FCC RF Test Report

For

Shenzhen Hangshi Technology Co.,Ltd.

Test Standards:	Part 15C Subpart C §15.247
Product Description:	Bluetooth Keyboard
Tested Model:	HB245
Additional Model No.:	N/A
Brand Name:	N/A
FCC ID:	2AKHJHB245
Classification	Digital Spread Spectrum (DSS)
Report No.:	EC1810004F01
Tested Date:	2018-10-25 to 2018-10-26
Issued Date:	2018-10-26
Prepared By:	Tiny Yang/ Engineer
Approved By:	Bacon Wu / RF Manager

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Report Revise Record

Report Version	Revise Time	Issued Date	Valid Version	Notes
V1.0	/	2018.10.26	Valid	Original Report

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Summary of Test Result

FCC Rule	IC Rule	Description	Limit	Result	Remark
15.247(a)(1)	RSS-247 5.1(1)	20dB Bandwidth	NA	Pass	-
-	RSS-Gen 6.6	99% Bandwidth	-	Pass	-
15.247(a)(1)	RSS-247 5.1(2)	Hopping Channel Separation	≥ 2/3 of 20dB BW	Pass	-
15.247(a)(1)	RSS-247 5.1(4)	Number of Channels	≥ 15Chs	Pass	-
15.247(a)(1)	RSS-247 5.1(4)	Average Time of Occupancy	≤ 0.4sec in 31.6sec period	Pass	-
15.247(b)(1)	RSS-247 5.4(2)	Peak Output Power	≤ 125 mW	Pass	-
15.247(d)	RSS-247 5.5	Conducted Band Edges	≤ 20dBc	Pass	-
15.247(d)	RSS-247 5.5	Conducted Spurious Emission	≤ 20dBc	Pass	-
15.247(d)	RSS-247 5.5	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit -6.68 dB at 9764.00 MHz
15.207	RSS-Gen 8.8	AC Conducted Emission	15.207(a)	Pass	Under limit -13.74 dB at 0.486 MHz
15.203 & 15.247(b)	N/A	Antenna Requirement	N/A	Pass	-

1 Test Laboratory

1.1 Test facility

CNAS (accreditation number: L11138)

Hunan Ecloud Testing Technology Co., Ltd. has obtained the accreditation of China National Accreditation Service for Conformity Assessment (CNAS).

FCC (Designation number: CN1244 , Test Firm Registration Number: 793308)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform electromagnetic emissions measurements.

A2LA (Certificate Code : 4895.01)

Hunan Ecloud Testing Technology Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

2 General Description

2.1 Applicant

Shenzhen Hangshi Technology Co.,Ltd.
Hangshi Technology Park,Democracy West Industry Area,Shajing Town,Bao'an District,Shenzhen,China.

2.2 Manufacturer

Shenzhen Hangshi Technology Co.,Ltd.
Hangshi Technology Park,Democracy West Industry Area,Shajing Town,Bao'an District,Shenzhen,China.

2.3 General Description Of EUT

Product	Bluetooth Keyboard
Model No.	HB245
Additional No.	N/A
Difference Description	N/A
FCC ID	2AKHJHB245
IC ID	N/A
Power Supply	5Vdc (adapter or host equipment) 3.7Vdc (Li-ion)
Modulation Technology	FHSS
Modulation Type	GFSK
Operating Frequency	2402MHz~2480MHz
Number Of Channel	79
Max. Output Power	Bluetooth BR(1Mbps) : -5.625 dBm (0.274 W)
Antenna Type	PCB Antenna type with 1.87dBi gain
I/O Ports	Refer to user's manual

NOTE:

1. For a more detailed features description, please refer to the manufacturer's specifications or the user's manual.

2. For the test results, the EUT had been tested with all conditions. But only the worst case was shown in test report.

2.4 Modification of EUT

No modifications are made to the EUT during all test items.

2.5 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- FCC Part 15 Subpart C §15.247
- ANSI C63.10-2013
- KDB 558074 D01 15.247 Meas Guidance v05

3 Test Configuration of Equipment Under Test

3.1 Descriptions of Test Mode

The transmitter has a maximum peak conducted output power as follows:

Channel	Frequency	Mode	Bluetooth RF Output Power
Ch00	2402MHz	GFSK	-5.625
Ch39	2441MHz	GFSK	-6.675
Ch78	2480MHz	GFSK	-7.828

Remark:

1. All the test data for each data rate were verified, but only the worst case was reported.
2. The data rate was set in 1Mbps for all the test items due to the highest RF output power.

a. Radiated emission and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

b. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

3.2 Test Mode

3.2.1 Antenna Port Conducted Measurement

Summary table of Test Cases	
Test Item	Data Rate / Modulation
	Bluetooth BR 1Mbps GFSK
Conducted Test Cases	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz

3.2.2 Radiated Emission Test (Below 1GHz)

	Bluetooth BR 1Mbps GFSK	
Radiated Test Cases	Transmitting+Charging	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz

Note : 1. Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, XYZ axis, antenna ports (if EUT with antenna diversity architecture) and packet type.

2. All above modes were tested, but only the worst case test mode 2 was reported.

3.2.3 Radiated Emission Test (Above 1GHz)

	Bluetooth BR 1Mbps GFSK	
Radiated Test Cases	Transmitting+Charging	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz

Note : 1. Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, XYZ axis, antenna ports (if EUT with antenna diversity architecture) and packet type.

2. Following channel(s) was (were) selected for the final test as listed above

3.2.4 Power Line Conducted Emission Test:

AC Conducted Emission	Mode 1 : Bluetooth Link + USB Cable (Charging from Adapter)

3.3 Support Equipment

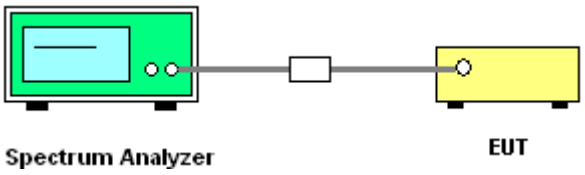
Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Adapter	HTC	TC E250	N/A	N/A	N/A
2.	Micro-USB Cable	HTC	N/A	N/A	N/A	unshielded 1.2m
3.	Notebook	Lenovo	E470C	FCC DoC	N/A	shielded cable DC O/P 1.8 m unshielded AC I/P cable1.2 m
4.	Ipad	Apple	A1822	BCGA1822	N/A	N/A

3.4 Test Setup

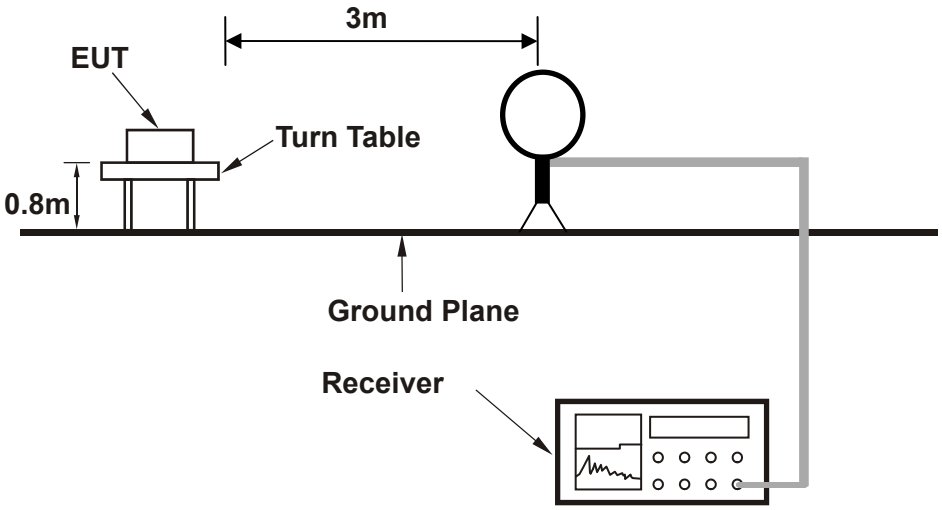
The EUT is continuously communicating to the Bluetooth tester during the tests.

EUT was set in the Hidden menu mode to enable BT communications.

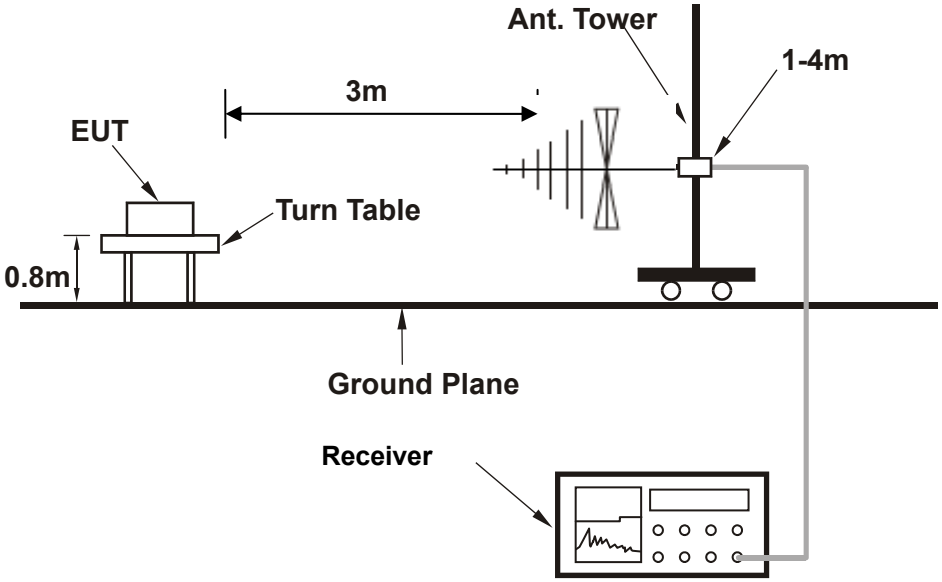
Setup diagram for Conducted Test



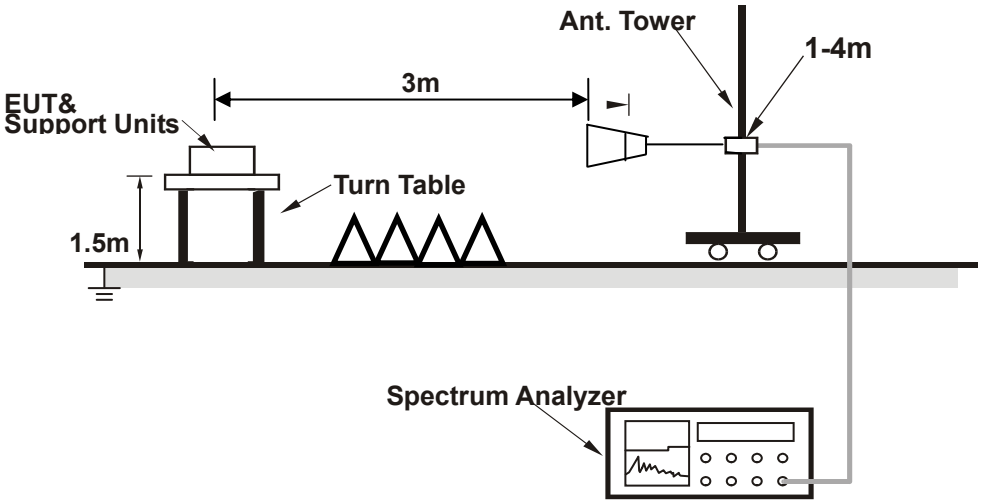
Setup diagram for Raidation(9KHz~30MHz) Test



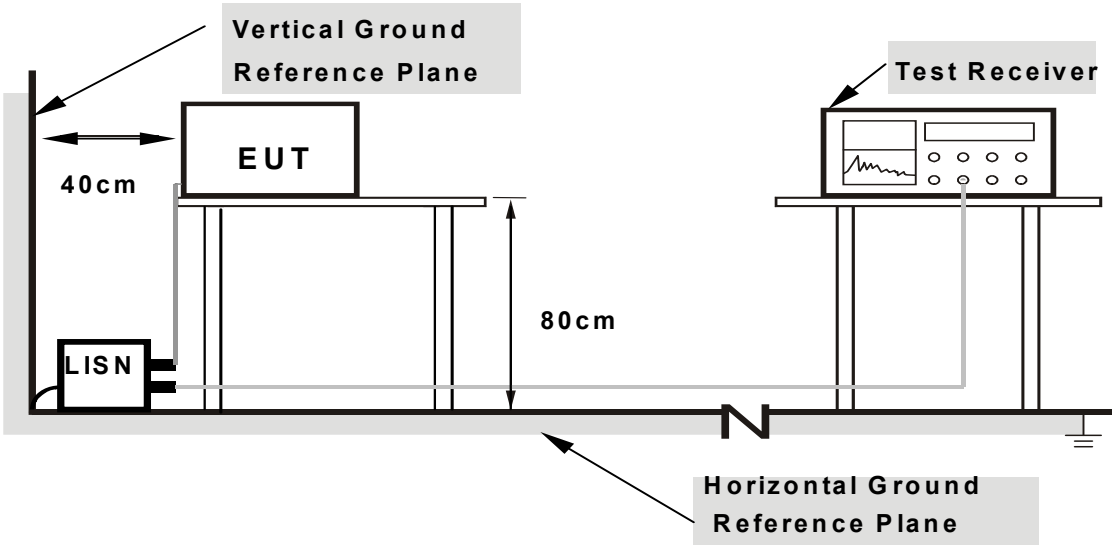
Setup diagram for Raidation(Below 1G) Test



Setup diagram for Raidation(Above1G) Test



Setup diagram for AC Conducted Emission Test



Note: 1.Support units were connected to second LISN.
2.Both of LISNs (AMN) are 80 cm from EUT and at least 80 from other units and other metal planes

3.5 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:
The spectrum analyzer offset is derived from RF cable loss and attenuator factor.
Offset = RF cable loss + attenuator factor.
Following shows an offset computation example with cable loss 5 dB and 10dB attenuator.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).
= 5 + 10 = 15 (dB)

4 Test Result

4.1 20dB and 99% Bandwidth Measurement

4.1.1 Limit of 20dB and 99% Bandwidth

None; for reporting purposes only.

4.1.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Use the following spectrum analyzer settings for 20dB Bandwidth measurement.

   Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel;

   RBW = 1% to 5% of the 20 dB bandwidth; VBW = approximately 3 times RBW; Sweep = auto; Detector function = peak; Trace = max hold.
4. Use the following spectrum analyzer settings for 99 % Bandwidth measurement.

   Span = approximately 1.5 to 5 times the 99% bandwidth, centered on a hopping channel;

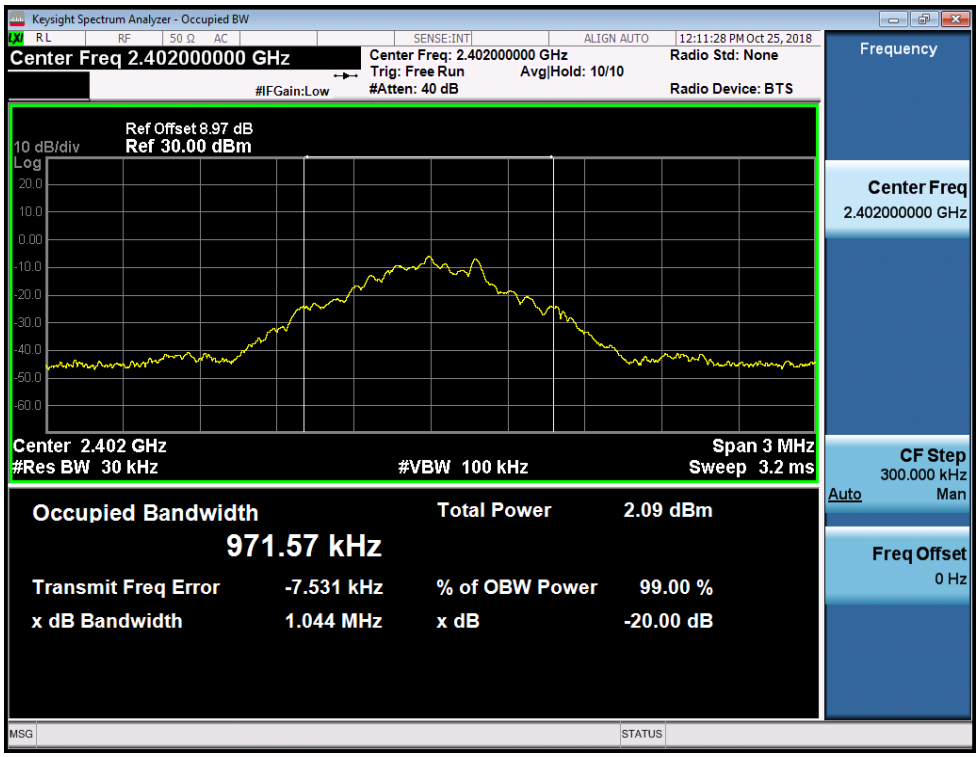
   RBW = 1% to 5% of the 99% bandwidth; VBW = approximately 3 times RBW; Sweep = auto; Detector function = peak; Trace = max hold.

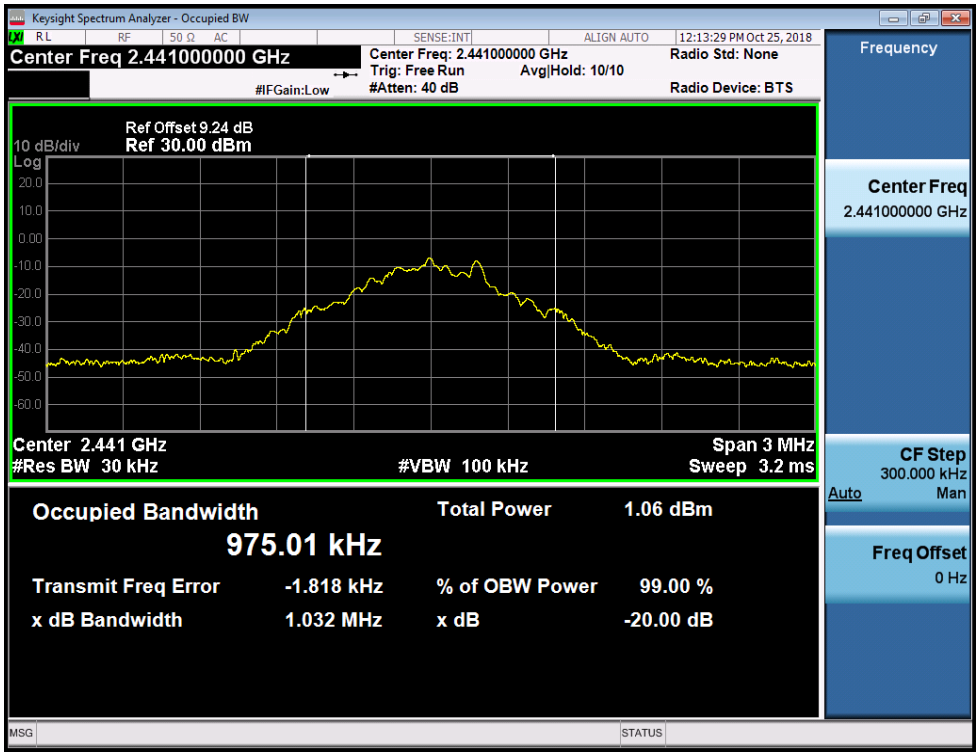
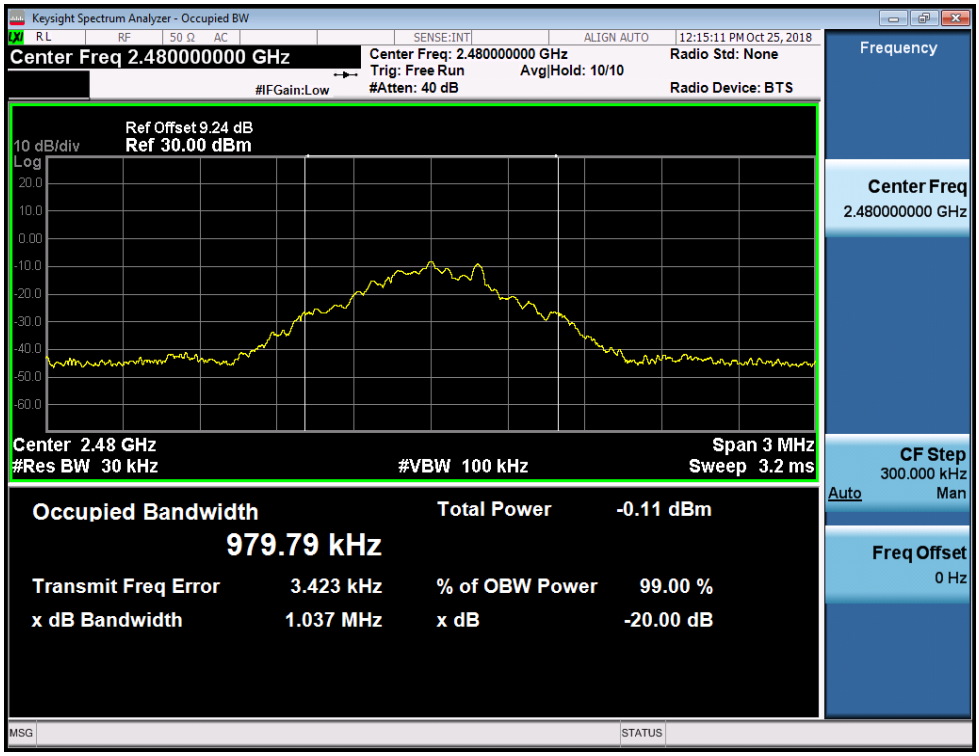
4.1.3 Test Result of 20dB Bandwidth and 99% Bandwidth

Test Mode :	Transmitting	Temperature :	24~26℃
Test Engineer :	Damon Zhang	Relative Humidity :	61~63

Data Rate	Modulation	Channel	20dB Bandwidth [MHz]	99% OBW [MHz]	Verdict
1Mbps	GFSK	LCH	1.044	0.97157	PASS
1Mbps	GFSK	MCH	1.032	0.97501	PASS
1Mbps	GFSK	HCH	1.037	0.97979	PASS

20dB and 99% Plot

Graphs	
GFSK/LCH	

GFSK/MCH	
GFSK/HCH	

4.2 Hopping Channel Separation Measurement

4.2.1 Limit of Hopping Channel Separation

FCC §15.247 (a) (1)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hoping 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.

4.2.2 Test Procedures

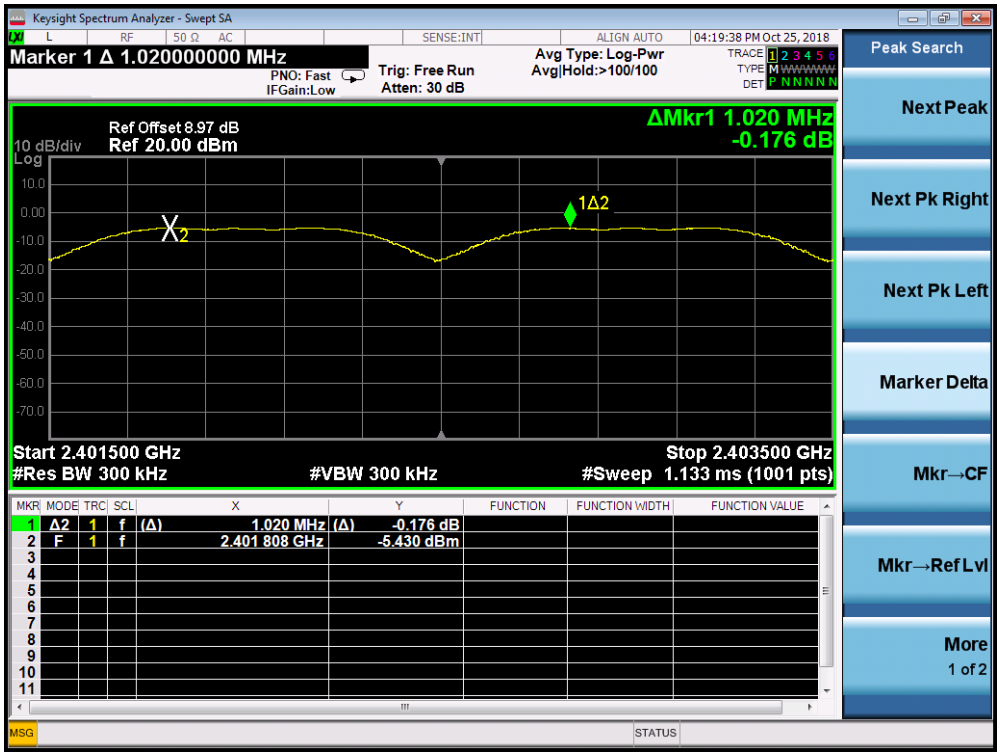
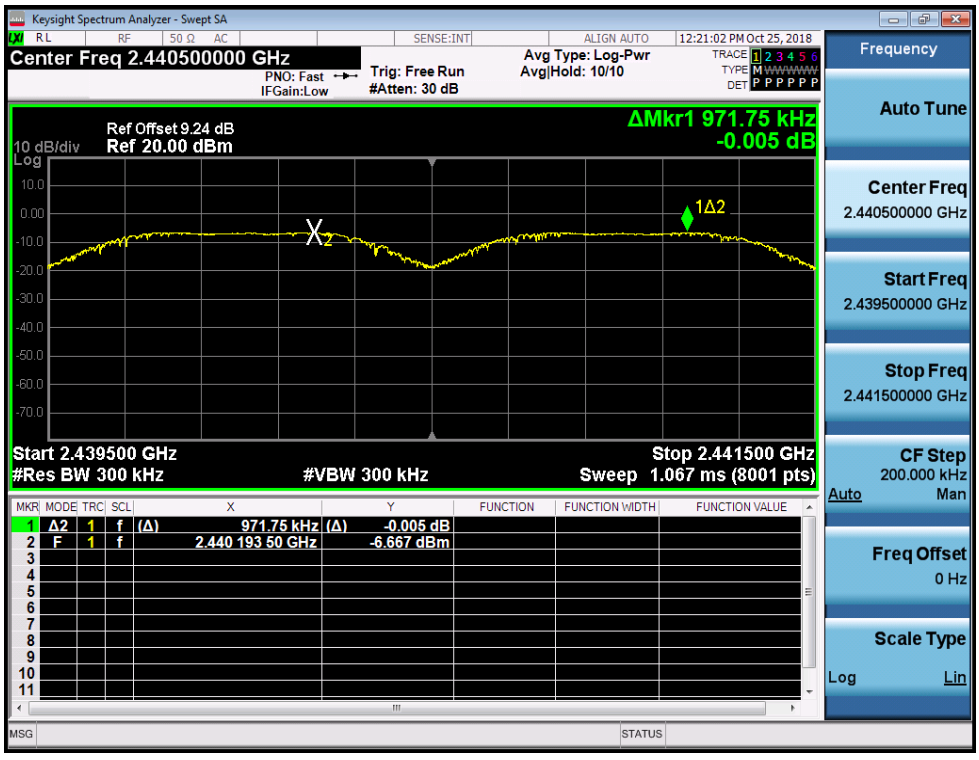
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. The transmitter output is connected to a spectrum analyzer. The RBW is set to 300 kHz and the VBW is set to 300 kHz. The sweep time is coupled.

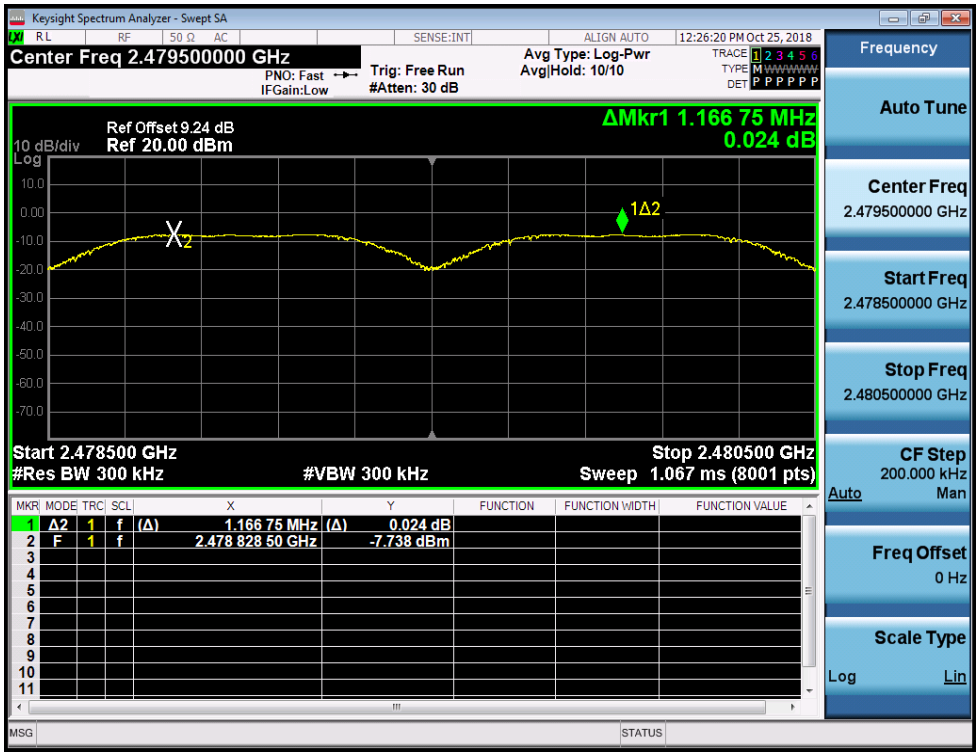
4.2.3 Test Result of Hopping Channel Separation

Test Mode :	Transmitting	**Temperature :**	24~26℃
Test Engineer :	Damon Zhang	**Relative Humidity :**	61~63

Data Rate	Modulation	Channel	Carrier Frequency Separation [MHz]	Verdict
1Mbps	GFSK	LCH	1.020	PASS
1Mbps	GFSK	MCH	0.972	PASS
1Mbps	GFSK	HCH	1.167	PASS

Hopping Frequency Separation Plot

Graphs	
GFSK/LCH	
GFSK/MCH	

GFSK/HCH	

Keysight Spectrum Analyzer - Swept SA
Center Freq 2.479500000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 10/10
12:26:20 PM Oct 25, 2018
Ref Offset 9.24 dB
10 dB/div
Log
Ref 20.00 dBm
ΔMkr1 1.166 75 MHz
0.024 dB
Start 2.478500 GHz
#Res BW 300 kHz
#VBW 300 kHz
Stop 2.480500 GHz
Sweep 1.067 ms (8001 pts)
1 Δ2 1 f (Δ) 1.166 75 MHz (Δ) 0.024 dB
2 F 1 f 2.478 828 50 GHz -7.738 dBm
Frequency
Auto Tune
Center Freq
2.479500000 GHz
Start Freq
2.478500000 GHz
Stop Freq
2.480500000 GHz
CF Step
200.000 kHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin

4.3 Number of Channel Measurement

4.3.1 Limits of Number of Hopping Frequency

FCC § 15.247(a)(1)(iii)

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

4.3.2 Test Procedure

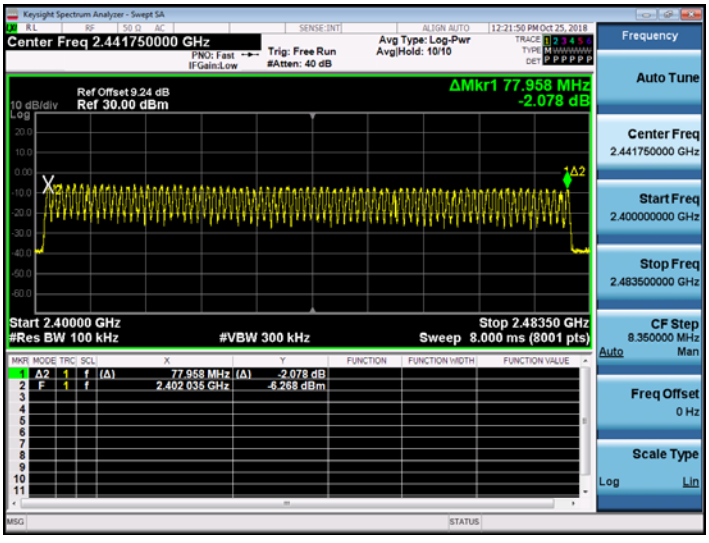
4. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
5. Turn on the EUT and connect it to measurement instrument.
6. The transmitter output is connected to a spectrum analyzer. The span is set to cover the entire authorized band, in either a single sweep or in multiple continuous sweeps. The RBW is set to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.. The analyzer is set to Max Hold.

4.3.3 Test Result of Number of Hopping Frequency

Test Mode :	Transmitting	Temperature :	24~26℃
Test Engineer :	Damon Zhang	Relative Humidity :	61~63

Data Rate	Modulation	Channel.	Number of Hopping Channel	Verdict
1Mbps	GFSK	Hop	79	PASS

Number of Hopping Channels

Graphs	
GFSK/Hop	

4.4 Average Time of Occupancy Measurement

4.4.1 Limit of Average Time of Occupancy

FCC §15.247 (a) (1) (iii)

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.

4.4.2 Test Procedures

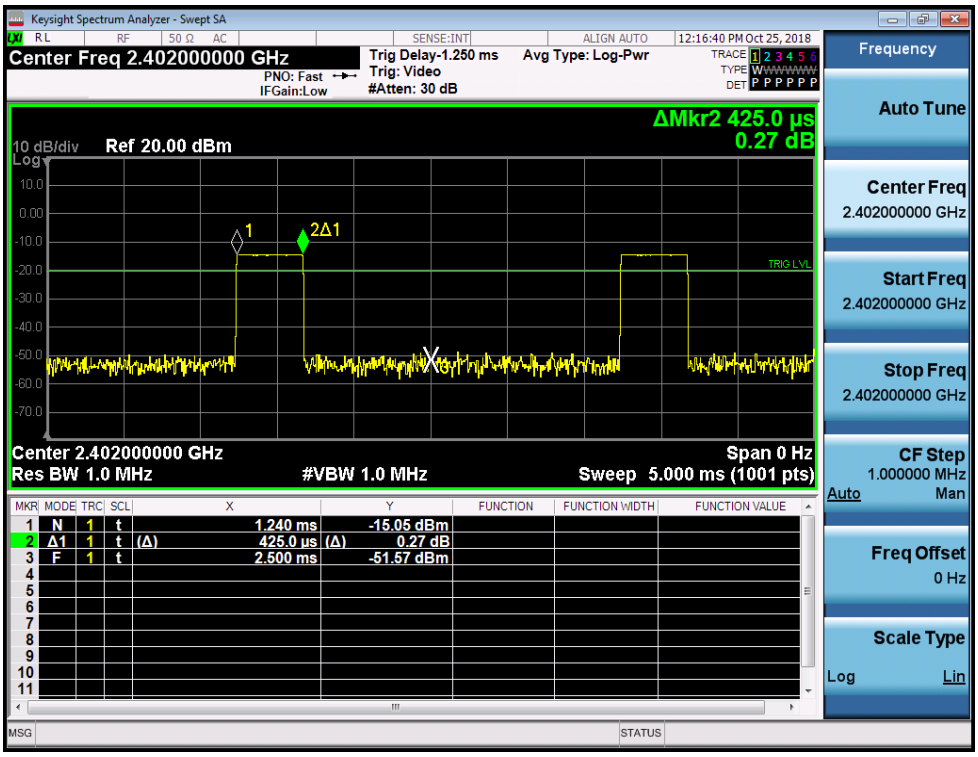
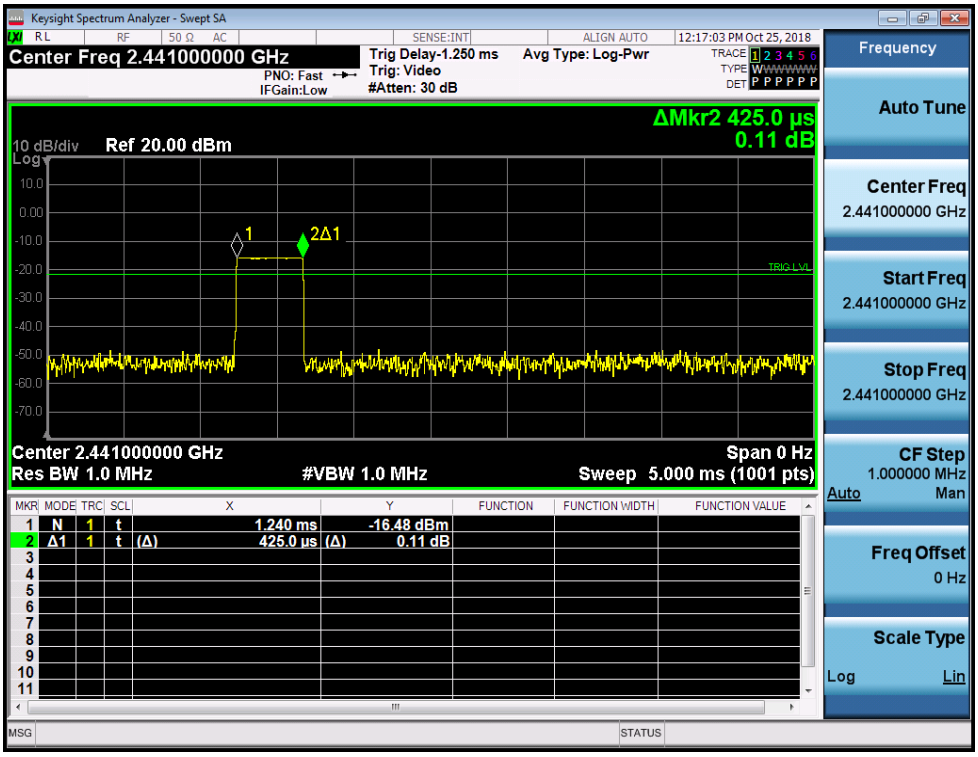
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. The transmitter output is connected to a spectrum analyzer. The span is set to 0 Hz, centered on a single, selected hopping channel. The width of a single pulse is measured in a fast scan The number of pulses is measured in a 3.16 second scan, to enable resolution of each occurrence.
4. The average time of occupancy in the specified 31.6 second period (79 channels * 0.4 s) is equal to 10 * (# of pulses in 3.16 s) * pulse width.

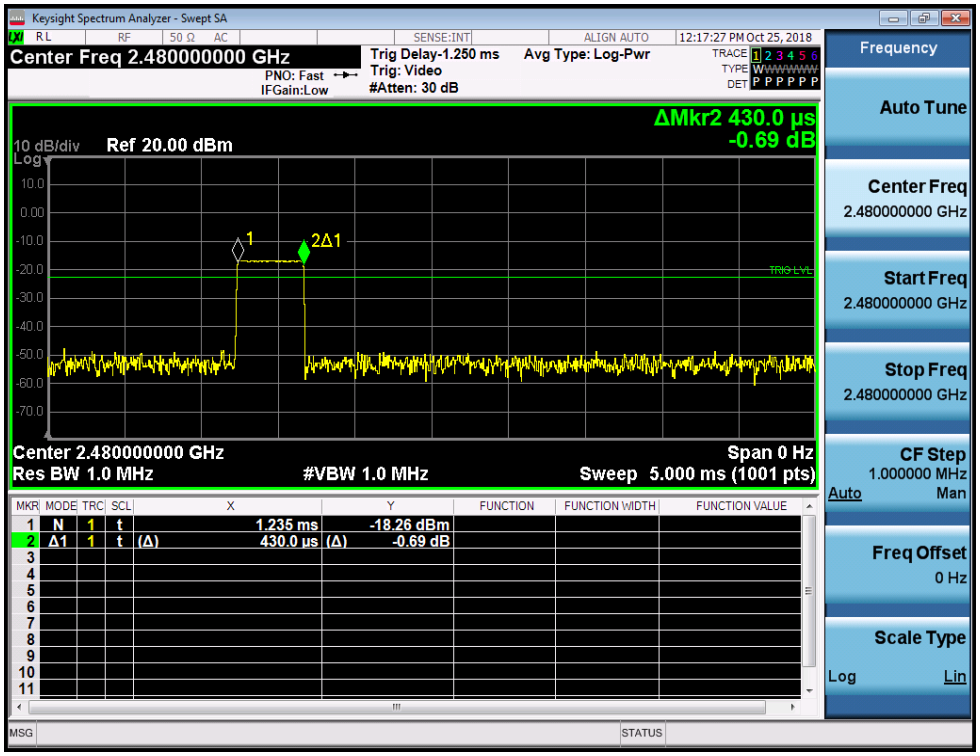
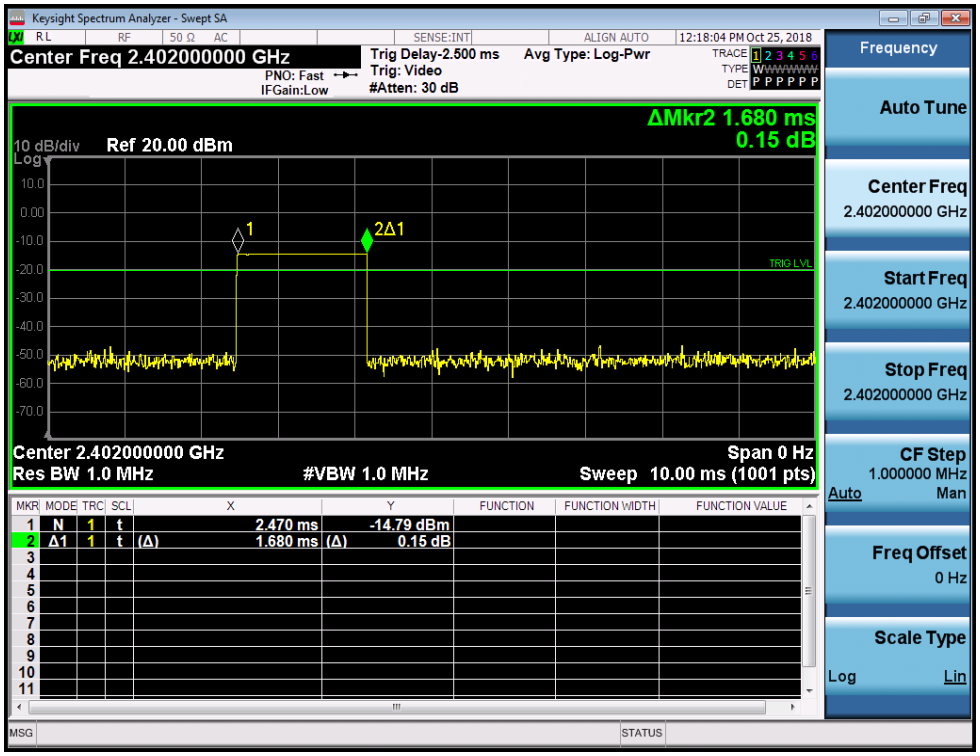
4.4.3 Test Result of Dwell Time

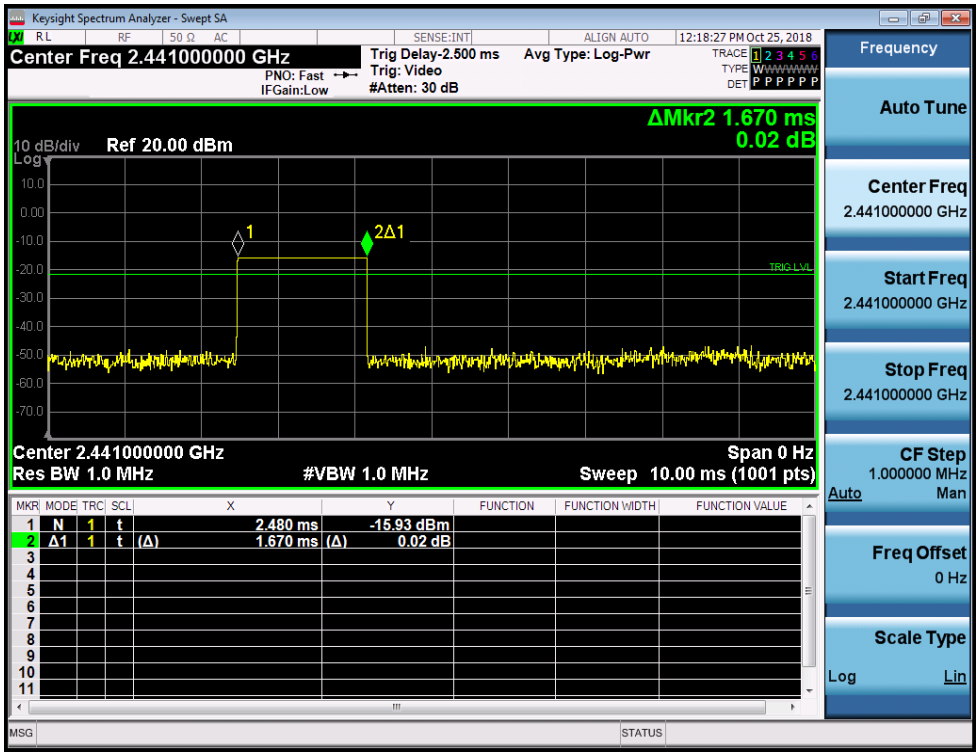
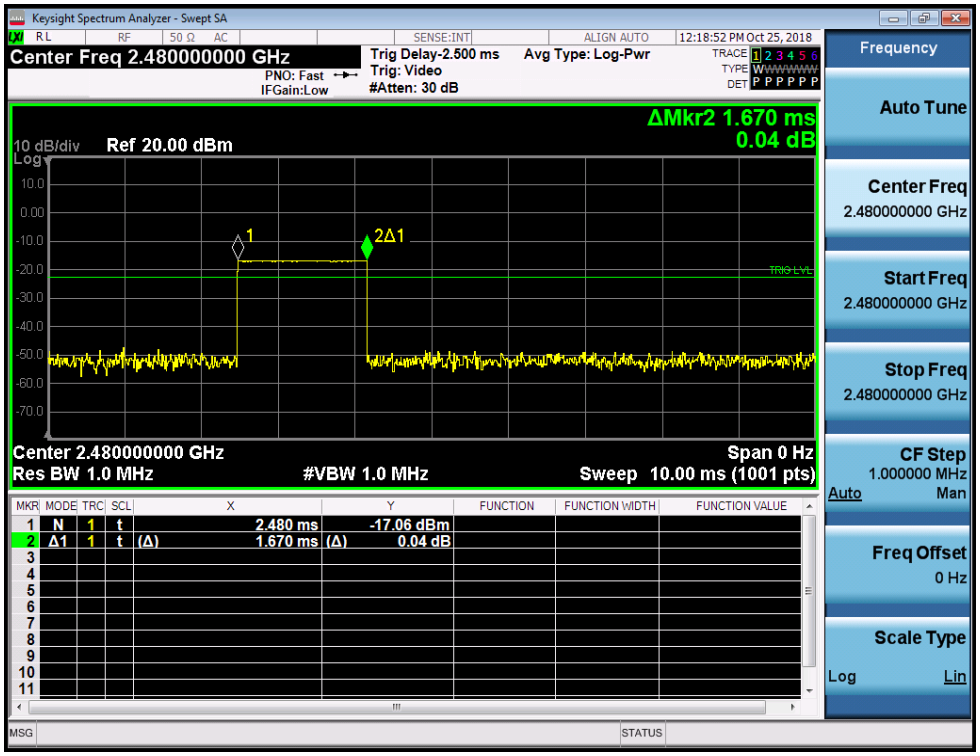
Test Mode :	Transmitting	Temperature :	24~26℃
Test Engineer :	Damon Zhang	Relative Humidity :	67~69%

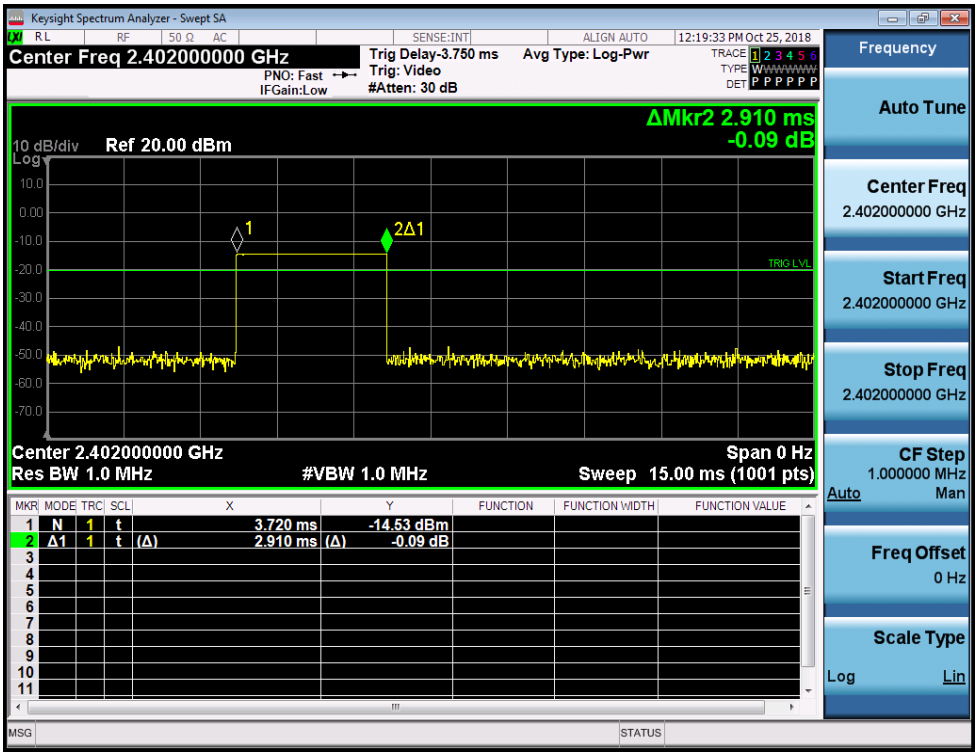
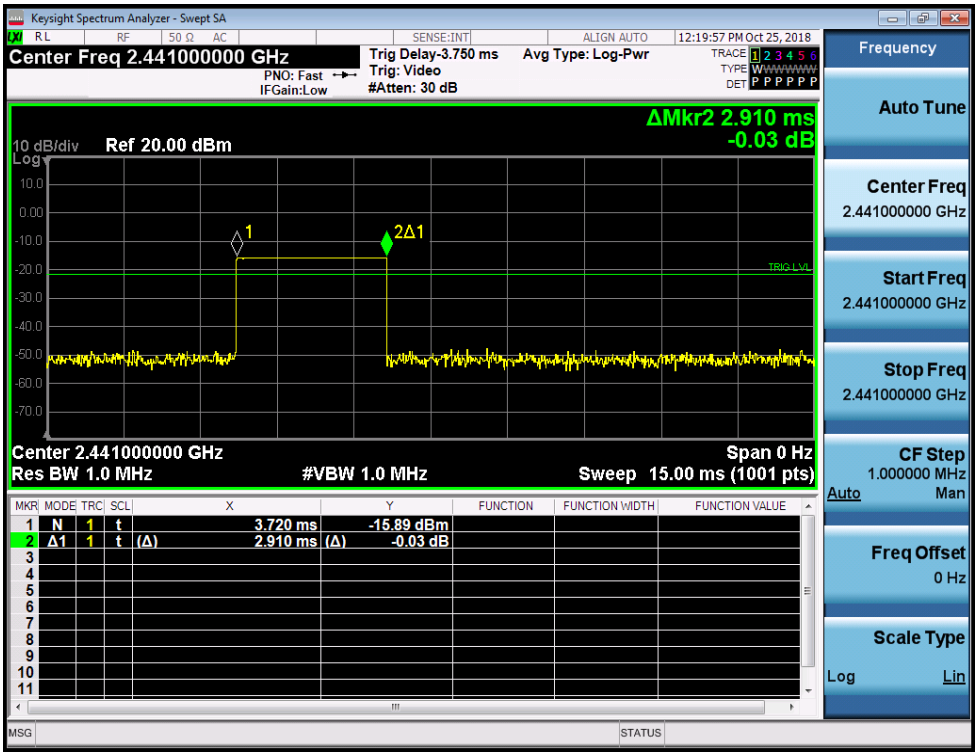
Data Rate	Modulation	Packet	Channel	Burst Width [ms/hop/ch]	Total Hops[hop*ch]	Dwell Time[s]	Verdict
1Mbps	GFSK	DH1	LCH	0.43	320	0.138	PASS
1Mbps	GFSK	DH1	MCH	0.43	320	0.138	PASS
1Mbps	GFSK	DH1	HCH	0.43	320	0.138	PASS
1Mbps	GFSK	DH3	LCH	1.68	160	0.269	PASS
1Mbps	GFSK	DH3	MCH	1.67	160	0.267	PASS
1Mbps	GFSK	DH3	HCH	1.67	160	0.267	PASS
1Mbps	GFSK	DH5	LCH	2.91	106.7	0.31	PASS
1Mbps	GFSK	DH5	MCH	2.91	106.7	0.31	PASS
1Mbps	GFSK	DH5	HCH	2.91	106.7	0.31	PASS

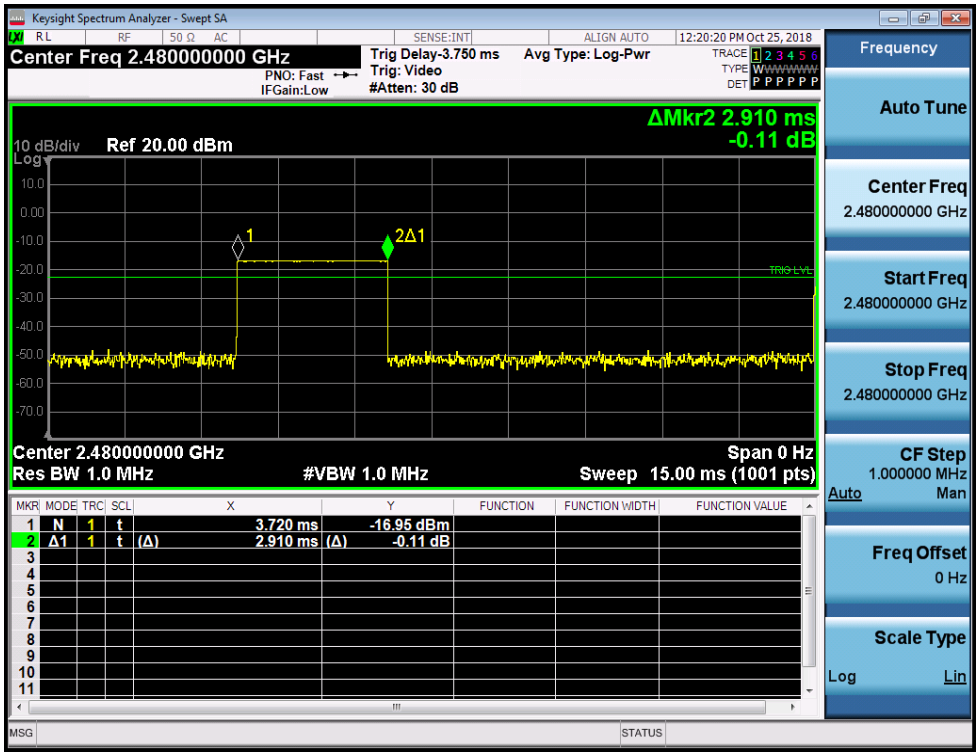
The Average Time of Occupancy Plot

Graphs	
GFSK_DH1/LCH	
GFSK_DH1/MCH	

GFSK_DH1/HCH	
GFSK_DH3/LCH	

GFSK_DH3/MCH	
GFSK_DH3/HCH	

GFSK_DH5/LCH	
GFSK_DH5/MCH	

GFSK_DH5/HCH	

Keysight Spectrum Analyzer - Swept SA
Center Freq 2.480000000 GHz
PNO: Fast
IFGain:Low
Trig Delay-3.750 ms
Trig: Video
#Atten: 30 dB
Avg Type: Log-Pwr
12:20:20 PM Oct 25, 2018
ΔMkr2 2.910 ms
-0.11 dB
10 dB/div
Log
Ref 20.00 dBm
Center 2.480000000 GHz
Res BW 1.0 MHz
#VBW 1.0 MHz
Span 0 Hz
Sweep 15.00 ms (1001 pts)
1 N 1 t 3.720 ms -16.95 dBm
2 Δ1 1 t (Δ) 2.910 ms (Δ) -0.11 dB
Frequency
Auto Tune
Center Freq
2.480000000 GHz
Start Freq
2.480000000 GHz
Stop Freq
2.480000000 GHz
CF Step
1.000000 MHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin

4.5 Peak Output Power Measurement

4.5.1 Limit of Peak Output Power

Section 15.247 (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following: (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.

4.5.2 Test Procedures

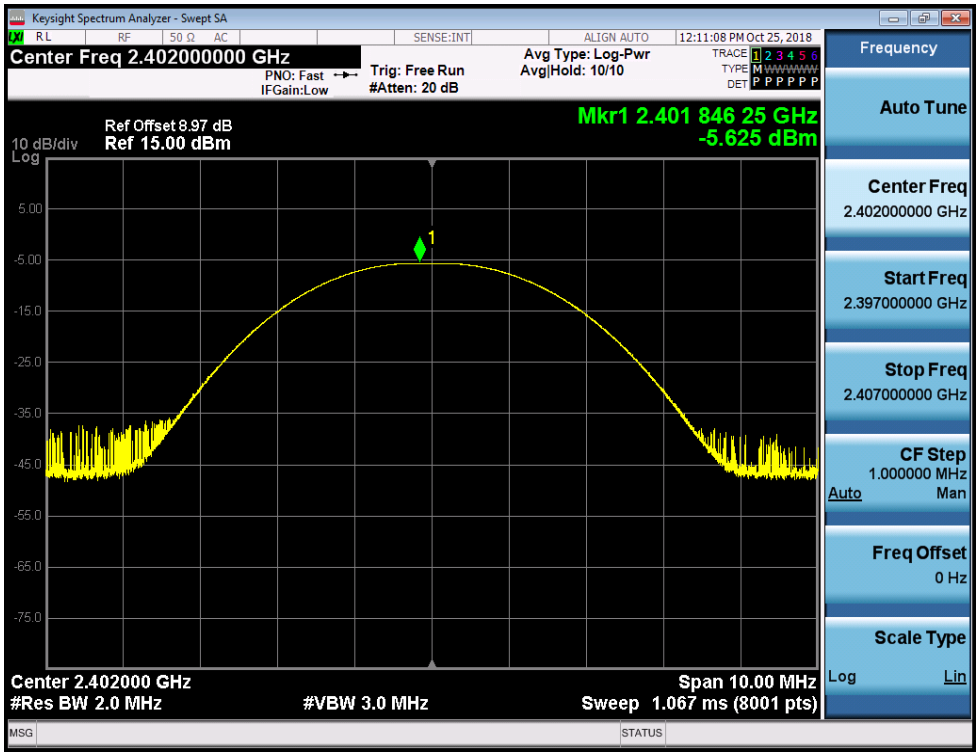
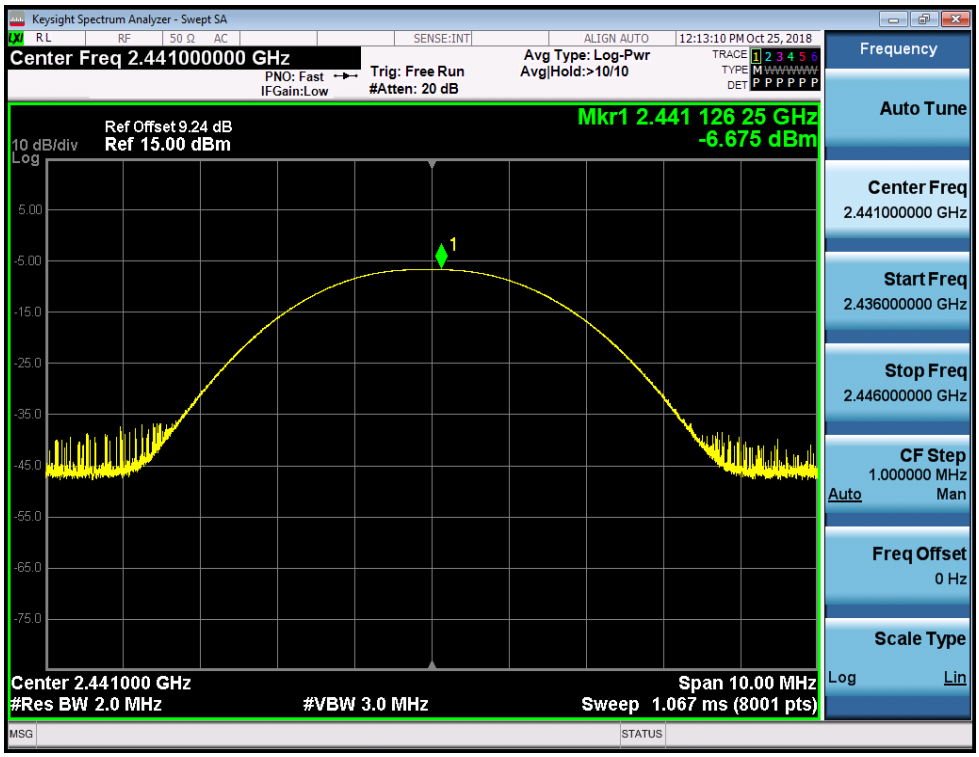
5. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
6. Turn on the EUT and connect it to measurement instrument.
7. The transmitter output is connected to a spectrum analyzer the analyzer bandwidth is set to a value greater than the 20 dB bandwidth of the EUT.

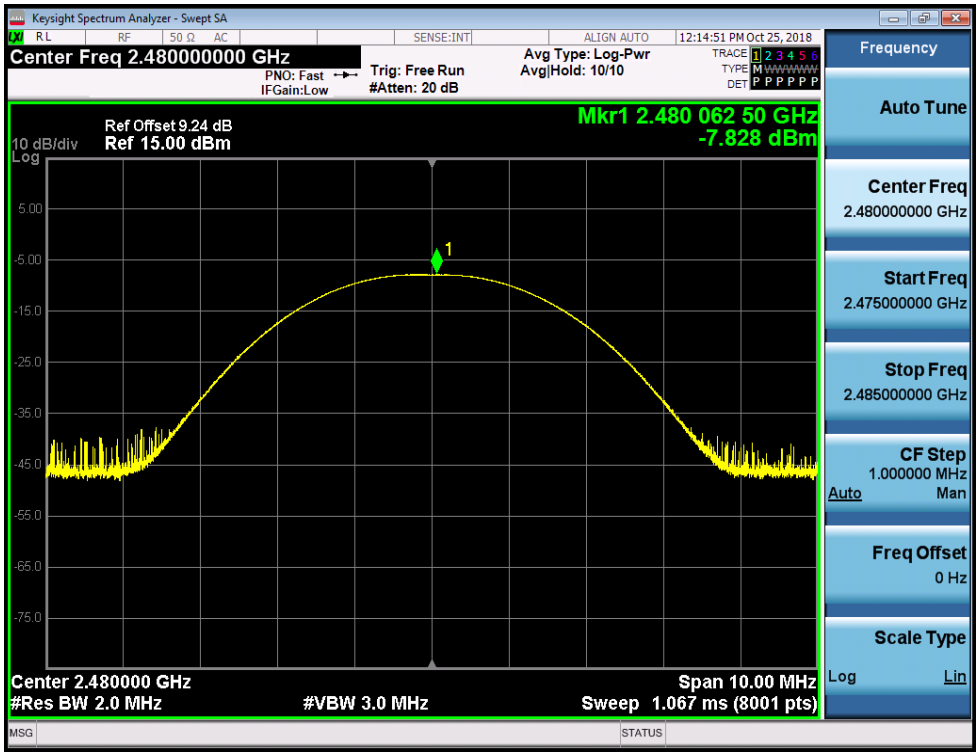
4.5.3 Test Result of Peak Output Power

Test Mode :	Transmitting	**Temperature :**	24~26℃
Test Engineer :	Damon Zhang	**Relative Humidity :**	67~69%

Data Rate	Modulation	Channel	Maximum Peak Output Power [dBm]	Limit[dBm]	Verdict
1Mbps	GFSK	LCH	-5.625	21	PASS
1Mbps	GFSK	MCH	-6.675	21	PASS
1Mbps	GFSK	HCH	-7.828	21	PASS

Peak Output Power Polt

Graphs	
GFSK/LCH	
GFSK/MCH	

GFSK/HCH	

Keysight Spectrum Analyzer - Swept SA
Center Freq 2.480000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 20 dB
Avg Type: Log-Pwr
Avg|Hold: 10/10
12:14:51 PM Oct 25, 2018
Ref Offset 9.24 dB
10 dB/div
Log
Ref 15.00 dBm
Mkr1 2.480 062 50 GHz
-7.828 dBm
Center 2.480000 GHz
#Res BW 2.0 MHz
#VBW 3.0 MHz
Span 10.00 MHz
Sweep 1.067 ms (8001 pts)
Frequency
Auto Tune
Center Freq
2.480000000 GHz
Start Freq
2.475000000 GHz
Stop Freq
2.485000000 GHz
CF Step
1.000000 MHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin
MSG
STATUS

4.6 Conducted Band Edges Measurement

4.6.1 Limit of Band Edges

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

4.6.2 Test Procedures

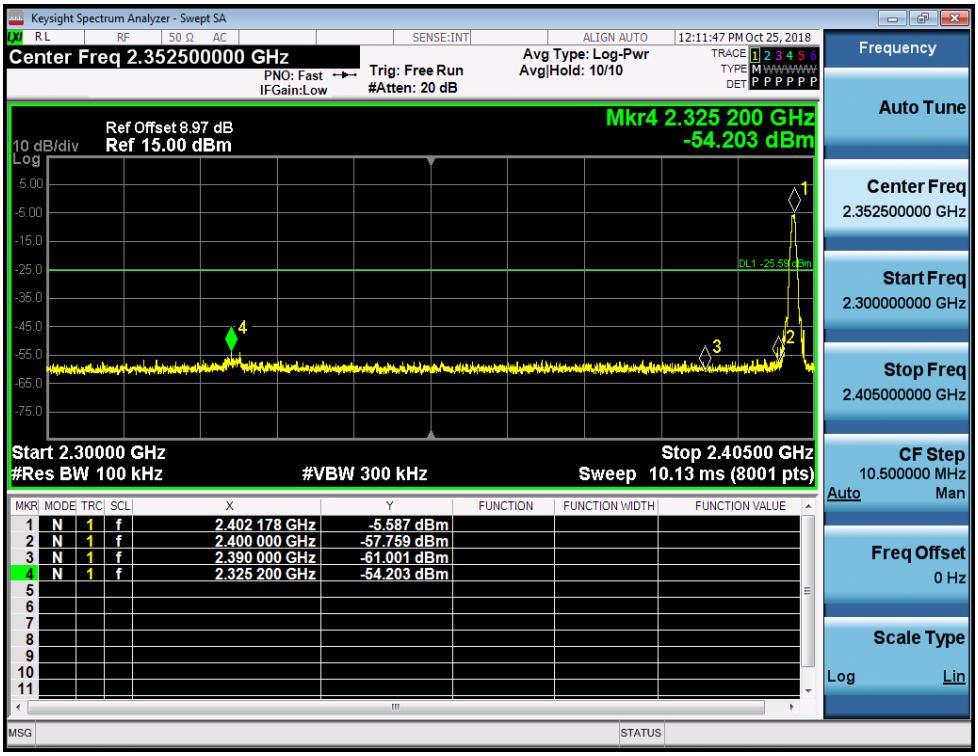
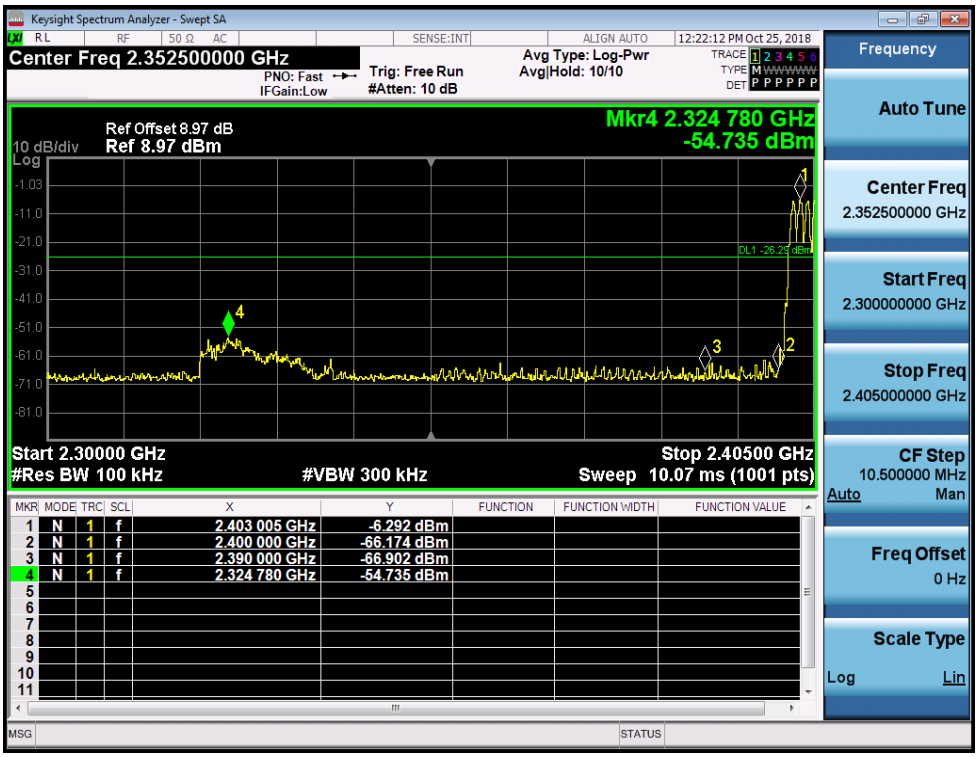
1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Set RBW = 100kHz, VBW = 300kHz. Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used.
4. Enable hopping function of the EUT and then repeat step 1~3.

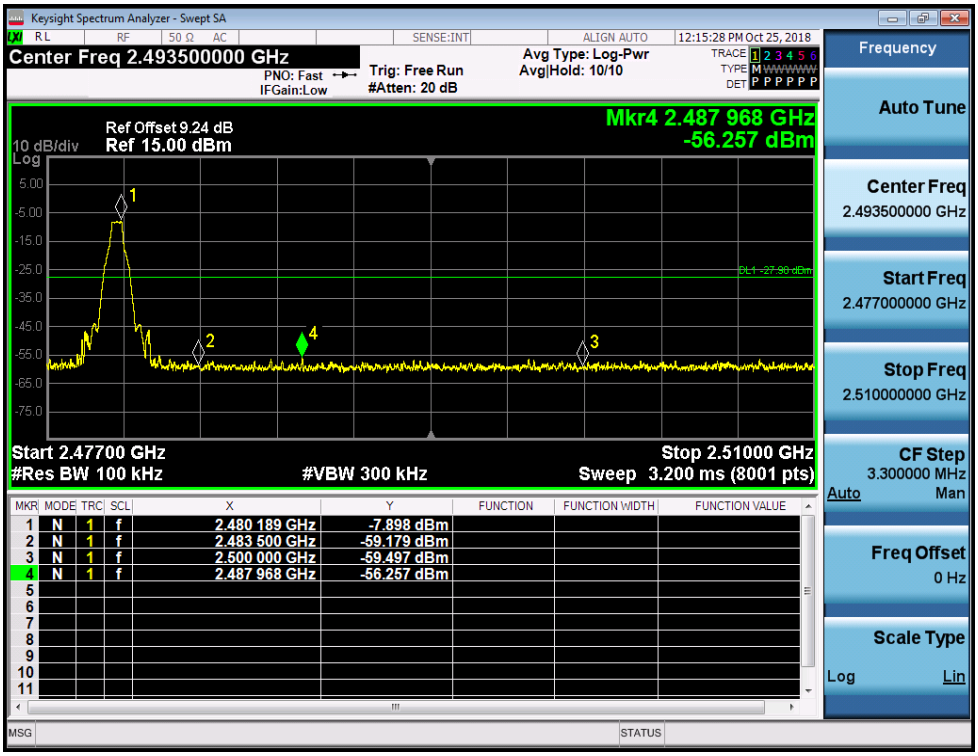
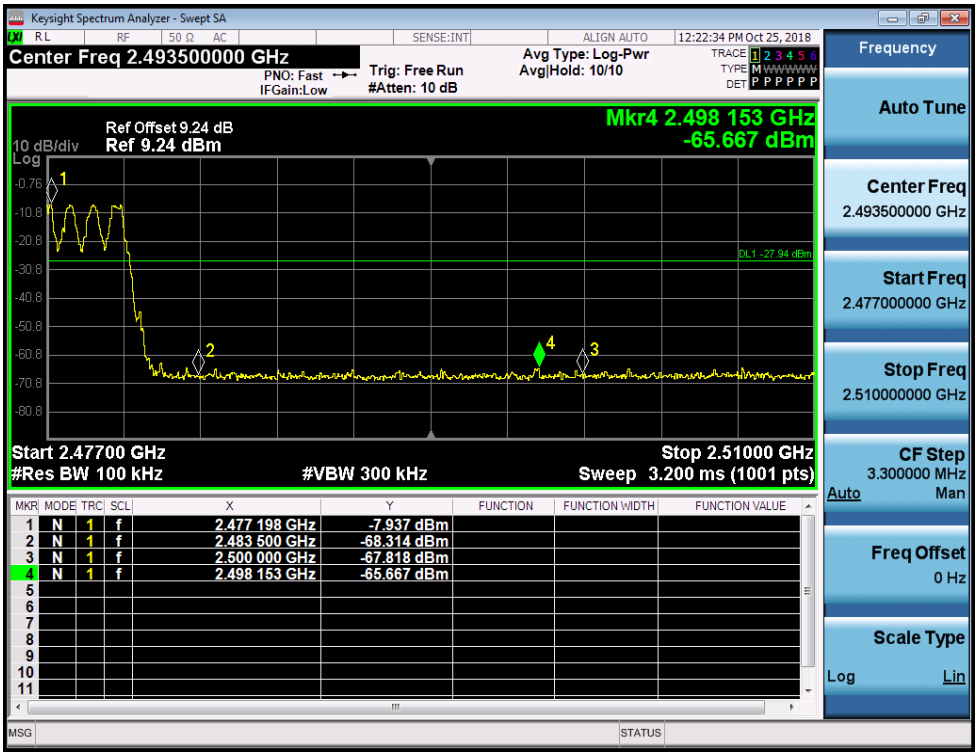
4.6.3 Test Result of Conducted Band Edges

Test Mode :	Transmitting	Temperature :	24~26℃
Test Engineer :	Damon Zhang	Relative Humidity :	67~69%

Data Rate	Modulation	Channel	Carrier Frequency [MHz]	Carrier Power [dBm]	Frequency Hopping	Max Spurious Level [dBm]	Limit [dBm]	Verdict
1Mbps	GFSK	LCH	2402	-5.587	Off	-54.203	-25.59	PASS
				-6.292	On	-54.735	-26.29	PASS
1Mbps	GFSK	HCH	2480	-7.898	Off	-56.257	-27.9	PASS
				-7.937	On	-65.667	-27.94	PASS

Conducted Band Edge Polt

Graphs	
GFSK/LCH/No Hop	
GFSK/LCH/Hop	

GFSK/HCH/No Hop	
GFSK/HCH/Hop	

4.7 Conducted Spurious Emission Measurement

4.7.1 Limit of Spurious Emission Measurement

In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.

4.7.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW.
5. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

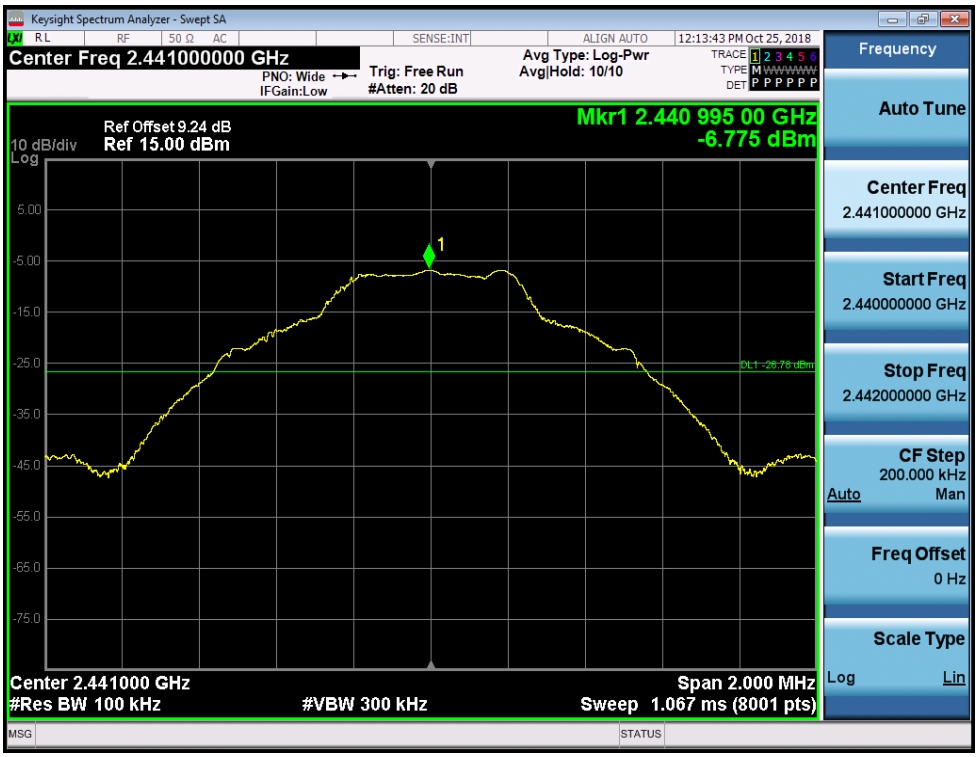
4.7.3 Test Result of Conducted Spurious Emission

Test Mode :	Transmitting	**Temperature :**	24~26℃
Test Engineer :	Damon Zhang	**Relative Humidity :**	67~69%

Data Rate	Modulation	Channel	Pref [dBm]	Puw[dBm]	Verdict
1Mbps	GFSK	LCH	-5.718	<Limit	PASS
1Mbps	GFSK	MCH	-6.775	<Limit	PASS
1Mbps	GFSK	HCH	-7.98	<Limit	PASS

Conducted Spurious Emission Polt

GFSK_LCH_Graphs	
Pref	
Puw	

GFSK_MCH_Graphs	
Pref	
Puw	

GFSK_HCH_Graphs

Pref	 Keysight Spectrum Analyzer - Swept SA Center Freq 2.480000000 GHz PNO: Wide IFGain:Low Trig: Free Run #Atten: 20 dB Avg Type: Log-Pwr Avg|Hold: 10/10 12:15:43 PM Oct 25, 2018 Ref Offset 9.24 dB 10 dB/div Ref 15.00 dBm Mkr1 2.480 000 75 GHz -7.980 dBm DL1 -27.98 dBm Center 2.480000 GHz #Res BW 100 kHz #VBW 300 kHz Span 2.000 MHz Sweep 1.067 ms (8001 pts) Frequency Auto Tune Center Freq 2.480000000 GHz Start Freq 2.479000000 GHz Stop Freq 2.481000000 GHz CF Step 200.000 kHz Auto Man Freq Offset 0 Hz Scale Type Log Lin
Puw	 Keysight Spectrum Analyzer - Swept SA Center Freq 12.515000000 GHz PNO: Fast IFGain:Low Trig: Free Run #Atten: 20 dB Avg Type: Log-Pwr Avg|Hold: 1/10 12:15:54 PM Oct 25, 2018 Ref Offset 9.24 dB 10 dB/div Ref 19.24 dBm Mkr2 24.810 GHz -38.737 dBm DL1 -27.98 dBm Start 30 MHz #Res BW 100 kHz #VBW 300 kHz Stop 25.00 GHz Sweep 2.387 s (8001 pts) Frequency Auto Tune Center Freq 12.515000000 GHz Start Freq 30.000000 MHz Stop Freq 25.000000000 GHz CF Step 2.497000000 GHz Auto Man Freq Offset 0 Hz Scale Type Log Lin

4.8 Radiated Band Edges and Spurious Emission Measurement

4.8.1 Limit of Radiated Band Edges and Spurious Emission

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. In addition, radiated emissions which fall in the restricted bands must also comply with the FCC section 15.209 limits as below.

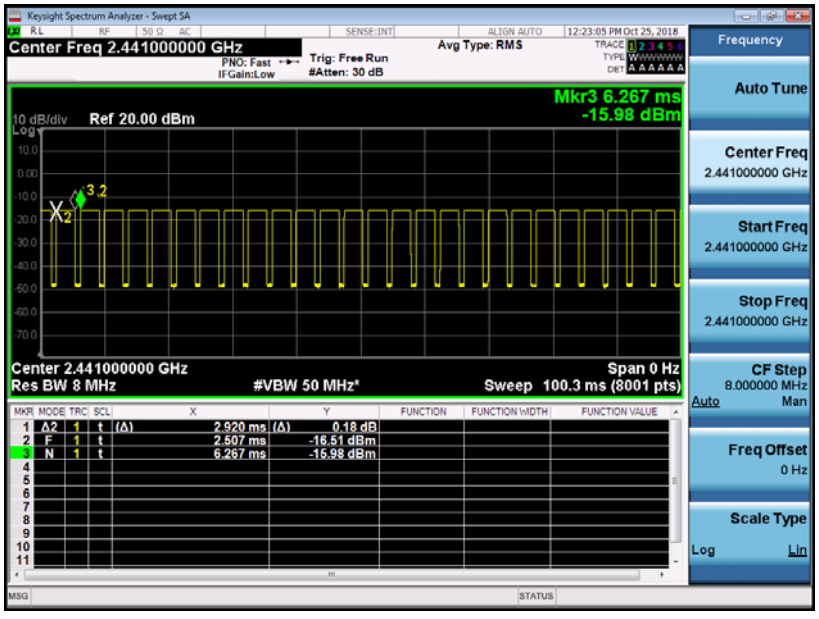
Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 - 960	200	3
Above 960	500	3

Note: The frequency range from 9KHz to 10th harmonic (25GHz) are checked, and no any emissions were found from 18GHz to 25GHz, So the radiated emissions from 18GHz to 25GHz were not record.

4.8.2 Test Procedures

6. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
7. The measurement distance is 3 meter.
8. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
9. Set to the maximum power setting and enable the EUT transmit continuously.
10. Use the following spectrum analyzer settings:
    (1) Span shall wide enough to fully capture the emission being measured;
    (2) Set RBW=100 kHz for f < 1 GHz, RBW=1MHz for f>1GHz ; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
    (3) For average measurement:
    VBW = 10 Hz, when duty cycle is no less than 98 percent.
    VBW ≥ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.

Band	Duty Cycle(%)	T(ms)	1/T(kHz)	VBW Setting
1Mbps	77.66	2.920	0.34	1KHz



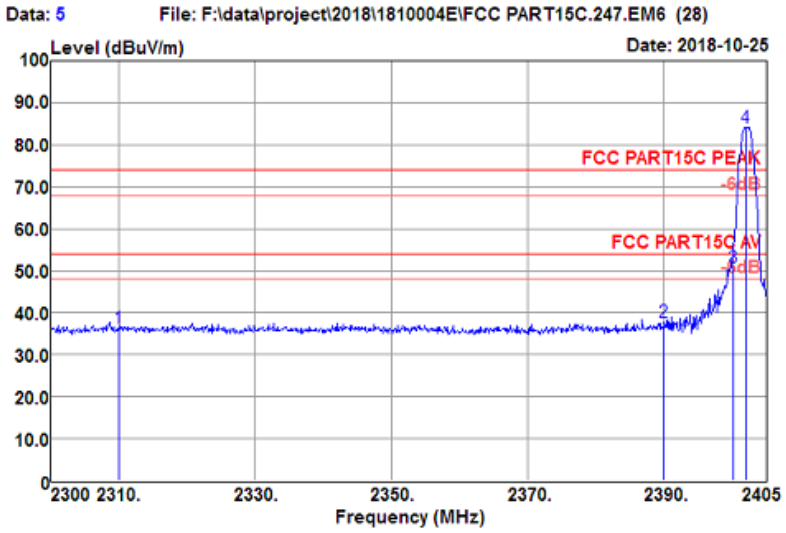
Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

4.8.3 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

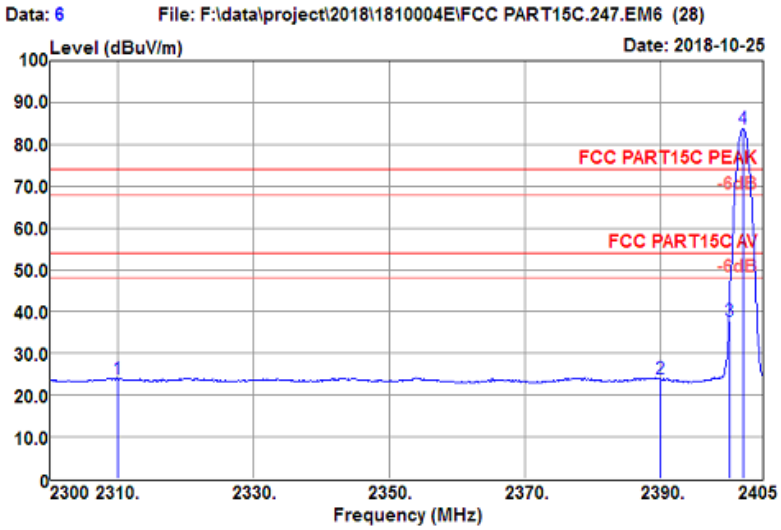
The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

4.8.4 Test Result of Radiated Spurious at Band Edges

Low Channel Horizontal:

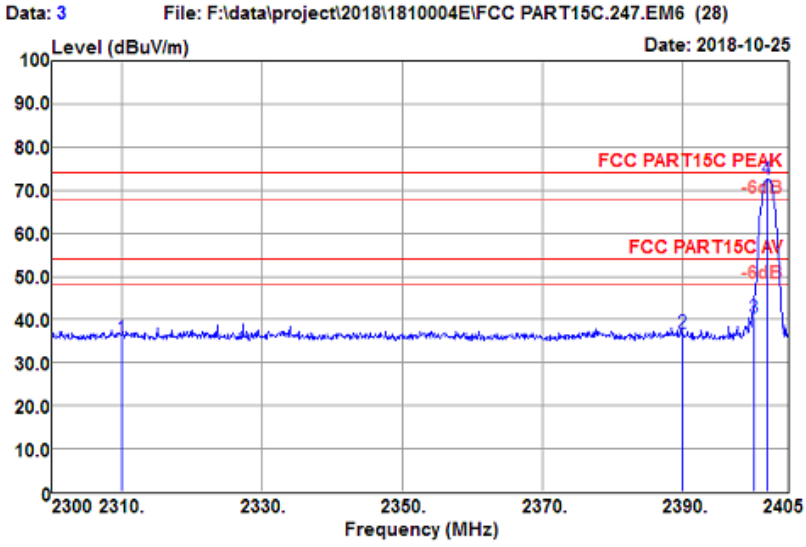


Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2310.000	41.70	26.91	3.56	35.87	36.30	74.00	-37.70	Peak
2390.000	43.03	27.11	3.64	36.08	37.70	74.00	-36.30	Peak
2400.000	56.03	27.14	3.65	36.11	50.71	74.00	-23.29	Peak
2401.850	89.38	27.14	3.65	36.11	84.06	74.00	10.06	Peak

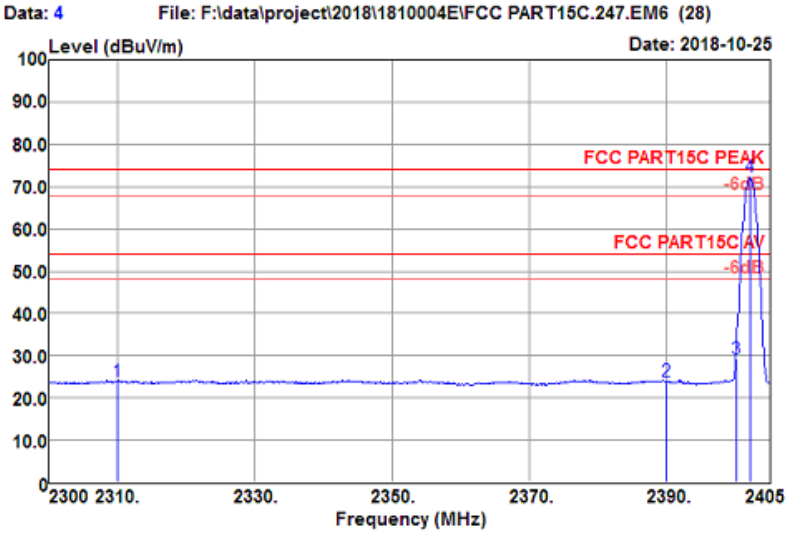


Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2309.975	29.43	26.91	3.56	35.87	24.03	54.00	-29.97	Average
2390.000	29.17	27.11	3.64	36.08	23.84	54.00	-30.16	Average
2400.000	43.20	27.14	3.65	36.11	37.88	54.00	-16.12	Average
2402.060	89.17	27.15	3.65	36.11	83.86	54.00	29.86	Average

Low Channel Vertical:

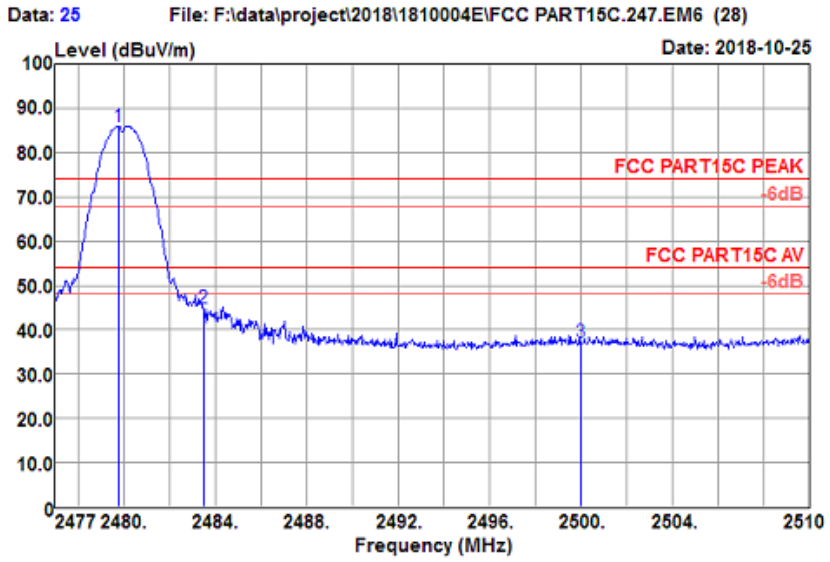


Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2309.975	41.24	26.91	3.56	35.87	35.84	74.00	-38.16	Peak
2390.000	42.12	27.11	3.64	36.08	36.79	74.00	-37.21	Peak
2400.000	45.83	27.14	3.65	36.11	40.51	74.00	-33.49	Peak
2401.850	77.78	27.14	3.65	36.11	72.46	74.00	-1.54	Peak

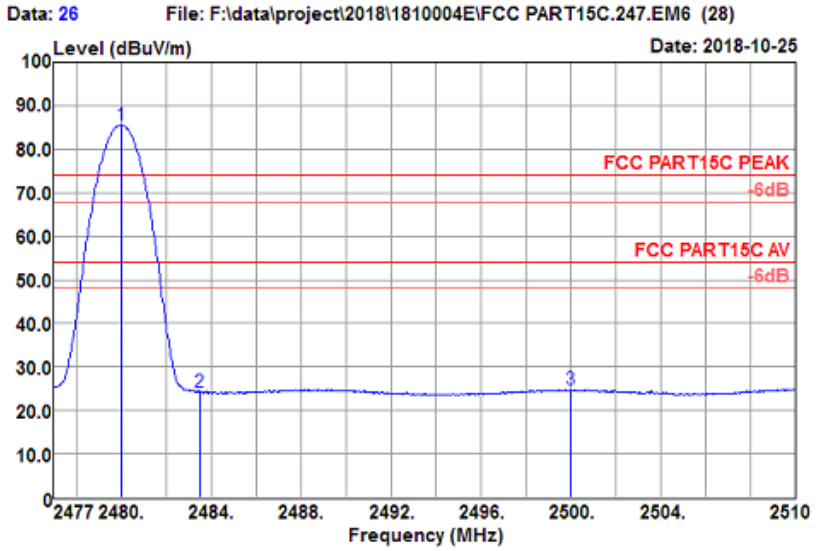


Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2309.975	29.27	26.91	3.56	35.87	23.87	54.00	-30.13	Average
2390.000	29.20	27.11	3.64	36.08	23.87	54.00	-30.13	Average
2400.000	34.51	27.14	3.65	36.11	29.19	54.00	-24.81	Average
2402.060	77.47	27.15	3.65	36.11	72.16	54.00	18.16	Average

High Channel Horizontal:

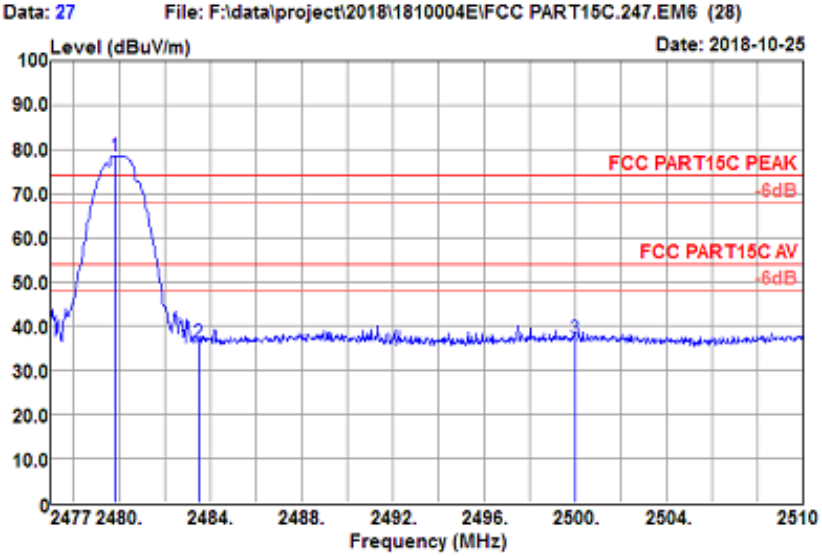


Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2479.805	91.19	27.35	3.68	36.32	85.90	74.00	11.90	Peak
2483.500	50.00	27.36	3.68	36.33	44.71	74.00	-29.29	Peak
2500.000	42.56	27.40	3.68	36.37	37.27	74.00	-36.73	Peak

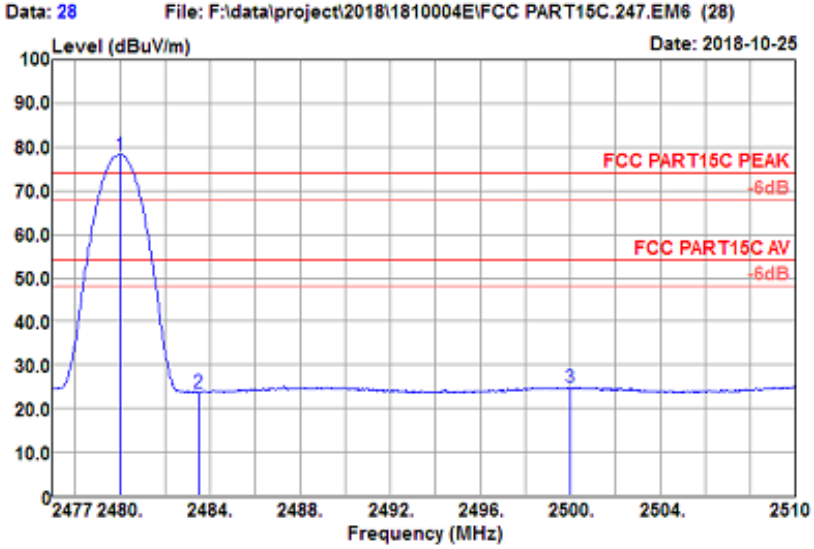


Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2480.036	90.86	27.35	3.68	36.32	85.57	54.00	31.57	Average
2483.501	29.51	27.36	3.68	36.33	24.22	54.00	-29.78	Average
2500.000	29.99	27.40	3.68	36.37	24.70	54.00	-29.30	Average

High Channel Vertical:



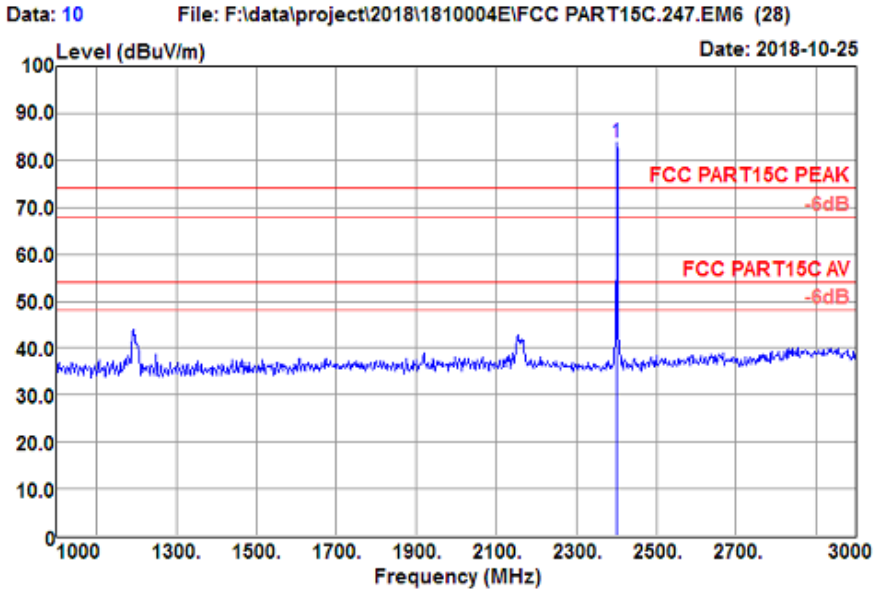
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
2479.838	83.85	27.35	3.68	36.32	78.56	74.00	4.56	Peak
2483.500	41.73	27.36	3.68	36.33	36.44	74.00	-37.56	Peak
2500.000	42.50	27.40	3.68	36.37	37.21	74.00	-36.79	Peak



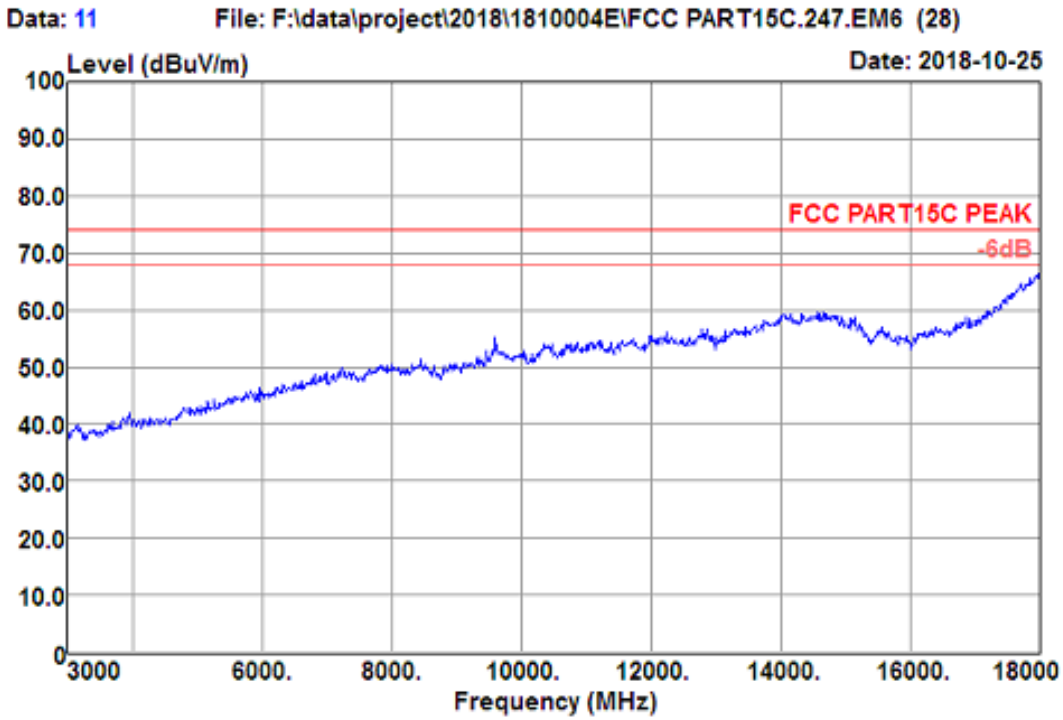
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2480.036	83.54	27.35	3.68	36.32	78.25	54.00	24.25	Average
2483.501	29.00	27.36	3.68	36.33	23.71	54.00	-30.29	Average
2500.000	29.97	27.40	3.68	36.37	24.68	54.00	-29.32	Average

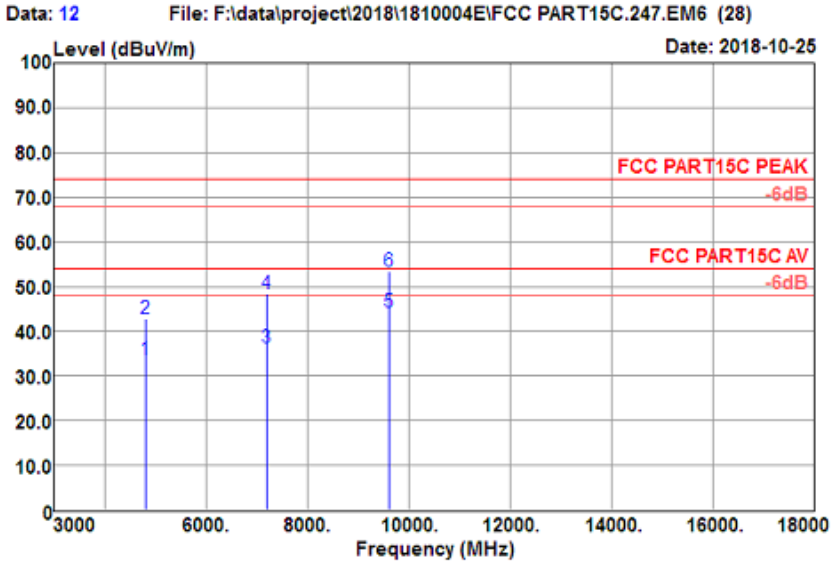
4.8.5 Test Result of Radiated Spurious Emission (1GHz ~ 10th Harmonic)

Low Channel Horizontal:



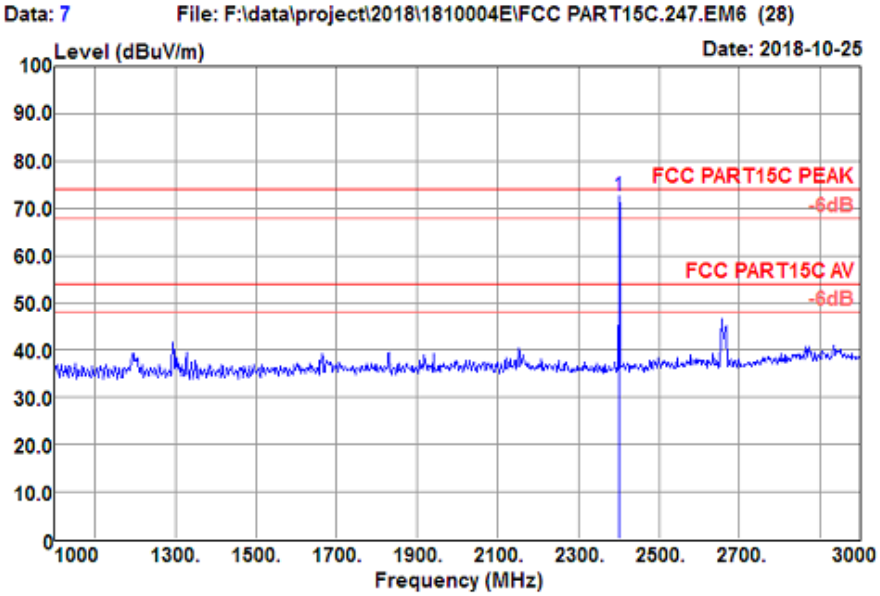
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2402.000	89.21	27.15	3.65	36.11	83.90	74.00	9.90	Peak



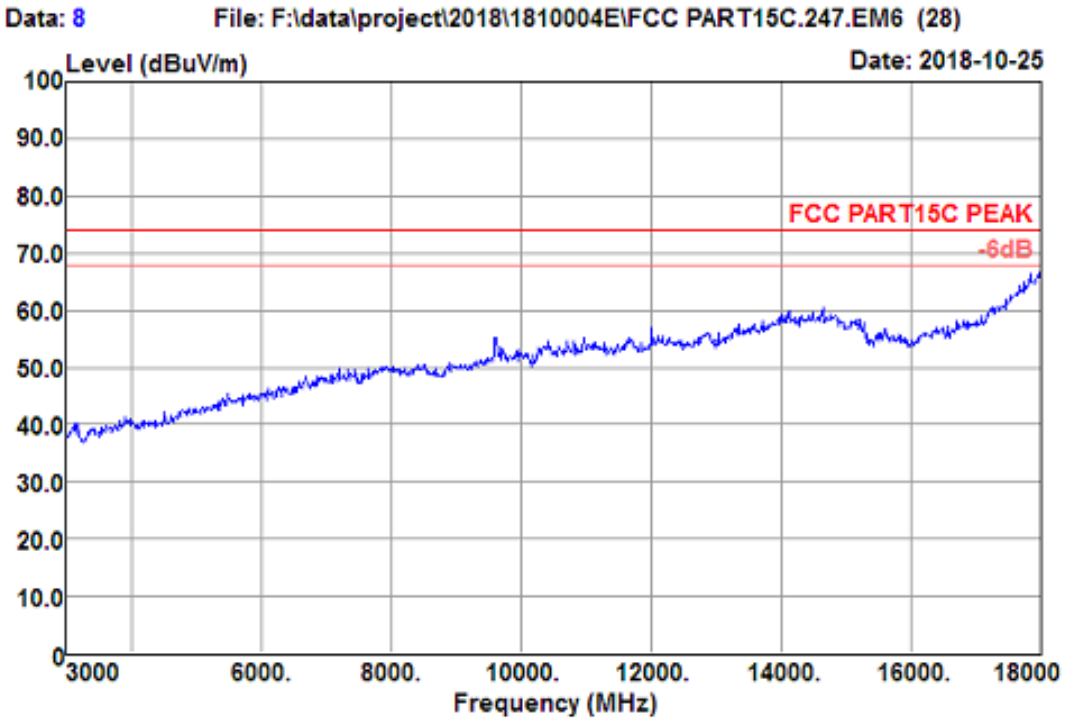


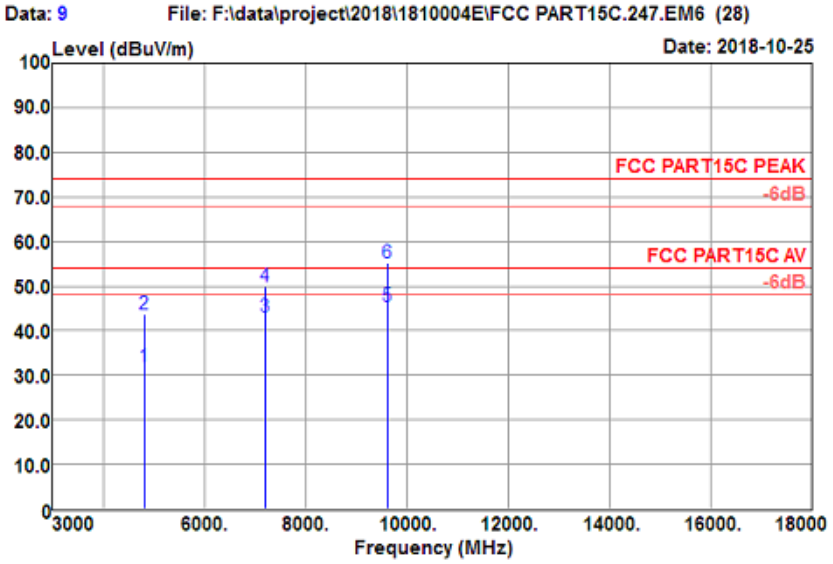
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
4804.000	33.33	31.23	5.45	36.27	33.74	54.00	-20.26	Average
4804.000	42.33	31.23	5.45	36.27	42.74	74.00	-31.26	Peak
7206.000	27.84	35.87	6.94	34.25	36.40	54.00	-17.60	Average
7206.000	39.89	35.87	6.94	34.25	48.45	74.00	-25.55	Peak
9608.000	32.75	37.79	7.77	34.13	44.18	54.00	-9.82	Average
9608.000	41.97	37.79	7.77	34.13	53.40	74.00	-20.60	Peak

Low Channel Vertical:



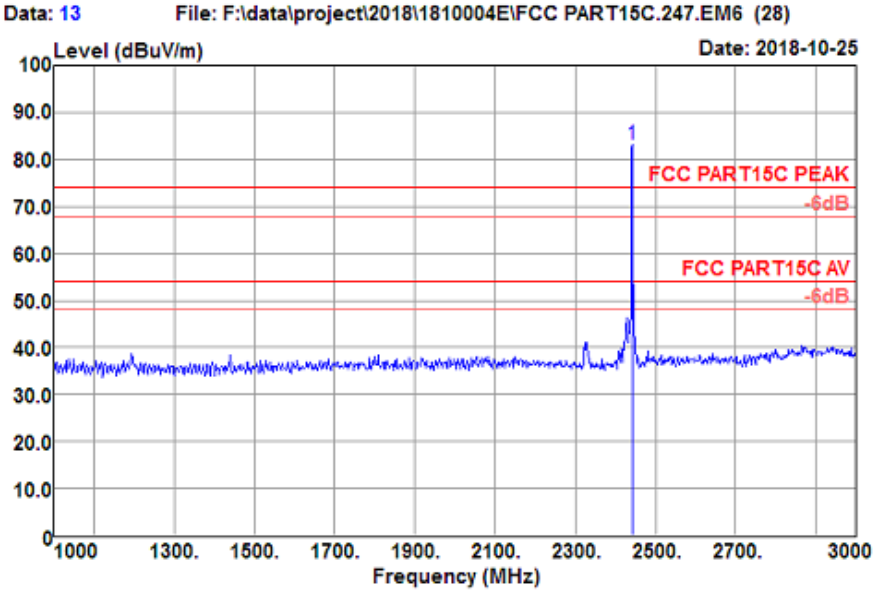
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2402.000	77.79	27.15	3.65	36.11	72.48	74.00	-1.52	Peak



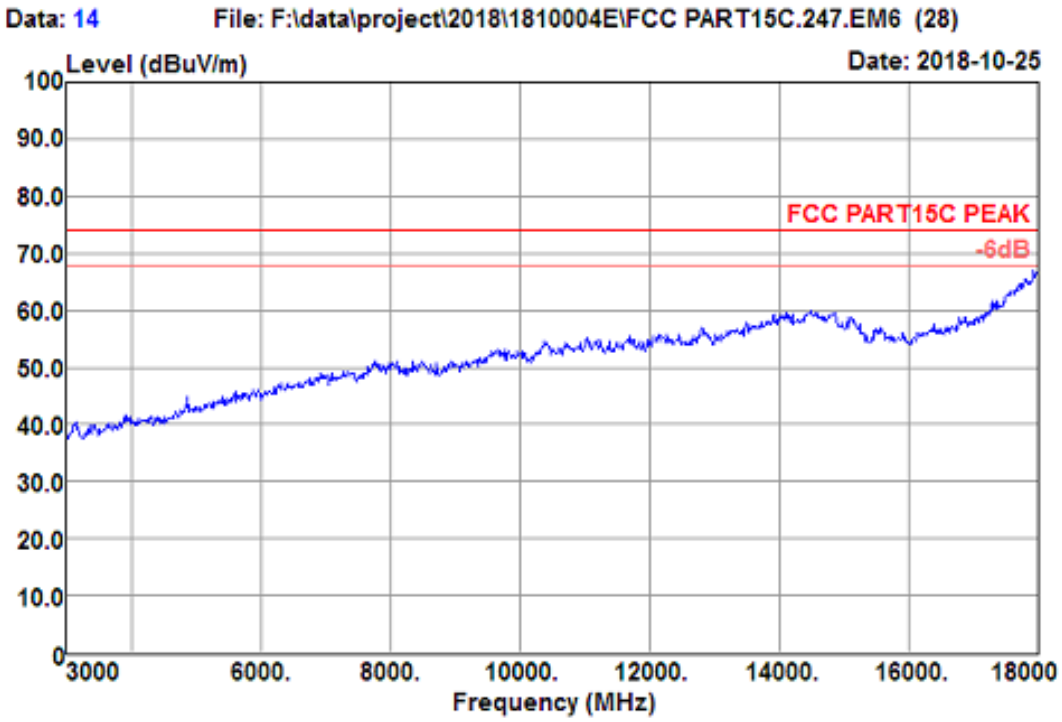


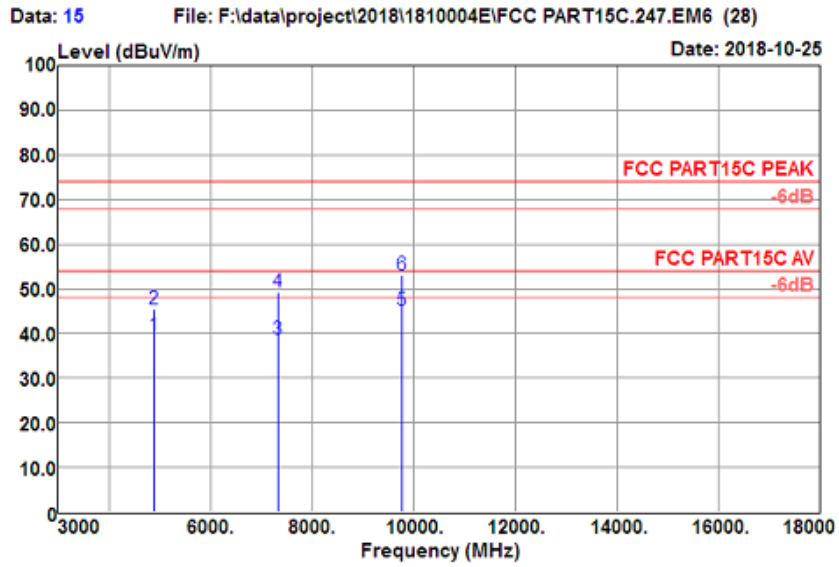
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
4804.000	31.46	31.23	5.45	36.27	31.87	54.00	-22.13	Average
4804.000	43.35	31.23	5.45	36.27	43.76	74.00	-30.24	Peak
7206.000	34.60	35.87	6.94	34.25	43.16	54.00	-10.84	Average
7206.000	41.35	35.87	6.94	34.25	49.91	74.00	-24.09	Peak
9608.000	34.13	37.79	7.77	34.13	45.56	54.00	-8.44	Average
9608.000	43.61	37.79	7.77	34.13	55.04	74.00	-18.96	Peak

Middle Channel Horizontal:



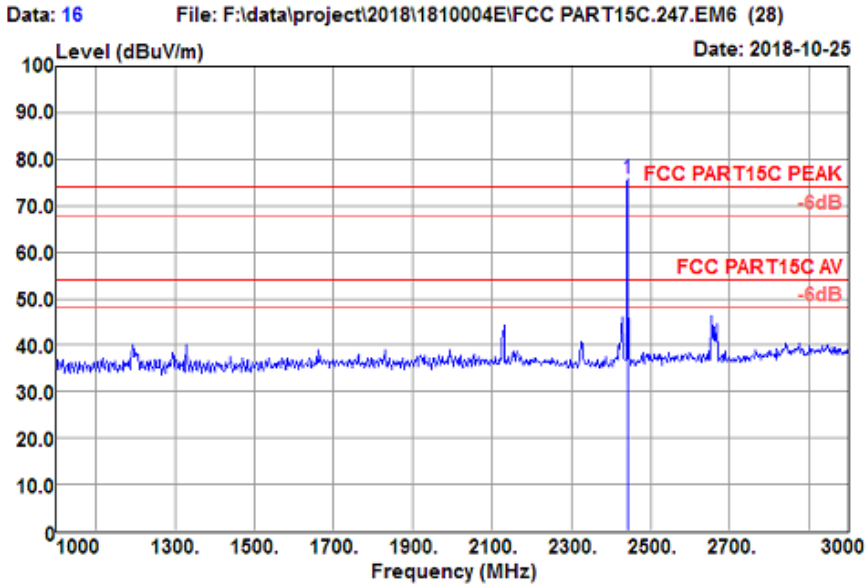
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2442.000	88.47	27.25	3.66	36.22	83.16	74.00	9.16	Peak



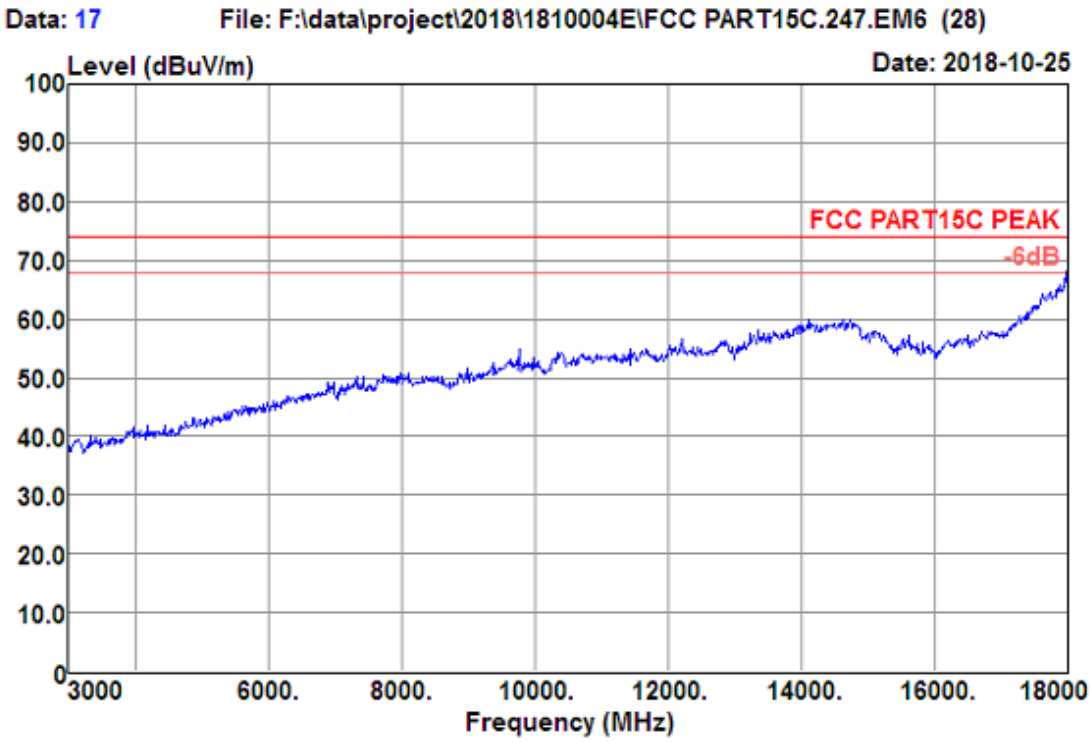


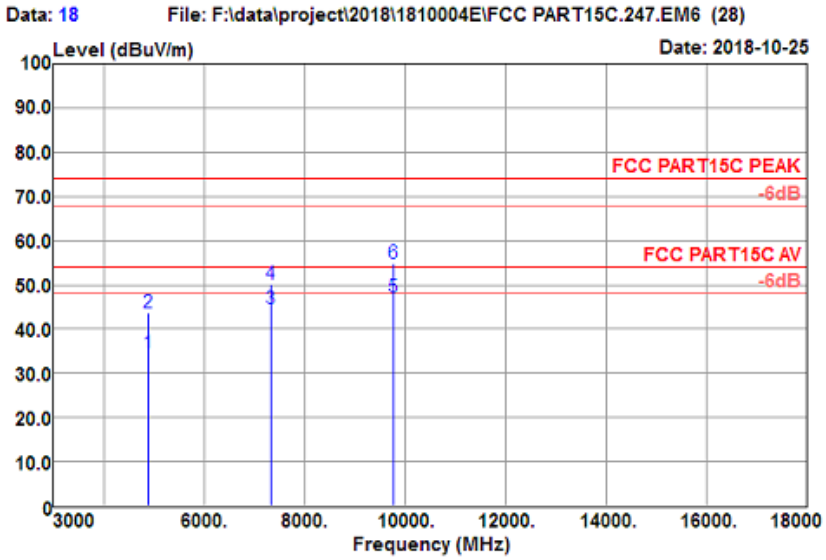
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
4882.000	39.10	31.42	5.40	36.24	39.68	54.00	-14.32	Average
4882.000	44.76	31.42	5.40	36.24	45.34	74.00	-28.66	Peak
7323.000	29.66	36.14	7.28	34.36	38.72	54.00	-15.28	Average
7323.000	40.09	36.14	7.28	34.36	49.15	74.00	-24.85	Peak
9764.000	33.26	38.08	7.98	34.20	45.12	54.00	-8.88	Average
9764.000	41.33	38.08	7.98	34.20	53.19	74.00	-20.81	Peak

Middle Channel Vertical:



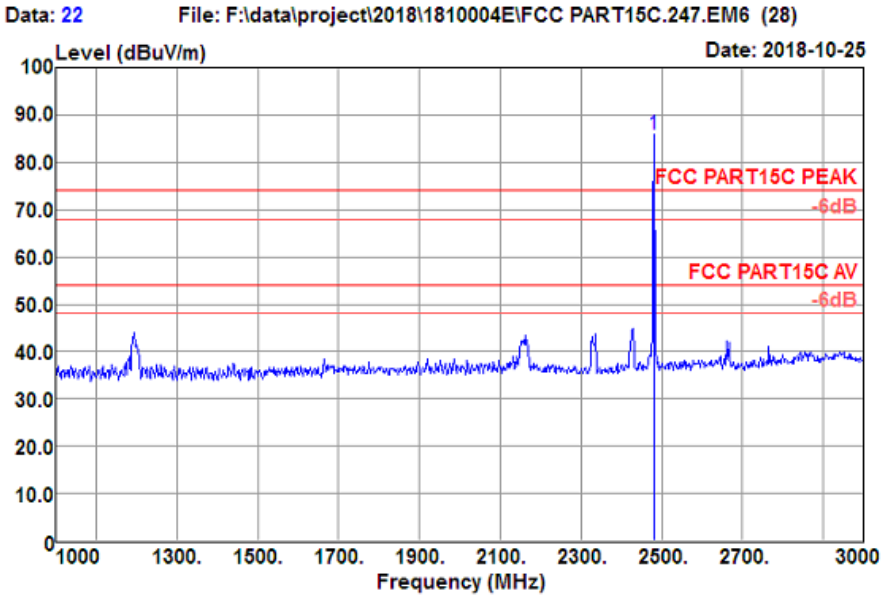
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2442.000	81.20	27.25	3.66	36.22	75.89	74.00	1.89	Peak



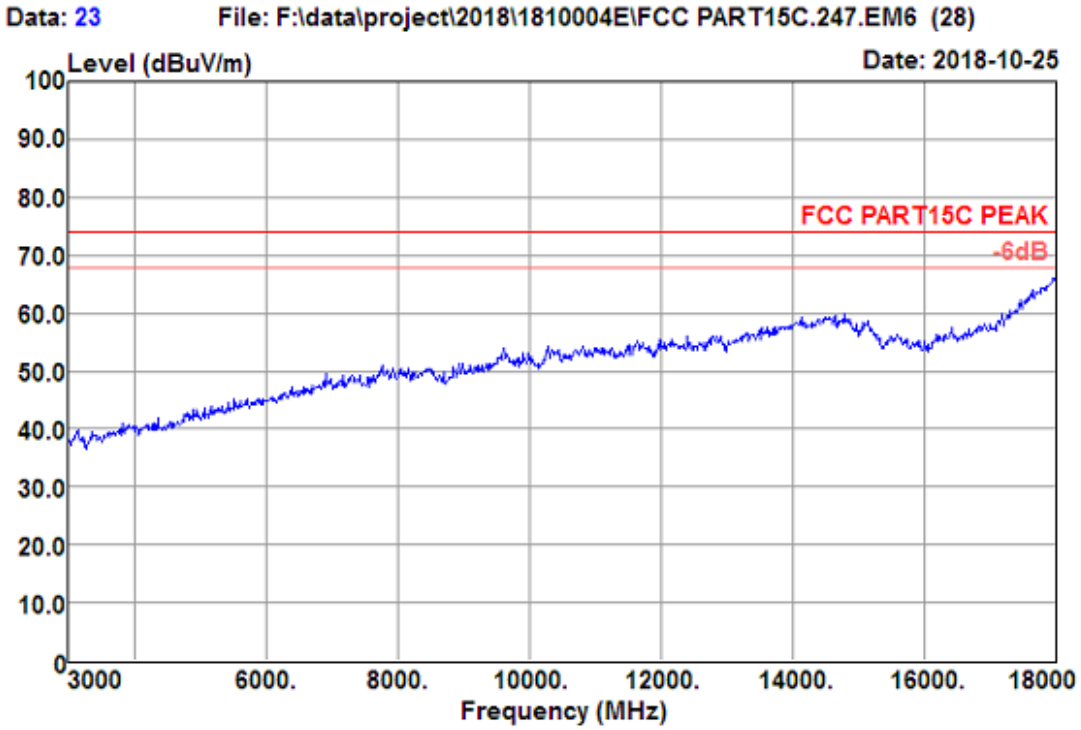


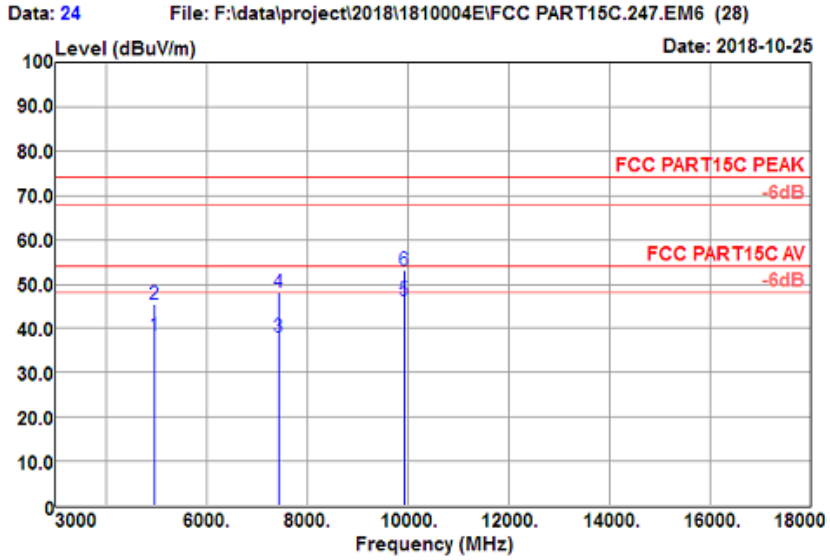
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
4882.000	33.96	31.42	5.40	36.24	34.54	54.00	-19.46	Average
4882.000	43.11	31.42	5.40	36.24	43.69	74.00	-30.31	Peak
7323.000	35.54	36.14	7.28	34.36	44.60	54.00	-9.40	Average
7323.000	41.05	36.14	7.28	34.36	50.11	74.00	-23.89	Peak
9764.000	35.46	38.08	7.98	34.20	47.32	54.00	-6.68	Average
9764.000	43.04	38.08	7.98	34.20	54.90	74.00	-19.10	Peak

High Channel Horizontal:



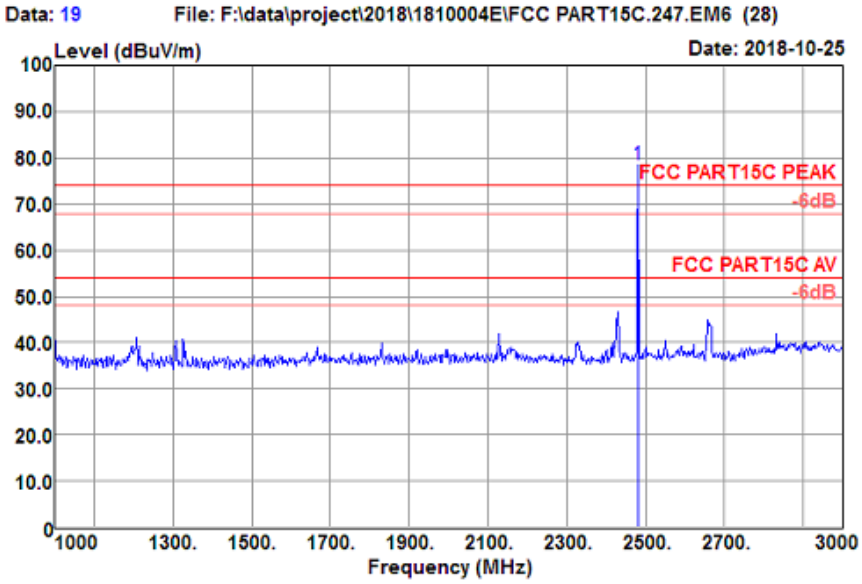
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2480.000	91.16	27.35	3.68	36.32	85.87	74.00	11.87	Peak



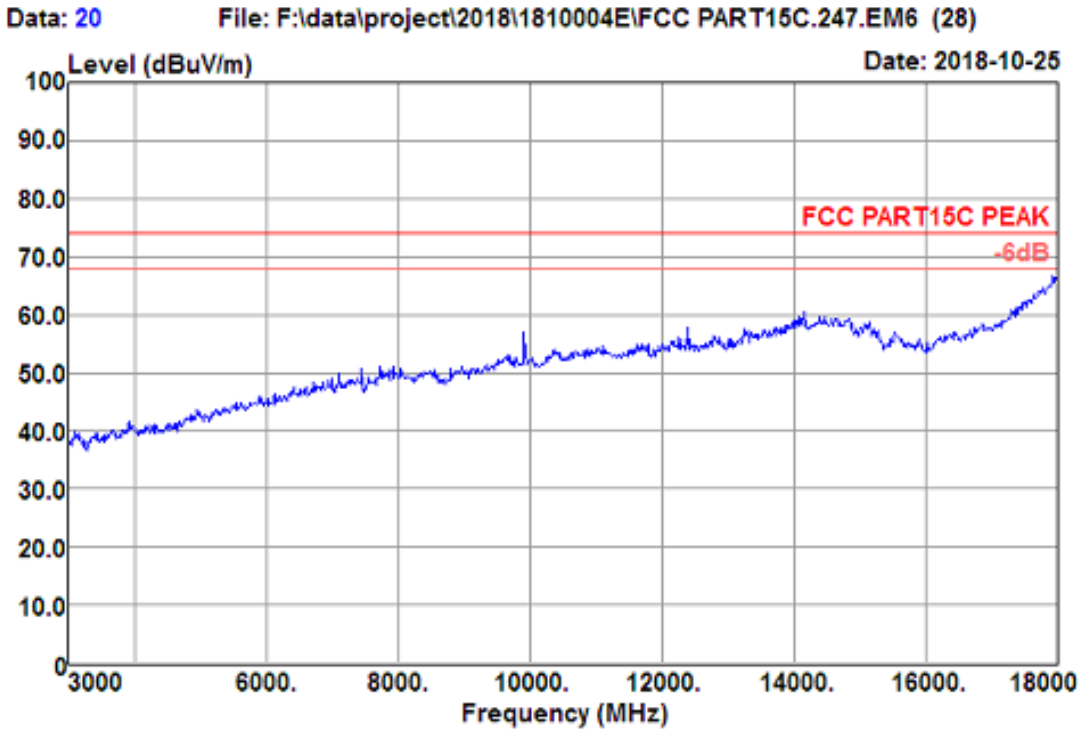


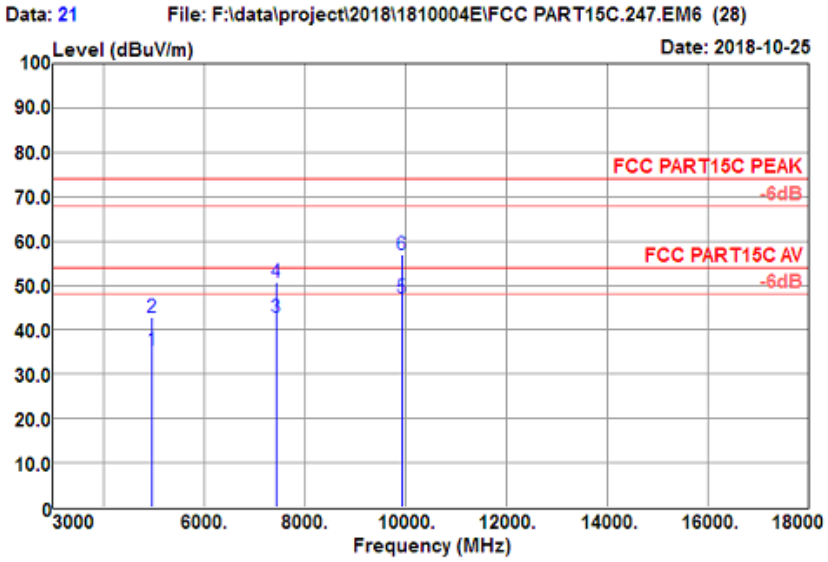
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
4960.000	37.65	31.60	5.36	36.21	38.40	54.00	-15.60	Average
4960.000	44.65	31.60	5.36	36.21	45.40	74.00	-28.60	Peak
7440.000	28.59	36.41	7.44	34.47	37.97	54.00	-16.03	Average
7440.000	38.80	36.41	7.44	34.47	48.18	74.00	-25.82	Peak
9920.000	34.18	38.36	8.05	34.26	46.33	54.00	-7.67	Average
9920.000	40.95	38.36	8.05	34.26	53.10	74.00	-20.90	Peak

High Channel Vertical:



Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
2480.000	83.89	27.35	3.68	36.32	78.60	74.00	4.60	Peak

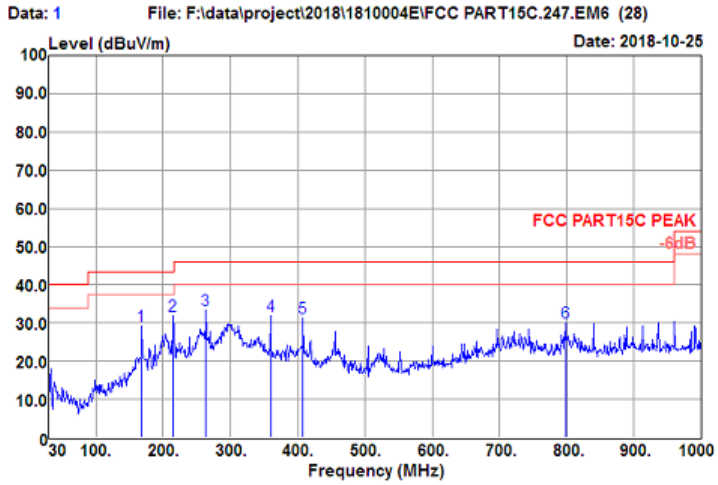




Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV	dBuV/m	dB	
4960.000	34.67	31.60	5.36	36.21	35.42	54.00	-18.58	Average
4960.000	42.05	31.60	5.36	36.21	42.80	74.00	-31.20	Peak
7440.000	33.34	36.41	7.44	34.47	42.72	54.00	-11.28	Average
7440.000	41.43	36.41	7.44	34.47	50.81	74.00	-23.19	Peak
9920.000	35.03	38.36	8.05	34.26	47.18	54.00	-6.82	Average
9920.000	44.76	38.36	8.05	34.26	56.91	74.00	-17.09	Peak

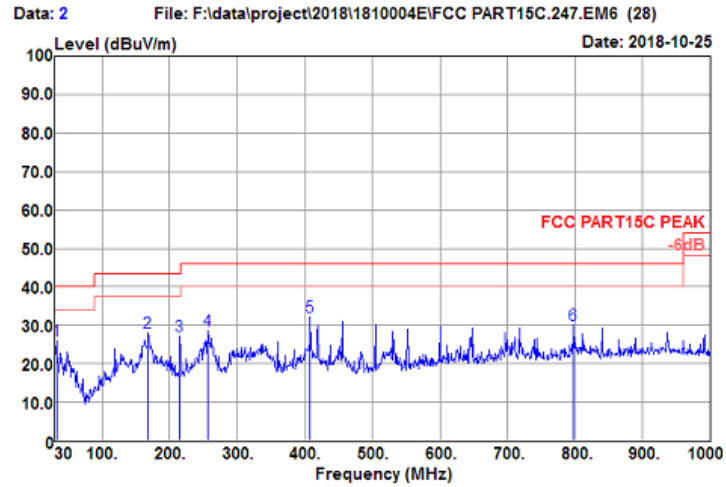
4.8.6 Test Result of Radiated Spurious Emission (30MHz ~ 1GHz)

Horizontal:



Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
167.740	45.63	13.43	2.53	32.52	29.07	43.50	-14.43	Peak
215.270	51.02	10.36	2.91	32.54	31.75	43.50	-11.75	Peak
263.770	50.94	11.81	3.25	32.53	33.47	46.00	-12.53	Peak
359.800	46.47	14.04	3.86	32.49	31.88	46.00	-14.12	Peak
408.300	44.90	14.94	4.04	32.48	31.40	46.00	-14.60	Peak
798.240	35.99	20.78	6.11	32.65	30.23	46.00	-15.77	Peak

Vertical:



Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV	Limit level dBuV/m	Over limit dB	Remark
32.910	44.24	13.32	1.04	32.53	26.07	40.00	-13.93	Peak
167.740	44.53	13.43	2.53	32.52	27.97	43.50	-15.53	Peak
215.270	46.53	10.36	2.91	32.54	27.26	43.50	-16.24	Peak
256.980	46.41	11.61	3.23	32.53	28.72	46.00	-17.28	Peak
408.300	45.73	14.94	4.04	32.48	32.23	46.00	-13.77	Peak
797.270	36.00	20.77	6.10	32.65	30.22	46.00	-15.78	Peak

4.9 AC Conducted Emission Measurement

4.9.1 Limit of AC Conducted Emission

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

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

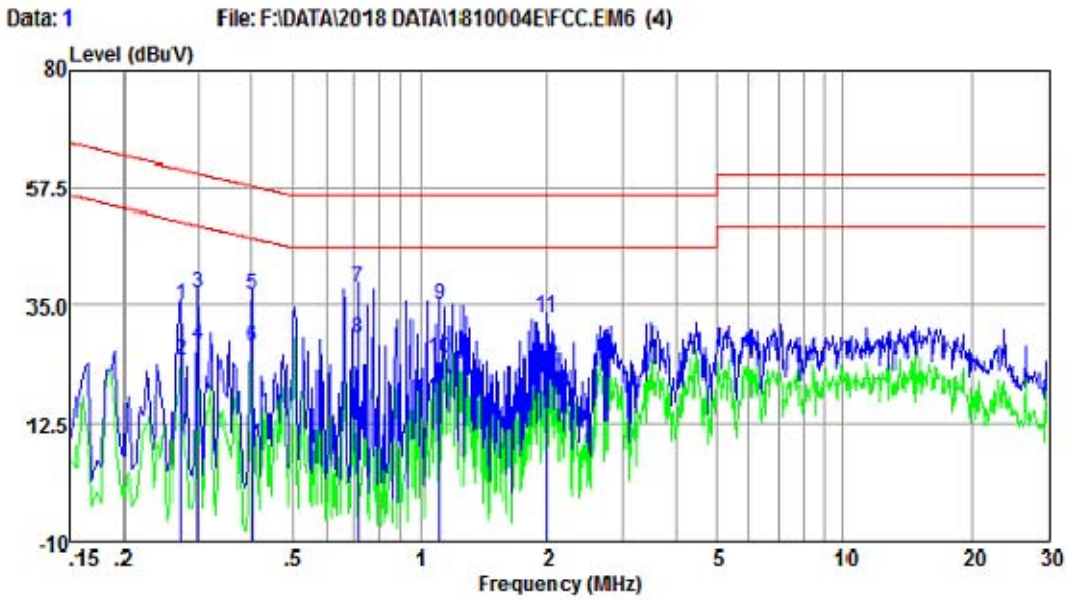
*Decreases with the logarithm of the frequency.

4.9.2 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

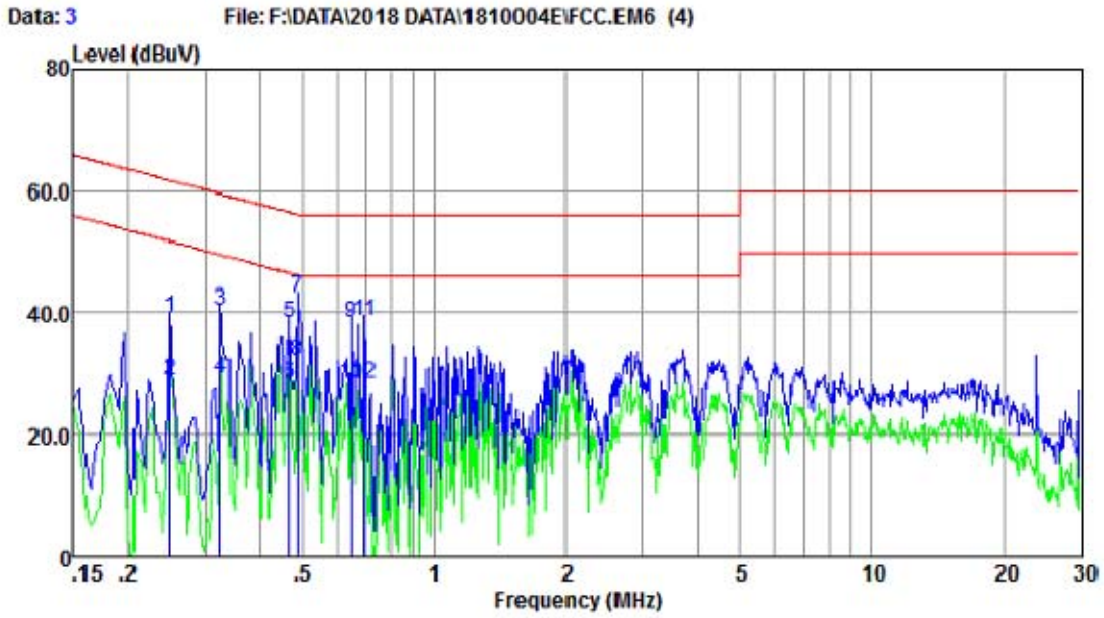
4.9.3 Test Result of AC Conducted Emission

Test Mode :	Mode 1	**Temperature :**	21~23℃
Test Engineer :	Damon Zhang	**Relative Humidity :**	61~63%
Test Voltage :	120Vac / 60Hz	**Phase :**	Line
Function Type :	Bluetooth Link + USB Cable (Charging from Adapter)		



Freq	Reading level	LISN/ISN factor	Cable loss	level	Limit level	Over limit	Remark
MHz	dBuV	dB	dB	dBuV	dBuV	dB	
0.272	25.56	9.57	0.01	35.14	61.07	-25.93	QP
0.272	14.92	9.57	0.01	24.50	51.07	-26.57	Average
0.299	27.86	9.57	0.01	37.44	60.28	-22.84	QP
0.299	17.84	9.57	0.01	27.42	50.28	-22.86	Average
0.402	27.42	9.58	0.02	37.02	57.81	-20.79	QP
0.402	17.47	9.58	0.02	27.07	47.81	-20.74	Average
0.716	29.02	9.59	0.03	38.64	56.00	-17.36	QP
0.716	19.17	9.59	0.03	28.79	46.00	-17.21	Average
1.111	25.40	9.59	0.04	35.03	56.00	-20.97	QP
1.111	15.37	9.59	0.04	25.00	46.00	-21.00	Average
1.991	23.09	9.59	0.03	32.71	56.00	-23.29	QP
1.991	13.88	9.59	0.03	23.50	46.00	-22.50	Average

Test Mode :	Mode 1	Temperature :	21~23℃
Test Engineer :	Damon Zhang	Relative Humidity :	61~63%
Test Voltage :	120Vac / 60Hz	Phase :	Neutral
Function Type :	Bluetooth Link + USB Cable (Charging from Adapter)		



Freq	Reading level	LISN/ISN factor	Cable loss	level	Limit level	Over limit	Remark
MHz	dBuV	dB	dB	dBuV	dBuV	dB	
0.249	29.52	9.59	0.01	39.12	61.78	-22.66	QP
0.249	19.18	9.59	0.01	28.78	51.78	-23.00	Average
0.325	30.73	9.61	0.02	40.36	59.57	-19.21	QP
0.325	19.73	9.61	0.02	29.36	49.57	-20.21	Average
0.466	28.68	9.63	0.02	38.33	56.58	-18.25	QP
0.466	18.83	9.63	0.02	28.48	46.58	-18.10	Average
0.486	32.84	9.63	0.02	42.49	56.23	-13.74	QP
0.486	22.40	9.63	0.02	32.05	46.23	-14.18	Average
0.644	28.85	9.64	0.03	38.52	56.00	-17.48	QP
0.644	18.53	9.64	0.03	28.20	46.00	-17.80	Average
0.694	28.98	9.64	0.03	38.65	56.00	-17.35	QP
0.694	18.81	9.64	0.03	28.48	46.00	-17.52	Average

4.10 Antenna Requirements

4.10.1 Standard Applicable

According to antenna requirement of §15.203.

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded..

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

4.10.2 Antenna Connected Construction

An embedded-in antenna design is used.

4.10.3 Antenna Gain

The antenna peak gain of EUT is 1.87dBi.

5 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
Spectrum Analyzer	Keysight	N9010A	MY56070788	2018-03-02	2019-03-01	Conducted
Power Sensor	Keysight	U2021XA	MY56510025	2018-03-02	2019-03-01	Conducted
Power Sensor	Keysight	U2021XA	MY57030005	2018-03-02	2019-03-01	Conducted
Power Sensor	Keysight	U2021XA	MY56510018	2018-03-02	2019-03-01	Conducted
Power Sensor	Keysight	U2021XA	MY56480002	2018-03-02	2019-03-01	Conducted
Thermal Chamber	Sanmtest	SMC-408-CD	2435	2018-07-05	2019-07-04	Conducted
Base Station	R&S	CMW 270	101231	2018-03-17	2019-03-16	Conducted
Signal Generator (Interferer)	Keysight	N5182B	MY56200384	2018-04-10	2019-04-09	Conducted
Signal Generator (Blocker)	Keysight	N5171B	MY56200661	2018-03-15	2019-03-14	Conducted

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV 40	101433	2018-03-14	2019-03-13	Radiation
Amplifier	Sonoma	310	363917	2018-03-06	2019-03-05	Radiation
Amplifier	Schwarzbeck	BBV 9718	327	2018-03-14	2019-03-13	Radiation
Amplifier	Narda	TTA1840-35-HG	2034380	2018-07-18	2019-07-17	Radiation
Broadband Antenna	Schwarzbeck	VULB 9168	9168-757	2017-03-03	2020-03-02	Radiation
Horn Antenna	Schwarzbeck	BBHA 9120 D	1677	2017-03-03	2020-03-02	Radiation
Horn Antenna	COM-POWER	AH-1840	101117	2018-06-20	2021-06-19	Radiation
Test Software	Auidx	E3	6.111221a	N/A	N/A	Radiation
Filter	Micro-Tronics	BRM 50702	G266	N/A	N/A	Radiation

N/A: No Calibration Required

6 Uncertainty of Evaluation

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

MEASUREMENT	FREQUENCY	UNCERTAINTY
Conducted emissions	9kHz~30MHz	2.64dB
Radiated emission	30MHz ~ 1GMHz	5.05dB
	1GHz ~ 18GHz	5.06 dB
	18GHz ~ 40GHz	3.65dB

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