FCC CO-LOCATION RADIO TEST REPORT

FCC ID	:	**2AUPE-8959**
Equipment	:	**Digital Media Receiver**
Model Name	:	**T4E4AT**
Applicant	:	**Turley White LLC** **35 Village Road, Suite 100** **Middleton, MA 01949** **United States**
Standard	:	**FCC Part 15 Subpart E §15.407**

The product was received on May 07, 2020 and testing was started from Jul. 13, 2020 and completed on Jul. 16, 2020. We, SPORTON INTERNATIONAL INC., EMC & Wireless Communications Laboratory, would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this 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

Approved by: Louis Wu

SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory
No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)

Table of Contents

History of this test report **3**
Summary of Test Result **4**
1 General Description **5**
1.1 Product Feature of Equipment Under Test 5
1.2 Product Specification of Equipment Under Test 5
1.3 Modification of EUT 5
1.4 Testing Location 6
1.5 Applicable Standards 6
2 Test Configuration of Equipment Under Test **7**
2.1 Carrier Frequency and Channel 7
2.2 Test Mode 7
2.3 Connection Diagram of Test System 8
2.4 EUT Operation Test Setup 8
3 Test Result **9**
3.1 Unwanted Emissions Measurement 9
3.2 Antenna Requirements 14
4 List of Measuring Equipment **15**
5 Uncertainty of Evaluation **16**
Appendix A. Radiated Spurious Emission
Appendix B. Radiated Spurious Emission Plots
Appendix C. Duty Cycle Plots

History of this test report

Report No.	Version	Description	Issued Date
FR020110-01G	01	Initial issue of report	Jul. 22, 2020

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)
3.1	15.407(b)	Unwanted Emissions	Pass
3.2	15.203 15.407(a)	Antenna Requirement	Pass

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: Tina Chuang

1 General Description

1.1 Product Feature of Equipment Under Test

Product Feature	
Equipment	Digital Media Receiver
Model Name	T4E4AT
FCC ID	2AUPE-8959
EUT supports Radios application	WLAN 11b/g/n HT20 WLAN 11a/n HT20/HT40 WLAN 11ac VHT20/VHT40/VHT80 Bluetooth BR/EDR/LE Zigbee/FSK/LoRa

1.2 Product Specification of Equipment Under Test

Standards-related Product Specification	
Tx/Rx Frequency Range	Zigbee: 2405 MHz ~ 2475 MHz LoRa: 902.5 MHz ~ 926.5 MHz Bluetooth-LE: 2402 MHz ~ 2480 MHz 802.11b: 2412 MHz ~ 2472 MHz 802.11a : 5250 MHz ~ 5350 MHz
Antenna Gain / Gain	Zigbee: Inverted F type with gain 2.15 dBi LoRa: Inverted F type Antenna with gain -0.48 dBi Bluetooth-LE: Inverted F type with gain 2.34 dBi **<2412 MHz ~ 2472 MHz>** **<Ant. 1>:** Loop Antenna with gain 4.89 dBi **<Ant. 2>:** Loop Antenna with gain 3.52 dBi **<5250MHz ~ 5350 MHz>** **<Ant. 1>:** Loop Antenna with gain 3.28 dBi **<Ant. 2>:** Loop Antenna with gain 3.56 dBi
Type of Modulation	Zigbee: OQPSK LoRa: LoRa Bluetooth-LE: GFSK 802.11b: DSSS (DBPSK / DQPSK / CCK) 802.11a : OFDM (BPSK / QPSK / 16QAM / 64QAM)

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.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.**
	03CH16-HY

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

FCC designation No.: 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 E
- FCC KDB 789033 D02 General UNII Test Procedures New Rules v02r01.
- FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05r02
- 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).

2.1 Carrier Frequency and Channel

2405-2480 MHz Zigbee		902.5 MHz ~ 926.5 MHz LoRa	
Channel	**Freq. (MHz)**	**Channel**	**Freq. (MHz)**
11	2405	16	914.5

2400-2483.5 MHz Bluetooth-LE (2Mbps)	
Channel	**Freq. (MHz)**
0	2402
1	2404
19	2440

2400-2483.5 MHz 802.11b		5725-5850 MHz 802.11a	
Channel	**Freq. (MHz)**	**Channel**	**Freq. (MHz)**
1	2412	64	5320

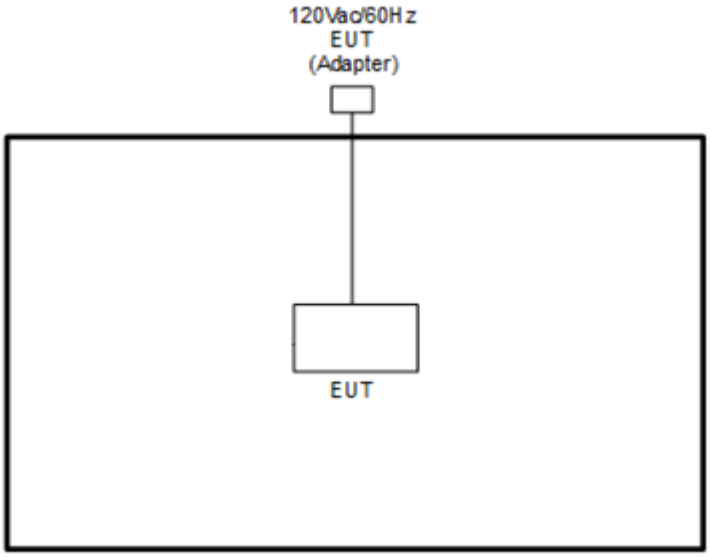
2.2 Test Mode

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

<Co-Location>

Modulation	Data Rate
Bluetooth - LE for Ant. 3 + 2.4GHz 802.11b for Ant. 1+2 +Zigbee for Ant. 4+ Lora for Ant. 4	**2Mbps + 1Mbps +500kHz**
Bluetooth - LE for Ant. 3 + 5GHz 802.11a for Ant. 1+2 + +Zigbee for Ant. 4+ Lora for Ant. 4	**2Mbps + 6Mbps + 500kHz**

2.3 Connection Diagram of Test System



2.4 EUT Operation Test Setup

The RF test items, utility “Compliance_v1.0.0.87” 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.

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

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

(3) 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

See list of measuring equipment of 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.

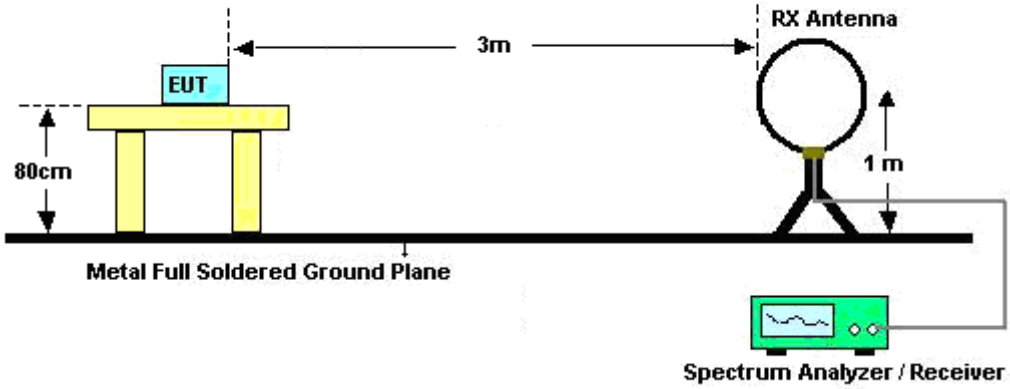
   (1) Procedure for Unwanted Emissions Measurements Below 1000MHz
   - RBW = 120 kHz
   - VBW = 300 kHz
   - Detector = Peak
   - Trace mode = max hold

   (2) Procedure for Peak Unwanted Emissions Measurements Above 1000 MHz
   - RBW = 1 MHz
   - VBW ≥ 3 MHz
   - Detector = Peak
   - Sweep time = auto
   - Trace mode = max hold

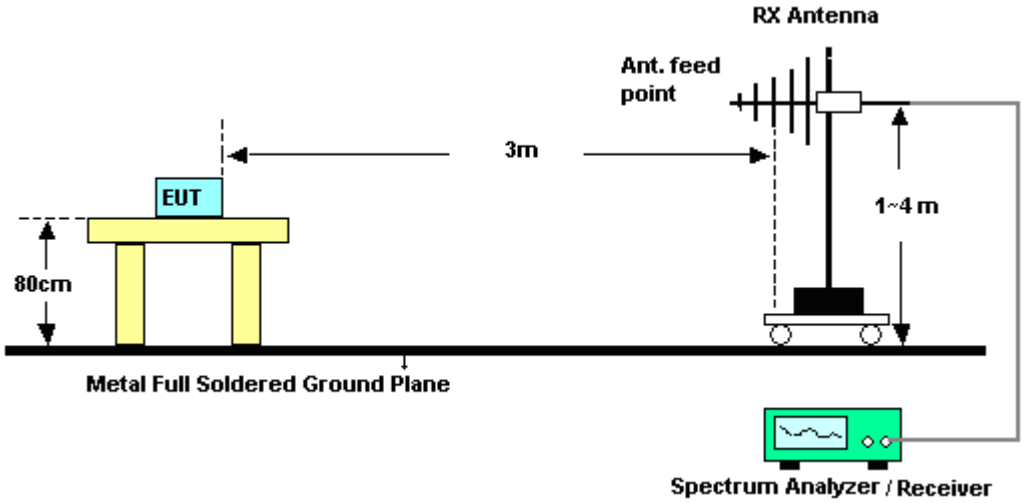
   (3) Procedures for Average Unwanted Emissions Measurements Above 1000MHz
   - RBW = 1 MHz
   - VBW = 10 Hz, when duty cycle is no less than 98 percent.
   - VBW ≥ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.
2. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
3. The EUT was set 3 meters from the interference receiving antenna which was 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 was 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. 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.
7. 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.

3.1.4 Test Setup

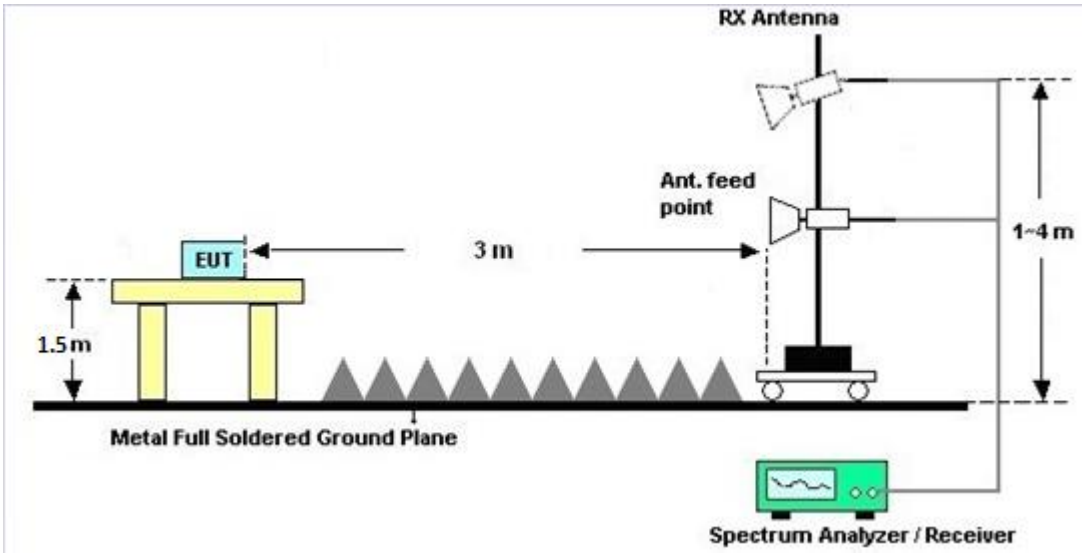
For radiated emissions below 30MHz



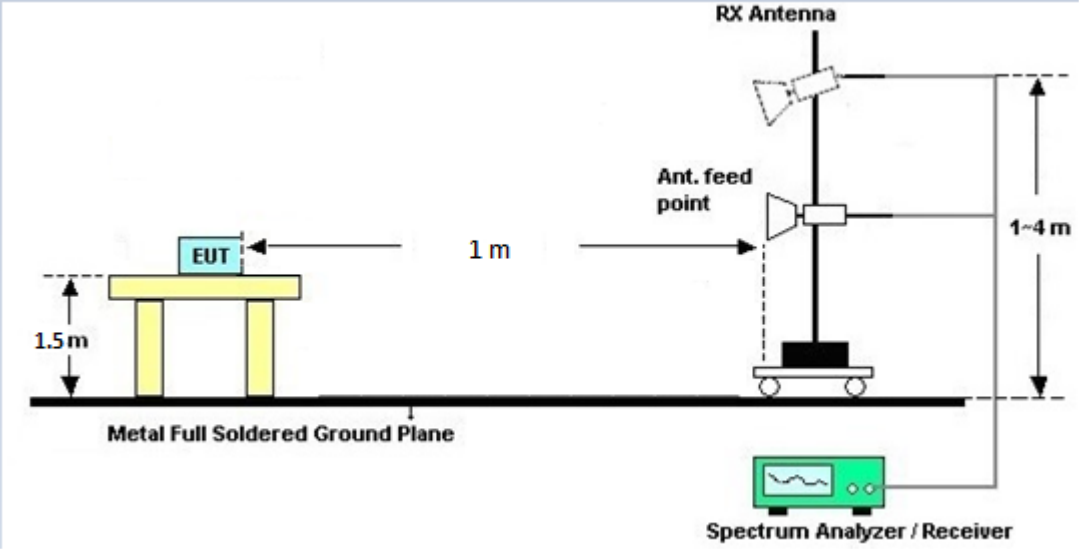
For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



For radiated emissions 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 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.

3.1.6 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

If transmitting antenna directional gain is greater than 6 dBi, both the peak transmit power and the peak power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

3.2.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.2.3 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
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Jan. 09, 2020	Jul. 13, 2020~ Jul. 16, 2020	Jan. 08, 2021	Radiation (03CH16-HY)
Bilog Antenna	TESEQ	CBL6111D&00802N1D01N-06	47020&06	30MHz to 1GHz	Oct. 12, 2019	Jul. 13, 2020~ Jul. 16, 2020	Oct. 11, 2020	Radiation (03CH16-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-1522	1G~18GHz	Sep. 19, 2019	Jul. 13, 2020~ Jul. 16, 2020	Sep. 18, 2020	Radiation (03CH16-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170980	18GHz~40GHz	Jan. 10, 2020	Jul. 13, 2020~ Jul. 16, 2020	Jan. 09, 2021	Radiation (03CH16-HY)
Amplifier	SONOMA	310N	371607	9kHz~1G	Oct. 01, 2019	Jul. 13, 2020~ Jul. 16, 2020	Sep. 30, 2020	Radiation (03CH16-HY)
Preamplifier	Jet-Power	JPA0118-55-303	17100018000 55006	1GHz~18GHz	May 07, 2020	Jul. 13, 2020~ Jul. 16, 2020	May 06, 2021	Radiation (03CH16-HY)
Preamplifier	EMEC	EM18G40G	060715	18GHz ~40GHz	Dec. 13, 2019	Jul. 13, 2020~ Jul. 16, 2020	Dec. 12, 2020	Radiation (03CH16-HY)
Preamplifier	Keysight	83017A	MY53270264	1GHz~26.5GHz	Dec. 11, 2019	Jul. 13, 2020~ Jul. 16, 2020	Dec.10, 2020	Radiation (03CH16-HY)
EMI Test Receiver	Keysight	N9038A(MXE)	MY57290111	3Hz~26.5GHz	Dec. 05, 2019	Jul. 13, 2020~ Jul. 16, 2020	Dec. 04, 2020	Radiation (03CH16-HY)
Spectrum Analyzer	Agilent	E4446A	MY50180136	3Hz~44GHz	May 04, 2020	Jul. 13, 2020~ Jul. 16, 2020	May 03, 2021	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY11680/4PE	NA	Aug. 30, 2019	Jul. 13, 2020~ Jul. 16, 2020	Aug. 29, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY11688/4PE	NA	Aug. 30, 2019	Jul. 13, 2020~ Jul. 16, 2020	Aug. 29, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	EC-A5-300-5757	NA	Aug. 30, 2019	Jul. 13, 2020~ Jul. 16, 2020	Aug. 29, 2020	Radiation (03CH16-HY)
Software	Audix	E3 6.2009-8-24	RK-001136	N/A	N/A	Jul. 13, 2020~ Jul. 16, 2020	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))	**4.9**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**6.7**

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	**3.9**

Appendix A. Radiated Spurious Emission

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

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

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)
Mode 1 Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		2374.575	57.88	-16.12	74	41.52	27.7	8.15	29.78	212	108	P	H
		2366.385	46.4	-7.6	54	30.02	27.73	8.13	29.77	212	108	A	H
	*	2412	110.51	-	-	94.22	27.6	8.21	29.79	212	108	P	H
	*	2412	107.55	-	-	91.26	27.6	8.21	29.79	212	108	A	H
		2378.67	57.29	-16.71	74	40.95	27.69	8.15	29.78	100	121	P	V
		2390	46.53	-7.47	54	30.22	27.64	8.17	29.78	100	121	A	V
	*	2412	112.27	-	-	95.98	27.6	8.21	29.79	100	121	P	V
	*	2412	109.28	-	-	92.99	27.6	8.21	29.79	100	121	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

BLE (Band Edge @ 3m)

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)
Mode 1 Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	*	2452	104.66	-	-	88.33	27.6	8.27	29.81	264	301	P	H
	*	2452	103.1	-	-	86.77	27.6	8.27	29.81	264	301	A	H
		2485.9	56.56	-17.44	74	40.25	27.53	8.33	29.82	264	301	P	H
		2483.62	46.11	-7.89	54	29.81	27.53	8.32	29.82	264	301	A	H
	*	2452	100.68	-	-	84.35	27.6	8.27	29.81	100	95	P	V
	*	2452	99.14	-	-	82.81	27.6	8.27	29.81	100	95	A	V
		2496.46	57.74	-16.26	74	41.45	27.51	8.34	29.83	100	95	P	V
		2492.74	46.44	-7.56	54	30.15	27.51	8.34	29.83	100	95	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Zigbee (Band Edge @ 3m)

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)
Mode 1 Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		2378.355	57.87	-16.13	74	41.53	27.69	8.15	29.78	264	255	P	H
		2366.385	47.91	-6.09	54	31.53	27.73	8.13	29.77	264	255	A	H
	*	2405	111.34	-	-	95.06	27.6	8.2	29.79	264	255	P	H
	*	2405	108.97	-	-	92.69	27.6	8.2	29.79	264	255	A	H
		2366.07	58.53	-15.47	74	42.14	27.74	8.13	29.77	100	334	P	V
		2366.385	49.57	-4.43	54	33.19	27.73	8.13	29.77	100	334	A	V
	*	2405	112.7	-	-	96.42	27.6	8.2	29.79	100	334	P	V
	*	2405	110.13	-	-	93.85	27.6	8.2	29.79	100	334	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

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

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)
Mode 1 Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		2366	60.9	-13.1	74	44.51	27.74	8.13	29.77	310	255	P	H
		2366	50.09	-3.91	54	33.7	27.74	8.13	29.77	310	255	A	H
		2744	49.82	-24.18	74	42.45	27.89	8.73	29.63	100	0	P	H
		4810	44	-30	74	59.56	31.12	11.9	59.09	100	0	P	H
		4904	41.71	-32.29	74	57.33	31.02	12.01	59.14	100	0	P	H
		7236	46.78	-27.22	74	53.52	36.24	15.19	58.67	100	0	P	H
		7356	47.22	-26.78	74	53.47	36.59	15.28	58.5	100	0	P	H
		2366	61.32	-12.68	74	44.93	27.74	8.13	29.77	100	335	P	V
		2366	50.95	-3.05	54	34.56	27.74	8.13	29.77	100	335	A	V
		2744	51.8	-22.2	74	44.43	27.89	8.73	29.63	176	193	P	V
		2744	42.43	-11.57	54	35.06	27.89	8.73	29.63	176	193	A	V
		4810	44.93	-29.07	74	60.49	31.12	11.9	59.09	100	0	P	V
		4904	41.42	-32.58	74	57.04	31.02	12.01	59.14	100	0	P	V
		7236	47.75	-26.25	74	54.49	36.24	15.19	58.67	100	0	P	V
		7356	47.42	-26.58	74	53.67	36.59	15.28	58.5	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

5GHz 5725~5850MHz (Band Edge @ 3m)

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)
Mode 2 Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	*	5320	112.28	-	-	97.16	31.26	12.5	28.96	253	113	P	H
	*	5320	104.91	-	-	89.79	31.26	12.5	28.96	253	113	P	H
		5361.76	55.44	-18.56	74	40.3	31.25	12.54	28.99	253	113	P	H
		5350.08	45.66	-8.34	54	30.57	31.2	12.53	28.98	253	113	P	H
	*	5320	112.87	-	-	97.75	31.26	12.5	28.96	200	51	P	V
	*	5320	104.98	-	-	89.86	31.26	12.5	28.96	200	51	P	V
		5373.6	54.67	-19.33	74	39.48	31.29	12.55	29	200	51	P	V
		5350.24	45.24	-8.76	54	30.15	31.2	12.53	28.98	200	51	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

BLE (Band Edge @ 3m)

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)
Mode 2 Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	*	2452	104.76	-	-	88.43	27.6	8.27	29.81	229	304	P	H
	*	2452	102.94	-	-	86.61	27.6	8.27	29.81	229	304	A	H
		2488.24	57.37	-16.63	74	41.08	27.52	8.33	29.83	229	304	P	H
		2498.68	46.31	-7.69	54	30.02	27.5	8.35	29.83	229	304	A	H
	*	2452	100.58	-	-	84.25	27.6	8.27	29.81	100	100	P	V
	*	2452	98.95	-	-	82.62	27.6	8.27	29.81	100	100	A	V
		2497.66	56.89	-17.11	74	40.6	27.5	8.35	29.83	100	100	P	V
		2490.58	46.15	-7.85	54	29.86	27.52	8.33	29.83	100	100	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Zigbee (Band Edge @ 3m)

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)
Mode 2 Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		2367.12	58.37	-15.63	74	41.98	27.73	8.14	29.77	265	255	P	H
		2366.385	48.2	-5.8	54	31.82	27.73	8.13	29.77	265	255	A	H
	*	2405	111.33	-	-	95.05	27.6	8.2	29.79	265	255	P	H
	*	2405	109.16	-	-	92.88	27.6	8.2	29.79	265	255	A	H
		2365.965	58.01	-15.99	74	41.62	27.74	8.13	29.77	125	338	P	V
		2366.595	49.13	-4.87	54	32.75	27.73	8.13	29.77	125	338	A	V
	*	2405	112.78	-	-	96.5	27.6	8.2	29.79	125	338	P	V
	*	2405	110.63	-	-	94.35	27.6	8.2	29.79	125	338	A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz, Band 2 5250~5350MHz ((Harmonic @ 3m)

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)
Mode 2 Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		2366	60.4	-13.6	74	44.01	27.74	8.13	29.77	310	250	P	H
		2366	50.03	-3.97	54	33.64	27.74	8.13	29.77	310	250	P	H
		1829	45.31	-22.89	68.2	42.17	25.36	7.17	29.78	100	0	P	H
		2744	49.71	-24.29	74	42.34	27.89	8.73	29.63	100	0	P	H
		4810	56.35	-17.65	74	40.42	31.12	11.9	28.76	235	120	P	H
		4810	44.49	-9.51	54	28.56	31.12	11.9	28.76	235	120	A	H
		4904	56.33	-17.67	74	40.35	31.02	12.01	28.75	100	100	P	H
		4904	44.79	-9.21	54	28.81	31.02	12.01	28.75	100	100	A	H
		7215	46.07	-22.13	68.2	52.47	36.16	15.17	58.7	100	0	P	H
		7356	46.97	-27.03	74	52.78	36.59	15.28	58.5	100	0	P	H
		10640	55.31	-18.69	74	56.81	40	19.13	61.1	126	142	P	H
		10640	44.8	-9.2	54	46.3	40	19.13	61.1	126	142	A	H
		15960	47.04	-26.96	74	46.33	37.04	23.89	60.69	100	0	P	H
		2366	61.38	-12.62	74	44.99	27.74	8.13	29.77	100	336	P	V
		2366	50.89	-3.11	54	34.5	27.74	8.13	29.77	100	336	P	V
		1829	46.78	-21.42	68.2	43.64	25.36	7.17	29.78	100	0	P	V
		2744	49.9	-24.1	74	42.53	27.89	8.73	29.63	100	0	P	V
		4810	56.48	-17.52	74	40.55	31.12	11.9	28.76	236	360	P	V
		4810	43.99	-10.01	54	28.06	31.12	11.9	28.76	236	360	A	V
		4904	56.87	-17.13	74	40.89	31.02	12.01	28.75	100	244	P	V
		4904	44.84	-9.16	54	28.86	31.02	12.01	28.75	100	244	A	V
		7215	47.3	-20.9	68.2	53.7	36.16	15.17	58.7	100	0	P	V
		7356	47.91	-26.09	74	53.72	36.59	15.28	58.5	100	0	P	V
		10640	57.08	-16.92	74	58.58	40	19.13	61.1	158	160	P	V
		10640	47.26	-6.74	54	48.76	40	19.13	61.1	158	160	A	V
		15960	47.77	-26.23	74	47.06	37.04	23.89	60.69	100	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission Above 18GHz

2.4GHz 2400~2483.5MHz (SHF)

Ant.	Note	Frequency	Level	Over Limit	Limit Line	Read Level	Antenna Factor	Path Loss	Preamp Factor	Ant Pos	Table Pos	Peak Avg.	Pol.
Simultaneously		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
Mode 1 Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		29836	42.6	-25.6	68.2	41.51	40.23	25.27	54.87	150	0	P	H
		37184	46.13	-22.07	68.2	40.5	42.76	29.33	56.92	150	0	P	H
		30606	43.46	-24.74	68.2	41.4	40.46	26.38	55.24	150	0	P	V
		38218	45.81	-22.39	68.2	38.61	43.49	29.21	55.96	150	0	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz 2400~2483.5MHz (LF)

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)
Mode 1 Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		112.45	29.96	-13.54	43.5	33.55	16.99	1.79	32.26	-	-	P	H
		219.15	31.03	-14.97	46	35.49	15.43	2.5	32.33	-	-	P	H
		363.68	31.53	-14.47	46	29.87	20.79	3.2	32.26	-	-	P	H
		471.35	35.47	-10.53	46	30.51	23.53	3.63	32.12	-	-	P	H
		575.14	38.43	-7.57	46	30.5	25.86	4.03	31.96	-	-	P	H
		640.13	38.68	-7.32	46	30.05	26.4	4.23	32.01	100	0	P	H
		914.5	116.04	-	-	103.35	29.33	5.03	31.75	179	170	P	H
		69.77	33.56	-6.44	40	42.45	12.18	1.41	32.36	105	343	Q	V
		192.96	28.49	-15.01	43.5	33.84	14.7	2.33	32.32	-	-	P	V
		359.8	31.53	-14.47	46	30.01	20.68	3.18	32.26	-	-	P	V
		494.63	36.11	-9.89	46	30.73	23.85	3.69	32.1	-	-	P	V
		575.14	39.25	-6.75	46	31.32	25.86	4.03	31.96	-	-	P	V
		677.96	39.5	-6.5	46	30.82	26.39	4.34	32.1	-	-	P	V
		914.5	113.48	-	-	100.79	29.33	5.03	31.75	100	61	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Emission below 1GHz

2.4GHz 2400~2483.5MHz, Band 2 5250~5350MHz (LF)

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)
Mode 2 Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16		113.42	29.83	-13.67	43.5	33.31	17.09	1.8	32.26	-	-	P	H
		216.24	30.85	-15.15	46	35.52	15.24	2.48	32.33	-	-	P	H
		347.19	29.9	-16.1	46	28.84	20.3	3.12	32.28	-	-	P	H
		446.13	34.62	-11.38	46	30.24	23.06	3.56	32.15	-	-	P	H
		493.66	35.34	-10.66	46	29.98	23.84	3.68	32.1	-	-	P	H
		564.47	38.28	-7.72	46	30.15	26.13	3.98	31.98	100	0	P	H
		914.5	116.11	-	-	103.42	29.33	5.03	31.75	119	167	P	H
		70.74	33.48	-6.52	40	42.27	12.28	1.41	32.36	109	352	Q	V
		196.84	28.13	-15.37	43.5	33.41	14.75	2.36	32.32	-	-	P	V
		360.77	30.4	-15.6	46	28.85	20.71	3.18	32.26	-	-	P	V
		482.99	35.67	-10.33	46	30.5	23.69	3.66	32.11	-	-	P	V
		556.71	37.95	-8.05	46	30.01	25.99	3.95	31.99	-	-	P	V
		643.04	38.84	-7.16	46	30.22	26.39	4.23	32.02	-	-	P	V
		914.5	111.94	-	-	99.25	29.33	5.03	31.75	109	303	P	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average 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:

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)
802.11b CH 01 2412MHz		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".

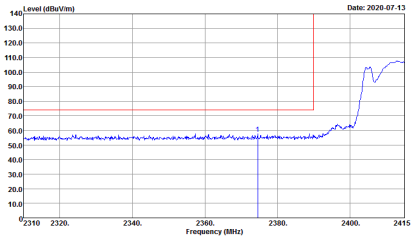
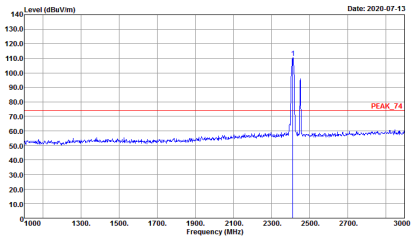
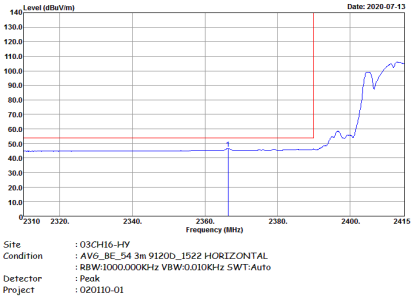
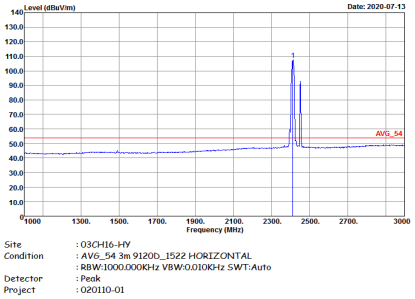
Appendix B. Radiated Spurious Emission Plots

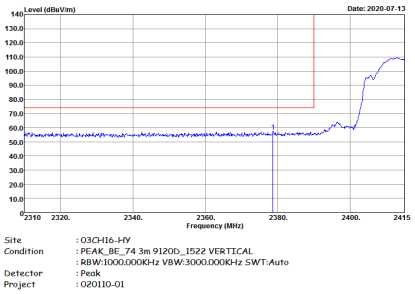
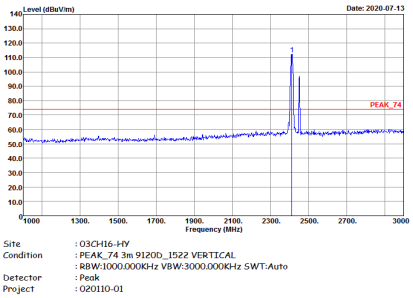
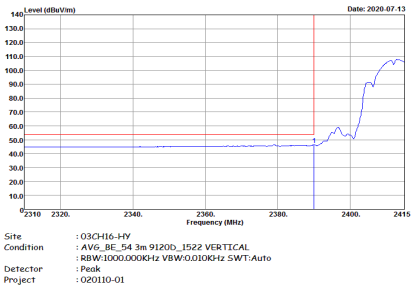
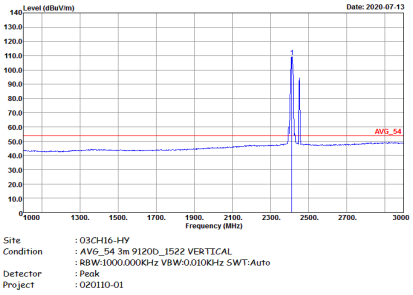
Test Engineer :	Karl Hou, Andy Yang and CR Liao	**Temperature :**	20~25°C
		Relative Humidity :	50~60%

Note symbol

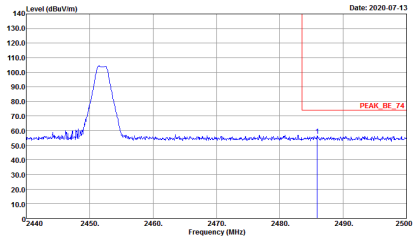
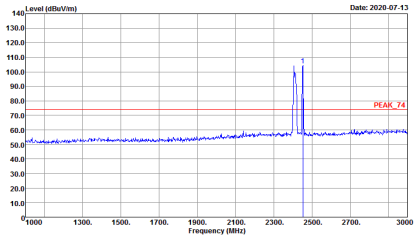
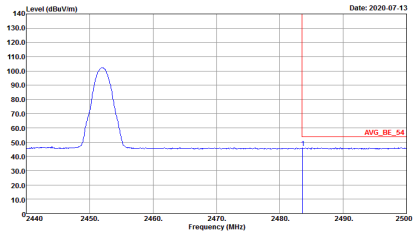
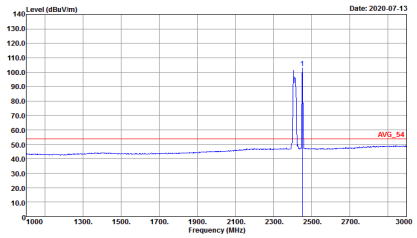
-L	**Low channel location**
-R	**High channel location**

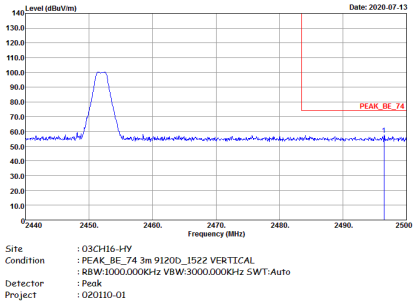
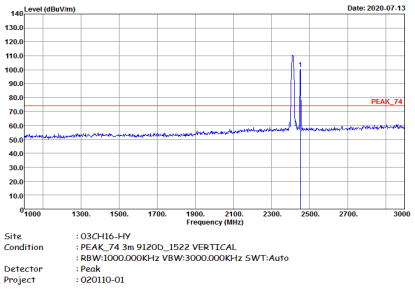
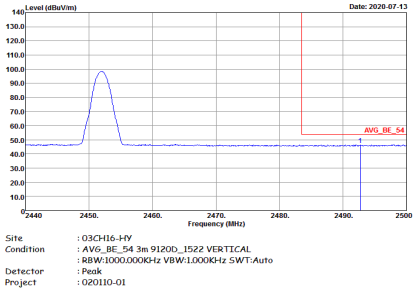
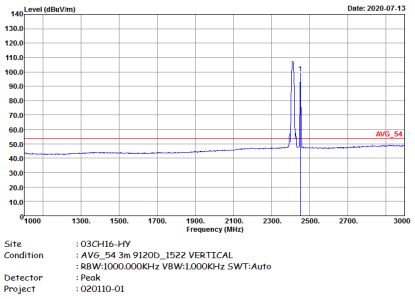
2.4GHz 2400~2483.5MHz (Band Edge @ 3m)

ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Fundamental
Peak		
Avg.		

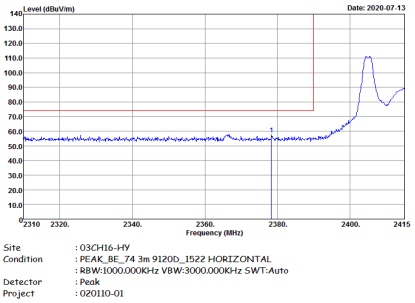
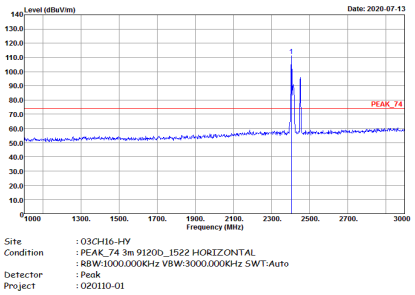
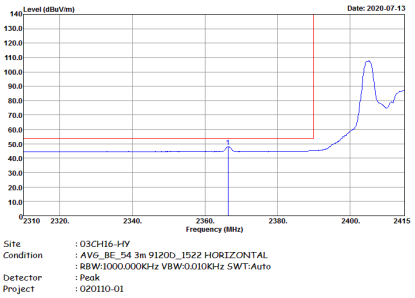
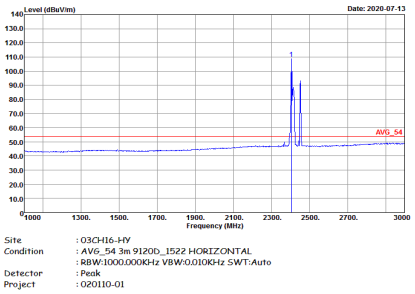
ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		

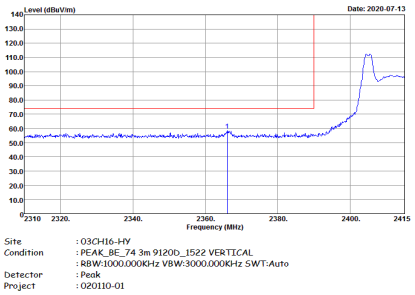
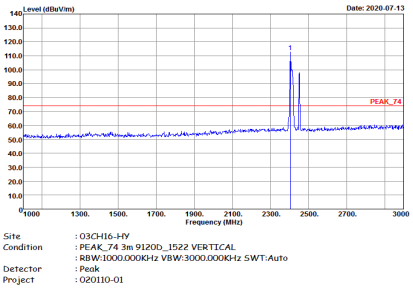
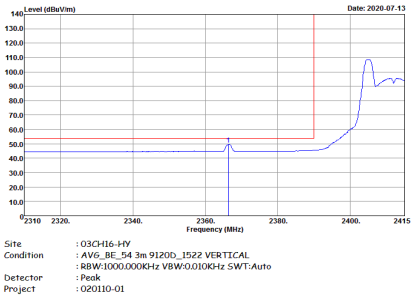
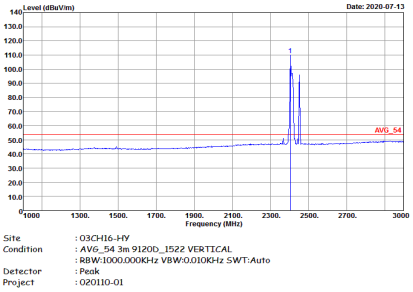
BLE (Band Edge @ 3m)

ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 020110-01	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 020110-01
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto Detector : Peak Project : 020110-01	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto Detector : Peak Project : 020110-01

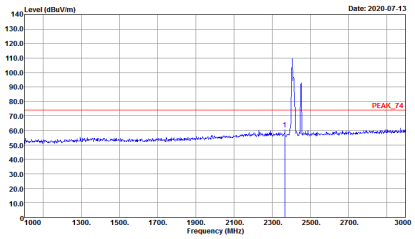
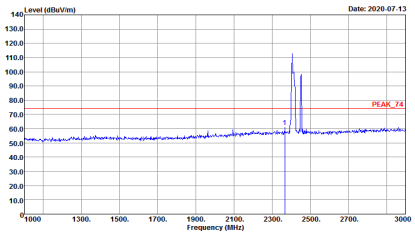
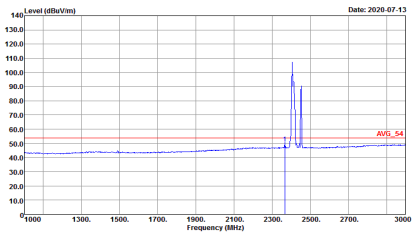
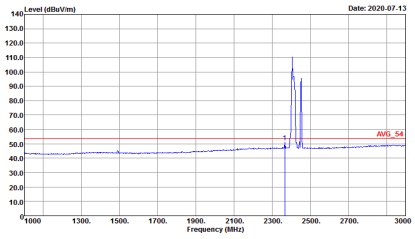
ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		

Zigbee (Band Edge @ 3m)

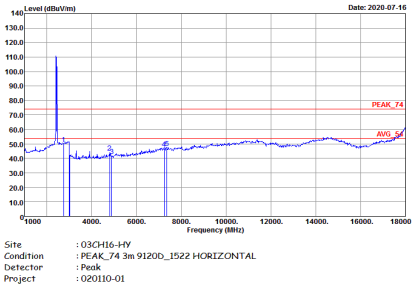
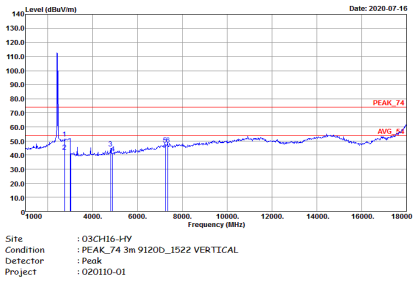
ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Fundamental
Peak		
Avg.		

ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		

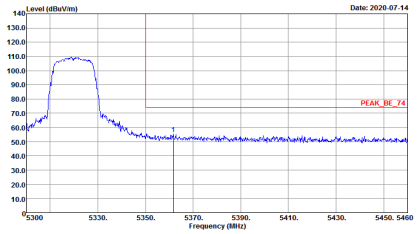
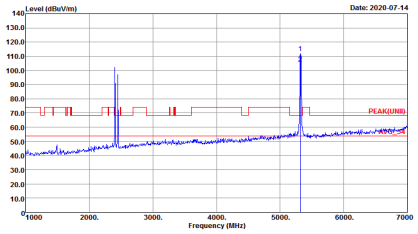
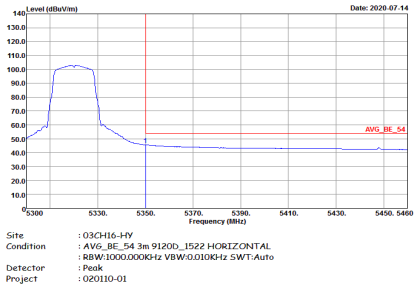
2.4GHz 2400~2483.5MHz (Harmonic @ 3m)

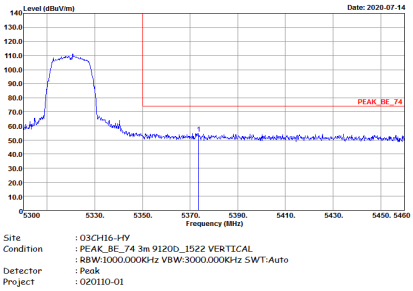
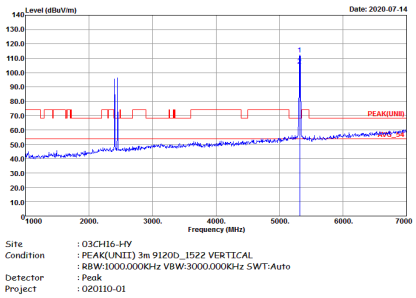
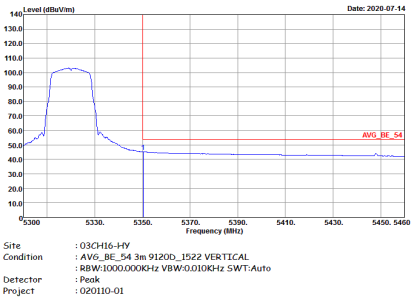
ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
Peak	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19
Avg.	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19

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

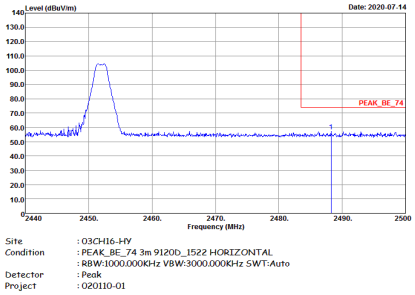
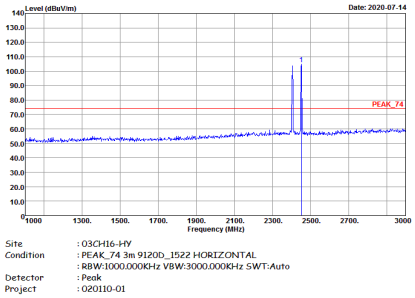
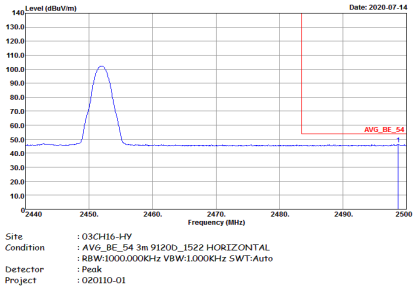
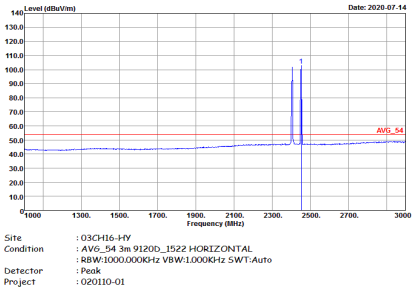
ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
Peak Avg.	 	

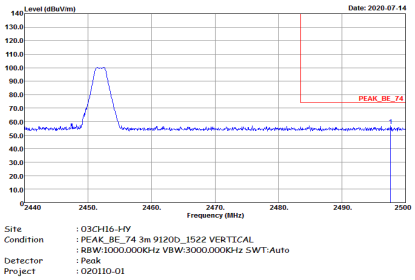
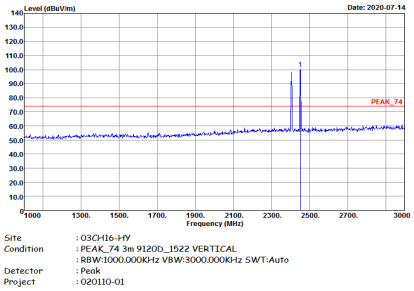
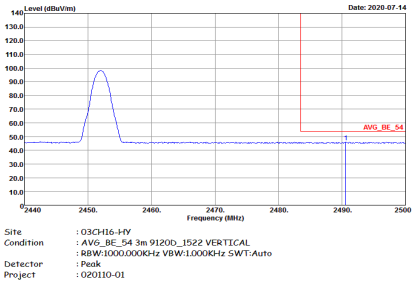
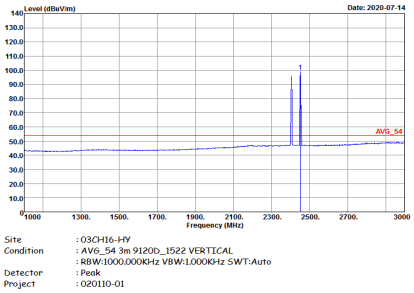
5GHz 5250~5350MHz (Band Edge @ 3m)

ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	**Horizontal**	**Fundamental**
Peak		
Avg.		Left blank

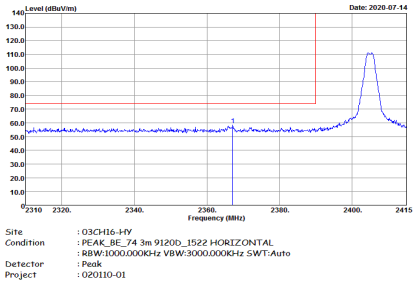
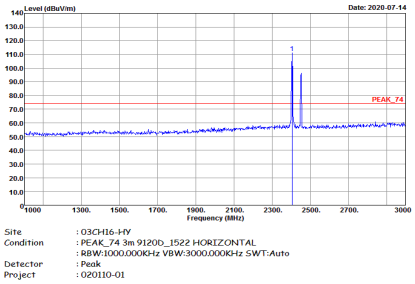
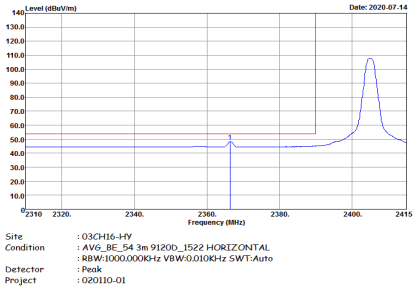
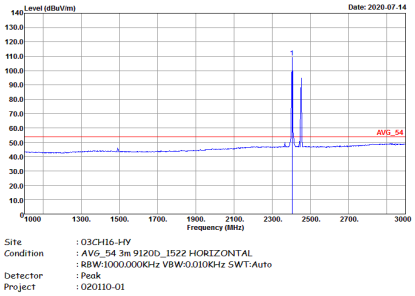
ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		Left blank

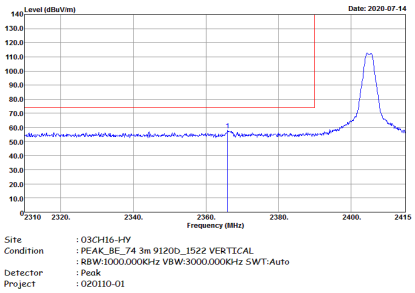
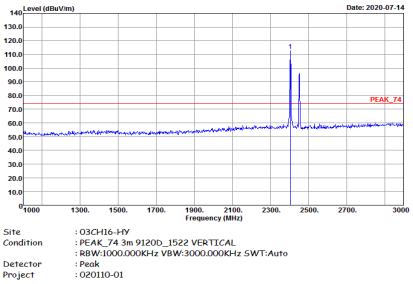
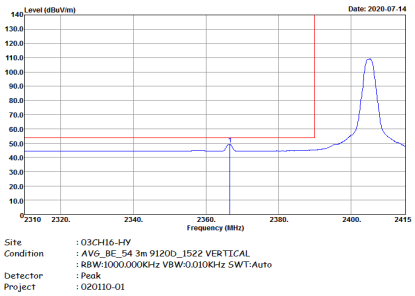
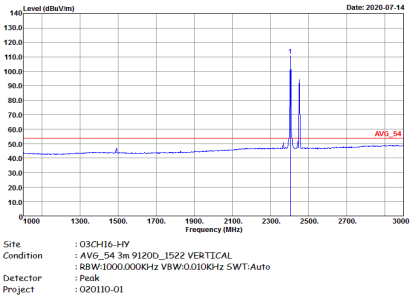
BLE (Band Edge @ 3m)

ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Fundamental
Peak		
Avg.		

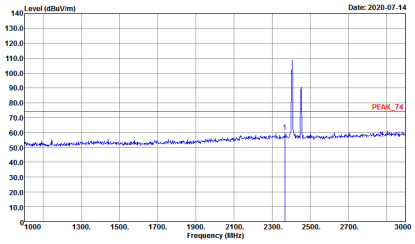
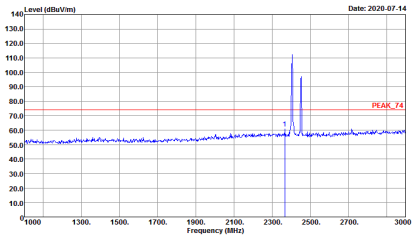
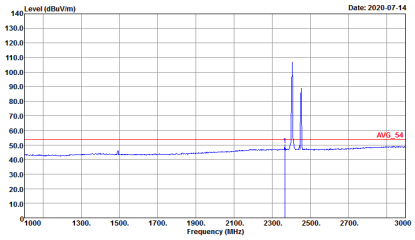
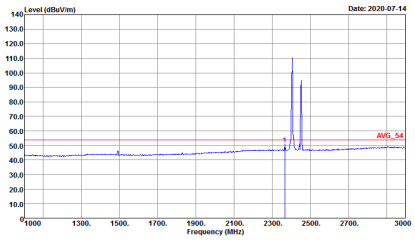
ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		

Zigbee (Band Edge @ 3m)

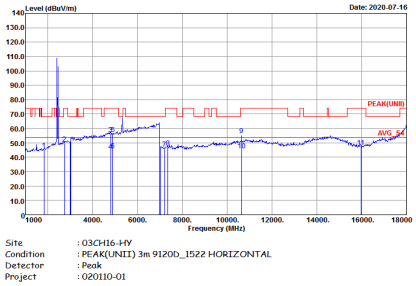
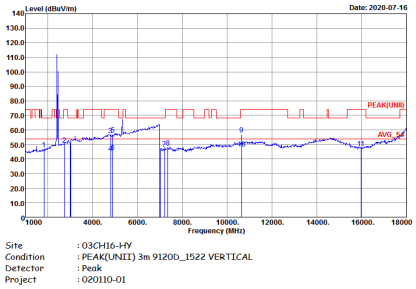
ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Fundamental
Peak		
Avg.		

ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		

2.4GHz 2400~2483.5MHz, Band 2 5250~5350MHz (Harmonic @ 3m)

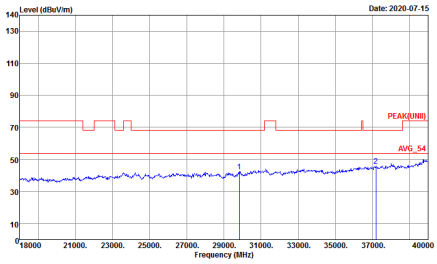
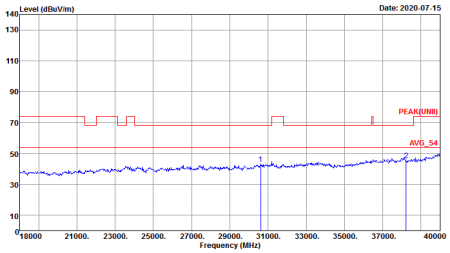
ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
Peak	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19
Avg.	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:0.010KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:1.000KHz SWT:Auto Detector : Peak Project : 020110-01 WLAN : 16 BLE : 5/0 Zigbee : 17 Lora : 19

2.4GHz 2400~2483.5MHz, Band 2 5250~5350MHz (Harmonic @ 3m)

ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
Peak Avg.		

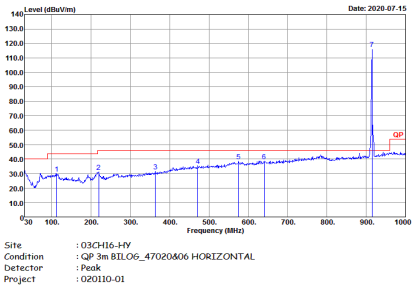
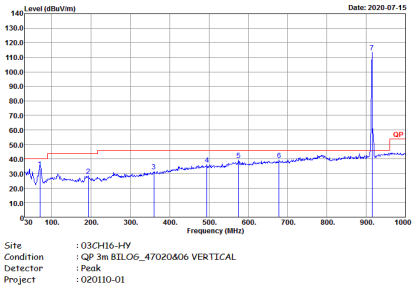
Emission Above 18GHz

2.4GHz 2400~2483.5MHz (SHF)

ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
QP / Peak	 Site : 03CH16-HY Condition : PEAK(UNII) 1m SHF HORN BBHA9170584 HORIZONTAL Detector : Peak Project : 020110-01	 Site : 03CH16-HY Condition : PEAK(UNII) 1m SHF HORN BBHA9170584 VERTICAL Detector : Peak Project : 020110-01

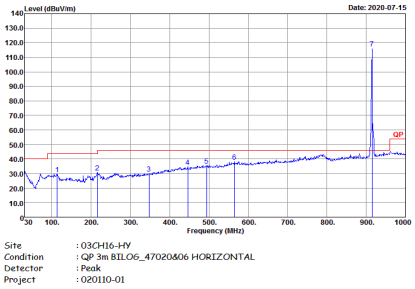
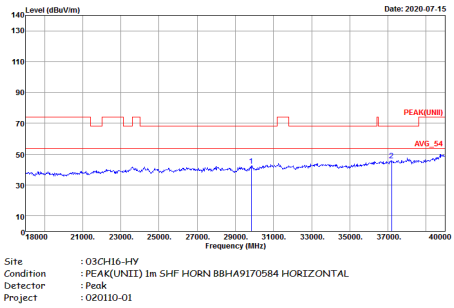
Emission below 1GHz

2.4GHz 2400~2483.5MHz (LF)

ANT	Mode 1: Ant 1+2 11b Ch01 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
QP / Peak		

Emission below 1GHz

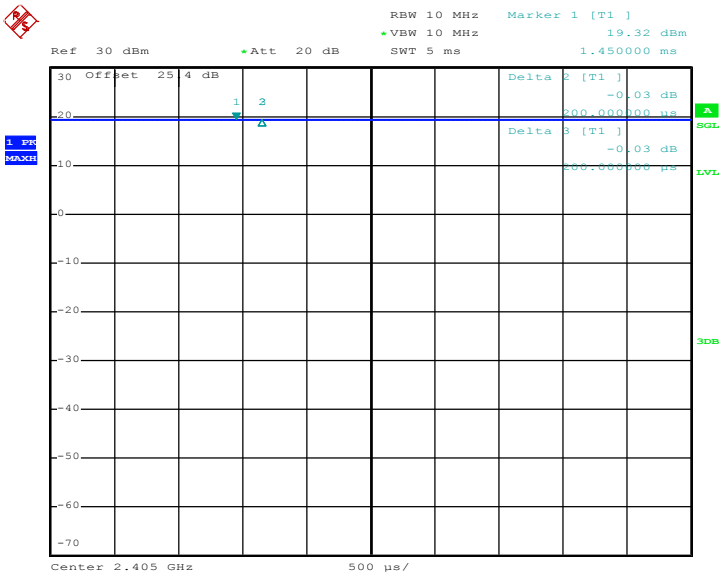
2.4GHz 2400~2483.5MHz, Band 2 5250~5350MHz (LF)

ANT	Mode 2: Ant 1+2 11a Ch64 + Ant 3 BLE(2M) Ch25 + Ant 4 Zigbee Ch11 + Ant 4 LoRa Ch16	
Simultaneously	Horizontal	Vertical
QP / Peak		

Appendix C. Duty Cycle Plots

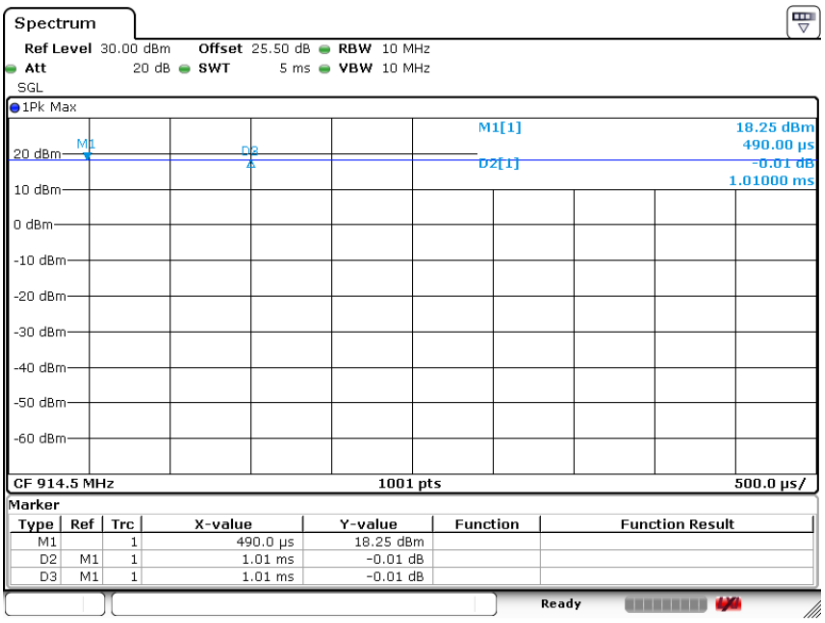
Antenna	Band	Duty Cycle(%)	T(us)	1/T(kHz)	VBW Setting	Duty Factor(dB)
-	Zigbee for Ant. 4	100.00	-	-	10Hz	0.00
-	LoRa for Ant. 4	100.00	-	-	10Hz	0.00
-	Bluetooth –LE for 2Mbps for Ant. 3	56.5	1065	0.94	1kHz	2.48
1+2	2.4GHz 802.11b for Ant. 1	100.00	-	-	10Hz	0.00
1+2	2.4GHz 802.11b for Ant. 2	100.00	-	-	10Hz	0.00
1+2	5GHz 802.11a for Ant. 1	100.00	-	-	10Hz	0.00
1+2	5GHz 802.11a for Ant. 2	100.00	-	-	10Hz	0.00

Zigbee



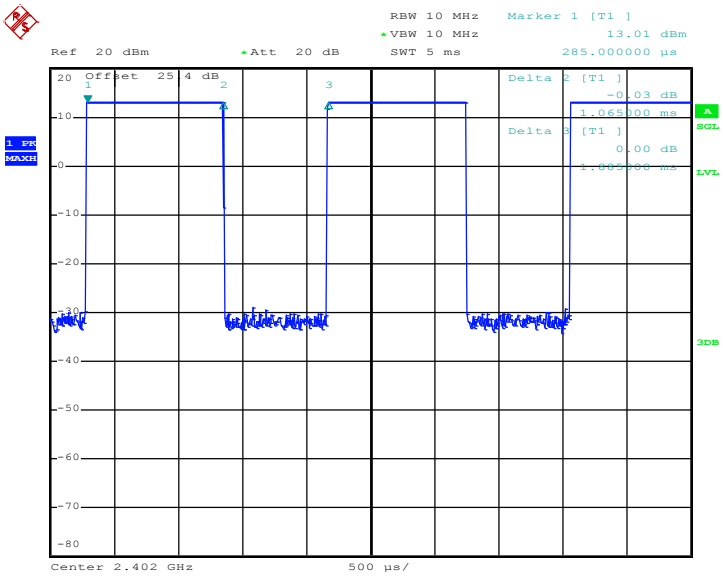
Date: 30.MAY.2020 03:09:27

LoRa



Date: 13.JUL.2020 15:08:18

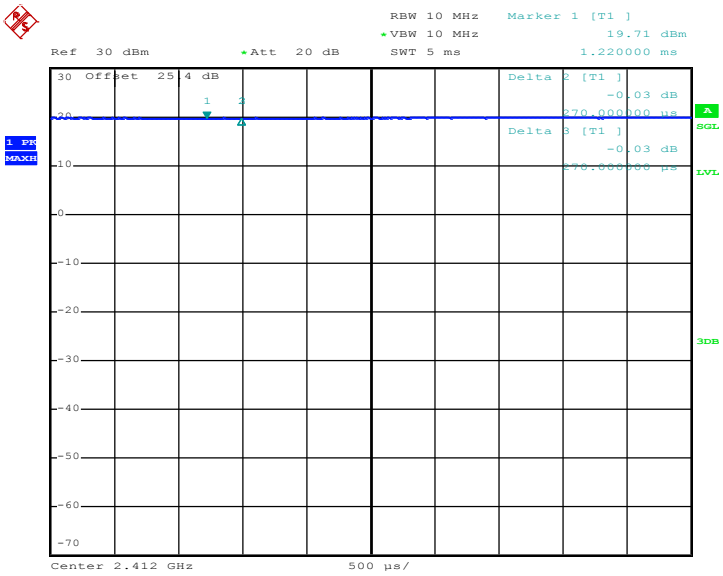
Bluetooth – LE (2Mbps)



Date: 30.MAY.2020 02:32:30

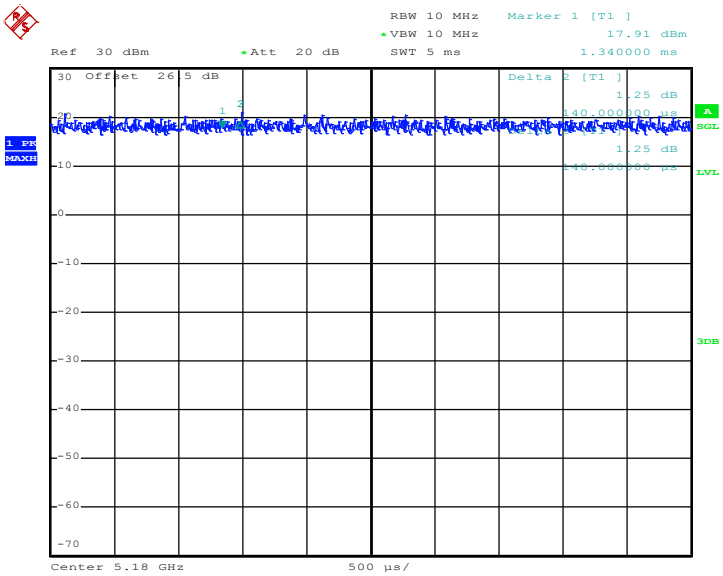
MIMO <Ant. 1>

802.11b



Date: 28.MAY.2020 03:08:44

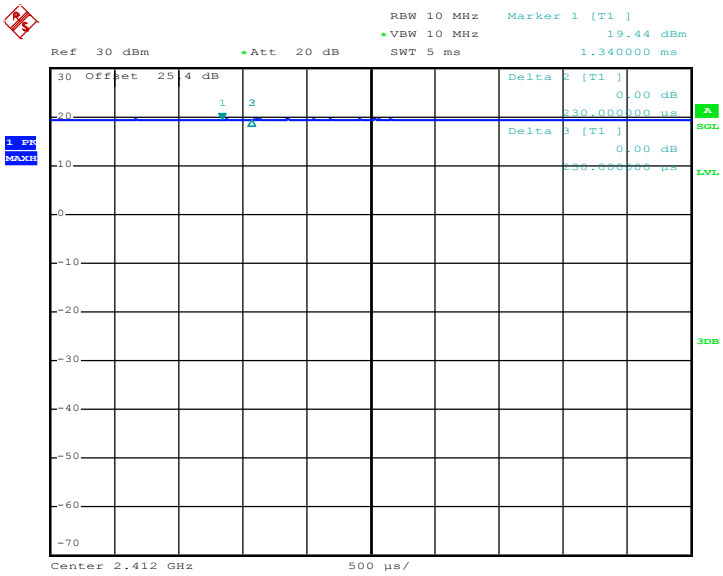
802.11a



Date: 28.MAY.2020 03:29:39

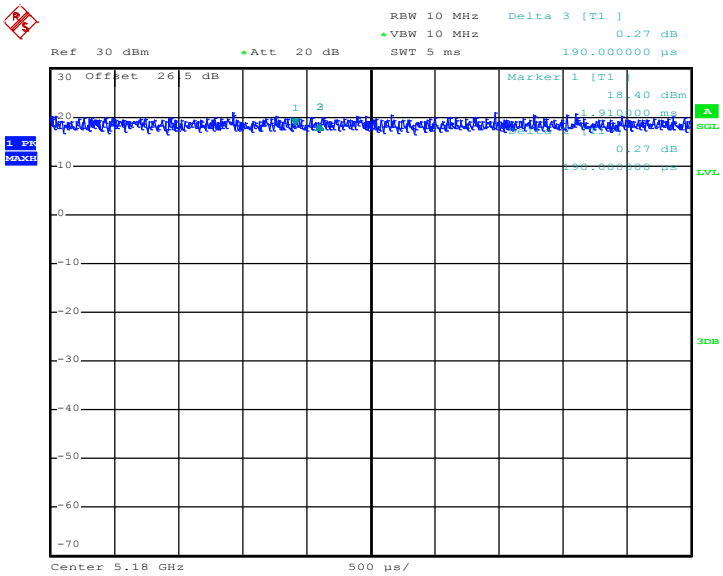
MIMO <Ant. 2>

802.11b



Date: 28.MAY.2020 03:10:42

802.11a



Date: 28.MAY.2020 03:30:31

———THE END———