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Amended

FCC/IC Test Report

Included NCEE Labs report R20150916-22-01A and its amendment in full

Prepared for: **Lester Electrical**

Address: **625 West A Street**
Lincoln, NE 68522

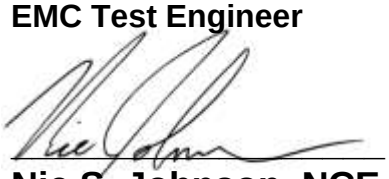
Product: **28170 Bluetooth LE Module**
FCC ID: **OBH-28170**

Test Report No: **R20150916-22-01B**

Prepared By:

Mahendra Karthik Vepuri
EMC Test Engineer

Approved By:



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DATE: **15 September 2016**

Total Pages: **52**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 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 Issue 4, RSS-247 Issue 1			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	Permanently attached antenna
FCC 15.207 ANSI C63.10, Section 6.2 RSS-Gen, Sect 8.8	Conducted Emissions	NA	Meets the requirement of the limit.
FCC 15.209 ANSI C63.10, Section 6.5, 6.6 RSS-Gen, Sect 6.1.3, 7.1.2	Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247(a)(2) ANSI C63.10, Section 11.8 RSS-247, 5.2(1)	Minimum Bandwidth, Limit Min. 500kHz	Pass	Meets the requirement of the limit.
FCC 15.247(b) ANSI C63.10, Section 11.9 RSS-247, 5.4	Maximum Peak Output Power	Pass	Meets the requirement of the limit.
FCC 15.209 ANSI C63.10, Section 6.5, 6.6 RSS-247, Sect.5.5 RSS-Gen, Sect. 6.13	Transmitter Radiated Emissions, Limit: Table 15.209	Pass	Meets the requirement of the limit.
FCC 15.247(d) ANSI C63.10, Section 11.13 RSS-247, Sect 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
FCC 15.247(d) ANSI C63.10, Section 11.10 RSS-247, Sect 5.2(2)	Power Spectral Density	Pass	Meets the requirement of the limit.

1.2 Test Methods

1.2.1 Radiated Emissions

1. IEEE/ANSI C63.10:2013

1.2.2 Test Setup

Several configurations were examined and the results presented represent a worst-case scenario. The EUT was placed on a wooden table approximately 80cm or 150cm 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 both vertically and horizontally. The vertical configuration produced the highest emissions, and that position was used for all radiated testing.

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

1.3 Reason for report amendment

The 6dB bandwidth measurements were repeated using a 6dB RBW and added to the report.

Conducted emissions measurements were performed and added to the report.

Section 4.5.2 was modified to show the test method was taken from Section 4.2.

The PSD method from ANSI C63.10 was added to Section 4.6.

Equipment was added to the equipment list for conducted emissions.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was a Low Energy Bluetooth module, which operates from 2402 to 2480 MHz.

EUT Received Date: 22 September 2015
EUT Tested Dates: 22 September 2015 – 23 September 2015
19 August 2016 (conducted emissions)

PRODUCT	Bluetooth LE Module
MODEL	28170
Serial No.	27
POWER SUPPLY	3 VDC - Power supply: Power Stream(M/N: MWS1898UC)
MODULATION TYPE	GFSK
ANTENNA TYPE	Internal PCB antenna

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 46 ± 4%
Temperature of 23 ± 3° Celsius

2.3 Description of test modes

The EUT was tested at the frequencies below:

Channel	Frequency
Lowest	2402
Middle	2440
Highest	2480

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)
FCC Part 15, Subpart C (15.207)
Industry Canada RSS-GEN, Issue 4
Industry Canada RSS-247, Issue 1

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	20 Jan 2015	20 Jan 2016
EMCO Biconilog Antenna	3142B	1654	26 Jan 2015	26 Jan 2016
EMCO Biconilog Antenna	3142B	1654	02 Aug 2016	02 Aug 2017**
EMCO Horn Antenna	3115	6416	14 Jan 2014	14 Jan 2016
EMCO Horn Antenna	3116	2576	31 Mar 2014	31 Mar 2016
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	19 Nov 2014*	19 Nov 2015*
Trilithic High Pass Filter	6HC330	23042	19 Nov 2014*	19 Nov 2015*
Rohde & Schwarz LISN	ESH3-Z5	100023	27 Jan 2016	27 Jan 2017

*Internal Characterization **Used for bandwidth measurements on 8/21/2016

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 (30Mhz – 1GHz) or 1.5 meters (>1GHz) above the ground plane in a 10 meter semi-anechoic chamber for measurements 30MHz - 1GHz and 1GHz -25 GHz respectively. 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.

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 of test receiver/spectrum analyzer is 1 MHz for peak and average detectors at frequencies above 1GHz.

4.2.3 Deviations from test standard

No deviation.

4.2.4 Test setup

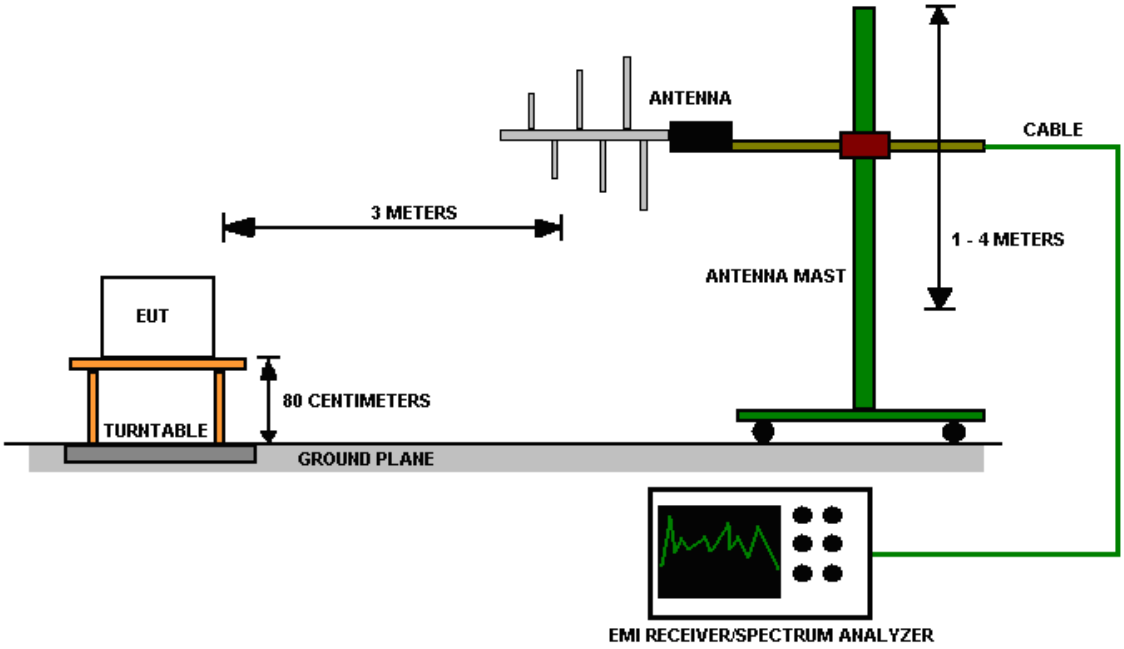

Figure 1 - Radiated Emissions Test Setup

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 a 3 VDC unless specified and set to transmit continuously on the lowest channel, one in the middle of the range and the highest frequency channel.

4.2.6 Test results

EUT MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Receive
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

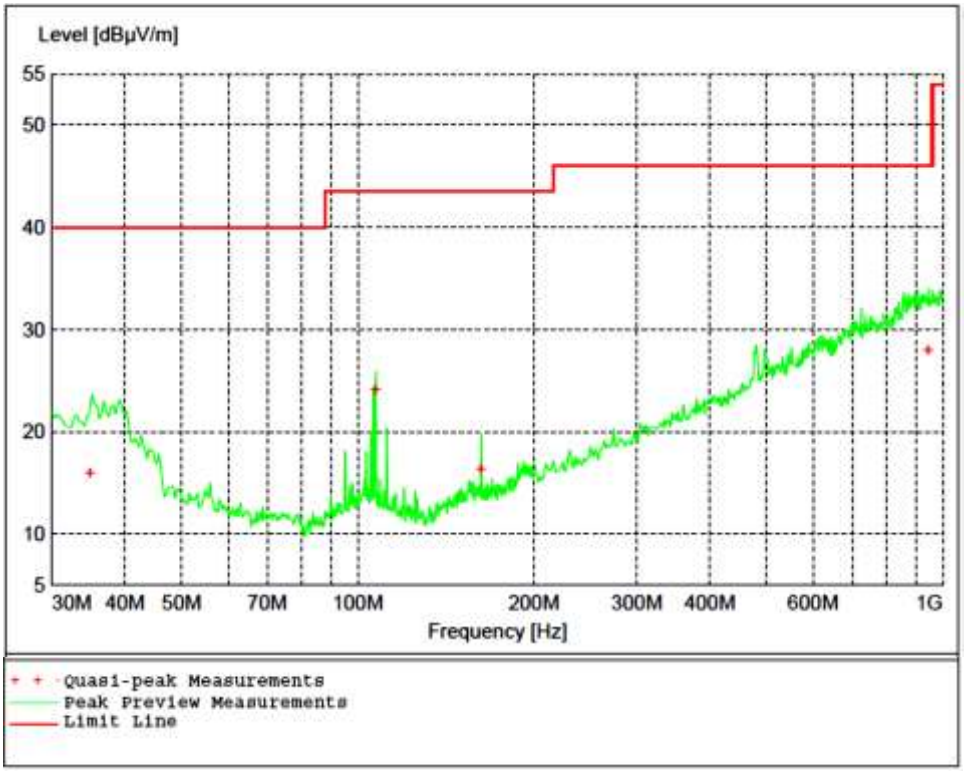

Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
34.860000	15.93	40.00	24.10	101	180	VERT
107.280000	24.12	43.50	19.40	100	20	VERT
162.480000	16.36	43.50	27.20	99	143	VERT
944.940000	27.99	46.00	18.00	142	112	VERT

Table 2 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2431.800000	37.00	54.00	17.00	312	192	HORI
4881.400000	43.03	54.00	11.00	399	7	HORI
7307.600000	45.28	54.00	8.70	100	55	HORI
9765.800000	45.99	54.00	8.00	400	182	HORI
12206.000000	39.61	54.00	14.40	99	190	VERT
2431.800000	37.00	54.00	17.00	312	192	HORI
4881.400000	43.03	54.00	11.00	399	7	HORI
7307.600000	45.28	54.00	8.70	100	55	HORI

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

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 MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Transmit, Lowest Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

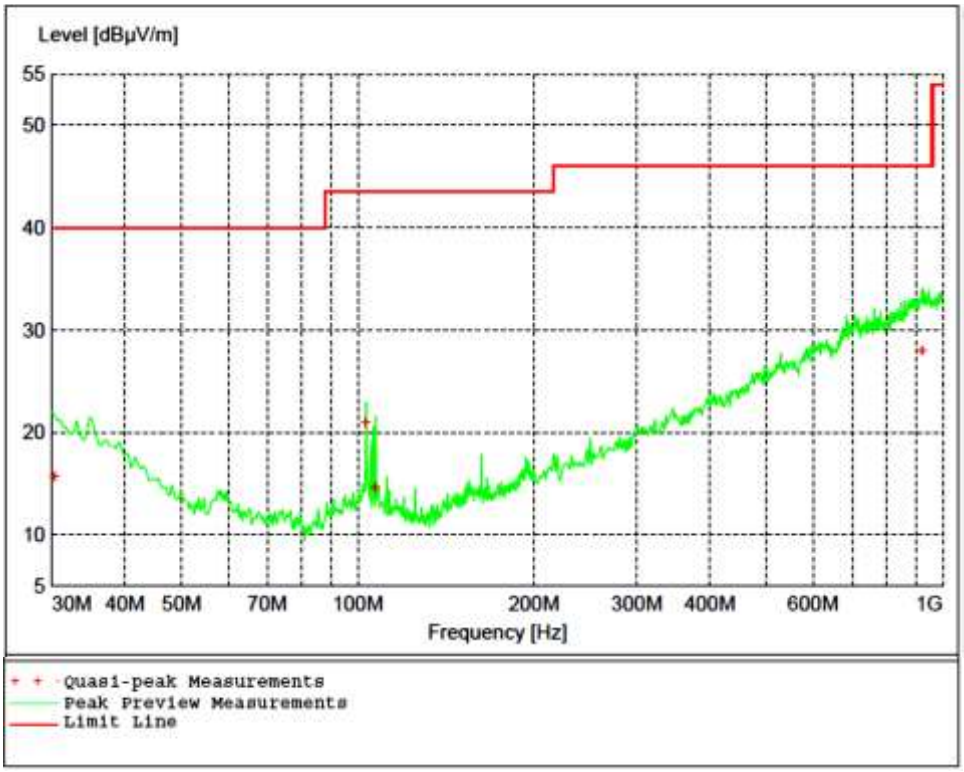

Figure 3 - Radiated Emissions Plot, Channel 1

Table 3 - Radiated Emissions Quasi-peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.300000	15.69	40.00	24.30	104	195	HORI
103.260000	20.94	43.50	22.60	99	155	VERT
107.280000	14.56	43.50	29.00	101	259	VERT
922.380000	27.92	46.00	18.10	121	256	VERT

Table 4 - Radiated Emissions Peak Measurements, Channel 1

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.000000	100.86	NA	NA	200	20	VERT
4814.000000	42.22	54.00	11.80	99	360	VERT
7185.600000	45.37	54.00	8.60	137	43	VERT
9586.800000	46.02	54.00	8.00	322	188	VERT
11993.800000	43.85	54.00	10.20	121	220	VERT
14390.600000	48.14	54.00	5.90	291	165	VERT
16828.600000	48.32	54.00	5.70	366	205	VERT

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

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 MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Transmit, Middle Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

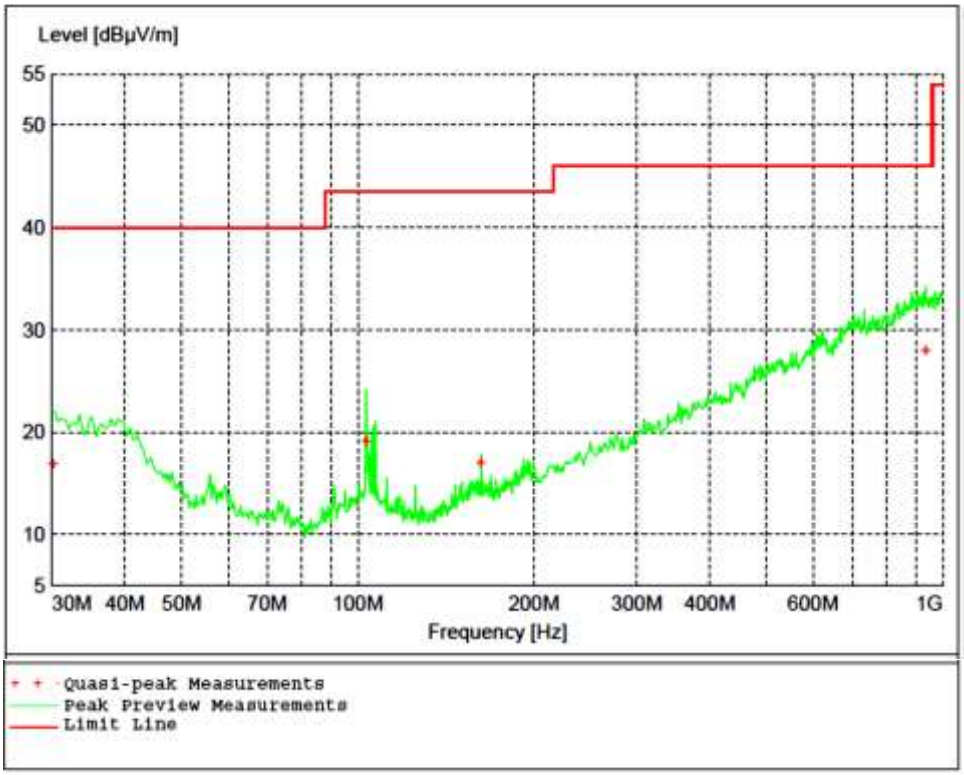

Figure 4 - Radiated Emissions Plot, Channel 2

Table 5 - Radiated Emissions Quasi-peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
30.120000	16.85	40.00	23.20	99	305	VERT
103.380000	19.05	43.50	24.50	102	227	VERT
162.480000	16.96	43.50	26.60	119	42	VERT
935.460000	27.94	46.00	18.10	223	10	VERT

Table 6 - Radiated Emissions Peak Measurements, Channel 2

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2440.000000	100.97	NA	NA	100	55	HORI
4880.600000	46.32	54.00	7.70	100	169	HORI
7339.200000	45.21	54.00	8.80	400	224	VERT
9769.400000	47.05	54.00	7.00	121	258	HORI
12205.000000	39.47	54.00	14.50	383	258	VERT
14639.800000	46.89	54.00	7.10	230	51	VERT
17114.000000	49.78	54.00	4.20	291	229	HORI

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

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 MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Transmit, Highest Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26 GHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

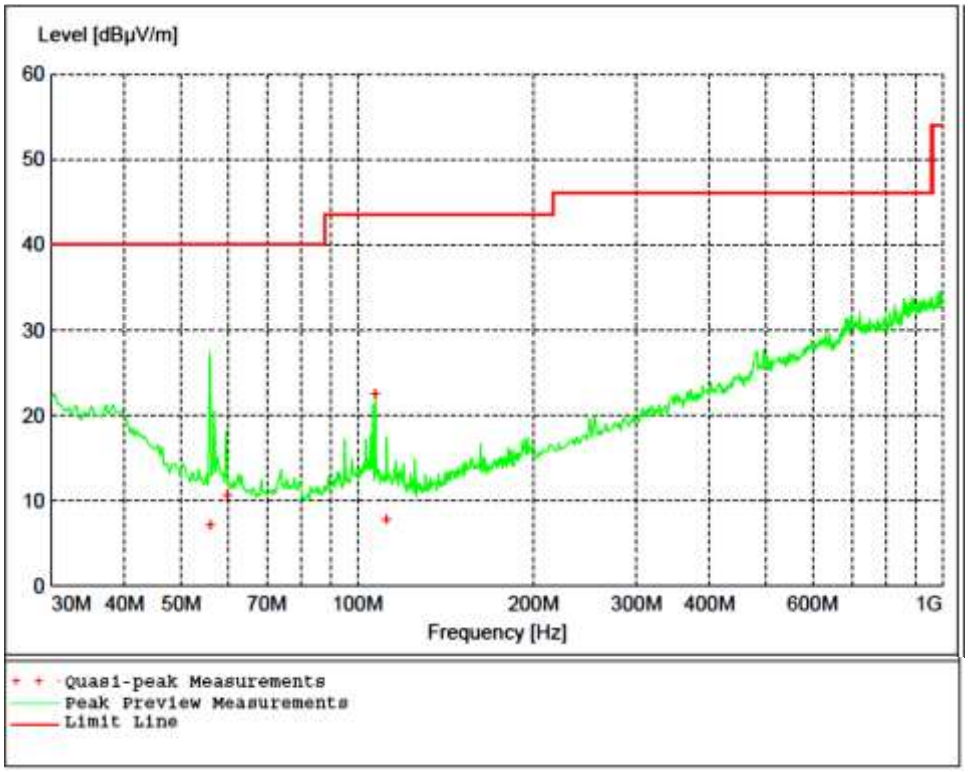

Figure 5 - Radiated Emissions Plot, Channel 3

Table 7 - Radiated Emissions Quasi-peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
56.040000	7.16	40.00	32.80	230	60	VERT
59.940000	10.64	40.00	29.40	354	0	VERT
107.220000	22.42	43.50	21.10	109	25	VERT
112.140000	7.71	43.50	35.80	288	0	HORI

Table 8 - Radiated Emissions Peak Measurements, Channel 3

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	99.63	NA	NA	140	314	HORI
4959.400000	48.30	54.00	5.70	99	108	VERT
7441.000000	49.75	54.00	4.20	99	146	VERT
9941.800000	46.83	54.00	7.20	146	103	HORI
12408.600000	38.79	54.00	15.20	400	153	HORI
14881.800000	47.07	54.00	6.90	380	360	VERT
17379.200000	50.59	54.00	3.40	145	59	HORI

Peak measurements were compared to average limit and found to be compliant so average measurements were not performed

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

4.3 Bandwidth

ANSI C63.10:2014, Section 11.8.1, Option 1.

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 10 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 1MHz 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

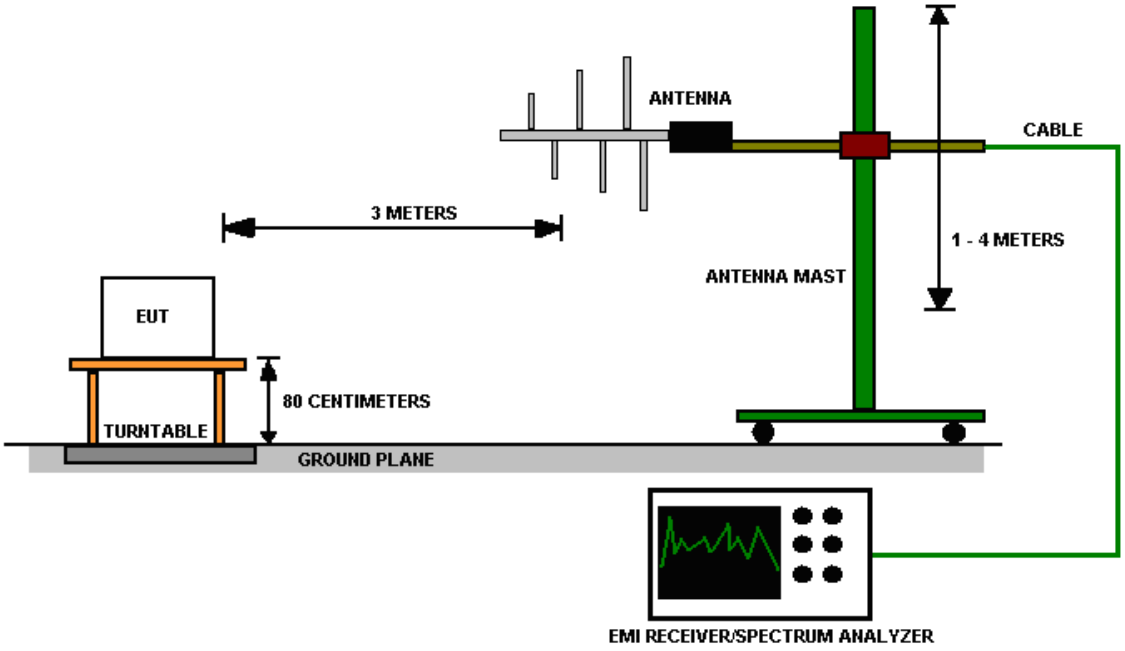

Figure 6 - Bandwidth Measurements Test Setup

4.3.5 EUT operating conditions

The EUT was powered by a 3 VDC unless specified and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

4.3.6 Test results

EUT MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Cont. Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	6dB BW (MHz)	6dB Limit Min (kHz)	RESULT
Lowest	2402	536.37	500.00	PASS
Middle	2440	513.19	500.00	PASS
Highest	2480	514.73	500.00	PASS

REMARKS:
None

REMARKS:
None

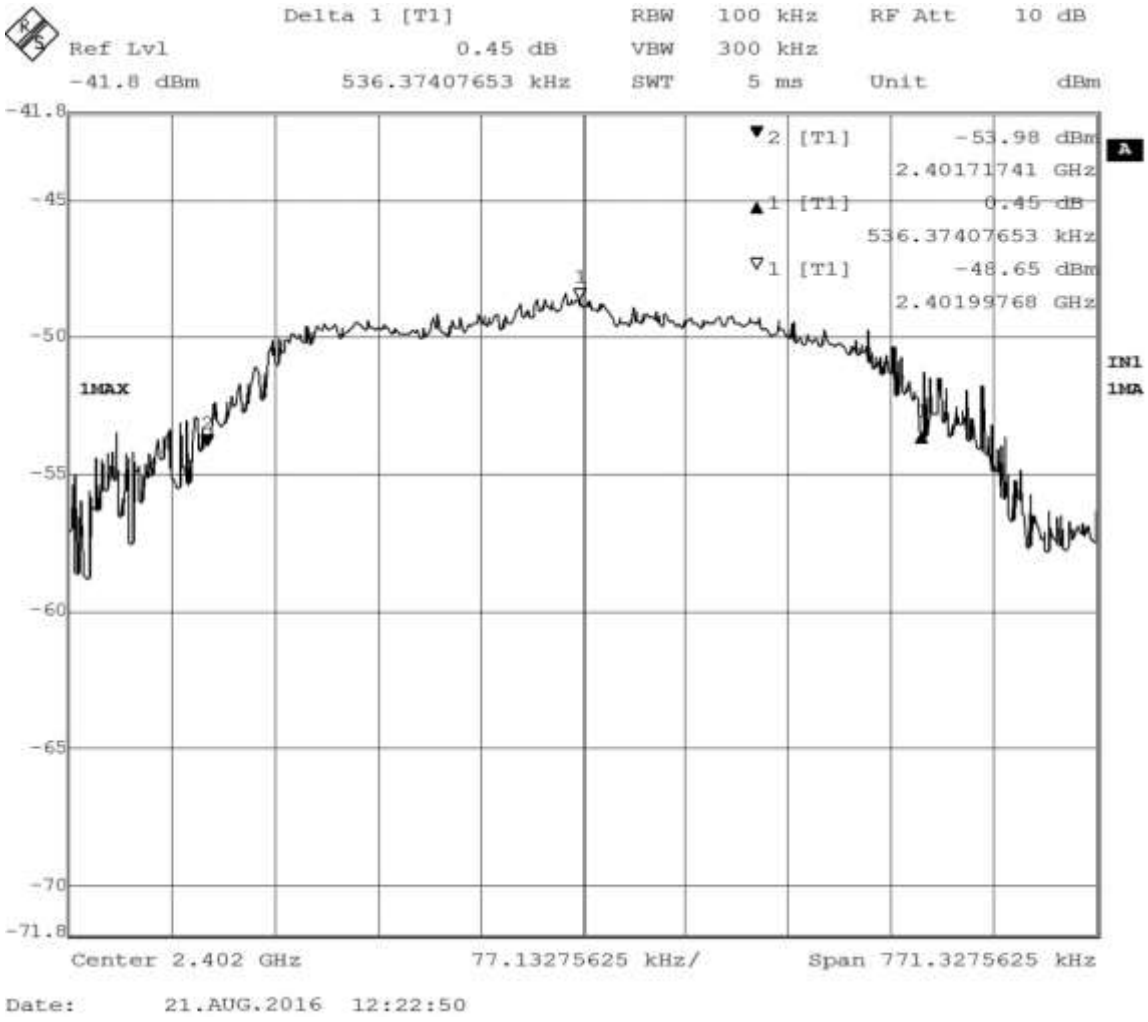

Figure 7 - 6dB Bandwidth, Lowest Channel

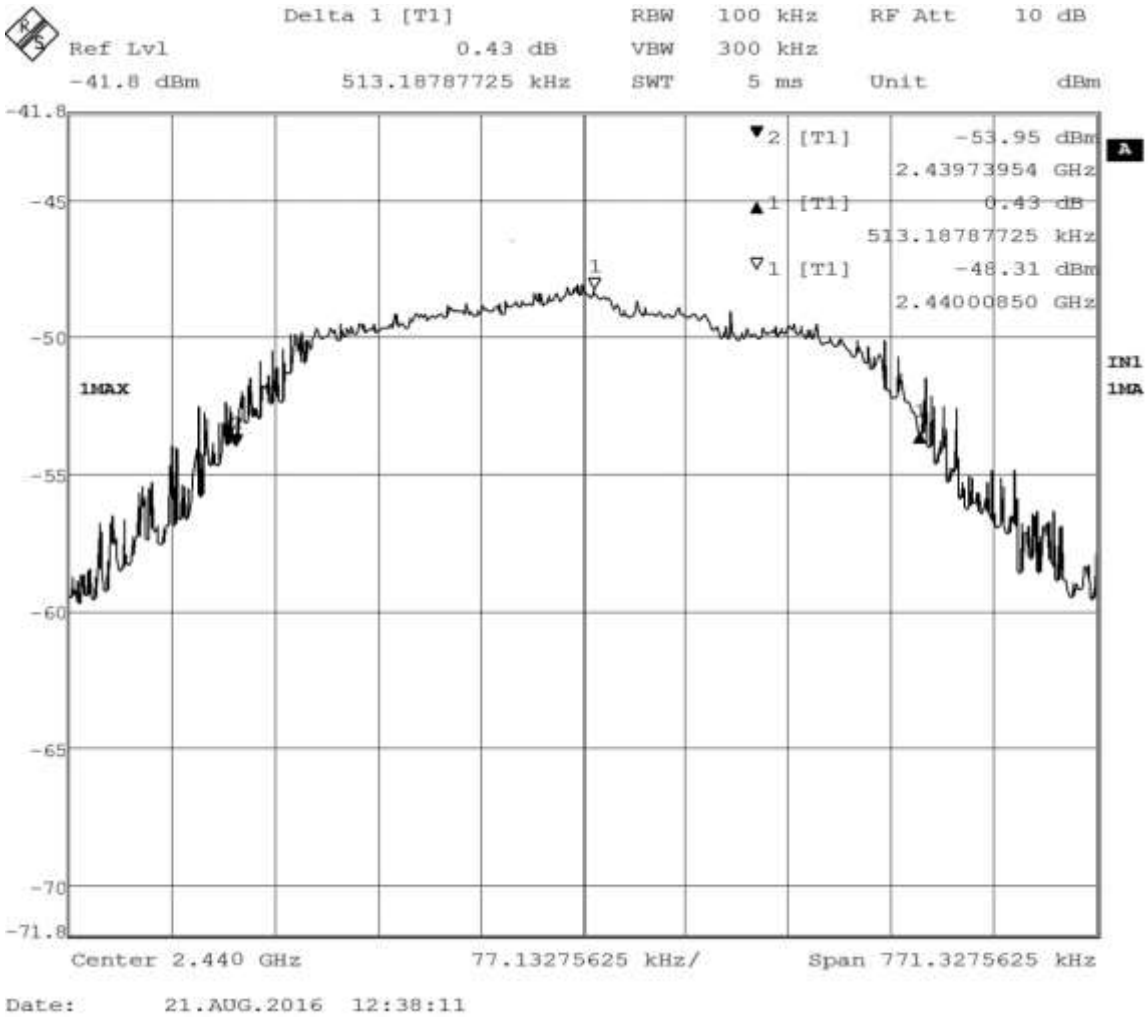

Figure 8 - 6dB Bandwidth, Middle Channel

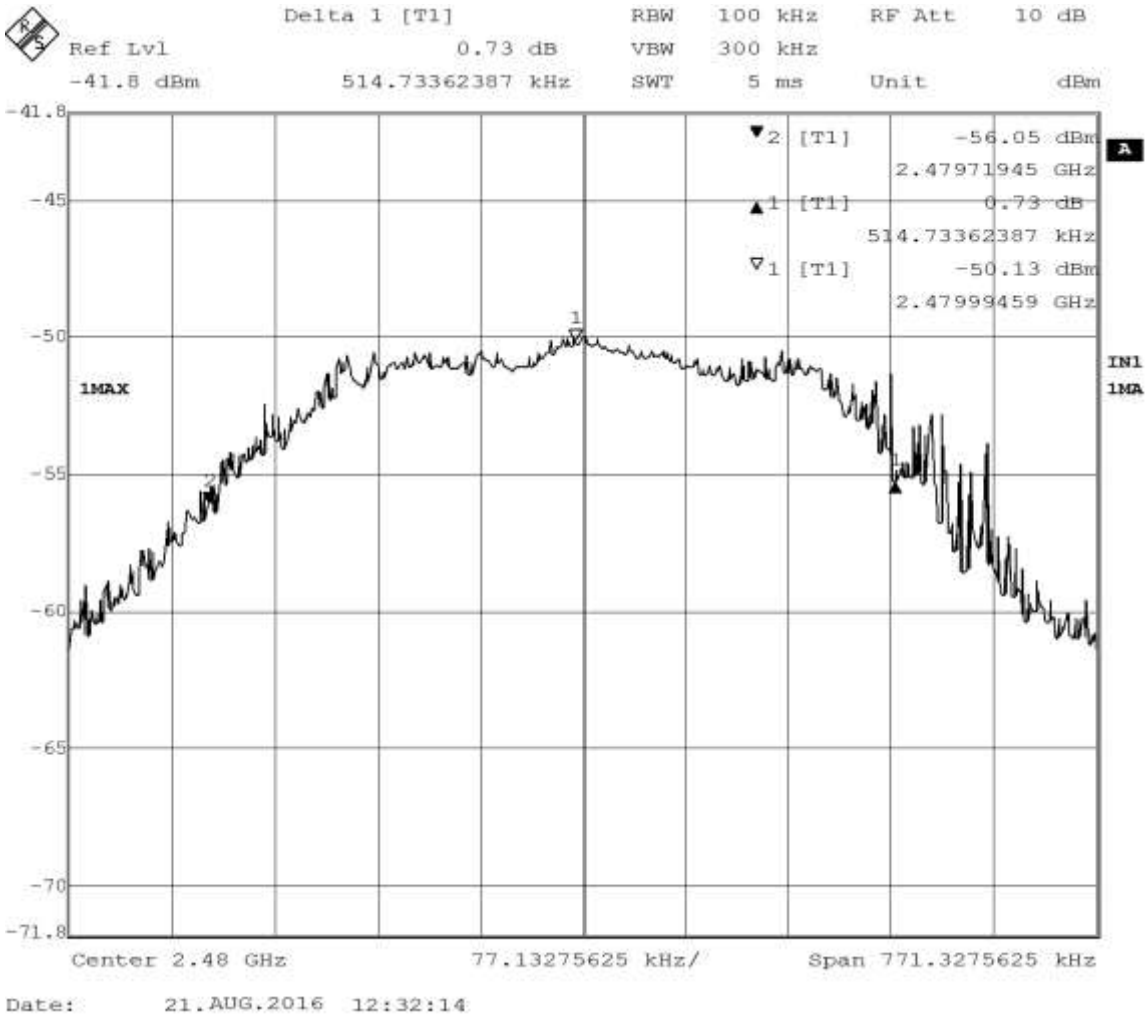

Figure 9 - 6dB Bandwidth, Highest Channel

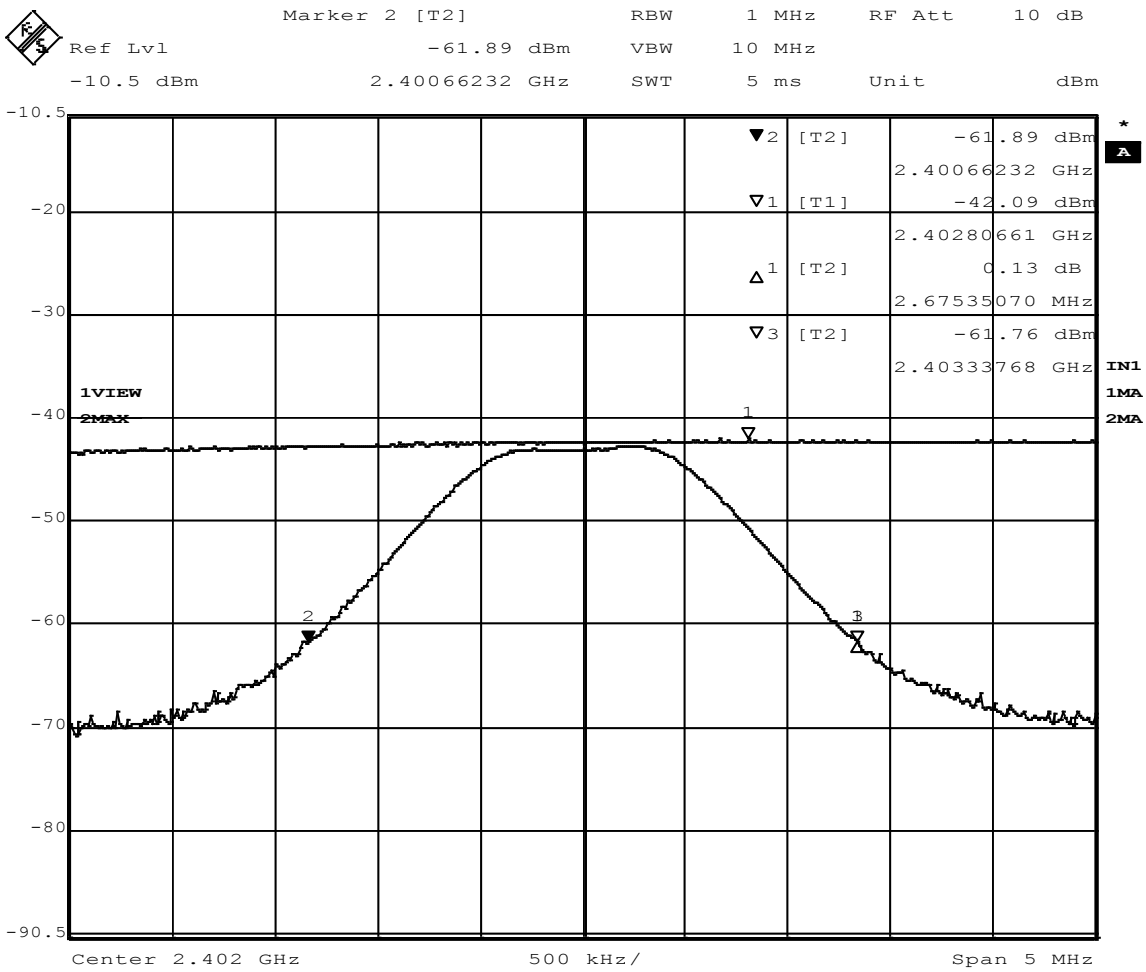

Figure 10 - 99% Occupied Bandwidth, Low Channel

Maximum power = -42.09 dBm + 107 + CL + AF - 95.23 = 5.55 dBm

CL = cable loss = 7.40 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: Trace 1 was measured with a 10MHz RBW and 10MHz VBW to show the maximum power. It was then captured on the screen and the RBW was changed to 1MHz for the bandwidth measurement using trace 2.

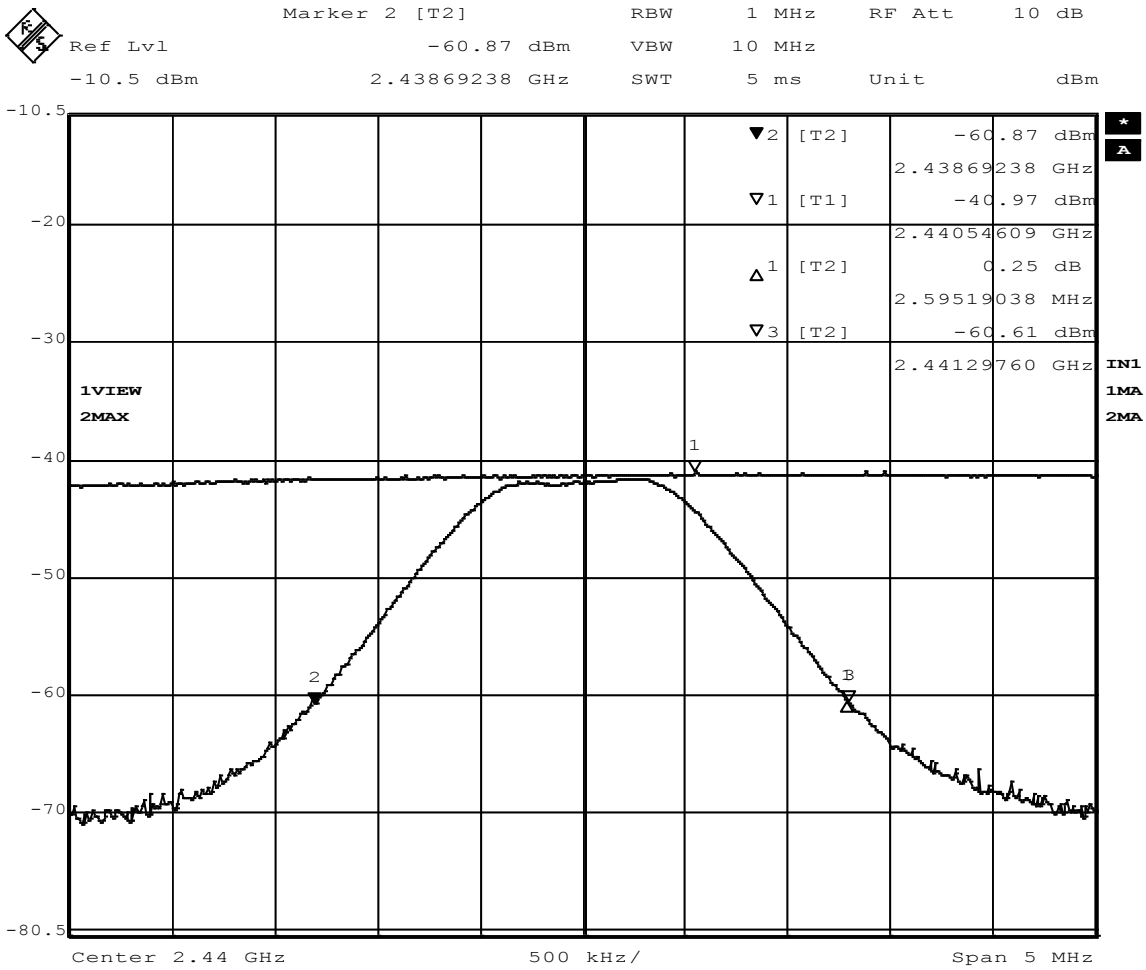

Figure 11 - 99% Occupied Bandwidth, Mid Channel

Maximum power = -40.97 dBm + 107 + CL + AF - 95.23 = 6.67 dBm

CL = cable loss = 7.40 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: Trace 1 was measured with a 10MHz RBW and 10MHz VBW to show the maximum power. It was then captured on the screen and the RBW was changed to 1MHz for the bandwidth measurement using trace 2.

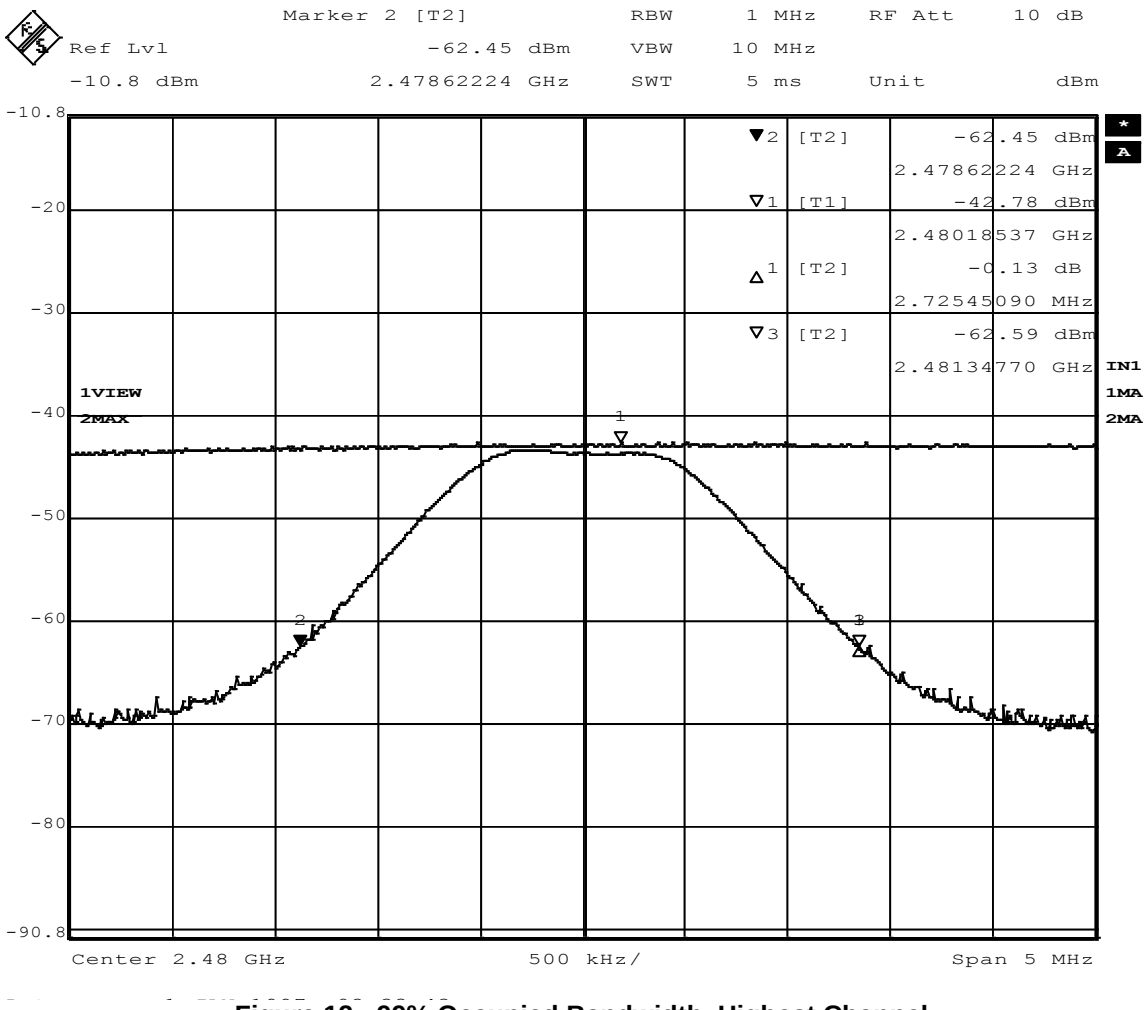

Figure 12 - 99% Occupied Bandwidth, Highest Channel

Maximum power = -42.78 dBm + 107 + CL + AF - 95.23 = 4.86 dBm

CL = cable loss = 7.40 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: Trace 1 was measured with a 10MHz RBW and 10MHz VBW to show the maximum power. It was then captured on the screen and the RBW was changed to 1MHz for the bandwidth measurement using trace 2.

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

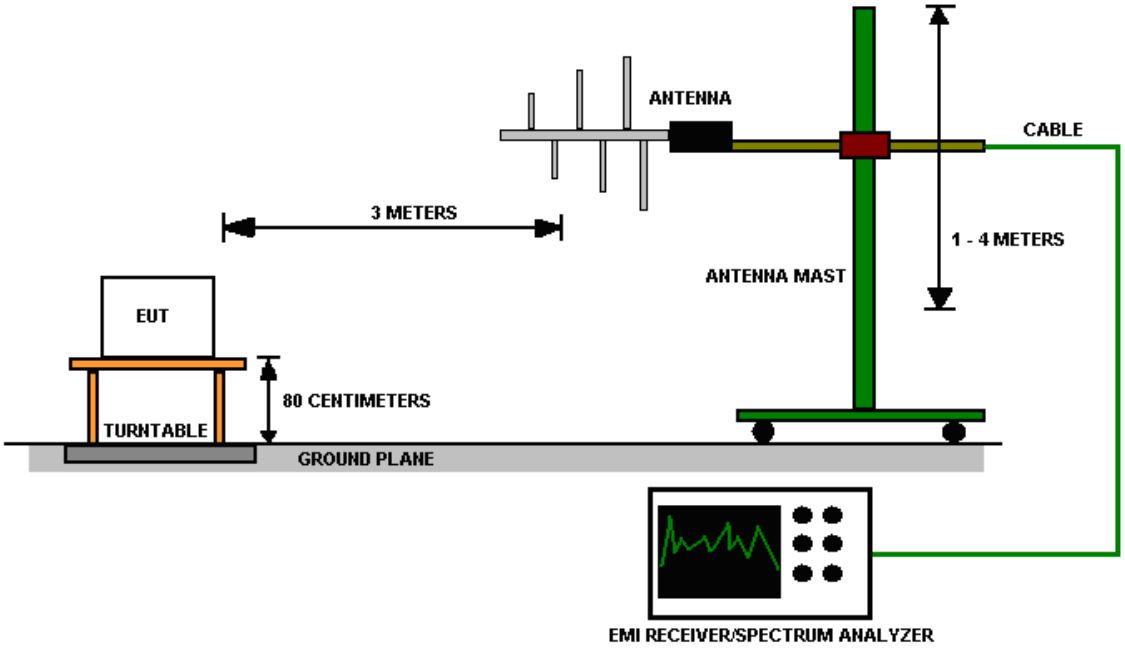

Figure 13 - Power Measurements Test Setup

4.4.5 EUT operating conditions

The EUT was powered by a 3 VDC unless specified and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

4.4.6 Test results

EUT MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Cont. Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	46 % ± 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	2402	5.55	30	PASS
2	2440	6.67	30	PASS
3	2480	4.86	30	PASS

All measurements were taken from the 99% occupied bandwidth screen captures in Section 4.3, Figures 10 -12

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 *4.2 – spurious emissions* The EUT was oriented as to produce the maximum emission levels. The resolution bandwidth was set to 30 kHz 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. All band edge measurements were evaluated to the general limits in Part 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 3 VDC unless specified and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

4.5.6 Test results

EUT MODULE	Low Energy Bluetooth Module (Hickorey)	MODE	Cont. Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Highest Out of Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Lowest	2390.0	-105.02	-46.72	58.30	46.86	PASS
Middle	2483.5	-99.85	-47.35	52.50	45.63	PASS

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

From Section 4.2

Fundamental average field strength at 2402MHz for low channel = 100.86 dBµV/m

Fundamental average field strength at 2480MHz for high channel = 99.63 dBµV/m

Channel 1 minimum delta = 100.86 – 54.0 dBµV/m = 46.86 dBc
Channel 3 minimum delta = 99.63 – 54.0 dBµV/m = 45.63 dBc

Highest In-Band Emissions

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest in-band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2400.0	-69.48	-42.74	26.74	20.0	PASS
3	2483.5	-71.82	-43.69	28.13	20.0	PASS

Measurements do not include correction factors and are intended to be relative measurements only.

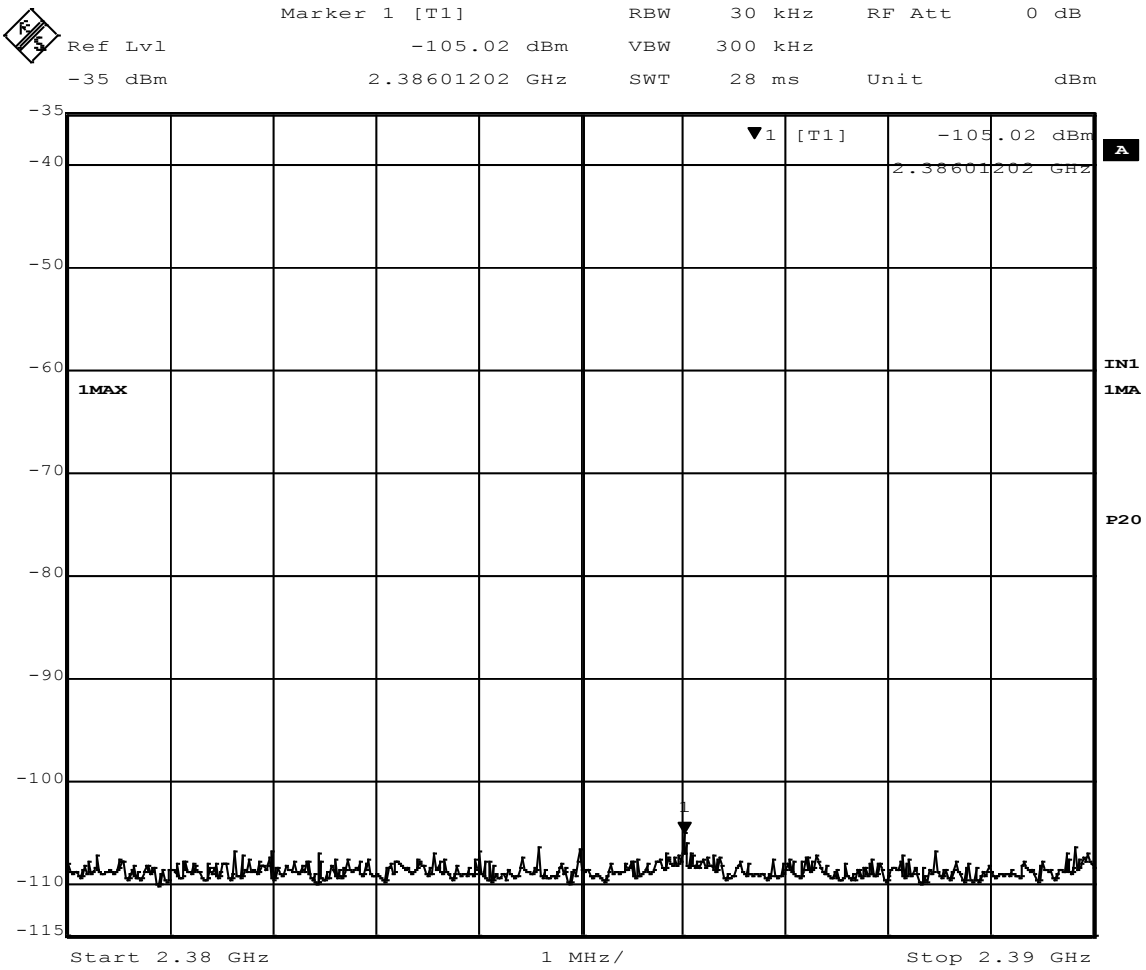

Figure 14 - Band-edge Measurement, Low Channel, Restricted Frequency

The plot shows an uncorrected measurement, used for relative measurements only.

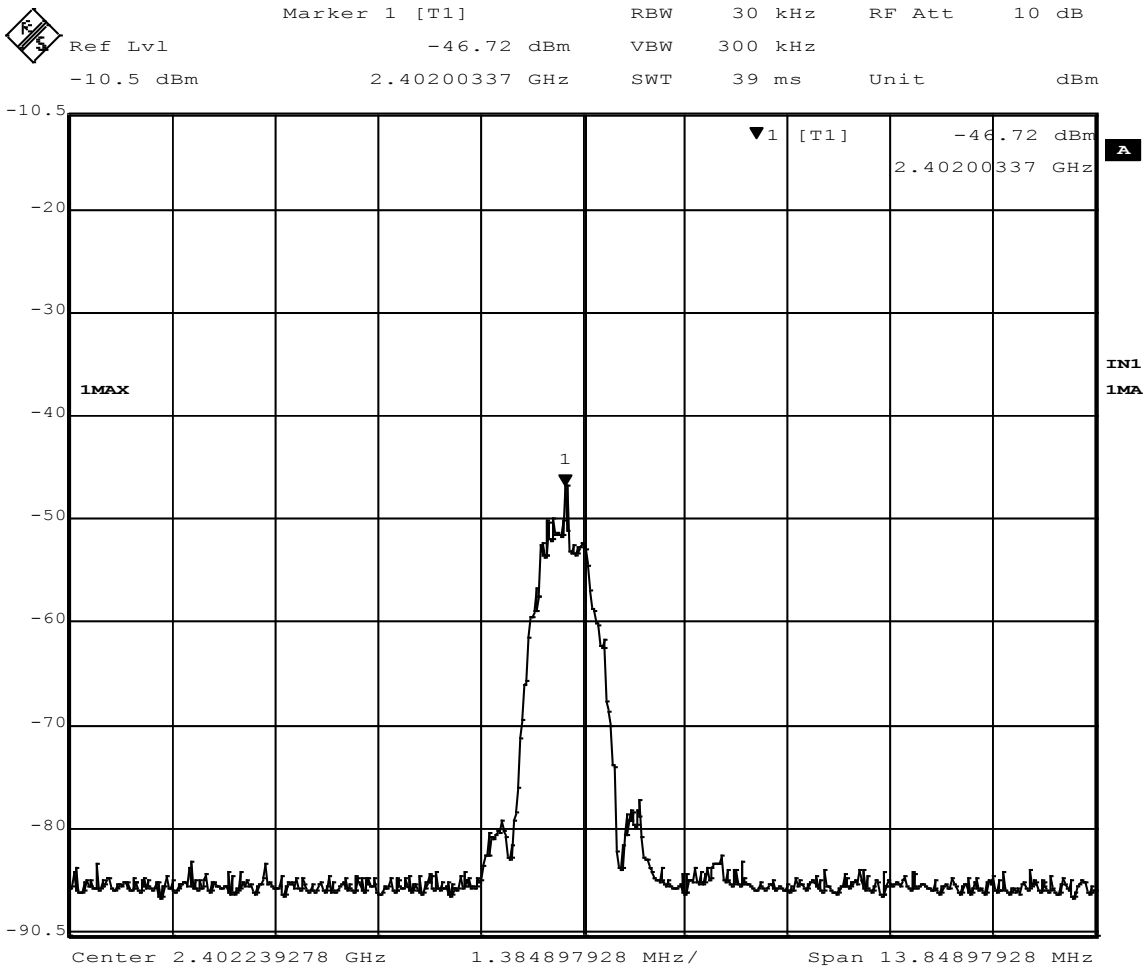

Figure 15 - Band-edge Measurement, Low Channel, Fundamental

The plot shows an uncorrected measurement, used for relative measurements only.

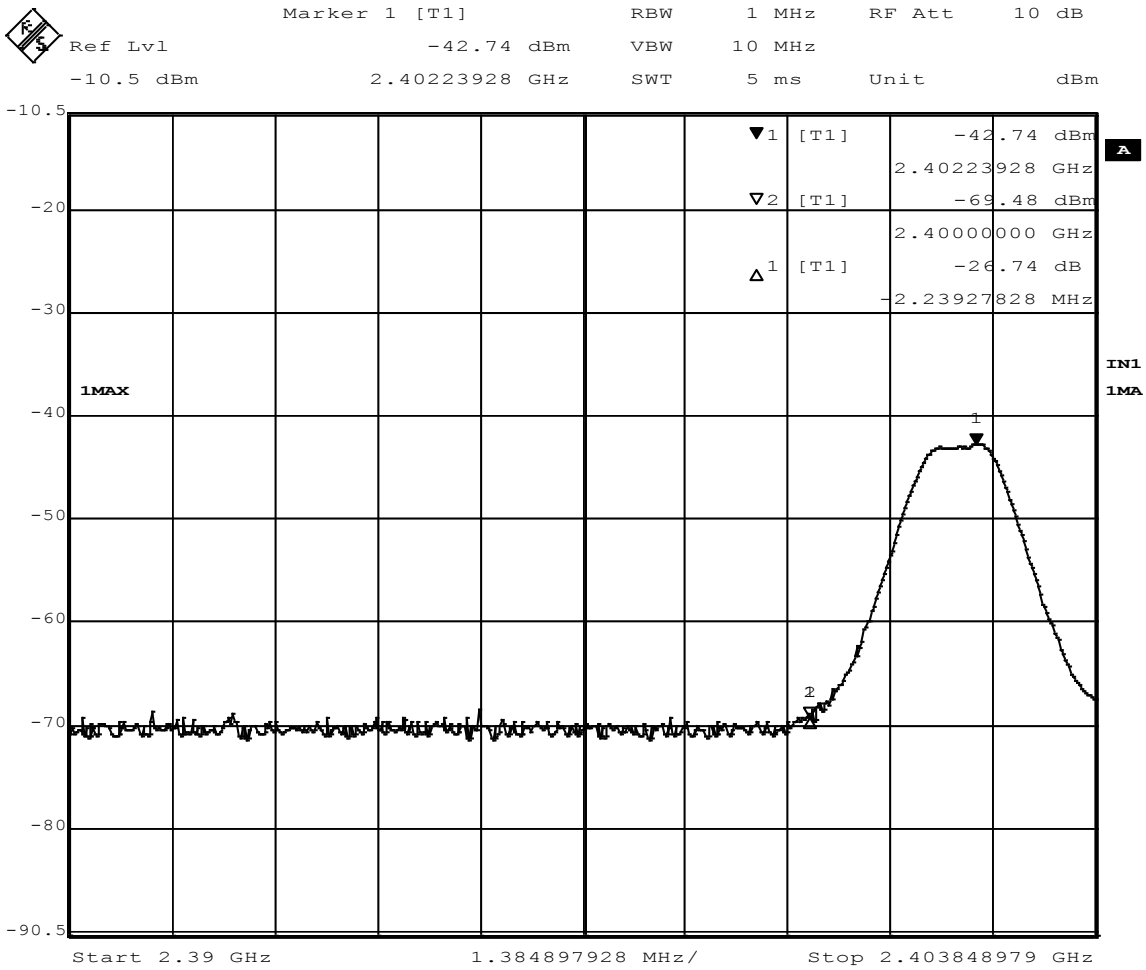

Figure 16 – Unrestricted Band-edge Measurement, Low Channel

The plot shows an uncorrected measurement, used for relative measurements only.

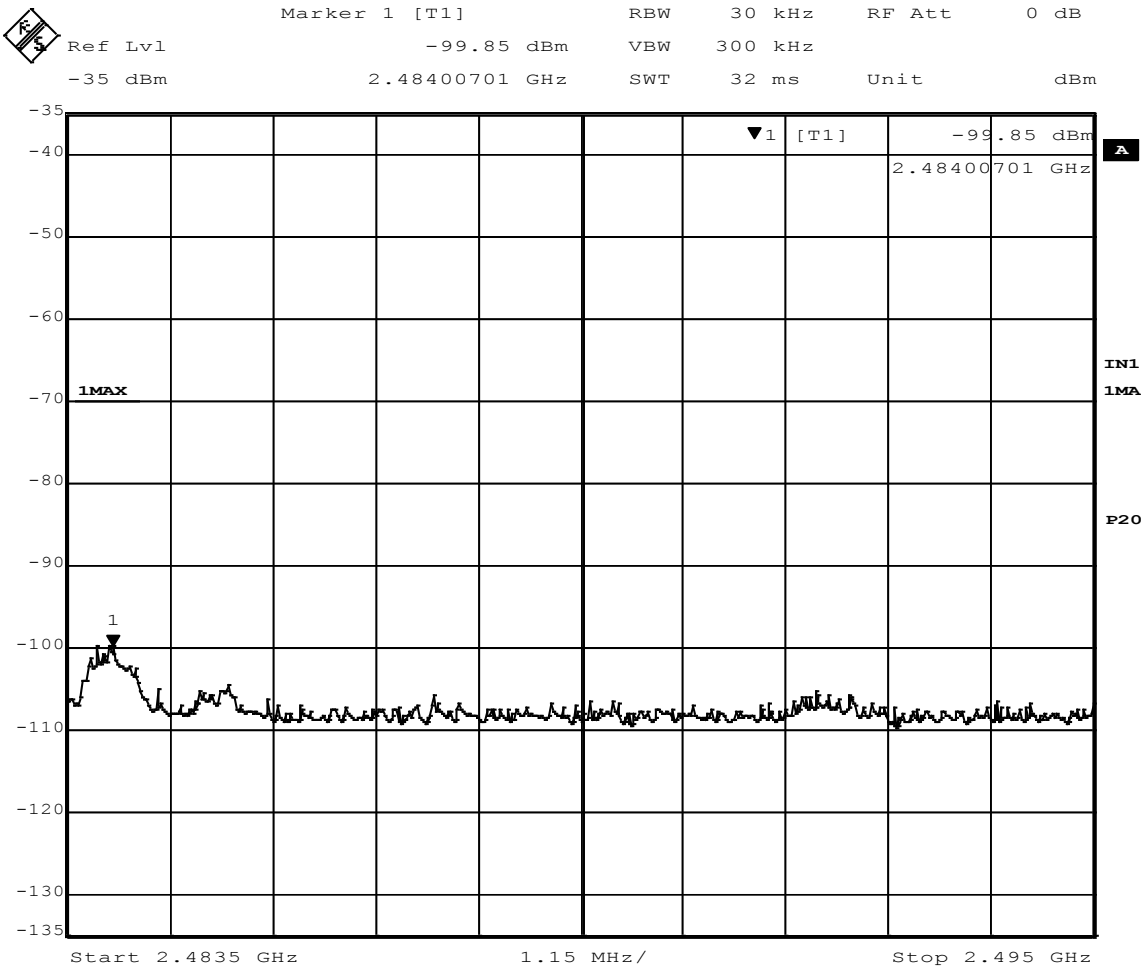

Figure 17 - Band-edge Measurement, High Channel, Restricted Frequency

The plot shows an uncorrected measurement, used for relative measurements only.

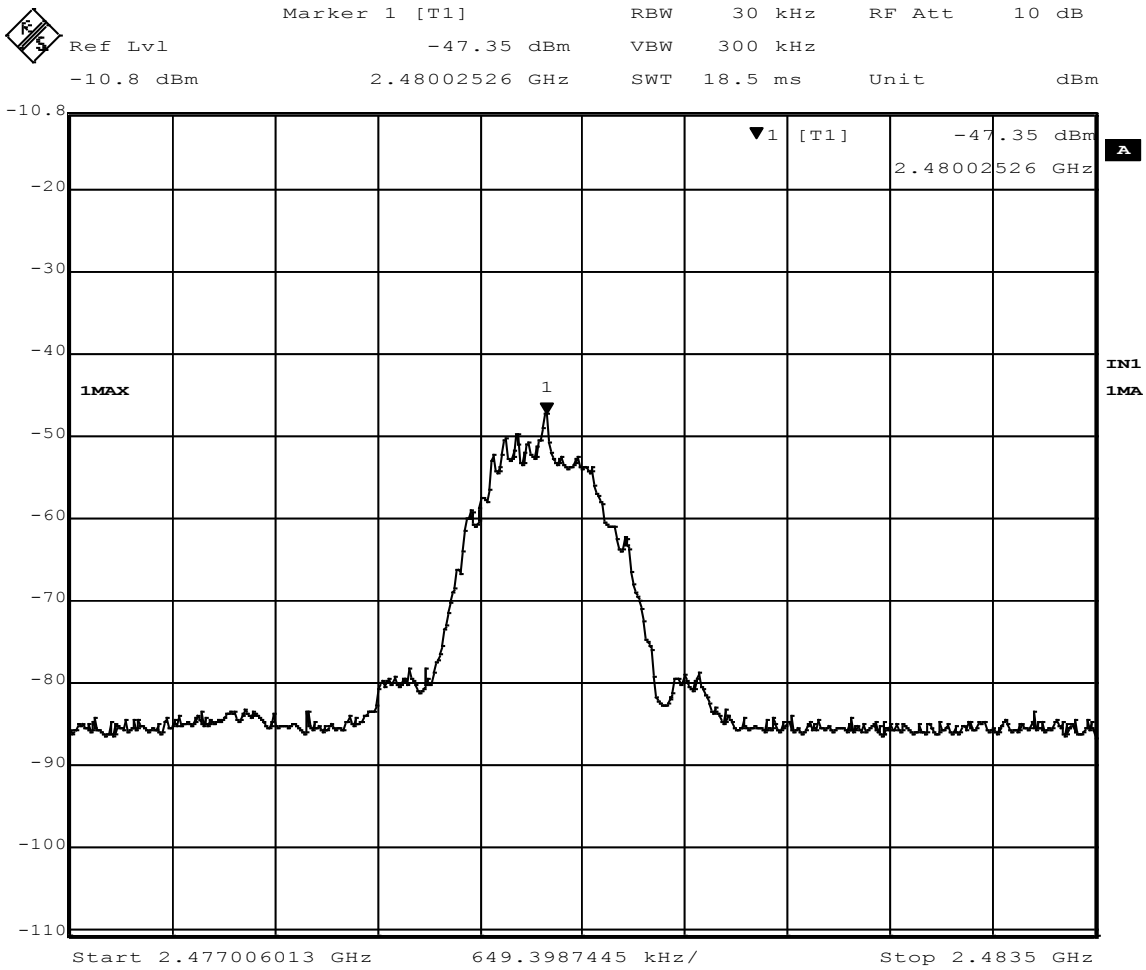

Figure 18 - Band-edge Measurement, High Channel, Fundamental

The plot shows an uncorrected measurement, used for relative measurements only.

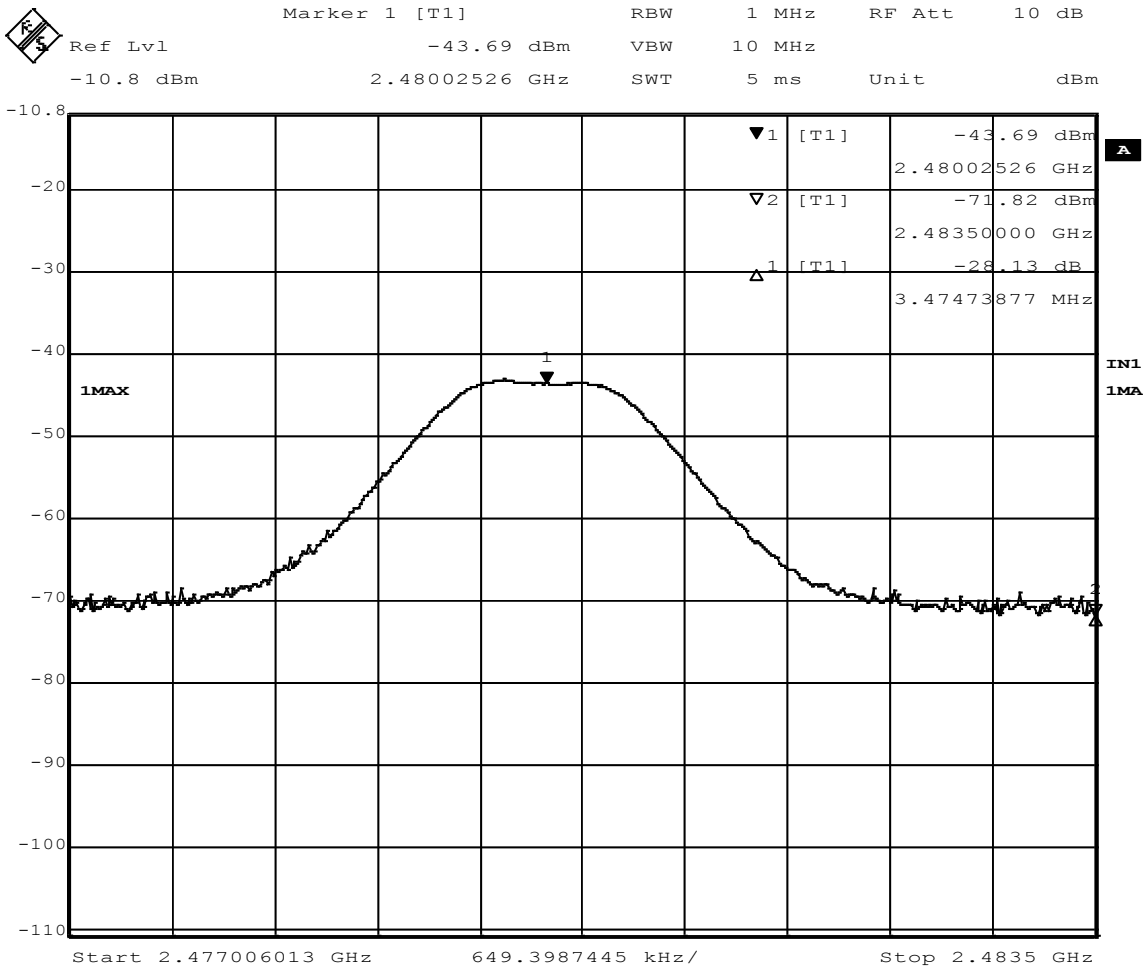

Figure 19 – Unrestricted Band-edge Measurement, High Channel

The plot shows an uncorrected measurement, used for relative measurements only.

4.6 Power Spectral Density

ANSI C63.10:2014, Section 11.10.2

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 3 VDC unless specified and set to transmit continuously on the lowest frequency channel and the highest frequency channel.

EUT MODULE	Low Energy Bluetooth Module (Hickory)	MODE	Cont. Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	46 % ± 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
Lowest	2402	-13.33	8.00	PASS
Middle	2440	-12.01	8.00	PASS
High	2480	-12.84	8.00	PASS

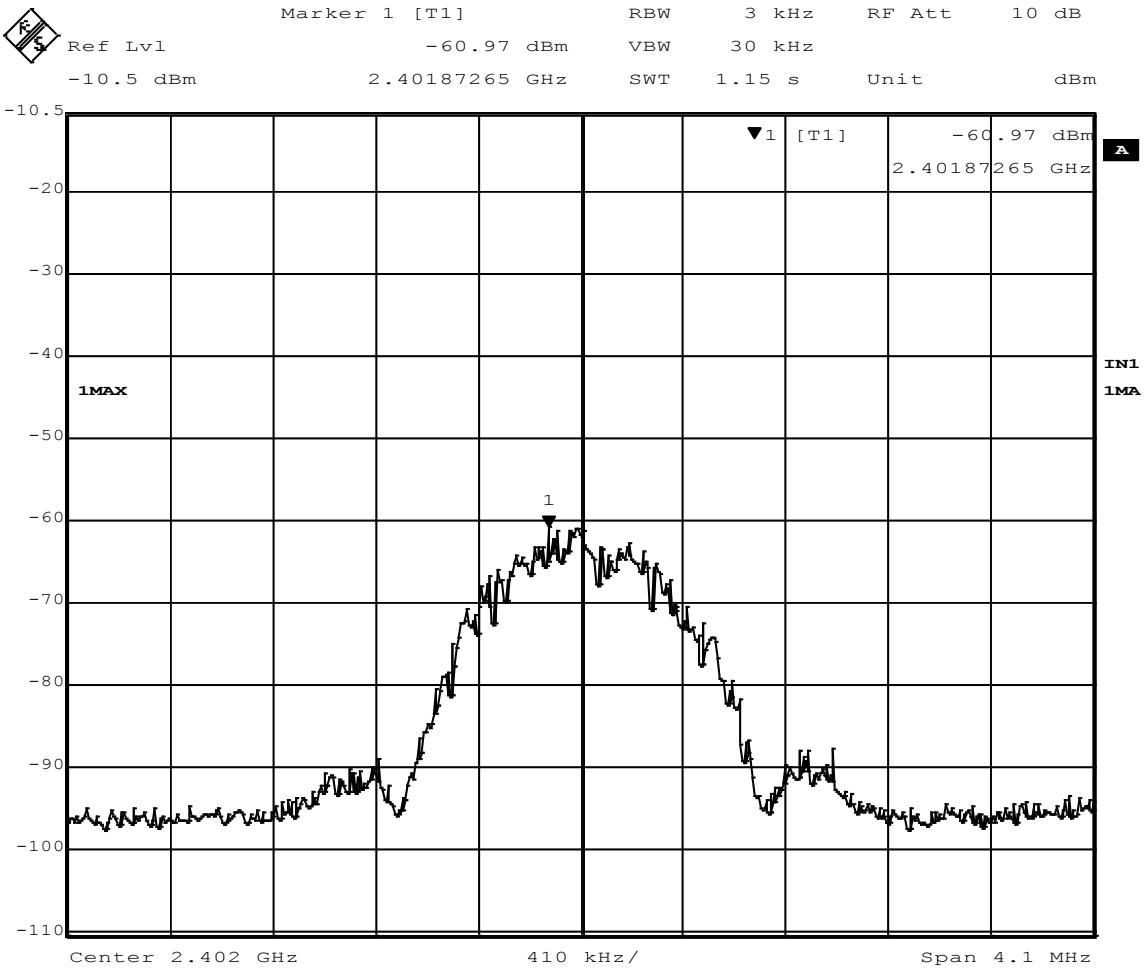

Figure 20 - Power Spectral Density Measurement, Lowest Channel

Power Spectral Density = -60.97 dBm + 107 + CL + AF - 95.23 = -13.33 dBm

CL = cable loss = 7.40 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.

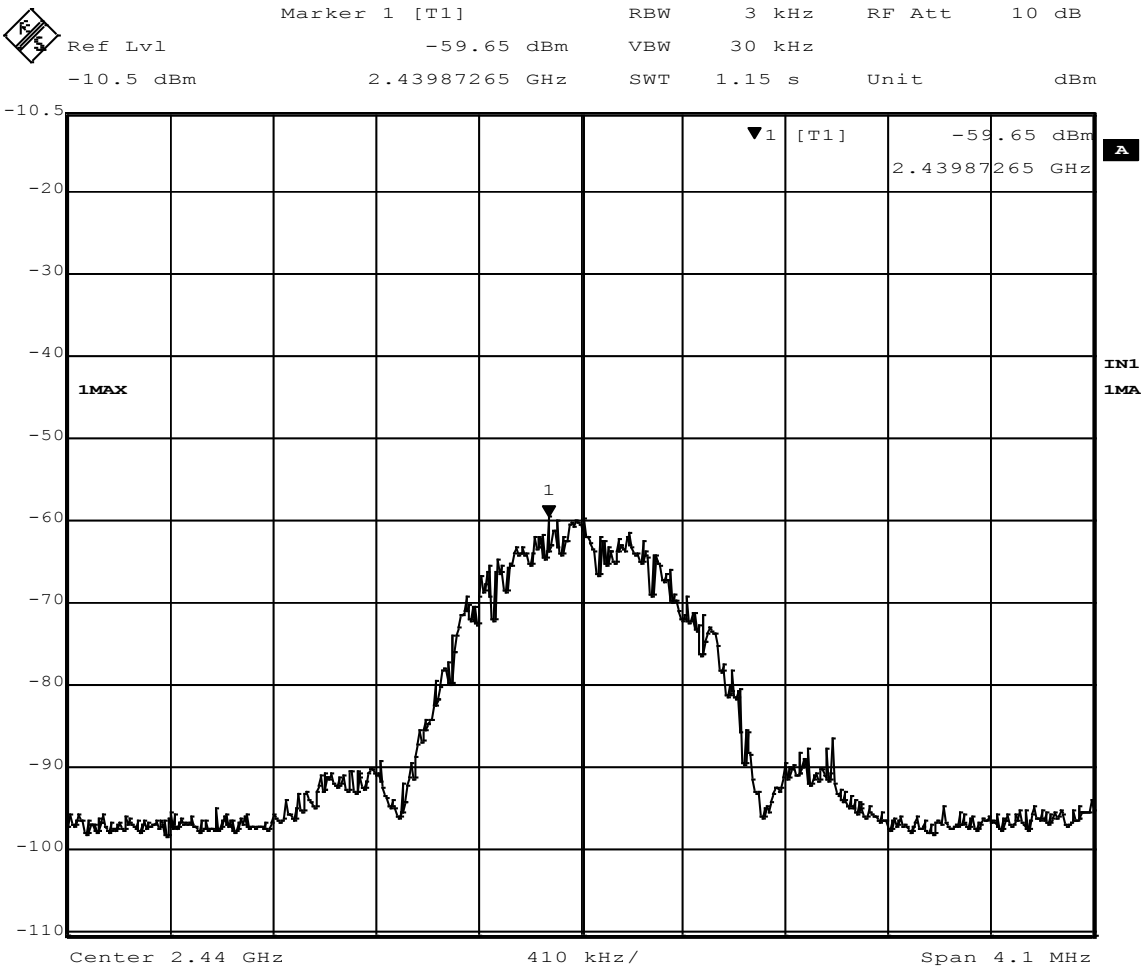

Figure 21 - Power Spectral Density Measurement, Middle Channel

Power Spectral Density = -59.65 dBm + 107 + CL + AF - 95.23 = -12.01 dBm

CL = cable loss = 7.40 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.

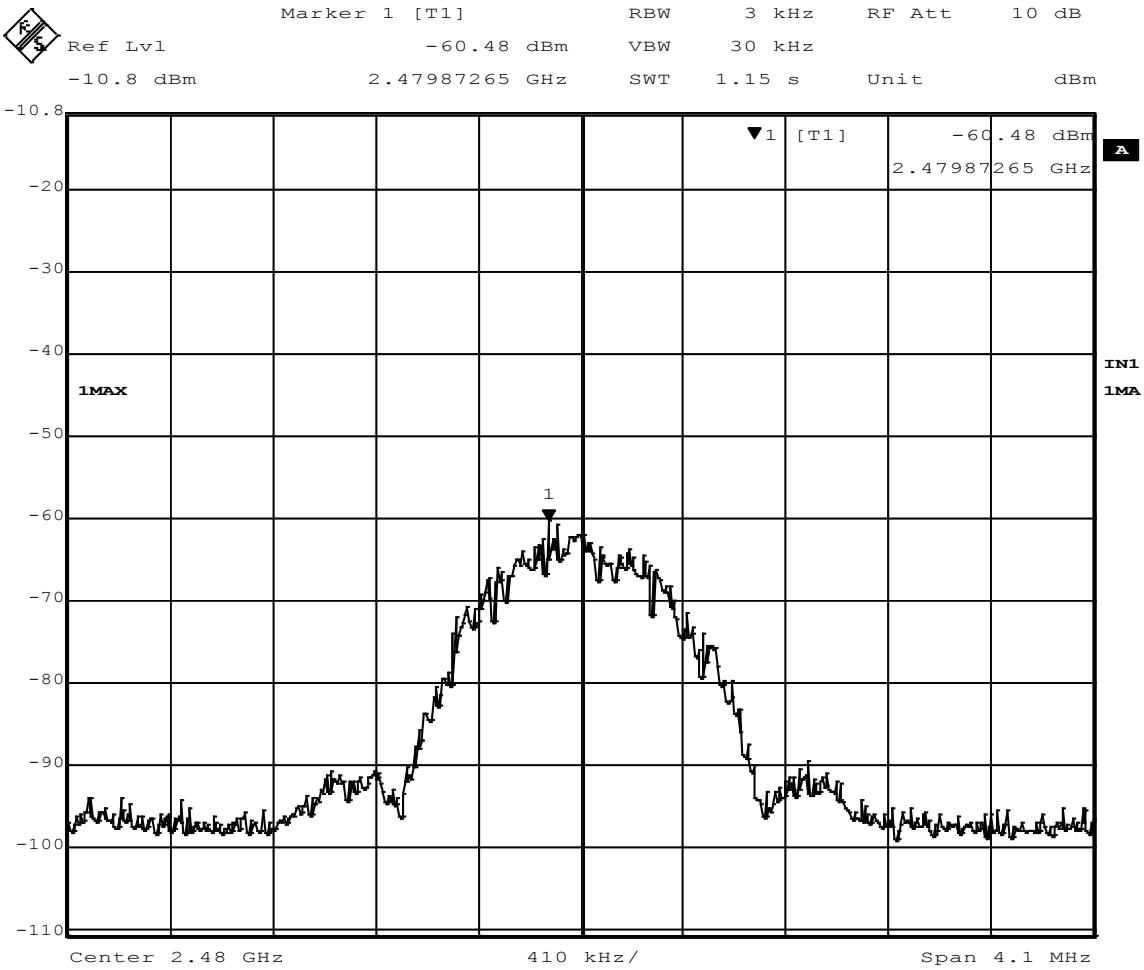

Figure 22 - Power Spectral Density Measurement, Highest Channel

Power Spectral Density = -60.48 dBm + 107 + CL + AF - 95.23 = -12.84 dBm

CL = cable loss = 7.40 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.

4.4 *Conducted AC Mains Emissions*

4.5.1 Limits for conducted emissions measurements

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50

NOTE: 1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz.
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

4.4.2 Test Procedures

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits could not be reported.
d. Results were compared to the 15.207 limits.

4.4.3 Deviation from the test standard

No deviation

4.4.4 Test setup

The EUT was tested as installed in a typical window blind controller application, model M40PV 344 from Hunter Douglas.

4.4.5 EUT operating conditions

The EUT was powered by 18 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.

4.4.6 Test Results

EUT MODULE	Low Energy Bluetooth Module (Hickory)	MODE	Cont. Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2400.0MHz - 2483.5MHz
ENVIRONMENTAL CONDITIONS	46 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

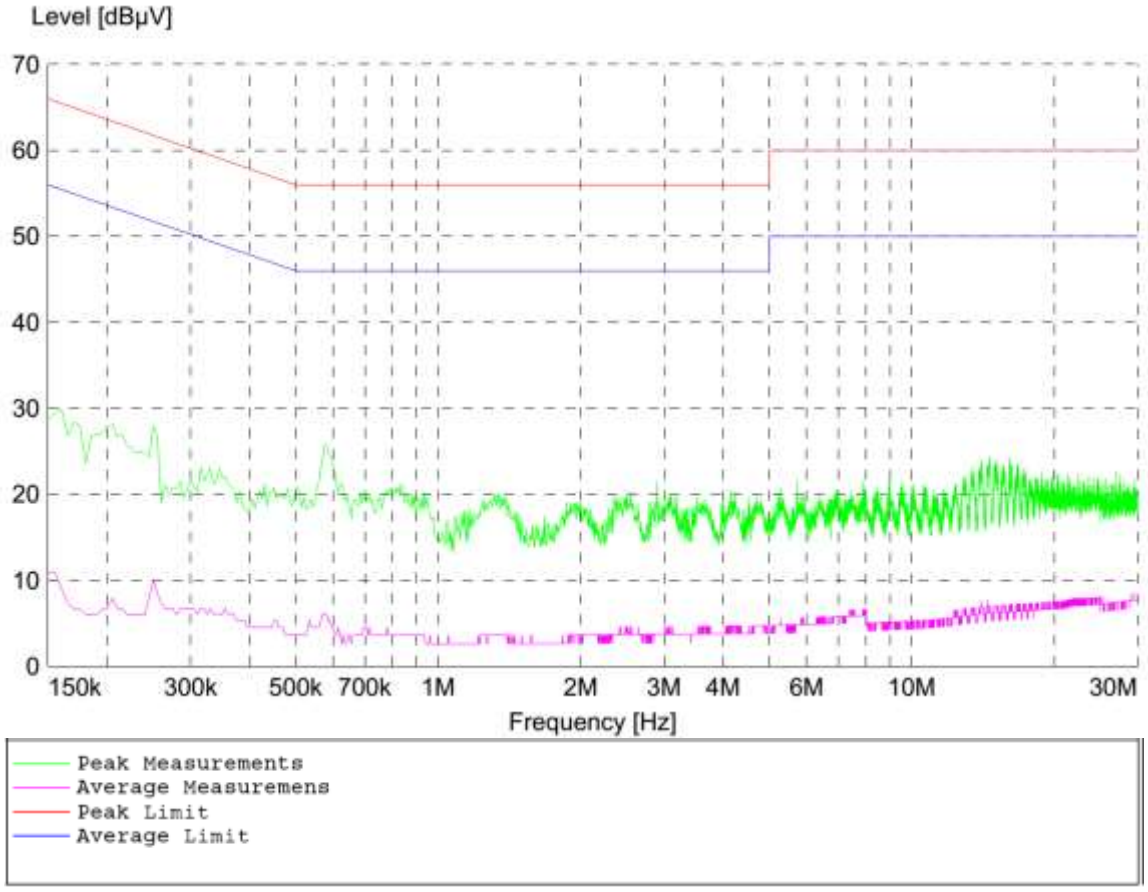

Figure 23 - Conducted Emissions Plot

All measurements were found to be at least 10dB below the applicable limit.

Appendix A: Test Photos

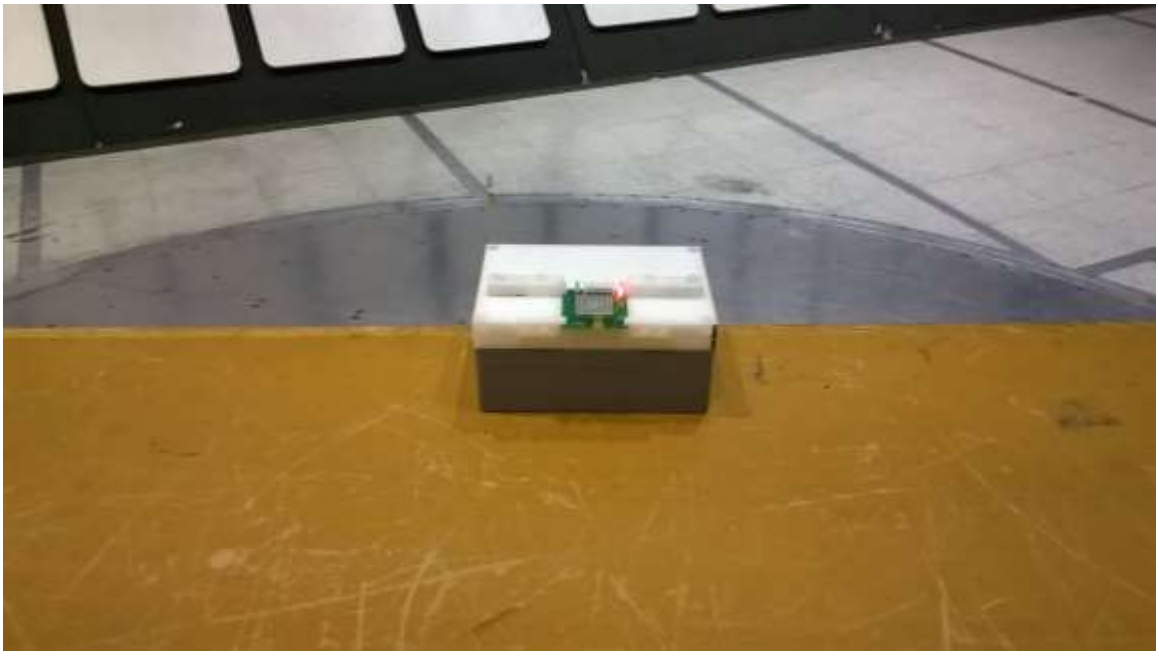

Figure 24 – Radiated Emissions Test Setup

Figure 25 - Radiated Emissions Test Setup

Figure 26 - Radiated Emissions Test Setup

Figure 27 – Power Supply Used for Radiated Emissions Tests

Figure 28 - AC/DC Power Used for Conducted Emissions

Figure 29 - Conducted Emissions Test Setup

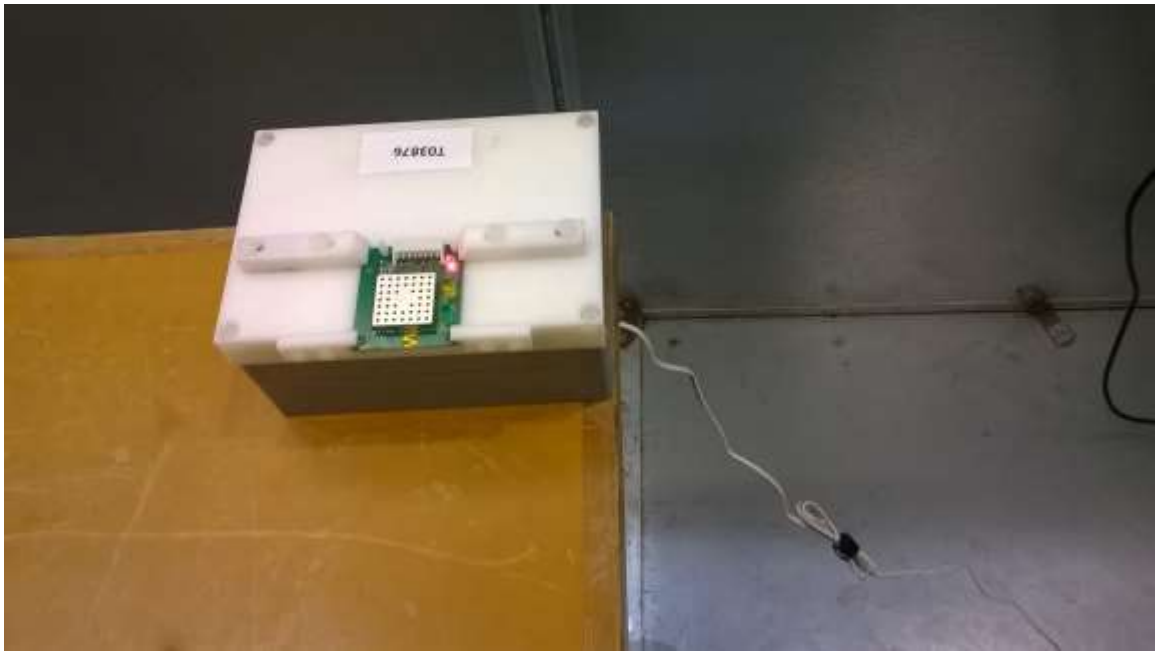

Figure 30 - Conducted Emission Test Setup

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

Annex C – Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB

Expanded uncertainty values are calculated to a confidence level of 95%.

Appendix D: Table of Figures