FCC RF Test Report

APPLICANT	:	Brammallite LLC
EQUIPMENT	:	Digital Receiver
MODEL NAME	:	B78C5E
FCC ID	:	2AYZO-2783
STANDARD	:	FCC Part 15 Subpart C §15.247
CLASSIFICATION	:	(DSS) Spread Spectrum Transmitter

The product was completed on Mar. 16, 2021. We, Sporton International (Kunshan) Inc., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International (Kunshan) Inc., the test report shall not be reproduced except in full.

Jason Jia

Reviewed by: Jason Jia / Supervisor

Alex wang

Approved by: Alex Wang / Manager

ACCREDITED
Cert #5145.02

Sporton International (Kunshan) Inc.
No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China

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REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR112616A	Rev. 01	Initial issue of report	Apr. 30, 2021

SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result
3.1	15.247(a)(1)	Number of Channels	≥ 15Chs	Pass
3.2	15.247(a)(1)	Hopping Channel Separation	≥ 2/3 of 20dB BW	Pass
3.3	15.247(a)(1)	Dwell Time of Each Channel	≤ 0.4sec in 31.6sec period	Pass
3.4	15.247(a)(1)	20dB Bandwidth	N/A	N/A
3.4	-	99% Bandwidth	-	N/A
3.5	15.247(b)(1)	Peak Output Power	≤ 125 mW	Pass
3.6	15.247(d)	Conducted Band Edges	≤ 20dBc	Pass
3.7	15.247(d)	Conducted Spurious Emission	≤ 20dBc	Pass
3.8	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass
3.9	15.207	AC Conducted Emission	15.207(a)	Pass
3.10	15.203 & 15.247(b)	Antenna Requirement	N/A	N/A

Declaration of Conformity:
The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.
Comments and Explanations:
The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.

1 General Description

1.1 Applicant

Brammallite LLC
1011 South Hamilton Road Chapel Hill, NC 27517

1.2 Product Feature of Equipment Under Test

Product Feature	
Equipment	Digital Receiver
Model Name	B78C5E
FCC ID	2AYZO-2783
EUT supports Radios application	Bluetooth BR/EDR/LE

1.3 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Frequency Range	2402 MHz ~ 2480 MHz
Number of Channels	79
Carrier Frequency of Each Channel	2402+n*1 MHz; n=0~78
Maximum Output Power to Antenna	Bluetooth BR(1Mbps) : 1.31 dBm (0.0014 W) Bluetooth EDR (2Mbps) : 4.22 dBm (0.0026 W)
99% Occupied Bandwidth	Bluetooth BR(1Mbps) : 0.955MHz Bluetooth EDR (2Mbps) : 1.201MHz
Antenna Type / Gain	Fixed internal Antenna with gain 3.5 dBi
Type of Modulation	Bluetooth BR (1Mbps) : GFSK Bluetooth EDR (2Mbps) :π/4-DQPSK

Note: The EUT does not support 3DH mode for BT EDR mode.

1.4 Modification of EUT

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

1.5 Testing Location

Sporton International (Kunshan) Inc. is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.02.

Test Firm	Sporton International (Kunshan) Inc.		
Test Site Location	No. 1098, Pengxi North Road, Kunshan Economic Development Zone Jiangsu Province 215300 People's Republic of China TEL : +86-512-57900158 FAX : +86-512-57900958		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	CO01-KS 03CH06-KS TH01-KS	CN1257	314309

1.6 Test Software

Item	Site	Manufacturer	Name	Version
1.	03CH06-KS	AUDIX	E3	6.2009-8-24al
2.	CO01-KS	Rohde&Schwarz	EMC32	10.60.0.0

1.7 Applicable Standards

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

- 47 CFR Part 15 Subpart C §15.247
- FCC KDB 558074 D01 15.247 Meas Guidance v05r02
- ANSI C63.10-2013

Remark: All test items were verified and recorded according to the standards and without any deviation during the test.

2 Test Configuration of Equipment Under Test

2.1 Carrier Frequency Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
2400-2483.5 MHz	0	2402	27	2429	54	2456
	1	2403	28	2430	55	2457
	2	2404	29	2431	56	2458
	3	2405	30	2432	57	2459
	4	2406	31	2433	58	2460
	5	2407	32	2434	59	2461
	6	2408	33	2435	60	2462
	7	2409	34	2436	61	2463
	8	2410	35	2437	62	2464
	9	2411	36	2438	63	2465
	10	2412	37	2439	64	2466
	11	2413	38	2440	65	2467
	12	2414	39	2441	66	2468
	13	2415	40	2442	67	2469
	14	2416	41	2443	68	2470
	15	2417	42	2444	69	2471
	16	2418	43	2445	70	2472
	17	2419	44	2446	71	2473
	18	2420	45	2447	72	2474
	19	2421	46	2448	73	2475
	20	2422	47	2449	74	2476
	21	2423	48	2450	75	2477
	22	2424	49	2451	76	2478
	23	2425	50	2452	77	2479
	24	2426	51	2453	78	2480
	25	2427	52	2454	-	-
	26	2428	53	2455	-	-

2.2 Test Mode

a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases(X-Plane) were recorded in this report, and the worst mode of radiated spurious emissions is Bluetooth 2Mbps mode, and recorded in this report.

b. AC power line Conducted Emission was tested under maximum output power.

The following summary table is showing all test modes to demonstrate in compliance with the standard.

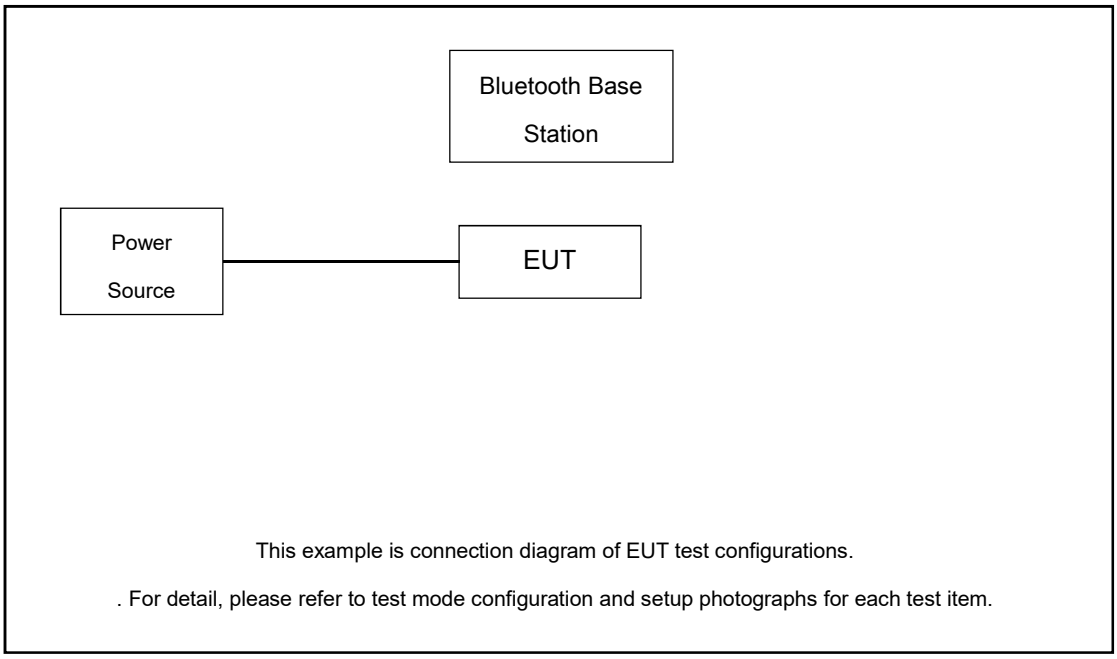
Summary table of Test Cases		
Test Item	**Data Rate / Modulation**	
	Bluetooth BR 1Mbps GFSK	**Bluetooth EDR 2Mbps π/4-DQPSK**
Conducted Test Cases	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz	Mode 4: CH00_2402 MHz Mode 5: CH39_2441 MHz Mode 6: CH78_2480 MHz
Radiated Test Cases	**Bluetooth EDR 2Mbps π/4-DQPSK**	
	Mode 1: CH00_2402 MHz Mode 2: CH39_2441 MHz Mode 3: CH78_2480 MHz	
AC Conducted Emission	Mode 1 : Bluetooth Link + Display (60fps animation, continuous) + PPG (IR LED + HRM AFE) + Haptics + Battery + Accelerometer + Flash Write + USB Cable (Charging from Adapter)	

Remark:

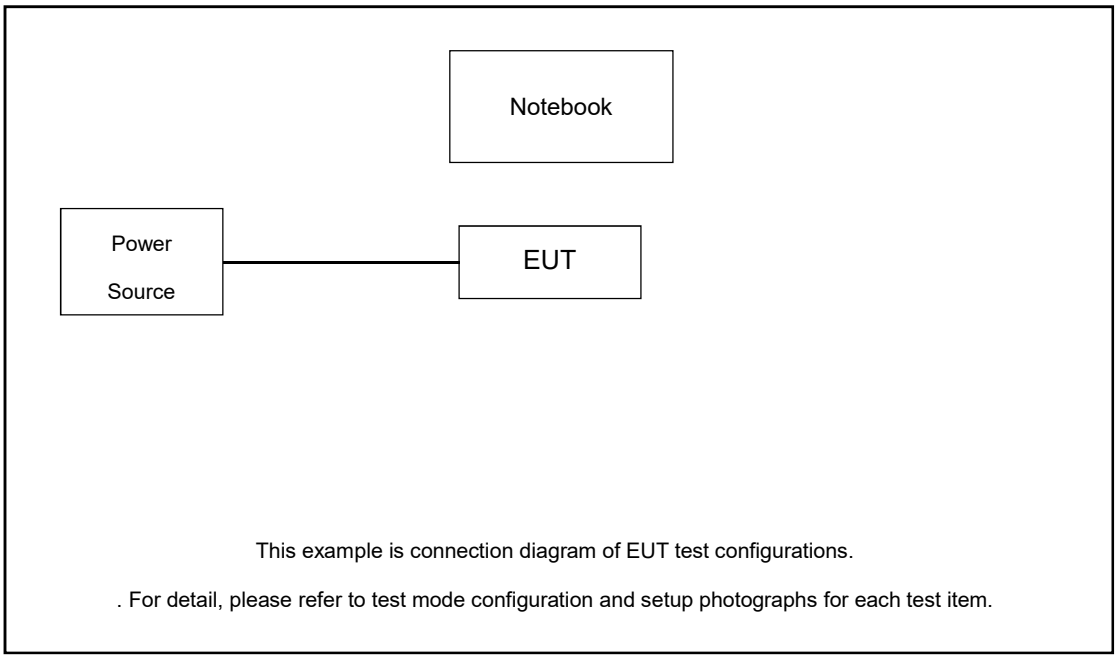
1. For radiated test cases, the worst mode data rate 2Mbps was reported only, because this data rate has the highest RF output power at preliminary tests, and no other significantly frequencies found in conducted spurious emission.
2. For Radiated Test Cases, The tests were performed with Adapter and USB Cable.

2.3 Connection Diagram of Test System

<Radiation>



<Conduction>



2.4 Support Unit used in test configuration and system

Item	Equipment	Model Name	FCC ID	Data Cable	Power Cord
1.	Bluetooth Base Station	CBT	N/A	N/A	Unshielded,1.8m
2.	Notebook	G410	N/A	N/A	AC I/P: Unshielded, 0.9 m DC O/P: Shielded, 1.8 m
3.	Adapter	N/A	N/A	N/A	N/A

2.5 EUT Operation Test Setup

For Bluetooth function, the engineering test program was provided and enabled to make EUT connect with Bluetooth base station to continuous transmit/receive.

For AC power line conducted emissions, the EUT was set to connect with the Notebook under large package sizes transmission.

2.6 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss 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.

Offset = RF cable loss.

Following shows an offset computation example with cable loss 6.2 dB.

Offset(dB) = RF cable loss(dB) .

= 6.2 (dB)

3 Test Result

3.1 Number of Channel Measurement

3.1.1 Limits of Number of Hopping Frequency

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

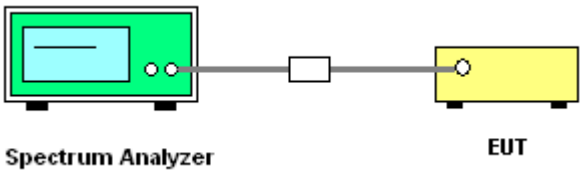
3.1.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.1.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = the frequency band of operation; RBW = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. The number of hopping frequency used is defined as the number of total channel.
7. Record the measurement data derived from spectrum analyzer.

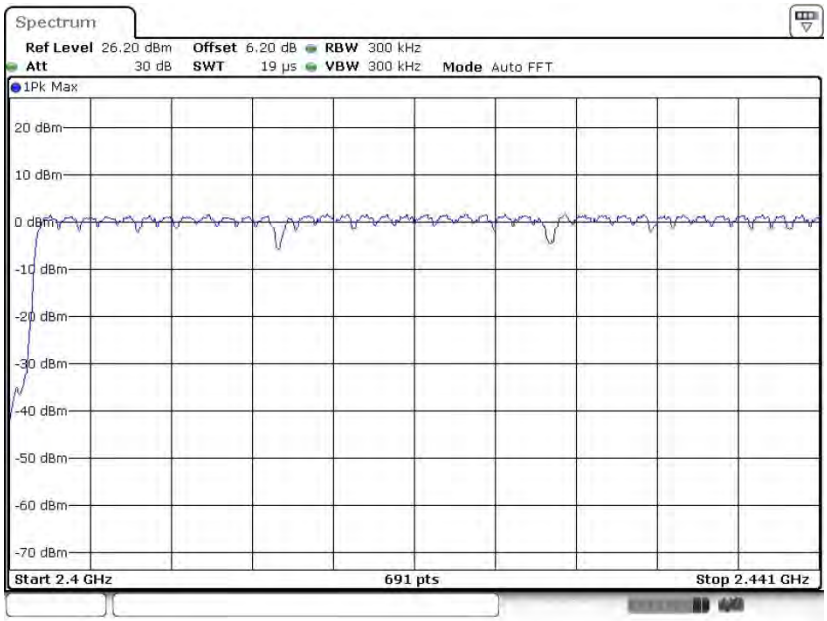
3.1.4 Test Setup



3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.

Number of Hopping Channel Plot on Channel 00 - 78



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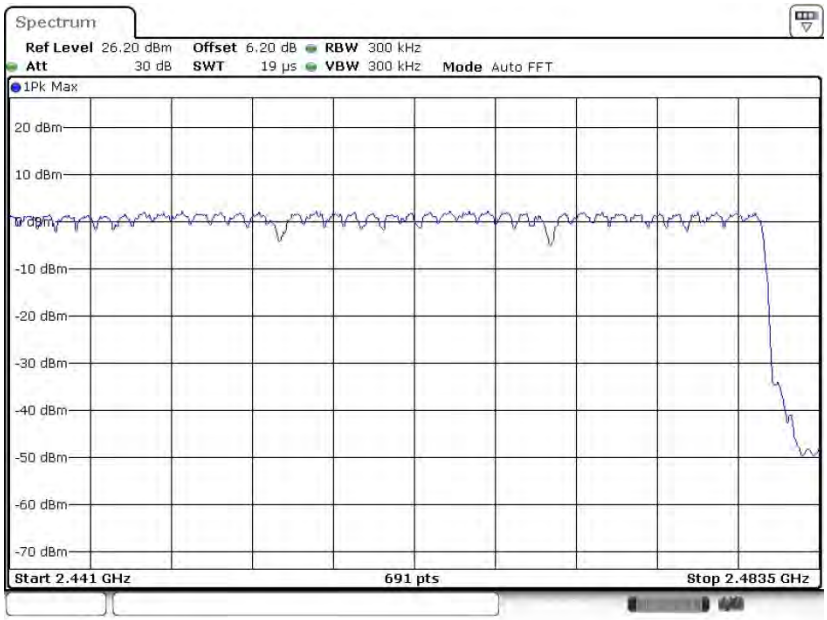


Date: 11.FEB.2021 07:36:02

3.2 Hopping Channel Separation Measurement

3.2.1 Limit of Hopping Channel Separation

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.

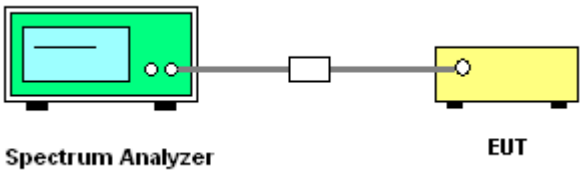
3.2.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.2.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.2.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings:
   Span = wide enough to capture the peaks of two adjacent channels;
   RBW = 300kHz; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.2.4 Test Setup

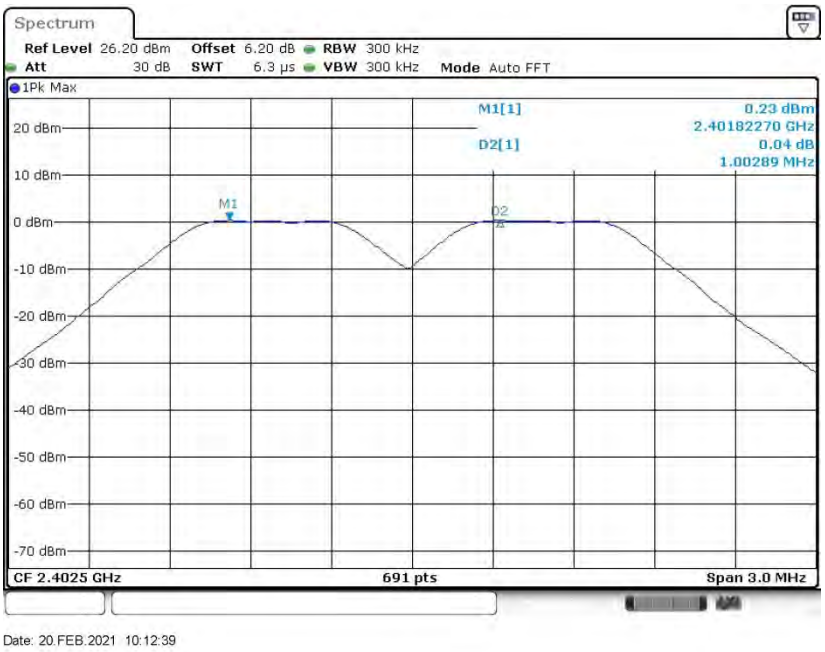


3.2.5 Test Result of Hopping Channel Separation

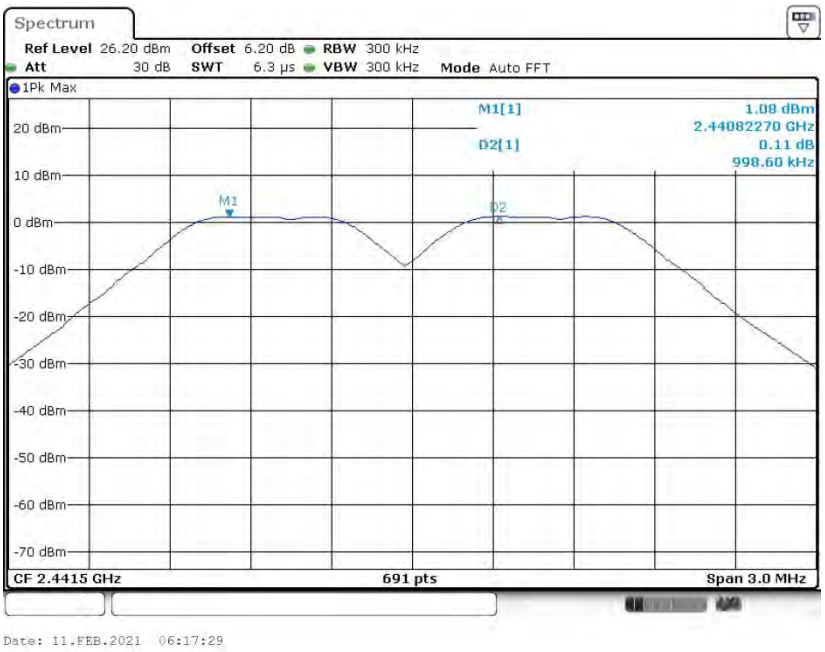
Please refer to Appendix A.

<1Mbps>

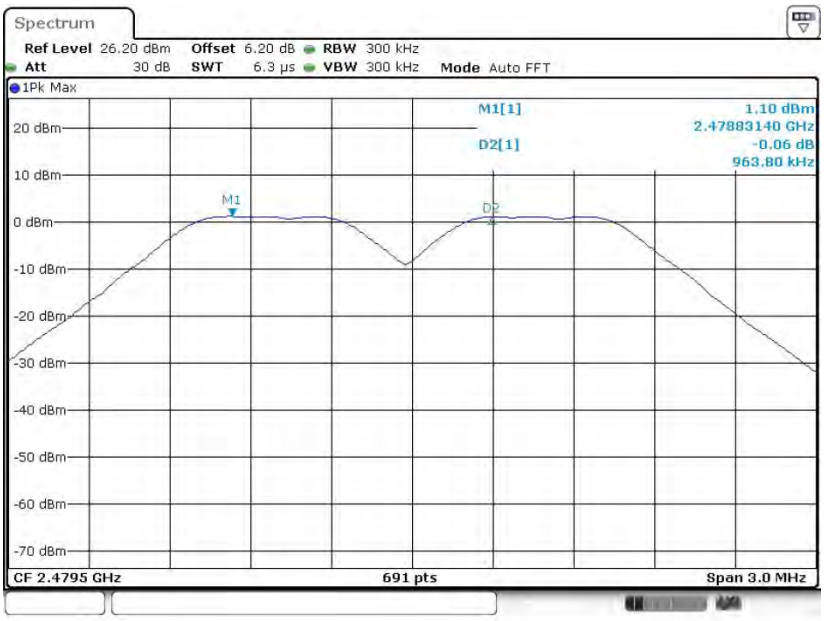
Channel Separation Plot on Channel 00 - 01



Channel Separation Plot on Channel 39 - 40



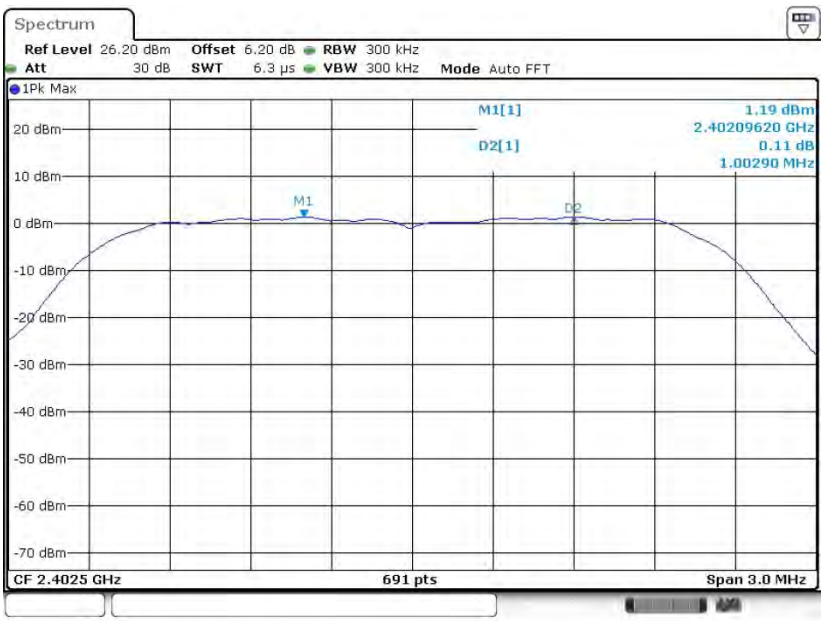
Channel Separation Plot on Channel 77 - 78



Date: 11.FEB.2021 06:24:47

<2Mbps>

Channel Separation Plot on Channel 00 - 01



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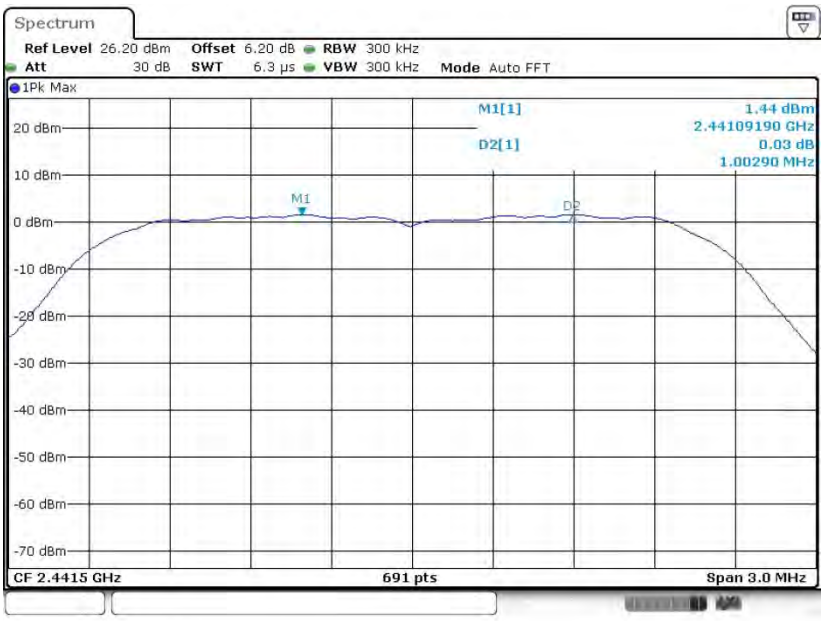
Channel Separation Plot on Channel 39 - 40



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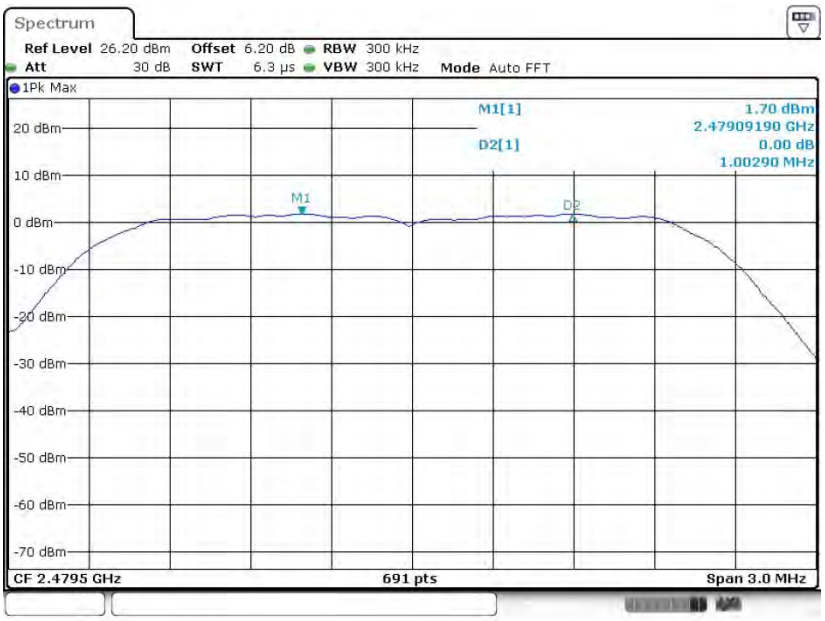
Channel Separation Plot on Channel 77 - 78



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3.3 Dwell Time Measurement

3.3.1 Limit of Dwell Time

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.

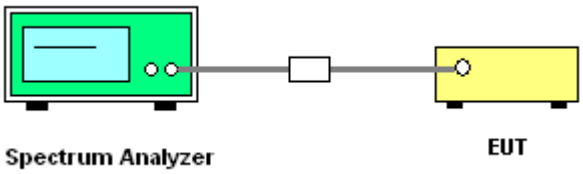
3.3.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.3.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.4.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW = 1 MHz; VBW ≥ RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

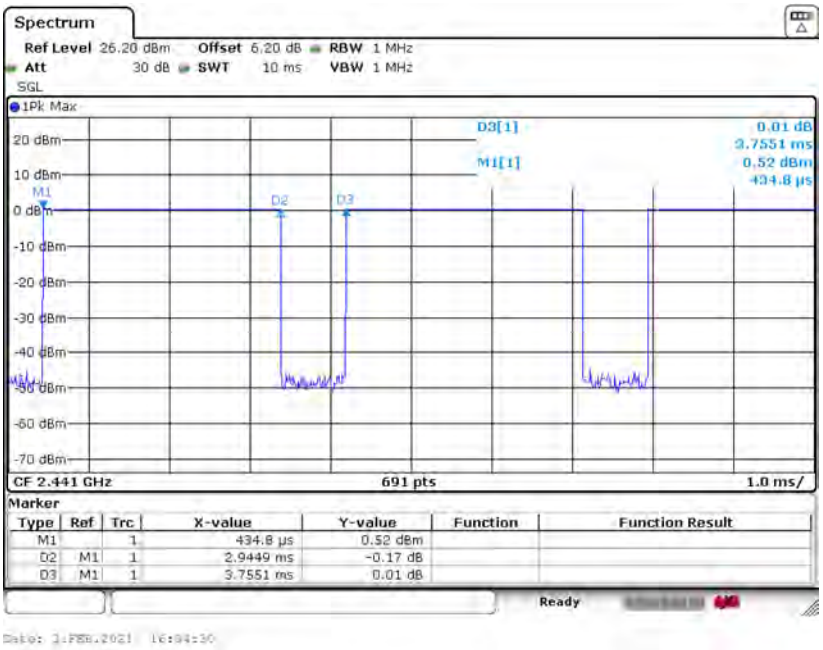
3.3.4 Test Setup



3.3.5 Test Result of Dwell Time

Please refer to Appendix A.

Package Transfer Time Plot



Remark:

1. In normal mode, hopping rate is 1600 hops/s with 6 slots (5 Transmit and 1 Receive slot) in 79 hopping channels.

   With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s),

   Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops.

2. In AFH mode, hopping rate is 800 hops/s with 6 slots in 20 hopping channels.

   With channel hopping rate (800 / 6 / 20) in Occupancy Time Limit (0.4 x 20) (s),

   Hops Over Occupancy Time comes to (800 / 6 / 20) x (0.4 x 20) = 53.33 hops.

3. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

3.4 20dB and 99% Bandwidth Measurement

3.4.1 Limit of 20dB and 99% Bandwidth

Reporting only

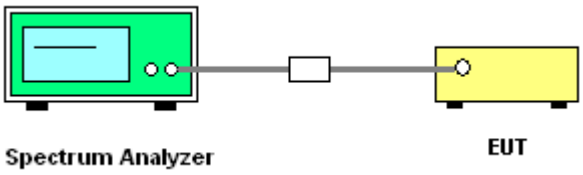
3.4.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.4.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 6.9.2 and 6.9.3.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. 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;
   The RBW is set to 1% to 5% of the 99% OBW, the VBW is set to 3 times the RBW;
   Sweep = auto; Detector function = peak;
   Trace = max hold.
5. 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;
   The RBW is set to 1% to 5% of the 99% OBW, the VBW is set to 3 times the RBW;
   Sweep = auto; Detector function = sample;
   Trace = max hold.
6. Measure and record the results in the test report.

3.4.4 Test Setup

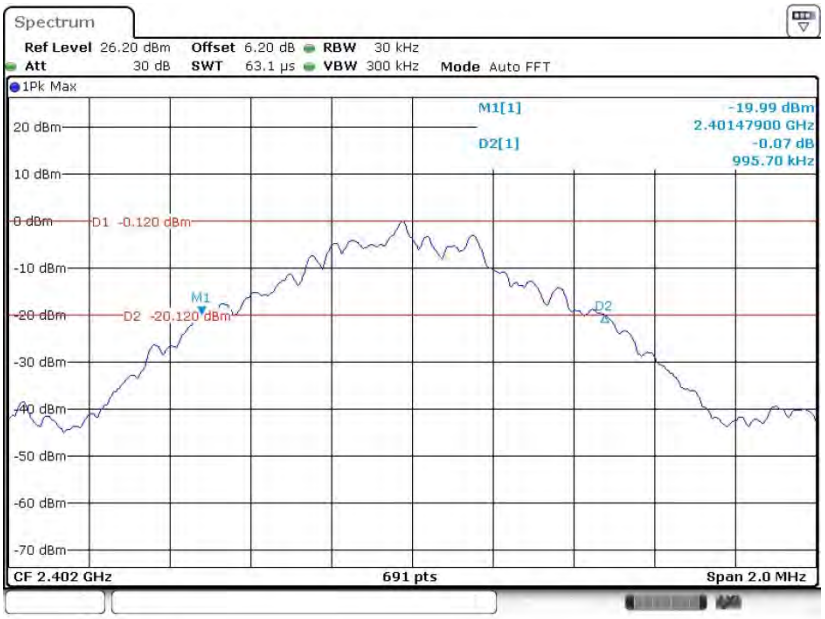


3.4.5 Test Result of 20dB Bandwidth

Please refer to Appendix A.

<1Mbps>

20 dB Bandwidth Plot on Channel 00



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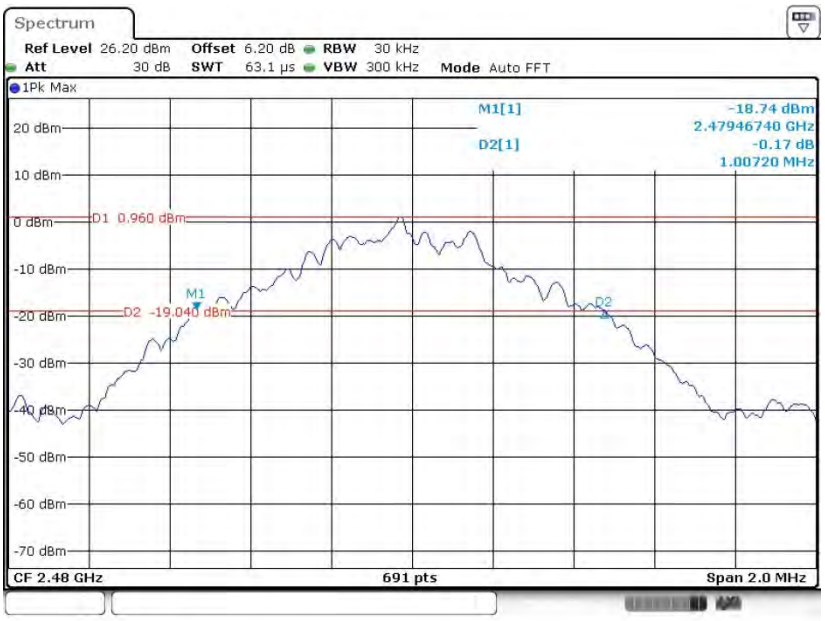
20 dB Bandwidth Plot on Channel 39

Date: 11.FEB.2021 06:13:56

20 dB Bandwidth Plot on Channel 78



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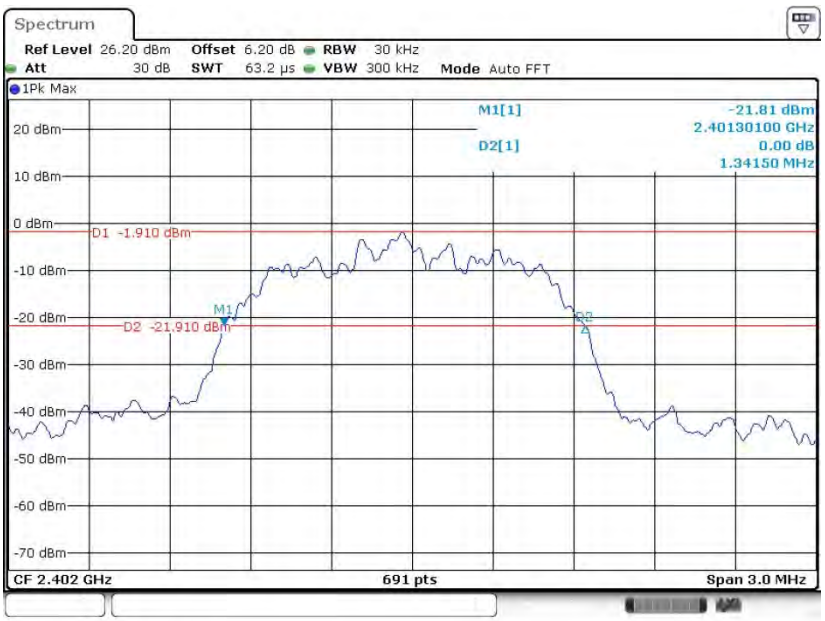
<2Mbps>

20 dB Bandwidth Plot on Channel 00



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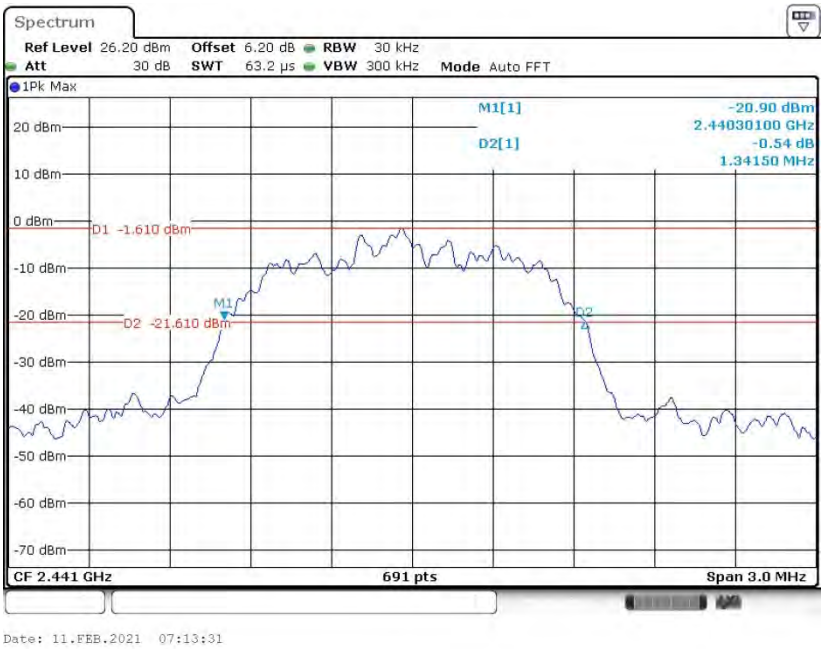
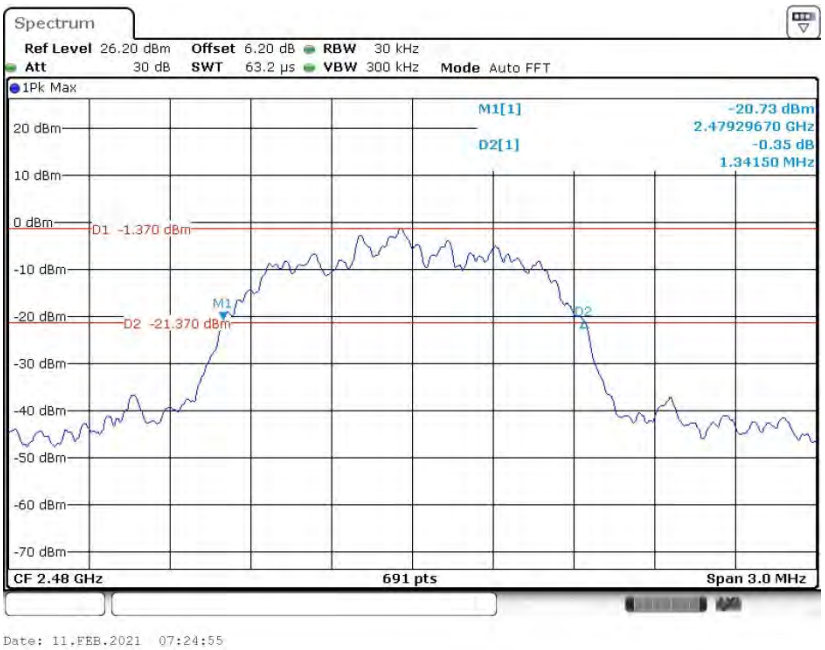
20 dB Bandwidth Plot on Channel 39



20 dB Bandwidth Plot on Channel 78



3.4.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

<1Mbps>

99% Occupied Bandwidth Plot on Channel 00

99% Occupied Bandwidth Plot on Channel 39

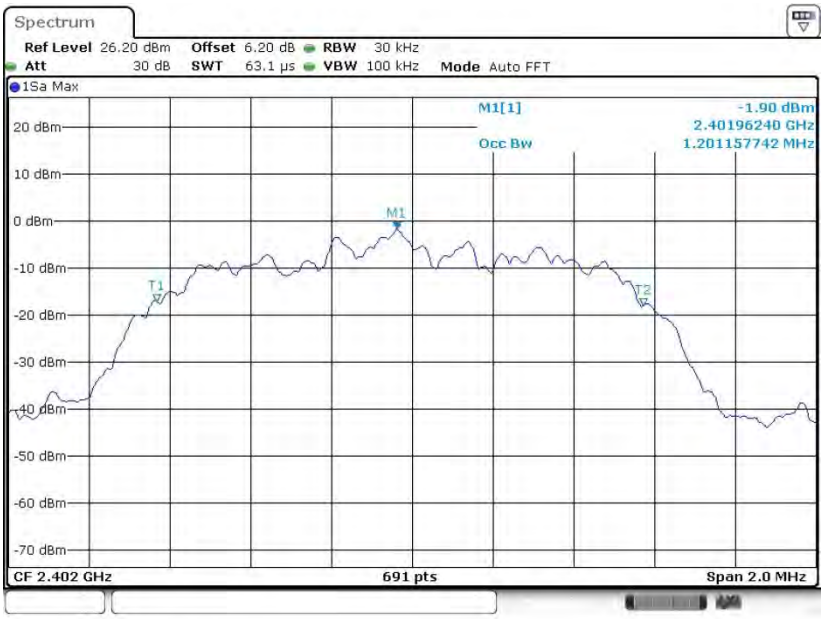
Date: 11.FEB.2021 06:15:06

99% Occupied Bandwidth Plot on Channel 78

Date: 11.FEB.2021 06:22:22

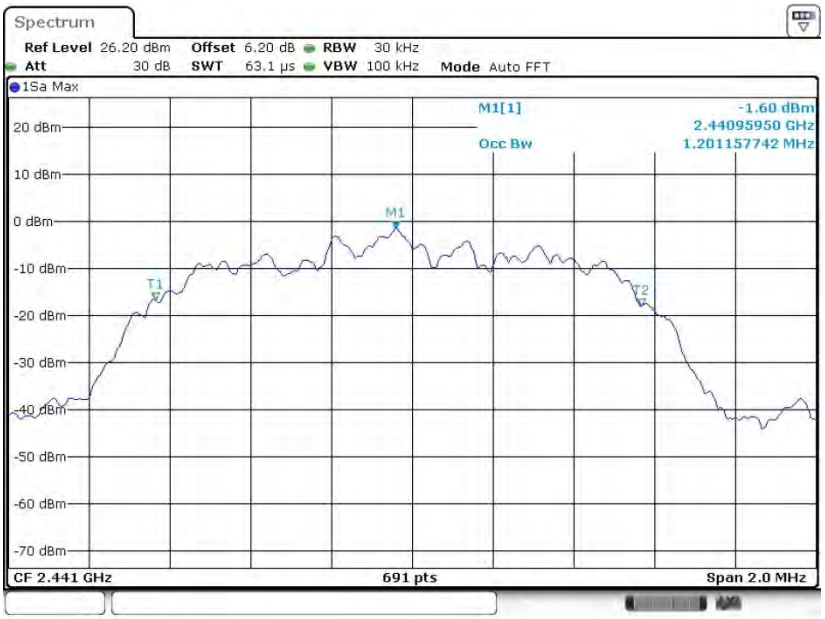
<2Mbps>

99% Occupied Bandwidth Plot on Channel 00



Date: 11.FEB.2021 07:05:28

99% Occupied Bandwidth Plot on Channel 39



Date: 11.FEB.2021 07:14:20

99% Occupied Bandwidth Plot on Channel 78

Note : The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

3.5 Output Power Measurement

3.5.1 Limit of Output Power

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.

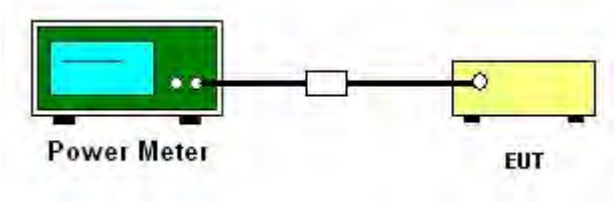
3.5.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.5.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.5.
2. The RF output of EUT was connected to the power meter by RF cable and attenuator. The path loss was compensated to the results for each measurement.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. Measure the conducted output power with cable loss and record the results in the test report.
5. Measure and record the results in the test report.

3.5.4 Test Setup



3.5.5 Test Result of Peak Output Power

Please refer to Appendix A.

3.6 Conducted Band Edges Measurement

3.6.1 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.

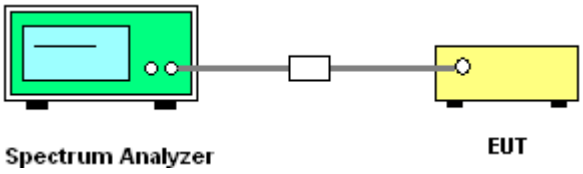
3.6.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.6.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.6.
2. Set to the maximum power setting and enable the EUT transmit continuously.
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 2. and 3.
5. Measure and record the results in the test report.

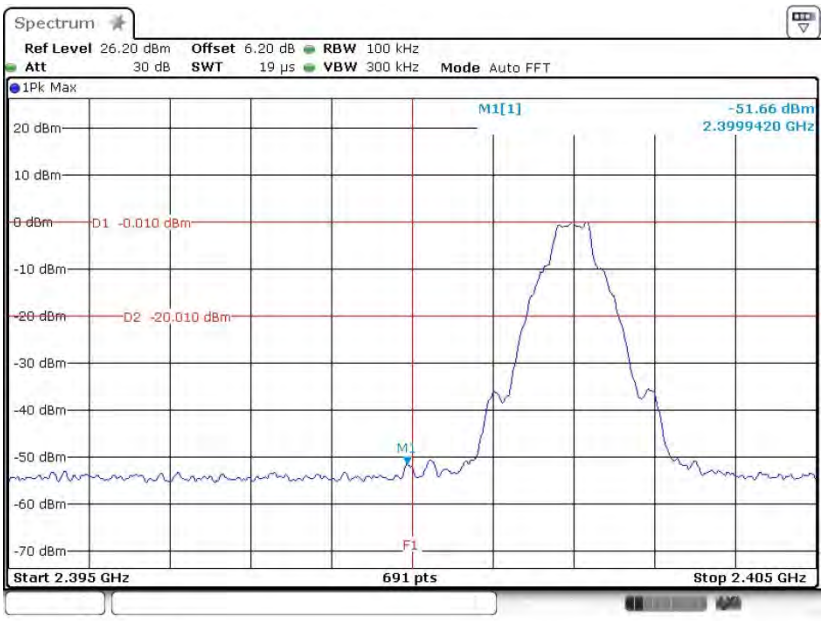
3.6.4 Test Setup



3.6.5 Test Result of Conducted Band Edges

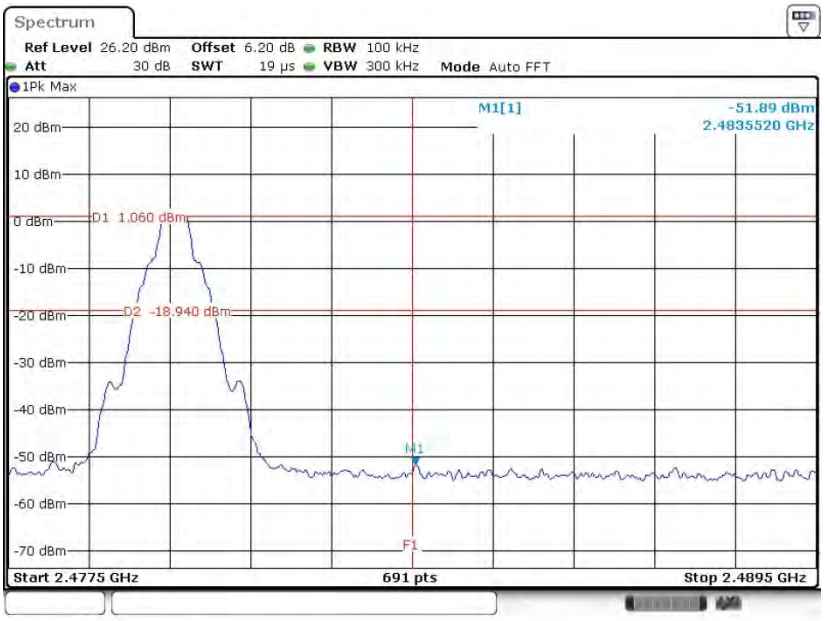
<1Mbps>

Low Band Edge Plot on Channel 00



Date: 11.FEB.2021 06:04:10

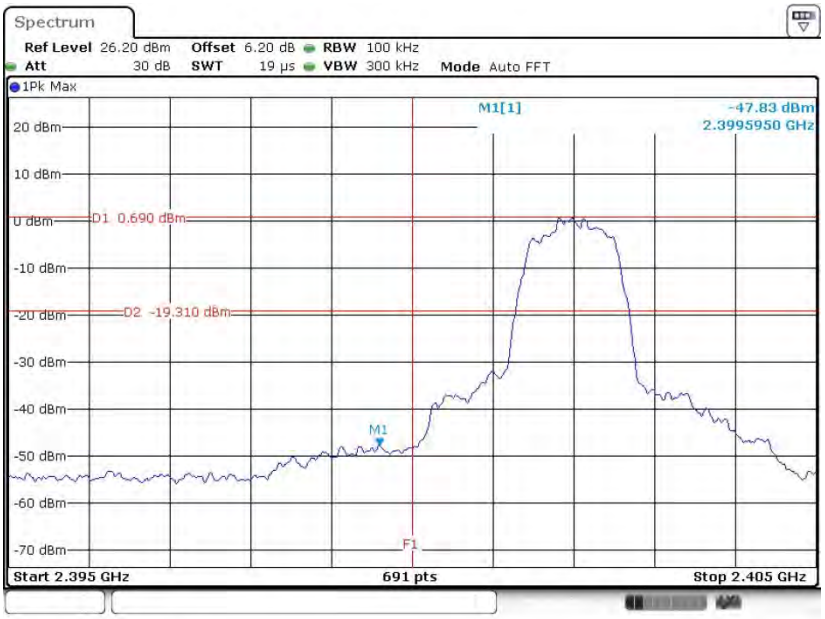
High Band Edge Plot on Channel 78



Date: 11.FEB.2021 06:21:40

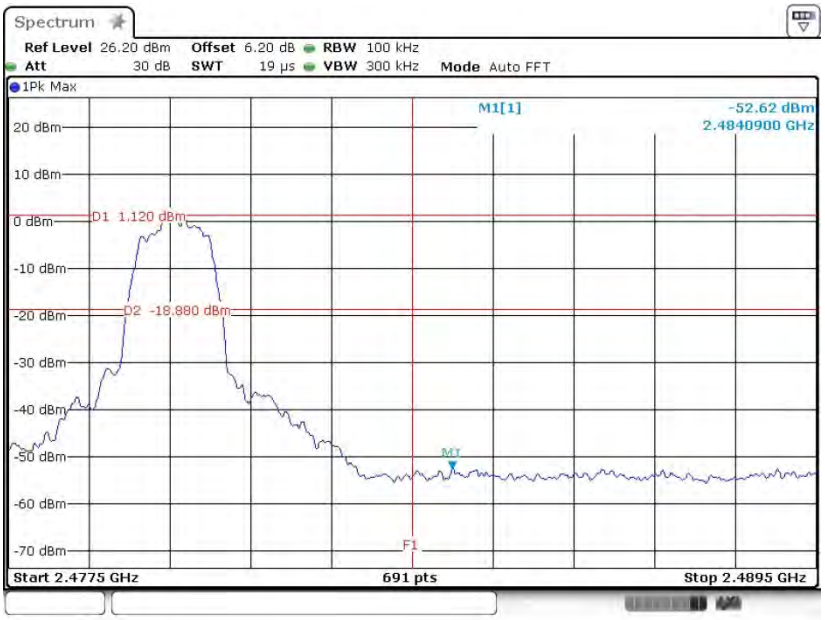
<2Mbps>

Low Band Edge Plot on Channel 00



Date: 11.FEB.2021 07:04:20

High Band Edge Plot on Channel 78

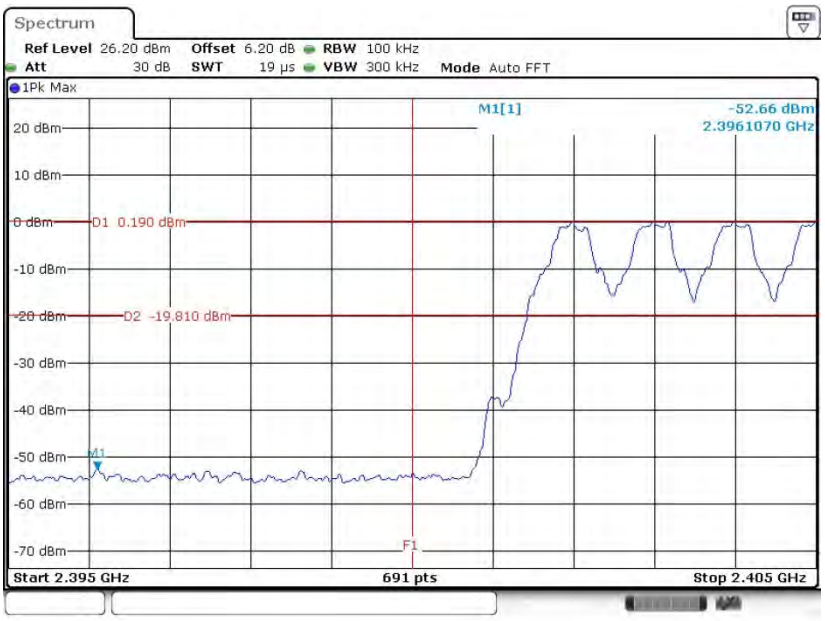


Date: 11.FEB.2021 07:26:13

3.6.6 Test Result of Conducted Hopping Mode Band Edges

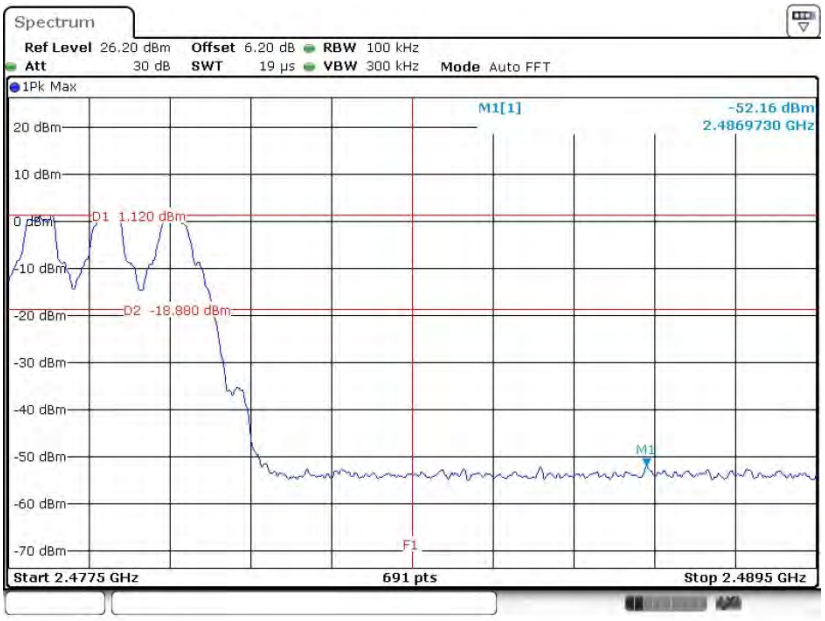
<1Mbps>

Hopping Mode Low Band Edge Plot



Date: 11.FEB.2021 06:11:31

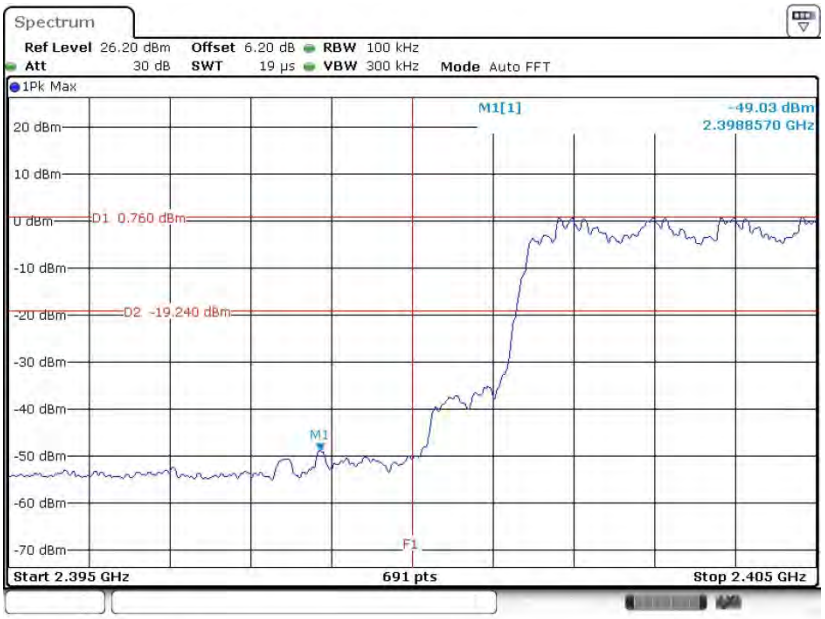
Hopping Mode High Band Edge Plot



Date: 11.FEB.2021 06:26:40

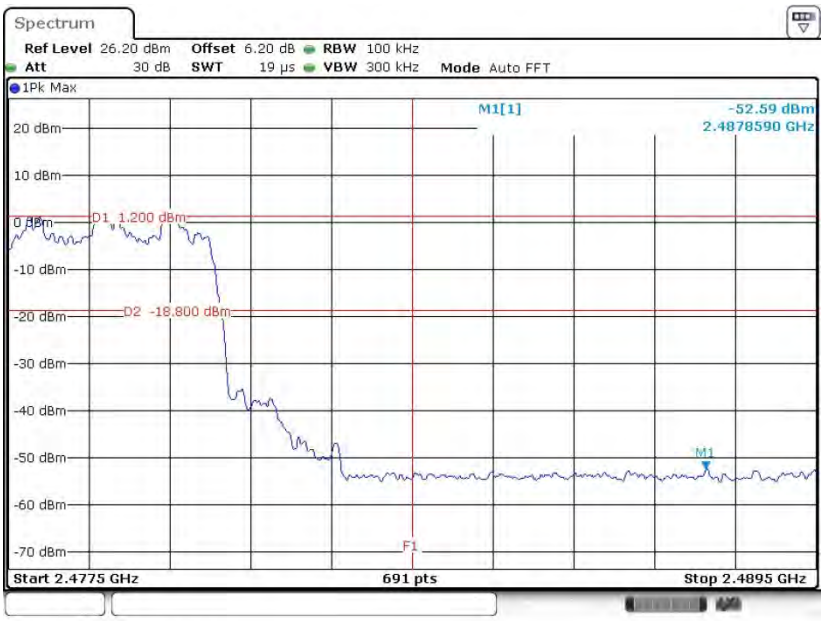
<2Mbps>

Hopping Mode Low Band Edge Plot



Date: 11.FEB.2021 07:10:47

Hopping Mode High Band Edge Plot



Date: 11.FEB.2021 07:30:21

3.7 Conducted Spurious Emission Measurement

3.7.1 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.

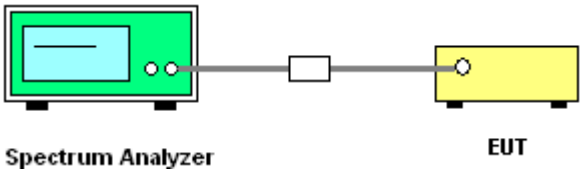
3.7.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.7.3 Test Procedure

1. The testing follows ANSI C63.10-2013 clause 7.8.8.
2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
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. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

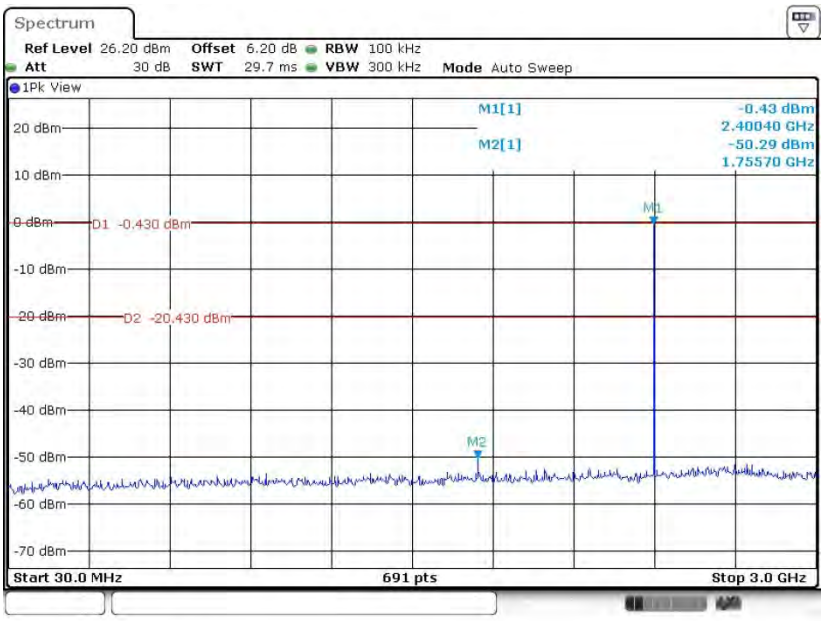
3.7.4 Test Setup



3.7.5 Test Result of Conducted Spurious Emission

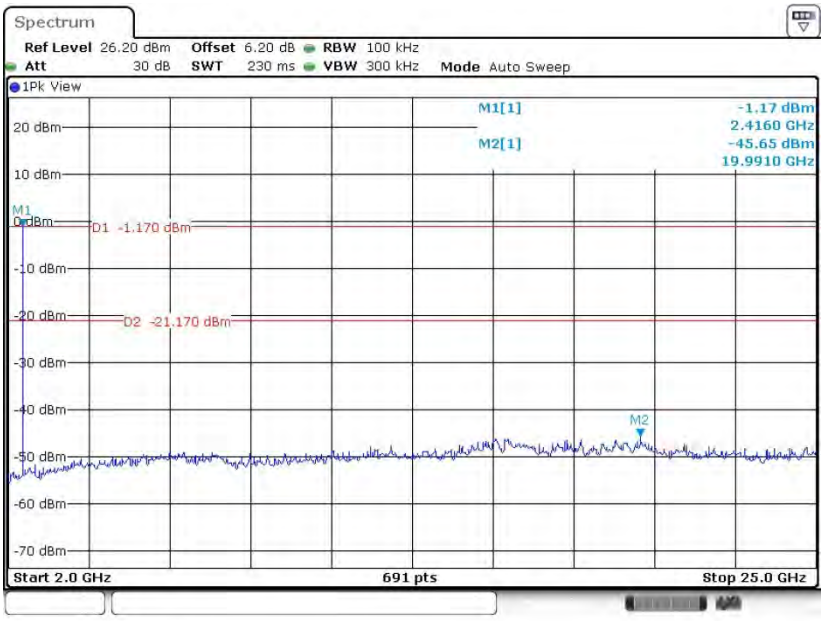
<1Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz



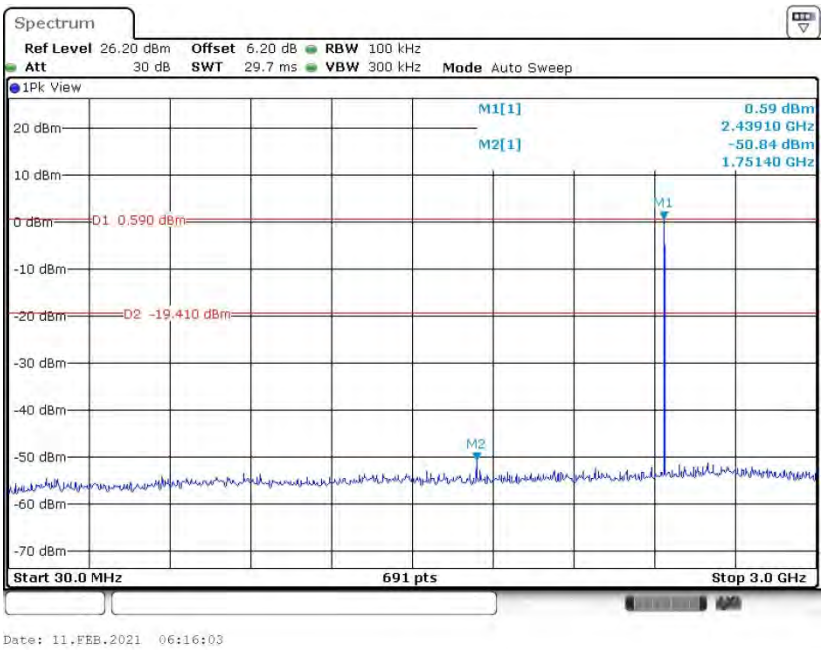
Date: 11.FEB.2021 06:09:02

1Mbps CSE Plot on Ch 00 between 2 GHz ~ 25 GHz



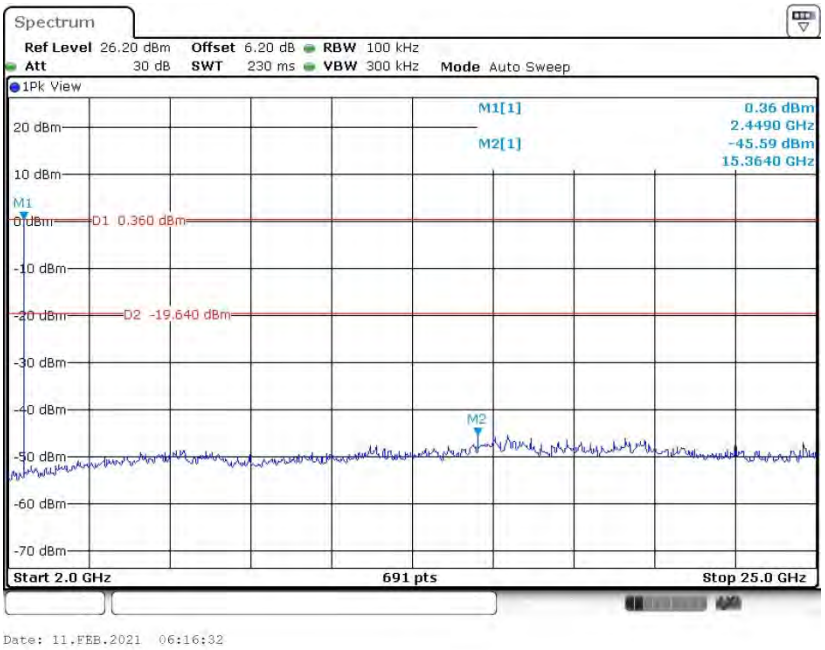
Date: 11.FEB.2021 06:09:34

CSE Plot on Ch 39 between 30MHz ~ 3 GHz



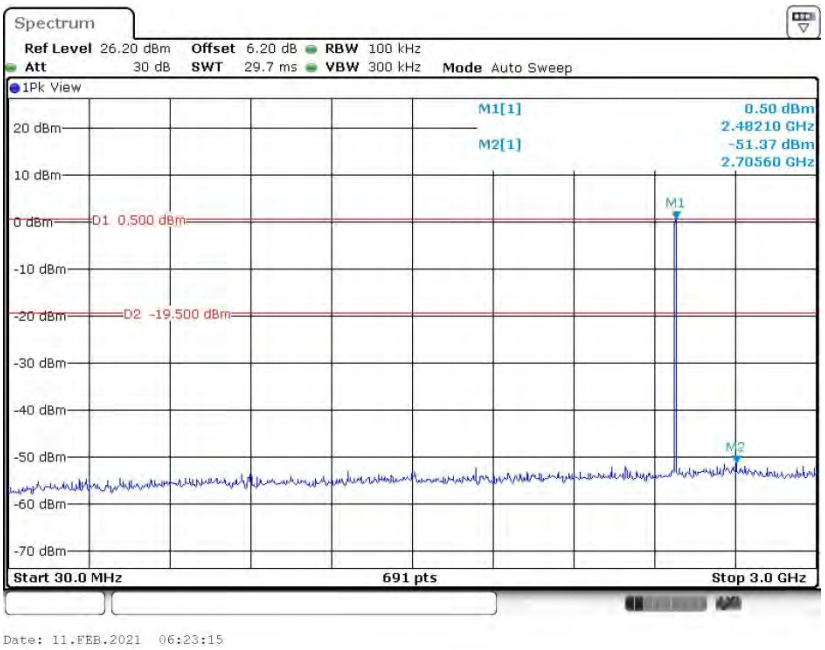
Date: 11.FEB.2021 06:16:03

CSE Plot on Ch 39 between 2 GHz ~ 25 GHz



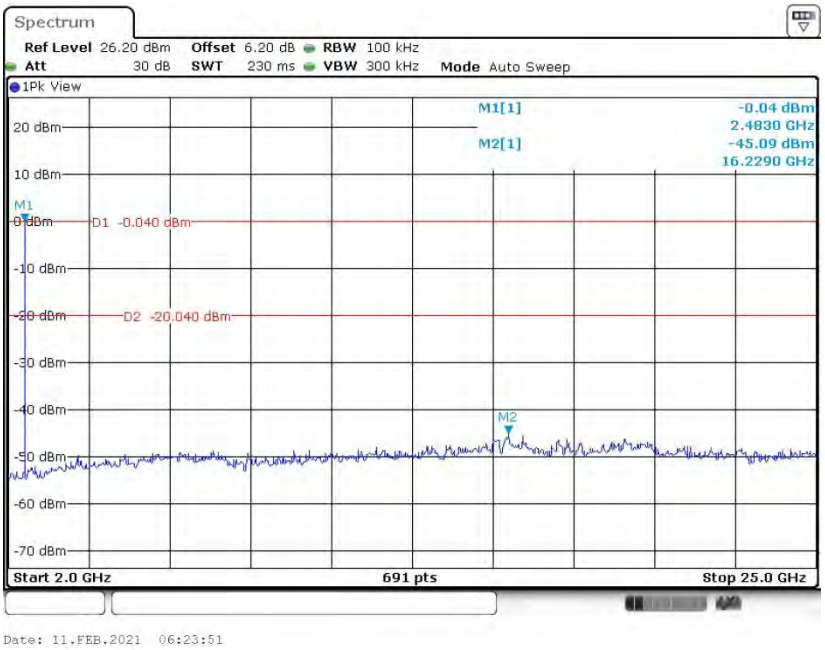
Date: 11.FEB.2021 06:16:32

CSE Plot on Ch 78 between 30MHz ~ 3 GHz



Date: 11.FEB.2021 06:23:15

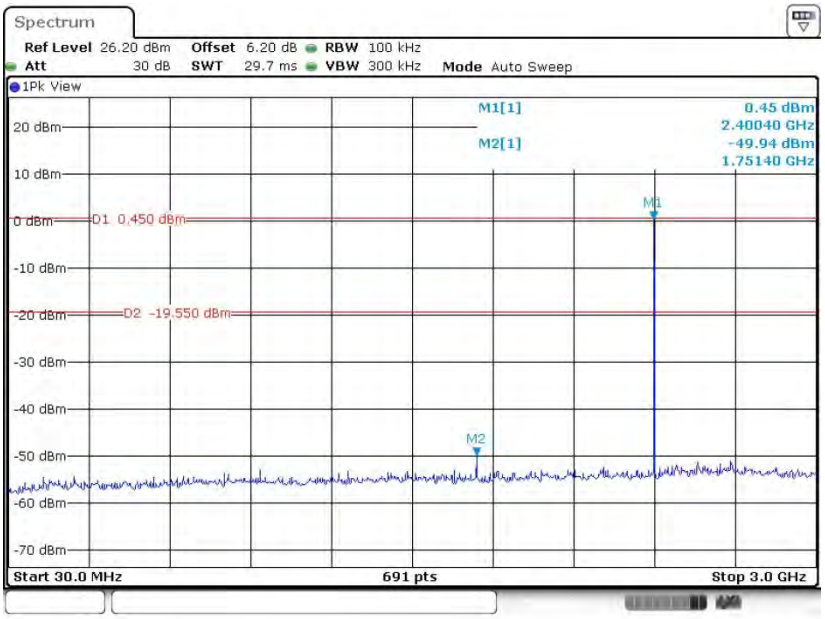
CSE Plot on Ch 78 between 2 GHz ~ 25 GHz



Date: 11.FEB.2021 06:23:51

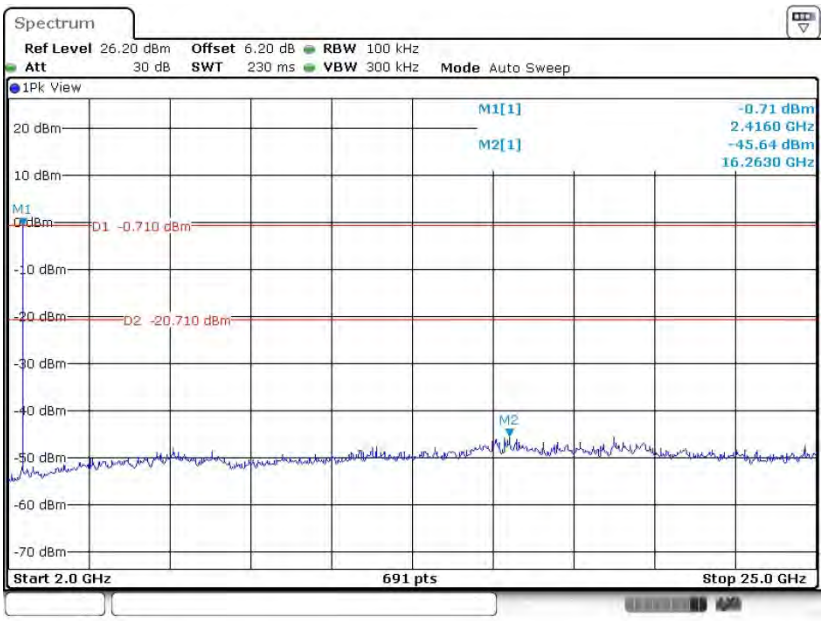
<2Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz



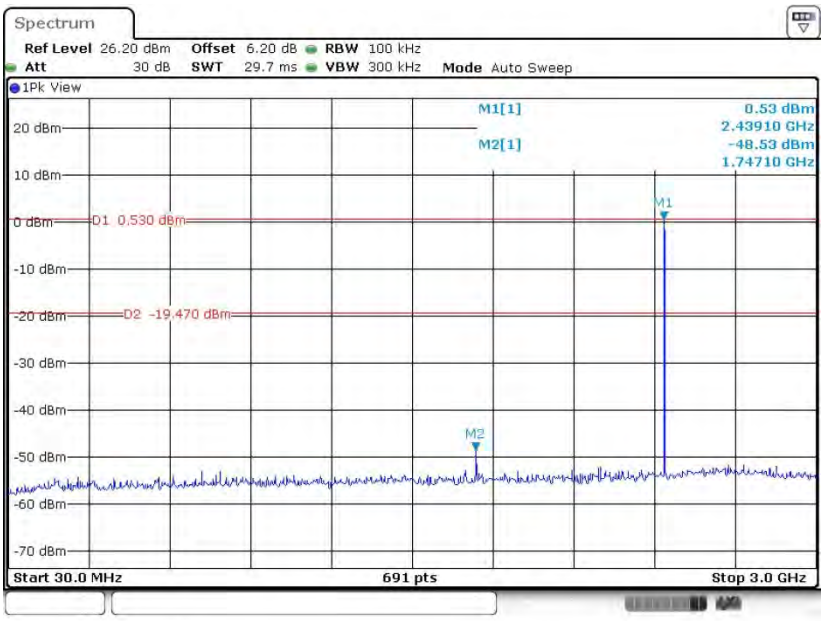
Date: 11.FEB.2021 07:06:46

CSE Plot on Ch 00 between 2 GHz ~ 25 GHz



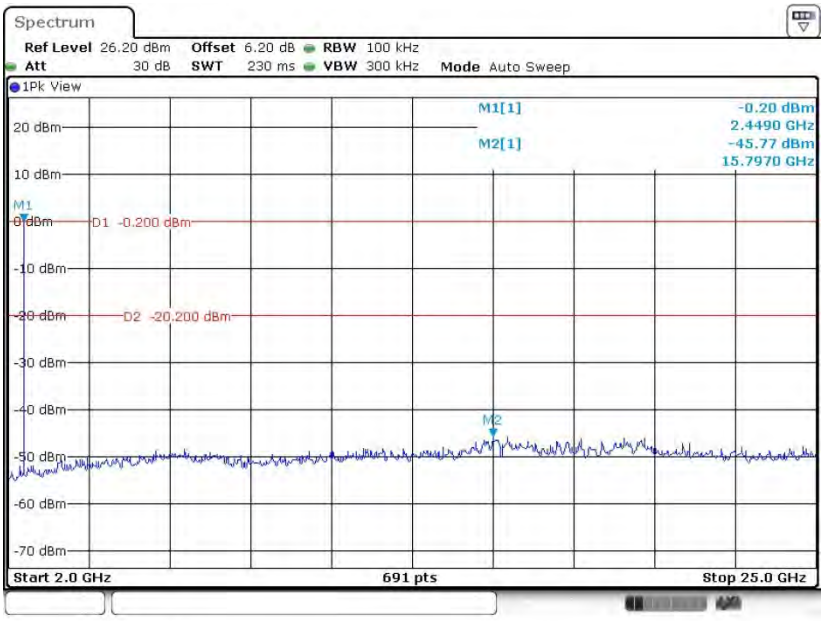
Date: 11.FEB.2021 07:07:27

CSE Plot on Ch 39 between 30MHz ~ 3 GHz



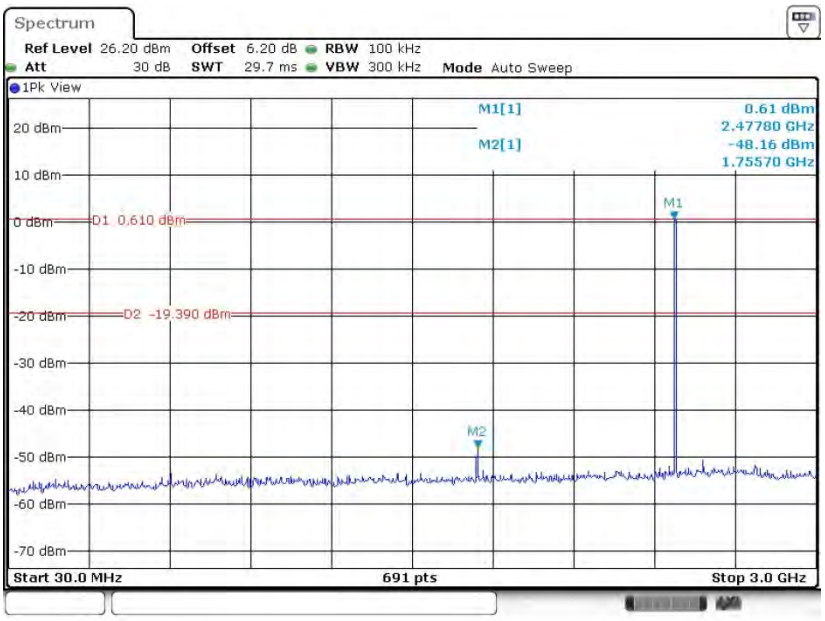
Date: 11.FEB.2021 07:21:03

CSE Plot on Ch 39 between 2 GHz ~ 25 GHz



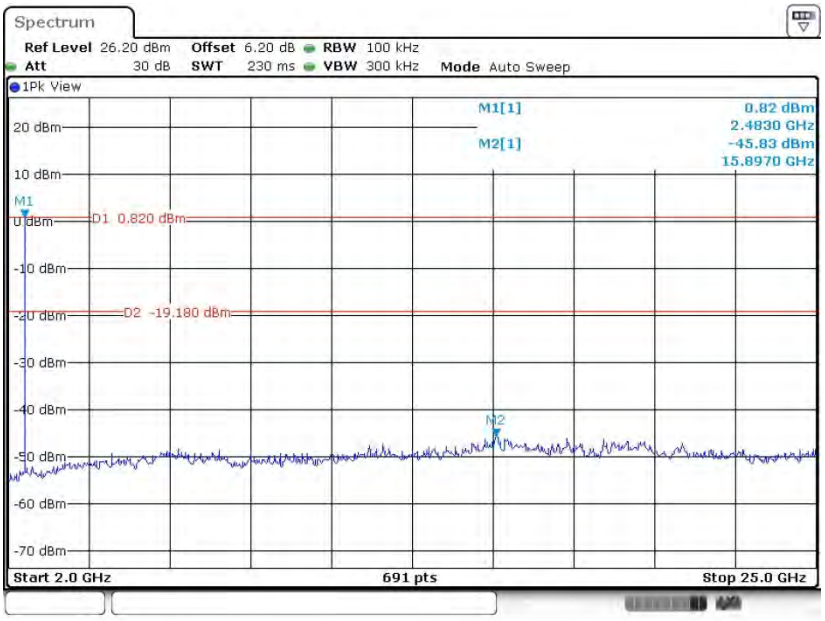
Date: 11.FEB.2021 07:21:42

CSE Plot on Ch 78 between 30MHz ~ 3 GHz



Date: 11.FEB.2021 07:27:40

CSE Plot on Ch 78 between 2 GHz ~ 25 GHz



Date: 11.FEB.2021 07:28:13

3.8 Radiated Band Edges and Spurious Emission Measurement

3.8.1 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 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

3.8.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

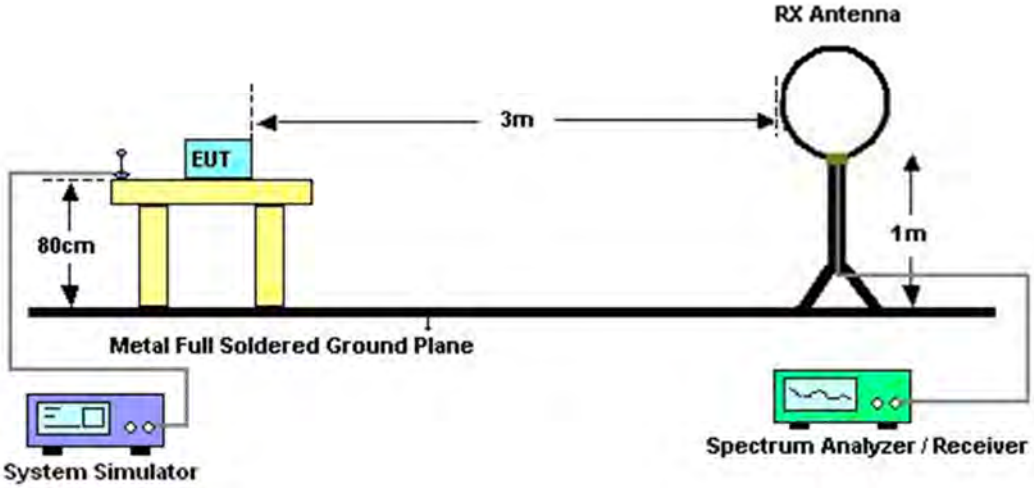
3.8.3 Test Procedures

1. 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.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. 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.
4. Set to the maximum power setting and enable the EUT transmit continuously.
5. 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: use duty cycle correction factor method per 15.35(c).
   Duty cycle = On time/100 milliseconds
   On time = $N_1*L_1+N_2*L_2+...+N_{n-1}*LN_{n-1}+N_n*L_n$
   Where N_1 is number of type 1 pulses, L_1 is length of type 1 pulses, etc.
   Average Emission Level = Peak Emission Level + 20*log(Duty cycle)
6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
7. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
8. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than peak limit (that means the emission level in average mode also complies with the limit in average mode), then peak values of EUT will be reported, otherwise, the emissions will be measured in average mode again and reported.

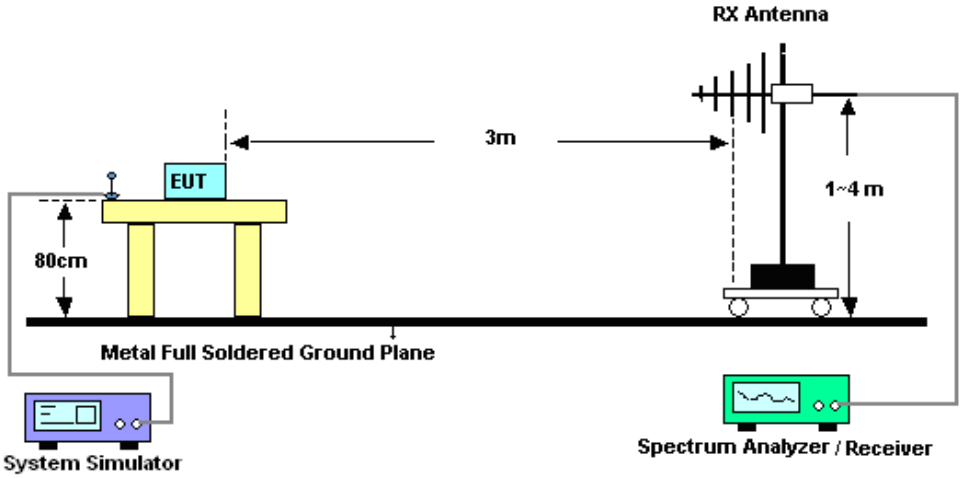
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.61dB) derived from 20log (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.

3.8.4 Test Setup

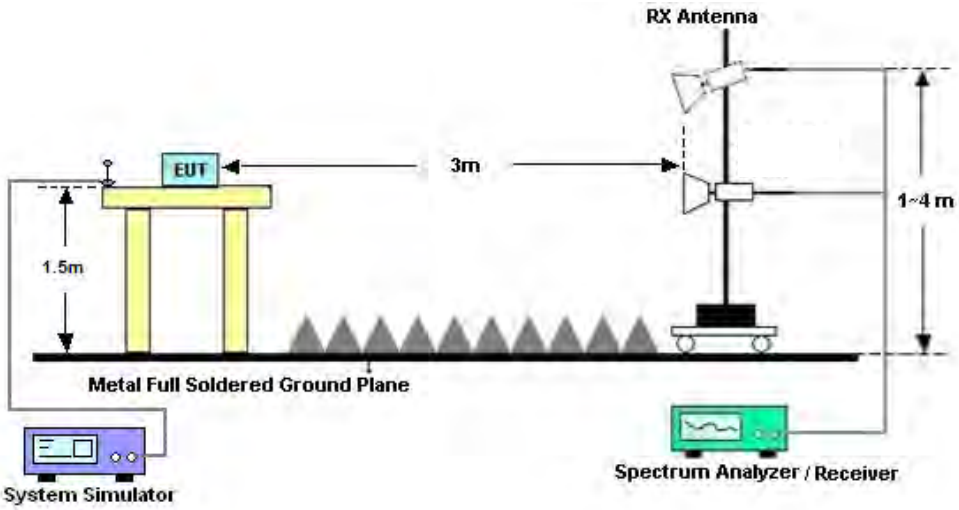
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



3.8.5 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 was not reported.

There is a comparison data of both open-field test site and semi-Anechoic chamber, and the result came out very similar.

3.8.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C & D

3.8.7 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic or 40GHz, whichever is lower)

Please refer to Appendix C & D

3.8.8 Duty cycle correction factor for average measurement

Please refer to Appendix E.

3.9 AC Conducted Emission Measurement

3.9.1 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.

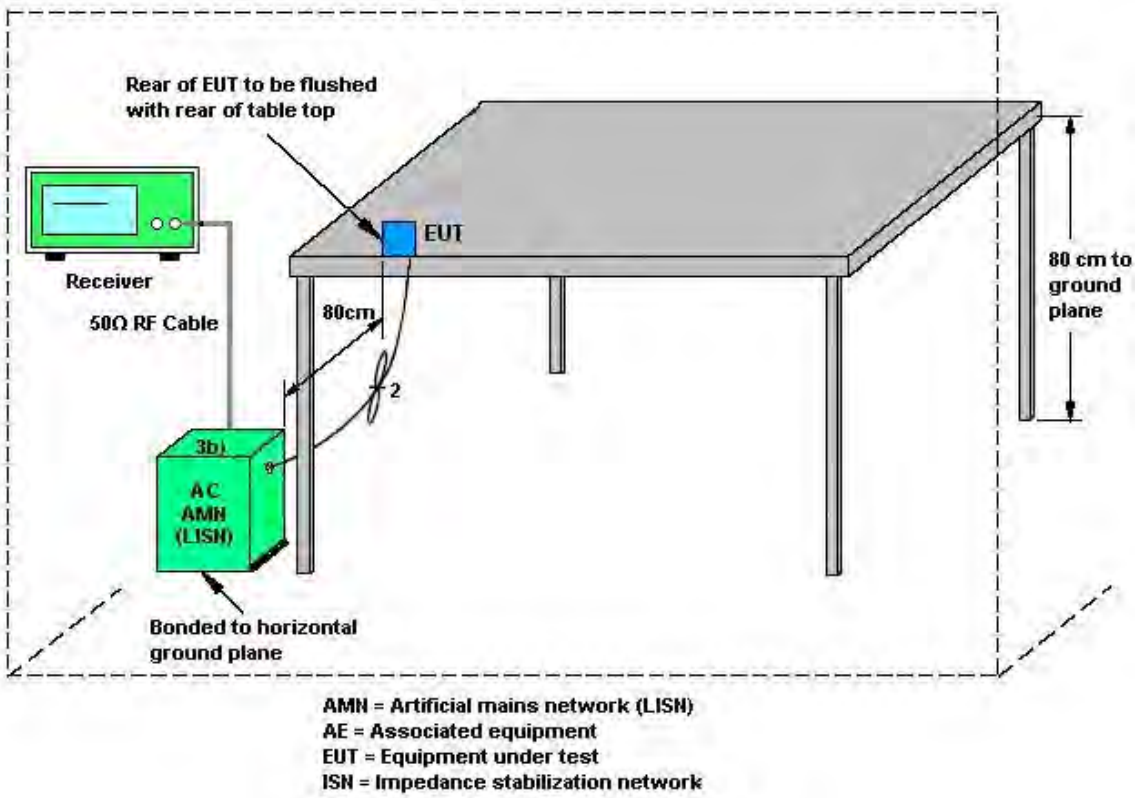
3.9.2 Measuring Instruments

The measuring equipment is listed in the section 4 of this test report.

3.9.3 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.

3.9.4 Test Setup



3.9.5 Test Result of AC Conducted Emission

Please refer to Appendix B.

3.10 Antenna Requirements

3.10.1 Standard Applicable

If directional gain of transmitting antennas is greater than 6dBi, the power shall be reduced by the same level in dB comparing to gain minus 6dBi. 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 rule.

3.10.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.10.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV40	101040	10Hz~40GHz	Nov. 01, 2020	Feb. 03, 2021~ Feb. 20, 2021	Oct. 31, 2021	Conducted (TH01-KS)
Pulse Power Senor	Anritsu	MA2411B	0917070	300MHz~40GHz	Jan. 07, 2021	Feb. 03, 2021~ Feb. 20, 2021	Jan. 06, 2022	Conducted (TH01-KS)
Power Meter	Anritsu	ML2495A	1005002	50MHz Bandwidth	Jan. 07, 2021	Feb. 03, 2021~ Feb. 20, 2021	Jan. 06, 2022	Conducted (TH01-KS)
EMI Test Receiver	Keysight	N9038A	MY56400004	3Hz~8.5GHz;Max 30dBm	Oct. 17, 2020	Mar. 09, 2021	Oct. 16, 2021	Radiation (03CH06-KS)
EXA Spectrum Analyzer	Keysight	N9010A	MY55150208	10Hz-44GHz	Apr. 14, 2020	Mar. 09, 2021	Apr. 13, 2021	Radiation (03CH06-KS)
Loop Antenna	R&S	HFH2-Z2	100321	9kHz~30MHz	Nov. 01, 2020	Mar. 09, 2021	Oct. 31, 2021	Radiation (03CH06-KS)
Bilog Antenna	TeseQ	CBL6111D	49921	30MHz-1GHz	May 29, 2020	Mar. 09, 2021	May 28, 2021	Radiation (03CH06-KS)
Double Ridge Horn Antenna	ETS-Lindgren	3117	00218652	1GHz~18GHz	Apr. 27, 2020	Mar. 09, 2021	Apr. 26, 2021	Radiation (03CH06-KS)
SHF-EHF Horn	Com-power	AH-840	101115	18GHz~40GHz	Nov. 06, 2020	Mar. 09, 2021	Nov. 05, 2021	Radiation (03CH06-KS)
Amplifier	SONOMA	310N	187289	9KHz ~1GHZ	Apr. 14, 2020	Mar. 09, 2021	Apr. 13, 2021	Radiation (03CH06-KS)
Amplifier	MITEQ	EM18G40GGA	060728	18~40GHz	Jan. 06, 2021	Mar. 09, 2021	Jan. 05, 2022	Radiation (03CH06-KS)
high gain Amplifier	MITEQ	AMF-7D-00101800-30-10P	2025788	1Ghz-18Ghz	Jan. 06, 2021	Mar. 09, 2021	Jan. 05, 2022	Radiation (03CH06-KS)
Amplifier	Keysight	83017A	MY53270203	500MHz~26.5GHz	Apr. 15, 2020	Mar. 09, 2021	Apr. 14, 2021	Radiation (03CH06-KS)
AC Power Source	Chroma	61601	F104090004	N/A	NCR	Mar. 09, 2021	NCR	Radiation (03CH06-KS)
Turn Table	ChamPro	EM 1000-T	060762-T	0~360 degree	NCR	Mar. 09, 2021	NCR	Radiation (03CH06-KS)
Antenna Mast	ChamPro	EM 1000-A	060762-A	1 m~4 m	NCR	Mar. 09, 2021	NCR	Radiation (03CH06-KS)
EMI Receiver	R&S	ESCI7	100768	9kHz~7GHz;	Apr. 14, 2020	Mar. 16, 2021	Apr. 13, 2021	Conduction (CO01-KS)
AC LISN (for auxiliary equipment)	MessTec	AN3016	060103	9kHz~30MHz	Oct. 17, 2020	Mar. 16, 2021	Oct. 16, 2021	Conduction (CO01-KS)
AC LISN	MessTec	AN3016	060105	9kHz~30MHz	Oct. 27, 2020	Mar. 16, 2021	Oct. 26, 2021	Conduction (CO01-KS)
AC Power Source	Chroma	61602	ABP000000811	AC 0V~300V, 45Hz~1000Hz	Oct. 17, 2020	Mar. 16, 2021	Oct. 16, 2021	Conduction (CO01-KS)

NCR: No Calibration Required

5 Uncertainty of Evaluation

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI 63.10-2013. All the measurement uncertainty value were shown with a coverage K=2 to indicate 95% level of confidence. The measurement data show herein meets or exceeds the CISPR measurement uncertainty values specified in CISPR 16-4-2 and can be compared directly to specified limit to determine compliance.

Uncertainty of Conducted Emission Measurement (150 kHz ~ 30 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**2.94dB**

Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.0dB**

Appendix A. Conducted Test Results

Report Number : FR112616A

Bluetooth

Test Engineer:	Long Wu	Temperature:	20~26	°C
Test Date:	2021/2/03~2021/2/20	Relative Humidity:	40~51	%

TEST RESULTS DATA
20dB and 99% Occupied Bandwidth and Hopping Channel Separation

Mod.	Data Rate	NTX	CH.	Freq. (MHz)	20db BW (MHz)	99% Bandwidth (MHz)	Hopping Channel Separation Measurement (kHz)	Hopping Channel Separation Measurement Limit (MHz)	Pass/Fail
DH	1Mbps	1	0	2402	0.996	0.941	1002.890	0.6638	Pass
DH	1Mbps	1	39	2441	1.001	0.944	998.600	0.6676	Pass
DH	1Mbps	1	78	2480	1.007	0.955	963.800	0.6715	Pass
2DH	2Mbps	1	0	2402	1.342	1.201	1002.900	0.8943	Pass
2DH	2Mbps	1	39	2441	1.342	1.201	1002.900	0.8943	Pass
2DH	2Mbps	1	78	2480	1.342	1.198	1002.900	0.8943	Pass

TEST RESULTS DATA
Dwell Time

Mod.	Hopping Channel Number Rate	Hops Over Occupancy Time(hops)	Package Transfer Time (msec)	Dwell Time (sec)	Limits (sec)	Pass/Fail
Nomal	79	106.67	2.9449	0.31	0.4	Pass
AFH	20	53.33	2.9449	0.16	0.4	Pass

TEST RESULTS DATA
Peak Power Table

DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH5	0	1	0.62	20.97	Pass
	39	1	1.10	20.97	Pass
	78	1	**1.31**	20.97	Pass

2DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
2DH1	0	1	4.02	20.97	Pass
	39	1	3.80	20.97	Pass
	78	1	**4.22**	20.97	Pass

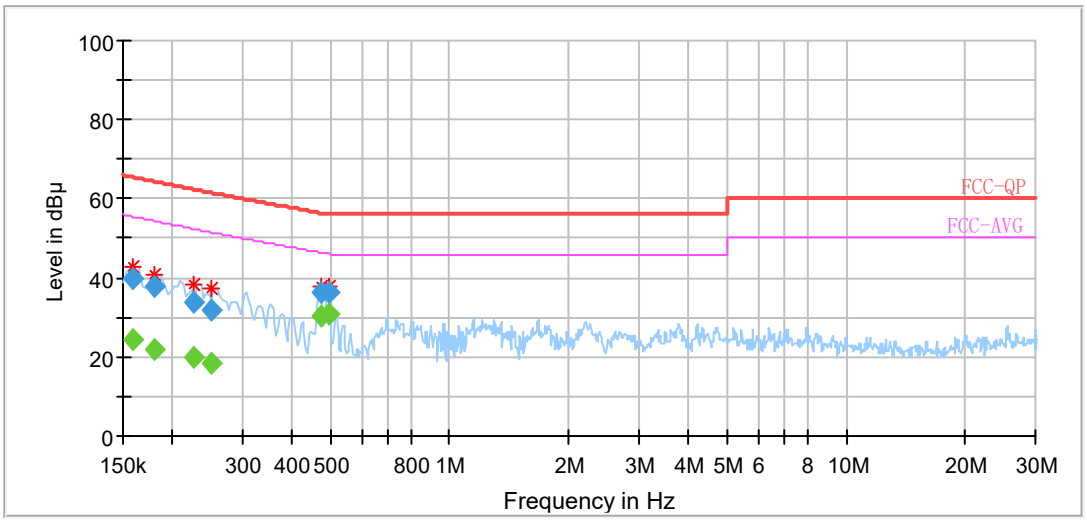
TEST RESULTS DATA
Number of Hopping Frequency

Number of Hopping (Channel)	Adaptive Frequency Hopping (Channel)	Limits (Channel)	Pass/Fail
79	79	> 15	Pass

Appendix B. AC Conducted Emission Test Results

Test Engineer :	Amos Zhang	**Temperature :**	24.2~25.6℃
		Relative Humidity :	37~39%
Test Voltage :	120Vac / 60Hz	**Phase :**	Line
Remark :	All emissions not reported here are more than 10 dB below the prescribed limit.		

Full Spectrum

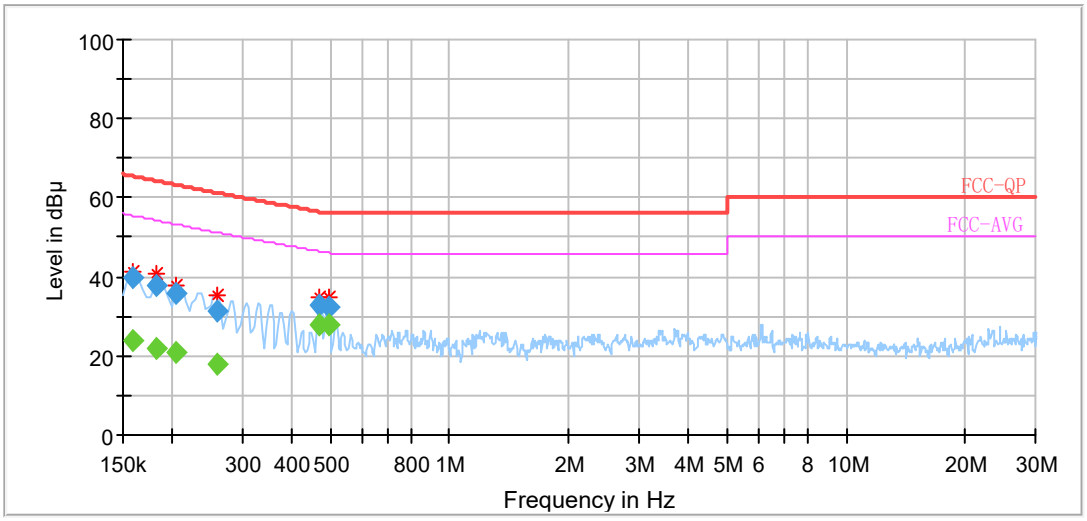


Final Result:

Frequency (MHz)	QuasiPeak (dBuV)	Average (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.158944	---	24.23	55.47	31.24	L1	OFF	20.1
0.158944	39.76	---	65.48	25.72	L1	OFF	20.1
0.180562	---	21.96	54.33	32.37	L1	OFF	20.0
0.180562	37.68	---	64.35	26.67	L1	OFF	20.0
0.226819	---	20.10	52.34	32.24	L1	OFF	19.9
0.226819	33.87	---	62.38	28.51	L1	OFF	19.9
0.249206	---	18.51	51.54	33.03	L1	OFF	19.9
0.249206	31.87	---	61.58	29.71	L1	OFF	19.9
0.473138	---	30.38	46.42	16.03	L1	OFF	19.8
0.473138	36.26	---	56.42	20.16	L1	OFF	19.8
0.495525	---	30.85	46.07	15.21	L1	OFF	19.8
0.495525	36.32	---	56.07	19.75	L1	OFF	19.8

Test Engineer :	Amos Zhang	**Temperature :**	24.2~25.6℃
		Relative Humidity :	37~39%
Test Voltage :	120Vac / 60Hz	**Phase :**	Neutral
Remark :	All emissions not reported here are more than 10 dB below the prescribed limit.		

Full Spectrum



Final Result:

Frequency (MHz)	QuasiPeak (dBuV)	Average (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.158944	---	23.99	55.47	31.49	N	OFF	20.2
0.158944	39.84	---	65.48	25.64	N	OFF	20.2
0.181331	---	22.05	54.29	32.24	N	OFF	20.2
0.181331	37.65	---	64.31	26.66	N	OFF	20.2
0.203719	---	20.97	53.27	32.30	N	OFF	20.2
0.203719	36.01	---	63.30	27.29	N	OFF	20.2
0.260456	---	17.97	51.17	33.20	N	OFF	20.1
0.260456	31.56	---	61.21	29.65	N	OFF	20.1
0.470888	---	27.85	46.45	18.60	N	OFF	19.9
0.470888	32.59	---	56.46	23.87	N	OFF	19.9
0.495524	---	27.79	46.07	18.27	N	OFF	19.9
0.495524	32.41	---	56.07	23.66	N	OFF	19.9

Appendix C. Radiated Spurious Emission

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Path Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH00 2402MHz		2387.35	55	-19	74	47.48	33.5	7.47	33.45	303	173	P	H
		2387.35	30.39	-23.61	54	-	-	-	-	-	-	A	H
	*	2402	94.07	-	-	86.54	33.5	7.47	33.44	303	173	P	H
		2402	69.46	-	-	-	-	-	-	-	-	A	H
		2388.65	55.28	-18.72	74	47.76	33.5	7.47	33.45	309	75	P	V
		2388.65	30.67	-23.33	54	-	-	-	-	-	-	A	V
	*	2402	90.48	-	-	82.95	33.5	7.47	33.44	309	75	P	V
		2402	65.87	-	-	-	-	-	-	-	-	A	V
BT CH 39 2441MHz		2382.28	55.99	-18.01	74	48.71	33.29	7.44	33.45	300	167	P	H
		2382.28	31.38	-22.62	54	-	-	-	-	-	-	A	H
		2490.16	54.98	-19.02	74	48.11	32.73	7.56	33.42	300	167	P	H
		2490.16	30.37	-23.63	54	-	-	-	-	-	-	A	H
	*	2442	95.41	-	-	88.22	33.11	7.51	33.43	300	167	P	H
		2442	70.8	-	-	-	-	-	-	-	-	A	H
		2374.87	55.14	-18.86	74	47.86	33.29	7.44	33.45	140	112	P	V
		2374.87	30.53	-23.47	54	-	-	-	-	-	-	A	V
		2485.84	55.42	-18.58	74	48.43	32.86	7.55	33.42	140	112	P	V
		2485.84	30.81	-23.19	54	-	-	-	-	-	-	A	V
	*	2442	90.62	-	-	83.43	33.11	7.51	33.43	140	112	P	V
		2442	66.01	-	-	-	-	-	-	-	-	A	V

BT CH 78 2480MHz		2483.98	54.83	-19.17	74	47.85	32.86	7.55	33.43	295	356	P	H
		2483.98	30.22	-23.78	54	-	-	-	-	-	-	A	H
	*	2480	94.7	-	-	87.72	32.86	7.55	33.43	295	356	P	H
		2480	70.09	-	-	-	-	-	-	-	-	A	H
		2493.64	54.9	-19.1	74	48.03	32.73	7.56	33.42	299	66	P	V
		2493.64	30.29	-23.71	54	-	-	-	-	-	-	A	V
	*	2480	91.67	-	-	84.69	32.86	7.55	33.43	299	66	P	V
		2480	67.06	-	-	-	-	-	-	-	-	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

BT (Harmonic @ 3m)

BT	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BT CH 00 2402MHz		4806	39.85	-34.15	74	55.9	34.84	10.83	61.72	100	360	P	H
		4806	40.53	-33.47	74	56.58	34.84	10.83	61.72	100	360	P	V
BT CH 39 2441MHz		4884	41.17	-32.83	74	57.16	34.83	10.89	61.71	100	360	P	H
		7320	42.28	-31.72	74	54.42	36.4	13.36	61.9	100	360	P	H
		4884	41.68	-32.32	74	57.67	34.83	10.89	61.71	100	360	P	V
		7320	41.45	-32.55	74	53.59	36.4	13.36	61.9	100	360	P	V
BT CH 78 2480MHz		4962	39.51	-34.49	74	55.44	34.81	10.96	61.7	100	360	P	H
		7440	40.51	-33.49	74	52.44	36.47	13.5	61.9	100	360	P	H
		4962	39	-35	74	54.93	34.81	10.96	61.7	100	360	P	V
		7440	40.78	-33.22	74	52.71	36.47	13.5	61.9	100	360	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz BT (LF)

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz BT LF		33.88	21.98	-18.02	40	30.29	22.98	0.91	32.2	-	-	P	H
		128.94	16.38	-27.12	43.5	28.94	17.6	1.98	32.14	-	-	P	H
		170.65	22.01	-21.49	43.5	36.18	15.65	2.28	32.1	-	-	P	H
		220.12	23.91	-22.09	46	38.16	15.3	2.59	32.14	-	-	P	H
		314.21	25.76	-20.24	46	35.26	19.54	3.09	32.13	-	-	P	H
		843.83	28.05	-17.95	46	26.23	29.17	5.04	32.39	100	0	P	H
		32.91	30.75	-9.25	40	38.55	23.51	0.89	32.2	100	360	P	V
		54.25	25.69	-14.31	40	43.22	13.4	1.27	32.2	-	-	P	V
		115.36	20.73	-22.77	43.5	33.7	17.33	1.87	32.17	-	-	P	V
		207.51	21.66	-21.84	43.5	36.07	15.18	2.52	32.11	-	-	P	V
		613.94	24.39	-21.61	46	26.36	25.99	4.31	32.27	-	-	P	V
		948.59	28.19	-17.81	46	24.08	30.96	5.35	32.2	-	-	P	V
Remark	1. No other spurious found. 2. All results are PASS against limit line.												

Note symbol

*	**Fundamental Frequency** which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is **over limit** line.
P/A	**P**eak or **A**verage
H/V	**H**orizontal or **V**ertical

A calculation example for radiated spurious emission is shown as below:

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH 00 2402MHz		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBμV/m) =

Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

3. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)

= 55.45 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 55.45(dBμV/m) – 74(dBμV/m)

= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)

= 43.54 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 43.54(dBμV/m) – 54(dBμV/m)

= -10.46(dB)

Both peak and average measured complies with the limit line, so test result is “PASS”.

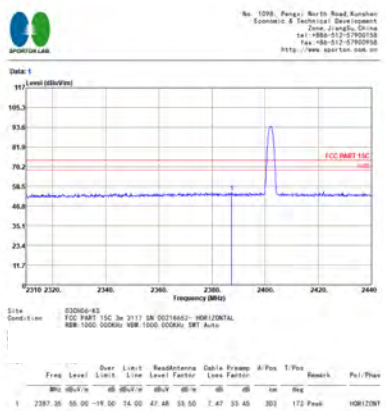
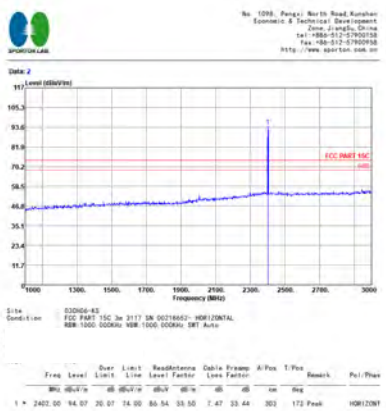
Appendix D. Radiated Spurious Emission Plots

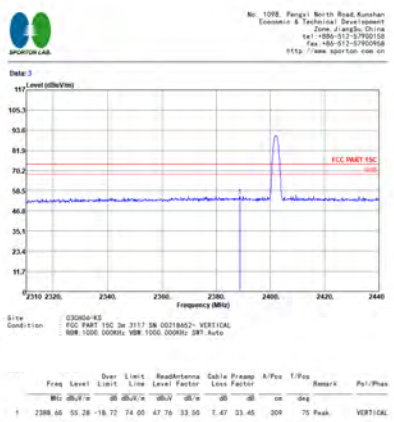
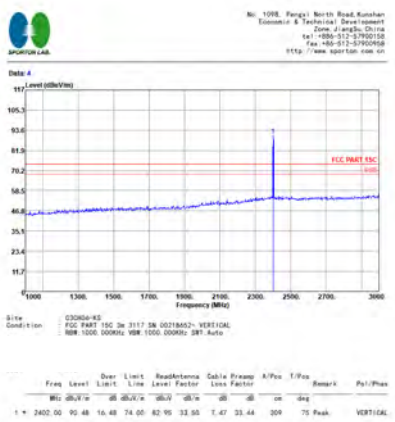
Note symbol

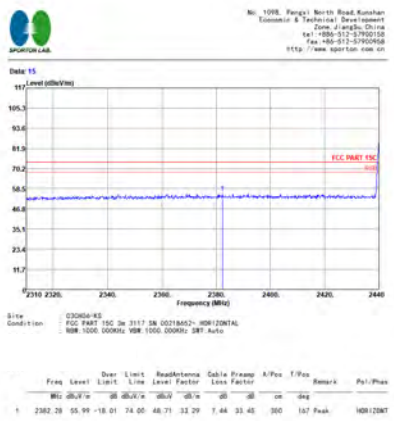
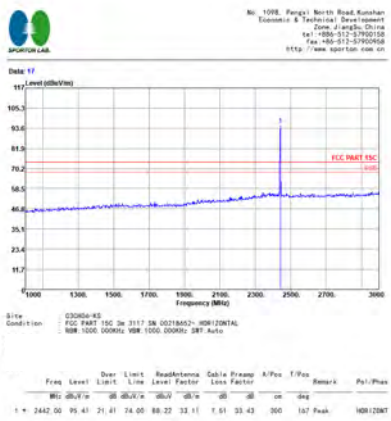
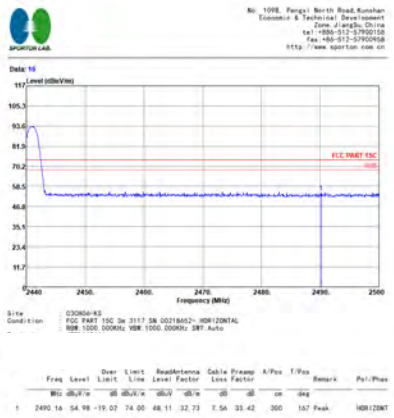
-L	**Low channel location**
-R	**High channel location**

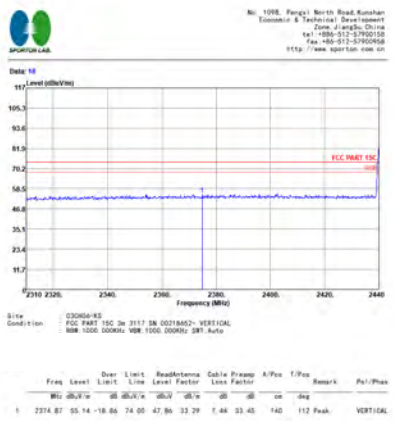
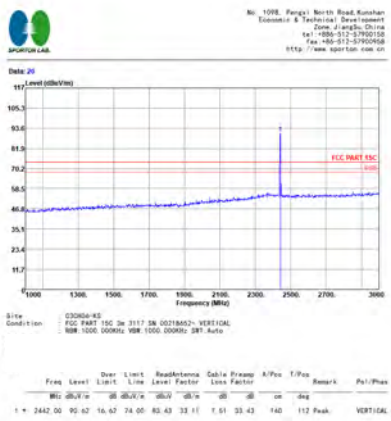
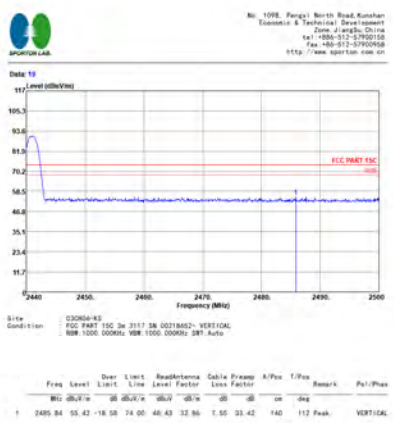
2.4GHz 2400~2483.5MHz

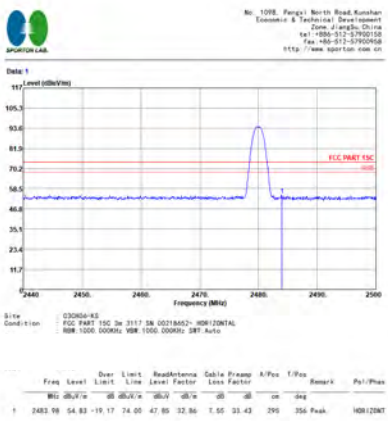
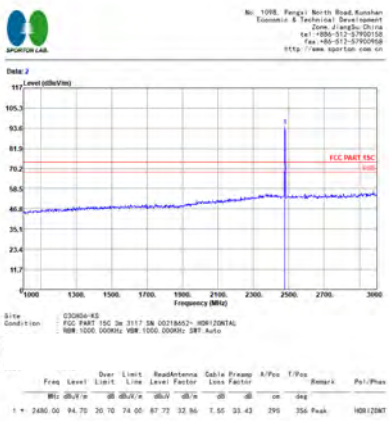
BT (Band Edge @ 3m)

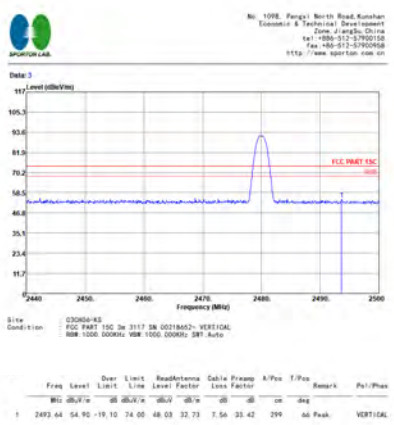
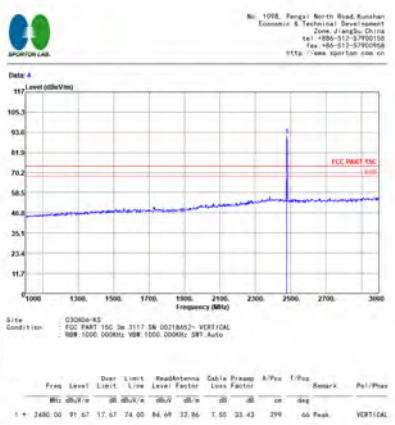
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH00 2402MHz	
1	Horizontal	Fundamental
Peak		

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH00 2402MHz	
1	Vertical	Fundamental
Peak		

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH39 2441MHz	
1	Horizontal	Fundamental
Peak		
Peak		–

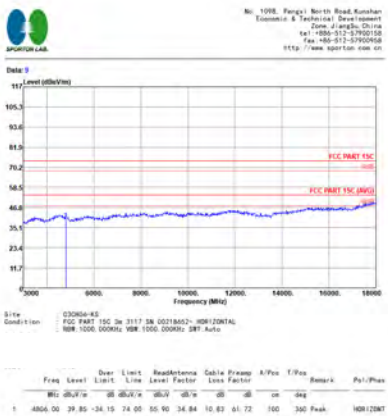
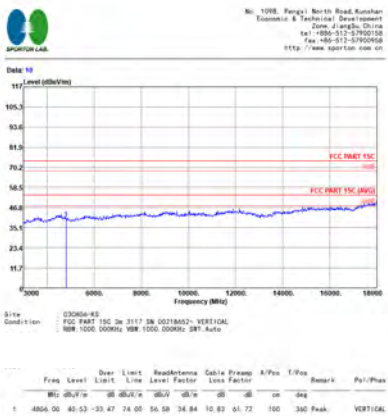
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH39 2441MHz	
1	Vertical	Fundamental
Peak		
Peak		–

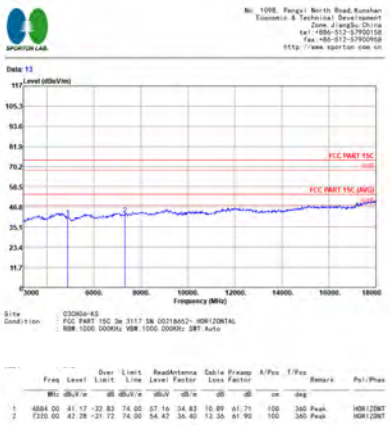
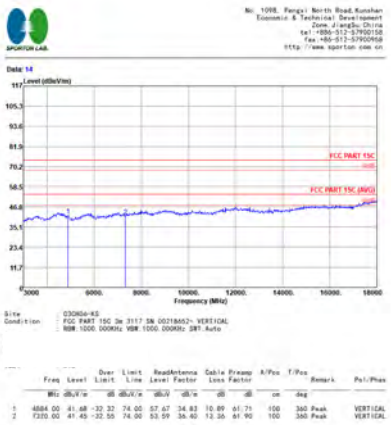
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH78 2480MHz	
1	Horizontal	Fundamental
Peak		

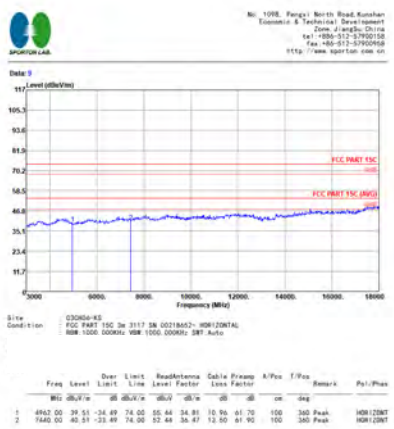
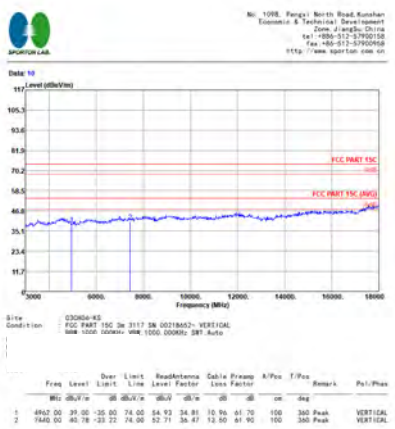
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH78 2480MHz	
1	Vertical	Fundamental
Peak		

2.4GHz 2400~2483.5MHz

BT (Harmonic @ 3m)

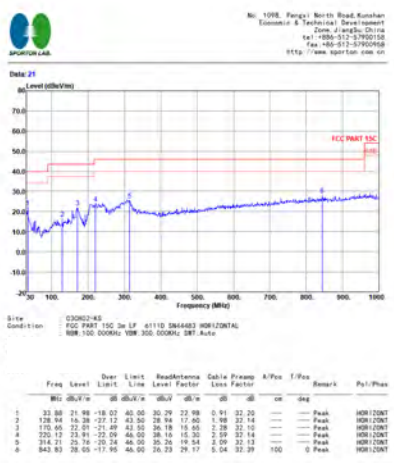
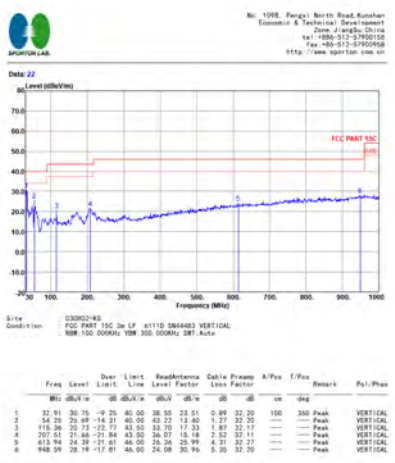
BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH00 2402MHz	
1	Horizontal	Vertical
Peak Avg.		

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH39 2441MHz	
1	Horizontal	Vertical
Peak Avg.		

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH78 2480MHz	
1	Horizontal	Vertical
Peak Avg.		

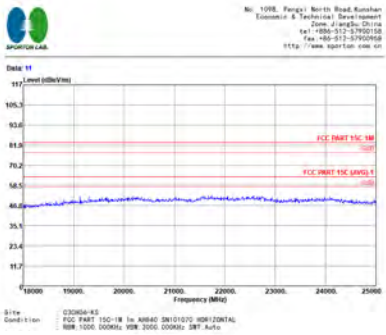
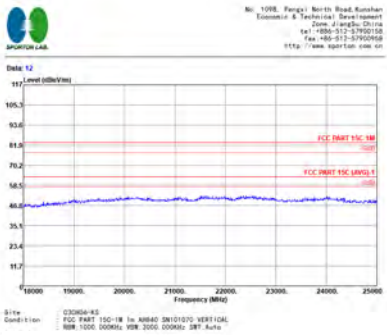
Emission below 1GHz

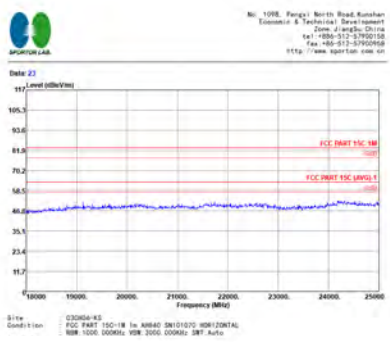
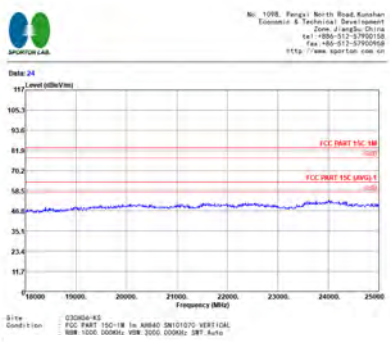
2.4GHz BT (LF)

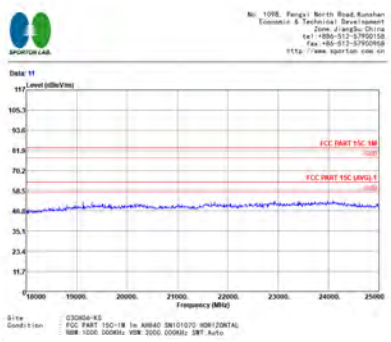
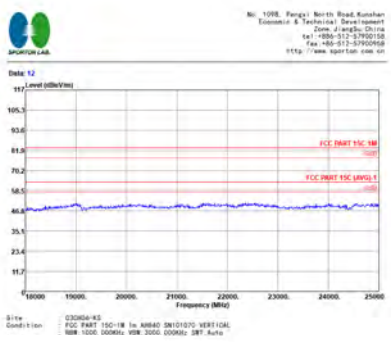
BT	2.4GHz 2400~2483.5MHz	
ANT	BT LF	
1	Horizontal	Vertical
QP / Peak		

Emission above 18-25GHz

2.4GHz BT (HF)

BT	2.4GHz 2400~2483.5MHz	
ANT	BT CH00 2402MHz	
1	Horizontal	Vertical
Peak Avg.		

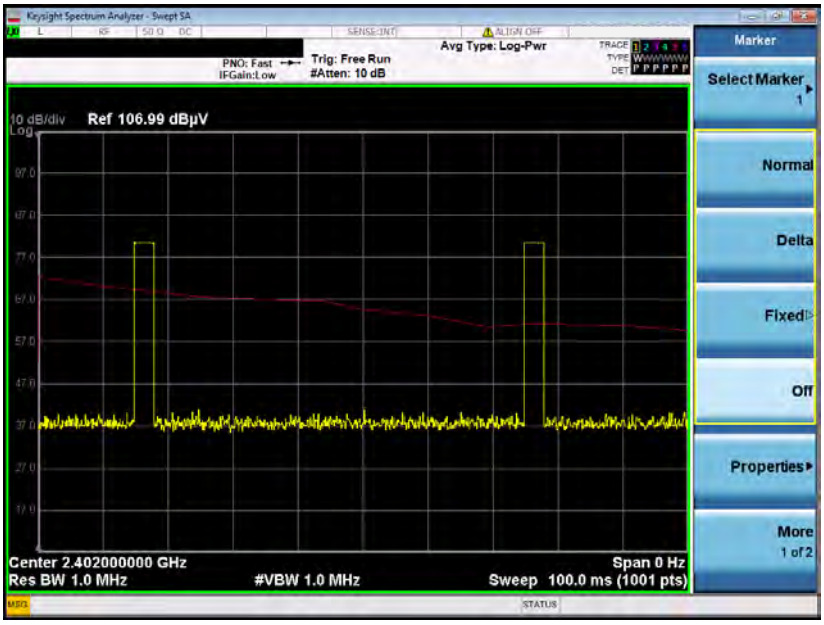
BT	2.4GHz 2400~2483.5MHz	
ANT	BT CH39 2441MHz	
1	Horizontal	Vertical
Peak Avg.		

BT	2.4GHz 2400~2483.5MHz	
ANT	BT CH78 2480MHz	
1	Horizontal	Vertical
Peak Avg.		

Appendix E. Duty Cycle Plots

2DH5 on time (One Pulse) Plot on Channel 00

2DH5 on time (Count Pulses) Plot on Channel 00



Note:

1. Worst case Duty cycle = on time/100 milliseconds = 2 * 2.942 / 100 = 5.88 %
2. Worst case Duty cycle correction factor = 20*log(Duty cycle) = -24.61 dB
3. 2DH5 has the highest duty cycle worst case and is reported.