

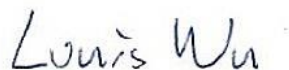


FCC CO-LOCATION RADIO TEST REPORT

FCC ID : A4RGQML3
Equipment : Phone
Applicant : Google LLC
1600 Amphitheatre Parkway,
Mountain View, California, 94043 USA
Standard : FCC Part 15 Subpart E §15.407

The product was received on Apr. 07, 2022 and testing was performed from Apr. 13, 2022 to May 18, 2022. We, Sporton International Inc. Wensan Laboratory, would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International Inc. Wensan Laboratory, the test report shall not be reproduced except in full.



Approved by: Louis Wu

Sporton International Inc. Wensan Laboratory

No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City 333010, Taiwan (R.O.C.)



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History of this test report

Report No.	Version	Description	Issued Date
FR1O2843-05I	01	Initial issue of report	Jun. 14, 2022

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	15.407(b)	Unwanted Emissions	Pass	2.01 dB under the limit at 5729.880 MHz
3.2	15.203 15.407(a)	Antenna Requirement	Pass	-

Declaration of Conformity:

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

Comments and Explanations:

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

Reviewed by: William Chen

Report Producer: Clio Lo



1 General Description

1.1 Product Feature of Equipment Under Test

Product Feature	
Equipment	Phone
FCC ID	A4RGQML3
EUT supports Radios application	GSM/EGPRS/WCDMA/HSPA/LTE/5G NR/NFC/GNSS/ WPC/WPT WLAN 11b/g/n HT20 WLAN 11a/n HT20/HT40 WLAN 11ac VHT20/VHT40/VHT80/VHT160 WLAN 11ax HE20/HE40/HE80/HE160 Bluetooth BR/EDR/LE

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

EUT Information List	
S/N	Performed Test Item
23121FDH20002A	Radiated Spurious Emission

1.2 Product Specification of Equipment Under Test

Product Specification is subject to this standard			
Tx/Rx Channel Frequency Range	2402 MHz ~ 2480 MHz 2412 MHz ~ 2472 MHz 5500 MHz ~ 5720 MHz		
Antenna Type / Gain	<Bluetooth> <Ant. 4> : IFA Antenna with gain -0.5 dBi <Ant. 3> : Loop Antenna with gain -1.5 dBi <2412 MHz ~ 2472 MHz> <Ant. 4> : IFA Antenna with gain -0.5 dBi <Ant. 3> : Loop Antenna with gain -1.5 dBi <5500 MHz ~ 5720 MHz> <Ant. 4> : IFA Antenna with gain -4.0 dBi <Ant. 3> : Loop Antenna with gain -2.8 dBi		
Type of Modulation	Bluetooth BR (1Mbps) : GFSK Bluetooth LE: GFSK 802.11g : OFDM (BPSK / QPSK / 16QAM / 64QAM) 802.11ax : OFDMA (BPSK / QPSK / 16QAM / 64QAM / 256QAM / 1024QAM)		
Antenna Function for Transmitter		Ant. 4	Ant. 3
	Bluetooth Bluetooth-LE 802.11 g/ax MIMO	V	V

Remark:

1. MIMO Ant. 4+3 is a calculated result from sum of the power MIMO Ant. 4 and MIMO Ant. 3.
2. The above EUT's information was declared by manufacturer. Please refer to Comments and Explanations in report summary.



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. Wensan Laboratory
Test Site Location	No.58, Aly. 75, Ln. 564, Wenhua 3rd, Rd., Guishan Dist., Taoyuan City 333010, Taiwan (R.O.C.) TEL: +886-3-327-0868 FAX: +886-3-327-0855
Test Site No.	Sporton Site No.
	03CH16-HY

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

FCC designation No.: TW3786

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 E
- ♦ FCC Part 15 Subpart C §15.247
- ♦ FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05r02
- ♦ FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01.
- ♦ FCC KDB 414788 D01 Radiated Test Site v01r01.
- ♦ FCC KDB 662911 D01 Multiple Transmitter Output v02r01.
- ♦ 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.

2 Test Configuration of Equipment Under Test

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: radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, the measured emission level of the EUT was maximized by rotating the EUT on a turntable, adjusting the orientation of the EUT and EUT antenna in three orthogonal axis (X: flat, Y: portrait, Z: landscape) and accessory (Adapter or Earphone), and adjusting the measurement antenna orientation, following C63.10 exploratory test procedures and find X plane with Adapter as worst plane.

2.1 Carrier Frequency and Channel

2402-2480 MHz Bluetooth BR		2402-2480 MHz Bluetooth – LE for 1Mbps	
Channel	Freq. (MHz)	Channel	Freq. (MHz)
78	2480	39	2480

2412-2472 MHz 802.11g		5470~5725 MHz 802.11a	
Channel	Freq. (MHz)	Channel	Freq. (MHz)
01	2412	140	5700

2.2 Test Mode

Final test modes are considering the modulation and worse data rates as below table.

<Co-Location>

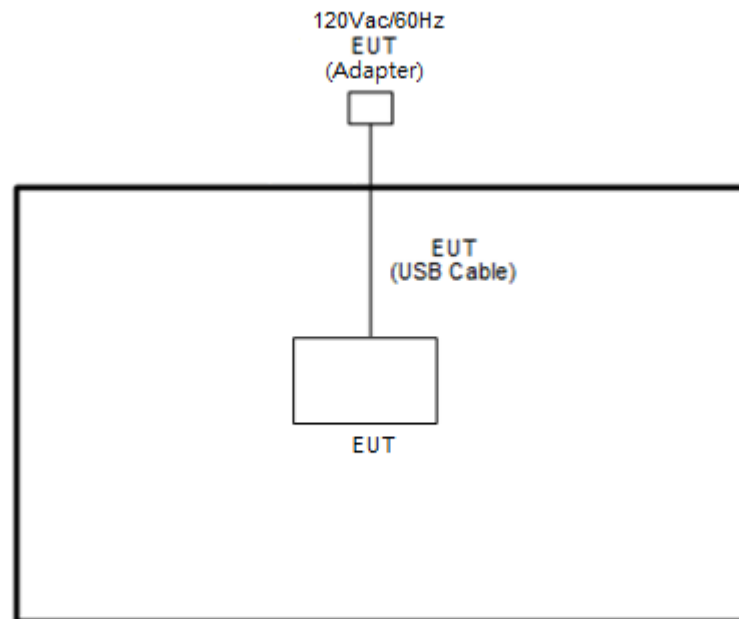
Test Mode	Modulation	Data Rate
Mode 1	Bluetooth for MIMO <Ant. 4+3> + WLAN 5GHz 802.11a for MIMO <Ant. 4+3>	1Mbps + MCS0
Mode 2	Bluetooth-LE for Ant. 4 + WLAN 5GHz 802.11a for MIMO < Ant. 4+3>	1Mbps + MCS0
Mode 3	WLAN 2.4GHz 802.11g for MIMO <Ant. 4+3> + WLAN 5GHz 802.11a for MIMO <Ant. 4+3>	1Mbps + MCS0

Remark:

1. For Radiated Test Cases, the tests were performed with Adapter 2 and USB Cable 1.
2. During the preliminary test, both charging modes (Adapter mode and WPC Charging mode) were verified. It is determined that the adapter mode is the worst case for official test.

2.3 Connection Diagram of Test System

<Co-Location Tx Mode>



2.4 EUT Operation Test Setup

The RF test items, utility "adb Command 1.0.36" was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to provide channel selection, power level, data rate and the application type and for continuous transmitting signals.

3 Test Result

3.1 Unwanted Emissions Measurement

This section is to measure unwanted emissions through radiated measurement for band edge spurious emissions and out of band emissions measurement.

3.1.1 Limit of Unwanted Emissions

- (1) Unwanted spurious emissions fallen in restricted bands shall comply with the general field strength limits as below table:

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

Note: The following formula is used to convert the EIRP to field strength.

$$E = \frac{1000000\sqrt{30P}}{3} \mu\text{V/m, where P is the eirp (Watts)}$$

EIRP (dBm)	Field Strength at 3m (dBμV/m)
- 27	68.3

- (2) KDB789033 D02 v02r01 G)2)c)

(i) Sections 15.407(b)(1-3) specifies the unwanted emissions limit for the U-NII-1 and U-NII-2 bands. As specified, emissions above 1000 MHz that are outside of the restricted bands are subject to a peak emission limit of -27 dBm/MHz.

(ii) Section 15.407(b)(4) specifies the unwanted emissions limit for the U-NII-3 band. A band emissions mask is specified in Section 15.407(b)(4)(i). The emission limits are based on the use of a peak detector.

3.1.2 Measuring Instruments

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

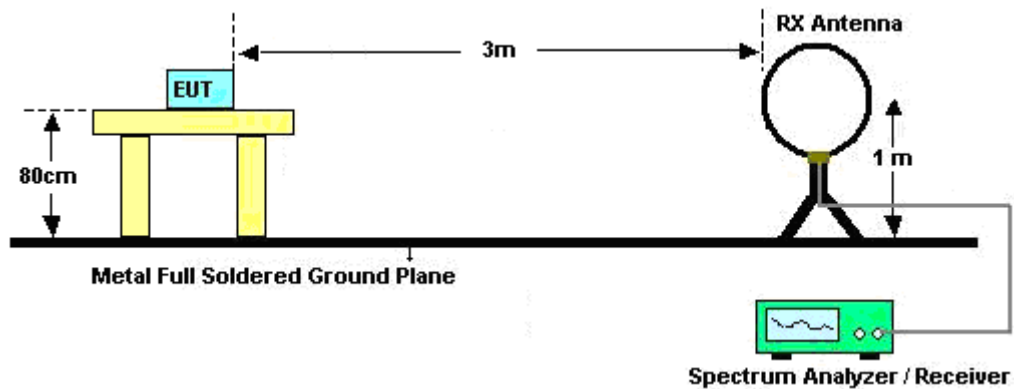
3.1.3 Test Procedures

1. The testing follows FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01. Section G) Unwanted emissions measurement.
 - (1) Procedure for Unwanted Emissions Measurements Below 1000MHz
 - RBW = 120 kHz
 - VBW = 300 kHz
 - Detector = Peak
 - Trace mode = max hold
 - (2) Procedure for Peak Unwanted Emissions Measurements Above 1000 MHz
 - RBW = 1 MHz
 - VBW $\geq$ 3 MHz
 - Detector = Peak
 - Sweep time = auto
 - Trace mode = max hold
 - (3) Procedures for Average Unwanted Emissions Measurements Above 1000MHz
 - RBW = 1 MHz
 - VBW = 10 Hz, when duty cycle is no less than 98 percent.
 - VBW $\geq$ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.
2. The EUT is placed on a turntable with 0.8 meter for frequency below 1 GHz and 1.5 meter for frequency above 1 GHz respectively above ground.
3. The EUT is set 3 meters away from the receiving antenna which is mounted on the top of a variable height antenna tower.
4. The antenna is a broadband antenna and its height is adjusted between one meter and four meters above ground to find the maximum value of the field strength for both horizontal polarization and vertical polarization of the antenna.
5. For each suspected emission, the EUT is arranged to its worst case and then adjust the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading.

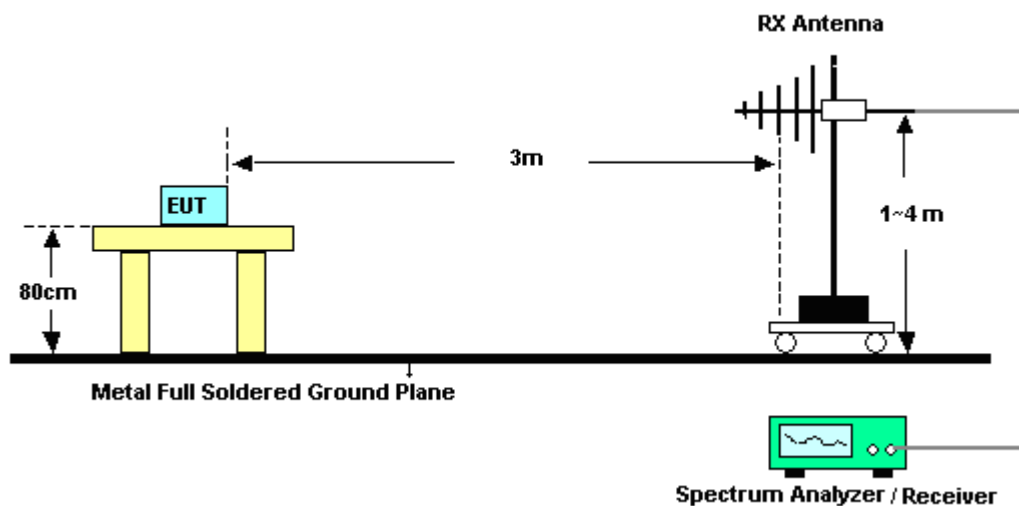
6. Radiated testing below 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading. When there is no suspected emission found and the emission level is with at least 6 dB margin against QP limit line, the position is marked as “-”.
7. Radiated testing above 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading for scanning all frequencies. When there is no suspected emission found and the harmonic emission level is with at least 6 dB margin against average limit line, the position is marked as “-”.

3.1.4 Test Setup

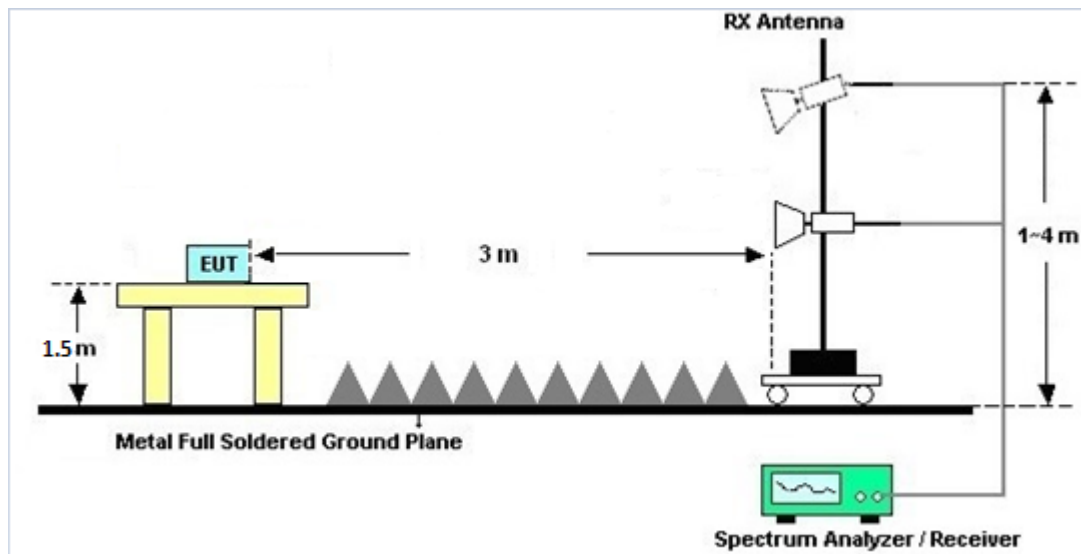
For radiated emissions below 30MHz



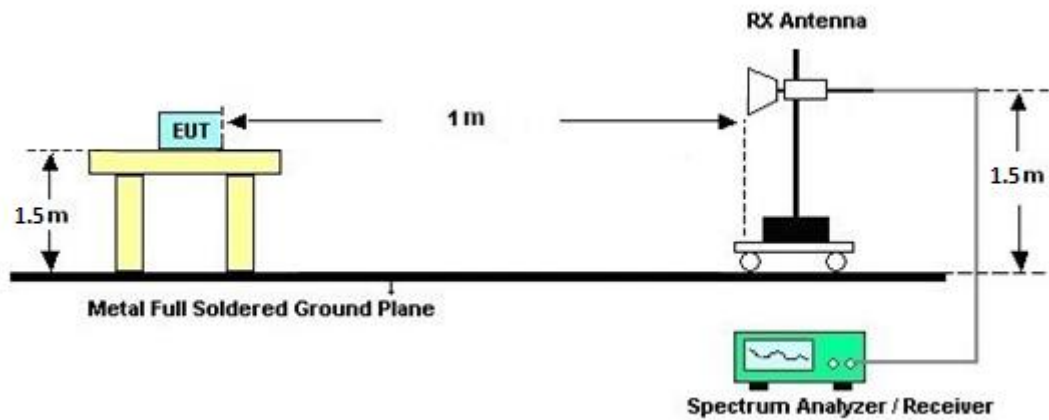
For radiated emissions from 30MHz to 1GHz



For radiated test from 1GHz to 18GHz



For radiated test above 18GHz



**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 was not reported.

There is adequate comparison measurement of both open-field test site and alternative test site - semi-Anechoic chamber according to 414788 D01 Radiated Test Site v01r01, and the result came out very similar.

3.1.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix A and B.

3.1.7 Duty Cycle

Please refer to Appendix C.

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

Please refer to Appendix A and B.



3.2 Antenna Requirements

3.2.1 Standard Applicable

<Bluetooth, Bluetooth-LE, WLAN 2.4GHz and WLAN 5GHz>

If directional gain of transmitting antennas is greater than 6dBi, the power and the peak power spectral density 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.

3.2.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.



4 List of Measuring Equipment

Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Sep. 07, 2021	Apr. 13, 2022~ May 18, 2022	Sep. 06, 2022	Radiation (03CH16-HY)
Bilog Antenna	TESEQ	CBL 6111D & 00802N1D01N -06	47020 & 06	30MHz to 1GHz	Oct. 09, 2021	Apr. 13, 2022~ May 18, 2022	Oct. 08, 2022	Radiation (03CH16-HY)
Horn Antenna	SCHWARZBE CK	BBHA 9120 D	9120D-02114	1G~18GHz	Aug. 04, 2021	Apr. 13, 2022~ May 18, 2022	Aug. 03, 2022	Radiation (03CH16-HY)
SHF-EHF Horn Antenna	SCHWARZBE CK	BBHA 9170	00993	18GHz ~40GHz	Nov. 30, 2021	Apr. 13, 2022~ May 18, 2022	Nov. 29, 2022	Radiation (03CH16-HY)
Amplifier	SONOMA	310N	371607	9kHz~1G	Jul. 05, 2021	Apr. 13, 2022~ May 18, 2022	Jul. 04, 2022	Radiation (03CH16-HY)
Amplifier	EMCI	EMC051845S E	980729	1-18GHz	Jul. 09, 2021	Apr. 13, 2022~ May 18, 2022	Jul. 08, 2022	Radiation (03CH16-HY)
Preamplifier	EMEC	EM18G40G	060801	18GHz~40GHz	Jun. 22, 2021	Apr. 13, 2022~ May 18, 2022	Jun. 21, 2022	Radiation (03CH16-HY)
Preamplifier	Keysight	83017A	MY53270264	1GHz~26.5GHz	Dec. 09, 2021	Apr. 13, 2022~ May 18, 2022	Dec. 08, 2022	Radiation (03CH16-HY)
EMI Test Receiver	Keysight	N9038A	MY59053012	3Hz~26.5GHz	Nov. 18, 2021	Apr. 13, 2022~ May 18, 2022	Nov. 17, 2022	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY11680/4P E	NA	Aug. 28, 2021	Apr. 13, 2022~ May 18, 2022	Aug. 27, 2022	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY11688/4P E	NA	Aug. 28, 2021	Apr. 13, 2022~ May 18, 2022	Aug. 27, 2022	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	EC-A5-300-5 757	NA	Aug. 28, 2021	Apr. 13, 2022~ May 18, 2022	Aug. 27, 2022	Radiation (03CH16-HY)
Software	Audix	E3 6.2009-8-24	RK-001136	N/A	N/A	Apr. 13, 2022~ May 18, 2022	N/A	Radiation (03CH16-HY)
Antenna Mast	ChainTek	MBS-520-1	N/A	1m~4m	N/A	Apr. 13, 2022~ May 18, 2022	N/A	Radiation (03CH16-HY)
Turn Table	ChainTek	T-200-S-1	N/A	0~360 Degree	N/A	Apr. 13, 2022~ May 18, 2022	N/A	Radiation (03CH16-HY)



5 Uncertainty of Evaluation

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.8 dB
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Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

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

Measuring Uncertainty for a Level of Confidence of 95% ($U = 2Uc(y)$)	5.8 dB
--	--------



Appendix A. Radiated Spurious Emission

Test Engineer :	Karl Hou and Andy Yang	Temperature :	20~25°C
		Relative Humidity :	50~60%

2.4GHz 2402~2480MHz + Band 3 - 5470~5725MHz

MIMO <Ant. 4+3>_BT_Tx_CH78 (Band Edge @ 3m)

BT Ant.	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Path Loss	Preampl Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
4+3		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH 78 2480MHz	*	2480	110.35	-	-	104.54	27.4	8.46	30.05	100	140	P	H
	*	2480	85.59	-	-	-	-	-	-	-	-	P	H
		2484.4	49.78	-24.22	74	43.95	27.4	8.47	30.04	100	140	P	H
		2484.4	25.02	-28.98	54	-	-	-	-	-	-	A	H
													H
													H
	*	2480	108.77	34.77	74	102.96	27.4	8.46	30.05	400	89	P	V
	*	2480	84.01	30.01	54	-	-	-	-	-	-	P	V
		2486.28	46.72	-27.28	74	40.88	27.4	8.48	30.04	400	89	P	V
		2486.28	21.96	-32.04	54	-	-	-	-	-	-	A	V
													V
													V



MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Band Edge @ 3m)

WIFI Ant. 4+3	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)
802.11a CH 140 5700MHz	*	5700	108.52	40.32	68.2	93.4	31.8	12.93	29.61	100	62	P	H
	*	5700	101.09	47.09	54	85.97	31.8	12.93	29.61	100	62	A	H
		5729.88	66.19	-2.01	68.2	50.93	31.92	12.95	29.61	100	62	P	H
													H
													H
													H
	*	5700	108.44	40.24	68.2	93.32	31.8	12.93	29.61	342	115	P	V
	*	5700	100.57	46.57	54	85.45	31.8	12.93	29.61	342	115	A	V
		5731.8	63.3	-4.9	68.2	48.03	31.93	12.95	29.61	342	115	P	V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

MIMO <Ant. 4+3>_BT_Tx_CH78 + MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Harmonic @ 3 m)

WIFI Ant. Simultaneously	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 + 802.11a CH 140 5700MHz		4960	56.51	-17.49	74	39.57	33.02	13.33	29.41	-	-	P	H
		7440	45.54	-28.46	74	48.54	36.22	16.45	55.67	-	-	P	H
		11400	47.37	-26.63	74	44.05	39.2	19.19	55.07	-	-	P	H
		14471	48.07	-25.93	74	40.26	40.4	21.73	54.32	-	-	P	H
		14471	42.39	-11.61	54	34.58	40.4	21.73	54.32	-	-	A	H
		17100	46.45	-21.75	68.2	39.12	37.7	25.03	55.4	-	-	P	H
		17989	52.38	-21.62	74	40.58	42.91	25.48	56.59	-	-	P	H
		17989	43.47	-10.53	54	31.67	42.91	25.48	56.59	-	-	A	H
													H
													H
													H
													H
		4960	56.63	-17.37	74	39.69	33.02	13.33	29.41	-	-	P	V
		7440	45.61	-28.39	74	48.61	36.22	16.45	55.67	-	-	P	V
		11400	47.75	-26.25	74	44.43	39.2	19.19	55.07	-	-	P	V
		14502	48.13	-20.07	68.2	40.3	40.4	21.76	54.33	-	-	P	V
		14502	42.62	-11.38	54	34.79	40.4	21.76	54.33	-	-	A	V
		17100	46.82	-21.38	68.2	39.49	37.7	25.03	55.4	-	-	P	V
		17956	52.88	-21.12	74	41.34	42.65	25.46	56.57	-	-	P	V
		17956	43.23	-10.77	54	31.69	42.65	25.46	56.57	-	-	A	V
													V
													V
													V
													V
Remark	1. No other spurious found.												
	2. All results are PASS against Peak and Average limit line.												
	3. The emission position marked as "-" means no suspected emission found with sufficient margin against limit line or noise floor only.												
	4. The emission level close to 18GHz is checked that the average emission level is noise floor only.												

Emission below 1GHz

MIMO <Ant. 4+3>_BT_Tx_CH78 + MIMO <Ant. 4+3>_802.11a_Tx_CH140 (LF)

[illegible]



2.4GHz 2402~2480MHz + Band 3 - 5470~5725MHz

Ant. 4_BLE_Tx_CH39 (Band Edge @ 3m)

BLE	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
4		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BLE CH 39 2480MHz	*	2480	110.9	-	-	95.17	27.4	18.38	30.05	100	140	P	H
	*	2480	110.43	-	-	94.7	27.4	18.38	30.05	100	140	P	H
		2494.48	56.5	-17.5	74	40.73	27.4	18.41	30.04	100	140	P	H
		2483.92	46.93	-7.07	54	31.18	27.4	18.39	30.04	100	140	A	H
												P	H
												A	H
	*	2480	109.45	-	-	93.72	27.4	18.38	30.05	400	80	P	V
	*	2480	108.89	-	-	93.16	27.4	18.38	30.05	400	80	P	V
		2498.52	56.47	-17.53	74	40.69	27.4	18.42	30.04	400	80	P	V
		2498.16	46.3	-7.7	54	30.52	27.4	18.42	30.04	400	80	A	V
												P	V
												A	V



MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Band Edge @ 3m)

WIFI Ant. 4+3	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)
802.11a CH 140 5700MHz	*	5700	108.29	-	-	93.17	31.8	12.93	29.61	100	62	P	H
	*	5700	100.56	-	-	85.44	31.8	12.93	29.61	100	62	A	H
		5729.8	65.96	-2.24	68.2	50.7	31.92	12.95	29.61	100	62	P	H
													H
													H
													H
	*	5700	108.2	-	-	93.08	31.8	12.93	29.61	342	116	P	V
	*	5700	99.44	-	-	84.32	31.8	12.93	29.61	342	116	A	V
		5727.16	62.26	-5.94	68.2	47.01	31.91	12.95	29.61	342	116	P	V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Ant. 4_BLE_Tx_CH39 + MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Harmonic @ 3 m)

WIFI Ant. Simultaneously	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)
BLE CH 39 2480MHz + 802.11a CH 140 5700MHz		4960	56.03	-17.97	74	39.09	33.02	13.33	29.41	-	-	P	H
		4960	45.18	-8.82	54	28.24	33.02	13.33	29.41	-	-	A	H
		7386	45.97	-28.03	74	48.68	36.41	16.54	55.66	-	-	P	H
		11400	47.01	-26.99	74	43.69	39.2	19.19	55.07	-	-	P	H
		14471	48.02	-25.98	74	40.21	40.4	21.73	54.32	-	-	P	H
		14471	42.42	-11.58	54	34.61	40.4	21.73	54.32	-	-	A	H
		17100	46.81	-21.39	68.2	39.48	37.7	25.03	55.4	-	-	P	H
		17945	53.19	-20.81	74	41.74	42.56	25.45	56.56	-	-	P	H
		17945	42.89	-11.11	54	31.44	42.56	25.45	56.56	-	-	A	H
													H
													H
													H
		4960	57.05	-16.95	74	40.11	33.02	13.33	29.41	-	-	P	V
		4960	45.29	-8.71	54	28.35	33.02	13.33	29.41	-	-	A	V
		7386	46.6	-27.4	74	49.31	36.41	16.54	55.66	-	-	P	V
		11400	47.46	-26.54	74	44.14	39.2	19.19	55.07	-	-	P	V
		14491	48.71	-25.29	74	40.89	40.4	21.75	54.33	-	-	P	V
		14491	42.43	-11.57	54	34.61	40.4	21.75	54.33	-	-	A	V
		17100	46.55	-21.65	68.2	39.22	37.7	25.03	55.4	-	-	P	V
		17956	52.26	-21.74	74	40.72	42.65	25.46	56.57	-	-	P	V
		17956	43.17	-10.83	54	31.63	42.65	25.46	56.57	-	-	A	V
													V
													V
													V
Remark	1. No other spurious found.												
	2. All results are PASS against Peak and Average limit line.												
	3. The emission position marked as "-" means no suspected emission found with sufficient margin against limit line or noise floor only.												
	4. The emission level close to 18GHz is checked that the average emission level is noise floor only.												



2.4GHz 2412~2472MHz + Band 3 - 5470~5725MHz

MIMO <Ant. 4+3>_802.11g_Tx_CH01 (Band Edge @ 3m)

WIFI	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
Ant				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
4+3		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
802.11g CH 01 2412MHz		2381.085	56.4	-17.6	74	40.96	27.32	18.2	30.08	100	98	P	H
		2377.62	44.89	-9.11	54	29.46	27.31	18.2	30.08	100	98	A	H
	*	2412	80.37	-	-	64.73	27.45	18.26	30.07	100	98	P	H
	*	2412	72.49	-	-	56.85	27.45	18.26	30.07	100	98	A	H
	*												H
													H
		2364.81	55.38	-18.62	74	40.03	27.26	18.17	30.08	367	94	P	V
		2383.5	44.66	-9.34	54	29.19	27.33	18.21	30.07	367	94	A	V
	*	2412	79.44	-	-	63.8	27.45	18.26	30.07	367	94	P	V
	*	2412	71.08	-	-	55.44	27.45	18.26	30.07	367	94	A	V
													V
													V



MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Band Edge @ 3m)

WIFI Ant. 4+3	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)
802.11a CH 140 5700MHz	*	5700	108.41	-	-	91.79	33.3	12.93	29.61	100	88	P	H
	*	5700	101.39	-	-	84.77	33.3	12.93	29.61	100	88	A	H
		5738.84	61.3	-6.9	68.2	44.42	33.53	12.96	29.61	100	88	P	H
													H
													H
													H
	*	5700	108.07	39.87	68.2	91.45	33.3	12.93	29.61	343	100	P	V
	*	5700	100.5	46.5	54	83.88	33.3	12.93	29.61	343	100	A	V
		5727.4	59.84	-8.36	68.2	43.04	33.46	12.95	29.61	343	100	P	V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												



MIMO <Ant. 4+3>_802.11g_Tx_CH01 + MIMO <Ant. 4+3>_802.11a_Tx_CH140

(Harmonic @ 3 m)

WIFI Ant. Simultaneously	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)
802.11g CH 01 2412MHz + 802.11a CH 140 5700MHz		4824	56.15	-17.85	74	39.75	32.45	13.37	29.42	-	-	P	H
		4824	45.1	-8.9	54	28.7	32.45	13.37	29.42	-	-	A	H
		11400	47.07	-26.93	74	43.75	39.2	19.19	55.07	-	-	P	H
		14471	47.98	-26.02	74	40.17	40.4	21.73	54.32	-	-	P	H
		14471	42.47	-11.53	54	34.66	40.4	21.73	54.32	-	-	P	H
		17100	46.84	-21.36	68.2	39.51	37.7	25.03	55.4	-	-	A	H
		17956	53.11	-20.89	74	41.57	42.65	25.46	56.57	-	-	P	H
		17956	43.28	-10.72	54	31.74	42.65	25.46	56.57	-	-	A	H
													H
													H
													H
		4824	55.95	-18.05	74	39.55	32.45	13.37	29.42	-	-	P	V
		4824	45.07	-8.93	54	28.67	32.45	13.37	29.42	-	-	A	V
		11400	46.64	-27.36	74	43.32	39.2	19.19	55.07	-	-	P	V
		14502	48.56	-19.64	68.2	40.73	40.4	21.76	54.33	-	-	P	V
		14502	42.59	-11.41	54	34.76	40.4	21.76	54.33	-	-	P	V
		17100	46.07	-22.13	68.2	38.74	37.7	25.03	55.4	-	-	A	V
		17956	52.96	-21.04	74	41.42	42.65	25.46	56.57	-	-	P	V
		17956	42.82	-11.18	54	31.28	42.65	25.46	56.57	-	-	A	V
													V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. The emission position marked as "-" means no suspected emission found with sufficient margin against limit line or noise floor only. 4. The emission level close to 18GHz is checked that the average emission level is noise floor only.												



Note symbol

*	Fundamental Frequency which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
-	The signal is Unintentional Radiators .
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	Path	Preamp	Ant	Table	Peak	Pol.
Ant.				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
Simultaneously		(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. 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”.



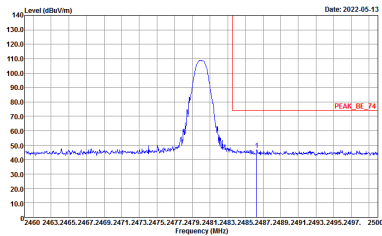
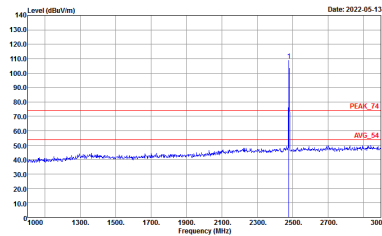
Appendix B. Radiated Spurious Emission Plots

Test Engineer :	Karl Hou and Andy Yang	Temperature :	20~25°C
		Relative Humidity :	50~60%

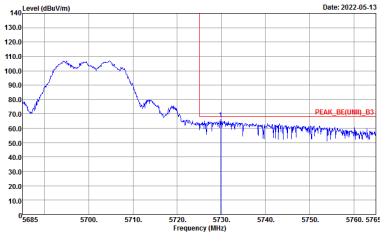
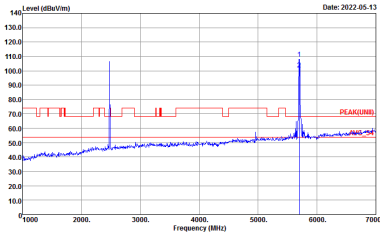
2.4GHz 2402~2480MHz + Band 3 - 5470~5725MHz

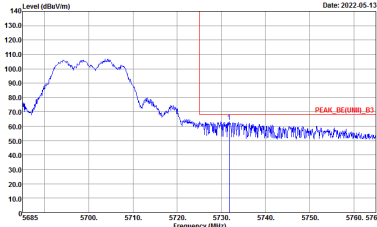
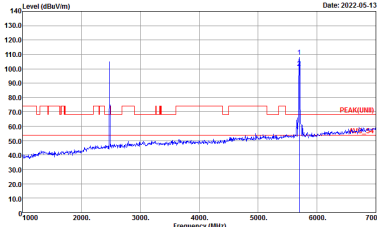
MIMO <Ant. 4+3>_BT_Tx_CH78 (Band Edge @ 3m)

BT	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BT CH78 2480MHz	
4+3	Horizontal	Fundamental
Peak	Site : 03CH16-HY Condition : PEAK_BC_74 3m 91200_1522_211012 HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	Site : 03CH16-HY Condition : PEAK_74 3m 91200_1522_211012 HORIZONTAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto

ANT	BT CH78 2480MHz	
4+3	Vertical	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 91200_1522_211012 VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK_74 3m 91200_1522_211012 VERTICAL RBW:1000.000KHz VBW:3000.000KHz SWT:Auto

MIMO <Ant. 4+3>_802.11a_Tx_ CH140 (Band Edge @ 3m)

WIFI	5470~5725MHz Band Edge @ 3m	
ANT	802.11a CH140 5700MHz	
4+3	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE[UNL1], B3 3m 9120D_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK[UNL1] 3m 9120D_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto

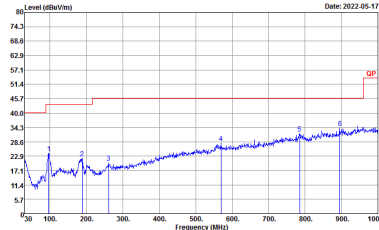
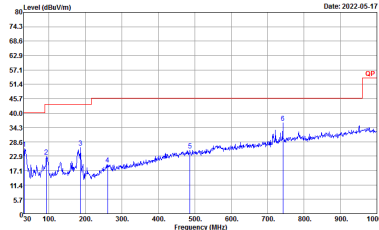
WIFI	5470~5725MHz Band Edge @ 3m	
ANT	802.11a CH140 5700MHz	
4+3	Vertical	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE(UNII)_B3 3m 9120D_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK(UNII) 3m 9120D_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto



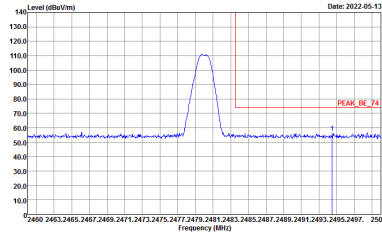
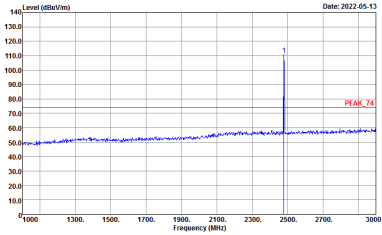
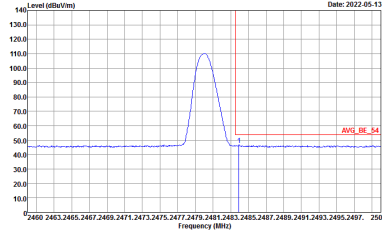
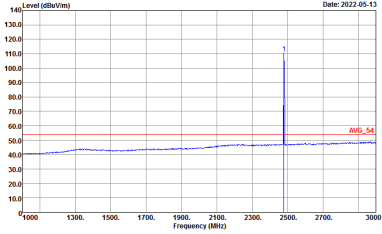
MIMO <Ant. 4+3>_BT_Tx_ CH78 + MIMO <Ant. 4+3>_802.11a_Tx_ CH140 (Harmonic @ 3 m)

ANT	BT CH78 2480MHz + 802.11a CH140 5700MHz	
Simultaneously	Horizontal	Vertical
Peak Avg.	Site : 03CH16-HY Condition : PEAK_74 3m 91200_02114_210804 HORIZONTAL	Site : 03CH16-HY Condition : PEAK_74 3m 91200_02114_210804 VERTICAL

Emission below 1GHz
MIMO <Ant. 4+3>_BT_Tx_CH78 + MIMO <Ant. 4+3>_802.11a_Tx_CH140 (LF)

ANT	BT CH78 2480MHz + 802.11a CH140 5700MHz	
Simultaneously	Horizontal	Vertical
QP / Peak	 Site : 03CH16-HY Condition : QP 3m B1L06_47020_211009 HORIZONTAL	 Site : 03CH16-HY Condition : QP 3m B1L06_47020_211009 VERTICAL

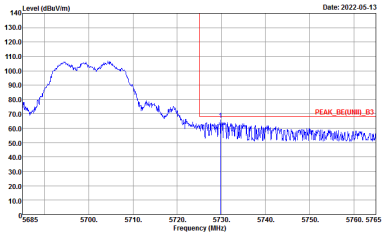
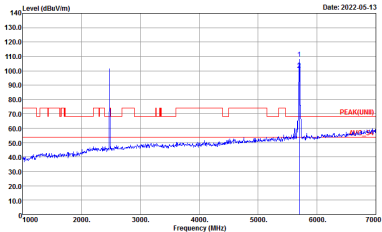
2.4GHz 2402~2480MHz + Band 3 - 5470~5725MHz
Ant. 4_BLE_Tx_CH39 (Band Edge @ 3m)

BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BLE_CH39 2480MHz	
4	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 91200_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK_74 3m 91200_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 91200_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto	 Site : 03CH16-HY Condition : AVG_54 3m 91200_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto

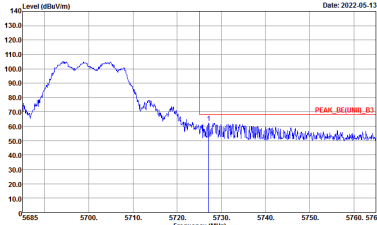
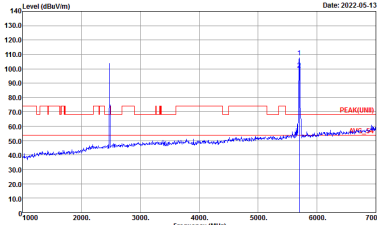


BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	BLE_CH39 2480MHz	
4	Vertical	Fundamental
Peak	Site : 03CH16-HY Condition : PEAK_BE_74 3m 91200_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	Site : 03CH16-HY Condition : PEAK_74 3m 91200_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto
Avg.	Site : 03CH16-HY Condition : AVG_BE_54 3m 91200_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto	Site : 03CH16-HY Condition : AVG_54 3m 91200_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto

MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Band Edge @ 3m)

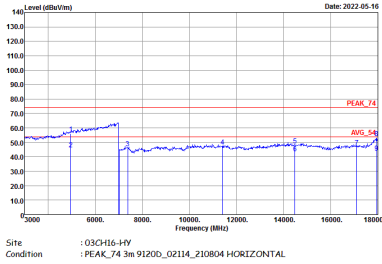
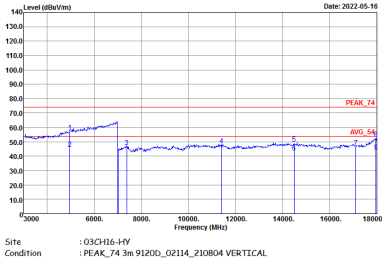
WIFI	5470~5725MHz Band Edge @ 3m	
ANT	802.11a CH140 5700MHz	
4+3	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE(UBI)_B3 3m 9120D_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK(UBI) 3m 9120D_1522_211012 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto



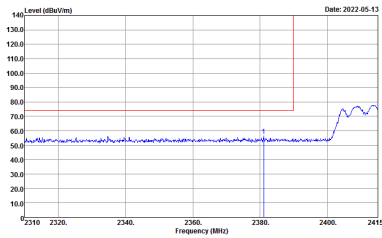
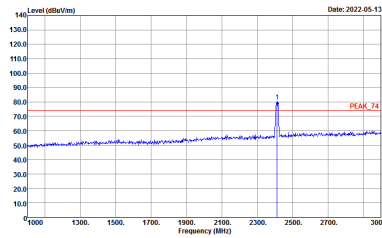
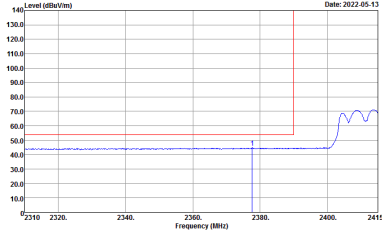
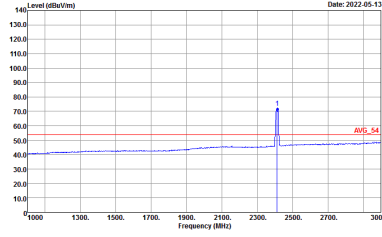
WIFI	5470~5725MHz Band Edge @ 3m	
ANT	802.11a CH140 5700MHz	
4+3	Vertical	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE(UH1)_B3 3m 9120D_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK_FU(B3) 3m 9120D_1522_211012 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto



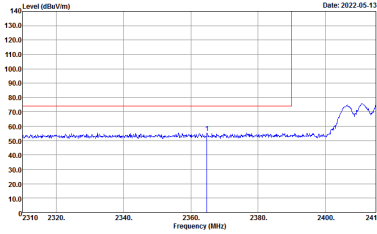
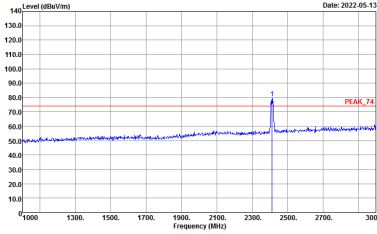
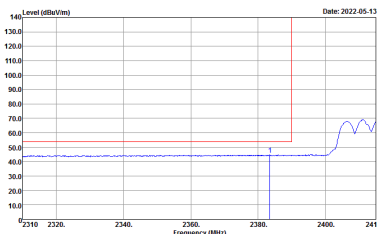
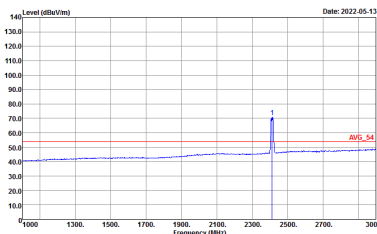
Ant. 4_BLE_Tx_CH39 + MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Harmonic @ 3 m)

ANT	BLE_CH39 2480MHz + 802.11a CH140 5700MHz	
Simultaneously	Horizontal	Vertical
Peak Avg.		

2.4GHz 2412~2472MHz + Band 3 - 5470~5725MHz
MIMO <Ant. 4+3>_802.11g_Tx_CH01 (Band Edge @ 3m)

WIFI	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	802.11g CH01 2412MHz	
4+3	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_02114_210804 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_02114_210804 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_02114_210804 HORIZONTAL : RBW:1000.000KHz VBW:1000KHz SWT:Auto	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_02114_210804 HORIZONTAL : RBW:1000.000KHz VBW:1000KHz SWT:Auto



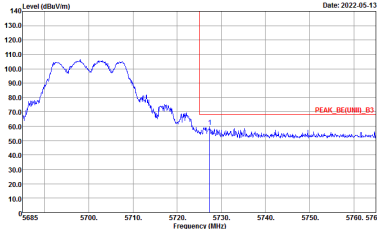
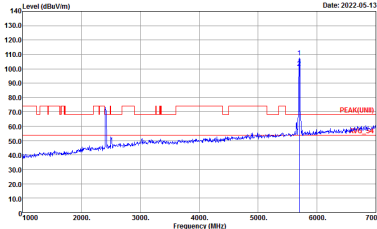
WIFI	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
ANT	802.11g CH01 2412MHz	
4+3	Vertical	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_02114_210804 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_02114_210804 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_02114_210804 VERTICAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_02114_210804 VERTICAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto



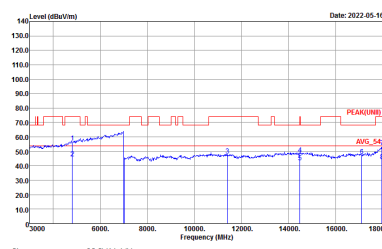
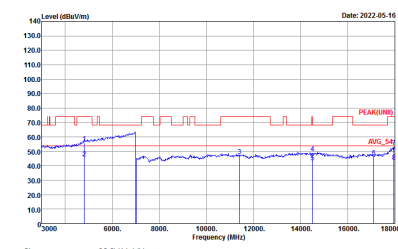
MIMO <Ant. 4+3>_802.11a_Tx_CH140 (Band Edge @ 3m)

WIFI	5470~5725MHz Band Edge @ 3m	
ANT	802.11a CH140 5700MHz	
4+3	Horizontal	Fundamental
Peak	Site : 03CH16-HY Condition : PEAK_BE(UNIT)_83 3m 9120D_0211A_210804 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	Site : 03CH16-HY Condition : PEAK(UNIT) 3m 9120D_0211A_210804 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto



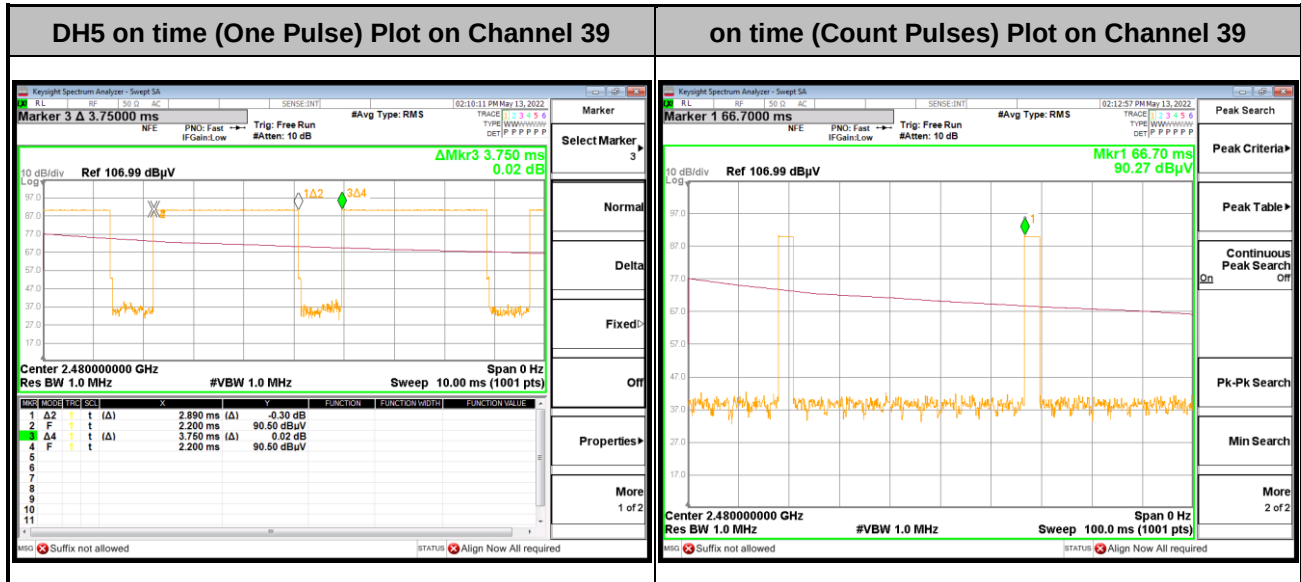
WIFI	5470~5725MHz Band Edge @ 3m	
ANT	802.11a CH140 5700MHz	
4+3	Vertical	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE(UNI)_B3 3m 9120D_02114_210804 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto	 Site : 03CH16-HY Condition : PEAK_F(UNI)_B3 3m 9120D_02114_210804 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto

MIMO <Ant. 4+3>_802.11g_Tx_CH01 + MIMO <Ant. 4+3>_802.11a_Tx_CH140
(Harmonic @ 3 m)

ANT	802.11g CH01 2412MHz + 802.11a CH140 5700MHz	
Simultaneously	Horizontal	Vertical
Peak Avg.	 Site : 03CH16-HY Condition : PEAK(UNIT) 3m 91200_02114_210804 HORIZONTAL	 Site : 03CH16-HY Condition : PEAK(UNIT) 3m 91200_02114_210804 VERTICAL

Appendix C. Duty Cycle Plots

MIMO <Ant. 4+3>



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. 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 on time period to have DH5 packet completing one hopping sequence is

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

There cannot be 2 complete hopping sequences within 100ms period, considering the random hopping behavior, maximum 2 hops can be possibly observed within the period. $[100 \text{ ms} / 57.8 \text{ ms}] = 2 \text{ hops}$

Thus, the maximum possible ON time:

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

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

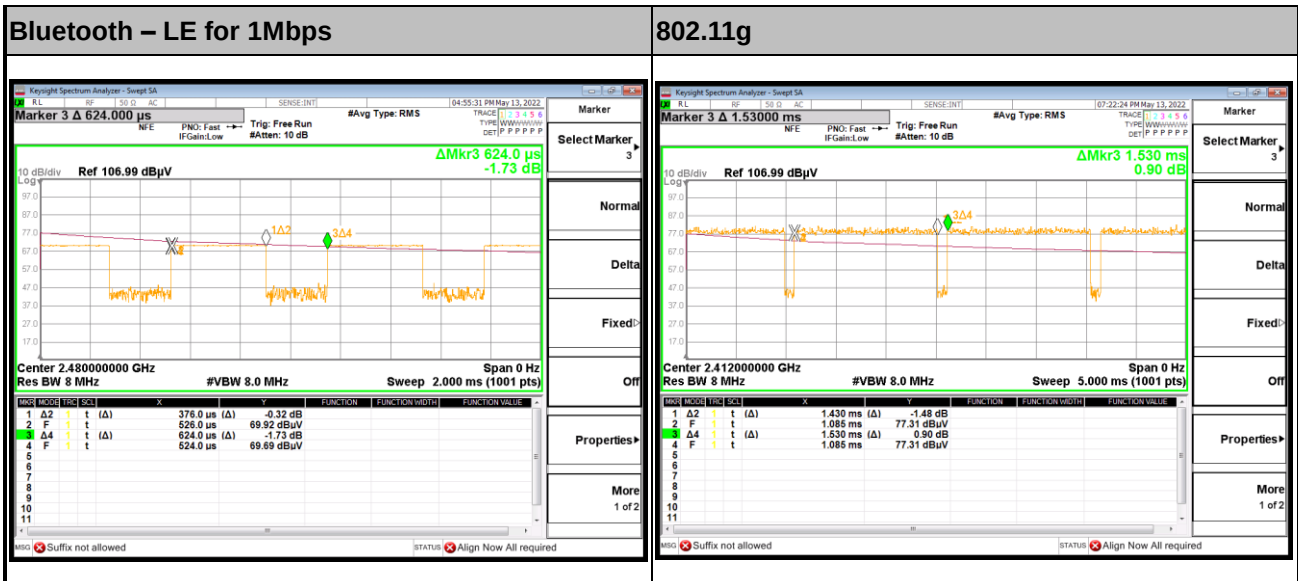
$$20 \times \log(5.78 \text{ ms}/100 \text{ ms}) = -24.76 \text{ dB}$$



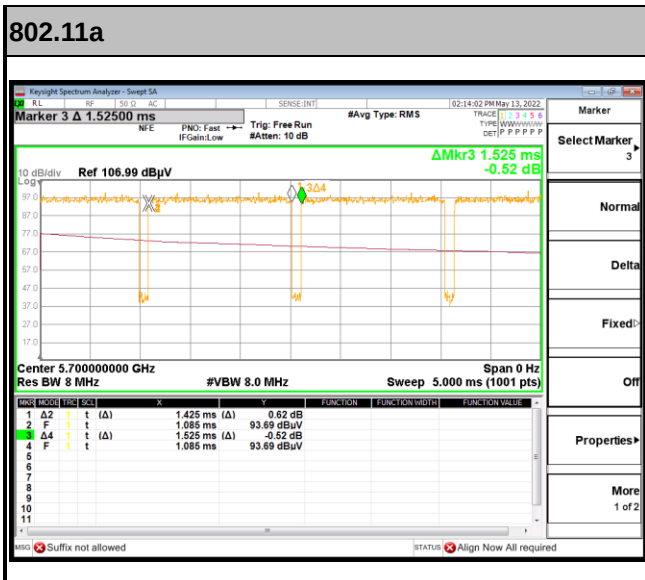
Antenna	Band	Duty Cycle(%)	T(us)	1/T(kHz)	VBW Setting
4	Bluetooth – LE for 1Mbps	60.26	376	2.66	3kHz
4+3	802.11g	93.46	1430	0.70	1kHz
4+3	802.11a	93.44	1425	0.70	1kHz

<Ant. 4>

MIMO <Ant. 4+3>



MIMO <Ant. 4+3>



—THE END—