ENGINEERING TEST REPORT

2400MHz OEM DTS / Frequency Hopping Module
Model: n2420BT
FCC ID: NS912P32

Applicant:

Microhard Systems Inc.
150 Country Hills Landing NW
Calgary, Alberta
Canada T3K 5P3

In Accordance With

Federal Communications Commission (FCC)
Part 15, Subpart C, Section 15.247 Frequency Hopping Spread Spectrum (FHSS)

UltraTech's File No.: MCRS-047F15C247DSS

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

Date: July 23, 2012

Report Prepared by: Dan Huynh	Tested by: Mr. Hung Trinh
Issued Date: July 23, 2012	Test Dates: March 30 - May 7, 2012

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. 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 Frequency Hopping Spread Spectrum (FHSS) Transmitter.
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

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

None.

1.3. NORMATIVE REFERENCES

Publication	Year	Title
47 CFR Parts 0-19	2011	Code of Federal Regulations (CFR), Title 47 – Telecommunication
ANSI C63.4	2009	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
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
FCC Public Notice DA 00-705	2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
FCC ET Docket No. 99-231	2002	Amendment to FCC Part 15 of the Commission's Rules Regarding to Spread Spectrum Devices

EXHIBIT 2. PERFORMANCE ASSESSMENT

2.1. CLIENT INFORMATION

APPLICANT	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248 2762 Email Address: shenouda@microhardcorp.com

MANUFACTURER	
Name:	Microhard Systems Inc.
Address:	150 Country Hills Landing NW Calgary, Alberta Canada T3K 5P3
Contact Person:	Mr. Hany Shenouda Phone #: 403 248-0028 Fax #: 403 248-2762 Email Address: shenouda@microhardcorp.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:	Microhard Systems Inc.
Product Name:	2400MHz OEM DTS / Frequency Hopping Module
Model Name or Number:	n2420BT
Serial Number:	Test Sample
Type of Equipment:	Spread Spectrum Transmitter
Input Power Supply Type:	External Regulated DC Sources
Primary User Functions of EUT:	Spread Spectrum OEM Transceiver

2.3. EUT'S TECHNICAL SPECIFICATIONS

TRANSMITTER	
Equipment Type:	▪ Mobile ▪ Base Station (fixed use)
Intended Operating Environment:	▪ Commercial, industrial or business environment ▪ Residential environment
Power Supply Requirement:	3.3V or (7 to 30VDC HV option)
RF Output Power Rating:	6.80 dBm to 30 dBm
Operating Frequency Range:	2401.6 – 2477.6 MHz
RF Output Impedance:	50 Ohm
Duty Cycle:	Continuous
Modulation Type:	FHSS*
Antenna Connector Type:	MMCX

*See Operational Description exhibit supplied by the manufacturer for details of modulation type for FHSS.

2.4. ASSOCIATED ANTENNA DESCRIPTIONS

There are four antenna types:

1. Rubber Ducky Antenna
2. Patch Antenna
3. Yagi Antenna
4. Omni Directional Antenna

The highest gain antenna from each of the above antenna types were selected for testing to represents the worst-case. Refer to antennas list exhibit for detailed specifications.

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 IN/OUT Port	1	MMCX	Shielded coaxial cable with unique coupling connectors
2	DC Supply & I/O Port	1	Pin Header	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
Brand name:	Microhard Systems Inc.
Model Name or Number:	N/A
Connected to EUT's Port:	I/O Port

Ancillary Equipment # 2	
Description:	AC/DC Adapter
Brand name:	CUI
Model Name or Number:	KSAFE1200200W1US
Connected to EUT's Port:	Test Jig of the EUT

Ancillary Equipment # 3	
Description:	Laptop
Brand name:	Dell
Model Name or Number:	PPL
Connected to EUT's Port:	Test Jig of the EUT

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°C
Humidity:	51%
Pressure:	102 kPa
Power Input Source:	3.3VDC

3.2. OPERATIONAL TEST CONDITIONS & ARRANGEMENT FOR TESTS

Operating Modes:	▪ Each of lowest, middle and highest channel frequencies transmits continuously for emissions measurements. ▪ The EUT operates in normal Frequency Hopping mode for occupancy duration, and frequency separation.
Special Test Software & Hardware:	Special software provided by the Applicant is installed to allow the EUT to operate in hopping mode or at each channel frequency continuously. For example, the transmitter will be operated at each of lowest, middle and highest frequencies individually continuously during testing.
Transmitter Test Antenna:	The EUT is tested with the antenna fitted in a manner typical of normal intended use as a non-integral antenna equipment as described with the test results.

Transmitter Test Signals	
Frequency Band(s):	2401.6 – 2477.6
Frequency(ies) Tested: (Near lowest, near middle & near highest frequencies in the frequency range of operation.)	2401.6, 2439.6 and 2477.6 MHz
RF Power Output: (measured maximum output power at antenna terminals)	1 Watt (conducted)
***Normal Test Modulation:**	Data Rate 5
Modulating Signal Source:	Internal

*See Operational Description exhibit supplied by the manufacturer for details of the data rates for FHSS.

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.: 91038) and Industry Canada office (Industry Canada File No.: 2049A-3). Expiry Date: 2014-04-04.

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)	Provisions for Frequency Hopping Systems	Yes
15.247(b)(1)	Peak Conducted Output Power	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(i), 1.1307, 1.1310, 2.1091	RF Exposure	Yes

4.3. MODIFICATIONS INCORPORATED IN THE EUT FOR COMPLIANCE PURPOSES

None.

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

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

5.1.1. Limit(s)

The equipment shall meet the limits of the following table:

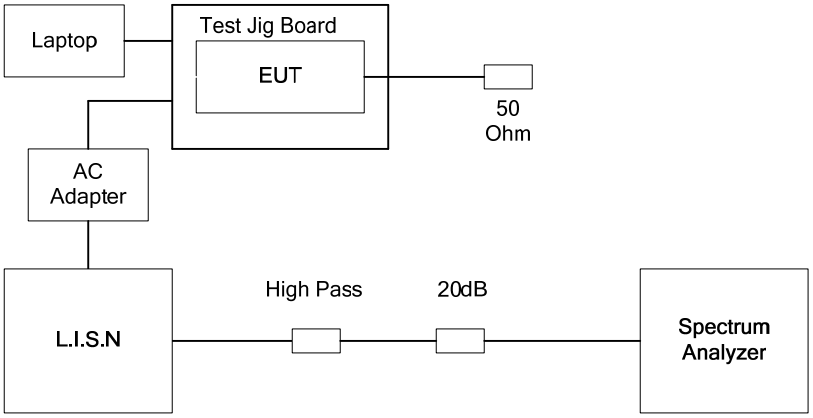
Frequency of emission (MHz)	Conducted Limits (dBμV)	
	Quasi-peak	Average
0.15–0.5 .....……..	66 to 56*	56 to 46*
0.5–5 .....……..	56	46
5-30 ……..……..	60 ……..……..	50

*Decreases linearly with the logarithm of the frequency

5.1.2. Method of Measurements

ANSI C63.4-2009

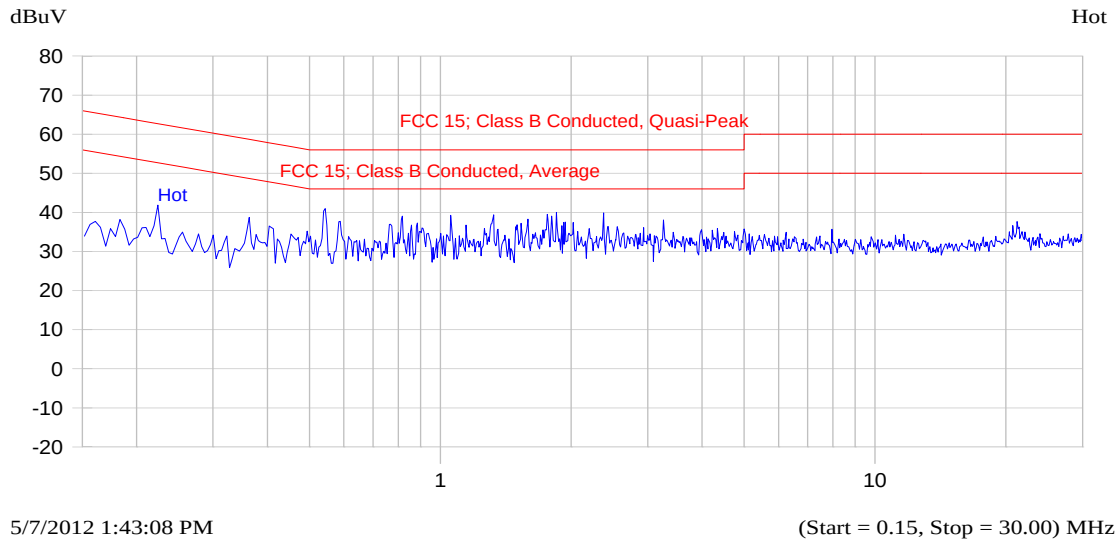
5.1.3. Test Arrangement



5.1.4. Test Data

Plot 5.1.4.1. Power Line Conducted Emissions; Line Voltage: 120 VAC; Line Tested: Hot

Current Graph

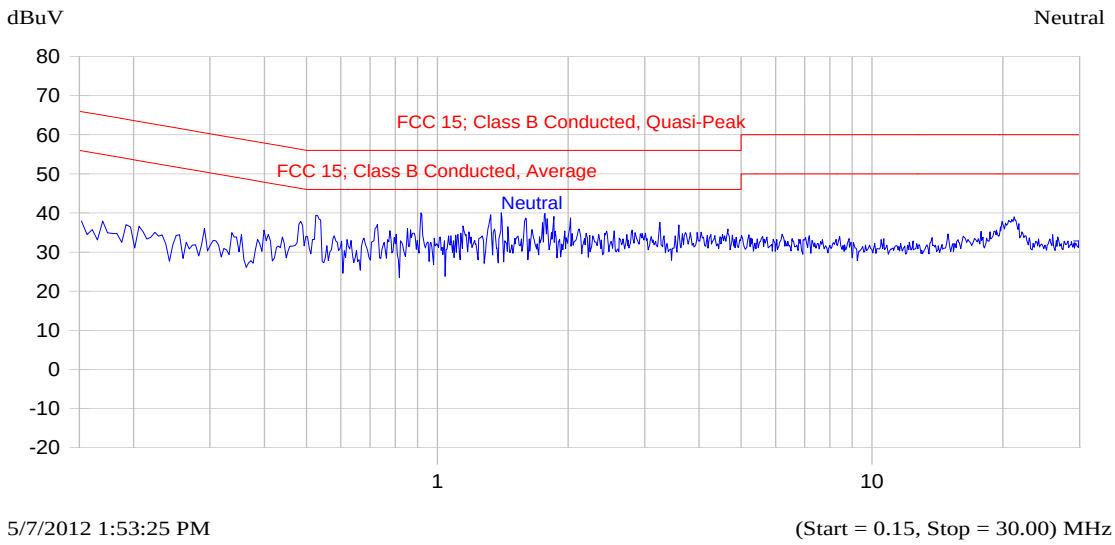


Current List

Frequency MHz	Peak dBuV	QP dBuV	Delta QP-QP Limit dB	Avg dBuV	Delta Avg-Avg Limit dB	Trace Name
0.222	38.8	34.6	-29.3	28.7	-25.2	Hot
0.527	48.5	46.2	-9.8	43.0	-3.0	Hot
1.318	42.4	39.0	-17.0	34.3	-11.7	Hot
2.370	37.7	33.1	-22.9	27.1	-18.9	Hot

Plot 5.1.4.2. Power Line Conducted Emissions; Line Voltage: 120 VAC; 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
0.530	48.2	45.7	-10.3	42.6	-3.4	Neutral
0.907	40.8	36.4	-19.6	27.6	-18.4	Neutral
1.398	41.6	37.0	-19.0	31.9	-14.1	Neutral
21.443	38.4	33.7	-26.3	27.5	-22.5	Neutral

5.2. COMPLIANCE WITH FCC PART 15 – GENERAL TECHNICAL REQUIREMENTS

FCC Section	FCC Rules	Manufacturer's Clarification
15.31	The hoping function must be disabled for tests, which should be performed with the EUT transmitting on the number of frequencies specified in this Section. The measurements made at the upper and lower ends of the band of operation should be made with the EUT tuned to the highest and lowest available channels.	See Operational Description
15.203	Described how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT. The exception is in those cases where EUT must be professionally installed. In order to demonstrate that professional installation is required, the following 3 points must be addressed: ➢ The application (or intended use) of the EUT ➢ The installation requirements of the EUT ➢ The method by which the EUT will be marketed	The antenna employs a unique antenna connector.
15.204	Provided the information for every antenna proposed for use with the EUT: ➢ type (e.g. Yagi, patch, grid, dish, etc…), ➢ manufacturer and model number ➢ gain with reference to an isotropic radiator	See proposed antenna list.
15.247(a)	Description of how the EUT meets the definition of a frequency hopping spread spectrum, found in Section 2.1. Based on the technical description.	See Operational Description
15.247(a)	Pseudo Frequency Hopping Sequence: Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, in order to demonstrate that the sequence meets the requirements specified in the definition of a frequency hopping spread spectrum system, found in Section 2.1	See Operational Description

FCC Section	FCC Rules	Manufacturer's Clarification
15.247(a)	Equal Hopping Frequency Use: Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g. that each new transmission event begins on the next channel in the hopping sequence after final channel used in the previous transmission events).	See Operational Description
15.247(g)	Describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system	See Operational Description
15.247(h)	Describe how the EUT complies with the requirement that it not have the ability to coordinated with other FHSS is an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters	See Operational Description
Public Notice DA 00-705	System Receiver Input Bandwidth: Describe how the associated receiver(s) complies with the requirement that its input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.	See Operational Description
Public Notice DA 00-705	System Receiver Hopping Capability: Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals	See Operational Description

5.3. PROVISIONS FOR FREQUENCY HOPPING SYSTEMS [§ 15.247(a)(1)]

5.3.1. Limit

§ 15.247(a)(1): Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

§ 15.247(a)(1)(iii): Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

5.3.2. Method of Measurements

FCC Public Notice DA 00-705

Carrier Frequency Separation:

The hopping function of the EUT is enabled. Use the spectrum analyzer setting as follows:

- Span = wide enough to capture the peaks of two adjacent channels
- RBW = 1% of the span
- VBW ≥ RBW
- Sweep = Auto
- Detector = peak
- Trace = max hold

Number of hopping frequency:

The hopping function of the EUT is enabled. Use the spectrum analyzer setting as follows:

- Span = the frequency band of operation
- RBW = 1% of the span
- VBW ≥ RBW
- Sweep = Auto
- Detector = peak
- Trace = max hold

Time of Occupancy (Dwell Time):

The hopping function of the EUT is enabled. Use the spectrum analyzer setting as follows:

- Span = 0 Hz centered on a hopping channel
- RBW = 1 MHz
- VBW ≥ RBW
- Sweep = as necessary to capture the entire dwell time per hopping channel
- Detector = peak
- Trace = max hold

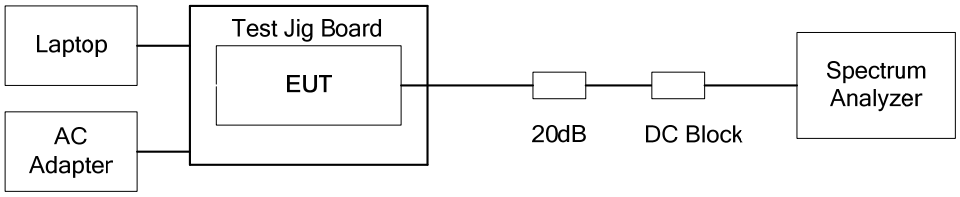
If possible, use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g. date rate modulation format, etc.), repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s). An oscilloscope may be used instead of a spectrum analyzer.

20 dB Bandwidth:

Use the spectrum analyzer setting as follows:

- Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel
- RBW = 1% of the 20 dB bandwidth
- VBW ≥ RBW
- Sweep = auto
- Detector = peak
- Trace = max hold
- The transmitter shall be transmitting at its maximum data rate.
- Allow the trace to stabilize.
- Use the marker-to-peak function to set the marker to the peak of the emission.
- Use the marker-delta function to measure 20 dB down on both sides of the emission.
- The 20 dB BW is the delta reading in frequency between two markers.

5.3.3. Test Arrangement



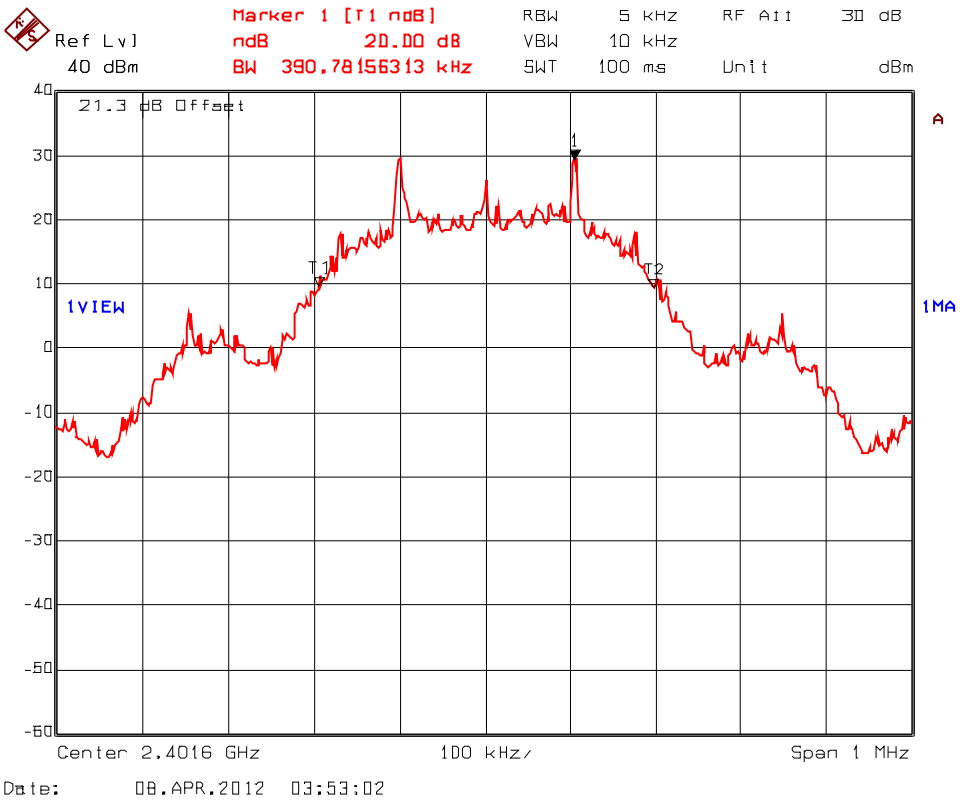
5.3.4. Test Data

Test Description	FCC Specification	Measured Values	Comments
Frequency Hopping Systems Requirements	The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.	--	See Note 1
20 dB BW of the hopping channel	--	394.79 kHz	See Note 2
Channel Hopping Frequency Separation	Minimum of 25 kHz or 20dB BW whichever is greater or 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW	396.79 kHz	See Note 2
Number hopping frequencies	Shall use at least 15 channels	76 hopping frequencies	See Note 1 and 2
Average Time of Occupancy	The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed	112.42 ms	See Note 2

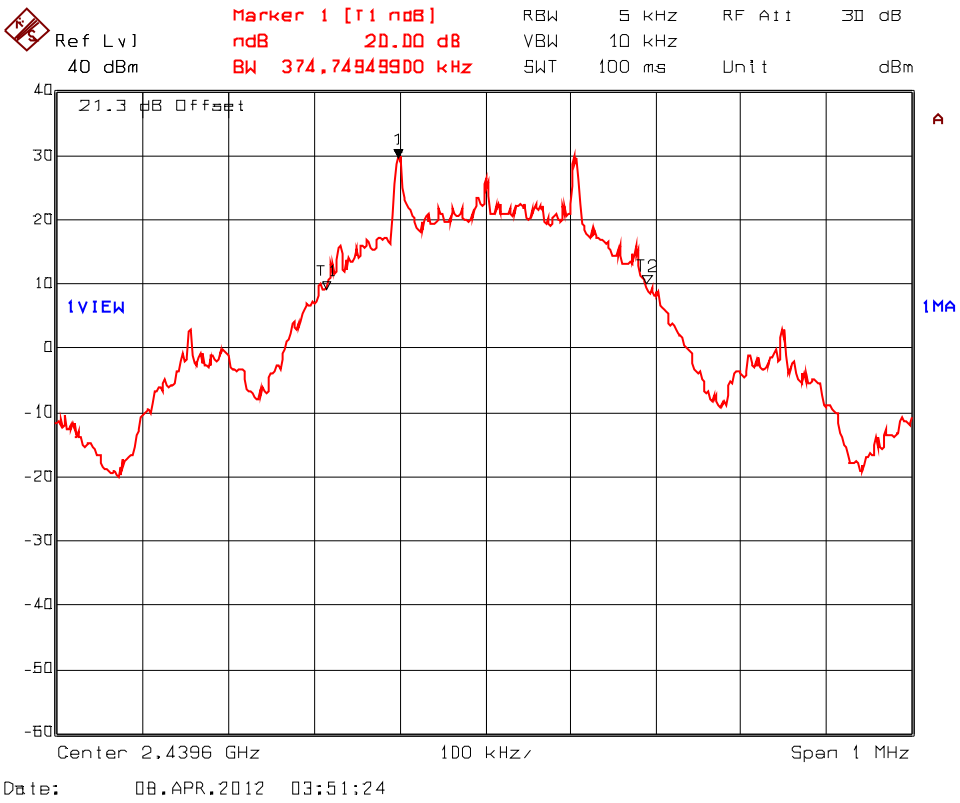
Note 1: See operational description exhibit for details.

Note 2: See the following plots for details.

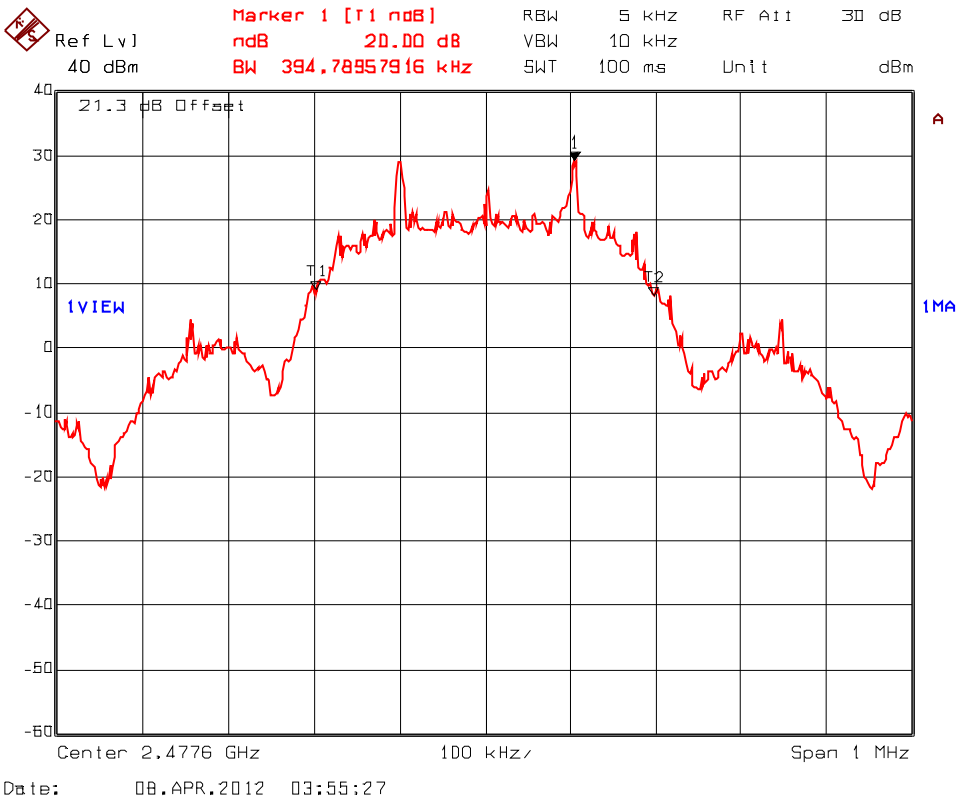
Plot 5.3.4.1. 20 dB Bandwidth, 2401.6 MHz, Data Rate 5



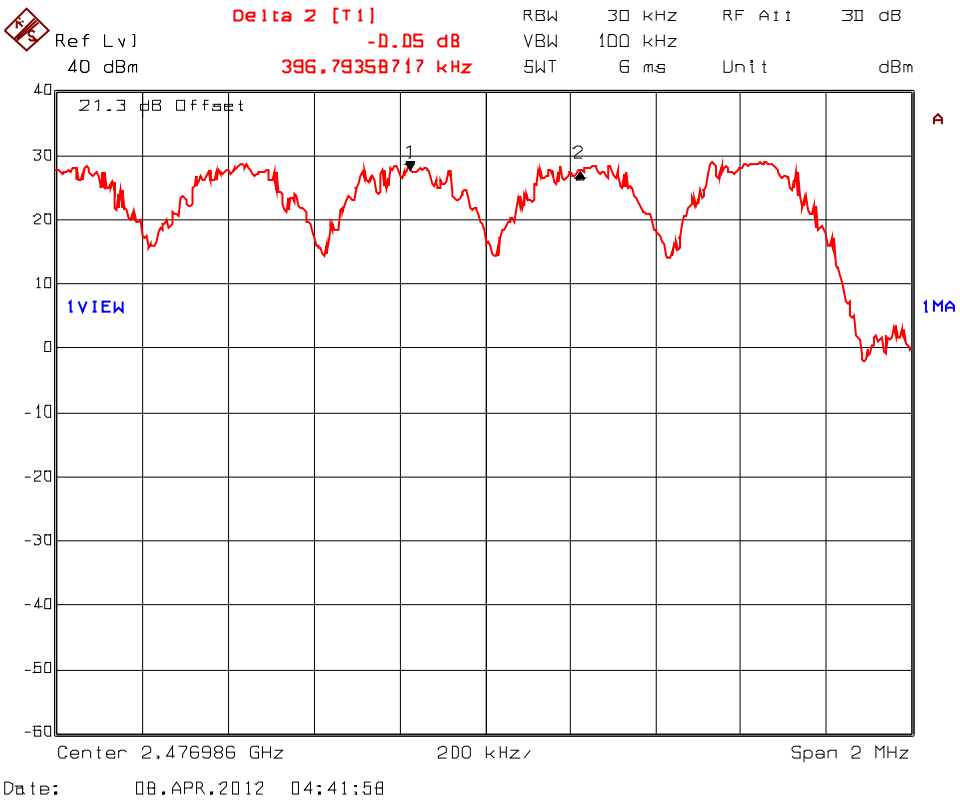
Plot 5.3.4.2. 20 dB Bandwidth, 2439.6 MHz, Data Rate 5



Plot 5.3.4.3. 20 dB Bandwidth, 2477.6 MHz, Data Rate 5

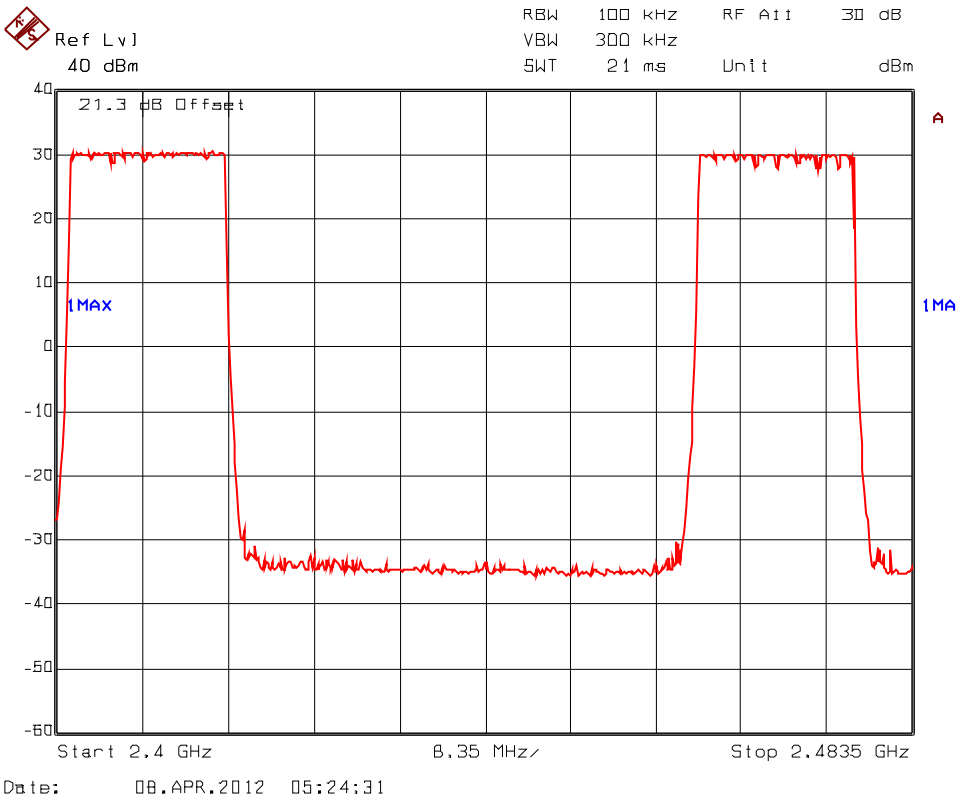


Plot 5.3.4.4. Carrier Frequency Separation, 2477.6 MHz, Data Rate 5

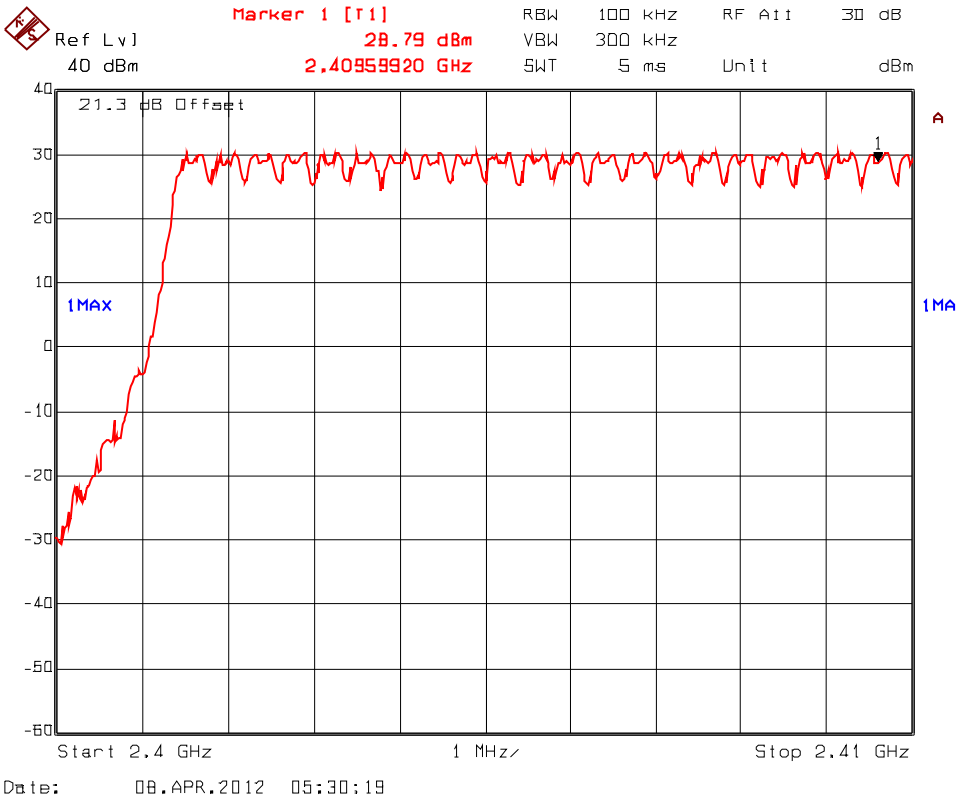


All test results contained in this engineering test report are traceable to National Institute of Standards and Technology (NIST)

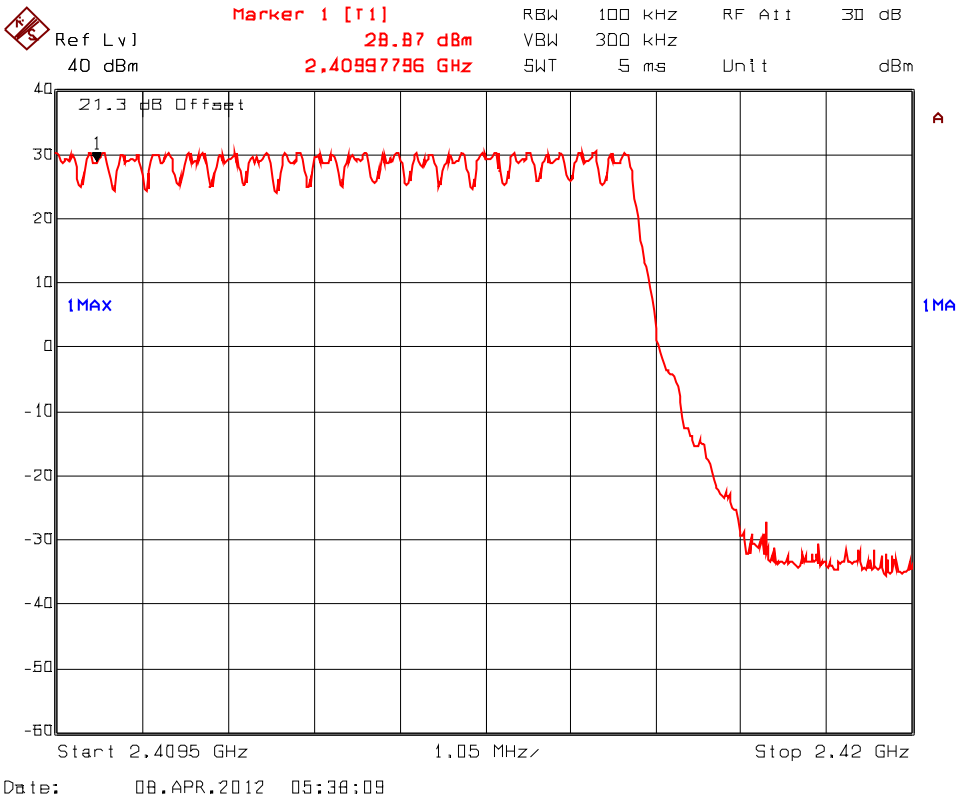
Plot 5.3.4.5. Number of Hopping Frequencies, Data Rate 5
76 Hopping Channels from 2400-2483.5 MHz



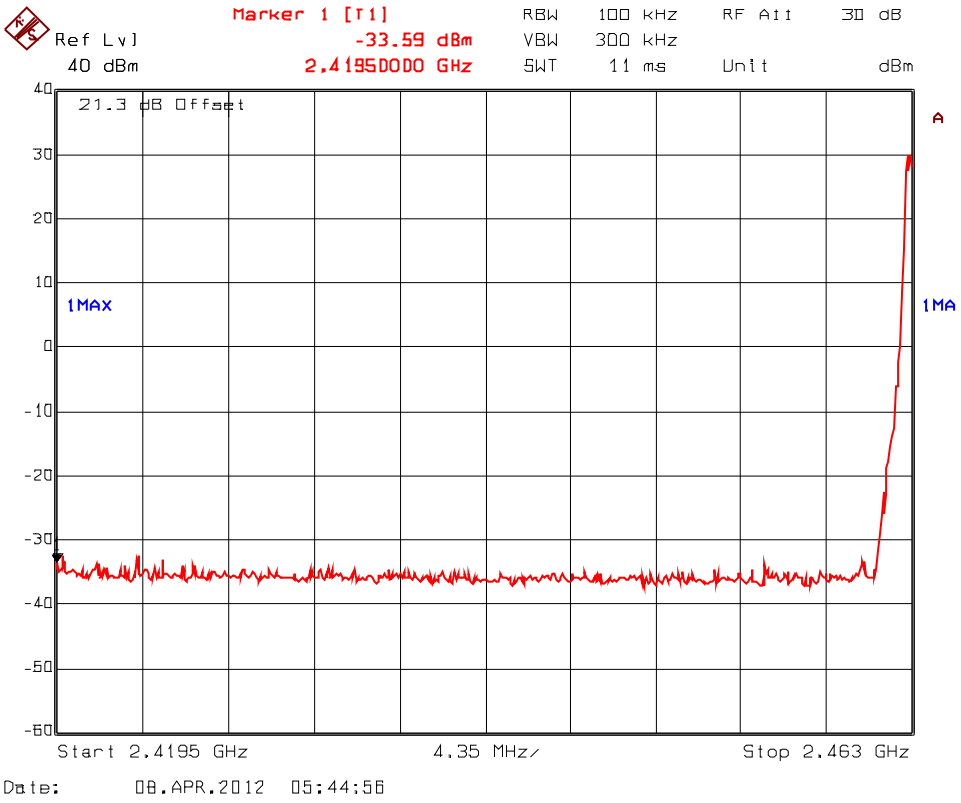
Plot 5.3.4.6. Number of Hopping Frequencies, Data Rate 5
21 Hopping Channels from 2400 – 2410 MHz



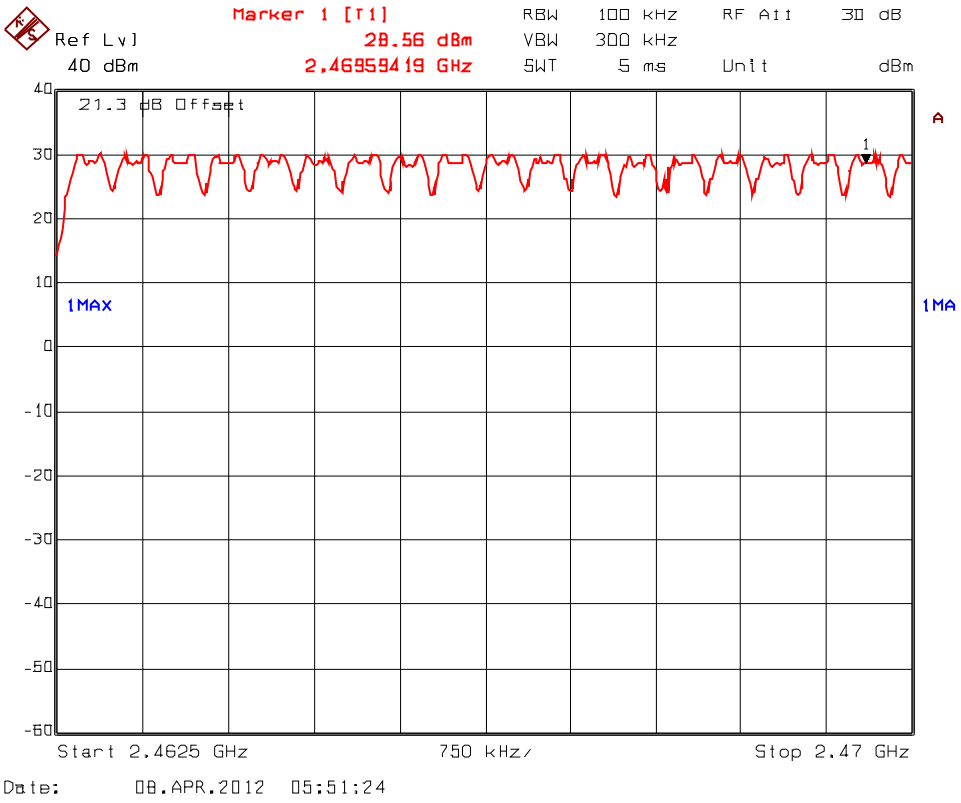
Plot 5.3.4.7. Number of Hopping Frequencies, Data Rate 5
17 Hopping Channels from 2409.5 - 2420 MHz



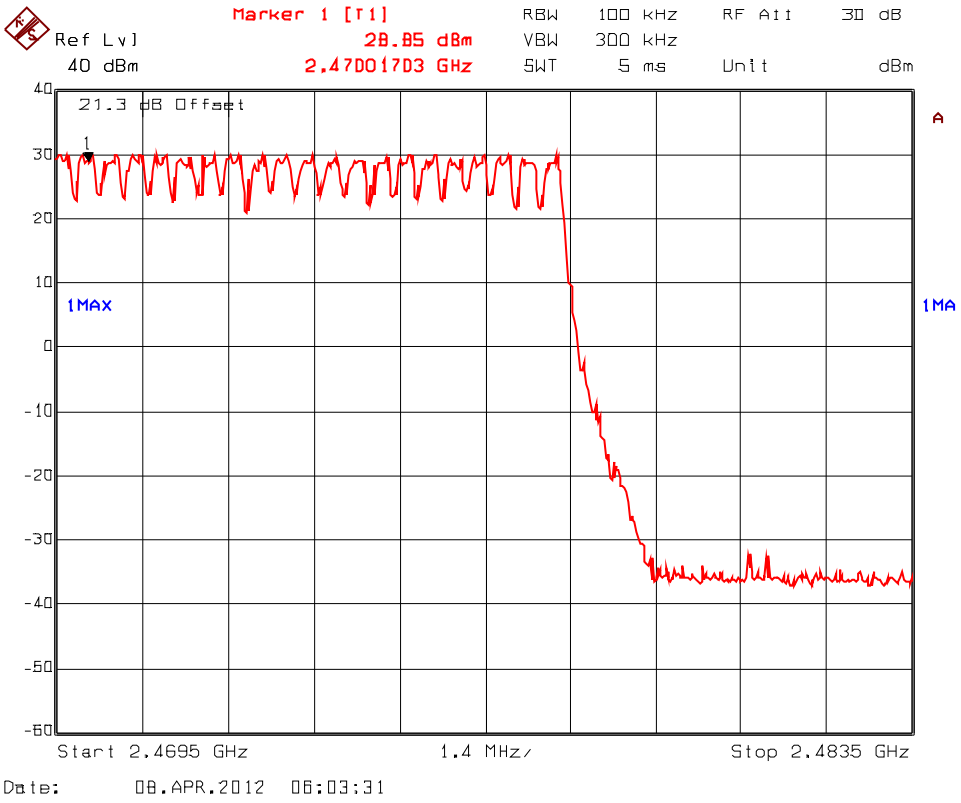
Plot 5.3.4.8. Number of Hopping Frequencies, Data Rate 5
0 Hopping Channels from 2419.5 - 2463 MHz



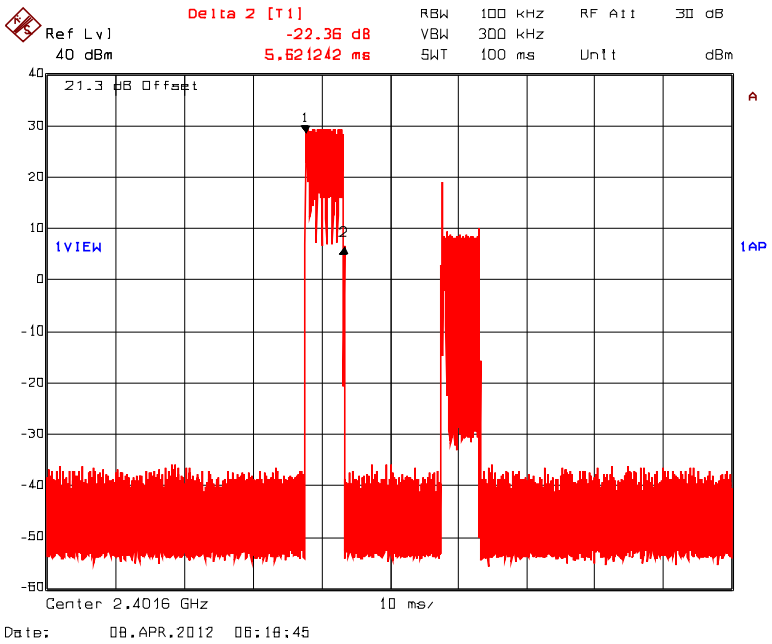
Plot 5.3.4.9. Number of Hopping Frequencies, Data Rate 5
18 Hopping Channels from 2462.5 – 2470 MHz



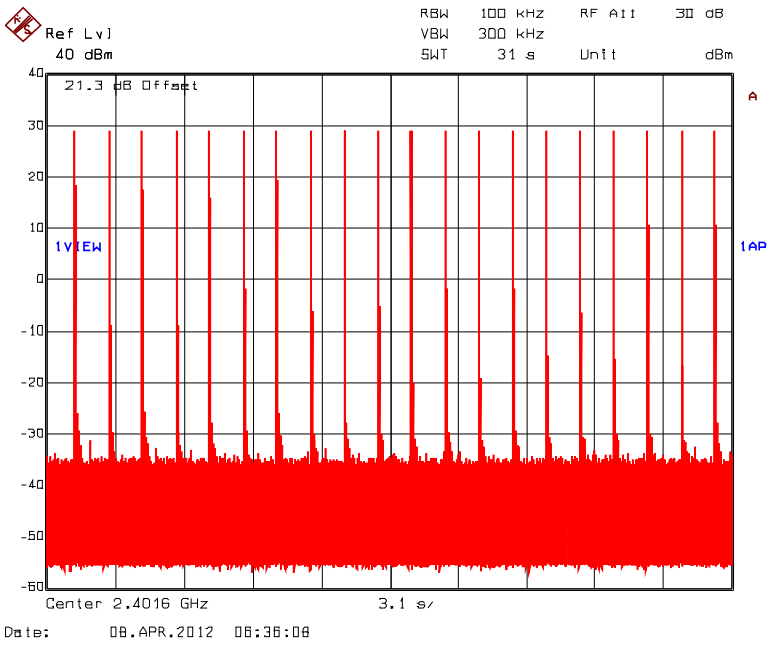
Plot 5.3.4.10. Number of Hopping Frequencies, Data Rate 5
20 Hopping Channels from 2469.5 - 2483.5 MHz



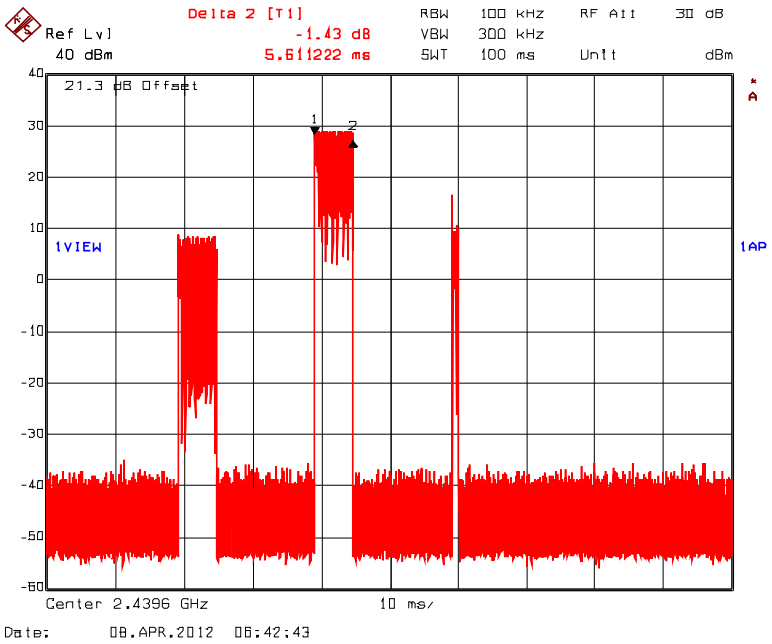
Plot 5.3.4.11. Time of Occupancy, 2401.6 MHz at Data Rate 5
Dwell Time @ 2401.6 MHz = 5.621242 ms



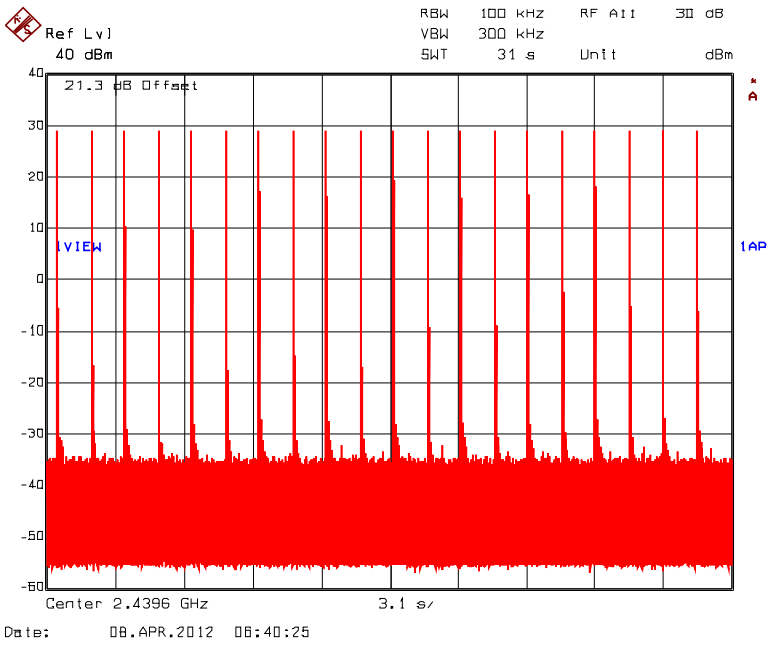
Plot 5.3.4.12. Time of Occupancy, 2401.6 MHz at Data Rate 5
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 5.621242 ms x 20 = 112.42 ms



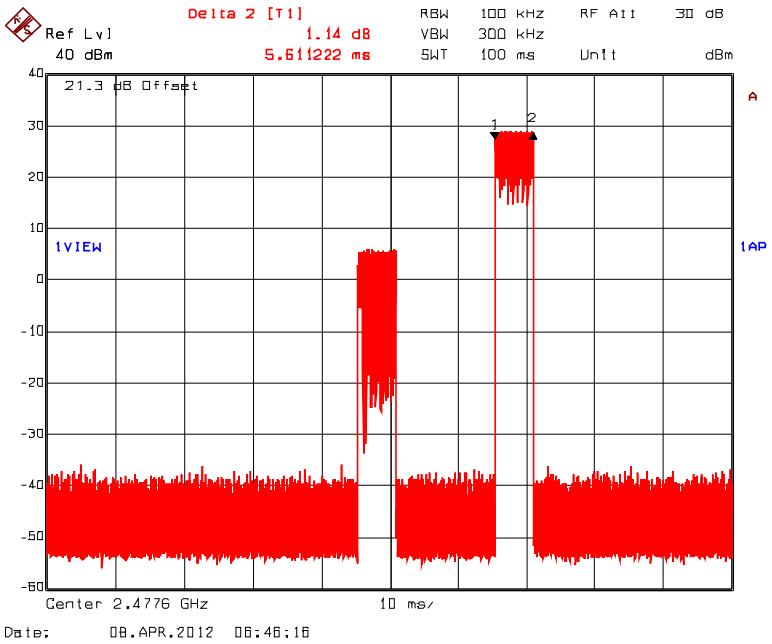
Plot 5.3.4.13. Time of Occupancy, 2439.6 MHz at Data Rate 5
Dwell Time @ 2439.6 MHz = 5.611222 ms



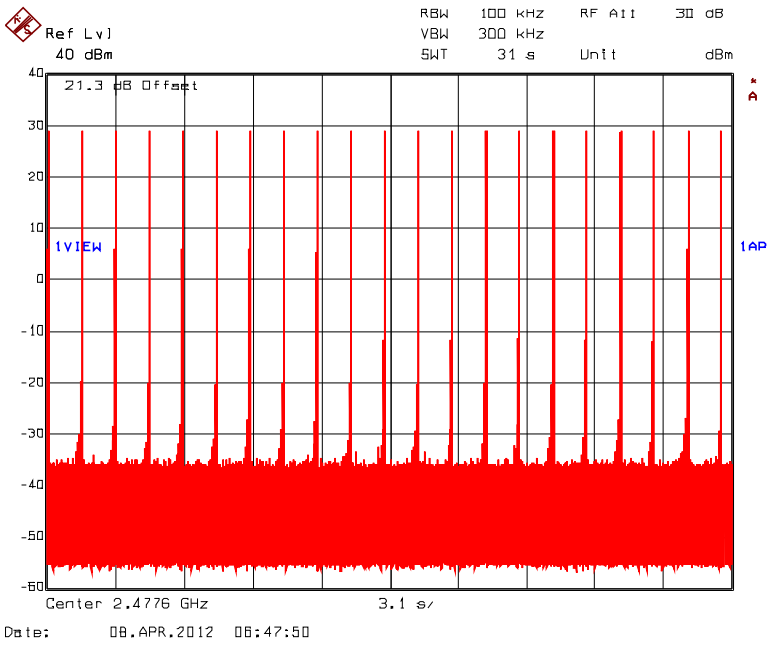
Plot 5.3.4.14. Time of Occupancy, 2439.6 MHz at Data Rate 5
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 5.611222 ms x 20 = 112.22 ms



Plot 5.3.4.15. Time of Occupancy, 2477.6 MHz at Data Rate 5
Dwell Time @ 2477.6 MHz = 5.611222 ms



Plot 5.3.4.16. Time of Occupancy, 2477.6 MHz at Data Rate 5
Average time of occupancy = (Dwell Time) x (number of hops within a period) = 5.611222 ms x 20 = 112.22 ms



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

5.4. PEAK CONDUCTED OUTPUT POWER [§ 15.247(b)(2)]

5.4.1. Limit

§15.247(b)(1): For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

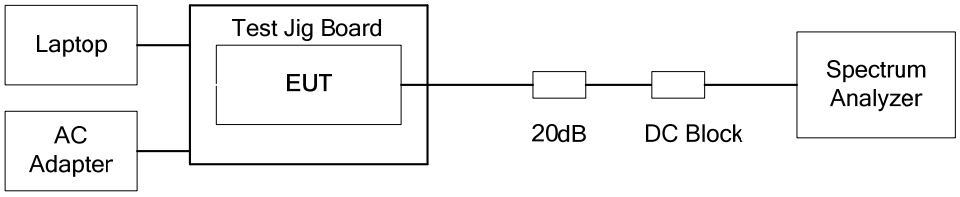
§15.247(b)(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted 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.

§15.247(b)(4)(i): Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

5.4.2. Method of Measurements

FCC Public Notice DA 00-705 and ANSI C63.10.

5.4.3. Test Arrangement



5.4.4. Test Data

Remarks:

1) Tests are performed at Data Rate 5, see operational description exhibit for details.
2) All non-integral antennas shall be connected to the n2420BT with an adaptor cable (11" MMCX to RPTNC male cable with 0.69dB loss)

Frequency (MHz)	Data Rate	Peak Output Power at Antenna Terminal (dBm)	Calculated EIRP (dBm)	Peak Output Power Limit (dBm)	EIRP Limit (dBm)	Power Setting
High Power Setting						
2401.6	5	29.99	See notes below	30	36	50
2439.6	5	29.99	See notes below	30	36	50
2477.6	5	29.80	See notes below	30	36	50
Low Power Setting						
2401.6	5	6.80	See notes below	30	36	0
2439.6	5	7.29	See notes below	30	36	0
2477.6	5	7.93	See notes below	30	36	0

Notes:
1. The EIRP shall be calculated based on the transmitter antenna gain (G_{dBi}), cable loss (CL_{dB}) and peak output power at antenna terminal (P_{dBm}). Calculated EIRP = $P_{dBm} + G_{dBi} - CL_{dB}$
2. The following power settings, measured powers and antenna assembly gains are conditions required for compliance with band-edge radiated emissions.

Frequency (MHz)	Data Rate	Peak Output Power at Antenna Terminal (dBm)	*Calculated EIRP (dBm)	Power Setting
14.0 dBi Patch Antenna with Maximum Antenna Assembly Gain of 12.51 dBi				
2401.6	5	21.35	33.86	40
2439.6	5	22.38	34.89	40
2477.6	5	22.38	34.89	40
14.5 dBi Yagi Directional Antenna with Maximum Antenna Assembly Gain of 13.01 dBi				
2401.6	5	17.97	30.98	38
2439.6	5	17.84	30.85	38
2477.6	5	17.71	30.72	38
15 dBi Yagi Directional Antenna with Maximum Antenna Assembly Gain of 13.51 dBi				
2401.6	5	21.35	34.86	40
2439.6	5	22.38	35.89	40
2477.6	5	22.38	35.89	40

* EIRP = P_{dBm} + Antenna Assembly Gain ($G_{dBi} - CL_{dB}$)

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

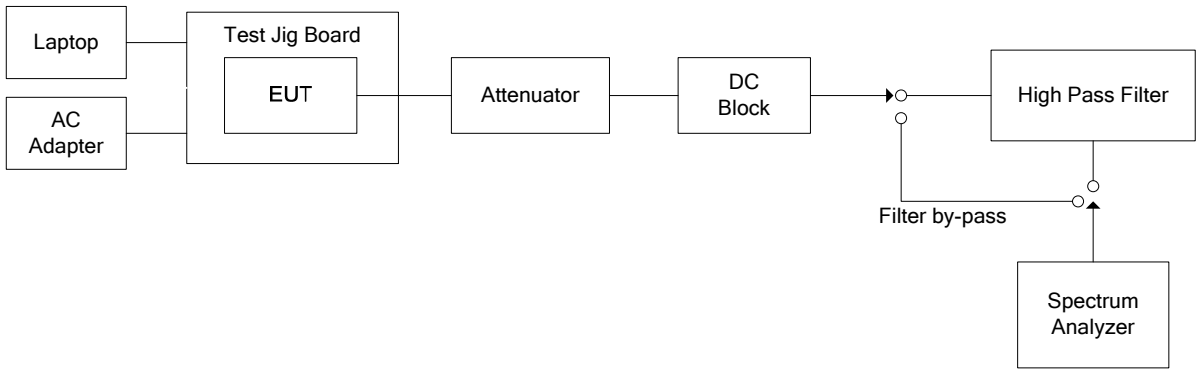
5.5.1. Limit

§ 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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

5.5.2. Method of Measurements

FCC Public Notice DA 00-705 and ANSI C63.10

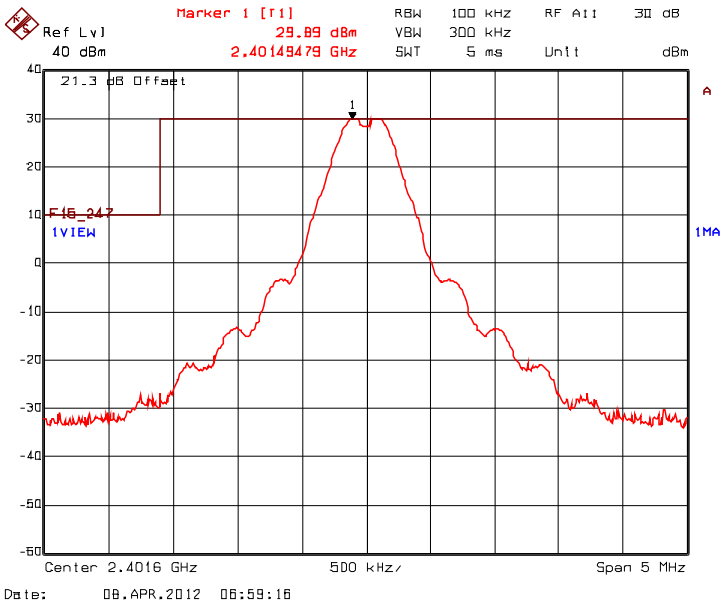
5.5.3. Test Arrangement



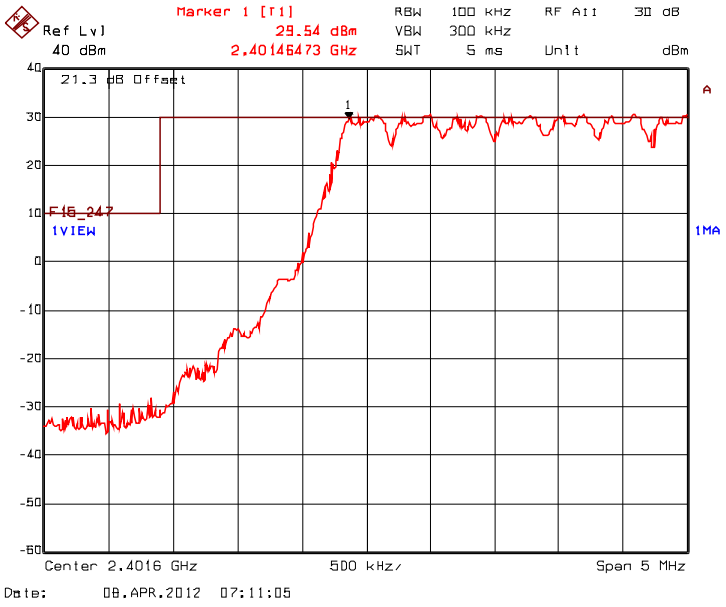
5.5.4. Test Data

5.5.4.1. Band-Edge RF Conducted Emissions

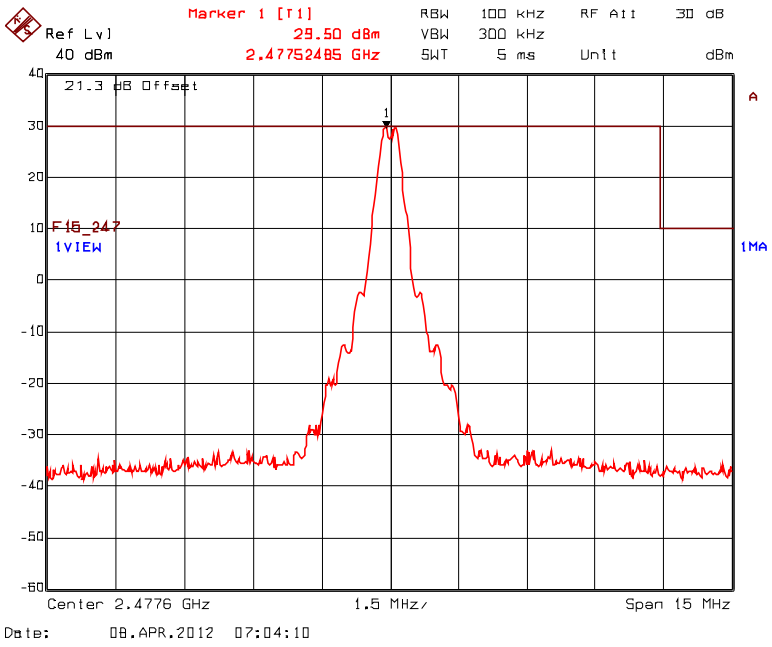
Plot 5.5.4.1.1. Band-Edge RF Conducted Emissions
Single Frequency Mode, Low End of Frequency Band, 2401.6 MHz



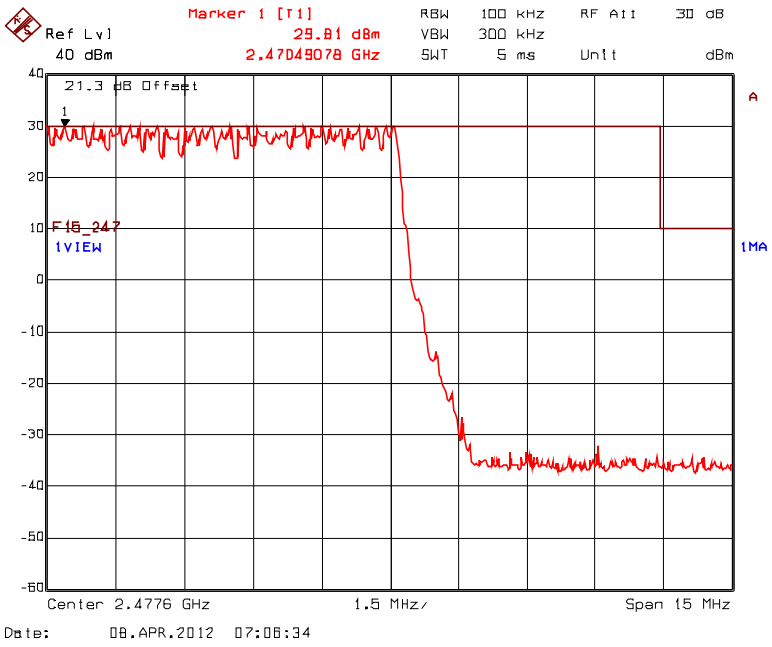
Plot 5.5.4.1.2. Band-Edge RF Conducted Emissions
Pseudorandom Channel Hopping Mode, Low End of Frequency Band, 2401.6 MHz



Plot 5.5.4.1.3. Band-Edge RF Conducted Emissions
Single Frequency Mode, High End of Frequency Band, 2477.6 MHz

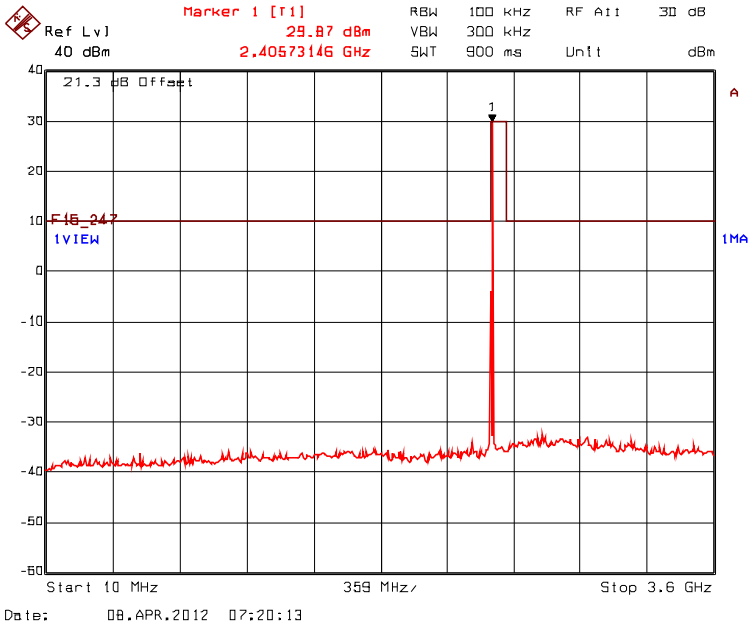


Plot 5.5.4.1.4. Band-Edge RF Conducted Emissions
Pseudorandom Channel Hopping Mode, High End of Frequency Band, 2477.6 MHz

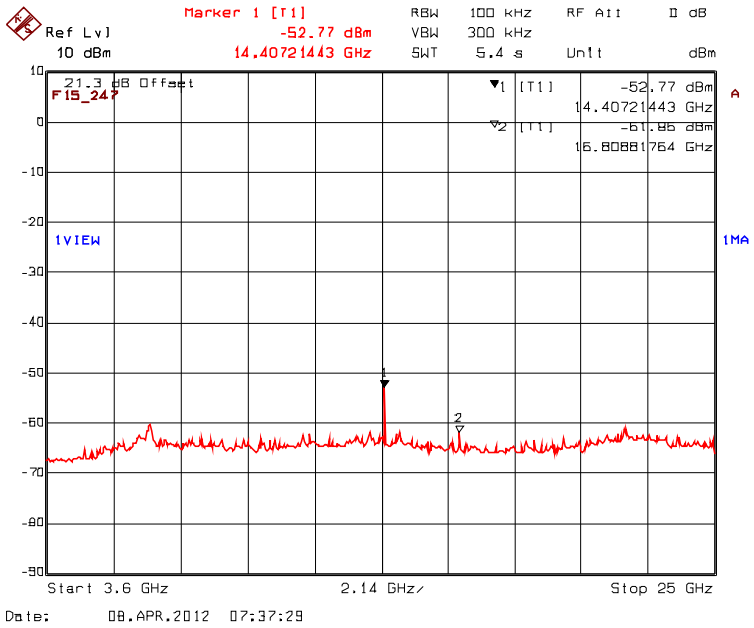


5.5.4.2. Spurious RF Conducted Emissions

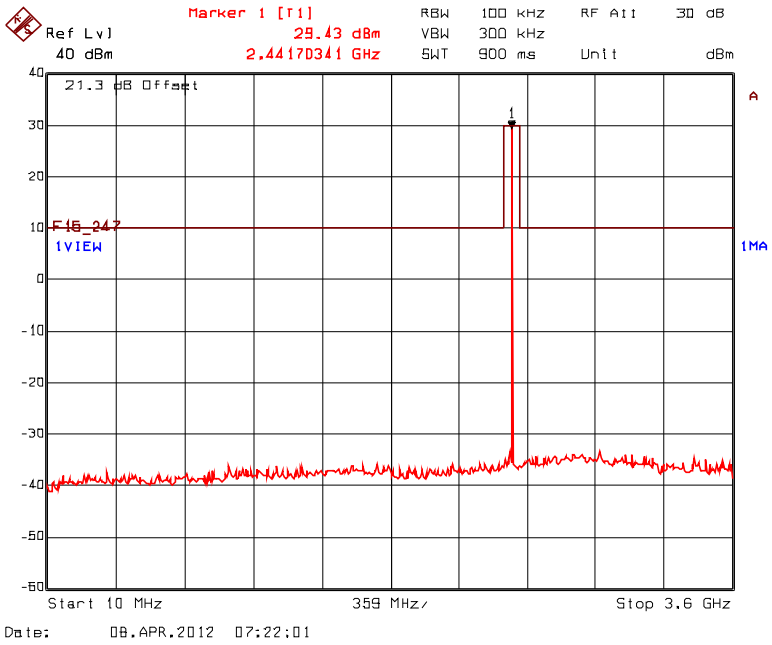
Plot 5.5.4.2.1. Spurious RF Conducted Emissions
High Power, 2401.6 MHz, Data Rate 5, 10 MHz – 3.6 GHz



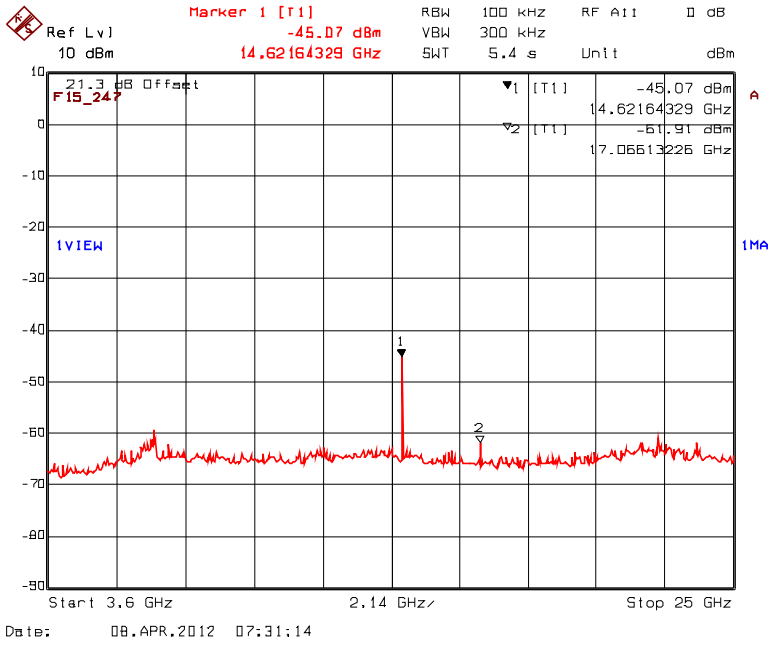
Plot 5.5.4.2.2. Conducted Spurious Emissions - Non Restricted Frequency Bands
High Power, 2401.6 MHz, Data Rate 5,,3.6 GHz - 25 GHz



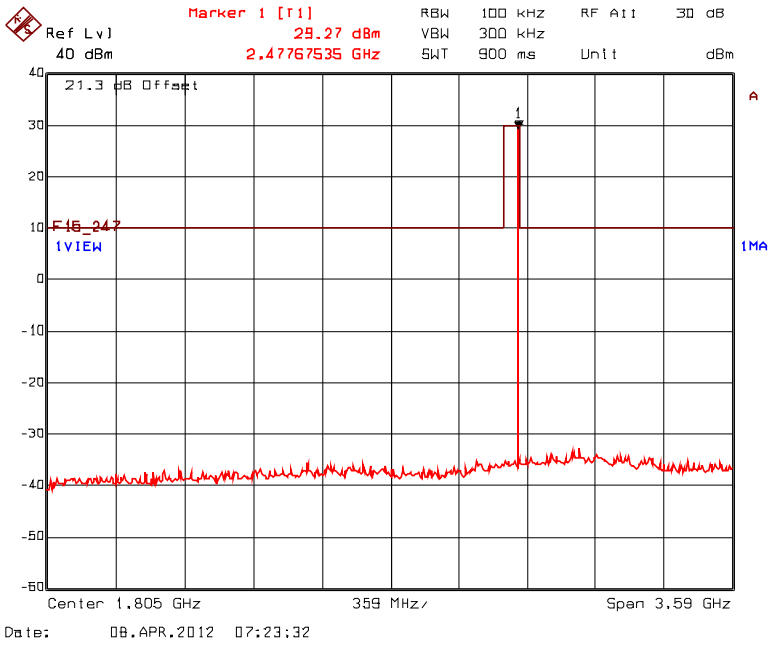
Plot 5.5.4.2.3. Spurious RF Conducted Emissions
High Power, 2439.6 MHz, Data Rate 5, 10 MHz – 3.6 GHz



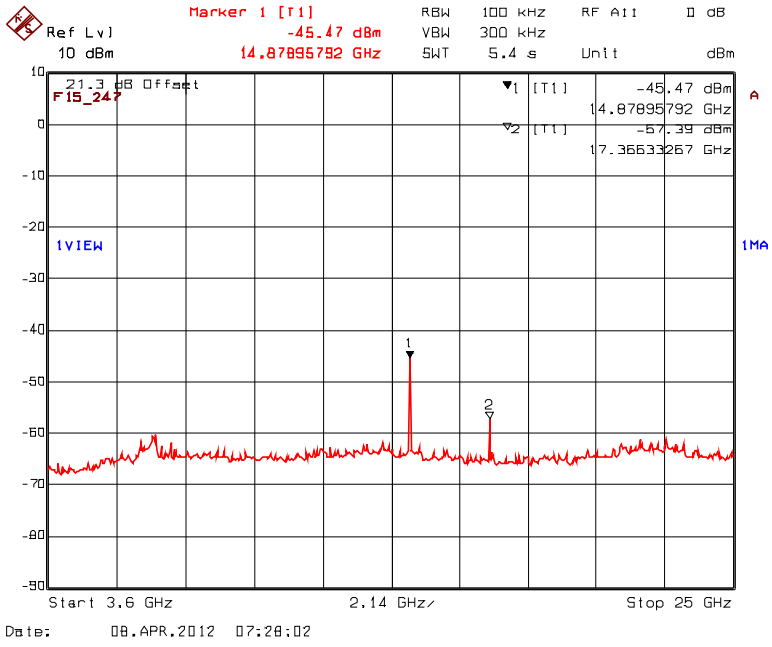
Plot 5.5.4.2.4. Conducted Spurious Emissions - Non Restricted Frequency Bands
High Power, 2439.6 MHz, Data Rate 5,,3.6 GHz - 25 GHz



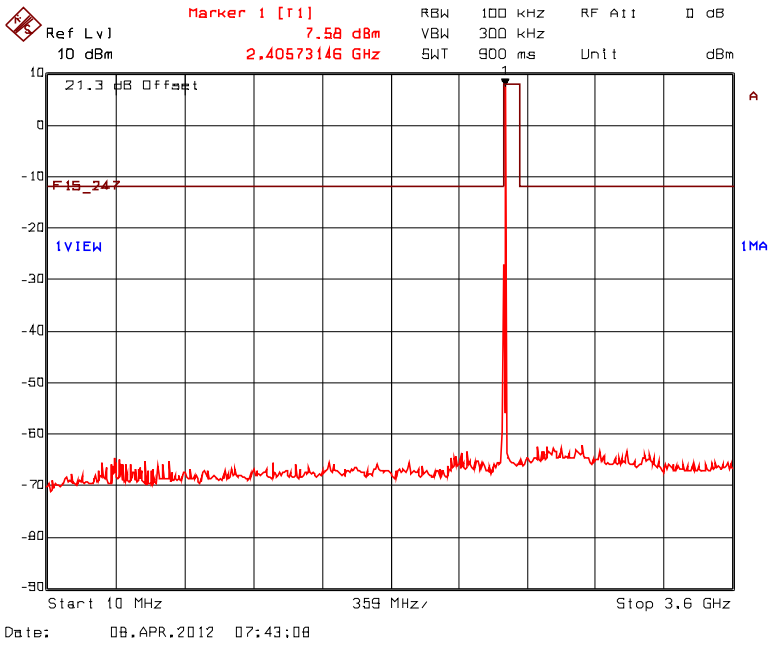
Plot 5.5.4.2.5. Spurious RF Conducted Emissions
High Power, 2477.6 MHz, Data Rate 5, 10 MHz – 3.6 GHz



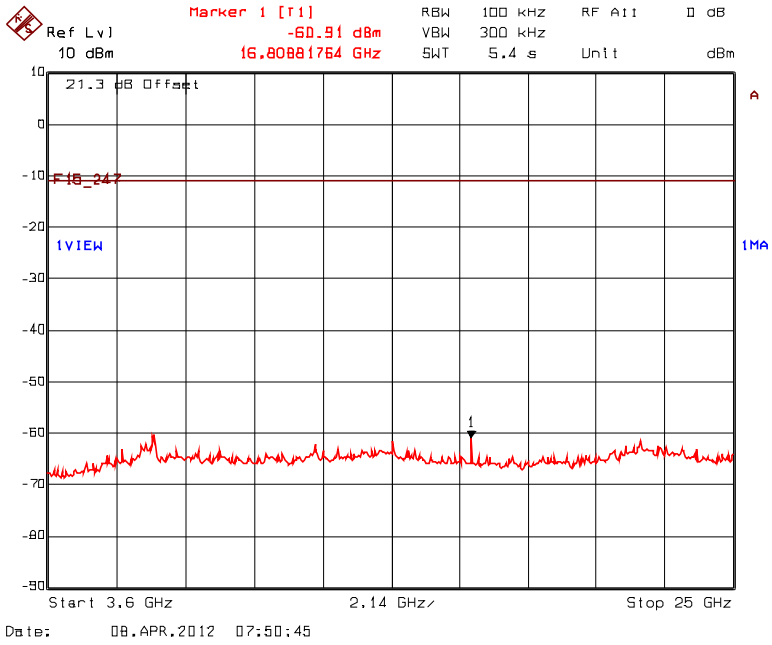
Plot 5.5.4.2.6. Conducted Spurious Emissions - Non Restricted Frequency Bands
High Power, 2477.6 MHz, Data Rate 5,,3.6 GHz - 25 GHz



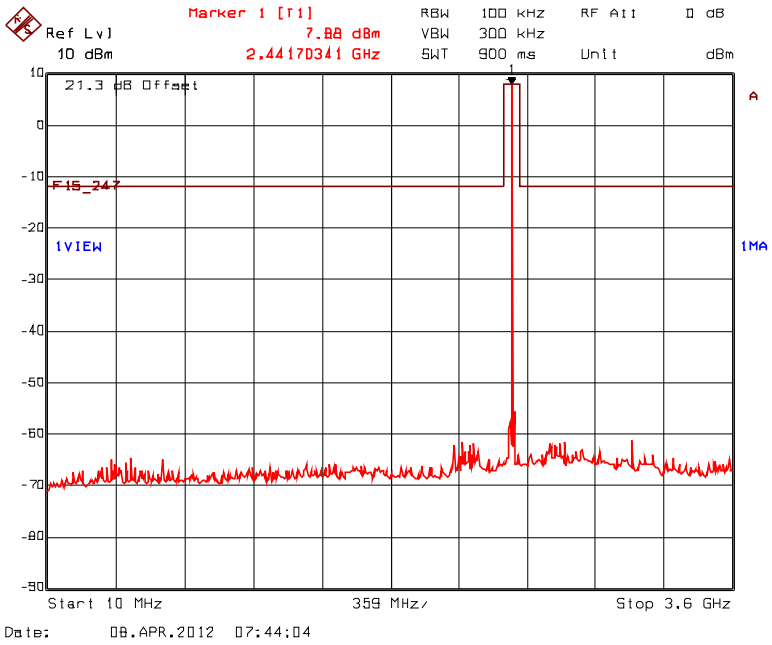
Plot 5.5.4.2.7. Spurious RF Conducted Emissions
Low Power, 2401.6 MHz, Data Rate 5, 10 MHz – 3.6 GHz



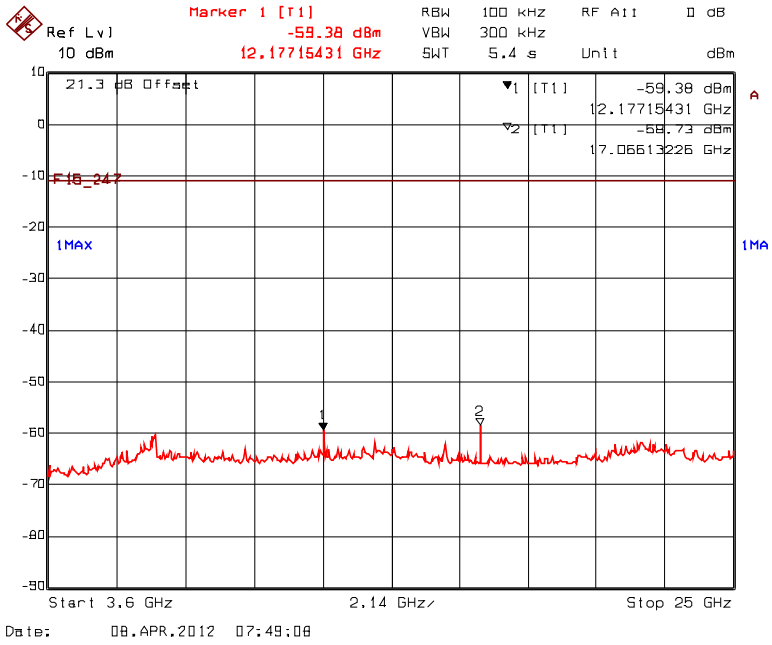
Plot 5.5.4.2.8. Conducted Spurious Emissions - Non Restricted Frequency Bands
Low Power, 2401.6 MHz, Data Rate 5,,3.6 GHz - 25 GHz



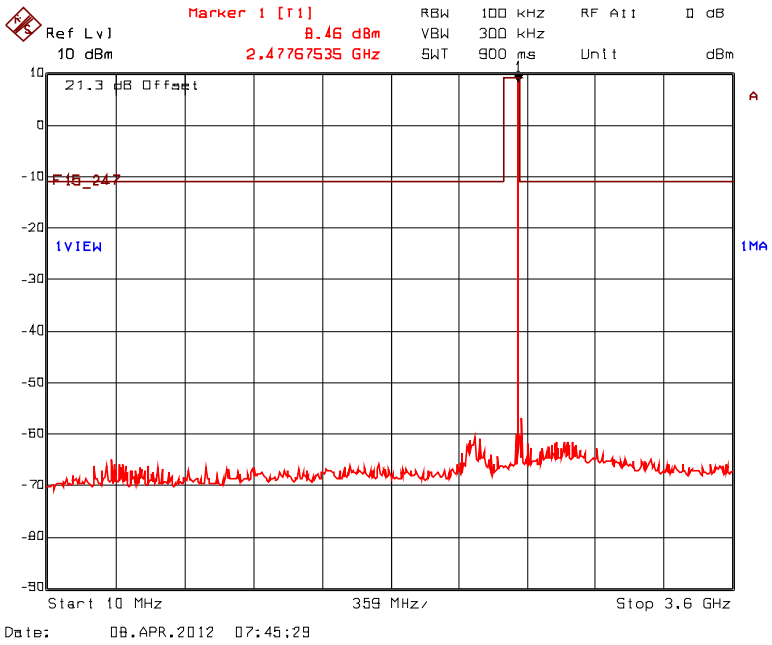
Plot 5.5.4.2.9. Spurious RF Conducted Emissions
Low Power, 2439.6 MHz, Data Rate 5, 10 MHz – 3.6 GHz



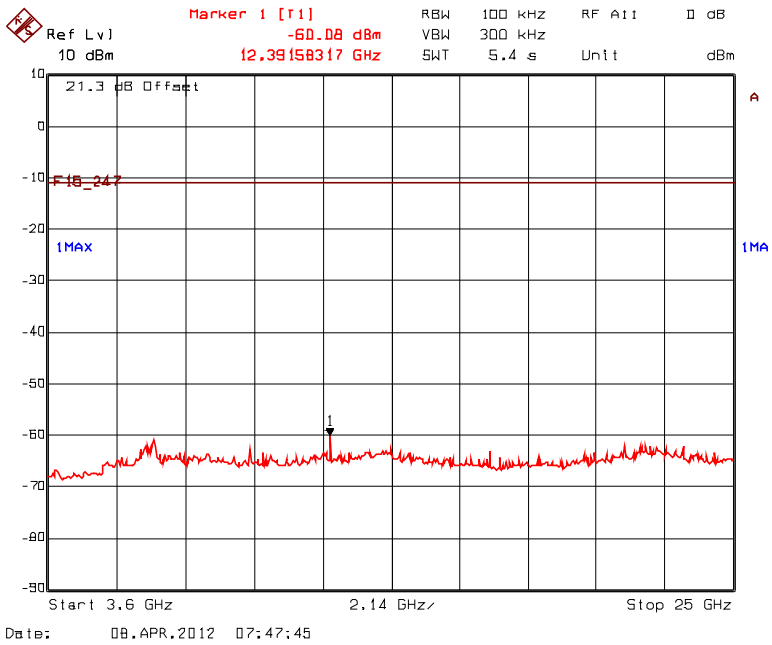
Plot 5.5.4.2.10. Conducted Spurious Emissions - Non Restricted Frequency Bands
High Power, 2439.6 MHz, Data Rate 5,,3.6 GHz - 25 GHz



Plot 5.5.4.2.11. Spurious RF Conducted Emissions
Low Power, 2477.6 MHz, Data Rate 5, 10 MHz – 3.6 GHz



Plot 5.5.4.2.12. Conducted Spurious Emissions - Non Restricted Frequency Bands
Low Power, 2477.6 MHz, Data Rate 5,,3.6 GHz - 25 GHz



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

5.6.1. Limit

§ 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

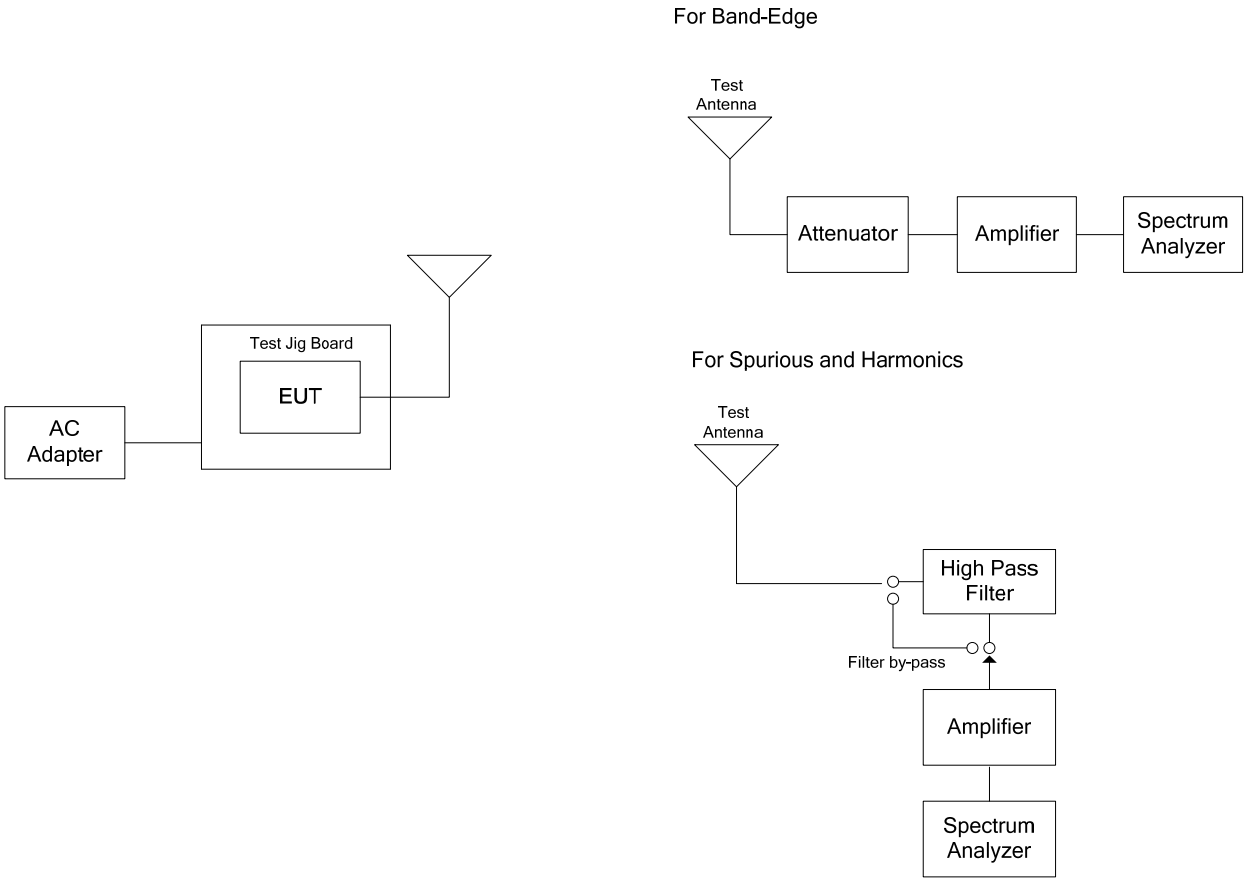
Section 15.209(a) - Field Strength Limits within Restricted Frequency Bands

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

5.6.2. Method of Measurements

FCC Public Notice DA 00-705, ANSI C63.10 and ANSI 63.4 procedures.

5.6.3. Test Arrangement



5.6.4. Test Data

Remark(s):

- 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.

5.6.4.1. EUT with 2 dBi Rubber Ducky Antenna and 0.69 dB Assembly Cable Loss

5.6.4.1.1. Spurious Radiated Emissions

Fundamental Frequency:	2401.6 MHz
Software Power Setting:	50
Measured Conducted Power:	29.99 dBm
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
2401.6	125.53	--	V	--	--	--	--
2401.6	124.89	--	H	--	--	--	--
4803.2	54.53	48.25	V	54.0	105.5	-5.8	Pass*
4803.2	50.95	43.58	H	54.0	105.5	-10.4	Pass*
12008.0	56.36	43.26	V	54.0	105.5	-10.7	Pass*
12008.0	58.14	47.51	H	54.0	105.5	-6.5	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2439.6 MHz
Software Power Setting:	50
Measured Conducted Power:	29.99 dBm
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
2439.6	126.42	--	V	--	--	--	--
2439.6	126.95	--	H	--	--	--	--
4879.2	51.47	45.50	V	54.0	107.0	-8.5	Pass*
4879.2	51.33	44.23	H	54.0	107.0	-9.8	Pass*
7318.8	53.47	44.26	V	54.0	107.0	-9.7	Pass*
7318.8	54.26	43.84	H	54.0	107.0	-10.2	Pass*
12198.0	58.02	45.33	V	54.0	107.0	-8.7	Pass*
12198.0	60.30	49.81	H	54.0	107.0	-4.2	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2477.6 MHz
Software Power Setting:	50
Measured Conducted Power:	29.80 dBm
Frequency Test Range:	30 MHz – 25 GHz

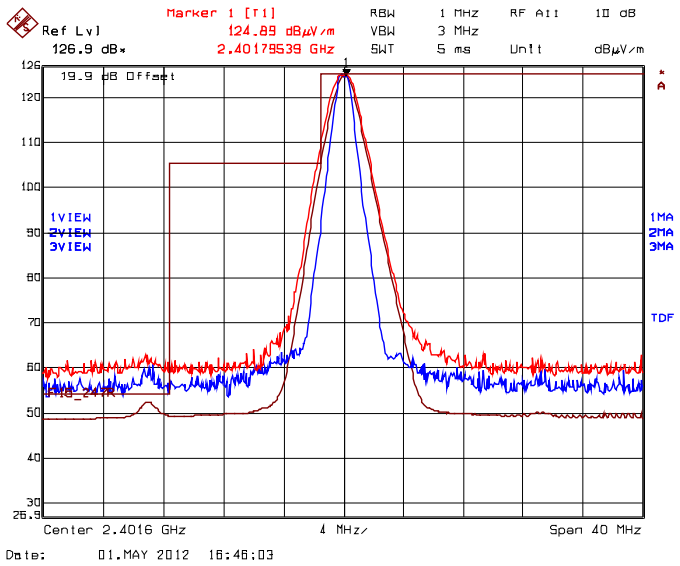
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2477.6	126.73	--	V	--	--	--	--
2477.6	127.74	--	H	--	--	--	--
4955.2	53.19	46.65	V	54.0	107.7	-7.4	Pass*
4955.2	48.67	42.62	H	54.0	107.7	-11.4	Pass*
7432.8	57.48	47.67	V	54.0	107.7	-6.3	Pass*
7432.8	55.46	47.33	H	54.0	107.7	-6.7	Pass*
12388.0	60.81	48.32	V	54.0	107.7	-5.7	Pass*
12388.0	56.39	45.24	H	54.0	107.7	-8.8	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

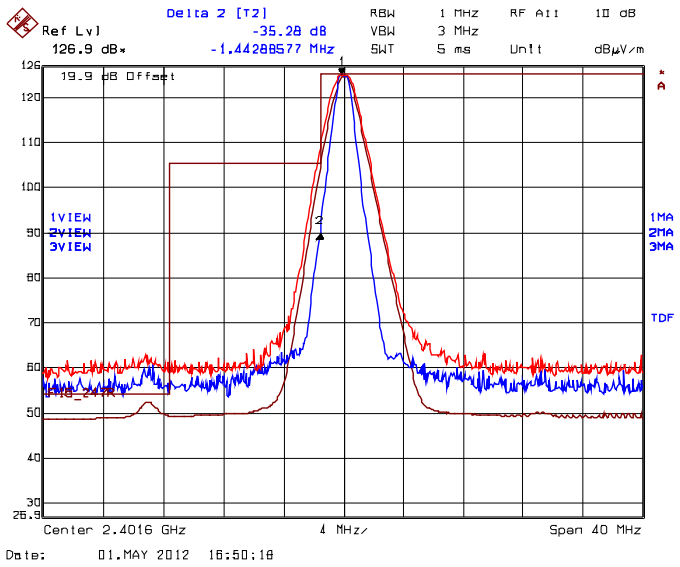
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.6.4.1.2. Band-Edge RF Radiated Emissions

Plot 5.6.4.1.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 50, Data Rate 5

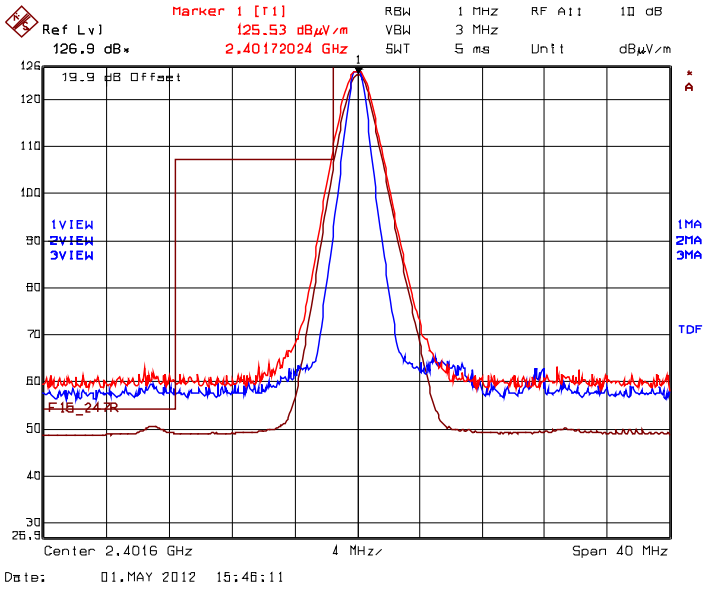


Plot 5.6.4.1.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 50, Data Rate 5

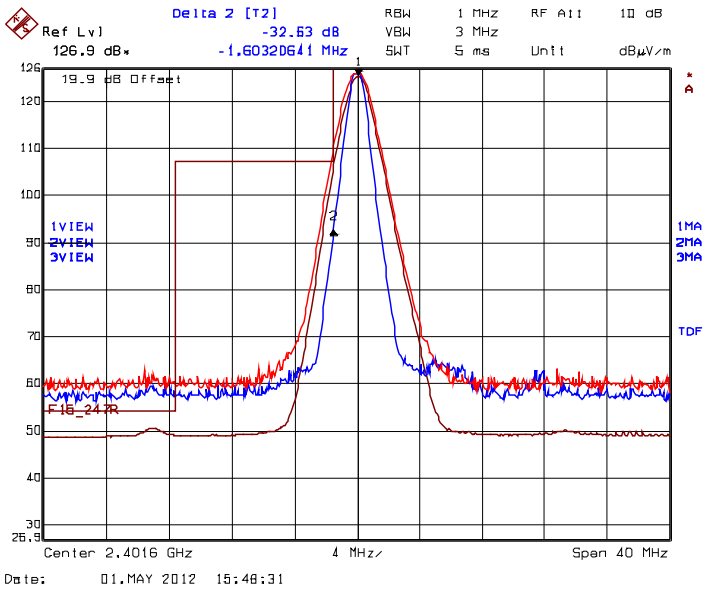


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 35.28 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 124.89 dBµV/m – 35.28 dB = 89.61 dBµV/m (limit 104.89 dBµV/m)
Average level at 2388.57 MHz = 52.32 dBµV/m (Restricted band 2310-2390 MHz) (limit 54 dBµV/m)

Plot 5.6.4.1.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 50, Data Rate 5

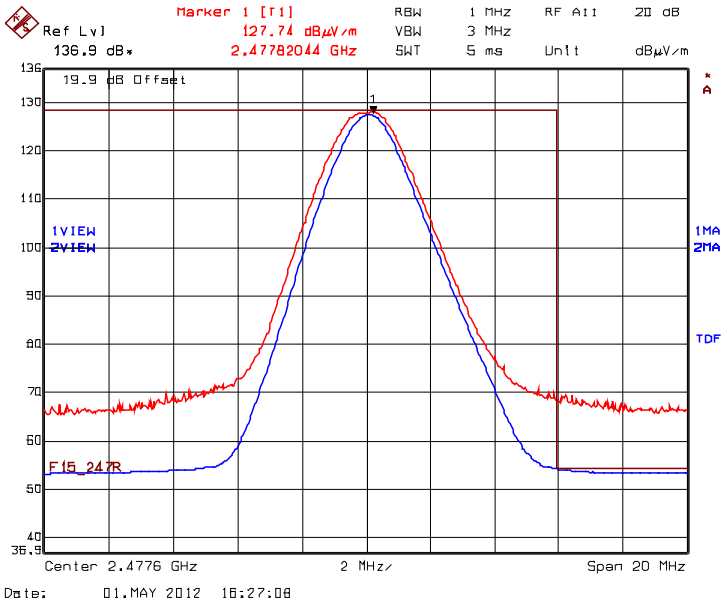


Plot 5.6.4.1.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 50, Data Rate 5

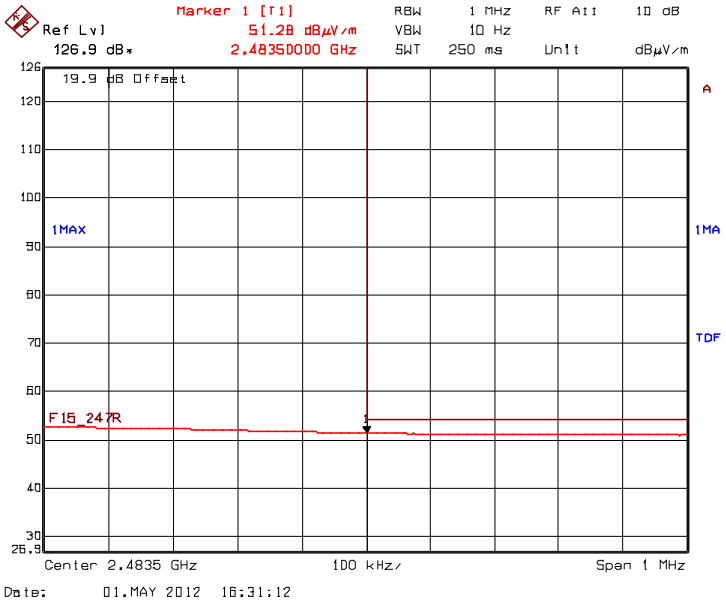


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 32.63 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 125.53 dBµV/m – 32.63 dB = 92.90 dBµV/m (limit 105.53 dBµV/m)
Average level at 2388.57 MHz = 50.37 dBµV/m (Restricted band 2310-2390 MHz) (limit 54 dBµV/m)

Plot 5.6.4.1.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 50, Data Rate 5

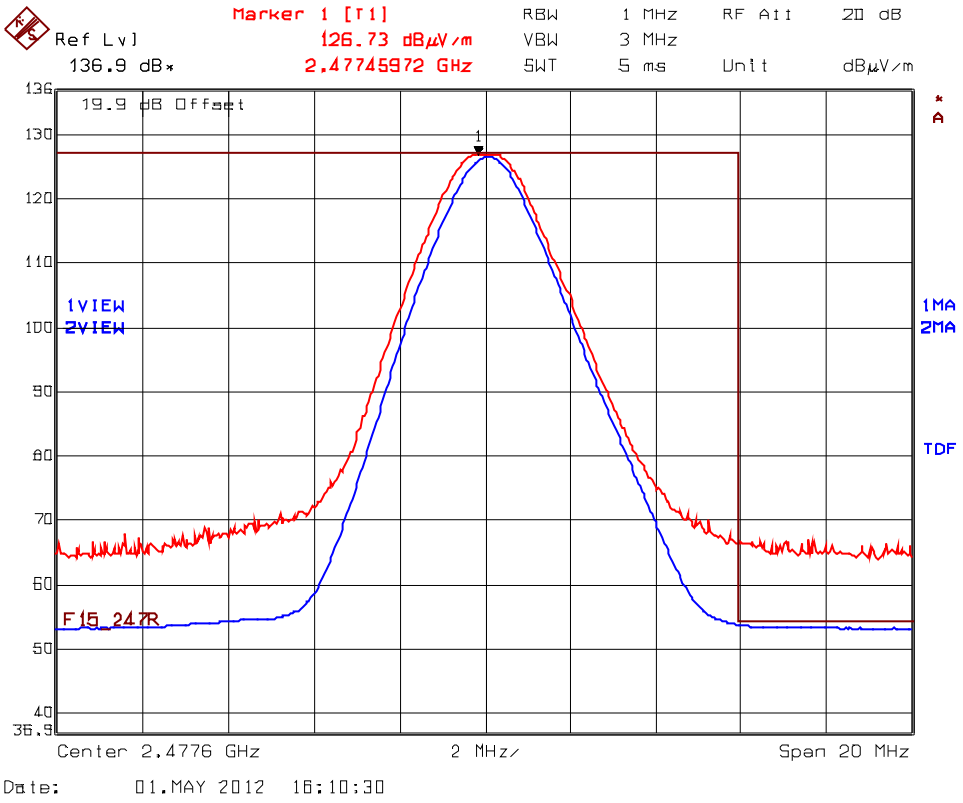


Plot 5.6.4.1.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 50, Data Rate 5



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

Plot 5.6.4.1.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 50, Data Rate 5



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

5.6.4.2. EUT with 14 dBi Patch Antenna and 1.49 dB Assembly Cable Loss

5.6.4.2.1. Spurious Radiated Emissions

Fundamental Frequency:	2401.6 MHz
Software Power Setting:	40
Measured Conducted Power:	21.35 dBm
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
2401.6	120.86	--	V	--	--	--	--
2401.6	120.43	--	H	--	--	--	--
4803.2	48.09	35.94	V	54.0	100.9	-18.1	Pass*
4803.2	47.82	34.79	H	54.0	100.9	-19.2	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2439.6 MHz
Software Power Setting:	40
Measured Conducted Power:	22.38 dBm
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
2439.6	121.63	--	V	--	--	--	--
2439.6	121.48	--	H	--	--	--	--
4879.2	49.59	37.99	V	54.0	101.6	-16.0	Pass*
4879.2	48.66	37.40	H	54.0	101.6	-16.6	Pass*
7318.8	54.08	40.91	V	54.0	101.6	-13.1	Pass*
7318.8	52.43	40.06	H	54.0	101.6	-13.9	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2477.6 MHz
Software Power Setting:	40
Measured Conducted Power:	22.38 dBm
Frequency Test Range:	30 MHz – 25 GHz

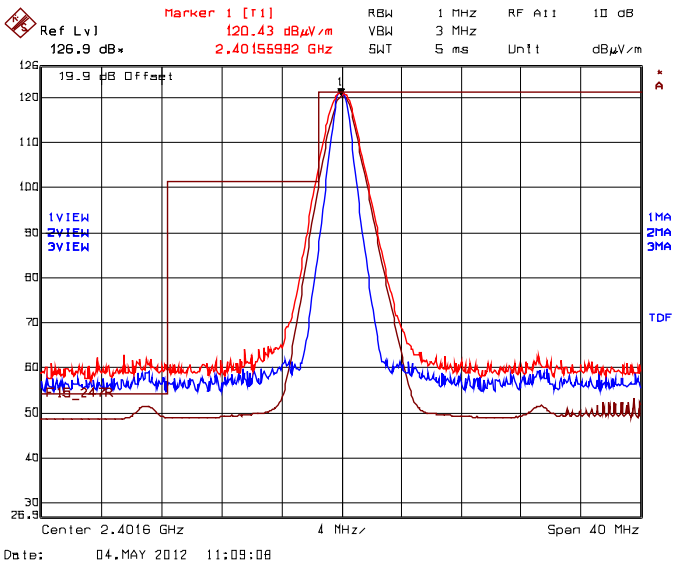
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2477.6	122.15	--	V	--	--	--	--
2477.6	121.93	--	H	--	--	--	--
4955.2	48.83	37.73	V	54.0	102.2	-16.3	Pass*
4955.2	48.79	37.45	H	54.0	102.2	-16.6	Pass*
7432.8	53.57	40.78	V	54.0	102.2	-13.2	Pass*
7432.8	54.22	43.43	H	54.0	102.2	-10.6	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

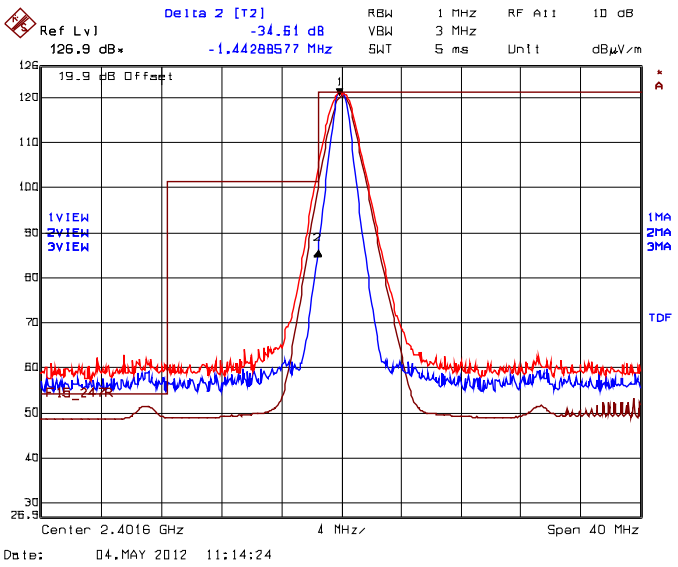
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.6.4.2.2. Band-Edge RF Radiated Emissions

Plot 5.6.4.2.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

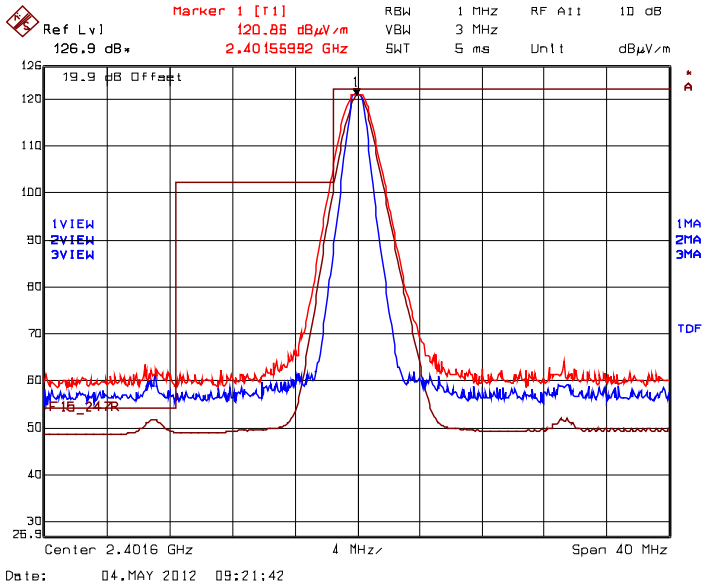


Plot 5.6.4.2.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

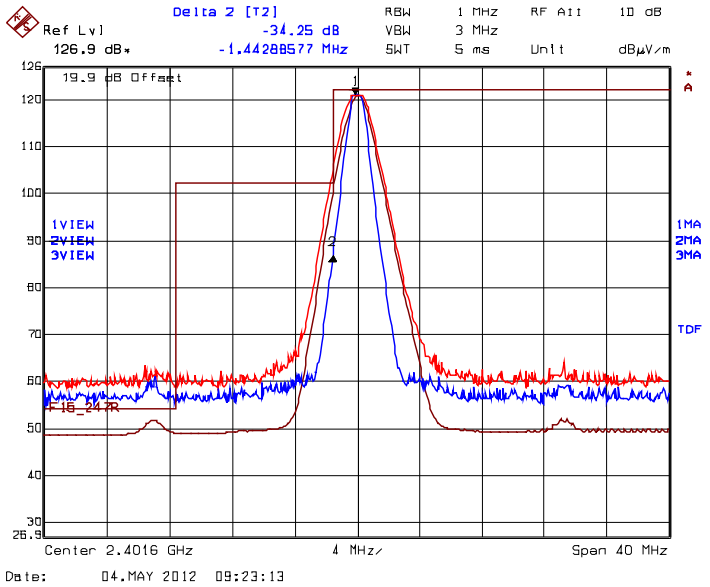


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 34.61 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 120.43 dBµV/m – 34.61 dB = 85.82 dBµV/m (limit 100.43 dBµV/m)

Plot 5.6.4.2.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

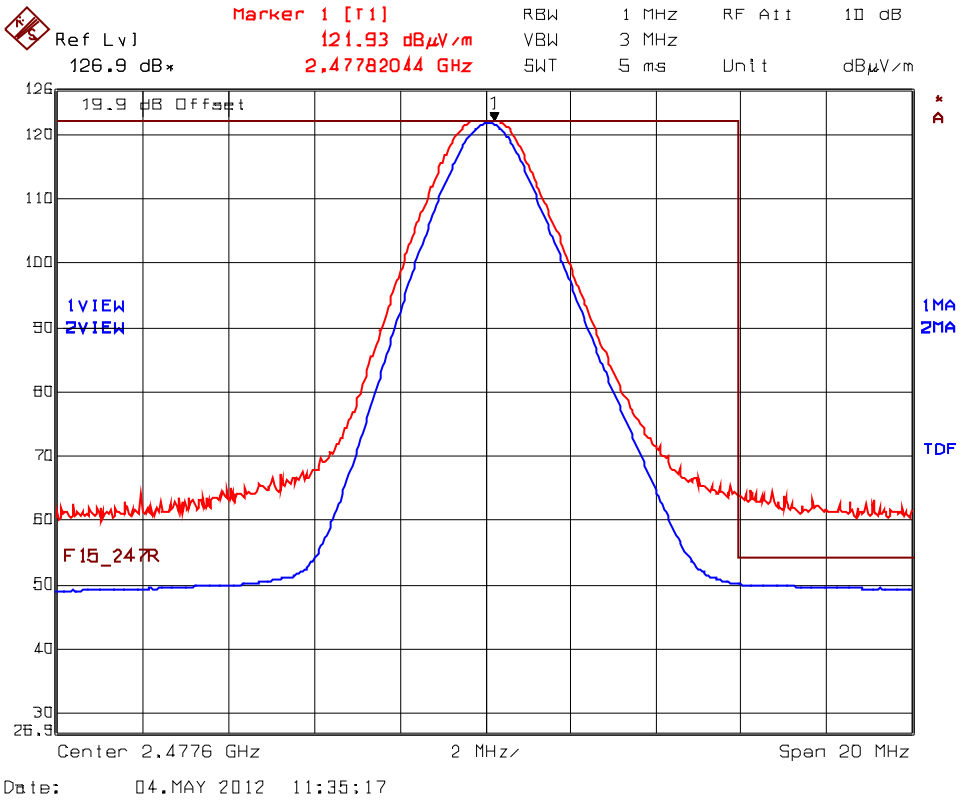


Plot 5.6.4.2.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5



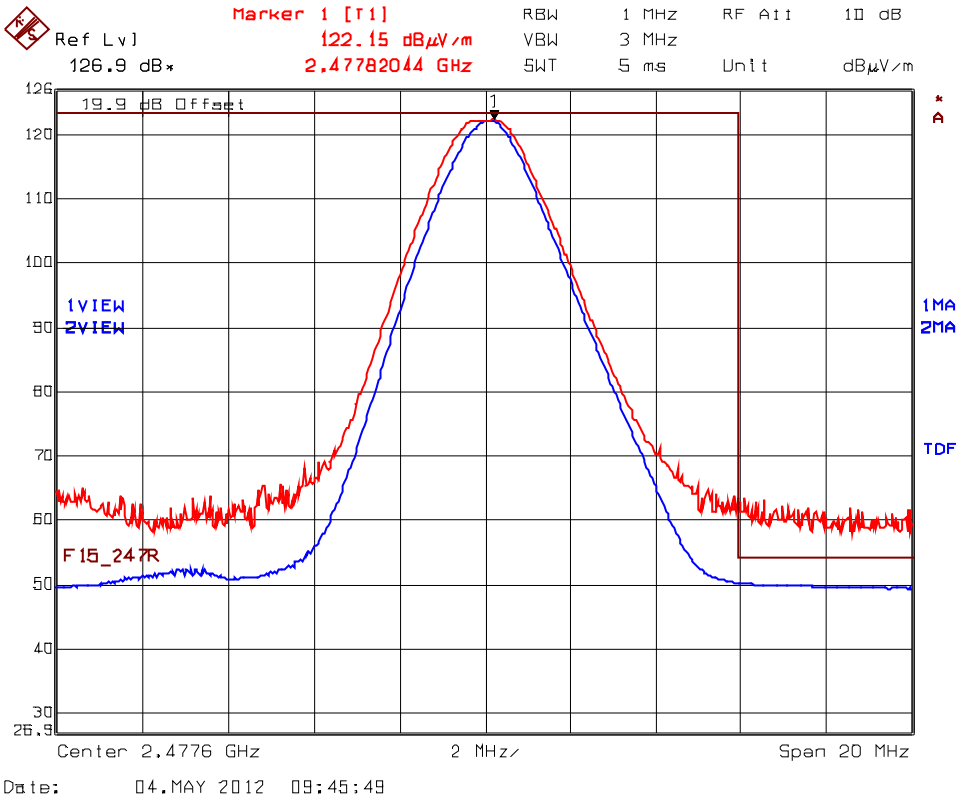
Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 34.25 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 120.86 dBµV/m – 34.25 dB = 86.61 dBµV/m (limit 100.86 dBµV/m)

Plot 5.6.4.2.2.5. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 40, Data Rate 5



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

Plot 5.6.4.2.2.6. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 40, Data Rate 5



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

5.6.4.3. EUT with 14.5 dBi Yagi Directional Antenna and 1.49 dB Assembly Cable Loss

5.6.4.3.1. Spurious Radiated Emissions

Fundamental Frequency:	2401.6 MHz
Software Power Setting:	38
Measured Conducted Power:	17.97 dBm
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
2401.6	122.03	--	V	--	--	--	--
2401.6	124.25	--	H	--	--	--	--
4803.2	47.24	34.16	V	54.0	104.3	-19.8	Pass*
4803.2	47.71	35.62	H	54.0	104.3	-18.4	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2439.6 MHz
Software Power Setting:	38
Measured Conducted Power:	17.84 dBm
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
2439.6	123.80	--	V	--	--	--	--
2439.6	123.67	--	H	--	--	--	--
4879.2	48.59	37.51	V	54.0	103.8	-16.5	Pass*
4879.2	48.33	37.29	H	54.0	103.8	-16.7	Pass*
7318.8	51.87	39.13	V	54.0	103.8	-14.9	Pass*
7318.8	52.97	40.00	H	54.0	103.8	-14.0	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2477.6 MHz
Software Power Setting:	38
Measured Conducted Power:	17.71 dBm
Frequency Test Range:	30 MHz – 25 GHz

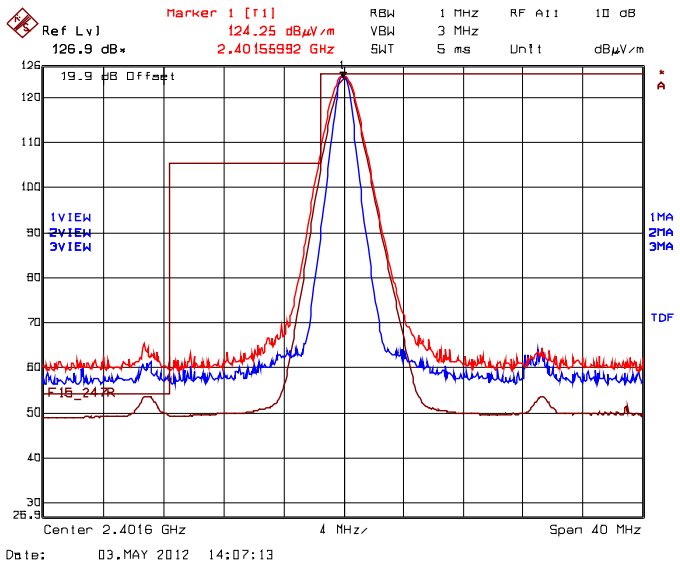
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2477.6	121.25	--	V	--	--	--	--
2477.6	124.66	--	H	--	--	--	--
4955.2	48.70	38.20	V	54.0	104.7	-15.8	Pass*
4955.2	47.80	36.57	H	54.0	104.7	-17.4	Pass*
7432.8	54.33	42.51	V	54.0	104.7	-11.5	Pass*
7432.8	53.45	42.73	H	54.0	104.7	-11.3	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

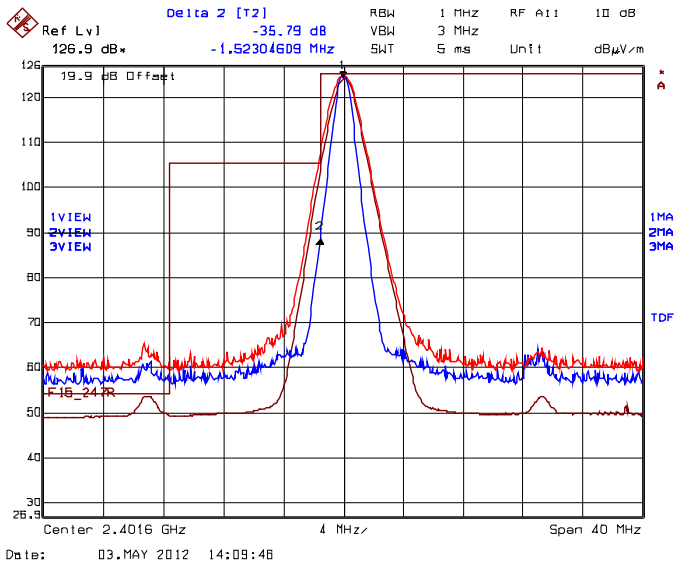
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.6.4.3.2. Band-Edge RF Radiated Emissions

Plot 5.6.4.3.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 38, Data Rate 5

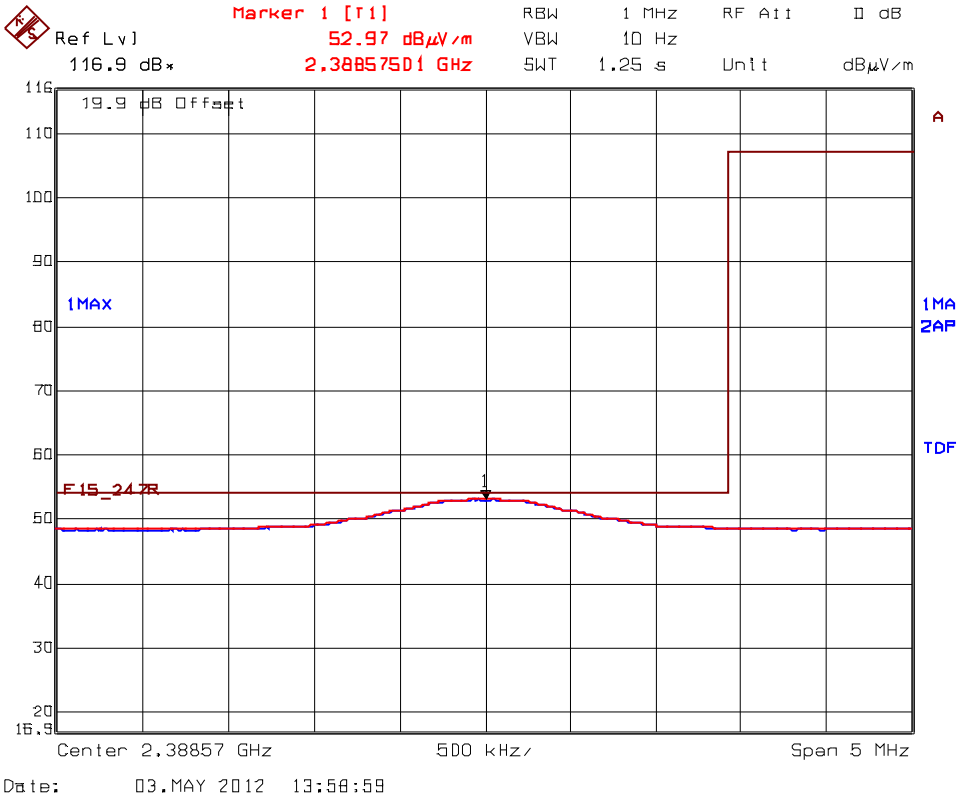


Plot 5.6.4.3.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 38, Data Rate 5

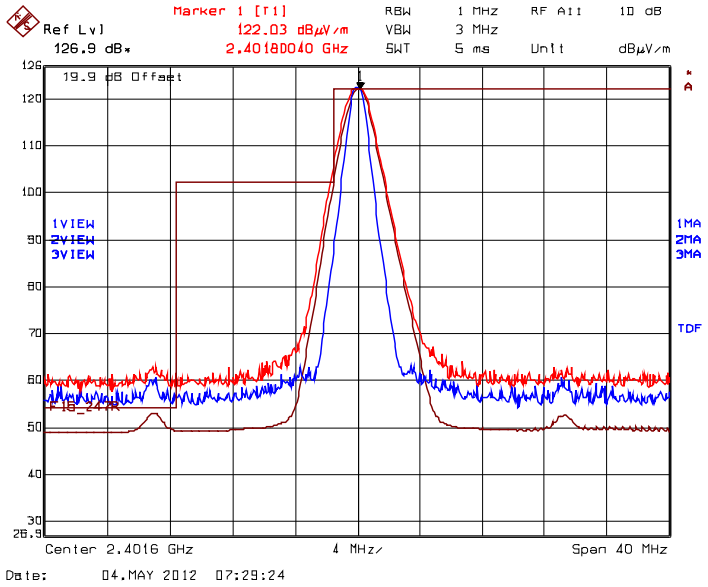


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 35.79 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 124.25 dBµV/m – 35.79 dB = 88.46 dBµV/m (limit 104.25 dBµV/m)
Average at 2388.57 MHz in 5 MHz Span = 52.97 dBµV/m (Restricted band 2310-2390 MHz) (limit 54 dBµV/m)

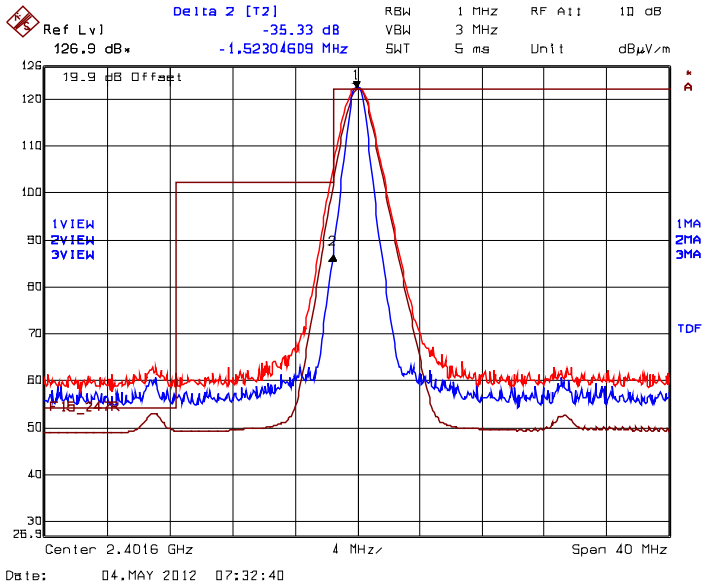
Plot 5.6.4.3.2.3. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 38, Data Rate 5
Average at 2388.57 MHz in 5 MHz Span = 52.97 dBµV/m



Plot 5.6.4.3.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 38, Data Rate 5

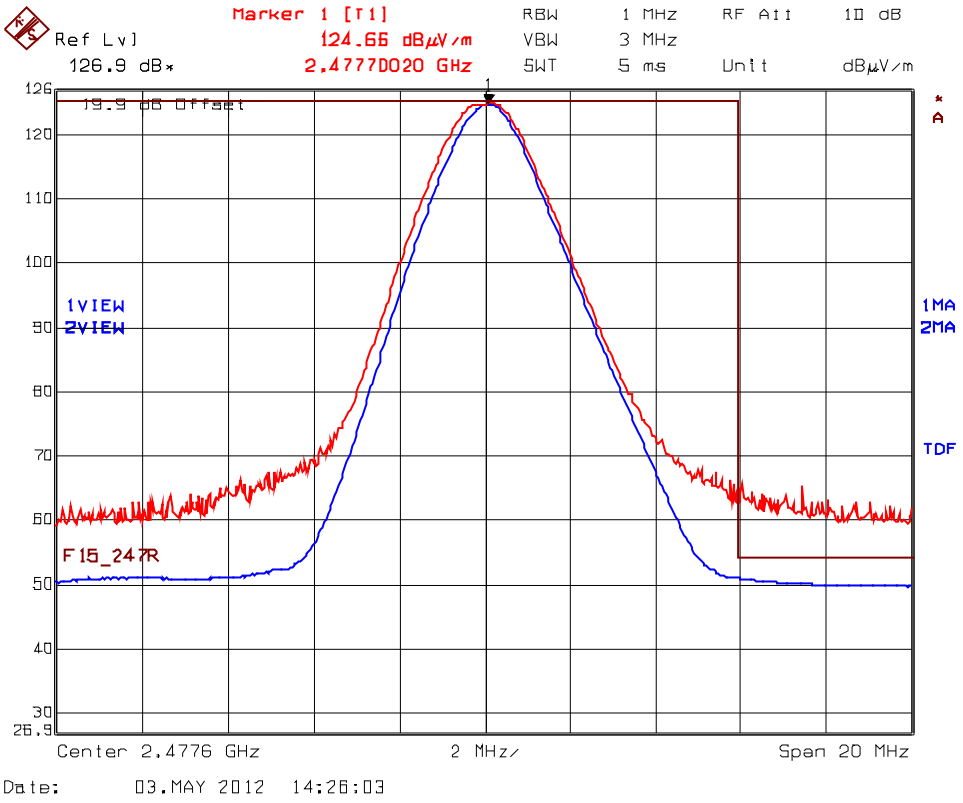


Plot 5.6.4.3.2.5. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 38, Data Rate 5



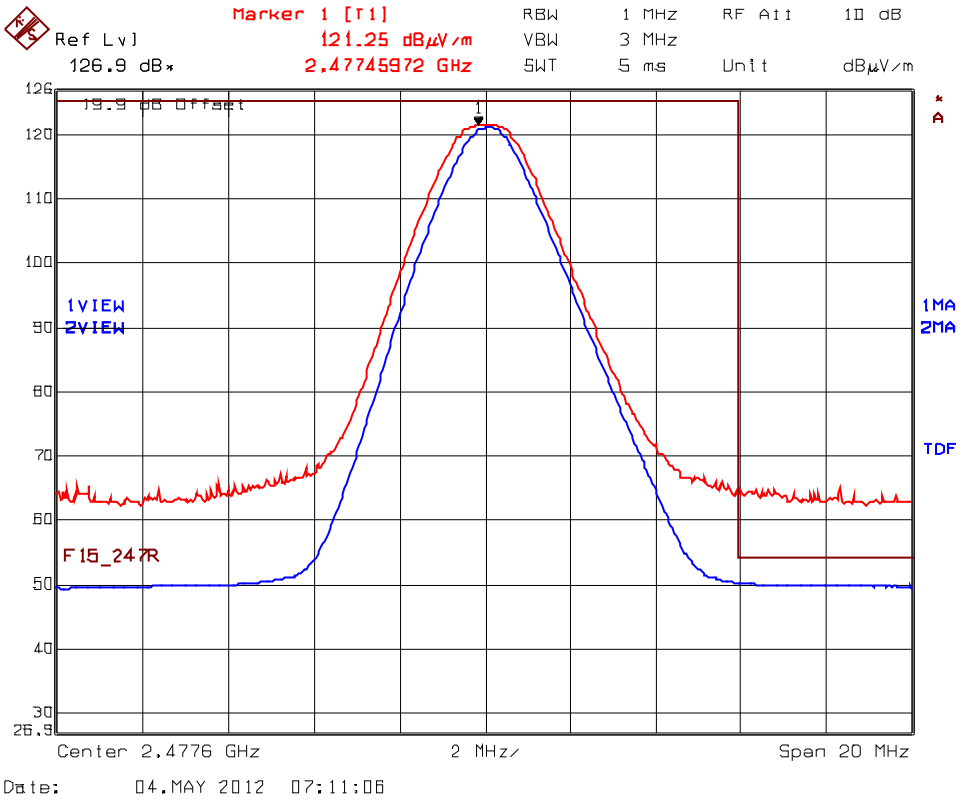
Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 35.33 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 122.03 dBµV/m – 35.33 dB = 86.70 dBµV/m (limit 102.03 dBµV/m)
Average at 2388.57 MHz = 52.79 dBµV/m (Restricted band 2310-2390 MHz) (limit 54 dBµV/m)

Plot 5.6.4.3.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 38, Data Rate 5



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

Plot 5.6.4.3.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 38, Data Rate 5



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

5.6.4.4. EUT with 15 dBi Omni Directional Antenna and 1.49 dB Assembly Cable Loss

5.6.4.4.1. Spurious Radiated Emissions

Fundamental Frequency:	2401.6 MHz
Software Power Setting:	40
Measured Conducted Power:	21.35 dBm
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
2401.6	126.58	--	V	--	--	--	--
2401.6	116.48	--	H	--	--	--	--
4803.2	48.73	37.21	V	54.0	106.6	-16.8	Pass*
4803.2	48.16	35.96	H	54.0	106.6	-18.0	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2439.6 MHz
Software Power Setting:	40
Measured Conducted Power:	22.38 dBm
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
2439.6	124.06	--	V	--	--	--	--
2439.6	116.29	--	H	--	--	--	--
4879.2	49.33	38.27	V	54.0	104.1	-15.7	Pass*
4879.2	48.86	37.87	H	54.0	104.1	-16.1	Pass*
7318.8	53.35	39.25	V	54.0	104.1	-14.8	Pass*
7318.8	53.84	39.96	H	54.0	104.1	-14.0	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

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

Fundamental Frequency:	2477.6 MHz
Software Power Setting:	40
Measured Conducted Power:	22.38 dBm
Frequency Test Range:	30 MHz – 25 GHz

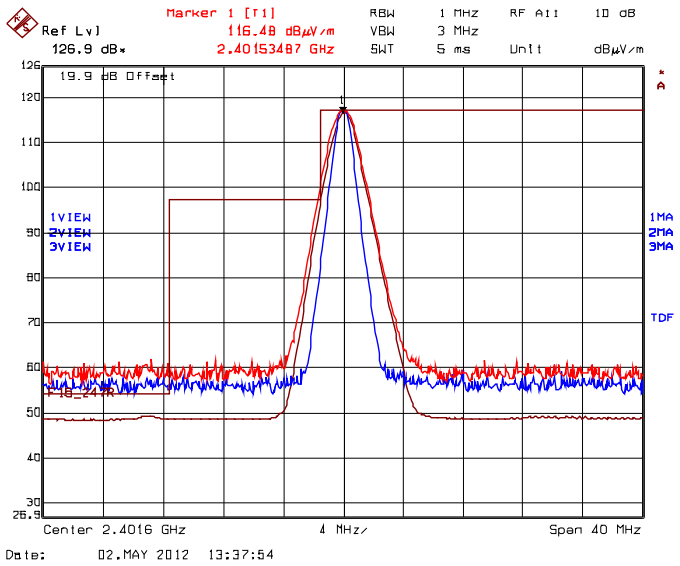
Frequency (MHz)	RF Peak Level (dBµV/m)	RF Avg Level (dBµV/m)	Antenna Plane (H/V)	Limit 15.209 (dBµV/m)	Limit 15.247 (dBµV/m)	Margin (dB)	Pass/ Fail
2477.6	124.68	--	V	--	--	--	--
2477.6	115.96	--	H	--	--	--	--
4955.2	50.08	38.91	V	54.0	104.7	-15.1	Pass*
4955.2	48.20	36.92	H	54.0	104.7	-17.1	Pass*
7432.8	54.03	43.08	V	54.0	104.7	-10.9	Pass*
7432.8	53.85	43.38	H	54.0	104.7	-10.6	Pass*

All other spurious emissions and harmonics are more than 20 dB below the applicable limit.

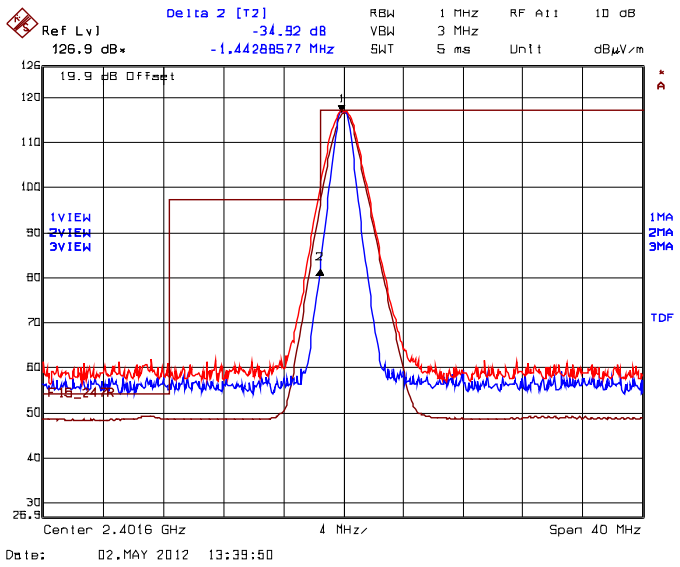
*Field strength of emissions appearing within restricted frequency bands shall not exceed the limits in § 15.209.

5.6.4.4.2. Band-Edge RF Radiated Emissions

Plot 5.6.4.4.2.1. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

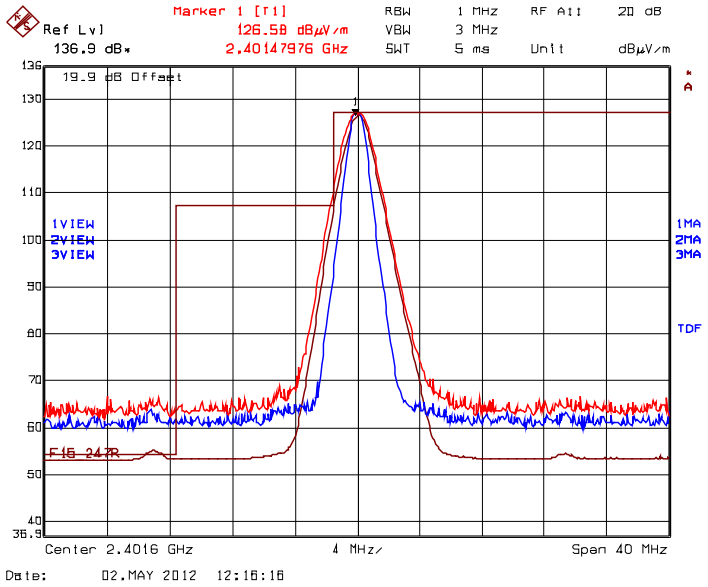


Plot 5.6.4.4.2.2. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

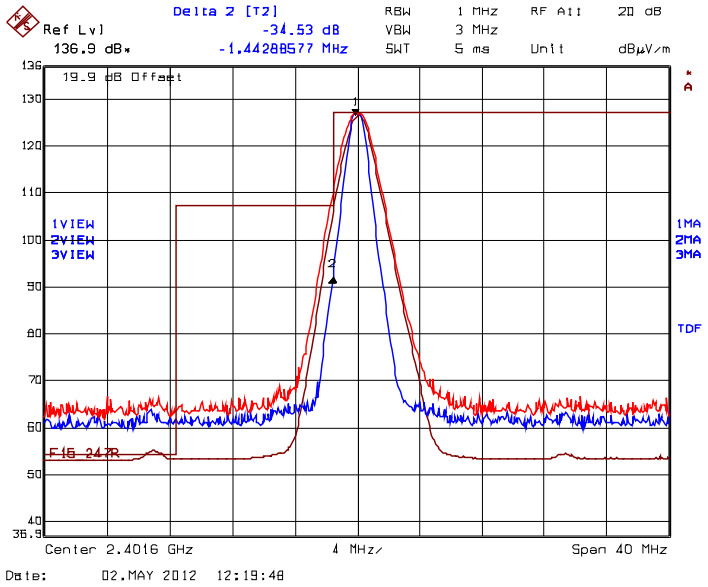


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 34.92 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 116.48 dBµV/m – 34.92 dB = 81.56 dBµV/m (limit 96.48 dBµV/m)

Plot 5.6.4.4.2.3. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

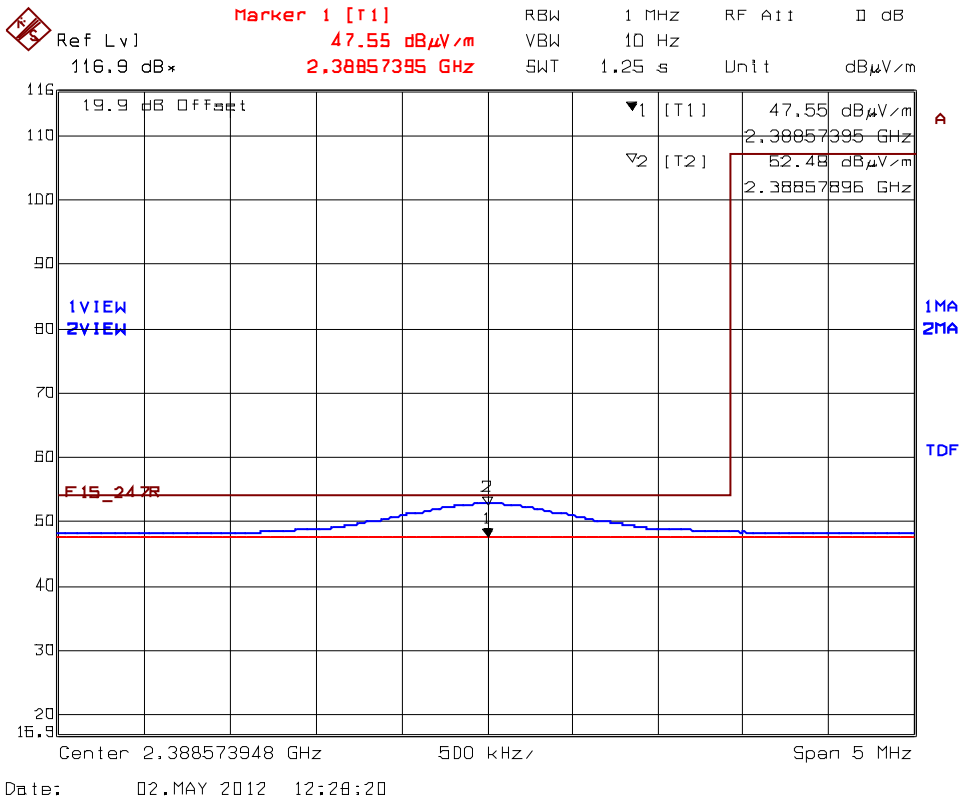


Plot 5.6.4.4.2.4. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5

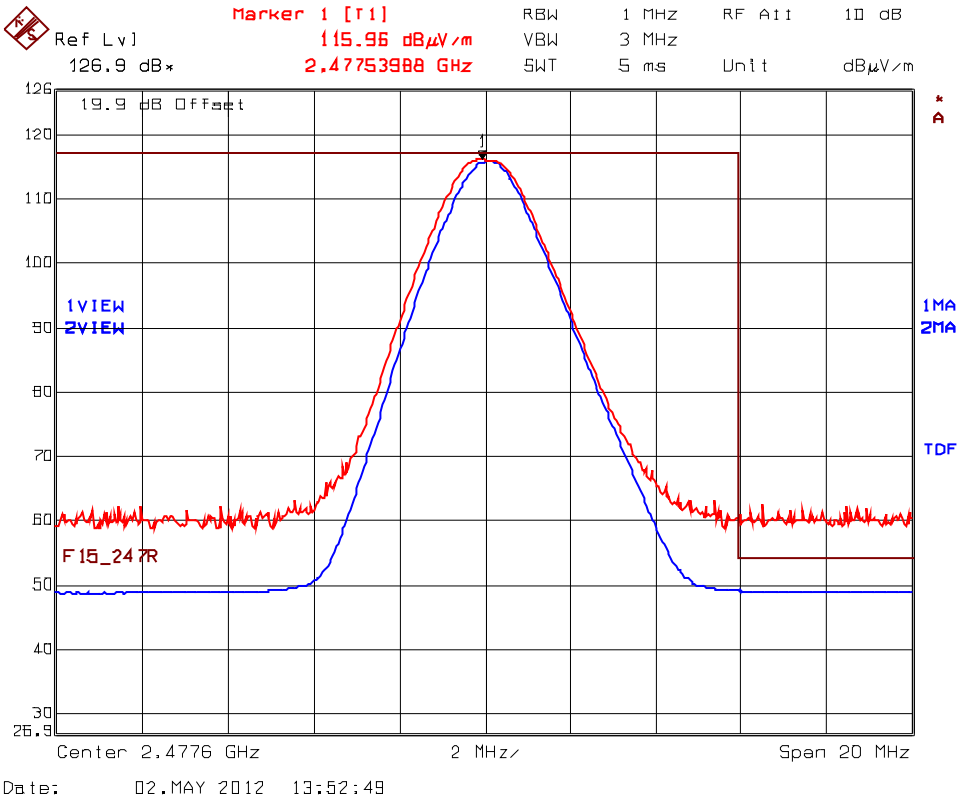


Trace 1: RBW = 1 MHz, VBW = 3 MHz
Trace 2: RBW = 500 kHz, VBW = 1 MHz, Delta (Peak to Band-Edge): 34.53 dB
Trace 3: RBW = 1 MHz, VBW = 10 Hz
Peak Band-Edge at 2400 MHz: Peak = 126.58 dBµV/m – 34.53 dB = 92.05 dBµV/m (limit 106.58 dBµV/m)
Average level at 2388.57 MHz in 5 MHz Span = 52.48 dBµV/m (Restricted band 2310-2390 MHz) (limit 54 dBµV/m)

Plot 5.6.4.4.2.5. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
Low End of Frequency Band, 2401.6 MHz, Power Setting 40, Data Rate 5
Average level at 2388.57 MHz in 5 MHz Span = 52.48 dBµV/m

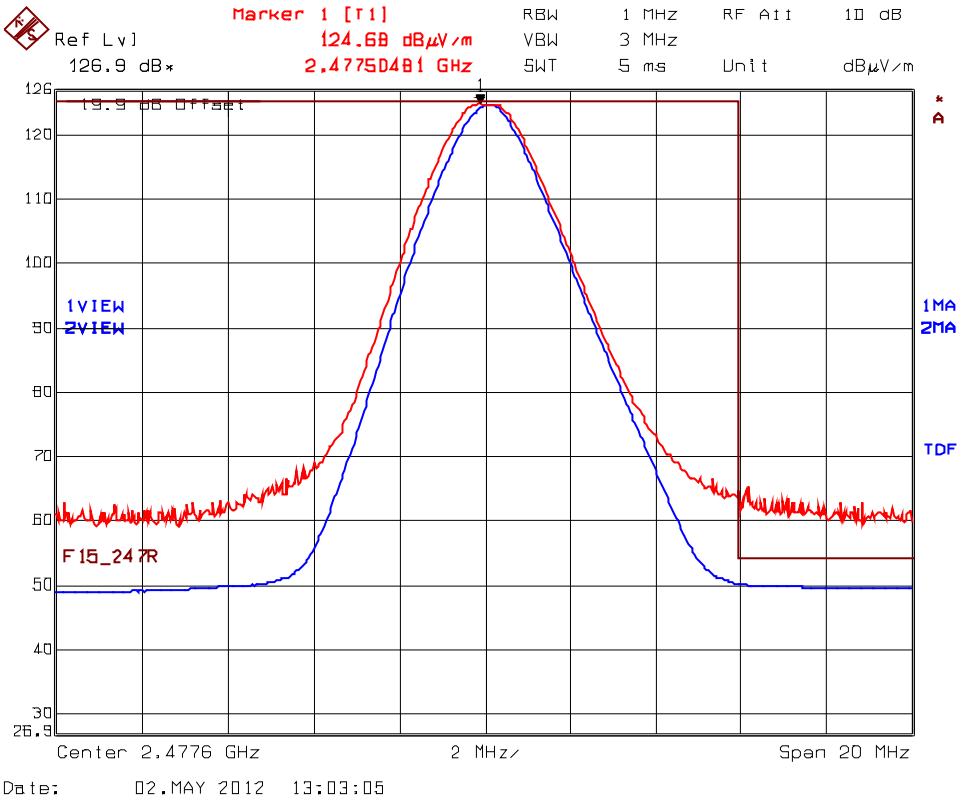


Plot 5.6.4.4.2.6. Band-Edge RF Radiated Emissions at 3 m, Horizontal Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 40, Data Rate 5



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

Plot 5.6.4.4.2.7. Band-Edge RF Radiated Emissions at 3 m, Vertical Polarization
High End of Frequency Band, 2477.6 MHz, Power Setting 40, Data Rate 5



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

5.7. 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.

5.7.1. 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

5.7.2. RF Evaluation

Evaluation of RF Exposure Compliance Requirements	
RF Exposure Requirements	**Compliance with FCC Rules**
Minimum calculated separation distance between antenna and persons required: ***18 cm**	Manufacturer' instruction for separation distance between antenna and persons required: **23 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 = 1.0 mW/cm^2
EIRP = 36.0 dBm = $10^{36/10}$ mW = 3981 mW (Worst Case)

(Minimum Safe Distance, r) = $\sqrt{\frac{EIRP}{4 \cdot \pi \cdot S}} = \sqrt{\frac{3981}{4 \cdot \pi \cdot (1.0)}} \approx 18cm$

EXHIBIT 6. TEST EQUIPMENT LIST

Test Instruments	Manufacturer	Model No.	Serial No.	Frequency Range	Cal. Due Date
Spectrum Analyzer	Hewlett Packard	HP 8593EM	3412A00103	9 kHz – 26.5 GHz	30 Jan 2013
L.I.S.N	ULT AC LISN	--	ULT-01;-02;-03;-04	10 kHz – 30 MHz	21 Feb 2013
Attenuator	Pasternack	PE7010-20	-	DC – 2 GHz	09 Jan 2013
Band Pass Filter	Telemeter Electronics	MTA-HPF-150	2110465-007	-	17 Aug 2013
Spectrum Analyzer	Rohde & Schwarz	FSEK30	100077	20Hz–40 GHz	27 Sep 2012
Attenuator	Narda	4768-20	-	DC–40 GHz	Cal on use
DC Block	Hewlett Packard	11742A	12460	0.045–26.5 GHz	Cal on use
High Pass Filter	K & L	11SH10-4000/T12000	4	Cut off 2400 MHz	Cal on use
Spectrum Analyzer	Rohde & Schwarz	ESU40	100037	20 Hz – 40 GHz	19 Mar 2013
RF Amplifier	Hewlett Packard	84498	3008A00769	1 – 26.5 GHz	01 Dec 2012
RF Amplifier	AH System	PAM-0118	225	20 MHz – 18 GHz	16 Mar 2013
Attenuator	Pasternack	PE7024-10	-	DC–26.5 GHz	Cal on use
Horn Antenna	EMCO	3155	5955	1 – 18 GHz	20 Feb 2013
Biconi-Log Antenna	EMCO	3142C	00034792	26 – 3000 MHz	04 May 2013
Horn Antenna	EMCO	3160-09	118385	18 – 26.5 GHz	30 May 2012

EXHIBIT 7. MEASUREMENT UNCERTAINTY

The measurement uncertainties stated were calculated in accordance with the requirements of CISPR 16-4-2 @ IEC:2003 and JCGM 100:2008 (GUM 1995) – Guide to the Expression of Uncertainty in Measurement.

7.1. LINE CONDUCTED EMISSION MEASUREMENT UNCERTAINTY

	Line Conducted Emission Measurement Uncertainty (150 kHz – 30 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 1.57**	**± 1.8**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.14**	**± 3.6**

7.2. RADIATED EMISSION MEASUREMENT UNCERTAINTY

	Radiated Emission Measurement Uncertainty @ 3m, Horizontal (30-1000 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 2.15**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.30**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3m, Vertical (30-1000 MHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 2.39**	**± 2.6**
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 4.78**	**± 5.2**

	Radiated Emission Measurement Uncertainty @ 3 m, Horizontal & Vertical (1 – 18 GHz):	**Measured**	**Limit**
u_c	**Combined standard uncertainty:** $u_c(y) = \sqrt{\sum_{i=1}^{m} u_i^2(y)}$	**± 1.87**	Under consideration
U	**Expanded uncertainty U:** $U = 2u_c(y)$	**± 3.75**	Under consideration