FCC RADIO TEST REPORT

FCC ID	:	**UZ7TC26BK**
Equipment	:	**Touch computer**
Brand Name	:	**Zebra**
Model Name	:	**TC26BK**
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 Mar. 23, 2020 and testing was started from Mar. 25, 2020 and completed on Apr. 24, 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 report must not be used by the client to claim product certification, approval, or endorsement by TAF or any agency of government.

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
FR010316A	01	Initial issue of report	Apr. 30, 2020
FR010316A	02	1. Add original report description and revise summary of test result 2. Revise FW Version 3. Revise specification of accessories table	May 06, 2020

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
-	15.247(a)(1)	Number of Channels	Pass	Please refer to Sporton Report Number FR010720A
-	15.247(a)(1)	Hopping Channel Separation	Pass	Please refer to Sporton Report Number FR010720A
-	15.247(a)(1)	Dwell Time of Each Channel	Pass	Please refer to Sporton Report Number FR010720A
-	15.247(a)(1)	20dB Bandwidth	Pass	Please refer to Sporton Report Number FR010720A
-	2.1049	99% Occupied Bandwidth	Reporting only	Please refer to Sporton Report Number FR010720A
3.1	15.247(b)(1)	Peak Output Power	Pass	-
-	15.247(d)	Conducted Band Edges	Pass	Please refer to Sporton Report Number FR010720A
-	15.247(d)	Conducted Spurious Emission	Pass	Please refer to Sporton Report Number FR010720A
3.2	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	Pass	Under limit 7.47 dB at 2386.650 MHz
3.3	15.207	AC Conducted Emission	Pass	Under limit 11.51 dB at 13.560 MHz
3.4	15.203 & 15.247(b)	Antenna Requirement	Pass	-
Remark: This is a variant report which can be referred Product Equality Declaration. All the test cases were performed on original report which can be referred to Sporton Report Number FR010720A as appendix F. Based on the original report, the test cases were verified.				

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: Cindy Liu

1 General Description

1.1 Product Feature of Equipment Under Test

Product Feature	
Equipment	Touch computer
Brand Name	Zebra
Model Name	TC26BK
FCC ID	UZ7TC26BK
Sample 1	Single-WAN, WLAN, GMS, SE4710, NFC, 3GB/32GB, Rear camera and Front camera, 2-pin connector
Sample 2	Single-WAN, WLAN, GMS, No Scanner, NFC, 3GB/32GB, Rear camera and Front camera, No back connector
EUT supports Radios application	GSM/EGPRS/WCDMA/HSPA/LTE/NFC/GNSS WLAN 11a/b/g/n HT20/HT40 WLAN 11ac VHT20/VHT40/VHT80 Bluetooth BR/EDR/LE
HW Version	EV1.7
SW Version	Android version 10
OS Version	FUSION_QA_2_1.0.0.008_Q
FW Version	Zebra/TC26PA/TC26:10/03-09-09.00-QN-U00-PRD/Nabe03091333:userdebug/test-keys
MFD	22FEB20
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 1	**Brand Name**	Zebra	**Part Number**	BT-000409-00
Battery 2	**Brand Name**	Zebra	**Part Number**	BT-000409-50
Battery 3	**Brand Name**	Zebra	**Part Number**	BT-000411-08
USB Cable 1 (TypeA plug to TypeC plug)	**Brand Name**	Zebra	**Part Number**	CBL-TC5X-USBC2A-01
USB Cable 2 (Type A plug to Type C plug)	**Brand Name**	Zebra	**Part Number**	CBL-TC2Y-USBC90A-01
Headset 3.5mm type with PTT/micassy	**Brand Name**	Zebra	**Part Number**	HDST-35MM-PTVP-01
Adapter Cable PTT headset (3.5mm to 3.5mm)	**Brand Name**	Zebra	**Part Number**	CBL-TC51-HDST35-01
Snap on Trigger handle	**Brand Name**	Zebra	**Part Number**	TRG-TC2Y-SNP1-01
Belt Holster	**Brand Name**	Zebra	**Part Number**	SG-TC2Y-HLSTR1-01
Wearable Arm Mount	**Brand Name**	Zebra	**Part Number**	SG-TC2Y-ARMNT-01

Supported Unit Used in Test Configuration and System				
Type C to 3.5mm headset adaptor	**Brand Name**	Google	**Part Number**	Pixel-2-2XL

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	**<Class I>** Bluetooth BR(1Mbps) : 7.78 dBm (0.0060 W) Bluetooth EDR (2Mbps) : 6.82 dBm (0.0048 W) Bluetooth EDR (3Mbps) : 7.24 dBm (0.0053 W) **<Class II>** Bluetooth BR(1Mbps) : 2.19 dBm (0.0017 W) Bluetooth EDR (2Mbps) : 4.65 dBm (0.0029 W) Bluetooth EDR (3Mbps) : 5.06 dBm (0.0032 W)
Antenna Type	PIFA Antenna type with gain 0.80 dBi
Type of Modulation	Bluetooth BR (1Mbps) : GFSK Bluetooth EDR (2Mbps) : π /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

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

Test Site	SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-0868 FAX: +886-3-327-0855
Test Site No.	**Sporton Site No.**
	03CH12-HY

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

FCC designation No.: TW1190 and TW0007

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. 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

<Class I>

Channel	Frequency	Bluetooth Average Output Power		
		GFSK / 1Mbps		
		DH1	DH3	DH5
Ch00	2402MHz	**7.45 dBm**	7.44 dBm	7.41 dBm
Ch39	2441MHz	7.05 dBm	7.04 dBm	6.97 dBm
Ch78	2480MHz	6.71 dBm	6.69 dBm	6.63 dBm

Channel	Frequency	Bluetooth Average Output Power		
		π/4-DQPSK / 2Mbps		
		2DH1	2DH3	2DH5
Ch00	2402MHz	**4.20 dBm**	4.02 dBm	4.00 dBm
Ch39	2441MHz	3.89 dBm	3.70 dBm	3.69 dBm
Ch78	2480MHz	3.64 dBm	3.45 dBm	3.41 dBm

Channel	Frequency	Bluetooth Average Output Power		
		8-DPSK / 3Mbps		
		3DH1	3DH3	3DH5
Ch00	2402MHz	**4.21 dBm**	4.02 dBm	4.00 dBm
Ch39	2441MHz	3.88 dBm	3.69 dBm	3.67 dBm
Ch78	2480MHz	3.61 dBm	3.43 dBm	3.40 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		GFSK / 1Mbps		
		DH1	DH3	DH5
Ch00	2402MHz	**7.78 dBm**	7.75 dBm	7.73 dBm
Ch39	2441MHz	7.43 dBm	7.41 dBm	7.35 dBm
Ch78	2480MHz	7.09 dBm	7.06 dBm	7.03 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		π/4-DQPSK / 2Mbps		
		2DH1	2DH3	2DH5
Ch00	2402MHz	**6.82 dBm**	6.80 dBm	6.76 dBm
Ch39	2441MHz	6.52 dBm	6.48 dBm	6.45 dBm
Ch78	2480MHz	6.27 dBm	6.22 dBm	6.17 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		8-DPSK / 3Mbps		
		3DH1	3DH3	3DH5
Ch00	2402MHz	**7.24 dBm**	7.08 dBm	7.07 dBm
Ch39	2441MHz	6.90 dBm	6.87 dBm	6.79 dBm
Ch78	2480MHz	6.59 dBm	6.58 dBm	6.55 dBm

<Class II>

Channel	Frequency	Bluetooth Average Output Power		
		GFSK / 1Mbps		
		DH1	DH3	DH5
Ch00	2402MHz	0.83 dBm	0.81 dBm	0.80 dBm
Ch39	2441MHz	**1.31 dBm**	1.28 dBm	1.27 dBm
Ch78	2480MHz	1.29 dBm	1.27 dBm	1.24 dBm

Channel	Frequency	Bluetooth Average Output Power		
		π/4-DQPSK / 2Mbps		
		2DH1	2DH3	2DH5
Ch00	2402MHz	1.37 dBm	1.26 dBm	1.24 dBm
Ch39	2441MHz	1.89 dBm	1.71 dBm	1.70 dBm
Ch78	2480MHz	**1.94 dBm**	1.78 dBm	1.73 dBm

Channel	Frequency	Bluetooth Average Output Power		
		8-DPSK / 3Mbps		
		3DH1	3DH3	3DH5
Ch00	2402MHz	1.43 dBm	1.27 dBm	1.23 dBm
Ch39	2441MHz	1.88 dBm	1.72 dBm	1.69 dBm
Ch78	2480MHz	**1.92 dBm**	1.78 dBm	1.76 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		GFSK / 1Mbps		
		DH1	DH3	DH5
Ch00	2402MHz	1.72 dBm	1.69 dBm	1.67 dBm
Ch39	2441MHz	2.14 dBm	2.13 dBm	2.12 dBm
Ch78	2480MHz	**2.19 dBm**	2.17 dBm	2.15 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		π/4-DQPSK / 2Mbps		
		2DH1	2DH3	2DH5
Ch00	2402MHz	4.09 dBm	4.07 dBm	4.05 dBm
Ch39	2441MHz	**4.65 dBm**	4.55 dBm	4.53 dBm
Ch78	2480MHz	4.63 dBm	4.60 dBm	4.56 dBm

Channel	Frequency	Bluetooth Peak Output Power		
		8-DPSK / 3Mbps		
		3DH1	3DH3	3DH5
Ch00	2402MHz	4.44 dBm	4.52 dBm	4.45 dBm
Ch39	2441MHz	5.00 dBm	4.99 dBm	4.83 dBm
Ch78	2480MHz	**5.06 dBm**	4.95 dBm	4.92 dBm

Remark: The class II was tested with power only.

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, and Accessory, and . The worst cases (X plane with Adapter) were recorded in this report, and the worst mode of radiated spurious emissions is Bluetooth 1Mbps mode, and recorded in this report.

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

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

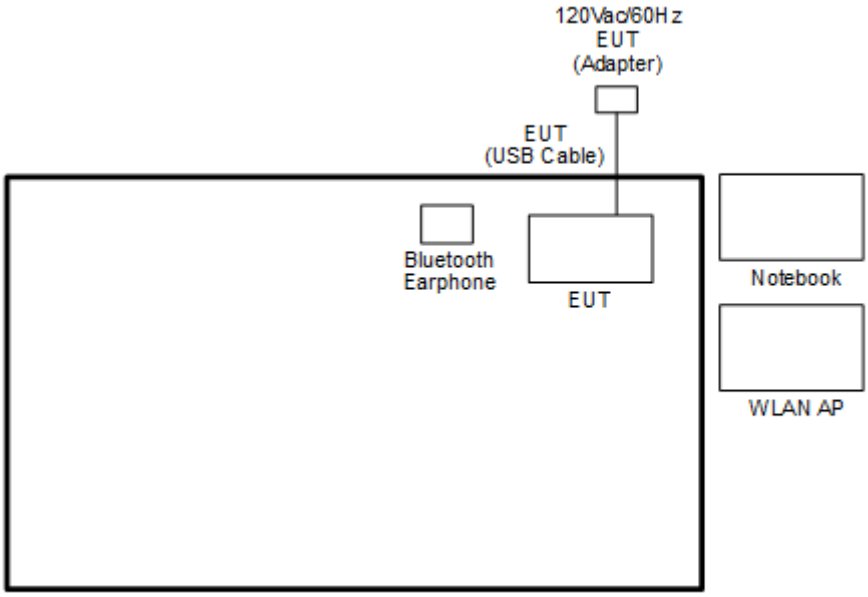
Summary table of Test Cases	
Test Item	**Data Rate / Modulation**
Radiated Test Cases	**Bluetooth BR 1Mbps GFSK**
	Mode 1: CH78_2480 MHz
AC Conducted Emission	Mode 1 :WLAN (2.4GHz) Link + Bluetooth Link + NFC On + USB Cable 1 (Charging from AC Adapter) + Battery 1 for Sample 1

Remark:

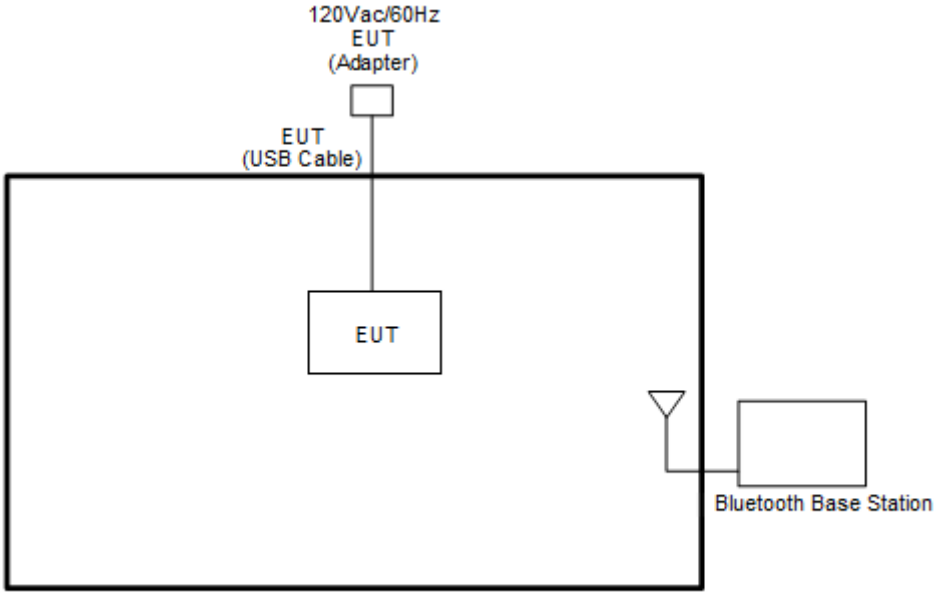
1. For radiated test cases, the worst mode data rate 1Mbps was reported only since the highest RF output power in the preliminary tests. The conducted spurious emissions and conducted band edge measurement for other data rates were not worse than 1Mbps, and no other significantly frequencies found in conducted spurious emission.
2. For Radiated Test Cases, the tests were performed with Battery 1, USB Cable 1 and Sample 1

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	Trade 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 V3.0” 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.

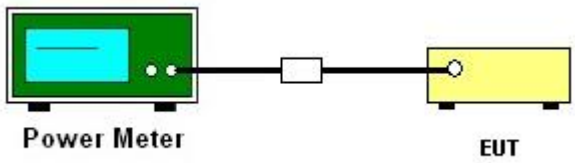
3.1.2 Measuring Instruments

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

3.1.4 Test Setup



3.1.5 Test Result of Peak Output Power

Test Engineer :	Kathy Chen	Temperature :	21~25℃
		Relative Humidity :	51~54%

<Class I>

DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH1	0	1	**7.78**	30.00	Pass
	39	1	7.43	30.00	Pass
	78	1	7.09	30.00	Pass

2DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
2DH1	0	1	**6.82**	20.97	Pass
	39	1	6.52	20.97	Pass
	78	1	6.27	20.97	Pass

3DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
3DH1	0	1	**7.24**	20.97	Pass
	39	1	6.90	20.97	Pass
	78	1	6.59	20.97	Pass

<Class II>

DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
DH1	0	1	1.72	30.00	Pass
	39	1	2.14	30.00	Pass
	78	1	**2.19**	30.00	Pass

2DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
2DH1	0	1	4.09	20.97	Pass
	39	1	**4.65**	20.97	Pass
	78	1	4.63	20.97	Pass

3DH	CH.	NTX	Peak Power (dBm)	Power Limit (dBm)	Test Result
3DH1	0	1	4.44	20.97	Pass
	39	1	5.00	20.97	Pass
	78	1	**5.06**	20.97	Pass

3.1.6 Test Result of Average Output Power (Reporting Only)

Test Engineer :	Kathy Chen	Temperature :	21~25℃
		Relative Humidity :	51~54%

<Class I>

DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
DH1	0	1	**7.45**	5.18
	39	1	7.05	5.18
	78	1	6.71	5.18

2DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
2DH1	0	1	**4.20**	5.12
	39	1	3.89	5.12
	78	1	3.64	5.12

3DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
3DH1	0	1	**4.21**	5.12
	39	1	3.88	5.12
	78	1	3.61	5.12

<Class II>

DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
DH1	0	1	0.83	5.18
	39	1	**1.31**	5.18
	78	1	1.29	5.18

2DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
2DH1	0	1	1.37	5.12
	39	1	1.89	5.12
	78	1	**1.94**	5.12

3DH	CH.	NTX	Average Power (dBm)	Duty Factor (dB)
3DH1	0	1	1.43	5.12
	39	1	1.88	5.12
	78	1	**1.92**	5.12

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.

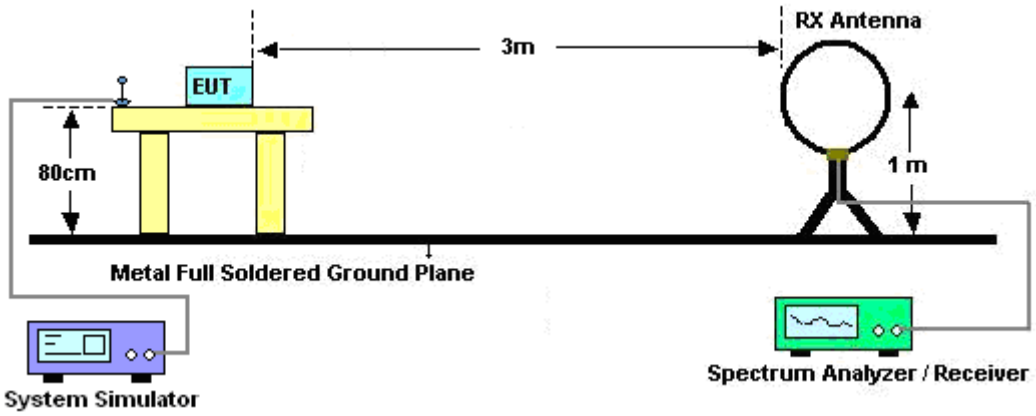
3.2.3 Test Procedures

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>1GHz ; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak
   (3) For average measurement: use duty cycle correction factor method per 15.35(c).
   Duty cycle = On time/100 milliseconds
   On time = $N_1*L_1+N_2*L_2+...+N_{n-1}*LN_{n-1}+N_n*L_n$
   Where N_1 is number of type 1 pulses, L_1 is length of type 1 pulses, etc.
   Average Emission Level = Peak Emission Level + 20*log(Duty cycle)
6. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
7. For testing below 1GHz, if the emission level of the EUT in peak mode was 3 dB lower than the limit specified, then peak values of EUT will be reported, otherwise, the emissions will be repeated one by one using the CISPR quasi-peak method and reported.
8. For testing above 1GHz, the emission level of the EUT in peak mode was 20dB lower than 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.

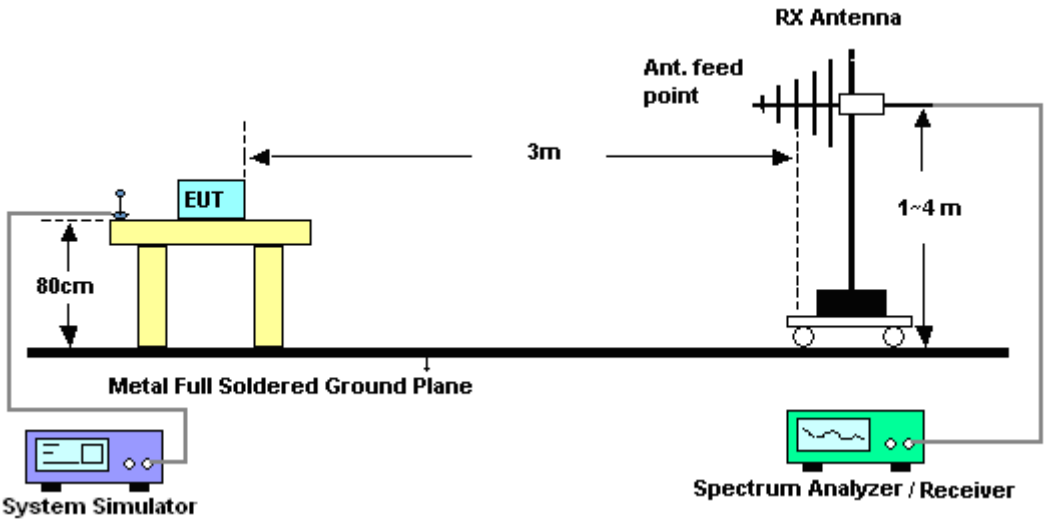
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.76dB) derived from 20log (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent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

3.2.4 Test Setup

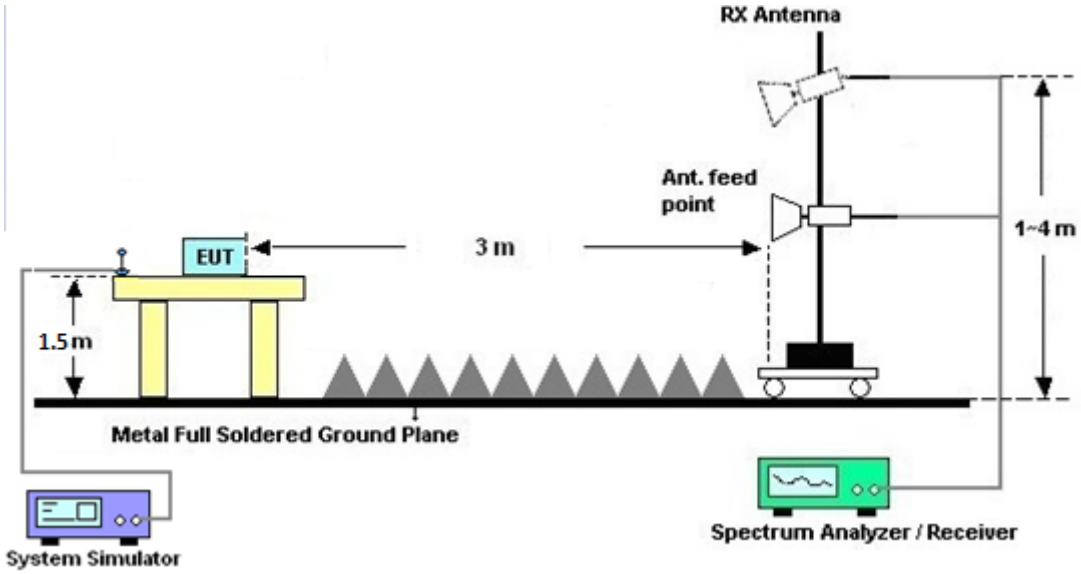
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



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 (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

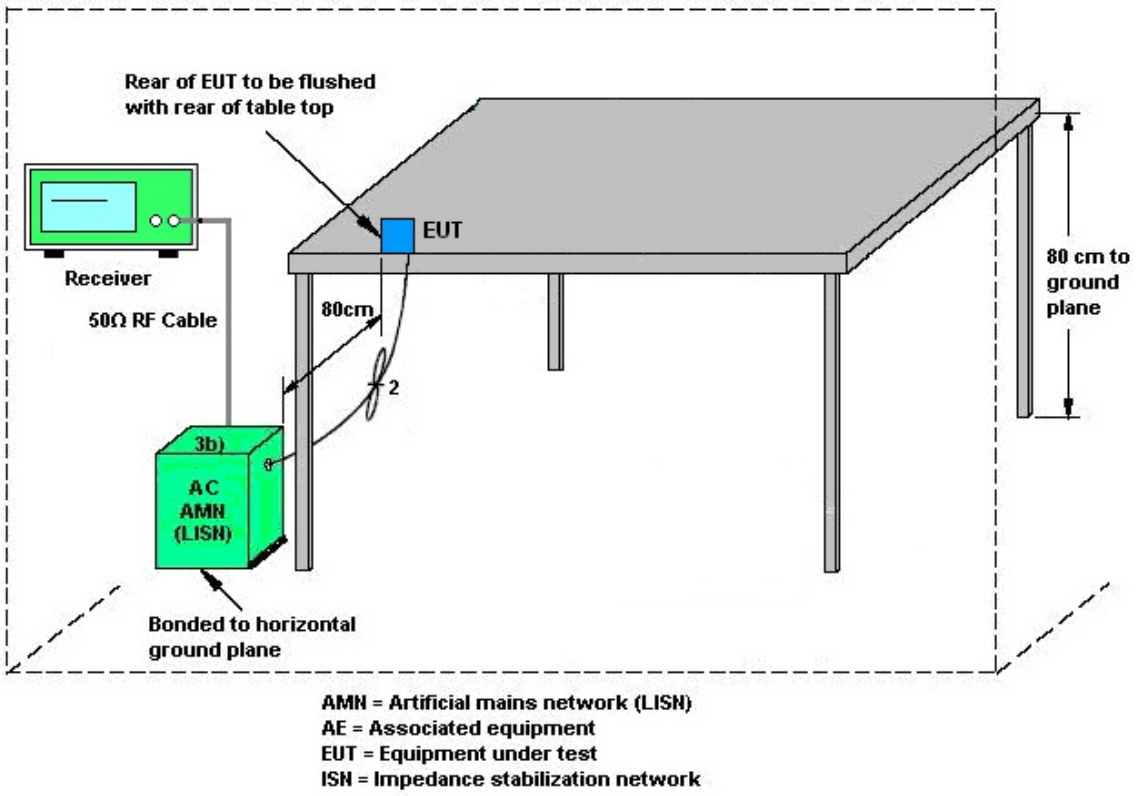
3.3.2 Measuring Instruments

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



AMN = Artificial mains network (LISN)
AE = Associated equipment
EUT = Equipment under test
ISN = Impedance stabilization network

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	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Hygrometer	Testo	608-H2	41410069	N/A	Jun. 17, 2019	Mar. 25, 2020	Jun. 16, 2020	Conducted (TH05-HY)
Power Meter	Agilent	E4416A	GB41292344	N/A	Dec. 27, 2019	Mar. 25, 2020	Dec. 26, 2020	Conducted (TH05-HY)
Power Sensor	Agilent	E9327A	US40441548	50MHz~18GHz	Dec. 27, 2019	Mar. 25, 2020	Dec. 26, 2020	Conducted (TH05-HY)
Signal Analyzer	Rohde & Schwarz	FSV40	101566	10Hz~40GHz	Jul. 15, 2019	Mar. 25, 2020	Jul. 14, 2020	Conducted (TH05-HY)
BT Base Station	Rohde & Schwarz	CBT	101136	BT 3.0	Oct. 27, 2019	Mar. 25, 2020	Oct. 26, 2020	Conducted (TH05-HY)
Switch Box & RF Cable	Burgeon	ETF-058	EC1208382	N/A	Mar. 27, 2019	Mar. 25, 2020	Mar. 26, 2020	Conducted (TH05-HY)
AC Power Source	ChainTek	APC-1000W	N/A	N/A	N/A	Mar. 27, 2020	N/A	Conduction (CO05-HY)
EMI Test Receiver	Rohde & Schwarz	ESR3	102388	9kHz~3.6GHz	Nov. 15, 2019	Mar. 27, 2020	Nov. 14, 2020	Conduction (CO05-HY)
Hygrometer	Testo	608-H1	34913912	N/A	Nov. 07, 2019	Mar. 27, 2020	Nov. 06, 2020	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100081	9kHz~30MHz	Nov. 15, 2019	Mar. 27, 2020	Nov. 14, 2020	Conduction (CO05-HY)
Software	Rohde & Schwarz	EMC32 V10.30	N/A	N/A	N/A	Mar. 27, 2020	N/A	Conduction (CO05-HY)
LF Cable	HUBER + SUHNER	RG-214/U	LF01	N/A	Jan. 02, 2020	Mar. 27, 2020	Jan. 01, 2021	Conduction (CO05-HY)
Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100851	N/A	Jan. 02, 2020	Mar. 27, 2020	Jan. 01, 2021	Conduction (CO05-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100315	9 kHz~30 MHz	Dec. 26, 2019	Apr. 18, 2020~ Apr. 24, 2020	Dec. 25, 2020	Radiation (03CH12-HY)
Bilog Antenna	TESEQ	CBL 6111D & 00800N1D01N-06	37059 & 01	30MHz~1GHz	Oct. 12, 2019	Apr. 18, 2020~ Apr. 24, 2020	Oct. 11, 2020	Radiation (03CH12-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120D	9120D-1328	1GHz ~ 18GHz	Nov. 14, 2019	Apr. 18, 2020~ Apr. 24, 2020	Nov. 13, 2020	Radiation (03CH12-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170584	18GHz ~ 40GHz	Dec. 10, 2019	Apr. 18, 2020~ Apr. 24, 2020	Dec. 09, 2020	Radiation (03CH12-HY)
Preamplifier	COM-POWER	PA-103	161075	10MHz~1GHz	Mar. 25, 2020	Apr. 18, 2020~ Apr. 24, 2020	Mar. 24, 2021	Radiation (03CH12-HY)
Preamplifier	Jet-Power	JPA00101800-30-10P	1601180002	1GHz~18GHz	Feb. 07, 2020	Apr. 18, 2020~ Apr. 24, 2020	Feb. 06, 2021	Radiation (03CH12-HY)
Preamplifier	Keysight	83017A	MY532701418	1GHz~26.5GHz	Dec. 20, 2019	Apr. 18, 2020~ Apr. 24, 2020	Dec. 19, 2020	Radiation (03CH12-HY)
Preamplifier	EMEC	EM18G40G	060715	18GHz ~ 40GHz	Dec. 13, 2019	Apr. 18, 2020~ Apr. 24, 2020	Dec. 12, 2020	Radiation (03CH12-HY)
Spectrum Analyzer	Rohde & Schwarz	FSV40	101408	10Hz~40GHz	Aug. 13, 2019	Apr. 18, 2020~ Apr. 24, 2020	Aug. 12, 2020	Radiation (03CH12-HY)
Hygrometer	TECPEL	DTM-303B	TP161243	N/A	May 11, 2019	Apr. 18, 2020~ Apr. 24, 2020	May 10, 2020	Radiation (03CH12-HY)

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
RF Cable	HUBER + SUHNER	SUCOFLEX 126E	0058/126E	30M-18G	Dec. 12, 2019	Apr. 18, 2020~ Apr. 24, 2020	Dec. 11, 2020	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30M~40GHz	Feb. 25, 2020	Apr. 18, 2020~ Apr. 24, 2020	Feb. 24, 2021	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	800740/2	30M~40GHz	Feb. 25, 2020	Apr. 18, 2020~ Apr. 24, 2020	Feb. 24, 2021	Radiation (03CH12-HY)
Controller	EMEC	EM1000	N/A	Control Turn table & Ant Mast	N/A	Apr. 18, 2020~ Apr. 24, 2020	N/A	Radiation (03CH12-HY)
Antenna Mast	EMEC	AM-BS-4500-B	N/A	1m~4m	N/A	Apr. 18, 2020~ Apr. 24, 2020	N/A	Radiation (03CH12-HY)
Turn Table	EMEC	TT2000	N/A	0~360 Degree	N/A	Apr. 18, 2020~ Apr. 24, 2020	N/A	Radiation (03CH12-HY)
Software	Audix	E3 6.2009-8-24	RK-000989	N/A	N/A	Apr. 18, 2020~ Apr. 24, 2020	N/A	Radiation (03CH12-HY)

5 Uncertainty of Evaluation

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

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

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.1**

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

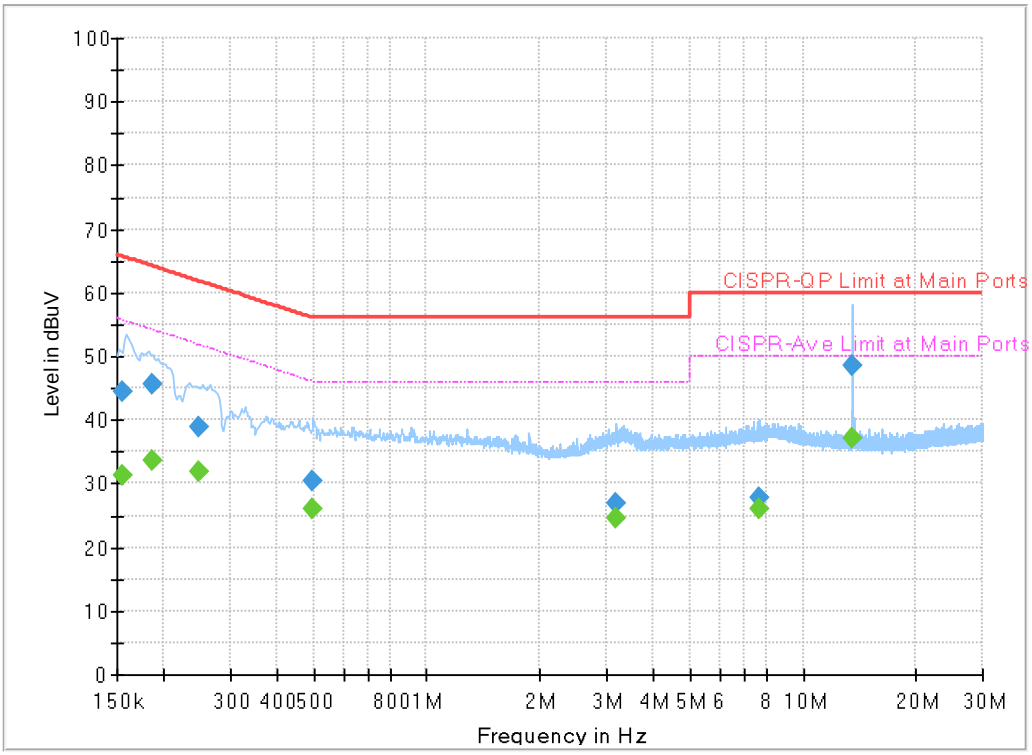
Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**5.6**

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

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

Appendix A. AC Conducted Emission Test Results

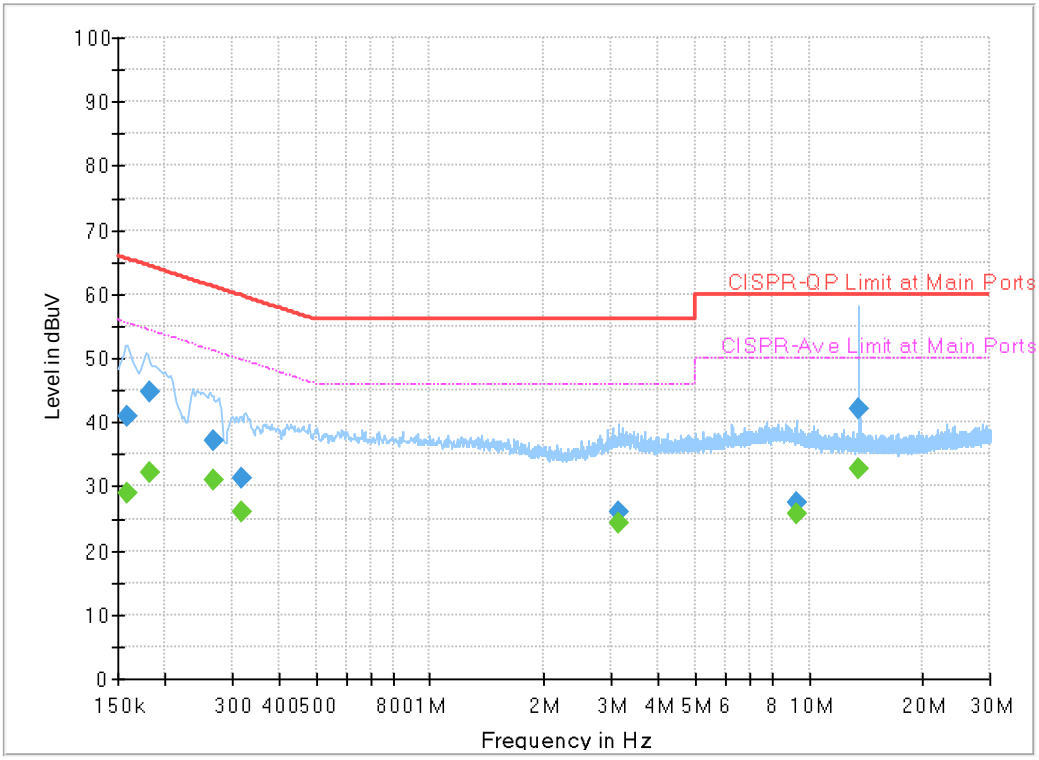
Test Engineer :	Howard Huang	Temperature :	21~24℃
		Relative Humidity :	42~50%
Test Voltage :	120Vac / 60Hz	Phase :	Line



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.154500	---	31.34	55.75	24.41	L1	OFF	19.6
0.154500	44.48	---	65.75	21.27	L1	OFF	19.6
0.186000	---	33.50	54.21	20.71	L1	OFF	19.6
0.186000	45.73	---	64.21	18.48	L1	OFF	19.6
0.249000	---	31.73	51.79	20.06	L1	OFF	19.6
0.249000	38.91	---	61.79	22.88	L1	OFF	19.6
0.496230	---	26.04	46.06	20.02	L1	OFF	19.6
0.496230	30.37	---	56.06	25.69	L1	OFF	19.6
3.173550	---	24.50	46.00	21.50	L1	OFF	19.7
3.173550	26.84	---	56.00	29.16	L1	OFF	19.7
7.631250	---	26.01	50.00	23.99	L1	OFF	20.0
7.631250	27.81	---	60.00	32.19	L1	OFF	20.0
13.560000	---	37.23	50.00	12.77	L1	OFF	20.2
13.560000	48.49	---	60.00	11.51	L1	OFF	20.2

Test Engineer :	Howard Huang	Temperature :	21~24℃
		Relative Humidity :	42~50%
Test Voltage :	120Vac / 60Hz	Phase :	Neutral



Final Result

Frequency (MHz)	QuasiPeak (dBuV)	CAverage (dBuV)	Limit (dBuV)	Margin (dB)	Line	Filter	Corr. (dB)
0.158280	---	28.87	55.55	26.68	N	OFF	19.6
0.158280	40.84	---	65.55	24.71	N	OFF	19.6
0.181500	---	32.07	54.42	22.35	N	OFF	19.6
0.181500	44.63	---	64.42	19.79	N	OFF	19.6
0.267000	---	30.86	51.21	20.35	N	OFF	19.6
0.267000	37.23	---	61.21	23.98	N	OFF	19.6
0.318750	---	26.03	49.74	23.71	N	OFF	19.6
0.318750	31.26	---	59.74	28.48	N	OFF	19.6
3.145020	---	24.29	46.00	21.71	N	OFF	19.7
3.145020	25.93	---	56.00	30.07	N	OFF	19.7
9.253500	---	25.82	50.00	24.18	N	OFF	20.1
9.253500	27.46	---	60.00	32.54	N	OFF	20.1
13.560000	---	32.71	50.00	17.29	N	OFF	20.2
13.560000	42.13	---	60.00	17.87	N	OFF	20.2

Appendix B. Radiated Spurious Emission

Test Engineer :	Jack Cheng, Lance Chiang and Chuan Chu	Temperature :	19.2~26.8°C
		Relative Humidity :	53.5~69%

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	94.41	-	-	90.38	27.34	5.95	29.26	100	73	P	H
	*	2480	69.65	-	-	-	-	-	-	-	-	A	H
		2483.52	49.88	-24.12	74	45.85	27.33	5.95	29.25	100	73	P	H
		2483.52	25.12	-28.88	54	-	-	-	-	-	-	A	H
													H
													H
	*	2480	90.93	-	-	86.9	27.34	5.95	29.26	371	38	P	V
	*	2480	66.17	-	-	-	-	-	-	-	-	A	V
		2483.92	48.34	-25.66	74	44.31	27.33	5.95	29.25	371	38	P	V
		2483.92	23.58	-30.42	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	41.08	-32.92	74	60.14	31.24	9.56	60.33	100	0	P	H
		4960	16.32	-37.68	54	-	-	-	-	-	-	A	H
		7440	44.07	-29.93	74	53.81	36.4	12.42	59.04	100	0	P	H
		7440	19.31	-34.69	54	-	-	-	-	-	-	A	H
		4960	44.19	-29.81	74	63.25	31.24	9.56	60.33	100	0	P	V
		4960	19.43	-34.57	54	-	-	-	-	-	-	A	V
		7440	44.46	-29.54	74	54.2	36.4	12.42	59.04	100	0	P	V
		7440	19.7	-34.3	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		33.88	24.51	-15.49	40	31.04	22.63	0.46	29.66	-	-	P	H
		95.96	27.48	-16.02	43.5	40.92	15.34	0.76	29.61	-	-	P	H
		150.28	24.05	-19.45	43.5	35.45	16.98	1.1	29.58	-	-	P	H
		721.61	35.4	-10.6	46	33.95	27.01	2.73	28.58	-	-	P	H
		867.11	35.67	-10.33	46	31.37	29.03	3.2	28.32	-	-	P	H
		950.53	36.58	-9.42	46	30.45	30.61	3.2	28.14	100	0	P	H
													H
													H
													H
													H
													H
													H
		31.94	29.74	-10.26	40	35.53	23.36	0.47	29.65	-	-	P	V
		46.49	29.02	-10.98	40	42.15	15.94	0.53	29.64	-	-	P	V
		73.65	23.06	-16.94	40	39.5	12.4	0.74	29.64	-	-	P	V
		720.64	35.17	-10.83	46	33.79	26.94	2.72	28.57	-	-	P	V
		827.34	34.06	-11.94	46	30.83	28.25	3.05	28.43	-	-	P	V
		944.71	36.75	-9.25	46	30.85	30.38	3.22	28.15	100	0	P	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

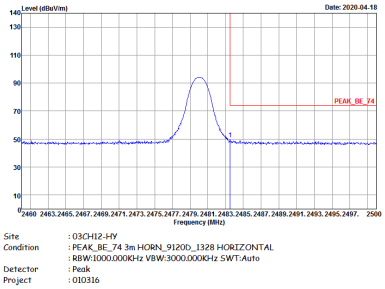
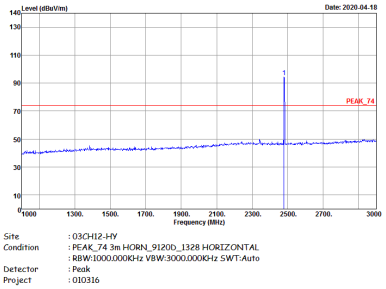
Test Engineer :	Jack Cheng, Lance Chiang and Chuan Chu	**Temperature :**	19.2~26.8°C
		Relative Humidity :	53.5~69%

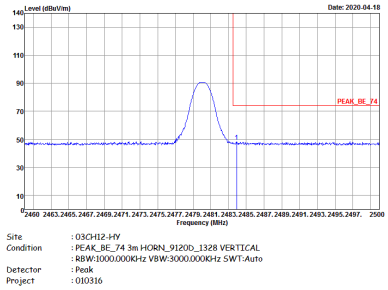
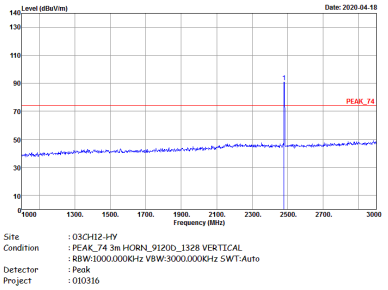
Note symbol

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

2.4GHz 2400~2483.5MHz

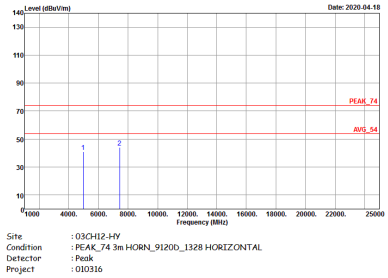
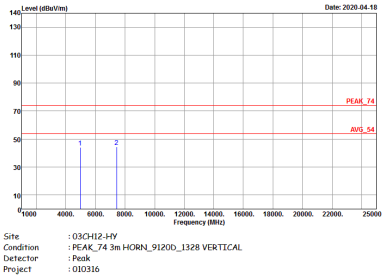
BT (Band Edge @ 3m)

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

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

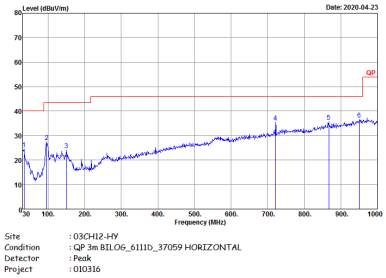
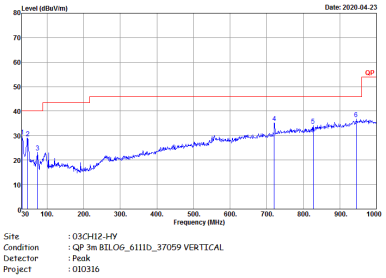
2.4GHz 2400~2483.5MHz

BT (Harmonic @ 3m)

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

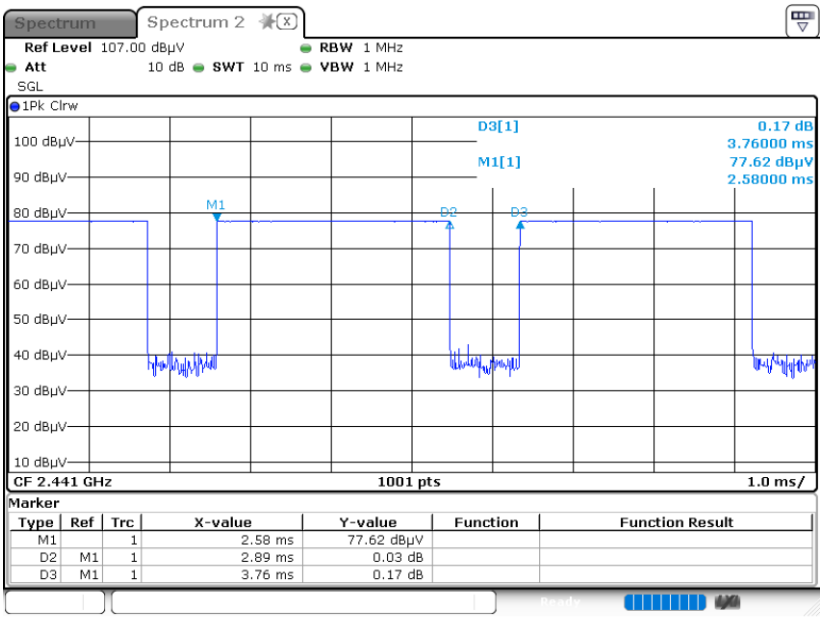
Emission below 1GHz

2.4GHz BT (LF)

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

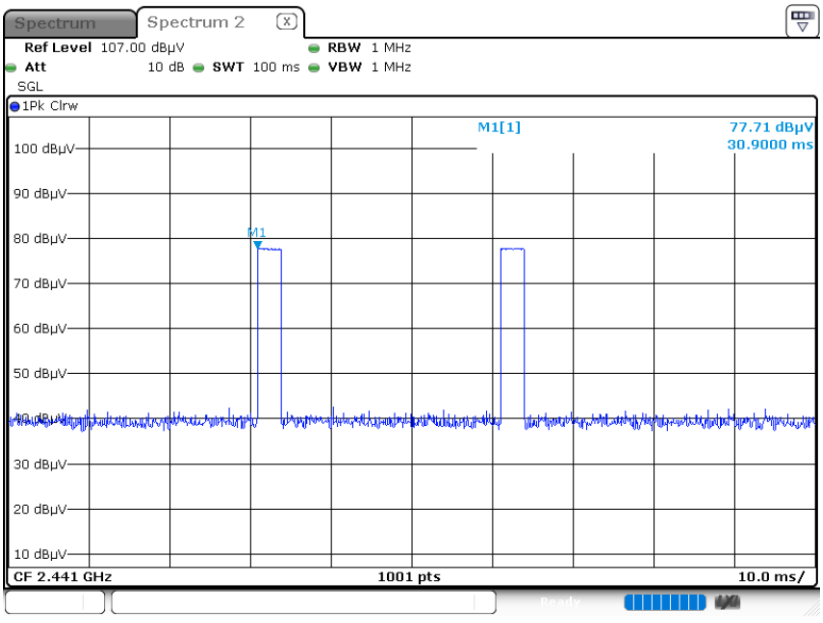
Appendix D. Duty Cycle Plots

DH5 on time (One Pulse) Plot on Channel 39



Date: 18.APR.2020 10:04:45

on time (Count Pulses) Plot on Channel 39



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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(Duty cycle) = -24.76 dB
3. **DH5** has the highest duty cycle worst case and is reported.

Duty Cycle Correction Factor Consideration for AFH mode:

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

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

2.89 ms x 20 channels = 57.8 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. [100ms / *57.8* ms] = 2 hops

Thus, the maximum possible ON time:

2.89 ms x 2 = 5.78 ms

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

20 x log(5.78 ms/100ms) = -24.76 dB