

ENGINEERING TEST REPORT



XBee S2C OEM RF Module Model No.: XBEE S2C

FCC ID: MCQ-XBS2C

Applicant:

Digi International Inc.
11001 Bren Road East
Minnetonka, MN 55343

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247
Digital Modulation Systems (DTS) Operating in 2400 – 2483.5 MHz Band

UltraTech's File No.: DIGI-028Q1F15C247

This Test report is Issued under the Authority
of
Tri M. Luu, Professional Engineer,
Vice President of Engineering
UltraTech Group of Labs



Date: June 14, 2010

Report Prepared by: Dan Huynh

Tested by: Mr. Hung Trinh, EMI/RFI Technician

Issued Date: June 14, 2010

Test Dates: April 6 - 19, 2010

*The results in this Test Report apply only to the sample(s) tested, and the sample tested is randomly selected.
This report must not be used by the client to claim product endorsement by NVLAP or any agency of the US Government.*

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46390-2049



NvLap Lab Code
200093-0



SL2-IN-E-1119R



CA2049

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EXHIBIT 1. INTRODUCTION

1.1. SCOPE

Reference:	FCC Part 15, Subpart C, Section 15.247
Title:	Code of Federal Regulations (CFR), Title 47 – Telecommunication, Part 15
Purpose of Test:	Equipment Certification for Digital Modulation Systems (DTS) Transmitter Operating in the Frequency Band 2400-2483.5 MHz.
Test Procedures:	American National Standards Institute ANSI C63.10 - American National Standard for Testing Unlicensed Wireless Devices
Environmental Classification:	<input checked="" type="checkbox"/> Commercial, industrial or business environment <input checked="" type="checkbox"/> Residential environment

1.2. RELATED SUBMITTAL(S)/GRANT(S)

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2009	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.10	2009	American National Standard for Testing Unlicensed Wireless Devices
CISPR 22 & EN 55022	2008-09, Edition 6.0 2006	Information Technology Equipment - Radio Disturbance Characteristics - Limits and Methods of Measurement
CISPR 16-1-1 +A1 +A2	2006 2006 2007	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-1-2 +A1 +A2	2003 2004 2006	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-2: Conducted disturbances
KDB Publication No. 558074	2005	Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Digi International Inc.
Address:	11001 Bren Road East Minnetonka, MN 55343 USA
Contact Person:	Mr. Paul Dahl Phone #: 801-765-9885 Fax #: 801-765-9895 Email Address: Paul.dahl@digi.com

MANUFACTURER	
Name:	Digi International Inc.
Address:	11001 Bren Road East Minnetonka, MN 55343 USA
Contact Person:	Mr. Paul Dahl Phone #: 801-765-9885 Fax #: 801-765-9895 Email Address: Paul.dahl@digi.com

2.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

The following information (with the exception of the Date of Receipt) has been supplied by the applicant.

Brand Name:	Digi International Inc.
Product Name:	XBee S2C OEM RF Module
Model Name or Number:	XBEE S2C
Serial Number:	Test Sample
Type of Equipment:	Digital Transmission System (DTS)
Input Power Supply Type:	3.3 Vdc using TENMA DC Regulated Power Supply Model: 72-7295
Primary User Functions of EUT:	Provide wireless connectivity to end-point devices in ZigBee mesh networks.

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	<ul style="list-style-type: none">• Mobile• Base Station (fixed use)
Intended Operating Environment:	Commercial, industrial or business
Power Supply Requirement:	2.1 - 3.6 VDC
RF Output Power Rating:	For 2405-2475 MHz: -26 dBm to 8 dBm (0.0025 to 6.3 mW) For 2480 MHz : -26 dBm to 3.73 dBm (0.0025 to 2.4 mW)
Operating Frequency Range:	2405 – 2480 MHz
RF Output Impedance:	50 Ω
Channel Spacing:	5 MHz
Duty Cycle:	27%
6 dB bandwidth:	1.62 MHz
Modulation Type:	QPSK
Oscillator Frequencies:	24 MHz
Antenna Connector Types:	RF Pad, PCB Antenna, or U.FL Connector

2.4. ASSOCIATED ANTENNA DESCRIPTION

The highest gain antenna from each type of antenna was selected for testing to represent the worst case. The following antennas were selected for testing in this filing:

1. Dipole Antenna (P/N: A24-HABUF-P5I; Max. Antenna Gain: 2.1 dBi)
2. Omni-directional Antenna (P/N: A24-F15NF; Max. Antenna Gain: 15 dBi)
3. Panel Antenna (P/N: A24-19NF; Max. Antenna Gain: 19 dBi)
4. Yagi Antenna (P/N: A24-Y18NF; Max. Antenna Gain: 15 dBi)
5. Integrated Whip Monopole Antenna (P/N: A24-QI; Max. Antenna Gain: 1.5 dBi)

2.5. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	RF port	1	U.FL	Shielded
2	RF Pad	1	Castellated Pad	No Cable, direct connection
3	DC supply and I/O port	1	Castellated Pads	No cable, direct connection

2.6. ANCILLARY EQUIPMENT

The EUT was tested while connected to the following representative configuration of ancillary equipment necessary to exercise the ports during tests:

Ancillary Equipment # 1	
Description:	Test Jig Cable
Brand name:	Digi International
Model Name or Number:	N/A
Serial Number:	N/A
Connected to EUT's Port:	Module pin signals

EXHIBIT 3. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

3.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21 to 23 °C
Humidity:	45 to 58%
Pressure:	102 kPa
Power Input Source:	3.3 Vdc

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements.
Special Test Software:	Special software and hardware by the Applicant to operate the EUT at each channel frequency continuously. For example, the transmitter will be operated at each of the lowest, middle and highest frequencies individually continuously during testing.
Special Hardware Used:	The RF Module could be tested outside of the enclosure using Digi International Test Jig Cable connected to EUT.
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as integral / non-integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	2405 - 2480 MHz
Frequency(ies) Tested: (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	2405, 2440, 2475 and 2480 MHz (Channels # 11, 18, 25 & 26)
RF Power Output: (measured maximum output power at antenna terminals)	7.97 dBm (6.3 mW) Peak
Normal Test Modulation:	QPSK
Modulating Signal Source:	Internal

EXHIBIT 4. SUMMARY OF TEST RESULTS

4.1. LOCATION OF TESTS

All of the measurements described in this report were performed at Ultratech Group of Labs located in the city of Oakville, Province of Ontario, Canada.

- AC Power Line Conducted Emissions were performed in UltraTech's shielded room, 24'(L) by 16'(W) by 8'(H).
- Radiated Emissions were performed at the Ultratech's 3-10 TDK Semi-Anechoic Chamber situated in the Town of Oakville, province of Ontario. This test site been calibrated in accordance with ANSI C63.4, and found to be in compliance with the requirements of Sec. 2.948 of the FCC Rules. The descriptions and site measurement data of the Oakville 3-10 TDK Semi-Anechoic Chamber has been filed with FCC office (FCC File No.: 31040/SIT 1300B3) and Industry Canada office (Industry Canada Site No.: 2049A-3, Expiry Date: May 1, 2011)

4.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes*
15.207(a)	AC Power Line Conducted Emissions	Yes
15.247(a)(2)	6 dB Bandwidth	Yes
15.247(b)(3)	Peak Conducted Output Power - DTS	Yes
15.247(d)	Band-Edge and RF Conducted Spurious Emissions at the Transmitter Antenna Terminal	Yes
15.247(d), 15.209 & 15.205	Transmitter Spurious Radiated Emissions	Yes
15.247(e)	Power Spectral Density	Yes
15.247(i) 1.1307, 1.1310, 2.1091 & 2.1093	RF Exposure	Yes
The digital circuit portion of the EUT has been tested and verified to comply with FCC Part 15, Subpart B, Class B Digital Devices. The engineering test report is available upon request.		

* The EUT complies with the requirement; it employs a unique (non-standard) antenna connector (RF Pad, PCB or U.FL Connector), for all external antennas proposed for use with the EUT and permanently mounted integral antenna.

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

EXHIBIT 5. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

5.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in ANSI C63.10; FCC KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems.

5.2. MEASUREMENT UNCERTAINTIES

The measurement uncertainties stated were calculated in accordance with requirements of UKAS Document NIS 81 with a confidence level of 95%. Please refer to Exhibit 7 for Measurement Uncertainties.

5.3. MEASUREMENT EQUIPMENT USED

The measurement equipment used complied with the requirements of the Standards referenced in the Methods & Procedures ANSI C63.4 and CISPR 16-1-1.

5.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUFACTURER

Provide wireless connectivity to end-point devices in ZigBee mesh networks.

5.5. AC POWER LINE CONDUCTED EMISSIONS [§15.207(a)]

5.5.1. Limit(s)

The equipment shall meet the limits of the following table:

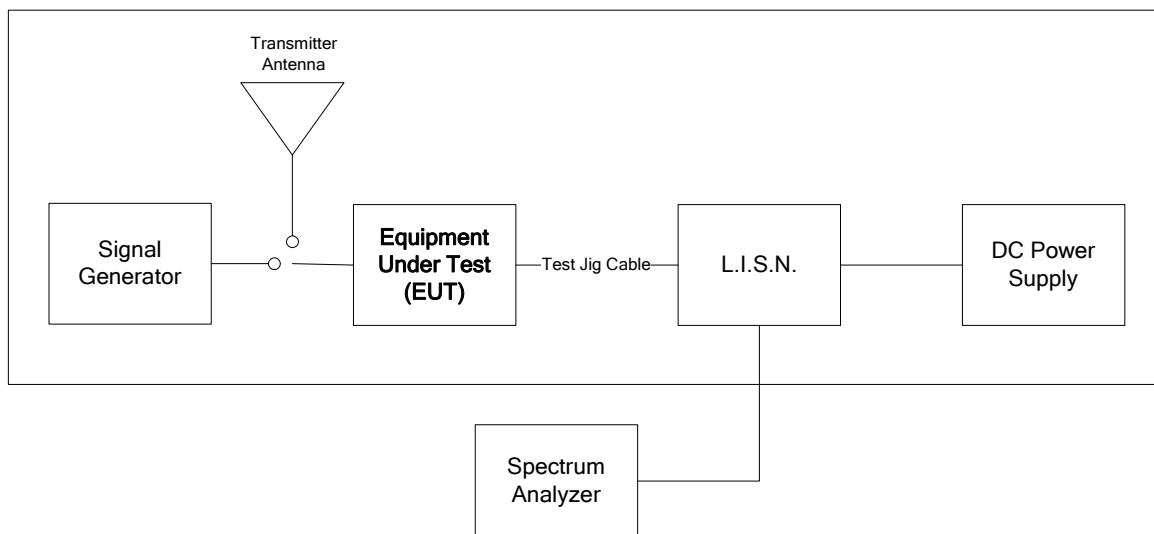
Frequency of emission (MHz)	Conducted Limits (dB μ V)		Measuring Bandwidth
	Quasi-peak	Average	
0.15–0.5	66 to 56*	56 to 46*	RBW = 9 kHz
0.5–5	56	46	VBW \geq 9 kHz for QP
5–30	60	50	VBW = 1 Hz for Average

*Decreases linearly with the logarithm of the frequency

5.5.2. Method of Measurements

ANSI C63.4

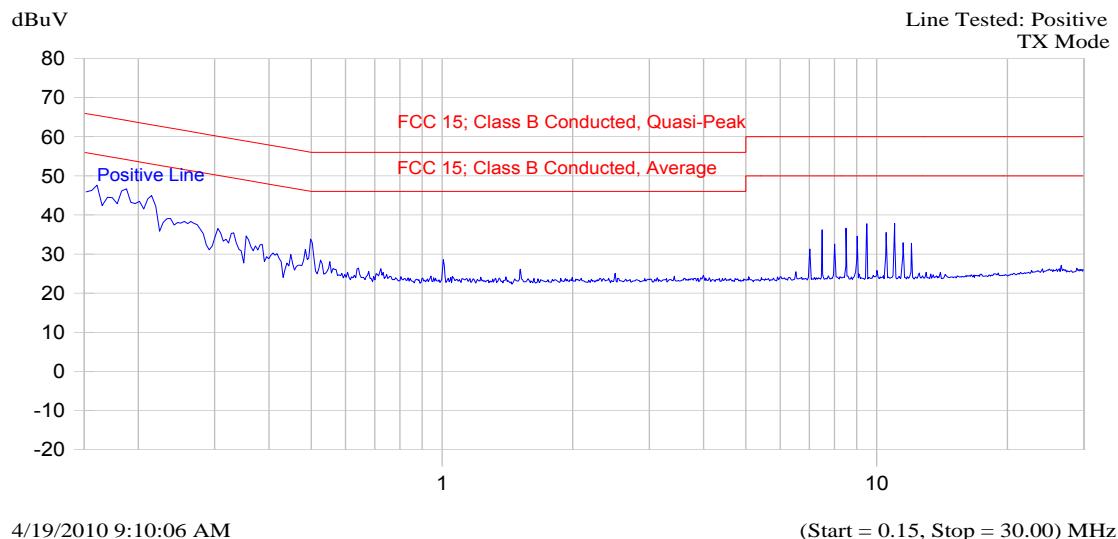
5.5.3. Test Arrangement



5.5.4. Test Data

Plot 5.5.4.1. Power Line Conducted Emissions (Tx Mode)
Line Voltage: 3.3VDC
Line Tested: Positive

Current Graph



Current List

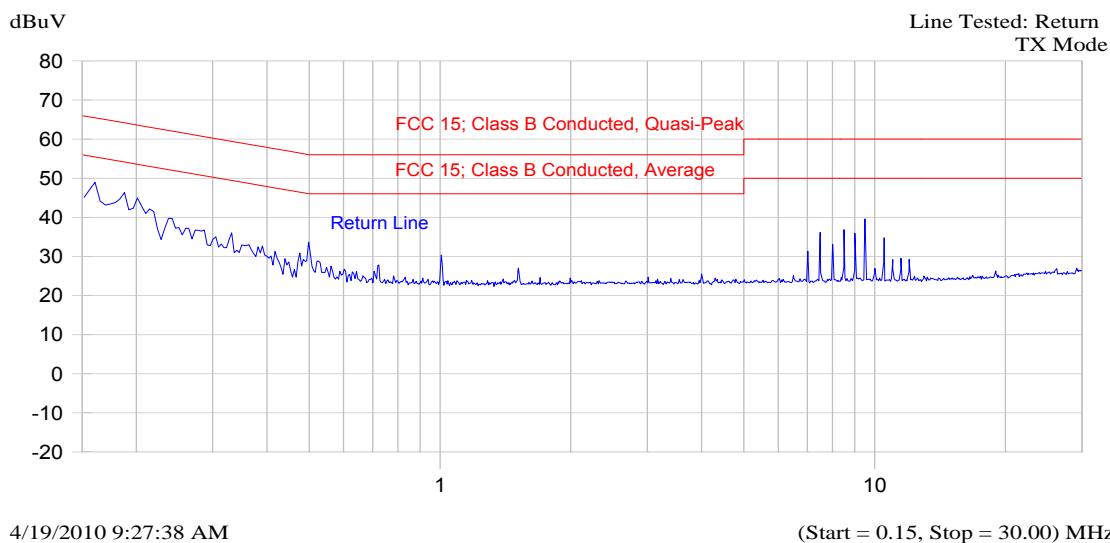
Frequency MHz	Peak dBuV	QP dBuV	Delta dBuV	QP-QP Limit dB	Avg dBuV	Delta dBuV	Avg-Avg Limit dB	Trace Name
0.167	49.6	46.2	-19.3		42.1	-13.4		Positive Line
0.191	48.9	45.9	-18.9		42.5	-12.3		Positive Line
0.204	48.0	43.9	-20.5		39.6	-14.8		Positive Line
7.495	37.0	33.8	-26.2		30.1	-19.9		Positive Line
8.498	37.2	34.1	-25.9		30.4	-19.6		Positive Line
9.501	38.9	36.2	-23.8		31.5	-18.5		Positive Line

Plot 5.5.4.2. Power Line Conducted Emissions (Tx Mode)

Line Voltage: 3.3VDC

Line Tested: Return

Current Graph



Current List

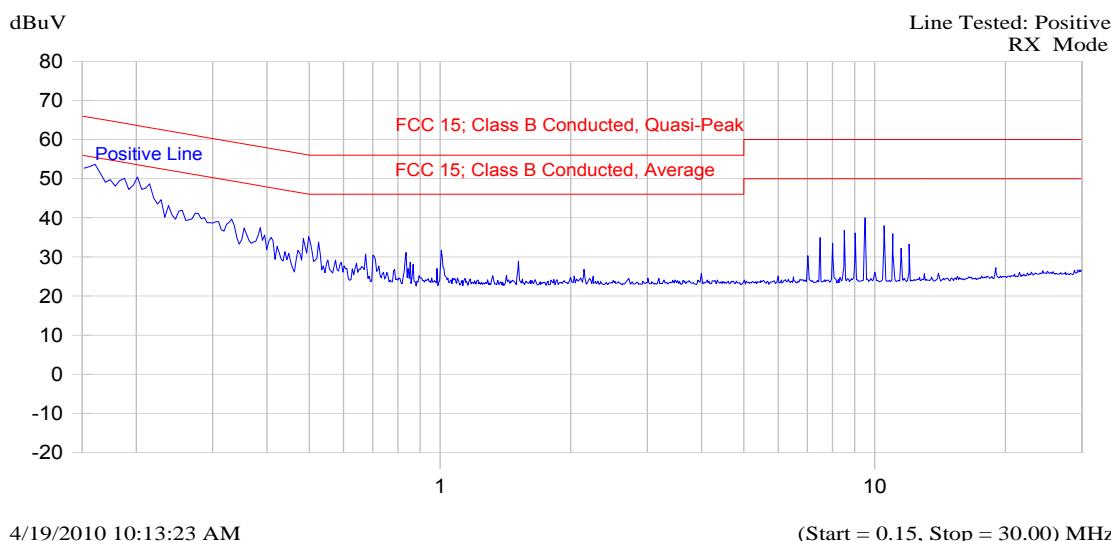
Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.165	50.0	46.3	-19.3	41.8	-13.8	Return Line
0.191	49.1	45.8	-19.0	42.5	-12.4	Return Line
0.194	48.5	45.1	-19.6	41.7	-13.0	Return Line
7.502	36.9	35.5	-24.5	31.4	-18.6	Return Line
8.494	38.1	36.1	-23.9	33.1	-16.9	Return Line
9.508	40.1	36.9	-23.1	32.2	-17.8	Return Line

Plot 5.5.4.3. Power Line Conducted Emissions (Rx Mode)

Line Voltage: 3.3VDC

Line Tested: Positive

Current Graph



Current List

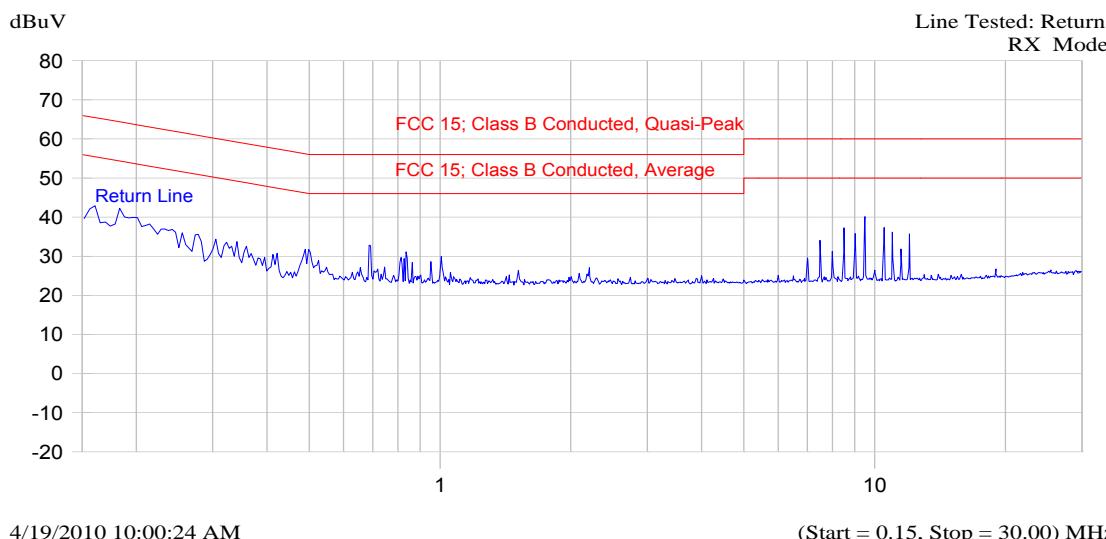
Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP dB	Avg dBuV	Delta Avg-Avg dB	Trace Name
0.167	55.0	50.8	-14.7	46.3	-9.2	Positive Line
0.192	54.5	50.2	-14.5	46.8	-8.0	Positive Line
0.204	51.2	47.9	-16.5	43.6	-10.8	Positive Line
7.498	35.9	33.1	-26.9	29.5	-20.5	Positive Line
8.500	38.1	36.5	-23.5	31.2	-18.8	Positive Line
9.503	41.3	39.5	-20.5	37.6	-12.4	Positive Line

Plot 5.5.4.4. Power Line Conducted Emissions (Rx Mode)

Line Voltage: 3.3VDC

Line Tested: Return

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP dB	Avg dBuV	Delta Avg-Avg dB	Trace Name
0.168	44.8	40.9	-24.6	36.1	-19.4	Return Line
0.190	44.8	40.5	-24.4	36.2	-18.7	Return Line
0.242	41.4	35.9	-27.4	29.5	-23.8	Return Line
8.499	38.0	36.2	-23.8	34.1	-15.9	Return Line
9.501	40.4	39.3	-20.7	37.0	-13.0	Return Line
10.506	38.0	34.9	-25.1	32.1	-17.9	Return Line

5.6. OCCUPIED BANDWIDTH [§ 15.247(a)(2)]

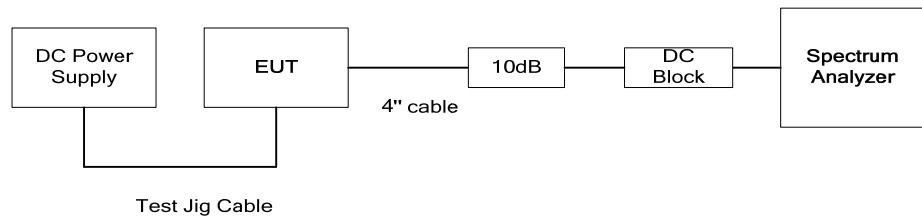
5.6.1. Limit(s)

For a Digital Modulation System, the minimum 6 dB bandwidth shall be at least 500 KHz.

5.6.2. Method of Measurements

KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) and ANSI C63.10.

5.6.3. Test Arrangement

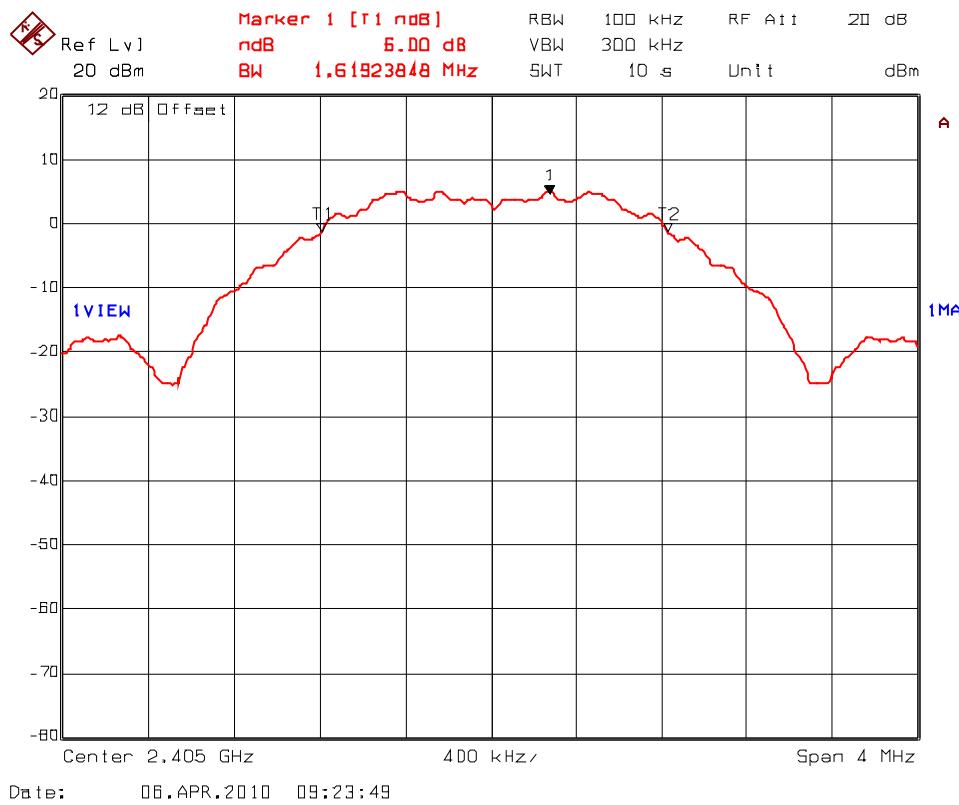


5.6.4. Test Data

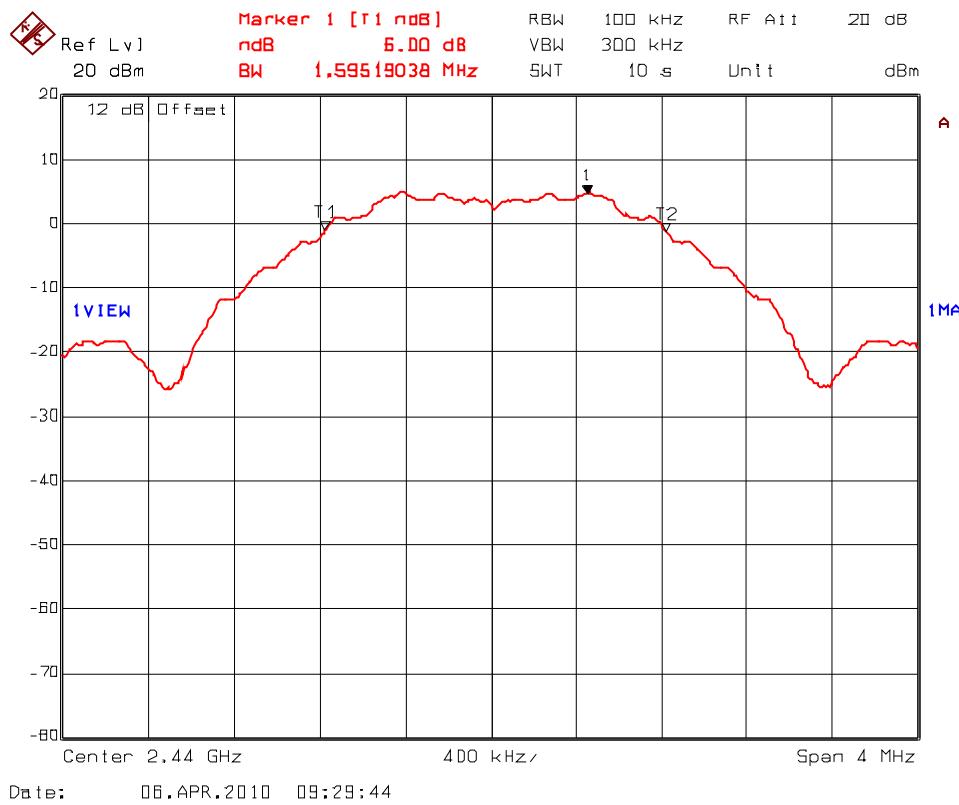
Frequency (MHz)	6 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2405	1.62	2.41
2440	1.60	2.39
2475	1.57	2.29
2480	1.61	2.39

See the following plots for detailed measurements.

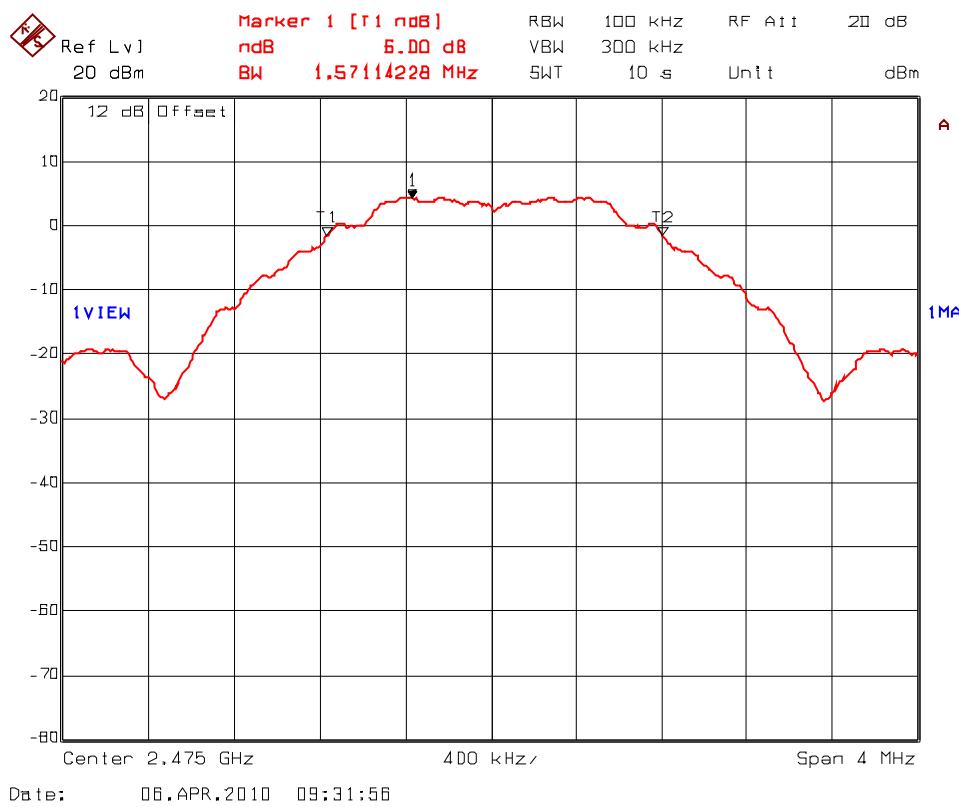
Plot 5.6.4.1. 6 dB Bandwidth
Frequency: 2405 MHz



Plot 5.6.4.2. 6 dB Bandwidth
Frequency: 2440 MHz

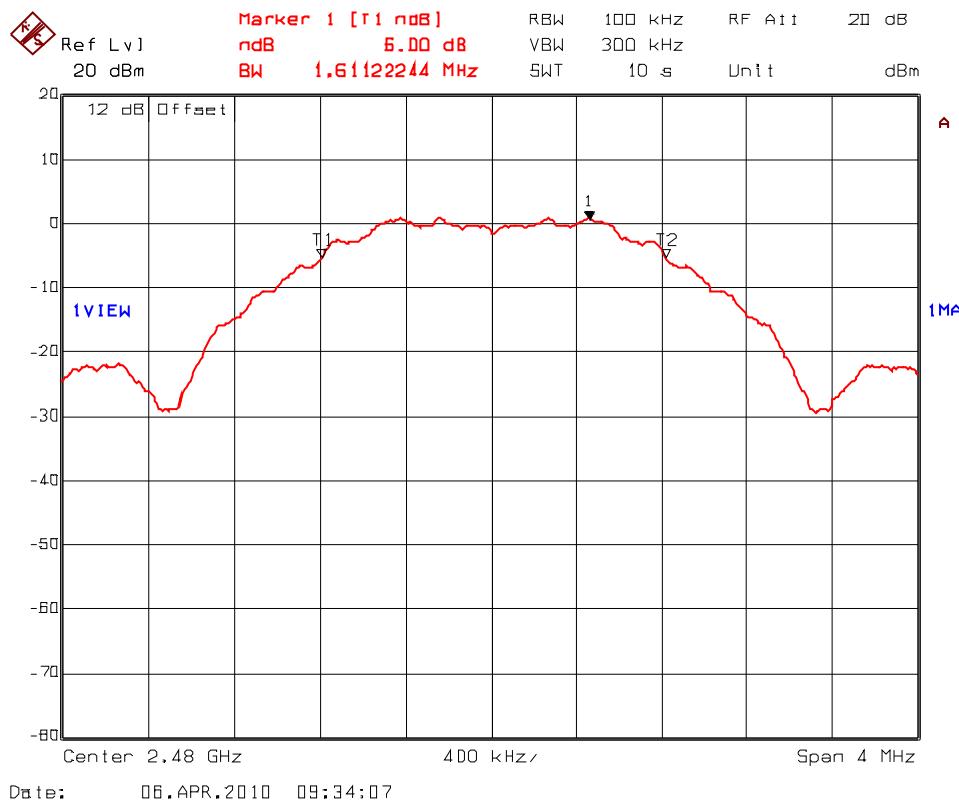


Plot 5.6.4.3. 6 dB Bandwidth
Frequency: 2475 MHz

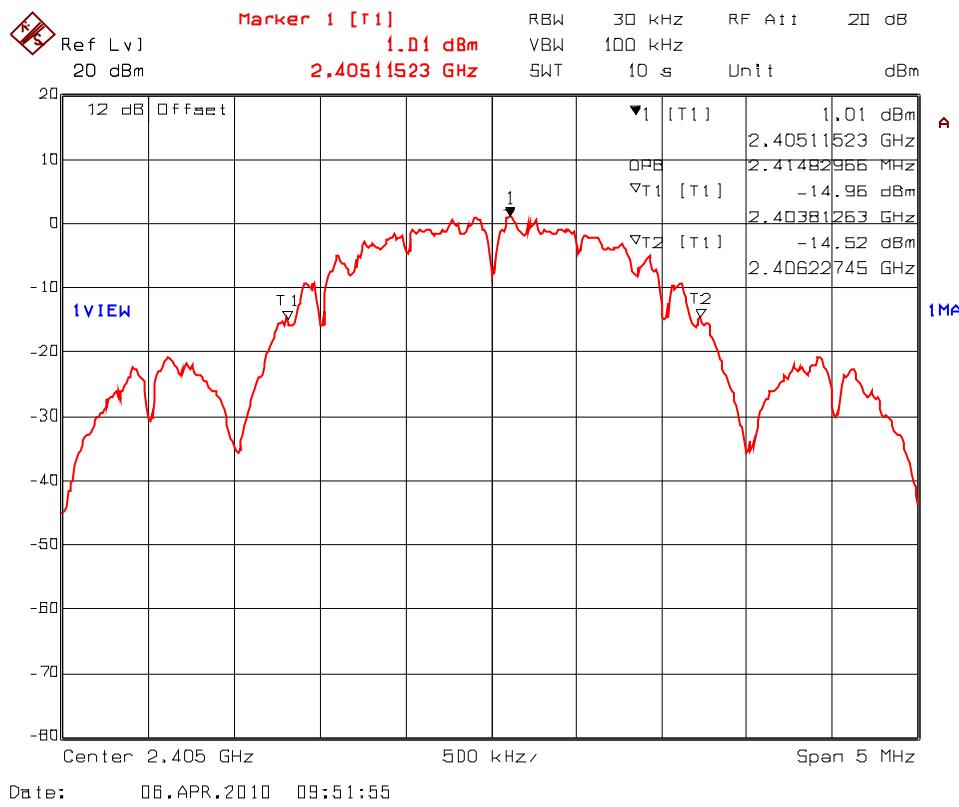


Date: 06.APR.2010 09:31:56

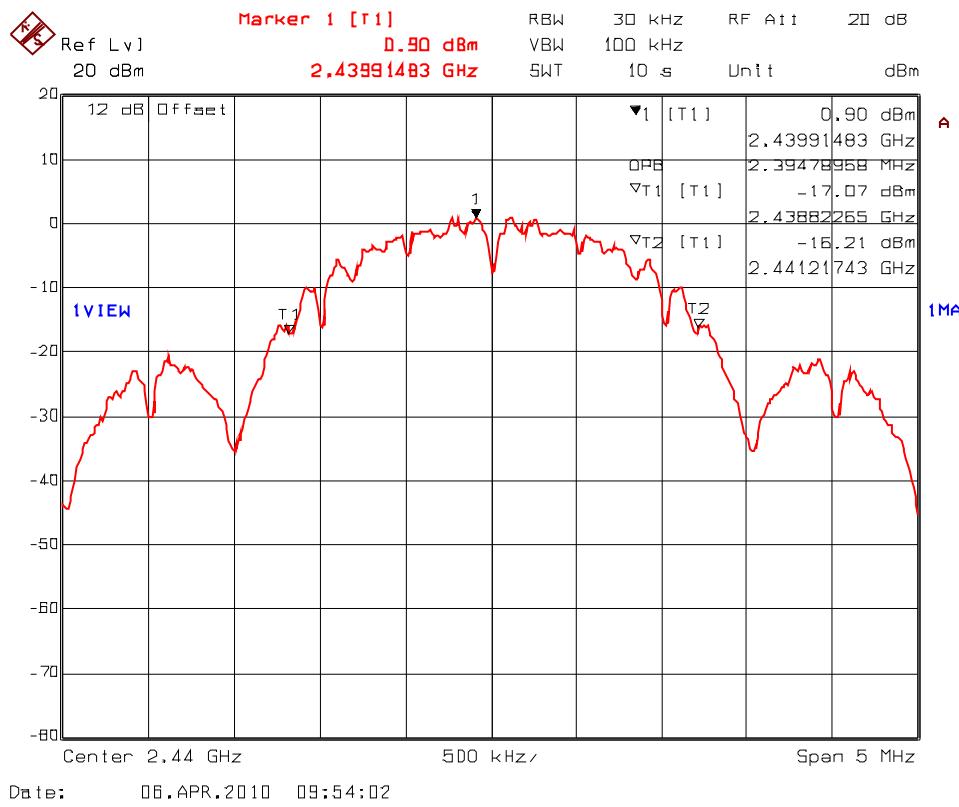
Plot 5.6.4.4. 6 dB Bandwidth
Frequency: 2480 MHz



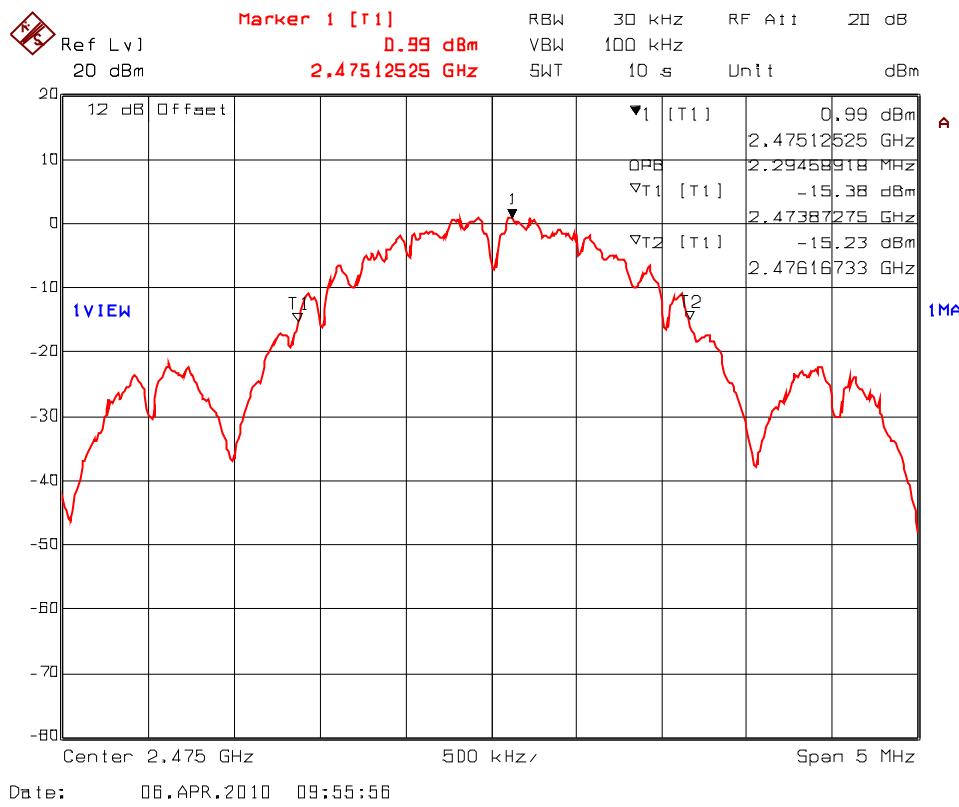
Plot 5.6.4.5. 99% Occupied Bandwidth
Frequency: 2405 MHz



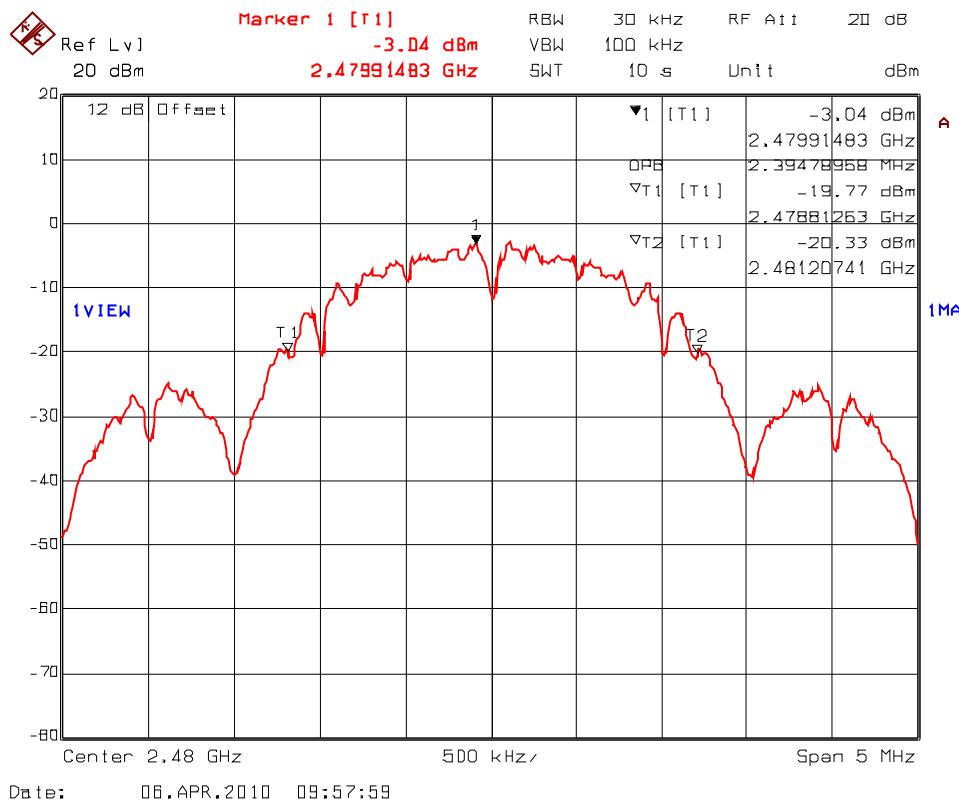
Plot 5.6.4.6. 99% Occupied Bandwidth
Frequency: 2440 MHz



Plot 5.6.4.7. 99% Occupied Bandwidth
Frequency: 2475 MHz



Plot 5.6.4.8. 99% Occupied Bandwidth
Frequency: 2480 MHz



5.7. PEAK CONDUCTED OUTPUT POWER - DTS [§ 15.247(b)(3)]

5.7.1. Limit(s)

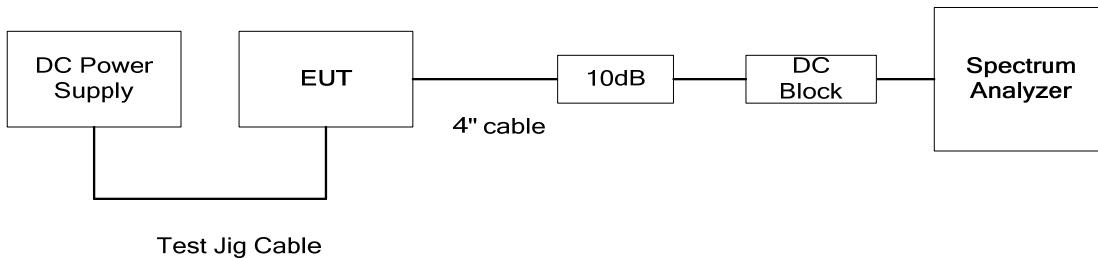
§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

§15.247(b)(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.7.2. Method of Measurements & Test Arrangement

KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) and ANSI C63.10.

5.7.3. Test Arrangement



5.7.4. Test Data

Remarks:					
Test method used: Power output option 1, peak measurement.					
Channel No.	Frequency (MHz)	Peak Conducted Power (dBm)	Peak EIRP ^(Note 1, 2) (dBm)	Peak Conducted Power Limit (dBm)	EIRP Limit (dBm)
High Power Setting (8 dBm), DC Voltage Input of 3.3 Vdc					
11	2405	7.97	26.97	30	36
18	2440	7.57	26.57	30	36
25	2475	7.21	26.21	30	36
26	2480	3.73	22.73	30	36
Low Power Setting (-26 dBm), DC Voltage Input of 3.3 Vdc					
11	2405	-25.47	-6.47	30	36
18	2440	-26.00	-7.00	30	36
25	2475	-25.21	-6.21	30	36
26	2480	-25.08	-6.08	30	36

Note 1: The Peak EIRP is calculated as the sum of Peak Conducted Power in dBm and antenna assembly gain of EUT in dBi (antenna gain – cable loss).

Note 2: The maximum antenna gain to be used with the EUT is 19 dBi.

5.8. TRANSMITTER BAND-EDGE & SPURIOUS CONDUCTED EMISSIONS [§ 15.247(d)]

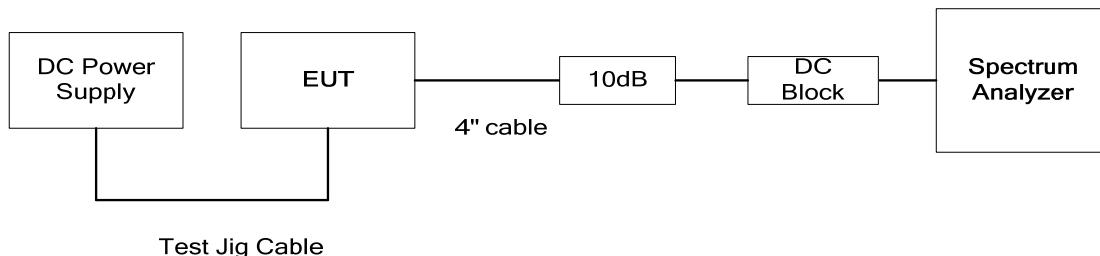
5.8.1. Limit(s)

§ 15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

5.8.2. Method of Measurements

KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) and ANSI C63.10.

5.8.3. Test Arrangement

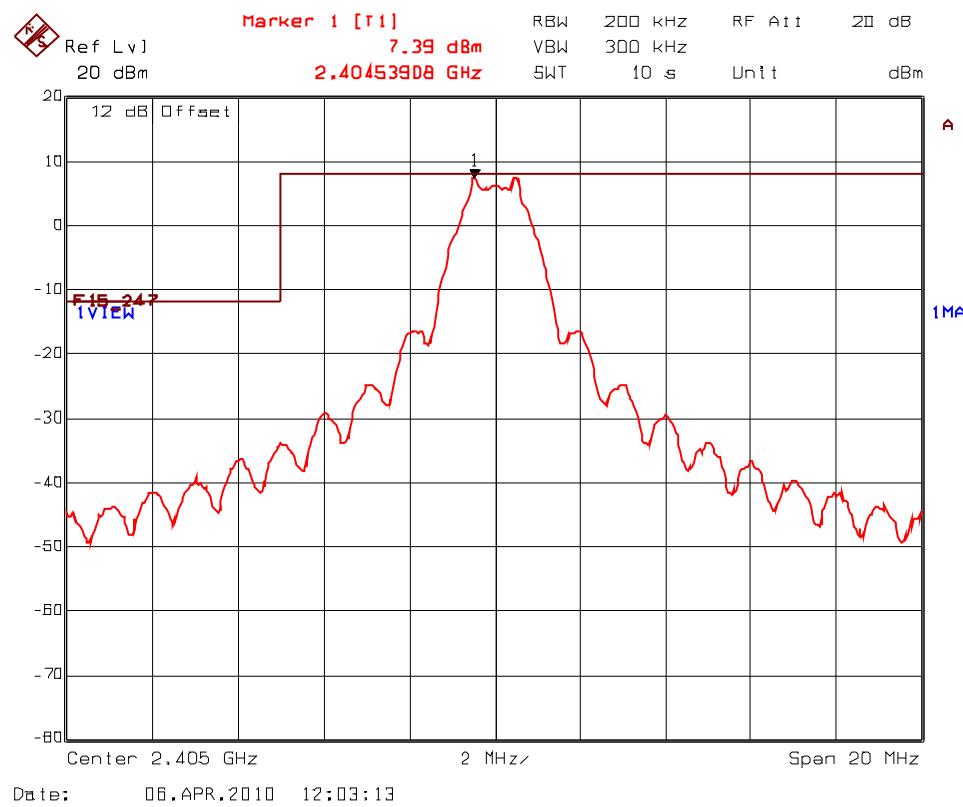


Test Jig Cable

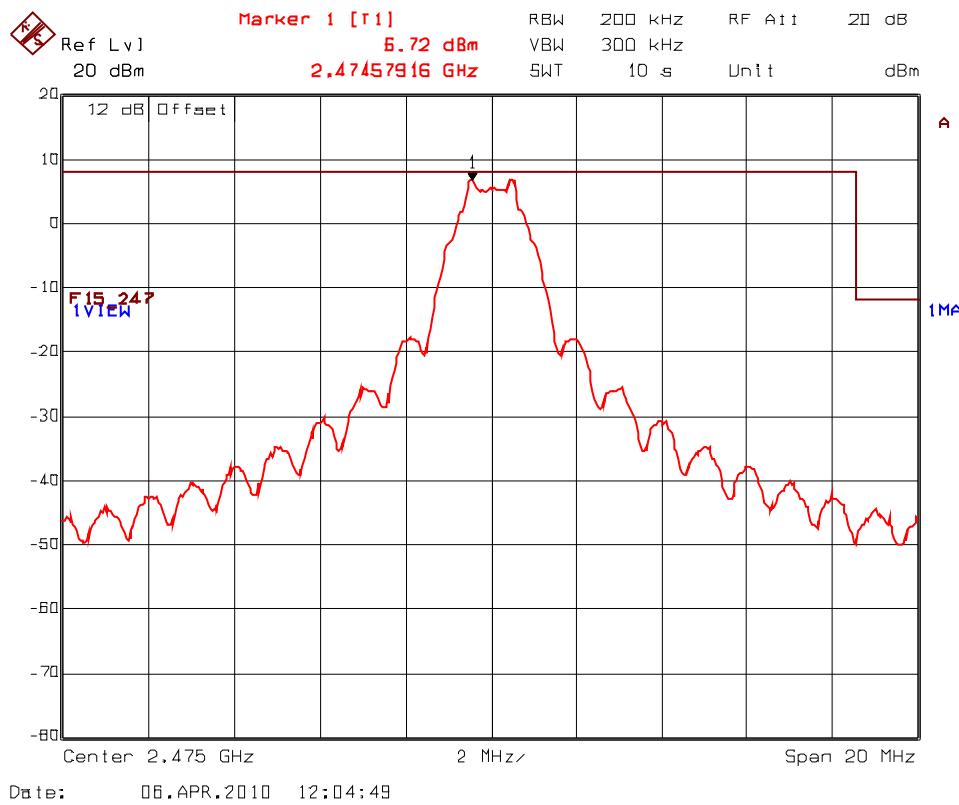
5.8.4. Test Data

5.8.4.1. Band-Edge RF Conducted Emissions

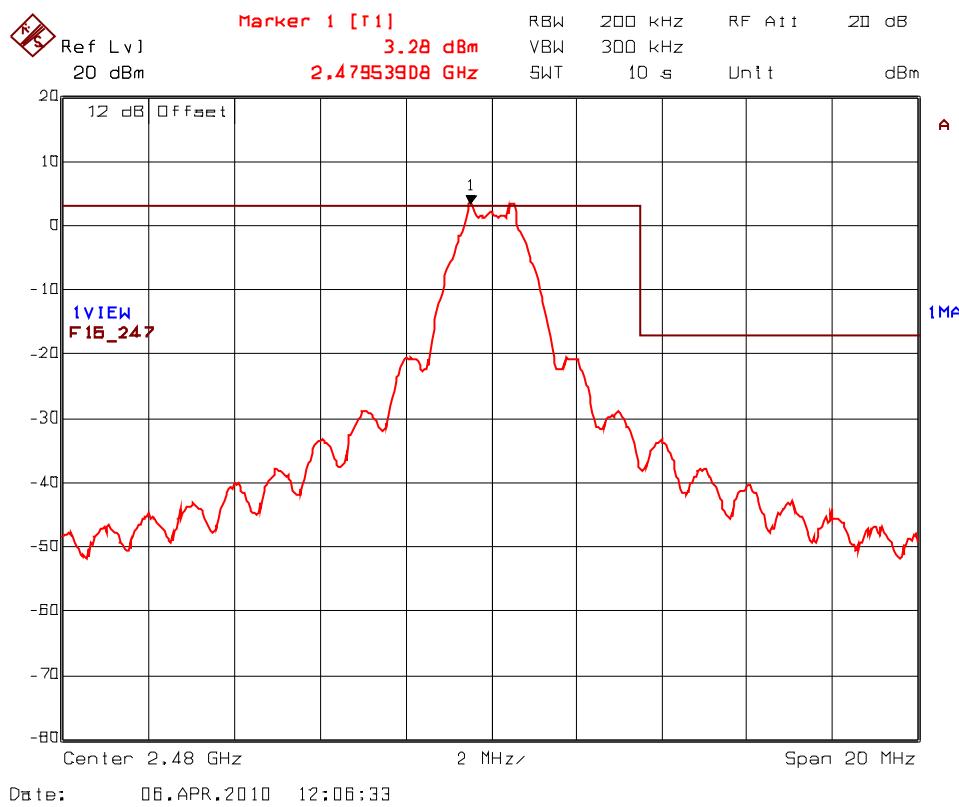
Plot 5.8.4.1.1. Band-Edge RF Conducted Emissions
Low End of Frequency Band (2405 MHz)



**Plot 5.8.4.1.2. Band-Edge RF Conducted Emissions
High End of Frequency Band (2475 MHz, Full Power Level)**

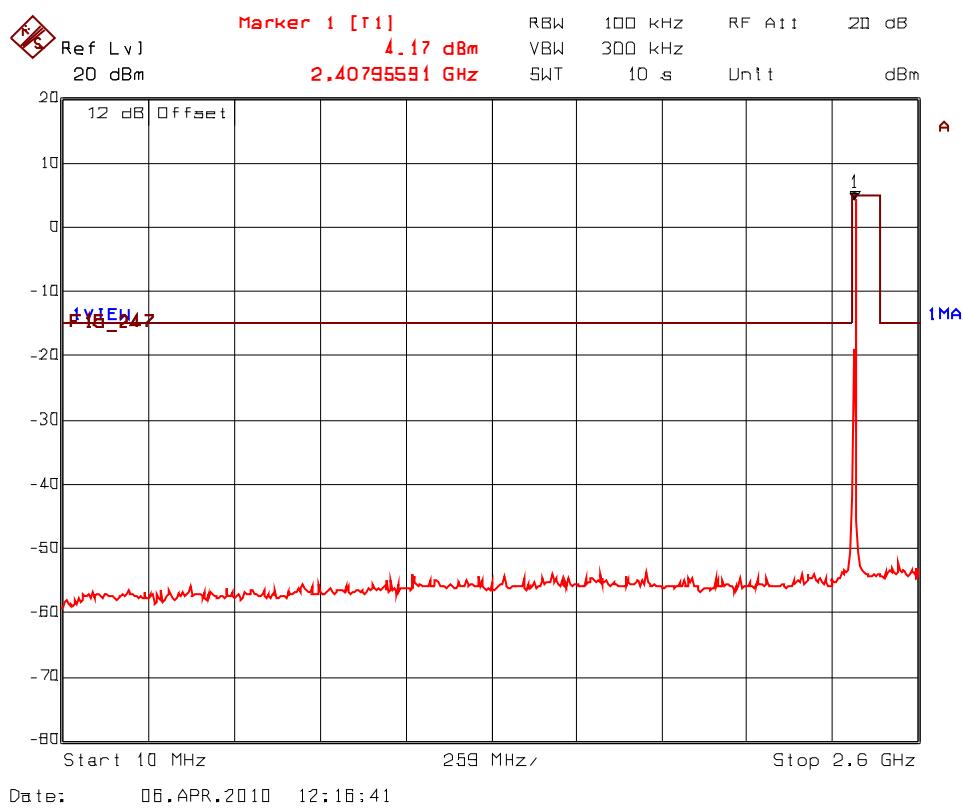


**Plot 5.8.4.1.3. Band-Edge RF Conducted Emissions
High End of Frequency Band (2480 MHz, at Reduced Power Level)**

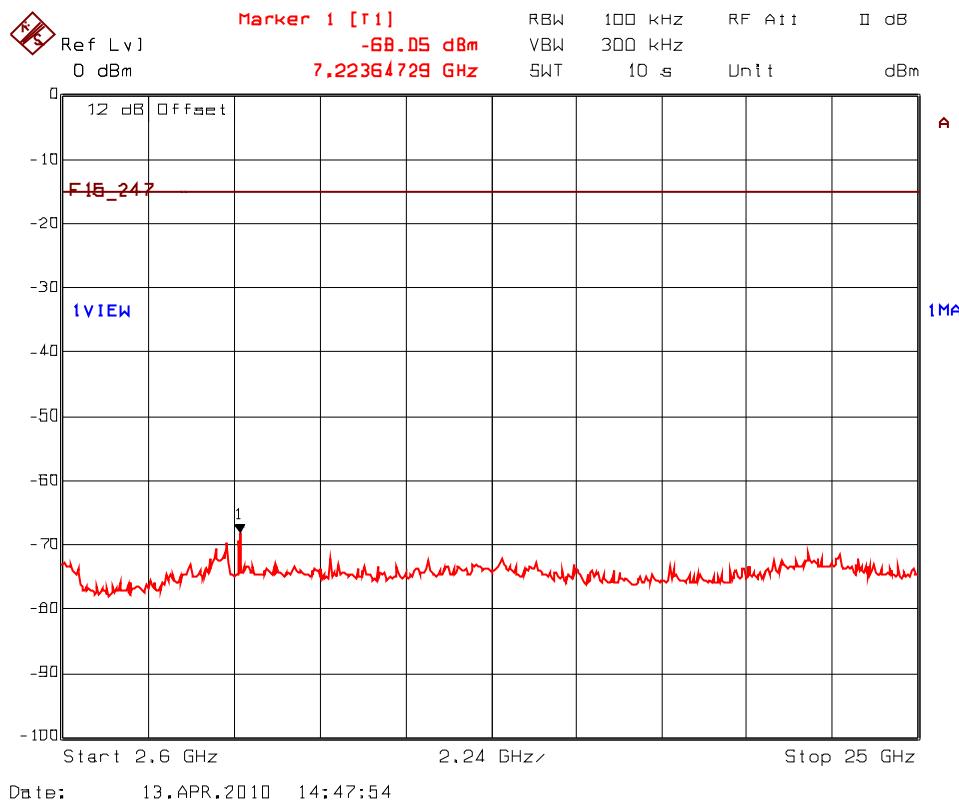


5.8.4.2. Spurious RF Conducted Emissions

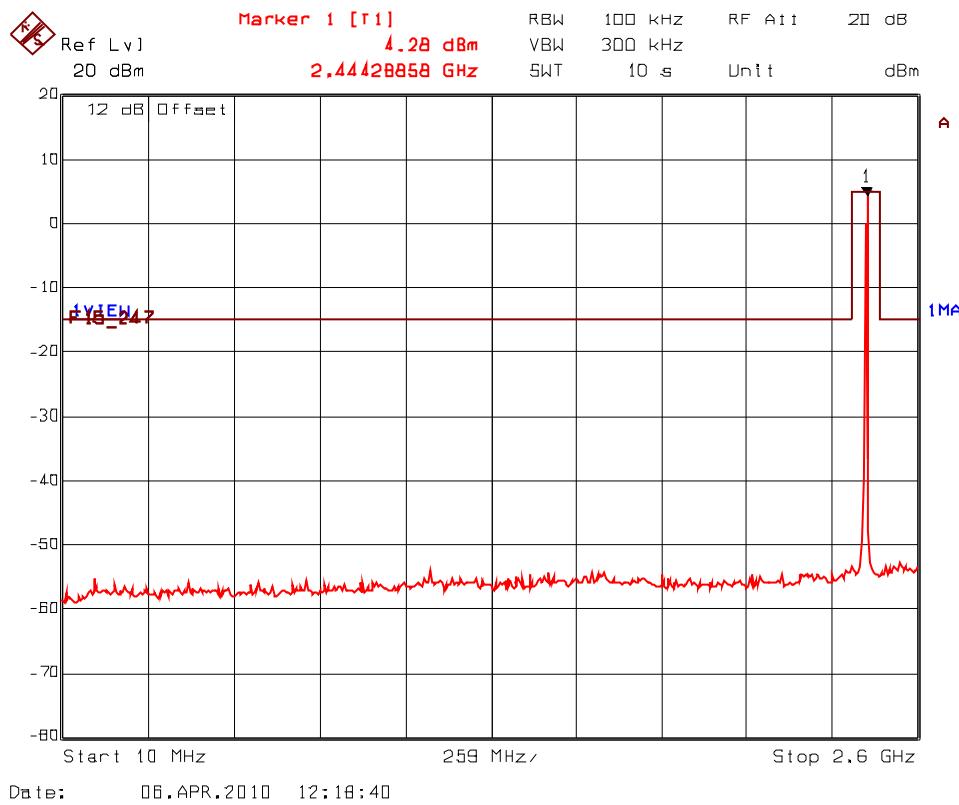
Plot 5.8.4.2.1. Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz, High Power



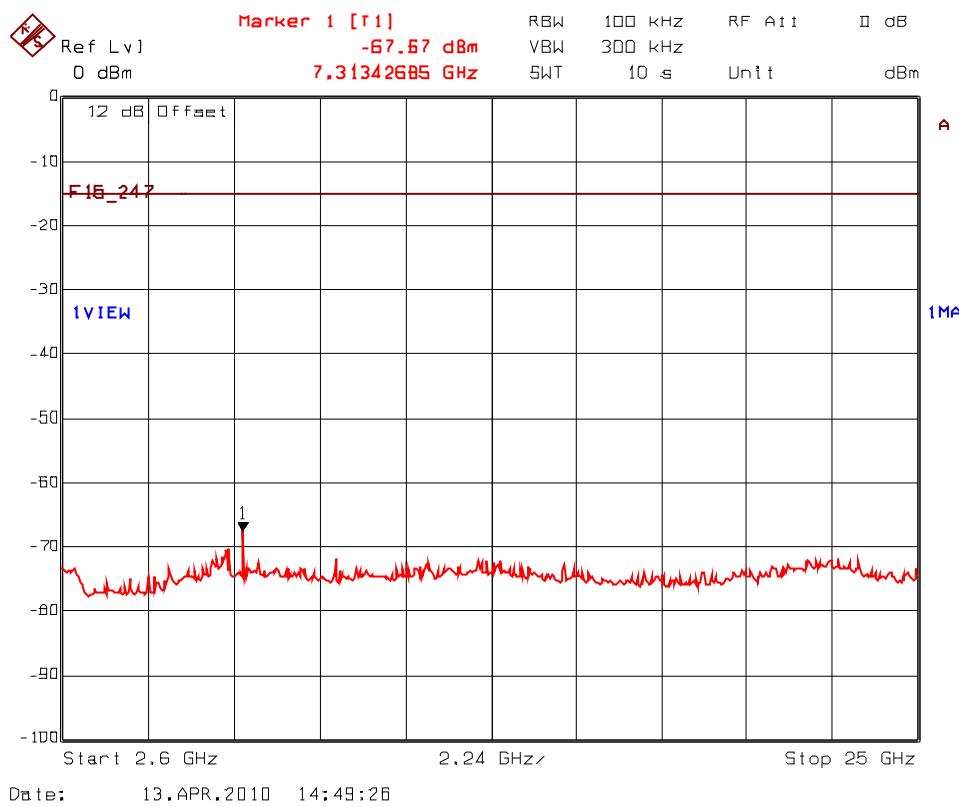
Plot 5.8.4.2.2. Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz, High Power



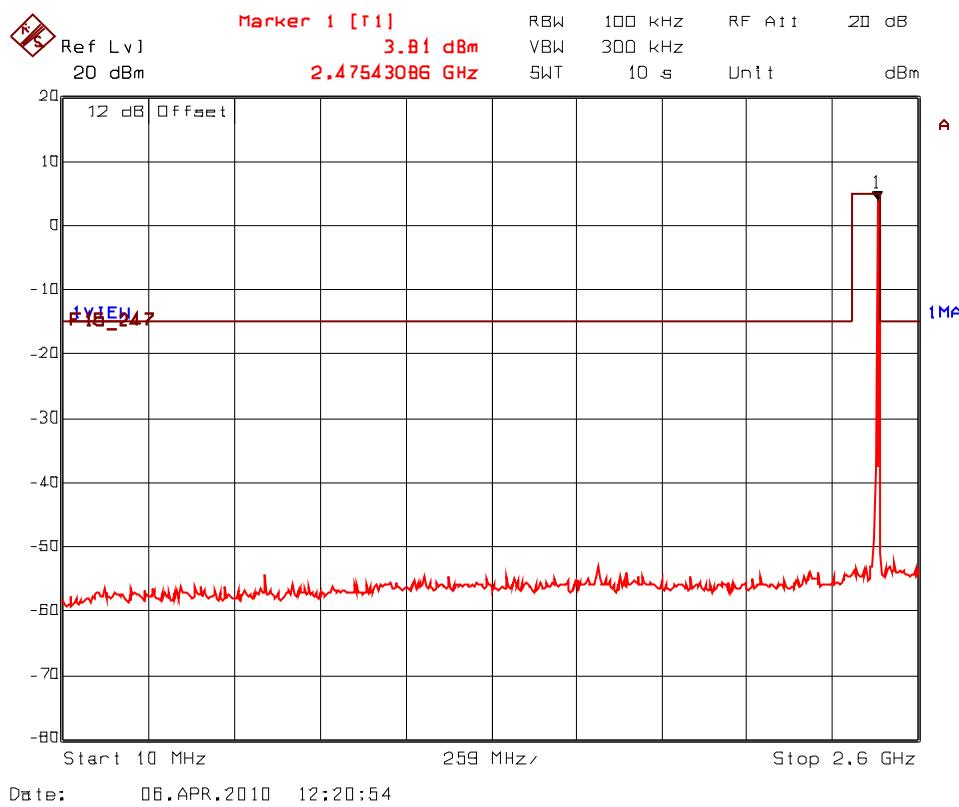
Plot 5.8.4.2.3. Spurious RF Conducted Emissions
Transmitter Frequency: 2440 MHz, High Power



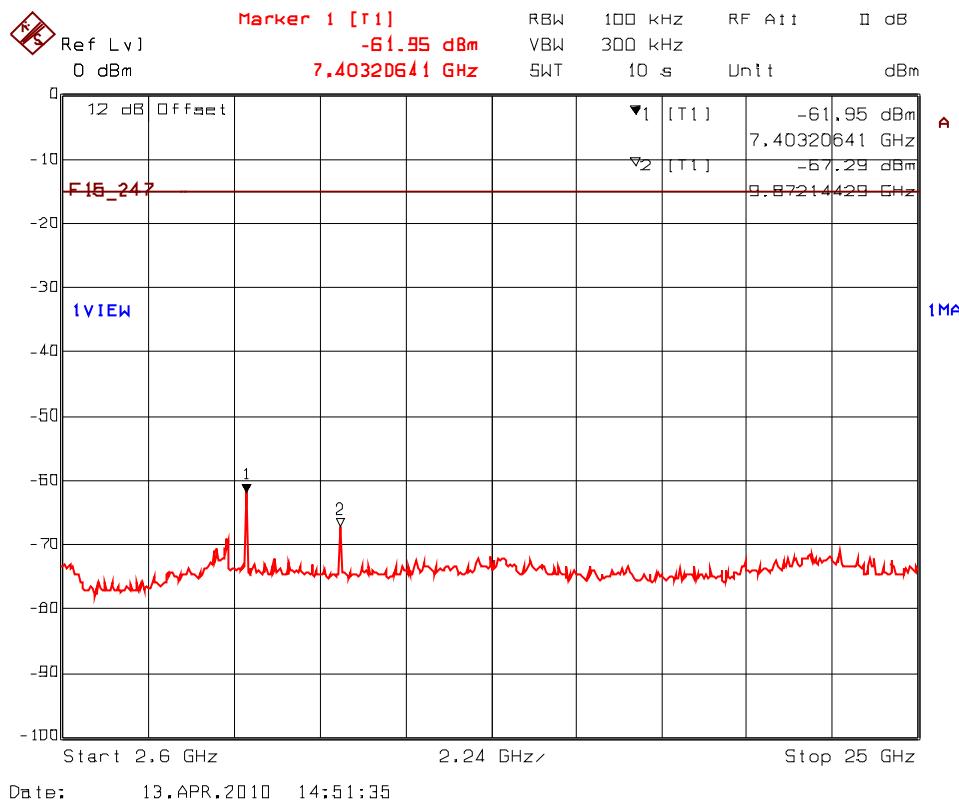
Plot 5.8.4.2.4. Spurious RF Conducted Emissions
Transmitter Frequency: 2440 MHz, High Power



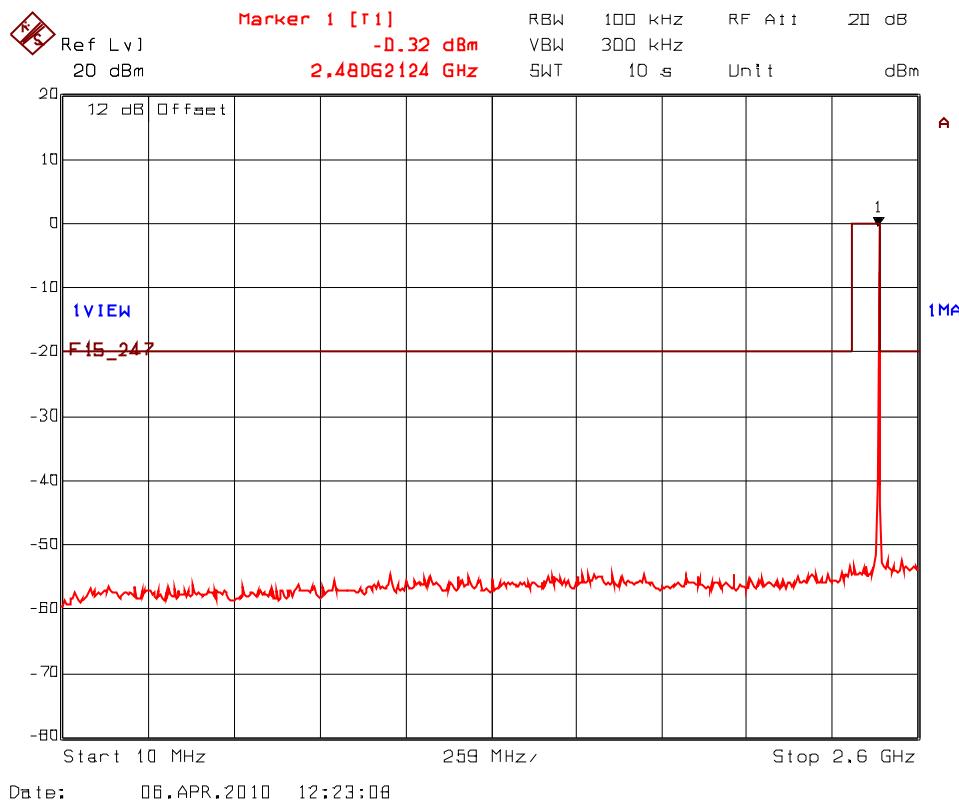
Plot 5.8.4.2.5. Spurious RF Conducted Emissions
Transmitter Frequency: 2475 MHz, High Power



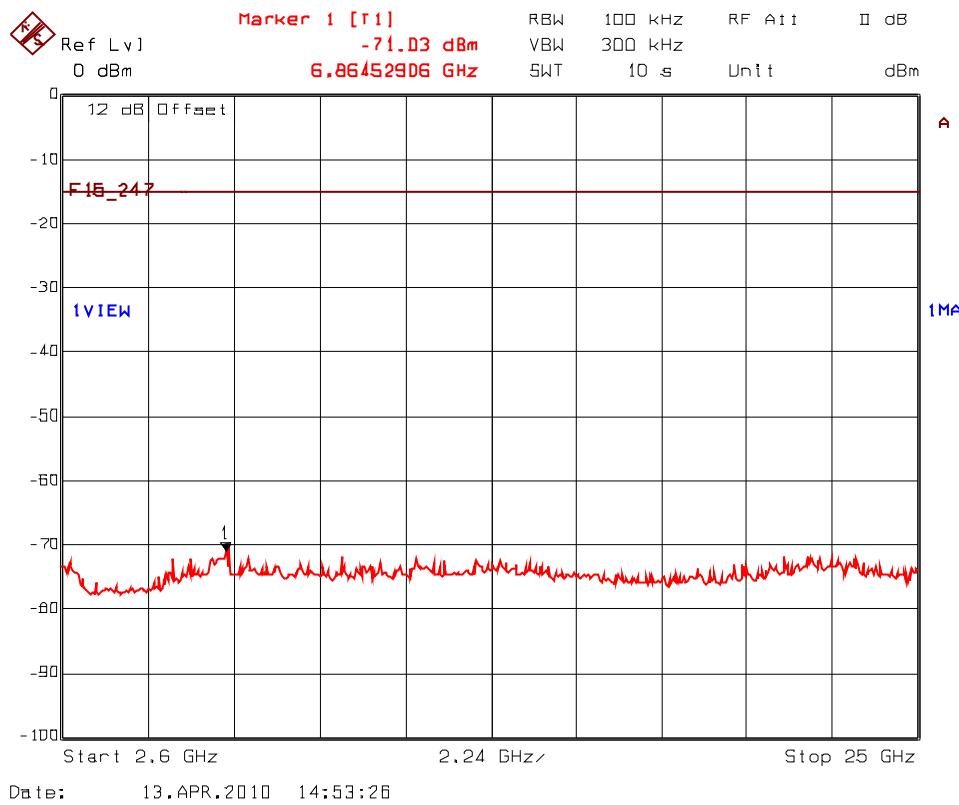
Plot 5.8.4.2.6. Spurious RF Conducted Emissions
Transmitter Frequency: 2475 MHz, High Power



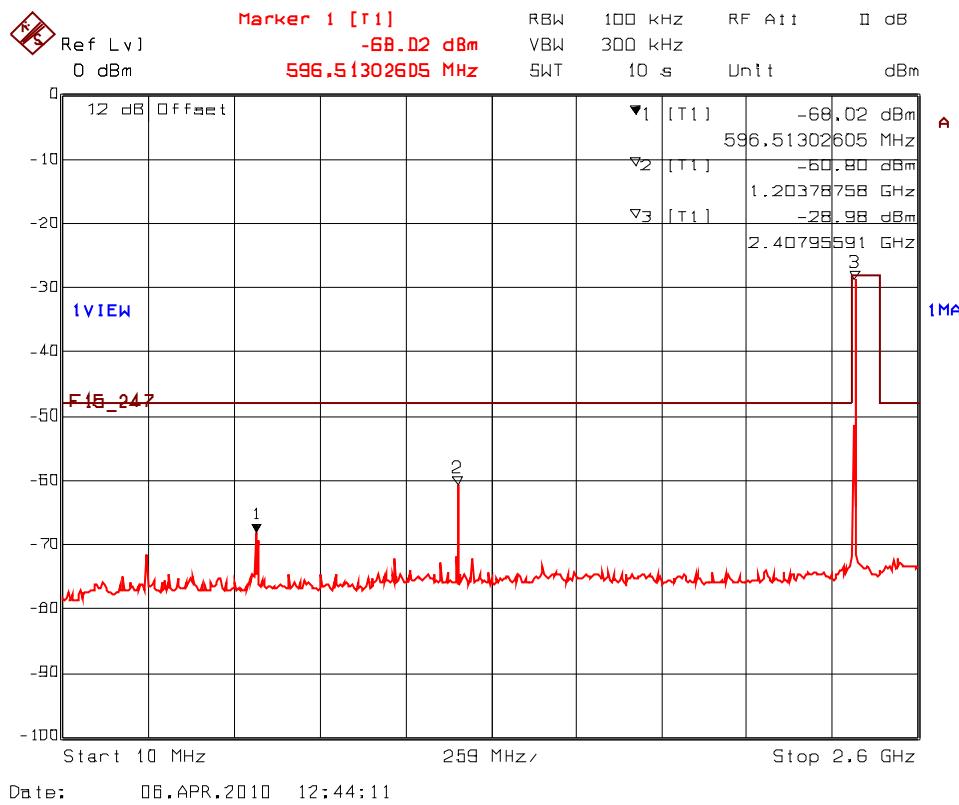
Plot 5.8.4.2.7. Spurious RF Conducted Emissions
Transmitter Frequency: 2480 MHz, High Power



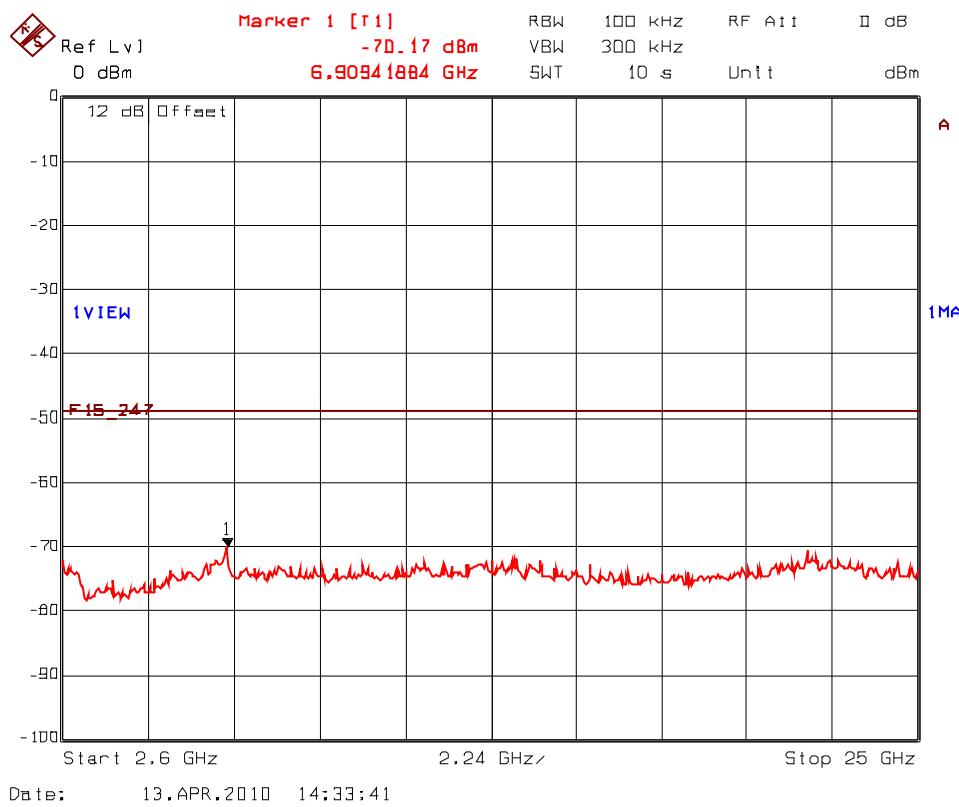
Plot 5.8.4.2.8. Spurious RF Conducted Emissions
Transmitter Frequency: 2480 MHz, High Power



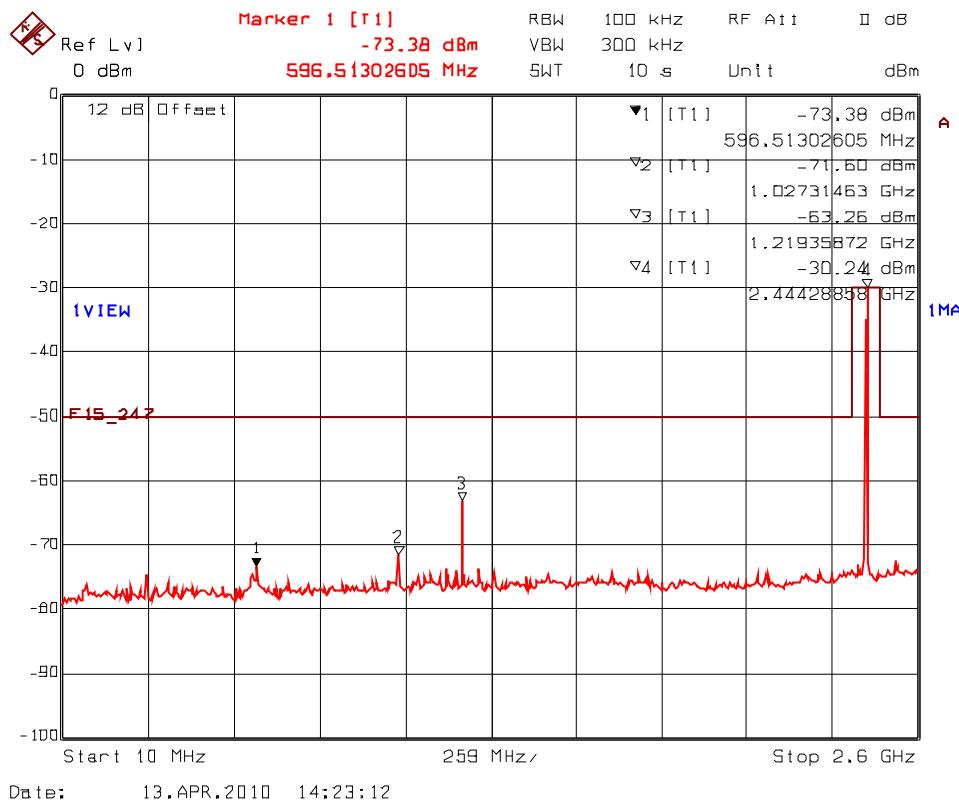
Plot 5.8.4.2.9. Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz, Low Power



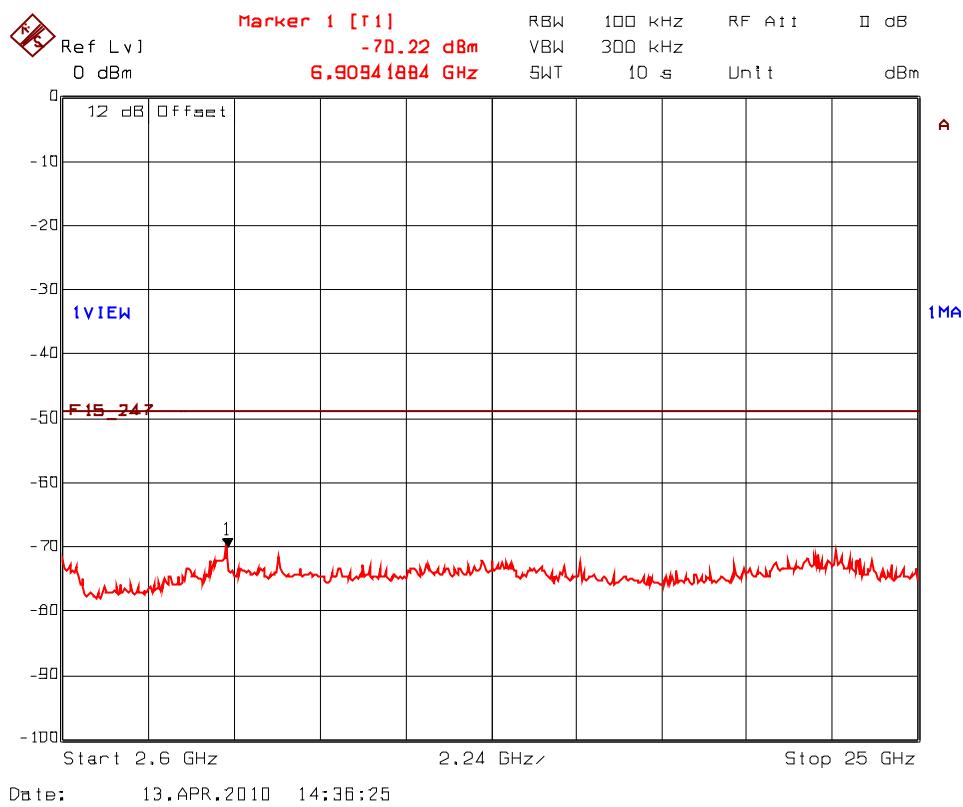
Plot 5.8.4.2.10. Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz, Low Power



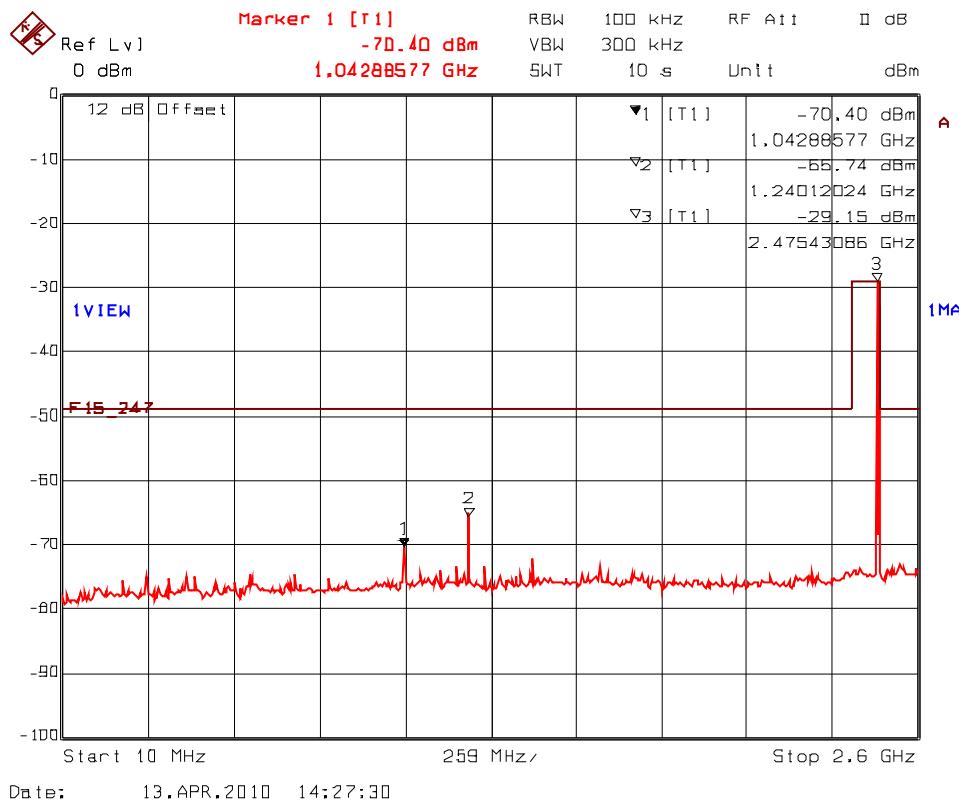
Plot 5.8.4.2.11. Spurious RF Conducted Emissions
Transmitter Frequency: 2440 MHz, Low Power



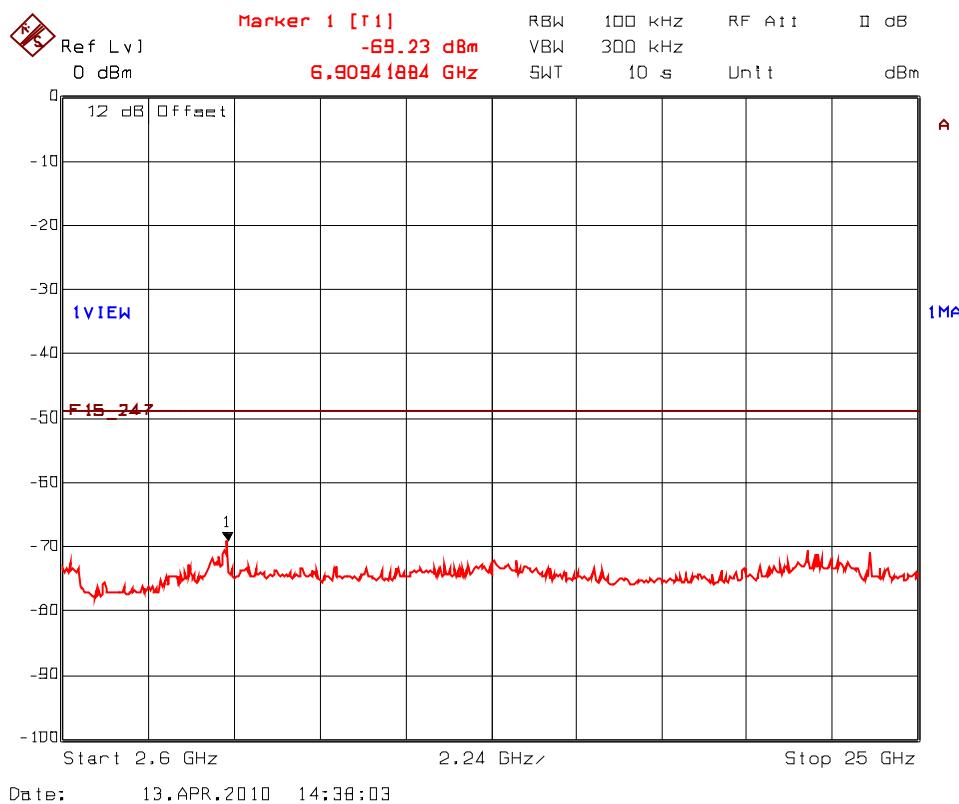
Plot 5.8.4.2.12. Spurious RF Conducted Emissions Transmitter Frequency: 2440 MHz, Low Power



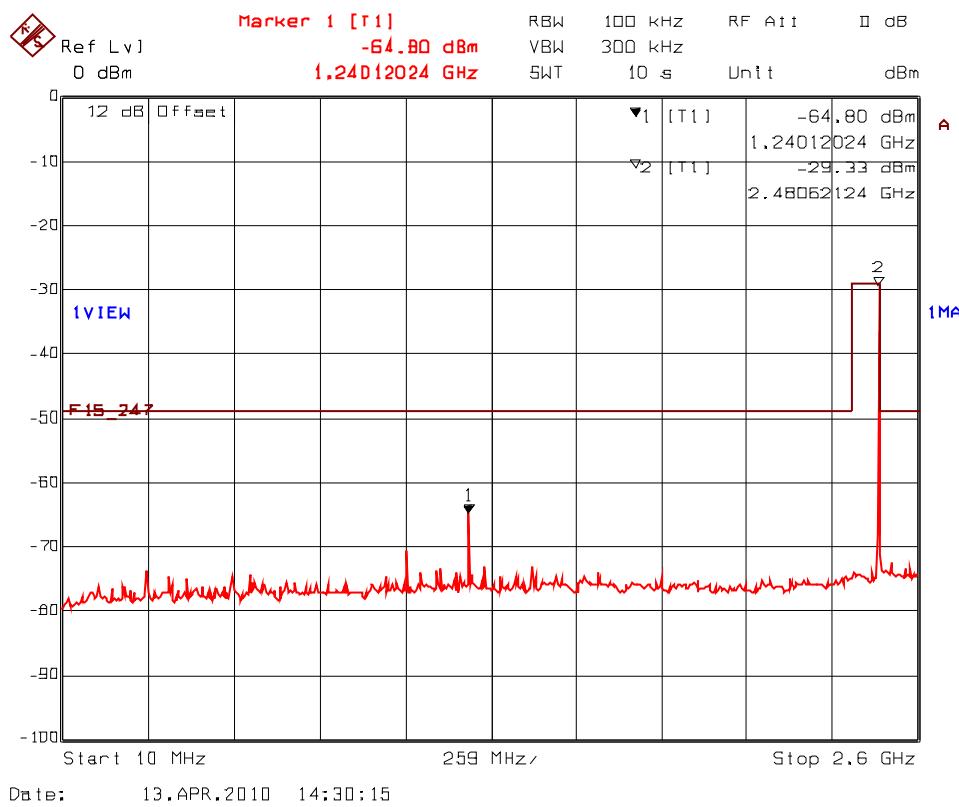
Plot 5.8.4.2.13. Spurious RF Conducted Emissions
Transmitter Frequency: 2475 MHz, Low Power



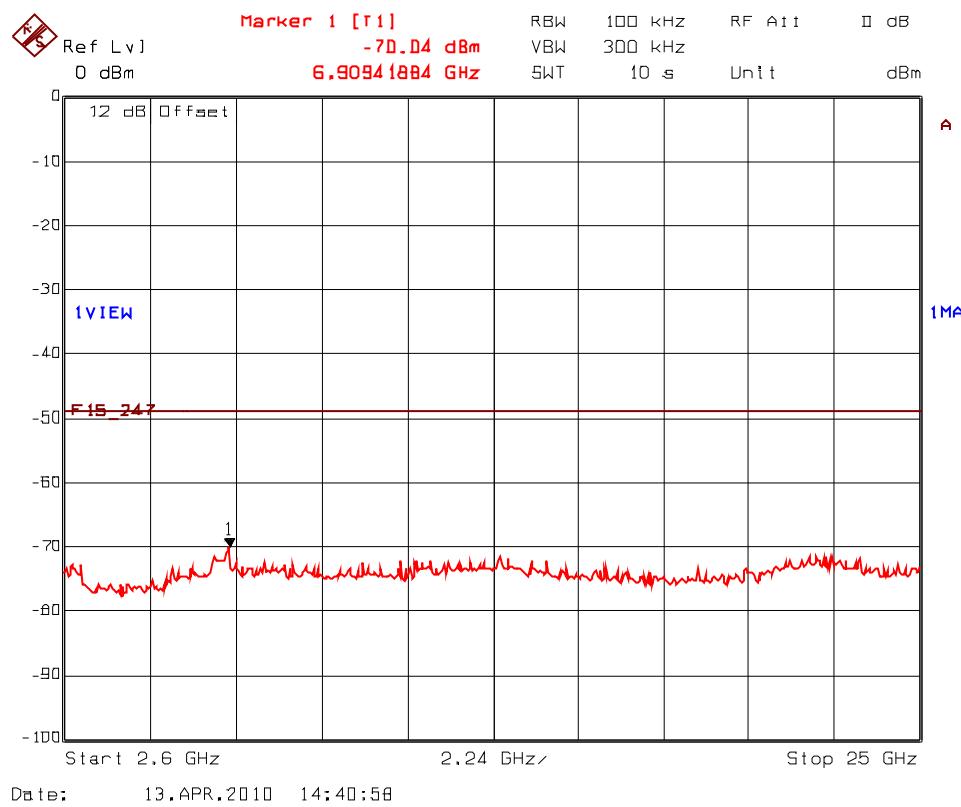
Plot 5.8.4.2.14. Spurious RF Conducted Emissions
Transmitter Frequency: 2475 MHz, Low Power



Plot 5.8.4.2.15. Spurious RF Conducted Emissions
Transmitter Frequency: 2480 MHz, Low Power



Plot 5.8.4.2.16. Spurious RF Conducted Emissions
Transmitter Frequency: 2480 MHz, Low Power



5.9. TRANSMITTER SPURIOUS RADIATED EMISSIONS AT 3 METERS [§§ 15.247(d), 15.209 & 15.205]

5.9.1. Limit(s)

§ 15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

Section 15.205(a) - Restricted Bands of Operation

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
1.0495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	(²)
13.36–13.41.			

¹ Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.

² Above 38.6

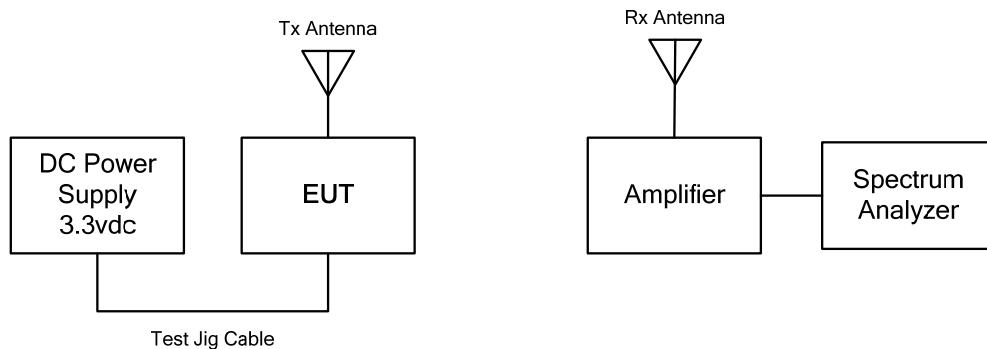
Section 15.209(a) -- Field Strength Limits within Restricted Frequency Bands --

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / 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

5.9.2. Method of Measurements

KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) and ANSI C63.10.

5.9.3. Test Arrangement



5.9.4. Test Data

Remarks:

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT shall be tested in three orthogonal positions.
- The following test results are the worst-case measurements.
- A duty cycle correction factor of 27% (-11.37dB) shall be applied to a measurement made with an average detector.
- Band-edges compliance condition: EUT connected to antennas via antenna feedline must have a minimum cable loss as specified in the test configurations and the following table.

Antenna Type	Maximum Antenna Gain (dBi)	Minimum Cable Loss (dB)	
		2405 - 2475 MHz	2480 MHz
Dipole Antenna	2.1	0.62	0.62
Omni Directional Antenna	15	0.62	5.12
Yagi Antenna	15	0.62	9.12
Panel Antenna	19	0.62	13.62
Integrated PCB/Monopole Antenna	1.5	N/A	N/A

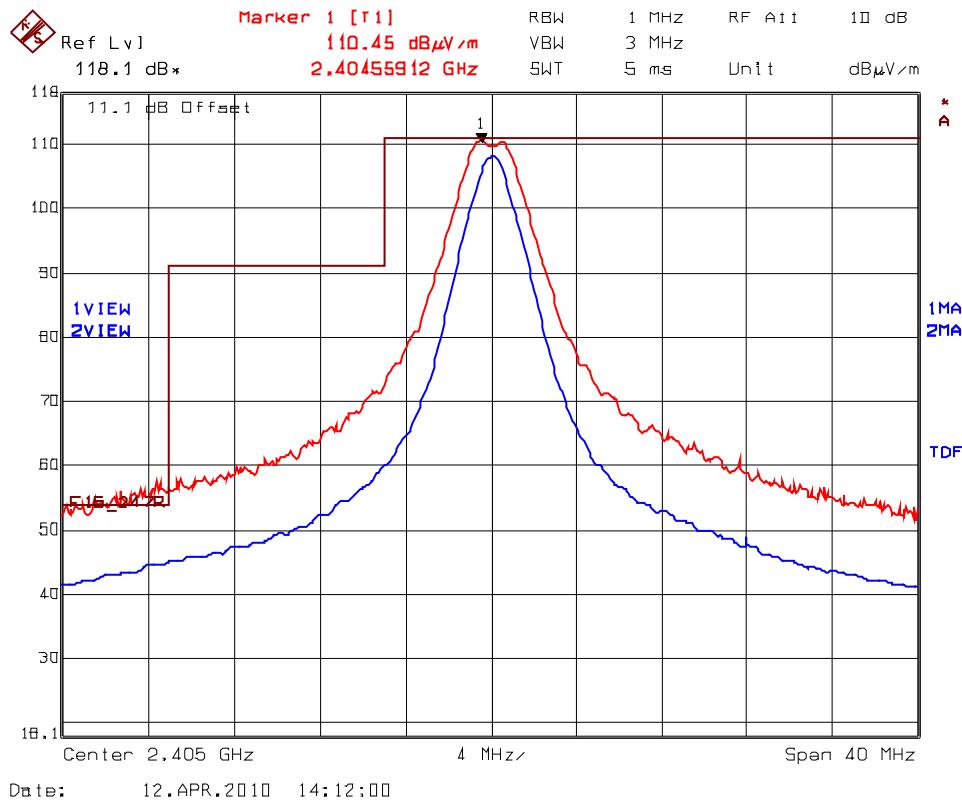
5.9.4.1. EUT with Dipole Antenna (2.1 dBi Gain with 0.62 dB Cable Loss)

Fundamental Frequency: 2405 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2405	103.55	--	V	--	--	--	--
2405	110.45	--	H	--	--	--	--
30 - 25000	*	*	V/H	*	90.5	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

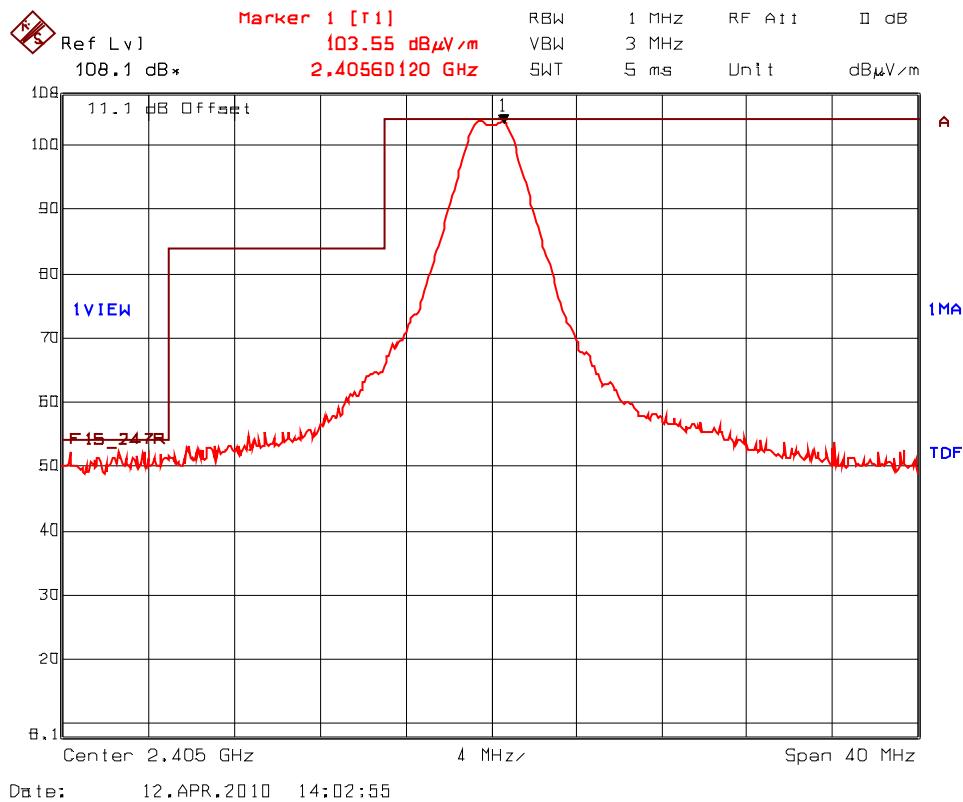
See the following test data plots for band-edge emissions.

Plot 5.9.4.1.1. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Horizontal



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.1.2. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Vertical



Fundamental Frequency: 2440 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2440	104.05	--	V	--	--	--	--
2440	110.24	--	H	--	--	--	--
30 - 25000	*	*	V/H	*	90.2	*	Pass

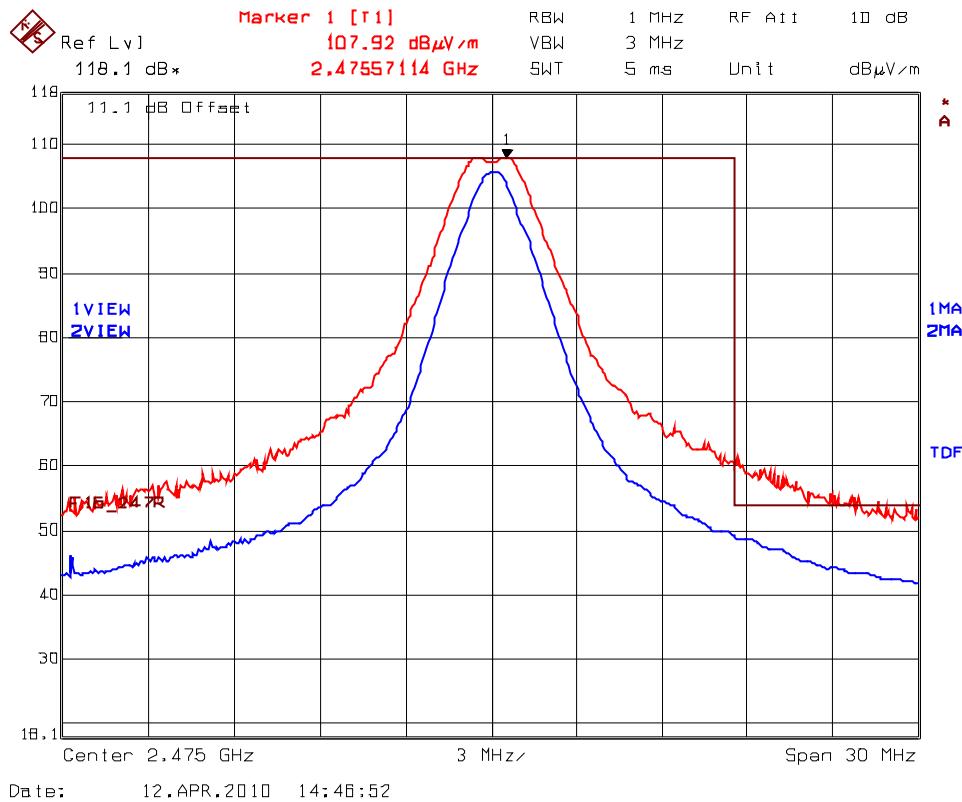
*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

Fundamental Frequency: 2475 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2475	105.15	--	V	--	--	--	--
2475	107.92	--	H	--	--	--	--
30 - 25000	*	*	V/H	*	87.9	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

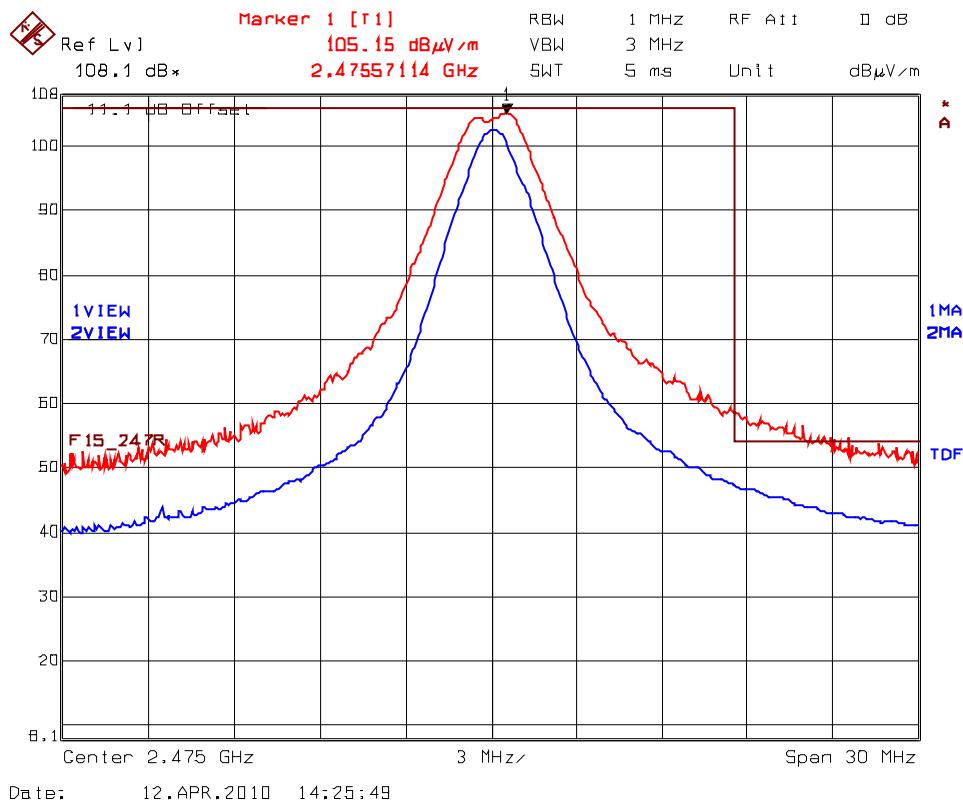
See the following test data plots for band-edge emissions.

Plot 5.9.4.1.3. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2475 MHz
Rx Antenna Orientation: Horizontal



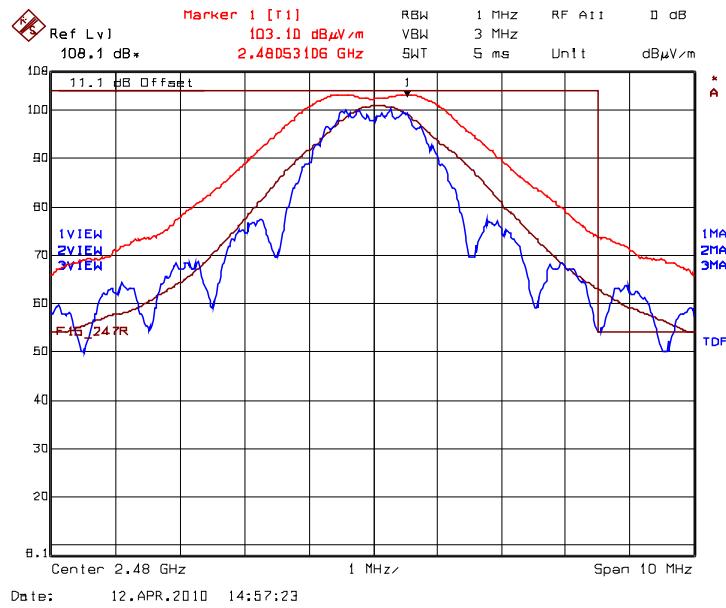
Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.1.4. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2475 MHz
Rx Antenna Orientation: Vertical

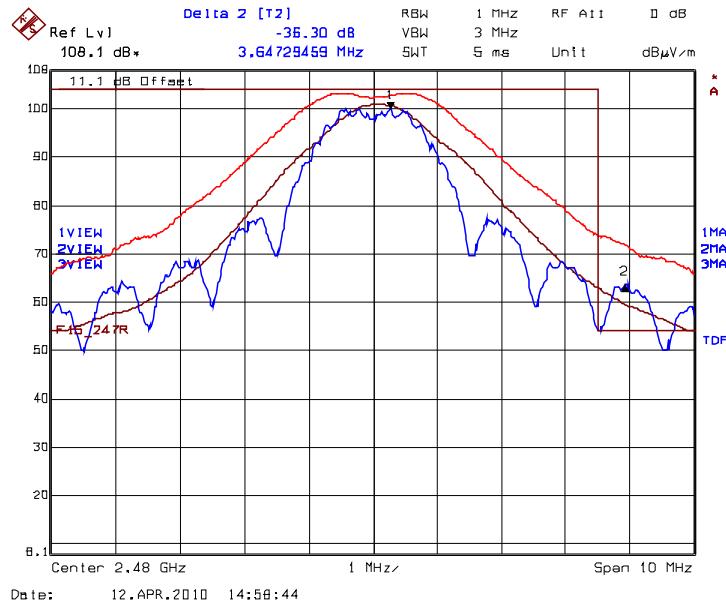


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.1.5. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.1.6. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



Trace 1: RBW= 1 MHz, VBW= 3 MHz

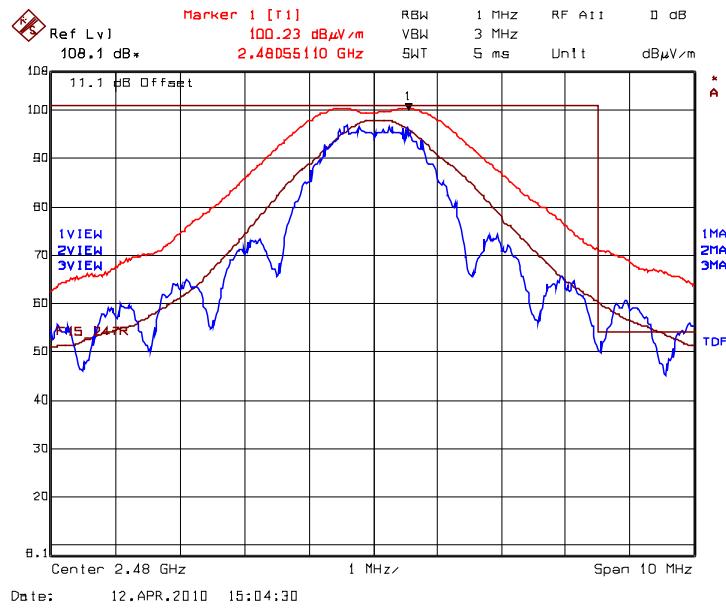
Trace 2: RBW= 100 kHz, VBW= 300 kHz, Delta (Peak to Band-Edge): 36.30dB

Trace 3: RBW= 1 MHz, VBW= 10 Hz

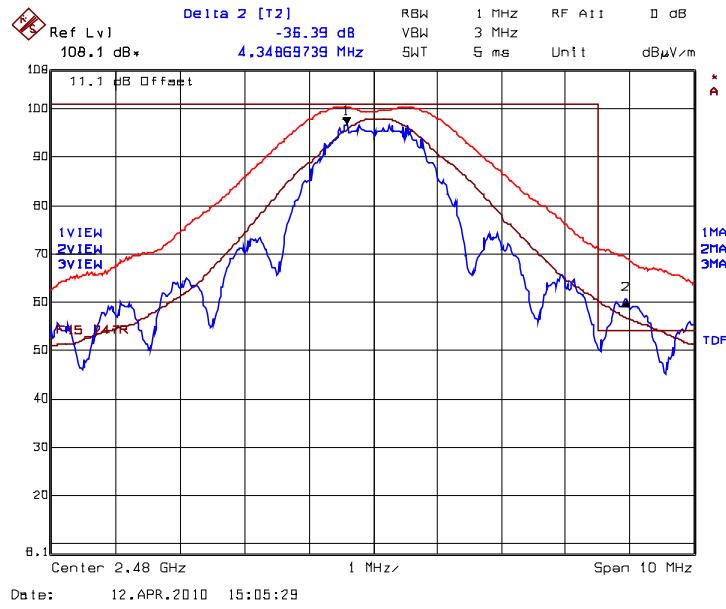
Peak Band-Edge at 2483.5 MHz: Peak = 103.10 dB μ V/m – 36.30 dB = 66.80 dB μ V/m (limit 74 dB μ V/m)

Average: 62.78 dB μ V/m – 11.37dB= 51.41 dB μ V/m (limit 54 dB μ V/m)

Plot 5.9.4.1.7. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.1.8. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 100 kHz, VBW = 300 kHz, Delta (Peak to Band-Edge): 36.39 dB

Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 100.23 dB μ V/m – 36.39 dB = 63.84 dB μ V/m (limit 74 dB μ V/m)

Average: 60.23 dB μ V/m – 11.37 dB = 48.86 dB μ V/m (limit 54 dB μ V/m)

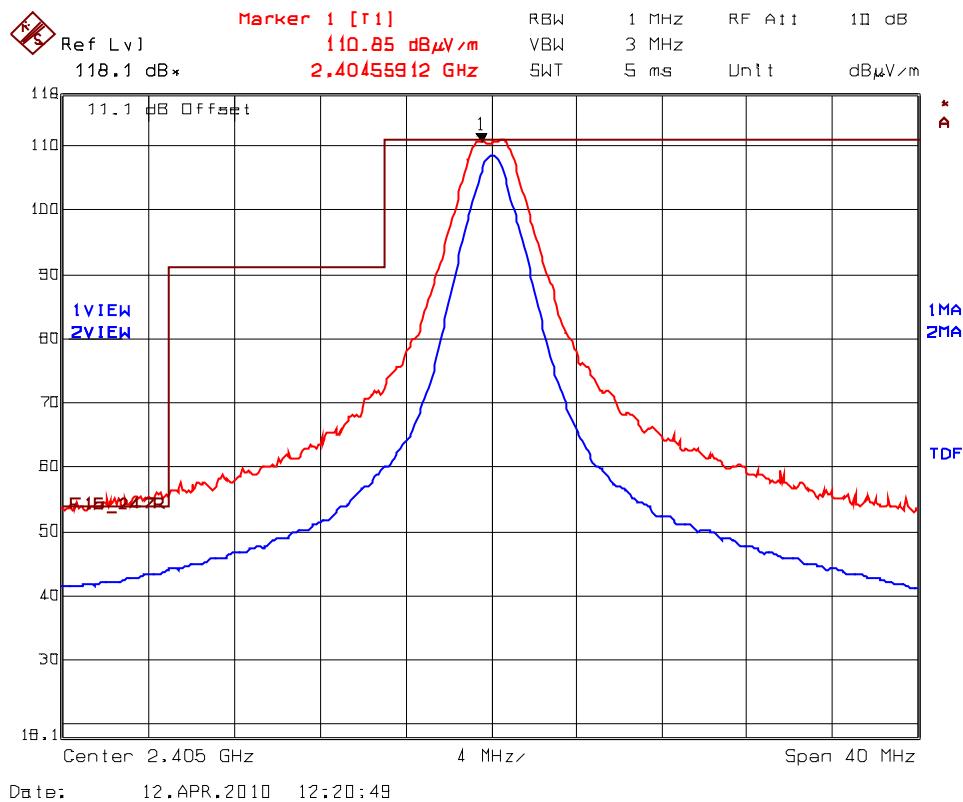
5.9.4.2. EUT with Omni Directional Antenna (15 dBi Gain with 0.62 dB Cable Loss (for 2405-2475 MHz) or 5.12 dB Cable Loss (for 2480MHz))

Fundamental Frequency: 2405 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2405	116.47	--	V	--	--	--	--
2405	110.85	--	H	--	--	--	--
30 -25000	*	*	V/H	*	96.5	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

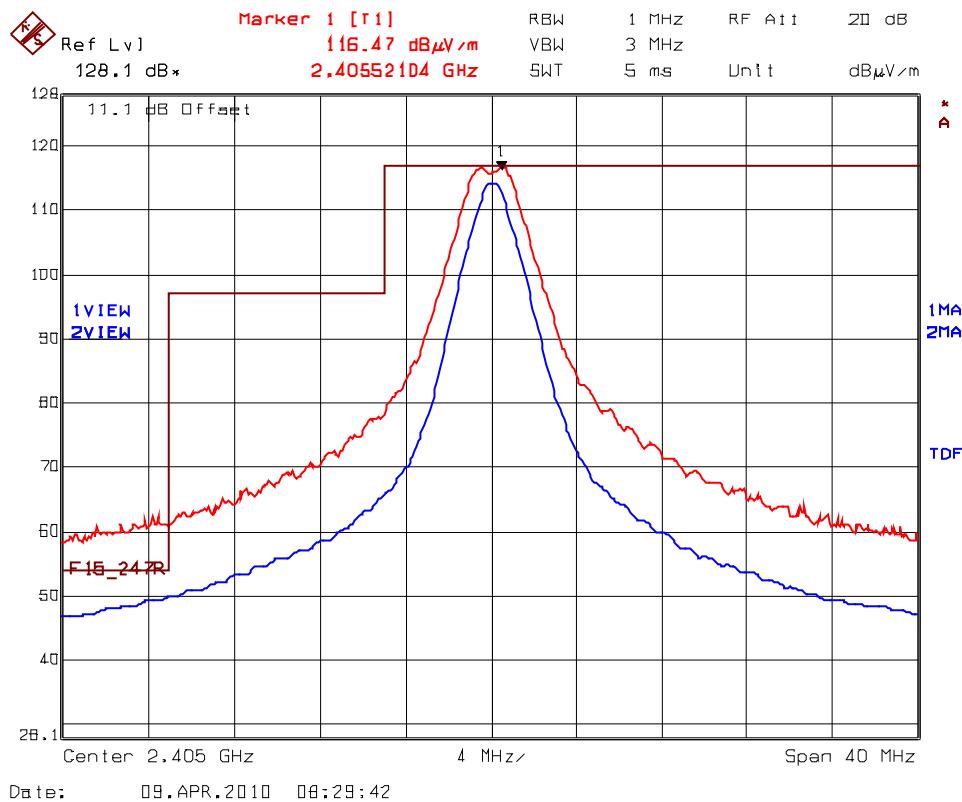
See the following test data plots for band-edge emissions.

Plot 5.9.4.2.1. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Horizontal



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.2.2. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Fundamental Frequency: 2440 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2440	115.89	--	V	--	--	--	--
2440	110.55	--	H	--	--	--	--
7320	57.50	35.46	V	54.0	95.9	-18.5	Pass*
7320	57.76	36.12	H	54.0	95.9	-17.9	Pass*

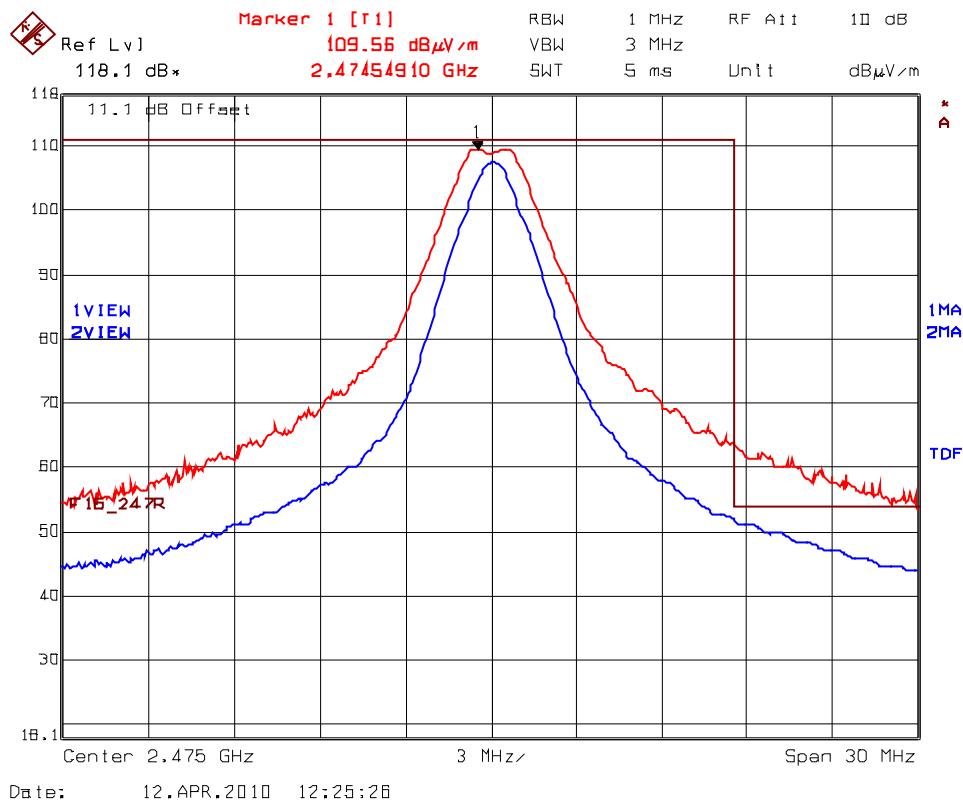
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency: 2475 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2475	113.08	--	V	--	--	--	--
2475	109.56	--	H	--	--	--	--
7425	59.08	36.78	V	54.0	93.1	-17.2	Pass*
7425	57.42	35.01	H	54.0	93.1	-19.0	Pass*

*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

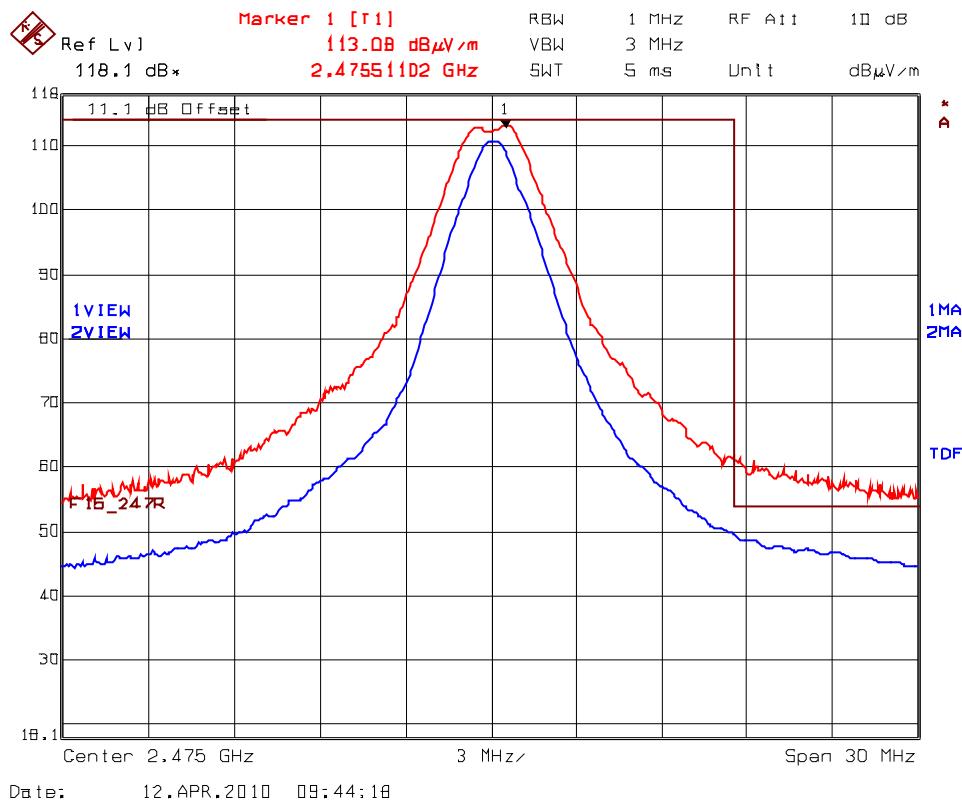
See the following test data plots for band-edge emissions.

Plot 5.9.4.2.3. Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band, 2475 MHz
Rx Antenna Orientation: Horizontal



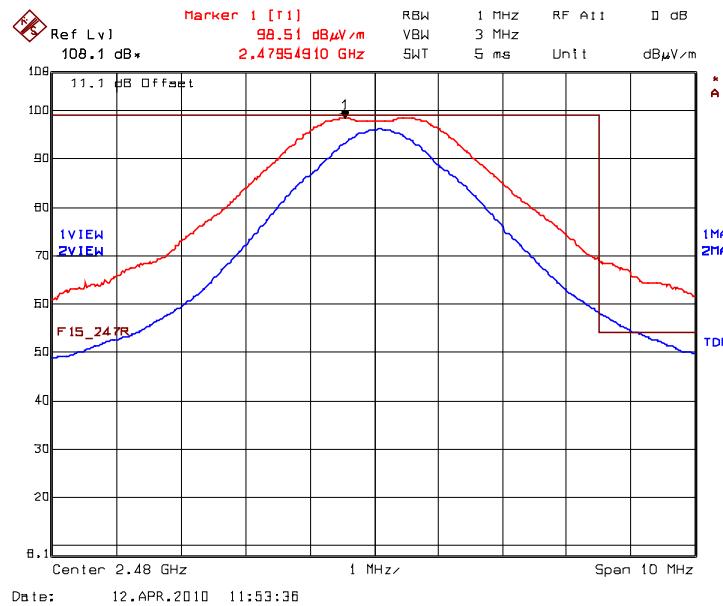
Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.2.4. Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band, 2475 MHz
Rx Antenna Orientation: Vertical

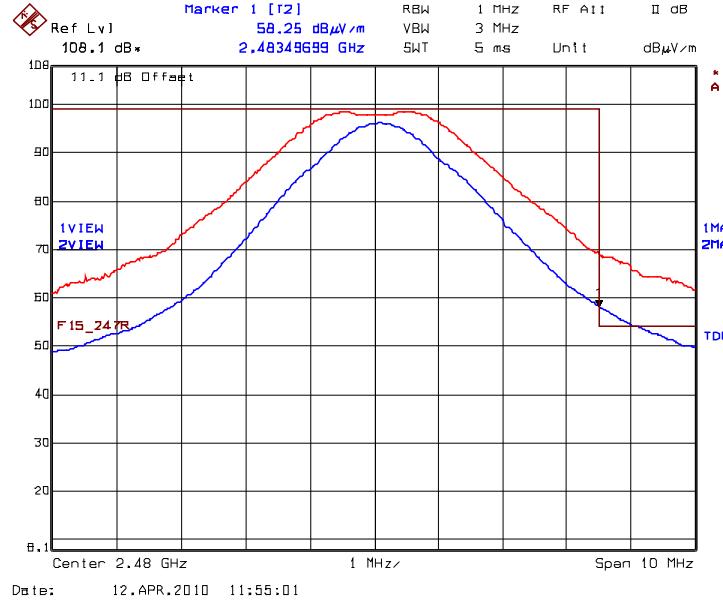


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.2.5. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.2.6. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal

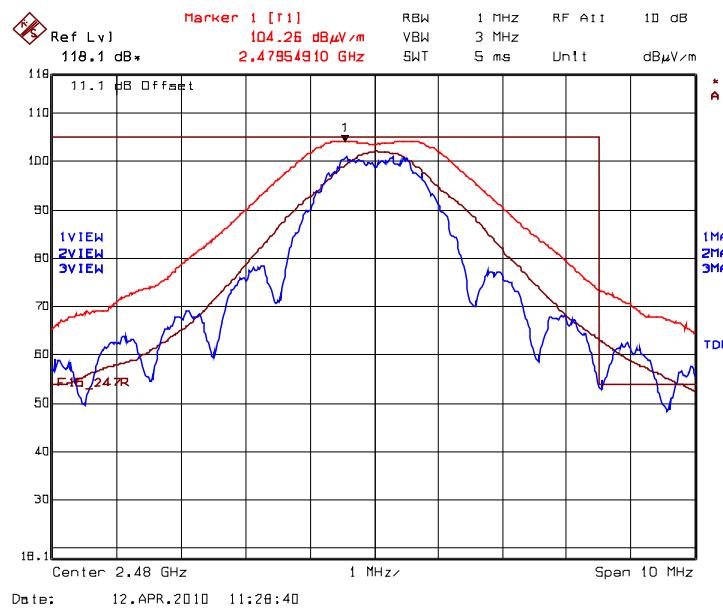


Trace 1: RBW = 1 MHz, VBW = 3 MHz

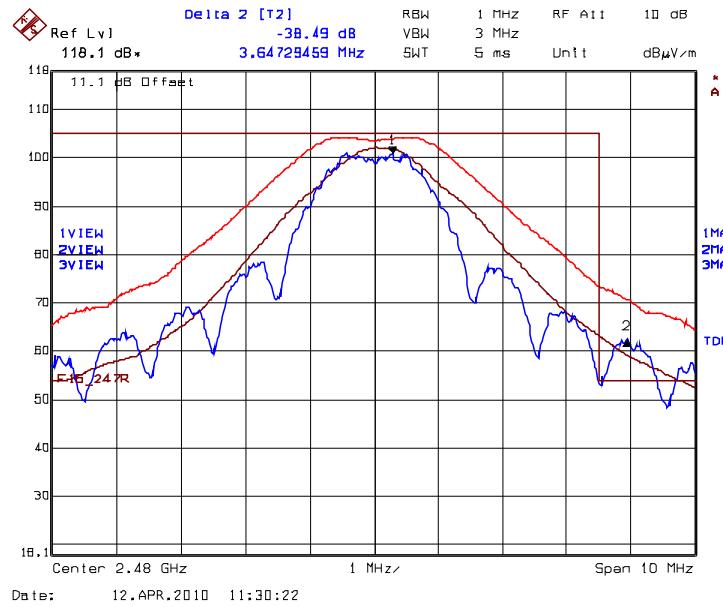
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Average: 58.25 dB μ V/m – 11.37 dB = 46.88 dB μ V/m (limit 54 dB μ V/m)

Plot 5.9.4.2.7. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.2.8. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 100 kHz, VBW = 300 kHz, Delta (Peak to Band-Edge): 38.49dB

Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 104.26 dB μ V/m - 38.49 dB = 65.77 dB μ V/m (limit 74 dB μ V/m)

Average: 63.19 dB μ V/m - 11.37 dB = 51.82 dB μ V/m (limit 54 dB μ V/m)

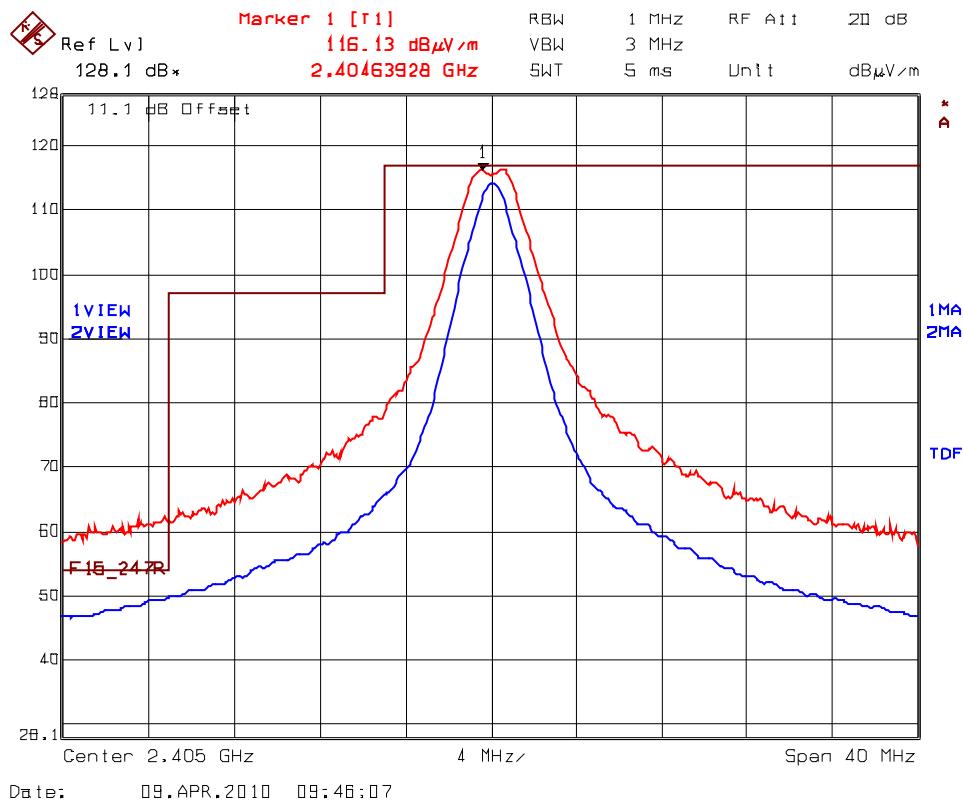
5.9.4.3. EUT with Yagi Antenna (15 dBi Gain with 0.62 dB Cable Loss (for 2405-2475 MHz) or 9.12 dB Cable Loss (for 2480 MHz))

Fundamental Frequency: 2405 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2405	116.47	--	V	--	--	--	--
2405	116.13	--	H	--	--	--	--
30-25000	*	*	V/H	*	96.5	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

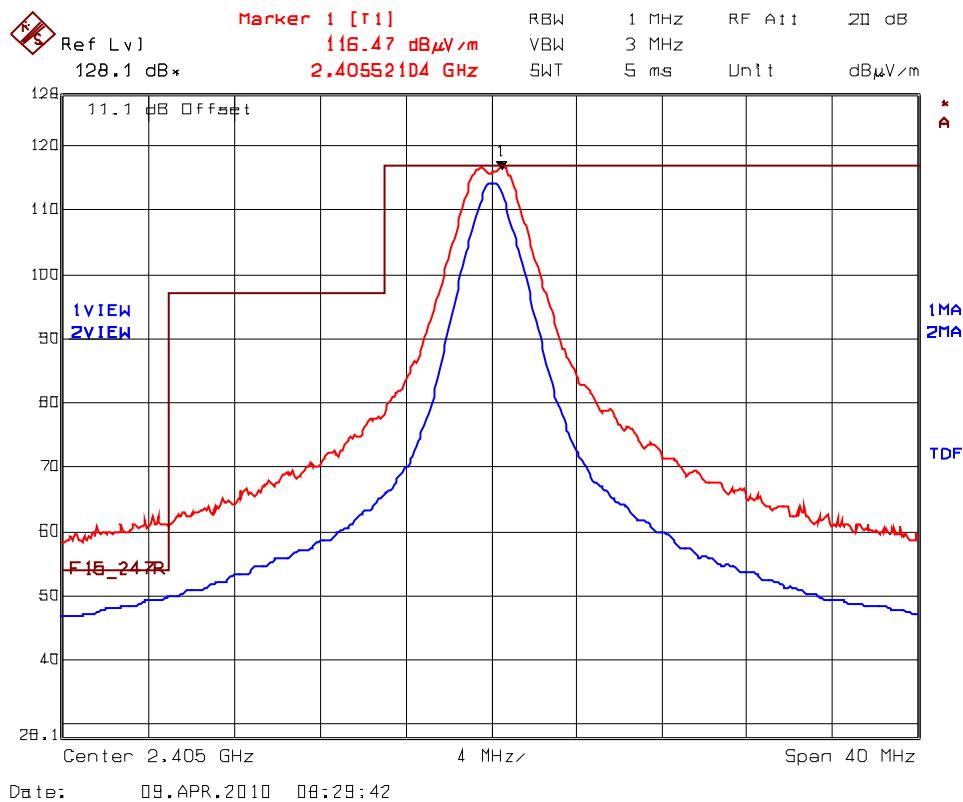
See the following test data plots for band-edge emissions.

Plot 5.9.4.3.1. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Horizontal



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.3.2. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Fundamental Frequency: 2440 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2440	116.70	--	V	--	--	--	--
2440	116.37	--	H	--	--	--	--
7320	56.79	34.62	V	54.0	96.7	-19.4	Pass*

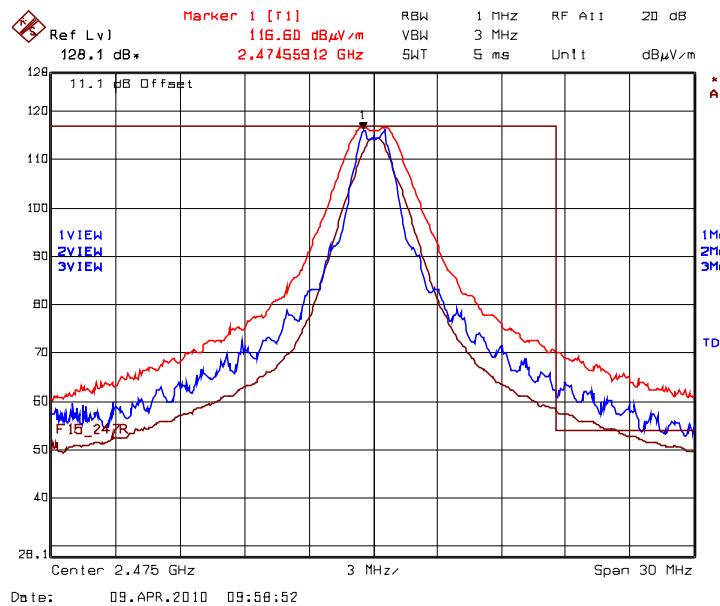
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency: 2475 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2475	116.92	--	V	--	--	--	--
2475	116.60	--	H	--	--	--	--
7425	59.19	37.10	V	54.0	96.9	-16.9	Pass*
7425	57.14	34.10	H	54.0	96.9	-19.9	Pass*

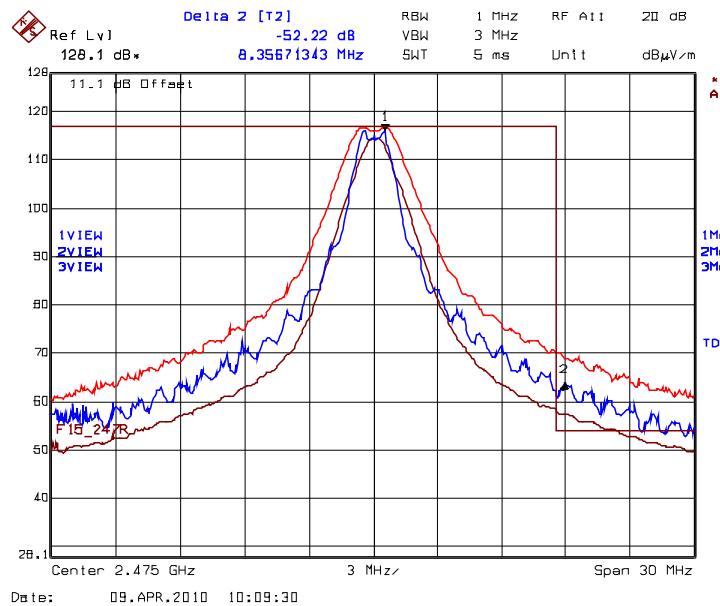
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

See the following test data plots for band-edge emissions.

Plot 5.9.4.3.3. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.3.4. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Horizontal



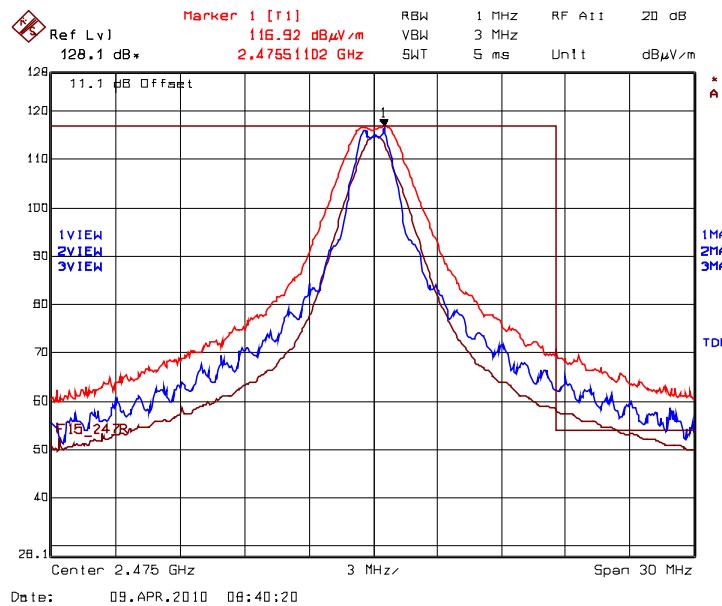
Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 300 kHz, VBW = 500 kHz, Delta (Peak to Band-Edge): 52.22 dB

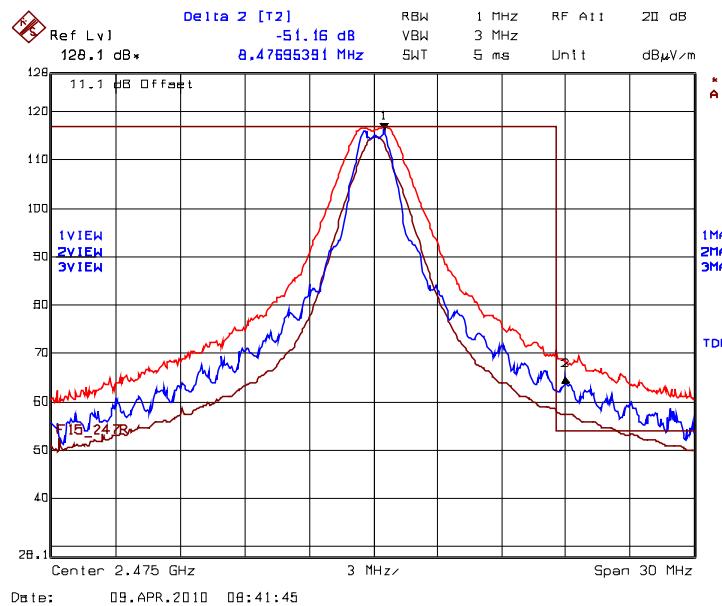
Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 116.60 dB μ V/m – 52.22 dB = 64.38 dB μ V/m (limit 74 dB μ V/m)
 Average: 58.18 dB μ V/m – 11.37dB = 46.81 dB μ V/m (limit 54 dB μ V/m)

Plot 5.9.4.3.5. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.3.6. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Vertical



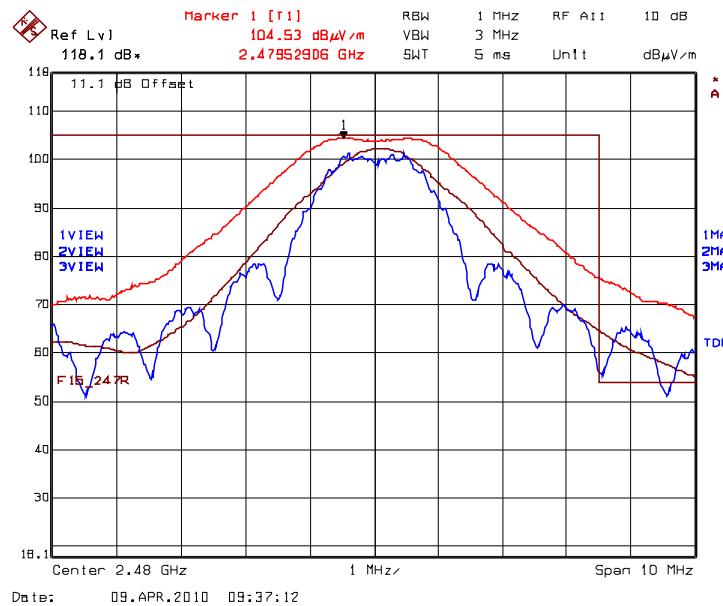
Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 300 kHz, VBW = 500 kHz, Delta (Peak to Band-Edge): 51.16 dB

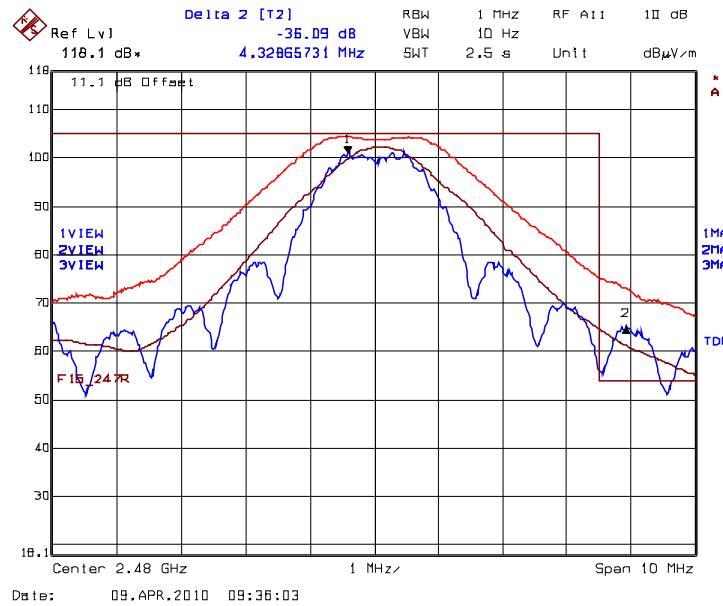
Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 116.92 dBμV/m – 51.16 dB = 65.76 dBμV/m (limit 74 dBμV/m)
 Average: 58.16 dBμV/m – 11.37dB = 46.79 dBμV/m (limit 54 dBμV/m)

Plot 5.9.4.3.7. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.3.8. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



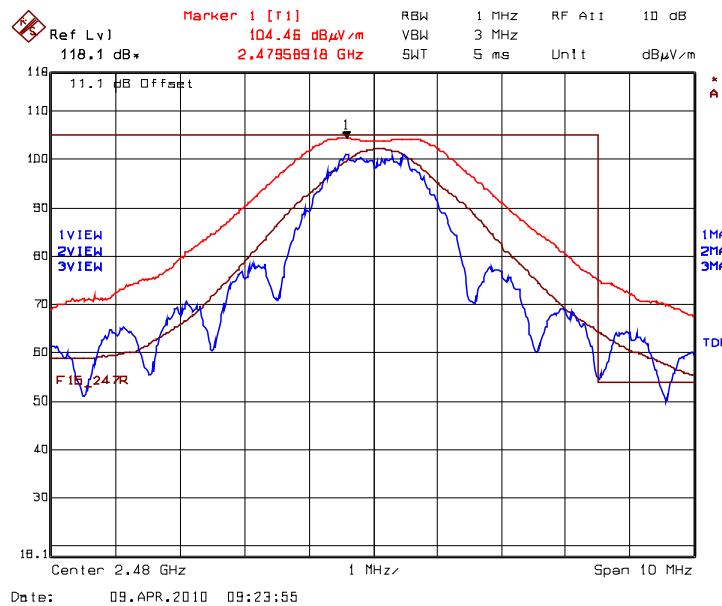
Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 100 kHz, VBW = 300 kHz, Delta (Peak to Band-Edge): 36.09 dB

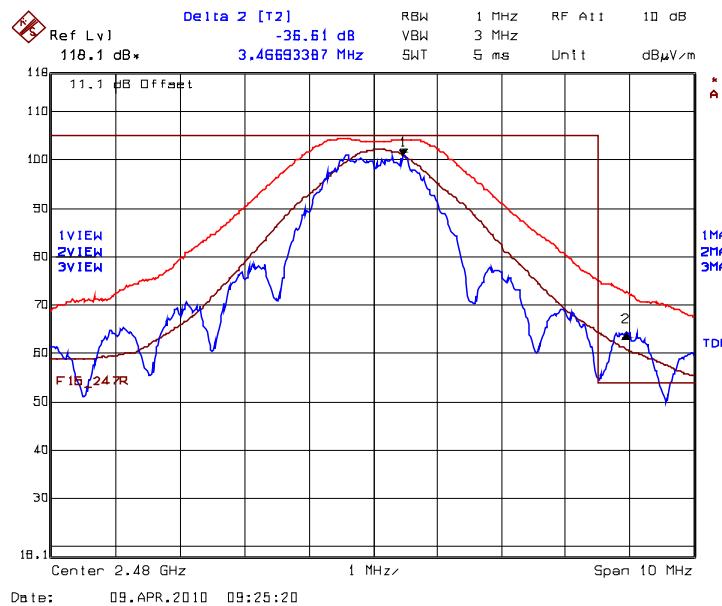
Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 104.53 dBμV/m – 36.09 dB = 68.44 dBμV/m (limit 74 dBμV/m)
 Average: 64.44 dBμV/m – 11.37 dB = 53.07 dBμV/m (limit 54 dBμV/m)

Plot 5.9.4.3.9. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.3.10. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 100 kHz, VBW = 300 kHz, Delta (Peak to Band-Edge): 36.61 dB

Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 104.46 dB μ V/m – 36.61 dB = 67.85 dB μ V/m (limit 74 dB μ V/m)
 Average: 64.39 dB μ V/m – 11.37 dB = 53.02 dB μ V/m (limit 54 dB μ V/m)

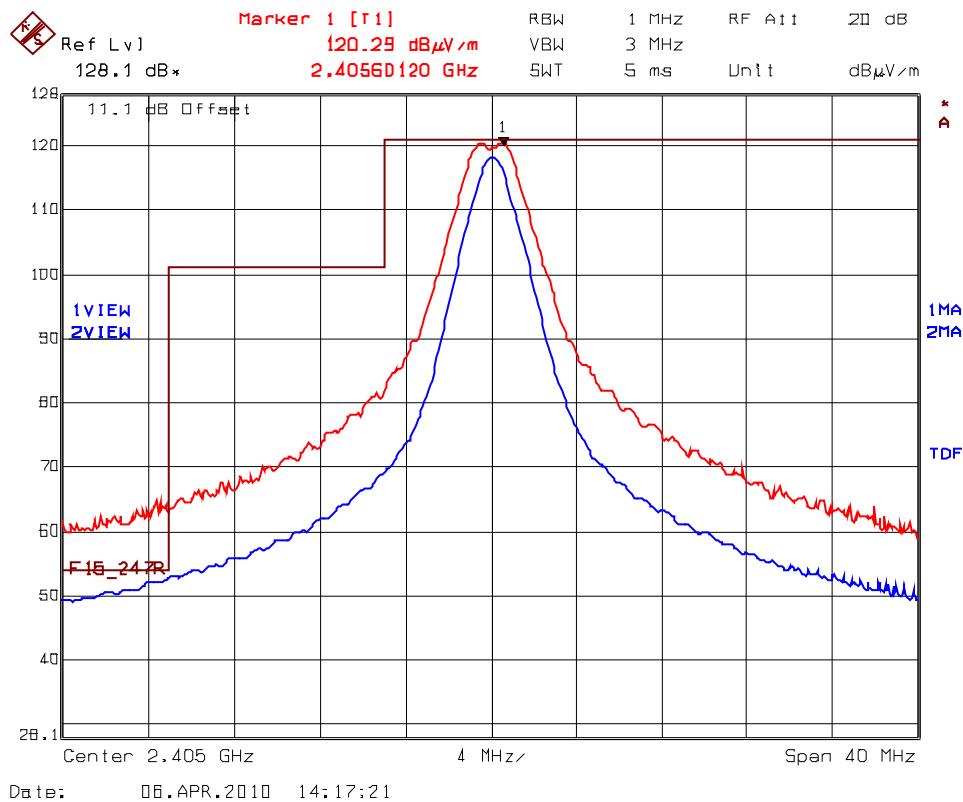
5.9.4.4. EUT with Panel Antenna (19 dBi Gain with 0.62 dB Cable Loss (for 2405-2475 MHz) or 13.62 dB Cable Loss (for 2480 MHz))

Fundamental Frequency: 2405 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2405	120.75	--	V	--	--	--	--
2405	120.29	--	H	--	--	--	--
30 -25000	*	*	H	*	100.8	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

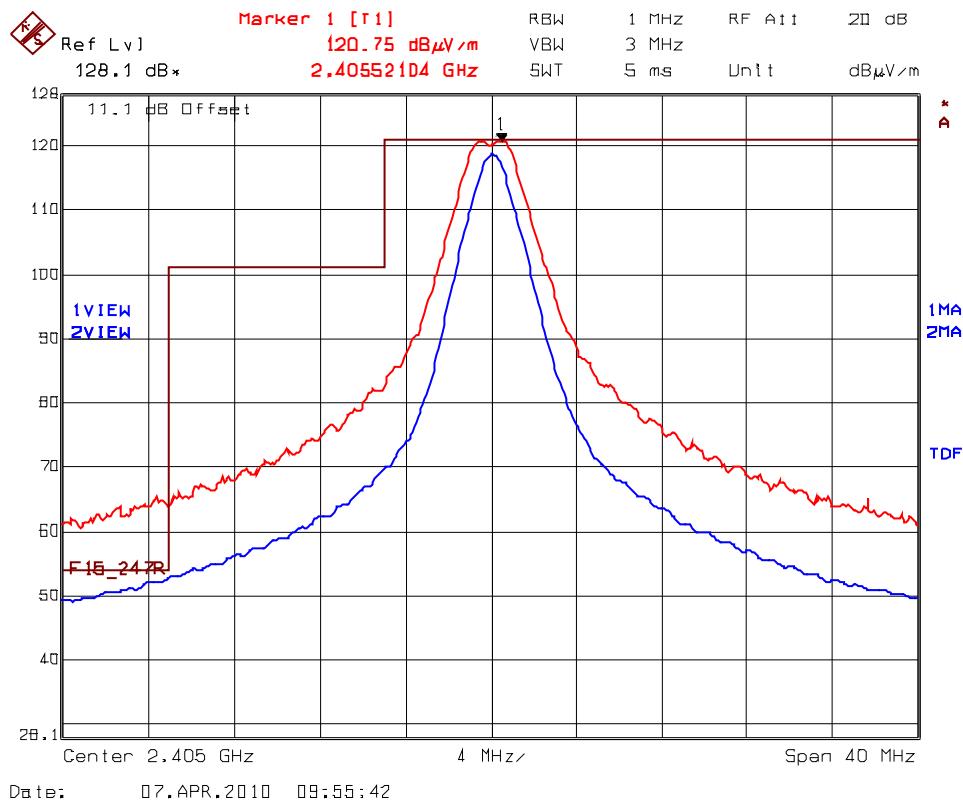
See the following test data plots for band-edge emissions.

Plot 5.9.4.4.1. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Horizontal



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.4.2. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Fundamental Frequency: 2440 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2440	121.11	--	V	--	--	--	--
2440	121.05	--	H	--	--	--	--
7320	59.80	37.66	V	54.0	101.1	-16.3	Pass*
7320	58.44	35.97	H	54.0	101.1	-18.0	Pass*

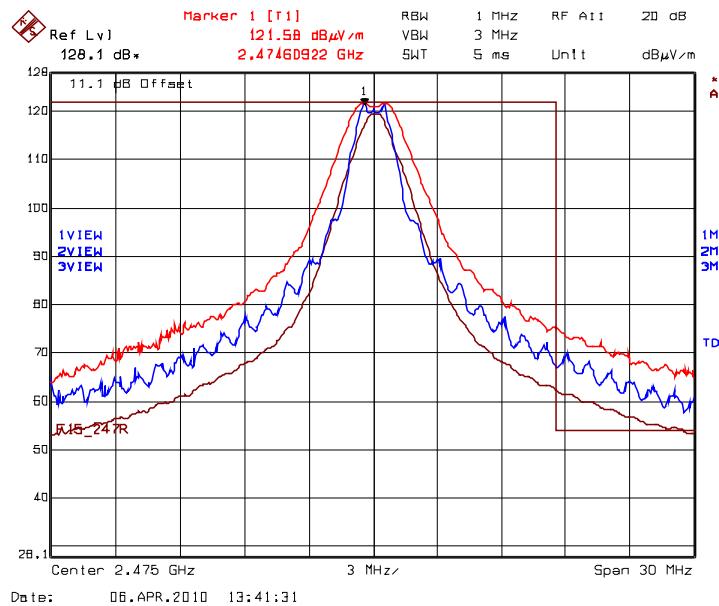
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

Fundamental Frequency: 2475 MHz Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2475	121.21	--	V	--	--	--	--
2475	121.58	--	H	--	--	--	--
7425	61.96	39.31	V	54.0	101.6	-14.7	Pass*
7425	60.13	37.33	H	54.0	101.6	-16.7	Pass*

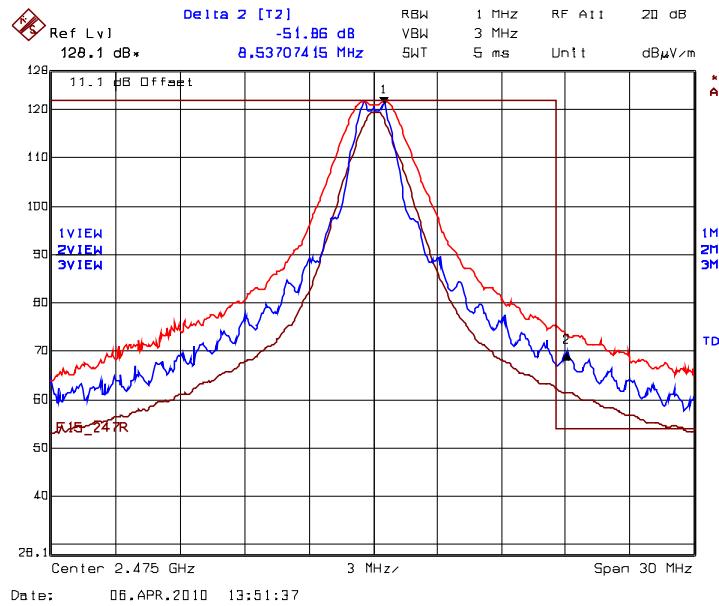
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

See the following test data plots for band-edge emissions.

Plot 5.9.4.4.3. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.4.4. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Horizontal



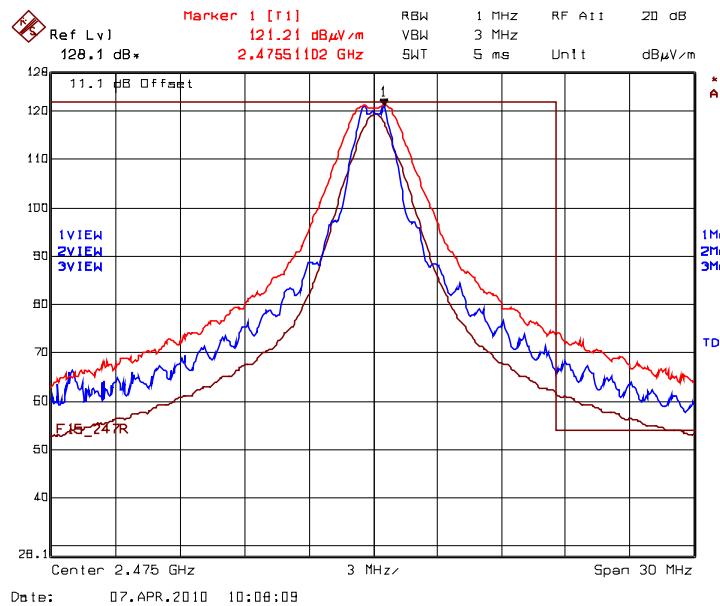
Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 300 kHz, VBW = 500 kHz, Delta (Peak to Band-Edge): 51.86 dB

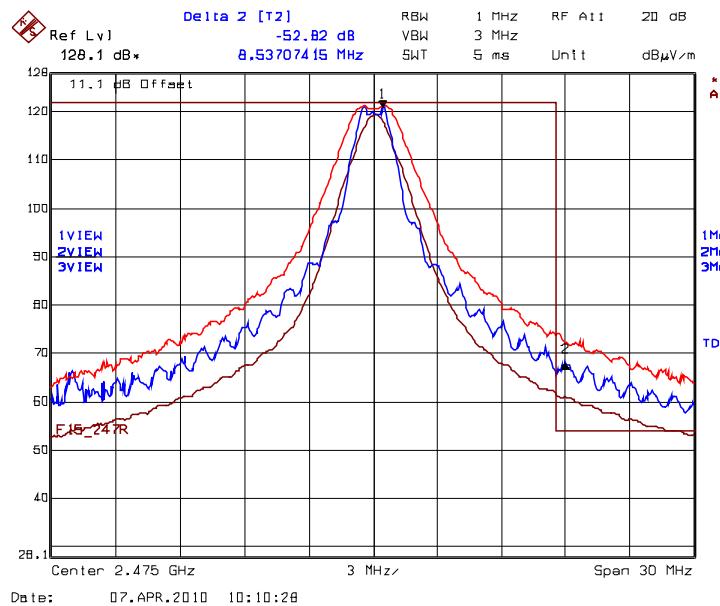
Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 121.58 dBμV/m - 51.86 dB = 69.72 dBμV/m (limit 74 dBμV/m)
 Average: 62.49 dBμV/m - 11.37 dB = 51.12 dBμV/m (limit 54 dBμV/m)

Plot 5.9.4.4.5. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.4.6. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2475 MHz, Rx Antenna Orientation: Vertical



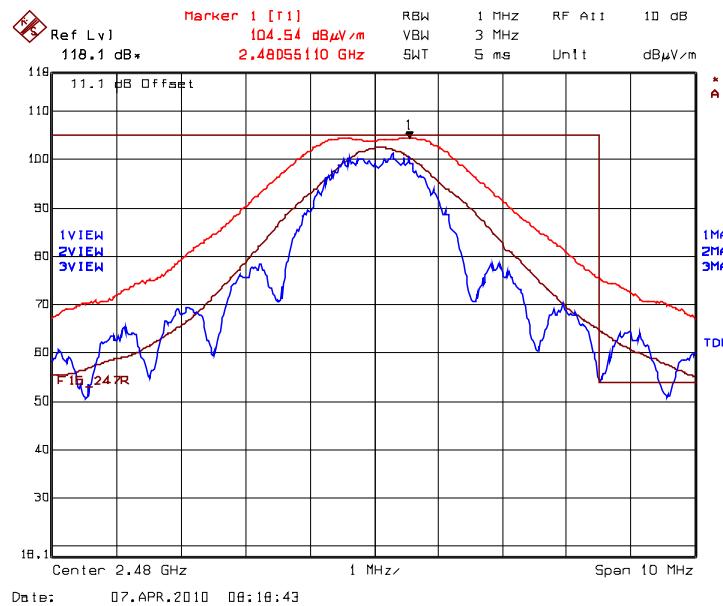
Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 300 kHz, VBW = 500 kHz, Delta (Peak to Band-Edge): 52.82 dB

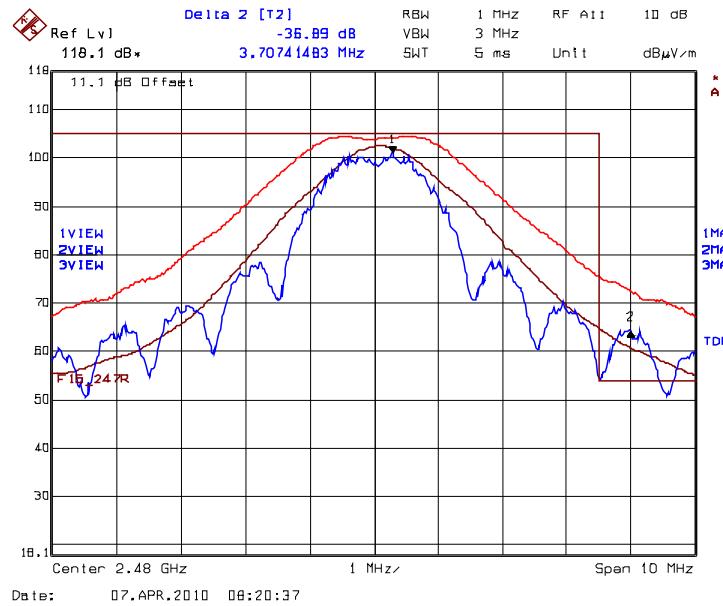
Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 121.21 dB μ V/m – 52.82dB = 68.39 dB μ V/m (limit 74 dB μ V/m)
 Average: 62.49 dB μ V/m – 11.37 dB = 51.12 dB μ V/m (limit 54 dB μ V/m)

Plot 5.9.4.4.7. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.4.8. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



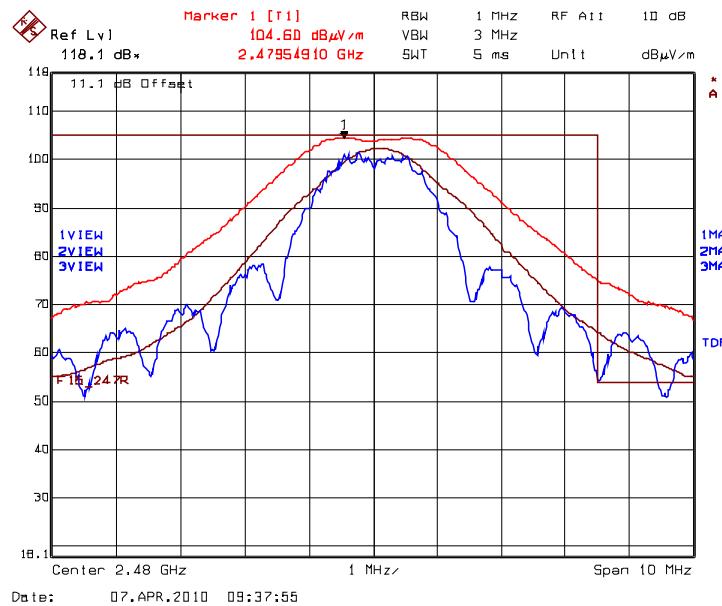
Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 100 kHz, VBW = 300 kHz, Delta (Peak to Band-Edge): 36.89 dB

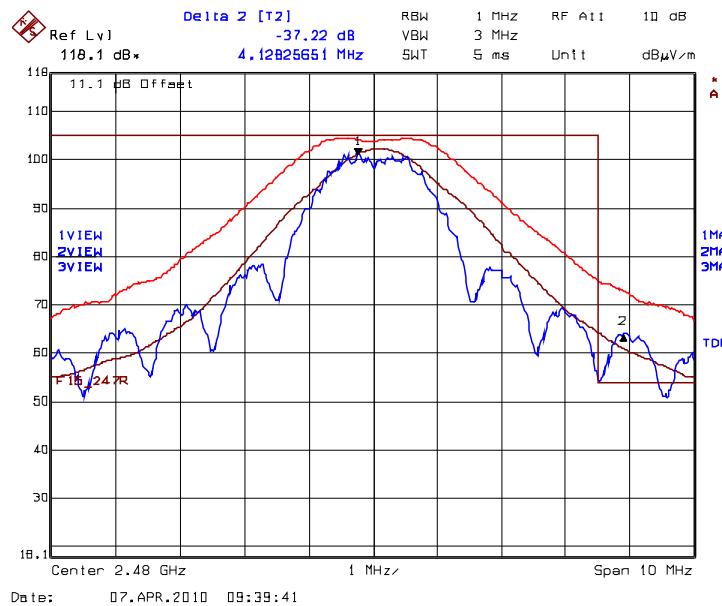
Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 104.54 dB μ V/m – 36.89 dB = 67.65 dB μ V/m (limit 74 dB μ V/m)
 Average: 64.72 dB μ V/m – 11.37 dB = 53.35 dB μ V/m (limit 54 dB μ V/m)

Plot 5.9.4.4.9. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.4.10. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 100 kHz, VBW = 300 kHz, Delta (Peak to Band-Edge): 37.22 dB

Trace 3: RBW = 1 MHz, VBW = 10 Hz

Peak Band-Edge at 2483.5 MHz: Peak = 104.60 dB μ V/m – 37.22 dB = 67.38 dB μ V/m (limit 74 dB μ V/m)
 Average: 64.27 dB μ V/m – 11.37 dB = 52.90 dB μ V/m (limit 54 dB μ V/m)

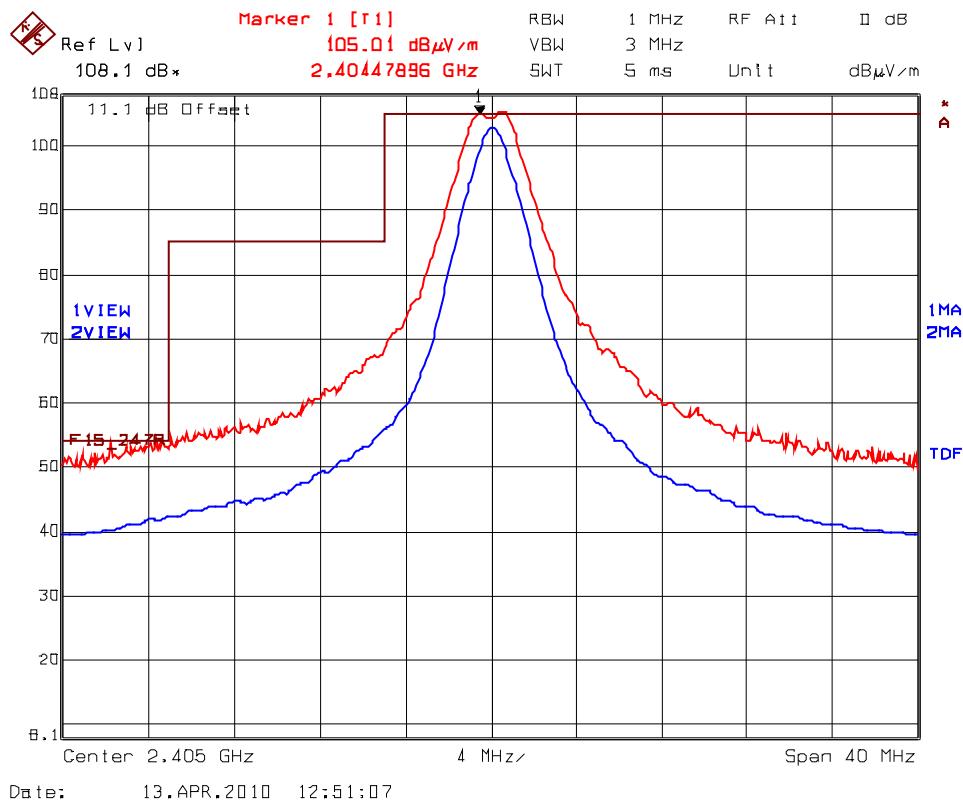
5.9.4.5. EUT with Integrated Whip Monopole Antenna (1.5 dBi Gain)

Fundamental Frequency: 2405 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/Fail
2405	100.95	--	V	--	--	--	--
2405	105.01	--	H	--	--	--	--
30-25000	*	*	V/H	*	85.0	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

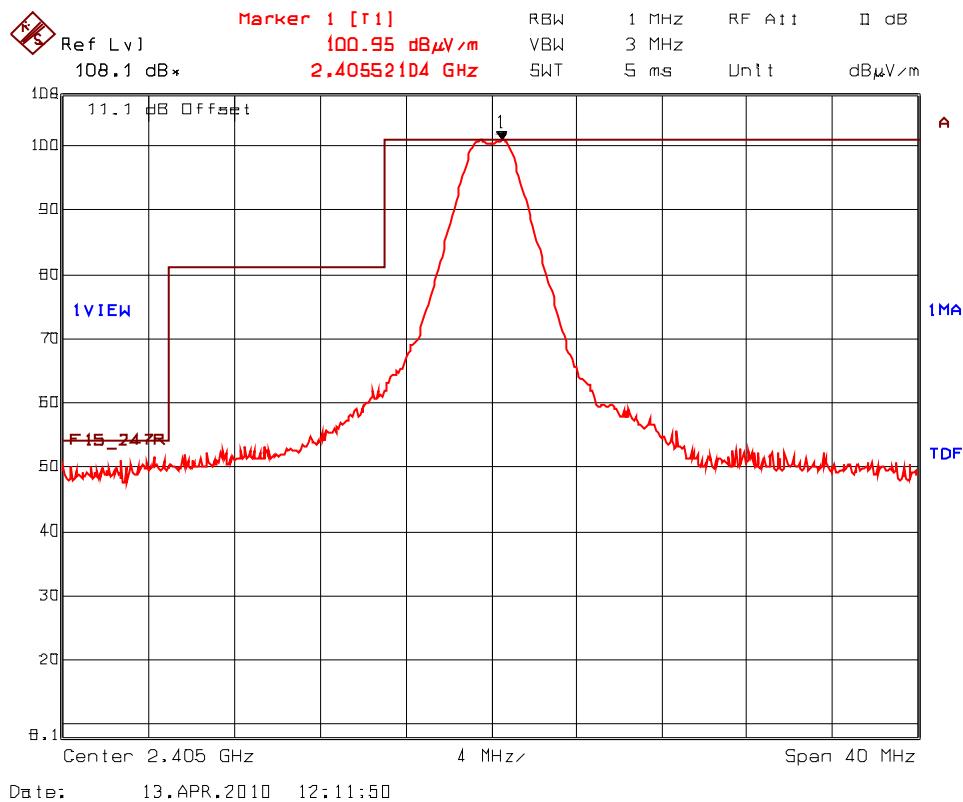
See the following test data plots for band-edge emissions.

Plot 5.9.4.5.1. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Horizontal



Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.5.2. Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band, 2405 MHz
Rx Antenna Orientation: Vertical



Fundamental Frequency: 2440 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2440	101.05	--	V	--	--	--	--
2440	106.30	--	H	--	--	--	--
30-25000	*	*	V/H	*	86.3	*	Pass

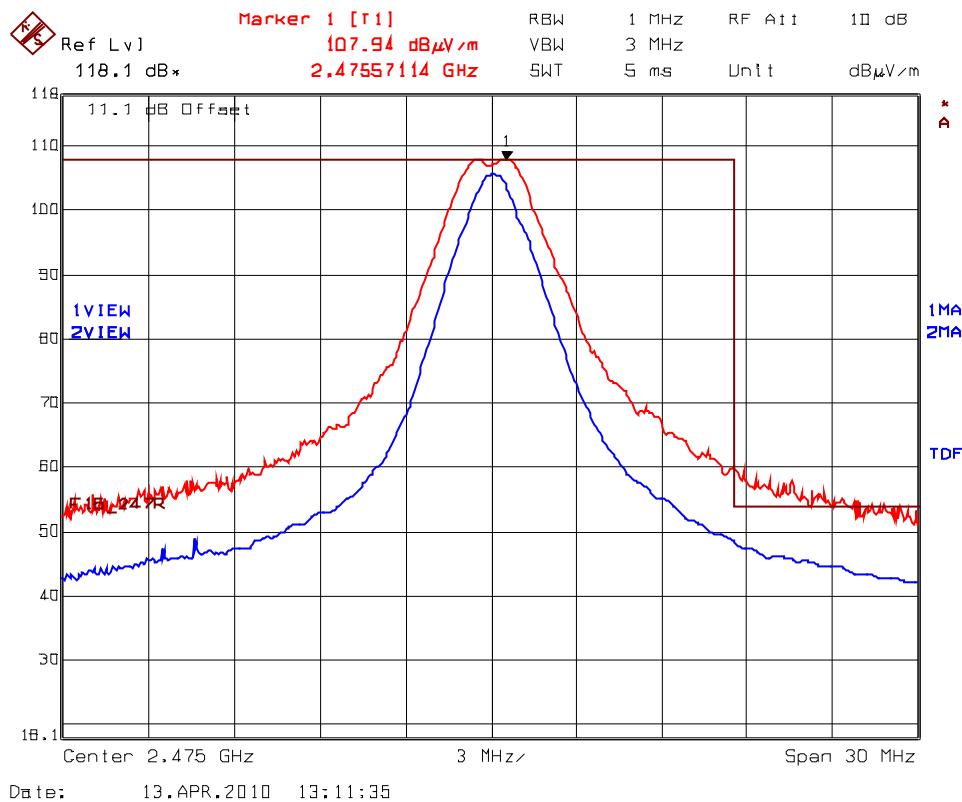
*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

Fundamental Frequency: 2475 MHz							
Test Frequency Range: 30 MHz – 25 GHz							
Frequency (MHz)	RF Peak Level (dB μ V/m)	RF Avg Level (dB μ V/m)	Antenna Plane (H/V)	Limit 15.209 (dB μ V/m)	Limit 15.247 (dB μ V/m)	Margin (dB)	Pass/ Fail
2475	102.39	--	V	--	--	--	--
2475	107.94	--	H	--	--	--	--
30-25000	*	*	V/H	*	87.9	*	Pass

*The spurious emissions from intentional radiators are more than 20 dB below the specified limit.

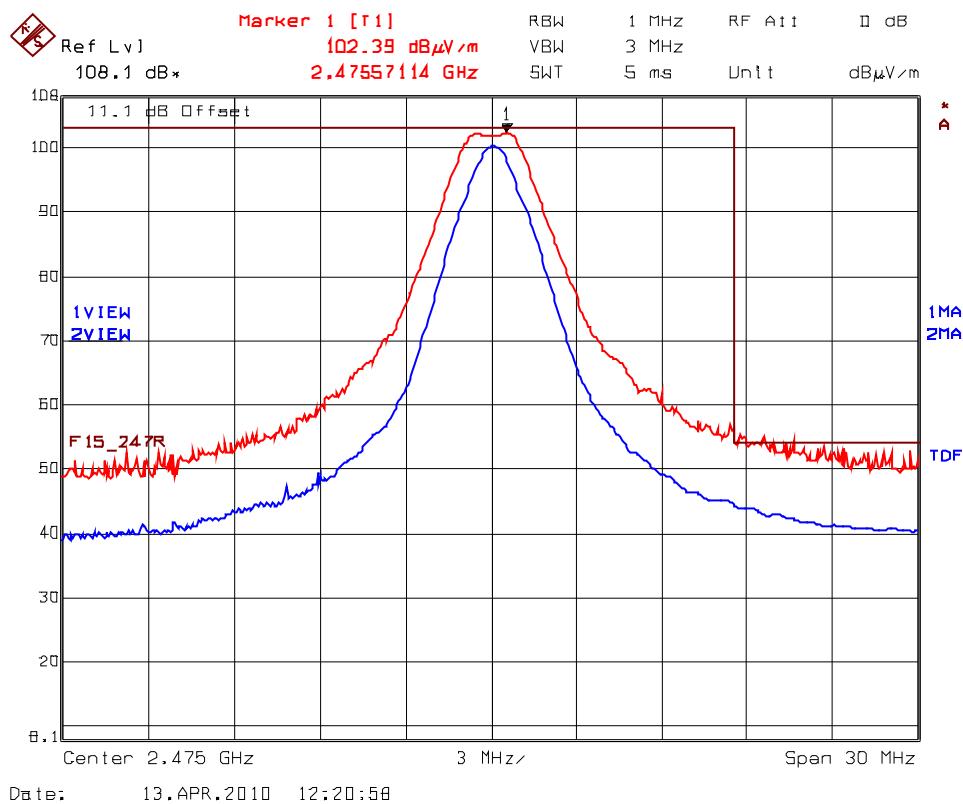
See the following test data plots for band-edge emissions.

Plot 5.9.4.5.3. Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band, 2475 MHz
Rx Antenna Orientation: Horizontal



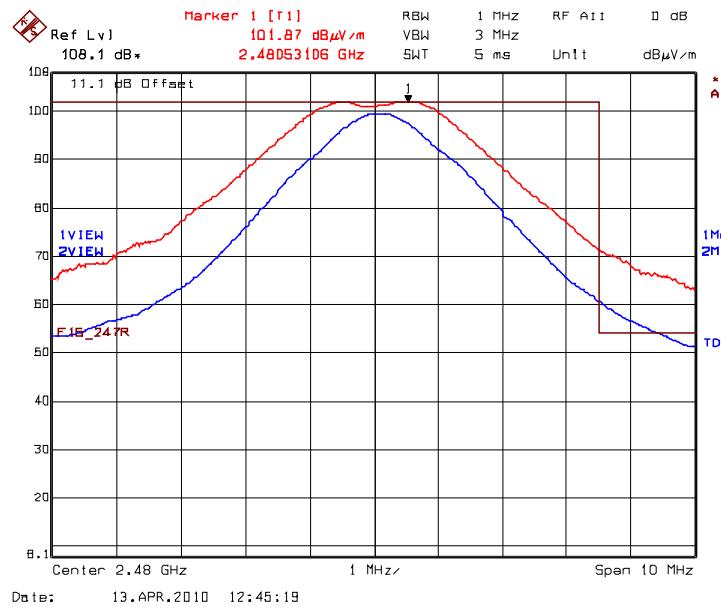
Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.5.4. Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band, 2475 MHz
Rx Antenna Orientation: Vertical

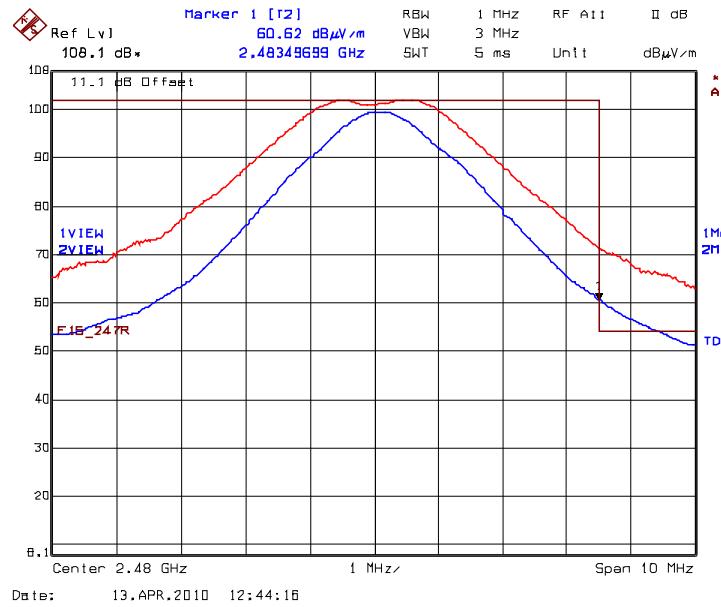


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Plot 5.9.4.5.5. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal



Plot 5.9.4.5.6. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Horizontal

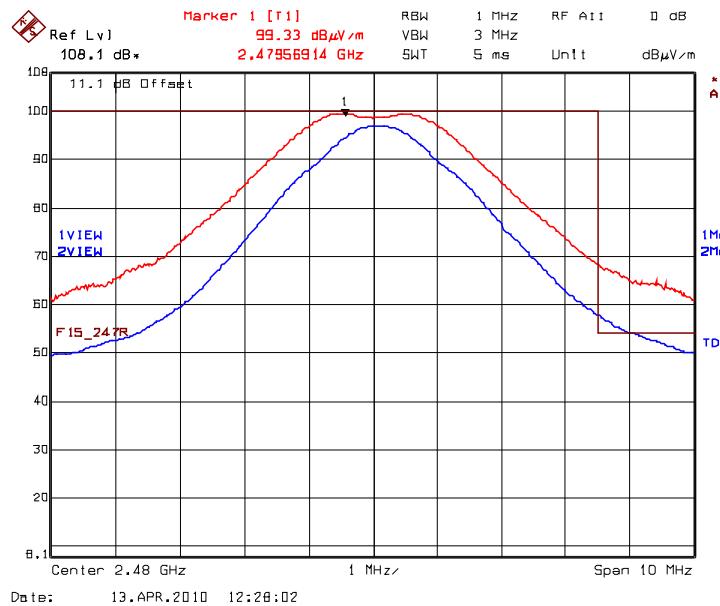


Trace 1: RBW = 1 MHz, VBW = 3 MHz

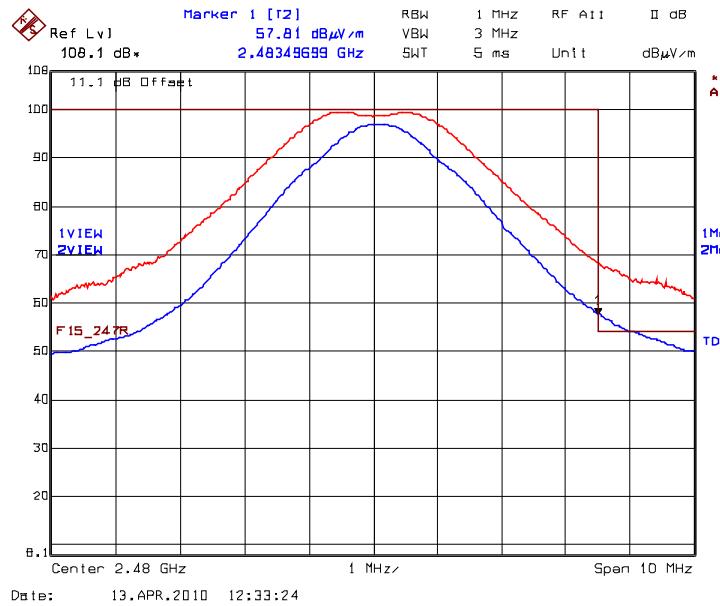
Trace 2: RBW = 1 MHz, VBW = 10 Hz

Average: 60.62 dB μ V/m – 11.37 dB = 49.25 dB μ V/m (limit 54 dB μ V/m)

Plot 5.9.4.5.7. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Plot 5.9.4.5.8. Band-Edge RF Radiated Emissions @ 3 m
 High End of Frequency Band, 2480 MHz, Rx Antenna Orientation: Vertical



Trace 1: RBW = 1 MHz, VBW = 3 MHz

Trace 2: RBW = 1 MHz, VBW = 10 Hz

Average: 57.81 dB μ V/m – 11.37 dB = 46.44 dB μ V/m (limit 54 dB μ V/m)

5.10. POWER SPECTRAL DENSITY [§ 15.247(e)]

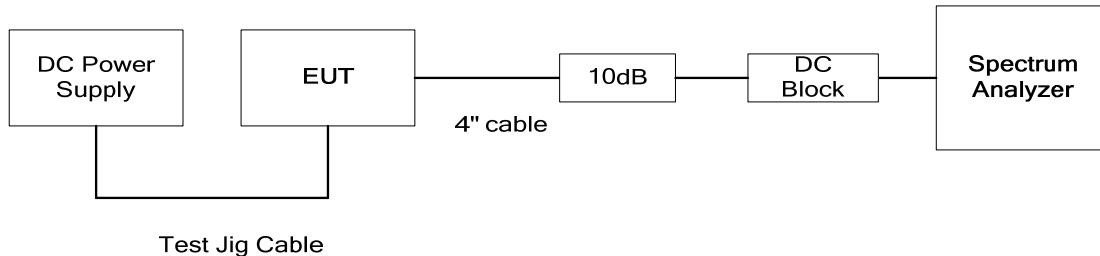
5.10.1. Limit(s)

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.10.2. Method of Measurements

KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247), PSD Option 1 method.

5.10.3. Test Arrangement



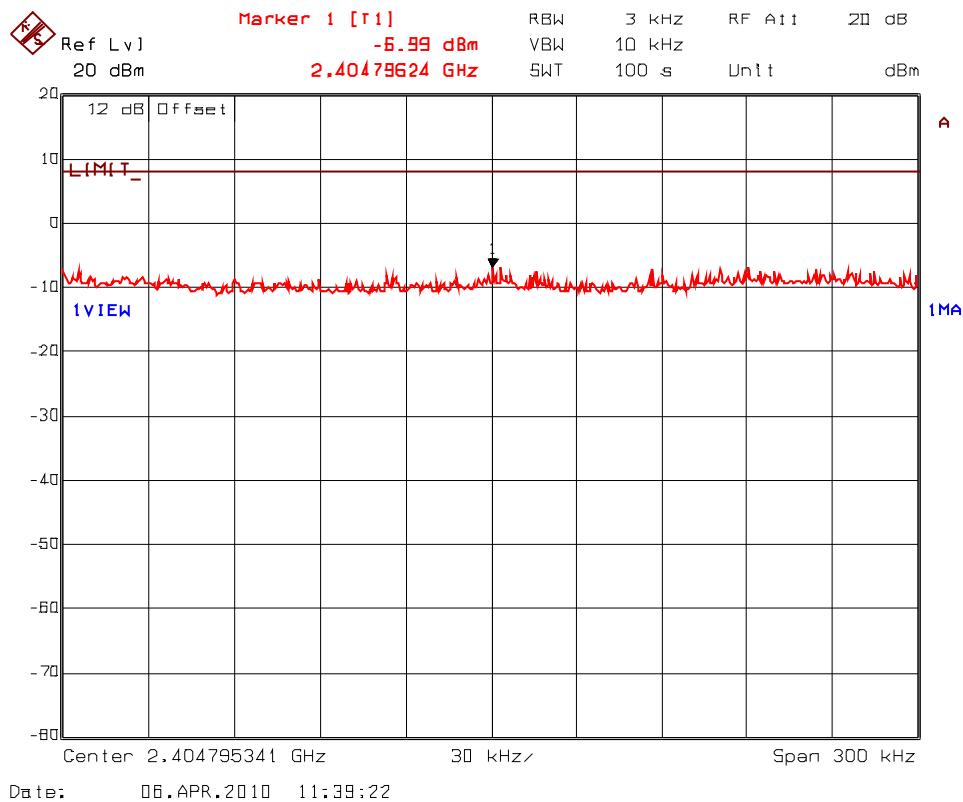
5.10.4. Test Data

Remark: Measurement method: Power spectral density (PSD) Option 1.

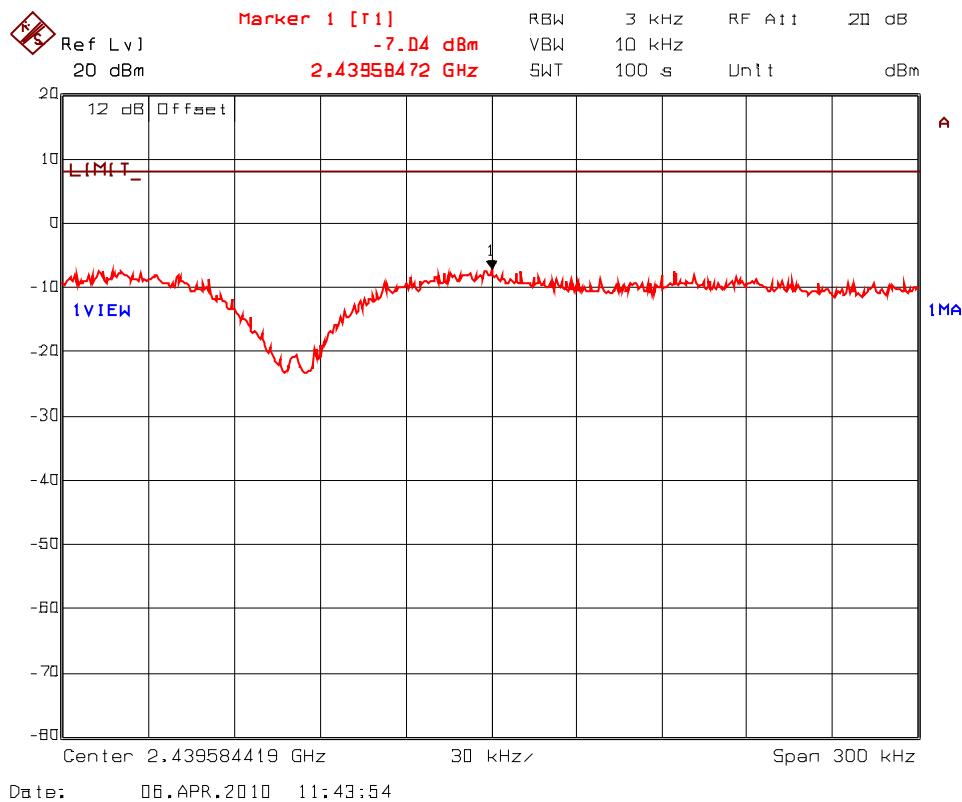
Channel	Frequency (MHz)	*PSD in 3 kHz BW (dBm)	Limit (dBm)	Margin (dB)	Results (Pass/Fail)
11	2405	-6.99	8	-14.99	Pass
18	2440	-7.04	8	-15.04	Pass
25	2475	-6.87	8	-14.87	Pass
26	2480	-11.40	8	-19.40	Pass

*See the following plots for measurement details.

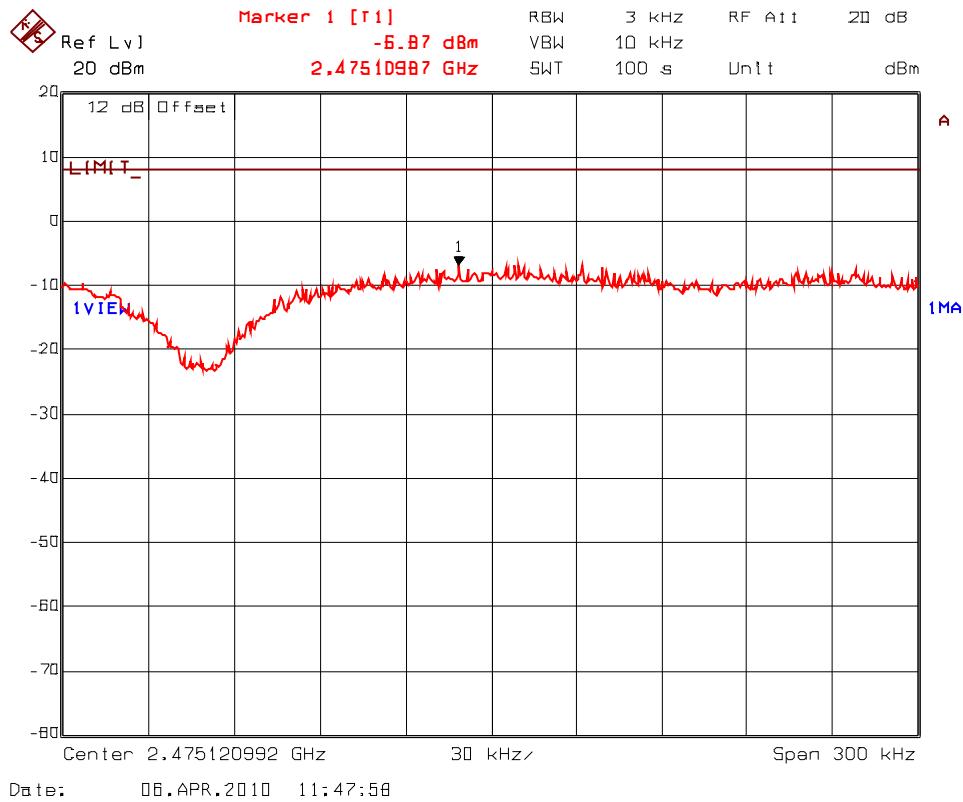
Plot 5.10.4.1. Power Spectral Density
Test Frequency: 2405 MHz (CH 11)



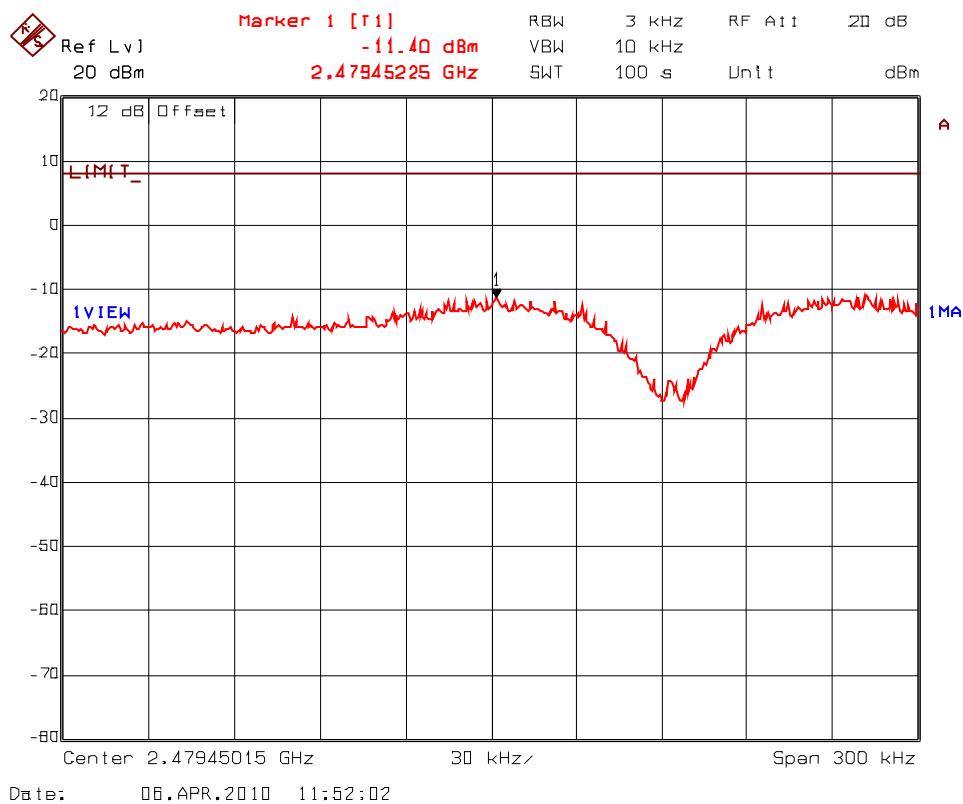
Plot 5.10.4.2. Power Spectral Density
Test Frequency: 2440 MHz (CH 18)



Plot 5.10.4.3. Power Spectral Density



Plot 5.10.4.4. Power Spectral Density
Test Frequency: 2480 MHz (CH 26)



5.11. RF EXPOSURE REQUIREMENTS [§§ 15.247(e)(i), 1.1310 & 2.1091]

The criteria listed in the following table shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation.

FCC 47 CFR § 1.1310:

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f ²)	6
30–300	61.4	0.163	1.0	6
300–1500 .....	.....	.....	f/300	6
1500–100,000 .....	.....	.....	5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f ²)	30
30–300	27.5	0.073	0.2	30
300–1500 .....	.....	.....	f/1500	30
1500–100,000 .....	.....	.....	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

5.11.1. Method of Measurements

Refer to Sections 1.1310, 2.1091

In order to demonstrate compliance with MPE requirements (see Section 2.1091), the following information is typically needed:

- (1) Calculation that estimates the minimum separation distance (20 cm or more) between an antenna and persons required to satisfy power density limits defined for free space.
- (2) Antenna installation and device operating instructions for installers (professional/unskilled users), and the parties responsible for ensuring compliance with the RF exposure requirement
- (3) Any caution statements and/or warning labels that are necessary in order to comply with the exposure limits
- (4) Any other RF exposure related issues that may affect MPE compliance

Calculation Method of RF Safety Distance:

$$S = \frac{P \cdot G}{4 \cdot \pi \cdot r^2} = \frac{EIRP}{4 \cdot \pi \cdot r^2}$$

Where:
 P: power input to the antenna in mW
 EIRP: Equivalent (effective) isotropic radiated power
 S: power density mW/cm²
 G: numeric gain of antenna relative to isotropic radiator
 r: distance to centre of radiation in cm

5.11.2. RF Evaluation

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	Compliance with FCC Rules
Minimum calculated separation distance between antenna and persons required: *6.3 cm	Manufacturer' instruction for separation distance between antenna and persons required: 20 cm.
Antenna installation and device operating instructions for installers (professional/unskilled users), and the parties responsible for ensuring compliance with the RF exposure requirement	Antenna installation and device operating instructions shall be provided to installers to maintain and ensure compliance with RF exposure requirements.
Caution statements and/or warning labels that are necessary in order to comply with the exposure limits	Refer to User's Manual for RF Exposure Information.
Any other RF exposure related issues that may affect MPE compliance	None.

*The minimum separation distance between the antenna and bodies of users are calculated using the following formula:

$$r = \sqrt{\frac{P \cdot G}{4 \cdot \pi \cdot S}} = \sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}}$$

S = 1.0 mW/cm²

EIRP = 8 dBm (max. conducted power) + 19 dBi (max. antenna gain) = 27 dBm = 10^(27/10) mW = 501 mW (Worst Case)

$$(\text{Minimum Safe Distance, } r) = \sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}} = \sqrt{\frac{501}{4 \cdot \pi \cdot (1.0)}} \approx 6.3cm$$

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Operating Range
Spectrum Analyzer/ EMI Receiver	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz
Transient Limiter	Hewlett Packard	11947A	310701998	9 kHz – 200 MHz 10 dB attenuation
L.I.S.N.	EMCO	3825/2	89071531	9 kHz – 200 MHz 50 Ohms / 50 μ H
RF Shielded Chamber	Braden Shielding	...	...	...
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20 Hz – 40 GHz with external mixer
DC Block	Hewlett Packard	11742A	12460	0.045 – 26.5 GHz
Attenuator	Narda	4768-10	-	DC - 40 GHz
High Pass Filter	K & L	11SH10-4000/T12000	4	Cut off 3.4 GHz
Biconi-Log Antenna	EMCO	3142	10005	0.03 – 2 GHz
Horn Antenna	EMCO	3155	9701-6570	1 – 18 GHz
Horn Antenna	ETS-Lindgren	360-09	00118385	18 – 26.5 GHz
RF Amplifier	Com-Power	PA-103A	161243	10 MHz – 1 GHz
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz
Signal Generator	Hewlett Packard	83752B	3610400457	0.01 – 20 GHz
Power Divider	Mini-Circuits	15542	0235	DC - 10 GHz
Signal Generator	Hewlett Packard	8648C	3443U00391	100 kHz-3200 MHz
Tenma DC Power Supply	Tenma	72-6153	0001526	20Vdc 10A

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of NIST Technical Note 1297 and NIS 81 (1994)

7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Line Conducted)	PROBABILITY DISTRIBUTION	UNCERTAINTY (dB)	
		9-150 kHz	0.15-30 MHz
EMI Receiver specification	Rectangular	± 1.5	± 1.5
LISN coupling specification	Rectangular	± 1.5	± 1.5
Cable and Input Transient Limiter calibration	Normal (k=2)	± 0.3	± 0.5
Mismatch: Receiver VRC $\Gamma_1 = 0.03$ LISN VRC $\Gamma_R = 0.8(9 \text{ kHz}) 0.2 (30 \text{ MHz})$ Uncertainty limits $20\text{Log}(1+\Gamma_1\Gamma_R)$	U-Shaped	± 0.2	± 0.3
System repeatability	Std. deviation	± 0.2	± 0.05
Repeatability of EUT	--	--	--
Combined standard uncertainty	Normal	± 1.25	± 1.30
Expanded uncertainty U	Normal (k=2)	± 2.50	± 2.60

Sample Calculation for Measurement Accuracy in 450 kHz to 30 MHz Band:

$$u_c(y) = \sqrt{\sum_{i=1}^m u_i^2(y)} = \pm \sqrt{(1.5^2 + 1.5^2)/3 + (0.5/2)^2 + (0.05/2)^2 + 0.35^2} = \pm 1.30 \text{ dB}$$

$$U = 2u_c(y) = \pm 2.6 \text{ dB}$$

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (+ dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	<u>+1.0</u>	<u>+1.0</u>
Cable Loss Calibration	Normal (k=2)	<u>+0.3</u>	<u>+0.5</u>
EMI Receiver specification	Rectangular	<u>+1.5</u>	<u>+1.5</u>
Antenna Directivity	Rectangular	<u>+0.5</u>	<u>+0.5</u>
Antenna factor variation with height	Rectangular	<u>+2.0</u>	<u>+0.5</u>
Antenna phase center variation	Rectangular	0.0	<u>+0.2</u>
Antenna factor frequency interpolation	Rectangular	<u>+0.25</u>	<u>+0.25</u>
Measurement distance variation	Rectangular	<u>+0.6</u>	<u>+0.4</u>
Site imperfections	Rectangular	<u>+2.0</u>	<u>+2.0</u>
Mismatch: Receiver VRC $\Gamma_1 = 0.2$ Antenna VRC $\Gamma_R = 0.67(Bi) 0.3 (Lp)$ Uncertainty limits $20\log(1+\Gamma_1\Gamma_R)$	U-Shaped	+1.1 -1.25	<u>+0.5</u>
System repeatability	Std. Deviation	<u>+0.5</u>	<u>+0.5</u>
Repeatability of EUT		-	-
Combined standard uncertainty	Normal	+2.19 / -2.21	+1.74 / -1.72
Expanded uncertainty U	Normal (k=2)	+4.38 / -4.42	+3.48 / -3.44

Calculation for maximum uncertainty when 3m biconical antenna including a factor of k = 2 is used:

$$U = 2u_c(y) = 2x(+2.19) = +4.38 \text{ dB} \quad \text{And} \quad U = 2u_c(y) = 2x(-2.21) = -4.42 \text{ dB}$$