Excellence in Compliance Testing

Certification Test Report

FCC ID: U9O-SM220
IC: 7084A-SM220

FCC Rule Part: 15.247
IC Radio Standards Specification: RSS-210

ACS Report Number: 14-2066.W06.1B

Applicant: Synapse Wireless, Inc.
Model(s): SM220

Test Begin Date: **June 5, 2014**
Test End Date: **August 19, 2014**

Report Issue Date: September 15, 2014

ACCREDITED TESTING

FOR THE SCOPE OF ACCREDITATION UNDER CERTIFICATE NUMBER AT-1533

This report must not be used by the client to claim product certification, approval, or endorsement by ACLASS, ANSI, or any agency of the Federal Government.

Reviewed by:

Thierry Jean-Charles
EMC Engineer
Advanced Compliance Solutions, Inc.

This report contains 52 pages

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1 GENERAL

1.1 Purpose

The purpose of this report is to demonstrate compliance with Part 15 Subpart C of the FCC's Code of Federal Regulations and Industry Canada's Radio Standards Specification RSS-210.

1.2 Applicant Information

Synapse Wireless
6723 Odyssey Drive
Huntsville, AL 35806

1.3 Product Description

The Synapse Wireless model SM220 is an IEEE 802.15.4 RF module. The radio contains two radio ports. Port one uses an internal compact F antenna and all 16 channels are available to transmit and receive; port two is for use with an external antenna. The last channel at 2.480 GHz is not available for use on port two except for receive mode.

Technical Details

Mode of Operation:	IEEE 802.15.4
Frequency Range:	2405 MHz - 2480 MHz (Port 1)
	2405 MHz - 2475 MHz (Port 2)
Number of Channels:	16 Channels (Port 1)
	15 Channels (Port 2)
Channel Separation:	5 MHz
Modulations:	O-QPSK
Antenna Type/Gain:	Inverted-F Antenna, 0 dBi
	Quarter Wavelength Dipole Antenna, 5.5 dBi
	Quarter Wavelength Dipole Antenna, 3.2 dBi
Input Power:	5 VDC

Model Number: SM220

Test Sample Serial Number(s): 50 (Radiated), 58 (RF Conducted)

Test Sample Condition: The EUT was in good condition with no observable physical damage.

1.4 Test Methodology and Considerations

The EUT was evaluated for radiated, power line and RF conducted measurements. The EUT was installed on an evaluation board.

The RF conducted measurements were performed on both port 1 and port 2 of the EUT which were provided with a U.FL. connector on each port.

The radiated emissions evaluation was performed for the EUT set in three orthogonal orientations. The final measurements were completed using the worst case orientation. The EUT was evaluated for each antenna configuration and where applicable, the results are provided for the worst case.

The EUT test software settings used for the measurements are provided below:

Table 1.4-1: Software Power Setting – RF Port 1

Frequency (MHz)	Power Setting
2405	9
2440	9
2480	15

Table 1.4-2: Software Power Setting – RF Port 2

Frequency (MHz)	Power Setting
2405	9
2440	9
2475	11

The EUT was also evaluated for unintentional emissions. The results are provided separately in a verification report.

2 TEST FACILITIES

2.1 Location

The radiated and conducted emissions test sites are located at the following address:

Advanced Compliance Solutions, Inc.
3998 FAU Blvd, Suite 310
Boca Raton, Florida 33431
Phone: (561) 961-5585
Fax: (561) 961-5587
www.acstestlab.com

FCC Test Firm Registration #: 475089
Industry Canada Lab Code: 4175C

2.2 Laboratory Accreditations/Recognitions/Certifications

ACS is accredited to ISO/IEC 17025 by ANSI-ASQ National Accreditation Board under their ACLASS program and has been issued certificate number AT-1533 in recognition of this accreditation. Unless otherwise specified, all test methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

2.3 Radiated & Conducted Emissions Test Site Description

2.3.1 Semi-Anechoic Chamber Test Site

The EMC radiated test facility consists of an RF-shielded enclosure. The interior dimensions of the indoor semi-anechoic chamber are approximately 48 feet (14.6 m) long by 36 feet (10.8 m) wide by 24 feet (7.3 m) high and consist of rigid, 1/8 inch (0.32 cm) steel-clad, wood core modular panels with steel framing. In the shielded enclosure, the faces of the panels are galvanized and the chamber is self-supporting. 8-foot RF absorbing cones are installed on 4 walls and the ceiling. The steel-clad ground plane is covered with vinyl floor.

The turntable is driven by pneumatic motor, which is capable of supporting a 2000 lb. load. The turntable is flushed with the chamber floor which it is connected to, around its circumference, with a continuous metallic loaded spring. An EMCO Model 1050 Multi-device Controller controls the turntable position.

A pneumatic motor is used to control antenna polarizations and height relative to the ground. The height information is displayed on the control unit EMCO Model 1050.

The control room is an RF shielded enclosure attached to the semi-anechoic chamber with two bulkhead panels for connecting RF, and control cables. The dimension of the room is 7.3 m x 4.9 m x 3 m high and the entrance doors of both control and conducted rooms are 3 feet (0.91 m) by 7 feet (2.13 m).

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 2.3.1-1 below:

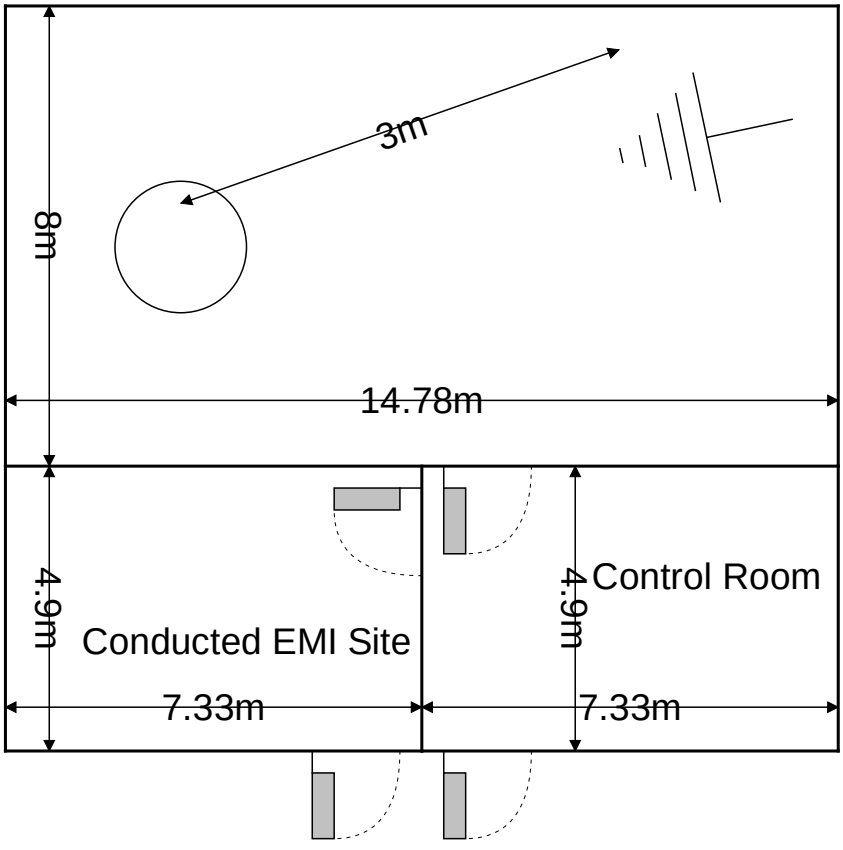

Figure 2.3.1-1: Semi-Anechoic Chamber Test Site

2.3.2 Conducted Emissions Test Site Description

The dimensions of the shielded conducted room are 7.3 x 4.9 x 3 m^3. As per ANSI C63.4 2003 requirements, the data were taken using two LISNs; a Solar Model 8028-50 50 Ω/50 µH and an EMCO Model 3825, which are installed as shown in Photograph 3. For 220 V, 50 Hz, a Polarad LISN (S/N 879341/048) is used in conjunction with a 1 kVA, 50 Hz/220 V EDGAR variable frequency generator, Model 1001B, to filter conducted noise from the generator.

A diagram of the room is shown below in figure 2.3.2-1:

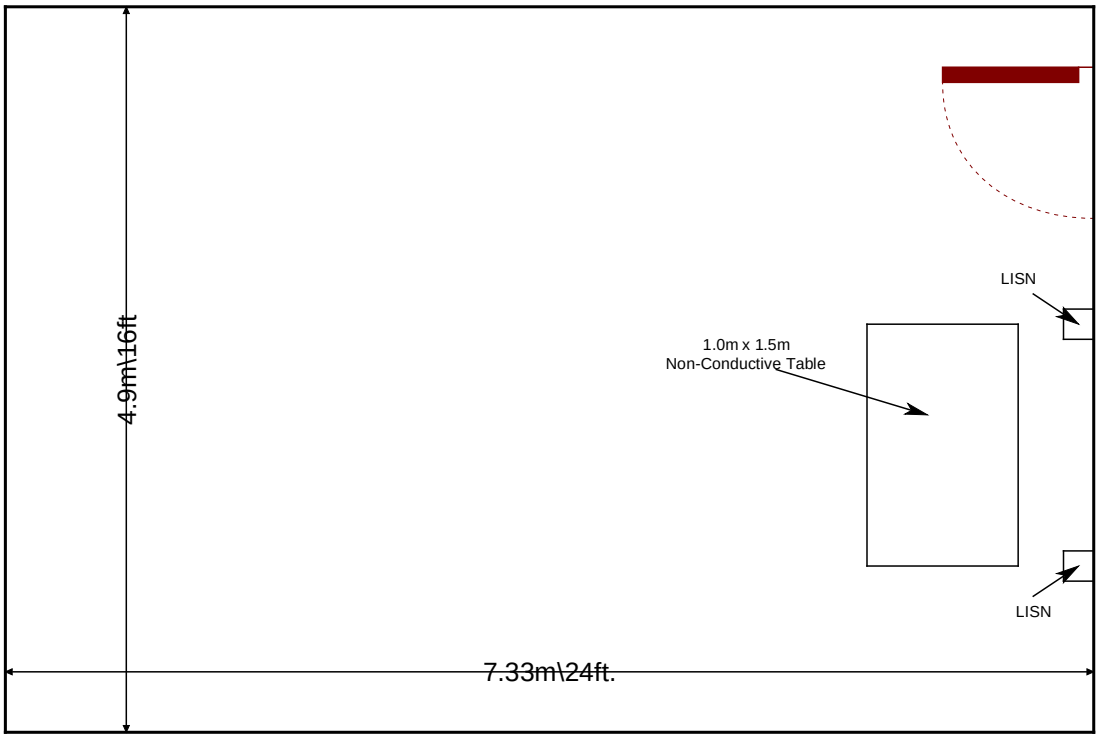

Figure 2.3.2-1: AC Mains Conducted EMI Site

3 APPLICABLE STANDARD REFERENCES

The following standards were used:

- ANSI C63.4-2003: Method of Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the 9 kHz to 40 GHz.
- ANSI C63.10-2009: American National Standard for Testing Unlicensed Wireless Devices.
- US Code of Federal Regulations (CFR): Title 47, Part 2, Subpart J: Equipment Authorization Procedures, 2014.
- US Code of Federal Regulations (CFR): Title 47, Part 15, Subpart C: Radio Frequency Devices, Intentional Radiators, 2014
- KDB Publication No. 558074 D01 DTS Meas Guidance v03r01 – Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under 15.247, June 5, 2014.
- Industry Canada Radio Standards Specification: RSS-210 - Low-power License-exempt Radiocommunication Devices (All Frequency Bands): Category I Equipment, Issue 8 December 2010.
- Industry Canada Radio Standards Specification: RSS-GEN – General Requirements and Information for the Certification of Radiocommunication Equipment, Issue 3, December 2010.

4 LIST OF TEST EQUIPMENT

The calibration interval of test equipment is annually or the manufacturer's recommendations. Where the calibration interval deviates from the annual cycle based on the instrument manufacturer's recommendations, it shall be stated below.

Table 4-1: Test Equipment

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
523	Agilent	E7405	Spectrum Analyzers	MY45103293	1/8/2013	1/8/2015
2002	EMCO	3108	Antennas	2147	11/22/2013	11/22/2015
2004	EMCO	3146	Antennas	1385	11/22/2013	11/22/2015
2006	EMCO	3115	Antennas	2573	4/24/2013	4/24/2015
2008	COM-Power	AH-826	Antennas	81009	NCR	NCR
2011	Hewlett-Packard	HP 8447D	Amplifiers	2443A03952	12/31/2013	12/31/2014
2022	EMCO	LISN3825/2R	LISN	1095	9/9/2013	9/9/2015
2037	ACS Boca	Chamber EMI Cable Set	Cable Set	2037	2/27/2014	2/27/2015
2044	QMI	N/A	Cables	2044	12/31/2013	12/31/2014
2045	ACS Boca	Conducted Cable Set	Cable Set	2045	1/1/2014	1/1/2015
2070	Mini Circuits	VHF-8400+	Filter	2070	1/1/2014	1/1/2015
2072	Mini Circuits	VHF-3100+	Filter	30737	1/1/2014	1/1/2015
341	Aeroflex/Weinschel	54A-20	Attenuators	4686	7/25/2014	7/25/2015
2076	Hewlett-Packard	HP5061-5458	Cables	2076	12/31/2013	12/31/2014
2086	Merrimac	FAN-6-10K	Attenuators	23148-83-1	12/31/2013	12/31/2014
2089	Agilent Technologies, Inc.	83017A	Amplifiers	3123A00214	12/16/2013	12/16/2014
2095	ETS Lindgren	TILE4! - Version 4.2.A	Software	85242	NCR	NCR
3004	Teseq	CFL 9206A	Attenuators	34720	10/21/2013	10/21/2015
283	Rohde & Schwarz	FSP40	Spectrum Analyzers	1000033	9/18/2013	9/18/2015

NCR = No Calibration Required

5 SUPPORT EQUIPMENT

Table 5-1: EUT and Support Equipment

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Synapse Wireless	SM220	50
2	RF Board Adapter	Synapse Wireless	SM400	50
3	Evaluation Board	Synapse Wireless	500202.01A	N/A
4	9 VDC Power Supply	Tamura Corporation	318AS09035	0705
5	5.5 dBi Antenna	L-COM Global Connectivity	HG2405RD-RSP	22335-07560
	3.2 dBi Antenna	Pulse Electronics Corporation	W1027	N/A

Table 5-2: Cable Description

Cable #	Cable Type	Length	Shield	Termination
A	Power Cable	1.96m	No	EUT to Power Supply
B	Coaxial Cable	0.1m	Yes	EUT to Antenna

Table 5-3: EUT and Support Equipment

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Synapse Wireless	SM220	50
2	RF Board Adapter	Synapse Wireless	SM400	50
3	Evaluation Board	Synapse Wireless	500202.01A	N/A
4	9 VDC Power Supply	Tamura Corporation	318AS09035	0705

Table 5-4: Cable Description

Cable #	Cable Type	Length	Shield	Termination
A	Power Cable	1.96m	No	EUT to Power Supply

6 EQUIPMENT UNDER TEST SETUP BLOCK DIAGRAM

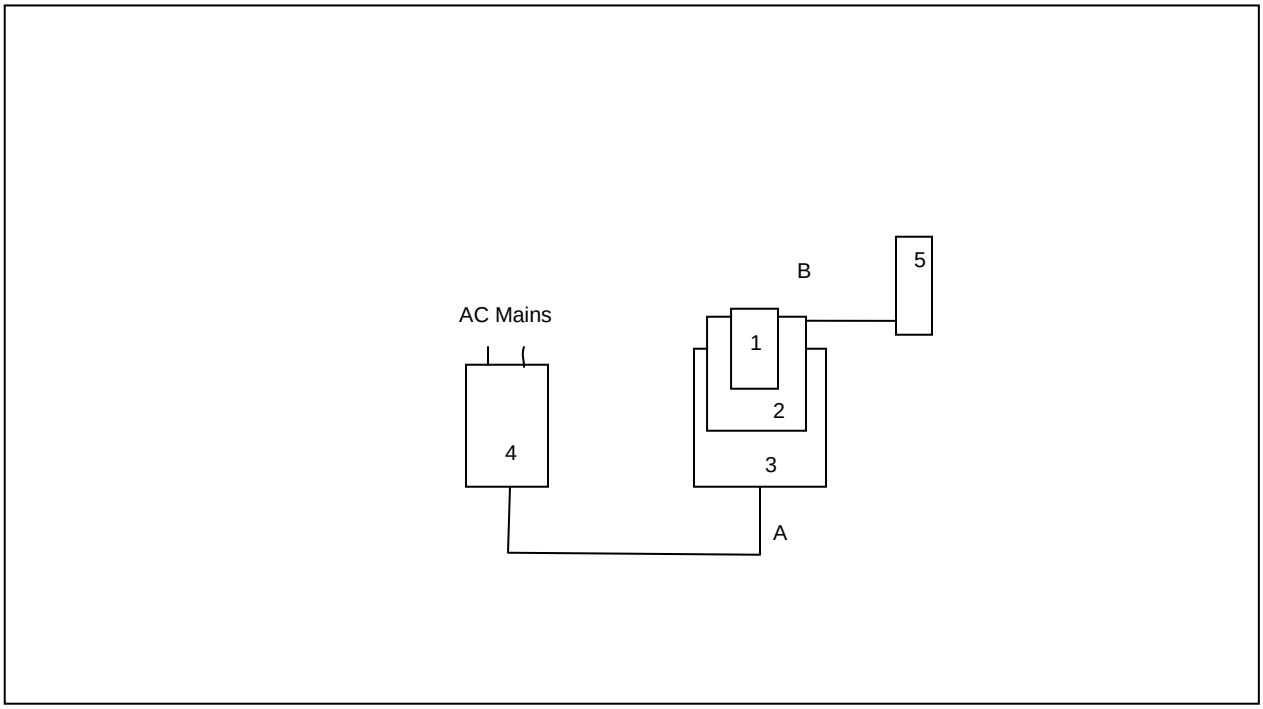

Figure 6-1: Test Setup – External Antenna

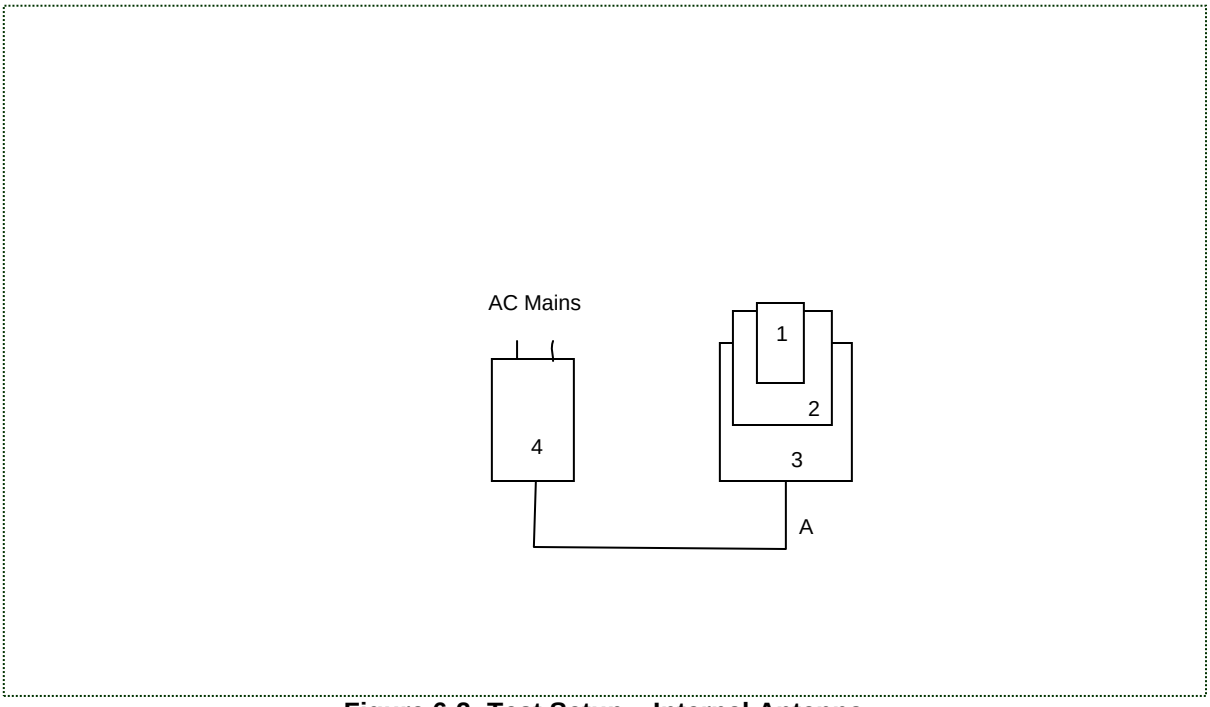

Figure 6-2: Test Setup – Internal Antenna

7 SUMMARY OF TESTS

Along with the tabular data shown below, plots were taken of all signals deemed important enough to document.

7.1 Antenna Requirement – FCC: Section 15.203

The EUT uses an integral Inverted-F Antenna which is printed on the PCB and also provides a U.FL. connector on for external antenna connection (RF Port 2). The 5.5 dBi and 3.2 dBi antennas marketed with the product use RSMA connectors which connect to the PCB module via a U.FL. to RSMA cable adapter. The EUT uses unique antenna connectors and therefore meets the requirements of FCC Section 15.203.

7.2 6 dB Bandwidth - FCC: Section 15.247(a)(2) 99% Bandwidth IC: RSS-210 A8.2(a)

7.2.1 Measurement Procedure

The 6dB bandwidth was measured in accordance with the FCC KDB Publication No. 558074 “Guidance for Performing Compliance Measurements on Digital Transmission Systems (47 CFR 15.247)” DTS 6-dB Signal Bandwidth Option 1. The RBW of the spectrum analyzer was set to 100 kHz and VBW 300 kHz. Span was set large enough to capture the entire emissions and >> RBW.

The 99% occupied bandwidth was measured with the spectrum analyzer span set to fully display the emission, including the emissions skirts. The RBW was to 1% of the span. The occupied 99% bandwidth was measured using the occupied bandwidth function of the analyzer.

7.2.2 Measurement Results

Results are shown below.

Table 7.2.2-1: 6dB / 99% Bandwidth – RF Port 1

Frequency [MHz]	6dB Bandwidth [kHz]	99% Bandwidth (kHz)
2405	1327.5	2595.0
2440	1207.5	2662.5
2480	1205.0	2797.5

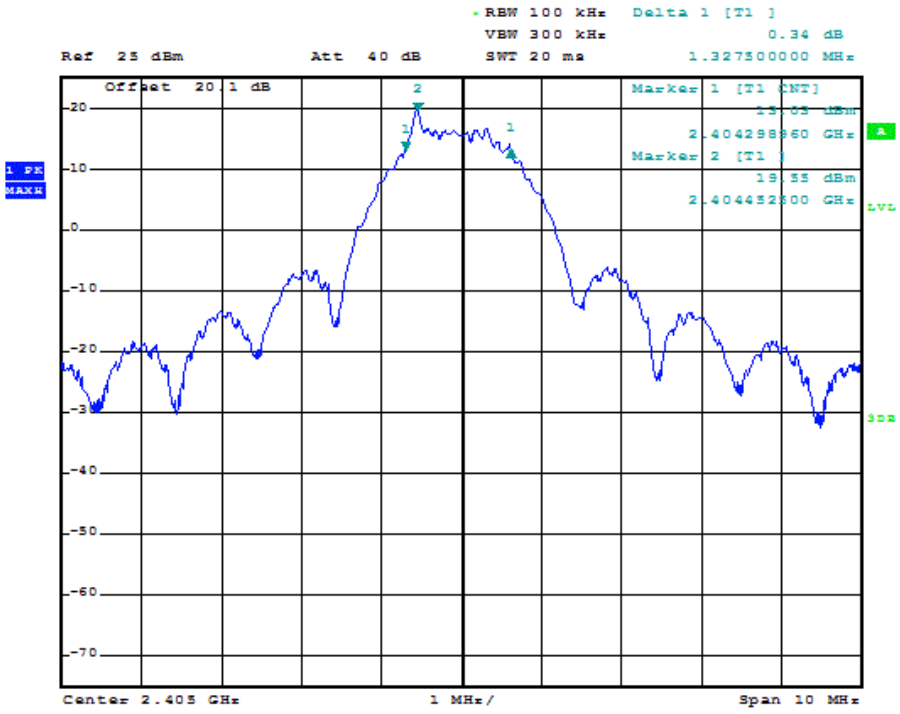

Figure 7.2.2-1: 6dB BW - Low Channel – RF Port 1

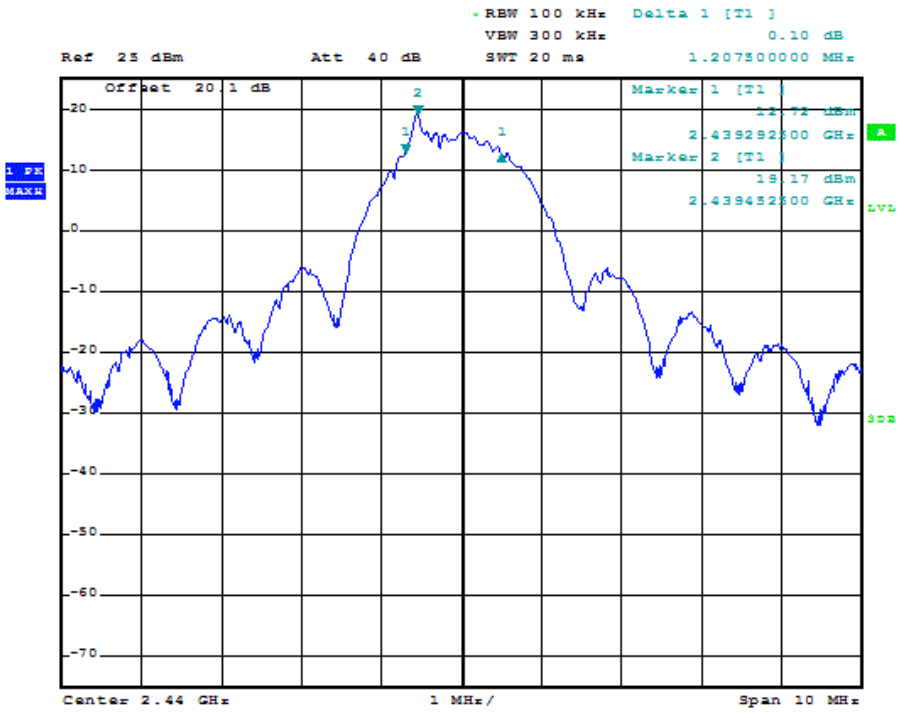

Figure 7.2.2-2: 6dB BW - Middle Channel – RF Port 1

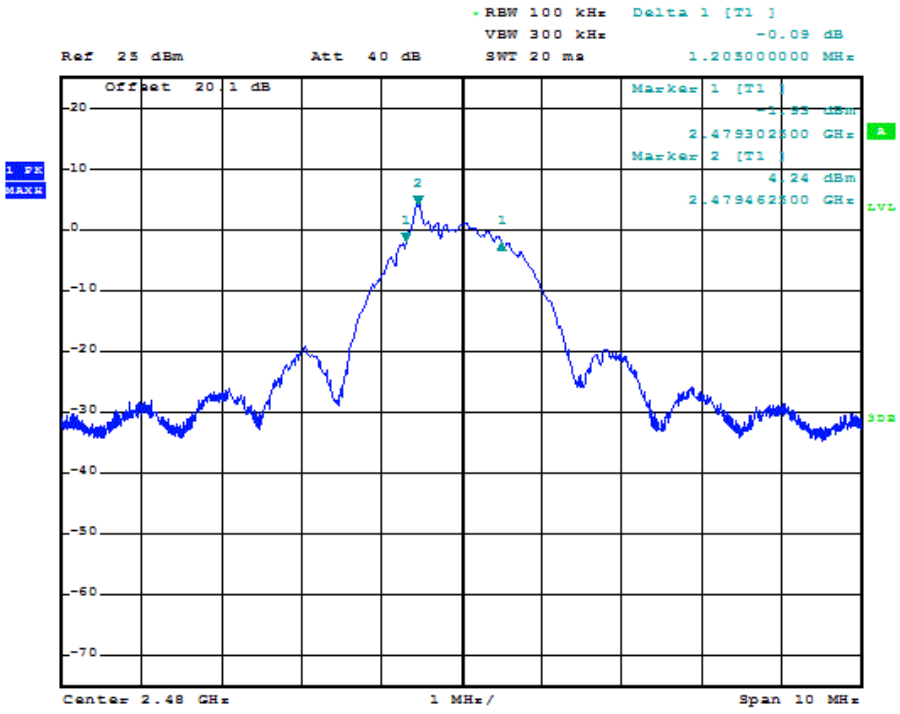

Figure 7.2.2-3: 6dB BW - High Channel – RF Port 1

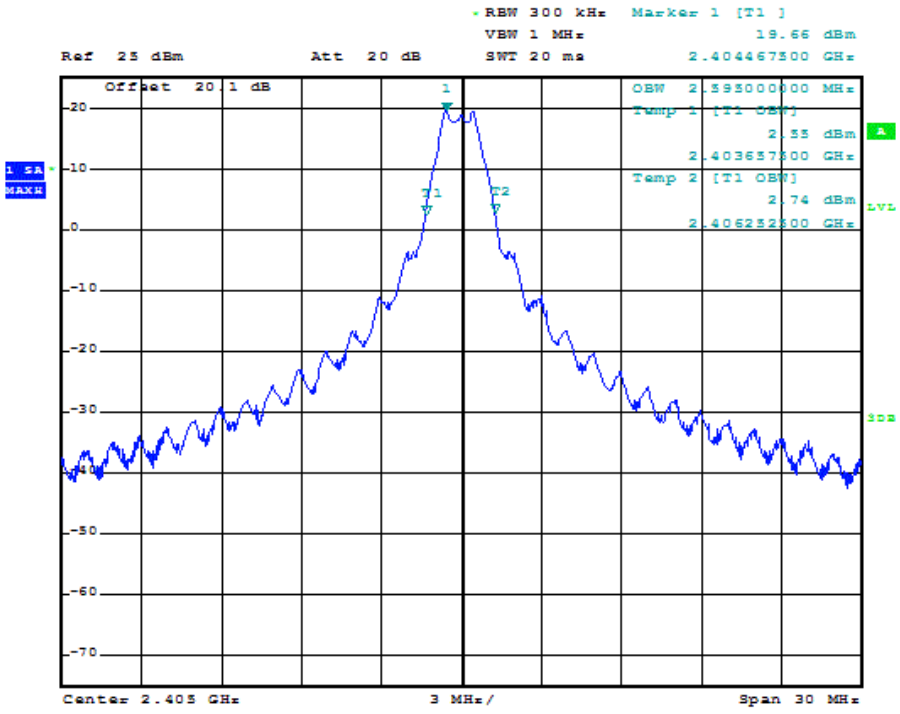

Figure 7.2.2-4: 99% OBW - Low Channel – RF Port 1

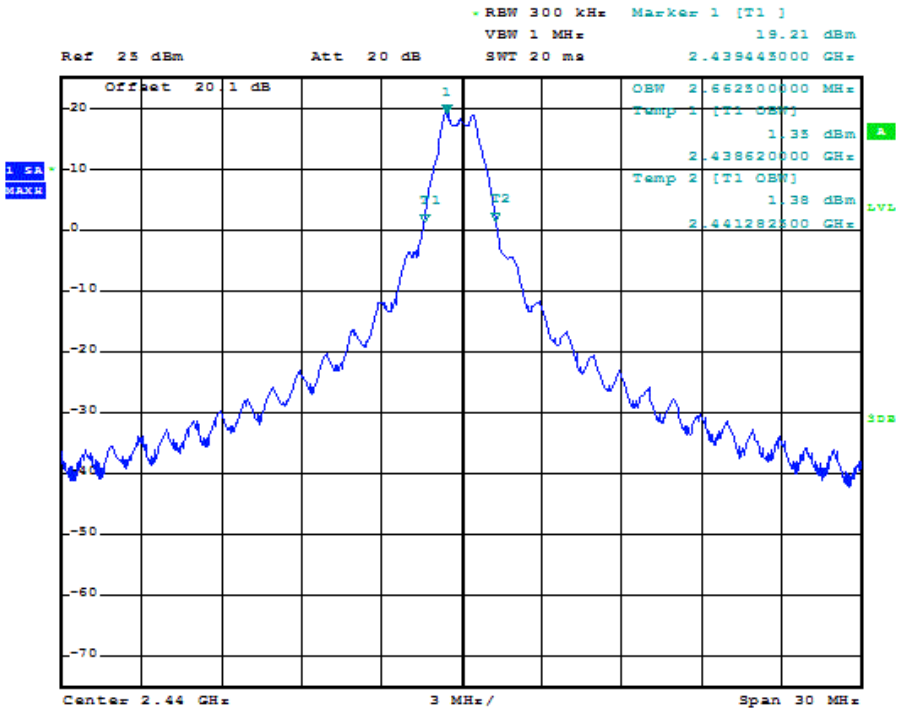

Figure 7.2.2-5: 99% OBW - Middle Channel – RF Port 1

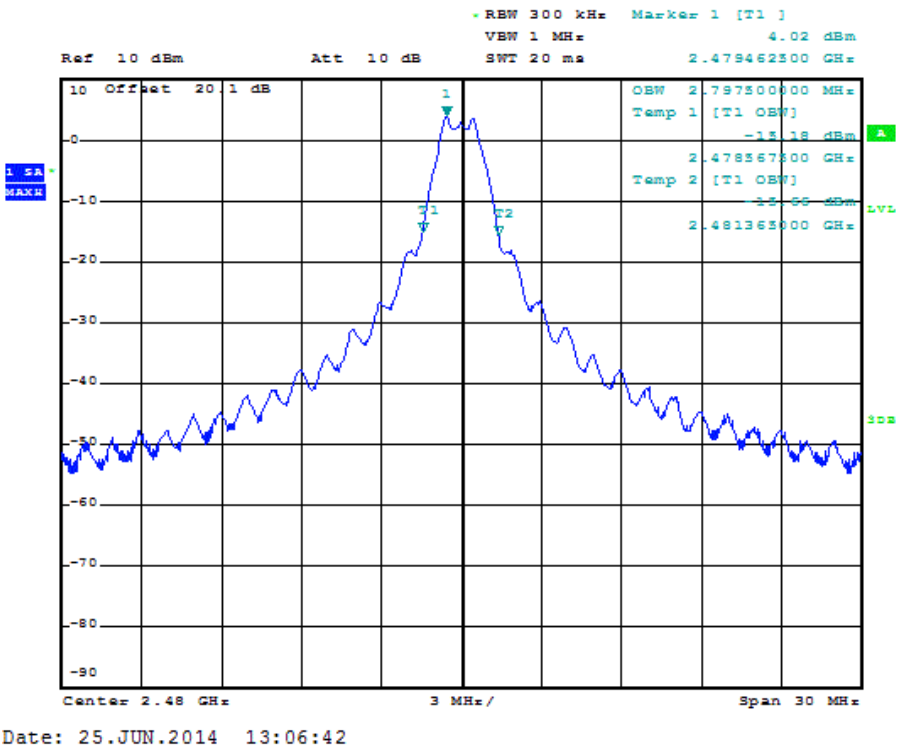

Figure 7.2.2-6: 99% OBW - High Channel – RF Port 1

Table 7.2.2-2: 6dB / 99% Bandwidth – RF Port 2

Frequency [MHz]	6dB Bandwidth [kHz]	99% Bandwidth (kHz)
2405	1297.5	2580.0
2440	1280.0	2640.0
2475	1200.0	2737.5

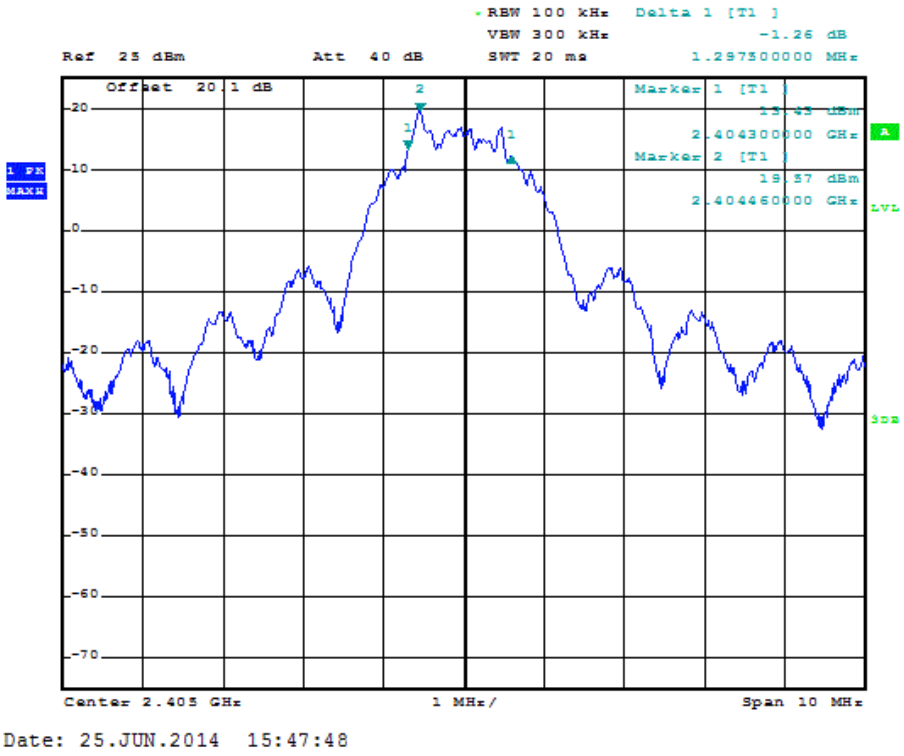

Figure 7.2.2-7: 6dB BW - Low Channel – RF Port 2

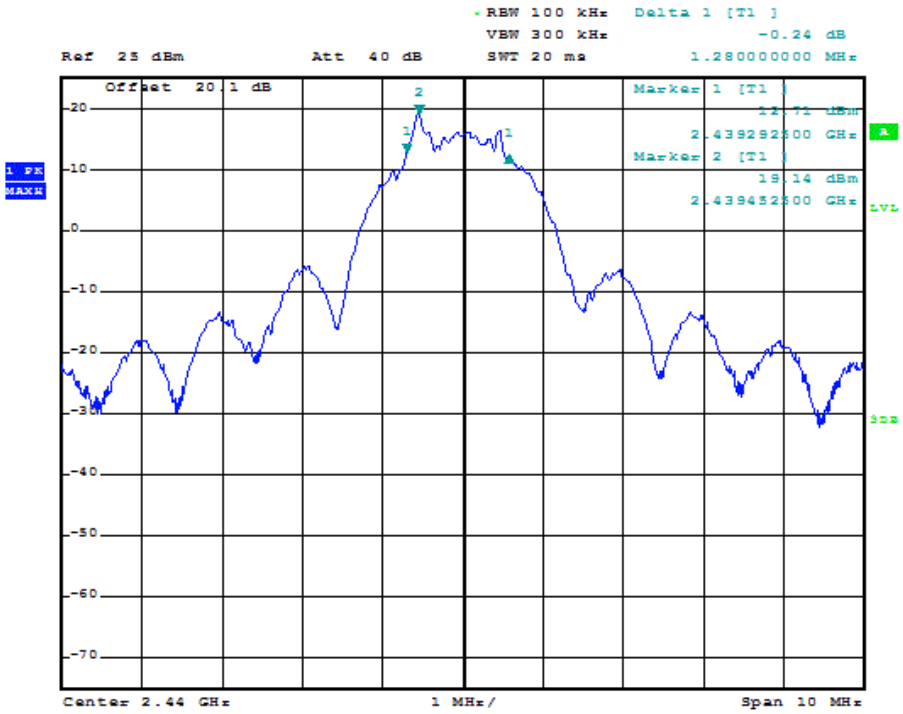

Figure 7.2.2-8: 6dB BW - Middle Channel – RF Port 2

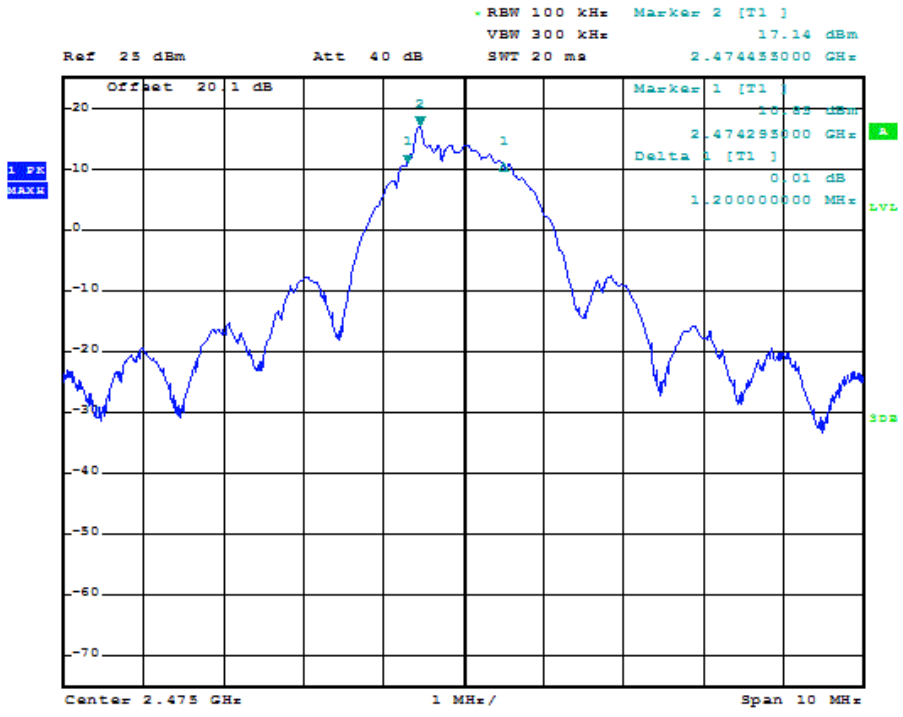

Figure 7.2.2-9: 6dB BW - High Channel – RF Port 2

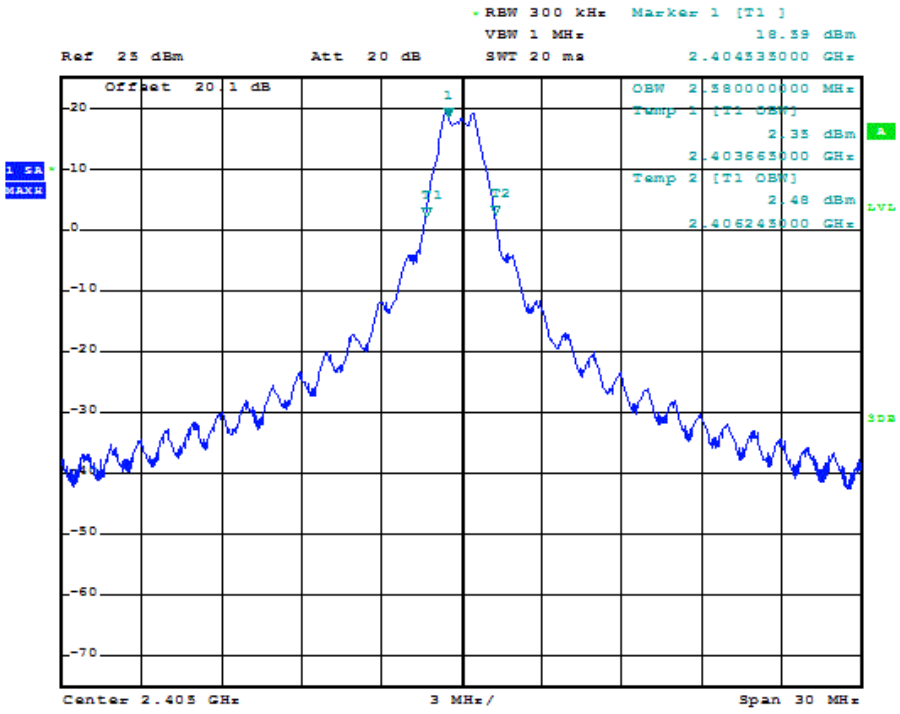

Figure 7.2.2-10: 99% OBW - Low Channel – RF Port 2

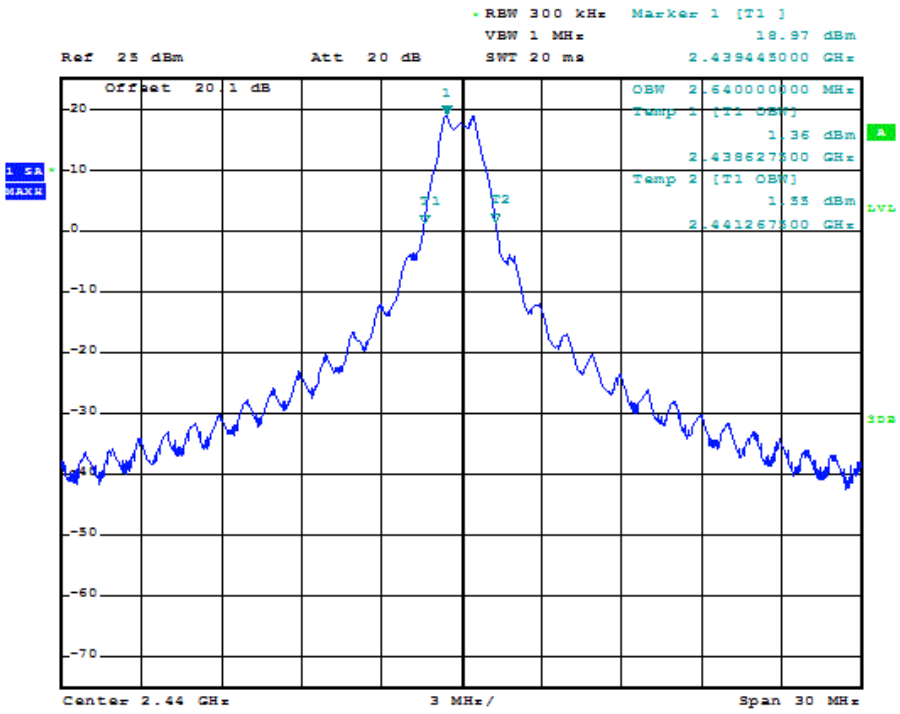

Figure 7.2.2-11: 99% OBW - Middle Channel – RF Port 2

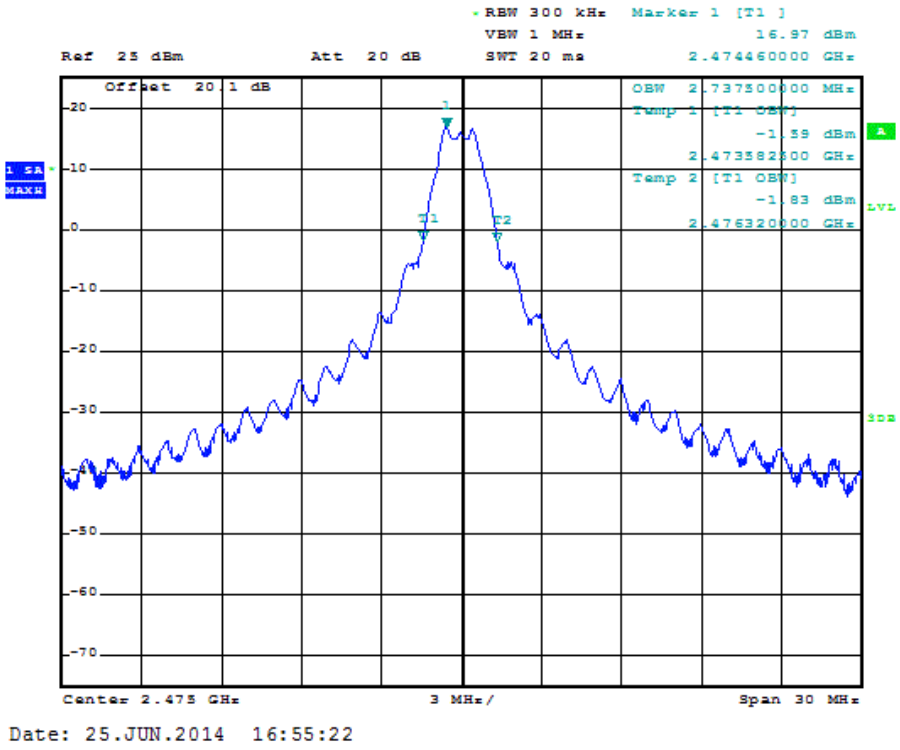

Figure 7.2.2-12: 99% OBW - High Channel – RF Port 2

7.3 Peak Output Power - FCC Section 15.247(b)(3) IC: RSS-210 A8.4(4)

7.3.1 Measurement Procedure (Conducted Method)

The Peak Output Power was measured in accordance with the FCC KDB Publication No. 558074 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (47 CFR 15.247)" Section 9.1.1 RBW ≥ DTS Bandwidth Method. The RF output of the equipment under test was directly connected to the input of the spectrum analyzer through suitable attenuation.

7.3.2 Measurement Results

Results are shown below.

Table 7.3.2-1: RF Output Power – RF Port 1

Frequency [MHz]	Level [dBm]
2405	19.93
2440	19.54
2480	4.14

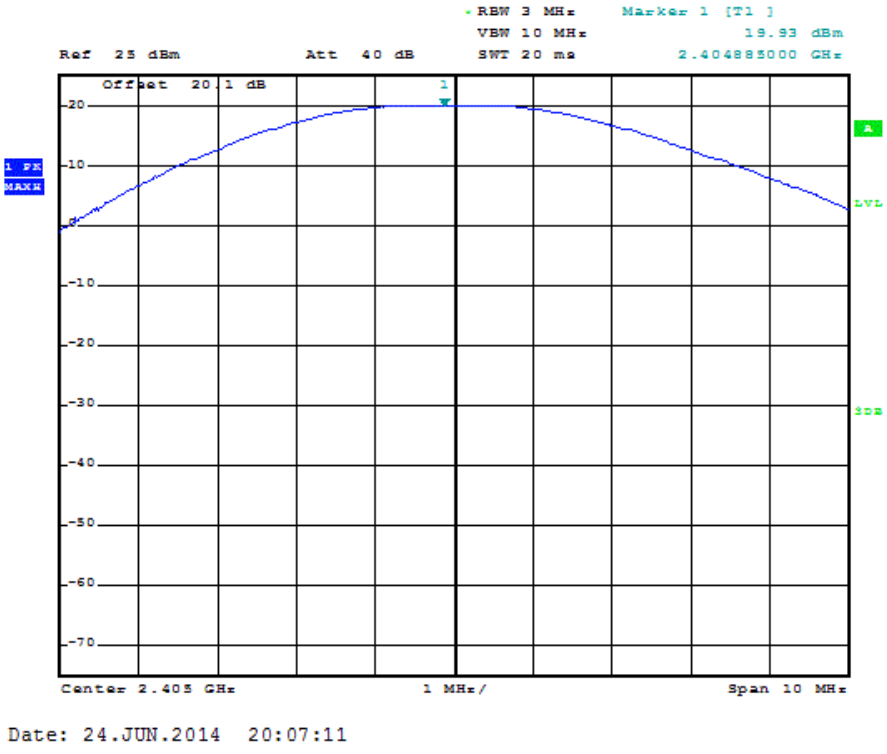

Figure 7.3.2-1: RF Output Power - Low Channel – RF Port 1

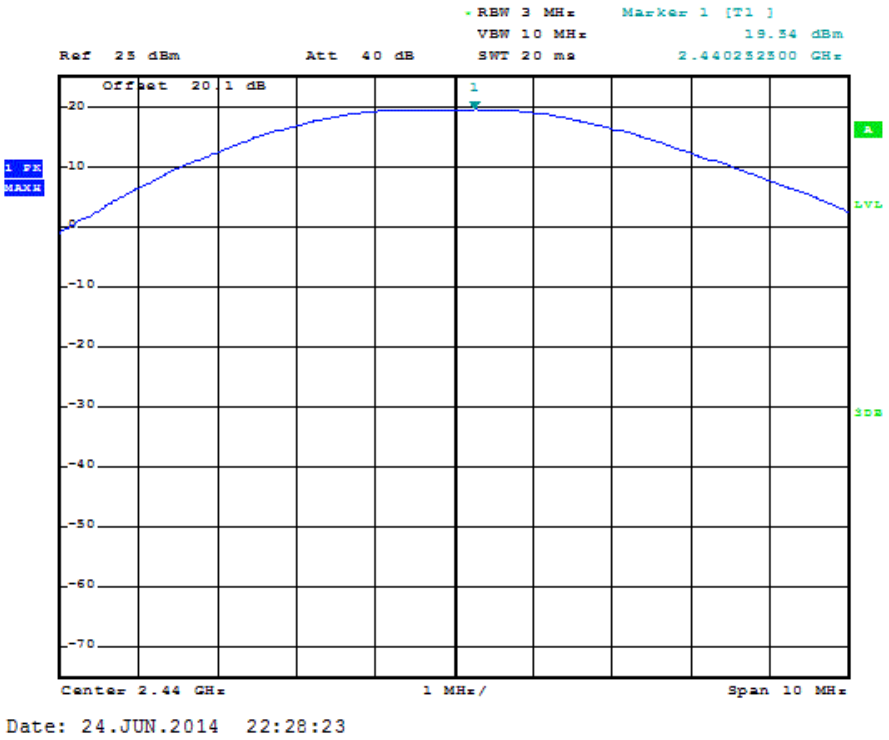

Figure 7.3.2-2: RF Output Power - Middle Channel – RF Port 1

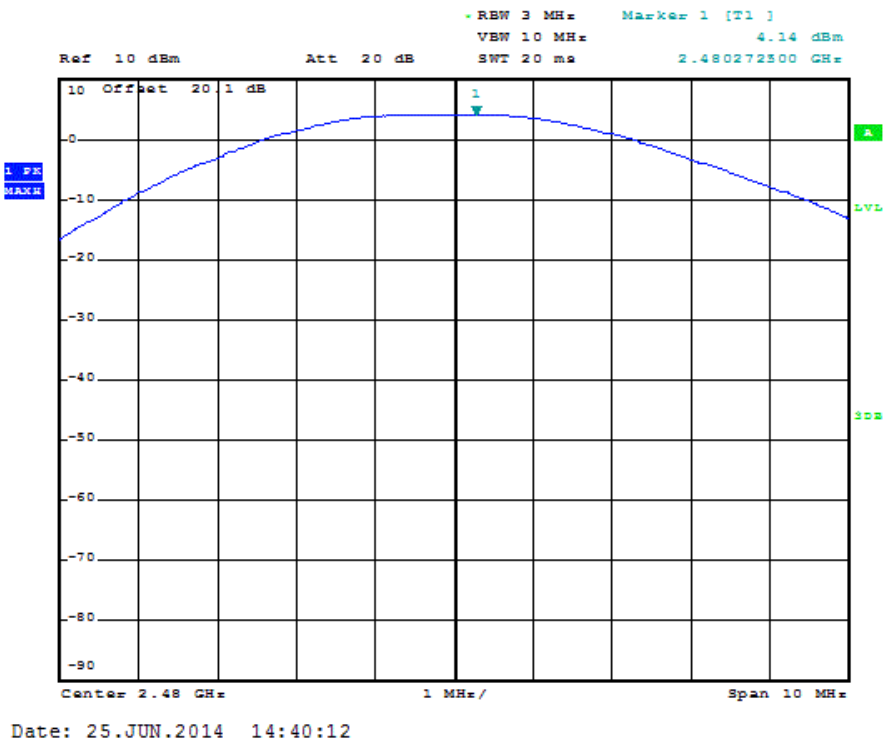

Figure 7.3.2-3: RF Output Power - High Channel – RF Port 1

Table 7.3.2-2: RF Output Power – RF Port 2

Frequency [MHz]	Level [dBm]
2405	19.51
2440	19.17
2475	17.28

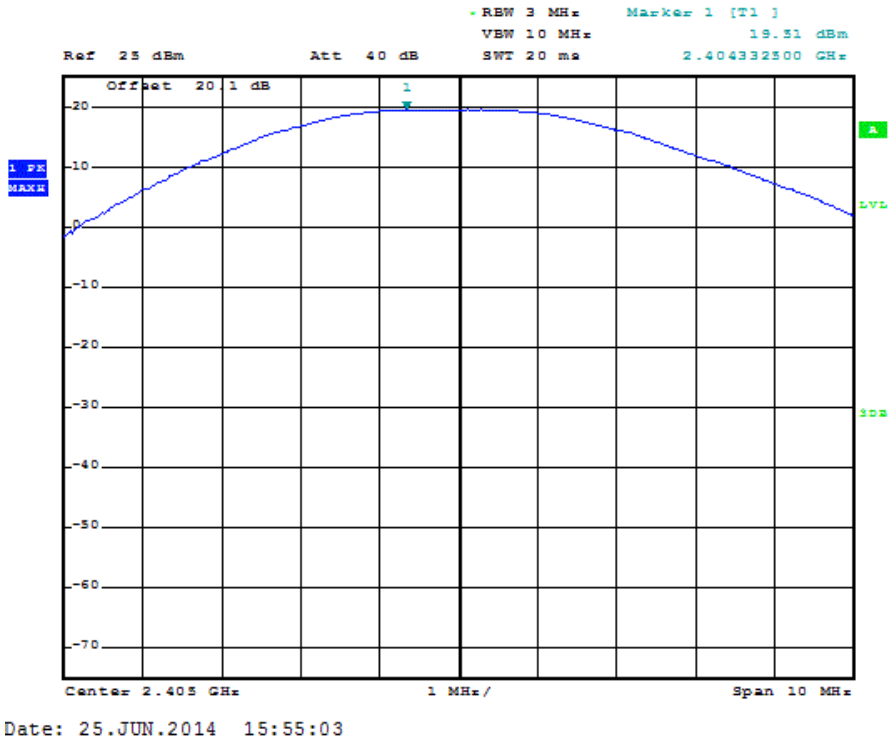

Figure 7.3.2-4: RF Output Power - Low Channel – RF Port 2

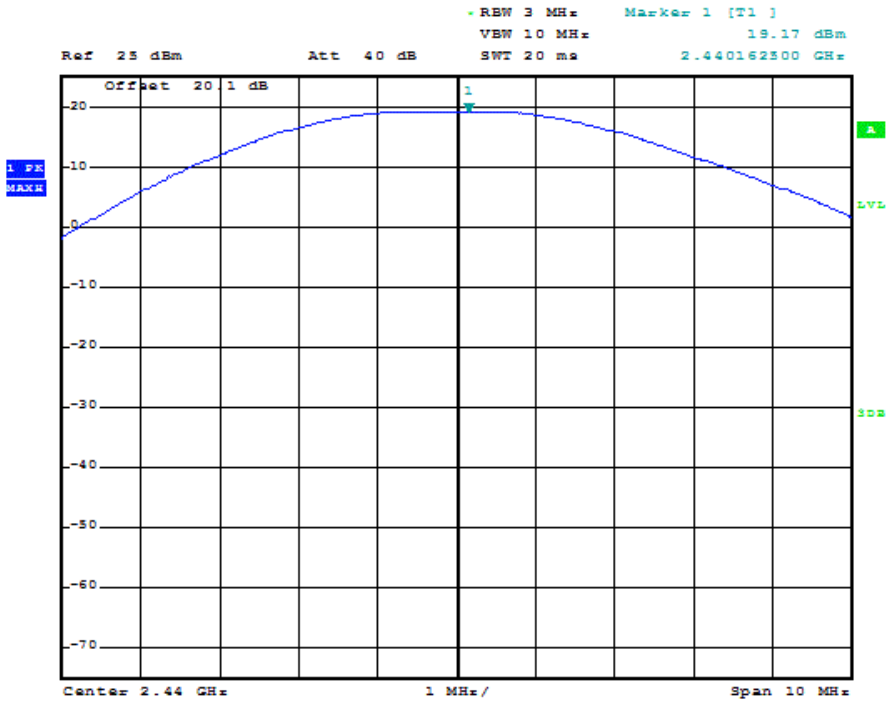

Figure 7.3.2-5: RF Output Power - Middle Channel – RF Port 2

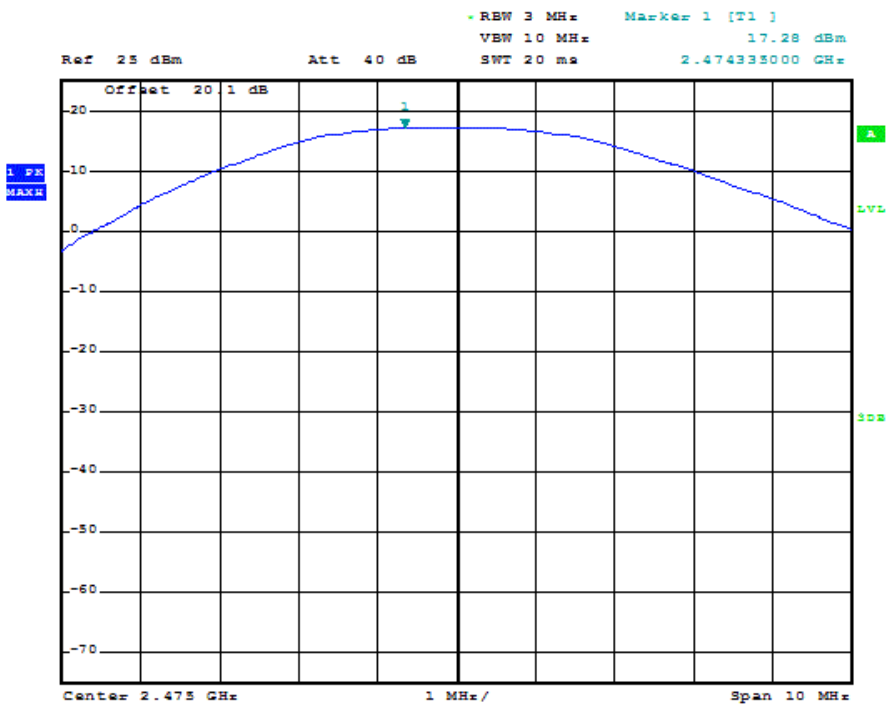

Figure 7.3.2-6: RF Output Power - High Channel – RF Port 2

7.4 Band-Edge Compliance and Spurious Emissions-FCC 15.247(d) IC: RSS-210 A8.5

7.4.1 Band-Edge Compliance of RF Conducted Emissions

7.4.1.1 Measurement Procedure

The RF output port of the EUT was directly connected to the input of the spectrum analyzer via suitable attenuation. The EUT was investigated at the lowest and highest channel available to determine band-edge compliance. For each measurement the spectrum analyzer's RBW was set to 100 kHz, and the VBW was set to 300 kHz.

7.4.1.2 Measurement Results

Results are shown below.

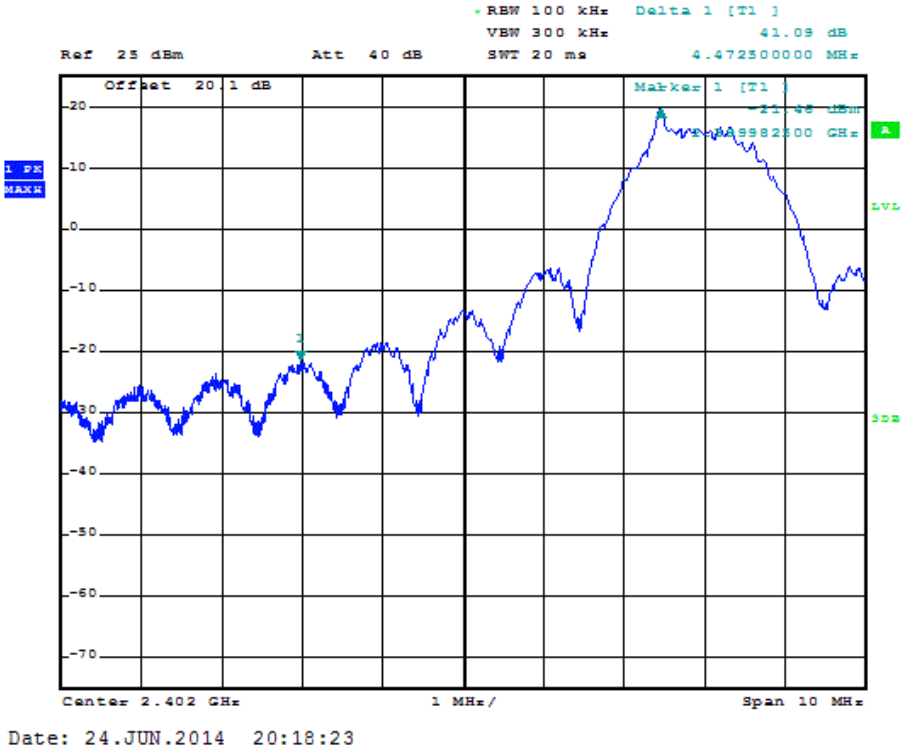

Figure 7.4.1.2-1: Lower Band-edge – RF Port 1

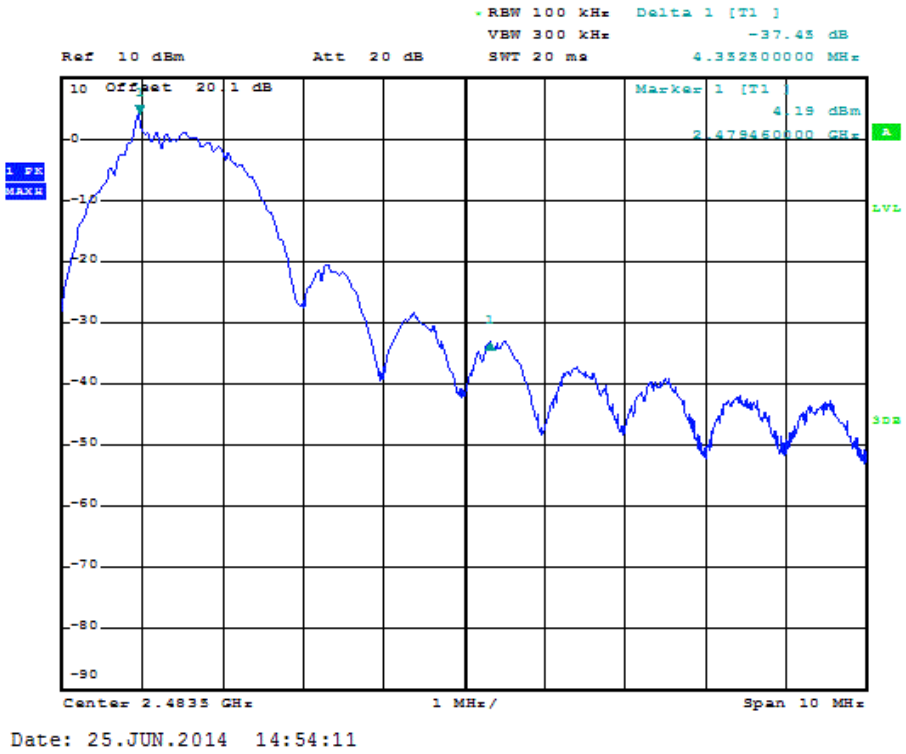

Figure 7.4.1.2-2: Upper Band-edge – RF Port 1

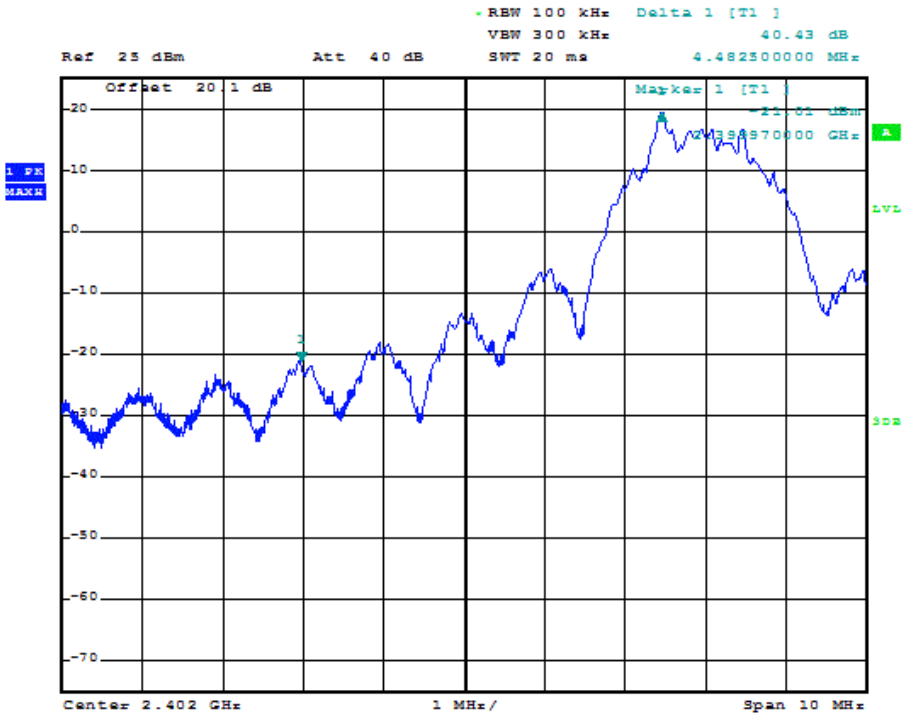

Figure 7.4.1.2-3: Lower Band-edge – RF Port 2

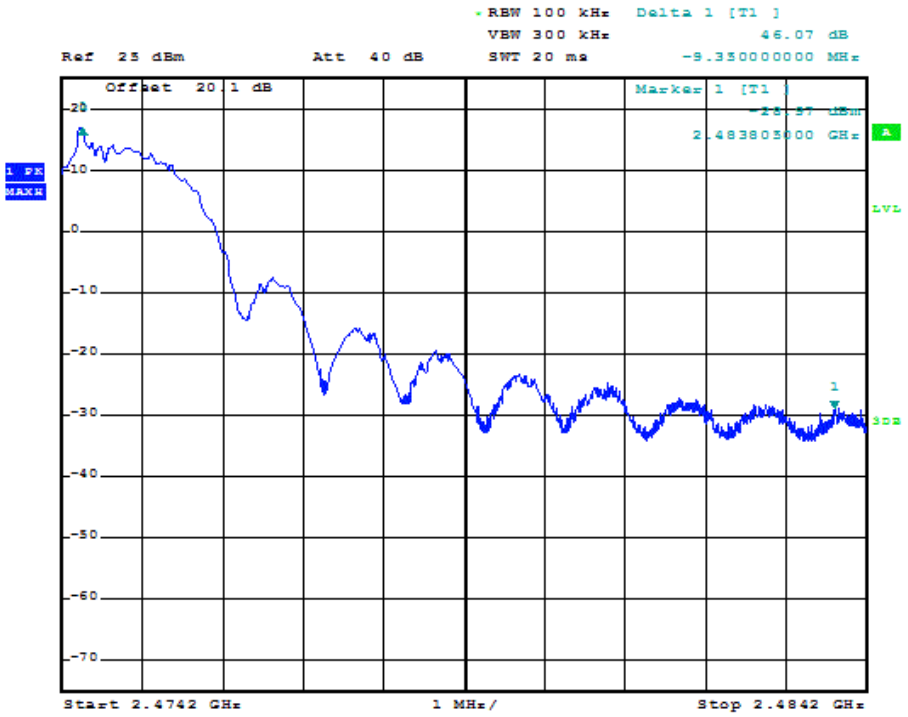

Figure 7.4.1.2-4: Upper Band-edge – RF Port 2

7.4.2 RF Conducted Spurious Emissions

7.4.2.1 Measurement Procedure

The RF Conducted Spurious Emissions were measured in accordance with the FCC KDB Publication No. 558074 “Guidance for Performing Compliance Measurements on Digital Transmission Systems (47 CFR 15.247)”. The RF output port of the equipment under test was directly connected to the input of the spectrum analyzer. The EUT was investigated for conducted spurious emissions from 30MHz to 26 GHz, 10 times the highest fundamental frequency. Measurements were made at the low, center and high channels of the EUT. For each measurement, the spectrum analyzer’s RBW was set to 100 kHz and the VBW was set to 300 kHz. The peak Max Hold function of the analyzer was utilized. The reference level for the limits was determined by measuring the Peak PSD level in any 100 kHz bandwidth within the DTS channel bandwidth.

7.4.2.2 Measurement Results

Results are shown below.

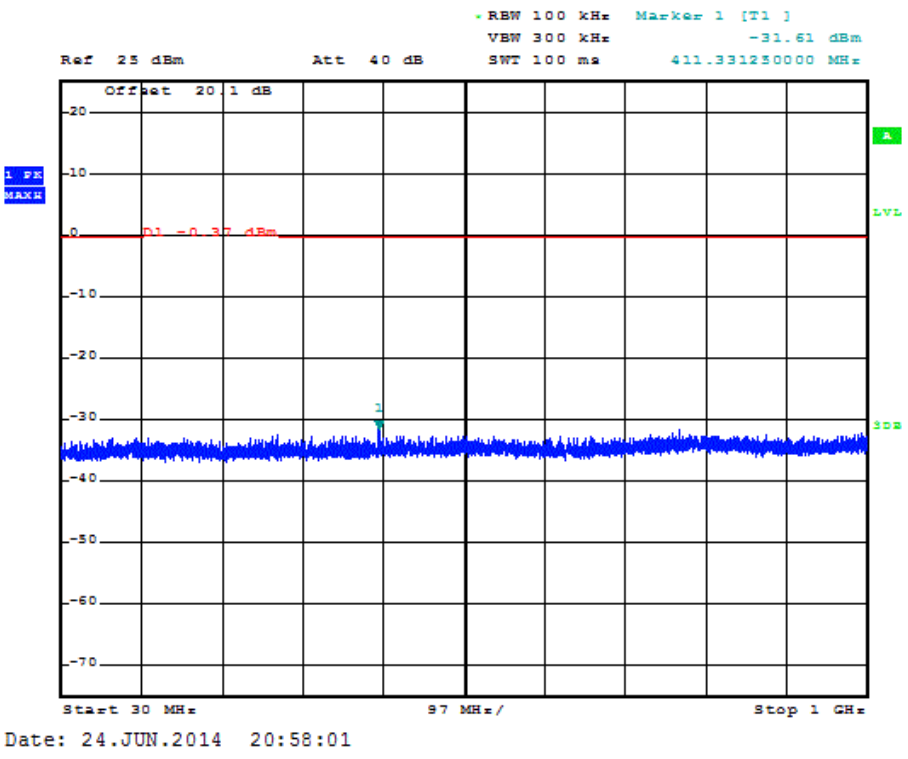

Figure 7.4.2.2-1: 30 MHz – 1 GHz – Low Channel – RF Port 1

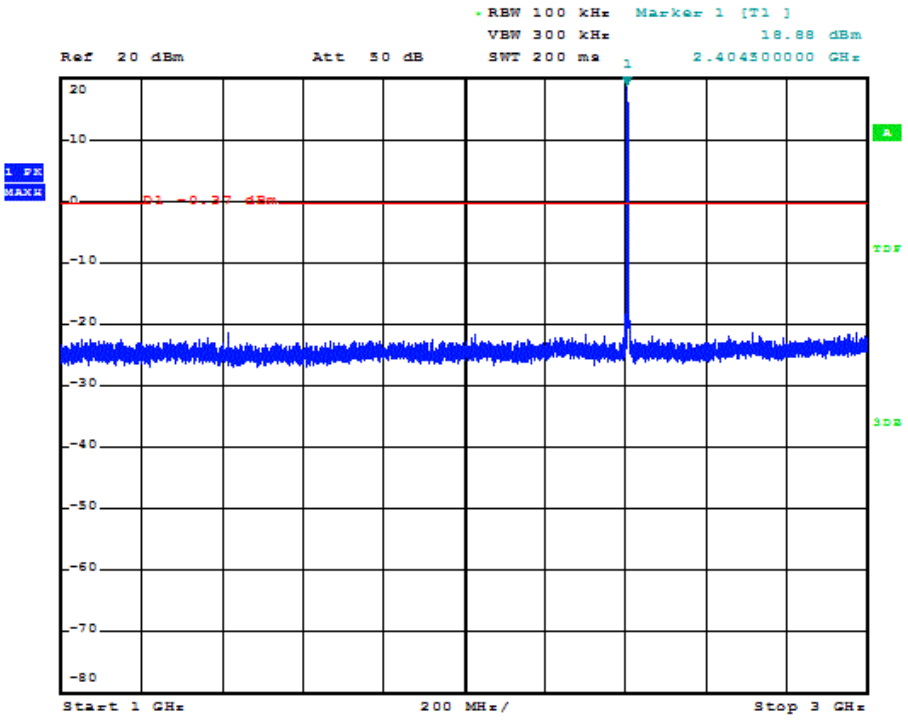

Figure 7.4.2.2-2: 1 GHz – 3 GHz – Low Channel – RF Port 1

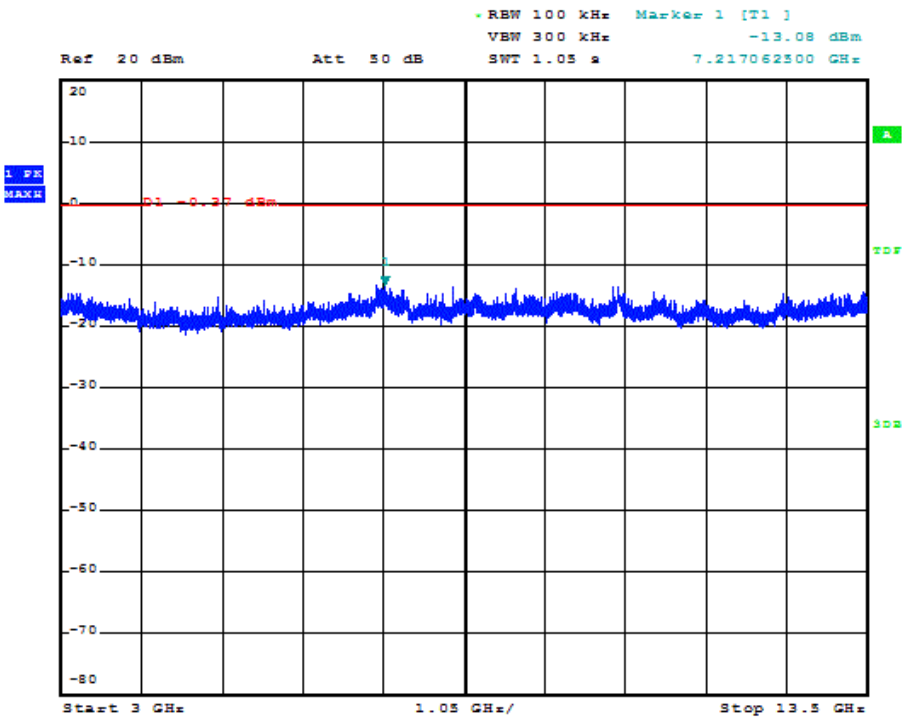

Figure 7.4.2.2-3: 3 GHz – 13.5 GHz – Low Channel – RF Port 1

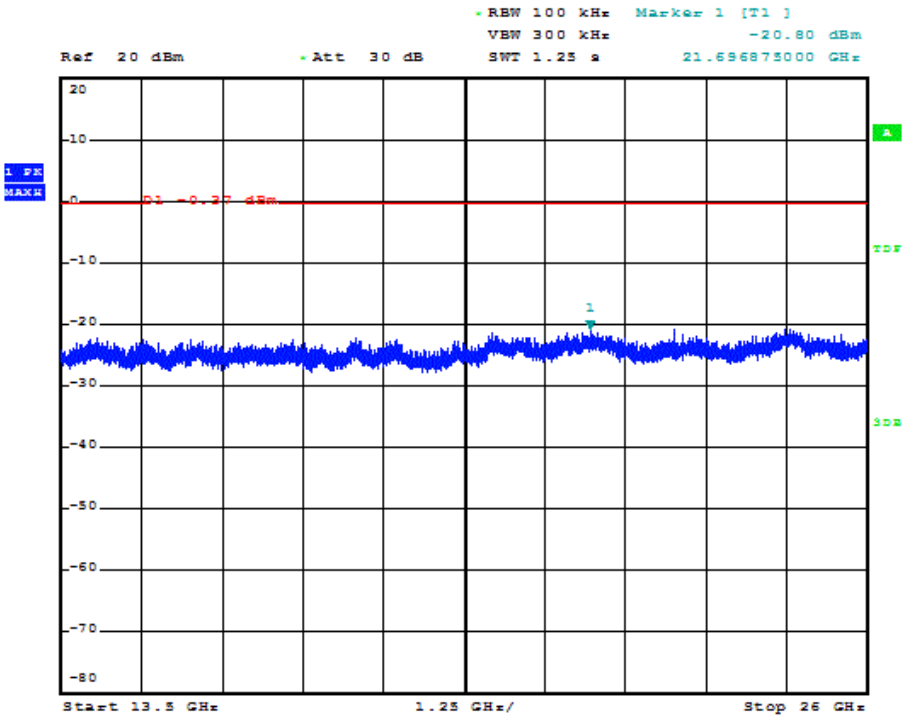

Figure 7.4.2.2-4: 13.5 GHz – 26 GHz – Low Channel – RF Port 1

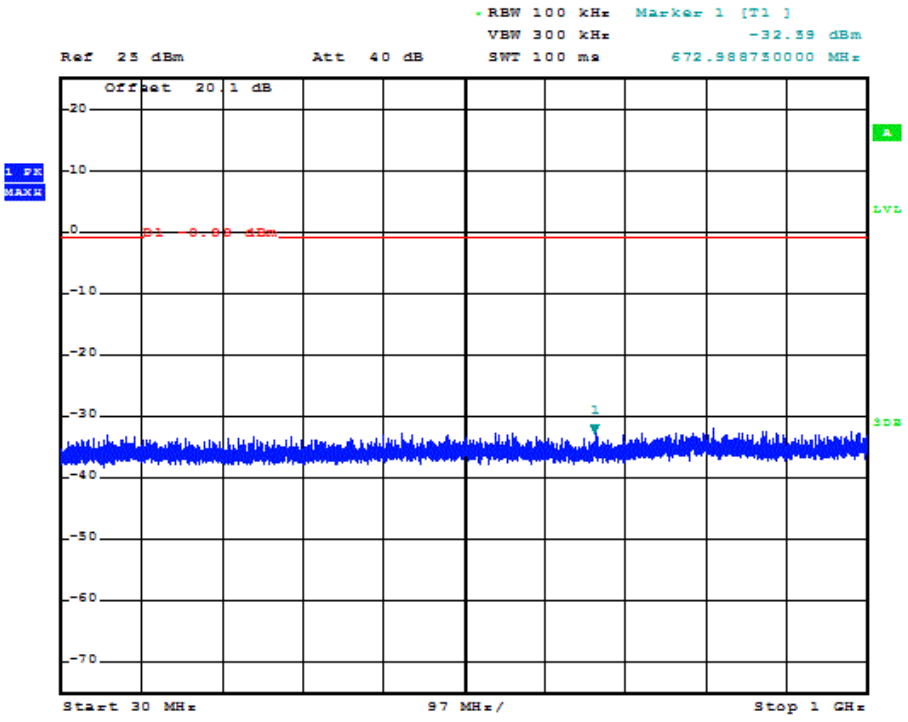

Figure 7.4.2.2-5: 30 MHz – 1 GHz –Middle Channel – RF Port 1

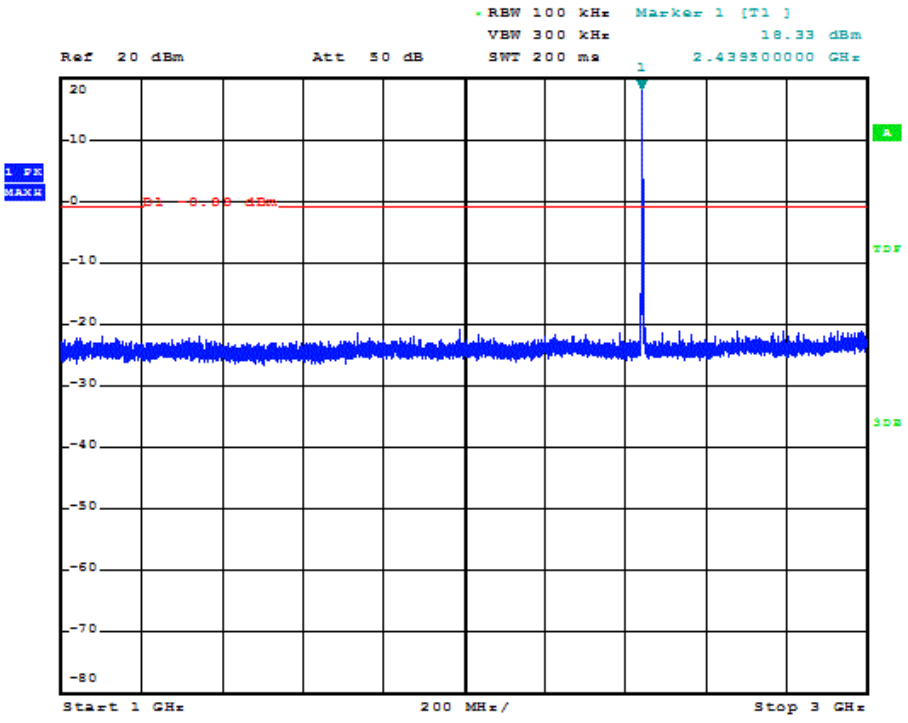

Figure 7.4.2.2-6: 1 GHz – 3 GHz – Middle Channel – RF Port 1

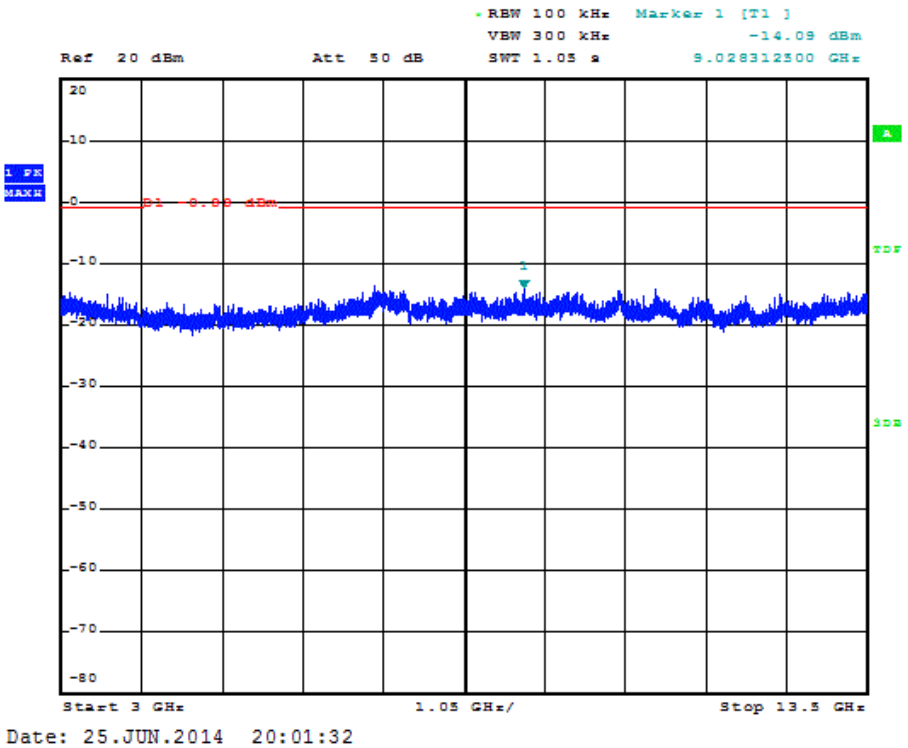

Figure 7.4.2.2-7: 3 GHz – 13.5 GHz – Middle Channel – RF Port 1

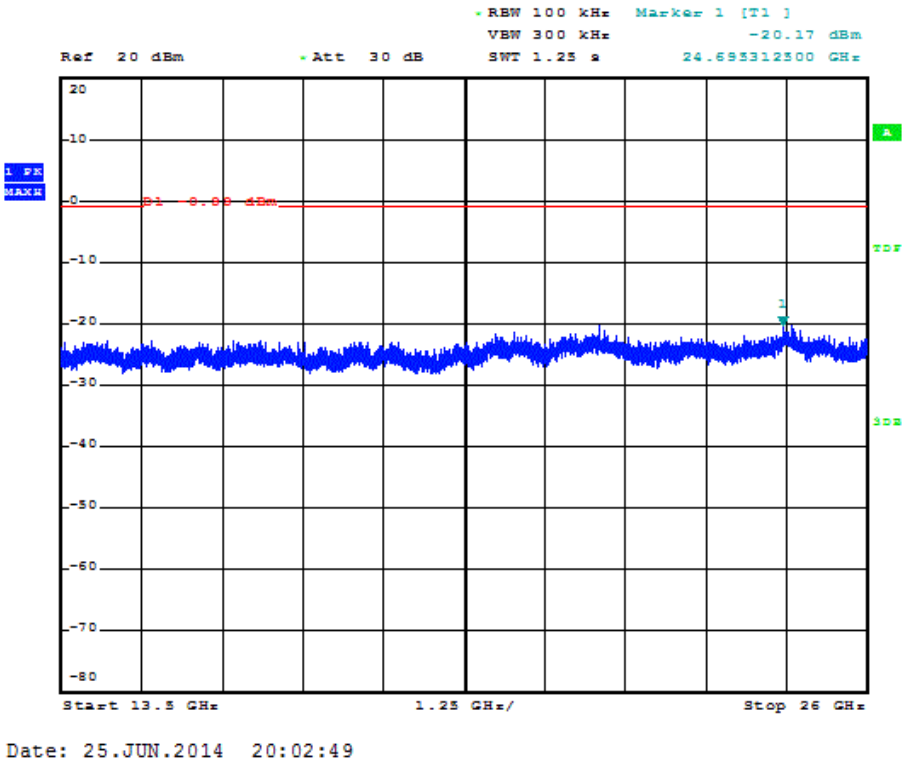

Figure 7.4.2.2-8: 13.5 GHz – 26 GHz – Middle Channel – RF Port 1

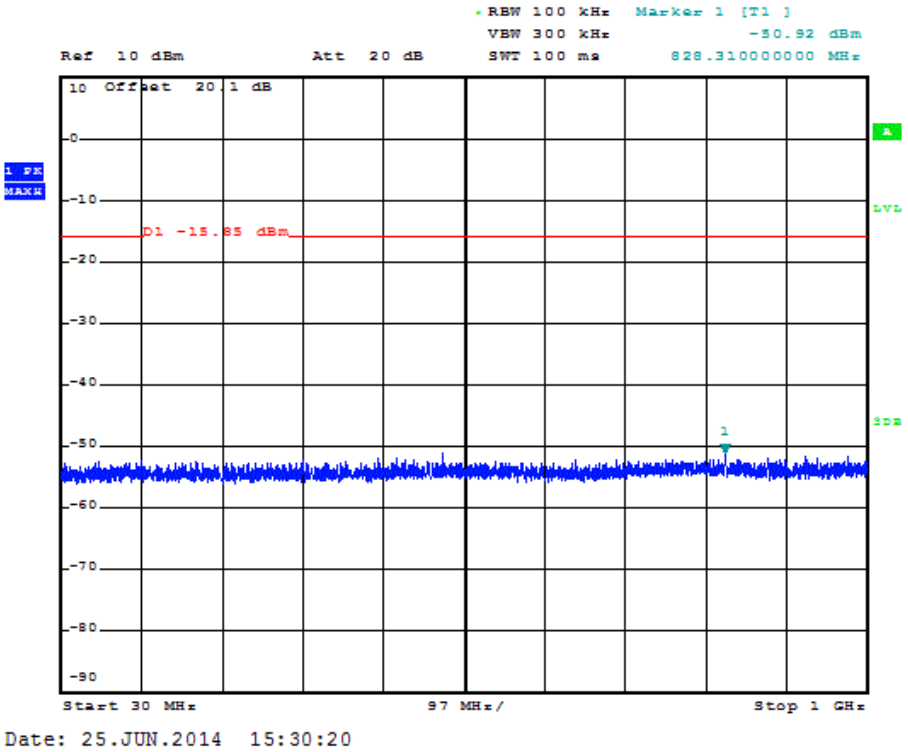

Figure 7.4.2.2-9: 30 MHz – 1 GHz – High Channel – RF Port 1

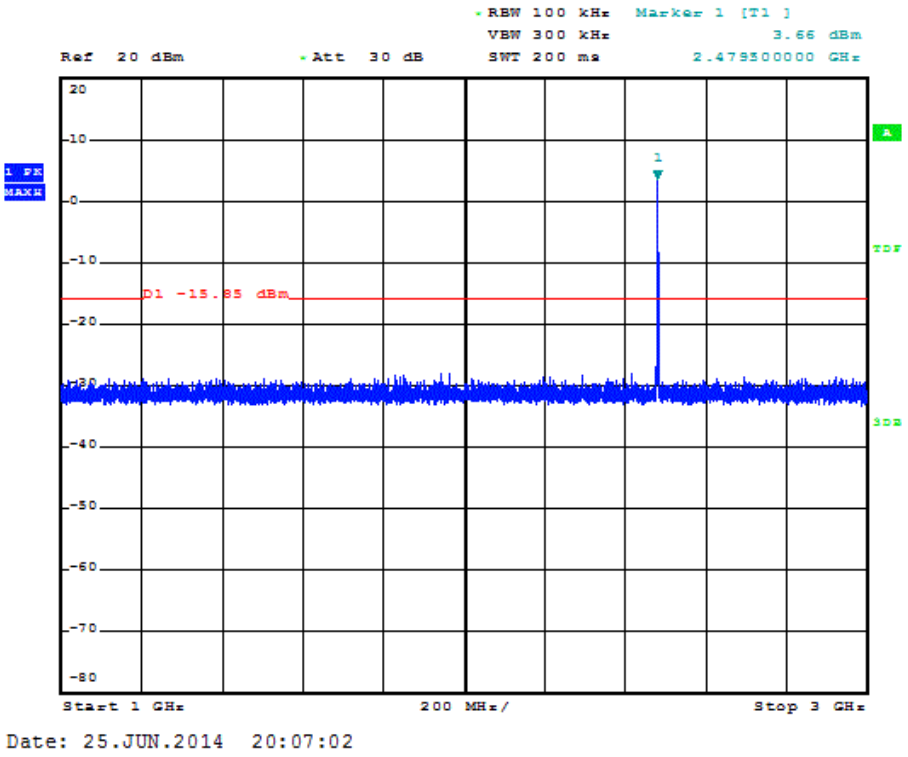

Figure 7.4.2.2-10: 1 GHz – 3 GHz –High Channel – RF Port 1

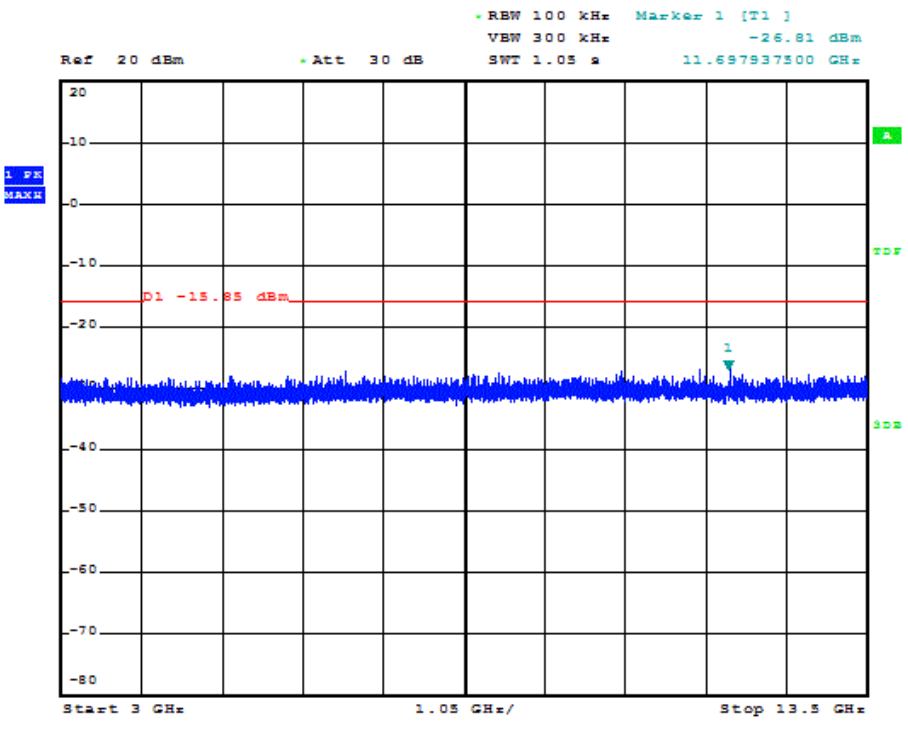

Figure 7.4.2.2-11: 3 GHz – 13.5 GHz –High Channel – RF Port 1

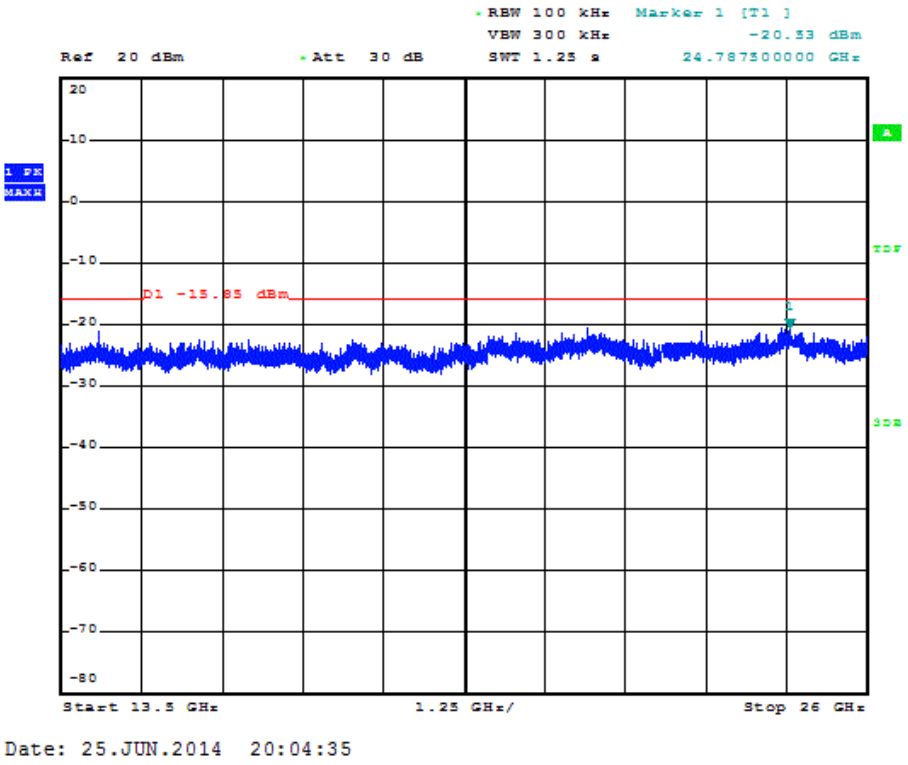

Figure 7.4.2.2-12: 13.5 GHz – 26 GHz –High Channel – RF Port 1

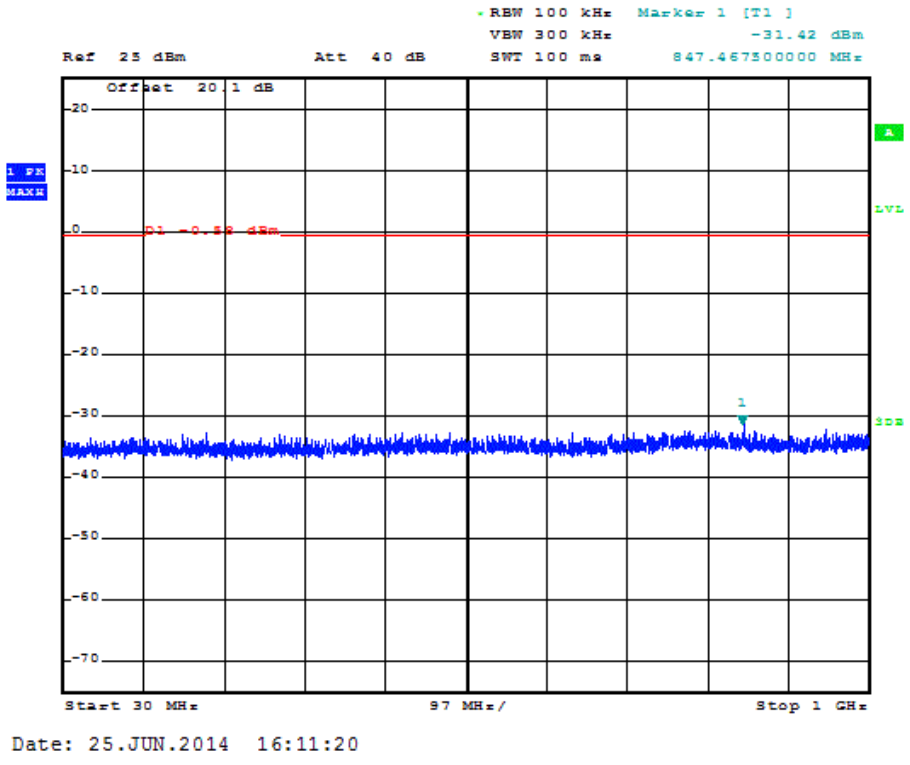

Figure 7.4.2.2-13: 30 MHz – 1 GHz – Low Channel – RF Port 2

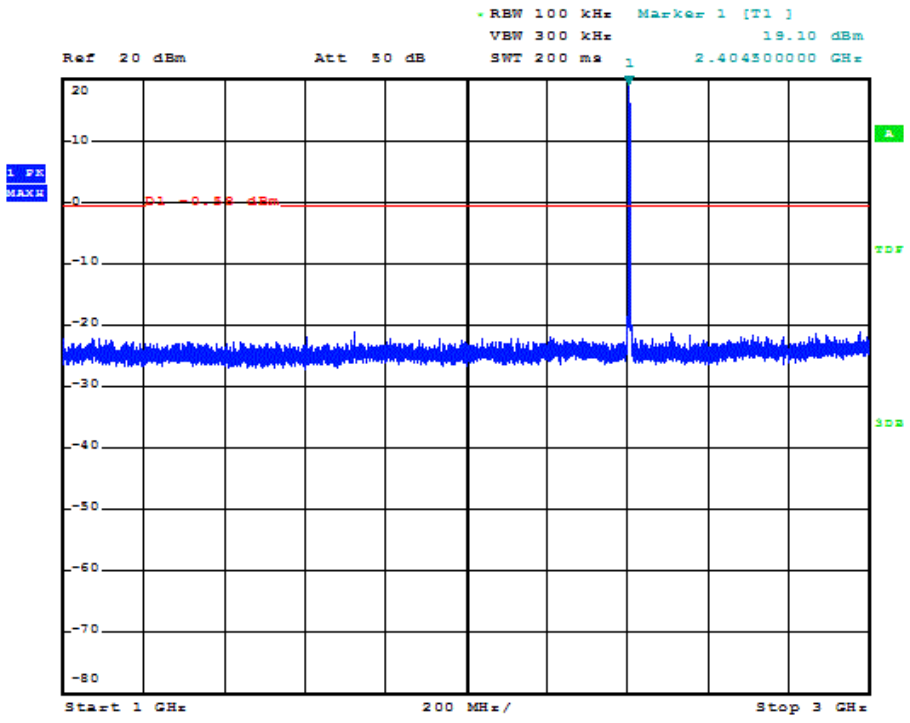

Figure 7.4.2.2-14: 1 GHz – 3 GHz – Low Channel – RF Port 2

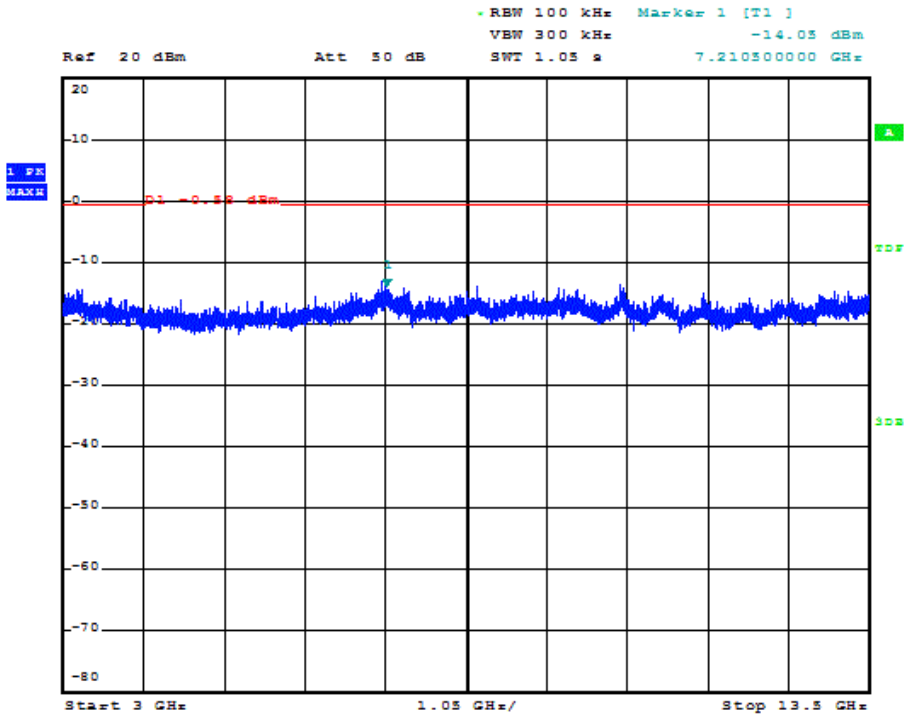

Figure 7.4.2.2-15: 3 GHz – 13.5 GHz – Low Channel – RF Port 2

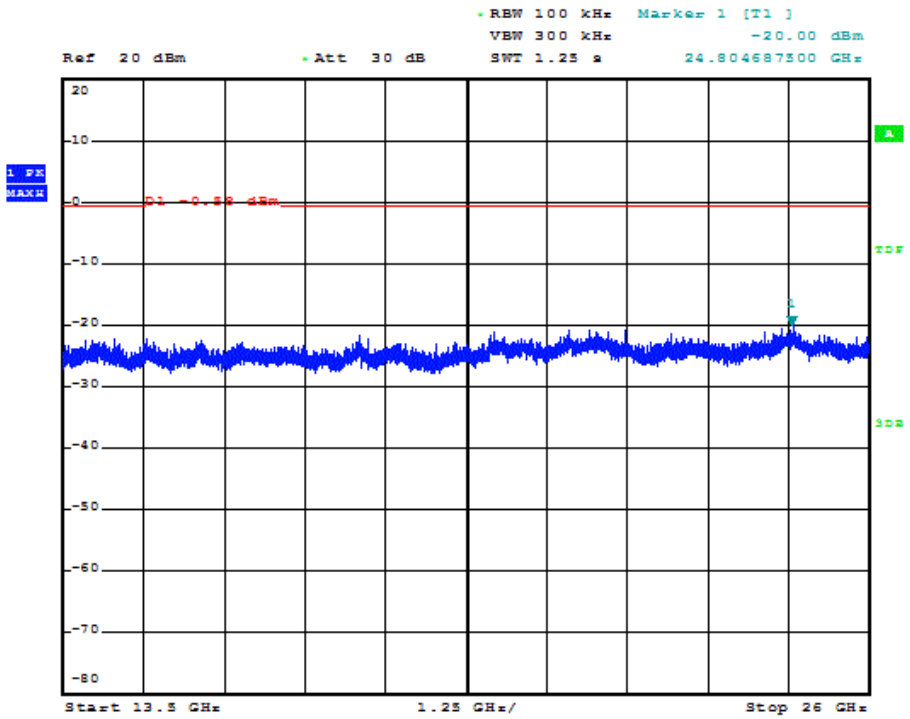

Figure 7.4.2.2-16: 13.5 GHz – 26 GHz – Low Channel – RF Port 2

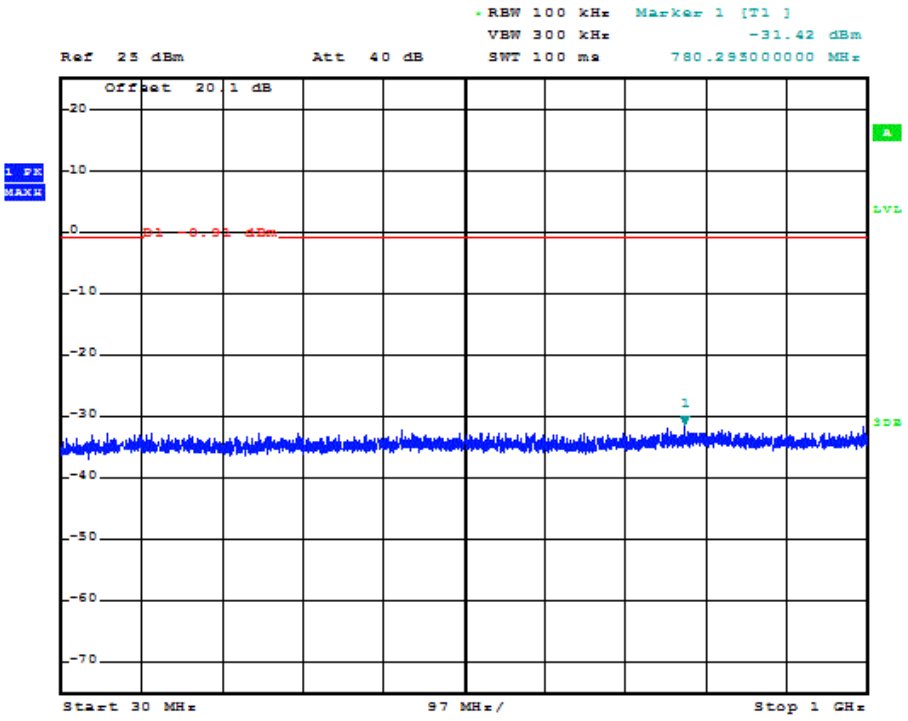

Figure 7.4.2.2-17: 30 MHz – 1 GHz –Middle Channel – RF Port 2

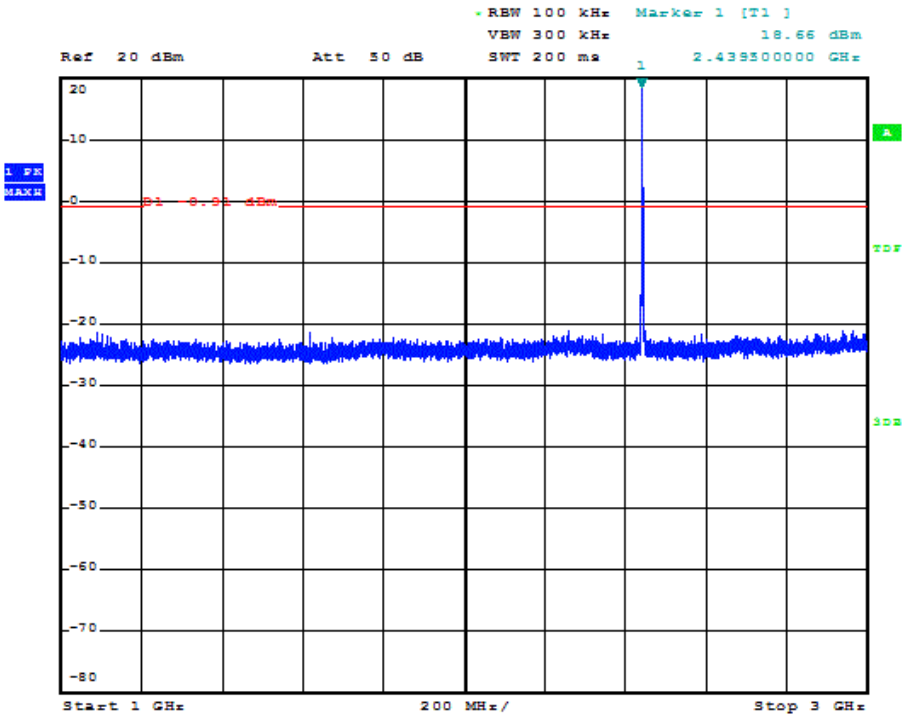

Figure 7.4.2.2-18: 1 GHz – 3 GHz – Middle Channel – RF Port 2

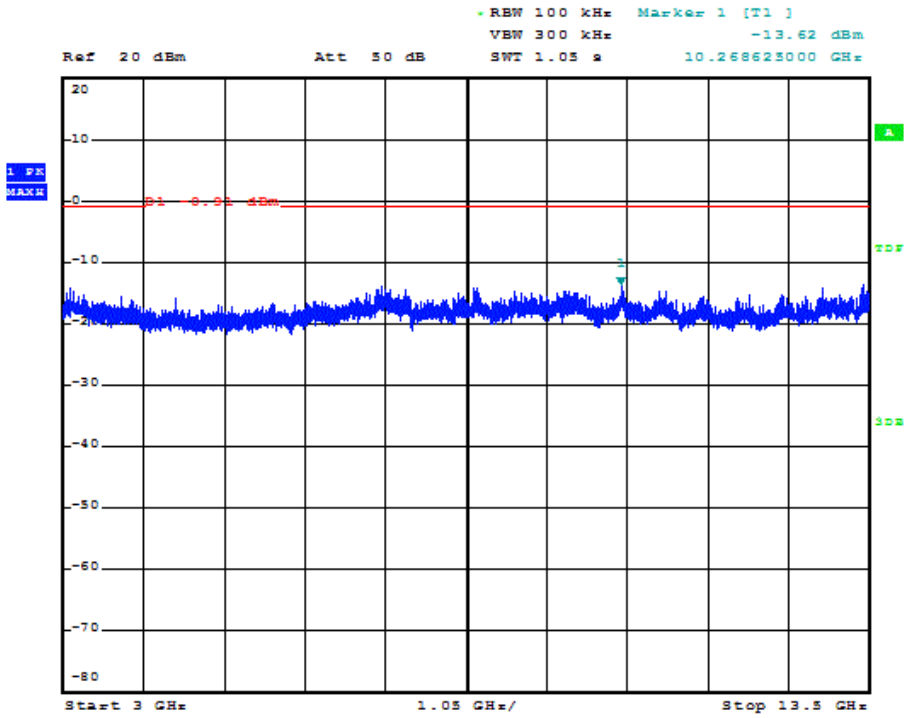

Figure 7.4.2.2-19: 3 GHz – 13.5 GHz – Middle Channel – RF Port 2

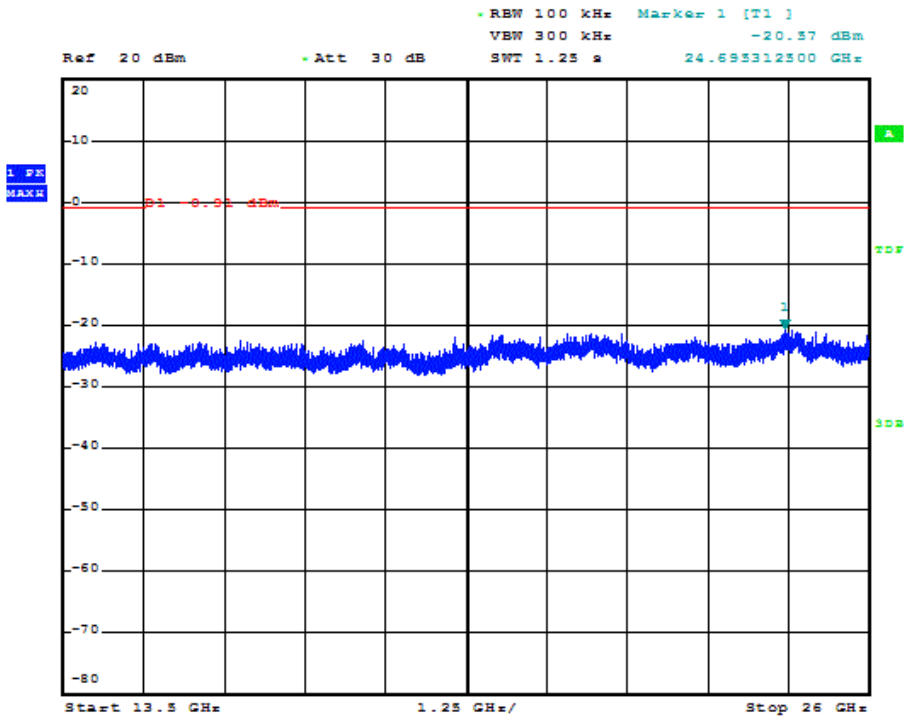

Figure 7.4.2.2-20: 13.5 GHz – 26 GHz – Middle Channel – RF Port 2

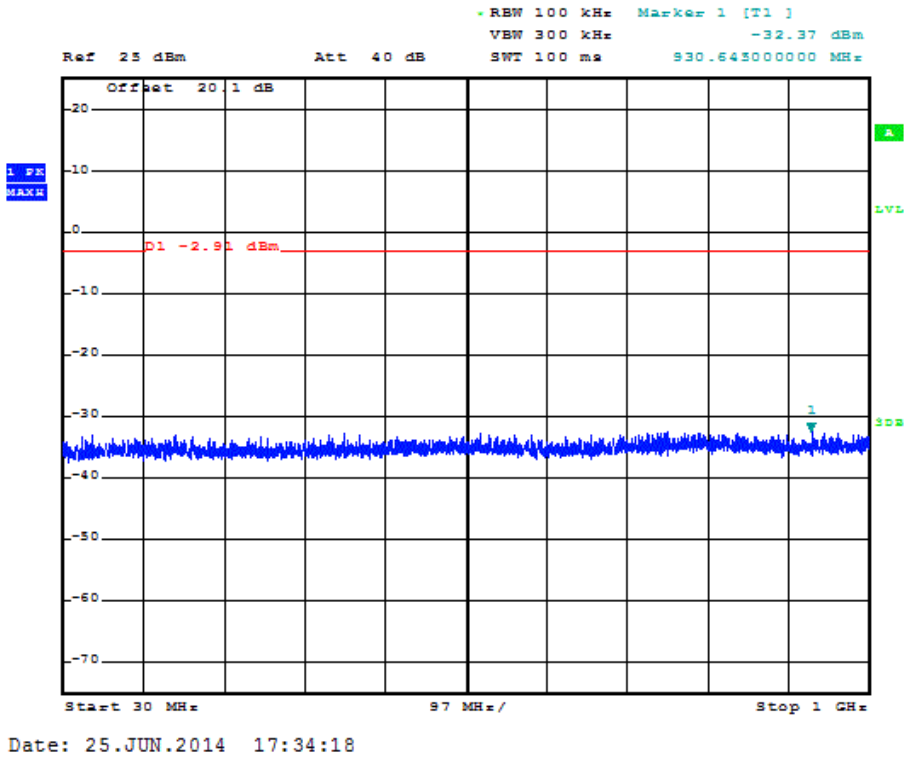

Figure 7.4.2.2-21: 30 MHz – 1 GHz – High Channel – RF Port 2

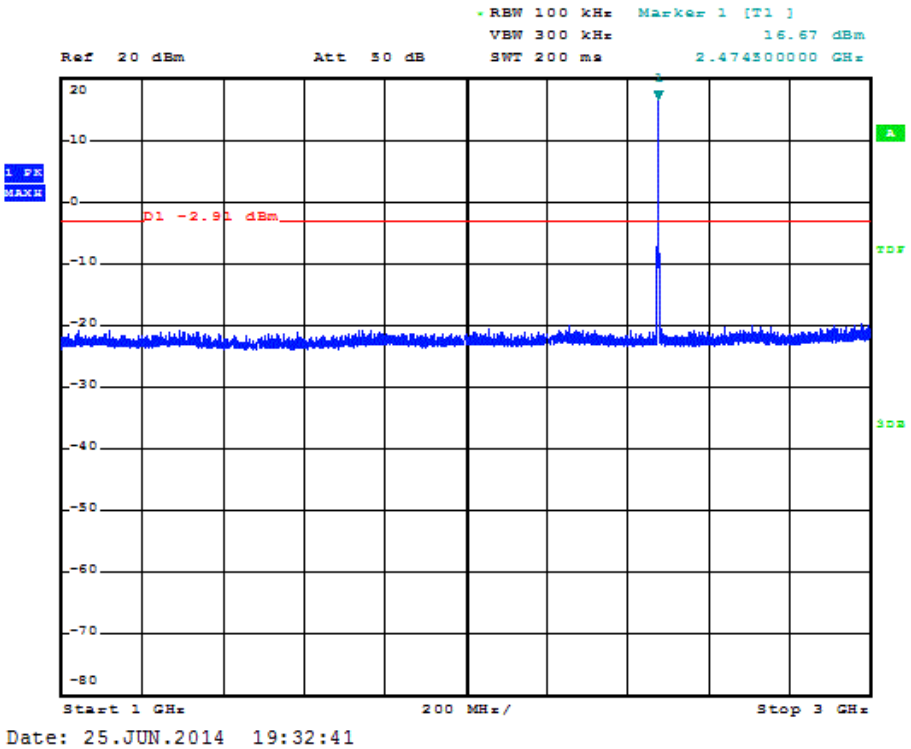

Figure 7.4.2.2-22: 1 GHz – 3 GHz –High Channel – RF Port 2

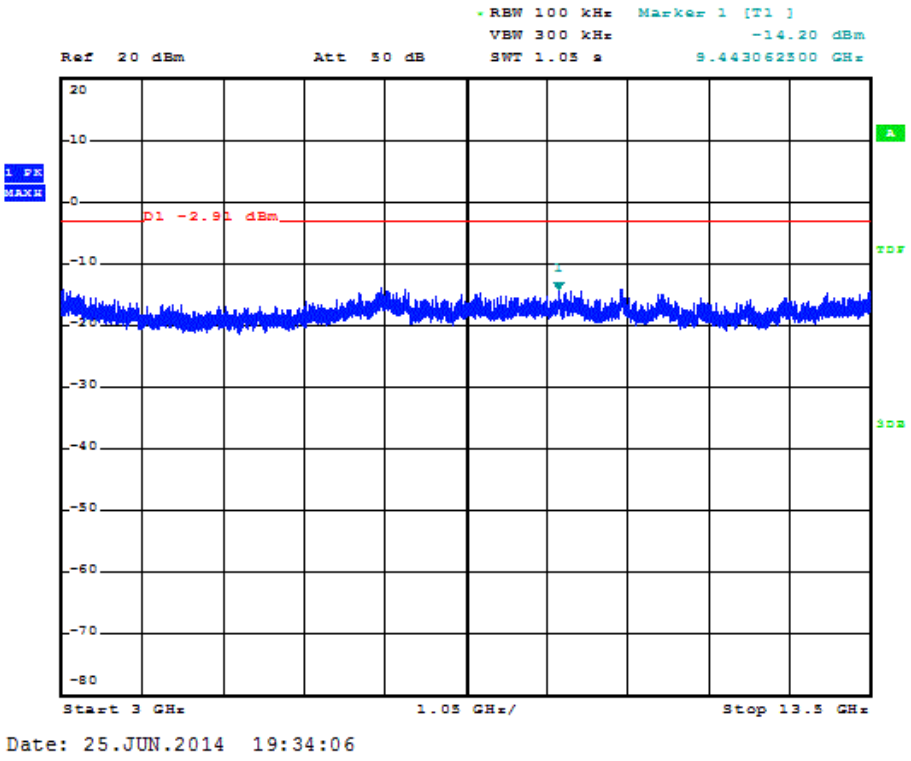

Figure 7.4.2.2-23: 3 GHz – 13.5 GHz –High Channel – RF Port 2

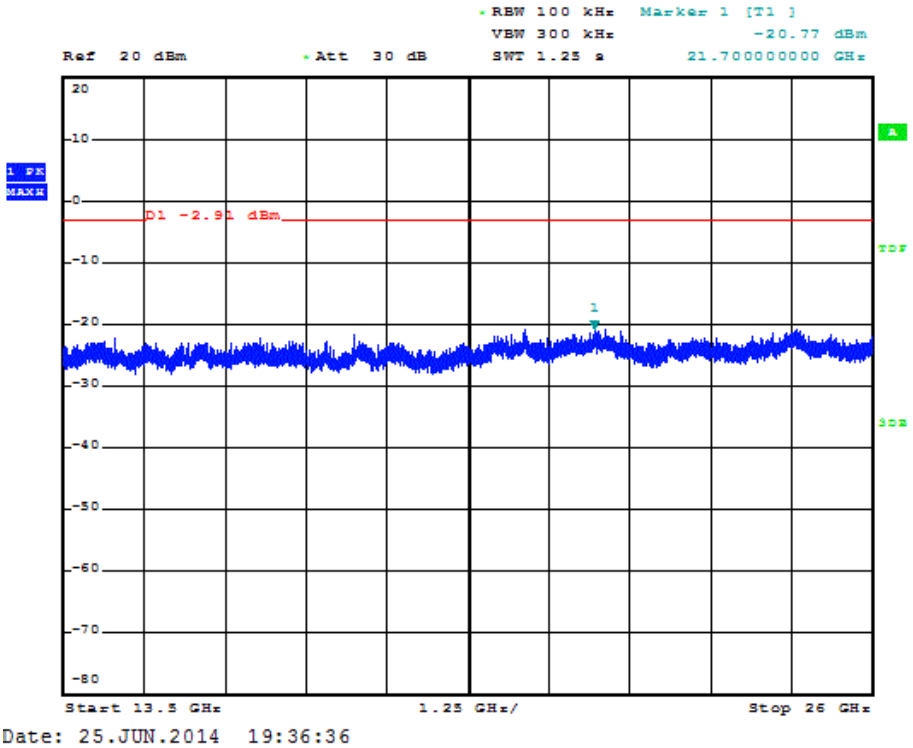

Figure 7.4.2.2-24: 13.5 GHz – 26 GHz –High Channel – RF Port 2

7.4.3 Radiated Spurious Emissions into Restricted Frequency Bands - FCC 15.205, 15.209; IC: RSS-210 2.2, RSS-Gen 7.2.2, 7.2.5

7.4.3.1 Measurement Procedure

Radiated emissions tests were made over the frequency range of 30 MHz to 26 GHz, 10 times the highest fundamental frequency. Each emission found to be in a restricted band as defined by section 15.205, including any emission at the operational band-edge, was compared to the radiated emission limits as defined in section 15.209.

The EUT was rotated through 360° and the receive antenna height was varied from 1m to 4m so that the maximum radiated emissions level would be detected. For frequencies below 1000MHz, quasi-peak measurements were made using a resolution bandwidth RBW of 120 kHz and a video bandwidth VBW of 300 kHz. For frequencies above 1000 MHz, peak measurements are made with RBW of 1 MHz and VBW of 3 MHz. Average measurements are performed in the linear scale using VBW of 30 Hz over a 5 second sweep.

A duty cycle correction factor corresponding to 14.1% was applied to the average measurement results. The justification for the duty cycle is provided in the theory of operations of the product.

7.4.3.2 Measurement Results

Radiated band-edge and spurious emissions found in the restricted frequency bands of 30MHz to 26 GHz are reported in the tables below.

Table 7.4.3.2-1: Radiated Spurious Emissions Tabulated Data
Internal Antenna

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel (2405 MHz)										
2390	67.94	59.74	H	-8.24	59.70	34.48	74.0	54.0	14.3	19.5
2390	68.02	59.00	V	-8.24	59.78	33.74	74.0	54.0	14.2	20.3
4810	57.27	50.30	H	-0.23	57.04	33.06	74.0	54.0	17.0	20.9
4810	58.05	50.29	V	-0.23	57.82	33.05	74.0	54.0	16.2	21.0
12025	46.27	34.81	H	13.17	59.44	30.96	83.5	63.5	24.1	32.5
12025	45.45	33.45	V	13.17	58.62	29.60	83.5	63.5	24.9	33.9
19240	42.52	29.28	H	10.96	53.48	23.23	83.5	63.5	30.0	40.3
Middle Channel (2440 MHz)										
4880	56.58	49.72	H	-0.04	56.54	32.66	74.0	54.0	17.5	21.3
4880	54.27	46.28	V	-0.04	54.23	29.22	74.0	54.0	19.8	24.8
7320	50.36	40.10	H	5.58	55.94	28.66	74.0	54.0	18.1	25.3
7320	49.23	39.03	V	5.58	54.81	27.59	74.0	54.0	19.2	26.4
12200	45.78	34.53	H	12.99	58.77	30.51	83.5	63.5	24.7	33.0
12200	45.05	32.86	V	12.99	58.04	28.84	83.5	63.5	25.5	34.7
19520	41.73	29.71	H	11.30	53.03	23.99	83.5	63.5	30.5	39.5
High Channel (2480 MHz)										
2483.5	79.46	69.20	H	-7.61	71.85	44.58	74.0	54.0	2.1	9.4
2483.5	77.49	67.59	V	-7.61	69.88	42.97	74.0	54.0	4.1	11.0
4960	47.99	37.12	H	0.20	48.19	20.30	74.0	54.0	25.8	33.7
4960	46.16	32.76	V	0.20	46.36	15.94	74.0	54.0	27.6	38.1
7440	45.13	32.06	H	6.00	51.13	21.04	74.0	54.0	22.9	33.0
7440	45.25	32.18	V	6.00	51.25	21.16	74.0	54.0	22.8	32.8

Notes:

- **A duty cycle correction factor of 14.1% was applied to the average measurements.**
- **The measurements above 10 GHz were performed at a test distance of 1m. The limits are corrected accordingly using a distance factor of 20*log(3/1)dB.**
- **The emissions above 19.52 GHz were attenuated below the limits and the noise floor of the measurement equipment.**

Table 7.4.3.2-2: Radiated Spurious Emissions Tabulated Data
3.2 dBi External Antenna

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel (2405 MHz)										
2390	64.41	54.78	H	-8.24	56.17	29.52	74.0	54.0	17.8	24.5
2390	71.99	63.50	V	-8.24	63.75	38.24	74.0	54.0	10.2	15.8
4810	55.73	48.90	H	-0.23	55.50	31.66	74.0	54.0	18.5	22.3
4810	52.87	44.89	V	-0.23	52.64	27.65	74.0	54.0	21.4	26.4
12025	47.19	36.01	H	13.17	60.36	32.16	83.5	63.5	23.1	31.3
12025	46.67	35.36	V	13.17	59.84	31.51	83.5	63.5	23.7	32.0
19240	40.82	28.35	H	10.96	51.78	22.30	83.5	63.5	31.7	41.2
Middle Channel (2440 MHz)										
4880	52.08	44.36	H	0.01	52.09	27.35	74.0	54.0	21.9	26.6
4880	50.04	41.25	V	0.01	50.05	24.24	74.0	54.0	24.0	29.8
7320	56.60	49.19	H	5.59	62.19	37.76	74.0	54.0	11.8	16.2
7320	55.91	47.99	V	5.59	61.50	36.56	74.0	54.0	12.5	17.4
12200	50.17	39.67	H	13.70	63.87	36.35	83.5	63.5	19.6	27.1
12200	49.49	40.46	V	13.70	63.19	37.14	83.5	63.5	20.3	26.4
19520	43.56	32.01	H	11.30	54.86	26.29	83.5	63.5	28.6	37.2
19520	40.66	28.61	V	11.30	51.96	22.89	83.5	63.5	31.5	40.6
High Channel (2475 MHz)										
2483.5	72.22	63.40	H	-7.61	64.61	38.78	74.0	54.0	9.4	15.2
2483.5	80.46	71.70	V	-7.61	72.85	47.08	74.0	54.0	1.1	6.9
4950	50.59	42.34	H	0.17	50.76	25.49	74.0	54.0	23.2	28.5
4950	49.99	41.19	V	0.17	50.16	24.34	74.0	54.0	23.8	29.7
7425	47.96	36.17	H	5.94	53.90	25.10	74.0	54.0	20.1	28.9
7425	48.19	37.24	V	5.94	54.13	26.17	74.0	54.0	19.9	27.8
12375	46.42	35.03	H	13.24	59.66	31.26	83.5	63.5	23.8	32.2
12375	47.06	35.56	V	13.24	60.30	31.79	83.5	63.5	23.2	31.7
19800	41.44	29.10	H	12.73	54.17	24.82	83.5	63.5	29.3	38.7

Notes:

- **A duty cycle correction factor of 14.1% was applied to the average measurements.**
- **The measurements above 10 GHz were performed at a test distance of 1m. The limits are corrected accordingly using a distance factor of 20*log(3/1)dB.**
- **The emissions above 19.8 GHz were attenuated below the limits and the noise floor of the measurement equipment.**

Table 7.4.3.2-3: Radiated Spurious Emissions Tabulated Data
5.5 dBi External Antenna

Frequency (MHz)	Level (dBuV)		Antenna Polarity	Correction Factors	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	pk	Qpk/Avg	(H/V)	(dB)	pk	Qpk/Avg	pk	Qpk/Avg	pk	Qpk/Avg
Low Channel (2405 MHz)										
2390	66.48	57.68	H	-8.24	58.24	32.42	74.0	54.0	15.8	21.6
2390	71.36	63.09	V	-8.24	63.12	37.83	74.0	54.0	10.9	16.2
4810	54.99	47.68	H	-0.23	54.76	30.44	74.0	54.0	19.2	23.6
4810	51.67	43.28	V	-0.23	51.44	26.04	74.0	54.0	22.6	28.0
12025	47.70	38.04	H	13.17	60.87	34.19	83.5	63.5	22.6	29.3
12025	48.50	38.91	V	13.17	61.67	35.06	83.5	63.5	21.8	28.4
19240	41.77	29.37	H	10.96	52.73	23.32	83.5	63.5	30.8	40.2
19240	40.67	28.28	V	10.96	51.63	22.23	83.5	63.5	31.9	41.3
Middle Channel (2440 MHz)										
4880	53.76	47.00	H	-0.04	53.72	29.94	74.0	54.0	20.3	24.1
4880	51.87	44.23	V	-0.04	51.83	27.17	74.0	54.0	22.2	26.8
7320	58.88	51.80	H	5.58	64.46	40.36	74.0	54.0	9.5	13.6
7320	59.02	52.10	V	5.58	64.60	40.66	74.0	54.0	9.4	13.3
12200	47.37	37.64	H	12.99	60.36	33.62	83.5	63.5	23.1	29.9
12200	49.83	39.99	V	12.99	62.82	35.97	83.5	63.5	20.7	27.5
19520	42.92	32.20	H	11.30	54.22	26.48	83.5	63.5	29.3	37.0
19520	41.71	28.84	V	11.30	53.01	23.12	83.5	63.5	30.5	40.4
High Channel (2475 MHz)										
2483.5	80.48	71.66	H	-7.61	72.87	47.04	74.0	54.0	1.1	7.0
2483.5	69.56	60.75	V	-7.61	61.95	36.13	74.0	54.0	12.0	17.9
4950	53.22	45.76	H	0.17	53.39	28.91	74.0	54.0	20.6	25.1
4950	51.48	42.92	V	0.17	51.65	26.07	74.0	54.0	22.4	27.9
7425	55.48	47.43	H	5.94	61.42	36.36	74.0	54.0	12.6	17.6
7425	53.97	46.46	V	5.94	59.91	35.39	74.0	54.0	14.1	18.6
12375	46.44	35.70	H	13.24	59.68	31.93	83.5	63.5	23.8	31.6
12375	48.27	38.32	V	13.24	61.51	34.55	83.5	63.5	22.0	29.0
19800	42.67	31.09	H	12.73	55.40	26.81	83.5	63.5	28.1	36.7

Notes:

- **A duty cycle correction factor of 14.1% was applied to the average measurements.**
- **The measurements above 10 GHz were performed at a test distance of 1m. The limits are corrected accordingly using a distance factor of 20*log(3/1)dB.**
- **The emissions above 19.8 GHz were attenuated below the limits and the noise floor of the measurement equipment.**

7.4.3.3 Sample Calculation:

$R_C = R_U + CF_T$

Where:

CF_T	=	Total Correction Factor (AF+CA+AG)-DC (Average Measurements Only)
R_U	=	Uncorrected Reading
R_C	=	Corrected Level
AF	=	Antenna Factor
CA	=	Cable Attenuation
AG	=	Amplifier Gain
DC	=	Duty Cycle Correction Factor

Duty Cycle Correction Factor = 20*log(14.1/100) dB = -17.02 dB

Example Calculation: Peak
Corrected Level: 67.94+ (-8.24) = 59.7 dBµV/m
Margin: 74 dBµV/m – 59.7 dBµV/m = 14.3 dB

Example Calculation: Average
Corrected Level: 59.74 + (-8.24) - 17.02 = 34.48dBµV/m
Margin: 54 dBµV/m – 34.48 dBµV/m = 19.5 dB

7.5 Power Spectral Density - FCC Section 15.247(e) IC: RSS-210 A8.2(b)

7.5.1 PSD Measurement Procedure (Conducted Method)

The power spectral density was measured in accordance with the FCC KDB Publication No. 558074 "Guidance for Performing Compliance Measurements on Digital Transmission Systems (47 CFR 15.247)" Section 10.2 Method PKPSD (peak PSD). The RF output port of the EUT was directly connected to the input of the spectrum analyzer. Reference level of the equipment was offset to account for cable loss and external attenuation. The spectrum analyzer RBW was set to 3 kHz and VBW 10 kHz. Span was adjusted to 1.5 times the 6 dB bandwidth and the sweep time was set to auto.

7.5.2 Measurement Results

Results are shown below.

Table 7.5.2-1: Power Spectral Density – RF Port 1

Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
2405	5.66	8.0	2.34
2440	3.98	8.0	4.02
2480	-10.73	8.0	18.73

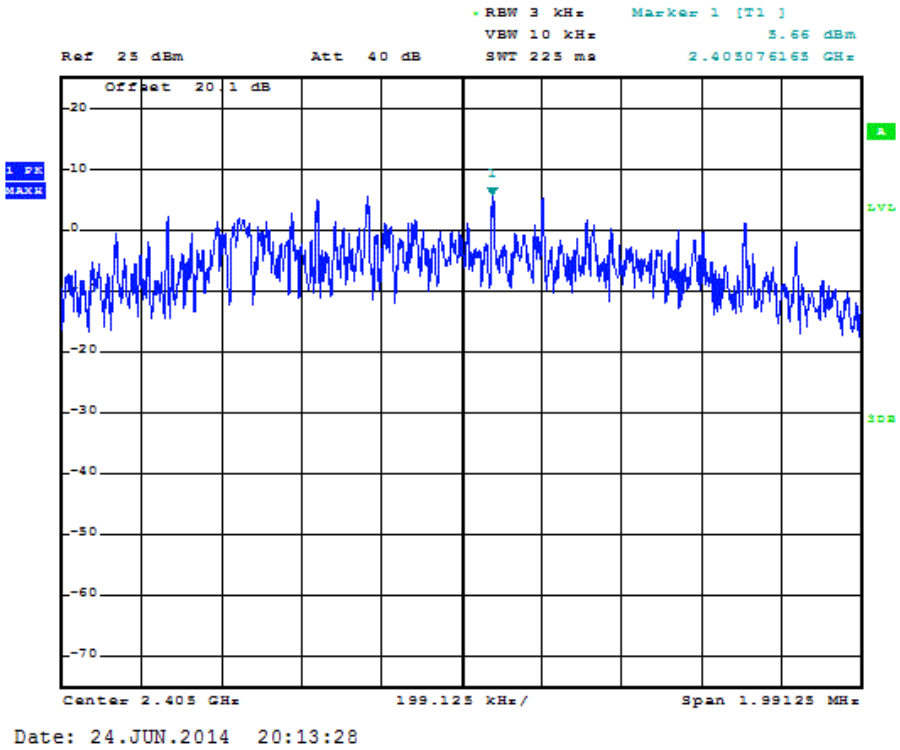

Figure 7.5.2-1: Power Spectral Density - Low Channel – RF Port 1

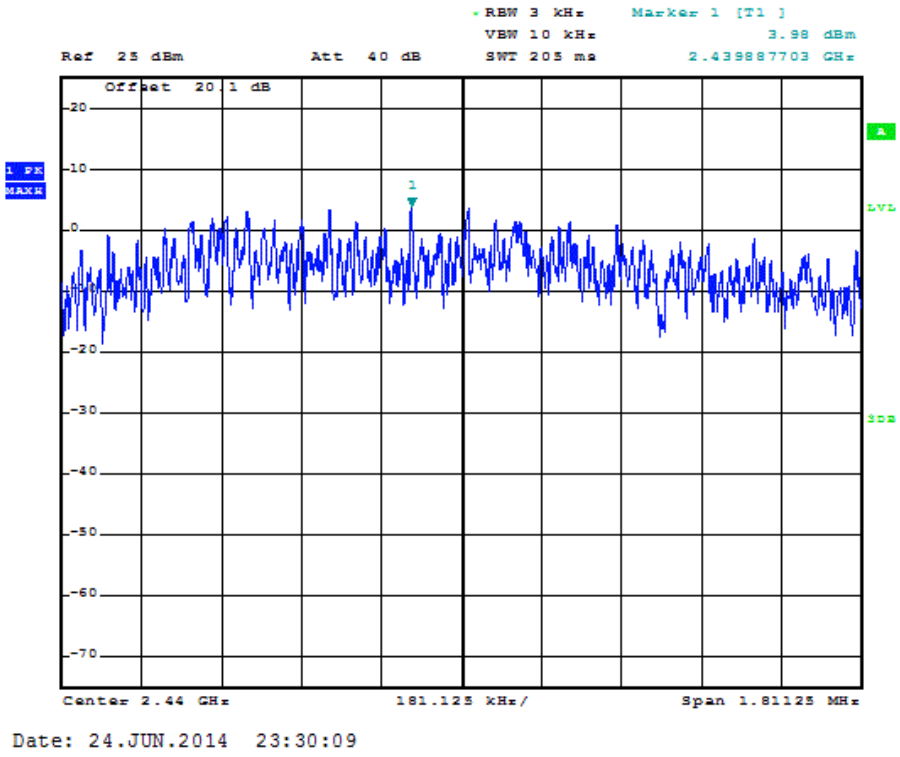

Figure 7.5.2-2: Power Spectral Density - Middle Channel – RF Port 1

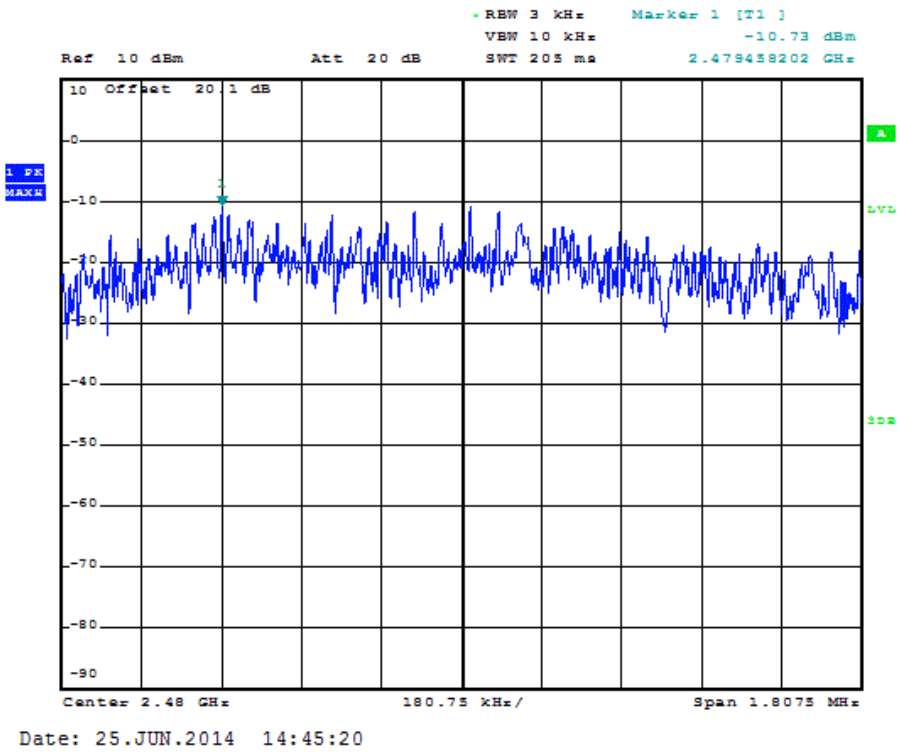

Figure 7.5.2-3: Power Spectral Density – High Channel – RF Port 1

Table 7.5.2-2: Power Spectral Density – RF Port 2

Frequency (MHz)	PSD (dBm)	Limit (dBm)	Margin (dB)
2405	5.24	8.0	2.76
2440	4.93	8.0	3.07
2475	2.02	8.0	5.98

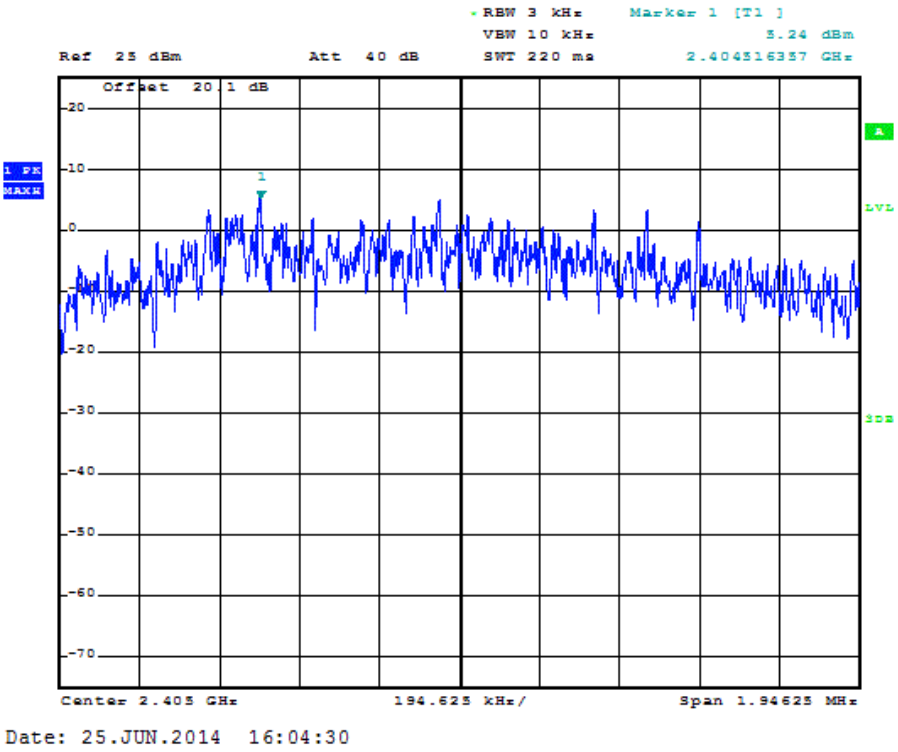

Figure 7.5.2-4: Power Spectral Density - Low Channel – RF Port 2

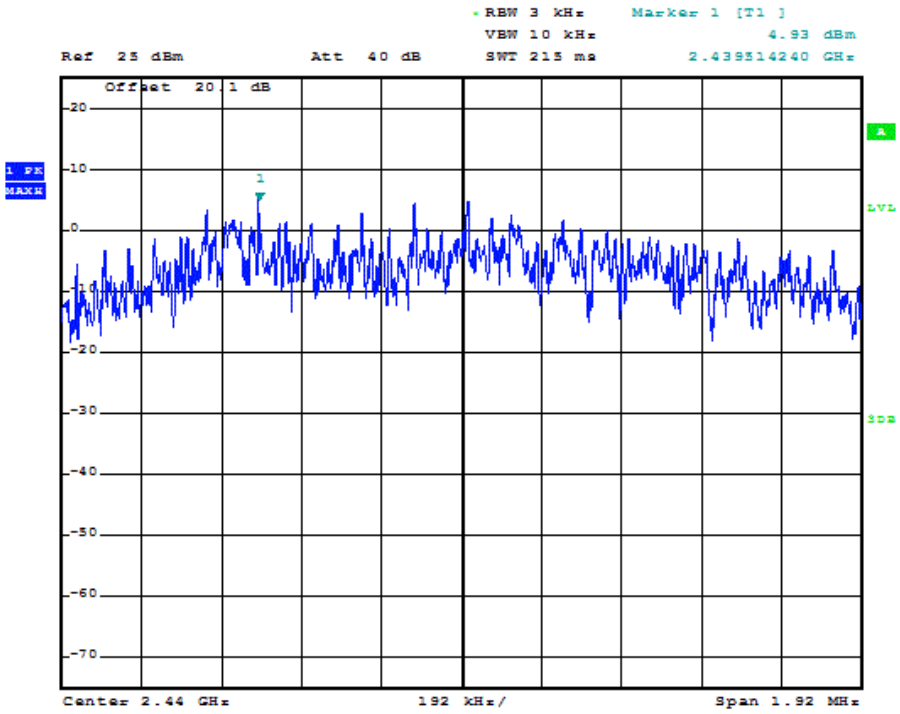

Figure 7.5.2-5: Power Spectral Density - Middle Channel – RF Port 2

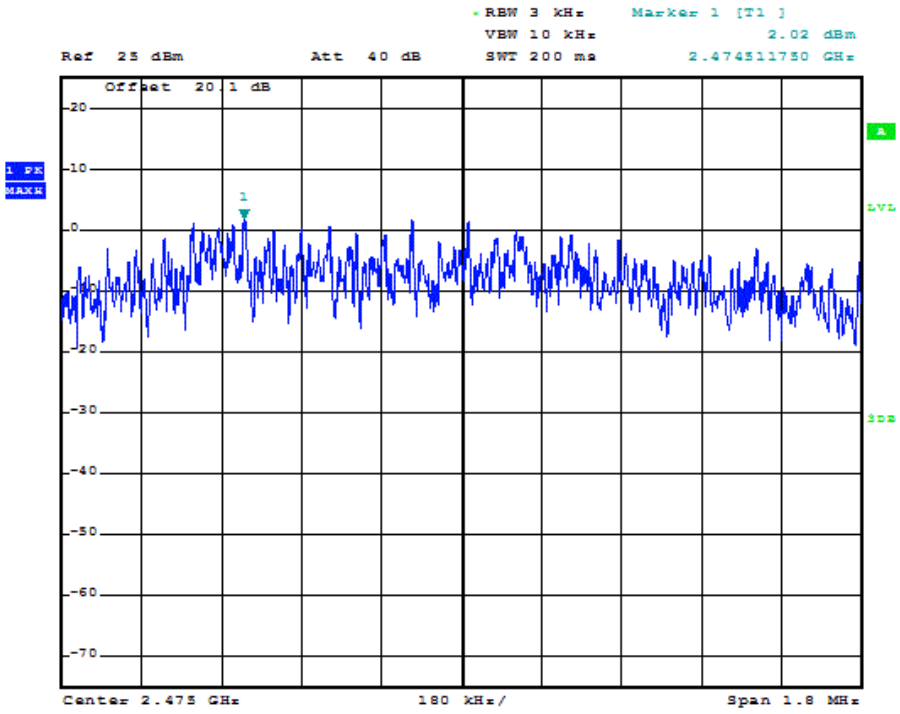

Figure 7.5.2-6: Power Spectral Density – High Channel – RF Port 2

7.6 Power Line Conducted Emissions – FCC: Section 15.207 IC: RSS-Gen 7.2.4

7.6.1 Measurement Procedure

ANSI C63.4 sections 6 and 7 were the guiding documents for this evaluation. Conducted emissions were performed from 150 kHz to 30 MHz with the spectrum analyzer's resolution bandwidth set to 9 kHz and the video bandwidth set to 30 kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Applicable Limit - Corrected Reading

7.6.2 Measurement Results

Results are shown below.

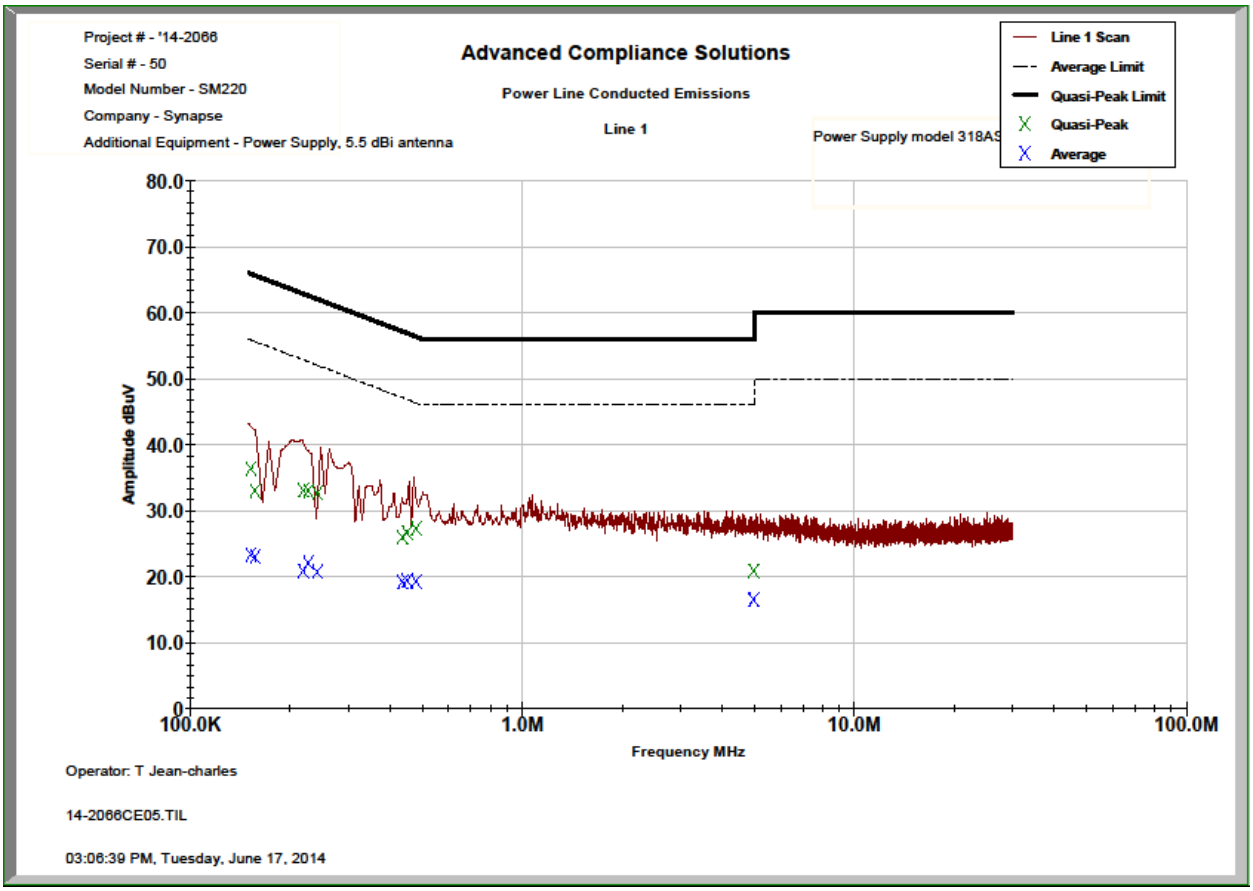

Figure 7.6.2-1: Conducted Emissions Results – Line 1

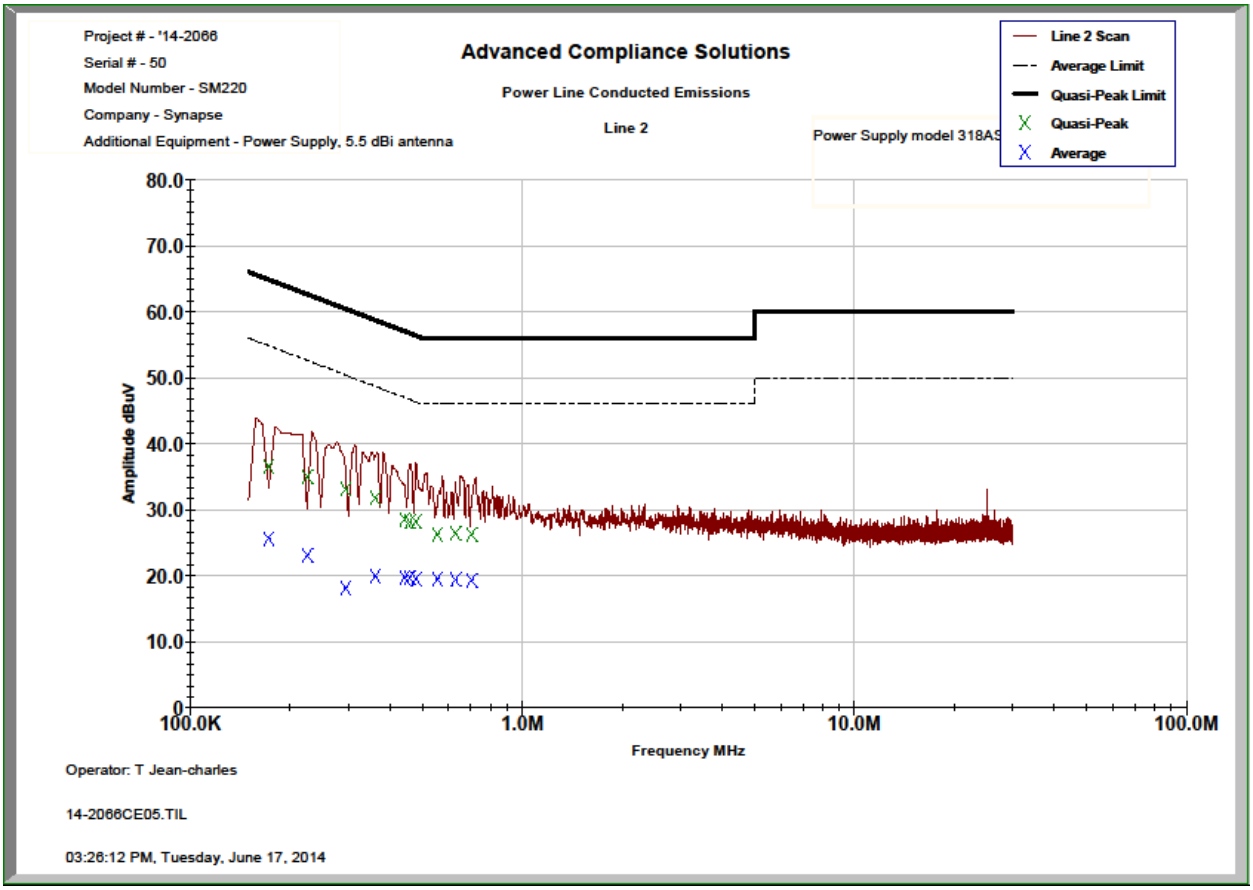

Figure 7.6.2-2: Conducted Emissions Results – Line 2

Table 7.6.2-1: Conducted EMI Results

☒ Line 1 ☒ Line 2 ☐ Line 3
☐ Line 4
☐ To Ground ☒ Floating
☐ Telecom Port _____
☒ dBµV ☐ dBµA

Plot Number: 14-2066CE05
Power Supply Description: 9 VDC

Frequency (MHz)	Uncorrected Reading		Total Correction Factor (dB)	Corrected Level		Limit		Margin (dB)	
	Quasi-Peak	Average		Quasi-Peak	Average	Quasi-Peak	Average	Quasi-Peak	Average
Line 1									
0.152481	26.28	13.316	10.10	36.38	23.41	65.86	55.86	29.5	32.5
0.156937	22.958	12.932	10.10	33.05	23.03	65.62	55.62	32.6	32.6
0.219313	23.015	10.793	10.10	33.11	20.89	62.84	52.84	29.7	32.0
0.227413	22.922	12.039	10.10	33.02	22.14	62.54	52.54	29.5	30.4
0.241937	22.606	10.645	10.10	32.70	20.74	62.03	52.03	29.3	31.3
0.435963	15.91	9.153	10.08	25.99	19.23	57.14	47.14	31.2	27.9
0.450887	16.651	9.312	10.08	26.73	19.39	56.86	46.86	30.1	27.5
0.479999	17.267	9.21	10.08	27.35	19.29	56.34	46.34	29.0	27.1
4.98	10.522	6.17	10.28	20.80	16.45	56.00	46.00	35.2	29.6
4.9801	10.529	6.184	10.28	20.81	16.46	56.00	46.00	35.2	29.5
Line 2									
0.172654	26.5	15.603	10.07	36.57	25.67	64.83	54.83	28.3	29.2
0.225888	24.931	13.048	10.08	35.01	23.13	62.60	52.60	27.6	29.5
0.294174	23.06	8.089	10.07	33.13	18.16	60.41	50.41	27.3	32.2
0.361338	21.681	9.891	10.05	31.73	19.94	58.70	48.70	27.0	28.8
0.443424	18.517	9.686	10.05	28.57	19.74	57.00	47.00	28.4	27.3
0.45835	18.137	9.666	10.05	28.19	19.72	56.72	46.72	28.5	27.0
0.48	18.121	9.491	10.05	28.17	19.54	56.34	46.34	28.2	26.8
0.555362	16.23	9.411	10.06	26.29	19.47	56.00	46.00	29.7	26.5
0.629988	16.337	9.324	10.08	26.41	19.40	56.00	46.00	29.6	26.6
0.704612	16.211	9.28	10.07	26.28	19.35	56.00	46.00	29.7	26.6

8 CONCLUSION

In the opinion of ACS, Inc., the model SM220 meets the requirements of FCC Part 15 subpart C and Industry Canada's Radio Standards Specification RSS-210 for the test procedures documented in the test report.

END REPORT