

FCC RF Test Report

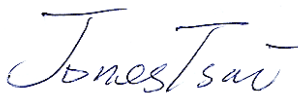
APPLICANT : HMD Global Oy
EQUIPMENT : Smart Phone
BRAND NAME : NOKIA
MODEL NAME : TA-1053
FCC ID : 2AJOTTA-1053
STANDARD : FCC Part 15 Subpart C §15.247
CLASSIFICATION : (DSS) Spread Spectrum Transmitter

The product was received on Jan. 26, 2017 and testing was completed on Mar. 11, 2017. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC., the test report shall not be reproduced except in full.



Reviewed by: Joseph Lin / Supervisor



Approved by: Jones Tsai / Manager



SPORTON INTERNATIONAL INC.

No. 52, Hwa Ya 1st Rd., Hwa Ya Technology Park, Kwei-Shan District, Tao Yuan City, Taiwan, R.O.C.

SPORTON INTERNATIONAL INC.

TEL : 886-3-327-3456

FAX : 886-3-328-4978

FCC ID : 2AJOTTA-1053

Page Number : 1 of 23

Report Issued Date : Apr. 06, 2017

Report Version : Rev. 01

Report Template No.: BU5-FR15CBT Version 2.0



TABLE OF CONTENTS

REVISION HISTORY.....	3
SUMMARY OF TEST RESULT	4
1 GENERAL DESCRIPTION.....	5
1.1 Applicant.....	5
1.2 Manufacturer.....	5
1.3 Product Feature of Equipment Under Test.....	5
1.4 Re-use of Measured Data	5
1.5 Modification of EUT	9
1.6 Testing Location	9
1.7 Applicable Standards.....	10
2 TEST CONFIGURATION OF EQUIPMENT UNDER TEST.....	11
2.1 Carrier Frequency Channel	11
2.2 Descriptions of Test Mode.....	12
2.3 Test Mode.....	13
2.4 Connection Diagram of Test System.....	14
2.5 Support Unit used in test configuration and system	14
2.6 EUT Operation Test Setup	14
3 TEST RESULT	15
3.1 Radiated Band Edges and Spurious Emission Measurement	15
3.2 AC Conducted Emission Measurement.....	19
3.3 Antenna Requirements	21
4 LIST OF MEASURING EQUIPMENT.....	22
5 UNCERTAINTY OF EVALUATION.....	23
APPENDIX A. AC CONDUCTED EMISSION TEST RESULT	
APPENDIX B. RADIATED SPURIOUS EMISSION	
APPENDIX C. RADIATED SPURIOUS EMISSION PLOTS	
APPENDIX D. DUTY CYCLE PLOTS	
APPENDIX E. SETUP PHOTOGRAPHS	



REVISION HISTORY

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
FR712016-02A	Rev. 01	Initial issue of report	Apr. 06, 2017



SUMMARY OF TEST RESULT

Report Section	FCC Rule	Description	Limit	Result	Remark
3.1	15.247(d)	Radiated Band Edges and Radiated Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 4.12 dB at 32.700 MHz
3.2	15.207	AC Conducted Emission	15.207(a)	Pass	Under limit 13.80 dB at 13.558 MHz
3.3	15.203 & 15.247(b)	Antenna Requirement	N/A	Pass	-



1 General Description

1.1 Applicant

HMD Global Oy

Karaportti 2, 02610 Espoo, Finland

1.2 Manufacturer

HMD Global Oy

Karaportti 2, 02610 Espoo, Finland

1.3 Product Feature of Equipment Under Test

GSM/WCDMA/LTE, Bluetooth, Wi-Fi 2.4GHz 802.11b/g/n, Wi-Fi 5GHz 802.11a/n, Ant.+, FM Receiver, NFC, and GPS.

Product Specification subjective to this standard	
Antenna Type	WWAN: PIFA Antenna WLAN: PIFA Antenna Bluetooth: PIFA Antenna Ant.+ : PIFA Antenna GPS/Glonass/Beidou : Monopole Antenna NFC : Loop Antenna

1.4 Re-use of Measured Data

1.4.1 Introduction Section

The original model (FCC ID: 2AJOTTA-1044) and the variant model (FCC ID: 2AJOTTA-1053) has identical PCB layout, antenna, SW implementation for Bluetooth/Wi-Fi/GPS. Based on their similarity, the FCC Part 15C & 15E(equipment class: DTS, DSS,DXX, NII) test data issued for original model also apply for the variant model.

The applicant takes full responsibility that the test data as referenced in section 4 below represent compliance for this FCC ID (FCC ID: 2AJOTTA-1053).



1.4.2 Difference Section

The original model (FCC ID: 2AJOTTA-1044) and the variant model (FCC ID: 2AJOTTA-1053) has identical PCB layout, antenna, SW implementation for Bluetooth/Wi-Fi/GPS. The details of similarity and difference can be found in the Operating Description.

The product specification is outlined in the following table:

FCC ID			2AJOTTA-1044	2AJOTTA-1053
Wireless Tech	Mode		Frequency (MHz)	
GSM	GSM Voice GPRS (GMSK) EDGE (8PSK)	Multi-Slot Class 11 DTM: Yes	850/1900	850/1900
UMTS	AMR/RCM12.2Kbps HSDPA/HSUPA/DC-HSDPA		B2/B4/B5	B2/B5
LTE	QPSK/16QAM VoLTE		B2/B4/B7/B12/B17/B38	B5/B7/B38
Wi-Fi	11b/11g/11n(HT20)		2412-2462 MHz/	
	11a/11n(HT20)/11n(HT40)		5180-5240 MHz 5260-5320 MHz 5500-5700 MHz 5745-5825 MHz	
Bluetooth	BR/EDR/LE		2402-2480 MHz	
ANT+	ANT+		2402-2480 MHz	



1.4.3 Spot Check Verification Data Section

Summary of the spot check:

Test Item	Mode	2AJOTTA-1044 Worst Result	2AJOTTA-1053 Worst Result	Difference (dB)
Average Conducted Power (dBm)	802.11b	13.99	13.89	0.10
	802.11g	11.64	11.65	0.01
	11n HT20	10.90	10.92	-0.02
	20MHz BW 5150-5250MHz	14.42	14.48	-0.06
	20MHz BW 5250-5350MHz	14.41	14.47	-0.06
	20MHz BW 5470-5725MHz	14.37	14.34	0.03
	20MHz BW 5725-5850MHz	14.43	14.40	0.03
	40MHz BW 5150-5250MHz	14.23	14.19	0.04
	40MHz BW 5250-5350MHz	14.21	14.26	-0.05
	40MHz BW 5470-5725MHz	14.17	14.04	0.13
	40MHz BW 5725-5850MHz	14.34	14.40	-0.06
	BT (1Mbps)	7.53	7.62	-0.09
	BT (2Mbps)	5.23	5.17	0.06
	BT (3Mbps)	5.20	5.13	0.07
	BT-LE	0.63	0.72	-0.09
	ANT+	0.47	0.48	-0.01
	Test date	2017/02/11 – 2017/02/24	2017/03/14 – 2017/03/14	
Peak Radiated Spurious Emission (Band Edge) (dBuV/m)	802.11b	54.48	54.95	-0.47
	11n HT20	56.36	57.04	-0.68
	BT (1Mbps)	44.35	43.75	0.60
	BT-LE	55.17	54.61	0.56
	ANT+	65.94	63.66	2.28
	Test date	2017/02/11 – 2017/02/24	2017/03/03 – 2017/03/11	
Average Radiated Spurious Emission (Band Edge) (dBuV/m)	802.11b	45.51	44.25	1.26
	11n HT20	45.77	46.96	-1.19
	BT (1Mbps)	19.59	18.99	0.60
	BT-LE	45.28	45.24	0.04
	ANT+	38.85	38.59	0.26
	Test date	2017/02/11 – 2017/02/24	2017/03/03 – 2017/03/11	
Peak Radiated Spurious Emission (Harmonic) (dBuV/m)	802.11b	45.27	46.25	-0.98
	11n HT20	41.37	43.54	-2.17
	BT (1Mbps)	40.93	41.49	-0.56
	BT-LE	40.63	42.23	-1.60
	ANT+	37.66	39.64	-1.98
	Test date	2017/02/11 – 2017/02/24	2017/03/03 – 2017/03/11	

**Conclusion:**

WLAN Radiated spurious emission test against the variant model for non-cellular part based on the worst-case condition from the original model was performed in this filing to demonstrate the test data from original model remains representative for the variant model.

Based on the spot check test result (power levels measured are within 0.5dB, and the worst case of RSE spot check verification based on the worst condition from the original model is within 3dB, and are compliance with the limits), the test data from the original model is representative for the variant model.

The unwanted, harmonics, radiated spurious emission is reported peak measurement only due to spurious lower than 20dB than the limit.

1.4.4 Reference detail Section

Equipment Class	Reference FCC ID	Type Grant/Permissive Change	Reference Application	Folder Test/RF Exposure	Report Title
DTS	2AJOTTA-1044	Original Grant	FR712016B	Part 15C	All sections applicable
			FR712016C	Part 15C	All sections applicable
			FA712016	RF Exposure	All sections applicable
DSS	2AJOTTA-1044	Original Grant	FR712016A	Part 15C	All sections applicable
			FA712016	RF Exposure	All sections applicable
DXX	2AJOTTA-1044	Original Grant	FR712016D	Part 15C	All sections applicable
			FA712016	RF Exposure	All sections applicable
NII	2AJOTTA-1044	Original Grant	FR712016F FR712016G FZ712016	Part 15E	Conducted sections applicable
			FA712016	RF Exposure	All sections applicable

1.5 Modification of EUT

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

1.6 Testing Location

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code : 1190) and the FCC designation No. TW0007 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC Test.

Test Site	SPORTON INTERNATIONAL INC.	
Test Site Location	No. 52, Hwa Ya 1 st Rd., Hwa Ya Technology Park, Kwei-Shan District, Tao Yuan 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.	
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.	
	03CH11-HY	

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



1.7 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
- ♦ 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 Descriptions of Test Mode

Preliminary tests were performed in different data rates and recorded the RF output power in the following table:

Channel	Frequency	Bluetooth RF Output Power		
		Data Rate / Modulation		
		GFSK	$\pi/4$ -DQPSK	8-DPSK
		1Mbps	2Mbps	3Mbps
Ch00	2402MHz	7.87 dBm	7.82 dBm	8.23 dBm
Ch39	2441MHz	6.41 dBm	6.36 dBm	6.75 dBm
Ch78	2480MHz	7.21 dBm	7.12 dBm	7.46 dBm

Remark:

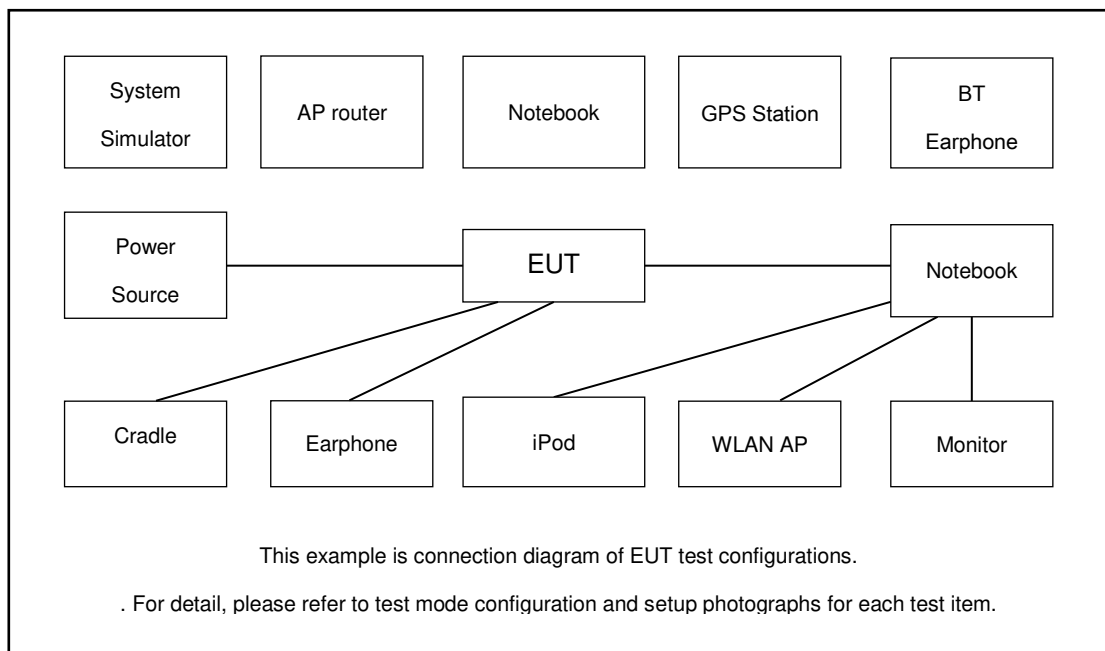
1. All the test data for each data rate were verified, but only the worst case was reported.
 2. The data rate was set in 3Mbps for all the test items due to the highest RF output power.
- a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission 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.

2.3 Test Mode

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

Summary table of Test Cases			
Test Item	Data Rate / Modulation		
	Bluetooth BR 1Mbps GFSK	Bluetooth EDR 2Mbps π /4-DQPSK	Bluetooth EDR 3Mbps 8-DPSK
Conducted Test Cases	Mode 1: CH00_2402 MHz	Mode 4: CH00_2402 MHz	Mode 7: CH00_2402 MHz
	Mode 2: CH39_2441 MHz	Mode 5: CH39_2441 MHz	Mode 8: CH39_2441 MHz
	Mode 3: CH78_2480 MHz	Mode 6: CH78_2480 MHz	Mode 9: CH78_2480 MHz
Radiated Test Cases	Bluetooth EDR 3Mbps 8-DPSK		
	Mode 2: CH39_2441 MHz		
AC Conducted Emission	Mode 1: GSM850 Idle + Bluetooth Link + WLAN (2.4GHz) Link + NFC On + Earphone + USB Cable (Charging from Adapter) + SIM 1		
Remark: For radiated test cases, the worst mode data rate 3Mbps was reported only, because this data rate has the highest RF output power at preliminary tests, and the conducted spurious emissions and conducted band edge measurement for each data rate are no worse than 3Mbps, and no other significantly frequencies found in conducted spurious emission.			

2.4 Connection Diagram of Test System



2.5 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	System Simulator	Anritsu	MT8820C	N/A	N/A	Unshielded, 1.8 m
2.	Bluetooth Base Station	R&S	CBT32	N/A	N/A	Unshielded, 1.8 m
3.	WLAN AP	ASUS	RT-AC66U	MSQ-RTAC66U	N/A	Unshielded, 1.8m
4.	Notebook	DELL	Latitude E6320	FCC DoC/ Contains FCC ID: QDS-BRCM1054	N/A	AC I/P: Unshielded, 1.2 m DC O/P: Shielded, 1.8 m
5.	Bluetooth Earphone	Sony Ericsson	MW600	PY7DDA-2029	N/A	N/A
6.	SD Card	SanDisk	MicroSD HC	FCC DoC	N/A	N/A

2.6 EUT Operation Test Setup

The RF test items utility, "QRCT" was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to contact with base station for continuous transmitting and receiving signals.

3 Test Result

3.1 Radiated Band Edges and Spurious Emission Measurement

3.1.1 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 FCC section 15.209 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

3.1.2 Measuring Instruments

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



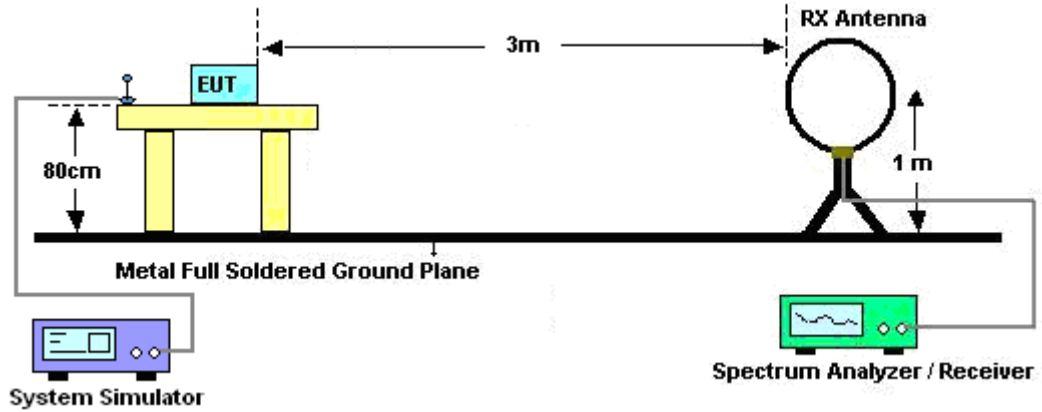
3.1.3 Test Procedures

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.
1. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
2. 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.
3. Set to the maximum power setting and enable the EUT transmit continuously.
4. 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 + $20 * \log(\text{Duty cycle})$
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

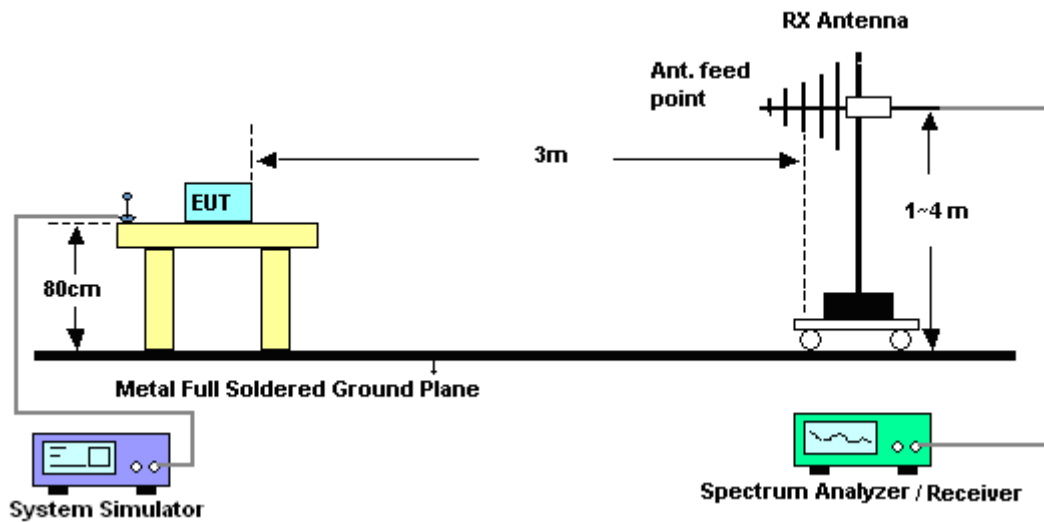
Note: The average levels were calculated from the peak level corrected with duty cycle correction factor (-24.76dB) derived from $20 \log(\text{dwell time}/100\text{ms})$. This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals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

3.1.4 Test Setup

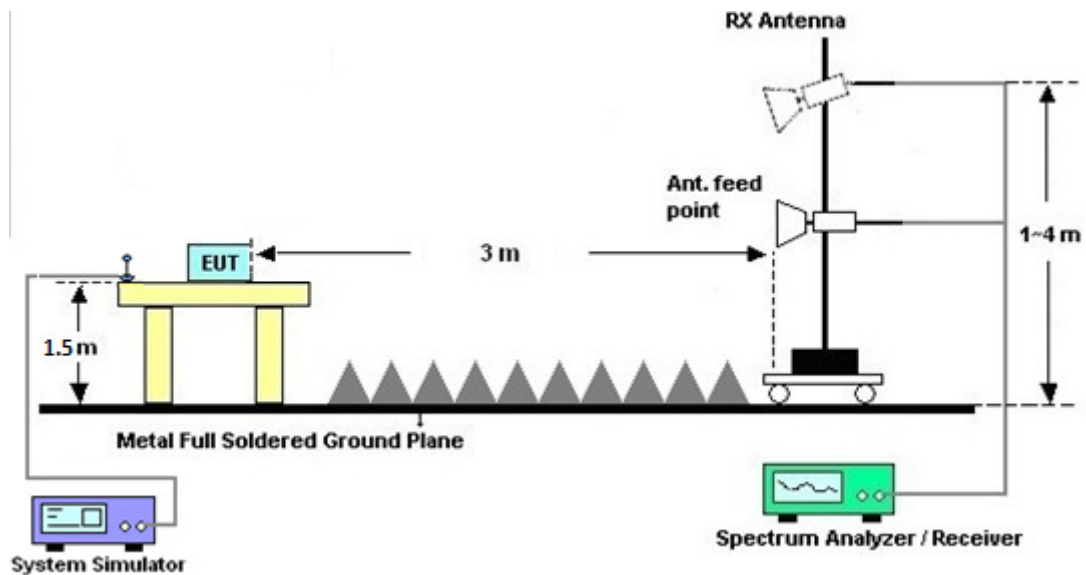
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



3.1.5 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 per 15.31(o) was not reported.

3.1.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B and C.

3.1.7 Duty Cycle

Please refer to Appendix D.

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

Please refer to Appendix B and C.

3.2 AC Conducted Emission Measurement

3.2.1 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.

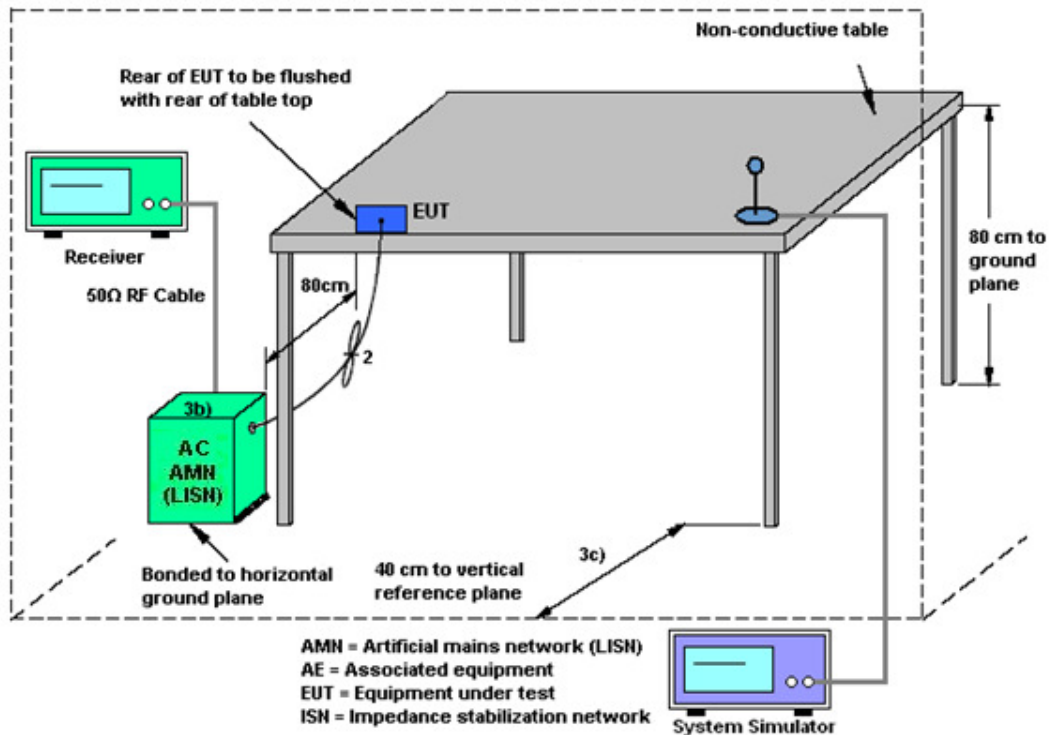
3.2.2 Measuring Instruments

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

3.2.3 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.

3.2.4 Test Setup



3.2.5 Test Result of AC Conducted Emission

Please refer to Appendix A.



3.3 Antenna Requirements

3.3.1 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 FCC rule.

3.3.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.3.3 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
Power Meter	Agilent	E4416A	GB41292344	300MHz~40GHz	Dec. 26, 2016	Feb. 09, 2017 ~ Feb. 24, 2017	Dec. 25, 2017	Conducted (TH05-HY)
Power Sensor	Agilent	E9327A	US40441548	300MHz~40GHz	Dec. 26, 2016	Feb. 09, 2017 ~ Feb. 24, 2017	Dec. 25, 2017	Conducted (TH05-HY)
Spectrum Analyzer	Rohde & Schwarz	FSP40	100055	9kHz-40GHz	Jul. 17, 2016	Feb. 09, 2017 ~ Feb. 24, 2017	Jul. 16, 2017	Conducted (TH05-HY)
BT Base Station(Measure)	Rohde & Schwarz	CBT	101136	BT 3.0	Sep. 21, 2016	Feb. 09, 2017 ~ Feb. 24, 2017	Sep. 20, 2017	Conducted (TH05-HY)
AC Power Source	ChainTek	APC-1000W	N/A	N/A	N/A	Feb. 11, 2017	N/A	Conduction (CO05-HY)
EMI Test Receiver	Rohde & Schwarz	ESCI 7	100724	9kHz~7GHz	Aug. 30, 2016	Feb. 11, 2017	Aug. 29, 2017	Conduction (CO05-HY)
LISN	Rohde & Schwarz	ENV216	100080	9kHz~30MHz	Nov. 29, 2016	Feb. 11, 2017	Nov. 28, 2017	Conduction (CO05-HY)
LF Cable	HUBER + SUHNER	RG-214/U	LF01	N/A	Jan. 05, 2017	Feb. 11, 2017	Jan. 04, 2018	Conduction (CO05-HY)
Pulse Limiter	Rohde & Schwarz	ESH3-Z2	100851	N/A	Jan. 05, 2017	Feb. 11, 2017	Jan. 04, 2018	Conduction (CO05-HY)
Amplifier	SONOMA	310N	187312	9kHz~1GHz	Nov. 10, 2016	Mar. 03, 2017 ~ Mar. 11, 2017	Nov. 09, 2017	Radiation (03CH11-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100315	9 kHz~30 MHz	Sep. 02, 2015	Mar. 03, 2017 ~ Mar. 11, 2017	Sep. 01, 2017	Radiation (03CH11-HY)
Bilog Antenna	TESEQ	CBL 6111D	35414	30MHz~1GHz	Oct. 15, 2016	Mar. 03, 2017 ~ Mar. 11, 2017	Oct. 14, 2017	Radiation (03CH11-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-1522	1GHz ~ 18GHz	Mar. 30, 2016	Mar. 03, 2017 ~ Mar. 11, 2017	Mar. 31, 2017	Radiation (03CH11-HY)
Preamplifier	Keysight	83017A	MY53270080	1GHz~26.5GHz	Nov. 10, 2016	Mar. 03, 2017 ~ Mar. 11, 2017	Nov. 09, 2017	Radiation (03CH11-HY)
Spectrum Analyzer	Keysight	N9010A	MY52350276	10Hz ~ 44GHZ	Mar. 21, 2016	Mar. 03, 2017 ~ Mar. 11, 2017	Mar. 20, 2017	Radiation (03CH11-HY)
Antenna Mast	EMEC	AM-BS-4500-B	N/A	1~4m	N/A	Mar. 03, 2017 ~ Mar. 11, 2017	N/A	Radiation (03CH11-HY)
Turn Table	EMEC	TT 2000	N/A	0~360 Degree	N/A	Mar. 03, 2017 ~ Mar. 11, 2017	N/A	Radiation (03CH11-HY)
Preamplifier	MITEQ	AMF-7D-00101800	2025787	1GHz~18GHz	Feb. 13, 2017	Mar. 03, 2017 ~ Mar. 11, 2017	Feb. 12, 2018	Radiation (03CH11-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170584	18GHz- 40GHz	Nov. 08, 2016	Mar. 03, 2017 ~ Mar. 11, 2017	Nov. 07, 2017	Radiation (03CH11-HY)

5 Uncertainty of Evaluation

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	2.7
---	-----

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.2
---	-----

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.5
---	-----

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.2
---	-----



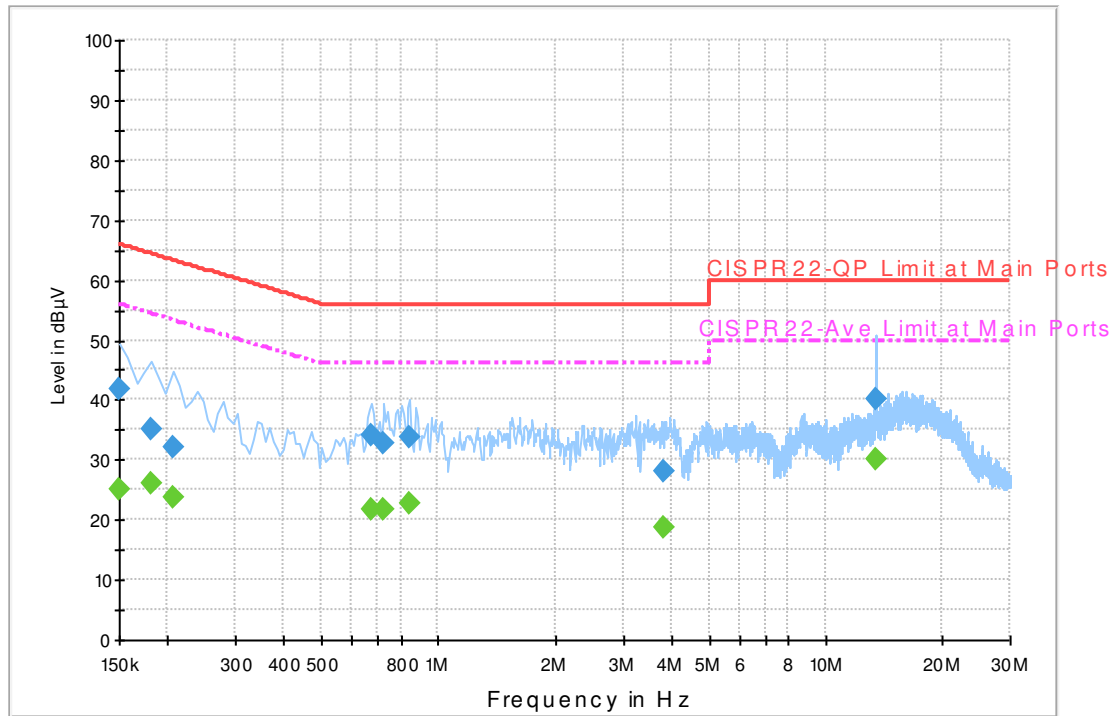
Appendix A. AC Conducted Emission Test Results

Test Engineer :	Arthur Hsieh	Temperature :	21~22°C
		Relative Humidity :	54~56%

EUT Information

Report NO : 712016-02
Test Mode : Mode 1
Test Voltage : 120Vac/60Hz
Phase : Line

ENV216 Auto Test FCC Power Bar - L



Final Result 1

Frequency (MHz)	QuasiPeak (dB μ V)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.150000	41.8	Off	L1	19.6	24.2	66.0
0.182000	35.2	Off	L1	19.6	29.2	64.4
0.206000	32.1	Off	L1	19.6	31.3	63.4
0.670000	34.3	Off	L1	19.6	21.7	56.0
0.726000	32.6	Off	L1	19.6	23.4	56.0
0.846000	33.9	Off	L1	19.6	22.1	56.0
3.846000	28.1	Off	L1	19.7	27.9	56.0
13.558000	40.2	Off	L1	20.2	19.8	60.0

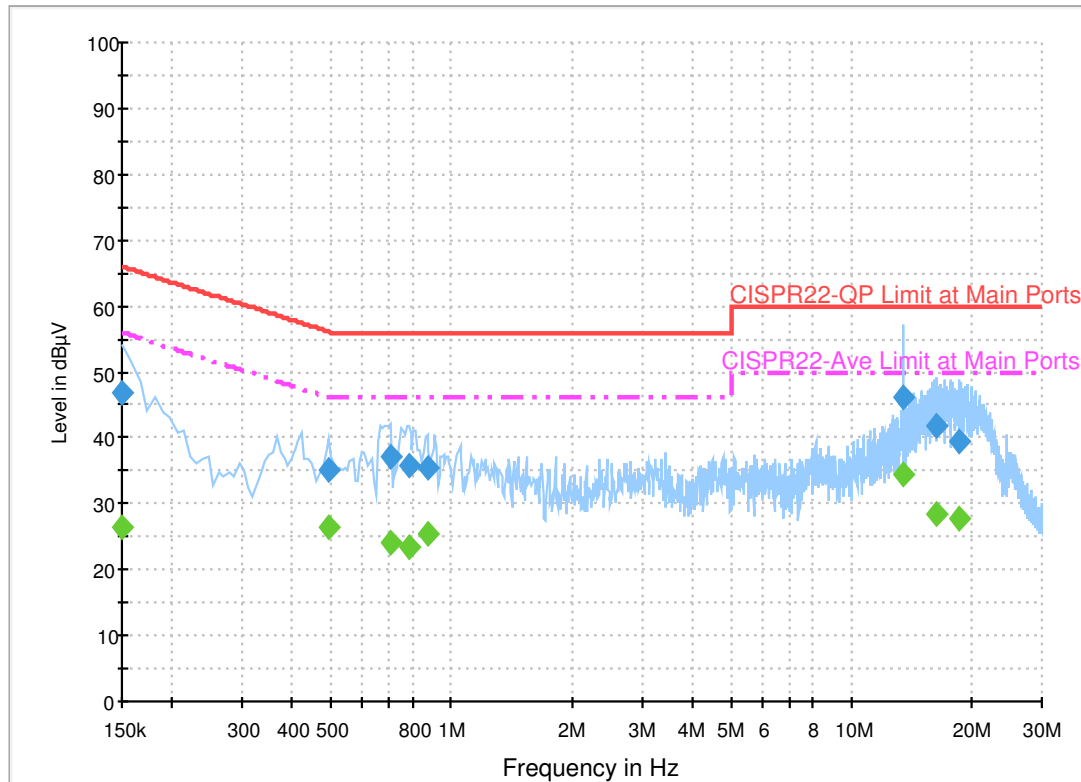
Final Result 2

Frequency (MHz)	Average (dB μ V)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.150000	25.2	Off	L1	19.6	30.8	56.0
0.182000	25.9	Off	L1	19.6	28.5	54.4
0.206000	23.8	Off	L1	19.6	29.6	53.4
0.670000	21.6	Off	L1	19.6	24.4	46.0
0.726000	21.7	Off	L1	19.6	24.3	46.0
0.846000	22.8	Off	L1	19.6	23.2	46.0
3.846000	18.6	Off	L1	19.7	27.4	46.0
13.558000	30.2	Off	L1	20.2	19.8	50.0

EUT Information

Report NO : 712016-02
Test Mode : Mode 1
Test Voltage : 120Vac/60Hz
Phase : Neutral

ENV216 Auto Test FCC Power Bar - N



Final Result 1

Frequency (MHz)	QuasiPeak (dBµV)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	46.8	Off	N	19.5	19.2	66.0
0.494000	35.0	Off	N	19.5	21.1	56.1
0.702000	37.2	Off	N	19.5	18.8	56.0
0.782000	35.9	Off	N	19.5	20.1	56.0
0.870000	35.4	Off	N	19.6	20.6	56.0
13.558000	46.2	Off	N	20.3	13.8	60.0
16.374000	41.8	Off	N	20.5	18.2	60.0
18.566000	39.3	Off	N	20.6	20.7	60.0

Final Result 2

Frequency (MHz)	Average (dBµV)	Filter	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	26.5	Off	N	19.5	29.5	56.0
0.494000	26.4	Off	N	19.5	19.7	46.1
0.702000	24.1	Off	N	19.5	21.9	46.0
0.782000	23.3	Off	N	19.5	22.7	46.0
0.870000	25.4	Off	N	19.6	20.6	46.0
13.558000	34.5	Off	N	20.3	15.5	50.0
16.374000	28.4	Off	N	20.5	21.6	50.0
18.566000	27.9	Off	N	20.6	22.1	50.0



Appendix B. Radiated Spurious Emission

Test Engineer :	J.C. Liang, Jacky Hung, and Ken Wu	Temperature :	20~24°C
		Relative Humidity :	50~54%

2.4GHz 2400~2483.5MHz

BT (Band Edge @ 3m)

BT	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BT CH 39 2441MHz		2321.2	43.75	-30.25	74	41.63	26.98	8.75	33.61	267	128	P	H
		2321.2	18.99	-35.01	54	-	-	-	-	-	-	A	H
	*	2441	92.59	-	-	89.89	27.34	8.94	33.58	267	128	P	H
	*	2441	67.83	-	-	-	-	-	-	-	-	A	H
		2483.9	43.6	-30.4	74	40.75	27.45	8.98	33.58	267	128	P	H
		2483.9	18.84	-35.16	54	-	-	-	-	-	-	A	H
		2312.66	43.21	-30.79	74	41.14	26.93	8.75	33.61	100	44	P	V
		2312.66	18.45	-35.55	54	-	-	-	-	-	-	A	V
	*	2441	94.82	-	-	92.12	27.34	8.94	33.58	100	44	P	V
	*	2441	70.06	-	-	-	-	-	-	-	-	A	V
		2488.31	43.74	-30.26	74	40.84	27.5	8.98	33.58	100	44	P	V
		2488.31	18.98	-35.02	54	-	-	-	-	-	-	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

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

BT	Note	Frequency (MHz)	Level (dBμV/m)	Over Limit (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Cable Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BT CH 39 2441MHz		4882	38.3	-35.7	74	60.39	31.78	10.83	64.7	100	0	P	H
		4882	13.54	-40.46	54	-	-	-	-	-	-	A	H
		7323	41.49	-32.51	74	55.51	37.29	13.52	64.83	100	0	P	H
		7323	16.73	-37.27	54	-	-	-	-	-	-	A	H
		4882	38.97	-35.03	74	61.06	31.78	10.83	64.7	100	0	P	V
		4882	14.21	-39.79	54	-	-	-	-	-	-	A	V
		7323	40.74	-33.26	74	54.76	37.29	13.52	64.83	100	0	P	V
		7323	15.98	-38.02	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	Cable	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		98.58	23.21	-20.29	43.5	38.2	15.98	1.51	32.48	-	-	P	H	
		199.56	25.03	-18.47	43.5	39.78	16	2.14	32.89	-	-	P	H	
		227.64	22.58	-23.42	46	36.25	16.76	2.31	32.74	-	-	P	H	
		657.7	27.79	-18.21	46	30.13	26.28	3.85	32.47	-	-	P	H	
		826.4	30.69	-15.31	46	29.8	28.62	4.31	32.04	-	-	P	H	
		940.5	33.86	-12.14	46	30.16	30.35	4.64	31.29	310	95	P	H	
													H	
													H	
													H	
													H	
													H	
													H	
		32.7	35.88	-4.12	40	43.35	24.14	0.88	32.49	196	255	P	V	
		38.1	35.66	-4.34	40	45.85	21.42	0.88	32.49	-	-	P	V	
		59.7	23.24	-16.76	40	42.57	11.9	1.26	32.49	-	-	P	V	
		790.7	29.78	-16.22	46	29.59	28.18	4.22	32.21	-	-	P	V	
		873.3	31.43	-14.57	46	29.73	29.04	4.46	31.8	-	-	P	V	
		934.2	32.8	-13.2	46	29.39	30.16	4.6	31.35	-	-	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	Peak or Average
H/V	Horizontal or Vertical



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

WIFI	Note	Frequency	Level	Over	Limit	Read	Antenna	Cable	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
1+2		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
802.11b		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
CH 01													
2412MHz		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Level(dBμV/m) =

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

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

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Cable 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) + Cable 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”.



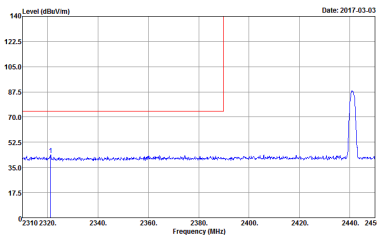
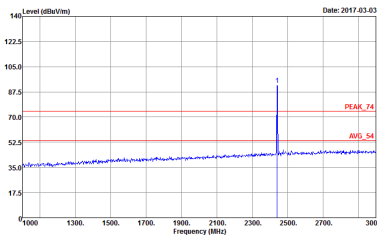
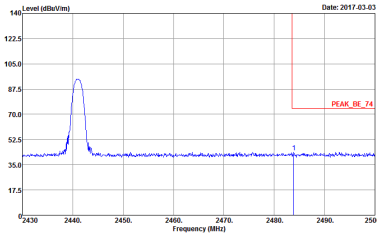
Appendix C. Radiated Spurious Emission Plots

Test Engineer :	J.C. Liang, Jacky Hung, and Ken Wu	Temperature :	20~24°C
		Relative Humidity :	50~54%

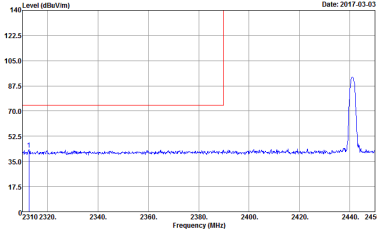
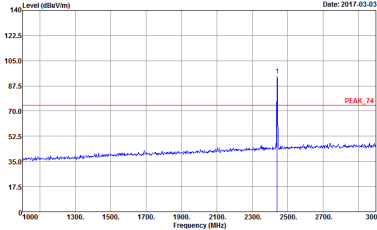
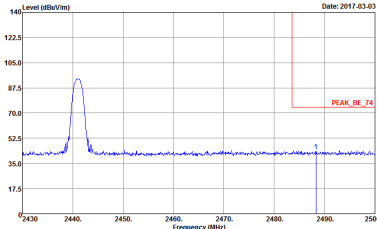
Note symbol

-L	Low channel location
-R	High channel location

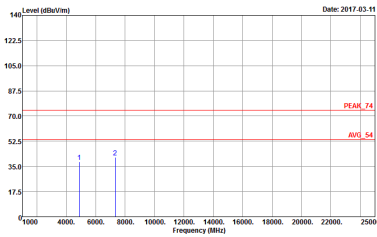
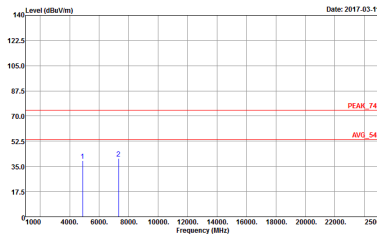
2.4GHz 2400~2483.5MHz
BT (Band Edge @ 3m)

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH39 2441MHz	
1	Horizontal	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF HORIZONTAL Detector : Peak Project : 712016-02	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF HORIZONTAL Detector : Peak Project : 712016-02
	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF HORIZONTAL Detector : Peak Project : 712016-02	Left blank

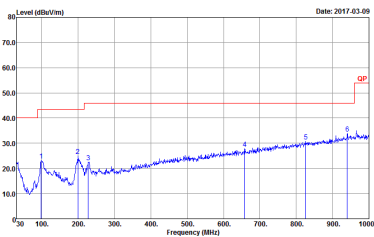
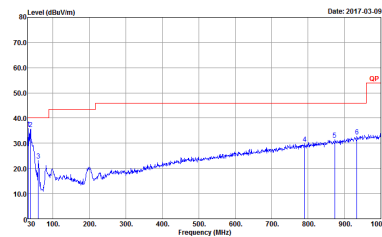


BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH39 2441MHz	
1	Vertical	Fundamental
Peak	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF VERTICAL Detector : Peak Project : 712016-02	 Site : 03CH11-HY Condition : PEAK_74 3m HORN 91200-HF VERTICAL Detector : Peak Project : 712016-02
	 Site : 03CH11-HY Condition : PEAK_BE_74 3m HORN 91200-HF VERTICAL Detector : Peak Project : 712016-02	Left blank

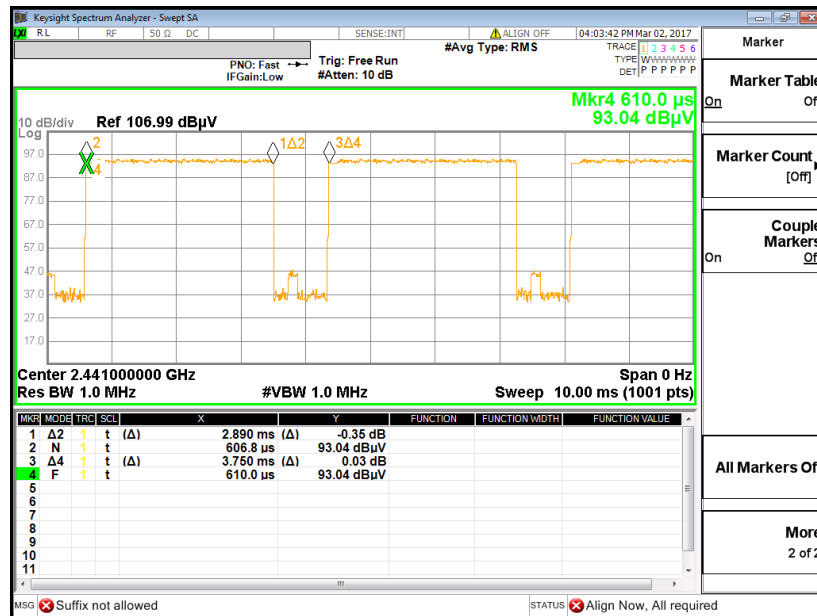
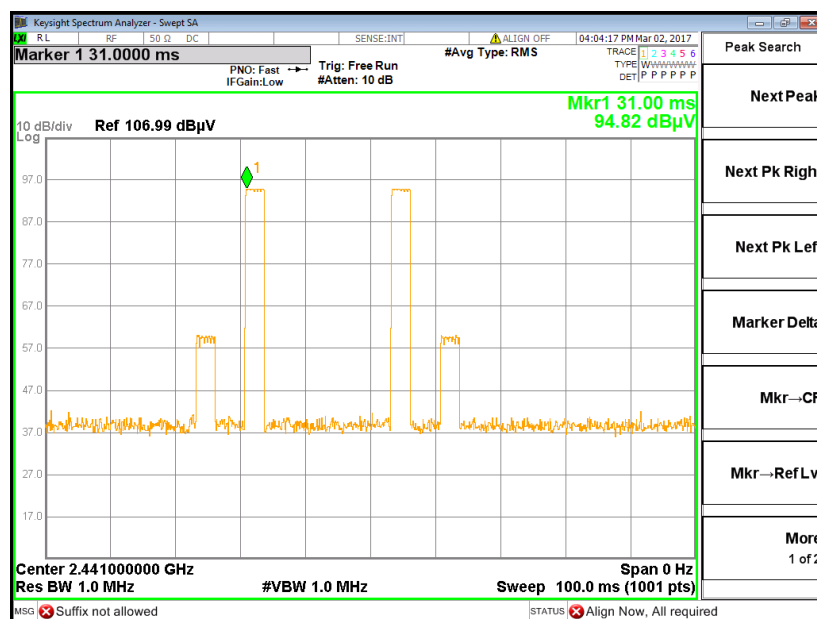
2.4GHz 2400~2483.5MHz
BT (Harmonic @ 3m)

BT	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
ANT	BT CH39 2441MHz	
1	Horizontal	Vertical
Peak Avg.	 Site : 03CH11-HY Condition : PEAK_74 3m 9170 SHF HORM_150809 HORIZONTAL Detector : Peak Project : 712016-02	 Site : 03CH11-HY Condition : PEAK_74 3m 9170 SHF HORM_150809 VERTICAL Detector : Peak Project : 712016-02

Emission below 1GHz
2.4GHz BT (LF)

BT	2.4GHz 2400~2483.5MHz	
ANT	BT LF	
1	Horizontal	Vertical
QP / Peak	 Site : 03CH11-HY Condition : QP 3m BT-LOG 6111D-LF_ETC HORIZONTAL Detector : Peak Project : 712016-02	 Site : 03CH11-HY Condition : QP 3m BT-LOG 6111D-LF_ETC VERTICAL Detector : Peak Project : 712016-02

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 = $2 * 2.89 / 100 = 5.78 \%$
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 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. $[100\text{ms} / 57.6\text{ms}] = 2 \text{ hops}$

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,

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