ENGINEERING TEST REPORT

Thermal Energy Controller
Model No.: TEC-001, TEC-002

FCC ID: VFC070501

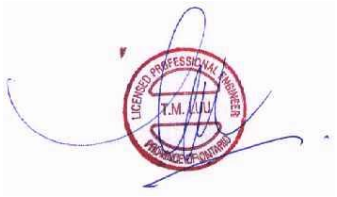
Applicant:

Etratech Inc.
1047 Cooke Boulevard
Burlington, Ontario
CANADA L7T 4A8

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.: ETR-050F15C247

This Test report is Issued under the Authority of Tri M. Luu, Professional Engineer, Vice President of Engineering UltraTech Group of Labs Date: May 14, 2008	
Report Prepared by: Santhosh Fernandez Issued Date: May 14, 2008	Tested by: Mr. Hung Trinh, EMI/RFI Technician Test Dates: April 18 to May 12, 2008

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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EXHIBIT 1. SUBMITTAL CHECK LIST

Annex No.	Exhibit Type	Description of Contents	Quality Check (OK)
--	Test Report	▪ Exhibit 1: Submittal check lists ▪ Exhibit 2: Introduction ▪ Exhibit 3: Performance Assessment ▪ Exhibit 4: EUT Operation and Configuration during Tests ▪ Exhibit 5: Summary of test Results ▪ Exhibit 6: Measurement Data ▪ Exhibit 7: Measurement Uncertainty	OK
1	Test Setup Photos	▪ Power Line Conducted Emissions Setup Photos ▪ Radiated Emissions Setup Photos	OK
2	External EUT Photos	External EUT Photos	OK
3	Internal EUT Photos	Internal EUT Photos	OK
4	Cover Letters	▪ Letter from Ultratech for Certification Request ▪ Letter from the Applicant to appoint Ultratech to act as an agent ▪ Letter from the Applicant to request for Confidentiality Filing	OK
5	Attestation Statements	--	--
6	ID Label/Location Info	ID Label and Location of Label	OK
7	Block Diagrams	Block Diagram	OK
8	Schematic Diagrams	Schematics	OK
9	Parts List/Tune Up Info	Parts List	OK
10	Operational Description	Operation Description	OK
11	RF Exposure Info	MPE Evaluation	OK
12	Users Manual	EnerWorks Solar Thermal Water Heating Appliances Thermal Energy Controller and thermal Energy Monitor Owner Manual	OK

EXHIBIT 2. INTRODUCTION

2.1. 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:	Both conducted and radiated emissions measurements were conducted in accordance with American National Standards Institute ANSI C63.4 - American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.
Environmental Classification:	[x] Commercial, industrial or business environment [x] Residential environment

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

None.

2.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2007	Code of Federal Regulations – Telecommunication
ANSI C63.4	2003	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
CISPR 22 & EN 55022	2006 2006	Information Technology Equipment - Radio Disturbance Characteristics – Limits and Methods of Measurement
CISPR 16-1-1	2003	Specification for radio disturbance and immunity measuring apparatus and methods. Part 1-1: Measuring Apparatus
CISPR 16-2-1	2003	Specification for radio disturbance and immunity measuring apparatus and methods. Part 2-1: Conducted disturbance measurement
KDB Publication No. 558074	2005	Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

EXHIBIT 3. PERFORMANCE ASSESSMENT

3.1. CLIENT INFORMATION

APPLICANT	
Name:	Etratech Inc.
Address:	1047 Cooke Boulevard Burlington, Ontario CANADA L7T 4A8
Contact Person:	John Bielby Phone #: (905) 681 7544 (ext 247) Fax #: (905) 681 7601 Email Address: jbielby@etratech.com

MANUFACTURER	
Name:	Etratech Inc.
Address:	1047 Cooke Boulevard Burlington, Ontario CANADA L7T 4A8
Contact Person:	John Bielby Phone #: (905) 681 7544 (ext 247) Fax #: (905) 681 7601 Email Address: jbielby@etratech.com

3.2. EQUIPMENT UNDER TEST (EUT) INFORMATION

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

Brand Name:	EnerWorks
Product Name:	Thermal Energy Controller
Model Name or Number*:	TEC-001,TEC-002
Serial Number:	Test Sample
Type of Equipment:	Digital Modulation Transmitter
Input Power Supply Type:	AC version (TEC-001):120VAC with transformer to 10VAC, 500mA DC Version (TEC-002):12VDC with 120VAC adaptor
Primary User Functions of EUT:	Control unit for a solar hot water heating system

* Note: Model: TEC-001 is the AC Version and TEC-002 is the DC Version

3.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	Mobile
Intended Operating Environment:	Residential Commercial, industrial or business
Power Supply Requirement:	AC version (TEC-001):120VAC with transformer to 10VAC, 500mA DC Version (TEC-002):12VDC with 120VAC adaptor
RF Output Power Rating:	2.3 mW (+3.56 dBm) Peak
Operating Frequency Range:	2405 – 2480 MHz
RF Output Impedance:	50 ohms
Channel Spacing:	5 MHz
Duty Cycle:	Tested continuous
6 dB bandwidth:	1.6 MHz
Modulation Type:	Offset-Quadrature Phase shift Keying
Oscillator Frequencies:	16 MHz
Antenna Description:	Manufacturer: Etratech Inc. Type: Integral Frequency Range: 2.400 GHz to 2.4835 GHz Gain (dBi): 0dBi
Antenna Connector Type:	No connector – on-board printed wire

3.4. LIST OF EUT'S PORTS

Port Number	EUT's Port Description	Number of Identical Ports	Connector Type	Cable Type (Shielded/Non-shielded)
1	(A) AC power out AC Heater	1	5 pin connector Header	**Non-shielded**
2	(B) DC/AC Input DC Pump, Solar PV	1	12 pin connector Header	**Non-shielded**
3	(C) Flow Sensor	1	8 pin connector Header	**Non-shielded**
4	(D) Thermistors	1	10 pin connector Header	**Non-shielded**
5	(E) Solar Sensor	1	3 pin connector Header	**Non-shielded**
6	(F) RF-MAC	1	5 pin connector Header	**Non-shielded**

3.5. 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:	Transformer (120VAC to 10V AC, 0.5A)
Brand name:	BA2DA
Connected to EUT's Port:	AC Input

Ancillary Equipment # 2	
Description:	AC Adaptor
Brand name:	MODE
Model Name or Number:	DV-1250
Part Number:	68-125-1
Connected to EUT's Port:	DC Input

EXHIBIT 4. EUT OPERATING CONDITIONS AND CONFIGURATIONS DURING TESTS

4.1. CLIMATE TEST CONDITIONS

The climate conditions of the test environment are as follows:

Temperature:	21°C
Humidity:	51%
Pressure:	102 kPa
Power input source:	AC version:120VAC with transformer to 10VAC, 500mA DC Version:12VDC with 120VAC adaptor

4.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements.
Special Test Software:	Software provided by the Applicant to operate the EUT at each channel frequency continuously.
Special Hardware Used:	None
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as integral antenna equipment.

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 MHz, 2440 MHz and 2480 MHz
RF Power Output: (measured maximum output power at antenna terminals)	3.56 dBm (2.3 mW) Peak
Normal Test Modulation:	Offset-Quadrature Phase shift Keying
Modulating Signal Source:	Internal

EXHIBIT 5. SUMMARY OF TEST RESULTS

5.1. 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 17, 2009).

5.2. APPLICABILITY & SUMMARY OF EMC EMISSION TEST RESULTS

FCC Section(s)	Test Requirements	Compliance (Yes/No)
15.203	Antenna requirements	Yes
15.207(a)	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.		

Note: This report pertains to two different versions of the EUT namely AC version and DC version. To determine the test plan for the worst configuration, preliminary tests were conducted and it was seen the results for the DC version were no different from the AC version. Hence, unless stated otherwise, the test data in this report are the results obtained on the AC version.

5.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

EXHIBIT 6. MEASUREMENTS, EXAMINATIONS & TEST DATA FOR EMC EMISSIONS

6.1. TEST PROCEDURES

This section contains test results only. Details of test methods and procedures can be found in ANSI C63.4; FCC KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems.

6.2. 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.

6.3. 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.

6.4. ESSENTIAL/PRIMARY FUNCTIONS AS DECLARED BY THE MANUACTURER

The Thermal Energy Controller (TEC) is a control unit for a solar hot water heating system. The TEC measures temperatures at several locations of the heating system and controls the circulation pump which transfers the hot fluid from the solar collector panel to the heat exchanger. The heat exchanger transfers the heat from the circulation fluid into the domestic hot water tank. The TEC also performs calculations and displays savings information (money, energy, carbon dioxide etc.) to the user. Using wireless transmission, the TEC sends information to the Thermal Energy Monitor.

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

6.5.1. Limit(s)

The equipment shall meet the limits of the following table:

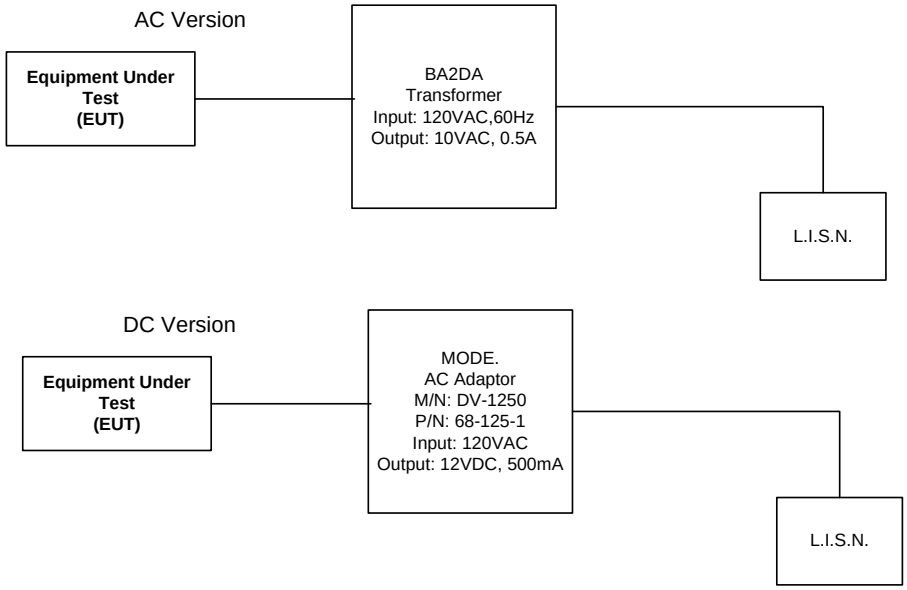
Frequency of emission (MHz)	Conducted Limits (dBμV)		Measuring Bandwidth
	Quasi-peak	Average	
0.15–0.5 .....…….. 0.5–5 .....…….. 5-30 ……..……..	66 to 56* ..... 56 ..... 60 ..……..	56 to 46* 46 50	RBW = 9 kHz VBW ≥ 9 kHz for QP VBW = 1 Hz for Average

*Decreases linearly with the logarithm of the frequency

6.5.2. Method of Measurements

ANSI C63.4

6.5.3. Test Arrangement



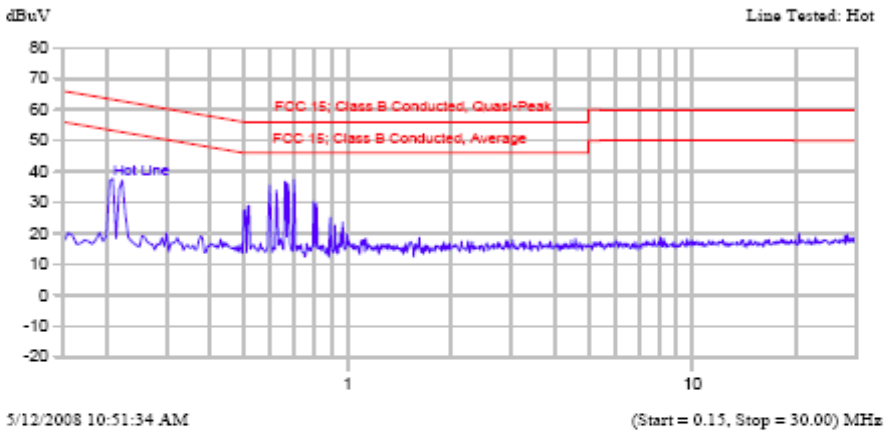
6.5.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency 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 μH
24'(L) x 16'(W) x 8'(H) RF Shielded Chamber	Braden Shielding	…	…	…

6.5.5. Test Data

Plot 6.5.5.1 Power Line Conducted Emissions (AC Version)
Line Voltage: 120 VAC 60 Hz
Line Tested: Hot

Current Graph

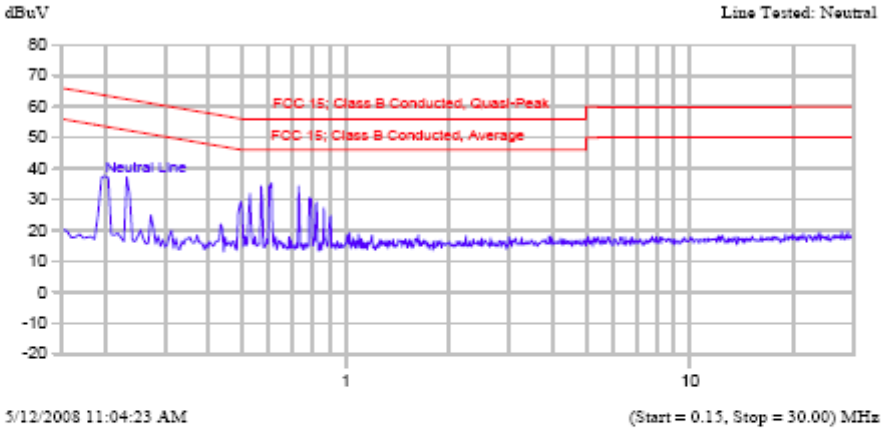


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.200	37.3	31.5	-33.1	10.0	-44.5	Hot Line
0.214	37.8	31.6	-32.6	10.1	-44.0	Hot Line
0.518	30.7	23.7	-32.3	5.2	-40.8	Hot Line
0.592	34.5	28.1	-27.9	7.2	-38.8	Hot Line
0.662	36.5	30.2	-25.8	6.4	-39.6	Hot Line
0.677	36.6	30.3	-25.7	7.3	-38.7	Hot Line
0.691	36.6	30.2	-25.8	6.2	-39.8	Hot Line
0.786	31.4	25.2	-30.8	5.0	-41.0	Hot Line

Plot 6.5.5.2 Power Line Conducted Emissions(AC Version)
Line Voltage: 120 VAC 60 Hz
Line Tested: Neutral

Current Graph

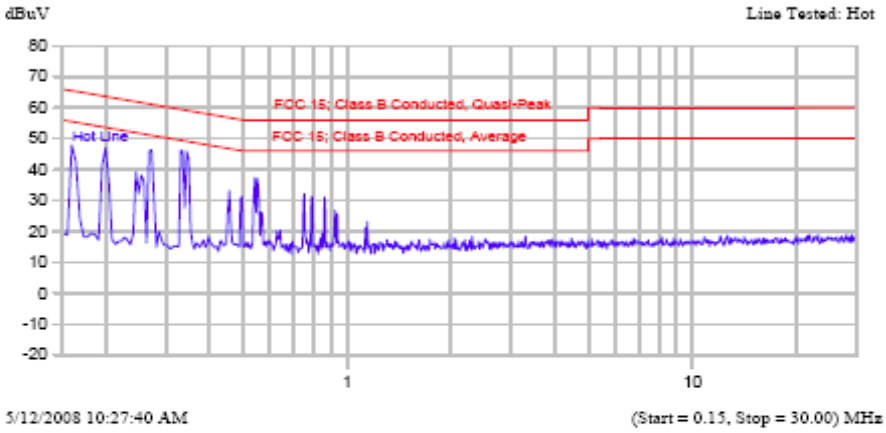


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.202	37.7	31.7	-32.8	10.0	-44.5	Neutral Line
0.222	37.8	31.3	-32.6	9.2	-44.7	Neutral Line
0.530	31.9	25.3	-30.7	5.4	-40.6	Neutral Line
0.571	33.8	27.6	-28.4	5.9	-40.1	Neutral Line
0.612	35.6	29.4	-26.6	6.2	-39.8	Neutral Line
0.722	35.0	29.6	-26.4	6.2	-39.8	Neutral Line
0.783	32.0	25.2	-30.8	4.8	-41.2	Neutral Line

Plot 6.5.5.3 Power Line Conducted Emissions (DC Version)
12VDC Using AC adaptor
Line Voltage: 120 VAC 60 Hz
Line Tested: Hot

Current Graph

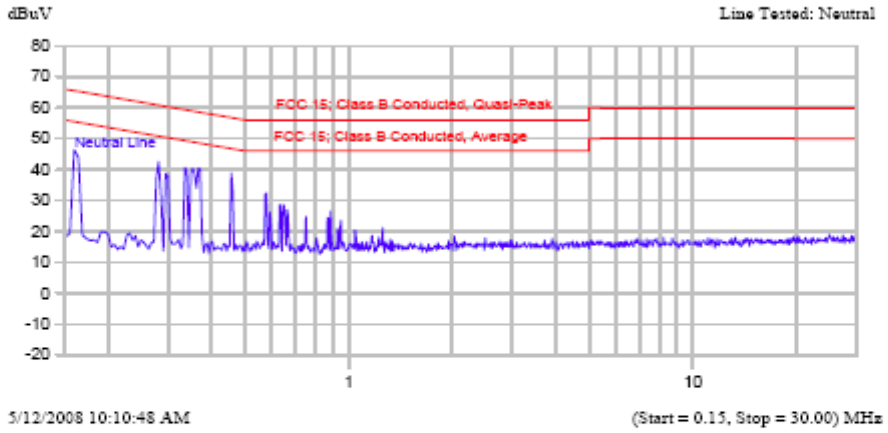


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.191	46.7	39.2	-25.6	12.6	-42.2	Hot Line
0.235	46.6	38.8	-24.8	12.6	-40.9	Hot Line
0.260	46.5	38.6	-24.2	10.0	-42.8	Hot Line
0.332	46.0	38.2	-22.5	9.1	-41.7	Hot Line
0.343	46.1	38.2	-22.2	8.9	-41.5	Hot Line
0.533	37.4	29.5	-26.5	6.0	-40.0	Hot Line

Plot 6.5.5.4 Power Line Conducted Emissions (DC Version)
12VDC Using AC adaptor
Line Voltage: 120 VAC 60 Hz
Line Tested: Neutral

Current Graph



Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.281	42.9	35.5	-26.7	9.5	-42.7	Neutral Line
0.286	42.2	35.3	-26.7	9.4	-42.6	Neutral Line
0.326	41.0	34.2	-26.7	8.7	-42.2	Neutral Line
0.344	40.7	34.1	-26.3	8.7	-41.7	Neutral Line
0.355	40.6	34.2	-25.9	8.7	-41.4	Neutral Line
0.455	38.8	31.5	-25.8	7.1	-40.2	Neutral Line

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

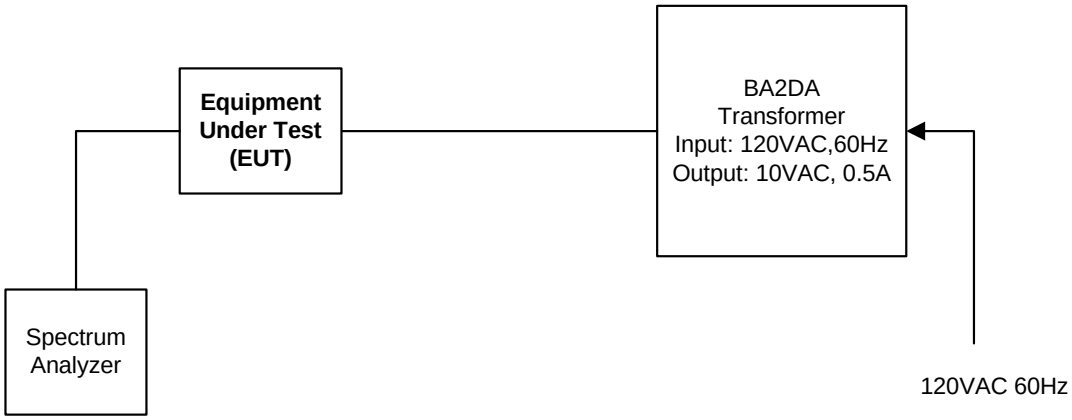
6.6.1. Limit(s)

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

6.6.2. Method of Measurements

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

6.6.3. Test Arrangement



6.6.4. Test Equipment List

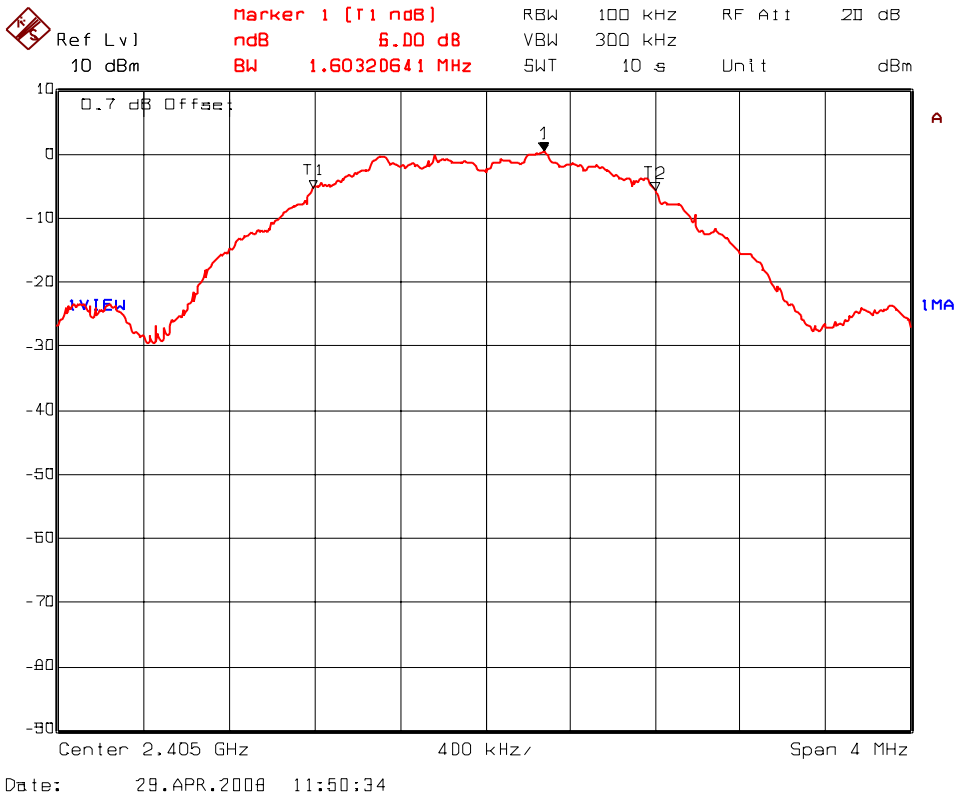
Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Rhode & Schwarz	FSEK 30	100077	20 Hz - 40 GHz

6.6.5. Test Data

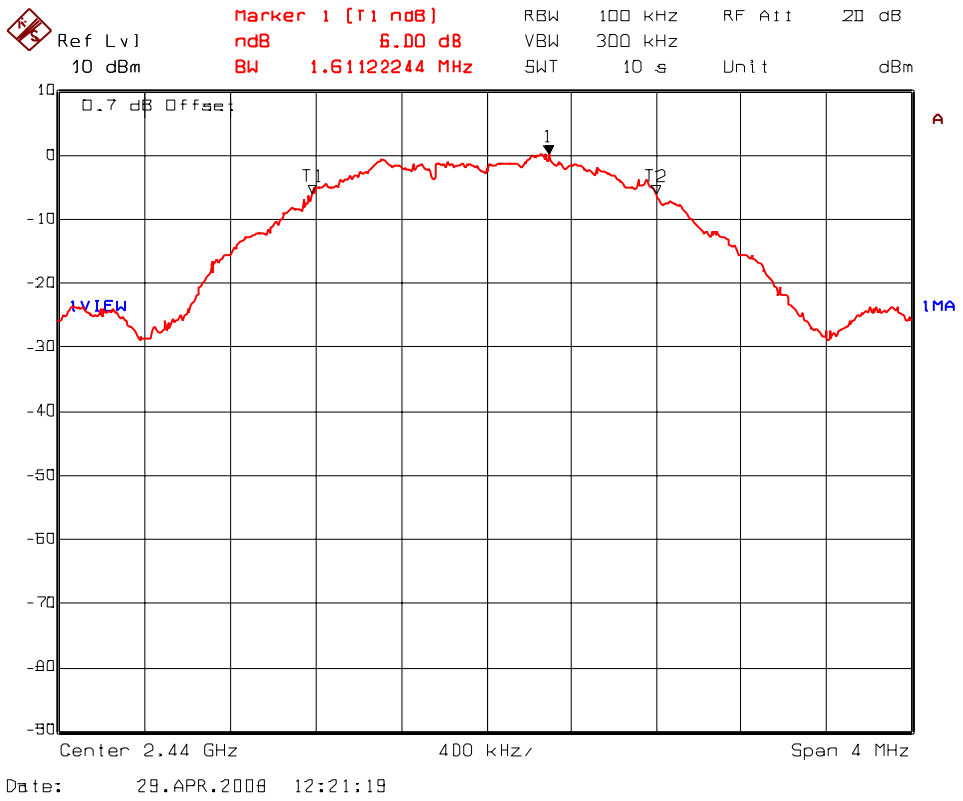
Frequency (MHz)	6 dB Bandwidth (MHz)
2405	1.603
2440	1.611
2480	1.603

See the following plots for detailed measurements.

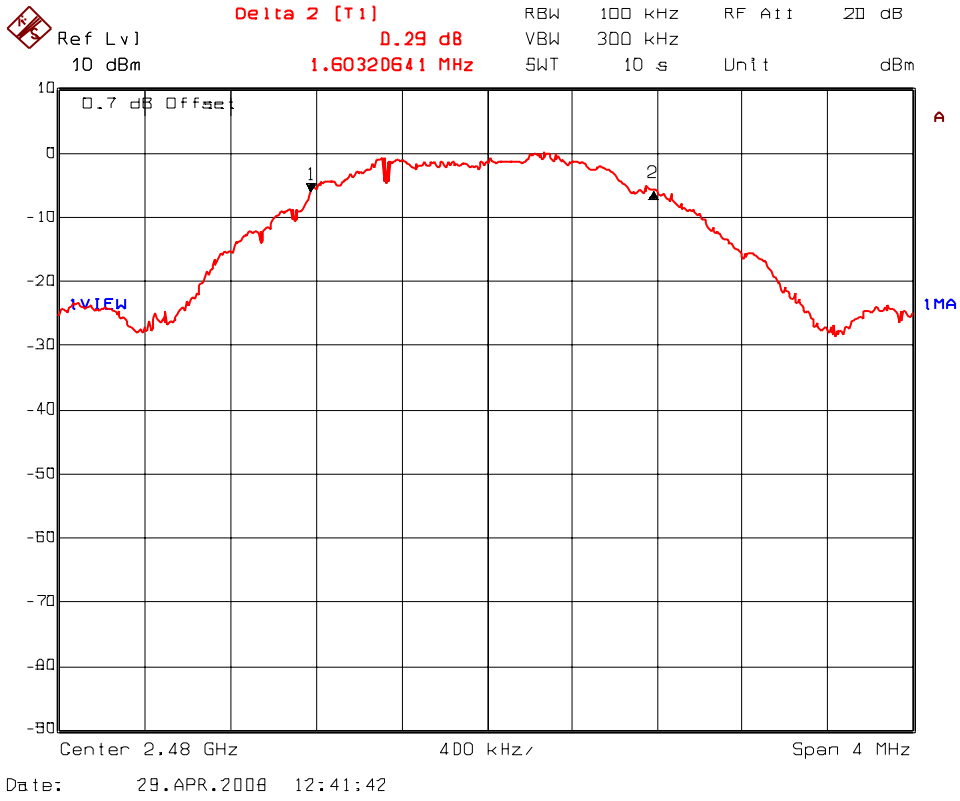
Plot 6.6.5.1 6 dB Bandwidth
Frequency: 2405 MHz



Plot 6.6.5.2 6 dB Bandwidth
Frequency: 2440 MHz



Plot 6.6.5.3 6 dB Bandwidth
Frequency: 2480 MHz



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

6.7.1. Limit(s)

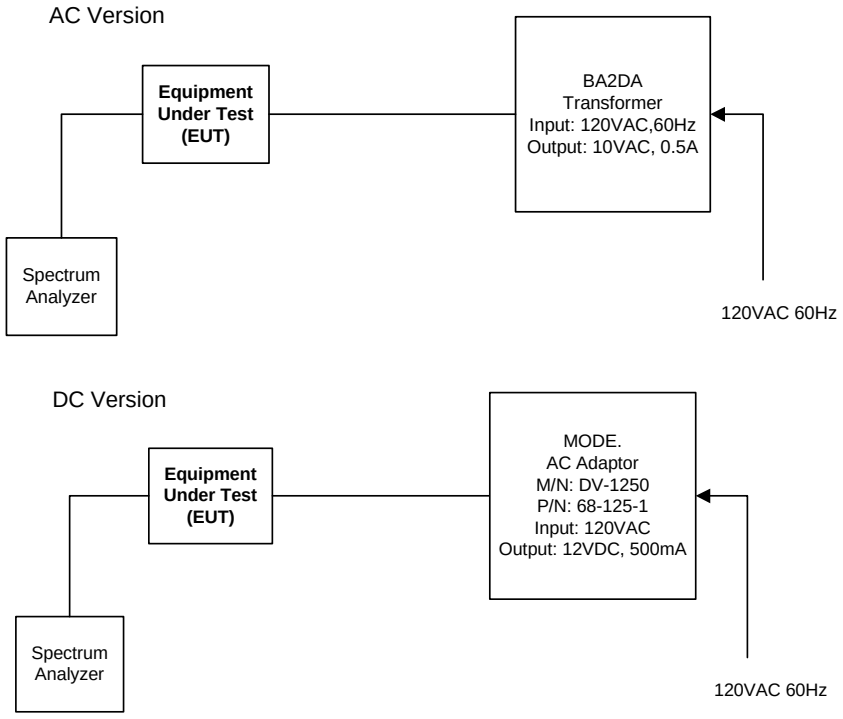
§ 15.247(b)(3): For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power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

6.7.2. Method of Measurements & Test Arrangement

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

6.7.3. Test Arrangement



6.7.4. Test Equipment List

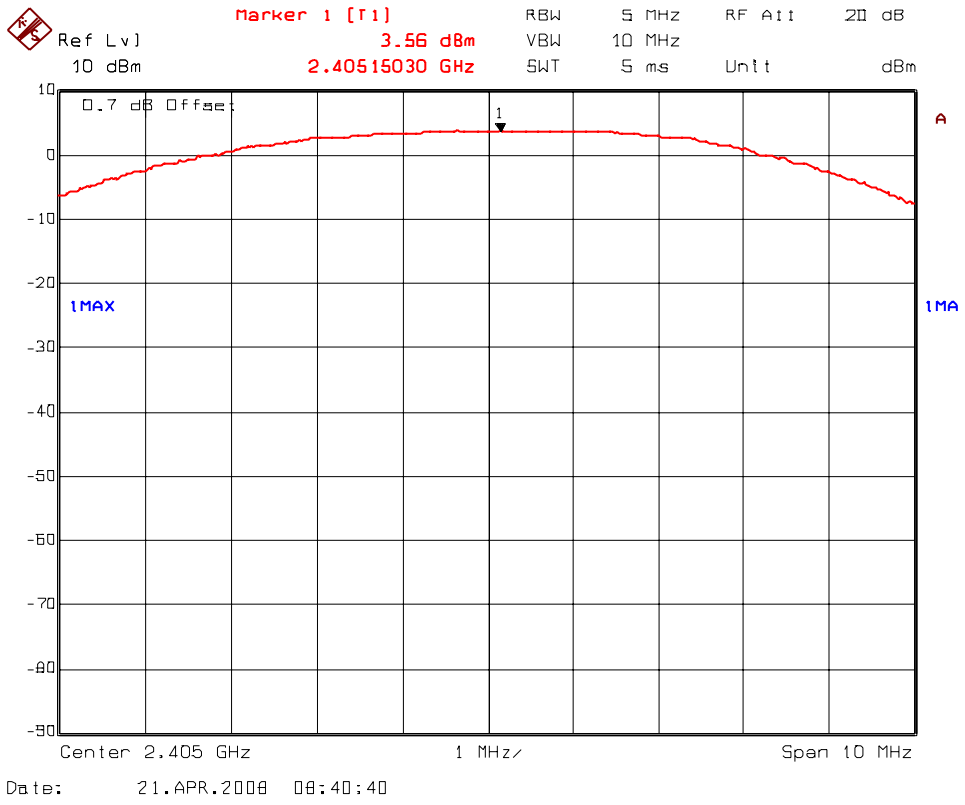
Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Rhode & Schwarz	FSEK 30	100077	20 Hz - 40 GHz

6.7.5. Test Data

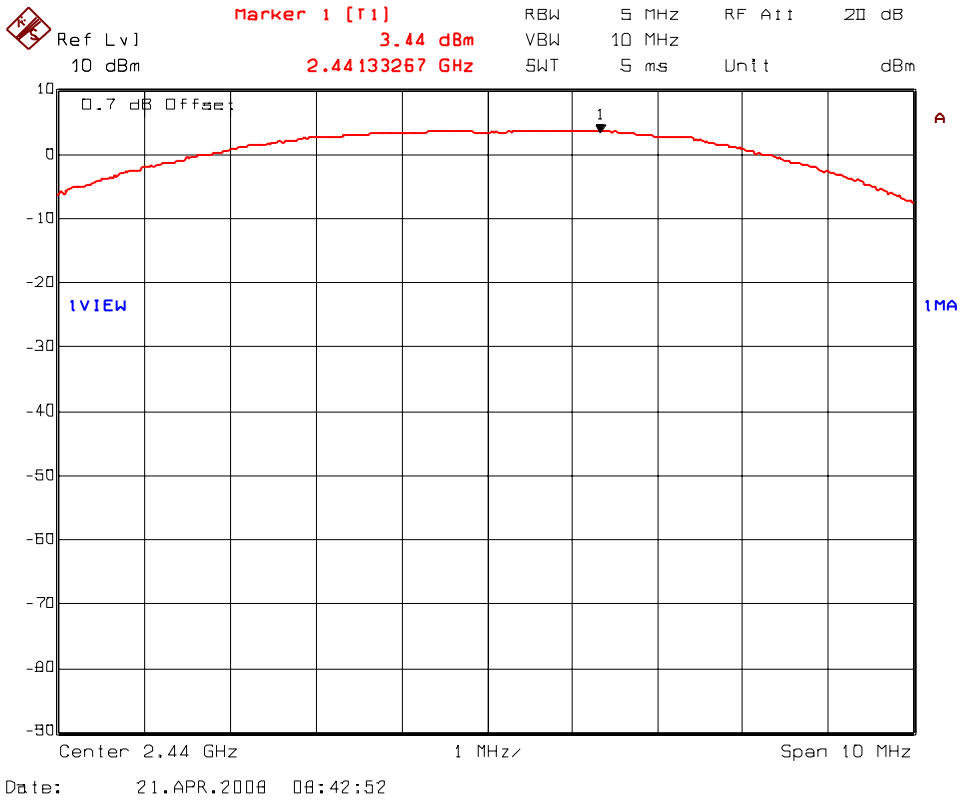
Frequency (MHz)	Peak Conducted Power (dBm)		Peak EIRP(Note 1, 2) (dBm)		Peak Conducted Power Limit (dBm)	EIRP Limit (dBm)
	AC version	DC Version	AC version	DC Version		
2405	3.56	3.44	3.56	3.44	30	36
2440	3.44	3.31	3.44	3.31	30	36
2480	3.44	3.44	3.44	3.44	30	36

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 0 dBi.

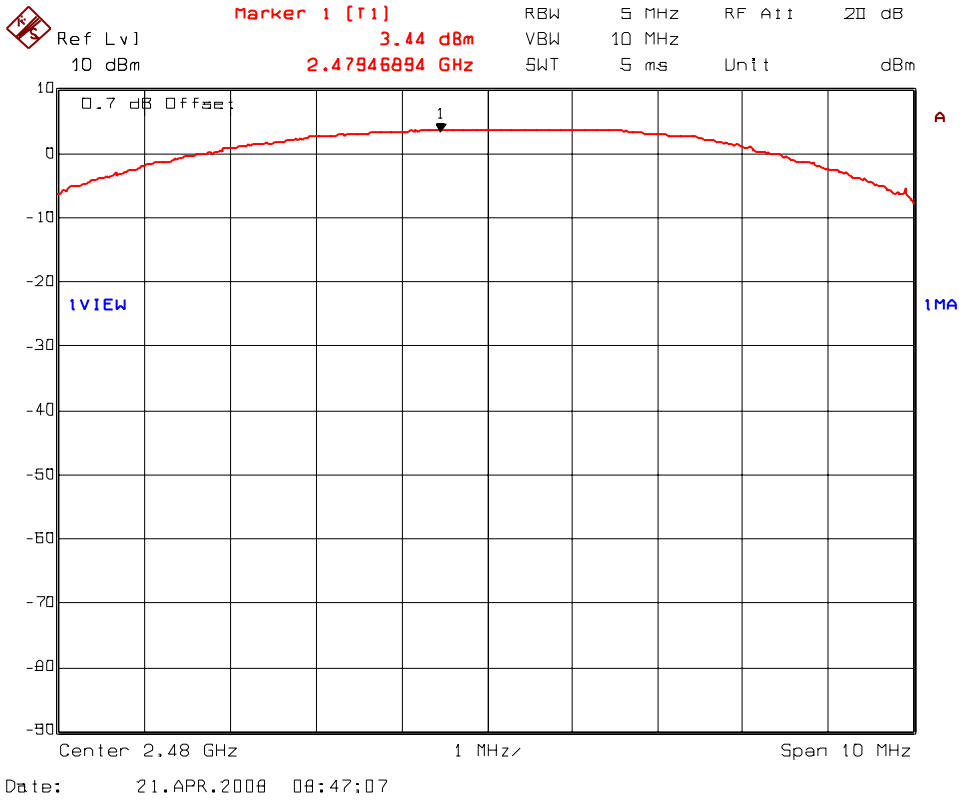
Plot 6.7.5.1 Peak Conducted Output Power (AC Supply)
Frequency: 2405 MHz



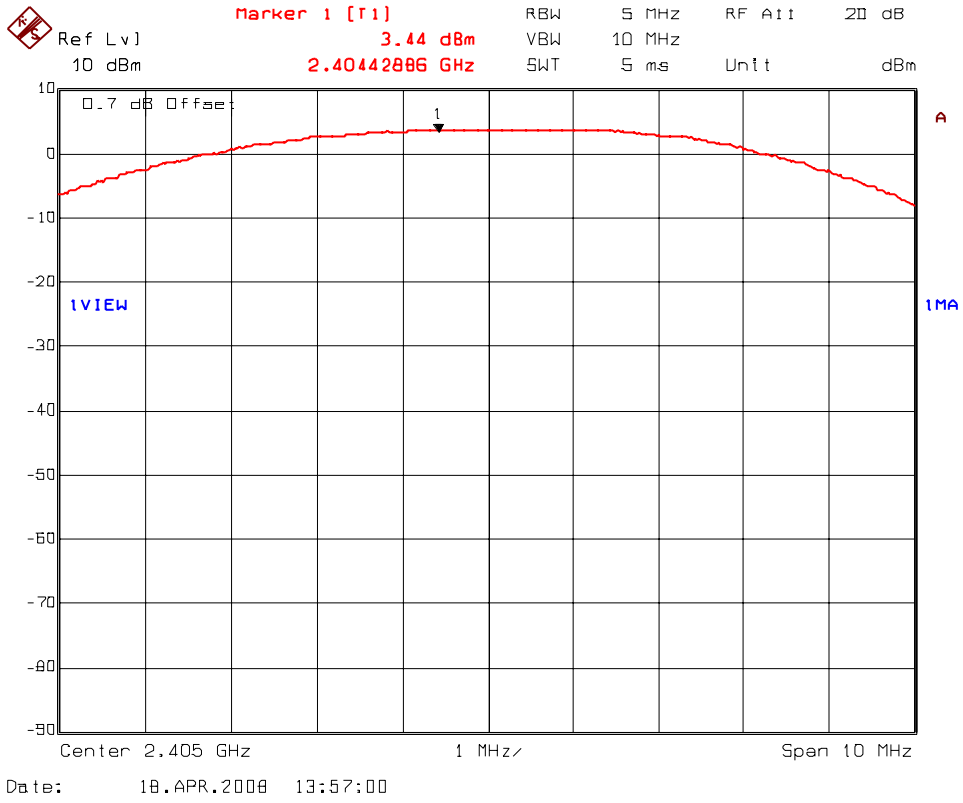
Plot 6.7.5.2 Peak Conducted Output Power (AC Supply)
Frequency: 2440 MHz



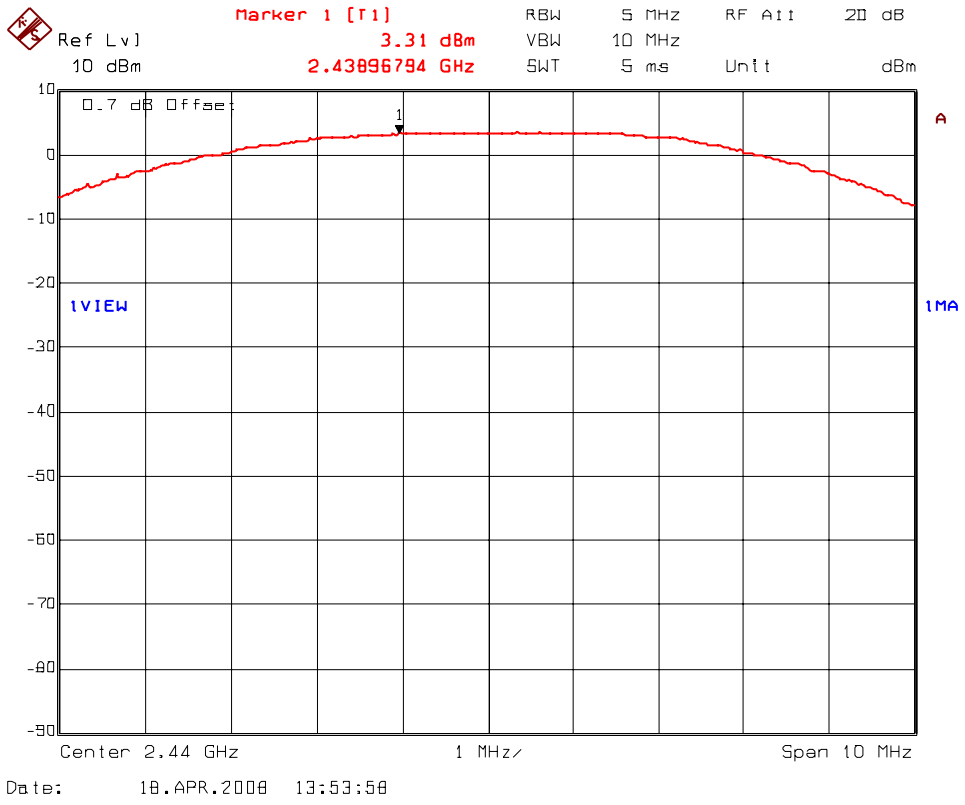
Plot 6.7.5.3 Peak Conducted Output Power (AC Supply)
Frequency: 2480 MHz



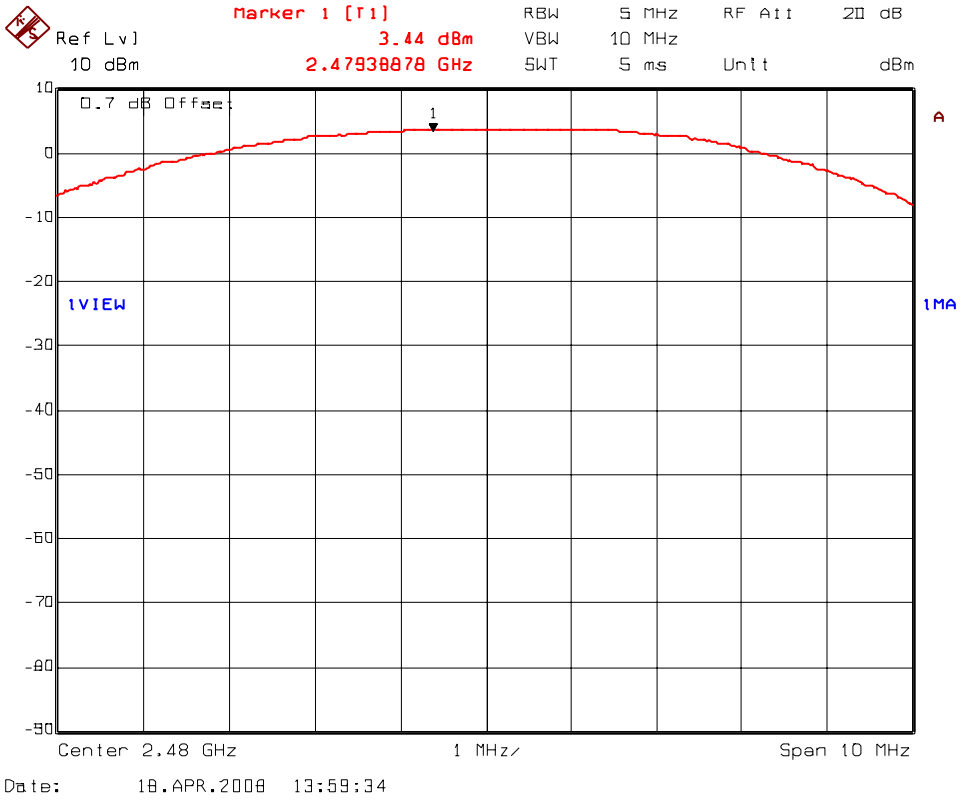
Plot 6.7.5.4 Peak Conducted Output Power (DC Supply)
Frequency: 2405 MHz



Plot 6.7.5.5 Peak Conducted Output Power (DC Supply)
Frequency: 2440 MHz



Plot 6.7.5.6 Peak Conducted Output Power (DC Supply)
Frequency: 2480 MHz



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

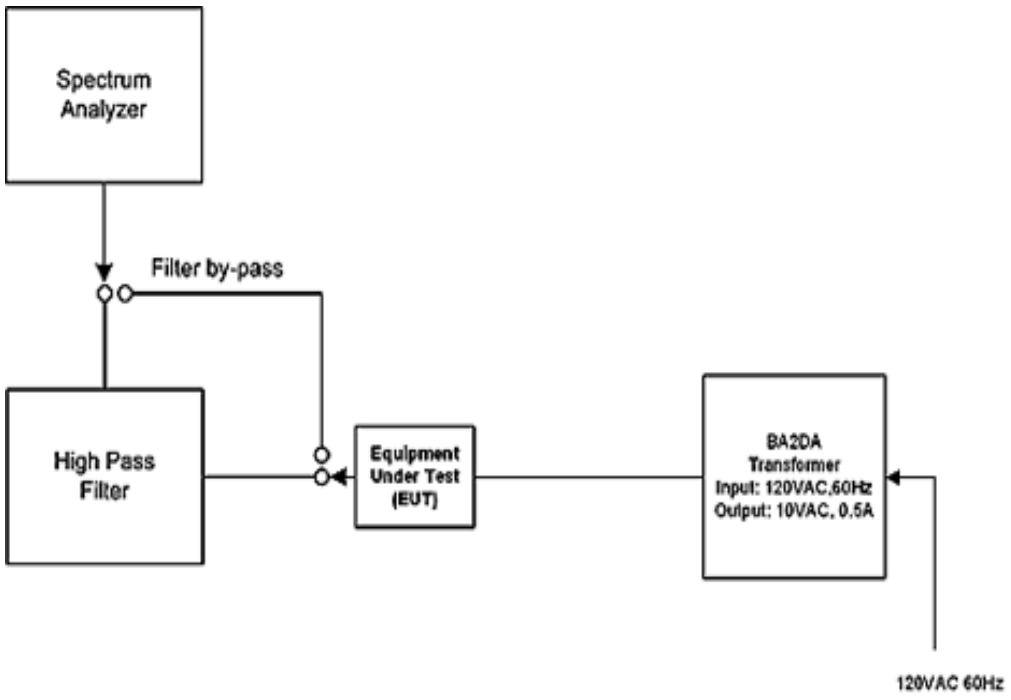
6.8.1. Limit(s)

§ 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.

6.8.2. Method of Measurements

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

6.8.3. Test Arrangement



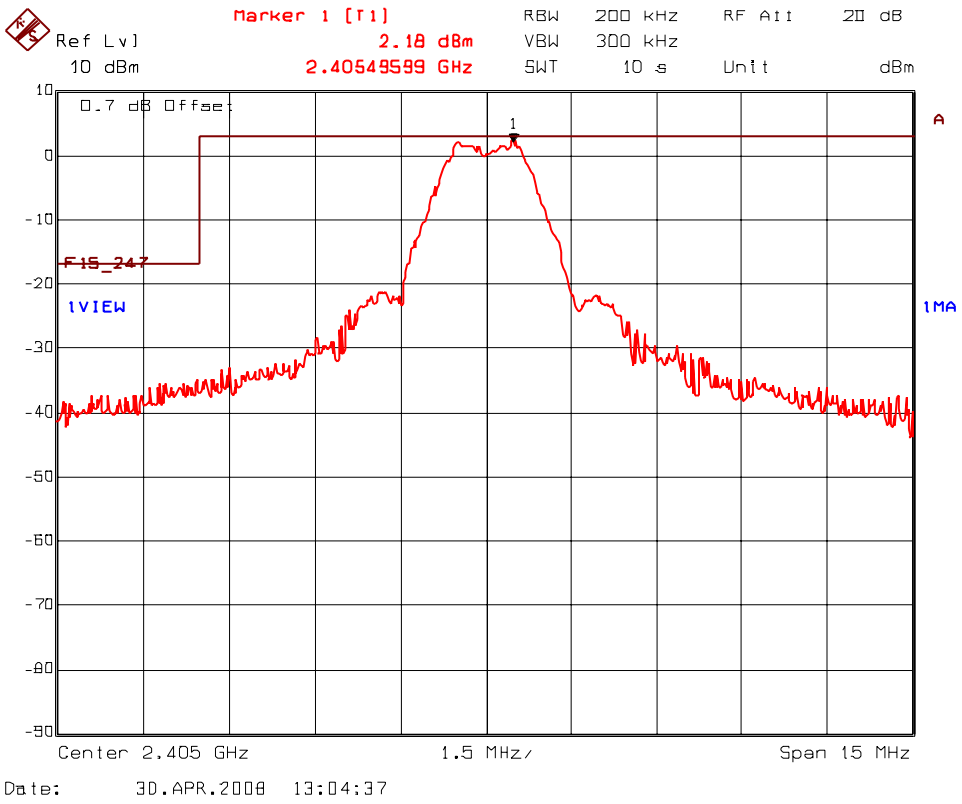
6.8.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Rhode & Schwarz	FSEK 30	100077	20 Hz - 40 GHz
Attenuator (10dB)	Narda	4768-10	N/A	DC – 40 GHz
High Pass Filter	K & L	11SH10-4000/T12000	4	3dB cutoff at 4 GHz

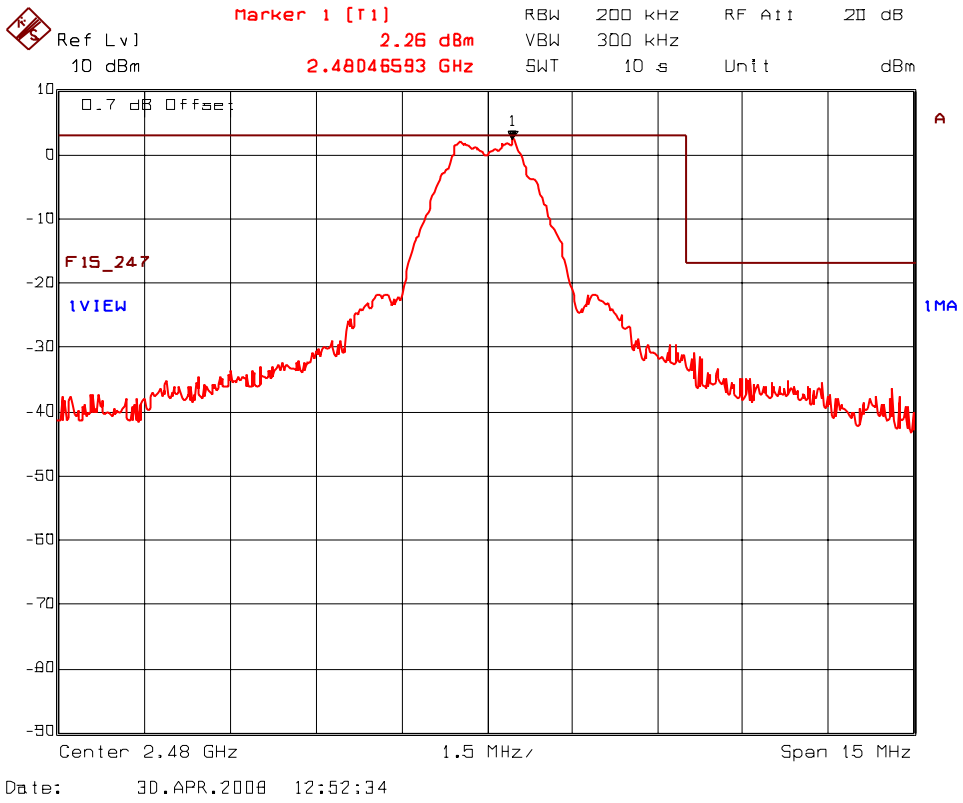
6.8.5. Test Data

6.8.5.1. Band-Edge RF Conducted Emissions

Plot 6.8.5.1.1 Band-Edge RF Conducted Emissions
Low End of Frequency Band

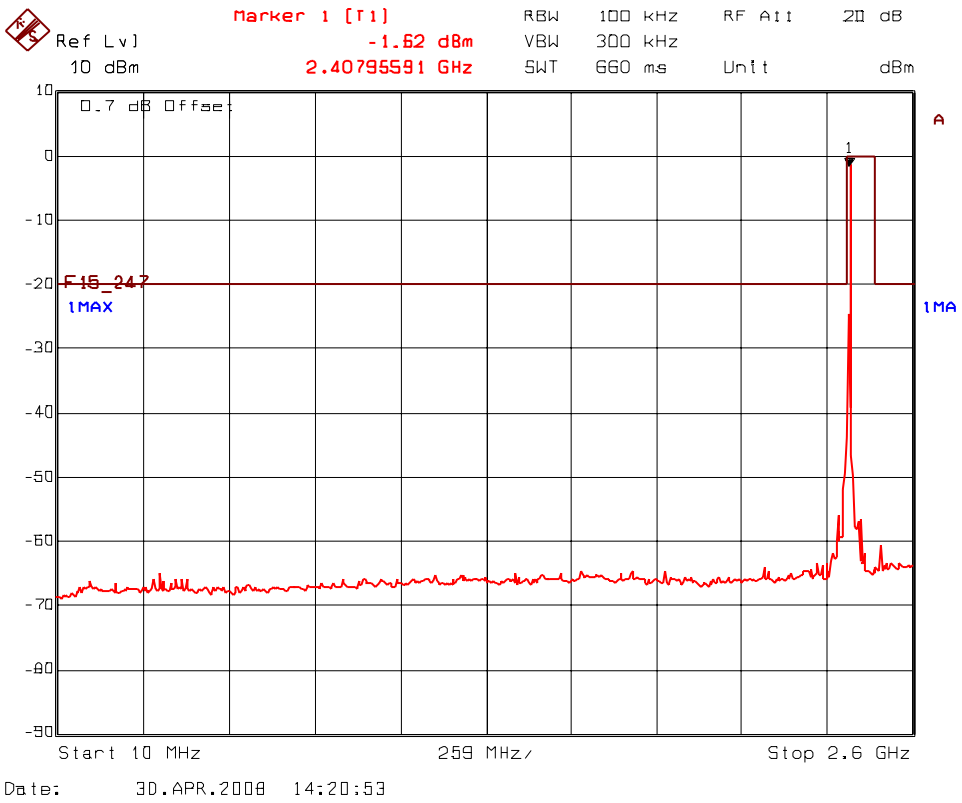


Plot 6.8.5.1.2 Band-Edge RF Conducted Emissions
High End of Frequency Band

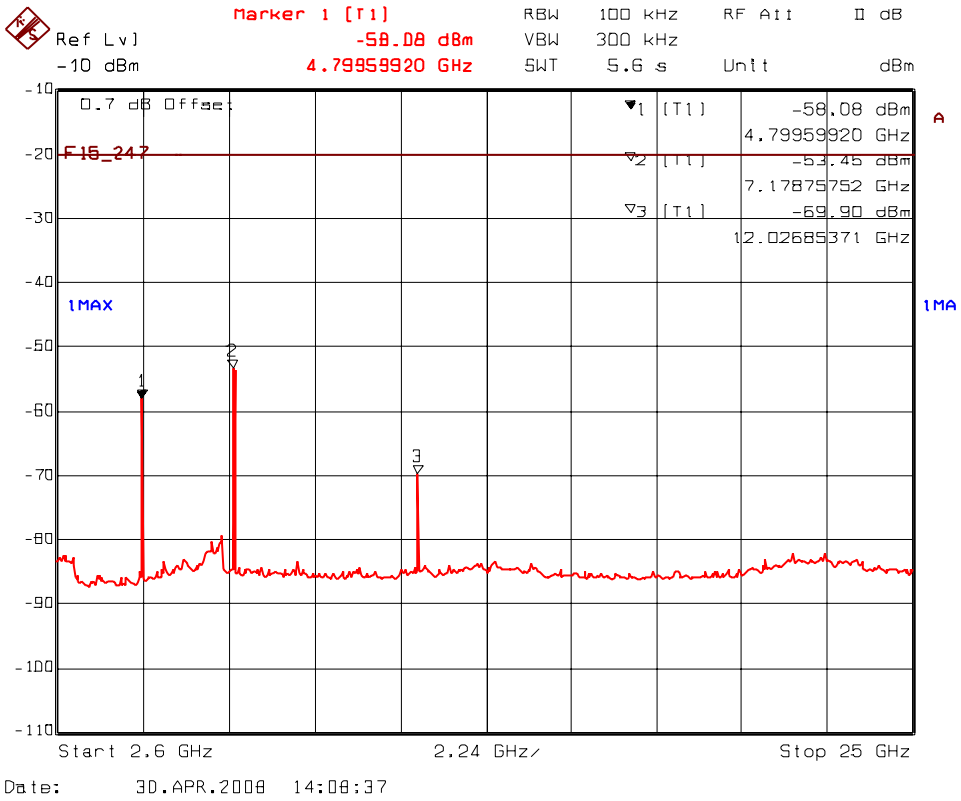


6.8.5.2. Spurious RF Conducted Emissions

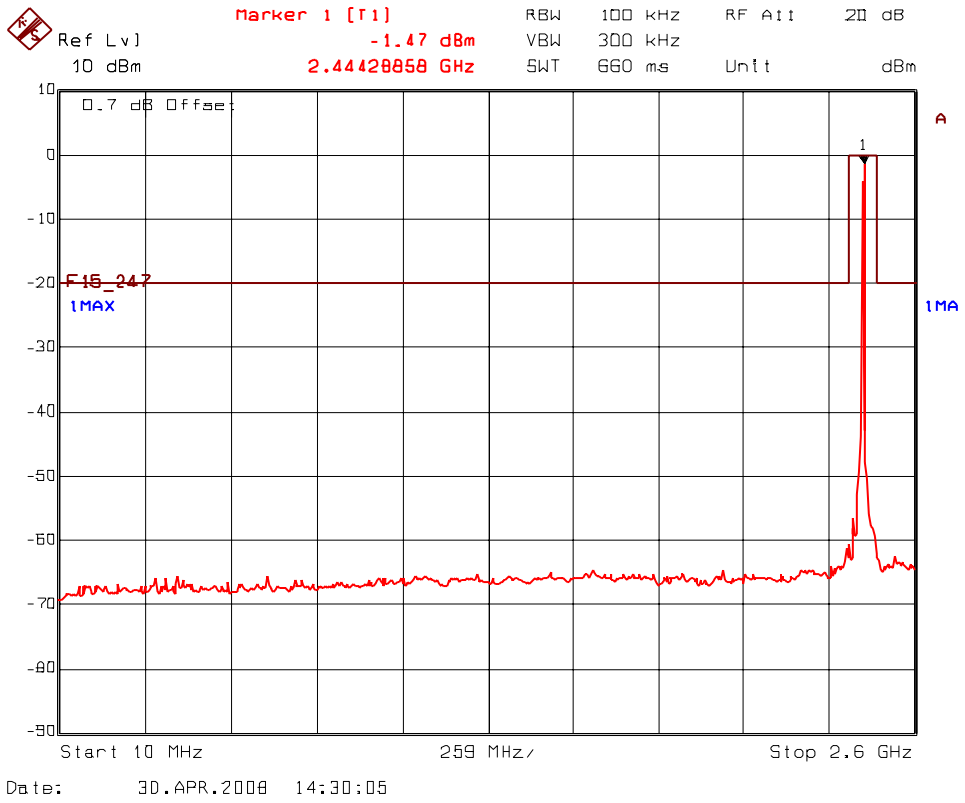
Plot 6.8.5.2.1(i) Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz



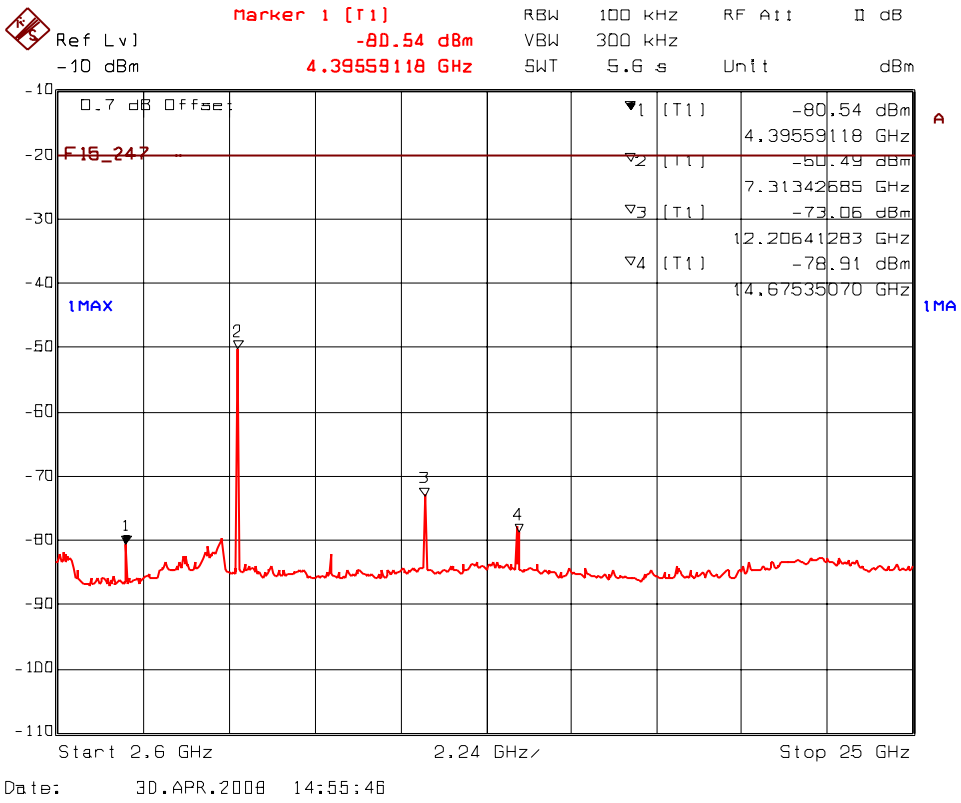
Plot 6.8.5.2.1(ii) Spurious RF Conducted Emissions
Transmitter Frequency: 2405 MHz



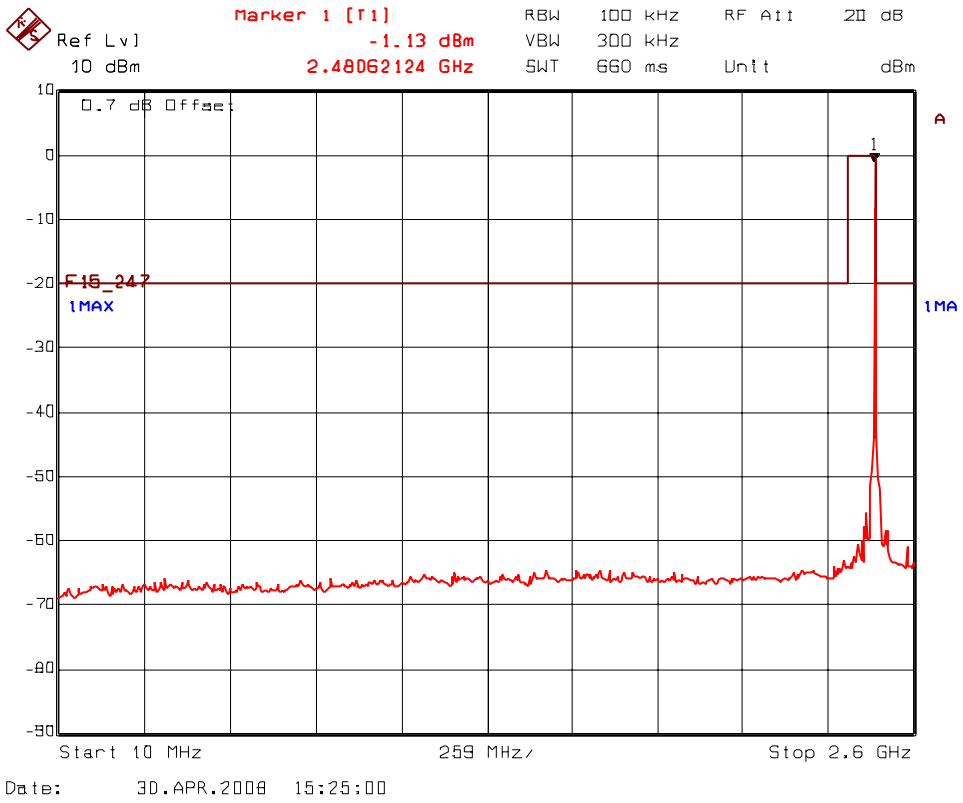
Plot 6.8.5.2.2(i) Spurious RF Conducted Emissions
Transmitter Frequency: 2440 MHz



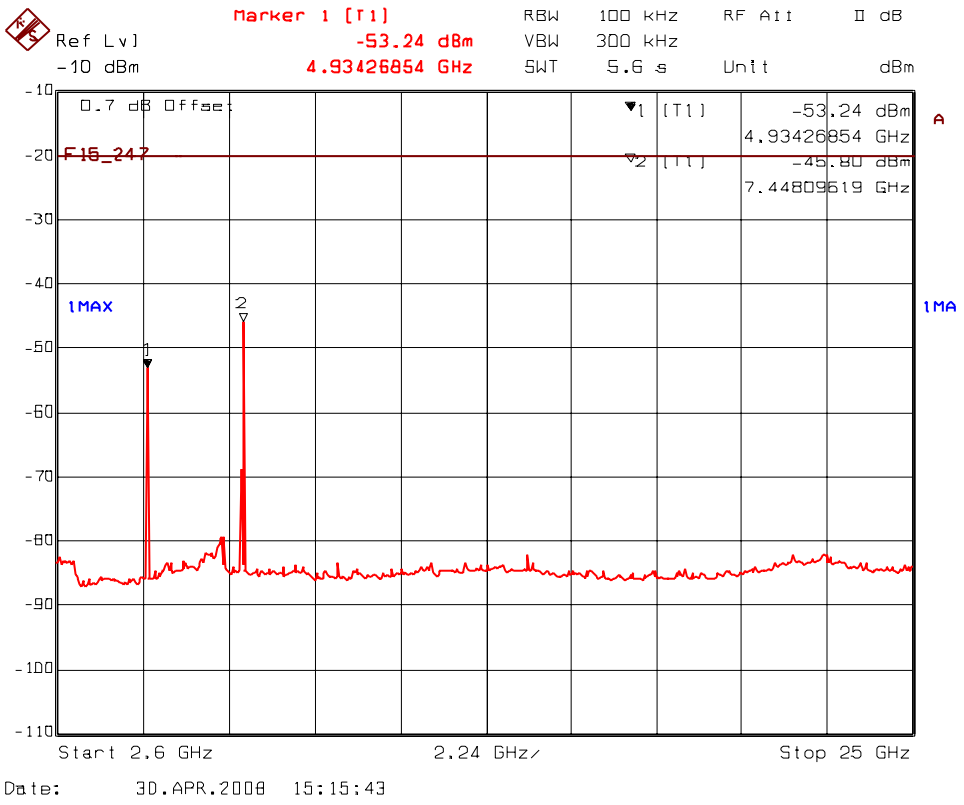
Plot 6.8.5.2.2(ii) Spurious RF Conducted Emissions
Transmitter Frequency: 2440 MHz



Plot 6.8.5.2.3(i) Spurious RF Conducted Emissions
Transmitter Frequency: 2480 MHz



Plot 6.8.5.2.3(ii) Spurious RF Conducted Emissions
Transmitter Frequency: 2480 MHz



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

6.9.1. 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] 0.495–0.505	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

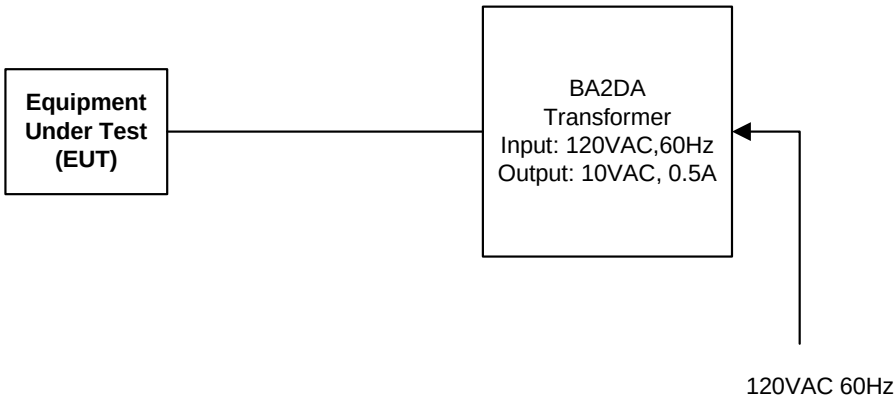
Section 15.209(a)
-- Field Strength Limits within Restricted Frequency Bands --

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

6.9.2. Method of Measurements

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

6.9.3. Test Arrangement



6.9.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Rhode & Schwarz	FSEK 30	100077	20 Hz - 40 GHz
Microwave Amplifier	Hewlett Packard	8449B	3008A00769	1 GHz to 26.5 GHz
RF Ampllifier	Hewlett Packard	8447F	2944A04098	0.1 to 1300 MHz
Biconilog Antenna	EMCO	3142C	34792	26 to 3000 MHz
Horn Antenna	EMCO	3155	6570	1 GHz – 18 GHz
Horn Antenna	EMCO	3160-09	1007	18 GHz – 26.5 GHz
Attenuator (10dB)	Narda	4768-10	N/A	DC – 40 GHz

6.9.5. Test Data

Remarks:

- All spurious emissions that are in excess of 20 dB below the specified limit shall be recorded.
- EUT is tested in three orthogonal positions.
- The following test results are with the AC version.

Fundamental Frequency:	2405 MHz
Frequency Test Range:	30 MHz – 25 GHz

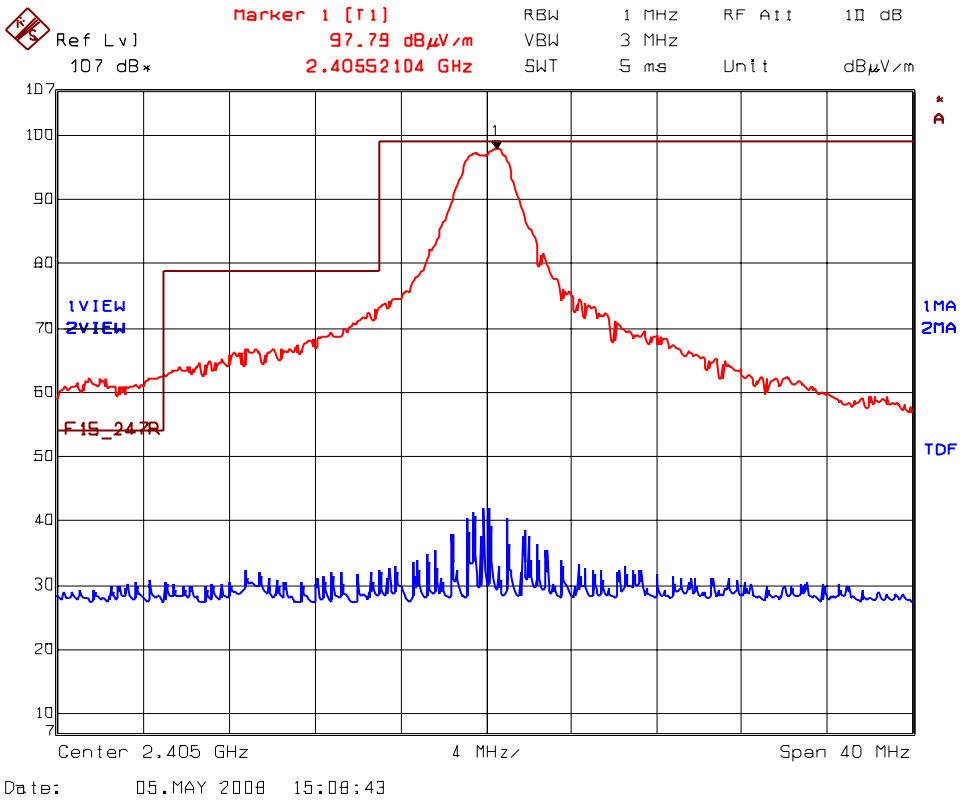
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2405	97.92	--	V	--	--	--	--
2405	97.79	--	H	--	--	--	--
4810	63.46	36.96	V	54.00	77.92	-17.04	Pass*
4810	60.94	36.34	H	54.00	77.92	-17.66	Pass*

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

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

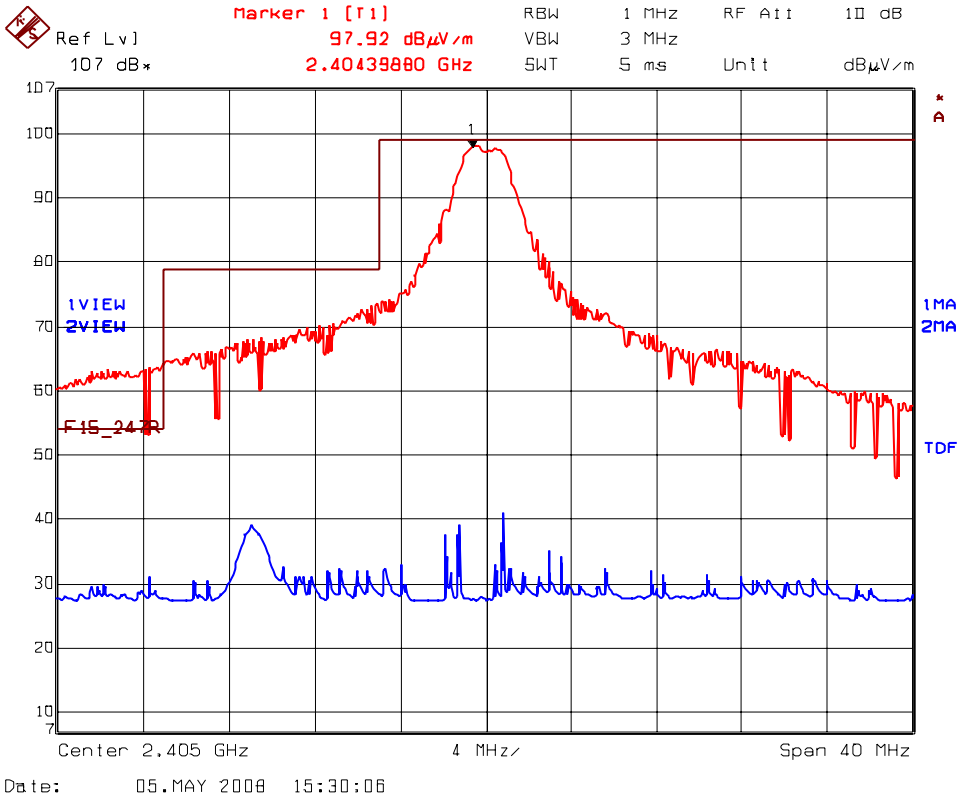
Plot 6.9.5.1 Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band
Rx Antenna Orientation: Horizontal

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



Plot 6.9.5.2 Band-Edge RF Radiated Emissions @ 3 m
Low End of Frequency Band
Rx Antenna Orientation: Vertical

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



Fundamental Frequency:	2440 MHz
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2440	98.26	--	V	--	--	--	--
2440	98.27	--	H	--	--	--	--
4880	62.13	36.19	V	54.00	78.27	-17.81	Pass*
4880	59.26	35.14	H	54.00	78.27	-18.86	Pass*
7320	57.76	35.74	V	54.00	78.27	-18.26	Pass*
7320	58.52	36.14	H	54.00	78.27	-17.86	Pass*

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

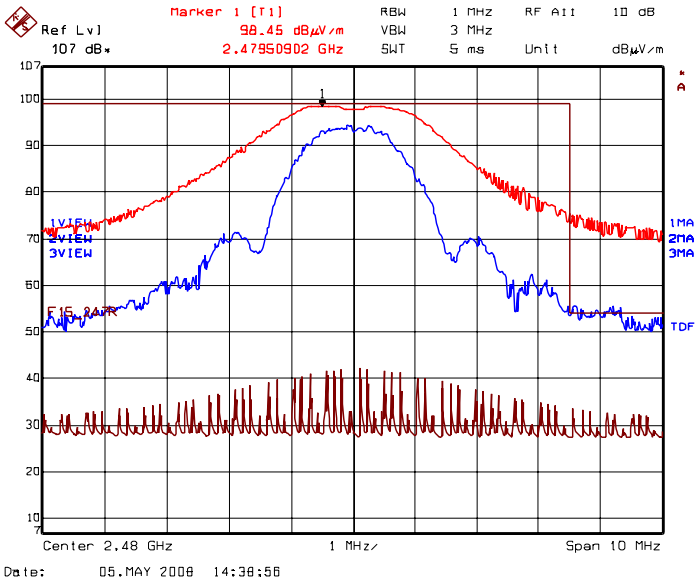
Fundamental Frequency:	2480 MHz
Frequency Test Range:	30 MHz – 25 GHz

Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2480	99.35	--	V	--	--	--	--
2480	98.45	--	H	--	--	--	--
4960	59.95	34.81	V	54.0	79.4	-19.2	Pass*
4960	59.27	36.16	H	54.0	79.4	-17.8	Pass*
7440	62.61	38.04	V	54.0	79.4	-16.0	Pass*
7440	68.13	39.22	H	54.0	79.4	-14.8	Pass*

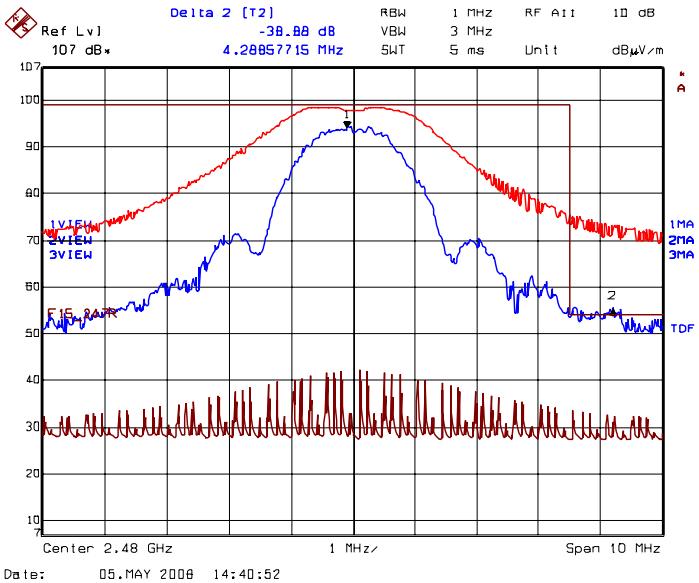
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits shown in § 15.209.

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

Plot 6.9.5.3(i) Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band
Rx Antenna Orientation: Horizontal

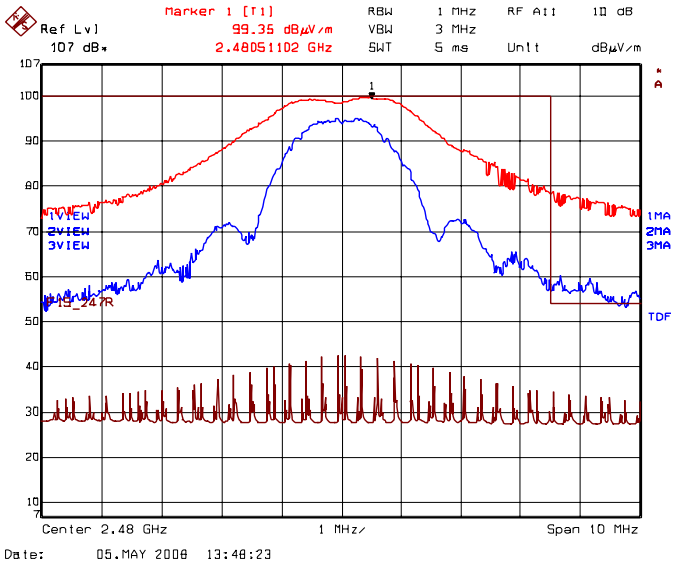


Plot 6.9.5.3(ii) Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band
Rx Antenna Orientation: Horizontal

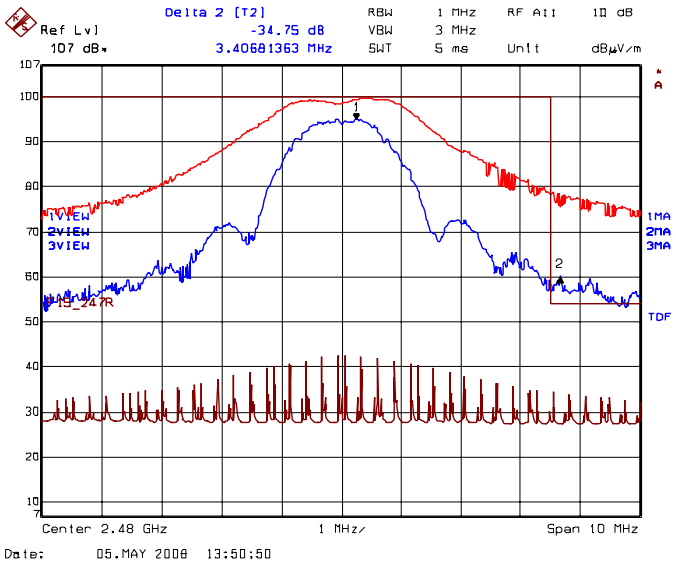


Trace 1: RBW= 1 MHz, VBW= 3 MHz
Trace 2: RBW= 100 kHz, VBW= 300 kHz, Delta (Peak to Band-Edge): 38.88dB
Trace 3: RBW= 1 MHz, VBW= 10 Hz
Peak Band-Edge at 2483.5 MHz: Peak= 98.45dBuV/m – 38.88dB= 59.57dBuV/m

Plot 6.9.5.4(i) Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band
Rx Antenna Orientation: Vertical



Plot 6.9.5.4(ii) Band-Edge RF Radiated Emissions @ 3 m
High End of Frequency Band
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): 34.75dB
Trace 3: RBW= 1 MHz, VBW= 10 Hz
Peak Band-Edge at 2483.5 MHz: Peak= 99.35dBuV/m – 34.75dB= 64.60dBuV/m

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

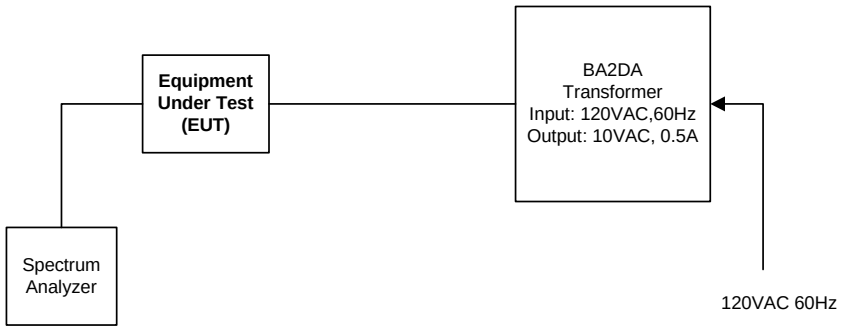
6.10.1. Limit(s)

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.

6.10.2. Method of Measurements

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

6.10.3. Test Arrangement



6.10.4. Test Equipment List

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range
Spectrum Analyzer	Rhode & Schwarz	FSEK 30	100077	20 Hz - 40 GHz

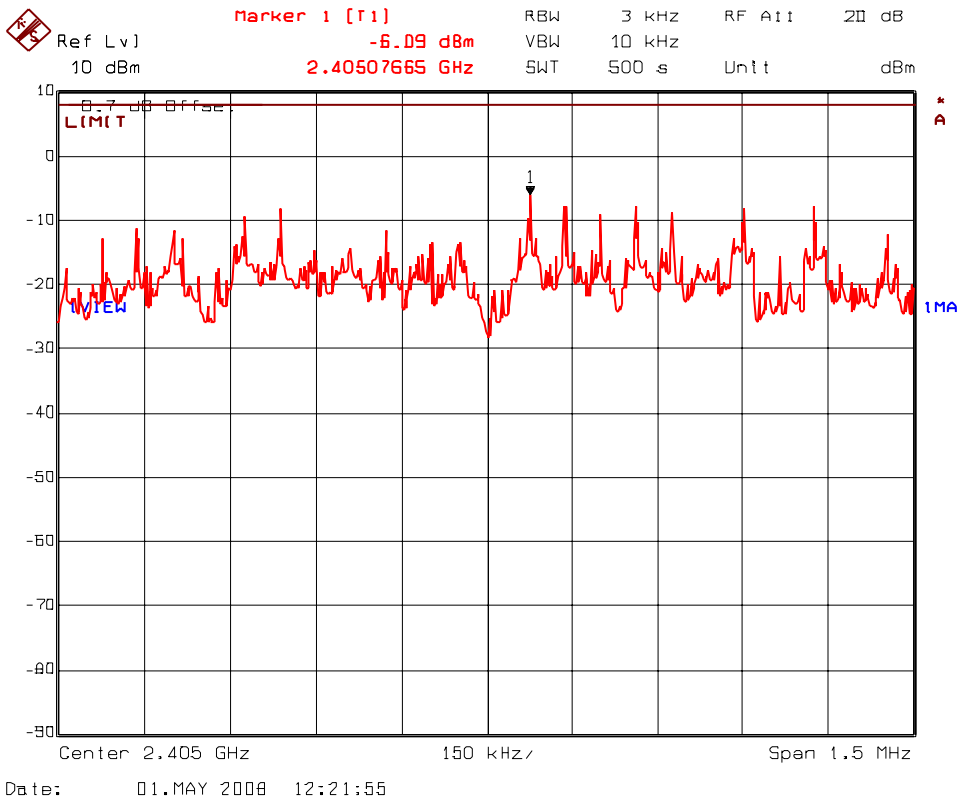
6.10.5. Test Data

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

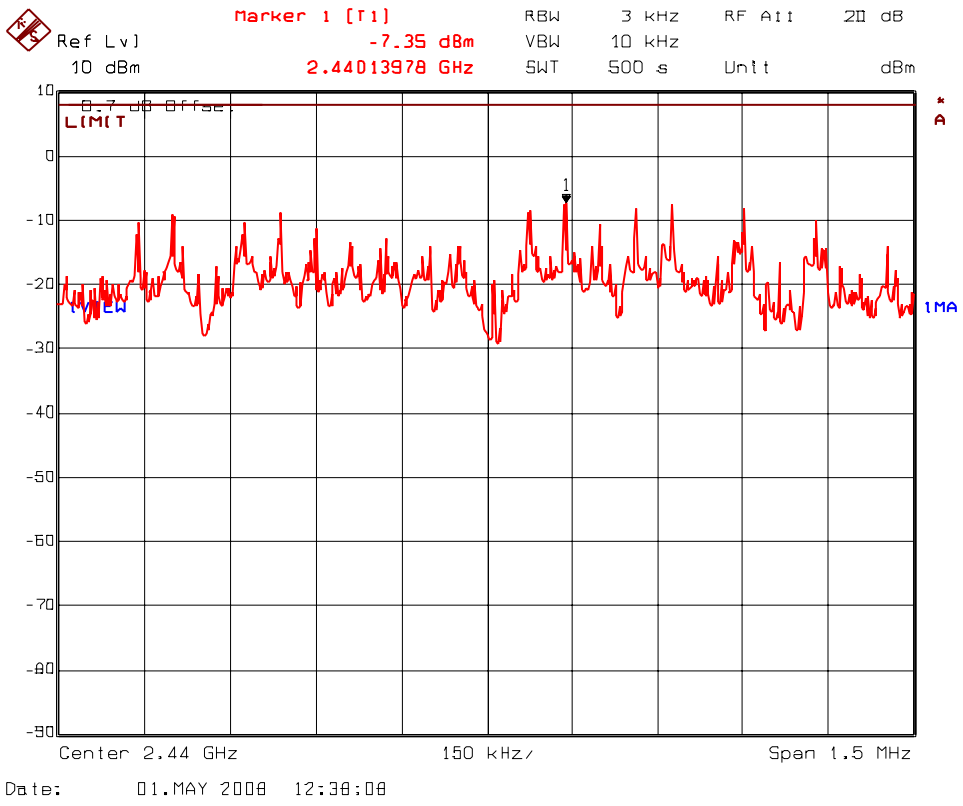
Frequency (MHz)	*PSD in 3 kHz BW (dBm)	Limit (dBm)	Margin (dB)	Comments (Pass/Fail)
2405	-6.09	8	-14.09	Pass
2440	-7.35	8	-15.35	Pass
2480	-6.92	8	-14.92	Pass

*See the following plots for measurement details.

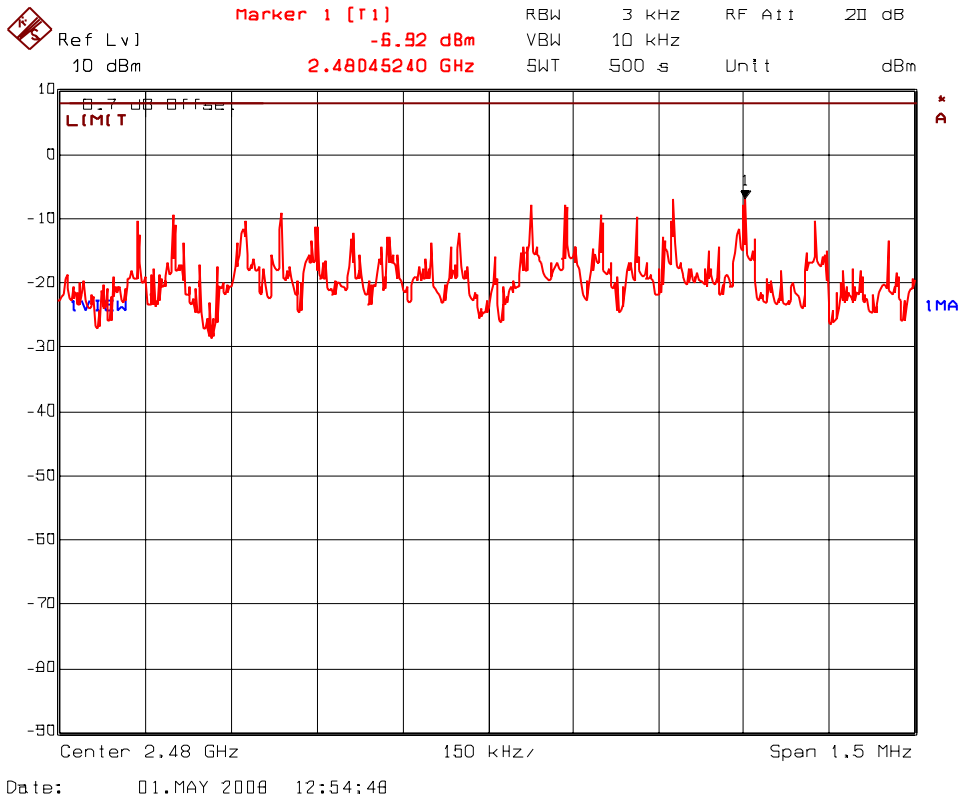
Plot 6.10.5.1 Power Spectral Density
Frequency: 2405 MHz



Plot 6.10.5.2 Power Spectral Density
Frequency: 2440 MHz



Plot 6.10.5.3 Power Spectral Density
Frequency: 2480 MHz



6.11. RF EXPOSURE REQUIRMENTS [§§ 15.247(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.

6.11.1. 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/cm^2
G: numeric gain of antenna relative to isotropic radiator
r: distance to centre of radiation in cm

6.11.2. RF Evaluation

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	**Compliance with FCC Rules**
Minimum calculated separation distance between antenna and persons required: **0.43* 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:

RF EXPOSURE DISTANCE LIMITS

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

S = 1 mW/cm^2
EIRP = 3.56 dBm = $10^{3.56/10}$ mW = 2.27 mW

(Minimum Safe Distance, r) = $\sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}} = \sqrt{\frac{2.27}{4 \cdot \pi \cdot (1)}} \approx 0.43cm$

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 Γ_1 = 0.03 LISN VRC Γ_R = 0.8(9 kHz) 0.2 (30 MHz) Uncertainty limits 20Log(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:

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

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

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

CONTRIBUTION (Radiated Emissions)	PROBABILITY DISTRIBUTION	UNCERTAINTY (± dB)	
		3 m	10 m
Antenna Factor Calibration	Normal (k=2)	±1.0	±1.0
Cable Loss Calibration	Normal (k=2)	±0.3	±0.5
EMI Receiver specification	Rectangular	±1.5	±1.5
Antenna Directivit	Rectangular	+0.5	+0.5
Antenna factor variation with height	Rectangular	±2.0	±0.5
Antenna phase center variation	Rectangular	0.0	±0.2
Antenna factor frequency interpolation	Rectangular	±0.25	±0.25
Measurement distance variation	Rectangular	±0.6	±0.4
Site imperfections	Rectangular	±2.0	±2.0
Mismatch: Receiver VRC Γ_1 = 0.2 Antenna VRC Γ_R = 0.67(Bi) 0.3 (Lp) Uncertainty limits 20Log(1±$\Gamma_1\Gamma_R$)	U-Shaped	+1.1 -1.25	±0.5
System repeatability	Std. Deviation	±0.5	±0.5
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:

$U = 2u_c(y) = 2x(+2.19) = +4.38$ dB And $U = 2u_c(y) = 2x(-2.21) = -4.42$ dB