Nebraska Center for Excellence in Electronics
4740 Discovery Drive
Lincoln, NE 68521
Phone: 402.323.6233
Fax: 402.323.6238

Amended Radio Test Report

Client: **Johnson Outdoors**
1531 Madison Ave.
Mankato, MN 56001

Product: **Ulterra with i-Pilot Standard System**
902-928 MHz band Main and Trim Boards

FCC ID: **T62-ULTERRAIP15**
IC: **4397A-ULTERRAIP15**

Test Report No: **R20131014-21-14A**

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **9 December 2014**

Total Pages: **47**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

1.0 Summary of test results

The EUT has been tested according to the following specifications:

APPLIED STANDARDS: FCC Part 15, Subpart C Industry Canada RSS-Gen, RSS-210 Issue 7 AS/NZS 4268:2008			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
15.203 RSS-Gen Issue 4	Unique Antenna Requirement	Pass	Permanently attached antenna
15.207 RSS-Gen Issue 4	Conducted Emissions	NA	No connection to AC mains network
15.209 RSS-Gen Issue 4	Radiated Emissions	Pass	Meets the requirement of the limit.
15.249 RSS-210 Issue 8	Transmitter Radiated Emissions, Limit: Table 15.209	Pass	Meets the requirement of the limit.

1.1 Reason for amendment: frequency range was corrected and all references to 15.247 were deleted. The bandwidth measurements reported for the main board were corrected to match the plots.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was an Ulterra trolling motor with i-Pilot Standard system controller pre-installed, which operates from 2452 to 2462 MHz. This radio is intended to communicate with an external remote, which has been tested separately.

The EUT included 2 additional transceivers on the main board and on the trim board which operate between 915 and 921 MHz. These radios communicate only between one another. This report is specific to these radios.

EUT Received Date: 10 March 2014
EUT Tested Dates: 10 March 2014 – 16 September 2014

PRODUCT	Ulterra with i-Pilot Standard system
POWER SUPPLY	24 VDC from battery
MODULATION TYPE	FM
RADIO TECHNOLOGY	Half-duplex RF Link
ANTENNA TYPE	Internal Dipole

NOTE:
1. For more detailed features description, please refer to the manufacturer's specifications or User's Manual.

2.2 Laboratory description

All testing was performed at the NCEE Lincoln facility. Laboratory environmental conditions varied slightly throughout the tests:

Relative humidity of 26 ± 4%
Temperature of 23 ± 3° Celsius

2.3 Description of test modes

The EUT operates on, and was tested at the frequencies below:

Main Board:

Channel	Frequency
1	915
2	918
3	921

These are the only three frequencies possible Main Board.

Trim Board:

Channel	Frequency
1	915
2	918
3	921

These are the only three frequencies possible Trim Board

2.4 Applied standards

The EUT uses digital modulation and operates between 2400.0MHz and 2483.5MHz. It has no provisions for connection to the AC mains connection. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

FCC Part 15, Subpart C (15.249)
FCC Part 15, Subpart C (15.209)
Industry Canada RSS-GEN Issue 4
Industry Canada RSS-210 Issue 8
ANSI C63.10:2013

All test items have been performed and recorded as per the above.

2.5 Description of support units

None

2.6 Configuration of system under test

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on Channel 1, 2 or 3.

3.0 Test equipment used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE
Rohde & Schwarz Test Receiver	ES126	100037	21 Jan 2014
EMCO Biconilog Antenna*	3142B	1654	13 Jan 2014
EMCO Horn Antenna**	3115	6416	14 Jan 2014
EMCO Horn Antenna***	3116	2576	31 Mar 2014
Rohde & Schwarz Preamp*	TS-PR18	NCEEPAHF20	26 Mar 2014****
Trilithic High Pass Filter*	6HC330	23042	26 Mar 2014****

*Used for radiated measurements above 3GHz
**Used for measurements above 6GHz
***Used for measurements above 18GHz
****Internal Characterization

4.0 Detailed results

4.1 Unique antenna requirement

4.1.1 Standard applicable

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

4.1.2 Antenna description

The antennas are permanently attached and internal to the EUT and not replaceable.

4.2 Radiated emissions

4.2.1 Limits for radiated emissions measurements

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (μV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

NOTE:

1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (μV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

4.2.2 Test procedures

a. The EUT was placed on the top of a rotating table 0.8 meters above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. The EUT was measured in both the horizontal and vertical orientation. It was found that the vertical position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

Table 1 – Correction Factor Applied in Sections 4.3, 4.4 and 4.6

CHANNEL	CHANNEL FREQUENCY (MHz)	ANTENNA FACTOR	CABLE LOSS
1	915	23.70	4.50
2	918	23.70	4.50
3	921	23.70	4.50

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, The video bandwidth was 1MHz for peak measurements and 10Hz for average measurements. A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

4.2.3 Deviations from test standard

No deviation.

4.2.4 Test setup

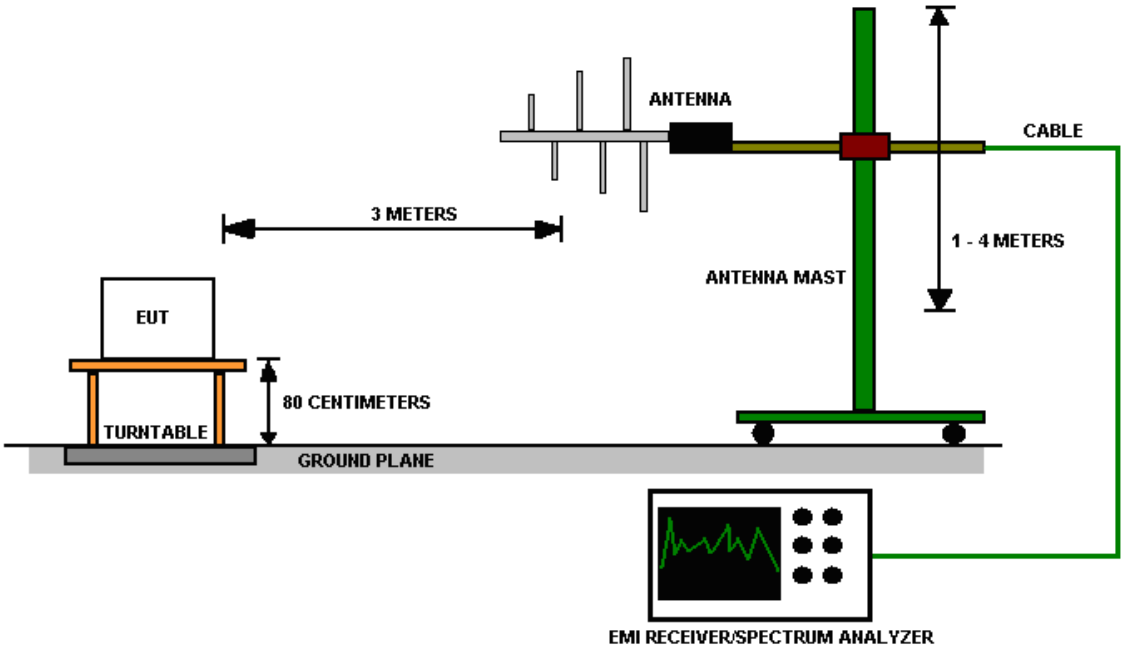

Figure 1 - Radiated Emissions Test Setup

For the actual test configuration, please refer to Appendix A for photographs of the test configuration.

4.2.5 EUT operating conditions

The EUT was powered by 24 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

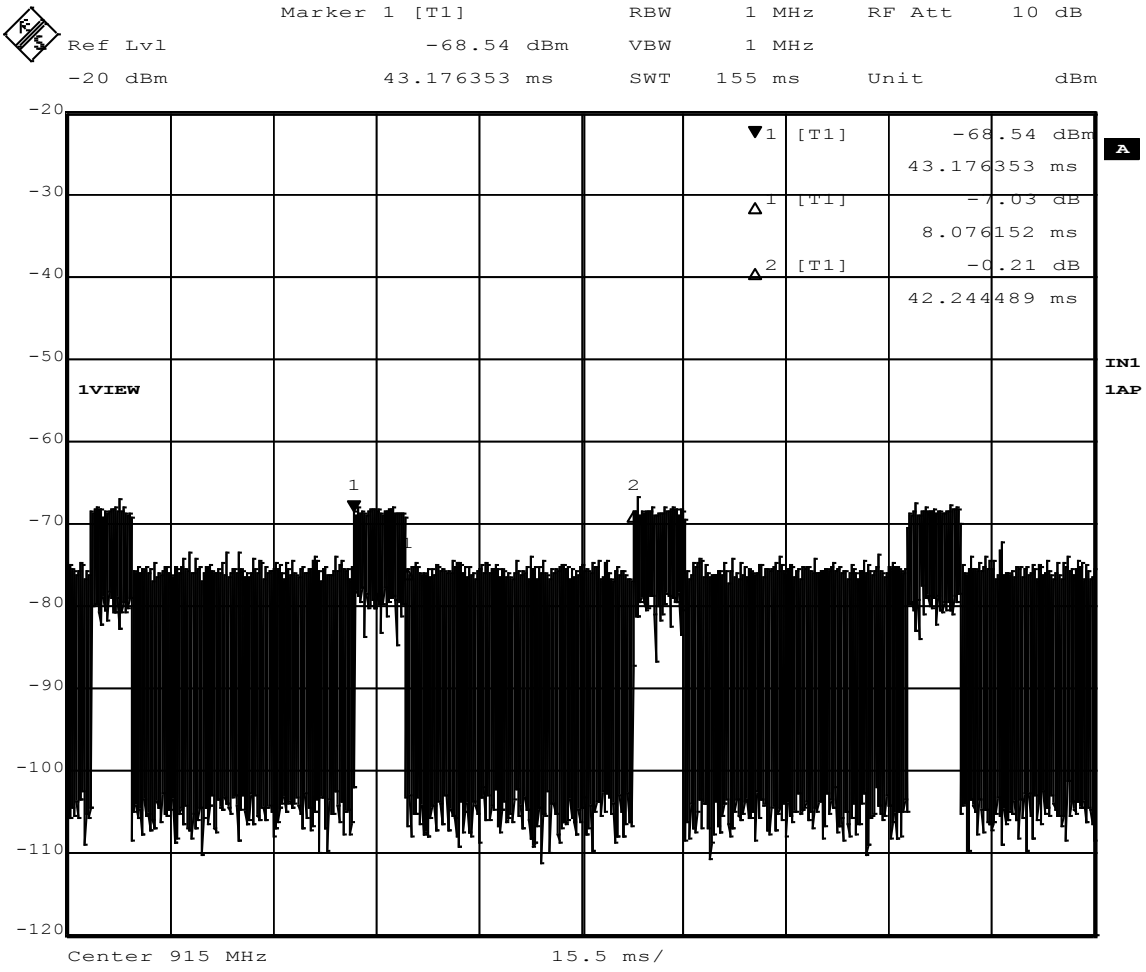

Figure 2 – Duty Cycle, Main Board

20 log (8.08 mS / 42.24 mS) = -14.36 dB

Note: Correction for peak to average measurement = -14.36 dB

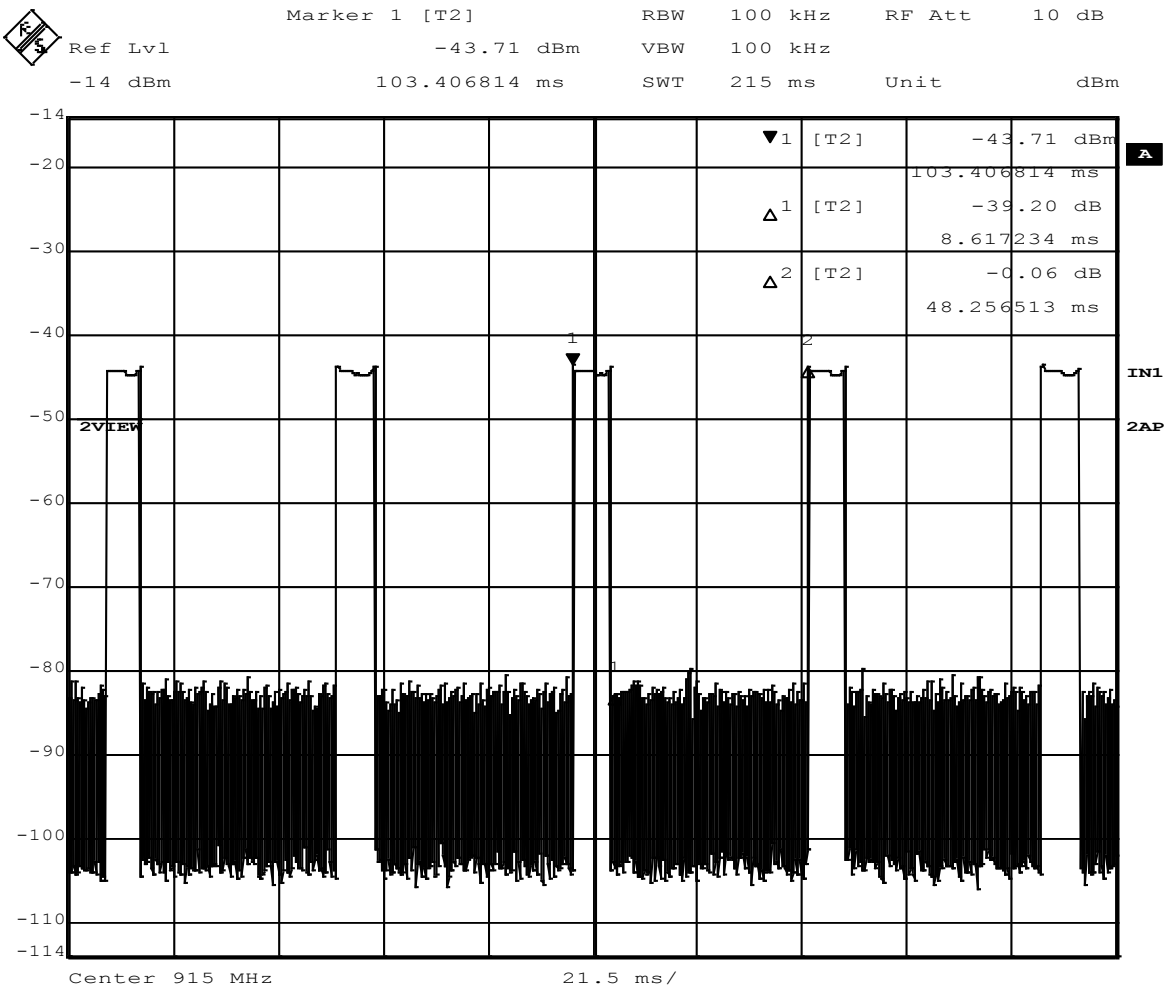

Figure 3 – Duty Cycle, Trim Board,
20 log (8.61 mS / 48.26 mS) = -14.97 dB
Note: Correction for peak to average measurement = -14.97 dB

4.2.6 Test results

EUT MODULE	Main Board	MODE	Receive
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

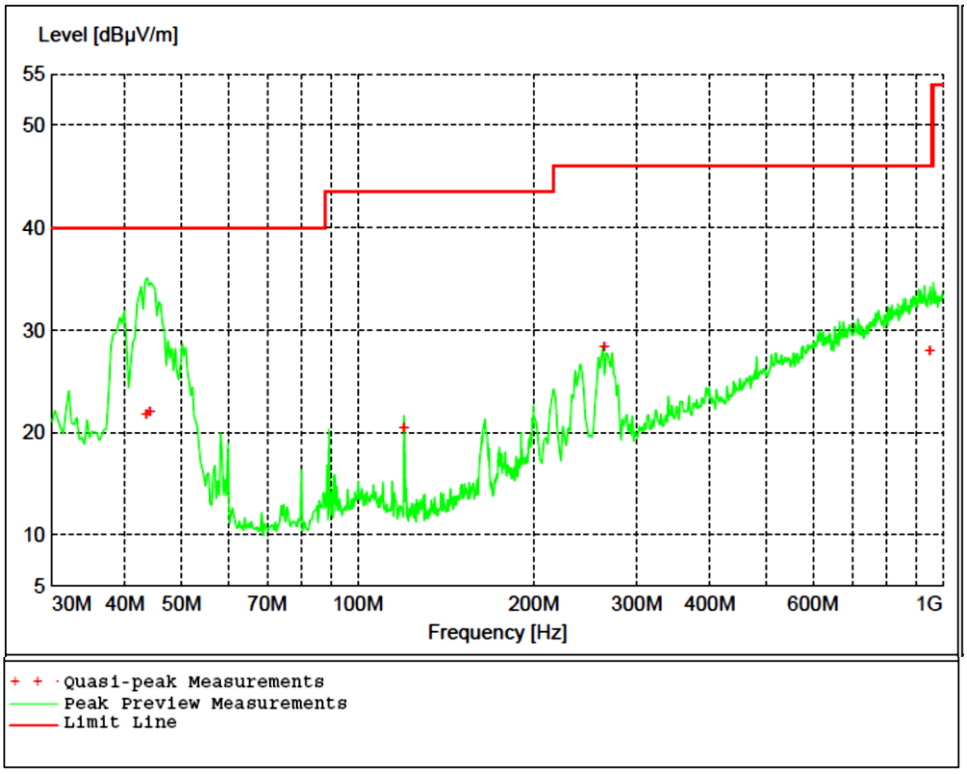

Figure 4 - Radiated Emissions Plot, Receive

Table 2 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.500000	21.80	40.00	18.20	99	53	VERT
44.100000	21.97	40.00	18.00	98	202	VERT
120.000000	20.42	43.50	23.10	101	283	VERT
263.880000	28.38	46.00	17.60	99	258	HORI
951.540000	27.94	46.00	18.10	228	312	HORI

Table 3 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1842.600000	35.80	74.00	38.20	267	99	VERT
2762.400000	38.71	74.00	35.29	217	0	HORI
3682.000000	48.27	74.00	25.73	100	241	HORI
4592.200000	45.12	74.00	28.88	381	184	VERT
5519.000000	49.13	74.00	24.87	224	33	VERT

Table 4 - Radiated Emissions Average Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1842.600000	21.43	54.00	32.57	267	99	VERT
2762.400000	24.34	54.00	29.66	217	0	HORI
3682.000000	33.90	54.00	20.10	100	241	HORI
4592.200000	30.75	54.00	23.25	381	184	VERT
5519.000000	34.76	54.00	19.24	224	33	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Main Board	MODE	Transmit, Ch 1 915 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

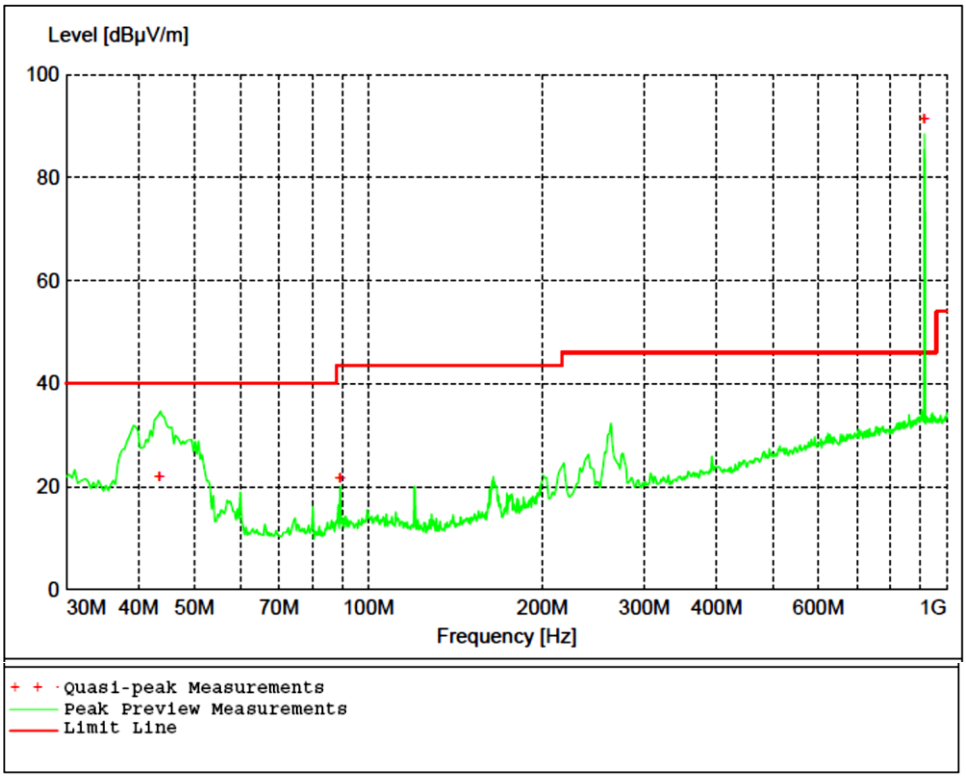

Figure 5 - Radiated Emissions Plot, Channel 1

Table 5 - Radiated Emissions Quasi-peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.500000	21.98	40.00	18.00	100	97	VERT
89.280000	21.66	43.50	21.90	264	72	HORI
915.000000	91.31*	93.98	2.67	122	289	VERT

*Peak measurement

Table 6 - Radiated Emissions Peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1830.000000	54.28	74.00	19.72	130	253	VERT
2745.000000	62.42	74.00	11.58	106	298	VERT
3659.800000	63.20	74.00	10.80	133	297	VERT
4574.800000	56.89	74.00	17.11	109	148	VERT
5489.800000	64.69	74.00	9.31	206	219	VERT
6412.200000	50.43	74.00	23.57	278	69	HORI
7332.400000	48.28	74.00	25.72	308	118	VERT
8220.800000	48.52	74.00	25.48	358	0	HORI
9174.400000	50.46	74.00	23.54	136	357	VERT

Table 7 - Radiated Emissions Average Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1830.000000	39.91	54.00	14.09	130	253	VERT
2745.000000	48.05	54.00	5.95	106	298	VERT
3659.800000	48.83	54.00	5.17	133	297	VERT
4574.800000	42.52	54.00	11.48	109	148	VERT
5489.800000	50.32	54.00	3.68	206	219	VERT
6412.200000	36.06	54.00	17.94	278	69	HORI
7332.400000	33.91	54.00	20.09	308	118	VERT
8220.800000	34.15	54.00	19.85	358	0	HORI
9174.400000	36.09	54.00	17.91	136	357	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Main Board	MODE	Transmit, Ch 2 918 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

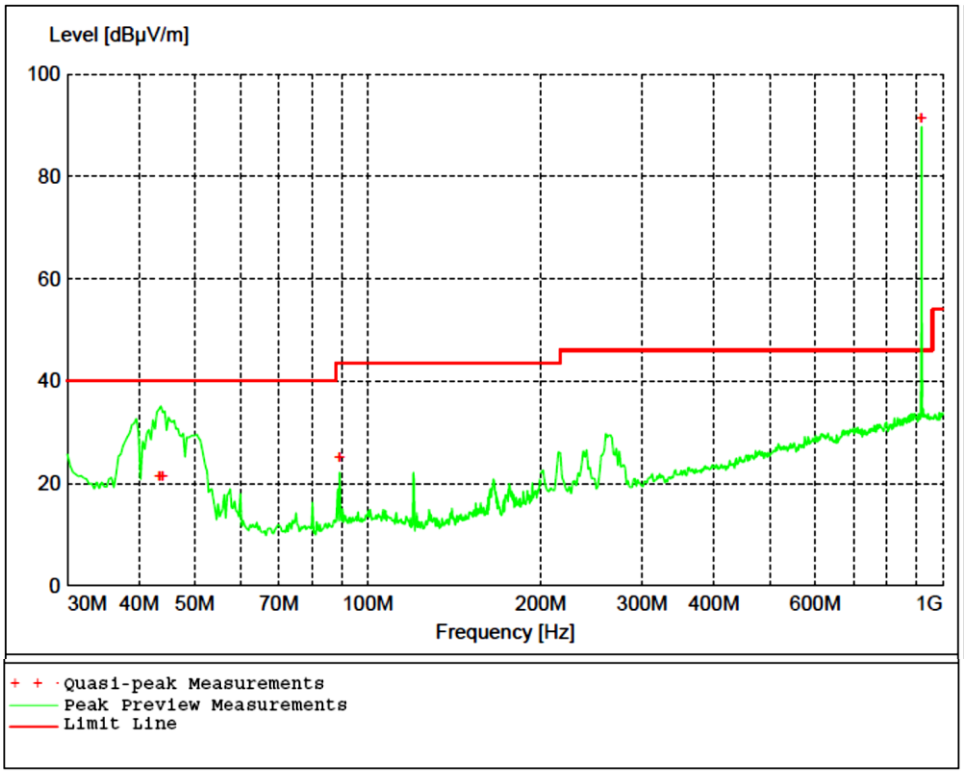

Figure 6 - Radiated Emissions Plot, Channel 2

Table 8 - Radiated Emissions Quasi-peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.380000	21.42	40.00	18.60	101	109	VERT
43.980000	21.41	40.00	18.60	99	106	VERT
89.340000	25.17	43.50	18.40	257	120	HORI
918.000000	91.45*	93.98	2.53	127	287	VERT

*Peak measurement

Table 9 - Radiated Emissions Peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1836.000000	55.10	74.00	18.90	176	263	VERT
2754.000000	62.07	74.00	11.93	140	288	VERT
3671.800000	63.44	74.00	10.56	99	244	HORI
4589.800000	55.65	74.00	18.35	130	157	VERT
5508.000000	64.59	74.00	9.41	217	224	VERT
6410.600000	50.17	74.00	23.83	399	8	VERT
7357.400000	48.67	74.00	25.33	233	50	VERT
8245.600000	48.25	74.00	25.75	206	34	HORI
9225.200000	50.95	74.00	23.05	99	221	VERT

Table 10 - Radiated Emissions Average Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1836.000000	40.73	54.00	13.27	176	263	VERT
2754.000000	47.70	54.00	6.30	140	288	VERT
3671.800000	49.07	54.00	4.93	99	244	HORI
4589.800000	41.28	54.00	12.72	130	157	VERT
5508.000000	50.22	54.00	3.78	217	224	VERT
6410.600000	35.80	54.00	18.20	399	8	VERT
7357.400000	34.30	54.00	19.70	233	50	VERT
8245.600000	33.88	54.00	20.12	206	34	HORI
9225.200000	36.58	54.00	17.42	99	221	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Main Board	MODE	Transmit, Ch 3 921 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

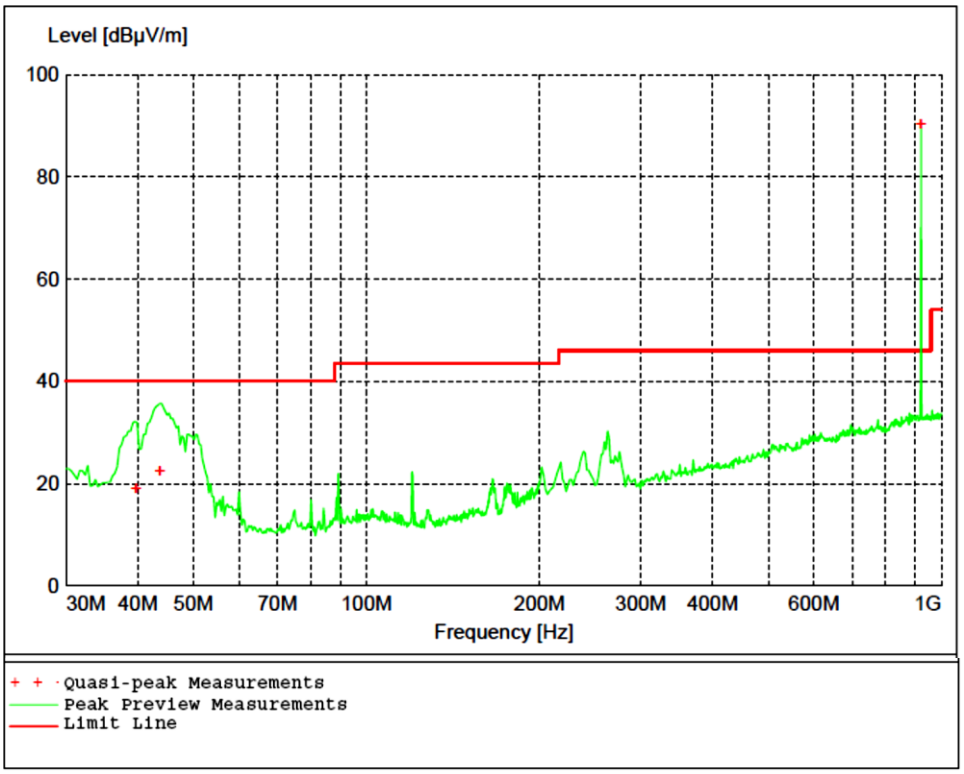

Figure 7 - Radiated Emissions Plot, Channel 3

Table 11 - Radiated Emissions Quasi-peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
39.720000	18.90	40.00	21.10	101	280	VERT
43.680000	22.37	40.00	17.60	99	86	VERT
921.000000	90.42*	93.98	3.56	115	250	VERT

*Peak measurement

Table 12 - Radiated Emissions Peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1842.000000	55.66	74.00	18.34	223	263	VERT
2763.000000	62.49	74.00	11.51	99	297	VERT
3683.800000	62.06	74.00	11.94	99	299	VERT
4604.800000	53.17	74.00	20.83	197	244	HORI
5525.800000	62.52	74.00	11.48	193	244	VERT
6446.600000	53.69	74.00	20.31	150	151	VERT
7372.200000	49.02	74.00	24.98	102	339	HORI
8272.000000	48.40	74.00	25.60	139	47	HORI
9221.200000	50.38	74.00	23.62	366	321	HORI

Table 13 - Radiated Emissions Average Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1842.000000	41.29	54.00	12.71	223	263	VERT
2763.000000	48.12	54.00	5.88	99	297	VERT
3683.800000	47.69	54.00	6.31	99	299	VERT
4604.800000	38.80	54.00	15.20	197	244	HORI
5525.800000	48.15	54.00	5.85	193	244	VERT
6446.600000	39.32	54.00	14.68	150	151	VERT
7372.200000	34.65	54.00	19.35	102	339	HORI
8272.000000	34.03	54.00	19.97	139	47	HORI
9221.200000	36.01	54.00	17.99	366	321	HORI

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Trim Board	MODE	Receive
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

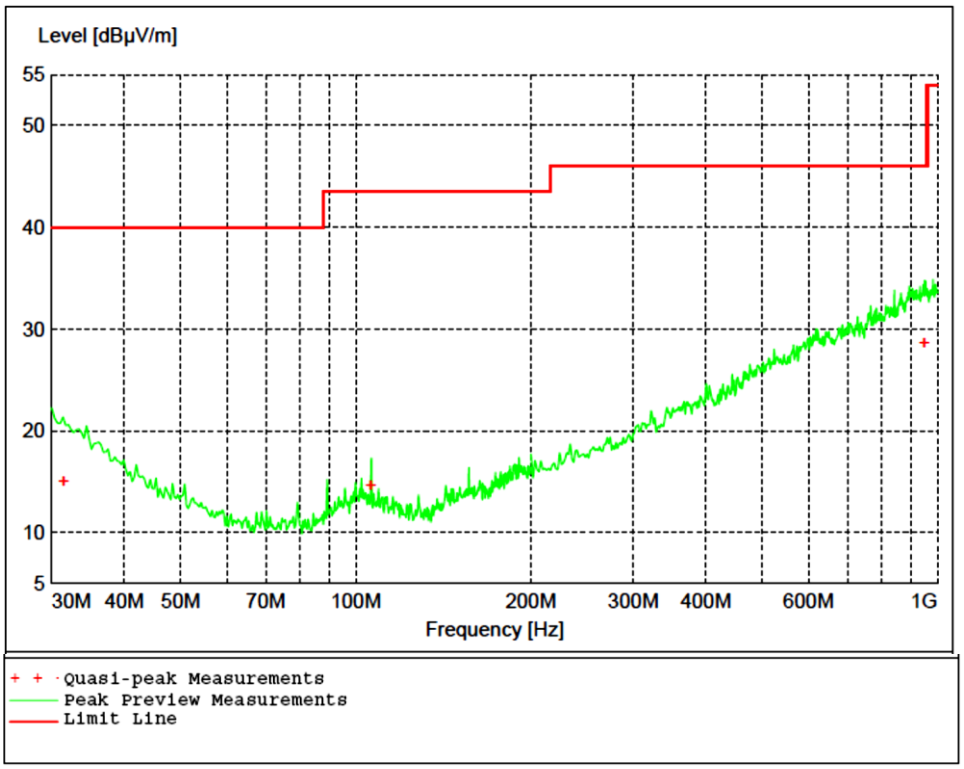

Figure 8 - Radiated Emissions Plot, Receive

Table 14 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
31.440000	15.04	40.00	25.00	254	185	VERT
106.260000	14.66	43.50	28.90	156	221	HORI
948.720000	28.57	46.00	17.40	130	160	HORI

Table 15 - Radiated Emissions Average Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1821.400000	20.54	54.00	33.46	288	327	VERT
2732.800000	24.05	54.00	29.95	100	181	HORI
3658.200000	34.20	54.00	19.80	100	6	VERT
4583.800000	29.17	54.00	24.83	278	147	VERT
5488.000000	33.22	54.00	20.78	274	127	VERT

Table 16 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1821.400000	35.51	74.00	38.49	288	327	VERT
2732.800000	39.02	74.00	34.98	100	181	HORI
3658.200000	49.17	74.00	24.83	100	6	VERT
4583.800000	44.14	74.00	29.86	278	147	VERT
5488.000000	48.19	74.00	25.81	274	127	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Trim Board	MODE	Transmit, Ch 1 915 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

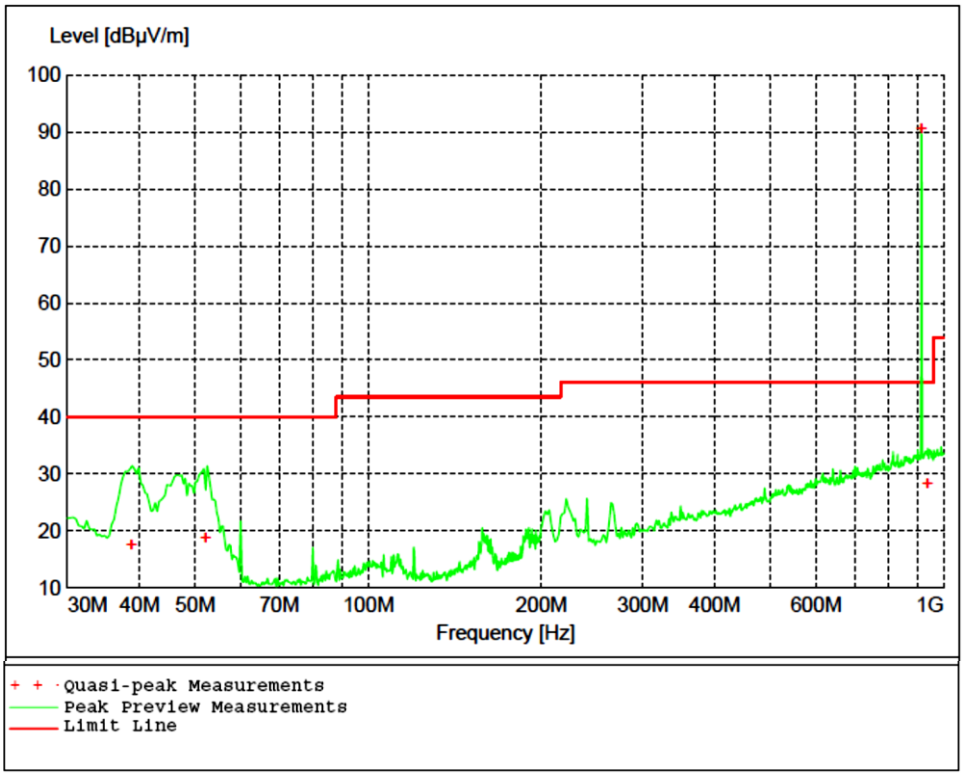

Figure 9 - Radiated Emissions Plot, Channel 1

Table 17 - Radiated Emissions Quasi-peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
38.760000	17.60	40.00	22.40	99	307	VERT
52.140000	18.59	40.00	21.40	100	341	VERT
915.000000	90.47*	93.98	3.51	123	333	VERT
938.220000	28.17	46.00	17.80	278	16	HORI

*Peak measurement

Table 18 - Radiated Emissions Average Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1830.000000	35.81	54.00	18.19	100	268	VERT
2750.000000	38.20	54.00	15.80	99	106	HORI
3659.800000	35.13	54.00	18.87	99	281	HORI
4574.800000	42.04	54.00	11.96	101	302	HORI
5490.200000	42.38	54.00	11.62	187	290	HORI
6404.800000	37.37	54.00	16.63	217	353	VERT
7313.200000	33.07	54.00	20.93	107	283	VERT
8224.400000	33.68	54.00	20.32	400	43	VERT
9158.600000	35.75	54.00	18.25	103	314	VERT

Table 19 - Radiated Emissions Peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1830.000000	50.78	74.00	23.22	100	268	VERT
2750.000000	53.17	74.00	20.83	99	106	HORI
3659.800000	50.10	74.00	23.90	99	281	HORI
4574.800000	57.01	74.00	16.99	101	302	HORI
5490.200000	57.35	74.00	16.65	187	290	HORI
6404.800000	52.34	74.00	21.66	217	353	VERT
7313.200000	48.04	74.00	25.96	107	283	VERT
8224.400000	48.65	74.00	25.35	400	43	VERT
9158.600000	50.72	74.00	23.28	103	314	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Trim Board	MODE	Transmit, Ch 2 918 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

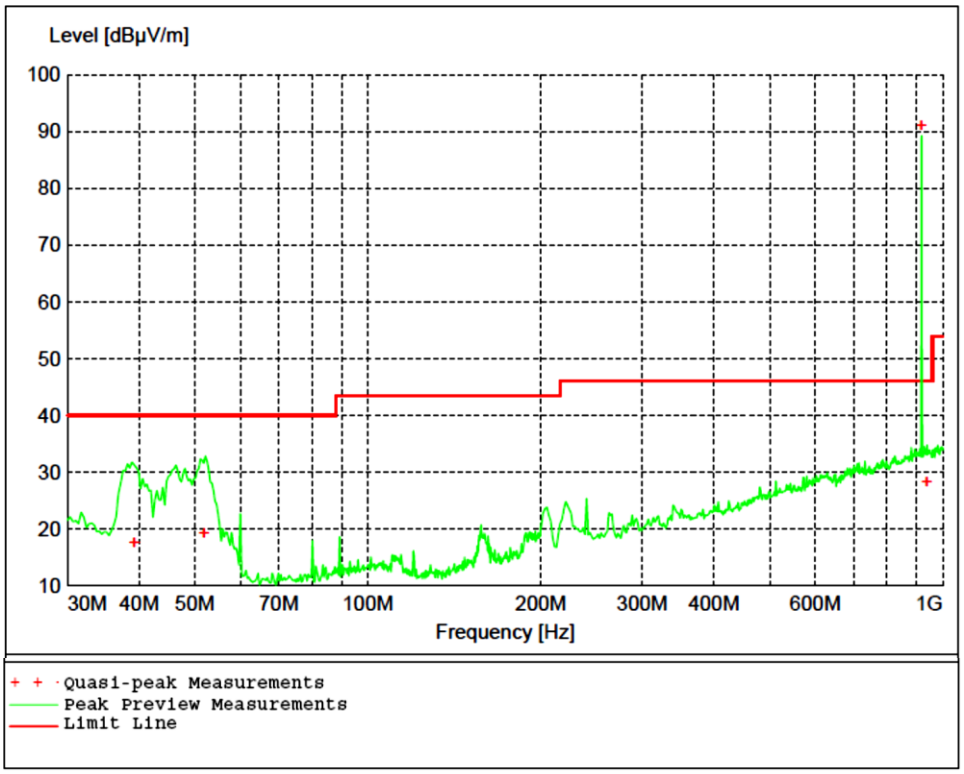

Figure 10 - Radiated Emissions Plot, Channel 2

Table 20 - Radiated Emissions Quasi-peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
39.240000	17.55	40.00	22.40	102	298	VERT
51.900000	19.14	40.00	20.90	100	319	VERT
918.000000	91.51*	93.98	2.47	119	333	VERT
938.640000	28.33	46.00	17.70	313	284	HORI

*Peak measurement

Table 21 - Radiated Emissions Average Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1847.500000	34.64	54.00	19.36	100	328	HORI
2754.500000	37.81	54.00	16.19	199	335	VERT
3672.200000	33.97	54.00	20.03	193	172	VERT
4589.800000	39.29	54.00	14.71	100	299	HORI
5507.800000	38.20	54.00	15.80	99	360	VERT
6426.200000	39.77	54.00	14.23	131	331	HORI
7323.600000	33.39	54.00	20.61	328	224	HORI
8267.600000	33.15	54.00	20.85	176	191	HORI
9203.800000	35.13	54.00	18.87	100	204	HORI

Table 22 - Radiated Emissions Peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1847.500000	49.61	74.00	24.39	100	328	HORI
2754.500000	52.78	74.00	21.22	199	335	VERT
3672.200000	48.94	74.00	25.06	193	172	VERT
4589.800000	54.26	74.00	19.74	100	299	HORI
5507.800000	53.17	74.00	20.83	99	360	VERT
6426.200000	54.74	74.00	19.26	131	331	HORI
7323.600000	48.36	74.00	25.64	328	224	HORI
8267.600000	48.12	74.00	25.88	176	191	HORI
9203.800000	50.10	74.00	23.90	100	204	HORI

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	Trim Board	MODE	Transmit, Ch 3 921 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 10 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

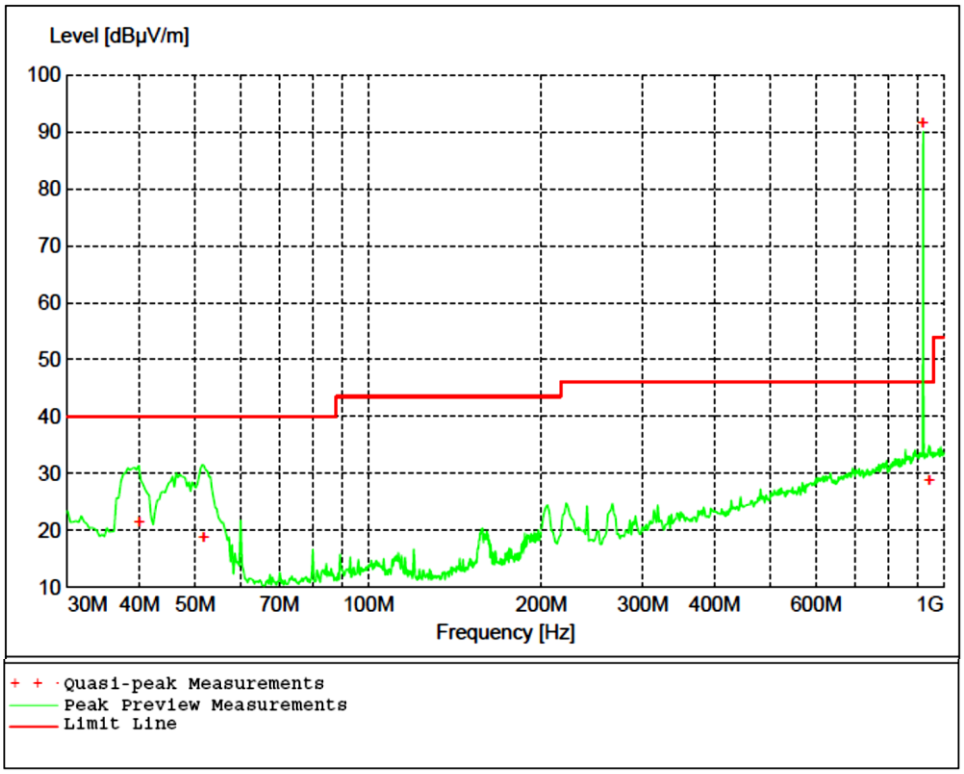

Figure 11 - Radiated Emissions Plot, Channel 3

Table 23 - Radiated Emissions Quasi-peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
40.020000	21.47	40.00	18.50	270	276	VERT
51.780000	18.76	40.00	21.20	100	302	VERT
921.000000	91.60*	93.98	2.38	115	337	VERT
945.180000	28.63	46.00	17.40	356	175	HORI

*Peak measurement

Table 24 - Radiated Emissions Average Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1845.500000	34.75	54.00	19.25	200	228	HORI
2755.500000	37.81	54.00	16.19	100	38	HORI
3684.000000	35.86	54.00	18.14	101	277	HORI
4605.200000	37.44	54.00	16.56	150	190	HORI
5526.000000	38.46	54.00	15.54	99	295	VERT
6446.800000	36.65	54.00	17.35	100	210	HORI
7370.600000	33.64	54.00	20.36	399	163	VERT
8272.800000	33.16	54.00	20.84	210	0	HORI
9216.600000	36.45	54.00	17.55	166	208	VERT

Table 25 - Radiated Emissions Peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1845.500000	49.72	74.00	24.28	200	228	HORI
2755.500000	52.78	74.00	21.22	100	38	HORI
3684.000000	50.83	74.00	23.17	101	277	HORI
4605.200000	52.41	74.00	21.59	150	190	HORI
5526.000000	53.43	74.00	20.57	99	295	VERT
6446.800000	51.62	74.00	22.38	100	210	HORI
7370.600000	48.61	74.00	25.39	399	163	VERT
8272.800000	48.13	74.00	25.87	210	0	HORI
9216.600000	51.42	74.00	22.58	166	208	VERT

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Limit value- Emission level
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

4.3 Bandwidth

4.3.1 Limits of bandwidth measurements

The bandwidth is measured for informational purposes.

4.3.2 Test procedures

All measurements were taken at a distance of 3m from the EUT. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 1 MHz VBW. The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 100kHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

4.3.3 Deviations from test standard

No deviation.

4.3.4 Test setup

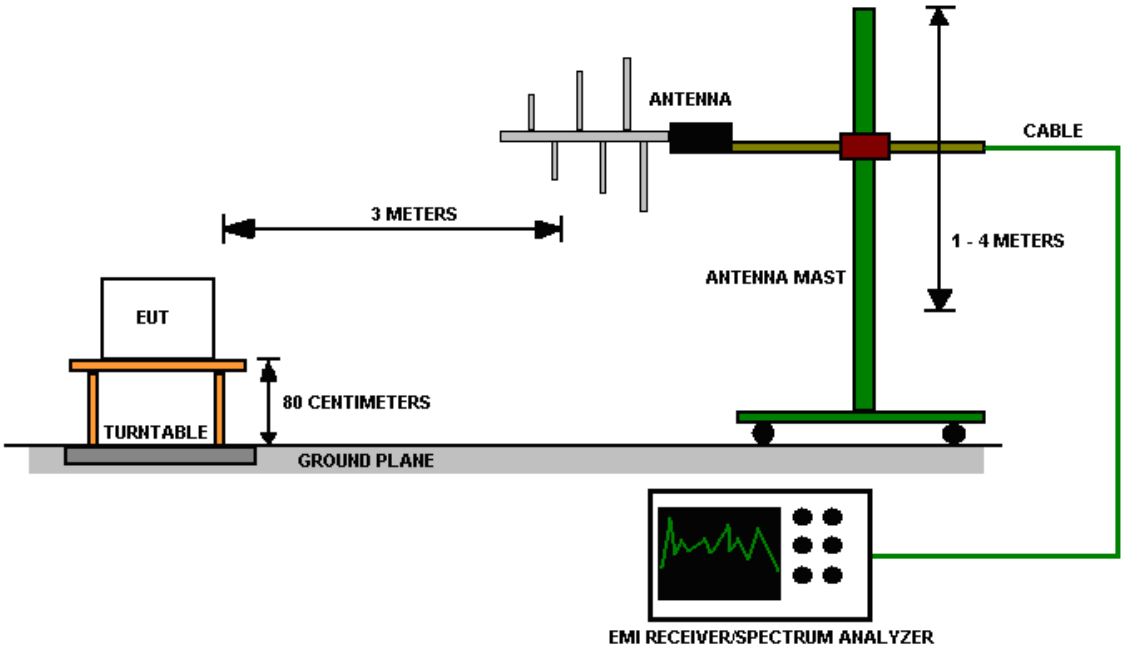

Figure 12 - Bandwidth Measurements Test Setup

4.3.5 EUT operating conditions

The EUT was powered by 24 VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.3.6 Test results

EUT MODULE	Main Board	MODE	Cont. Transmit
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	902-928 MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
1	915	434.87
2	918	440.88
3	921	444.89

REMARKS:
None

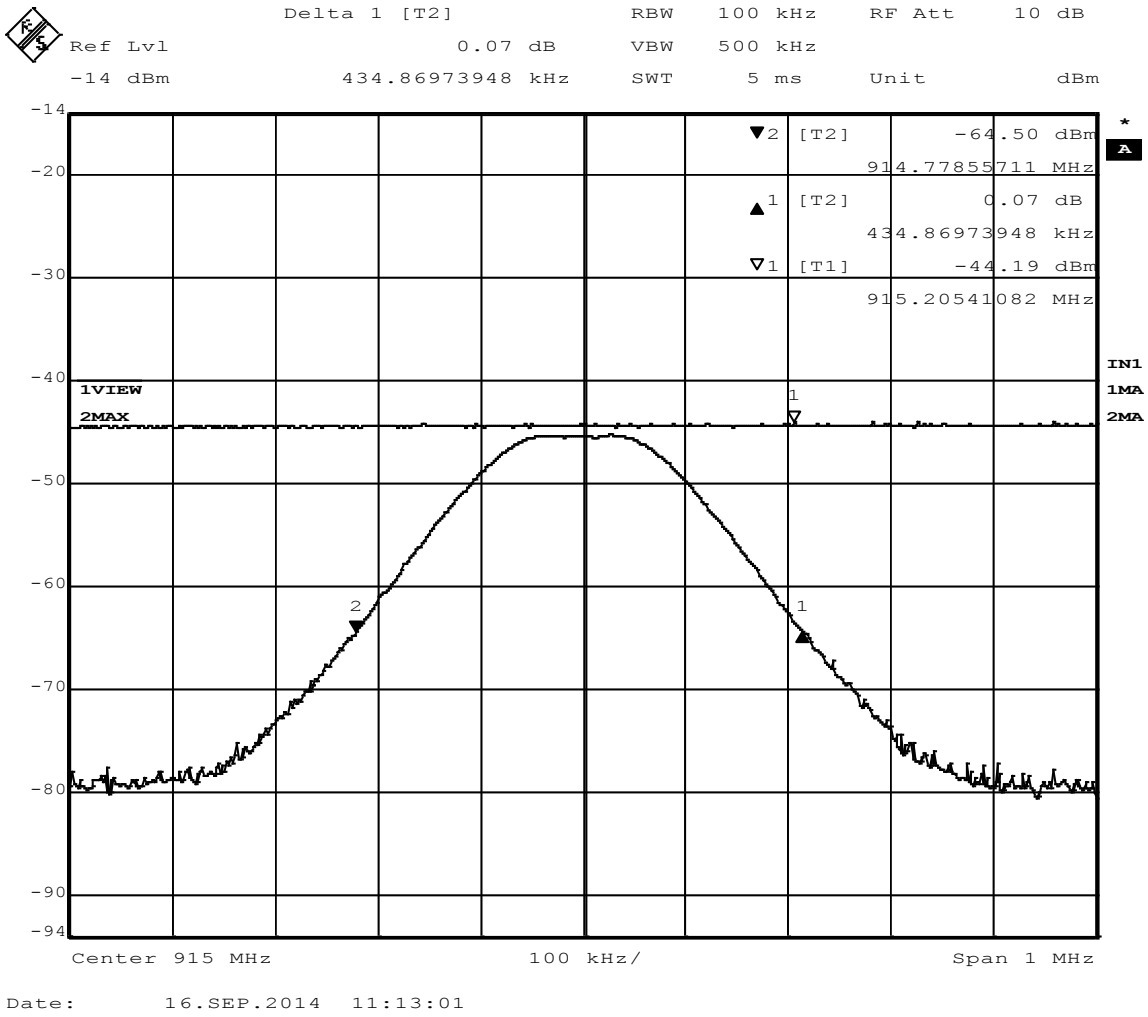

Figure 13 - 99% Occupied Bandwidth, Low Channel
The plot shows an uncorrected measurement.

Maximum power = -44.19 dBm + 107 + CL + AF - 95.23 = -4.22 dBm

CF = cable loss = 4.50 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

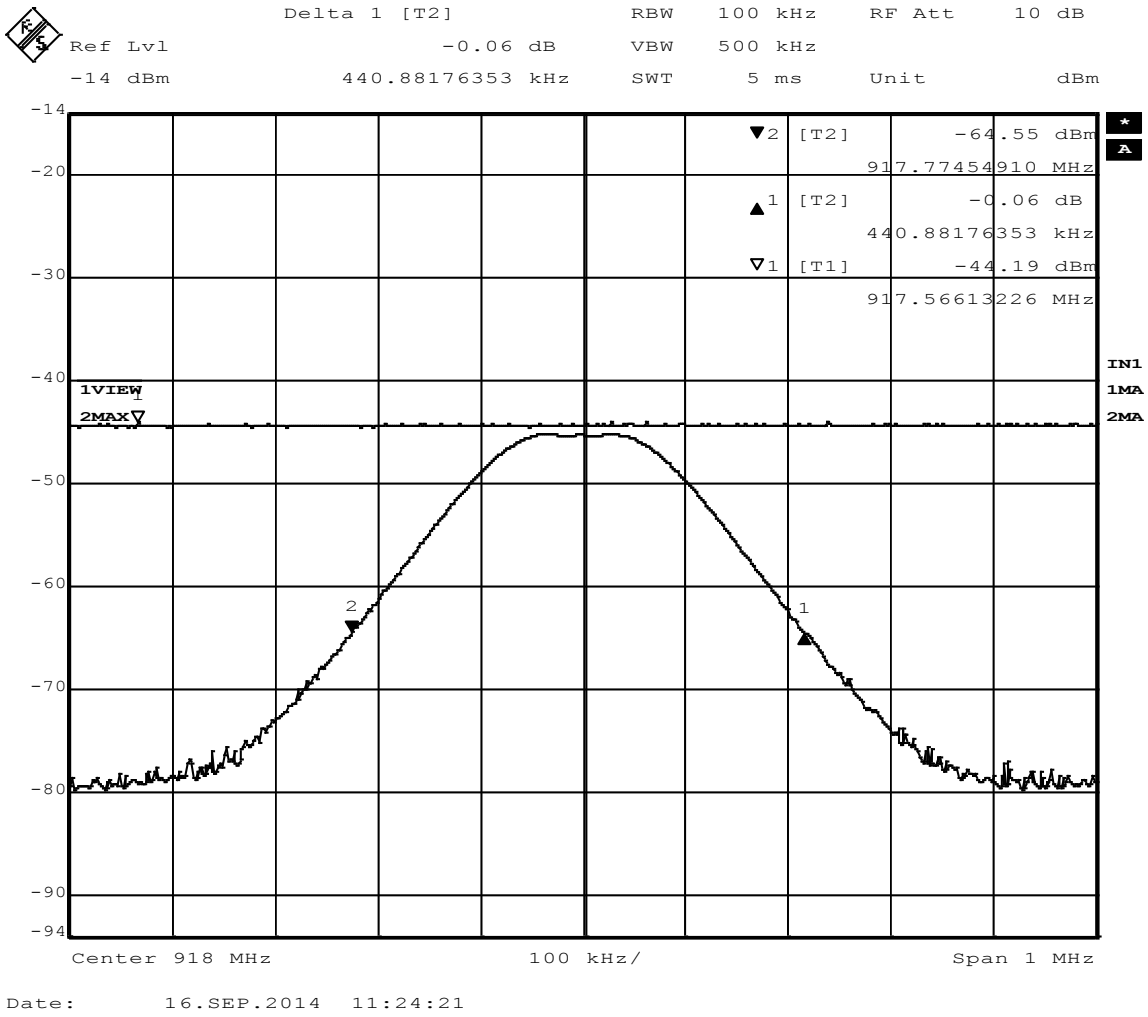

Figure 14 - 99% Occupied Bandwidth, Mid Channel
The plot shows an uncorrected measurement.

Maximum power = -44.19 dBm + 107 + CL + AF - 95.23 = -4.22 dBm

CF = cable loss = 4.50 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

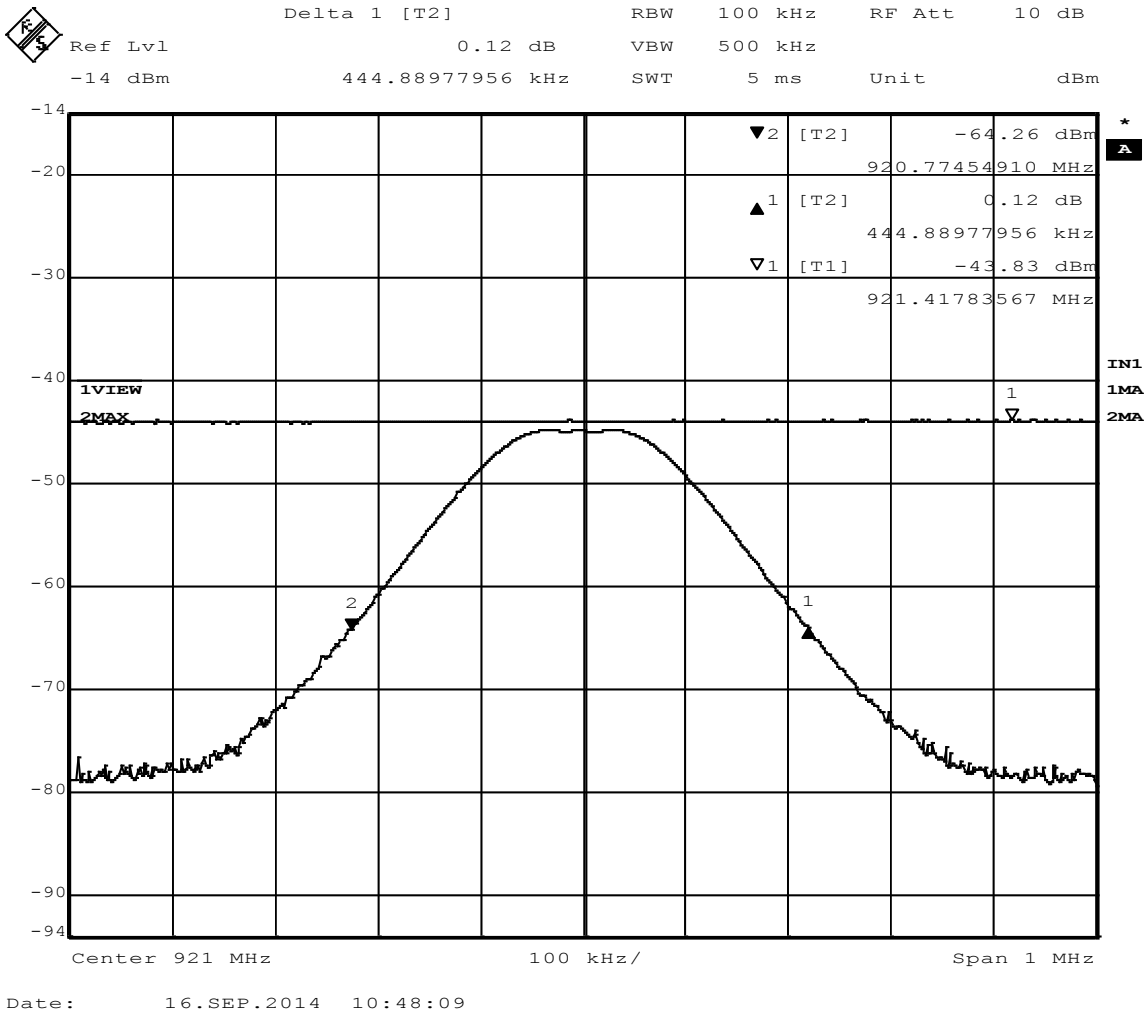

Figure 15 - 99% Occupied Bandwidth, High Channel
The plot shows an uncorrected measurement.

Maximum power = -43.83 dBm + 107 + CL + AF - 95.23 = -3.86 dBm

CF = cable loss = 4.50 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

EUT MODULE	Trim Board	MODE	Cont. Transmit
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	902-928 MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (kHz)
1	915	438.88
2	918	434.87
3	921	436.87

REMARKS:
None

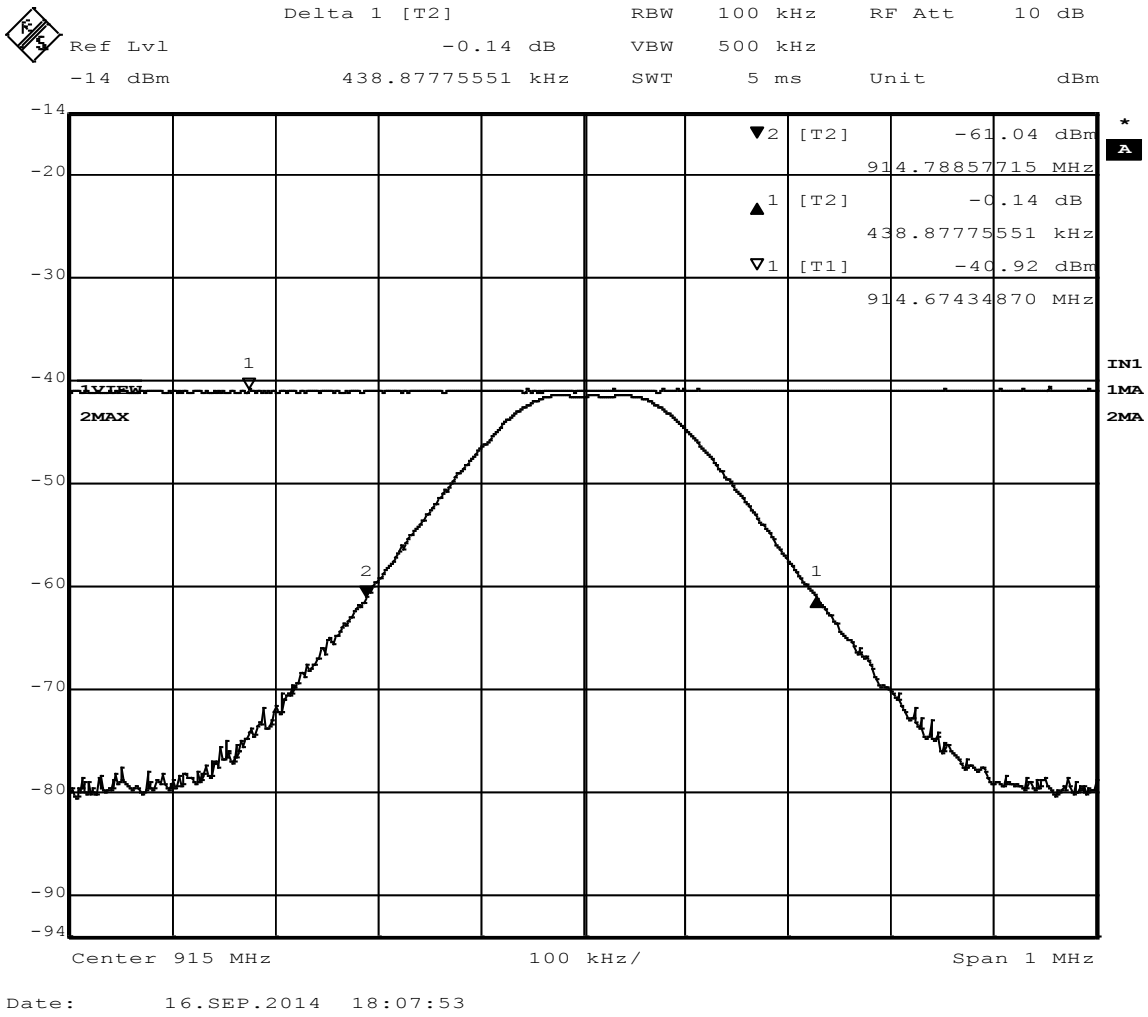

Figure 16 - 99% Occupied Bandwidth, Low Channel
The plot shows an uncorrected measurement.

Maximum power = -40.92 dBm + 107 + CL + AF - 95.23 = -0.97 dBm

CF = cable loss = 4.50 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

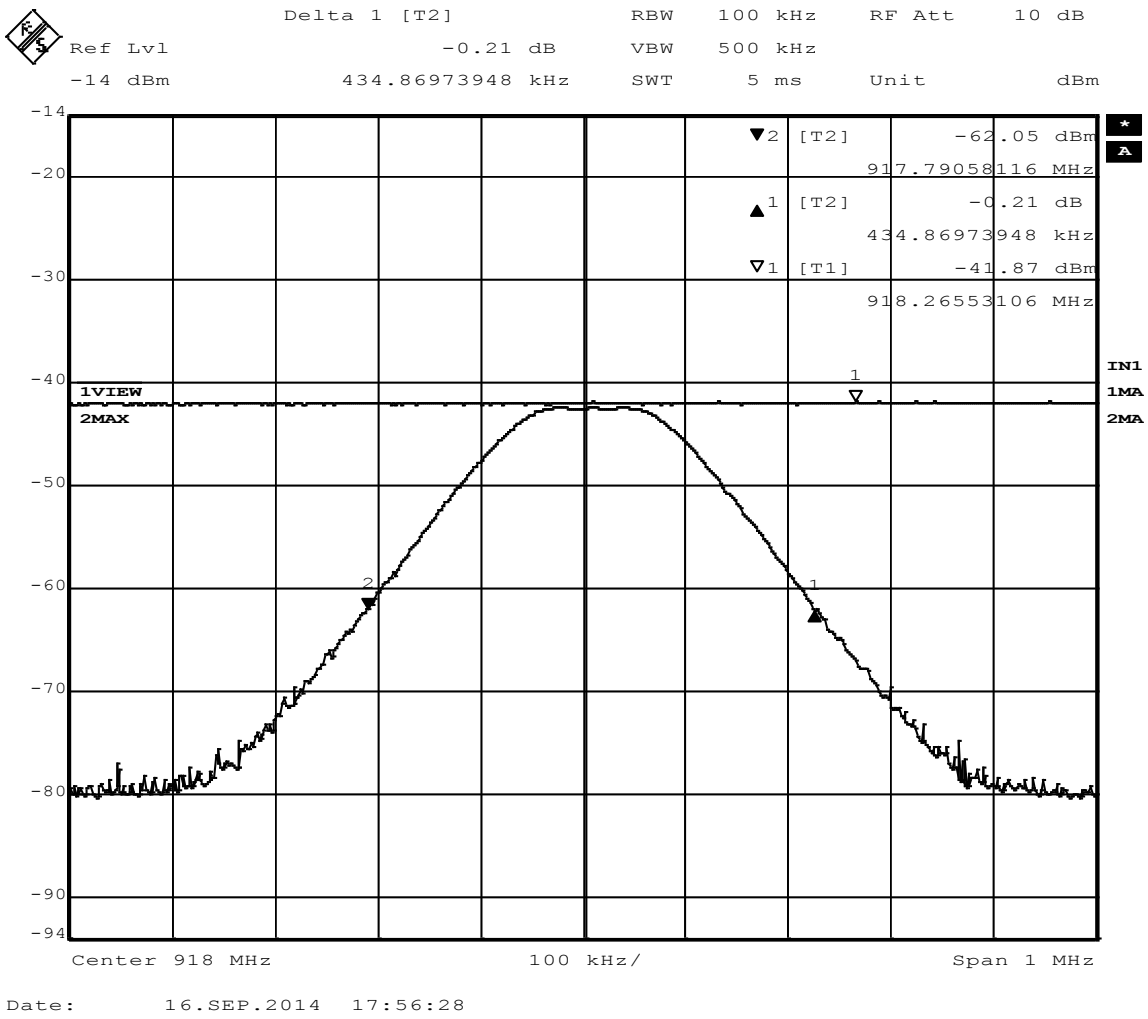

Figure 17 - 99% Occupied Bandwidth, Mid Channel
The plot shows an uncorrected measurement.

Maximum power = -41.87 dBm + 107 + CL + AF - 95.23 = -1.90 dBm

CF = cable loss = 4.50 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

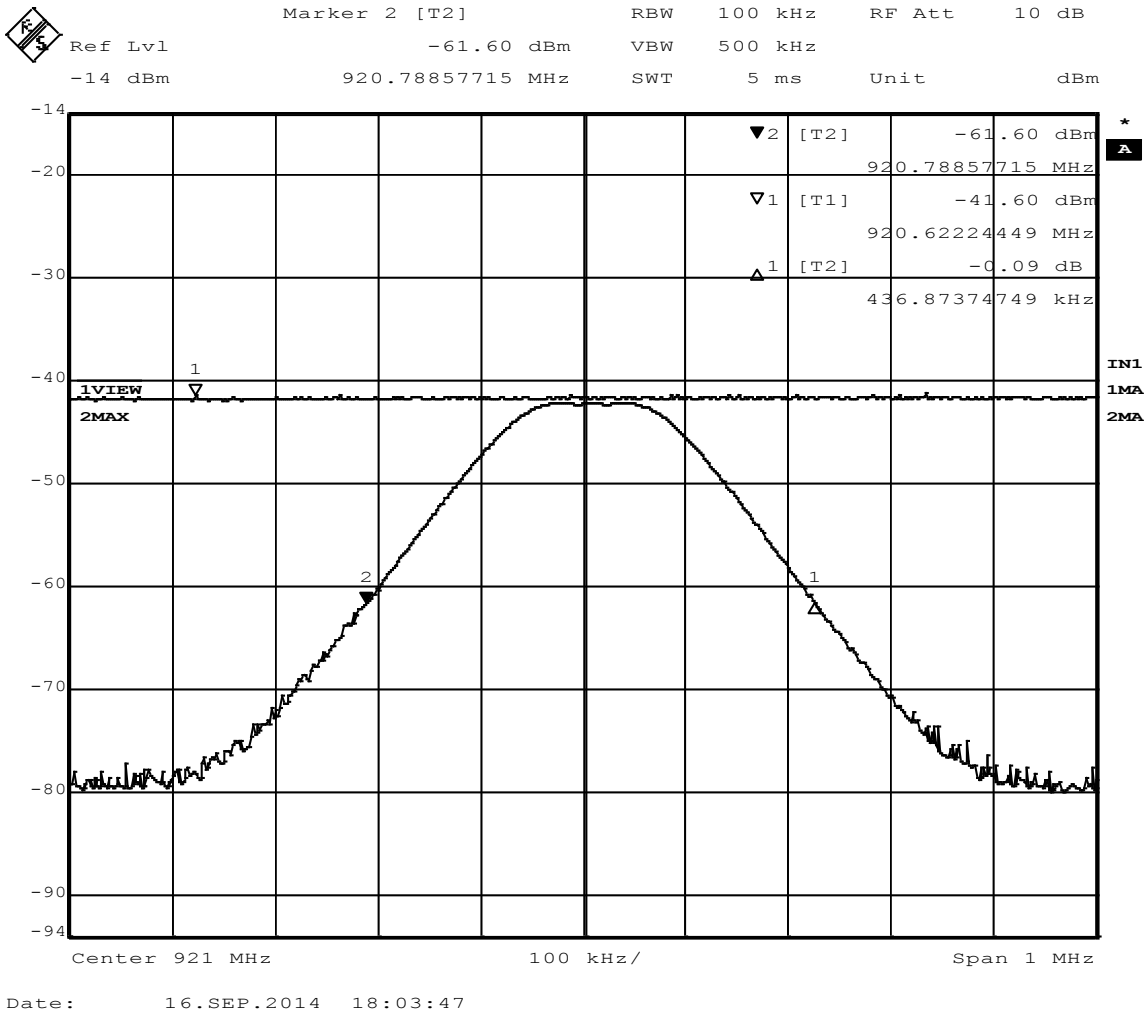

Figure 18 - 99% Occupied Bandwidth, High Channel
The plot shows an uncorrected measurement.

Maximum power = -41.60 dBm + 107 + CL + AF - 95.23 = -1.63 dBm

CF = cable loss = 4.50 dB
AF = antenna factor = 23.70 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

Note: the trace at the top where Marker 1 is located was made with a 10MHz resolution bandwidth and saved on the screen.

4.4 Maximum peak output power

4.4.1 Limits of power measurements

The maximum peak output power allowed is 30dBm (1000mW).

4.4.2 Test procedures

1. All measurements were taken at a distance of 3m from the EUT.

2. The resolution bandwidth was set to 10MHz and the video bandwidth was set to 10MHz to capture the maximum amount of signal. The analyzer used a peak detector in max hold mode. This represented the maximum output power.

3. See Annex B for an example of how the EIRP is calculated in order to report maximum power output.

4.4.3 Deviations from test standard

No deviation.

4.4.4 Test setup

See Section 4.2 for test setup

4.4.5 EUT operating conditions

a 24 VDC battery supply and set to transmit continuously unless specified on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.4.6 Test results

EUT MODULE	Main Board	MODE	Cont. Transmit
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	902-928 MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Maximum peak output power

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	PEAK POWER LIMIT (dBm)	RESULT
1	915	-4.22	30	PASS
2	918	-4.22	30	PASS
3	921	-3.86	30	PASS

All measurements were taken from the 99% occupied bandwidth screen captures in Section 4.3.

REMARKS:
None

EUT MODULE	Trim Board	MODE	Cont. Transmit
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	902-928 MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Maximum peak output power

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	PEAK POWER LIMIT (dBm)	RESULT
1	915	-0.95	30	PASS
2	918	-1.90	30	PASS
3	921	-1.63	30	PASS

All measurements were taken from the 99% occupied bandwidth screen captures in Section 4.3.

REMARKS:
None

4.5 Bandedges

4.5.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (902 MHz – 921 MHz), the field strength levels need to be under that of the limits in 15.209.

4.5.2 Test procedures

The EUT was tested in the same method as described in section *4.3 - Bandwidth*. The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 120kHz and the EMI receiver was used to scan from the bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge was measured and recorded. If the out of band emissions do not fall within a restricted band from 15.205, then it is required that the out of band emission be 20dB below that of the fundamental emission level. If the out of band emission falls with a restricted band from 15.205, then it is required that the emission be below the limits from 15.209.

4.5.3 Deviations from test standard

No deviation.

4.5.4 Test setup

See Section 4.4

4.5.5 EUT operating conditions

The EUT was powered by a 24 VDC battery supply unless specified and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

4.5.6 Test results

EUT MODULE	Main Board	MODE	Cont. Transmit
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	902-928 MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest Out of Band Emissions

CHANNEL	Bandedge/Measurement Frequency (MHz)	Level (dBm)	Fund. Level (dBm)	Delta
1	902 MHz	-74.14	-15.77	58.37
3	928 MHz	-74.11	-16.61	57.50

EUT MODULE	Trim Board	MODE	Cont. Transmit
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	902-928 MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest Out of Band Emissions

CHANNEL	Bandedge/Measurement Frequency (MHz)	Level (dBm)	Fund. Level (dBm)	Delta
1	902 MHz	-74.45	-16.54	57.91
3	928 MHz	-73.52	-15.47	58.05

Appendix A: Test Photos

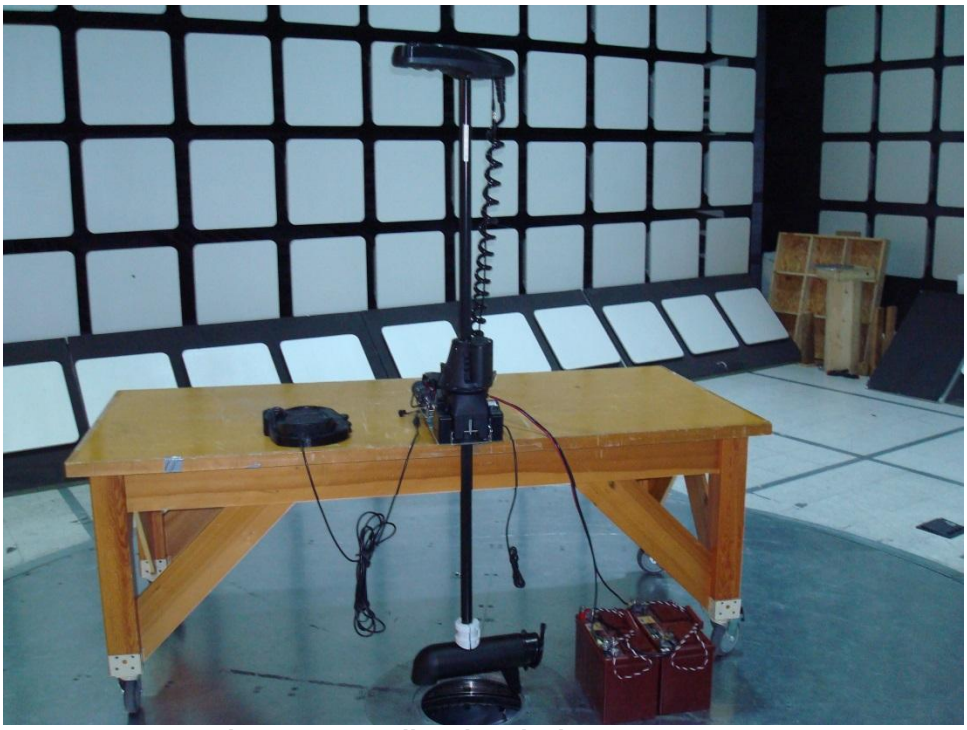

Figure 19 – Radiated Emissions Test Setup

Figure 20 - Radiated Emissions Test Setup

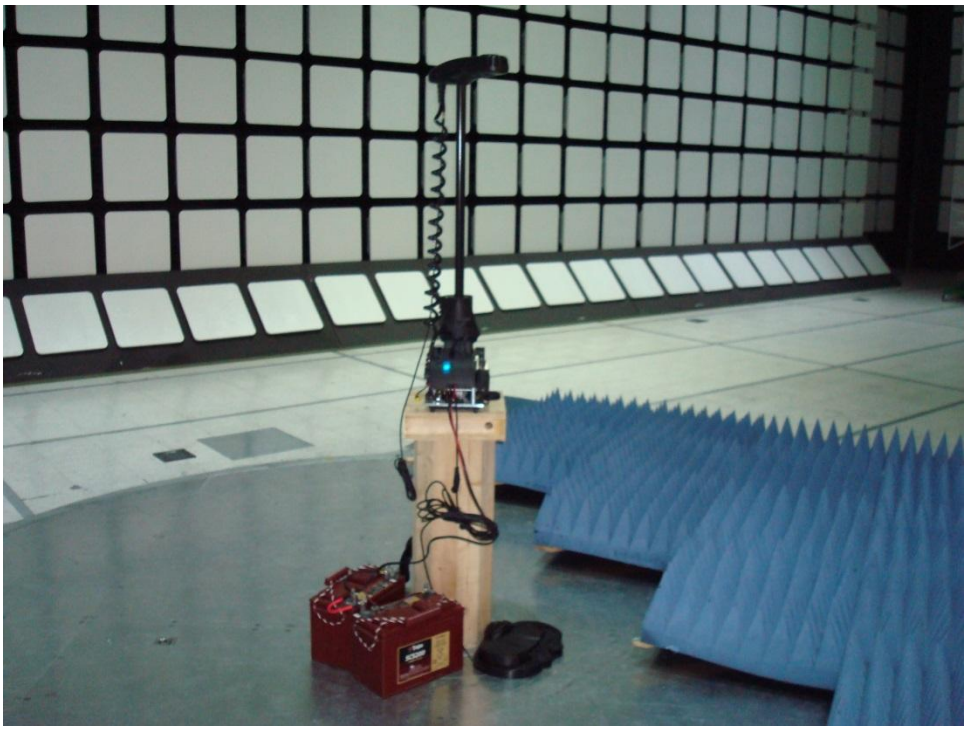

Figure 21 - Radiated Emissions Test Setup

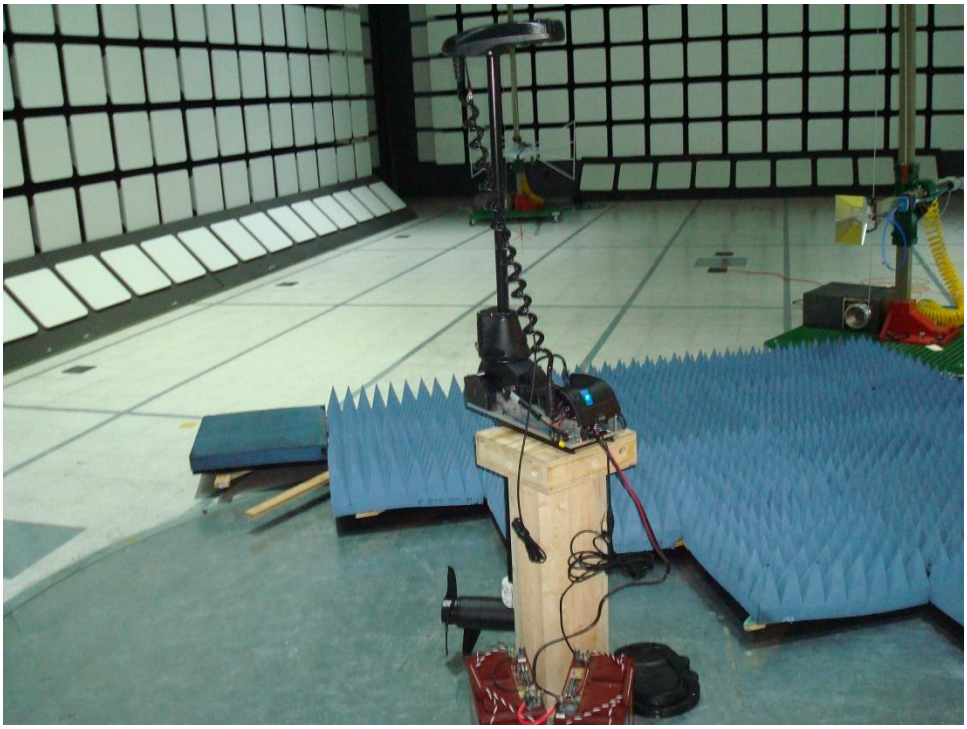

Figure 22 - Radiated Emissions Test Setup

Appendix B: Sample Calculation

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Stregnth (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

Power (watts) = 10^[Power (dBm)/10] x 1000

Field Strength (dBµV/m) = Field Stregth (dBm) = 107 (for 50Ω measurement systems)

Field Stregnth (V/m) = 10^[Field Stregnth (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator

Appendix C: Table of Figures

Figure Number **Page**

Table Number **Page**