FCC Part 15C
Measurement and Test Report

For

IAG Group Ltd.

Sanecore Science & Technology Industry Park, Jiuwei Village, Xixiang Town,

Shenzhen, China

FCC ID: 2AO5F-AX12BT

FCC Rule(s):	FCC Part 15.247
Product Description:	Active Speaker
Tested Model:	Typhon-AX12-BT
Report No.:	WTG19G03013154W-1
Sample Receipt Date:	2019-03-11
Tested Date:	2019-03-13 to 2019-05-24
Issued Date:	2019-05-24
Tested By:	Jason Su/ Engineer
Reviewed By:	Silin Chen / EMC Manager
Approved & Authorized By:	Jandy So / PSQ Manager

Prepared By:

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1. GENERAL INFORMATION

1.1 Product Description for Equipment Under Test (EUT)

Client Information

Applicant:	IAG Group Ltd.
Address of applicant:	Sanecore Science & Technology Industry Park, Jiuwei Village, Xixiang Town, Shenzhen, China
Manufacturer:	IAG Group Ltd.
Address of manufacturer:	Sanecore Science & Technology Industry Park, Jiuwei Village, Xixiang Town, Shenzhen, China

General Description of EUT	
Product Name:	Active Speaker
Brand Name:	Wharfedale Pro
Model No.:	Typhon-AX12-BT
Adding Model(s):	N/A
Rated Voltage:	N/A
Battery Capacity:	N/A
Power Adapter:	Input: AC100-120V, 400W, 50/60Hz
Software Version:	100
Hardware Version:	A00
Note: The test data is gathered from a production sample,provided by the manufacturer.	

Technical Characteristics of EUT	
Bluetooth Version:	V4.2 (BDR/EDR mode)
Frequency Range:	2402-2480MHz
RF Output Power:	1.343dBm (Conducted)
Data Rate:	1Mbps, 2Mbps, 3Mbps
Modulation:	GFSK,π/4-DQPSK, 8DPSK
Quantity of Channels:	79
Channel Separation:	1MHz
Type of Antenna:	PCB Antenna
Antenna Gain:	0dBi
Lowest Internal Frequency of EUT:	26MHz

1.2 Test Standards

The tests were performed according to following standards:

FCC Rules Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product, which result in lowering the emission, should be checked to ensure compliance has been maintained.

1.3 Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013,
The equipment under test (EUT) was configured to measure its highest possible emission level. Thetest modes were adapted accordingly in reference to the Operating Instructions.

1.4 Test Facility

FCC – Registration No.: 125990

Shenzhen SEM Test Technology Co., Ltd. Laboratory has been recognized to perform compliance testing on equipment subject to the Commissions Declaration Of Conformity (DOC). The Designation Number is CN5010, and Test Firm Registration Number is 125990.

Industry Canada (IC) Registration No.: 11464A

The 3m Semi-anechoic chamber of Shenzhen SEM.Test Technology Co., Ltd. has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 11464A.

1.5 EUT Setup and Test Mode

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. All testing shall be performed under maximum output power condition, and to measure itshighest possible emissions level, more detailed description as follows:

Test Mode List		
Test Mode	Description	Remark
TM1	Low Channel	2402MHz
TM2	Middle Channel	2441MHz
TM3	High Channel	2480MHz
TM4	Hopping	2402-2480MHz

Modulation Configure			
Modulation	Packet	Packet Type	Packet Size
GFSK	DH1	4	27
	DH3	11	183
	DH5	15	339
Π/4 DQPSK	2DH1	20	54
	2DH3	26	367
	2DH5	30	679
8DPSK	3DH1	24	83
	3DH3	27	552
	3DH5	31	1021
Normal mode: the Bluetooth has been tested on the modulation of GFSK, π/4-DQPSK and 8DPSK, compliance test and record the worst case.			

Test Conditions	
Temperature:	22~25°C
Relative humidity	50~55 %.
ATM Pressure:	1019 mbar

EUT Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
/	/	/	/

Special Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
/	/	/	/

Auxiliary Equipment List and Details			
Description	Manufacturer	Model	Serial Number

1.6 Measurement Uncertainty

Measurement uncertainty		
Parameter	Conditions	Uncertainty
RF Output Power	Conducted	±0.42dB
Occupied Bandwidth	Conducted	±1.5%
Conducted Spurious Emission	Conducted	±2.17dB
Conducted Emissions	Conducted	9-150kHz ±3.74dB
		0.15-30MHz ±3.34dB
Transmitter Spurious Emissions	Radiated	30-200MHz ±4.52dB
		0.2-1GHz ±5.56dB
		1-6GHz ±3.84dB
		6-18GHz ±3.92dB

1.7 Test Equipment List and Details

No.	Description	Manufacturer	Model	Serial No.	Cal Date	Due Date
SEMT-1072	Spectrum Analyzer	Agilent	E4407B	MY41440400	2019-04-30	2020-04-29
SEMT-1031	Spectrum Analyzer	Rohde & Schwarz	FSP30	836079/035	2019-04-30	2020-04-29
SEMT-1007	EMI Test Receiver	Rohde & Schwarz	ESVB	825471/005	2019-04-30	2020-04-29
SEMT-1008	Amplifier	Agilent	8447F	3113A06717	2019-04-30	2020-04-29
SEMT-1043	Amplifier	C&D	PAP-1G18	2002	2019-04-30	2020-04-29
SEMT-1011	Broadband Antenna	Schwarz beck	VULB9163	9163-333	2019-05-05	2021-05-04
SEMT-1042	Horn Antenna	ETS	3117	00086197	2019-05-05	2021-05-04
SEMT-1121	Horn Antenna	Schwarzbeck	BBHA 9170	BBHA9170582	2019-05-05	2021-05-04
SEMT-1069	Loop Antenna	Schwarz beck	FMZB 1516	9773	2019-05-05	2021-05-04
SEMT-1001	EMI Test Receiver	Rohde & Schwarz	ESPI	101611	2019-04-30	2020-04-29
SEMT-1003	L.I.S.N	Schwarz beck	NSLK8126	8126-224	2019-04-30	2020-04-29
SEMT-1002	Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100911	2019-04-30	2020-04-29
SEMT-1168	Pre-amplifier	Direction Systems Inc.	PAP-0126	14141-12838	2019-04-30	2020-04-29
SEMT-1169	Pre-amplifier	Direction Systems Inc.	PAP-2640	14145-14153	2019-04-30	2020-04-29
SEMT-1163	Spectrum Analyzer	Rohde & Schwarz	FSP40	100612	2019-04-30	2020-04-29
SEMT-1170	DRG Horn Antenna	A.H. SYSTEMS	SAS-574	571	2019-05-05	2021-05-04
SEMT-1166	Power Limiter	Agilent	N9356B	MY45450376	2019-04-30	2020-04-29
SEMT-1048	RF Limiter	ATTEN	AT-BSF-2400~2500	/	2019-04-30	2020-04-29
SEMT-1076	RF Switcher	Top Precision	RCS03-A2	/	2019-04-30	2020-04-29
SEMT-C001	Cable	Zheng DI	LL142-07-07-10M(A)	/	2019-03-18	2020-03-17
SEMT-C002	Cable	Zheng DI	ZT40-2.92J-2.92J-6M	/	2019-03-18	2020-03-17
SEMT-C003	Cable	Zheng DI	ZT40-2.92J-2.92J-2.5M	/	2019-03-18	2020-03-17
SEMT-C004	Cable	Zheng DI	2M0RFC	/	2019-03-18	2020-03-17
SEMT-C005	Cable	Zheng DI	1M0RFC	/	2019-03-18	2020-03-17
SEMT-C006	Cable	Zheng DI	1M0RFC	/	2019-03-18	2020-03-17

2. SUMMARY OF TEST RESULTS

FCC Rules	Description of Test Item	Result
§ 2.1093	RF Exposure	Compliant
§ 15.203; § 15.247(b)(4)(i)	Antenna Requirement	Compliant
§15.205	Restricted Band of Operation	Compliant
§ 15.207(a)	Conducted Emission	Compliant
§ 15.209(a)	Radiated Spurious Emissions	Compliant
§ 15.247(a)(1)(iii)	Quantity of Hopping Channel	Compliant
§ 15.247(a)(1)	Channel Separation	Compliant
§ 15.247(a)(1)(iii)	Time of Occupancy (Dwell time)	Compliant
§ 15.247(a)	20dB Bandwidth	Compliant
§ 15.247(b)(1)	RF Power Output	Compliant
§ 15.247(d)	Band Edge (Out of Band Emissions)	Compliant
§ 15.247(a)(1)	Frequency Hopping Sequence	Compliant
§ 15.247(g), (h)	Frequency Hopping System	Compliant

N/A: not applicable

3. RF Exposure

3.1 Standard Applicable

According to § 1.1307 and § 2.1093, the portable transmitter must comply the RF exposure requirements.

3.2 Test Result

This product complied with the requirement of the RF exposure, please see the RF Exposure Report.

4. Antenna Requirement

4.1 Standard Applicable

According to FCC Part 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.

4.2 Evaluation Information

This product has an integral antenna, fulfill the requirement of this section.

5. Frequency Hopping System Requirements

5.1 Standard Applicable

According to FCC Part 15.247(a)(1), The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

5.2 Frequency Hopping System

This transmitter device is frequency hopping device, and complies with FCC part 15.247 rule.

This device uses Bluetooth radio which operates in 2400-2483.5 MHz band. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each; centred from 2402 to 2480 MHz) in the range 2,400-2,483.5 MHz. The transmitter switches hop frequencies 1,600 times per second to assure a high degree of data security. All Bluetooth devices participating in a given piconet are synchronized to the frequency-hopping channel for the piconet. The frequency hopping sequence is determined by the master's device address and the phase of the hopping sequence (the frequency to hop at a specific time) is determined by the master's internal clock. Therefore, all slaves in a piconet must know the master's device address and must synchronize their clocks with the master's clock.

Adaptive Frequency Hopping (AFH) was introduced in the Bluetooth specification to provide an effective way for a Bluetooth radio to counteract normal interference. AFH identifies "bad" channels, where either other wireless devices are interfering with the Bluetooth signal or the Bluetooth signal is interfering with another device. The AFH-enabled Bluetooth device will then communicate with other devices within its piconet to share details of any identified bad channels. The devices will then switch to alternative available "good" channels, away from the areas of interference, thus having no impact on the bandwidth used.

This device was tested with an bluetooth system receiver to check that the device maintained hopping synchronization, and the device complied with these requirements for DA 00-705 and FCC Part 15.247 rule.

5.3 EUT Pseudorandom Frequency Hopping Sequence

Pseudorandom Frequency Hopping Sequence Table as below:
Channel: 08, 24, 40, 56, 40, 56, 72, 09, 01, 09, 33, 41, 33, 41, 65, 73, 53, 69, 06, 22, 04, 20, 36, 52, 38, 46, 70, 78, 68, 76, 21, 29, 10, 26, 42, 58, 44, 60, 76, 13, 03, 11, 35, 43, 37, 45, 69, 77, 55, 71, 08, 24, 08, 24, 40, 56, 40, 48, 72, 01, 72, 01, 25, 33, 12, 28, 44, 60, 42, 58, 74, 11, 05, 13, 37, 45 etc.

The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

6. Quantity of Hopping Channels and Channel Separation

6.1 Standard Applicable

According to FCC 15.247(a)(1), 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,and frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

6.2 Test Procedure

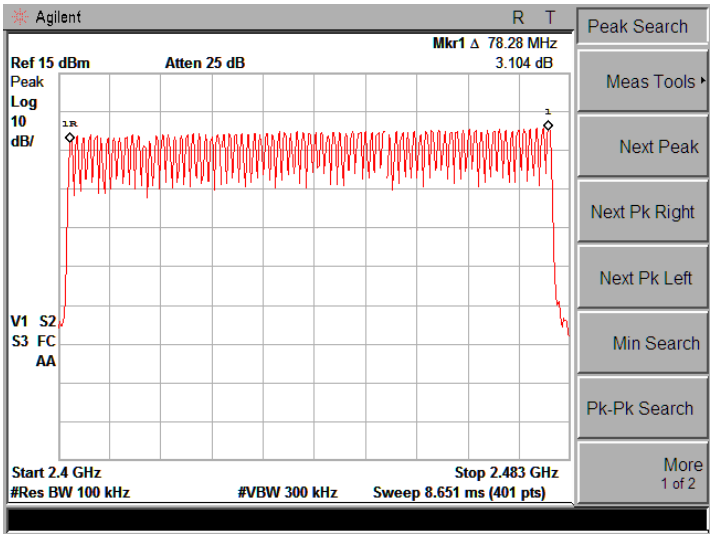
According to ANSI C63.10-2013 section 7.8.3, the number of hopping frequencies test method as follows.

a) Span: The frequency band of operation. Depending on the number of channels the devicesupports, it may be necessary to divide the frequency range of operation across multiple spans,to allow the individual channels to be clearly seen.
b) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channelspacing or the 20 dB bandwidth, whichever is smaller.
c) VBW≥RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

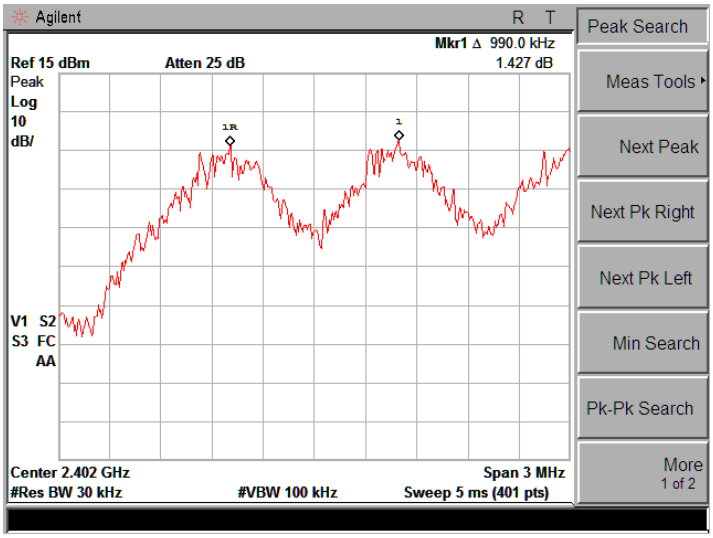
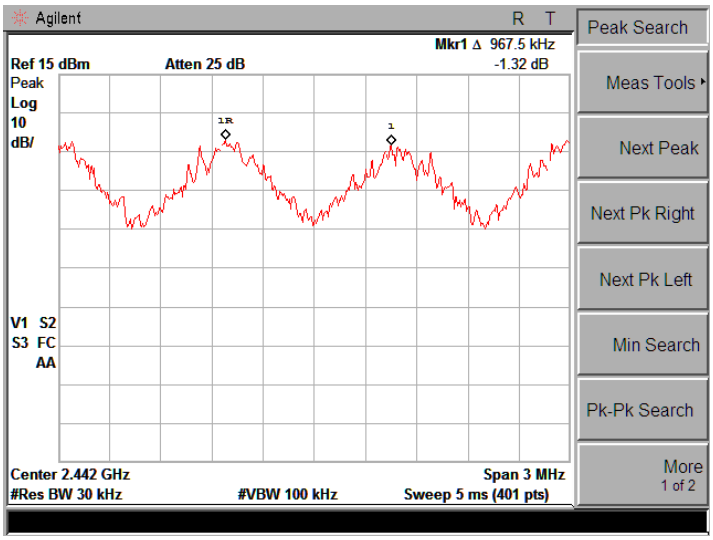
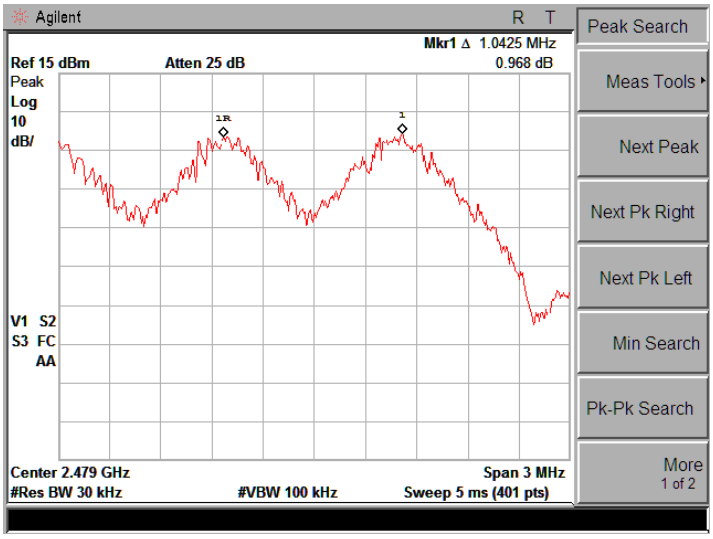
According to ANSI C63.10-2013 section 7.8.2, the EUT shall have its hopping function enabled, the Carrier frequency separation test method as follows:

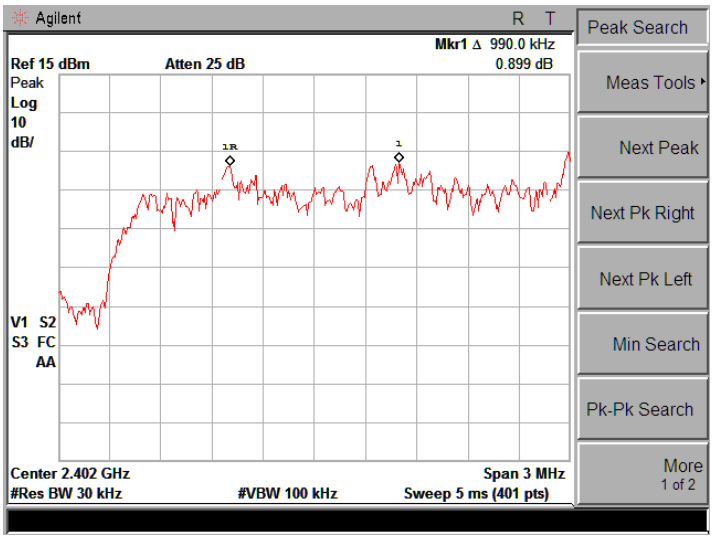
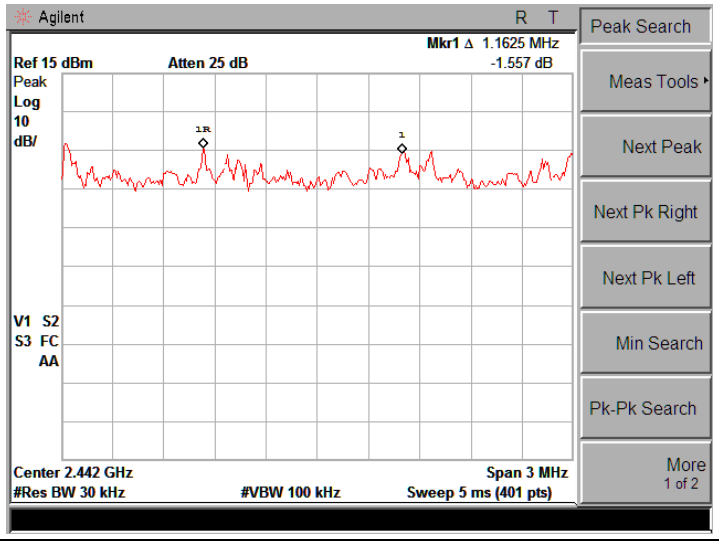
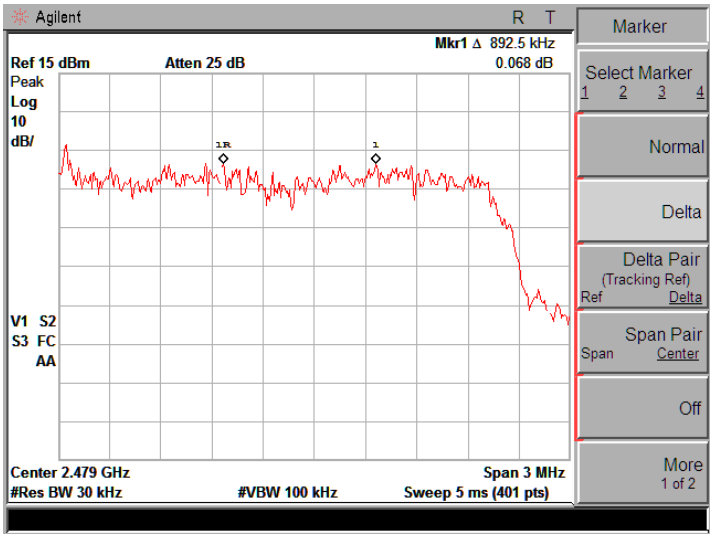
a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessaryto best identify the center of each individual channel.
c) Video (or average) bandwidth (VBW) ≥RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.
Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

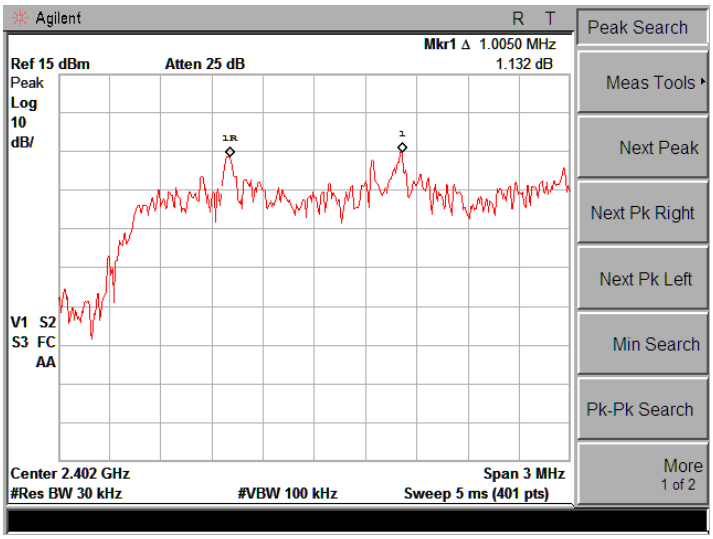
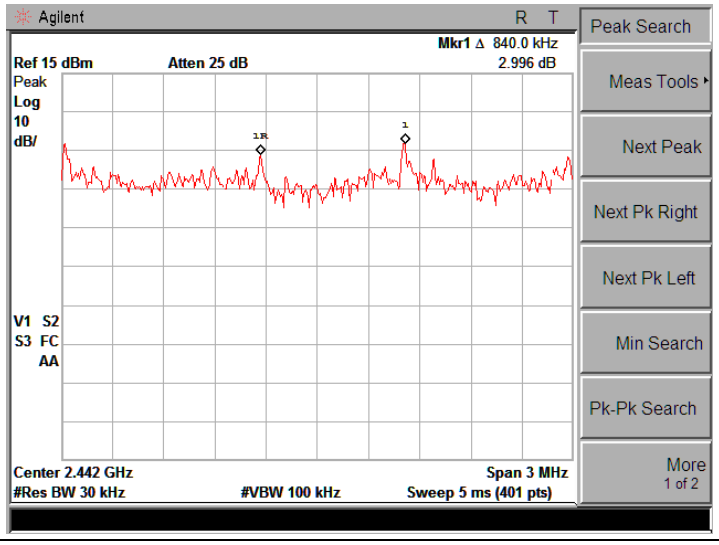
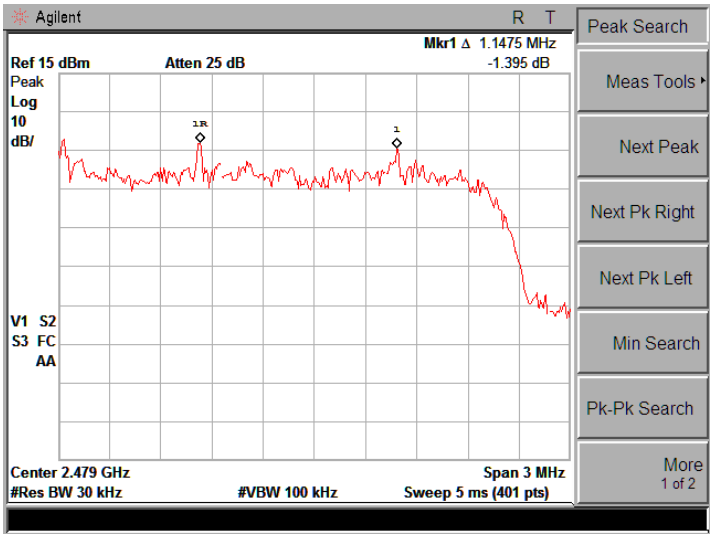
6.3Summary of Test Results/Plots

Hopping Channels =79	
Hopping Channel	

Mode	Channel	Carrier Frequencies Separation (kHz)	Result
GFSK	Low	1000	Pass
	Middle	1000	Pass
	High	1000	Pass
π /4 DQPSK	Low	1000	Pass
	Middle	1000	Pass
	High	1000	Pass
8DPSK	Low	1000	Pass
	Middle	1000	Pass
	High	1000	Pass

Channel Separation-GFSK	
Low Channel	
Middle Channel	
High Channel	

Channel Separation- π /4 DQPSK	
Low Channel	
Middle Channel	
High Channel	

Channel Separation-8DPSK	
Low Channel	
Middle Channel	
High Channel	

7. Dwell Time of Hopping Channel

7.1 Standard Applicable

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.

7.2 Test Procedure

According to ANSI C63.10-2013 section 7.8.4, the dwell time of a hopping channel test method as follows.

a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use avideo trigger and trigger delay so that the transmitted signal starts a little to the right of the start
of the plot. The trigger level might need slight adjustment to prevent triggering when the systemhops on an adjacent channel; a second plot might be needed with a longer sweep time to showtwo successive hops on a channel.
d) Detector function: Peak.
e) Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with differentmodes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this testfor each variation in transmit time.
Repeat the measurement using a longer sweep time to determine the number of hops over the periodspecified in the requirements. The sweep time shall be equal to, or less than, the period specified in therequirements. Determine the number of hops over the sweep time and calculate the total number of hops inthe period specified in the requirements, using the following equation:
(Number of hops in the period specified in the requirements) =
(number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)
The average time of occupancy is calculated from the transmit time per hop multiplied by the number ofhops in the period specified in the requirements. If the number of hops in a specific time varies withdifferent modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeatthis test for each variation.
The measured transmit time and time between hops shall be consistent with the values described in theoperational description for the EUT.

7.3Summary of Test Results/Plots

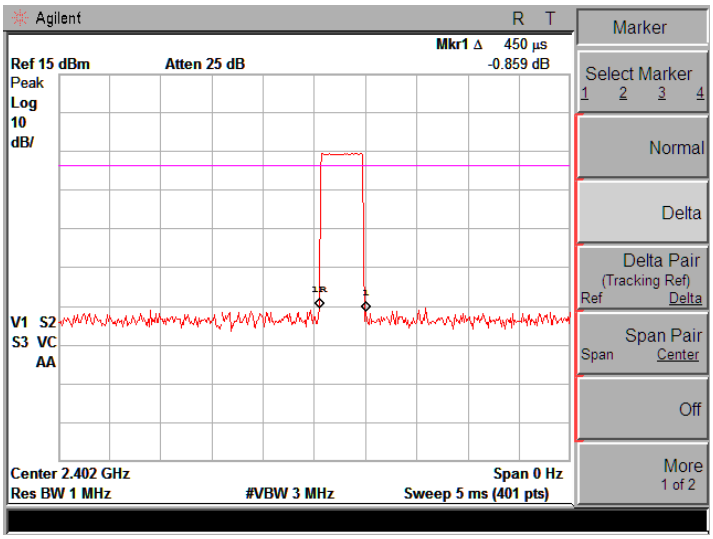
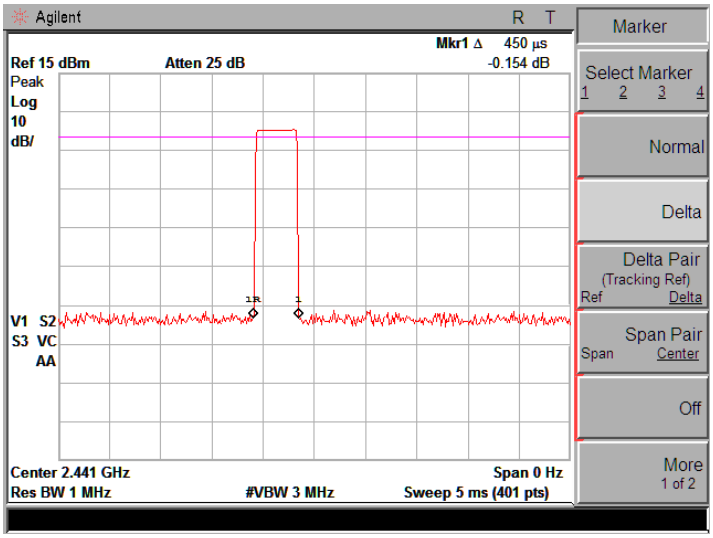
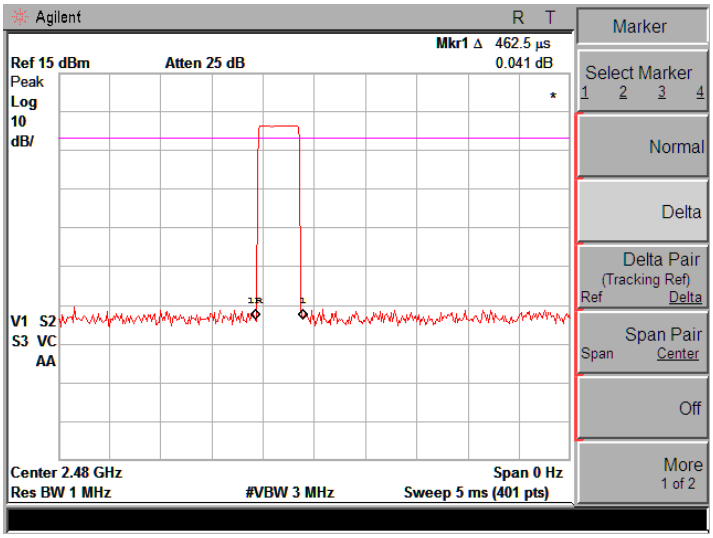
The dwell time within a period in data mode is independent from the packettype (packet length).
Test data is corrected with the worse case, which the packet length is 1DH1, 1DH3, and 1DH5.

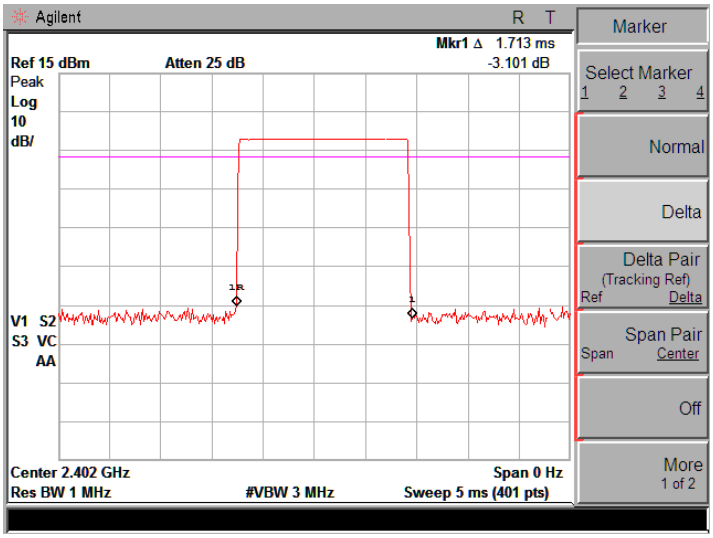
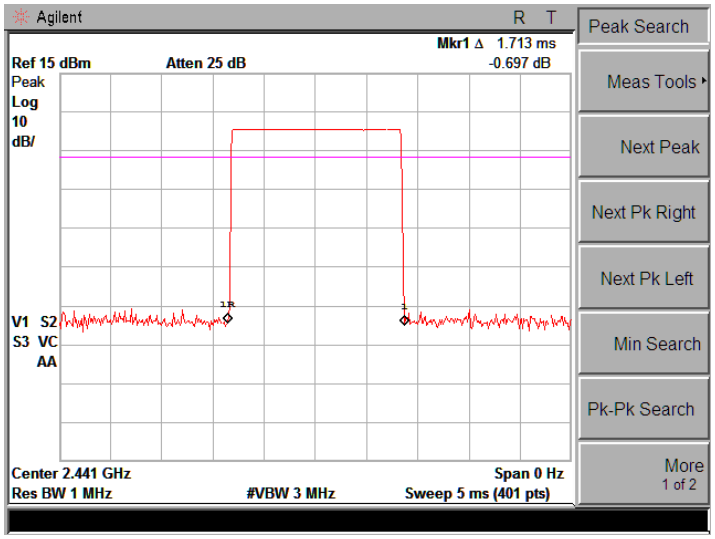
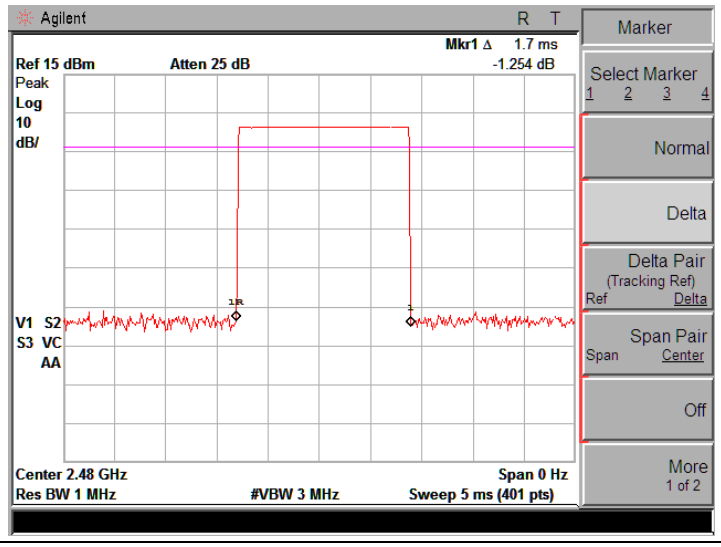
The test period: T = 0.4 Second * 79 Channel = 31.6 s

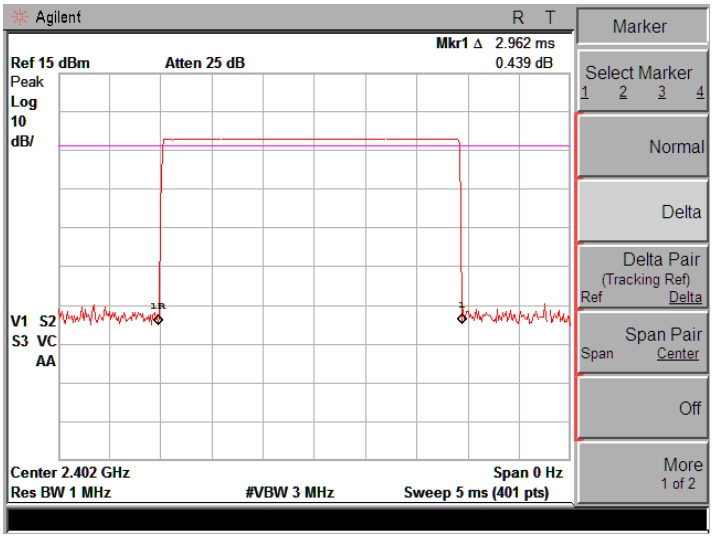
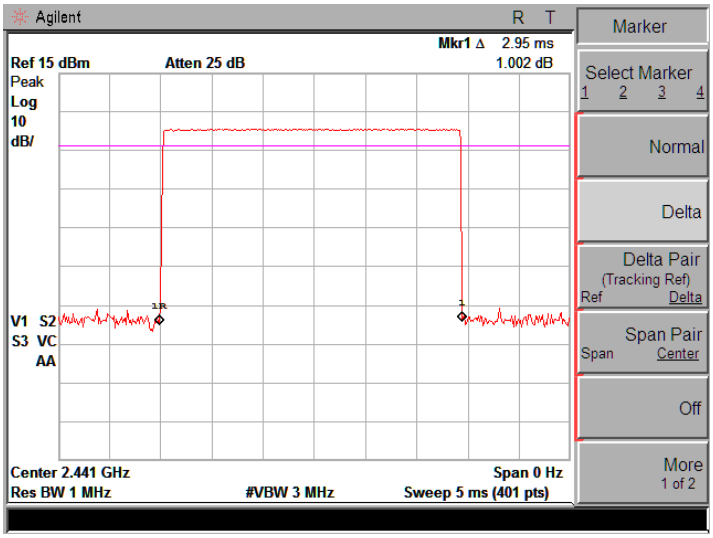
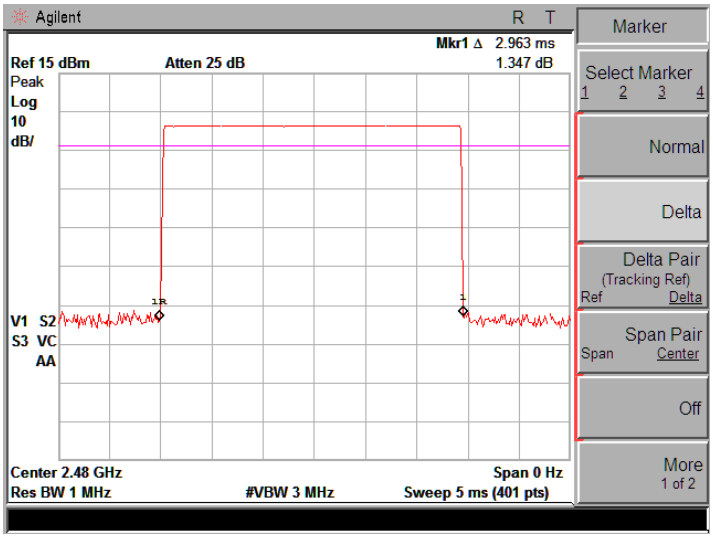
Dwell time = time slot length * (Hopping rate / Number of hopping channels) * Period

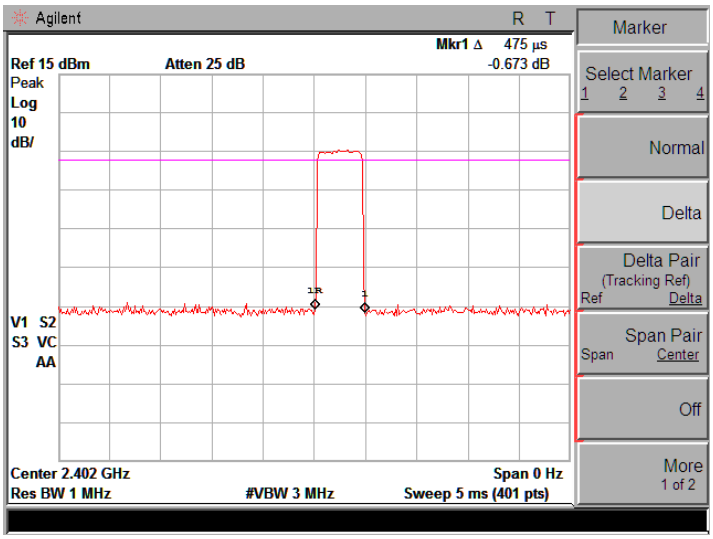
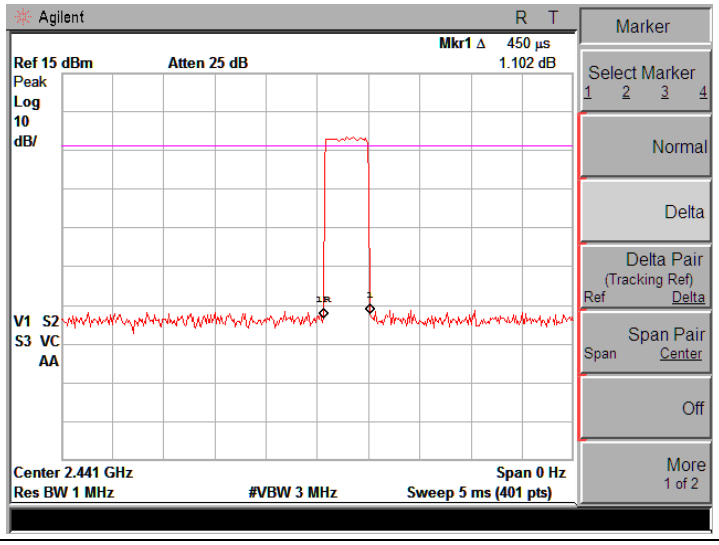
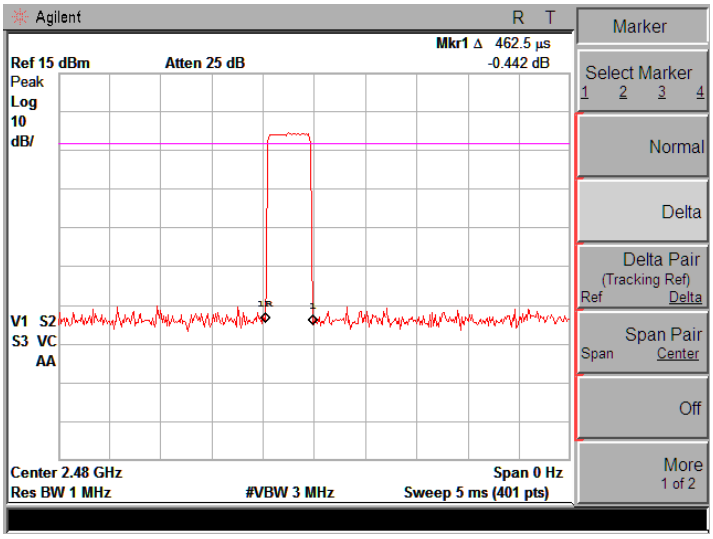
Modulation	Test Channel	Packet	Time Slot Length	Dwell Time	Limit
			ms	ms	ms
GFSK	Low	DH1	0.450	144.00	400
		DH3	1.713	274.08	400
		DH5	2.962	315.95	400
	Middle	DH1	0.450	144.00	400
		DH3	1.713	274.08	400
		DH5	2.950	314.67	400
	High	DH1	0.462	147.84	400
		DH3	1.700	272.00	400
		DH5	2.963	316.05	400
π /4 DQPSK	Low	2DH1	0.475	152.00	400
		2DH3	1.713	274.08	400
		2DH5	2.962	315.95	400
	Middle	2DH1	0.450	144.00	400
		2DH3	1.725	276.00	400
		2DH5	2.975	317.33	400
	High	2DH1	0.462	147.84	400
		2DH3	1.712	273.92	400
		2DH5	2.962	315.95	400
8DPSK	Low	3DH1	0.475	152.00	400
		3DH3	1.725	276.00	400
		3DH5	2.975	317.33	400
	Middle	3DH1	0.475	152.00	400
		3DH3	1.712	273.92	400
		3DH5	2.950	314.67	400
	High	3DH1	0.475	152.00	400
		3DH3	1.725	276.00	400
		3DH5	2.962	315.95	400

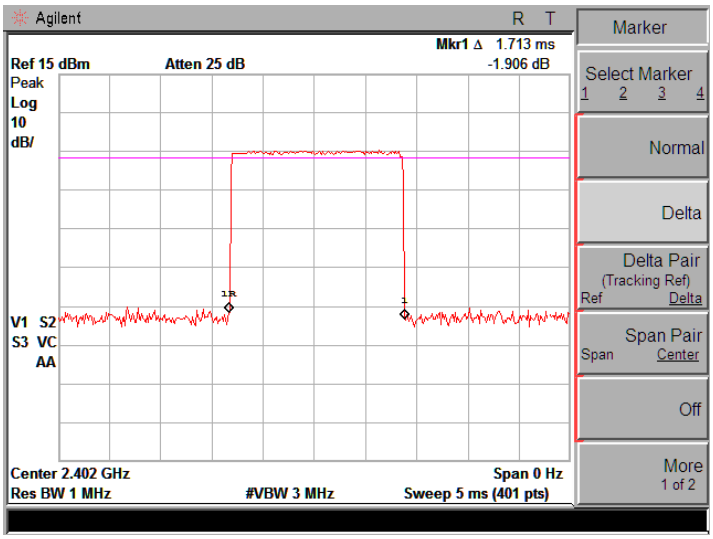
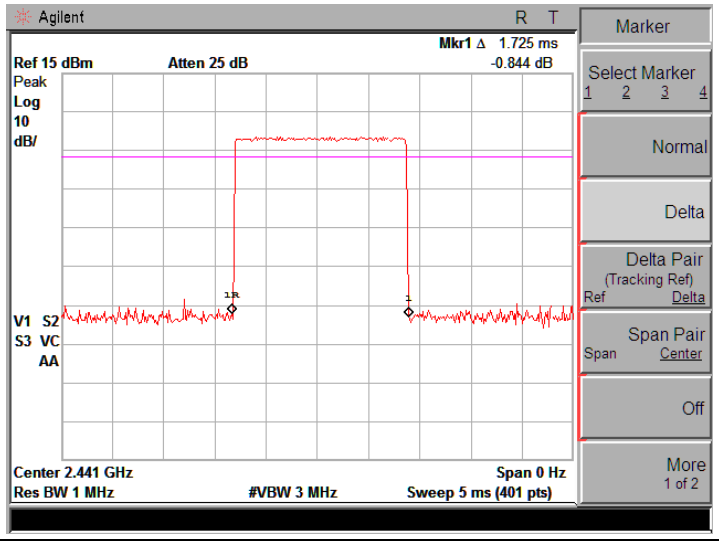
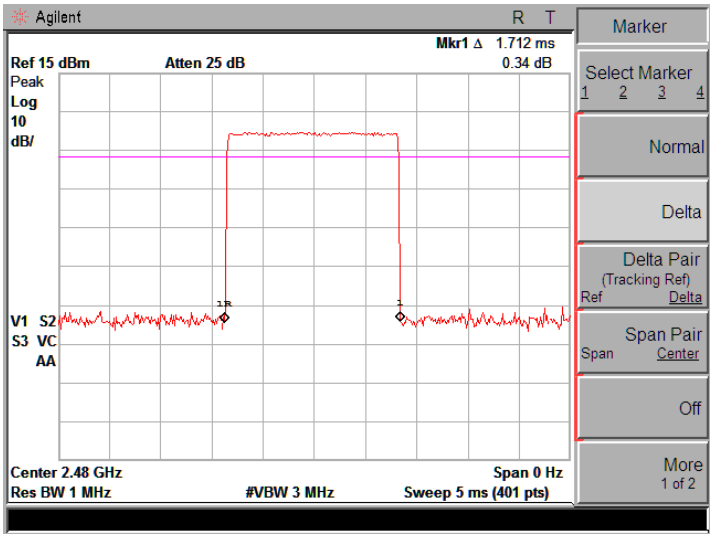
Please refer to the test plots as below:

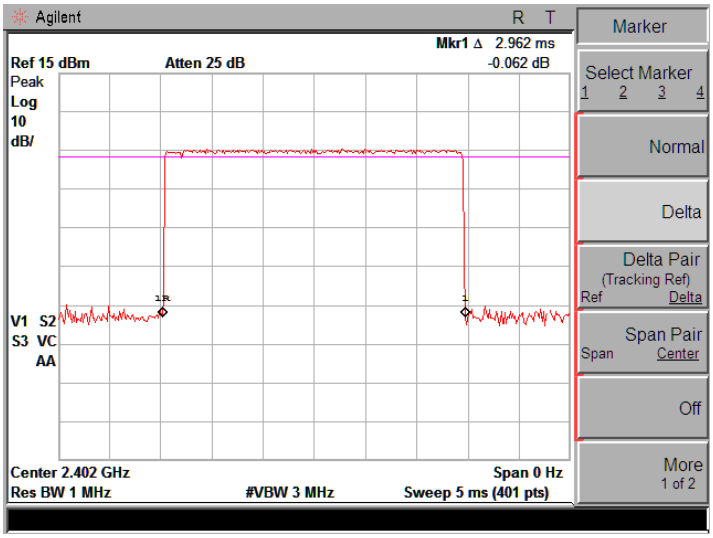
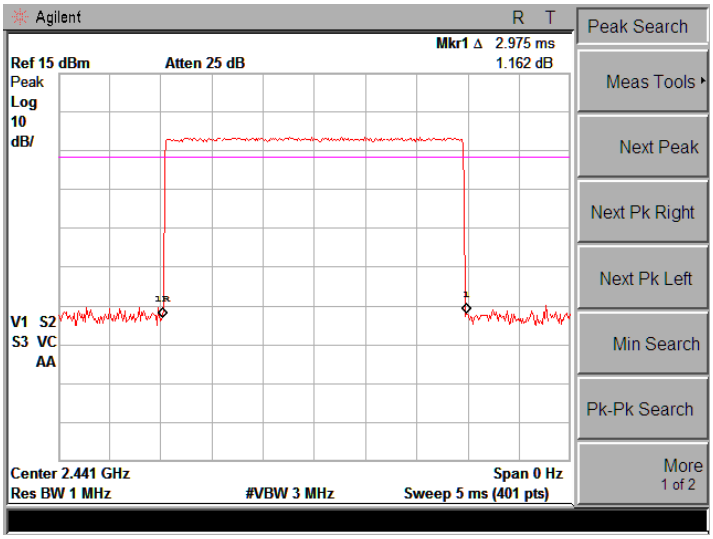
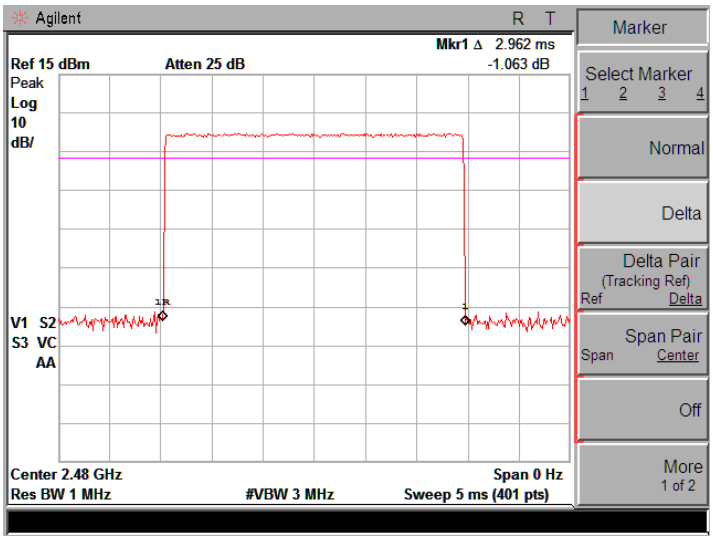
DH1	
Low Channel	
Middle Channel	
High Channel	

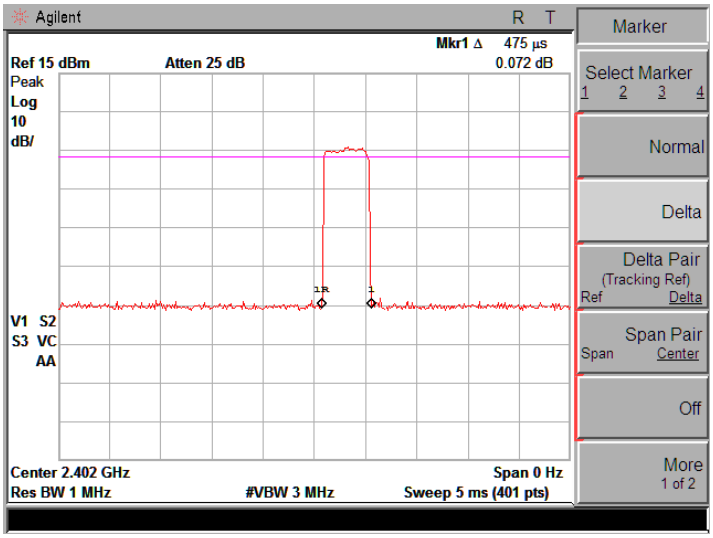
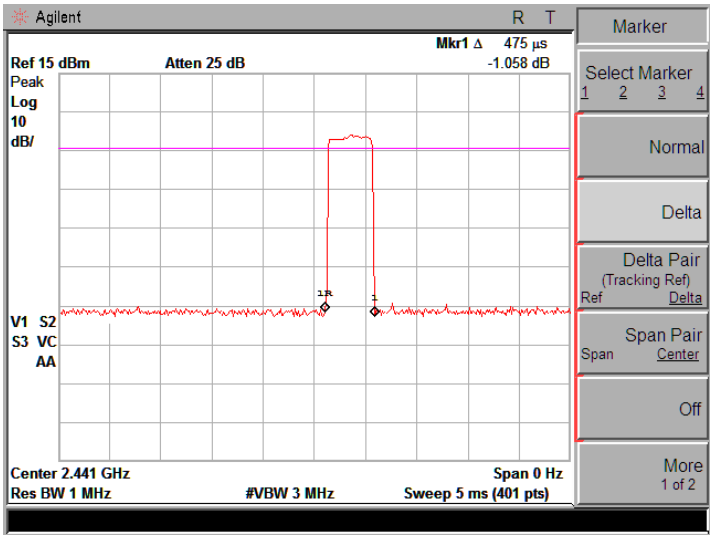
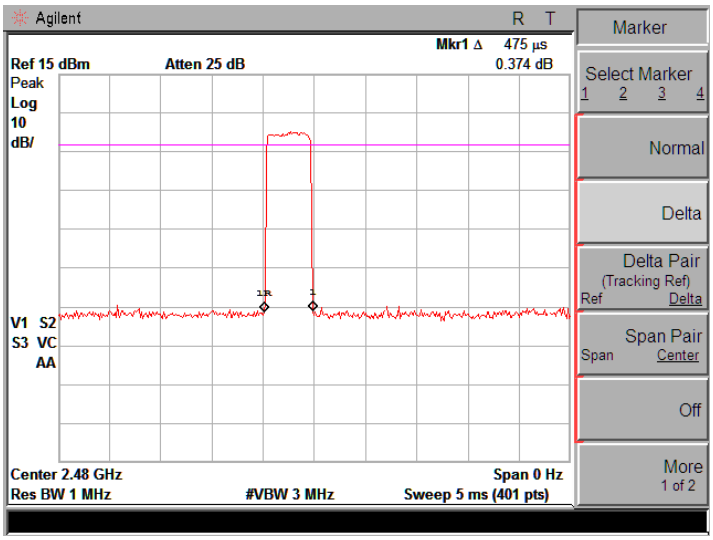
DH3	
Low Channel	
Middle Channel	
High Channel	

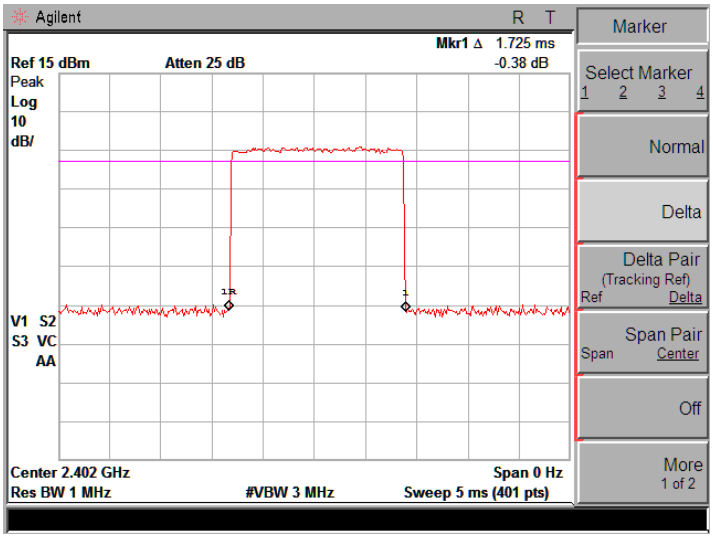
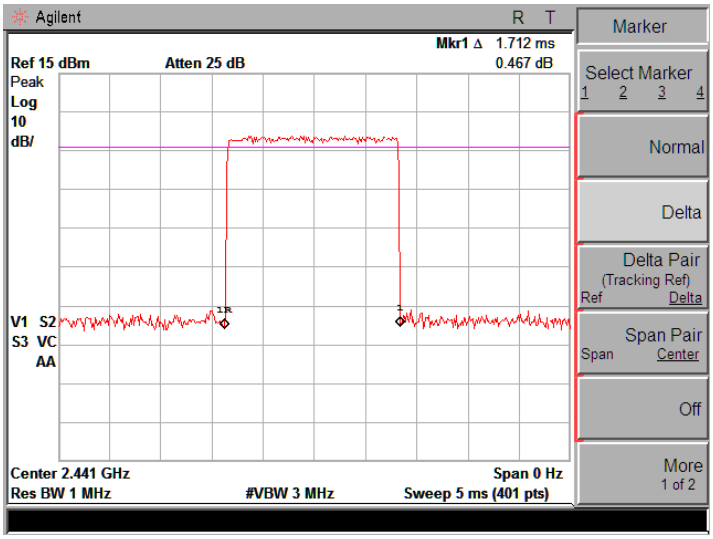
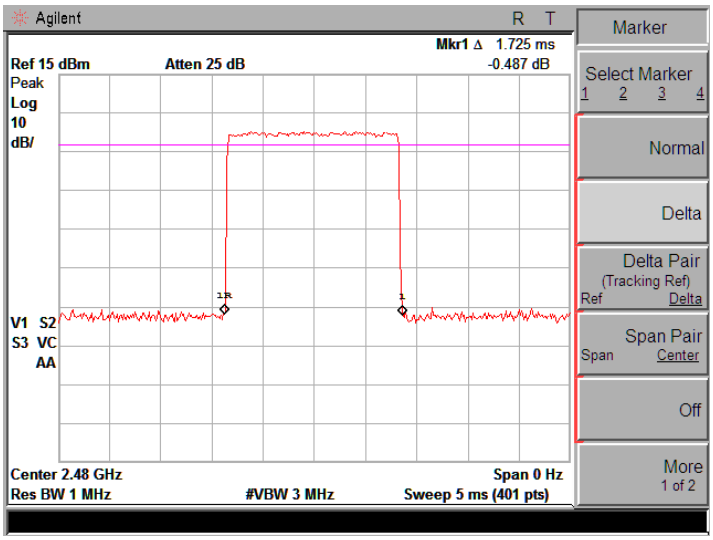
DH5	
Low Channel	
Middle Channel	
High Channel	

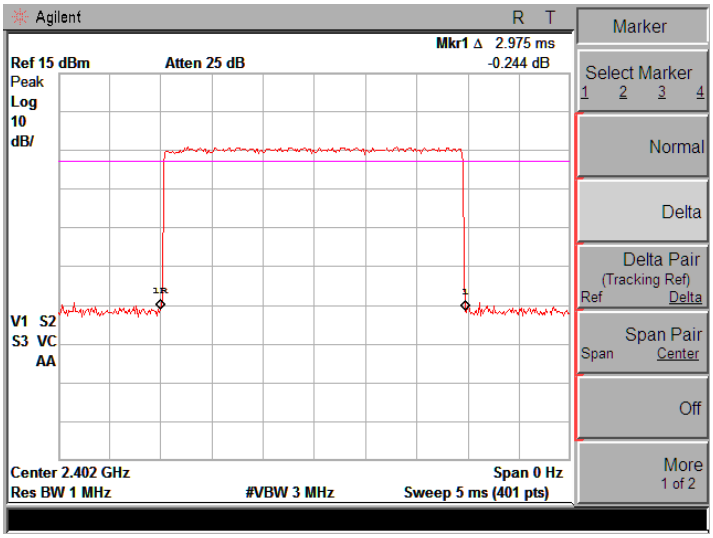
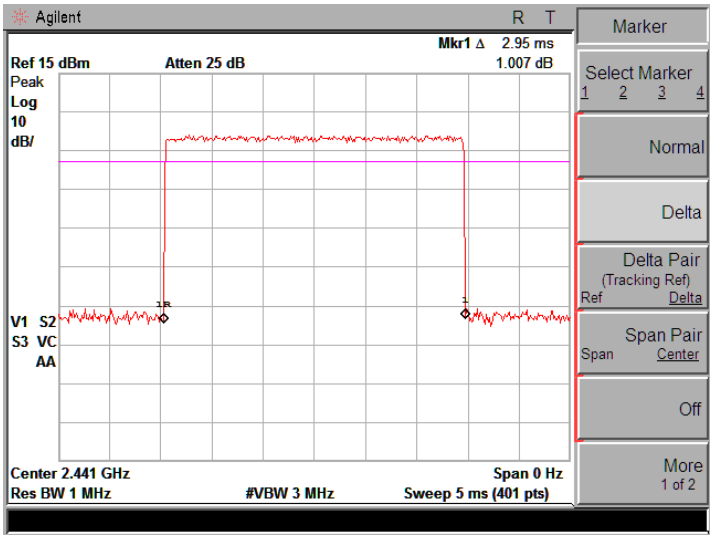
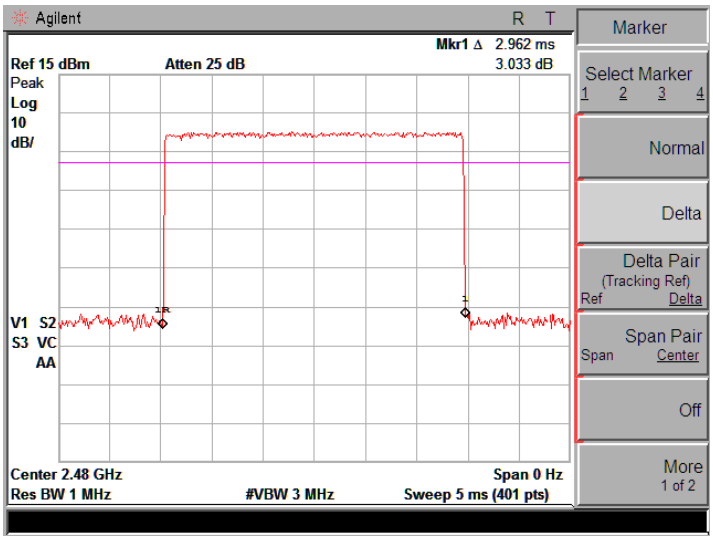
2DH1	
Low Channel	
Middle Channel	
High Channel	

2DH3	
Low Channel	
Middle Channel	
High Channel	

2DH5	
Low Channel	
Middle Channel	
High Channel	

3DH1	
Low Channel	
Middle Channel	
High Channel	

3DH3	
Low Channel	
Middle Channel	
High Channel	

3DH5	
Low Channel	
Middle Channel	
High Channel	

8. 20dB Bandwidth

8.1 Standard Applicable

According to 15.247(a) and 15.215(c). 20dB bandwidth is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

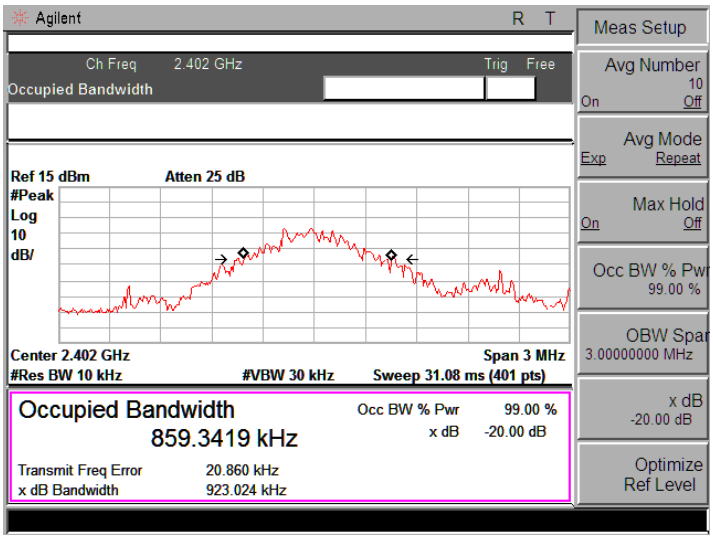
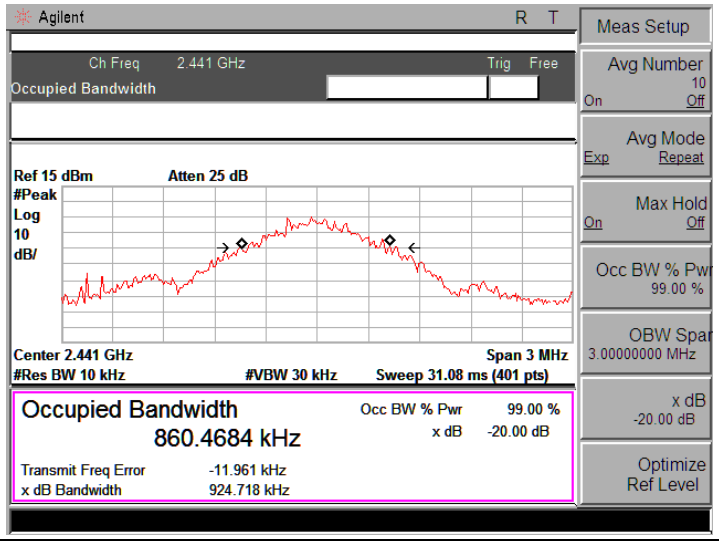
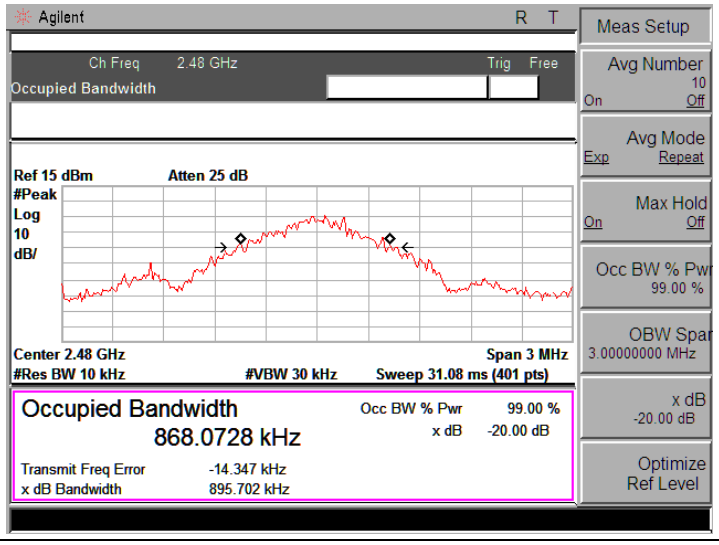
8.2 Test Procedure

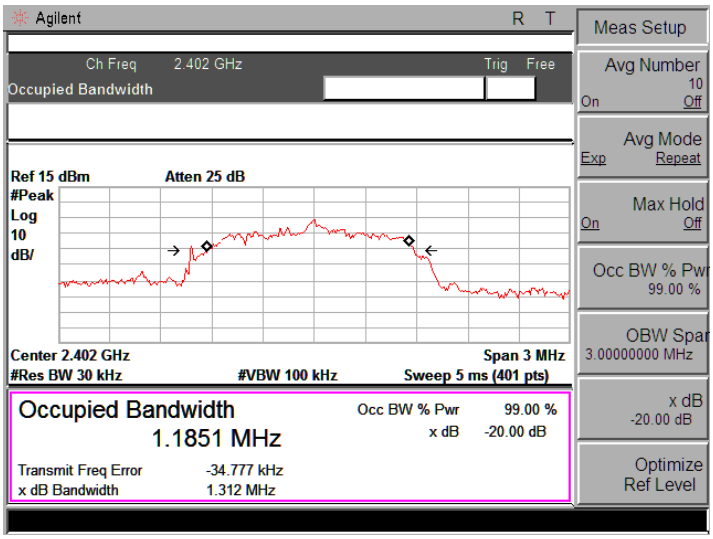
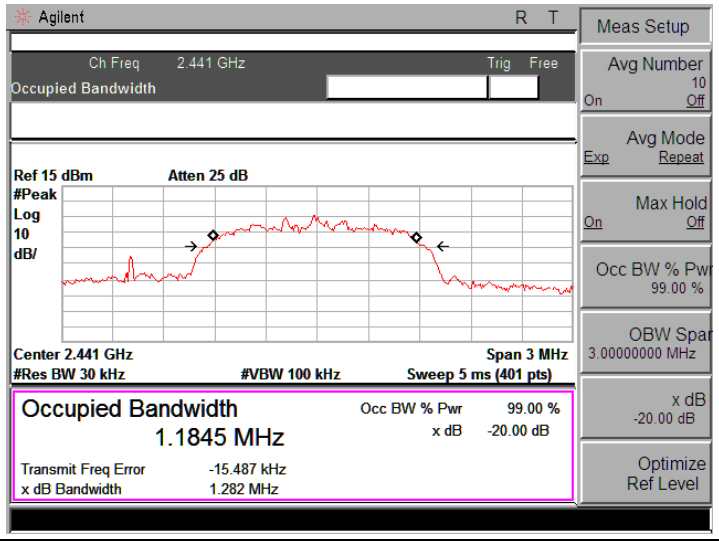
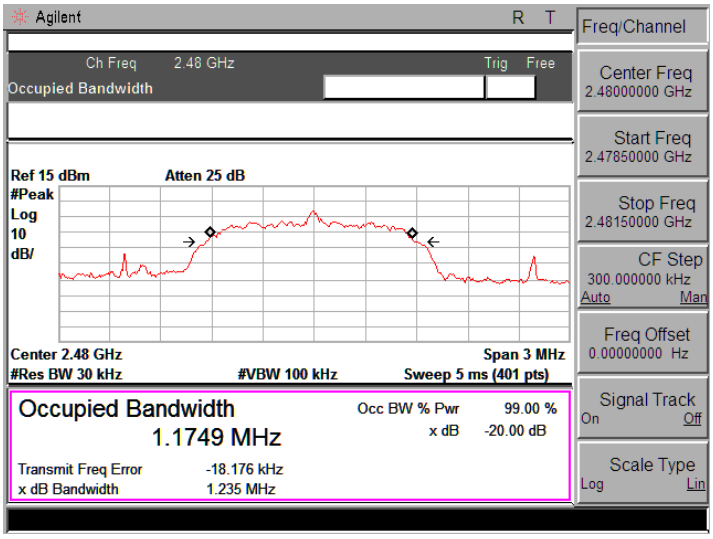
According to ANSI C63.10-2013 section 6.9.2, the 20dB bandwidth test method as follows.

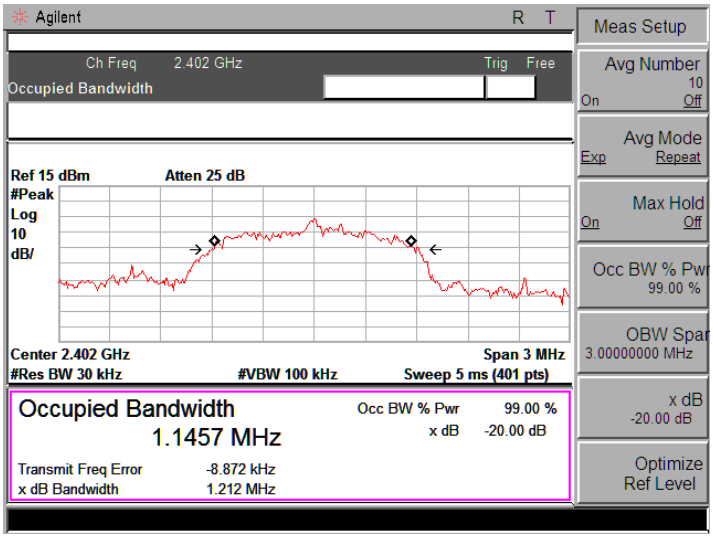
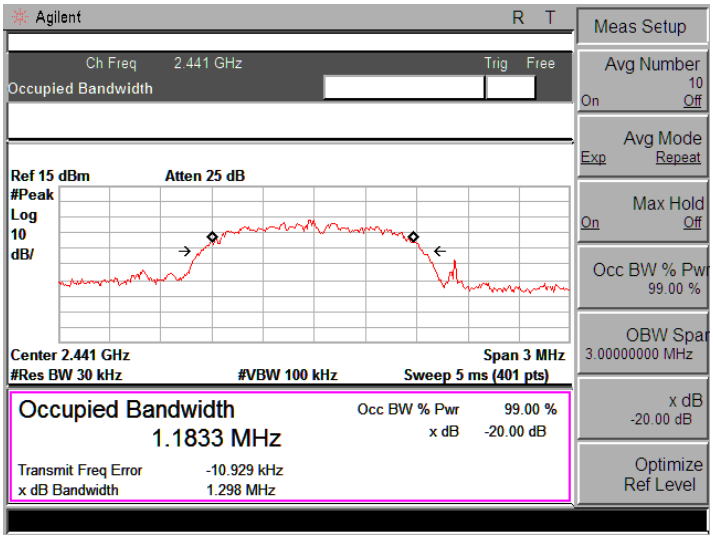
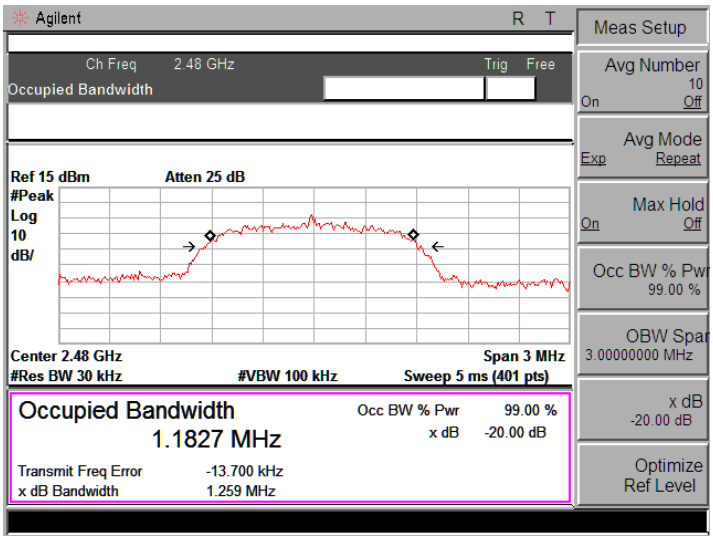
a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency.The span range for the EMI receiver or spectrum analyzer shall be between two times and fivetimes the OBW.
b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW andvideo bandwidth (VBW) shall be approximately three times RBW, unless otherwise specifiedby the applicable requirement.
c) Set the reference level of the instrument as required, keeping the signal from exceeding themaximum input mixer level for linear operation. In general, the peak of the spectral envelopeshall be more than [10 log (OBW/RBW)] below the reference level.
d) Steps a) through c) might require iteration to adjust within the specified tolerances.
e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below thetarget "−xx dB down" requirement; that is, if the requirement calls for measuring the −20 dBOBW, the instrument noise floor at the selected RBW shall be at least 30 dB below thereference value.
f) Set detection mode to peak and trace mode to max hold.
g) Determine the reference value: Set the EUT to transmit an unmodulated carrier or modulatedsignal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to thehighest level of the displayed trace (this is the reference value).
h) Determine the "−xx dB down amplitude" using [(reference value) − xx]. Alternatively, thiscalculation may be made by using the marker-delta function of the instrument.
i) If the reference value is determined by an unmodulated carrier, then turn the EUT modulationON, and either clear the existing trace or start a new trace on the spectrum analyzer and allow thenew trace to stabilize. Otherwise, the trace from step g) shall be used for step j).
j) Place two markers, one at the lowest frequency and the other at the highest frequency of theenvelope of the spectral display, such that each marker is at or slightly below the "−xx dB downamplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value,then it shall be as close as possible to this value. The occupied bandwidth is the frequencydifference between the two markers. Alternatively, set a marker at the lowest frequency of theenvelope of the spectral display, such that the marker is at or slightly below the "−xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to theother side of the emission until the delta marker amplitude is at the same level as the referencemarker amplitude. The marker-delta frequency reading at this point is the specified emissionbandwidth.
k) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrumentdisplay; the plot axes and the scale units per division shall be clearly labeled. Tabular data maybe reported in addition to the plot(s).

8.3Summary of Test Results/Plots

Test Mode	Test Channel MHz	20 dB Bandwidth KHz	Result
GFSK	2402	923.024	Pass
	2441	924.718	Pass
	2480	895.702	Pass
Π/4 DQPSK	2402	1312.000	Pass
	2441	1282.000	Pass
	2480	1235.000	Pass
8DPSK	2402	1212.000	Pass
	2441	1298.000	Pass
	2480	1259.000	Pass

GFSK	
Low Channel	
Middle Channel	
High Channel	

Π/4 DQPSK	
Low Channel	
Middle Channel	
High Channel	

8DPSK	
Low Channel	
Middle Channel	
High Channel	

9. RF Output Power

9.1 Standard Applicable

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.

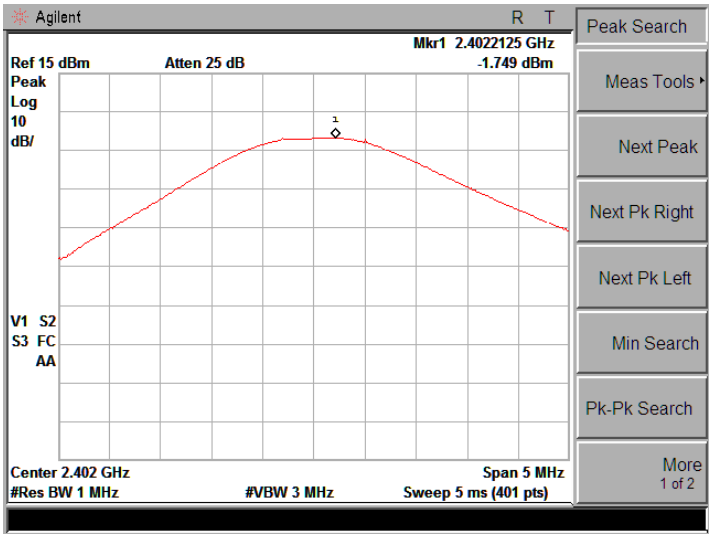
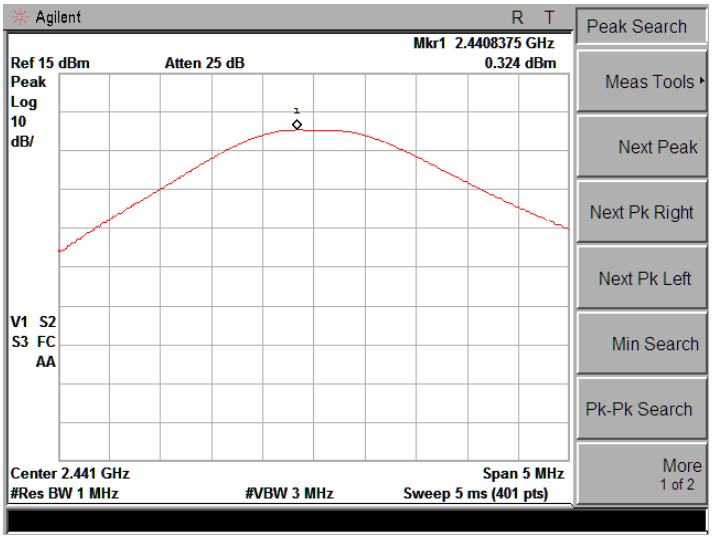
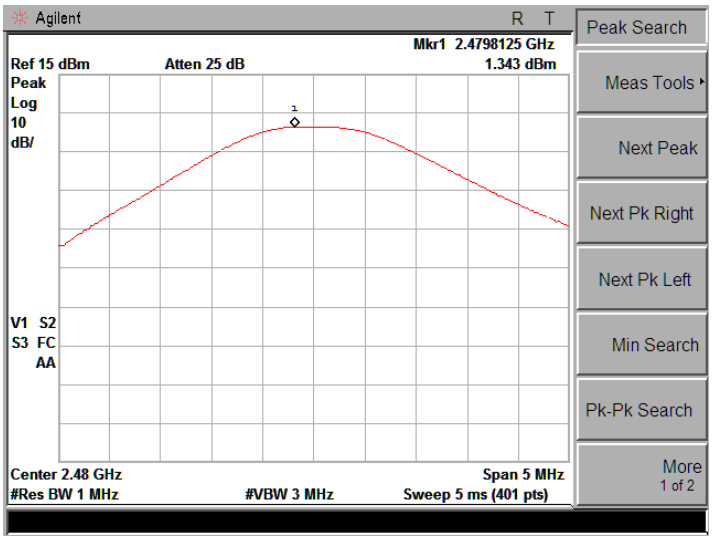
9.2 Test Procedure

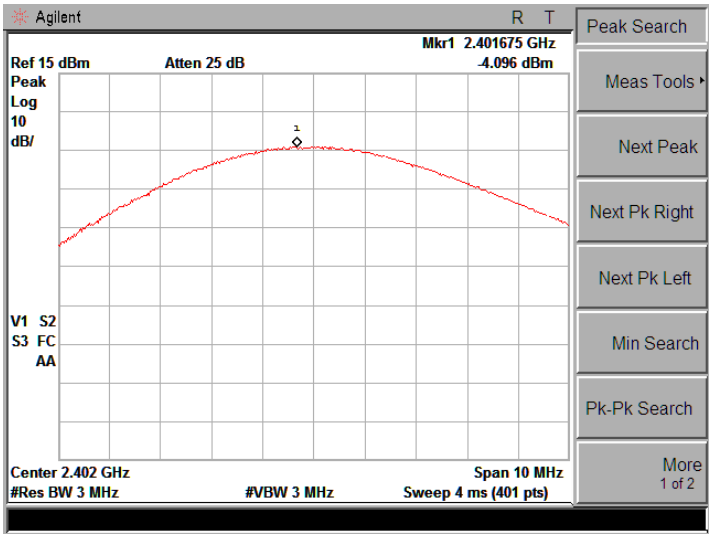
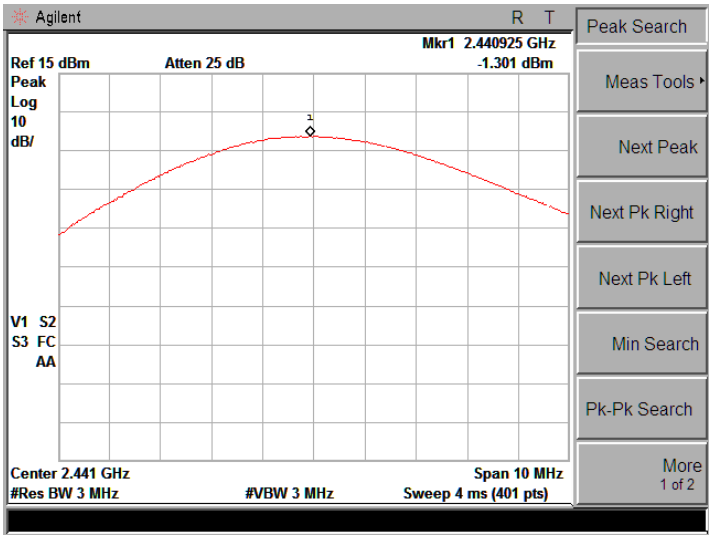
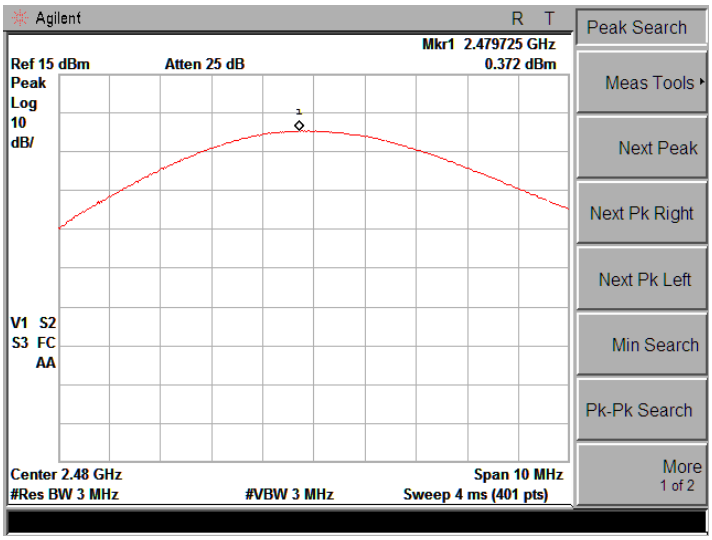
According to ANSI C63.10-2013 section 7.8.5, the output power test method as follows.
Remove the antenna from the EUT and then connect a low loss RF cable from the antennaport to the spectrum analyzer.
This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between theantenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation.
Thehopping shall be disabled for this test:
a) Use the following spectrum analyzer settings:
   1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
   2) RBW> 20 dB bandwidth of the emission being measured.
   3) VBW⩾RBW.
   4) Sweep: Auto.
   5) Detector function: Peak.
   6) Trace: Max hold.
b) Allow trace to stabilize.
c) Use the marker-to-peak function to set the marker to the peak of the emission.
d) The indicated level is the peak output power, after any corrections for external attenuators andcables.
e) A plot of the test results and setup description shall be included in the test report.

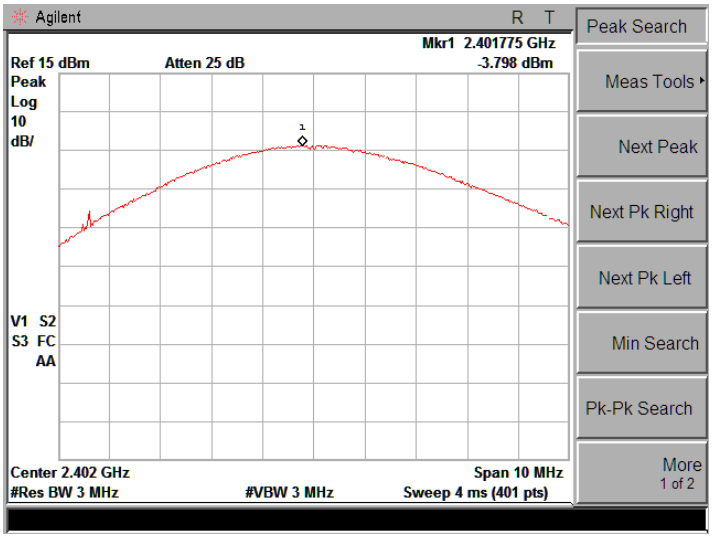
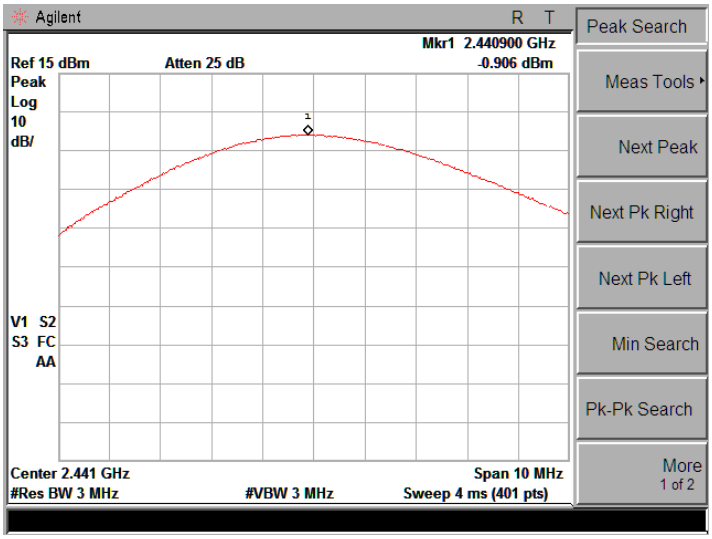
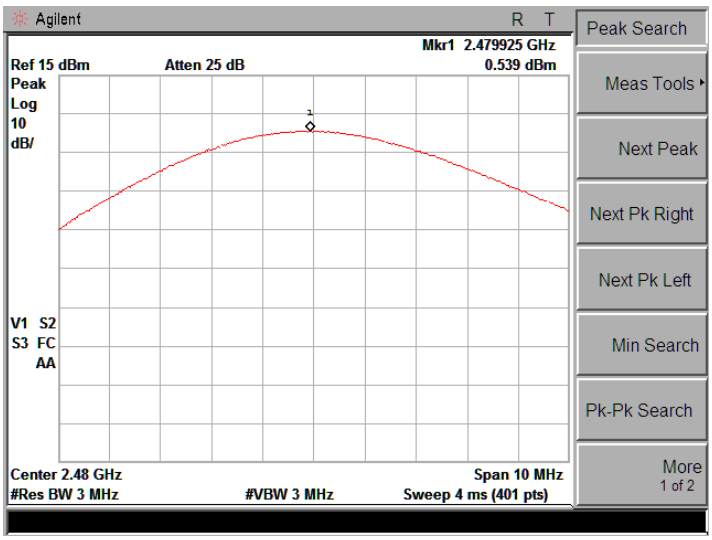
9.3Summary of Test Results/Plots

Modulation type	Channel	Output power (dBm)	Output power (mW)	Limit (mW)	Result
GFSK	Low	-1.749	0.7	1000	Pass
	Middle	0.324	1.1		
	High	1.343	1.4		
π/4DQPSK	Low	-4.096	0.4	125	Pass
	Middle	-1.301	0.7		
	High	0.372	1.1		
8DPSK	Low	-3.798	0.4	125	Pass
	Middle	-0.906	0.8		
	High	0.539	1.1		

Note: the antenna gain of 0dBi less than 6dBi maximum permission antenna gain value based on 1 watt peak output power limit.

GFSK	
Low Channel	
Middle Channel	
High Channel	

Π/4 DQPSK	
Low Channel	
Middle Channel	
High Channel	

8DPSK	
Low Channel	
Middle Channel	
High Channel	

10. Field Strength of Spurious Emissions

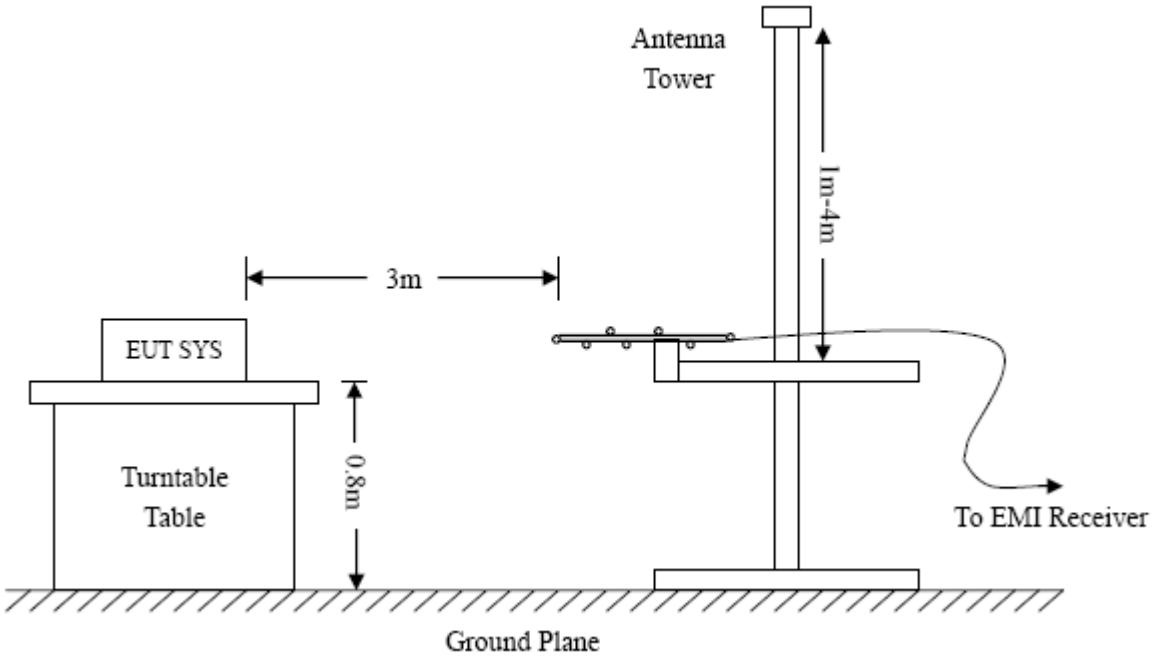
10.1 Standard Applicable

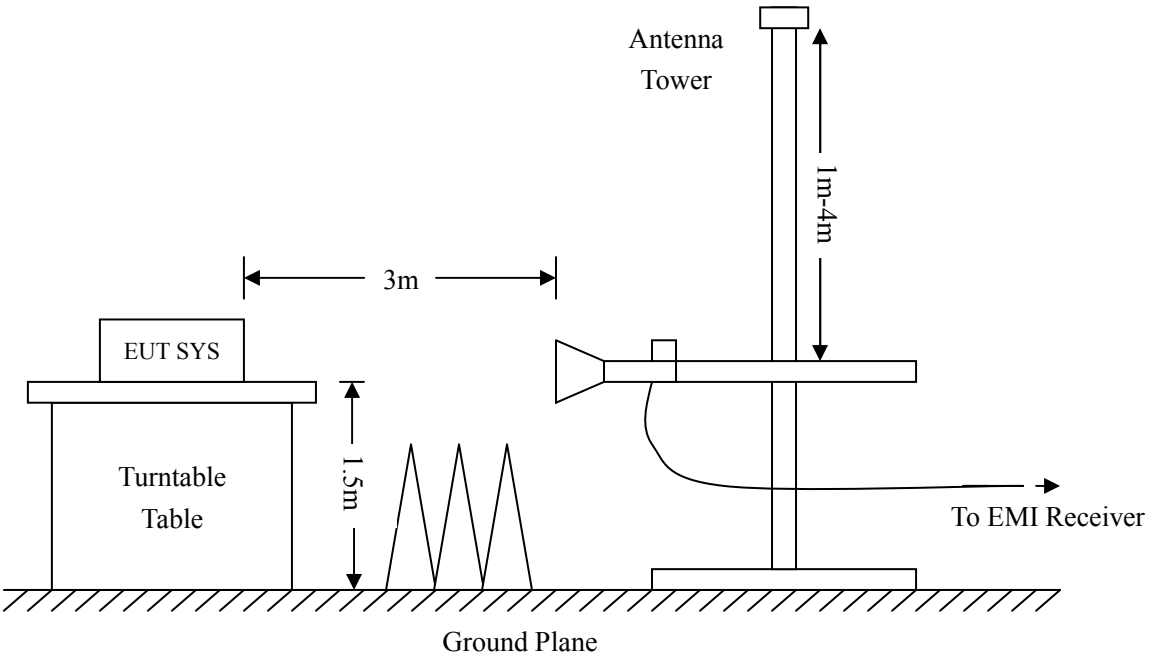
According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within 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 §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a).

The emission limit in this paragraph is based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply. Spurious Radiated Emissions measurements starting below or at the lowest crystal frequency.

10.2 Test Procedure

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.205 15.247(a) and FCC Part 15.209 Limit.
The external I/O cables were draped along the test table and formed a bundle 30 to 40 cm long in the middle.
The spacing between the peripherals was 10 cm.





Frequency :9kHz-30MHz	Frequency :30MHz-1GHz	Frequency :Above 1GHz
RBW=10KHz,	RBW=120KHz,	RBW=1MHz,
VBW =30KHz	VBW=300KHz	VBW=3MHz(Peak), 10Hz(AV)
Sweep time= Auto	Sweep time= Auto	Sweep time= Auto
Trace = max hold	Trace = max hold	Trace = max hold
Detector function = peak	Detector function = peak, QP	Detector function = peak, AV

10.3 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and the Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

Corr. Ampl. = Indicated Reading + Ant. Factor + Cable Loss – Ampl. Gain

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -6dBμV means the emission is 6dBμV below the maximum limit. The equation for margin calculation is as follows:

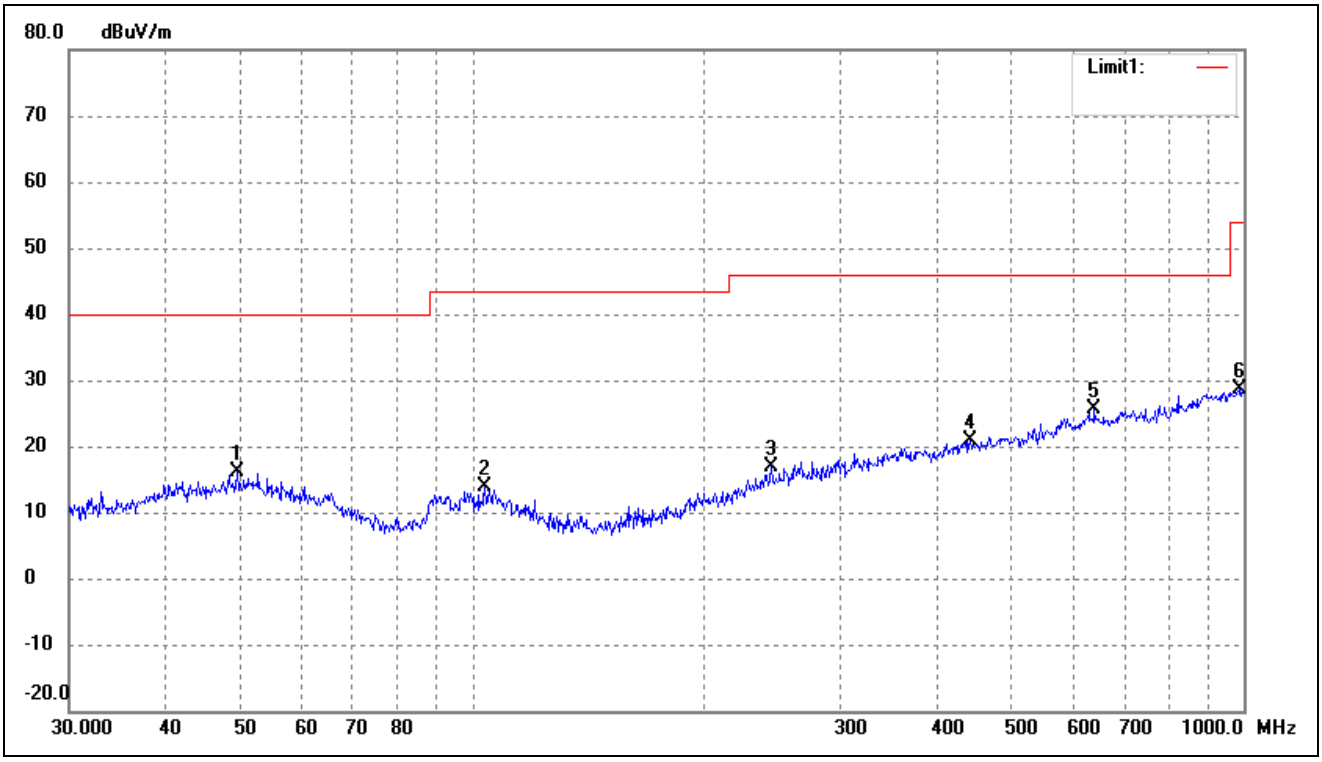
Margin = Corr. Ampl. – FCCPart15 Limit

10.4Summary of Test Results/Plots

Note: this EUT was tested in 3 orthogonal positions and the worst case position data was reported.
All test modes (different data rate and different modulation) are performed, but only the worst case is recorded in this report.

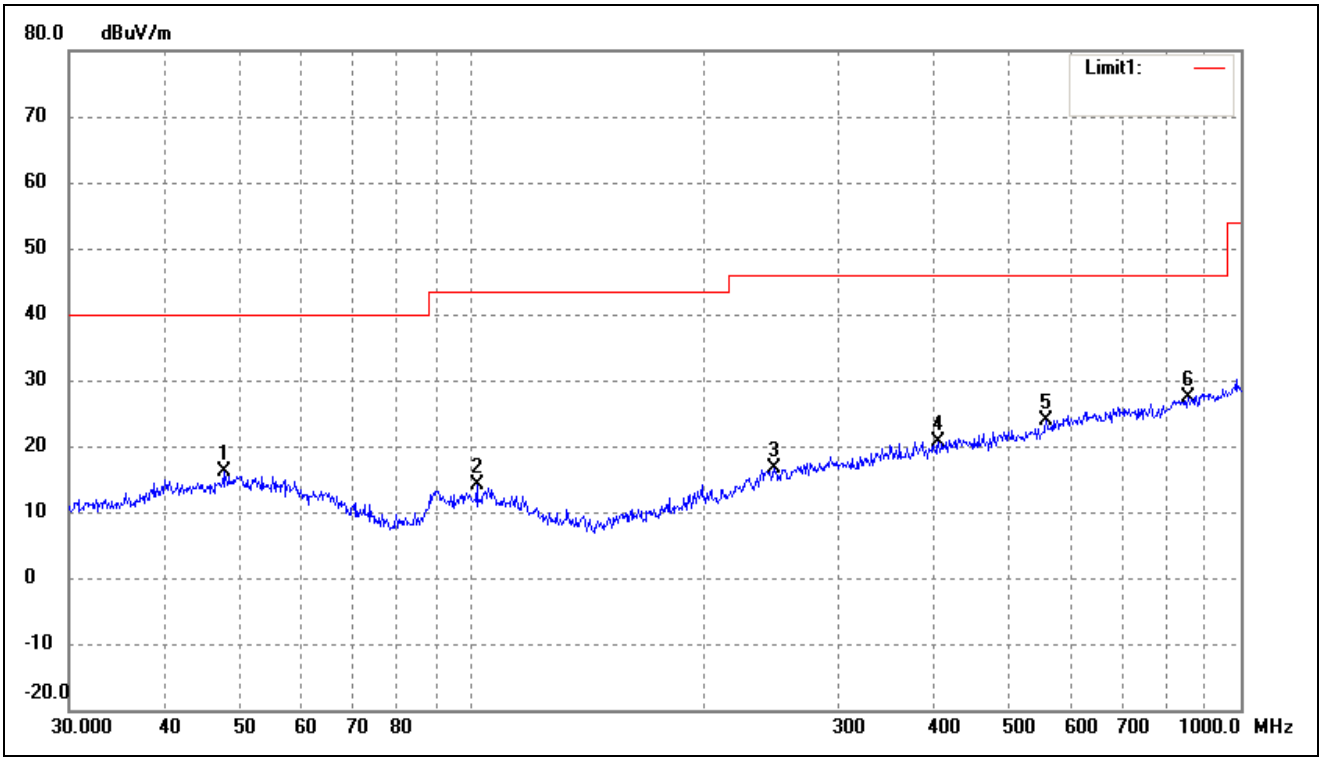
➢ Spurious Emissions Below 1GHz

Test Channel	Low	Polarity:	Horizontal



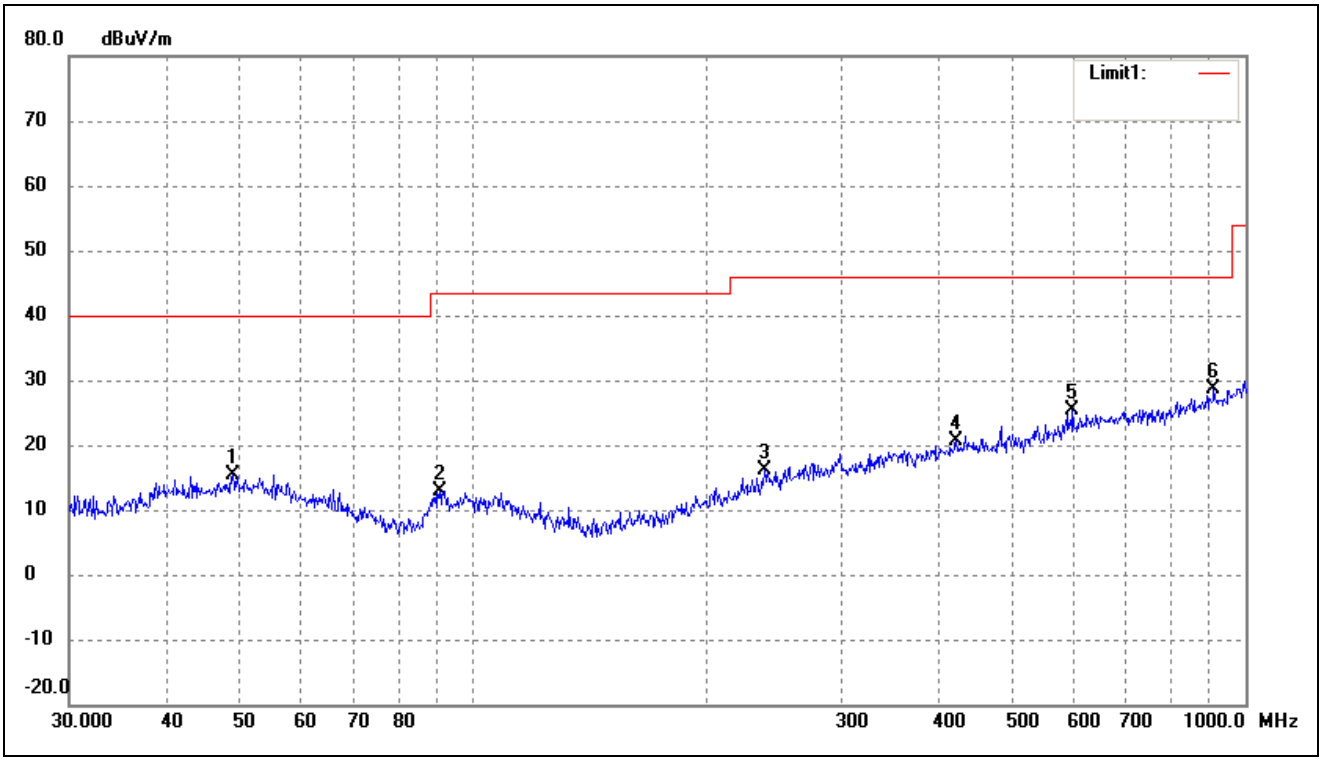
No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	
1	49.5328	27.82	-11.61	16.21	40.00	-23.79	peak
2	103.8054	27.33	-13.48	13.85	43.50	-29.65	peak
3	244.2321	27.11	-10.11	17.00	46.00	-29.00	peak
4	441.7425	26.94	-6.11	20.83	46.00	-25.17	peak
5	640.6109	28.37	-2.68	25.69	46.00	-20.31	peak
6	986.0716	26.54	2.16	28.70	54.00	-25.30	peak

Test Channel	Low	Polarity:	Vertical



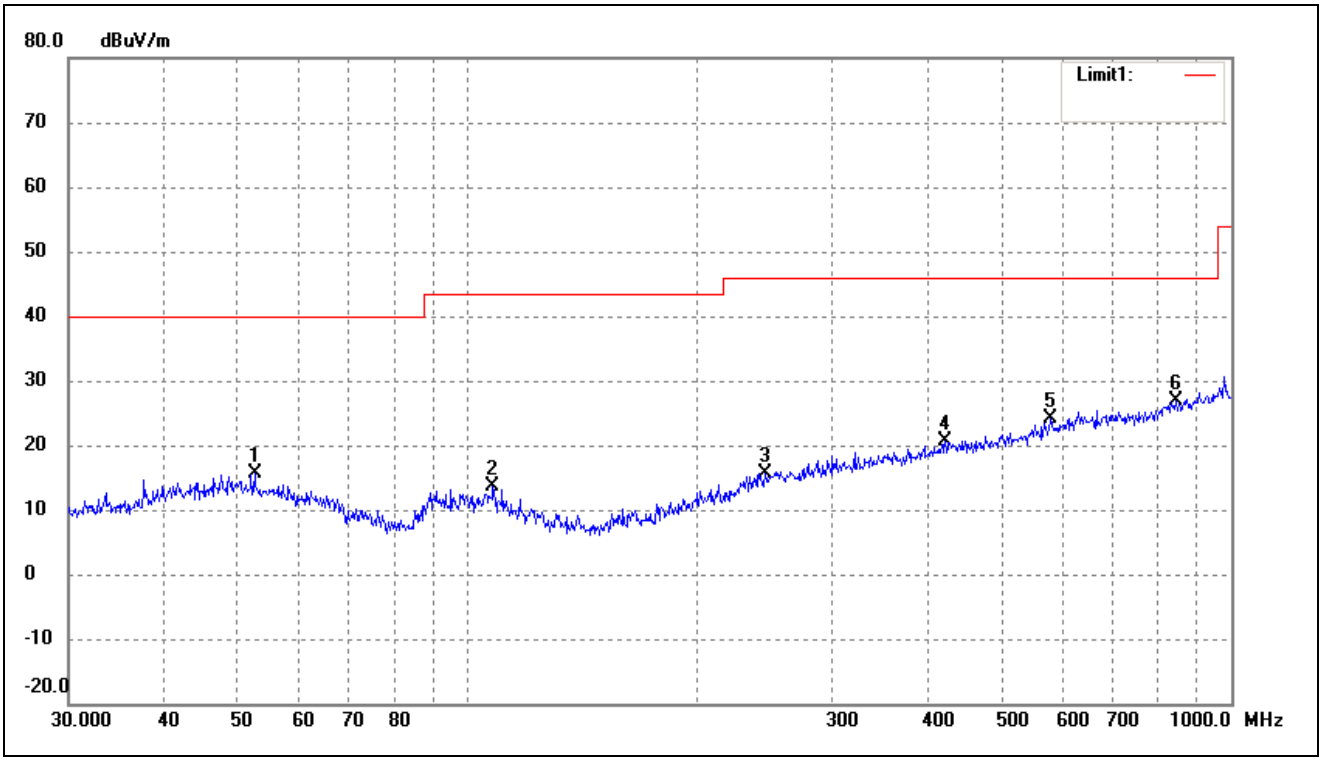
No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	
1	47.6585	27.74	-11.69	16.05	40.00	-23.95	peak
2	101.6443	27.70	-13.66	14.04	43.50	-29.46	peak
3	247.6819	26.66	-9.96	16.70	46.00	-29.30	peak
4	404.6664	27.37	-6.62	20.75	46.00	-25.25	peak
5	558.7301	28.51	-4.52	23.99	46.00	-22.01	peak
6	854.0247	27.36	-0.10	27.26	46.00	-18.74	peak

Test Channel	Middle	Polarity:	Horizontal



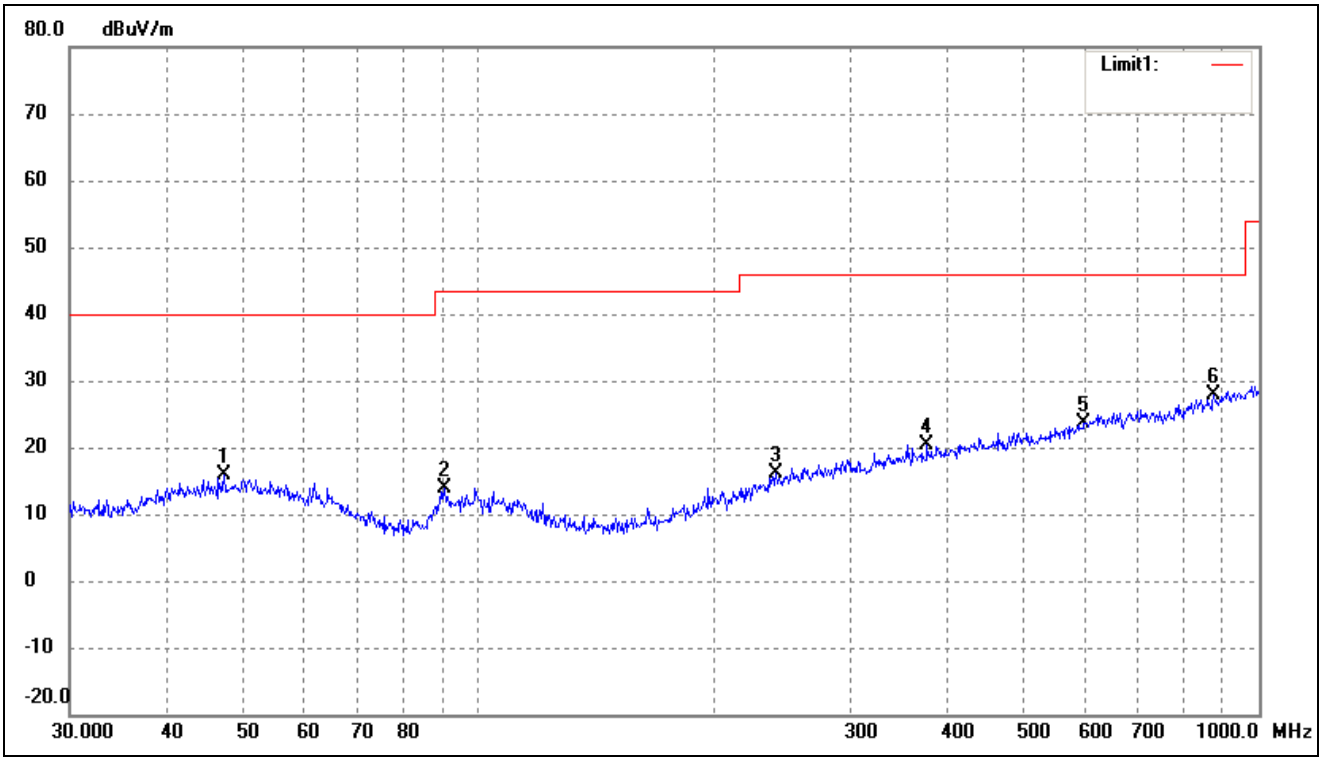
No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	
1	48.8429	26.89	-11.63	15.26	40.00	-24.74	peak
2	90.5374	26.44	-13.51	12.93	43.50	-30.57	peak
3	238.3102	26.24	-10.23	16.01	46.00	-29.99	peak
4	422.0577	26.83	-6.27	20.56	46.00	-25.44	peak
5	597.2233	28.68	-3.35	25.33	46.00	-20.67	peak
6	909.6666	27.33	1.35	28.68	46.00	-17.32	peak

Test Channel	Middle	Polarity:	Vertical



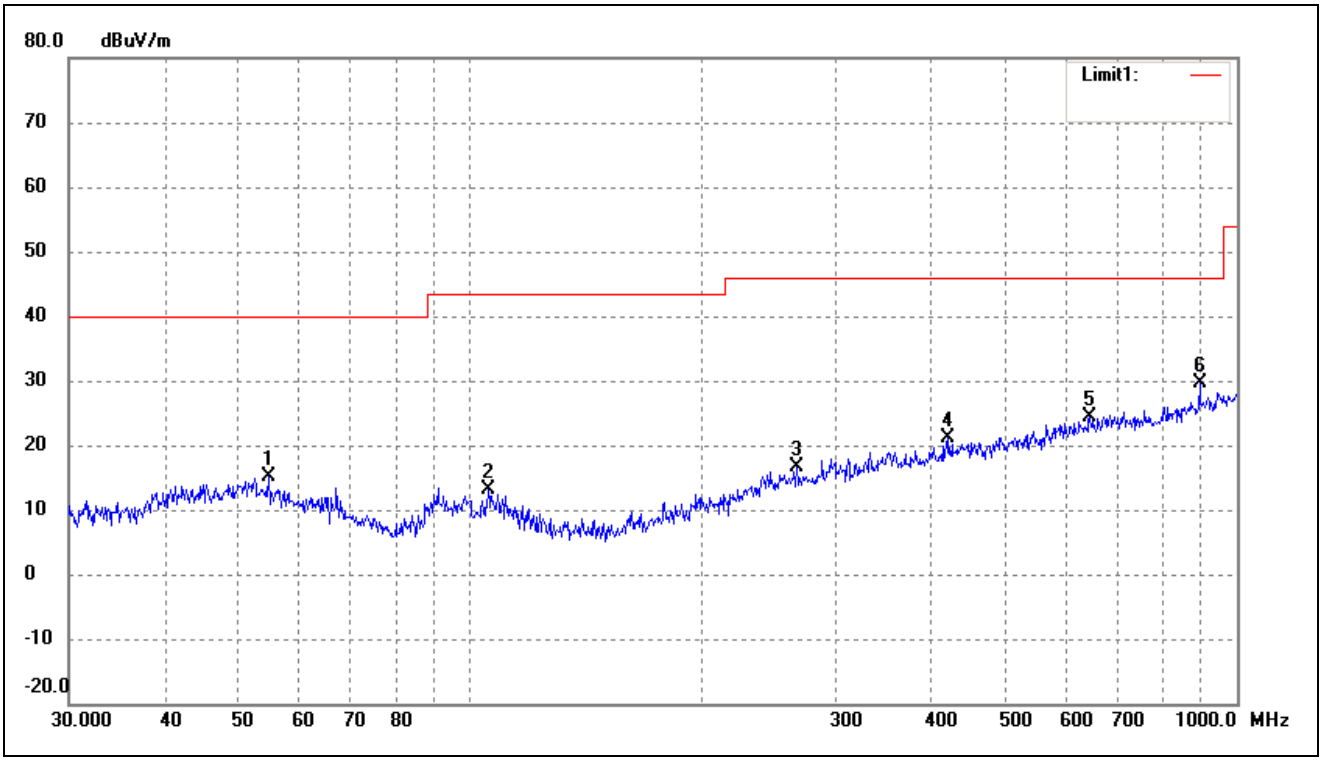
No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	
1	52.5752	27.25	-11.67	15.58	40.00	-24.42	peak
2	107.8876	27.20	-13.66	13.54	43.50	-29.96	peak
3	245.0900	25.81	-10.14	15.67	46.00	-30.33	peak
4	422.0577	26.91	-6.27	20.64	46.00	-25.36	peak
5	580.7025	27.76	-3.69	24.07	46.00	-21.93	peak
6	845.0878	27.10	-0.28	26.82	46.00	-19.18	peak

Test Channel	High	Polarity:	Horizontal



No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	
1	47.3254	27.56	-11.70	15.86	40.00	-24.14	peak
2	90.5374	27.47	-13.51	13.96	43.50	-29.54	peak
3	240.8303	26.07	-10.01	16.06	46.00	-29.94	peak
4	375.9384	27.52	-7.11	20.41	46.00	-25.59	peak
5	597.2233	27.01	-3.35	23.66	46.00	-22.34	peak
6	875.2469	27.44	0.51	27.95	46.00	-18.05	peak

Test Channel	High	Polarity:	Vertical



No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	
1	54.6428	27.19	-12.03	15.16	40.00	-24.84	peak
2	105.6414	26.64	-13.44	13.20	43.50	-30.30	peak
3	266.6089	25.59	-8.97	16.62	46.00	-29.38	peak
4	420.5803	27.36	-6.30	21.06	46.00	-24.94	peak
5	642.8613	26.87	-2.61	24.26	46.00	-21.74	peak
6	893.8567	28.98	0.72	29.70	46.00	-16.30	peak

➢ Spurious Emissions Above 1GHz

Frequency	Reading	Correct	Result	Limit	Margin	Polar	Detector
(MHz)	(dBuV/m)	dB	(dBuV/m)	(dBuV/m)	(dB)	H/V	
Low Channel-2402MHz							
4804	61.74	-3.59	58.15	74	-15.85	H	Peak
4804	38.06	-3.59	34.47	54	-19.53	H	AV
7206	59.93	-0.52	59.41	74	-14.59	H	Peak
7206	39.92	-0.52	39.4	54	-14.6	H	AV
4804	61.98	-3.59	58.39	74	-15.61	V	Peak
4804	41.54	-3.59	37.95	54	-16.05	V	AV
7206	59.27	-0.52	58.75	74	-15.25	V	Peak
7206	39.07	-0.52	38.55	54	-15.45	V	AV
Middle Channel-2441MHz							
4882	61.05	-3.49	57.56	74	-16.44	H	Peak
4882	41.16	-3.49	37.67	54	-16.33	H	AV
7323	60.97	-0.47	60.5	74	-13.5	H	Peak
7323	41.56	-0.47	41.09	54	-12.91	H	AV
4882	61.99	-3.49	58.5	74	-15.5	V	Peak
4882	39.9	-3.49	36.41	54	-17.59	V	AV
7323	61.1	-0.47	60.63	74	-13.37	V	Peak
7323	38.04	-0.47	37.57	54	-16.43	V	AV
High Channel-2480MHz							
4960	61.98	-3.41	58.57	74	-15.43	H	Peak
4960	38.81	-3.41	35.4	54	-18.6	H	AV
7440	58.15	-0.42	57.73	74	-16.27	H	Peak
7440	40.71	-0.42	40.29	54	-13.71	H	AV
4960	61.9	-3.41	58.49	74	-15.51	V	Peak
4960	38.42	-3.41	35.01	54	-18.99	H	AV
7440	61.31	-0.42	60.89	74	-13.11	V	Peak
7440	40.28	-0.42	39.86	54	-14.14	V	AV

Note: Testing is carried out with frequency rang 9kHz to the tenth harmonics, other than listed in the table above are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

11. Out of Band Emissions

11.1 Standard Applicable

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

11.2 Test Procedure

According to ANSI C63.10-2013 section 7.8.6, the Band-edge measurements for RF conducted emissions test method as follows.

a) Connect the EMI receiver or spectrum analyzer to the EUT using an appropriate RF cableconnected to the EUT output. Configure the spectrum analyzer settings as described in step e)(be sure to enter all losses between the unlicensed wireless device output and the spectrumanalyzer).
b) Set the EUT to the lowest frequency channel (for the hopping on test, the hopping sequenceshall include the lowest frequency channel).
c) Set the EUT to operate at maximum output power and 100% duty cycle, or equivalent “normalmode of operation” as specified in 6.10.3.
d) If using the radiated method, then use the applicable procedure(s) of 6.4, 6.5, or 6.6, and orientthe EUT and measurement antenna positions to produce the highest emission level.
e) Perform the test as follows:

1) Span: Wide enough to capture the peak level of the emission operating on the channelclosest to the band edge, as well as any modulation products that fall outside of theauthorized band of operation.
2) Reference level: As required to keep the signal from exceeding the maximuminstrument input mixer level for linear operation. In general, the peak of the spectralenvelope shall be more than [10 log (OBW/RBW)] below the reference level. Specificguidance is given in 4.1.5.2.
3) Attenuation: Auto (at least 10 dB preferred).
4) Sweep time: Coupled.
5) Resolution bandwidth: 100 kHz.
6) Video bandwidth: 300 kHz.
7) Detector: Peak.
8) Trace: Max hold.

f) Allow the trace to stabilize. For the test with the hopping function turned ON, this can takeseveral minutes to achieve a reasonable probability of intercepting any emissions due tooscillator overshoot.
g) Set the marker on the emission at the band edge, or on the highest modulation product outside ofthe band, if this level is greater than that at the band edge. Enable the marker-delta function, andthen use the marker-to-peak

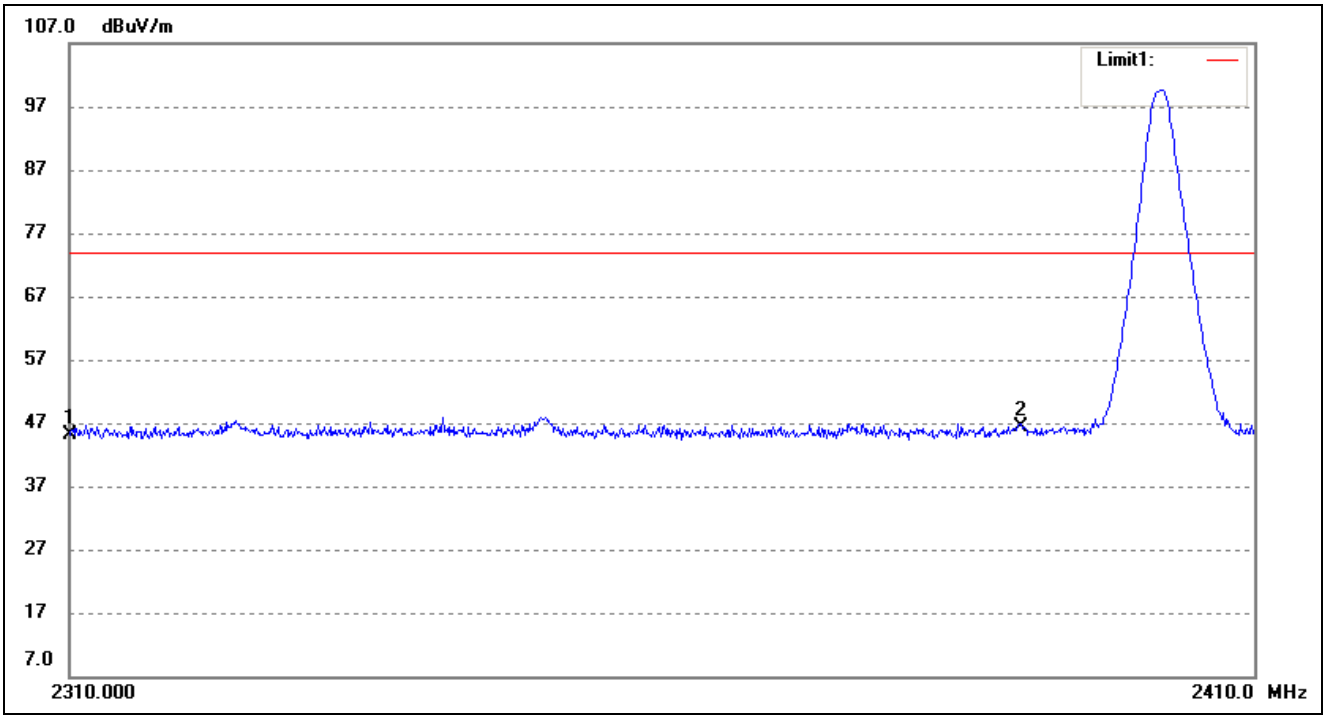
function to move the marker to the peak of the in-band emission.
h) Repeat step c) through step e) for every applicable modulation.
i) Set the EUT to the highest frequency channel (for the hopping on test, the hopping sequenceshall include the highest frequency channel) and repeat step c) through step d).
j) The band-edge measurement shall be reported by providing plot(s) of the measuring instrumentdisplay; the plot axes and the scale units per division shall be clearly labeled. Tabular data maybe reported in addition to the plot(s).

Restricted-band band-edge test method please refers to ANSI C63.10-2013 section 6.10.5. The emission must comply with the 15.209 limit for fall in the restricted bands listed in section 15.205. Note that the method of measurement KDB publication number: 913591 may be used for the radiated band-edge measurements.

According to ANSI C63.10-2013 section 7.8.8, Conducted spurious emissions shall be measured for the transmit frequency, per 5.5 and 5.6, and at themaximum transmit powers.
Connect the primary antenna port through an attenuator to the spectrum analyzer input; in the results,account for all losses between the unlicensed wireless device output and the spectrum analyzer. Theinstrument shall span 30 MHz to 10 times the operating frequency in GHz, with a resolution bandwidth of100 kHz, video bandwidth of 300 kHz, and a coupled sweep time with a peak detector. The band 30 MHzto the highest frequency may be split into smaller spans, as long as the entire spectrum is covered.

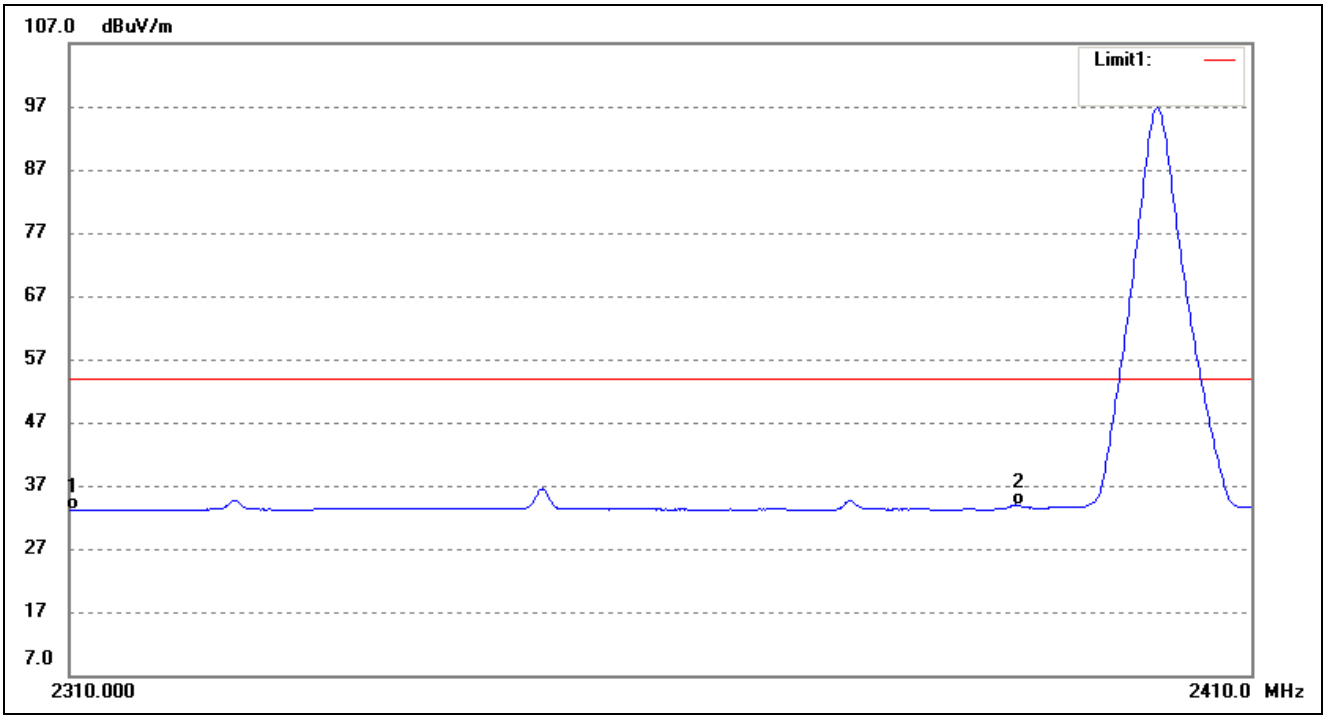
11.3Summary of Test Results/Plots

Test Channel	Low	Polarity:	Vertical (worst case)



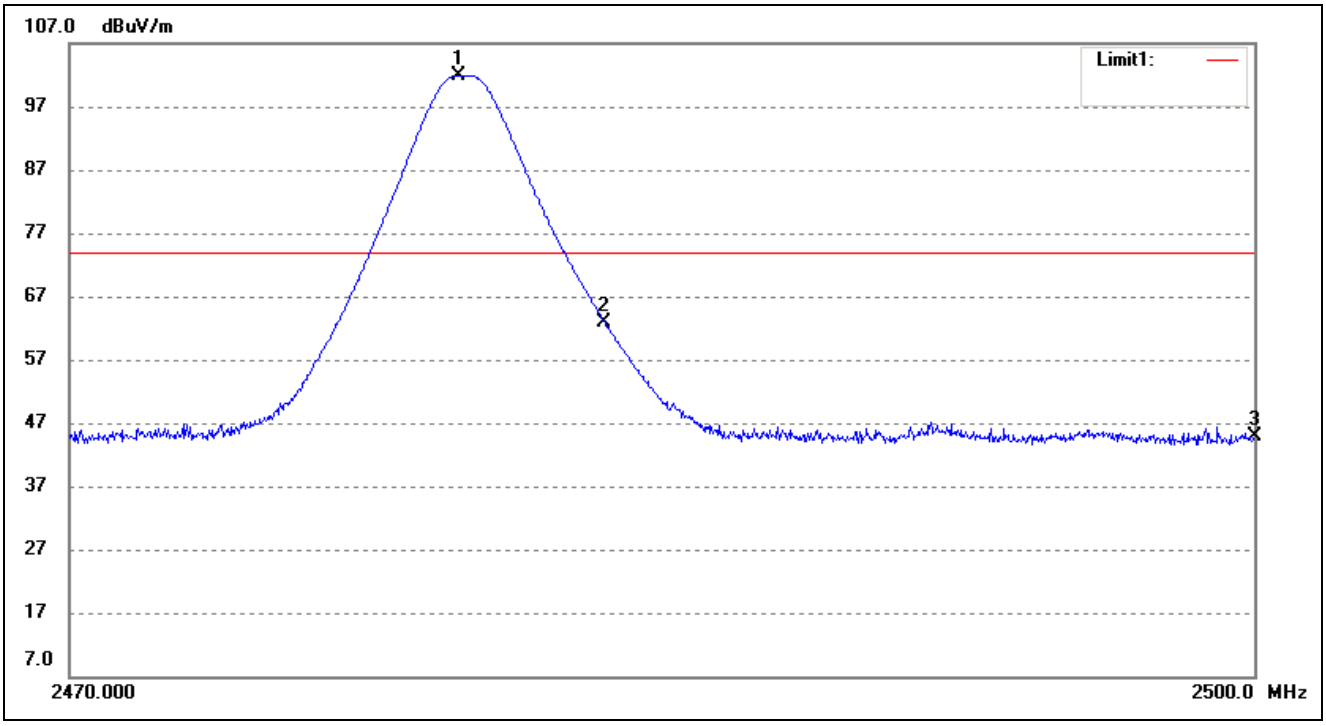
No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2310.000	52.82	-7.78	45.04	74.00	-28.96	peak
2	2390.000	53.66	-7.32	46.34	74.00	-27.66	peak
3	2402.047	106.97	-7.25	99.72	74.00	25.72	peak

Test Channel	Low	Polarity:	Vertical (worst case)



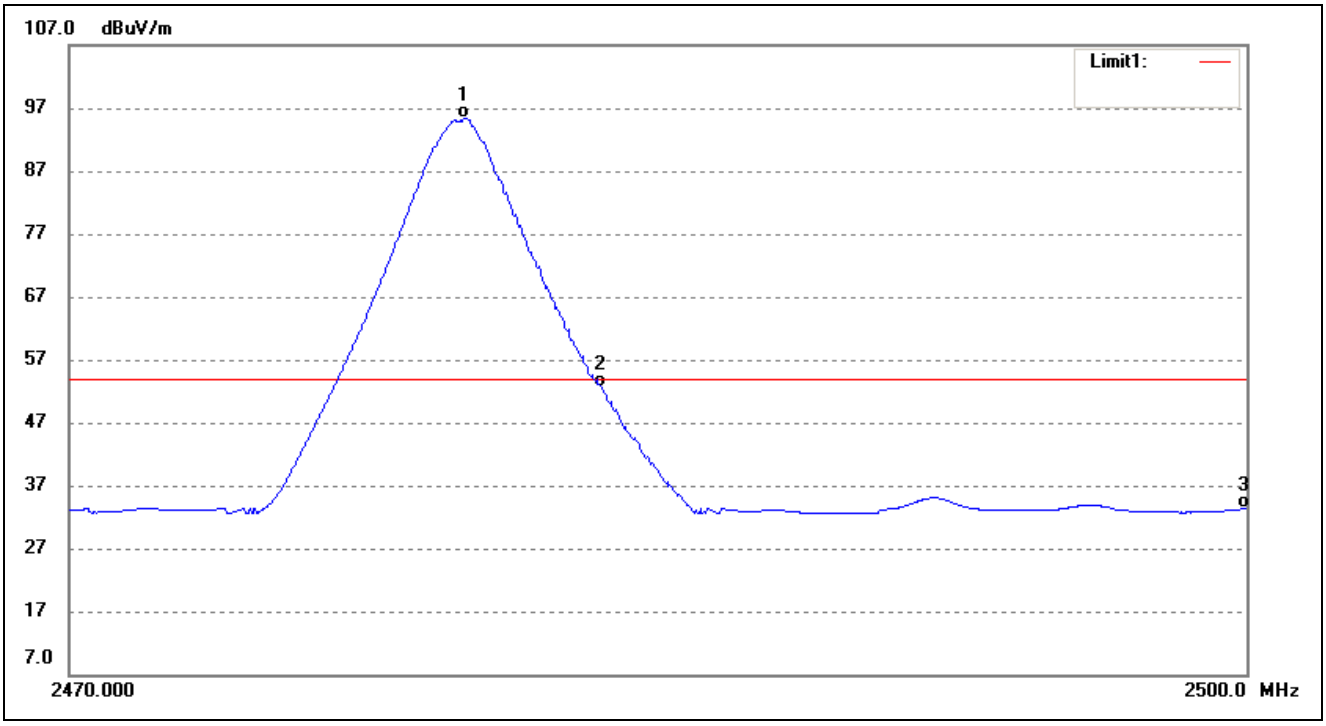
No.	Frequency (MHz)	Reading (dBuV/m)	Correct Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	2310.000	40.88	-7.78	33.10	54.00	-20.90	AVG
2	2390.000	41.17	-7.32	33.85	54.00	-20.15	AVG
3	2401.843	104.20	-7.25	96.95	54.00	42.95	AVG

Test Channel	High	Polarity:	Vertical (worst case)

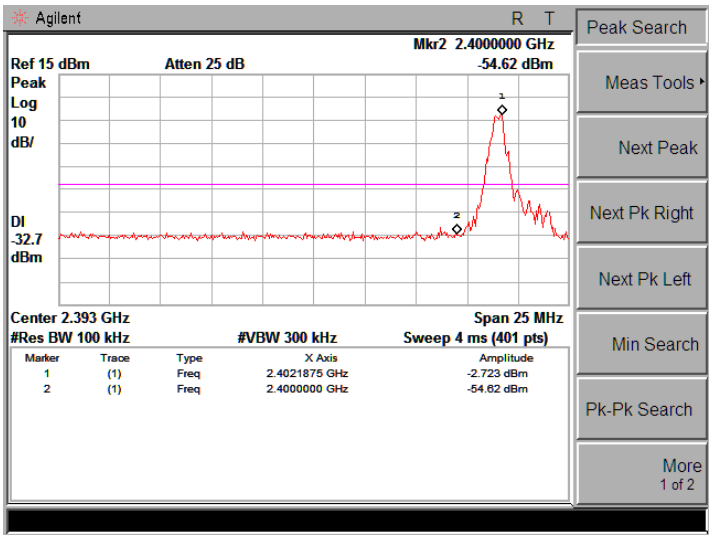
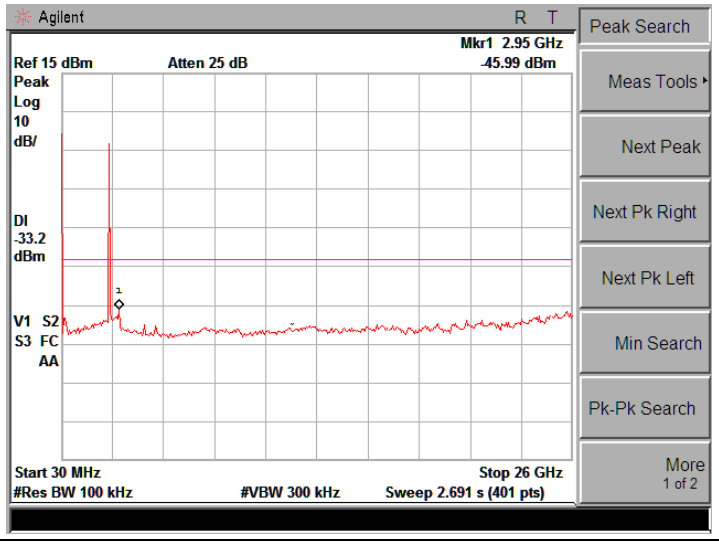
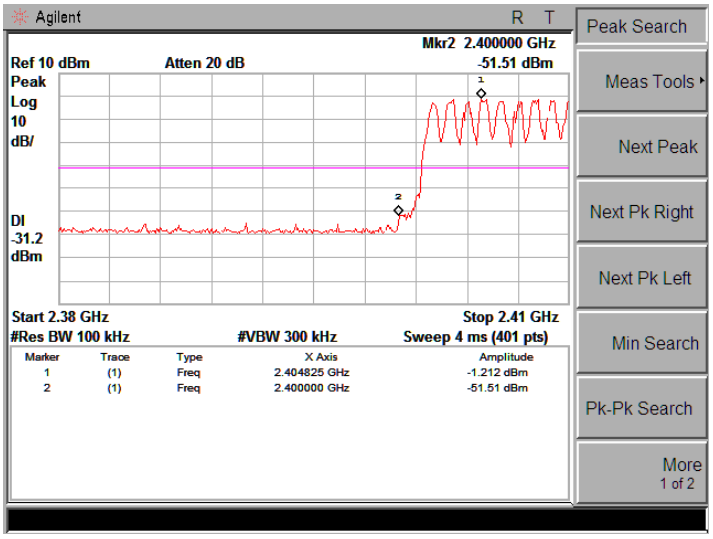


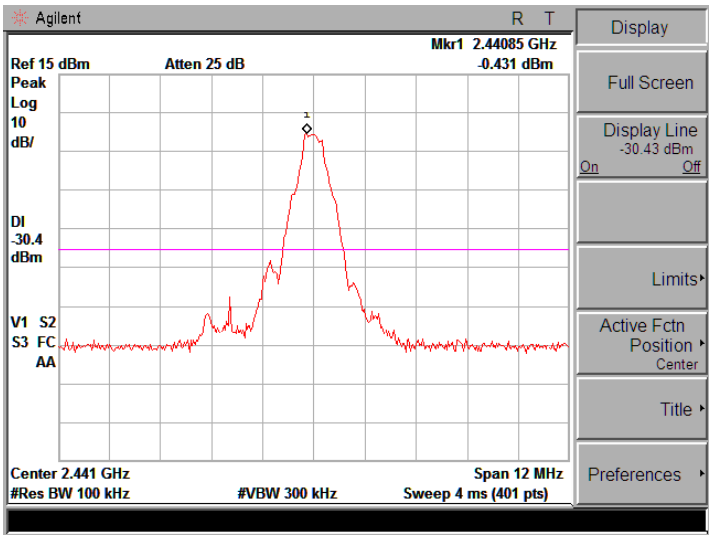
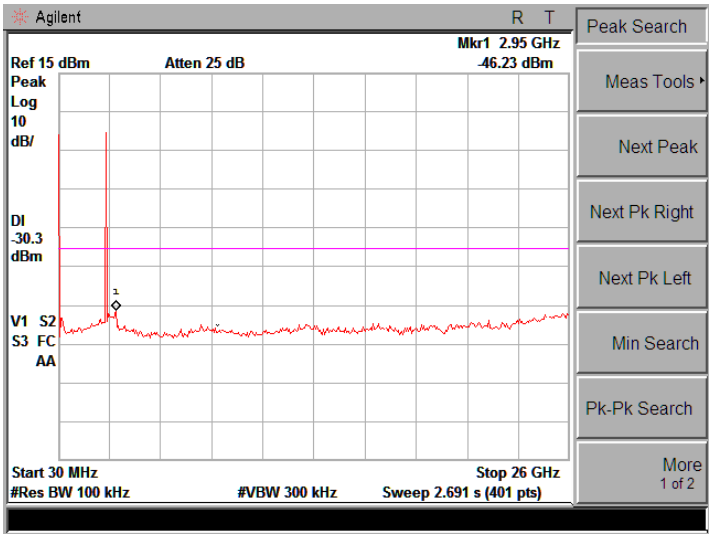
No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	Factor(dB)	(dBuV/m)	(dBuV/m)	(dB)	
1	2479.800	108.76	-6.79	101.97	74.00	27.97	peak
2	2483.500	69.68	-6.77	62.91	74.00	-11.09	peak
3	2500.000	51.60	-6.67	44.93	74.00	-29.07	peak

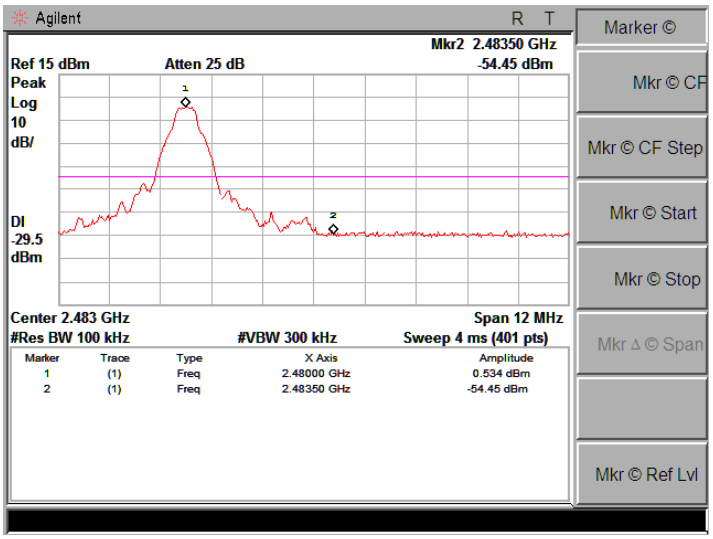
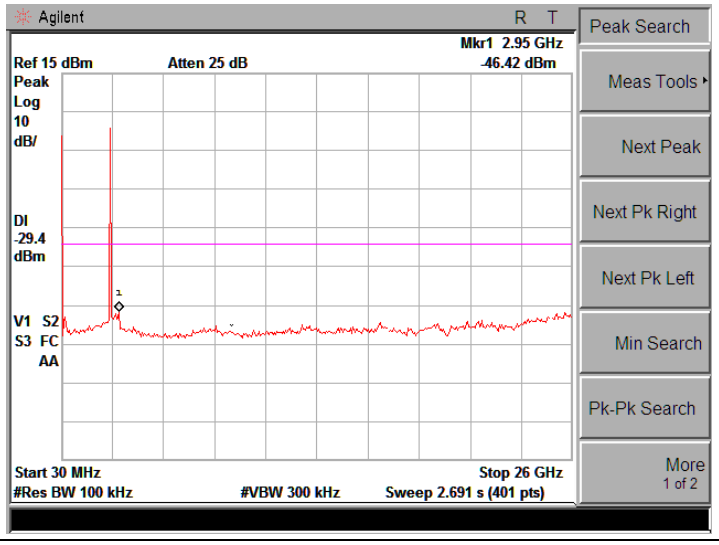
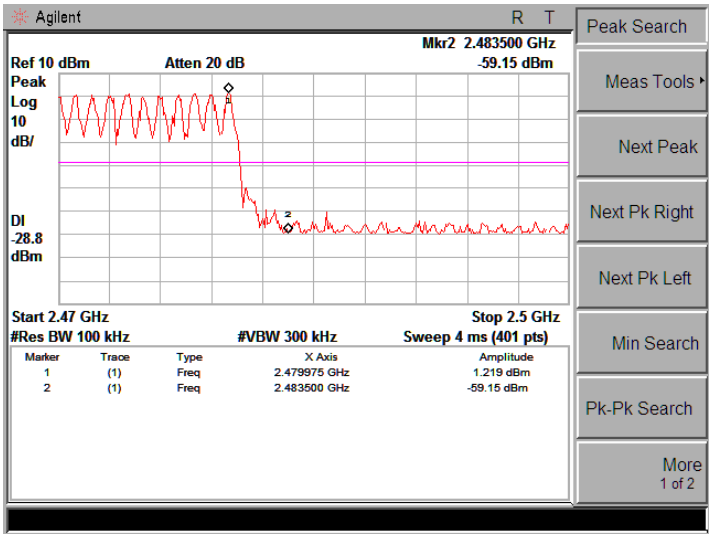
Test Channel	High	Polarity:	Vertical (worst case)



No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV/m)	Factor(dB)	(dBuV/m)	(dBuV/m)	(dB)	
1	2480.010	102.25	-6.79	95.46	54.00	41.46	AVG
2	2483.500	59.41	-6.77	52.64	54.00	-1.36	AVG
3	2500.000	39.94	-6.67	33.27	54.00	-20.73	AVG

Worst mode 1DH1	
Low channel	
	
	

Worst mode 1DH1	
Middle channel	
	

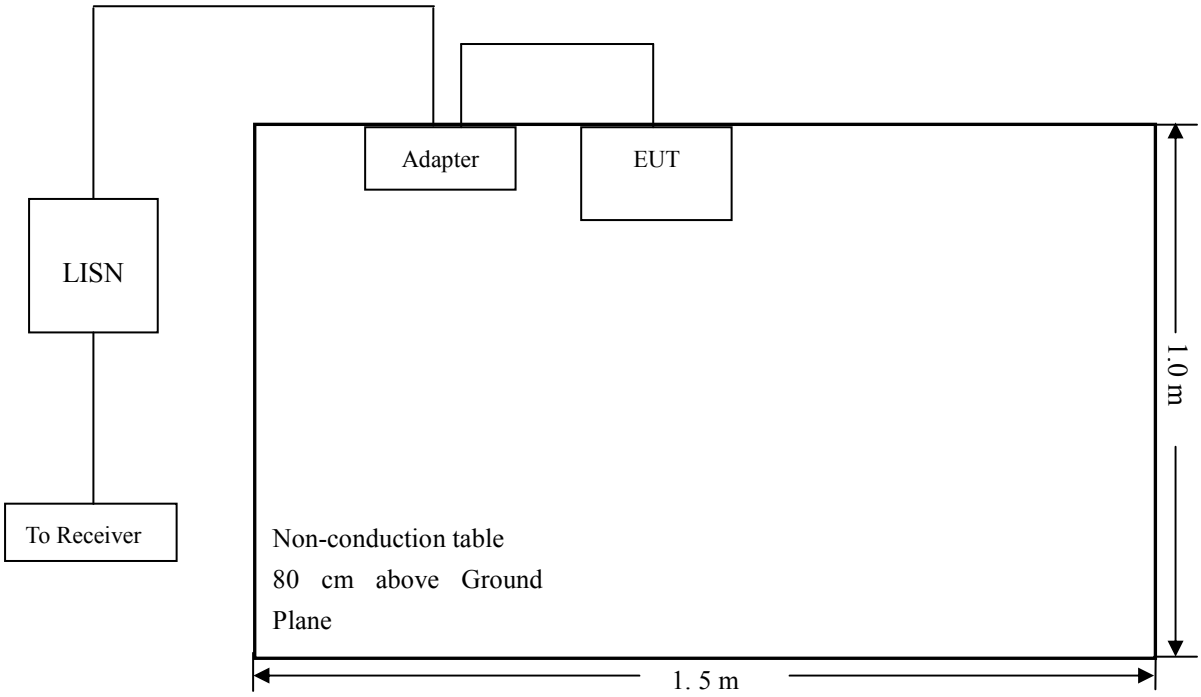
Worst mode 1DH1	
High channel	  

12. Conducted Emissions

12.1 Test Procedure

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 Limit.
The external I/O cables were draped along the test table and formed a bundle 30 to 40 cm long in the middle.
The spacing between the peripherals was 10 cm.

12.2Basic Test Setup Block Diagram



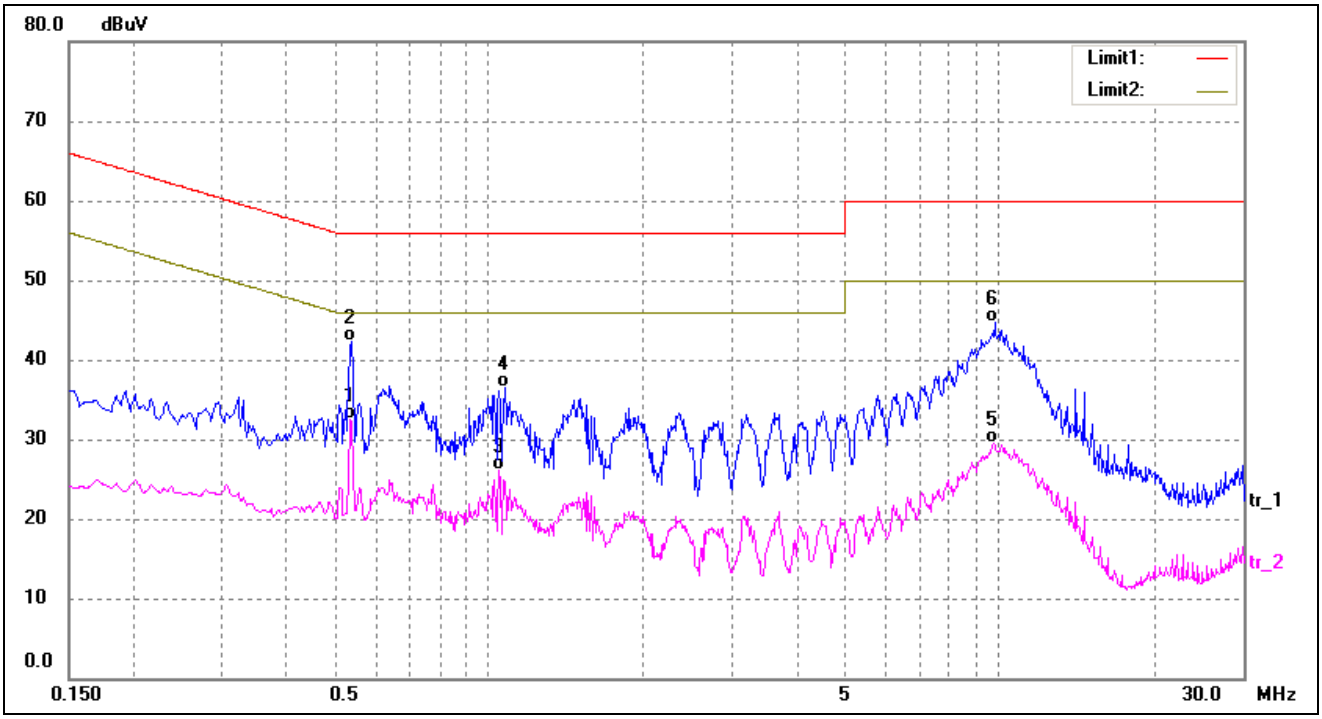
12.3Test Receiver Setup

During the conducted emission test, the test receiver was set with the following configurations:

Start Frequency ..... 150 kHz
Stop Frequency ..... 30 MHz
Sweep Speed ..... Auto
IF Bandwidth..... 10 kHz
Quasi-Peak Adapter Bandwidth ..... 9 kHz
Quasi-Peak Adapter Mode ..... Normal

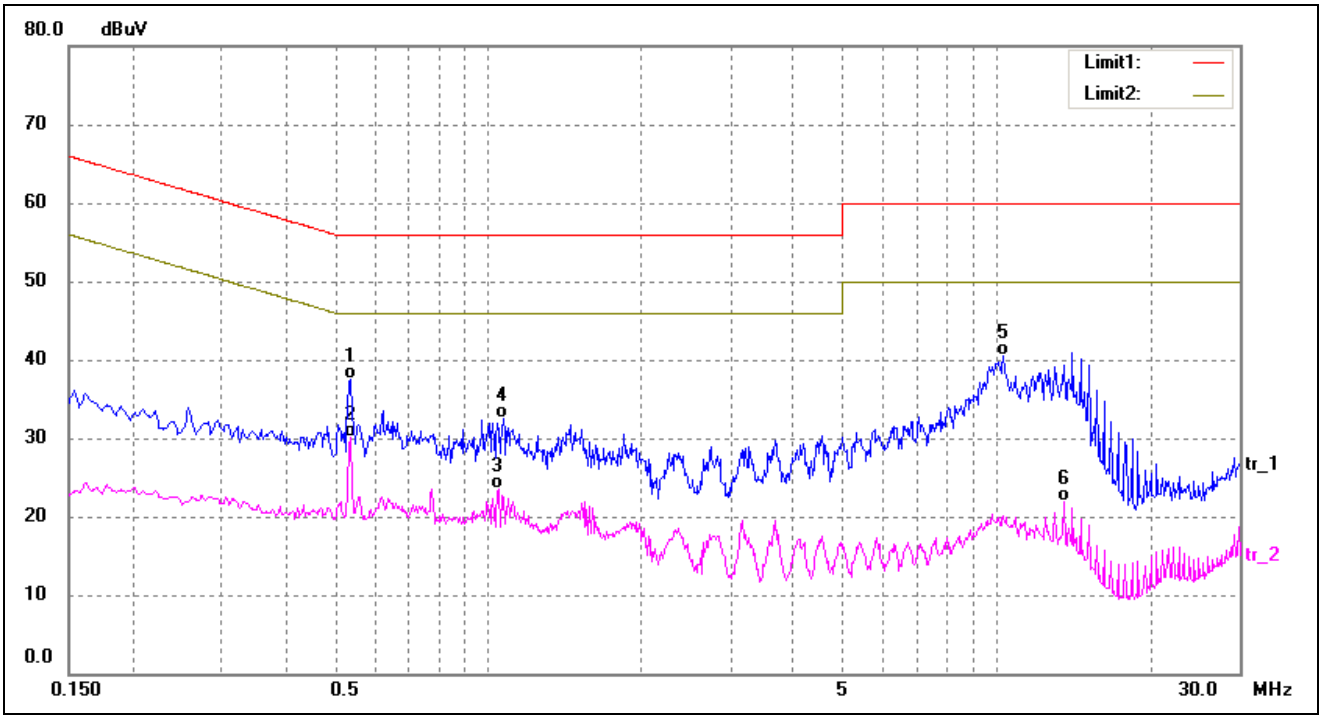
12.5 Summary of Test Results/Plots

Test Mode	Communication	AC120V 60Hz	Polarity:	Neutral



No.	Frequency	Reading	Correct	Result	Limit	Margin	Detector
	(MHz)	(dBuV)	(dB/m)	(dBuV)	(dBuV)	(dB)	
1*	0.5340	22.10	10.31	32.41	46.00	-13.59	AVG
2	0.5380	31.95	10.31	42.26	56.00	-13.74	QP
3	1.0460	15.51	10.51	26.02	46.00	-19.98	AVG
4	1.0740	26.02	10.51	36.53	56.00	-19.47	QP
5	9.7140	18.54	10.94	29.48	50.00	-20.52	AVG
6	9.7620	33.82	10.94	44.76	60.00	-15.24	QP

Test Mode	Communication	AC120V 60Hz	Polarity:	Line



No.	Frequency	Reading	Correct	Result	Limit	Margin	Detector
	(MHz)	(dBuV)	(dB/m)	(dBuV)	(dBuV)	(dB)	
1	0.5380	27.22	10.31	37.53	56.00	-18.47	QP
2*	0.5380	19.78	10.31	30.09	46.00	-15.91	AVG
3	1.0500	12.93	10.51	23.44	46.00	-22.56	AVG
4	1.0740	22.02	10.51	32.53	56.00	-23.47	QP
5	10.3060	29.61	10.96	40.57	60.00	-19.43	QP
6	13.5740	10.80	11.01	21.81	50.00	-28.19	AVG

******* END OF REPORT *******