5.5. Radiated Emissions Measurement

5.5.1. Standard Applicable

15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
\1\ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293.	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(\2\)
13.36-13.41			

\1\ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
\2\ Above 38.6

For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz (68.2dBuV/m at 3m).

In addition, In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequencies (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

5.5.2. Measuring Instruments and Setting

Please refer to section 6 of equipment list in this report. The following table is the setting of spectrum analyzer and receiver.

Spectrum Parameter	Setting
Attenuation	Auto
Start Frequency	1000 MHz
Stop Frequency	10th carrier harmonic
RB / VB (Emission in restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average
RB / VB (Emission in non-restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average

Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~150kHz / RB/VB 200Hz/1KHz for QP/AVG
Start ~ Stop Frequency	150kHz~30MHz / RB/VB 9kHz/30KHz for QP/AVG
Start ~ Stop Frequency	30MHz~1000MHz / RB/VB 120kHz/1MHz for QP

5.5.3. Test Procedures

1) **Sequence of testing 9 kHz to 30 MHz**

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna height is 1.5 meter.

--- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

--- Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).

--- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QPK detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

2) **Sequence of testing 30 MHz to 1 GHz**

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height changes from 1 to 3 meter.

--- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter.

--- The final measurement will be done with QP detector with an EMI receiver.

--- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

3) **Sequence of testing 1 GHz to 18 GHz**

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height scan range is 1 meter to 2.5 meter.

--- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.

--- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

4) **Sequence of testing above 18 GHz**

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 1 meter.

--- The EUT was set into operation.

Premeasurement:

--- The antenna is moved spherical over the EUT in different polarizations of the antenna.

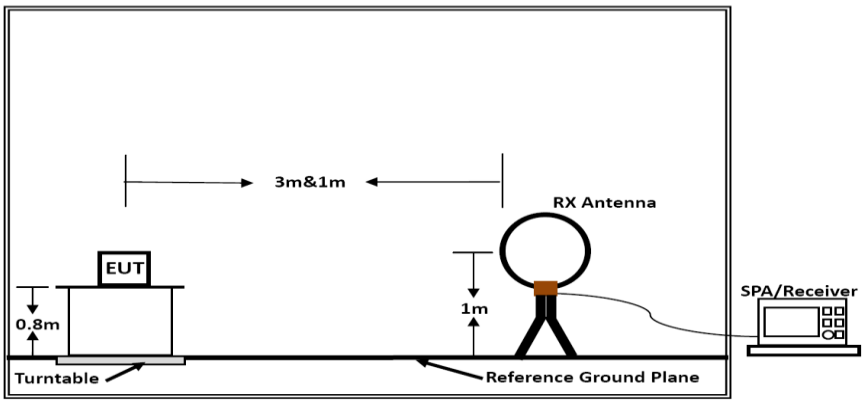
Final measurement:

--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.

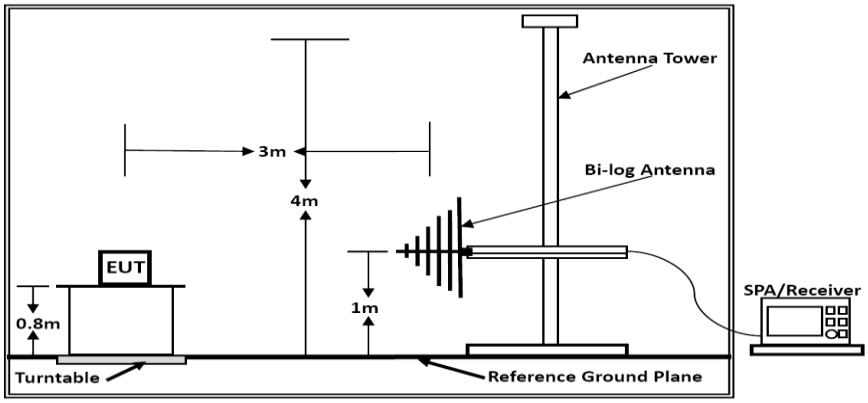
--- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

5.5.4. Test Setup Layout

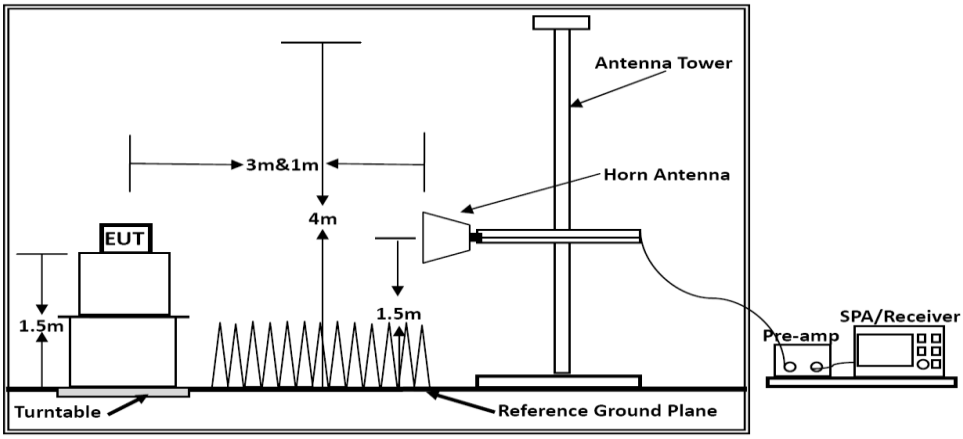
For radiated emissions below 30MHz



Below 30MHz



Below 1GHz



Above 1GHz

Above 10 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m.

Distance extrapolation factor = 20 log (specific distanc [3m] / test distance [1.5m]) (dB);

Limit line = specific limits (dBuV) + distance extrapolation factor [6 dB].

5.5.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.5.6. Results of Radiated Emissions (9 KHz~30MHz)

Temperature	24.5℃	Humidity	56.2%
Test Engineer	Gary Qian	Configurations	IEEE 802.11a/n/ac

Freq. (MHz)	Level (dBuV)	Over Limit (dB)	Over Limit (dBuV)	Remark
-	-	-	-	See Note

Note:

The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = 40 log (specific distance / test distance) (dB);

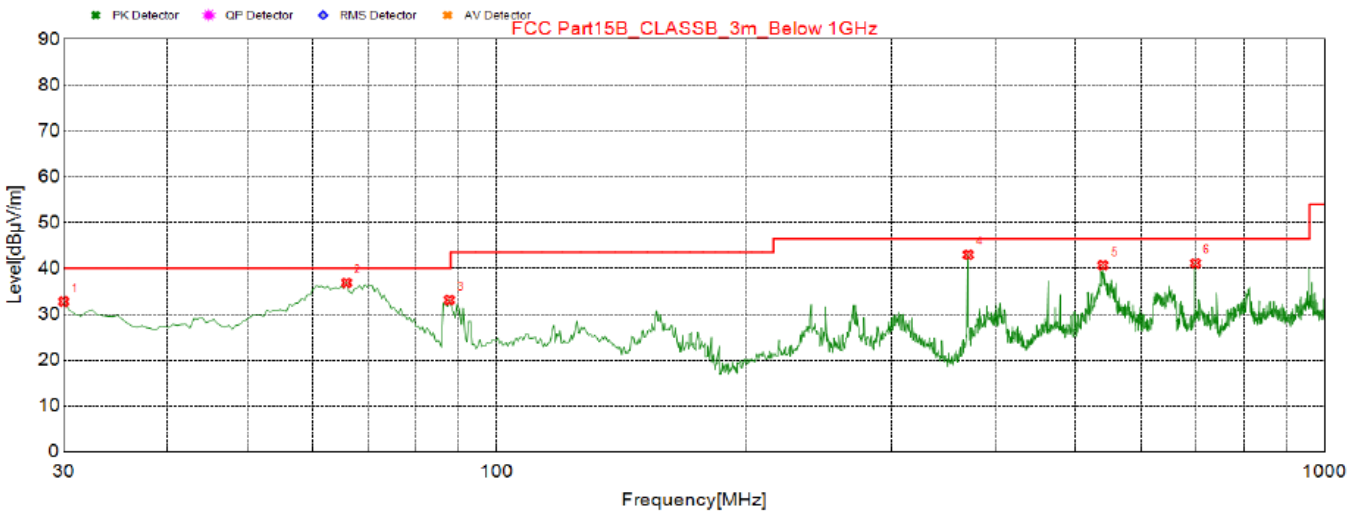
Limit line = specific limits (dBuV) + distance extrapolation factor.

5.5.7. Results of Radiated Emissions (30MHz~1GHz)

Temperature	24.5℃	Humidity	56.2%
Test Engineer	Gary Qian	Configurations	IEEE 802.11a, 5240MHz

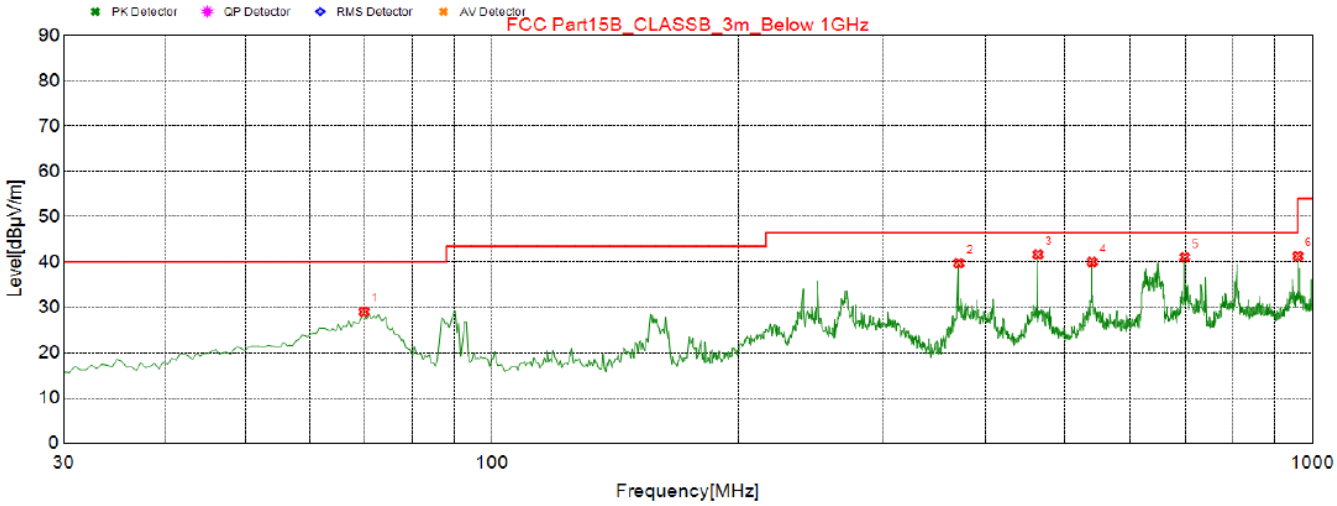
Test result for IEEE 802.11a-5240MHz

Vertical:



NO.	Freq. [MHz]	Result Level [dBµV/m]	Factor [dB/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	30.000	32.76	-16.22	40.00	7.24	200	216	Vertical
2	65.890	36.87	-17.16	40.00	3.13	100	161	Vertical
3	87.715	33.1	-18.23	40.00	6.90	100	295	Vertical
4	371.440	43	-10.83	46.50	3.50	200	144	Vertical
5	540.220	40.67	-7.07	46.50	5.83	100	190	Vertical
6	698.815	41.13	-4.36	46.50	5.37	100	84	Vertical

Horizontal:



NO.	Freq. [MHz]	Result Level [dBµV/m]	Factor [dB/m]	Limit [dBµV/m]	Margin [dB]	Height [cm]	Angle[°]	Polarity
1	69.770	29.03	-18.15	40.00	10.97	300	322	Horizontal
2	371.440	39.75	-10.83	46.50	6.75	100	153	Horizontal
3	464.075	41.66	-8.76	46.50	4.84	100	1	Horizontal
4	540.220	40.02	-7.07	46.50	6.48	100	252	Horizontal
5	698.815	41.06	-4.36	46.50	5.44	300	109	Horizontal
6	960.230	41.31	-0.34	54.00	12.69	100	286	Horizontal

Note:

Pre-scan all modes and recorded the worst case results in this report (IEEE 802.11a-5240MHz).

Emission level (dBuV/m) = 20 log Emission level (uV/m).

Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level.

5.5.8. Results for Radiated Emissions (Above 1GHz)

Remark: Measured all modes and recorded worst case;

IEEE 802.11a/ Antenna Chain 0

Channel 36/5180 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.54	57.36	33.06	35.04	3.94	59.32	68.20	-8.88	Peak	Horizontal
15.54	41.77	33.06	35.04	3.94	43.73	54.00	-10.27	Average	Horizontal
15.54	54.37	33.06	35.04	3.94	56.33	68.20	-11.87	Peak	Vertical
15.54	42.69	33.06	35.04	3.94	44.65	54.00	-9.35	Average	Vertical

Channel 40 / 5200 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.60	58.20	33.16	35.15	3.96	60.17	68.20	-8.03	Peak	Horizontal
15.60	44.34	33.16	35.15	3.96	46.31	54.00	-7.69	Average	Horizontal
15.60	56.03	33.16	35.15	3.96	58.00	68.20	-10.20	Peak	Vertical
15.60	41.20	33.16	35.15	3.96	43.17	54.00	-10.83	Average	Vertical

Channel 48 / 5240 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.72	55.63	33.26	35.14	3.98	57.73	68.20	-10.47	Peak	Horizontal
15.72	40.80	33.26	35.14	3.98	42.90	54.00	-11.10	Average	Horizontal
15.72	55.27	33.26	35.14	3.98	57.37	68.20	-10.83	Peak	Vertical
15.72	41.61	33.26	35.14	3.98	43.71	54.00	-10.29	Average	Vertical

IEEE 802.11n-HT20/Combined Antenna Chain 0 and Antenna Chain 1

Channel 36 / 5180 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.54	57.27	33.06	35.04	3.94	59.23	68.20	-8.97	Peak	Horizontal
15.54	44.49	33.06	35.04	3.94	46.45	54.00	-7.55	Average	Horizontal
15.54	57.37	33.06	35.04	3.94	59.33	68.20	-8.87	Peak	Vertical
15.54	44.90	33.06	35.04	3.94	46.86	54.00	-7.14	Average	Vertical

Channel 40 / 5200 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.60	57.54	33.16	35.15	3.96	59.51	68.20	-8.69	Peak	Horizontal
15.60	41.04	33.16	35.15	3.96	43.01	54.00	-10.99	Average	Horizontal
15.60	56.18	33.16	35.15	3.96	58.15	68.20	-10.05	Peak	Vertical
15.60	44.64	33.16	35.15	3.96	46.61	54.00	-7.39	Average	Vertical

Channel 48 / 5240 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.72	56.59	33.26	35.14	3.98	58.69	68.20	-9.51	Peak	Horizontal
15.72	44.28	33.26	35.14	3.98	46.38	54.00	-7.62	Average	Horizontal
15.72	54.36	33.26	35.14	3.98	56.46	68.20	-11.74	Peak	Vertical
15.72	44.57	33.26	35.14	3.98	46.67	54.00	-7.33	Average	Vertical

IEEE 802.11ac VHT20/ Combined Antenna Chain 0 and Antenna Chain 1

Channel 36 / 5180 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.54	58.67	33.06	35.04	3.94	60.63	68.20	-7.57	Peak	Horizontal
15.54	40.11	33.06	35.04	3.94	42.07	54.00	-11.93	Average	Horizontal
15.54	59.00	33.06	35.04	3.94	60.96	68.20	-7.24	Peak	Vertical
15.54	40.91	33.06	35.04	3.94	42.87	54.00	-11.13	Average	Vertical

Channel 40 / 5200 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.60	54.85	33.16	35.15	3.96	56.82	68.20	-11.38	Peak	Horizontal
15.60	42.68	33.16	35.15	3.96	44.65	54.00	-9.35	Average	Horizontal
15.60	56.12	33.16	35.15	3.96	58.09	68.20	-10.11	Peak	Vertical
15.60	40.51	33.16	35.15	3.96	42.48	54.00	-11.52	Average	Vertical

Channel 48 / 5240 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.72	57.00	33.26	35.14	3.98	59.10	68.20	-9.10	Peak	Horizontal
15.72	42.45	33.26	35.14	3.98	44.55	54.00	-9.45	Average	Horizontal
15.72	54.84	33.26	35.14	3.98	56.94	68.20	-11.26	Peak	Vertical
15.72	42.88	33.26	35.14	3.98	44.98	54.00	-9.02	Average	Vertical

IEEE 802.11n HT40 / Antenna Chain 0 and Antenna Chain 1

Channel 38 / 5190 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.57	57.98	33.06	35.04	3.94	59.94	68.20	-8.26	Peak	Horizontal
15.57	44.83	33.06	35.04	3.94	46.79	54.00	-7.21	Average	Horizontal
15.57	56.01	33.06	35.04	3.94	57.97	68.20	-10.23	Peak	Vertical
15.57	44.88	33.06	35.04	3.94	46.84	54.00	-7.16	Average	Vertical

Channel 46 / 5230 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.69	56.73	33.16	35.15	3.96	58.70	68.20	-9.50	Peak	Horizontal
15.69	43.17	33.16	35.15	3.96	45.14	54.00	-8.86	Average	Horizontal
15.69	56.52	33.16	35.15	3.96	58.49	68.20	-9.71	Peak	Vertical
15.69	42.59	33.16	35.15	3.96	44.56	54.00	-9.44	Average	Vertical

IEEE 802.11ac VHT40 / Antenna Chain 0 and Antenna Chain 1

Channel 38 / 5190 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.57	55.40	33.06	35.04	3.94	57.36	68.20	-10.84	Peak	Horizontal
15.57	41.93	33.06	35.04	3.94	43.89	54.00	-10.11	Average	Horizontal
15.57	55.70	33.06	35.04	3.94	57.66	68.20	-10.54	Peak	Vertical
15.57	40.37	33.06	35.04	3.94	42.33	54.00	-11.67	Average	Vertical

Channel 46 / 5230 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.69	57.94	33.16	35.15	3.96	59.91	68.20	-8.29	Peak	Horizontal
15.69	43.33	33.16	35.15	3.96	45.30	54.00	-8.70	Average	Horizontal
15.69	58.57	33.16	35.15	3.96	60.54	68.20	-7.66	Peak	Vertical
15.69	41.88	33.16	35.15	3.96	43.85	54.00	-10.15	Average	Vertical

IEEE 802.11ac VHT80 / Antenna Chain 0 and Antenna Chain 1

Channel 42 / 5210 MHz

Freq GHz	Read Level dBuV	Ant. Fac dB/m	Pre. Fac dB	Cab.Los dB	Measured Level dBuV	Limit Line dBuV/m	Over limit dB	Remark	Pol/Phase
15.63	58.00	33.06	35.04	3.94	59.96	68.20	-8.24	Peak	Horizontal
15.63	42.18	33.06	35.04	3.94	44.14	54.00	-9.86	Average	Horizontal
15.63	55.26	33.06	35.04	3.94	57.22	68.20	-10.98	Peak	Vertical
15.63	44.26	33.06	35.04	3.94	46.22	54.00	-7.78	Average	Vertical

Notes:

1. *Measuring frequencies from 9 KHz ~40 GHz, No emission found between lowest internal used/generated frequencies to 30MHz.*
2. *Radiated emissions measured in frequency range from 9 KHz ~40GHz were made with an instrument using Peak detector mode.*
3. *Data of measurement within this frequency range shown "---" in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.*
4. *Worst case data at 6Mbps at IEEE 802.11a; MCS0 at IEEE 802.11n HT20, IEEE 802.11n HT40, IEEE 802.11a VHT20, IEEE 802.11ac VHT40 and IEEE 802.11ac VHT80;*

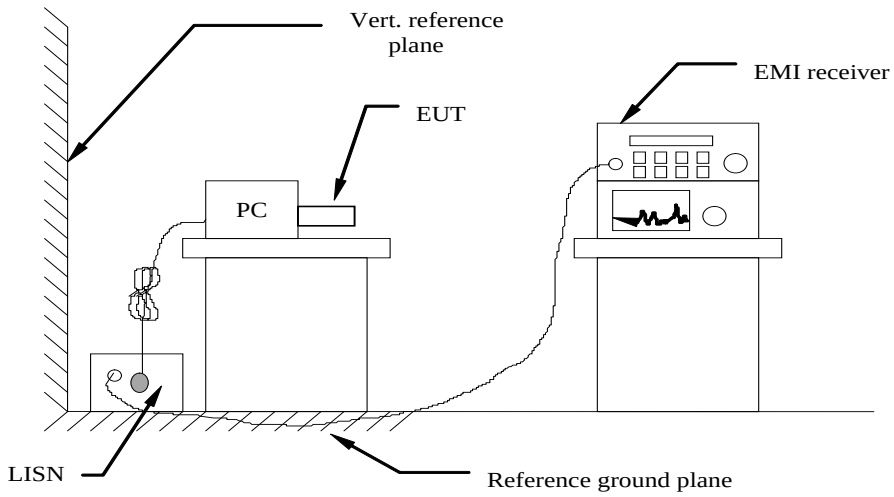
5.6. Power line conducted emissions

5.6.1 Standard Applicable

According to §15.207 (a): For an intentional radiator which is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed 250 microvolts (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range are listed as follows:

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

* Decreasing linearly with the logarithm of the frequency



5.6.2 Block Diagram of Test Setup

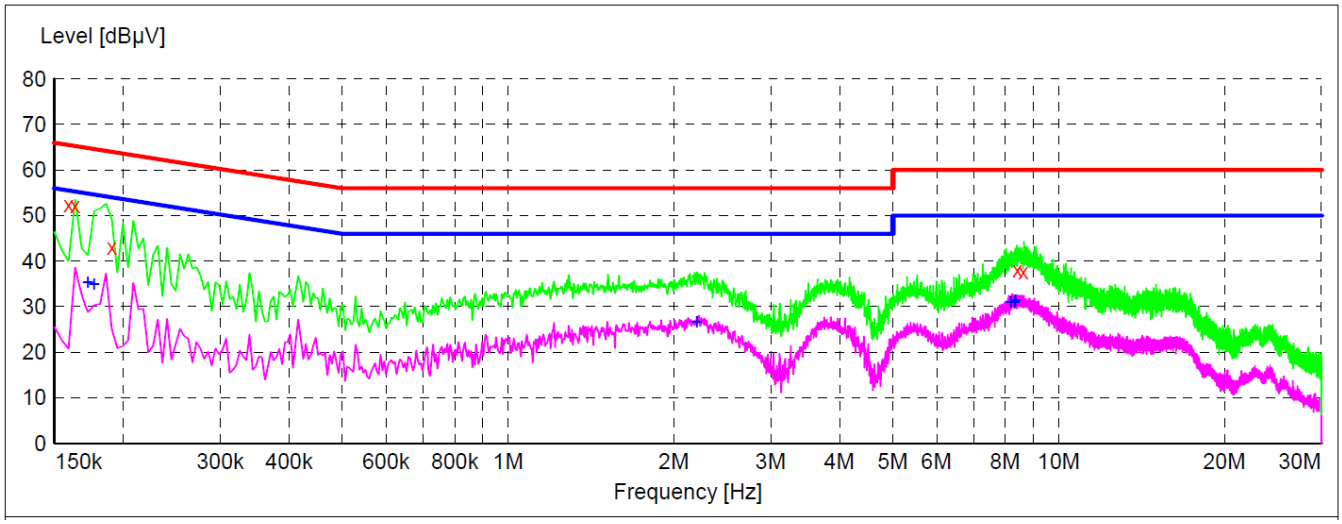
5.6.3 Test Results

PASS.

The test data please refer to following page.

The worst result for EEE 802.11a-5240MHz @Chain 0

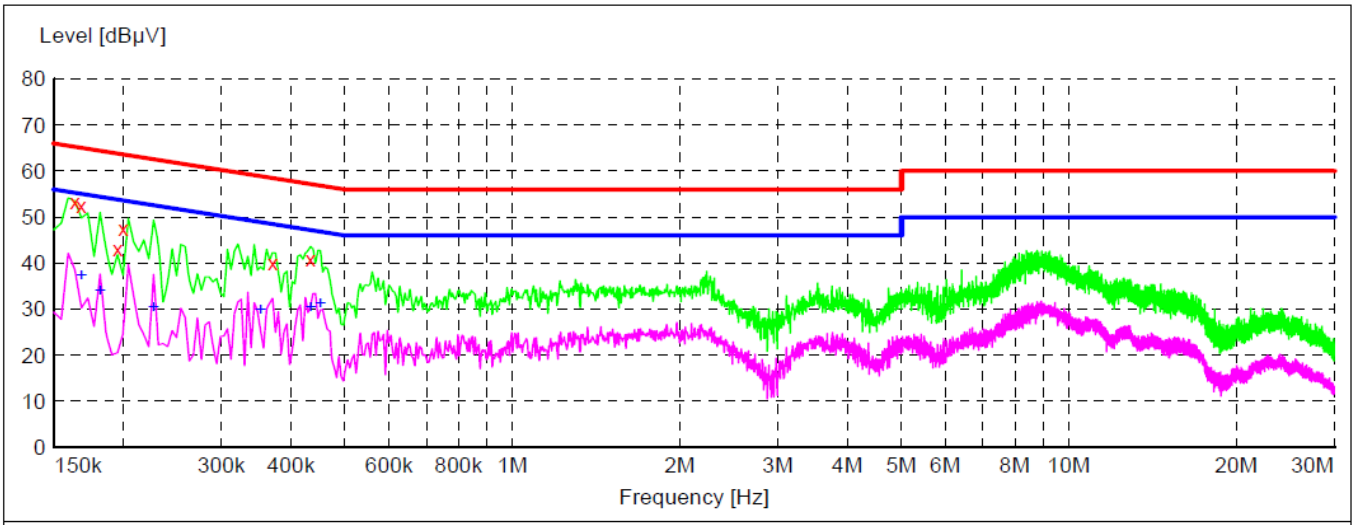
Line



Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.159000	52.30	10.0	66	13.2	QP	L1	GND
0.163500	52.20	10.1	65	13.1	QP	L1	GND
0.190500	43.00	10.5	64	21.0	QP	L1	GND
8.416500	38.10	9.9	60	21.9	QP	L1	GND
8.628000	37.70	9.9	60	22.3	QP	L1	GND

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.172500	35.40	10.2	55	19.4	AV	L1	GND
0.177000	34.90	10.3	55	19.7	AV	L1	GND
2.202000	26.60	9.8	46	19.4	AV	L1	GND
8.182500	30.90	9.9	50	19.1	AV	L1	GND
8.304000	31.00	9.9	50	19.0	AV	L1	GND
8.340000	31.50	9.9	50	18.5	AV	L1	GND

Neutral



Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.163500	53.20	10.1	65	12.1	QP	N	GND
0.168000	52.40	10.2	65	12.7	QP	N	GND
0.195000	43.20	10.6	64	20.6	QP	N	GND
0.199500	47.40	10.7	64	16.2	QP	N	GND
0.370500	40.20	10.1	59	18.3	QP	N	GND
0.433500	40.90	10.1	57	16.3	QP	N	GND

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Detector	Line	PE
0.168000	37.40	10.2	55	17.7	AV	N	GND
0.181500	34.10	10.4	54	20.3	AV	N	GND
0.226500	30.40	10.6	53	22.2	AV	N	GND
0.352500	29.90	10.2	49	19.0	AV	N	GND
0.433500	30.40	10.1	47	16.8	AV	N	GND
0.451500	31.10	10.0	47	15.7	AV	N	GND

******Note: Pre-scan all modes and recorded the worst case results in this report (IEEE 802.11a) @ Chain 0 for 120V/60Hz.***

5.7 Undesirable Emissions Measurement

5.7.1 LIMIT

According to §15.407 (b) Undesirable emission limits. Except as shown in paragraph (b) (7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(a) For transmitters operating in the 5.15-5.25 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(b) For transmitters operating in the 5.25-5.35 GHz band: All emissions outside of the 5.15-5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(c) For transmitters operating in the 5.47-5.725 GHz band: All emissions outside of the 5.47-5.725 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(d) For transmitters operating in the 5.725-5.85 GHz band:

(i) All emissions shall be limited to a level of −27 dBm/MHz at 75 MHz or more above or below the band edge increasing linearly to 10 dBm/MHz at 25 MHz above or below the band edge, and from 25 MHz above or below the band edge increasing linearly to a level of 15.6 dBm/MHz at 5 MHz above or below the band edge, and from 5 MHz above or below the band edge increasing linearly to a level of 27 dBm/MHz at the band edge.

(ii) Devices certified before March 2, 2017 with antenna gain greater than 10 dBi may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease by March 2, 2018. Devices certified before March 2, 2018 with antenna gain of 10 dBi or less may demonstrate compliance with the emission limits in §15.247(d), but manufacturing, marketing and importing of devices certified under this alternative must cease before March 2, 2020.

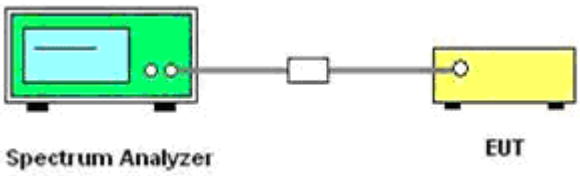
(e) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(f) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209. Further, any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207.

(g) The provisions of §15.205 apply to intentional radiators operating under this section.

(h) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

5.7.2 TEST CONFIGURATION



5.7.3 TEST PROCEDURE

According to KDB789033 D02 General UNII Test Procedures New Rules v02r01 Section G: Unwanted Emission Measurement

1. Unwanted Emissions in the Restricted Bands

a) For all measurements, follow the requirements in section II.G.3. “General Requirements for Unwanted Emissions Measurements.”

b) At frequencies below 1000 MHz, use the procedure described in section II.G.4. “Procedure for Unwanted Emissions Measurements below 1000 MHz.”

c) At frequencies above 1000 MHz, measurements performed using the peak and average measurement procedures described in sections II.G.5. and II.G.6, respectively, must satisfy the respective peak and average limits. If all peak measurements satisfy the average limit, then average measurements are not required.

d) For conducted measurements above 1000 MHz, EIRP shall be computed as specified in section II.G.3.b) and then field strength shall be computed as follows (see KDB Publication 412172):

i) E[dBμV/m] = EIRP[dBm] - 20 log (d[meters]) + 104.77, where E = field strength and d = distance at which field strength limit is specified in the rules;

ii) E[dBμV/m] = EIRP[dBm] + 95.2, for d = 3 meters

e) For conducted measurements below 1000 MHz, the field strength shall be computed as specified in d), above, and then an additional 4.7 dB shall be added as an upper bound on the field strength that would be observed on a test range with a ground plane for frequencies between 30 MHz and 1000 MHz, or an additional 6 dB shall be added for frequencies below 30 MHz.

2. Unwanted Emissions that fall Outside of the Restricted Bands

a) For all measurements, follow the requirements in section II.G.3. “General Requirements for Unwanted Emissions Measurements.”

b) At frequencies below 1000 MHz, use the procedure described in section II.G.4. “Procedure for Unwanted Emissions Measurements below 1000 MHz.”

c) At frequencies above 1000 MHz, use the procedure for maximum emissions described in section II.G.5., “Procedure for Unwanted Maximum Unwanted Emissions Measurements Above 1000 MHz.”

d) Section 15.407(b) (1-3) specifies the unwanted emissions limit for the U-NII-1 and 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. However, 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 dBm/MHz peak emission limit.

i) Section 15.407(b) (4) specifies the unwanted emissions limit for the U-NII-3 band. A band emissions mask is specified in Section 15.407(b) (4) (i). 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 alternative limit.

e) If radiated measurements are performed, field strength is then converted to EIRP as follows:

i) EIRP = ((E×d) ^2) / 30

Where:

- E is the field strength in V/m;
- d is the measurement distance in meters;
- EIRP is the equivalent isotopically radiated power in watts;

ii) Working in dB units, the above equation is equivalent to:

EIRP [dBm] = E [dBμV/m] + 20 log (d [meters]) - 104.77

iii) Or, if d is 3 meters:

EIRP [dBm] = E [dBμV/m] - 95.23

3) Radiated versus Conducted Measurements.

The unwanted emission limits in both the restricted and non-restricted bands are based on radiated measurements; however, as an alternative, antenna-port conducted measurements in conjunction with cabinet emissions tests will be permitted to demonstrate compliance provided that the following steps are performed:

(i) Cabinet emissions measurements. A radiated test shall be performed to ensure that cabinet emissions are below the emission limits. For the cabinet-emission measurements the antenna may be replaced by a termination matching the nominal impedance of the antenna.

(ii) Impedance matching. Conducted tests shall be performed using equipment that matches the nominal impedance of the antenna assembly used with the EUT.

(iii) EIRP calculation. A value representative of an upper bound on out-of-band antenna gain (in dBi) shall be added to the measured antenna-port conducted emission power to compute EIRP within the specified measurement bandwidth. (For emissions in the restricted bands, additional calculations are required to convert EIRP to field strength at the specified distance.) 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.[3] However, for devices that operate in multiple bands using the same transmit antenna, the highest gain of the antenna within the operating band nearest to the out-of-band frequency being measured may be used in lieu of the overall highest gain when measuring emissions at frequencies within 20% of the absolute frequency at the nearest edge of that band, but in no case shall a value less than 2 dBi be selected.

(iv) EIRP adjustments for multiple outputs. For devices with multiple outputs occupying the same or overlapping frequency ranges in the same band (e.g., MIMO or beamforming devices), compute the total EIRP as follows:

- Compute EIRP for each output, as described in (iii), above.
- Follow the procedures specified in KDB Publication 662911 for summing emissions across the outputs or adjusting emission levels measured on individual outputs by 10 log (N_{ANT}), where N_{ANT} is the number of outputs.
- Add the array gain term specified in KDB Publication 662911 for out-of-band and spurious signals.

(v) Direction of maximum emission.

For all radiated emissions tests, measurements shall correspond to the direction of maximum emission level for each measured emission (see ANSI C63.10 for guidance).

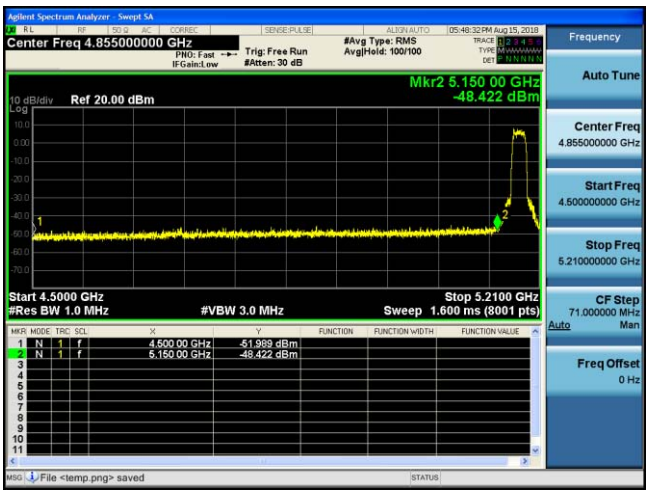
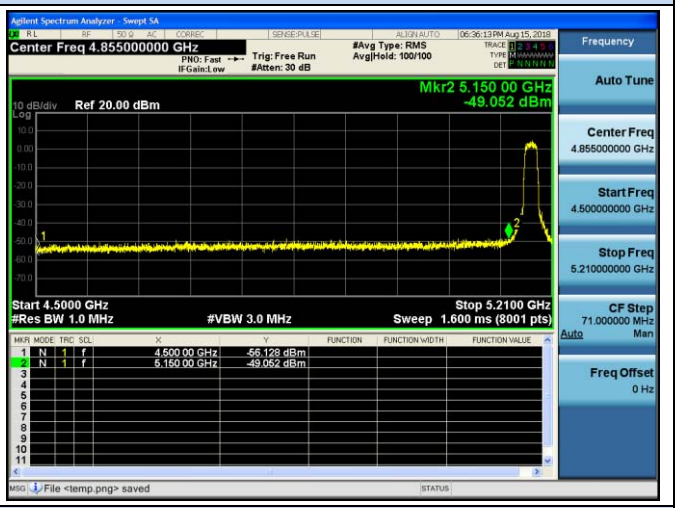
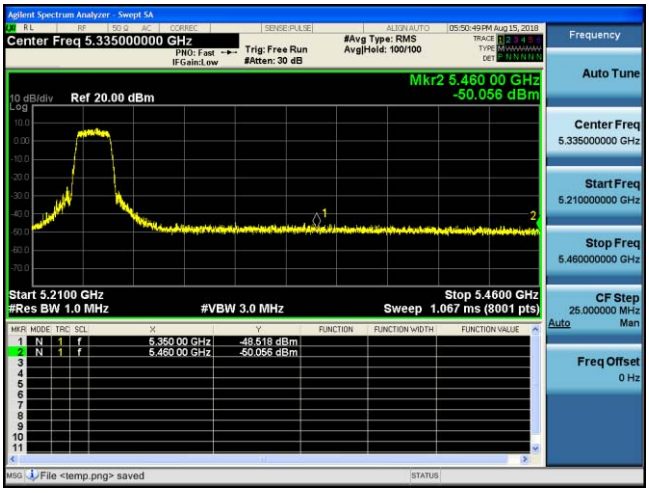
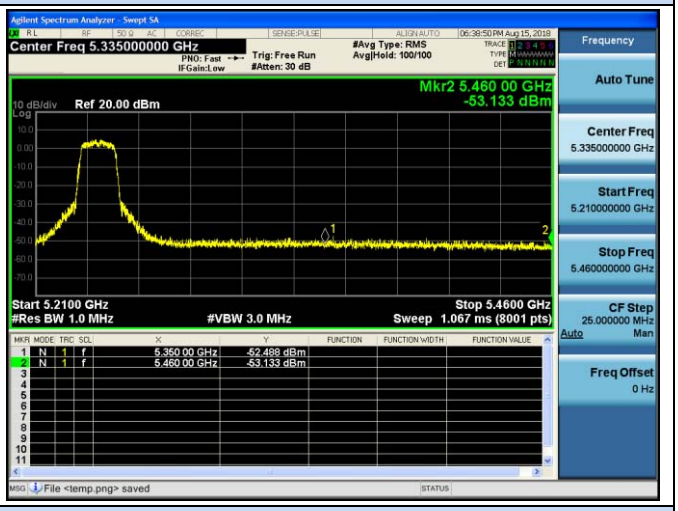
5.7.4 TEST RESULTS

Type	Frequency (MHz)	Nominal Bandwidth (MHz)	Frequency (MHz)	Bandedge Peak(dBm) Ant0	Bandedge Peak(dBm) Ant1	Sum Value (dBm)	Directional Gain (dBi)	Ground Reflection Factor (dB)	Max Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit (dB)	Verdict
802.11a	5180	20	4500	-51.99	-56.13	/	4.03	0.00	47.24	Peak	68.20	-20.96	Pass
802.11a	5180	20	5150	-48.42	-49.05	/	4.03	0.00	50.81	Peak	68.20	-17.39	Pass
802.11a	5240	20	5350	-48.52	-52.49	/	4.03	0.00	50.71	Peak	68.20	-17.49	Pass
802.11a	5240	20	5460	-50.06	-53.13	/	4.03	0.00	49.17	Peak	68.20	-19.03	Pass
802.11n	5180	20	4500	-50.63	-53.70	-48.89	7.03	0.00	53.34	Peak	68.20	-14.86	Pass
802.11n	5180	20	5150	-48.14	-51.37	-46.45	7.03	0.00	55.78	Peak	68.20	-12.42	Pass
802.11n	5240	20	5350	-48.55	-52.65	-47.12	7.03	0.00	55.11	Peak	68.20	-13.09	Pass
802.11n	5240	20	5460	-51.66	-53.29	-49.39	7.03	0.00	52.84	Peak	68.20	-15.36	Pass
802.11ac	5180	20	4500	-51.09	-53.73	-49.20	7.03	0.00	53.03	Peak	68.20	-15.17	Pass
802.11ac	5180	20	5150	-47.97	-50.37	-46.00	7.03	0.00	56.23	Peak	68.20	-11.97	Pass
802.11ac	5240	20	5350	-48.59	-49.17	-45.86	7.03	0.00	56.37	Peak	68.20	-11.83	Pass
802.11ac	5240	20	5460	-50.16	-52.00	-47.97	7.03	0.00	54.26	Peak	68.20	-13.94	Pass
802.11n	5190	40	4500	-53.72	-60.84	-52.95	7.03	0.00	49.28	Peak	68.20	-18.92	Pass
802.11n	5190	40	5150	-48.41	-46.93	-44.60	7.03	0.00	57.63	Peak	68.20	-10.57	Pass
802.11n	5230	40	5350	-55.98	-56.72	-53.32	7.03	0.00	48.91	Peak	68.20	-19.29	Pass
802.11n	5230	40	5460	-57.66	-56.98	-54.30	7.03	0.00	47.93	Peak	68.20	-20.27	Pass
802.11ac	5190	40	4500	-59.98	-58.28	-56.04	7.03	0.00	46.19	Peak	68.20	-22.01	Pass
802.11ac	5190	40	5150	-47.82	-42.61	-41.47	7.03	0.00	60.76	Peak	68.20	-7.44	Pass
802.11ac	5230	40	5350	-54.77	-55.31	-52.02	7.03	0.00	50.21	Peak	68.20	-17.99	Pass
802.11ac	5230	40	5460	-59.22	-58.41	-55.79	7.03	0.00	46.44	Peak	68.20	-21.76	Pass
802.11ac	5210	80	4500	-59.31	-59.80	-56.54	7.03	0.00	45.69	Peak	68.20	-22.51	Pass
802.11ac	5210	80	5150	-40.77	-43.18	-38.80	7.03	0.00	63.43	Peak	68.20	-4.77	Pass
802.11ac	5210	80	5350	-55.40	-52.67	-50.81	7.03	0.00	51.42	Peak	68.20	-16.78	Pass
802.11ac	5210	80	5460	-58.22	-55.75	-53.80	7.03	0.00	48.43	Peak	68.20	-19.77	Pass

Type	Frequency (MHz)	Nominal Bandwidth (MHz)	Frequency (MHz)	Bandedge Average (dBm) Ant0	Bandedge Average (dBm) Ant1	Sum Value (dBm)	Directional Gain (dBi)	Ground Reflection Factor (dB)	Max Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit (dB)	Verdict
802.11a	5180	20	4500	-58.33	-60.84	/	4.03	0.00	40.90	Avg	54.00	-13.10	Pass
802.11a	5180	20	5150	-53.77	-56.67	/	4.03	0.00	45.46	Avg	54.00	-8.54	Pass
802.11a	5240	20	5350	-55.22	-58.36	/	4.03	0.00	44.01	Avg	54.00	-9.99	Pass
802.11a	5240	20	5460	-56.74	-59.92	/	4.03	0.00	42.49	Avg	54.00	-11.51	Pass
802.11n	5180	20	4500	-58.34	-60.85	-56.41	7.03	0.00	45.82	Avg	54.00	-8.18	Pass
802.11n	5180	20	5150	-54.56	-57.58	-52.80	7.03	0.00	49.43	Avg	54.00	-4.57	Pass
802.11n	5240	20	5350	-55.74	-58.76	-53.98	7.03	0.00	48.25	Avg	54.00	-5.75	Pass
802.11n	5240	20	5460	-56.92	-60.06	-55.20	7.03	0.00	47.03	Avg	54.00	-6.97	Pass
802.11ac	5180	20	4500	-58.38	-60.85	-56.43	7.03	0.00	45.80	Avg	54.00	-8.20	Pass
802.11ac	5180	20	5150	-54.46	-57.46	-52.70	7.03	0.00	49.53	Avg	54.00	-4.47	Pass
802.11ac	5240	20	5350	-55.72	-57.70	-53.59	7.03	0.00	48.64	Avg	54.00	-5.36	Pass
802.11ac	5240	20	5460	-56.92	-59.68	-55.07	7.03	0.00	47.16	Avg	54.00	-6.84	Pass
802.11n	5190	40	4500	-66.25	-66.22	-63.22	7.03	0.00	39.01	Avg	54.00	-14.99	Pass
802.11n	5190	40	5150	-52.48	-53.60	-49.99	7.03	0.00	52.24	Avg	54.00	-1.76	Pass
802.11n	5230	40	5350	-62.48	-62.10	-59.28	7.03	0.00	42.95	Avg	54.00	-11.05	Pass
802.11n	5230	40	5460	-64.71	-64.51	-61.60	7.03	0.00	40.63	Avg	54.00	-13.37	Pass
802.11ac	5190	40	4500	-66.23	-66.22	-63.21	7.03	0.00	39.02	Avg	54.00	-14.98	Pass
802.11ac	5190	40	5150	-53.52	-53.03	-50.26	7.03	0.00	51.97	Avg	54.00	-2.03	Pass
802.11ac	5230	40	5350	-62.12	-62.11	-59.10	7.03	0.00	43.13	Avg	54.00	-10.87	Pass
802.11ac	5230	40	5460	-64.54	-64.55	-61.53	7.03	0.00	40.70	Avg	54.00	-13.30	Pass
802.11ac	5210	80	4500	-66.21	-66.23	-63.21	7.03	0.00	39.02	Avg	54.00	-14.98	Pass
802.11ac	5210	80	5150	-52.88	-52.70	-48.78	7.03	0.00	53.45	Avg	54.00	-1.55	Pass
802.11ac	5210	80	5350	-61.84	-61.41	-58.61	7.03	0.00	43.62	Avg	54.00	-10.38	Pass
802.11ac	5210	80	5460	-64.81	-64.71	-61.75	7.03	0.00	40.48	Avg	54.00	-13.52	Pass

Remark:

1. *Measured Undesirable emission at difference data rate for each mode and recorded worst case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 6Mbps at IEEE 802.11a; MCS0 at IEEE 802.11n HT20, IEEE 802.11n HT40, IEEE 802.11a VHT20, IEEE 802.11ac VHT40 and IEEE 802.11ac VHT80;*
4. *For MIMO with CCD technology device, The Directional Gain= Gain of individual transmit antennas (dBi) + Array gain;*
   Array gain = 10 log (N_{ant}), where N_{ant} is the number of transmit antennas.
5. *Covert Radiated E Level At 3m = Conducted average power + Directional Gain + 104.77-20*log(3);*
6. *Please refer to following test plots;*

Undesirable emission	
IEEE 802.11a	
Antenna Chain 0	Antenna Chain 1
	
Channel 36 / 5180 MHz – Peak	Channel 36 / 5180 MHz – Peak
	
Channel 48 / 5240 MHz – Peak	Channel 48 / 5240 MHz – Peak

Undesirable emission	
IEEE 802.11n HT20	
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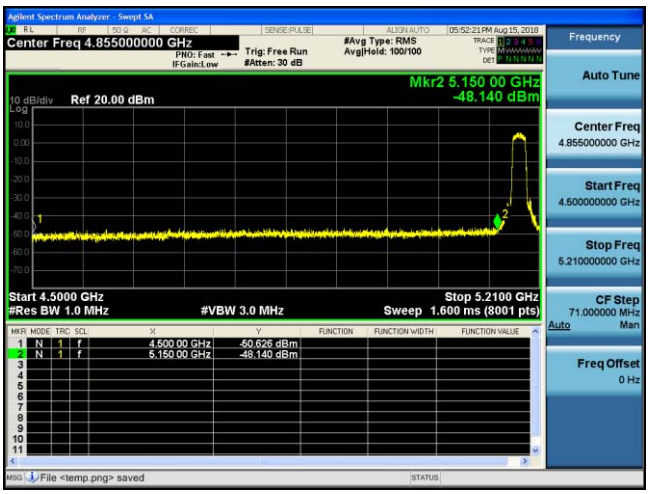
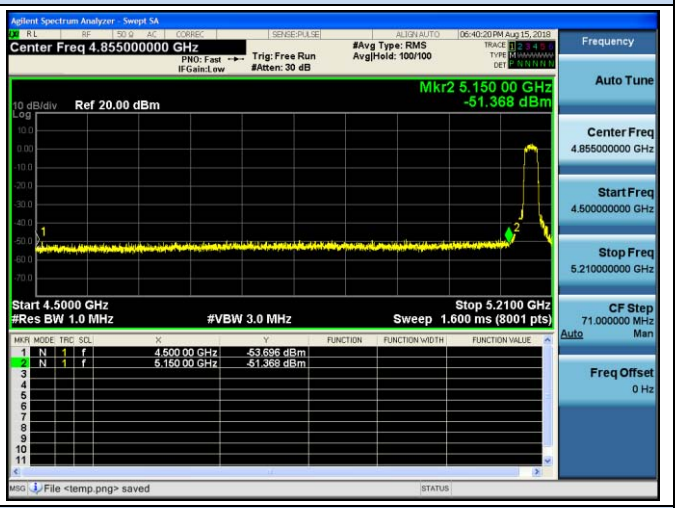
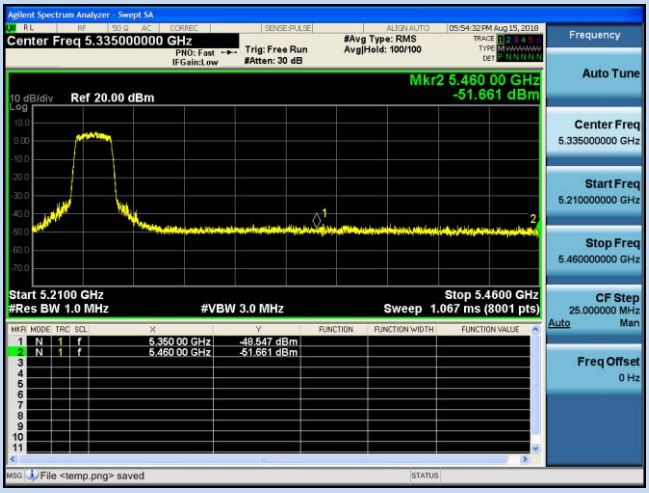
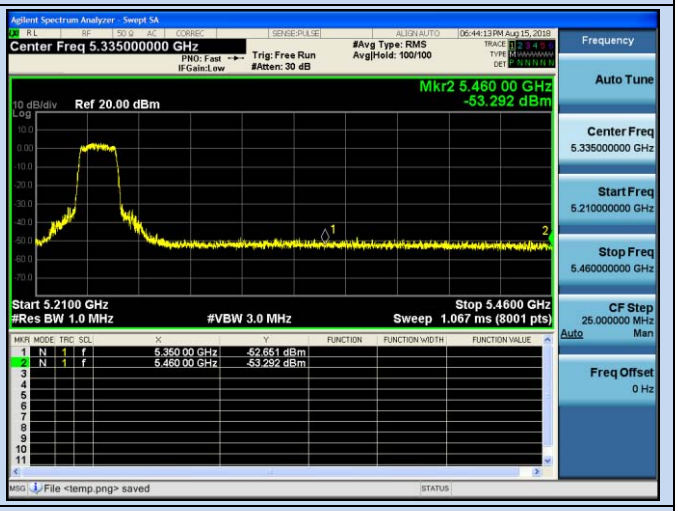
	
Channel 36 / 5180 MHz – Peak	Channel 36 / 5180 MHz – Peak
	
Channel 48 / 5240 MHz – Peak	Channel 48 / 5240 MHz – Peak

Undesirable emission	
IEEE 802.11ac VHT20	
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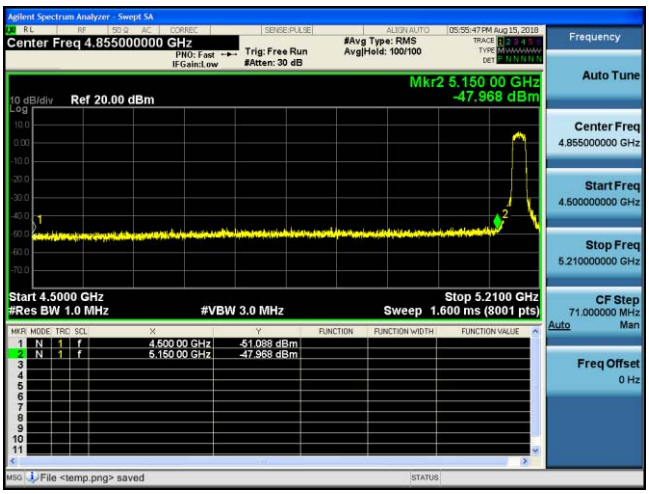
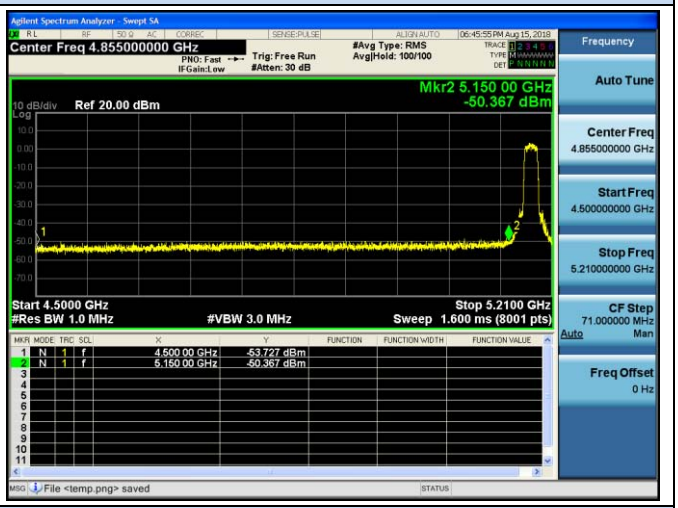
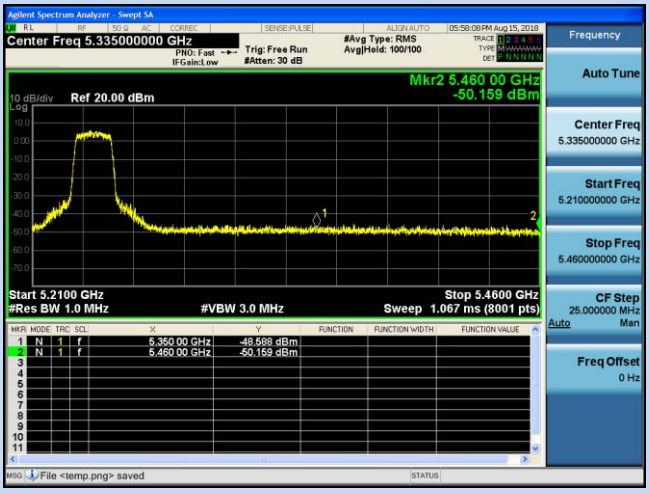
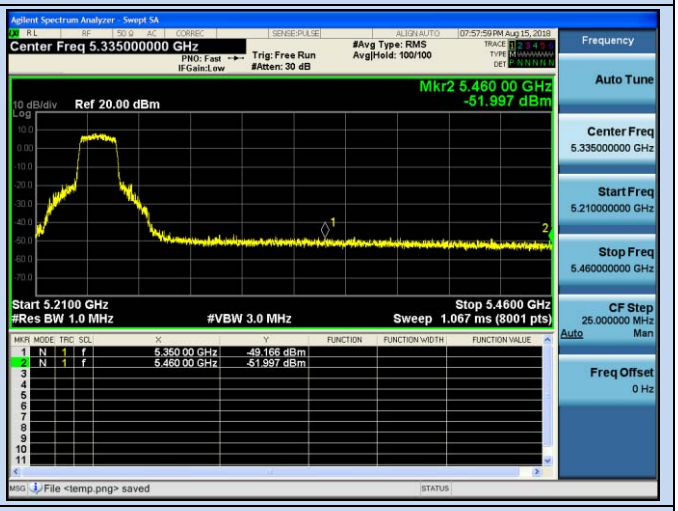
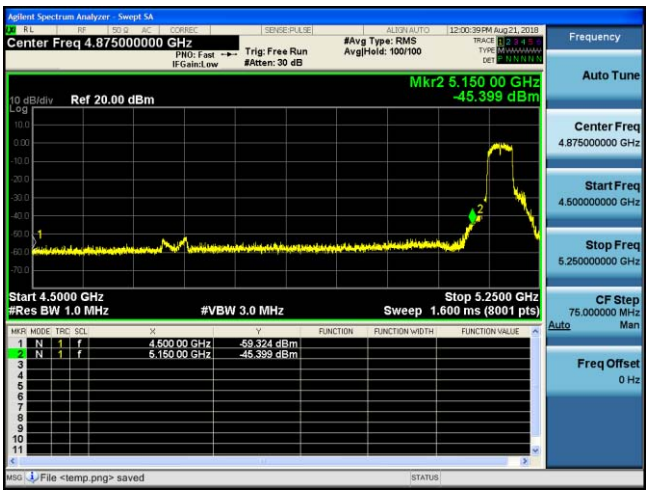
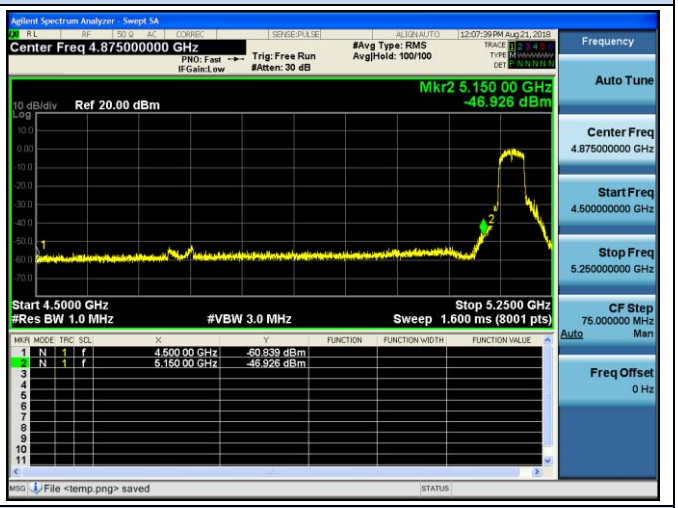
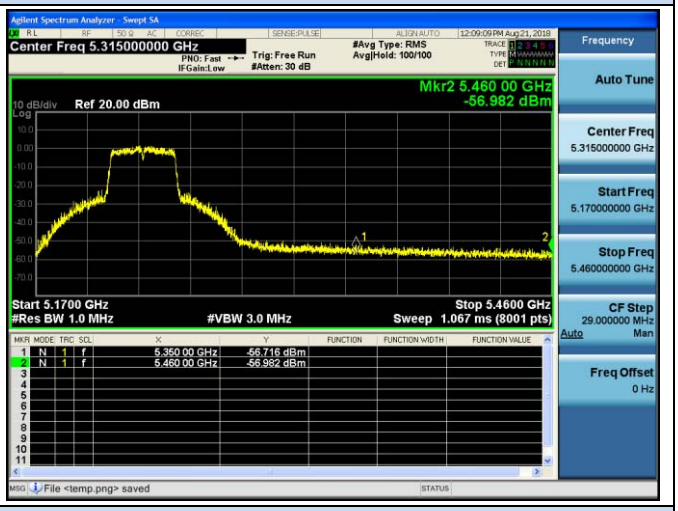
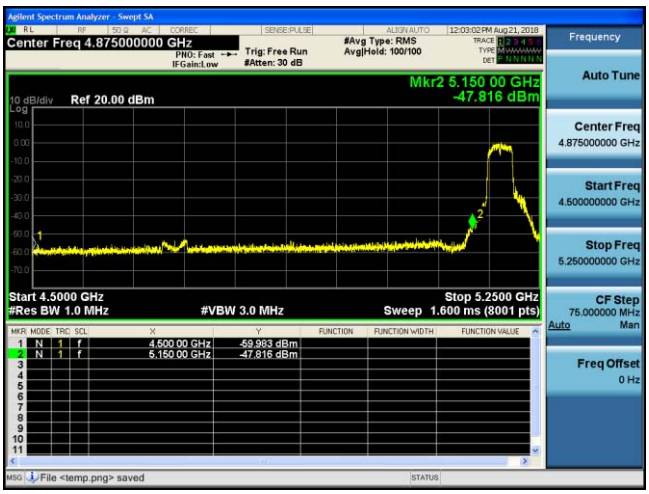
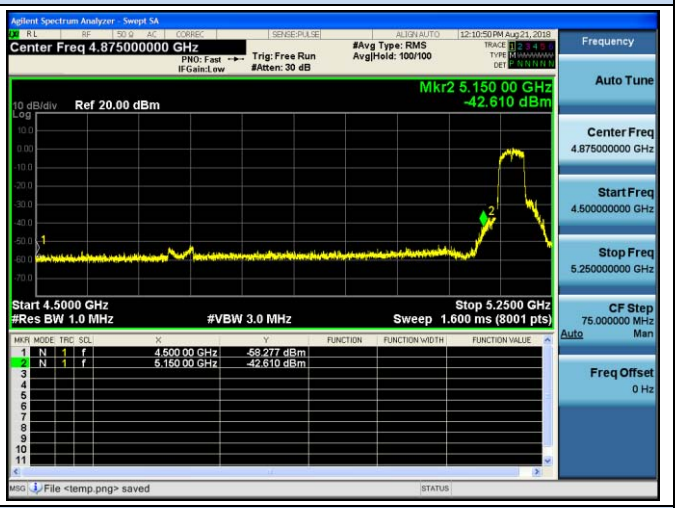
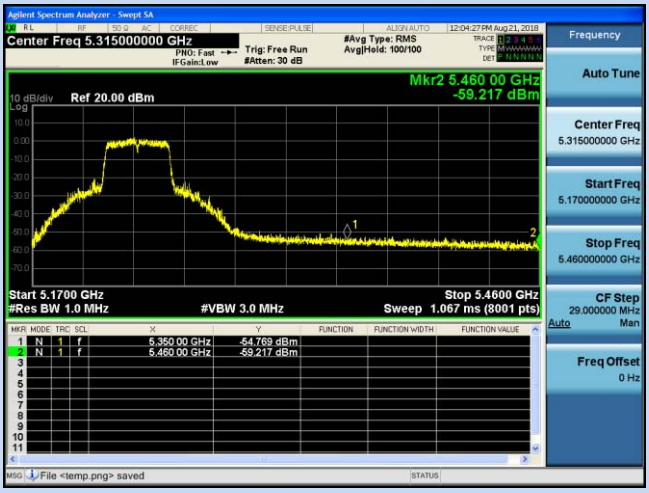
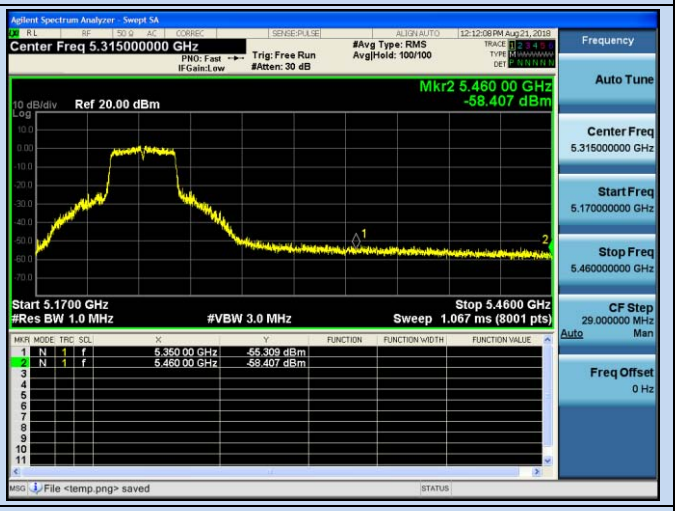
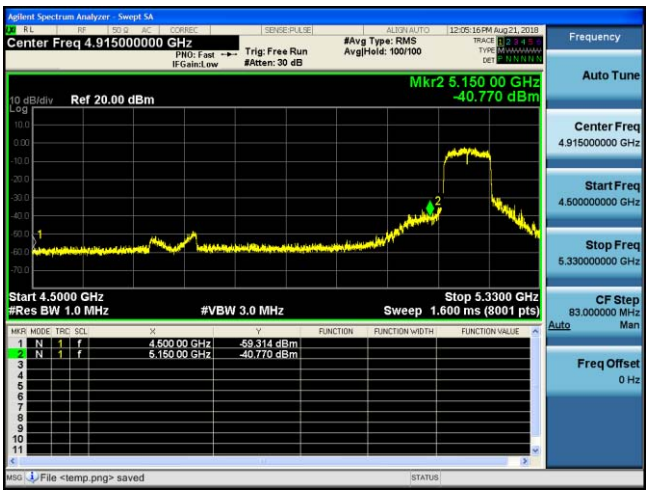
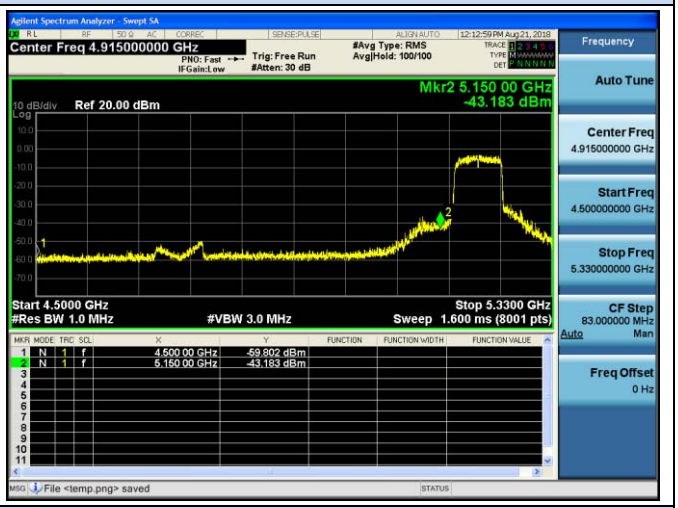
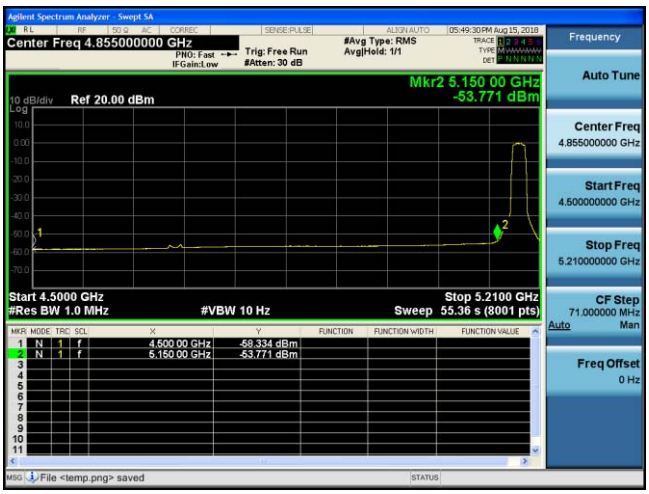
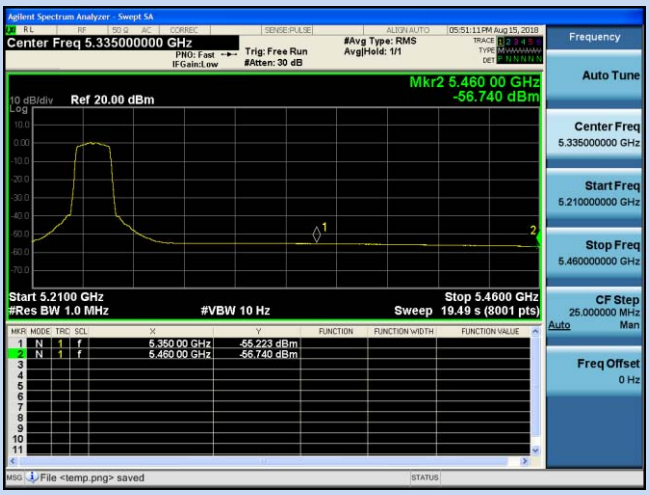
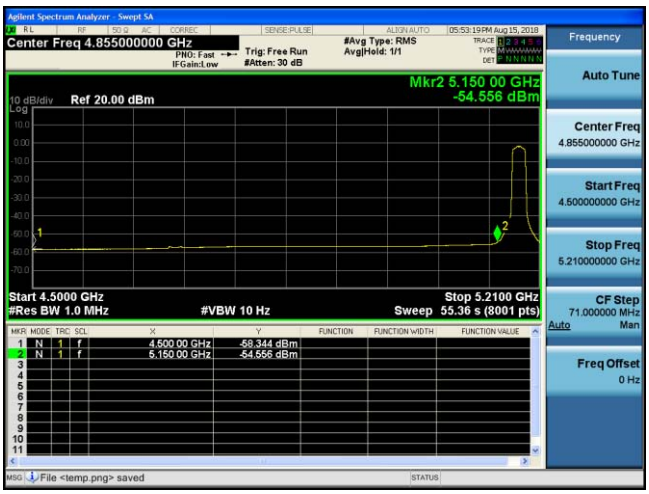
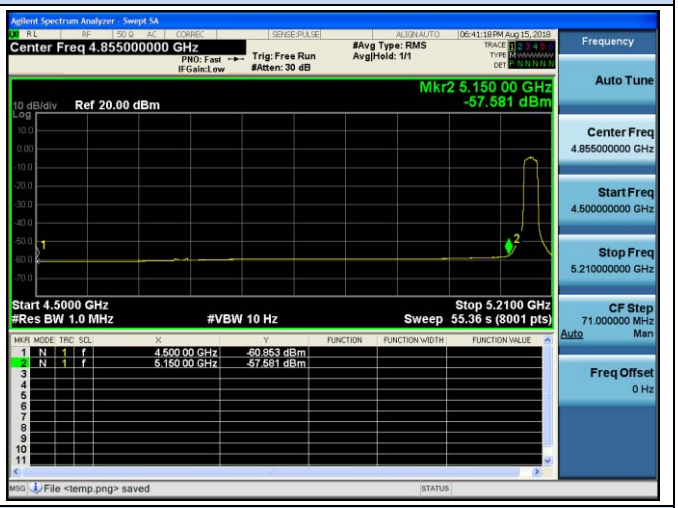
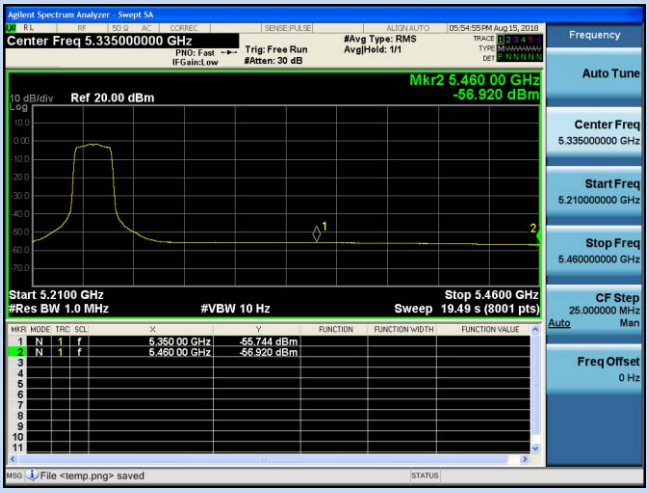
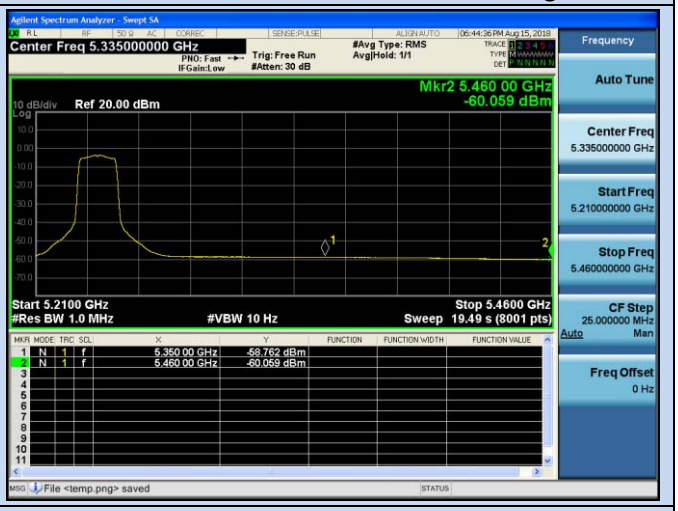
	
Channel 36 / 5180 MHz – Peak	Channel 36 / 5180 MHz – Peak
	
Channel 48 / 5240 MHz – Peak	Channel 48 / 5240 MHz – Peak

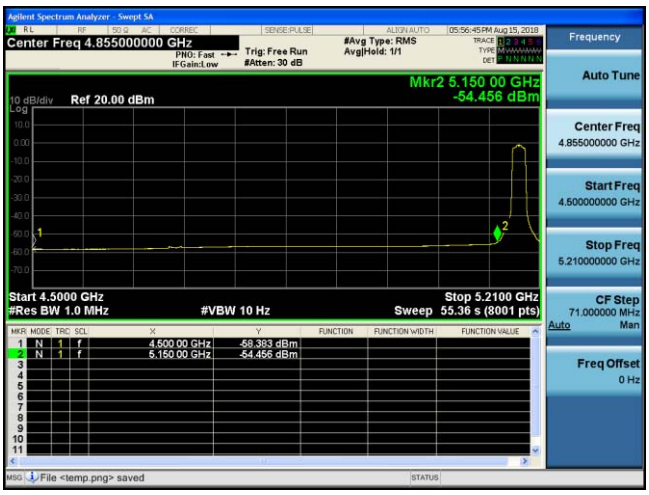
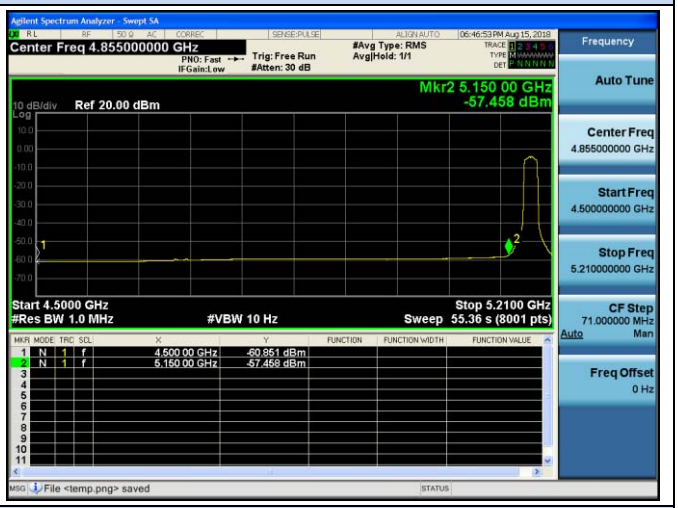
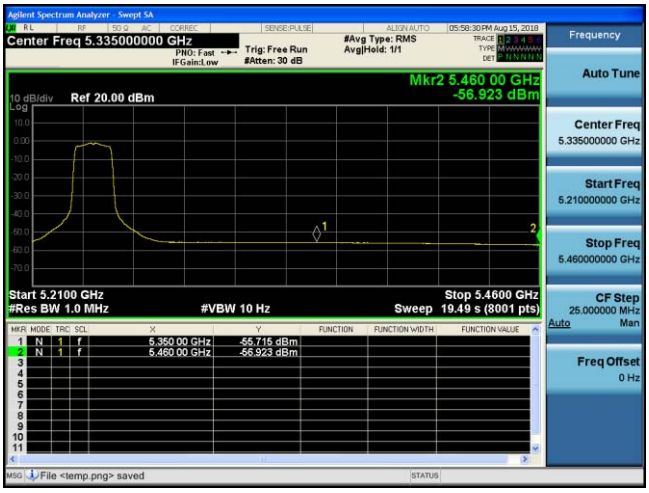
Undesirable emission	
IEEE 802.11n HT40	
Antenna Chain 0	Antenna Chain 1
	
Channel 38 / 5190 MHz – Peak	Channel 38 / 5190 MHz – Peak
	
Channel 46 / 5230 MHz – Peak	Channel 46 / 5230 MHz – Peak

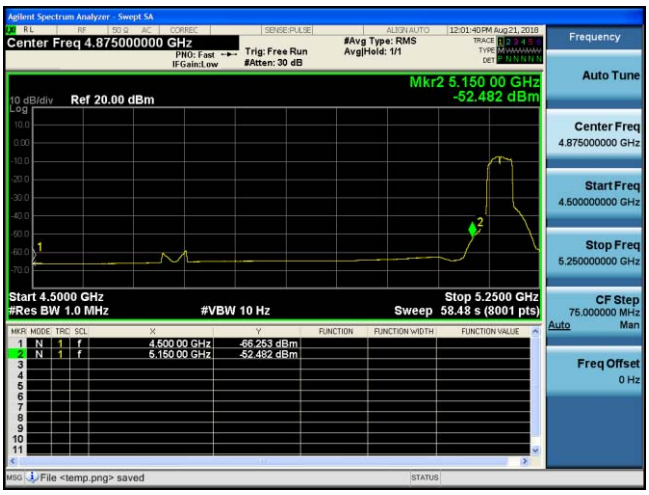
Undesirable emission	
IEEE 802.11ac VHT40	
Antenna Chain 0	Antenna Chain 1
	
Channel 38 / 5190 MHz – Peak	Channel 38 / 5190 MHz – Peak
	
Channel 46 / 5230 MHz – Peak	Channel 46 / 5230 MHz – Peak

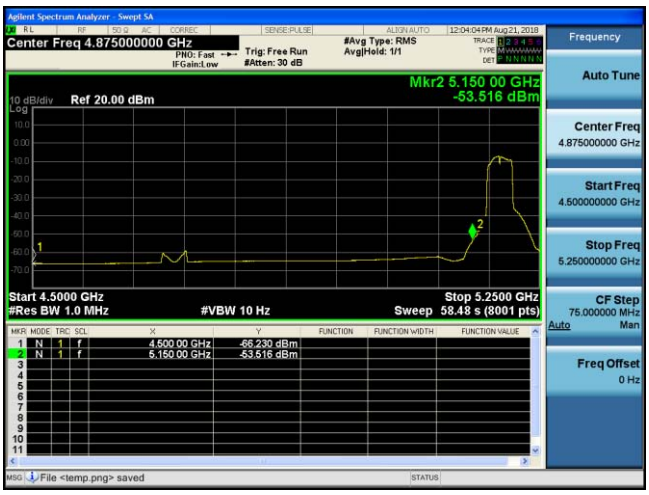
Undesirable emission	
IEEE 802.11ac VHT80	
Antenna Chain 0	Antenna Chain 1
	
Channel 42 / 5210 MHz – Peak	Channel 42 / 5210 MHz – Peak
Channel 42 / 5210 MHz – Peak	Channel 42 / 5210 MHz – Peak

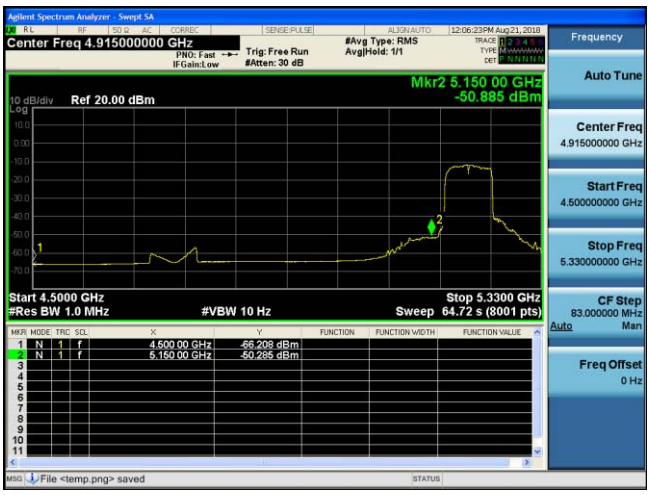
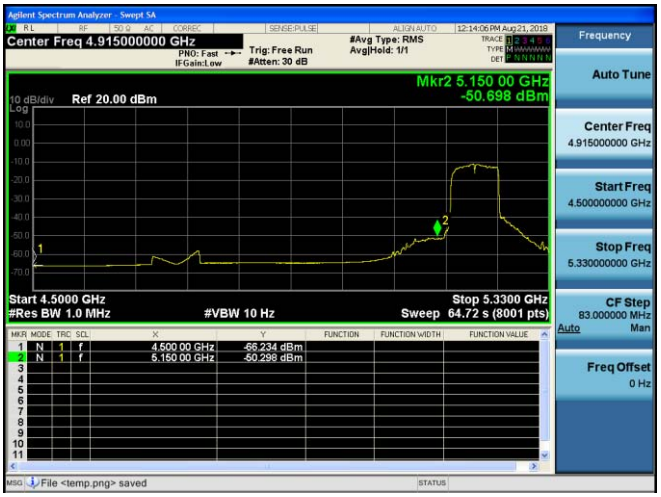
Undesirable emission	
IEEE 802.11a	
Antenna Chain 0	Antenna Chain 1
	
Channel 36 / 5180 MHz – Average	Channel 36 / 5180 MHz – Average
	
Channel 48 / 5240 MHz – Average	Channel 48 / 5240 MHz – Average

Undesirable emission	
IEEE 802.11n HT20	
Antenna Chain 0	Antenna Chain 1
	
Channel 36 / 5180 MHz – Average	Channel 36 / 5180 MHz – Average
	
Channel 48 / 5240 MHz – Average	Channel 48 / 5240 MHz – Average

Undesirable emission	
IEEE 802.11ac VHT20	
Antenna Chain 0	Antenna Chain 1
	
Channel 36 / 5180 MHz – Average	Channel 36 / 5180 MHz – Average
	
Channel 48 / 5240 MHz – Average	Channel 48 / 5240 MHz – Average

Undesirable emission	
IEEE 802.11n HT40	
Antenna Chain 0	Antenna Chain 1
	
Channel 38 / 5190 MHz – Average	Channel 38 / 5190 MHz – Average
Channel 46 / 5230 MHz – Average	Channel 46 / 5230 MHz – Average

Undesirable emission	
IEEE 802.11ac VHT40	
Antenna Chain 0	Antenna Chain 1
	
Channel 38 / 5190 MHz – Average	Channel 38 / 5190 MHz – Average
Channel 46 / 5230 MHz – Average	Channel 46 / 5230 MHz – Average

Undesirable emission	
IEEE 802.11ac VHT80	
Antenna Chain 0	Antenna Chain 1
	
Channel 42 / 5210 MHz – Average	Channel 42 / 5210 MHz – Average
Channel 42 / 5210 MHz – Average	Channel 42 / 5210 MHz – Average

5.8. Antenna Requirements

5.8.1. 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. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited
And according to FCC 47 CFR Section 15.407 (a), 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.

5.8.2. Antenna Connector Construction

The directional gains of antenna used for transmitting is 4.03 dBi, and the antenna is an internal antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details.

5.8.3. Results: Compliance.

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.

Conducted power refers ANSI C63.10:2013 Output power test procedure for UNII devices.

Radiated power refers to ANSI C63.10:2013 Radiated emissions tests.

Measurement parameters

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

Note: 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 5G WLAN devices, the IEEE 802.11a mode is used.

Limits

FCC	ISED
Antenna Gain	
6 dBi	

Antenna Chain 0

T_{nom}	V_{nom}	Lowest Channel 5180 MHz	Middle Channel 5220 MHz	Highest Channel 5240 MHz
Conducted power [dBm] Measured with OFDM modulation		10.97	11.03	10.63
Radiated power [dBm] Measured with OFDM modulation		13.98	13.14	12.56
Gain [dBi] Calculated		3.01	2.11	1.93
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

Antenna Chain 1

T_{nom}	V_{nom}	Lowest Channel 5180 MHz	Middle Channel 5220 MHz	Highest Channel 5240 MHz
Conducted power [dBm] Measured with OFDM modulation		7.98	8.08	8.41
Radiated power [dBm] Measured with OFDM modulation		10.39	9.73	10.73
Gain [dBi] Calculated		2.41	1.65	2.32
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

6. LIST OF MEASURING EQUIPMENTS

Item	Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
1.	L.I.S.N. Artificial Mains	R&S	ENV216	HKE-002	Dec. 28, 2017	1 Year
2.	Receiver	R&S	ESCI 7	HKE-010	Dec. 28, 2017	1 Year
3.	RF automatic control unit	Tonscend	JS0806-2	HKE-060	Dec. 28, 2017	1 Year
4.	Spectrum analyzer	R&S	FSP40	HKE-025	Dec. 28, 2017	1 Year
5.	Spectrum analyzer	Agilent	N9020A	HKE-048	Dec. 28, 2017	1 Year
6.	Preamplifier	Schwarzbeck	BBV 9743	HKE-006	Dec. 28, 2017	1 Year
7.	EMI Test Receiver	Rohde & Schwarz	ESCI 7	HKE-010	Dec. 28, 2017	1 Year
8.	Bilog Broadband Antenna	Schwarzbeck	VULB9163	HKE-012	Dec. 28, 2017	1 Year
9.	Loop Antenna	Schwarzbeck	FMZB 1519 B	HKE-014	Dec. 28, 2017	1 Year
10.	Horn Antenna	Schewarzbeck	9120D	HKE-013	Dec. 28, 2017	1 Year
11.	Broadband Horn Antenna	Schewarzbeck	BBHA 9170	HKE-017	Dec. 28, 2017	1 Year
12.	Pre-amplifier	EMCI	EMC051845 SE	HKE-015	Dec. 28, 2017	1 Year
13.	Pre-amplifier	Agilent	83051A	HKE-016	Dec. 28, 2017	1 Year
14.	EMI Test Software EZ-EMC	Tonscend	JS1120-B	HKE-083	Dec. 28, 2017	N/A
15.	Power Sensor	Agilent	E9300A	HKE-086	Dec. 28, 2017	1 Year
16.	Spectrum analyzer	Agilent	N9020A	HKE-048	Dec. 28, 2017	1 Year
17.	Signal generator	Agilent	N5182A	HKE-029	Dec. 28, 2017	1 Year
18.	Signal Generator	Agilent	83630A	HKE-028	Dec. 28, 2017	1 Year
19.	Shielded room	Shiel Hong	4*3*3	HKE-039	Dec. 28, 2017	3 Year
20.	RF Cable(below 1GHz)	HUBER+SUHNER	RG214	HKE-055	Dec. 28, 2017	1 Year
21.	RF Cable(above 1GHz)	HUBER+SUHNER	RG214	HKE-056	Dec. 28, 2017	1 Year

----------THE END OF REPORT----------