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Amended Test Report

Includes NCEE Labs report R20130208-20-04A and its amendment in full

Client:	**Johnson Outdoors** **1531 Madison Ave.** **Mankato, MN 56001**
Product:	**i-Pilot Link System** **Motor Controller**
FCC ID:	**T62-IPCON20**
IC ID:	**4397A-IPCON20**
Test Report No:	**R20130208-20- 04B**
Approved By:	**Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
Date:	**30 September 2013**
Total Pages:	**46**

ACCREDITED
Test Laboratory Certificate 1953.01

1.0 Summary of test results

1.1 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	Unique Antenna Requirement	Pass	Permanently attached antenna
15.207 RSS-Gen	Conducted Emissions	NA	No connection to AC mains network
15.209 RSS-Gen	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.

1.2 Test Methods

1.2.1 Radiated Emissions

Compliance to 47 CFR Parts 15.209 and 15.247 and Industry Canada RSS 210, Issue 8 was tested in accordance with the methods of ANSI/IEEE C63.4: 2003 and KDB Publication No. 558074: 2013. Several configurations were examined and the results presented represent a worst-case scenario. The EUT was placed on a wooden table approximately 80cm high and centered on a 4m diameter turntable. The table was rotated to find the angles of maximum emissions and the height of the receiving antenna above the ground plane was moved from 1m to 4m in both vertical and horizontal positions. The EUT was tested while sitting horizontally.

1.3 Reason for amendment

Band edge measurements were repeated as documented in KDB 558074:2013.

Section 2.3 was modified to show channel 1 is actually 2437 MHz.

Channel 1 on page 4.3.6 has been changed to 2437 MHz. This matches the data in Figure 8 for this channel.

References to KDB 558074 were changed to the 2013 version.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was controller used to install into a trolling motor to allow control from an i-Pilot remote using the i-Pilot Link System.

EUT Received Date: 21 March 2013
EUT Tested Dates: 22 March 2013 – 16 April 2013

PRODUCT	i-Pilot Link System Motor Controller
MODEL NUMBER	NCEETEST 1(assigned)
SERIAL NUMBER	M290UM00068
POWER SUPPLY	12VDC
MODULATION TYPE	FM
RADIO TECHNOLOGY	Half-duplex RF Link
FREQUENCY RANGE	2.4GHz
MAX OUTPUT POWER	21.36 dBm EIRP
ANTENNA TYPE	Internal Dipole
ASSOCIATED EQUIPMENT	i-Pilot Link System Remote

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 40 ± 4%
Temperature of 22 ± 3° Celsius

2.3 Description of test modes

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

Channel	Frequency
1	2437
2	2441
3	2447

These are the only three frequencies possible.

2.4 Applied standards

The EUT uses digital modulation and operates between 2400.0MHz and 2483.5MHz. There are no provisions for connection to the AC mains. 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)
KDB Publication No. 558074: 2013
Industry Canada RSS-GEN
Industry Canada RSS-210 issue 9

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	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver**	ES126	100037	2/01/ 2013	02/01/2014
EMCO Biconilog Antenna*	3142B	1647	12/7/2012	12/7/2013
EMCO Horn Antenna**	3115	6415	1/12/2011	1/12/2014
EMCO Horn Antenna***	3116	2576	6/14/2011	6/14/2014
NCEEPAHF2*	TS-PR18	NCEEPA2(assigned)	03/15/2013	03/15/2014****
Trilithic High Pass Filter*	6HC330	23042	12/15/2012****	12/15/2013****

*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 antenna is 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. For measurements from 30MHz – 1GHz, the EUT was set 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower. Measurements from 1GHz to 26GHz were performed at a 3m test distance.

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.

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.

3. Measurements were performed at 10m. The limit was extrapolated to a 10m test distance.

4.2.3 Deviations from test standard

No deviation.

4.2.4 Test setup

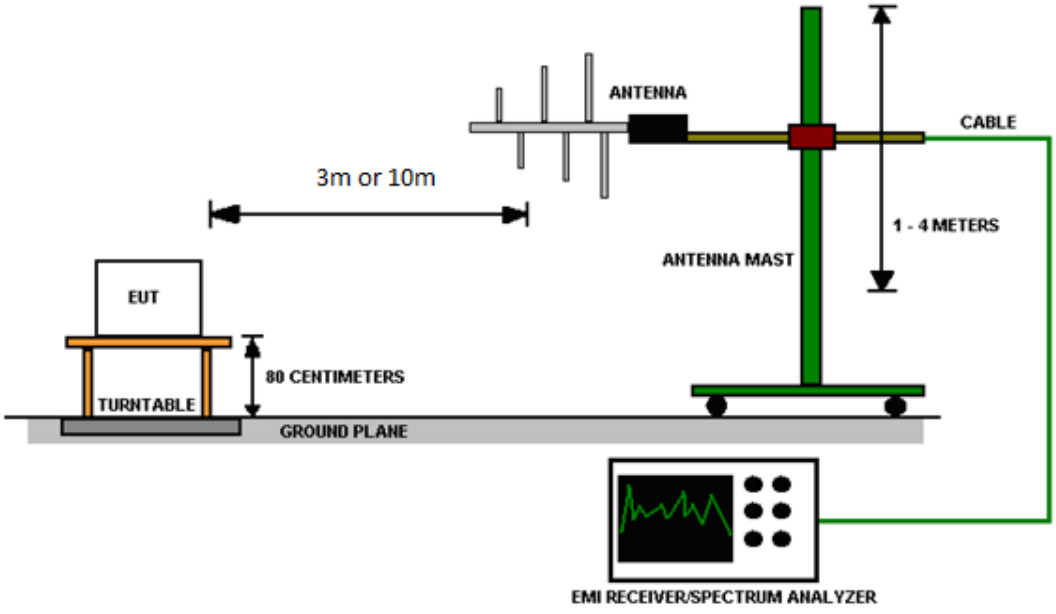

Figure 1 - Radiated Emissions Test Setup

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 12VDC and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. For measurements the EUT was tested alone in the horizontal position.

4.2.6 Calculation of EUT duty cycle

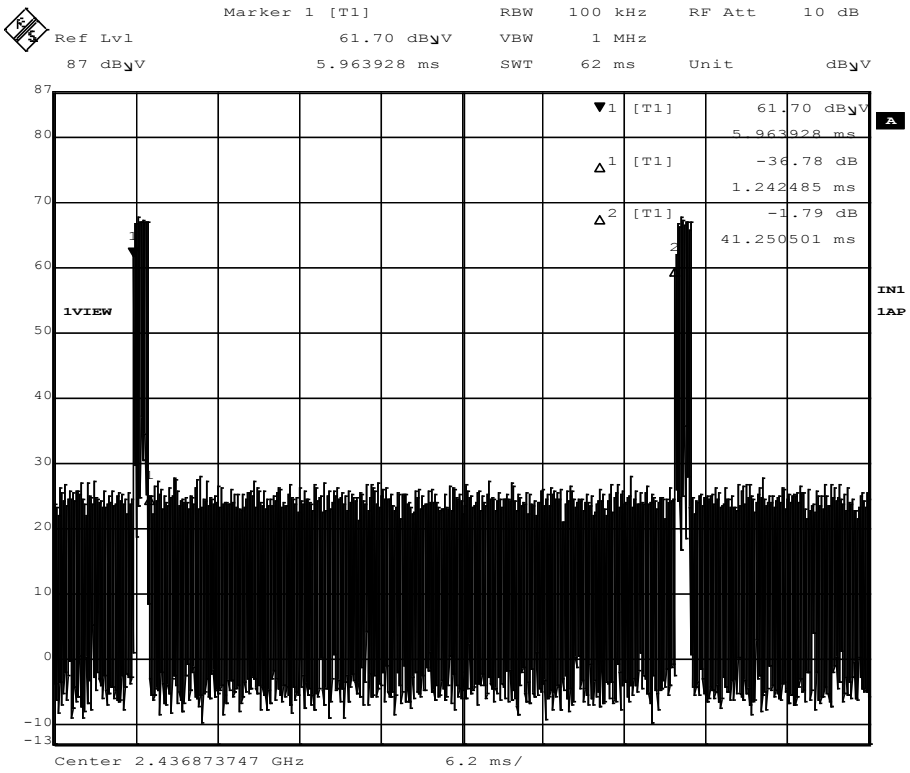

Figure 2 - Duty Cycle = 20log(1.24/41.25) = -30.44dB

Maximum duty cycle allowed is 20dB.

Pulse length;
Marker 1 to Delta 1 = 1.24285 ms (as displayed on plot as a delta measurement)

Pulse period;
Marker 1 to Delta 2 = 41.250501 ms (as displayed on plot as a delta measurement)

4.2.6 Test results

EUT	i-Pilot Link System Motor Controller	MODE	Receive
INPUT POWER	12VDC	FREQUENCY RANGE	30MHz – 1GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

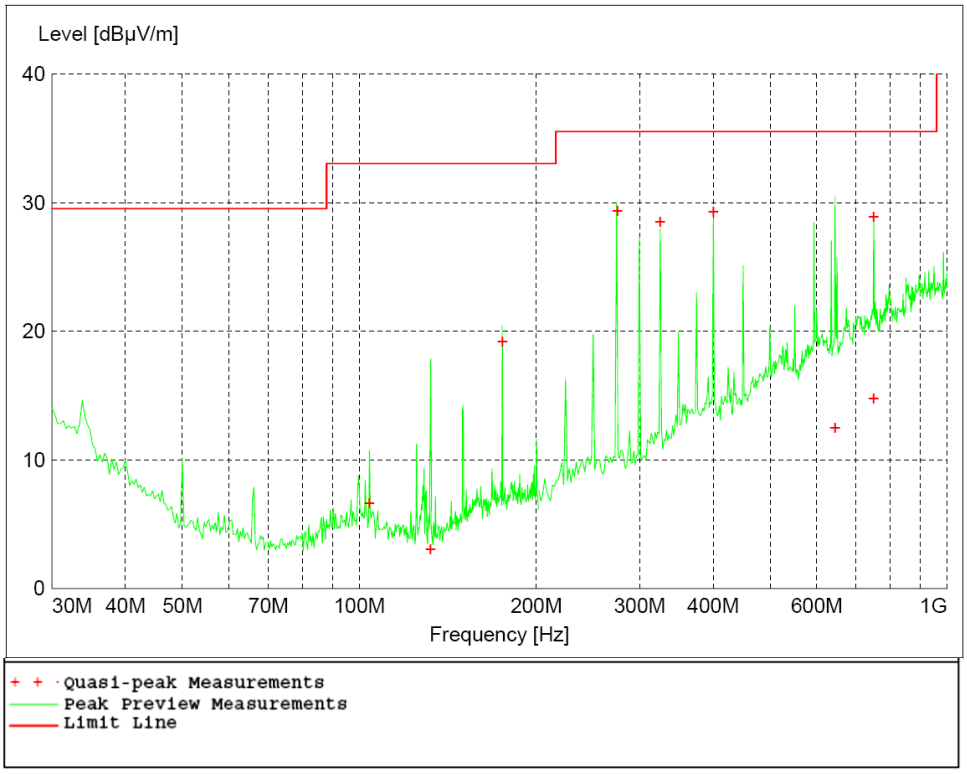

Figure 3 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
103.980000	6.59	33.04	26.45	376	57	VERT
132.180000	3.04	33.04	30.00	102	25	VERT
175.020000	19.18	33.04	13.86	98	206	VERT
275.020000	29.31	35.40	6.09	313	274	HORI
325.000000	28.47	35.40	6.93	100	308	VERT
400.000000	29.27	35.40	6.13	250	113	HORI
644.320000	12.47	35.40	22.93	249	337	VERT
749.980000	28.85	35.40	6.55	115	298	HORI
750.220000	14.76	35.40	20.64	139	335	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.

EUT	i-Pilot Link System Motor Contorller	MODE	Channel 1
INPUT POWER	12VDC	FREQUENCY RANGE	30MHz – 1GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

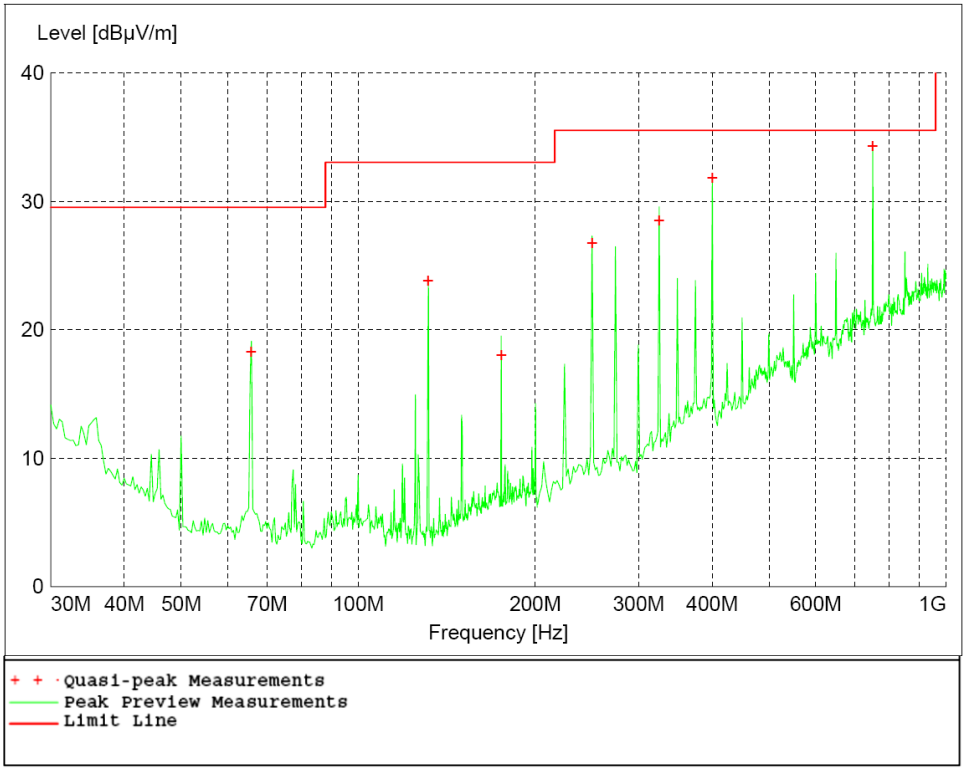

Figure 4 - Radiated Emissions Plot, Channel 1

Table 2 - Radiated Emissions Quasi-peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
65.760000	18.28	29.54	11.26	356	210	VERT
131.520000	23.76	33.04	9.28	103	24	VERT
175.020000	17.97	33.04	15.07	152	56	VERT
250.000000	26.70	35.40	8.70	99	193	VERT
325.000000	28.47	35.40	6.93	104	151	VERT
400.000000	31.80	35.40	3.60	193	308	HORI
749.980000	34.30	35.40	1.10	99	293	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.

EUT	i-Pilot Link System Motor Controller	MODE	Channel 2
INPUT POWER	12VDC	FREQUENCY RANGE	30MHz – 1GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

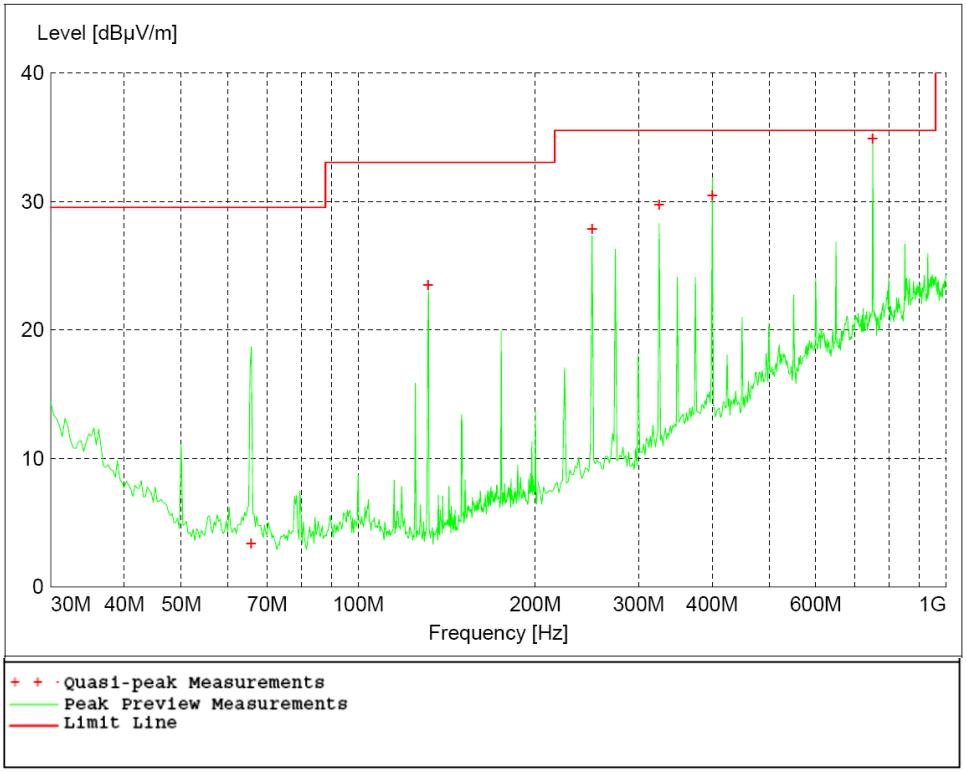

Figure 5 - Radiated Emissions Plot, Channel 2

Table 3 - Radiated Emissions Quasi-peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
65.760000	3.34	29.54	26.20	263	229	VERT
131.520000	23.45	33.04	9.59	103	359	VERT
250.000000	27.83	35.40	7.57	99	193	VERT
325.000000	29.70	35.40	5.70	100	152	VERT
400.000000	30.40	35.40	5.00	152	296	HORI
749.980000	34.84	35.40	0.56	101	300	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.

EUT	i-Pilot Link System Motor Contorller	MODE	Channel 3
INPUT POWER	12VDC	FREQUENCY RANGE	30MHz – 1GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

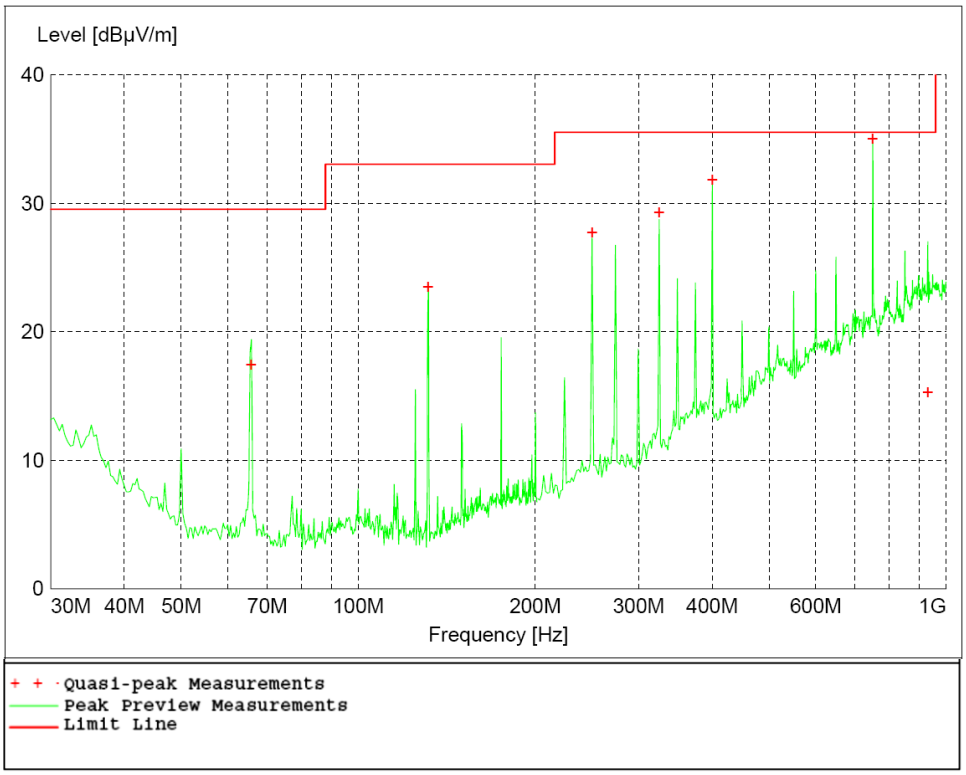

Figure 6 - Radiated Emissions Plot, Channel 3

Table 4 - Radiated Emissions Quasi-peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
65.760000	17.43	29.54	12.11	349	307	VERT
131.460000	23.45	33.04	9.59	103	356	VERT
250.000000	27.72	35.40	7.68	101	187	VERT
325.000000	29.28	35.40	6.12	102	149	VERT
400.000000	31.78	35.40	3.62	206	306	HORI
749.980000	35.02	35.40	0.38	103	295	HORI
930.640000	15.27	35.40	20.13	150	316	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.

EUT	i-Pilot Link System Motor Controller	MODE	Receive
INPUT POWER	12VDC	FREQUENCY RANGE	1GHz – 26GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Table 5 - Radiated Emissions Average Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
4893.00000	46.06	54.00	7.90	163.00	237	HORI

Table 6 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
4893.00000	63.07	74.00	10.93	163.00	237	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.

EUT	i-Pilot Link System Motor Controller	MODE	Channel 1
INPUT POWER	12VDC	FREQUENCY RANGE	1GHz – 26GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Table 7 - Radiated Emissions Average Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2437.50000	82.44*	NA	NA	106.00	216	HORI
4889.50000	39.75*	54.00	14.25	224.00	360	HORI

Table 8 - Radiated Emissions Peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2437.50000	112.44	NA	NA	106.00	216	HORI
4889.50000	59.75	74.00	14.25	224.00	360	HORI

*Calculated from the peak measurement and the duty cycle correction from Section

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.
highest emission
5. Measurements at the fundamental frequency were done with a peak detector only.
6. *NA Field strength limits do not apply at the fundamental frequency.

EUT	i-Pilot Link System Motor Controller	MODE	Channel 2
INPUT POWER	12VDC	FREQUENCY RANGE	1GHz – 26GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Table 9 - Radiated Emissions Average Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2442.50000	89.93*	NA	NA	166.00	203	HORI
4875.00000	39.17*	54.00	14.83	187.00	116	VERT

Table 10 - Radiated Emissions Peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2442.50000	109.93	NA	NA	166.00	203	HORI
4875.00000	59.17	74.00	14.83	187.00	116	VERT

*Calculated from the peak measurement and the duty cycle correction from Section

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.
highest emission
5. Measurements at the fundamental frequency were done with a peak detector only.
6. *NA Field strength limits do not apply at the fundamental frequency.

EUT	i-Pilot Link System Motor Controller	MODE	Channel 3
INPUT POWER	12VDC	FREQUENCY RANGE	1GHz – 26GHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Table 11 - Radiated Emissions Average Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2446.50000	90.80*	NA	NA	106.00	209	HORI
4882.50000	39.32*	54.00	14.68	274.00	182	VERT

Table 12 - Radiated Emissions Peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2446.50000	110.80	NA	NA	106.00	209	HORI
4882.50000	59.32	74.00	14.68	274.00	182	VERT

*Calculated from the peak measurement and the duty cycle correction from Section

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.
highest emission
5. Measurements at the fundamental frequency were done with a peak detector only.
6. *NA Field strength limits do not apply at the fundamental frequency.

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. 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

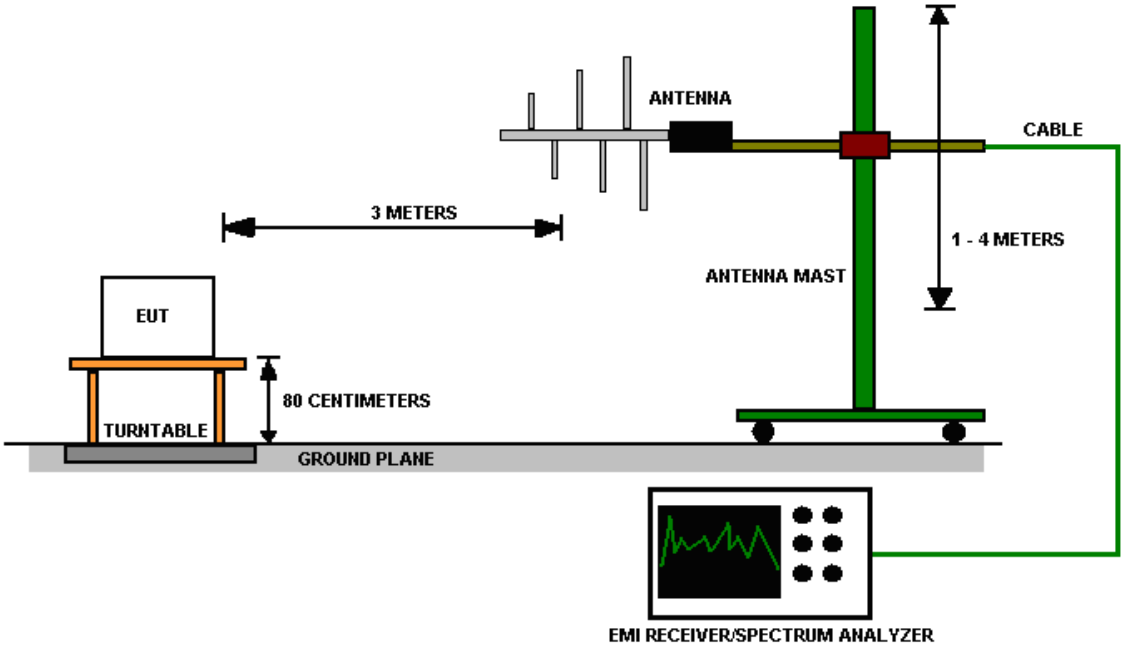

Figure 7 - Bandwidth Measurements Test Setup

4.3.5 EUT operating conditions

The EUT was powered by 12VDC 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	i-Pilot Link System Motor Controller	MODE	Cont. Transmit
INPUT POWER	12VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	6dB BW (MHz)	6dB Limit Min (kHz)	RESULT
1	2437	1663	500.00	PASS
2	2441	1553	500.00	PASS
3	2447	1543	500.00	PASS

REMARKS:
None

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
1	2437	2525
2	2441	2484
3	2447	2585

REMARKS:
None

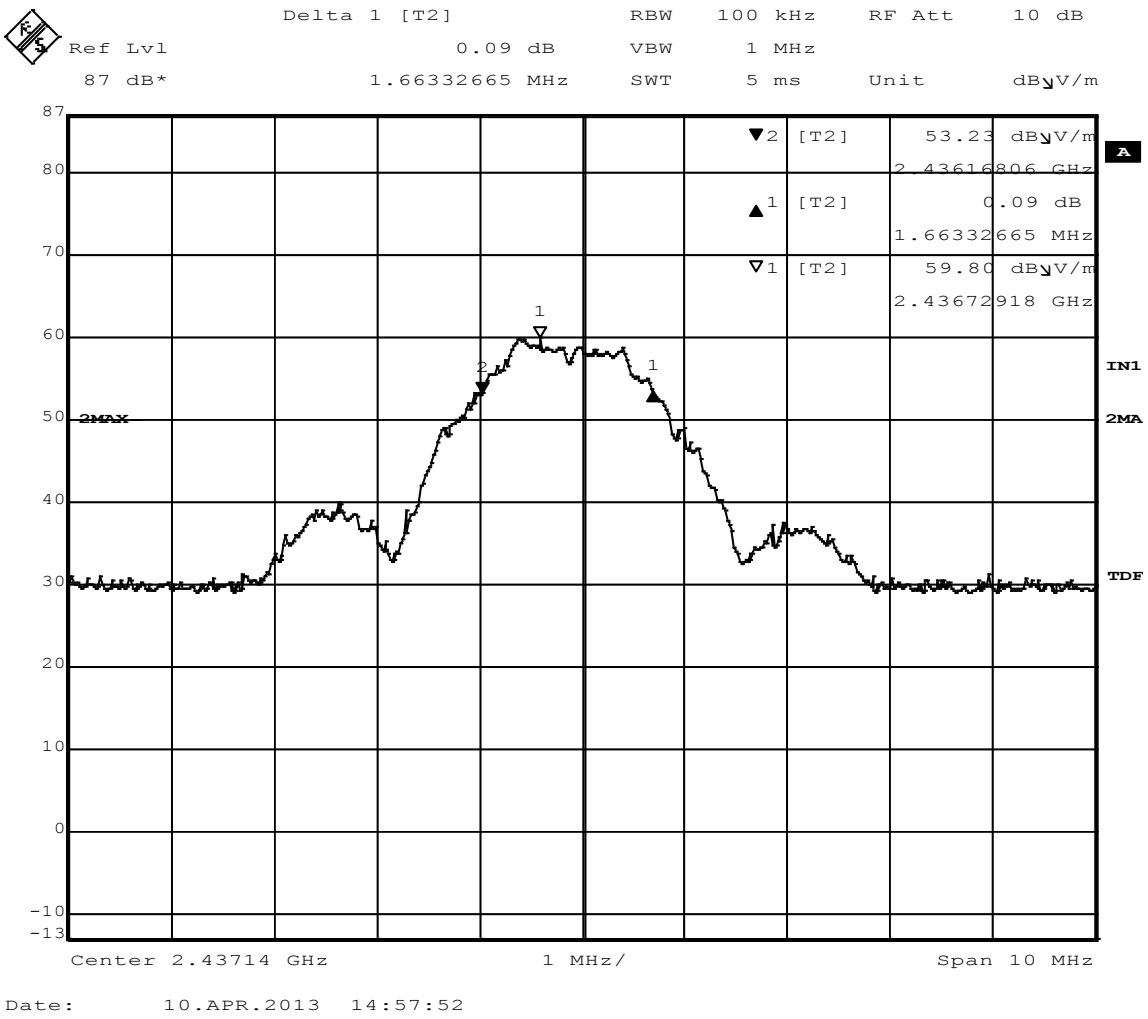

Figure 8 - 6dB Bandwidth, Low Channel

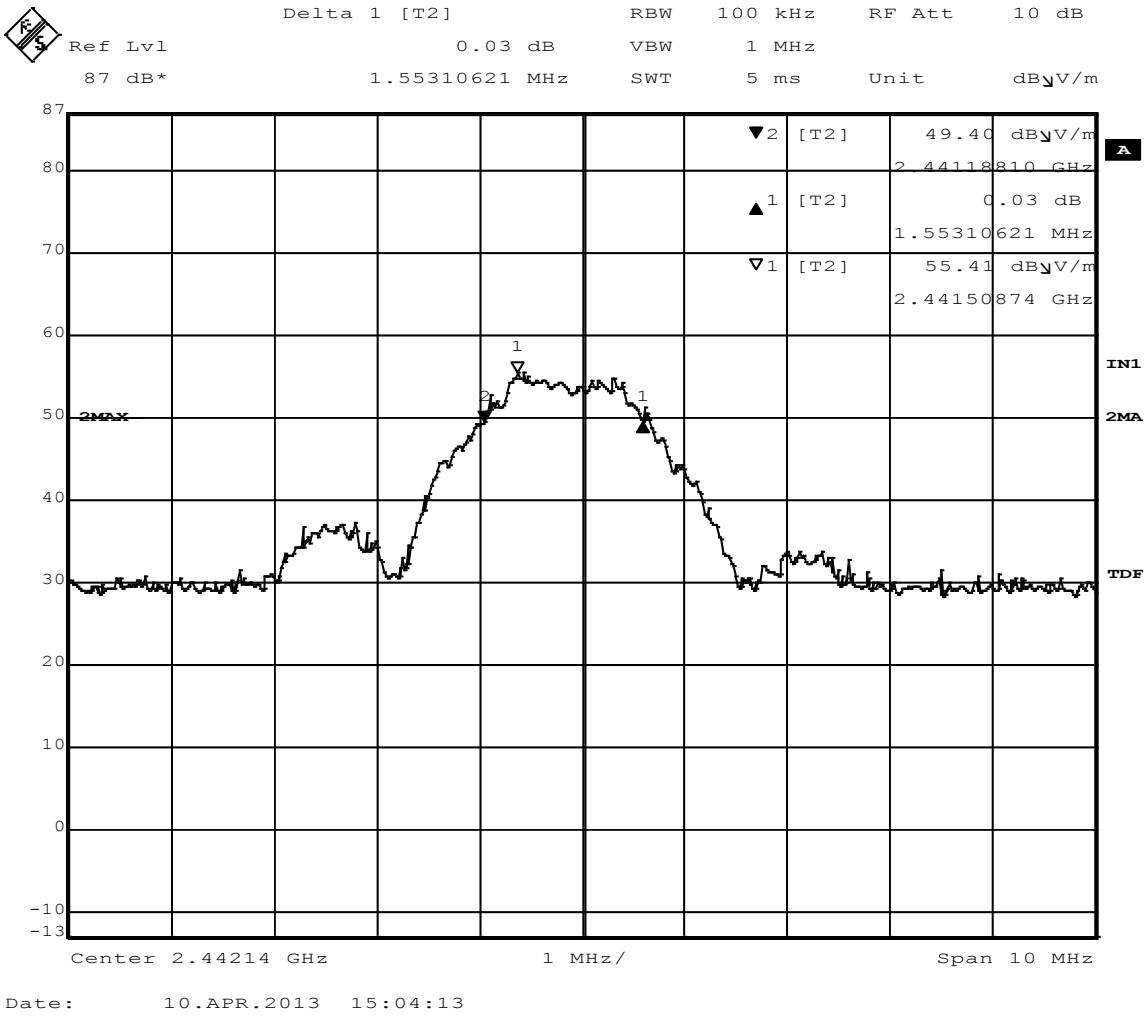

Figure 9 - 6dB Bandwidth, Middle Channel

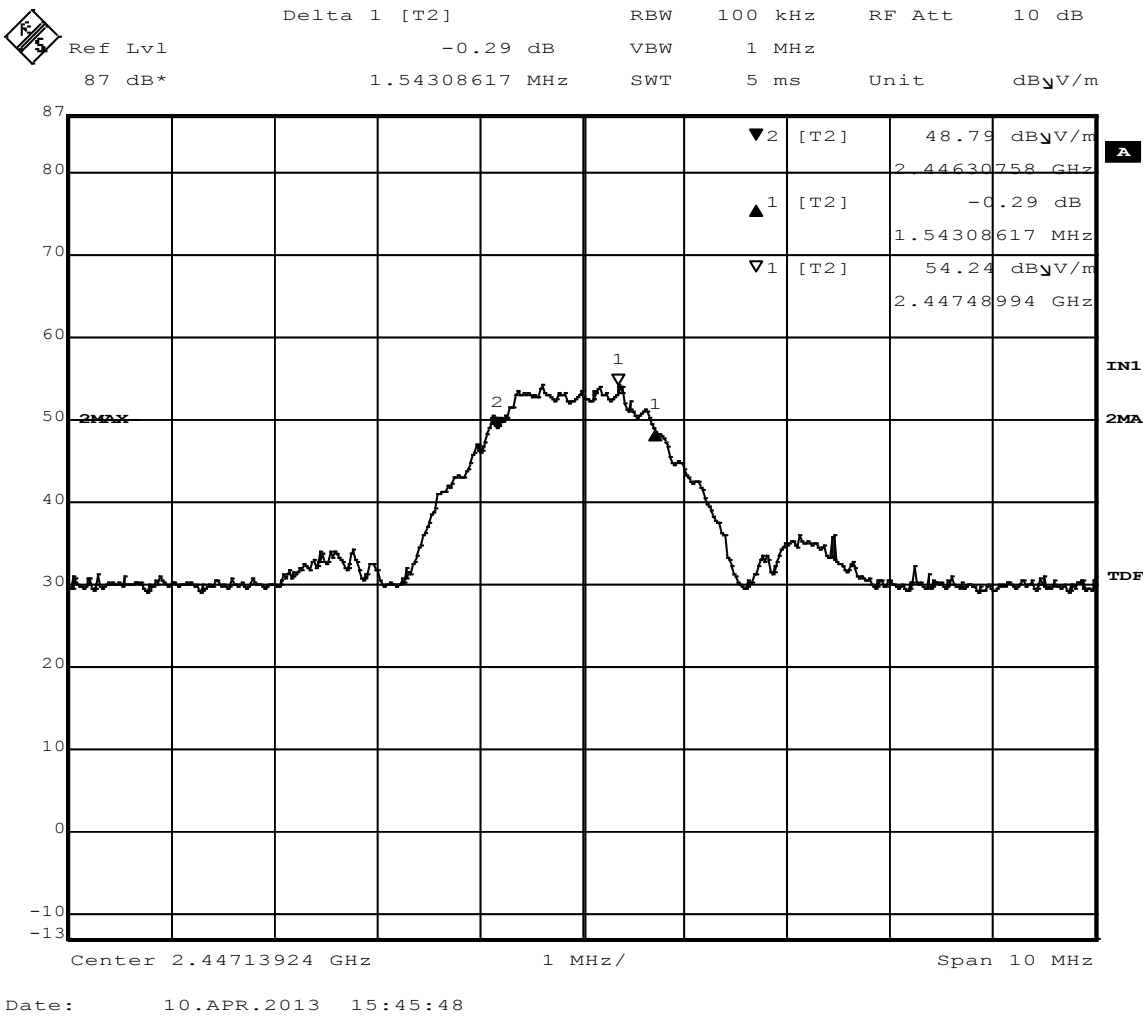

Figure 10 - 6dB Bandwidth, High Channel

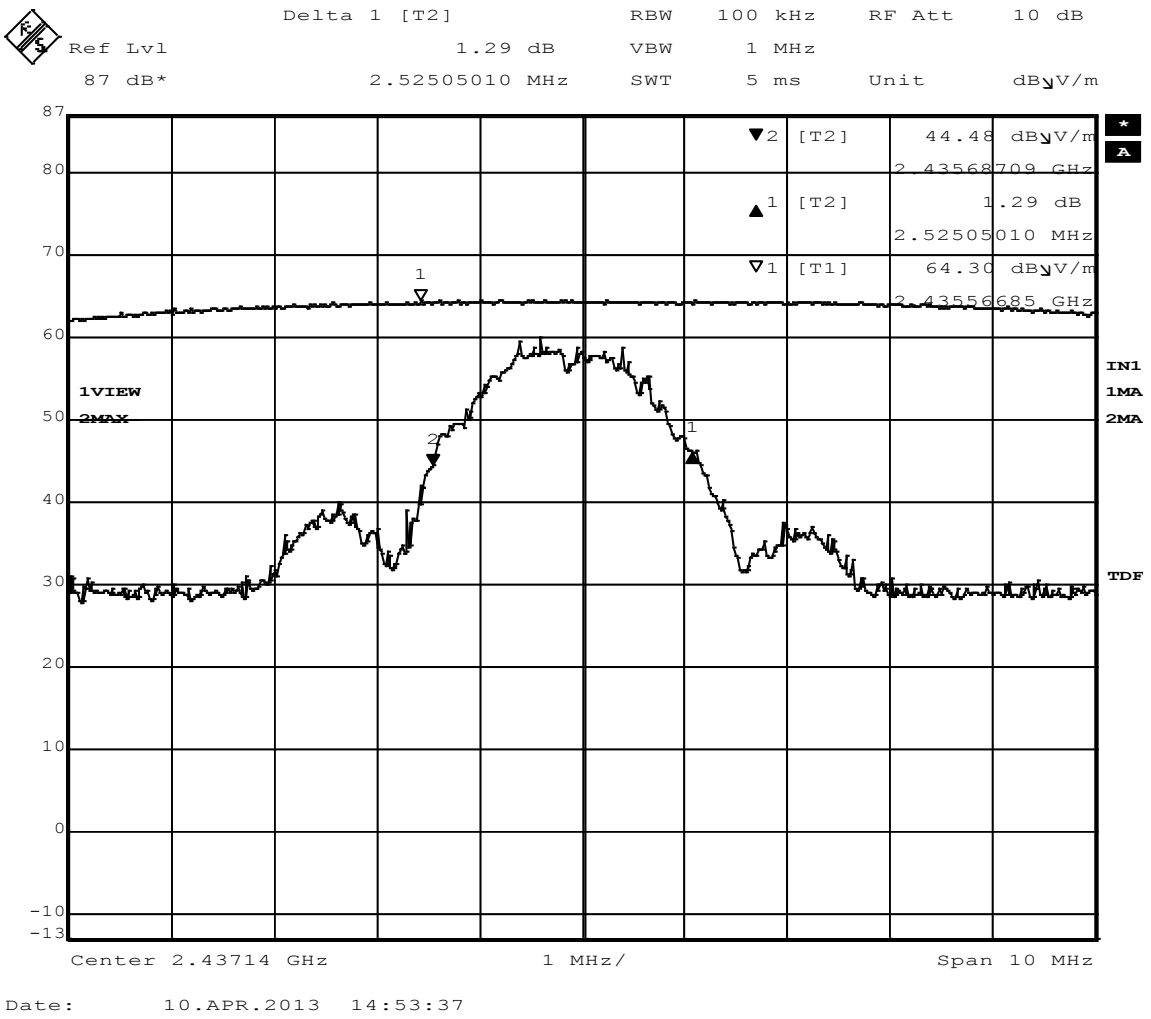

Figure 11 - 99% Occupied Bandwidth, Low Channel

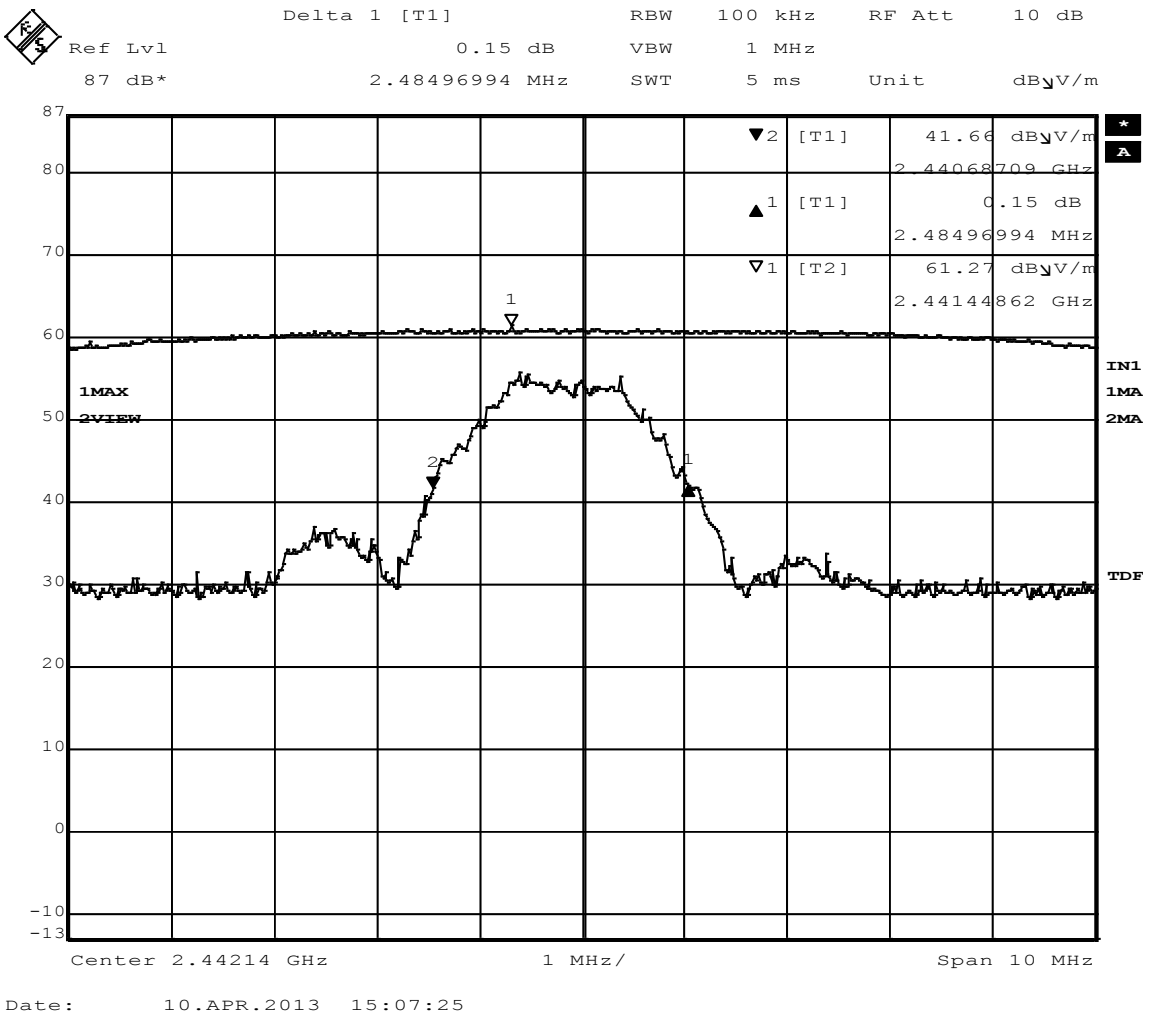

Figure 12 - 99% Occupied Bandwidth, Mid Channel

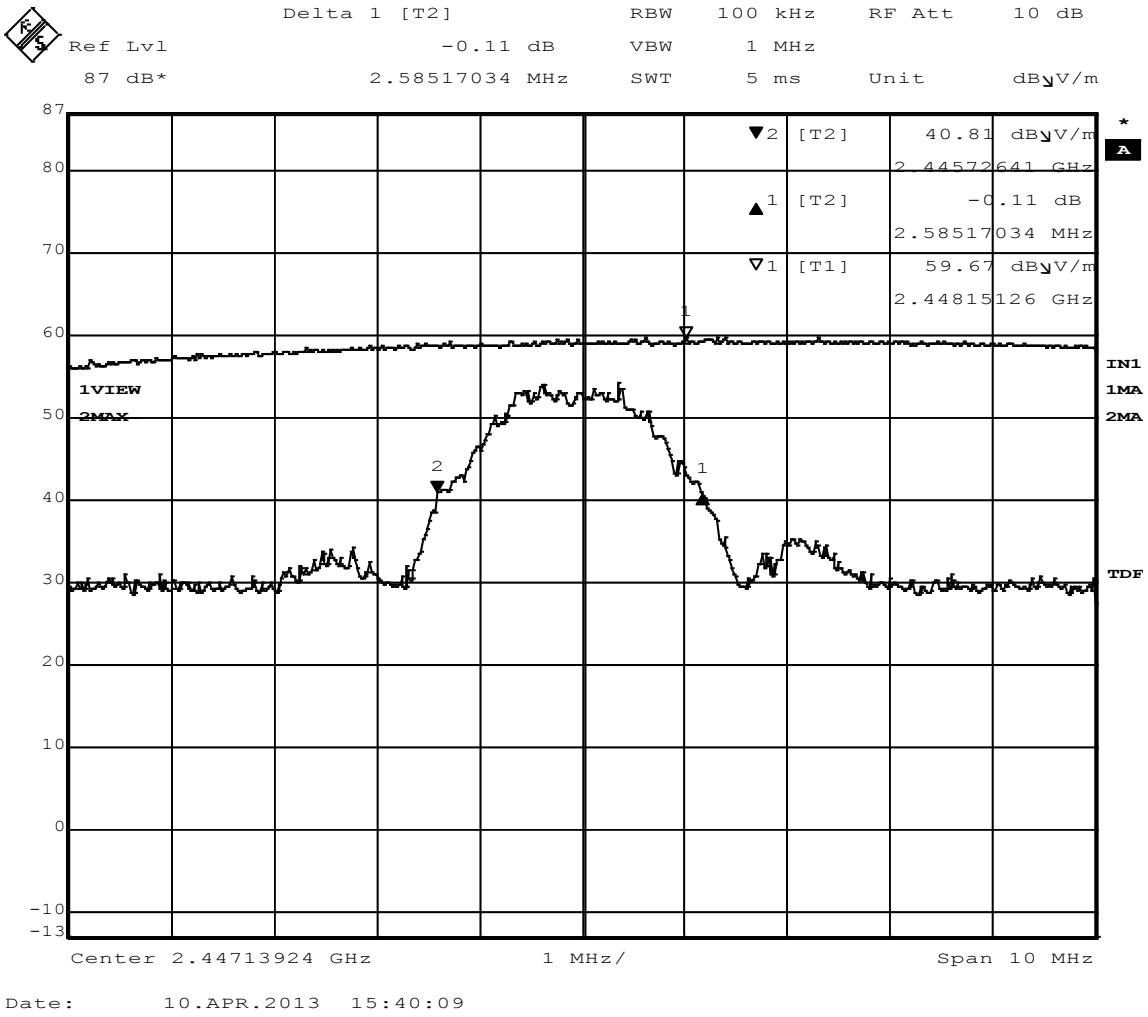

Figure 13 - 99% Occupied Bandwidth, High Channel

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

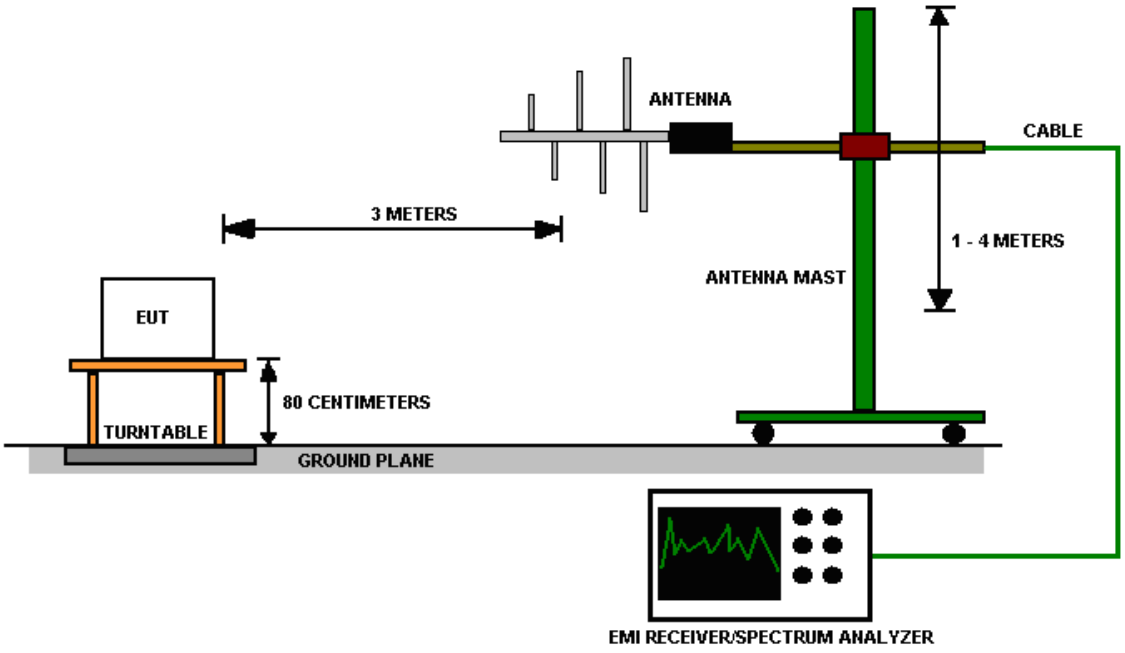

Figure 14 - Power Measurements Test Setup

4.4.5 EUT operating conditions

The EUT was powered by 12VDC and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

4.4.6 Test results

EUT	i-Pilot Link System Motor Controller	MODE	Cont. Transmit
INPUT POWER	12VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Maximum peak output power

CHANNEL	CHANNEL FREQUENCY (MHz)	1 MHz RBW EIPR (dBm)	EIRP PEAK POWER OUTPUT (dBm)	PEAK POWER LIMIT (dBm)	RESULT
1	2436	17.21	21.36	30	PASS
2	2441	14.70	18.85	30	PASS
3	2447	15.57	19.72	30	PASS

All measurements were taken from the maximum peak measurements in Section 4.2.6. Since the spurious emissions measurements were made with a 1MHz resolution bandwidth. A bandwidth correction of 10*log(2.6 MHz / 1MHz) = 4.15 dB was added to the EIRP values. This presents a worse-case maximum output power.

REMARKS:
None

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 band edge to the fundamental frequency with a peak and average detector. The highest emissions level beyond the band edge 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 an internal 12VDC and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

4.5.6 Test results

EUT	i-Pilot Link System Motor Controller	MODE	Cont. tranmsit
INPUT POWER	12VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Highest Out of Band Emissions with Peak Detector

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBµV)	Fundamental Level (dBµV)	Delta	Min (dB)	Result
1	2400.0	50.42	109.53	59.11	20.00	PASS
3	2483.5	62.80	103.00	40.20	58.44	PASS

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

Highest Restricted Band Emissions Near Fundamental

CHANNEL	Band edge Frequency (MHz)	Measurement Frequency (MHz)	Highest out of band level (dBµV)	Detector	Limit (dBµV/m)	Margin (dB)	Result
1	2390.0	2373.1	52.06	Average	54.00	1.94	PASS
1	2390.0	2373.1	61.07	Peak	74.00	12.93	PASS
3	2483.5	2500.0	51.44	Average	54.00	2.56	PASS
3	3483.5	2500.0	62.19	Peak	74.00	11.81	PASS

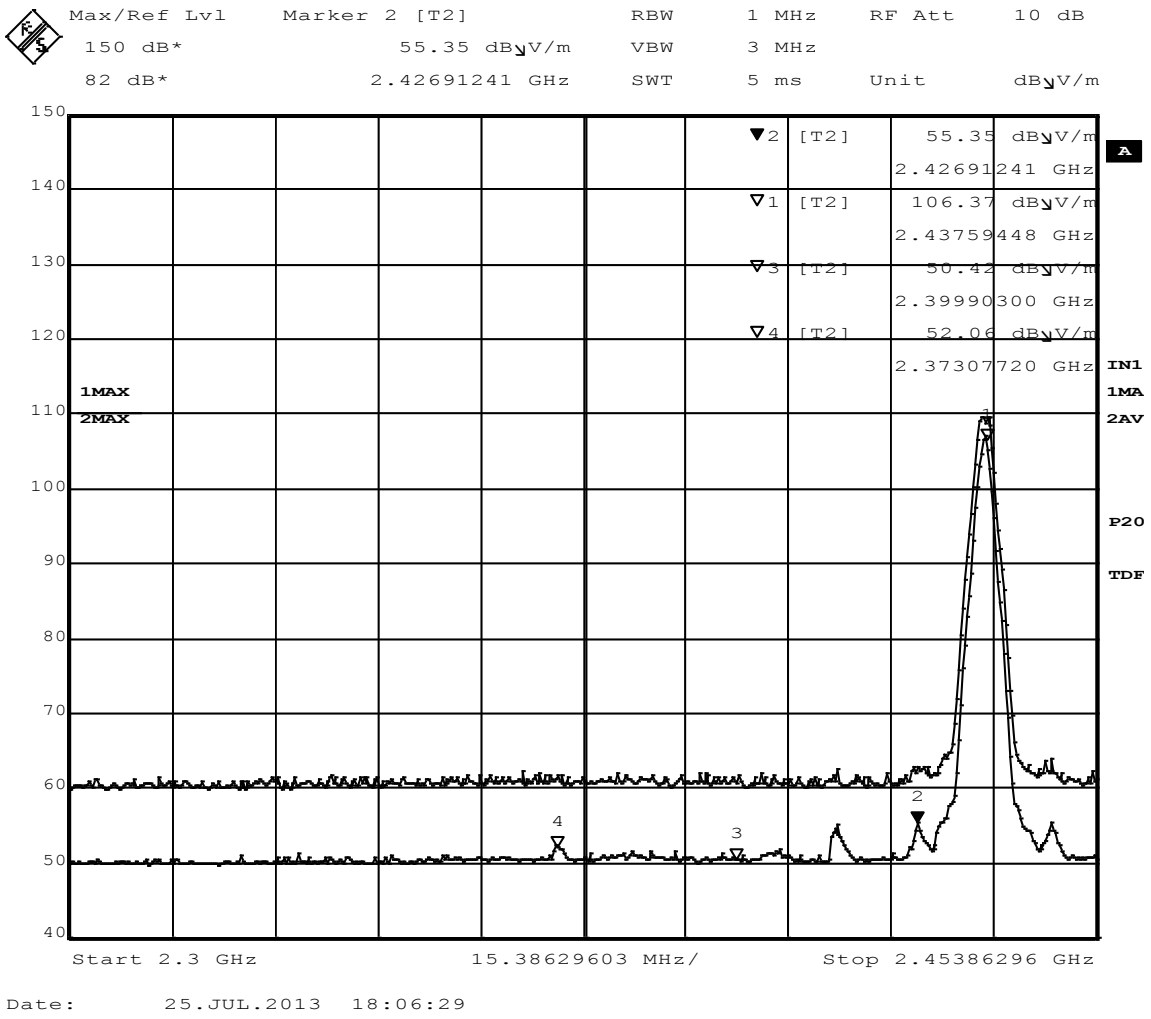

Figure 15 - Band Edge Measurements with Average Detector, 2437 MHz

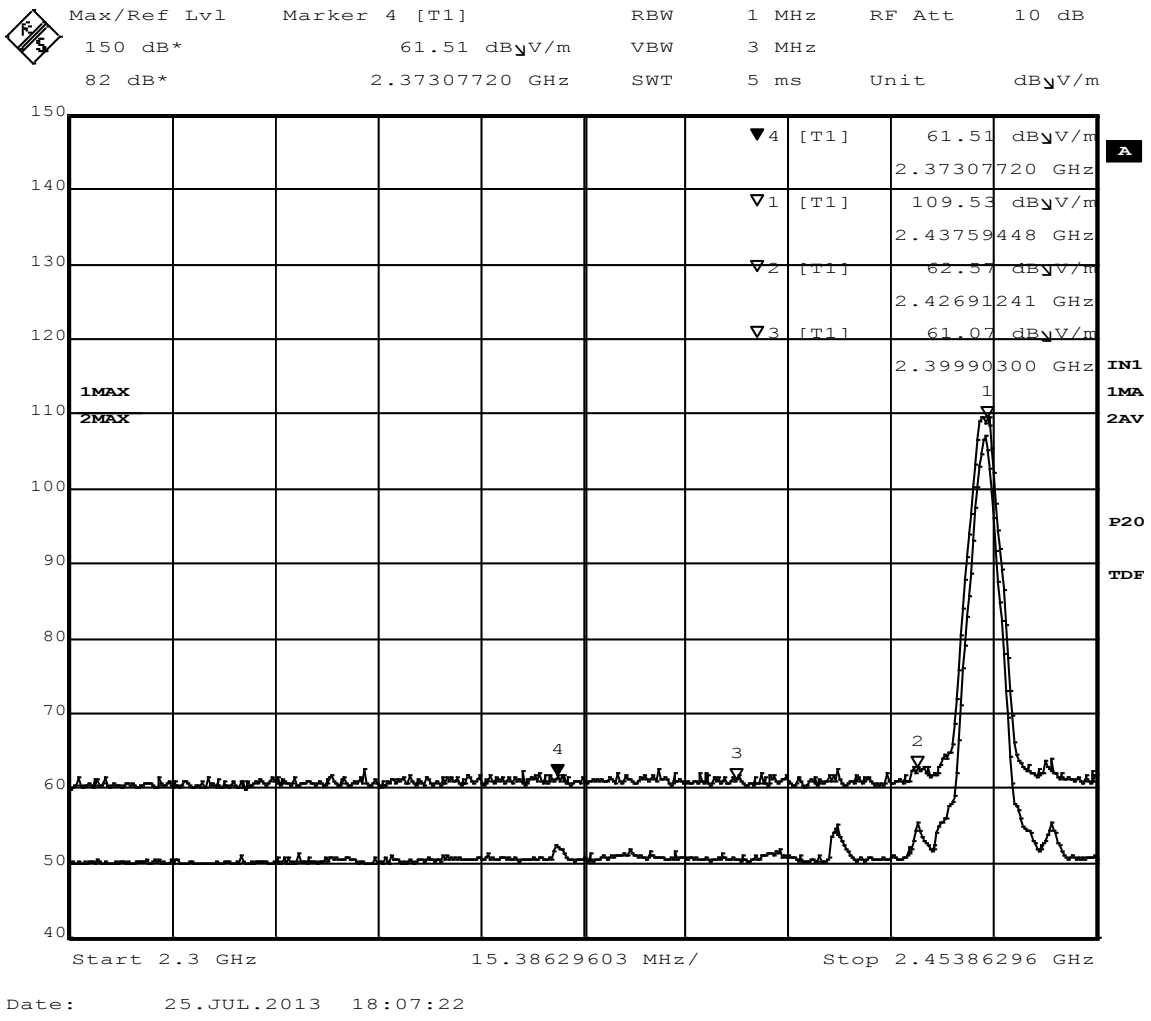

Figure 16 - Band Edge Measurements with Peak Detector, 2437 MHz

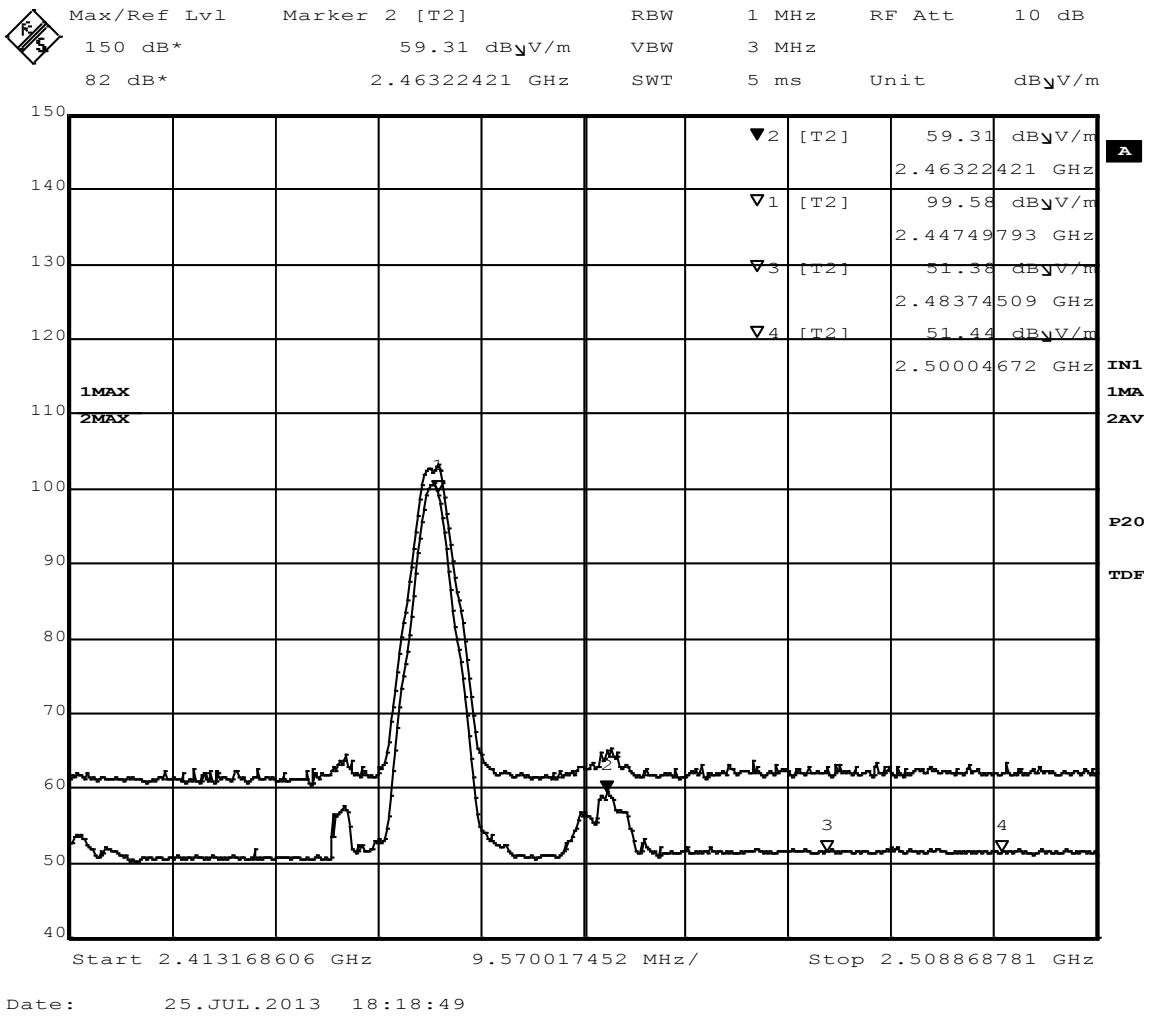

Figure 17 - Band Edge Measurements with Average Detector, 2447 MHz

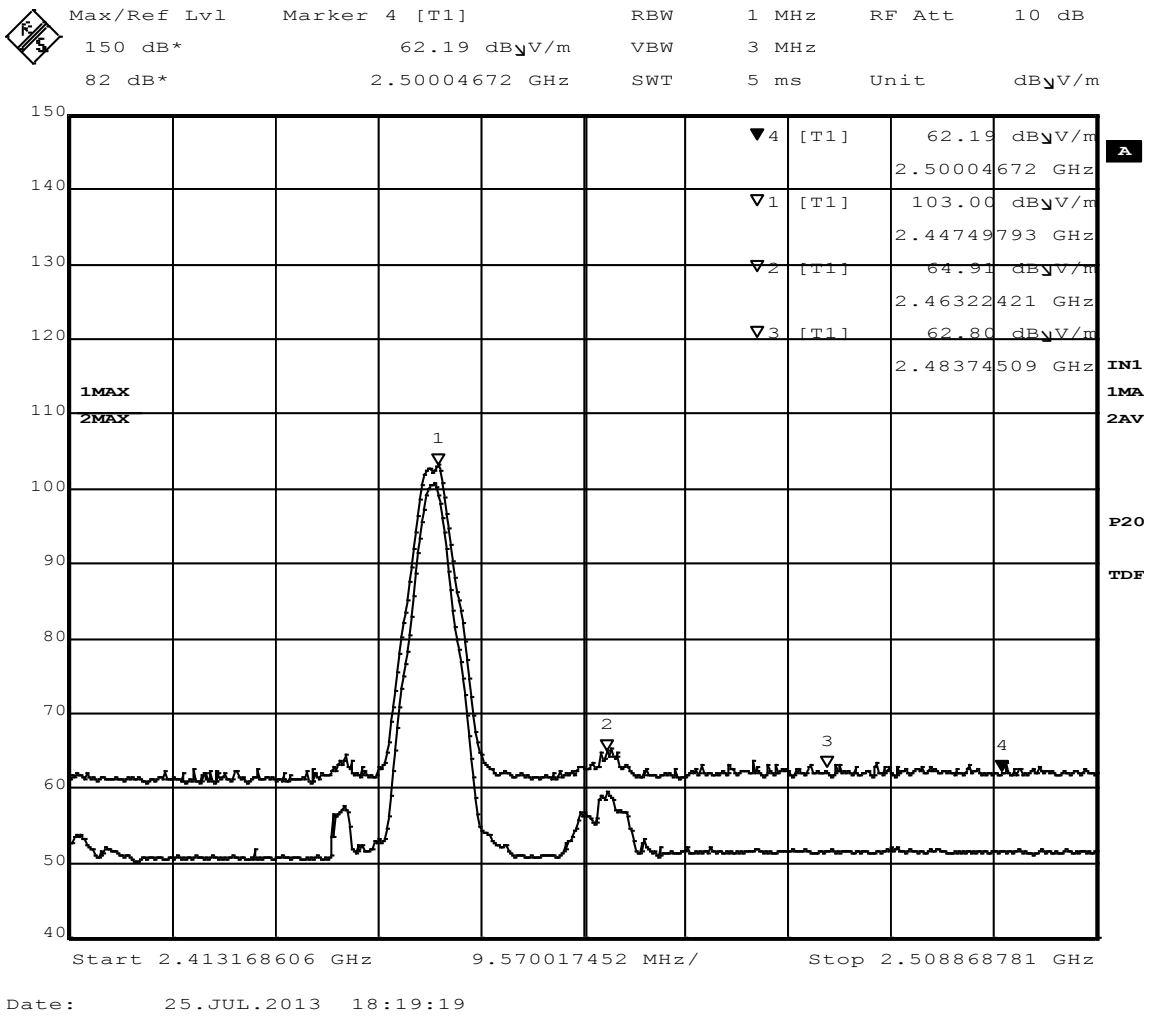

Figure 18 - Band Edge Measurements with Average Detector, 2447 MHz

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 500s. 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.

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 12VDC and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

EUT	i-Pilot Link System Motor Controller	MODE	Continuous transmit
INPUT POWER	12VDC	FREQUENCY RANGE	2400.0MHz – 2483.5MHz
ENVIRONMENTAL CONDITIONS	40% ± 5% RH 22 ± 3ºC	TECHNICIAN	KVepuri

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	RF POWER LEVEL IN # KHz BW (dBm)	MAXIMUM POWER LIMIT (dBm)	RESULT
1	2437	-24.46	8.00	PASS
2	2441	-28.56	8.00	PASS
3	2447	-32.36	8.00	PASS

EIRP calculations;

EIRP = [(V/m * 3)^2]/(30)

or

$EIRP_{dBm} = FS_{dB\mu V/m} - 95.23$ dB

$FS_{dB\mu V/m}$ can be taken from the plots in Figures 17 – 19.

Seen Appendix B for more information.

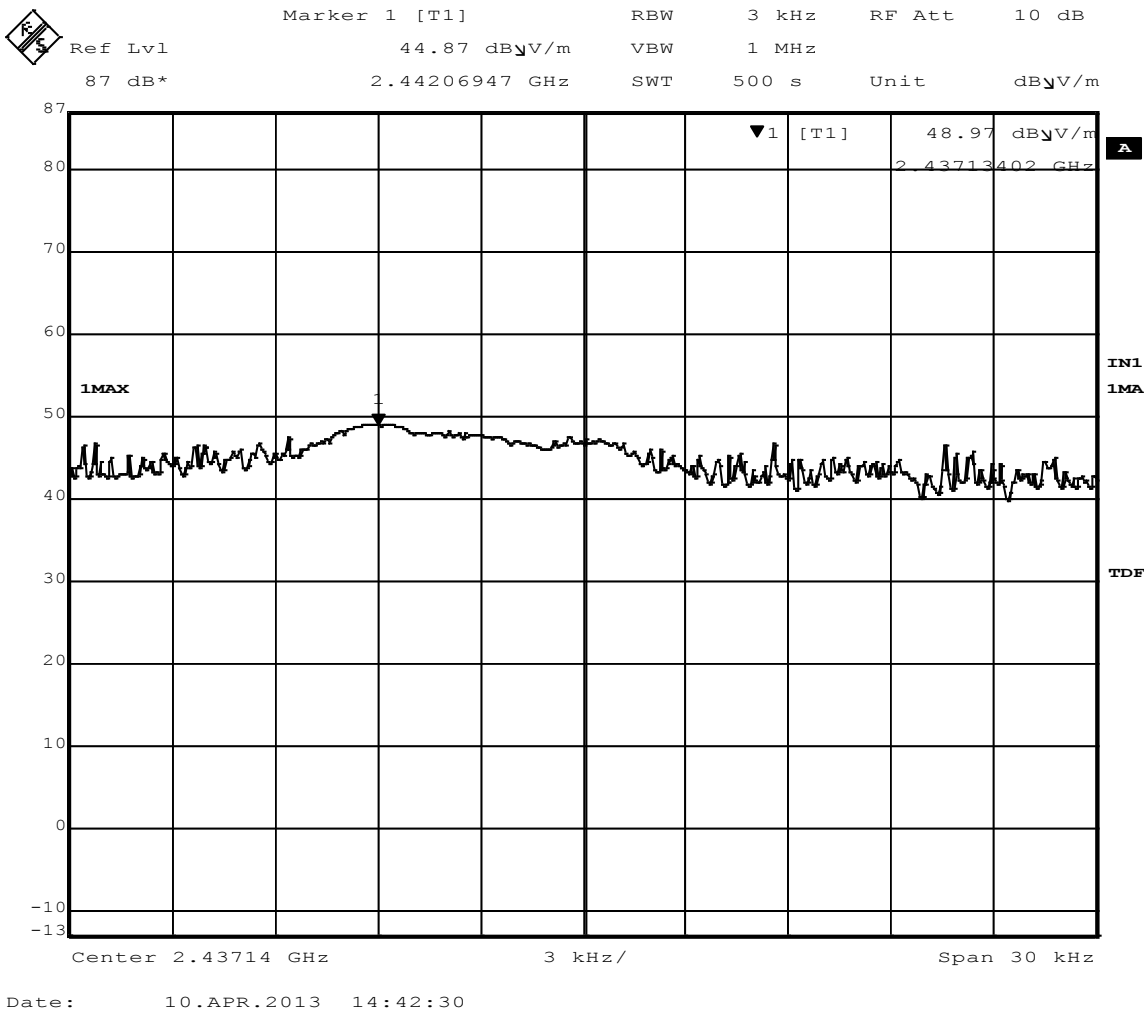

Figure 19 - Power Spectral Density Measurement, Low Channel
Corrected field strength measurement at 3m

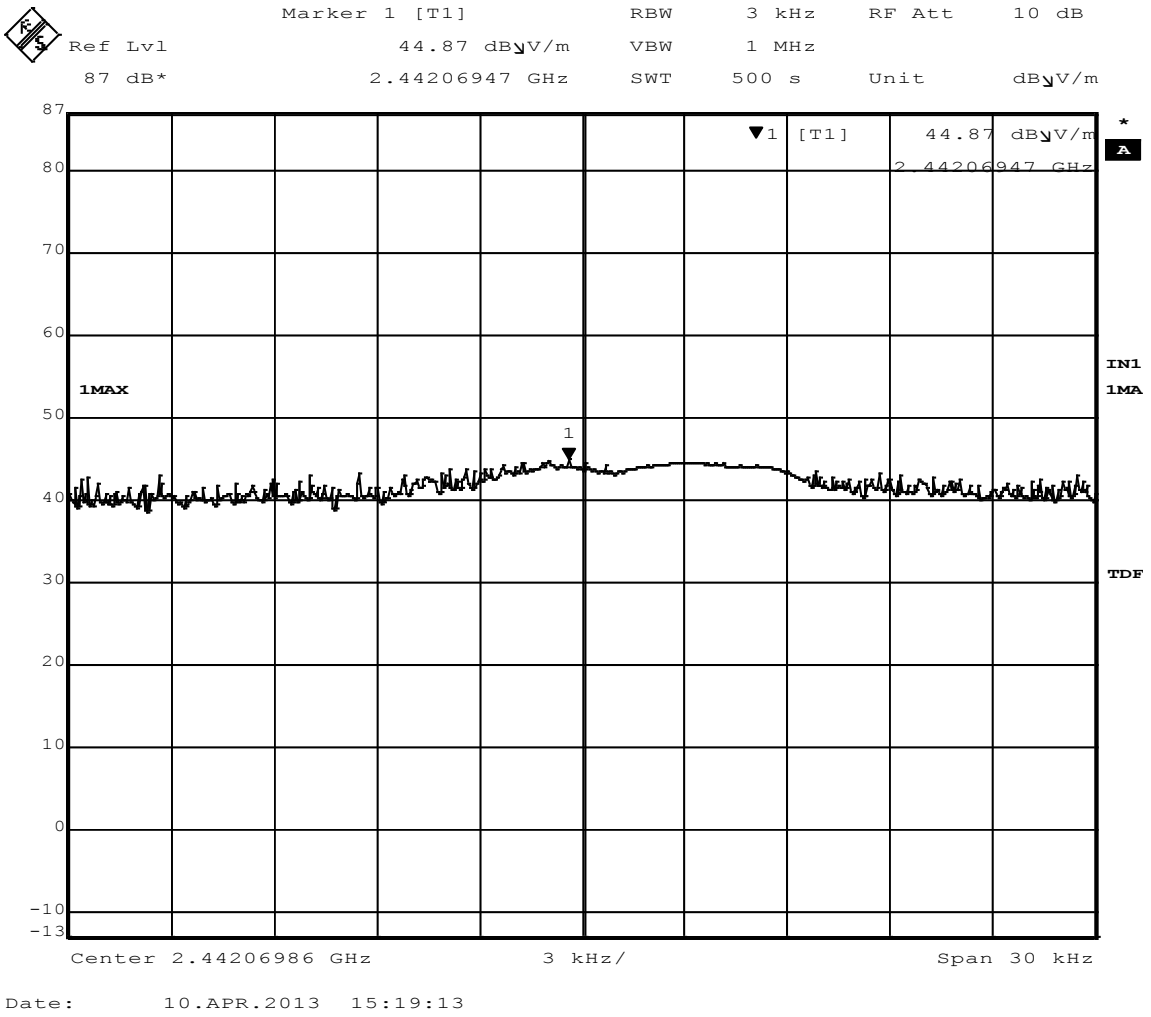

Figure 20 - Power Spectral Density Measurement, Mid Channel
Corrected field strength measurement at 3m

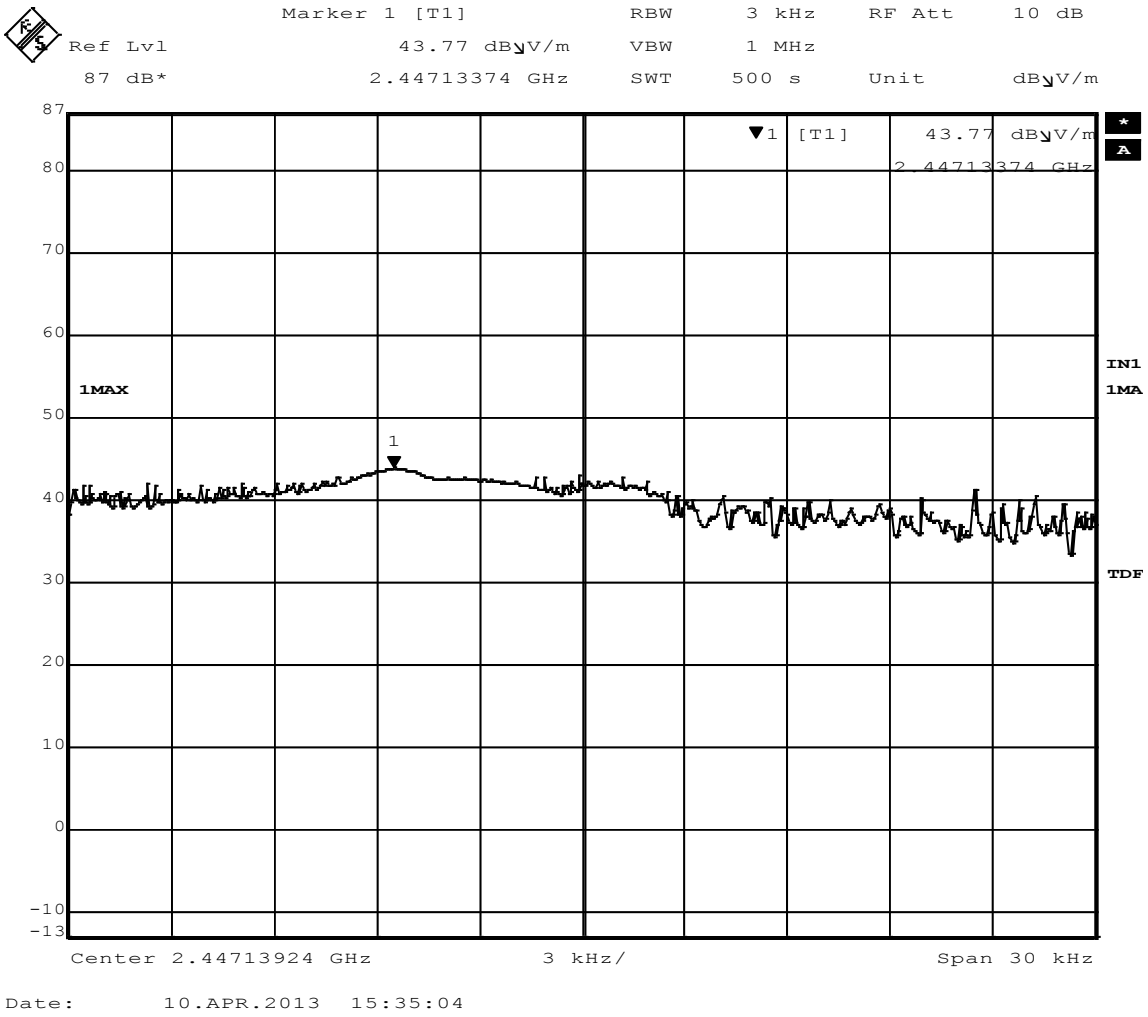

Figure 21 - Power Spectral Density Measurement, High Channel
Corrected field strength measurement at 3m

Appendix A: Test Photos

Figure 22 - Test Setup

Figure 23 - 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 Strength (V/m) x antenna distance (m)]^2 / [30 x Gain (numeric)]

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

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

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

Gain = 1 (numeric gain for isotropic radiator

Appendix C: Table of Figures

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