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FCC/ISED Test Report

Prepared for: **Hunter Douglas**

Address: **2550 Midway Boulevard**
Broomfield, CO 80020

Product: **High Power Roll Single Chip**

Test Report No: **R20180301-22-02B**

Approved By:

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

DATE: **17 May 2018**

Total Pages: **52**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	27 March 2018	Original – NJohnson Prepared by KVepuri
A	24 April 2018	Repeated conducted emissions testing and updated reported data -NJ
B	17 May 2017	Band edge chart in Section 4.5 was updated to show restricted band edge measurements as well as operating band edges. -NJ

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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(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) 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 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) 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

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	High Power Roll Single Chip
EUT Received	13 March 2018
EUT Tested	13 March 2018 - 27 March 2018 24 April 2018 (conducted emissions only)
PCB No.	2002000037
Serial No.	NCEETEST1 (Assigned)
Operating Band	2400.0 - 2483.5 GHz
Device Type	DTS
Power Supply	18 VDC Power Supply Model: ADS0366-W180200 Input: 100-240VAC, 1.0 A Output: 18V, 2.0 A 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 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 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

No.	PERSONNEL	TITLE	ROLE
1	Karthik Vepuri	EMC Test Engineer	Testing
2	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	30 Jan 2018	30 Jan 2019
Rohde & Schwarz Test Receiver	ES17	100007	31 Jul 2017	31 Jul 2018
Tektronix USB Power Meter	PSM4110	11C944	31 Jan 2018	31 Jan 2019
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2018
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2020
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2020
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2019*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2019*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	25 Jul 2017	25 Jul 2018
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2019*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2019*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2019*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2019*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2019*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2019*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2019*

*Internal Characterization

Notes:
All equipment is owned by NCEE Labs. No equipment listed above is rented or borrowed for testing purposes.

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:

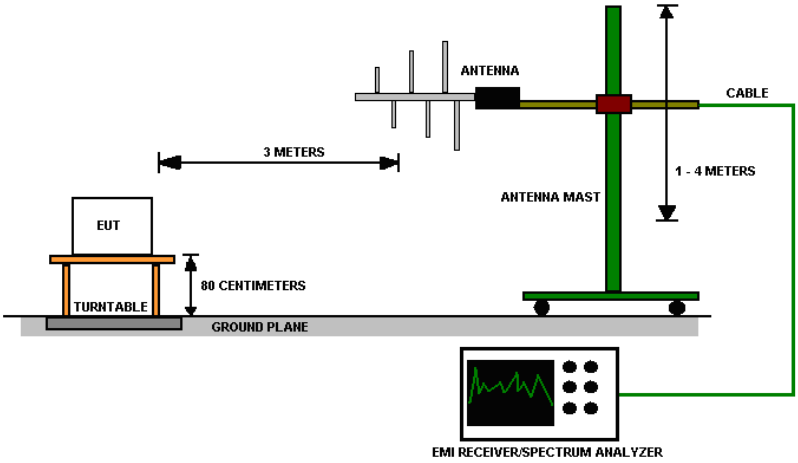

Figure 1 - Radiated Emissions Test Setup

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 modified by manufacturer to make the EUT transmit with worst case duty cycle.

Test results:

Duty cycle correction = 31.68 dB

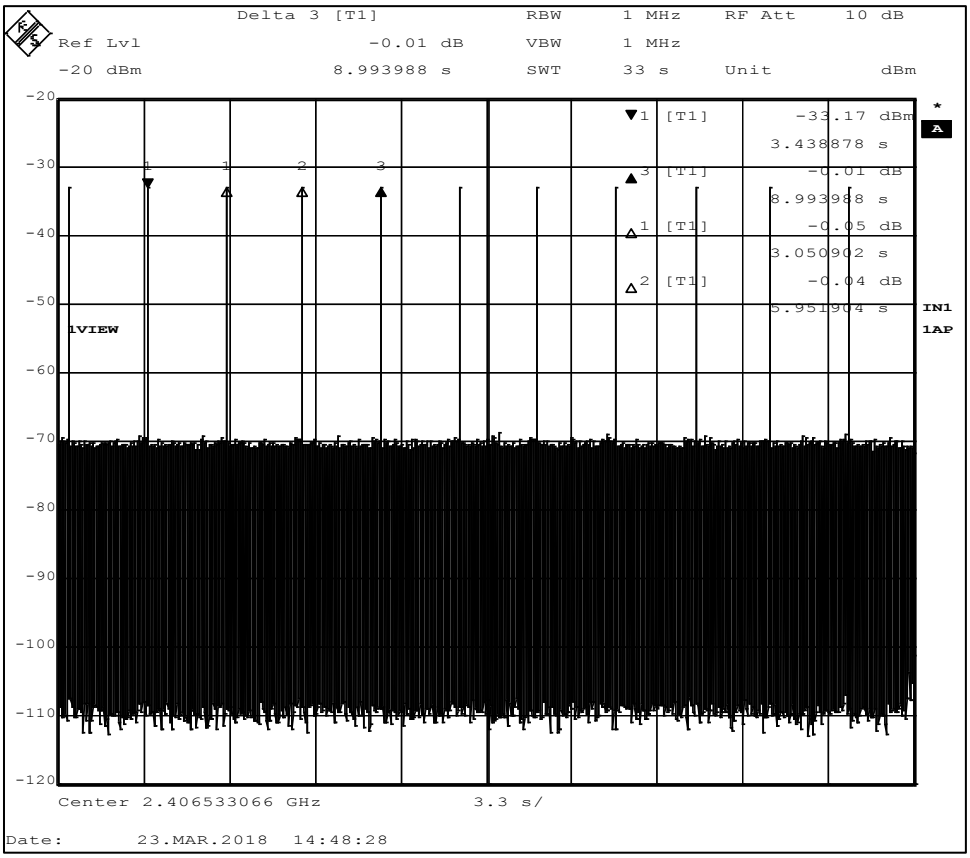

Figure 2 – Duty Cycle - Period

Maximum 1 pulse can occur in any 100 ms window

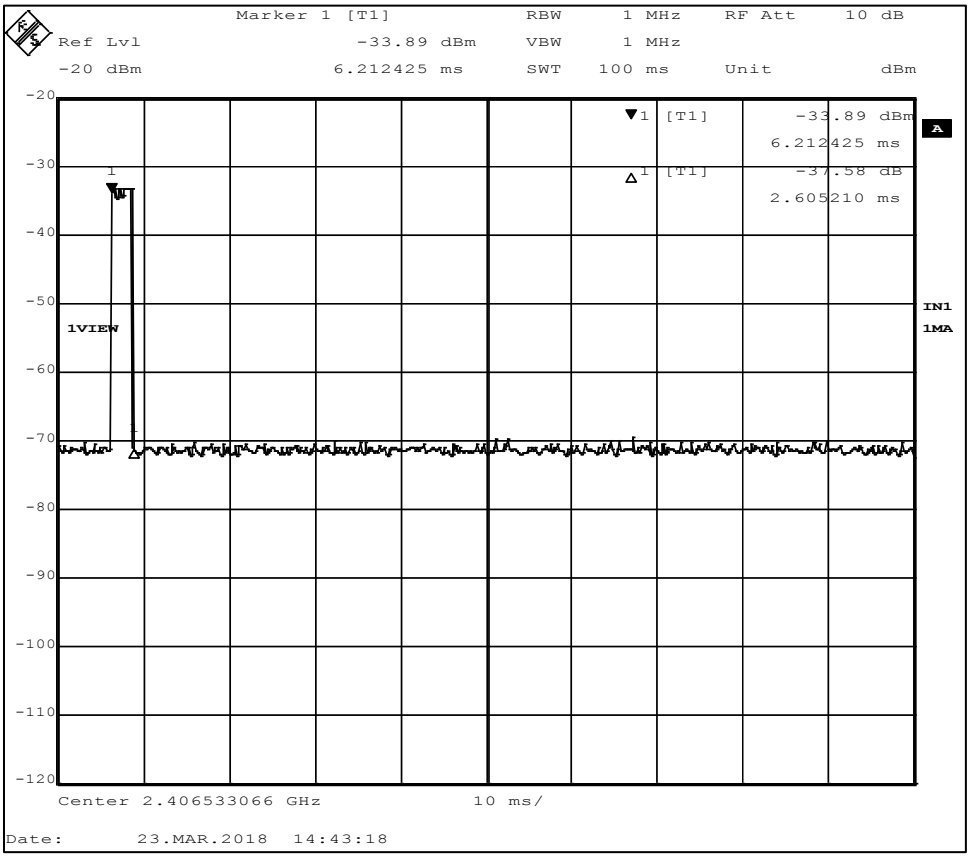

Figure 3 – Maximum Pulse Width

Duty cycle correction factor = 20*log((2.6052)/100) = -31.68 dB

On time = 2.6052 ms per Figure 3

Period = 100 ms (Figure 1 shows 3.05 sec. maximum 100ms was used)

20dB is the maximum useable averaging factor, so that was used.

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:

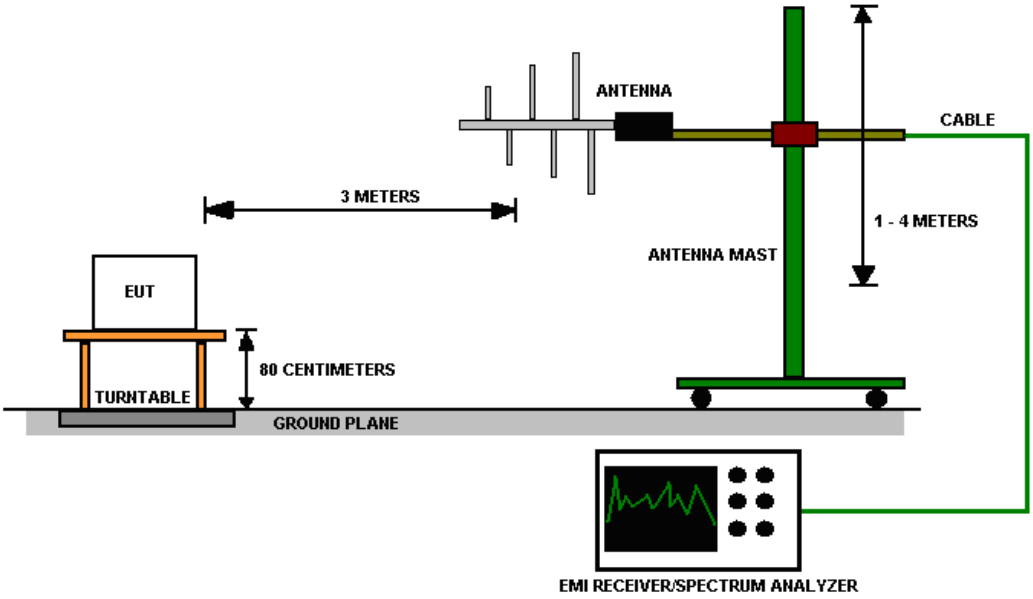

Figure 4 - Radiated Emissions Test Setup

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:

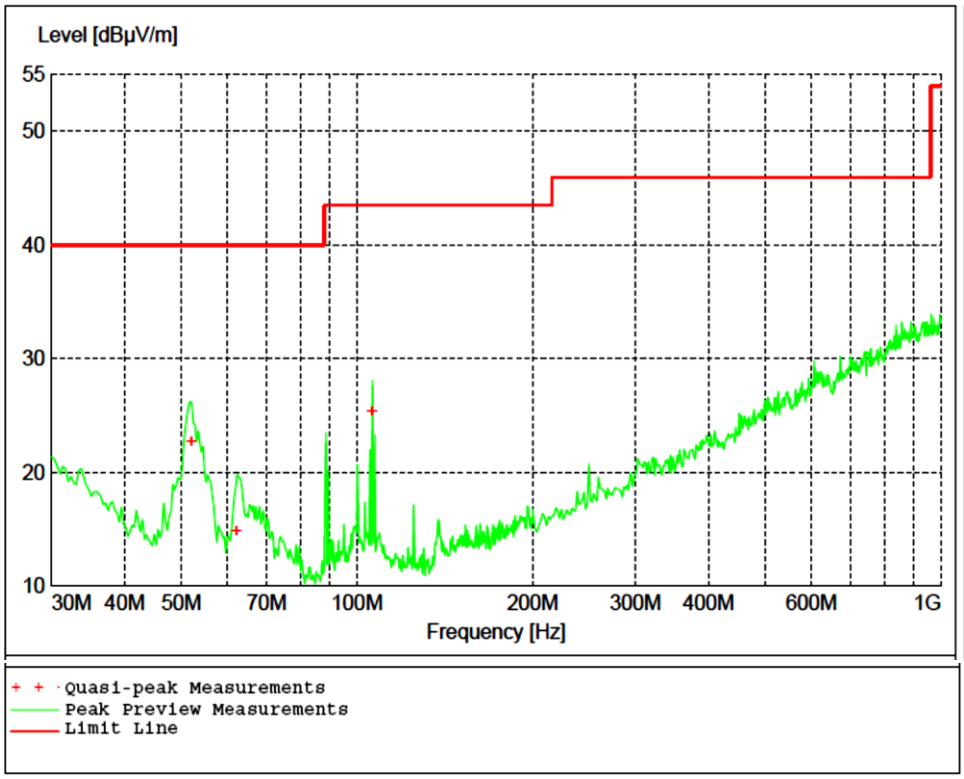

Figure 5 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
52.020000	22.72	40.00	17.30	99	344	VERT	X
62.220000	14.86	40.00	25.10	108	87	VERT	X
106.260000	25.39	43.50	18.10	128	266	HORI	X

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.		
2414.000000	47.40	54.00	6.60	182	167	VERT	Z
5936.600000	44.79	54.00	9.20	396	139	HORI	Z

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

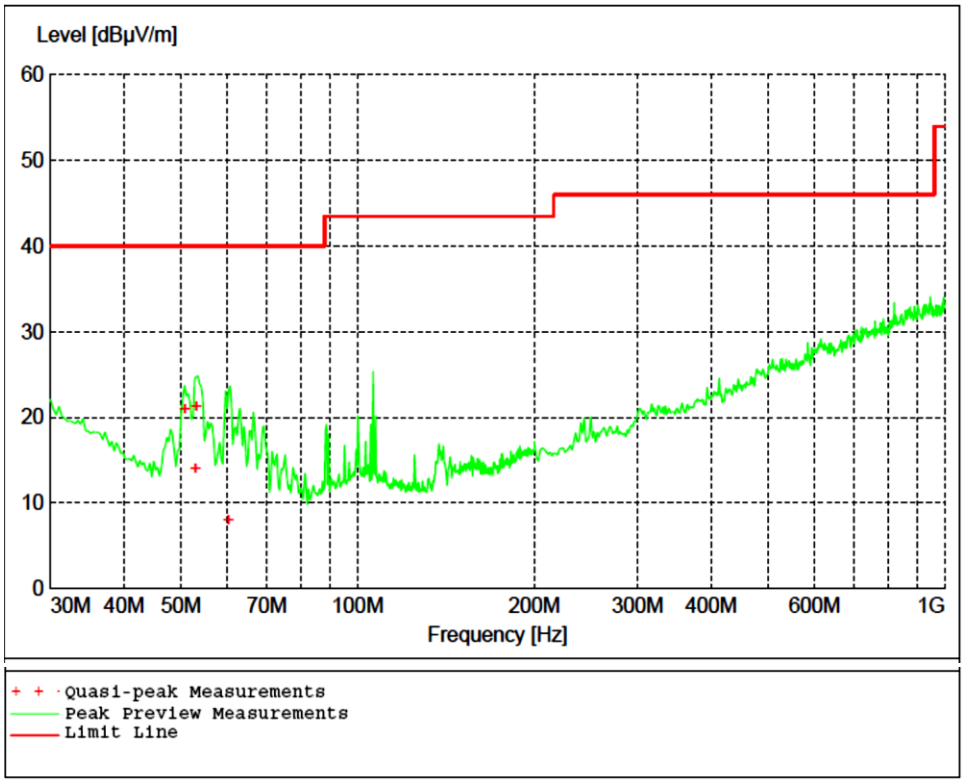

Figure 6 - Radiated Emissions Plot, Low Channel

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.		
50.820000	21.01	40.00	19.00	99	279	VERT	X
52.980000	14.07	40.00	25.90	98	96	VERT	X
53.160000	21.23	40.00	18.80	101	59	VERT	X
60.300000	8.07	40.00	31.90	99	301	VERT	X

Table 4 - Radiated Emissions Peak Measurement, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2407.000000	100.78	NA	NA	153	159	VERT	X
4814.000000	53.89	74.00	20.11	190	126	HORI	Z
12030.200000	40.19	74.00	33.81	126	157	VERT	Z
14431.000000	35.04	74.00	38.96	248	325	HORI	Z
16853.000000	49.36	74.00	24.64	115	151	VERT	Z

Table 5 - Radiated Emissions Average Measurement, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2407.000000	69.10	NA	NA	153	159	VERT	X
4814.000000	22.21	54.00	31.79	190	126	HORI	Z
12030.200000	8.51	54.00	45.49	126	157	VERT	Z
14431.000000	3.36	54.00	50.64	248	325	HORI	Z
16853.000000	17.68	54.00	36.32	115	151	VERT	Z

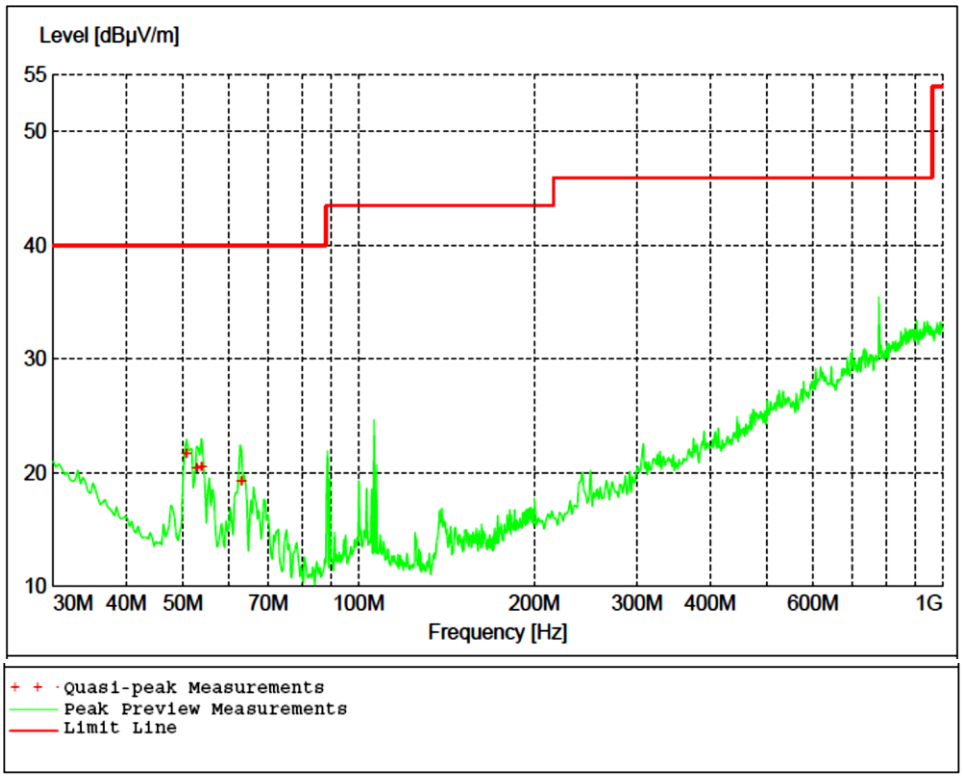

Figure 7 - Radiated Emissions Plot, Mid Channel

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.		
50.760000	21.70	40.00	18.30	101	358	VERT	X
52.920000	20.39	40.00	19.60	108	80	VERT	X
53.940000	20.57	40.00	19.40	109	126	VERT	X
63.000000	19.30	40.00	20.70	102	325	VERT	X

Table 7 - Radiated Emissions Peak Measurement, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2440.000000	100.52	NA	NA	163	168	VERT	X
4880.000000	45.17	74.00	28.83	166	121	HORI	Z
12217.800000	41.18	74.00	32.82	332	228	HORI	Z
14640.600000	50.00	74.00	24.00	315	315	VERT	Z
17065.000000	50.97	74.00	23.03	206	33	VERT	Z

Table 8 - Radiated Emissions Average Measurement, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2440.000000	68.84	NA	NA	163	168	VERT	X
4880.000000	13.49	54.00	40.51	166	121	HORI	Z
12217.800000	9.50	54.00	44.50	332	228	HORI	Z
14640.600000	18.32	54.00	35.68	315	315	VERT	Z
17065.000000	19.29	54.00	34.71	206	33	VERT	Z

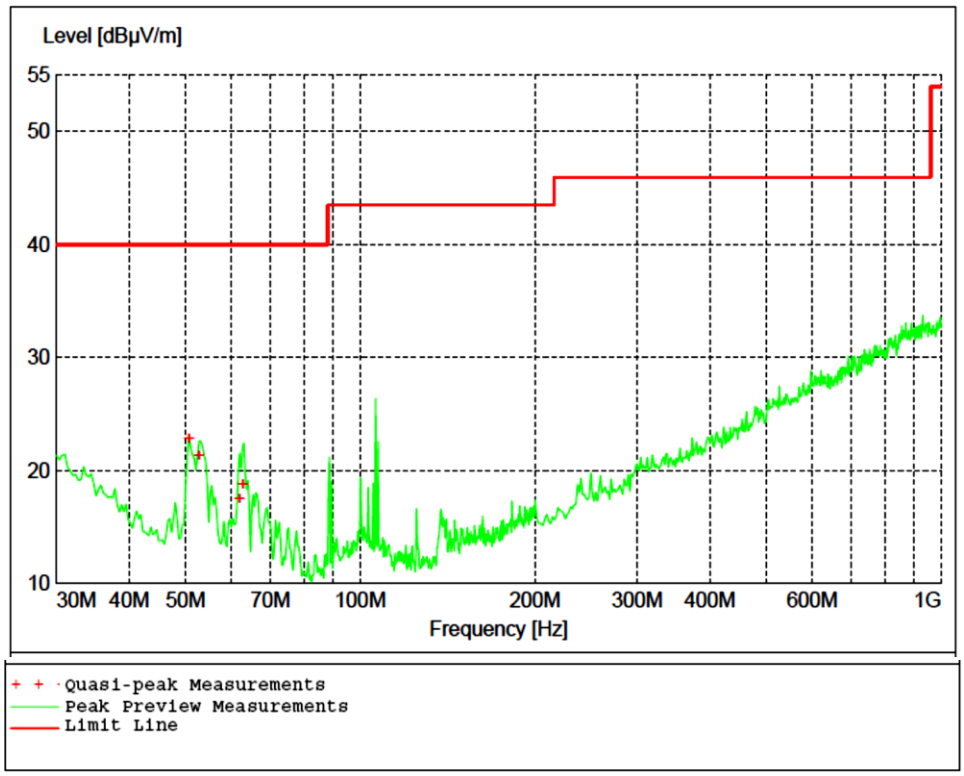

Figure 8 - Radiated Emissions Plot, High Channel

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.		
50.700000	22.84	40.00	17.20	102	360	VERT	X
52.800000	21.35	40.00	18.60	100	85	VERT	X
61.980000	17.58	40.00	22.40	99	3	VERT	X
62.880000	18.84	40.00	21.20	109	30	VERT	X

Table 10 - Radiated Emissions Peak Measurement, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	100.66	NA	NA	150	162	VERT	X
4960.000000	53.64	74.00	20.36	160	46	HORI	Z
12414.200000	43.56	74.00	30.44	174	28	VERT	Z
14874.400000	49.16	74.00	24.84	390	360	HORI	Z
17375.800000	51.93	74.00	22.07	264	296	HORI	Z

Table 11 - Radiated Emissions Average Measurement, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	68.98	NA	NA	150	162	VERT	X
4960.000000	21.96	54.00	32.04	160	46	HORI	Z
12414.200000	11.88	54.00	42.12	174	28	VERT	Z
14874.400000	17.48	54.00	36.52	390	360	HORI	Z
17375.800000	20.25	54.00	33.75	264	296	HORI	Z

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.

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 10 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:

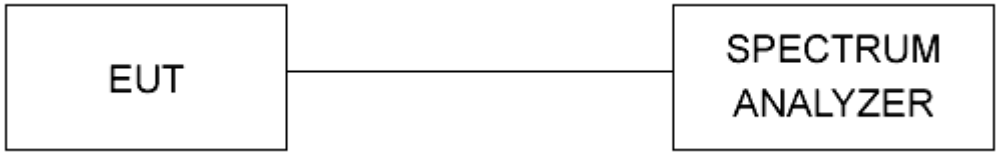

Figure 9 – Peak Output Power Measurements Test Setup
*1.1 dB of cable loss was used and it was accounted for in the plots

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	4.32	Conducted	PASS
Middle	2440	4.19	Conducted	PASS
High	2480	4.19	Conducted	PASS

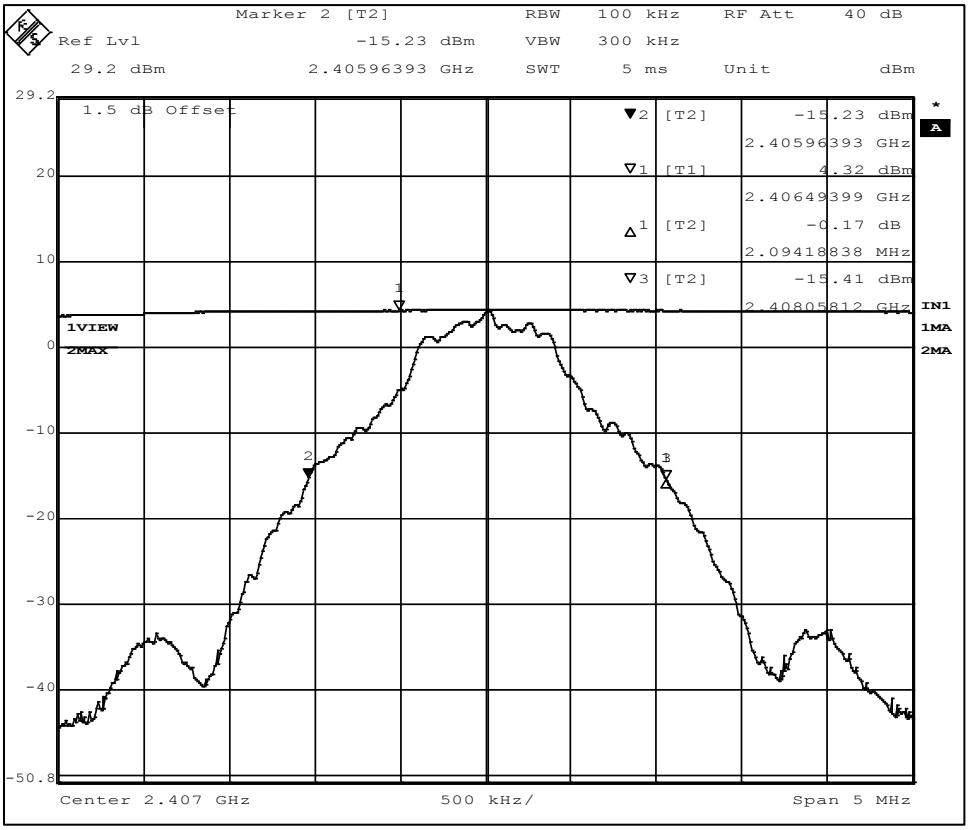

Figure 10 – Output Power, Low Channel

The screen capture states that the resolution bandwidth was 100 kHz. This RBW was used for the bandwidth measurement and was used only for Trace 2. Trace 1 in the plot above was measured with a 10 MHz RBW and 10 MHz VBW in order to measure the full output power.

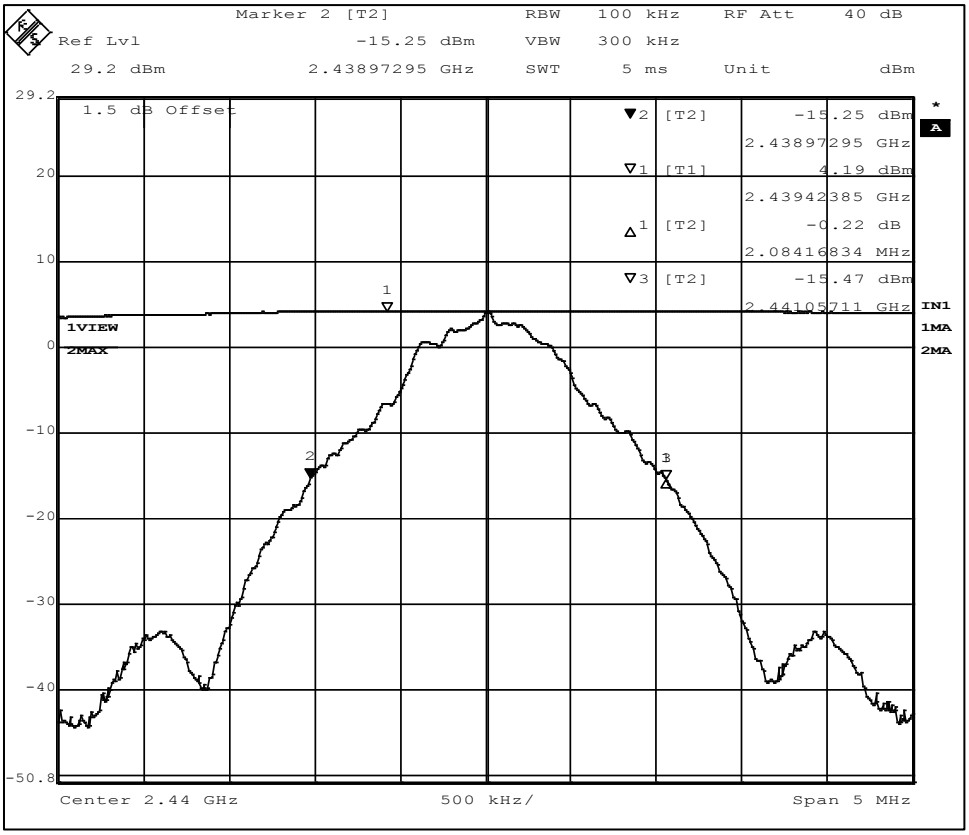

Figure 11 - Output Power, Mid Channel

The screen capture states that the resolution bandwidth was 100 kHz. This RBW was used for the bandwidth measurement and was used only for Trace 2. Trace 1 in the plot above was measured with a 10 MHz RBW and 10 MHz VBW in order to measure the full output power.

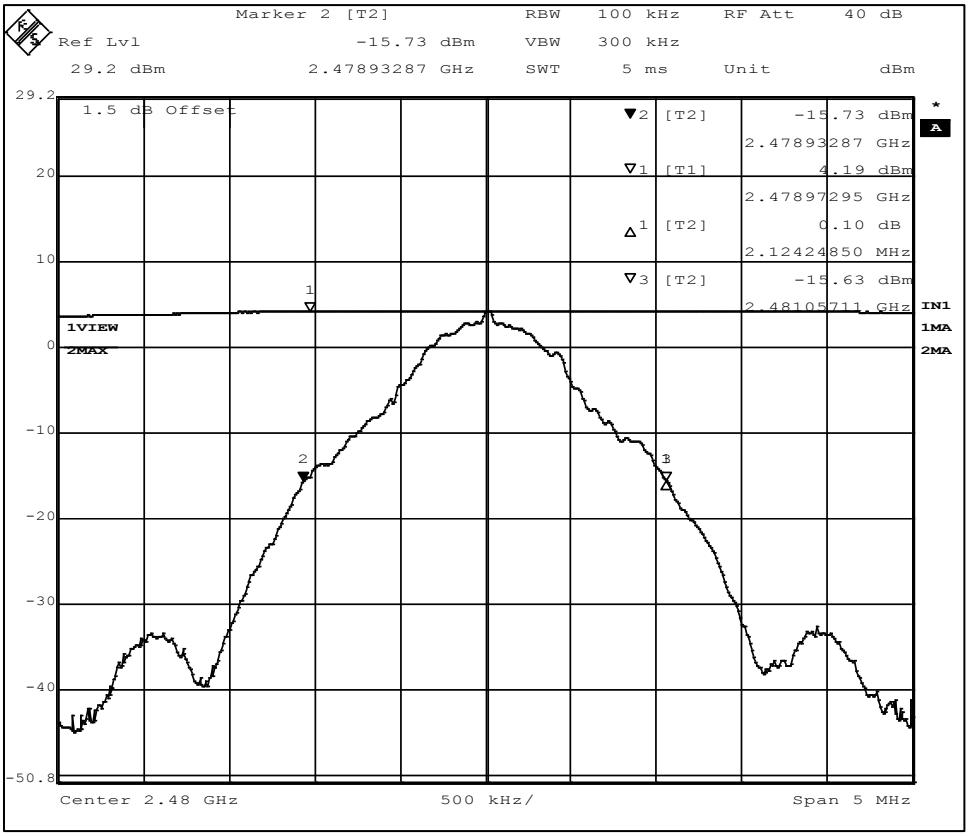

Figure 12 - Output Power, High Channel

The screen capture states that the resolution bandwidth was 100 kHz. This RBW was used for the bandwidth measurement and was used only for Trace 2. Trace 1 in the plot above was measured with a 10 MHz RBW and 10 MHz VBW in order to measure the full output power.

4.4 BANDWIDTH

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

Limits of bandwidth measurements:
The 99% occupied bandwidth and peak output powers are displayed. The maximum allowed peak output power is 30 dBm.

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

Test procedures:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable. 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.

For peak output power measurements, the EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 3 MHz RBW and 10 MHz VBW.

Deviations from test standard:
No deviation.

Test setup:

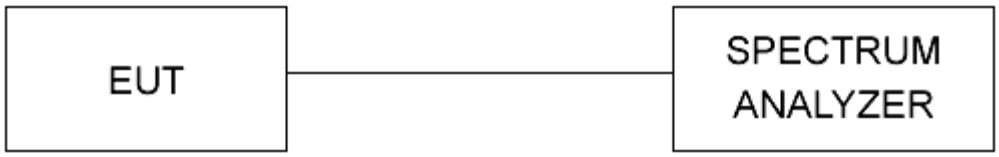

Figure 13 – Peak Output Power Measurements Test Setup

*1.1 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:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)
1	2407	2.09
2	2440	2.08
3	2480	2.12

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	6 dB BW (kHz)
1	2407	851.70
2	2440	891.78
3	2480	831.66

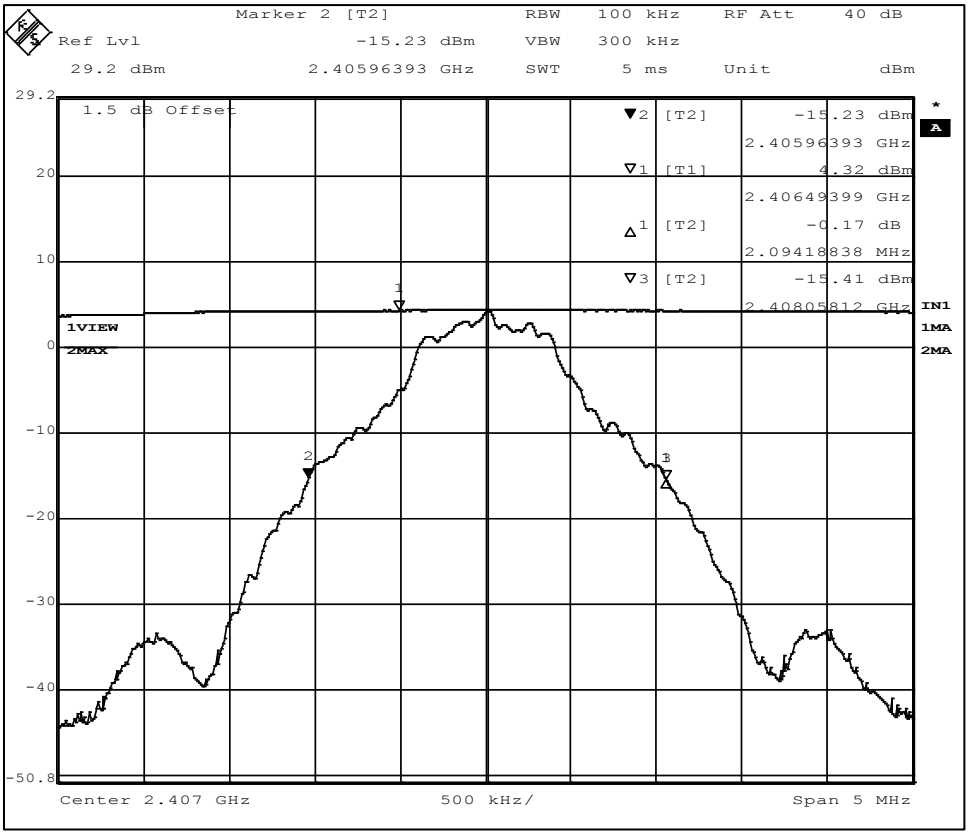

Figure 14 - 99% Occupied Bandwidth, Low Channel

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.

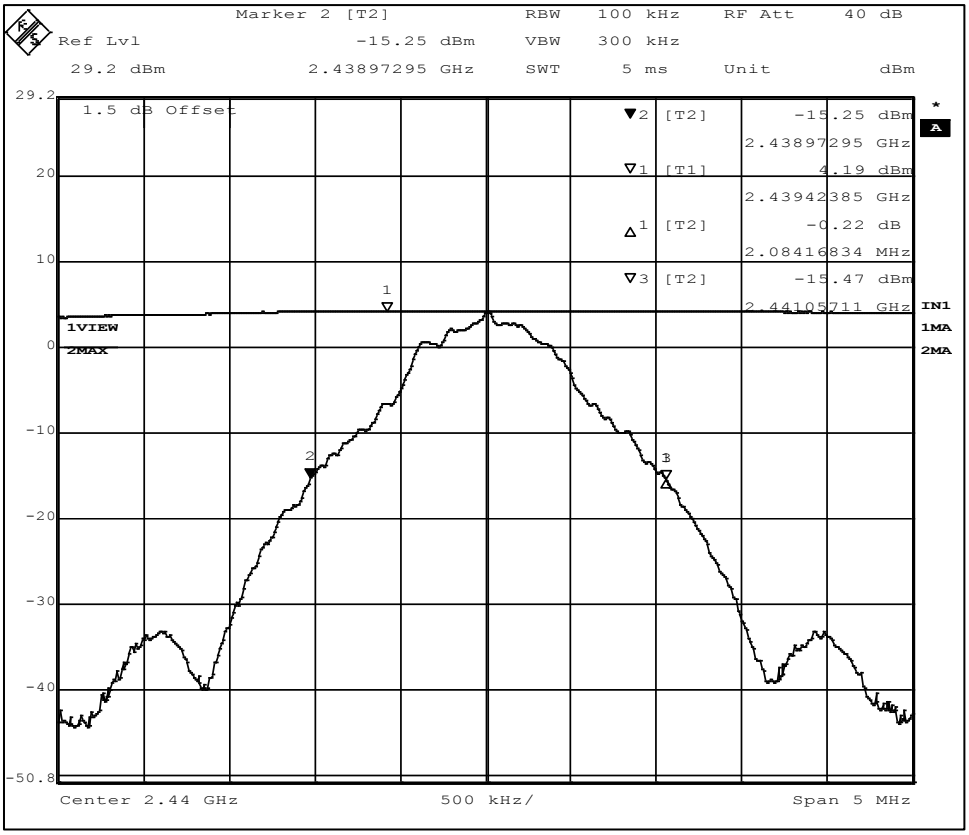

Figure 15 - 99% Occupied Bandwidth, Mid Channel

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.

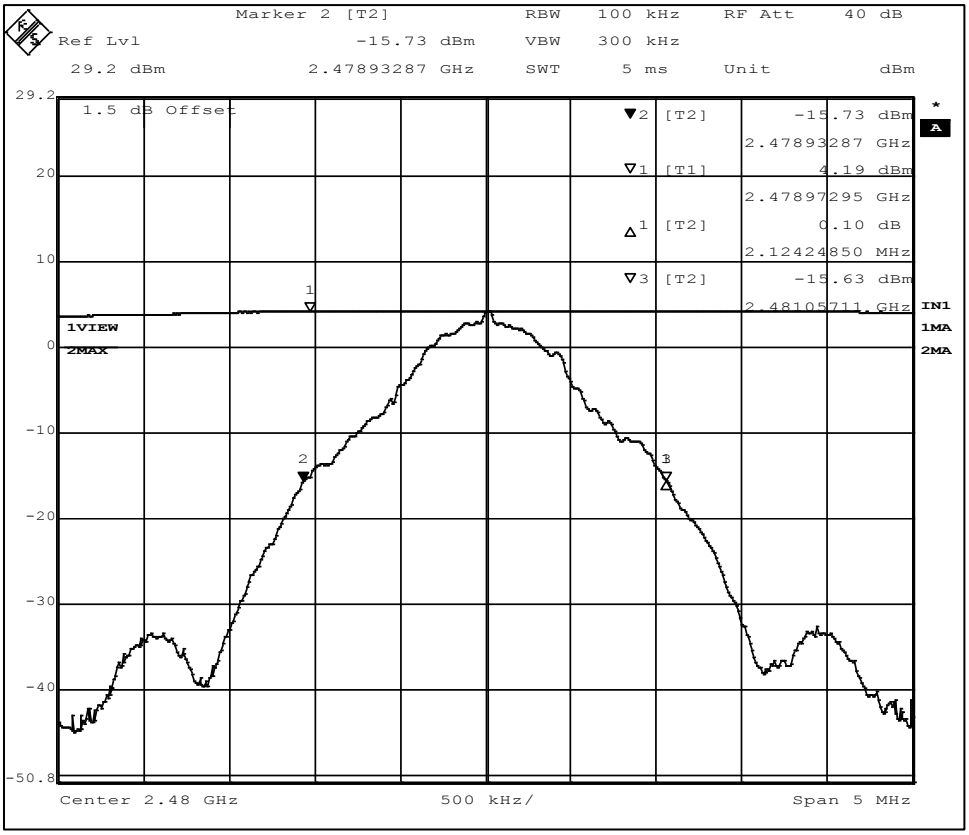

Figure 16 - 99% Occupied Bandwidth, High Channel

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.

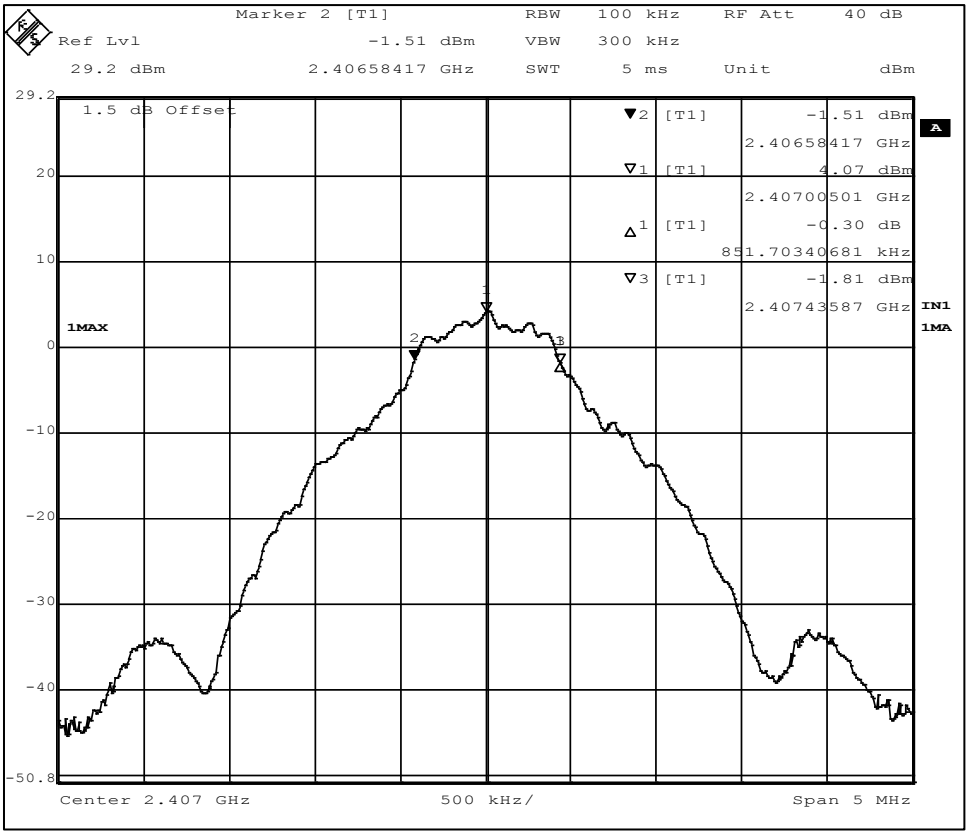

Figure 17 - 6dB Bandwidth, Low Channel

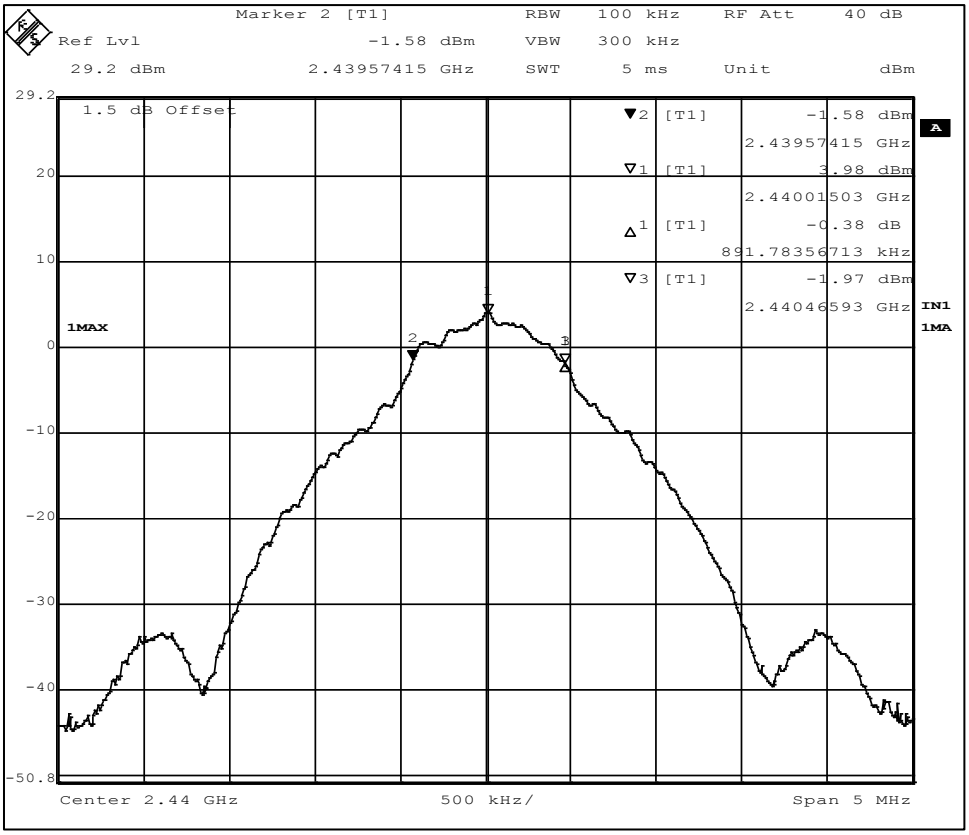

Figure 18 - 6dB Bandwidth, Mid Channel

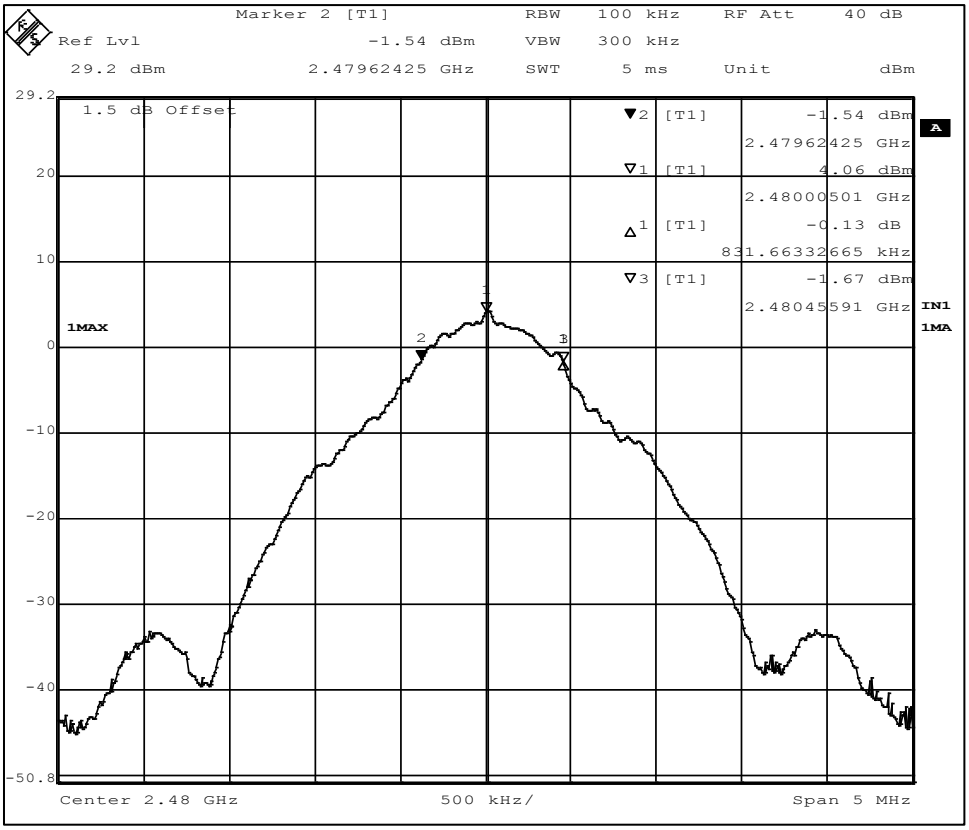

Figure 19 - 6dB Bandwidth, High Channel

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* for unrestricted bands,However the restricted bands were measured in radiated manner. The resolution bandwidth was set to 30kHz and 100 kHz 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)	Band	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dB)	Result
1	2390.0	Restricted per FCC Part 15.209	-97.57	-43.34	54.23	15.10*	PASS
3	2483.5	Restricted per FCC Part 15.209	-101.76	-44.50	57.26	14.98*	PASS
1	2400.0	Band edge from FCC Part 15.247	-64.37	-16.53	47.84	20.00	PASS
3	2483.5	Band edge from FCC Part 15.247	-101.76	-44.50	57.26	20.00	PASS

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

For restricted band measurements per FCC Part 15.209:

From Section 4.2

Fundamental average field strength at 2407MHz for low channel = 69.10 dBµV/m
Fundamental average field strength at 2480MHz for high channel = 68.98 dBµV/m

Channel 1 minimum delta = 69.10 – 54.0 dBµV/m = 15.10 dBc
Channel 3 minimum delta = 68.98 – 54.0 dBµV/m = 14.98 dBc

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

For band edges defined in Part 15.247, all emissions outside of the defined band must be at least 20 dB below the highest level of the fundamental emission.

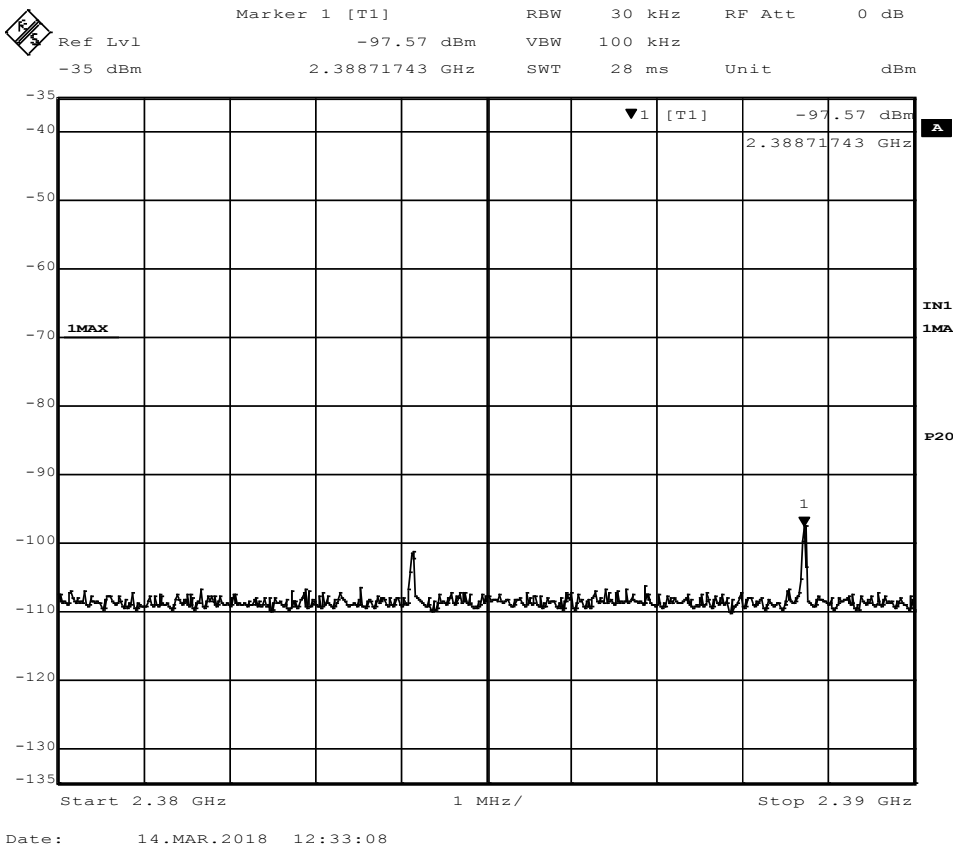

Figure 20 - Band-edge Measurement, Low Channel, Restricted Frequency, Radiated Measurement

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

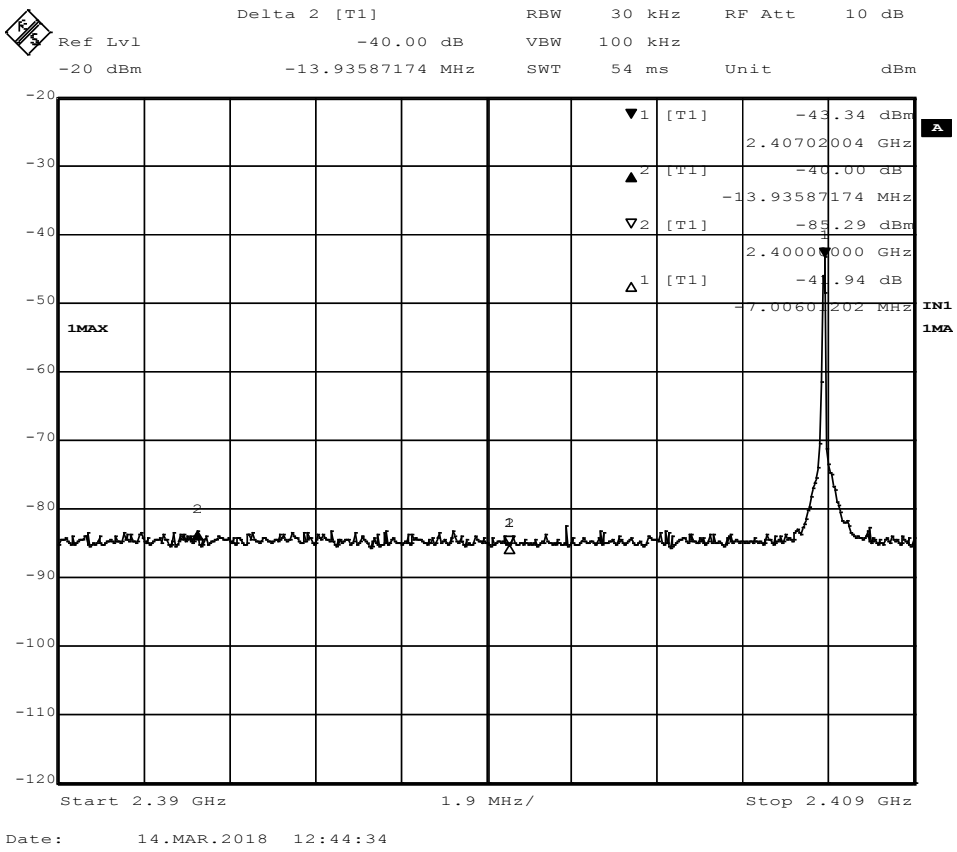

Figure 21 - Band-edge Measurement, Low Channel, Fundamental, Radiated Measurement

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

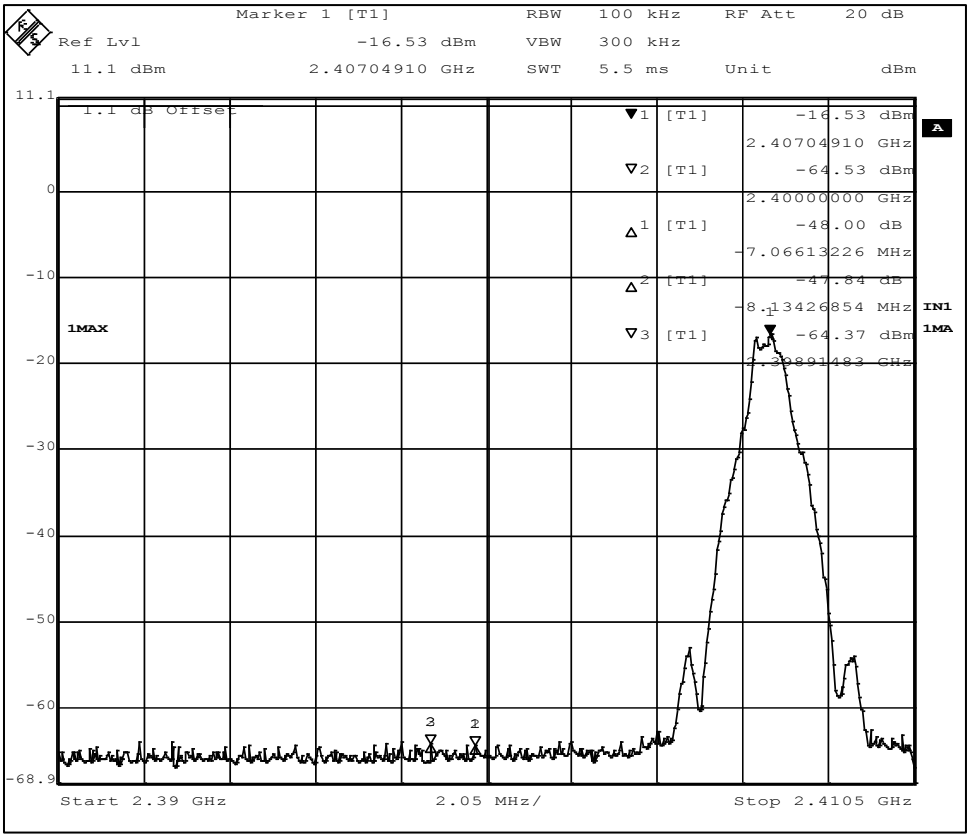

Figure 22 - Band-edge Measurement, Low Channel, Unrestricted Frequency, Conducted Measurement

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

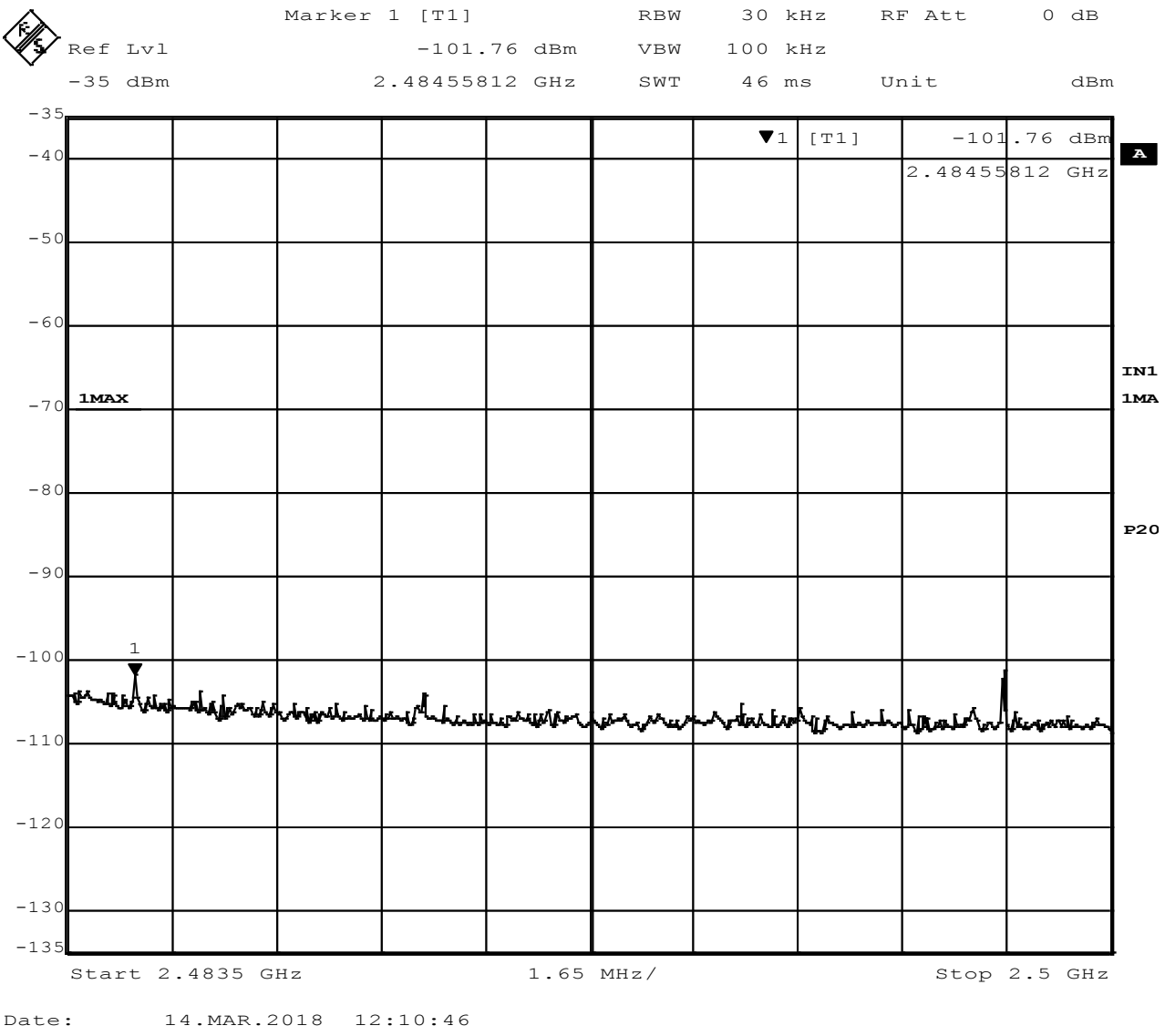

Figure 23 - Band-edge Measurement, High Channel, Restricted Frequency, Radiated Measurement

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

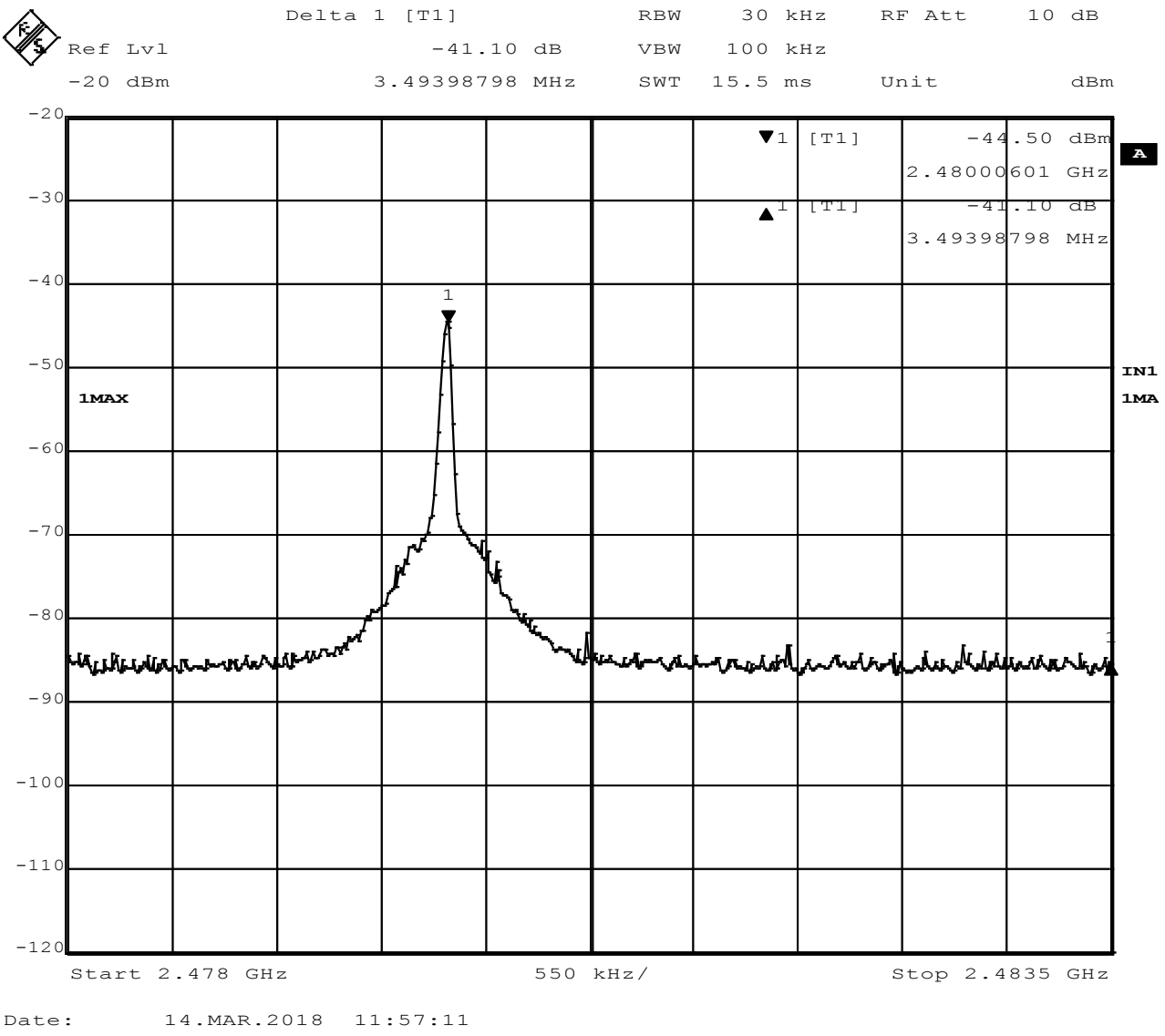

Figure 24 - Band-edge Measurement, High Channel, Fundamental, Radiated Measurement

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

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. The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable.

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 EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable on a bench top.

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
1	2407	-10.90	Conducted	8.00	PASS
2	2440	-10.23	Conducted	8.00	PASS
3	2480	-10.64	Conducted	8.00	PASS

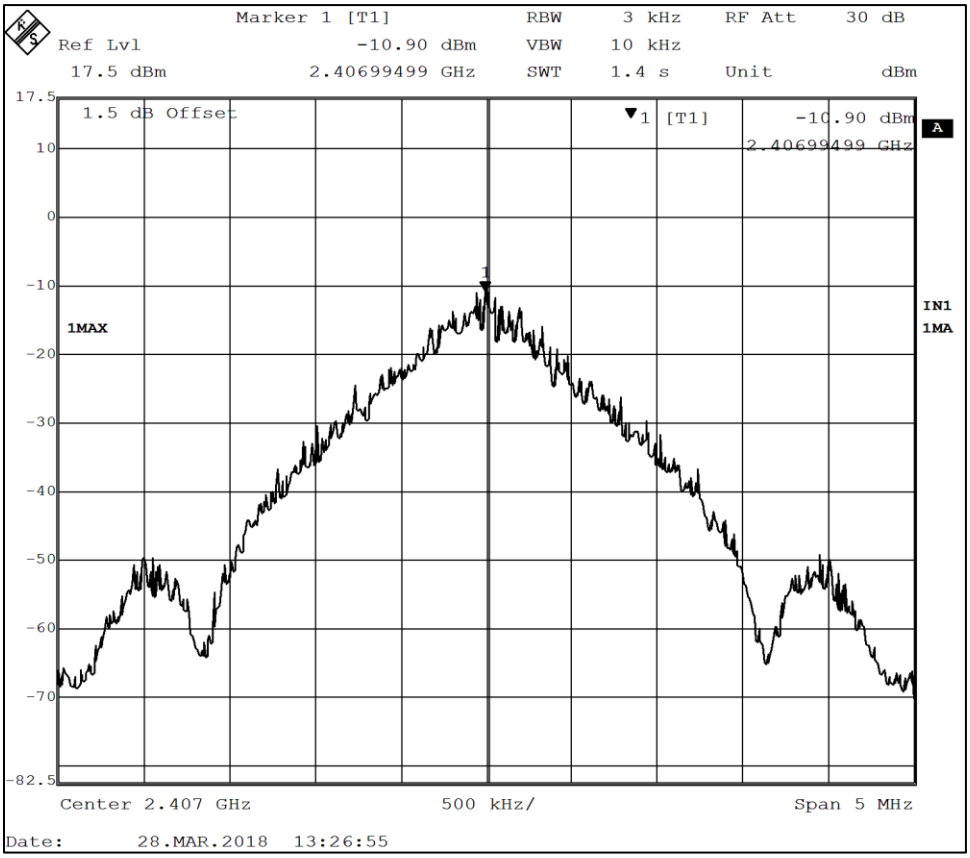

Figure 25 - Power Spectral Density, Low Channel

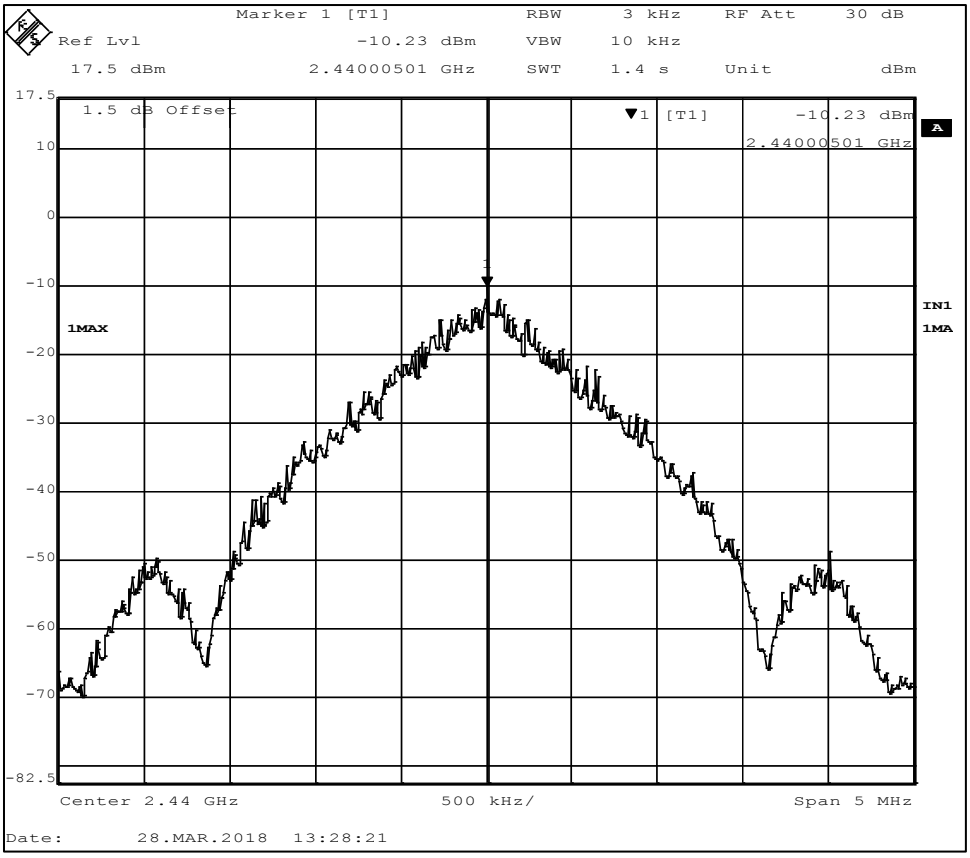

Figure 26 - Power Spectral Density, Mid Channel

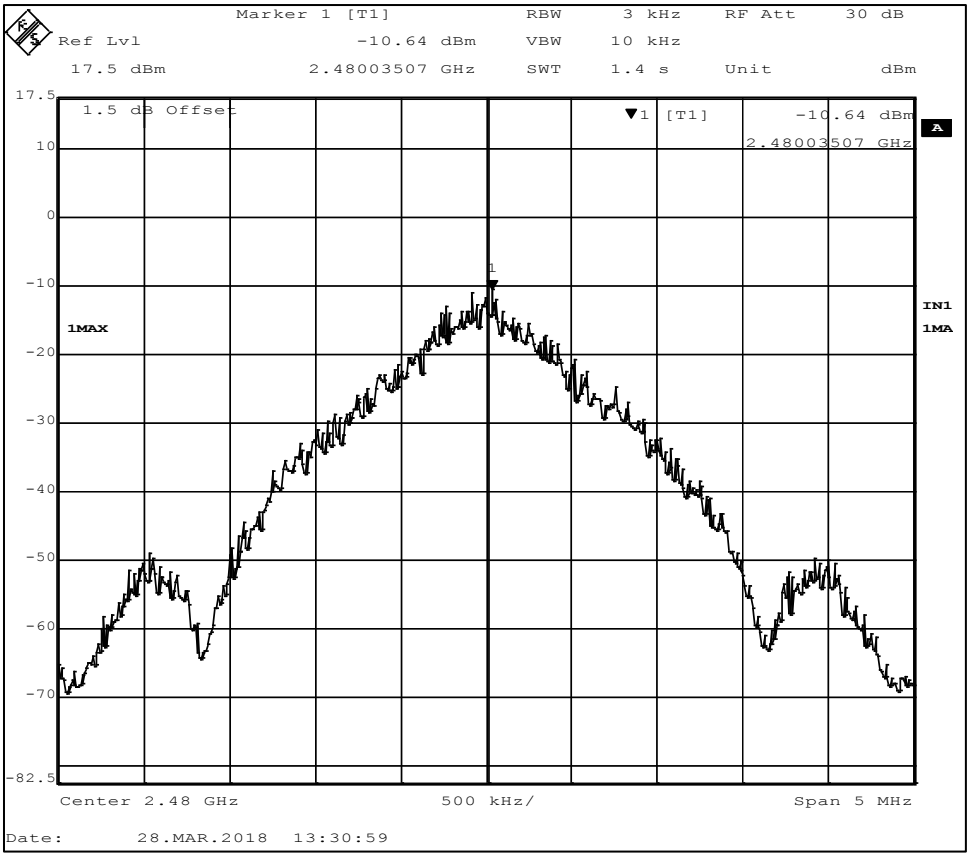

Figure 27 - Power Spectral Density, High Channel

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:

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 are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

Test setup:
The EUT was tested as module. A representative DC “wall-wart” style power supply was used with a 1 ± 0.2 meter cable length.

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:

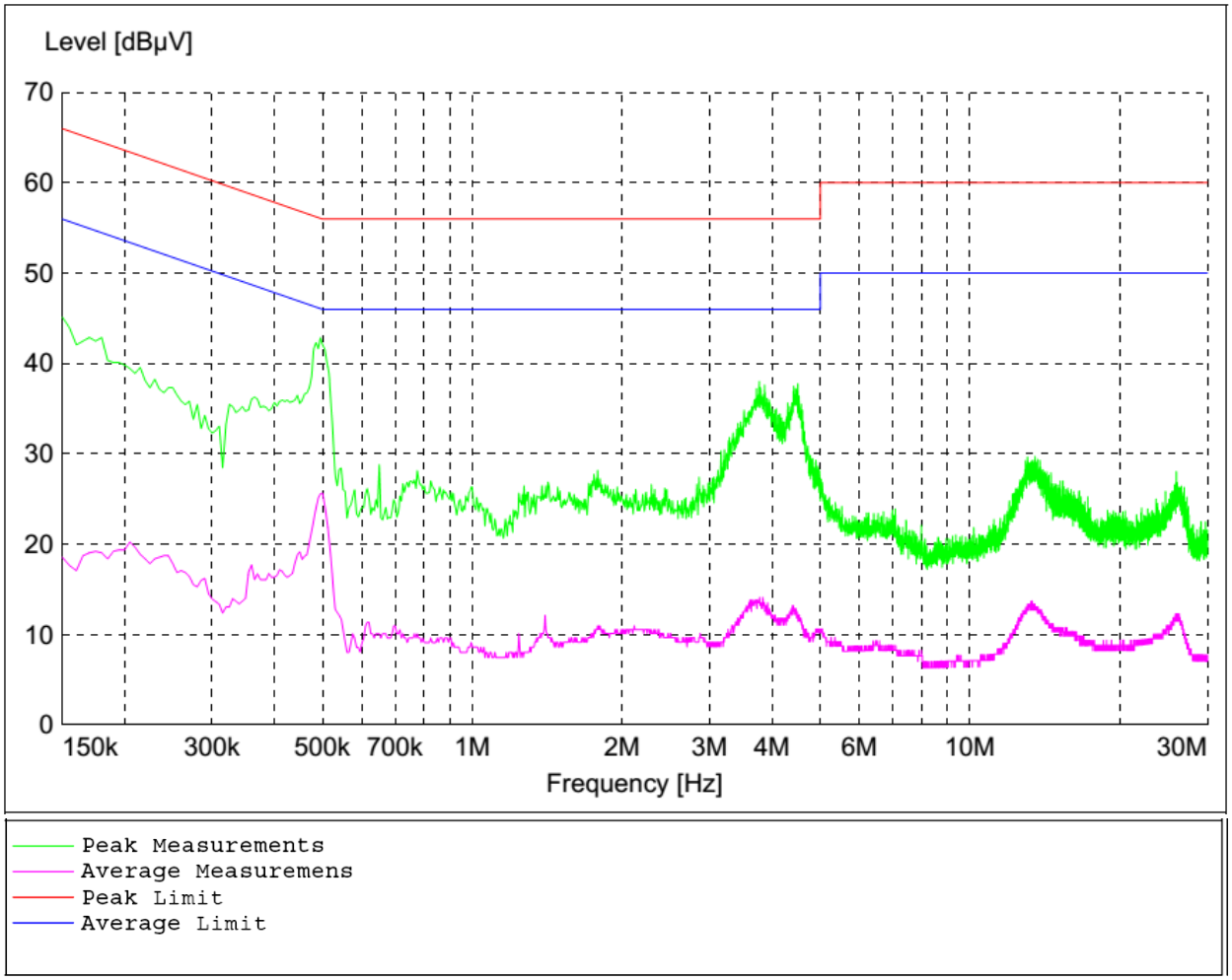

Figure 28 - Conducted Emissions Plot

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