



FCC RADIO TEST REPORT

FCC ID : S9E-121900
Equipment : Rugged Handheld Computer
Brand Name : Trimble
Model Name : 121900
Marketing Name : TSC5
Applicant : Trimble Inc.
5475 Kellenburger Rd., Dayton, Ohio, United States 45424
Manufacturer : Trimble Inc.
5475 Kellenburger Rd., Dayton, Ohio, United States 45424
Standard : FCC Part 15 Subpart C §15.247

The product was received on Aug. 19, 2020 and testing was started from Sep. 09, 2020 and completed on Oct. 08, 2020. We, SPORTON INTERNATIONAL INC., EMC & Wireless Communications Laboratory, 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 INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.

Louis Wu

Reviewed by: Louis Wu

SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory
No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)



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History of this test report

Report No.	Version	Description	Issued Date
FR081931A	01	Initial issue of report	Oct. 28, 2020

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	15.247(a)(1)	Number of Channels	Pass	-
3.2	15.247(a)(1)	Hopping Channel Separation	Pass	-
3.3	15.247(a)(1)	Dwell Time of Each Channel	Pass	-
3.4	15.247(a)(1)	20dB Bandwidth	Pass	-
3.4	2.1049	99% Occupied Bandwidth	Reporting only	-
3.5	15.247(b)(1)	Peak Output Power	Pass	-
3.6	15.247(d)	Conducted Band Edges	Pass	-
3.7	15.247(d)	Conducted Spurious Emission	Pass	-
3.8	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	Pass	Under limit 6.85 dB at 745.860 MHz
3.9	15.207	AC Conducted Emission	Pass	Under limit 10.18 dB at 0.172 MHz
3.10	15.203 & 15.247(b)	Antenna Requirement	Pass	-

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.

Reviewed by: Wii Chang

Report Producer: Amy Chen

1 General Description

1.1 Product Feature of Equipment Under Test

WCDMA/LTE, Bluetooth, Wi-Fi 2.4GHz 802.11b/g/n/ac, Wi-Fi 5GHz 802.11a/n/ac, and GNSS.

Product Specification subjective to this standard	
Antenna Type	WWAN: PIFA Antenna WLAN <Ant. 1>: Dipole Antenna <Ant. 2>: Dipole Antenna Bluetooth: Dipole Antenna GPS/Glonass/BDS/Galileo: Patch Antenna

1.2 Modification of EUT

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

1.3 Testing Location

Test Site	SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory	
Test Site Location	No.52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-3456 FAX: +886-3-328-4978	
Test Site No.	Sporton Site No.	
	TH05-HY	CO05-HY

Note: The test site complies with ANSI C63.4 2014 requirement.

Test Site	SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory	
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-0868 FAX: +886-3-327-0855	
Test Site No.	Sporton Site No.	
	03CH15-HY	

Note: The test site complies with ANSI C63.4 2014 requirement.

FCC designation No.: TW1190 and TW0007



1.4 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
- ♦ FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05r02
- ♦ FCC KDB 414788 D01 Radiated Test Site v01r01
- ♦ ANSI C63.10-2013

Remark:

1. All test items were verified and recorded according to the standards and without any deviation during the test.
2. The TAF code is not including all the FCC KDB listed without accreditation.
3. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.



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 (Y plane) were recorded in this report, and the worst mode of radiated spurious emissions is Bluetooth 1Mbps 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	Bluetooth EDR 3Mbps 8-DPSK
Conducted Test Cases	Mode 1: CH00_2402 MHz	Mode 4: CH00_2402 MHz	Mode 7: CH00_2402 MHz
	Mode 2: CH39_2441 MHz	Mode 5: CH39_2441 MHz	Mode 8: CH39_2441 MHz
	Mode 3: CH78_2480 MHz	Mode 6: CH78_2480 MHz	Mode 9: CH78_2480 MHz
Radiated Test Cases	Bluetooth BR 1Mbps GFSK		
	Mode 1: CH00_2402 MHz		
	Mode 2: CH39_2441 MHz		
AC Conducted Emission	Mode 3: CH78_2480 MHz		
	Mode 1 : LTE Band 41 Link + WLAN (2.4GHz) Link + Bluetooth Link + Color Bar + USB Cable (Charging from AC Adapter)		
AC Conducted Emission			
Mode 2 : LTE Band 41 Idle + WLAN (2.4GHz) Idle + Bluetooth Idle + Color Bar + USB Cable (Charging from AC Adapter)			
Remark:			
1. For radiated test cases, the worst mode data rate 1Mbps was reported only since the highest RF output power in the preliminary tests. The conducted spurious emissions and conducted band edge measurement for other data rates were not worse than 1Mbps, and no other significantly frequencies found in conducted spurious emission.			
2. The worst case of conducted emission is mode 1; only the test data of it was reported.			

2.3 Connection Diagram of Test System



2.4 Support Unit used in test configuration and system

Item	Equipment	Brand Name	Model Name	FCC ID	Data Cable	Power Cord
1.	System Simulator	Anritsu	MT8820C	N/A	N/A	Unshielded, 1.8 m
2.	Bluetooth Earphone	Sony Ericsson	MW600	PY7DDA-2029	N/A	N/A
3.	WLAN AP	ASUS	RT-AC66U	MSQ-RTAC66U	N/A	Unshielded, 1.8 m
4.	Notebook	DELL	Latitude 3400	FCC DoC	N/A	AC I/P: Unshielded, 1.2 m DC O/P: Shielded, 1.8 m
5.	Bluetooth Base Station	R&S	CBT32	N/A	N/A	Unshielded, 1.8 m
6.	Battery	Trimble	U80596R01	N/A	N/A	N/A



2.5 EUT Operation Test Setup

The RF test items, utility “QRCT4.0” was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to contact with base station to provide channel selection, power level, data rate and the application type and for continuous transmitting signals.

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 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 4.2 dB and 10dB attenuator.

$$\begin{aligned}\text{Offset(dB)} &= \text{RF cable loss(dB)} + \text{attenuator factor(dB)} \\ &= 4.2 + 10 = 14.2 \text{ (dB)}\end{aligned}$$

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

See list of measuring equipment 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 $\geq$ 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

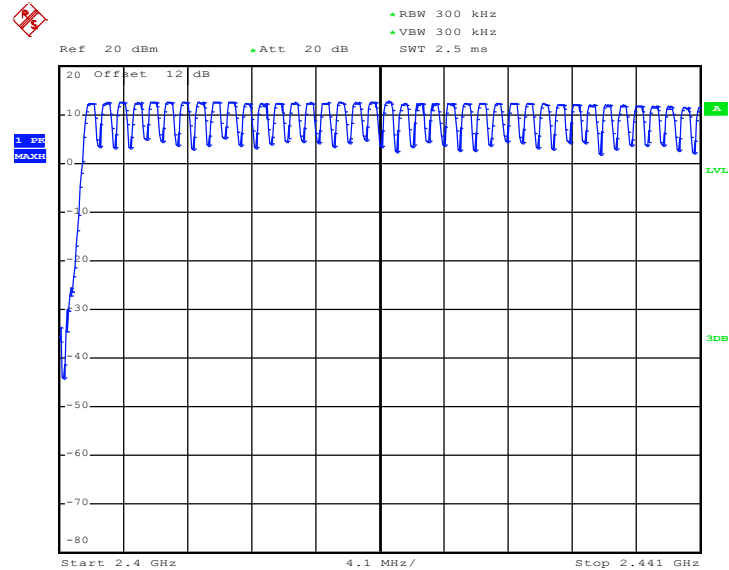




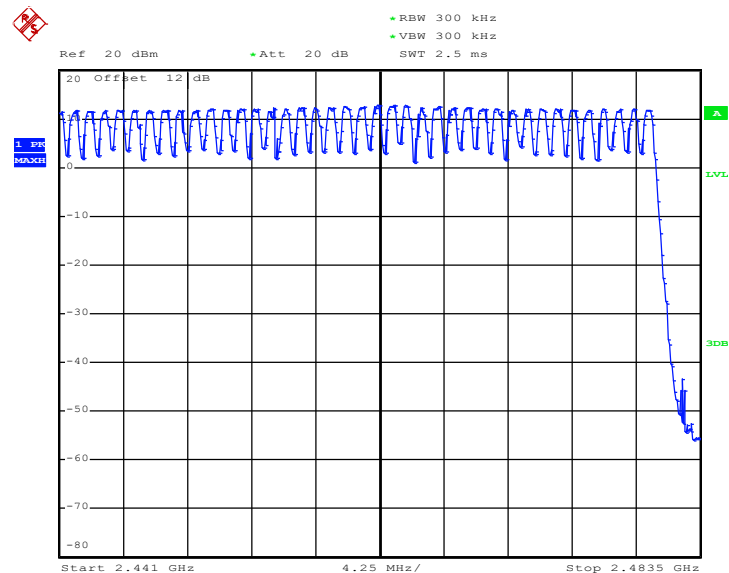
3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.

Number of Hopping Channel Plot on Channel 00 - 78



Date: 21.SEP.2020 09:31:54



Date: 21.SEP.2020 09:32:29

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

See list of measuring equipment 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 $\geq$ RBW; Sweep = auto; Detector function = peak; Trace = max hold.
6. Measure and record the results in the test report.

3.2.4 Test Setup



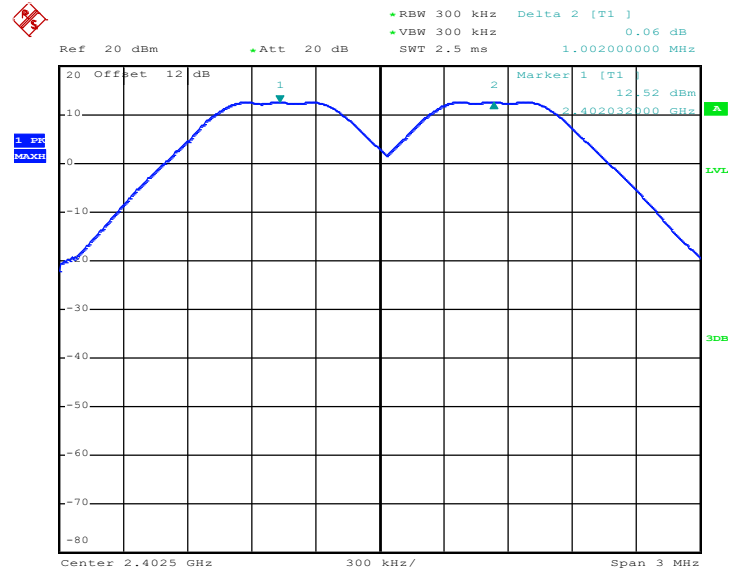
3.2.5 Test Result of Hopping Channel Separation

Please refer to Appendix A.



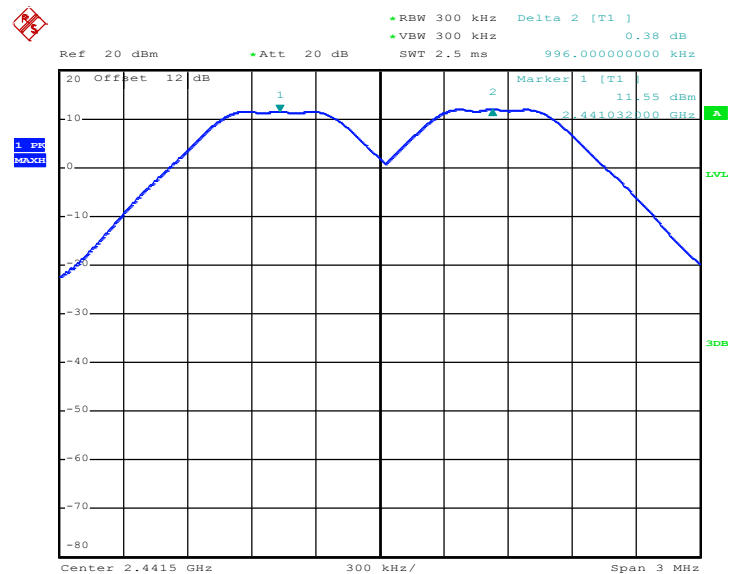
<1Mbps>

Channel Separation Plot on Channel 00 - 01



Date: 21.SEP.2020 10:07:00

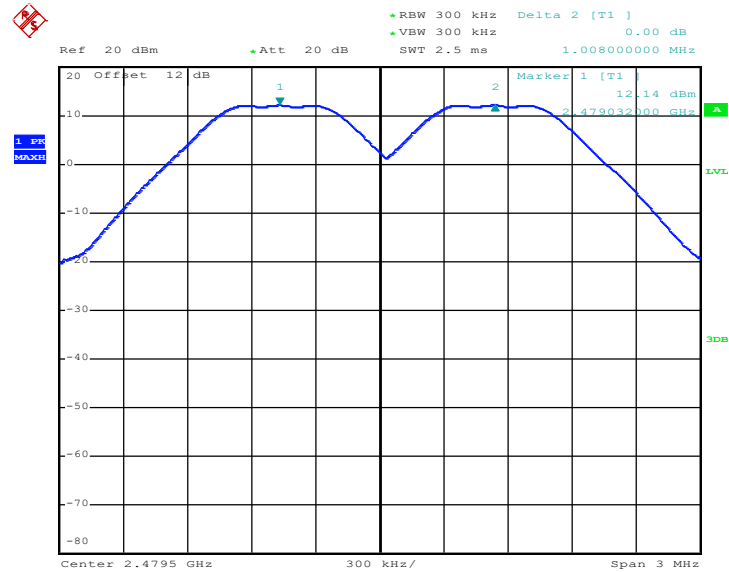
Channel Separation Plot on Channel 39 - 40



Date: 21.SEP.2020 10:15:04



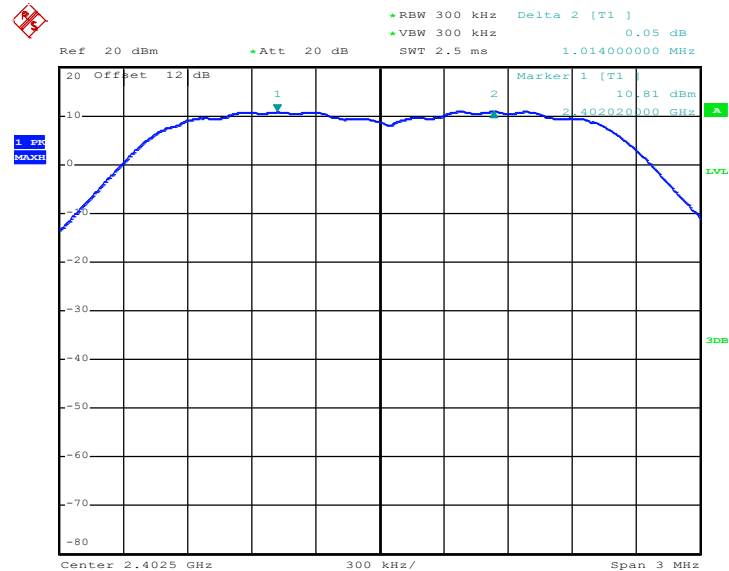
Channel Separation Plot on Channel 77 - 78



Date: 21.SEP.2020 10:23:09

<2Mbps>

Channel Separation Plot on Channel 00 - 01



Date: 21.SEP.2020 10:57:03

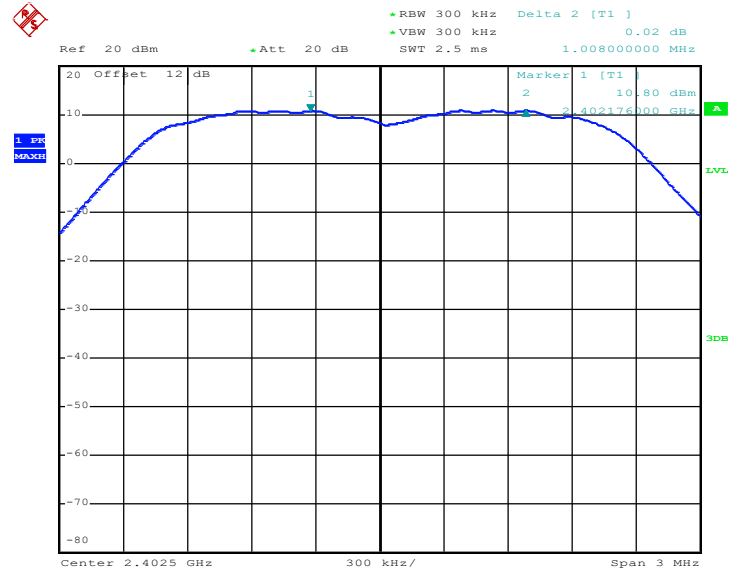


Date: 21.SEP.2020 11:13:55



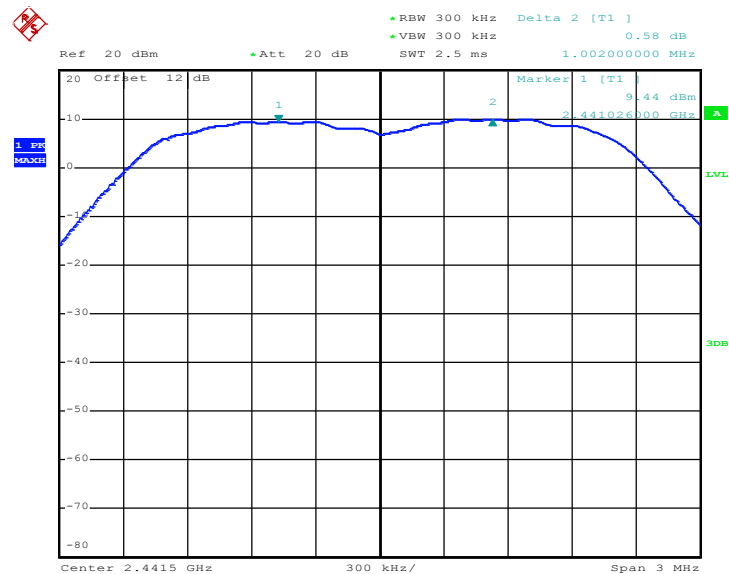
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Channel Separation Plot on Channel 00 - 01



Date: 21.SEP.2020 11:35:38

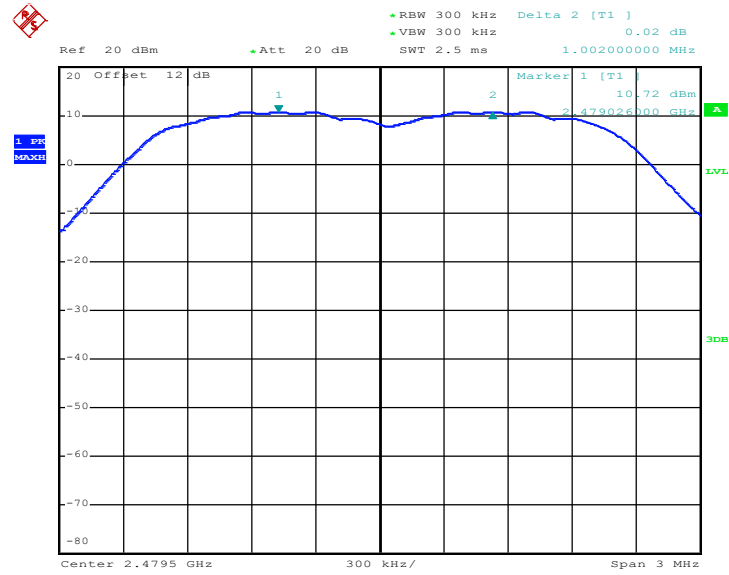
Channel Separation Plot on Channel 39 - 40



Date: 21.SEP.2020 11:51:03



Channel Separation Plot on Channel 77 - 78



Date: 21.SEP.2020 12:00:24

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.

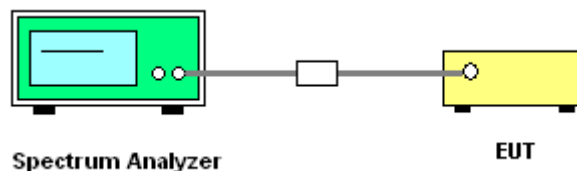
3.3.2 Measuring Instruments

See list of measuring equipment 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 $\geq$ 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.

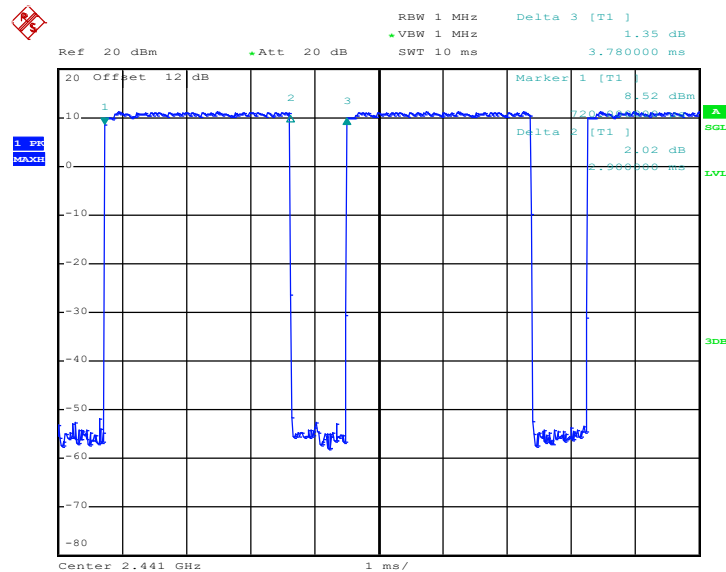
3.3.4 Test Setup



3.3.5 Test Result of Dwell Time

Please refer to Appendix A.

Package Transfer Time Plot



Date: 9.SEP.2020 17:24:22

Remark:

1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels. With channel hopping rate $(1600 / 6 / 79)$ in Occupancy Time Limit (0.4×79) (s), Hops Over Occupancy Time comes to $(1600 / 6 / 79) \times (0.4 \times 79) = 106.67$ 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 (0.4×20) (s), Hops Over Occupancy Time comes to $(800 / 6 / 20) \times (0.4 \times 20) = 53.33$ 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

See list of measuring equipment 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;
RBW $\geq$ 1% of the 20 dB bandwidth; VBW $\geq$ 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;
RBW $\geq$ 1-5% of the 99% bandwidth; VBW $\geq$ 3 * RBW; Sweep = auto; Detector function = peak;
Trace = max hold.
6. Measure and record the results in the test report.

3.4.4 Test Setup



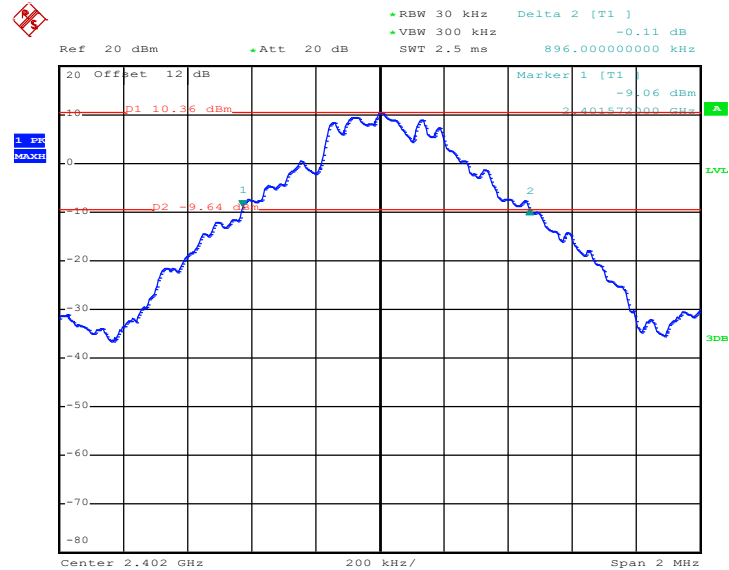
3.4.5 Test Result of 20dB Bandwidth

Please refer to Appendix A.



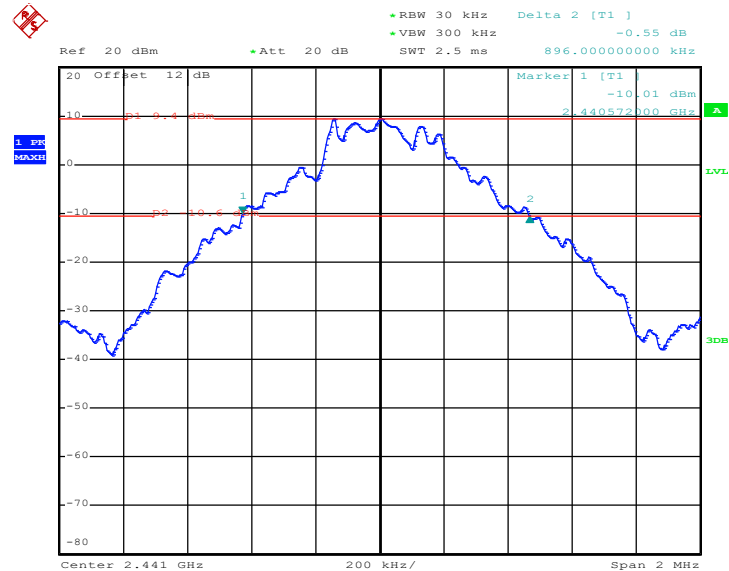
<1Mbps>

20 dB Bandwidth Plot on Channel 00



Date: 21.SEP.2020 09:59:04

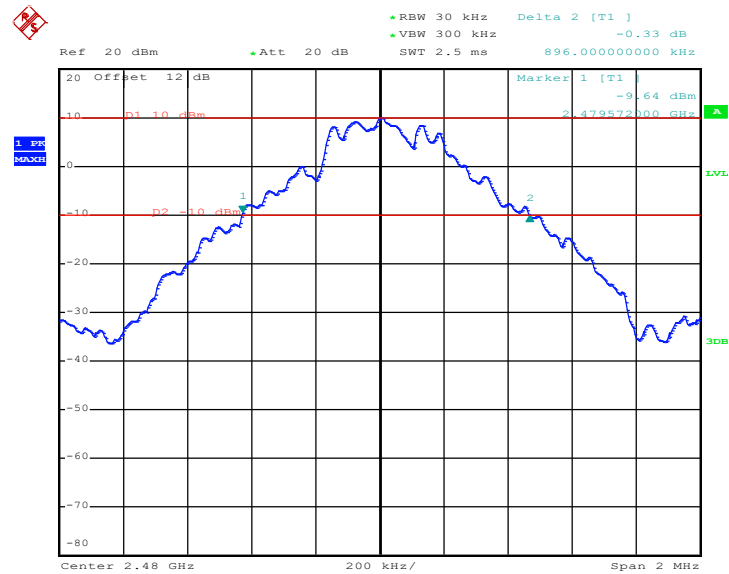
20 dB Bandwidth Plot on Channel 39



Date: 21.SEP.2020 10:10:30



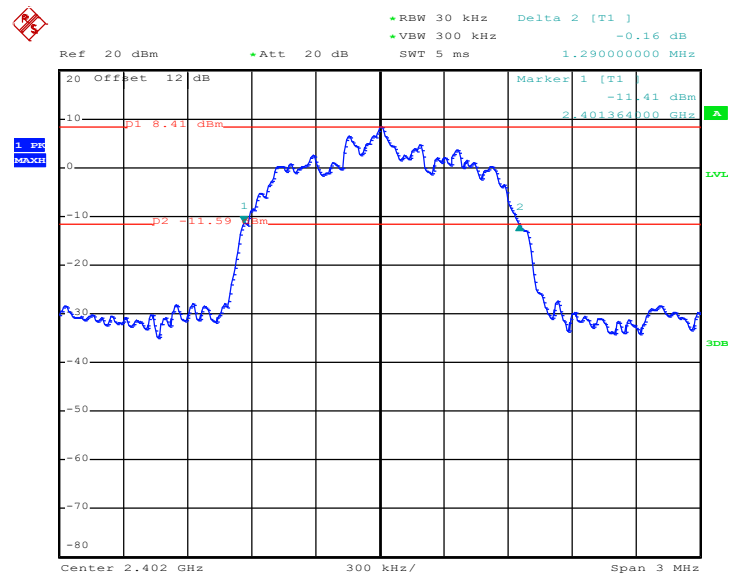
20 dB Bandwidth Plot on Channel 78



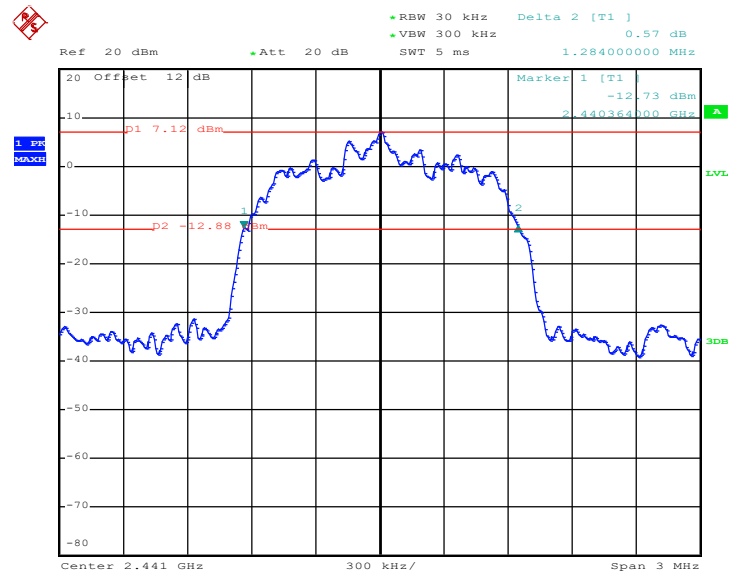
Date: 21.SEP.2020 10:16:49

<2Mbps>

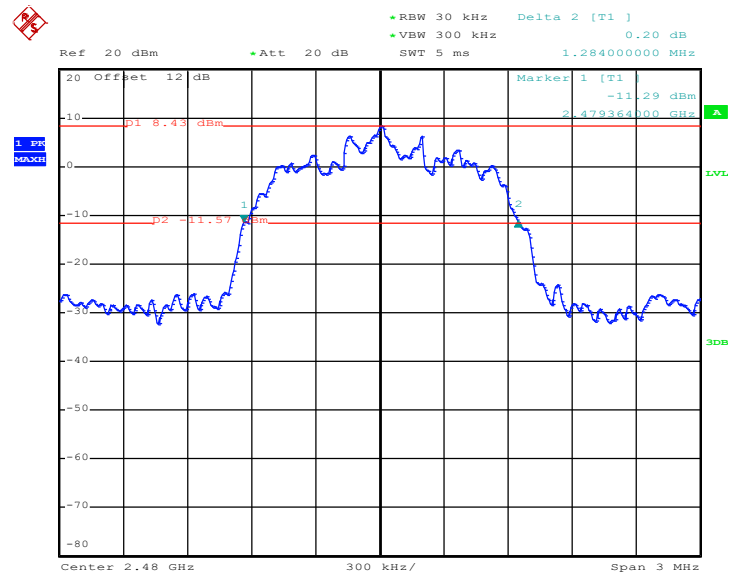
20 dB Bandwidth Plot on Channel 00



Date: 21.SEP.2020 10:48:05

**20 dB Bandwidth Plot on Channel 39**

Date: 21.SEP.2020 10:59:25

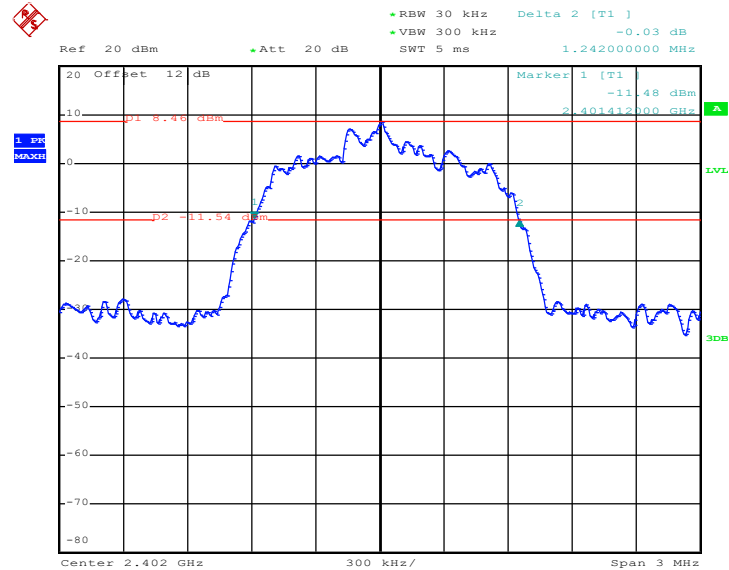
20 dB Bandwidth Plot on Channel 78

Date: 21.SEP.2020 11:06:31



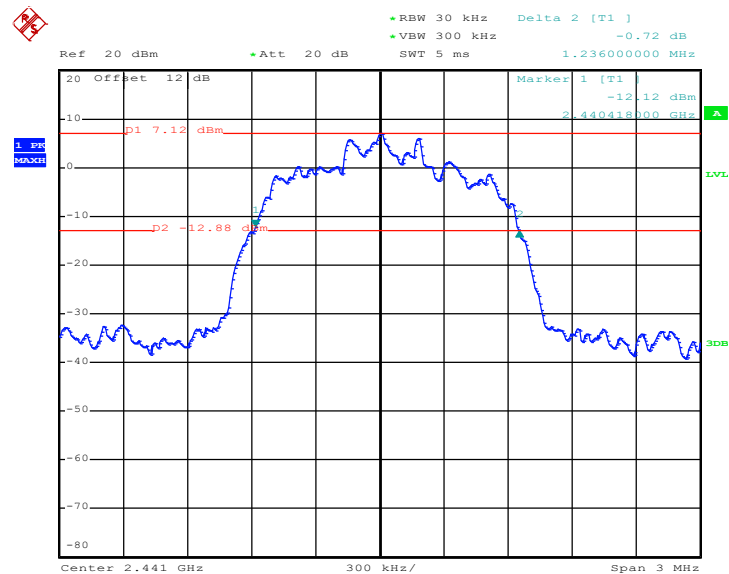
<3Mbps>

20 dB Bandwidth Plot on Channel 00



Date: 21.SEP.2020 11:21:26

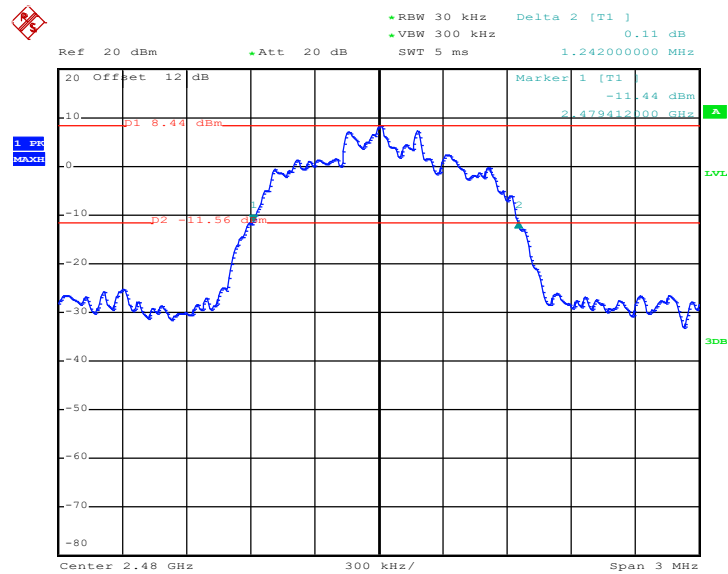
20 dB Bandwidth Plot on Channel 39



Date: 21.SEP.2020 11:38:44



20 dB Bandwidth Plot on Channel 78



Date: 21.SEP.2020 11:55:27

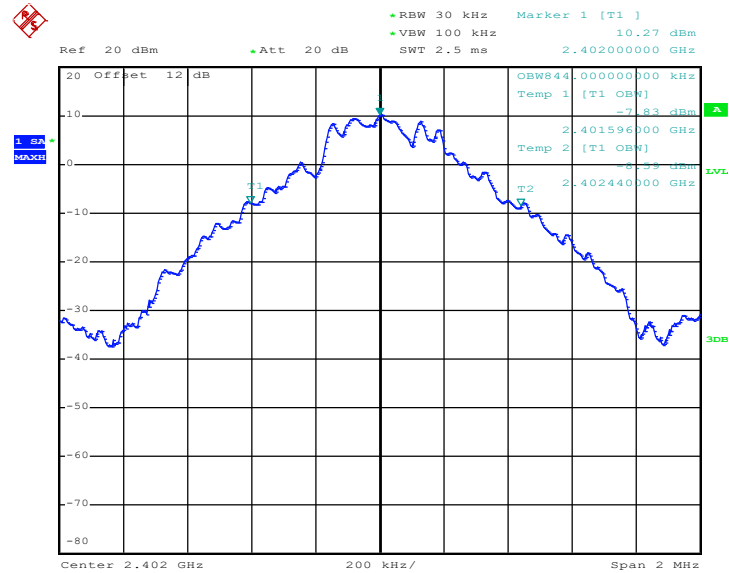


3.4.6 Test Result of 99% Occupied Bandwidth

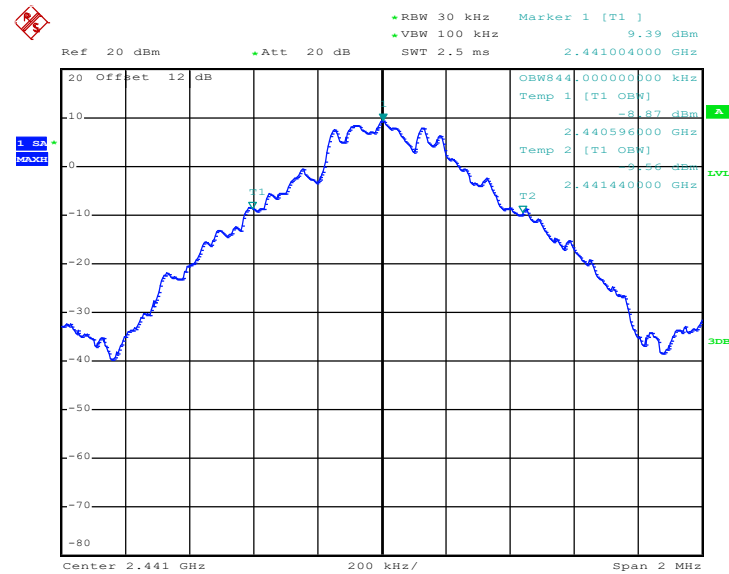
Please refer to Appendix A.

<1Mbps>

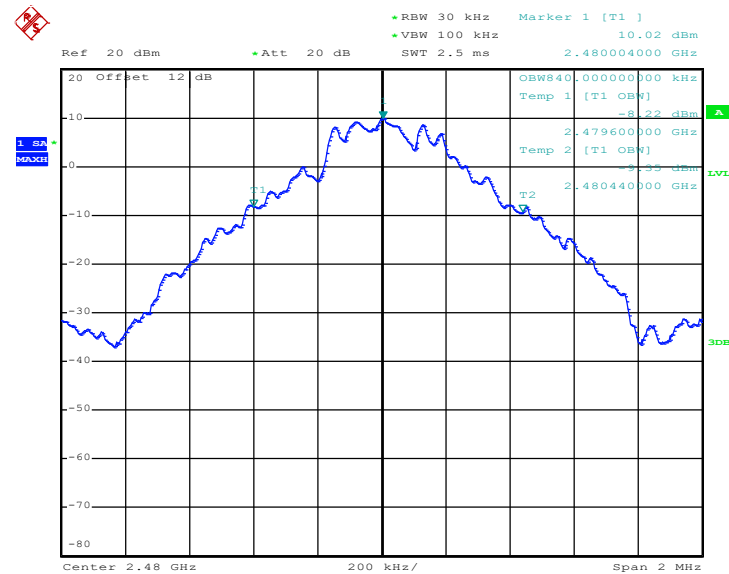
99% Occupied Bandwidth Plot on Channel 00



Date: 21.SEP.2020 10:03:32

99% Occupied Bandwidth Plot on Channel 39


Date: 21.SEP.2020 10:12:10

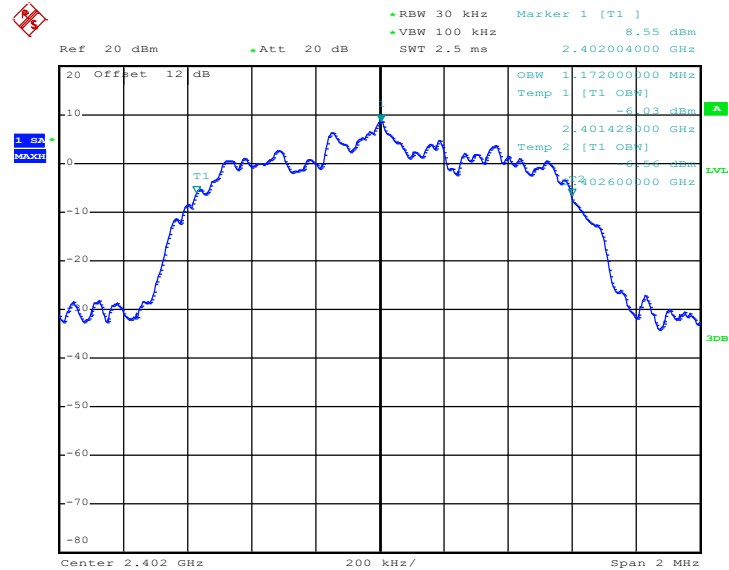
99% Occupied Bandwidth Plot on Channel 78


Date: 21.SEP.2020 10:19:40



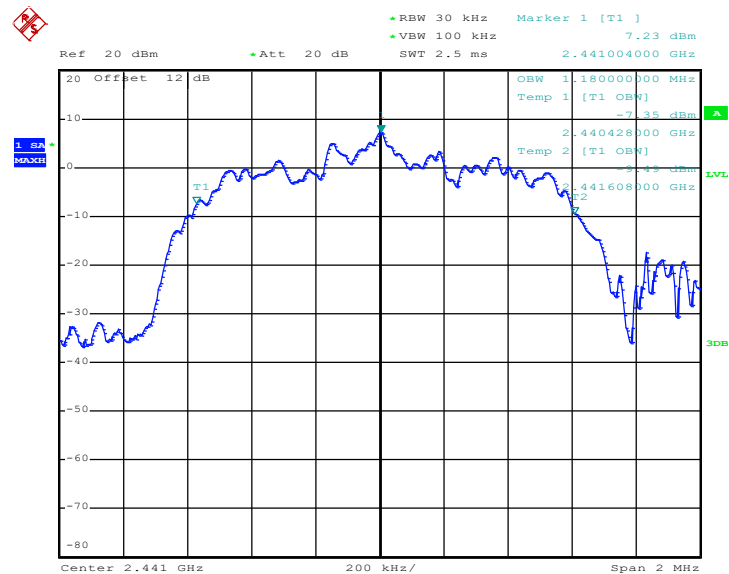
<2Mbps>

99% Occupied Bandwidth Plot on Channel 00

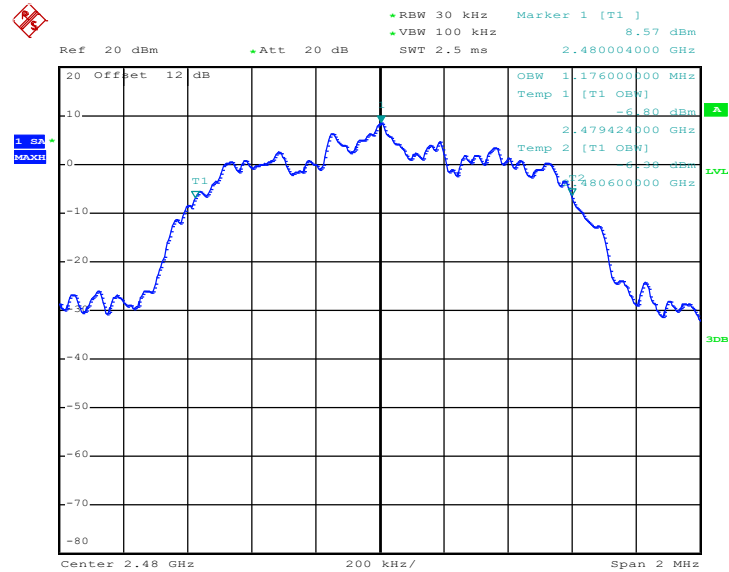


Date: 21.SEP.2020 10:50:39

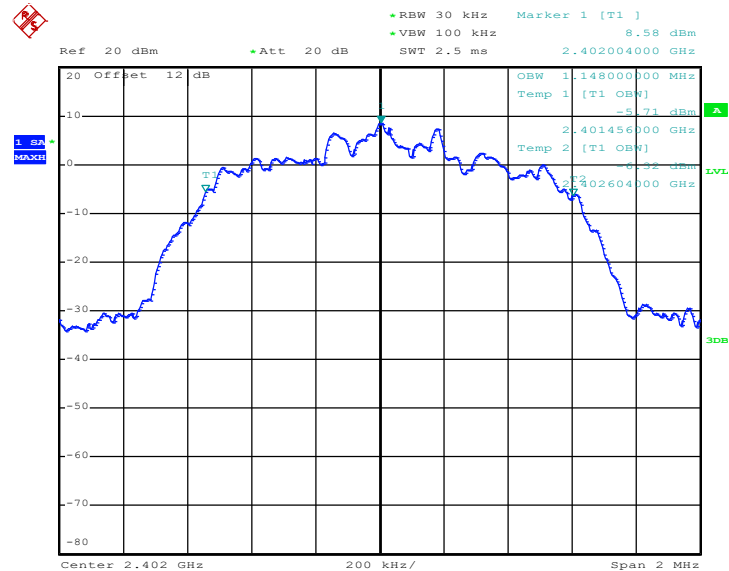
99% Occupied Bandwidth Plot on Channel 39



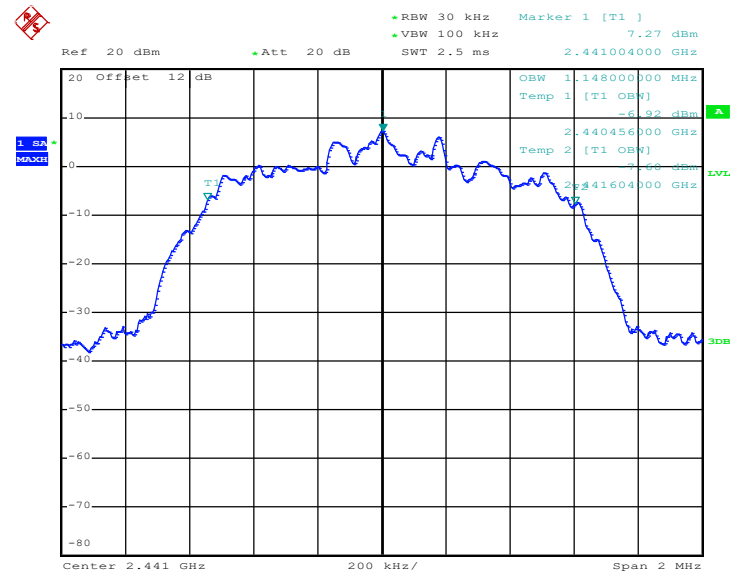
Date: 21.SEP.2020 11:00:26

**99% Occupied Bandwidth Plot on Channel 78**

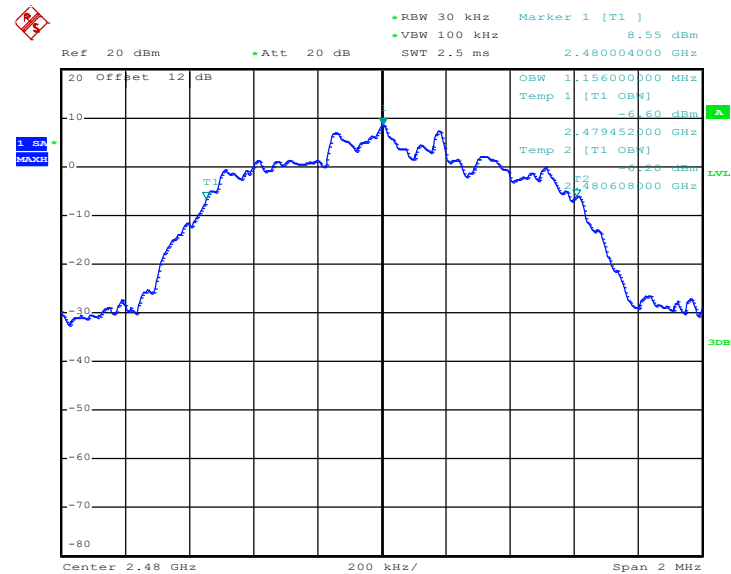
Date: 21.SEP.2020 11:08:07

<3Mbps>**99% Occupied Bandwidth Plot on Channel 00**

Date: 21.SEP.2020 11:23:01

99% Occupied Bandwidth Plot on Channel 39


Date: 21.SEP.2020 11:39:49

99% Occupied Bandwidth Plot on Channel 78


Date: 21.SEP.2020 11:56:47

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:
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.

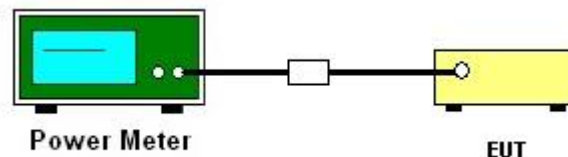
3.5.2 Measuring Instruments

See list of measuring equipment 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.

3.5.6 Test Result of Average Output Power (Reporting Only)

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.

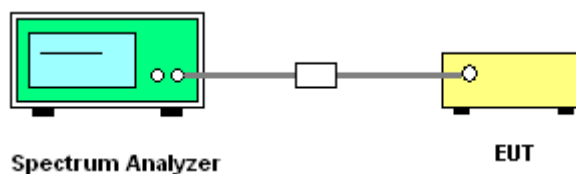
3.6.2 Measuring Instruments

See list of measuring equipment 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

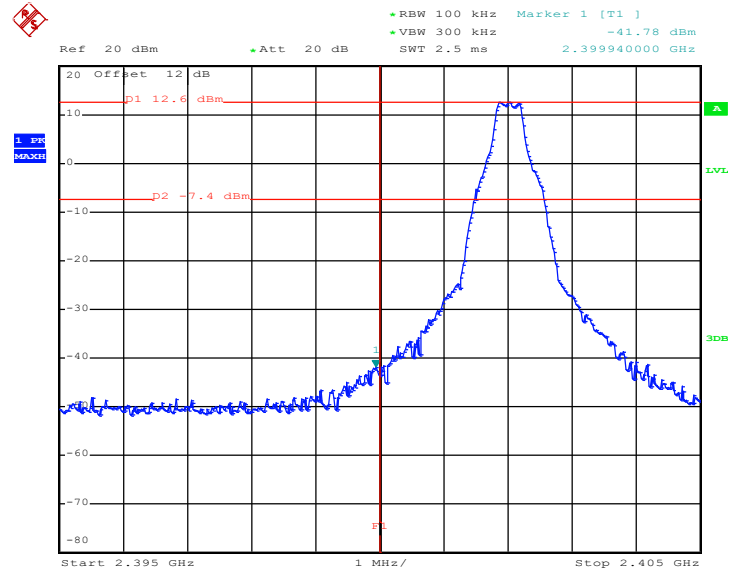




3.6.5 Test Result of Conducted Band Edges

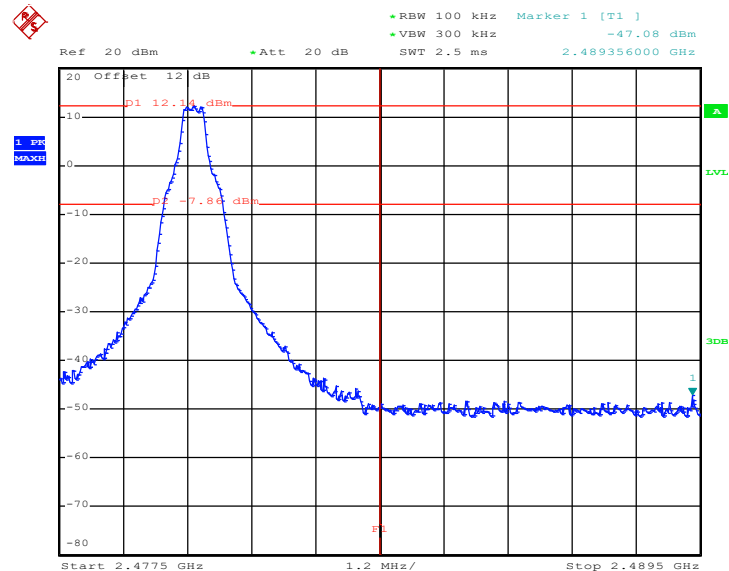
<1Mbps>

Low Band Edge Plot on Channel 00



Date: 21.SEP.2020 10:02:32

High Band Edge Plot on Channel 78

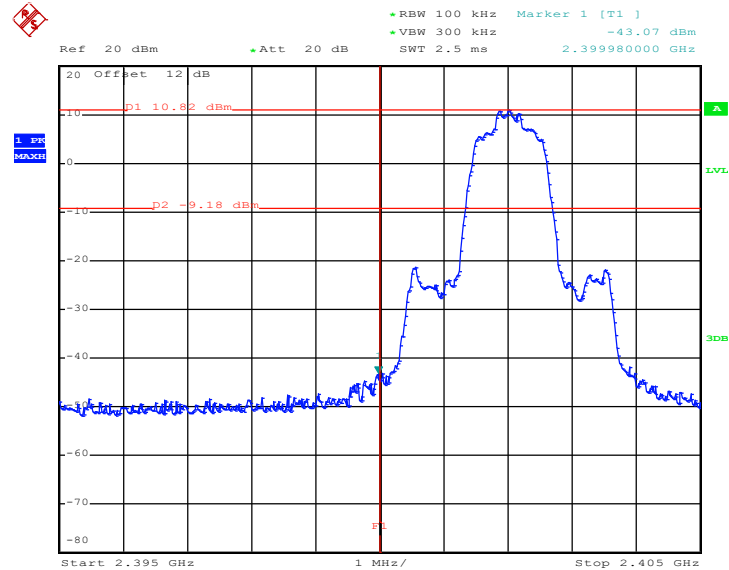


Date: 21.SEP.2020 10:18:59



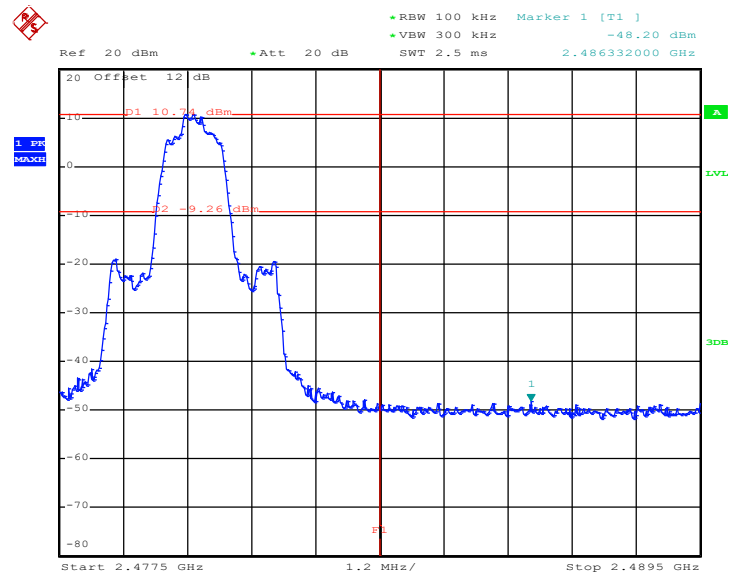
<2Mbps>

Low Band Edge Plot on Channel 00



Date: 21.SEP.2020 10:48:54

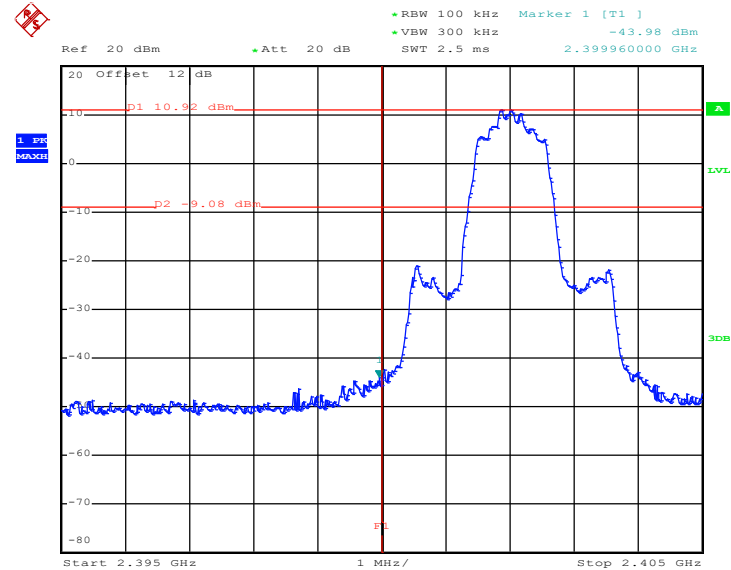
High Band Edge Plot on Channel 78



Date: 21.SEP.2020 11:07:24

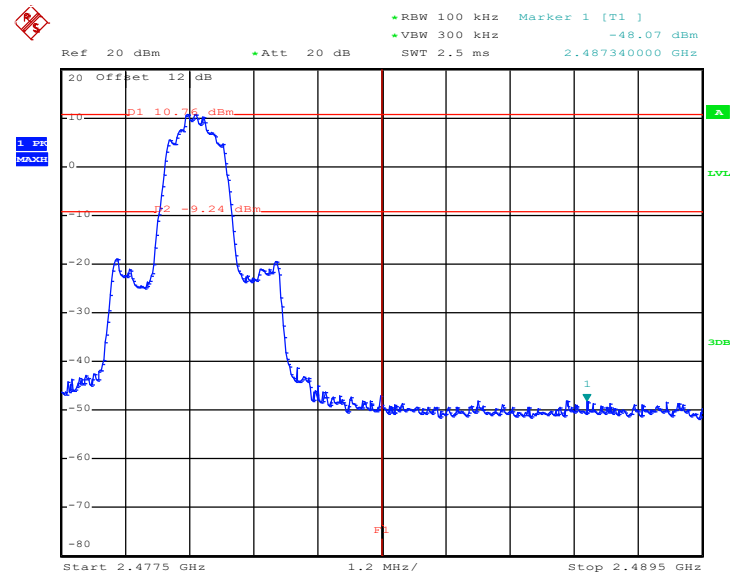
<3Mbps>

Low Band Edge Plot on Channel 00



Date: 21.SEP.2020 11:22:18

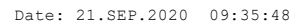
High Band Edge Plot on Channel 78



Date: 21.SEP.2020 11:56:03



Hopping Mode Low Band Edge Plot

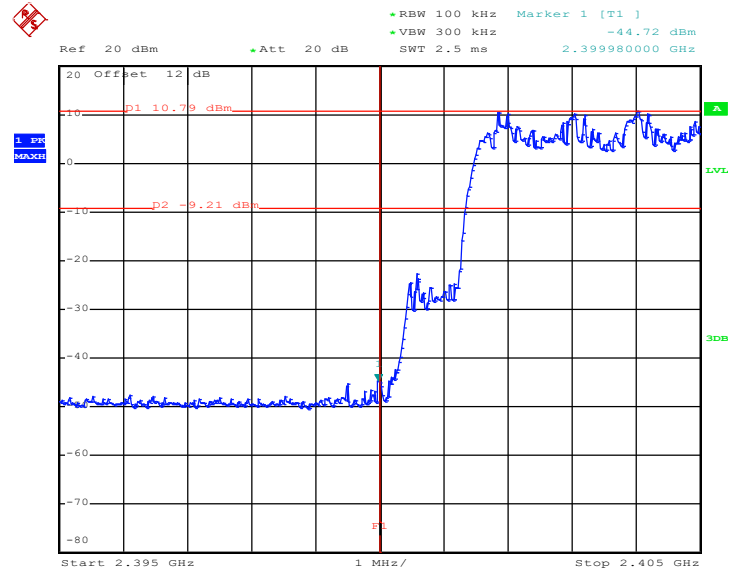


Hopping Mode High Band Edge Plot



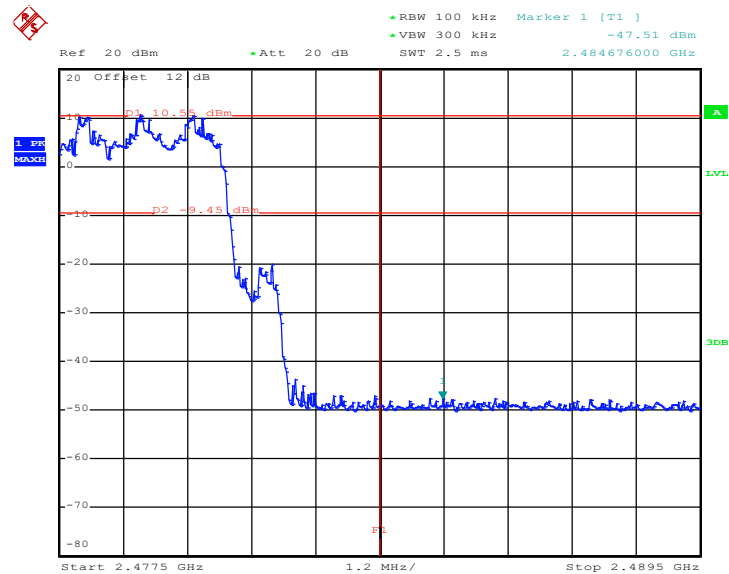
<2Mbps>

Hopping Mode Low Band Edge Plot



Date: 21.SEP.2020 09:42:16

Hopping Mode High Band Edge Plot



Date: 21.SEP.2020 09:44:13



Ref 20 dBm • Att 20 dB SWT 2.5 ms 2.399820000 GHz

• RBW 100 kHz Marker 1 [T1] -44.84 dBm

• VSW 300 kHz

1.55 MAX10

Offset 12 dB

D1 10.89 dBm

D2 -9.11 dBm

1

FL

Start 2.395 GHz 1 MHz/ Stop 2.405 GHz

Date: 21.SEP.2020 09:47:11

Ref 20 dBm Att 20 dB RBW 100 kHz VBW 300 kHz Marker 1 [T1] -46.86 dBm SWT 2.5 ms 2.487100000 GHz

20 Offset 12 dB

P1 10.9 dBm

P2 -9.1 dBm

1.2 MHz/

Start 2.4775 GHz Stop 2.4895 GHz

Date: 21.SEP.2020 09:48:39

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.

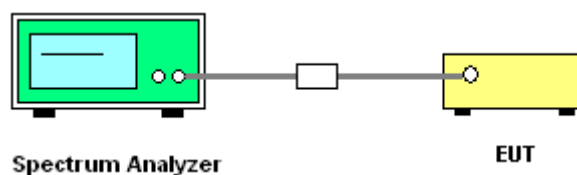
3.7.2 Measuring Instruments

See list of measuring equipment 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

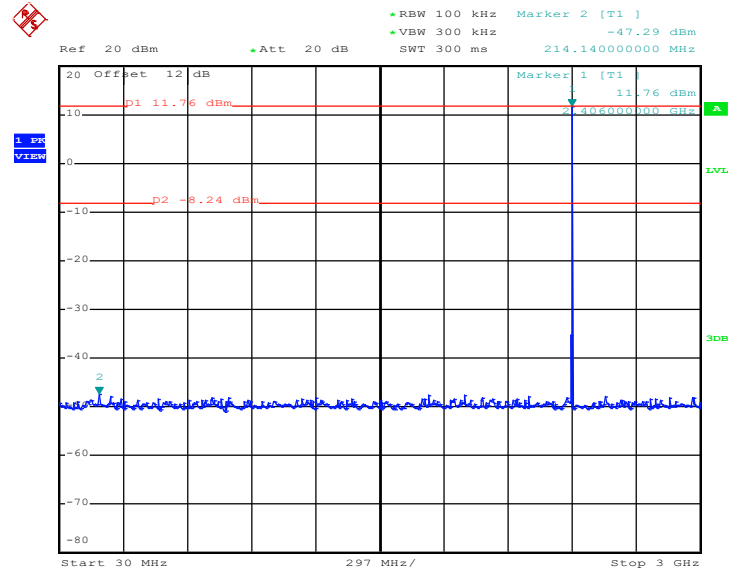




3.7.5 Test Result of Conducted Spurious Emission

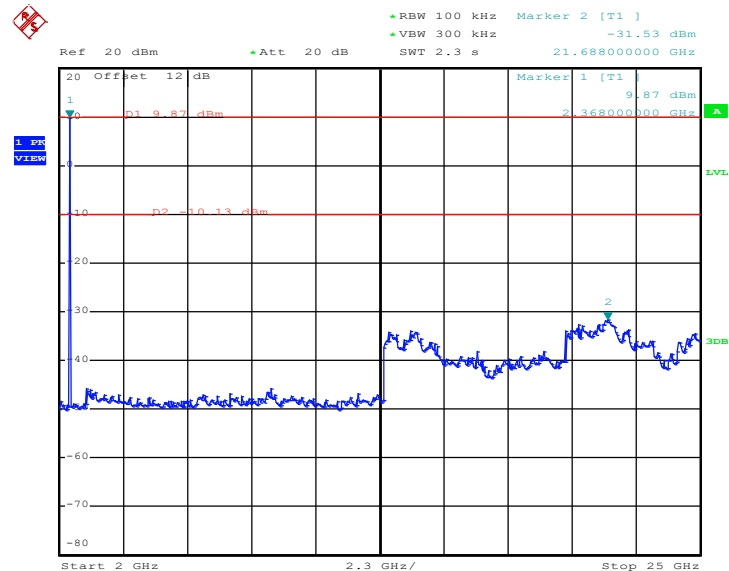
<1Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz



Date: 21.SEP.2020 10:05:22

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

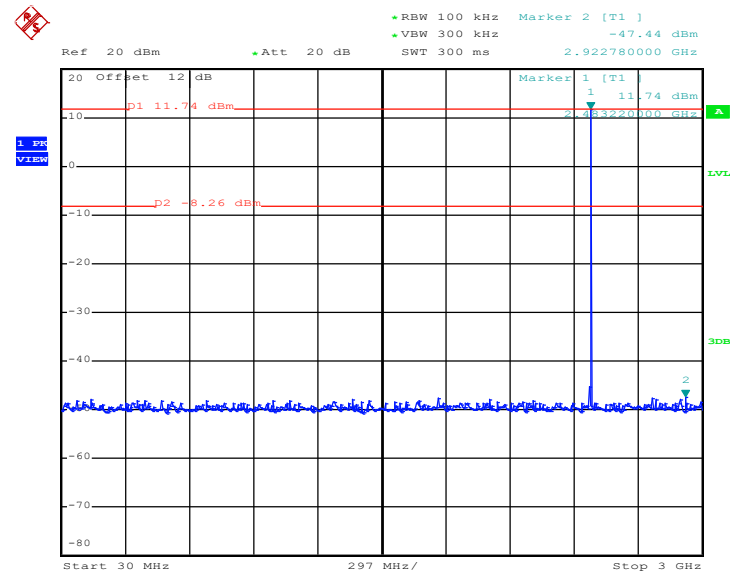


Date: 21.SEP.2020 10:06:05

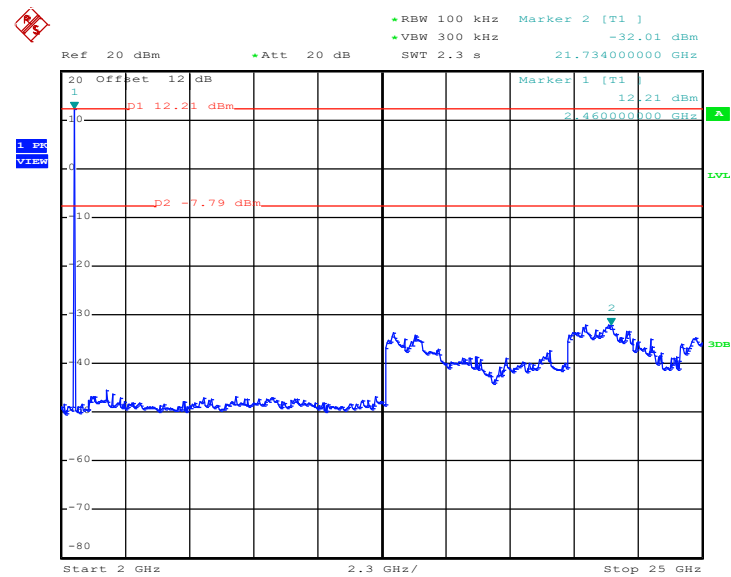


CSE Plot on Ch 39 between 2 GHz ~ 25 GHz



CSE Plot on Ch 78 between 30MHz ~ 3 GHz


Date: 21.SEP.2020 10:21:01

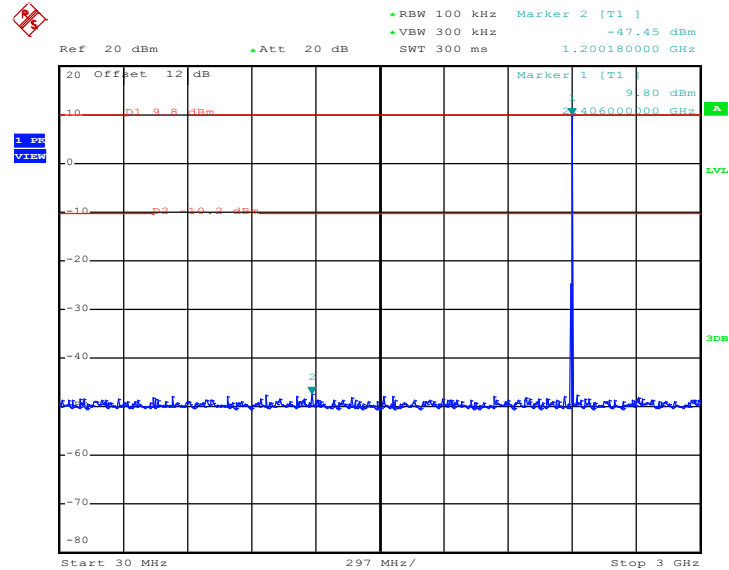
CSE Plot on Ch 78 between 2 GHz ~ 25 GHz


Date: 21.SEP.2020 10:21:48



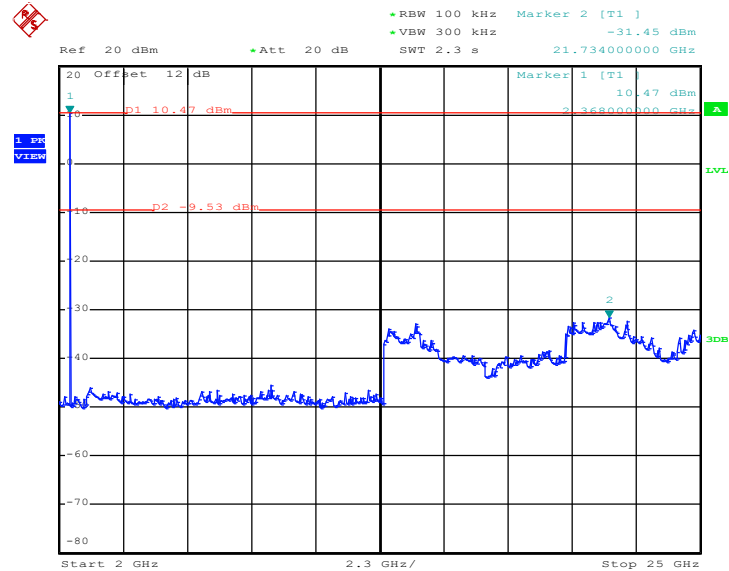
<2Mbps>

CSE Plot on Ch 00 between 30MHz ~ 3 GHz

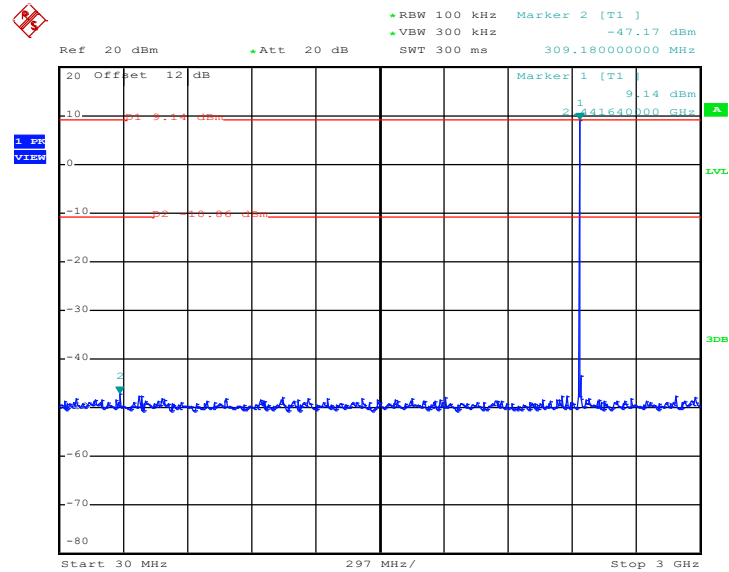


Date: 21.SEP.2020 10:53:41

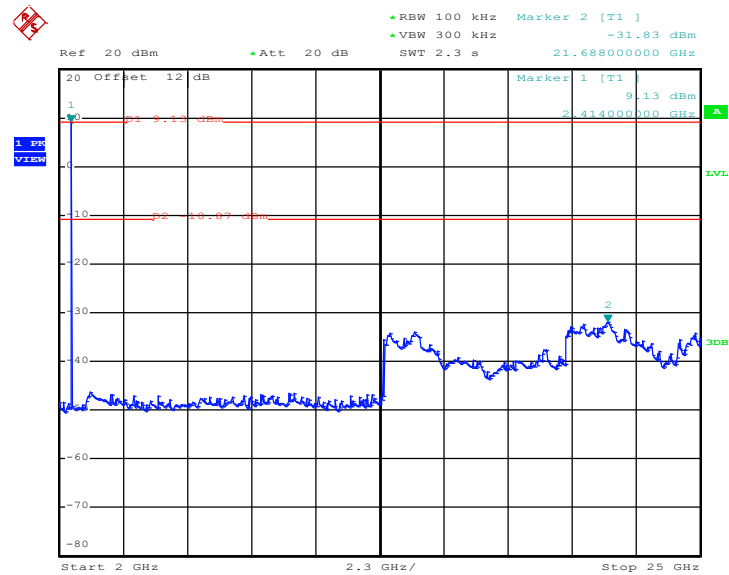
CSE Plot on Ch 00 between 2 GHz ~ 25 GHz



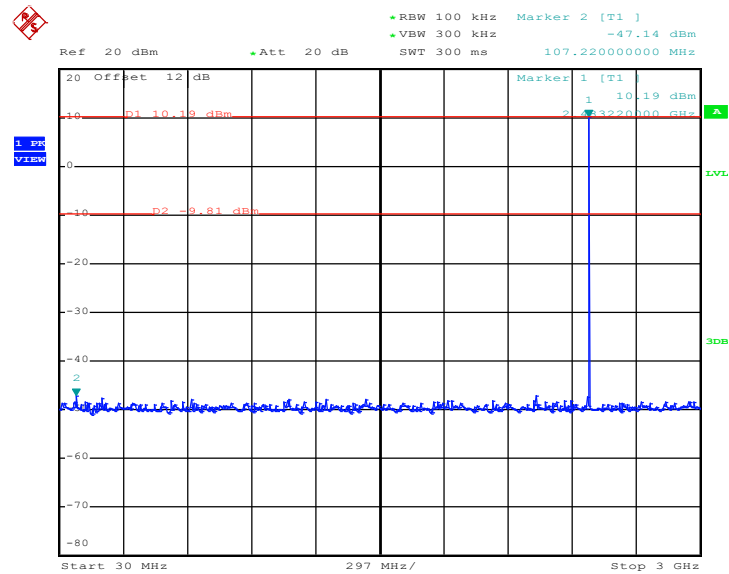
Date: 21.SEP.2020 10:54:40

CSE Plot on Ch 39 between 30MHz ~ 3 GHz


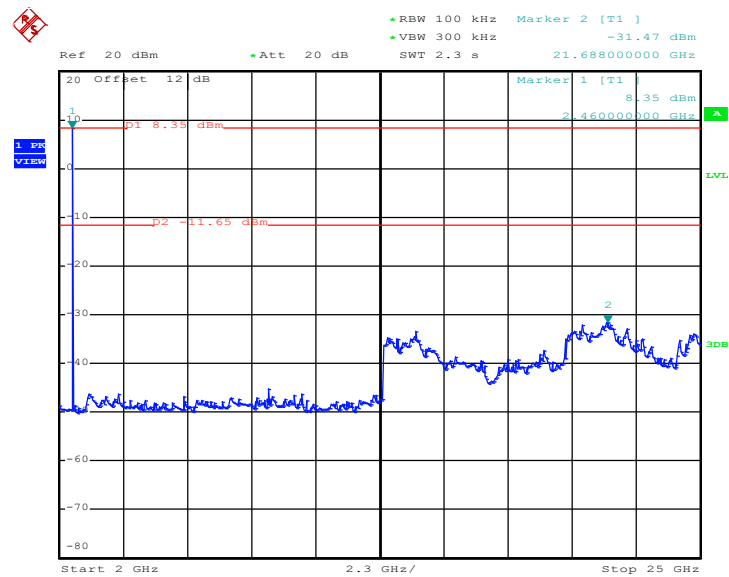
Date: 21.SEP.2020 11:02:15

CSE Plot on Ch 39 between 2 GHz ~ 25 GHz


Date: 21.SEP.2020 11:02:48

CSE Plot on Ch 78 between 30MHz ~ 3 GHz


Date: 21.SEP.2020 11:08:51

CSE Plot on Ch 78 between 2 GHz ~ 25 GHz


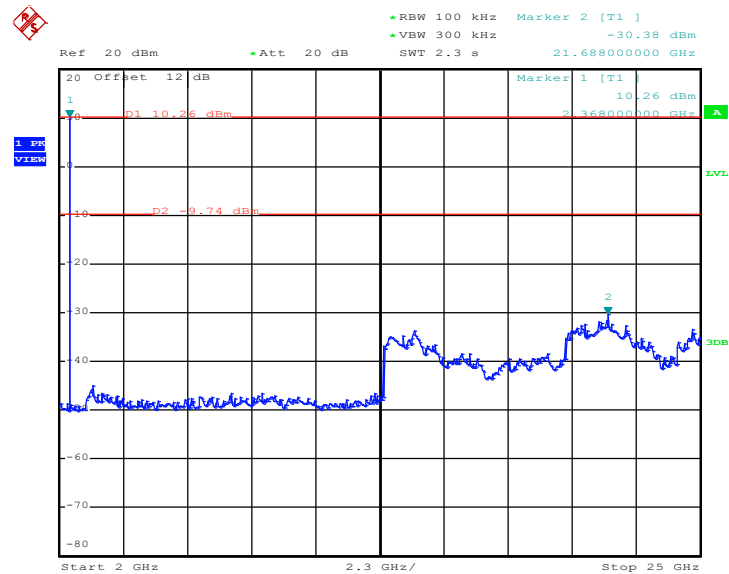
Date: 21.SEP.2020 11:09:25



The screenshot shows a Spectrum Analyzer interface with the following details:

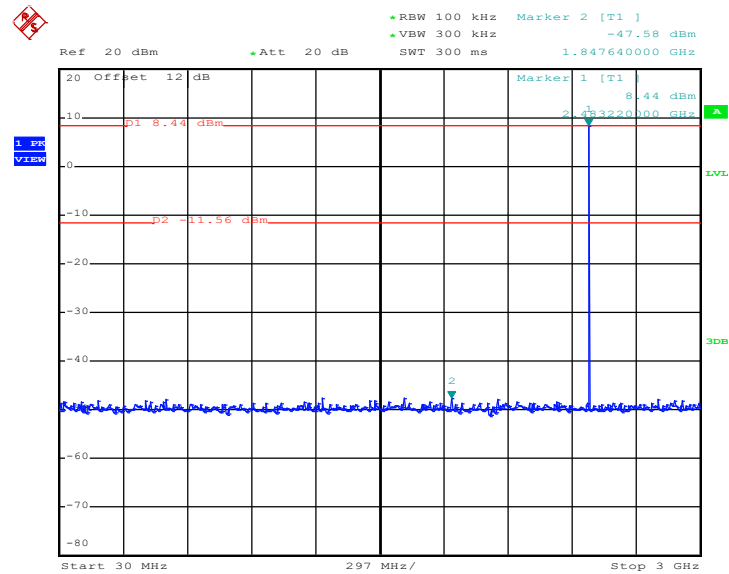
- Top Bar:**
 - Left: A red diamond icon with a white 'X' inside.
 - Center: "Ref 20 dBm" and "Att 20 dB".
 - Right: "RBW 100 kHz", "Marker 2 [T1]", "-47.35 dBm", "VBW 300 kHz", "SWT 300 ms", and "1.568460000 GHz".
- Grid and Trace:**
 - The grid has a vertical center line and horizontal lines at 20, -10, -20, -30, -40, -50, -60, -70, and -80 dB.
 - A red horizontal line is labeled "D1 10.32 dBm".
 - A red horizontal line is labeled "D2 -9.68 dBm".
 - A blue trace shows a signal at approximately -50 dB.
 - A green arrow points to a peak on the blue trace, labeled "2".
- Bottom Bar:**
 - Left: "Start 30 MHz".
 - Center: "297 MHz/".
 - Right: "Stop 3 GHz".
- Other Elements:**
 - A "1.568 VIEW" button is on the left.
 - A "Marker 1 [T1]" label is at the top right.
 - A "10.32 dBm" label is next to the marker.
 - A "3dB" label is on the right side.

CSE Plot on Ch 00 between 2 GHz ~ 25 GHz

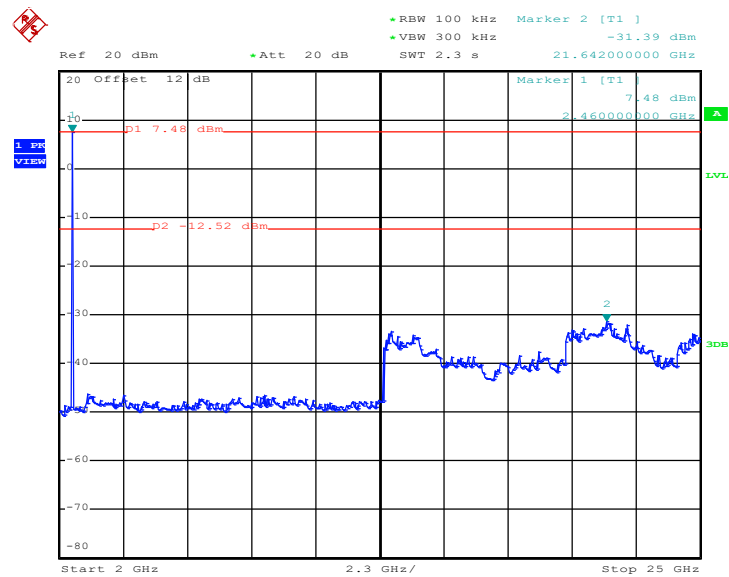


Date: 21.SEP.2020 11:31:37



**CSE Plot on Ch 78 between 30MHz ~ 3 GHz**

Date: 21.SEP.2020 11:57:27

CSE Plot on Ch 78 between 2 GHz ~ 25 GHz

Date: 21.SEP.2020 11:58:00

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

See list of measuring equipment of this test report.



3.8.3 Test Procedures

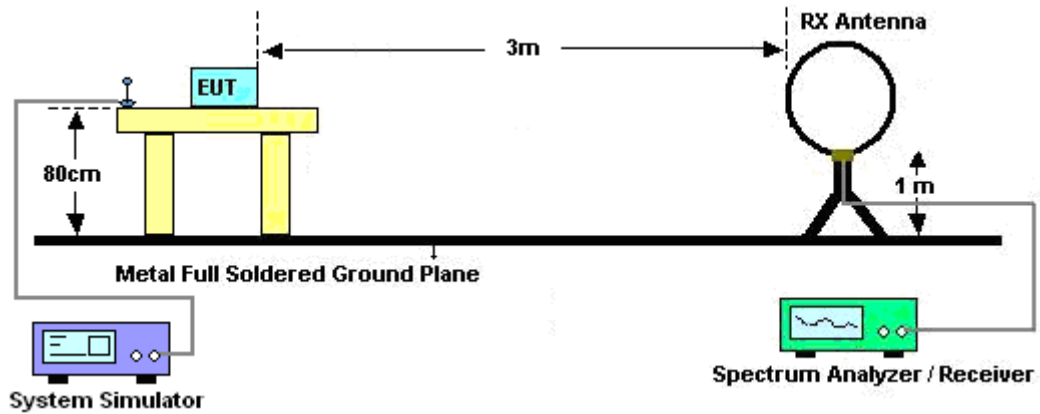
1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
3. For each suspected emission, 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 $f > 1$ GHz ; VBW $\geq$ 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
$$\text{On time} = N_1 * L_1 + N_2 * L_2 + \dots + N_{n-1} * L_{n-1} + N_n * L_n$$

Where N_1 is number of type 1 pulses, L_1 is length of type 1 pulses, etc.
Average Emission Level = Peak Emission Level + $20 * \log(\text{Duty cycle})$
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 average 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.

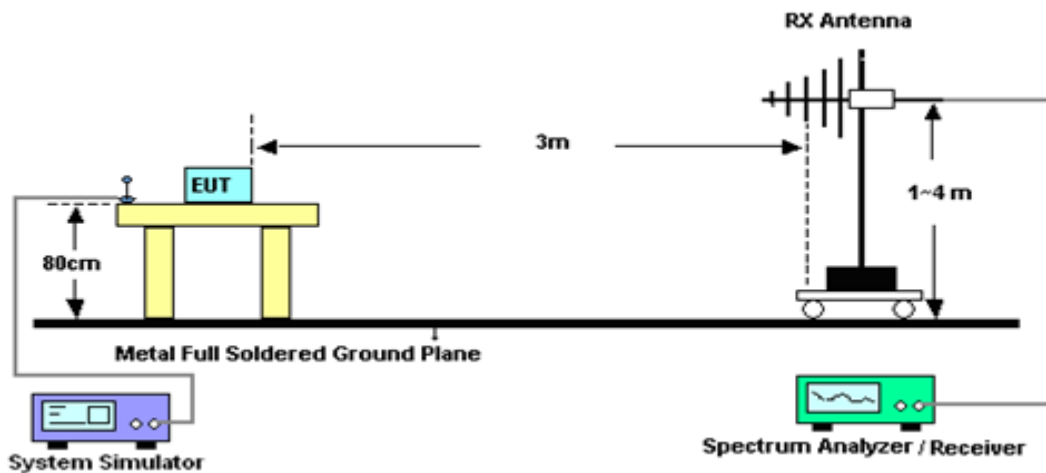
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.79dB) derived from $20 \log(\text{dwell time}/100\text{ms})$. This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.

3.8.4 Test Setup

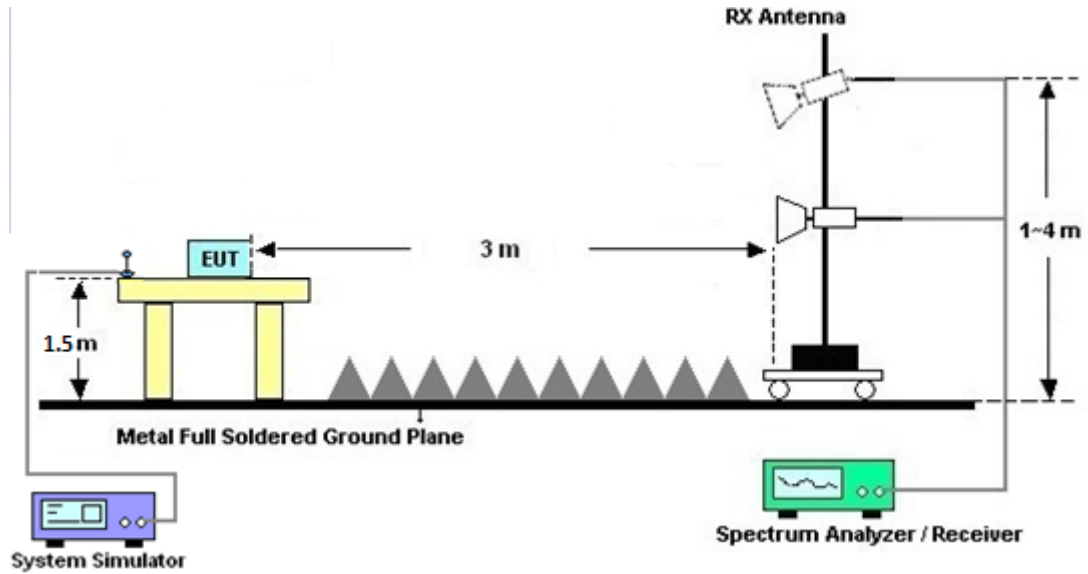
For radiated emissions below 30MHz



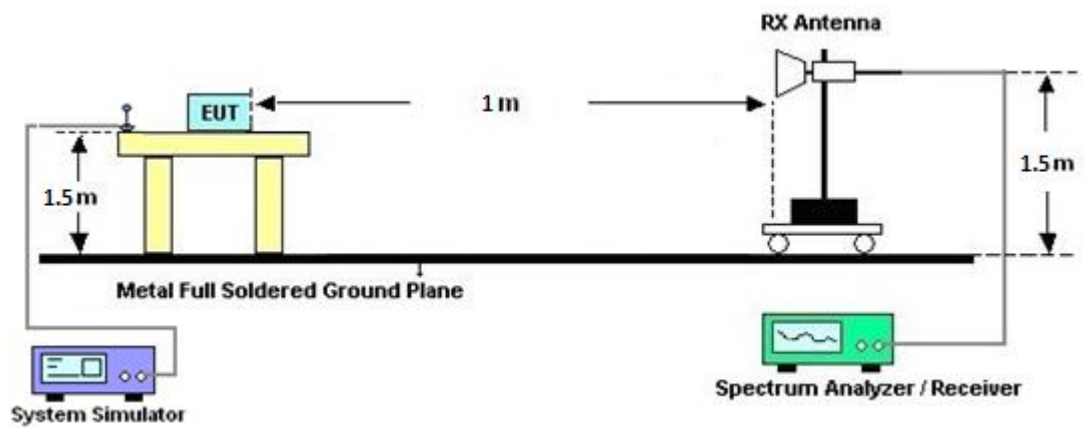
For radiated emissions from 30MHz to 1GHz



For radiated emissions from 1GHz to 18GHz



For radiated emissions above 18GHz



**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 alternative test site - semi-Anechoic chamber according to 414788 D01 Radiated Test Site v01r01, and the result came out very similar.

3.8.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix C and D.

3.8.7 Duty Cycle

Please refer to Appendix E.

3.8.8 Test Result of Radiated Spurious Emission (30MHz ~ 10th Harmonic)

Please refer to Appendix C and D.

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 (dB μ V)	
	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.

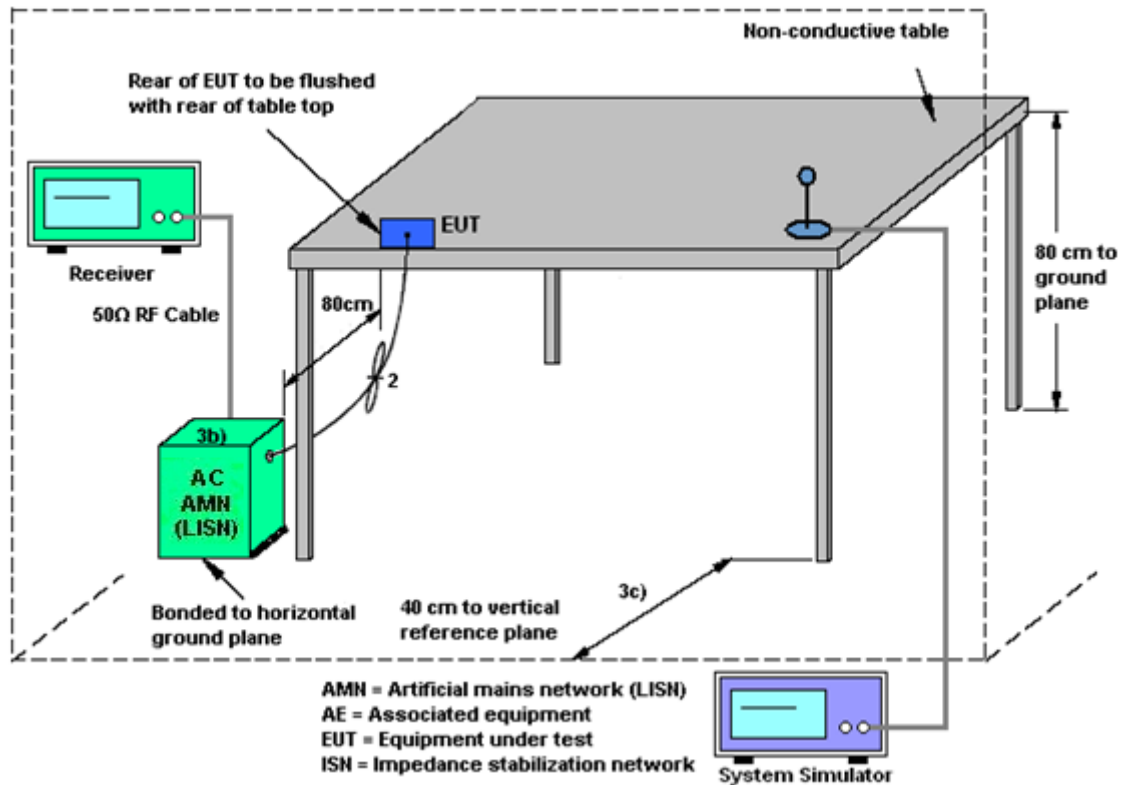
3.9.2 Measuring Instruments

See list of measuring equipment 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	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Jan. 09, 2020	Sep. 17, 2020~ Oct. 08, 2020	Jan. 08, 2021	Radiation (03CH15-HY)
Bilog Antenna	TESEQ	CBL6111D& 00800N1D0 1N-06	41912&05	30MHz to 1GHz	Feb. 09, 2020	Sep. 17, 2020~ Oct. 08, 2020	Feb. 08, 2021	Radiation (03CH15-HY)
Amplifier	SONOMA	310N	363440	9kHz~1GHz	Dec. 27, 2019	Sep. 17, 2020~ Oct. 08, 2020	Dec. 26, 2020	Radiation (03CH15-HY)
Horn Antenna	SCHWARZBE CK	BBHA 9120 D	9120D-1620	1-18GHz	Oct. 28, 2019	Sep. 17, 2020~ Oct. 08, 2020	Oct. 27, 2020	Radiation (03CH15-HY)
SHF-EHF Horn Antenna	SCHWARZBE CK	BBHA 9170	BBHA9170584	18GHz- 40GHz	Dec. 10, 2019	Sep. 17, 2020~ Oct. 08, 2020	Dec. 09, 2020	Radiation (03CH15-HY)
Preamplifier	Jet-Power	JPA0118-55- 303	171000180005 5006	1GHz~18GHz	May 07, 2020	Sep. 17, 2020~ Oct. 08, 2020	May 06, 2021	Radiation (03CH15-HY)
Preamplifier	Keysight	83017A	MY53270195	1GHz~26.5GHz	Aug. 21, 2020	Sep. 17, 2020~ Oct. 08, 2020	Aug. 20, 2021	Radiation (03CH15-HY)
Preamplifier	EMEC	EM18G40G	060715	18GHz ~ 40GHz	Dec. 13, 2019	Sep. 17, 2020~ Oct. 08, 2020	Dec. 12, 2020	Radiation (03CH15-HY)
EMI Test Receiver	Keysight	N9038A(MX E)	MY54130085	20MHz~8.4GHz	Nov. 01, 2019	Sep. 17, 2020~ Oct. 08, 2020	Oct. 31, 2020	Radiation (03CH15-HY)
Spectrum Analyzer	Agilent	E4446A	MY50180136	3Hz~44GHz	May 04, 2020	Sep. 17, 2020~ Oct. 08, 2020	May 03, 2021	Radiation (03CH15-HY)
Antenna Mast	ChainTek	MBS-520-1	N/A	1m~4m	N/A	Sep. 17, 2020~ Oct. 08, 2020	N/A	Radiation (03CH15-HY)
Turn Table	ChainTek	T-200-S-1	N/A	0~360 Degree	N/A	Sep. 17, 2020~ Oct. 08, 2020	N/A	Radiation (03CH15-HY)
Software	Audix	E3 6.2009-8-24 (k5)	RK-000451	N/A	N/A	Sep. 17, 2020~ Oct. 08, 2020	N/A	Radiation (03CH15-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY36980/4	30M-18G	Apr. 14, 2020	Sep. 17, 2020~ Oct. 08, 2020	Apr. 13, 2021	Radiation (03CH15-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY9838/4PE	30M-18G	Apr. 14, 2020	Sep. 17, 2020~ Oct. 08, 2020	Apr. 13, 2021	Radiation (03CH15-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY37710/4	30M-18G	Apr. 17, 2020	Sep. 17, 2020~ Oct. 08, 2020	Apr. 16, 2021	Radiation (03CH15-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30MHz-40GHz	Feb. 25, 2020	Sep. 17, 2020~ Oct. 08, 2020	Feb. 24, 2021	Radiation (03CH15-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	800740/2	30MHz-40GHz	Feb. 25, 2020	Sep. 17, 2020~ Oct. 08, 2020	Feb. 24, 2021	Radiation (03CH15-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY9837/4PE	9kHz~30MHz	Mar. 12, 2020	Sep. 17, 2020~ Oct. 08, 2020	Mar. 11, 2021	Radiation (03CH15-HY)
Filter	Wainwright	WLK4-1000- 1530-8000-4 OSS	SN4	1.53G Low Pass	Jul. 03, 2020	Sep. 17, 2020~ Oct. 08, 2020	Jul. 02, 2021	Radiation (03CH15-HY)
Filter	Wainwright	WHKX12-27 00-3000-180 00-60ST	SN4	3GHz High Pass Filter	Sep. 16, 2020	Sep. 17, 2020~ Oct. 08, 2020	Sep. 15, 2021	Radiation (03CH15-HY)



Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Hygrometer	Testo	608-H1	34893241	N/A	Mar. 02, 2020	Sep. 09, 2020~ Sep. 21, 2020	Mar. 01, 2021	Conducted (TH05-HY)
Power Meter	Agilent	E4416A	GB41292344	N/A	Dec. 27, 2019	Sep. 09, 2020~ Sep. 21, 2020	Dec. 26, 2020	Conducted (TH05-HY)
Power Sensor	Agilent	E9327A	US40441548	50MHz~18GHz	Dec. 27, 2019	Sep. 09, 2020~ Sep. 21, 2020	Dec. 26, 2020	Conducted (TH05-HY)
Spectrum Analyzer	Rohde & Schwarz	FSP40	100055	9kHz-40GHz	Dec. 30, 2019	Sep. 09, 2020~ Sep. 21, 2020	Dec. 29, 2020	Conducted (TH05-HY)
BT Base Station	Rohde & Schwarz	CBT	101136	BT 3.0	Oct. 27, 2019	Sep. 09, 2020~ Sep. 21, 2020	Oct. 26, 2020	Conducted (TH05-HY)
Switch Box & RF Cable	EM Electronics	EMSW18SE	SW200302	N/A	Mar. 17, 2020	Sep. 09, 2020~ Sep. 21, 2020	Mar. 16, 2021	Conducted (TH05-HY)
AC Power Source	ChainTek	APC-1000W	N/A	N/A	N/A	Sep. 28, 2020	N/A	Conduction (CO05-HY)
EMI Test Receiver	Rohde & Schwarz	ESR3	102388	9kHz~3.6GHz	Nov. 15, 2019	Sep. 28, 2020	Nov. 14, 2020	Conduction (CO05-HY)
Hygrometer	Testo	608-H1	34913912	N/A	Nov. 07, 2019	Sep. 28, 2020	Nov. 06, 2020	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100081	9kHz~30MHz	Nov. 15, 2019	Sep. 28, 2020	Nov. 14, 2020	Conduction (CO05-HY)
Software	Rohde & Schwarz	EMC32 V10.30	N/A	N/A	N/A	Sep. 28, 2020	N/A	Conduction (CO05-HY)
LF Cable	HUBER + SUHNER	RG-214/U	LF01	N/A	Jan. 02, 2020	Sep. 28, 2020	Jan. 01, 2021	Conduction (CO05-HY)
Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100851	N/A	Jan. 02, 2020	Sep. 28, 2020	Jan. 01, 2021	Conduction (CO05-HY)

5 Uncertainty of Evaluation

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	2.3
---	-----

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

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

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.4
---	-----

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

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

Appendix A. Test Result of Conducted Test Items

Test Engineer:	Kathy Chen	Temperature:	23.5~24	°C
Test Date:	2020/09/09~2020/09/21	Relative Humidity:	53.6~54.2	%

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 (MHz)	Hopping Channel Separation Measurement Limit (MHz)	Pass/Fail
DH	1Mbps	1	0	2402	0.896	0.844	1.002	0.5973	Pass
DH	1Mbps	1	39	2441	0.896	0.844	0.996	0.5973	Pass
DH	1Mbps	1	78	2480	0.896	0.840	1.008	0.5973	Pass
2DH	2Mbps	1	0	2402	1.290	1.172	1.014	0.8600	Pass
2DH	2Mbps	1	39	2441	1.284	1.180	1.164	0.8560	Pass
2DH	2Mbps	1	78	2480	1.284	1.176	1.002	0.8560	Pass
3DH	3Mbps	1	0	2402	1.242	1.148	1.008	0.8280	Pass
3DH	3Mbps	1	39	2441	1.236	1.148	1.002	0.8240	Pass
3DH	3Mbps	1	78	2480	1.242	1.156	1.002	0.8280	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	2.90	0.31	0.4	Pass
AFH	20	53.33	2.90	0.15	0.4	Pass

TEST RESULTS DATA**Peak Power Table**

DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH1	0	1	12.68	20.97	Pass
	39	1	11.85	20.97	Pass
	78	1	12.34	20.97	Pass
2DH1	0	1	12.28	20.97	Pass
	39	1	11.81	20.97	Pass
	78	1	12.00	20.97	Pass
3DH1	0	1	12.51	20.97	Pass
	39	1	11.84	20.97	Pass
	78	1	12.19	20.97	Pass

TEST RESULTS DATA**Average Power Table****(Reporting Only)**

DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
DH1	0	1	12.64	5.16
	39	1	11.63	5.16
	78	1	12.36	5.16
2DH1	0	1	10.50	5.16
	39	1	9.34	5.16
	78	1	10.38	5.16
3DH1	0	1	10.57	5.12
	39	1	9.37	5.12
	78	1	10.43	5.12

TEST RESULTS DATA**Number of Hopping Frequency**

Number of Hopping (Channel)	Adaptive Frequency Hopping (Channel)	Limits (Channel)	Pass/Fail
79	20	> 15	Pass



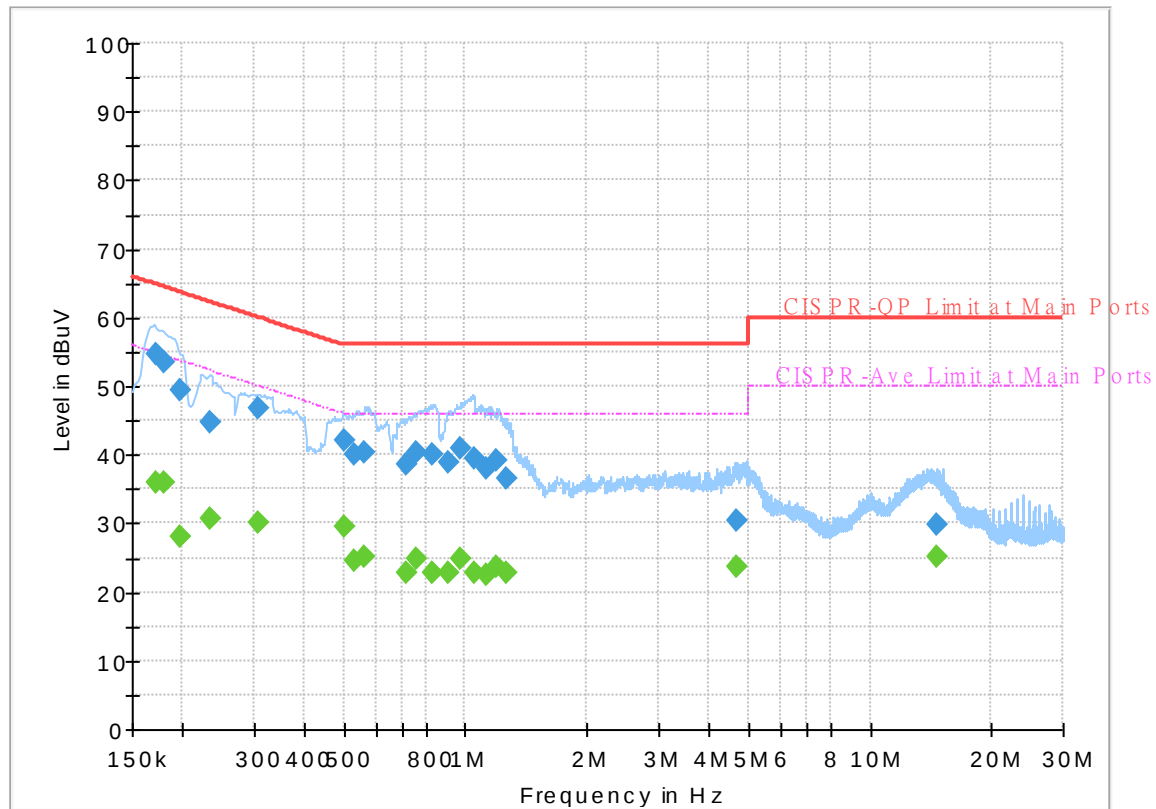
Appendix B. AC Conducted Emission Test Results

Test Engineer :	Tom Lee	Temperature :	24~26℃
		Relative Humidity :	42~50%

EUT Information

Report NO : 081931
 Test Mode : Mode 1
 Test Voltage : 120Vac/60Hz
 Phase : Line

Full Spectrum



Final_Result

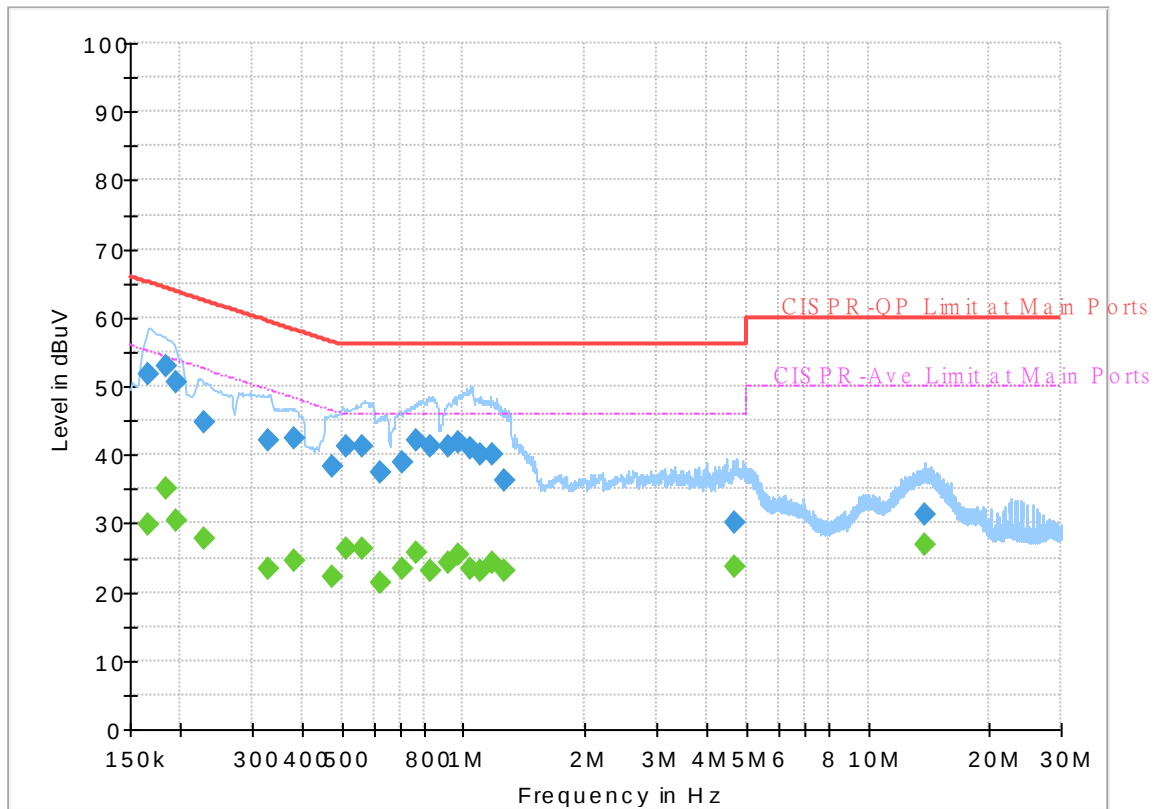
Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.171600	54.70	---	64.88	10.18	L1	OFF	19.6
0.171600	---	35.82	54.88	19.06	L1	OFF	19.6
0.181000	53.59	---	64.44	10.85	L1	OFF	19.6
0.181000	---	35.97	54.44	18.47	L1	OFF	19.6
0.197250	49.46	---	63.73	14.27	L1	OFF	19.6
0.197250	---	28.20	53.73	25.53	L1	OFF	19.6
0.234240	44.79	---	62.30	17.51	L1	OFF	19.6
0.234240	---	30.82	52.30	21.48	L1	OFF	19.6
0.307500	46.71	---	60.04	13.33	L1	OFF	19.6
0.307500	---	30.25	50.04	19.79	L1	OFF	19.6
0.501000	42.21	---	56.00	13.79	L1	OFF	19.6
0.501000	---	29.47	46.00	16.53	L1	OFF	19.6
0.530250	40.16	---	56.00	15.84	L1	OFF	19.6
0.530250	---	24.44	46.00	21.56	L1	OFF	19.6
0.560490	40.46	---	56.00	15.54	L1	OFF	19.6
0.560490	---	25.02	46.00	20.98	L1	OFF	19.6
0.714480	38.48	---	56.00	17.52	L1	OFF	19.6
0.714480	---	22.77	46.00	23.23	L1	OFF	19.6
0.759390	40.44	---	56.00	15.56	L1	OFF	19.6
0.759390	---	24.91	46.00	21.09	L1	OFF	19.6
0.831750	39.97	---	56.00	16.03	L1	OFF	19.6

0.831750	---	22.80	46.00	23.20	L1	OFF	19.6
0.906000	38.85	---	56.00	17.15	L1	OFF	19.6
0.906000	---	22.77	46.00	23.23	L1	OFF	19.6
0.971700	40.89	---	56.00	15.11	L1	OFF	19.6
0.971700	---	24.99	46.00	21.01	L1	OFF	19.6
1.050000	39.59	---	56.00	16.41	L1	OFF	19.6
1.050000	---	22.77	46.00	23.23	L1	OFF	19.6
1.121550	37.92	---	56.00	18.08	L1	OFF	19.6
1.121550	---	22.42	46.00	23.58	L1	OFF	19.6
1.192830	39.28	---	56.00	16.72	L1	OFF	19.6
1.192830	---	23.82	46.00	22.18	L1	OFF	19.6
1.261500	36.60	---	56.00	19.40	L1	OFF	19.6
1.261500	---	22.91	46.00	23.09	L1	OFF	19.6
4.695090	30.29	---	56.00	25.71	L1	OFF	19.7
4.695090	---	23.67	46.00	22.33	L1	OFF	19.7
14.559180	29.91	---	60.00	30.09	L1	OFF	20.0
14.559180	---	25.17	50.00	24.83	L1	OFF	20.0

EUT Information

Report NO : 081931
Test Mode : Mode 1
Test Voltage : 120Vac/60Hz
Phase : Neutral

Full Spectrum



Final_Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.165570	---	29.91	55.18	25.27	N	OFF	19.6
0.165570	51.76	---	65.18	13.42	N	OFF	19.6
0.183750	---	35.23	54.31	19.08	N	OFF	19.6
0.183750	52.85	---	64.31	11.46	N	OFF	19.6
0.195490	---	30.49	53.80	23.31	N	OFF	19.6
0.195490	50.68	---	63.80	13.12	N	OFF	19.6
0.228750	---	27.76	52.50	24.74	N	OFF	19.6
0.228750	44.64	---	62.50	17.86	N	OFF	19.6
0.329640	---	23.39	49.46	26.07	N	OFF	19.6
0.329640	41.98	---	59.46	17.48	N	OFF	19.6
0.381750	---	24.59	48.24	23.65	N	OFF	19.6
0.381750	42.27	---	58.24	15.97	N	OFF	19.6
0.476250	---	22.35	46.40	24.05	N	OFF	19.6
0.476250	38.42	---	56.40	17.98	N	OFF	19.6
0.515040	---	26.26	46.00	19.74	N	OFF	19.6
0.515040	41.18	---	56.00	14.82	N	OFF	19.6
0.564000	---	26.31	46.00	19.69	N	OFF	19.6
0.564000	41.35	---	56.00	14.65	N	OFF	19.6
0.622770	---	21.21	46.00	24.79	N	OFF	19.6
0.622770	37.51	---	56.00	18.49	N	OFF	19.6
0.703950	---	23.45	46.00	22.55	N	OFF	19.6

0.703950	38.96	---	56.00	17.04	N	OFF	19.6
0.767490	---	25.75	46.00	20.25	N	OFF	19.6
0.767490	42.02	---	56.00	13.98	N	OFF	19.6
0.827250	---	23.11	46.00	22.89	N	OFF	19.6
0.827250	41.22	---	56.00	14.78	N	OFF	19.6
0.919500	---	24.19	46.00	21.81	N	OFF	19.6
0.919500	41.26	---	56.00	14.74	N	OFF	19.6
0.969000	---	25.45	46.00	20.55	N	OFF	19.6
0.969000	41.90	---	56.00	14.10	N	OFF	19.6
1.043250	---	23.48	46.00	22.52	N	OFF	19.6
1.043250	41.03	---	56.00	14.97	N	OFF	19.6
1.103100	---	23.09	46.00	22.91	N	OFF	19.6
1.103100	39.93	---	56.00	16.07	N	OFF	19.6
1.182210	---	24.25	46.00	21.75	N	OFF	19.6
1.182210	39.94	---	56.00	16.06	N	OFF	19.6
1.264110	---	22.98	46.00	23.02	N	OFF	19.6
1.264110	36.14	---	56.00	19.86	N	OFF	19.6
4.695000	---	23.82	46.00	22.18	N	OFF	19.8
4.695000	30.13	---	56.00	25.87	N	OFF	19.8
13.799850	---	26.79	50.00	23.21	N	OFF	20.1
13.799850	31.37	---	60.00	28.63	N	OFF	20.1



Appendix C. Radiated Spurious Emission

Test Engineer :	Leo Lee, Mancy Chou, and Bigshow Wang	Temperature :	22.1~23.2°C
		Relative Humidity :	45~59%

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Path Loss	Preamplifier 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		2364.18	46.79	-27.21	74	42.43	27.91	7.38	30.93	364	315	P	H
		2364.18	22	-32	54	-	-	-	-	-	-	A	H
	*	2402	110.62	-	-	106.38	27.7	7.45	30.91	364	315	P	H
	*	2402	85.83	-	-	-	-	-	-	-	-	A	H
													H
													H
		2312.625	47.23	-26.77	74	42.84	28.07	7.27	30.95	376	121	P	V
		2312.625	22.44	-31.56	54	-	-	-	-	-	-	A	V
	*	2402	106.43	-	-	102.19	27.7	7.45	30.91	376	121	P	V
	*	2402	81.64	-	-	-	-	-	-	-	-	A	V
													V
													V
BT CH 39 2441MHz		2338.28	46.45	-27.55	74	42.05	28.02	7.32	30.94	400	315	P	H
		2338.28	21.66	-32.34	54	-	-	-	-	-	-	A	H
	*	2441	109.77	-	-	105.52	27.62	7.52	30.89	400	315	P	H
	*	2441	84.98	-	-	-	-	-	-	-	-	A	H
		2496.43	46.63	-27.37	74	42.37	27.51	7.62	30.87	400	315	P	H
		2496.43	21.84	-32.16	54	-	-	-	-	-	-	A	H
		2353.12	46	-28	74	41.6	27.98	7.35	30.93	367	130	P	V
		2353.12	21.21	-32.79	54	-	-	-	-	-	-	A	V
	*	2441	106	-	-	101.75	27.62	7.52	30.89	367	130	P	V
	*	2441	81.21	-	-	-	-	-	-	-	-	A	V
		2496.15	45.66	-28.34	74	41.4	27.51	7.62	30.87	367	130	P	V
		2496.15	20.87	-33.13	54	-	-	-	-	-	-	A	V



BT CH 78 2480MHz	*	2480	110.12	-	-	105.87	27.54	7.59	30.88	341	312	P	H
	*	2480	85.33	-	-	-	-	-	-	-	-	A	H
		2483.56	59.91	-14.09	74	55.66	27.53	7.6	30.88	341	312	P	H
		2483.56	35.12	-18.88	54	-	-	-	-	-	-	A	H
													H
													H
	*	2480	107.02	-	-	102.77	27.54	7.59	30.88	392	132	P	V
	*	2480	82.23	-	-	-	-	-	-	-	-	A	V
		2483.52	56.96	-17.04	74	52.71	27.53	7.6	30.88	392	132	P	V
		2483.52	32.17	-21.83	54	-	-	-	-	-	-	A	V
													V
													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		4804	41.16	-32.84	74	58.42	31.21	10.61	59.08	100	0	P	H
		4804	16.37	-37.63	54	-	-	-	-	-	-	A	H
													H
													H
		4804	40.49	-33.51	74	57.75	31.21	10.61	59.08	100	0	P	V
		4804	15.7	-38.3	54	-	-	-	-	-	-	A	V
													V
													V
BT CH 39 2441MHz		4882	39.96	-34.04	74	57.24	31.24	10.61	59.13	100	0	P	H
		4882	15.17	-38.83	54	-	-	-	-	-	-	A	H
		7323	44.5	-29.5	74	53.89	36.55	12.61	58.55	100	0	P	H
		7323	19.71	-34.29	54	-	-	-	-	-	-	A	H
		4882	39.23	-34.77	74	56.51	31.24	10.61	59.13	100	0	P	V
		4882	14.44	-39.56	54	-	-	-	-	-	-	A	V
		7323	44.26	-29.74	74	53.65	36.55	12.61	58.55	100	0	P	V
		7323	19.47	-34.53	54	-	-	-	-	-	-	A	V
BT CH 78 2480MHz		4960	39.84	-34.16	74	56.85	31.54	10.63	59.18	100	0	P	H
		4960	15.05	-38.95	54	-	-	-	-	-	-	A	H
		7440	45.85	-28.15	74	54.93	36.56	12.74	58.38	100	0	P	H
		7440	21.06	-32.94	54	-	-	-	-	-	-	A	H
		4960	39.72	-34.28	74	56.73	31.54	10.63	59.18	100	0	P	V
		4960	14.93	-39.07	54	-	-	-	-	-	-	A	V
		7440	44.87	-29.13	74	53.95	36.56	12.74	58.38	100	0	P	V
		7440	20.08	-33.92	54	-	-	-	-	-	-	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

**Emission above 18GHz****2.4GHz BT (SHF)**

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		19890	39.09	-34.91	74	43.84	37.78	11.34	53.87	150	0	P	H
													H
													H
													H
		20954	40.38	-33.62	74	43.38	38.36	12.05	53.41	150	0	P	V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against 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		97.9	32.66	-10.84	43.5	47.68	15.91	1.35	32.28	-	-	P	H
		221.09	31.79	-14.21	46	46.88	15.18	2.12	32.39	-	-	P	H
		489.78	31.78	-14.22	46	37.54	23.62	3.08	32.46	-	-	P	H
		703.18	37.52	-8.48	46	39.95	26.28	3.69	32.4	-	-	P	H
		746.83	38.95	-7.05	46	39.93	27.66	3.82	32.46	100	0	P	H
		777.87	36.99	-9.01	46	37.58	27.7	3.91	32.2	-	-	P	H
													H
													H
													H
													H
													H
													H
													H
		64.92	29.32	-10.68	40	47.84	12.24	1.05	31.81	-	-	P	V
		97.9	30.12	-13.38	43.5	45.14	15.91	1.35	32.28	-	-	P	V
		218.18	25.85	-20.15	46	41.13	15.01	2.1	32.39	-	-	P	V
		486.87	29.9	-16.1	46	35.75	23.55	3.07	32.47	-	-	P	V
		745.86	39.15	-6.85	46	40.14	27.65	3.82	32.46	100	0	P	V
		777.87	38.96	-7.04	46	39.55	27.7	3.91	32.2	-	-	P	V
													V
													V
													V
													V
													V
												V	
												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

$$1. \text{ Path Loss(dB)} = \text{Cable loss(dB)} + \text{Filter loss(dB)} + \text{Attenuator loss(dB)}$$

$$2. \text{ Level(dB}\mu\text{V/m)} =$$

$$\text{Antenna Factor(dB/m)} + \text{Path Loss(dB)} + \text{Read Level(dB}\mu\text{V)} - \text{Preamp Factor(dB)}$$

$$3. \text{ Over Limit(dB)} = \text{Level(dB}\mu\text{V/m)} - \text{Limit Line(dB}\mu\text{V/m)}$$

For Peak Limit @ 2390MHz:

$$1. \text{ Level(dB}\mu\text{V/m)}$$

$$= \text{Antenna Factor(dB/m)} + \text{Path Loss(dB)} + \text{Read Level(dB}\mu\text{V)} - \text{Preamp Factor(dB)}$$

$$= 32.22(\text{dB/m}) + 4.58(\text{dB}) + 54.51(\text{dB}\mu\text{V}) - 35.86(\text{dB})$$

$$= 55.45(\text{dB}\mu\text{V/m})$$

$$2. \text{ Over Limit(dB)}$$

$$= \text{Level(dB}\mu\text{V/m)} - \text{Limit Line(dB}\mu\text{V/m)}$$

$$= 55.45(\text{dB}\mu\text{V/m}) - 74(\text{dB}\mu\text{V/m})$$

$$= -18.55(\text{dB})$$

For Average Limit @ 2390MHz:

$$1. \text{ Level(dB}\mu\text{V/m)}$$

$$= \text{Antenna Factor(dB/m)} + \text{Path Loss(dB)} + \text{Read Level(dB}\mu\text{V)} - \text{Preamp Factor(dB)}$$

$$= 32.22(\text{dB/m}) + 4.58(\text{dB}) + 42.6(\text{dB}\mu\text{V}) - 35.86(\text{dB})$$

$$= 43.54(\text{dB}\mu\text{V/m})$$

$$2. \text{ Over Limit(dB)}$$

$$= \text{Level(dB}\mu\text{V/m)} - \text{Limit Line(dB}\mu\text{V/m)}$$

$$= 43.54(\text{dB}\mu\text{V/m}) - 54(\text{dB}\mu\text{V/m})$$

$$= -10.46(\text{dB})$$

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



Appendix D. Radiated Spurious Emission Plots

Test Engineer :	Leo Lee, Mancy Chou, and Bigshow Wang	Temperature :	22.1~23.2°C
		Relative Humidity :	45~59%

2.4GHz 2400~2483.5MHz

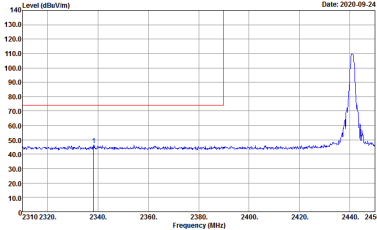
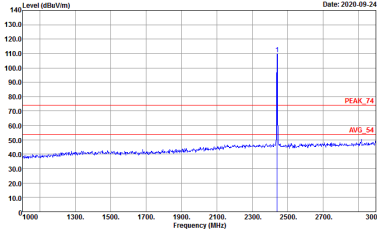
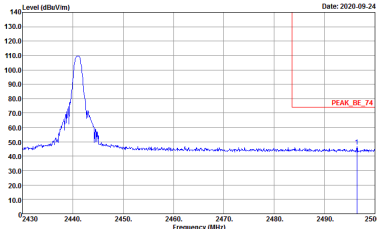
BT (Band Edge @ 3m)

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH00 2402MHz	
	Horizontal	Fundamental
Peak	Site : 03CH15-HV Condition : PEAK_BE_74 3m 91200_15_1620 HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 081931	Site : 03CH15-HV Condition : PEAK_74 3m 91200_15_1620 HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 081931

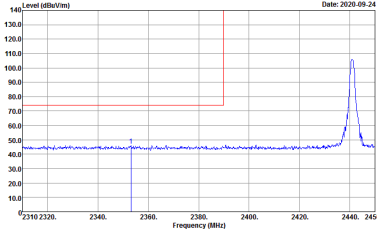
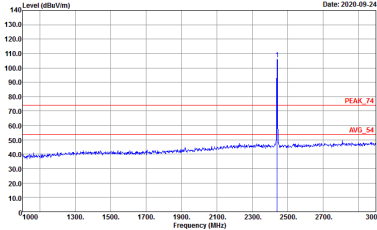
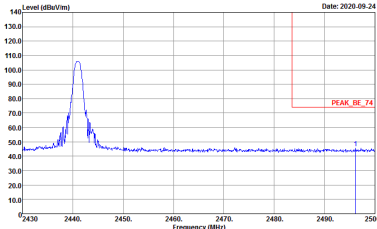


BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH00 2402MHz	
	Vertical	Fundamental
Peak	Level (dBuV/m) Date: 2020-09-24 Frequency (MHz) Site : 03CH15-11Y Condition : PEAK_BE_74 3m 91200_15_1620 VERTICAL Detector : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Project : Peak Project : 081931	Level (dBuV/m) Date: 2020-09-24 Frequency (MHz) Site : 03CH15-11Y Condition : PEAK_74 3m 91200_15_1620 VERTICAL Detector : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Project : Peak Project : 081931



BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH39 2441MHz	
	Horizontal	Fundamental
Peak	 Site : 03CH15-HY Condition : PEAK_BE_74 3m 91200_15_1620 HORIZONTAL Detector : Peak Project : 081931	 Site : 03CH15-HY Condition : PEAK_74 3m 91200_15_1620 HORIZONTAL Detector : Peak Project : 081931
Peak	 Site : 03CH15-HY Condition : PEAK_BE_74 3m 91200_15_1620 HORIZONTAL Detector : Peak Project : 081931	Left blank



BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH39 2441MHz	
	Vertical	Fundamental
Peak	 Site : 03CH15-HY Condition : PEAK_BE_74 3m 91200_15_1620 VERTICAL Detector : Peak Project : 081931	 Site : 03CH15-HY Condition : PEAK_74 3m 91200_15_1620 VERTICAL Detector : Peak Project : 081931
Peak	 Site : 03CH15-HY Condition : PEAK_BE_74 3m 91200_15_1620 VERTICAL Detector : Peak Project : 081931	Left blank



BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH78 2480MHz	
	Horizontal	Fundamental
Peak	Level (dBuV/m) Date: 2020-09-24 2460 2463.2465 2467.2469 2471 2473.2475 2477.2479 2481.2483 2485.2487 2489 2491 2493 2495 2497 2500 Frequency (MHz) Site : 03CH15-14Y Condition : PEAK_BE_74 3m 91200_15_1620 HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 081931	Level (dBuV/m) Date: 2020-09-24 1000 1300 1500 1700 1900 2100 2300 2500 2700 2900 3000 Frequency (MHz) Site : 03CH15-14Y Condition : PEAK_74 3m 91200_15_1620 HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 081931

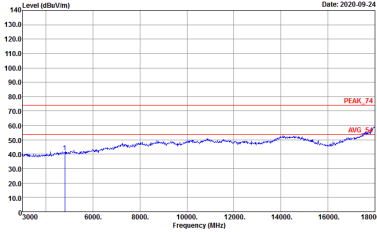
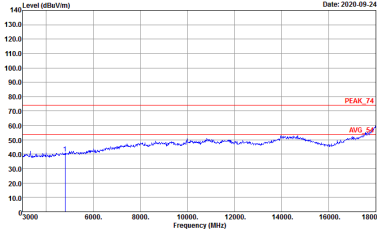


BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH78 2480MHz	
	Vertical	Fundamental
Peak	Level (dBm/Vm) Date: 2020-09-24 2460 2463.2465 2467.2469 2471 2473.2475 2477.2479 2481.2483 2485.2487 2489 2491 2493 2495 2497 2500 Frequency (MHz) Site : 03CH15-14Y Condition : PEAK_BE_74 3m 91200_15_1620 VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 081931	Level (dBm/Vm) Date: 2020-09-24 1000 1300 1600 1900 2100 2300 2500 2700 3000 Frequency (MHz) Site : 03CH15-14Y Condition : PEAK_74 3m 91200_15_1620 VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 081931

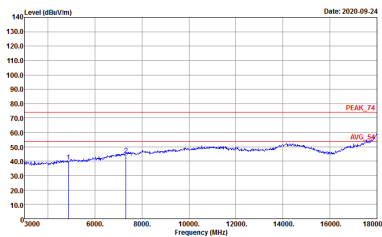
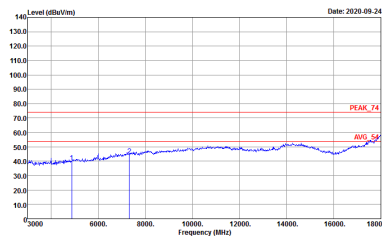


2.4GHz 2400~2483.5MHz

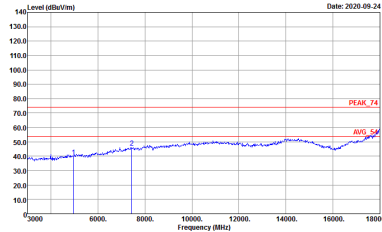
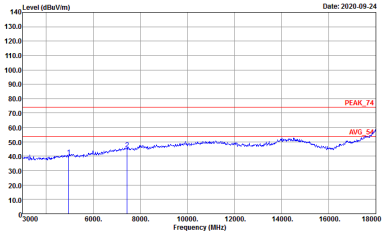
BT (Harmonic @ 3m)

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH00 2402MHz	
	Horizontal	Vertical
Peak Avg.	 Site : 03CH15-HY Condition : PEAK_74 3m 91200_15_1620 HORIZONTAL Detector : Peak Project : 081931	 Site : 03CH15-HY Condition : PEAK_74 3m 91200_15_1620 VERTICAL Detector : Peak Project : 081931



BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH39 2441MHz	
	Horizontal	Vertical
Peak Avg.	 Site : 03CH15-11Y Condition : PEAK_74 3m 91200_15_1620 HORIZONTAL Detector : Peak Project : 081931	 Site : 03CH15-11Y Condition : PEAK_74 3m 91200_15_1620 VERTICAL Detector : Peak Project : 081931



BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH78 2480MHz	
	Horizontal	Vertical
Peak Avg.	 Site : 03CH15-11Y Condition : PEAK_74 3m 91200_15_1620 HORIZONTAL Detector : Peak Project : 081931	 Site : 03CH15-11Y Condition : PEAK_74 3m 91200_15_1620 VERTICAL Detector : Peak Project : 081931



Emission above 18GHz

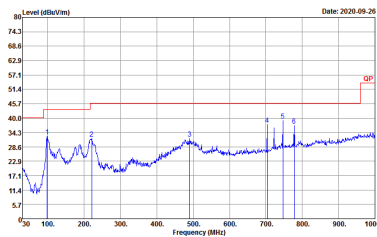
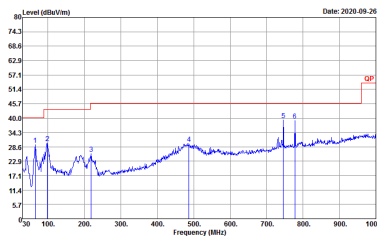
2.4GHz BT (SHF)

BT	2.4GHz 2400~2483.5MHz	
	BT	
	Horizontal	Vertical
Peak Avg.	Level (dBuV/m) Date: 2020-09-26 Frequency (MHz) Site : 03CH15-HY Condition : PEAK_74 In SHF HORN BBHA9170584 HORIZONTAL Detector : Peak Project : 081931	Level (dBuV/m) Date: 2020-09-26 Frequency (MHz) Site : 03CH15-HY Condition : PEAK_74 In SHF HORN BBHA9170584 VERTICAL Detector : Peak Project : 081931

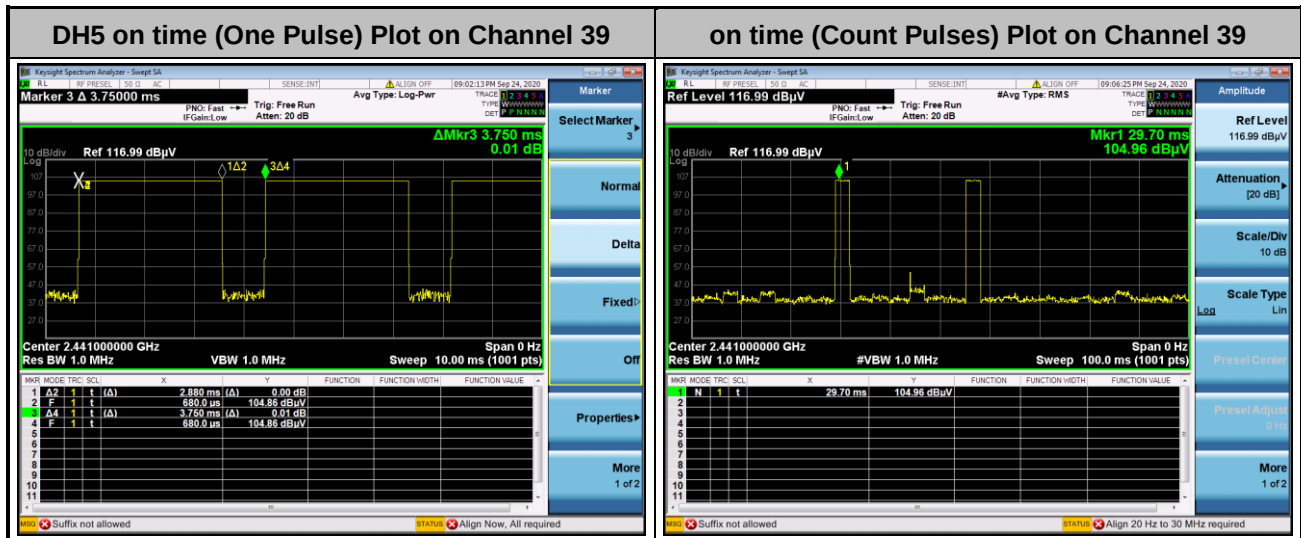


Emission below 1GHz

2.4GHz BT (LF)

BT	2.4GHz 2400~2483.5MHz	
	BT LF	
	Horizontal	Vertical
QP / Peak	 Site : 03CH15-HY Condition : QP 3m BTLOG_15_41912 HORIZONTAL Detector : Peak Project : 081931	 Site : 03CH15-HY Condition : QP 3m BTLOG_15_41912 VERTICAL Detector : Peak Project : 081931

Appendix E. Duty Cycle Plots



Note:

- Worst case Duty cycle = on time/100 milliseconds = $2 * 2.88 / 100 = 5.76 \%$
- Worst case Duty cycle correction factor = $20 * \log(\text{Duty cycle}) = -24.79 \text{ dB}$
- DH5 has the highest duty cycle worst case and is reported.

Duty Cycle Correction Factor Consideration for AFH mode:

Bluetooth normal hopping rate is 1600Hz and reduced to 800Hz in AFH mode; due to the reduced number of hopping frequencies, with the same packet configuration the dwell time in each channel frequency within 100msec period is longer in AFH mode than normal mode.

In AFH mode, the minimum hopping frequencies are 20, to get the longest dwell time DH5 packet is observed; the period to have DH5 packet completing one hopping sequence is

$$2.88 \text{ ms} \times 20 \text{ channels} = 57.6 \text{ ms}$$

There cannot be 2 complete hopping sequences within 100ms period, considering the random hopping behavior, maximum 2 hops can be possibly observed within the period. $[100 \text{ ms} / 57.6 \text{ ms}] = 2 \text{ hops}$

Thus, the maximum possible ON time:

$$2.88 \text{ ms} \times 2 = 5.76 \text{ ms}$$

Worst case Duty Cycle Correction factor, which is derived from the maximum possible ON time,

$$20 \times \log(5.76 \text{ ms}/100 \text{ ms}) = -24.79 \text{ dB}$$