FCC CO-LOCATION RADIO TEST REPORT

FCC ID	:	2ABZ2-EE149
Equipment	:	Smart Phone
Brand Name	:	ONEPLUS
Model Name	:	IN2019
Applicant	:	OnePlus Technology (Shenzhen) Co., Ltd 18C02, 18C03, 18C04 and 18C05, Shum Yip Terra Building, Binhe Avenue North, Futian District, Shenzhen
Manufacturer	:	OnePlus Technology (Shenzhen) Co., Ltd 18C02, 18C03, 18C04 and 18C05, Shum Yip Terra Building, Binhe Avenue North, Futian District, Shenzhen
Standard	:	FCC Part 15 Subpart E §15.407

The product was received on Feb. 11, 2020 and testing was started from Feb. 24, 2020 and completed on Feb. 24, 2020. We, SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory, would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The report must not be used by the client to claim product certification, approval, or endorsement by TAF or any agency of government.

The test results in this 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

Report No.	Version	Description	Issued Date
FR9D0701G	01	Initial issue of report	Mar. 06, 2020

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	15.407(b)	Unwanted Emissions	Pass	Under limit 7.08 dB at 2488.680 MHz
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: Yimin Ho

1 General Description

1.1 Product Feature of Equipment Under Test

GSM/WCDMA/LTE/5G NR, Bluetooth, Wi-Fi 2.4GHz 802.11b/g/n/ac/ax, Wi-Fi 5GHz 802.11a/n/ac/ax, NFC, and GNSS.

Product Specification subjective to this standard	
Antenna Type	**WWAN:** Loop Antenna / IFA Antenna **WLAN 2.4GHz:** <Ant. 1> Couple Loop Antenna <Ant. 2> Monopole Antenna **WLAN 5GHz:** <Ant. 1> Couple Loop Antenna <Ant. 2> Loop Antenna **Bluetooth:** Couple Loop Antenna **GPS / Glonass / BDS / Galileo / SBAS:** Couple Loop Antenna **NFC:** Coil Antenna

1.2 Modification of EUT

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

1.3 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

1.4 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 414788 D01 Radiated Test Site v01r01.
- FCC KDB 662911 D01 Multiple Transmitter Output v02r01.
- FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05r02
- ANSI C63.10-2013

Remark:

1. All test items were verified and recorded according to the standards and without any deviation during the test.
2. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

2 Test Configuration of Equipment Under Test

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, pre-scanned in three orthogonal panels, X, Y, Z. The worst cases (Z plane) were recorded in this report.

2.1 Carrier Frequency and Channel

2400-2483.5 MHz						5150-5250 MHz	
Bluetooth		Bluetooth - LE		802.11b		802.11a	
Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)	Channel	Freq. (MHz)
78	2480	39	2480	11	2462	36	5180

2.2 Test Mode

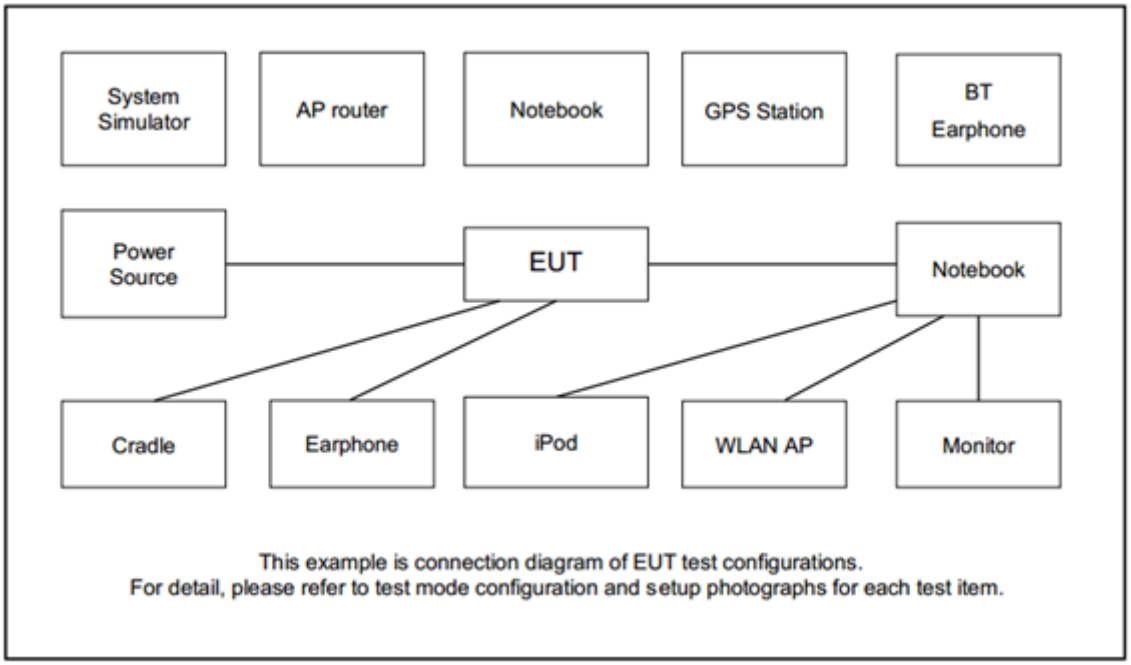
Final test modes are considering the modulation and worse data rates as below table.

<Co-Location>

Modulation	Data Rate
Bluetooth + 5GHz 802.11a for MIMO Ant. 1+2	1Mbps + 6Mbps
Bluetooth - LE + 5GHz 802.11a for MIMO Ant. 1+2	1Mbps + 6Mbps
2.4GHz 802.11b for MIMO Ant. 1+2 + 5GHz 802.11a for MIMO Ant. 1+2	1Mbps + 6Mbps

Remark: All the tests were performed with AC Adapter 2 and USB Cable 2.

2.3 Connection Diagram of Test System



2.4 Support Unit used in test configuration and system

Item	Equipment	Trade Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Bluetooth Earphone	Sony Ericsson	MW600	PY7DDA-2029	N/A	N/A

2.5 EUT Operation Test Setup

The RF test items, utility “QSPR v5.0-00188” 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

(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

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

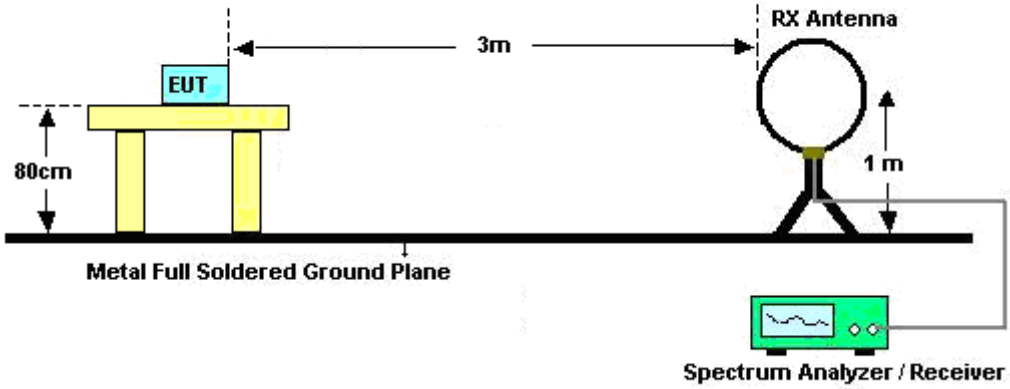
   - RBW = 1 MHz
   - VBW ≥ 3 MHz
   - Detector = Peak
   - Sweep time = auto
   - Trace mode = max hold

   (3) Procedures for Average Unwanted Emissions Measurements Above 1000MHz

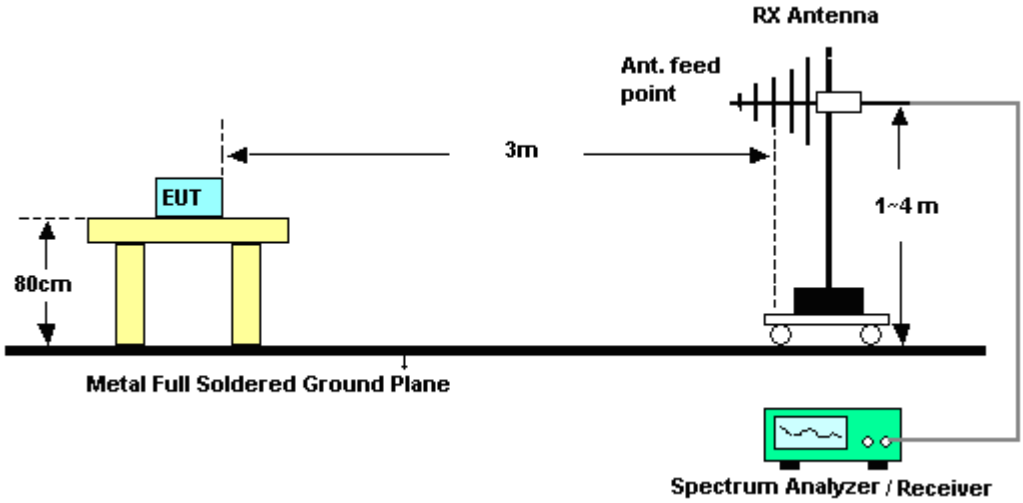
   - RBW = 1 MHz
   - VBW = 10 Hz, when duty cycle is no less than 98 percent.
   - VBW ≥ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control level for the tested mode of operation.
2. 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

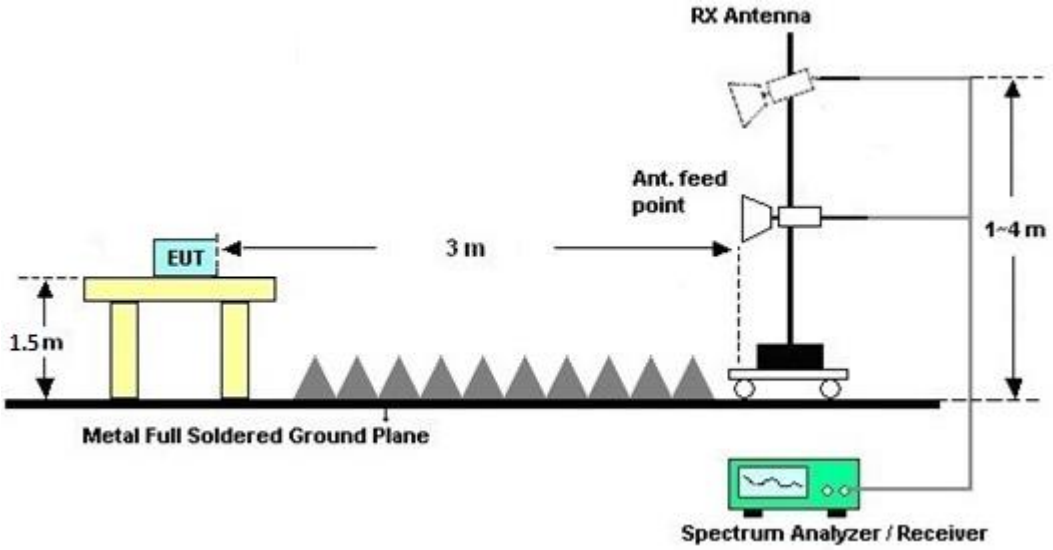
For radiated emissions below 30MHz



For radiated emissions from 30MHz to 1GHz



For radiated emissions above 1GHz



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
Bilog Antenna	TESEQ	CBL6111D&00802N1D01N-06	47020&06	30MHz to 1GHz	Oct. 13, 2019	Feb. 24, 2020	Oct. 12, 2020	Radiation (03CH16-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120 D	9120D-1522	1G~18GHz	Sep. 19, 2019	Feb. 24, 2020	Sep. 18, 2020	Radiation (03CH16-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170576	18GHz~40GHz	May 14, 2019	Feb. 24, 2020	May 13, 2020	Radiation (03CH16-HY)
Amplifier	SONOMA	310N	371607	9kHz~1000MHz	Oct. 01, 2019	Feb. 24, 2020	Sep. 30, 2020	Radiation (03CH16-HY)
Preamplifier	Keysight	83017A	MY532702604	1GHz~26.5GHz	Dec. 11, 2019	Feb. 24, 2020	Dec. 10, 2020	Radiation (03CH16-HY)
Preamplifier	Jet-Power	JPA0118-55-303	1710001800054001	1GHz~18GHz	May 19, 2019	Feb. 24, 2020	May 18, 2020	Radiation (03CH16-HY)
Preamplifier	EMEC	EM18G40G	060715	18GHz~40GHz	Dec. 13, 2019	Feb. 24, 2020	Dec. 12, 2020	Radiation (03CH16-HY)
EMI Test Receiver	Keysight	N9038A (MXE)	MY572901111	3Hz~26.5GHz	Dec. 05, 2019	Feb. 24, 2020	Dec. 04, 2020	Radiation (03CH16-HY)
Spectrum Analyzer	Agilent	E4446A	MY501801336	3Hz~44GHz	Apr. 29, 2019	Feb. 24, 2020	Apr. 28, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY11680/4PE	NA	Aug. 30, 2019	Feb. 24, 2020	Aug. 29, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 104	MY11688/4PE	NA	Aug. 30, 2019	Feb. 24, 2020	Aug. 29, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	EC-A5-300-5757	NA	Aug. 30, 2019	Feb. 24, 2020	Aug. 29, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30MHz~40GHz	Feb. 26, 2019	Feb. 24, 2020	Feb. 25, 2020	Radiation (03CH16-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	800740/2	30MHz~40GHz	Feb. 26, 2019	Feb. 24, 2020	Feb. 25, 2020	Radiation (03CH16-HY)
Notch Filter	Wainwright	WRCGV10-2375-2400-2483-2508-40SS	SN3	2.4G	Mar. 14, 2019	Feb. 24, 2020	Mar. 13, 2020	Radiation (03CH16-HY)
Notch Filter	Wainwright	WRCJV12-5120-5150-5350-5380-40SS	SN6	5G Band 1~2	Jul. 03, 2019	Feb. 24, 2020	Jul. 02, 2020	Radiation (03CH16-HY)
Hygrometer	TECPEL	DTM-303B	TP161243	N/A	Jun. 17, 2019	Feb. 24, 2020	Jun. 16, 2020	Radiation (03CH16-HY)
Software	Audix	E3 6.2009-8-24	RK-001136	N/A	N/A	Feb. 24, 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 :	Jacky Hung, Andy Yang and CR Liao	Temperature :	20~25°C
		Relative Humidity :	50~60%

Band 1 - 5150~5250MHz

WIFI 802.11a (Band Edge @ 3m)

WIFI 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)
BT CH78 2480 MHz Ant 1 + 802.11a CH36 5180 MHz Ant 1+2		5087.62	53.55	-20.45	74	38.34	31.78	12.24	28.81	300	9	P	H
		5150	43.16	-10.84	54	27.99	31.7	12.32	28.85	300	9	A	H
	*	5180	112.04	-	-	96.97	31.58	12.36	28.87	300	9	P	H
	*	5180	104.55	-	-	89.48	31.58	12.36	28.87	300	9	A	H
													H
													H
		5088.4	53.8	-20.2	74	38.59	31.78	12.24	28.81	102	98	P	V
		5150	41.66	-12.34	54	26.49	31.7	12.32	28.85	102	98	A	V
	*	5180	106.5	-	-	91.43	31.58	12.36	28.87	102	98	P	V
	*	5180	98.82	-	-	83.75	31.58	12.36	28.87	102	98	A	V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

BT (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.	
Simultaneously		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BT CH78 2480 MHz Ant 1 + 802.11a CH36 5180 MHz Ant 1+2	*	2480	107.96	-	-	101.92	27.54	8.32	29.82	106	61	P	H
	*	2480	83.2	-	-	-	-	-	-	-	-	A	H
		2483.52	55.67	-18.33	74	49.64	27.53	8.32	29.82	106	61	P	H
		2483.52	30.91	-23.09	54	-	-	-	-	-	-	A	H
													H
													H
	*	2480	108.67	-	-	102.63	27.54	8.32	29.82	100	111	P	V
	*	2480	83.91	-	-	-	-	-	-	-	-	A	V
		2483.52	56.35	-17.65	74	50.32	27.53	8.32	29.82	100	111	P	V
		2483.52	31.59	-22.41	54	-	-	-	-	-	-	A	V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Band 1 - 5150~5250MHz

WIFI 802.11a (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.	
Simultaneously		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BLE CH39 2480 MHz Ant 1 + 802.11a CH36 5180 MHz Ant 1+2		5027.3	52.87	-21.13	74	37.87	31.61	12.16	28.77	300	9	P	H
		5150	43.77	-10.23	54	28.6	31.7	12.32	28.85	300	9	A	H
	*	5180	112.29	-	-	97.22	31.58	12.36	28.87	300	9	P	H
	*	5180	104.3	-	-	89.23	31.58	12.36	28.87	300	9	A	H
												P	H
												A	H
		5146.64	53.27	-20.73	74	38.09	31.71	12.32	28.85	103	87	P	V
		5150	42.01	-11.99	54	26.84	31.7	12.32	28.85	103	87	A	V
	*	5180	107.48	-	-	92.41	31.58	12.36	28.87	103	87	P	V
	*	5180	99.38	-	-	84.31	31.58	12.36	28.87	103	87	A	V
												P	V
												A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

BLE (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.	
Simultaneously		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BLE CH39 2480 MHz Ant 1 + 802.11a CH36 5180 MHz Ant 1+2	*	2480	102.15	-	-	86.19	27.54	8.32	29.82	106	345	P	H
	*	2480	101.03	-	-	85.07	27.54	8.32	29.82	106	345	A	H
		2498.2	56.98	-17.02	74	41.04	27.5	8.35	29.83	106	345	P	H
		2488.68	46.92	-7.08	54	30.98	27.52	8.33	29.83	106	345	A	H
												P	H
												A	H
	*	2480	103.99	-	-	88.03	27.54	8.32	29.82	100	90	P	V
	*	2480	102.74	-	-	86.78	27.54	8.32	29.82	100	90	A	V
		2484.88	57	-17	74	41.04	27.53	8.33	29.82	100	90	P	V
		2497.92	46.71	-7.29	54	30.77	27.5	8.35	29.83	100	90	A	V
												P	V
												A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

Band 1 - 5150~5250MHz

WIFI 802.11a (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.	
Simultaneously		(MHz)	(dBµV/m)	(dB)	(dBµV/m)	(dBµV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
802.11b CH11 2462 MHz Ant 1+2 + 802.11a CH36 5180 MHz Ant 1+2		5150	53.63	-20.37	74	38.46	31.7	12.32	28.85	299	4	P	H
		5150	44.76	-9.24	54	29.59	31.7	12.32	28.85	299	4	A	H
	*	5180	110.78	-	-	95.71	31.58	12.36	28.87	299	4	P	H
	*	5180	103.3	-	-	88.23	31.58	12.36	28.87	299	4	A	H
												P	H
												A	H
		5120.12	53.07	-20.93	74	37.86	31.76	12.28	28.83	100	98	P	V
		5150	42.41	-11.59	54	27.24	31.7	12.32	28.85	100	98	A	V
	*	5180	105.69	-	-	90.62	31.58	12.36	28.87	100	98	P	V
	*	5180	98.02	-	-	82.95	31.58	12.36	28.87	100	98	A	V
												P	V
												A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

WIFI 802.11b (Band Edge @ 3m)

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)
802.11b CH11 2462 MHz Ant 1+2 + 802.11a CH36 5180 MHz Ant 1+2	*	2462	100.37	-	-	84.39	27.58	8.29	29.81	302	59	P	H
	*	2462	97.79	-	-	81.81	27.58	8.29	29.81	302	59	A	H
		2485.52	56.27	-17.73	74	40.31	27.53	8.33	29.82	302	59	P	H
		2483.88	44.4	-9.6	54	28.45	27.53	8.32	29.82	302	59	A	H
												P	H
												A	H
	*	2462	100.17	-	-	84.19	27.58	8.29	29.81	101	75	P	V
	*	2462	97.67	-	-	81.69	27.58	8.29	29.81	101	75	A	V
		2498.24	56.15	-17.85	74	40.21	27.5	8.35	29.83	101	75	P	V
		2484	44.3	-9.7	54	28.35	27.53	8.32	29.82	101	75	A	V
												P	V
												A	V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz and 5GHz Band 1 5150~5250MHz (Harmonic @ 3m)

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 CH78 2480 MHz Ant 1 + 802.11a CH36 5180 MHz Ant 1+2		4960	54.52	-19.48	74	38.21	31.26	12.07	28.75	100	0	P	H
		4960	29.76	-24.24	54	-	-	-	-	-	-	A	H
		7440	41.99	-32.01	74	46.56	36.58	15.4	57.33	100	0	P	H
		10360	46.35	-21.85	68.2	46.83	39.64	18.71	59.29	100	0	P	H
		15540	45.73	-28.27	74	43.36	37.94	23.82	59.95	100	0	P	H
													H
		4960	54.13	-19.87	74	37.82	31.26	13.8	28.75	100	0	P	V
		4960	29.37	-24.63	54	-	-	-	-	-	-	A	V
		7440	42.54	-31.46	74	47.11	36.58	16.18	57.33	100	0	P	V
		10360	47.24	-20.96	68.2	47.72	39.64	19.17	59.29	100	0	P	V
		15540	45.25	-28.75	74	42.88	37.94	24.38	59.95	100	0	P	V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz and 5GHz Band 1 5150~5250MHz (Harmonic @ 3m)

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 CH39 2480 MHz Ant 1 + 802.11a CH36 5180 MHz Ant 1+2		4960	54.72	-19.28	74	38.41	31.26	12.07	28.75	100	144	P	H
		4960	44.59	-9.41	54	28.28	31.26	12.07	28.75	100	144	A	H
		7440	42.22	-31.78	74	46.79	36.58	15.4	57.33	100	0	P	H
		10360	48.28	-19.92	68.2	48.76	39.64	18.71	59.29	100	0	P	H
		15540	45.51	-28.49	74	43.14	37.94	23.82	59.95	100	0	P	H
													H
		4960	54.77	-19.23	74	38.46	31.26	12.07	28.75	100	98	P	V
		4960	44.54	-9.46	54	28.23	31.26	12.07	28.75	100	98	A	V
		7440	42.09	-31.91	74	46.66	36.58	15.4	57.33	100	0	P	V
		10360	47.29	-20.91	68.2	47.77	39.64	18.71	59.29	100	0	P	V
		15540	45.25	-28.75	74	42.88	37.94	23.82	59.95	100	0	P	V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz and 5GHz Band 1 5150~5250MHz (Harmonic @ 3m)

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)
802.11b CH11 2462 MHz Ant 1+2 + 802.11a CH36 5180 MHz Ant 1+2		4924	53.39	-20.61	74	37.3	31.1	12.03	28.75	100	305	P	H
		4924	44.72	-9.28	54	28.63	31.1	12.03	28.75	100	305	A	H
		7386	42.3	-31.7	74	47.07	36.53	15.31	57.4	100	0	P	H
		10360	46.97	-21.23	68.2	47.45	39.64	18.71	59.29	100	0	P	H
		15540	45.21	-28.79	74	42.84	37.94	23.82	59.95	100	0	P	H
													H
		4924	53.96	-20.04	74	37.87	31.1	12.03	28.75	100	345	P	V
		4924	43.81	-10.19	54	27.72	31.1	12.03	28.75	100	345	A	V
		7386	43.18	-30.82	74	47.95	36.53	15.31	57.4	100	0	P	V
		10360	48.59	-19.61	68.2	49.07	39.64	18.71	59.29	100	0	P	V
		15540	45.66	-28.34	74	43.29	37.94	23.82	59.95	100	0	P	V
													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.
-	The signal is **Unintentional Radiators**.
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:

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)
802.11b 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

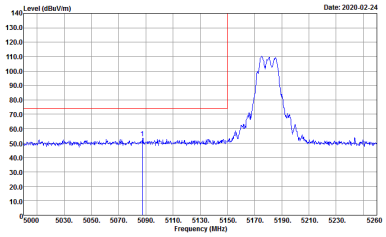
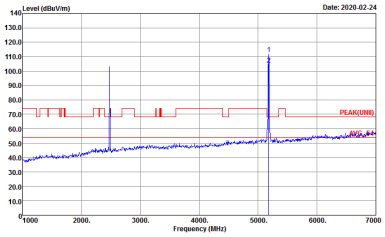
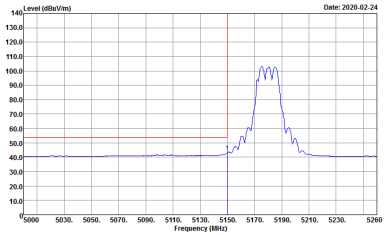
Test Engineer :	Jacky Hung, Andy Yang and CR Liao	**Temperature :**	20~25°C
		Relative Humidity :	50~60%

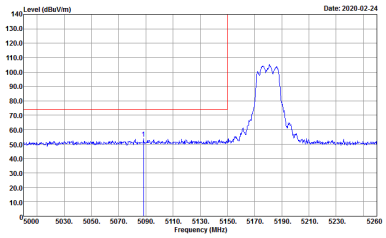
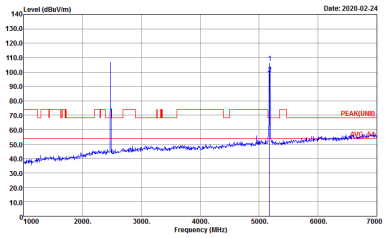
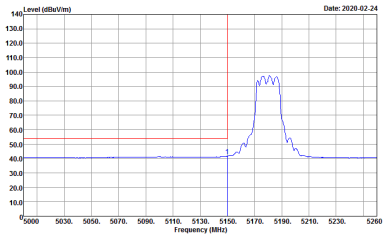
Note symbol

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

Band 1 - 5150~5250MHz

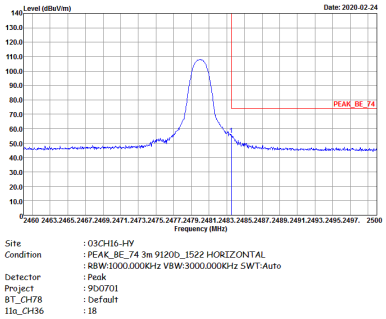
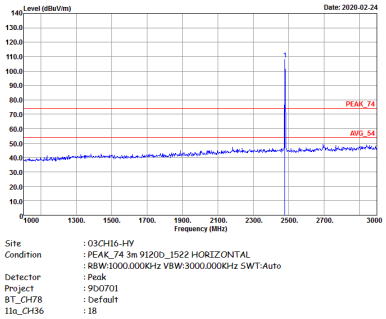
WIFI 802.11a (Band Edge @ 3m)

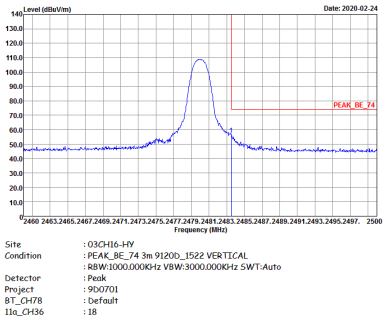
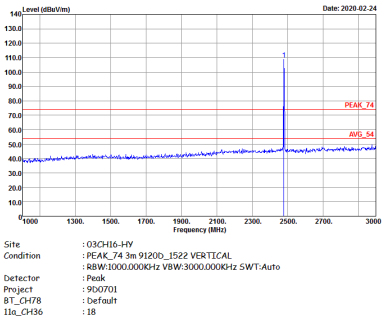
ANT	BT_Ch78_Ant 1 + WIFI 802. 11a_Tx_CH36 ANT 1+2	
Simultaneously	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BT_CH78 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK(UNII) 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BT_CH78 : Default 11a_CH36 : 18
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:0.010KHz SWT:Auto Detector : Peak Project : 9D0701 BT_CH78 : Default 11a_CH36 : 18	Left blank

ANT	BT_Ch78_Ant 1 + WIFI 802. 11a_Tx_CH36 ANT 1+2	
Simultaneously	**Vertical**	**Fundamental**
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BT_CH78 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK(UNII) 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BT_CH78 : Default 11a_CH36 : 18
Avg.	 Site : 03CH16-HY Condition : AV6_BE_54 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:0.010KHz SWT:Auto Detector : Peak Project : 9D0701 BT_CH78 : Default 11a_CH36 : 18	Left blank

2.4GHz 2400~2483.5MHz

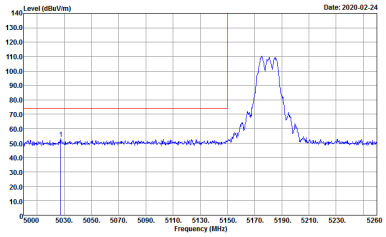
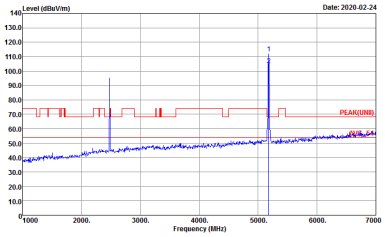
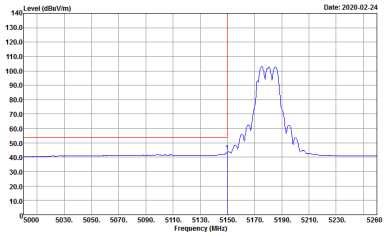
BT (Band Edge @ 3m)

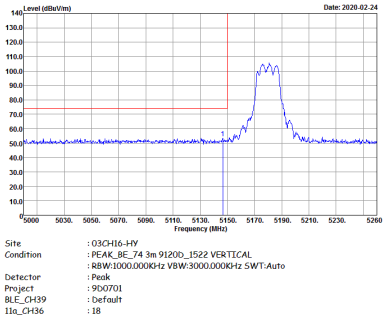
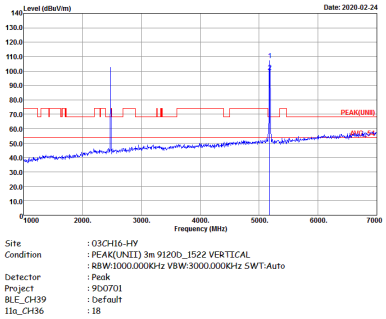
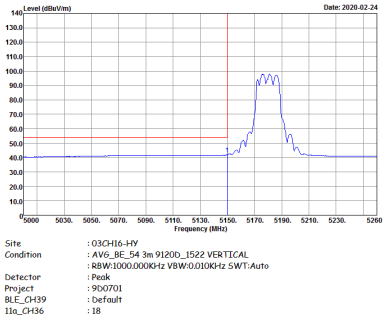
ANT	BT_Ch78_Ant 1 + WIFI 802. 11a_Tx_CH36 ANT 1+2	
Simultaneously	Horizontal	Fundamental
Peak		

ANT	BT_Ch78_Ant 1 + WIFI 802. 11a_Tx_CH36 ANT 1+2	
Simultaneously	**Vertical**	**Fundamental**
Peak		

Band 1 - 5150~5250MHz

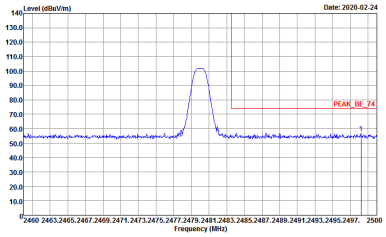
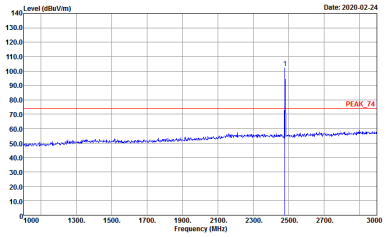
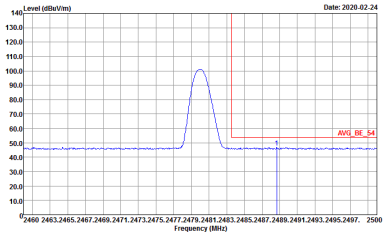
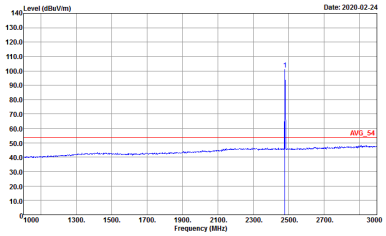
WIFI 802.11a (Band Edge @ 3m)

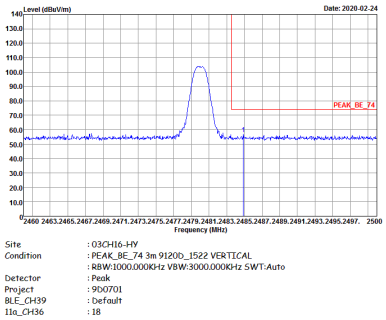
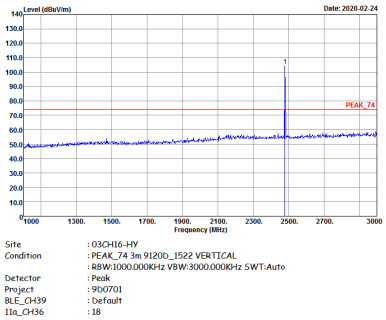
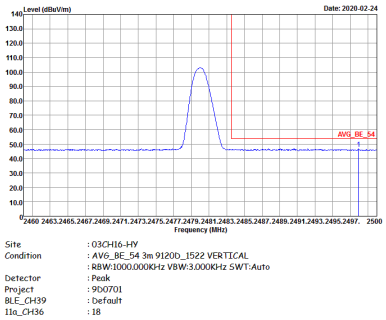
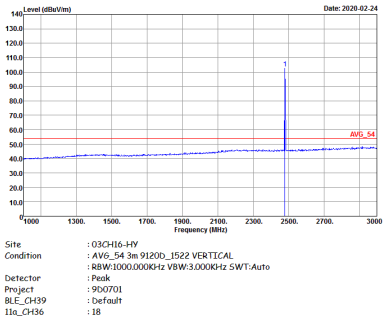
ANT	BLE_Ch39_Ant 1 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Horizontal	Fundamental
Peak		
Avg.		Left blank

ANT	BLE_Ch39_Ant 1 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	**Vertical**	**Fundamental**
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK(UNII) 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:0.010KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	Left blank

2.4GHz 2400~2483.5MHz

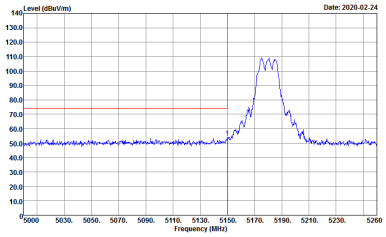
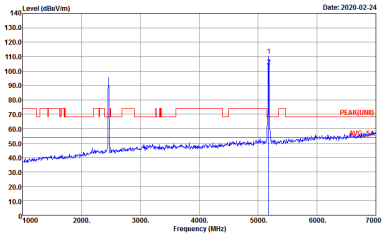
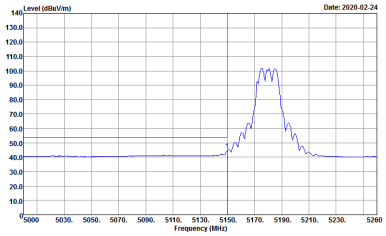
BLE (Band Edge @ 3m)

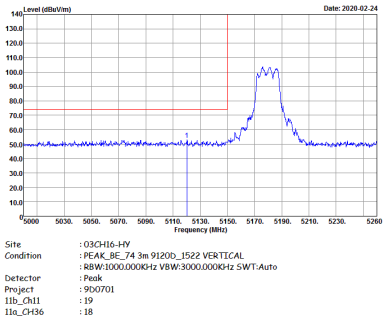
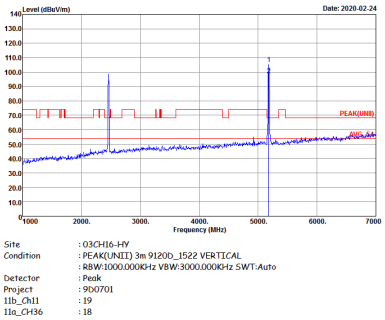
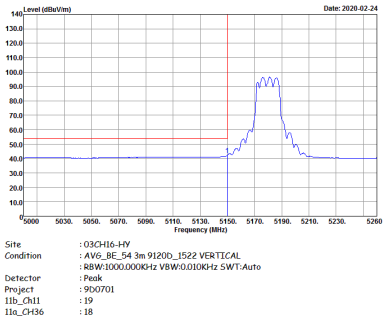
ANT	BLE_Ch39_Ant 1 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18

ANT	BLE_Ch39_Ant 1 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Vertical	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18
Avg.	 Site : 03CH16-HY Condition : AV6_BE_54 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : AV6_54 3m 9120D_1522 VERTICAL : RBW:1000.000KHz VBW:3.000KHz SWT:Auto Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18

Band 1 - 5150~5250MHz

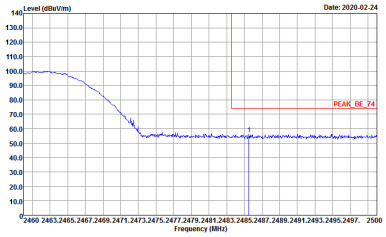
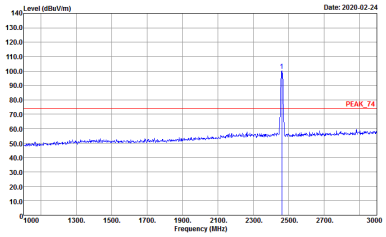
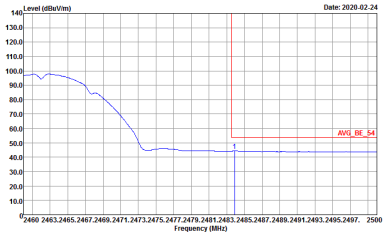
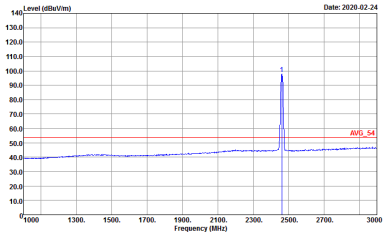
WIFI 802.11a (Band Edge @ 3m)

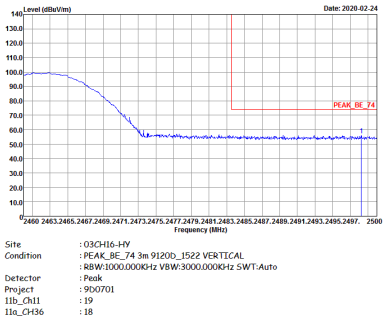
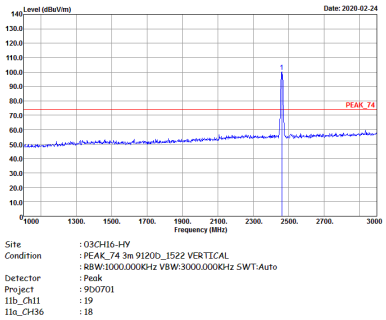
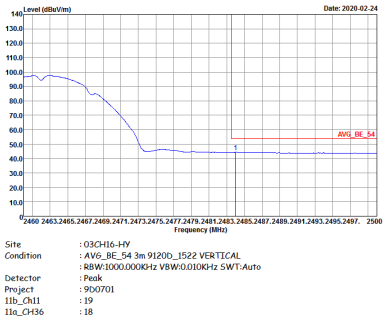
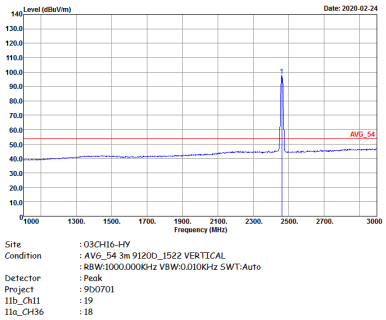
ANT	11b_Ch11_Ant 1+2 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Horizontal	Fundamental
Peak		
Avg.		Left blank

ANT	11b_Ch11_Ant 1+2 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	**Vertical**	**Fundamental**
Peak		
Avg.		Left blank

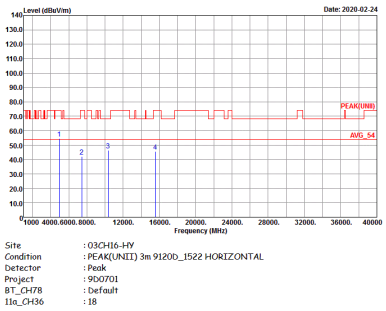
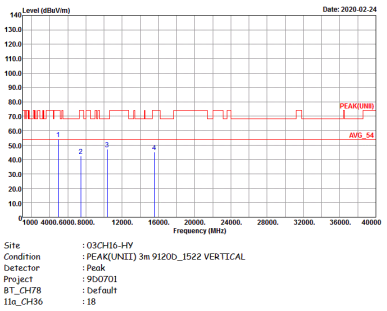
2.4GHz 2400~2483.5MHz

WIFI 802.11b (Band Edge @ 3m)

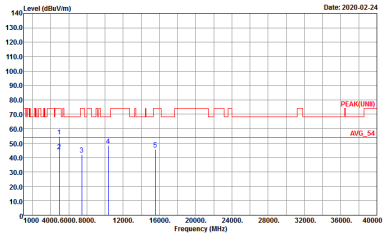
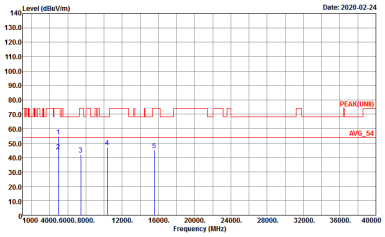
ANT	11b_Ch11_Ant 1+2 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Horizontal	Fundamental
Peak	 Site : 03CH16-HY Condition : PEAK_BE_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 11b_Ch11 : 19 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK_74 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:3000.000KHz SWT:Auto Detector : Peak Project : 9D0701 11b_Ch11 : 19 11a_CH36 : 18
Avg.	 Site : 03CH16-HY Condition : AVG_BE_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:0.010KHz SWT:Auto Detector : Peak Project : 9D0701 11b_Ch11 : 19 11a_CH36 : 18	 Site : 03CH16-HY Condition : AVG_54 3m 9120D_1522 HORIZONTAL : RBW:1000.000KHz VBW:0.010KHz SWT:Auto Detector : Peak Project : 9D0701 11b_Ch11 : 19 11a_CH36 : 18

ANT	11b_Ch11_Ant 1+2 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Vertical	Fundamental
Peak		
Avg.		

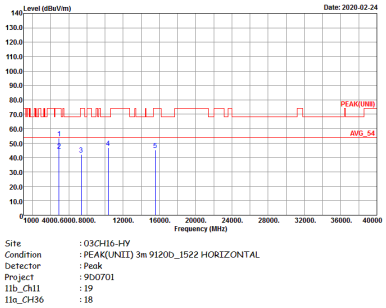
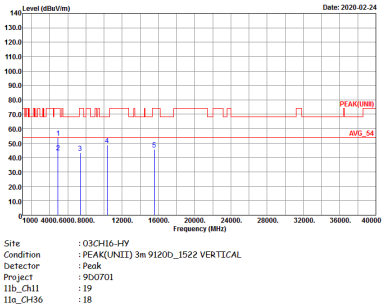
2.4GHz 2400~2483.5MHz and 5GHz Band 1 5150~5250MHz (Harmonic @ 3m)

ANT	BT_Ch78_Ant 1 + WIFI 802. 11a_Tx_CH36 ANT 1+2	
Simultaneously	Horizontal	Vertical
Peak Avg.		

2.4GHz 2400~2483.5MHz and 5GHz Band 1 5150~5250MHz (Harmonic @ 3m)

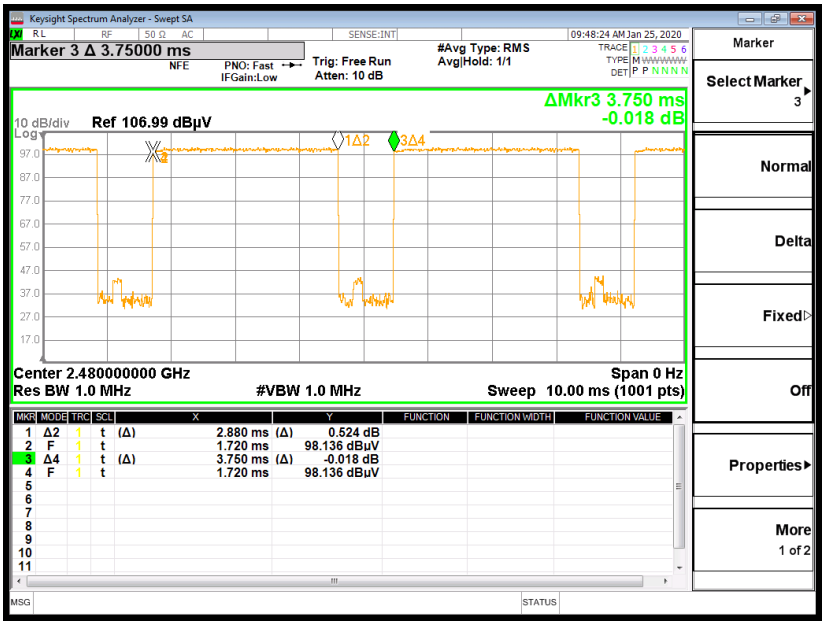
ANT	BLE_Ch39_Ant 1 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Horizontal	Vertical
Peak Avg.	 Site : 03CH16-HY Condition : PEAK(UNII) 3m 9120D_1522 HORIZONTAL Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18	 Site : 03CH16-HY Condition : PEAK(UNII) 3m 9120D_1522 VERTICAL Detector : Peak Project : 9D0701 BLE_CH39 : Default 11a_CH36 : 18

2.4GHz 2400~2483.5MHz and 5GHz Band 1 5150~5250MHz (Harmonic @ 3m)

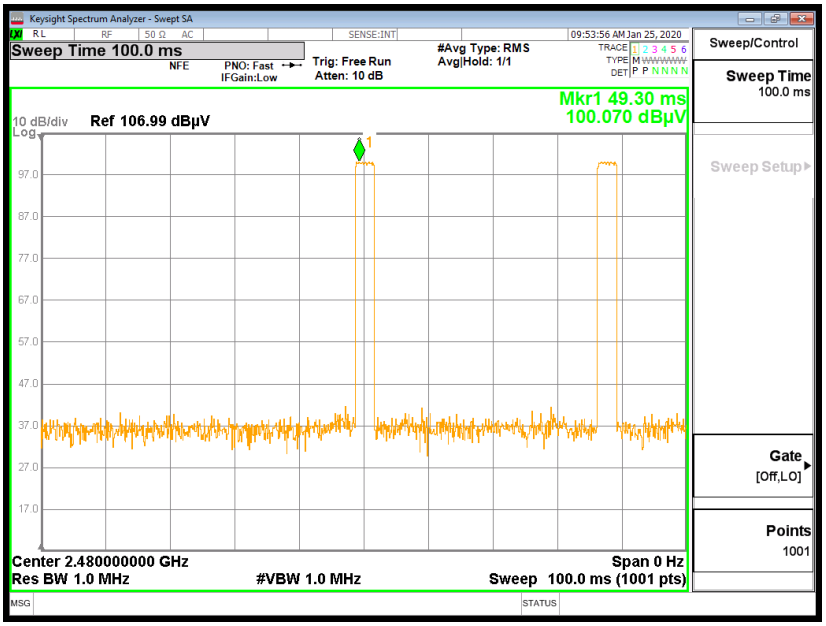
ANT	11b_Ch11_Ant 1+2 + WIFI 802.11a_Ch36_Ant 1+2	
Simultaneously	Horizontal	Vertical
Peak Avg.	 Site : 03CH16-HV Condition : PEAK(UNII) 3m 9120D_1522 HORIZONTAL Detector : Peak Project : 9D0701 11b_Ch11 : 19 11a_CH36 : 18	 Site : 03CH16-HV Condition : PEAK(UNII) 3m 9120D_1522 VERTICAL Detector : Peak Project : 9D0701 11b_Ch11 : 19 11a_CH36 : 18

Appendix C. Duty Cycle Plots

DH5 on time (One Pulse) Plot on Channel 39



on time (Count Pulses) Plot on Channel 39



Note:

1. Worst case Duty cycle = on time/100 milliseconds = 2 * 2.88 / 100 = 5.76 %
2. Worst case Duty cycle correction factor = 20*log(Duty cycle) = -24.79 dB
3. **DH5** has the highest duty cycle worst case and is reported.

Duty Cycle Correction Factor Consideration for AFH mode:

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

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

2.88 ms x 20 channels = 57.6 ms

There cannot be 2 complete hopping sequences within 100ms period, considering the random hopping behavior, maximum 2 hops can be possibly observed within the period. [100ms / 57.6ms] = 2 hops

Thus, the maximum possible ON time:

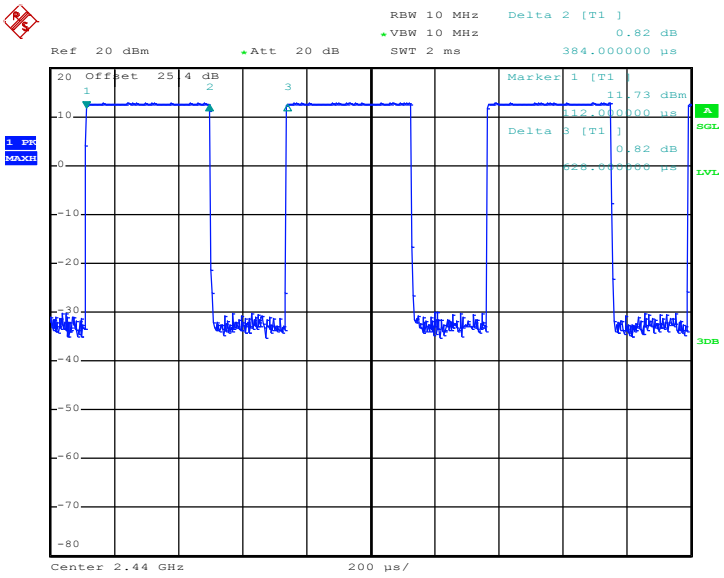
2.88 ms x 2 = 5.76 ms

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

20 x log(5.76 ms/100ms) = -24.79 dB

Antenna	Band	Duty Cycle (%)	T(us)	1/T(kHz)	VBW Setting	Duty Factor (dB)
1	Bluetooth - LE for 1Mbps	61.15	384	2.60	3kHz	2.14
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	99.06	-	-	10Hz	0.04
1+2	5GHz 802.11a for Ant. 2	98.59	-	-	10Hz	0.06

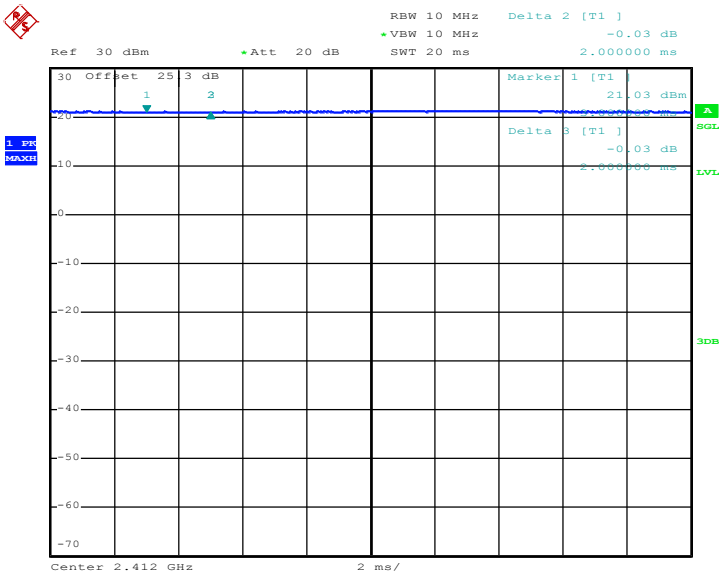
Bluetooth - LE for 1Mbps



Date: 18.FEB.2020 13:19:12

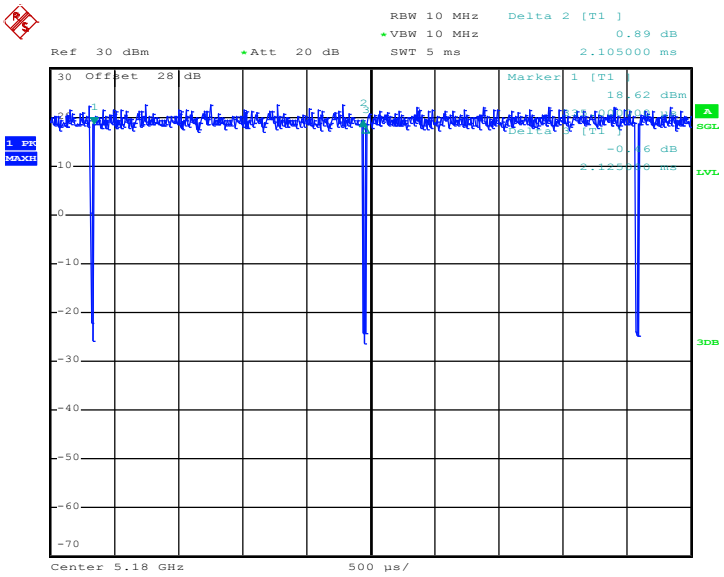
MIMO <Ant. 1>

2.4GHz 802.11b



Date: 13.JAN.2020 08:14:07

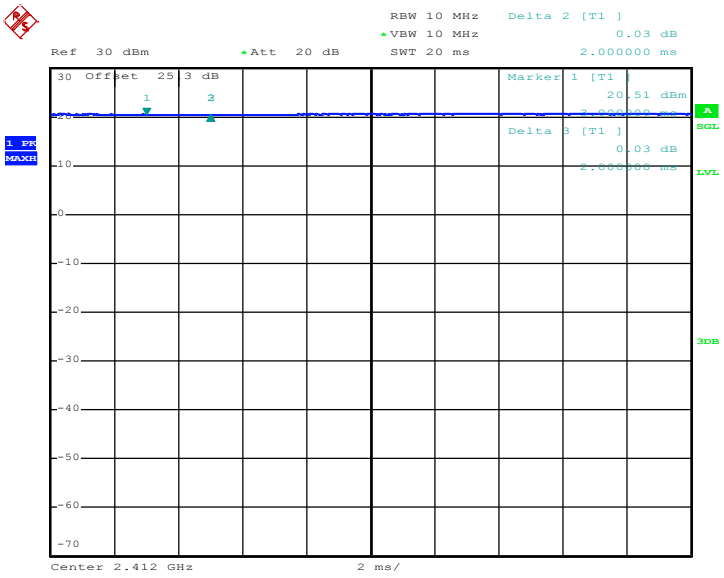
5GHz 802.11a



Date: 13.JAN.2020 16:29:22

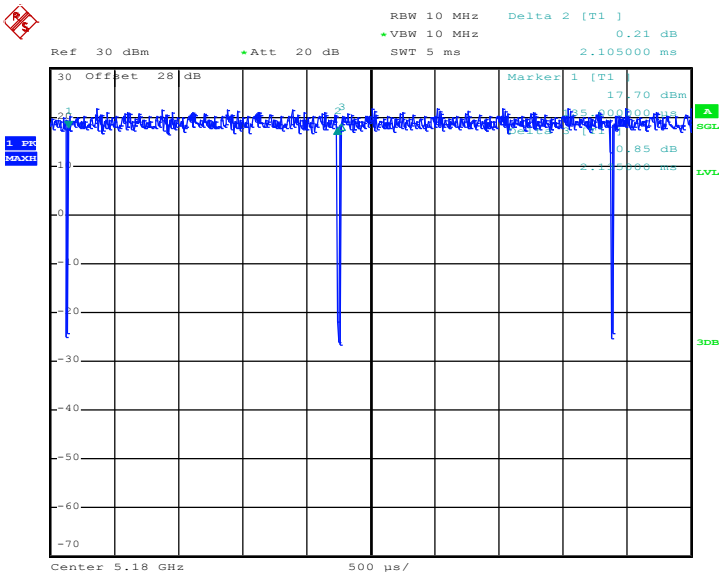
MIMO <Ant. 2>

2.4GHz 802.11b



Date: 13.JAN.2020 08:15:13

802.11a



Date: 13.JAN.2020 16:30:24