FCC RF TEST REPORT

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Test Report Number: SKT-RFC-140004

Date of issue: March 31, 2014

Applicant:	**G.I.T Co., Ltd.** GIT BLDG., 38-5 Garakbon-Dong, Songpa-Gu, Seoul, 138-801 Korea
Manufacturer:	**G.I.T Co., Ltd.** GIT BLDG., 38-5 Garakbon-Dong, Songpa-Gu, Seoul, 138-801 Korea
Product:	Scan Tool
Model:	**VCI II** (please see P5 for all the model numbers)
FCC ID:	TMGG1XDDMN001
File number:	SKTEU14-0179
EUT received:	February 20, 2014
Applied standards:	ANSI C63.10-2009 and ANSI C63.4-2009 558074 D01 DTS Meas Guidance v03r01
Rule parts:	FCC Part 15 Subpart C - Intentional radiators
Equipment Class:	**DTS - Part 15 Digital Transmission System** **DSS - Part 15 Spread Spectrum Transmitter**
Remarks to the standards:	None

The above equipment has been tested by SK Tech Co., Ltd., and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product or system, which was tested.

Jungtae Kim / **Testing Engineer**

Jongsoo Yoon / **Technical Manager**

Revision History of Report

Rev.	Revisions	Effect page	Reviewed by	Date
-	Initial issue	All	Jongsoo Yoon	March 31, 2014

TABLE OF CONTENTS

1 Summary of test results

(WLAN)

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203, 15.247(b)(4)	Meets the requirements
6dB Bandwidth	15.247(a)(2)	Meets the requirements
Maximum Peak Output Power	15.247(b)(3), (4)	Meets the requirements
Spurious Emission, Band Edge, and Restricted bands	15.247(d), 15.205(a), 15.209(a)	Meets the requirements
Peak Power Spectral Density	15.247(e)	Meets the requirements
AC power line Conducted emissions	15.207(a)	N/A

** The product is powered from a DC 12 V or 24 V lead-acid battery in a vehicle

(Bluetooth)

Requirement	CFR 47 Section	Result
Antenna Requirement	15.203, 15.247(b)(4)	Meets the requirements
Maximum Peak Output Power	15.247(b)(1), (4)	Meets the requirements
Carrier Frequency Separation	15.247(a)(1)	Meets the requirements
20dB Channel Bandwidth	15.247(a)(1)	Meets the requirements
Number of Hopping Channels	15.247(a)(iii), 15.247(b)(1)	Meets the requirements
Time of Occupancy (Dwell Time)	15.247(a)(iii)	Meets the requirements
Spurious Emission, Band Edge, and Restricted bands	15.247(d), 15.205(a), 15.209(a)	Meets the requirements
AC power line Conducted emissions	15.207(a)	N/A

** The product is powered from a DC 12 V or 24 V lead-acid battery in a vehicle

2 Description of equipment under test (EUT)

Product:	Scan Tool
Model:	**VCI Ⅱ**
Serial number:	None (prototype)

Model differences:

Model name	Difference	Tested (checked)
VCI Ⅱ	Original (basic model that was fully tested)	☒

Note: *All the differences were compared with the tested sample.*

Technical data:

Power source	12 V/ 24 V lead-acid battery installed in vehicles
Local Oscillator or X-Tal	32.768 kHz, 4 MHz, 12 MHz, 25 MHz, 38.4 MHz
Transmit Frequency	IEEE 802.11a/n(HT20): 5180 MHz ~ 5240 MHz (4 channels), IEEE 802.11b/g/n(HT20): 2412 MHz ~ 2462 MHz (11 channels), Bluetooth: 2402 MHz ~ 2480 MHz (79 channels)
Antenna Type	WLAN and Bluetooth (integral PCB antenna, peak gain: 4.864 dBi)
Type of Modulation	IEEE 802.11a/g/n(HT20): OFDM(64QAM, 16QAM, QPSK, BPSK), IEEE 802.11b: DSSS (DBPSK, DQPSK, CCK), Bluetooth: GFSK
RF Output power	WLAN: 18.56 dBm PEAK (measured), Bluetooth: 5.48 dBm PEAK(measured)

Note: *1) The test report for the compliance with FCC Part 15B as a digital device was issued with other test report number*
2) The test report for U-NII(5 GHz, WLAN) was issued with other test report number

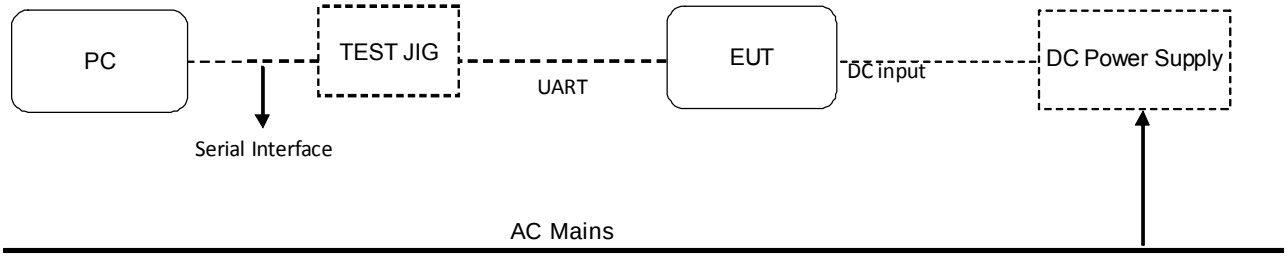
I/O port	Type	Q'ty	Remark
OBD Ⅱ(DC Input)	OBD Ⅱ(16 pin)	1	
USB	USB (30 pin)	1	

Equipment Modifications
none

3 Test and measurement conditions

3.1. Test configuration (arrangement of EUT)

The measurements were taken in continuous transmitting/receiving mode using the TEST MODE. For controlling the EUT as TEST MODE, the test program and the cable assembly were provided by the applicant.



The measurements were taken in TEST MODE provided by the applicant for controlling the EUT.

■ Software version (driver version): 1.0.6.21
■ Software manufacturer: Taiyo Yuden Co., Ltd.
■ Power setting
- IEEE 802.11b(target power: 15 dBm)
- IEEE 802.11g(target power: 13 dBm)
- IEEE 802.11n(HT20)(target power: 12 dBm)
- Bluetooth : Power setting could not be adjusted

3.2. Description of support units (accessory equipment)

The following support units or accessories were used to form a representative test configuration during the tests.

#	Equipment	Manufacturer	Model No.	Serial No.
1	PC	DELL INC.	7XH86BX	17261795085
2	TEST JIG	-	-	-

Note: *1) For control of the RF module via Serial interface at the Debug port(UART) in the EUT.*
2) For radiated spurious emission measurements, the measurements were performed without PC after setting the radio module to TEST MODE.

3.3. Interconnection and I/O cables

The following support units or accessories were used to form a representative test configuration during the tests.

#	Start		End		Cable	
	Name	I/O port	Name	I/O port	length (m)	shielded (Y/N)
1	EUT	8 PIN(Debug)	TEST JIG	RS232	0.3	N
2	TEST JIG	RS232	PC	RS232	2.0	N

3.4. Measurement Uncertainty (*U*)

Measurement Item	Combined Standard Uncertainty *Uc*	Expanded Uncertainty $U = k \times Uc$ (k = 2)
Conducted RF power	±1.49 dB	±2.98 dB
Radiated disturbance	±2.30 dB	±4.60 dB
Conducted disturbance	±1.96 dB	±3.92 dB

3.5. Test date

Date Tested	March 4, 2014 – March 17, 2014

4 Facilities and accreditations

4.1. Facilities

All of the measurements described in this report were performed at SK Tech Co., Ltd
Site I: 820-2, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, Korea
Site II: 688-8, Wolmoon-ri, Wabu-up, Namyangju-si, Kyunggi-do, Korea

The sites are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-4. The sites comply with the Normalized Site Attenuation requirements given in ANSI C63.4, and site VSWR requirements specified in CISPR 16-1-4. The measuring apparatus and ancillary equipment conform to CISPR 16-1 series.

4.2. Accreditations

The laboratory has been also notified to FCC by RRA as a Conformity Assessment Body, and designated to perform compliance testing on equipment subject to Declaration of Conformity (DOC) and Certification under Parts 15 and 18 of the FCC Rules.

Designation No.	KR0007

4.3. List of test and measurement instruments

No	Description	Manufacturer	Model	Serial No.	Cal. due	Use
1	Spectrum Analyzer	Agilent	E4405B	US40520856	2015.03.06	
2	Spectrum Analyzer	Agilent	E4440A	MY46186322	2015.03.07	☒
3	EMC Spectrum Analyzer	Agilent	E7405A	US40240203	2014.07.08	
4	EMI Test Receiver	Rohde&Schwarz	ESPI7	101206	2014.07.08	☒
5	EMI Test Receiver	Rohde&Schwarz	ESHS10	835871/002	2014.07.08	
6	Artificial Mains Network	Rohde&Schwarz	ESH2-Z5	834549/011	2014.07.08	
7	Pre-amplifier	HP	8447F	3113A05153	2014.07.08	☒
8	Pre-amplifier	MITEQ	AFS44	1116321	2014.12.06	
9	Pre-amplifier	MITEQ	AFS44	1116322	2015.03.06	☒
10	Power Meter	Agilent	E4417A	MY45100426	2014.07.09	
11	Power Meter	Agilent	E4418B	US39402176	2014.07.09	
12	Power Sensor	Agilent	E9327A	MY44420696	2014.07.09	
13	Power Sensor	Agilent	8485A	3318A13916	2014.07.09	
14	Attenuator (10dB)	HP	8491B	38072	2014.07.08	☒
15	High Pass Filter	Wainwright	WHKX3.0/18G	8	2014.07.08	☒
16	VHF Precision Dipole Antenna (TX/RX)	Schwarzbeck	VHAP	1014 / 1015	2014.10.25	
17	UHF Precision Dipole Antenna (TX/RX)	Schwarzbeck	UHAP	989 / 990	2014.10.25	
18	Loop Antenna	Schwarzbeck	HFH2-Z2	863048/019	2015.12.04	☒
19	TRILOG Broadband Antenna	Schwarzbeck	VULB9168	189	2014.05.21	☒
20	Horn Antenna	AH Systems	SAS-200/571	304	N/A	
21	Horn Antenna	EMCO	3115	00040723	2014.03.26	☒
22	Horn Antenna	EMCO	3115	00056768	2014.09.05	
23	Horn Antenna	Schwarzbeck	BBHA9170	BBHA9170318	2015.09.06	☒
24	Vector Signal Generator	Agilent	E4438C	MY42080359	2014.07.09	
25	PSG analog signal generator	Agilent	E8257D-520	MY45141255	2014.07.09	
26	DC Power Supply	HP	6622A	3348A03223	2014.07.09	☒
27	DC Power Supply	TOYOTECH	DP30-05A	-	N/A	☒
28	Hygro/Thermo Graph	SATO	PC-5000TRH-II	-	2014.07.12	☒
29	Temperature/Humidity Chamber	All Three	ATM-50M	20030425	2015.03.06	

5 Test and measurements (WLAN)

5.1. Antenna requirement

5.1.1 Regulation

According to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.
And according to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

5.1.2 Result: PASS

The transmitter has the integral PCB antenna. The directional gain of the antenna is 4.864 dBi.

5.2. Test Configuration of Equipment Under Test

Pre-Scanned RF Power

Preliminary tests were performed in different data rate as below table and the highest power data rates (11b, 11g,11n(BW 20MHz), were chosen for full test in the following sections to demonstrate compliance to the limits.

The Gain control in the test software was set to the below table as the maximum power output.

	802.11b	802.11g	802.11n(20)
2412 MHz	15	13	12
2437 MHz	15	13	12
2462 MHz	15	13	12

Measured peak power (dBm) operating 802.11b mode

	1 Mbps	2 Mbps	5.5 Mbps	**11 Mbps**
2412 MHz	14.79	15.04	16.45	**17.93**
2437 MHz	15.39	15.63	17.06	**18.56**
2462 MHz	15.06	15.46	16.76	**18.18**

Measured peak power (dBm) operating 802.11g mode

	6 Mbps	9 Mbps	12 Mbps	18 Mbps	24 Mbps	36 Mbps	48 Mbps	**54 Mbps**
2412 MHz	16.75	16.82	16.97	16.72	17.61	17.23	17.31	**17.39**
2437 MHz	17.08	17.14	17.30	17.00	17.96	17.51	17.63	**17.68**
2462 MHz	16.63	16.93	17.22	16.84	17.78	17.36	17.42	**17.43**

Measured peak power (dBm) operating 802.11n(HT20) mode

	MCS0	MCS1	MCS2	MCS3	MCS4	MCS5	MCS6	**MCS7**
2412 MHz	15.59	15.57	15.59	15.64	15.58	15.58	15.58	**15.71**
2437 MHz	15.97	15.98	15.96	15.96	15.95	15.95	15.96	**15.99**
2462 MHz	15.79	15.68	15.66	15.64	15.65	15.61	15.59	**15.74**

5.3. 6 dB bandwidth

5.3.1 Regulation

According to §15.247(a)(2), systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

5.3.2 Test Procedure

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW) ≥ 3 x RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

5.3.3 Test Results: PASS

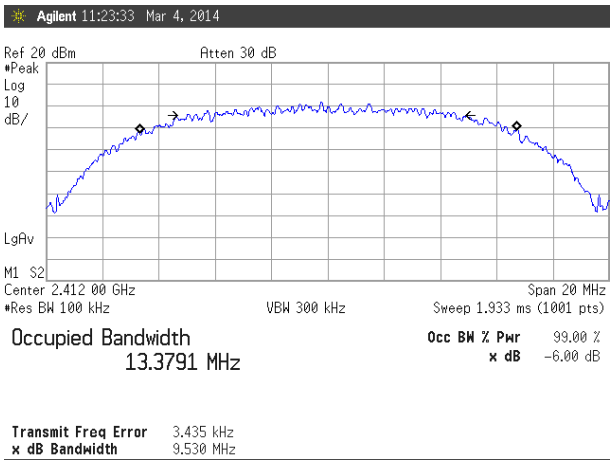
Table 1: Measured values of the 6 dB Bandwidth

Modulation	Operating frequency	Transfer Rate	Occupied Bandwidth (99%)	6dB Bandwidth	Limit
802.11b	2412 MHz	11 Mbps	13.3791 MHz	9.530 MHz	≥ 500 kHz
	2437 MHz	11 Mbps	13.3613 MHz	9.595 MHz	≥ 500 kHz
	2462 MHz	11 Mbps	13.3488 MHz	10.071 MHz	≥ 500 kHz
802.11g	2412 MHz	54 Mbps	16.4047 MHz	16.365 MHz	≥ 500 kHz
	2437 MHz	54 Mbps	16.4114 MHz	16.381 MHz	≥ 500 kHz
	2462 MHz	54 Mbps	16.4044 MHz	16.421 MHz	≥ 500 kHz
802.11n HT20	2412 MHz	MCS 7	17.6389 MHz	17.617 MHz	≥ 500 kHz
	2437 MHz	MCS 7	17.6205 MHz	17.602 MHz	≥ 500 kHz
	2462 MHz	MCS 7	17.6138 MHz	17.590 MHz	≥ 500 kHz

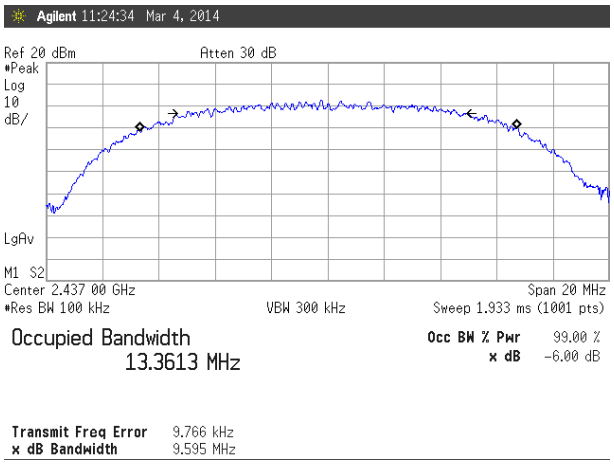
Figure 1. Plot of the 6dB Bandwidth & Occupied Bandwidth (99%)

802.11b mode:

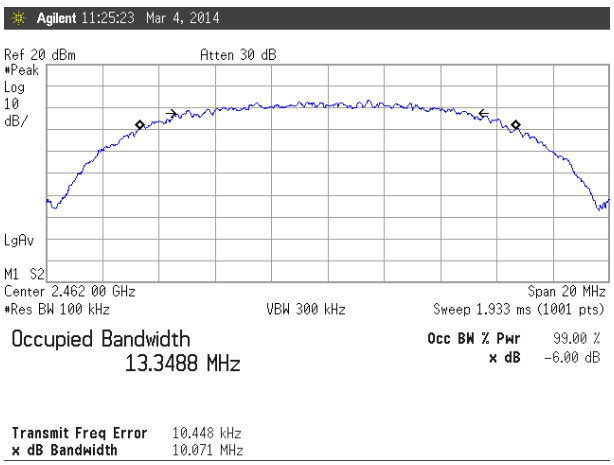
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)

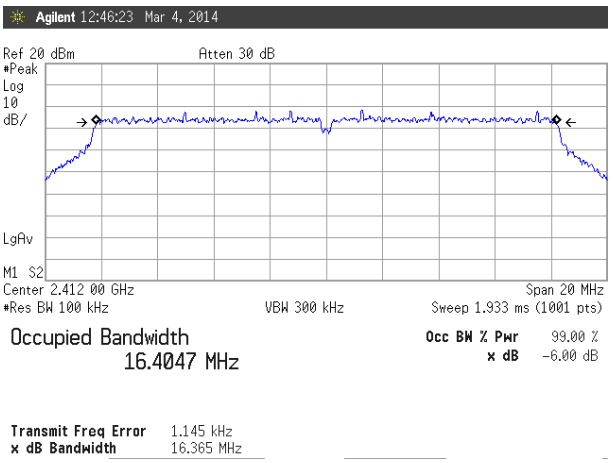


Highest Channel (2462 MHz)

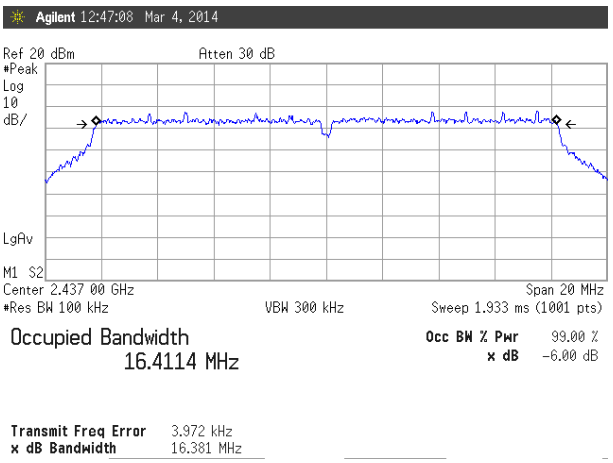


802.11g mode:

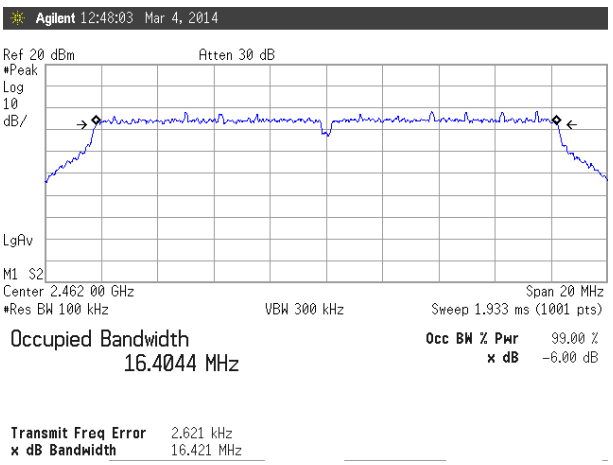
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)



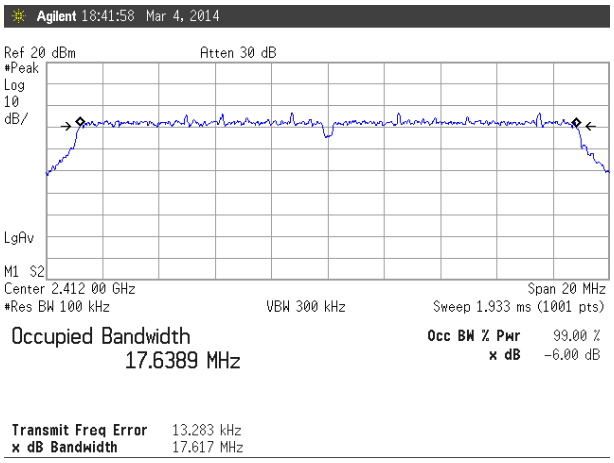
Highest Channel (2462 MHz)



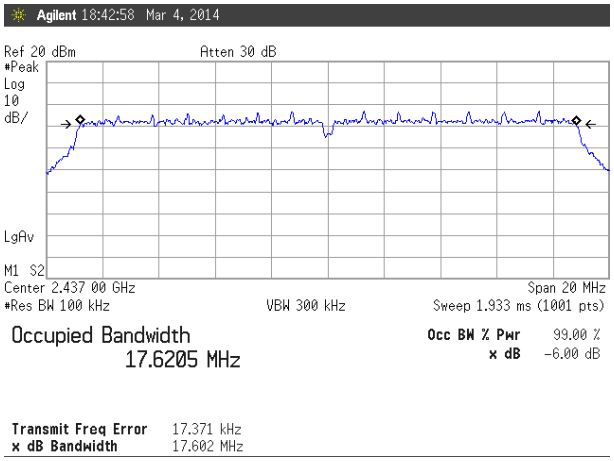
Plot of the 6dB Bandwidth & Occupied Bandwidth (99%) *(continued)*

802.11n HT20 mode:

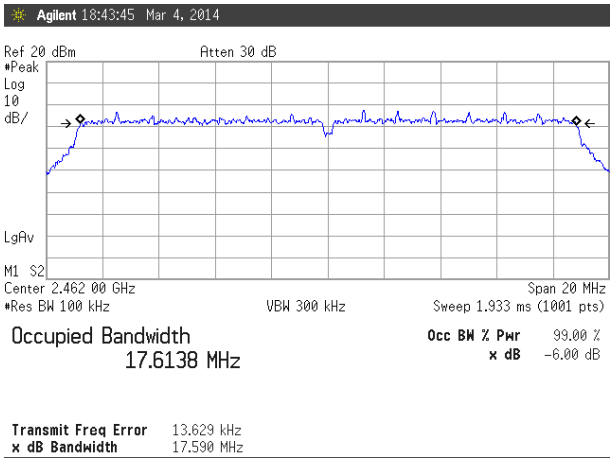
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)



Highest Channel (2462 MHz)



5.4. Maximum peak output power

5.4.1 Regulation

According to §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.

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

5.4.2 Test Procedure

1. Set the RBW = 1 MHz.
2. Set the VBW ≥ 3 x RBW
3. Set the span ≥ 1.5 x DTS bandwidth.
4. Detector = peak.
5. Sweep time = auto couple.
6. Trace mode = max hold.
7. Allow trace to fully stabilize.
8. Use the instrument's band/channel power measurement function with the band limits set equal to the DTS bandwidth edges (for some instruments, this may require a manual override to select peak detector). If the instrument does not have a band power function, 6 558074 D01 DTS Meas Guidance v03r01

5.4.3 Test Results: PASS

Table 2: Measured values of the Maximum Peak Conducted Output Power

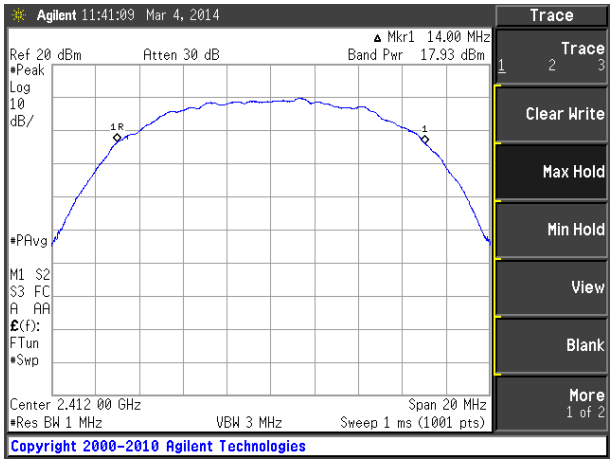
Modulation	Operating Frequency	Transfer Rate	Peak Power		Average Power [dBm] (NOTE)	Limit
			[dBm]	W		
802.11b	2412 MHz	11 Mbps	17.93	0.062	11.84	1 W
	2437 MHz		18.56	0.072	12.43	1 W
	2462 MHz		18.18	0.066	12.09	1 W
802.11g	2412 MHz	54 Mbps	17.39	0.055	8.98	1 W
	2437 MHz		17.68	0.059	9.25	1 W
	2462 MHz		17.42	0.055	9.13	1 W
802.11n HT20	2412 MHz	MCS7	15.71	0.037	7.80	1 W
	2437 MHz		15.99	0.040	8.14	1 W
	2462 MHz		15.74	0.037	7.75	1 W

NOTE The Average power were measured using AVGSA- 1 method as the reference only.

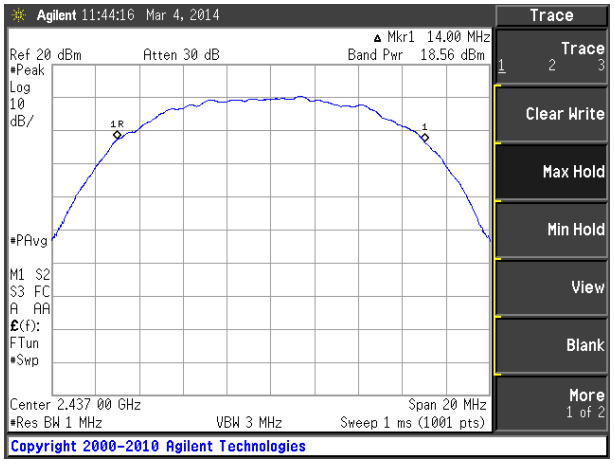
Figure 2. Plot of the Maximum Peak Conducted Output Power

802.11b mode:

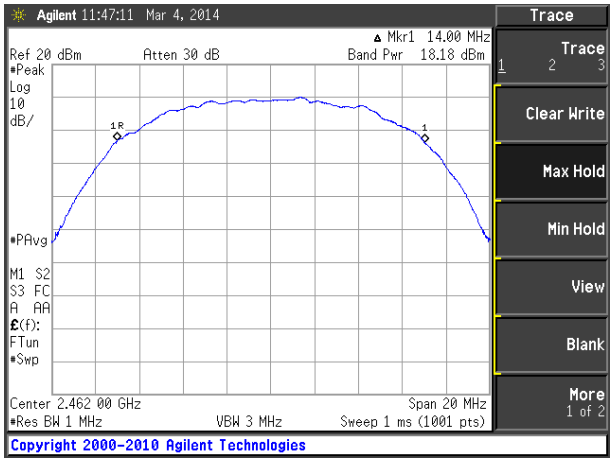
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)

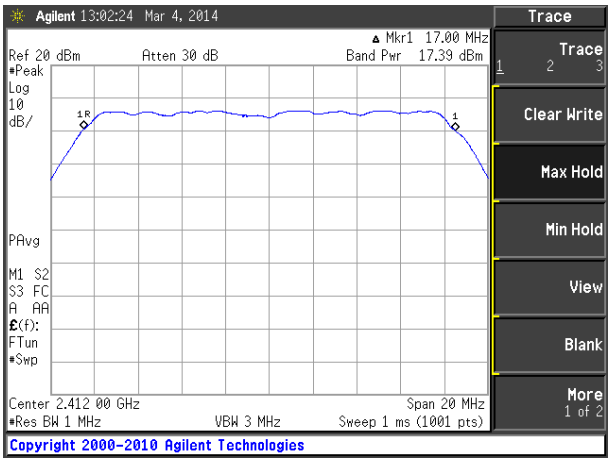


Highest Channel (2462 MHz)

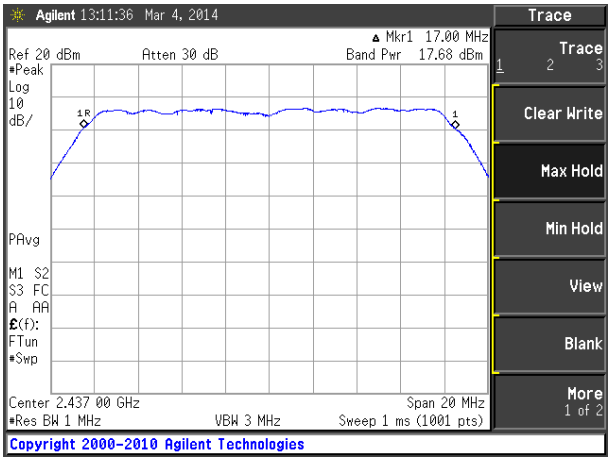


802.11g mode:

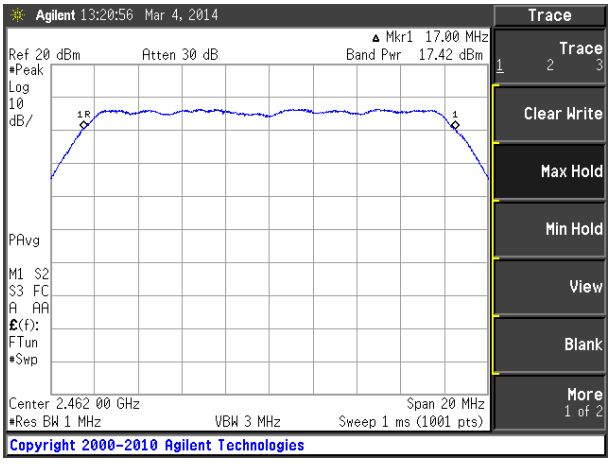
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)



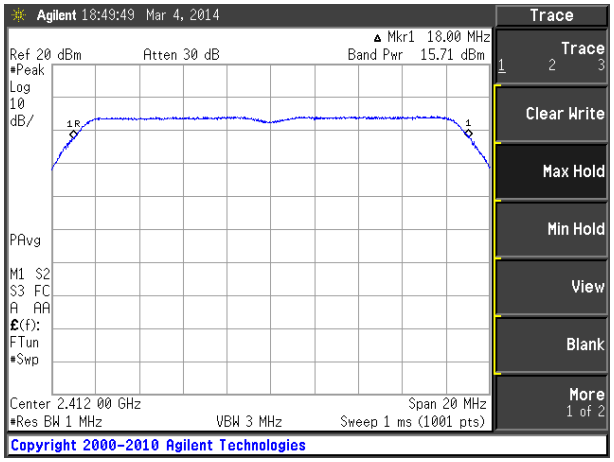
Highest Channel (2462 MHz)



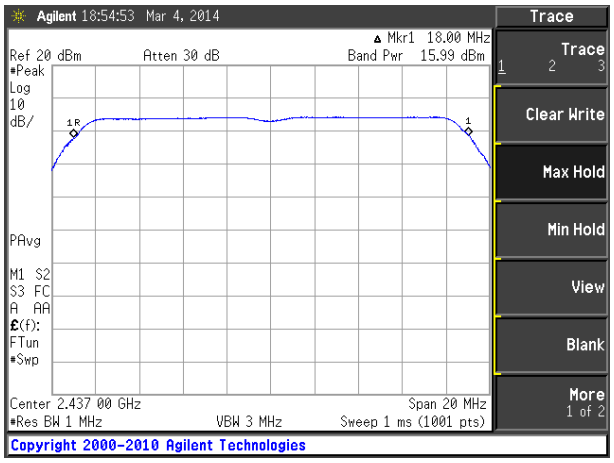
Plot of the Maximum Peak Conducted Output Power *(continued)*

802.11n HT20 mode:

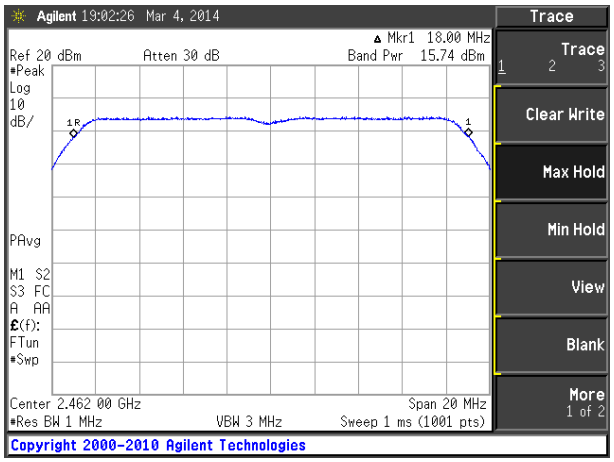
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)



Highest Channel (2462 MHz)



5.5. Spurious emissions, Band edge, and Restricted bands

5.5.1 Regulation

According to §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)).
According to §15.209(a), for an intentional device, the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency (MHz)	Field strength (μV/m @ 3m)	Field strength (dBμV/m @ 3m)
30–88	100	40.0
88–216	150	43.5
216–960	200	46.0
Above 960	500	54.0

According to §15.109(a), for an unintentional device, except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the above table.

** The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector and above 1000 MHz are based on the average value of measured emissions.

5.5.2 Test Procedure

1) Band-edge measurements for RF conducted emissions

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the emission operating on the channel closest to the band-edge, as well as any modulation products which fall outside of the authorized band of operation
   RBW ≥ 1 % of spectrum analyzer display span
   VBW ≥ 3 x RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
3. Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
   RBW = 100 kHz
   VBW ≥ 3 x RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters for above 30 MHz, and at 1 meter / 3 meter distance for below 30 MHz.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 kHz to 30 MHz using the loop antenna, from 30 to 1000 MHz using the Trilog broadband antenna, and from 1 GHz to tenth harmonic of the highest fundamental frequency using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The EUT is situated in three orthogonal planes (if appropriate)
7. The presence of ambient signals was verified by turning the EUT off. In case an ambient signal was detected, the measurement bandwidth was reduced temporarily and verification was made that an additional adjacent peak did not exist. This ensures that the ambient signal does not hide any emissions from the EUT.
8. If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative “marker-delta” method may be employed.

4) Marker-Delta Method at the edge of the authorized band of operation:

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function specified in 6.3 and 6.4, 6.5, or 6.6, as applicable, and the appropriate regulatory requirements for the frequency being measured.43
2. Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to approximately 1 % to 5 % of the total span, unless otherwise specified, with a video bandwidth equal to or greater than the RBW.
   Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not an absolute field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band edge relative to the highest fundamental emission level.
3. Subtract the delta measured in b) from the field strengths measured in a). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance of the restricted bands, described in 5.9.
4. The above “delta” measurement technique may be used for measuring emissions that are up to two “standard” bandwidths away from the band edge, where a “standard” bandwidth is the bandwidth specified by 4.2.3.2 for the frequency being measured. For example, band-edge measurements in the restricted band that begins at 2483.5 MHz require a measurement bandwidth of at least 1 MHz.
   Therefore the “delta” technique for measuring emissions up to 2 MHz removed from the band edge may be used. Radiated emissions that are removed by more than two “standard” bandwidths shall be measured in the conventional manner.

5.5.3 Test Results: PASS

Band-edge compliance of RF conducted/radiated emissions was shown in the Figure 3 and 4.
Spurious RF conducted emissions were shown in the Figure 5.

NOTE : for conducted measurement, we took the insertion loss of the cable loss into consideration within the measuring instrument. And for radiated measurement, the results were calibrated to the field strength within the measuring instrument; Table 3 contains the correction factors at the operating frequencies such as antenna factor, cable loss, etc.

Table 3: Measured values of the Field strength of spurious emission (Radiated)

BELOW 1 GHz

Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	dB(1/m)	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
Average/Peak/Quasi-peak data, emissions below 30 MHz												
Quasi-peak data, emissions below 1000 MHz **(802.11 b/g/n HT20 mode)**												
840.01	120	H	1.86	30	40.1	28.8	-	23.1	3.7	38.1	46.0	7.9
840.01	120	V	1.77	47	39.5	28.8	-	23.1	3.7	37.5	46.0	8.5

No Radiated Spurious Emissions Found

Margin (dB) = Limit – Actual
[Actual = Reading – Amp Gain + Attenuator + AF + CL]
1. H = Horizontal, V = Vertical Polarization
2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss
NOTE: All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

Measured values of the Field strength of spurious emission (Radiated) *(continued)*

ABOVE 1 GHz

Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	dB(1/m)	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
PEAK data, emissions above 1000 MHz **(802.11b mode)**												
2413.20	1000	H	1.22	260	104.59	48.46	10.23	28.19	6.52	101.07	Not Applicable	
2413.20	1000	V	1.18	331	107.30	48.46	10.23	28.19	6.52	103.78		
2366.40	1000	H	1.22	260	55.96	48.44	10.23	28.04	6.45	52.24	74.00	21.76
2338.00	1000	V	1.18	331	54.44	48.44	10.24	27.95	6.40	50.59	74.00	23.41
4824.00	1000	H/V	1.00	0	---	49.00	0.42	33.14	9.70	---	74.00	---
7236.00	1000	H/V	1.00	0	---	49.22	0.31	35.91	9.61	---	74.00	---
2438.00	1000	H	1.29	228	103.54	48.48	10.23	28.27	6.55	100.11	Not Applicable	
2438.12	1000	V	1.24	347	106.30	48.48	10.23	28.27	6.55	102.87		
4874.00	1000	H/V	1.00	0	---	49.02	0.39	33.17	9.75	---	74.00	---
7311.00	1000	H/V	1.00	0	---	49.26	0.31	36.00	9.63	---	74.00	---
2463.20	1000	H	1.30	271	105.94	48.49	10.23	28.35	6.59	102.62	Not Applicable	
2463.20	1000	V	1.25	324	107.46	48.49	10.23	28.35	6.59	104.14		
2483.60	1000	H	1.30	271	51.10	48.50	10.23	28.41	6.62	47.86	74.00	26.14
2483.60	1000	V	1.25	324	51.59	48.50	10.23	28.41	6.62	48.35	74.00	25.65
4924.00	1000	H/V	1.00	0	---	49.03	0.36	33.20	9.80	---	74.00	---
7386.00	1000	H/V	1.00	0	---	49.31	0.32	36.09	9.64	---	74.00	---
AVERAGE data, emissions above 1000 MHz **(802.11b mode)**												
2413.20	1000	H	1.22	260	95.86	48.46	10.23	28.19	6.52	92.34	Not Applicable	
2413.20	1000	V	1.18	331	99.12	48.46	10.23	28.19	6.52	95.60		
2366.40	1000	H	1.22	260	38.72	48.44	10.23	28.04	6.45	35.00	54.00	19.00
2338.00	1000	V	1.18	331	40.05	48.44	10.24	27.95	6.40	36.20	54.00	17.80
4824.00	1000	H/V	1.00	0	---	49.00	0.42	33.14	9.70	---	54.00	---
7236.00	1000	H/V	1.00	0	---	49.22	0.31	35.91	9.61	---	54.00	---
2438.00	1000	H	1.29	228	95.46	48.48	10.23	28.27	6.55	92.03	Not Applicable	
2438.12	1000	V	1.24	347	98.29	48.48	10.23	28.27	6.55	94.86		
4874.00	1000	H/V	1.00	0	---	49.02	0.39	33.17	9.75	---	54.00	---
7311.00	1000	H/V	1.00	0	---	49.26	0.31	36.00	9.63	---	54.00	---
2463.20	1000	H	1.30	271	97.71	48.49	10.23	28.35	6.59	94.39	Not Applicable	
2463.20	1000	V	1.25	324	99.22	48.49	10.23	28.35	6.59	95.90		
2483.60	1000	H	1.30	271	39.42	48.50	10.23	28.41	6.62	36.18	54.00	17.82
2483.60	1000	V	1.25	324	39.94	48.50	10.23	28.41	6.62	36.70	54.00	17.30
4924.00	1000	H/V	1.00	0	---	49.03	0.36	33.20	9.80	---	54.00	---
7386.00	1000	H/V	1.00	0	---	49.31	0.32	36.09	9.64	---	54.00	---

Margin (dB) = Limit – Actual

[Actual = Reading – Amp Gain + Attenuator + AF + CL]

1. H = Horizontal, V = Vertical Polarization
2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

NOTE: "---" means the emission level was too low to be measured or in the noise floor.

Measured values of the Field strength of spurious emission (Radiated) *(continued)*												
ABOVE 1 GHz												
Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	dB(1/m)	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
PEAK data, emissions above 1000 MHz **(802.11g mode)**												
2414.00	1000	H	1.22	260	102.27	48.46	10.23	28.19	6.52	98.75	Not Applicable	
2414.00	1000	V	1.18	331	103.28	48.46	10.23	28.19	6.52	99.76		
2439.00	1000	H	1.22	260	60.25	48.48	10.23	28.27	6.55	56.82	74.00	17.18
2439.00	1000	V	1.18	331	60.19	48.48	10.23	28.27	6.55	56.76	74.00	17.24
4824.00	1000	H/V	1.00	0	---	49.00	0.42	33.14	9.70	---	74.00	---
7236.00	1000	H/V	1.00	0	---	49.22	0.31	35.91	9.61	---	74.00	---
2438.50	1000	H	1.29	228	101.46	48.48	10.23	28.27	6.55	98.03	Not Applicable	
2438.30	1000	V	1.24	347	102.59	48.48	10.23	28.27	6.55	99.16		
4874.00	1000	H/V	1.00	0	---	49.02	0.39	33.17	9.75	---	74.00	---
7311.00	1000	H/V	1.00	0	---	49.26	0.31	36.00	9.63	---	74.00	---
2456.40	1000	H	1.30	271	103.37	48.48	10.23	28.33	6.58	100.03	Not Applicable	
2468.00	1000	V	1.25	324	103.99	48.49	10.23	28.36	6.60	100.69		
2483.60	1000	H	1.30	271	64.20	48.50	10.23	28.41	6.62	60.96	74.00	13.04
2483.60	1000	V	1.25	324	63.20	48.50	10.23	28.41	6.62	59.96	74.00	14.04
4924.00	1000	H/V	1.00	0	---	49.03	0.36	33.20	9.80	---	74.00	---
7386.00	1000	H/V	1.00	0	---	49.31	0.32	36.09	9.64	---	74.00	---
AVERAGE data, emissions above 1000 MHz **(802.11g mode)**												
2414.00	1000	H	1.22	260	92.02	48.46	10.23	28.19	6.52	88.50	Not Applicable	
2414.00	1000	V	1.18	331	93.57	48.46	10.23	28.19	6.52	90.05		
2439.00	1000	H	1.22	260	45.80	48.48	10.23	28.27	6.55	42.37	54.00	11.63
2439.00	1000	V	1.18	331	44.79	48.48	10.23	28.27	6.55	41.36	54.00	12.64
4824.00	1000	H/V	1.00	0	---	49.00	0.42	33.14	9.70	---	54.00	---
7236.00	1000	H/V	1.00	0	---	49.22	0.31	35.91	9.61	---	54.00	---
2438.50	1000	H	1.29	228	91.30	48.48	10.23	28.27	6.55	87.87	Not Applicable	
2438.30	1000	V	1.24	347	92.36	48.48	10.23	28.27	6.55	88.93		
4874.00	1000	H/V	1.00	0	---	49.02	0.39	33.17	9.75	---	54.00	---
7311.00	1000	H/V	1.00	0	---	49.26	0.31	36.00	9.63	---	54.00	---
2456.40	1000	H	1.30	271	93.47	48.48	10.23	28.33	6.58	90.13	Not Applicable	
2468.00	1000	V	1.25	324	94.64	48.49	10.23	28.36	6.60	91.34		
2483.60	1000	H	1.30	271	49.45	48.50	10.23	28.41	6.62	46.21	54.00	7.79
2483.60	1000	V	1.25	324	48.05	48.50	10.23	28.41	6.62	44.81	54.00	9.19
4924.00	1000	H/V	1.00	0	---	49.03	0.36	33.20	9.80	---	54.00	---
7386.00	1000	H/V	1.00	0	---	49.31	0.32	36.09	9.64	---	54.00	---

Margin (dB) = Limit – Actual

[Actual = Reading – Amp Gain + Attenuator + AF + CL]

1. H = Horizontal, V = Vertical Polarization
2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

NOTE: "---" means the emission level was too low to be measured or in the noise floor.

Measured values of the Field strength of spurious emission (Radiated) *(continued)*												
ABOVE 1 GHz												
Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	dB(1/m)	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
PEAK data, emissions above 1000 MHz **(802.11n HT20 mode)**												
2410.08	1000	H	1.22	260	100.13	48.46	10.23	28.18	6.51	96.59	Not Applicable	
2420.00	1000	V	1.18	331	101.01	48.47	10.23	28.21	6.53	97.51		
2439.00	1000	H	1.22	260	66.57	48.48	10.23	28.27	6.55	63.14	74.00	10.86
2439.00	1000	V	1.18	331	65.50	48.48	10.23	28.27	6.55	62.07	74.00	11.93
4824.00	1000	H/V	1.00	0	---	49.00	0.42	33.14	9.70	---	74.00	---
7236.00	1000	H/V	1.00	0	---	49.22	0.31	35.91	9.61	---	74.00	---
2430.24	1000	H	1.29	228	99.48	48.47	10.23	28.24	6.54	96.02	Not Applicable	
2434.77	1000	V	1.24	347	100.65	48.47	10.23	28.26	6.55	97.22		
4874.00	1000	H/V	1.00	0	---	49.02	0.39	33.17	9.75	---	74.00	---
7311.00	1000	H/V	1.00	0	---	49.26	0.31	36.00	9.63	---	74.00	---
2455.20	1000	H	1.30	271	101.19	48.48	10.23	28.32	6.58	97.84	Not Applicable	
2465.20	1000	V	1.25	324	101.83	48.49	10.23	28.35	6.59	98.51		
2483.60	1000	H	1.30	271	66.62	48.50	10.23	28.41	6.62	63.38	74.00	10.62
2483.60	1000	V	1.25	324	64.77	48.50	10.23	28.41	6.62	61.53	74.00	12.47
4924.00	1000	H/V	1.00	0	---	49.03	0.36	33.20	9.80	---	74.00	---
7386.00	1000	H/V	1.00	0	---	49.31	0.32	36.09	9.64	---	74.00	---
AVERAGE data, emissions above 1000 MHz **(802.11n HT20 mode)**												
2410.08	1000	H	1.22	260	91.56	48.46	10.23	28.18	6.51	88.02	Not Applicable	
2420.00	1000	V	1.18	331	92.86	48.47	10.23	28.21	6.53	89.36		
2439.00	1000	H	1.22	260	46.72	48.48	10.23	28.27	6.55	43.29	54.00	10.71
2439.00	1000	V	1.18	331	45.56	48.48	10.23	28.27	6.55	42.13	54.00	11.87
4824.00	1000	H/V	1.00	0	---	49.00	0.42	33.14	9.70	---	54.00	---
7236.00	1000	H/V	1.00	0	---	49.22	0.31	35.91	9.61	---	54.00	---
2430.24	1000	H	1.29	228	90.87	48.47	10.23	28.24	6.54	87.41	Not Applicable	
2434.77	1000	V	1.24	347	92.05	48.47	10.23	28.26	6.55	88.62		
4874.00	1000	H/V	1.00	0	---	49.02	0.39	33.17	9.75	---	54.00	---
7311.00	1000	H/V	1.00	0	---	49.26	0.31	36.00	9.63	---	54.00	---
2455.20	1000	H	1.30	271	92.68	48.48	10.23	28.32	6.58	89.33	Not Applicable	
2465.20	1000	V	1.25	324	93.12	48.49	10.23	28.35	6.59	89.80		
2483.60	1000	H	1.30	271	50.93	48.50	10.23	28.41	6.62	47.69	54.00	6.31
2483.60	1000	V	1.25	324	48.37	48.50	10.23	28.41	6.62	45.13	54.00	8.87
4924.00	1000	H/V	1.00	0	---	49.03	0.36	33.20	9.80	---	54.00	---
7386.00	1000	H/V	1.00	0	---	49.31	0.32	36.09	9.64	---	54.00	---

Margin (dB) = Limit – Actual

[Actual = Reading – Amp Gain + Attenuator + AF + CL]

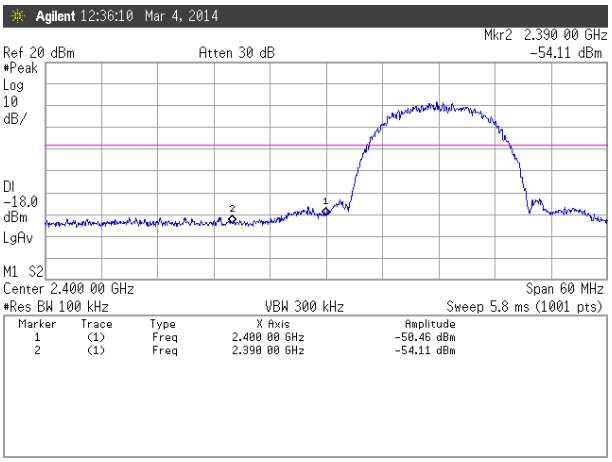
1. H = Horizontal, V = Vertical Polarization
2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

NOTE: "---" means the emission level was too low to be measured or in the noise floor.

Figure 3. Plot of the Band Edge (Conducted)

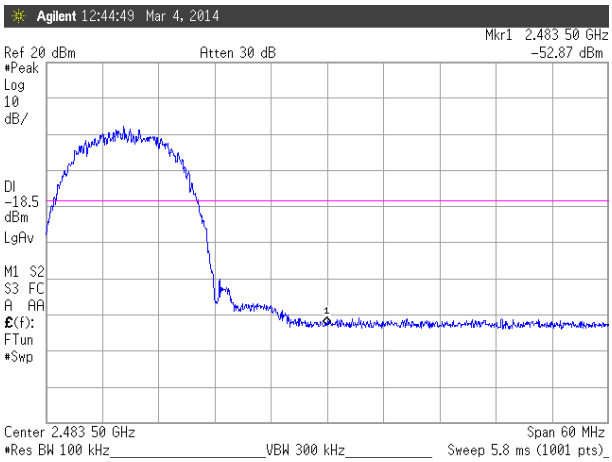
802.11b mode:

Lowest Channel (2412 MHz)



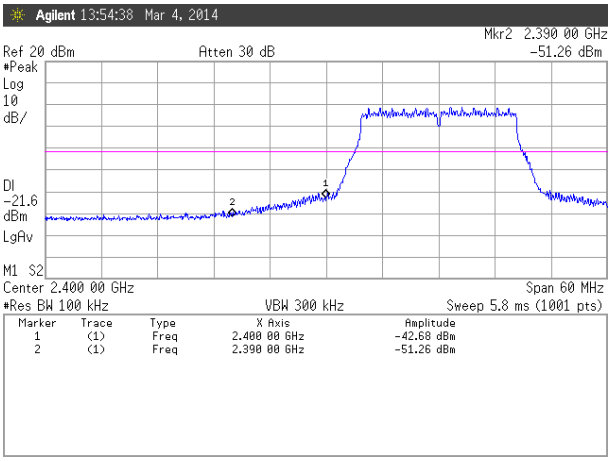
802.11b mode:

Highest Channel (2462 MHz)



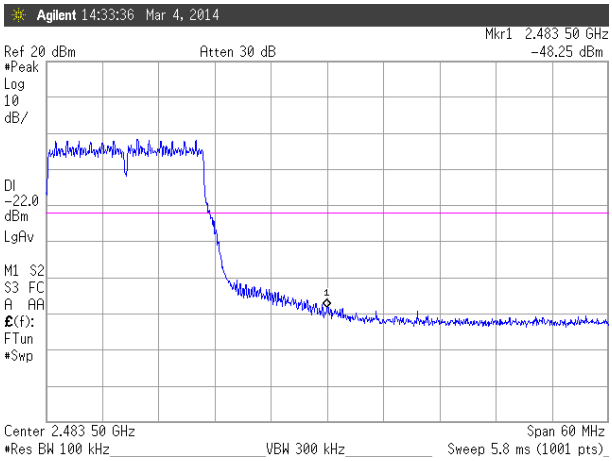
802.11g mode:

Lowest Channel (2412 MHz)



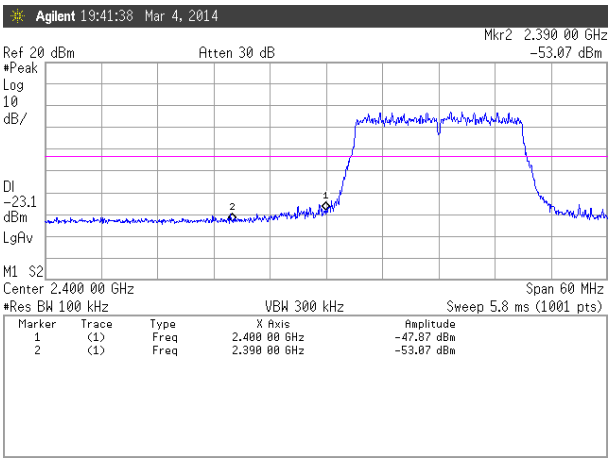
802.11g mode:

Highest Channel (2462 MHz)



802.11n HT20 mode:

Lowest Channel (2412 MHz)



802.11n HT20 mode:

Highest Channel (2462 MHz)

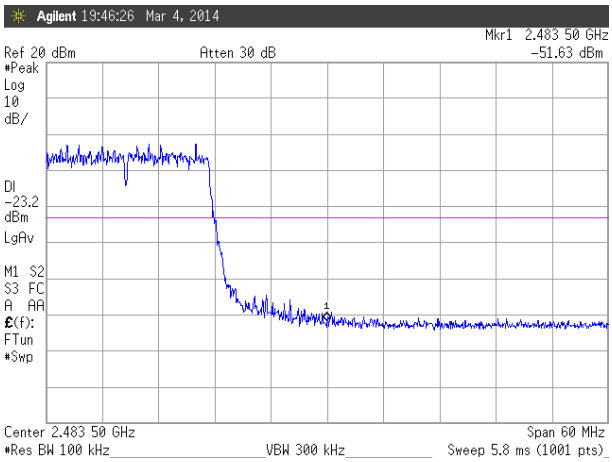
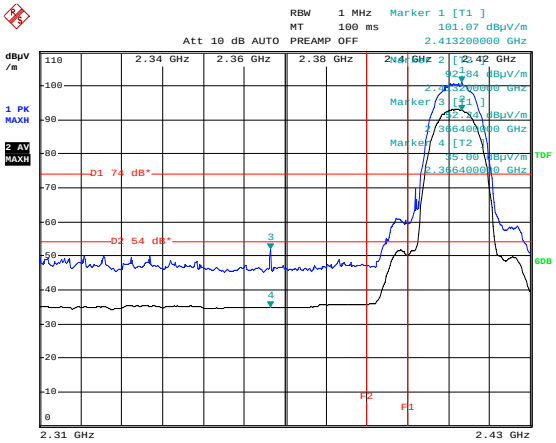


Figure 4. Plot of the Band Edge (Radiated)

802.11b mode:

Lowest Channel (2412 MHz)

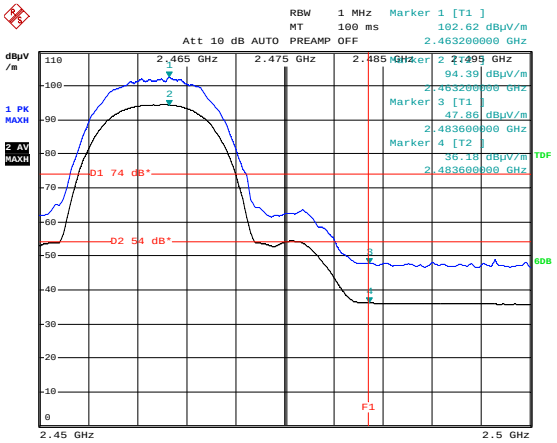
Horizontal



Date: 17.MAR.2014 19:01:47

Highest Channel (2462 MHz)

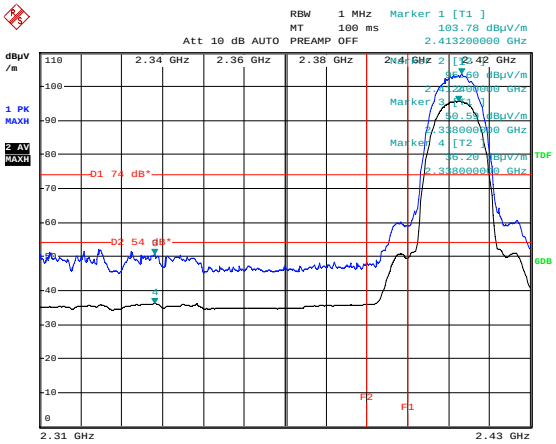
Horizontal



Date: 17.MAR.2014 19:45:34

Lowest Channel (2412 MHz)

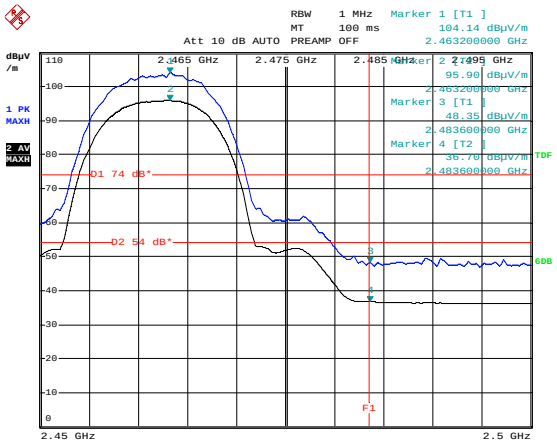
Vertical



Date: 17.MAR.2014 17:53:30

Highest Channel (2462 MHz)

Vertical



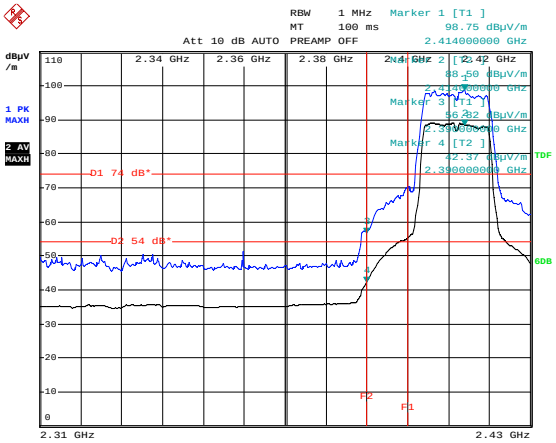
Date: 17.MAR.2014 18:30:55

Plot of the Band Edge (Radiated) *(continued)*

802.11g mode:

Lowest Channel (2412 MHz)

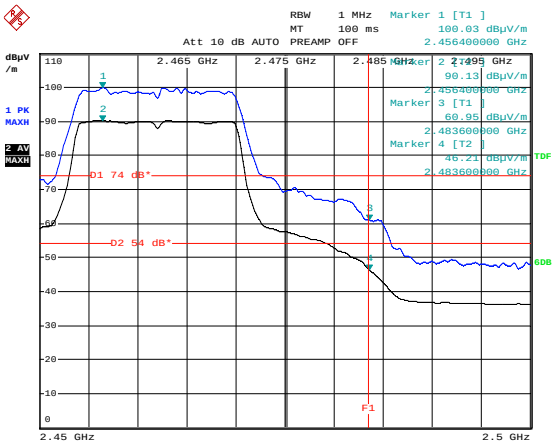
Horizontal



Date: 17.MAR.2014 19:06:13

Highest Channel (2462 MHz)

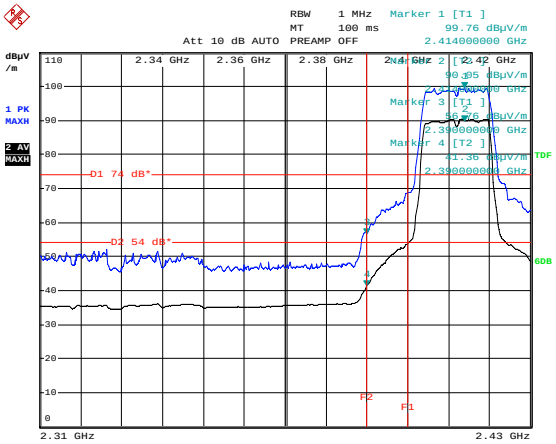
Horizontal



Date: 17.MAR.2014 19:53:12

Lowest Channel (2412 MHz)

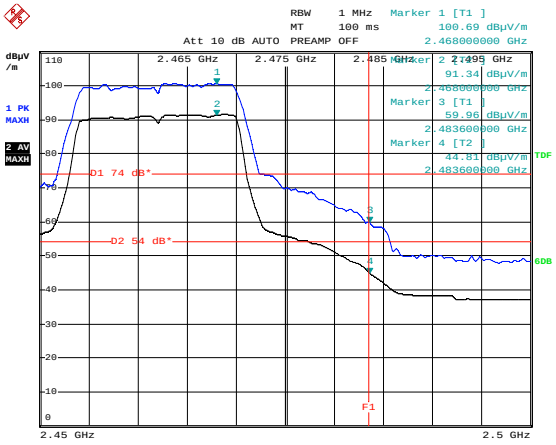
Vertical



Date: 17.MAR.2014 18:40:05

Highest Channel (2462 MHz)

Vertical



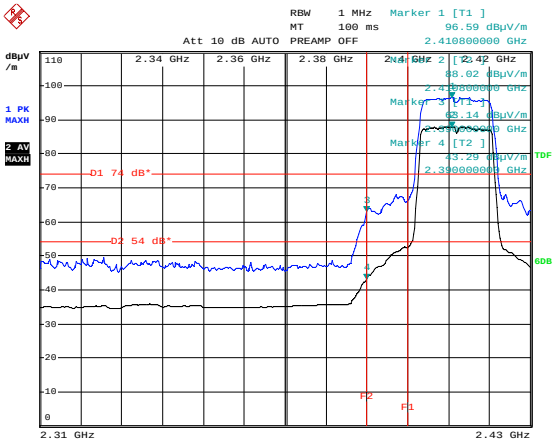
Date: 17.MAR.2014 18:25:51

Plot of the Band Edge (Radiated) *(continued)*

802.11n HT20 mode:

Lowest Channel (2412 MHz)

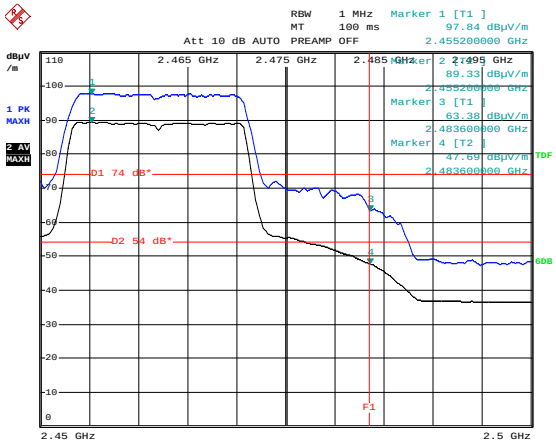
Horizontal



Date: 17.MAR.2014 19:13:02

Highest Channel (2462 MHz)

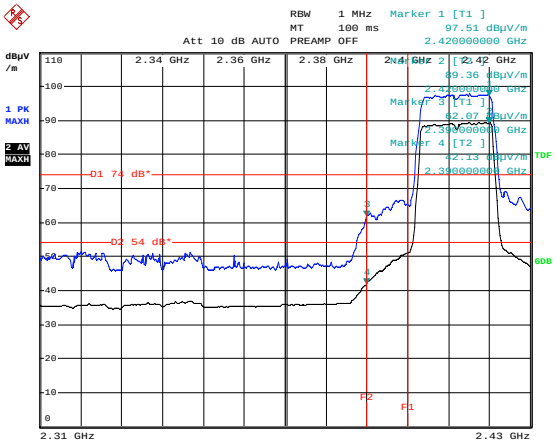
Horizontal



Date: 17.MAR.2014 20:00:21

Lowest Channel (2412 MHz)

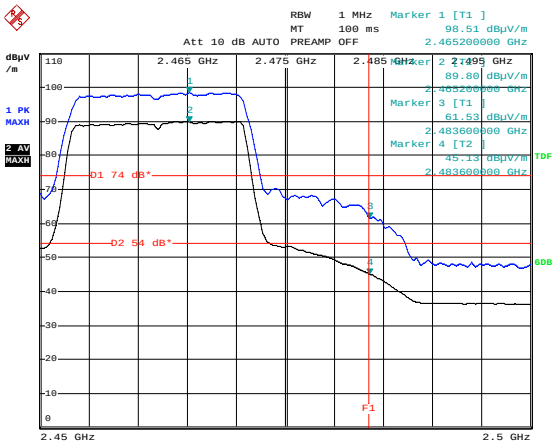
Vertical



Date: 17.MAR.2014 18:47:33

Highest Channel (2462 MHz)

Vertical

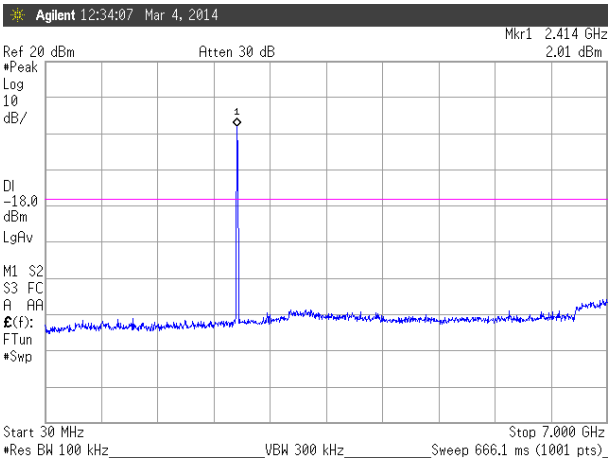


Date: 17.MAR.2014 18:18:10

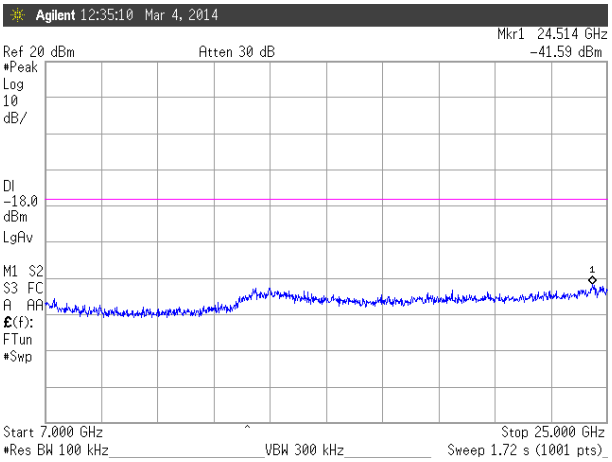
Figure 5. Spurious RF conducted emissions

802.11b mode:

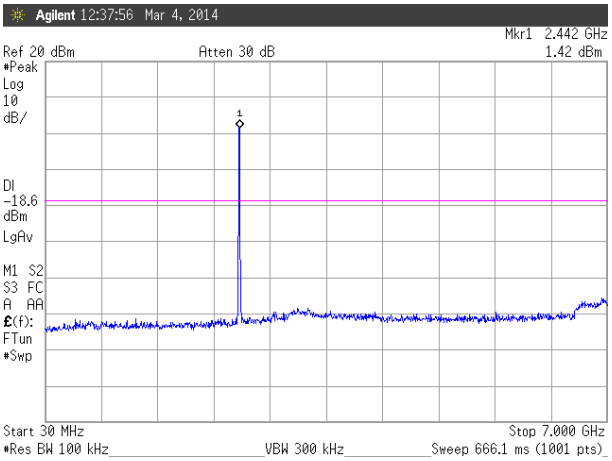
Lowest Channel (2412 MHz): 30 MHz ~ 7 GHz



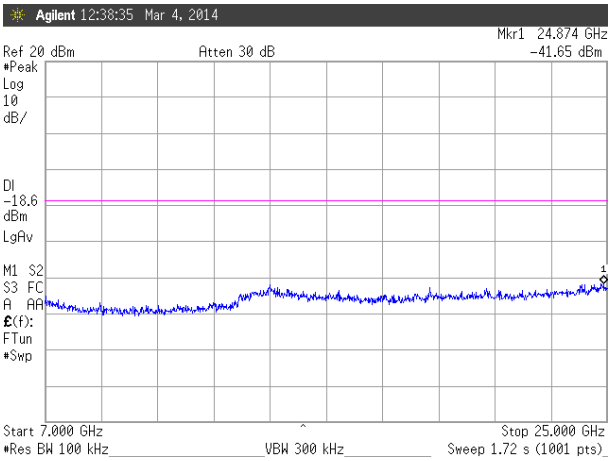
Lowest Channel (2412 MHz): 7 GHz ~ 25 GHz



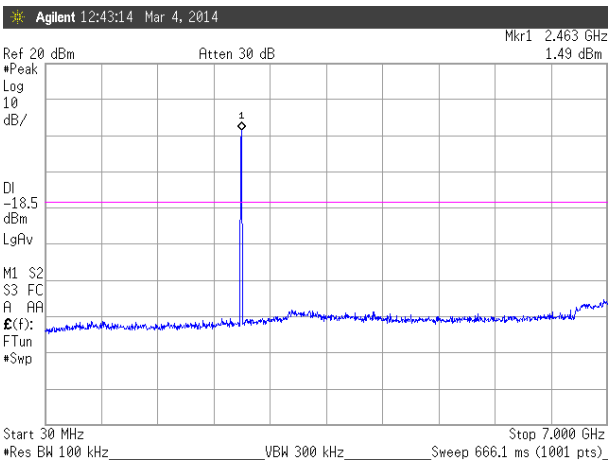
Middle Channel (2437 MHz): 30 MHz ~ 7 GHz



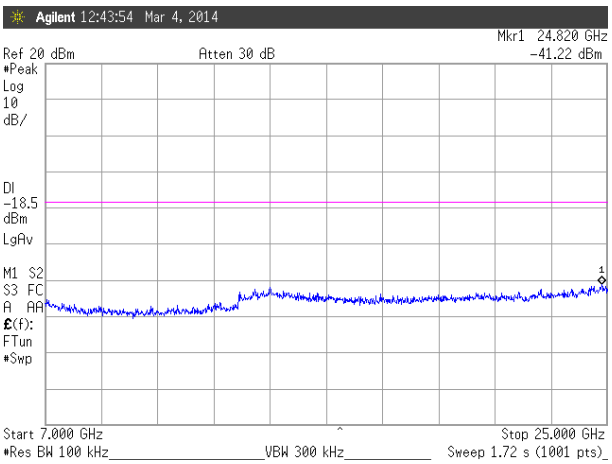
Middle Channel (2437 MHz): 7 GHz ~ 25 GHz



Highest Channel (2462 MHz): 30 MHz ~ 7 GHz



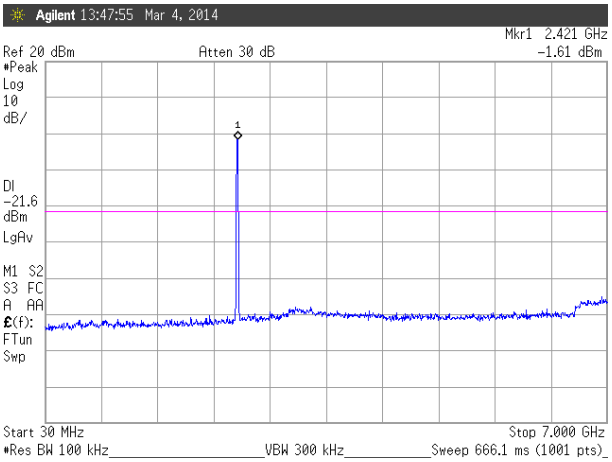
Highest Channel (2462 MHz): 7 GHz ~ 25 GHz



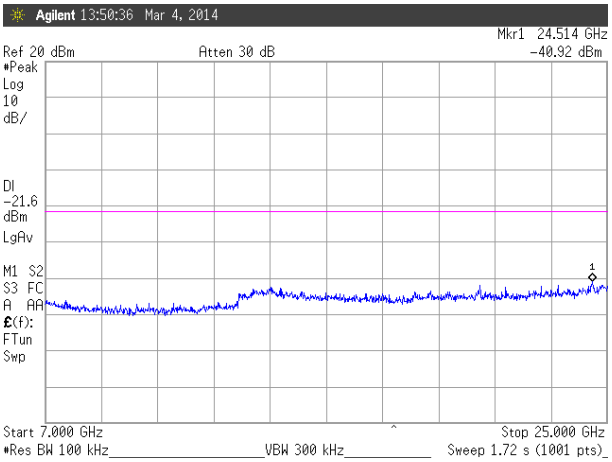
Spurious RF conducted emissions *(continued)*

802.11g mode:

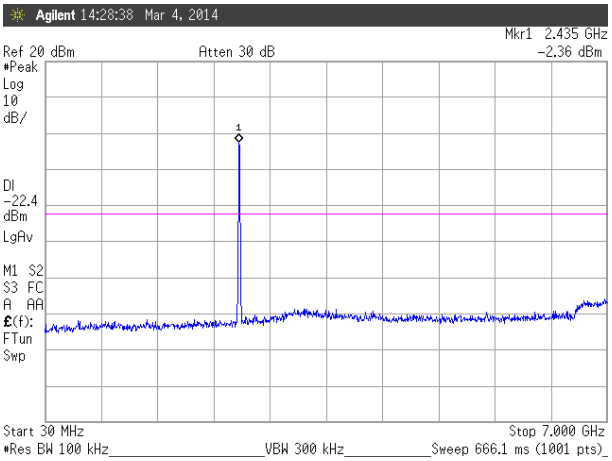
Lowest Channel (2412 MHz): 30 MHz ~ 7 GHz



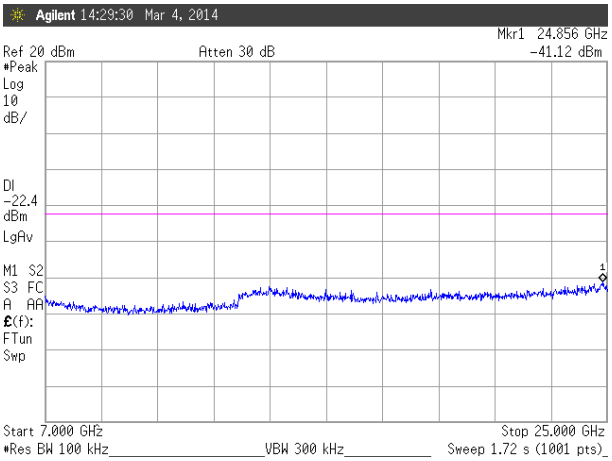
Lowest Channel (2412 MHz): 7 GHz ~ 25 GHz



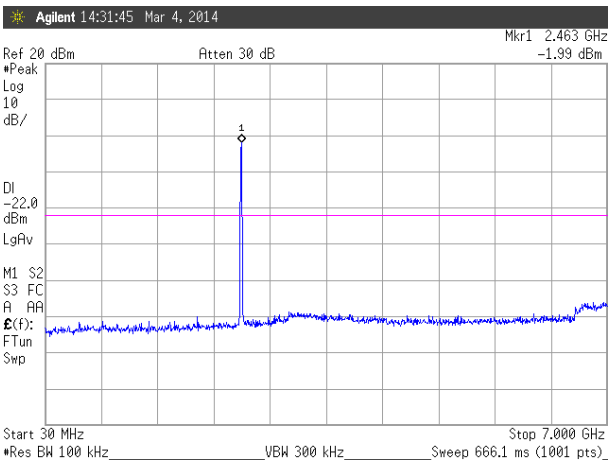
Middle Channel (2437 MHz): 30 MHz ~ 7 GHz



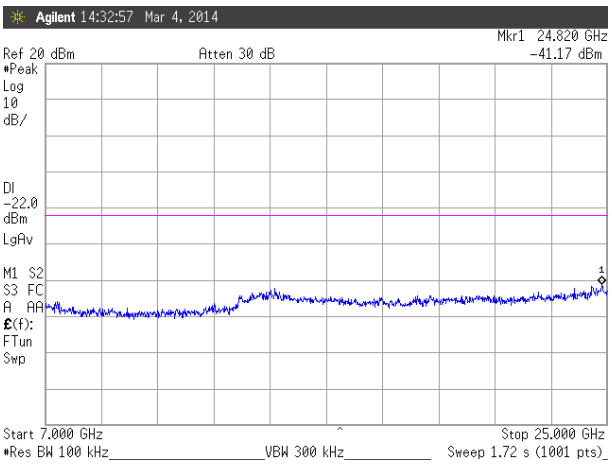
Middle Channel (2437 MHz): 7 GHz ~ 25 GHz



Highest Channel (2462 MHz): 30 MHz ~ 7 GHz



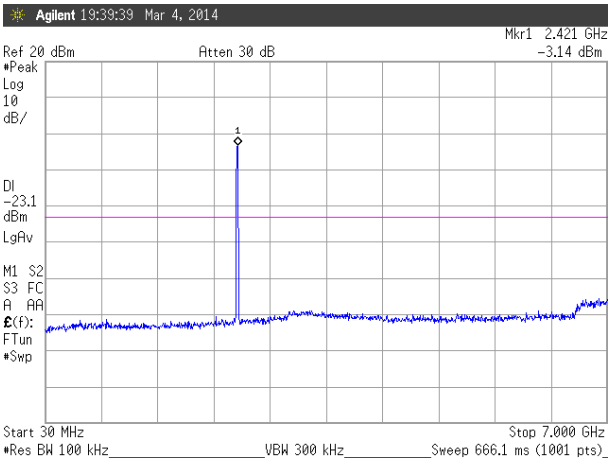
Highest Channel (2462 MHz): 7 GHz ~ 25 GHz



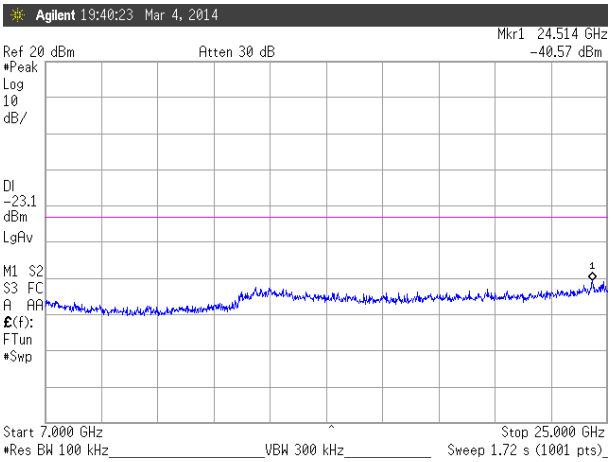
Spurious RF conducted emissions *(continued)*

802.11n HT20 mode:

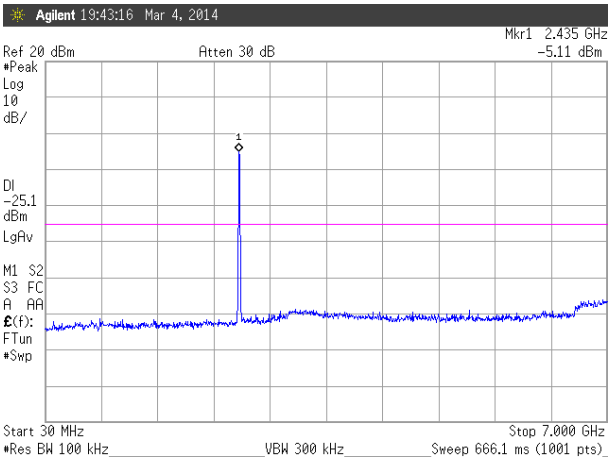
Lowest Channel (2412 MHz): 30 MHz ~ 7 GHz



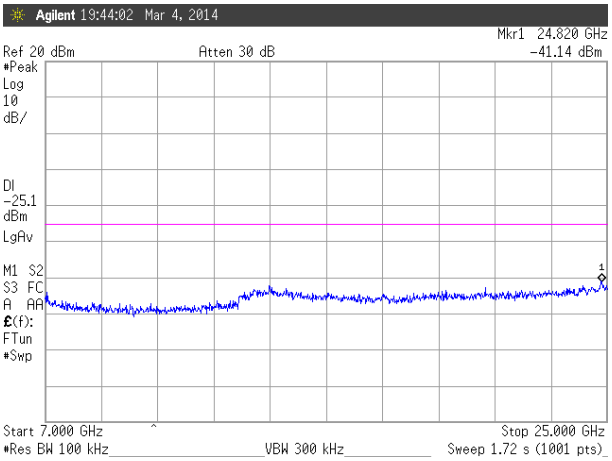
Lowest Channel (2412 MHz): 7 GHz ~ 25 GHz



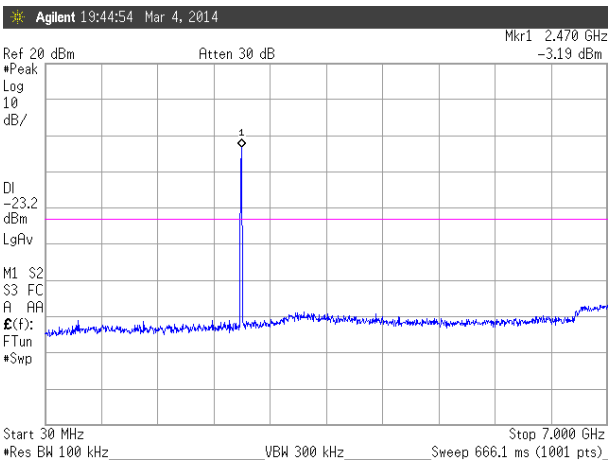
Middle Channel (2437 MHz): 30 MHz ~ 7 GHz



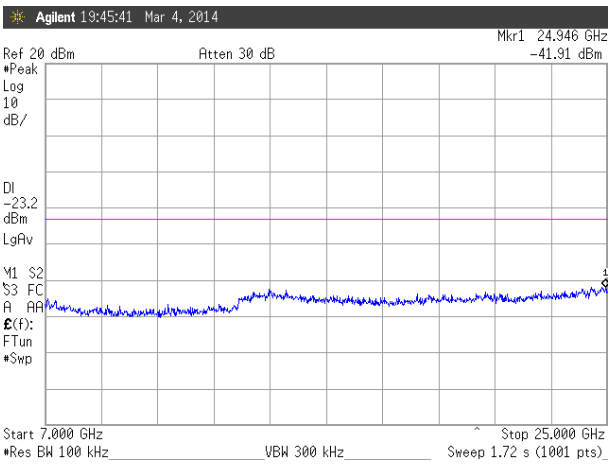
Middle Channel (2437 MHz): 7 GHz ~ 25 GHz



Highest Channel (2462 MHz): 30 MHz ~ 7 GHz



Highest Channel (2462 MHz): 7 GHz ~ 25 GHz



5.6. Peak power spectral density

5.6.1 Regulation

According to §15.247(e), 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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

5.6.2 Test Procedure(peak PSD)

Set the spectrum analyzer as follows:

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS bandwidth.
3. Set the 3 kHz ≤ RBW ≤ 100 kHz.
4. Set the VBW ≥ 3 x RBW.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

5.6.3 Test Results: PASS

Table 4: Measured values of the Peak Power Spectral Density (Conducted)

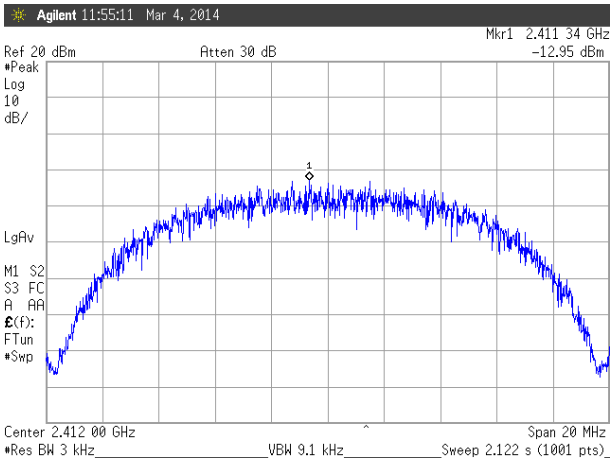
Modulation	Operating frequency	Transfer Rate	PSD/3 kHz (dBm)	Limit (dBm)
802.11b	2412 MHz	11 Mbps	-12.95	8
	2437 MHz	11 Mbps	-12.54	8
	2462 MHz	11 Mbps	-12.75	8
802.11g	2412 MHz	54 Mbps	-16.42	8
	2437 MHz	54 Mbps	-16.11	8
	2462 MHz	54 Mbps	-15.70	8
802.11n HT20	2412 MHz	MCS7	-17.57	8
	2437 MHz	MCS7	-14.95	8
	2462 MHz	MCS7	-19.44	8

NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.

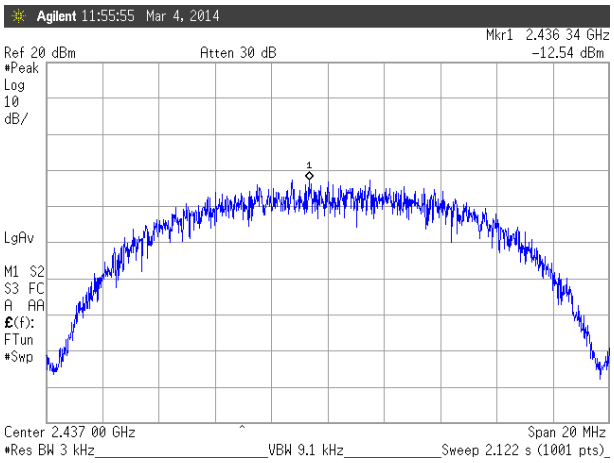
Figure 6. Plot of the Peak Power Spectral Density

802.11b mode:

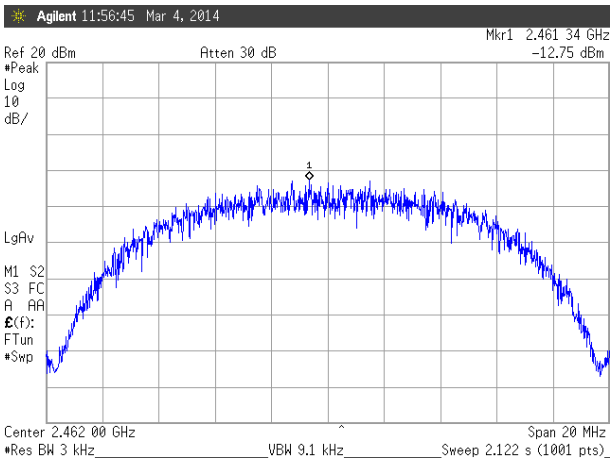
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)

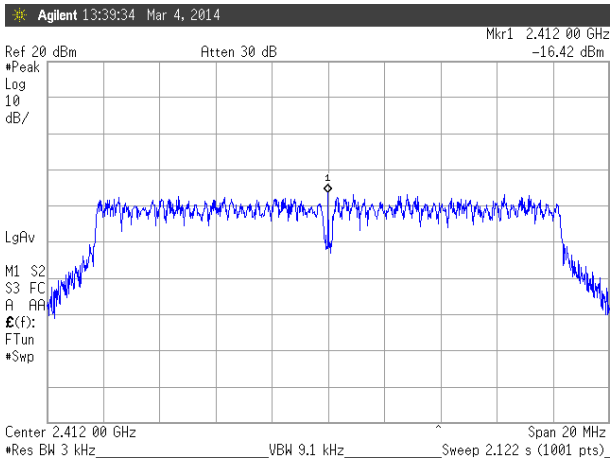


Highest Channel (2462 MHz)

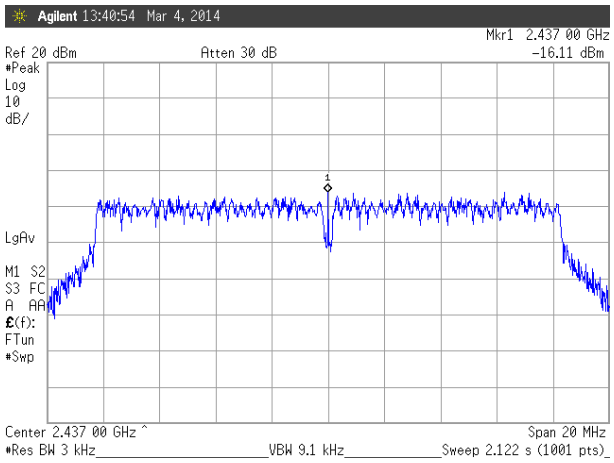


802.11g mode:

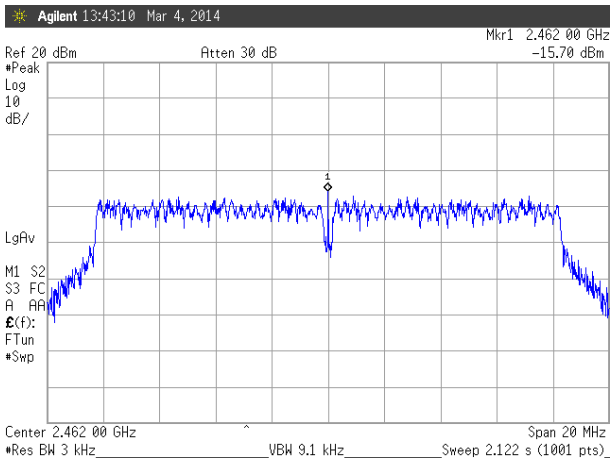
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)



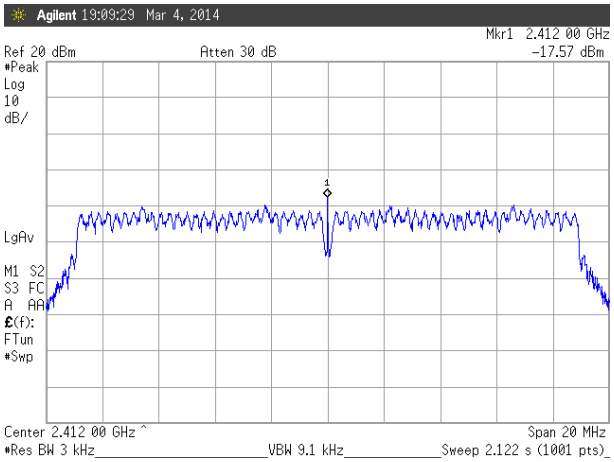
Highest Channel (2462 MHz)



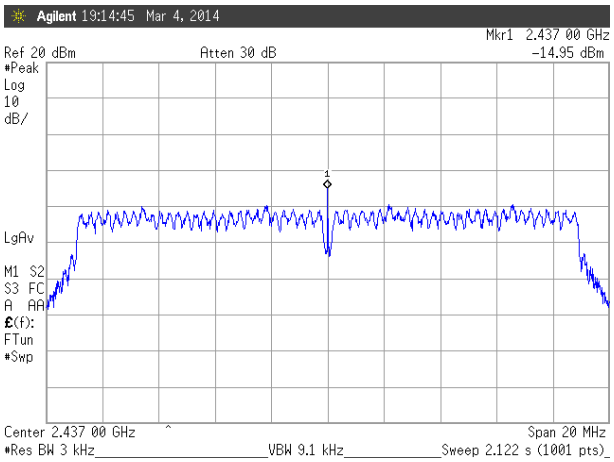
Plot of the Peak Power Spectral Density (continued)

802.11n HT20 mode:

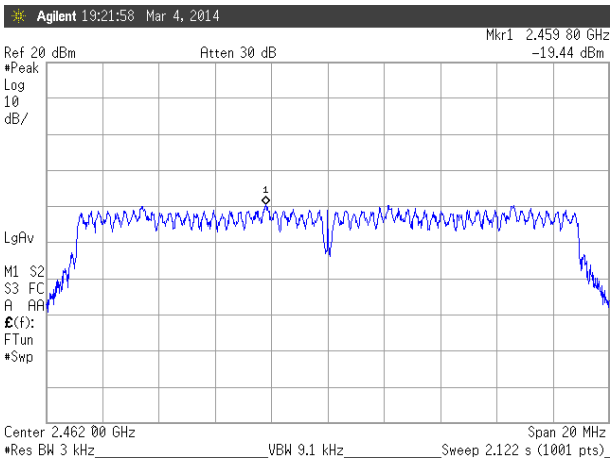
Lowest Channel (2412 MHz)



Middle Channel (2437 MHz)



Highest Channel (2462 MHz)



6 Test and measurements (Bluetooth)

6.1. Antenna requirement

6.1.1 Regulation

According to §15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.
And according to §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.

6.1.2 Result: PASS

The transmitter has the integral PCB antenna. The directional gain of the antenna is 4.864 dBi.

6.2. Maximum peak output power

6.2.1 Regulation

According to §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.

According to §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.

6.2.2 Test Procedure

1. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
2. The measurements were taken in TEST MODE provided by the applicant for controlling the EUT.
3. Set the spectrum analyzer as follows:
   Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel
   RBW > the 20 dB bandwidth of the emission being measured
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
4. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
5. Repeat above procedures until all frequencies measured were complete.

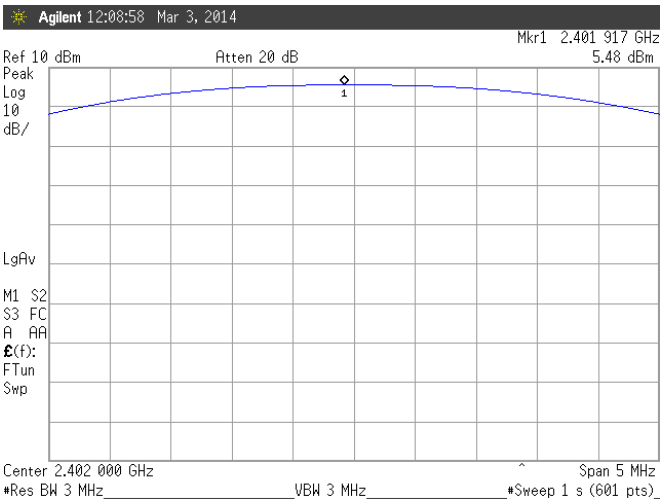
5.2.3 Test Results: PASS

Table 5: Measured values of the Maximum Peak Conducted Output Power

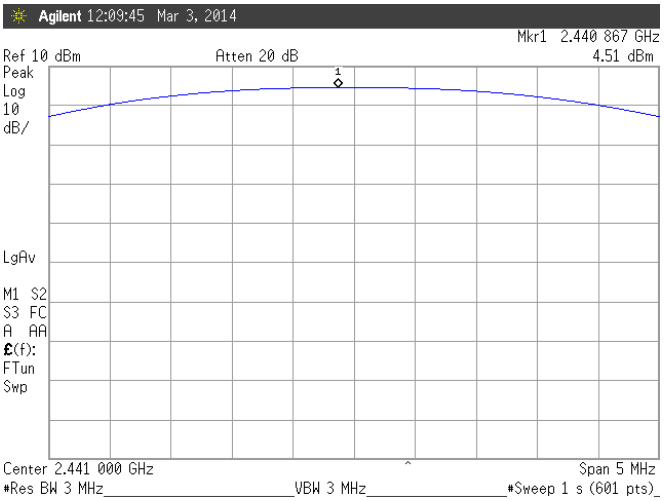
Modulation	Operating Frequency	Resolution Bandwidth	Measured value		Limit
			dBm	W	
Basic (GFSK)	2402 MHz	3 MHz	5.48	0.003 53	1 W (the number of the non-overlapping hopping channels is equal to or greater than 75)
	2441 MHz	3 MHz	4.51	0.002 82	
	2480 MHz	3 MHz	4.10	0.002 57	

Figure 7. Plot of the Maximum Peak Conducted Output Power (Conducted)

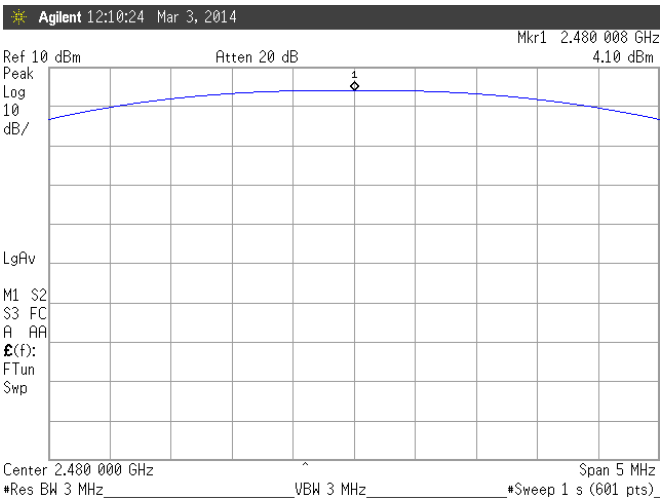
Lowest Channel (2402 MHz)



Middle Channel (2441 MHz)



Highest Channel (2480 MHz)



6.3. Carrier frequency separations and 20 dB bandwidth

5.3.1 Regulation

According to §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.

6.3.2 Test Procedure

1. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
2. The measurements were taken in TEST MODE provided by the applicant for controlling the EUT.
3. Set the spectrum analyzer as follows:
   For measurements of Carrier Frequency Separation
   Span = wide enough to capture the peaks of two adjacent channels
   Resolution (or IF) Bandwidth (RBW) ≥ 1% of the span
   Video (or Average) Bandwidth (VBW) ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
   For measurements of 20 dB Bandwidth
   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 function = peak
   Trace = max hold
4. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
5. Repeat above procedures until all frequencies measured were complete.

6.3.3 Test Results: PASS

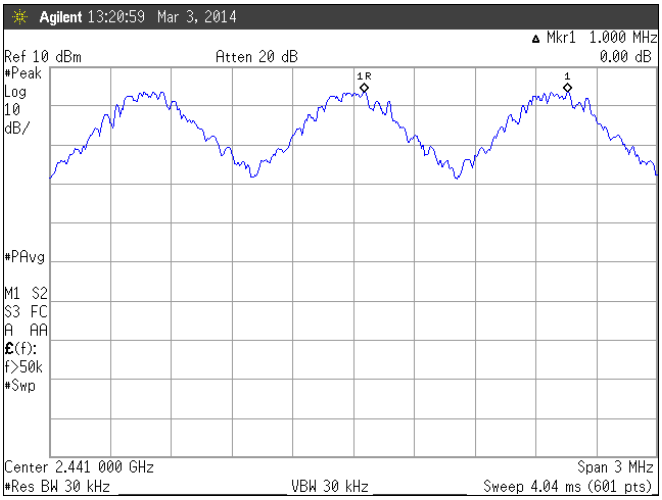
Table 6: Measured values of the Carrier Frequency Separation and 20 dB Bandwidth

Modulation	Operating Frequency	Frequency Separation	20 dB Bandwidth	LIMIT (Frequency Separation)
Basic (GFSK)	2402 MHz	1060 kHz	942 kHz	≥ 25 kHz or 20 dB bandwidth, whichever is greater
	2441 MHz	1000 kHz	933 kHz	
	2480 MHz	1000 kHz	942 kHz	

Figure 8. Plot of the Carrier Frequency Separation

Lowest Channel (2402 MHz)

Middle Channel (2441 MHz)



Highest Channel (2480 MHz)

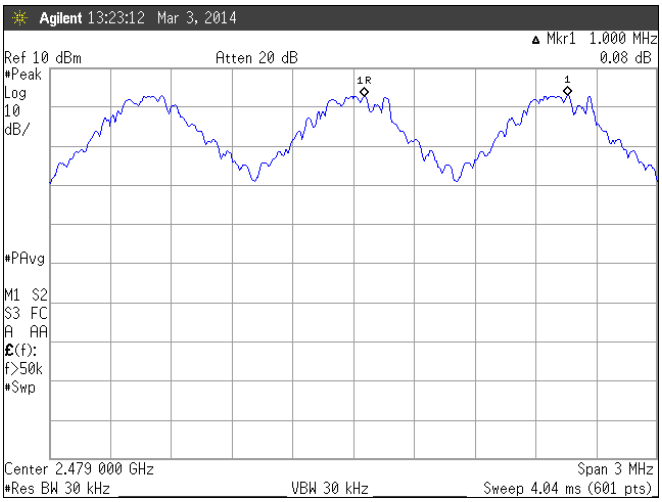
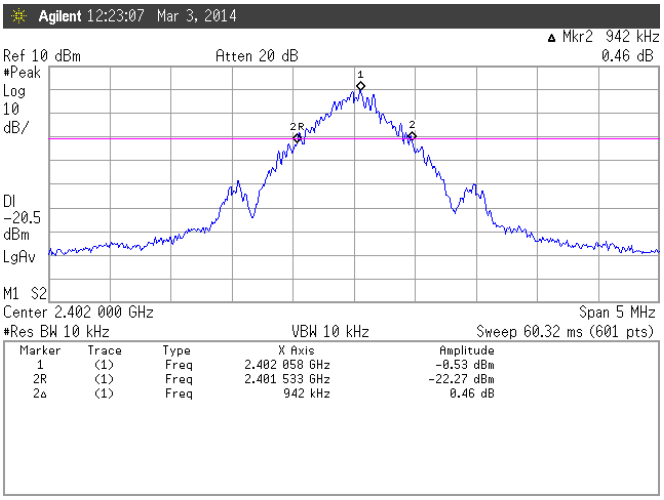
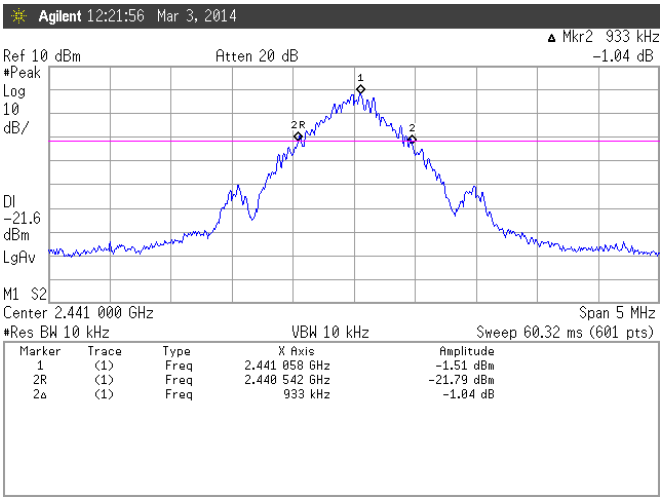


Figure 9. Plot of the 20 dB Channel Bandwidth

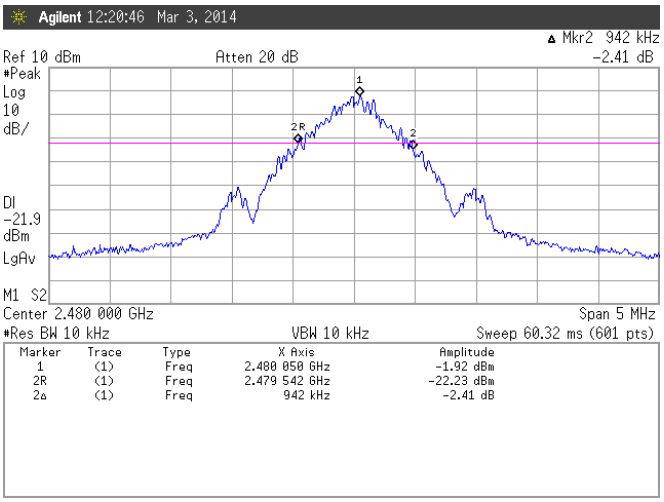
Lowest Channel (2402 MHz)



Middle Channel (2441 MHz)



Highest Channel (2480 MHz)



6.4. Number of Hopping channels

6.4.1 Regulation

According to §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.

According to §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.

6.4.2 Test Procedure

1. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable and attenuator.
2. The measurements were taken in TEST MODE provided by the applicant for controlling the EUT.
3. Set the spectrum analyzer as follows:
   Span = the frequency band of operation
   RBW ≥ 1% of the span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
4. Record the number of hopping channels.

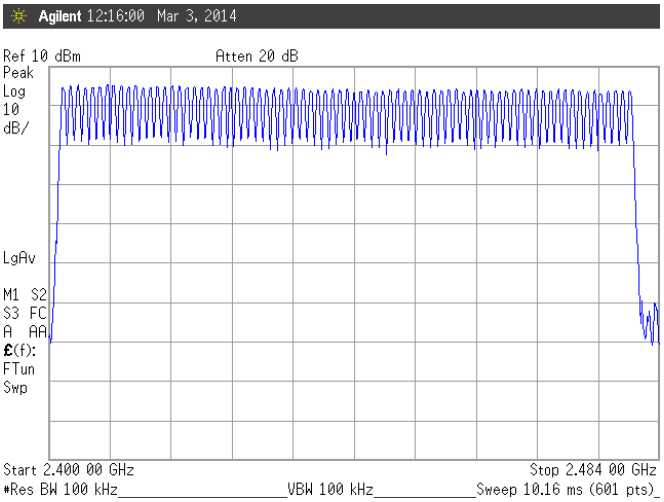
6.4.3 Test Results: PASS

Table 7: Measured values of the Number of Hopping Channels

Modulation	Operating Frequency	Number of hopping channels	LIMIT
Basic (GFSK)	2402 - 2480 MHz	79	≥ 15

Figure 10. Plot of the Number of Hopping Channels

Basic(GFSK)



6.5. Time of occupancy (Dwell time)

6.5.1 Regulation

According to §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.

6.5.2 Test Procedure

1. Connect the antenna port of the EUT to RF input on the spectrum analyzer via a low loss cable.
2. The measurements were taken in TEST MODE provided by the applicant for controlling the EUT.
3. Set the spectrum analyzer as follows:
   Span = zero span, centered on a hopping channel
   RBW = 1 MHz
   VBW ≥ RBW
   Sweep = as necessary to capture the entire dwell time per hopping channel
   Detector function = peak
   Trace = max hold
4. Measure the dwell time using the marker-delta function.
5. Repeat above procedures until all frequencies measured were complete.
6. Repeat this test for different modes of operation (e.g., data rate, modulation format, etc.), if applicable.

6.5.3 Test Results: PASS

Table 9: Measured values of the Time of Occupancy

Modulation	Operating Frequency	Reading (ms)	Hopping rate (hops/s)	Number of Channels	Actual (seconds)	LIMIT (seconds)
Basic (GFSK)	2402 MHz	2.880	266.667	79	0.31	0.4
	2441 MHz	2.880	266.667	79	0.31	0.4
	2480 MHz	2.880	266.667	79	0.31	0.4

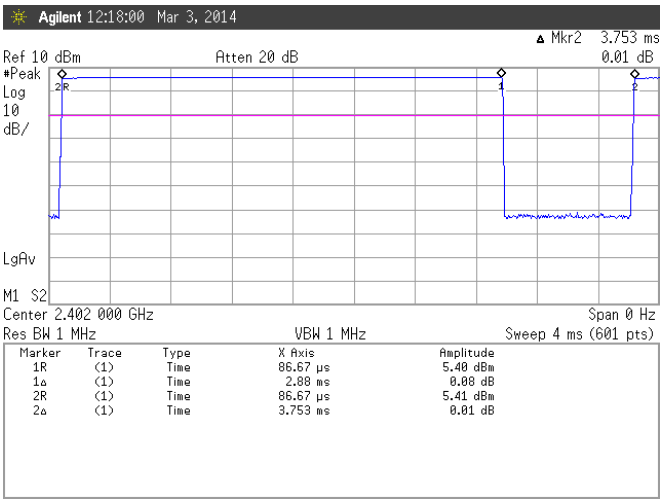
Actual = Reading × (Hopping rate / Number of channels) × Test period

Test period = 0.4 [seconds / channel] × 79 [channel] = 31.6 [seconds]

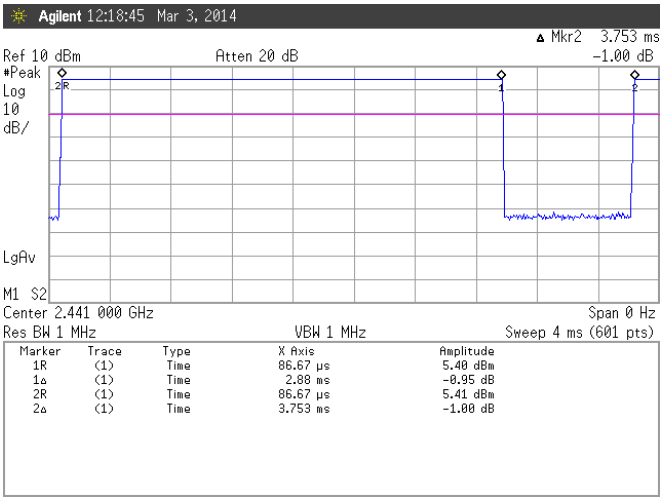
NOTE: The EUT makes worst case 1600 hops per second or 1 time slot has a length of 625μs with 79 channels. The DH5 Packet needs 5 time slot for transmitting and 1 time slot for receiving. Then the EUT makes worst case 266.667 hops per second with 79 channels.

Figure 11. Plot of the Time of Occupancy

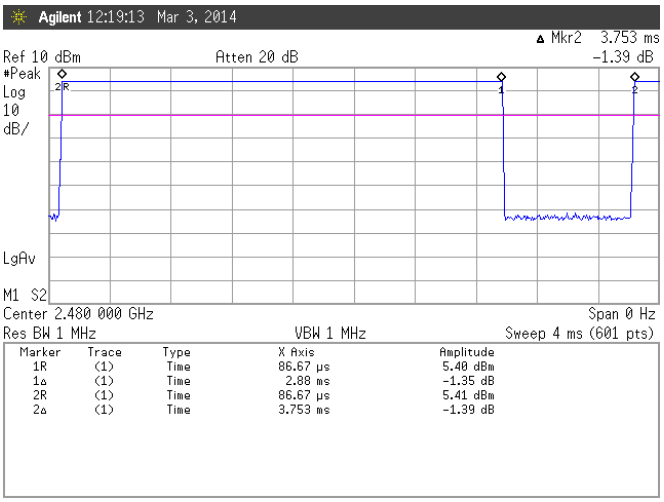
Lowest Channel (2402 MHz)



Middle Channel (2441 MHz)



Highest Channel (2480 MHz)



6.6. Spurious emissions, Band edge, and Restricted bands

6.6.1 Regulation

According to §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)).
According to §15.209(a), for an intentional device, the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency (MHz)	Field strength (μV/m @ 3m)	Field strength (dBμV/m @ 3m)
30–88	100	40.0
88–216	150	43.5
216–960	200	46.0
Above 960	500	54.0

According to §15.109(a), for an unintentional device, except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the above table.

** The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector and above 1000 MHz are based on the average value of measured emissions.

6.6.2 Test Procedure

1) Band-edge measurements for RF conducted emissions

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the emission operating on the channel closest to the band-edge, as well as any modulation products which fall outside of the authorized band of operation
   RBW ≥ 1 % of spectrum analyzer display span
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the emission at the band-edge, or on the highest modulation product outside of the band, if this level is greater than that at the band-edge. Enable the marker-delta function, and then use the marker-to-peak function to move the marker to the peak of the in-band emission.
3. Now, using the same instrument settings, enable the hopping function of the EUT. Allow the trace to stabilize. Follow the same procedure listed above to determine if any spurious emissions caused by the hopping function also comply with the specified limit.

2) Spurious RF Conducted Emissions:

1. Set the spectrum analyzer as follows:
   Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.
   RBW = 100 kHz
   VBW ≥ RBW
   Sweep = auto
   Detector function = peak
   Trace = max hold
2. Allow the trace to stabilize. Set the marker on the peak of any spurious emission recorded.

3) Spurious Radiated Emissions:

1. The preliminary radiated measurements were performed to determine the frequency producing the maximum emissions in an anechoic chamber at a distance of 3 meters for above 30 MHz, and at 1 meter / 3 meter distance for below 30 MHz.
2. The EUT was placed on the top of the 0.8-meter height, 1 × 1.5 meter non-metallic table. To find the maximum emission levels, the height of a measuring antenna was changed and the turntable was rotated 360˚.
3. The antenna polarization was also changed from vertical to horizontal. The spectrum was scanned from 9 kHz to 30 MHz using the loop antenna, from 30 to 1000 MHz using the Trilog broadband antenna, and from 1 GHz to tenth harmonic of the highest fundamental frequency using the horn antenna.
4. To obtain the final measurement data, the EUT was arranged on a turntable situated on a 4 × 4 meter at the Open Area Test Site. The EUT was tested at a distance 3 meters.
5. Each frequency found during preliminary measurements was re-examined and investigated. The test-receiver system was set up to average, peak, and quasi-peak detector function with specified bandwidth.
6. The EUT is situated in three orthogonal planes (if appropriate)
7. The presence of ambient signals was verified by turning the EUT off. In case an ambient signal was detected, the measurement bandwidth was reduced temporarily and verification was made that an additional adjacent peak did not exist. This ensures that the ambient signal does not hide any emissions from the EUT.
8. If the emission on which a radiated measurement must be made is located at the edge of the authorized band of operation, then the alternative “marker-delta” method may be employed.

4) Marker-Delta Method at the edge of the authorized band of operation:

1. Perform an in-band field strength measurement of the fundamental emission using the RBW and detector function specified in 6.3 and 6.4, 6.5, or 6.6, as applicable, and the appropriate regulatory requirements for the frequency being measured.43
2. Choose a spectrum analyzer span that encompasses both the peak of the fundamental emission and the band-edge emission under investigation. Set the analyzer RBW to approximately 1 % to 5 % of the total span, unless otherwise specified, with a video bandwidth equal to or greater than the RBW.
   Record the peak levels of the fundamental emission and the relevant band-edge emission (i.e., run several sweeps in peak hold mode). Observe the stored trace and measure the amplitude delta between the peak of the fundamental and the peak of the band-edge emission. This is not an absolute field strength measurement; it is only a relative measurement to determine the amount by which the emission drops at the band edge relative to the highest fundamental emission level.
3. Subtract the delta measured in b) from the field strengths measured in a). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance of the restricted bands, described in 5.9.
4. The above “delta” measurement technique may be used for measuring emissions that are up to two “standard” bandwidths away from the band edge, where a “standard” bandwidth is the bandwidth specified by 4.2.3.2 for the frequency being measured. For example, band-edge measurements in the restricted band that begins at 2483.5 MHz require a measurement bandwidth of at least 1 MHz.
   Therefore the “delta” technique for measuring emissions up to 2 MHz removed from the band edge may be used. Radiated emissions that are removed by more than two “standard” bandwidths shall be measured in the conventional manner.

6.6.3 Test Results: PASS

Band-edge compliance of RF conducted/radiated emissions was shown in the Figure 12 and 13. Spurious RF conducted emissions were shown in the Figure 14.

NOTE : for conducted measurement, we took the insertion loss of the cable loss into consideration within the measuring instrument. And for radiated measurement, the results were calibrated to the field strength within the measuring instrument; Table 10 contains the correction factors at the operating frequencies such as antenna factor, cable loss, etc.

Table 10: Measured values of the Field strength of spurious emission (Radiated)

BELOW 1 GHz

Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	dB(1/m)	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
Average/Peak/Quasi-peak data, emissions below 30 MHz												
Quasi-peak data, emissions below 1000 MHz												
840.01	120	H	1.86	30	40.1	28.8	-	23.1	3.7	38.1	46.0	7.9
840.01	120	V	1.77	47	39.5	28.8	-	23.1	3.7	37.5	46.0	8.5

No Radiated Spurious Emissions Found

Margin (dB) = Limit – Actual

[Actual = Reading – Amp Gain + Attenuator + AF + CL]

1. H = Horizontal, V = Vertical Polarization

2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

NOTE: All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

Measured values of the Field strength of spurious emission (Radiated) *(continued)*												
ABOVE 1 GHz												
Frequency	Receiver Bandwidth	Pol.	Antenna Height	Turn Table	Reading	Amp Gain	ATT	AF	CL	Actual	Limit	Margin
[MHz]	[kHz]	[V/H]	[m]	[degree]	[dB(μV)]	[dB]	[dB]	dB(1/m)	[dB]	[dB(μV/m)]	[dB(μV/m)]	[dB]
PEAK data, emissions above 1000 MHz												
2402.0	1000	H	1.20	262	101.37	48.46	10.23	28.15	6.50	97.79	Not Applicable	
2402.0	1000	V	1.16	330	102.55	48.46	10.23	28.15	6.50	98.97		
2324.0	1000	H	1.20	262	58.23	48.44	10.24	27.90	6.38	54.31	74.00	19.69
2326.0	1000	V	1.16	330	56.33	48.44	10.24	27.91	6.38	52.42	74.00	21.58
4804.2	1000	H	1.69	270	58.16	49.00	0.43	33.12	9.68	52.39	74.00	21.61
4804.2	1000	V	1.00	283	59.50	49.00	0.43	33.12	9.68	53.73	74.00	20.27
2441.0	1000	H	1.24	230	99.63	48.48	10.23	28.28	6.56	96.22	Not Applicable	
2441.0	1000	V	1.20	330	100.94	48.48	10.23	28.28	6.56	97.53		
4882.3	1000	H	1.23	264	57.33	49.02	0.38	33.17	9.76	51.62	74.00	22.38
4882.3	1000	V	1.24	302	58.25	49.02	0.38	33.17	9.76	52.54	74.00	21.46
2480.0	1000	H	1.32	314	98.59	48.49	10.23	28.40	6.61	95.34	Not Applicable	
2480.0	1000	V	1.27	344	100.36	48.49	10.23	28.40	6.61	97.11		
2483.6	1000	H	1.32	314	53.89	48.50	10.23	28.41	6.62	50.65	74.00	23.35
2483.6	1000	V	1.27	344	55.11	48.50	10.23	28.41	6.62	51.87	74.00	22.13
4960.2	1000	H	1.34	247	57.69	49.04	0.34	33.22	9.83	52.04	74.00	21.96
4960.2	1000	V	1.15	333	58.47	49.04	0.34	33.22	9.83	52.82	74.00	21.18
AVERAGE data, emissions above 1000 MHz												
2402.0	1000	H	1.20	262	98.44	48.46	10.23	28.15	6.50	94.86	Not Applicable	
2402.0	1000	V	1.16	330	99.64	48.46	10.23	28.15	6.50	96.06		
2324.0	1000	H	1.20	262	41.26	48.44	10.24	27.90	6.38	37.34	54.00	16.66
2326.0	1000	V	1.16	330	40.95	48.44	10.24	27.91	6.38	37.04	54.00	16.96
4804.2	1000	H	1.69	270	44.37	49.00	0.43	33.12	9.68	38.60	54.00	15.40
4804.2	1000	V	1.00	283	45.83	49.00	0.43	33.12	9.68	40.06	54.00	13.94
2441.0	1000	H	1.24	230	96.88	48.48	10.23	28.28	6.56	93.47	Not Applicable	
2441.0	1000	V	1.20	330	98.23	48.48	10.23	28.28	6.56	94.82		
4882.3	1000	H	1.23	264	43.62	49.02	0.38	33.17	9.76	37.91	54.00	16.09
4882.3	1000	V	1.24	302	44.56	49.02	0.38	33.17	9.76	38.85	54.00	15.15
2480.0	1000	H	1.32	314	95.65	48.49	10.23	28.40	6.61	92.40	Not Applicable	
2480.0	1000	V	1.27	344	97.47	48.49	10.23	28.40	6.61	94.22		
2483.6	1000	H	1.32	314	41.51	48.50	10.23	28.41	6.62	38.27	54.00	15.73
2483.6	1000	V	1.27	344	42.21	48.50	10.23	28.41	6.62	38.97	54.00	15.03
4960.2	1000	H	1.34	247	44.00	49.04	0.34	33.22	9.83	38.35	54.00	15.65
4960.2	1000	V	1.15	333	44.84	49.04	0.34	33.22	9.83	39.19	54.00	14.81

Margin (dB) = Limit – Actual

[Actual = Reading – Amp Gain + Attenuator + AF + CL]

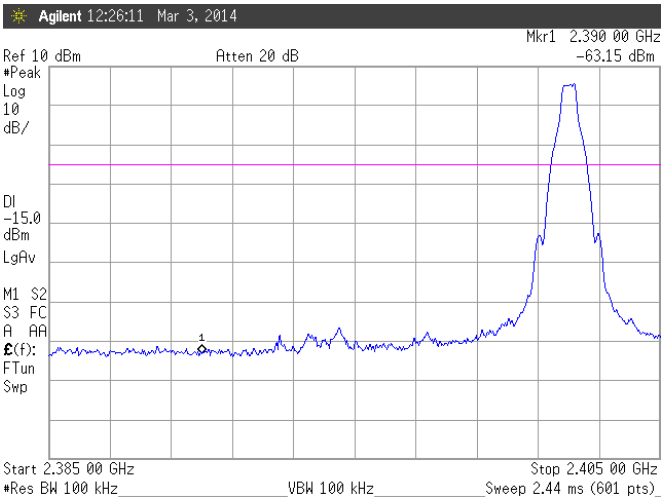
1. H = Horizontal, V = Vertical Polarization

2. ATT = Attenuation (10dB pad and/or Insertion Loss of HPF), AF/CL = Antenna Factor and Cable Loss

NOTE: All emissions not reported were more than 20 dB below the specified limit or in the noise floor.

Figure 12. Plot of the Band Edge (Conducted)

Lowest Channel (2402 MHz)



Highest Channel (2480 MHz)

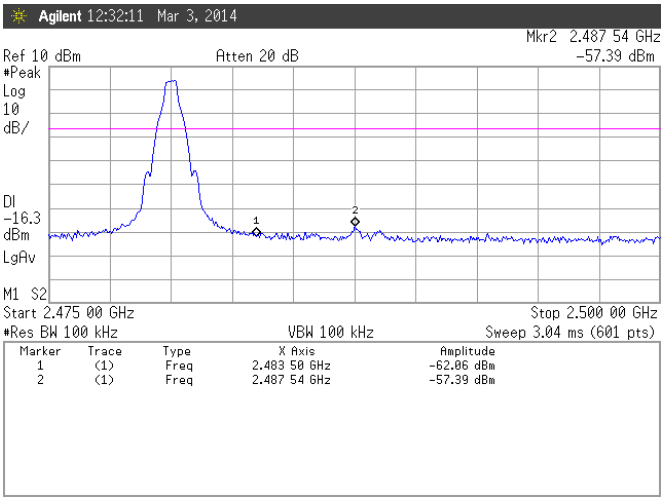
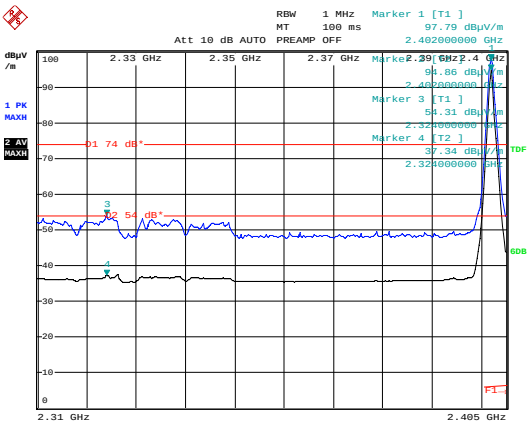


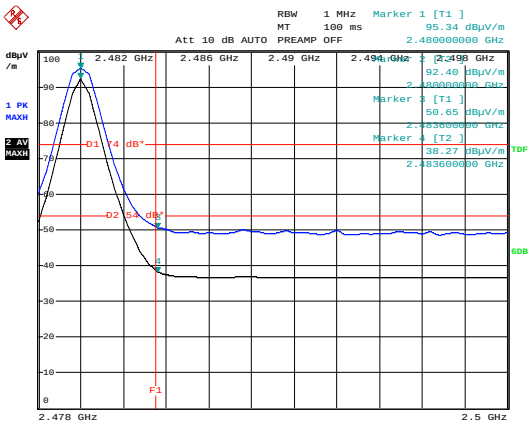
Figure 13. Plot of the Band Edge (Radiated)

Lowest Channel (2402 MHz) - Horizontal



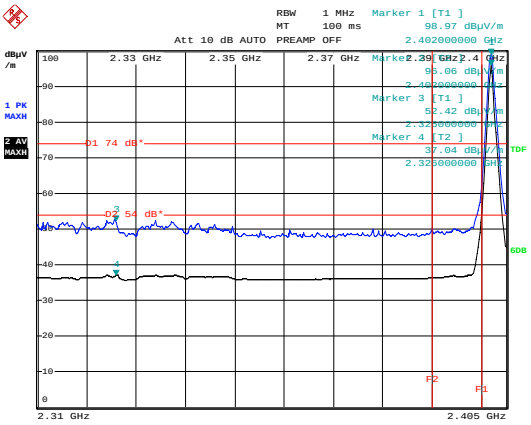
Date: 17.MAR.2014 17:09:39

Highest Channel (2480 MHz) - Horizontal



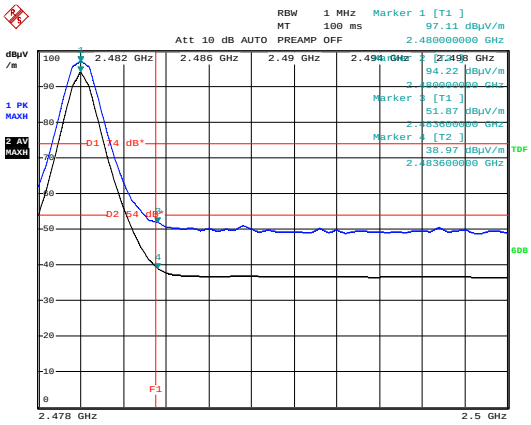
Date: 17.MAR.2014 16:49:02

Lowest Channel (2402 MHz) - Vertical



Date: 17.MAR.2014 16:31:58

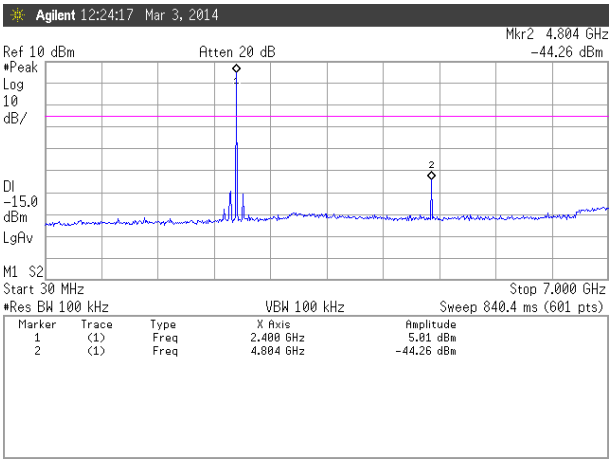
Highest Channel (2480 MHz) - Vertical



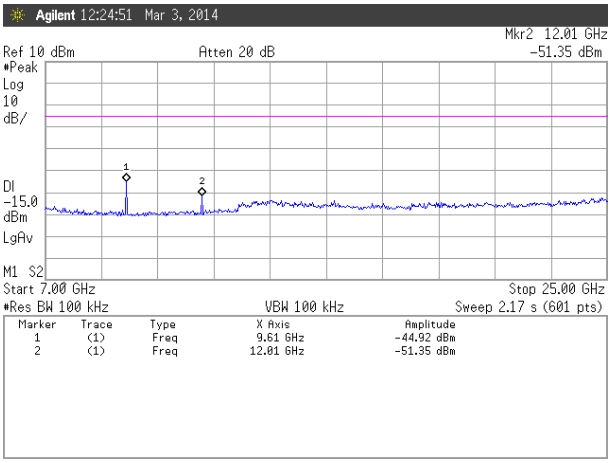
Date: 17.MAR.2014 16:59:54

Figure 14. Spurious RF conducted emissions

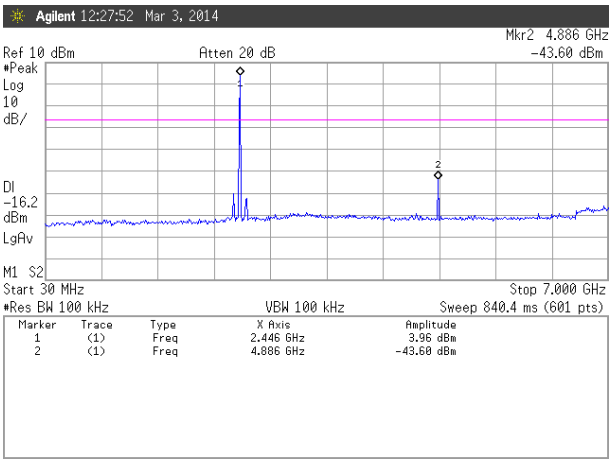
Lowest Channel(2402 MHz): 30 MHz ~ 7 GHz



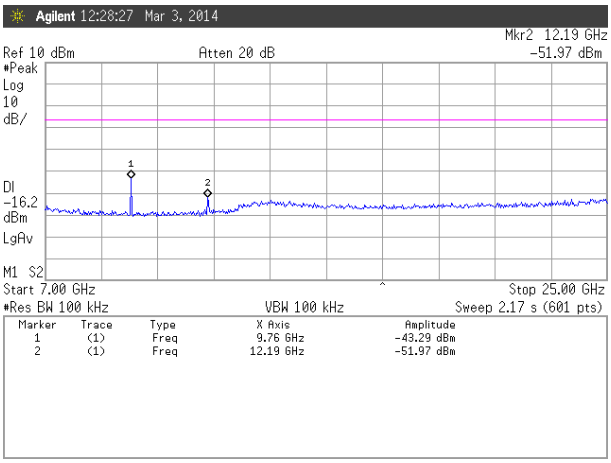
Lowest Channel (2402 MHz): 7 GHz ~ 25 GHz



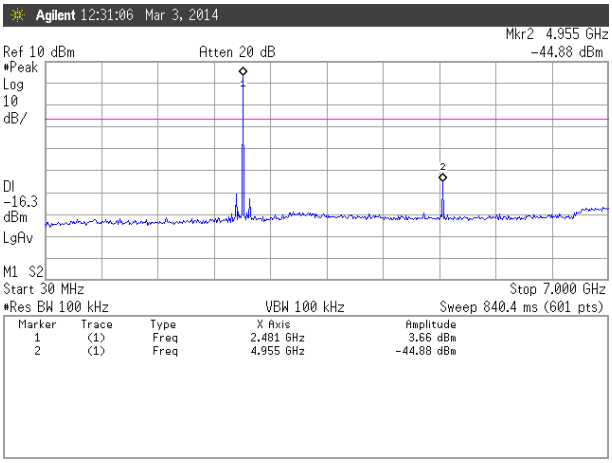
Middle Channel (2441 MHz): 30 MHz ~ 7 GHz



Middle Channel (2441 MHz): 7 GHz ~ 25 GHz



Highest Channel(2480 MHz): 30 MHz ~ 7 GHz



Highest Channel(2480 MHz): 7 GHz ~ 25 GHz