FCC RF CO-LOCATION TEST REPORT

FCC ID	:	**UDX-60053020**
Equipment	:	**LTE & Wi-Fi Router**
Brand Name	:	**CISCO**
Model Name	:	**Z3C-HW-NA**
Applicant	:	**Cisco Systems, Inc.** **170 West Tasman Drive, San Jose, CA 95134**
Standard	:	**FCC Part 15 Subpart E §15.407**

The product was received on Jan. 17, 2018 and testing was started from Jun. 06, 2018 and completed on Jun. 07, 2018. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The 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 INTERTIONAL INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.

Jones Tsai

Approved by: Jones Tsai

SPORTON INTERTIONAL INC. EMC & Wireless Communications Laboratory

No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)

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History of this test report

Report No.	Version	Description	Issued Date
FR811724F	01	Initial issue of report	Jul. 27, 2018

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 5.27 dB at 33.240 MHz
3	15.203 15.407(a)	Antenna Requirement	Pass	-

Reviewed by: Joseph Lin

Report Producer: Polly Tsai

1 General Description

1.1 Product Feature of Equipment Under Test

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

Product Specification subjective to this standard	
Antenna Type	WWAN: PIFA Antenna WLAN <Ant. 1>: PIFA Antenna <Ant. 2>: Dipole Antenna Bluetooth: PIFA Antenna

1.2 Modification of EUT

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

1.3 Testing Location

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

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

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

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 662911 D01 Multiple Transmitter Output v02r01.
- ANSI C63.10-2013

Remark: All test items were verified and recorded according to the standards and without any deviation during the test.

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

2400-2483.5 MHz Bluetooth - LE	
Channel	**Freq. (MHz)**
39	2480

5180-5240 MHz 802.11n HT40		5500-5720 MHz 802.11n HT40	
Channel	**Freq. (MHz)**	**Channel**	**Freq. (MHz)**
38	5190	102	5510

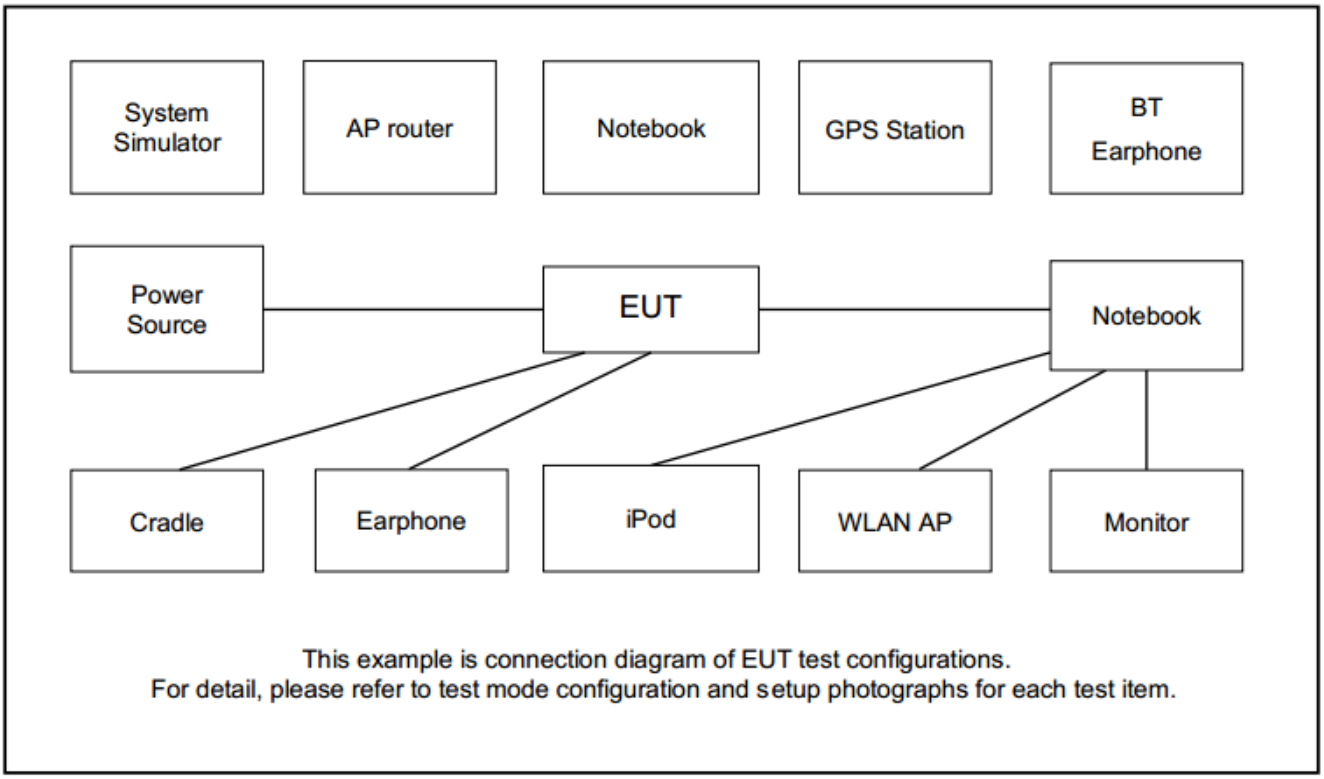
2.2 Test Mode

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

<Co-Location>

Modulation	Data Rate
11n (HT40) + Bluetooth LE	**MCS0 + 1 Mbps**
11n (HT40) + Bluetooth LE	**MCS0 + 1 Mbps**

2.3 Connection Diagram of Test System



2.4 EUT Operation Test Setup

For WLAN test items, utility “QRCT” 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.

For Bluetooth - LE test items, utility “CMD” 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

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) to (b)(3) specify the unwanted emission limits 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.[3]

(ii) Section 15.407(b)(4) specifies the unwanted emission limit for the U-NII-3 band. A band emissions mask is specified in Section 15.407(b)(4)(i). The emission limits are in terms of a Peak detector. An alternative to the band emissions mask is specified in Section 15.407(b)(4)(ii). The alternative limits are based on the highest antenna gain specified in the filing. There are also marketing and importation restrictions for the devices using the alternative limit.[4]

Note 3: An out-of-band emission that complies with both the average and peak limits of Section 15.209 is not required to satisfy the -27 dBm/MHz peak emission limit.

Note 4: Only devices with antenna gains of 10 dBi or less may be approved using the emission limits specified in Section 15.247(d) till March 2, 2018; all other devices operating in this band must use the mask specified in Section 15.407(b)(4)(i).

3.1.2 Measuring Instruments

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

3.1.3 Test Procedures

1. The 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

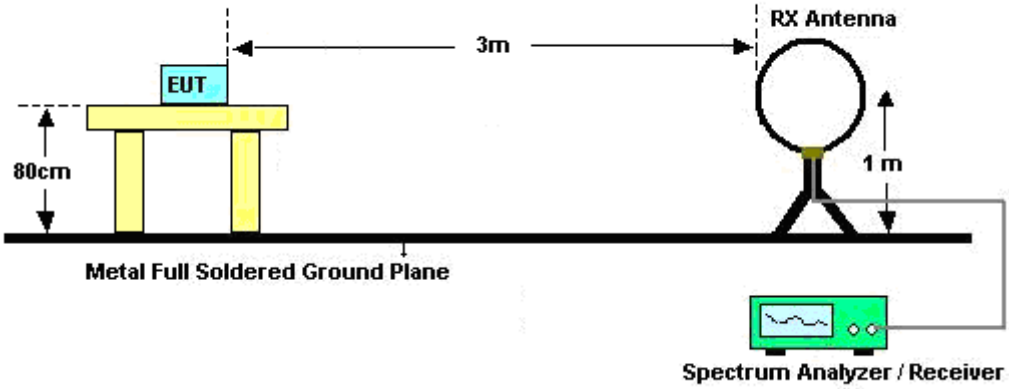
(3) Procedures for Average Unwanted Emissions Measurements Above 1000MHz

- 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.

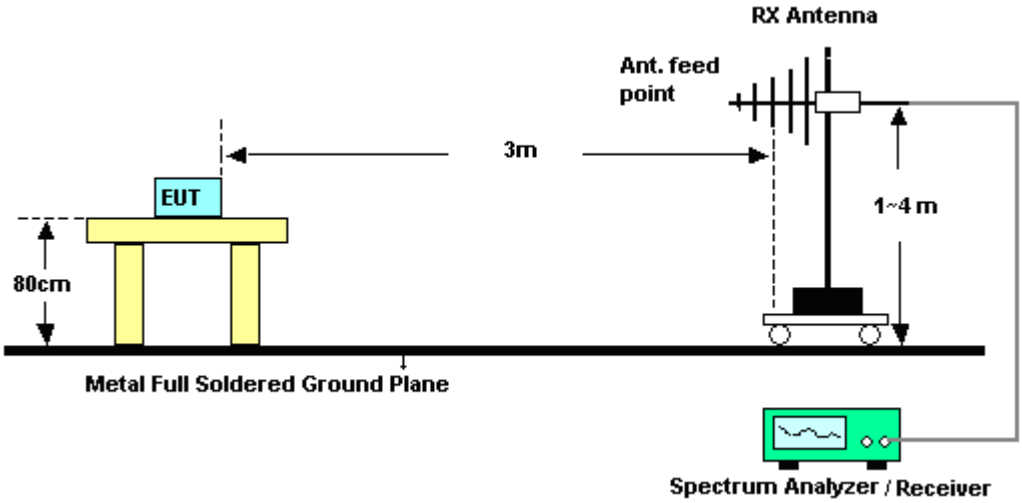
2. he EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
3. The EUT was set 3 meters from the interference receiving antenna which was mounted on the top of a variable height antenna tower.
4. The antenna is a broadband 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

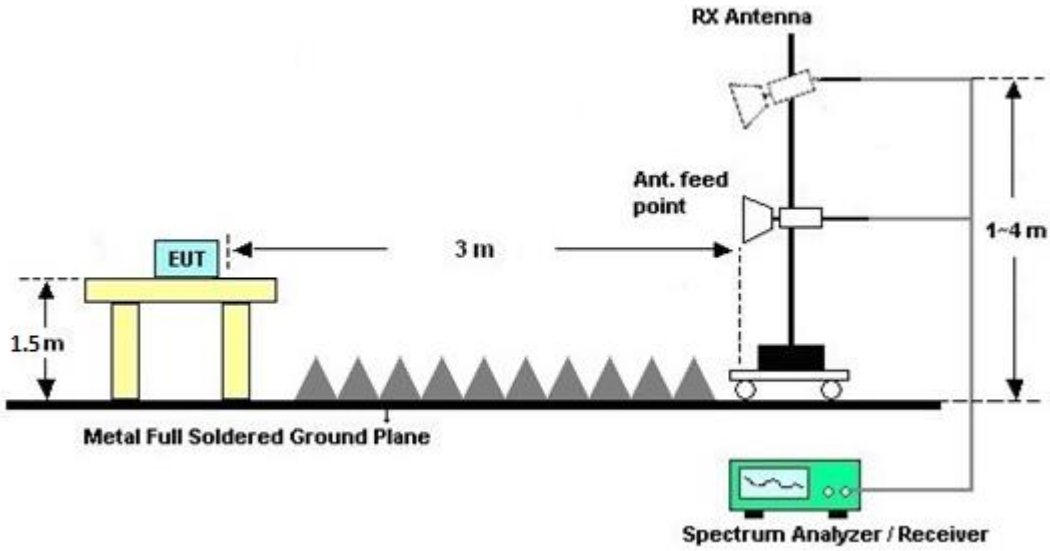
For radiated emissions below 30MHz



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 semi-Anechoic chamber, and the result came out very similar.

3.1.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix A.

3.1.7 Duty Cycle

Please refer to Appendix B.

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

Please refer to Appendix A.

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

<CDD Modes>

FCC KDB 662911 D01 Multiple Transmitter Output v02r01

For CDD transmissions, directional gain is calculated as

Directional gain = GANT + Array Gain, where Array Gain is as follows.

For power spectral density (PSD) measurements on all devices,

Array Gain = 10 log(NANT/NSS=1) dB.

For power measurements on IEEE 802.11 devices,

Array Gain = 0 dB (i.e., no array gain) for NANT ≤ 4.

Directional gain may be calculated by using the formulas applicable to equal gain antennas with GANT set equal to the gain of the antenna having the highest gain;

The EUT supports CDD mode.

For power, the directional gain GANT is set equal to the antenna having the highest gain, i.e., F)2)f)i).

For PSD, the directional gain calculation is following F)2)f)ii) of KDB 662911 D01 v02r01.

The power and PSD limit should be modified if the directional gain of EUT is over 6 dBi,

The directional gain “DG” is calculated as following table.

<CDD Modes>

	Ant. 1 (dBi)	Ant. 2 (dBi)	DG for Power (dBi)	DG for PSD (dBi)	Power Limit Reduction (dB)	PSD Limit Reduction (dB)
Band I	4.00	3.50	4.00	6.76	0.00	0.76
Band III	4.00	3.50	4.00	6.76	0.00	0.76

Power limit reduction = Composite gain – 6dBi, (min = 0)

PSD limit reduction = Composite gain + PSD Array gain – 6dBi, (min = 0)

4 List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Amplifier	MITEQ	TTA1840-35-HG	1871923	18GHz~40GHz, VSWR : 2.5:1 max	Jul. 18, 2017	Jun. 06, 2018~ Jun. 07, 2018	Jul. 17, 2018	Radiation (03CH12-HY)
Spectrum Analyzer	Keysight	N9010A	MY54200485	10Hz ~ 44GHz	Oct. 31, 2017	Jun. 06, 2018~ Jun. 07, 2018	Oct. 30, 2018	Radiation (03CH12-HY)
Bilog Antenna	TESEQ	CBL 6111D&N-6-06	35414&AT-N 0602	30MHz~1GHz	Oct. 14, 2017	Jun. 06, 2018~ Jun. 07, 2018	Oct. 13, 2018	Radiation (03CH12-HY)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100488	9 kHz~30 MHz	Nov. 23, 2017	Jun. 06, 2018~ Jun. 07, 2018	Nov. 22, 2018	Radiation (03CH12-HY)
EMI Test Receiver	Rohde & Schwarz	ESU26	100390	20Hz~26.5GHz	Dec. 25, 2017	Jun. 06, 2018~ Jun. 07, 2018	Dec. 24, 2018	Radiation (03CH12-HY)
Horn Antenna	SCHWARZBECK	BBHA 9120D	9120D-1328	1GHz ~ 18GHz	Oct. 20, 2017	Jun. 06, 2018~ Jun. 07, 2018	Oct. 19, 2018	Radiation (03CH12-HY)
Preamplifier	COM-POWER	PA-103	161075	10MHz~1GHz	Mar. 26, 2018	Jun. 06, 2018~ Jun. 07, 2018	Mar. 25, 2019	Radiation (03CH12-HY)
Preamplifier	Keysight	83017A	MY53270148	1GHz~26.5GHz	Jan. 15, 2018	Jun. 06, 2018~ Jun. 07, 2018	Jan. 14, 2019	Radiation (03CH12-HY)
Filter	Wainwright	WLKS1200-12SS	SN2	1.2G Low Pass	Jul. 17, 2017	Jun. 06, 2018~ Jun. 07, 2018	Jul. 16, 2018	Radiation (03CH12-HY)
Filter	Woken	WHKX8-5272.5-6750-18000-40ST	SN2	6.75G Highpass	Jul. 17, 2017	Jun. 06, 2018~ Jun. 07, 2018	Jul. 16, 2018	Radiation (03CH12-HY)
Antenna Mast	EMEC	AM-BS-4500-B	N/A	1m~4m	N/A	Jun. 06, 2018~ Jun. 07, 2018	N/A	Radiation (03CH12-HY)
Turn Table	EMEC	TT2000	N/A	0~360 Degree	N/A	Jun. 06, 2018~ Jun. 07, 2018	N/A	Radiation (03CH12-HY)
SHF-EHF Horn Antenna	SCHWARZBECK	BBHA 9170	BBHA9170584	18GHz ~ 40GHz	Nov. 27, 2017	Jun. 06, 2018~ Jun. 07, 2018	Nov. 26, 2018	Radiation (03CH12-HY)
Preamplifier	Jet-Power	JPA0118-55-303	1710001800054001	1GHz~18GHz	Apr. 16, 2018	Jun. 06, 2018~ Jun. 07, 2018	Apr. 15, 2019	Radiation (03CH12-HY)
Software	Audix	E3 6.2009-8-24	RK-000989	N/A	N/A	Jun. 06, 2018~ Jun. 07, 2018	N/A	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 126E	0058/126E	30M-18G	Mar. 14, 2018	Jun. 06, 2018~ Jun. 07, 2018	Mar. 13, 2019	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	505134/2	30M~40GHz	Oct. 17, 2017	Jun. 06, 2018~ Jun. 07, 2018	Oct. 16, 2018	Radiation (03CH12-HY)
RF Cable	HUBER + SUHNER	SUCOFLEX 102	800740/2	30M~40GHz	Oct. 17, 2017	Jun. 06, 2018~ Jun. 07, 2018	Oct. 16, 2018	Radiation (03CH12-HY)

5 Uncertainty of Evaluation

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

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

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

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

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

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	4.7

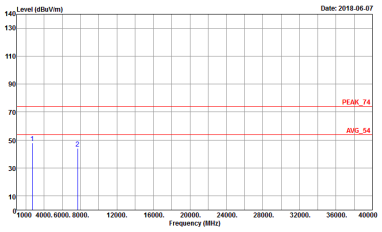
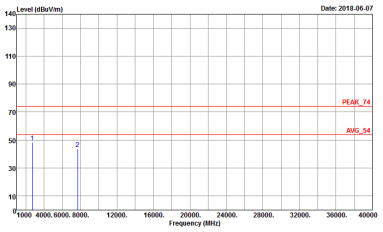
Appendix A. Radiated Spurious Emission Plots

Test Engineer :	Karl Hou	**Temperature :**	21~23°C
		Relative Humidity :	59~62%

Note symbol

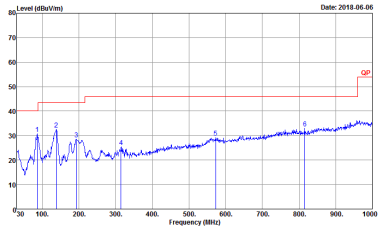
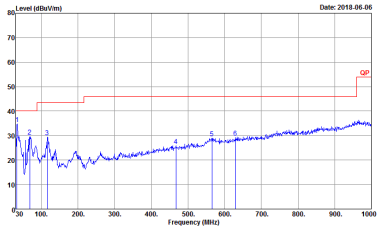
-L	**Low channel location**
-R	**High channel location**

11a(n40)CH38 + BLE CH39 (Harmonic @ 3m)

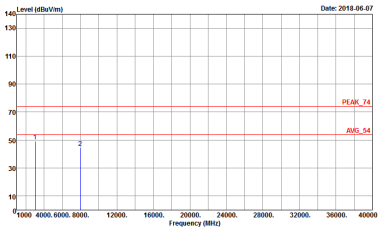
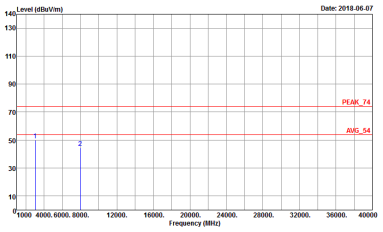
	11a(n40)C*H*38 + BLE C*H*39	
	Horizontal	**Vertical**
Peak **Avg.**	 Site : 03CH12-HY Condition : PEAK_74 3m HORN_9120D_1328 HORIZONTAL Detector : Peak Project : 811724 Mode : 21 1 2710.00 48.11 -25.89 74.00 44.64 27.92 7.09 31.54 100 0 Peak 2 7670.00 44.02 -29.98 74.00 52.21 36.80 13.01 58.80 100 0 Peak	 Site : 03CH12-HY Condition : PEAK_74 3m HORN_9120D_1328 VERTICAL Detector : Peak Project : 811724 Mode : 21 1 2710.00 48.23 -25.77 74.00 44.76 27.92 7.09 31.54 100 0 Peak 2 7670.00 43.87 -30.13 74.00 52.06 36.80 13.01 58.80 100 0 Peak

Emission below 1GHz

11a(n40)CH38 + BLE CH39 (LF)

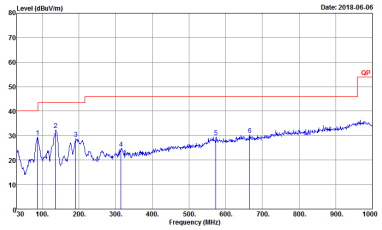
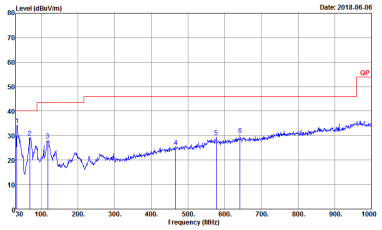
	11a(n40)C*H*38 + BLE C*H*39	
	Horizontal	Vertical
QP / Peak	 Site : 03CH12-HY Condition : QP 3m BILOG_6111D_35414 HORIZONTAL Detector : Peak Project : 811724 Mode : 21 1 86.16 30.84 -9.16 40.00 45.96 13.99 1.27 30.44 100 0 Peak 2 138.54 32.45 -11.05 43.50 43.96 17.21 1.60 30.39 --- --- Peak 3 193.08 28.61 -14.89 43.50 42.24 14.65 1.91 30.33 --- --- Peak 4 314.70 25.36 -20.64 46.00 33.78 19.19 2.42 30.12 --- --- Peak 5 573.00 29.10 -16.90 46.00 29.75 25.66 3.26 29.67 --- --- Peak 6 815.90 32.87 -13.13 46.00 30.30 27.83 3.88 29.27 --- --- Peak	 Site : 03CH12-HY Condition : QP 3m BILOG_6111D_35414 VERTICAL Detector : Peak Project : 811724 Mode : 21 1 33.24 34.73 -5.27 40.00 41.44 22.77 0.78 30.23 100 0 Peak 2 68.34 29.62 -10.38 40.00 46.97 11.93 1.13 30.46 --- --- Peak 3 116.13 29.38 -14.12 43.50 41.21 17.08 1.47 30.41 --- --- Peak 4 467.30 25.84 -20.16 46.00 29.43 23.26 2.94 29.85 --- --- Peak 5 565.30 28.89 -17.11 46.00 29.33 25.89 3.24 29.68 --- --- Peak 6 629.00 29.10 -16.90 46.00 29.24 25.94 3.42 29.60 --- --- Peak

11a(n40)_Tx_Ch102 + BLE_Tx_Ch39 (Harmonic @ 3m)

	11a(n40)_Tx_Ch102 + BLE_Tx_Ch39	
	Horizontal	Vertical
Peak Avg.	 Site : 03CH12-HY Condition : PEAK_74 3m HORN_9120D_1328 HORIZONTAL Detector : Peak Project : 811724 Mode : 26 1 3030.00 49.05 -24.95 74.00 44.45 28.60 7.52 31.52 100 0 Peak 2 7990.00 44.45 -29.55 74.00 52.39 37.18 13.29 59.18 100 0 Peak	 Site : 03CH12-HY Condition : PEAK_74 3m HORN_9120D_1328 VERTICAL Detector : Peak Project : 811724 Mode : 26 1 3030.00 49.95 -24.05 74.00 45.35 28.60 7.52 31.52 100 0 Peak 2 7990.00 44.47 -29.53 74.00 52.41 37.18 13.29 59.18 100 0 Peak

Emission below 1GHz

11a(n40)_Tx_Ch102 + BLE_Tx_Ch39 (LF)

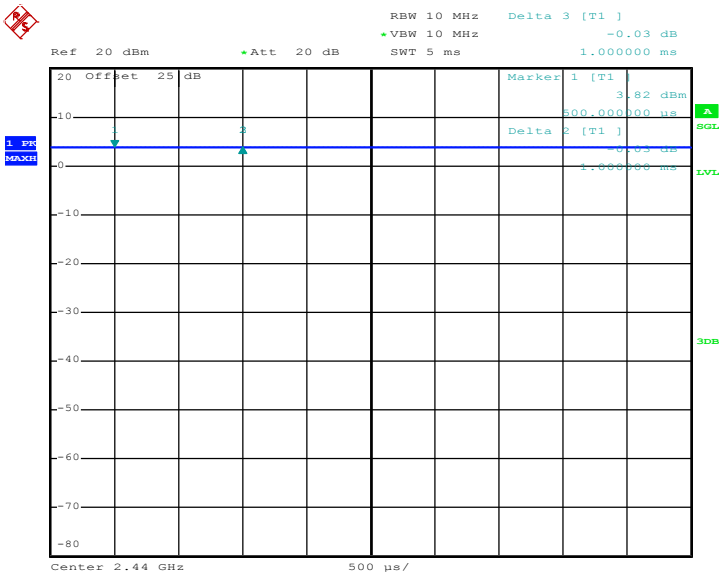
	11a(n40)_Tx_Ch102 + BLE_Tx_Ch39	
	Horizontal	Vertical
QP / Peak	 Site : 03CH12-HY Condition : QP 3m BILOG_6111D_35414 HORIZONTAL Detector : Peak Project : 811724 Mode : Z6 1 86.97 29.34 -10.66 40.00 44.31 14.14 1.27 30.44 100 0 Peak 2 136.11 32.22 -11.28 43.50 43.80 17.16 1.59 30.39 --- --- Peak 3 190.92 28.80 -14.70 43.50 42.48 14.61 1.89 30.33 --- --- Peak 4 314.70 24.79 -21.21 46.00 33.21 19.19 2.42 30.12 --- --- Peak 5 573.70 29.46 -16.54 46.00 30.14 25.63 3.26 29.67 --- --- Peak 6 665.40 30.36 -15.64 46.00 30.05 26.25 3.51 29.56 --- --- Peak	 Site : 03CH12-HY Condition : QP 3m BILOG_6111D_35414 VERTICAL Detector : Peak Project : 811724 Mode : Z6 1 33.51 34.38 -5.62 40.00 41.56 22.31 0.78 30.24 100 0 Peak 2 68.07 29.15 -10.85 40.00 46.54 11.90 1.12 30.46 --- --- Peak 3 117.48 28.09 -15.41 43.50 39.85 17.14 1.48 30.41 --- --- Peak 4 466.60 25.39 -20.61 46.00 28.99 23.25 2.94 29.85 --- --- Peak 5 577.20 29.41 -16.59 46.00 30.16 25.54 3.27 29.66 --- --- Peak 6 641.60 30.21 -15.79 46.00 29.90 26.33 3.45 29.58 --- --- Peak

Appendix B. Duty Cycle Plots

Antenna	Band	Duty Cycle(%)	T(us)	1/T(kHz)	VBW Setting	Duty Factor(dB)
1	Bluetooth - LE	100.00	-	-	10Hz	0.00
1+2	5GHz 802.11n HT40 for Ant. 1	96.03	2420.00	0.41	1kHz	0.18
1+2	5GHz 802.11n HT40 for Ant. 2	96.03	2420.00	0.41	1kHz	0.18

<Ant. 1>

Bluetooth - LE



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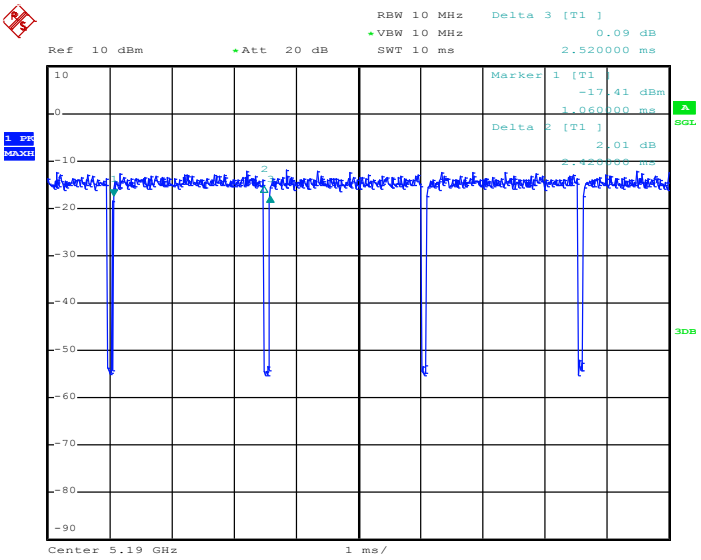
802.11n HT40



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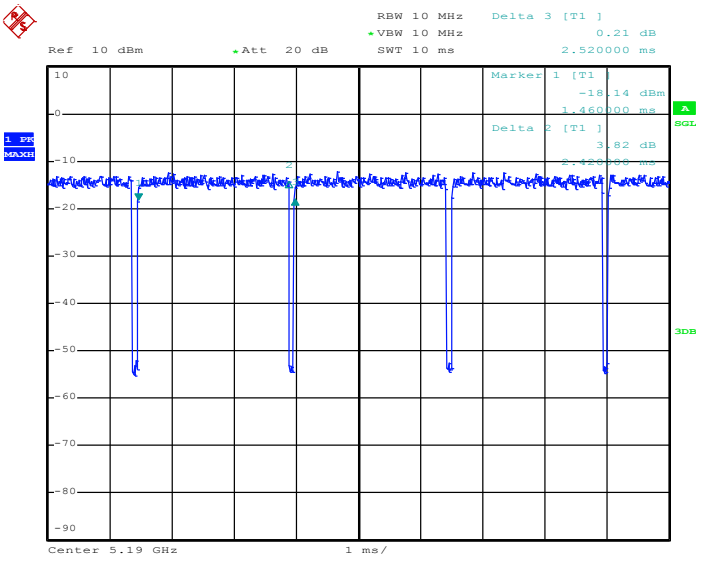
802.11n HT40



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