Global No.1 Testing Laboratory Universal Certification Solution

FCC TEST REPORT

Product name: MCS_Bluetooth_Device

FCC ID: 2ADECMCS-BTD-001

Model: MCS-BTD-001

Standards: FCC CFR 47 PART 15 SUBPART C, Section 15.247

Applicant: Maroo MCS INC.

Test Report No.: UCSFR-1410-007

UCS Co., Ltd.

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FCC Test Report

Report Number		UCSFR-1410-007		
Applicant	Company Name	Maroo MCS INC.		
	Address	25 Mojeong-gil Ochang-eup, Cheongwon-Gu, Cheongju-city, Chungbuk, Republic of Korea		
Product	Product Name	MCS_Bluetooth_Device		
	FCC ID	2ADECMCS-BTD-001		
	Model No.	MCS-BTD-001		
	Manufacturer	Maroo MCS INC.		
	Serial No.	-	Country of origin	Korea
Other	Receipt Date	2014.09.02	Receipt Number	UCS-R-2014-629
	Issued Date	2014.10.24	Tested Date	2014.10.21 ~ 2014.10.23
Standards		FCC CFR 47 PART 15 SUBPART C, Section 15.247		
Tested by		H. K. Lee (Sign) 이종기.		
Approved by		Y. M. Choi (Sign)		

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Contents

1. Applicant Information 4
2. EUT (Equipment under test) Information 4
3. Laboratory Information 5
4. Test Configuration and condition 6
5. Summary of Test Results and Measurement Procedures 7
6. Test Results 8
7. Radio Frequency Exposure 31
8. Test Equipment Used for Test 32

Revision History

Issued Report No.	Issued Date	Revisions	Effect Section
UCSFR-1410-007	14-Oct-24	Initial Issue	All

1. Applicant Information

Applicant Name : Maroo MCS INC.
Address : 25 Mojeong-gil Ochang-eup, Cheongwon-Gu, Cheongju-city, Chungbuk, Republic of Korea
Manufacturer : Maroo MCS INC.
Addressant Name : 25 Mojeong-gil Ochang-eup, Cheongwon-Gu, Cheongju-city, Chungbuk, Republic of Korea
Country of Origin : Korea

2. EUT (Equipment under test) Information

Product name	MCS_Bluetooth_Device
Model name	MCS-BTD-001
Power source	DC 3.3 V
Output Power	MAX 0.041 879 W
Ferquency range	2 402 MHz ~ 2 480 MHz
Number of channels	79 CH
Modulation Technique	GFSK
Antenna specification	4.5 dBi gain (Peak Gain)

2.1 Information about the FHSS characteristics:

2.1.1 Pseudorandom frequency hopping sequence

The channel is represented by a pseudo-random hopping sequence hopping through the 79 RF channels. The hopping sequence is unique for the piconet and is determined by the Bluetooth device address of the master; the phase in the hopping sequence is determined by the Bluetooth clock of the master. The channel is divided into time slots where each slot corresponds to anRF hop frequency. Consecutive hops correspond to different RF hop frequencies. The nominal hop rate is 1 600 hops/s.

2.1.2 Equal hopping frequency use

All channels will be used equally to comply with the requirements stated in Part 15.247(a)(1) and DA 00-705.
All Bluetooth units participating in the piconet are time and hop-synchronized to the channel.
Example of a 79 hopping sequence in data mode:
40, 21, 44, 23, 42, 53, 46, 55, 48, 33, 52, 35, 50, 65, 54, 67, 56, 37, 60, 39, 58, 69, 62, 71, 64, 25, 68, 27, 66, 57, 70, 59, 72, 29, 76, 31, 74, 61, 78, 63, 01, 41, 05, 43, 03, 73, 07, 75, 09, 45, 13, 47, 11, 77, 15, 00, 64, 49, 66, 53, 68, 02, 70, 06, 01, 51, 03, 55, 05, 04

2.1.3 System receiver input bandwidth

Each channel bandwidth is 1 ㎒

2.1.4 Equipment description

15.247(a)(1) that the rx input bandwidths shift frequencies in synchronization with the transmitted

15.247(g): In accordance with the Bluetooth Industry Standard, the system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuousdata (or information) system.

15.247(h): In accordance with the Bluetooth Industry Standard, the system does not coordinate it channels selection/ hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

3. Laboratory Information

UCS Co., Ltd.

#702, Anyang Megavalley799, Gwanyang2-dong, Dongan-gu, Anyang-si, Gyeonggi-do, 431-767, Korea

ER Center

#476-4, Hwalcho-dong, Hwaseong-si, Gyeonggi-do, 445-150, Korea

Test site

- FCC Registration Number: 803225
- This test site is in compliance with ISO/IEC 17025 for general requirements for the competence of testing and calibration laboratories.

4. Test Configuration and condition

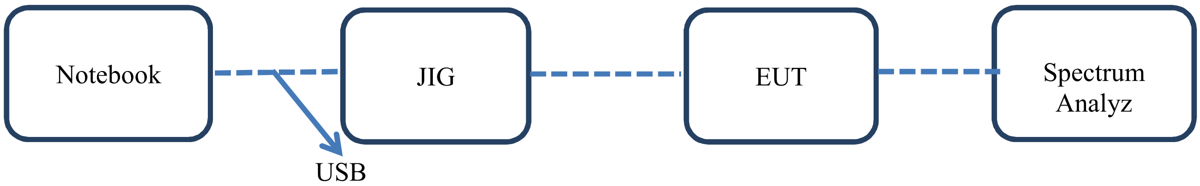
4.1 EUT operating condition

- The EUT had been tested under the operating condition.
- There are three channels have been tested as following:
- Channel Low and Channel High with higher data rate were chosen for full testing.

Channel	Frequency (MHz)
Low	2 402
Middle	2 441
High	2 480

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

4.2 EUT test configuration diagram



4.3 Peripheral equipments list for test

Equipment Name	Model	Serial Number	Manufacturer
Notebook	20058	WB00450910	Lenovo Pte. Ltd
TEST JIG	-	-	Maroo MCS INC

4.4 Cable connections

Start		End		Cable	
Name	**I/O Port**	**Name**	**I/O Port**	**Length**	**Spec.**
Notebook	USB	TEST JIG	USB	1.0	Shielded

4.5 EUT modifications

- None

5. Summary of Test Results and Measurement Procedures

5.1 Summary of test results

Standard	Test Item	CFR 47 Section	Result
FCC CFR 47 Part 15.247 Subpart C	Antenna requirement	15.203, 15.247(b)(4)	PASS
	20 dB bandwidth	15.247(a)(1)	PASS
	Maximum peak output power	15.247(b)(1)	PASS
	Carrier frequency separation	15.247(a)(1)	PASS
	Number of hopping channels	15.247(a)(1)(iii)	PASS
	Time of occupancy (dwell time)	15.247(a)	PASS
	Spurious emission, band edge, and restricted bands	15.247(d), 15.209	PASS
	AC power line conducted emissions	15.247(a)	PASS
	RF exposure	15.247(i), .1307(b)(1)	PASS

5.2 AC powerline conducted emission test

The EUT was connected to adaptor and the power of adaptor was connected to LISN. All supporting equipments were connected to another LISN. Preliminary Power line Conducted Emission test was performed by using the procedure in ANSI C63.10: 2009 to determine the worse operating conditions.

5.3 Radiated emission test

Preliminary radiated emissions test were conducted using the procedure in ANSI C63.10: 2009 to determine the worse operating conditions. The radiated emissions measurements were performed on the 10 m Semi Anechoic Chamber.
For frequencies from 150 kHz to 30 MHz measurements were made of the magnetic H field.
The measuring antenna is an electrically screened loop antenna.
The frequency spectrum from 30 MHz to 1 000 MHz was scanned and maximum emission levels maximized at each frequency recorded. The system was rotated 360°, and the antenna was varied in the height between 1.0 m and 4.0 m in order to determine the maximum emission levels. This procedure was performed for both horizontal and verticalpolarization of the receiving antenna.

6. Test Results

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 Results: Pass

The transmitter has an integral dipole antenna. The directional gain of the antenna is 4.5 dBi.

6.2 20 dB bandwidth

6.2.1 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 2 400 MHz ~ 2 483.5 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.

6.2.2 Test condition

- Set RBW of Spectrum analyzer to 10 kHz, Span = 3 MHz, Sweep = auto
- The 20 dB bandwidth is defined as the frequency range where the power is higher than the peak power minus 20 dB. 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.

6.2.3 Test results: Pass

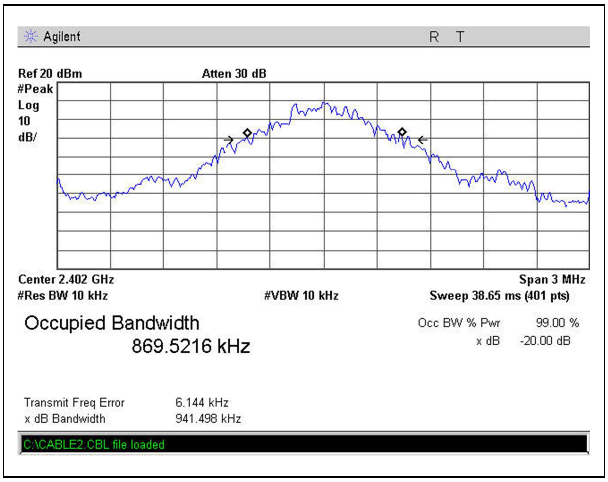
Table 1: Measured values of the 20 dB bandwidth

Modulation	Frequency [MHz]	Result [kHz]	Limit [kHz]	Verdict
1 Mbps	2 402	941.49	> 25 kHz	Pass
	2 441	941.29		Pass
	2 480	941.65		Pass

6.2.4 Plot of the 20 dB channel bandwidth

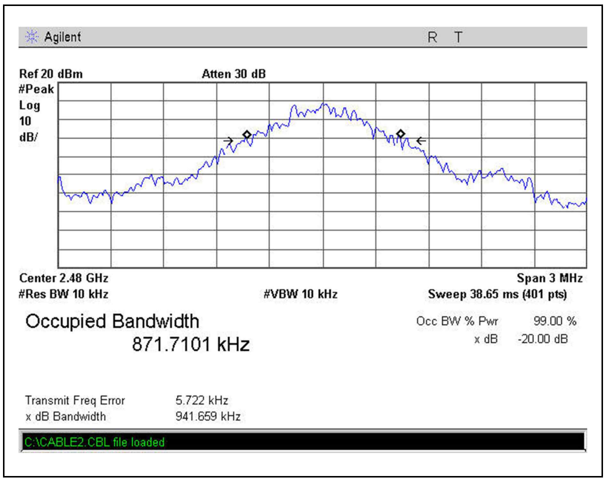
1 Mbps

Lowest channel



Middle channel

Highest channel



6.3 Maximum peak output power

6.3.1 Regulation

According to §15.247(b)(1), for frequency hopping systems operating in the 2 400 MHz ~ 2 483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 MHz ~ 5 850 MHz band: 1 watt.

For all other frequency hopping systems in the 2 400 MHz ~ 2 483.5 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.

6.3.2 Test condition

- Set RBW of Spectrum analyzer to 1 MHz
- The Maximum 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. For frequency hopping systems operating in the 2 400 MHz ~ 2 483.5 MHz band employing at least 75 hopping channels, and all frequency hopping systems in the 5 725 MHz ~ 5 850 MHz band: 1 watt.

6.3.3 Test results: Pass

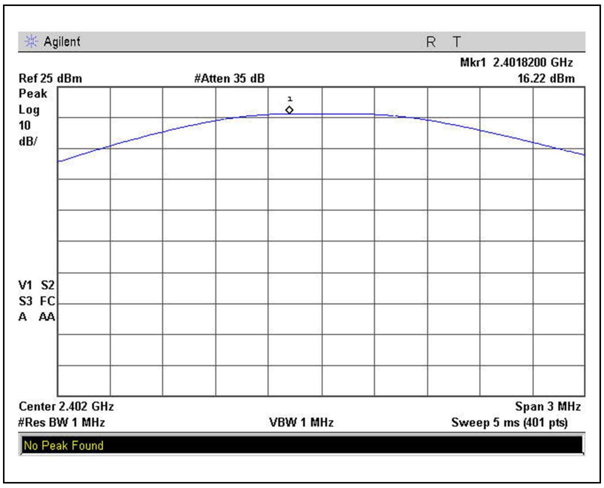
Table 2: Measured values of the Maximum Peak Output Power(Conducted)

Modulation	Frequency [MHz]	Reading Power [dBm]	Output power [W]	Limit [W]	Verdict
1 Mbps	2 401.82	16.22	0.041 879	1	Pass
	2 441.15	15.47	0.035 237	1	Pass
	2 479.82	14.81	0.030 269	1	Pass

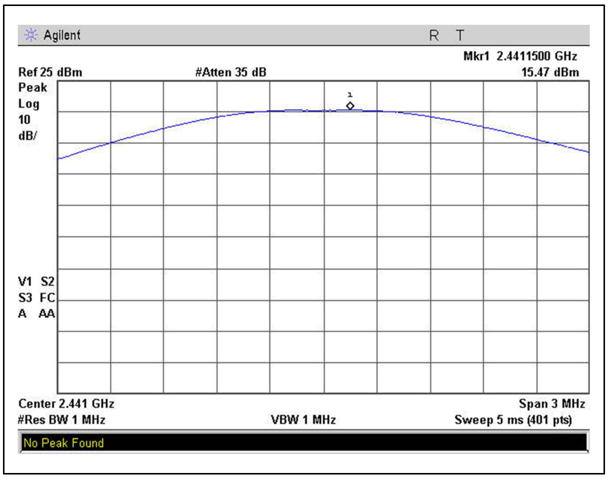
6.3.4 Plot of the maximum peak output power (Conducted)

1 Mbps

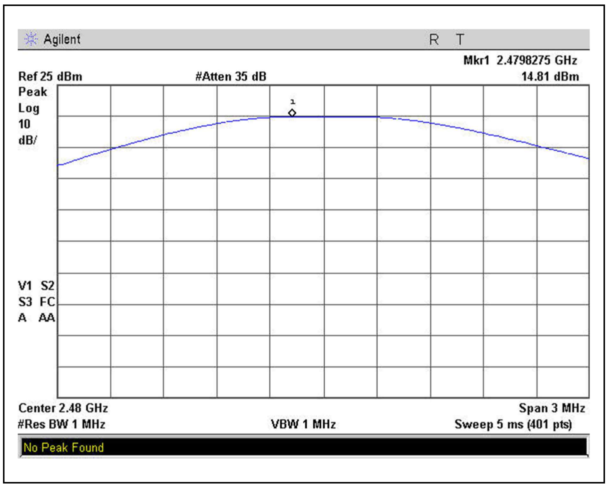
Lowest channel



Middle channel



Highest channel



6.4 Carrier frequency separation

6.4.1 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 2 400 ~ 2 483.5 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 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.

6.4.2 Test Condition

- Set RBW of Spectrum analyzer to 10 kHz, Span = 3 MHz, Sweep = auto
- Frequency hopping system shall have hopping channel carrier frequencies separated by minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

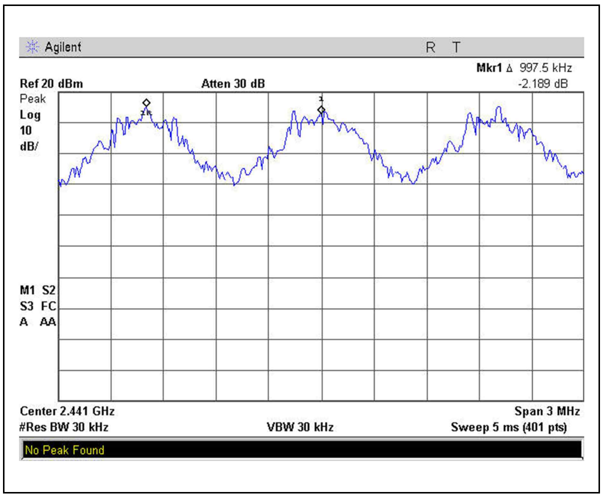
6.4.3 Test results: Pass

Table 3: Measured values of the Carrier Frequency Separation

Modulation	Operating frequency [MHz]	Frequency separation [kHz]	Limit (frequency separation)	Verdict
1 Mbps	2 402 ~ 2 480	997.50	> 25 kHz or > 2/3 of the 20 dB BW	Pass

6.4.4 Plot of the carrier frequency separation

1 Mbps



6.5 Number of hopping channels

6.5.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2 400 MHz ~ 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 condition

- Set RBW of Spectrum analyzer to 100 kHz
- Frequency hopping systems in the 2 400 MHz ~ 2 483.5 MHz band shall use at least 15 channels.

6.5.3 Test results: Pass

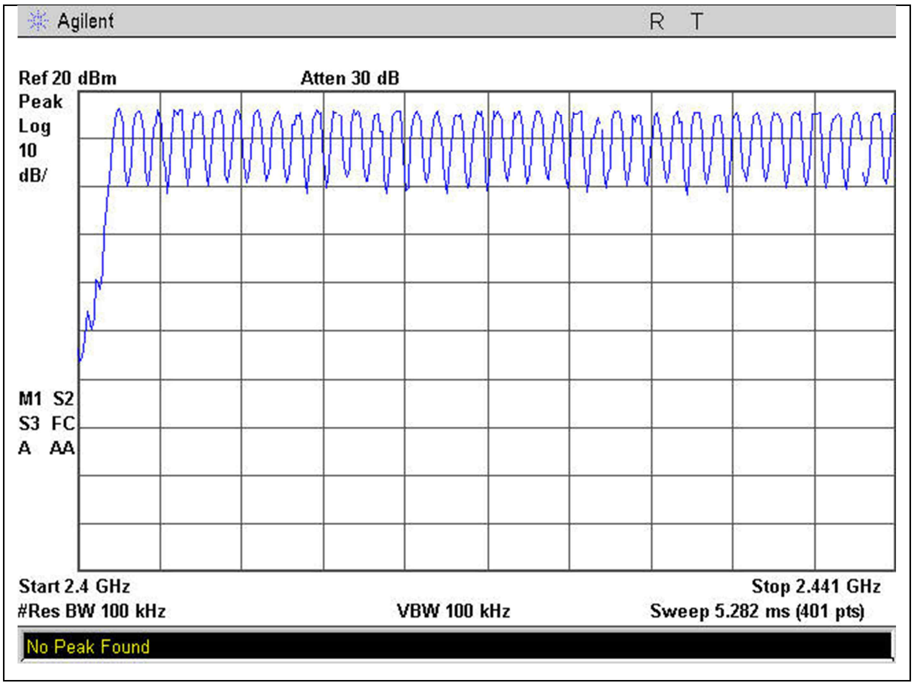
Table 4: Measured values of the Number of Hopping Channels

Modulation	Operating frequency [MHz]	Result (channel)	Limit (channel)	Verdict
1 Mbps	2 402 ~ 2 480	79	> 15	Pass

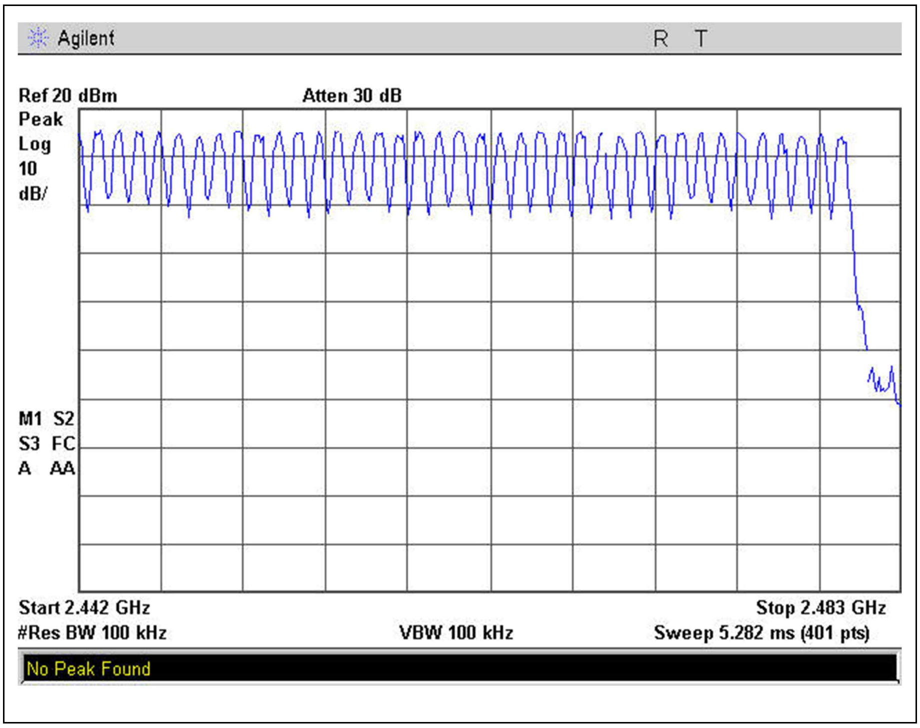
6.5.4 Plot of the number of hopping channels

1 Mbps

2 402 MHz ~ 2 441MHz



2 442 MHz ~ 2 480MHz



6.6 Time of occupancy (dwell time)

6.6.1 Regulation

According to §15.247(a)(1)(iii), frequency hopping systems in the 2 400 MHz ~ 2 483.5 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.

6.6.2 Test Condition

- Set RBW of Spectrum analyzer to 1 MHz, sweep time is 4.0 ms
- Frequency hopping systems in the 2 400 MHz ~ 2 483.5 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. Since the Bluetooth technology uses 79 channels this period is calculated to be 31.6 seconds.

6.6.3 Test results: Pass

<table>
<tr><th colspan="9">Table 5: Measured values of the Dwell Time</th></tr>
<tr><th>Modulation</th><th>Operating frequency [MHz]</th><th>Reading [ms]</th><th>Hops per second with channels</th><th>Number of hopping Channels</th><th>Period Time [ms]</th><th>Dwell time [ms]</th><th>Limits [ms]</th><th>Verdict</th></tr>
<tr><td rowspan="3">1 Mbps</td><td>2 402</td><td>2.900</td><td>3.38</td><td>79</td><td>31.6</td><td>309.7</td><td rowspan="3">≤ 400</td><td>Pass</td></tr>
<tr><td>2 441</td><td>2.900</td><td>3.38</td><td>79</td><td>31.6</td><td>309.7</td><td>Pass</td></tr>
<tr><td>2 480</td><td>2.900</td><td>3.38</td><td>79</td><td>31.6</td><td>309.7</td><td>PASS</td></tr>
</table>

Dwell time = Reading X (Hop rate / Number of hopping Channels) X Period Time

Period Time = 0.4[milliseconds / channel] X 79[channel] = 31.6 [milliseconds]

Note: The EUT makes worst case 1600 hops second or 1time slot has a length of 625us with 79 chanels.

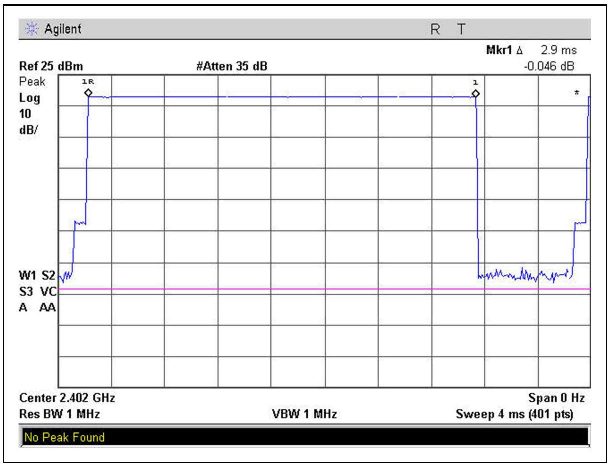
The DH5 packet need 5 times slot for transmitting and 1 time slot for receiving.

Then the EUT makes worst case 3.38 times (= 1 600/6/79) hops per second with 79 channels.

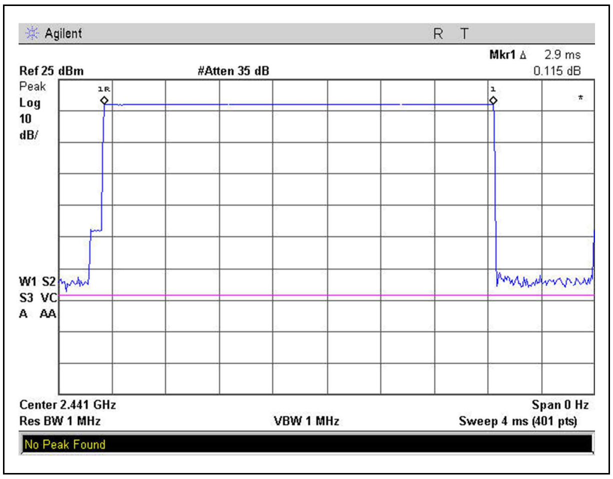
6.6.4 Plot of the Carrier Dwell Time

1 Mbps

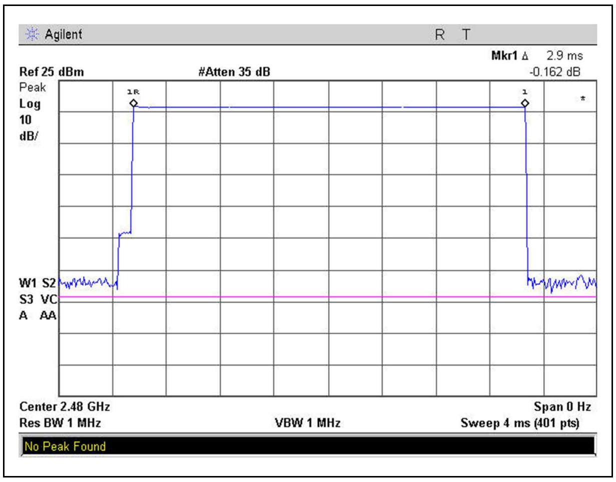
Lowest Channel



Middle Channel



Highest Channel



6.7 Spurious emissions and band edge, restricted bands

6.7.1 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)).

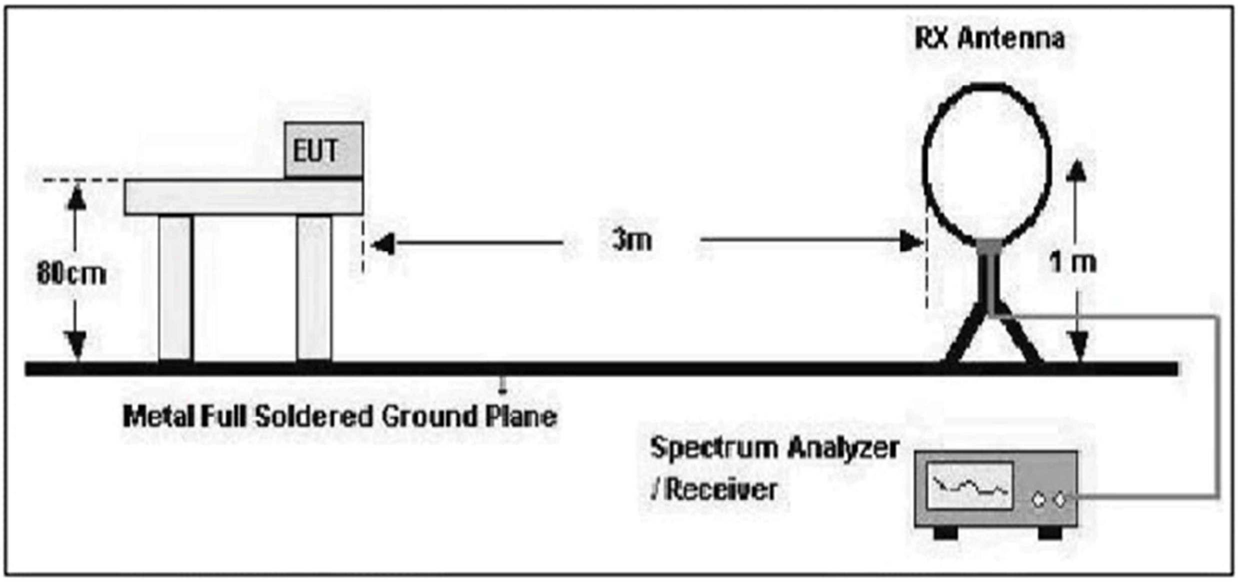
According to §15.209(a), for an intentional device, the general requirement of field strength of radiated emissions from intentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency [MHz]	Field strength [µV/m]	Field strength [dBµV/m]	Measurement distance [m]
0.009 ~ 0.490	2 400 / F (kHz)	-	300
0.490 ~ 1.705	24 000 / F (kHz)	-	30
1.705 ~ 30	30	29.5	30
30 ~ 88	100	40.0	3
88 ~ 216	150	43.5	3
216 ~ 960	200	46.0	3
Above 960	500	54.0	3

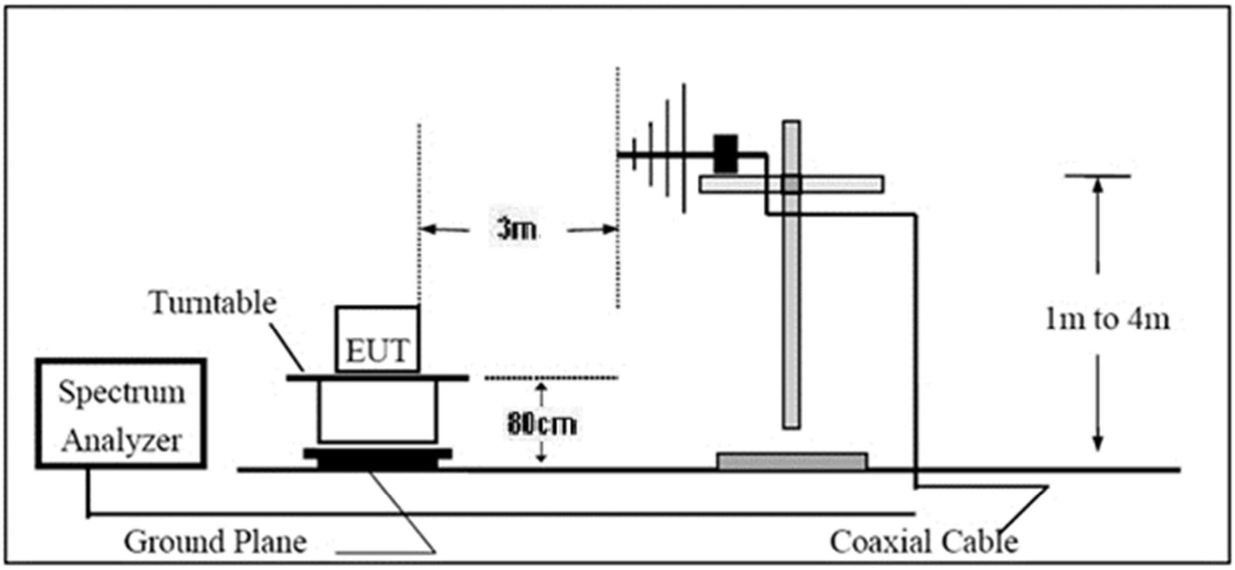
The emission limits shown in the above table are based on measurement instrumentation employing a CISPR quasi-peak detector and above 1 000 MHz are based on the average value of measured emissions.

6.7.2 Test setup layout

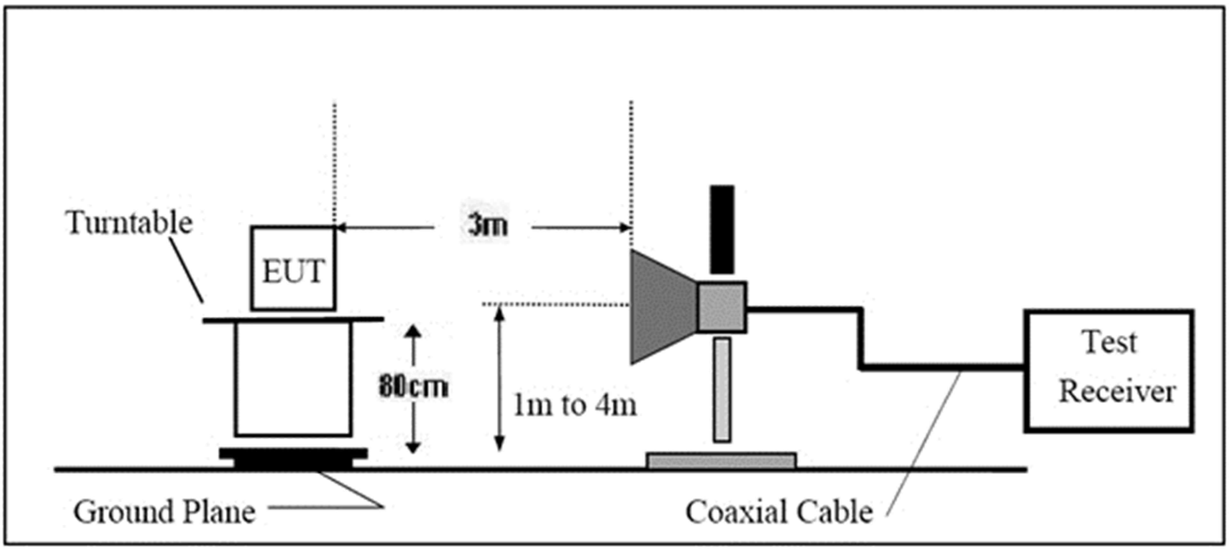
6.7.2.1 Radiated emission test set-up, frequency below 30 MHz



6.7.2.2 Radiated emission test set-up, frequency above 30 MHz



6.7.2.3 Radiated emission test set-up frequency above 1 000 MHz



6.7.3 Test procedure

1) Band-edge Compliance of 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 bandedge, as well as any modulation products which fall outside of the authorized band of operation

RBW ≥ 1 % of the 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 10^{th} 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 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 1 000 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 as the above Spurious Radiated Emissions test procedure.
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 1 % of the total span (but never less than 30 kHz) 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 a 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 step (2) from the field strengths measured in step (1). The resultant field strengths (CISPR QP, average, or peak, as appropriate) are then used to determine band-edge compliance as required by

Section 15.205.

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 C63.4 for the frequency being measured. For example, for band-edge measurements in the restricted band that begins at 2 483.5 MHz, C63.4 specifies a measurement bandwidth of at least 1 MHz. Therefore you may use the "delta" technique for measuring emissions up to 2 MHz removed from the band-edge. Radiated emissions that are removed by more than two “standard” bandwidths must be measured as the above Spurious Radiated Emissions test procedure.

6.7.4 Test results: Pass

Band-edge compliance of RF conducted/radiated emissions was shown in the 6.7.5 and 6.7.6

NOTE: We took the insertion loss of the cable loss into consideration within the measuring instrument.
Spurious RF conducted emissions were shown in the 6.7.7

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

Table 6: Measured values of the Field strength of spurious emission (1 Mbps Transmit mode)						
Frequency [MHz]		Detect Mode	Polarization [V/H]	Emission Level [dBμV/m]	Limit [dBμV/m]	Margin [dB]
Average/Peak/Quasi-peak data, emissions below 30 MHz						
		No Critical peaks Found				
Quasi-peak data, emissions below 1 000 MHz						
2 402	71.21	Qausi-peak	V	27.50	40.00	-12.50
	144.00	Qausi-peak	V	31.03	43.52	-12.49
	159.77	Qausi-peak	H	24.10	43.52	-19.42
	254.66	Qausi-peak	H	25.50	46.02	-20.52
	600.56	Qausi-peak	V	36.84	46.02	-9.18
2 441	72.02	Qausi-peak	V	28.38	40.00	-11.62
	143.79	Qausi-peak	V	32.05	43.52	-11.47
	160.23	Qausi-peak	H	23.26	43.52	-20.26
	255.11	Qausi-peak	H	26.61	46.02	-19.41
	601.82	Qausi-peak	V	35.92	46.02	-10.10
2 480	71.54	Qausi-peak	V	28.88	40.00	-11.12
	144.86	Qausi-peak	V	32.71	43.52	-10.81
	158.86	Qausi-peak	H	22.29	43.52	-21.23
	255.11	Qausi-peak	H	25.95	46.02	-20.07
	600.77	Qausi-peak	V	36.30	46.02	-9.72
Peak/Average data, emissions above 1 000 MHz						
		No Critical peaks Found				

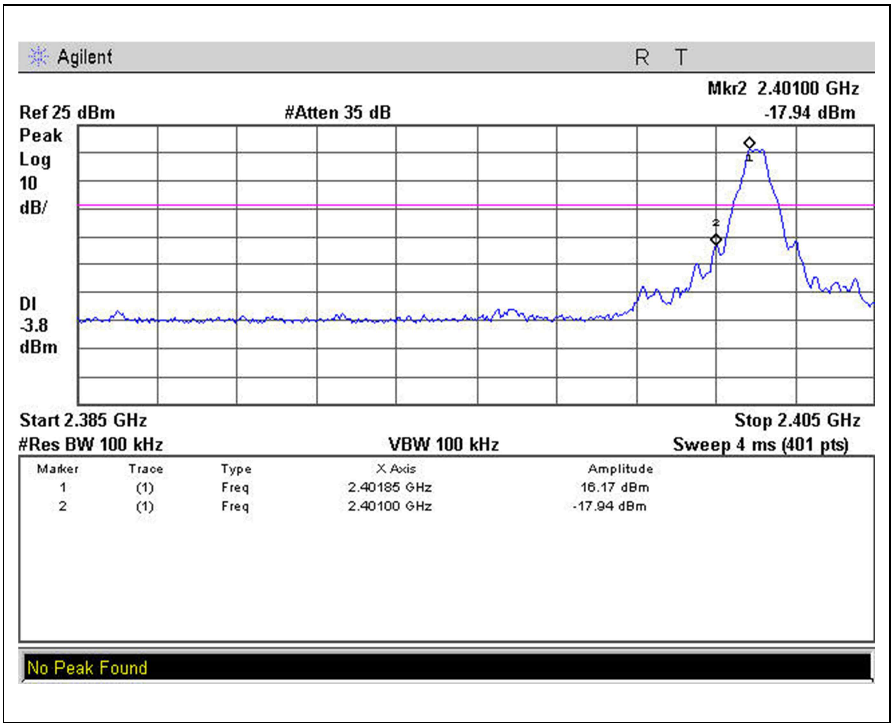
* Remark: “H”: Horizontal, “V”: Vertical

* Margin [dB] = Emission Level [dBμV/m] – Limit [dBμV/m]

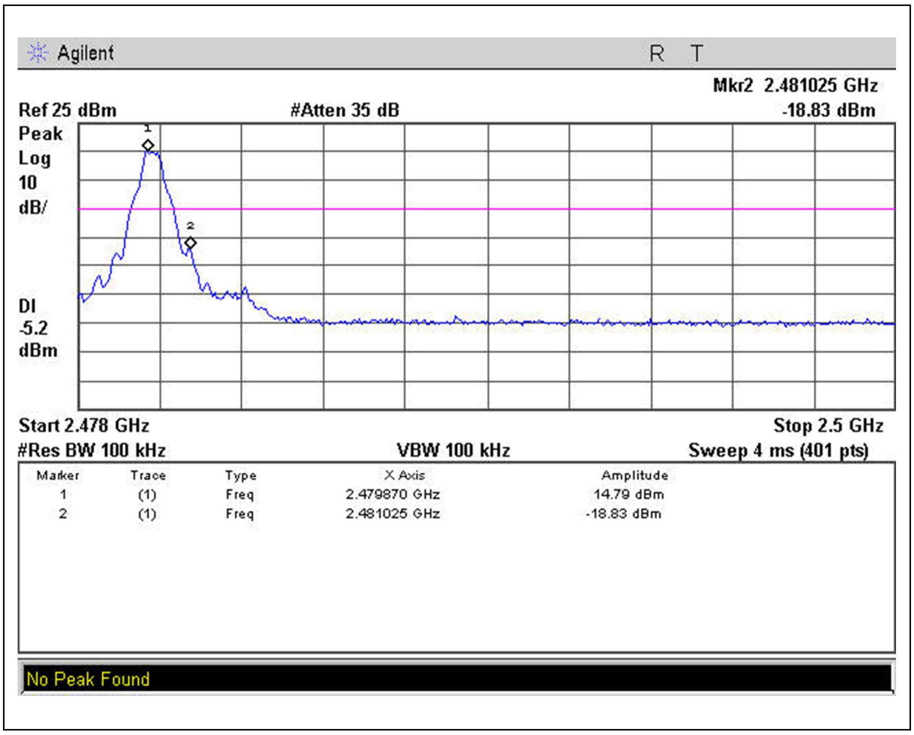
6.7.5 Plot of the band edge (Conducted)

1 Mbps

Lowest channel

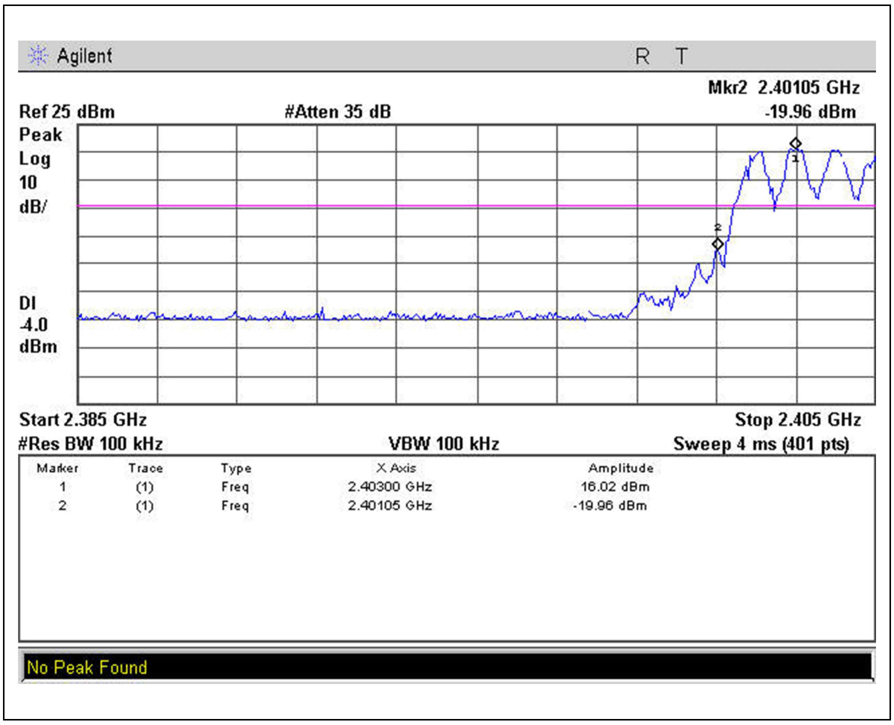


Highest channel

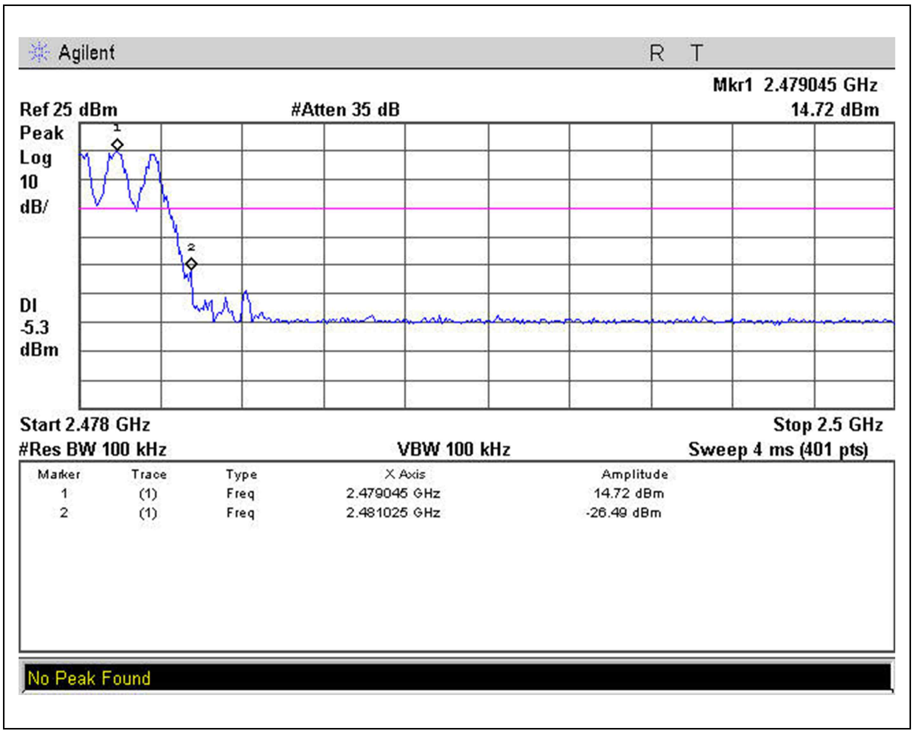


1 Mbps (Hopping Mode)

Lowest channel



Highest channel



6.7.6 Plot of the band edge (radiated)

Table 7: Measured values of the Band Edge (1 Mbps Transmit mode)						
Frequency [MHz]		**Detect Mode**	**Polarization [V/H]**	**Emission Level [dBμV/m]**	**Limit [dBμV/m]**	**Margin [dB]**
2 402	2 401.00	Peak	H	51.38	74.00	-22.62
	2 401.00	Average	H	33.60	54.00	-20.40
	2 401.00	Peak	V	57.33	74.00	-16.67
	2 401.00	Average	V	35.39	54.00	-18.61
2 480	2 483.50	Peak	H	63.09	74.00	-10.91
	2 483.50	Average	H	41.51	54.00	-12.49
	2 483.50	Peak	V	68.41	74.00	-5.59
	2 483.50	Average	V	43.61	54.00	-10.39

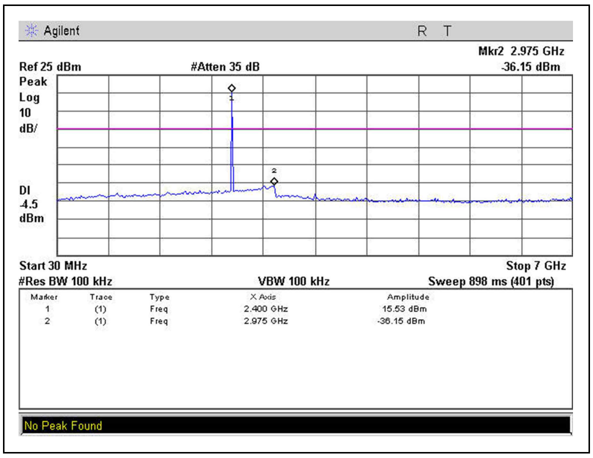
* Remark: “H”: Horizontal, “V”: Vertical

* Margin [dB] = Emission Level [dBμV/m] – Limit [dBμV/m]

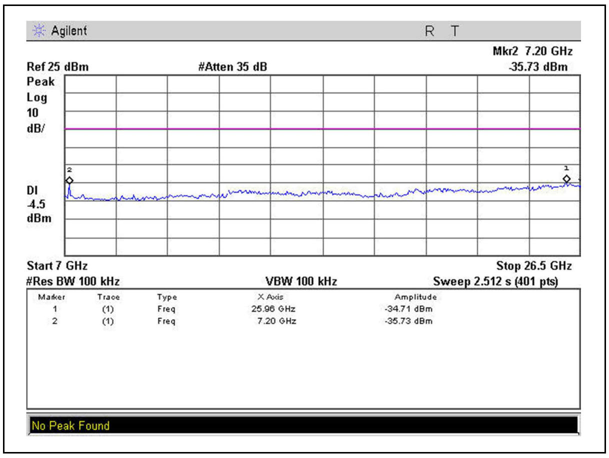
6.7.7 Plot of the Spurious RF conducted emissions

1 Mbps

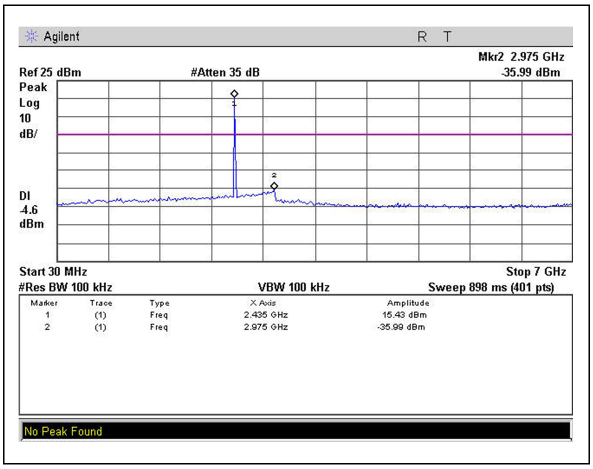
Lowest channel: 30 MHz ~ 7 GHz



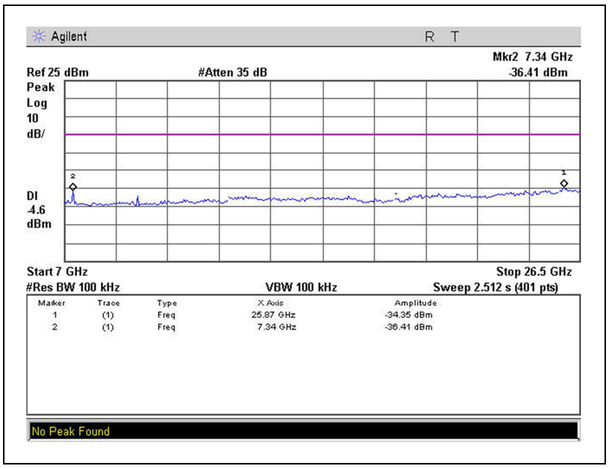
Lowest channel: 7 GHz ~ 26.5 GHz



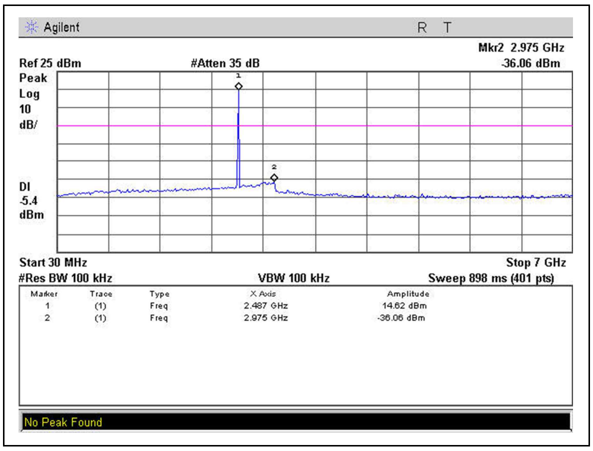
Middle channel: 30 MHz ~ 7 GHz



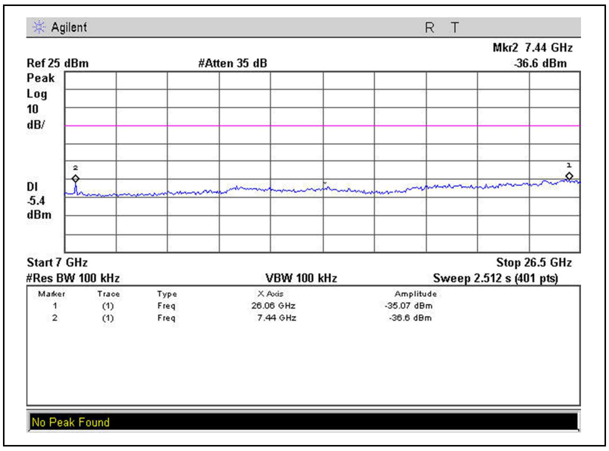
Middle channel: 7 GHz ~ 26.5 GHz



Highest channel: 30 MHz ~ 7 GHz



Highest channel: 7 GHz ~ 26.5 GHz



6.8 AC power line conducted emissions

6.8.1 Regulation

According to §15.207(a), for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any following table, as measured using a 50μH/50Ω line impedance stabilization network (LISN).

Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission [MHz]	Conducted limit [dBμV]	
	Qausi-peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency.

6.8.2 Test procedure

1. The EUT was placed on a wooden table of size, 1 m by 1.5 m, raised 80 cm in which is located 40 cm away from the vertical wall and 1.5m away from the side wall of the shielded room.
2. Each current-carrying conductor of the EUT power cord was individually connected through a 50 Ω / 50 μH LISN, which is an input transducer to a Spectrum Analyzer or an EMI/Field Intensity Meter, to the input power source.
3. Exploratory measurements were made to identify the frequency of the emission that had the highest amplitude relative to the limit by operating the EUT in a range of typical modes of operation, cable position, and with a typical system equipment configuration and arrangement. Based on the exploratory tests of the EUT, the one EUT cable configuration and arrangement and mode of operation that had produced the emission with the highest amplitude relative to the limit was selected for the final measurement.
4. The final test on all current-carrying conductors of all of the power cords to the equipment that comprises the EUT (but not the cords associated with other non-EUT equipment is the system) was then performed over the frequency range of 0.15 MHz to 30 MHz.
5. The measurements were made with the detector set to PEAK amplitude within a bandwidth of 10 kHz or to QUASI-PEAK and AVERAGE within a bandwidth of 9 kHz. The EUT was in transmitting mode during the measurements.

6.8.3 Test Results: Pass

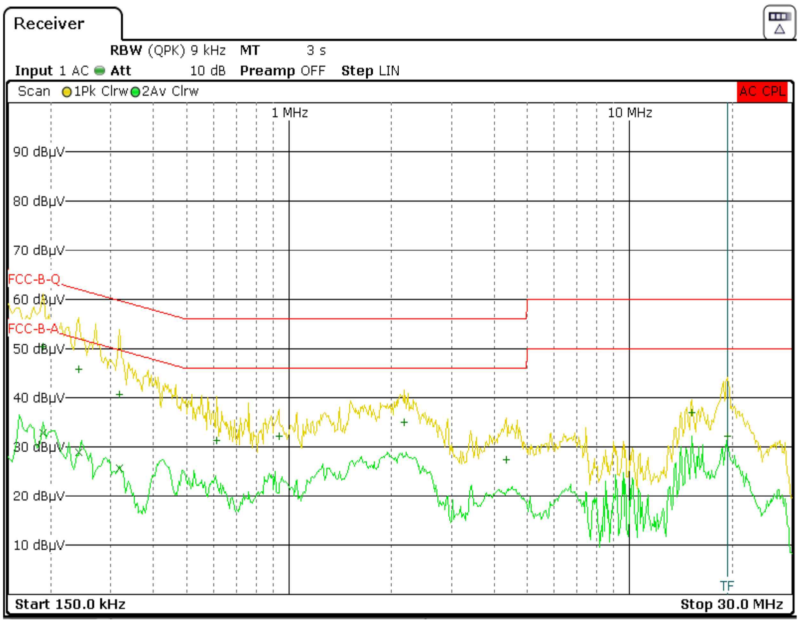
Table 8: Measured values of the AC Power Line Conducted Emissions

Frequency [MHz]	Factor		Line	Quasi-Peak			Average		
	LISN [dB]	Cable [dB]		Limit [dBμV]	Reading [dBμV]	Results [dBμV]	Limit [dBμV]	Reading [dBμV]	Results [dBμV]
0.15	0.03	0.03	N	66.00	56.16	56.22	56.00	38.50	38.56
0.25	0.03	0.03	N	61.76	46.88	46.94	51.76	32.30	32.36
0.32	0.04	0.04	H	59.71	40.64	40.72	49.71	25.69	25.77
0.54	0.03	0.05	N	56.00	39.82	39.90	46.00	30.28	30.36
1.64	0.05	0.10	N	56.00	41.91	42.06	46.00	-	-
2.18	0.05	0.12	H	56.00	34.94	35.11	46.00	-	-
15.23	0.45	0.49	H	60.00	36.88	37.82	50.00	-	-
19.27	0.39	0.51	N	60.00	42.82	43.71	50.00	-	-

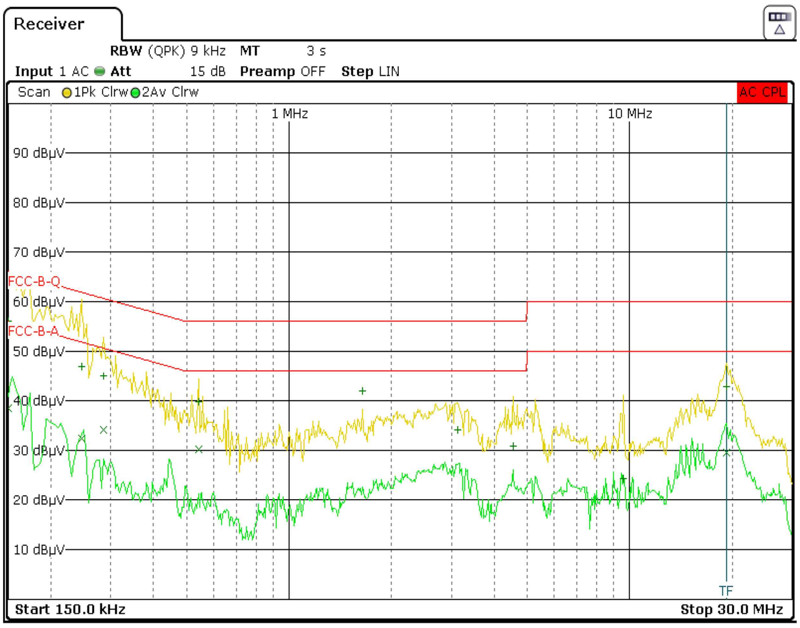
***** Remark: “H”: Hot Line, “N”: Neutral Line

6.8.4 Plot of the ac power line conducted emissions

[Hot line]



[Neutral line]



7. Radio Frequency Exposure

7.1 RF exposure calculation

According to the FCC rule 1.1310 table 1B, the limit for the maximum permissible RF exposure for an uncontrolled environment are f/1 500 mW/cm² for the frequency range between 300 MHz and 1 500 MHz and 1.0 mW/cm² for the frequency range between 1 500 MHz and 100 000 MHz.

The electric field generated for a 1 mW/cm² exposure is calculated as follows:

$E = \sqrt{(30 * P * G)} / d$, and $S = E^2 / Z = E^2 / 377$, because 1 mW/cm² = 10 W/m²

Where

S = Power density in mW/cm², Z = Impedance of free space, 377 Ω

E = Electric filed strength in V/m, G = Numeric antenna gain, and d = distance in meter

Combing equations and rearranging the terms to express the distance as a function of the remaining variable

$d = \sqrt{(30 * P * G) / (377 * 10 S)}$

Changing to units of mW and cm, using P (mW) = P (W) / 1 000, d (cm) = 0.01 * d (m)

$d = 0.282 * \sqrt{(P * G) / S}$

Where

d = distance in cm, P = Power in mW, G = Numeric antenna gain, and S = Power density in mW/cm²

7.2 Calculated MPE safe distance

According to above equation, the following result was obtained.

Peak Output Power		Antenna Gain		Safe Distance [cm]	Power Density [mW/cm²] @ 20 cm Separation	Limit [mW/cm²]
[dBm]	[mW]	Log	Linear			
16.22	41.88	4.50	2.82	3.06	0.023 49	1.00

According to above table, for example safe distance,

$D = 0.282 * \sqrt{(41.88 * 2.82)/1.00} = 3.06$ cm.

For getting power density at 20 cm separation in above table, following formula was used.

$S = P * G / (4\pi * R^2) = 41.88 * 2.82 / (4 * 3.14 * 20^2) = 0.023\ 49$

Where:

S = Power Density,

P = Power input to the external antenna (Output power from the EUT antenna port (dBm) – cable loss (dB)),

G = Gain of Transmit Antenna (linear gain), R = Distance from Transmitting Antenna

8. Test Equipment Used for Test

Used	Description	Manufacturer	Model Name	Serial Number	Specifications	Next Cal. Data	DUE CAL
■	Spectrum Analyzer	H.P	E4407B	US39010225	9 kHz ~ 26.5 GHz	2015-02-13	1 Year
■	EPM-P SERIES POWER METER	Agilent	E4416A	GB38272722	1 CH 100-240 VAC	2015-08-28	1 Year
□	Power Sensor	Agilent	8481A	US41030240	MAX.23 dBm AVG, 18 GHz	2015-08-28	1 Year
■	Test receiver	ROHDE&SCHWARZ	ESPI3	101171	9 kHz ~ 3 GHz	2015-08-08	1 Year
■	BI-LOG ANT	SCHWARZBECK	VULB 9163	691	30 MHz ~ 1 GHz	2016-02-28	2 Years
■	Loop Antenna	EMCO	6502	9801-3191	9 kHz ~ 30 MHz	2016-02-04	2 Years
□	Horn antenna	Schwarzbeck	BBHA 9120D	769	1 GHz ~ 18 GHz	2015-11-29	2 Years
■	Horn antenna	Schwarzbeck	BBHA 9120D	768	1 GHz ~ 18 GHz	2015-12-11	2 Years
■	Horn antenna	Schwarzbeck	BBHA9170	BBHA9170178	18 GHz ~ 40 GHz	2016-02-26	2 Years
■	Amplifier	310N	291723	SONOMA	9 kHz ~ 1 GHz	2015-08-28	1 Year
■	Amplifier	TESTEK	TK-PA1	110013	1 GHz ~ 6G Hz	2015-08-28	1 Year
□	DC Power Supply	Maynuo	M8811	080010960011103046	30 V 5 A	2015-08-29	1 Year
■	EMI TEST RECEIVER	ROHDE & SCHWARZ	ESR7	101120	10 Hz ~ 7 GHz	2015-01-03	1 Year
■	LISN	SCHWARZBECK	NSLK 8127	8127518	9 kHz ~ 30 MHz	2015-08-28	1 Year