RHEIN TECH LABORATORIES, INC.

Engineering Solutions & Electromagnetic Compatibility Services

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

Test Lab:	Applicant:
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FCC/IC ID	RMK-NVQZIGB1 10839A-NVQZIGB1	**Test Report Date**	January 31, 2013
Platform	N/A	**RTL Work Order #**	2013010
Model #	NVQRADIOZIGB1	**RTL Quote #**	QRTL13-010A
American National Standard Institute	ANSI C63.4-2003: Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz		
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 November 1, 2012, 558074 D01 DTS Meas Guidance v01		
Industry Canada	RSS-210 Issue 8: Low Power License-Exempt Communications Devices RSS-Gen Issue 3; 2010: General Requirements and Information for the Certification of Radio Apparatus		
Digital Interface Information	Digital Interface was found to be compliant		

Frequency Range (MHz)	Output Power (W)	Frequency Tolerance	Emission Designator
2405 – 2480	0.002	N/A	1M66FXD

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, IC RSS-210, IC RSS-Gen and ANSI C63.4.

Signature: _____ Date: January 31, 2013

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

These tests are accredited and meet the requirements of ISO/IEC 17025 as verified by ANSI-ASQ National Accreditation Board/ACLASS. Refer to certificate and scope of accreditation AT-1445.

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1 General Information

1.1 Scope

This is an original certification application request for the TMI-USA, Inc. NanoVACQ 2.4 GHz, Model # NVQRADIOZIGB1.

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: Low Power License-Exempt Communications Devices

1.2 Description of EUT

Equipment Under Test	Data Logger
Model/Model #	NanoVACQ 2.4 GHz/NVQRADIOZIGB1
Power Supply	TMI-Orion battery pack
Modulation Type	DSSS
Frequency Range	2405 – 2480 MHz
Antenna Connector Type	Reverse polarity SMA
Antenna Type	External Omni

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 (ANSI C63.4-2003).

1.4 Related Submittal(s)/Grant(s)

This is an original certification application for TMI-USA, Inc., NanoVACQ 2.4 GHz, Model # NVQRADIOZIGB1, FCC ID: RMK-NVQZIGB1, IC: 10839A-NVQZIGB1.

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 (11)	2405
Middle (18)	2440
High (26)	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.

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

2.4 Test System Details

The test samples were received on January 16, 2013. 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
Data Logger	TMI-USA, Inc.	NVQRADIOZIGB1	N/A	RMK-NVQZIGB1	N/A	20973

2.5 Configuration of Tested System

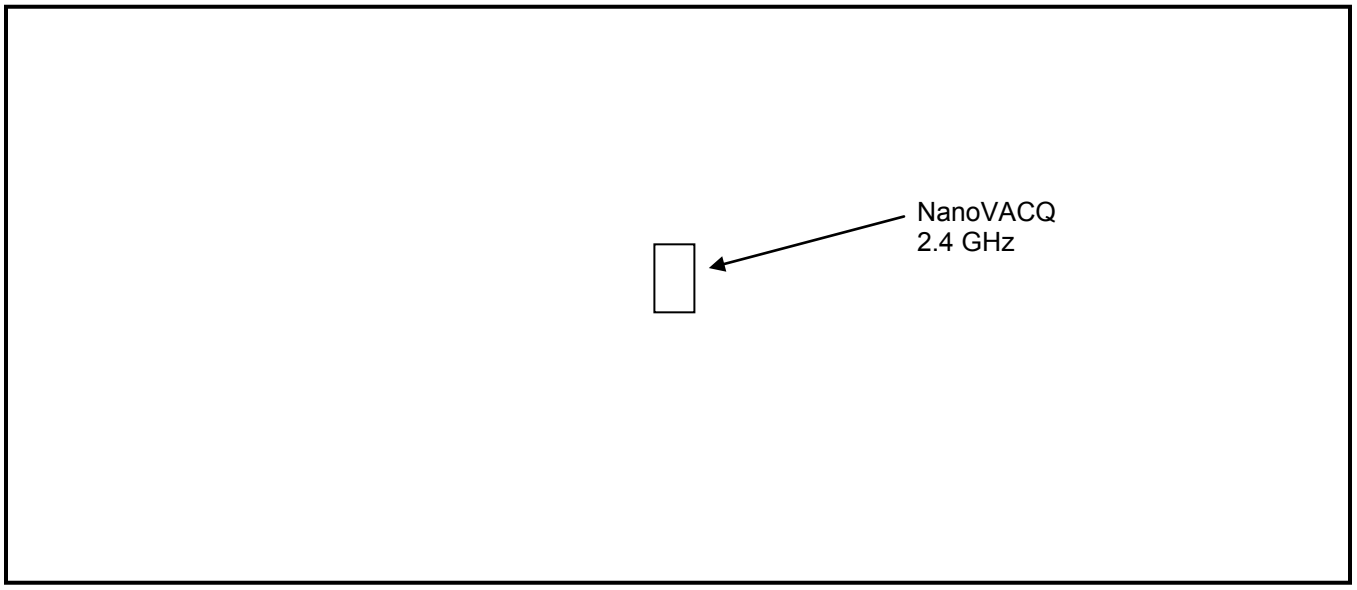


Figure 2-1: Configuration of System Under Test

3 Peak Output Power – FCC §15.247(b)(1); RSS-210 §A8.4(4)

3.1 Power Output Test Procedure

A conducted power measurement of the EUT was taken using a Rhode & Schwarz FSU Spectrum Analyzer.

Table 3-1: Power Output Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13

3.2 Power Output Test Data

Table 3-2: Power Output Test Data

Channel	Frequency (MHz)	Peak Power Conducted Output (dBm)
11	2405	2.4
18	2440	2.1
26	2480	1.7

Test Personnel:

Daniel W. Baltzell		January 17, 2013
Test Engineer	Signature	Date of Test

4 Compliance with the Band Edge – FCC §15.247(d); RSS-210 §2.2

4.1 Band Edge Test Procedure

The transmitter output was connected to its appropriate antenna. Peak and average radiated measurements were taken with a suitable span to encompass the peak of the fundamental. A delta measurement was performed from the highest peak in the restricted band to the peak of the fundamental, and subtracted from the field strength; the result was compared to the limit in the restricted band (54 dBuV/m).

Table 4-1: Band Edge Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13
900878	Rhein Tech Laboratories	AM3-1197-0005	3 meter antenna mast, polarizing	Outdoor Range 1	Not Required
901242	Rhein Tech Laboratories	WRT-000-0003	Wood rotating table	N/A	Not Required
900772	EMCO	3161-02	Horn Antenna (2-4 GHz)	9804-1044	4/19/14

4.2 Restricted Band Edge Test Results

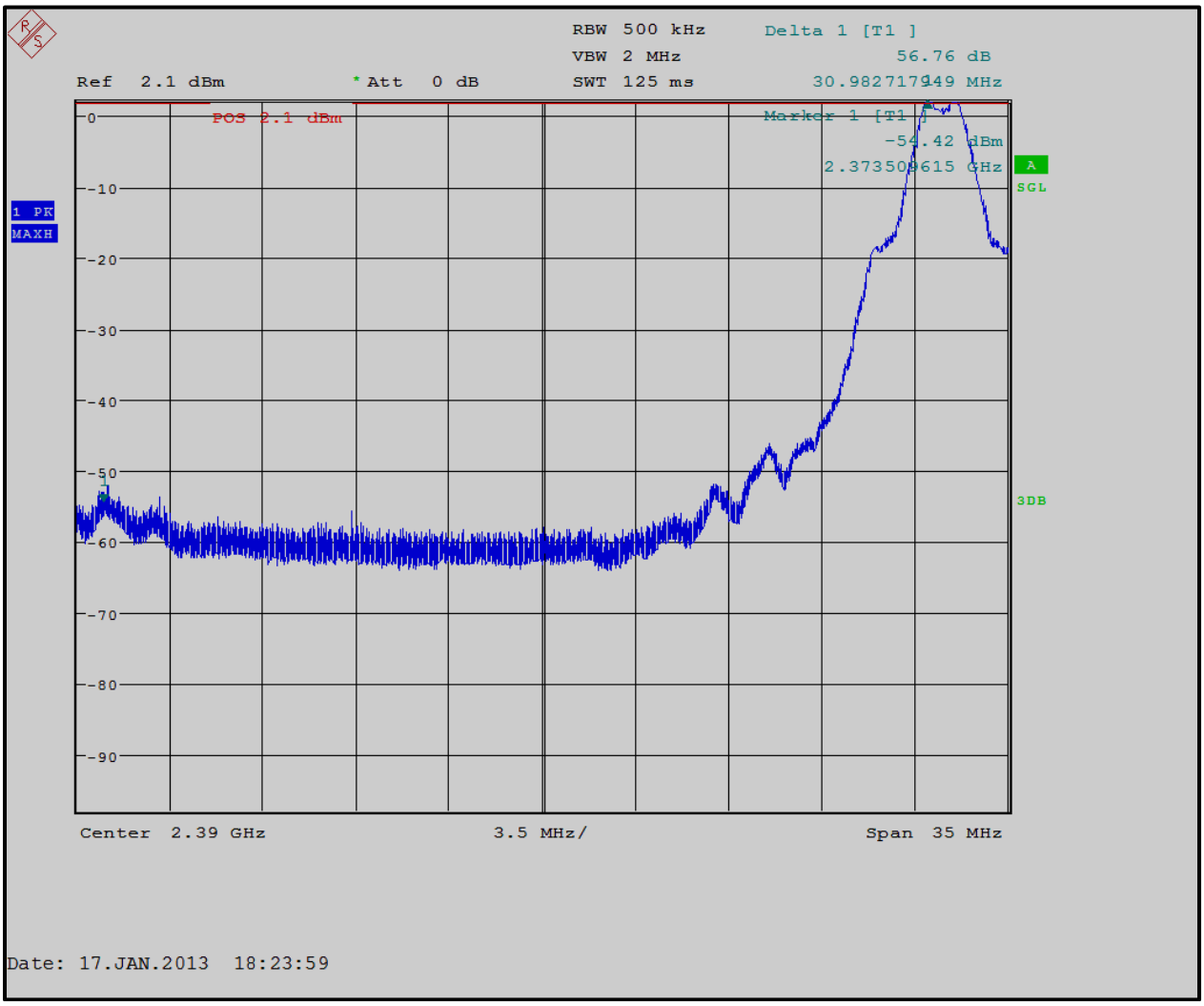
4.2.1 Calculation of Lower Band Edge

95.3 dBuV/m is the field strength measurement, from which the delta measurement of 56.8 dB is subtracted (reference plots), resulting in a level of 38.5 dBuV/m. This level has a margin of 15.5 dB below the limit of 54 dBuV/m.

Calculation: 95.3 dBuV/m – 56.8 dB – 54 dBuV/m = -15.5 dB

Peak Field Strength of Lower Band Edge (1 MHz RBW/3 MHz VBW, Pk Det.) = 97.9 dBuV/m
Average Field Strength of Lower Band Edge (1 MHz RBW/3 MHz VBW, Av Det.) = 95.3 dBuV/m
Delta measurement = 56.8 dB

Plot 4-1: Lower Band Edge - 2405 MHz



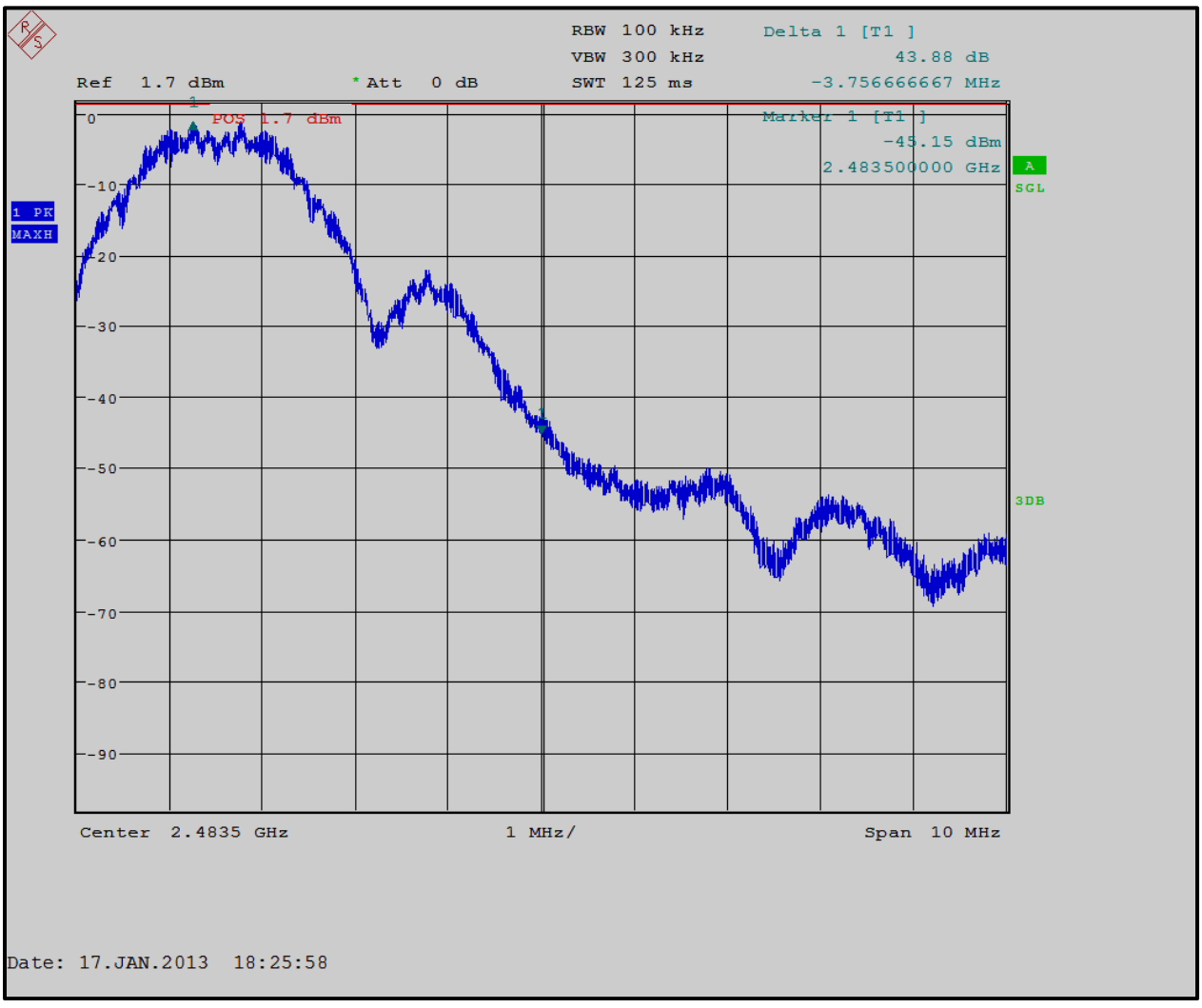
4.2.2 Calculation of Upper Band Edge – 802.11b

95.5 dBuV/m is the field strength measurement, from which the delta measurement of 43.9 dB is subtracted (reference plots), resulting in a level of 51.6 dBuV/m. This level has a margin of 2.4 dB below the limit of 54 dBuV/m.

Calculation: 95.5 dBuV/m – 43.9 dB – 54 dBuV/m = -2.4 dB

Peak Field Strength of Upper Band Edge (1 MHz RBW/3 MHz VBW, Pk. Det.) = 97.8 dBuV/m
Average Field Strength of Upper Band Edge (1 MHz RBW/3 MHz VBW, Av Det.) = 95.5 dBuV/m
Delta measurement = 43.9 dB

Plot 4-2: Upper Band Edge - 2480 MHz



Test Personnel:

Daniel W. Baltzell		January 17, 2013
Test Engineer	Signature	Date of Test

5 Antenna Conducted Spurious Emissions – FCC §15.247(d); RSS-Gen

5.1 Antenna Conducted Spurious Emissions Test Procedure

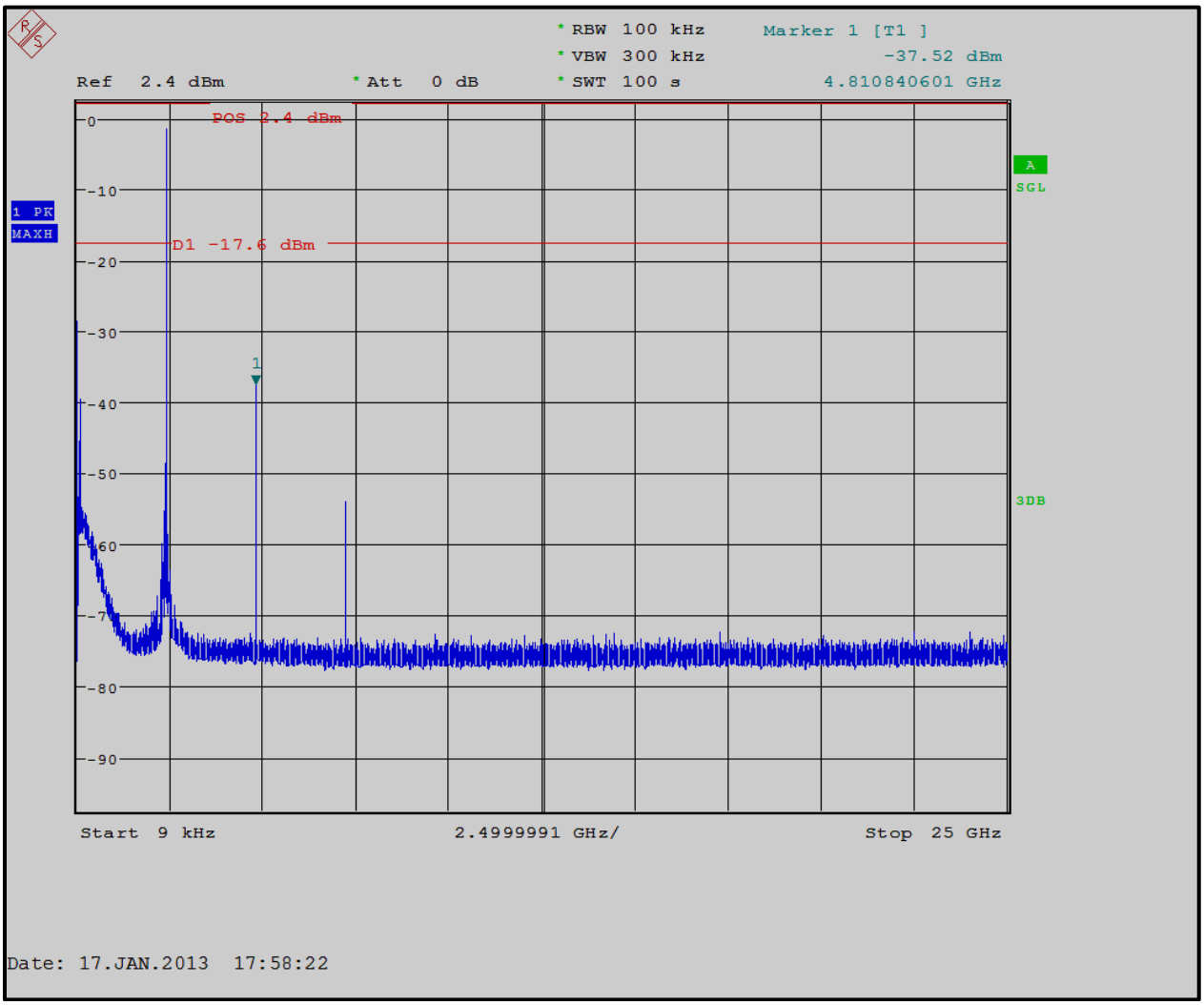
Antenna spurious emissions per FCC 15.247(d) were measured from the EUT antenna port using a 50-ohm spectrum analyzer with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 300 kHz. The modulated carrier was identified at the following frequencies: 2405 MHz, 2440 MHz and 2480 MHz.

Table 5-1: Antenna Conducted Spurious Emissions Test Equipment

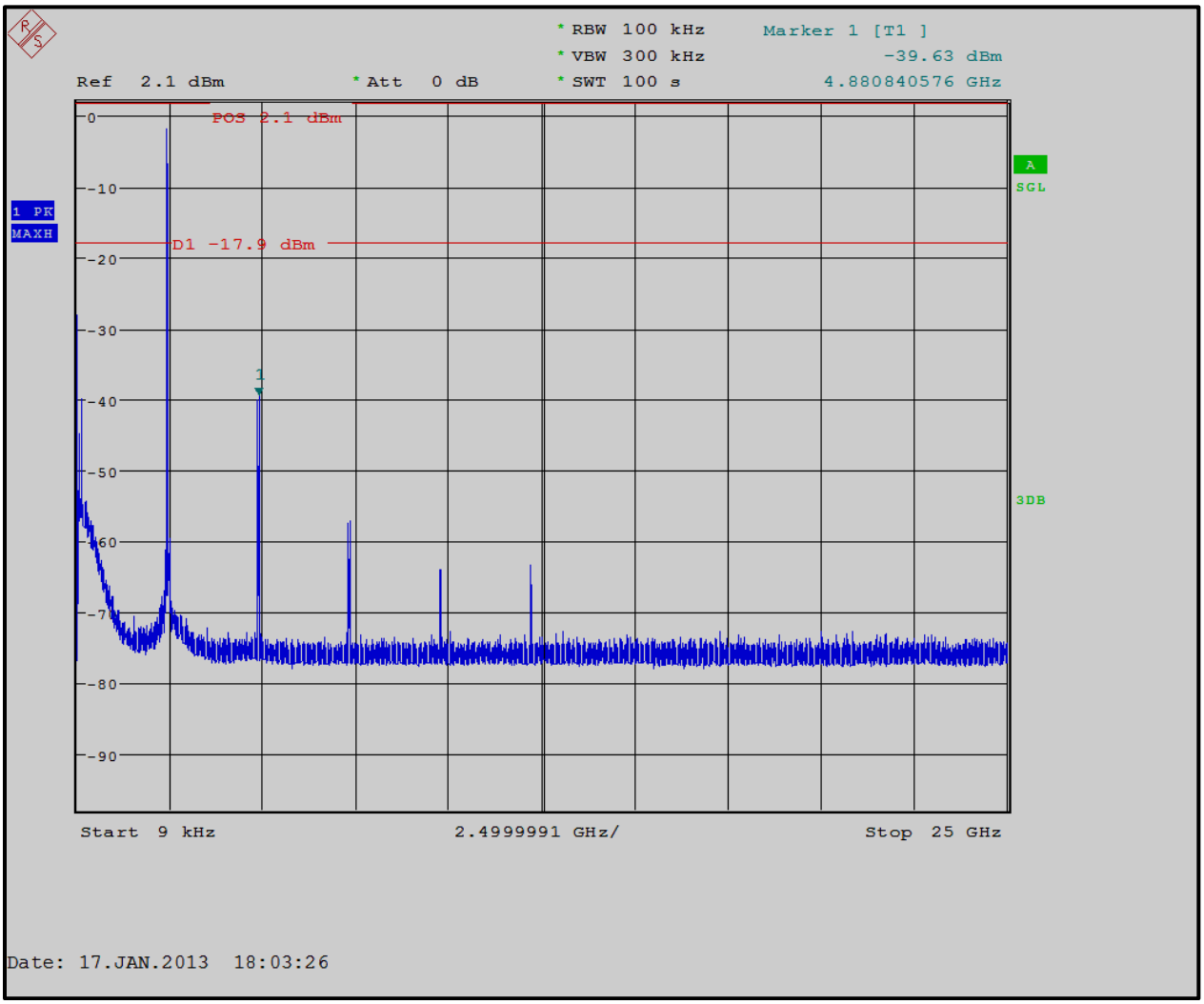
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13

5.2 Antenna Conducted Spurious Emissions Test Results

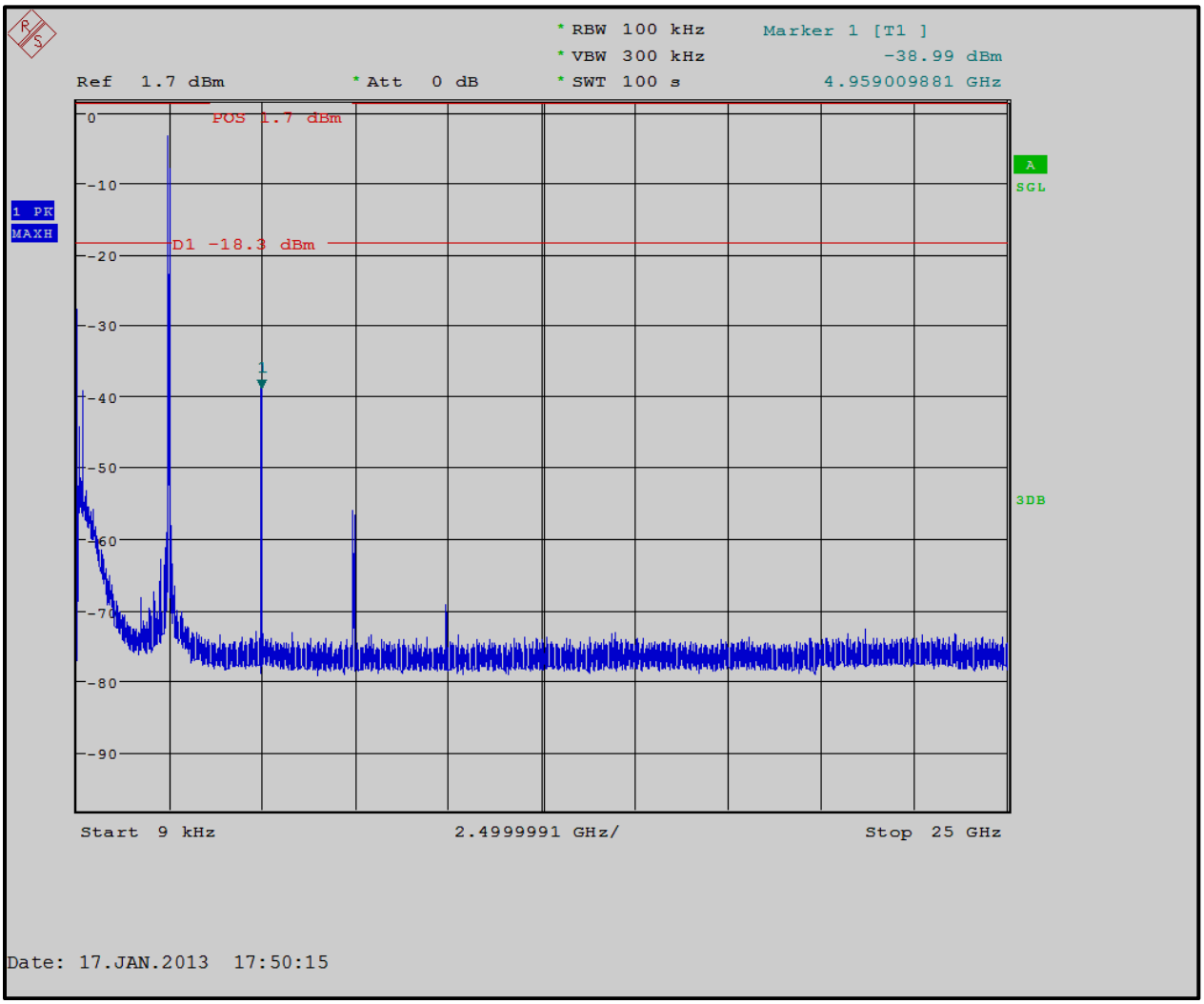
Plot 5-1: Antenna Conducted Spurious Emissions - 2405 MHz



Plot 5-2: Antenna Conducted Spurious Emissions - 2440 MHz



Plot 5-3: Antenna Conducted Spurious Emissions - 2480 MHz



Test Personnel:

Daniel W. Baltzell	Daniel W. Baltzell	January 17, 2013
Test Engineer	Signature	Date of Test

6 Power Spectral Density – FCC §15.247(e); RSS-210 §A8.2

6.1 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 equal to or greater than 10 times the RBW, and the sweep time set at 500 seconds. The spectral lines were resolved for the modulated carriers at 2405 MHz, 2440 MHz, and 2480 MHz respectively. These levels are below the +8 dBm limit. See the power spectral density table and plots.

Table 6-1: Power Spectral Density Test Equipment

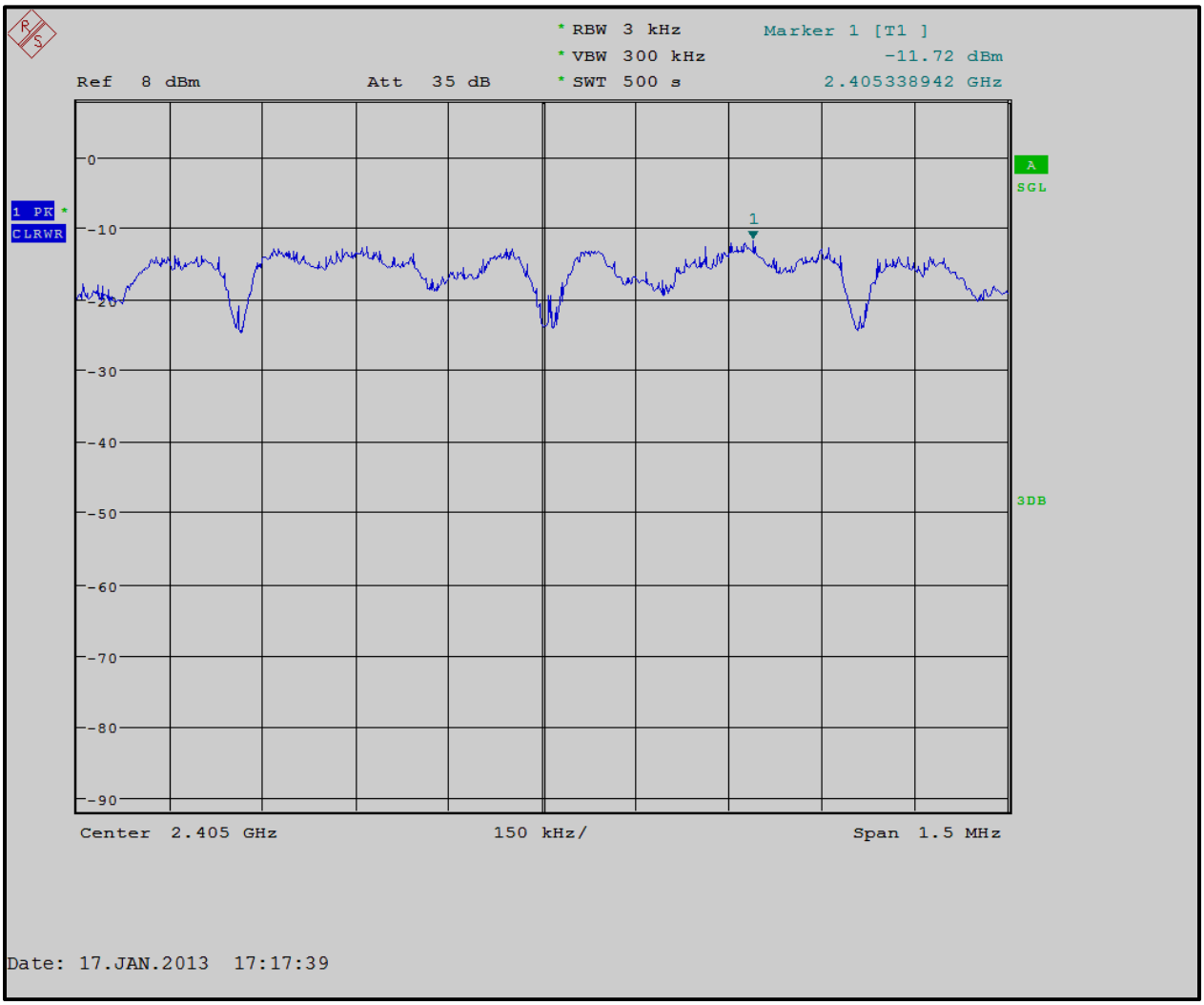
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13

6.2 Power Spectral Density Test Data

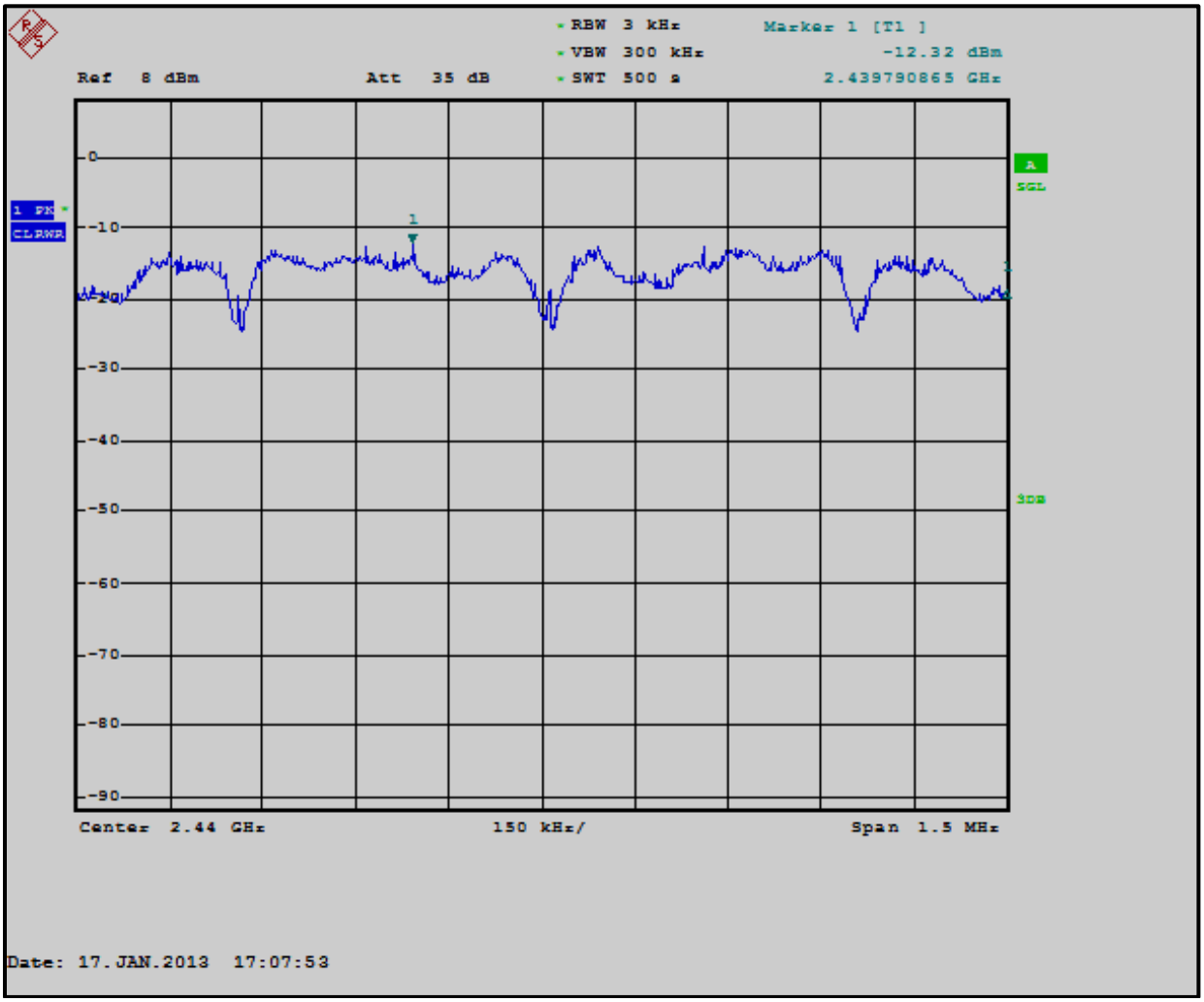
Table 6-2: Power Spectral Density Test Data

Channel	Frequency (MHz)	RF Power Level (dBm)	Maximum Limit +8dBm	Pass/Fail
11	2405	-11.7	8	Pass
18	2440	-12.3	8	Pass
26	2480	-13.0	8	Pass

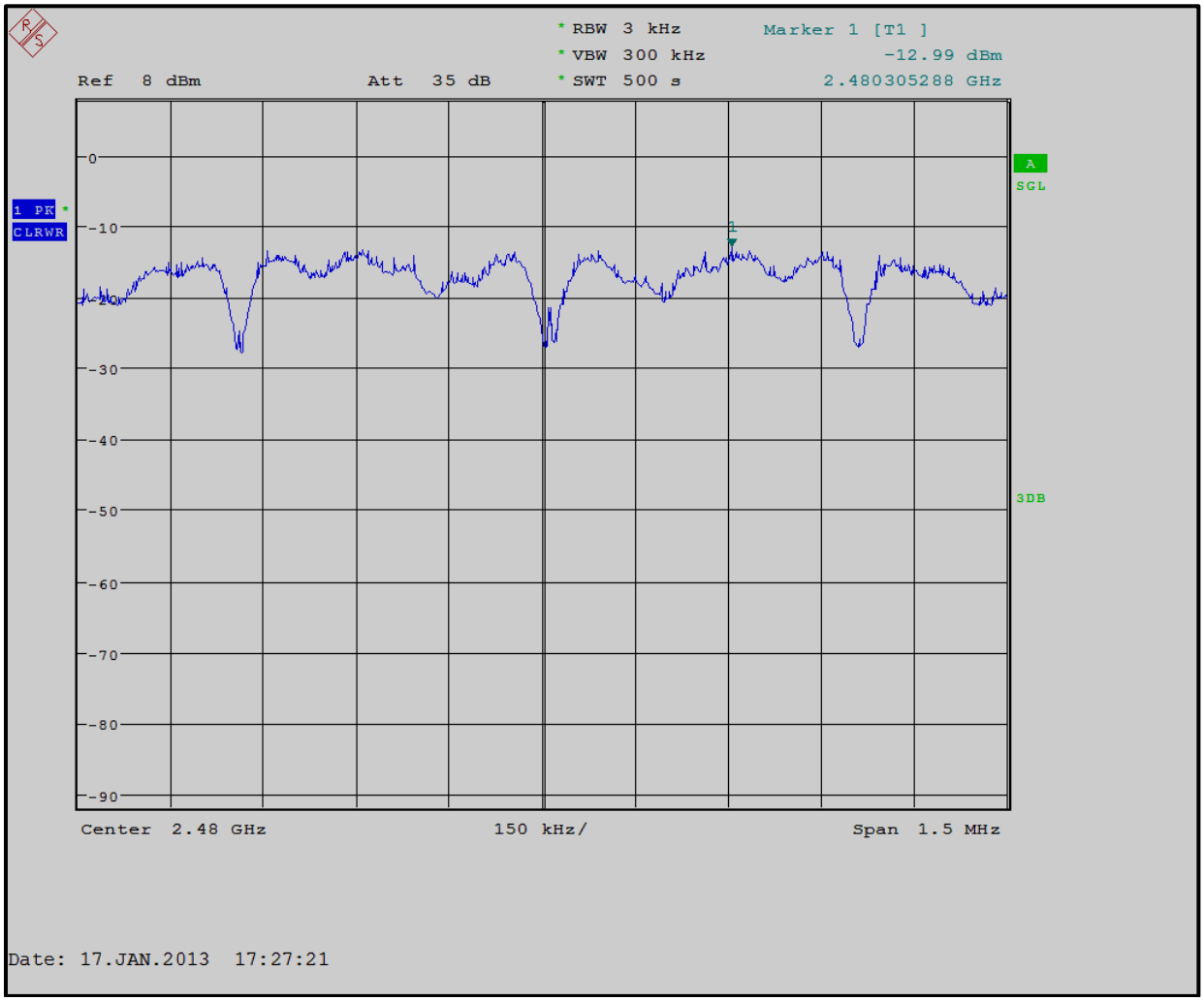
Plot 6-1: Power Spectral Density - 2405 MHz



Plot 6-2: Power Spectral Density - 2440 MHz



Plot 6-3: Power Spectral Density - 2480 MHz



Test Personnel:

Daniel W. Baltzell	Daniel W. Baltzell	January 17, 2013
Test Engineer	Signature	Date of Test

7 Restricted Band Emissions – FCC §15.209, RSS-210 §A8.5

7.1 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.

7.2 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.

The EUT was terminated with a 50 ohm load to represent chassis emissions, an EIRP measurement was determined using the conducted measurements.

Table 7-1: Radiated Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
900932	Hewlett Packard	8449B OPT H02	Preamplifier (1-26.5 GH)z	3008A00505	7/14/13
900772	EMCO	3161-02	Horn Antenna (2-4 GHz)	9804-1044	4/19/14
900321	EMCO	3161-03	Horn Antenna (4.0-8.2 GHz)	9508-1020	4/19/14
900323	EMCO	3160-07	Horn Antenna (8.2-12.4 GHz)	9605-1054	4/19/14
900356	EMCO	3160-08	Horn Antenna (12.4-18 GHz)	9607-1044	4/19/14
900325	EMCO	3160-9	Horn Antenna (18-26.5 GHz)	9605-1051	4/19/14
900151	Rohde and Schwarz	HFH2-Z2	Loop Antenna (9 kHz-30 MHz)	827525/019	10/1/13
901595	Mini-Circuits	ZHL-4240V	Amplifier	H090293-5	2/17/13
900878	Rhein Tech Laboratories	AM3-1197-0005	3 meter antenna mast, polarizing	Outdoor Range 1	Not Required
901242	Rhein Tech Laboratories	WRT-000-0003	Wood rotating table	N/A	Not Required
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13
900791	Chase	CBL6111B	Bilog Antenna (30 MHz–2000 MHz)	N/A	1/31/13
901592	Insulated Wire Inc.	KPS-1503-3600-KPR	SMK RF Cables 20'	NA	8/16/13
901593	Insulated Wire Inc.	KPS-1503-360-KPR	SMK RF Cables 36"	NA	8/16/13

The following data shows compliance with the emissions falling within the restricted bands. The "conducted" method from 558074 D01 DTS Meas Guidance v01 section 5.4.2 was utilized.

The conducted emissions were converted to EIRP by adding a 2.0 dBi antenna gain (this is the worst case gain specified by558074 D01 DTS Meas Guidance v01 since the actual EUT antenna gain is 1 dBi) and further converted to 3 m field strength and compared to the radiated limit using the following formula (logarithmic):

$$E = EIRP - 20 \log (d) + 104.8$$

where:

EIRP = the equivalent isotropic radiated power in dBm (conducted power + antenna gain)
E = electric field strength in dBuV/m
d = measurement distance in meters (3 m)

For example, the first emission at 4810 MHz below is calculated:

$$E = 2 \text{ dBi} - 33.9 \text{ dBm} - 20 \log (3) + 104.8 = 63.3 \text{ dBuV/m @ 3 m}$$

Peak measurements were taken and compared to the 15.209 limit + 20 dB as specified by 15.35(b).

Average levels were then calculated by using the maximum EUT duty cycle of 30%, and compared to the 15.209 limit:

Correction: 20 log (0.3) = -10.5 dB

Table 7-2: Antenna Conducted Spurious Emissions Test Equipment

RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13

7.3 Restricted Band Emissions Test Results

Table 7-3: Restricted Band Emissions - 2405 MHz – Peak Detector

Emission Frequency (MHz)	Peak Analyzer Reading (dBm) (1 MHz RBW/ 10 MHz VBW)	Corrected with Antenna Factor (2.0 dBi) and converted to dBuV/m	Peak Limit (dBuV/m)	Peak Margin (dB)
4810.0	-33.9	63.3	74.0	-10.7
12025.0	-60.2	37.0	74.0	-37.0
19240.0	-69.6	27.6	74.0	-46.4

Table 7-4: Restricted Band Emissions - 2405 MHz – Calculated Average

Emission Frequency (MHz)	Average (dBm) (Peak – 30% duty cycle)	Corrected with Antenna Factor (2.0 dBi) and converted to dBuV/m)	Average Limit (dBuV/m)	Average Margin (dB)
4810.0	-44.4	52.8	54.0	-1.2
12025.0	-70.7	26.5	54.0	-27.5
19240.0	-80.1	17.1	54.0	-36.9

Table 7-5: Restricted Band Emissions - 2440 MHz – Peak Detector

Emission Frequency (MHz)	Peak Analyzer Reading (dBm) (1 MHz RBW/VBW)	Corrected with Antenna Factor (2.0 dBi) and converted to dBuV/m	Peak Limit (dBuV/m)	Peak Margin (dB)
4880.0	-32.8	64.4	74.0	-9.6
7320.0	-44.1	53.1	74.0	-20.9
12200.0	-69.9	27.3	74.0	-46.7

Table 7-6: Restricted Band Emissions - 2440 MHz – Calculated Average

Emission Frequency (MHz)	Average (dBm) (Peak – 30% duty cycle)	Corrected with Antenna Factor (2.0 dBi) and converted to dBuV/m	Average Limit (dBuV/m)	Average Margin (dB)
4880.0	-43.3	53.9	54.0	-0.1
7320.0	-54.6	42.6	54.0	-11.4
12200.0	-80.4	16.8	54.0	-37.2

Table 7-7: Restricted Band Emissions - 2480 MHz – Peak Detector

Emission Frequency (MHz)	Peak Analyzer Reading (dBm) (1 MHz RBW/VBW)	Corrected with Antenna Factor (2.0 dBi) and converted to dBuV/m	Peak Limit (dBuV/m)	Peak Margin (dB)
4960.0	-35.2	62.0	74.0	-12.0
7440.0	-44.2	53.0	74.0	-21.0
12400.0	-50.5	46.7	74.0	-27.3

Table 7-8: Restricted Band Emissions - 2480 MHz – Calculated Average

Emission Frequency (MHz)	Average (dBm) (Peak – 30% duty cycle)	Corrected with Antenna Factor (2.0 dBi) and converted to dBuV/m	Average Limit (dBuV/m)	Average Margin (dB)
4960.0	-45.7	51.5	54.0	-2.5
7440.0	-54.7	42.5	54.0	-11.5
12400.0	-61.0	36.2	54.0	-17.8

Test Personnel:

Daniel W. Baltzell		January 29, 2013
Test Engineer	Signature	Date of Test

7.4 Radiated Emissions Harmonics/Spurious Test Data – Cabinet Radiation with Antenna Port Terminated

Since we are using the "conducted" method for measuring restricted band emissions (per 558074 D01 DTS Meas Guidance v01 section 5.4.2), measurements for unwanted emissions radiated from the EUT cabinet are also required with the antenna port terminated with a load representing the impedance of the antenna. The data presented below is for cabinet radiation with the antenna port terminated; note that peak measurements were performed and compared to the average limit. All measurements were found to be compliant.

Table 7-9: Radiated Emissions Harmonics/Spurious - 2405 MHz – Peak Detector

Emission Frequency (MHz)	Peak Analyzer Reading (dBuV/m) (1 MHz RBW/VBW)	Site Correction Factor (dB/m)	Peak Corrected (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)
4810.0	34.6	-5.0	29.6	54.0	-24.4
12025.0	34.4	2.7	37.1	54.0	-16.9

Table 7-10: Radiated Emissions Harmonics/Spurious - 2440 MHz – Peak Detector

Emission Frequency (MHz)	Peak Analyzer Reading (dBuV/m) (1 MHz RBW/VBW)	Site Correction Factor (dB/m)	Peak Corrected (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)
4880.0	35.2	-5.0	30.2	54.0	-23.8
7320.0	40.1	-3.1	37.0	54.0	-17.0
12200.0	35.3	3.4	38.7	54.0	-15.3

Table 7-11: Radiated Emissions Harmonics/Spurious - 2480 MHz – Peak Detector

Emission Frequency (MHz)	Peak Analyzer Reading (dBuV/m) (1 MHz RBW/VBW)	Site Correction Factor (dB/m)	Peak Corrected (dBuV/m)	Average Limit (dBuV/m)	Margin (dB)
4960	35.1	-5.6	29.5	54.0	-24.5
7440	34.4	-3.4	31.0	54.0	-23.0
12400	35.1	3.3	38.4	54.0	-15.6

Test Personnel:

Daniel W. Baltzell		January 29, 2013
Test Engineer	Signature	Date of Test

8 AC Conducted Emissions - FCC §15.207; RSS-Gen §7.2.4: Conducted Limits

No AC conducted tests are required since the device is solely battery powered.

9 6 dB Bandwidth – FCC §15.247(a)(2); RSS-210 §A8.2

9.1 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 with the resolution bandwidth set at 100 kHz, and the video bandwidth set at 300 kHz. The device was modulated. The minimum 6 dB bandwidths are presented below.

Table 9-1: 6 dB Bandwidth Test Equipment

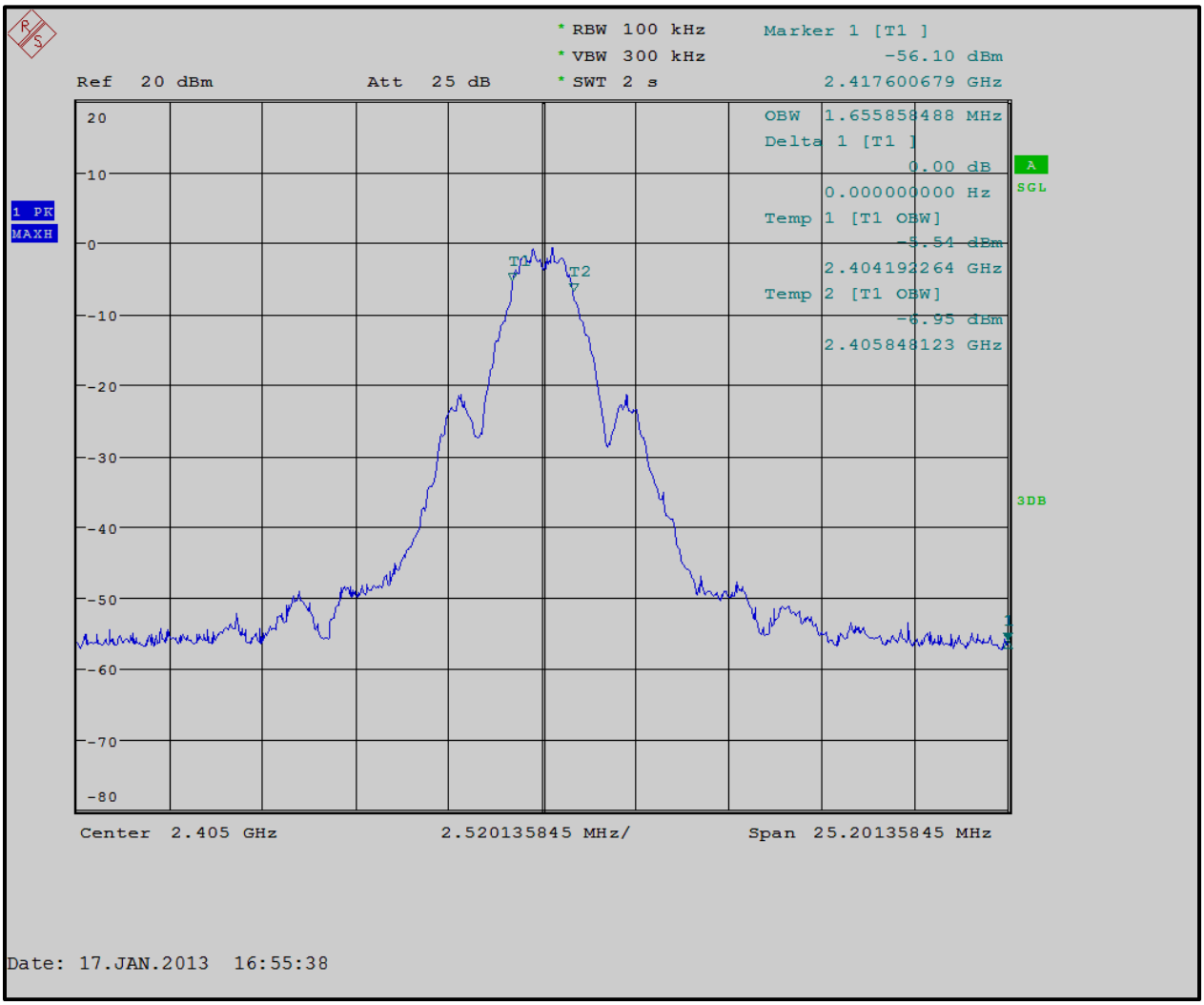
RTL Asset #	Manufacturer	Model	Part Type	Serial Number	Calibration Due Date
901581	Rohde & Schwarz	1166.1660.50	Spectrum Analyzer	2001006	6/3/13

9.2 6 dB Modulated Bandwidth Test Data

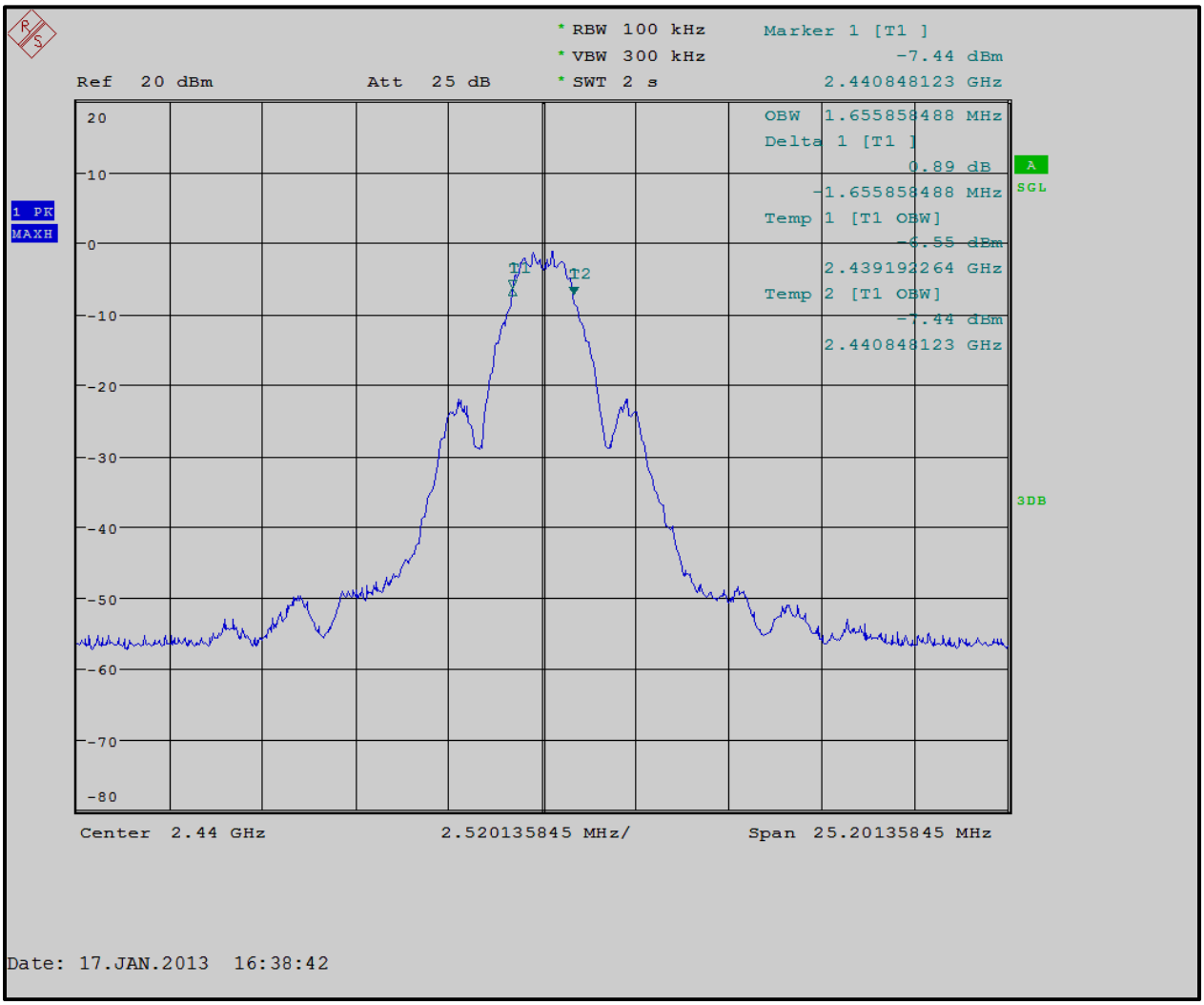
Table 9-2: 6 db Bandwidth Test Data – 802.11b

Channel	Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum Limit (kHz)	Pass/Fail
11	2405	1.66	500	Pass
18	2440	1.66	500	Pass
26	2480	1.66	500	Pass

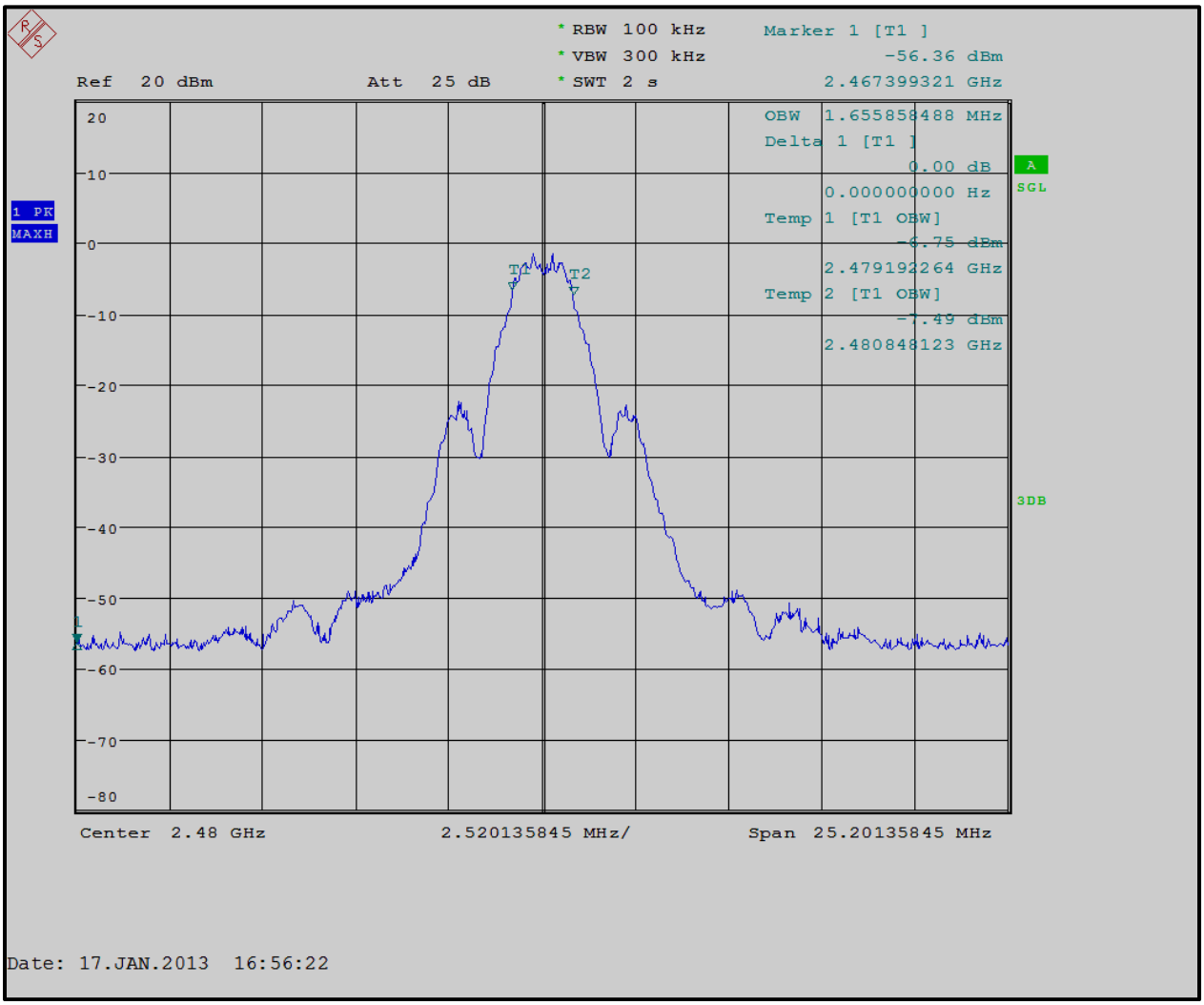
Plot 9-1: 6 dB Bandwidth - 2405 MHz



Plot 9-2: 6 dB Bandwidth - 2440 MHz



Plot 9-3: 6 dB Bandwidth - 2480 MHz



Test Personnel:

Daniel W. Baltzell		January 17, 2013
Test Engineer	Signature	Date of Test

10 Conclusion

The data in this measurement report shows that the EUT as tested, TMI-USA, Inc. Model NanoVACQ 2.4 GHz, Model # NVQRADIOZIGB1, FCC ID: RMK-NVQZIGB1, IC: 10839A-NVQZIGB1, complies with all the applicable requirements of Parts 2 and 15 of the FCC Rules and Regulations, and IC RSS-210 and RSS-Gen.