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Amended Radio Test Report

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

Product: **Ulterra with i-Pilot Link System**
2400 – 2483.5 MHz band iPilot Link Radio

FCC ID: **T62 –ULTERRAIP20**
IC: **IC:4397A-ULTERRAIP20**

Test Report No: **R20131014-21-11B**

Approved By:

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

DATE: **8 December 2014**

Total Pages: **43**

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.
15.247(a)(1) RSS-210 Issue 8	Minimum Bandwidth, Limit Min. 500kHz	Pass	Meets the requirement of the limit.
15.247(b) RSS-210 Issue 8	Maximum Peak Output Power, Limit: Max. 23.9dBm	Pass	Meets the requirement of the limit.
15.247(c) RSS-210 Issue 8	Transmitter Radiated Emissions, Limit: Table 15.209	Pass	Meets the requirement of the limit.
15.247(c) RSS-210 Issue 8	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
15.247(a) RSS-210 Issue 8	Power Spectral Density	Pass	Meets the requirement of the limit.

1.1 Reason for amendment

References to 15.249 were removed and RSS-Gen was updated to Issue 4.
The frequency range in Section 2.1 and 2.3 was corrected ito 2437 to 2447 MHz.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was an Ulterra trolling motor with i-Pilot Link system controller pre-installed, which operates from 2437 to 2447 MHz. This radio is intended to communicate with an external remote (previously tested). This report is specific to this radio.

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. The test results from this radio are covered in NCEE Labs report R20141014-21-12.

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

PRODUCT	Ulterra with i-Pilot Link system Remote
POWER SUPPLY	24 VDC 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 the 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:

Ipilot link head

Channel	Frequency
1	2437
2	2442
3	2447

These are the only three frequencies possible Ipilot link head

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 (15.247)
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.

The EUT was tested with an optional foot pedal and fish finder.

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	2437	28.47	7.20
2	2442	28.47	7.20
3	2447	28.47	7.20

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

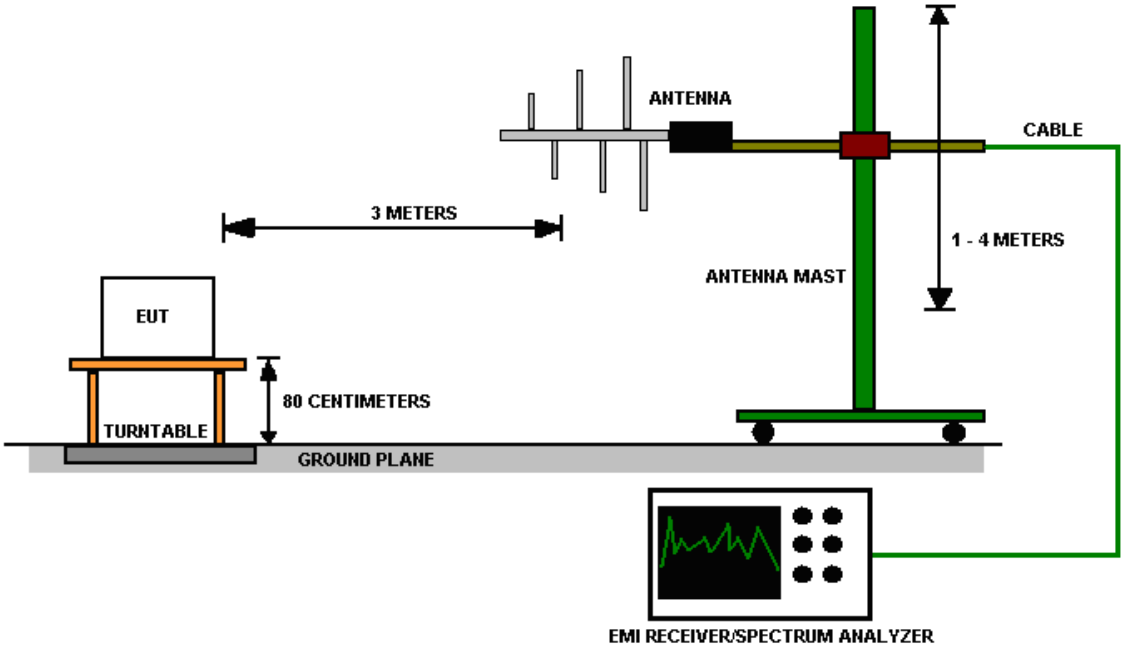

Figure 1 - Radiated Emissions Test Setup

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.

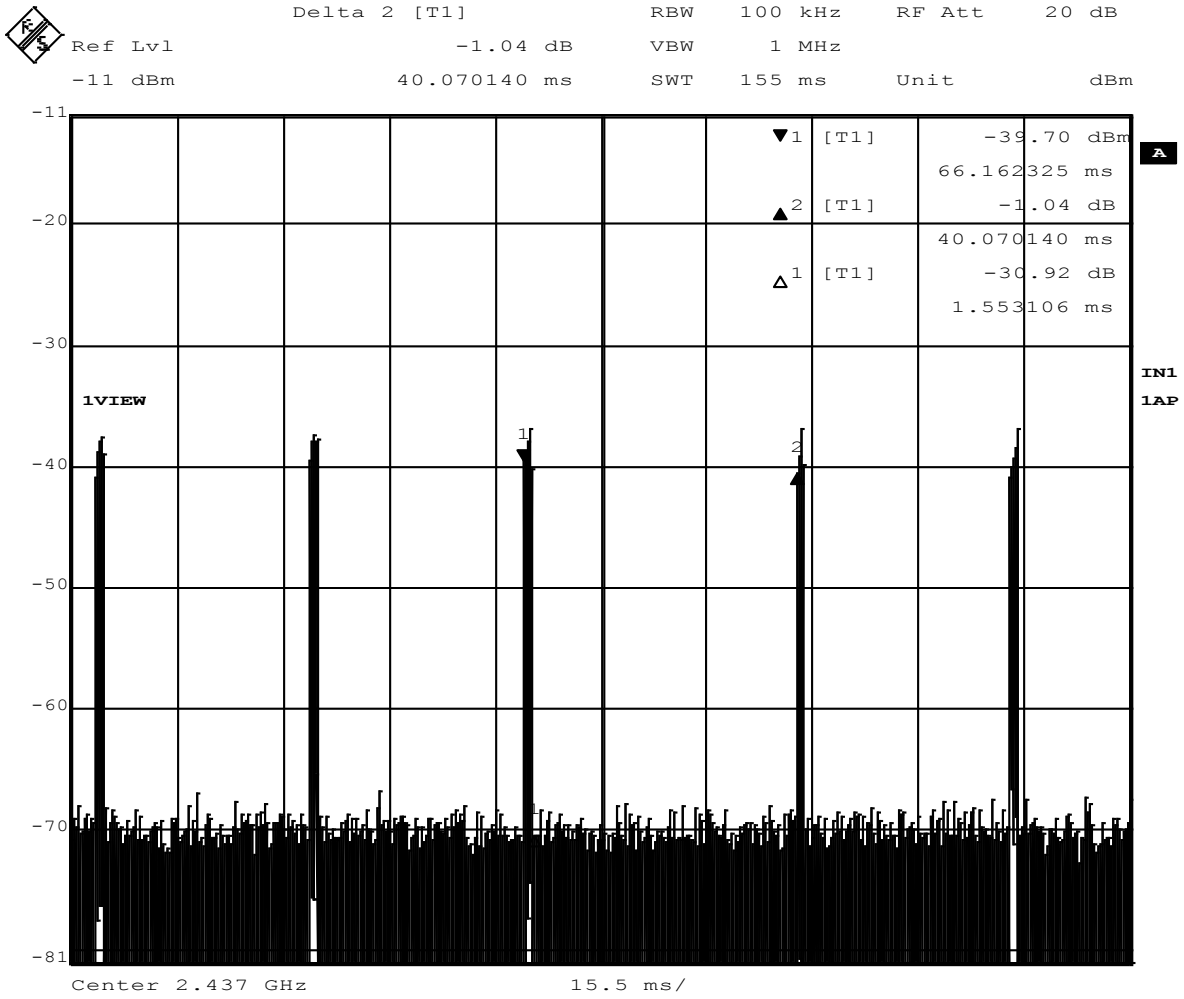

Figure 2 – Duty Cycle, ipilot Link

20 log (1.55 mS / 26.09 mS) = -24.52

Note: Correction for peak to average measurement = 20 dB (Max allowed)

4.2.6 Test results

EUT MODULE	i-Pilot Link Head	MODE	Receive
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

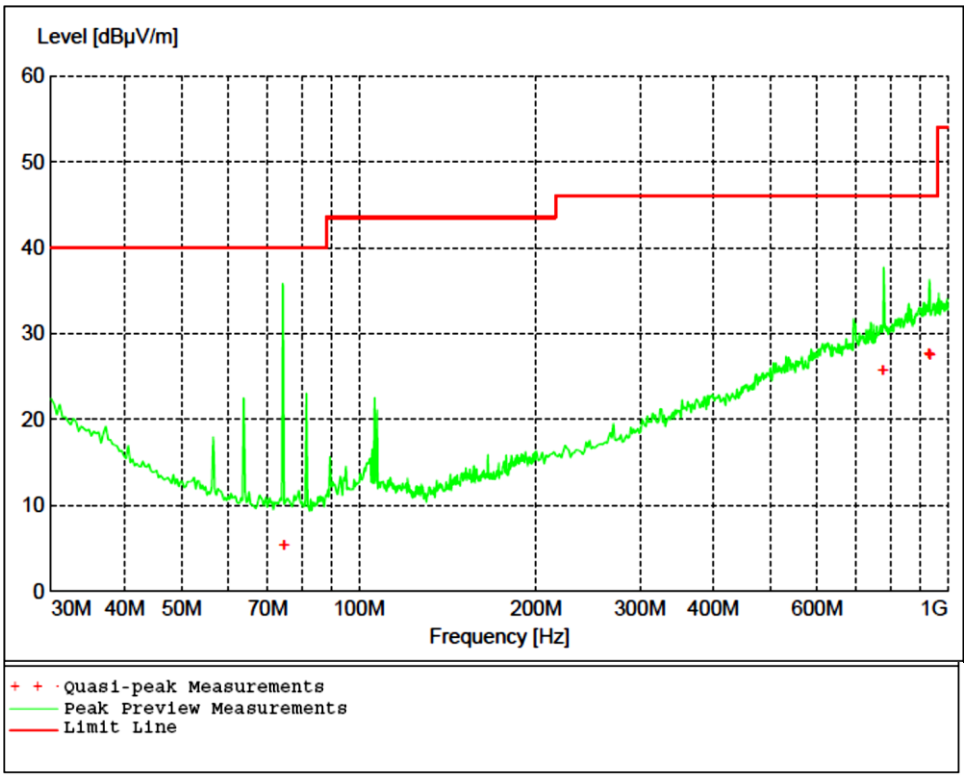

Figure 3 - Radiated Emissions Plot, Receive

Table 2 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
74.580000	5.38	40.00	34.60	361	327	VERT
777.000000	25.66	46.00	20.30	335	0	HORI
929.640000	27.59	46.00	18.40	199	201	VERT
933.660000	27.47	46.00	18.50	400	107	VERT

Table 3 - Radiated Emissions Average Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2436.600000	15.78	54.00	38.22	400	11	HORI
4895.800000	25.12	54.00	28.88	99	15	HORI
7341.600000	27.69	54.00	26.31	376	272	VERT
9732.800000	31.92	54.00	22.08	389	11	HORI
12246.400000	33.46	54.00	20.54	133	354	HORI
14667.800000	39.52	54.00	14.48	237	118	HORI
17120.200000	39.31	54.00	14.69	100	202	HORI

Table 4 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2436.600000	35.78	74.00	38.22	400	11	HORI
4895.800000	45.12	74.00	28.88	99	15	HORI
7341.600000	47.69	74.00	26.31	376	272	VERT
9732.800000	51.92	74.00	22.08	389	11	HORI
12246.400000	53.46	74.00	20.54	133	354	HORI
14667.800000	59.52	74.00	14.48	237	118	HORI
17120.200000	59.31	74.00	14.69	100	202	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 = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	i-Pilot Link Head	MODE	Transmit, Ch 1 2437 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

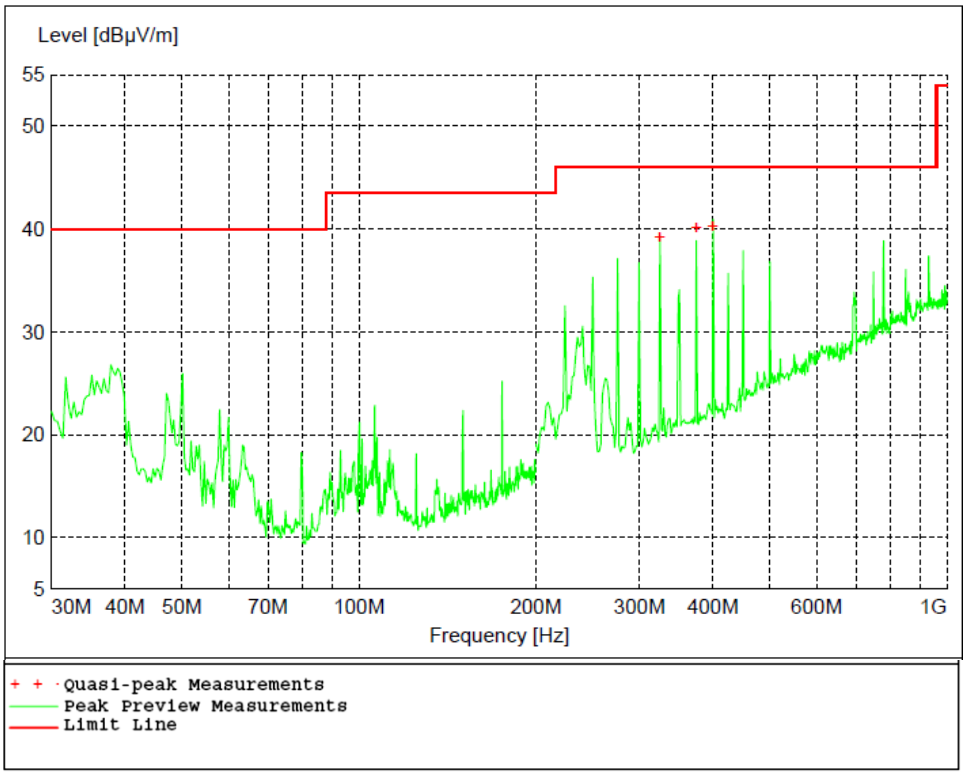

Figure 4 - Radiated Emissions Plot, Channel 1

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
324.960000	39.15	46.00	6.80	274	249	HORI
375.000000	40.12	46.00	5.90	227	342	VERT
399.960000	40.19	46.00	5.80	99	38	HORI

Table 6 - Radiated Emissions Average Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2437.500000	91.50	N/A	N/A	188	332	VERT
4873.400000	28.54	54.00	25.46	194	1	VERT
7312.600000	45.91	54.00	8.09	204	335	VERT
9752.800000	31.76	54.00	22.24	278	195	HORI
12164.000000	33.99	54.00	20.01	115	15	VERT
14647.800000	40.07	54.00	13.93	210	200	VERT
17098.200000	39.33	54.00	14.67	130	151	HORI

Table 7 - Radiated Emissions Peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2437.500000	111.50	N/A	N/A	188	332	VERT
4873.400000	48.54	74.00	25.46	194	1	VERT
7312.600000	65.91	74.00	8.09	204	335	VERT
9752.800000	51.76	74.00	22.24	278	195	HORI
12164.000000	53.99	74.00	20.01	115	15	VERT
14647.800000	60.07	74.00	13.93	210	200	VERT
17098.200000	59.33	74.00	14.67	130	151	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 = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	i-Pilot Link Head	MODE	Transmit, Ch 2 2442 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

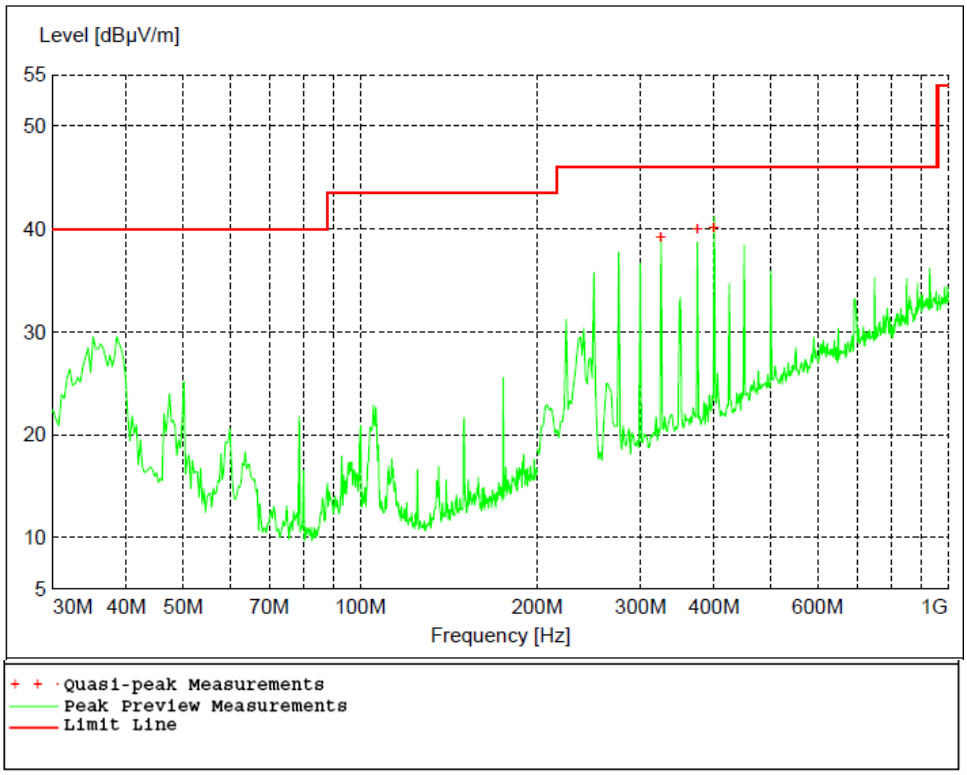

Figure 5 - Radiated Emissions Plot, Channel 2

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
324.960000	39.15	46.00	6.80	278	252	HORI
375.000000	40.01	46.00	6.00	226	342	VERT
399.960000	40.10	46.00	5.90	100	35	HORI

Table 9 - Radiated Emissions Average Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2442.500000	93.54	N/A	N/A	154	312	HORI
4893.800000	25.24	54.00	28.76	113	13	VERT
7327.400000	45.09	54.00	8.91	122	238	VERT
9783.600000	31.17	54.00	22.83	119	360	VERT
12179.200000	33.59	54.00	20.41	187	136	VERT
14670.400000	38.78	54.00	15.22	139	258	HORI
17119.200000	39.56	54.00	14.44	379	357	VERT

Table 10 - Radiated Emissions Peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2442.500000	113.54	N/A	N/A	154	312	HORI
4893.800000	45.24	74.00	28.76	113	13	VERT
7327.400000	65.09	74.00	8.91	122	238	VERT
9783.600000	51.17	74.00	22.83	119	360	VERT
12179.200000	53.59	74.00	20.41	187	136	VERT
14670.400000	58.78	74.00	15.22	139	258	HORI
17119.200000	59.56	74.00	14.44	379	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 = Emission level – Limit value.
5. Average measurements were calculated from applying the averaging factors from Figures 2 – 4 to the peak measurements

EUT MODULE	i-Pilot Link Head	MODE	Transmit, Ch 3 2447 MHz
INPUT POWER	24 VDC Battery	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

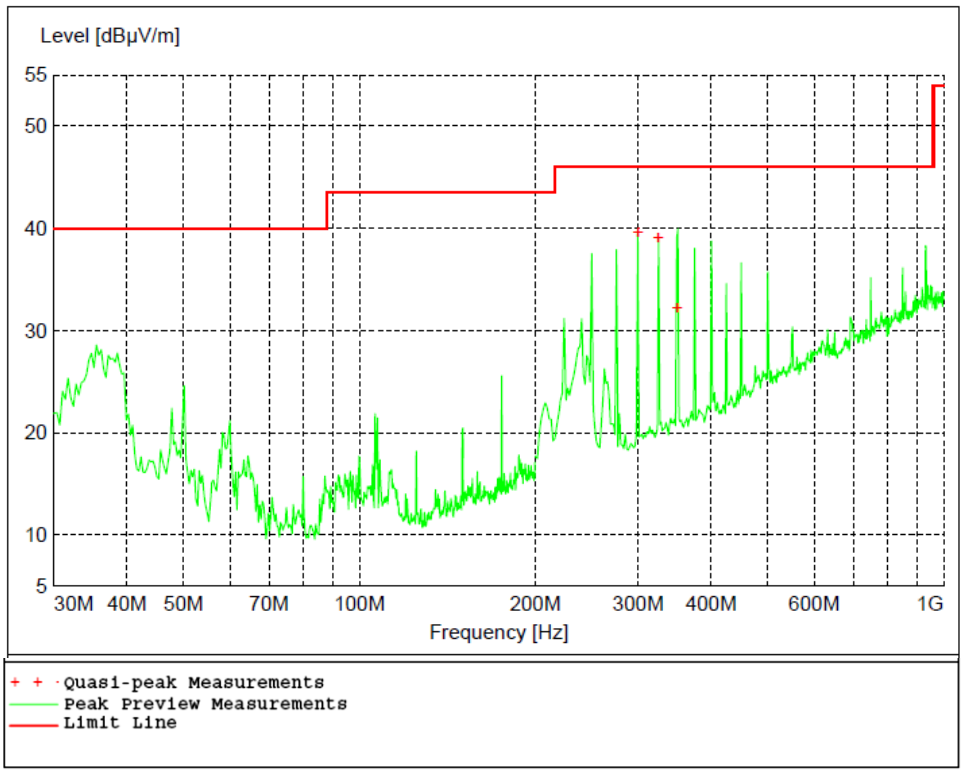

Figure 6 - Radiated Emissions Plot, Channel 3

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
300.000000	39.56	46.00	6.40	100	337	VERT
324.960000	39.01	46.00	7.00	271	248	HORI
349.980000	32.18	46.00	13.80	115	27	HORI

Table 12 - Radiated Emissions Average Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2447.500000	93.96	N/A	N/A	153	311	HORI
4903.800000	25.56	54.00	28.44	115	360	VERT
7342.600000	43.05	54.00	10.95	244	341	VERT
9785.800000	30.89	54.00	23.11	261	205	VERT
12222.800000	33.66	54.00	20.34	267	6	VERT
14692.000000	38.86	54.00	15.14	389	9	VERT
17104.600000	40.03	54.00	13.97	150	51	VERT

Table 13 - Radiated Emissions Peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2447.500000	113.96	N/A	N/A	153	311	HORI
4903.800000	45.56	74.00	28.44	115	360	VERT
7342.600000	63.05	74.00	10.95	244	341	VERT
9785.800000	50.89	74.00	23.11	261	205	VERT
12222.800000	53.66	74.00	20.34	267	6	VERT
14692.000000	58.86	74.00	15.14	389	9	VERT
17104.600000	60.03	74.00	13.97	150	51	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

4.3 Bandwidth

4.3.1 Limits of bandwidth measurements

The 6dB bandwidth of the signal must be greater than 0.500MHz.

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 on Marker 1. 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

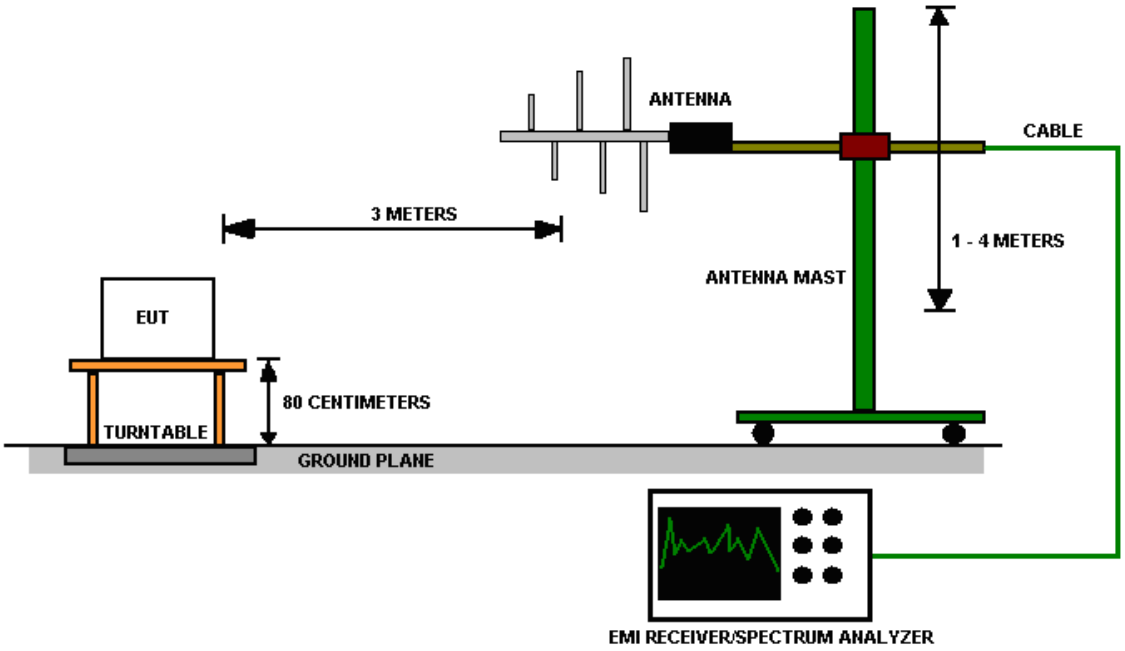

Figure 7 - Bandwidth Measurements Test Setup

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	i-Pilot Link Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	6dB BW (MHz)	6dB Limit Min (kHz)	RESULT
1	2437	1.64	500.00	PASS
2	2442	1.66	500.00	PASS
3	2447	1.65	500.00	PASS

REMARKS:
None

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
1	2437	2.79
2	2442	2.70
3	2447	2.73

REMARKS:
None

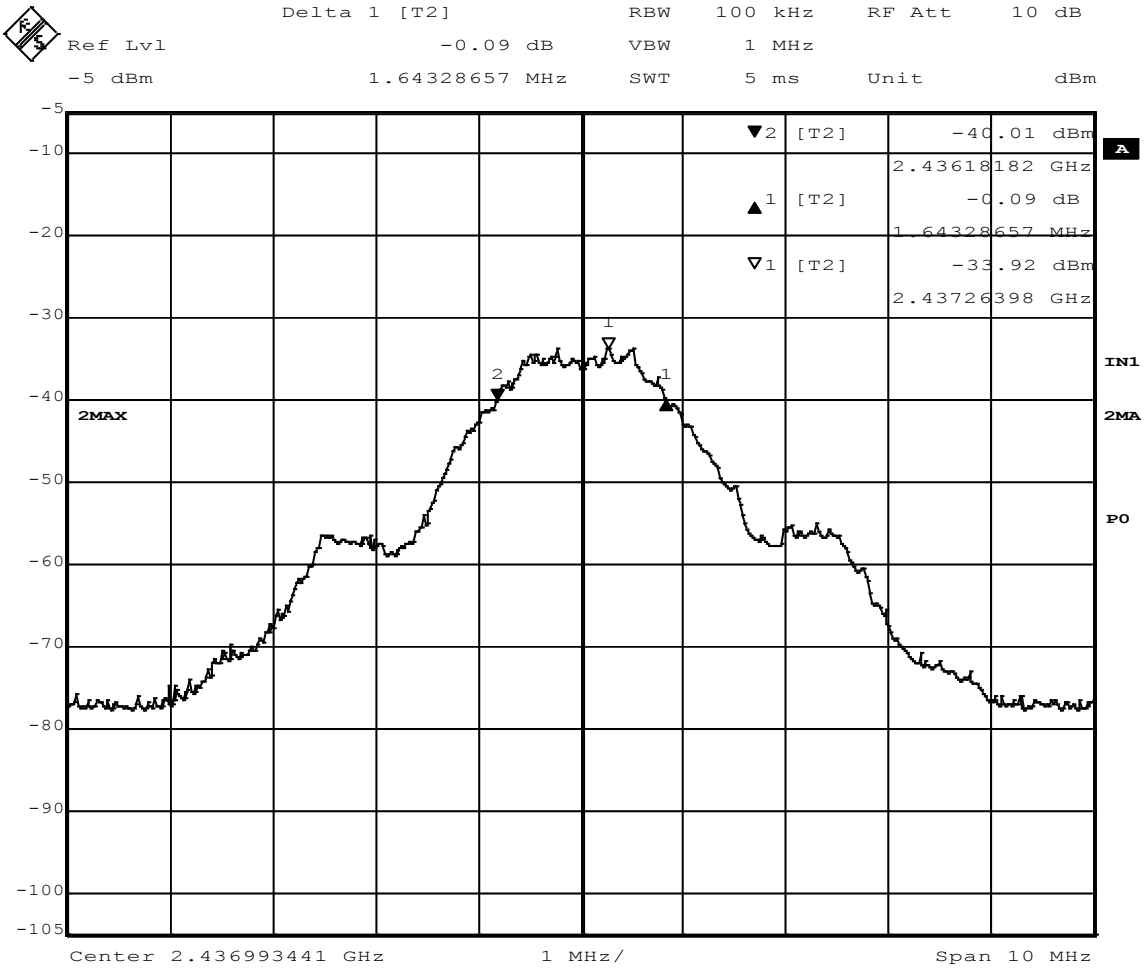

Figure 8 - 6dB Bandwidth, Low Channel
The plot shows an uncorrected measurement.

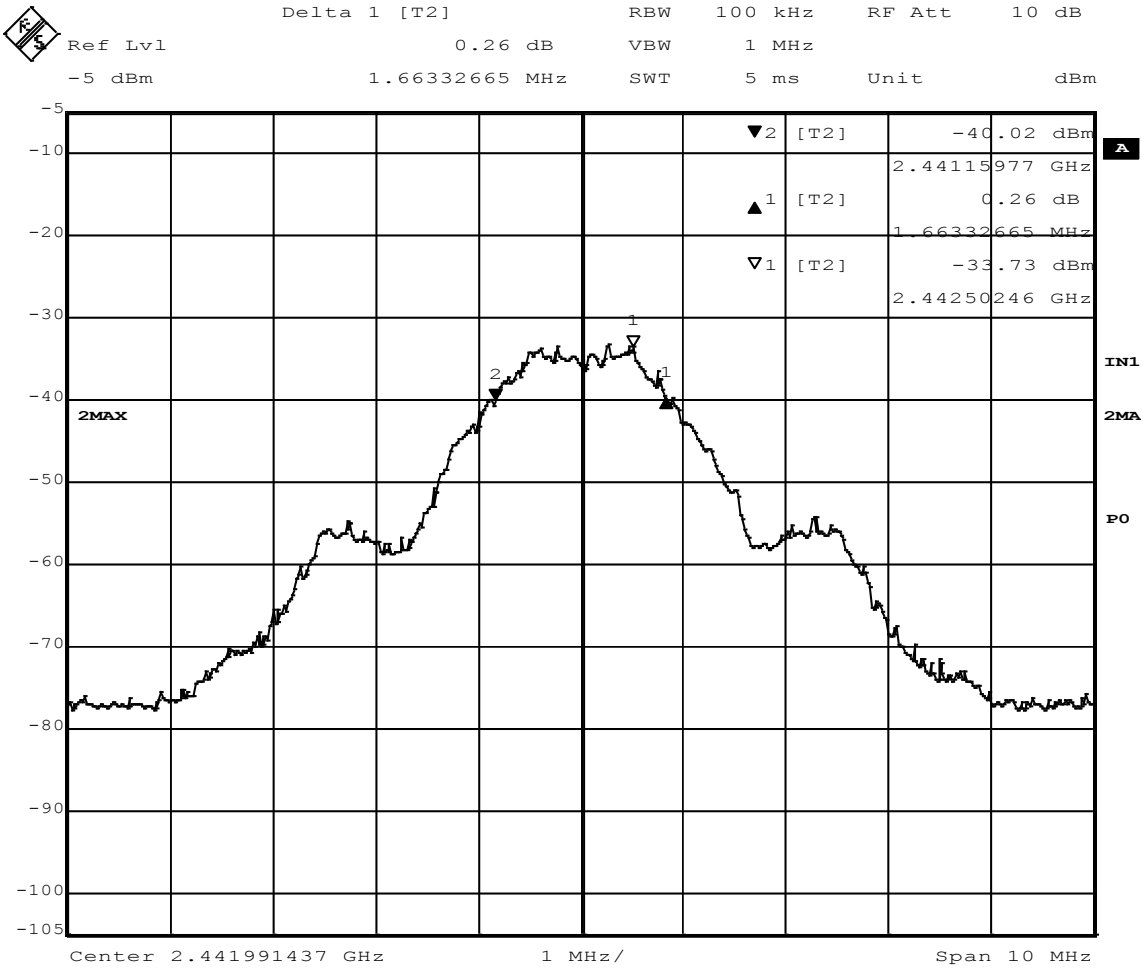

Figure 9 - 6dB Bandwidth, Middle Channel
The plot shows an uncorrected measurement.

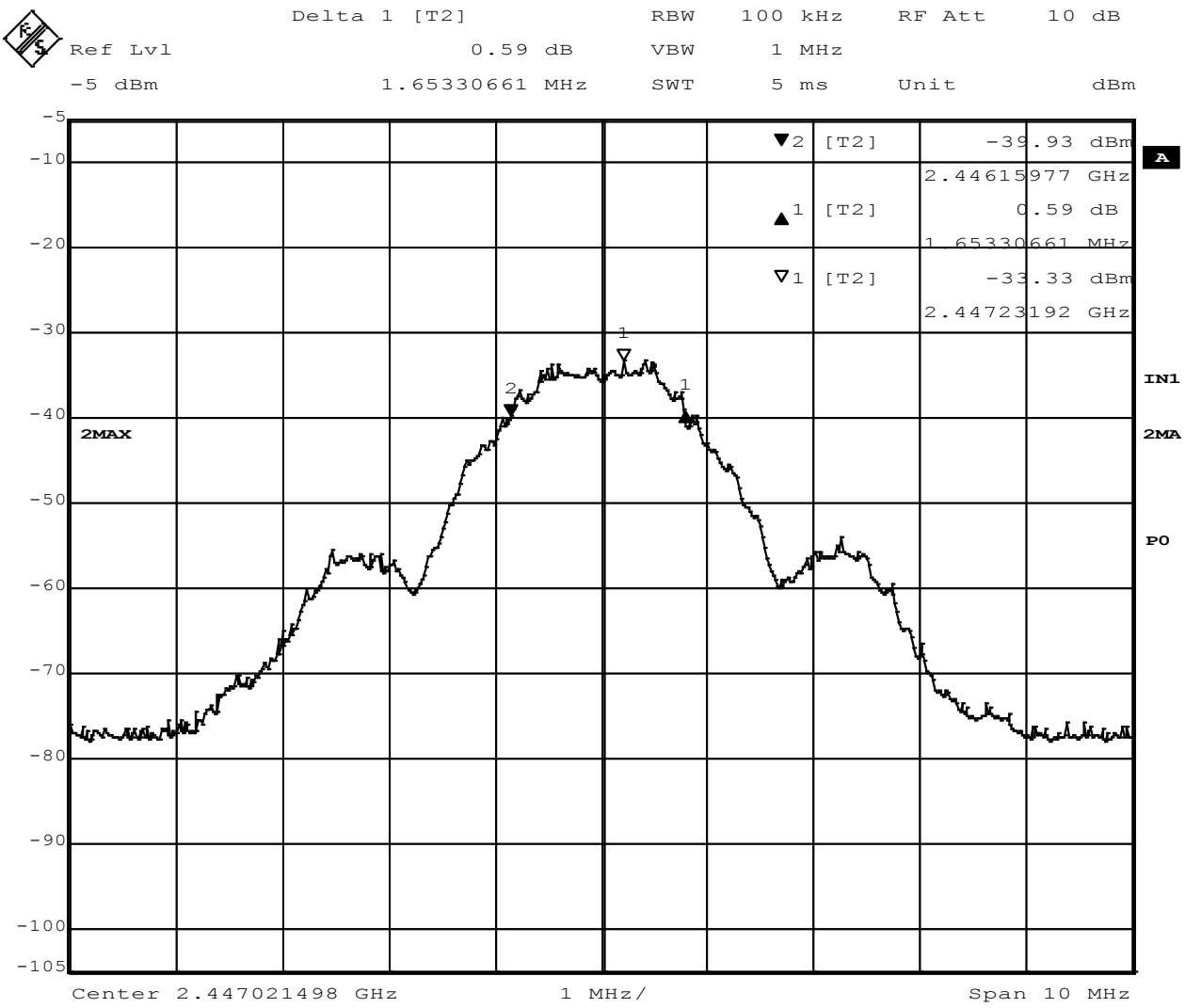

Figure 10 - 6dB Bandwidth, High Channel
The plot shows an uncorrected measurement.

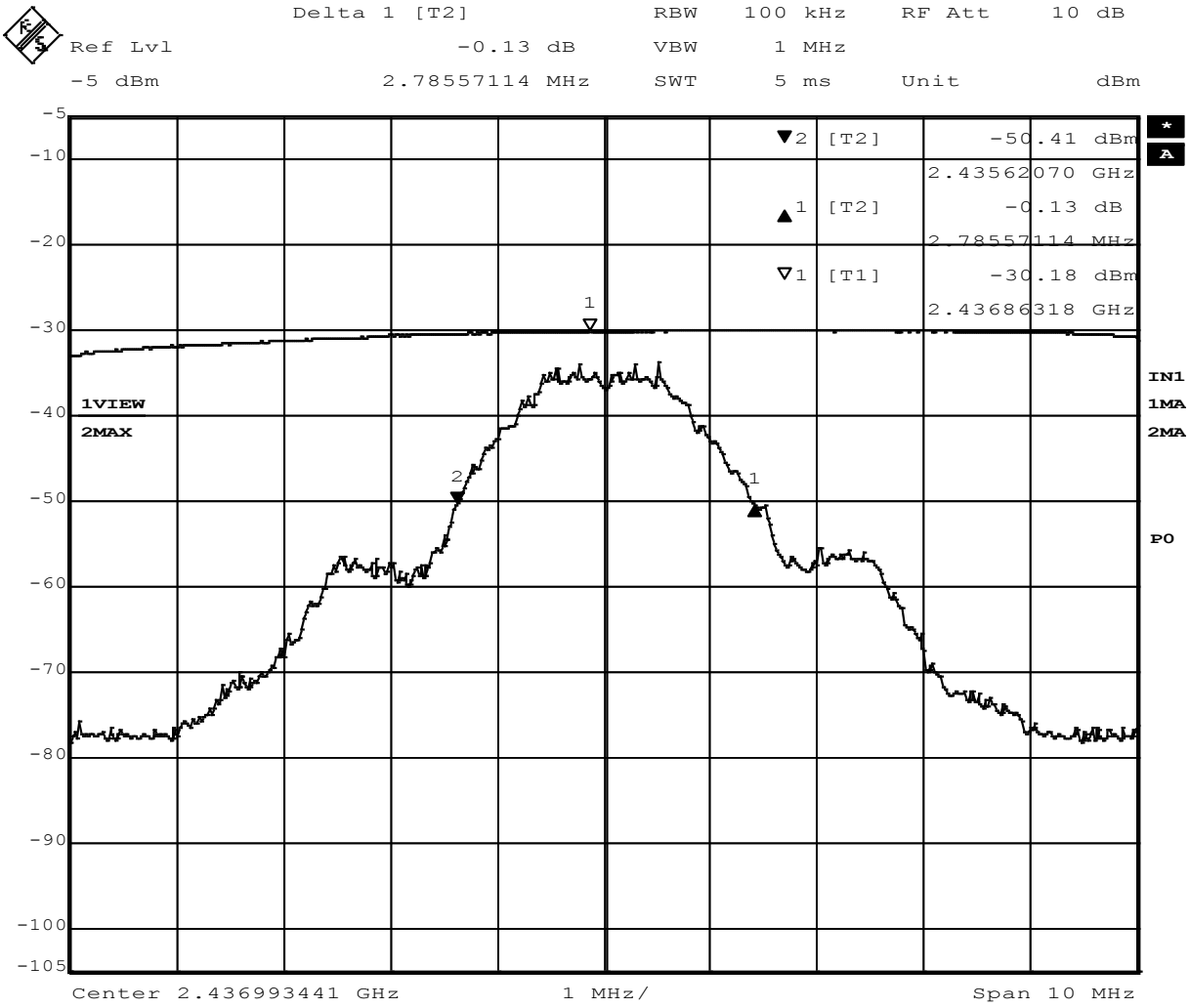

Figure 11 - 99% Occupied Bandwidth, Low Channel
The plot shows an uncorrected measurement.

Maximum power = -30.18 dBm + 107 + CL + AF - 95.23 = 17.26 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 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.

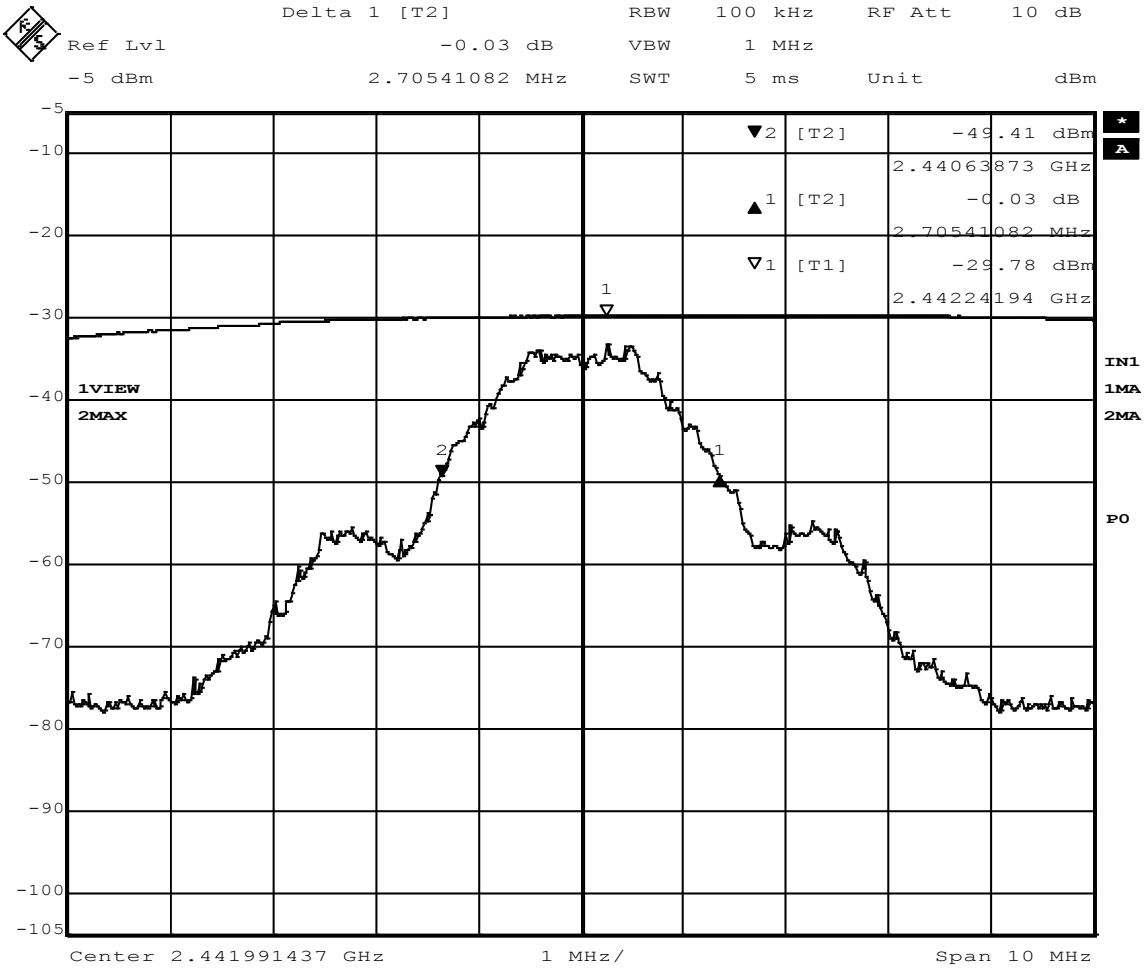

Figure 12 - 99% Occupied Bandwidth, Mid Channel
The plot shows an uncorrected measurement.

Maximum power = -29.78 dBm + 107 + CL + AF - 95.23 = 17.66 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 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.

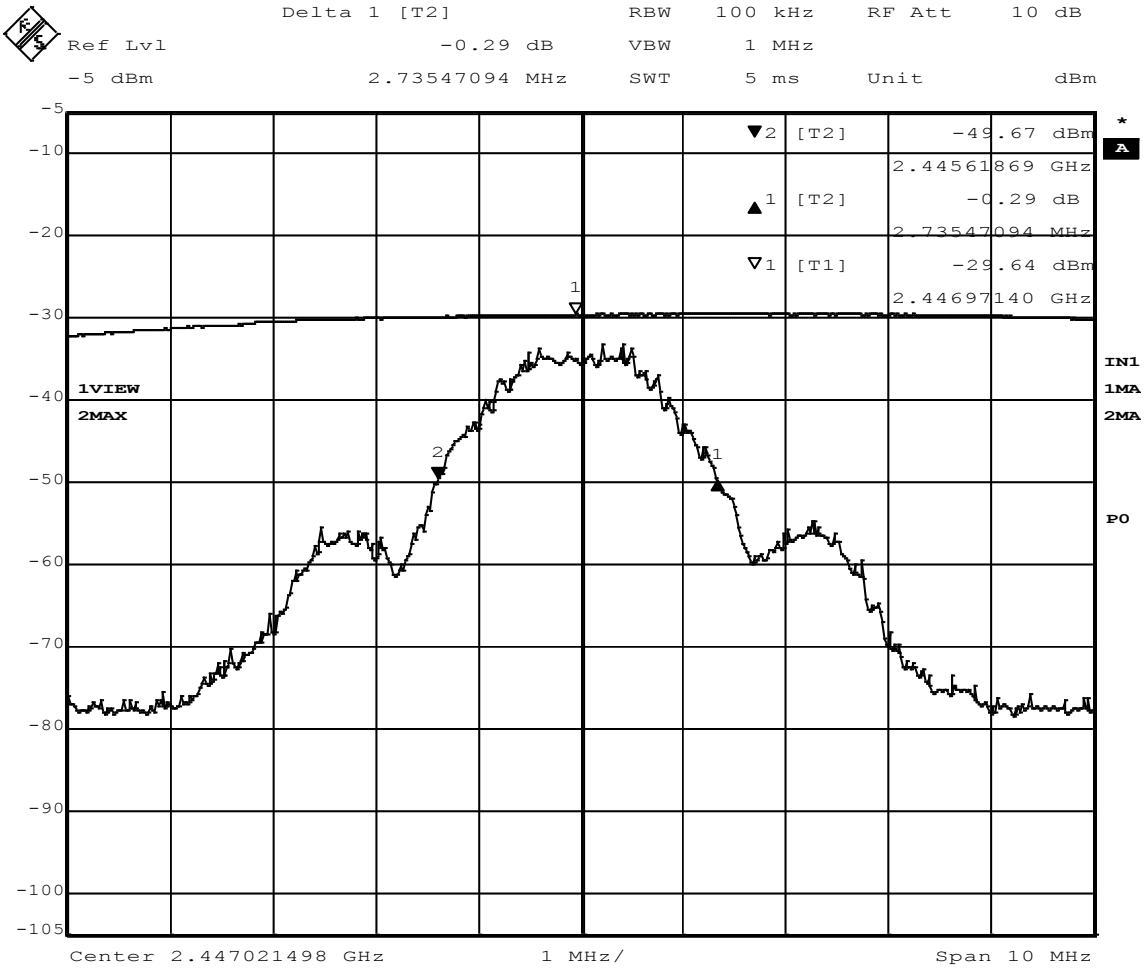

Figure 13 - 99% Occupied Bandwidth, High Channel
The plot shows an uncorrected measurement.

Maximum power = -29.64 dBm + 107 + CL + AF - 95.23 = 17.80 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 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.

4.4.3 Deviations from test standard

No deviation.

4.4.4 Test setup

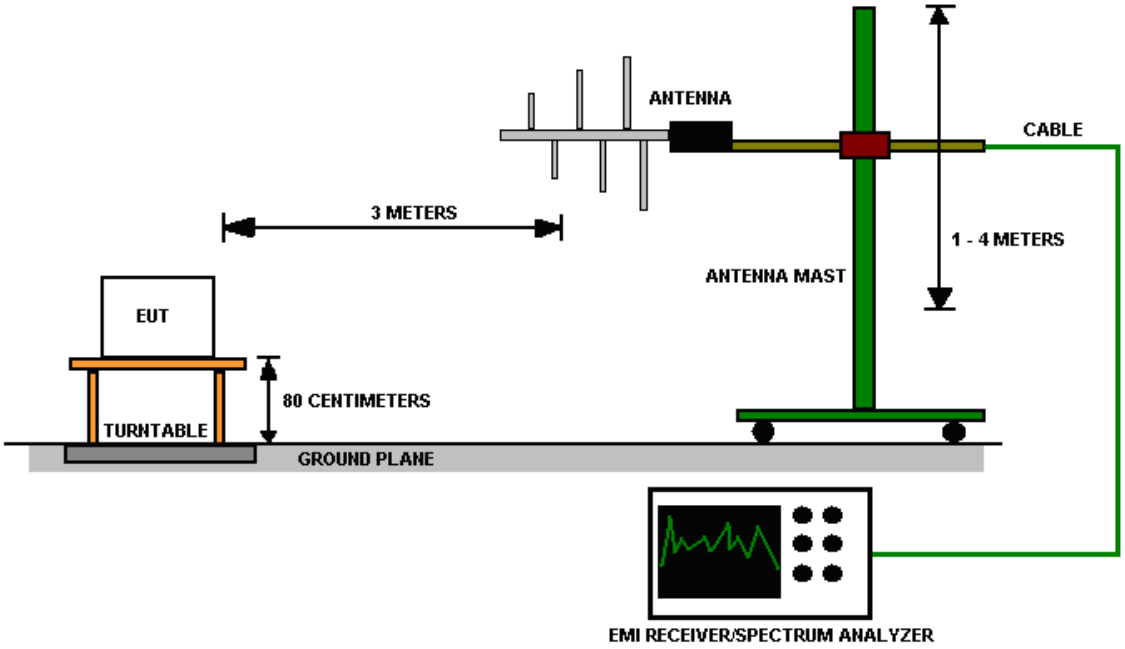

Figure 14 - Power Measurements Test Setup

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	i-Pilot Link Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
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	2437	17.26	30	PASS
2	2442	17.66	30	PASS
3	2447	17.80	30	PASS

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

REMARKS:

Section 4.3 gives the peak radiated field strength in dBm without correction factors

FS (dBµV/m) = FS (dBm) + 107 + CL + AF (50Ω measurement system)

CL = Cable loss (see section 4.2.2 or Appendix B for values)
AF = Antenna factor (see section 4.2.2 or Appendix B for values)
FS = Field strength

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

For an antenna distance of 3m and a numeric antenna gain of zero,

EIRP (dBm) = FS (dBµV/m) – 95.23

4.5 Bandedges

4.5.1 Limits of bandedge measurements

For emissions outside of the allowed band of operation (2400.0MHz – 2483.5MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 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	i-Pilot Link Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY BAND	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest Out of Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1 (2437 MHz)	2390.0	-100.29	-38.92	61.37	57.50*	PASS
3 (2447 MHz)	2483.5	-101.41	-38.15	63.26	59.96*	PASS

Highest In-Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest in-band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1 (2437 MHz)	2400.0	-98.96	-38.92	60.04	20.0	PASS
3 (2447 MHz)	2483.5	-101.41	-38.15	63.26	20.0	PASS

*Minimum delta = [highest fundamental peak field strength from Section 4.2] – [Part 15.209 radiated emissions limit.]

Measurements do not include correction factors

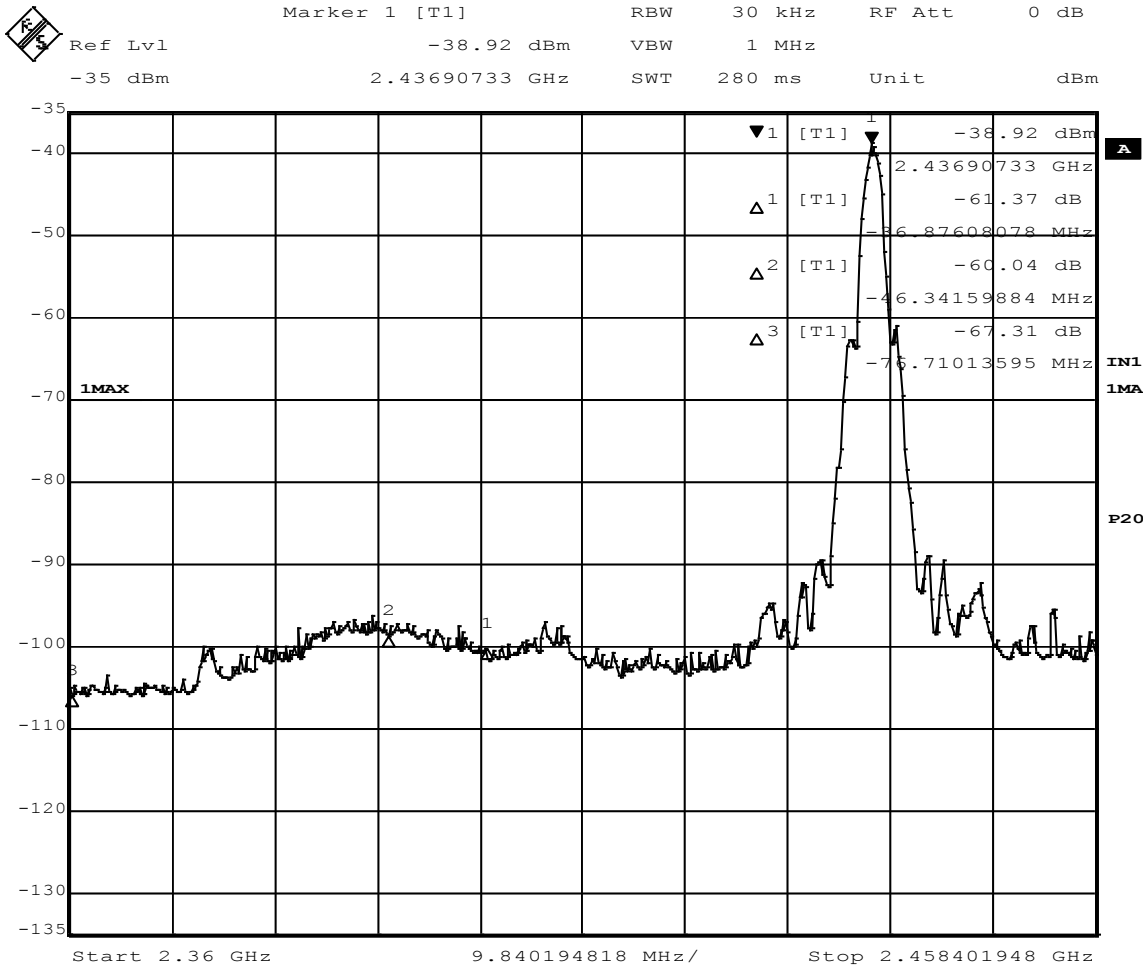

Figure 15 - Band-edge Measurement, Low Channel

The plot shows an uncorrected measurement. Used only for delta measurements.

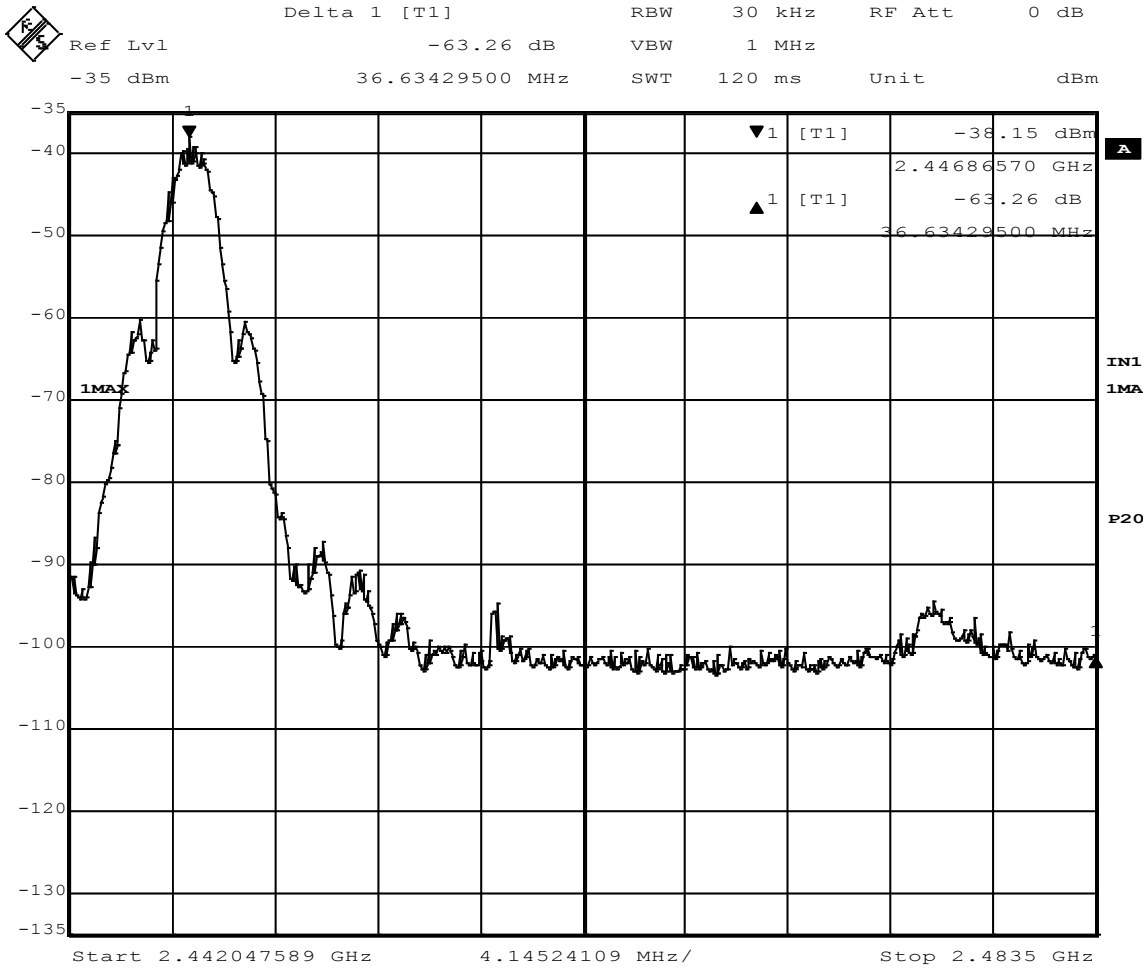

Figure 16 - Band-edge Measurement, High Channel

The plot shows an uncorrected measurement. Used only for delta measurements.

4.6 Power Spectral Density

4.6.1 Power spectral density measurements

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

4.6.2 Test procedures

All measurements were taken at a distance of 3m from the EUT. The spectrum analyzer was set to 3 kHz RBW and 30 kHz VBW, the sweep time was set to auto. The power spectral density was measured and recorded at the frequency with the highest emission. The sweep time is allowed to be longer than span/3KHz for a full response of the mixer in the spectrum analyzer.

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

4.6.3 Deviations from test standard

No deviation.

4.6.4 Test setup

See section 4.3

4.6.5 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, highest frequency channel and one in the middle of its operating range.

EUT MODULE	i-Pilot Link Head	MODE	Cont. Transmit
INPUT POWER	12 VDC Battery	FREQUENCY BAND	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	26 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	MAXIMUM POWER LIMIT (dBm)	RESULT
1	2437	1.77	8.00	PASS
2	2442	2.36	8.00	PASS
3	2447	2.06	8.00	PASS

The plots below give the peak radiated field strength in dBm without correction factors

FS (dBµV/m) = FS (dBm) + 107 + CL + AF (50Ω measurement system)

CL = Cable loss (see section 4.2.2 or Appendix B for values)
AF = Antenna factor (see section 4.2.2 or Appendix B for values)
FS = Field strength

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

For an antenna distance of 3m and a numeric antenna gain of zero,

EIRP (dBm) = FS (dBµV/m) – 95.23

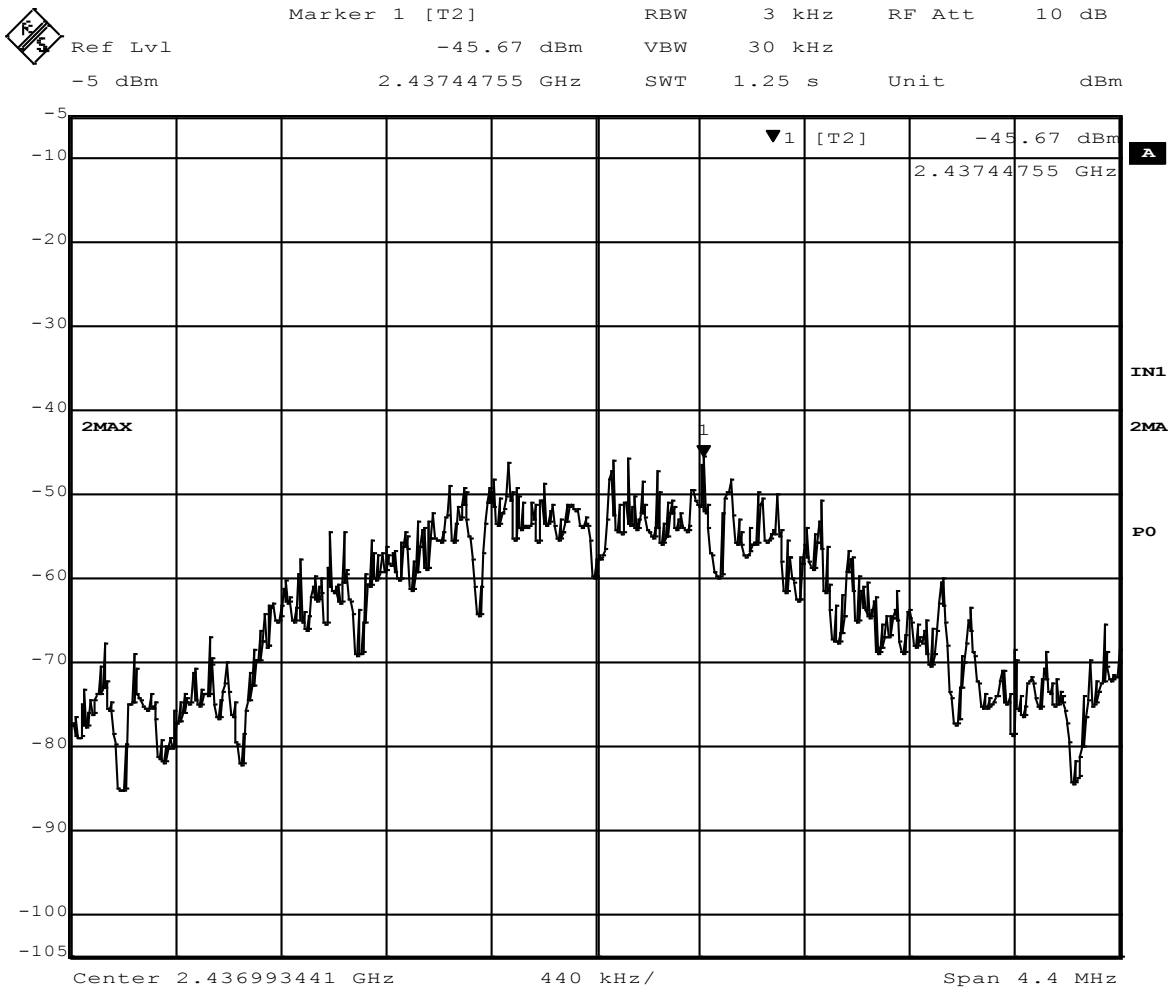

Figure 17 - Power Spectral Density Measurement, Low Channel
The plot shows an uncorrected measurement.

Maximum PSD = -45.67 dBm + 107 + CL + AF - 95.23 = 1.77 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 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.

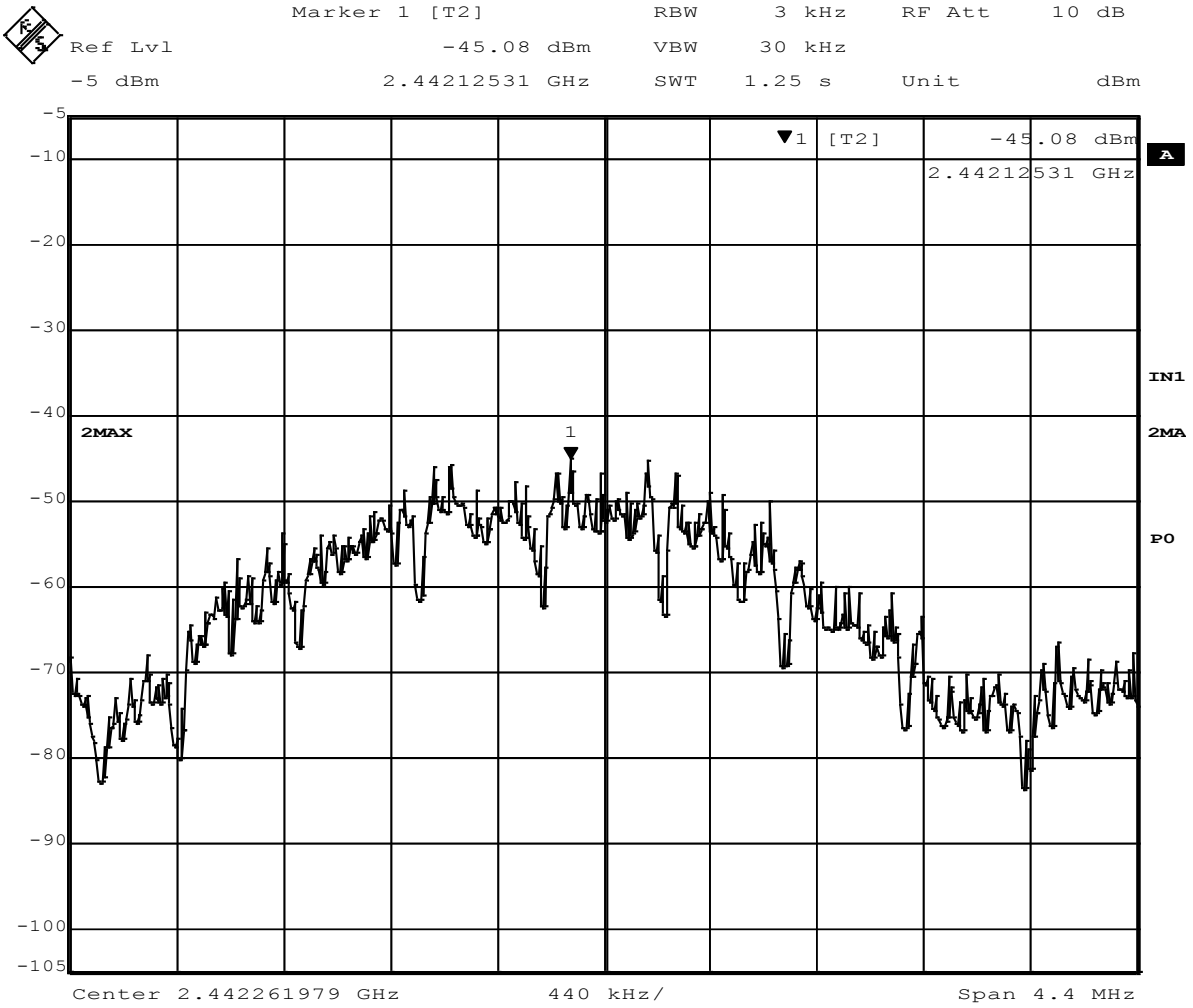

Figure 18 - Power Spectral Density Measurement, Mid Channel
The plot shows an uncorrected measurement.

Maximum PSD = -45.08 dBm + 107 + CL + AF - 95.23 = 2.36 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 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.

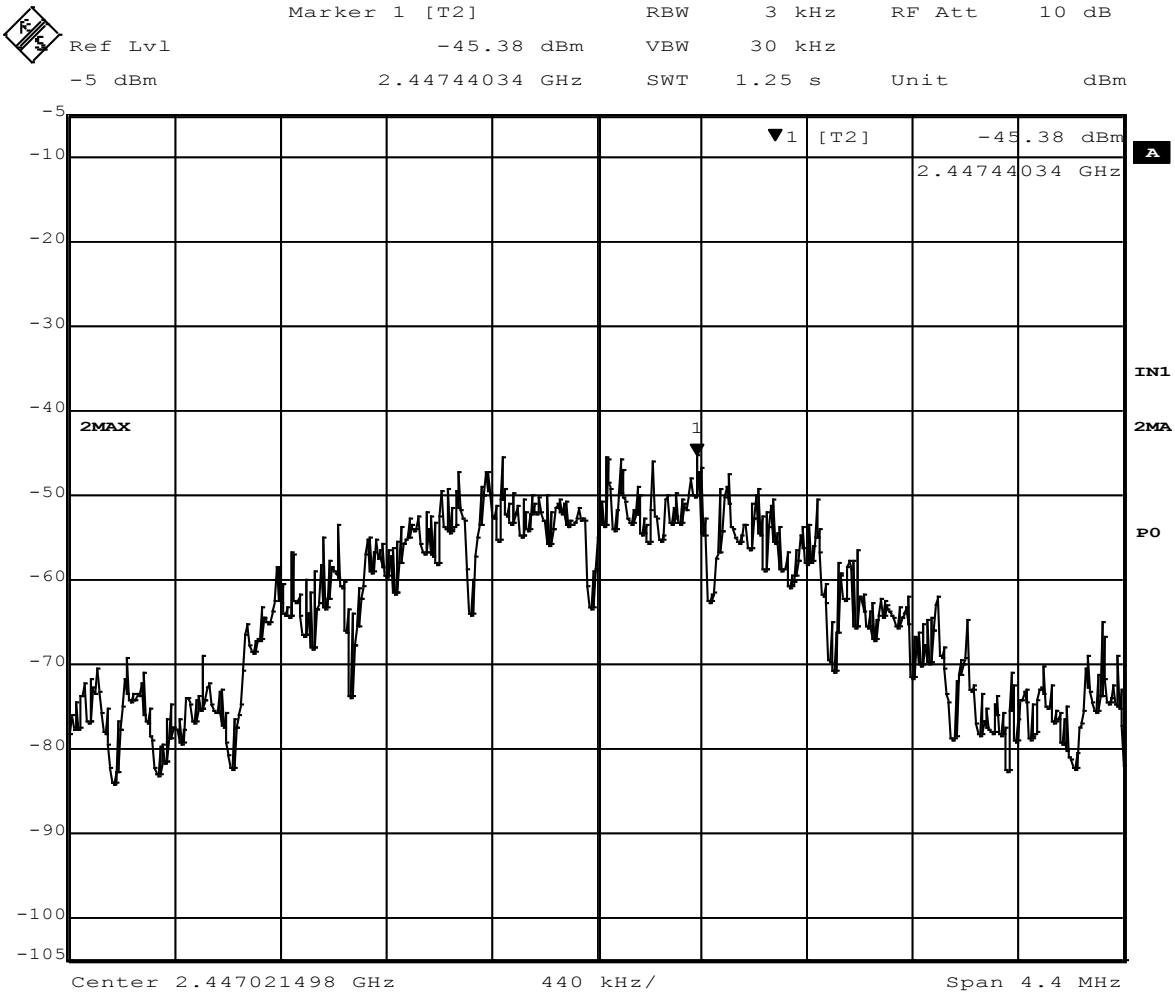

Figure 19 - Power Spectral Density Measurement, High Channel
The plot shows an uncorrected measurement.

Maximum PSD = -45.38 dBm + 107 + CL + AF - 95.23 = 2.06 dBm

CF = cable loss = 7.20 dB
AF = antenna factor = 28.47 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.

Appendix A: Test Photos

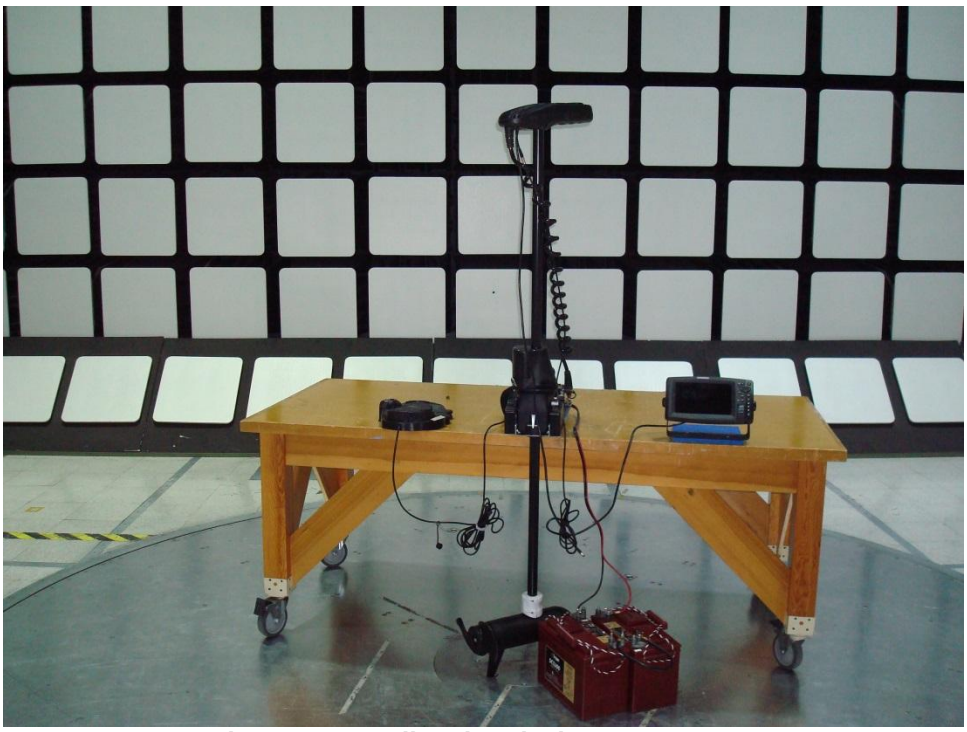

Figure 20 – Radiated Emissions Test Setup

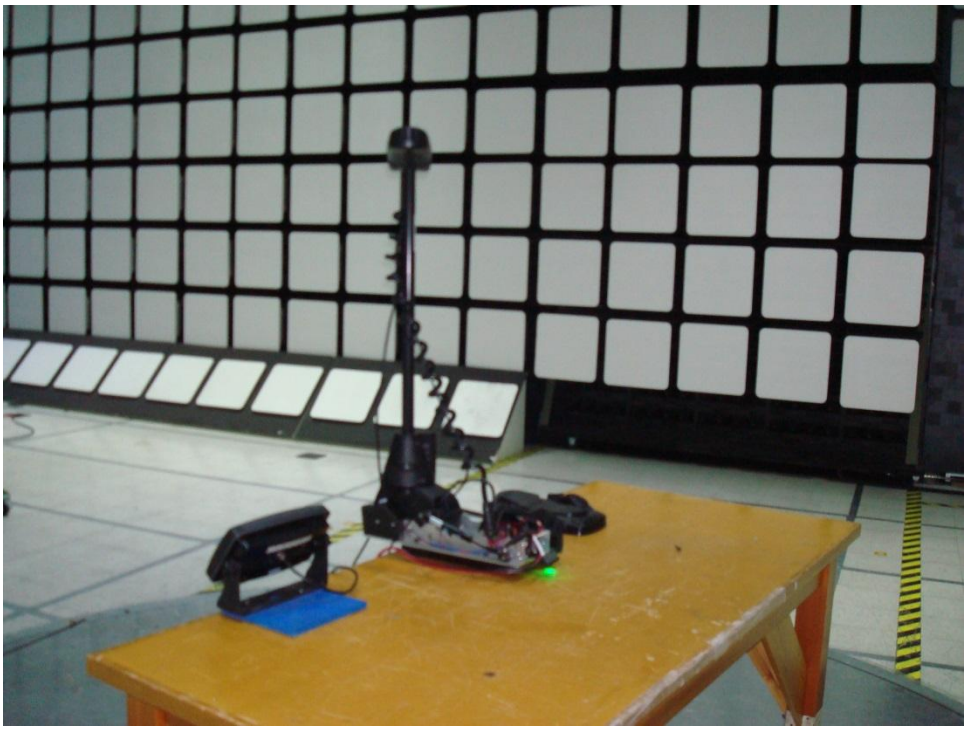

Figure 21 - Radiated Emissions Test Setup

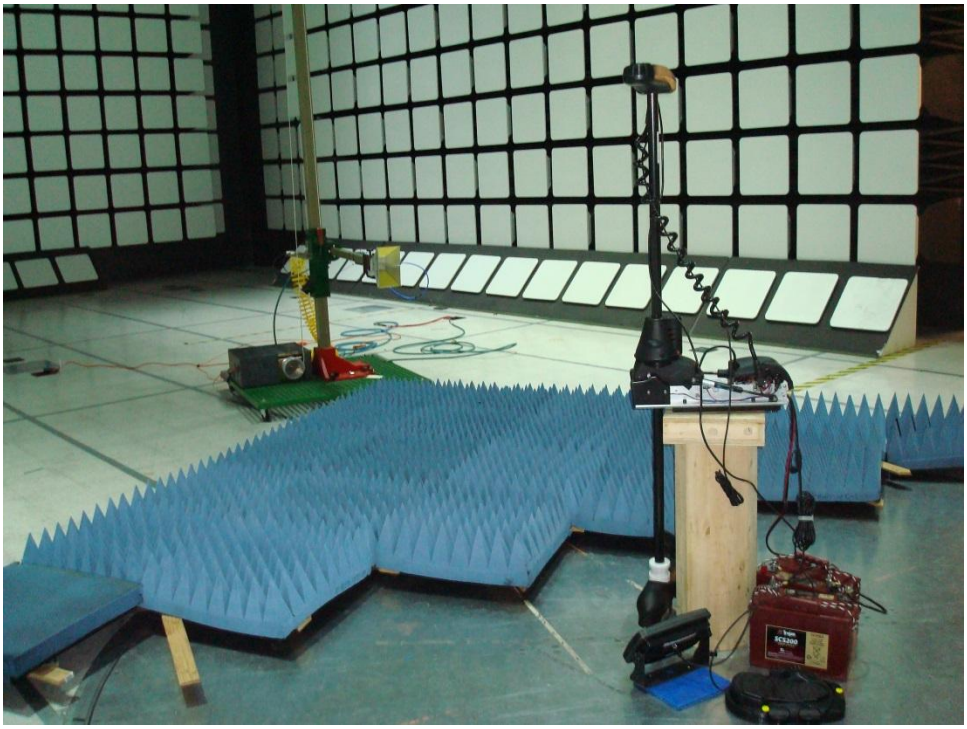

Figure 22 - Radiated Emissions Test Setup

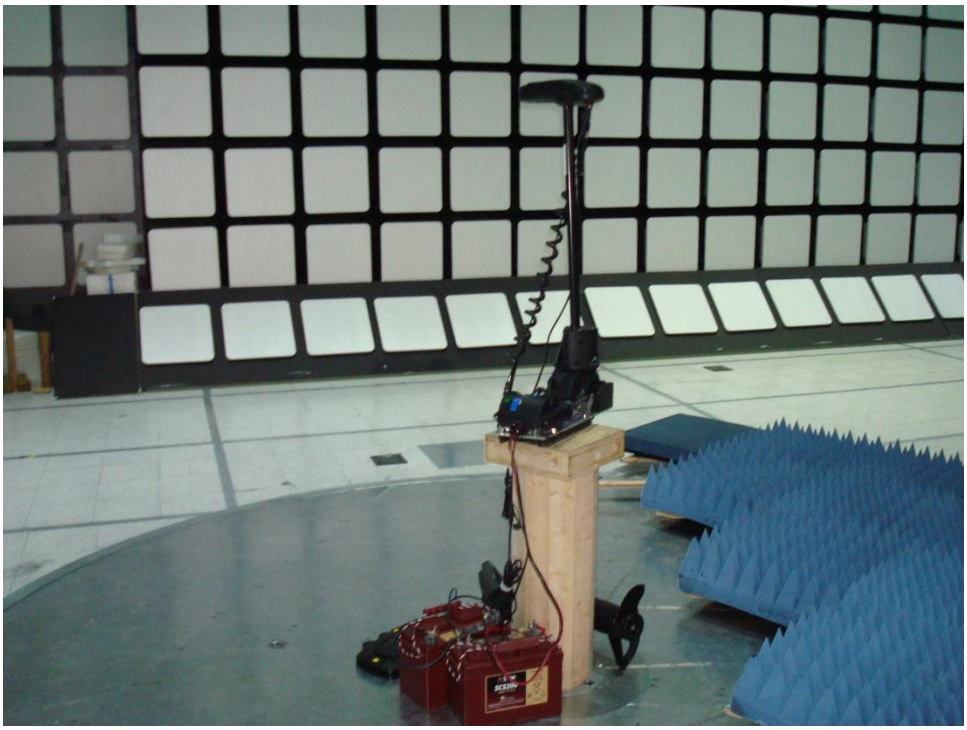

Figure 23 - Radiated Emissions Test Setup

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

For an antenna distance of 3m and a numeric antenna gain of zero,

EIRP (dBm) = FS (dBµV/m) – 95.23

Table 14 – Correction Factor Applied in Sections 4.3, 4.4 and 4.6

CHANNEL	CHANNEL FREQUENCY (MHz)	ANTENNA FACTOR	CABLE LOSS
1	2437	28.47	7.20
2	2442	28.47	7.20
3	2447	28.47	7.20

Appendix C: Table of Figures

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Table Number **Page**