4.8. Band Edge Compliance of RF Emission

TEST REQUIREMENT

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

TEST PROCEDURE

According to KDB 558074 D01 for Antenna-port conducted measurement. Antenna-port conducted measurements may also be used as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case spurious emissions is required.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz for peak detector and RBW=1MHz, VBW=10Hz for average detector.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 12.2.2, 12.2.3, and 12.2.4 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
7. Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
8. Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).
9. For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
10. Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:
    $E = EIRP – 20\log D + 104.8$

where:
E = electric field strength in dBμV/m,
EIRP = equivalent isotropic radiated power in dBm
D = specified measurement distance in meters.

11. Since the out-of-band characteristics of the EUT transmit antenna will often be unknown, the use of a conservative antenna gain value is necessary. Thus, when determining the EIRP based on the measured conducted power, the upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands, or 2 dBi, whichever is greater. However, for devices that operate in multiple frequency bands while using the same transmit antenna, the highest gain of the antenna within the operating band nearest in frequency to the restricted band emission being measured may be used in lieu of the overall highest gain when the emission is at a frequency that is within 20 percent of the nearest band edge frequency, but in no case shall a value less than 2 dBi be used.
12. Compare the resultant electric field strength level to the applicable regulatory limit.
13. Perform radiated spurious emission test dures until all measured frequencies were complete.

LIMIT

Below -20dB of the highest emission level in operating band.
Radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

TEST RESULTS

IEEE 802.11b

Frequency(MHz):			2412			Polarity:			HORIZONTAL		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2390.00	55.64	PK	74.00	18.36	1.00	77	60.95	27.49	3.32	36.12	-5.31
2390.00	42.66	AV	54.00	11.34	1.00	77	47.97	27.49	3.32	36.12	-5.31
Frequency(MHz):			**2412**			**Polarity:**			**VERTICAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2390.00	57.62	PK	74.00	16.38	1.00	122	62.93	27.49	3.32	36.12	-5.31
2390.00	42.47	AV	54.00	11.53	1.00	122	47.78	27.49	3.32	36.12	-5.31
Frequency(MHz):			**2462**			**Polarity:**			**HORIZONTAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2483.50	58.28	PK	74.00	15.72	1.00	215	64.00	27.45	3.38	36.55	-5.72
2483.50	41.64	AV	54.00	12.36	1.00	215	47.36	27.45	3.38	36.55	-5.72
Frequency(MHz):			**2462**			**Polarity:**			**VERTICAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2483.50	59.12	PK	74.00	14.88	1.00	165	64.84	27.45	3.38	36.55	-5.72
2483.50	41.36	AV	54.00	12.64	1.00	165	47.08	27.45	3.38	36.55	-5.72

IEEE 802.11g

Frequency(MHz):			2412			Polarity:			HORIZONTAL		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2390.00	59.06	PK	74.00	14.94	1.00	148	64.37	27.49	3.32	36.12	-5.31
2390.00	42.73	AV	54.00	11.27	1.00	148	48.04	27.49	3.32	36.12	-5.31
Frequency(MHz):			**2412**			**Polarity:**			**VERTICAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2390.00	60.28	PK	74.00	13.72	1.00	231	65.59	27.49	3.32	36.12	-5.31
2390.00	41.35	AV	54.00	12.65	1.00	231	46.66	27.49	3.32	36.12	-5.31
Frequency(MHz):			**2462**			**Polarity:**			**HORIZONTAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2483.50	57.89	PK	74.00	16.11	1.00	164	63.61	27.45	3.38	36.55	-5.72
2483.50	42.94	AV	54.00	11.06	1.00	164	48.66	27.45	3.38	36.55	-5.72
Frequency(MHz):			**2462**			**Polarity:**			**VERTICAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2483.50	56.36	PK	74.00	17.64	1.00	93	62.08	27.45	3.38	36.55	-5.72
2483.50	42.59	AV	54.00	11.41	1.00	93	48.31	27.45	3.38	36.55	-5.72

IEEE 802.11n HT20

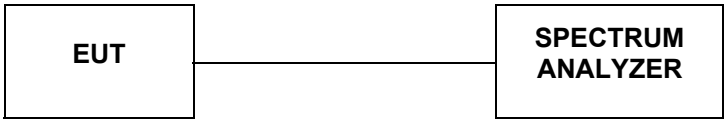
Frequency(MHz):			2412			Polarity:			HORIZONTAL		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2390.00	51.24	PK	74.00	22.76	1.00	182	56.55	27.49	3.32	36.12	-5.31
2390.00	42.54	AV	54.00	11.46	1.00	182	47.85	27.49	3.32	36.12	-5.31
Frequency(MHz):			**2412**			**Polarity:**			**VERTICAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2390.00	52.06	PK	74.00	21.94	1.00	215	57.37	27.49	3.32	36.12	-5.31
2390.00	43.22	AV	54.00	10.78	1.00	215	48.53	27.49	3.32	36.12	-5.31
Frequency(MHz):			**2462**			**Polarity:**			**HORIZONTAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2483.50	51.16	PK	74.00	22.84	1.00	113	56.88	27.45	3.38	36.55	-5.72
2483.50	43.17	AV	54.00	10.83	1.00	113	48.89	27.45	3.38	36.55	-5.72
Frequency(MHz):			**2462**			**Polarity:**			**VERTICAL**		
Frequency (MHz)	Emission Level (dBuV/m)		Limit (dBuV/m)	Margin (dB)	Antenna Height (m)	Table Angle (Degree)	Raw Value (dBuV)	Antenna Factor (dB/m)	Cable Factor (dB)	Pre-amplifier (dB)	Correction Factor (dB/m)
2483.50	50.67	PK	74.00	23.33	1.00	168	56.39	27.45	3.38	36.55	-5.72
2483.50	43.92	AV	54.00	10.08	1.00	168	49.64	27.45	3.38	36.55	-5.72

4.9. Band-edge measurements for RF conducted emissions

LIMIT

1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.

TEST CONFIGURATION



TEST PROCEDURE

According to KDB 558074 D01 V03 for Antenna-port conducted measurement.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge,
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 12.2.2, 12.2.3, and 12.2.4 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).

TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Conductd Band-edge Emission (dBc)	Limits (dBc)	Verdict
IEEE 802.11 b	1	2412	<-20dBc	-20	PASS
	11	2462	<-20dBc	-20	
IEEE 802.11 g	1	2412	<-20dBc	-20	PASS
	11	2462	<-20dBc	-20	
IEEE 802.11 n HT20	1	2412	<-20dBc	-20	PASS
	11	2462	<-20dBc	-20	

Remark:

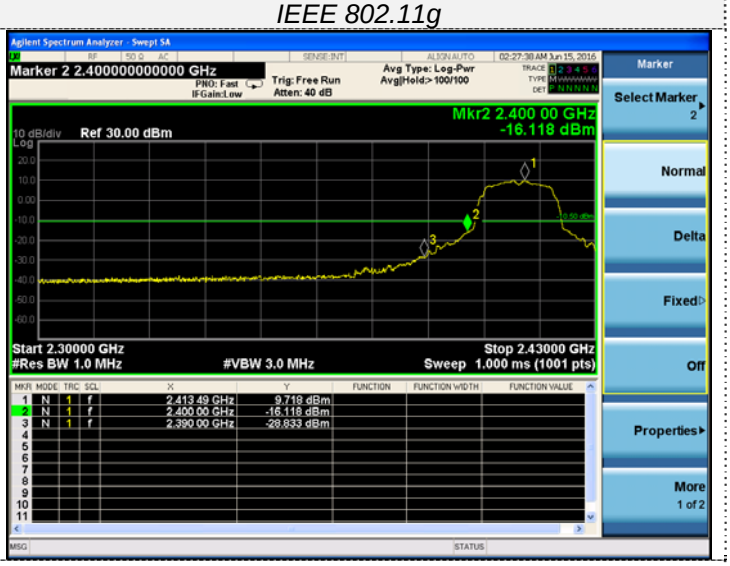
1. *Measured output power at difference data rate for each mode and recorded woest case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11 b; 6Mbps at IEEE 802.11 g; 6.5Mbps at IEEE 802.11 n HT20;*
4. *"---" means that the fundamental frequency not for 15.209 limits requirement.*
5. *please refer to following plots;*

Band-edge measurements for RF conducted emissions

IEEE 802.11b

2412 MHz

IEEE 802.11g



2412 MHz

2462 MHz

2462 MHz

Band-edge measurements for RF conducted emissions

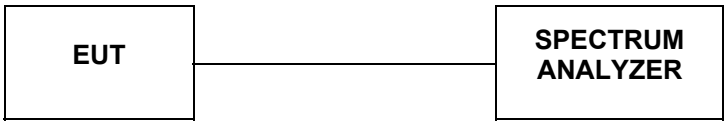
IEEE 802.11n HT20

2412 MHz

2462 MHz *2462 MHz*

4.10. Spurious RF Conducted Emission

TEST CONFIGURATION



TEST PROCEDURE

The Spurious RF conducted emissions compliance of RF radiated emission should be measured by following the guidance in ANSI C63.10-2013ith respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization etc. Set RBW=100kHz and VBW= 300KHz to measure the peak field strength , and mwasure frequeny range from 9KHz to 25GHz.

LIMIT

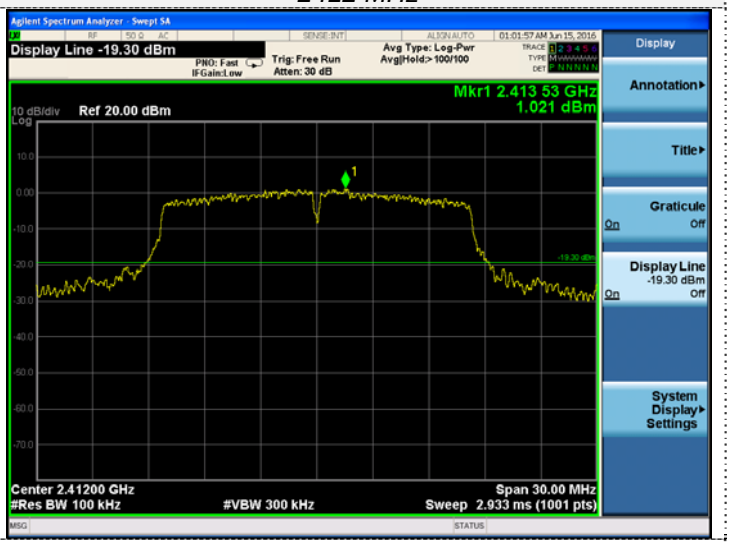
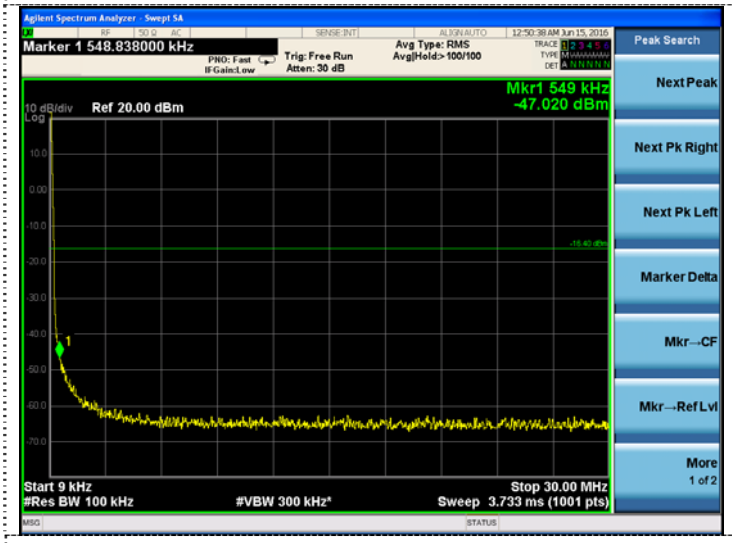
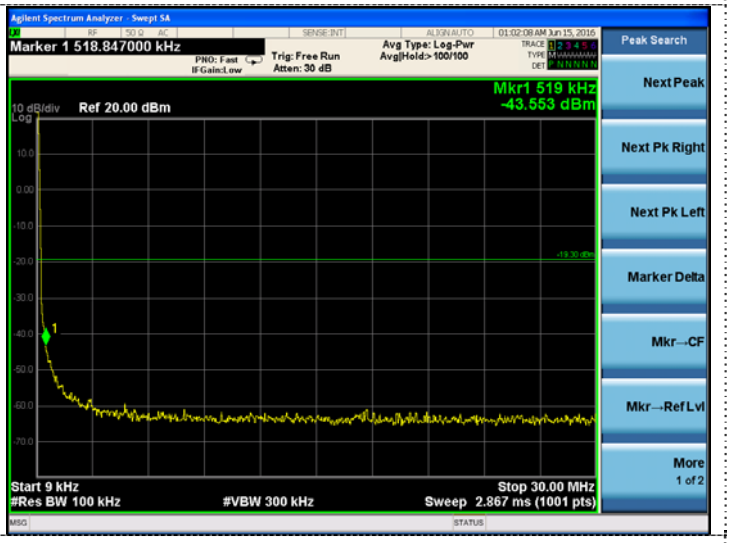
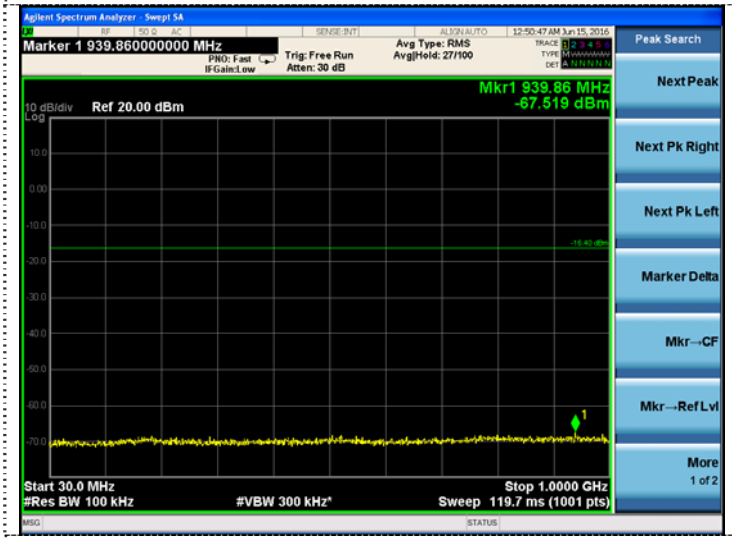
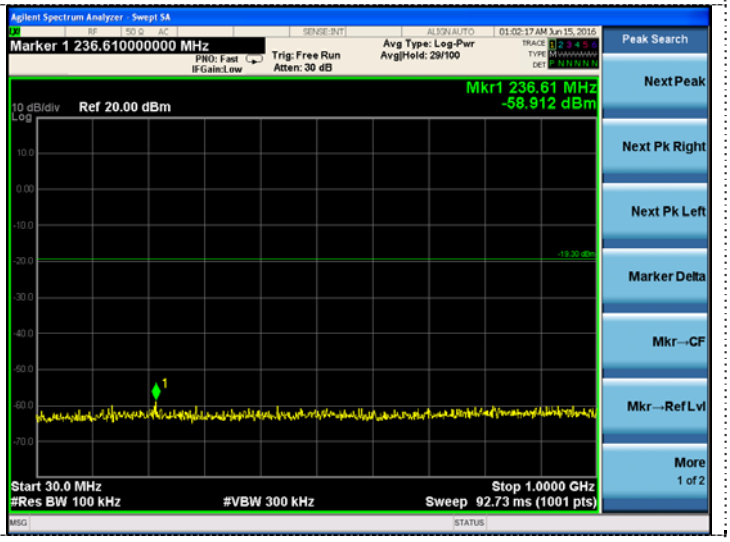
1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.

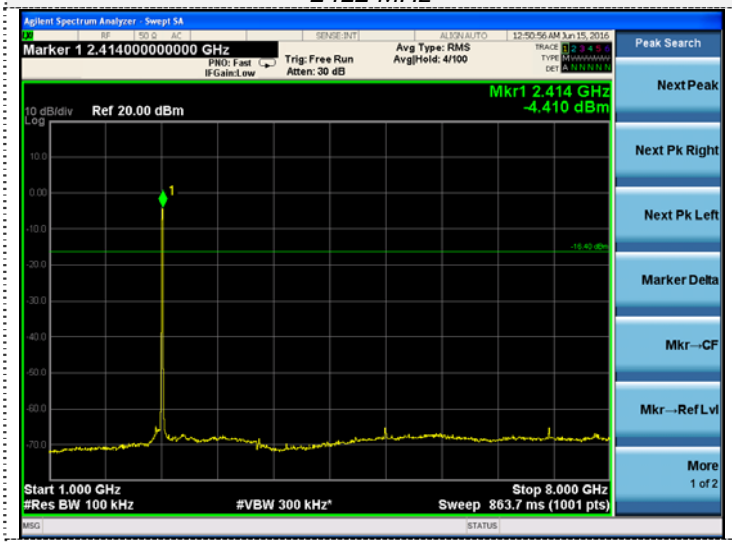
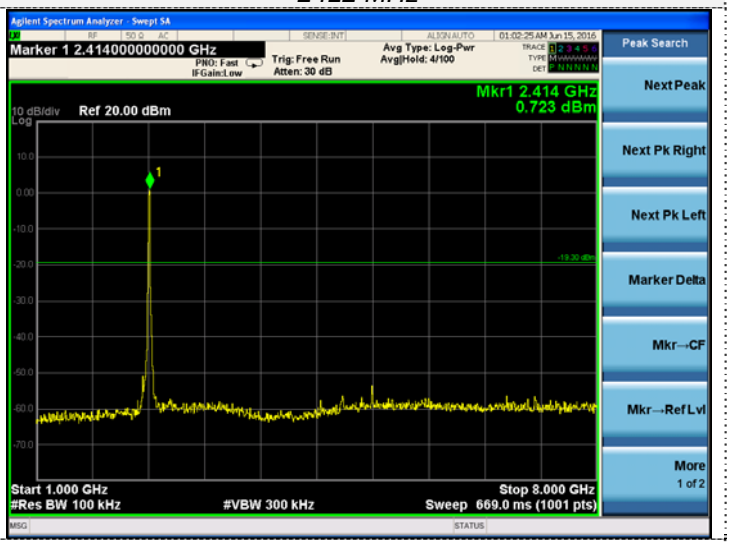
TEST RESULTS

Test Mode	Channel	Frequency (MHz)	Spurious RF Conducted Emission (dBc)	Limits (dBc)	Verdict
IEEE 802.11 b	1	2412	<-20dBc	-20	PASS
	6	2437	<-20dBc	-20	
	11	2462	<-20dBc	-20	
IEEE 802.11 g	1	2412	<-20dBc	-20	PASS
	6	2437	<-20dBc	-20	
	11	2462	<-20dBc	-20	
IEEE 802.11 n HT20	1	2412	<-20dBc	-20	PASS
	6	2437	<-20dBc	-20	
	11	2462	<-20dBc	-20	

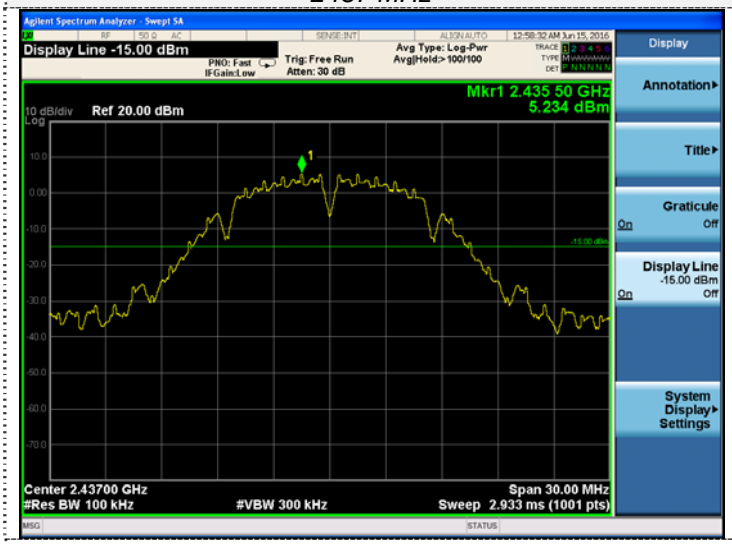
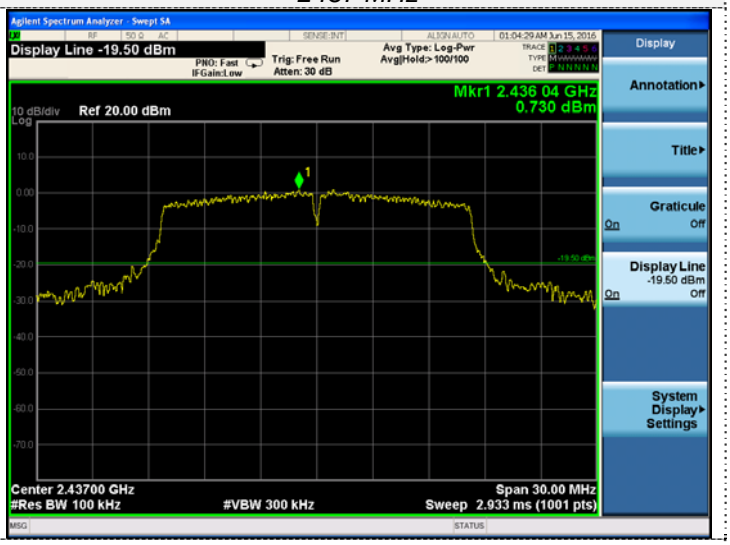
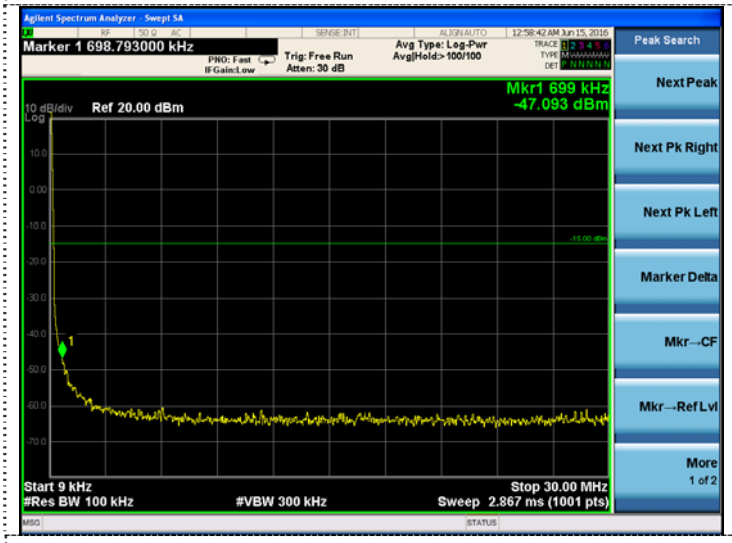
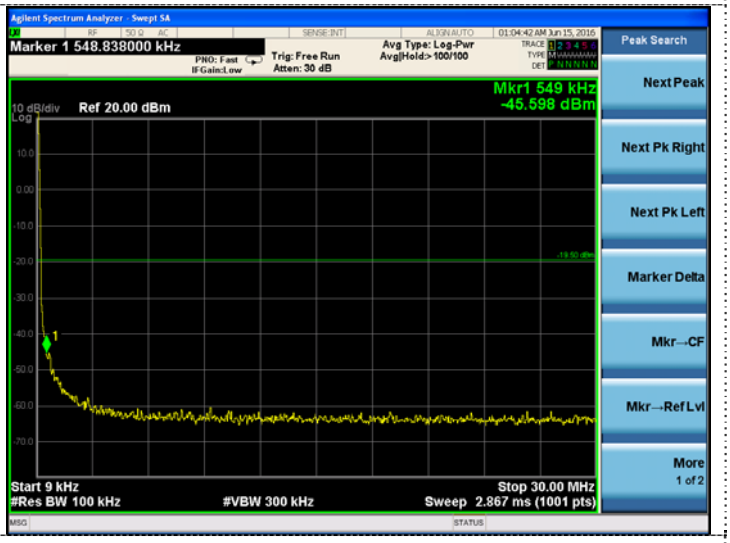
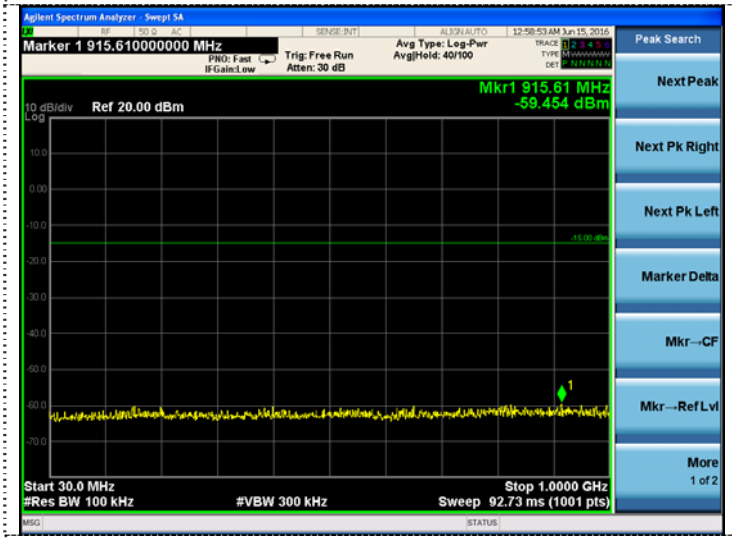
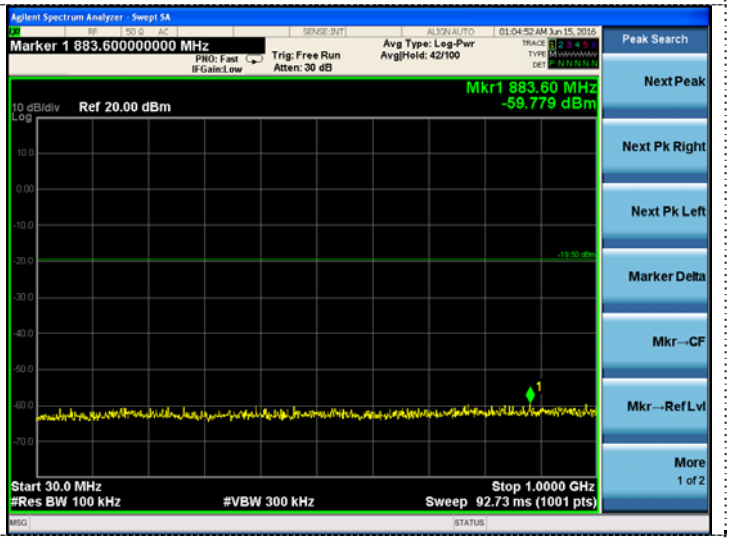
Remark:
1. *Measured output power at difference data rate for each mode and recorded woest case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11 b; 6Mbps at IEEE 802.11 g; 6.5Mbps at IEEE 802.11 n HT20;*
4. *"---" means that the fundamental frequency not for 15.209 limits requirement.*
5. *please refer to following plots;*

Spurious RF conducted emissions

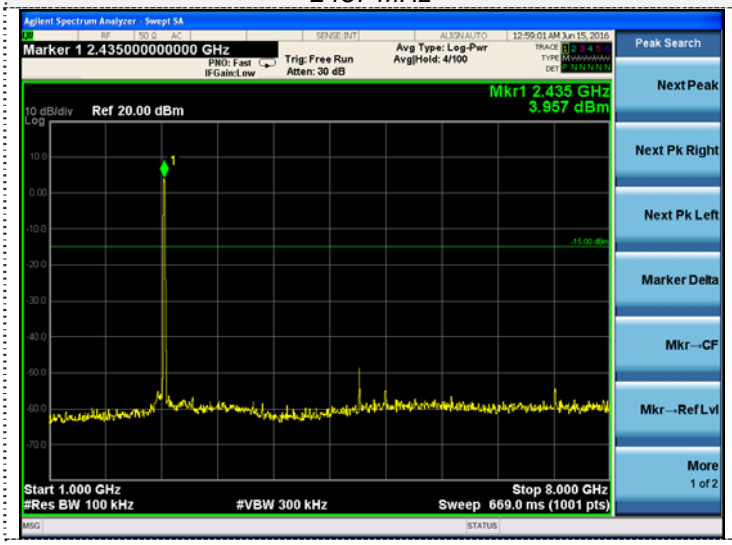
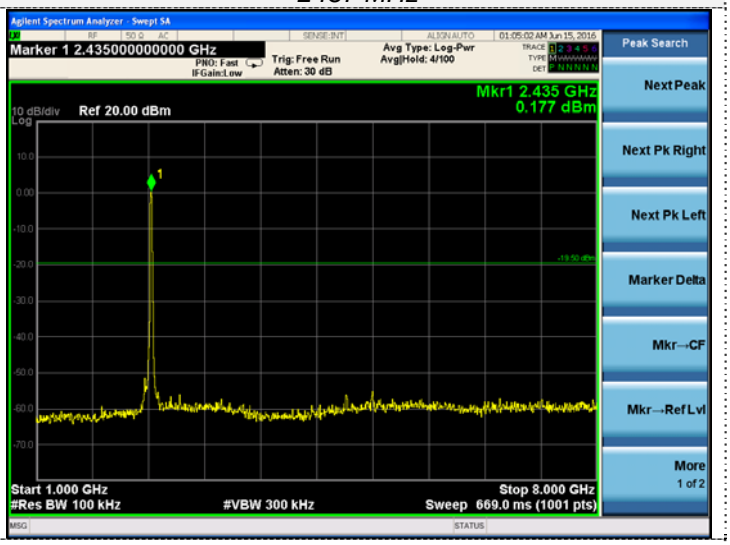
IEEE 802.11b	*IEEE 802.11g*
2412 MHz	*2412 MHz*
	
2397 MHz – 2427 MHz	*2397 MHz – 2427 MHz*
	
9 KHz – 30 MHz	*9 KHz – 30 MHz*
	
30 MHz – 1000 MHz	*30 MHz – 1000 MHz*

Spurious RF conducted emissions	
IEEE 802.11b	*IEEE 802.11g*
2412 MHz	*2412 MHz*
	
1 GHz – 8 GHz	*1 GHz – 8 GHz*
	
8 GHz – 16 GHz	*8 GHz – 16 GHz*
	
16 GHz – 25 GHz	*16 GHz – 25 GHz*

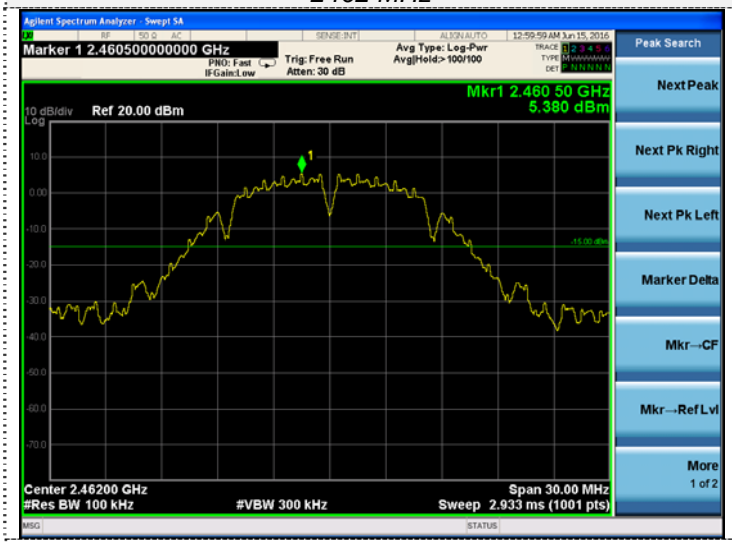
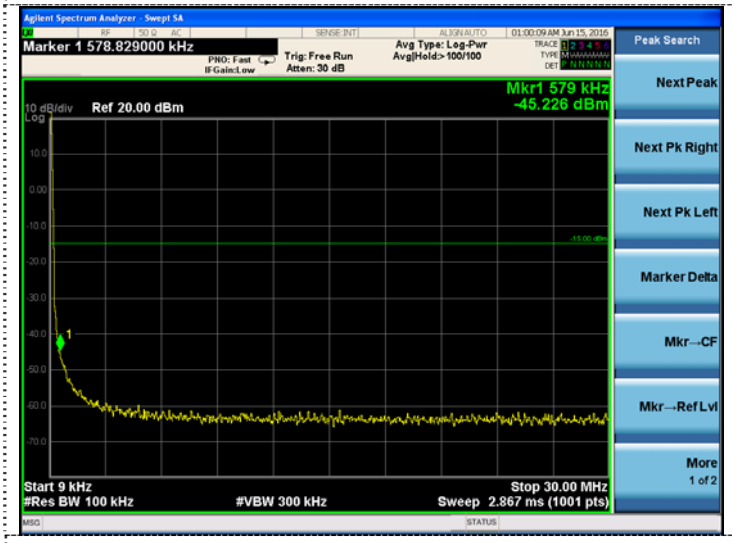
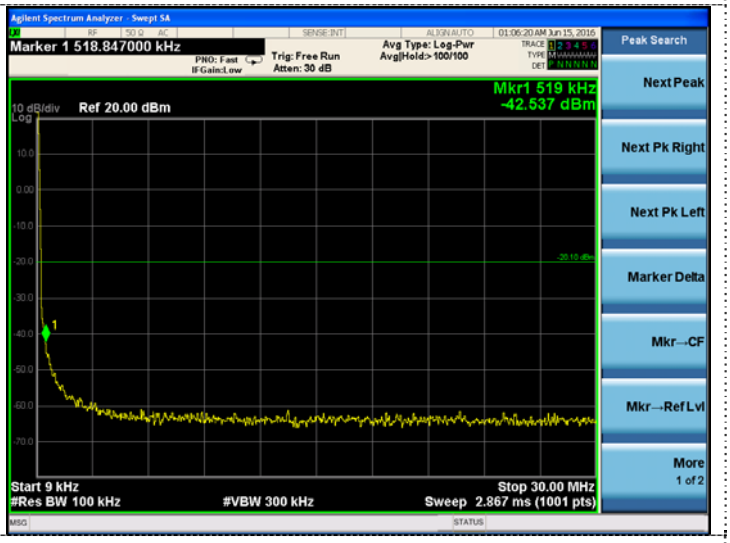
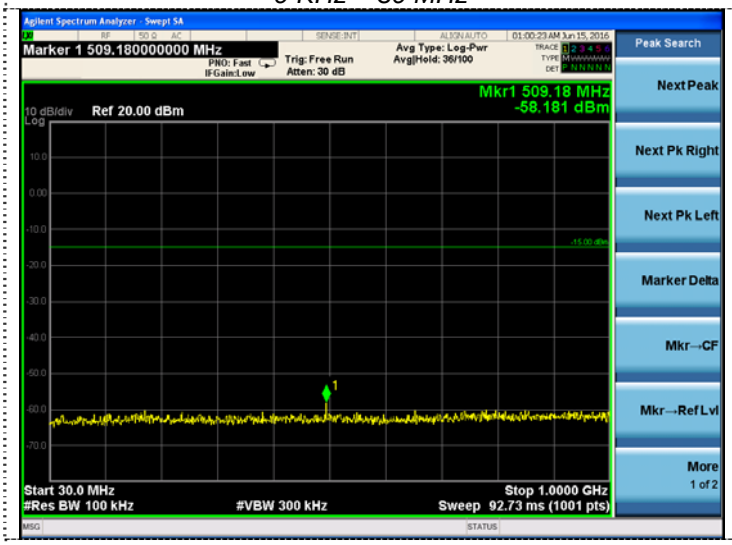
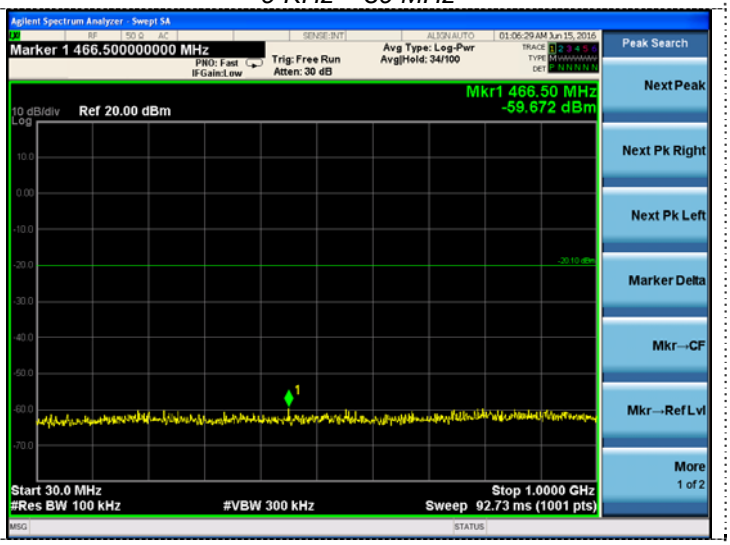
Spurious RF conducted emissions

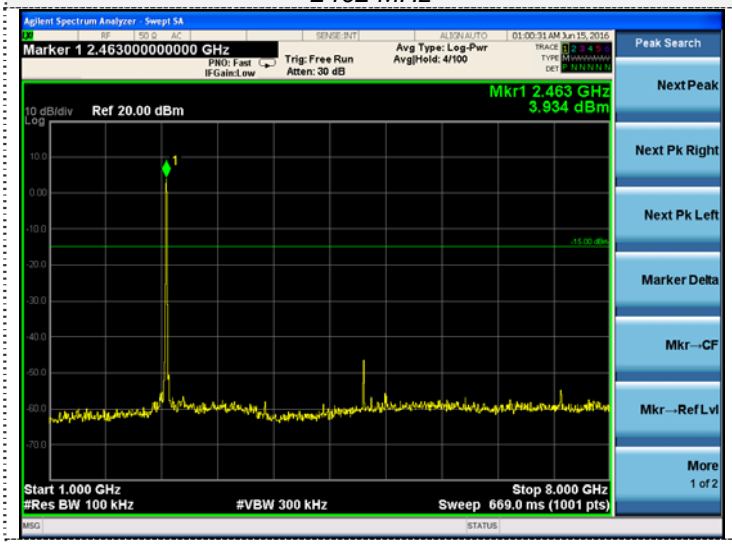
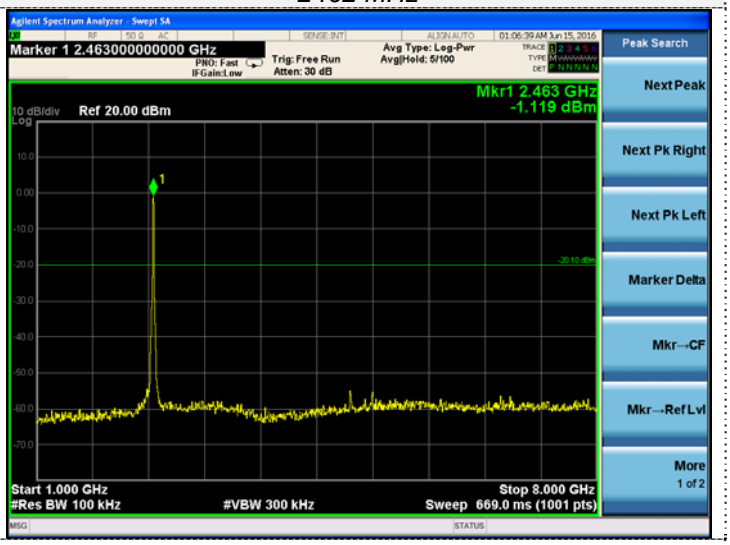
IEEE 802.11b	*IEEE 802.11g*
2437 MHz	*2437 MHz*
	
2422 MHz – 2452 MHz	*2422 MHz – 2452 MHz*
	
9 KHz – 30 MHz	*9 KHz – 30 MHz*
	
30 MHz – 1000 MHz	*30 MHz – 1000 MHz*

Spurious RF conducted emissions

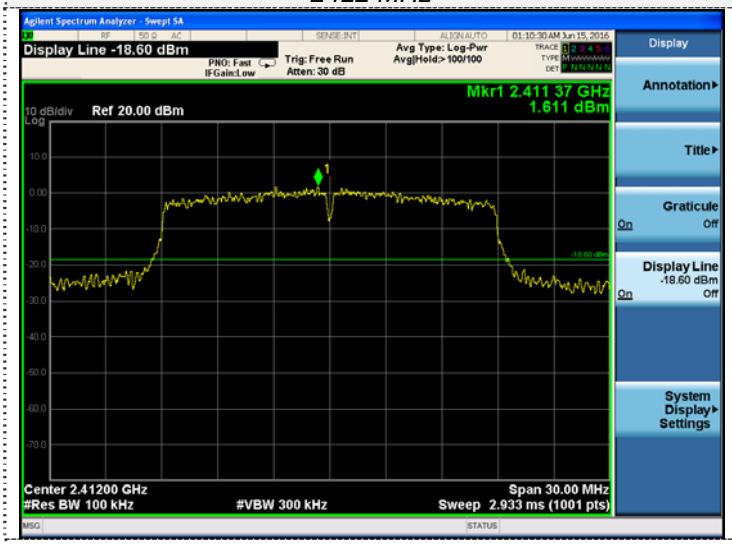
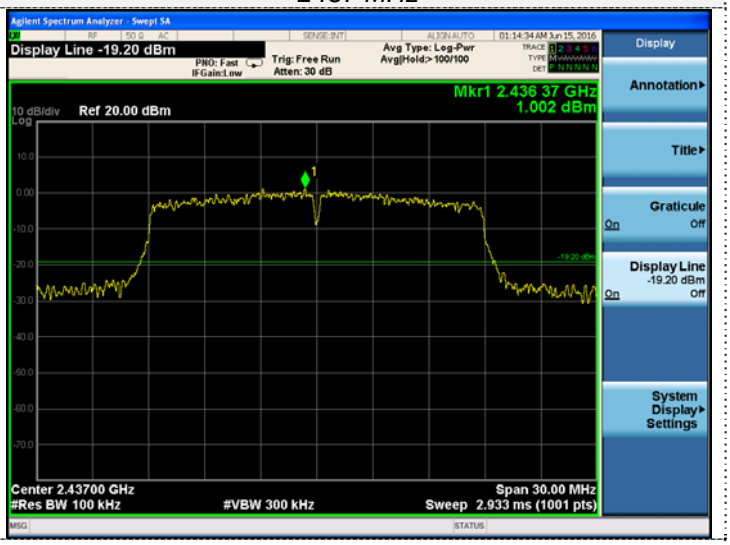
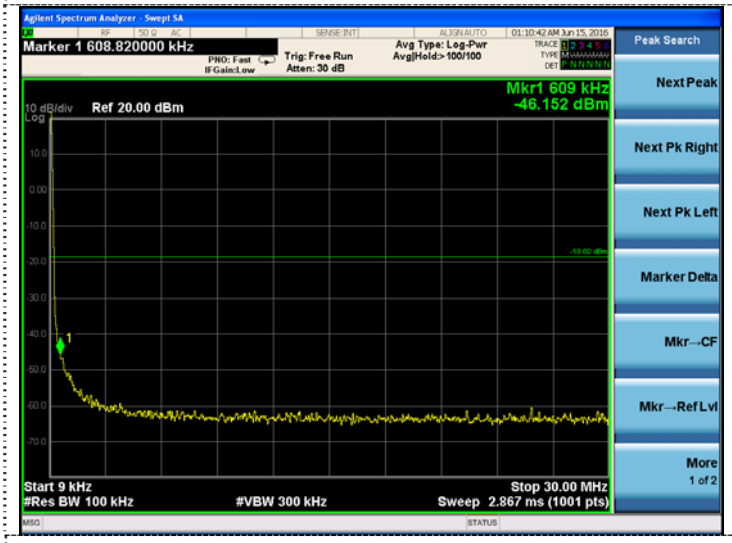
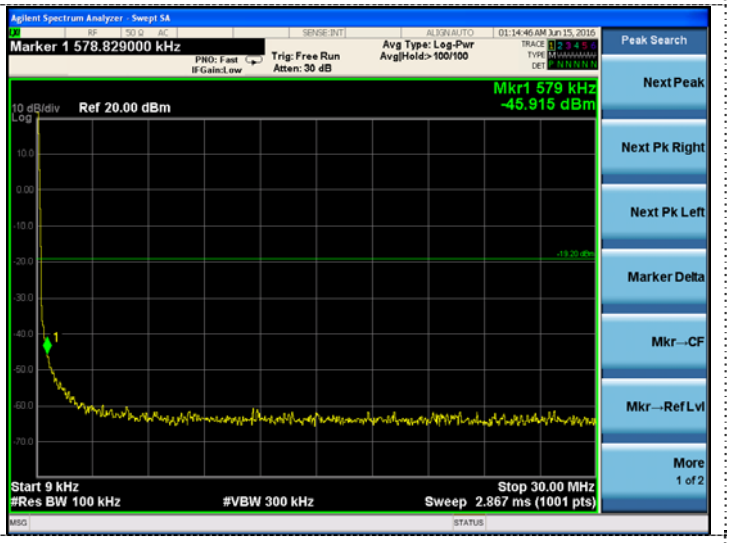
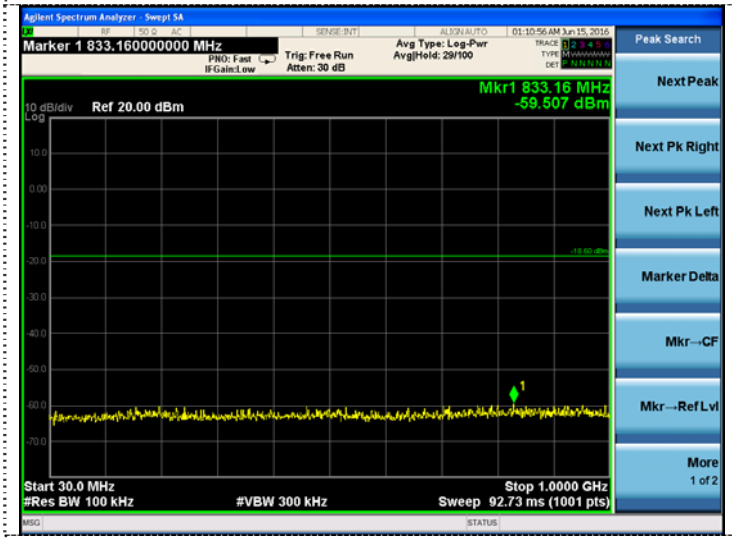
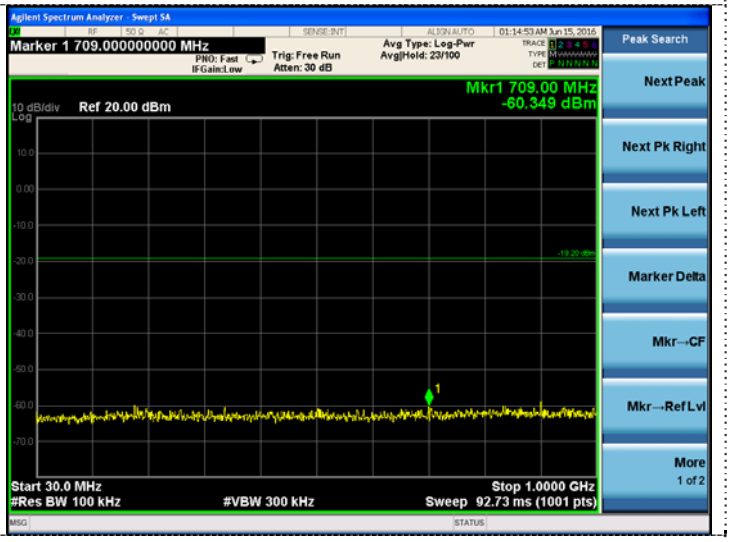
IEEE 802.11b	*IEEE 802.11g*
2437 MHz	*2437 MHz*
	
1 GHz – 8 GHz	*1 GHz – 8 GHz*
	
8 GHz – 16 GHz	*8 GHz – 16 GHz*
	
16 GHz – 25 GHz	*16 GHz – 25 GHz*

Spurious RF conducted emissions

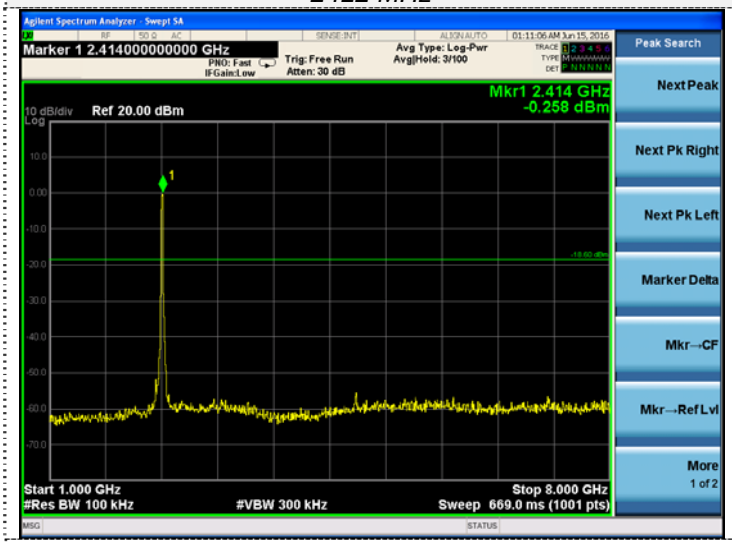
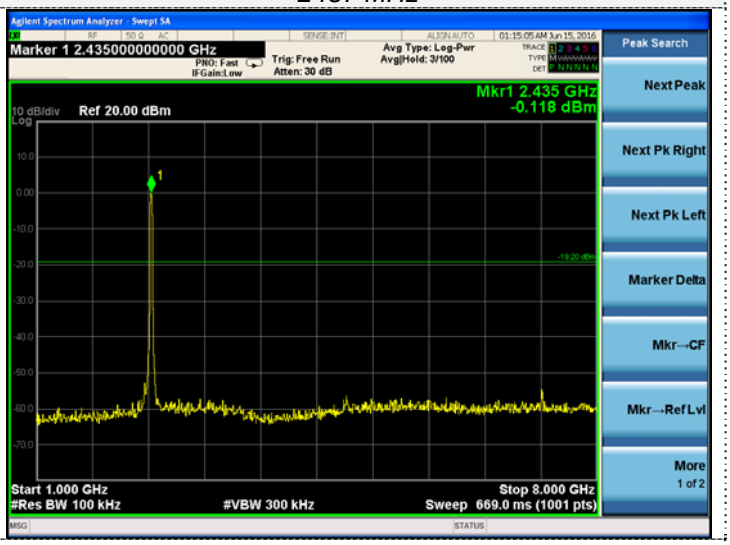
IEEE 802.11b	*IEEE 802.11g*
2462 MHz	*2462 MHz*
	
2447 MHz – 2477 MHz	*2447 MHz – 2477 MHz*
	
9 KHz – 30 MHz	*9 KHz – 30 MHz*
	
30 MHz – 1000 MHz	*30 MHz – 1000 MHz*

Spurious RF conducted emissions	
IEEE 802.11b	*IEEE 802.11g*
2462 MHz	*2462 MHz*
	
1 GHz – 8 GHz	*1 GHz – 8 GHz*
	
8 GHz – 16 GHz	*8 GHz – 16 GHz*
	
16 GHz – 25 GHz	*16 GHz – 25 GHz*

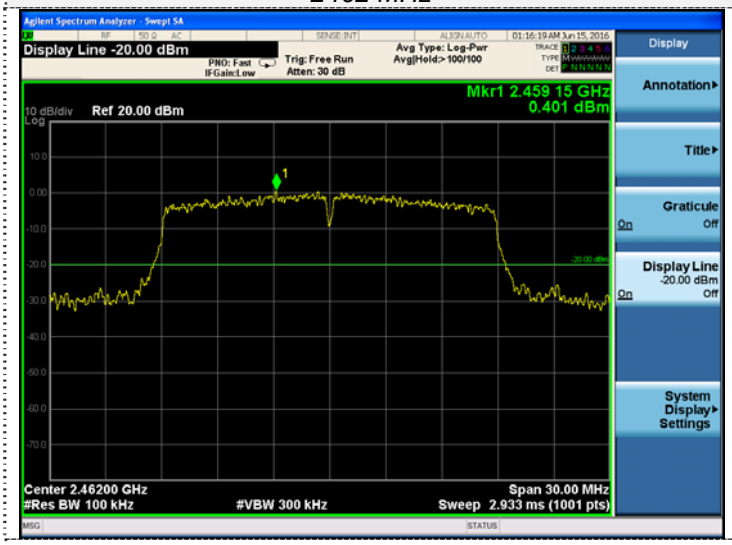
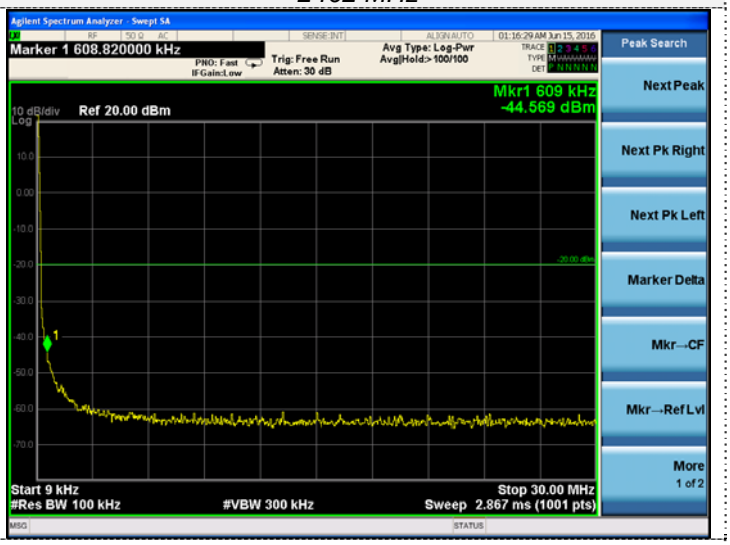
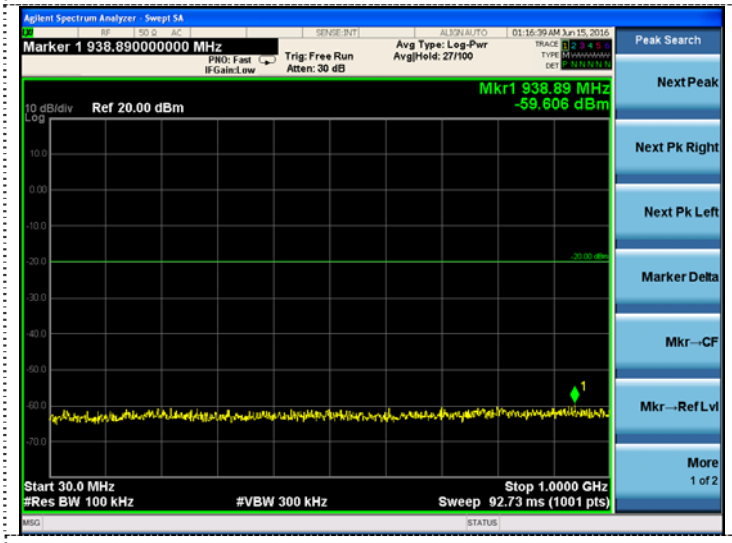
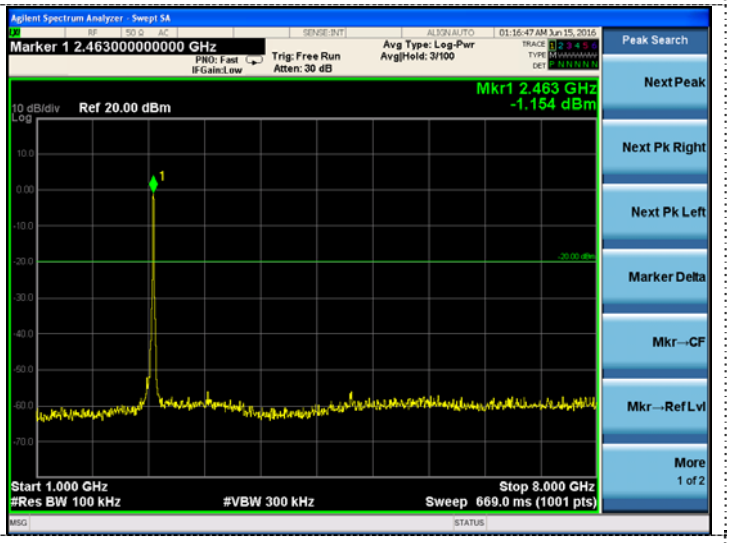
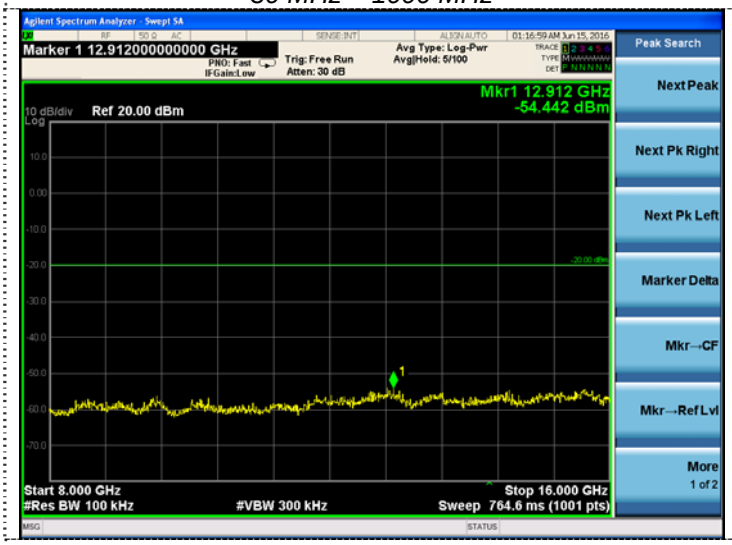
Spurious RF conducted emissions

IEEE 802.11n HT20	*IEEE 802.11n HT20*
2412 MHz	*2437 MHz*
	
2397 MHz – 2427 MHz	*2422 MHz – 2452 MHz*
	
9 KHz – 30 MHz	*9 KHz – 30 MHz*
	
30 MHz – 1000 MHz	*30 MHz – 1000 MHz*

Spurious RF conducted emissions

IEEE 802.11n HT20	*IEEE 802.11n HT20*
2412 MHz	*2437 MHz*
	
1 GHz – 8 GHz	*1 GHz – 8 GHz*
	
8 GHz – 16 GHz	*8 GHz – 16 GHz*
	
16 GHz – 25 GHz	*16 GHz – 25 GHz*

Spurious RF conducted emissions

IEEE 802.11n HT20	*IEEE 802.11n HT20*
2462 MHz	*2462 MHz*
	
2447 MHz – 2477 MHz	*9 KHz – 30 MHz*
	
30 MHz – 1000 MHz	*1 GHz – 8 GHz*
	
8 GHz – 16 GHz	*16 GHz – 25 GHz*

4.11. Antenna Requirement

Standard Applicable

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

And according to FCC 47 CFR Section 15.247 (c), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

Refer to statement below for compliance.

The manufacturer may design the unit so that the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited. Further, this requirement does not apply to intentional radiators that must be professionally installed.

Antenna Connected Construction

According to § 15.203 & RSS-Gen, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

The sample use internal antenna and maximum antenna gain is 0dBi, the sample also use reversed antenan connector meets § 15.203 requirement. Please see EUT photo for details.
The WLAN and Bluetooth Lower Energy share same antenna.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.For normal WLAN devices, the DSSS mode is used.

Measurement parameters

Measurement parameter	
Detector:	Peak
Sweep time:	Auto
Resolution bandwidth:	1MHz
Video bandwidth:	3MHz
Trace-Mode:	Max hold

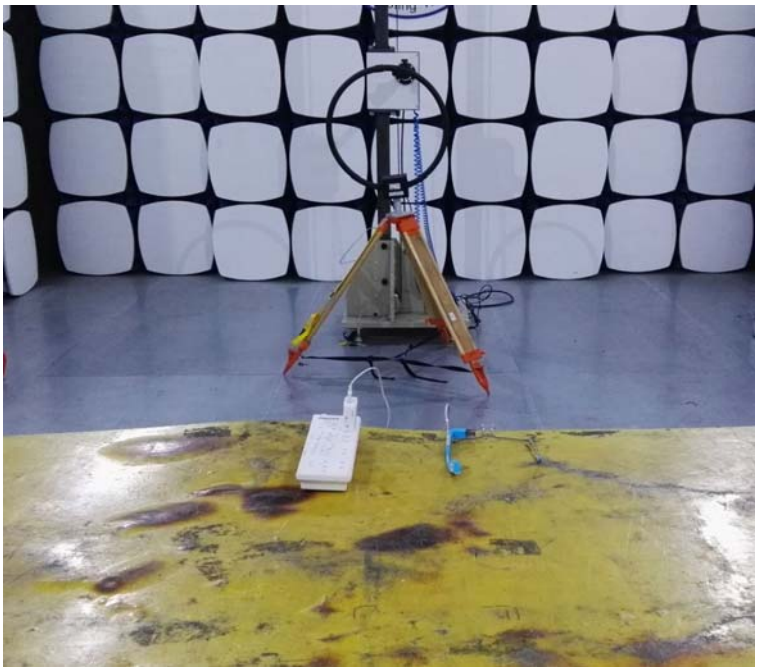
Limits

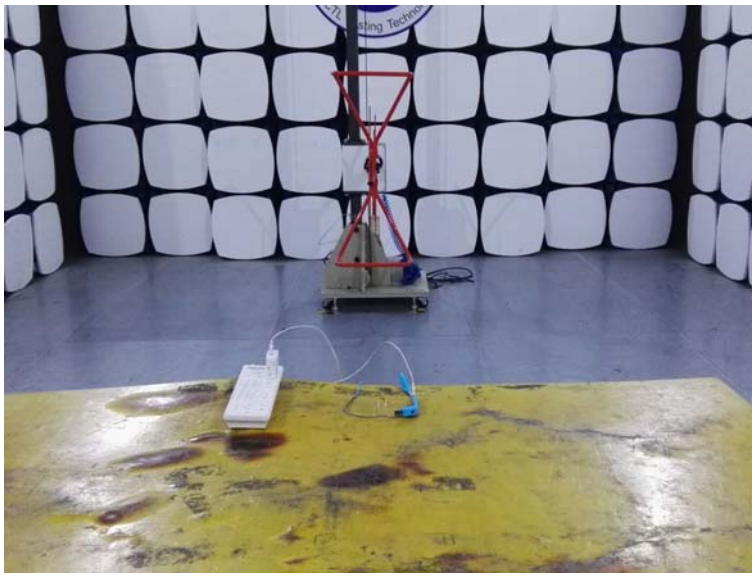
Antenna Gain	6 dBi

Results

T_{nom}	V_{nom}	Lowest Channel 2412 MHz	Middle Channel 2437 MHz	Highest Channel 2462 MHz
Conducted power [dBm] Measured with DSSS modulation		7.06	7.00	6.95
Radiated power [dBm] Measured with DSSS modulation		4.19	5.93	4.82
Gain [dBi] Calculated		-2.87	-1.07	-2.13
Measurement uncertainty		± 0.6 dB (cond.) / ± 4.32 dB (rad.)		

5. Test Setup Photos of the EUT





6. External and Internal Photos of the EUT

Reference to the test report No. GTSR16060030-BLE

.....End of Report.....