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Amended

Test Report

Prepared for: **Hunter Douglas**

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

Product: **Wireless window blind controller**
Hub 2.0 High Power
Radio 2

Test Report No: **R20171024-24-01B**

Approved By:

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DATE: **19 April 2018**

Total Pages: **40**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	29 January 2018	Original – NJohnson
A	19 March 2018	Band edge measurements from 2390 – 2400 MHz were repeated with a 100 kHz RBW. -NJ
B	19 April 2018	It was discovered the device tested included an additional radio module that was populated. The radio was not intended to be populated in production models. A second device was supplied for testing with that particular de-populated as intended for production models. This device was briefly tested to verify that the presence of this radio did not affect testing. Power output, band edge measurements and the highest 6 emissions points were re-tested and found to be within 1 dB of the original results. -NJ

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1.0 Summary of test results

1.1 Test Results

The EUT has been tested according to the following specifications:

SUMMARY			
Standard Section	**Test Type and Limit**	**Result**	**Remark**
FCC 15.203	Unique Antenna Requirement	Pass	Internal Antenna
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1.2	Receiver Radiated Emissions	Pass	Meets the requirement of the limit.
FCC Part 15.247(a)(2) RSS-247 Issue 2, Section 5.2(a)	Minimum Bandwidth, Limit: Min. 500kHz	Pass	Meets the requirement of the limit.
FCC Part 15.247(b) RSS-247 Issue 2 section 5. 4	Maximum Peak Output Power, Limit: Max. 30dBm Conducted spurious measurements	Pass	Meets the requirement of the limit.
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	Meets the requirement of the limit.
FCC Part 15.247(a)(2) RSS-247 Issue 2 Section 5.2(b)	Power Spectral Density, Limit: Max. 8dBm	Pass	Meets the requirement of the limit.
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 5.5	Band Edge Measurement, Limit: 20dB less than the peak value of fundamental frequency	Pass	Meets the requirement of the limit.
FCC Part 15.207 RSS-Gen Issue 4, Section 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: 8 January 2018 (EUT 1)
6 April 2018 (EUT 2)
EUT Tested Dates: 8 January 2018 – 19 January 2018 (EUT 1)
9 April 2018 (EUT 2, verification)

Description	Wireless window blind controller hub
MODEL	Radio 2 (uses Nordic NRF52832 chip)
Serial No.	EUT 1: 1706020061 (Thread radio populated, not active. Full testing was performed on this sample) EUT 2: 17092724A7 (Thread radio was de-populated on this sample as intended for production).*
POWER SUPPLY	5 VDC (MN:HDP-QB05010U)
ANTENNA TYPE	Antenna is not user replaceable

*Note: It was discovered the device tested included an additional radio module that was populated. The radio was not intended to be populated in production models.

A second device was supplied for testing with that particular de-populated as intended for production models. This device was briefly tested to verify that the presence of this radio did not affect testing. Power output, band edge measurements and the highest 6 emissions points were re-tested and found to be within 1 dB of the original results.

Pictures of these two test samples can be seen in the test setup photos.

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 2017	02 Aug 2018**
EMCO Biconilog Antenna	3141	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
**Calibrated before

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 C63.10:2013, Section(s) 6.5, 6.6, 11.11, 11.12

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 2 different transmitters, referred to as, Radio 2 and Radio 3 (Radio 1 is inactive). 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

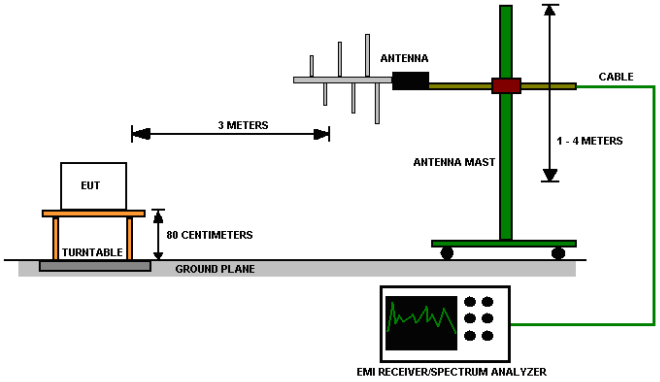

Figure 1 - Radiated Emissions Test Setup

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

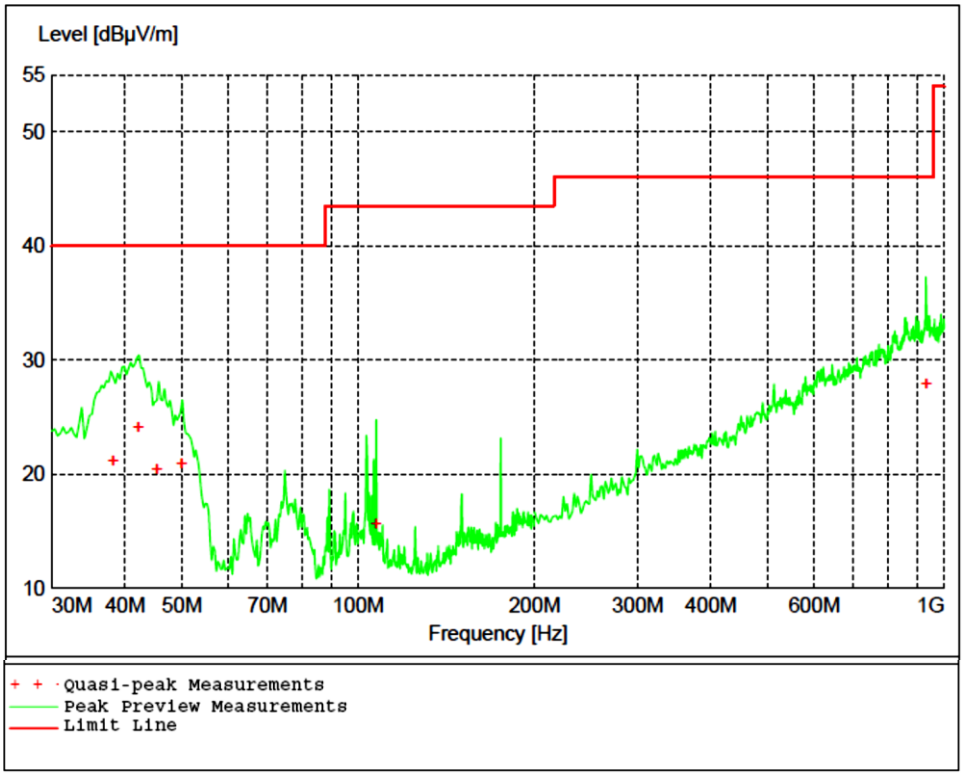

Figure 2 - Radiated Emissions Plot, Receive

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	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
38.160000	21.15	40.00	18.80	100	192	VERT	X
42.120000	24.03	40.00	16.00	100	260	VERT	X
45.300000	20.38	40.00	19.60	100	138	VERT	X
49.980000	20.87	40.00	19.10	100	70	VERT	X
107.340000	15.60	43.50	27.90	99	103	VERT	X
931.860000	27.84	46.00	18.20	136	236	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.		
2421.800000	34.48	54.00	19.50	393	5	HORI	X
5966.200000	45.66	54.00	8.30	99	260	VERT	X

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

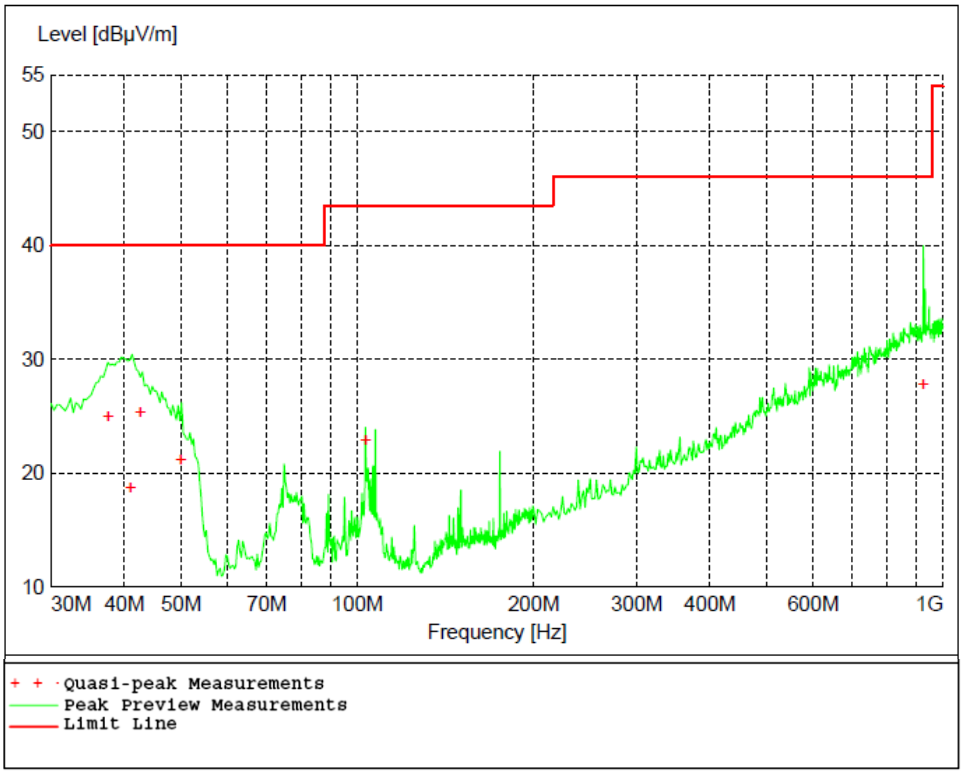

Figure 3 - Radiated Emissions Plot, Low Channel

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	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
37.560000	24.95	40.00	15.00	101	148	VERT	X
40.980000	18.62	40.00	21.40	399	114	VERT	X
42.600000	25.29	40.00	14.70	99	114	VERT	X
49.980000	21.10	40.00	18.90	100	286	VERT	X
103.320000	22.84	43.50	20.70	100	192	VERT	X
924.840000	27.74	46.00	18.30	237	258	HORI	X

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2407.000000	101.44	NA	NA	178	45	HORI	X
4817.800000	42.10	54.00	11.90	180	175	VERT	X
7221.000000	51.09	54.00	2.90	100	81	VERT	X
9611.200000	45.53	54.00	8.50	366	214	VERT	X
12019.200000	38.99	54.00	15.00	170	102	VERT	X

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

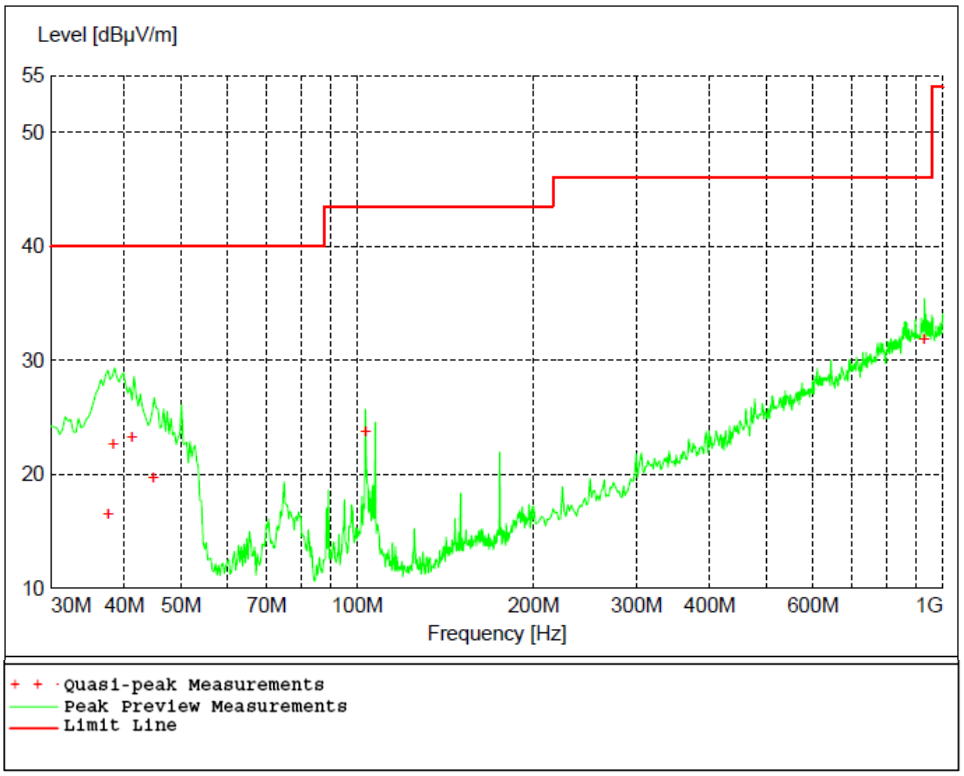

Figure 4 - Radiated Emissions Plot, Mid Channel

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	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
37.560000	16.42	40.00	23.60	364	144	VERT	X
38.340000	22.57	40.00	17.40	100	128	VERT	X
41.220000	23.22	40.00	16.80	99	192	VERT	X
44.880000	19.59	40.00	20.40	100	148	VERT	X
103.320000	23.72	43.50	19.80	113	178	VERT	X
929.820000	31.83	46.00	14.20	99	0	VERT	X

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

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2440.000000	100.53	NA	NA	140	131	HORI	X
4877.200000	41.58	54.00	12.40	113	109	VERT	X
7321.000000	50.40	54.00	3.60	221	324	HORI	X
9774.200000	46.61	54.00	7.40	100	160	HORI	X
12207.800000	40.59	54.00	13.40	396	29	HORI	X
14672.200000	49.80	54.00	4.20	328	311	VERT	X

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

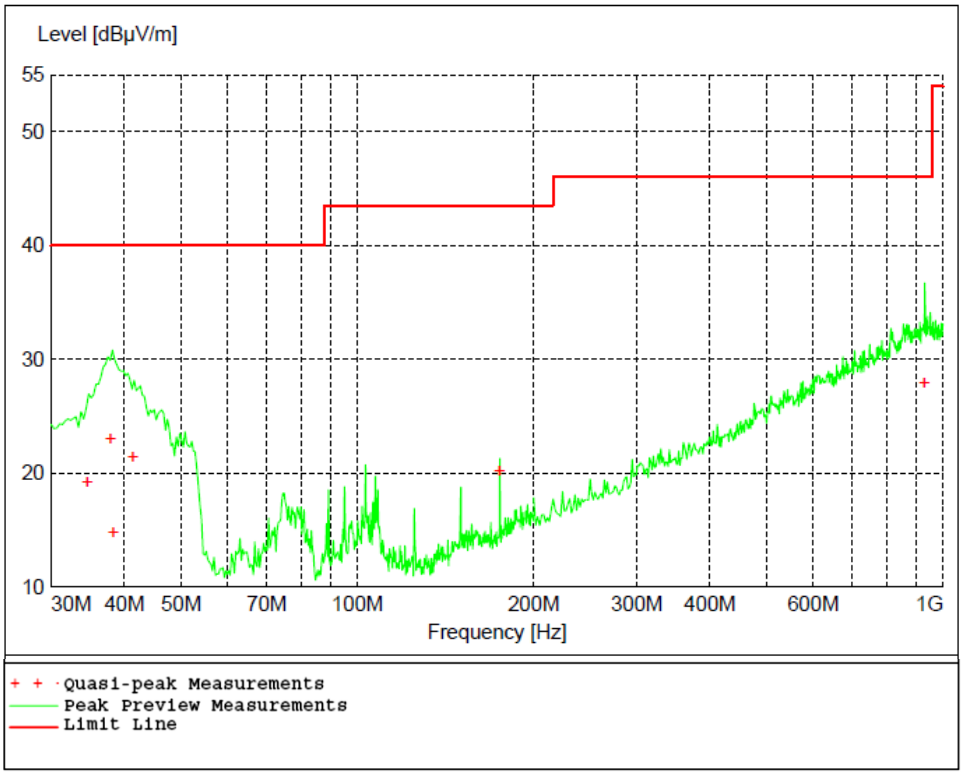

Figure 5 - Radiated Emissions Plot, High Channel

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	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
34.560000	19.21	40.00	20.80	102	123	VERT	X
37.860000	22.95	40.00	17.00	98	183	VERT	X
38.340000	14.80	40.00	25.20	98	153	VERT	X
41.340000	21.39	40.00	18.60	101	181	VERT	X
174.960000	20.15	43.50	23.40	233	90	VERT	X
929.640000	27.89	46.00	18.10	399	83	VERT	X

Table 8 - Radiated Emissions Average Measurements, High Channel

Frequency	Level	Limit	Margin	Height	Angle	Pol	Axis
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2480.000000	101.17	NA	NA	187	114	HORI	X
4962.800000	41.22	54.00	12.80	124	356	VERT	X
7440.000000	44.44	54.00	9.60	100	162	VERT	X
9919.400000	45.16	54.00	8.80	167	307	VERT	X
12421.000000	43.62	54.00	10.40	126	309	VERT	X
14848.400000	49.02	54.00	5.00	278	283	VERT	X

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.

INTERMODULATION: The EUT contained two different radio modules (Nordic NRF52832 & MURATA WIFI Module) which operate in 2.4 GHz band and the intermodulation products were investigated and found to be below the noise floor.

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

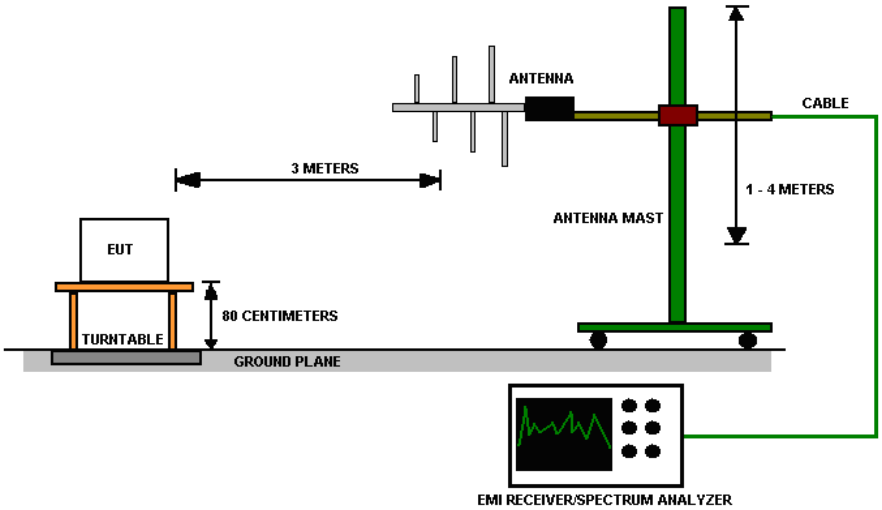

Figure 6 - Bandwidth Measurements Test Setup

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	2.07	0.865
Mid	2440	2.01	0.841
High	2480	2.10	0.841

REMARKS:
None

Peak EIRP

CHANNEL	CHANNEL FREQUENCY (MHz)	EIRP PEAK POWER OUTPUT (dBm)	RESULT
Low	2407	6.35	Pass
Mid	2440	6.70	Pass
High	2480	6.15	Pass

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

REMARKS:
None

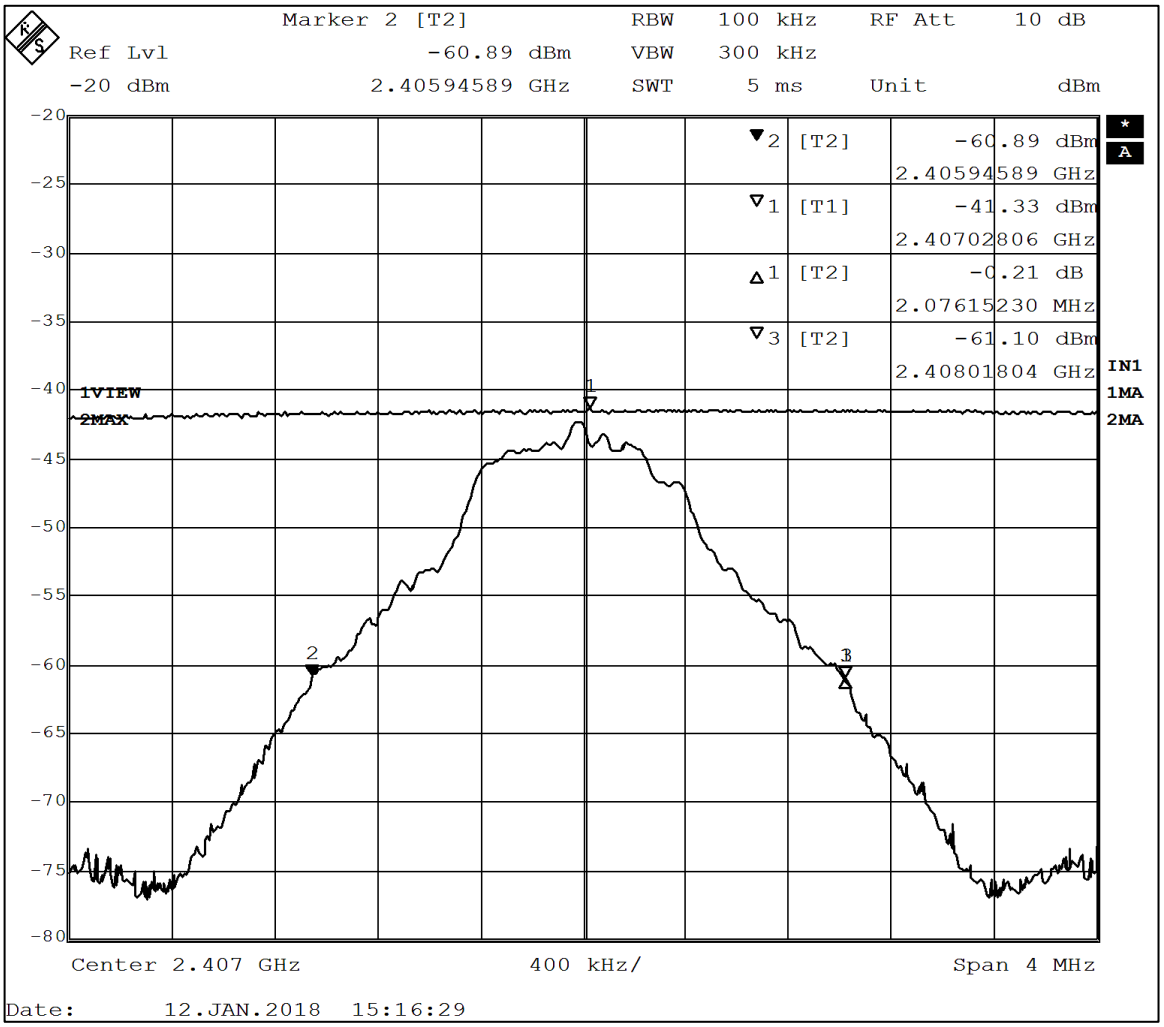

Figure 7 - 99% Occupied Bandwidth, Low Channel.

Maximum power = -41.33 dBm + 107 + CL + AF - 95.23 = 6.35 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

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.

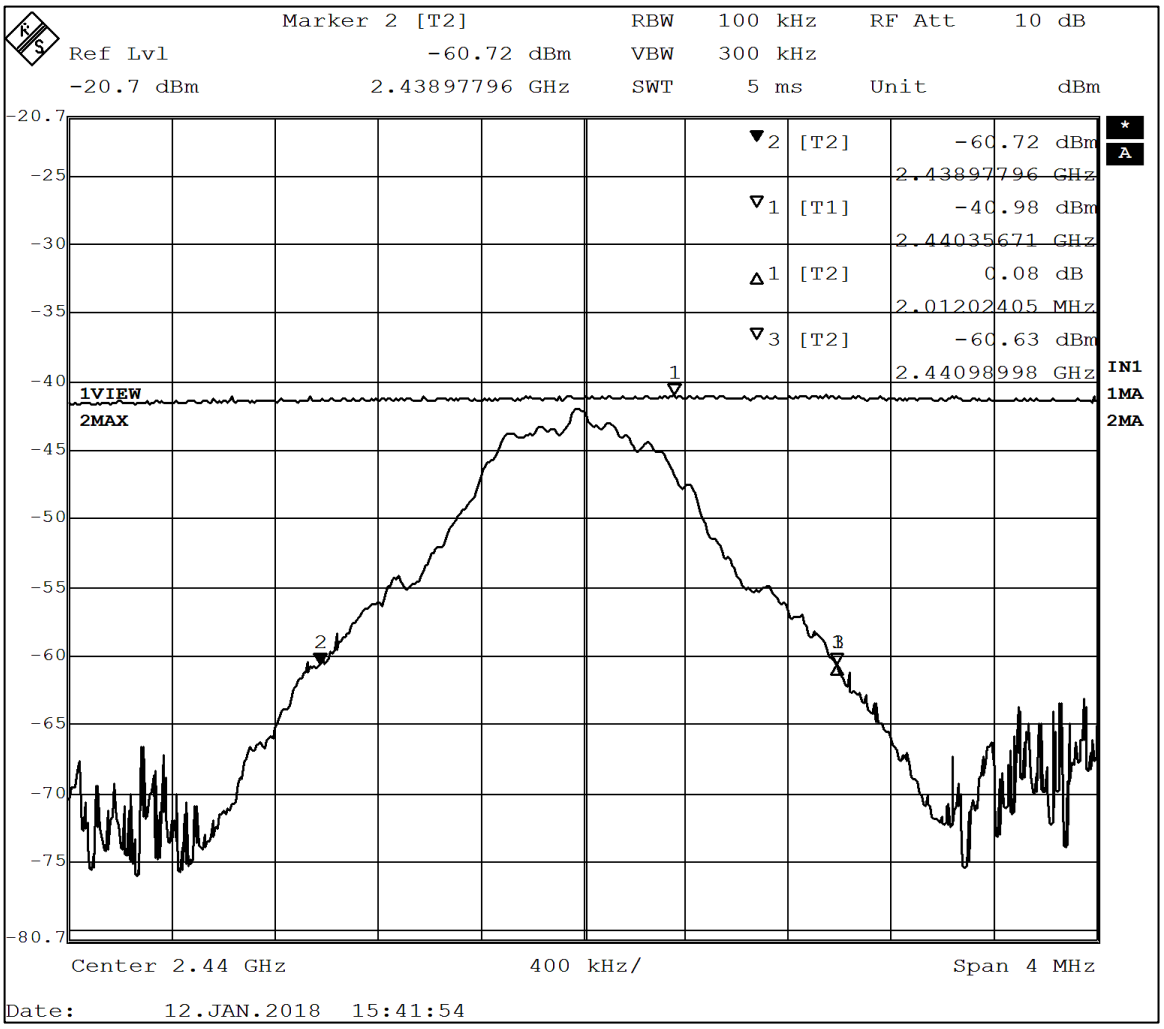

Figure 8 - 99% Occupied Bandwidth, Mid Channel

Maximum power = -40.98 dBm + 107 + CL + AF - 95.23 = 6.70 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.

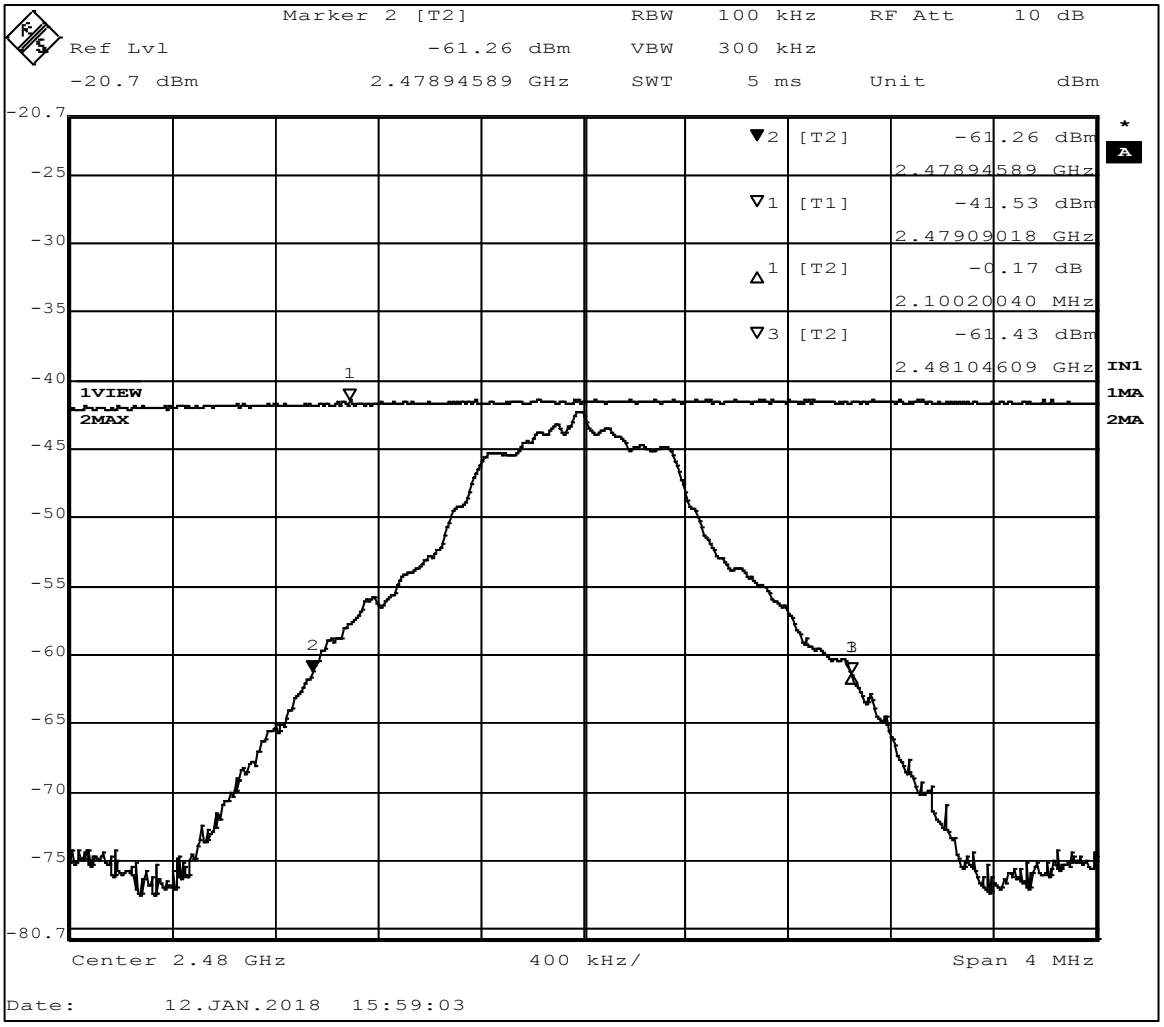

Figure 9 - 99% Occupied Bandwidth, High Channel

Maximum power = -41.53 dBm + 107 + CL + AF - 95.23 = 6.15 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.

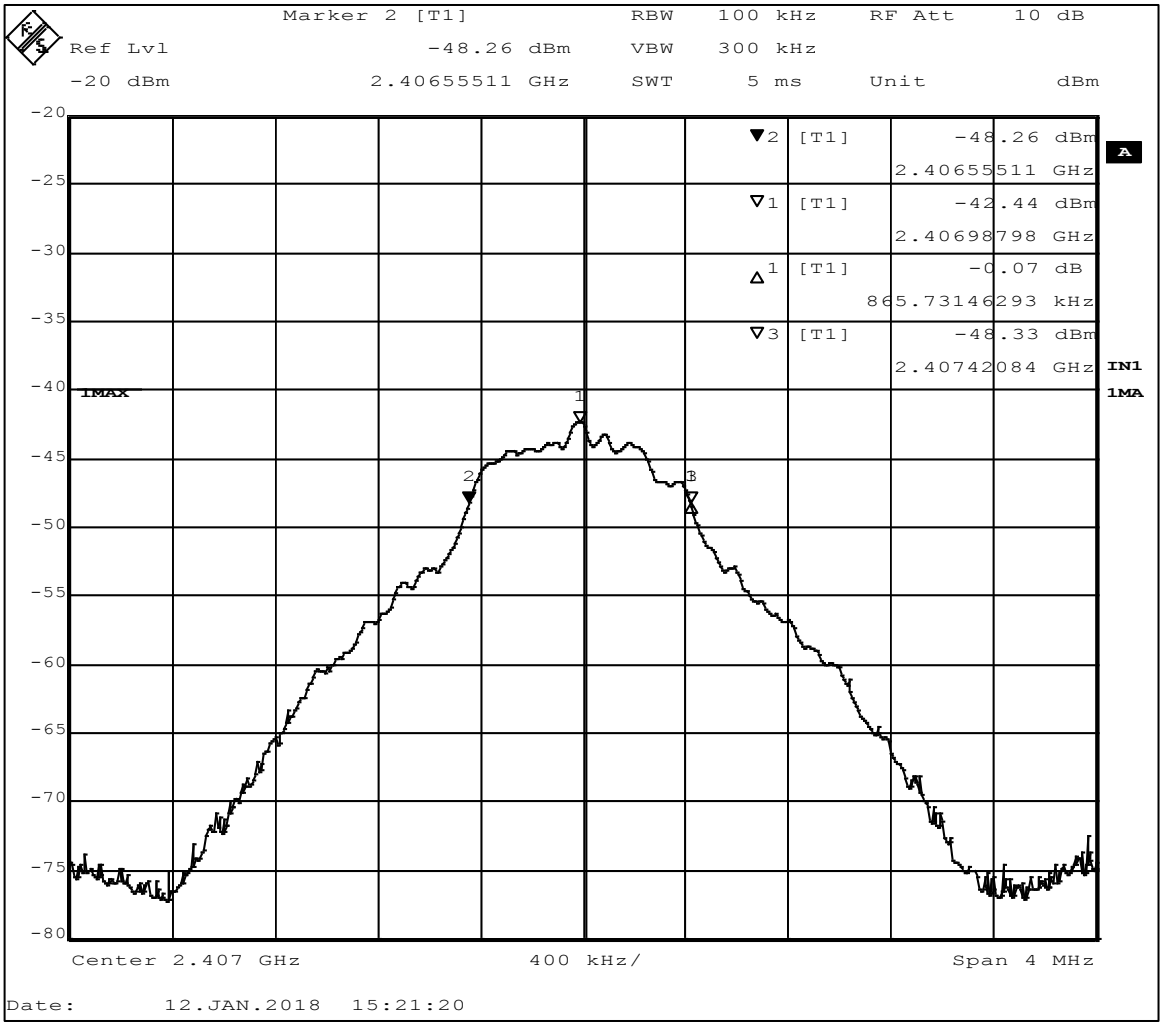

Figure 10 - 6dB Bandwidth, Low Channel

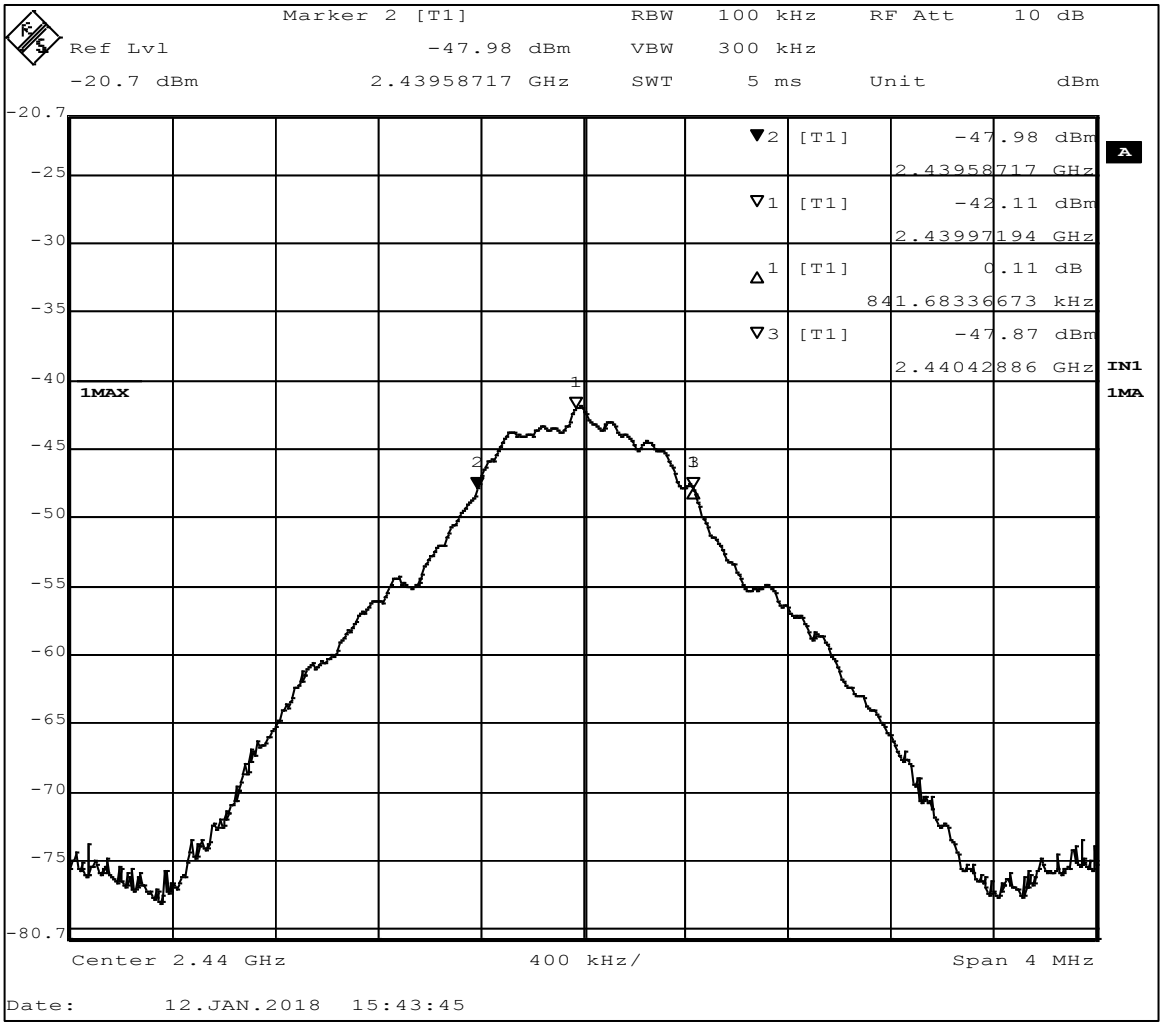

Figure 11 - 6dB Bandwidth, Middle Channel

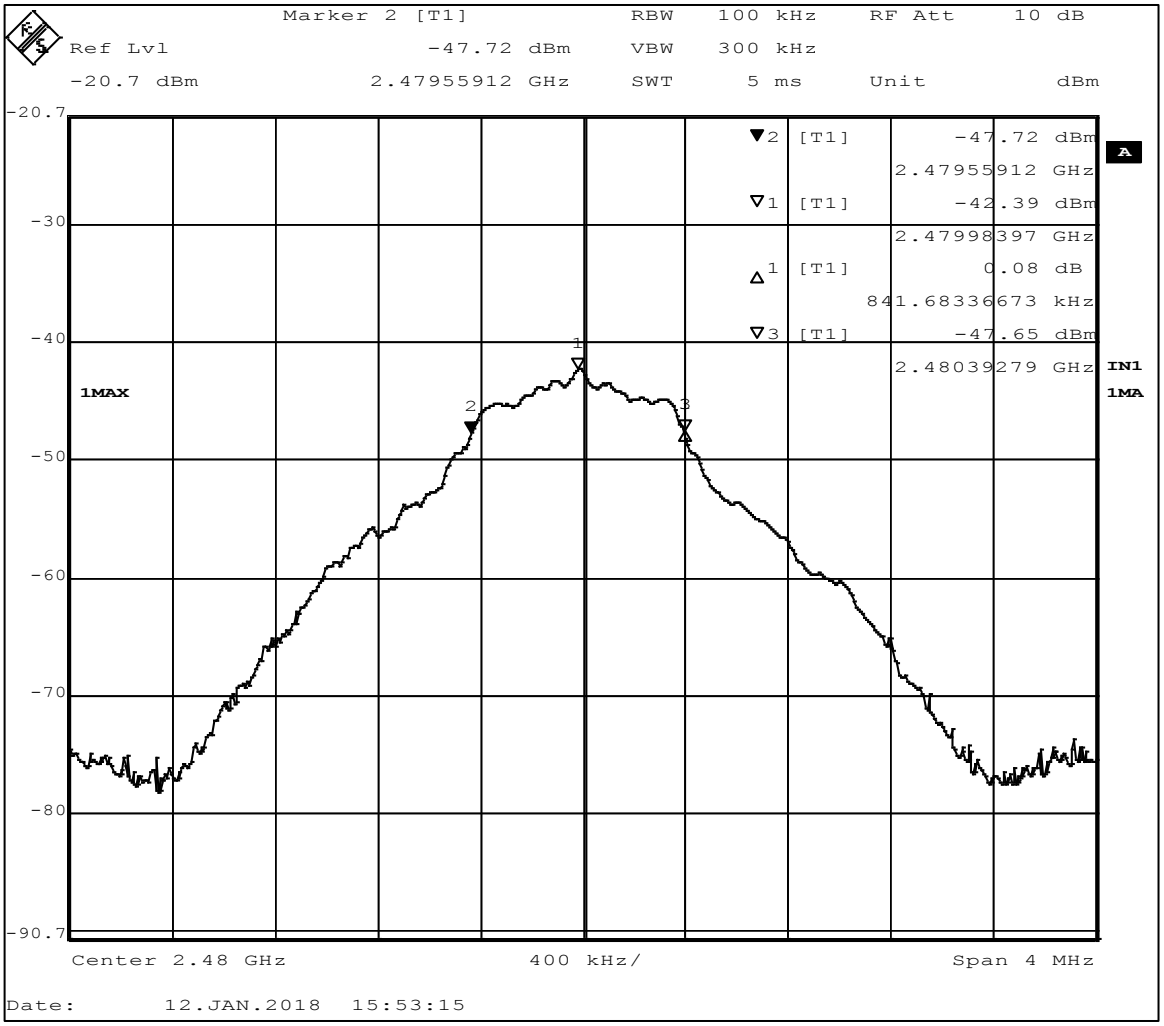

Figure 12 - 6dB Bandwidth, High Channel

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 Band-edge Emissions in Unrestricted Bands

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low	2400.0	-75.38	-43.91	38.65	20.0	PASS

Highest Band-edge Emissions in Restricted Bands

CHANNEL	Band edge /Measurement Frequency (MHz)	Relative Highest out of band level dBm	Relative Fundamental Level (dBm)	Delta	Min (dBc)	Result
Low	2390.0	-103.62	-45.40	58.22	47.44	PASS
High	2483.5	-101.17	-45.21	55.96	47.17	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=101.44dBµV/m
Fundamental average field strength at 2480MHz for high channel=101.17dBµV/m

Channel 1 minimum delta = 101.44- 54.00=47.44
Channel 3 minimum delta = 101.17- 54.00=47.17

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

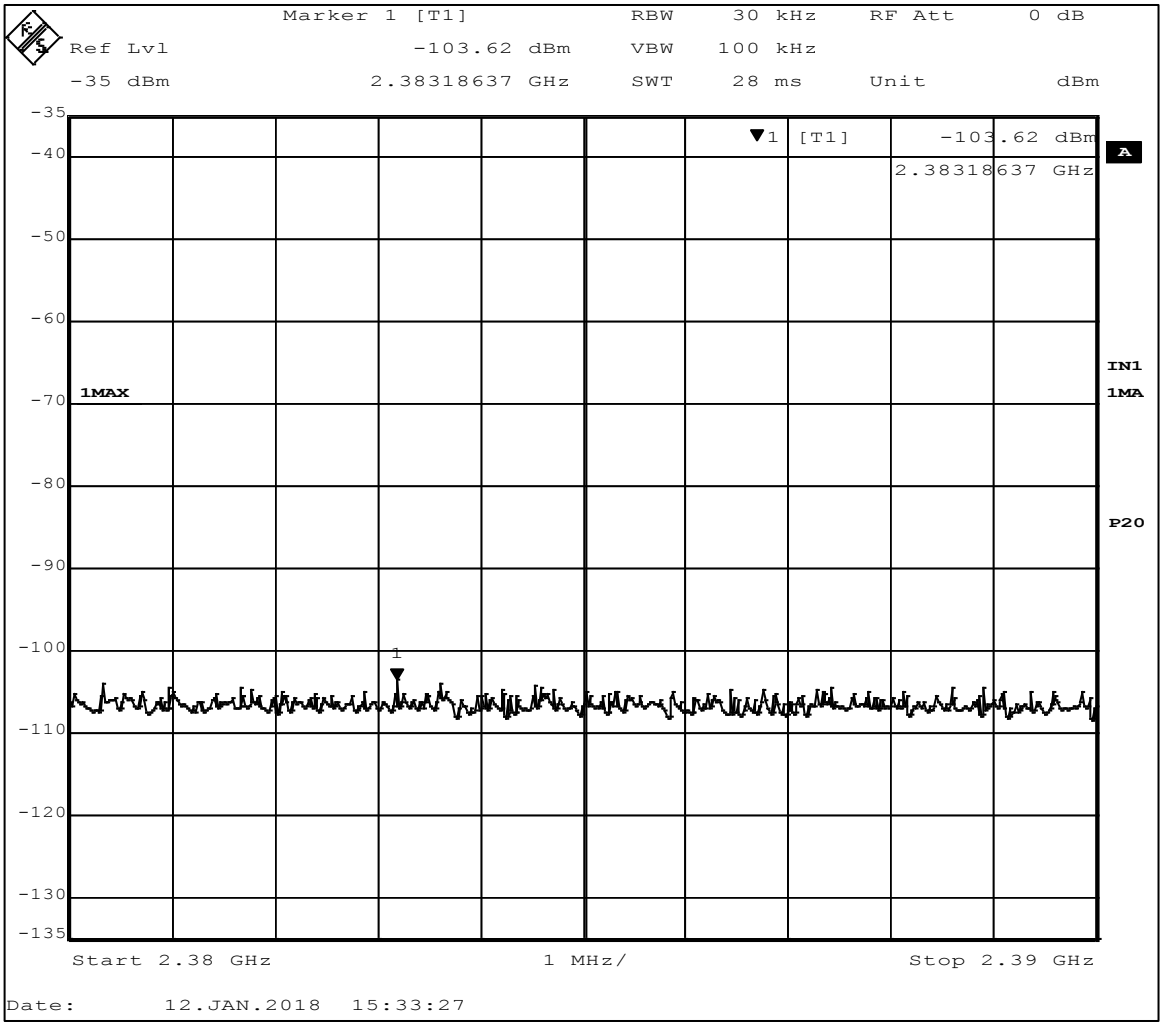

Figure 13 - Band-edge Measurement, Low Channel, Restricted Frequency

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

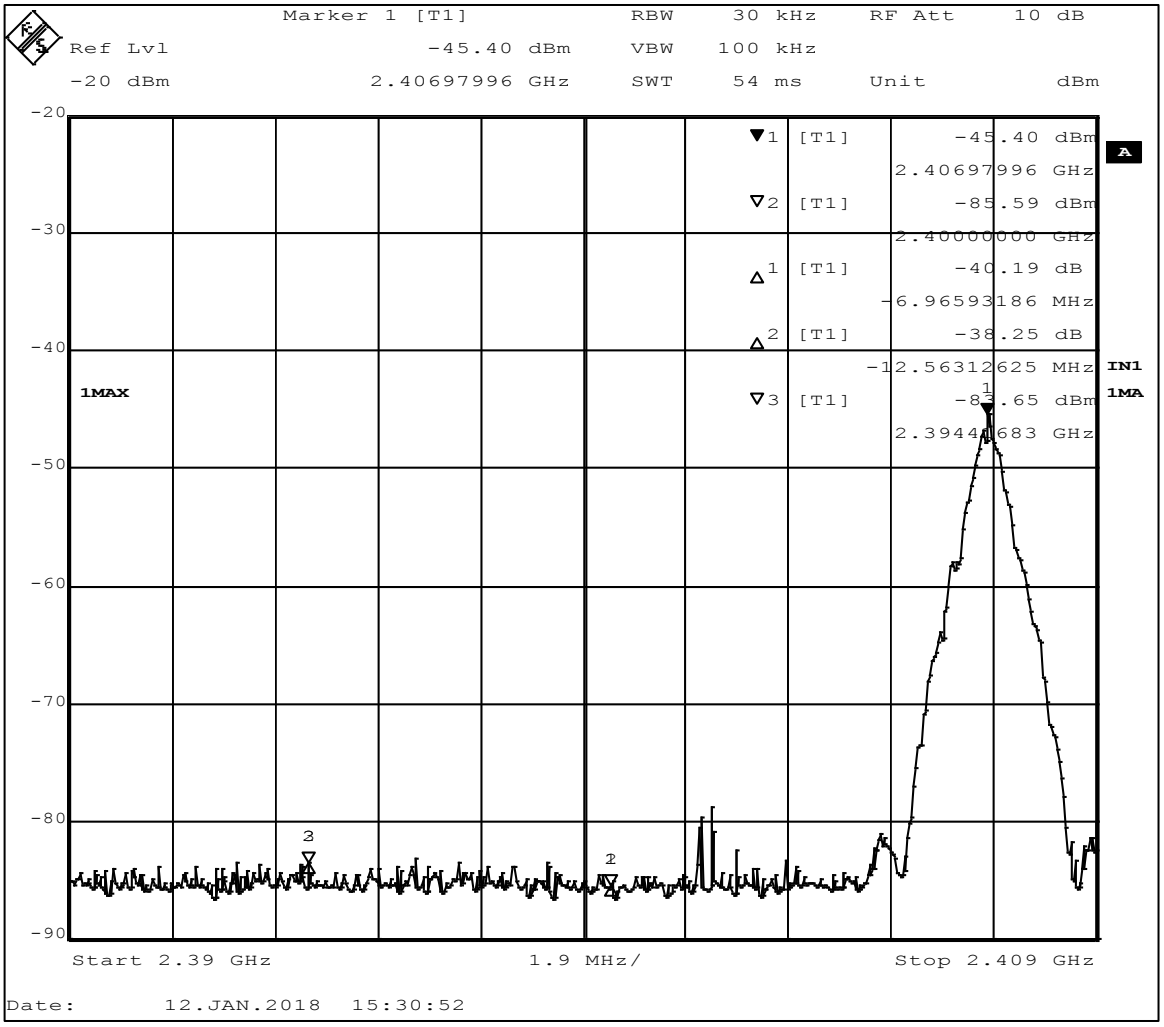

Figure 14 – Restricted Band-edge Measurement, Low Channel, Fundamental

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

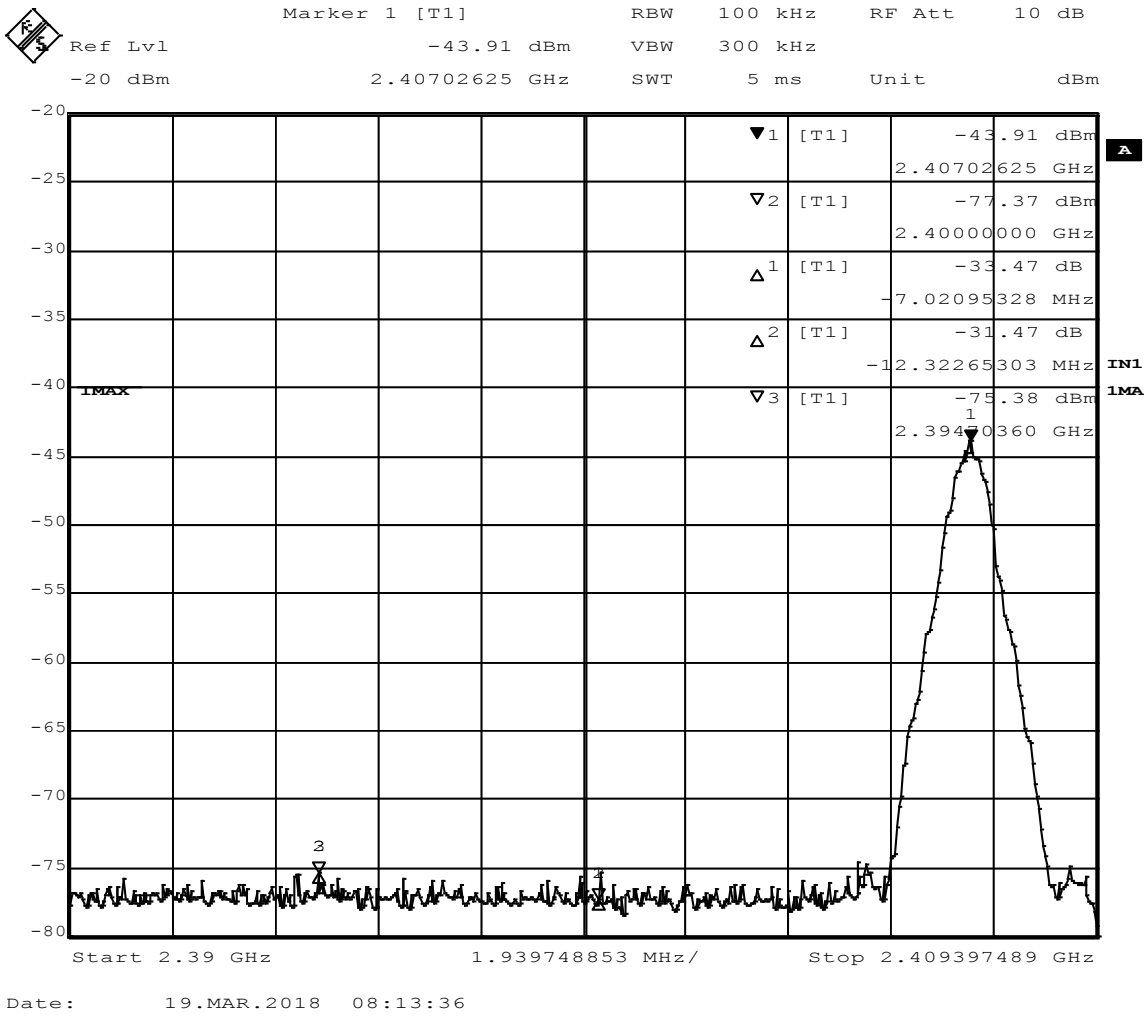

Figure 15 - Unestricted Band-edge Measurement, Low Channel, Fundamental

Delta = 31.47 dB; Minimum = 20 dB

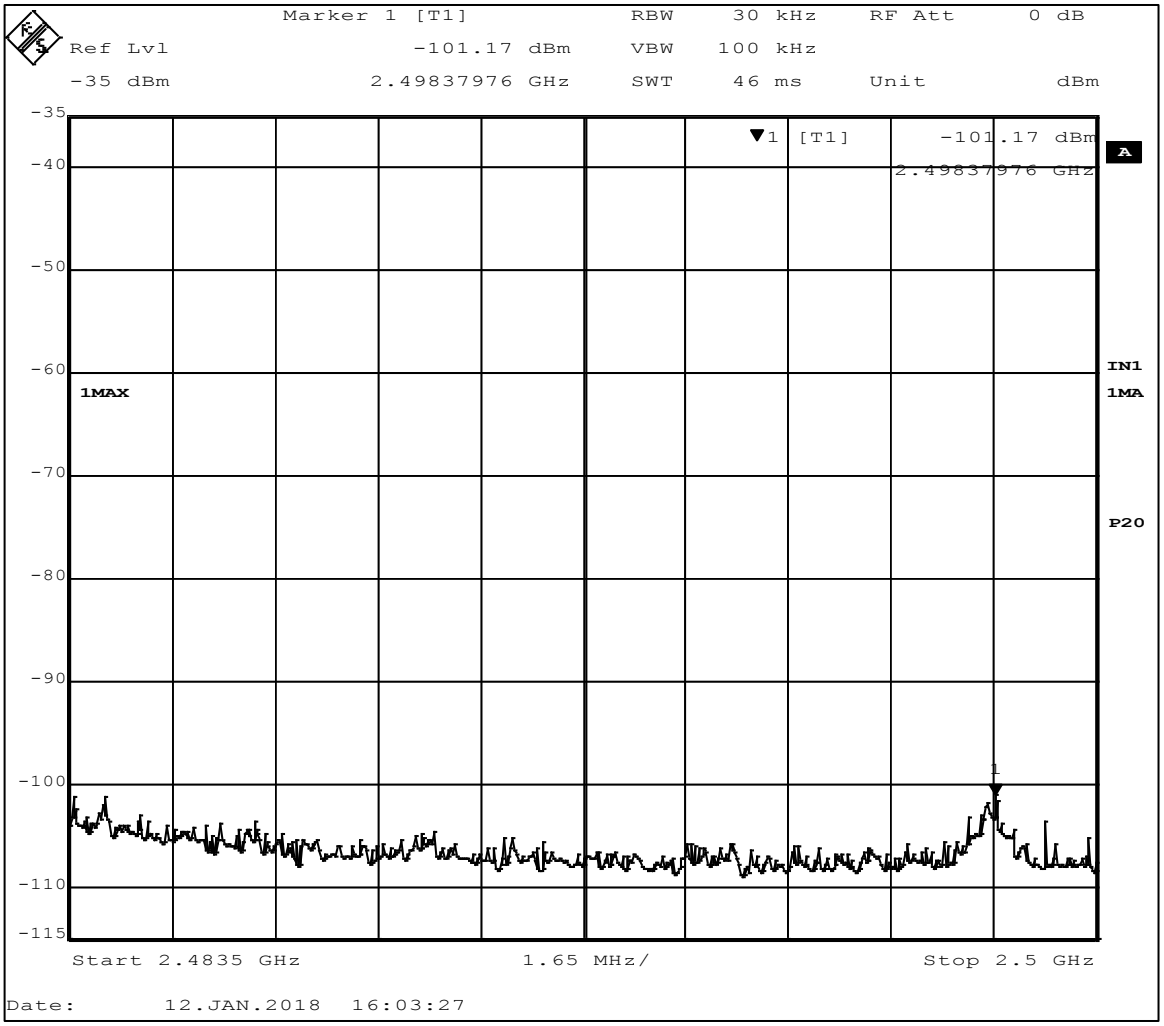

Figure 16 – Restricted Band-edge Measurement, High Channel, Restricted Frequency
The plot shows an uncorrected measurement, used for relative measurements only.

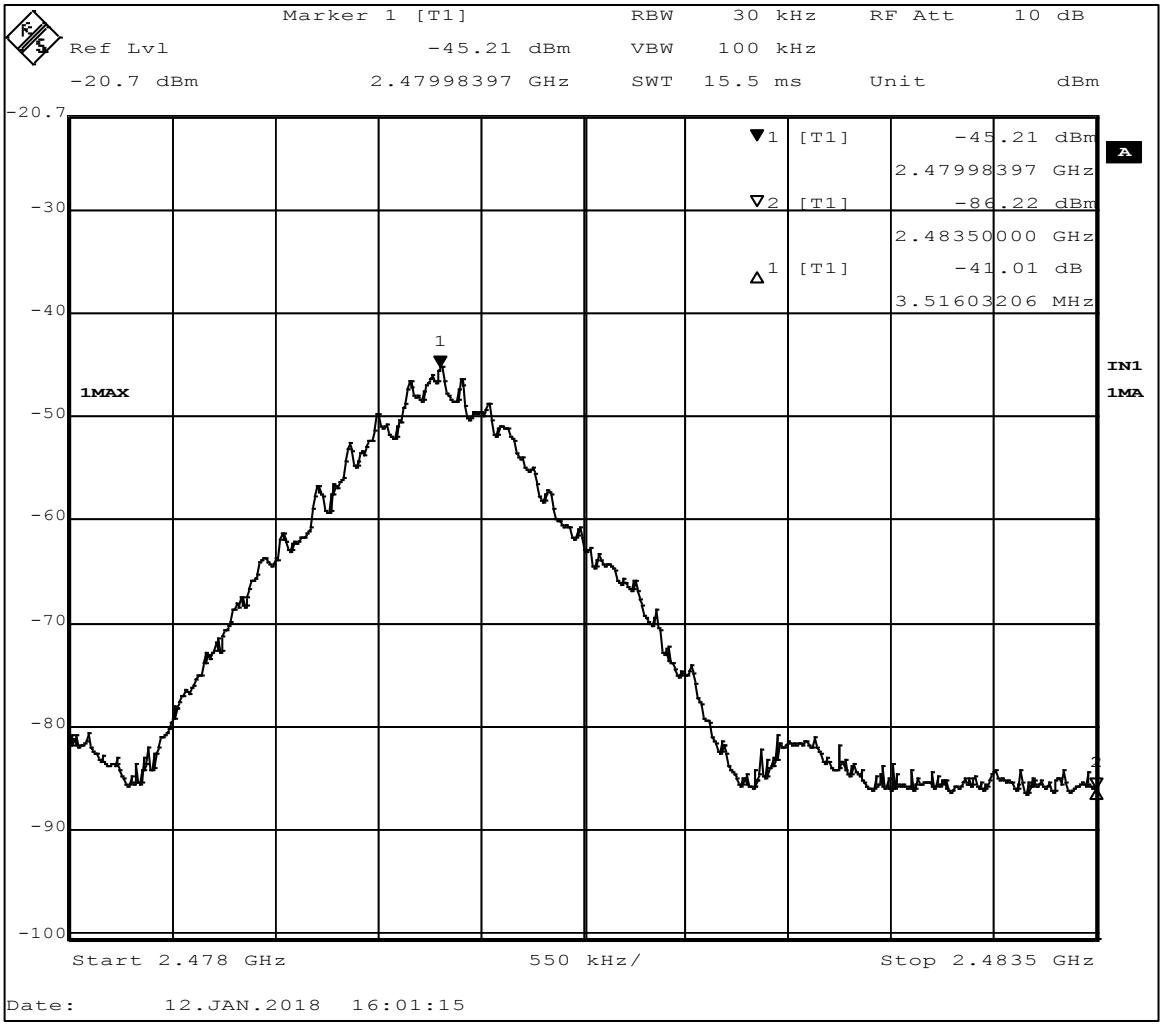

Figure 17 - Band-edge Measurement, High Channel, Fundamental

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

Delta = 41.01 dB; Minimum = 20 dB

4.5 Power spectral density (PSD)

Test Method: ANSI C63.10, Section 11.10.2

4.5.1 Limits of PSD measurements

The maximum power spectral density allowed is 8dBm.

4.5.2 Test procedures

The transmitter output was measured at 3 m test distance with a spectrum analyzer. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using **3 kHz RBW and 30 kHz VBW**; the sweep time was set to **auto-couple**. The power spectral density was measured and recorded at the frequency with the highest emission. The sweep time is allowed to be longer than span/3KHz for a full response of the mixer in the spectrum analyzer.

4.5.3 Deviations from test standard

No deviation.

4.5.4 Test setup

See Section 4.3

4.5.5 EUT operating conditions

See Section 2.6.

4.5.6 Test results

Power Spectral Density

EUT MODULE	Wireless Window Blind Controller Hub – Radio 2	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	-7.59	8.0	PASS
Mid	2440	-7.56	8.0	PASS
High	2480	-7.55	8.0	PASS

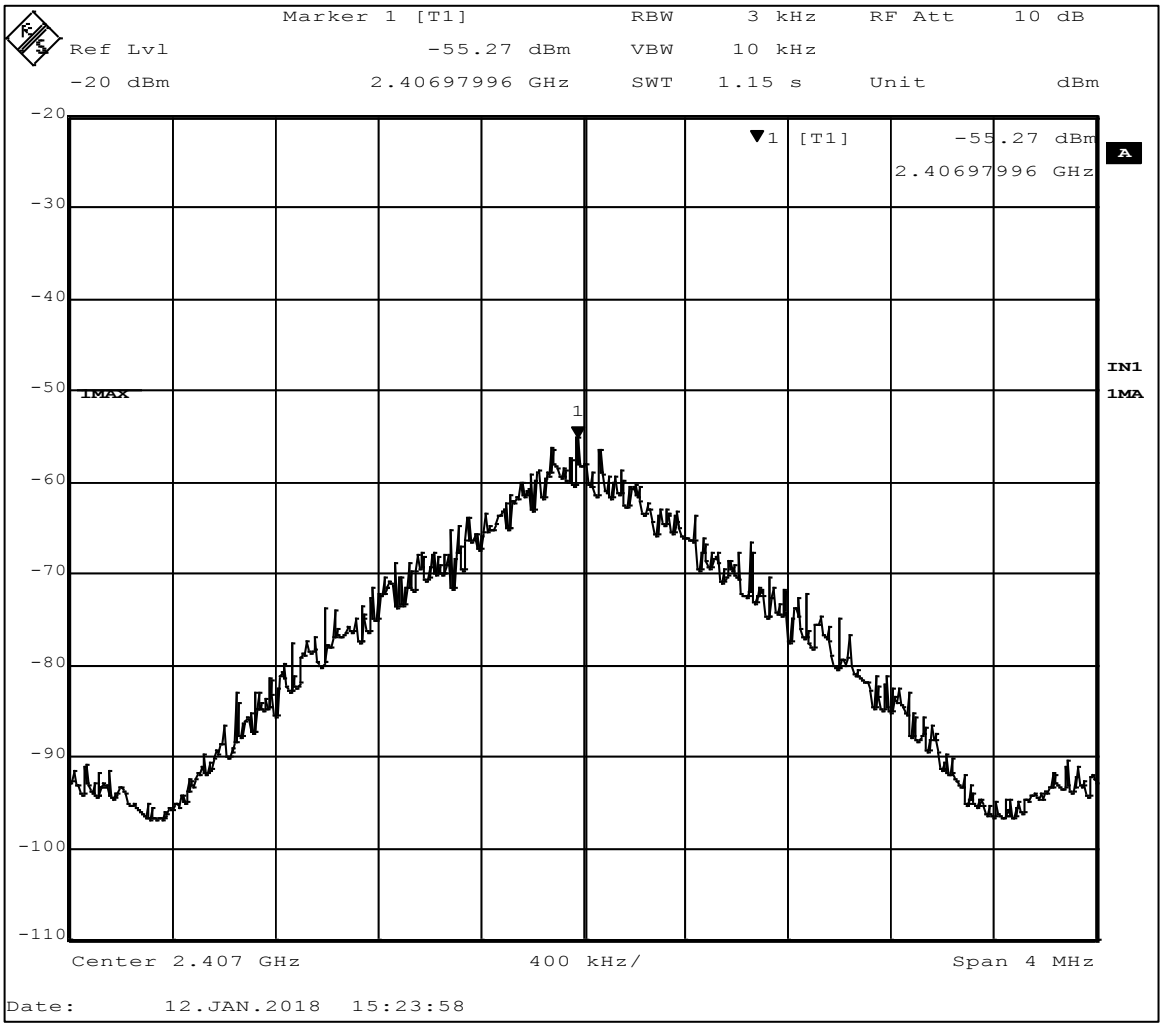

Figure 18 - Power Spectral Density Measurement, Low Channel

Power Spectral Density = -55.27 dBm + 107 + CL + AF - 95.23 = -7.59 dBm

CL = cable loss = 7.60 dB
AF = antenna factor = 28.31 dB
107 = conversion from dBm to dBµV on a 50Ω measurement system
-95.23 = Conversion from field strength (dBµV/m) to EIRP (dBm) at a 3m measurement distance.

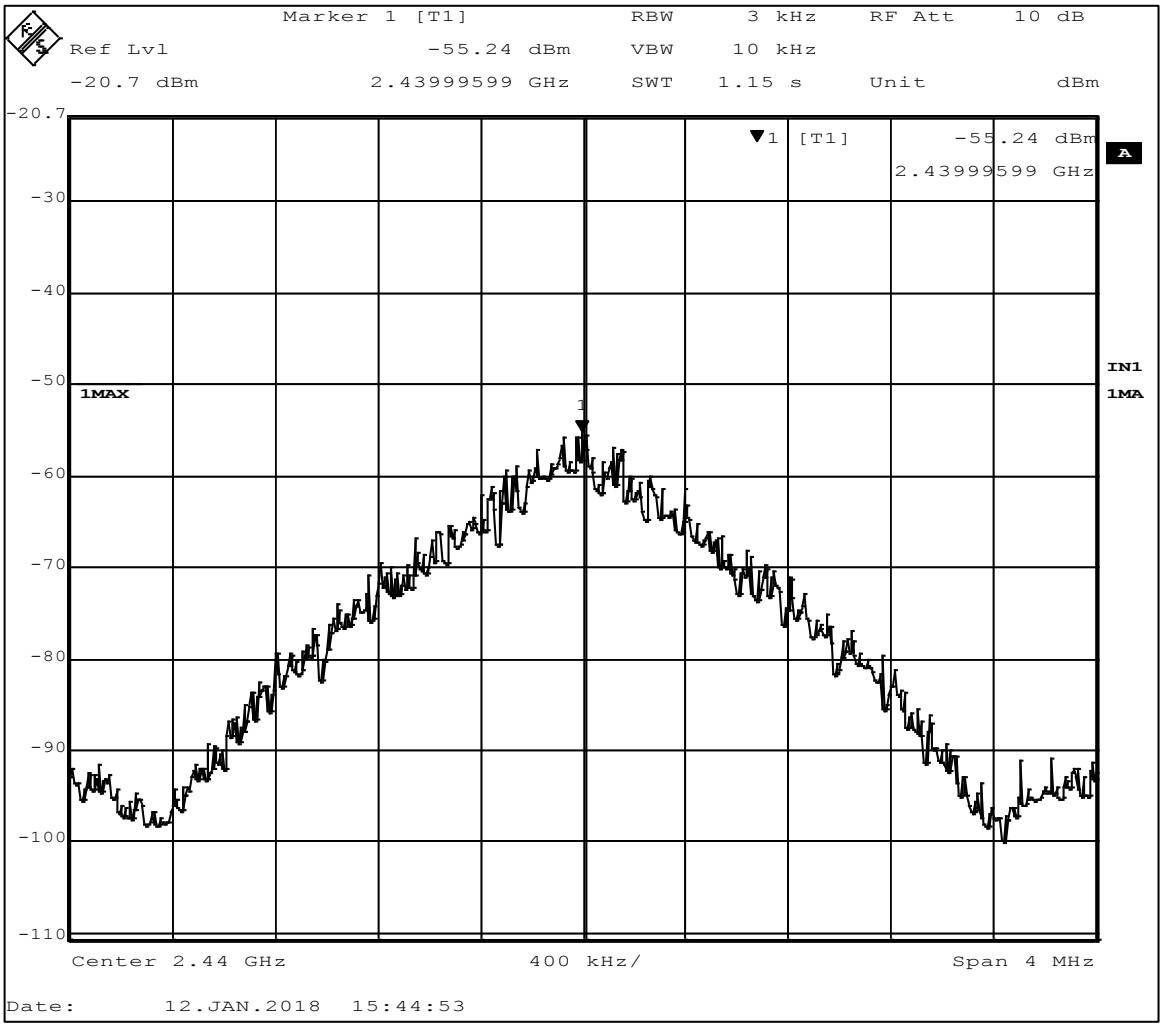

Figure 19 - Power Spectral Density Measurement, Mid Channel

Power Spectral Density = -55.24 dBm + 107 + CL + AF - 95.23 = -7.56 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.

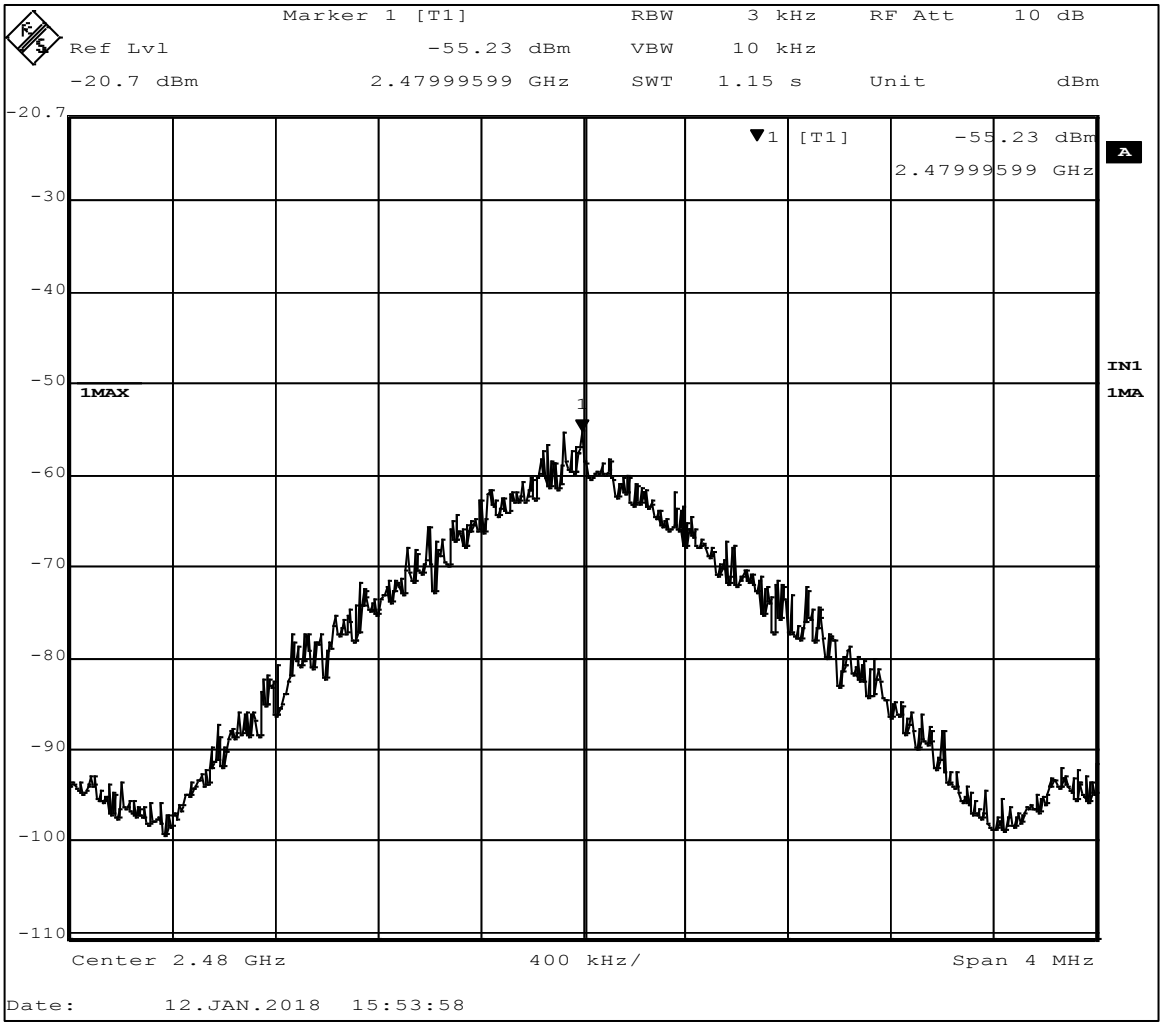

Figure 20 - Power Spectral Density Measurement, High Channel

Power Spectral Density = -55.23 dBm + 107 + CL + AF - 95.23 = -7.55 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

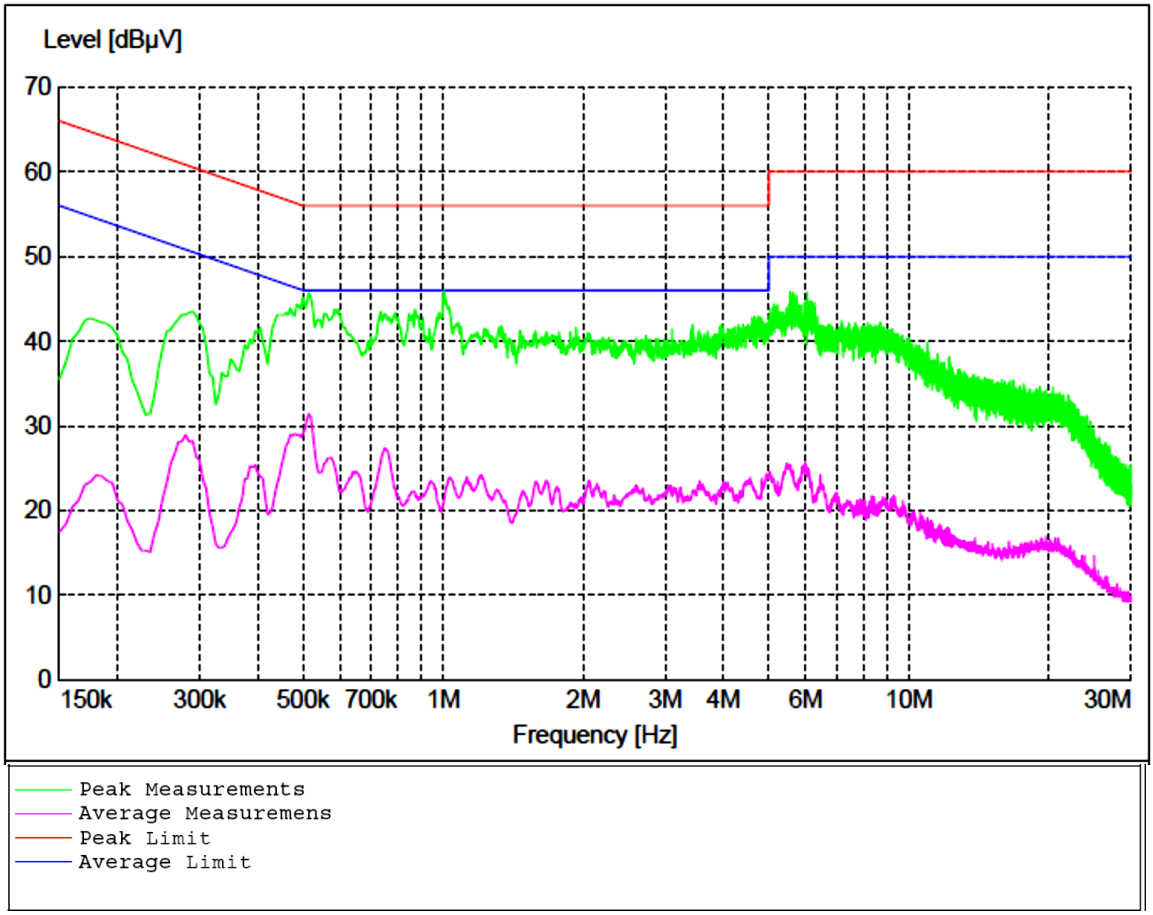

Figure 21 - Conducted Emissions Plot

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.