ENGINEERING TEST REPORT

XBee S2C OEM RF Module
Model No.: XBEE S2C

FCC ID: MCQ-XBS2C

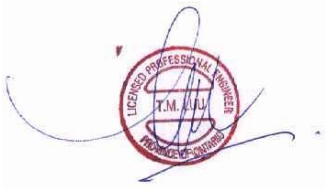
Applicant:

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 Issued Date: June 14, 2010	Tested by: Mr. Hung Trinh, EMI/RFI Technician 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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91038	1309	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:	[x] Commercial, industrial or business environment [x] 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:	• 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 calbe, 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) **Normal Test Modulation:** **Modulating Signal Source:**	 7.97 dBm (6.3 mW) Peak QPSK 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 MANUACTURER

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:

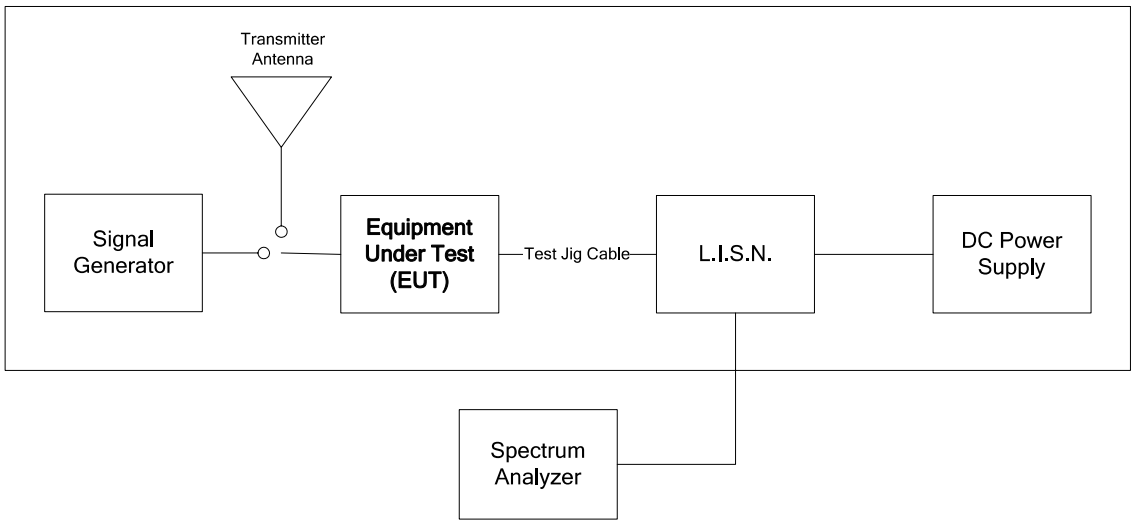
Frequency of emission (MHz)	Conducted Limits (dBμV)		Measuring Bandwidth
	Quasi-peak	Average	
0.15–0.5	66 to 56*	56 to 46*	RBW = 9 kHz
0.5–5	56	46	VBW ≥ 9 kHz for QP
5-30	60	50	VBW = 1 Hz for Average

*Decreases linearly with the logarithm of the frequency

5.5.2. Method of Measurements

ANSI C63.4

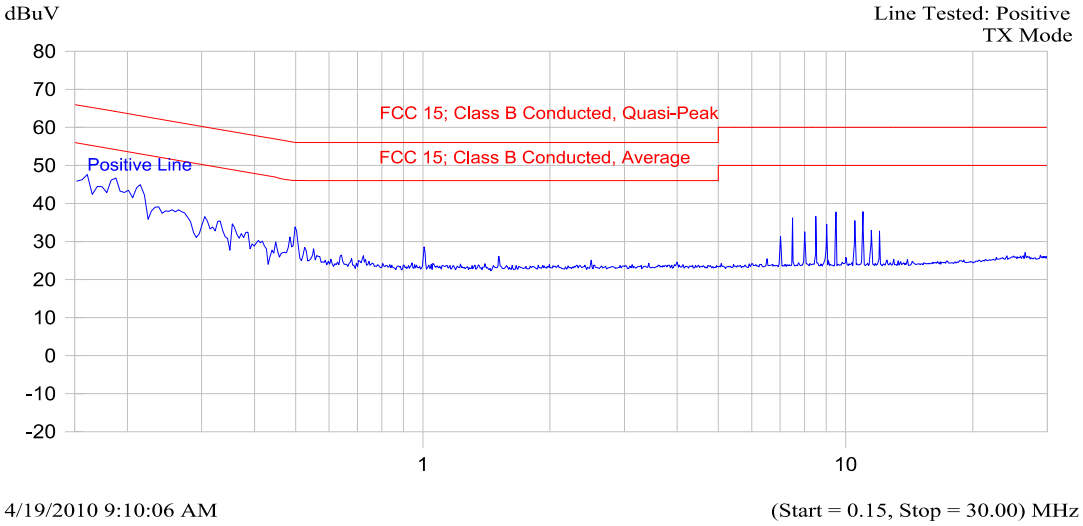
5.5.3. Test Arrangement



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

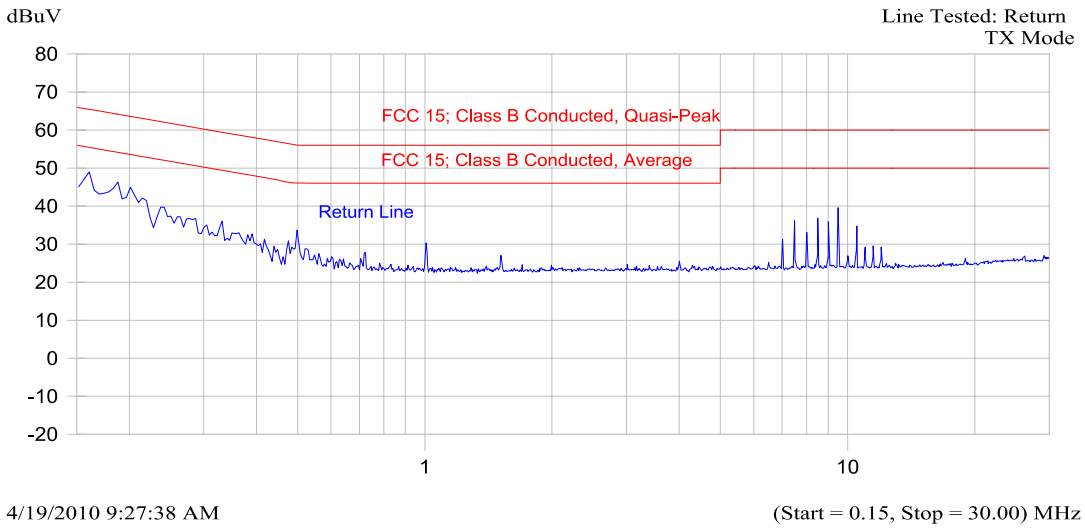


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta 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

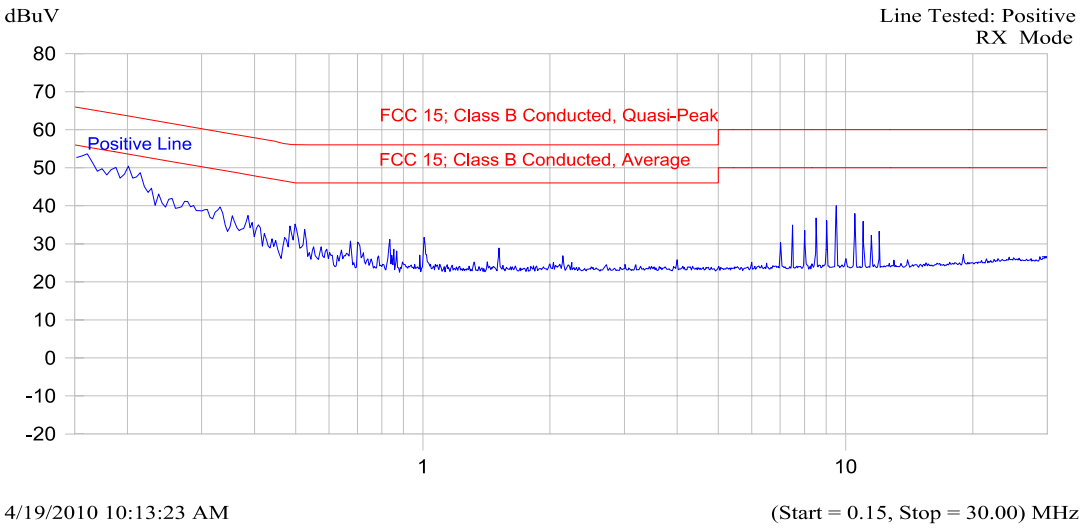


Current List

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

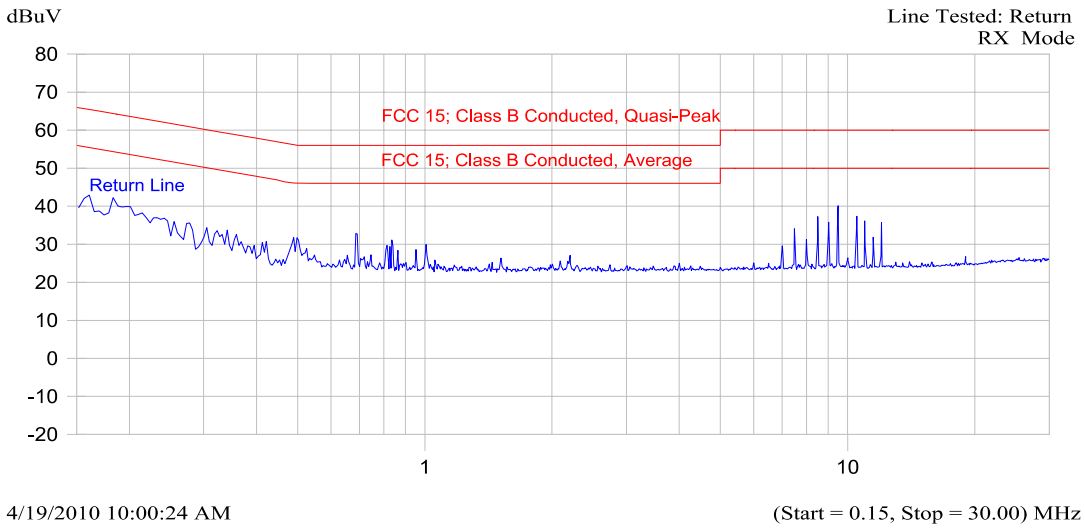


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit 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 Limit dB	Avg dBuV	Delta Avg-Avg Limit 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)]

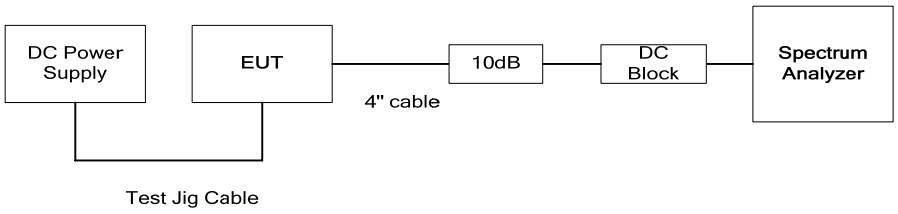
5.6.1. Limit(s)

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

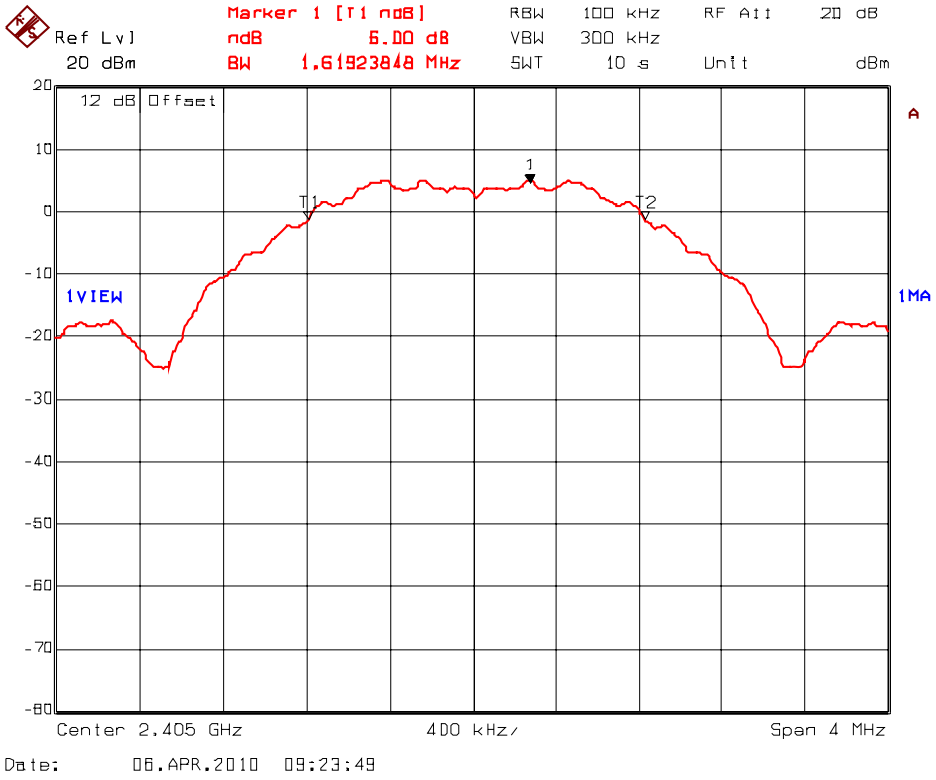


5.6.4. Test Data

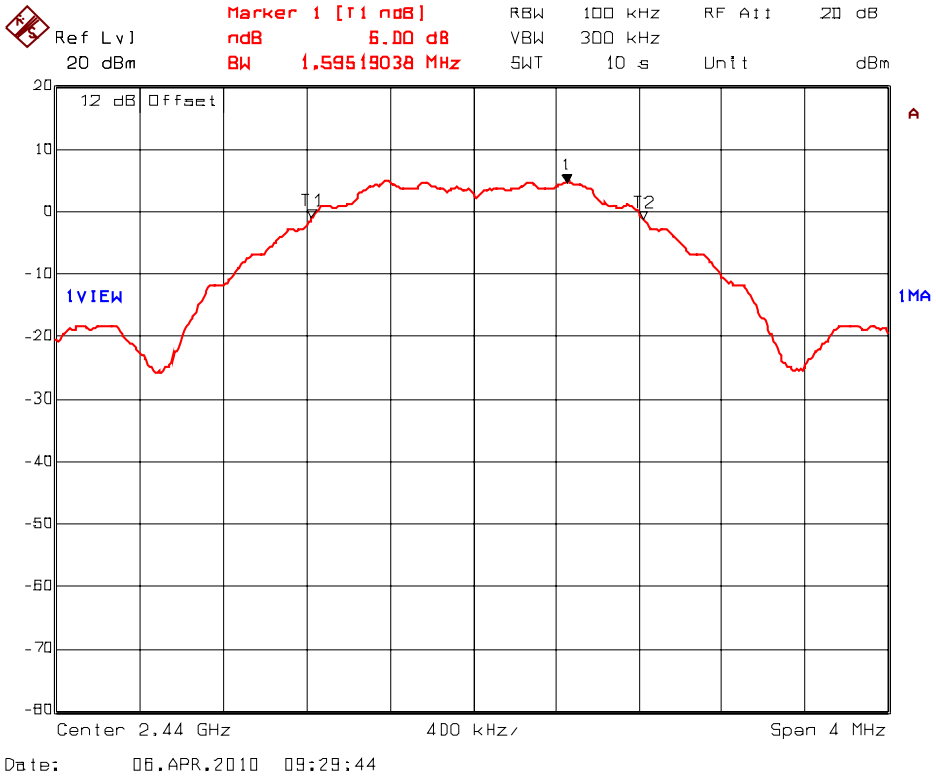
Frequency (MHz)	6 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2405	1.62	2.41
2440	1.60	2.39
2475	1.57	2.29
2480	1.61	2.39

See the following plots for detailed measurements.

Plot 5.6.4.1. 6 dB Bandwidth
Frequency: 2405 MHz

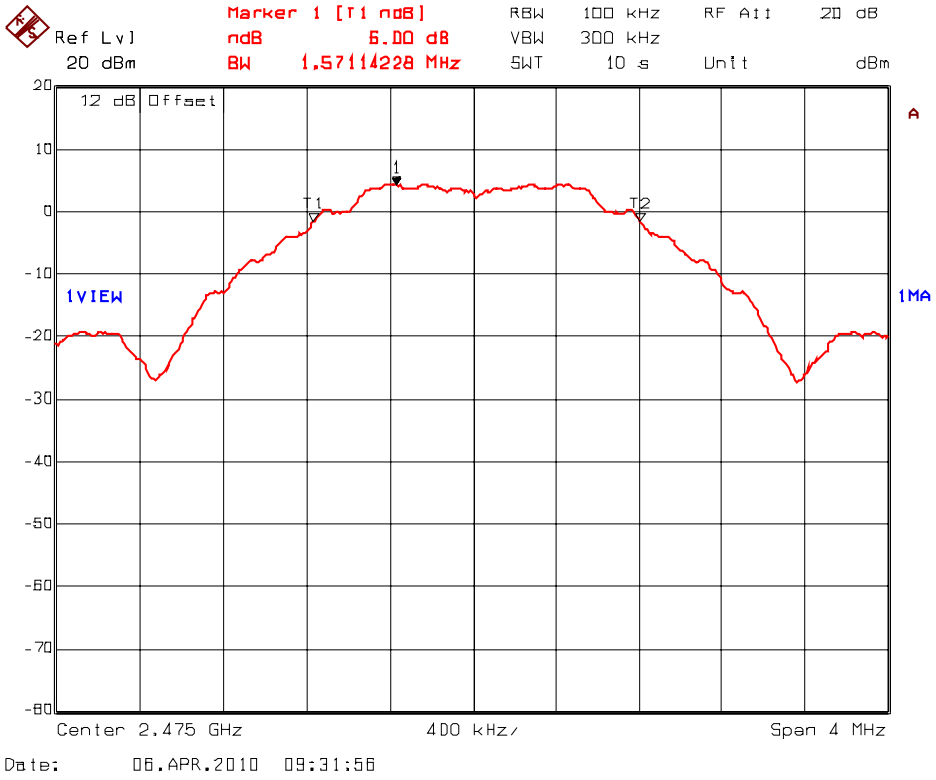


Plot 5.6.4.2. 6 dB Bandwidth
Frequency: 2440 MHz



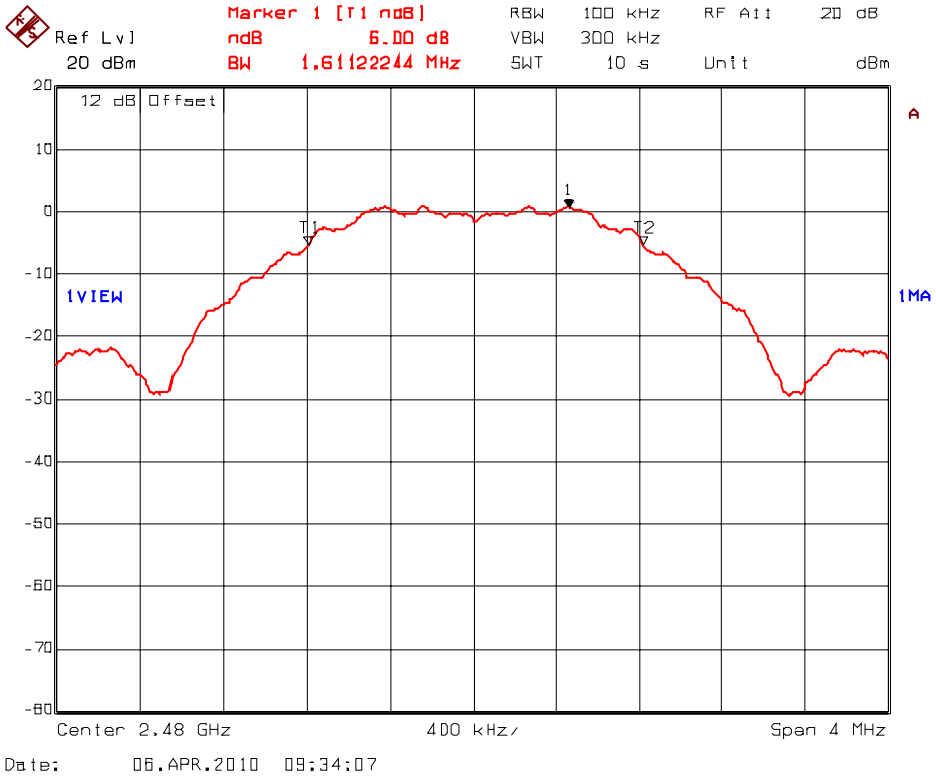
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.6.4.3. 6 dB Bandwidth
Frequency: 2475 MHz



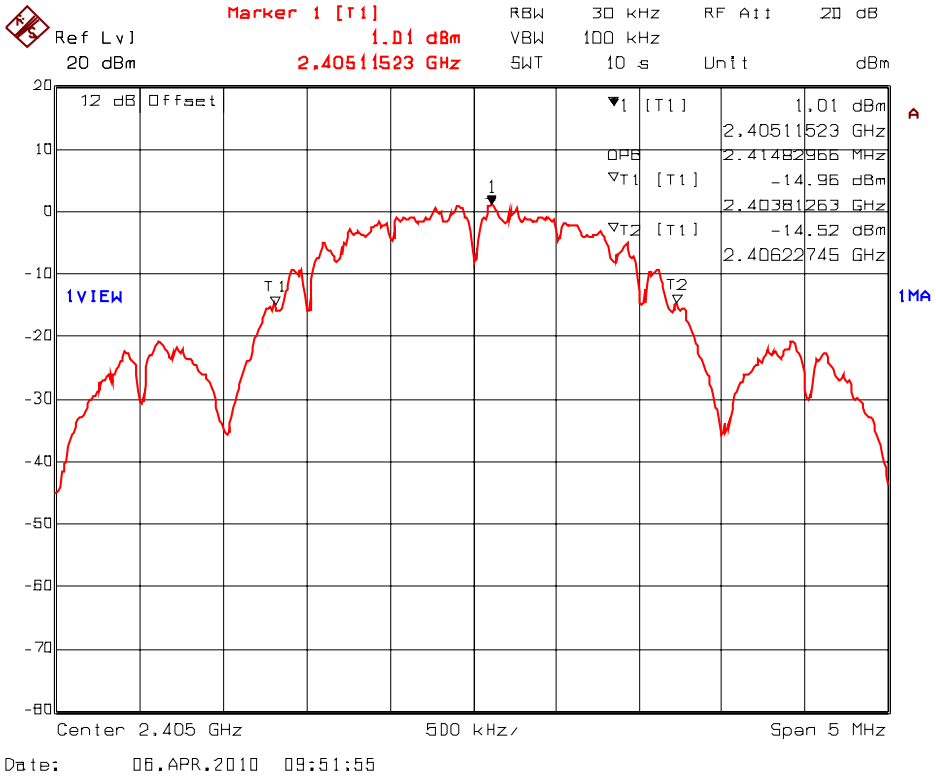
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.6.4.4. 6 dB Bandwidth
Frequency: 2480 MHz



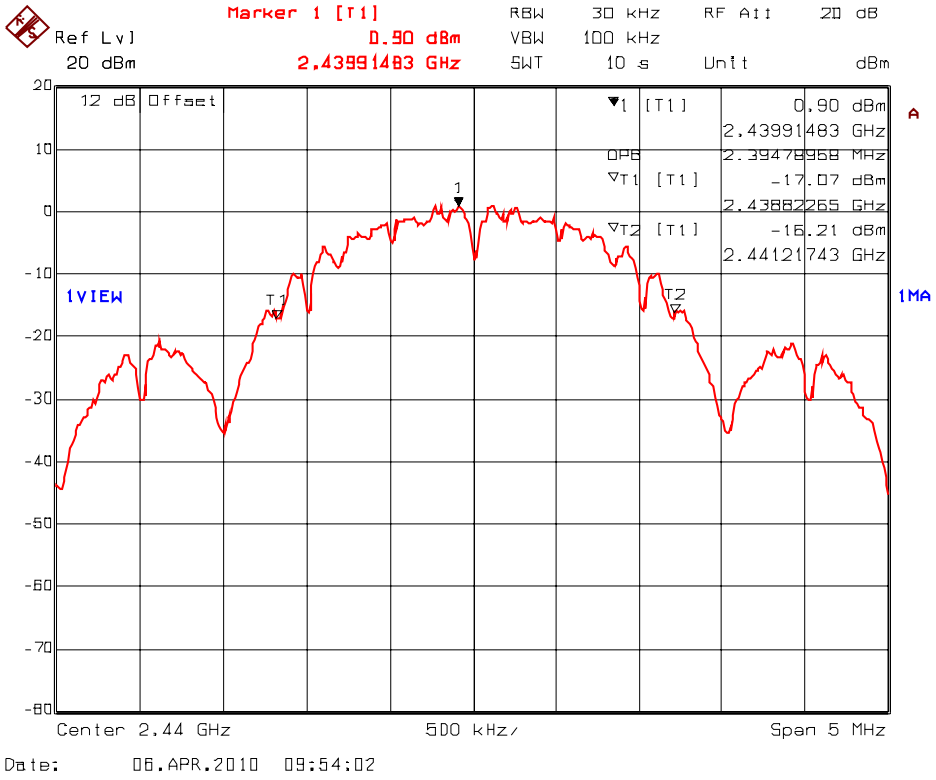
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.6.4.5. 99% Occupied Bandwidth
Frequency: 2405 MHz



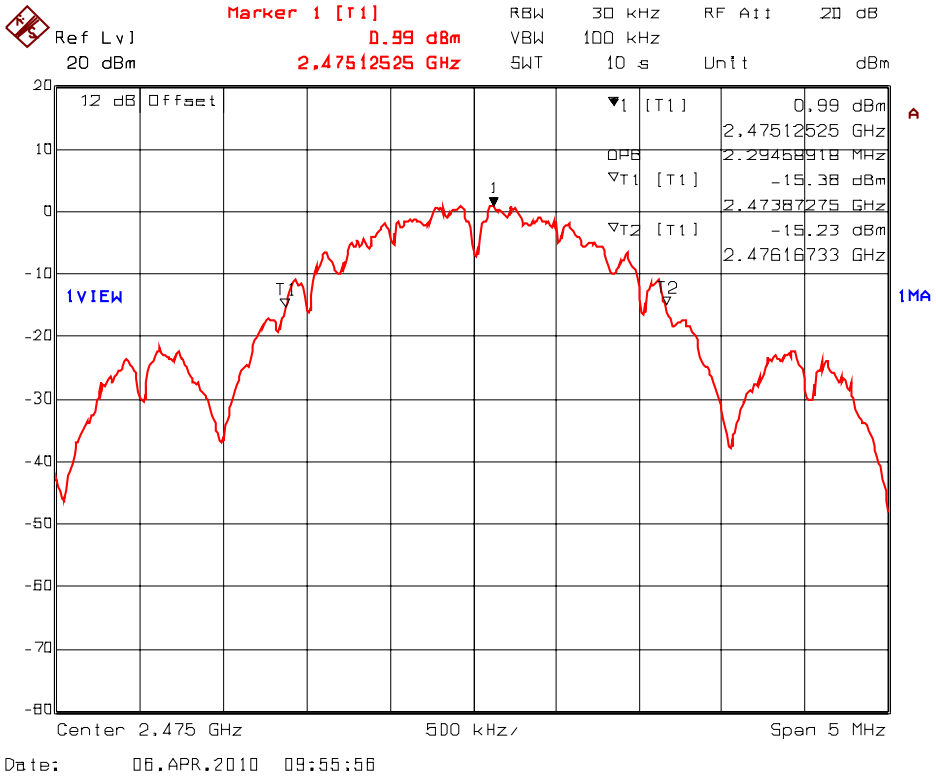
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.6.4.6. 99% Occupied Bandwidth
Frequency: 2440 MHz



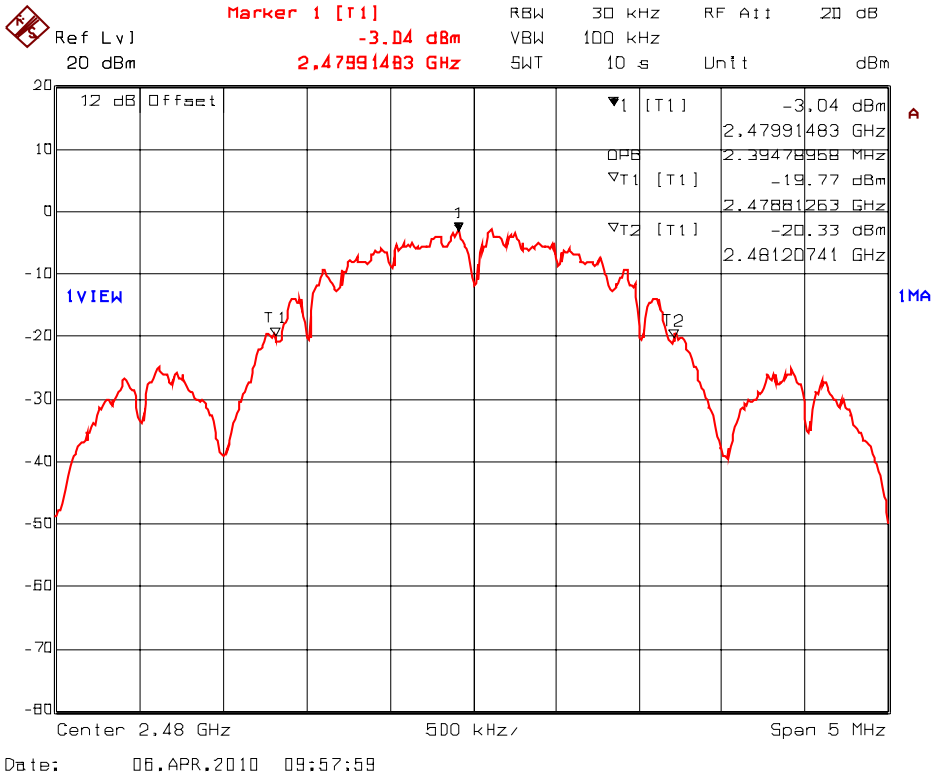
All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.6.4.7. 99% Occupied Bandwidth
Frequency: 2475 MHz



All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

Plot 5.6.4.8. 99% Occupied Bandwidth
Frequency: 2480 MHz



All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

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

5.7.1. Limit(s)

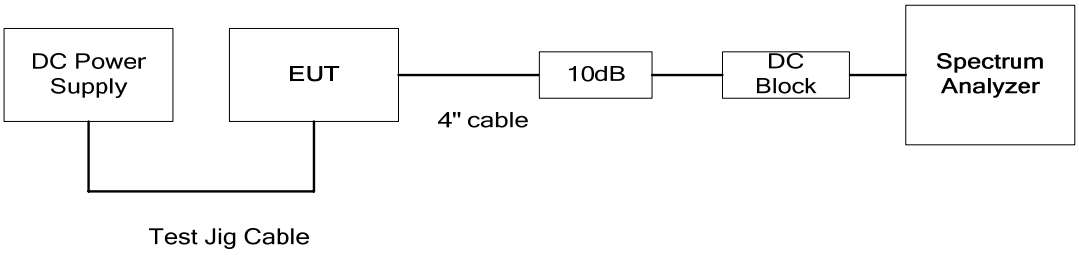
§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power 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)]

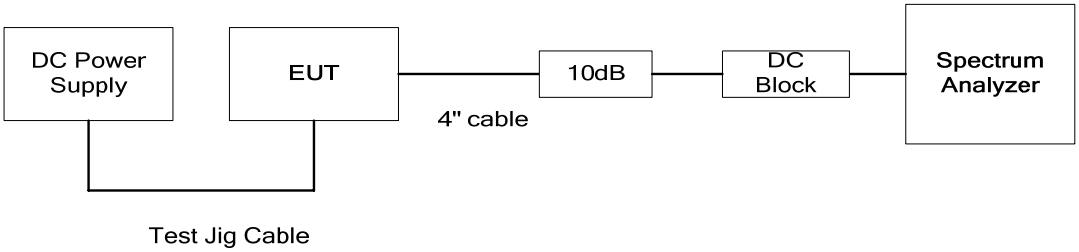
5.8.1. Limit(s)

§ 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.

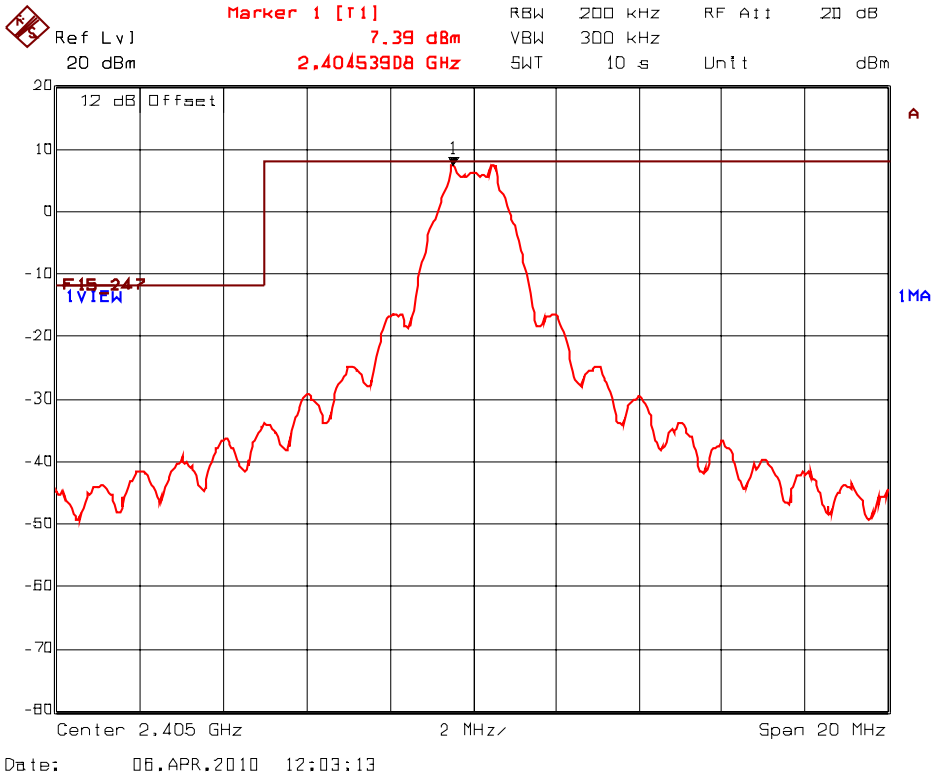
5.8.3. Test Arrangement



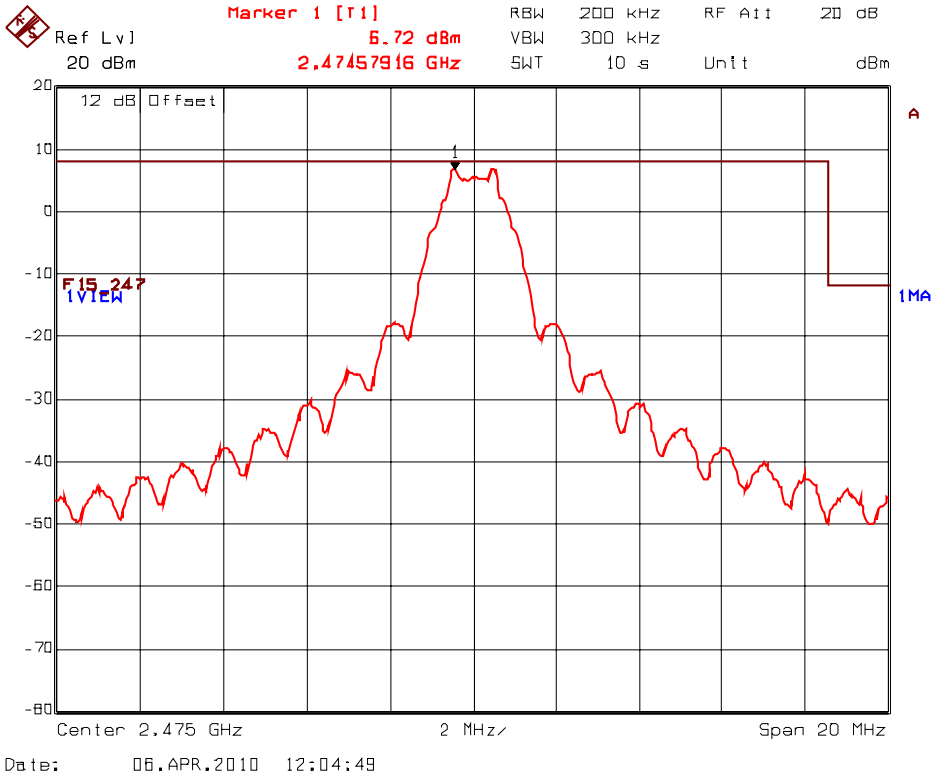
5.8.4. Test Data

5.8.4.1. Band-Edge RF Conducted Emissions

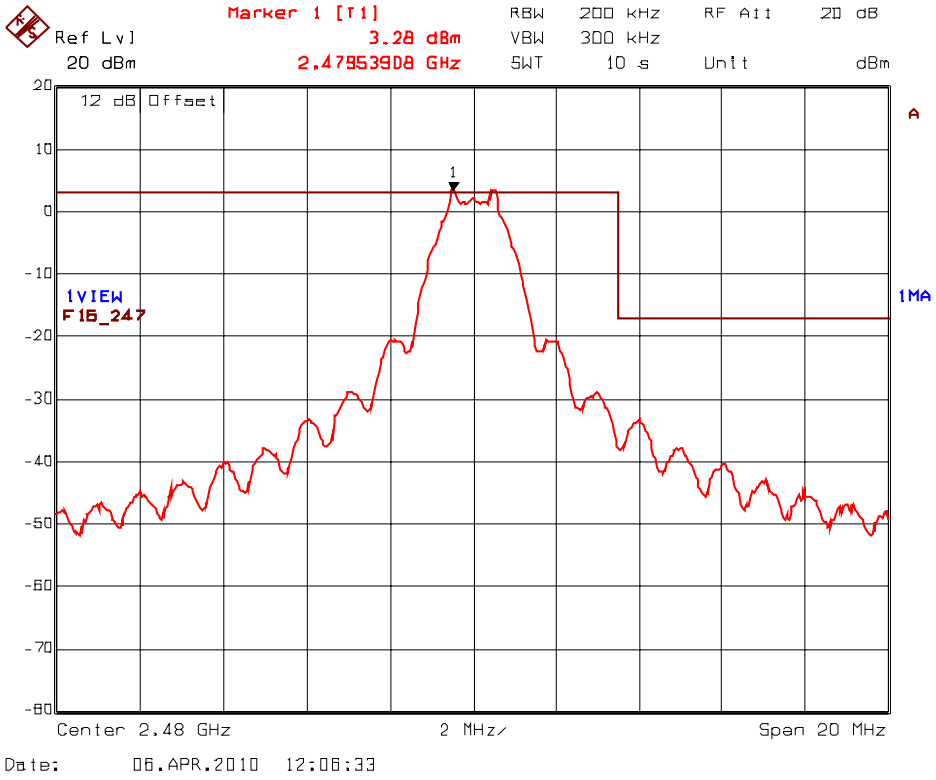
Plot 5.8.4.1.1. Band-Edge RF Conducted Emissions
Low End of Frequency Band (2405 MHz)



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

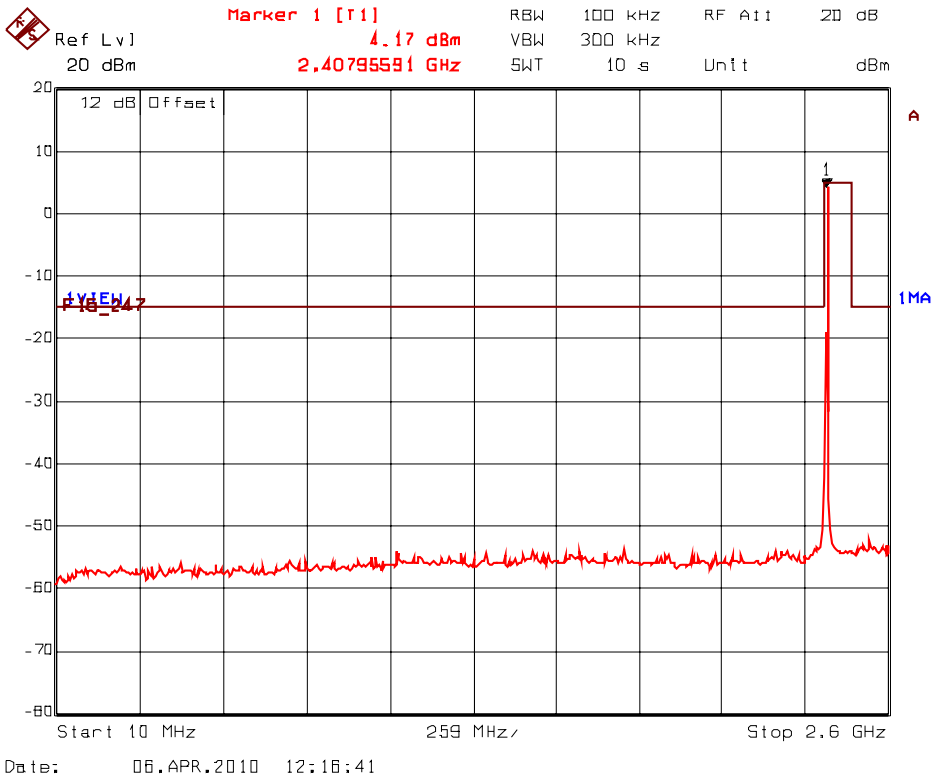


Plot 5.8.4.1.3. Band-Edge RF Conducted Emissions
High End of Frequency Band (2480 MHz, at Reduced Power Level)

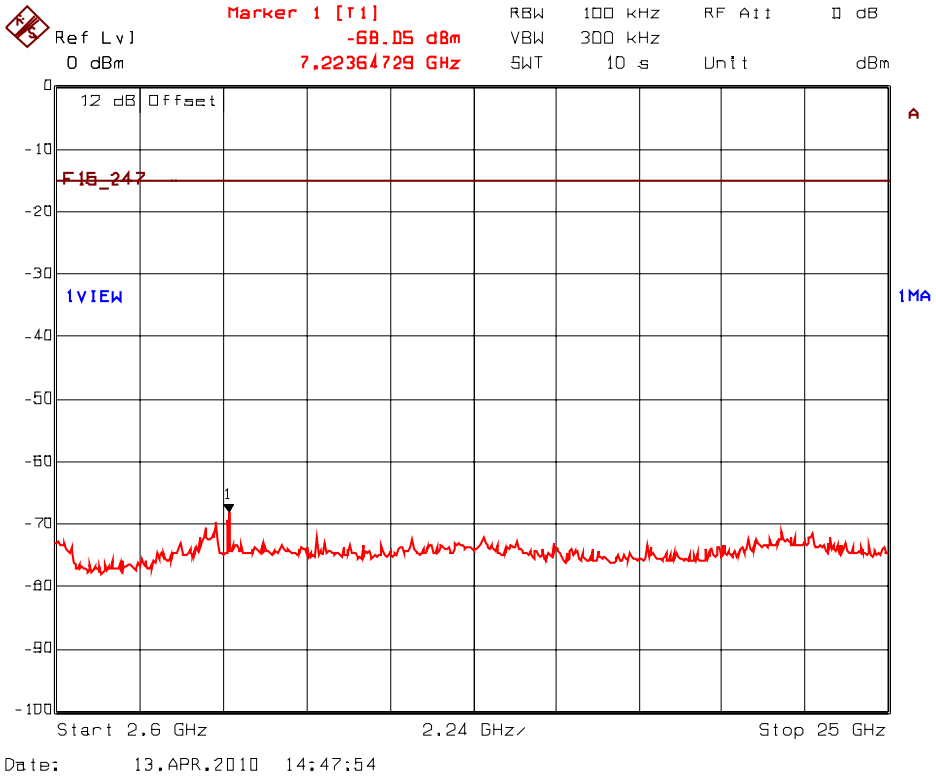


5.8.4.2. Spurious RF Conducted Emissions

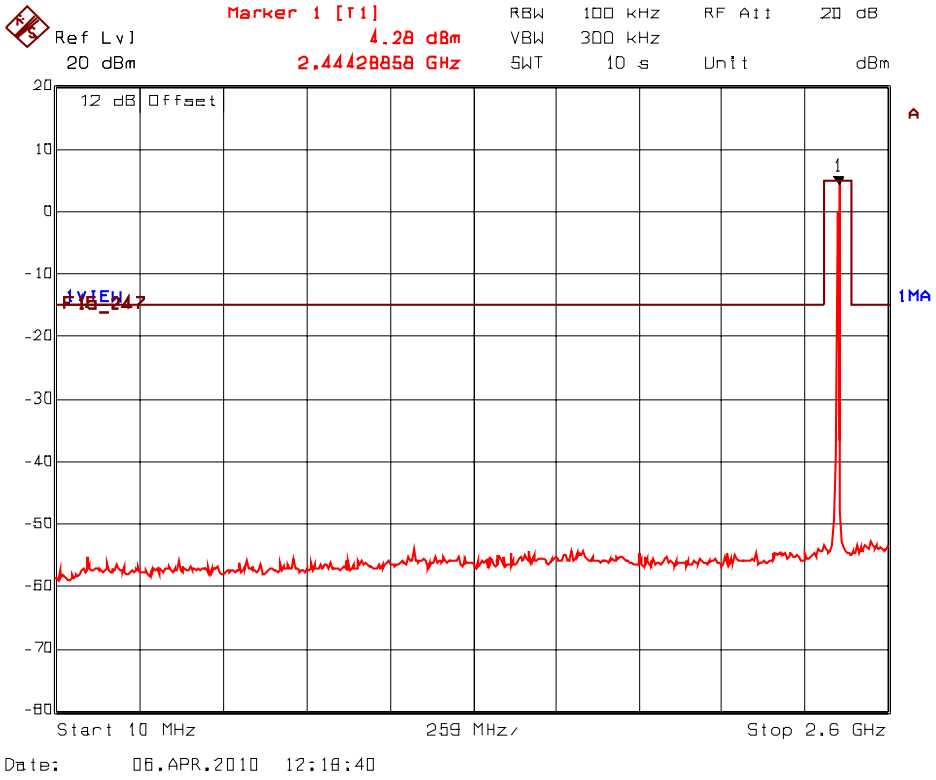
Plot 5.8.4.2.1. Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz, High Power



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



All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)