



# FCC RADIO TEST REPORT

**FCC ID** : PU5-TP00139AS  
**Equipment** : Notebook Computer  
**Brand Name** : Lenovo  
**Model Name** : TP00139A  
**Applicant** : Wistron Corporation  
21F, No. 88, Sec. 1, Hsin Tai Wu Rd., Hsichih  
Dist, New Taipei City 221, Taiwan  
**Manufacturer** : Lenovo PC HK Limited.  
23/F, Lincoln House, Taikoo Place, 979 King's  
Road, Quarry Bay, Hong Kong, China  
**Standard** : FCC Part 15 Subpart C §15.247

Equipment: Murata LBEE5QG2CX tested inside of Lenovo Notebook Computer.

The product was received on Dec. 29, 2021 and testing was performed from Jan. 14, 2022 to Feb. 22, 2022. We, Sporton International Inc. Wensan 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 from Sporton International Inc. Wensan Laboratory, the test report shall not be reproduced except in full.

*Louis Wu*

Approved by: Louis Wu

**Sporton International Inc. Wensan Laboratory**



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### History of this test report

Report No.	Version	Description	Issue Date
FR1D1645-01A	01	Initial issue of report	Feb. 16, 2022
FR1D1645-01A	02	Revise test data and module information	Feb. 23, 2022

## 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	7.33 dB under the limit at 776.900 MHz
3.9	15.207	AC Conducted Emission	Pass	12.69 dB under the limit at 11.746 MHz
3.10	15.203 & 15.247(b)	Antenna Requirement	Pass	-

**Declaration of Conformity:**

- The test results (PASS/FAIL) with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.  
It's means measurement values may risk exceeding the limit of regulation standards, if measurement uncertainty is include in test results.
- The measurement uncertainty please refer to this report "Uncertainty of Evaluation".

**Comments and Explanations:**

The product specifications of the EUT presented in the report are declared by the manufacturer who shall take full responsibility for the authenticity.

**Reviewed by: Sheng Kuo**

**Report Producer: Vivian Hsu**

# 1 General Description

## 1.1 Product Feature of Equipment Under Test

Product Feature	
Equipment	Notebook Computer
Brand Name	Lenovo
Model Name	TP00139A
FCC ID	PU5-TP00139AS
Sample 1	EUT with INPAQ Antenna
Sample 2	EUT with WNC Antenna
EUT supports Radios application	WCDMA/HSPA/LTE/5G NR/GNSS WLAN 11a/b/g/n HT20/HT40 WLAN 11ac VHT20/VHT40/VHT80/VHT160 WLAN 11ax HE20/HE40/HE80/HE160 Bluetooth BR/EDR/LE
EUT Stage	Production Unit

**Remark:**

1. The above EUT's information was declared by manufacturer.
2. Equipment: Murata LBEE5QG2CX tested inside of Lenovo Notebook Computer.

Antenna Information			
Antenna 1	Manufacturer	INPAQ	
	Antenna Type	PIFA Antenna	PIFA Antenna
	Part number	025.901YK.0011	025.901YL.0011
	Peak gain (dbi)	Main Antenna :	Aux Antenna :
WLAN (2.4G): 2.48 dBi		Bluetooth: 2.45 dBi	WLAN (2.4G): 2.45 dBi
Antenna 2	Manufacturer	WNC	
	Antenna Type	PIFA Antenna	PIFA Antenna
	Part number	025.901YK.0001	025.901YL.0001
	Peak gain (dbi)	Main Antenna :	Aux Antenna :
WLAN (2.4G): 2.62 dBi		Bluetooth: 2.54 dBi	WLAN (2.4G): 2.54 dBi

**Remark:** The EUT's information above is declared by manufacturer. Please refer to Comments and Explanations in report summary.

## 1.2 Product Specification of Equipment Under Test

Product Specification subjective to this standard	
<b>Tx/Rx Frequency Range</b>	2402 MHz ~ 2480 MHz
<b>Number of Channels</b>	79
<b>Carrier Frequency of Each Channel</b>	2402+n*1 MHz; n=0~78
<b>Maximum Output Power to Antenna</b>	Bluetooth BR (1Mbps): 8.97 dBm / 0.0079 W Bluetooth BR (2Mbps): 8.03 dBm / 0.0064 W Bluetooth BR (3Mbps): 8.21 dBm / 0.0066 W
<b>99% Occupied Bandwidth</b>	Bluetooth BR (1Mbps): 0.813MHz Bluetooth BR (2Mbps): 1.184MHz Bluetooth BR (3Mbps): 1.164MHz
<b>Type of Modulation</b>	Bluetooth BR (1Mbps) : GFSK Bluetooth EDR (2Mbps) : $\pi/4$ -DQPSK Bluetooth EDR (3Mbps) : 8-DPSK

**Remark:** The EUT's information above is declared by manufacturer. Please refer to Comments and Explanations in report summary.

## 1.3 Modification of EUT

No modifications made to the EUT during the testing.



### 1.4 Testing Location

Test Site	Sporton International Inc. Wensan Laboratory
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City 333010
Test Site No.	<b>Sporton Site No.</b>
	TH05-HY, 03CH20HY, CO07-HY

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

FCC designation No.: TW3786

### 1.5 Applicable Standards

According to the specifications declared by 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 the test items were validated and recorded in accordance with the standards without any modification during the testing.
2. The TAF code is not including all the FCC KDB listed without accreditation.



## 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). 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		
<b>Conducted Test Cases</b>	<b>Bluetooth BR 1Mbps GFSK</b>	<b>Bluetooth EDR 2Mbps <math>\pi/4</math>-DQPSK</b>	<b>Bluetooth EDR 3Mbps 8-DPSK</b>
	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
<b>Radiated Test Cases</b>	<b>Bluetooth BR 1Mbps GFSK</b>		
	Mode 1: CH00_2402 MHz		
	Mode 2: CH39_2441 MHz		
	Mode 3: CH78_2480 MHz		
<b>AC Conducted Emission</b>	Mode 1 : WLAN Link (2.4GHz) + Bluetooth Link + Earphone + Battery 1 + Adapter + USB Cable (Data Link with HD) for Sample 2		
<b>Remark:</b>			
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. For Radiated Test Cases, the tests were performed with Battery 1 and Sample 2.			
3. Data Link with USB HD means data application transferred mode between EUT and USB HD.			

### 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.	Bluetooth Earphone	Sony Ericsson	MW600	PY7DDA-2029	N/A	N/A
2.	WLAN AP	ASUS	GT-AXE11000	MSQ-RTAXJF00	N/A	Unshielded, 1.8m
3.	iPod Earphone	Apple	N/A	Verification	Unshielded, 1.0 m	N/A
4.	Notebook	Dell	Latitude 3400	FCC DoC	N/A	AC I/P : Unshielded, 1.2m DC O/P : Shielded, 1.8m
5.	USB HD	WD	WDBGPU0010BBL	FCC DoC	Shielded, 1m	N/A



## 2.5 EUT Operation Test Setup

The RF test items, utility “QRCT v4.0.00195.0” was installed in EUT which was programmed in order to make the EUT get into the engineering modes 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 10 dB 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

Please refer to the measuring equipment list in 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 is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Enable the EUT hopping function.
5. Use the following spectrum analyzer settings: Span = the frequency band of operation; RBW = 300 kHz; 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.

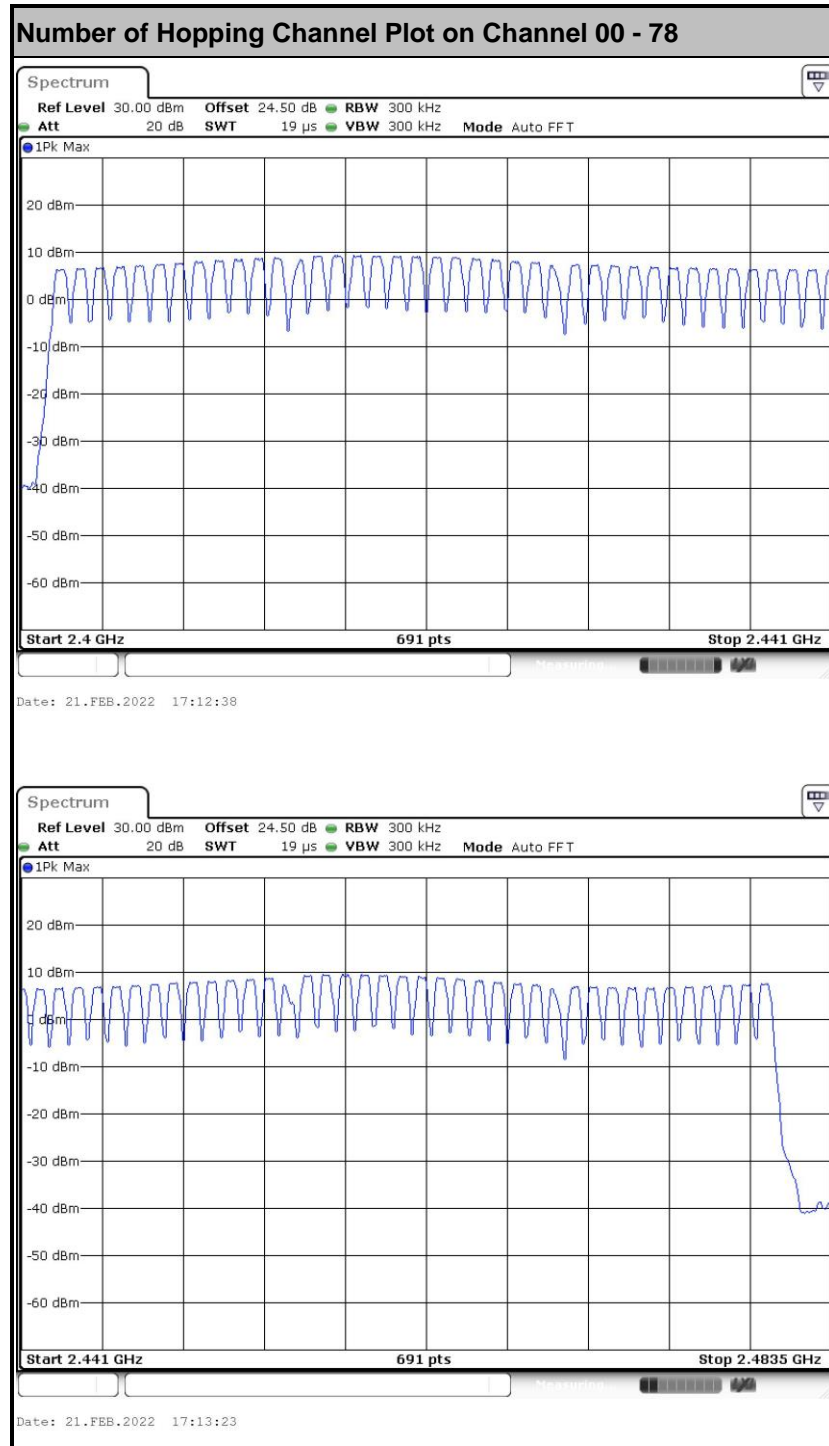
##### 3.1.4 Test Setup





### 3.1.5 Test Result of Number of Hopping Frequency

Please refer to Appendix A.



## 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

Please refer to the measuring equipment list in 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 is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to 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 = 300 kHz; 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

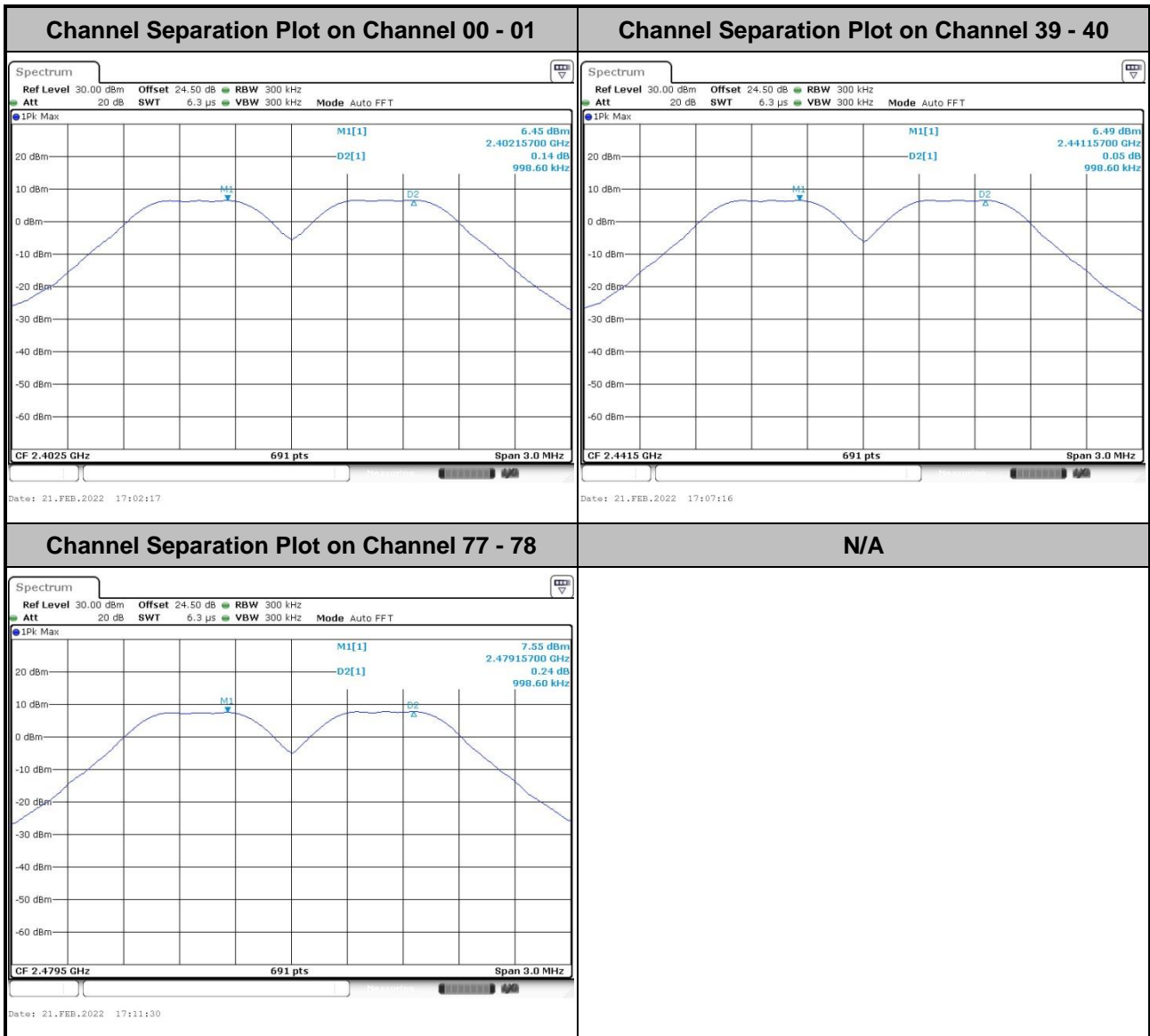


### 3.2.5 Test Result of Hopping Channel Separation

Please refer to Appendix A.

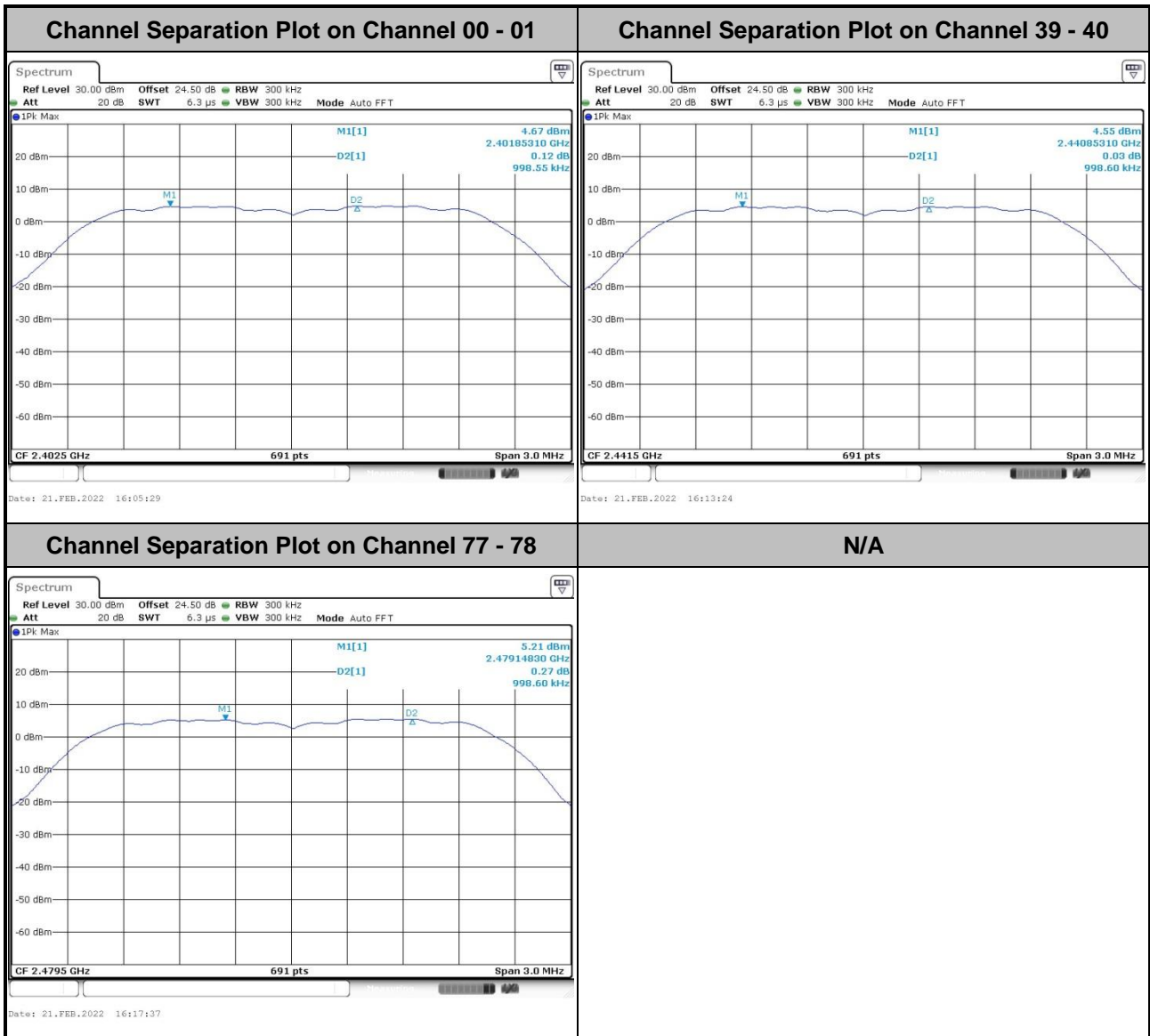


<1Mbps>





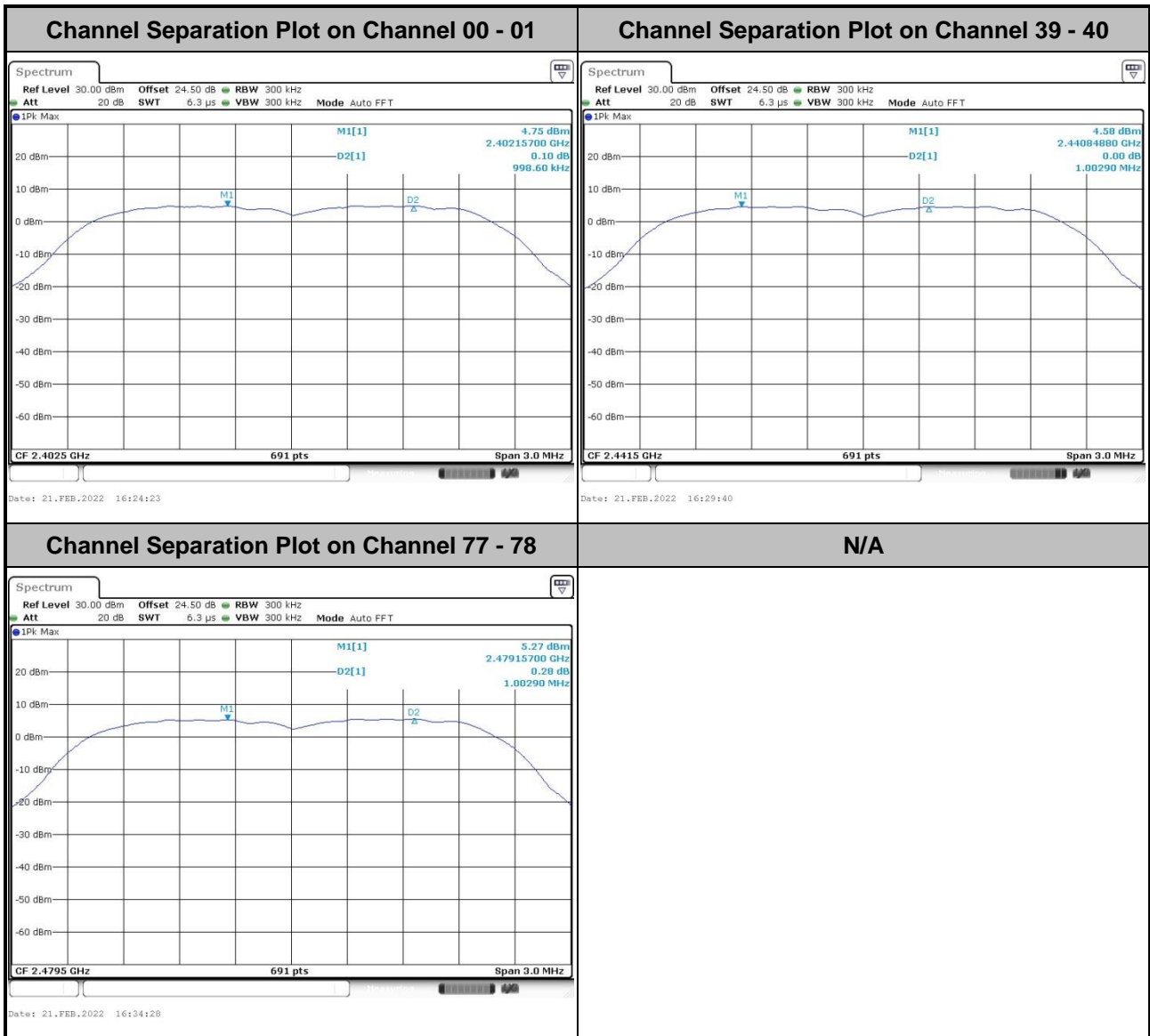
<2Mbps>







<3Mbps>



### 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.

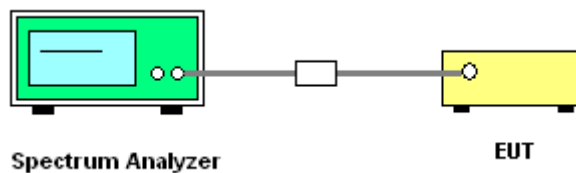
#### 3.3.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

#### 3.3.3 Test Procedures

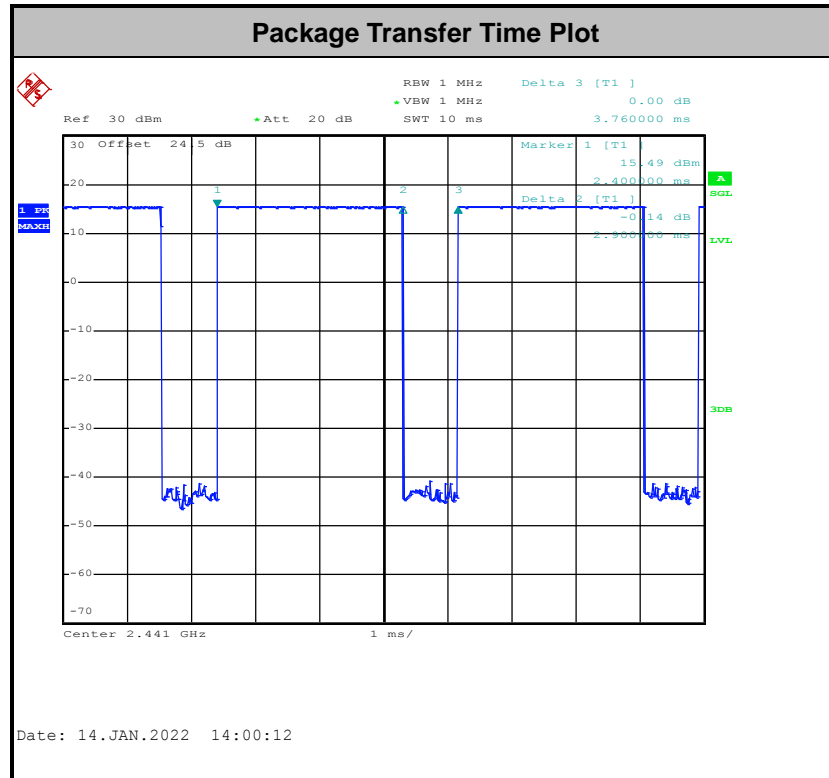
1. The testing follows ANSI C63.10-2013 clause 7.8.4.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Enable the 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.



**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 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

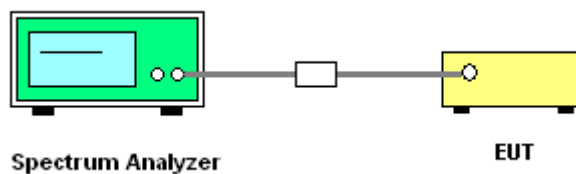
### 3.4.2 Measuring Instruments

Please refer to the measuring equipment list in 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 is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Use the following spectrum analyzer settings for 20 dB 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

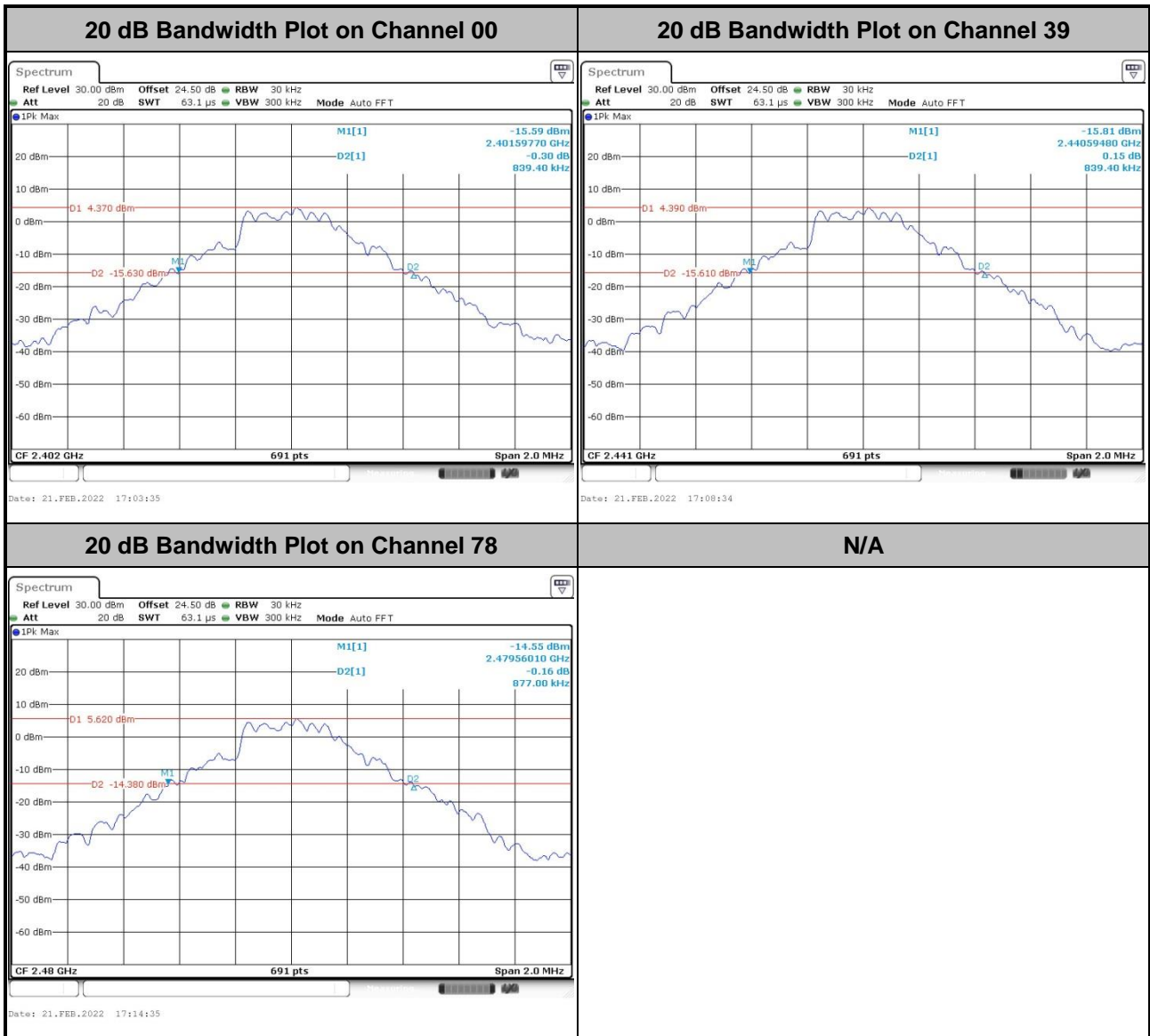


### 3.4.5 Test Result of 20dB Bandwidth

Please refer to Appendix A.

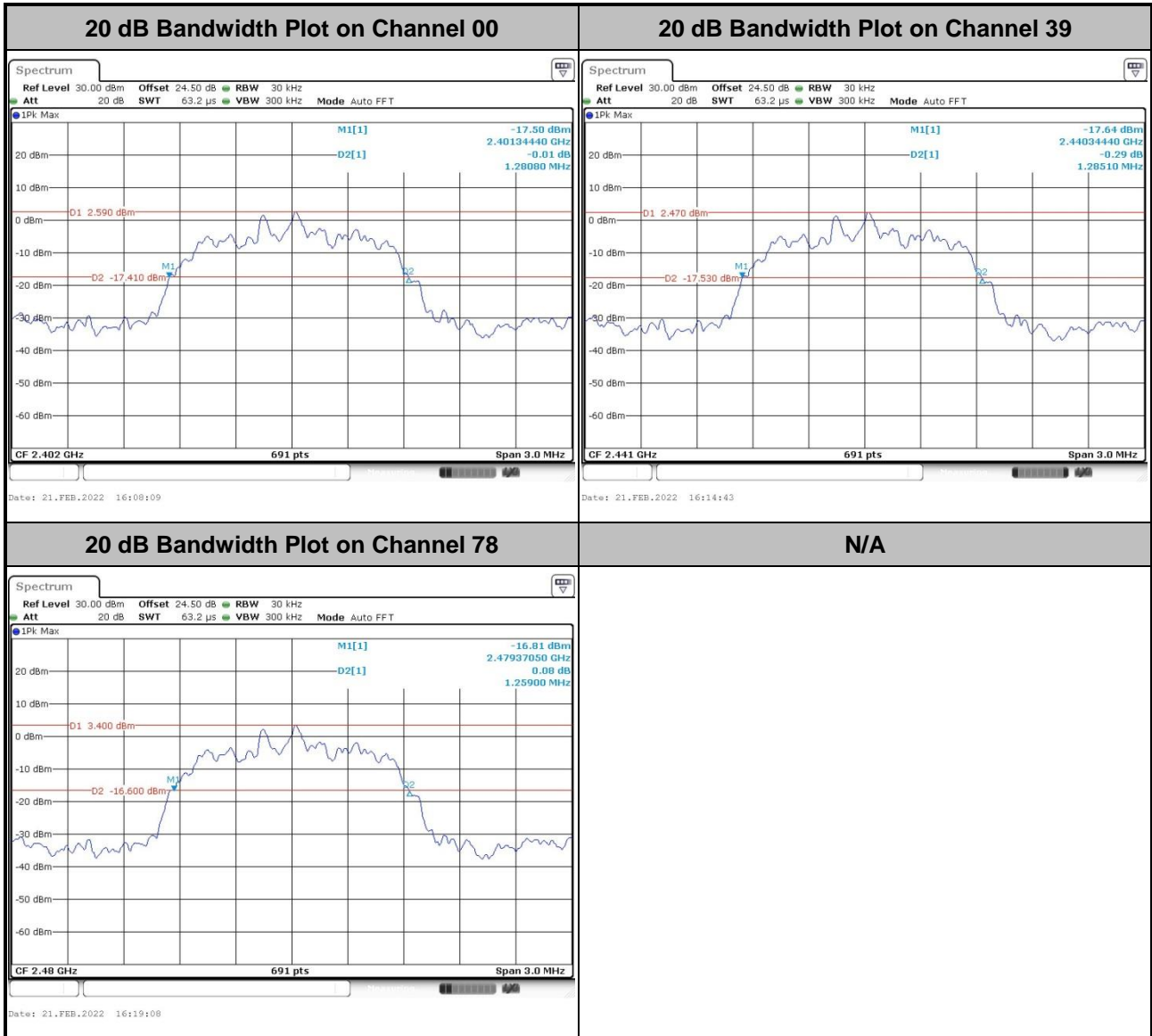


<1Mbps>



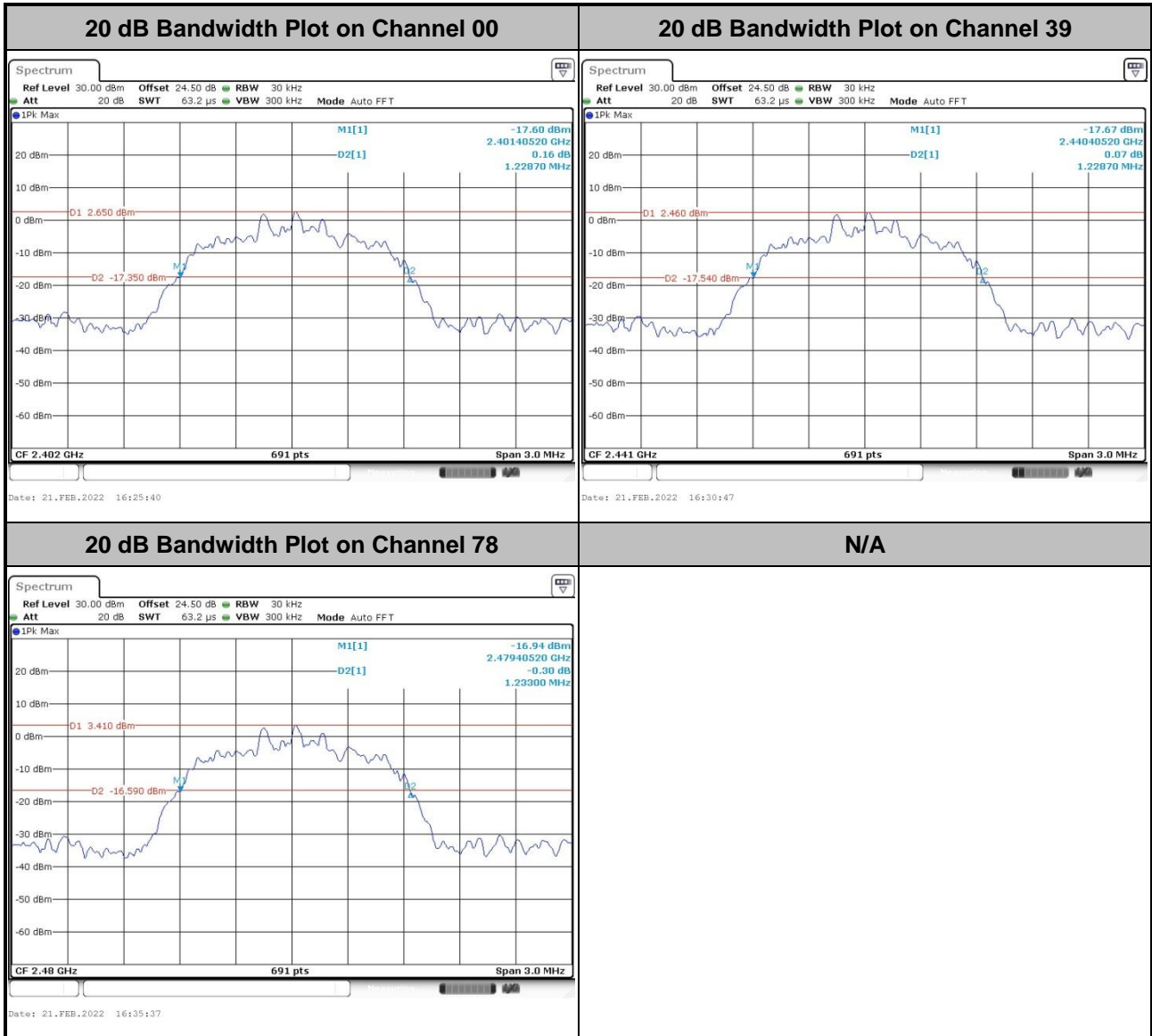


<2Mbps>





<3Mbps>

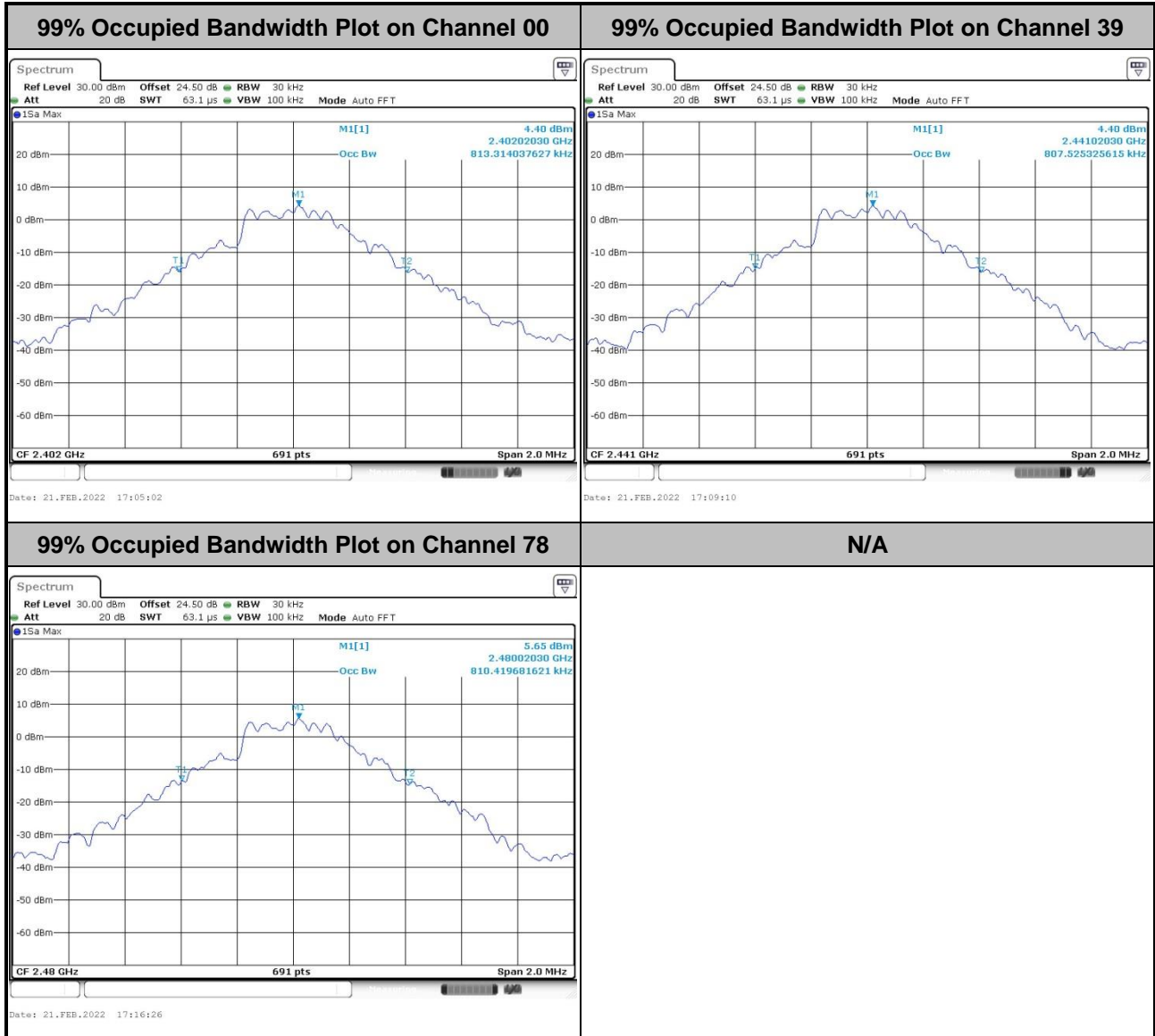




### 3.4.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

<1Mbps>

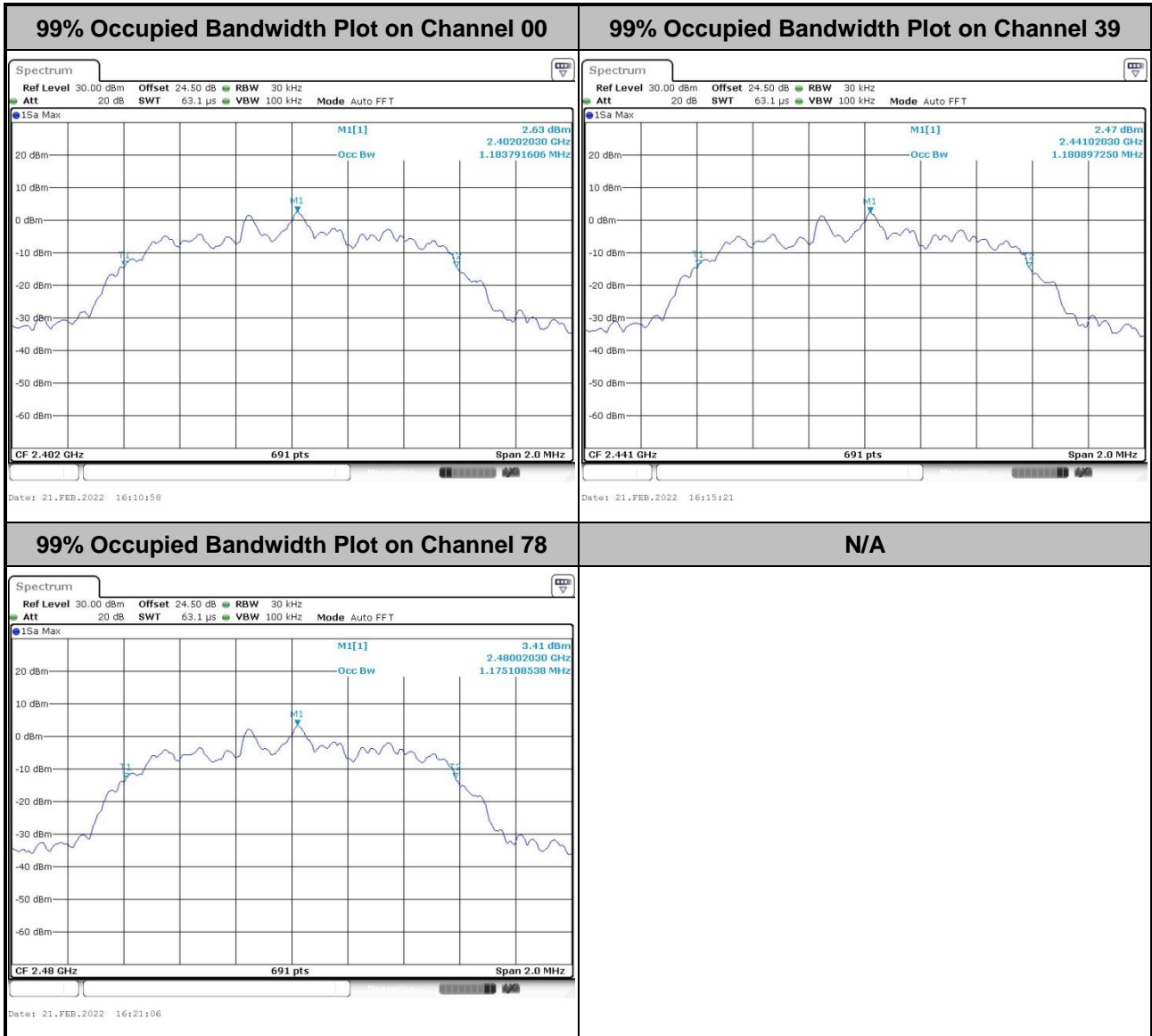


**Note:** The occupied channel bandwidth is maintained within the band of operation for all of the modulations.





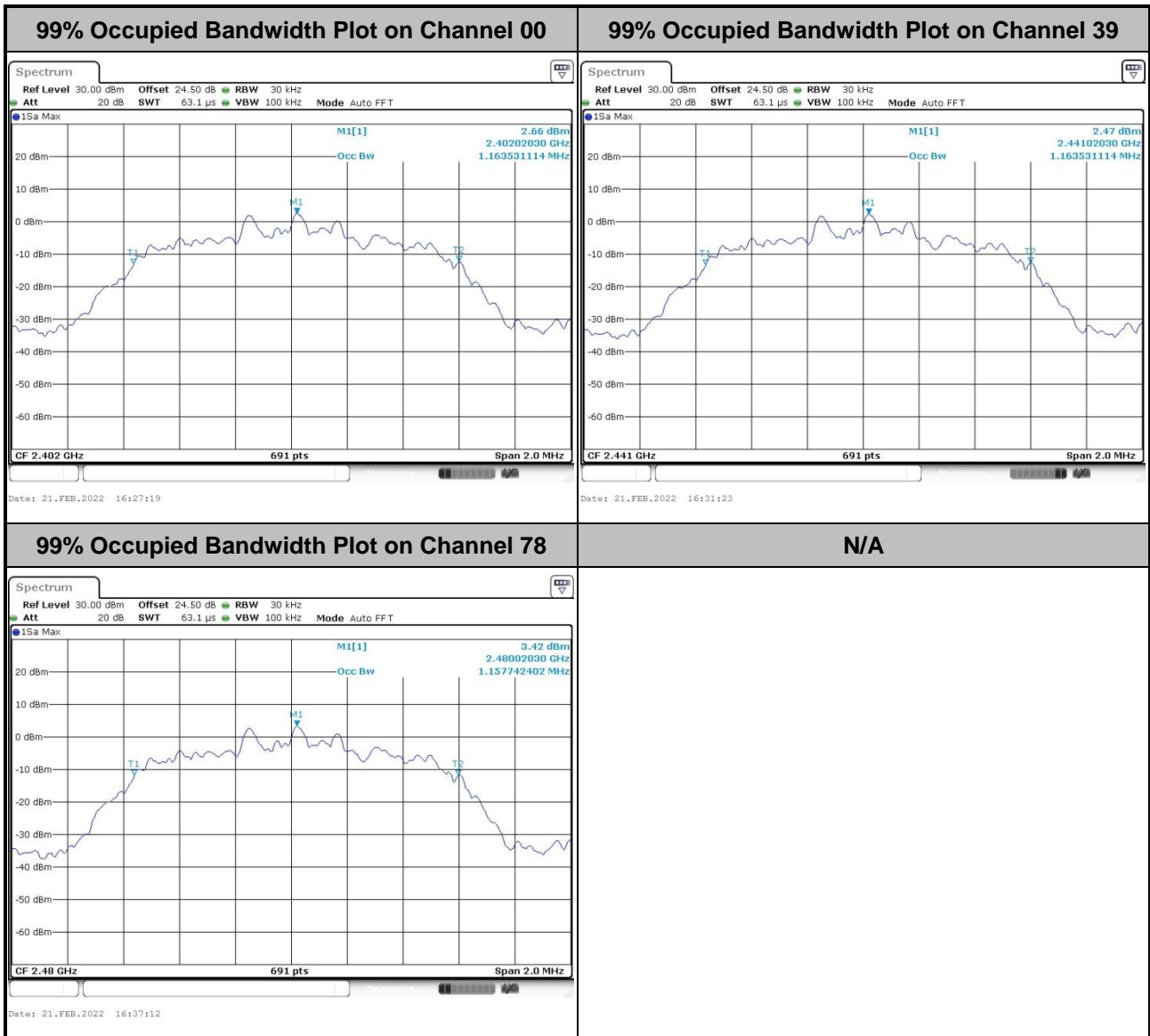
<2Mbps>



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



<3Mbps>



**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.

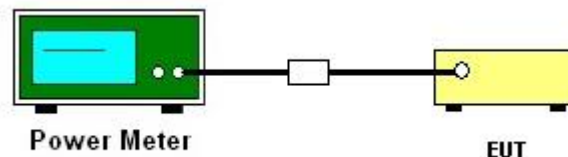
### 3.5.2 Measuring Instruments

Please refer to the measuring equipment list in 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 is connected to the power meter by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to 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

Please refer to the measuring equipment list in this test report.

### 3.6.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.6.
2. Set the maximum power setting and enable the EUT to transmit continuously.
3. Set RBW = 100 kHz, VBW = 300 kHz. Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz 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.

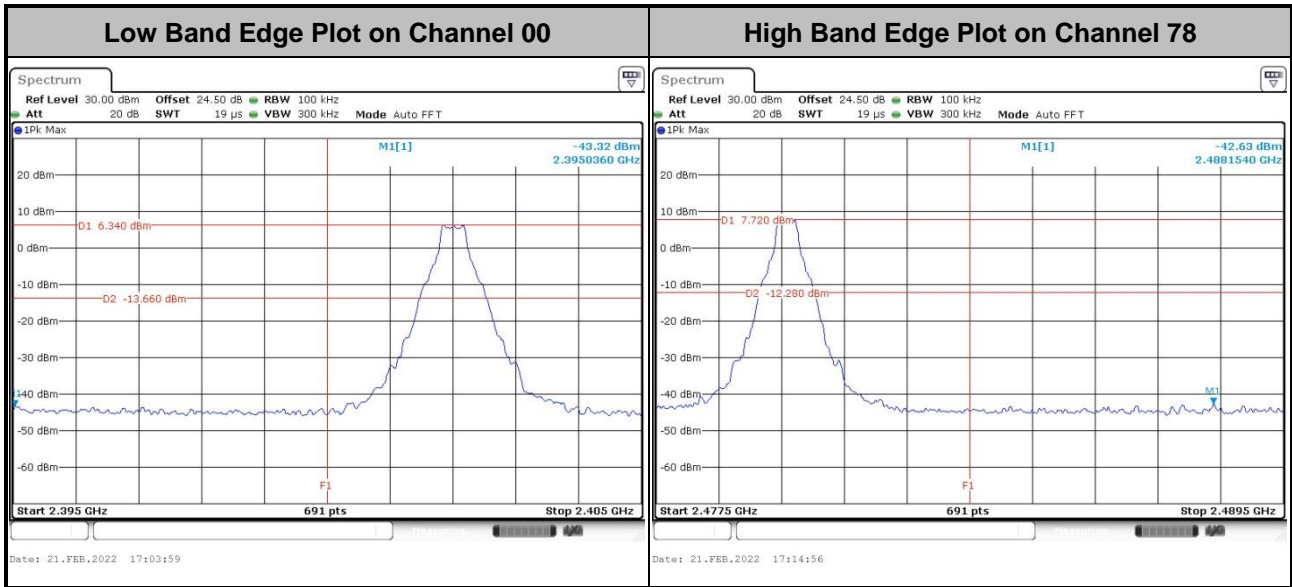
### 3.6.4 Test Setup



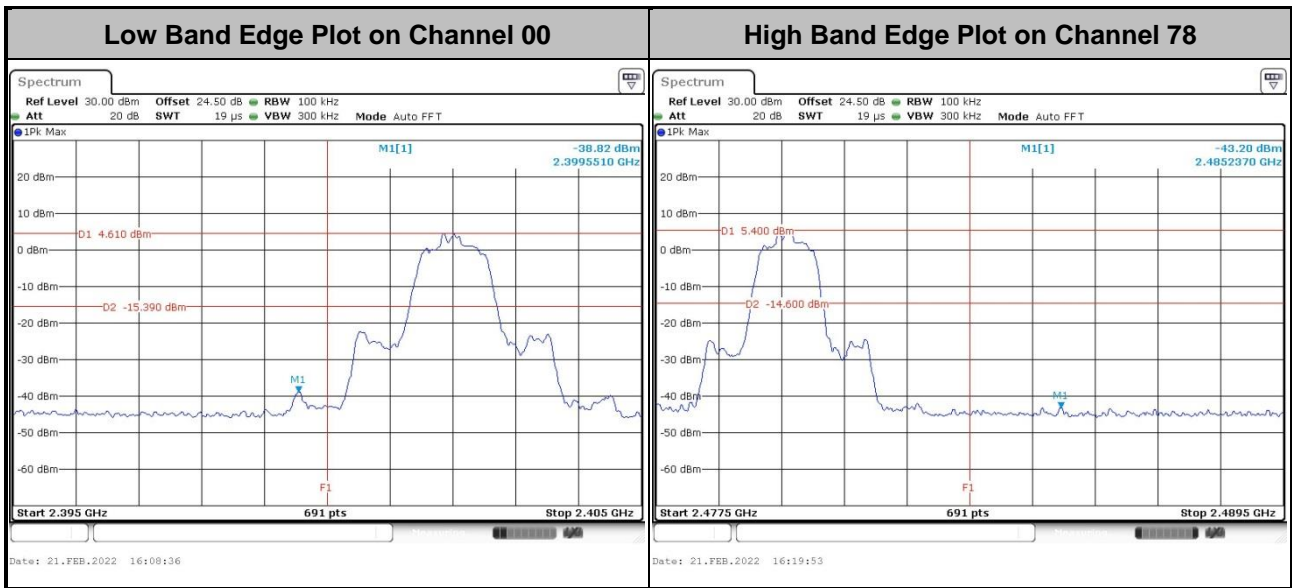


### 3.6.5 Test Result of Conducted Band Edges

<1Mbps>

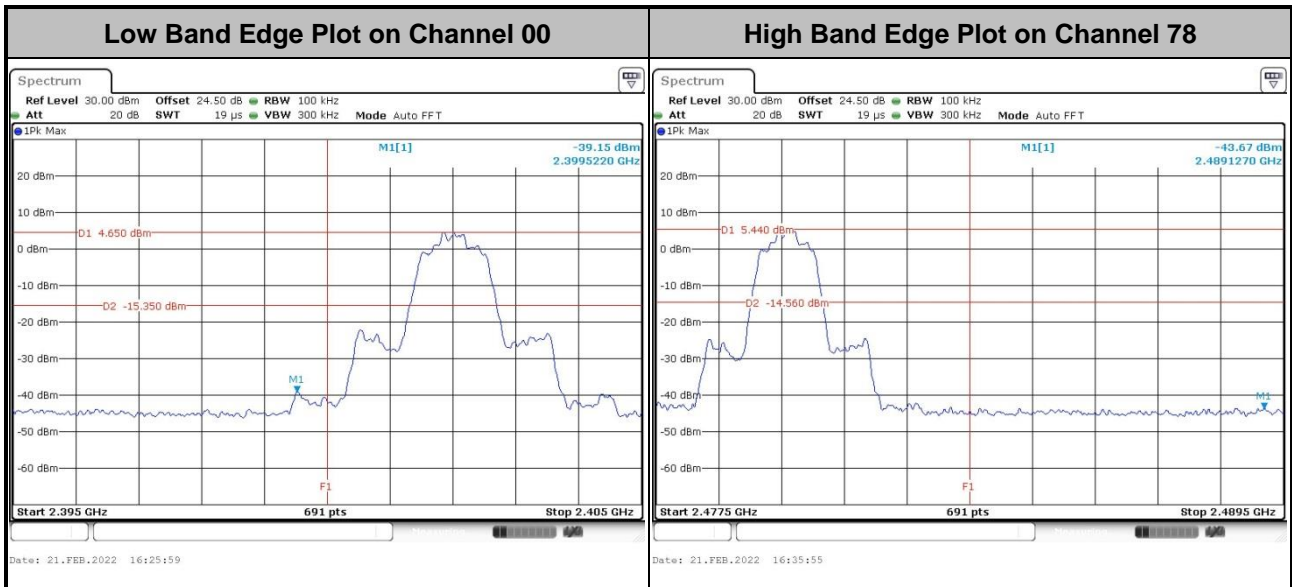


<2Mbps>





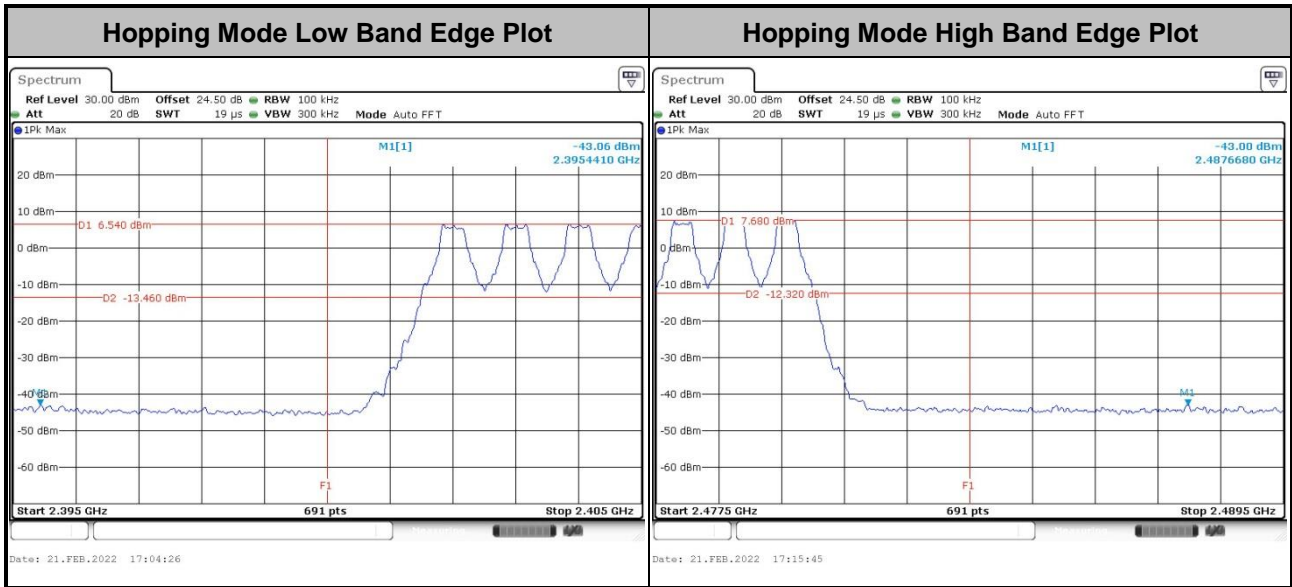
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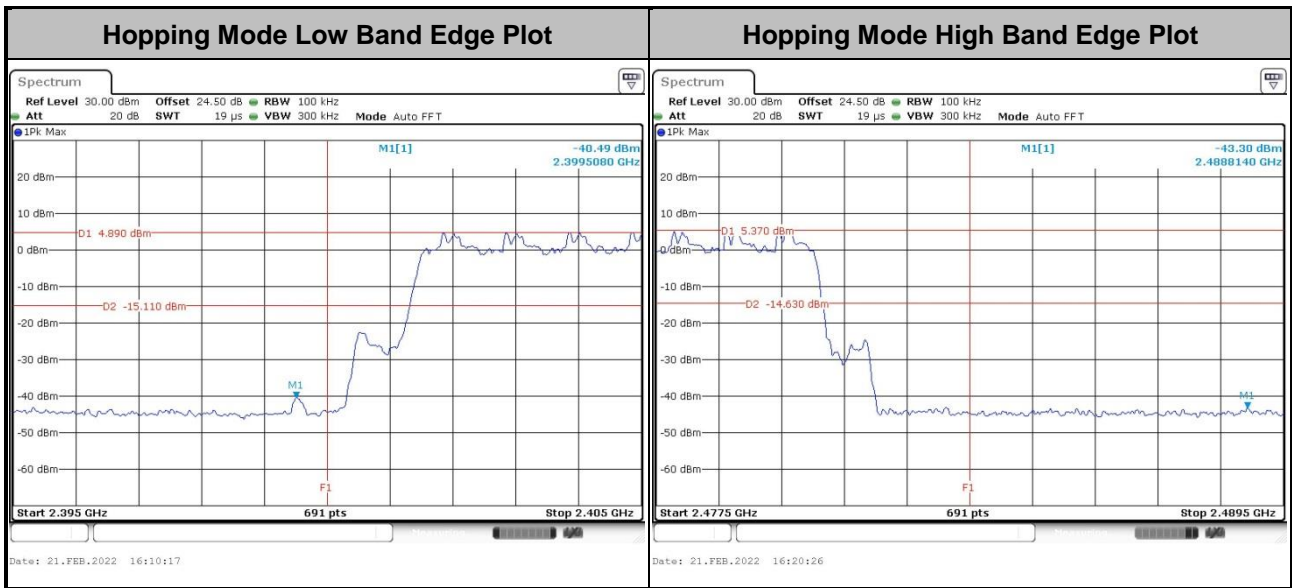


### 3.6.6 Test Result of Conducted Hopping Mode Band Edges

<1Mbps>

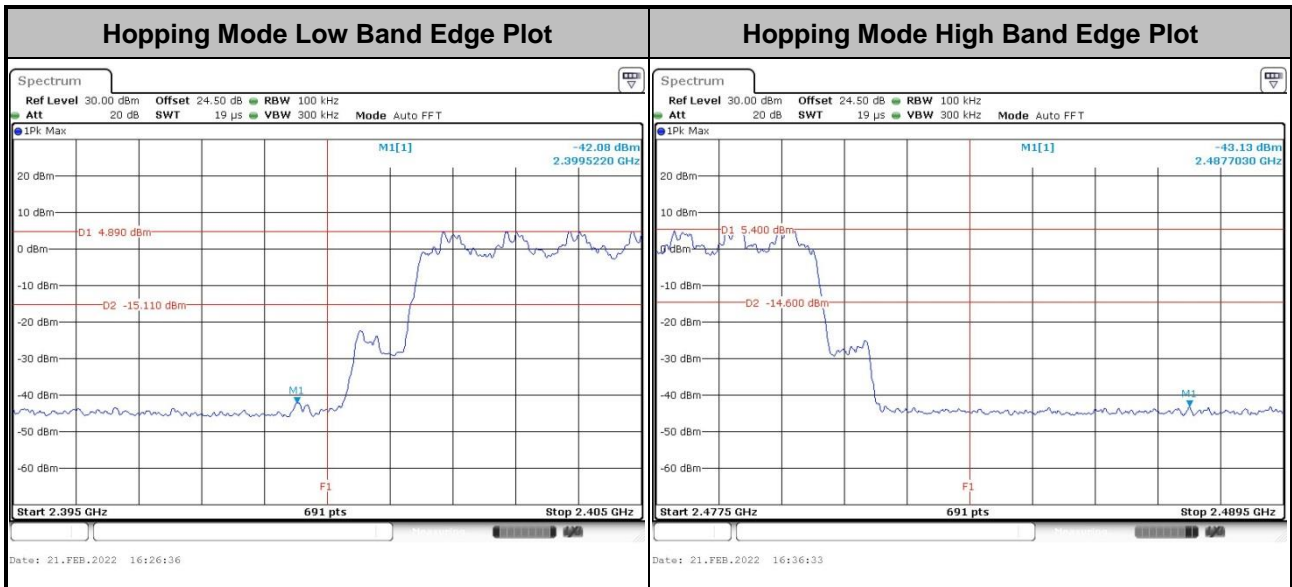


<2Mbps>





<3Mbps>





## 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

Please refer to the measuring equipment list in 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 is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. Set RBW = 100 kHz, VBW = 300 kHz, scan up through 10th harmonic. All harmonics / spurious 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.

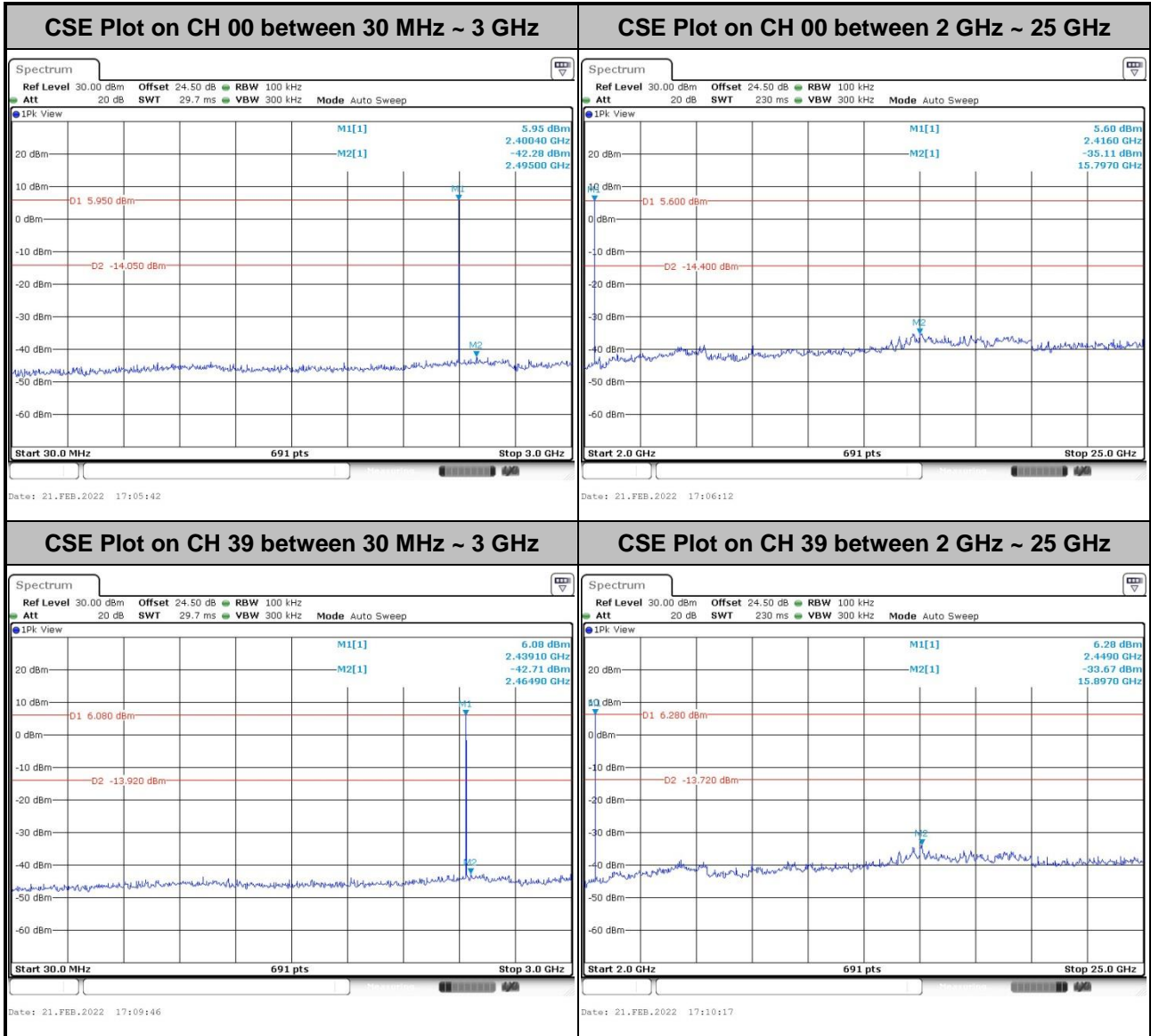
### 3.7.4 Test Setup

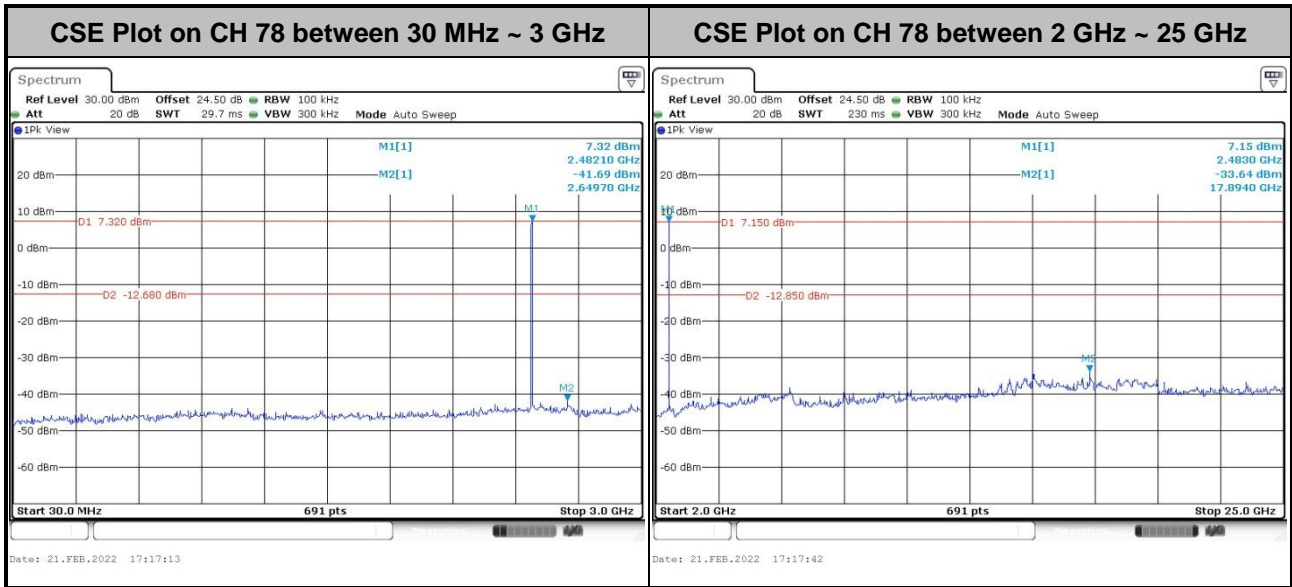




### 3.7.5 Test Result of Conducted Spurious Emission

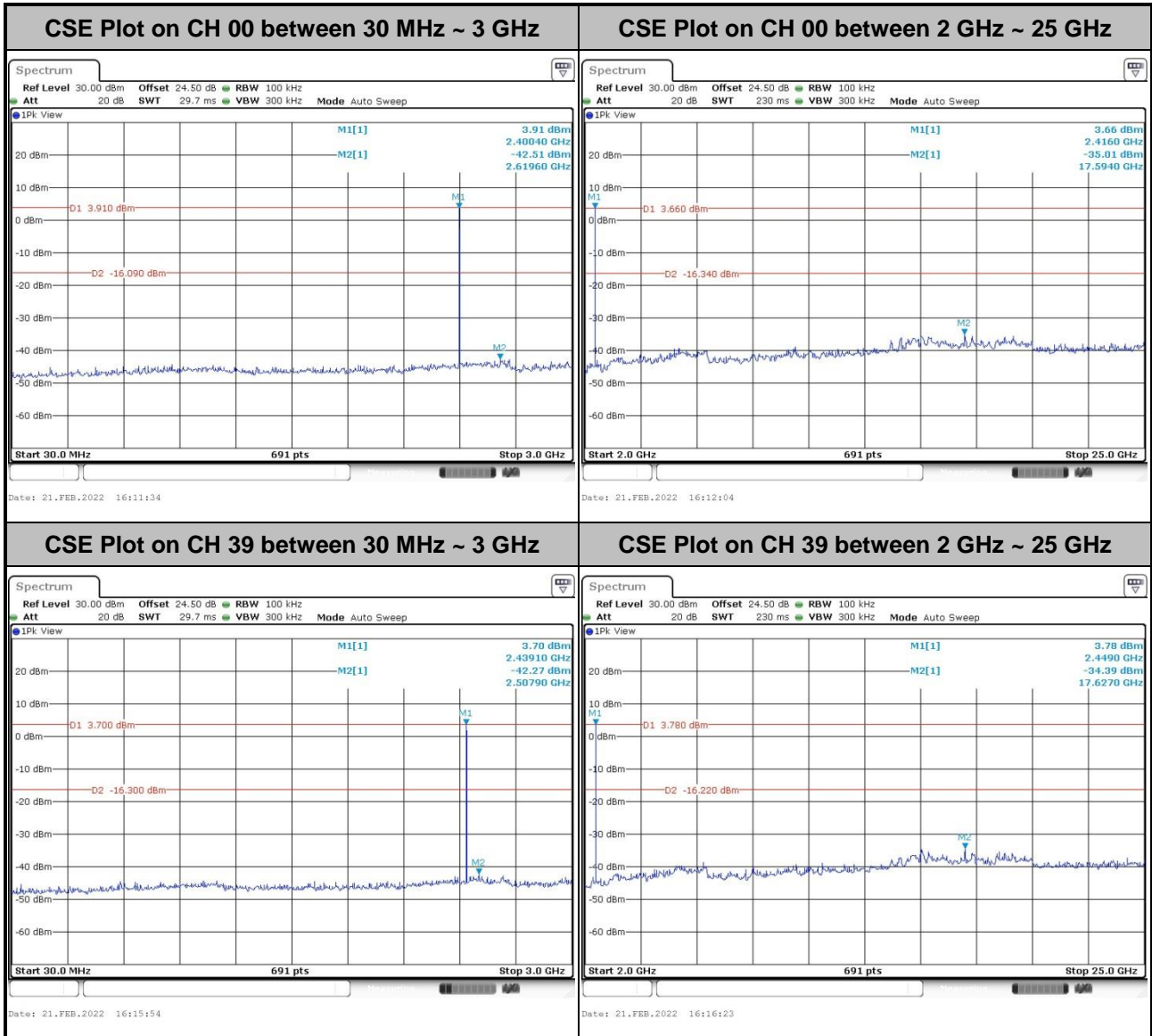
<1Mbps>

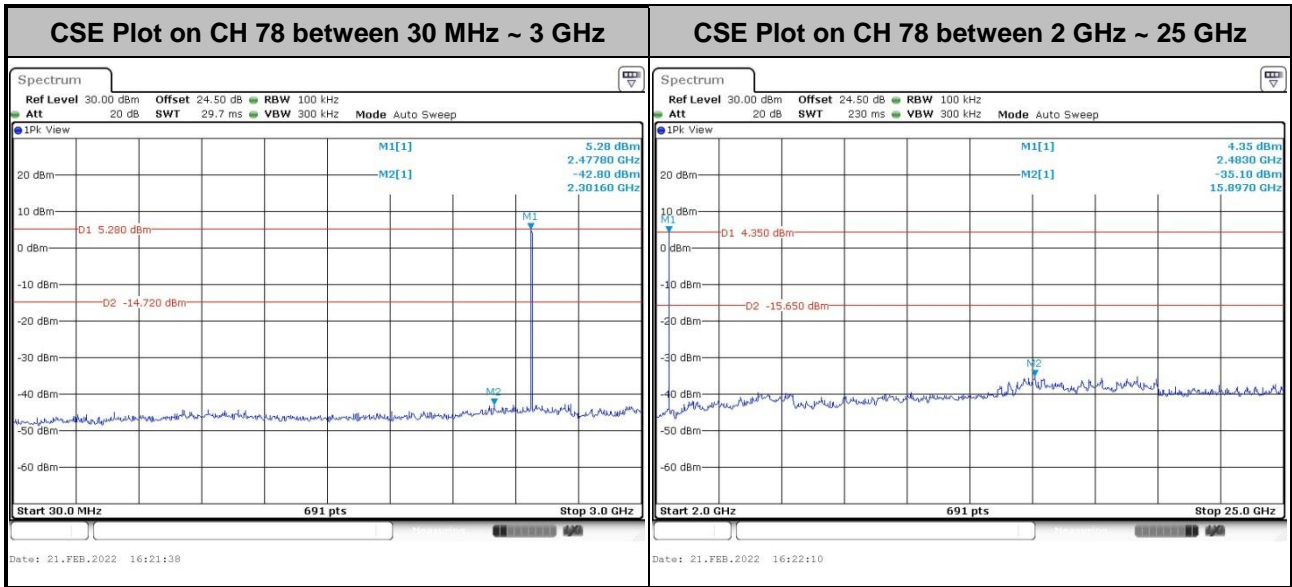






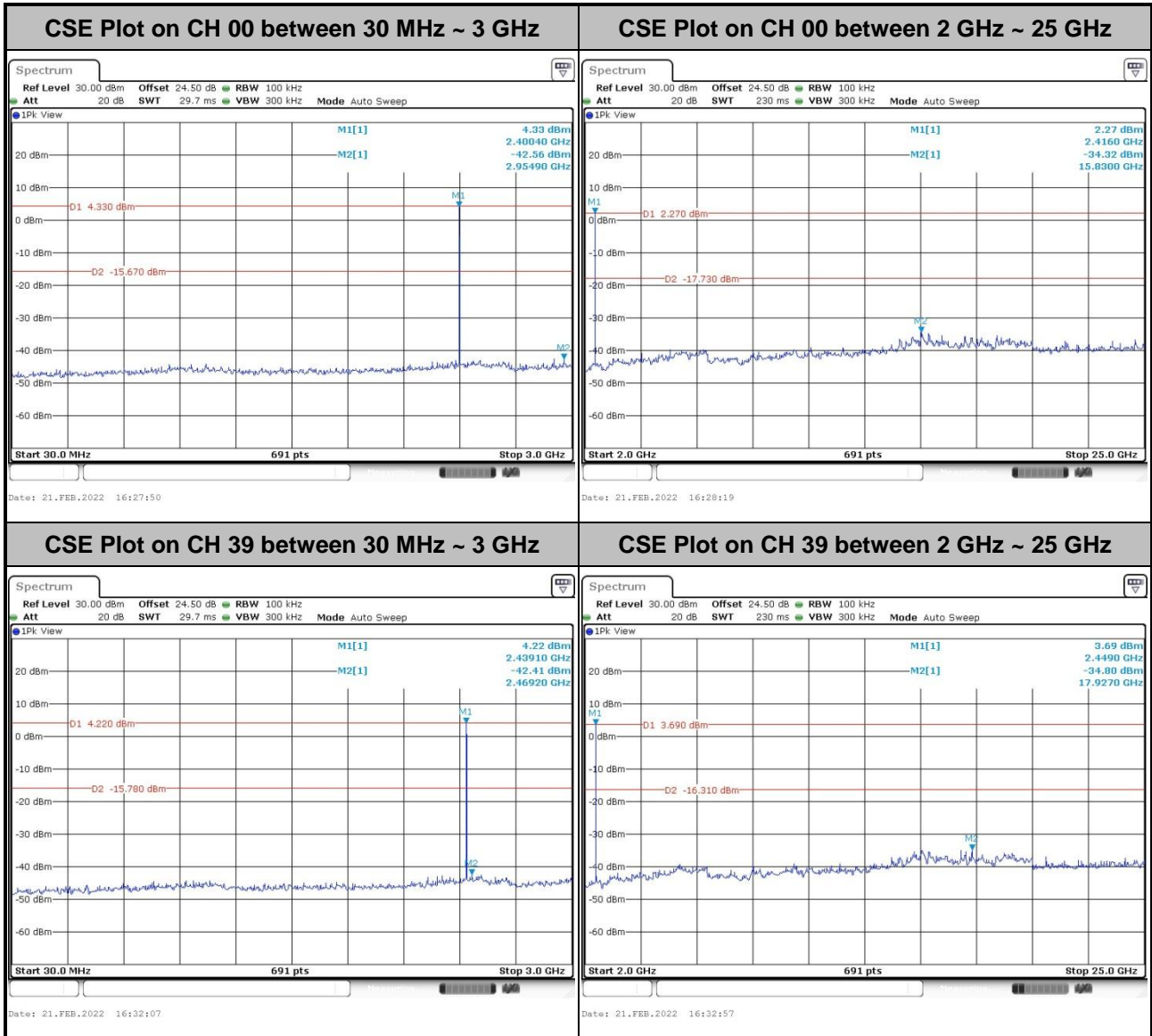
<2Mbps>

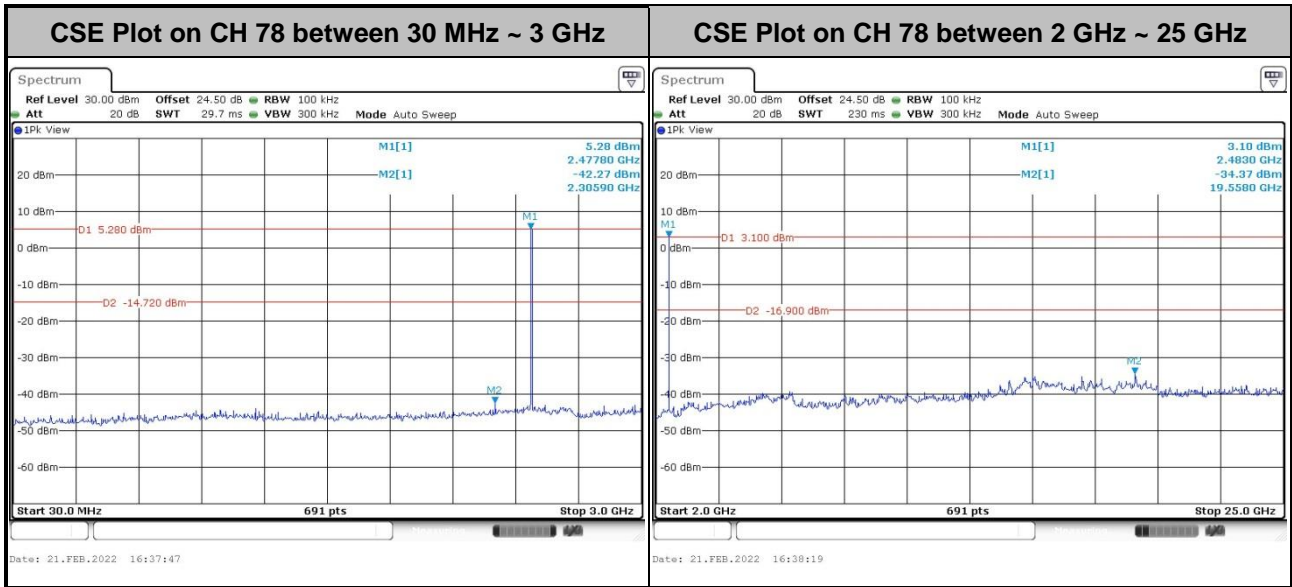






<3Mbps>







### 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

Please refer to the measuring equipment list in this test report.





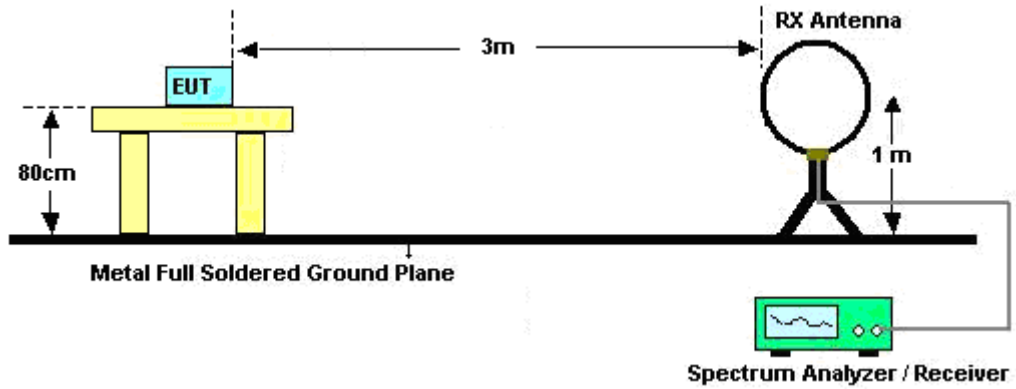
### 3.8.3 Test Procedures

1. The EUT is placed on a turntable with 0.8 meter for frequency below 1 GHz and 1.5 meter for frequency above 1 GHz respectively above ground.
2. The EUT is set 3 meters away from the receiving antenna, which is mounted on the top of a variable height antenna tower.
3. For each suspected emission, the EUT is 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 the maximum power setting and enable the EUT to 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 = 1 MHz 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  
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 +  $20 * \log$  (Duty cycle)
6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
7. Radiated testing below 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading. When there is no suspected emission found and the emission level is with at least 6 dB margin against QP limit line, the position is marked as “-“.
8. Radiated testing above 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading for scanning all frequencies. When there is no suspected emission found and the harmonic emission level is with at least 6 dB margin against average limit line, the position is marked as “-“.

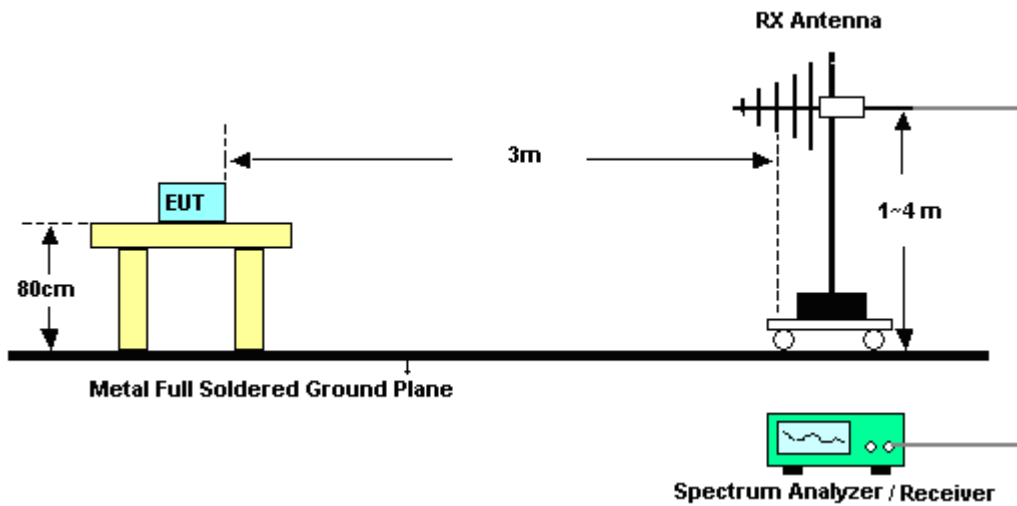
Note: The average levels are calculated from the peak level corrected with duty cycle correction factor (-24.76dB) derived from  $20 \log$  (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.

### 3.8.4 Test Setup

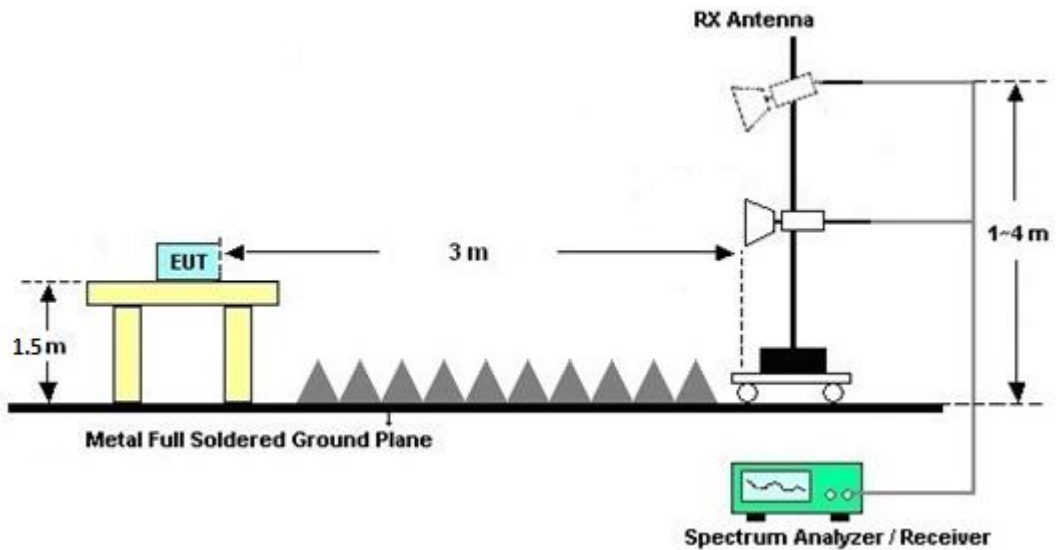
For radiated test below 30MHz



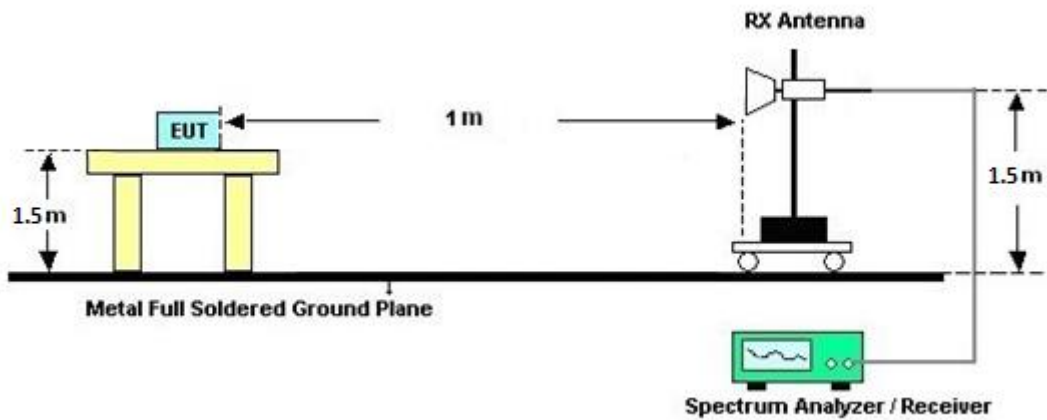
For radiated test from 30MHz to 1GHz



For radiated test from 1GHz to 18GHz



For radiated test above 18GHz



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

The low frequency, which starts from 9 kHz to 30 MHz, is pre-scanned and the result which is 20 dB lower than the limit line is not reported.

There is adequate comparison measurement of both open-field test site and alternative test site - semi-Anechoic chamber according to 414788 D01 Radiated Test Site v01r01, and the result comes 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 ~ 10<sup>th</sup> 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 $\mu$ 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.

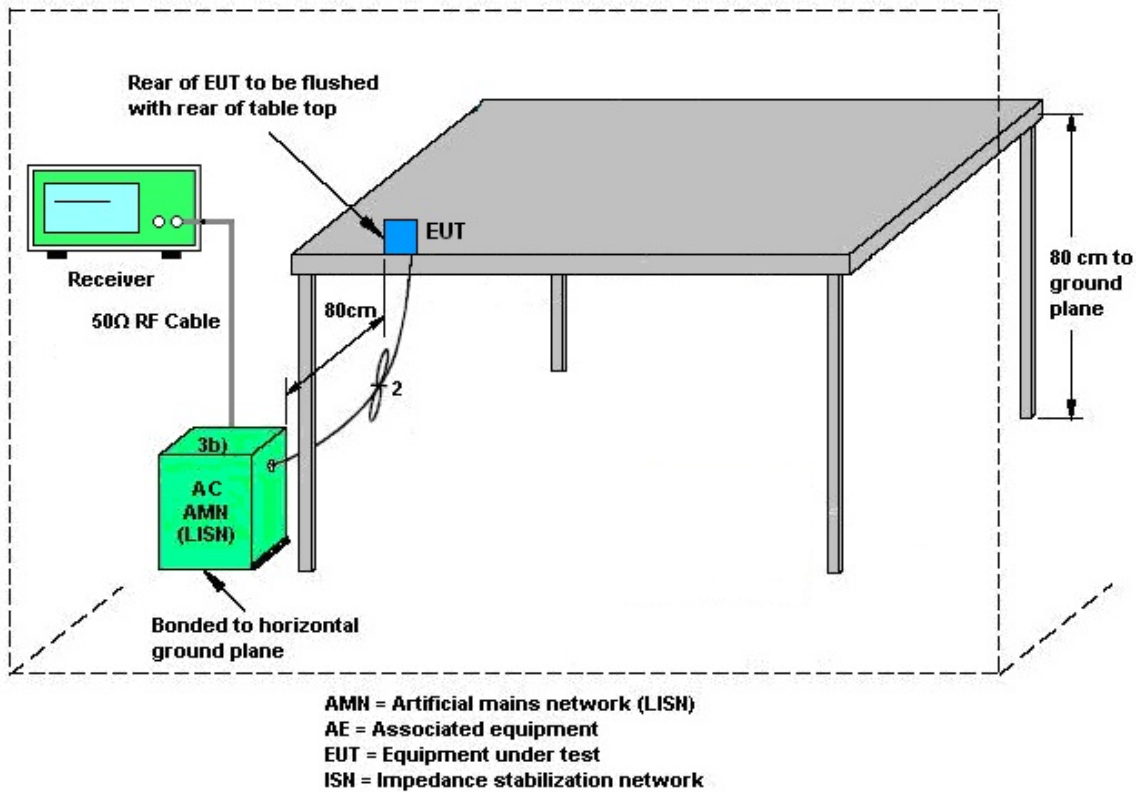
### 3.9.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

### 3.9.3 Test Procedures

1. The EUT is placed 0.4 meter away from the conducting wall of the shielding room, and is 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 shall be used.
6. Both Line and Neutral shall be tested in order to find out the maximum conducted emission.
7. The frequency range from 150 kHz to 30 MHz is scanned.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9 kHz) 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 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. 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
EMI Test Receiver	Keysight	N9010B	MY60241055	10Hz~44GHz	Jul. 12, 2021	Jan. 18, 2022~ Feb. 22, 2022	Jul. 11, 2022	Radiation (03CH20-HY)
Preamplifier	COM-POWER	PAM-103	18020201	1MHz-1000MHz	Jan. 03, 2022	Jan. 18, 2022~ Feb. 22, 2022	Jan. 02, 2023	Radiation (03CH20-HY)
Amplifier	EMCI	EMC118A45SE	980792	N/A	Nov. 15, 2021	Jan. 18, 2022~ Feb. 22, 2022	Nov. 14, 2022	Radiation (03CH20-HY)
Preamplifier	EMEC	EM18G40G	060801	18GHz~40GHz	Jun. 22, 2021	Jan. 18, 2022~ Feb. 22, 2022	Jun. 21, 2022	Radiation (03CH20-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100315	9 kHz~30 MHz	Jan. 07, 2022	Jan. 18, 2022~ Feb. 22, 2022	Jan. 06, 2023	Radiation (03CH20-HY)
Bilog Antenna	TESEQ	CBL 6111D&00802 N1D01N-06	55606 & 08	30MHz~1GHz	Oct. 17, 2021	Jan. 18, 2022~ Feb. 22, 2022	Oct. 16, 2022	Radiation (03CH20-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-02294	1GHz~18GHz	Jun. 23, 2021	Jan. 18, 2022~ Feb. 22, 2022	Jun. 22, 2022	Radiation (03CH20-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA9170	00991	18GHz-40GHz	May 12, 2021	Jan. 18, 2022~ Feb. 22, 2022	May 11, 2022	Radiation (03CH20-HY)
Hygrometer	TECPEL	DTM-303B	TP200728	N/A	Mar. 09, 2021	Jan. 18, 2022~ Feb. 22, 2022	Mar. 08, 2022	Radiation (03CH20-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	519229/2,804 015/2,804027 /2	N/A	Jan. 20, 2021	Jan. 18, 2022	Jan. 19, 2022	Radiation (03CH20-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	519229/2,804 015/2,804027 /2	N/A	Jan. 19, 2022	Jan. 19, 2022~ Feb. 22, 2022	Jan. 18, 2023	Radiation (03CH20-HY)
1.53GHz Low Pass Filter	Wainwright	WLK4-1000-15 30-8000-40SS	SN27	N/A	May 25, 2021	Jan. 18, 2022~ Feb. 22, 2022	May 24, 2022	Radiation (03CH20-HY)
Filter	Wainwright	WHKX12-2700 -3000-18000-6 OST	SN8	N/A	Mar. 26, 2021	Jan. 18, 2022~ Feb. 22, 2022	Mar. 25, 2022	Radiation (03CH20-HY)
Software	Audix	E3 6.2009-8-24	RK-002156	N/A	N/A	Jan. 18, 2022~ Feb. 22, 2022	N/A	Radiation (03CH20-HY)
Antenna Mast	EMEC	AM-BS-4500-B	N/A	1m~4m	N/A	Jan. 18, 2022~ Feb. 22, 2022	N/A	Radiation (03CH20-HY)
Turn Table	EMEC	TT2000	N/A	0~360 Degree	N/A	Jan. 18, 2022~ Feb. 22, 2022	N/A	Radiation (03CH20-HY)
Controller	EMEC	EM1000	N/A	Control Turn table & Ant Mast	N/A	Jan. 18, 2022~ Feb. 22, 2022	N/A	Radiation (03CH20-HY)
Hygrometer	TECPEL	DTM-303A	TP201996	N/A	Nov. 16, 2021	Jan. 14, 2022~ Feb. 22, 2022	Nov. 15, 2022	Conducted (TH05-HY)
Power Meter	Anritsu	ML2495A	1036004	N/A	Aug. 01, 2021	Jan. 14, 2022~ Feb. 22, 2022	Jul. 31, 2022	Conducted (TH05-HY)
Power Sensor	Anritsu	MA2411B	1027253	300MHz~40GHz	Aug. 01, 2021	Jan. 14, 2022~ Feb. 22, 2022	Jul. 31, 2022	Conducted (TH05-HY)
Spectrum Analyzer	Rohde & Schwarz	FSP40	100057	9kHz-40GHz	Dec. 30, 2021	Jan. 14, 2022~ Feb. 22, 2022	Dec. 29, 2022	Conducted (TH05-HY)
Switch Control Manframe	E-IUSTRUMENT	ETF-1405-0	EC1900067 (BOX7)	N/A	Aug. 12, 2021	Jan. 14, 2022~ Feb. 22, 2022	Aug. 11, 2022	Conducted (TH05-HY)



Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
AC Power Source	ACPOWER	AFC-11003G	F317040033	N/A	N/A	Jan. 25, 2022	N/A	Conduction (CO07-HY)
Software	Rohde & Schwarz	EMC32 V10.30	N/A	N/A	N/A	Jan. 25, 2022	N/A	Conduction (CO07-HY)
Pulse Limiter	SCHWARZBECK	VTSD 9561-FN	9561-FN00373	9kHz-200MHz	Oct. 29, 2021	Jan. 25, 2022	Oct. 28, 2022	Conduction (CO07-HY)
RF Cable	HUBER + SUHNER	RG 214/U	1358175	9kHz~30MHz	N/A	Jan. 25, 2022	N/A	Conduction (CO07-HY)
Two-Line V-Network	TESEQ	NNB 51	45051	N/A	Feb. 01, 2021	Jan. 25, 2022	Jan. 31, 2022	Conduction (CO07-HY)
EMI Test Receiver	Rohde & Schwarz	ESC17	100724	9kHz~7GHz	Feb. 18, 2021	Jan. 25, 2022	Feb. 17, 2022	Conduction (CO07-HY)
Hygrometer	TECPEL	DTM-303B	TP200728	N/A	Mar. 09, 2021	Jan. 25, 2022	Mar. 08, 2022	Conduction (CO07-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 dB
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### Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	5.9 dB
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### Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	5.2 dB
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### Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ( $U = 2Uc(y)$ )	5.7 dB
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**Appendix A. Test Result of Conducted Test Items**

Test Engineer:	Benny Ku	Temperature:	21~25	°C
Test Date:	2022/1/14~2/22	Relative Humidity:	51~54	%

<b>TEST RESULTS DATA</b>									
<b>20dB and 99% Occupied Bandwidth and Hopping Channel Separation</b>									
Mod.	Data Rate	NTX	CH.	Freq. (MHz)	20db BW (MHz)	99% Bandwidth (MHz)	Hopping Channel Separation Measurement (MHz)	Hopping Channel Separation Limit (MHz)	Pass/Fail
DH	1Mbps	1	0	2402	0.839	0.813	0.999	0.5596	Pass
DH	1Mbps	1	39	2441	0.839	0.808	0.999	0.5596	Pass
DH	1Mbps	1	78	2480	0.877	0.810	0.999	0.5847	Pass
2DH	2Mbps	1	0	2402	1.281	1.184	0.999	0.8539	Pass
2DH	2Mbps	1	39	2441	1.285	1.181	0.999	0.8567	Pass
2DH	2Mbps	1	78	2480	1.259	1.175	0.999	0.8393	Pass
3DH	3Mbps	1	0	2402	1.229	1.164	0.999	0.8191	Pass
3DH	3Mbps	1	39	2441	1.229	1.164	1.003	0.8191	Pass
3DH	3Mbps	1	78	2480	1.233	1.158	1.003	0.8220	Pass

<b>TEST RESULTS DATA</b>						
<b>Dwell Time</b>						
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

<b>TEST RESULTS DATA</b>					
<b>Peak Power Table</b>					
DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH1	0	1	7.80	20.97	Pass
	39	1	7.91	20.97	Pass
	78	1	8.97	20.97	Pass
2DH1	0	1	6.89	20.97	Pass
	39	1	6.90	20.97	Pass
	78	1	8.03	20.97	Pass
3DH1	0	1	7.15	20.97	Pass
	39	1	7.21	20.97	Pass
	78	1	8.21	20.97	Pass

<b>TEST RESULTS DATA</b>				
<b>Average Power Table</b>				
<b>(Reporting Only)</b>				
DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
DH1	0	1	7.62	5.21
	39	1	7.91	5.21
	78	1	8.66	5.21
2DH1	0	1	4.66	5.16
	39	1	5.03	5.16
	78	1	6.25	5.16
3DH1	0	1	5.24	5.16
	39	1	5.11	5.16
	78	1	6.30	5.16

<b>TEST RESULTS DATA</b>			
<b>Number of Hopping Frequency</b>			
Number of Hopping (Channel)	Adaptive Frequency Hopping (Channel)	Limits (Channel)	Pass/Fail
79	20	> 15	Pass



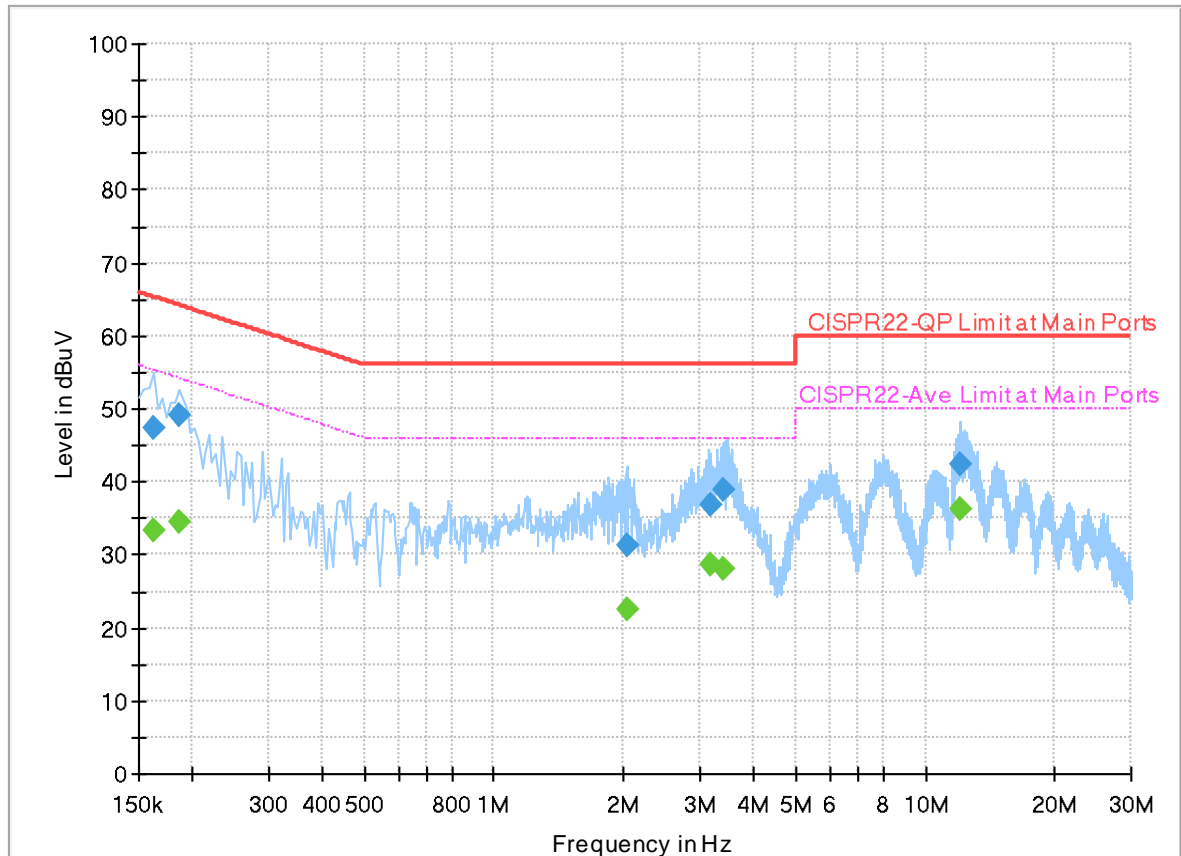
## Appendix B. AC Conducted Emission Test Results

Test Engineer :	Calvin Wang	Temperature :	23~26°C
		Relative Humidity :	45~55%

## EUT Information

Report NO : 1D1645-01  
 Test Mode : Mode 1  
 Test Voltage : 120Vac/60Hz  
 Phase : Line

Full Spectrum



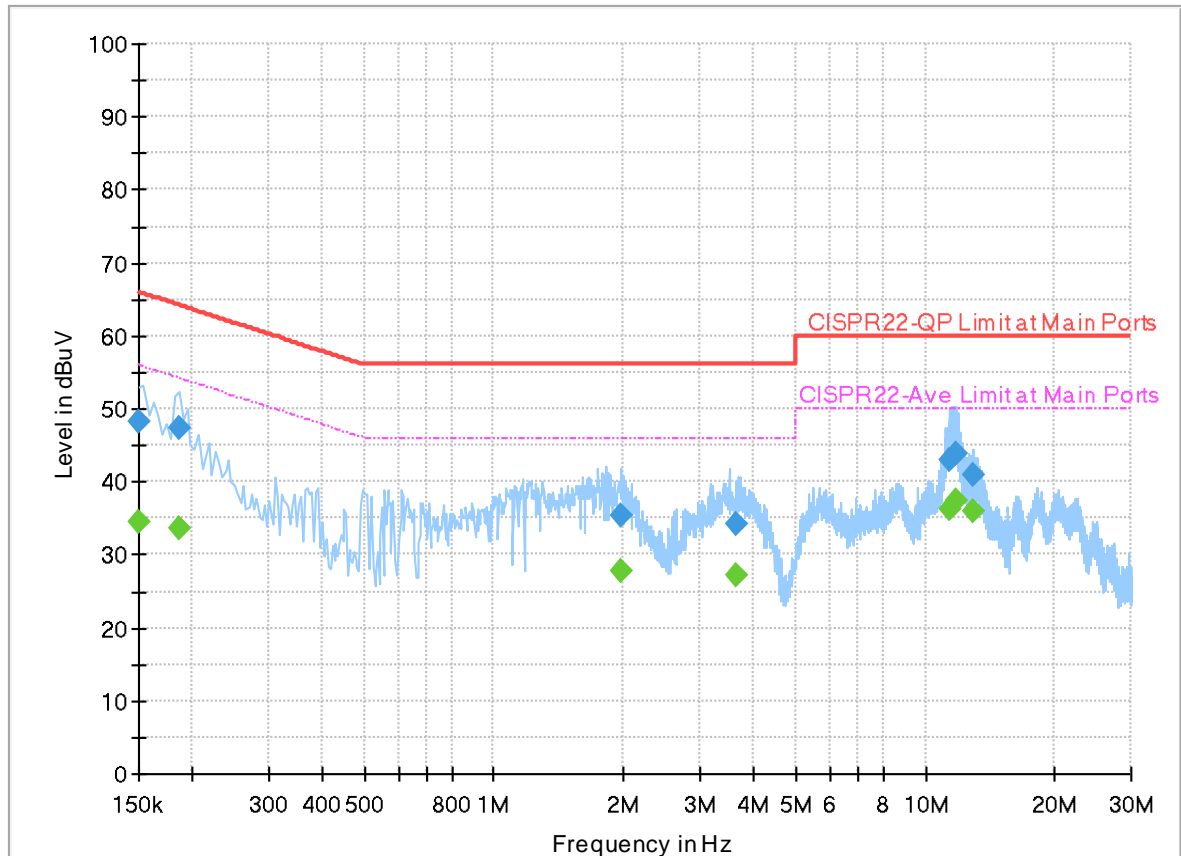
## Final\_Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.162000	---	33.30	55.36	22.06	L1	OFF	20.1
0.162000	47.33	---	65.36	18.03	L1	OFF	20.1
0.186000	---	34.39	54.21	19.82	L1	OFF	20.0
0.186000	49.25	---	64.21	14.96	L1	OFF	20.0
2.030000	---	22.63	46.00	23.37	L1	OFF	20.1
2.030000	31.30	---	56.00	24.70	L1	OFF	20.1
3.190000	---	28.58	46.00	17.42	L1	OFF	20.1
3.190000	36.70	---	56.00	19.30	L1	OFF	20.1
3.406000	---	28.06	46.00	17.94	L1	OFF	20.1
3.406000	38.92	---	56.00	17.08	L1	OFF	20.1
12.038000	---	36.27	50.00	13.73	L1	OFF	20.3
12.038000	42.35	---	60.00	17.65	L1	OFF	20.3

## EUT Information

Report NO : 1D1645-01  
 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)
0.150000	---	34.40	56.00	21.60	N	OFF	20.1
0.150000	48.35	---	66.00	17.65	N	OFF	20.1
0.186000	---	33.49	54.21	20.72	N	OFF	20.1
0.186000	47.37	---	64.21	16.84	N	OFF	20.1
1.970000	---	27.89	46.00	18.11	N	OFF	20.1
1.970000	35.30	---	56.00	20.70	N	OFF	20.1
3.634000	---	27.31	46.00	18.69	N	OFF	20.1
3.634000	34.22	---	56.00	21.78	N	OFF	20.1
11.386000	---	36.32	50.00	13.68	N	OFF	20.2
11.386000	42.93	---	60.00	17.07	N	OFF	20.2
11.746000	---	37.31	50.00	12.69	N	OFF	20.2
11.746000	43.78	---	60.00	16.22	N	OFF	20.2
12.870000	---	35.96	50.00	14.04	N	OFF	20.2
12.870000	40.93	---	60.00	19.07	N	OFF	20.2



### Appendix C. Radiated Spurious Emission

Test Engineer :	Bill Chang, JC Liang, Karl Hou and Wilson Wu	Temperature :	20~25°C
		Relative Humidity :	50~60%

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.	
		( MHz )	( dBμV/m )	( dB )	Limit	Level	Factor	Loss	Factor	Pos	Pos	Avg.		
					Line	( dBμV )	( dB/m )	( dB )	( dB )	( cm )	( deg )	( P/A )	( H/V )	
BT CH00 2402MHz		2389.38	41.07	-32.93	74	41.43	27.26	8.65	36.27	330	67	P	H	
		2389.38	16.31	-37.69	54	-	-	-	-	-	-	A	H	
	*	2402	107.98	-	-	108.28	27.31	8.67	36.28	330	67	P	H	
	*	2402	83.22	-	-	-	-	-	-	-	-	A	H	
													H	
														H
			2389.065	41.18	-32.82	74	41.54	27.26	8.65	36.27	306	120	P	V
			2389.065	16.42	-37.58	54	-	-	-	-	-	-	A	V
	*		2402	108.34	-	-	108.64	27.31	8.67	36.28	306	120	P	V
	*		2402	83.58	-	-	-	-	-	-	-	-	A	V
													V	
													V	
BT CH 39 2441MHz		2372.02	38.89	-35.11	74	39.34	27.19	8.62	36.26	321	65	P	H	
		2372.02	14.13	-39.87	54	-	-	-	-	-	-	A	H	
	*	2441	107.77	-	-	107.85	27.46	8.75	36.29	321	65	P	H	
	*	2441	83.01	-	-	-	-	-	-	-	-	A	H	
			2484.18	40.22	-33.78	74	40.06	27.64	8.83	36.31	321	65	P	H
			2484.18	15.46	-38.54	54	-	-	-	-	-	-	A	H
			2389.8	39.58	-34.42	74	39.94	27.26	8.65	36.27	280	123	P	V
			2389.8	14.82	-39.18	54	-	-	-	-	-	-	A	V
	*		2441	108.99	-	-	109.07	27.46	8.75	36.29	280	123	P	V
	*		2441	84.23	-	-	-	-	-	-	-	-	A	V
			2485.65	40.26	-33.74	74	40.1	27.64	8.83	36.31	280	123	P	V
			2485.65	15.5	-38.5	54	-	-	-	-	-	-	A	V



<b>BT CH 78 2480MHz</b>	*	2480	107.02	-	-	106.89	27.62	8.82	36.31	357	64	P	H
	*	2480	82.26	-	-	-	-	-	-	-	-	A	H
		2483.72	48.88	-25.12	74	48.73	27.63	8.83	36.31	357	64	P	H
		2483.72	24.12	-29.88	54	-	-	-	-	-	-	A	H
													H
													H
	*	2480	107.9	-	-	107.77	27.62	8.82	36.31	292	120	P	V
	*	2480	83.14	-	-	-	-	-	-	-	-	A	V
		2483.8	49.94	-24.06	74	49.78	27.64	8.83	36.31	292	120	P	V
		2483.8	25.18	-28.82	54	-	-	-	-	-	-	A	V
													V
													V
<b>Remark</b>	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	42.43	-31.57	74	34.72	32.22	13.03	37.54	-	-	P	H	
		4804	17.67	-36.33	54	-	-	-	-	-	-	A	H	
		10875	50.73	-23.27	74	34.07	38.88	19.46	41.68	-	-	P	H	
		10875	25.97	-28.03	54	-	-	-	-	-	-	A	H	
		14491	53.16	-20.84	74	34.68	39.89	22.78	44.19	-	-	P	H	
		14491	28.4	-25.6	54	-	-	-	-	-	-	A	H	
		17970	55.94	-18.06	74	34.93	41.59	24.87	45.45	-	-	P	H	
		17970	31.18	-22.82	54	-	-	-	-	-	-	A	H	
													H	
													H	
													H	
													H	
			4804	41.16	-32.84	74	33.45	32.22	13.03	37.54	-	-	P	V
			4804	16.4	-37.6	54	-	-	-	-	-	-	A	V
			10880	49.88	-24.12	74	33.24	38.86	19.46	41.68	-	-	P	V
			10880	25.12	-28.88	54	-	-	-	-	-	-	A	V
			14491	53.06	-20.94	74	34.58	39.89	22.78	44.19	-	-	P	V
			14491	28.3	-25.7	54	-	-	-	-	-	-	A	V
			18000	54.96	-19.04	74	33.74	41.8	24.89	45.47	-	-	P	V
			18000	30.2	-23.8	54	-	-	-	-	-	-	A	V
													V	
													V	
													V	
													V	





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 39 2441MHz		4882	42.57	-31.43	74	34.58	32.59	13	37.6	-	-	P	H	
		4882	17.81	-36.19	54	-	-	-	-	-	-	A	H	
		7323	47.67	-26.33	74	33.52	36.75	15.93	38.53	-	-	P	H	
		7323	22.91	-31.09	54	-	-	-	-	-	-	A	H	
		10875	50.2	-23.8	74	33.54	38.88	19.46	41.68	-	-	P	H	
		10875	25.44	-28.56	54	-	-	-	-	-	-	A	H	
		14491	51.88	-22.12	74	33.4	39.89	22.78	44.19	-	-	P	H	
		14491	27.12	-26.88	54	-	-	-	-	-	-	A	H	
		18000	54.94	-19.06	74	33.72	41.8	24.89	45.47	-	-	P	H	
		18000	30.18	-23.82	54	-	-	-	-	-	-	A	H	
													H	
													H	
			4882	42.33	-31.67	74	34.34	32.59	13	37.6	-	-	P	V
			4882	17.57	-36.43	54	-	-	-	-	-	-	A	V
			7323	47.85	-26.15	74	33.7	36.75	15.93	38.53	-	-	P	V
			7323	23.09	-30.91	54	-	-	-	-	-	-	A	V
			10875	50.35	-23.65	74	33.69	38.88	19.46	41.68	-	-	P	V
			10875	25.59	-28.41	54	-	-	-	-	-	-	A	V
			14491	53.21	-20.79	74	34.73	39.89	22.78	44.19	-	-	P	V
		14491	28.45	-25.55	54	-	-	-	-	-	-	A	V	
		17970	54.63	-19.37	74	33.62	41.59	24.87	45.45	-	-	P	V	
		17970	29.87	-24.13	54	-	-	-	-	-	-	A	V	
													V	



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 78 2480MHz		4960	43.73	-30.27	74	35.41	33.02	12.96	37.66	-	-	P	H	
		4960	18.97	-35.03	54	-	-	-	-	-	-	A	H	
		7440	46.51	-27.49	74	32.94	36.22	15.98	38.63	-	-	P	H	
		7440	21.75	-32.25	54	-	-	-	-	-	-	A	H	
		10880	49.54	-24.46	74	32.9	38.86	19.46	41.68	-	-	P	H	
		10880	24.78	-29.22	54	-	-	-	-	-	-	A	H	
		14491	53	-21	74	34.52	39.89	22.78	44.19	-	-	P	H	
		14491	28.24	-25.76	54	-	-	-	-	-	-	A	H	
		17940	55.58	-18.42	74	34.78	41.38	24.85	45.43	-	-	P	H	
		17940	30.82	-23.18	54	-	-	-	-	-	-	A	H	
													H	
													H	
			4960	43.96	-30.04	74	35.64	33.02	12.96	37.66	-	-	P	V
			4960	19.2	-34.8	54	-	-	-	-	-	-	A	V
			7440	46.51	-27.49	74	32.94	36.22	15.98	38.63	-	-	P	V
			7440	21.75	-32.25	54	-	-	-	-	-	-	A	V
			10875	49.94	-24.06	74	33.28	38.88	19.46	41.68	-	-	P	V
			10875	25.18	-28.82	54	-	-	-	-	-	-	A	V
			14491	52.39	-21.61	74	33.91	39.89	22.78	44.19	-	-	P	V
			14491	27.63	-26.37	54	-	-	-	-	-	-	A	V
		17955	55.08	-18.92	74	34.17	41.49	24.86	45.44	-	-	P	V	
		17955	30.32	-23.68	54	-	-	-	-	-	-	A	V	
													V	
													V	
<b>Remark</b>	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.
		( MHz )	( dBμV/m )	( dB )	( dBμV/m )	( dBμV )	( dB/m )	( dB )	( dB )	( cm )	( deg )	( P/A )	( H/V )
2.4GHz BT SHF		24622	37.63	-36.37	74	32.57	39.05	19.34	53.33	-	-	P	H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
			23929	36.41	-37.59	74	32.88	38.8	18.56	53.83	-	-	P
													V
													V
													V
													V
													V
													V
													V
													V
													V
													V
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													V
													V
													V
<b>Remark</b>	<ol style="list-style-type: none"> <li>No other spurious found.</li> <li>All results are PASS against Peak and Average limit line.</li> <li>The emission position marked as "-" means no suspected emission found with sufficient margin against limit line or noise floor only.</li> </ol>												



Emission below 1GHz

2.4GHz BT (LF)

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.	
		( MHz )	( dBμV/m )	( dB )	( dBμV/m )	( dBμV )	( dB/m )	( dB )	( dB )	( cm )	( deg )	( P/A )	( H/V )	
2.4GHz BT LF		32.91	18.89	-21.11	40	30.46	22.84	1.24	35.65	-	-	P	H	
		360.77	22.29	-23.71	46	32.96	20.68	3.62	34.97	-	-	P	H	
		507.24	27.96	-18.04	46	34.33	23.93	4.29	34.59	-	-	P	H	
		648.86	29.5	-16.5	46	32.73	26.12	4.81	34.16	-	-	P	H	
		764.29	32.24	-13.76	46	33	27.72	5.25	33.73	-	-	P	H	
		943.74	34.21	-11.79	46	31.08	30.15	5.98	33	-	-	P	H	
													H	
													H	
													H	
													H	
													H	
													H	
			260.86	20.94	-25.06	46	32.96	20.12	3.12	35.26	-	-	P	V
			442.25	25.54	-20.46	46	33.34	22.96	4.02	34.78	-	-	P	V
			505.3	27.29	-18.71	46	33.67	23.93	4.28	34.59	-	-	P	V
			627.52	29.78	-16.22	46	33.33	25.95	4.75	34.25	-	-	P	V
			776.9	38.67	-7.33	46	39.32	27.75	5.31	33.71	-	-	P	V
			952.47	35.67	-10.33	46	32.14	30.51	5.99	32.97	-	-	P	V
												V		
												V		
												V		
												V		
												V		
												V		

**Remark**

- No other spurious found.
- All results are PASS against limit line.
- The emission position marked as "-" means no suspected emission found and emission level has at least 6dB margin against limit or emission is noise floor only.



**Note symbol**

*	<b>Fundamental Frequency</b> which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is <b>over limit</b> line.
P/A	<b>Peak</b> or <b>Average</b>
H/V	<b>Horizontal</b> or <b>Vertical</b>



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.
		( 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)

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



## Appendix D. Radiated Spurious Emission Plots

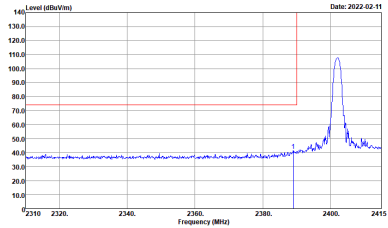
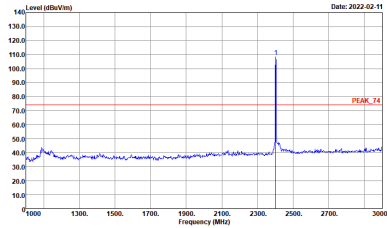
Test Engineer :	Bill Chang, JC Liang, Karl Hou and Wilson Wu	Temperature :	20~25°C
		Relative Humidity :	50~60%

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH00 2402MHz	
	Horizontal	Fundamental
Peak	<p>Site : 03CH20-HY Condition : PEAK_BE_74 3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>	<p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>



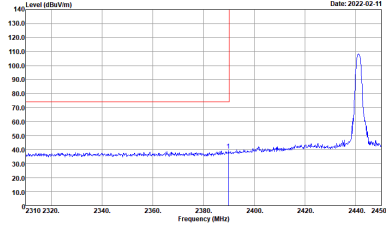
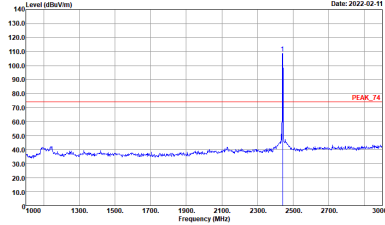
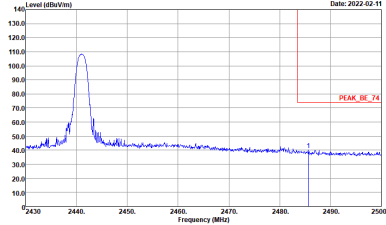
BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH00 2402MHz	
	Vertical	Fundamental
Peak	 <p>Site : 03CH20-HY Condition : PEAK_RE_74 3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>	 <p>Site : 03CH20-HY Condition : PEAK_FA_3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>



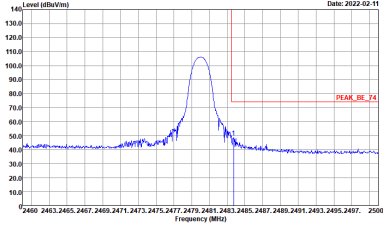
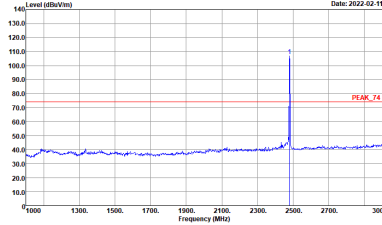


BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
BT CH39 2441MHz		
Horizontal		Fundamental
Peak	<p>Site : 03CH20-HY Condition : PEAK_BE_74 3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SW1:Auto</p>	<p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SW1:Auto</p>
Peak	<p>Site : 03CH20-HY Condition : PEAK_BE_74 3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SW1:Auto</p>	Left blank

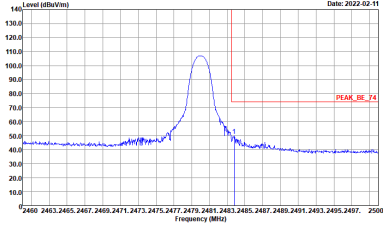
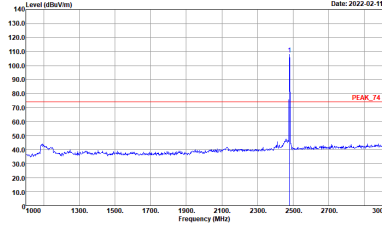


BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
BT CH39 2441MHz		
Vertical		Fundamental
Peak	 <p>Site : 03CH20-HY Condition : PEAK_BE_74 3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>	 <p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>
Peak	 <p>Site : 03CH20-HY Condition : PEAK_BE_74 3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>	Left blank



BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH78 2480MHz	
	Horizontal	Fundamental
Peak	 <p>Site : 03CH20-HV Condition : PEAK_BE_74 3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>	 <p>Site : 03CH20-HV Condition : PEAK_FA_3m 91200_02294_1110622 HORIZONTAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>



BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
BT CH78 2480MHz		
	Vertical	Fundamental
Peak	 <p>Site : 03CH20-HV Condition : PEAK_BE_74 3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>	 <p>Site : 03CH20-HV Condition : PEAK_FA_3m 91200_02294_1110622 VERTICAL : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto</p>

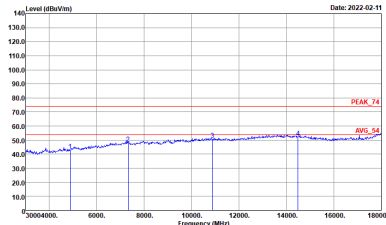
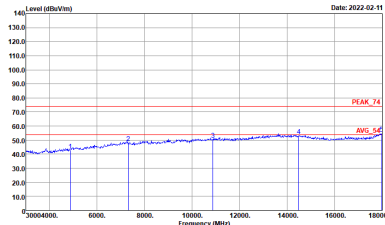


2.4GHz 2400~2483.5MHz

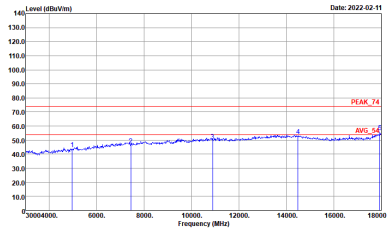
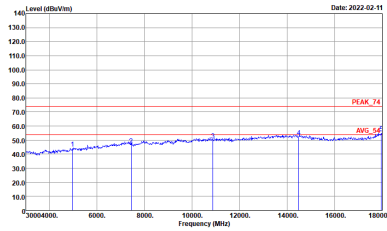
BT (Harmonic @ 3m)

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH00 2402MHz	
	Horizontal	Vertical
<b>Peak</b> <b>Avg.</b>	<p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 HORIZONTAL</p>	<p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 VERTICAL</p>



BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH39 2441MHz	
	Horizontal	Vertical
Peak Avg.	 <p data-bbox="427 689 813 716">Date: 2022-02-11 Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 HORIZONTAL</p>	 <p data-bbox="901 689 1287 716">Date: 2022-02-11 Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 VERTICAL</p>

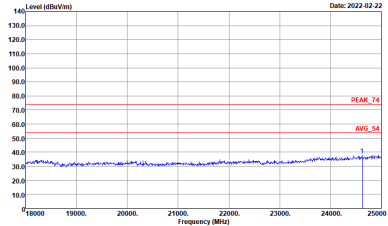
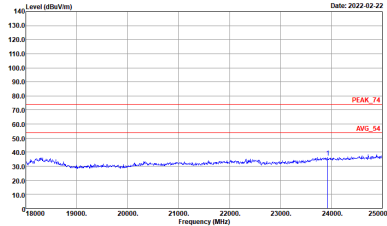


BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH78 2480MHz	
	Horizontal	Vertical
<p>Peak</p> <p>Avg.</p>	 <p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 HORIZONTAL</p>	 <p>Site : 03CH20-HY Condition : PEAK_74 3m 91200_02294_1110622 VERTICAL</p>



Emission above 18GHz

2.4GHz BT (SHF @ 1m)

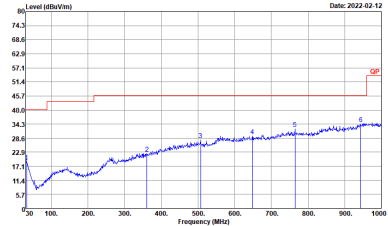
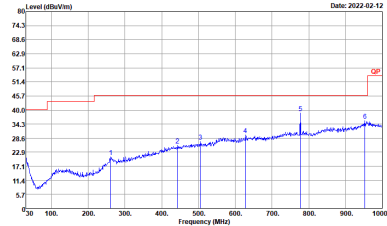
BT	2.4GHz 2400~2483.5MHz	
	BT SHF	
	Horizontal	Vertical
Peak Avg.	 <p>Site : 03CH20-HY Condition : PEAK_74 1m SHF_00993_211130 HORIZONTAL</p>	 <p>Site : 03CH20-HY Condition : PEAK_74 1m SHF_00993_211130 VERTICAL</p>



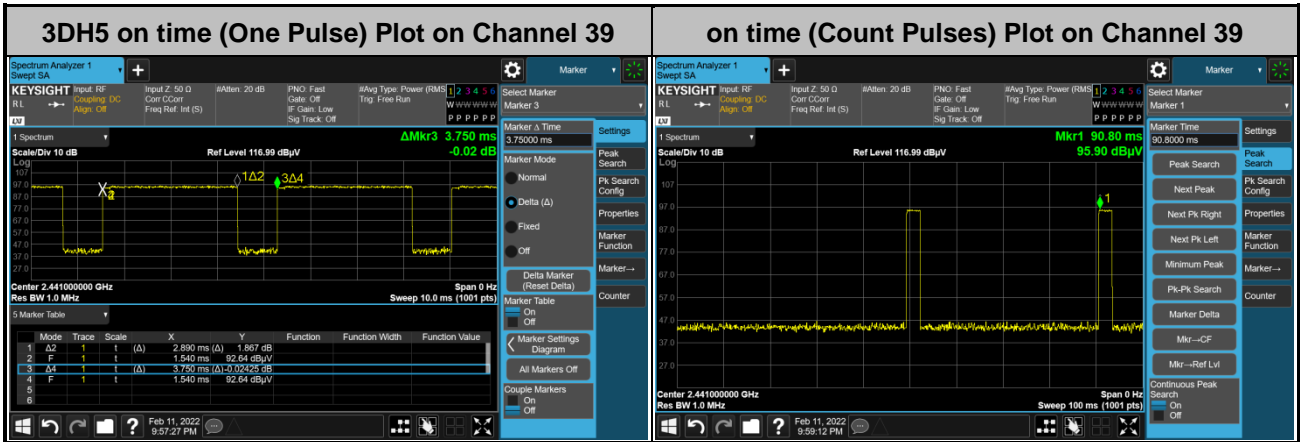


Emission below 1GHz

2.4GHz BT (LF)

BT	2.4GHz 2400~2483.5MHz	
	BT LF	
	Horizontal	Vertical
QP / Peak	 <p>Site : 03CH20-HY Condition : QP 3m LF_55606608_1101017 HORIZONTAL</p>	 <p>Site : 03CH20-HY Condition : QP 3m LF_55606608_1101017 VERTICAL</p>

## Appendix E. Duty Cycle Plots



**Note:**

1. Worst case Duty cycle = on time/100 milliseconds =  $2 * 2.89 / 100 = 5.78 \%$
2. Worst case Duty cycle correction factor =  $20 * \log(\text{Duty cycle}) = -24.76 \text{ dB}$
3. **3DH5** 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 on time period to have DH5 packet completing one hopping sequence is

$$2.89 \text{ ms} \times 20 \text{ channels} = 57.8 \text{ ms}$$

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.  $[100 \text{ ms} / 57.8 \text{ ms}] = 2 \text{ hops}$

Thus, the maximum possible ON time:

$$2.89 \text{ ms} \times 2 = 5.78 \text{ ms}$$

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

$$20 \times \log(5.78 \text{ ms}/100 \text{ ms}) = -24.76 \text{ dB}$$