Shenzhen CTL Testing Technology Co., Ltd.
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TEST REPORT

FCC PART 15.247 & RSS-247

Report Reference No.: **CTL1610188601-WF**

Compiled by: (position+printed name+signature)	Jacky Chen (File administrators)	Jacky Chen
Tested by: (position+printed name+signature)	Allen Wang (Test Engineer)	Allen Wang
Approved by: (position+printed name+signature)	Tracy Qi (Manager)	Tracy Qi

Product Name:	**Audio infotainment unit**
Model/Type reference:	**2DF**
List Model(s):	**N/A**
Trade Mark:	**N/A**
FCC ID:	**2ACRL2DF**
ISED Certification number:	**12339A-2DF**
Applicant's name:	**Harman Automotive Electronic Systems (Suzhou) Co., Ltd**
Address of applicant:	No125 Fangzhou Rd, Suzhou SIP, Jiangsu, China
Test Firm:	**Shenzhen CTL Testing Technology Co., Ltd.**
Address of Test Firm:	Floor 1-A, Baisha Technology Park, No.3011, Shahexi Road, Nanshan District, Shenzhen, China 518055
Test specification:	
Standard:	**FCC Part 15 Subpart C - 15.247** **RSS -247 Issue 1**
TRF Originator:	Shenzhen CTL Testing Technology Co., Ltd.
Master TRF:	Dated 2011-01
Date of Receipt:	Sep. 19, 2016
Date of Test Date:	Sep. 26, 2016–Oct. 10, 2016
Data of Issue:	Oct. 10, 2016
Result:	PASS

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TEST REPORT

Test Report No. : CTL1610188601-WF	Oct. 10, 2016 Date of issue

Equipment under Test	:	**Audio infotainment unit**
Model /Type	:	2DF
Listed Models	:	N/A
Applicant	:	**Harman Automotive Electronic Systems (Suzhou) Co., Ltd**
Address	:	No125 Fangzhou Rd, Suzhou SIP, Jiangsu, China
Manufacturer	:	**Harman Automotive Electronic Systems (Suzhou) Co., Ltd**
Address	:	No125 Fangzhou Rd, Suzhou SIP, Jiangsu, China

Test result	**Pass ***

*In the configuration tested, the EUT complied with the standards specified page 5.

The test report merely corresponds to the test sample.
It is not permitted to copy extracts of these test result without the written permission of the test laboratory.

** Modified History **

Revisions	Description	Issued Data	Report No.	Remark
Version 1.0	Initial Test Report Release	2016-10-18	CTL1610188601-WF	Tracy Qi
Version 1.1	Revised according to reviewer comments	2016-12-14	CTL1610188601-WF	Tracy Qi
Version 1.2	Revised according to reviewer comments	2016-12-19	CTL1610188601-WF	Tracy Qi

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1. SUMMARY

1.1. 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 of Procedures for Compliance Testing of Unlicensed Wireless Devices
DA 00-705: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
RSS-247 Issue 1 May 2015: Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.2. Test Conditions

Test Case	Test Conditions	
	Configuration	Description
20dB Emission Bandwidth (EBW)	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH5_Ch0,TM1_DH5_Ch39,TM1_DH5_Ch78 TM3_3DH5_Ch0,TM3_3DH5_Ch39,TM3_3DH5_Ch 78,
Carrier Frequency Separation	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH5_Hop, TM3_3DH5_Hop,
Number of Hopping Channel	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH5_Hop,TM3_3DH5_Hop,
Time of Occupancy (Dwell Time)	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH5_Ch39,TM3_3DH5_Ch39.
Maximum Peak Conducted Output Power	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH3_Ch0,TM1_DH3_Ch39,TM1_DH3_Ch78, TM2_2DH3_Ch0,TM2_2DH3_Ch39,TM2_2DH3_Ch 78,TM3_3DH3_Ch0,TM3_3DH3_Ch39,TM3_3DH3 _Ch78,
Bandedge spurious emission (Conducted)	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH3_Ch0,TM1_DH3_Ch78, TM1_DH3_Hop TM3_3DH3_Ch0,TM3_3DH3_Ch78, TM3_3DH3_Hop
Conducted RF Spurious Emission	Meas. Method	ANSI C63.10:2013
	Test Environment	NTNV
	EUT Conf.	TM1_DH5_Ch0, TM1_DH5_Ch39, TM1_DH5_Ch78, TM3_3DH5_Ch39, TM3_3DH5_Ch78.
Radiated Emissions in the Restricted Bands	Meas. Method	ANSI C63.10:2013 30 MHz to 1 GHz: Pre: RBW=100kHz; VBW=300kHz; Det. = Peak. Final: RBW=120kHz; Det. = CISPR Quasi-Peak. 1 GHz to 26.5GHz: Average: RBW=1 MHz; VBW= 10Hz; Det. = Peak; Sweep-time= Auto; Trace = Single. Peak: RBW=1 MHz; VBW= 3 MHz; Det. = Peak; Sweep-time= Auto; Trace≥ MaxHold * 100.
	Test Environment	NTNV

	EUT Conf.	30 MHz-1GHz TM1_DH5_Ch00 (Worst Conf.).
		1-18 GHz: TM1_DH5_Ch00, TM1_DH5_Ch39, TM1_DH5_Ch78, (Worst Conf.).

Remark:
1. For π/4 QPSK its same modulation type with 8-DPSK, and based exploratory test, there is no significant difference of that two types test result, so except output power, all other items final test were only performed with the worst case 8-DPSK and GFSK.

1.3. Summary of measurement results

Test Specification clause		Test case	Test Mode	Test Channel	Recorded In Report		Pass	Fail	NA	NP	Remark
§15.247 (b)(4)	RSS-247 5.4 (6)	Antenna gain	GFSK	☒ Lowest ☒ Middle ☒ Highest	GFSK	☒ Lowest ☒ Middle ☒ Highest	☒	☐	☐	☐	
§15.247(e)	RSS-247 5.2 (2)	Power spectral density	-/-	-/-	-/-	-/-	☐	☐	☒	☐	Not applicable for FHSS!
§15.247 (a)(1)	RSS-247 5.1 (2)	Carrier Frequency separation	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	☒ ☒	☐	☐	☐	complies
§15.247 (a)(1)	RSS-247 5.1 (4)	Number of Hopping channels	GFSK 8DPSK	☒ Full (Hopping)	GFSK 8DPSK	☒ Full (Hopping)	☒ ☒	☐	☐	☐	complies
§15.247 (a)(1)	RSS-247 5.1 (4)	Time of Occupancy (dwell time)	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	☒ ☒	☐	☐	☐	complies
§15.247 (a)(1)	RSS-247 5.1 (2)	Spectrum bandwidth of a FHSS system 20dB bandwidth	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	☒ ☒	☐	☐	☐	complies
§15.247 (b)(1)	RSS-247 5.4 (2)	Maximum output power	GFSK π/4DQPSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK π/4DQPSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	☒ ☒ ☒	☐	☐	☐	complies
§15.247(d)	RSS-247 5.5	Band edge compliance conducted	GFSK 8DPSK	☒ Lowest ☒ Highest ☒Hopping	GFSK 8DPSK	☒ Lowest ☒ Highest ☒Hopping	☒ ☒	☐	☐	☐	complies
§15.205	RSS-247 5.5	Band edge compliance radiated	GFSK 8DPSK	☒ Lowest ☒ Highest ☒Hopping	GFSK	☒ Lowest ☒ Highest	☒	☐	☐	☐	complies
§15.247(d)	RSS-247 5.5	TX spurious emissions conducted	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	☒ ☒	☐	☐	☐	complies
§15.247(d)	RSS-247 5.5	TX spurious emissions radiated	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK 8DPSK	☒ Lowest ☒ Middle ☒ Highest	☒	☐	☐	☐	complies
§15.109	RSS-Gen	RX spurious emissions radiated	-/-	-/-	-/-	-/-	☒	☐	☐	☐	complies
§15.209(a)	RSS-247 5.5	TX spurious Emissions radiated < 30 MHz	GFSK	-/-	GFSK	-/-	☒	☐	☐	☐	complies
§15.107(a) §15.207	RSS-Gen	Conducted Emissions < 30 MHz	GFSK	-/-	GFSK	-/-	☐	☐	☒	☐	Not applicable for powered DC battery

Remark:
1. *The measurement uncertainty is not included in the test result.*
2. *NA = Not Applicable; NP = Not Performed*
3. *We tested all test mode and recorded worst case in report*

1.4. Test Facility

1.3.1 Address of the test laboratory

Shenzhen CTL Testing Technology Co., Ltd.
Floor 1-A, Baisha Technology Park, No. 3011, Shahexi Road, Nanshan, Shenzhen 518055 China

There is one 3m semi-anechoic chamber and one line conducted labs for final test. The Test Sites meet the requirements in documents ANSI C63.4: 2014, CISPR 22/EN 55022 and CISPR16-1-4 SVSWR requirements.

1.3.2 Laboratory accreditation

The test facility is recognized, certified, or accredited by the following organizations:

IC Registration No.: 9618B

The 3m alternate test site of Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered by Certification and Engineer Bureau of Industry Canada for the performance of with Registration No.: 9618B on November 13, 2013.

FCC-Registration No.: 970318

Shenzhen CTL Testing Technology Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration 970318, December 19, 2013.

1.5. Statement of the measurement uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16 - 4 “Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements“ and is documented in the Shenzhen CTL Testing Technology Co., Ltd. quality system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for CTL laboratory is reported:

Test	Measurement Uncertainty	Notes
Transmitter power conducted	0.57 dB	(1)
Transmitter power Radiated	2.20 dB	(1)
Conducted spurious emission 9KHz-40 GHz	2.20 dB	(1)
Occupied Bandwidth	0.01ppm	(1)
Radiated Emission 30~1000MHz	4.10dB	(1)
Radiated Emission Above 1GHz	4.32dB	(1)
Conducted Disturbance0.15~30MHz	3.20dB	(1)

(1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

2. GENERAL INFORMATION

2.1. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Normal Temperature:	25°C
Relative Humidity:	55 %
Air Pressure:	101 kPa

2.2. General Description of EUT

Product Name	Audio infotainment unit
Model/Type reference	2DF
Power supply	DC 12.0V from battery
Hardware Version	PV Sample
Software Version	R10
Product Type	End Product
PMN (Product Marketing Name)	Audio infotainment unit
HVIN	2DF
FVIN	R10
Bluetooth :	
Version:	Bluetooth Core Version 2.1 + EDR
Modulation:	GFSK, π/4DQPSK, 8DPSK
Operation frequency:	2402MHz~2480MHz
Channel number:	79
Channel separation:	1MHz
Antenna type:	External antenna
Maximum antenna peak gain:	0dBi

Note: For more details, please refer to the user's manual of the EUT.

2.3. Description of Test Modes and Test Frequency

The Applicant provides communication tools software (BIOS Control) to control the EUT for staying in continuous transmitting (Duty Cycle more than 98%) and typical mode (hopping mode) for test; we choose Channel 0 / 39 / 78 as default channels.

Operation Frequency：

Channel	Frequency(MHz)	Channel	Frequency(MHz)
0	**2402**	40	2442
1	2403	41	2443
2	2404	42	2444
3	2405	43	2445
4	2406	44	2446
5	2407	45	2447
6	2408	46	2448
7	2409	47	2449
8	2410	48	2450
9	2411	49	2451
10	2412	50	2452
11	2413	51	2453
12	2414	52	2454
13	2415	53	2455
14	2416	54	2456
15	2417	55	2457
16	2418	56	2458
17	2419	57	2459
18	2420	58	2460

19	2421	59	2461
20	2422	60	2462
21	2423	61	2463
22	2424	62	2464
23	2425	63	2465
24	2426	64	2466
25	2427	65	2467
26	2428	66	2468
27	2429	67	2469
28	2430	68	2470
29	2431	69	2471
30	2432	70	2472
31	2433	71	2473
32	2434	72	2474
33	2435	73	2475
34	2436	74	2476
35	2437	75	2477
36	2438	76	2478
37	2439	77	2479
38	2440	**78**	**2480**
39	**2441**		

2.4. Equipment Used during the Test

Radiated Emission & Radiated Bandedge Emission					
Test Equipment	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Due Date
Bilog Antenna	Sunol Sciences Corp.	JB1	A061713	2016/06/02	2017/06/01
EMI Test Receiver	R&S	ESCI	103710	2016/06/02	2017/06/01
Spectrum Analyzer	Agilent	N9020A	US46220290	2016/01/17	2017/01/16
Controller	EM Electronics	Controller EM 1000	N/A	2016/05/21	2017/05/20
Horn Antenna	Sunol Sciences Corp.	DRH-118	A062013	2016/05/19	2017/05/18
Horn Antenna	Schwarzbeck	9170	816	2016/05/19	2017/05/18
Active Loop Antenna	SCHWARZBECK	FMZB1519	1519-037	2016/05/19	2017/05/18
Amplifier	Agilent	8349B	3008A02306	2016/05/19	2017/05/18
Amplifier	Agilent	8447D	2944A10176	2016/05/19	2017/05/18
EMC Test Software	R&S	ES-K1	N/A	N/A	N/A
EMC Test Software	Audix	E3	N/A	N/A	N/A
Coaxial Cables	HUBER+SUHNER	SUCOFLEX 104PEA-10M	10m	2016/06/02	2017/06/01
Coaxial Cables	HUBER+SUHNER	SUCOFLEX 104PEA-3M	3m	2016/06/02	2017/06/01
Coaxial Cables	HUBER+SUHNER	SUCOFLEX 104PEA-3M	3m	2016/06/02	2017/06/01
RF Cable	Megalon	RF-A303	N/A	2016/06/02	2017/06/01

Maximum Peak Output Power / 20dB Bandwidth / Band Edge Compliance of RF Emission / Spurious RF Conducted Emission					
Test Equipment	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Due Date
Spectrum Analyzer	Agilent	N9020A	US46220290	2016/01/17	2017/01/16
RF Cable	HUBER+SUHNER	RF-306	N/A	2016/06/02	2017/06/01

2.5. Modifications

No modifications were implemented to meet testing criteria.

3. TEST CONDITIONS AND RESULTS

3.1. Conducted Emissions Test (Not Applicable)

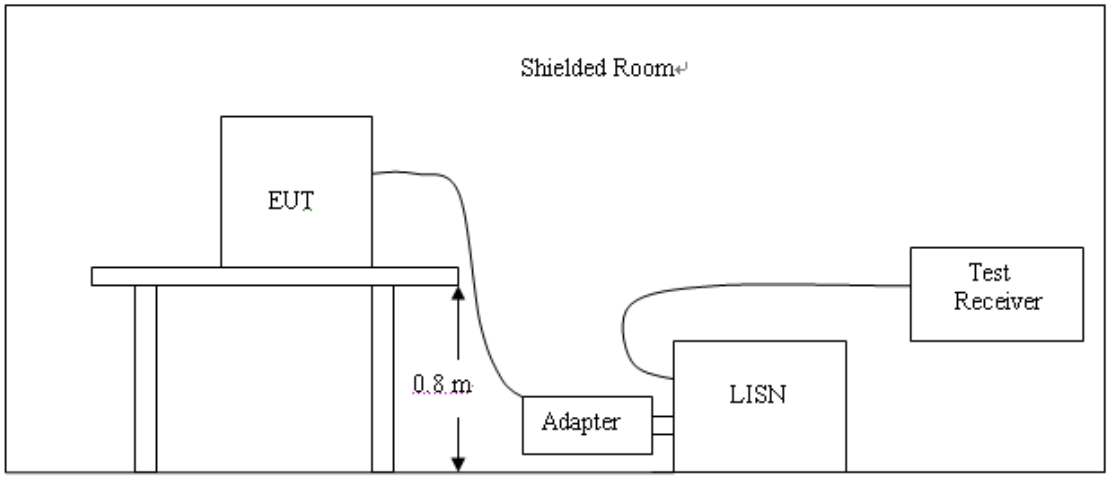
LIMIT

For intentional device, according to § 15.207(a) AC Power Conducted Emission Limits is as following：

Frequency range (MHz)	Limit (dBuV)	
	Quasi-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.

TEST CONFIGURATION



TEST PROCEDURE

1. The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system; a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10:2013.
2. Support equipment, if needed, was placed as per ANSI C63.10:2013.
3. All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10:2013.
4. The adapter received AC120V/60Hz power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.
5. All support equipment received AC power from a second LISN, if any.
6. The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
7. Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.
8. During the above scans, the emissions were maximized by cable manipulation.

TEST RESULTS

Not Applicable (The sample was powered by DC battery)

3.2. Radiated Emission

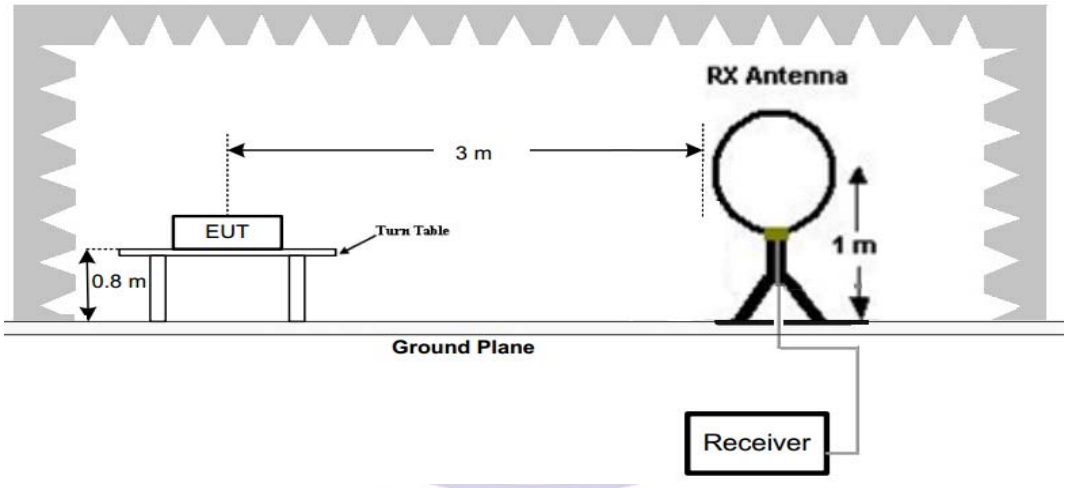
LIMIT

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission from intentional radiators at a distance of 3 meters shall not exceed the following table. According to § 15.247(d), in any 100kHz bandwidth outside the frequency band in which the EUT is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the100kHz bandwidth within the band that contains the highest level of desired power.
The pre-test have done for the EUT in three axes and found the worst emission at position shown in test setup photos.

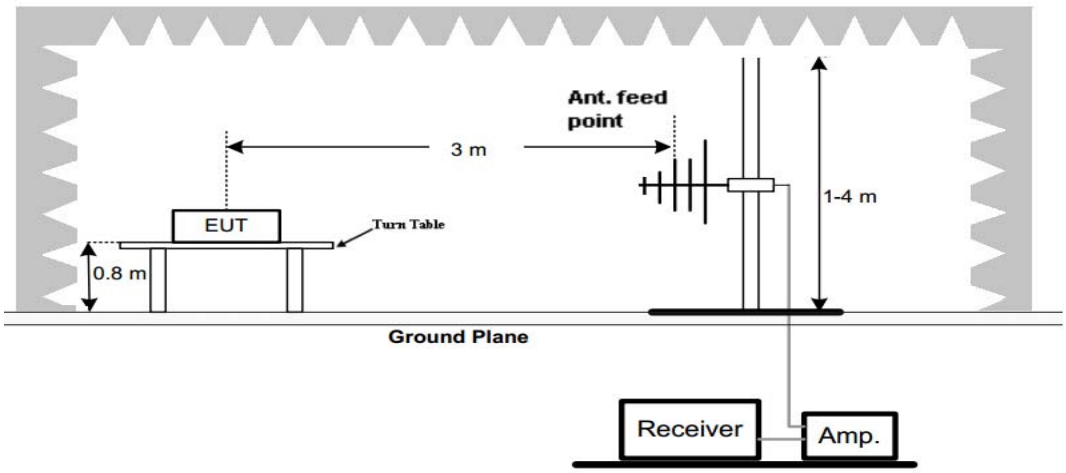
Frequency (MHz)	Distance (Meters)	Radiated (dBμV/m)	Radiated (μV/m)
0.009-0.49	300	20log(2400/F(KHz))+80	2400/F(KHz)
0.49-1.705	30	20log(24000/F(KHz))+40	24000/F(KHz)
1.705-30	30	20log(30)+40	30
30-88	3	40.0	100
88-216	3	43.5	150
216-960	3	46.0	200
Above 960	3	54.0	500

TEST CONFIGURATION

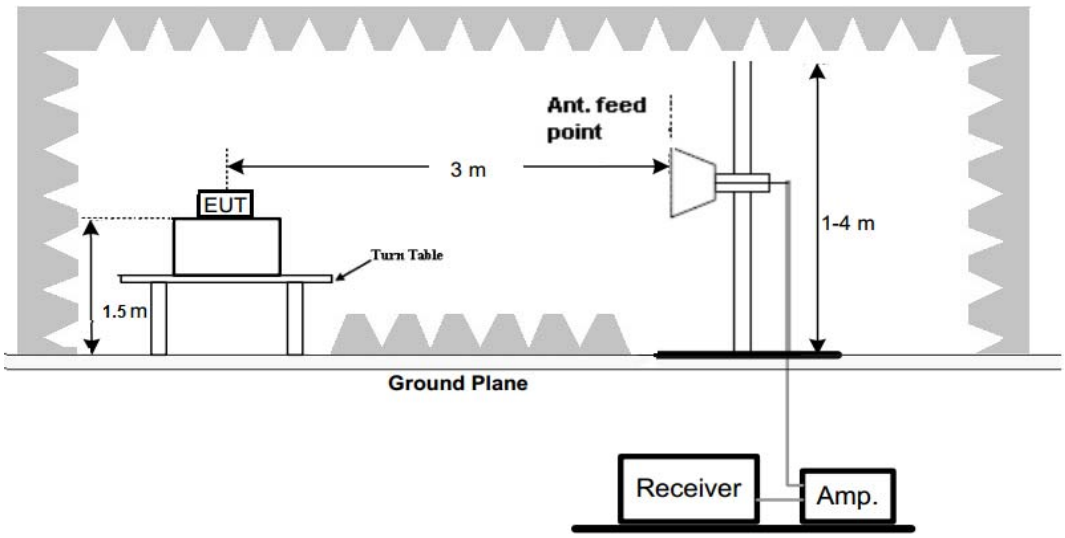
(A) Radiated Emission Test Set-Up, Frequency Below 30MHz



(B) Radiated Emission Test Set-Up, Frequency below 1000MHz



(C) Radiated Emission Test Set-Up, Frequency above 1000MHz



TEST PROCEDURE

1. The EUT was placed on a turn table which is 0.8m above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0℃ to 360℃ to acquire the highest emissions from EUT.
3. For the radiated emission test above 1GHz:
   Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane.
4. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
5. Repeat above procedures until all frequency measurements have been completed.
6. The EUT maximum operation frequency was 2480MHz.so radiated emission test frequency band from 9 KHz to 26.5GHz.
7. The distance between test antenna and EUT as following table states:

Test Frequency range	Test Antenna Type	Test Distance
9KHz-30MHz	Active Loop Antenna	3
30MHz-1GHz	Ultra-Broadband Antenna	3
1GHz-18GHz	Double Ridged Horn Antenna	3
18GHz-26.5GHz	Double Ridged Horn Antenna	1

8. Setting test receiver/spectrum as following table states:

Test Frequency range	Test Receiver/Spectrum Setting	Detector
9KHz-150KHz	RBW=200Hz/VBW=3KHz,Sweep time=Auto	QP
150KHz-30MHz	RBW=9KHz/VBW=100KHz,Sweep time=Auto	QP
30MHz-1GHz	RBW=120KHz/VBW=1000KHz,Sweep time=Auto	QP
1GHz-26.5GHz	Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto	Peak
	Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto	Peak

9. More description of radiated emission as:

a. Sequence of testing 9 kHz to 30 MHz

Setup:

---The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
---If the EUT is a tabletop system, a rotatable table with 0.8m height is used.
---If the EUT is a floor standing device, it is placed on the ground.
---Auxiliary equipment and cables were positioned to simulate normal operation conditions.
---The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
---The measurement distance is 3 meter.
---The EUT was set into operation.

Premeasurement:

---The turntable rotates from 0° to 315° using 45° steps.
---The antenna height is 0.8meter.
---At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

---Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).
---The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QPK detector.
---The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

b. Sequence of testing 30 MHz to 1 GHz

Setup:

---The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
---If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.
---If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
---Auxiliary equipment and cables were positioned to simulate normal operation conditions
---The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
---The measurement distance is 3 meter.
---The EUT was set into operation.

Premeasurement:

---The turntable rotates from 0° to 315° using 45° steps.
---The antenna is polarized vertical and horizontal.
---The antenna height changes from 1 to 3 meter.
---At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

---The final measurement will be performed with minimum the six highest peaks.
---According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter.
---The final measurement will be done with QP detector with an EMI receiver.
---The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

c. Sequence of testing 1 GHz to 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.
--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
--- Auxiliary equipment and cables were positioned to simulate normal operation conditions
--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
--- The measurement distance is 3 meter.
--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.
--- The antenna is polarized vertical and horizontal.
--- The antenna height scan range is 1 meter to 2.5 meter.
--- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.
--- Measure three axis (X, Y and Z) position of EUT.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.
--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.
--- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.
--- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

d. Sequence of testing above 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.
--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.
--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
--- Auxiliary equipment and cables were positioned to simulate normal operation conditions
--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
--- The measurement distance is 1 meter.
--- The EUT was set into operation.

Premeasurement:

--- The antenna is moved spherical over the EUT in different polarizations of the antenna.

Final measurement:

--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.
--- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CL - AG

Where FS = Field Strength	CL = Cable Attenuation Factor (Cable Loss)
RA = Reading Amplitude	AG = Amplifier Gain
AF = Antenna Factor	

For example

Frequency (MHz)	FS (dBμV/m)	RA (dBμV/m)	AF (dB)	CL (dB)	AG (dB)	Transd (dB)
300.00	40	58.1	12.2	1.6	31.90	-18.1

Transd=AF +CL-AG

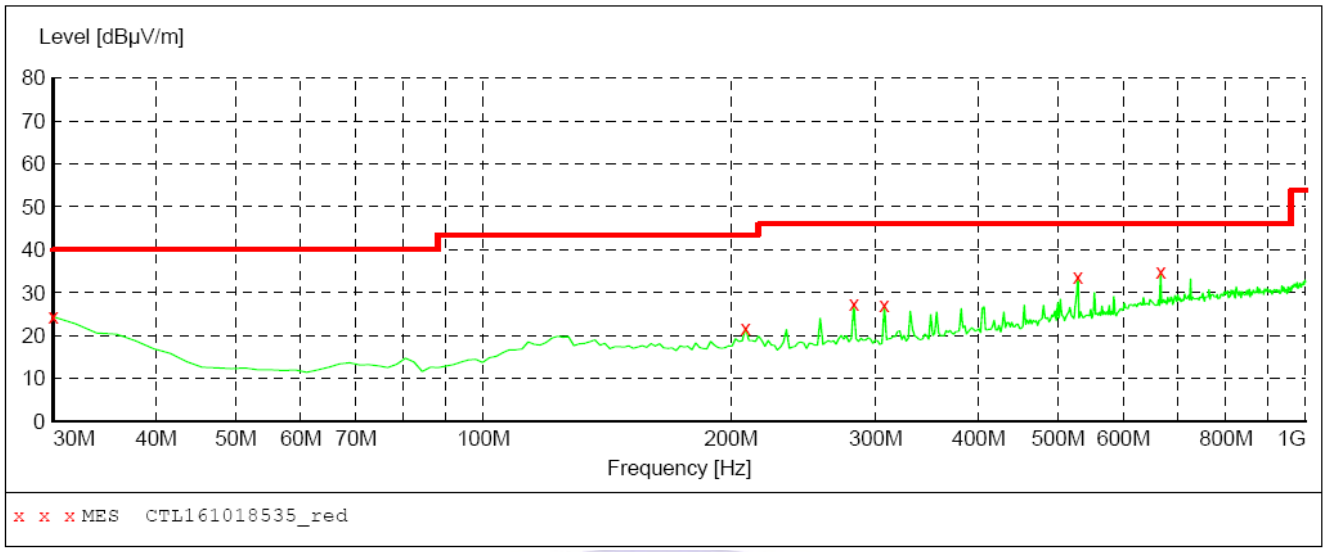
TEST RESULTS

Remark:
1. The radiated measurement are performed the each channel (low/mid/high) at all Packet type (DH1, DH3 and DH5) also for difference modulation type (GFSK, 8DPSK), recorded worst case at GFSK_DH5_Low channel (Channel 0) for below 1GHz and GFSK_DH5_Low channel (Channel 00), GFSK_DH5_Middle channel (Channel 39), GFSK_DH5_High channel (Channel 78).
2. ULTRA-BROADBAND ANTENNA for the radiation emission test below 1G.
3. HORN ANTENNA for the radiation emission test above 1G.
4. We tested radiated emission from 9 KHz to 26.5 GHz, recorded from 30 MHz to 18 GHz.
5. "---" means not recorded as emission levels lower than limit at least 20 dB.
6. Margin= Limit - Level

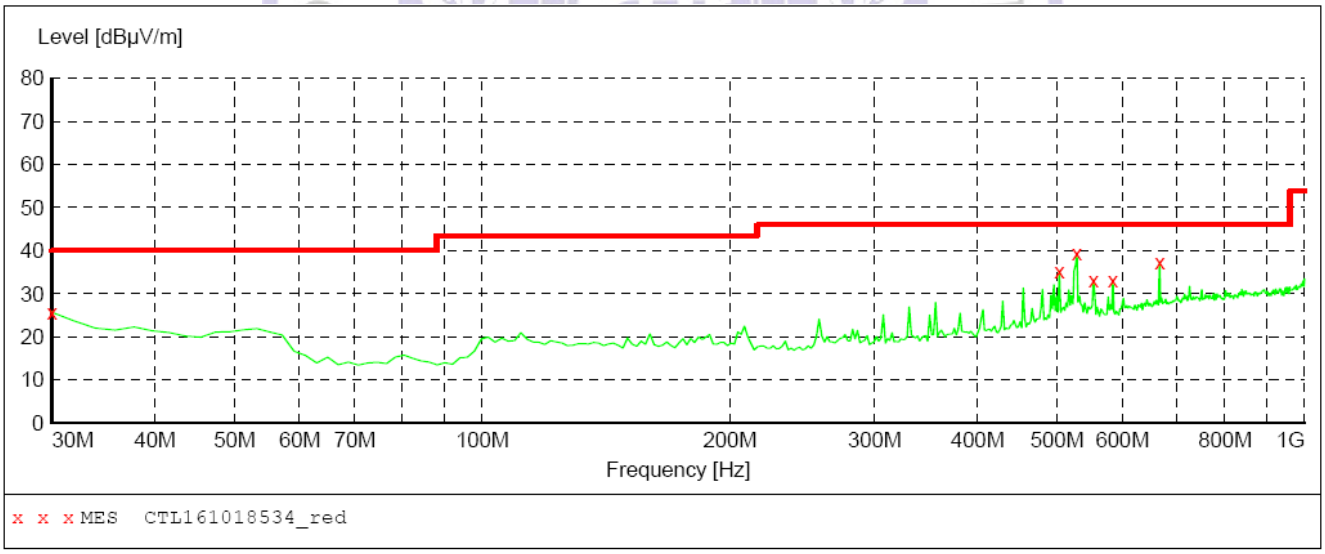
For 9 KHz to 30MHz

Frequency (MHz)	*QuasiPeak (dBμV/m)*	*Limit (dBμV/m)*	*Margin (dB)*	*Meas.Time (ms)*	*Bandwidth (kHz)*	*Pol*	*Azimuth (deg)*	*Corr. (dB)*
---	---	---	---	1000.0	0.200	H	---	---
---	---	---	---	1000.0	0.200	H	---	---

For 30MHz-1GHz



Frequency	Level	Transd	Limit	Margin	Det.	Height	Azimuth	Polarization
MHz	dBµV/m	dB	dBµV/m	dB		cm	deg	
30.000000	24.42	20.80	40.00	15.58	Peak	100.00	256.00	HORIZONTAL
208.480000	21.80	14.00	43.50	21.70	Peak	125.00	214.00	HORIZONTAL
282.200000	27.49	15.20	46.00	18.51	Peak	100.00	8.00	HORIZONTAL
307.420000	27.10	15.40	46.00	18.90	Peak	300.00	147.00	HORIZONTAL
528.580000	33.70	20.40	46.00	12.30	Peak	250.00	128.00	HORIZONTAL
666.320000	34.82	22.90	46.00	11.18	Peak	154.00	197.00	HORIZONTAL



Frequency	Level	Transd	Limit	Margin	Det.	Height	Azimuth	Polarization
MHz	dBµV/m	dB	dBµV/m	dB		cm	deg	
30.000000	25.78	20.80	40.00	14.22	Peak	108.00	238.00	VERTICAL
503.360000	35.36	20.30	46.00	10.64	Peak	124.00	144.00	VERTICAL
528.580000	39.29	20.40	46.00	6.71	Peak	100.00	241.00	VERTICAL
553.800000	33.33	21.00	46.00	12.67	Peak	150.00	36.00	VERTICAL
584.840000	33.24	21.50	46.00	12.76	Peak	100.00	349.00	VERTICAL
666.320000	37.46	22.90	46.00	8.54	Peak	122.00	129.00	VERTICAL

For 1GHz to 25GHz

Low Channel @ Channel 0 @ 2402 MHz

Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	4804.00	39.80	34.47	30.27	8.24	52.24	74.00	21.76	Peak	Horizontal
1	4804.00	28.27	34.47	30.27	8.24	40.71	54.00	13.29	AV[1]	Horizontal
2	7206.00	41.74	37.12	31.34	11.39	58.91	74.00	15.09	Peak	Horizontal
2	7206.00	27.06	37.12	31.34	11.39	44.23	54.00	9.77	AV[1]	Horizontal

Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	4804.00	37.73	34.47	30.27	8.24	50.17	74.00	23.83	Peak	Vertical
1	4804.00	26.45	34.47	30.27	8.24	38.89	54.00	15.11	AV[1]	Vertical
2	7206.00	38.25	37.12	31.34	11.39	55.42	74.00	18.58	Peak	Vertical
2	7206.00	24.16	37.12	31.34	11.39	41.33	54.00	12.67	AV[1]	Vertical

Middle Channel @ Channel 39 @ 2441 MHz

Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	4882.00	43.73	34.51	30.33	8.55	56.46	74.00	17.54	Peak	Horizontal
1	4882.00	32.85	34.51	30.33	8.55	45.58	54.00	8.42	AV[1]	Horizontal
2	7323.00	41.76	37.26	31.94	12.11	59.19	74.00	14.81	Peak	Horizontal
2	7323.00	27.48	37.26	31.94	12.11	44.91	54.00	9.09	AV[1]	Horizontal

Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	4882.00	42.28	34.51	30.33	8.55	55.01	74.00	18.99	Peak	Vertical
1	4882.00	27.66	34.51	30.33	8.55	40.39	54.00	13.61	AV[1]	Vertical
2	7323.00	40.32	37.26	31.94	12.11	57.75	74.00	16.25	Peak	Vertical
2	7323.00	24.70	37.26	31.94	12.11	42.13	54.00	11.87	AV[1]	Vertical

High Channel @ Channel 78 @ 2480 MHz

Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	4960.00	40.48	34.92	30.24	10.09	55.25	74.00	18.75	Peak	Horizontal
1	4960.00	29.20	34.92	30.24	10.09	43.97	54.00	10.03	AV[1]	Horizontal
2	7440.00	40.92	38.17	31.55	13.35	60.89	74.00	13.11	Peak	Horizontal
2	7440.00	24.99	38.17	31.55	13.35	44.96	54.00	9.04	AV[1]	Horizontal

Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	4960.00	38.97	34.92	30.24	10.09	53.74	74.00	20.26	Peak	Vertical
1	4960.00	25.11	34.92	30.24	10.09	39.88	54.00	14.12	AV[1]	Vertical
2	7440.00	38.21	38.17	31.55	13.35	58.18	74.00	15.82	Peak	Vertical
2	7440.00	22.69	38.17	31.55	13.35	42.66	54.00	11.34	AV[1]	Vertical

Remark:

1. Result Level = Read Level + Antenna Factor + Cable loss - PRM Factor.

2. The other emission levels were very low against the limit.

3. Over Limit= Limit - Emission Level.

4. The average measurement was not performed when the peak measured data under the limit of average detection.

5. Detector AV is setting spectrum/receiver. RBW=1MHz/VBW=10Hz/Sweep time=Auto/Detector=Peak;

6."---" Mean the PK detector measured value is below average limit.

3.3. Maximum Peak Output Power

LIMIT

FCC Part 15C §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.

RSS-247 Issue 1 Section 5.4 (2) - For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W and the e.i.r.p. shall not exceed 4 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W and the e.i.r.p. shall not exceed 0.5 W if the hopset uses less than 75 hopping channels (see Section 5.4(5) for exceptions).

TEST PROCEDURE

According to ANSI C63.10:2013 Output power test procedure for frequency-hopping spread-spectrum (FHSS) devices; this is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping 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 and cables.

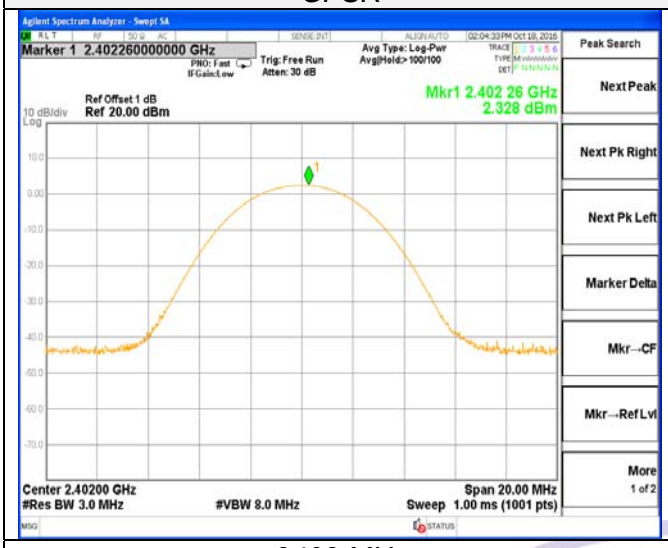
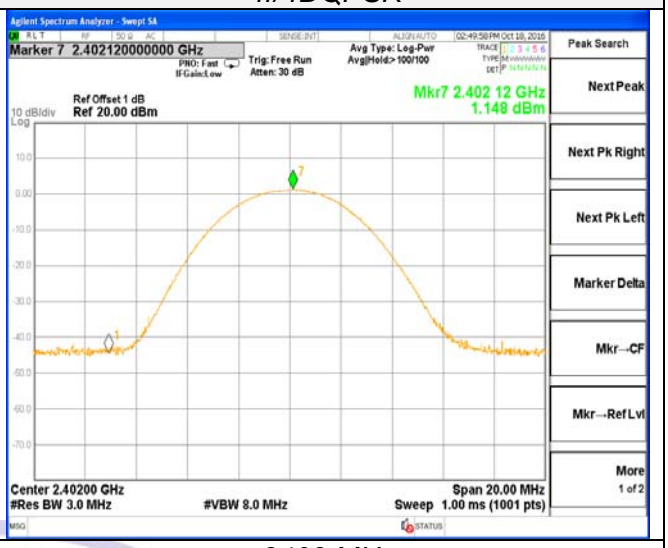
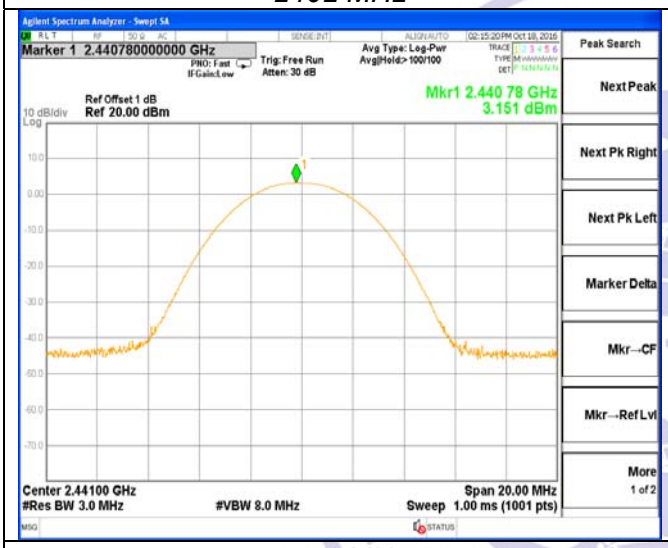
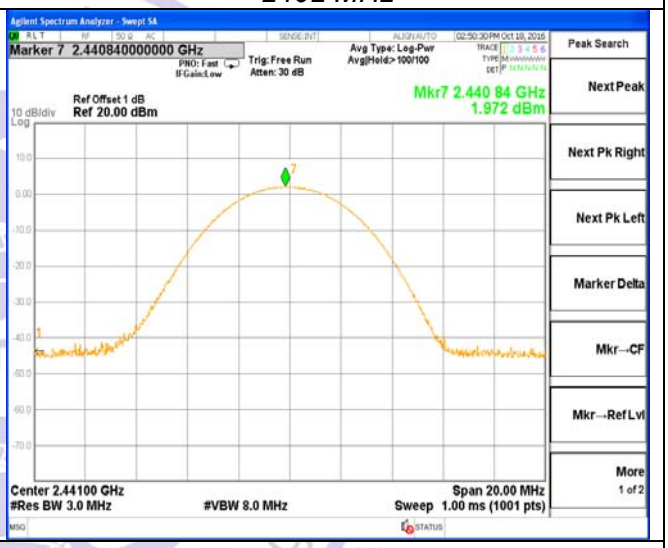
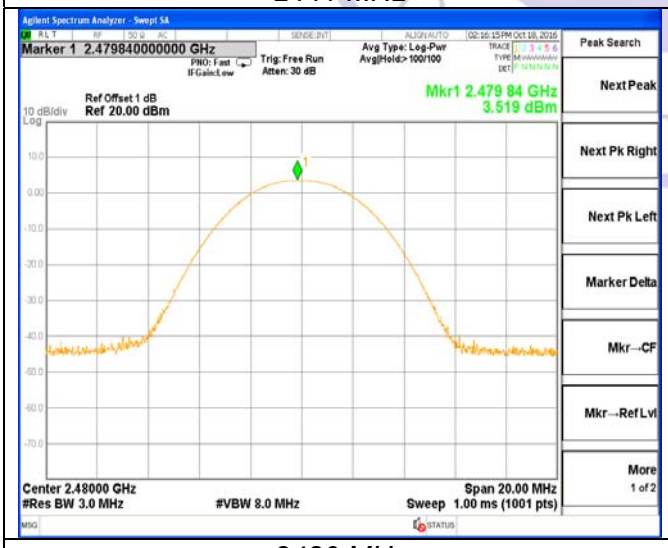
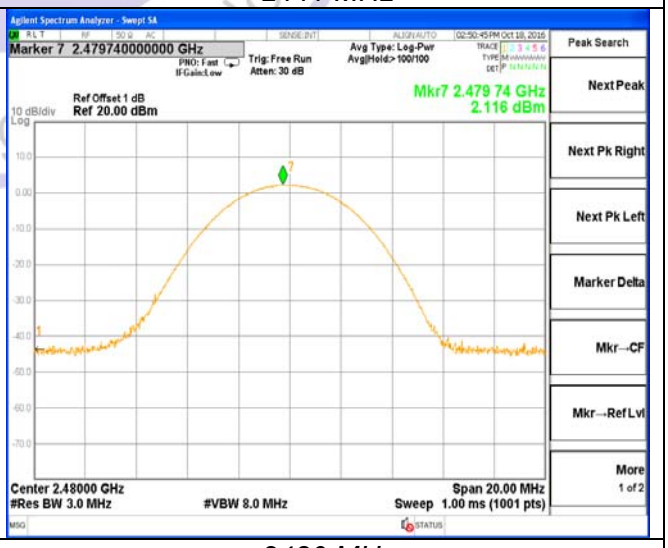
TEST CONFIGURATION

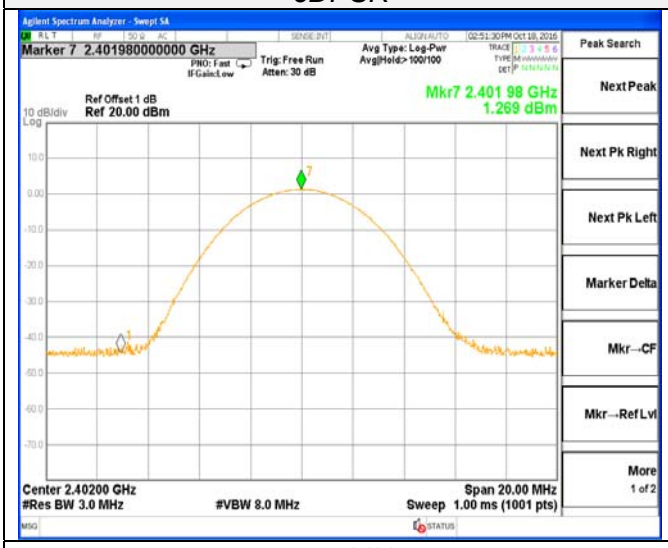
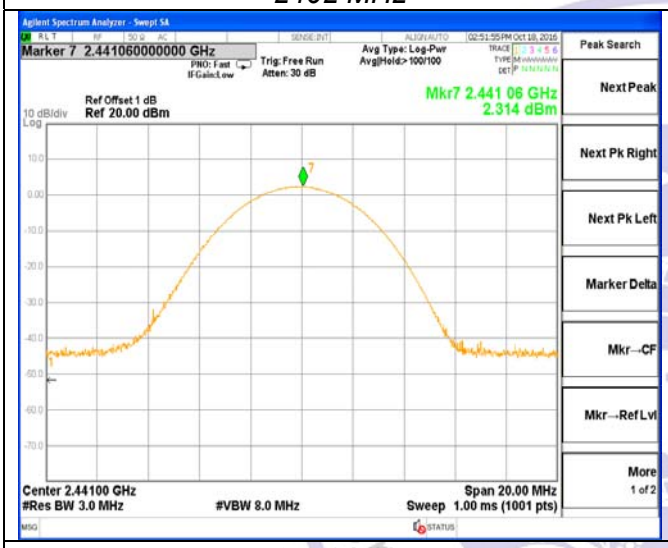
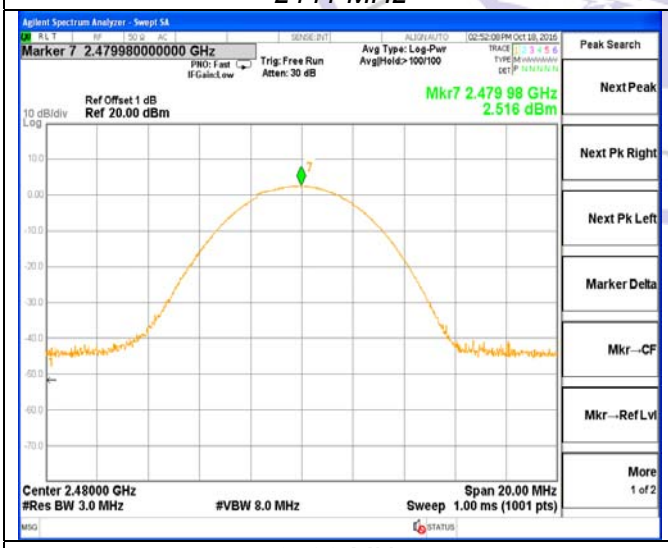
TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Measured Maximum Peak Power (dBm)	Limits (dBm)	Verdict
GFSK	0	2402	2.328	30	PASS
	39	2441	3.151		
	78	2480	3.519		
π/4DQPSK	0	2402	1.148	21	PASS
	39	2441	1.972		
	78	2480	2.116		
8DPSK	0	2402	1.269	21	PASS
	39	2441	2.314		
	78	2480	2.516		

Remark:

1. *Test results including cable loss;*
2. *Measured output power at difference Packet Type for each mode and recorded worst case for each mode.*
3. *Worst case data at DH5 for GFSK, π/4DQPSK, 8DPSK modulation type;*
4. *please refer to following plots;*

Maximum Peak Output Power	
GFSK	π/4DQPSK
	
2402 MHz	2402 MHz
	
2441 MHz	2441 MHz
	
2480 MHz	2480 MHz

Maximum Peak Output Power	
8DPSK	
	
2402 MHz	
	
2441 MHz	
	
2480 MHz	

3.4. 20dB Bandwidth

LIMIT

For frequency hopping systems operating in the 2400MHz-2483.5MHz no limit for 20dB bandwidth.

TEST PROCEDURE

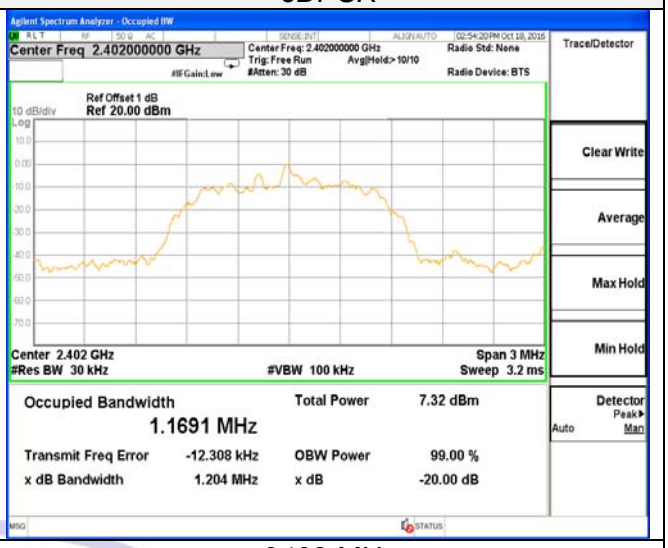
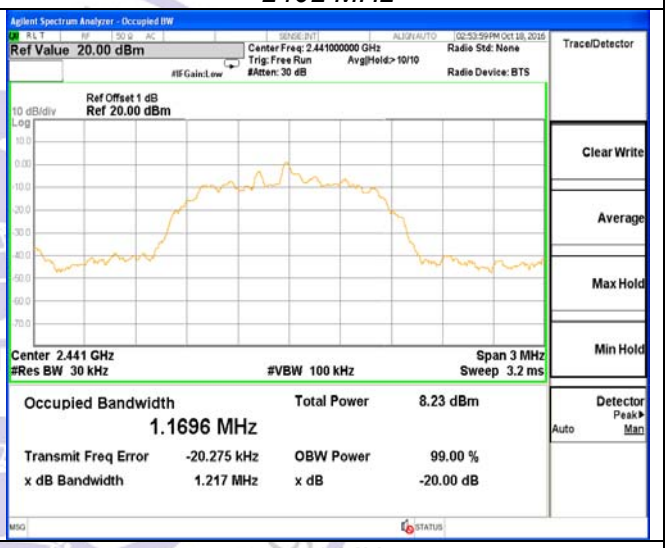
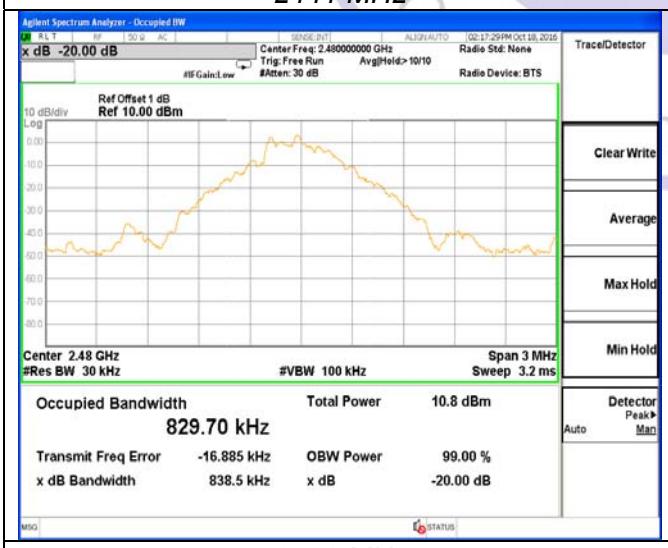
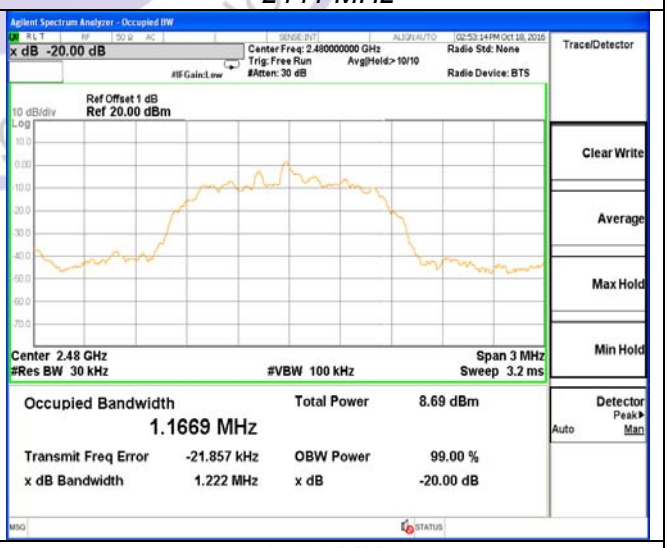
The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=30 KHz and VBW=100 KHz.
The 20dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 20dB.

TEST CONFIGURATION

TEST RESULTS

Channel	Frequency (MHz)	20dB Bandwidth (KHz)		99% Bandwidth (KHz)		Limits (KHz)	Verdict
		GFSK	8DPSK	GFSK	8DPSK		
0	2402	862.50	1204.00	837.39	1169.10	/	PASS
39	2441	861.90	1217.00	836.00	1169.60	/	PASS
78	2480	838.50	1222.00	829.70	1166.90	/	PASS

Remark:
1. Test results including cable loss;
2. Measured at difference Packet Type for each mode and recorded worst case for each mode.
3. Worst case data at DH5 for GFSK, 8DPSK modulation type;
4. Please refer to following plots;

20dB & 99% Bandwidth	
GFSK	8DPSK
	
2402 MHz	2402 MHz
	
2441 MHz	2441 MHz
	
2480 MHz	2480 MHz

3.5. Frequency Separation

LIMIT

FCC Part 15 Subpart C 5.247(a)(1) - frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25KHz or the 2/3*20dB bandwidth of the hopping channel, whichever is greater.
RSS-247 Issue 1 Section 5.1 (2) - FHSs 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, FHSs operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W. 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.

TEST PROCEDURE

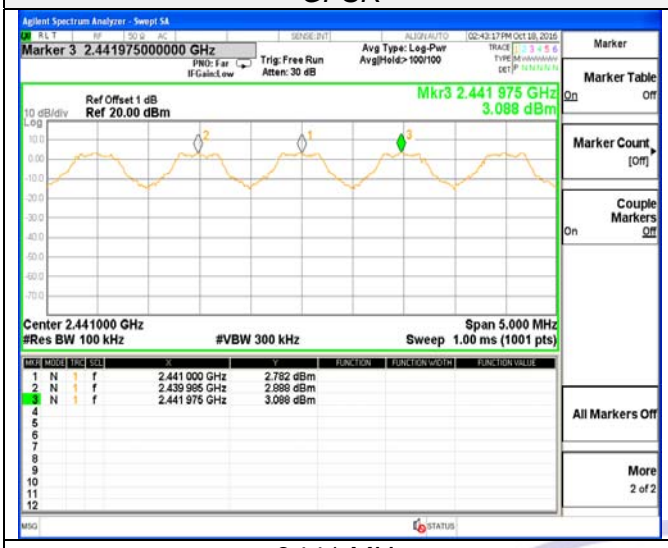
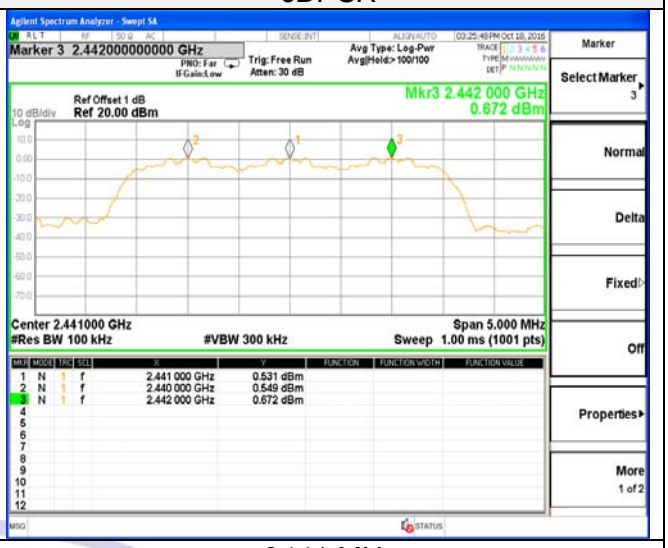
The EUT shall have its hopping function enabled. Use the following spectrum analyser settings:
a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the centre of each individual 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.

TEST CONFIGURATION

TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Frequency Separation (MHz)	Limits (MHz)	Verdict
GFSK	38	2440	0.9750	0.8625	PASS
	39	2441			
	40	2442			
8DPSK	38	2440	1.0000	0.7797	PASS
	39	2441			
	40	2442			

Remark:
1. Test results including cable loss;
2. Measured at difference Packet Type for each mode and recorded worst case for each mode.
3. Worst case data at DH5 for GFSK, 8DPSK modulation type;
4. Please refer to following plots;

Frequency Separation	
GFSK	*8DPSK*
	
2441 MHz	*2441 MHz*

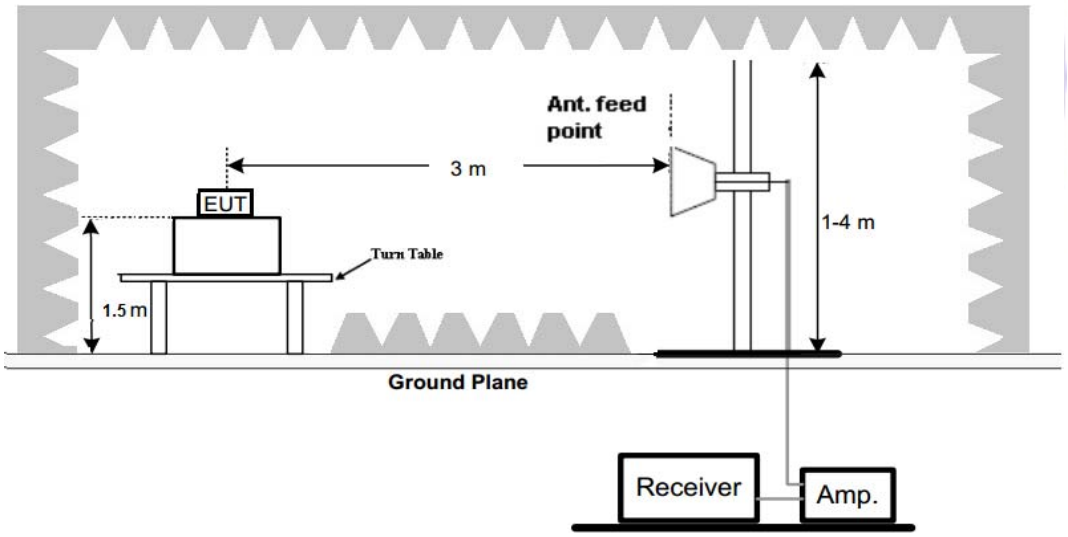
3.6. Band-edge measurements for radiated emissions

TEST REQUIREMENT

FCC Part 15.247 - In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

RSS-247 Issue 1 Section 5.5 - In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

TEST CONFIGURATION



TEST PROCEDURE

1. The EUT was placed on a turn table which is 1.5m above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0℃ to 360℃ to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed.
5. The distance between test antenna and EUT was 3 meter:
6. Setting test receiver/spectrum as following table states:

Test Frequency range	Test Receiver/Spectrum Setting	Detector
1GHz-40GHz	Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto	Peak

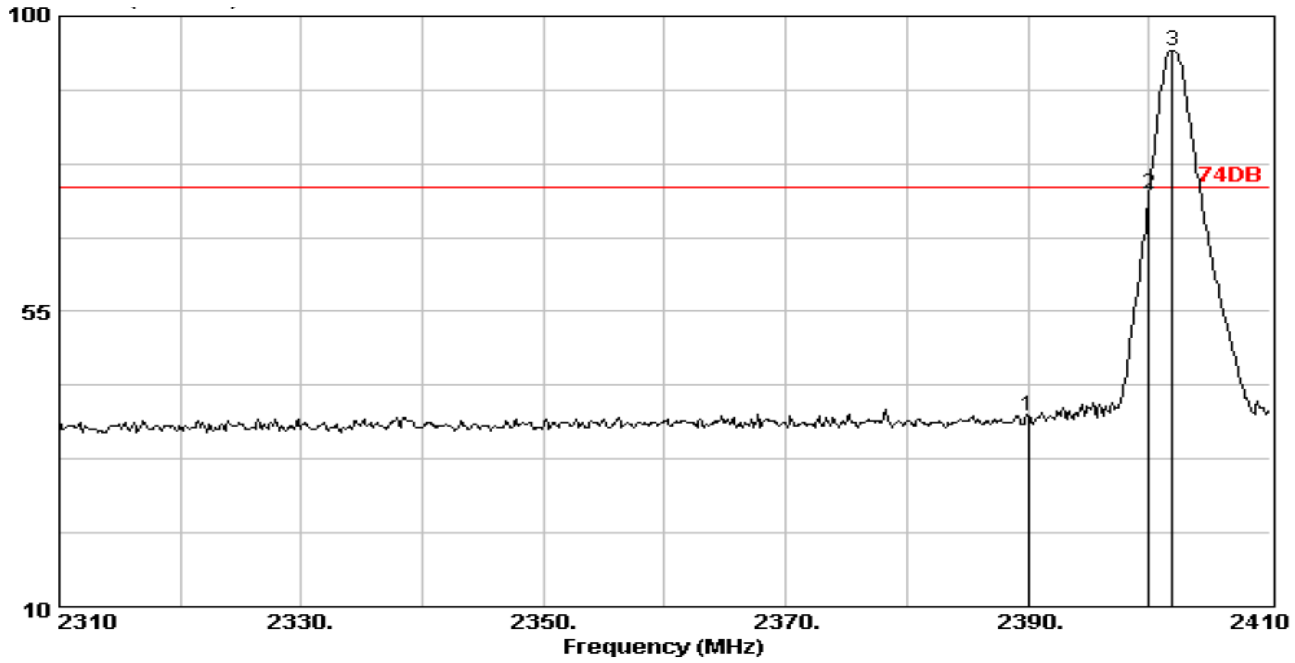
7. Measurement in peak detector for measurement plots, measured average values if frequency points peak values over average limits.

LIMIT

Below -20dB of the highest emission level in operating band.
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)
Radiated emissions which fall in the restricted bands, as defined in RSS-Gen, must also comply with the radiated emission limits specified in RSS-Gen

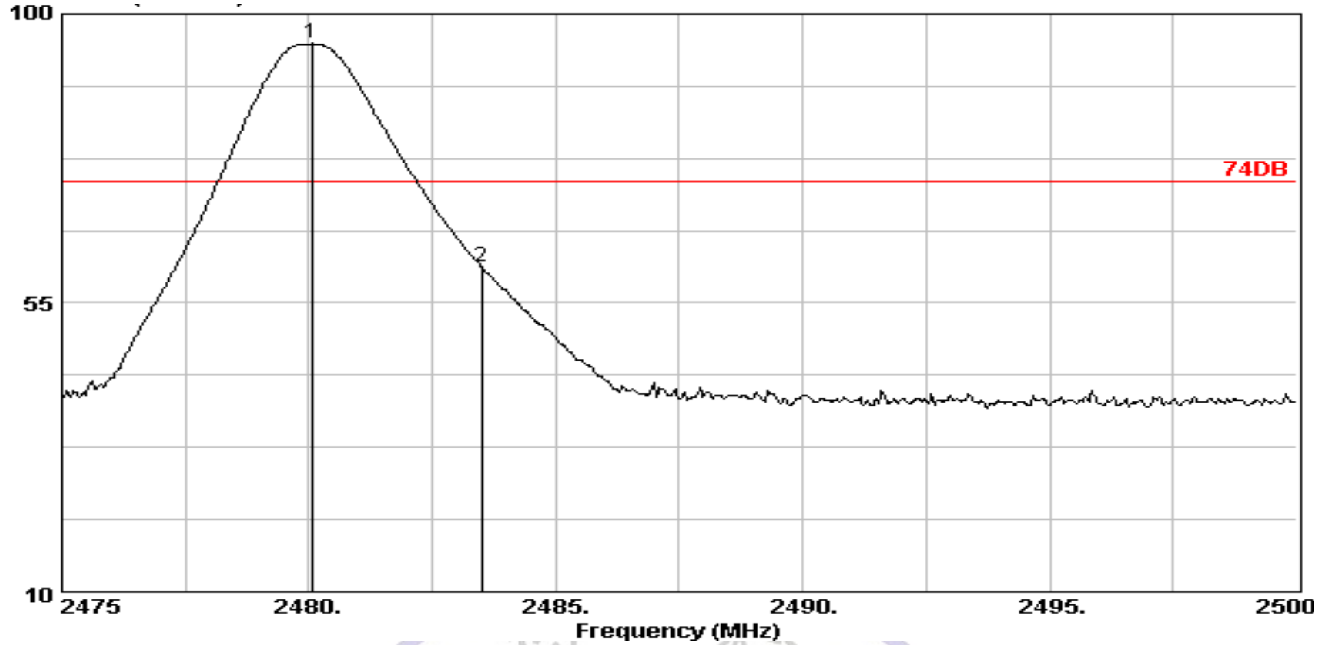
TEST RESULTS

Test mode:	2402 MHz (GFSK)	Polarization	Horizontal & Vertical



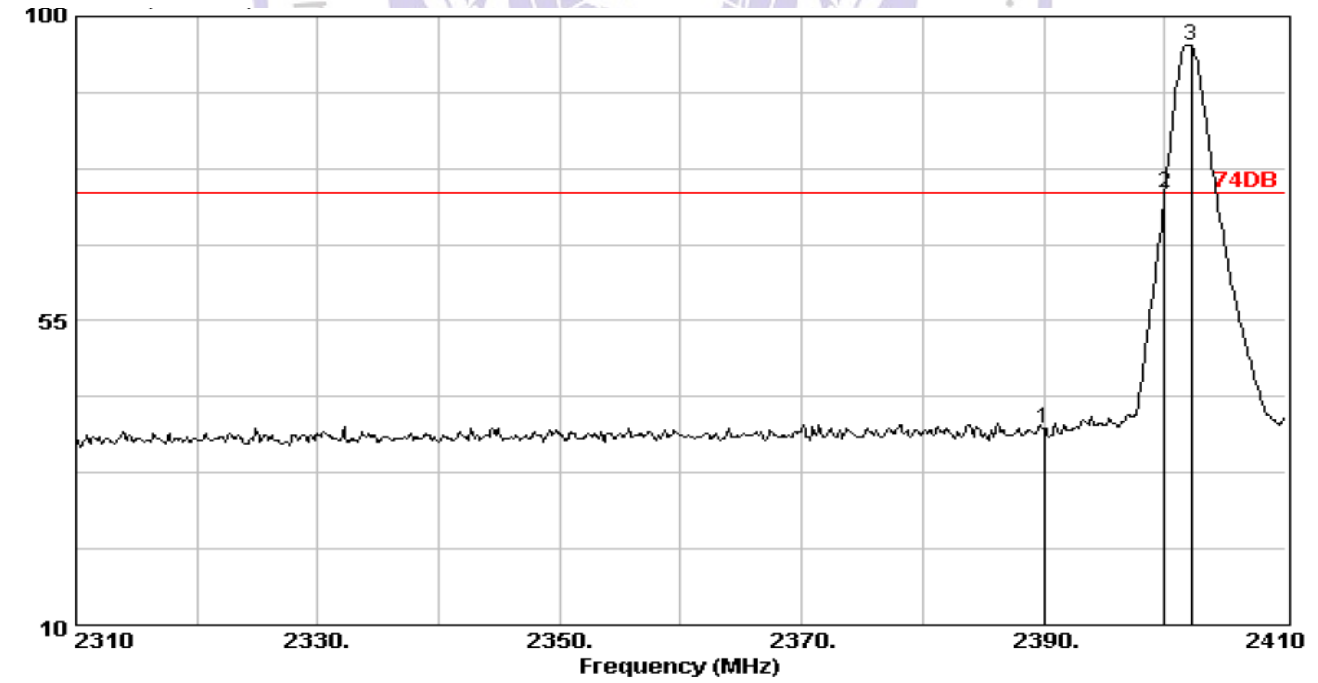
Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	2390.00	41.94	28.78	36.15	4.61	39.18	74.00	34.82	Peak	Horizontal
1	2390.00	31.40	28.78	36.15	4.61	28.64	54.00	25.36	AV[1]	Horizontal
2	2400.00	75.67	28.78	36.15	4.61	72.91	74.00	1.09	Peak	Horizontal
2	2400.00	56.40	28.78	36.15	4.61	53.64	54.00	0.36	AV[1]	Horizontal
3	2401.96*	101.54	28.78	36.15	4.61	98.78	---	---	Peak	Horizontal
3	2401.96*	89.00	28.78	36.15	4.61	86.24	---	---	AV[1]	Horizontal

Test mode:	2480 MHz (GFSK)	Polarization	Horizontal & Vertical



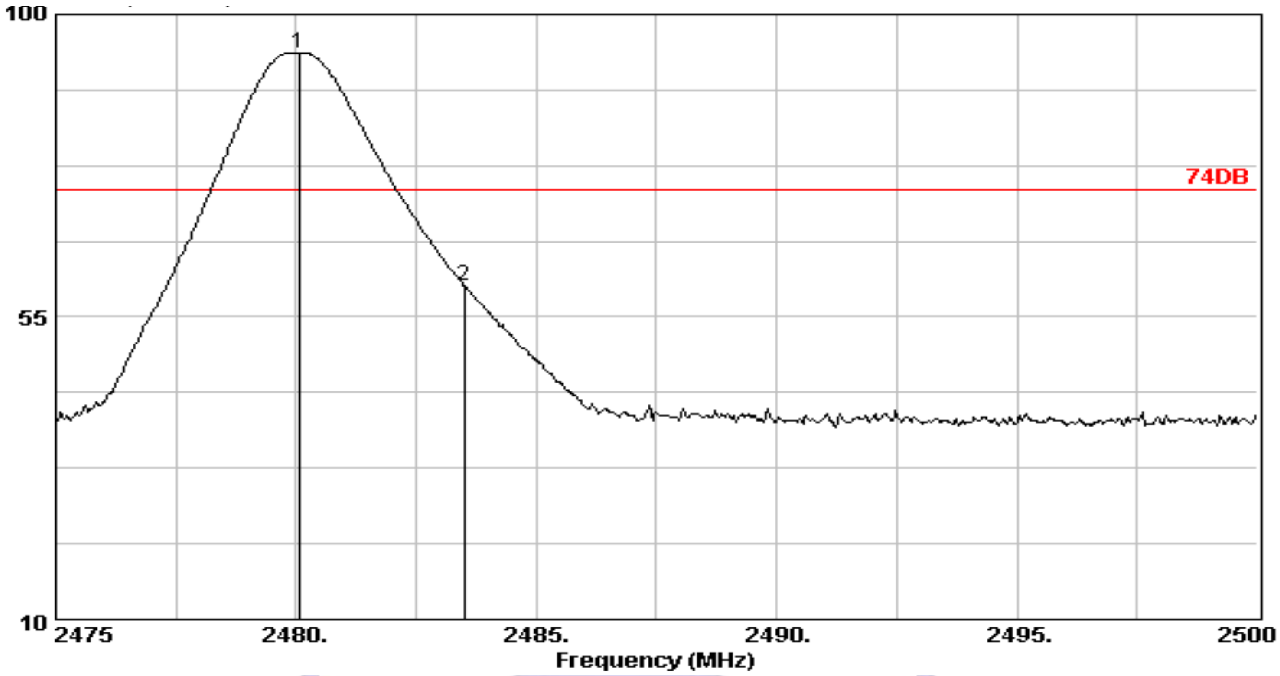
Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	2480.09	99.78	28.93	36.15	4.70	97.26	74.00	-23.26	Peak	Horizontal
1	2480.09	90.86	28.93	36.15	4.70	88.34	54.00	-34.34	AV[1]	Horizontal
2	2483.50	63.19	28.93	36.15	4.70	60.67	74.00	13.33	Peak	Horizontal
2	2483.50	50.70	28.93	36.15	4.70	48.18	54.00	5.82	AV[1]	Horizontal

Test mode:	2402 MHz (8-DPSK)	Polarization	Horizontal & Vertical



Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	2390.00	41.95	28.78	36.15	4.61	39.19	74.00	34.81	Peak	Horizontal
1	2390.00	31.13	28.78	36.15	4.61	28.37	54.00	25.63	AV[1]	Horizontal
2	2400.00	76.58	28.78	36.15	4.61	73.82	74.00	0.18	Peak	Horizontal
2	2400.00	56.71	28.78	36.15	4.61	53.95	54.00	0.05	AV[1]	Horizontal
3	2401.96*	99.43	28.78	36.15	4.61	96.67	---	---	Peak	Horizontal
3	2401.96*	89.90	28.78	36.15	4.61	87.14	---	---	AV[1]	Horizontal

Test mode:	2480 MHz (8-DPSK)	Polarization	Horizontal & Vertical



Item (Mark)	Frequency (MHz)	Read Level (dBμV)	Antenna Factor (dB/m)	PRM Factor dB	Cable Loss (dB)	Result Level (dBμV/m)	Limit Line (dBμV/m)	Margin (dB)	Detector	Polarization
1	2480.02	99.69	28.93	36.15	4.70	97.17	74.00	-23.17	Peak	Horizontal
1	2480.02	91.48	28.93	36.15	4.70	88.96	54.00	-34.96	AV[1]	Horizontal
2	2483.50	63.81	28.93	36.15	4.70	61.29	74.00	12.71	Peak	Horizontal
2	2483.50	54.76	28.93	36.15	4.70	52.24	54.00	1.76	AV[1]	Horizontal

Remark:

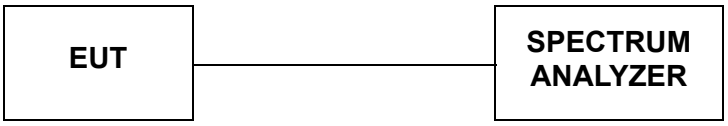
1. Measured at difference Packet Type for each mode and recorded worst case for each mode.
2. Worst case data at DH5 for GFSK, 8DPSK modulation type;
3. Measured at Hopping and no-Hopping mode, recorded worst at no-Hopping mode.
4. Result Level = Read Level + Antenna Factor + Cable loss - PRM Factor.
5. The other emission levels were very low against the limit.
6. Margin = Limit - Emission Level.
7. "" means fundamental frequency, No emission limit required;*
8. The average measurement was not performed when the peak measured data under the limit of average detection.
9. Detector AV is setting spectrum/receiver.
RBW=1MHz/VBW=10Hz/Sweep time=Auto/Detector=Peak;

3.7. Band-edge measurements for conducted emissions

LIMIT

1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.
3. Fall in the restricted bands listed in section RSS-Gen. The maximum permitted average field strength is listed in section RSS-Gen.

TEST CONFIGURATION



TEST PROCEDURE

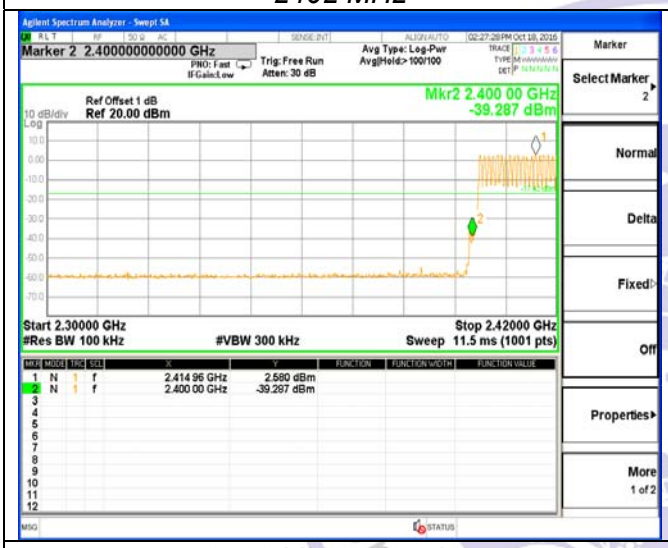
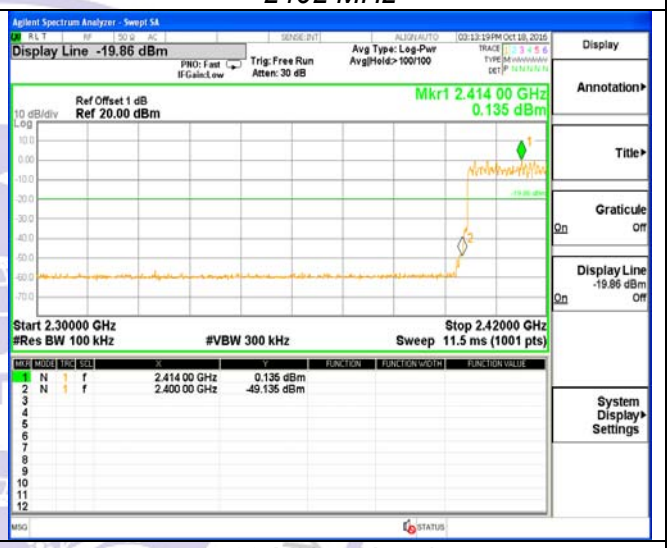
According to ANSI C63.10:2013 for Antenna-port conducted measurement.

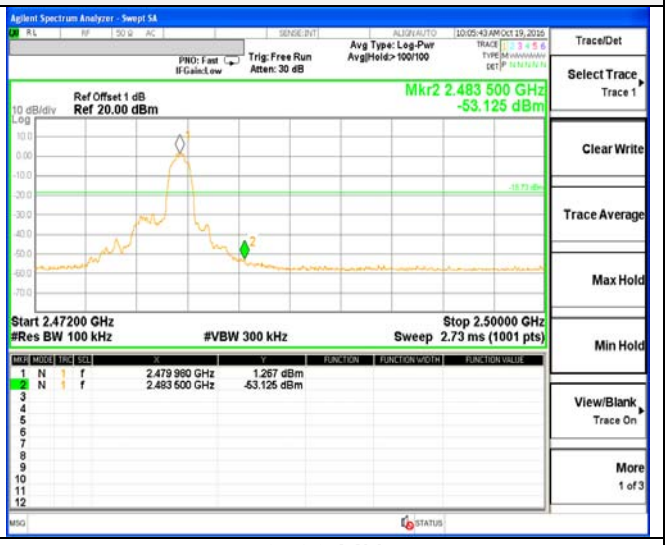
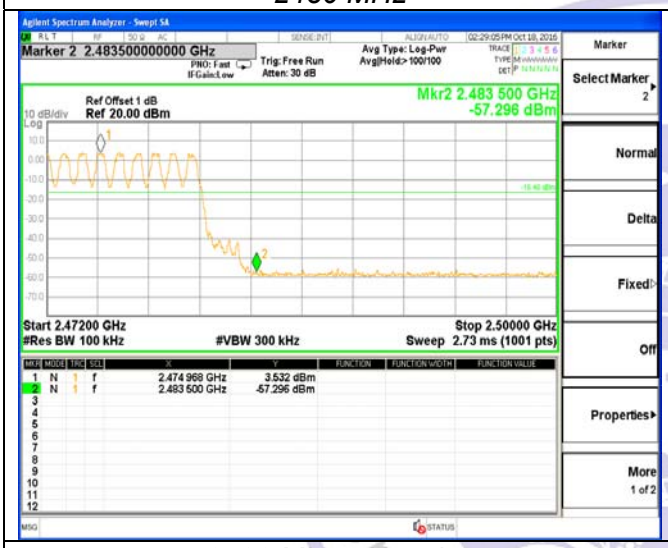
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge,
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency.

TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Conducted Band-edge Emission (dBc)	Limits (dBc)	Verdict
GFSK	0	2402	<-20dBc	-20	PASS
	78	2480	<-20dBc	-20	
	Hopping	Full	<-20dBc	-20	
8DPSK	0	2402	<-20dBc	-20	PASS
	78	2480	<-20dBc	-20	
	Hopping	Full	<-20dBc	-20	

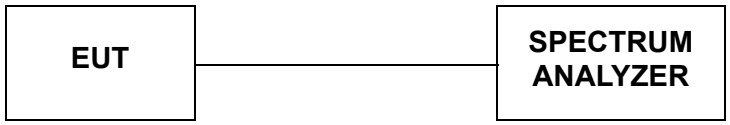
Remark:
1. Test results including cable loss;
2. Measured at difference Packet Type for each mode and recorded worst case for each mode.
3. Worst case data at DH5 for GFSK, 8DPSK modulation type;
4. *Please refer to following plots;*

Band-edge measurements for RF conducted emissions	
GFSK	*8DPSK*
	
2402 MHz	*2402 MHz*
	
2402 MHz - Hopping	*2402 MHz - Hopping*

Band-edge measurements for RF conducted emissions	
GFSK	*8DPSK*
	
2480 MHz	*2480 MHz*
	
2480 MHz - Hopping	*2480 MHz - Hopping*

3.8. Number of hopping frequency

TEST CONFIGURATION



TEST PROCEDURE

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
a) Span: The frequency band of operation. Depending on the number of channels the device supports, 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 channel spacing or the 20 dB bandwidth;
c) VBW ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

LIMIT

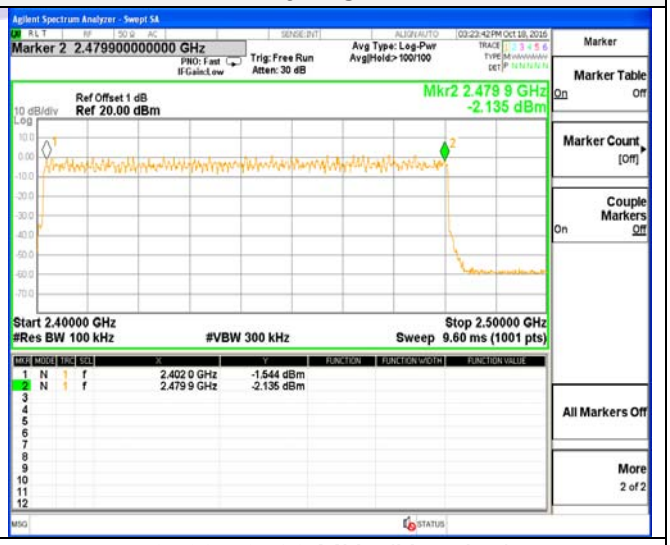
Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Numbers of Channel	Limits	Verdict
GFSK	Full (hopping)	2402-2480	79	15	PASS
8DPSK	Full (hopping)	2402-2480	79	15	PASS

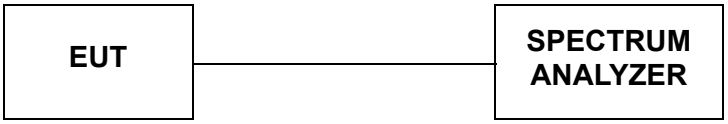
Remark:
1. Test results including cable loss;
2. Measured at difference Packet Type for each mode and recorded worst case for each mode.
3. Worst case data at DH5 for GFSK, 8DPSK modulation type;
4. *Please refer to following plots;*

Number of hopping frequency

GFSK	*8DPSK*
	
2402 - 2480 MHz (Hopping)	*2402 - 2480 MHz (Hopping)*

3.9. Time of Occupancy (Dwell Time)

TEST CONFIGURATION



TEST PROCEDURE

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:
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 a video 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 system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d) Detector function: Peak.
e) Trace: Max hold.

LIMIT

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.

TEST RESULTS

The Dwell Time=Burst Width*Total Hops. The detailed calculations are showed as follows:
The duration for dwell time calculation:0.4[s]*hopping number=0.4[s]*79[ch]=31.6[s*ch];
The burst width [ms/hop/ch], which is directly measured, refers to the duration on one channel hop.
The hops per second for all channels: The selected EUT Conf uses a slot type of 5-Tx&1-Rx and a hopping rate of 1600 [ch*hop/s] for all channels. So the final hopping rate for all channels is 1600/6=266.67 [ch*hop/s]
The hops per second on one channel: 266.67 [ch*hops/s]/79 [ch]=3.38 [hop/s];
The total hops for all channels within the dwell time calculation duration: 3.38 [hop/s]*31.6[s*ch]=106.67 [hop*ch];
The dwell time for all channels hopping: 106.67 [hop*ch]*Burst Width [ms/hop/ch].

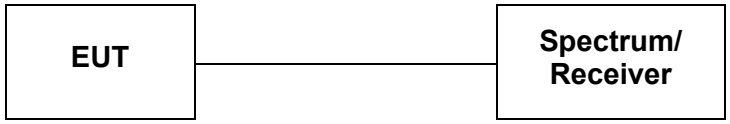
Mode	Frequency (MHz)	Burst Type	Pulse Width (ms)	Dwell Time (S)	Limit (S)	Verdict
GFSK	2441	DH1	0.390	0.1248	0.4	PASS
		DH3	1.630	0.2608	0.4	PASS
		DH5	2.900	0.3093	0.4	PASS
8DPSK	2441	DH1	0.390	0.1248	0.4	PASS
		DH3	1.660	0.2656	0.4	PASS
		DH5	2.900	0.3093	0.4	PASS

Remark:
1. Test results including cable loss;
2. Measured at difference Packet Type for each mode and recorded worst case for each mode.
3. Worst case data at DH5 for GFSK, 8DPSK modulation type;
4. Dwell Time Calculate formula:
DH1: Dwell time=Pulse time (s) × (1600 ÷ 2 ÷ 79) ×31.6 Second
DH3: Dwell time=Pulse time (s) × (1600 ÷ 4 ÷ 79) ×31.6 Second
DH5: Dwell time=Pulse Time (s) × (1600 ÷ 6 ÷ 79) ×31.6 Second
5. Measured at low, middle and high channel, recorded worst at middle channel;
6. Please refer to following plots;

Time Of Occupancy (Dwell Time)	
GFSK	8DPSK
2441 MHz	2441 MHz
	
DH1	3DH1
	
DH3	3DH3
	
DH5	3DH5

3.10. Spurious RF conducted emission

TEST CONFIGURATION



TEST PROCEDURE

The Spurious RF conducted emissions compliance of RF radiated emission should be measured by following the guidance in ANSI C63.10-2013 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization etc. Set RBW=100 kHz and VBW= 300 KHz to measure the peak field strength, and measurement frequency range from 9 KHz to 26.5GHz.

LIMIT

1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.
3. Fall in the restricted bands listed in section RSS-Gen. The maximum permitted average field strength is listed in section RSS-Gen.

TEST RESULTS

Test Mode	Frequency (MHz)	Frequency Range (MHz)	RF Conducted Spurious Emission (dBc)	Limits (dBc)	Verdict
GFSK	2402	2401 – 2403	---	---	PASS
		0.000009 – 0.00015	<-20dBc	-20	
		0.00015 - 30	<-20dBc	-20	
		30 - 1000	<-20dBc	-20	
		1000 - 8000	<-20dBc	-20	
		8000 - 16000	<-20dBc	-20	
		16000 - 26500	<-20dBc	-20	
	2441	2438.5 –2443.5	---	---	PASS
		0.000009 – 0.00015	<-20dBc	-20	
		0.00015 - 30	<-20dBc	-20	
		30 - 1000	<-20dBc	-20	
		1000 - 8000	<-20dBc	-20	
		8000 - 16000	<-20dBc	-20	
		16000 - 26500	<-20dBc	-20	
	2480	2477.5 –2482.5	---	---	PASS
		0.000009 – 0.00015	<-20dBc	-20	
		0.00015 - 30	<-20dBc	-20	
		30 - 1000	<-20dBc	-20	
		1000 - 8000	<-20dBc	-20	
		8000 - 16000	<-20dBc	-20	
		16000 - 26500	<-20dBc	-20	
8DPSK	2402	2399.5 –2404.5	---	---	PASS
		0.000009 – 0.00015	<-20dBc	-20	
		0.00015 - 30	<-20dBc	-20	
		30 - 1000	<-20dBc	-20	
		1000 - 8000	<-20dBc	-20	
		8000 - 16000	<-20dBc	-20	
		16000 - 26500	<-20dBc	-20	

	2441	2438.5 –2443.5	---	---	PASS
		0.000009 – 0.00015	<-20dBc	-20	
		0.00015 - 30	<-20dBc	-20	
		30 - 1000	<-20dBc	-20	
		1000 - 8000	<-20dBc	-20	
		8000 - 16000	<-20dBc	-20	
		16000 - 26500	<-20dBc	-20	
	2480	2477.5 –2482.5	---	---	PASS
		0.000009 – 0.00015	<-20dBc	-20	
		0.00015 - 30	<-20dBc	-20	
		30 - 1000	<-20dBc	-20	
		1000 - 8000	<-20dBc	-20	
		8000 - 16000	<-20dBc	-20	
		16000 - 26500	<-20dBc	-20	

Remark:

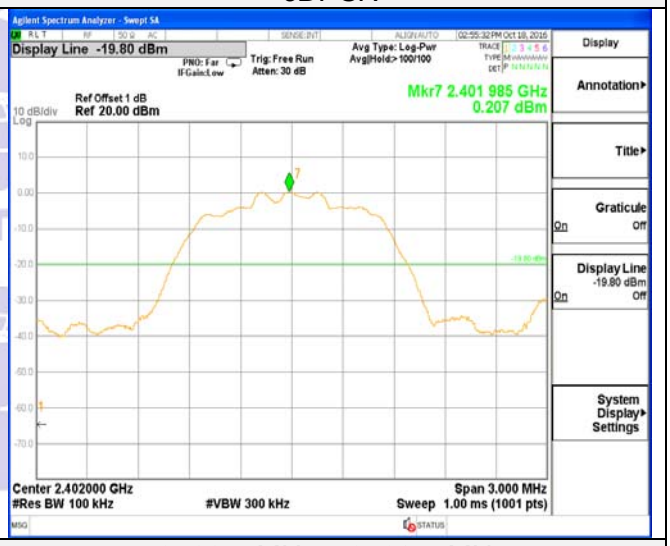
1. *We test Frequency Separation at difference Packet Type (DH1, DH3 and DH5), recorded worst case at DH1.*
2. *The test results including the cable lose.*
3. *Test Plots for following page*

RF Conducted Spurious Emission

GFSK

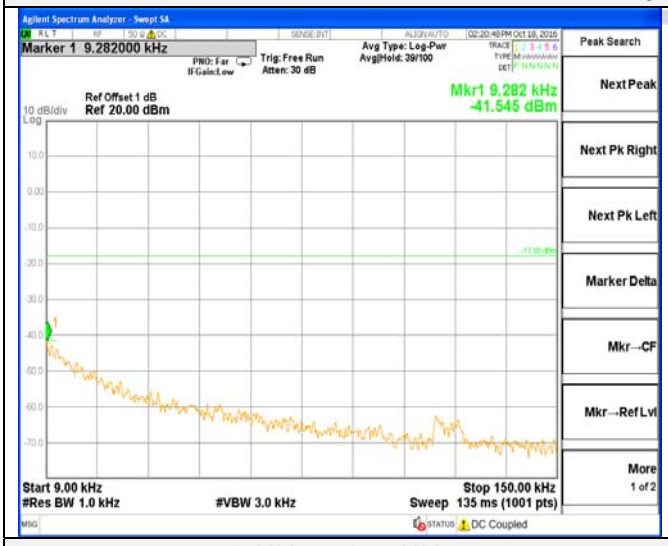
2400.5 MHz – 2403.5 MHz

8DPSK

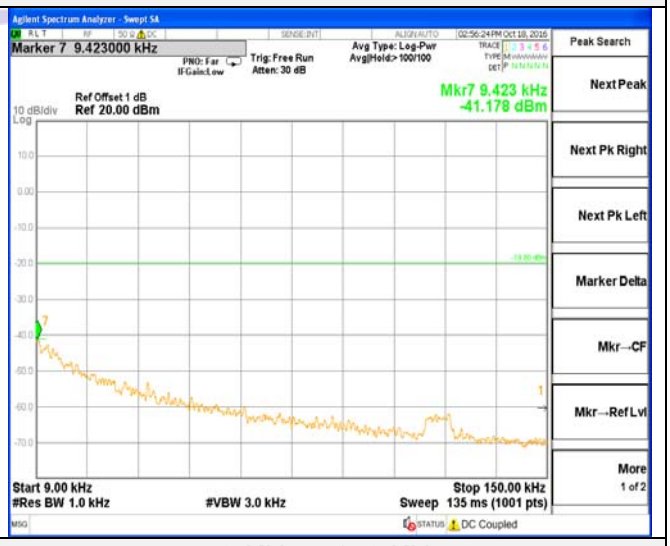


2400.5 MHz – 2403.5 MHz

2402 MHz

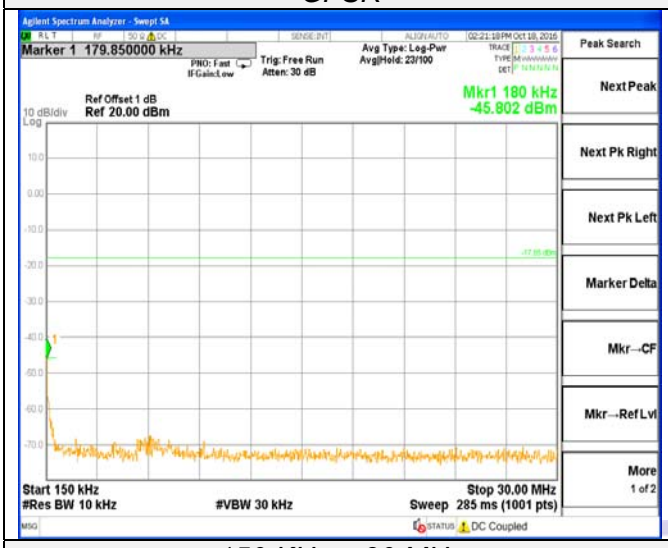
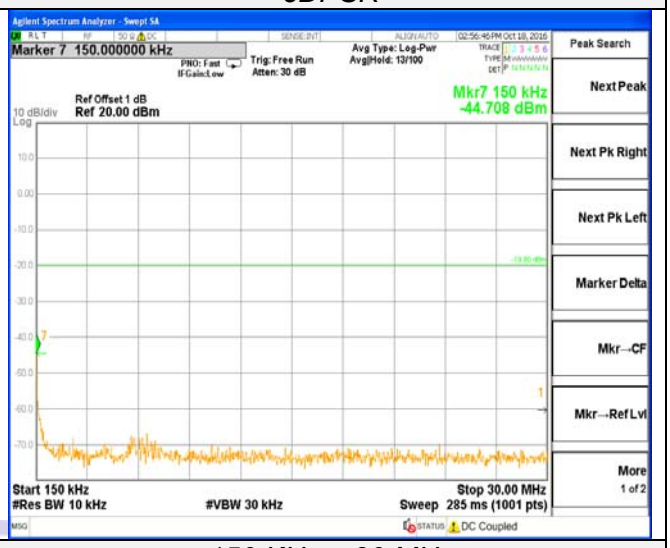
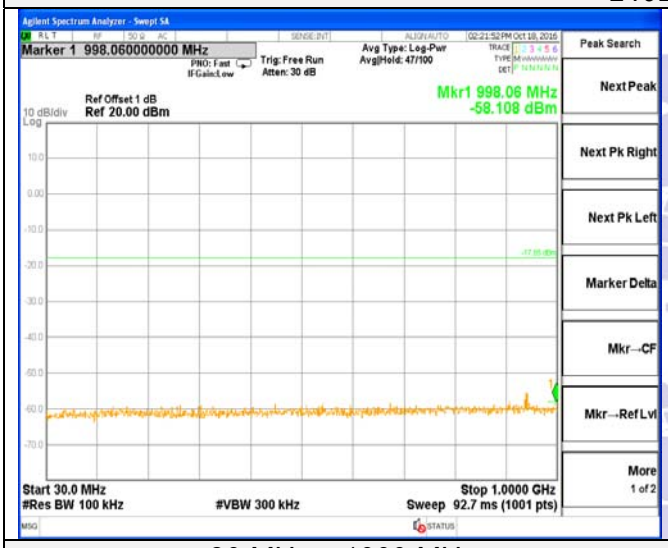
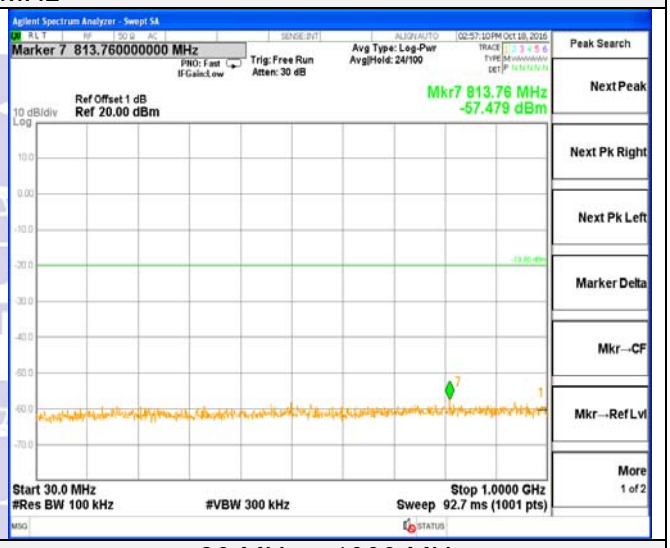
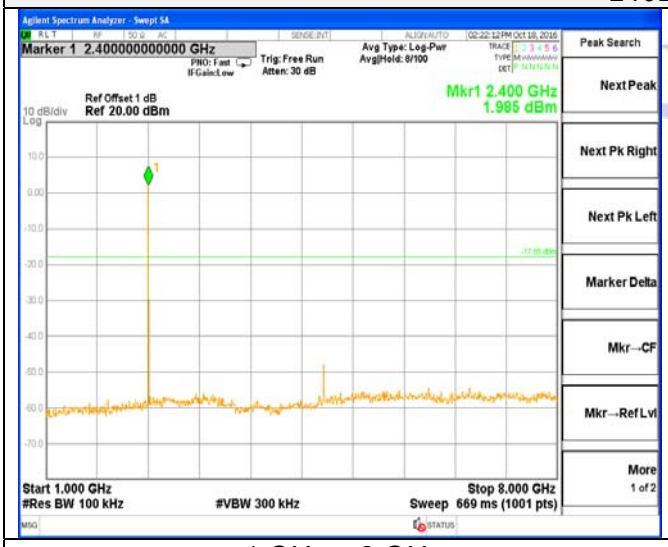
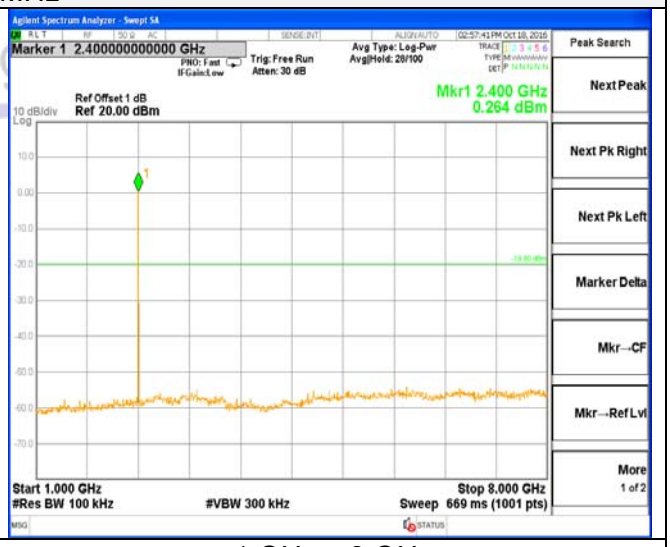


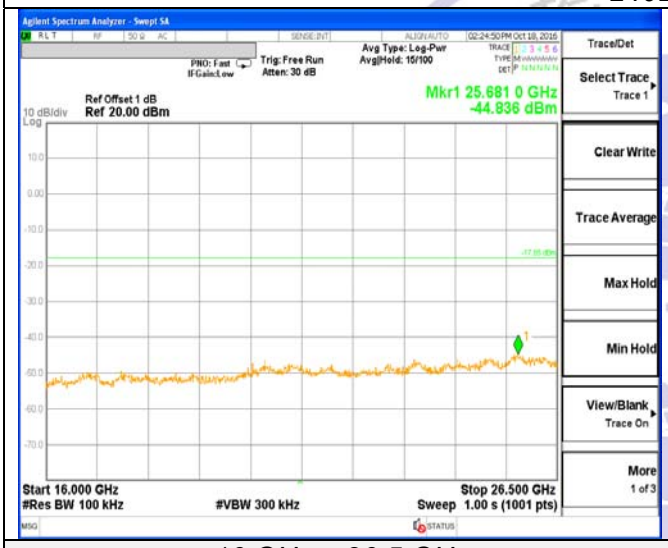
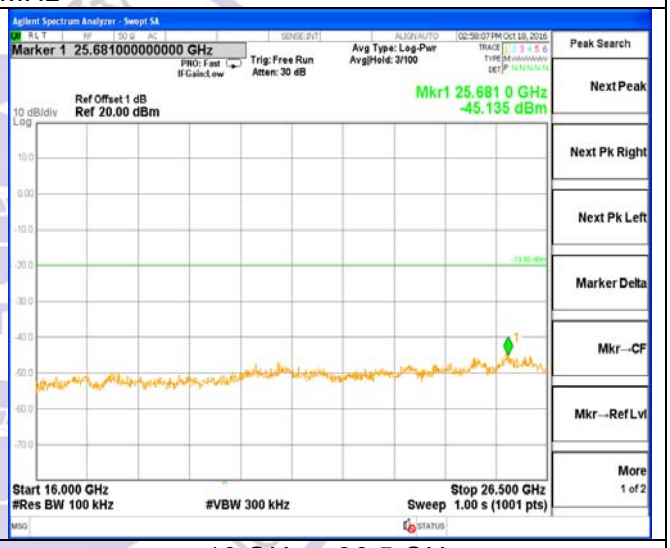
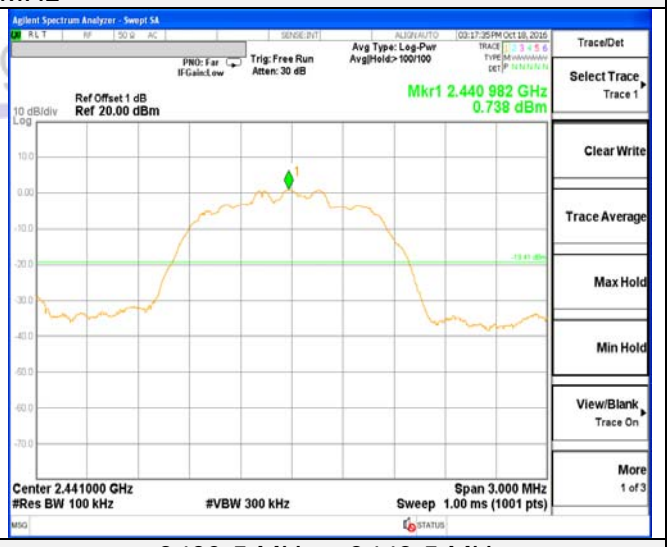
9 KHz – 150 KHz

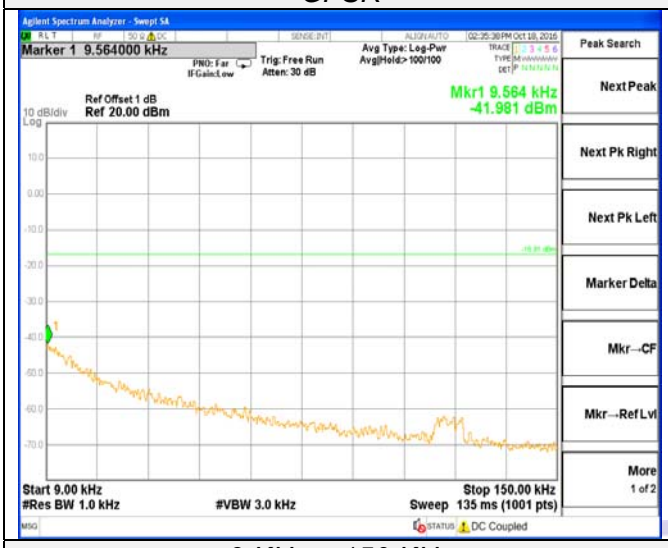
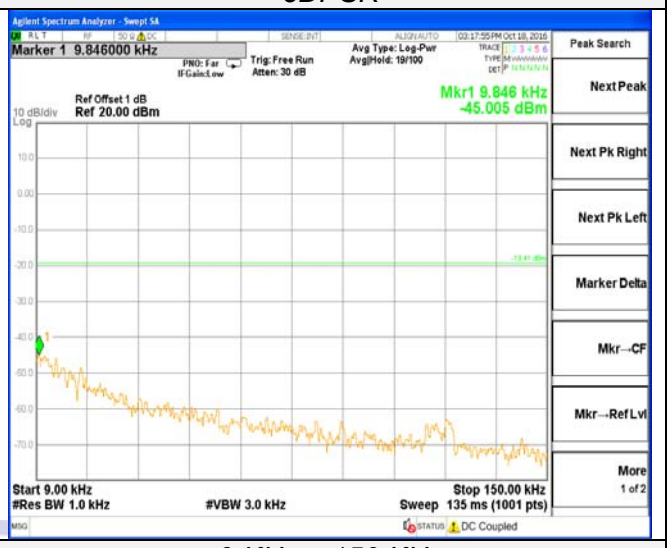
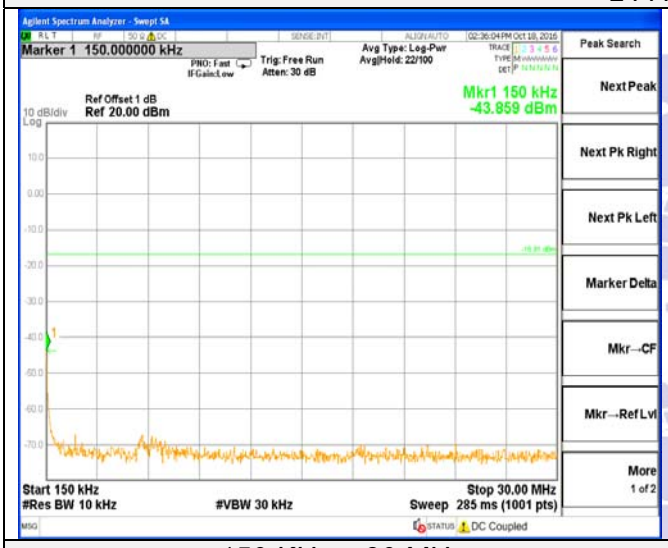
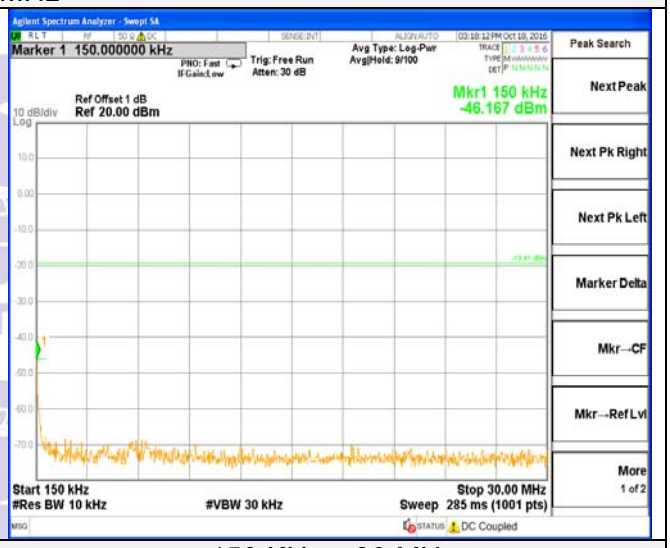
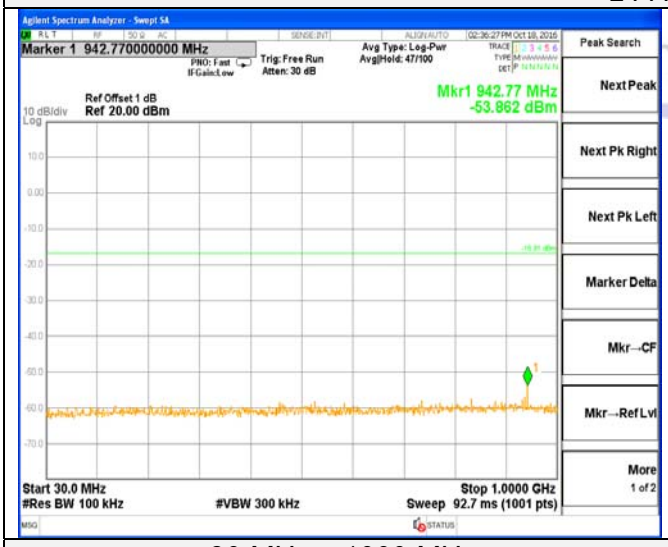
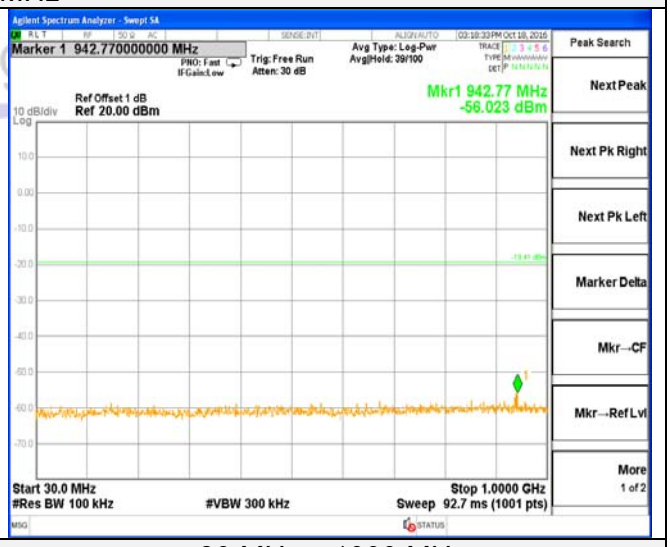


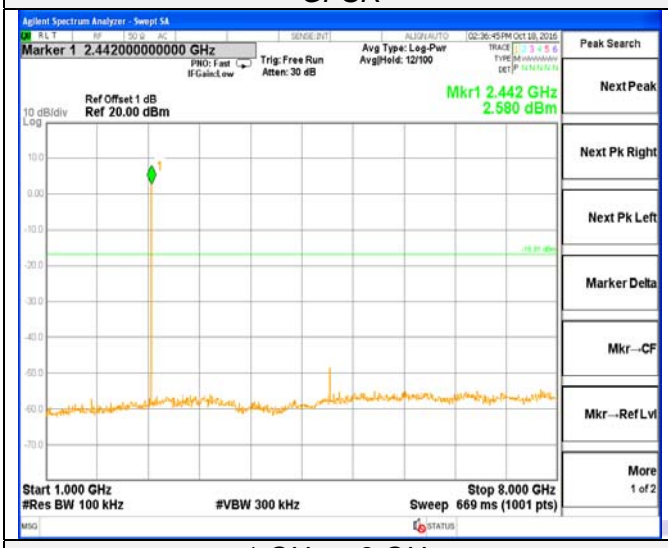
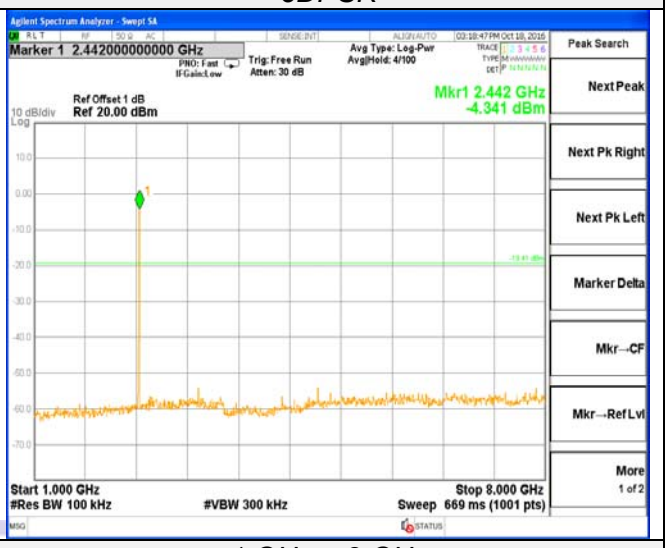
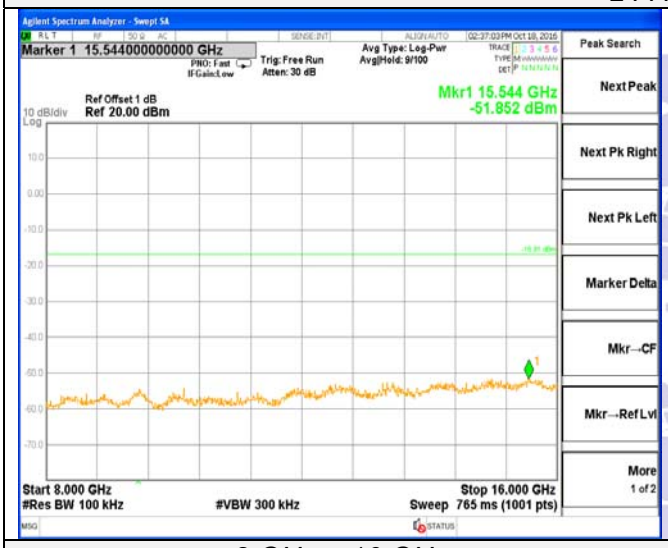
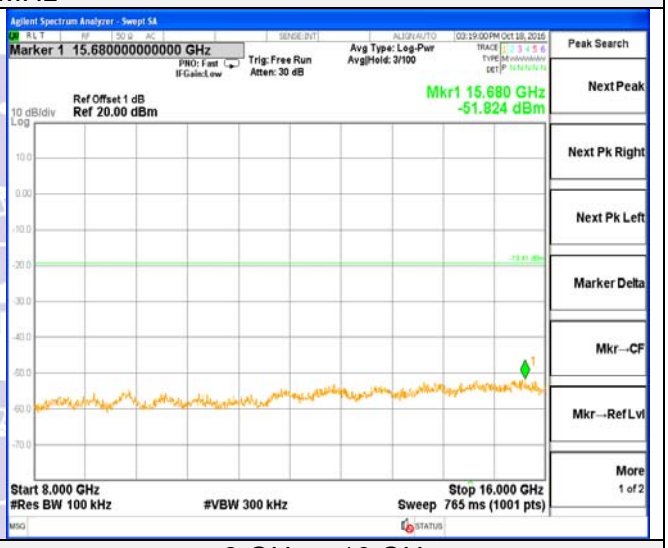
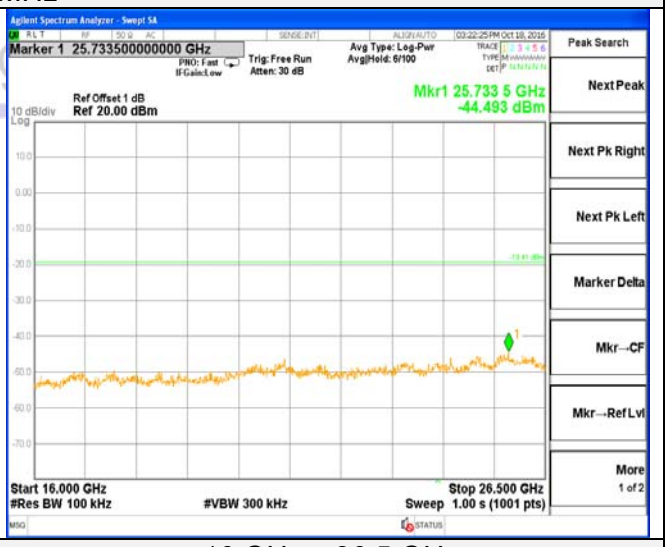
9 KHz – 150 KHz

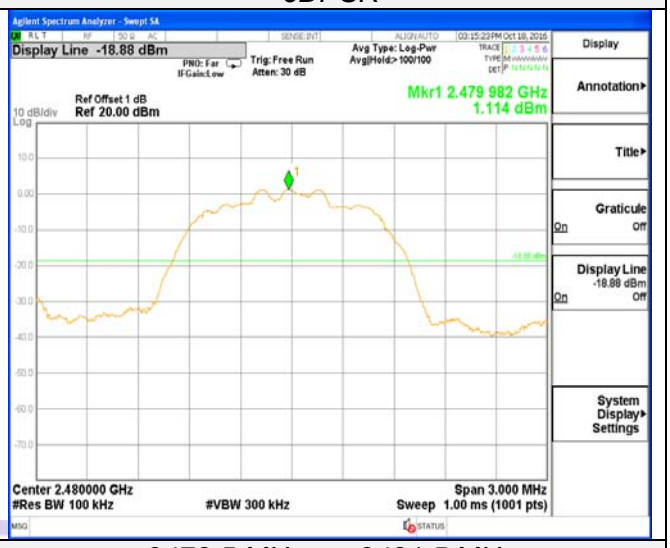
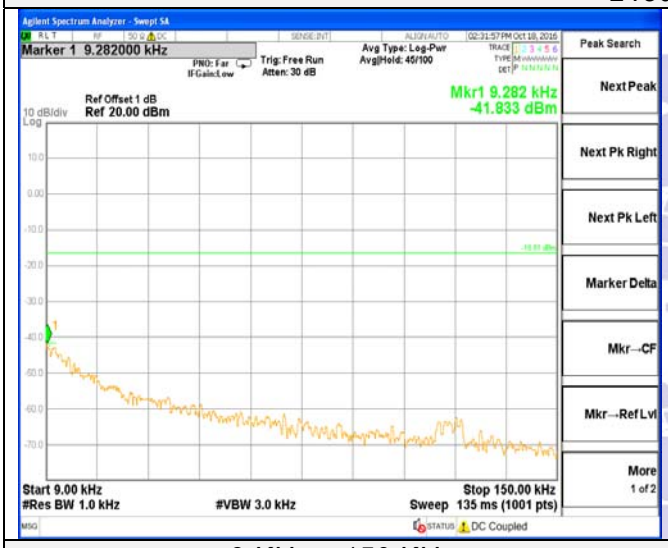
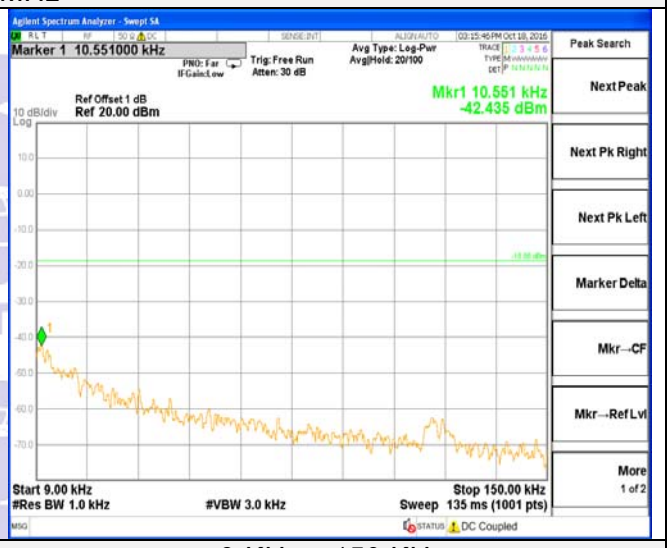
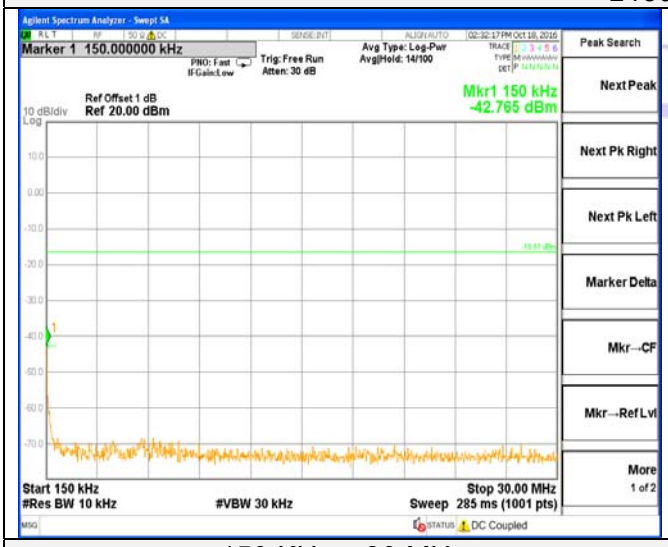
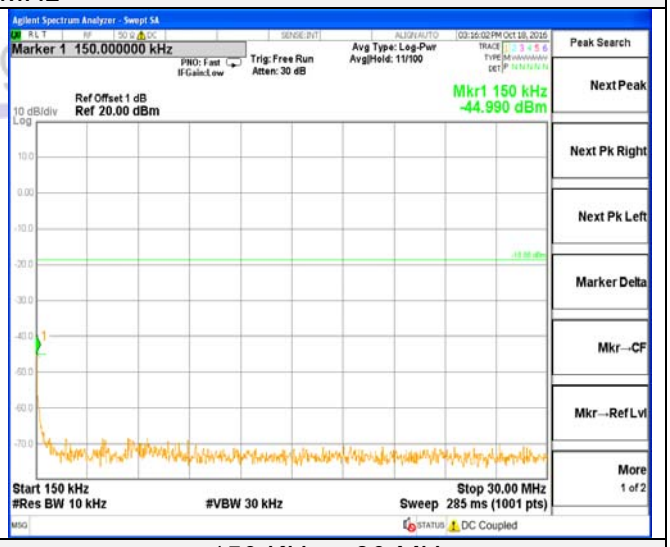
2402 MHz

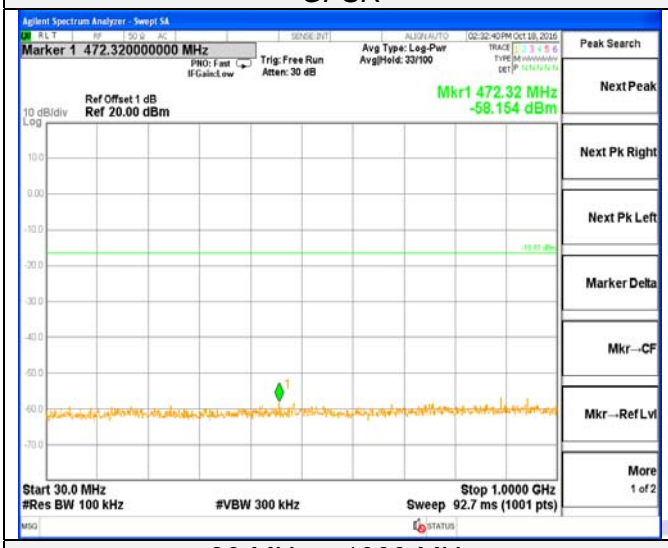
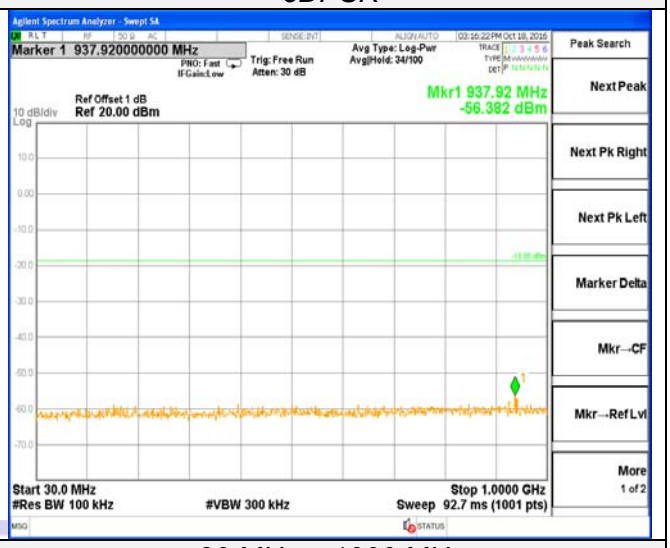
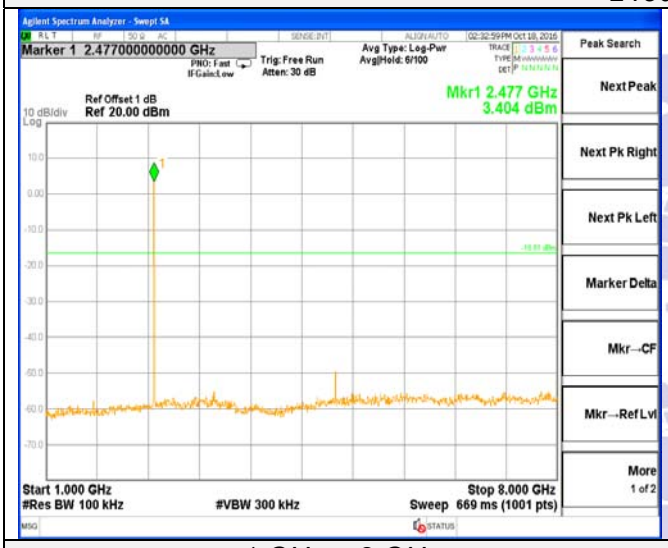
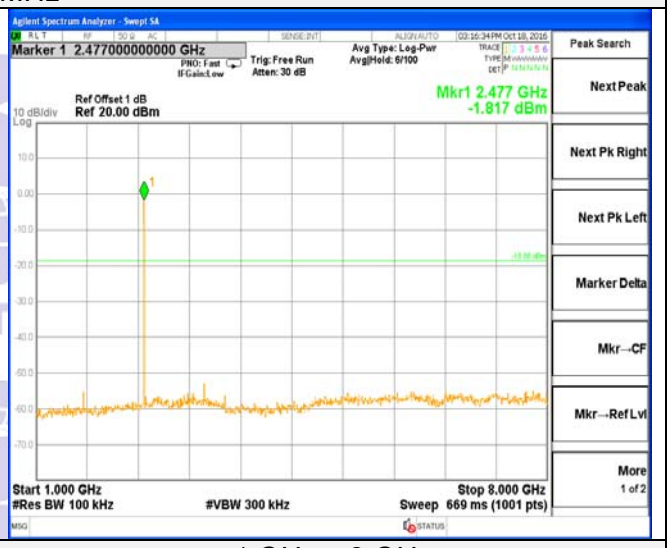
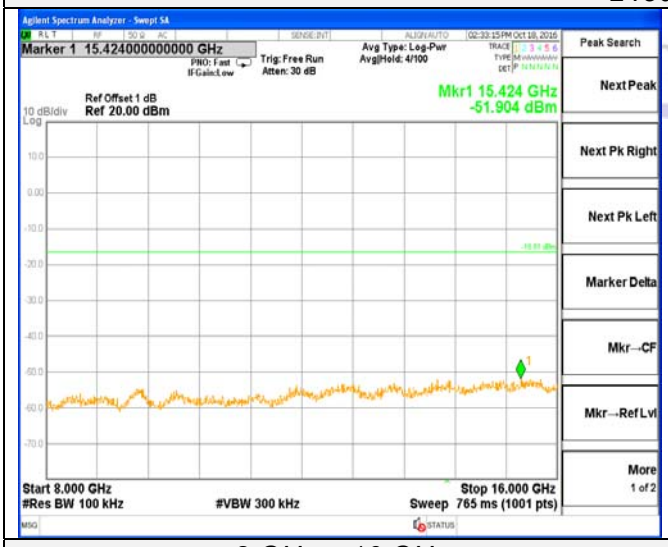
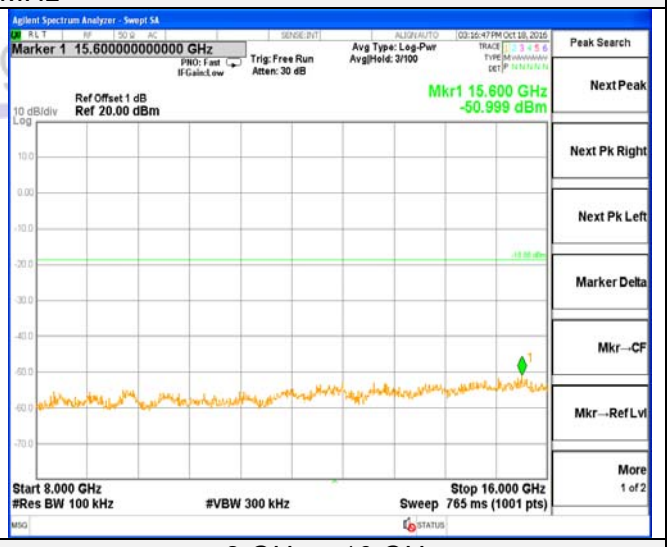
RF Conducted Spurious Emission	
GFSK	8DPSK
	
150 KHz – 30 MHz	150 KHz – 30 MHz
2402 MHz	
	
30 MHz – 1000 MHz	30 MHz – 1000 MHz
2402 MHz	
	
1 GHz – 8 GHz	1 GHz – 8 GHz
2402 MHz	

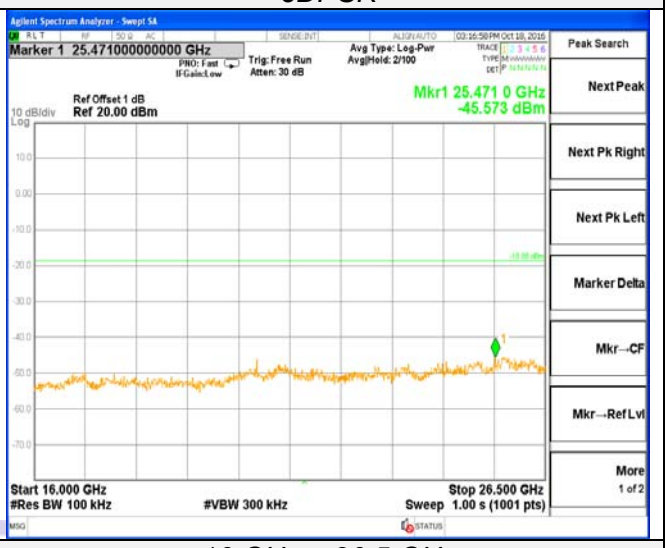
RF Conducted Spurious Emission	
GFSK	8DPSK
	
8 GHz – 16 GHz	8 GHz – 16 GHz
2402 MHz	
	
16 GHz – 26.5 GHz	16 GHz – 26.5 GHz
2402 MHz	
	
2439.5 MHz – 2442.5 MHz	2439.5 MHz – 2442.5 MHz
2441 MHz	

RF Conducted Spurious Emission	
GFSK	8DPSK
	
9 KHz – 150 KHz	9 KHz – 150 KHz
2441 MHz	
	
150 KHz – 30 MHz	150 KHz – 30 MHz
2441 MHz	
	
30 MHz – 1000 MHz	30 MHz – 1000 MHz
2441 MHz	

RF Conducted Spurious Emission	
GFSK	8DPSK
	
1 GHz – 8 GHz	1 GHz – 8 GHz
2441 MHz	
	
8 GHz – 16 GHz	8 GHz – 16 GHz
2441 MHz	
	
16 GHz – 26.5 GHz	16 GHz – 26.5 GHz
2441 MHz	

RF Conducted Spurious Emission	
GFSK	8DPSK
	
2478.5 MHz – 2481.5 MHz	2478.5 MHz – 2481.5 MHz
2480 MHz	
	
9 KHz – 150 KHz	9 KHz – 150 KHz
2480 MHz	
	
150 KHz – 30 MHz	150 KHz – 30 MHz
2480 MHz	

RF Conducted Spurious Emission	
GFSK	8DPSK
	
30 MHz – 1000 MHz	30 MHz – 1000 MHz
2480 MHz	
	
1 GHz – 8 GHz	1 GHz – 8 GHz
2480 MHz	
	
8 GHz – 16 GHz	8 GHz – 16 GHz
2480 MHz	

RF Conducted Spurious Emission	
GFSK	8DPSK
	
16 GHz – 26.5 GHz	16 GHz – 26.5 GHz
2480 MHz	

3.11. Pseudorandom Frequency Hopping Sequence

TEST APPLICABLE

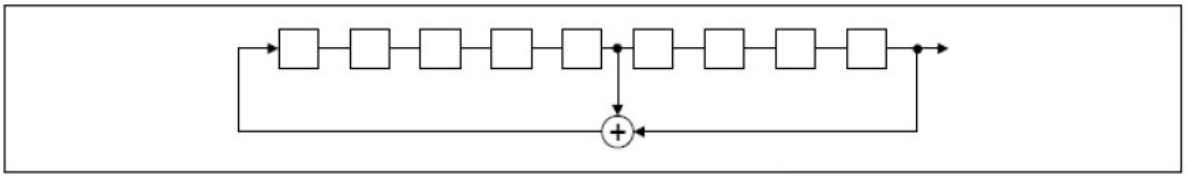
For 47 CFR Part 15C sections 15.247 (a) (1) requirement:

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

EUT Pseudorandom Frequency Hopping Sequence Requirement

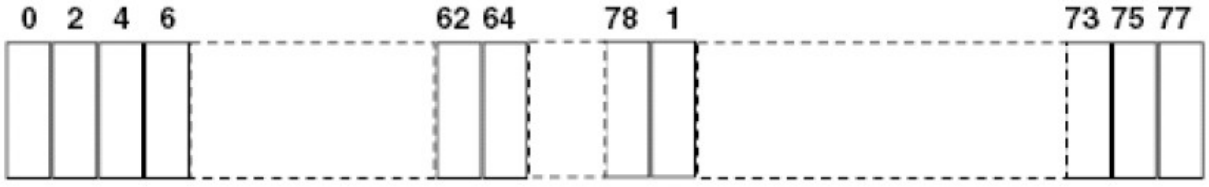
The pseudorandom frequency hopping sequence may be generated in a nice-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones, for example: the shift register is initialized with nine ones.

- Number of shift register stages:9
- Length of pseudo-random sequence:29-1=511 bits
- Longest sequence of zeros:8(non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of pseudorandom frequency hopping sequence as follows:



Each frequency used equally one the average by each transmitter.
The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitter and shift frequencies in synchronization with the transmitted signals.

3.12. Antenna Requirement

Standard Applicable

For intentional device, according to FCC 47 CFR Section 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.

And according to FCC 47 CFR Section 15.247 (c), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

According to RSS-Gen, The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the license-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.
Licence-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the licence-exempt apparatus.
Testing shall be performed using the highest gain antenna of each combination of licence-exempt transmitter and antenna type, with the transmitter output power set at the maximum level.9 When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna manufacturer.

Refer to statement below for compliance

The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. Further, this requirement does not apply to intentional radiators that must be professionally installed.

Antenna Connector Construction
The antenna used for transmitting is external antenna and use reverse SMA antenna connector meets FCC Part 15.203 antenna requirements. Please see EUT photo for details.
The Bluetooth use external antenna and maximum peak antenna gain is 0dBi.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module. For normal BT devices, the GFSK mode is used.

Conducted power refer ANSI C63.10:2013 Section 7.8.5 Output power test procedure for frequency-hopping spread-spectrum (FHSS) devices
Radiated power refers to ANSI C63.10:2013 Section 6.6.4 Radiated emissions tests.

Measurement parameters:

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	3MHz
Video bandwidth:	8MHz
Trace-Mode:	Max hold

Limits

FCC	ISED
Antenna Gain	
6 dBi	

Results

T_{nom}	V_{nom}	Lowest Channel 2402 MHz	Middle Channel 2441 MHz	Highest Channel 2480 MHz
Conducted power [dBm] Measured with GFSK modulation		2.328	3.151	3.519
Radiated power [dBm] Measured with GFSK modulation		1.971	3.018	3.166
Gain [dBi] Calculated		-0.357	-0.133	-0.353
Measurement uncertainty		0.57 dB (cond.) / 2.20 dB (rad.)		

4. Accreditation Certificate

China National Accreditation Service for Conformity Assessment

LABORATORY ACCREDITATION CERTIFICATE

(Registration No. CNAS L7497)

Shenzhen CTL Testing Technology Co., Ltd.

Floor 1-A, Baisha Technology Park, No.3011, Shahexi Road, Nanshan District, Shenzhen, Guangdong, China

is accredited in accordance with ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories(CNAS-CL01 Accreditation Criteria for the Competence of Testing and Calibration Laboratories) for the competence to undertake the service described in the schedule attached to this certificate.

The scope of accreditation is detailed in the attached schedule bearing the same registration number as above. The schedule form an integral part of this certificate.

Date of Issue：2016-04-05

Date of Expiry：2018-02-14

Date of Initial Accreditation：2015-02-15

Signed on behalf of China National Accreditation Service for Conformity Assessment

China National Accreditation Service for Conformity Assessment(CNAS) is authorized by Certification and Accreditation Administration of the People's Republic of China (CNCA) to operate the national accreditation schemes for conformity assessment. CNAS is a signatory of the International Laboratory Accreditation Cooperation Mutual Recognition Arrangement (ILAC MRA) and the Asia Pacific Laboratory Accreditation Cooperation Mutual Recognition Arrangement (APLAC MRA).

The validity of the certificate can be checked on CNAS website at http://www.cnas.org.cn/english/findanaccreditedbody/index.shtml

5. **Test** Setup Photos of the EUT

Please refer to separated files for Test Setup Photos of the EUT.

6. External Photos of the EUT

Please refer to separated files for External Photos of the EUT.

7. Internal Photos of the EUT

Please refer to separated files for Internal Photos of the EUT.

********** End of Report **********