FCC 47 CFR PART 15 SUBPART C

for

ULTUNE BLE module

Model: UNRF5-M22

Brand: ULTUNE

Test Report Number:

C180515Z01-RP1

Issued for

ULTUNE Technologies
Xiangruiyuan 5B-701, Longzhu Road, Nanshan District, Shenzhen, Guangdong, China

Issued by:

Compliance Certification Services (Shenzhen) Inc.
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Issued Date: August 10, 2018

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Revision History

Rev.	Issue Data	Revisions	Effect Page	Revised By
00	August 10, 2018	Initial Issue	ALL	Sabrina Wang

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1 TEST CERTIFICATION

Product	ULTUNE BLE module
Model	UNRF5-M22
Brand	ULTUNE
Tested	May 15~August 10, 2018
Applicant	**ULTUNE Technologies** Xiangruiyuan 5B-701, Longzhu Road, Nanshan District, Shenzhen, Guangdong, China
Manufacturer	**ULTUNE Technologies** Xiangruiyuan 5B-701, Longzhu Road, Nanshan District, Shenzhen, Guangdong, China

APPLICABLE STANDARDS			
Standard	**Test Type**	**Standard**	**Test Type**
15.207(a)	Power Line Conducted Emissions	15.247(d) 15.209(a)	● Spurious Emissions ● Conducted Measurement ● Radiated Emissions
15.247(a)(2)	6dB Bandwidth Measurement	15.247(b)(3) 15.247(b)(4)	Peak Power Measurement
15.247(d)	Band Edges Measurement	15.247(e)	Peak Power Spectral Density

We hereby certify that:

The above equipment was tested by Compliance Certification Services (Shenzhen) Inc. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in **ANSI C63.10: 2013** and the energy emitted by the sample EUT tested as described in this report is in compliance with the requirements of FCC Rules Part 15.207, 15.209, 15.247.

The test results of this report relate only to the tested sample EUT identified in this report.

Approved by:

Eve. Wang

Darry Wu
Supervisor of EMC Dept.
Compliance Certification Service (Shenzhen) Inc.

Reviewed by:

Nancy Fu

Nancy Fu
Supervisor of Report Dept.
Compliance Certification Service (Shenzhen) Inc.

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2 TEST RESULT SUMMARY

APPLICABLE STANDARDS			
Standard	**Test Type**	**Result**	**Remark**
15.247(a)(2)	6dB Bandwidth Measurement	Pass	Meet the requirement of limit.
15.247(b)(3) 15.247(b)(4)	Peak Power Measurement	Pass	Meet the requirement of limit.
15.247(d)	Band Edges Measurement	Pass	Meet the requirement of limit.
15.247(e)	Peak Power Spectral Density	Pass	Meet the requirement of limit.
15.247(d) 15.209(a)	● Spurious Emissions ● Conducted Measurement ● Radiated Emissions	Pass	Meet the requirement of limit.
15.207(a)	Power line Conducted Emissions	Pass	Meet the requirement of limit.

Note: 1. The statements of test result on the above are decided by the request of test standard only; the measurement uncertainties are not factored into this compliance determination.
2. The information of measurement uncertainty is available upon the customer's request.

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3 EUT DESCRIPTION

Product	ULTUNE BLE module
Model	UNRF5-M22
Brand	ULTUNE
Model Discrepancy	N/A
Identify Number	C180515Z01-RP1
Received Date	May 15, 2018
Power Supply	DC3.3V supply by the PCB board
Frequency Range	2402MHz ~2480MHz
Transmit Power	-3.25dBm
Modulation Technique	GFSK for 1Mbps
Number of Channels	40 Channels
Antenna Specification	Internal antenna with 1.7dBi gain (Max)
Temperature Range	-40°C ~ +85°C
Hardware Version	V3.1
Software Version	V15

Note: *1. The sample selected for test was engineering sample that approximated to production product and was provided by manufacturer.*

2. This submittal(s) (test report) is intended for FCC ID: 2AQJ4-UNRF5-M22 module filing to comply with Section 15.207, 15.209 and 15.247of the FCC Part 15, Subpart C Rules.

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4 TEST METHODOLOGY

4.1. DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition.

Used the “ultune_radio_test.hex” to control the EUT for staying in continuous transmitting and receiving mode is programmed.

Conducted emissions	
Test Mode	Description
1	Normal

Radiated Emission	
Test Mode	Description
1	Continuously Transmitting
The worst test results were recorded in the report.	

After verification, all tests were carried out with the worst case test modes as shown below except radiated spurious emission below 1GHz, which worst case was in normal link mode only.

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5 SETUP OF EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF SUPPORT UNITS

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

No	Equipment	Model	Serial No.	FCC ID	Brand	Data Cable	Power Cord
1	Notebook	Thinkpad S2	SL 10K92342	N/A	Lenovo	N/A	Unshielded 1.00m (AC Cable) Unshielded 1.80m (DC Cable)

Note: Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use

5.2. CONFIGURATION OF SYSTEM UNDER TEST

See test photographs attached in Appendix II for the actual connections between EUT and support equipment.

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5.3. TEST INSTRUMENTS

Conducted Emission Test Site					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
EMI TEST RECEIVER	ROHDE&SCHWARZ	ESCI	100783	01/27/2018	01/26/2019
LISN(EUT)	ROHDE&SCHWARZ	ENV216	101543-WX	01/27/2018	01/26/2019
LISN	EMCO	3825/2	8901-1459	01/27/2018	01/26/2019
Temp. / Humidity Meter	VICTOR	HTC-1	N/A	01/29/2018	01/28/2019
Test S/W	FARAD	EZ-EMC/ CCS-3A1-CE			

Radiated Emission Test Site 966 (2)					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019
EMI TEST RECEIVER	ROHDE&SCHWARZ	ESCI	100783	01/27/2018	01/26/2019
Amplifier	EMEC	EM330	060661	01/27/2018	01/26/2019
High Noise Amplifier	Agilent	8449B	3008A01838	01/27/2018	01/26/2019
Loop Antenna	COM-POWER	AL-130	121044	01/30/2018	01/29/2019
Bilog Antenna	SCHAFFNER	CBL6143	5082	02/21/2018	02/20/2019
Horn Antenna	SCHWARZBECK	BBHA9120	D286	01/27/2018	01/26/2019
Board-Band Horn Antenna	Schwarzbeck	BBHA 9170	9170-497	01/24/2018	01/23/2019
Turn Table	N/A	N/A	N/A	N.C.R	N.C.R
Antenna Tower	SUNOL	TLT2	N/A	N.C.R	N.C.R
Controller	Sunol Sciences	SC104V	022310-1	N.C.R	N.C.R
Controller	CT	N/A	N/A	N.C.R	N.C.R
Temp. / Humidity Meter	Anymetre	JR913	N/A	01/29/2018	01/28/2019
Test S/W	FARAD	LZ-RF / CCS-SZ-3A2			

Antenna Conducted Spurious Emission					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019

6dB Bandwidth					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019

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Antenna Gain					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019

Peak Output Power					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Power Meter	Anritsu	ML2495A	1204003	01/27/2018	01/26/2019
Power Sensor	Anritsu	MA2411B	1126150	01/27/2018	01/26/2019

Band edges					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019

Peak Power Spectral Density					
Name of Equipment	**Manufacturer**	**Model Number**	**Serial Number**	**Last Calibration**	**Due Calibration**
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019

Note: 1. The calibration interval of the above test instruments is 12 months and the calibrations are traceable to NML/ROC and NIST/USA.

2. N.C.R = No Calibration Request.

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6 FACILITIES AND ACCREDITATIONS

6.1. FACILITIES

All measurement facilities used to collect the measurement data are located at
No. 10-1, Mingkeda Logistics Park, No.18 Huanguan South RD. Guan Lan Town, Baoan District, Shenzhen China

The sites are constructed in conformance with the requirements of ANSI C63.10, ANSI C63.7 and CISPR Publication 22. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

6.2. ACCREDITATIONS

Our laboratories are accredited and approved by the following accreditation body according to ISO/IEC 17025.

USA	**A2LA**
China	**CNAS**

The measuring facility of laboratories has been authorized or registered by the following approval agencies.

USA	**FCC**
Japan	**VCCI(C-4815, R-4320, T-2317, G-10624)**
Canada	**INDUSTRY CANADA**

Copies of granted accreditation certificates are available for downloading from our web site, http://www.ccssz.com

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6.3. MEASUREMENT UNCERTAINTY

ULTUNE relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

Parameter	Uncertainty
Radiated Emission, 30 to 200 MHz Test Site : 966(2)	+/-3.6880dB
Radiated Emission, 200 to 1000 MHz Test Site : 966(2)	+/-3.6695dB
Radiated Emission, 1 to 8 GHz	+/-5.1782dB
Radiated Emission, 8 to 18 GHz	+/-5.2173dB
Conducted Emissions	+/-3.6836dB
Band Width	178kHz
Peak Output Power MU	+/-1.906dB
Band Edge MU	+/-0.182dB
Channel Separation MU	416.178Hz
Duty Cycle MU	0.054ms
Frequency Stability MU	226Hz

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

The measured result is above (below) the specification limit by a margin less than the measurement uncertainty; it is therefore not possible to state compliance based on the 95% level of confidence. However, the result indicates that compliance (non-compliance) is more probable than non-compliance) with the specification limit.

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7 FCC PART 15.247 REQUIREMENTS

7.1. POWER LINE CONDUCTED EMISSIONS MEASUREMENT

7.1.1. LIMITS OF CONDUCTED EMISSIONS MEASUREMENT

According to §15.207(a), except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that 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 the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

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

NOTE:
(1) The lower limit shall apply at the transition frequencies.
(2) The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz.
(3) All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

7.1.2. TEST PROCEDURES (please refer to measurement standard)

- The EUT and Support equipment, if needed, was placed on a non-conducted table, which is 0.8m above the ground plane and 0.4m away from the conducted wall.
- The test equipment EUT installed received AC main power, through a Line Impedance Stabilization Network (LISN), which supplied power source and was grounded to the ground plane. All support equipment power received from a second LISN. The two LISNs provide 50 ohm/ 50uH of coupling impedance for the measuring instrument.
- The EUT test program was started. Emissions were measured on each current carrying line of the EUT using an EMI Test Receiver connected to the LISN powering the EUT.
- The frequency range from 150 kHz to 30 MHz was searched. The test data of the worst-case condition(s) was recorded. Emission levels under limit 20dB were not recorded.

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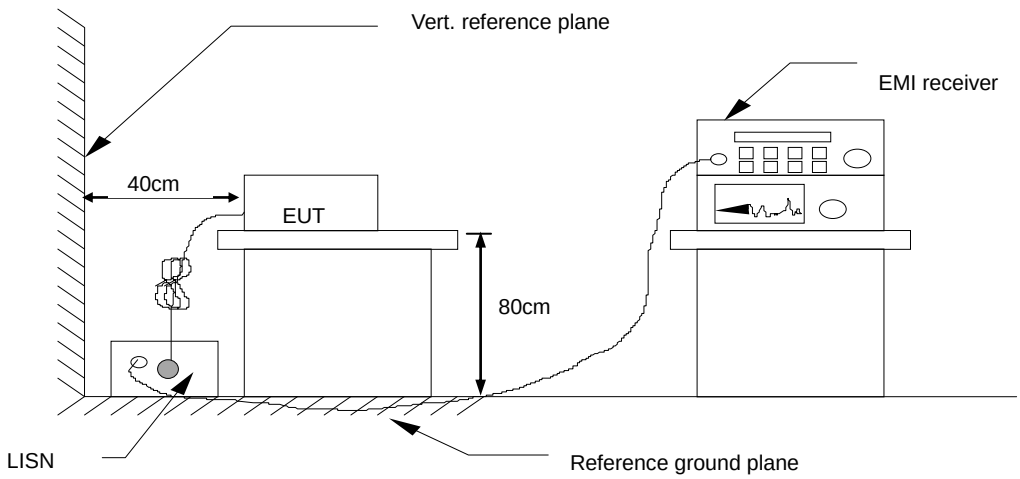
7.1.3. TEST SETUP



For the actual test configuration, please refer to the related item – Photographs of the Test Configuration.

7.1.4. DATA SAMPLE

Frequency (MHz)	QuasiPeak Reading (dBuV)	Average Reading (dBuV)	Correction Factor (dB)	QuasiPeak Result (dBuV)	Average Result (dBuV)	QuasiPeak Limit (dBuV)	Average Limit (dBuV)	QuasiPeak Margin (dB)	Average Margin (dB)	Remark (Pass/Fail)
X.XXXX	34.99	19.33	10.15	45.14	29.48	65.99	56.00	-20.85	-26.52	Pass

Factor = Insertion loss of LISN + Cable Loss
Result = Quasi-peak Reading/ Average Reading + Factor
Limit = Limit stated in standard
Margin = Result (dBuV) – Limit (dBuV)

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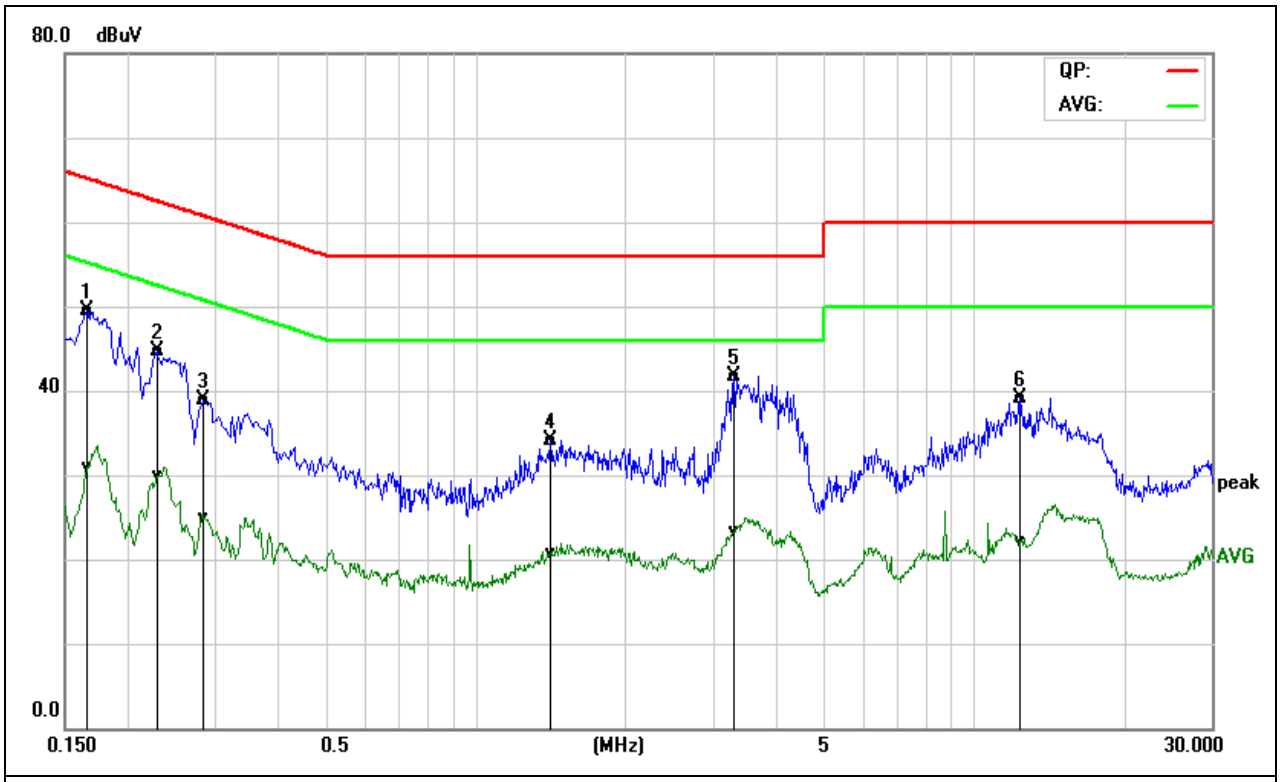
7.1.5. TEST RESULTS

Model No.	UNRF5-M22	**RBW,VBW**	9 kHz
Environmental Conditions	22°C, 45% RH	**Test Mode**	Mode 1
Tested by	Darry Wu	**Line**	L
Test Voltage	AC120V/60Hz	**Test Date**	May 24, 2018



Frequency (MHz)	QuasiPeak Reading (dBuV)	Average Reading (dBuV)	Correction Factor (dB)	QuasiPeak Result (dBuV)	Average Result (dBuV)	QuasiPeak Limit (dBuV)	Average Limit (dBuV)	QuasiPeak Margin (dB)	Average Margin (dB)	Remark (Pass/Fail)
0.1660	29.89	11.31	19.63	49.52	30.94	65.15	55.16	-15.63	-24.22	Pass
0.2300	25.02	10.26	19.63	44.65	29.89	62.45	52.45	-17.80	-22.56	Pass
0.2860	19.35	5.32	19.61	38.96	24.93	60.64	50.64	-21.68	-25.71	Pass
1.4140	14.48	1.14	19.62	34.10	20.76	56.00	46.00	-21.90	-25.24	Pass
3.3020	21.99	3.65	19.72	41.71	23.37	56.00	46.00	-14.29	-22.63	Pass
12.3460	18.95	2.02	20.09	39.04	22.11	60.00	50.00	-20.96	-27.89	Pass

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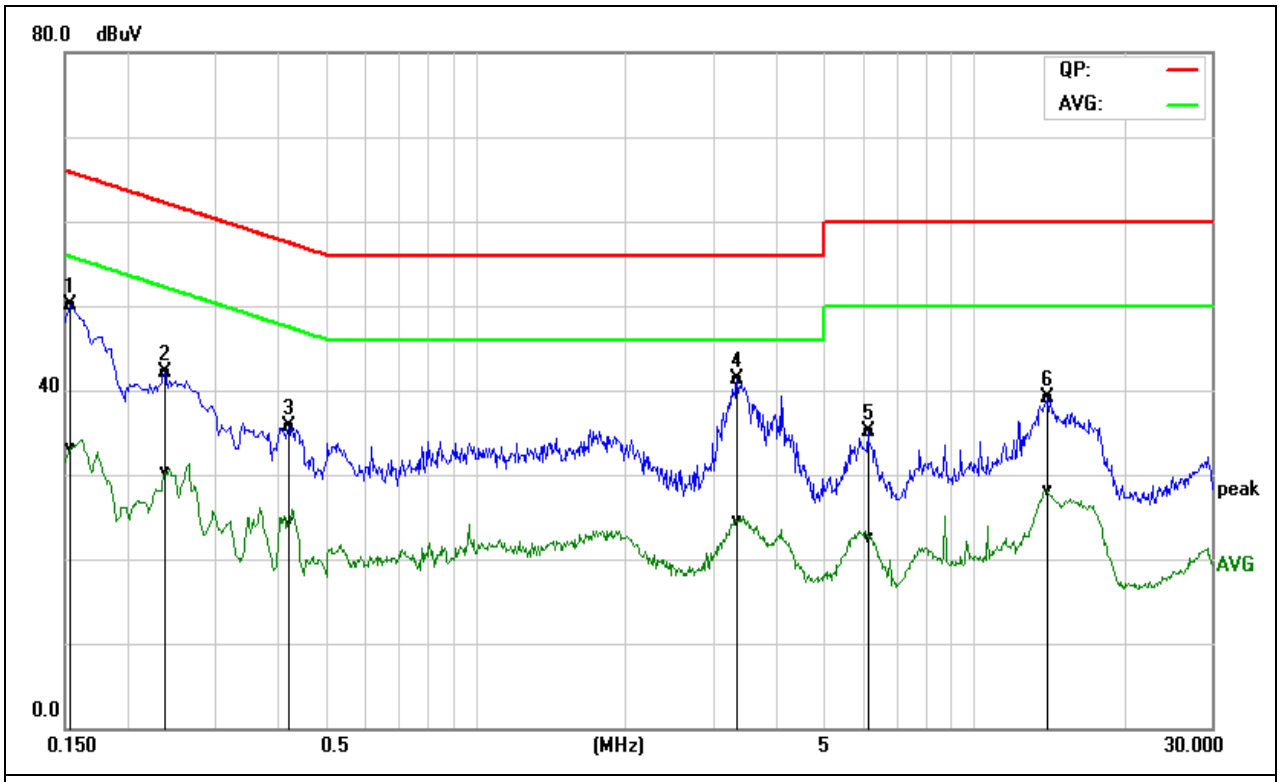
Model No.	UNRF5-M22	**RBW,VBW**	9 kHz
Environmental Conditions	22°C, 45% RH	**Test Mode**	Mode 1
Tested by	Darry Wu	**Line**	N
Test Voltage	AC120V/60Hz	**Test Date**	May 24, 2018



Frequency (MHz)	QuasiPeak Reading (dBuV)	Average Reading (dBuV)	Correction Factor (dB)	QuasiPeak Result (dBuV)	Average Result (dBuV)	QuasiPeak Limit (dBuV)	Average Limit (dBuV)	QuasiPeak Margin (dB)	Average Margin (dB)	Remark (Pass/Fail)
0.1539	30.63	13.64	19.52	50.15	33.16	65.78	55.79	-15.63	-22.63	Pass
0.2380	22.56	10.72	19.54	42.10	30.26	62.16	52.17	-20.06	-21.91	Pass
0.4220	16.25	4.77	19.53	35.78	24.30	57.41	47.41	-21.63	-23.11	Pass
3.3580	21.47	4.76	19.76	41.23	24.52	56.00	46.00	-14.77	-21.48	Pass
6.1340	15.29	2.67	19.83	35.12	22.50	60.00	50.00	-24.88	-27.50	Pass
14.0420	19.04	8.05	20.04	39.08	28.09	60.00	50.00	-20.92	-21.91	Pass

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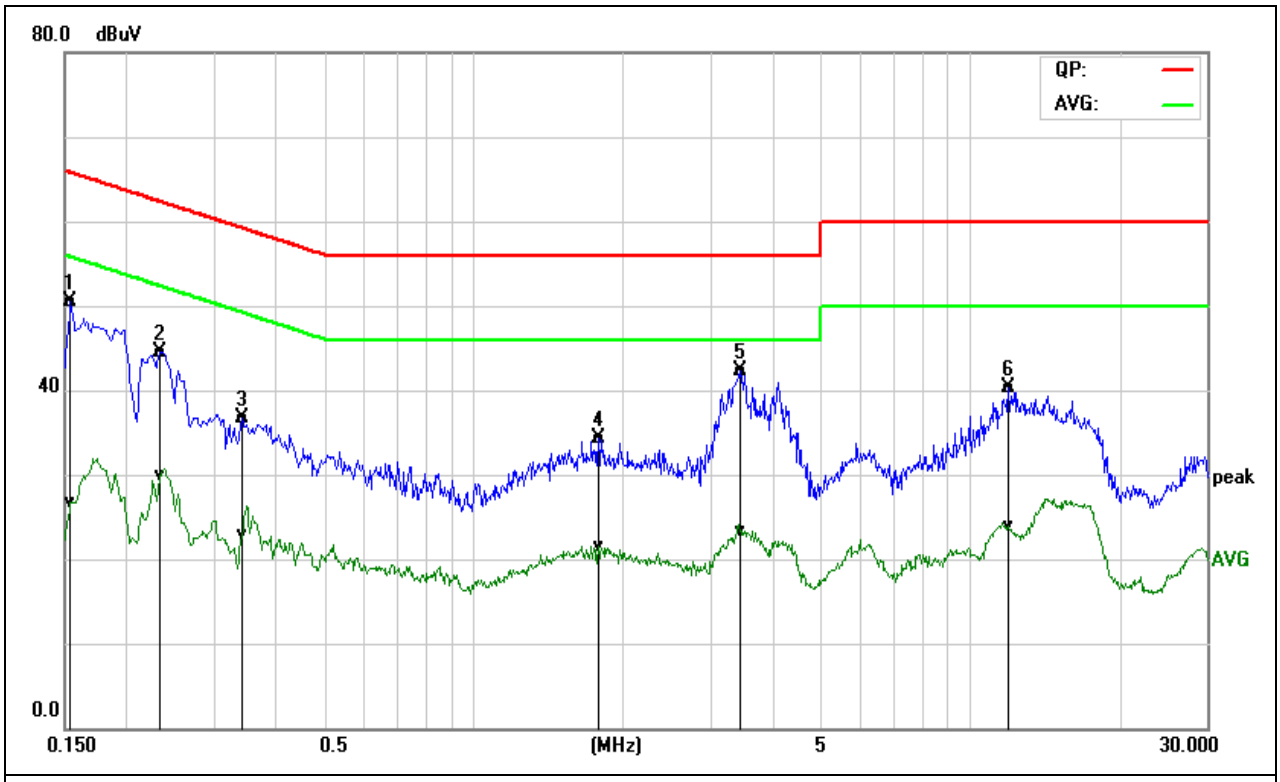
Model No.	UNRF5-M22	**RBW,VBW**	9 kHz
Environmental Conditions	22°C, 45% RH	**Test Mode**	Mode 1
Tested by	Darry Wu	**Line**	L
Test Voltage	AC240V/50Hz	**Test Date**	May 24, 2018



Frequency (MHz)	QuasiPeak Reading (dBuV)	Average Reading (dBuV)	Correction Factor (dB)	QuasiPeak Result (dBuV)	Average Result (dBuV)	QuasiPeak Limit (dBuV)	Average Limit (dBuV)	QuasiPeak Margin (dB)	Average Margin (dB)	Remark (Pass/Fail)
0.1540	30.88	7.03	19.62	50.50	26.65	65.78	55.78	-15.28	-29.13	Pass
0.2340	24.84	10.18	19.63	44.47	29.81	62.30	52.31	-17.83	-22.50	Pass
0.3420	17.19	3.31	19.58	36.77	22.89	59.15	49.15	-22.38	-26.26	Pass
1.7900	14.53	1.89	19.69	34.22	21.58	56.00	46.00	-21.78	-24.42	Pass
3.4380	22.66	3.64	19.72	42.38	23.36	56.00	46.00	-13.62	-22.64	Pass
11.9900	20.23	3.78	20.09	40.32	23.87	60.00	50.00	-19.68	-26.13	Pass

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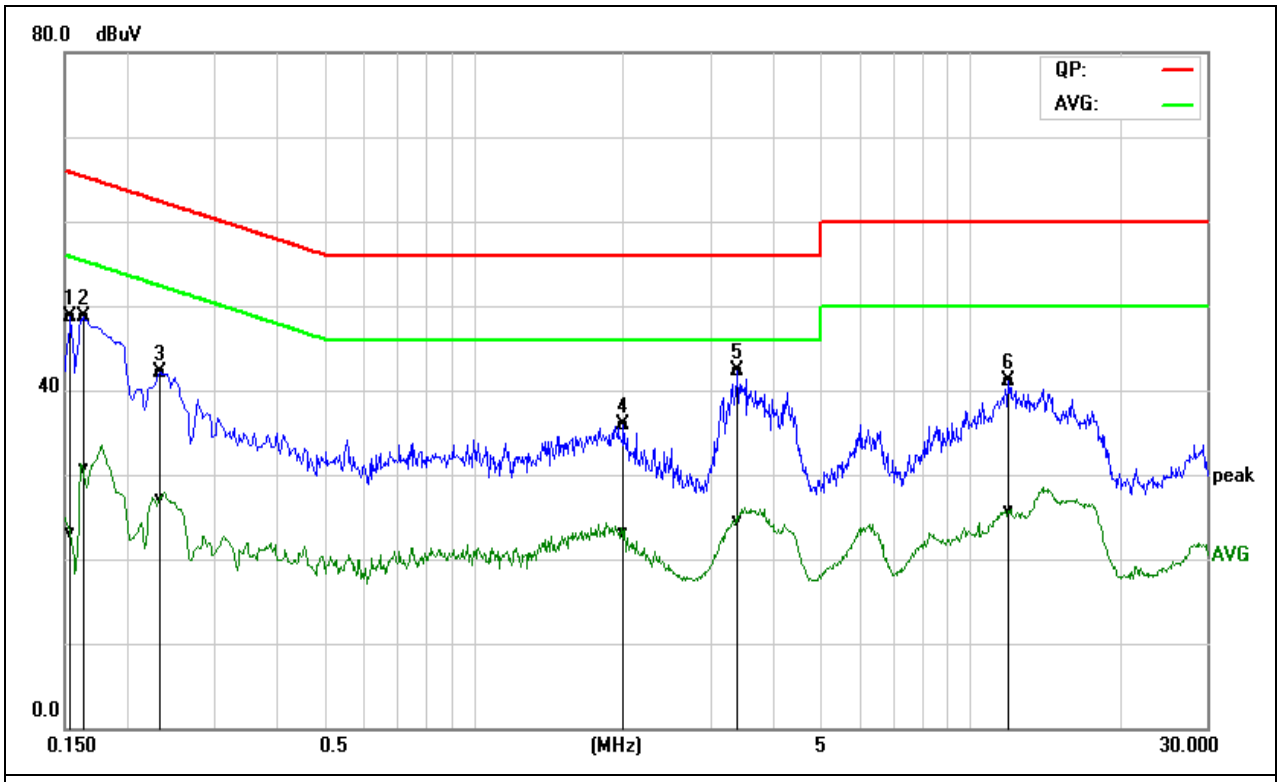
Model No.	UNRF5-M22	**RBW,VBW**	9 kHz
Environmental Conditions	22°C, 45% RH	**Test Mode**	Mode 1
Tested by	Darry Wu	**Line**	N
Test Voltage	AC240V/50Hz	**Test Date**	May 24, 2018



Frequency (MHz)	QuasiPeak Reading (dBuV)	Average Reading (dBuV)	Correction Factor (dB)	QuasiPeak Result (dBuV)	Average Result (dBuV)	QuasiPeak Limit (dBuV)	Average Limit (dBuV)	QuasiPeak Margin (dB)	Average Margin (dB)	Remark (Pass/Fail)
0.1539	29.09	3.65	19.52	48.61	23.17	65.78	55.79	-17.17	-32.62	Pass
0.1633	29.10	11.21	19.53	48.63	30.74	65.29	55.29	-16.66	-24.55	Pass
0.2340	22.62	7.66	19.54	42.16	27.20	62.30	52.31	-20.14	-25.11	Pass
2.0100	16.12	3.33	19.72	35.84	23.05	56.00	46.00	-20.16	-22.95	Pass
3.4100	22.62	4.80	19.77	42.39	24.57	56.00	46.00	-13.61	-21.43	Pass
11.9420	20.99	5.61	20.10	41.09	25.71	60.00	50.00	-18.91	-24.29	Pass

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7.2. 6dB BANDWIDTH MEASUREMENT

7.2.1. LIMITS

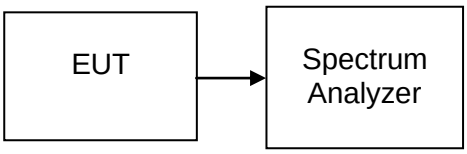
According to §15.247(a)(2), systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5MHz. The minimum 6 dB bandwidth shall be at least 500 kHz.

7.2.2. TEST PROCEDURES (please refer to measurement standard)

8.1 Option 2:

The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

7.2.3. TEST SETUP



7.2.4. TEST RESULTS

No non-compliance noted

Test Data

Channel	Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
Low	2402	535.2	>500	PASS
Mid	2440	545.5		PASS
High	2480	552.7		PASS

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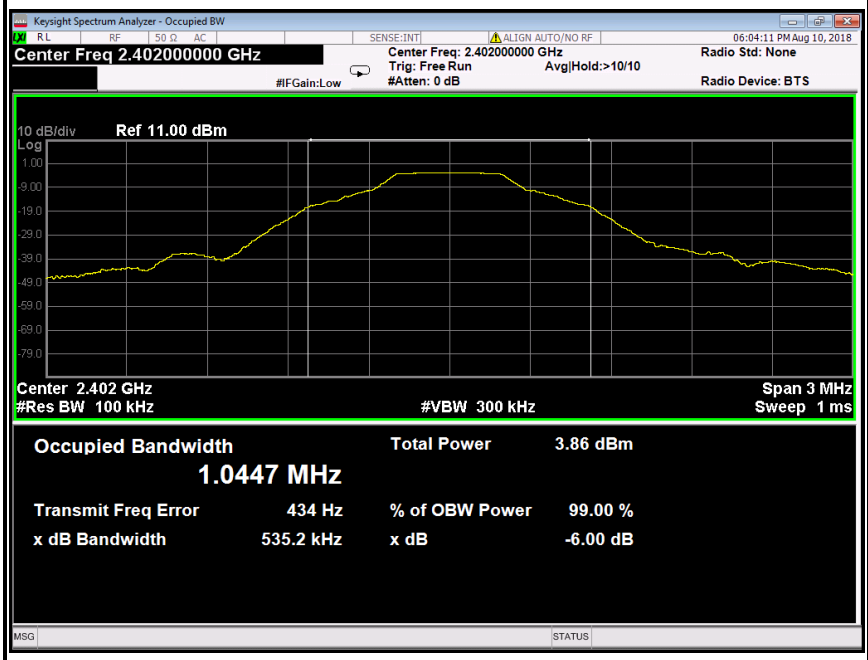
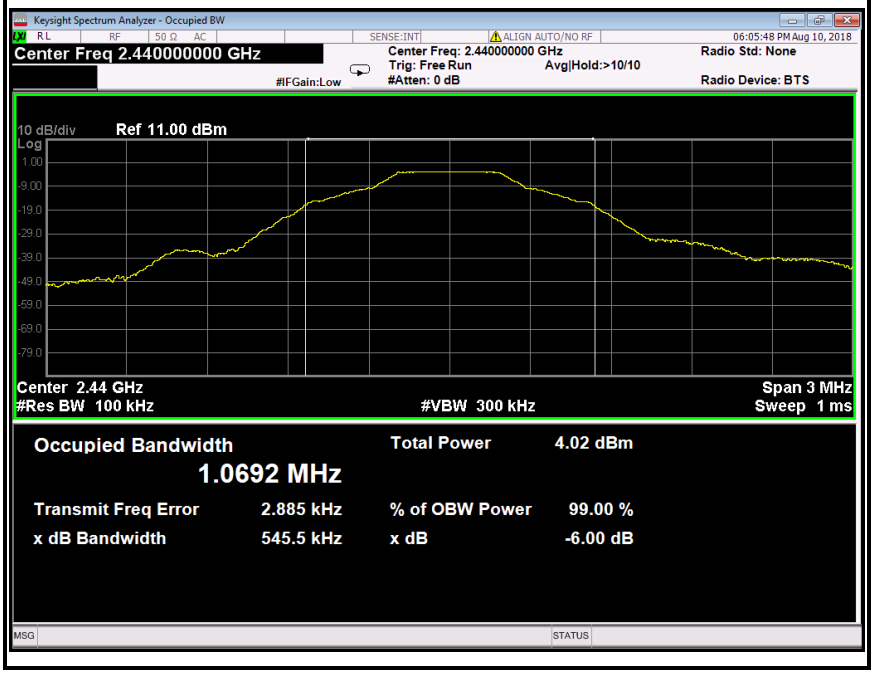
Test Plot

6dB Bandwidth (CH Low)



6dB Bandwidth (CH Mid)



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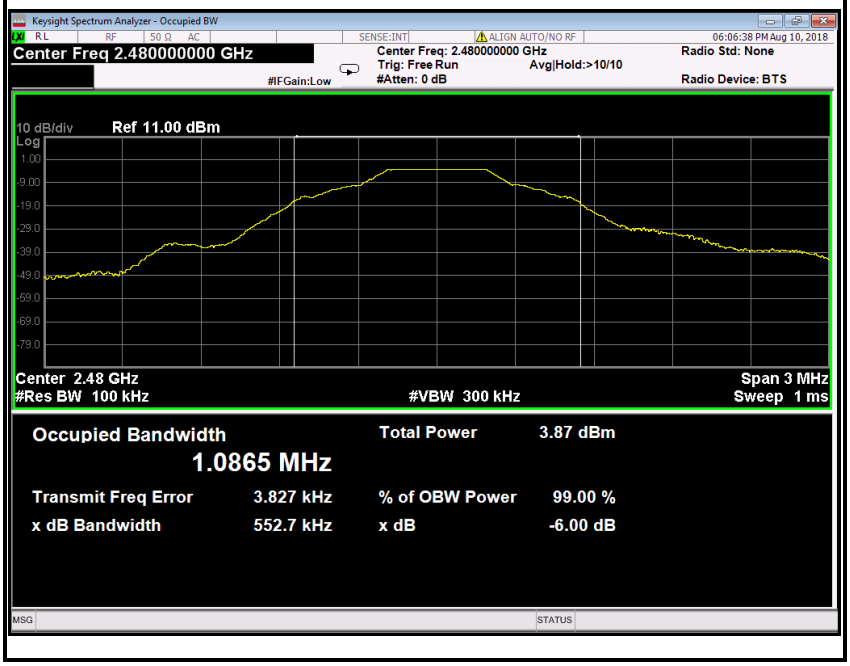
6dB Bandwidth (CH High)



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7.3. ANTENNA GAIN

7.3.1. 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.

7.3.2. MEASUREMENT PARAMETERS

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

7.3.3. LIMITS

FCC	IC
Antenna Gain	
6 dBi	

7.3.4. TEST RESULTS

GFSK

T_{nom}	V_{nom}	Lowest channel 2402MHz	Middle channel 2440MHz	Highest channel 2480MHz
Conducted power [dBm] Measured with GFSK modulation		-3.32	-3.32	-3.25
Radiated power [dBm] Measured with GFSK modulation		-1.86	-1.73	-1.69
Gain [dBi] Calculated		1.46	1.59	1.56
Measurement uncertainty		± 1.5 dB (cond.) / ± 3 dB (rad.)		

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7.4. PEAK OUTPUT POWER

7.4.1. LIMITS

The maximum peak output power of the intentional radiator shall not exceed the following:

1. According to §15.247(b)(3), for systems using digital modulation in the bands of 902-928 MHz, 2400-2483.5 MHz: 1 Watt.
2. According to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

7.4.2. TEST PROCEDURES (please refer to measurement standard)

9.1.1 RBW ≥ *DTS bandwidth*

This procedure shall be used when the measurement instrument has available a resolution bandwidth that is greater than the *DTS bandwidth*.
a) Set the RBW ≥ *DTS bandwidth*.
b) Set VBW ≥ 3 RBW.
c) Set span ≥ 3 x RBW
d) Sweep time = auto couple.
e) Detector = peak.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use peak marker function to determine the peak amplitude level.

9.1.2 PKPM1 Peak power meter method

The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

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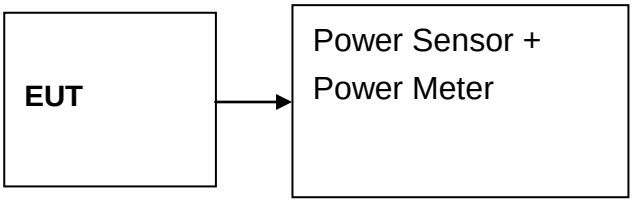
7.4.3. TEST SETUP



7.4.4. TEST RESULTS

No non-compliance noted

Test Data

Channel	Frequency (MHz)	Output Power (dBm)	Output Power (W)	Limit (W)	Peak /AVG	Result
Low	2402.00	-3.32	0.00047	1.00	peak	PASS
Mid	2440.00	-3.32	0.00047			PASS
High	2480.00	-3.25	0.00047			PASS
Low	2402.00	-3.54	0.00044	1.00	AVG	PASS
Mid	2440.00	-3.54	0.00044			PASS
High	2480.00	-3.47	0.00045			PASS

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7.5. BAND EDGES MEASUREMENT

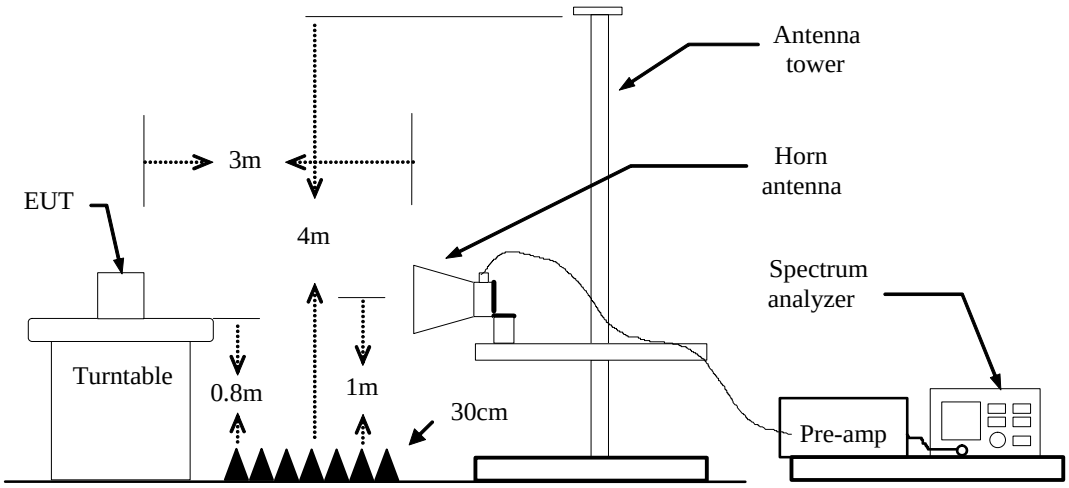
7.5.1. LIMITS

According to §15.247(d), in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator in 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. 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 Section 15.205(c)).

7.5.2. TEST PROCEDURES (please refer to measurement standard)

1. The EUT is placed on a turntable, which is 0.8m above the ground plane.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. EUT is set 3m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emission.
4. Set the spectrum analyzer in the following setting in order to capture the lower and upper band-edges of the emission:
   (a) PEAK: RBW=1MHz / VBW=3MHz / Sweep=AUTO
   (b) AVERAGE: RBW=1MHz / VBW=1/T / Sweep=AUTO
5. Repeat the procedures until all the PEAK and AVERAGE versus POLARIZATION are measured.

7.5.3. TEST SETUP



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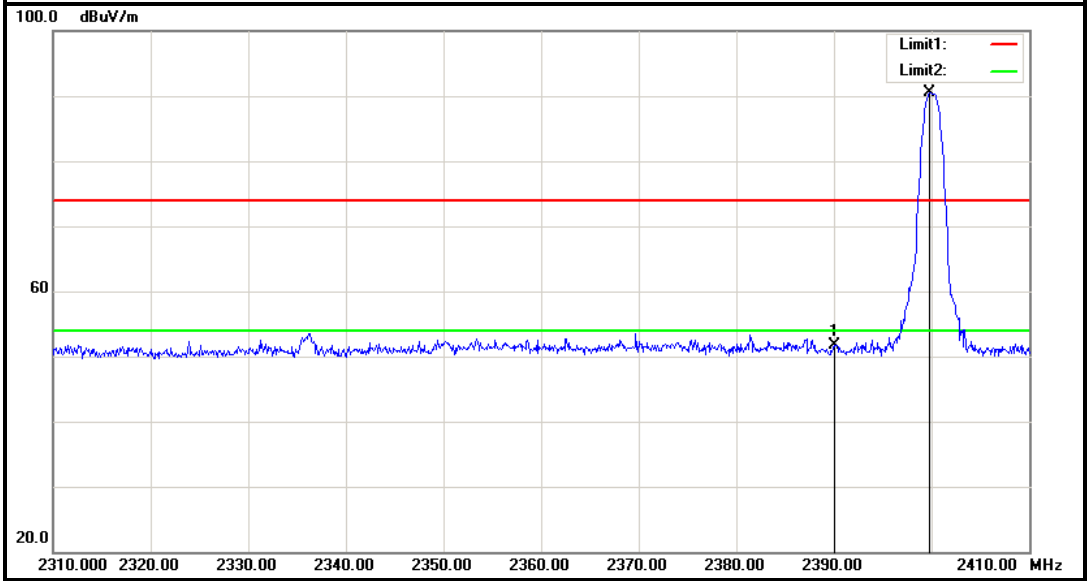
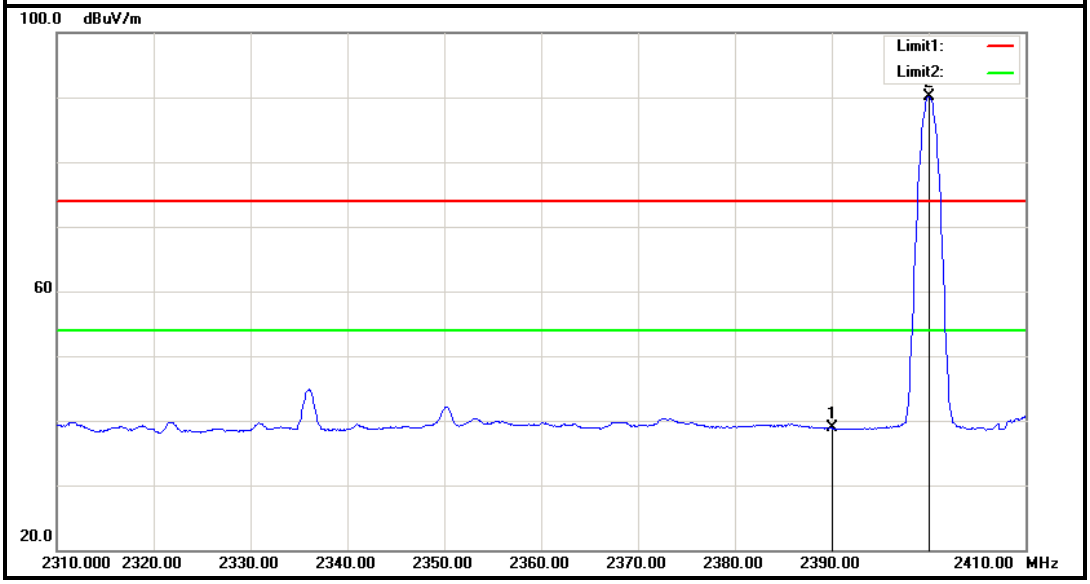
7.5.4. TEST RESULTS
Test Plot

Band Edges (CH Low)

Detector mode: Peak **Polarity: Vertical**



Detector mode: Average **Polarity: Vertical**



No.	Frequency (MHz)	Reading (dB)	Factor (dB/m)	Result (dB/m)	Limit (dB/m)	Margin (dB)	Remark	Antenna Polar
1.	2390.000	54.50	-2.86	51.64	74.00	-22.36	Peak	Vertical
2.	2399.800	93.22	-2.81	90.41	---	---	Peak	Vertical
1.	2390.000	41.78	-2.86	38.92	54.00	-15.08	Average	Vertical
2.	2400.000	92.94	-2.81	90.13	---	---	Average	Vertical

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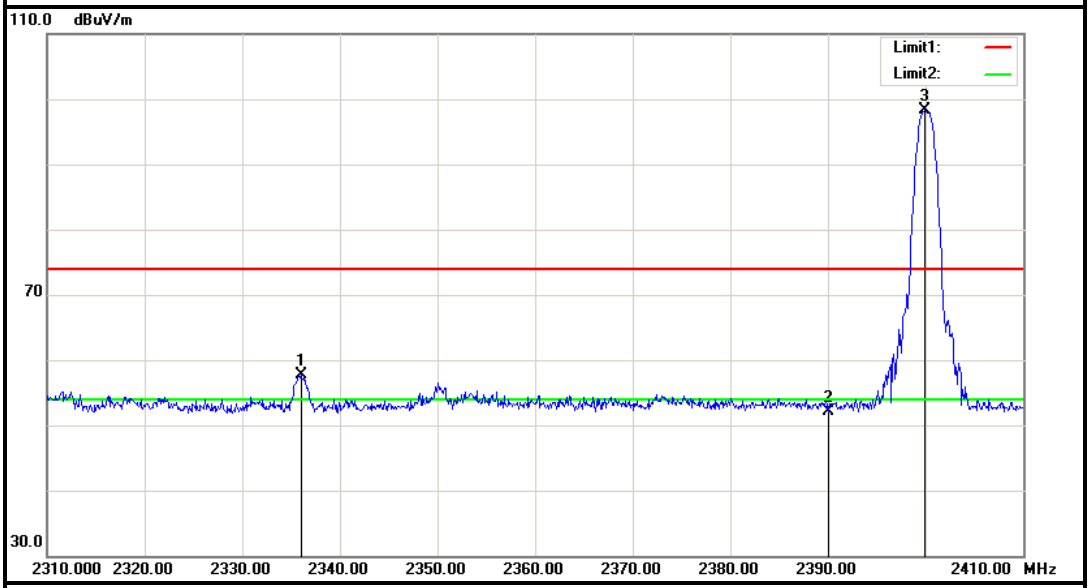
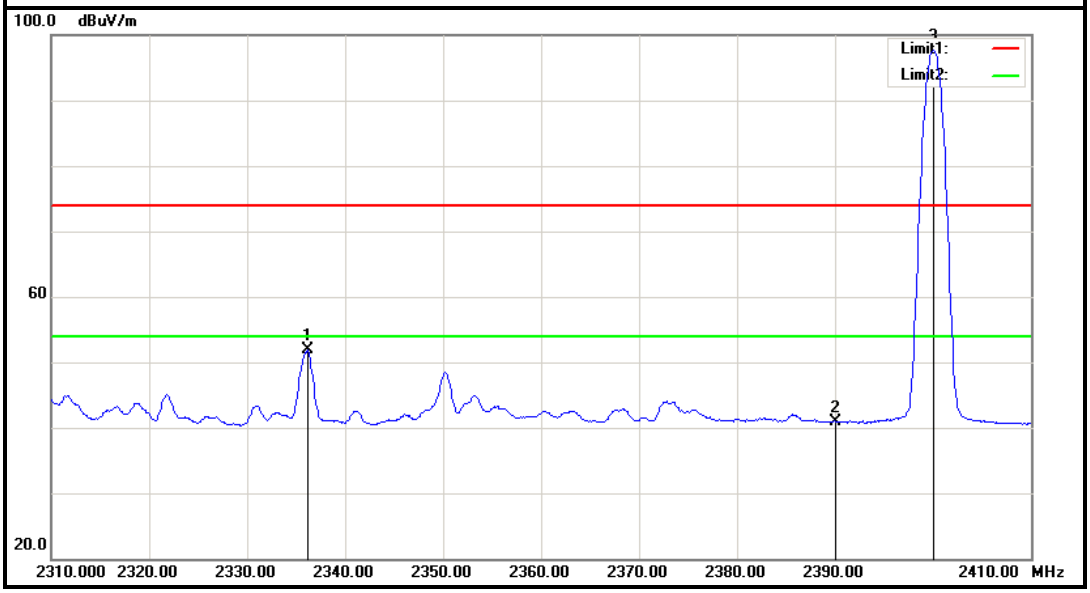
Detector mode: Peak **Polarity: Horizontal**



Detector mode: Average **Polarity: Horizontal**



No.	Frequency (MHz)	Reading (dB)	Factor (dB/m)	Result (dB/m)	Limit (dB/m)	Margin (dB)	Remark	Antenna Polar
1	2336.000	60.88	-3.16	57.72	74.00	-16.28	Peak	Horizontal
2	2390.000	54.95	-2.86	52.09	74.00	-21.91	Peak	Horizontal
3	2399.900	101.02	-2.81	98.21	---	---	Peak	Horizontal
1	2336.200	55.02	-3.16	51.86	54.00	-2.14	Average	Horizontal
2	2390.000	43.83	-2.86	40.97	54.00	-13.03	Average	Horizontal
3	2400.000	100.47	-2.81	97.66	---	---	Average	Horizontal

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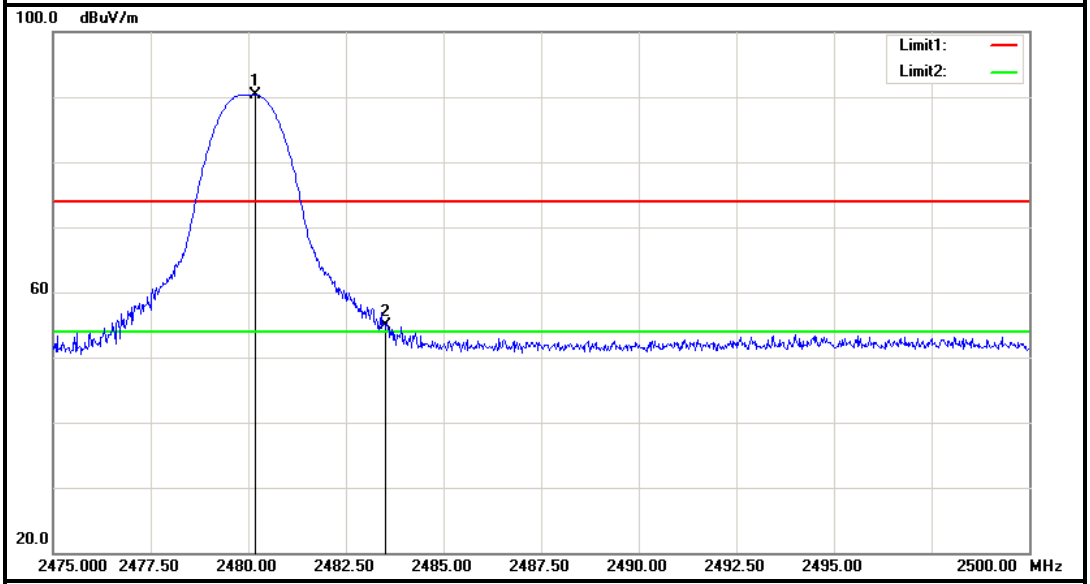
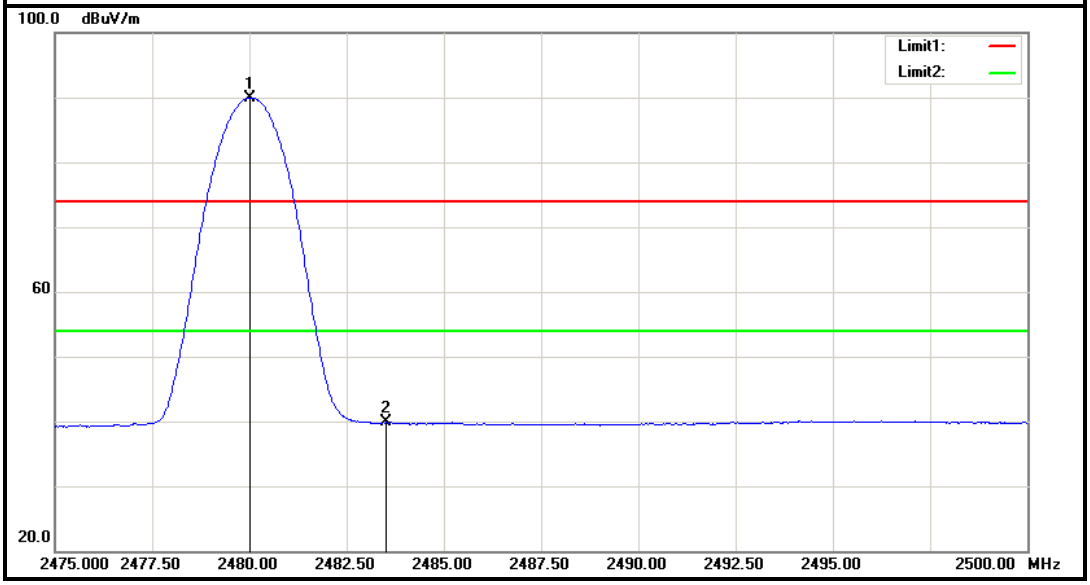
Band Edges (CH High)

Detector mode: Peak **Polarity: Vertical**



Detector mode: Average **Polarity: Vertical**



No.	Frequency (MHz)	Reading (dB)	Factor (dB/m)	Result (dB/m)	Limit (dB/m)	Margin (dB)	Remark	Antenna Polar
1.	2480.175	92.71	-2.37	90.34	---	---	Peak	Vertical
2.	2483.500	57.28	-2.35	54.93	74.00	-19.07	Peak	Vertical
1.	2480.025	92.36	-2.37	89.99	---	---	Average	Vertical
2.	2483.500	42.20	-2.35	39.85	54.00	-14.15	Average	Vertical

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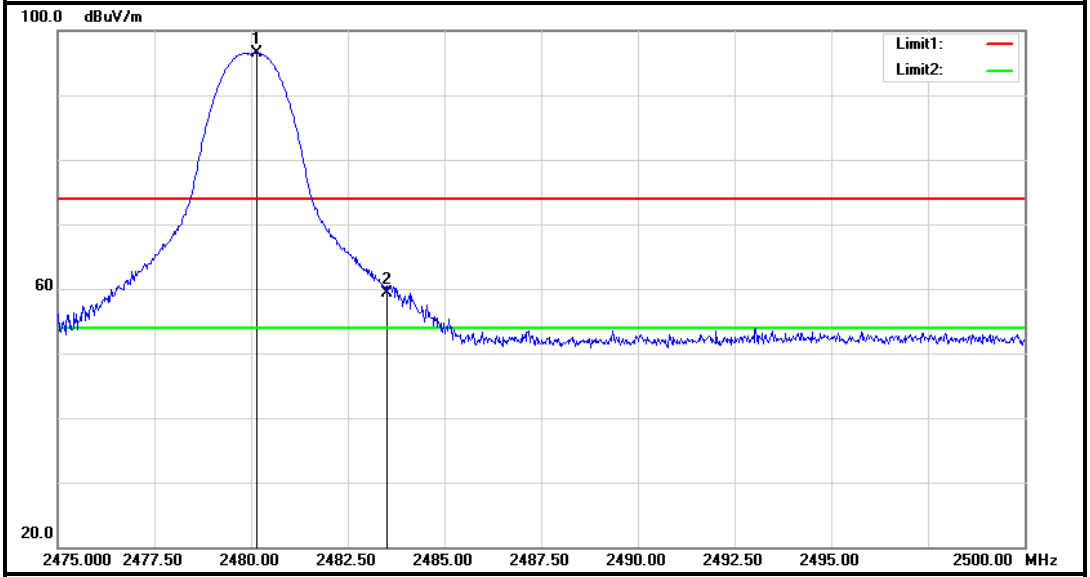
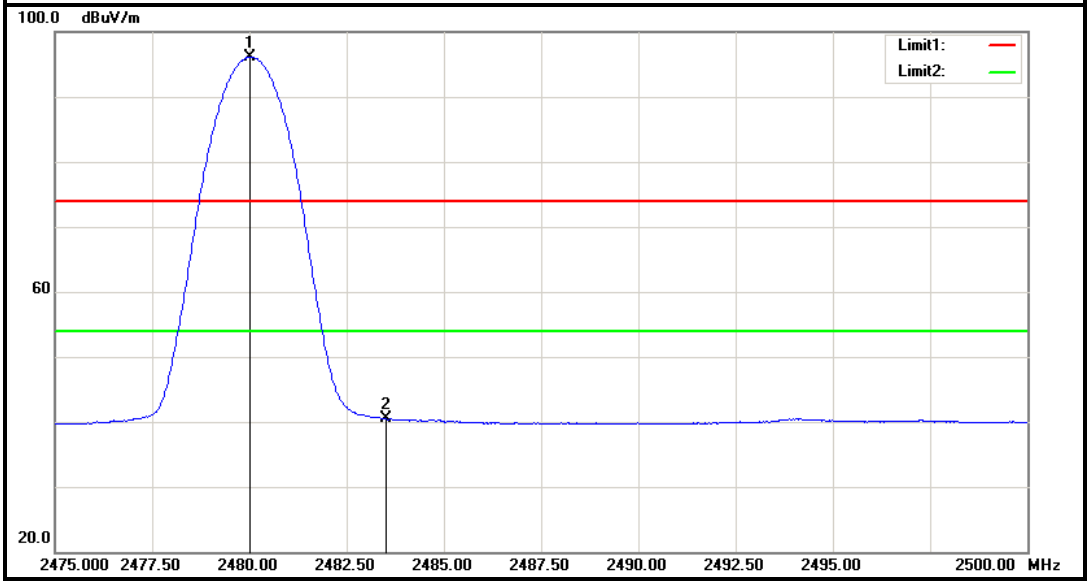
Detector mode: Peak **Polarity: Horizontal**



Detector mode: Average **Polarity: Horizontal**



No.	Frequency (MHz)	Reading (dB)	Factor (dB/m)	Result (dB/m)	Limit (dB/m)	Margin (dB)	Remark	Antenna Polar
1.	2480.150	98.85	-2.37	96.48	---	---	Peak	Horizontal
2.	2483.500	61.65	-2.35	59.30	74.00	-14.70	Peak	Horizontal
1.	2480.025	98.48	-2.37	96.11	---	---	Average	Horizontal
2.	2483.500	42.78	-2.35	40.43	54.00	-13.57	Average	Horizontal

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7.6. PEAK POWER SPECTRAL DENSITY MEASUREMENT

7.6.1. LIMITS

According to §15.247(e), for digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

According to §15.247(f), the digital modulation operation of the hybrid system, with the frequency hopping turned off, shall comply with the power density requirements of paragraph (d) of this section.

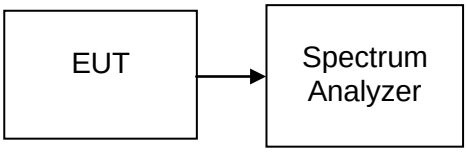
7.6.2. TEST INSTRUMENTS

Name of Equipment	Manufacturer	Model	Serial Number	Last Calibration	Calibration Due
Spectrum Analyzer	Agilent	N9010A	MY52221469	01/27/2018	01/26/2019

7.6.3. TEST PROCEDURES (please refer to measurement standard)

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS bandwidth.
3. Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
4. Set the VBW ≥ 3 RBW.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

7.6.4. TEST SETUP



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7.6.5. TEST RESULTS

No non-compliance noted

Test Data

Channel	Frequency (MHz)	PPSD (dBm)	Limit (dBm)	Test Result
Low	2402	-13.021	8.00	PASS
Mid	2440	-13.048		PASS
High	2480	-10.975		PASS

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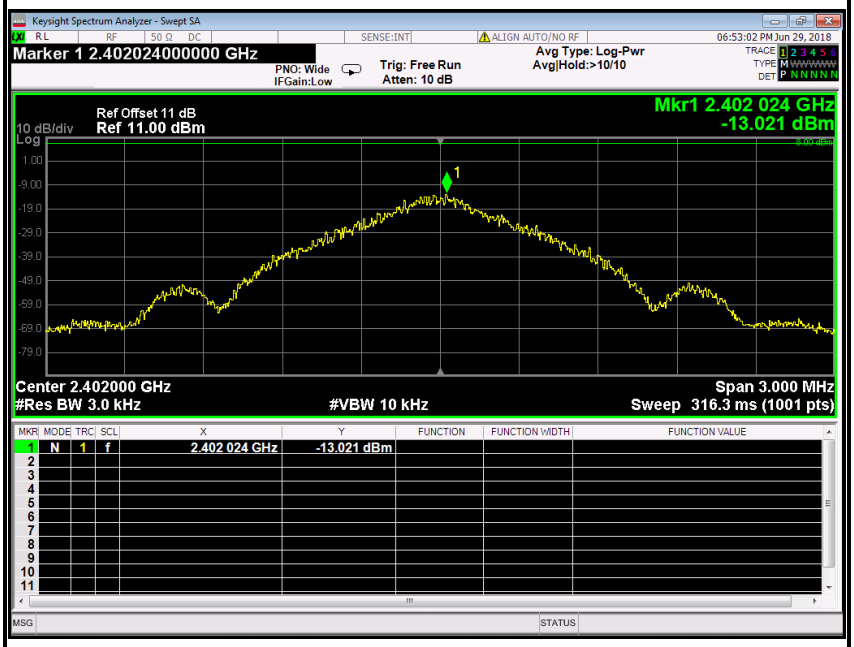
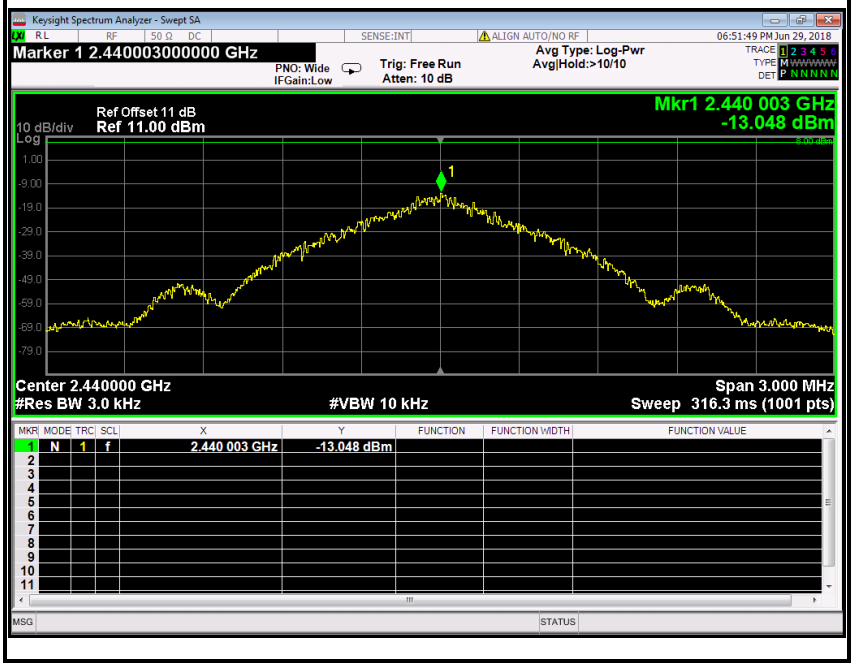
Test Plot

PPSD (CH Low)



PPSD (CH Mid)



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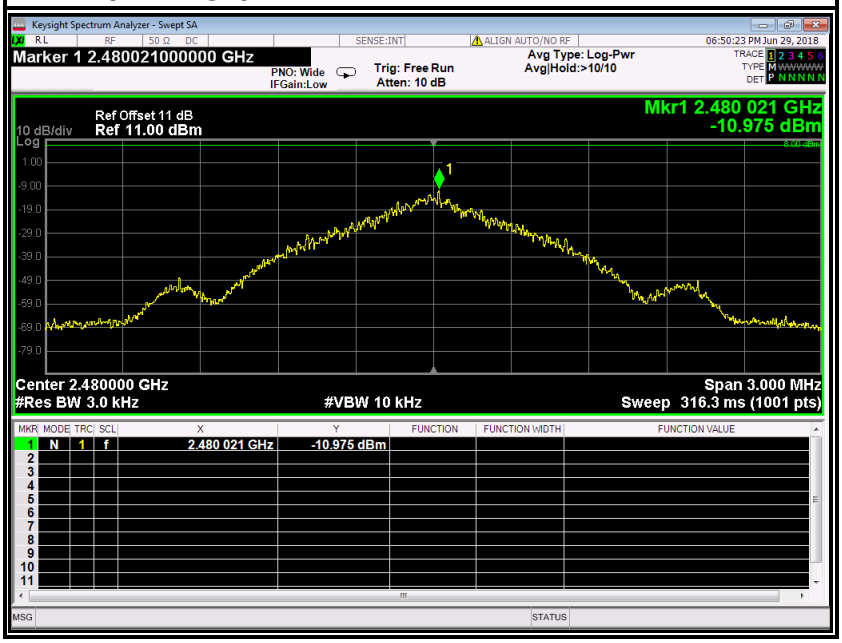
PPSD (CH High)



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7.7. SPURIOUS EMISSIONS MEASUREMENT

7.7.1. CONDUCTED EMISSIONS MEASUREMENT

7.7.1.1. LIMITS OF CONDUCTED EMISSIONS MEASUREMENT

According to §15.247(d), in any 100 kHz bandwidth outside the frequency bands in which the spread spectrum intentional radiator in 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. 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 Section 15.205(c)).

7.7.1.2. TEST PROCEDURE (please refer to measurement standard)

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.
The transmitter output is connected to the spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz.
Measurements are made over the 9kHz to 26.5GHz range with the transmitter set to the lowest, middle, and highest channels. No emission found between lowest internal used/generated frequency to 10MHz，it is only recorded 10MHz to 26GHz.

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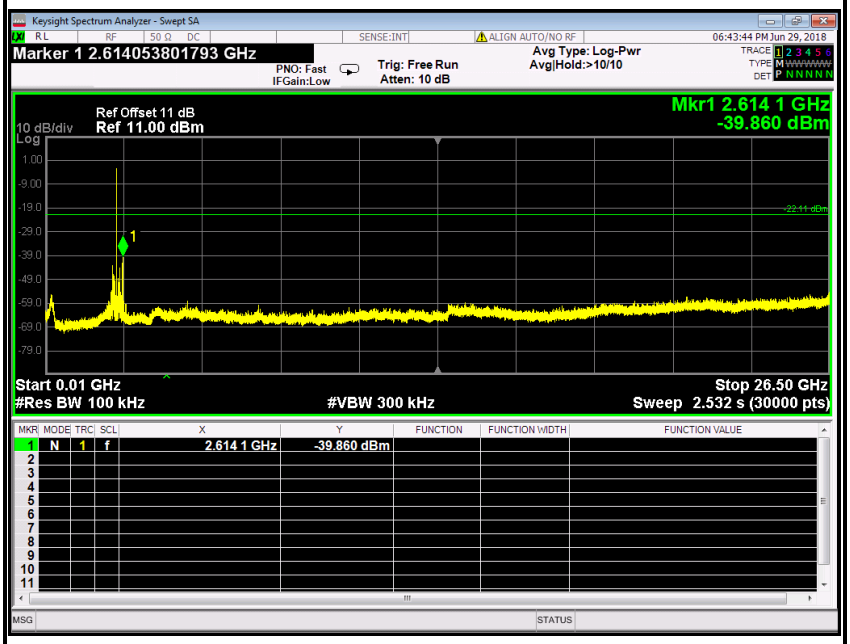
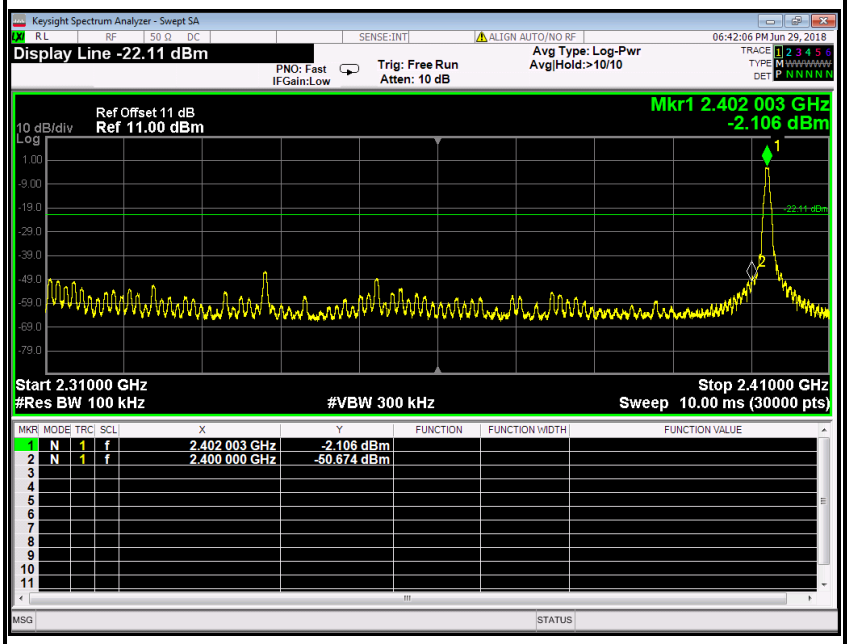
7.7.1.3. TEST RESULTS

Test Plot

CH Low (10MHz ~26.5GHz)



CH Low (2.31GHz ~2.41GHz)



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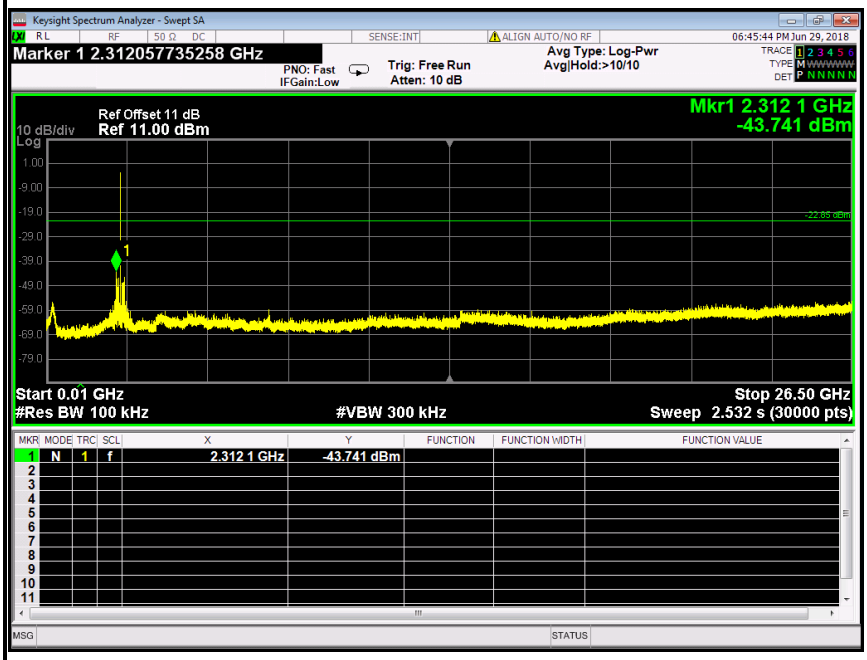
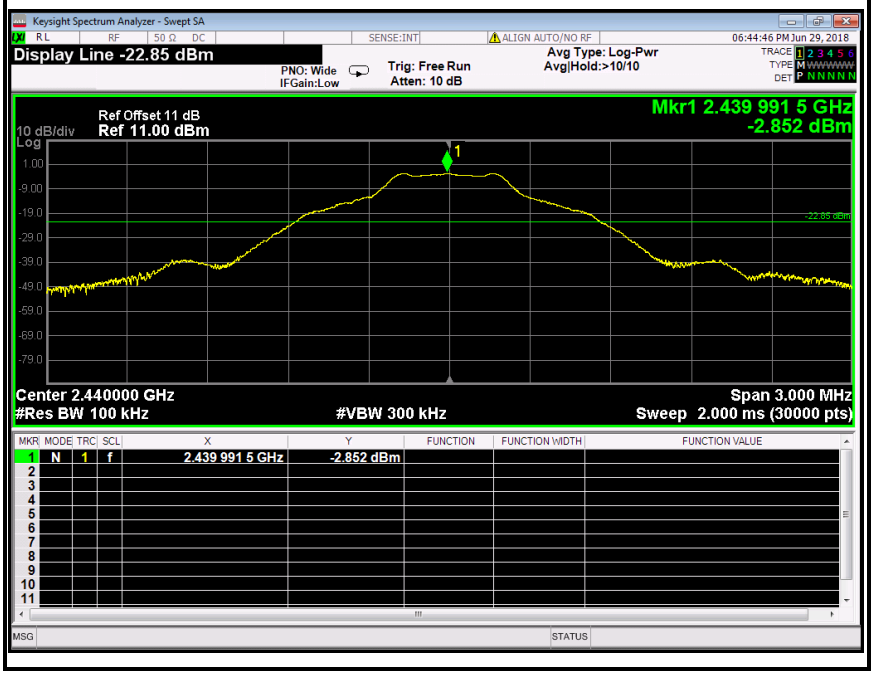
CH Mid (10MHz ~26.5GHz)



CH Mid (2.31GHz ~2.41GHz)



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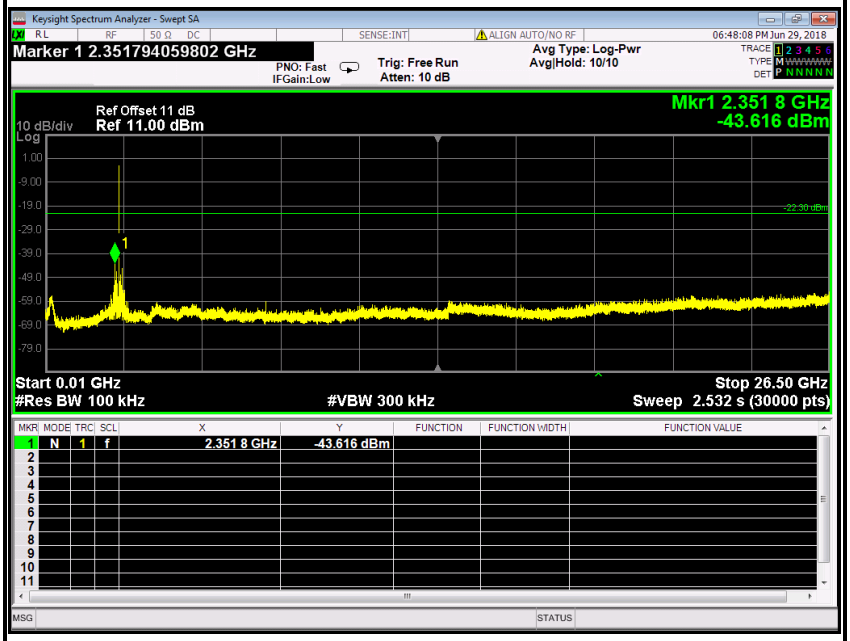
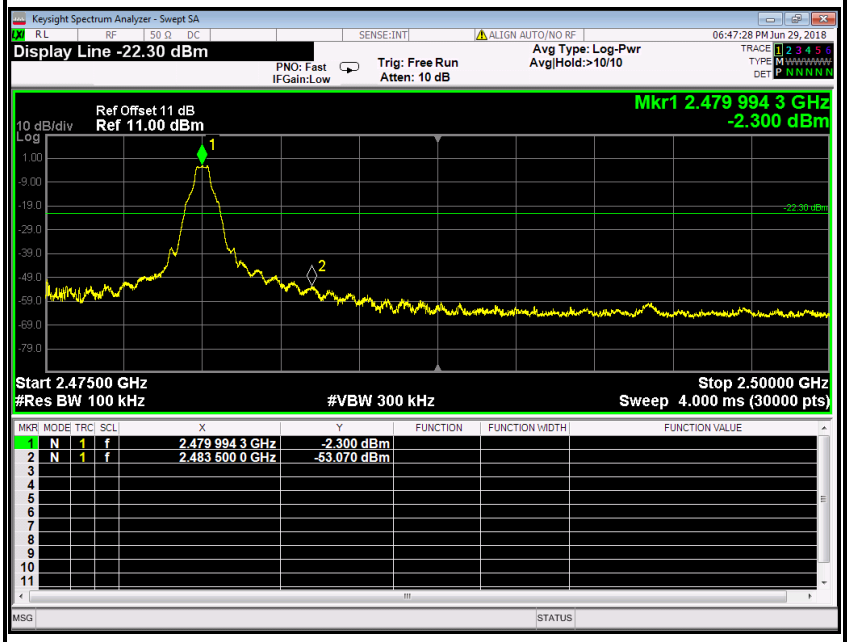
CH High (10MHz ~26.5GHz)



CH High(2.475GHz ~2.5GHz)



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7.7.2. RADIATED EMISSIONS MEASUREMENT

7.7.2.1. LIMITS OF RADIATED EMISSIONS MEASUREMENT

According to §15.209(a), except as provided elseULTUNE in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (mV/m)	Measurement Distance (m)
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

Remark: Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

1. In the emission table above, the tighter limit applies at the band edges.

Frequency (MHz)	Field Strength (µV/m at 3-meter)	Field Strength (dBµV/m at 3-meter)
30-88	100	40
88-216	150	43.5
216-960	200	46
Above 960	500	54

NOTE: (1) The lower limit shall apply at the transition frequencies.

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

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7.7.2.2. Measuring Instruments and Setting

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/ T for Average
RB / VB (Emission in non-restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/ T for Average

Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~150kHz / RB 200Hz for QP/AVG
Start ~ Stop Frequency	150kHz~30MHz / RB 9kHz for QP/AVG
Start ~ Stop Frequency	30MHz~1000MHz / RB 100kHz for QP

7.7.2.3. TEST PROCEDURE (please refer to measurement standard)

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.

Pre measurement:

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

--- The antenna height is 0.8 meter.

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

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Final measurement:

--- Identified emissions during the pre measurement 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 pre measurement 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.

Pre measurement:

--- 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.

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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.

Pre measurement:

--- 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.

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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 pre measurement 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.

Pre measurement:

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

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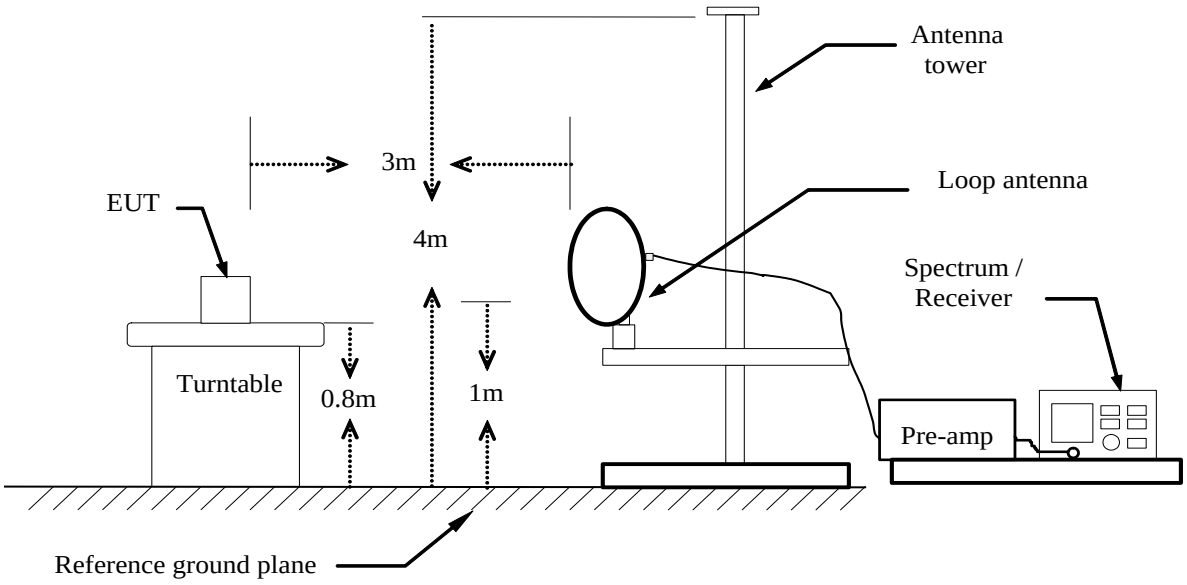
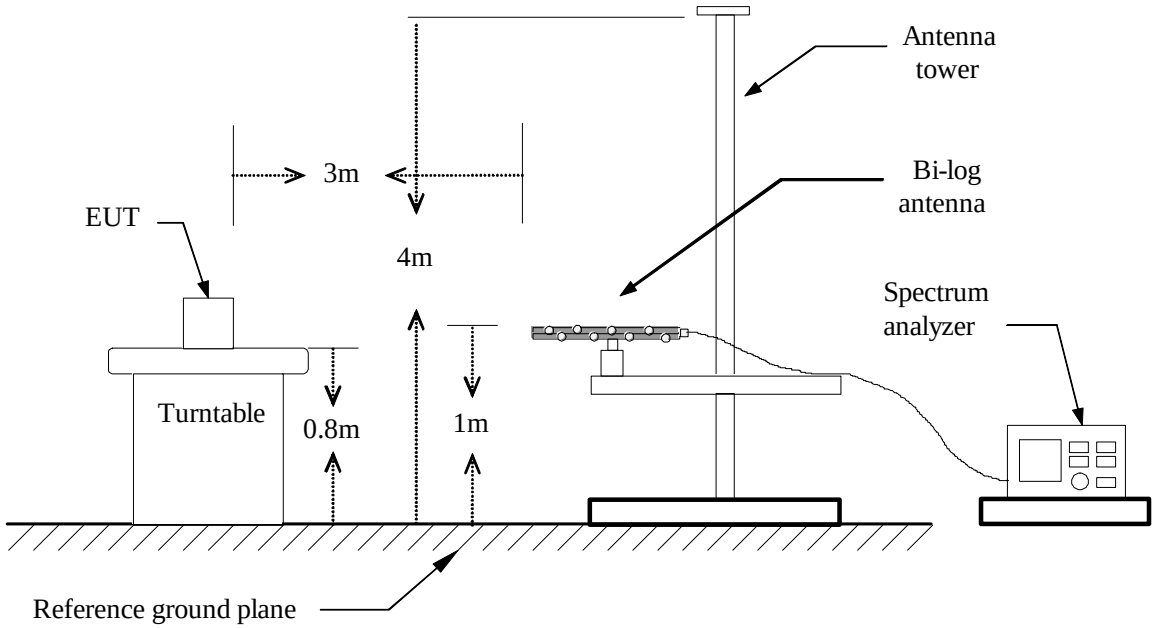
7.7.2.4. TEST SETUP

Below 30MHz



Below 1 GHz



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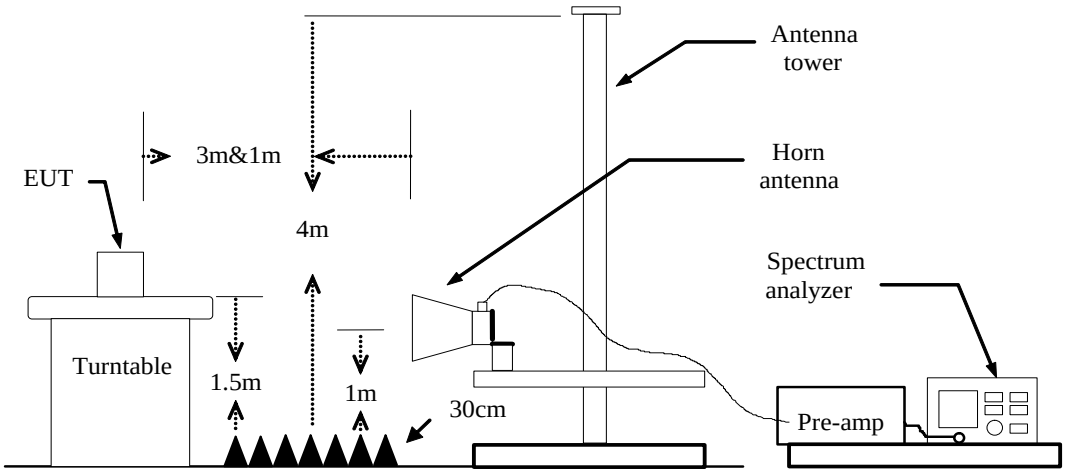
Above 1 GHz



For the actual test configuration, please refer to the related item – Photographs of the Test Configuration.

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7.7.2.5. DATA SAMPLE

Below 1GHz

Frequency (MHz)	Reading (dBuV)	Correct Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Pole (V/H)	Remark
XXX.XXXX	53.41	-18.63	34.78	43.50	-8.72	V	QP

Frequency (MHz) = Emission frequency in MHz
Reading (dBuV) = Uncorrected Analyzer / Receiver reading
Correct Factor (dB/m) = Antenna factor + Cable loss – Amplifier gain
Result (dBuV/m) = Reading (dBuV) + Corr. Factor (dB/m)
Limit (dBuV/m) = Limit stated in standard
Margin (dB) = Result (dBuV/m) – Limit (dBuV/m)
Q.P. = Quasi-peak Reading

Above 1GHz

Frequency (MHz)	Reading (dBuV)	Correction Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Pole (V/H)	Remark
XXXX.XXXX	62.09	-11.42	50.67	74.00	-23.33	V	Peak
XXXX.XXXX	49.78	-11.42	38.36	54.00	-15.64	V	AVG

Frequency (MHz) = Emission frequency in MHz
Reading (dBuV) = Uncorrected Analyzer / Receiver reading
Correction Factor (dB/m) = Antenna factor + Cable loss – Amplifier gain
Result (dBuV/m) = Reading (dBuV) + Corr. Factor (dB/m)
Limit (dBuV/m) = Limit stated in standard
Margin (dB) = Result (dBuV/m) – Limit (dBuV/m)
Peak = Peak Reading
AVG = Average Reading

Calculation Formula

Margin (dB) = Result (dBuV/m) – Limits (dBuV/m)
Result (dBuV/m) = Reading (dBuV) + Correction Factor

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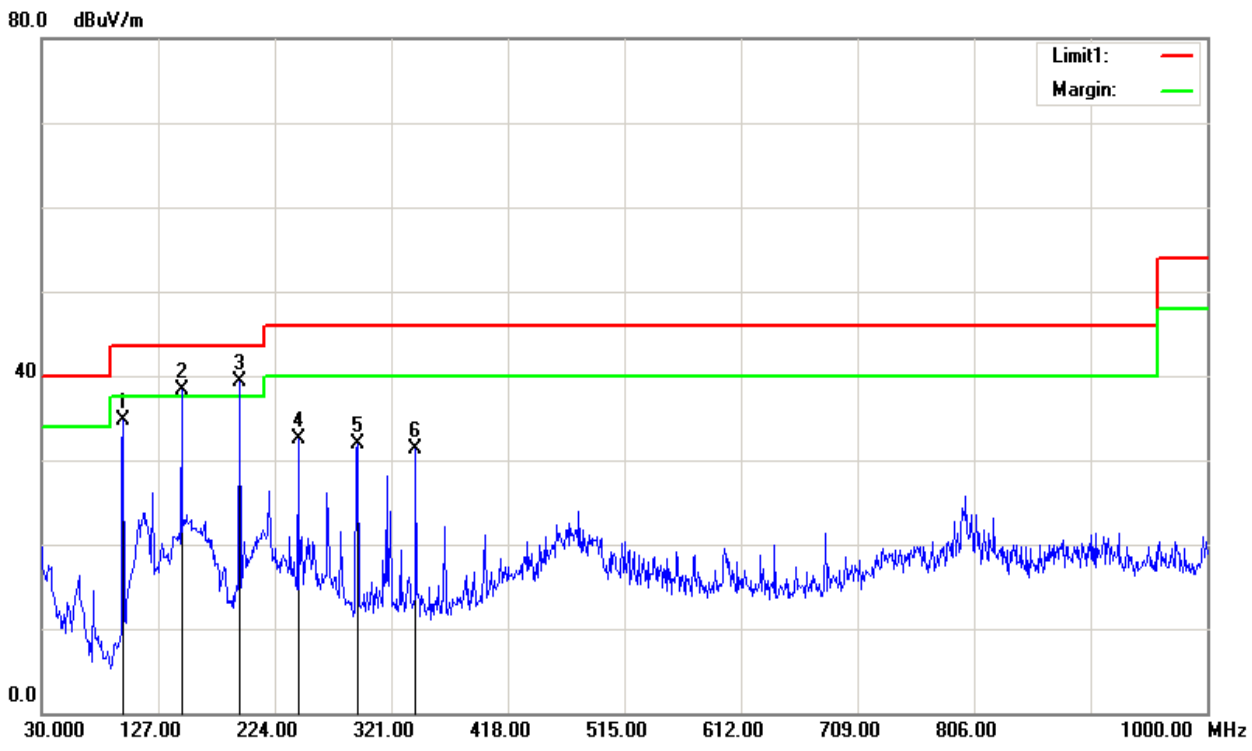
7.7.2.6. TEST RESULTS

Below 1 GHz

Notes:

1. No emission found between lowest internal used/generated frequency to 30MHz.
2. Pre-scan all mode and recorded the worst case results in this report (BT LE (Low)

Temp. & Humidity	24°C, 52%	Test By	Darry Wu
Polarization	Vertical	Test Date	2018/05/24
Test Mode	TX / GFSK / CH Low		



Frequency (MHz)	Reading (dBuV)	Correction Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
97.9000	58.59	-23.90	34.69	43.50	-8.81	QP
146.4000	59.93	-21.58	38.35	43.50	-5.15	QP
194.9000	62.01	-22.80	39.21	43.50	-4.29	QP
243.4000	53.94	-21.36	32.58	46.00	-13.42	QP
292.8700	52.15	-20.21	31.94	46.00	-14.06	QP
341.3700	49.32	-18.08	31.24	46.00	-14.76	QP

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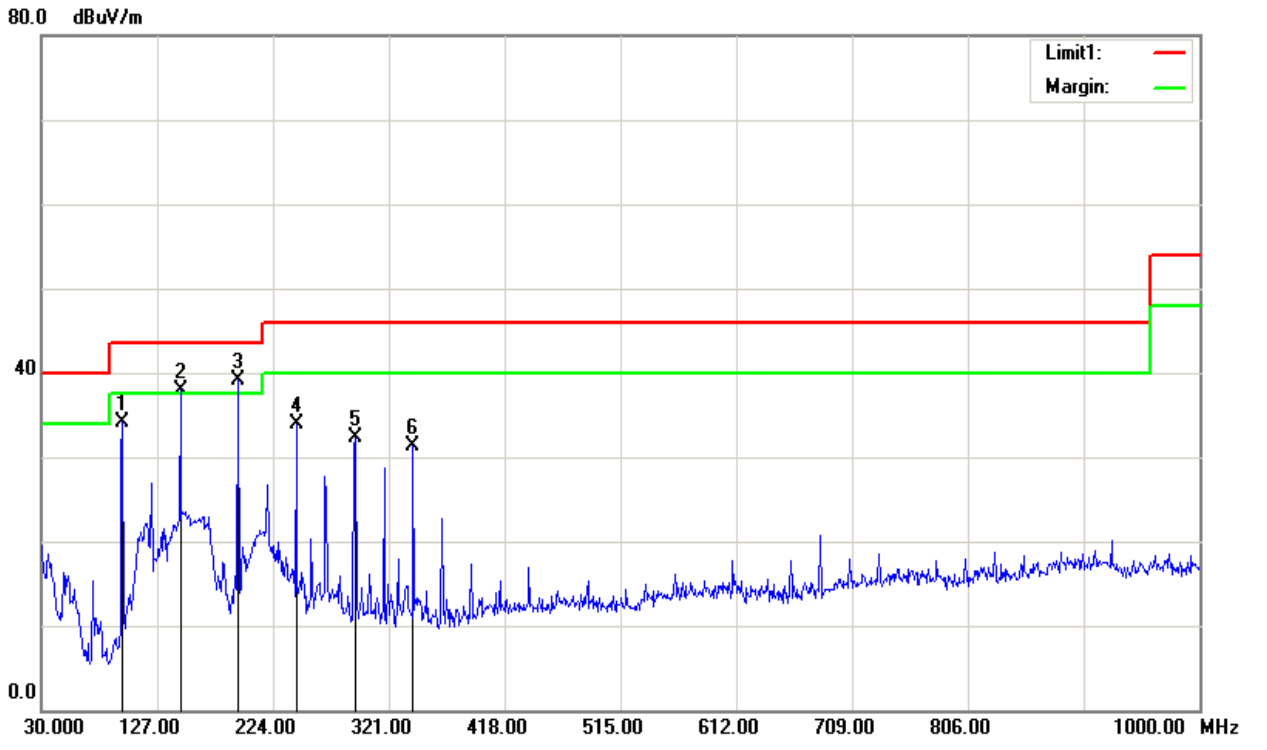
Temp. & Humidity	24°C, 52%	Test By	Darry Wu
Polarization	Horizontal	Test Date	2018/05/24
Test Mode	TX / GFSK / CH Low		



Frequency (MHz)	Reading (dBuV)	Correction Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
97.9000	58.02	-23.90	34.12	43.50	-9.38	QP
146.4000	59.43	-21.58	37.85	43.50	-5.65	QP
194.9000	61.94	-22.80	39.14	43.50	-4.36	QP
243.4000	55.18	-21.36	33.82	46.00	-12.18	QP
292.8700	52.57	-20.21	32.36	46.00	-13.64	QP
341.3700	49.43	-18.08	31.35	46.00	-14.65	QP

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Above 1 GHz

Temp. & Humidity	24°C, 52%	Test By	Darry Wu
Polarization	Vertical / Horizontal	Test Date	2018/06/19
Test Mode	TX / GFSK / CH Low		

Frequency (MHz)	Reading (dBuV)	Correction Factor (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Antenna Pole (V/H)	Remark
1999.000	49.01	-5.01	44.00	74.00	-30.00	V	peak
4807.000	43.94	4.35	48.29	74.00	-25.71	V	peak
5653.000	41.46	5.93	47.39	74.00	-26.61	V	peak
7210.000	44.21	8.11	52.32	74.00	-21.68	V	peak
7210.000	41.15	8.11	49.26	54.00	-4.74	V	AVG
7660.000	41.57	8.99	50.56	74.00	-23.44	V	peak
8371.000	41.45	9.45	50.90	74.00	-23.10	V	peak
2809.000	45.12	-1.70	43.42	74.00	-30.58	H	Peak
4807.000	47.36	4.35	51.71	74.00	-22.29	H	Peak
5113.000	41.87	5.18	47.05	74.00	-26.95	H	Peak
7210.000	44.53	8.11	52.64	74.00	-21.36	H	Peak
7210.000	42.02	8.11	50.13	54.00	-3.87	H	AVG
7471.000	41.31	8.62	49.93	74.00	-24.07	H	peak
8056.000	41.05	9.62	50.67	74.00	-23.33	H	peak

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Temp. & Humidity	24°C, 52%	Test By	Darry Wu
Polarization	Vertical / Horizontal	Test Date	2018/06/19
Test Mode	TX / GFSK / CH Mid		

Frequency	Reading	Correction Factor	Result	Limit	Margin	Antenna Pole	Remark
(MHz)	(dBuV)	(dB/m)	(dBuV/m)	(dBuV/m)	(dB)	(V/H)	
1999.000	49.44	-5.01	44.43	74.00	-29.57	V	peak
4879.000	43.49	4.59	48.08	74.00	-25.92	V	peak
4996.000	43.78	4.97	48.75	74.00	-25.25	V	peak
6670.000	41.82	7.17	48.99	74.00	-25.01	V	peak
7318.000	43.43	8.32	51.75	74.00	-22.25	V	peak
8146.000	40.93	9.57	50.50	74.00	-23.50	V	peak
1828.000	50.05	-6.09	43.96	74.00	-30.04	H	Peak
2503.000	45.47	-2.25	43.22	74.00	-30.78	H	Peak
4879.000	48.42	4.59	53.01	74.00	-20.99	H	Peak
4879.000	46.67	4.59	51.26	54.00	-2.74	H	AVG
5878.000	41.50	6.03	47.53	74.00	-26.47	H	peak
7318.000	45.10	8.32	53.42	74.00	-20.58	H	peak
7318.000	42.03	8.32	50.35	54.00	-3.65	H	AVG
8425.000	40.87	9.42	50.29	74.00	-23.71	H	peak

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Temp. & Humidity	24°C, 52%	Test By	Darry Wu
Polarization	Vertical / Horizontal	Test Date	2018/06/19
Test Mode	TX / GFSK / CH High		

Frequency	Reading	Correction Factor	Result	Limit	Margin	Antenna Pole	Remark
(MHz)	(dBuV)	(dB/m)	(dBuV/m)	(dBuV/m)	(dB)	(V/H)	
1999.000	49.85	-5.01	44.84	74.00	-29.16	V	peak
4591.000	43.47	3.65	47.12	74.00	-26.88	V	peak
4960.000	43.82	4.85	48.67	74.00	-25.33	V	peak
5761.000	41.97	5.98	47.95	74.00	-26.05	V	peak
6337.000	41.96	6.63	48.59	74.00	-25.41	V	peak
7444.000	41.64	8.57	50.21	74.00	-23.79	V	peak
1801.000	48.28	-6.26	42.02	74.00	-31.98	H	Peak
2809.000	44.76	-1.70	43.06	74.00	-30.94	H	Peak
4960.000	48.56	4.85	53.41	74.00	-20.59	H	Peak
4960.000	46.91	4.85	51.76	54.00	-2.24	H	AVG
7453.000	42.78	8.58	51.36	74.00	-22.64	H	peak
8362.000	41.27	9.45	50.72	74.00	-23.28	H	peak
8983.000	41.99	9.11	51.10	74.00	-22.90	H	peak

Remark:

1. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency.
2. Radiated emissions measured in frequency above 1000MHz were made with an instrument using peak/average detector mode.
3. Average test would be performed if the peak result were greater than the average limit or as required by the applicant.
4. 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.
5. Measurements above show only up to 6 maximum emissions noted, or would be lesser, with " N/A " remark, if no specific emissions from the EUT are recorded (ie: margin>20dB from the applicable limit) and considered that's already beyond the background noise floor.
6. Margin (dB) = Remark result (dBuV/m) – Average limit (dBuV/m).

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