MEASUREMENT REPORT

FCC PART 15.247 WLAN 802.11b/g/n

FCC ID	:	TK4WLE1216V220
APPLICANT	:	Compex Systems Pte Ltd
Application Type	:	Certification
Product	:	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module
Model No.	:	WLE1216V2-20, WLE1216V2-20-I
Brand Name	:	COMPEX
FCC Classification	:	Digital Transmission System (DTS)
FCC Rule Part(s)	:	Part 15 Subpart C (Section 15.247)
Test Procedure(s)	:	ANSI C63.10-2013, KDB 558074 D01v04
Test Date	:	January 19 ~ March 08, 2018

Reviewed By : Jame Yuan
(Jame Yuan)

Approved By : Marlin Chen
(Marlin Chen)

ACCREDITED
TESTING LABORATORY
CERTIFICATE #3628.01

The test results relate only to the samples tested.
This equipment has been shown to be capable of compliance with the applicable technical standards as indicated in the measurement report and was tested in accordance with the measurement procedures specified in KDB 558074 D01v04. Test results reported herein relate only to the item(s) tested.
The test report shall not be reproduced except in full without the written approval of MRT Technology (Suzhou) Co., Ltd.

Revision History

Report No.	Version	Description	Issue Date	Note
1801RSU037-U1	Rev. 01	Initial report	03-08-2018	Valid

CONTENTS

Description Page

§2.1033 General Information 5

1. INTRODUCTION 6

1.1. Scope 6
1.2. MRT Test Location 6

2. PRODUCT INFORMATION 7

2.1. Feature of Equipment under Test 7
2.2. Product Specification Subjective to this Report 7
2.3. Working Frequencies for this report 7
2.4. Description of Available Antennas 8
2.5. Description of Support Units 8
2.6. Description of Antenna RF Port 8
2.7. Test Mode 9
2.8. Test Software 10
2.9. Device Capabilities 11
2.10. Test Configuration 12
2.11. EMI Suppression Device(s)/Modifications 12
2.12. Labeling Requirements 12

3. DESCRIPTION of TEST 13

3.1. Evaluation Procedure 13
3.2. AC Line Conducted Emissions 13
3.3. Radiated Emissions 14

4. ANTENNA REQUIREMENTS 15

5. TEST EQUIPMENT CALIBRATION DATE 16

6. MEASUREMENT UNCERTAINTY 17

7. TEST RESULT 18

7.1. Summary 18
7.2. 6dB Bandwidth Measurement 19
7.2.1. Test Limit 19
7.2.2. Test Procedure used 19
7.2.3. Test Setting 19
7.2.4. Test Setup 19
7.2.5. Test Result 20
7.3. Output Power Measurement 25

7.3.1. Test Limit 25
7.3.2. Test Procedure Used 25
7.3.3. Test Setting 25
7.3.4. Test Setup 25
7.3.5. Test Result of Output Power 26
7.4. Power Spectral Density Measurement 28
7.4.1. Test Limit 28
7.4.2. Test Procedure Used 28
7.4.3. Test Setting 28
7.4.4. Test Setup 29
7.4.5. Test Result 30
7.5. Conducted Band Edge and Out-of-Band Emissions 64
7.5.1. Test Limit 64
7.5.2. Test Procedure Used 64
7.5.3. Test Settitng 64
7.5.4. Test Setup 65
7.5.5. Test Result 66
7.6. Radiated Spurious Emission Measurement 75
7.6.1. Test Limit 75
7.6.2. Test Procedure Used 75
7.6.3. Test Setting 75
7.6.4. Test Setup 77
7.6.5. Test Result 79
7.7. Radiated Restricted Band Edge Measurement 141
7.7.1. Test Result 141
7.8. AC Conducted Emissions Measurement 301
7.8.1. Test Limit 301
7.8.2. Test Setup 301
7.8.3. Test Result 302

8. CONCLUSION 304

§2.1033 General Information

Applicant:	Compex Systems Pte Ltd
Applicant Address:	No:9 Harrison Road, Harrison Industrial Building, #05-01, Singapore 369651
Manufacturer:	Compex Systems Pte Ltd
Manufacturer Address:	No:9 Harrison Road, Harrison Industrial Building, #05-01, Singapore 369651
Test Site:	MRT Technology (Suzhou) Co., Ltd
Test Site Address:	D8 Building, No.2 Tian'edang Rd., Wuzhong Economic Development Zone, Suzhou, China
FCC Registration No.:	893164
FCC Rule Part(s):	Part 15.247
Test Device Serial No.:	N/A ☐ Production ☒ Pre-Production ☐ Engineering
FCC Classification:	Digital Transmission System (DTS)

Test Facility / Accreditations

Measurements were performed at MRT Laboratory located in Tian'edang Rd., Suzhou, China.

- **MRT facility is a FCC registered (MRT Reg. No. 893164) test facility with the site description report on file and has met all the requirements specified in Section 2.948 of the FCC Rules.**
- **MRT facility is an IC registered (MRT Reg. No. 11384A-1) test laboratory with the site description on file at Industry Canada.**
- **MRT facility is a VCCI registered (R-20025, G-20034, C-20020, T-20020) test laboratory with the site description on file at VCCI Council.**
- **MRT Lab is accredited to ISO 17025 by the American Association for Laboratory Accreditation (A2LA) under the American Association for Laboratory Accreditation Program (A2LA Cert. No. 3628.01) in EMC, Telecommunications and Radio testing for FCC, Industry Canada, EU and TELEC Rules.**

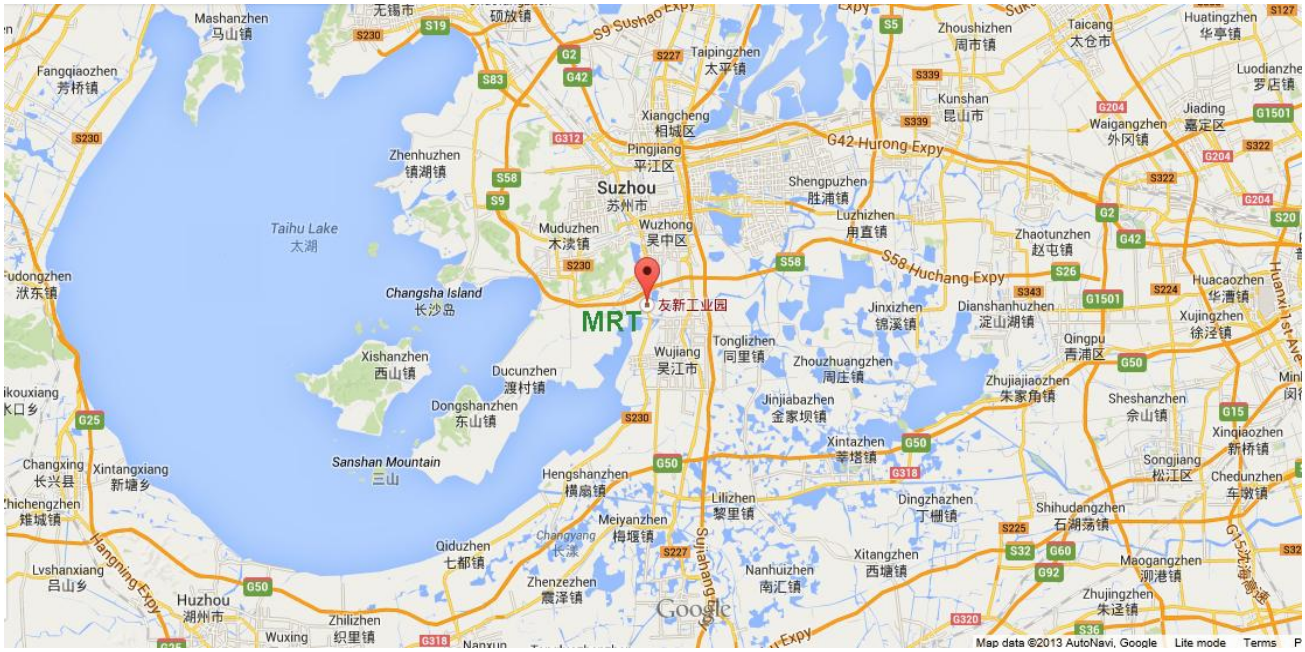
1. INTRODUCTION

1.1. Scope

Measurement and determination of electromagnetic emissions (EMC) of radio frequency devices including intentional and/or unintentional radiators for compliance with the technical rules and regulations of the Federal Communications Commission and the Industry Canada Certification and Engineering Bureau.

1.2. MRT Test Location

The map below shows the location of the MRT LABORATORY, its proximity to the Taihu Lake. These measurement tests were conducted at the MRT Technology (Suzhou) Co., Ltd. Facility located at D8 Building, No.2 Tian'edang Rd., Wuzhong Economic Development Zone, Suzhou, China. The detailed description of the measurement facility was found to be in compliance with the requirements of § 2.948 according to ANSI C63.4-2009 on September 30, 2013.



2. PRODUCT INFORMATION

2.1. Feature of Equipment under Test

Product Name:	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module
Model No.:	WLE1216V2-20, WLE1216V2-20-I
Wi-Fi Specification:	802.11b/g/n
Antenna Delivery	4*TX + 4*RX

2.2. Product Specification Subjective to this Report

Wi-Fi Specification	
Frequency Range:	802.11b/g/n-HT20: 2412 ~ 2462 MHz 802.11n-HT40: 2422 ~ 2452 MHz
Type of Modulation:	802.11b: DSSS 802.11g/n: OFDM
Data Rate:	802.11b: 1/2/5.5/11Mbps 802.11g: 6/9/12/18/24/36/48/54Mbps 802.11n: up to 600Mbps

2.3. Working Frequencies for this report

Channel List for 802.11b/g/n-HT20

Channel	Frequency	Channel	Frequency	Channel	Frequency
01	2412 MHz	02	2417 MHz	03	2422 MHz
04	2427 MHz	05	2432 MHz	06	2437 MHz
07	2442 MHz	08	2447 MHz	09	2452 MHz
10	2457 MHz	11	2462 MHz	--	--

Channel List for 802.11n-HT40

Channel	Frequency	Channel	Frequency	Channel	Frequency
03	2422 MHz	04	2427 MHz	05	2432 MHz
06	2437 MHz	07	2442 MHz	08	2447 MHz
09	2452 MHz	--	--	--	--

2.4. Description of Available Antennas

Antenna Type	Frequency Band (GHz)	TX Paths	Max Peak Gain (dBi)
Dipole Antenna	2.4	4	5
Panel Antenna	2.4	4	11

Note: The device didn't support beam-forming technology and Cyclic Delay Diversity (CDD) technology, and the transmit signals are uncorrected, so no add array gain to the band power and band PSD.

2.5. Description of Support Units

The EUT has been tested with associated equipment below:

Description	Manufacturer	Model No.
Client Terminal	Compex Systems Pte Ltd	WPJXXX

2.6. Description of Antenna RF Port

Antenna RF Port				
--	2.4GHz RF Port			
Software Control Port	Ant 0	Ant 1	Ant 2	Ant 3

2.7. Test Mode

Test Mode	Mode 1: Transmit by 802.11b (1Mbps)
	Mode 2: Transmit by 802.11g (6Mbps)
	Mode 3: Transmit by 802.11n-HT20 (MCS24)
	Mode 4: Transmit by 802.11n-HT40 (MCS24)

2.8. Test Software

The test utility software used during testing was “QRCT”, and the version was “3.0.268.0”.

Final Power Parameter Value

Test Mode	Test Channel (MHz)	Power Parameter Value				
		SISO Mode				MIMO Mode
		Ant 0	Ant 1	Ant 2	Ant 3	Ant 0+1+2+3
For Dipole Antenna						
802.11b	2412	20.0	18.5	20.0	20.0	Not Support
	2437	20.0	20.0	20.0	20.0	
	2462	20.0	20.0	20.0	20.0	
802.11g	2412	17.5	19.0	19.0	18.5	
	2437	20.0	20.0	20.0	20.0	
	2462	18.5	19.0	19.0	19.0	
802.11n-HT20	2412	Not Support				14.0
	2437					20.0
	2462					14.5
802.11n-HT40	2422					13.5
	2437					14.0
	2452					13.0
For Panel Antenna						
802.11b	2412	17.0	18.0	17.0	17.5	Not Support
	2437	20.0	20.0	20.0	20.0	
	2462	17.0	20.0	20.0	20.0	
802.11g	2412	12.5	12.0	11.0	11.0	
	2437	20.0	20.0	20.0	20.0	
	2462	15.0	17.0	15.0	16.5	
802.11n-HT20	2412	Not Support				7.0
	2437					17.0
	2462					11.0
802.11n-HT40	2422					5.5
	2437					10.0
	2452					11.0

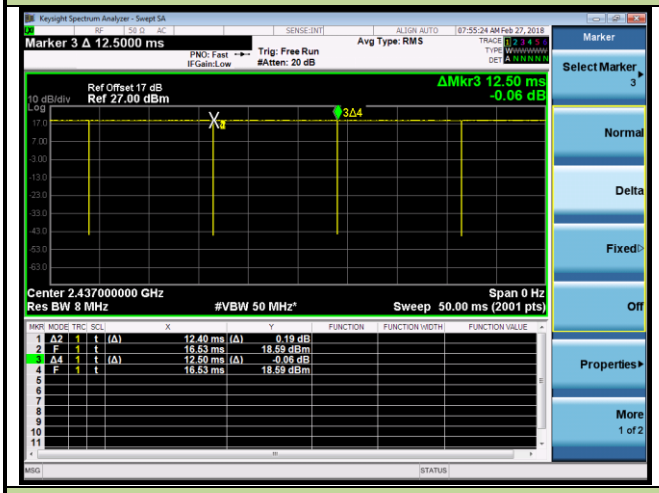
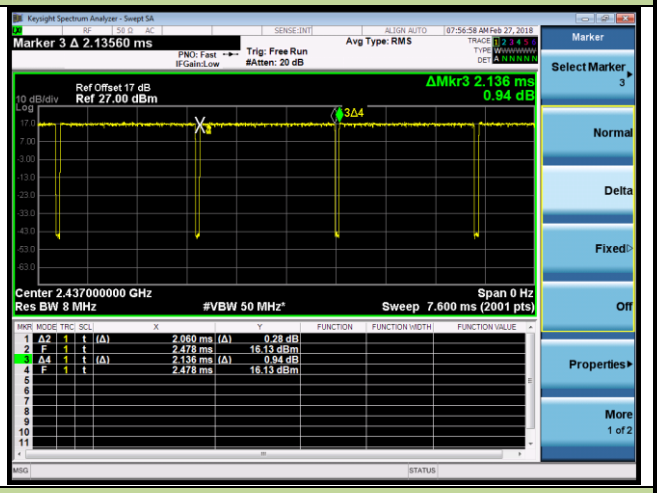
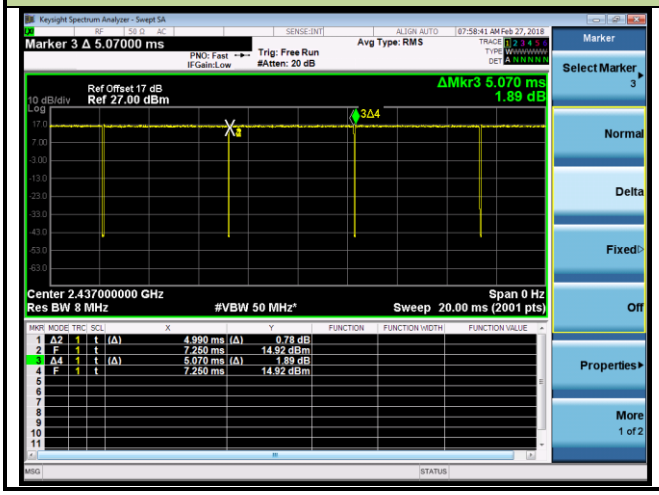
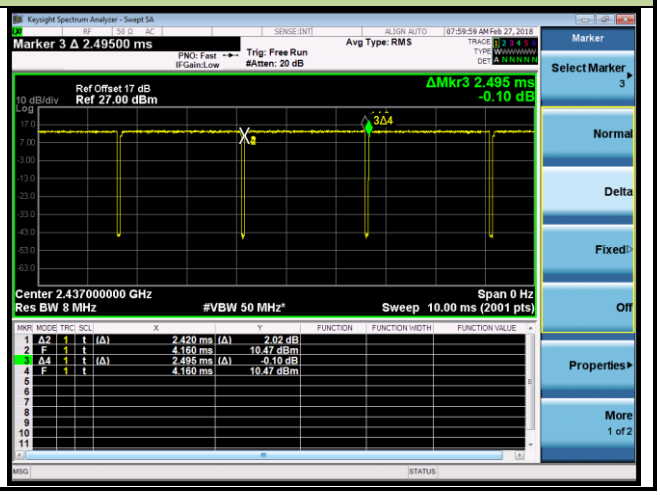
2.9. Device Capabilities

This device contains the following capabilities:

802.11b/g/n Wi-Fi Device.

Note: 2.4GHz WLAN (DTS) operation is possible in 20MHz, and 40MHz channel bandwidths. The maximum achievable duty cycles for all modes were determined based on measurements performed on a spectrum analyzer in zero-span mode with RBW = 8MHz, VBW = 50MHz, and detector = peak per the guidance of Section 6.0 b) of KDB 558074 D01v04. The RBW and VBW were both greater than 50/T, where T is the minimum transmission duration, and the number of sweep points across T was greater than 100. The duty cycles are as follows:

Test Mode	Duty Cycle
11b	99.20 %
11g	96.44 %
11n-HT20	98.42 %
11n-HT40	96.99 %

11b - T = 12.40 ms	11g - T = 2.060 ms
	
11n-HT20 - T = 4.990 ms	**11n-HT40 - T = 2.420 ms**
	

2.10. Test Configuration

The **4x4 Wave-2 802.11BGN Mini PCIe WiFi Module** was tested per the guidance of KDB 558074 D01v04. ANSI C63.10-2013 was used to reference the appropriate EUT setup for radiated spurious emissions testing and AC line conducted testing.

2.11. EMI Suppression Device(s)/Modifications

No EMI suppression device(s) were added and/or no modifications were made during testing.

2.12. Labeling Requirements

Per 2.1074 & 15.19; Docket 95-19

The label shall be permanently affixed at a conspicuous location on the device; instruction manual or pamphlet supplied to the user and be readily visible to the purchaser at the time of purchase. However, when the device is so small wherein placement of the label with specified statement is not practical, only the FCC ID must be displayed on the device per Section 15.19(a)(5). Please see attachment for FCC ID label and label location.

3. DESCRIPTION of TEST

3.1. Evaluation Procedure

The measurement procedures described in the American National Standard for Testing Unlicensed Wireless Devices (ANSI C63.10-2013), and the guidance provided in KDB 558074 D01v04 were used in the measurement of the **4x4 Wave-2 802.11BGN Mini PCIe WiFi Module.**

Deviation from measurement procedure…….....None

3.2. AC Line Conducted Emissions

The line-conducted facility is located inside an 8'x4'x4' shielded enclosure. A 1m x 2m wooden table 80cm high is placed 40cm away from the vertical wall and 80cm away from the sidewall of the shielded room. Two 10kHz-30MHz, 50Ω/50uH Line-Impedance Stabilization Networks (LISNs) are bonded to the shielded room floor. Power to the LISNs is filtered by external high-current high-insertion loss power line filters. These filters attenuate ambient signal noise from entering the measurement lines. These filters are also bonded to the shielded enclosure.

The EUT is powered from one LISN and the support equipment is powered from the second LISN. All interconnecting cables more than 1 meter were shortened to a 1 meter length by non-inductive bundling (serpentine fashion) and draped over the back edge of the test table. All cables were at least 40cm above the horizontal reference ground-plane. Power cables for support equipment were routed down to the second LISN while ensuring that that cables were not draped over the second LISN.

Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The RF output of the LISN was connected to the receiver and exploratory measurements were made to determine the frequencies producing the maximum emission from the EUT. The receiver was scanned from 150kHz to 30MHz. The detector function was set to peak mode for exploratory measurements while the bandwidth of the analyzer was set to 9kHz. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Each emission was also maximized by varying: power lines, the mode of operation or data exchange speed, or support equipment whichever determined the worst-case emission. Once the worst case emissions have been identified, the one EUT cable configuration/arrangement and mode of operation that produced these emissions are used for final measurements on the same test site. The analyzer is set to CISPR quasi-peak and average detectors with a 9kHz resolution bandwidth for final measurements.

An extension cord was used to connect to a single LISN which powered by EUT. The extension cord was calibrated with LISN, the impedance and insertion loss are compliance with the requirements as stated in ANSI C63.10-2013.

3.3. Radiated Emissions

The radiated test facilities consisted of an indoor 3 meter semi-anechoic chamber used for final measurements and exploratory measurements, when necessary. The measurement area is contained within the semi-anechoic chamber which is shielded from any ambient interference. For measurements above 1GHz absorbers are arranged on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1GHz, the absorbers are removed. A MF Model 210SS turntable is used for radiated measurement. It is a continuously rotatable, remote controlled, metallic turntable and 2 meters (6.56 ft.) in diameter. The turn table is flush with the raised floor of the chamber in order to maintain its function as a ground plane. An 80cm high PVC support structure is placed on top of the turntable.
For all measurements, the spectrum was scanned through all EUT azimuths and from 1 to 4 meter receive antenna height using a broadband antenna from 30MHz up to the upper frequency shown in 15.33(b)(1) depending on the highest frequency generated or used in the device or on which the device operates or tunes. For frequencies above 1GHz, linearly polarized double ridge horn antennas were used. For frequencies below 30MHz, a calibrated loop antenna was used. When exploratory measurements were necessary, they were performed at 1 meter test distance inside the semi-anechoic chamber using broadband antennas, broadband amplifiers, and spectrum analyzers to determine the frequencies and modes producing the maximum emissions. Sufficient time for the EUT, support equipment, and test equipment was allowed in order for them to warm up to their normal operating condition. The test set-up for frequencies below 1GHz was placed on top of the 0.8 meter high, 1 x 1.5 meter table; and test set-up for frequencies 1-40GHz was placed on top of the 1.5 meter high, 1 x 1.5 meter table. The EUT, support equipment, and interconnecting cables were arranged and manipulated to maximize each emission. Appropriate precaution was taken to ensure that all emissions from the EUT were maximized and investigated. The system configuration, clock speed, mode of operation or video resolution, if applicable, turntable azimuth, and receive antenna height was noted for each frequency found.
Final measurements were made in the semi-anechoic chamber using calibrated, linearly polarized broadband and horn antennas. The test setup was configured to the setup that produced the worst case emissions. The spectrum analyzer was set to investigate all frequencies required for testing to compare the highest radiated disturbances with respect to the specified limits. The turntable containing the EUT was rotated through 360 degrees and the height of the receive antenna was varied 1 to 4 meters and stopped at the azimuth and height producing the maximum emission. Each emission was maximized by changing the orientation of the EUT through three orthogonal planes and changing the polarity of the receive antenna, whichever produced the worst-case emissions. According to 3dB Beam-Width of horn antenna, the horn antenna should be always directed to the EUT when rising height.

4. ANTENNA REQUIREMENTS

Excerpt from §15.203 of the FCC Rules/Regulations:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

- The antenna of the EUT uses a unique (IPEX) connector.

Conclusion:

The **4x4 Wave-2 802.11BGN Mini PCIe WiFi Module** unit complies with the requirement of §15.203.

5. TEST EQUIPMENT CALIBRATION DATE

Conducted Emissions - SR2

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
EMI Test Receiver	R&S	ESR7	MRTSUE06001	1 year	2018/08/18
Two-Line V-Network	R&S	ENV216	MRTSUE06002	1 year	2018/06/21
Two-Line V-Network	R&S	ENV216	MRTSUE06003	1 year	2018/06/21
Thermohygrometer	Testo	608-H1	MRTSUE06404	1 year	2018/08/14
Shielding Anechoic Chamber	Mikebang	Chamber-SR2	MRTSUE06215	1 year	2018/05/10

Radiated Disturbance - AC1

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
PXA Signal Analyzer	Keysight	9030B	MRTSUE06395	1 year	2018/09/13
EMI Test Receiver	R&S	ESR7	MRTSUE06001	1 year	2018/08/18
Loop Antenna	Schwarzbeck	FMZB 1519	MRTSUE06025	1 year	2018/11/20
EXA Signal Analyzer	Agilent	N9020A	MRTSUE06106	1 year	2018/04/25
Microwave System Amplifier	Agilent	83017A	MRTSUE06076	1 year	2018/11/17
Bilog Period Antenna	Schwarzbeck	VULB 9168	MRTSUE06172	1 year	2018/11/18
Broad Band Horn Antenna	Schwarzbeck	BBHA9120D	MRTSUE06023	1 year	2018/10/21
Broad Band Horn Antenna	Schwarzbeck	BBHA 9170	MRTSUE06024	1 year	2018/12/14
Amplifier	Schwarzbeck	BBV 9721	MRTSUE06121	1 year	2018/06/14
Thermohygrometer	Testo	608-H1	MRTSUE06403	1 year	2018/08/14
Anechoic Chamber	TDK	Chamber-AC1	MRTSUE06212	1 year	2018/05/10

Conducted Test Equipment - TR3

Instrument	Manufacturer	Type No.	Asset No.	Cali. Interval	Cali. Due Date
Spectrum Analyzer	Agilent	N9020A	MRTSUE06106	1 year	2018/04/25
Power Meter	Agilent	U2021XA	MRTSUE06030	1 year	2018/12/06
Thermohygrometer	Testo	608-H1	MRTSUE06401	1 year	2018/08/14

Software	Version	Function
e3	V8.3.5	EMI Test Software

6. MEASUREMENT UNCERTAINTY

Where relevant, the following test uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k = 2.

AC Conducted Emission Measurement - SR2
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 150kHz~30MHz: ± 3.46dB
Radiated Emission Measurement - AC1
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 9kHz ~ 1GHz: ± 4.18dB 1GHz ~ 25GHz: ± 4.76dB
Spurious Emissions, Conducted - TR3
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 0.78dB
Output Power - TR3
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 1.13dB
Power Spectrum Density - TR3
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 1.15dB
Occupied Bandwidth - TR3
Measuring Uncertainty for a Level of Confidence of 95% (U=2Uc(y)): 0.28%

7. TEST RESULT

7.1. Summary

Company Name: **Compex Systems Pte Ltd**

FCC ID: **TK4WLE1216V220**

FCC Part Section(s)	Test Description	Test Limit	Test Condition	Test Result	Reference
15.247(a)(2)	6dB Bandwidth	≥ 500kHz	Conducted	Pass	Section 7.2
15.247(b)(3), (4)	Output Power	≤ 30dBm		Pass	Section 7.3
15.247(e)	Power Spectral Density	≤ 8dBm/3kHz		Pass	Section 7.4
15.247(d)	Band Edge / Out-of-Band Emissions	≤ 30dBc(Average)		Pass	Section 7.5
15.205 15.209	General Field Strength Limits (Restricted Bands and Radiated Emission Limits)	Emissions in restricted bands must meet the radiated limits detailed in 15.209	Radiated	Pass	Section 7.6 & 7.7
15.207	AC Conducted Emissions 150kHz - 30MHz	< FCC 15.207 limits	Line Conducted	Pass	Section 7.8

Notes:

1) All modes of operation and data rates were investigated. For radiated emission test, every axis (X, Y, Z) was also verified. The test results shown in the following sections represent the worst case emissions.
2) All antenna port conducted emissions testing was performed on a test bench with the antenna port of the EUT connected to the spectrum analyzer through calibrated cables and attenuators.
3) Test Items “6dB Bandwidth” & “Band Edge / Out-of-Band Emissions” have been assessed Single and MIMO transmission, and showed the worst test data in this report.

7.2. 6dB Bandwidth Measurement

7.2.1.Test Limit

The minimum 6dB bandwidth shall be at least 500 kHz.

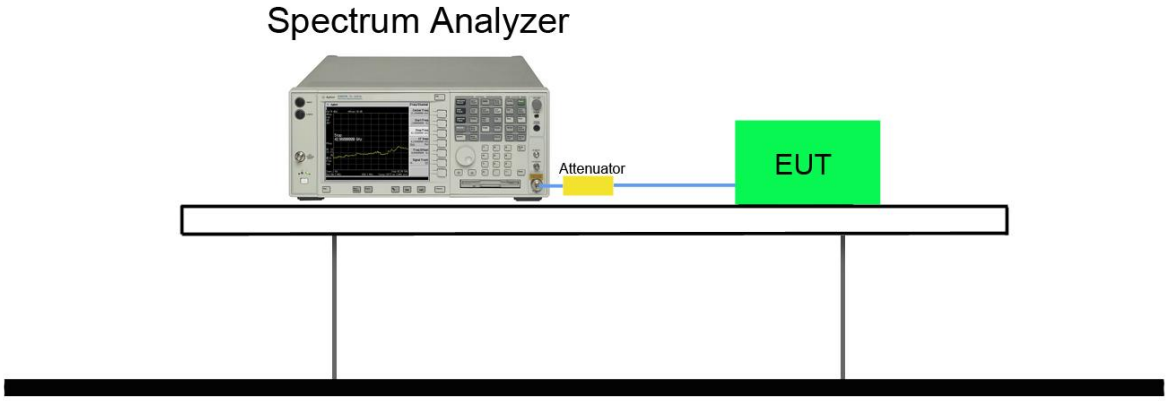
7.2.2.Test Procedure used

KDB 558074 D01v04 - Section 8.2 Option 2

7.2.3.Test Setting

1. The Spectrum's automatic bandwidth measurement capability was used to perform the 6dB bandwidth measurement. The "X" dB bandwidth parameter was set to X = 6. The bandwidth measurement was not influenced by any intermediate power nulls in the fundamental emission.
2. Set RBW = 100 kHz
3. VBW ≥ 3 × RBW
4. Detector = Peak
5. Trace mode = max hold
6. Sweep = auto couple
7. Allow the trace was allowed to stabilize

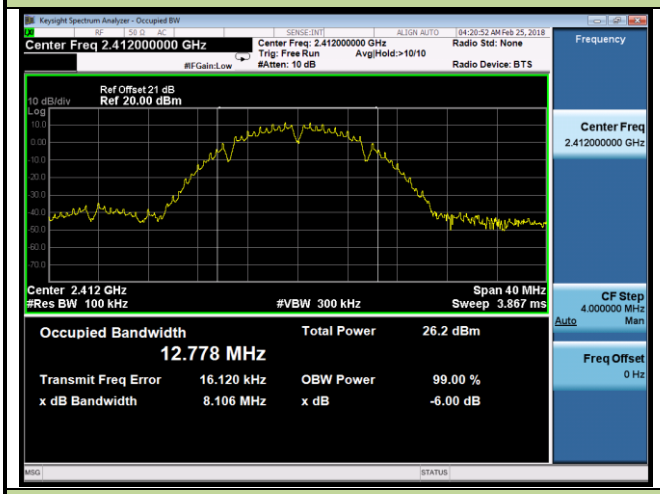
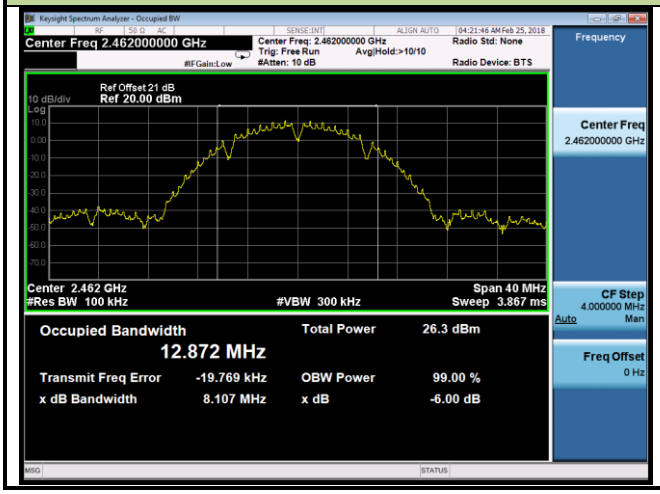
7.2.4.Test Setup

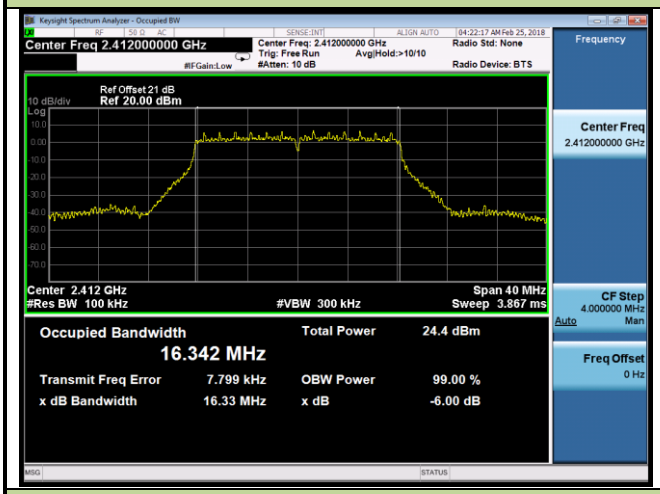
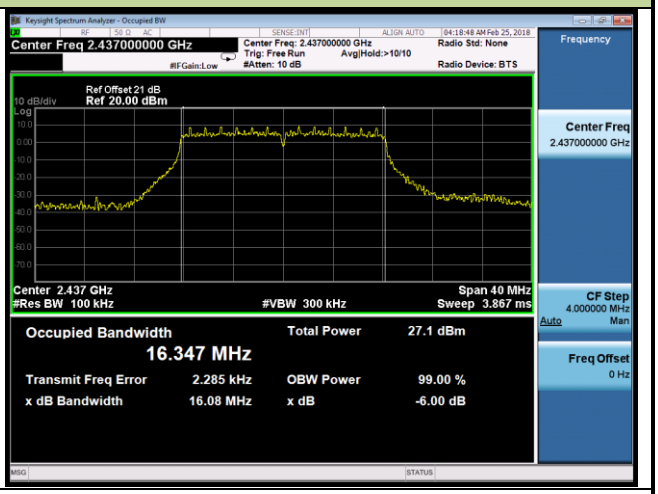
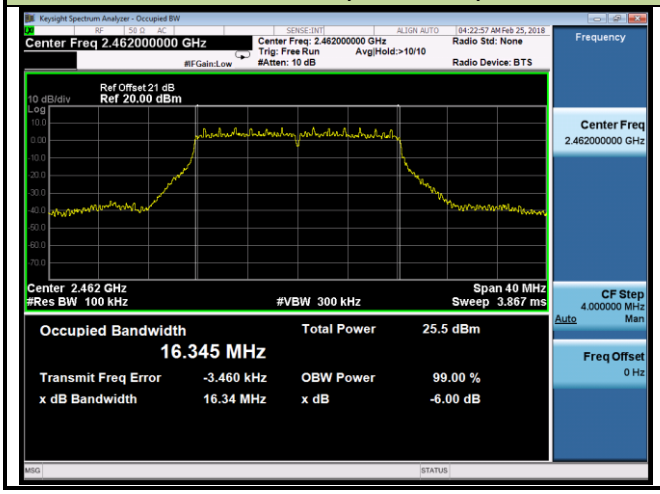


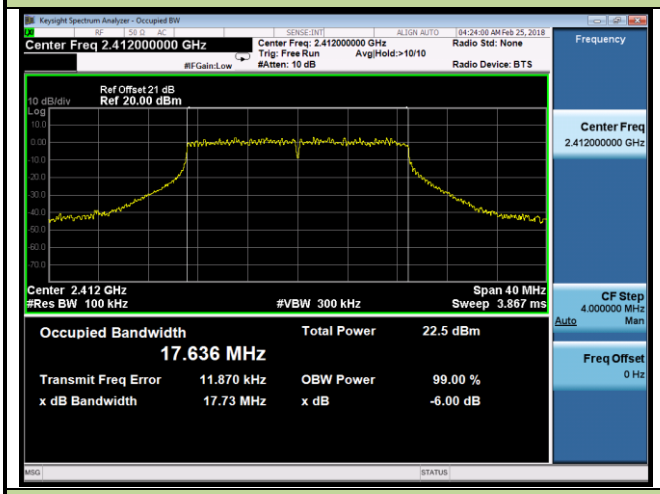
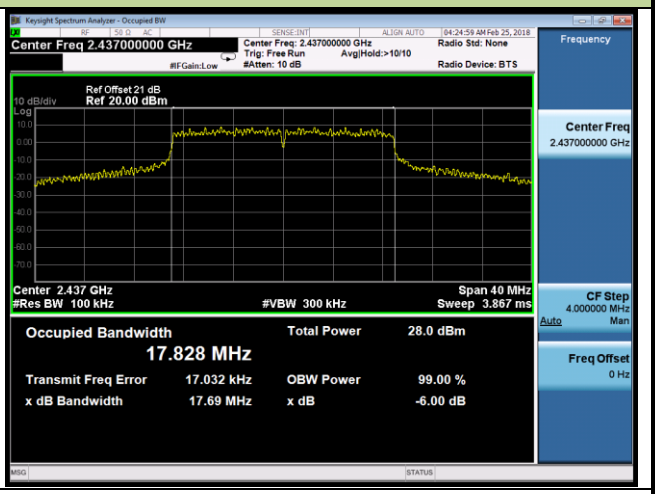
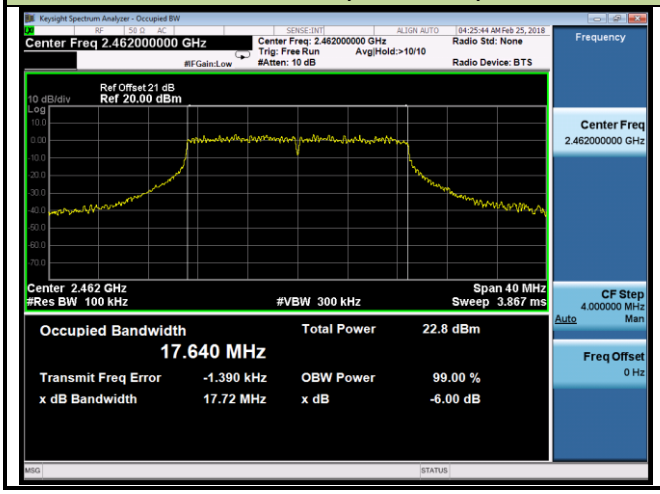
7.2.5.Test Result

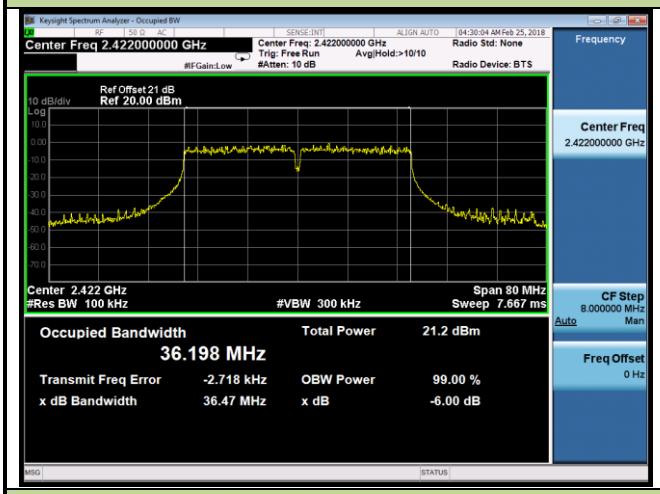
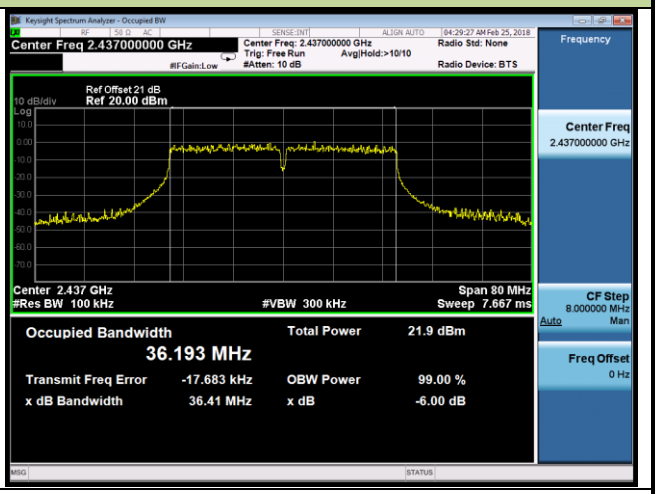
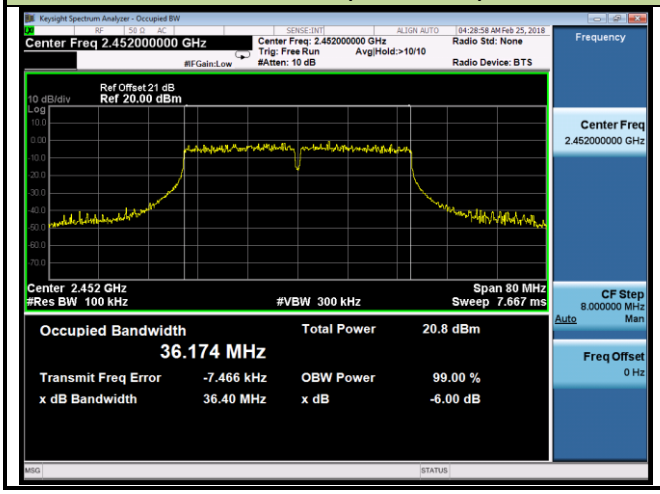
Product	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module	Temperature	25°C
Test Engineer	Vince Yu	Relative Humidity	52%
Test Site	TR3	Test Date	2018/02/25
Antenna Type	Dipole Antenna		

Test Mode	Data Rate (Mbps)	Channel No.	Frequency (MHz)	6dB Bandwidth (MHz)	Limit (MHz)	Result
Ant 0						
11b	1Mbps	01	2412	8.11	≥ 0.5	Pass
11b	1Mbps	06	2437	8.11	≥ 0.5	Pass
11b	1Mbps	11	2462	8.11	≥ 0.5	Pass
11g	6Mbps	01	2412	16.33	≥ 0.5	Pass
11g	6Mbps	06	2437	16.08	≥ 0.5	Pass
11g	6Mbps	11	2462	16.34	≥ 0.5	Pass
Ant 0 / Ant 0 + 1 + 2 + 3						
11n-HT20	MCS24	01	2412	17.73	≥ 0.5	Pass
11n-HT20	MCS24	06	2437	17.69	≥ 0.5	Pass
11n-HT20	MCS24	11	2462	17.72	≥ 0.5	Pass
11n-HT40	MCS24	03	2422	36.47	≥ 0.5	Pass
11n-HT40	MCS24	06	2437	36.41	≥ 0.5	Pass
11n-HT40	MCS24	09	2452	36.40	≥ 0.5	Pass

802.11b 6dB Bandwidth - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11g 6dB Bandwidth - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT20 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT40 6dB Bandwidth - Ant 0 / Ant 0 + 1 + 2 + 3	
Channel 03 (2422MHz)	Channel 06 (2437MHz)
	
Channel 09 (2452MHz)	
	

7.3. Output Power Measurement

7.3.1.Test Limit

The maximum out power shall be less 1 Watt (30dBm).

The conducted output power limit is based on the use of antennas with directional gains that do not exceed 6 dBi. If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

For Dipole Antenna: Power Limit = 30dBm;

For Panel Antenna: Power Limit = 30dBm – (11dBi – 6dBi) = 25dBm;

7.3.2.Test Procedure Used

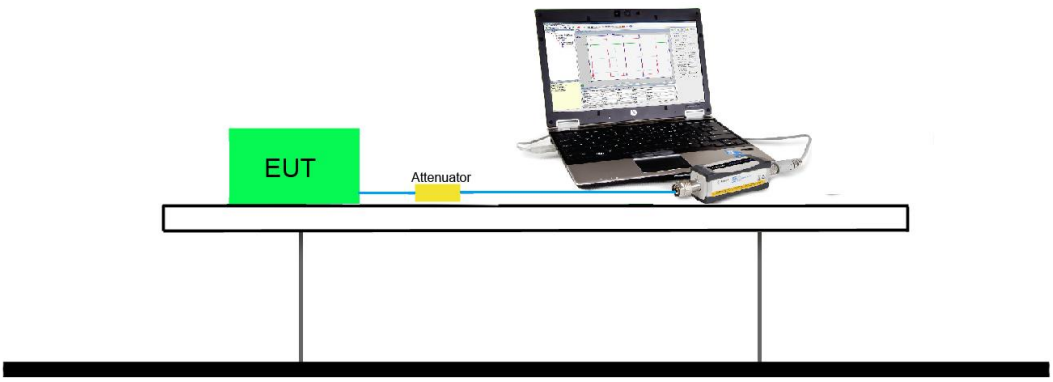
KDB 558074 D01v04 - Section 9.2.3.2 AVGPM-G

7.3.3.Test Setting

Method AVGPM-G (Measurement using a gated RF average-reading power meter)

Measurements may be performed using a wideband gated RF power meter provided that the gate parameters are adjusted such that the power is measured only when the EUT is transmitting at its maximum power control level. Since this measurement is made only during the ON time of the transmitter, no duty cycle correction is required.

7.3.4.Test Setup



7.3.5.Test Result of Output Power

Power output test was verified over all data rates of each mode shown as below, and then choose the maximum power output (Gray marker) for final test of each channel.

Output power at various data rates for Ant 0 & Ant 0 / Ant 0 + 1 + 2 + 3 port:

Test Mode	Bandwidth (MHz)	Channel No.	Frequency (MHz)	Data Rate (Mbps)	Average Power (dBm)
Ant 0					
802.11b	20	6	2437	1	19.61
				5.5	19.24
				11	18.3
802.11g	20	6	2437	6	20.10
				24	19.73
				54	19.44
Ant 0 / Ant 0 + 1 + 2 + 3					
802.11n	20	6	2437	MCS24	20.42
				MCS28	20.19
				MCS31	19.77
802.11n	40	6	2437	MCS24	13.78
				MCS28	13.47
				MCS31	13.11

Product	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module	Temperature	23°C
Test Engineer	Vince Yu	Relative Humidity	51%
Test Site	TR3	Test Date	2018/01/19

Test Mode	Data Rate/ MCS	Channel No.	Freq. (MHz)	Ant 0 Average Power (dBm)	Ant 1 Average Power (dBm)	Ant 2 Average Power (dBm)	Ant 3 Average Power (dBm)	Total Average Power (dBm)	Limit (dBm)	Result
For Dipole Antenna										
11b	1Mbps	1	2412	19.54	17.39	19.53	19.26	--	≤ 30.00	Pass
11b	1Mbps	6	2437	19.61	19.13	19.51	19.11	--	≤ 30.00	Pass
11b	1Mbps	11	2462	19.51	19.53	19.53	19.45	--	≤ 30.00	Pass
11g	6Mbps	1	2412	17.41	18.65	18.98	18.13	--	≤ 30.00	Pass
11g	6Mbps	6	2437	20.10	19.67	20.01	19.68	--	≤ 30.00	Pass
11g	6Mbps	11	2462	18.44	18.99	18.98	18.90	--	≤ 30.00	Pass
11n-HT20	MCS24	1	2412	14.44	14.03	14.72	14.48	20.45	≤ 30.00	Pass
11n-HT20	MCS24	6	2437	20.42	20.07	20.39	19.99	26.24	≤ 30.00	Pass
11n-HT20	MCS24	11	2462	14.96	14.90	14.98	14.93	20.96	≤ 30.00	Pass
11n-HT40	MCS24	3	2422	13.08	12.88	13.24	13.01	19.08	≤ 30.00	Pass
11n-HT40	MCS24	6	2437	13.78	13.07	13.65	13.51	19.53	≤ 30.00	Pass
11n-HT40	MCS24	9	2452	12.89	12.48	12.50	12.85	18.70	≤ 30.00	Pass
For Panel Antenna										
11b	1Mbps	1	2412	16.50	16.73	16.42	16.81	--	≤ 25.00	Pass
11b	1Mbps	6	2437	19.63	19.15	19.51	19.12	--	≤ 25.00	Pass
11b	1Mbps	11	2462	16.32	19.52	19.50	19.45	--	≤ 25.00	Pass
11g	6Mbps	1	2412	12.56	11.71	11.02	10.92	--	≤ 25.00	Pass
11g	6Mbps	6	2437	20.09	19.63	20.01	19.65	--	≤ 25.00	Pass
11g	6Mbps	11	2462	14.70	16.67	14.72	16.25	--	≤ 25.00	Pass
11n-HT20	MCS24	1	2412	7.65	7.46	7.73	7.70	13.66	≤ 25.00	Pass
11n-HT20	MCS24	6	2437	17.58	16.96	17.79	17.31	23.44	≤ 25.00	Pass
11n-HT20	MCS24	11	2462	11.72	11.51	11.57	11.81	17.67	≤ 25.00	Pass
11n-HT40	MCS24	3	2422	5.18	4.87	4.90	5.01	11.01	≤ 25.00	Pass
11n-HT40	MCS24	6	2437	9.72	9.34	9.66	9.78	15.65	≤ 25.00	Pass
11n-HT40	MCS24	9	2452	10.82	10.41	10.49	10.65	16.62	≤ 25.00	Pass

Note: Total Average Power (dBm) = $10*\log\{10^{(\text{Ant 0 Average Power }/10)}+10^{(\text{Ant 1 Average Power }/10)}+10^{(\text{Ant 2 Average Power }/10)}+10^{(\text{Ant 3 Average Power }/10)}\}$ (dBm)

7.4. Power Spectral Density Measurement

7.4.1.Test Limit

The maximum permissible power spectral density is 8dBm in any 3 kHz band.

For Dipole Antenna: PSD Limit = 8dBm/3kHz;

For Panel Antenna: PSD Limit = [8 – (11 – 6)]dBm/3kHz = 3dBm/3kHz;

7.4.2.Test Procedure Used

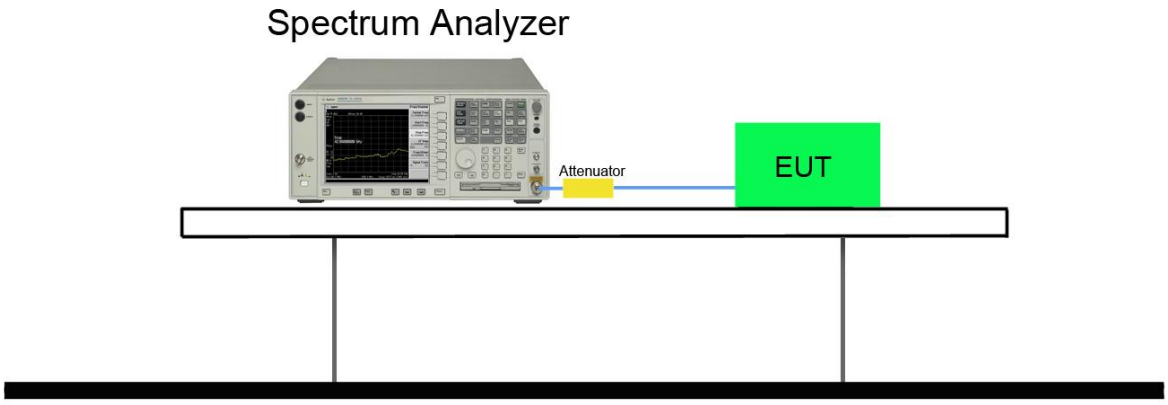
KDB 558074 D01v04 - Section 10.3 Method AVGPSD-1

KDB 558074 D01v04 - Section 10.5 Method AVGPSD-2

7.4.3.Test Setting

1. Measure the duty cycle (x) of the transmitter output signal
2. Analyzer was set to the center frequency of the DTS channel under investigation
3. Span = 1.5 times the DTS channel bandwidth
4. RBW = 10kHz
5. VBW = 30kHz
6. Detector = RMS
7. Ensure that the number of measurement points in the sweep ≥ 2 span/RBW
8. Sweep time = auto couple
9. Employ trace averaging (RMS) mode over a minimum of 100 traces
10. Use the peak marker function to determine the maximum amplitude level
11. If duty cycle < 98 %, add 10 log (1/x), where x is the duty cycle measured in step (a, to the measured PSD to compute the average PSD during the actual transmission time.
12. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat (note that this may require zooming in on the emission of interest and reducing the span in order to meet the minimum measurement point requirement as the RBW is reduced).

7.4.4.Test Setup



7.4.5.Test Result

Product	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module	Temperature	23°C
Test Engineer	Vince Yu	Relative Humidity	52%
Test Site	TR3	Test Date	2018/02/25
Antenna Type	Dipole Antenna		

Test Mode	Data Rate/ MCS	Channel No.	Freq. (MHz)	Ant 0 AVGPSD (dBm / 10kHz)	Ant 1 AVGPSD (dBm / 10kHz)	Ant 2 AVGPSD (dBm / 10kHz)	Ant 3 AVGPSD (dBm / 10kHz)	Duty Cycle (%)	Constant Factor	Final AVGPSD (dBm / 3kHz)	Limit (dBm / 3kHz)	Result
1TX												
11b	1Mbps	1	2412	-7.30	-6.94	-6.30	-7.28	99.20	-5.23	-11.53	≤ 8.00	Pass
11b	1Mbps	6	2437	-5.46	-7.13	-4.80	-6.76	99.20	-5.23	-10.03	≤ 8.00	Pass
11b	1Mbps	11	2462	-6.91	-5.37	-6.84	-7.38	99.20	-5.23	-10.60	≤ 8.00	Pass
11g	6Mbps	1	2412	-11.71	-10.40	-10.12	-10.85	96.44	-5.23	-15.19	≤ 8.00	Pass
11g	6Mbps	6	2437	-8.96	-9.66	-9.20	-9.48	96.44	-5.23	-14.03	≤ 8.00	Pass
11g	6Mbps	11	2462	-10.32	-9.81	-10.25	-10.16	96.44	-5.23	-14.88	≤ 8.00	Pass
4TX												
11n-HT20	MCS24	1	2412	-13.11	-14.17	-13.60	-14.12	98.42	-5.23	-12.94	≤ 8.00	Pass
11n-HT20	MCS24	6	2437	-7.47	-8.20	-7.79	-8.33	98.42	-5.23	-7.14	≤ 8.00	Pass
11n-HT20	MCS24	11	2462	-12.87	-13.27	-13.31	-13.24	98.42	-5.23	-12.38	≤ 8.00	Pass
11n-HT40	MCS24	3	2422	-16.16	-16.55	-15.77	-16.23	96.99	-5.23	-15.24	≤ 8.00	Pass
11n-HT40	MCS24	6	2437	-15.94	-16.59	-15.24	-15.84	96.99	-5.23	-14.95	≤ 8.00	Pass
11n-HT40	MCS24	9	2452	-16.97	-16.97	-17.02	-17.09	96.99	-5.23	-16.09	≤ 8.00	Pass

Note 1: For 802.11b/g

When EUT duty cycle < 98%, Each AVGPSD (dBm / 3kHz) = AVGPSD (dBm / 10kHz) + Constant Factor + 10*log(1/Duty cycle).

When EUT duty cycle ≥ 98%, Each AVGPSD (dBm / 3kHz) = AVGPSD (dBm / 10kHz) + Constant Factor

Final AVGPSD (dBm / 3kHz) = Max Each AVGPSD (dBm / 3kHz)

Note 2: For 802.11n

When EUT duty cycle < 98%, Final AVGPSD (dBm / 3kHz) = $10*\log\{10^{(\text{Ant 0 PSD}/10)} + 10^{(\text{Ant 1 PSD}/10)} + 10^{(\text{Ant 2 PSD}/10)} + 10^{(\text{Ant 3 PSD}/10)}\}$ + 10*log (1/Duty Cycle) + Constant Factor.

When EUT duty cycle ≥ 98%, Final AVGPSD (dBm / 3kHz) = $10*\log\{10^{(\text{Ant 0 PSD}/10)} + 10^{(\text{Ant 1 PSD}/10)} + 10^{(\text{Ant 2 PSD}/10)} + 10^{(\text{Ant 3 PSD}/10)}\}$ + Constant Factor.

Product	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module	Temperature	23°C
Test Engineer	Vince Yu	Relative Humidity	52%
Test Site	TR3	Test Date	2018/02/25
Antenna Type	Panel Antenna		

Test Mode	Data Rate/ MCS	Channel No.	Freq. (MHz)	Ant 0 AVGPSD (dBm / 10kHz)	Ant 1 AVGPSD (dBm / 10kHz)	Ant 2 AVGPSD (dBm / 10kHz)	Ant 3 AVGPSD (dBm / 10kHz)	Duty Cycle (%)	Constant Factor	Final AVGPSD (dBm / 3kHz)	Limit (dBm / 3kHz)	Result
1TX												
11b	1Mbps	1	2412	-9.40	-9.76	-8.58	-9.48	99.20	-5.23	-13.81	≤ 3.00	Pass
11b	1Mbps	6	2437	-4.83	-4.29	-6.96	-7.49	99.20	-5.23	-9.52	≤ 3.00	Pass
11b	1Mbps	11	2462	-9.72	-5.35	-6.24	-5.58	99.20	-5.23	-10.58	≤ 3.00	Pass
11g	6Mbps	1	2412	-16.60	-17.12	-18.04	-18.06	96.44	-5.23	-21.67	≤ 3.00	Pass
11g	6Mbps	6	2437	-9.03	-9.33	-9.20	-9.43	96.44	-5.23	-14.10	≤ 3.00	Pass
11g	6Mbps	11	2462	-14.09	-12.20	-14.17	-12.73	96.44	-5.23	-17.27	≤ 3.00	Pass
4TX												
11n-HT20	MCS24	1	2412	-20.60	-20.64	-19.46	-20.01	98.42	-5.23	-19.36	≤ 3.00	Pass
11n-HT20	MCS24	6	2437	-9.88	-11.21	-10.33	-10.25	98.42	-5.23	-9.60	≤ 3.00	Pass
11n-HT20	MCS24	11	2462	-16.35	-16.74	-16.76	-16.66	98.42	-5.23	-15.83	≤ 3.00	Pass
11n-HT40	MCS24	3	2422	-24.05	-25.34	-24.45	-24.36	96.99	-5.23	-23.60	≤ 3.00	Pass
11n-HT40	MCS24	6	2437	-20.18	-20.72	-19.66	-19.77	96.99	-5.23	-19.14	≤ 3.00	Pass
11n-HT40	MCS24	9	2452	-18.88	-19.39	-18.61	-19.00	96.99	-5.23	-18.04	≤ 3.00	Pass

Note 1: For 802.11b/g

When EUT duty cycle < 98%, Each AVGPSD (dBm / 3kHz) = Each AVGPSD (dBm / 10kHz) + Constant Factor + 10*log(1/Duty cycle).

When EUT duty cycle ≥ 98%, Each AVGPSD (dBm / 3kHz) = Each AVGPSD (dBm / 10kHz) + Constant Factor

Final AVGPSD (dBm / 3kHz) = Max Each AVGPSD (dBm / 3kHz)

Note 2: For 802.11n

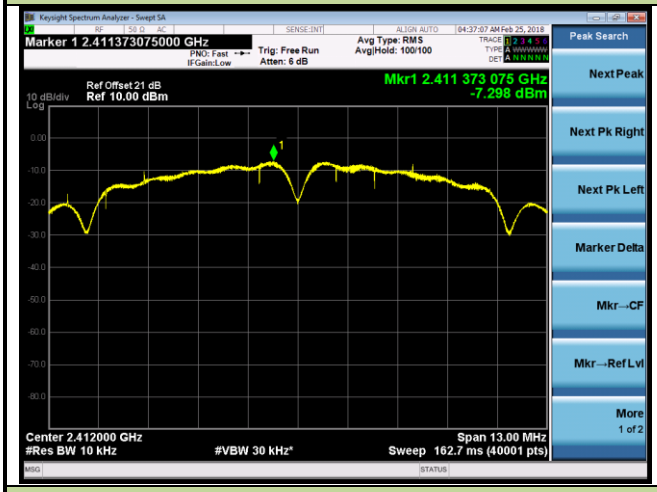
When EUT duty cycle < 98%, Final AVGPSD (dBm / 3kHz) = $10*\log\{10^{(\text{Ant 0 PSD}/10)} + 10^{(\text{Ant 1 PSD}/10)} + 10^{(\text{Ant 2 PSD}/10)} + 10^{(\text{Ant 3 PSD}/10)}\} + 10*\log(1/\text{Duty Cycle}) + \text{Constant Factor}$.

When EUT duty cycle ≥ 98%, Final AVGPSD (dBm / 3kHz) = $10*\log\{10^{(\text{Ant 0 PSD}/10)} + 10^{(\text{Ant 1 PSD}/10)} + 10^{(\text{Ant 2 PSD}/10)} + 10^{(\text{Ant 3 PSD}/10)}\} + \text{Constant Factor}$.

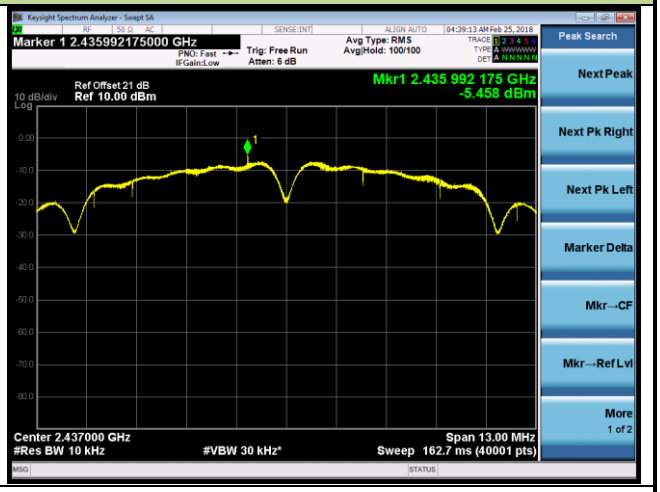
Product	4x4 Wave-2 802.11BGN Mini PCIe WiFi Module	Temperature	23°C
Test Engineer	Vince Yu	Relative Humidity	52%
Test Site	TR3	Test Date	2018/02/25
Antenna Type	Dipole Antenna		

802.11b AVGPSD - Ant 0

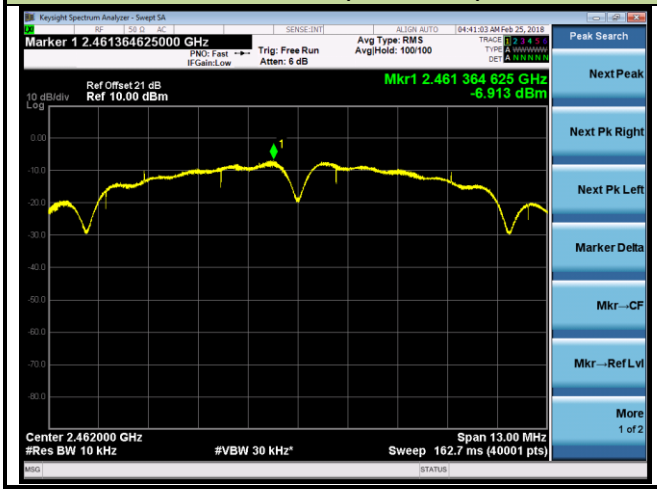
Channel 01 (2412MHz)

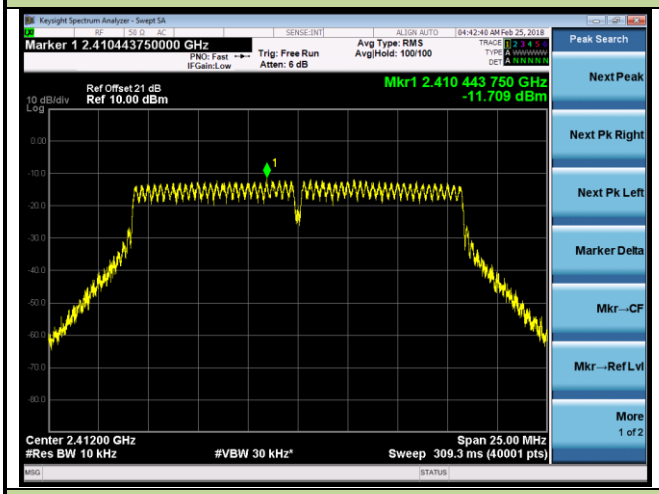
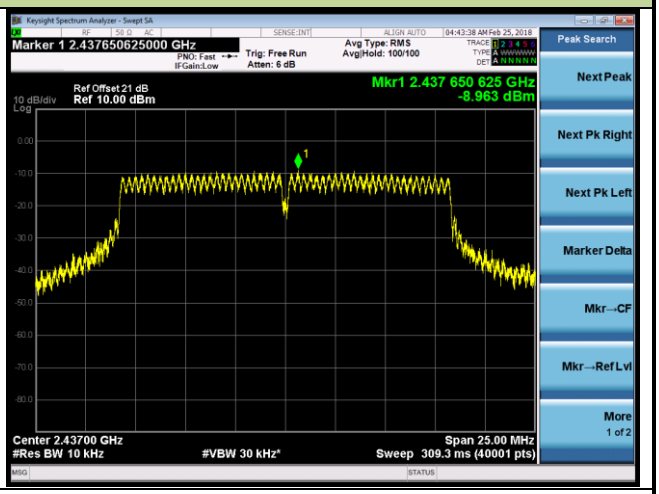
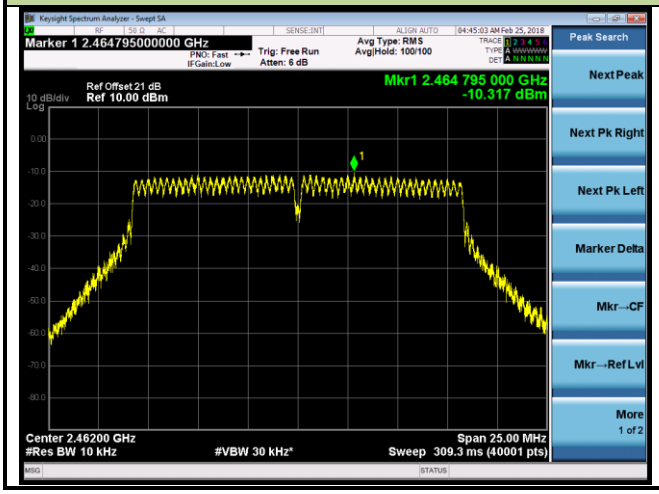


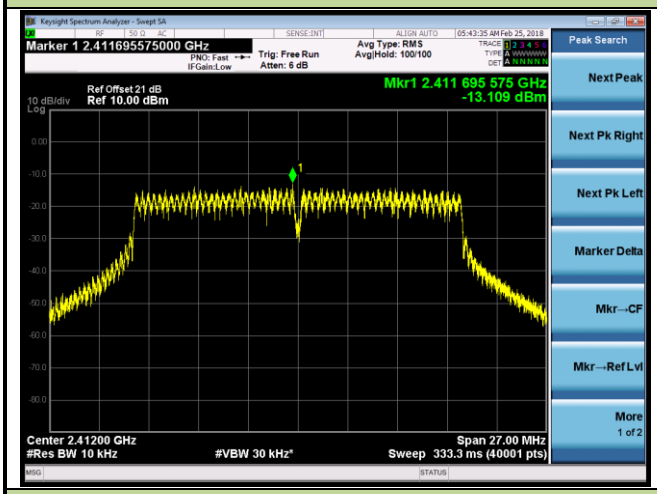
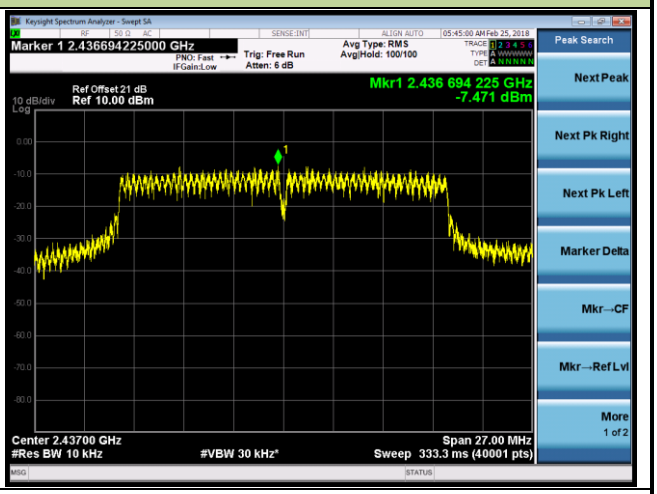
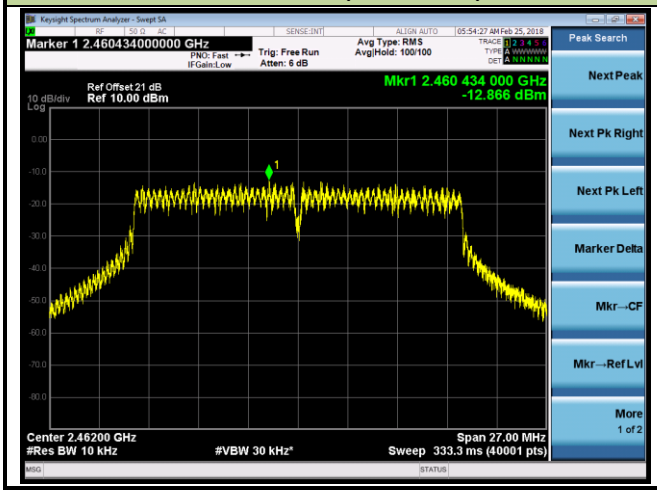
Channel 06 (2437MHz)

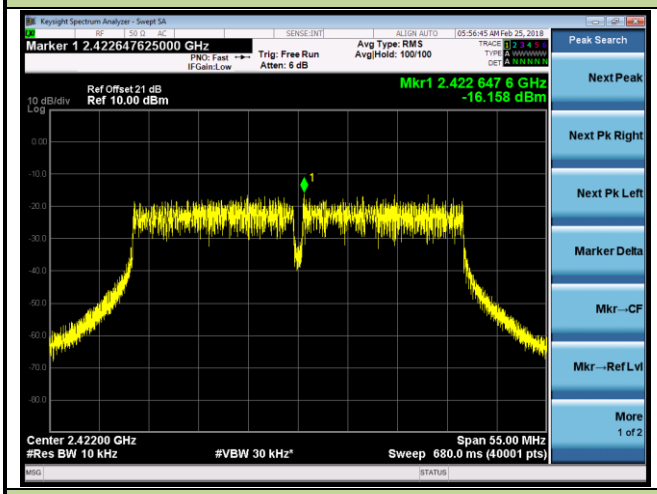
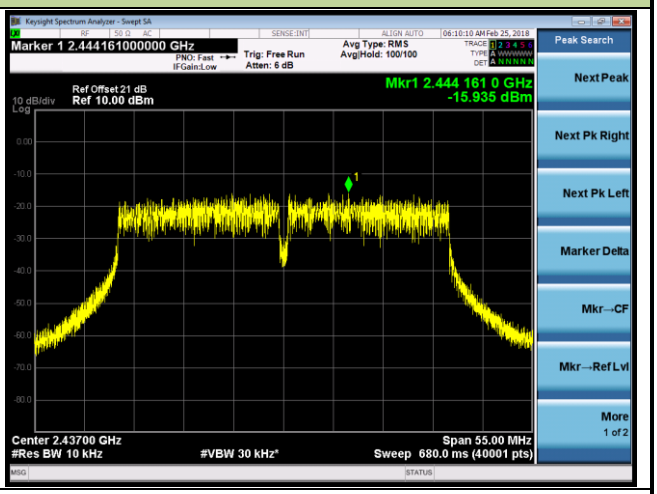
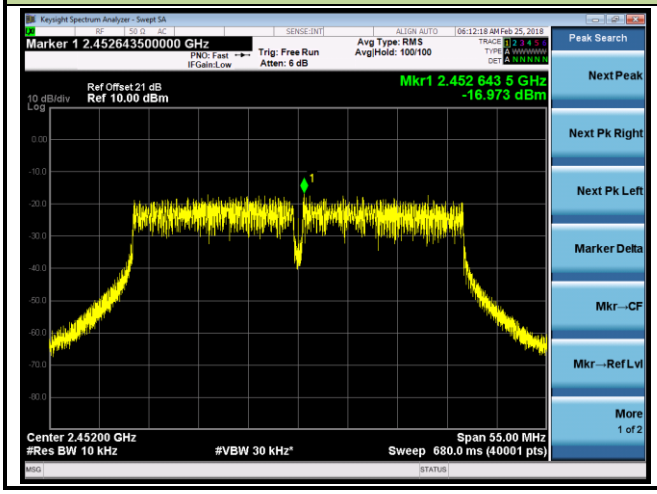


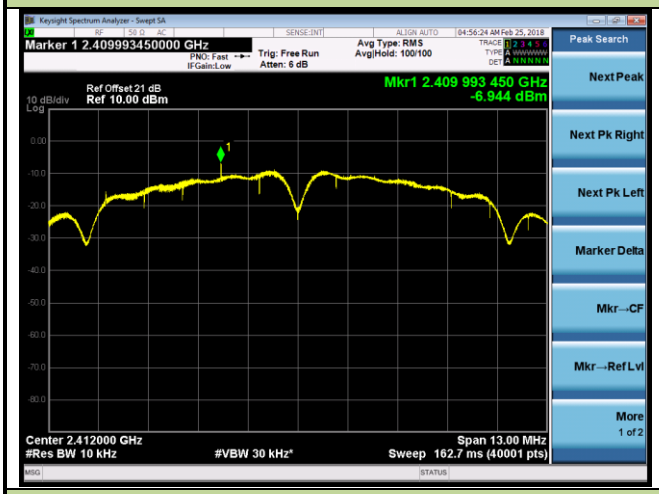
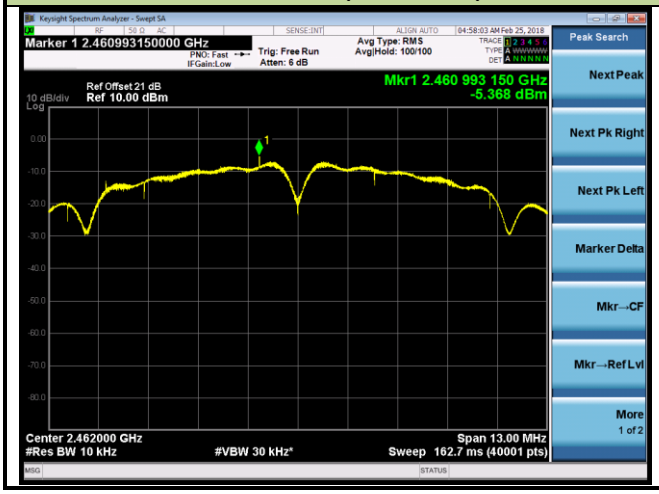
Channel 11 (2462MHz)

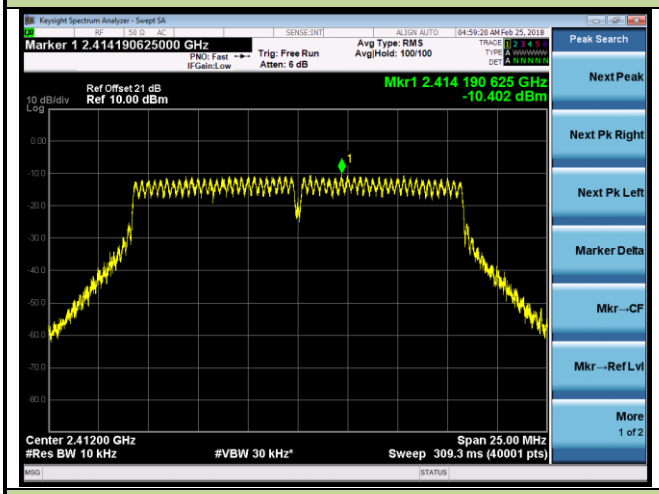
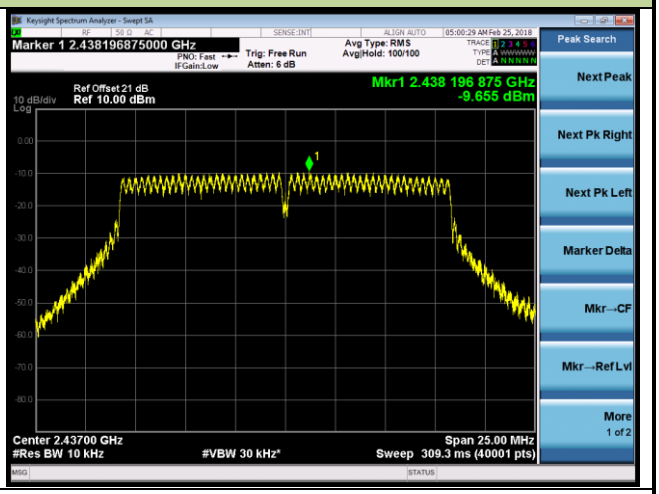
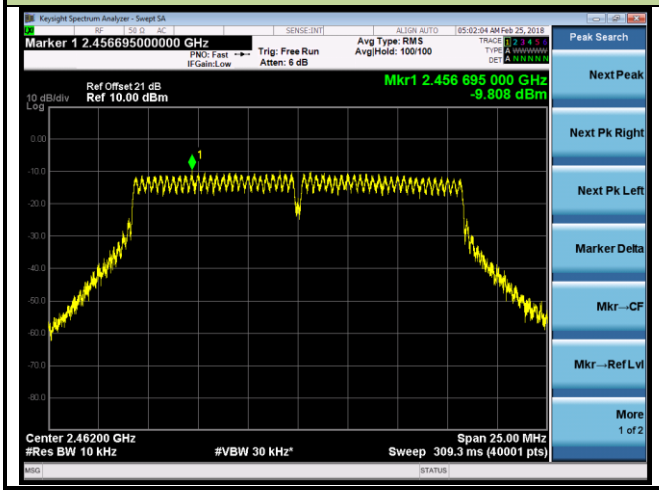


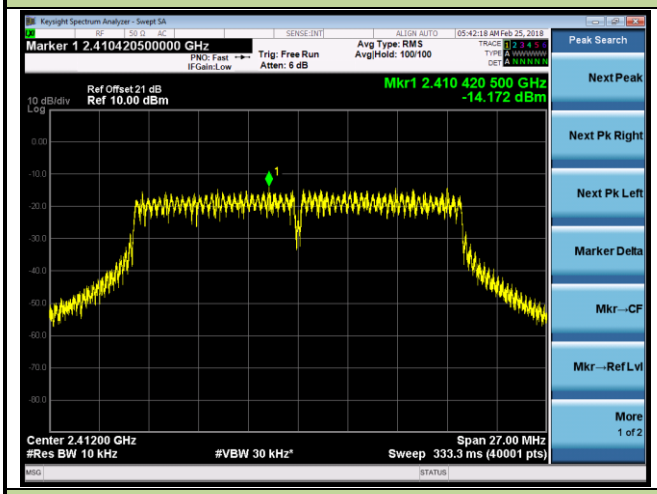
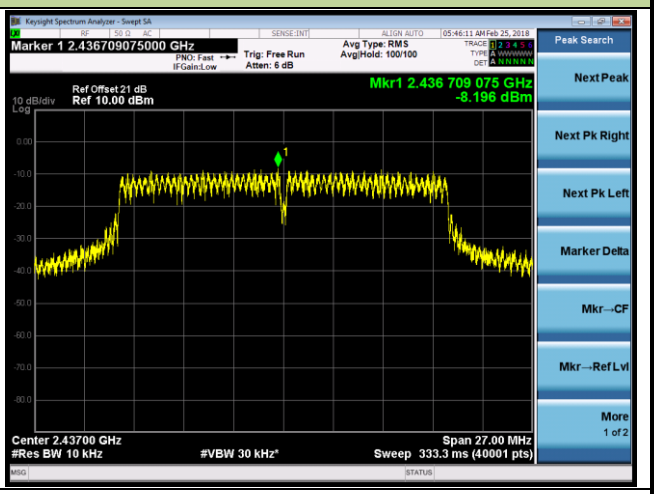
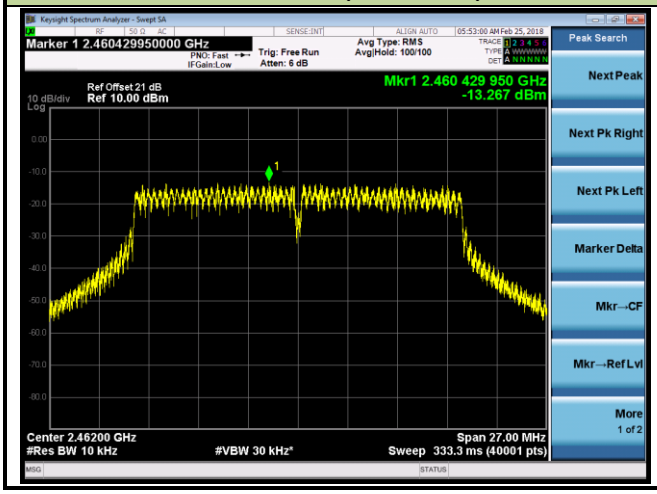
802.11g AVGPSD - Ant 0	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

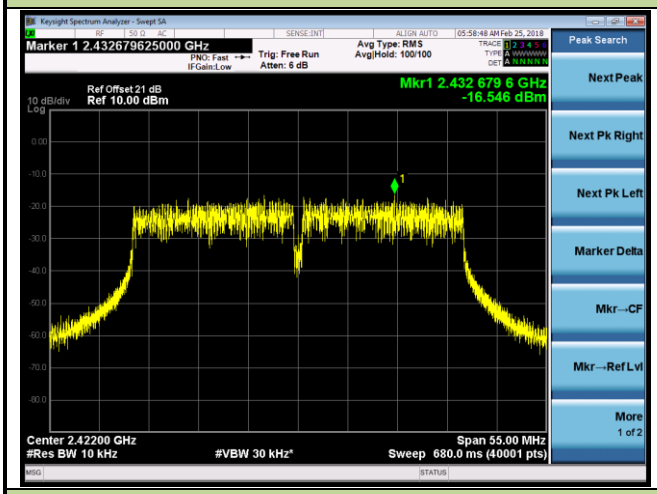
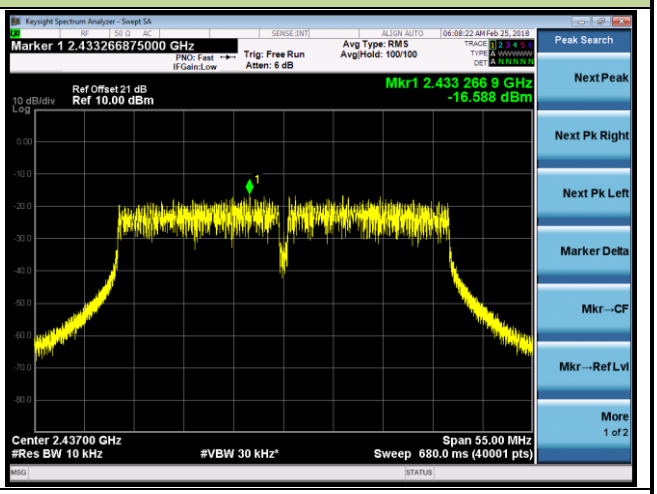
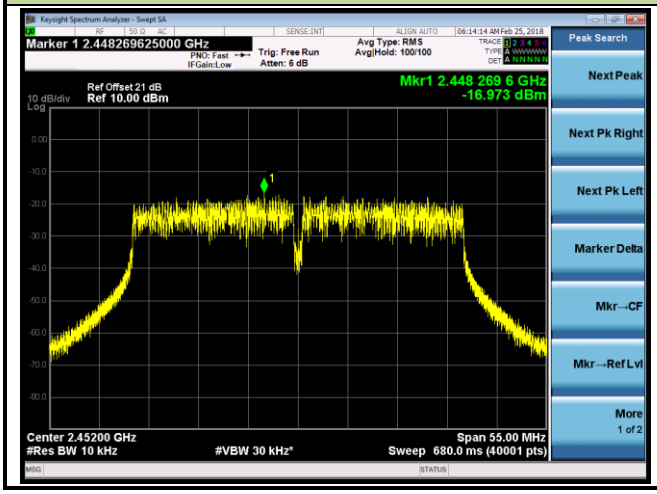
802.11n-HT20 AVGPSD - Ant 0 / Ant 0 + 1 + 2 + 3	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

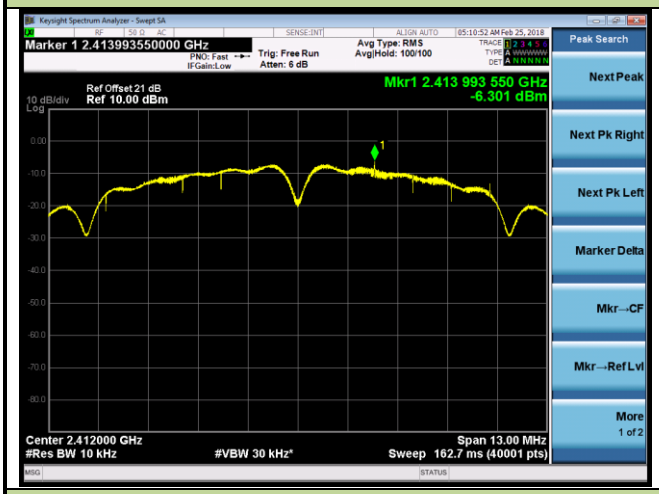
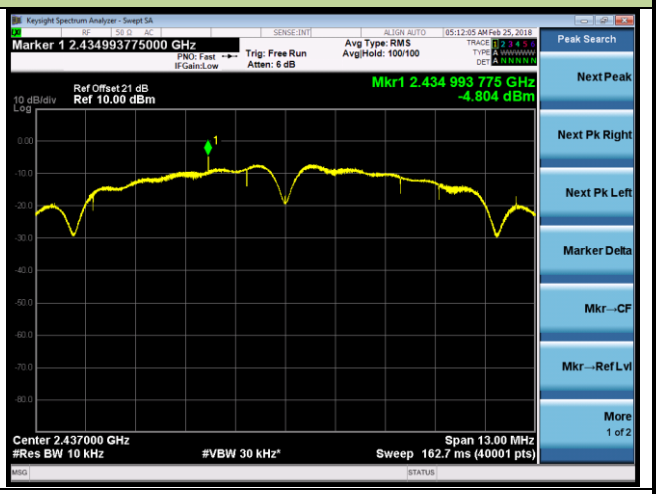
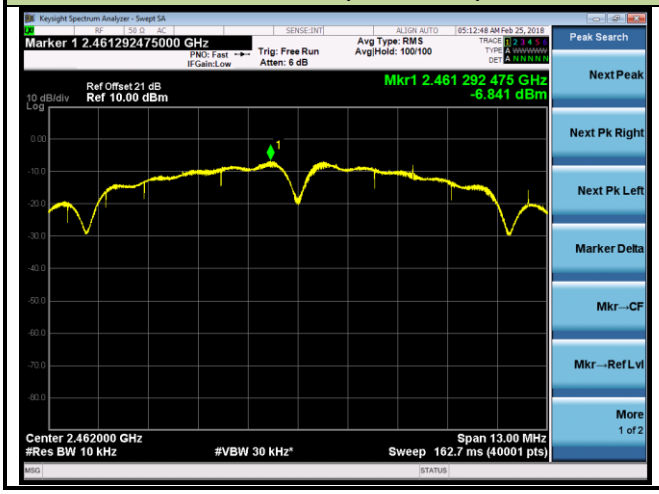
802.11n-HT40 AVGPSD - Ant 0 / Ant 0 + 1 + 2 + 3	
Channel 03 (2422MHz)	Channel 06 (2437MHz)
	
Channel 09 (2452MHz)	
	

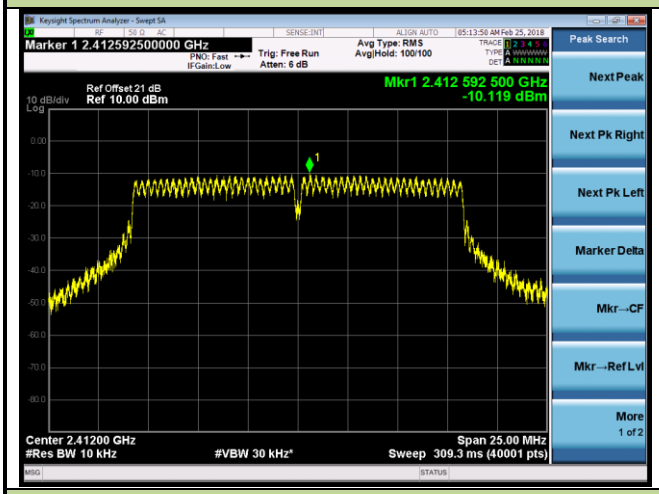
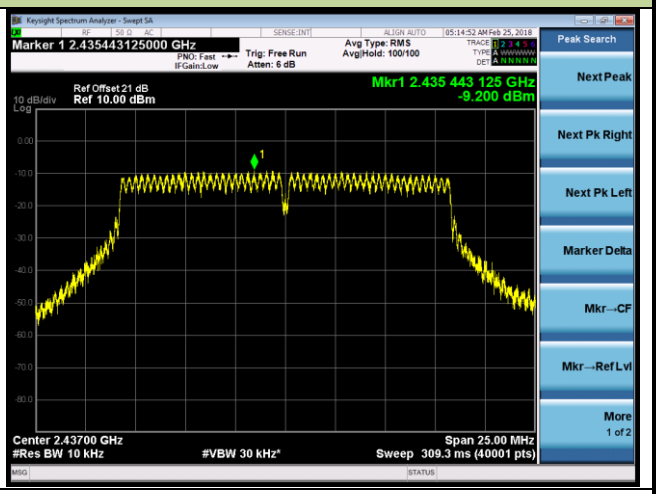
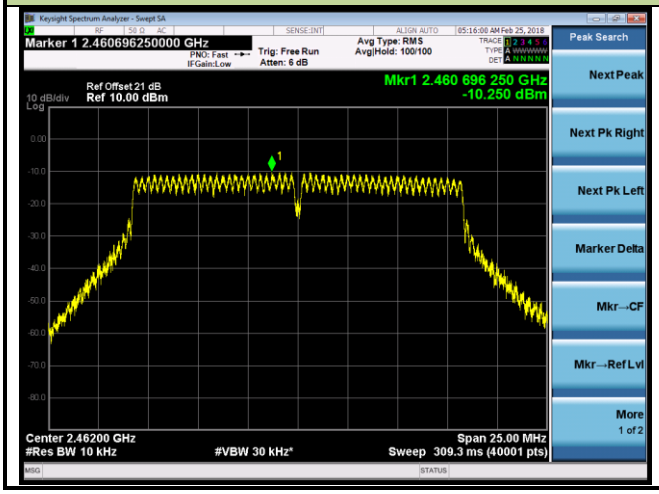
802.11b AVGPSD - Ant 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

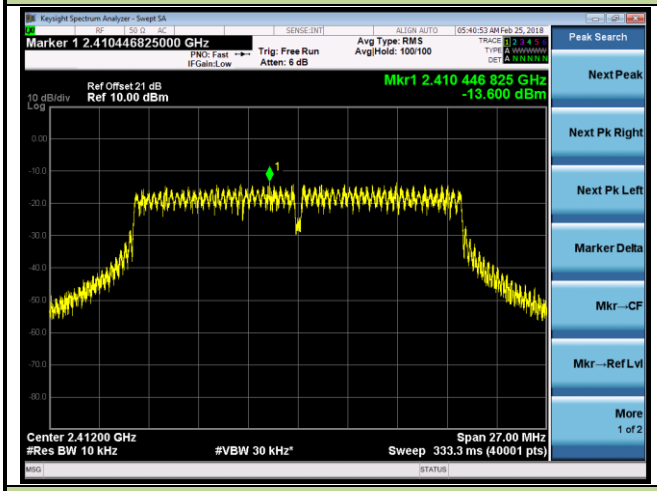
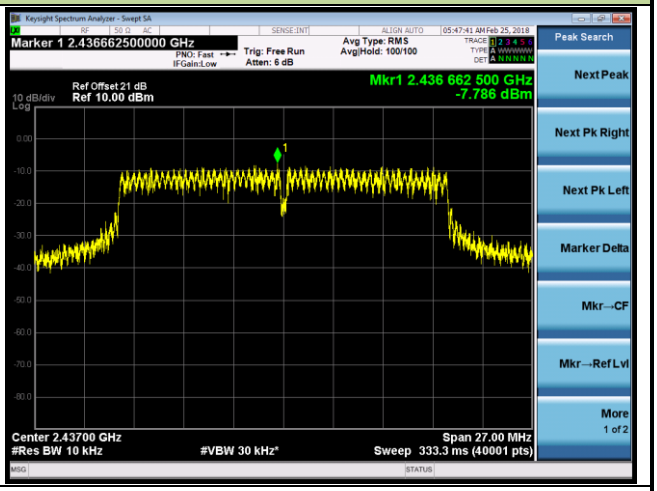
802.11g AVGPSD - Ant 1	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT20 AVGPSD - Ant 1 / Ant 0 + 1 + 2 + 3	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT40 AVGPSD - Ant 1 / Ant 0 + 1 + 2 + 3	
Channel 03 (2422MHz)	Channel 06 (2437MHz)
	
Channel 09 (2452MHz)	
	

802.11b AVGPSD - Ant 2	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11g AVGPSD - Ant 2	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)	
	

802.11n-HT20 AVGPSD - Ant 2 / Ant 0 + 1 + 2 + 3	
Channel 01 (2412MHz)	Channel 06 (2437MHz)
	
Channel 11 (2462MHz)