The Nebraska Center for Excellence in Electronics
4740 Discovery Drive
Lincoln, NE 68521
Phone: 402.323.6233
Fax: 402.323.6238
www.nceelabs.com

Amended

Test Report

Includes NCEE Labs report R0170317-0-0A and its amendment in full

Prepared for: **Hunter Douglas**

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

Product: **Wireless window blind controller hub**
Radio 2

Test Report No: **R20170317-20-02A**

Approved By:

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

DATE: **30 October 2017**

Total Pages: **45**

A2LA ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Table of Figures

Figure Number **Page**

Table Number **Page**

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	Pass	Meets the requirement of the limit.

2.0 Description

2.1 Equipment under test

The Equipment Under Test (EUT) was a wireless module used to control window blinds. It operates from 2407 to 2480 MHz and has transmit and receive capabilities. It is intended to be paired with a remote.

EUT Received Date: 3 May 2017
EUT Tested Dates: 17 May 2017 – 26 June 2017

Description	Wireless window blind controller hub
MODEL	Radio 2 (uses Nordic NRF52832 chip)
Serial No.	C8 (used for radiated emissions tests, 30 MHz – 1 GHz), 1706020170 (used for radio measurements and 1 GHz -26 GHz)
POWER SUPPLY	5 VDC (MN:HDP-QB05010U)
ANTENNA TYPE	Antenna is not user replaceable

NOTE 1: The EUT with serial number 1706020170 was modified (Matching at the antenna was improved) by the manufacturer to pass the radiated emissions test. The unit with serial number C8 is not modified but manufacturer believes that the modification will not affect the performance of the unit in the frequency ranges between 30MHz and 1GHz so these tests were not repeated on the unit with serial number 1706020170.
NOTE 2: 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	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.

2.4 Applied standards

The EUT uses digital modulation and operates between 2407-2480MHz. 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, 15.247)
(2) FCC Part 15, Subpart B (15.107, 15.109)
(3) ANSI C63.10:2013
(4) Industry Canada RSS-Gen Issue 4
(5) 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.

AC/DC Power Supply used for testing:

Manufacturer:	HDP
M/N:	HDP-QB05010U
Input:	100 – 240VAC, 50/60Hz
Output:	5VDC, 1.0A

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	1647	02 Aug 2016	02 Aug 2017
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 attached to the PCB and internal to the plastic case. It is not user accessible.

4.2 Radiated emissions

Test Method: ANSI C63.10, Section(s) 6.5
ANSI C63.4. Section(s) 8.3

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.

h. The EUT contains 3 different transmitters, referred to as Radio 1, Radio 2 and Radio 3. The preview scan was also performed with each possible combination of radios transmitting to investigate for intermodulation products. There were none measured within 10 dB of the limit.

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

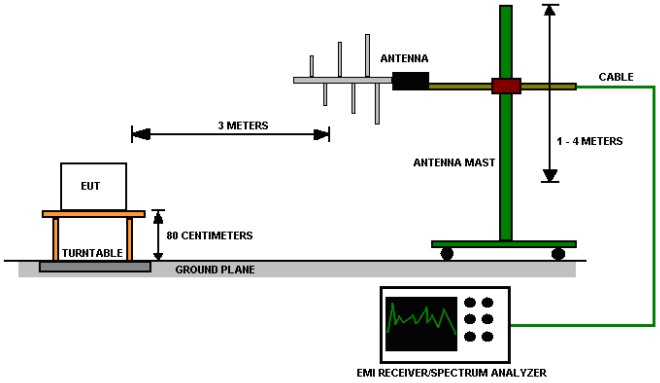

Figure 1 - Radiated Emissions Test Setup

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 5 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	Wireless Window Blind Controller Hub – Radio 2	MODE	Receive
INPUT POWER	5 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

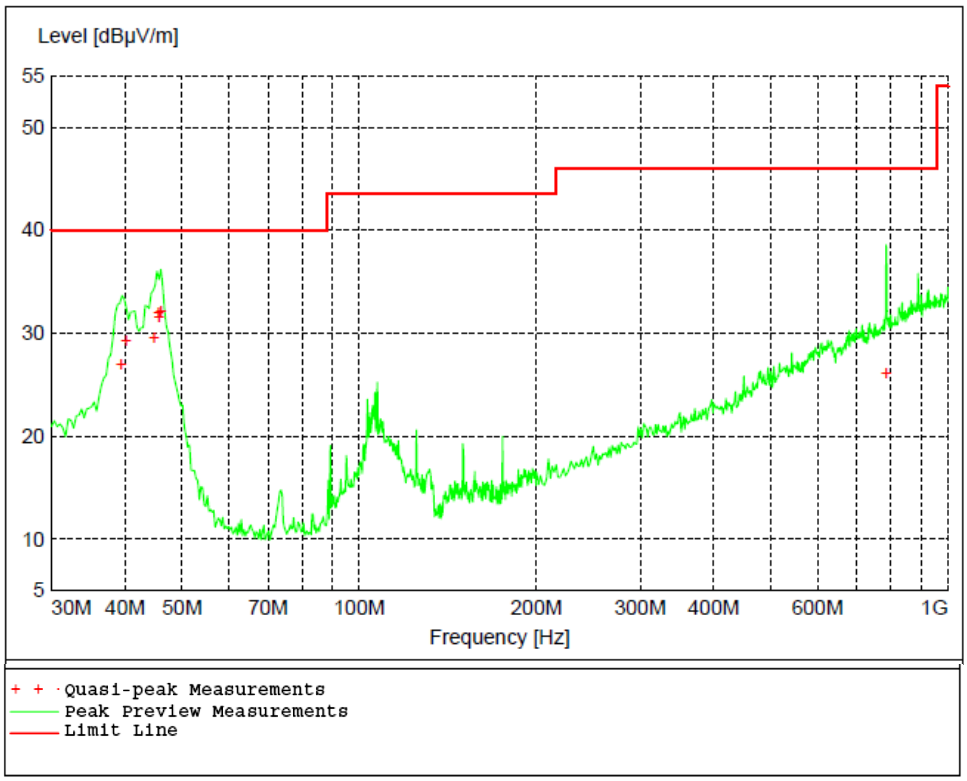

Figure 2 - Radiated Emissions Plot, Receive

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 EUT was measured in both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

Table 1 - Radiated Emissions Quasi-peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
39.420000	26.99	40.00	13.00	100	96	VERT
40.200000	29.27	40.00	10.70	100	26	VERT
44.880000	29.55	40.00	10.50	126	4	VERT
45.660000	31.96	40.00	8.00	99	13	VERT
45.720000	31.63	40.00	8.40	107	11	VERT
46.080000	32.11	40.00	7.90	100	1	VERT
785.940000	26.09	46.00	19.90	366	307	VERT

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2400.200000	22.85	54.00	31.10	158	0	VERT
4799.200000	28.65	54.00	25.30	258	299	VERT
7212.400000	30.07	54.00	23.90	184	16	VERT
9643.200000	50.91	54.00	3.10	369	151	VERT
12037.600000	29.74	54.00	24.30	336	285	VERT
14472.400000	33.32	54.00	20.70	100	48	HORI
16829.800000	35.31	54.00	18.70	199	104	VERT

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

EUT MODULE	Wireless Window Blind Controller Hub – Radio 2	MODE	Transmit, Low Channel
INPUT POWER	5 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

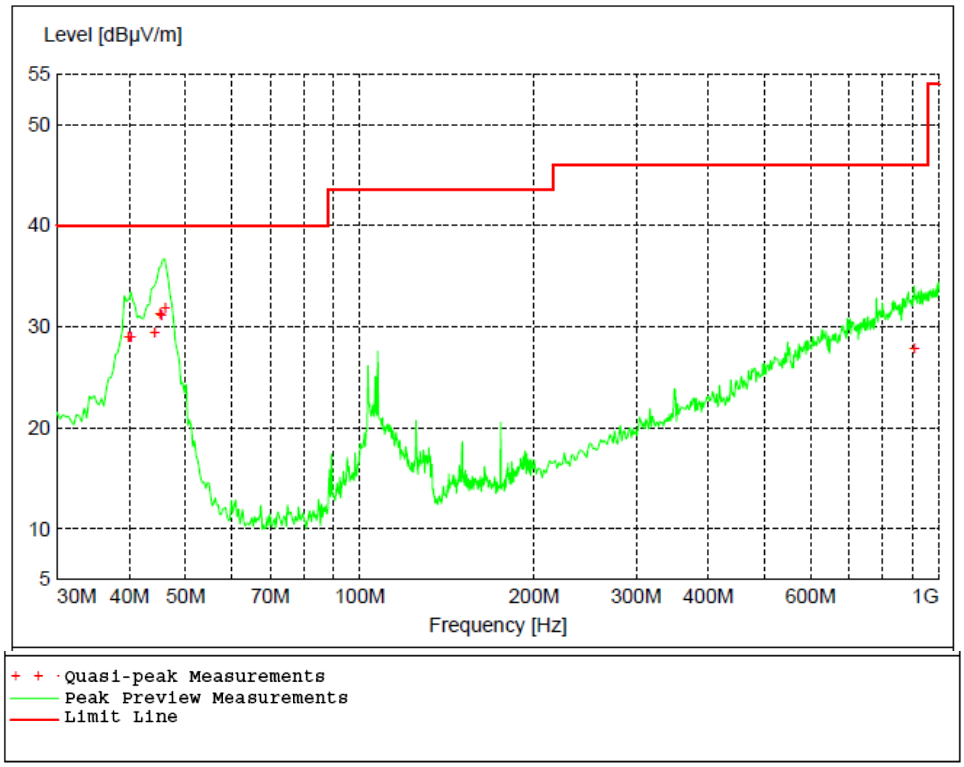

Figure 3 - Radiated Emissions Plot, Low Channel

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 EUT was measured in both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
39.900000	29.06	40.00	10.90	99	125	VERT
40.260000	29.01	40.00	11.00	99	86	VERT
44.220000	29.39	40.00	10.60	107	35	VERT
45.180000	31.25	40.00	8.80	98	5	VERT
45.480000	31.24	40.00	8.80	101	41	VERT
46.140000	31.85	40.00	8.10	100	0	VERT
907.980000	27.88	46.00	18.10	364	258	VERT

Table 4 - Radiated Emissions Peak Measurements vs. Average Limit, Low Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2407.000000	96.26	NA	NA	115	109	HORI
4815.800000	41.97	54.00	12.00	136	151	VERT
7221.000000	49.77	54.00	4.20	99	177	VERT
9600.400000	45.78	54.00	8.20	109	228	VERT
12011.200000	43.74	54.00	10.30	120	360	HORI

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

EUT MODULE	Wireless Window Blind Controller Hub – Radio 2	MODE	Transmit, Mid Channel
INPUT POWER	5 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

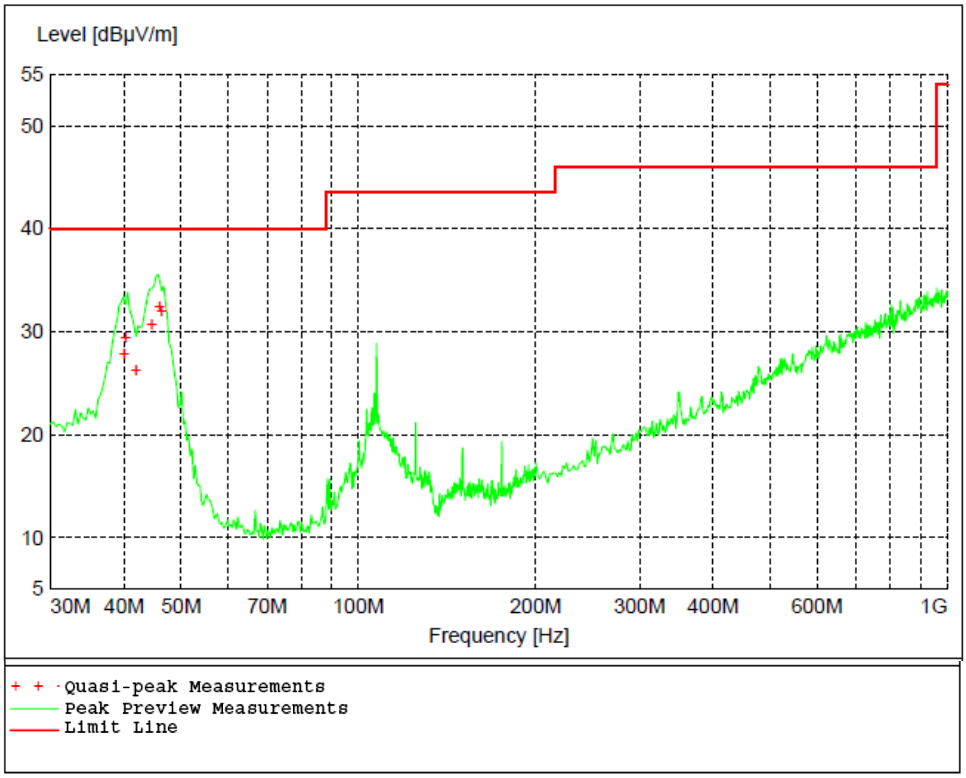

Figure 4 - Radiated Emissions Plot, Mid Channel

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 EUT was measured in both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
40.020000	27.84	40.00	12.20	124	60	VERT
40.260000	29.40	40.00	10.60	98	30	VERT
41.940000	26.27	40.00	13.70	101	7	VERT
44.580000	30.70	40.00	9.30	100	14	VERT
46.020000	32.43	40.00	7.60	102	20	VERT
46.320000	32.03	40.00	8.00	100	0	VERT

Table 6 - Radiated Emissions Peak Measurements vs. Average Limit, Mid Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2440.000000	96.64	NA	NA	166	116	HORI
4892.400000	41.37	54.00	12.60	103	266	VERT
7306.600000	42.82	54.00	11.20	101	49	VERT
9732.600000	46.39	54.00	7.60	321	360	VERT
12211.800000	41.03	54.00	13.00	100	174	VERT
14645.000000	50.45	54.00	3.50	99	187	VERT
17078.600000	51.28	54.00	2.70	105	145	VERT

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

EUT MODULE	Wireless Window Blind Controller Hub – Radio 2	MODE	Transmit, High Channel
INPUT POWER	5 VDC	FREQUENCY RANGE	30MHz – 26GHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

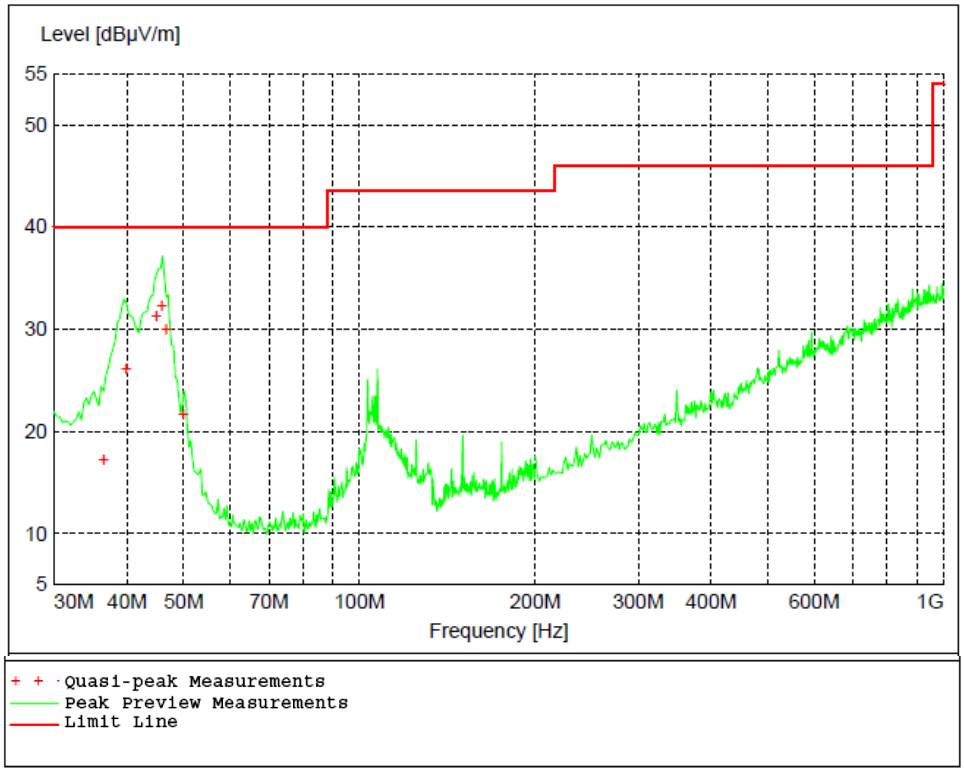

Figure 5 - Radiated Emissions Plot, High Channel

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 EUT was measured in both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
36.480000	17.21	40.00	22.80	126	312	VERT
39.840000	26.20	40.00	13.80	126	81	VERT
44.940000	31.31	40.00	8.70	100	31	VERT
45.900000	32.35	40.00	7.60	100	0	VERT
46.740000	29.97	40.00	10.00	100	0	VERT
49.980000	21.74	40.00	18.30	126	18	VERT

Table 8 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
2480.000000	97.65	NA	NA	153	114	HORI
4959.600000	41.06	54.00	12.90	361	234	VERT
5836.200000	43.53	54.00	10.50	400	328	HORI
7439.800000	45.35	54.00	8.70	99	168	VERT
9909.600000	45.27	54.00	8.70	168	177	VERT
12424.600000	44.58	54.00	9.40	147	342	VERT

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

REMARKS:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value
5. The EUT was measured in both the horizontal and vertical orientation. It was found that the Horizontal position produced the highest emissions, and this orientation was used for all testing. See Annex A for test photos.

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

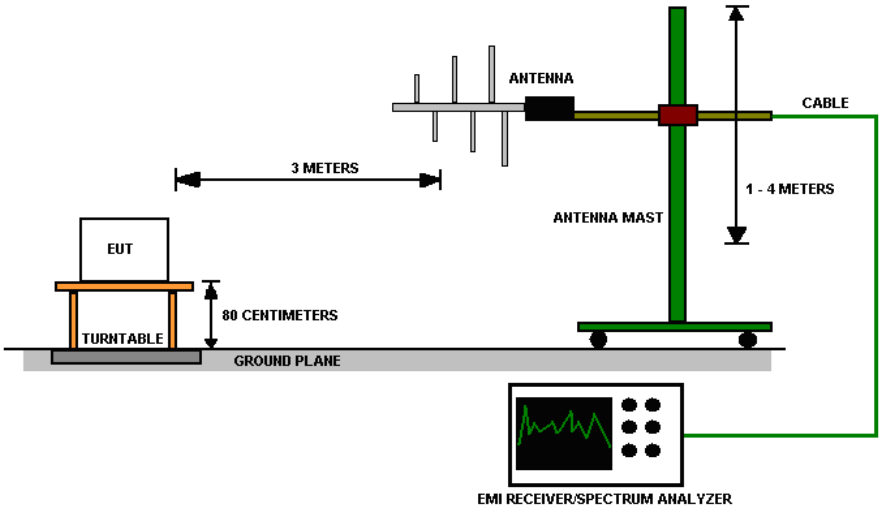

Figure 6 - Bandwidth Measurements Test Setup

4.3.5 EUT operating conditions

The EUT was powered by 5 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	Wireless Window Blind Controller – Radio 2	MODE	Transmit
INPUT POWER	5 VDC	FREQUENCY RANGE	2407- 2480 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	99% Occupied BW (MHz)	6 dB BW (MHz)
Low	2407	2.13	0.818
Mid	2440	2.02	0.888
High	2480	2.10	0.834

REMARKS:
None

Peak EIRP

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	RESULT
Low	2407	2.94	Pass
Mid	2440	2.68	Pass
High	2480	2.41	Pass

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

REMARKS:
None

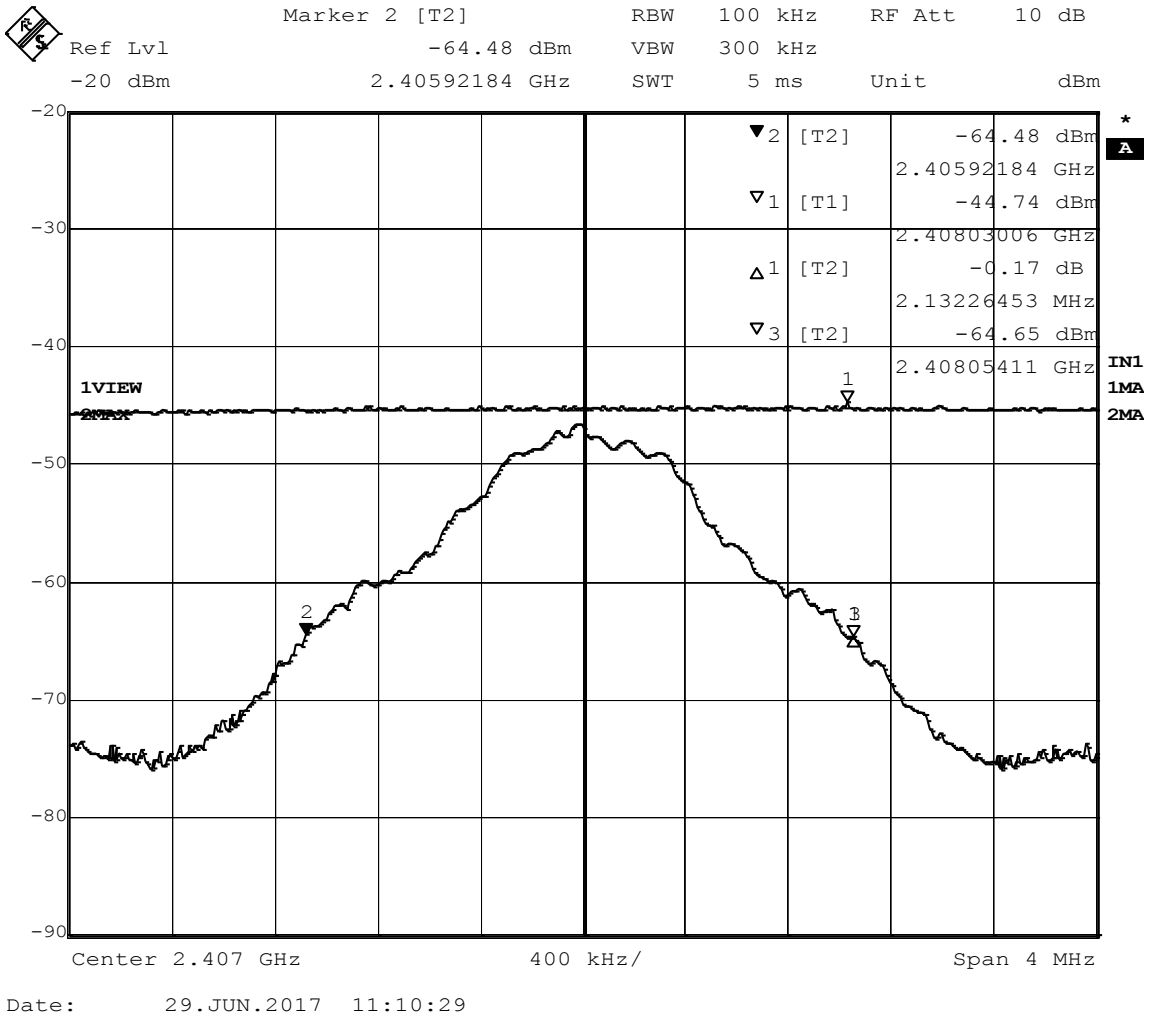

Figure 7 - 99% Occupied Bandwidth, Low Channel. 2.13 MHz

Maximum power = -44.74 dBm + 107 + CL + AF - 95.23 = 2.94 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.

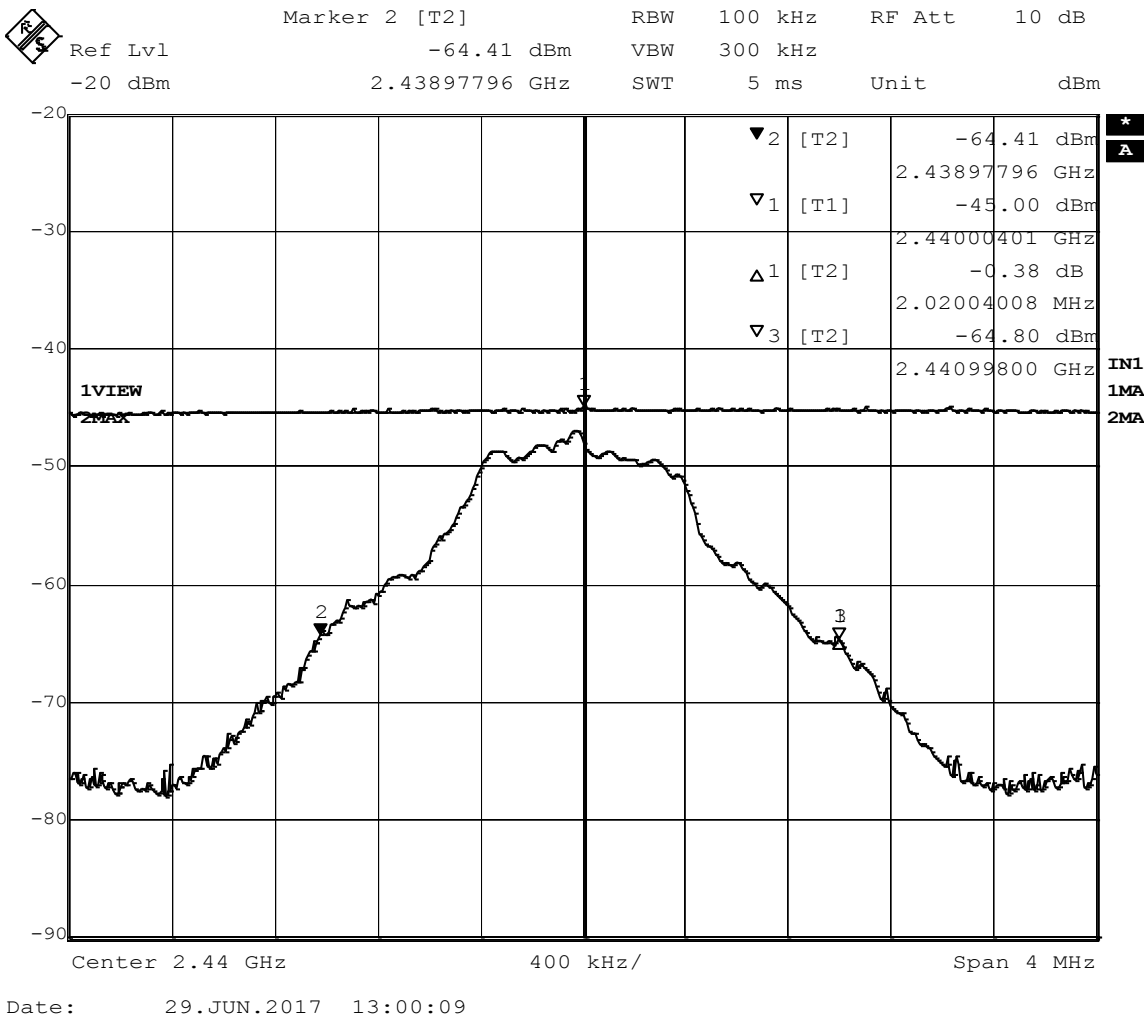

Figure 8 - 99% Occupied Bandwidth, Mid Channel, 2.02 MHz

Maximum power = -45.00 dBm + 107 + CL + AF - 95.23 = 2.68 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.

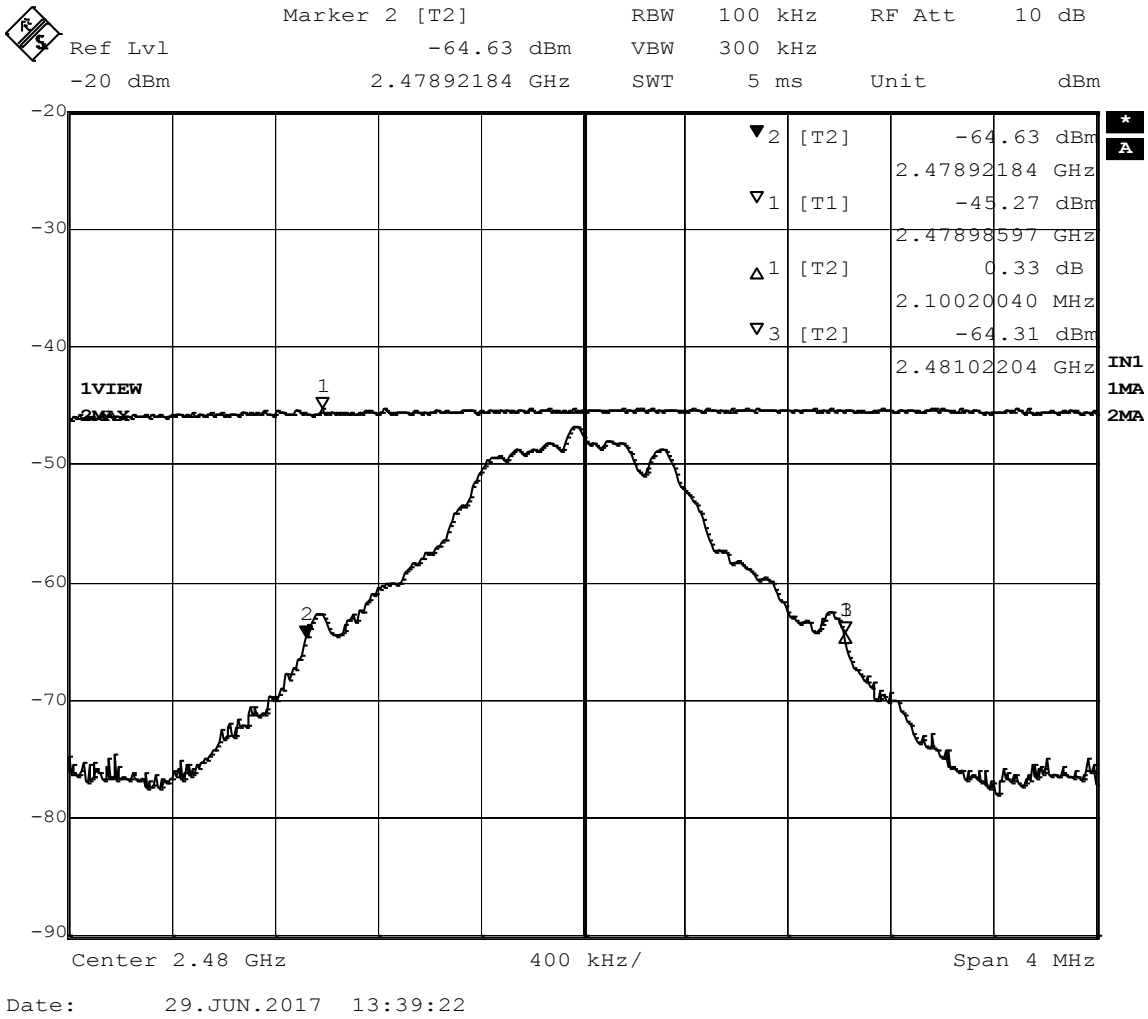

Figure 9 - 99% Occupied Bandwidth, High Channel, 2.10 MHz

Maximum power = -45.27 dBm + 107 + CL + AF - 95.23 = 2.41 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.

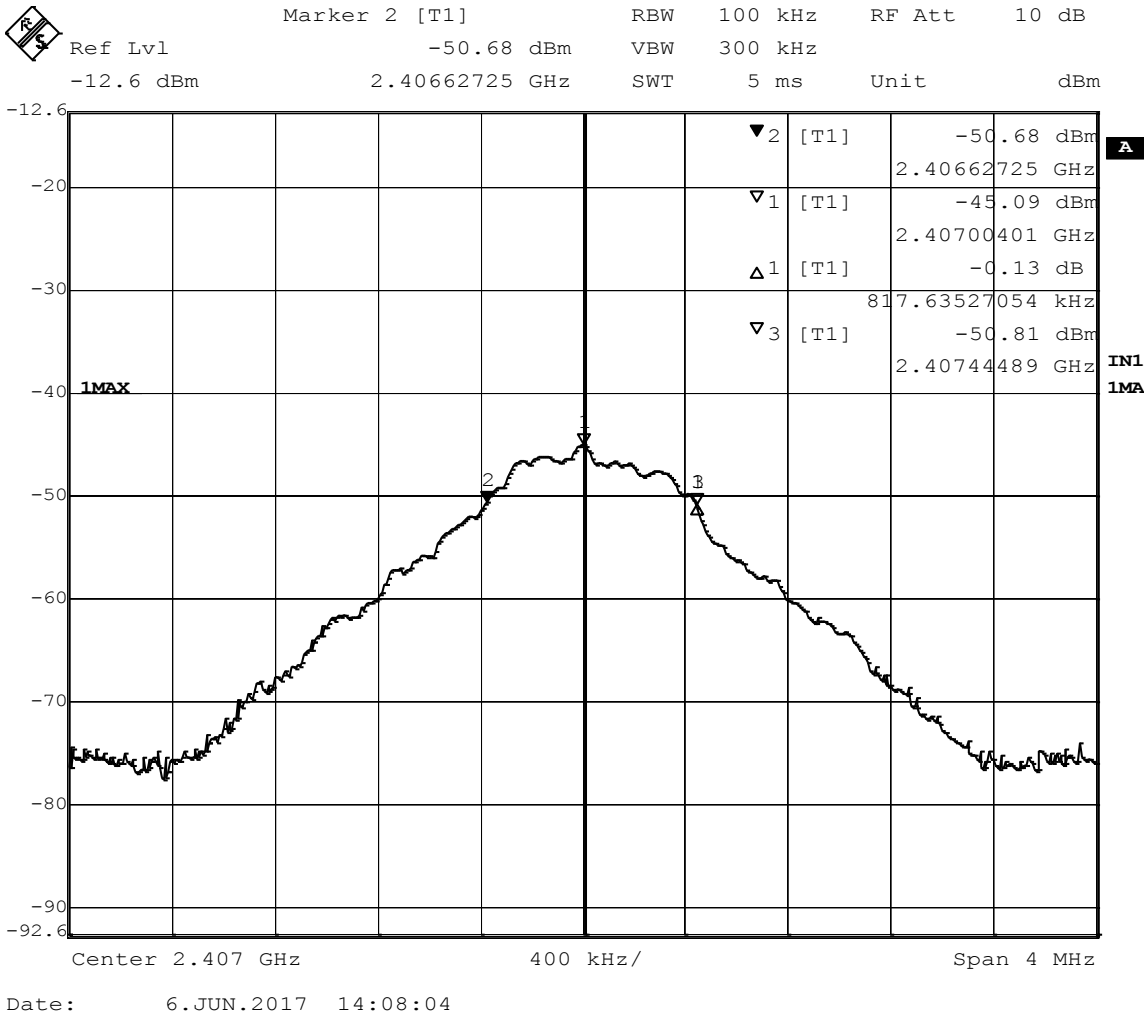

Figure 10 - 6dB Bandwidth, Low Channel, 0.818 MHz

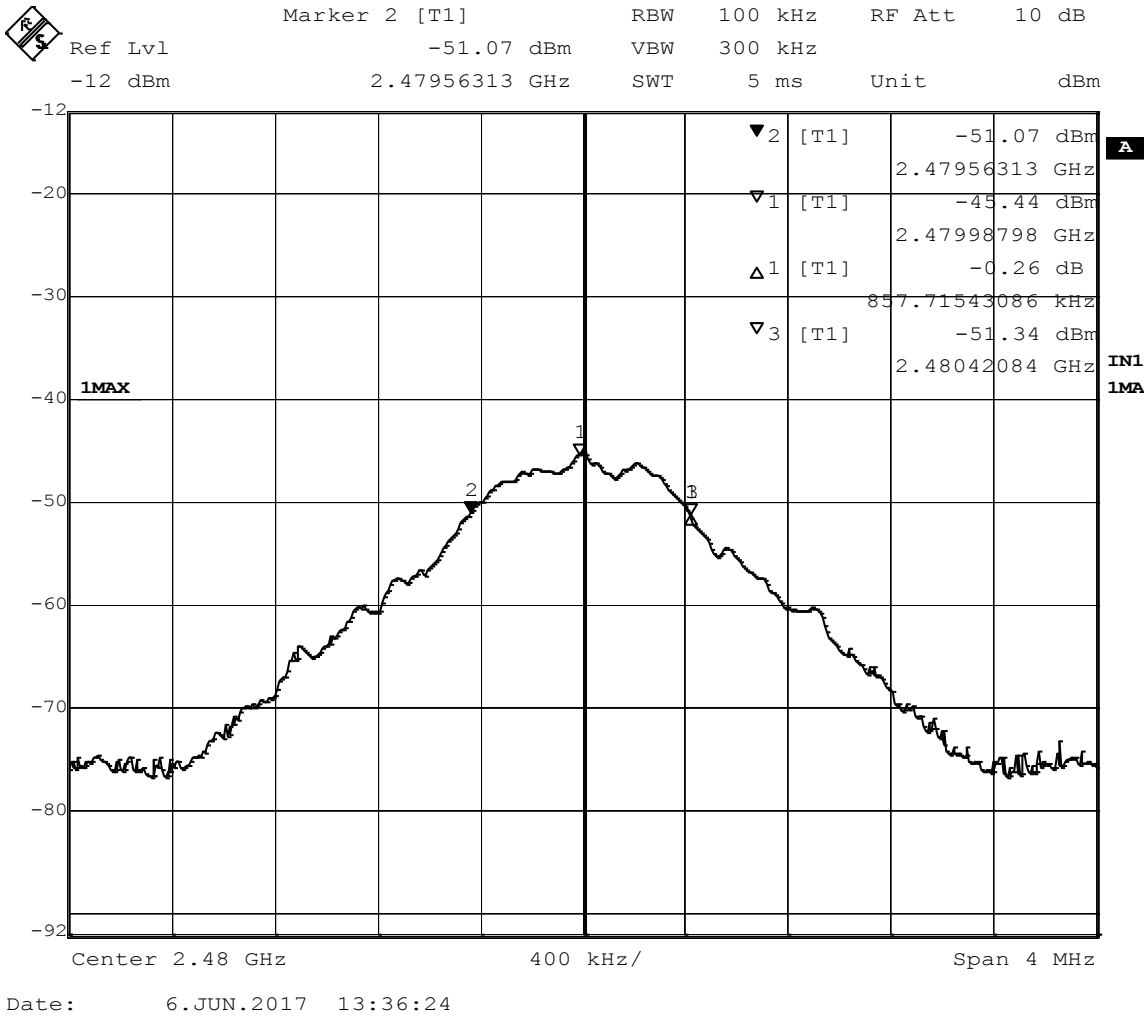

Figure 11 - 6dB Bandwidth, Middle Channel, 0.888 MHz

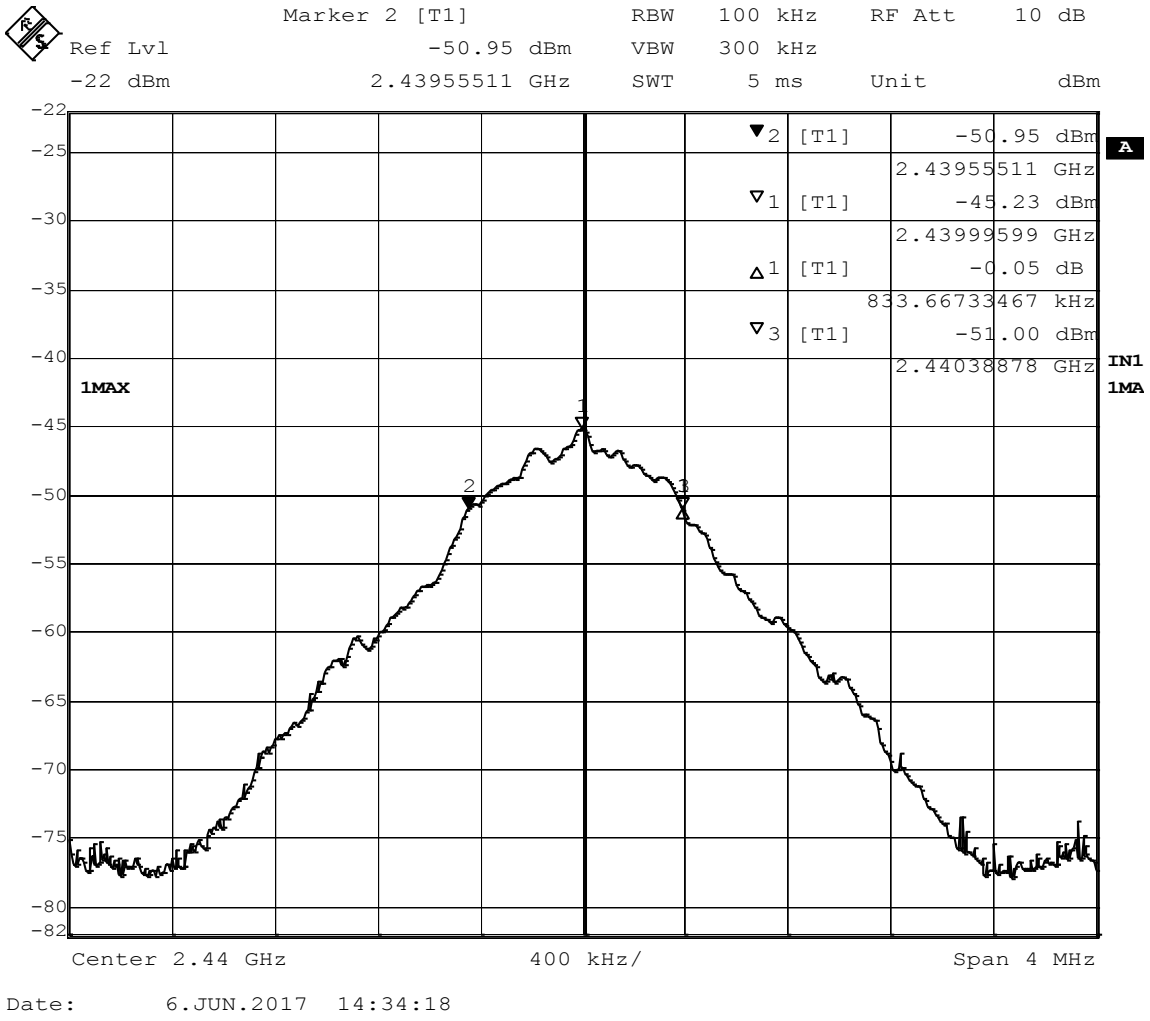

Figure 12 - 6dB Bandwidth, Middle Channel, 0.834 MHz

4.4 Bandedges

Test Method: ANSI C63.10, Section(s) 6.10.5.2

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 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.

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 5 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	Wireless Window Blind Controller Hub – Radio 2	MODE	Transmit
INPUT POWER	5 VDC	FREQUENCY RANGE	2407 MHz – 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	2390.0	-99.03	-47.57	51.46	42.26	PASS
Low	2400.0	-76.70	-47.45	29.25	20.0	PASS
High	2483.5	-104.79	-48.92	55.87	43.65	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 = 96.26 μV/m
Fundamental average field strength at 2480MHz for high channel =97.65 μV/m

Channel 1 minimum delta = 96.26- 54.00=42.26
Channel 3 minimum delta = 97.65- 54.00=43.65

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

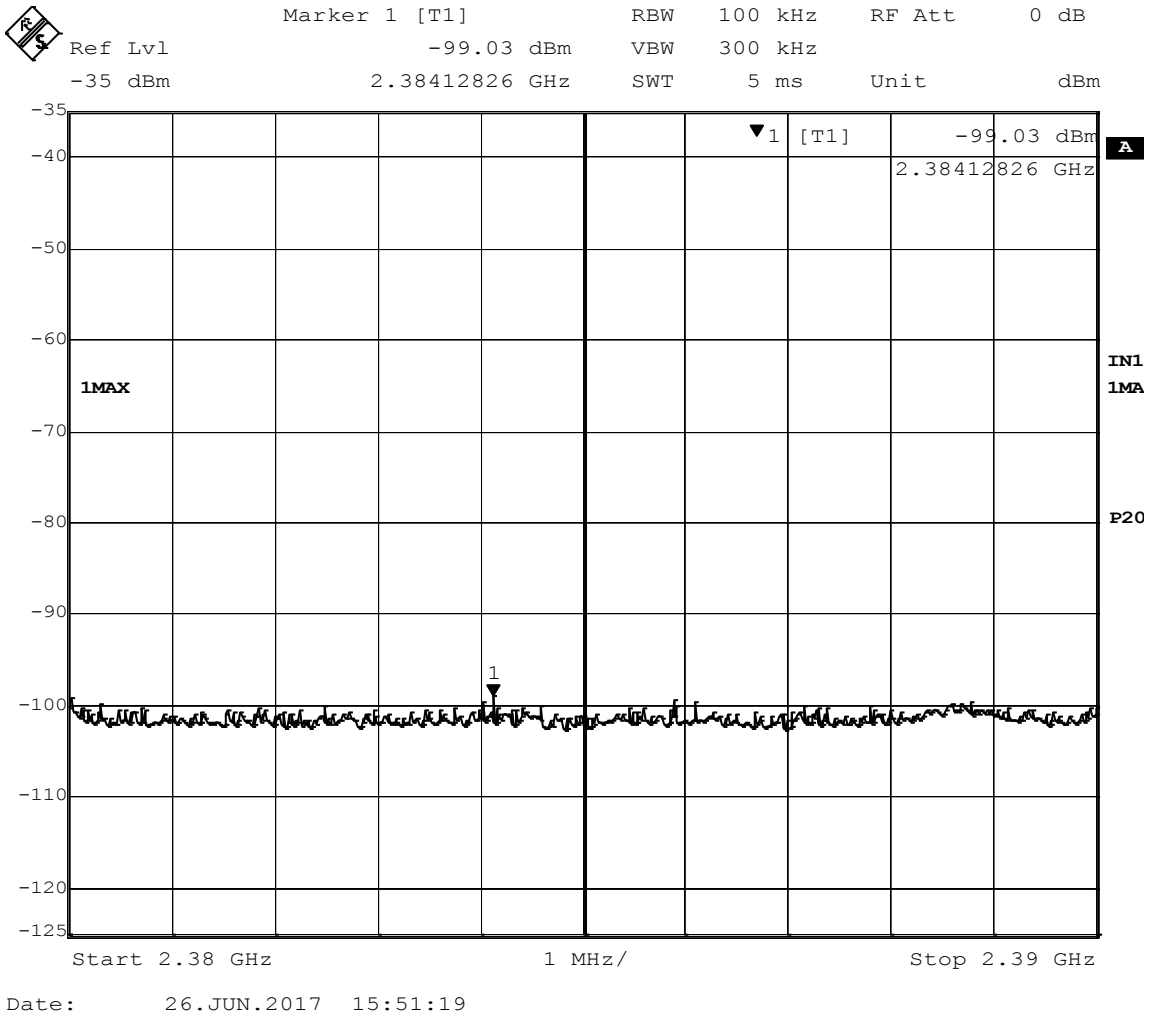

Figure 13 - Band-edge Measurement, Low Channel, Restricted Frequency

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

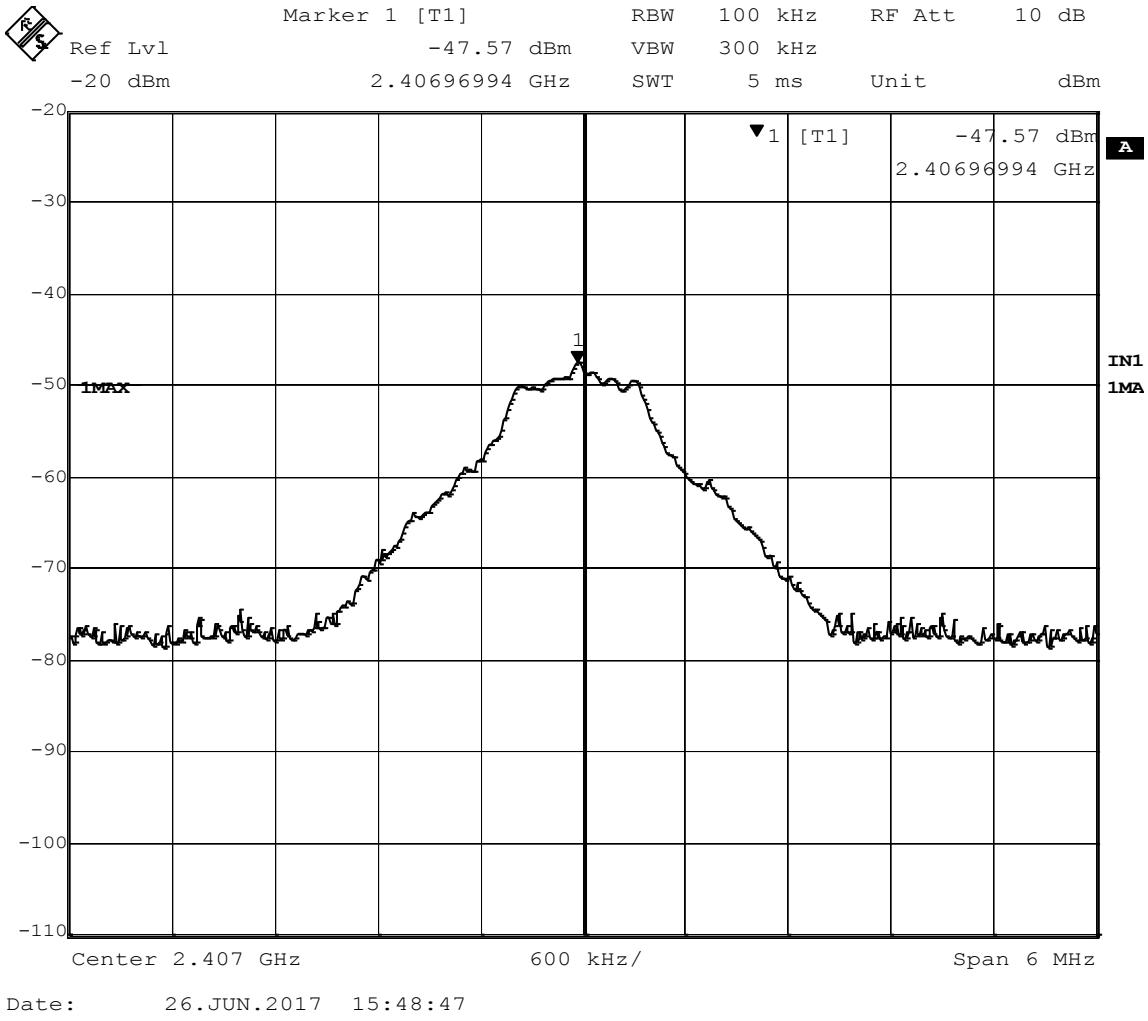

Figure 14 - Band-edge Measurement, Low Channel, Fundamental

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

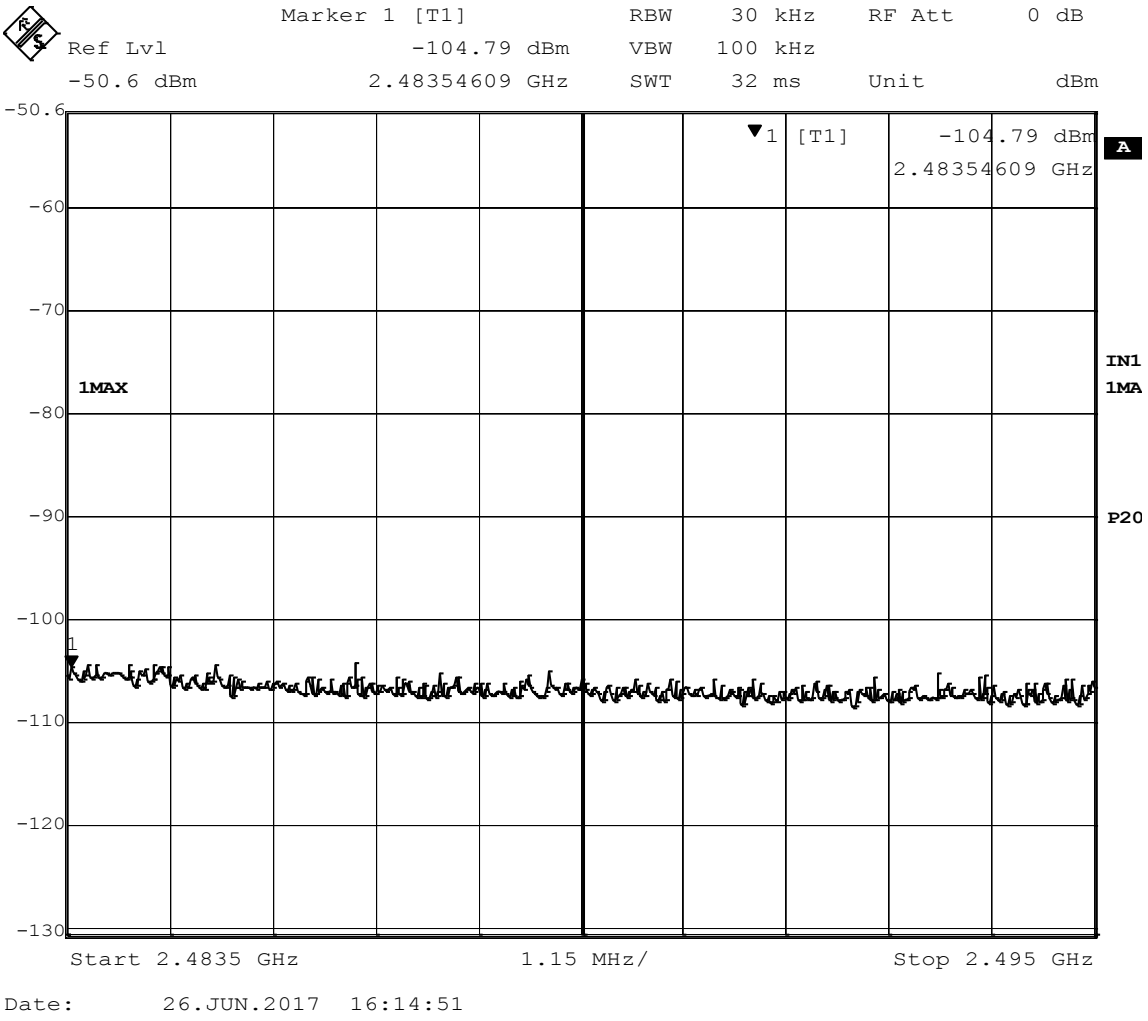

Figure 15 - Band-edge Measurement, High Channel, Restricted Frequency

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

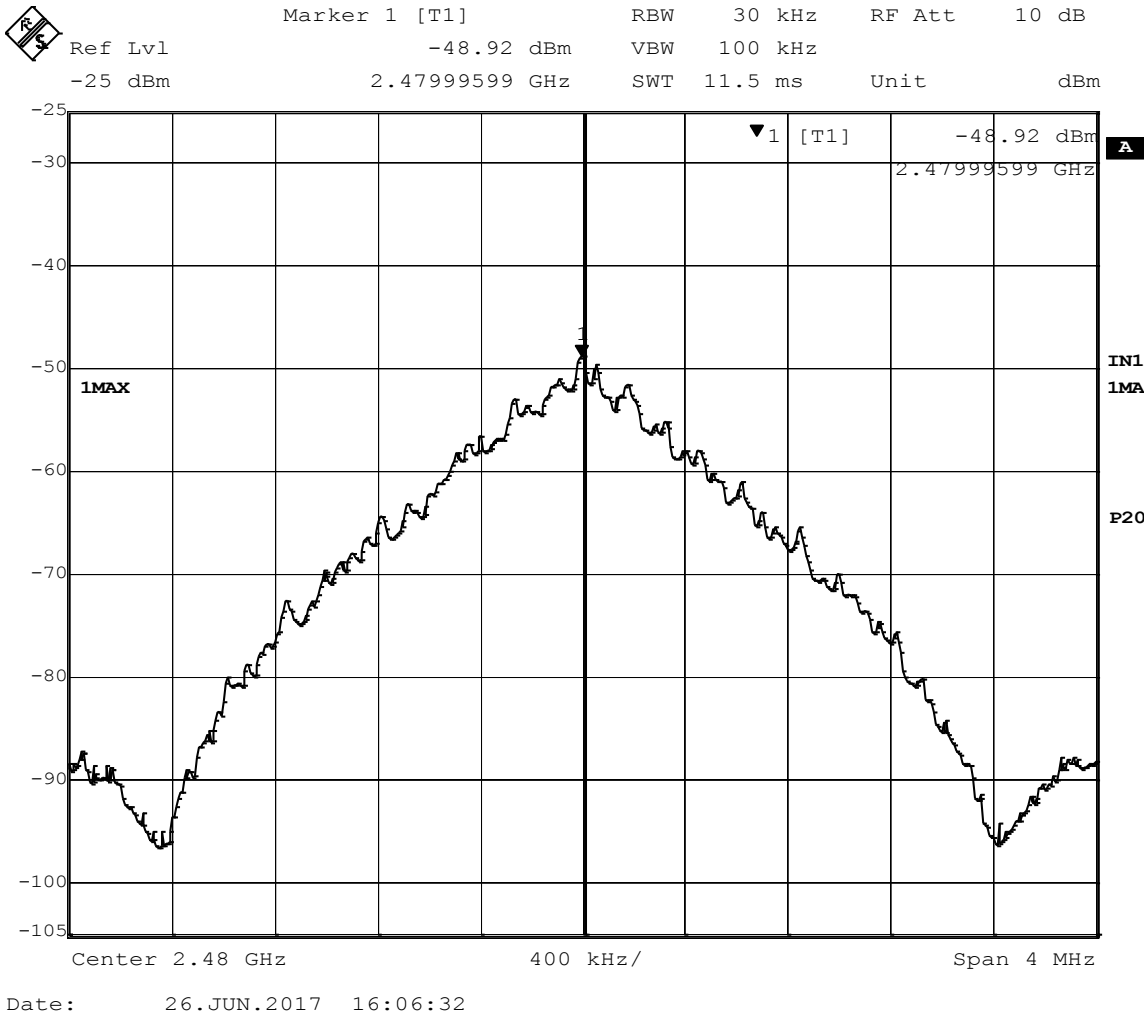

Figure 16 - Band-edge Measurement, High Channel, Fundamental

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

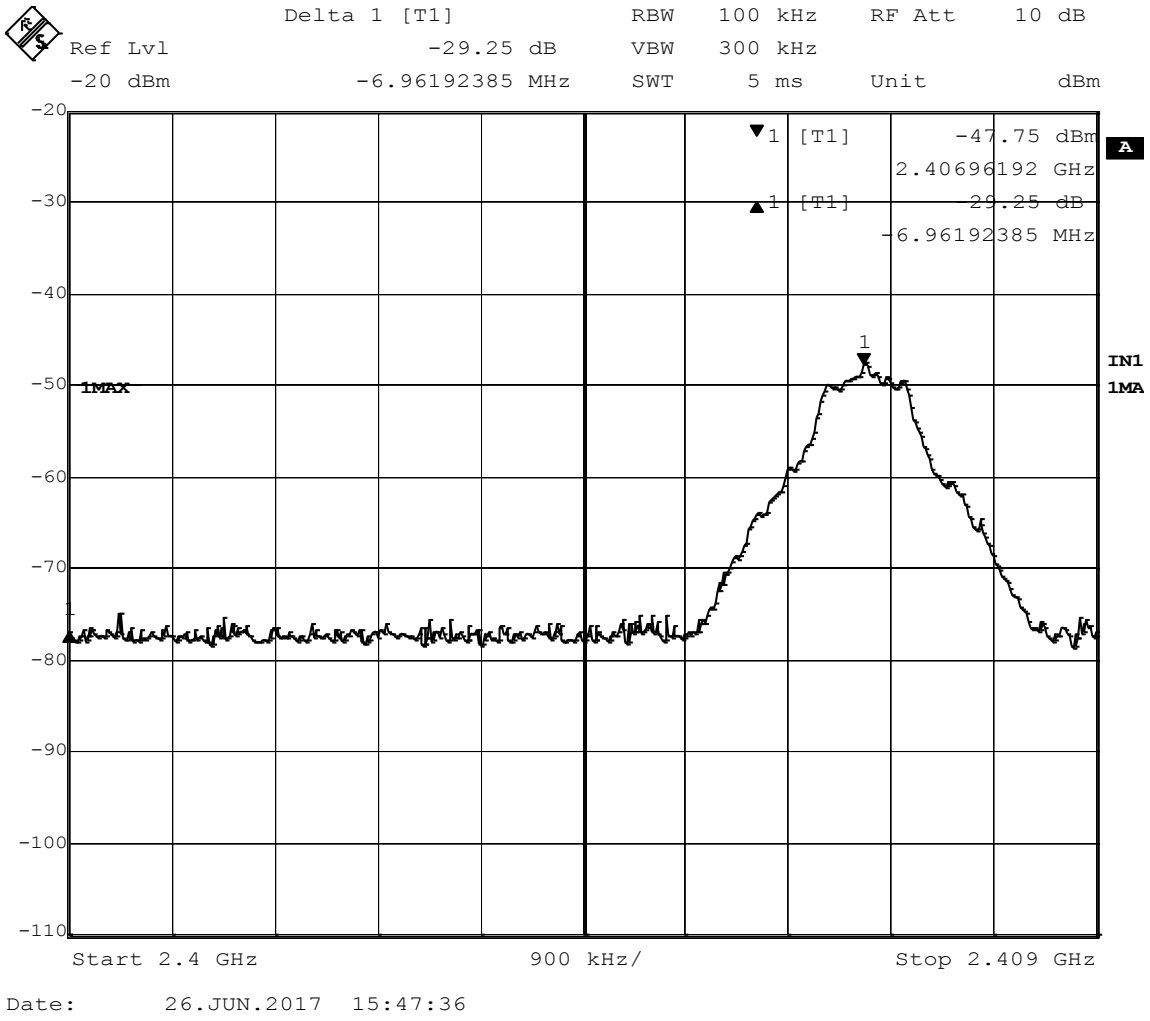

Figure 17 - Band-edge Measurement, Low Channel, out-of-band

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

Delta = 29.25 dB; Minimum = 20 dB

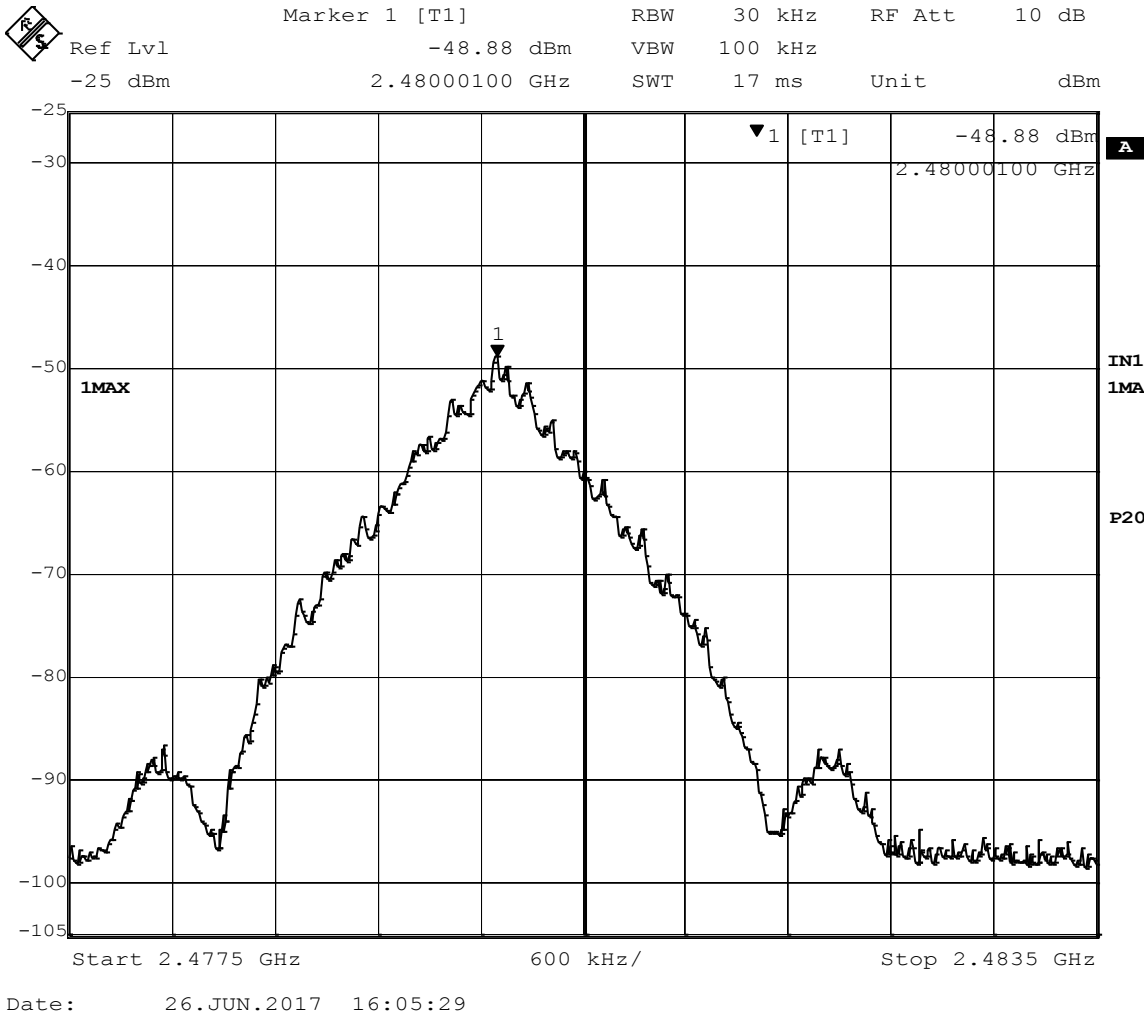

Figure 18 - Band-edge Measurement, High Channel, out-of-band

Delta = 41.12 dB; Minimum = 20 dB

Delta = 48.88 – 90.00

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	Wireless Window Blind Controller Hub – Radio 3	MODE	Transmit
INPUT POWER	5 VDC	FREQUENCY RANGE	2407-2480 MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

CHANNEL	CHANNEL FREQUENCY (MHz)	RF POWER LEVEL (dBm)	MAXIMUM POWER LIMIT (dBm)	RESULT
Low	2407	-10.94	8.0	PASS
Mid	2440	-11.77	8.0	PASS
High	2480	-10.90	8.0	PASS

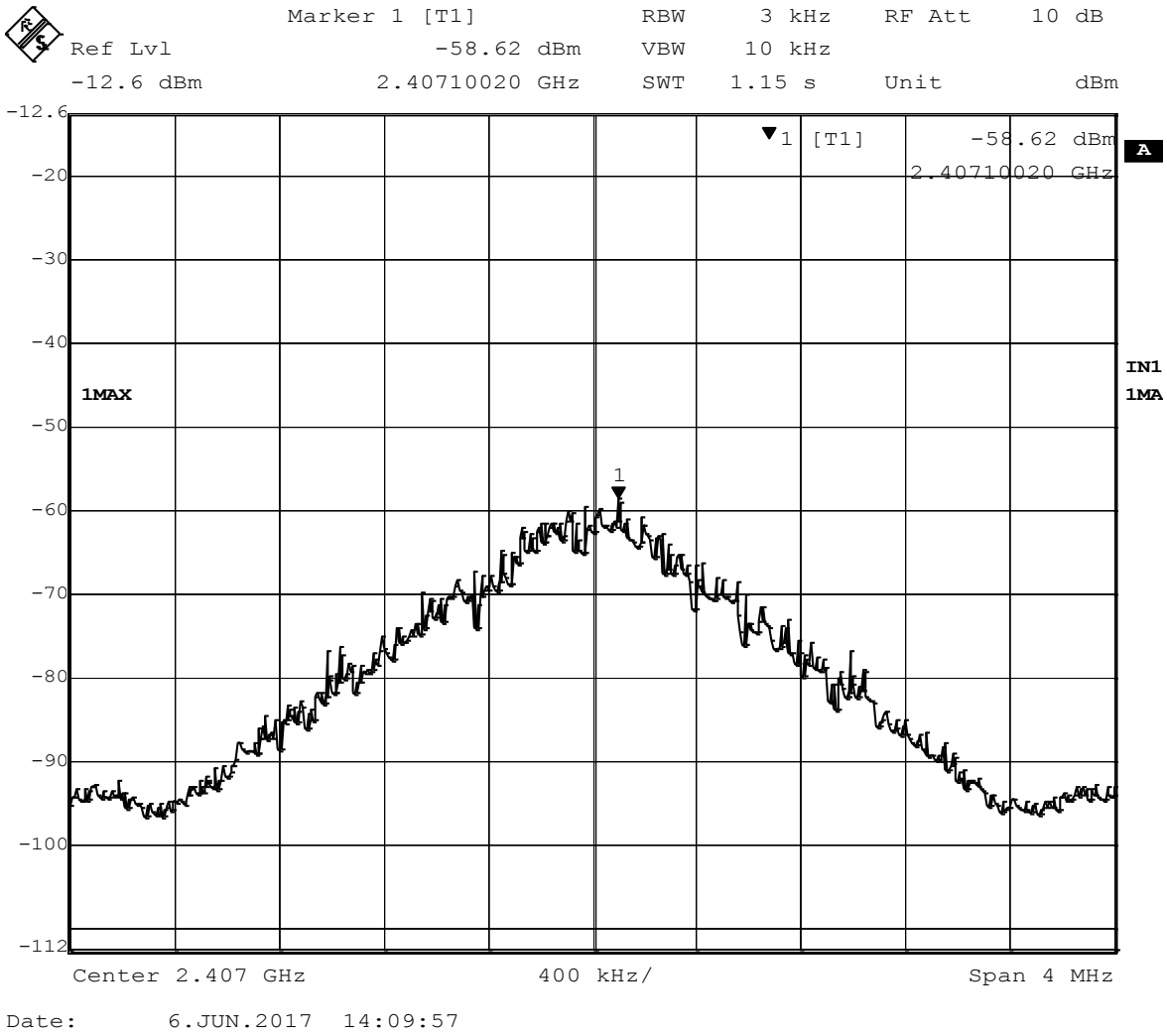

Figure 19 - Power Spectral Density Measurement, Low Channel

Power Spectral Density = -58.62 dBm + 107 + CL + AF - 95.23 = -10.94 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.

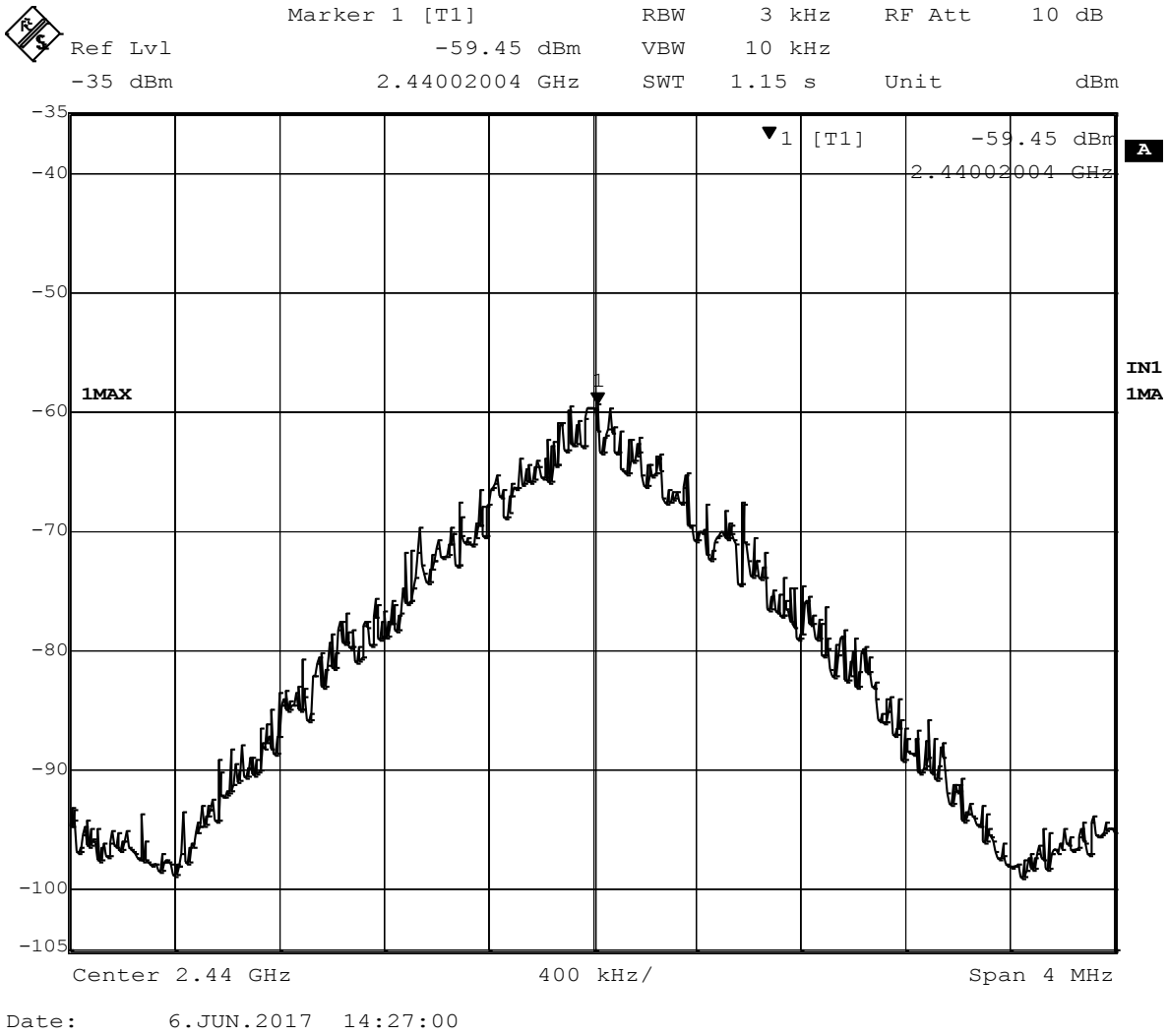

Figure 20 - Power Spectral Density Measurement, Mid Channel

Power Spectral Density = -59.45 dBm + 107 + CL + AF - 95.23 = -11.77 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.

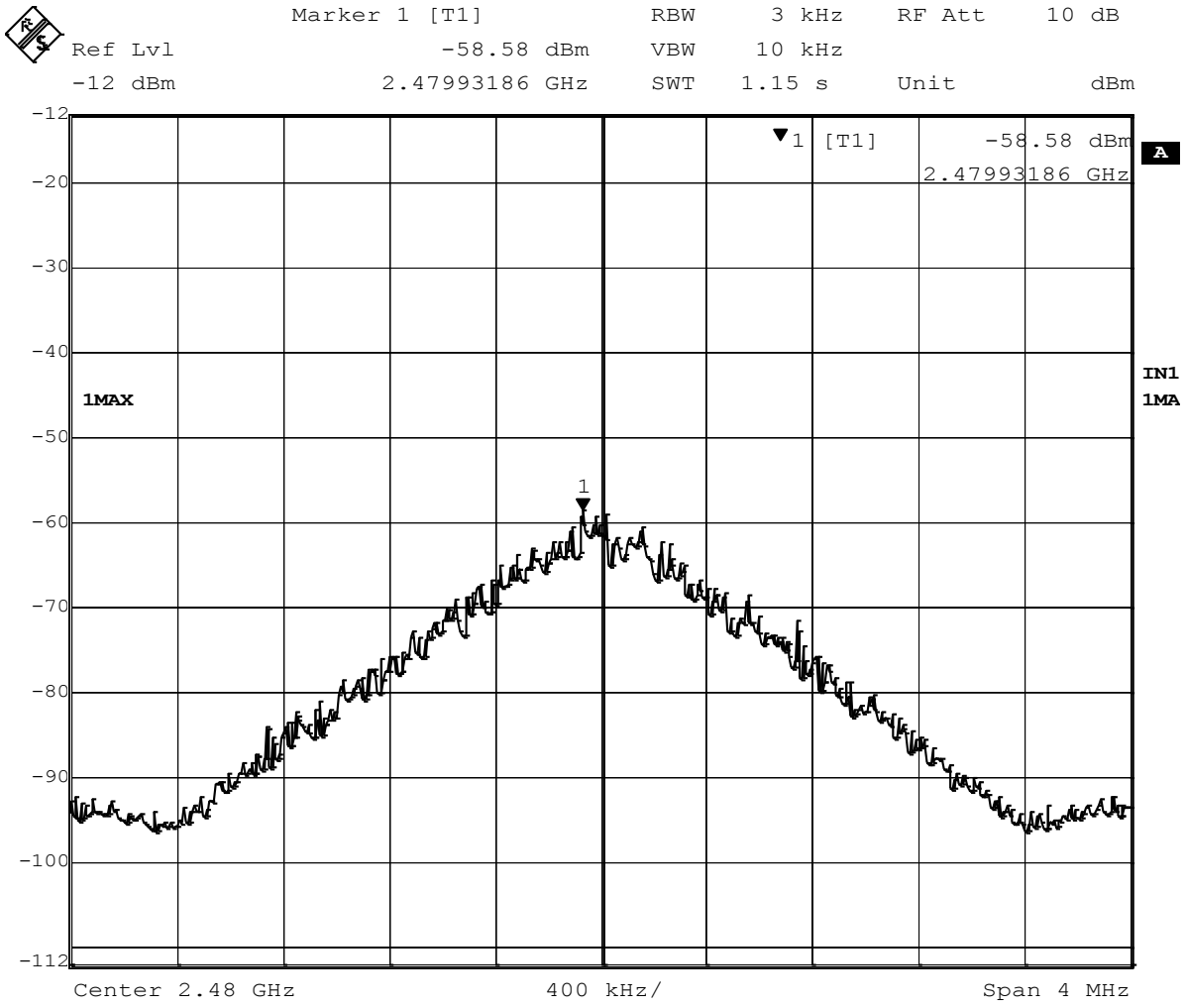

Figure 21 - Power Spectral Density Measurement, High Channel

Power Spectral Density = -58.58 dBm + 107 + CL + AF - 95.23 = -10.90 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.

4.6 *Conducted AC Mains Emissions*

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

4.5.1 Limits for conducted emissions measurements

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

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

4.6.2 Test Procedures

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

4.6.3 Deviation from the test standard

No deviation

4.6.4 Test setup

The EUT was tested as a module.

4.6.5 EUT operating conditions

The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle of its operating range for this test.

4.6.6 Test Results

EUT MODULE	Wireless Window Blind Controller Hub – Radio 2	MODE	Transmit (Mid channel used)
INPUT POWER	5 VDC	FREQUENCY RANGE	150kHz – 30MHz
ENVIRONMENTAL CONDITIONS	32 % ± 5% RH 23 ± 3ºC	TECHNICIAN	KVepuri

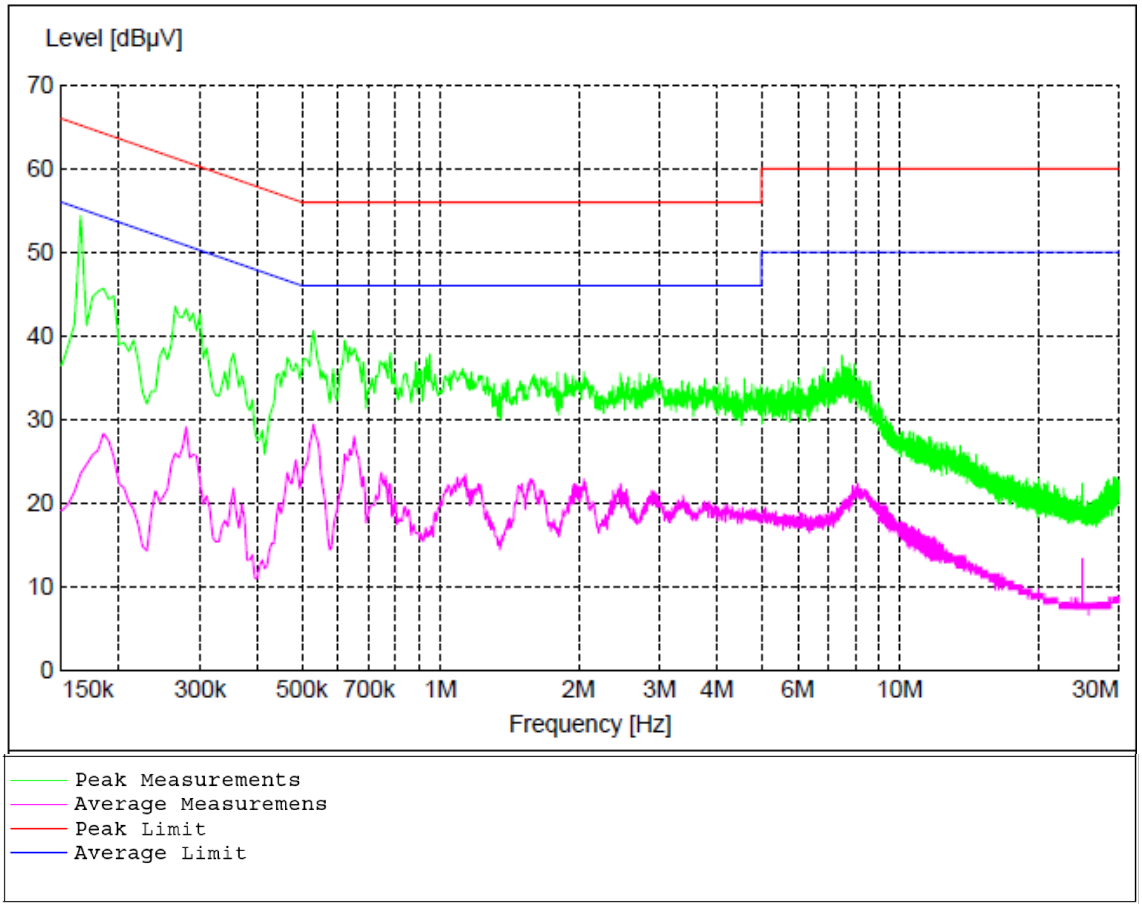

Figure 22 - Conducted Emissions Plot

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

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.