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Amended

Test Report

Includes NCEE Labs report R2017717-22-03A and its amendment in full

Prepared for: **MoJo Labs**

Address: **600 S Airport Rd Suite AF1**
Longmont CO 80503

Product: **MoJo Remote**

Test Report No: **R20170717-22-03B**

Approved By:

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

DATE: **18 January 2017**

Total Pages: **41**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

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1.0 Summary of test results

1.1 Test Results

The EUT has been tested according to the following specifications:

SUMMARY			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	Internal Antenna
FCC 15.209 RSS-Gen, 7.1.2	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247(a)(2) RSS-247, 5.2(a)	Minimum Bandwidth, Limit: Min. 500kHz	Pass	Meets the requirement of the limit.
FCC 15.247(b) RSS-247, 5.4	Maximum Peak Output Power, Limit: Max. 30dBm Conducted spurious measurements	Pass	Meets the requirement of the limit.
FCC 15.209 RSS-Gen, 8.9 RSS-247, 5.5	Transmitter Radiated Emissions	Pass	Meets the requirement of the limit.
FCC 15.247 RSS-247, 5.2(b)	Power Spectral Density, Limit: Max. 8dBm	Pass	Meets the requirement of the limit.
FCC 15.247 RSS-247, 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
FCC 15.207 RSS-Gen, 8.8	Conducted AC power-line emissions	NA	Meets the requirement of the limit.

1.2 Reason for amendment

Unused antenna was removed from equipment list in Section 3.0.
6 dB BW measurements were added

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was a wireless remote control for advanced smart wireless lighting that transmits from 2402-2480 MHz. It enables personal control of light levels with a gesture user interface, as well as enabling daylighting with its onboard light sensors.

EUT Received Date: 12 July 2017
EUT Tested Dates: 12 July 2017 – 1 November 2017

Description	Smart Lighting Remote
MODEL	MoJo Remote
Serial No.	NCEETEST0001
POWER SUPPLY	3 VDC (2x AAA Batteries)
ANTENNA TYPE	Antenna is not user replaceable

NOTE: 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 following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number :	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:
Relative humidity of 32 ± 4%
Temperature of 22 ± 3° Celsius

2.3 Description of test modes

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

Channel	Frequency
Low	2402
Middle	2440
High	2480

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

The maximum duty cycle was 21.8% as calculated based off of the communication rate and packet sizes.

2.4 Applied standards

The EUT uses digital modulation and operates between 2402-2480MHz. According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

(1) FCC Part 15, Subpart C (15.207, 15.209, 15.249)
(2) ANSI C63.10:2013
(3) Industry Canada RSS-Gen Issue 4
(4) Industry Canada RSS-247 Issue 2

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 the lowest, highest and one channel in the middle.

3.0 Test equipment used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	24 Jan 2017	24 Jan 2018
EMCO Biconilog Antenna	3142B	1654	26 Jan 2017	26 Jan 2018
EMCO Horn Antenna	3115	6416	25 Jan 2016	25 Jan 2018
EMCO Horn Antenna	3116	2576	26 Jan 2016	26 Jan 2018
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	9 Feb 2017*	9 Feb 2018*
Trilithic High Pass Filter	6HC330	23042	9 Feb 2017*	9 Feb 2018*
Rohde & Schwarz LISN	ESH3-Z5	100023	23 Jan 2017	23 Jan 2018
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Feb 2017*	09 Feb 2018*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Feb 2017*	09 Feb 2018*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Feb 2017*	09 Feb 2018*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Feb 2017*	09 Feb 2018*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Feb 2017*	09 Feb 2018*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Feb 2017*	09 Feb 2018*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Feb 2017*	09 Feb 2018*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Feb 2017*	09 Feb 2018*

*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 on the EUT is a PCB antenna attached to the PCB.

4.2 Radiated emissions

Test Method: ANSI C63.10, Section(s) 6.5, 6.6

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 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. The table was 0.8m high for measurements form 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

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 preview scan was performed with the EUT oriented in all 3 orthogonal axis. It was found that the X-axis (laying flat) position produced the highest emissions, and this orientation was used for all final measurements.

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, 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

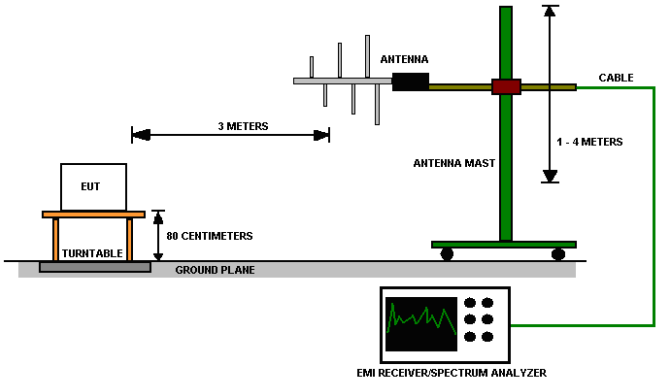

Figure 1 - Radiated Emissions Test Setup

The EUT was tested in all **3 orthogonal axis** to meet the requirements from **ANS C63.10 Section 5.10.1**.

4.2.5 EUT operating conditions

The EUT was powered by 3 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.

4.2.6 Test results

EUT MODULE	MOJO REMOTE	MODE	Receive
INPUT POWER	3 VDC	FREQUENCY RANGE	2402- 2480 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

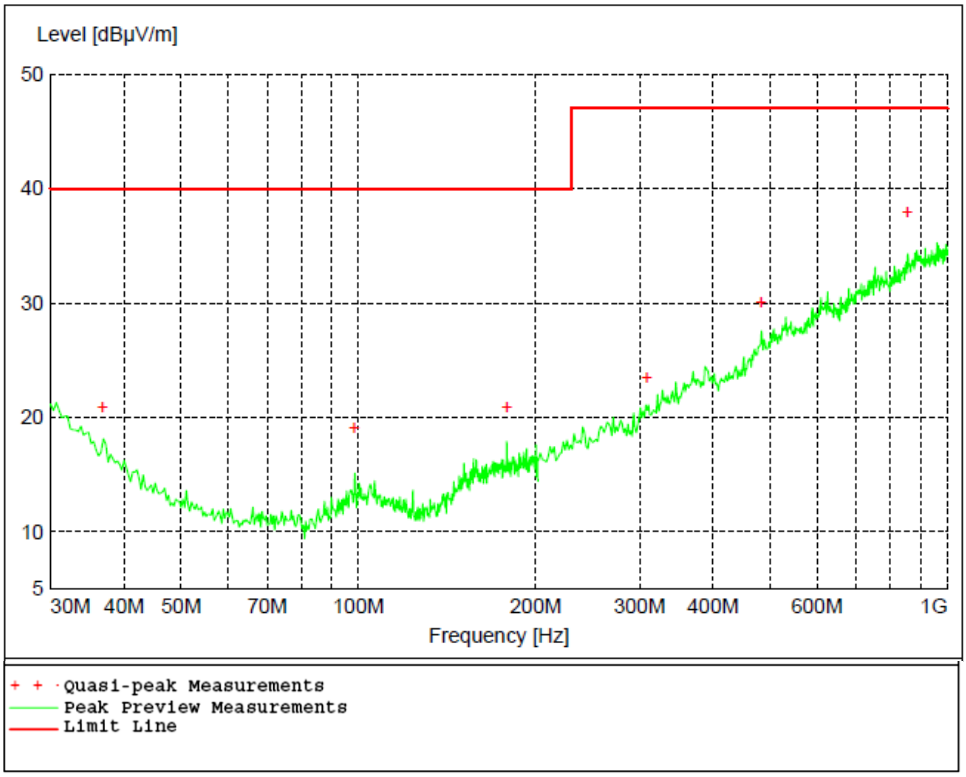

Figure 2 - Radiated Emissions Plot, Receive

Horizontal orientation of EUT was found to be the worse-case

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. Since peak measurements were compliant with the average limit, average measurements were not required.
6. The preview scan was performed with the EUT oriented in all 3 orthogonal axis. It was found that the X-axis (laying flat) position produced the highest emissions, and this orientation was used for all final measurements.

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
36.780000	20.89	40.00	19.10	390	146	HORI
98.460000	19.07	40.00	20.90	140	104	VERT
178.680000	20.90	40.00	19.10	113	23	VERT
308.800000	23.54	47.00	23.50	387	348	HORI
482.560000	30.10	47.00	16.90	400	321	HORI
855.220000	37.96	47.00	9.00	349	11	VERT

Table 2 - Radiated Emissions Peak Measurements
Compared to average limits to show compliance.

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2447.000000	38.51	54.00	15.49	156	104	HORI
4878.000000	47.90	54.00	6.10	113	256	HORI
7335.400000	43.89	54.00	10.10	173	60	VERT
9777.400000	45.57	54.00	8.40	170	321	VERT
12226.400000	41.09	54.00	12.90	217	172	VERT

EUT MODULE	MOJO REMOTE	MODE	Transmit, Low Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

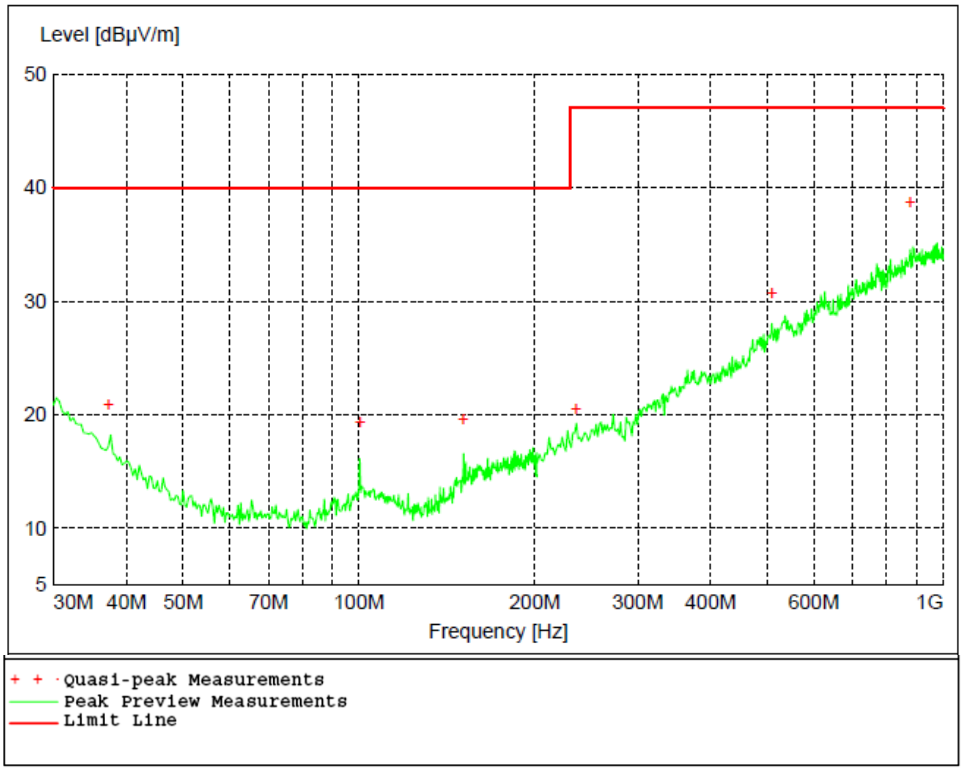

Figure 3 - Radiated Emissions Plot, Low Channel

Horizontal orientation of EUT was found to be the worse-case

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. The preview scan was performed with the EUT oriented in all 3 orthogonal axis. It was found that the X-axis (laying flat) position produced the highest emissions, and this orientation was used for all final measurements.

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
36.780000	20.89	40.00	19.10	390	146	HORI
98.460000	19.07	40.00	20.90	140	104	VERT
178.680000	20.90	40.00	19.10	113	23	VERT
308.800000	23.54	47.00	23.50	387	348	HORI
482.560000	30.10	47.00	16.90	400	321	HORI
855.220000	37.96	47.00	9.00	349	11	VERT

Table 4 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.000000	98.73	74.00	NA	163	304	HORI
4804.600000	52.91	74.00	21.09	163	330	HORI
7194.800000	44.42	74.00	29.58	397	124	VERT
9606.200000	46.17	74.00	27.83	101	126	HORI
12027.200000	42.73	74.00	31.27	238	84	VERT
14423.400000	51.20	74.00	22.80	99	348	VERT
16796.000000	49.88	74.00	24.12	327	236	HORI

Table 5 – Radiated Emissions, Average Measurements, Low Channel

Frequency	Level*	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2402.000000	85.50	NA	NA	163	304	HORI
4804.600000	39.68	54.00	14.32	163	330	HORI
7194.800000	31.19	54.00	22.81	397	124	VERT
9606.200000	32.94	54.00	21.06	101	126	HORI
12027.200000	29.50	54.00	24.50	238	84	VERT
14423.400000	37.97	54.00	16.03	99	348	VERT
16796.000000	36.65	54.00	17.35	327	236	HORI

*-13.23 dB was subtracted from the peak measurement to calculate the average measurement. This was done to account for the 21.8% duty cycle.

EUT MODULE	MOJO REMOTE	MODE	Transmit, Mid Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

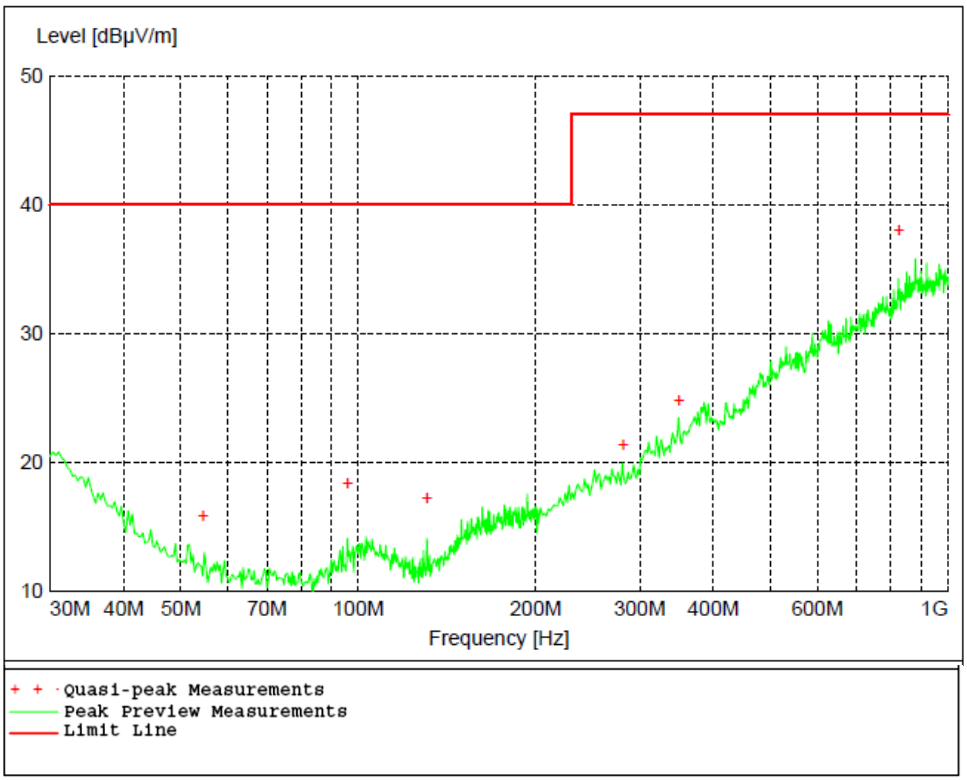

Figure 4 - Radiated Emissions Plot, Mid Channel

Horizontal orientation of EUT was found to be the worse-case

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. The preview scan was performed with the EUT oriented in all 3 orthogonal axis. It was found that the X-axis (laying flat) position produced the highest emissions, and this orientation was used for all final measurements.

Table 6 - Radiated Emissions Quasi-peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
54.600000	15.90	40.00	24.10	143	0	HORI
96.000000	18.44	40.00	21.60	326	359	HORI
130.860000	17.25	40.00	22.80	350	94	VERT
281.500000	21.46	47.00	25.50	129	65	HORI
350.080000	24.83	47.00	22.20	120	59	VERT
825.760000	38.00	47.00	9.00	100	59	VERT

Table 7 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2440.000000	98.01	NA	NA	115	242	HORI
4880.600000	52.11	74.00	21.89	100	84	HORI
7328.000000	42.99	74.00	31.01	349	0	VERT
9771.200000	47.15	74.00	26.85	369	257	VERT
12199.400000	38.96	74.00	35.04	256	329	HORI
14655.800000	50.92	74.00	23.08	362	216	HORI
17051.400000	52.48	74.00	21.52	399	94	VERT

Table 8 - Radiated Emissions Average Measurement, Mid Channel

Frequency	Level*	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2440.000000	84.78	NA	NA	115	242	HORI
4880.600000	38.88	54.00	15.12	100	84	HORI
7328.000000	29.76	54.00	24.24	349	0	VERT
9771.200000	33.92	54.00	20.08	369	257	VERT
12199.400000	25.73	54.00	28.27	256	329	HORI
14655.800000	37.69	54.00	16.31	362	216	HORI
17051.400000	39.25	54.00	14.75	399	94	VERT

*-13.23 dB was subtracted from the peak measurement to calculate the average measurement. This was done to account for the 21.8% duty cycle.

EUT MODULE	MOJO REMOTE	MODE	Transmit, High Channel
INPUT POWER	3 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

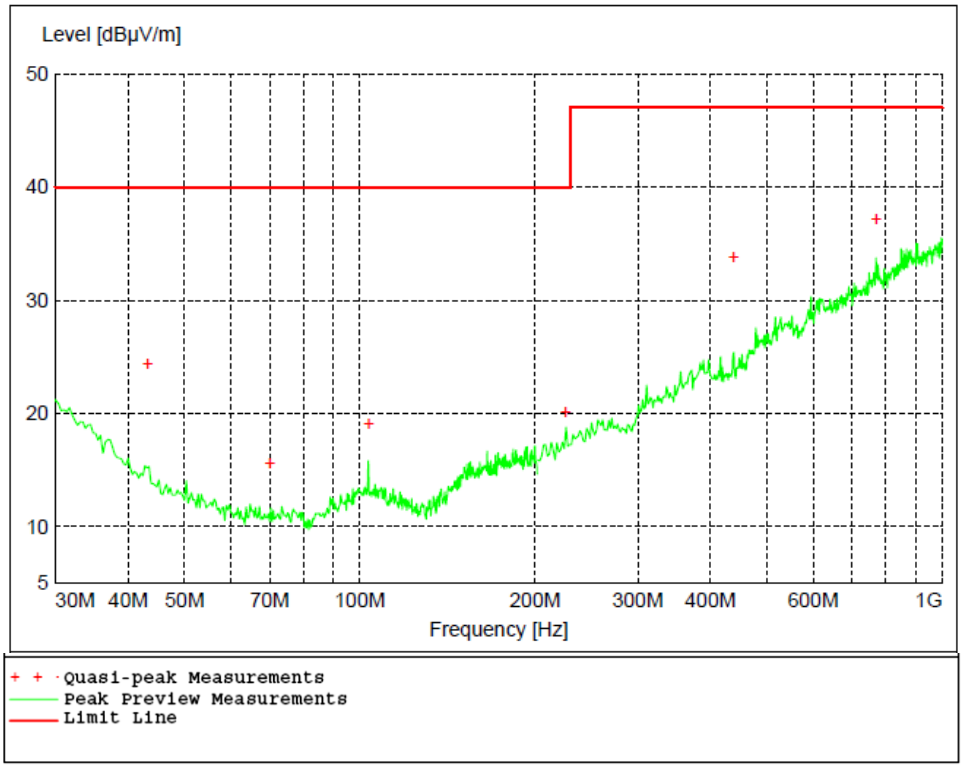

Figure 5 - Radiated Emissions Plot, High Channel

Horizontal orientation of EUT was found to be the worse-case

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. The preview scan was performed with the EUT oriented in all 3 orthogonal axis. It was found that the X-axis (laying flat) position produced the highest emissions, and this orientation was used for all final measurements.

Table 9 - Radiated Emissions Quasi-peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
43.200000	24.43	40.00	15.60	100	352	VERT
70.140000	15.69	40.00	24.30	397	359	HORI
103.680000	19.18	40.00	20.80	150	313	VERT
225.580000	20.18	40.00	19.80	176	291	HORI
438.580000	33.85	47.00	13.20	249	358	VERT
770.500000	37.20	47.00	9.80	149	255	VERT

Table 10 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	100.08	NA	NA	115	236	HORI
4959.600000	46.25	74.00	27.75	99	286	HORI
7435.800000	42.14	74.00	31.86	100	253	VERT
9932.800000	45.81	74.00	28.19	362	268	VERT
12409.600000	44.80	74.00	29.20	331	349	HORI
14866.000000	50.25	74.00	23.75	227	231	VERT
17347.600000	53.80	74.00	20.20	166	202	HORI

Table 11 - Radiated Emissions Average Measurements, High Channel

Frequency	Level*	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	86.85	NA	NA	115	236	HORI
4959.600000	33.02	54.00	20.98	99	286	HORI
7435.800000	28.91	54.00	25.09	100	253	VERT
9932.800000	32.58	54.00	21.42	362	268	VERT
12409.600000	31.57	54.00	22.43	331	349	HORI
14866.000000	37.02	54.00	16.98	227	231	VERT
17347.600000	40.57	54.00	13.43	166	202	HORI

*-13.23 dB was subtracted from the peak measurement to calculate the average measurement. This was done to account for the 21.8% duty cycle.

4.3 Bandwidth and Peak EIRP

Test Method: ANSI C63.10,
Section(s) 6.7, 6.9, 11.8.1, 11.9.1.1

4.3.1 Limits of bandwidth measurements

The 99% occupied bandwidth and peak EIRP are displayed for informational purposes only. The peak EIRP was measured using a 10 MHz RBW, which was over-laid on the plot showing the bandwidth using a 100 kHz RBW.

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 300 kHz VBW.

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 100 kHz 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

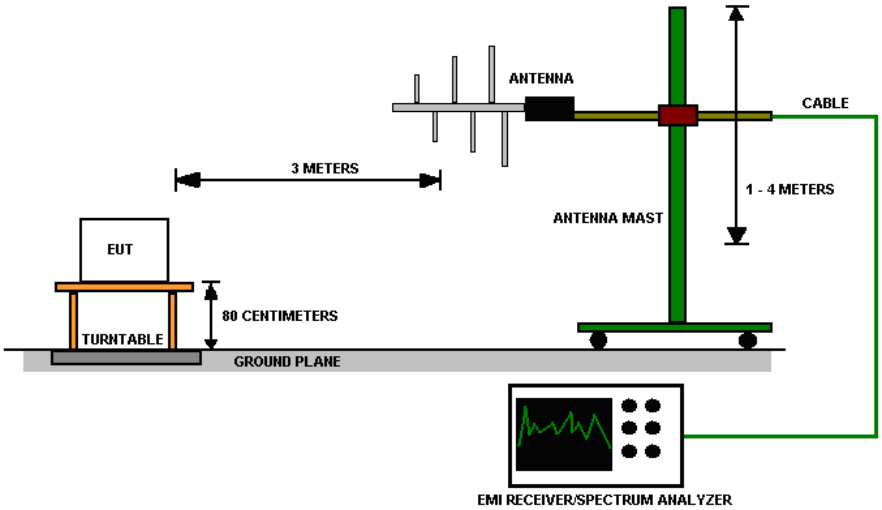

Figure 6 - Bandwidth Measurements Test Setup

4.3.5 EUT operating conditions

The EUT was powered by 3 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	MOJO REMOTE	MODE	Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2402- 2480 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)	6 dB BW (MHz)
Low	2402	1.23	0.737
Mid	2440	1.18	0.749
High	2480	1.24	0.749

REMARKS:
None

Peak EIRP

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	RESULT
Low	2402	4.65	Pass
Mid	2440	7.41	Pass
High	2480	6.00	Pass

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

REMARKS:
None

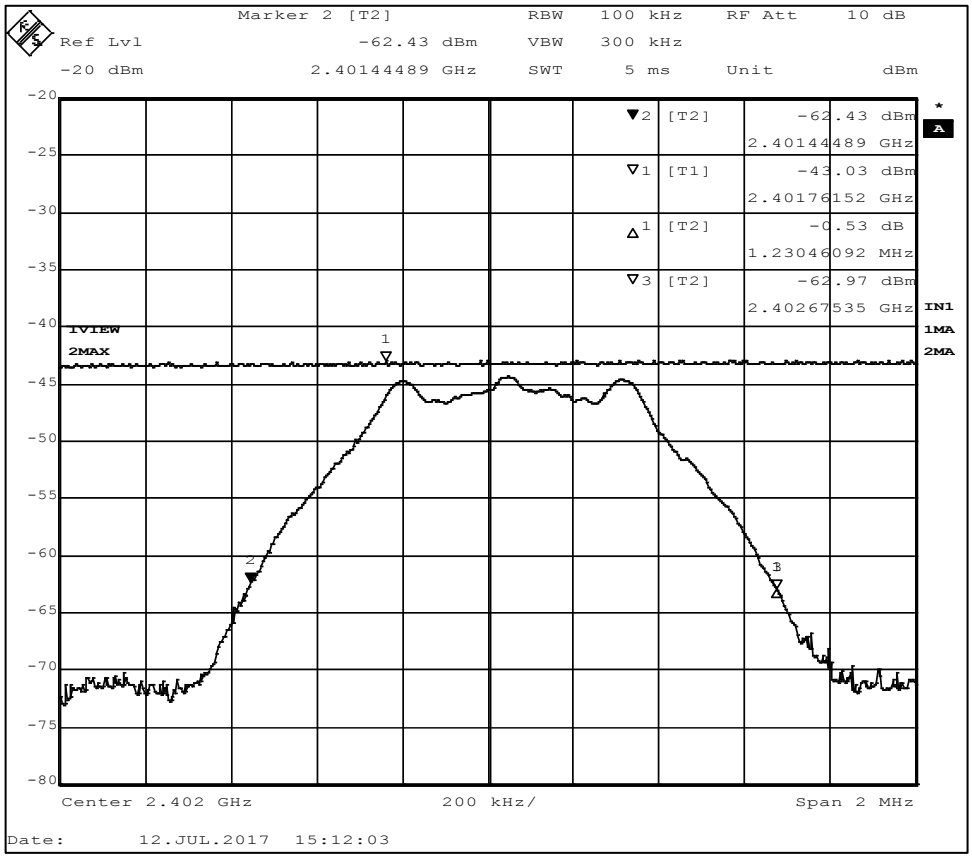

Figure 7 - 99% Occupied Bandwidth, Low Channel. 1.23 MHz

Maximum power = -31.79 dBm + 107 + CL + AF - 95.23 = 4.65 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 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. The trace on the bottom was made with a 100 kHz RBW.

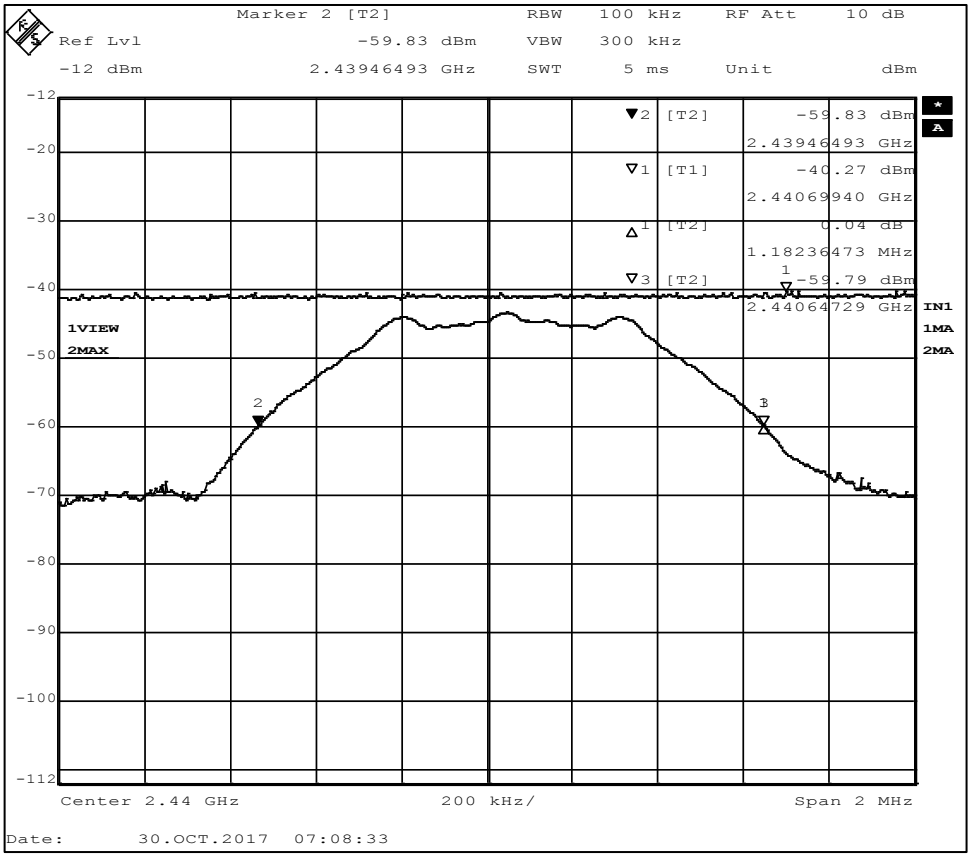

Figure 8 - 99% Occupied Bandwidth, Mid Channel, 1.18 MHz

Maximum power = -40.27 dBm + 107 + CL + AF - 95.23 = 7.41 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 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. The trace on the bottom was made with a 100 kHz RBW.

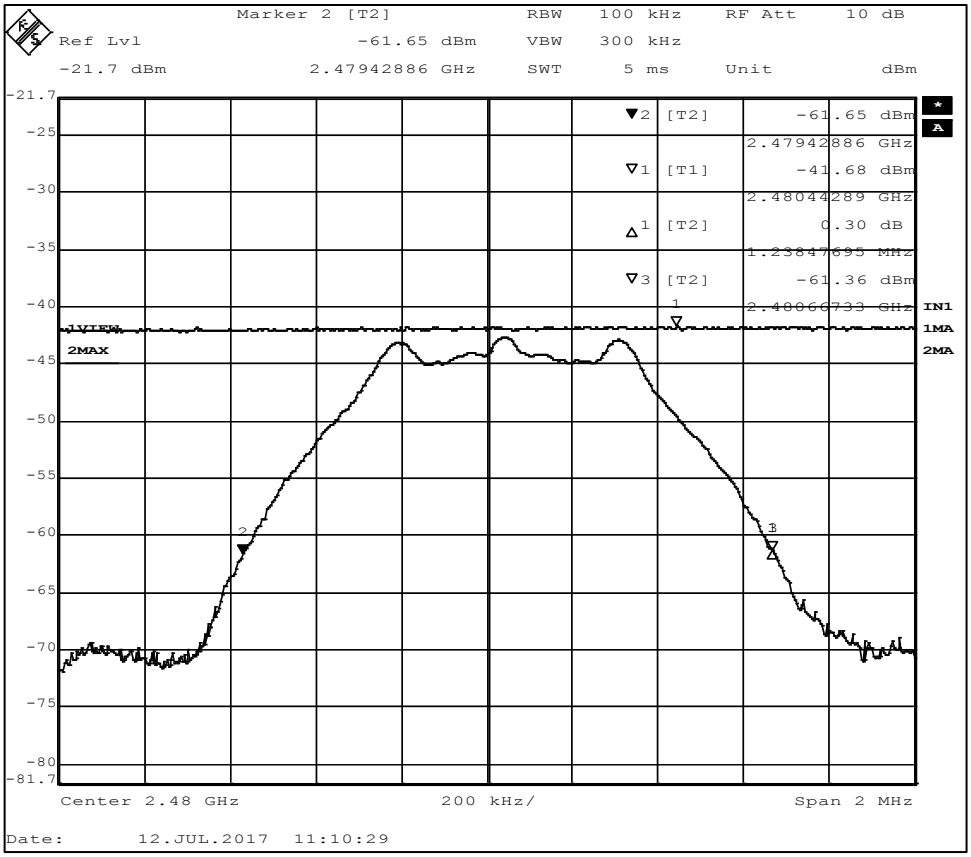

Figure 9 - 99% Occupied Bandwidth, High Channel, 1.24 MHz

Maximum power = -41.68 dBm + 107 + CL + AF - 95.23 = 6.00 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 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. The trace on the bottom was made with a 100 kHz RBW.

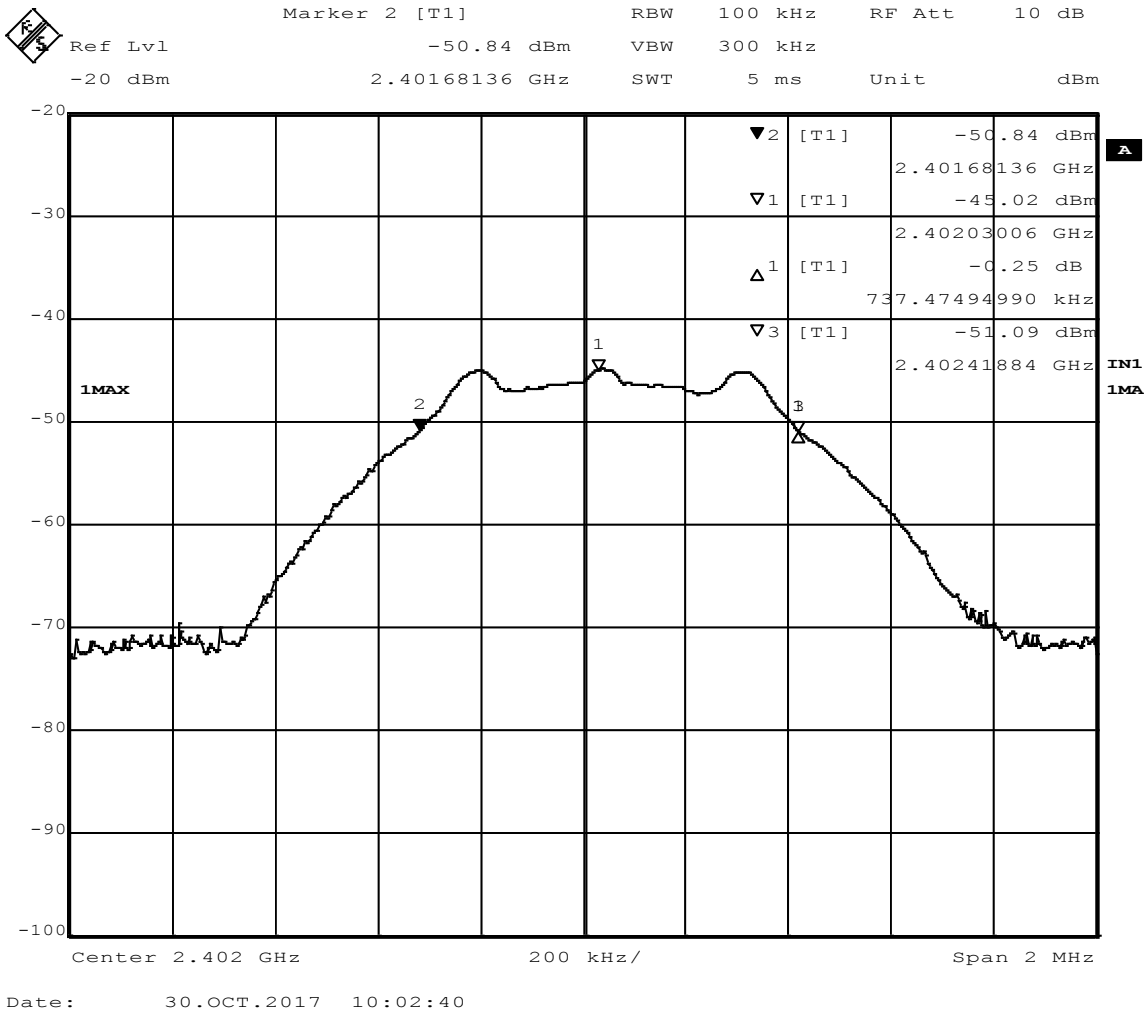

Figure 10 - 6 dB Bandwidth, Low-channel, 737.47 kHz

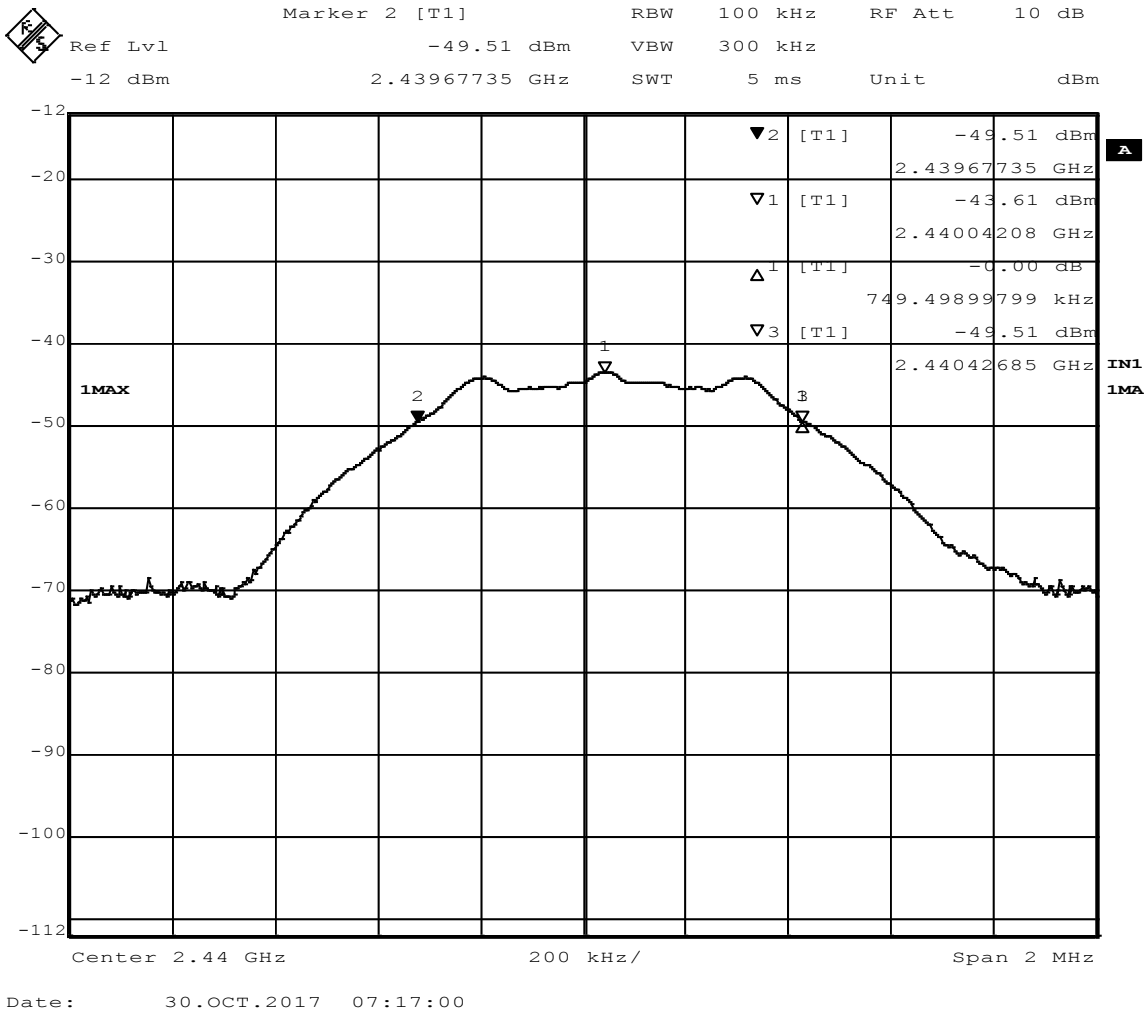

Figure 11 - 6 dB Bandwidth, Mid-channel, 749.50 kHz

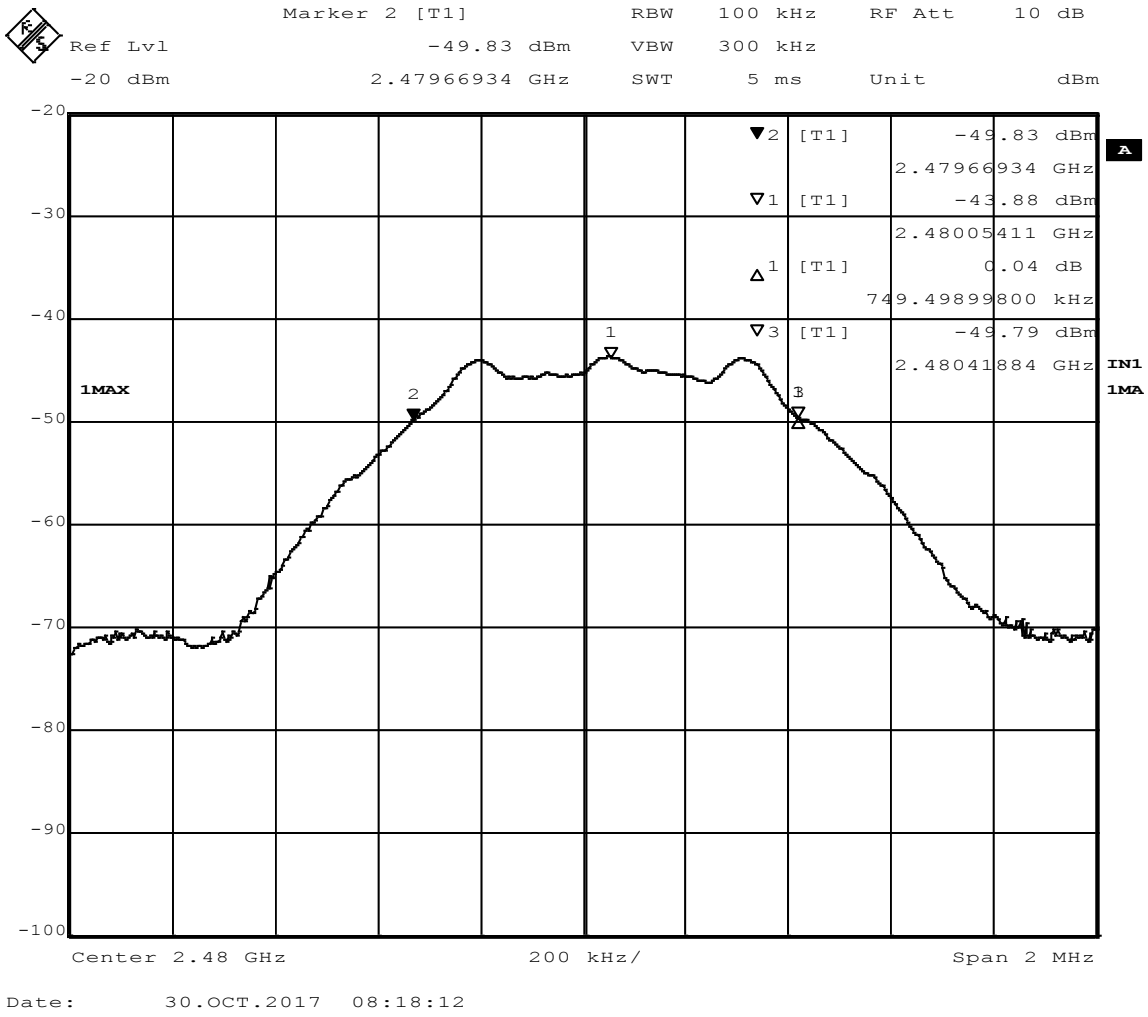

Figure 12 – 6 dB Bandwidth, High Channel, 749.50 kHz

4.4 Bandedges

Test Method: ANSI C63.10, Section(s) 6.10.6, 11.13.2

4.4.1 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.

4.4.2 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 100 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.

4.4.3 Deviations from test standard

No deviation.

4.4.4 Test setup

See Section 4.3

4.4.5 EUT operating conditions

The EUT was powered by 3 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	MOJO REMOTE	MODE	Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2402-2480 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 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
Low	2402.1	-106.31	-55.58	50.73	44.37	Pass
High	2480.0	-102.35	-45.05	57.30	46.08	Pass

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

From Section 4.2

Fundamental field strength at 2405MHz for low channel =98.37 dBµV/m
Fundamental field strength at 2480MHz for high channel = 100.08 dBµV/m

Channel 1 minimum delta = 98.37 dBµV/m - 54 dBµV/m=44.37 dBc
Channel 3 minimum delta = 100.08 dBµV/m - 54 dBµV/m=46.08 dBc

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

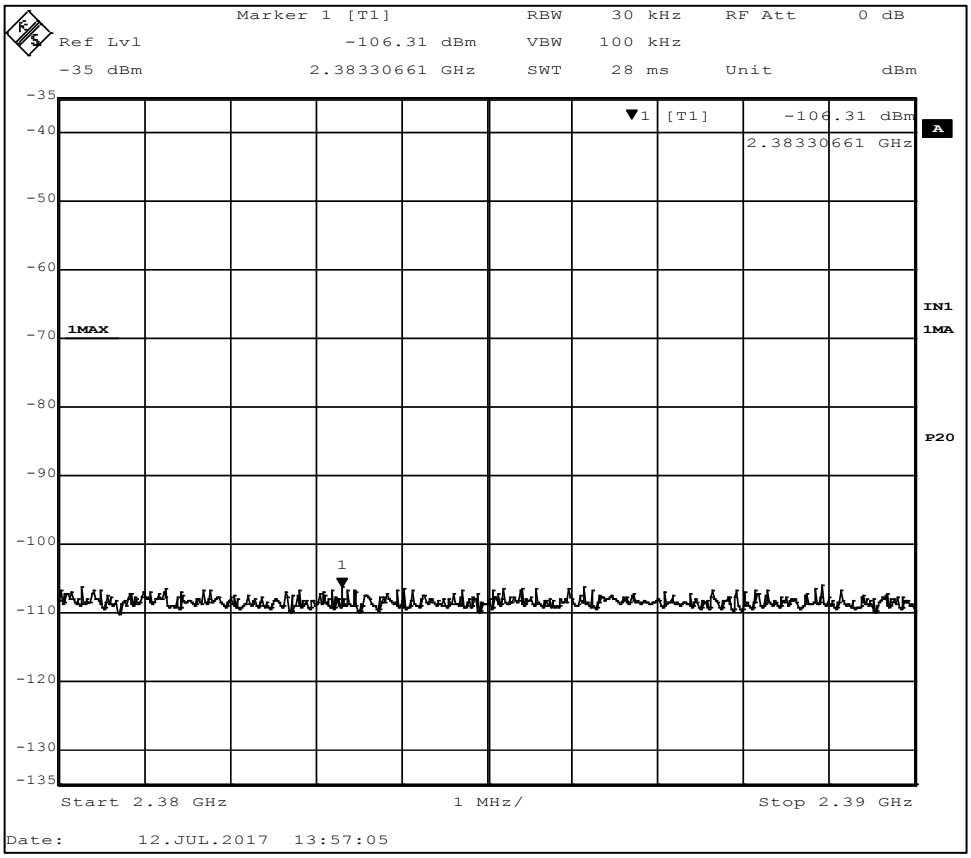

Figure 13 - Band-edge Measurement, Low Channel, Restricted Frequency

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

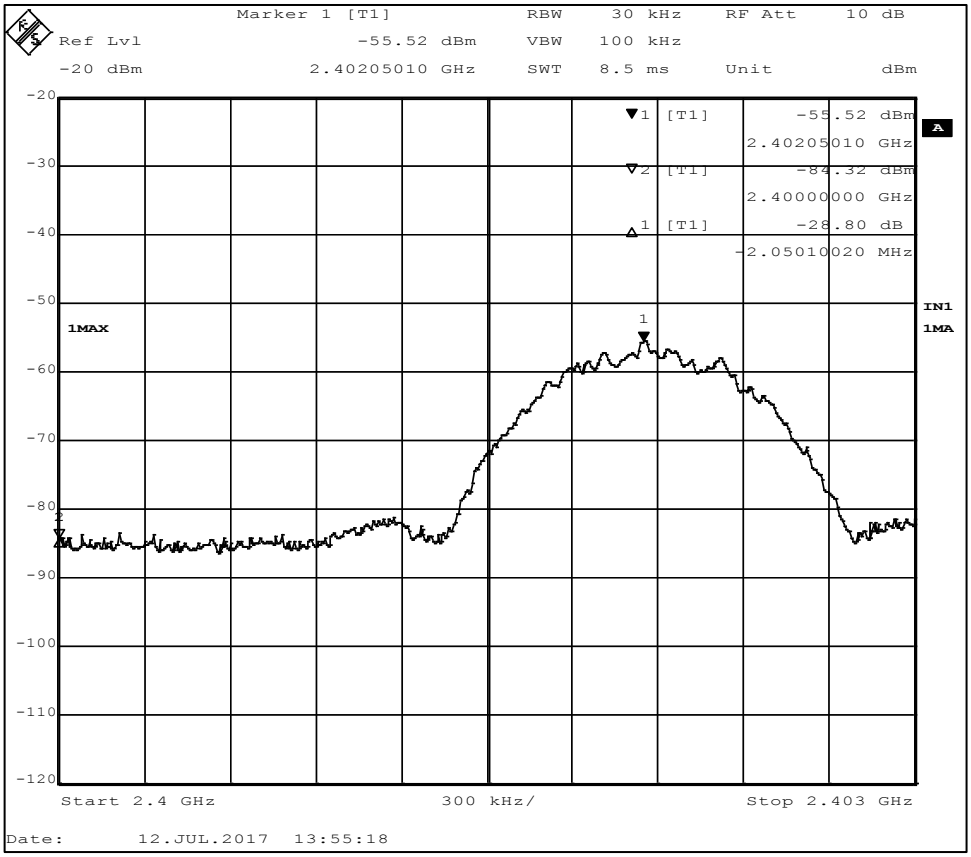

Figure 14 - Band-edge Measurement, Low Channel, Unrestricted Frequency

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

Delta = 28.80 dB Minimum =20 dB

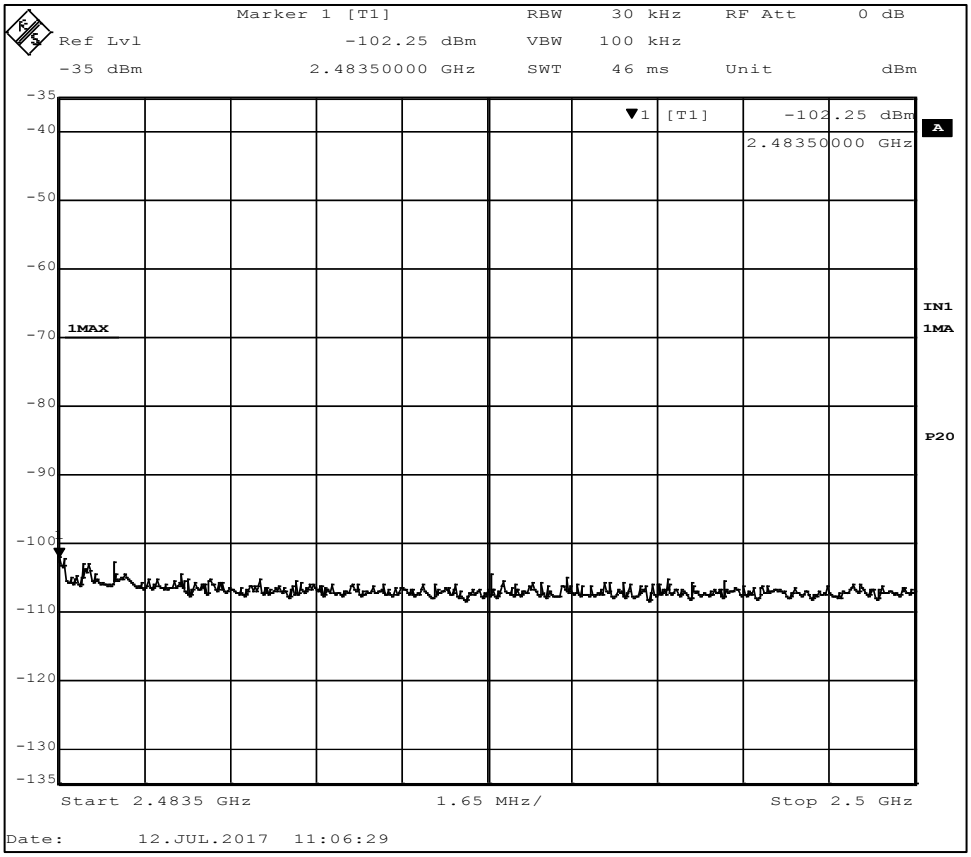

Figure 15 - Band-edge Measurement, High Channel, Restricted Frequency

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

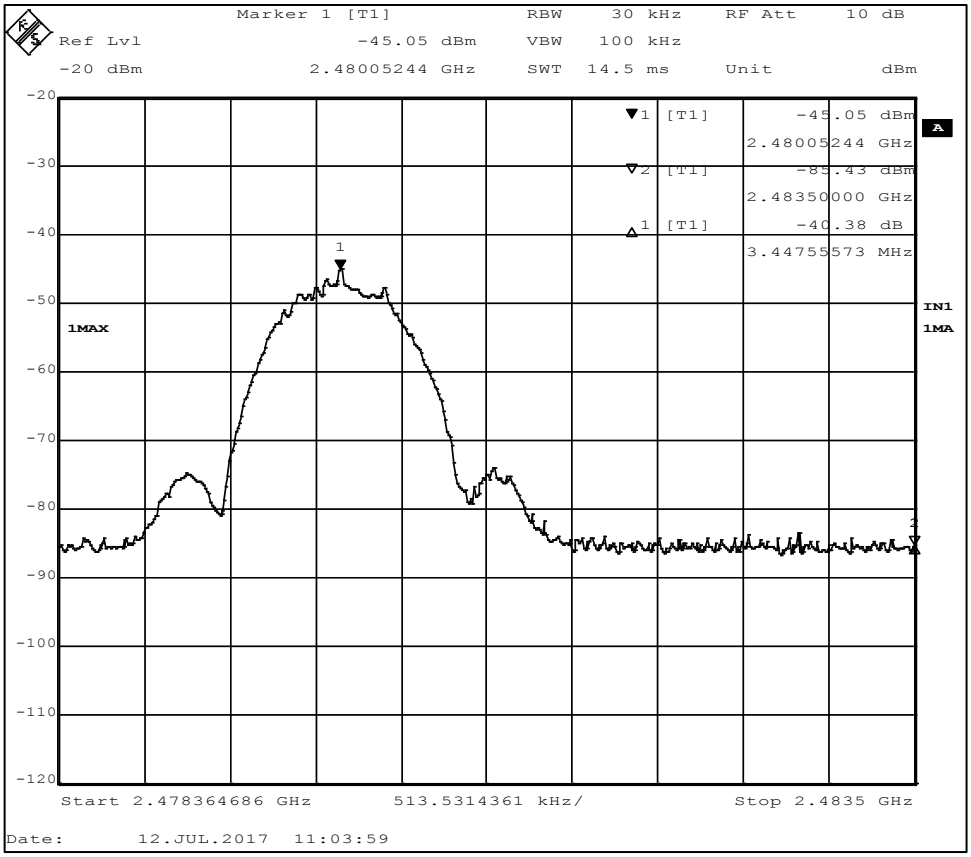

Figure 16 - Band-edge Measurement, High Channel, Unrestricted Frequency

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

Delta = 40.38 dB; Minimum = 20 dB

4.5 Power spectral density (PSD)

Test Method: ANSI C63.10, Section 11.10.2

4.5.1 Limits of PSD measurements

The maximum power spectral density allowed is 8dBm.

4.5.2 Test procedures

The transmitter output was measured at 3 m test distance with a spectrum analyzer. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using **3 kHz RBW and 30 kHz VBW**; the sweep time was set to **auto-couple**. 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.

4.5.3 Deviations from test standard

No deviation.

4.5.4 Test setup

See Section 4.3

4.5.5 EUT operating conditions

See Section 2.6.

4.5.6 Test results

Power Spectral Density

EUT MODULE	MOJO REMOTE	MODE	Transmit
INPUT POWER	3 VDC	FREQUENCY RANGE	2402-2480 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	RF POWER LEVEL (dBm)	MAXIMUM POWER LIMIT (dBm)	RESULT
Low	2402	-9.92	8.0	PASS
Mid	2440	-8.78	8.0	PASS
High	2480	-8.35	8.0	PASS

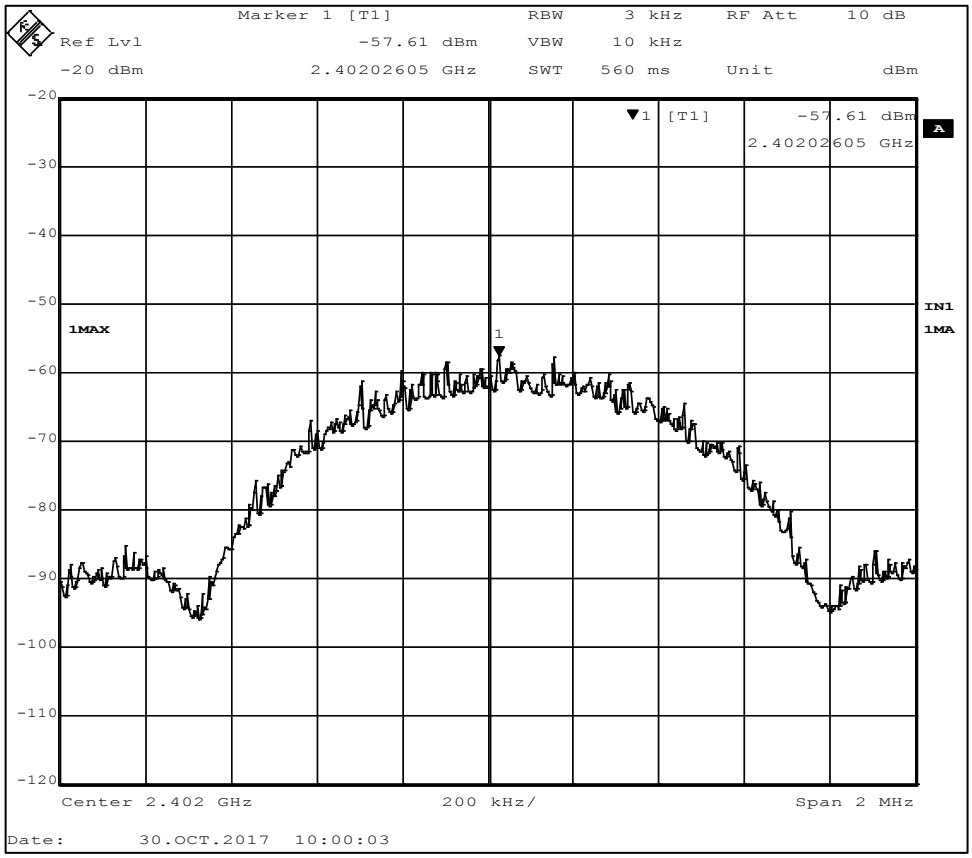

Figure 17 - Power Spectral Density Measurement, Low Channel

Power Spectral Density = -57.61 dBm + 107 + CL + AF - 95.23 = -9.92 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 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.

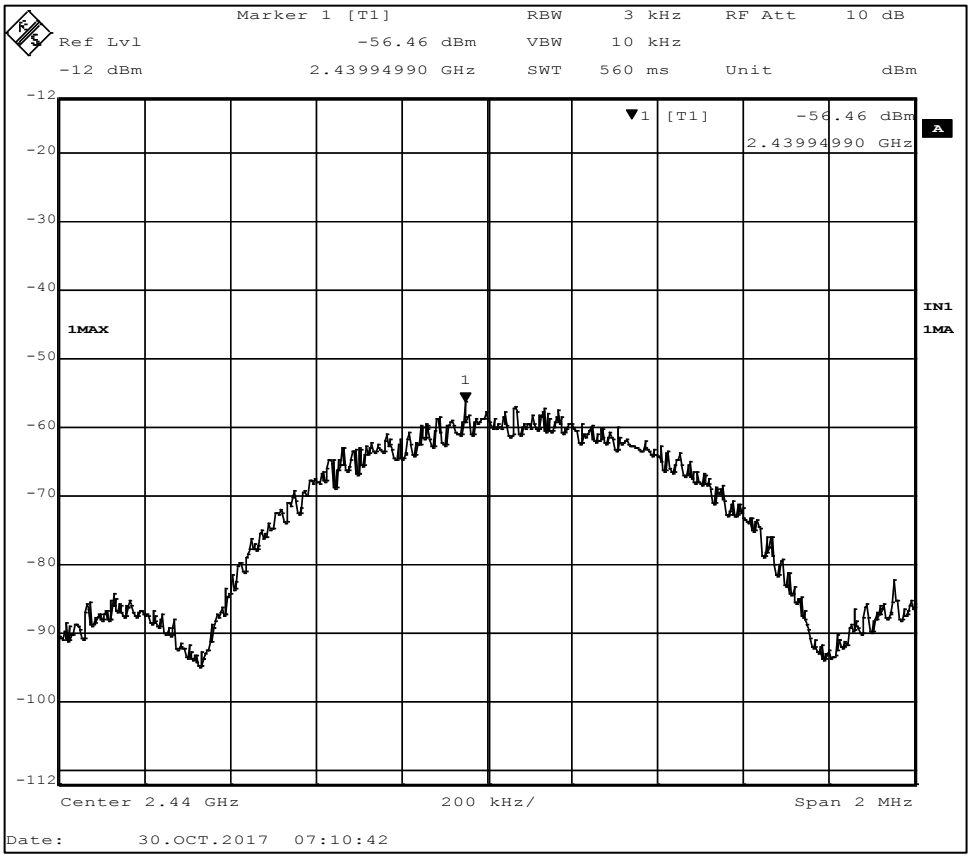

Figure 18 - Power Spectral Density Measurement, Mid Channel

Power Spectral Density = -56.46 dBm + 107 + CL + AF - 95.23 = -8.78 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 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.

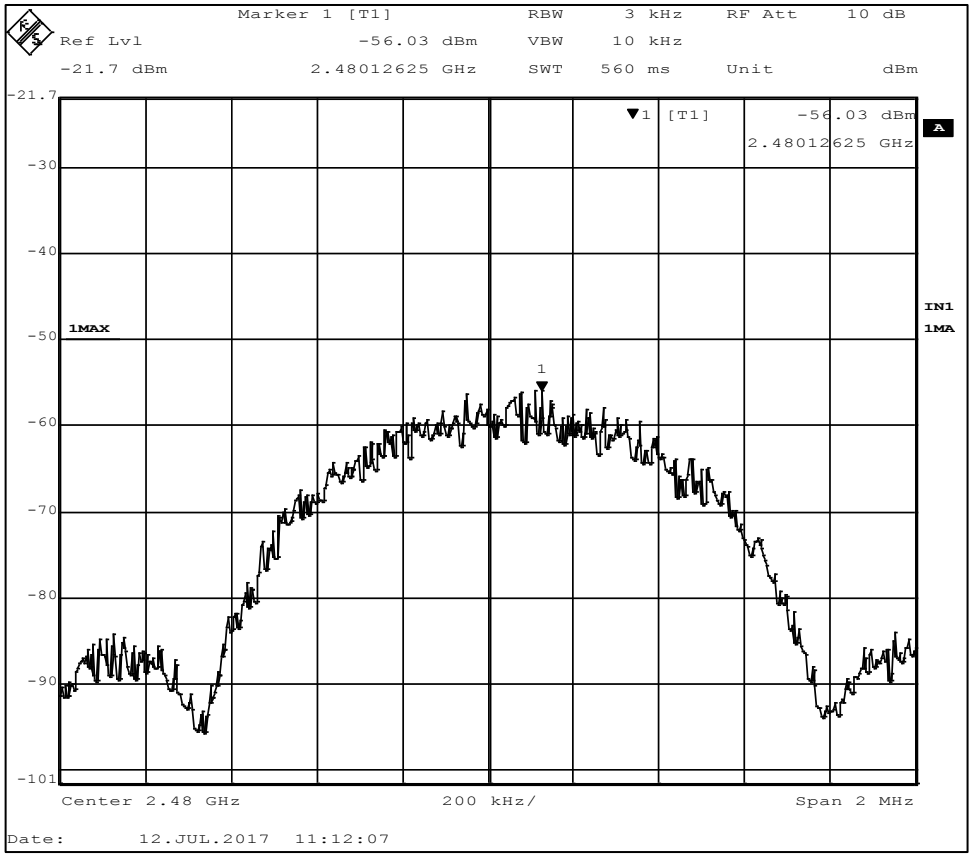

Figure 19 - Power Spectral Density Measurement, High Channel

Power Spectral Density = -56.03 dBm + 107 + CL + AF - 95.23 = -8.35 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 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.

Appendix A: 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)

Conversion from 3m field strength to EIRP (d=3):

EIRP = (FS x d^2)/30 = FS [(d^2)/30] = FS [0.3}

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = -95.23

10log(10^) is the conversion from micro to milli

Annex B – 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	150kHz – 18GHz	±3.30 dB

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

CISPR 16-4-2:2011 was used to calculate the above values.