



FCC RADIO TEST REPORT

FCC ID : UZ7MC220J
Equipment : Mobile computer
Brand Name : Zebra
Model Name : MC220J
Applicant : Zebra Technologies Corporation
1 Zebra Plaza, Holtsville, NY 11742
Manufacturer : Zebra Technologies Corporation
1 Zebra Plaza, Holtsville, NY 11742
Standard : FCC Part 15 Subpart C §15.247

The product was received on Jun. 12, 2020 and testing was started from Jun. 30, 2020 and completed on Aug. 21, 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 variant 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									
FR040803-03A	01	This is a variant report for MC220J (FCC ID: UZ7MC220J), and the differences between this model name and MC220K (FCC ID: UZ7MC220K) are as listed below:	Aug. 28, 2020									
		<table><tr><td>Item/Model</td><td>MC220K</td><td>MC220J</td></tr><tr><td>Camera</td><td>O</td><td>X</td></tr><tr><td>NFC</td><td>O</td><td>X</td></tr></table>		Item/Model	MC220K	MC220J	Camera	O	X	NFC	O	X
		Item/Model		MC220K	MC220J							
		Camera		O	X							
NFC	O	X										
All the test cases were performed on original report which can be referred to Sporton Report Number FR040803-02A as appendix F. Based on the original report, the test cases were verified.												
FR040803-03A	02	Revising history description.	Sep. 02, 2020									

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
-	15.247(a)(1)	Number of Channels	Not Required	-
-	15.247(a)(1)	Hopping Channel Separation	Not Required	-
-	15.247(a)(1)	Dwell Time of Each Channel	Not Required	-
-	15.247(a)(1)	20dB Bandwidth	Not Required	-
-	2.1049	99% Occupied Bandwidth	Not Required	-
3.1	15.247(b)(1)	Peak Output Power	Pass	-
-	15.247(d)	Conducted Band Edges	Not Required	-
-	15.247(d)	Conducted Spurious Emission	Not Required	-
3.2	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	Pass	Under limit 8.55 dB at 246.540 MHz
3.3	15.207	AC Conducted Emission	Pass	Under limit 15.19 dB at 0.162 MHz
3.4	15.203 & 15.247(b)	Antenna Requirement	Pass	-

Note: Not required means after assessing, test items are not necessary to carry out.

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: Vivian Hsu

1 General Description

1.1 Product Feature of Equipment Under Test

Product Specification subjective to this standard	
Equipment	Mobile computer
Brand Name	Zebra
Model Name	MC220J
FCC ID	UZ7MC220J
EUT supports Radios application	WLAN 11a/b/g/n HT20/HT40 WLAN 11ac VHT20/VHT40/VHT80 Bluetooth BR/EDR/LE
HW Version	EV1
SW Version	10-11-31.00-QG-U00-PRD-HEL-04
OS Version	Android 10
MFD	02JUN20
EUT Stage	Engineering Sample

Remark: The above EUT's information was declared by manufacturer.

Specification of Accessories				
AC Adapter	Brand Name	Zebra	Part Number	PWR-WUA5V12W0US
Battery	Brand Name	Zebra	Part Number	BT-000418-10
USB Cable (TypeA plug to TypeC plug)	Brand Name	Zebra	Part Number	CBL-TC2X-USBC-01
Trigger Handle	Brand Name	Zebra	Part Number	TRG-MC2X-SNP1-01
Holster 1	Brand Name	Zebra	Part Number	SG-MC2X-HLSTR-01
Holster 2	Brand Name	Zebra	Part Number	SG-MC3021212-01R

1.2 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Frequency Range	2402 MHz ~ 2480 MHz
Number of Channels	79
Carrier Frequency of Each Channel	2402+n*1 MHz; n=0~78
Maximum Output Power to Antenna	Bluetooth BR(1Mbps) : 7.27 dBm (0.0053 W) Bluetooth EDR (2Mbps) : 9.87 dBm (0.0097 W) Bluetooth EDR (3Mbps) : 10.24 dBm (0.0106 W)
Antenna Type	Monopole Antenna with gain 1.96 dBi
Type of Modulation	Bluetooth BR (1Mbps) : GFSK Bluetooth EDR (2Mbps) : $\pi/4$ -DQPSK Bluetooth EDR (3Mbps) : 8-DPSK

1.3 Modification of EUT

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



1.4 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	03CH07-HY

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

FCC designation No.: TW1190

1.5 Applicable Standards

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

- ♦ FCC Part 15 Subpart C §15.247
- ♦ 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

Channel	Frequency	Bluetooth Average Output Power		
		GFSK / 1Mbps		
		DH1	DH3	DH5
Ch00	2402MHz	6.90 dBm	6.80 dBm	6.77 dBm
Ch39	2441MHz	6.85 dBm	6.84 dBm	6.74 dBm
Ch78	2480MHz	7.16 dBm	7.13 dBm	7.06 dBm

Channel	Frequency	Bluetooth Average Output Power		
		$\pi/4$ -DQPSK / 2Mbps		
		2DH1	2DH3	2DH5
Ch00	2402MHz	7.38 dBm	7.25 dBm	7.12 dBm
Ch39	2441MHz	7.56 dBm	7.37 dBm	7.26 dBm
Ch78	2480MHz	7.70 dBm	7.57 dBm	7.45 dBm

Channel	Frequency	Bluetooth Average Output Power		
		8-DPSK / 3Mbps		
		3DH1	3DH3	3DH5
Ch00	2402MHz	7.40 dBm	7.27 dBm	7.15 dBm
Ch39	2441MHz	7.54 dBm	7.40 dBm	7.29 dBm
Ch78	2480MHz	7.72 dBm	7.59 dBm	7.48 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		GFSK / 1Mbps		
		DH1	DH3	DH5
Ch00	2402MHz	6.99 dBm	6.97 dBm	6.96 dBm
Ch39	2441MHz	7.05 dBm	7.03 dBm	7.01 dBm
Ch78	2480MHz	7.27 dBm	7.24 dBm	7.22 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		$\pi/4$ -DQPSK / 2Mbps		
		2DH1	2DH3	2DH5
Ch00	2402MHz	9.60 dBm	9.59 dBm	9.53 dBm
Ch39	2441MHz	9.80 dBm	9.78 dBm	9.75 dBm
Ch78	2480MHz	9.87 dBm	9.86 dBm	9.83 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		8-DPSK / 3Mbps		
		3DH1	3DH3	3DH5
Ch00	2402MHz	9.96 dBm	9.92 dBm	9.85 dBm
Ch39	2441MHz	10.17 dBm	10.10 dBm	10.04 dBm
Ch78	2480MHz	10.24 dBm	10.23 dBm	10.16 dBm



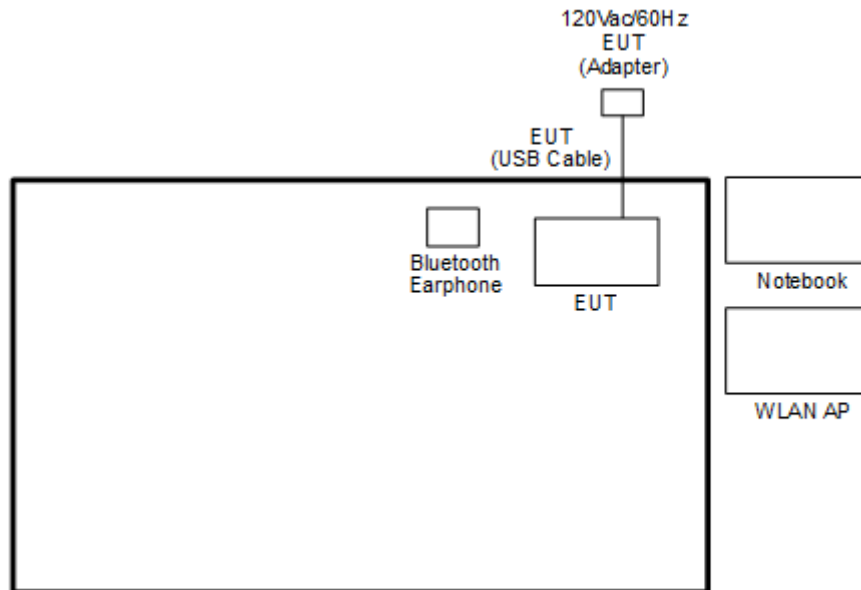
- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: conduction emission (150 kHz to 30 MHz), radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (Z plane) were recorded in this report, and the worst mode of radiated spurious emissions is Bluetooth 3Mbps 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.

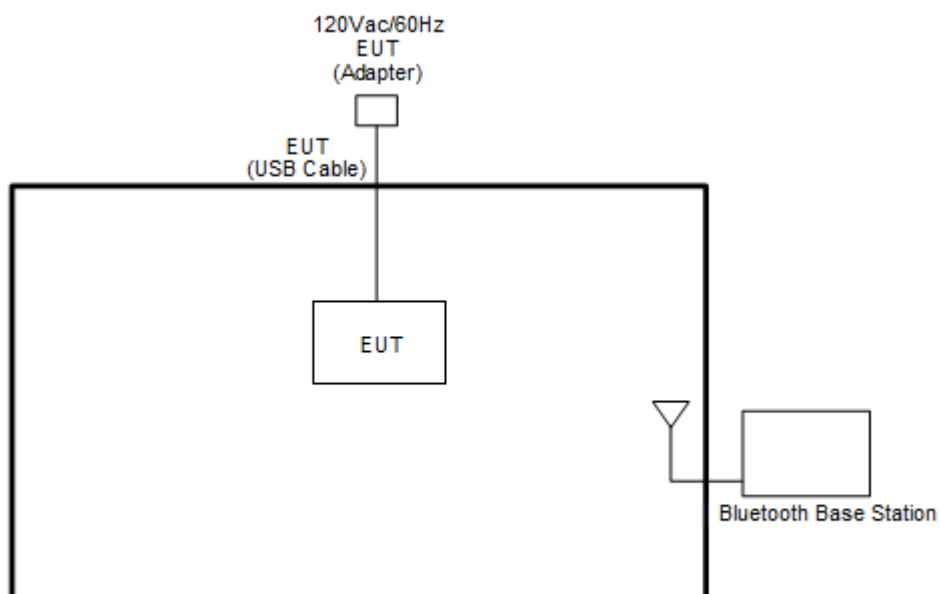
Summary table of Test Cases	
Test Item	Data Rate / Modulation
Radiated Test Cases	Bluetooth EDR 3Mbps 8-DPSK
	Mode 1: CH78_2480 MHz
AC Conducted Emission	Mode 1: WLAN (2.4GHz) Link + Bluetooth Link + USB Cable (Charging from AC Adapter) + Battery
Remark: For radiated test cases, the worst mode data rate 3Mbps 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 3Mbps, and no other significantly frequencies found in conducted spurious emission.	

2.3 Connection Diagram of Test System

<AC Conducted Emission Mode>



<Bluetooth Tx Mode>



2.4 Support Unit used in test configuration and system

Item	Equipment	Brand Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Bluetooth Base Station	R&S	CBT32	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, 1.2m DC O/P : Shielded, 1.8m
5.	SD Card	SanDisk	MicroSD HC	FCC DoC	N/A	N/A

2.5 EUT Operation Test Setup

The RF test items, utility "QRCT V_4.0.00156.0" 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.

3 Test Result

3.1 Output Power Measurement

3.1.1 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.

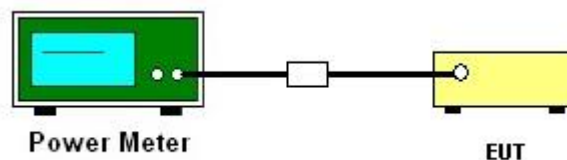
3.1.2 Measuring Instruments

See list of measuring equipment of this test report.

3.1.3 Test Procedures

1. The testing follows ANSI C63.10-2013 clause 7.8.5.
1. 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.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Measure the conducted output power with cable loss and record the results in the test report.
4. Measure and record the results in the test report.

3.1.4 Test Setup





3.1.5 Test Result of Peak Output Power

Test Engineer :	Tommy Lee	Temperature :	21~25℃
		Relative Humidity :	51~54%

DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH1	0	1	6.99	20.97	Pass
	39	1	7.05	20.97	Pass
	78	1	7.27	20.97	Pass

2DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
2DH1	0	1	9.60	20.97	Pass
	39	1	9.80	20.97	Pass
	78	1	9.87	20.97	Pass

3DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
3DH1	0	1	9.96	20.97	Pass
	39	1	10.17	20.97	Pass
	78	1	10.24	20.97	Pass

3.1.6 Test Result of Average Output Power (Reporting Only)

Test Engineer :	Tommy Lee	Temperature :	21~25℃
		Relative Humidity :	51~54%

DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
DH1	0	1	6.90	5.18
	39	1	6.85	5.18
	78	1	7.16	5.18

2DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
2DH1	0	1	7.38	5.12
	39	1	7.56	5.12
	78	1	7.70	5.12

3DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
3DH1	0	1	7.40	5.08
	39	1	7.54	5.08
	78	1	7.72	5.08



3.2 Radiated Band Edges and Spurious Emission Measurement

3.2.1 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

3.2.2 Measuring Instruments

See list of measuring equipment of this test report.

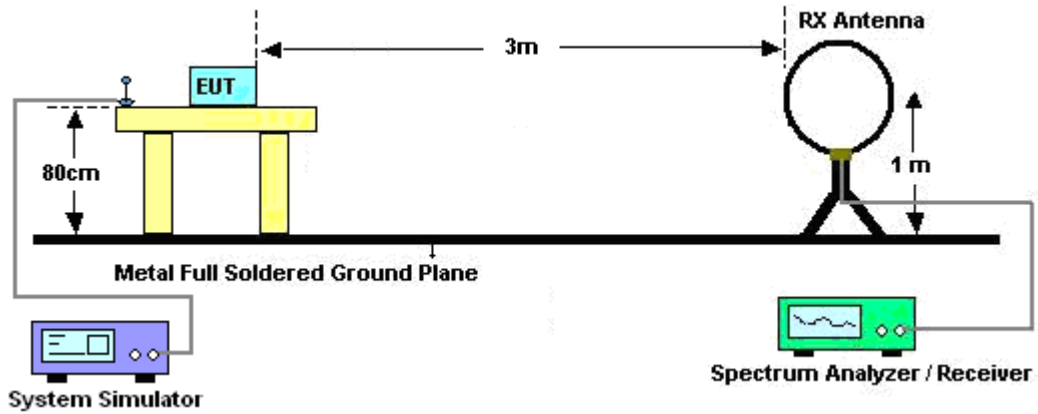
3.2.3 Test Procedures

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
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.

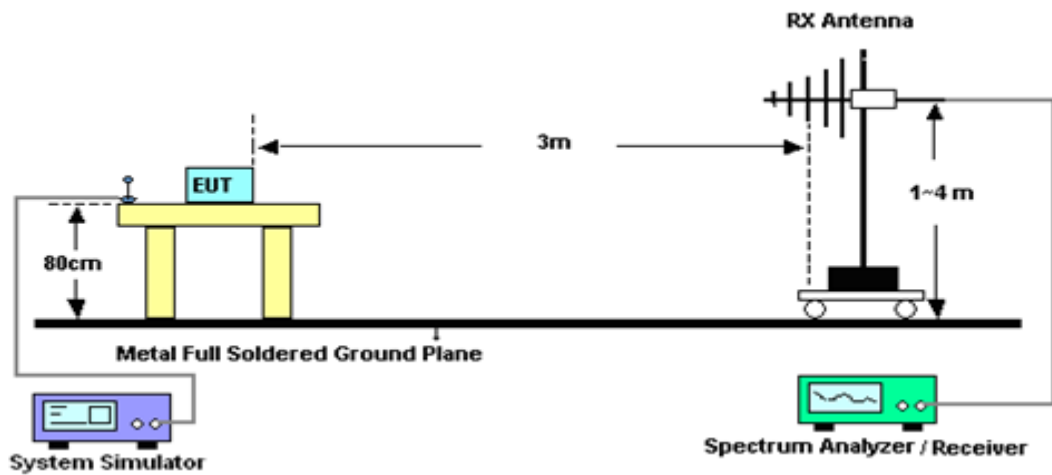
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.76dB) derived from $20 \log(\text{dwell time}/100\text{ms})$. This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals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

3.2.4 Test Setup

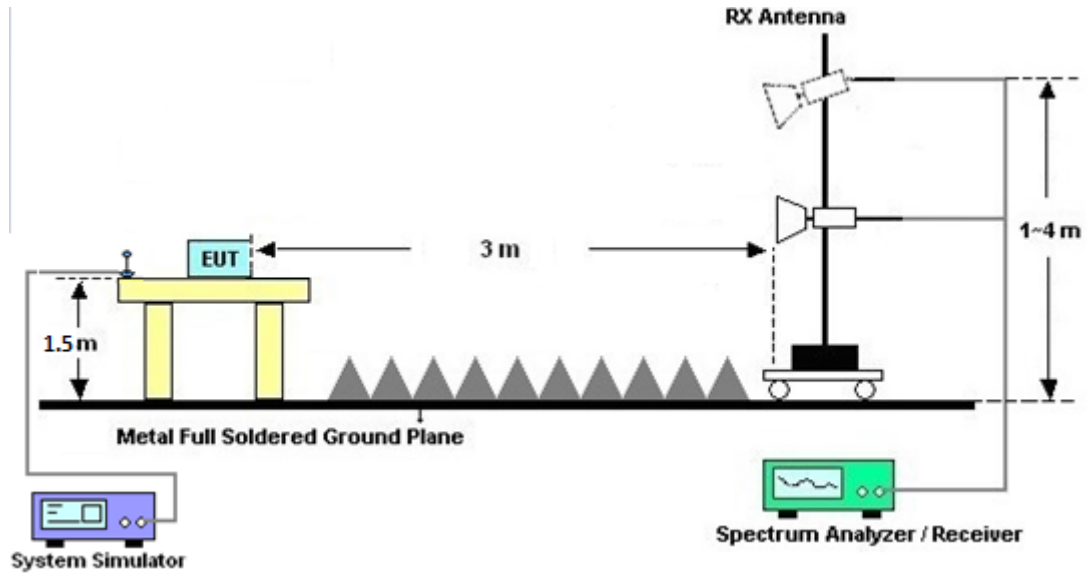
For radiated emissions below 30MHz



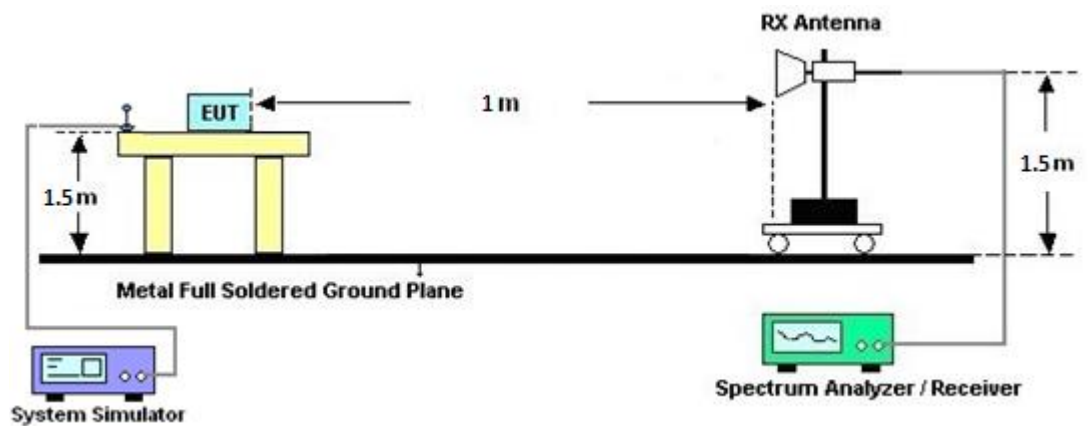
For radiated emissions from 30MHz to 1GHz



For radiated emissions from 1GHz to 18GHz



For radiated emissions above 18GHz



**3.2.5 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.

3.2.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B and C.

3.2.7 Duty Cycle

Please refer to Appendix D.

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

Please refer to Appendix B and C.

3.3 AC Conducted Emission Measurement

3.3.1 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.

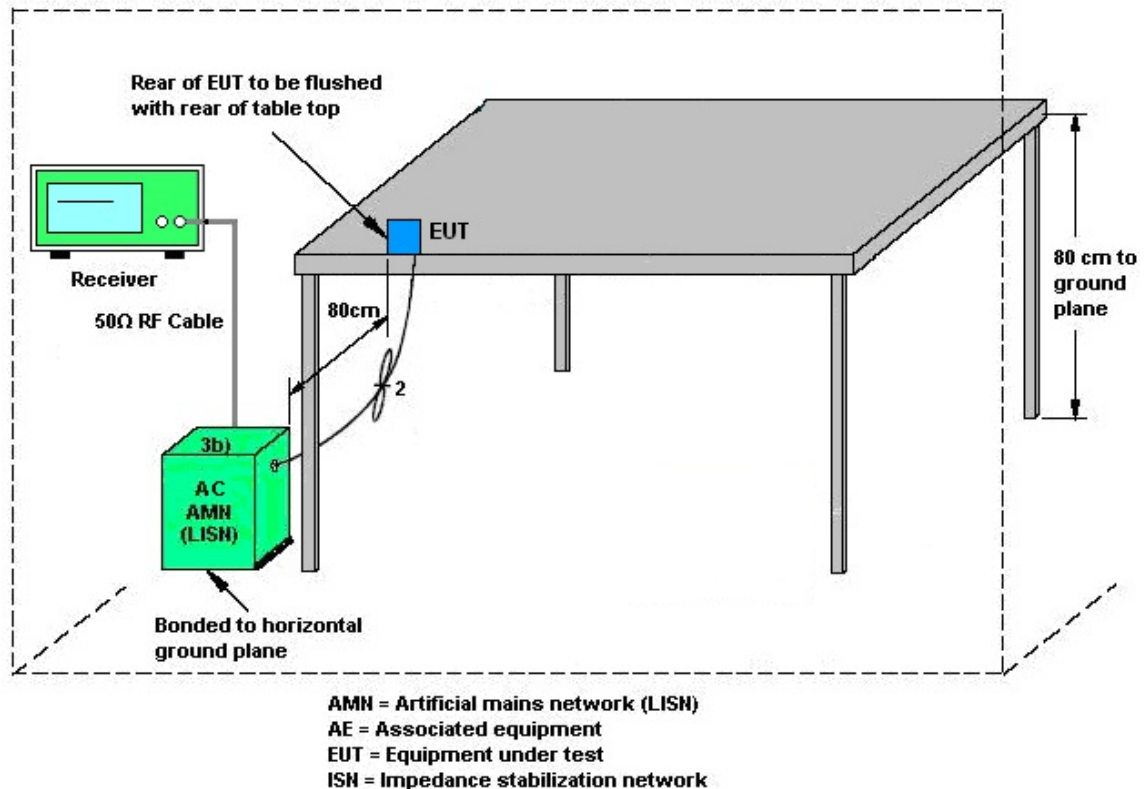
3.3.2 Measuring Instruments

See list of measuring equipment of this test report.

3.3.3 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.

3.3.4 Test Setup



3.3.5 Test Result of AC Conducted Emission

Please refer to Appendix A.



3.4 Antenna Requirements

3.4.1 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.

3.4.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.4.3 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
Bilog Antenna	TESEQ	CBL 6111D & 00800N1D0 1N-06	35419 & 03	30MHz~1GHz	Apr. 29, 2020	Aug. 08, 2020	Apr. 28, 2021	Radiation (03CH07-HY)
Double Ridge Horn Antenna	ESCO	3117	00075962	1GHz ~ 18GHz	Dec. 06, 2019	Aug. 08, 2020	Dec. 05, 2020	Radiation (03CH07-HY)
EMI Test Receiver	Agilent	N9038A (MXE)	MY53290053	20Hz~26.5GHz	May 21, 2020	Aug. 08, 2020	May 20, 2021	Radiation (03CH07-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100315	9 kHz~30 MHz	Dec. 26, 2019	Aug. 08, 2020	Dec. 25, 2020	Radiation (03CH07-HY)
Preamplifier	MITEQ	AMF-7D-001 01800-30-10 P	1590075	1GHz~18GHz	Apr. 23, 2020	Aug. 08, 2020	Apr. 22, 2021	Radiation (03CH07-HY)
Preamplifier	COM-POWE R	PA-103A	161241	10MHz~1GHz	May 19, 2020	Aug. 08, 2020	May 18, 2021	Radiation (03CH07-HY)
Preamplifier	Agilent	8449B	3008A02362	1GHz~26.5GHz	Nov. 01, 2019	Aug. 08, 2020	Oct. 31, 2020	Radiation (03CH07-HY)
Notch Filter	Wainwright	WRCJV12-5 695-5725-58 50-5880-40S S	SN1	5G Band 4	Mar. 15, 2020	Aug. 08, 2020	Mar. 14, 2021	Radiation (03CH07-HY)
Filter	Microwave	H3G018G 1	SN477220	3GHz High Pass Filter	Nov. 11, 2019	Aug. 08, 2020	Nov. 11, 2020	Radiation (03CH07-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	MY2858/2,80 1606/2	18GHz~40GHz	Feb. 25, 2020	Aug. 08, 2020	Feb. 24, 2021	Radiation (03CH07-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY24971/4, MY28655/4	9kHz~30MHz	Feb. 25, 2020	Aug. 08, 2020	Feb. 24, 2021	Radiation (03CH07-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY28655/4, MY24971/4, MY15682/4	30MHz~1GHz	Feb. 25, 2020	Aug. 08, 2020	Feb. 24, 2021	Radiation (03CH07-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY28655/4, MY24971/4, MY15682/4	1GHz~18GHz	Feb. 25, 2020	Aug. 08, 2020	Feb. 24, 2021	Radiation (03CH07-HY)
Controller	ChainTek	Chaintek 3000	N/A	Control Turn table	N/A	Aug. 08, 2020	N/A	Radiation (03CH07-HY)
Controller	Max-Full	MF7802	MF78020836 8	Control Ant Mast	N/A	Aug. 08, 2020	N/A	Radiation (03CH07-HY)
Antenna Mast	Max-Full	MFA520BS	N/A	1m~4m	N/A	Aug. 08, 2020	N/A	Radiation (03CH07-HY)
Turn Table	ChainTek	Chaintek 3000	N/A	0~360 Degree	N/A	Aug. 08, 2020	N/A	Radiation (03CH07-HY)
USB Data Logger	TECPEL	TR-32	HE17XB2495	N/A	N/A	Aug. 08, 2020	N/A	Radiation (03CH07-HY)
SHF-EHF Horn Antenna	SCHWARZBE CK	BBHA 9170	BBHA917025 1	18GHz~40GHz	Nov. 26, 2019	Aug. 08, 2020	Nov. 25, 2020	Radiation (03CH07-HY)



Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Software	Audix	E3 6.2009-8-24	N/A	N/A	N/A	Aug. 08, 2020	N/A	Radiation (03CH07-HY)
Preamplifier	EMEC	EM18G40G	060715	18GHz~40GHz	Dec. 13, 2019	Aug. 08, 2020	Dec. 12, 2020	Radiation (03CH07-HY)
AC Power Source	ChainTek	APC-1000W	N/A	N/A	N/A	Jun. 30, 2020	N/A	Conduction (CO05-HY)
EMI Test Receiver	Rohde & Schwarz	ESR3	102388	9kHz~3.6GHz	Nov. 15, 2019	Jun. 30, 2020	Nov. 14, 2020	Conduction (CO05-HY)
Hygrometer	Testo	608-H1	34913912	N/A	Nov. 07, 2019	Jun. 30, 2020	Nov. 06, 2020	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100081	9kHz~30MHz	Nov. 15, 2019	Jun. 30, 2020	Nov. 14, 2020	Conduction (CO05-HY)
Software	Rohde & Schwarz	EMC32 V10.30	N/A	N/A	N/A	Jun. 30, 2020	N/A	Conduction (CO05-HY)
LF Cable	HUBER + SUHNER	RG-214/U	LF01	N/A	Jan. 02, 2020	Jun. 30, 2020	Jan. 01, 2021	Conduction (CO05-HY)
Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100851	N/A	Jan. 02, 2020	Jun. 30, 2020	Jan. 01, 2021	Conduction (CO05-HY)
Hygrometer	Testo	608-H1	34893241	N/A	Mar. 02, 2020	Jul. 21, 2020~ Aug. 21, 2020	Mar. 01, 2021	Conducted (TH05-HY)
Power Meter	Agilent	E4416A	GB41292344	N/A	Dec. 27, 2019	Jul. 21, 2020~ Aug. 21, 2020	Dec. 26, 2020	Conducted (TH05-HY)
Power Sensor	Agilent	E9327A	US40441548	50MHz~18GHz	Dec. 27, 2019	Jul. 21, 2020~ Aug. 21, 2020	Dec. 26, 2020	Conducted (TH05-HY)
Signal Analyzer	Rohde & Schwarz	FSV40	101397	10Hz~40GHz	Nov. 15, 2019	Jul. 21, 2020~ Aug. 21, 2020	Nov. 14, 2020	Conducted (TH05-HY)
BT Base Station	Rohde & Schwarz	CBT	101136	BT 3.0	Oct. 27, 2019	Jul. 21, 2020~ Aug. 21, 2020	Oct. 26, 2020	Conducted (TH05-HY)
Switch Box & RF Cable	Burgeon	ETF-058	EC1300484	N/A	Aug. 22, 2019	Jul. 21, 2020~ Aug. 21, 2020	Aug. 21, 2020	Conducted (TH05-HY)

5 Uncertainty of Evaluation

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

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

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2U_c(y)$)	4.7
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Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2U_c(y)$)	5.3
--	-----

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2U_c(y)$)	5.0
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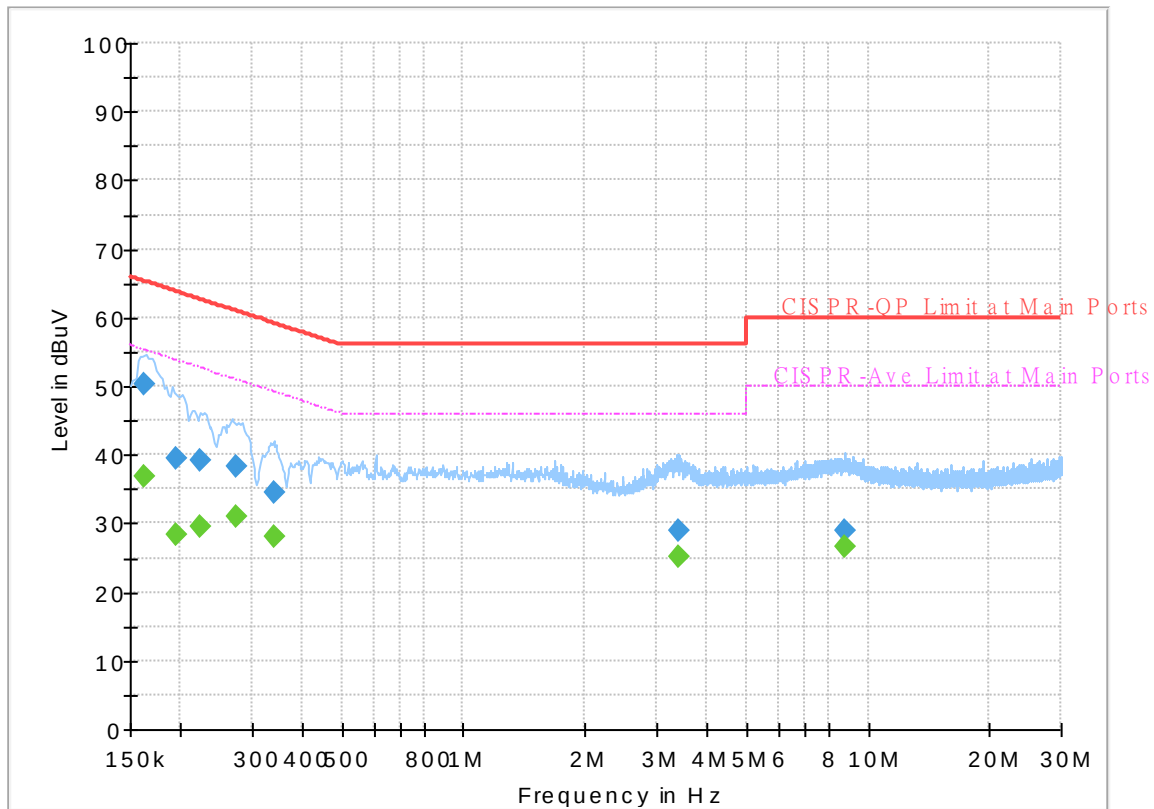
Appendix A. AC Conducted Emission Test Results

Test Engineer :	Tom Lee	Temperature :	23~25℃
		Relative Humidity :	42~50%

EUT Information

Report NO : 040803-03
Test Mode : Mode 1
Test Voltage : 120Vac/60Hz
Phase : Line

Full Spectrum



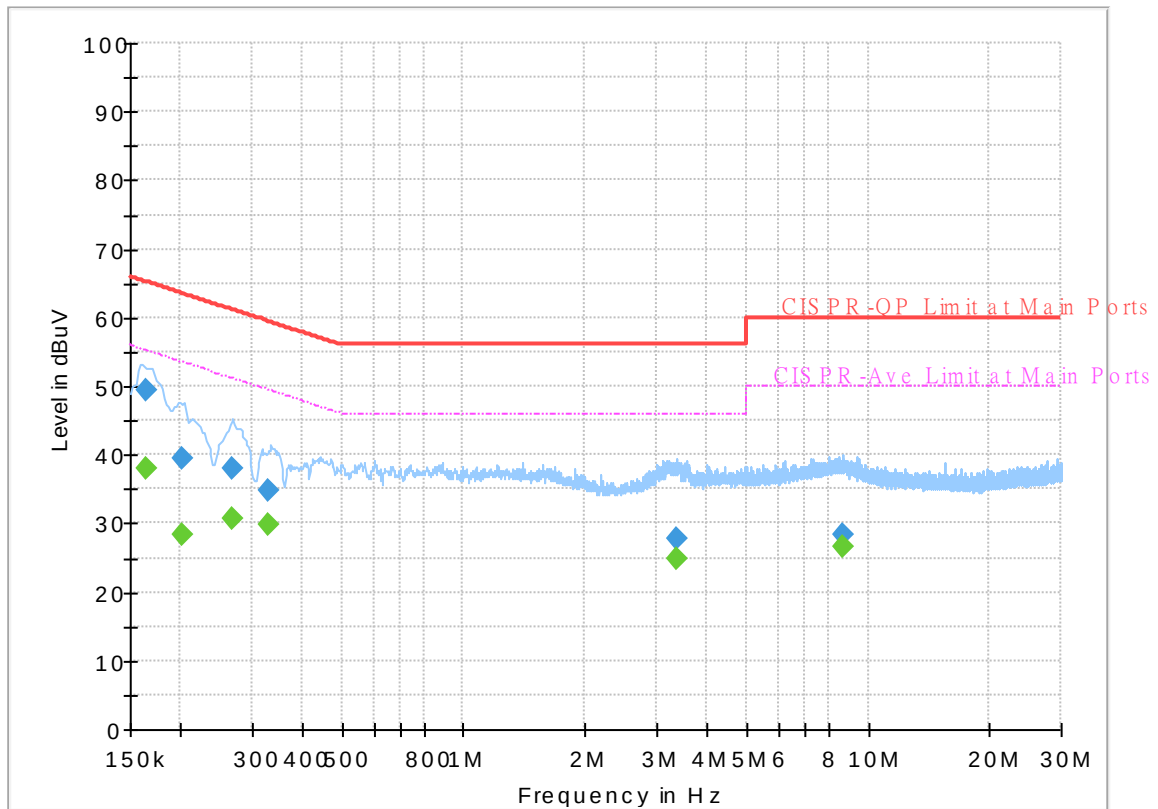
Final_Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.161790	---	36.88	55.37	18.49	L1	OFF	19.6
0.161790	50.18	---	65.37	15.19	L1	OFF	19.6
0.195000	---	28.27	53.82	25.55	L1	OFF	19.6
0.195000	39.36	---	63.82	24.46	L1	OFF	19.6
0.223350	---	29.63	52.69	23.06	L1	OFF	19.6
0.223350	39.29	---	62.69	23.40	L1	OFF	19.6
0.273300	---	30.90	51.02	20.12	L1	OFF	19.6
0.273300	38.20	---	61.02	22.82	L1	OFF	19.6
0.342600	---	28.15	49.14	20.99	L1	OFF	19.6
0.342600	34.48	---	59.14	24.66	L1	OFF	19.6
3.419610	---	25.18	46.00	20.82	L1	OFF	19.7
3.419610	28.81	---	56.00	27.19	L1	OFF	19.7
8.749140	---	26.68	50.00	23.32	L1	OFF	20.0
8.749140	29.02	---	60.00	30.98	L1	OFF	20.0

EUT Information

Report NO : 040803-03
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)
0.163500	49.28	---	65.28	16.00	N	OFF	19.5
0.163500	---	38.16	55.28	17.12	N	OFF	19.5
0.201480	39.49	---	63.55	24.06	N	OFF	19.5
0.201480	---	28.28	53.55	25.27	N	OFF	19.5
0.268710	38.10	---	61.16	23.06	N	OFF	19.5
0.268710	---	30.61	51.16	20.55	N	OFF	19.5
0.330000	---	29.72	49.45	19.73	N	OFF	19.5
0.330000	34.75	---	59.45	24.70	N	OFF	19.5
3.354000	---	24.98	46.00	21.02	N	OFF	19.6
3.354000	27.84	---	56.00	28.16	N	OFF	19.6
8.643750	---	26.50	50.00	23.50	N	OFF	19.8
8.643750	28.36	---	60.00	31.64	N	OFF	19.8



Appendix B. Radiated Spurious Emission

Test Engineer :	Jesse Wang, Stan Hsieh and Ken Wu	Temperature :	23~25°C
		Relative Humidity :	51~53%

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Path Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH 78 2480MHz	*	2480	100.55	-	-	95.65	32.07	8.12	35.29	222	360	P	H
	*	2480	75.79	-	-	-	-	-	-		-	A	H
		2483.52	48.41	-25.59	74	43.51	32.07	8.12	35.29	222	360	P	H
		2483.52	23.65	-30.35	54	-	-	-	-		-	A	H
													H
													H
	*	2480	98.65	-	-	93.75	32.07	8.12	35.29	226	82	P	V
	*	2480	73.89	-	-	-	-	-	-		-	A	V
		2488.32	44.94	-29.06	74	40	32.1	8.13	35.29	226	82	P	V
		2488.32	20.18	-33.82	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 78 2480MHz		4960	39.55	-34.45	74	51.69	34.23	12.18	58.55	100	0	P	H
		4960	14.79	-39.21	54	-	-	-	-	-	-	A	H
		7440	40.25	-33.75	74	47.66	35.5	14.68	57.59	100	0	P	H
		7440	15.49	-38.51	54	-	-	-	-	-	-	A	H
		4960	39.44	-34.56	74	51.58	34.23	12.18	58.55	100	0	P	V
		4960	14.68	-39.32	54	-	-	-	-	-	-	A	V
		7440	39.71	-34.29	74	47.12	35.5	14.68	57.59	100	0	P	V
		7440	14.95	-39.05	54	-	-	-	-	-	-	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz BT (LF)

BT	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz BT LF		213.33	30.5	-13	43.5	43	14.98	2.45	29.93	-	-	P	H
		246.54	37.45	-8.55	46	47	17.73	2.64	29.92	100	0	P	H
		281.37	34.15	-11.85	46	42.49	18.74	2.83	29.91	-	-	P	H
		301.4	32.84	-13.16	46	40.54	19.26	2.94	29.9	-	-	P	H
		800.5	33.45	-12.55	46	30.33	27.72	4.85	29.45	-	-	P	H
		955.2	34.15	-11.85	46	27.02	30.53	5.27	28.67	-	-	P	H
													H
													H
													H
													H
													H
													H
													H
		30	30.31	-9.69	40	35.07	24.32	0.93	30.01	100	0	P	V
		64.56	25.64	-14.36	40	42.4	11.87	1.35	29.98	-	-	P	V
		233.31	31.4	-14.6	46	42.21	16.54	2.57	29.92	-	-	P	V
		776.7	31.08	-14.92	46	28.12	27.71	4.75	29.5	-	-	P	V
		891.5	34.09	-11.91	46	29.38	28.65	5.09	29.03	-	-	P	V
		941.9	36.09	-9.91	46	29.83	29.77	5.24	28.75	-	-	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. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBμV/m) =
Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
3. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)
= 55.45 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 55.45(dBμV/m) – 74(dBμV/m)
= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)
= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)
= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)
= 43.54 (dBμV/m)
2. Over Limit(dB)
= Level(dBμV/m) – Limit Line(dBμV/m)
= 43.54(dBμV/m) – 54(dBμV/m)
= -10.46(dB)

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



Appendix C. Radiated Spurious Emission Plots

Test Engineer :	Jesse Wang, Stan Hsieh and Ken Wu	Temperature :	23~25°C
		Relative Humidity :	51~53%

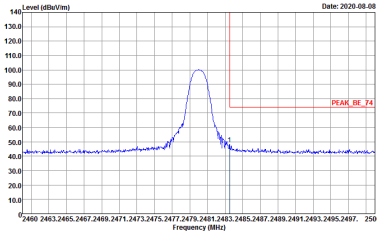
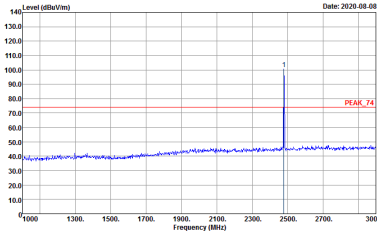
Note symbol

-L	Low channel location
-R	High channel location



2.4GHz 2400~2483.5MHz

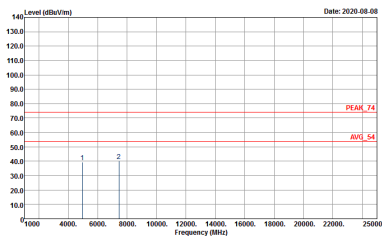
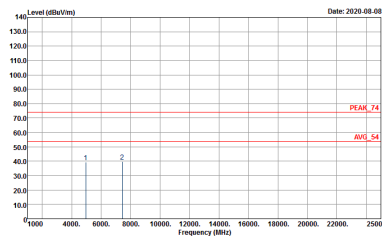
BT (Band Edge @ 3m)

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH78 2480MHz	
	Horizontal	Fundamental
Peak	 Site : 03CH07-HY Condition : PEAK_BE_74 3m HF_ANT_00075862 HORIZONTAL Detector : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto Project : 040803-03 Mode : 3	 Site : 03CH07-HY Condition : PEAK_74 3m HF_ANT_00075862 HORIZONTAL Detector : RBW:1000.000kHz VBW:3000.000kHz SWT:Auto Project : 040803-03 Mode : 3



BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BT CH78 2480MHz	
	Vertical	Fundamental
Peak	Level (dBm/Vm) Date: 2020-08-08 2460 2463.2465.2467.2469.2471.2473.2475.2477.2479.2481.2483.2485.2487.2489.2491.2493.2495.2497. 2500 Frequency (MHz) Site : E0CH07-HY Condition : PEAK BE 74 3m HF_ANT_00075962 VERTICAL RBW:1000.000kHz VBW:3000.000kHz SWT:Auto Detector : Peak Project : 040803-03 Mode : 3	Level (dBm/Vm) Date: 2020-08-08 1000 1300. 1500. 1700. 1900. 2100. 2300. 2500. 2700. 3000 Frequency (MHz) Site : E0CH07-HY Condition : PEAK 74 3m HF_ANT_00075962 VERTICAL RBW:1000.000kHz VBW:3000.000kHz SWT:Auto Detector : Peak Project : 040803-03 Mode : 3

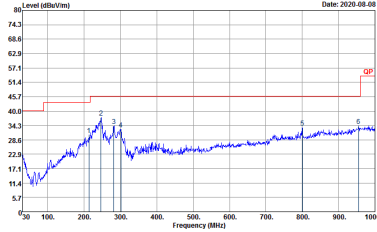
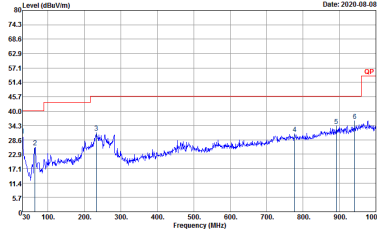
2.4GHz 2400~2483.5MHz
BT (Harmonic @ 3m)

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BT CH78 2480MHz	
	Horizontal	Vertical
Peak Avg.	 Site : 03CH07-HY Condition : PEAK_74 3m HF_ANT_00075862 HORIZONTAL Detector : Peak Project : 040803-03 Mode : 3	 Site : 03CH07-HY Condition : PEAK_74 3m HF_ANT_00075862 VERTICAL Detector : Peak Project : 040803-03 Mode : 3



Emission below 1GHz

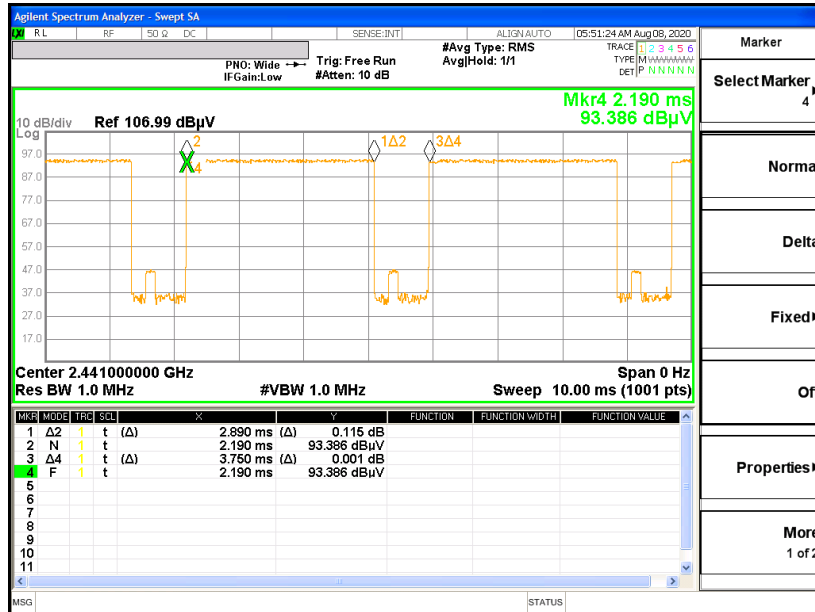
2.4GHz BT (LF)

BT	2.4GHz 2400~2483.5MHz	
	BT LF	
	Horizontal	Vertical
QP / Peak	 Site : 03CH07-HY Condition : QP 3m LF-ANT-35419(G) HORIZONTAL Detector : Peak Project : 040803-03 Mode : 23	 Site : 03CH07-HY Condition : QP 3m LF-ANT-35419(G) VERTICAL Detector : Peak Project : 040803-03 Mode : 23

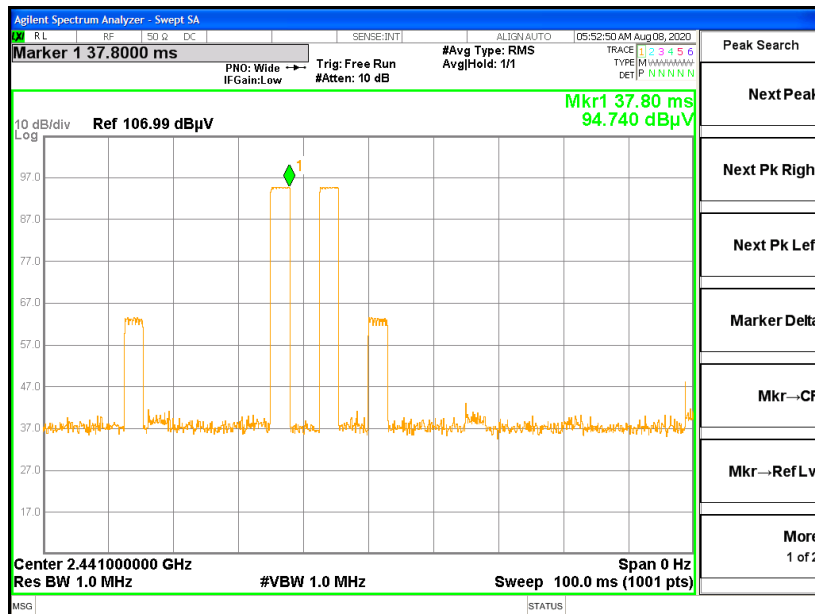


Appendix D. Duty Cycle Plots

3DH5 on time (One Pulse) Plot on Channel 39



on time (Count Pulses) Plot on Channel 39



Note:

1. Worst case Duty cycle = on time/100 milliseconds = $2 * 2.89 / 100 = 11.56 \%$
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 period to have DH5 packet completing one hopping sequence is

$$2.89 \text{ ms} \times 20 \text{ channels} = 115.6 \text{ ms}$$

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. $[100 \text{ ms} / 115.6 \text{ ms}] = 2 \text{ hops}$

Thus, the maximum possible ON time:

$$2.89 \text{ ms} \times 2 = 11.56 \text{ ms}$$

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

$$20 \times \log(11.56 \text{ ms}/100 \text{ ms}) = -24.76 \text{ dB}$$



Appendix F. Original Report

Please refer to Sporton report number FR040803-02A as below.