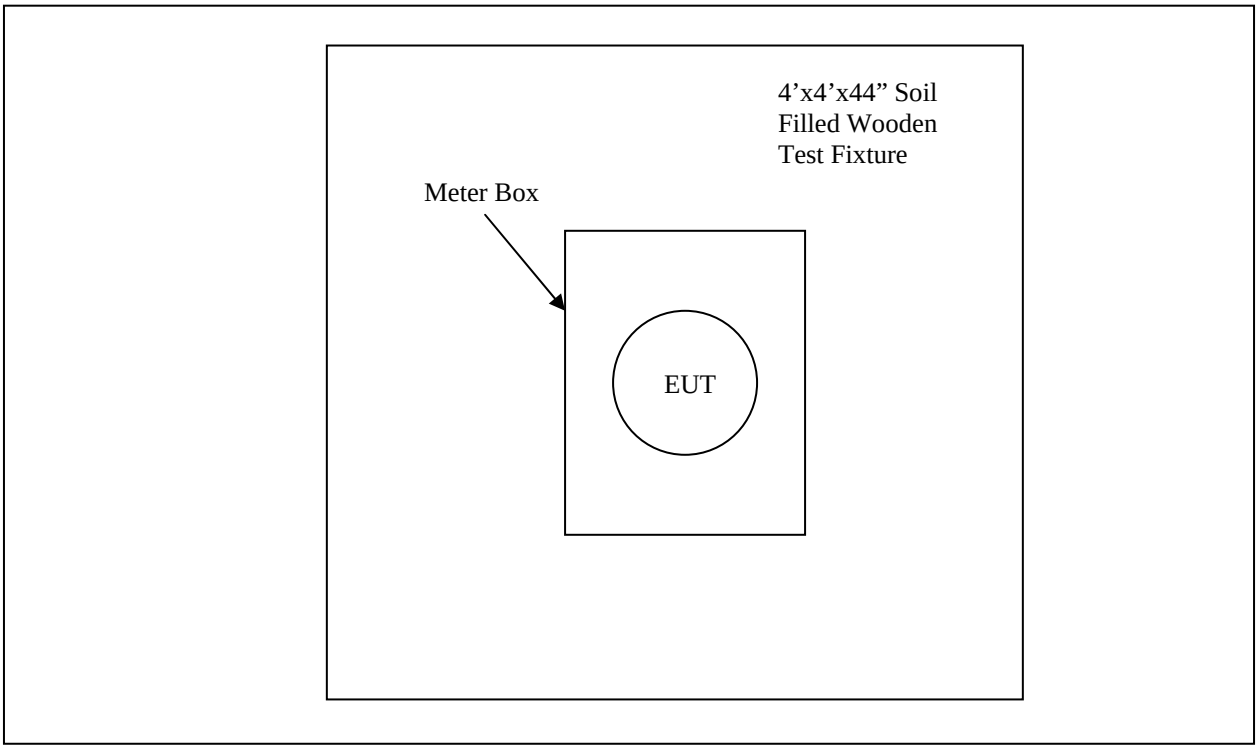
Table 5-3: Support Equipment

Item	Equipment Type	Manufacturer	Model Number	Serial Number	FCC ID
The EUT was tested as a stand alone device and no support equipment was utilized.					

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

The EUT was tested in a stand alone configuration which utilized an internal battery for operation. Consistent with the typical installation, all measurements were made in cast iron and composite meter boxes buried in a 4'x4'x44", measured from the outer dimensions, wooden fixture surrounded by soil. The meter boxes represent the upper and lower extremes of materials used in the industry. They were chosen to represent the materials with the highest and lowest shielding properties. The meter box lid was installed flush with the top of the soil grade which was measured at 80cm above the ground plan.

Detailed photographs of the test setup can be found in the accompanying exhibits of this test report.



7.0 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement - FCC Section 15.203

The EUT employs an external patch antenna attached by a 50 semi-rigid RF cable soldered directly to the printed circuit board. The antenna gain is 2dBi +/-0.5dB.

7.2 Power Line Conducted Emissions - FCC Section 15.207

The UWE is battery powered therefore Power Line Conducted Emissions is not required.

7.3 Radiated Emissions - FCC Section 15.109(Unintentional Radiation)

7.3.1 Test Methodology

Radiated emissions tests were performed over the frequency range of 30MHz to 1 GHz. Measurements of the radiated field strength were made at a distance of 3m from the boundary of the equipment under test (EUT) and the receiving antenna. The antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. Radiated measurements were made with the Spectrum Analyzer's resolution bandwidth set to 120 KHz for measurements above 30MHz. Average measurements are taken with the RBW and VBW were set to 1MHz and 10 Hz respectively for measurements above 1000MHz.

7.3.2 Test Results

Results of the test are given below in Table 7.3.2-1:

Table 7.3.2-1: Radiated Emissions

Frequency (MHz)	Uncorrected Reading (dBµV/m)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Azimuth (°)	Total Correction Factor (dB)	Corrected Reading (dBµV/m)	Limit (dBµV/m)	Margin (dB)
35.38	33.6	V	100	0	-6.66	26.94	40	13.1
84.96	23.87	V	100	0	10.79	34.66	40	5.3
87.12	24.31	V	100	0	11.38	35.69	40	4.3
96.82	30.24	V	100	0	11.74	41.98	43.5	1.5
267.11	31.09	V	100	45	-7.92	23.17	46	22.8
276.9	29.19	V	100	180	-8.20	20.99	46	25.0
286.51	29.67	V	100	310	-8.22	21.45	46	24.5
689.6	25.85	V	100	270	0.94	26.79	46	19.2
869.4	29.03	V	100	200	3.61	32.64	46	13.4
945.9	26.14	V	100	280	6.00	32.14	46	13.9

* Note: All emissions above 945.9 MHz were attenuated at least 20 dB below the permissible limit

7.4 6dB Bandwidth – FCC Section 15.247(a)

7.4.1 Test Methodology

The 6dB bandwidth was measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247". The RBW of the spectrum analyzer was set to 100 kHz and VBW 300 kHz. Span was set large enough to capture the entire emissions and >> RBW.

7.4.2 Test Results

Results are shown below in table 7.4.2-1 and figure 7.4.2-1:

Table 7.4.2-1: 6dB Bandwidth

Frequency [MHz]	Bandwidth [MHz]	Limit	Result
917.58	1.03	≥ 500 kHz	PASS

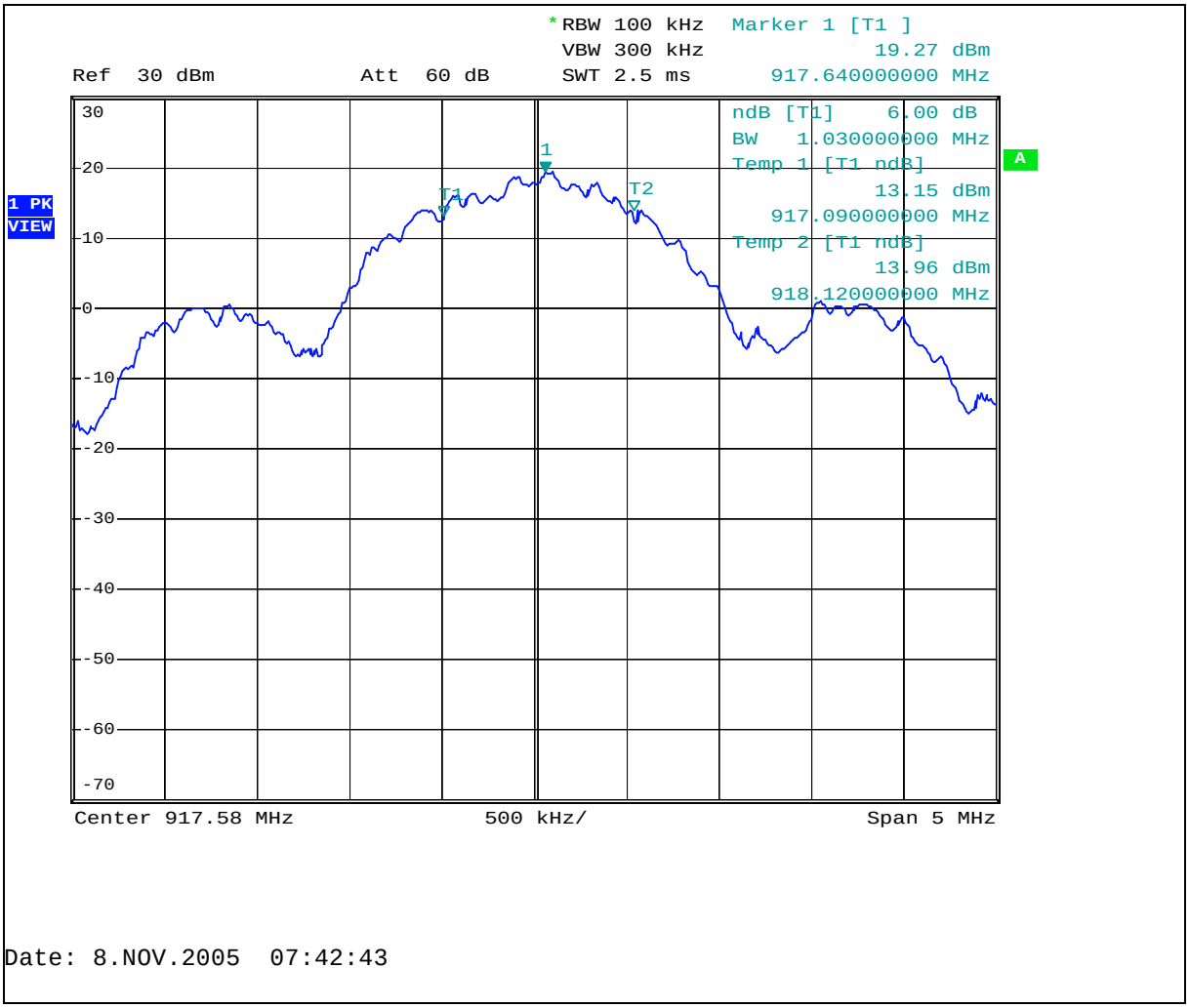


Figure 7.4.2-1: 6dB Bandwidth Plot

7.5 Peak Output Power Requirement - FCC Section 15.247(b)

7.5.1 Test Methodology

The Peak Output Power was measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247" Power Option 1. The RF output of the equipment under test was directly connected to the input of the Spectrum Analyzer. The resolution bandwidth of the spectrum analyzer was set to 3 MHz.

Data was collected with the EUT operating at maximum power.

Results are shown below in Table 7.5.2-1 and Figure 7.5.2-1.

7.5.2 Test Results

Table 7.5.2-1: Peak Output Power

Frequency (MHz)	Output Power (dBm)
917.58	24.16

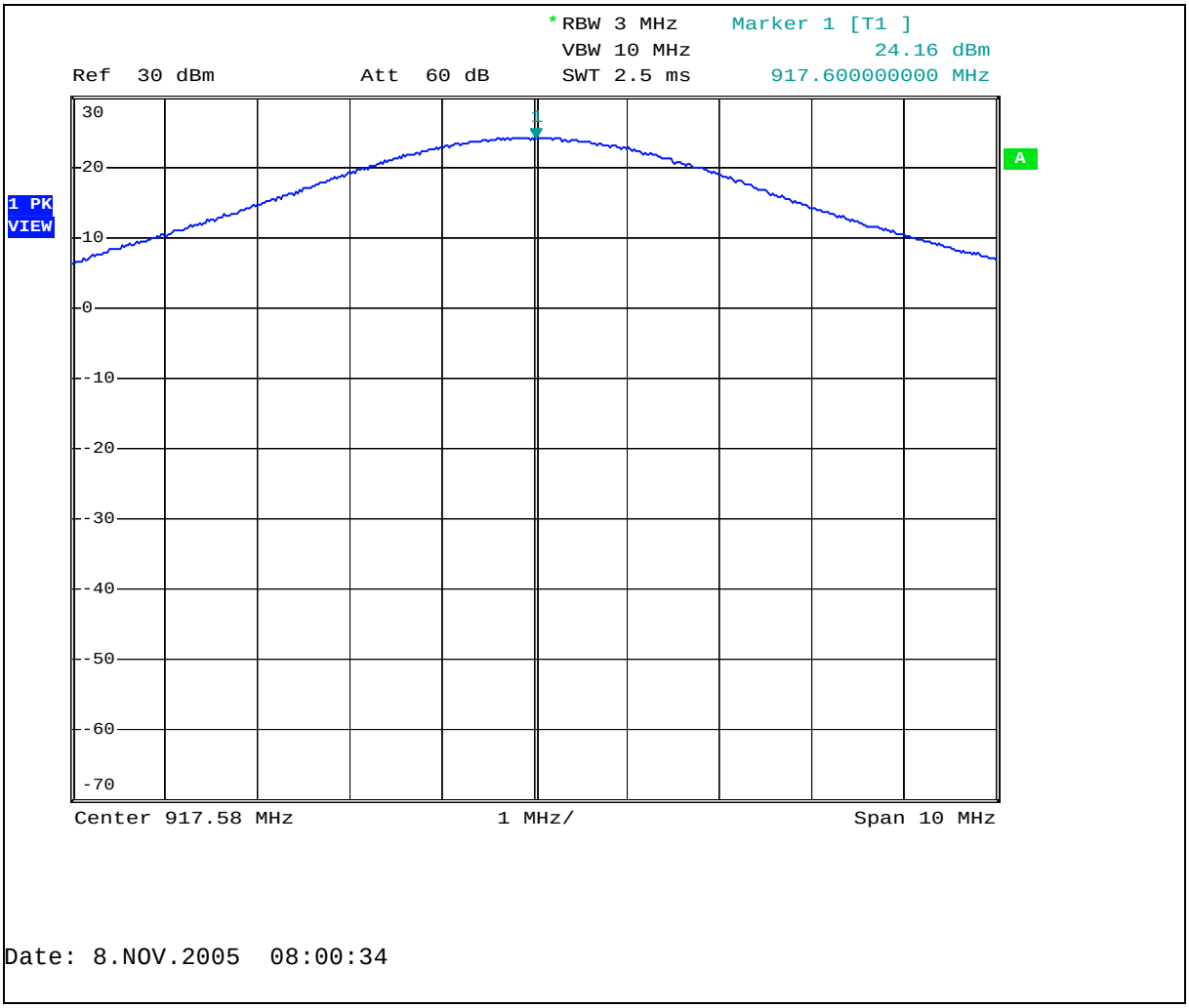


Figure 7.5.2-1: Output power

7.6 Band-Edge Compliance and Spurious Emissions - FCC Section 15.247(d)

7.6.1 Band-Edge Compliance of RF Emissions

7.6.1.1 Test Methodology

The EUT was investigated at 917.58 MHz to determine band-edge compliance. The spectrum analyzer's RBW was set to 300 kHz, which is ≥ 1% of the span, and the VBW was set to 1 MHz.

7.6.1.2 Test Results

Band-edge compliance is displayed in Figure 7.6.1.2-1.

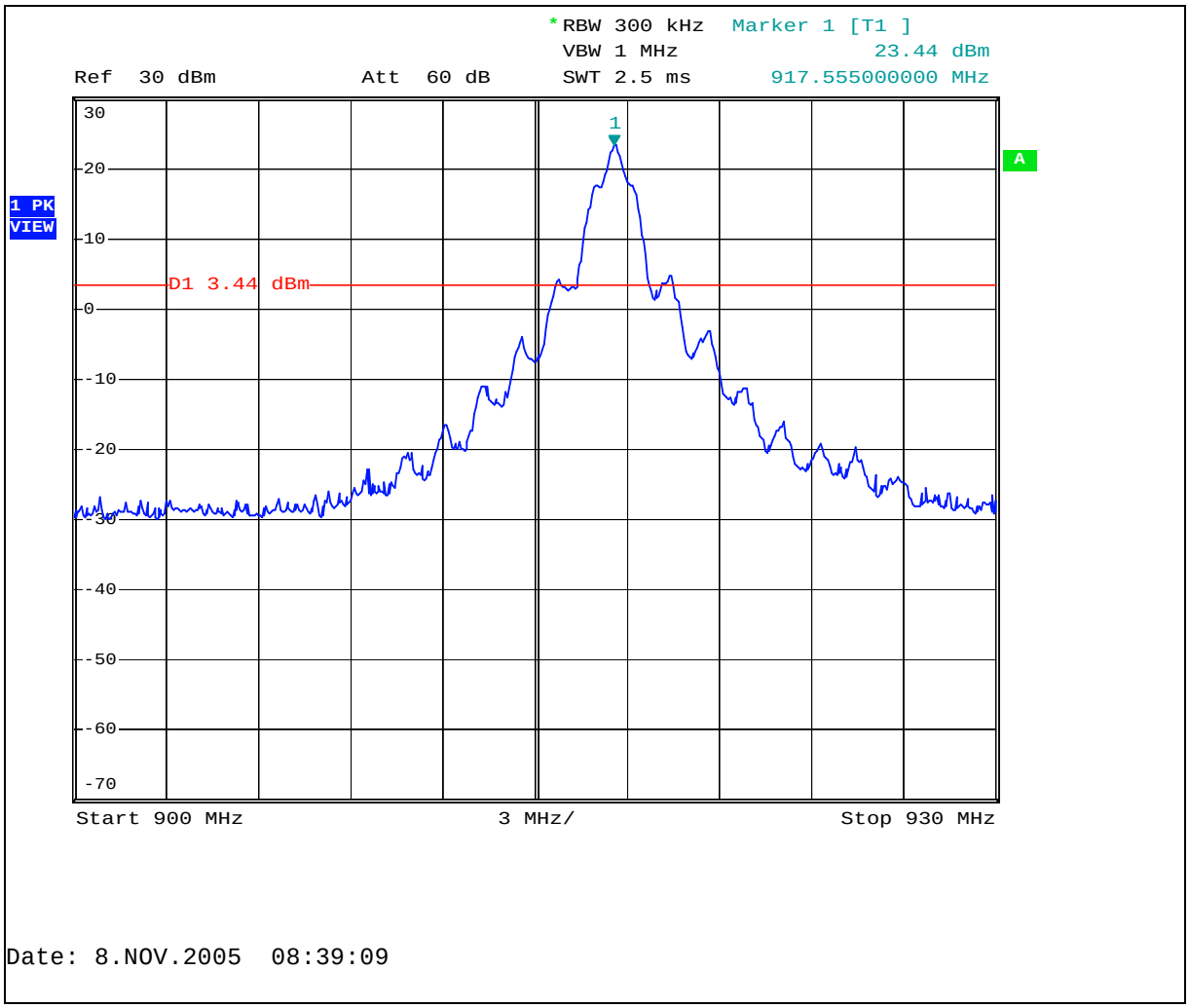


Figure 7.6.1.2-1: Band-edge

7.6.2 RF Conducted Spurious Emissions

7.6.2.1 Test Methodology

The EUT was investigated for conducted spurious emissions from 30MHz to 10GHz, 10 times the highest fundamental frequency. Measurements were made at the low, center and high channels of the EUT. For each measurement, the spectrum analyzer's RBW was set to 100kHz. A peak detector function was used with the trace set to max hold.

7.6.2.2 Test Results

All emission found were greater than 20dB down from the fundamental carrier. Results are shown below in Figure 7.6.2.2-1 through 7.6.2.2-2.

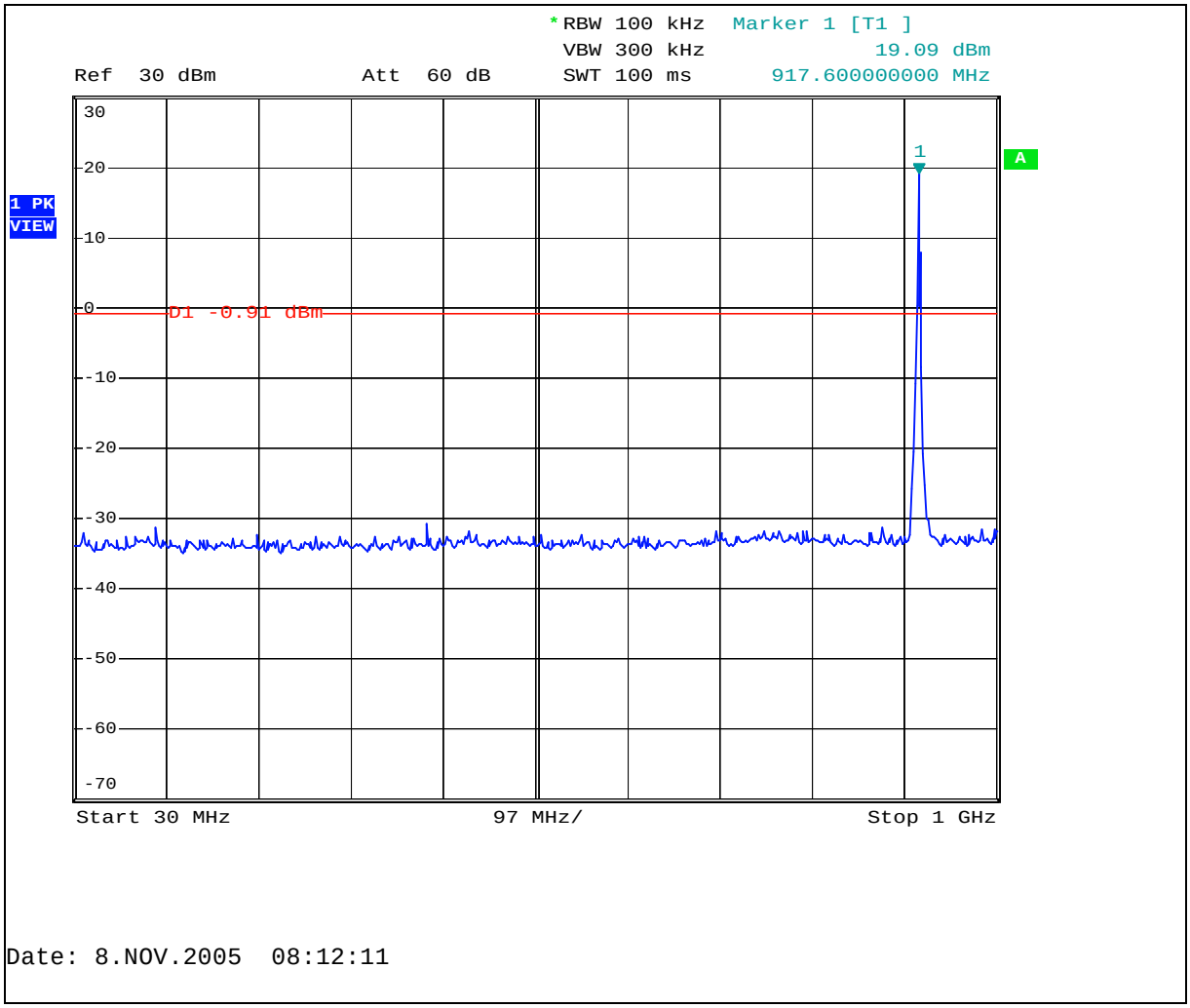


Figure 7.6.2.2-1 RF Conducted Spurious Emissions

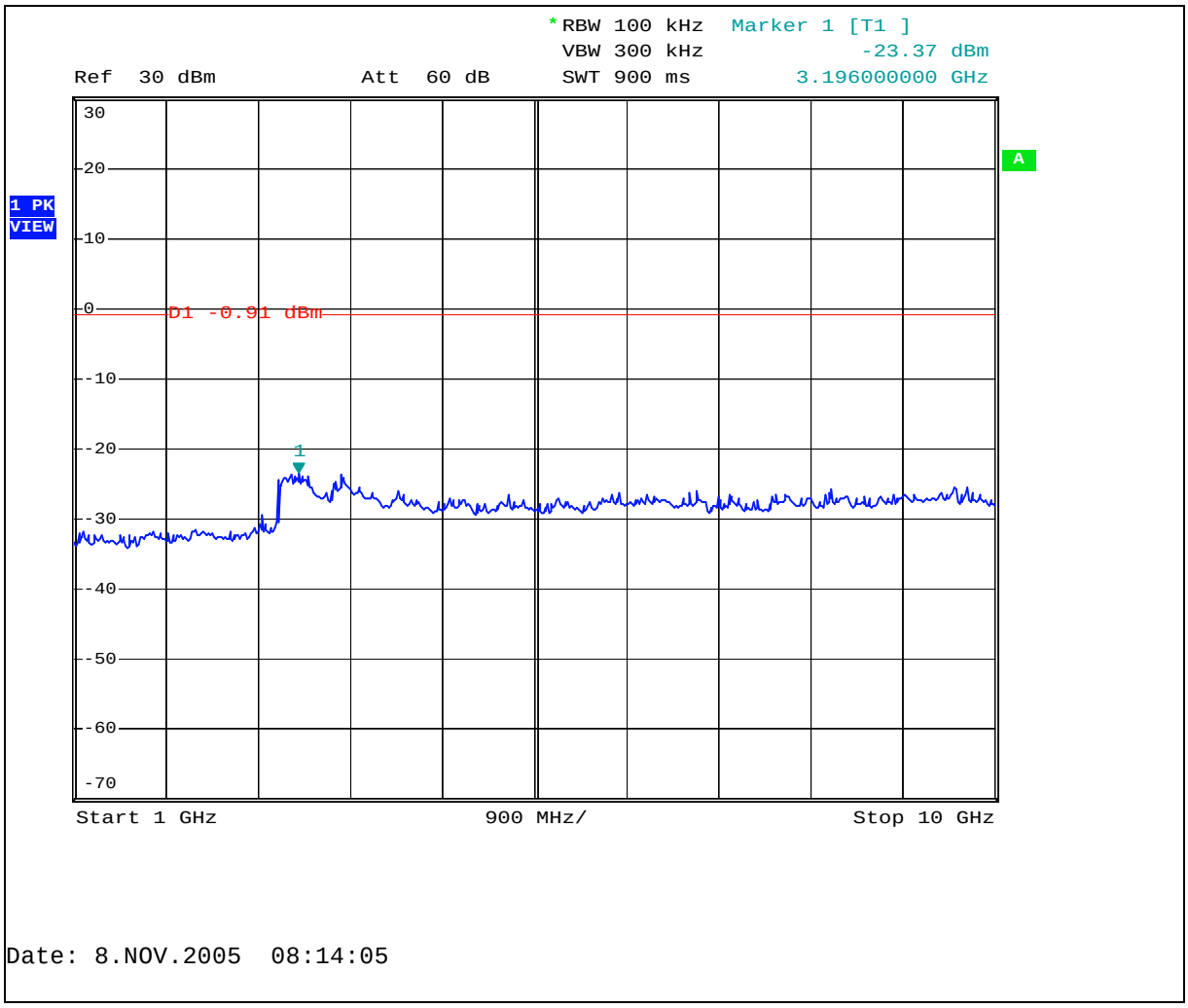


Figure 7.6.2.2-2 RF Conducted Spurious Emissions

7.6.3 Radiated Spurious Emissions (Restricted Bands) - FCC Section 15.205

7.6.3.1 Test Methodology

Radiated emissions tests were made over the frequency range of 30MHz to 10GHz, 10 times the highest fundamental frequency.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth (RBW) of 120 kHz and a video bandwidth (VBW) of 300 kHz. For frequencies above 1000MHz, peak measurements were made using an RBW of 1 MHz and a VBW of 3 MHz and the average emission was calculated by correcting for the duty cycle of the EUT.

Radiated spurious emissions were measured as described according to Section 6.0. The device was tested in a typical configuration in a meter box. The meter box was buried in a 4'x4'x44" wooden box which was filled with soil. The EUT was placed in both a cast iron and composite meter box and fully tested for each configuration.

7.6.3.2 Duty Cycle Correction

For average radiated measurements, the measured level was reduced by a factor 18.4dB to account for the duty cycle of the EUT. The EUT transmits for a maximum duration of 12mS within a 100ms period. Therefore the duty cycle is 12%. The duty cycle correction factor is determined using the formula: 20log (0.12) = -18.4dB. A detailed description of the duty cycle determination is included in the theory of operations.

7.6.3.3 Test Results

Using the procedures set forth in the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247", radiated spurious emissions are reported in Table 7.6.3.3-1 and Table 7.6.3.3-2. Each emission found to be in a restricted band as defined by section 15.205, was compared to the radiated emission limits as defined in section 15.209.

Table 7.6.3.3-1: Radiated Spurious Emissions – Composite Meter Box

Frequency	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
(MHz)	pk	avg	(H/V)	(dB)	pk	avg	pk	avg	pk	avg
Spurious Emissions										
2752.74	51.01	51.01	H	2.39	53.40	34.98	74	54	20.60	19.02
2752.74	57.32	57.32	V	2.39	59.71	41.29	74	54	14.29	12.71
3670.32	50.56	50.56	H	5.91	56.47	38.05	74	54	17.53	15.95
3670.32	54.27	54.27	V	5.91	60.18	41.76	74	54	13.82	12.24
4587.9	50.40	50.40	H	7.98	58.38	39.97	74	54	15.62	14.03
4587.9	56.28	56.28	V	7.98	64.26	45.85	74	54	9.74	8.15

Table 7.6.3.3-2: Radiated Spurious Emissions – Cast Iron Meter Box

Frequency	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
(MHz)	pk	avg	(H/V)	(dB)	pk	avg	pk	avg	pk	avg
Spurious Emissions										
2752.74	52.08	52.08	H	2.39	54.47	36.05	74	54	19.53	17.95
2752.74	53.52	53.52	V	2.39	55.91	37.49	74	54	18.09	16.51
3670.32	48.34	48.34	H	5.91	54.25	35.83	74	54	19.75	18.17
3670.32	50.68	50.68	V	5.91	56.59	38.17	74	54	17.41	15.83
4587.9	48.22	48.22	H	7.98	56.20	37.79	74	54	17.80	16.21
4587.9	50.18	50.18	V	7.98	58.16	39.75	74	54	15.84	14.25

7.6.3.4 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Example Calculation: Peak

Corrected Level: 51.01 + 2.39 = 53.40 dBuV
Margin: 74dBuV – 53.40 dBuV = 20.60 dB

Example Calculation: Average

Corrected Level: 51.01 + 2.39 -18.4 = 34.98 dBuV
Margin: 54dBuV – 34.98 dBuV = 19.02 dB

7.7 Peak Power Spectral Density- FCC Section 15.247(d)

7.7.1 Test Methodology

The power spectral density was measured in accordance with the FCC publication "New Guidance on Measurements for Digital Transmission Systems in Section 15.247". The emission peaks within the pass band were located and zoomed in on. The spectrum analyzer RBW was set to 3 kHz and VBW 10 kHz. Span was adjusted to 500 kHz and the sweep time was calculated to be 170s (Span/3 kHz).

7.7.2 Test Results

Results are shown below in table 7.7.2-1 and figures 7.7.2-1 – 7.7.2-3:

Table 7.7.2-1: Peak Power Spectral Density

Frequency [MHz]	Level [dBm]	Limit [dBm]	Result
917.58	7.92	8	PASS

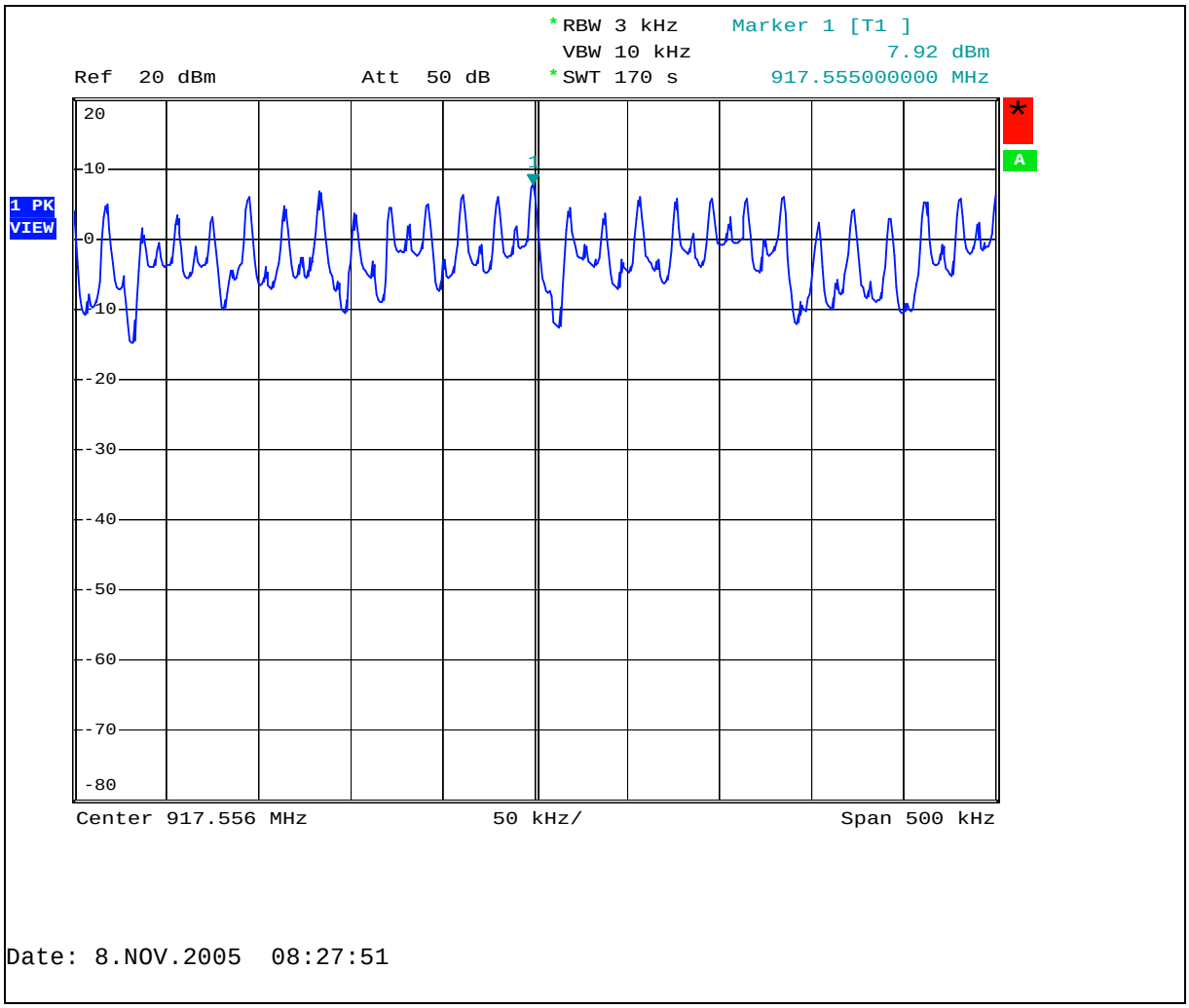


Figure 7.7.2-1: Peak Power Spectral Density

8.0 CONCLUSION

In the opinion of ACS, Inc. the Cellnet Water Endpoint – Pit, manufactured by Cellnet Technology, Inc., does meet the requirements of FCC Part 15 subpart C.