Certification Application Report for
FCC Part 15.247 & Industry Canada RSS-210

Test Lab:	Applicant:
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FCC ID/ IC	LS3-146591 2938A-146591	**Test Report Date**	May 28, 2015
Platform	N/A	**RTL Work Order #**	2015070
Model	146-59-1	**RTL Quote #**	QRTL15-070A
American National Standard Institute	FCC: ANSI C63.4-2009: American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz IC: ANSI C63.4-2014: American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (using test site validation per ANSI C63.4-2009)		
FCC Classification	DTS – Part 15 Digital Transmission System		
FCC Rule Part(s)/Guidance	FCC Rules Part 15.247: Operation within the bands 920-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz Direct Sequence System (2014)		
Industry Canada	RSS-210 Issue 8: Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment RSS-Gen Issue 4: General Requirements for Compliance of Radio Apparatus		

Frequency Range (MHz)	Output Power (W)*	Frequency Tolerance	Emission Designator
2405 – 2480	0.033	N/A	1M60FXD

** power is peak conducted*

I, the undersigned, hereby declare that the equipment tested and referenced in this report conforms to the identified standard(s) as described in this test report. No modifications were made to the equipment during testing in order to achieve compliance with these standards. Furthermore, there was no deviation from, additions to, or exclusions from, the applicable parts of FCC Part 2, FCC Part 15, Industry Canada RSS-210, RSS-Gen, and ANSI C63.4.

Signature: _____ Date: May 28, 2015

Typed/Printed Name: Desmond A. Fraser Position: President

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1 General Information

1.1 Scope

This is an original FCC and Industry Canada certification application request.

Applicable Standards:

- FCC Rules Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz.
- Industry Canada RSS-210: Licence-exempt Radio Apparatus (All Frequency Bands): Category I Equipment
- Industry Canada RSS-Gen: General Requirements for Compliance of Radio Apparatus

1.2 Description of EUT

Equipment Under Test	Transceiver
Model	146-59-1
Power Supply	2 AA batteries (1.5V each)
Modulation Type	DSSS
Frequency Range	2405 – 2480 MHz
Antenna Type & Gain	PCB Inverted F 3.3 dBi

1.3 Test Facility

The open area test site and conducted measurement facility used to collect the radiated data is located at 360 Herndon Parkway, Suite 1400, Herndon, Virginia 20170. This site has been fully described in a report and approved by the Federal Communications Commission to perform AC line conducted and radiated emissions testing.

1.4 Related Submittal(s)/Grant(s)

This is an original application for Hunter Engineering Company Model 146-59-1, FCC ID: LS3-146591, IC: 2938A-146591.

1.5 Modifications

No modifications were made to the equipment during testing in order to achieve compliance with these standards.

2 Test Information

2.1 Description of Test Modes

In accordance with FCC 15.31(m), and because the EUT utilizes an operating band greater than 10 MHz, the following frequencies were tested:

Table 2-1: Channels Tested

Channel	Frequency
Low	2405
Middle	2440
High	2480

2.2 Exercising the EUT

The EUT was supplied with test firmware programmed with a high, mid, and low channel for testing. The EUT was tested in all three orthogonal planes in order to determine worst-case emissions. The EUT was provided with software to continuously transmit during testing. The carrier was also checked to verify that information was being transmitted. There were no deviations from the test standard(s) and/or methods. The test results reported relate only to the item tested.

2.3 Test Result Summary

Table 2-2: Test Result Summary – FCC Part 15 Subpart C (Section 15.247)

Standard	Test	Pass/Fail or N/A
FCC 15.207	AC Power Conducted Emissions	N/A
FCC 15.209	Radiated Emissions	Pass
FCC 15.247(a)(2)	6 dB Bandwidth	Pass
FCC 15.247(b)	Maximum Peak Power Output	Pass
FCC 15.247(d)	Antenna Conducted Spurious Emissions	Pass
FCC 15.247(e)	Power Spectral Density	Pass
FCC 15.247(d)	Band Edge Measurement	Pass
RSS-Gen	99% Bandwidth	N/A

2.4 Test System Details

The test samples were received on April 28, 2015. The FCC identifiers for all applicable equipment, plus descriptions of all cables used in the tested system, are identified in the following table.

Table 2-3: Equipment under Test

Part	Manufacturer	Model	Serial Number	FCC ID	Cable Description	RTL Bar Code
Transceiver	Hunter Engineering Company	146-59-1	15315CZ	LS3-146591	N/A	21685
Transceiver	Hunter Engineering Company	146-59-1	15314CZ	LS3-146591	N/A	21686

2.5 Configuration of Tested System

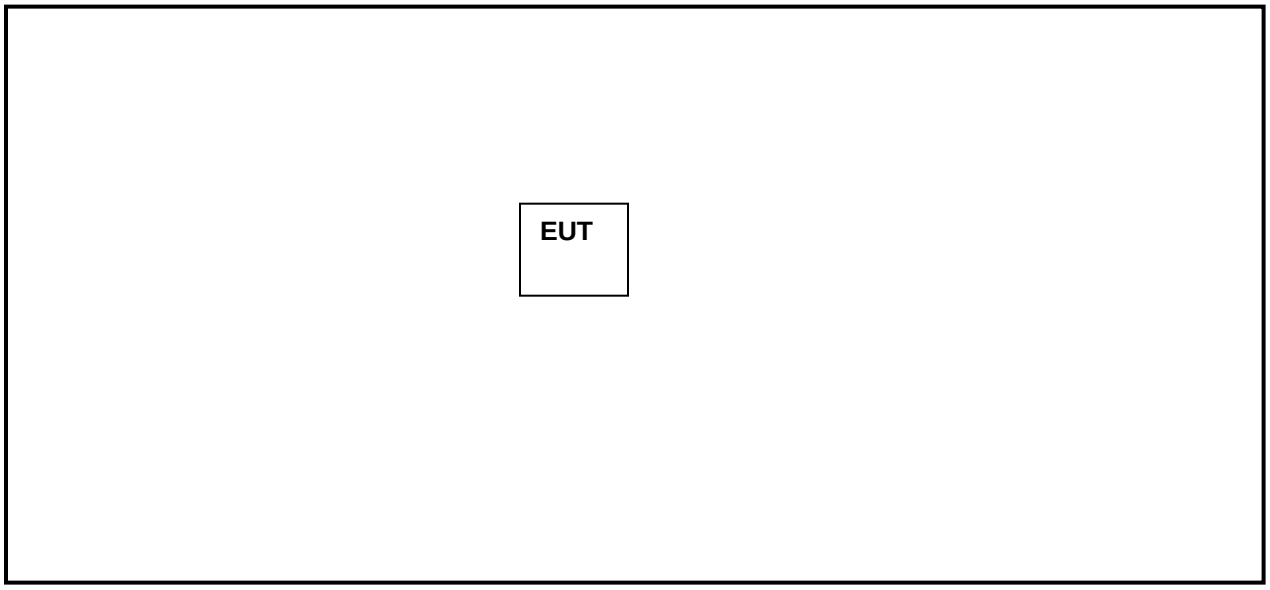


Figure 2-1: Configuration of System under Test

3 Peak Output Power - 15.247(b)(3); IC RSS-210 A8.4(4), RSS-Gen 6.12

3.1 Power Output Test Procedure

A conducted power measurement of the EUT was taken.

Table 3-1: Power Output Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	FSU	Spectrum Analyzer	1166.1660.50	11/13/15

3.2 Power Output Test Data

Table 3-2: Power Output Test Data

Channel	Frequency (MHz)	Peak Power Conducted Output (dBm)
Low	2405	15.2
Middle	2440	14.4
High	2480	14.2

Test Personnel:

Dan Baltzell		May 14, 2015
Test Engineer	Signature	Date of Test

4 Duty Cycle Correction Factor

Hunter Engineering Company duty cycle attestation:

10 bytes data

33 bytes Zigbee packet overhead

250KBaud data rate

(10+33) * (8 * (1/250000) = .0014

Duty Cycle per 100ms = .0014/.1 = 1.4%

20 Log (0.014) = -37.1 dB

5 Compliance with the Band Edge – FCC 15.247(d); RSS-210 A8.5

5.1 Band Edge Test Procedure

The transmitter output was connected to its appropriate antenna. A conducted antenna port delta measurement was performed from the highest peak in the restricted band to the peak of the fundamental, and subtracted from the radiated field strength; the result was compared to the limit.

Table 5-1: Band Edge Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
900772	EMCO	3161-02	Horn Antenna (2 - 4 GHz)	9804-1044	4/9/18
900878	Rhein Tech Laboratories	AM3-1197-0005	3 meter Antenna Mast, Polarizing	Outdoor Range 1	Not Required
901594	Insulated Wire Inc.	KPS-1503-360-KPR	SMK RF Cables 36"	NA	9/3/15
901242	Rhein Tech Laboratories	WRT-000-0003	Wood Rotating Table	N/A	Not Required
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	11/13/15

5.2 Band Edge Test Results

5.2.1 Calculation of Lower Band Edge

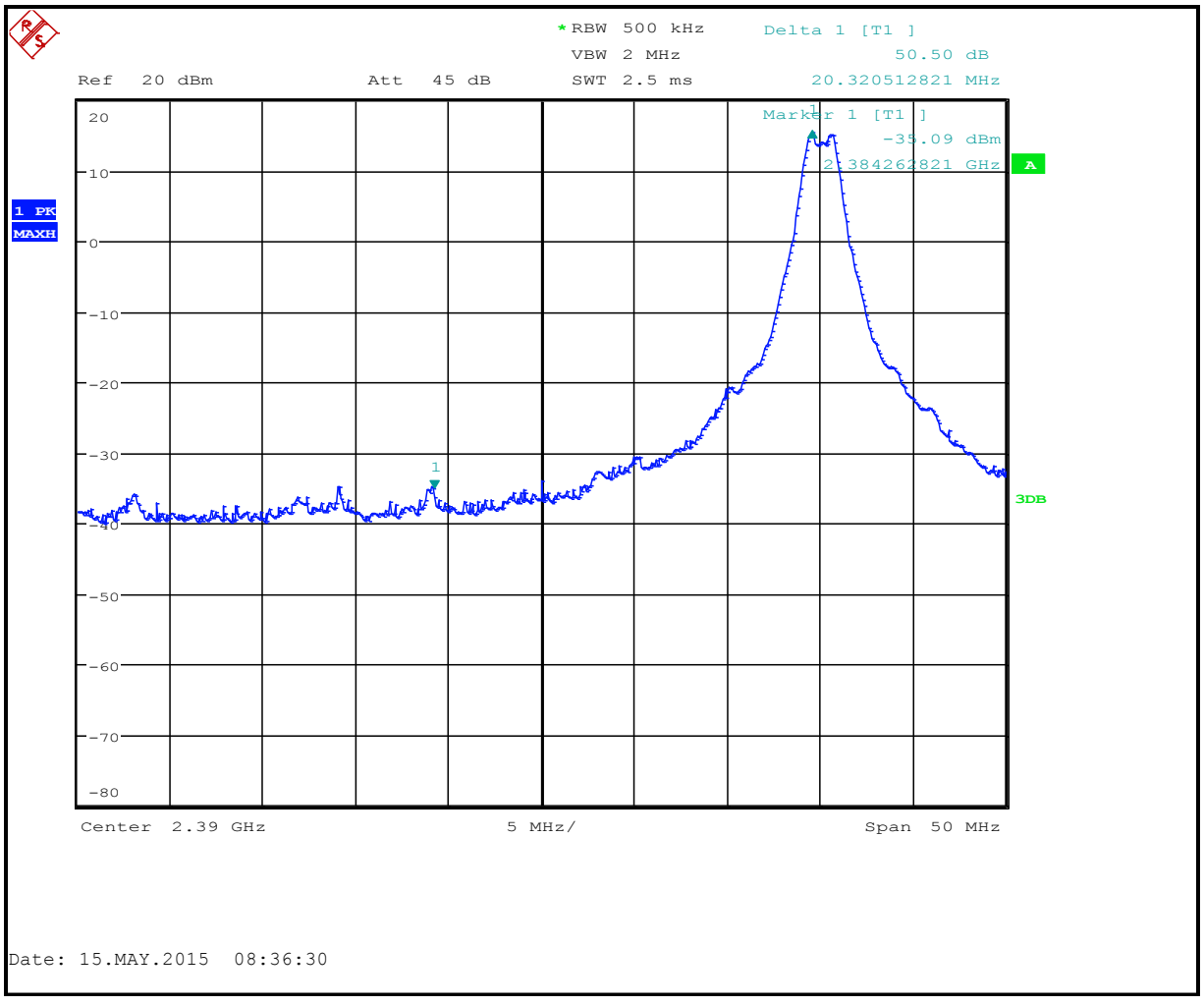
72.7 dBuV/m is the field strength measurement, from which the delta measurement of 50.5 dB is subtracted, resulting in a level of 22.2 dB. This level has a margin of 31.8 dB below the limit of 54 dBuV/m.

Calculation: 72.7 dBuV/m – 50.5 dB – 54 dBuV/m = -31.8 dB

Peak Field Strength of Lower Band Edge (1 MHz RBW/8 MHz VBW) = 109.8 dBuV/m
Calculated Average Field Strength of Lower Band Edge (duty cycle 1.4%) = 72.7 dBuV/m
Delta measurement = 50.5 dB

5.2.2 Lower Band Edge – Conducted Delta Plot

Plot 5-1: Lower Band Edge



5.2.3 Calculation of Upper Band Edge

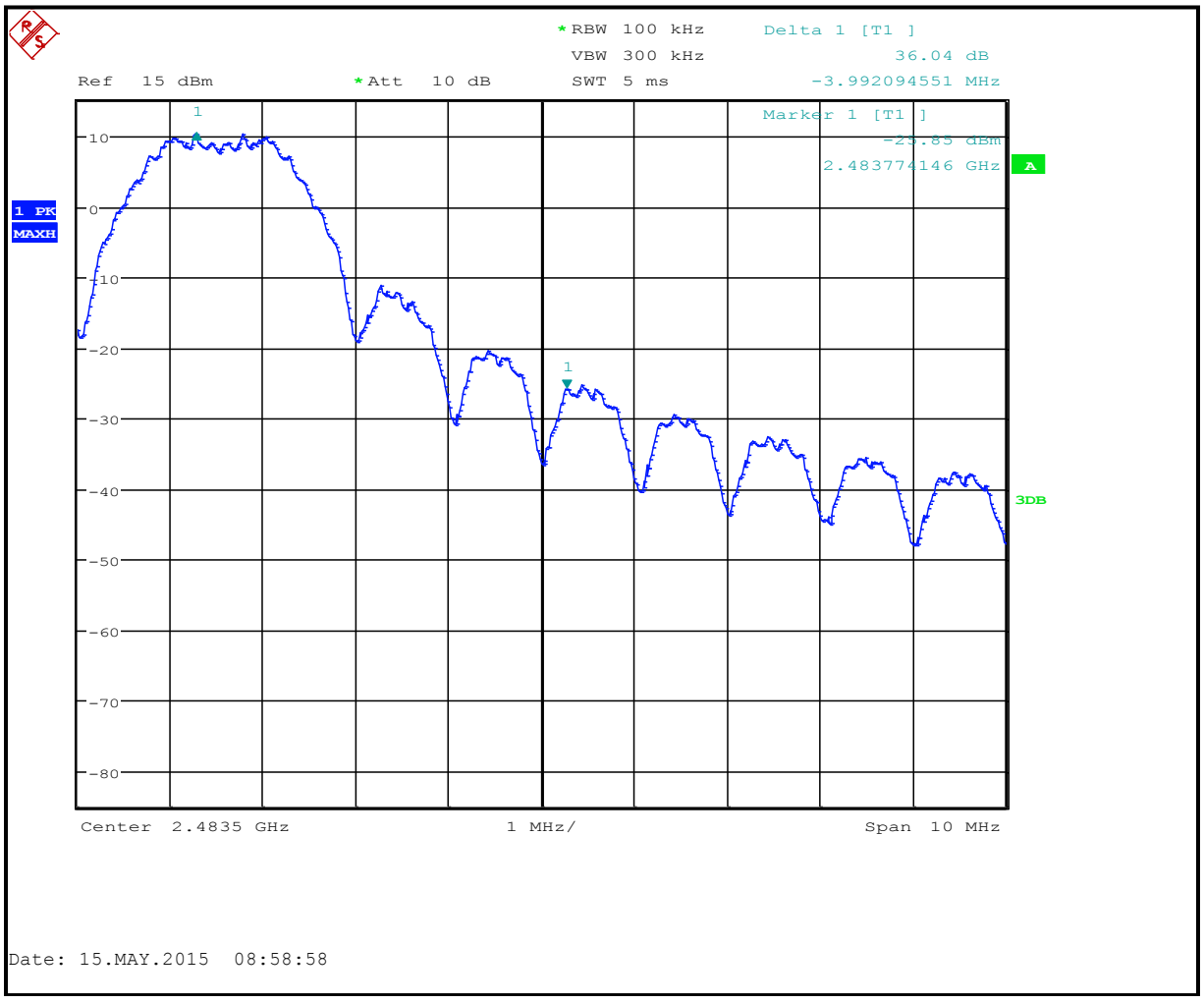
66.0 dBuV/m is the field strength measurement, from which the delta measurement of 36 dB is subtracted, resulting in a level of 30 dB. This level has a margin of 24 dB below the limit of 54 dBuV/m.

Calculation: 66.0 dBuV/m – 36 dB – 54 dBuV/m = -24.0 dB

Peak Field Strength of Upper Band Edge (1 MHz RBW/10 MHz VBW) = 103.1 dBuV/m
Calculated Average Field Strength of Upper Band Edge (1.4% duty cycle) = 66.0 dBuV/m
Delta measurement = 36 dB

5.2.4 Upper Band Edge – Conducted Delta Plot

Plot 5-2: Upper Band Edge



Test Personnel:

Dan Baltzell		May 15, 2015
Test Engineer	Signature	Date of Test

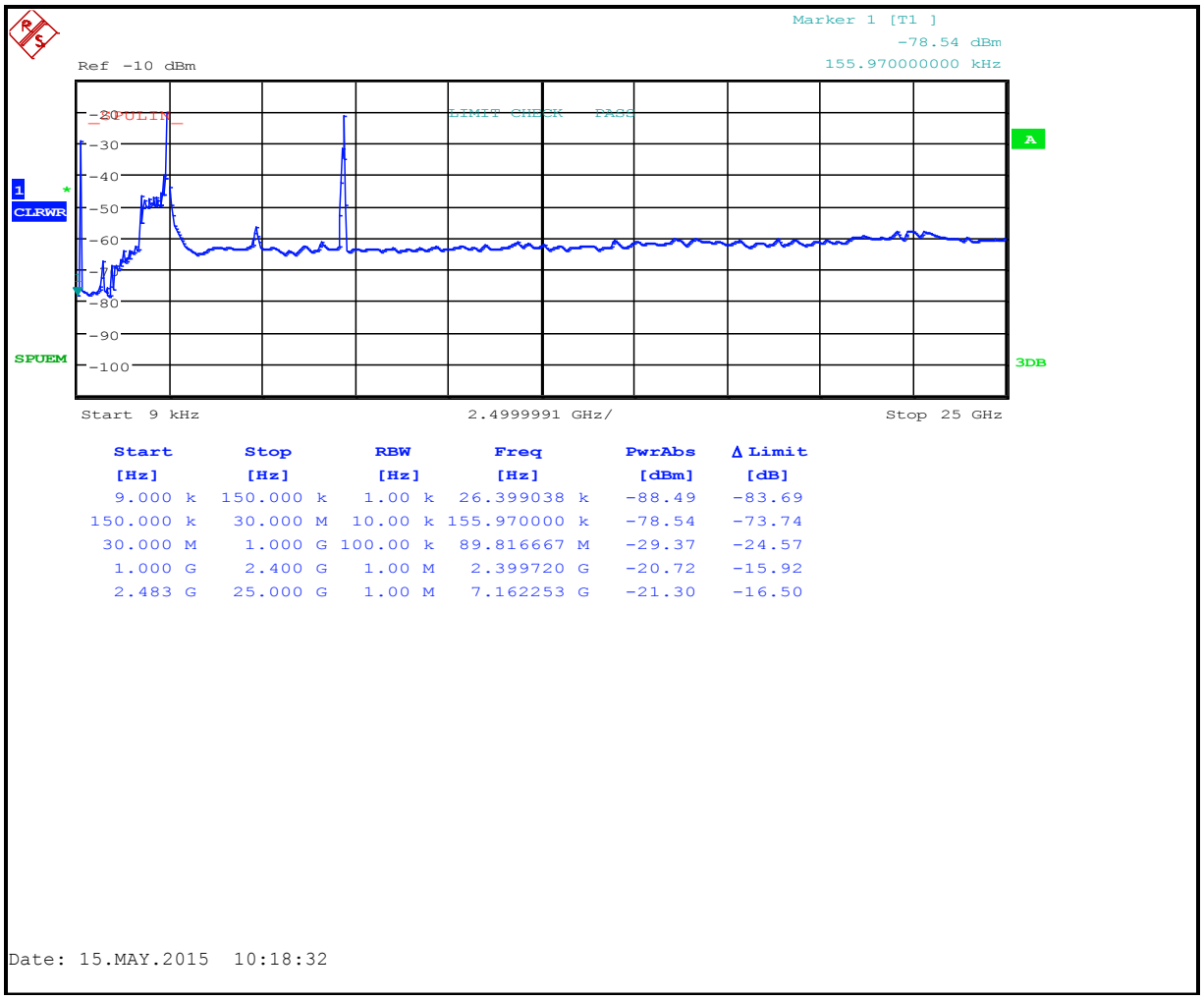
6 Antenna Conducted Spurious Emissions - 15.247(d); RSS-210 A8.5

6.1 Antenna Conducted Spurious Emissions Test Procedures

Antenna spurious emissions per FCC 15.247(d) was measured from the EUT antenna port using a 50 ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 1 MHz. The modulated carrier was identified at the following frequencies: 2405 MHz, 2440 MHz and 2480 MHz.

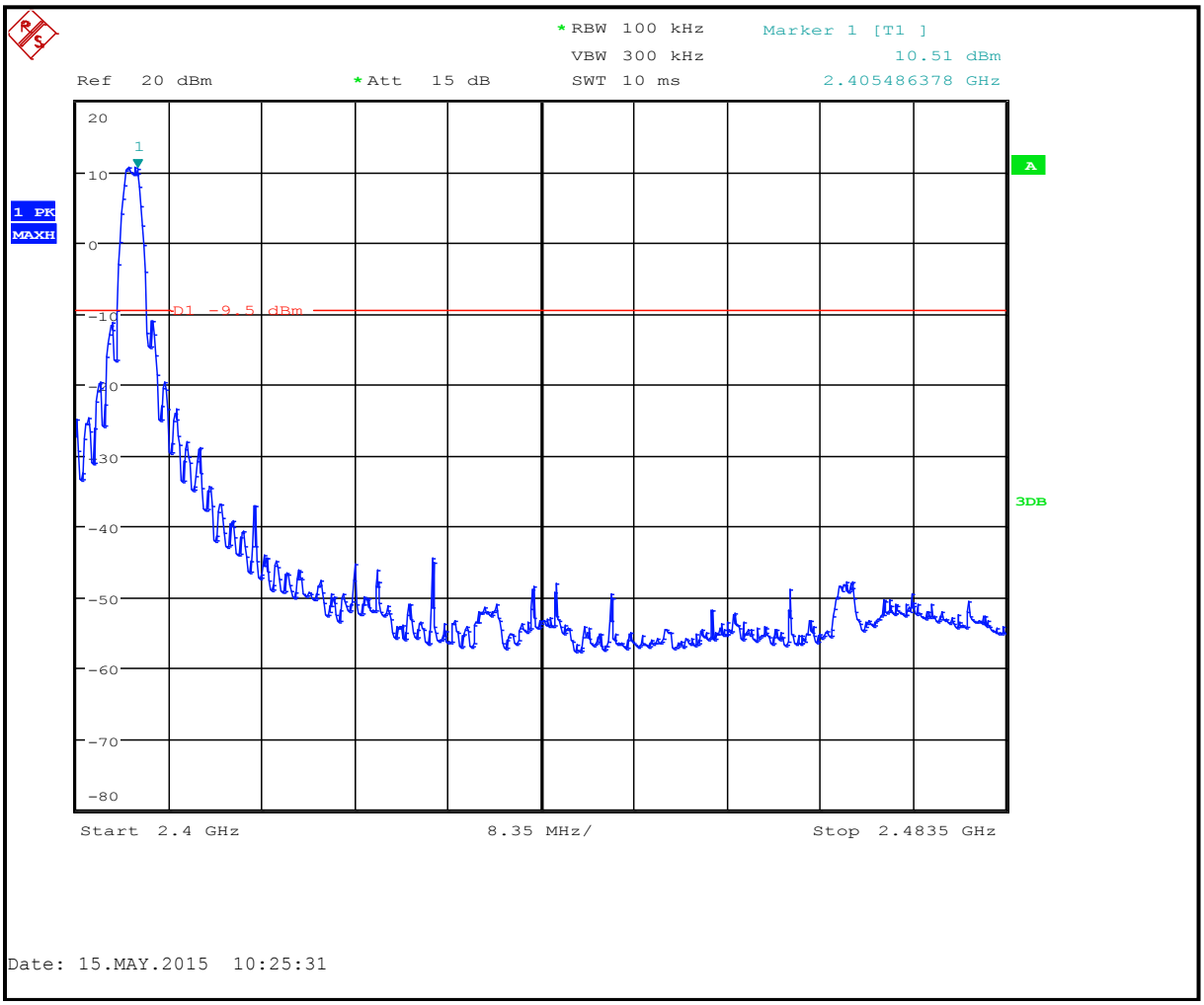
6.2 Antenna Conducted Spurious Emissions Data

Plot 6-1: Out of Band Antenna Conducted Spurious Emissions – 2405 MHz

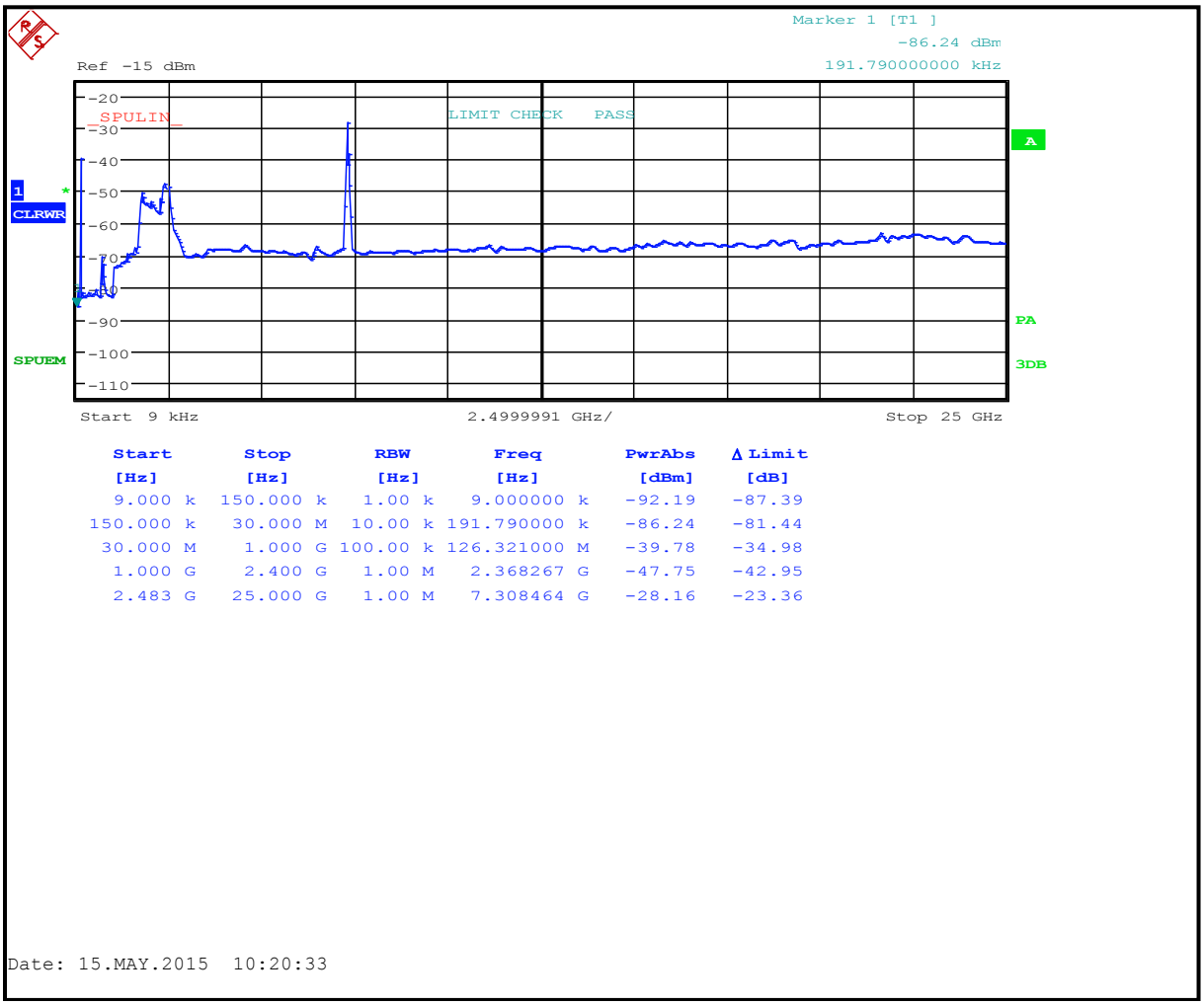


Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	26.399038 k	-88.49	-83.69
150.000 k	30.000 M	10.00 k	155.970000 k	-78.54	-73.74
30.000 M	1.000 G	100.00 k	89.816667 M	-29.37	-24.57
1.000 G	2.400 G	1.00 M	2.399720 G	-20.72	-15.92
2.483 G	25.000 G	1.00 M	7.162253 G	-21.30	-16.50

Plot 6-2: In Band Antenna Conducted Spurious Emissions – 2405 MHz



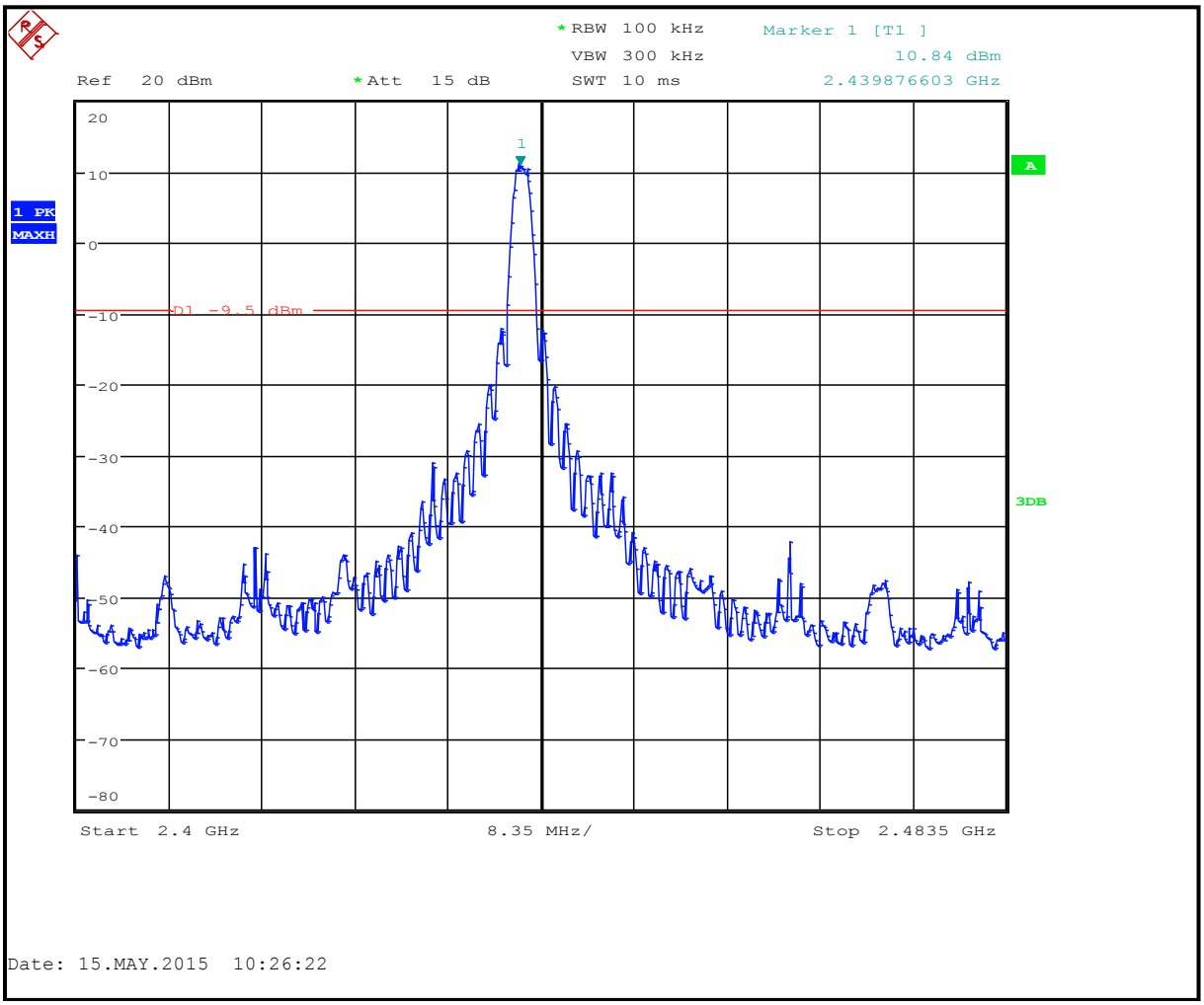
Plot 6-3: Out of Band Antenna Conducted Spurious Emissions – 2440 MHz



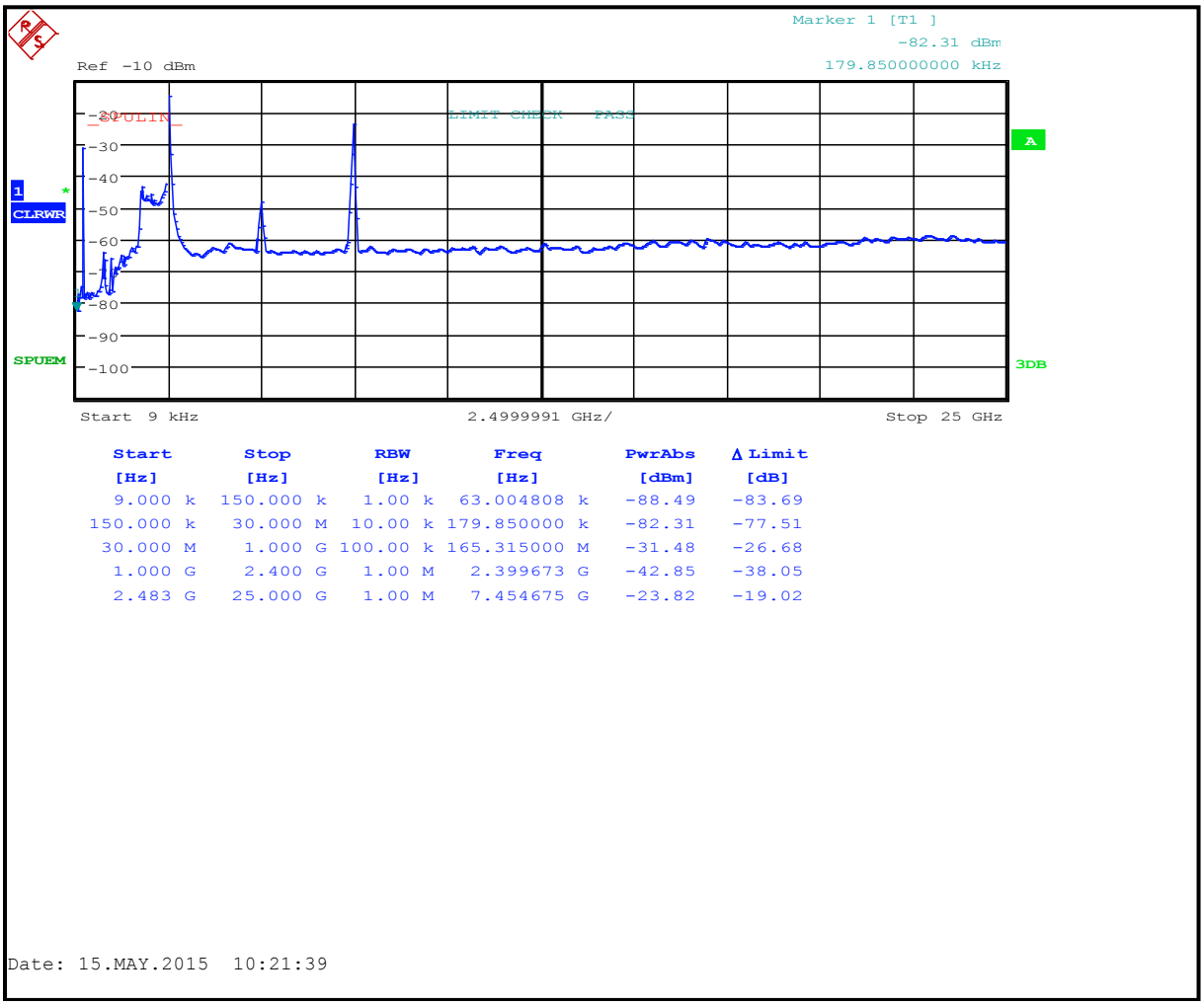
Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.000000 k	-92.19	-87.39
150.000 k	30.000 M	10.00 k	191.790000 k	-86.24	-81.44
30.000 M	1.000 G	100.00 k	126.321000 M	-39.78	-34.98
1.000 G	2.400 G	1.00 M	2.368267 G	-47.75	-42.95
2.483 G	25.000 G	1.00 M	7.308464 G	-28.16	-23.36

Date: 15.MAY.2015 10:20:33

Plot 6-4: In Band Antenna Conducted Spurious Emissions – 2440 MHz



Plot 6-5: Out of Band Antenna Conducted Spurious Emissions – 2480 MHz



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	63.004808 k	-88.49	-83.69
150.000 k	30.000 M	10.00 k	179.850000 k	-82.31	-77.51
30.000 M	1.000 G	100.00 k	165.315000 M	-31.48	-26.68
1.000 G	2.400 G	1.00 M	2.399673 G	-42.85	-38.05
2.483 G	25.000 G	1.00 M	7.454675 G	-23.82	-19.02

Date: 15.MAY.2015 10:21:39

Plot 6-6: In Band Antenna Conducted Spurious Emissions – 2480 MHz

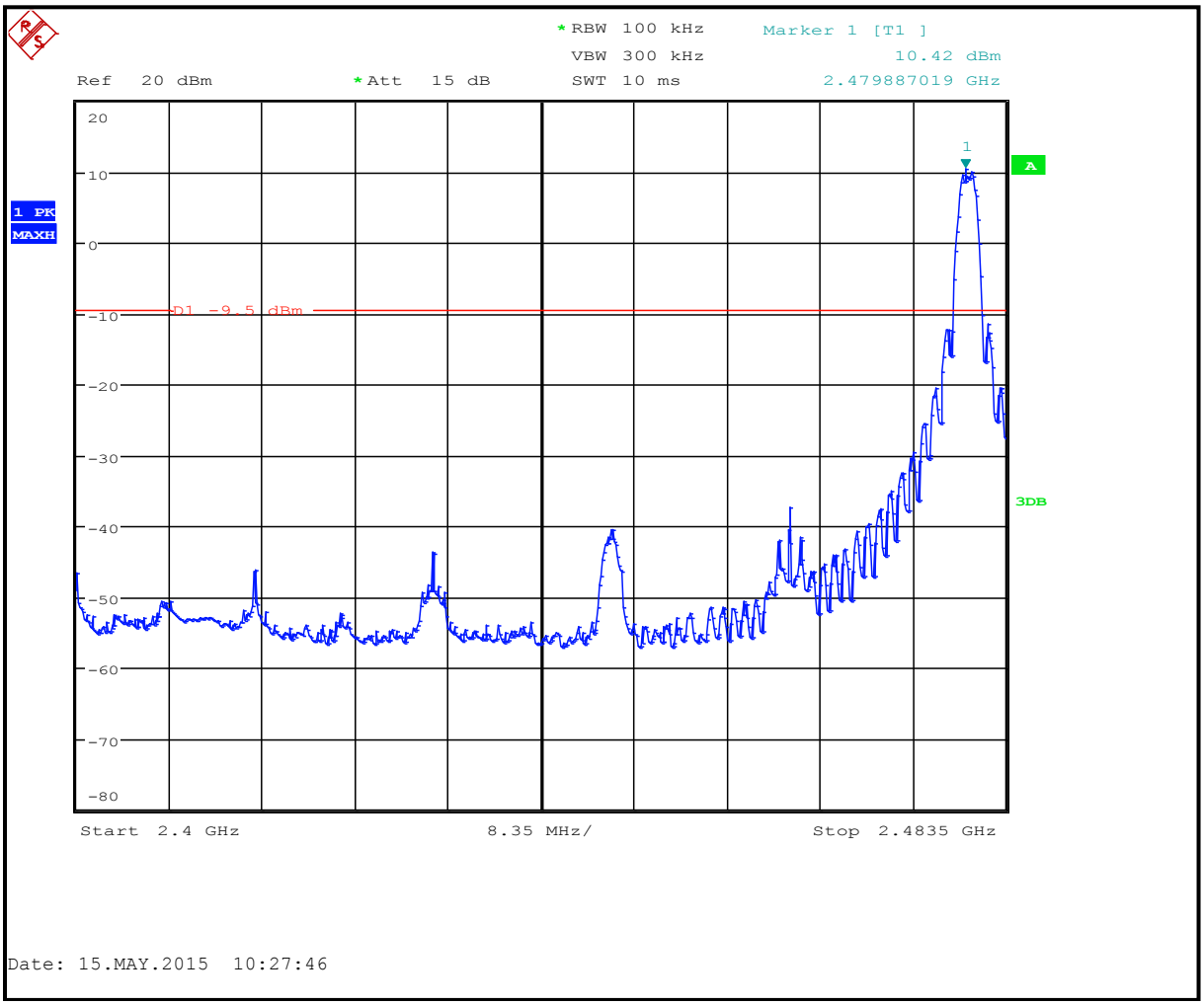


Table 6-1: Antenna Conducted Spurious Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	FSU	Spectrum Analyzer	1166.1660.50	11/13/15

Test Personnel:

Dan Baltzell		May 15, 2015
Test Engineer	Signature	Date of Test

7 6 dB Bandwidth - 15.247(a)(2); RSS-210 A8.2(a)

7.1 6 dB Bandwidth Test Procedure – Minimum 6 dB Bandwidth

The minimum 6 dB bandwidths per FCC 15.247(a)(2) were measured using a 50 ohm spectrum analyzer. The device was modulated. The minimum 6 dB bandwidths are presented below.

Table 7-1: 6 dB Bandwidth Test Equipment

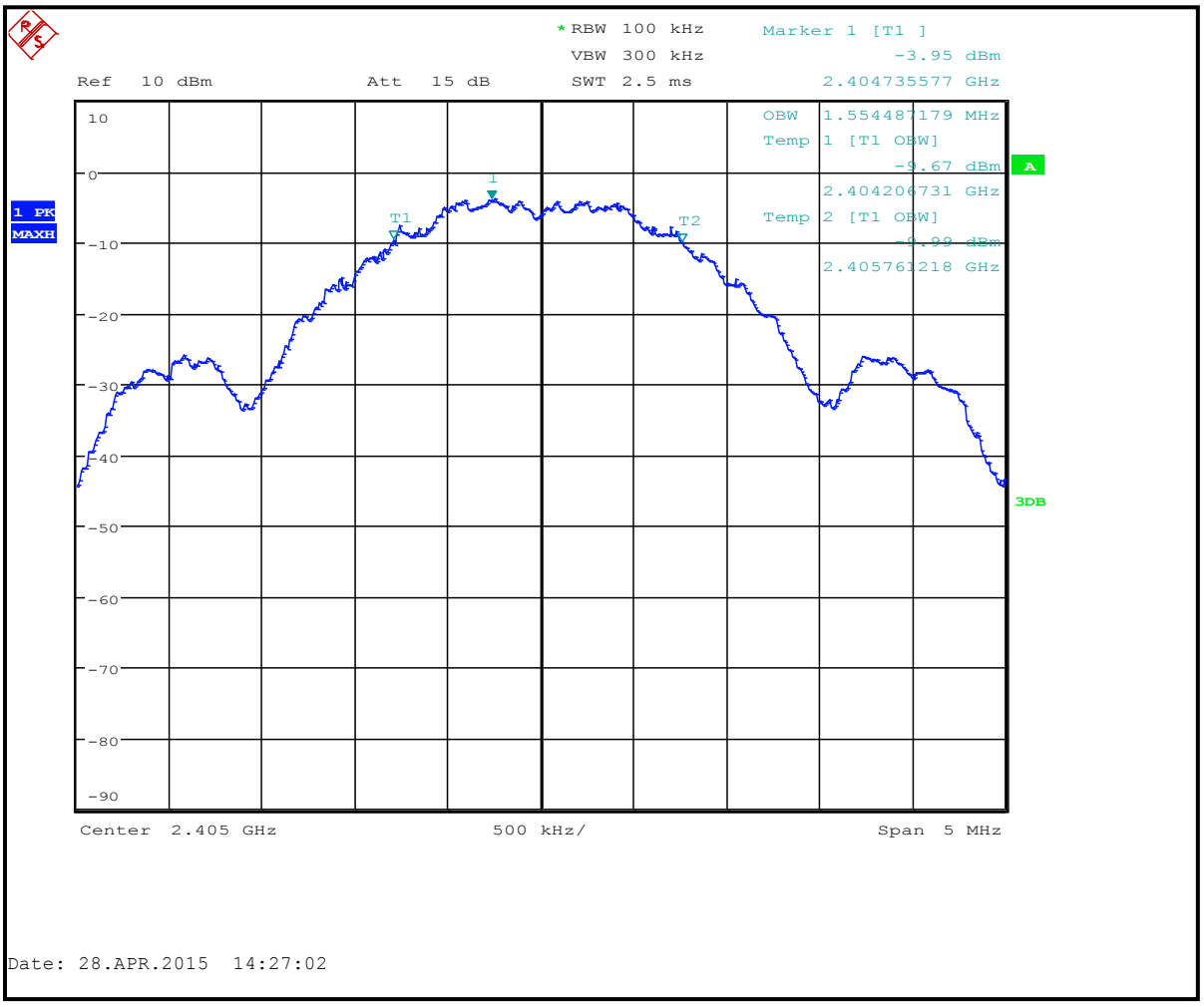
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	FSU	Spectrum Analyzer	1166.1660.50	11/13/15

7.2 6 dB Bandwidth Test Results

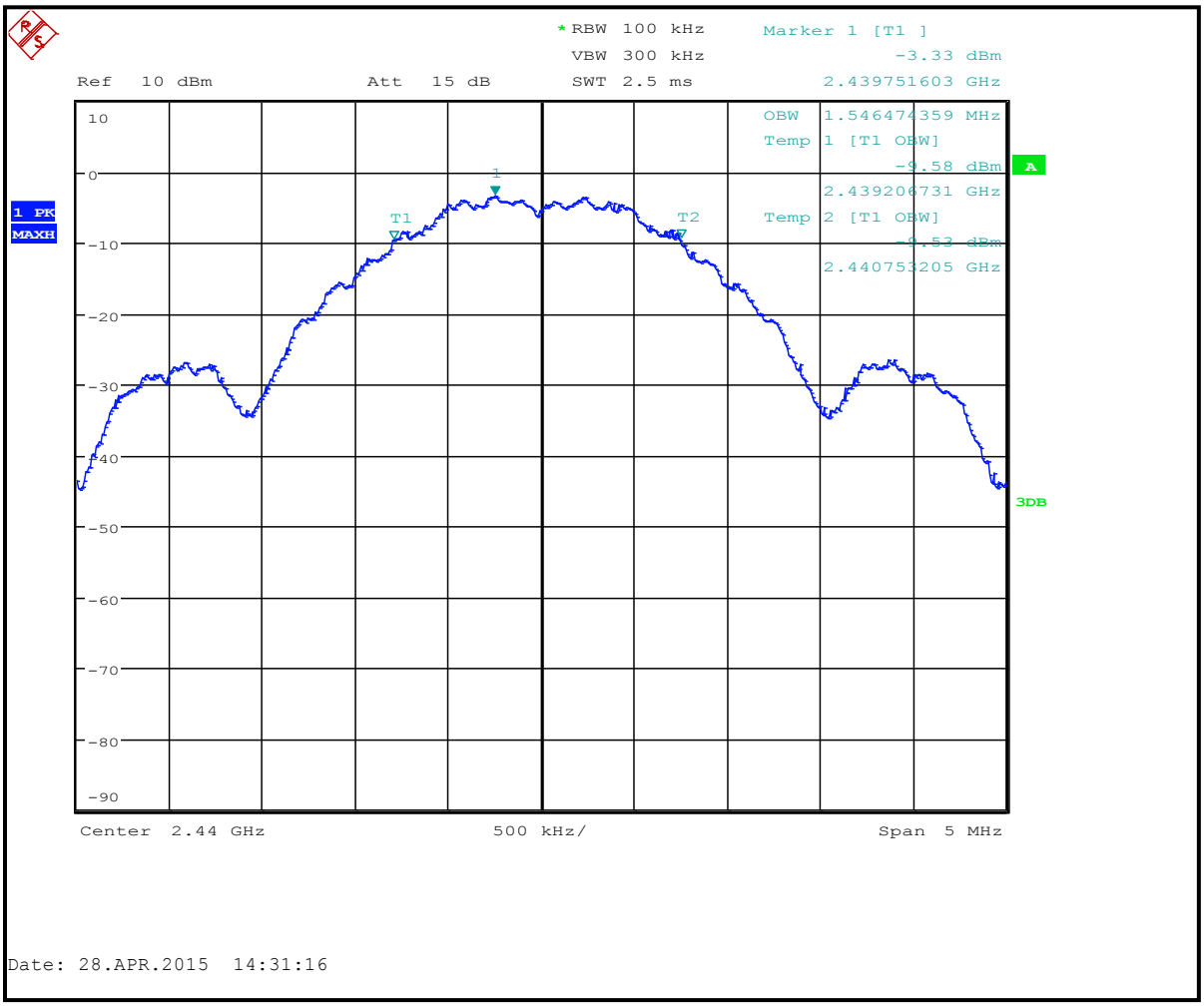
Table 7-2: 6 dB Bandwidth Test Data

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (MHz)	Pass/Fail
2405	1.6	0.5	Pass
2440	1.6	0.5	Pass
2480	1.5	0.5	Pass

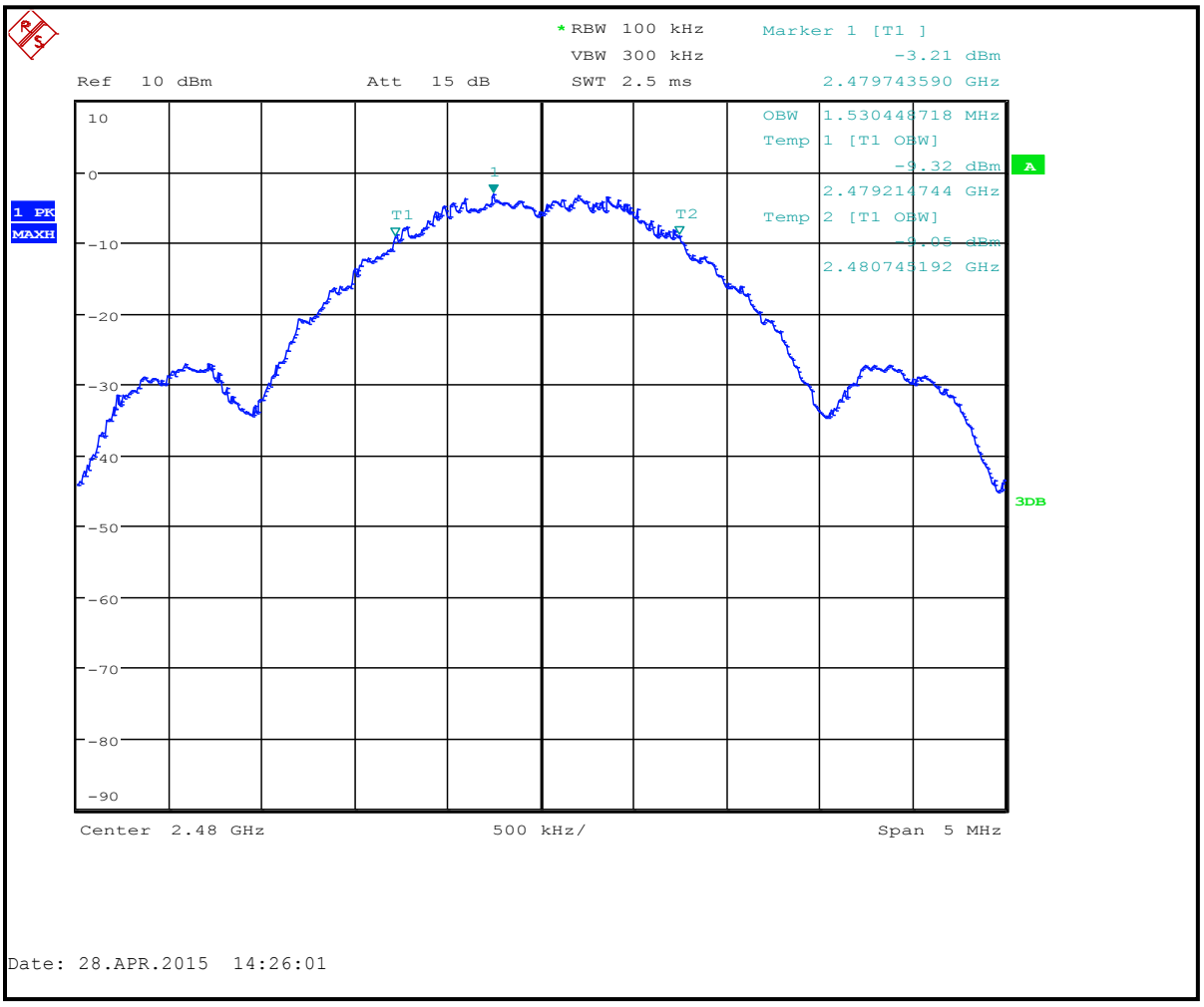
Plot 7-1: 6 dB Bandwidth – 2405 MHz



Plot 7-2: 6 dB Bandwidth – 2440 MHz



Plot 7-3: 6 dB Bandwidth – 2480 MHz



Test Personnel:

Dan Baltzell		April 28, 2015
Test Engineer	Signature	Date of Test

8 Power Spectral Density - 15.247(e); RSS-210 A8.2(b)

8.1 Power Spectral Density Test Procedure

The power spectral density per FCC 15.247(e) was measured using a 50 ohm spectrum analyzer with the resolution bandwidth set at 3 kHz, the video bandwidth set at 10 kHz, and the sweep time set at 150 seconds. The spectral lines were resolved for the modulated carriers at 2405, 2440 and 2480 MHz. These levels are below the +8 dBm limit. See the power spectral density table and plots.

Table 8-1: Power Spectral Density Test Equipment

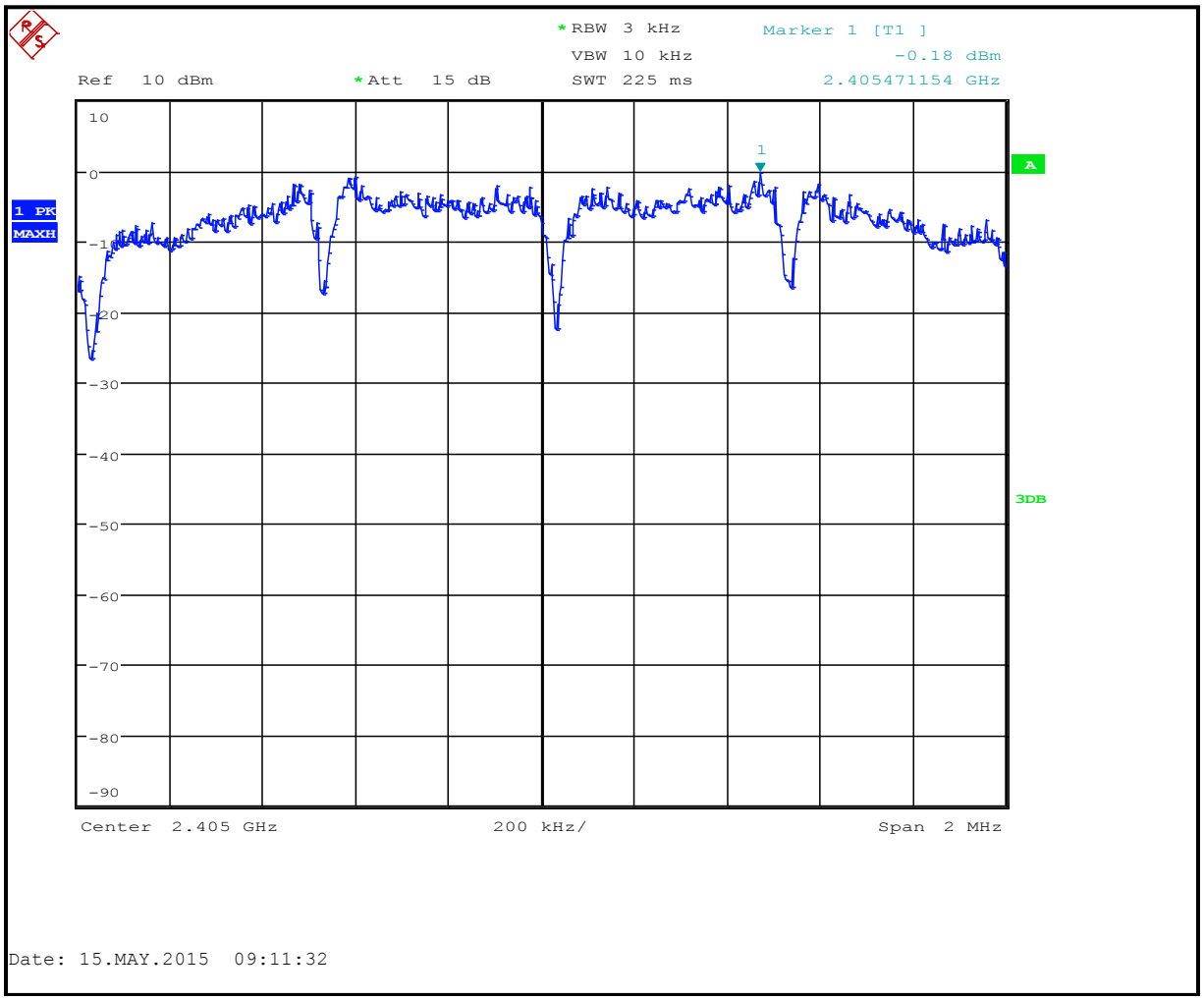
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	FSU	Spectrum Analyzer	1166.1660.50	11/13/15

8.2 Power Spectral Density Test Data

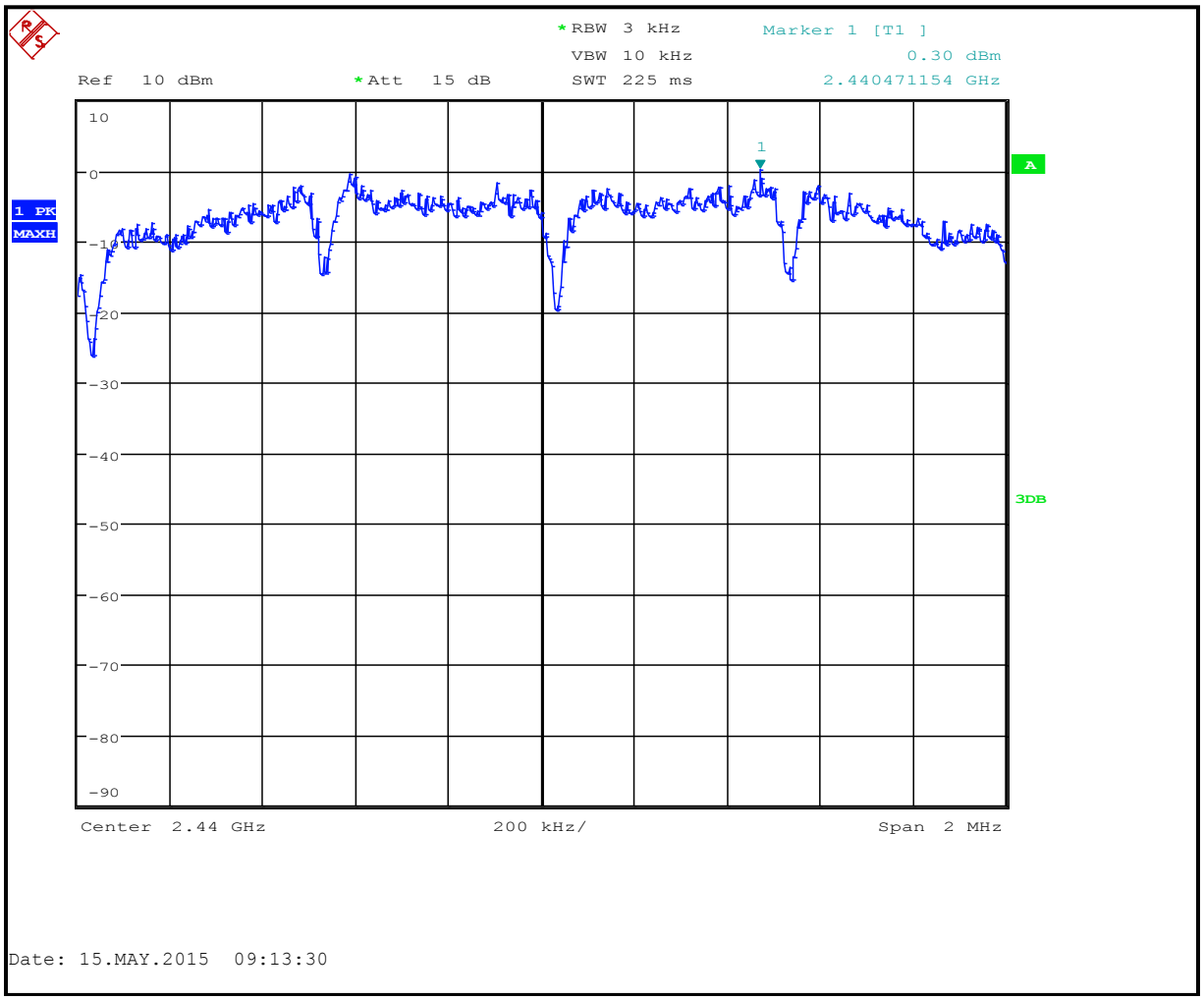
Table 8-2: Power Spectral Density Test Data

Frequency (MHz)	RF Power Level (dBm)	Maximum Limit +8dBm	Pass/Fail
2405	-0.2	8	Pass
2440	0.3	8	Pass
2480	-0.4	8	Pass

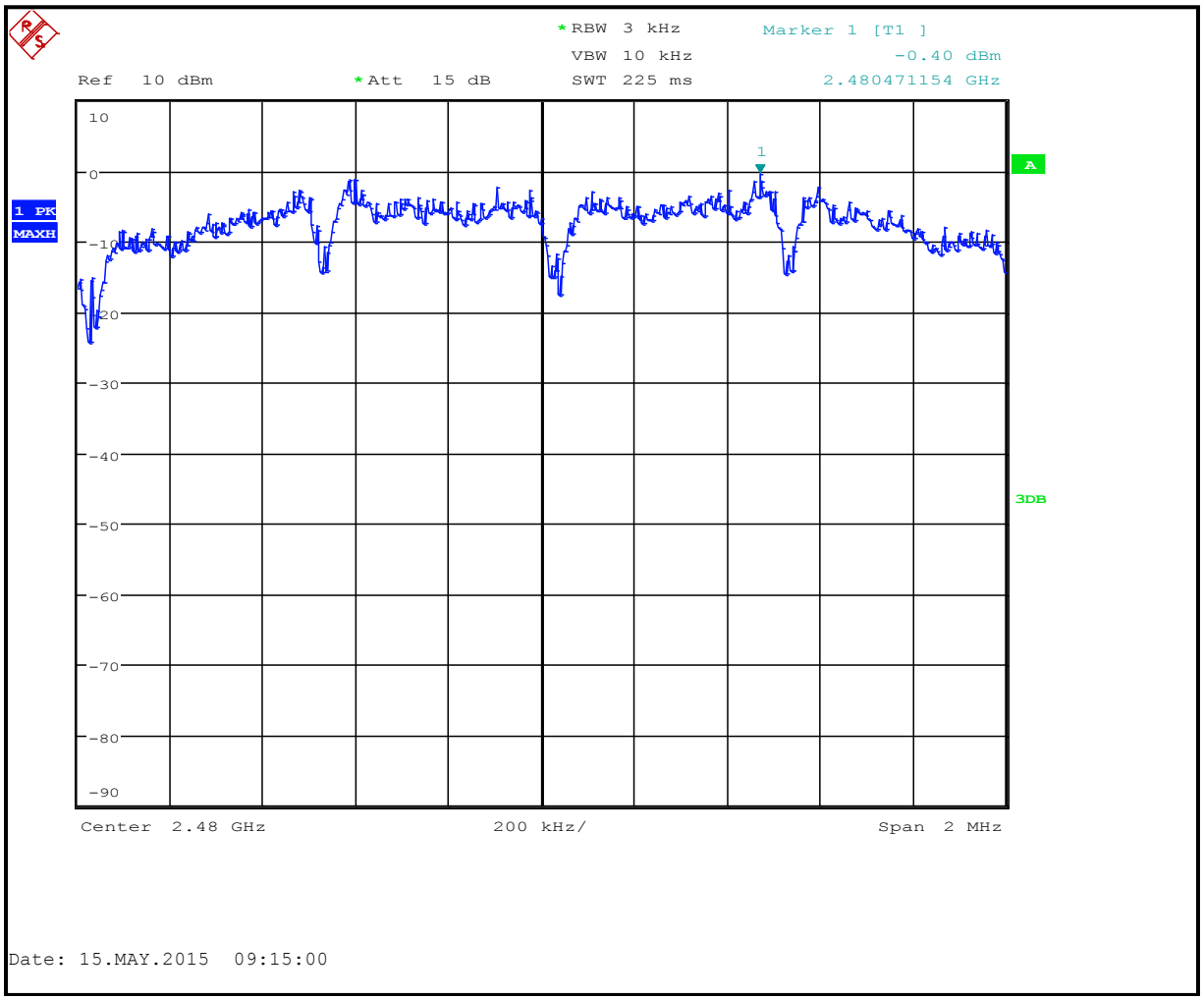
Plot 8-1: Power Spectral Density – 2405 MHz



Plot 8-2: Power Spectral Density – 2440 MHz



Plot 8-3: Power Spectral Density – 2480 MHz



Test Personnel:

Dan Baltzell		May 15, 2015
Test Engineer	Signature	Date of Test

9 Radiated Emissions - 15.209; RSS-210 2.2; RSS-Gen 6.13/7.1

9.1 Limits of Radiated Emissions Measurement

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
0.009-0.490	2400/f (kHz)	300
0.490-1.705	2400/f (kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

As shown in 15.35(b), for frequencies above 1000 MHz, 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, specified above by more than 20 dB under any circumstances of modulation.

9.2 Radiated Emissions Measurement Test Procedure

Before final measurements of radiated emissions were made on the open-field three/ten meter range, the EUT was scanned indoors at one and three meter distances. This was done in order to determine its emissions spectrum signature. The physical arrangement of the test system and associated cabling was varied in order to determine the effect on the EUT's emissions in amplitude, direction and frequency. This process was repeated during final radiated emissions measurements on the open-field range, at each frequency, in order to ensure that maximum emission amplitudes were attained.

Final radiated emissions measurements were made on the three/ten-meter, open-field test site. The EUT was placed on a nonconductive turntable 0.8 meters above the ground plane. The spectrum was examined from 9 kHz to the 10^{th} harmonic of the highest fundamental transmitter frequency (24.8 GHz).

At each frequency, the EUT was rotated 360°, and the antenna was raised and lowered from 1 to 4 meters in order to determine the emission's maximum level. Measurements were taken using both horizontal and vertical antenna polarizations. For frequencies between 30 and 1000 MHz, the spectrum analyzer's 6 dB bandwidth was set to 120 kHz, and the analyzer was operated in the CISPR quasi-peak detection mode. For emissions above 1000 MHz, emissions are measured using the average detector function with a minimum resolution bandwidth of 1 MHz. No video filter less than 10 times the resolution bandwidth was used. The highest emission amplitudes relative to the appropriate limit were measured and recorded in this report.

Table 9-1: Radiated Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
900878	Rhein Tech Laboratories	AM3-1197-0005	3 meter Antenna Mast, Polarizing	Outdoor Range 1	Not Required
901592	Insulated Wire Inc.	KPS-1503-3600-KPR	SMK RF Cables 20'	NA	9/3/15
901593	Insulated Wire Inc.	KPS-1503-360-KPR	SMK RF Cables 36"	NA	9/3/15
901242	Rhein Tech Laboratories	WRT-000-0003	Wood Rotating Table	N/A	Not Required
901581	Rohde & Schwarz	FSU	Spectrum Analyzer	1166.1660.50	11/13/15
900772	EMCO	3161-02	Horn Antenna (2 - 4 GHz)	9804-1044	4/9/18
900321	EMCO	3161-03	Horn Antenna (4.0 - 8.2 GHz)	9508-1020	4/9/18
900323	EMCO	3160-07	Horn Antenna (8.2 - 12.4 GHz)	9605-1054	4/9/18
900356	EMCO	3160-08	Horn Antenna (12.4 - 18 GHz)	9607-1044	4/9/18
900325	EMCO	3160-9	Horn Antennas (18 - 26.5 GHz)	9605-1051	4/9/18
900791	Chase	CBL6111B	Bilog Antenna (30 MHz – 2000 MHz)	N/A	6/11/17

9.3 Radiated Emissions Test Results

9.3.1 Radiated Emissions Digital Test Data

Table 9-2: Digital Radiated Emissions Test Data

Temperature: 75°F Humidity: 27%										
Emission Frequency (MHz)	Test Detector	Antenna Polarity (H/V)	Turntable Azimuth (deg)	Antenna Height (m)	Analyzer Reading (dBuV)	Site Correction Factor (dB/m)	Emission Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Pass/ Fail
136.500	Qp	V	180	1.0	6.0	12.5	18.5	43.5	-25.0	Pass
204.647	Qp	H	70	1.5	7.8	10.6	18.4	43.5	-25.1	Pass
385.000	Qp	V	225	1.0	4.0	16.9	20.9	46.0	-25.1	Pass
473.942	Qp	H	270	1.5	5.0	18.7	23.7	46.0	-22.3	Pass
240.015	Qp	V	80	1.0	13.1	12.7	25.8	46.0	-20.2	Pass
288.015	Qp	V	90	1.0	9.0	14.6	23.6	46.0	-22.4	Pass

9.3.2 Radiated Emissions Harmonics/Spurious Test Data

Table 9-3: Radiated Emissions Harmonics/Spurious - Peak - 2405 MHz

Emission Frequency (MHz)	Peak Analyzer Reading (dBuV) (1 MHz RBW/VBW)	Site Correction Factor (dB/m)	Peak Emission Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)
4810.0	29.8	33.2	63.0	74.0	-11.0
12025.0	16.8	44.0	60.8	74.0	-13.2
19240.0	11.4	52.9	64.3	74.0	-9.7

Table 9-4: Radiated Emissions Harmonics/Spurious – Average - 2405 MHz

Emission Frequency (MHz)	Average Analyzer Reading (dBuV)	Site Correction Factor (dB/m)	Average Emission Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)
4810.0	3.8	33.2	37.0	54.0	-5.6
12025.0	-9.2	44.0	34.8	54.0	-30.0
19240.0	-14.6	52.9	38.3	54.0	-11.1

Table 9-5: Radiated Emissions Harmonics/Spurious – Peak - 2440 MHz

Emission Frequency (MHz)	Peak Analyzer Reading (dBuV) (1 MHz RBW/VBW)	Site Correction Factor (dB/m)	Peak Emission Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)
4880.0	27.9	33.3	61.2	74.0	-12.8
7320.0	30.6	35.7	66.3	74.0	-7.7
12200.0	13.9	44.0	57.9	74.0	-16.1
19520.0	13.5	53.0	66.5	74.0	-7.5

Table 9-6: Radiated Emissions Harmonics/Spurious – Average - 2440 MHz

Emission Frequency (MHz)	Average Analyzer Reading (dBuV)	Site Correction Factor (dB/m)	Average Emission Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)
4880.0	1.9	33.3	35.2	54.0	-18.8
7320.0	4.6	35.7	40.3	54.0	-13.7
12200.0	-12.1	44.0	31.9	54.0	-22.1
19520.0	-12.5	53.0	40.5	54.0	-13.5

Table 9-7: Radiated Emissions Harmonics/Spurious – Peak - 2480 MHz

Emission Frequency (MHz)	Peak Analyzer Reading (dBuV) (1 MHz RBW/VBW)	Site Correction Factor (dB/m)	Peak Emission Level (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)
4960.0	29.8	33.4	63.2	74.0	-10.8
7440.0	33.3	35.8	69.1	74.0	-4.9
12400.0	12.5	44.0	56.5	74.0	-17.5
19840.0	12.4	53.2	65.6	74.0	-8.4
22320.0	13.8	54.2	68.0	74.0	-6.0

Table 9-8: Radiated Emissions Harmonics/Spurious – Average - 2480 MHz

Emission Frequency (MHz)	Average Analyzer Reading (dBuV)	Site Correction Factor (dB/m)	Average Emission Level (dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)
4960.0	3.8	33.4	37.2	54.0	-16.8
7440.0	7.3	35.8	43.1	54.0	-10.9
12400.0	-13.5	44.0	30.5	54.0	-23.5
19840.0	-13.6	53.2	39.6	54.0	-14.4
22320.0	-12.2	54.2	42.0	54.0	-12.0

Test Personnel:

Daniel W. Baltzell		May 21, 2015
Test Engineer	Signature	Date of Test

10 Conclusion

The data in this measurement report shows that the EUT as tested, Hunter Engineering Company Model 146-59-1, FCC ID: LS3-146591, IC: 2938A-146591, complies with the applicable requirements of Parts 2 and 15 of the FCC Rules and Regulations and Industry Canada RSS-210 and RSS-Gen.