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FCC/ISED Test Report

Prepared for:	**Hunter Douglas**
Address:	**2550 Midway Boulevard Broomfield, CO 80020**
Product:	**Stacking Single Chip Wireless Module**
Test Report No:	**20171020-21-01**
Approved By:	**Nic S. Johnson, NCE Technical Manager iNARTE Certified EMC Engineer #EMC-003337-NE**
DATE:	**November 22, 2017**
Total Pages:	**57**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	20 November 2017	Original – NJohnson Prepared by KVepuri

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1.0 SUMMARY OF TEST RESULTS

The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 4, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(b)(3) RSS-247 Issue 2 Section 5.24	Peak output power	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247(d) (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Pass

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

EUT	Stacking Single Chip Module
Description	The Equipment Under Test (EUT) was a wireless module used to control window blinds. It has transmit and receive capabilities. It is intended to be paired with a remote.
EUT Received	2017 NOV 7
EUT Tested	2017 NOV 10 - 13
Serial No.	1710209/1-0007
Operating Band	2400.0 - 2483.5 GHz
Device Type	DTS
Power Supply	18 VDC Power Supply Model: TRG70A180 Input: 100-240VAC, 1.5A Output: 18V, 3.9A Note: the power supply was used as a representative “off-the-shelf” sample and the EUT will not be sold with a specific power supply. It contains the required power regulation to meet the modular approval requirements.

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

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

Channel	Frequency
Low	2407
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 EUT was tested as module. 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.

2.3 DESCRIPTION OF SUPPORT UNITS

None

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DETAILS

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 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Karthik Vepuri	EMC Test Engineer	Testing, Supervision of Testing
2	Andrew Reicks	EMC Test Technician	Testing
3	Nic Johnson	Technical Manager	Review of Results

Notes:
All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

3.3 TEST EQUIPMENT

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	1647	02 Aug 2017	02 Aug 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

Notes:
All equipment is owned by NCEE Labs and stored permanently at the laboratory. All calibrations are performed by A2LA or NVLAP accredited calibration laboratories.

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Test Method: ANSI C63.10:2013, Section 7.5

Limits for duty cycle:

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.

(c) Unless otherwise specified, *e.g.,* §§15.255(b), and 15.256(l)(5), when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity.

Test procedures:

Because the EUT did not have provisions for making conducted measurements, the duty cycle was measured in a 10m semi-anechoic chamber with the test receiver set to “Zero span” mode.

All field strength or power measurements shown in these plots are arbitrary and only the times and levels of the EUT relative to the remote are considered for compliance.

Deviations from test standard:

No deviation.

Test setup:

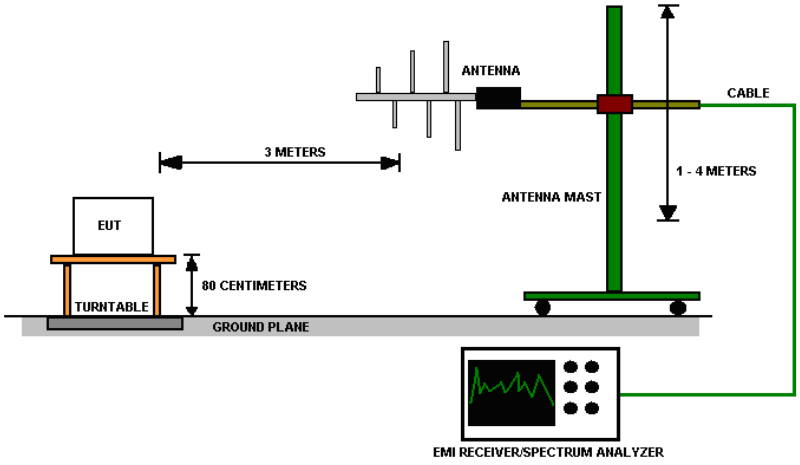

Figure 1 - Radiated Emissions Test Setup

EUT operating conditions:

The EUT was powered by 18 VDC unless specified. The duty cycle was only tested on the lowest channel as it will be identical for all channels.

The EUT will only transmit when triggered by a paired remote. In order to measure the maximum possible duty cycle in a user application, a button was held down on the remote.

Test results:

Duty cycle correction = 20 dB

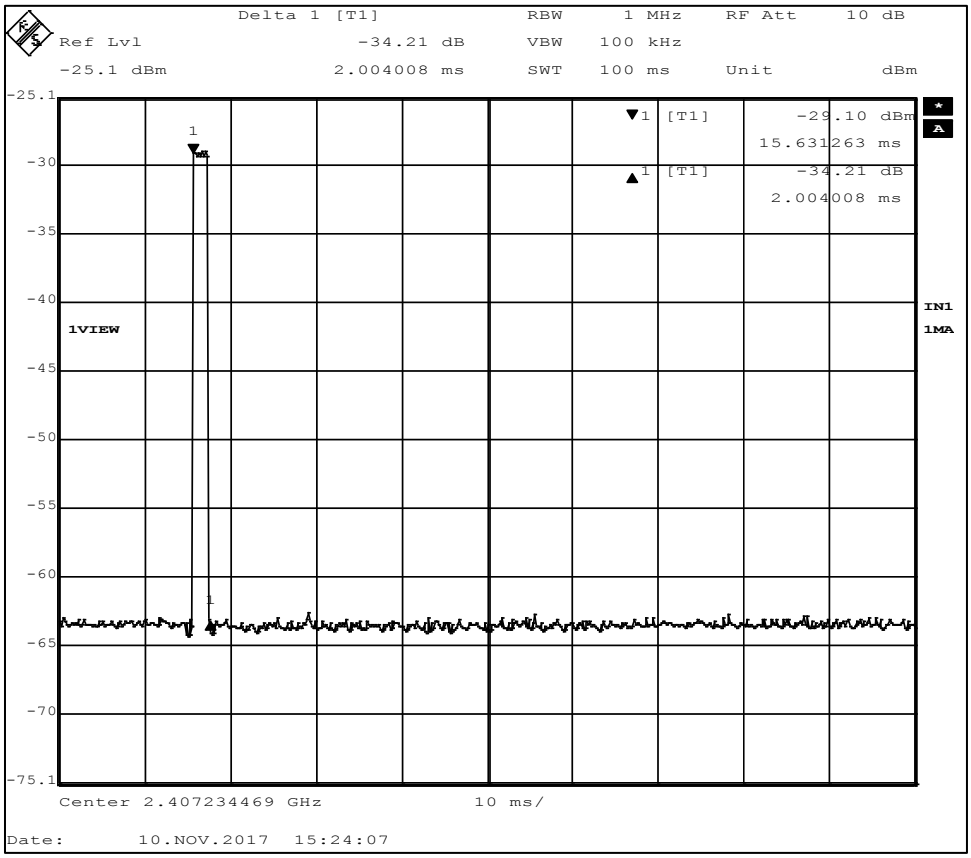

Figure 2 – Duty Cycle 1

Maximum 1 pulse can occur in any 100 ms window

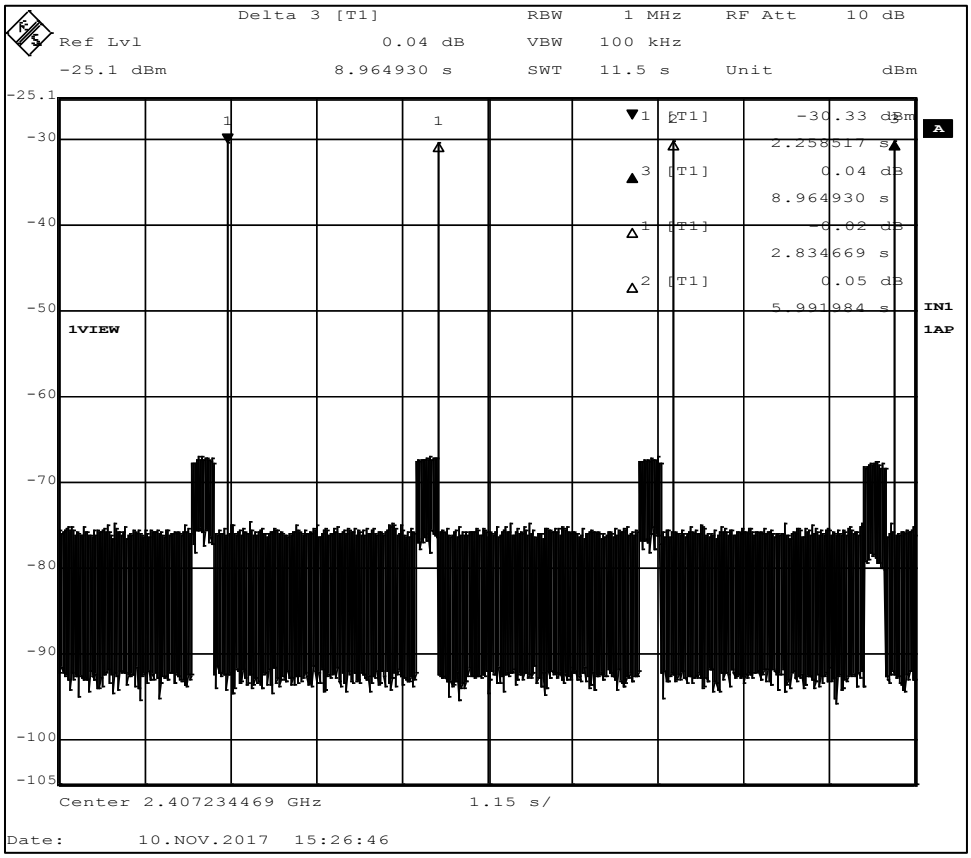

Figure 3 – Duty Cycle 2

Maximum of 1 pulse can occur in any 100 ms window

Note: the signal between -60 and -70 dBm are from the remote and are not considered in the duty cycle. The remote was required to trigger the EUT.

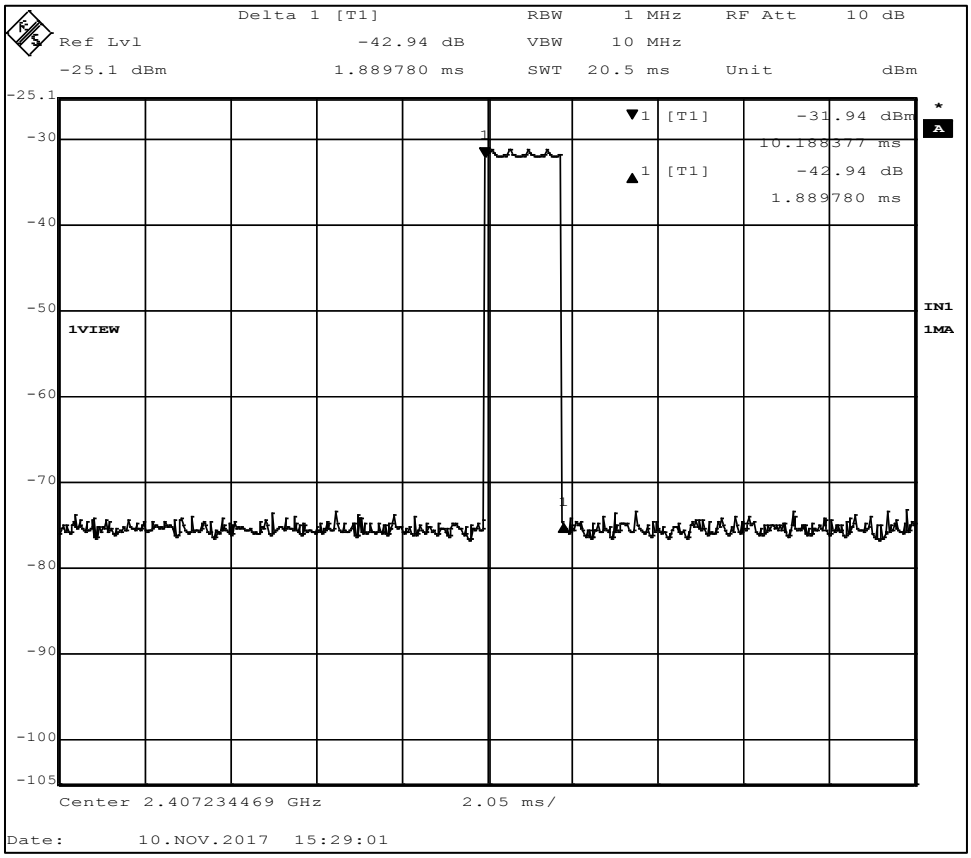

Figure 4 – Maximum Pulse Width

Measurement	Duration (ms)	Reference Figure
On Time	1.89	8
Period*	100	7

*Maximum 100ms

On time / Period =	Duty Cycle Factor = 20×log(duty cycle)**
0.019	-20

**Minimum -20 dB allowed

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013, Section 6.5, 6.6, 11.11, 11.12

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.

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 EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

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.

Deviations from test standard:

No deviation.

Test setup:

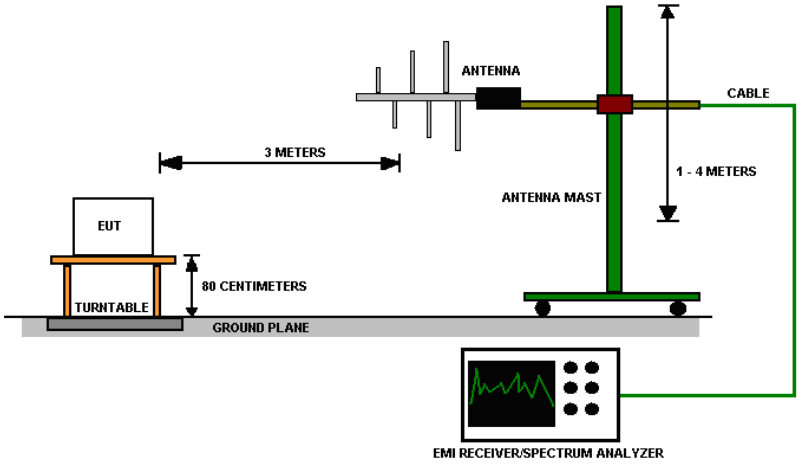

Figure 5 - Radiated Emissions Test Setup

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.

Test results:

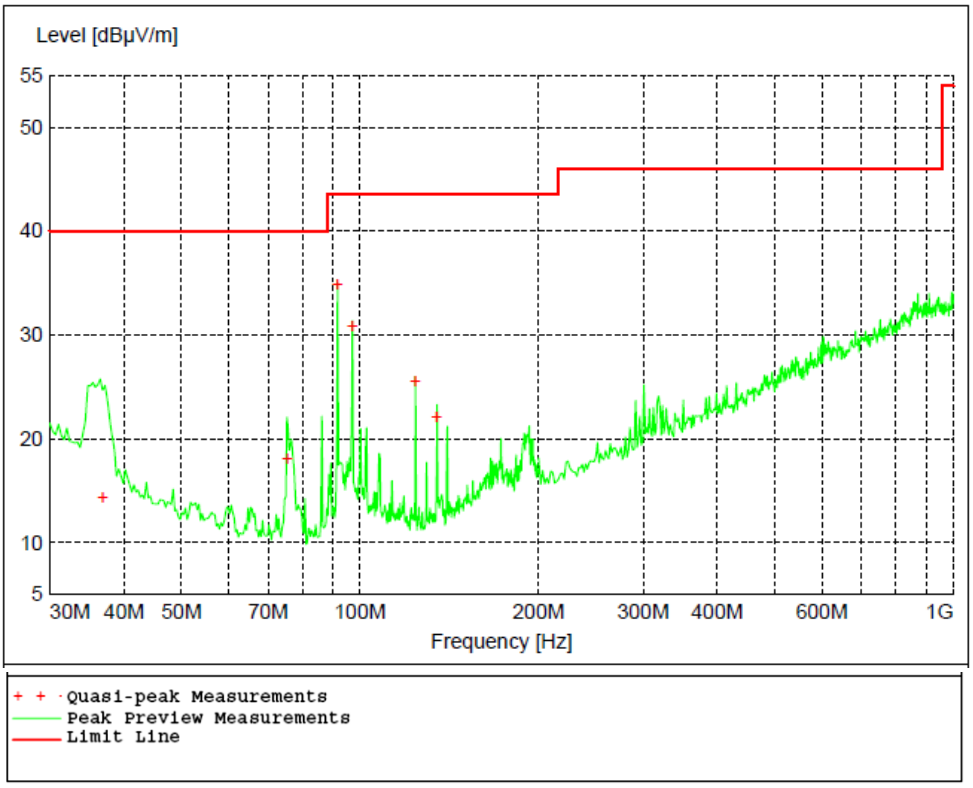

Figure 6 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
36.840000	14.43	40.00	25.60	127	0	VERT	Y
75.420000	18.10	40.00	21.90	308	358	VERT	Y
91.620000	34.93	43.50	8.60	136	237	VERT	Y
97.020000	30.90	43.50	12.60	99	251	VERT	Y
123.960000	25.64	43.50	17.90	99	192	VERT	Y
134.700000	22.20	43.50	21.30	101	207	VERT	Y

Table 2 - Radiated Emissions Peak Measurements vs. Average Limit, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2401.800000	36.26	54.00	17.70	170	144	HORI	Y
4810.000000	38.63	54.00	15.40	177	197	HORI	Y
7224.000000	43.53	54.00	10.50	382	106	VERT	Y
9613.200000	45.99	54.00	8.00	298	100	HORI	Y
12041.200000	43.46	54.00	10.50	139	0	VERT	Y

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

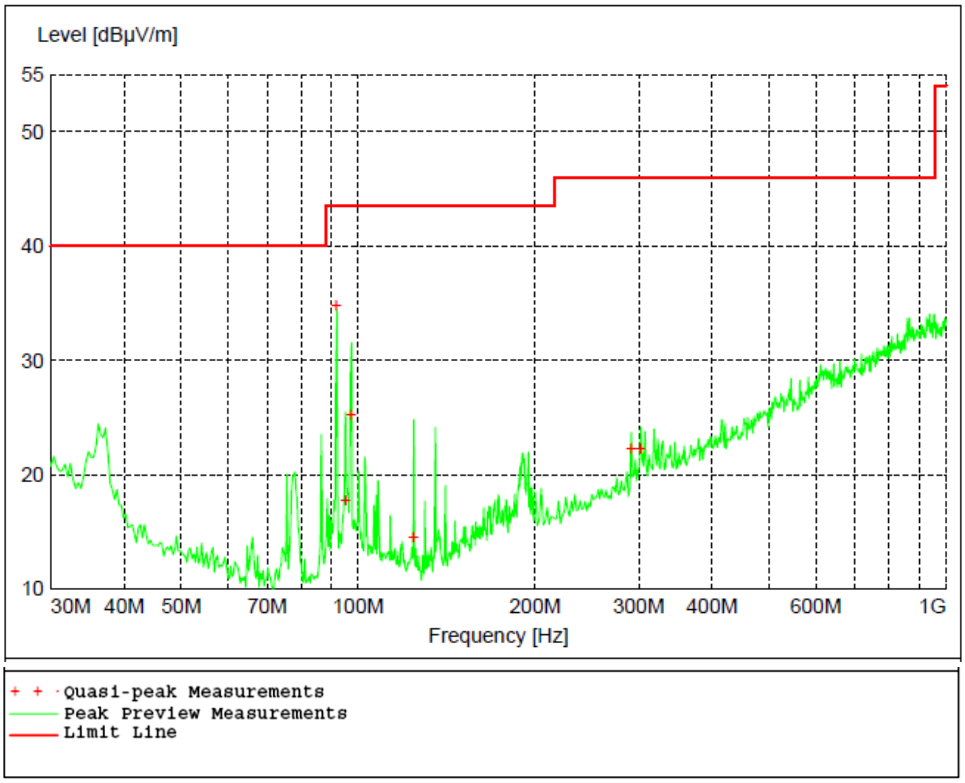

Figure 7 - Radiated Emissions Plot, Low Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
91.740000	34.84	43.50	8.70	136	255	VERT	Y
95.160000	17.76	43.50	25.80	162	118	VERT	Y
97.200000	25.35	43.50	18.20	398	256	VERT	Y
124.200000	14.56	43.50	29.00	100	167	VERT	Y
291.360000	22.34	46.00	23.70	101	359	HORI	Y
302.220000	22.31	46.00	23.70	99	11	VERT	Y

Table 4 - Radiated Emissions Average Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2407.000000	79.96	NA	NA	163	28	HORI	Y
4814.000000	34.60	54.00	19.40	217	51	HORI	Y
7220.800000	11.39	54.00	42.61	100	82	VERT	Y
9628.000000	29.43	54.00	24.57	150	36	HORI	Y
12027.600000	22.98	54.00	31.02	352	260	VERT	Y
14468.600000	29.37	54.00	24.63	204	153	HORI	Y
16849.800000	31.12	54.00	22.88	137	326	HORI	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6, 7 and 8. 20dB was used.

Table 5 - Radiated Emissions Peak Measurements, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2407.000000	99.96	NA	NA	163	28	HORI	Y
4814.000000	54.60	74.00	19.40	217	51	HORI	Y
7220.800000	31.39	74.00	42.61	100	82	VERT	Y
9628.000000	49.43	74.00	24.57	150	36	HORI	Y
12027.600000	42.98	74.00	31.02	352	260	VERT	Y
14468.600000	49.37	74.00	24.63	204	153	HORI	Y
16849.800000	51.12	74.00	22.88	137	326	HORI	Y

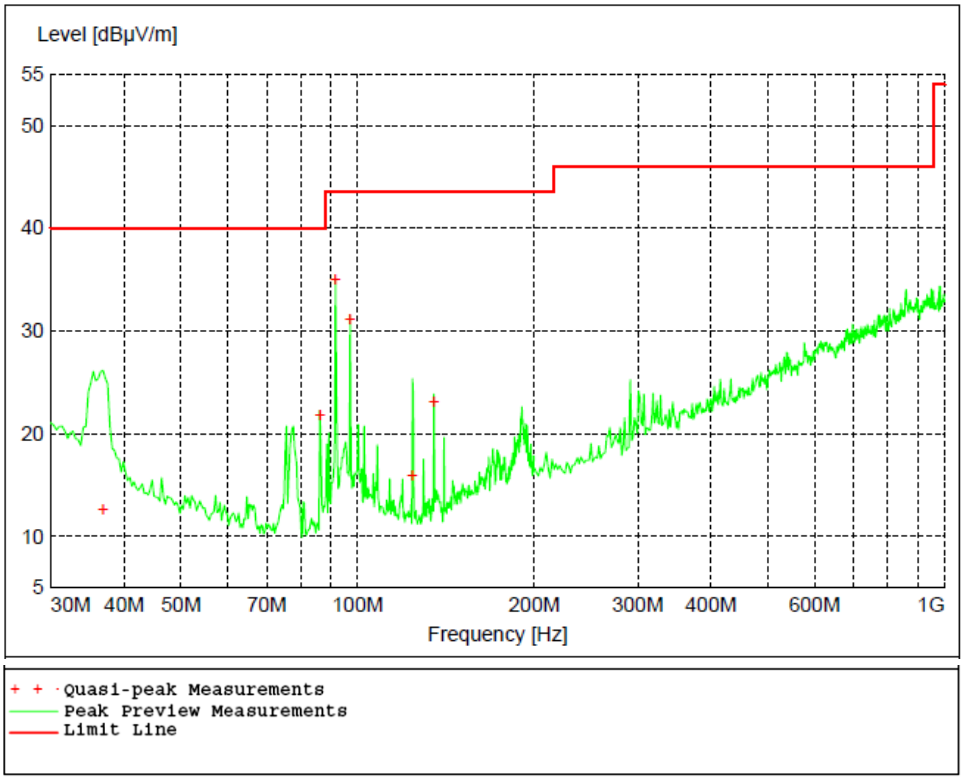

Figure 8 - Radiated Emissions Plot, Mid Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
36.840000	12.63	40.00	27.40	377	246	VERT	Y
86.280000	21.85	40.00	18.10	211	230	VERT	Y
91.680000	35.02	43.50	8.50	136	261	VERT	Y
97.080000	31.12	43.50	12.40	99	251	VERT	Y
124.020000	15.93	43.50	27.60	101	165	VERT	Y
134.820000	23.15	43.50	20.40	99	328	VERT	Y

Table 7 - Radiated Emissions Average Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2440.000000	80.39	NA	NA	153	4	HORI	Y
4880.000000	35.89	54.00	18.11	100	0	HORI	Y
7319.800000	28.14	54.00	25.86	100	83	VERT	Y
9759.800000	31.30	54.00	22.70	163	330	HORI	Y
12220.000000	23.84	54.00	30.16	140	234	HORI	Y
14668.800000	30.99	54.00	23.01	325	200	HORI	Y
17067.400000	32.65	54.00	21.35	359	258	HORI	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6, 7 and 8. 20dB was used.

Table 8 - Radiated Emissions Peak Measurements, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2440.000000	100.39	NA	NA	153	4	HORI	Y
4880.000000	55.89	74.00	18.11	100	0	HORI	Y
7319.800000	48.14	74.00	25.86	100	83	VERT	Y
9759.800000	51.30	74.00	22.70	163	330	HORI	Y
12220.000000	43.84	74.00	30.16	140	234	HORI	Y
14668.800000	50.99	74.00	23.01	325	200	HORI	Y
17067.400000	52.65	74.00	21.35	359	258	HORI	Y

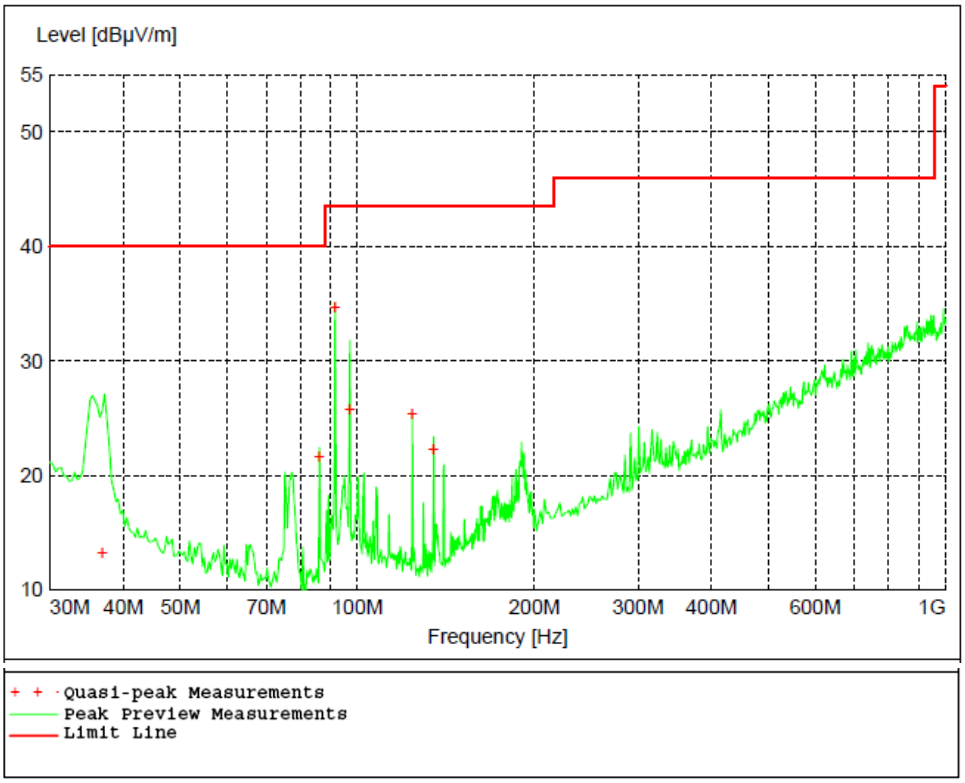

Figure 9 - Radiated Emissions Plot, High Channel

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
36.840000	13.25	40.00	26.70	257	16	VERT	Y
86.220000	21.66	40.00	18.30	102	255	VERT	Y
91.620000	34.77	43.50	8.70	131	241	VERT	Y
97.020000	25.82	43.50	17.70	113	251	VERT	Y
123.960000	25.42	43.50	18.10	105	182	VERT	Y
134.700000	22.36	43.50	21.20	99	344	VERT	Y

Table 10 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	80.08	NA	NA	153	10	HORI	Y
4960.000000	28.27	54.00	25.73	113	280	VERT	Y
7440.000000	18.60	54.00	35.40	112	82	VERT	Y
9920.000000	19.31	54.00	34.69	230	250	VERT	Y
12420.200000	12.11	54.00	41.89	399	2	VERT	Y
14848.800000	18.09	54.00	35.91	287	305	HORI	Y
17356.400000	25.88	54.00	28.12	147	55	VERT	Y

Note: Average Level = Peak Level – Duty Cycle Correction Factor
Duty Cycle Correction Factor is calculated in Figures 6, 7 and 8. 20dB was used.

Table 11 - Radiated Emissions Peak Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	100.08	NA	NA	153	10	HORI	Y
4960.000000	48.27	74.00	25.73	113	280	VERT	Y
7440.000000	38.60	74.00	35.40	112	82	VERT	Y
9920.000000	39.31	74.00	34.69	230	250	VERT	Y
12420.200000	32.11	74.00	41.89	399	2	VERT	Y
14848.800000	38.09	74.00	35.91	287	305	HORI	Y
17356.400000	45.88	74.00	28.12	147	55	VERT	Y

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 EUT was measured in all 3 orthagonal axis. It was found that the Y-axis produced the highest emissions, and this orientation was used for all testing. See the test setup photo exhibit for details on the orientations.
6. The axis shown in the last column of the data tables shows the axis where the emissions were found to be the highest.

4.3 PEAK OUTPUT POWER

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

Limits of bandwidth measurements:
The maximum allowed peak output power is 30 dBm.

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 3 MHz RBW and 10 MHz VBW. The RBW was set to a value larger than the DTS bandwidth.

Deviations from test standard:
No deviation.

Test setup:

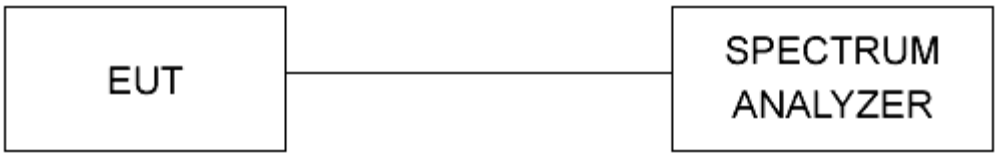

Figure 10 – Peak Output Power Measurements Test Setup
*0.8 dB of cable loss was used and it was accounted for in the plots

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.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	PEAK OUTPUT POWER (dBm)	METHOD	RESULT
Low	2407	2.41	Conducted	PASS
Middle	2440	2.02	Conducted	PASS
High	2480	2.41	Conducted	PASS

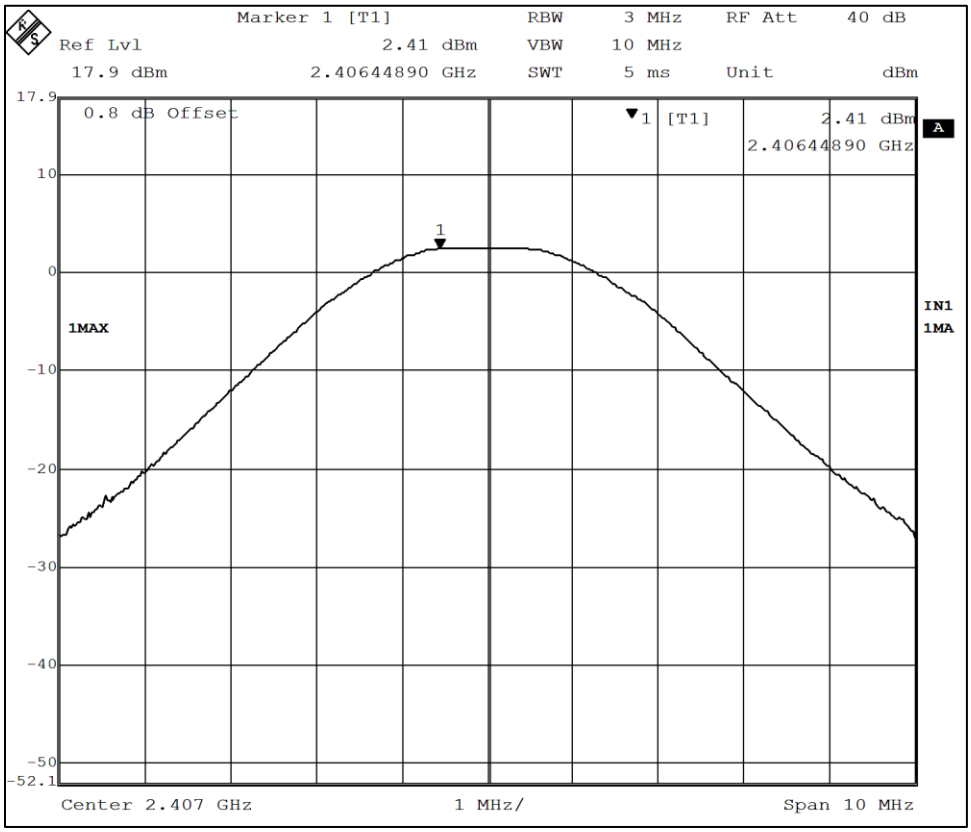

Figure 11 – Output Power, Low Channel. 2.41 dBm

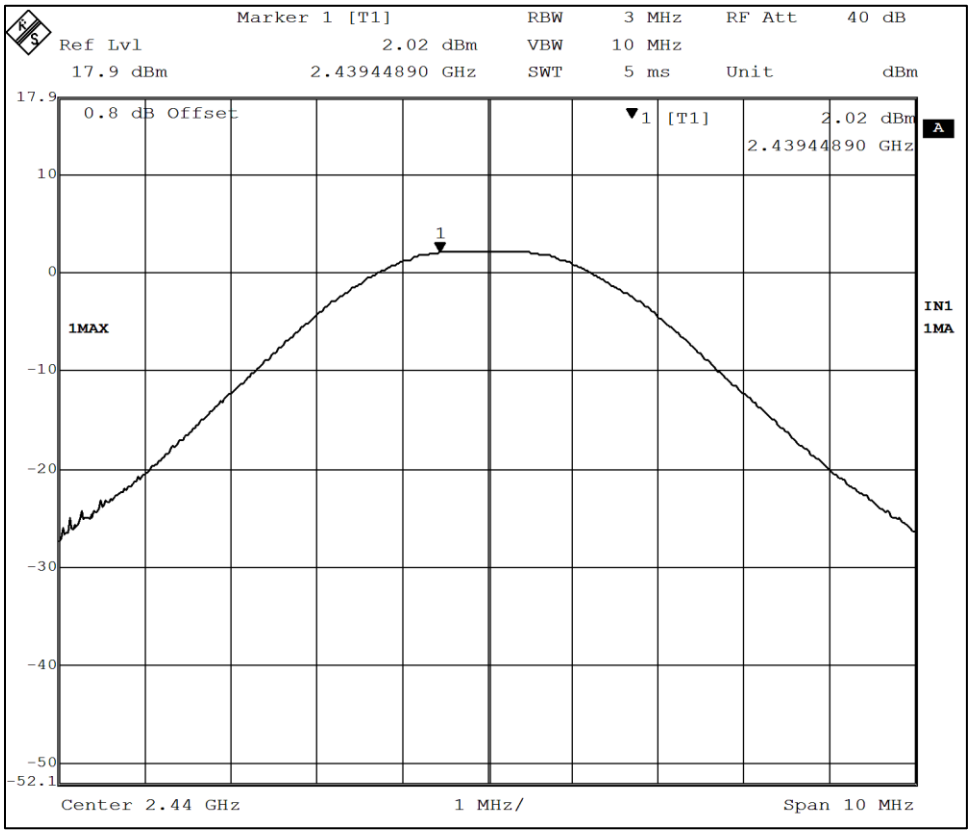

Figure 12 - Output Power, Mid Channel, 2.02 dBm

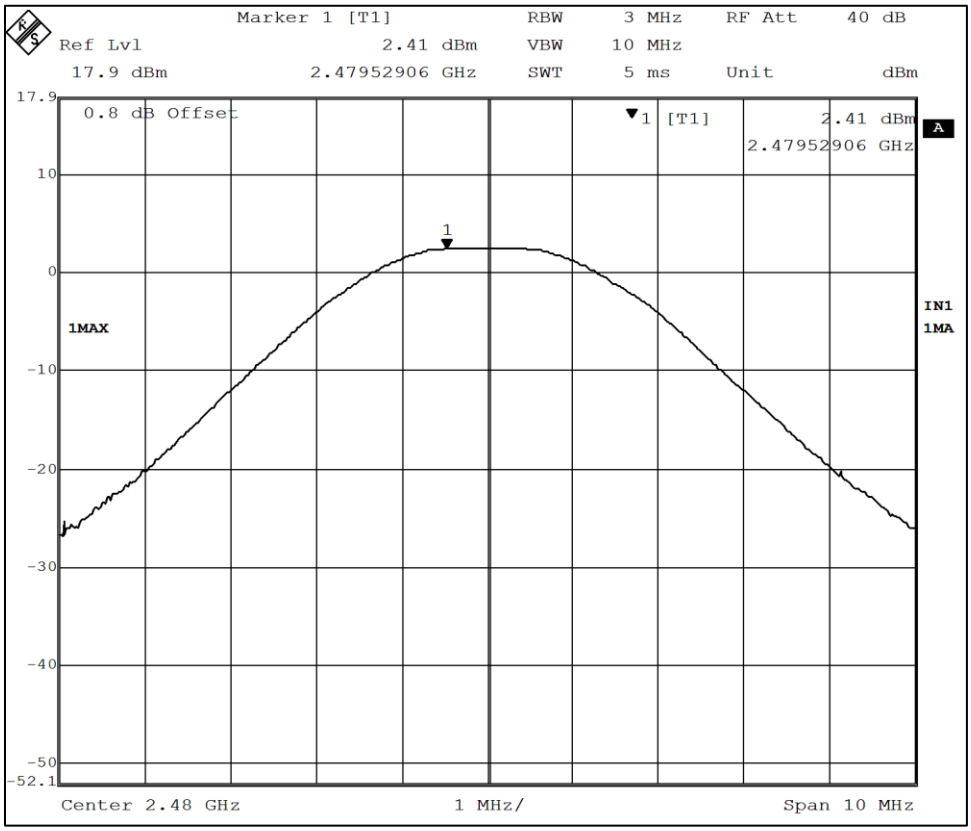

Figure 13 - Output Power, High Channel, 2.41 dBm

4.4 BANDWIDTH

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

Limits of bandwidth measurements:
The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:
Bandwidth measurement was 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 1 MHz 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.

The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

Deviations from test standard:
No deviation.

Test setup:

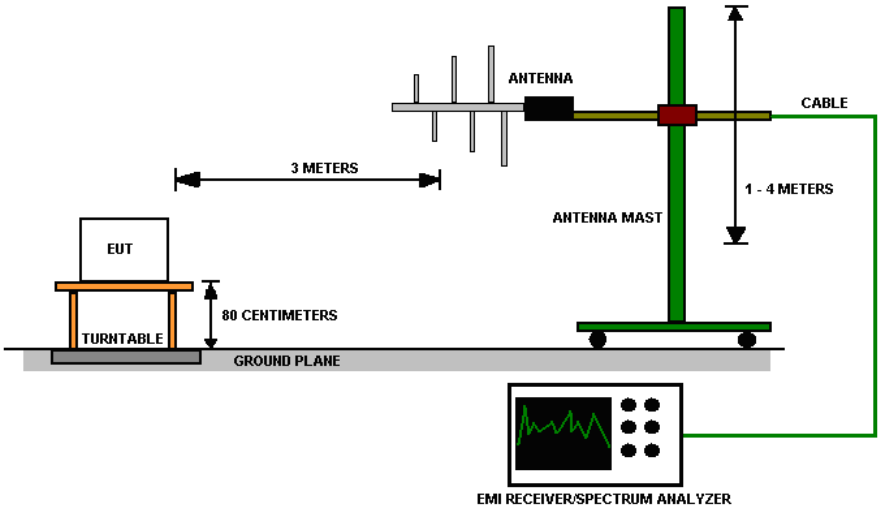

Figure 14 - Bandwidth Measurements Test Setup

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.

Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
Low	2407	2.12
Middle	2440	1.96
High	2480	2.02

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	6 dB BW (kHz)
Low	2407	825.65
Middle	2440	849.69
High	2480	897.79

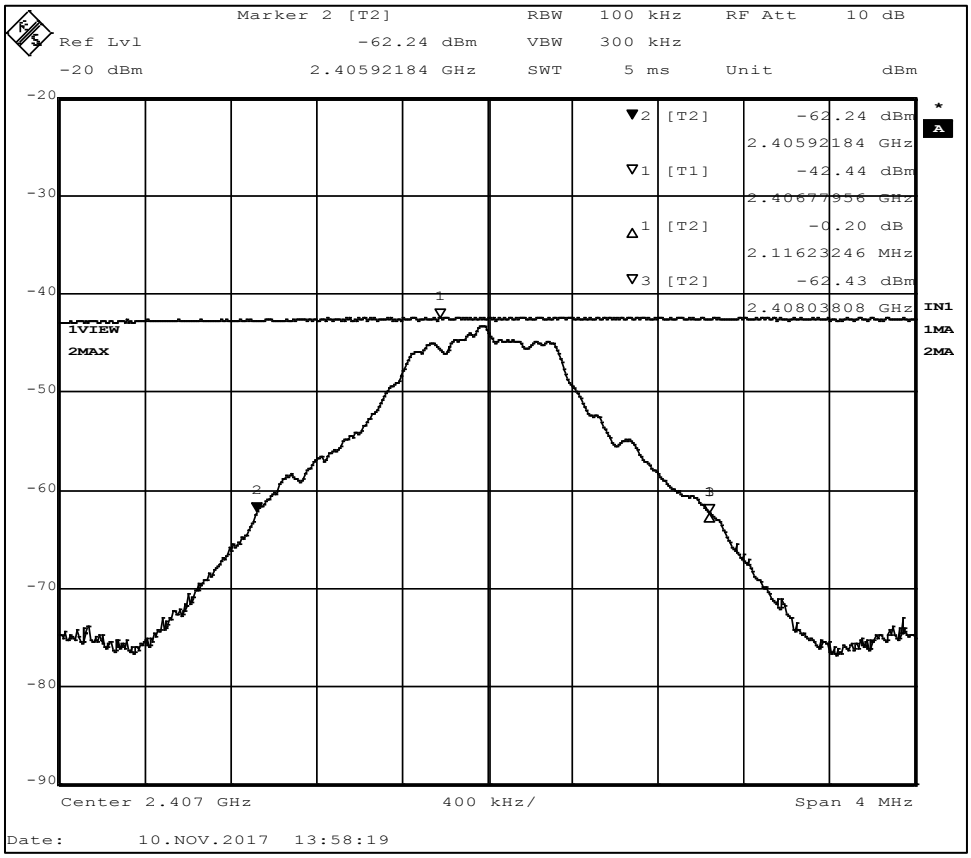

Figure 15 - 99% Occupied Bandwidth, Low Channel. 2.12 MHz

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.

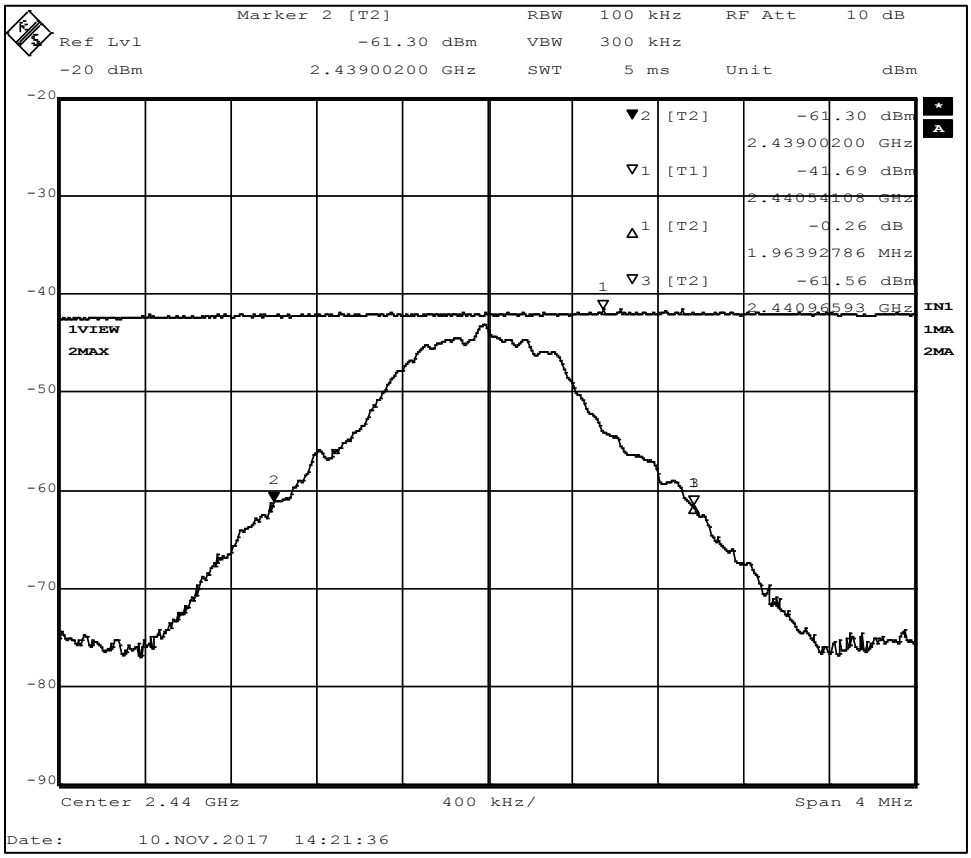

Figure 16 - 99% Occupied Bandwidth, Mid Channel, 1.96 MHz

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.

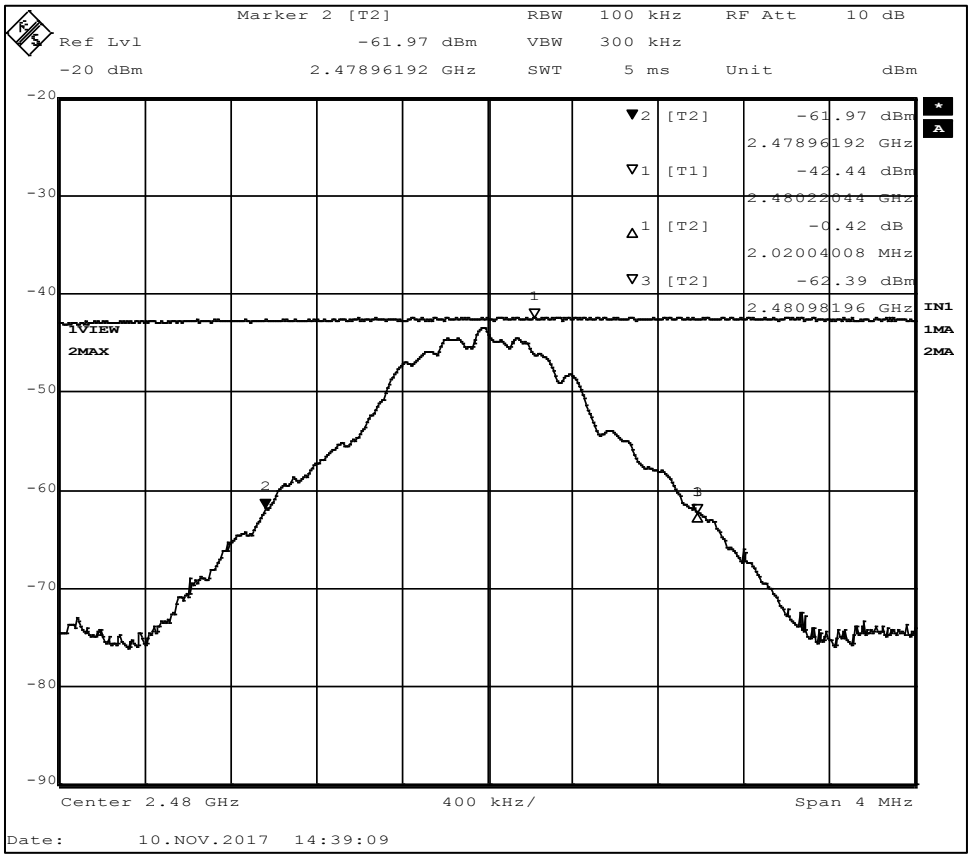

Figure 17 - 99% Occupied Bandwidth, High Channel, 2.02 MHz

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.

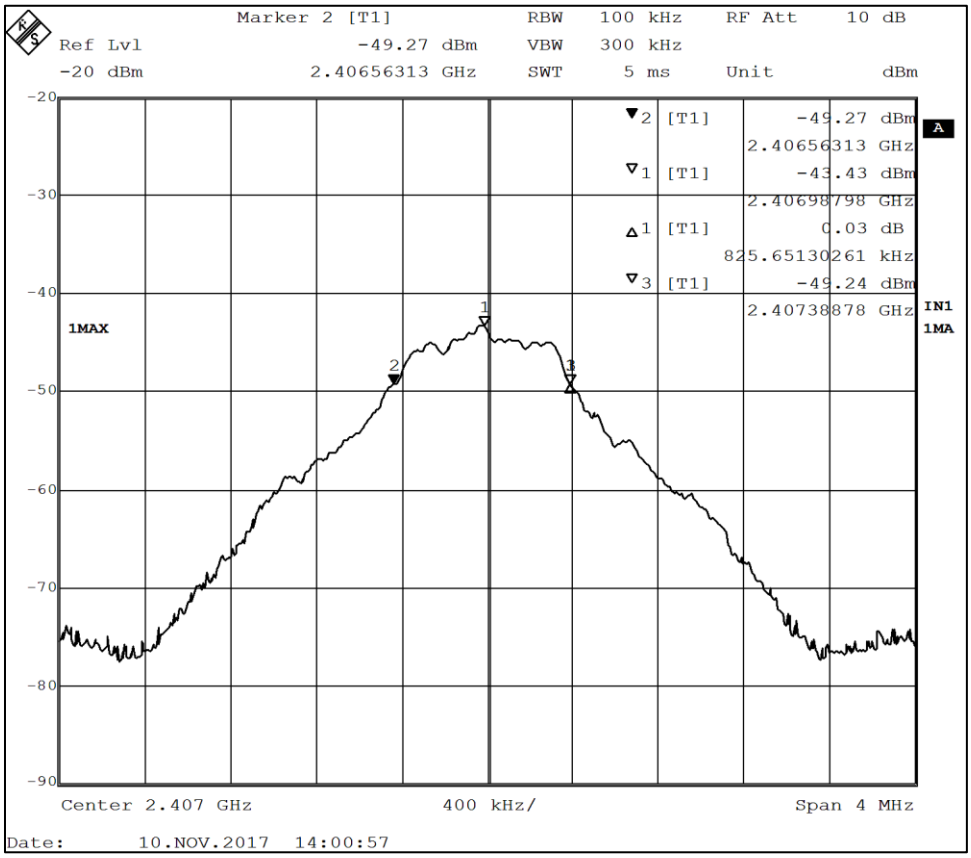

Figure 18 – 6dB Bandwidth, Low Channel, 825.65 kHz

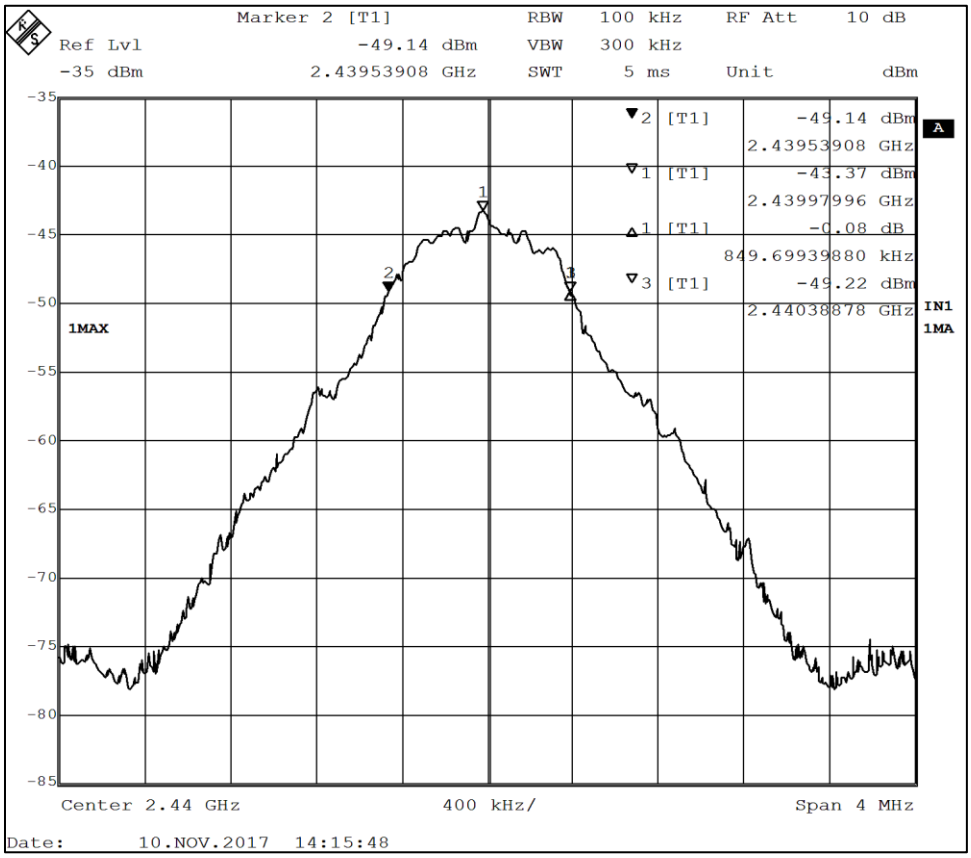

Figure 19 - 6dB Bandwidth, Mid Channel, 849.69 kHz

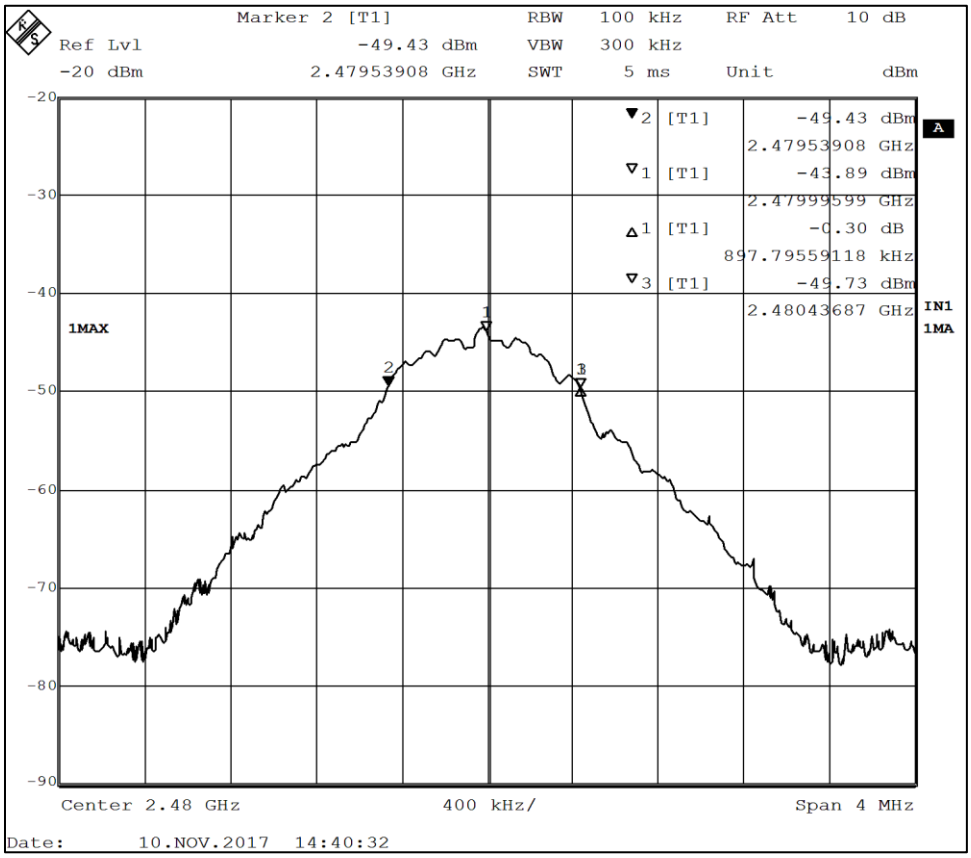

Figure 20 - 6dB Bandwidth, High Channel, 897.79 kHz

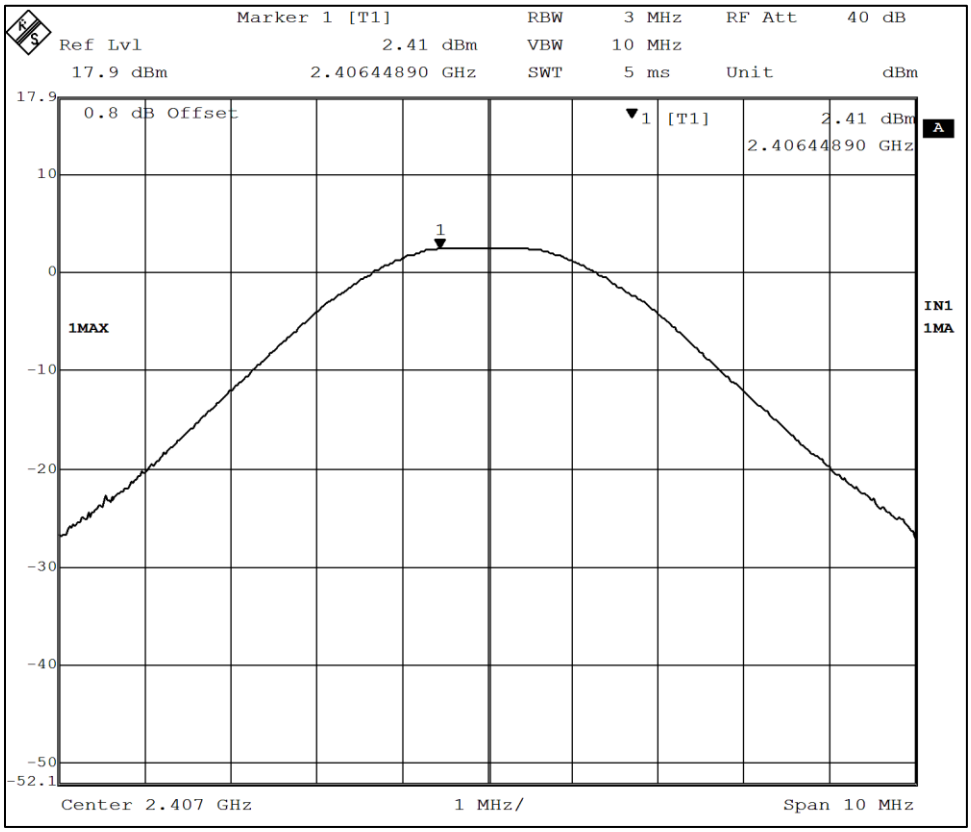

Figure 21 – Output Power, Low Channel. 2.41 dBm

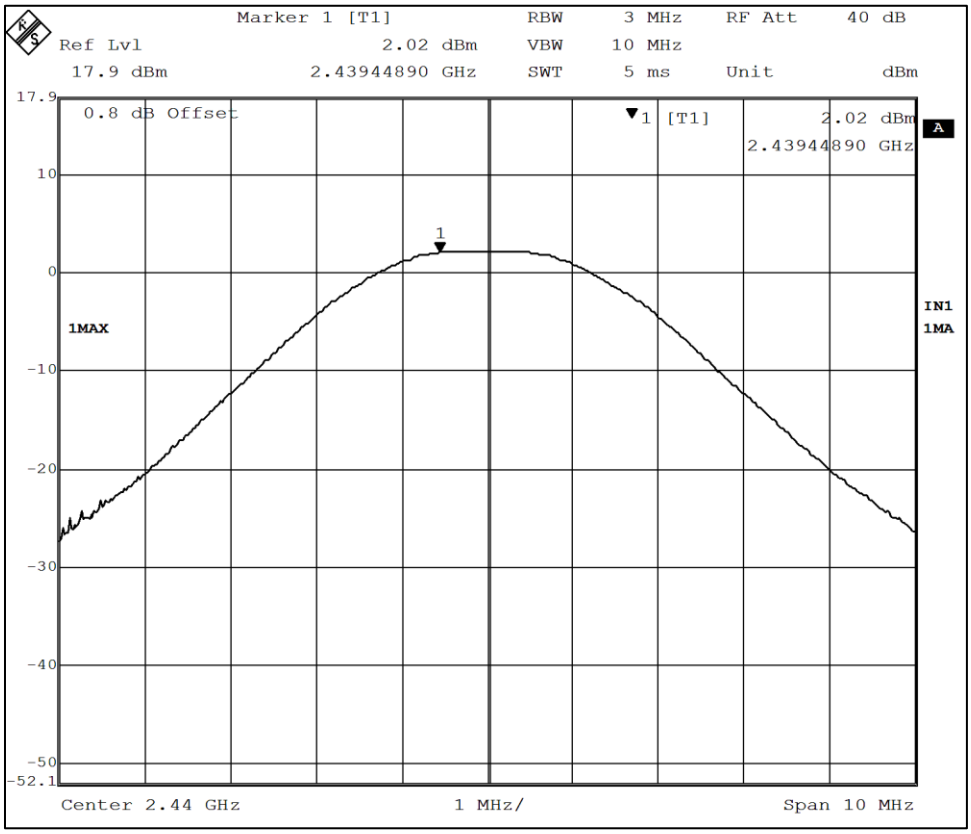

Figure 22 - Output Power, Mid Channel, 2.02 dBm

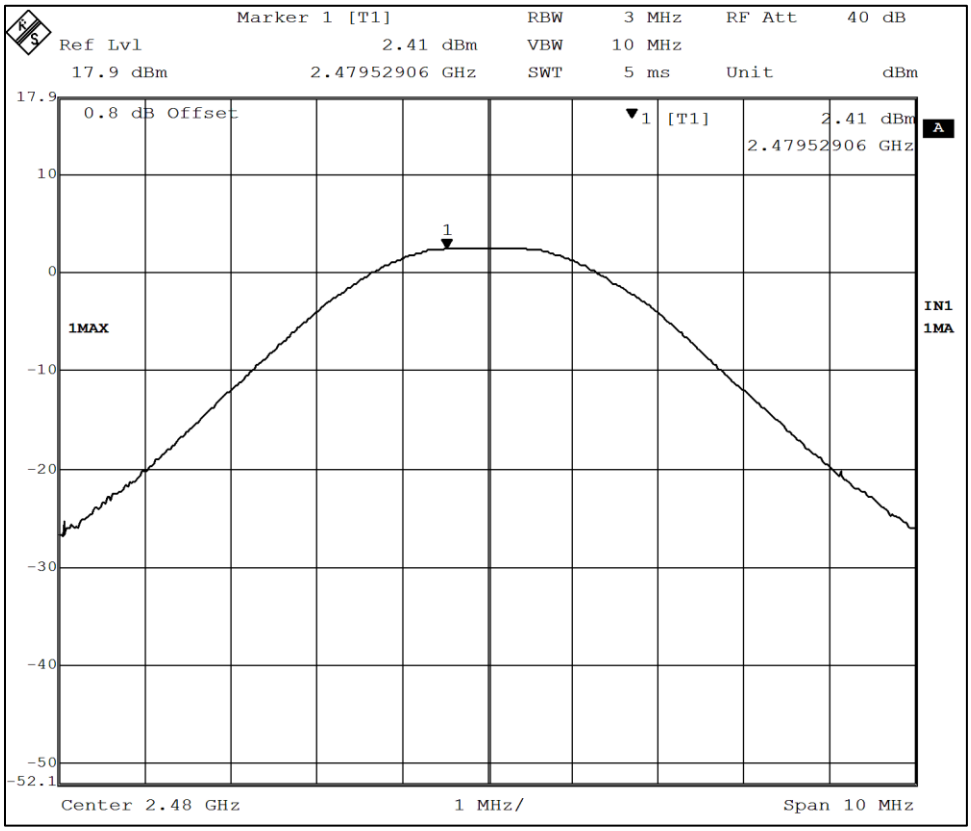

Figure 23 - Output Power, High Channel, 2.41 dBm

4.5 BANDEDGES

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

Limits of bandedge measurements:
For emissions outside of the allowed band of operation (2400.0MHz – 2480.0MHz), 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.

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 30kHz 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.

Deviations from test standard:
No deviation.

Test setup:
See Section 4.3

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.

Test results:

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 (restricted)	2390.0	-96.71	-45.70	51.01	25.99	PASS
Low (unrestricted)	2340.0	-85.70	-45.70	40.00	20.00	PASS
High	2483.5	-103.13	-46.26	56.87	26.08	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 2407MHz for low channel = 79.96dBµV/m
Fundamental average field strength at 2480MHz for high channel = 80.08dBµV/m

Channel 1 minimum delta = 79.96 – 54.0 dBµV/m = 25.99 dBc
Channel 3 minimum delta = 80.08 – 54.0 dBµV/m = 26.08 dBc

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

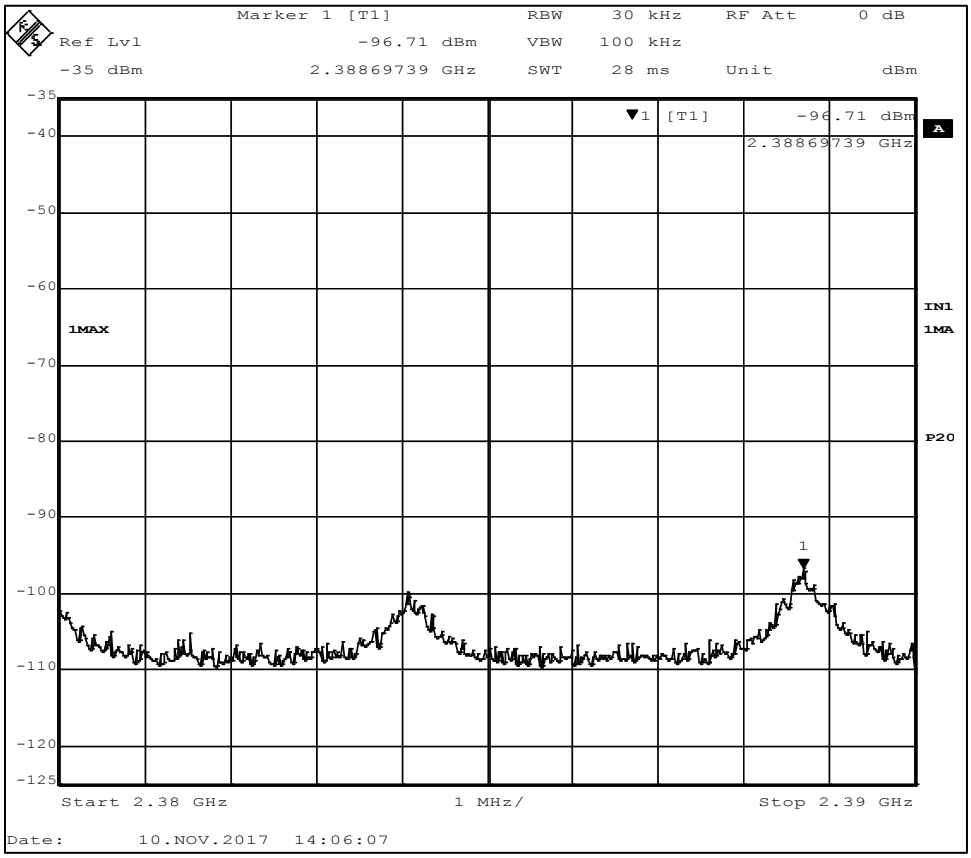

Figure 24 - Band-edge Measurement, Low Channel, Restricted Frequency

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

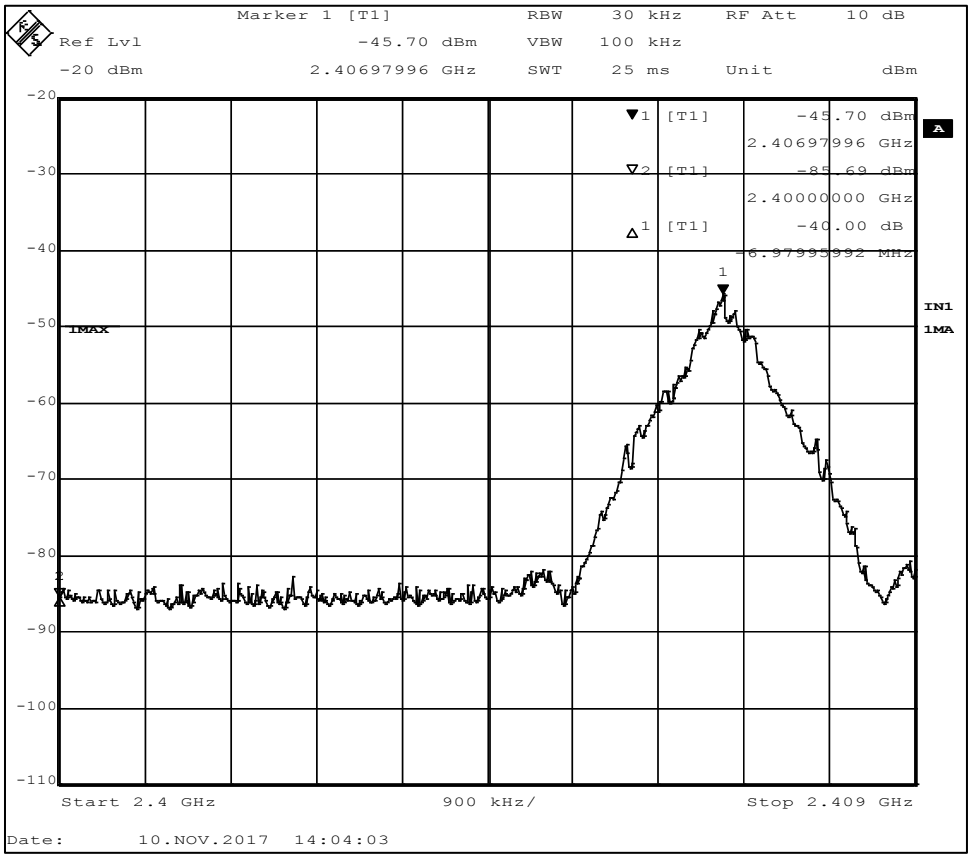

Figure 25 - Band-edge Measurement, Low Channel, Fundamental

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

Delta = 40 dB > 20 dB minimum

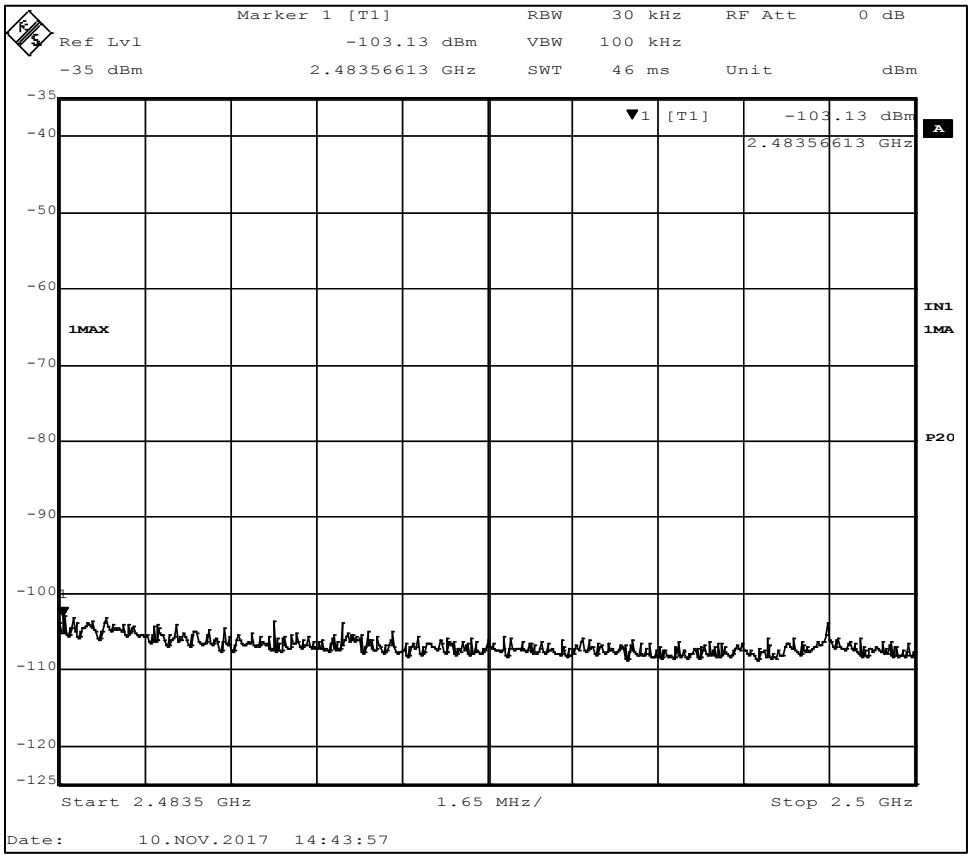

Figure 26 - Band-edge Measurement, High Channel, Restricted Frequency

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

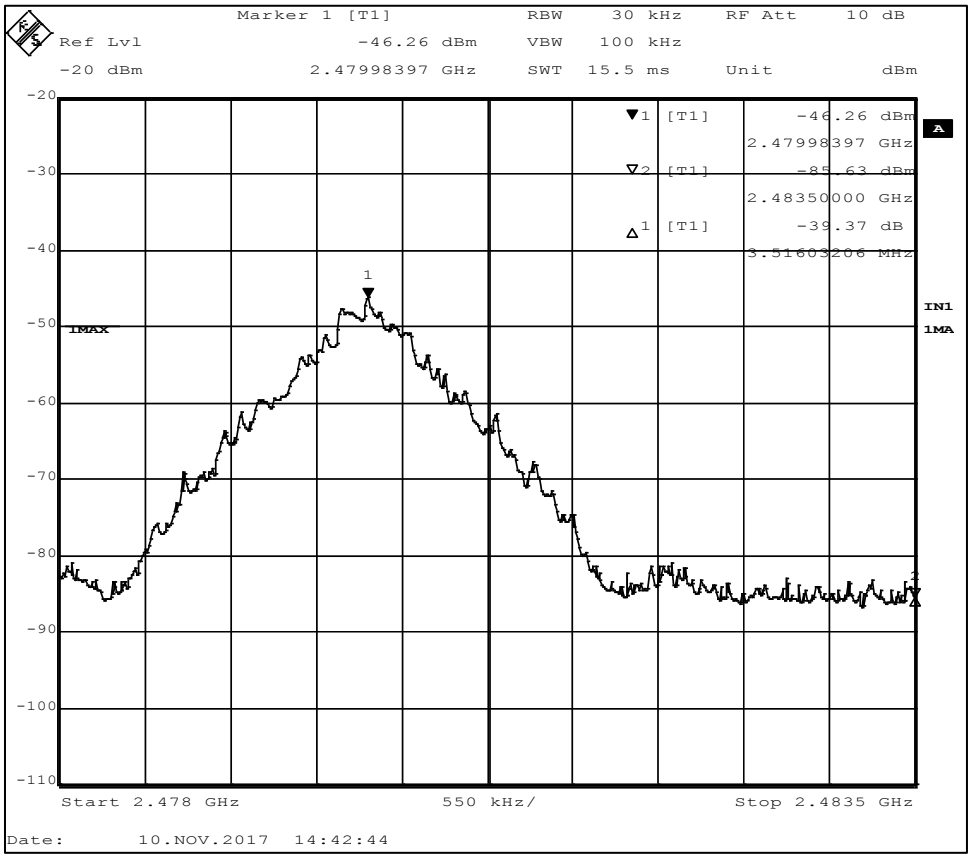

Figure 27 - Band-edge Measurement, High Channel, Fundamental

The plot shows an uncorrected measurement, used for relative measurements only.
Delta = 39.37 dB > 20 dB minimum

4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10, Section 11.10.2

Limits of power measurements:
The maximum PSD allowed is 8 dBm.

Test procedures:
1. All measurements were taken at a distance of 3m from the EUT and listed as EIRP.

2. The resolution bandwidth was set to 3 kHz and the video bandwidth was set to 10 kHz to capture the signal. The analyzer used a peak detector in max hold mode.

Test setup:
The field strength was measured at a distance of 3m and the EIRP was calculated using field strength equation below each plot.

EUT operating conditions:
The EUT was powered by 18VDC unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP RF POWER LEVEL IN # KHz BW (dBm)	METHOD	MAXIMUM POWER LIMIT (dBm)	RESULT
Low	2407	-8.38	EIRP	8.00	PASS
Middle	2440	-9.75	EIRP	8.00	PASS
High	2480	-8.03	EIRP	8.00	PASS

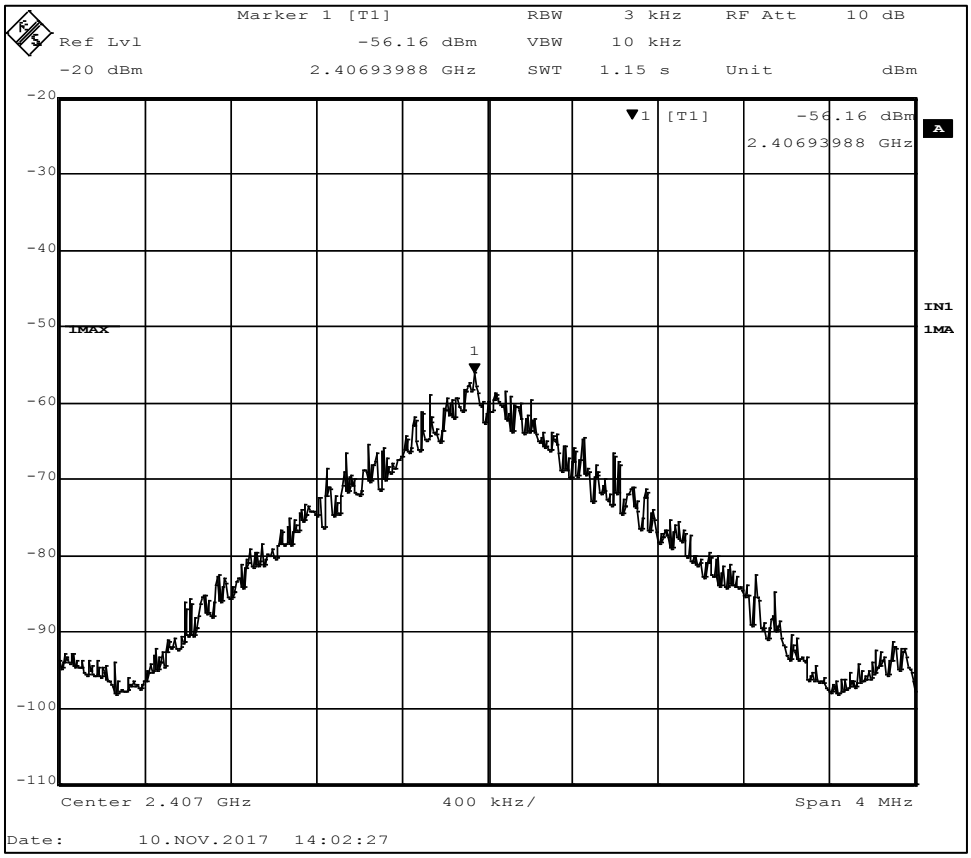

Figure 28 – Power Spectral Density, Low Channel

Spectrum Analyzer Reading (SA)	Cable Loss (CL)	Antenna Factor (AF)	dBm to dBµV/m on 50Ω System	Convert for Field Strength to EIRP*
dBm	dB	dB		
-56.08	7.60	28.31	107.00	-95.23

PSD = SA +CL + AF + 107.00 - 95.23

PSD =
-8.38 dBm

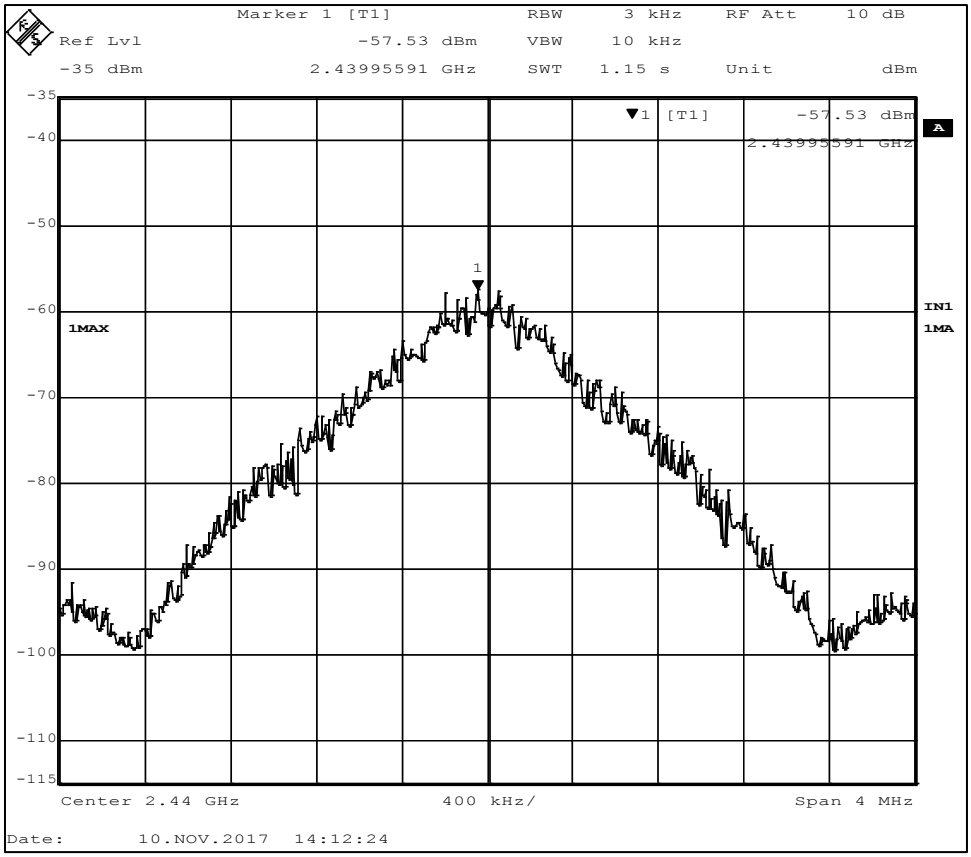

Figure 29 – Power Spectral Density, Mid Channel

Spectrum Analyzer Reading (SA)	Cable Loss (CL)	Antenna Factor (AF)	dBm to dBµV/m on 50Ω System	Convert for Field Strength to EIRP*
dBm	dB	dB		
-56.08	7.60	28.31	107.00	-95.23

PSD = SA +CL + AF + 107.00 - 95.23

PSD =
-9.75 dBm

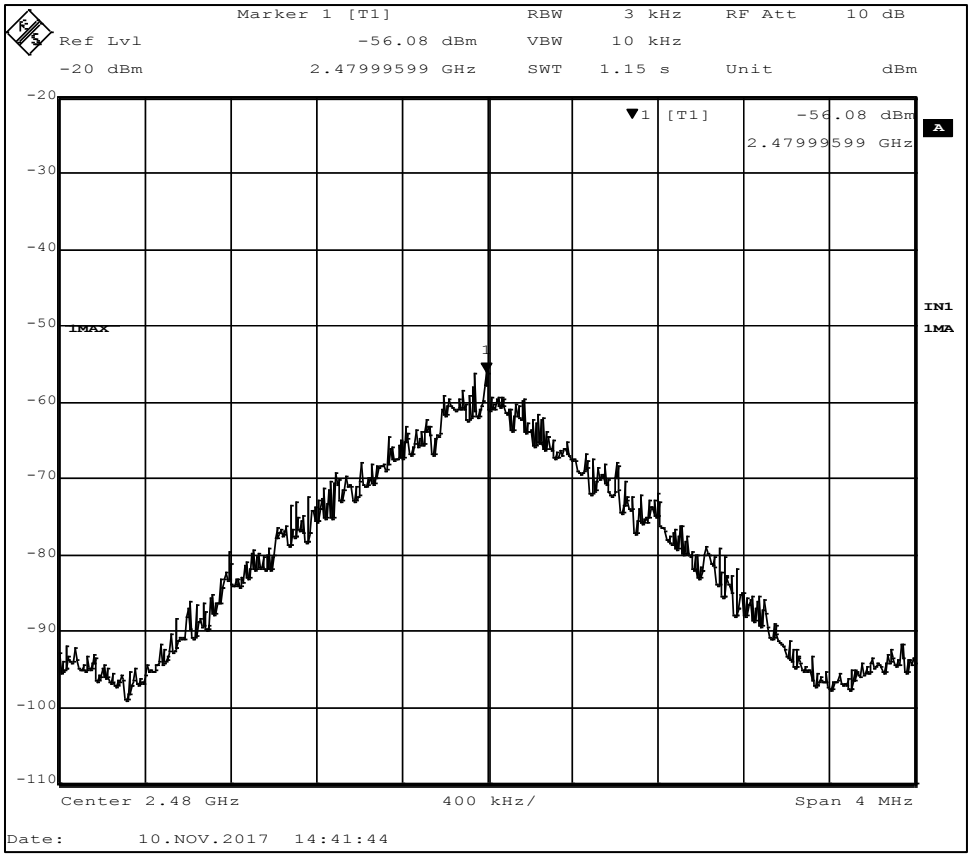

Figure 30 – Power Spectral Density, High Channel

Spectrum Analyzer Reading (SA)	Cable Loss (CL)	Antenna Factor (AF)	dBm to dBµV/m on 50Ω System	Convert for Field Strength to EIRP*
dBm	dB	dB		
-56.08	7.60	28.31	107.00	-95.23

PSD = SA +CL + AF + 107.00 - 95.23

PSD =
-8.40 dBm

4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10, Section(s) 6.2

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

Notes:
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.

Test Procedures:

1. 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.
2. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
3. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
4. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

Test setup:
The EUT was tested as module

EUT operating conditions:
The EUT was powered by 18 VDC unless specified and set to transmit continuously on the Middle channel of its operating range.

Test Results:

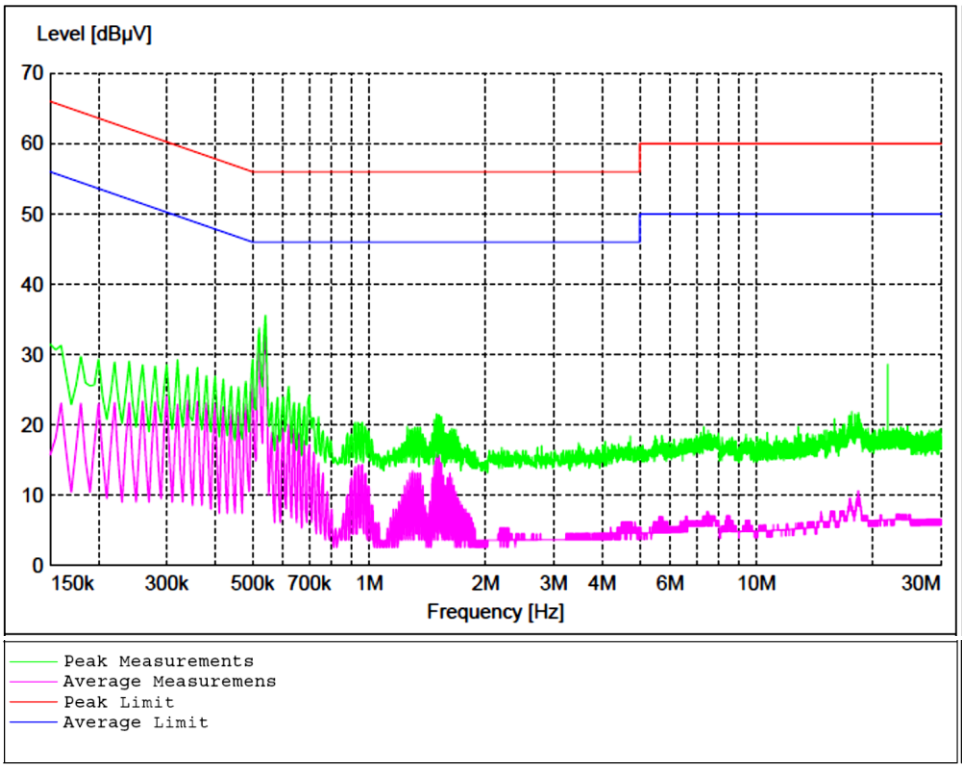

Figure 31 - Conducted Emissions Plot

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

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

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

Voltage (dBµV) = Power (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(V/m) x d^2]/30 = FS [0.3] for d = 3

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

10log(10^9) is the conversion from micro to milli

APPENDIX 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	30MHz – 18GHz	±3.30 dB

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

REPORT END