FCC Part 15.247
Transmitter Certification

Frequency Hopping Spread Spectrum Transmitter

<u>Test Report</u>

FCC ID: P2SNTGSRFER900

FCC Rule Part: 15.247

ACS Report Number: 04-0349-15C-B

Manufacturer: Neptune Technology Group, Inc.
Model: E-Coder R900

Test Begin Date: November 3, 2004
Test End Date: November 4, 2004

Report Issue Date: November 5, 2004

FOR THE SCOPE OF ACCREDITATION UNDER LAB Code 200612

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This report contains <u>19</u> pages

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Additional Exhibits Included In Filing

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 E-Coder R900 is combination encoder register and transmitter which collects meter-usage data and transmits the data for collection by the meter reader. The E-Coder R900 provides water utilities with a reliable and economical RF reading solution. Data transmitted by the E-Coder R900 is received by the Neptune walk-by or drive-by data collection system and stored for downloading at the utility office. The E-Coder R900 is a one-way communication device that transmits data using frequency-hopping spread-spectrum technology to ensure data security and improve meter reading accuracy.

Detailed photographs of the EUT are filed separately with this filing.

1.2.2 Intended Use

The E-Coder R900's intended use is to transmit meter-usage data for collection by water utility companies.

1.2.3 Technical Specifications

Table 1.2.3-1: Specifications

Frequency Band	902-928
Number of Channels	50
Channel Bandwidth	92kHz Nominal
Channel Spacing	N/A
Output power	18dBm nominal
Antenna Type	Integral Monopole 2dBi
Antenna Connector Type	NA

1.2.4 Antennas

The antenna type is a monopole (Neptune Technology Group Inc. model 12641-001) which sealed inside the enclosure. The maximum gain is 2dBi.

2.0 LOCATION OF TEST FACILTY

All testing was performed by qualified ACS personnel located at the following address:

ACS, Inc.
5015 B.U. Bowman Drive
Buford, GA 30518

2.1 DESCRIPTION OF TEST FACILITY

Both the 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.

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

2.1.1 Open Area Test Site

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 3.2-1 below:

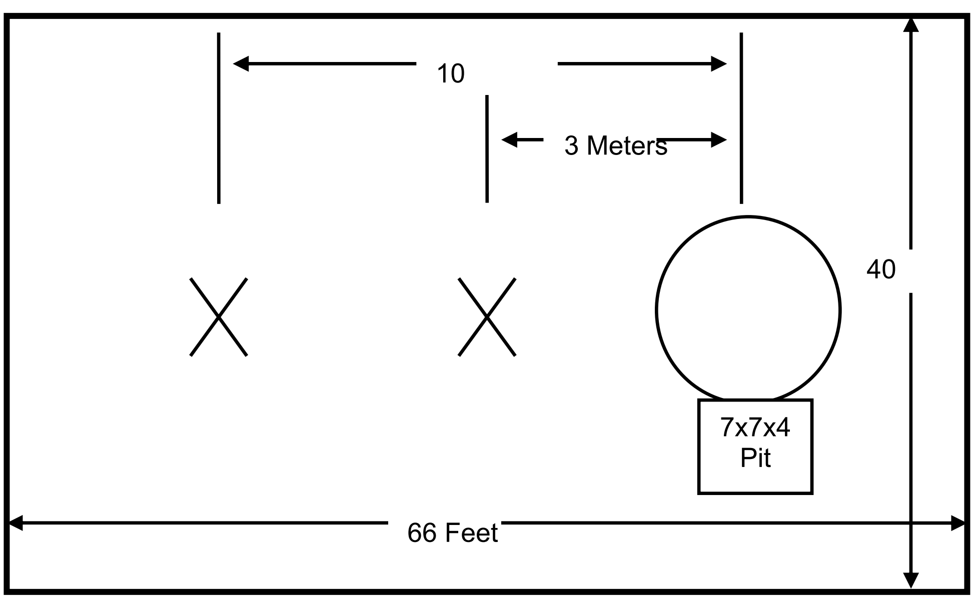

Figure 2.1.1-1: Open Area Test Site

2.1.2 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 2.1.2-1:

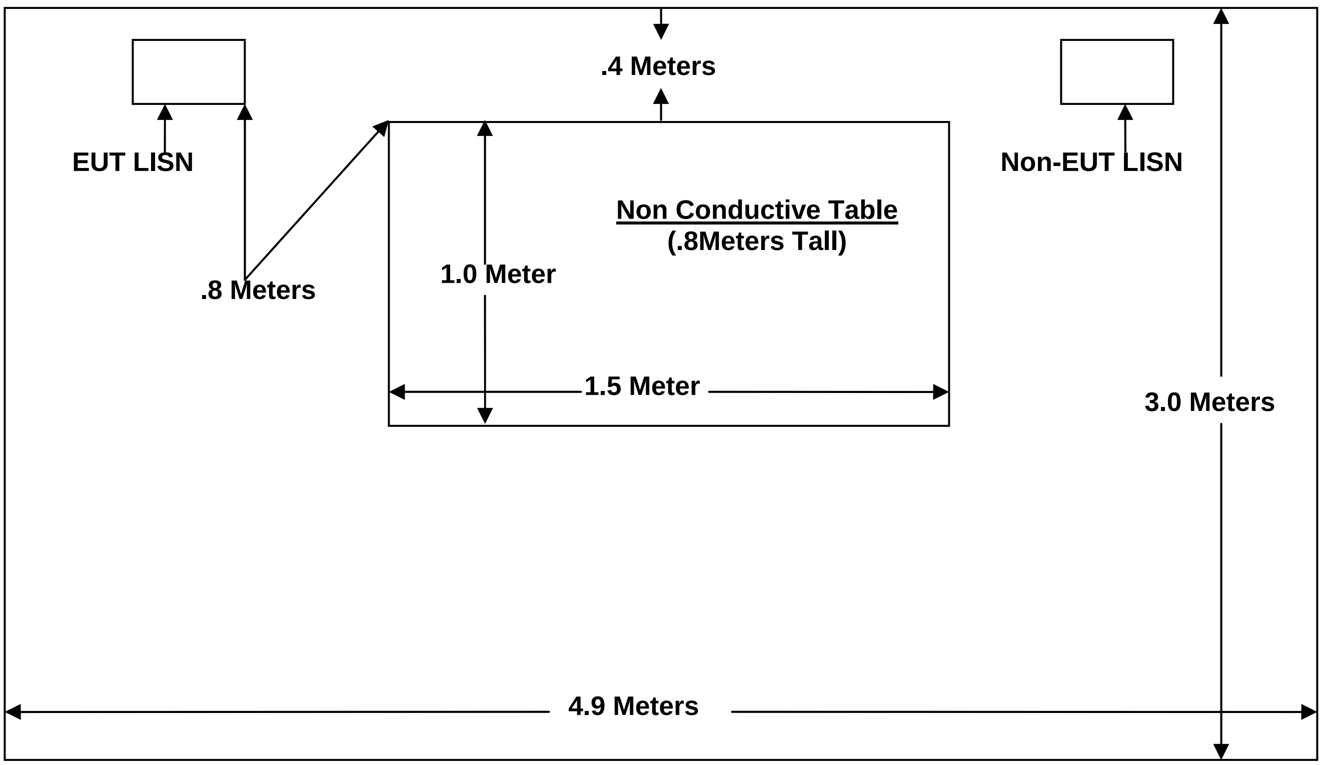

Figure 2.1.2-1: AC Mains Conducted EMI Site

3.0 APPLICABLE STANDARD REFERENCES

The following standards were used:

1 - ANSI C63.4-1992: 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 (October 2000)

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**
---	Agilent	Spectrum Analyzer	E7402A	US40240259	02/26/05
26	Chase	Bi-Log Antenna	CBL6111	1044	10/11/05
152	EMCO	LISN	3825/2	9111-1905	01/08/05
153	EMCO	LISN	3825/2	9411-2268	12/11/04
193	ACS	OATS Cable Set	RG8	193	01/09/05
167	ACS	Conducted EMI Cable Set	RG8	167	01/09/05
22	Agilent	Pre-Amplifier	8449B	3008A00526	05/12/05
73	Agilent	Pre-Amplifier	8447D	272A05624	04/30/05
30	Spectrum Technologies	Horn Antenna	DRH-0118	970102	05/08/05
105	Microwave Circuits	High Pass Filter	H1G810G1	2123-01 DC0225	06/09/05
209	Microwave Circuits	High Pass Filters	H3G020G2	4382-01 DC0421	06/09/05
1	Rohde & Schwarz	Receiver	804.8932.52	833771/007	02/26/05
2	Rohde & Schwarz	Receiver	1032.5640.53	839587/003	02/26/05
3	Rohde & Schwarz	ESMI Receiver	804.8932.52	839379/011	*
4	Rohde & Schwarz	ESMI Receiver	1032.5640.53	833827/003	*
213	Test Equipment Corp.	Pre-Amplifier	PA-102	44927	06/28/05
211	Eagle	Band Reject Filter	C7RFM3NFNM	n/a	06/28/05
168	Hewlett Packard	Pulse Limiter	11947A	3107A02268	04/30/05
93	Chase	EM Clamp	CIC 8101	65	01/12/05
184	ACS	Cable	RG8	184	01/09/05
169	Solar Electronics	LISN	9117-5-TS-50-N	031032	04/12/05
6	Harbour Industries	HF RF Cable	LL-335	00006	03/15/05
7	Harbour Industries	HF RF Cable	LL-335	00007	03/15/05
208	n/a	HF RF Cable	n/a	00208	06/14/05
5	ChaseRF Current Probe	Current Probe	CSP-8441	19	01/23/05

* Note: No calibration required – used for pre-scan data only

5.0 SUPPORT EQUIPMENT

Table 5-3: Support Equipment

Manufacturer	Equipment Type	Model Number	Serial Number	FCC ID
	EUT Was Self Supporting			

6.0 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

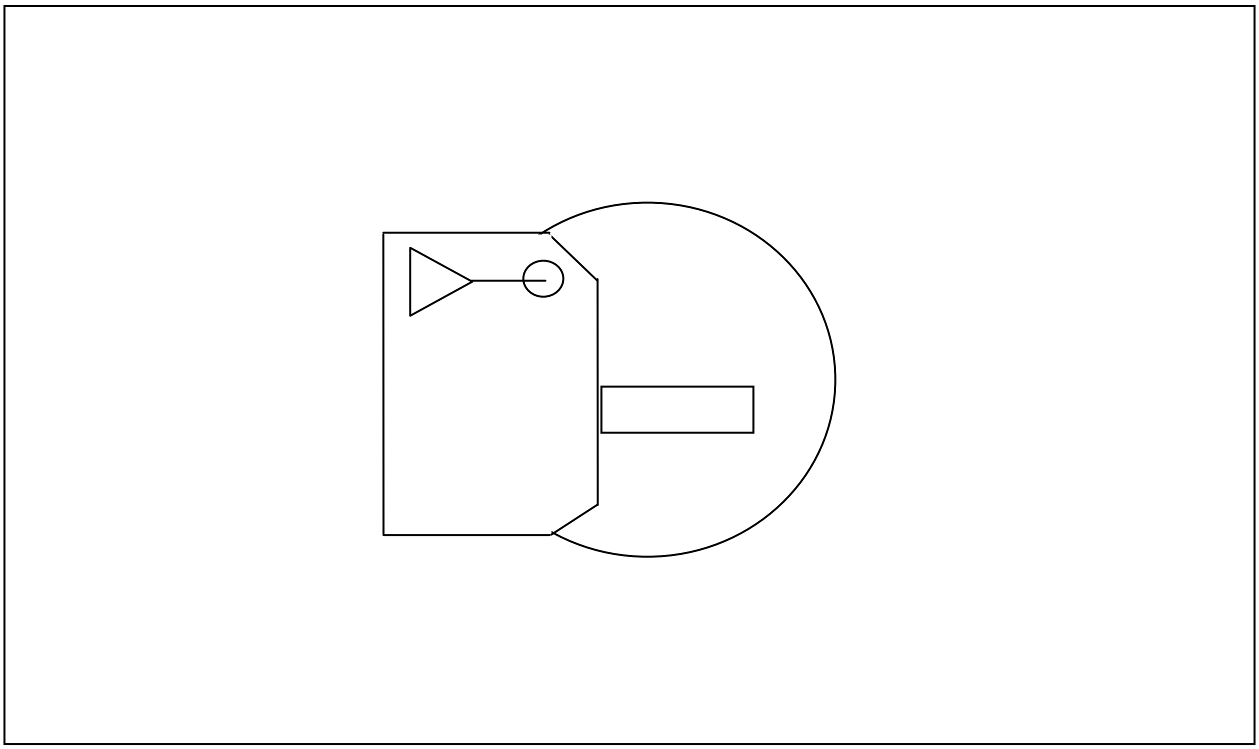

Figure 6-1: EUT Test Setup

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 antenna type is a monopole (Neptune Technology Group Inc. model 12641-001) which sealed inside the enclosure. The EUT is also professionally installed.

7.2 Power Line Conducted Emissions - FCC Section 15.207

The E-Coder R900 is battery powered therefore Power Line Conducted Emissions is not required.

7.3 Radiated Emissions - FCC Section 15.109(Unintentional Radiation)

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.

Results of the test are given in Table 7.3-1 below:

Table 7.3-1: Radiated Emissions Tabulated Data

Frequency (MHz)	Uncorrected Reading (dBµV/m)	Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (°)	Total Correction Factor (dB)	Corrected Reading (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Results
30.48	19.5	H	100	55	-5.2	14.3	40	25.7	**Pass**
267.2	31.1	V	110	147	-7.7	23.4	46	22.6	**Pass**
295.84	36	V	327	266	-7.1	28.9	46	17.1	**Pass**
305.44	22.9	V	192	80	-6.6	16.3	46	29.7	**Pass**
343.44	31.7	V	100	322	-5.2	26.5	46	19.5	**Pass**
591.2	23.7	H	250	173	-0.3	23.4	46	22.6	**Pass**
868.72	21.6	V	307	257	3.2	24.8	46	21.2	**Pass**
926	21.1	V	388	124	4.5	25.6	46	20.4	**Pass**
944.8	33.1	V	250	35	5	38.1	46	7.9	**Pass**

* Note: All emissions above 944.8 MHz were attenuated at least 20 dB below the permissible limit.

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

Antenna conducted measurements could not be performed on this device, therefore radiated tests were performed to show compliance with the peak output power limit specified in Section 15.247(b) according to FCC DA 00-705.

The procedures set forth in ANSI C63.4 were followed with respect to maximizing the peak emission.

The EUT was caused to generate a continuous carrier signal on the hopping channel. The resolution bandwidth of the spectrum analyzer was set 100 kHz which was slightly greater the 20 dB bandwidth measured in section 7.5.4. The video bandwidth was set to 300 kHz and a peak detector using the Max Hold function was utilized.

The power was calculated using the following equation:

$$P = {(E * d)^2} \big/ {30 * G}$$

Where: G = Numeric Gain of the transmitting antenna with reference to an isotropic radiator
d = The distance in meters from which the field strength was measured
E = The measured maximum fundamental field strength in V/m

Results are shown below in Table 7.4-1 and Figures 7.4-1 to 7.4-3.

Table 7.4-1: Peak Output Power

Channel	Frequency (MHz)	Numeric Gain	Distance (m)	Max. Fund. Field Strength (V/m)	Output Power (dBm)
Low	911.0815	1.58	3	0.381	16.11
Mid	915.2758	1.58	3	0.359	15.60
High	919.0779	1.58	3	0.356	15.53

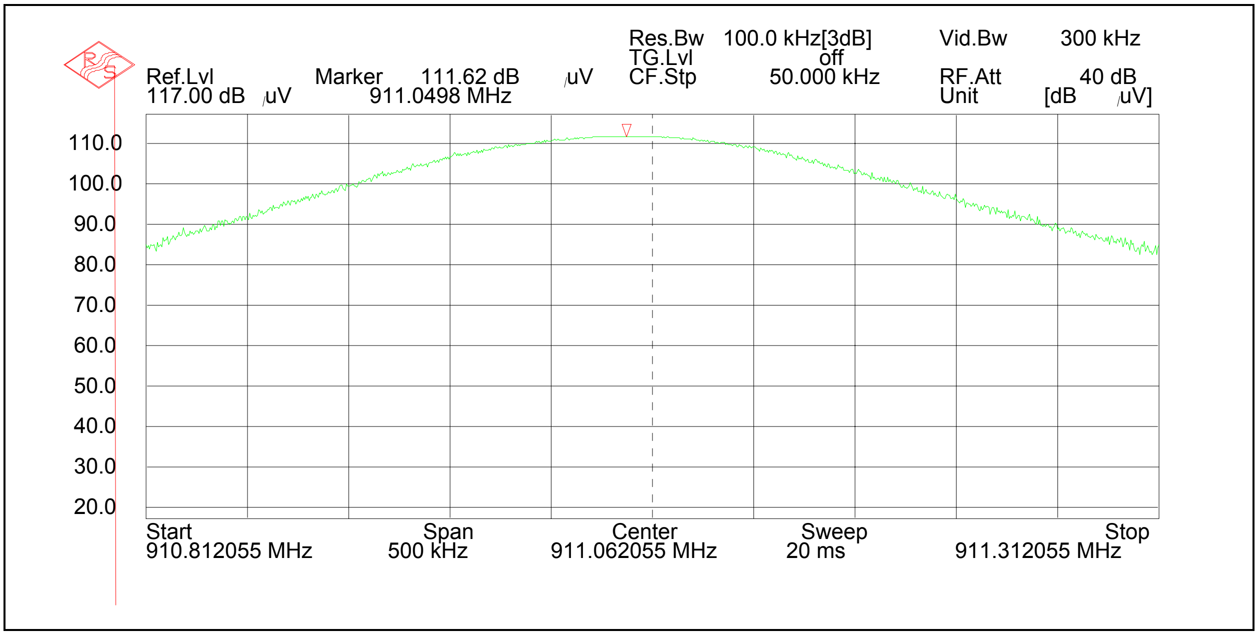

Figure 7.4-1: Output power – Low Channel

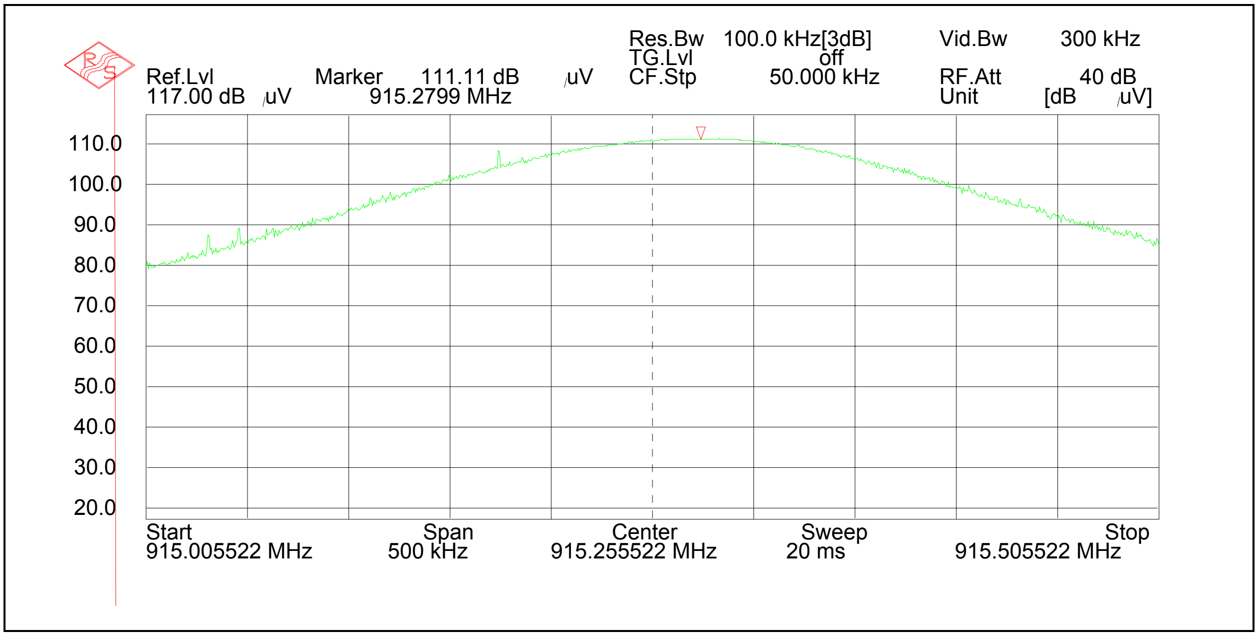

Figure 7.4-2: Output power – Mid Channel

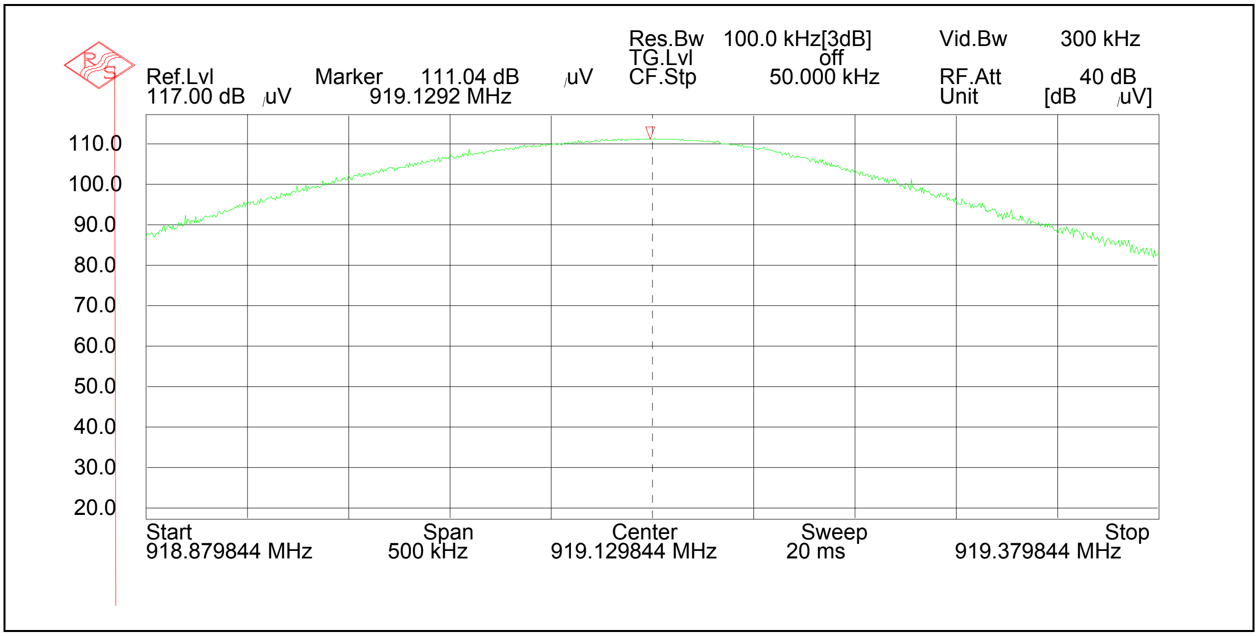

Figure 7.4-3: Output power – High Channel

7.5 Channel Usage Requirements - FCC Section 15.247(a) (1)

15.247(a)(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudorandomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

15.247(a) (1) (i): For frequency hopping systems operating in the 902–928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

7.5.1 Carrier Frequency Separation

The maximum 20dB bandwidth of the hopping channel was measured to be 92.8 kHz (See figure 7.5.4-1 to 7.5.4-3 below). The adjacent channel separation was measured to be 131.6 kHz. Results are shown in figure 7.5.1-1 below:

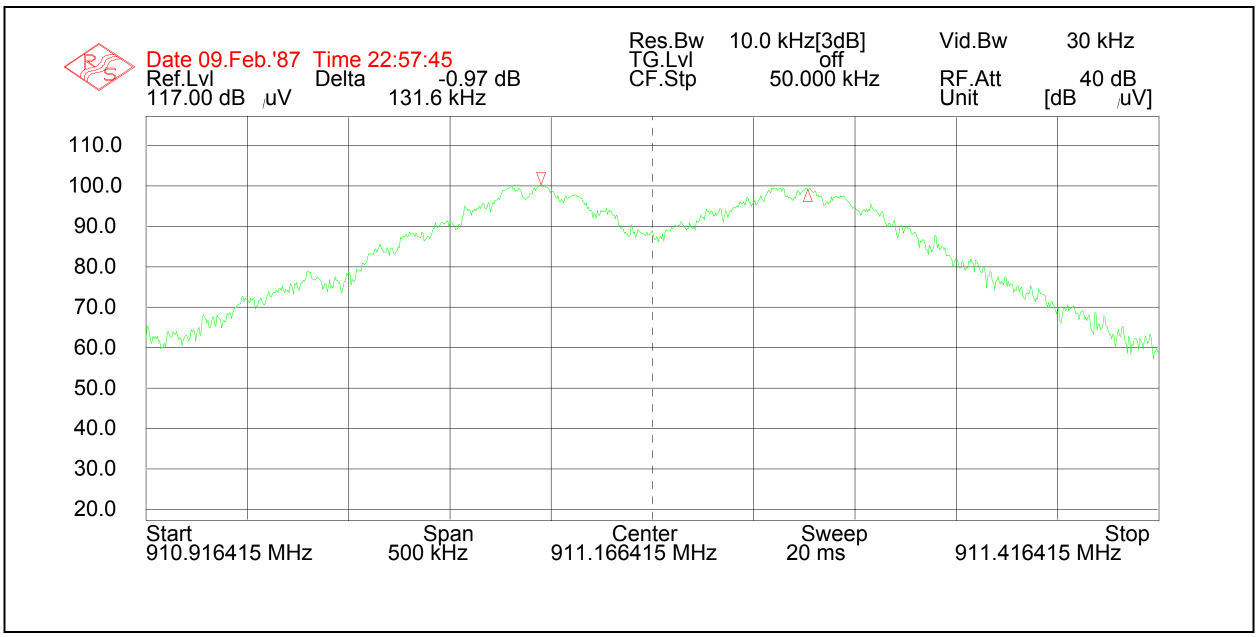

Figure 7.5.1-1: Carrier Frequency Separation

7.5.2 Number of Hopping Channels

The 20dB bandwidth of the device is less than 250 kHz. The device employs 50 hopping channels as required. Results are shown in table 7.5.2-1 and figure 7.5.2-1 below:

Table 7.5.2-1: Frequency Table

True Sequence	Frequency (MHz)
1	911.0815
2	915.9311
3	912.3922
4	917.2419
5	915.2758
6	918.5526
7	911.7368
8	916.5865
9	913.0476
10	917.8972
11	911.2125
12	916.12
13	912.5233
14	917.44
15	915.4068
16	918.6836
17	911.92
18	916.8
19	913.1786
20	918.0283
21	911.3436
22	916.1933
23	912.6543
24	917.504
25	915.5379
26	918.8147
27	911.999
28	916.8486
29	914.8826
30	918.1594
31	911.4747
32	916.3244
33	912.7854
34	917.6351
35	915.669
36	918.9458
37	912.13
38	916.9797
39	915.0136
40	918.2904
41	911.6058
42	916.4554
43	912.9165
44	917.7661
45	915.8001
46	919.0769
47	912.2611
48	917.1108
49	915.1447
50	918.4215

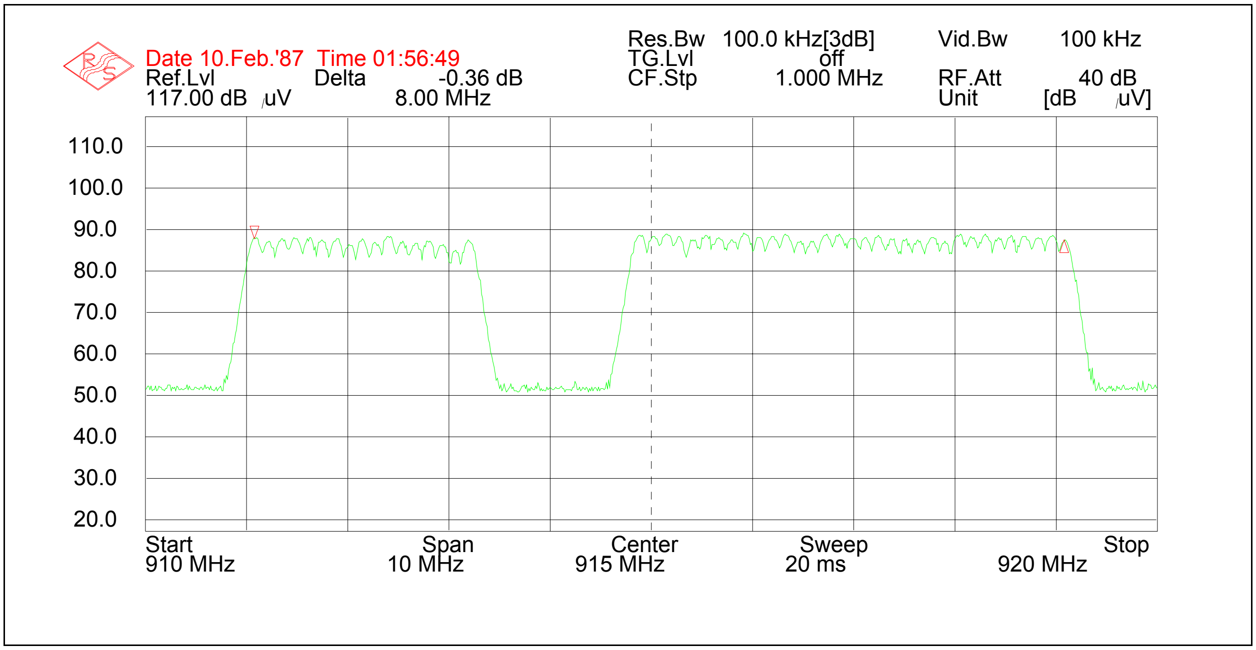

Figure 7.5.2-1: Number of Hopping Channels

7.5.3 Channel Dwell Time

The duration of the RF transmission is 7.05 ms. There is a minimum 10 second rest period in which the device hops to another channel according to the pseudorandom frequency table before transmitting another 7.05mS burst. Therefore the average time of occupancy on any channel in a 20 second period is 7.05mS. A single transmission is shown in figure 7.5.3-1 below:

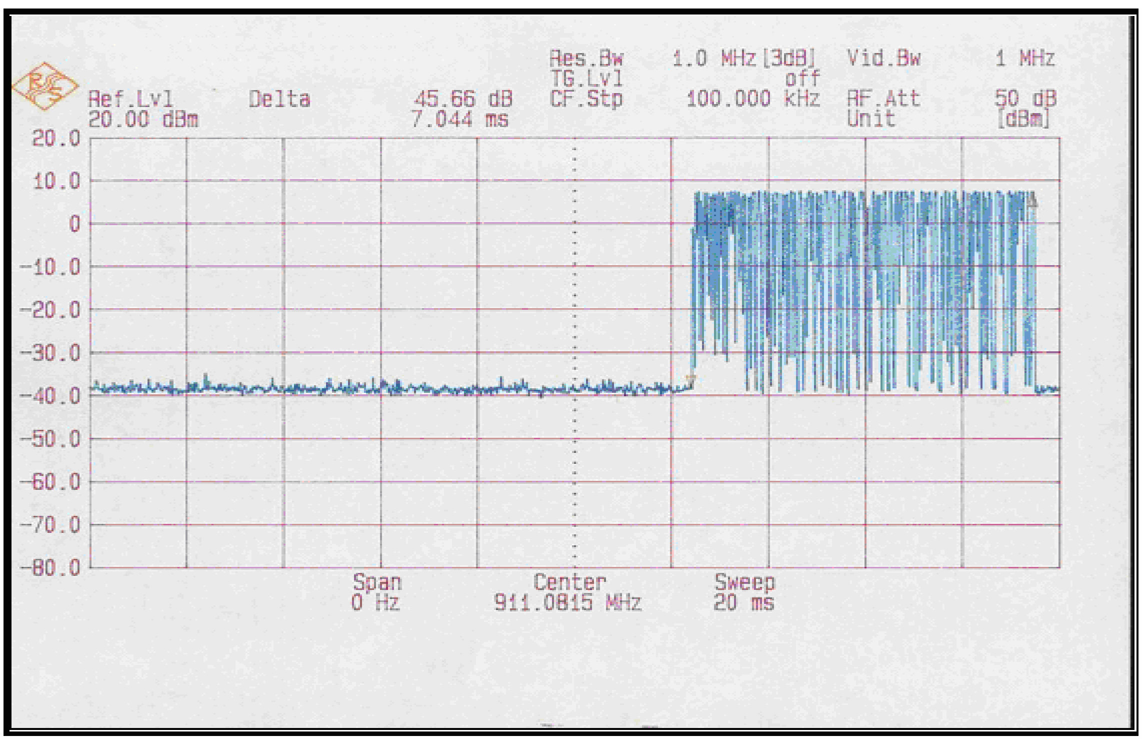

Figure 7.5.3-1: Channel Dwell Time

7.5.4 20dB Bandwidth

The maximum 20dB bandwidth was found to be approximately 92.8 kHz. Results are shown below in Figure 7.5.4-1 through 7.5.4-3.

Channel	Frequency	20dB Bandwidth
Low	911.0815	92.8 kHz
Mid	915.2758	89.7 kHz
High	919.0779	92.8 kHz

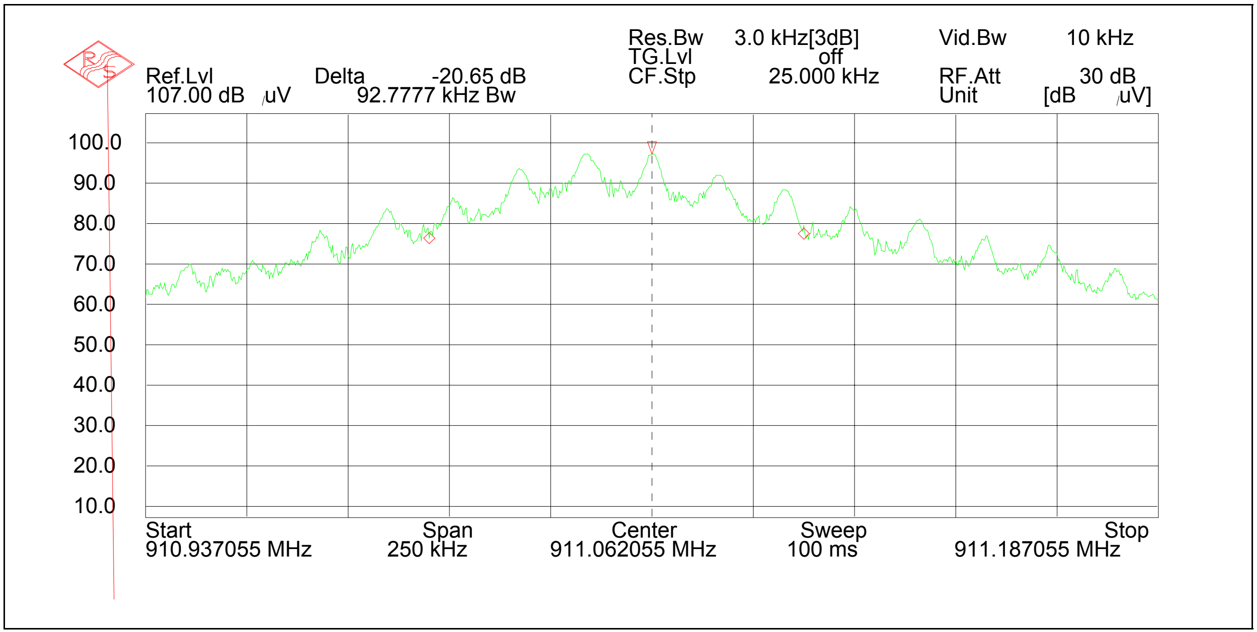

Figure 7.5.4-1: 20dB Bandwidth Low Channel

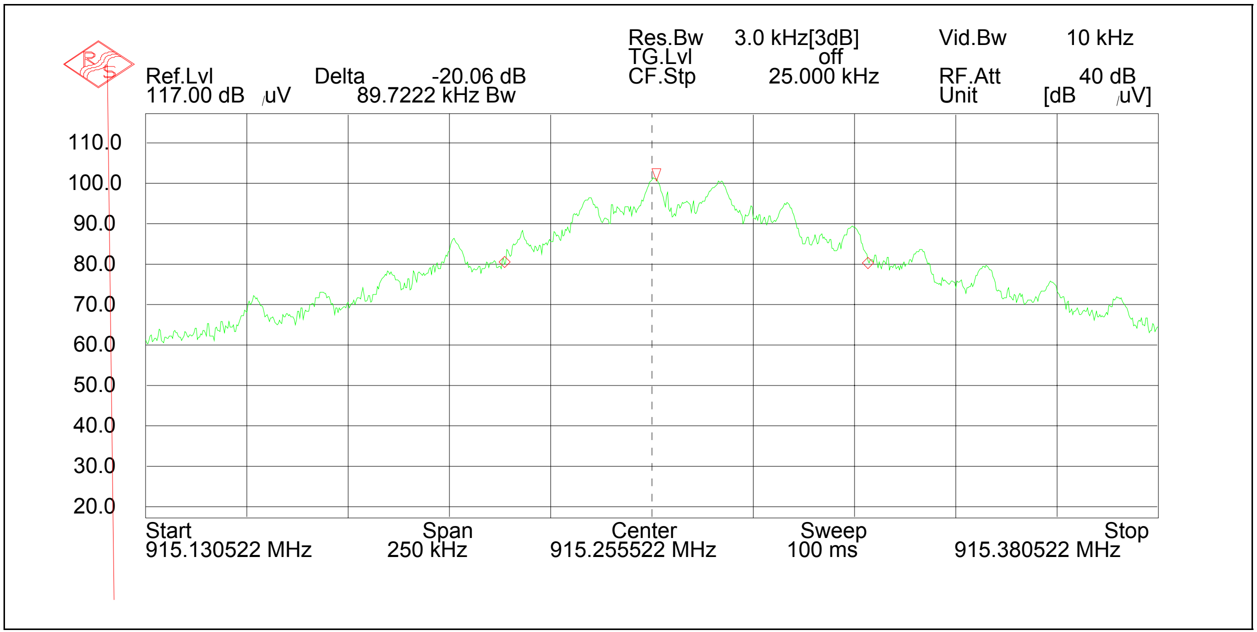

Figure 7.5.4-2: 20dB Bandwidth Mid Channel

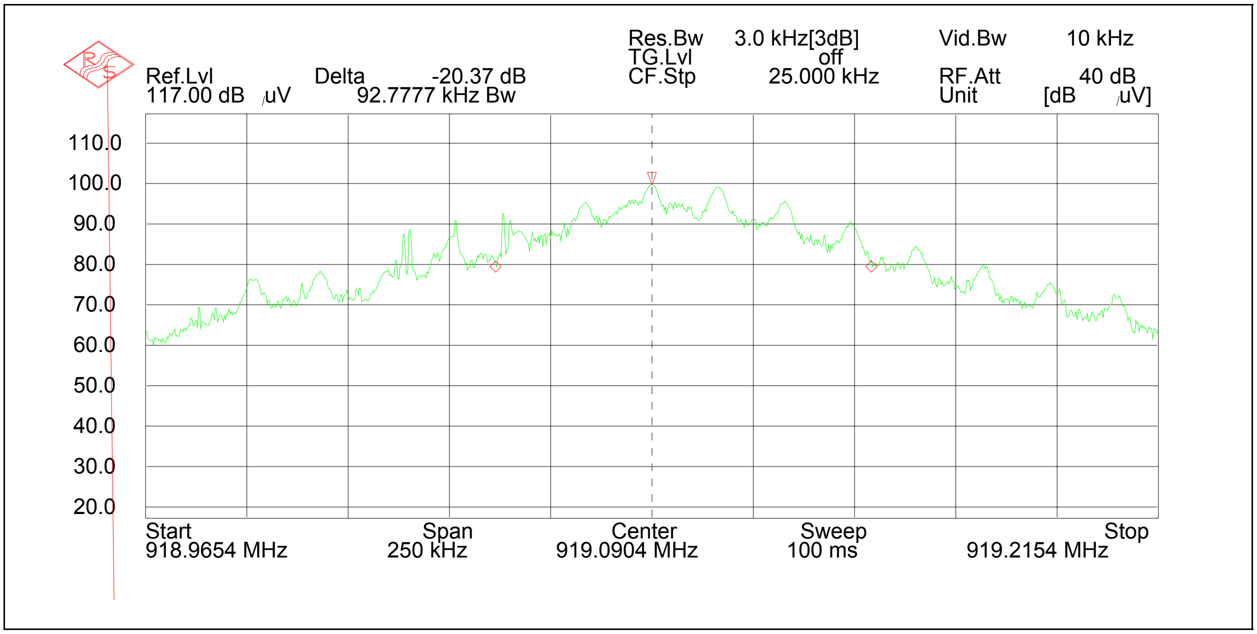

Figure 7.5.4-3: 20dB Bandwidth High Channel

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

7.6.1 Band-Edge Compliance of RF Conducted Emissions

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

7.6.1.1 Test Results

In a 100 kHz bandwidth at the lower and upper band-edge, the radio frequency power that was produced by the EUT is at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of desired power. Band-edge compliance is displayed in Figures 7.6.1-1 and 7.6.2-2

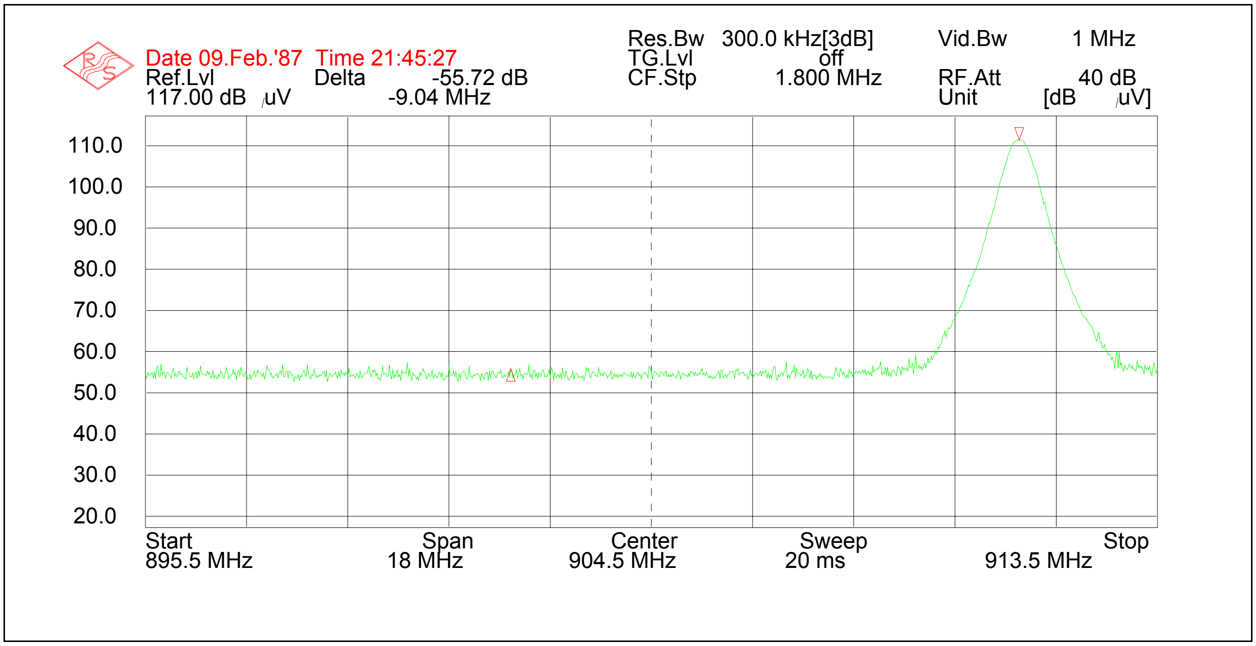

Figure 7.6.1-1: Lower Band-edge

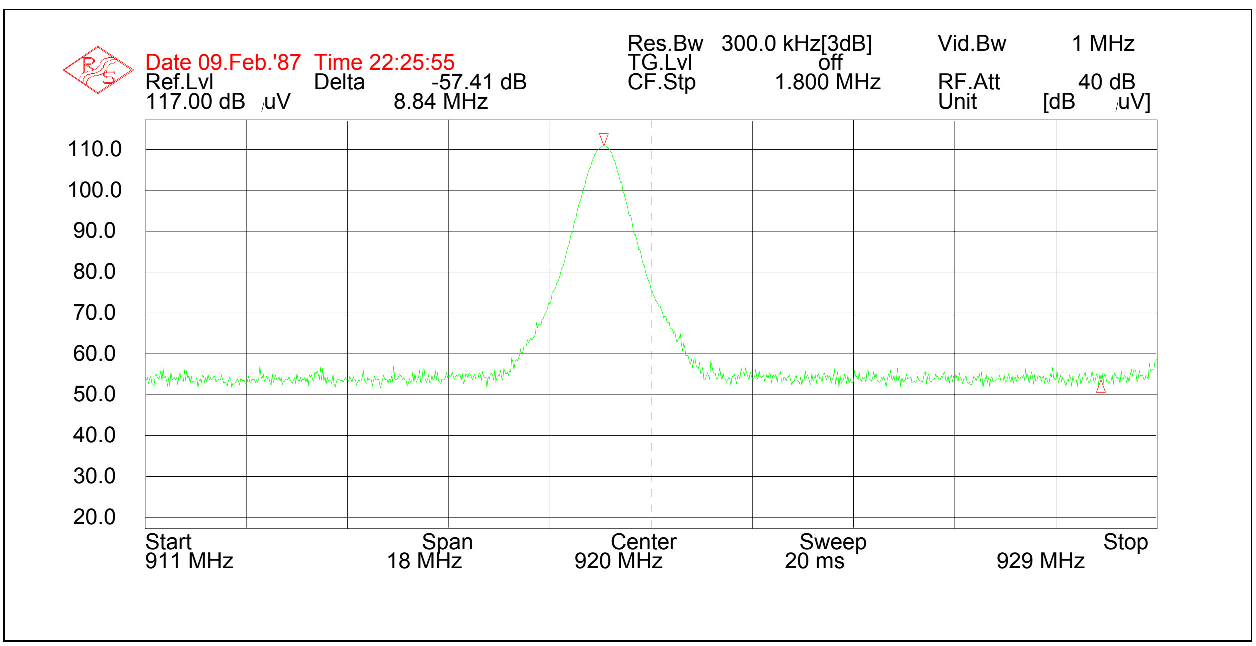

Figure 7.6.1-2: Upper Band-edge

7.6.2 RF Conducted Spurious Emissions

The EUT was investigated for conducted spurious emissions from 30MHz to 10GHz, 10 times the highest fundamental frequency.

Antenna conducted measurements could not be performed on this device, therefore radiated tests were performed to show compliance with the spurious RF conducted limit specified in Section 15.247(c) according to FCC DA 00-705.

For each measurement, the spectrum analyzer's RBW was set to 100 kHz and the VBW was set to 300 kHz. The peak detector and Max Hold function of the analyzer were utilized. The field strength of both the fundamental emission and all spurious emissions were measured with these settings. Procedures in C63.4-1992 with respect to maximizing the emissions were followed. The measured field strength of all spurious emissions must be below the measured field strength of the fundamental emission by the amount specified in Section 15.247(c).

7.6.2.1 Test Results

The magnitude of all emissions are reported in section 7.6.3 with the appropriate limit as referenced to 20 dB below the fundamental frequency field strength. Emissions that fell within the restricted bands were referenced to the radiated emissions limit set forth in Section 15.209 which is more stringent than that called out in 15.247(c).

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

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, average measurements were made using an RBW of 1 MHz and a VBW of 10 Hz and peak measurements were made with RBW of 1 MHz and a VBW of 1 MHz. For those frequencies that fell outside the restricted bands as defined in 15.205, the alternative procedure set forth in FCC DA 00-0705 for conducted spurious emissions was followed using a RBW of 100 kHz and VBW of 300 kHz.

The EUT was caused to generate a continuous carrier signal on the hopping channel.

7.6.3.1 Duty Cycle Correction

For average radiated measurements, the measured level was reduced by a factor 23dB to account for the duty cycle of the EUT. The EUT transmits for 7.05mS on a channel followed by a minimum 10 second rest period before hopping to the next channel. The EUT does not return to the same channel for over 500 seconds. Therefore the duty cycle is 7.05%. The duty cycle correction factor is determined using the formula: 20log (.0705)=-23dB.

7.6.3.2 Test Results

Radiated spurious emissions and conducted spurious emissions, using the alternative test procedures set forth in FCC DA 00-0705, found in the band of 30MHz to 10GHz are reported in Table 7.6.3-1 to 7.6.3-3. 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. Those spurious emissions outside the restricted bands were compared to the limits of 15.247(c), 20 dB below the fundamental frequency field strength.

Table 7.6.3-1: Radiated Spurious Emissions – Low Channel

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Fundamental Field Strength								
911.0815	111.39	v	120	334	4.90	116.29		
Spurious Emissions								
1.822	74.41	p	V	90	-2.79	71.62	96.29	24.67
2.733	70.25	p	H	45	2.37	72.62	74.00	1.38
2.733	62.55	a	H	45	-20.63	41.92	54.00	12.08
3.644	64.35	p	H	35	6.09	70.44	74.00	3.56
3.644	45.05	a	H	35	-16.91	28.14	54.00	25.86
4.555	49.5	p	H	90	8.11	57.61	74.00	16.39
4.555	40.18	a	H	90	-14.89	25.29	54.00	28.71
5.466	50.67	p	V	180	11.86	62.53	96.29	33.76
6.378	42.72	p	V	35	13.81	56.53	96.29	39.76
7.289	46.4	p	H	25	14.49	60.89	74.00	13.11
7.289	30.96	a	H	25	-8.51	22.45	54.00	31.55

Table 7.6.3-2: Radiated Spurious Emissions – Mid Channel

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Fundamental Field Strength								
915.2758	111.11	v	120	64	5.12	116.23		
Spurious Emissions								
1.831	72.10	p	v	350	-2.74	69.36	96.23	26.87
2.746	71.54	p	v	45	2.44	73.98	74.00	0.02
2.746	62.58	a	v	45	-20.56	42.02	54.00	11.98
3.661	65.37	p	h	180	6.17	71.54	74.00	2.46
3.661	46.71	a	h	180	-16.83	29.88	54.00	24.12
4.576	52.93	p	h	25	8.21	61.14	74.00	12.86
4.576	42.72	a	h	25	-14.79	27.93	54.00	26.07
5.492	50.95	p	h	0	11.96	62.91	96.23	33.32
6.407	40.38	p	h	135	13.83	54.21	96.23	42.02
7.322	46.38	p	h	315	14.38	60.76	74.00	13.24
7.322	34.19	a	h	315	-8.62	25.57	54.00	28.43

Table 7.6.3-3: Radiated Spurious Emissions – High Channel

Frequency (MHz)	Level (dBuV/m)	Detector (P/A)	Antenna Polarity (H/V)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
Fundamental Field Strength								
919.0779	111.04	v	120	375	5.32	116.36		
Spurious Emissions								
1.838	73.52	p	h	170.00	-2.70	70.82	96.36	3.18
2.757	71.06	p	h	35	2.50	73.56	74.00	0.44
2.757	63.34	a	h	35	-20.50	42.84	54.00	11.16
3.676	64.68	p	h	15	6.23	70.91	74.00	3.09
3.676	45.87	a	h	15	-16.77	29.10	54.00	24.90
4.595	52.27	p	h	20	8.29	60.56	74.00	13.44
4.595	41.88	a	h	20	-14.71	27.17	54.00	26.83
5.514	54.63	p	h	35	12.04	66.67	96.36	7.33
6.434	41.91	p	v	180	13.84	55.75	96.36	18.25
7.353	46.32	p	h	160	14.28	60.60	74.00	13.40
7.353	33.68	a	h	160	-8.72	24.96	54.00	29.04

7.6.3.3 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: 70.25 + 2.37 = 72.62 dBuV
Margin: 74dBuV – 72.62 dBuV = 1.38 dB

Example Calculation: Average

Corrected Level: 62.55 + 2.37-23 = 41.92 dBuV
Margin: 54dBuV – 41.92 dBuV = 12.08 dB

8.0 CONCLUSION
In the opinion of ACS, Inc. the E-Coder R900, manufactured by Neptune Technology Group, Inc., meets the requirements of FCC Part 15 subpart C.