

TEST REPORT

Application No.: HKEM2008000895AT
Applicant: Ecolab, Inc
Address of Applicant: Ecolab Schuman Center -F6, 655 Lone Oak Drive Eagan, MN 55121, United States Of America

Equipment Under Test (EUT):

EUT Name: HHCM915 Installation Tool
Model No.: 92053074
Trade Mark: Ecolab
Standard(s) : 47 CFR Part 15, Subpart C 15.247
RSS-247 Issue 2: May 2017
RSS-Gen: Issue 5, Amendment 1, March 2019
FCC ID: Z9O-92053074
IC : 10060A-92053074
HVIN : 92053074
Date of Receipt: 2020-08-08
Date of Test: 2020-08-09 to 2020-09-10
Date of Issue: 2020-09-17

Test Result:	Pass*
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* In the configuration tested, the EUT complied with the standards specified above.



Law Man Kit
EMC Manager

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Unless otherwise stated the results shown in this test report refer only to the sample(s) tested and such sample(s) are retained for 30 days only.

Revision Record				
Version	Chapter	Date	Modifier	Remark
01		2020-09-17		Original

Authorized for issue by:			
			
		Leo Xu /Project Engineer	Date: 2020-09-17
			
		Law Man Kit /Reviewer	Date: 2020-09-17

2 Test Summary

Radio Spectrum Technical Requirement				
Item	Standard	Method	Requirement	Result
Antenna Requirement	47 CFR Part 15, Subpart C 15.247	N/A	47 CFR Part 15, Subpart C 15.203 & 15.247(b)(4)	Pass
Other requirements Frequency Hopping Spread Spectrum System Hopping Sequence	47 CFR Part 15, Subpart C 15.247	N/A	47 CFR Part 15, Subpart C 15.247(a)(1),(g),(h)	Pass

Radio Spectrum Matter Part				
Item	Standard	Method	Requirement	Result
Conducted Peak Output Power	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.5	47 CFR Part 15, Subpart C 15.247(b)(1)	Pass
20dB Bandwidth	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.7	47 CFR Part 15, Subpart C 15.247(a)(1)	Pass
Carrier Frequencies Separation	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.2	47 CFR Part 15, Subpart C 15.247a(1)	Pass
Hopping Channel Number	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.3	47 CFR Part 15, Subpart C 15.247a(1)(iii)	Pass
Dwell Time	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.4	47 CFR Part 15, Subpart C 15.247a(1)(iii)	Pass
Conducted Band Edges Measurement	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.6	47 CFR Part 15, Subpart C 15.247(d)	Pass
Conducted Spurious Emissions	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 7.8.8	47 CFR Part 15, Subpart C 15.247(d)	Pass
Radiated Emissions which fall in the restricted bands	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 6.10.5	47 CFR Part 15, Subpart C 15.205 & 15.209	Pass
Radiated Spurious Emissions	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 6.4,6.5,6.6	47 CFR Part 15, Subpart C 15.205 & 15.209	Pass

Radio Spectrum Technical Requirement				
Item	Standard	Method	Requirement	Result
Antenna Requirement	RSS-247 Issue 2, February 2017	N/A	RSS-Gen Section 6.8	Pass
Pseudorandom Frequency Hopping Sequence	RSS-247 Issue 2, February 2017	N/A	RSS-247 Section 5.1(a)	Pass

Radio Spectrum Matter Part				
Item	Standard	Method	Requirement	Result
99% Bandwidth	RSS-247 Issue 2, February 2017	ANSI C63.10 Section 6.9.3	RSS-Gen Section 6.7	Pass
Conducted Peak Output Power	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 7.8.5	RSS-247 Section 5.4(b)	Pass
20dB Bandwidth	RSS-247 Issue 2, February 2017	ANSI C63.10 Section 6.9.2	RSS-247 Section 5.1(a)	Pass
Carrier Frequencies Separation	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 7.8.2	RSS-247 Section 5.1(b)	Pass
Hopping Channel Number	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 7.8.3	RSS-247 Section 5.1(d)	Pass
Dwell Time	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 7.8.4	RSS-247 Section 5.1(d)	Pass
Conducted Band Edges Measurement	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 7.8.6	RSS-247 Section 5.5	Pass
Conducted Spurious Emissions	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 7.8.8	RSS-247 Section 5.5	Pass
Radiated Emissions which fall in the restricted bands	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 6.10.5	Section 3.3 & RSS-Gen Section 8.10	Pass
Radiated Spurious Emissions	RSS-247 Issue 2, February 2017	ANSI C63.10 (2013) Section 6.4&6.5&6.6	Section 3.3 & RSS-Gen Section 8.9	Pass
Frequency stability	-	RSS-Gen Section 6.11	RSS-Gen Section 8.11	PASS*

Note: Frequency stability requested in RSS GEN Section 8.1.1 has been complied since the result of band edge can demonstrate.

Declaration of EUT Family Grouping:

N/A

Abbreviation:

- Tx: In this whole report Tx (or tx) means Transmitter.
- Rx: In this whole report Rx (or rx) means Receiver.
- RF: In this whole report RF means Radiated Frequency.
- CH: In this whole report CH means channel.
- Volt: In this whole report Volt means Voltage.
- Temp: In this whole report Temp means Temperature.
- Humid: In this whole report Humid means humidity.
- Press: In this whole report Press means Pressure.
- N/A: In this whole report not application.



3 Contents

	Page
1 COVER PAGE	1
2 TEST SUMMARY	3
3 CONTENTS	5
4 GENERAL INFORMATION	7
4.1 DETAILS OF E.U.T.	7
4.2 DESCRIPTION OF SUPPORT UNITS	8
4.3 MEASUREMENT UNCERTAINTY	8
4.4 TEST LOCATION	9
4.5 TEST FACILITY	9
4.6 DEVIATION FROM STANDARDS	9
4.7 ABNORMALITIES FROM STANDARD CONDITIONS	9
5 EQUIPMENT LIST	10
6 RADIO SPECTRUM TECHNICAL REQUIREMENT	12
6.1 ANTENNA REQUIREMENT	12
6.1.1 <i>Test Requirement:</i>	12
6.1.2 <i>Conclusion:</i>	12
6.2 PSEUDORANDOM FREQUENCY HOPPING SEQUENCE	13
6.2.1 <i>Test Requirement:</i>	13
6.2.2 <i>Test Setup Diagram:</i>	13
6.2.3 <i>Conclusion:</i>	13
6.1 99% BANDWIDTH	14
6.1.1 <i>E.U.T. Operation</i>	14
6.1.2 <i>Test Setup Diagram:</i>	14
6.1.3 <i>Measurement Procedure and Data:</i>	15
6.2 CONDUCTED PEAK OUTPUT POWER	16
6.2.1 <i>E.U.T. Operation</i>	16
6.2.2 <i>Test Setup Diagram:</i>	16
6.2.3 <i>Measurement Procedure and Data:</i>	17
6.3 20dB BANDWIDTH	18
6.3.1 <i>E.U.T. Operation</i>	18
6.3.2 <i>Test Setup Diagram:</i>	18
6.3.3 <i>Measurement Procedure and Data:</i>	19
6.4 CARRIER FREQUENCIES SEPARATION	20
6.4.1 <i>E.U.T. Operation</i>	20
6.4.2 <i>Test Setup Diagram:</i>	20
6.4.3 <i>Measurement Procedure and Data:</i>	21
6.5 HOPPING CHANNEL NUMBER	22
6.5.1 <i>E.U.T. Operation</i>	22
6.5.2 <i>Test Setup Diagram:</i>	22
6.5.3 <i>Measurement Procedure and Data:</i>	23
6.6 DWELL TIME	24
6.6.1 <i>E.U.T. Operation</i>	24
6.6.2 <i>Test Setup Diagram:</i>	24
6.6.3 <i>Measurement Procedure and Data:</i>	25
6.7 CONDUCTED BAND EDGES MEASUREMENT	26
6.7.1 <i>E.U.T. Operation</i>	28



6.7.2	Test Setup Diagram	28
6.7.3	Measurement Procedure and Data	29
6.8	RADIATED EMISSIONS WHICH FALL IN THE RESTRICTED BANDS	33
6.8.1	E.U.T. Operation	34
6.8.2	Test Setup Diagram	34
6.8.3	Measurement Procedure and Data	35
6.8.4	Measurement Procedure and data	35
6.9	RADIATED SPURIOUS EMISSIONS	36
6.9.1	E.U.T. Operation	37
6.9.2	Test Setup Diagram	37
6.9.3	Measurement Procedure and Data	38
7	PHOTOGRAPHS	45

4 General Information

4.1 Details of E.U.T.

Power supply:	DC 4.5 V ('AA' size battery x 3)
Test voltage:	DC 4.5 V
Antenna Gain:	-1dBi
Antenna Type:	Ceramic Chip Antenna
Channel Spacing:	0.05MHz
Modulation Type:	GFSK
Number of Channels:	52
Operation Frequency:	913.75MHz to 916.30MHz
Spectrum Spread Technology:	Frequency Hopping Spread Spectrum(FHSS)
Series no.:	A1
Firmware version:	FW92053140 v0.04

EUT channels and frequencies list:

Channel	Frequency (MHz)	Channel	Frequency (MHz)	Channel	Frequency (MHz)
1	913.75	20	914.70	39	915.65
2	913.80	21	914.75	40	915.70
3	913.85	22	914.80	41	915.75
4	913.90	23	914.85	42	915.80
5	913.95	24	914.90	43	915.85
6	914.00	25	914.95	44	915.90
7	914.05	26	915.00	45	915.95
8	914.10	27	915.05	46	916.00
9	914.15	28	915.10	47	916.05
10	914.20	29	915.15	48	916.10
11	914.25	30	915.20	49	916.15
12	914.30	31	915.25	50	916.20
13	914.35	32	915.30	51	916.25
14	914.40	33	915.35	52	916.30
15	914.45	34	915.40		
16	914.50	35	915.45		
17	914.55	36	915.50		
18	914.60	37	915.55		
19	914.65	38	915.60		

Test frequencies are the lowest channel: 913.75 MHz, and highest channel:916.30 MHz

4.2 Description of Support Units

The EUT has been tested as an independent unit.

4.3 Measurement Uncertainty

EMI

No.	Item	Measurement Uncertainty
1	Conduction emission	2.5dB (9kHz to 150kHz)
		2.6dB (150kHz to 30MHz)
2	Radiated emission	5.1dB (30MHz-1GHz)
		4.9dB (1GHz-6GHz)

RF

No.	Item	Measurement Uncertainty
1	Radio Frequency	$\pm 7.25 \times 10^{-8}$
2	Duty cycle	$\pm 0.37\%$
3	Occupied Bandwidth	$\pm 3\%$
4	RF conducted power (30MHz-40GHz)	1.5dB
5	RF power density	1.5dB
6	Conducted Spurious emissions	1.5dB
7	RF Radiated power	5.1dB (below 1GHz)
		5.3dB (above 1GHz)
8	Radiated Spurious emission test	5.1dB (below 1GHz)
		5.3dB (above 1GHz)
9	Temperature test	$\pm 1^{\circ}\text{C}$
10	Humidity test	$\pm 3\%$
11	Supply voltages	$\pm 1.5\%$
12	Time	$\pm 3\%$

Remark:

The U_{lab} (lab Uncertainty) is less than U_{CISPR} (CISPR Uncertainty), so the test results

- compliance is deemed to occur if no measured disturbance level exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance level exceeds the disturbance limit.

According to decision rule based on Clause 4.2 of CISPR 16-4-2, the EUT complied with the standards specified above.

4.4 Test Location

All tests were performed at:

SGS Hong Kong Limited
Unit 2 and 3, G/F, Block A, Po Lung Centre,
11 Wang Chiu Road, Kowloon Bay, Kowloon, Hong Kong
Tel: +852 2305 2570 Fax: +852 2756 4480

No tests were sub-contracted.

4.5 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

• **HOKLAS (Lab Code: 009)**

SGS Hong Kong Limited has been accepted by HKAS Executive, on the recommendation of the Accreditation Advisory Board, as a HOKLAS Accredited Laboratory, this laboratory meets the requirements of ISO/IEC 17025:2017 and it has been accredited for performing specific test as listed in the scope of accreditation within the test category of Electrical and Electronic Products.

• **IAS Accreditation (Lab Code: TL-187)**

SGS Hong Kong Limited has met the requirements of AC89, IAS Accreditation Criteria for Testing Laboratories, and has demonstrated compliance with ISO/IEC Standard 17025:2017, General requirements for the competence of testing and calibration laboratories. This organization is accredited to provide the services specified in the scope of accreditation maintained on the IAS website (www.iasonline.org).

The report must not be used by the client to claim product certification, approval, or endorsement by IAS, NIST, or any agency of the Federal Government.

• **FCC Recognized Accredited Test Firm (CAB Registration No.: 514599)**

SGS Hong Kong Limited has been accredited and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Designation Number: HK0015, Test Firm Registration Number: 514599.

• **Industry Canada (Site Registration No.: 26103; CAB Identifier No.: HK0015)**

SGS Hong Kong Limited has been recognized by Department of Innovation, Science and Economic Development (ISED) Canada as a wireless testing laboratory. The acceptance letter from the ISED is maintained in our files. CAB Identifier No: HK0015, Site Registration Number: 26103.

4.6 Deviation from Standards

None

4.7 Abnormalities from Standard Conditions

None

5 Equipment List

Minimum 6dB Bandwidth, Conducted Peak Output Power, Power Spectrum Density, Conducted Band Edges Measurement, Conducted Spurious Emissions

Equipment	Manufacturer	Model No	Inventory No	Cal Date	Cal Due Date
SMBV100A VECTOR SIGNAL GENERATOR	Rohde & Schwarz	SMBV100A	E234	2020/08/31	2021/08/30
FSV40 SIGNAL ANALYZER 40GHz	Rohde & Schwarz	FSV40	E235	2020/08/31	2021/08/30
Wireless Conn. Tester (CMW)	Rohde & Schwarz	CMW270	E240	CAL IN USE	CAL IN USE
OSP	Rohde & Schwarz	OSP-B157W8	E242	2020/08/31	2021/08/30
Cable	Rohde & Schwarz	J12J103539-00-2	E239	2019/09/23	2020/09/22
WMS32 Test Software	R&S	Version 10	N/A	--	--

Radiated Spurious Emissions (30MHz-1GHz)

Equipment	Manufacturer	Model No	Inventory No	Cal Date	Cal Due Date
3m Semi-Anechoic Chamber	ChamPro	N/A	E229	2020/08/09	2021/08/08
Coaxial Cable	SGS	N/A	E167	2020/7/20	2021/7/19
EMI Test Receiver 9kHz to 3.6GHz	Rohde & Schwarz	ESR3 / 102326	E231	2019/09/02	2020/10/01
TRILOG Super Broadb. Test Antenna, (25) 30-1000 (2)	Schwarzbeck	VULB 9168	E264	2018/10/20	2020/10/19
Boresight Mast Controller	ChamPro	AM-BS-4500-E	E237	--	--
Turntable with Controller	ChamPro	EM1000	E238	--	--
EMC32 Test Software	R&S	Version 10	N/A	--	--

Radiated Spurious Emissions (above 1GHz)

Equipment	Manufacturer	Model No	Inventory No	Cal Date	Cal Due Date
3m Semi-Anechoic Chamber	ChamPro	N/A	E229	2020/08/09	2021/08/08
Coaxial Cable	SGS	N/A	E167	2020/07/20	2021/07/19
EMI Test Receiver 9kHz to 3.6GHz	Rohde & Schwarz	ESR3 / 102326	E231	2019/09/2	2020/10/01
Signal and Spectrum Analyzer 2Hz - 26.5GHz	Rohde & Schwarz	FSW26	E296	2019/10/29	2020/10/28
Spectrum Analyzer 9kHz - 30GHz	Rohde & Schwarz	FSP30	E204	2020/05/11	2021/05/10
Horn Antenna 1 - 18GHz	Schwarzbeck	BBHA9120D	E211	2020/01/30	2022/01/29
Horn Antenna 15 - 40GHz	Schwarzbeck	BBHA9170	E212	2020/01/30	2022/01/29

Preamplifier 33dB, 1 - 18GHz	Schwarzbeck	BBV9718	E214	2020/04/14	2021/04/12
Preamplifier 33dB, 18 - 26.5GHz	Schwarzbeck	BBV9719	E215	2019/04/24	2021/04/23
Broadband Coaxial Preamplifier typ. 30 dB, 18-40GHz	Schwarzbeck	BBV 9721	E266	2019/08/22	2020/09/21
Highpass Filter 3.5-26.5GHz	Wainwright	WHNX3.5/26.5 G-6SS	E205	2019/04/24	2021/04/23
Band Reject Filter 2.4-2.5GHz	Wainwright	WRCJV 2400/2500- 2100	E206	2019/04/24	2021/04/23
RF cable SMA to SMA 10000mm	HUBER+SUHNER	SF104- 26.5/2*11SMA 45	E207-1	2019/09/26	2020/09/25
Boresight Mast Controller	ChamPro	AM-BS-4500-E	E237	--	--
Turntable with Controller	ChamPro	EM1000	E238	--	--
EMC32 Test Software	R&S	Version 10	N/A	--	--

General used equipment					
Equipment	Manufacturer	Model No	Inventory No	Cal Date	Cal Due Date
Digital temperature & humidity data logger	SATO	SK-L200TH II	E232	2019/10/28	2020/10/27
Electronic Digital Thermometer with Hygrometer	nil	2074/2075	E159	2019/10/28	2020/10/27
Barometer with digital thermometer	SATO	7612-00	E218	2020/04/23	2021/04/22
Conditional Chamber	Zhong Zhi Testing Instruments	CZ-E-608D	E216	2020/8/31	2021/08/30

6 Radio Spectrum Technical Requirement

6.1 Antenna Requirement

6.1.1 Test Requirement:

47 CFR Part 15, Subpart C 15.203 & 15.247(b)(4)

6.1.2 Conclusion

Standard Requirement:

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.

15.247(b) (4) requirement:

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.

EUT Antenna:

The antenna is integrated on the main PCB and no consideration of replacement. The best case gain of the antenna is -1dBi.



Photo of antenna refer to Appendix – Internal photo.

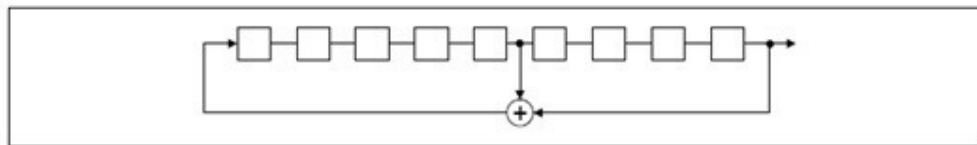
6.2 Pseudorandom Frequency Hopping Sequence

6.2.1 Test Requirement:

FCC Part 15 Subpart C Section 15.247(a)(1)

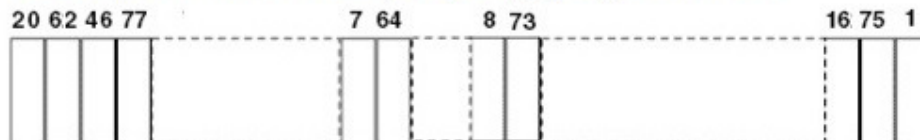
RSS-247 Section 5.1(a)

6.2.2 Test Setup Diagram



Linear Feedback Shift Register for Generation of the PRBS sequence

An example of Pseudorandom Frequency Hopping Sequence as follow:



6.2.3 Conclusion

Standard Requirement:

The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONES; i.e. the shift register is initialized with nine ones.

- Number of shift register stages: 9
- Length of pseudo-random sequence: $2^9 - 1 = 511$ bits
- Longest sequence of zeros: 8 (non-inverted signal)

Linear Feedback Shift Register for Generation of the PRBS sequence

An example of Pseudorandom Frequency Hopping Sequence as follow:

Each frequency used equally on the average by each transmitter.

According to Technical Specification, the receivers are designed to have input and IF bandwidths that match the hopping channel bandwidths of any transmitters and shift frequencies in synchronization with the transmitted signals.

According to Technical specification, the system incorporates with an adaptive system to detect other user within the spectrum band so that it individually and independently to avoid hopping on the occupied channels.

The system is designed not have the ability to coordinated with other FHSS System in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitter.

6.1 99% Bandwidth

Test Requirement RSS-Gen Section 6.7
Test Method: ANSI C63.10 Section 6.9.3

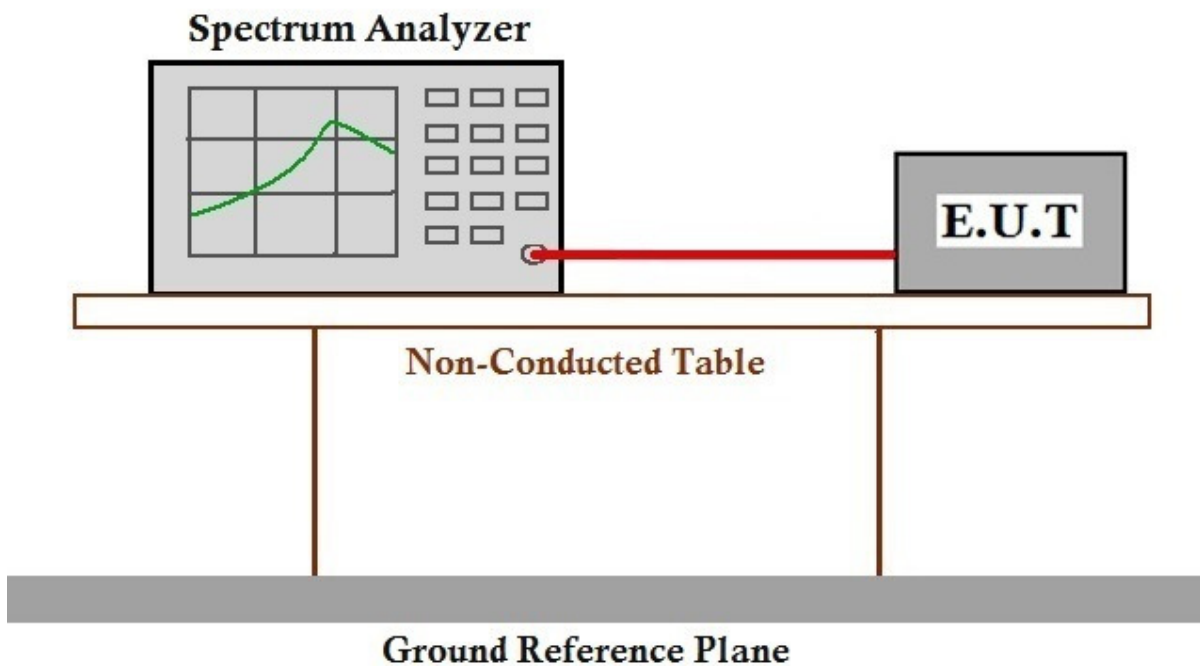
6.1.1 E.U.T. Operation

Operating Environment:

Temperature: 22.5 °C Humidity: 51.2 % RH :

Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

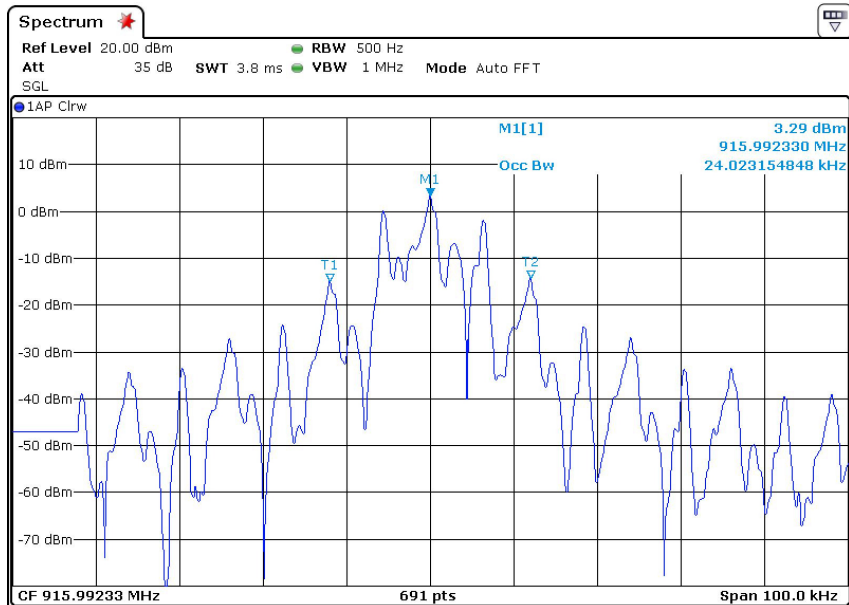
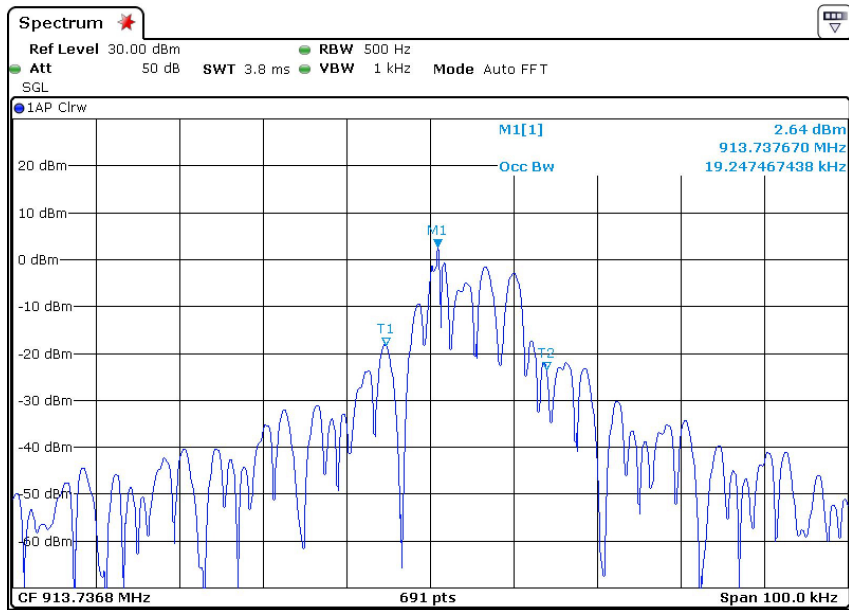
6.1.2 Test Setup Diagram



6.1.3 Measurement Procedure and Data

DUT Frequency (MHz)	Bandwidth (kHz)	Limit (MHz)	Result
913.74	19.2	---	PASS
916.30	24.0	---	PASS

Test plots:



6.2 Conducted Peak Output Power

Test Requirement 47 CFR Part 15, Subpart C 15.247:2019(b)(1) & 15.247(b)(3), RSS-247 Section 5.4(b)

Test Method: ANSI C63.10 (2013) Section 7.8.5

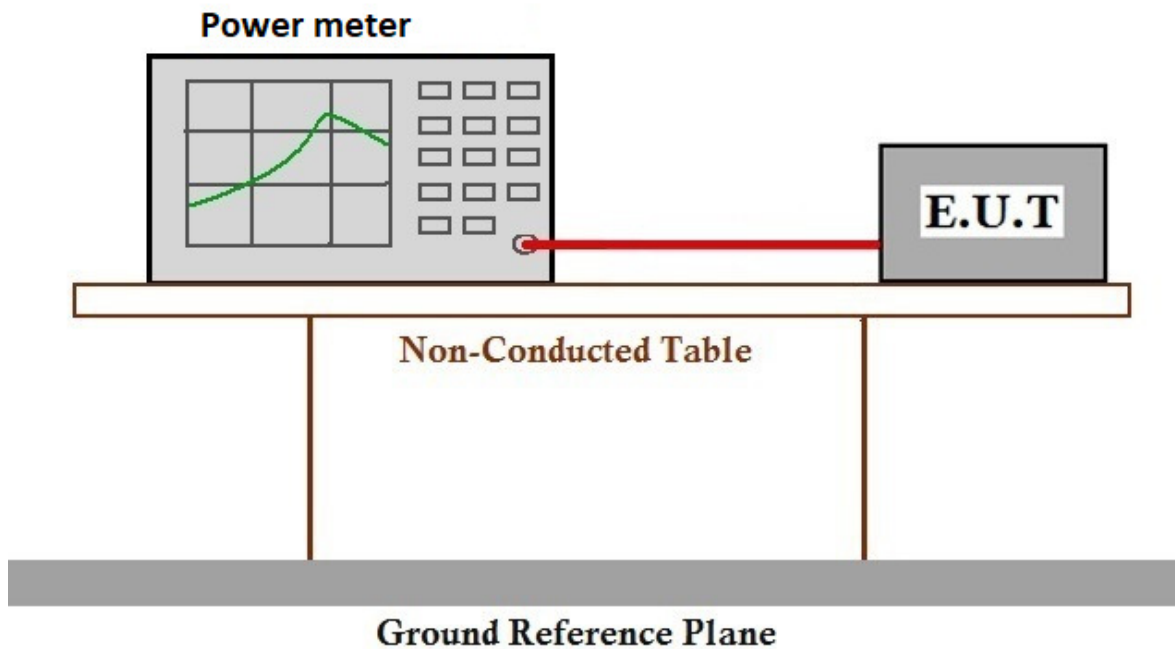
6.2.1 E.U.T. Operation

Operating Environment:

Temperature: 22.5 °C Humidity: 51.2 % RH :

Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

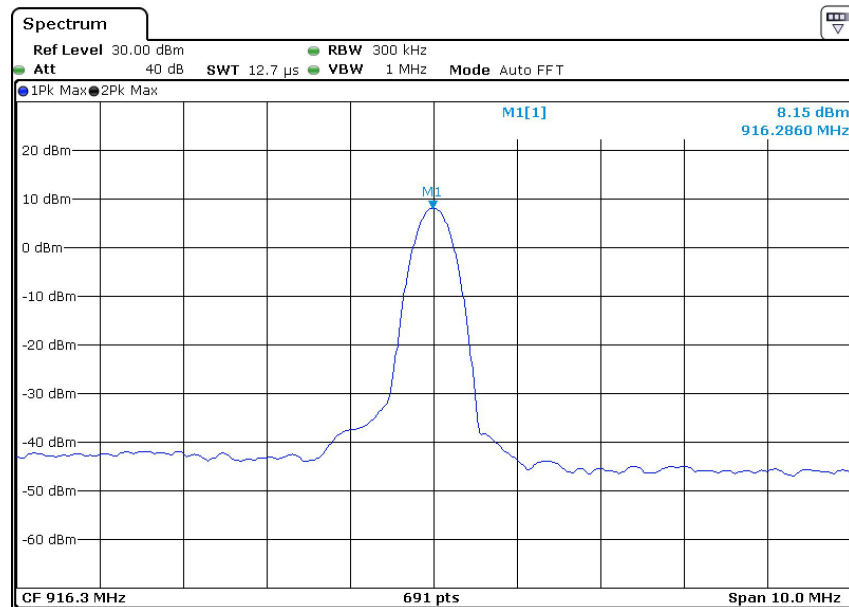
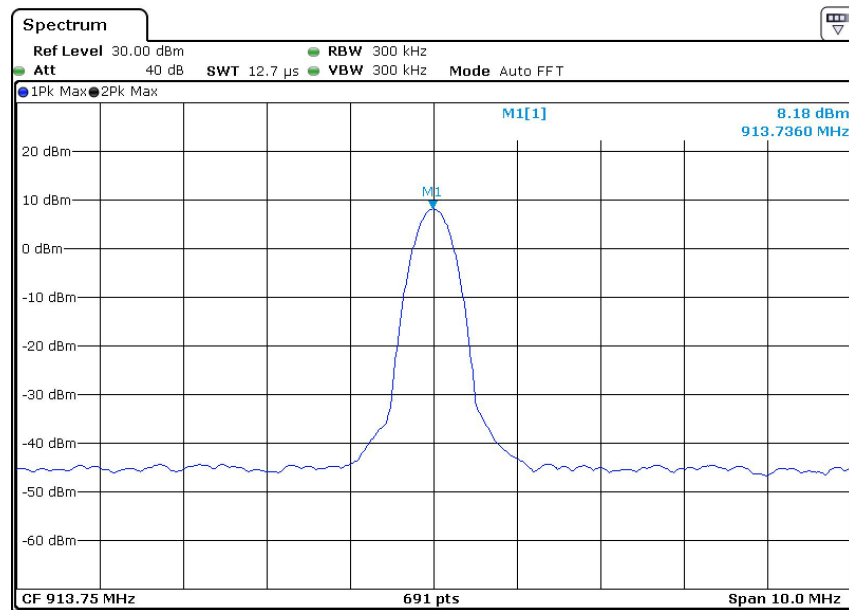
6.2.2 Test Setup Diagram



6.2.3 Measurement Procedure and Data

DUT Frequency (MHz)	Peak Power (dBm)	Limit Max (dBm)	Result
913.75	8.2	30.0	PASS
916.30	8.2	30.0	PASS

Test plots:



6.3 20dB Bandwidth

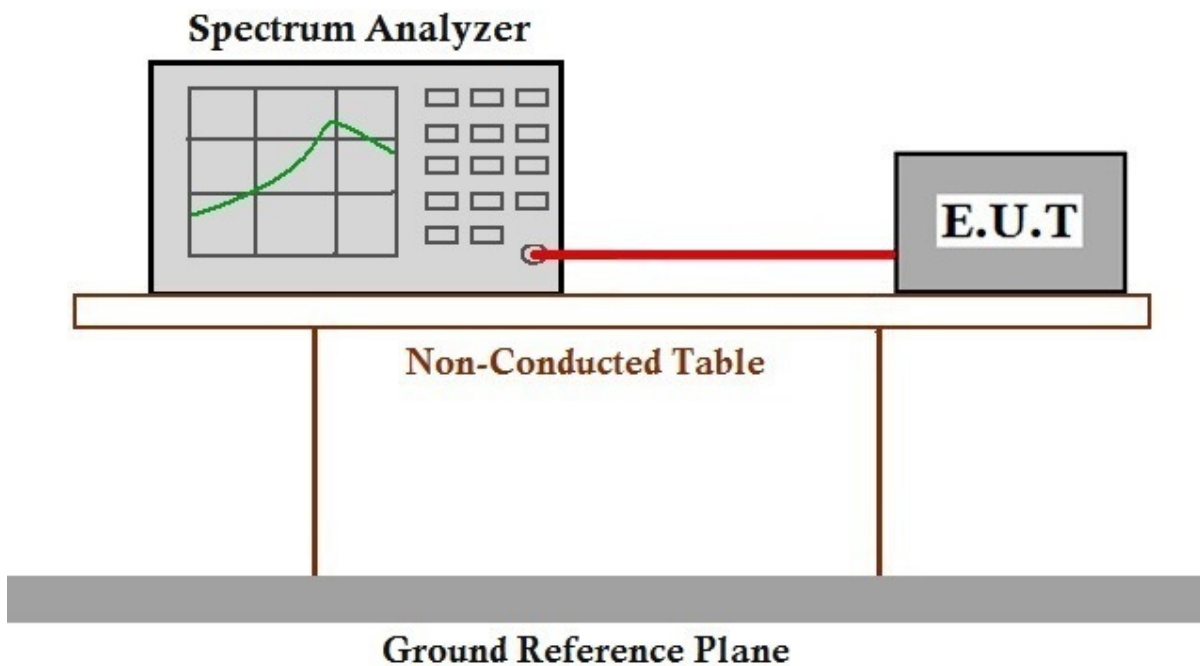
Test Requirement 47 CFR Part 15, Subpart C 15.215, RSS-247 Section 5.1(a)
Test Method: ANSI C63.10 Section 6.9.2

6.3.1 E.U.T. Operation

Operating Environment:

Temperature: 23.1 °C Humidity: 51.2 % RH :

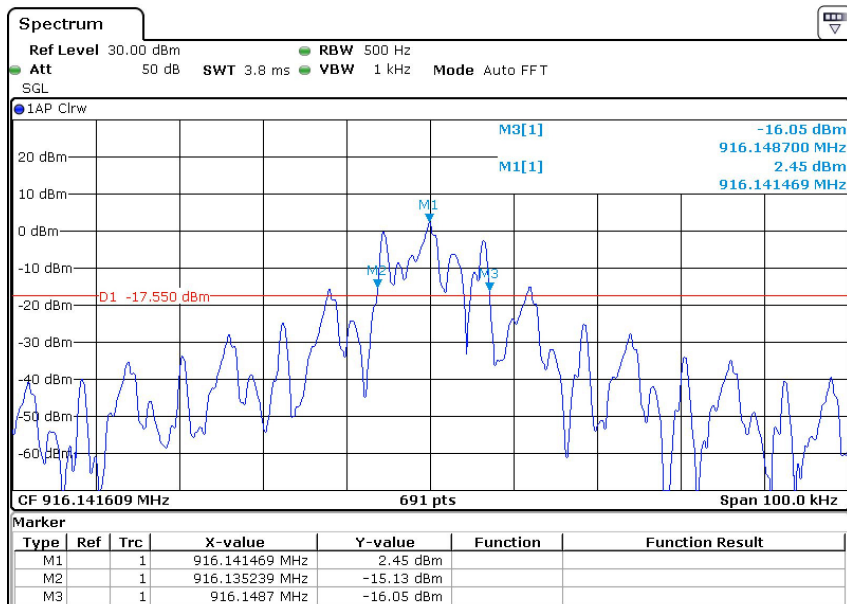
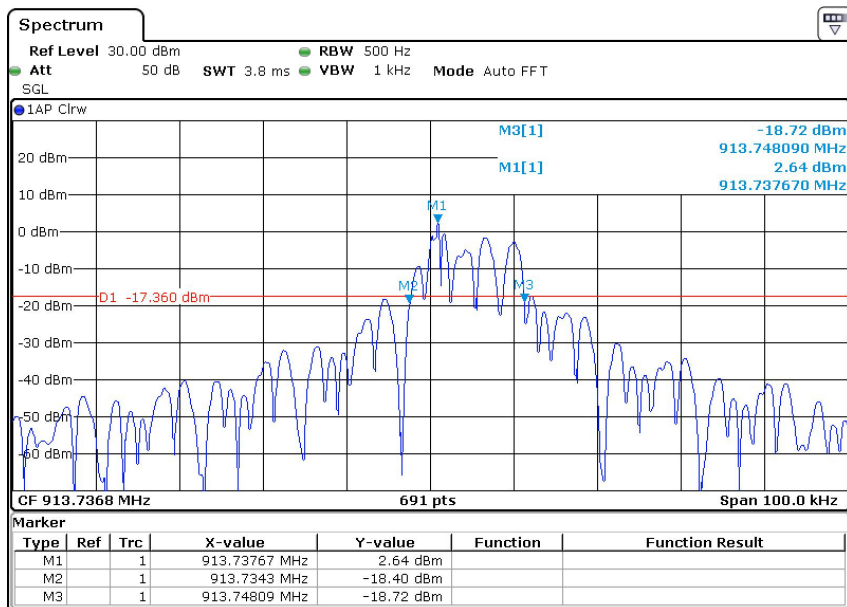
Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

6.3.2 Test Setup Diagram

6.3.3 Measurement Procedure and Data

DUT Frequency (MHz)	Bandwidth (kHz)	Limit (MHz)	Result
913.75	13.8	---	PASS
916.30	13.5	---	PASS

Test plots:



6.4 Carrier Frequencies Separation

Test Requirement 47 CFR Part 15, Subpart C 15.247:2019a(1), RSS-247 Section 5.1(b)
Test Method: ANSI C63.10 (2013) Section 7.8.2
Limit: 2/3 of the 20dB bandwidth base on the transmission power is less than 0.125W

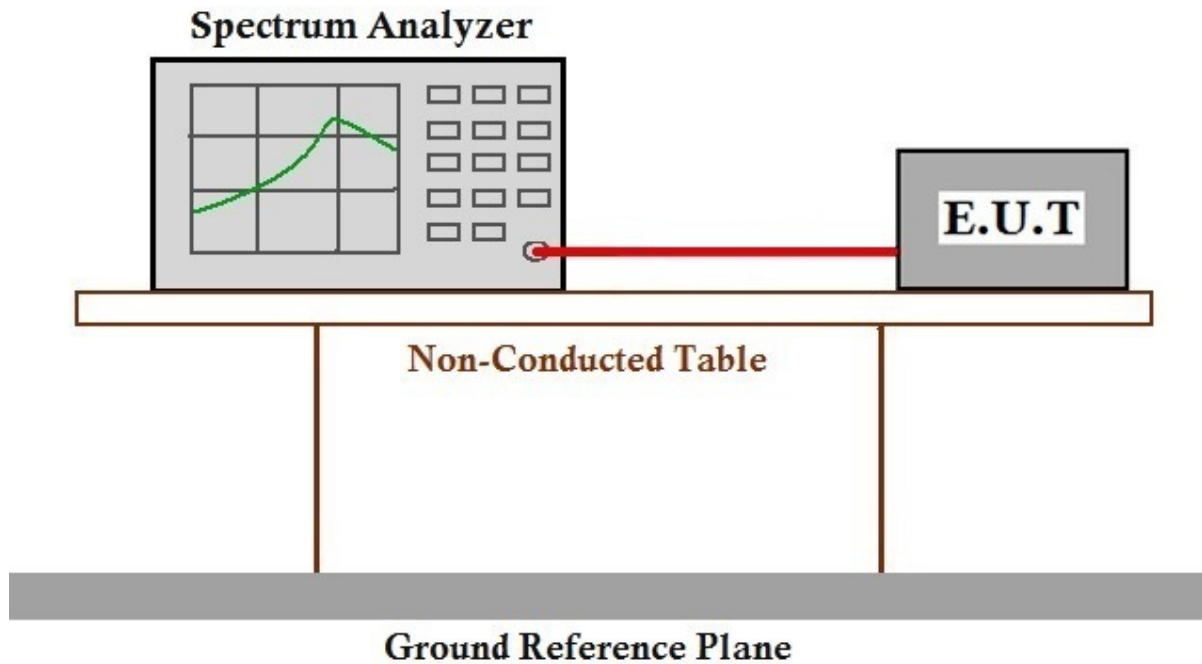
6.4.1 E.U.T. Operation

Operating Environment:

Temperature: 22.5 °C Humidity: 51.2 ± 1 % RH :

Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

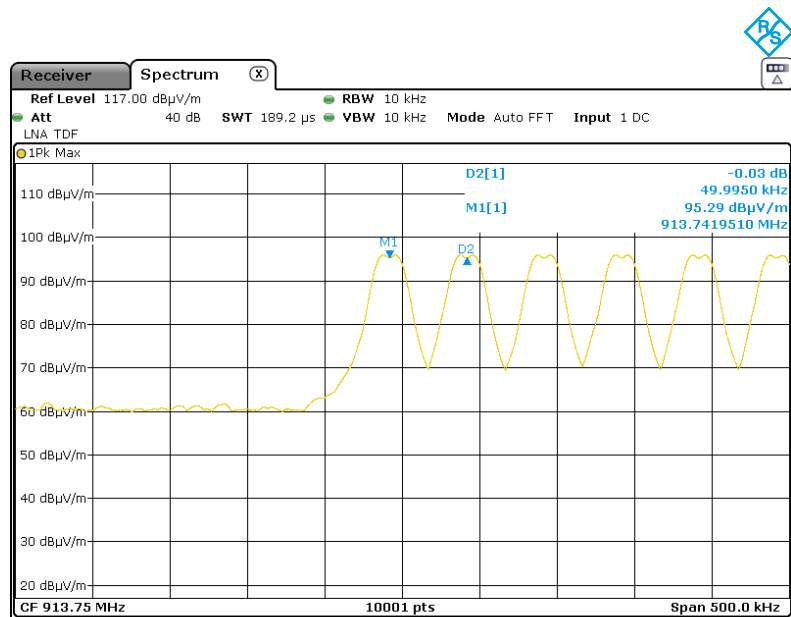
6.4.2 Test Setup Diagram



6.4.3 Measurement Procedure and Data

DUT Frequency (MHz)	Frequency Separation (kHz)	Limit (kHz)	Result
913.741951	50.0	13.7	PASS

Remark: Limit = $2/3 \times 20\text{dB Bandwidth}$



6.5 Hopping Channel Number

Test Requirement 47 CFR Part 15, Subpart C 15.247:2019a(1)(iii), RSS-247 Section 5.1(d)

Test Method: ANSI C63.10 (2013) Section 7.8.3

Limit:

Frequency range(MHz)	Number of hopping channels (minimum)
902-928	50 for 20dB bandwidth <250kHz
	25 for 20dB bandwidth ≥250kHz
2400-2483.5	15
5725-5850	75

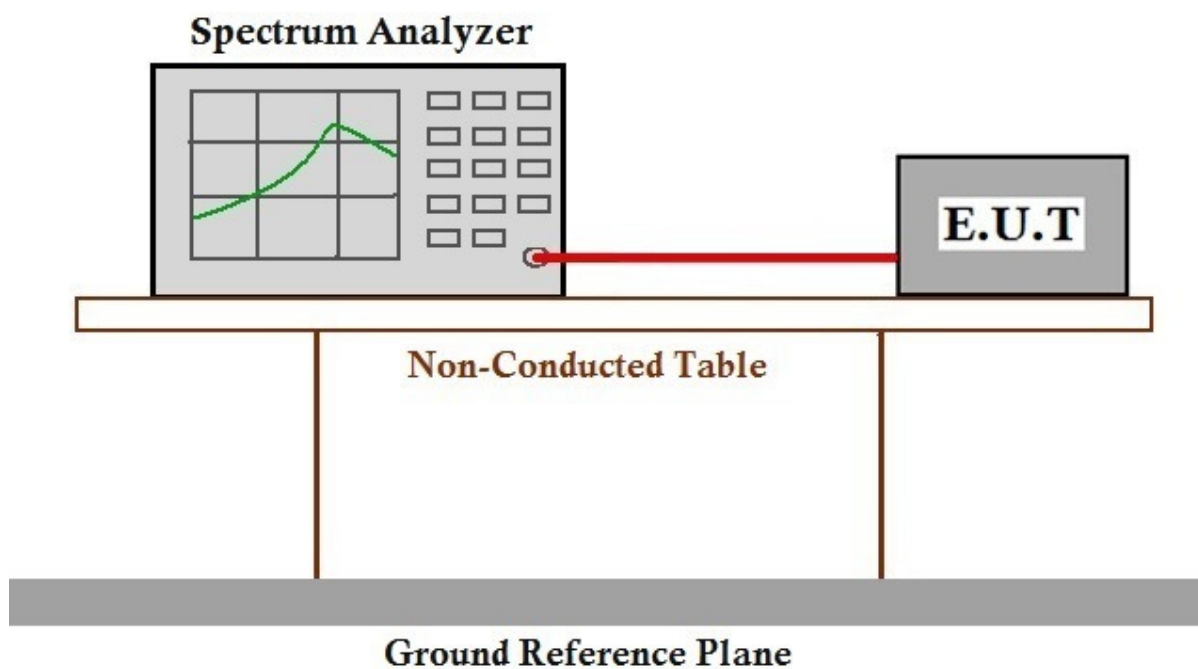
6.5.1 E.U.T. Operation

Operating Environment:

Temperature: 22.5 °C Humidity: 51.2 % RH :

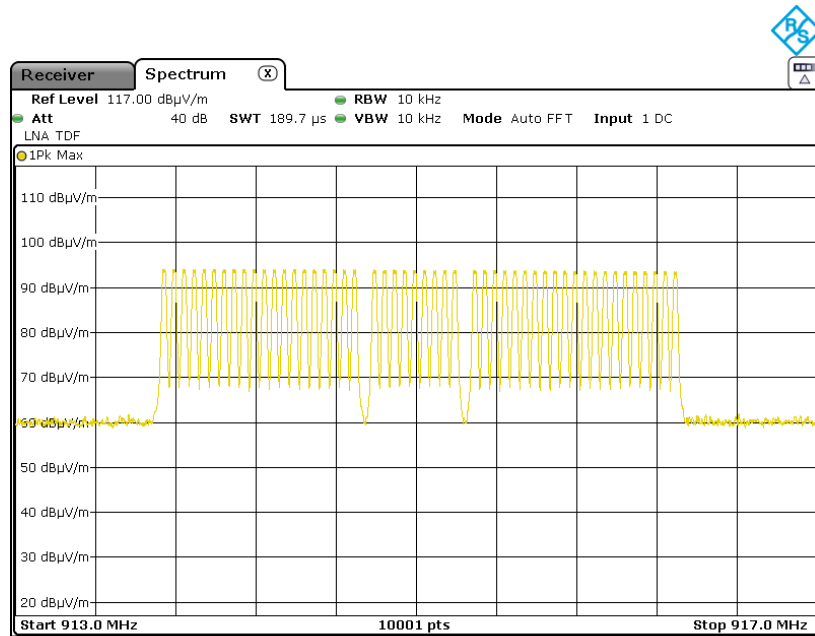
Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

6.5.2 Test Setup Diagram



6.5.3 Measurement Procedure and Data

Channels	Limit Min	Result
50	50	PASS



6.6 Dwell Time

Test Requirement 47 CFR Part 15, Subpart C 15.247:2019a(1)(iii), RSS-247 Section 5.1(d)
Test Method: ANSI C63.10 (2013) Section 7.8.4
Limit:

Frequency(MHz)	Limit
902-928	0.4S within a 20S period(20dB bandwidth<250kHz)
	0.4S within a 10S period(20dB bandwidth≥250kHz)
2400-2483.5	0.4S within a period of 0.4S multiplied by the number of hopping channels
5725-5850	0.4S within a 30S period

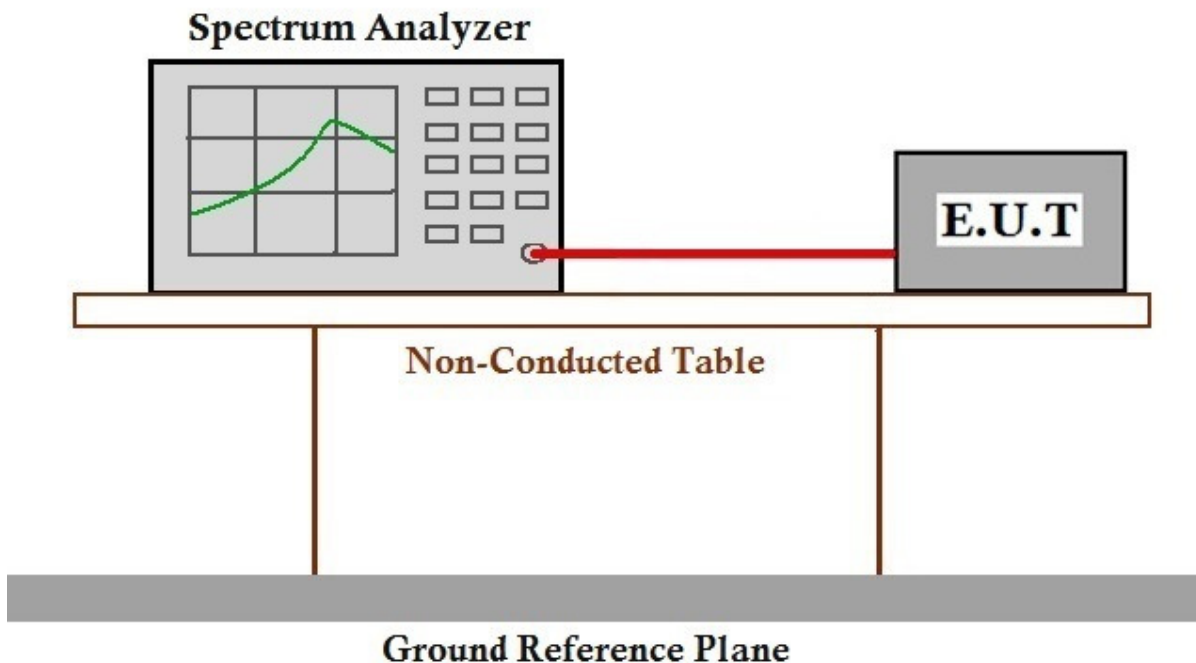
6.6.1 E.U.T. Operation

Operating Environment:

Temperature: 22.5 °C Humidity: 51.2 % RH :

Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

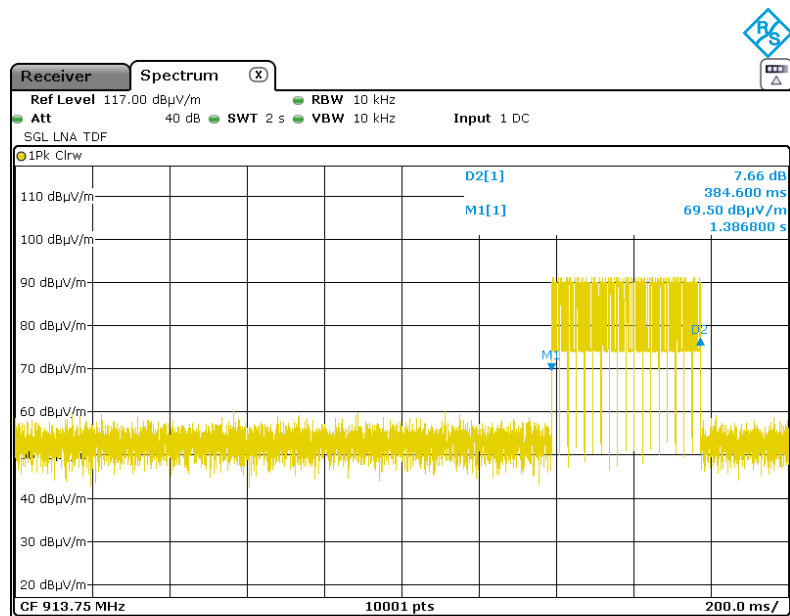
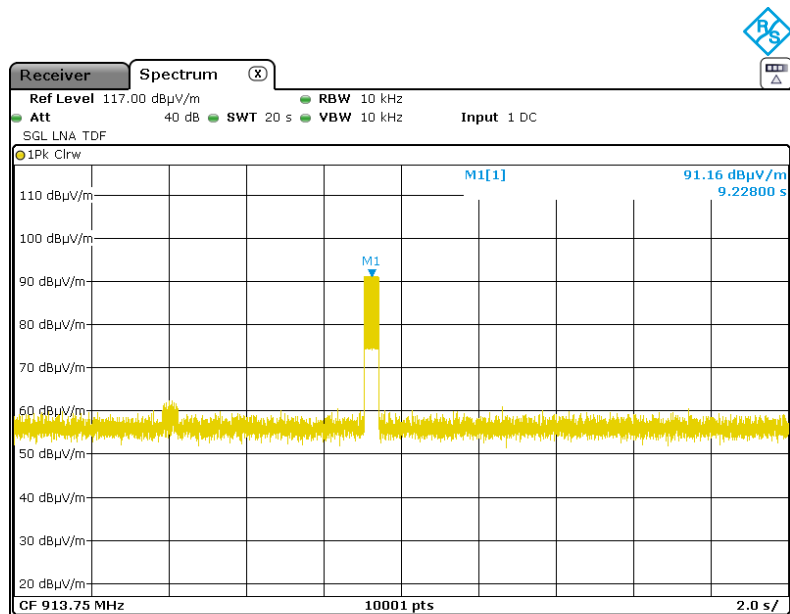
6.6.2 Test Setup Diagram



6.6.3 Measurement Procedure and Data

Channel (MHz)	Width of Burst (ms)	Number of Burst (s)	Measurement Time (s)	Dwell Time (ms)	Limit (ms)	Result
913.75	2.34	1	20	384.6	≤400	Pass

*Remark: the channel shown is the worst case.



6.7 Conducted Band Edges Measurement

Test Requirement	47 CFR Part 15, Subpart C 15.247:2019(d), RSS-247 Section 5.5
Test Method:	ANSI C63.10 (2013) Section 7.8.6
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c))

FCC Part 15 C Section 15.205 Restricted bands of operation.

(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	2655 - 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	
13.36 - 13.41			

RSS-Gen Section 8.10 Restricted bands of operation.

Restricted frequency bands, identified in table 7, are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following conditions related to the restricted frequency bands apply:

(a) The transmit frequency, including fundamental components of modulation, of licence-exempt radio

apparatus shall not fall within the restricted frequency bands listed in table 7 except for apparatus compliant with RSS-287, *Emergency Position Indicating Radio Beacons (EPIRB)*, *Emergency Locator Transmitters (ELT)*, *Personal Locator Beacons (PLB)*, and *Maritime Survivor Locator Devices (MSLD)*.

(b) Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table 5 and table 6.

(c) Unwanted emissions that do not fall within the restricted frequency bands listed in table 7 shall comply either with the limits specified in the applicable RSS or with those specified in table 5 and table 6.

Table 7 – Restricted frequency bands* MHz	MHz	GHz
0.090 - 0.110	149.9 - 150.05	9.0 - 9.2
0.495 - 0.505	156.52475 - 156.52525	9.3 - 9.5
2.1735 - 2.1905	156.7 - 156.9	10.6 - 12.7
3.020 - 3.026	162.0125 - 167.17	13.25 - 13.4
4.125 - 4.128	167.72 - 173.2	14.47 - 14.5
4.17725 - 4.17775	240 - 285	15.35 - 16.2
4.20725 - 4.20775	322 - 335.4	17.7 - 21.4
5.677 - 5.683	399.9 - 410	22.01 - 23.12
6.215 - 6.218	608 - 614	23.6 - 24.0
6.26775 - 6.26825	960 - 1427	31.2 - 31.8
6.31175 - 6.31225	1435 - 1626.5	36.43 - 36.5
8.291 - 8.294	1645.5 - 1646.5	Above 38.6
8.362 - 8.366	1660 - 1710	* Certain frequency bands listed in table 7 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.
8.37625 - 8.38675	1718.8 - 1722.2	
8.41425 - 8.41475	2200 - 2300	
12.29 - 12.293	2310 - 2390	
12.51975 - 12.52025	2483.5 - 2500	
12.57675 - 12.57725	2655 - 2900	
13.36 - 13.41	3260 - 3267	
16.42 - 16.423	3332 - 3339	
16.69475 - 16.69525	3345.8 - 3358	
16.80425 - 16.80475	3500 - 4400	
25.5 - 25.67	4500 - 5150	
37.5 - 38.25	5350 - 5460	
73 - 74.6	7250 - 7750	
74.8 - 75.2	8025 - 8500	
108 - 138	--	

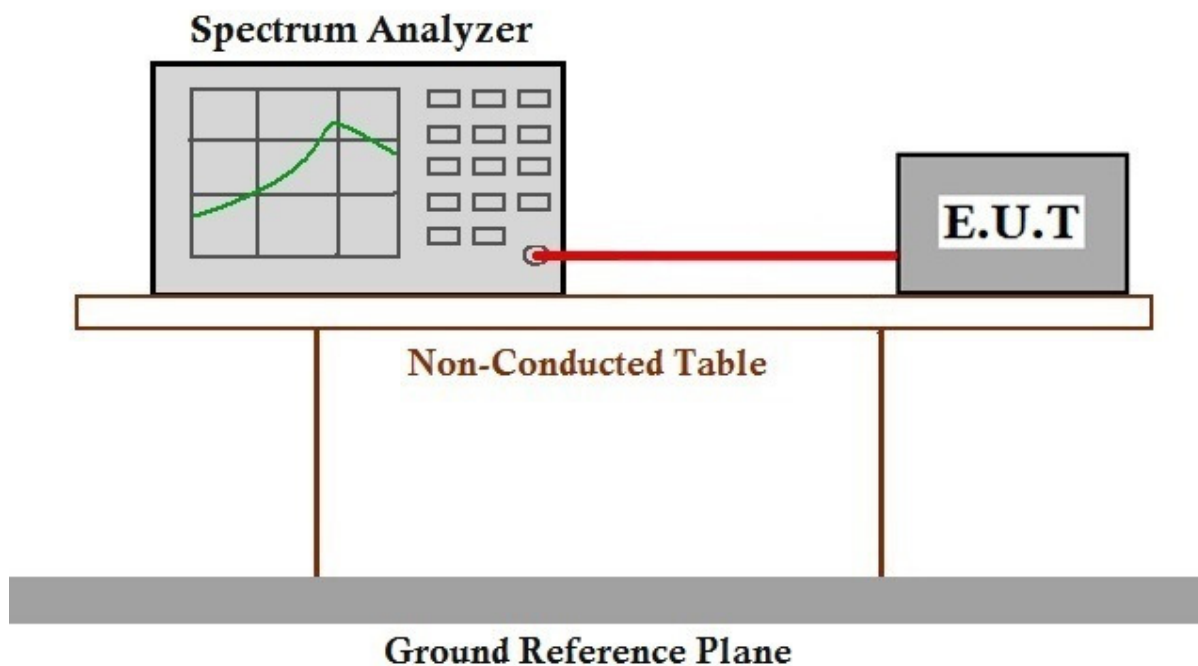
6.7.1 E.U.T. Operation

Operating Environment:

Temperature: 22.5 °C Humidity: 51.1 % RH :

Test mode a:TX_Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

6.7.2 Test Setup Diagram



6.7.3 Measurement Procedure and Data

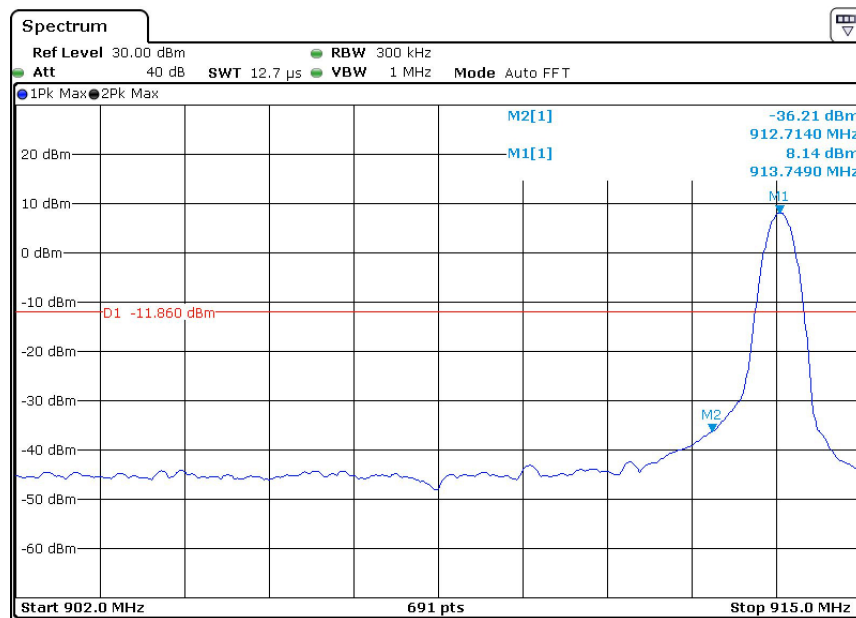
Non-hopping mode

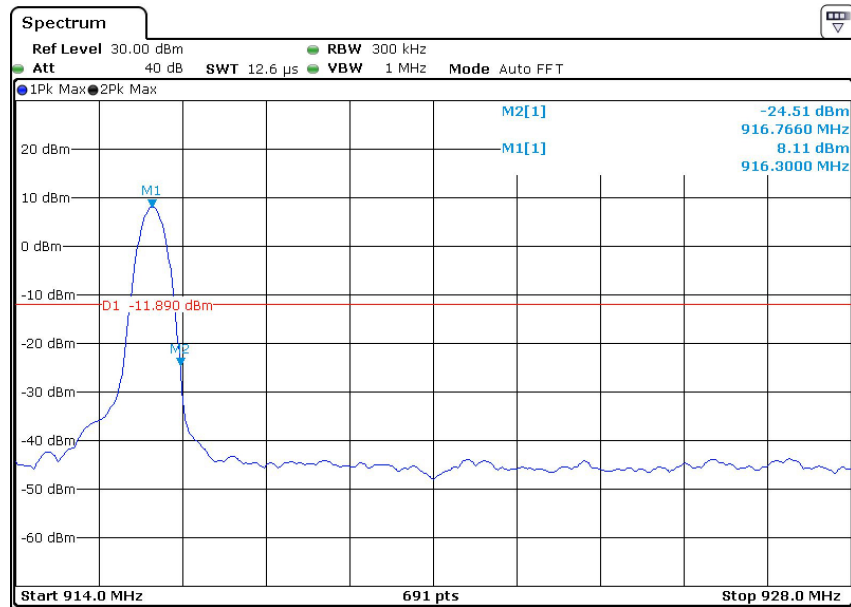
Inband Peak

Frequency (MHz)	Level (dBm)
913.749000	8.14
916.760000	8.11

Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
912.714000	-36.2	-11.8	-24.4	PASS
916.300000	-24.5	-11.9	-12.6	PASS

Remark: Limit = Inband peak – 20dB





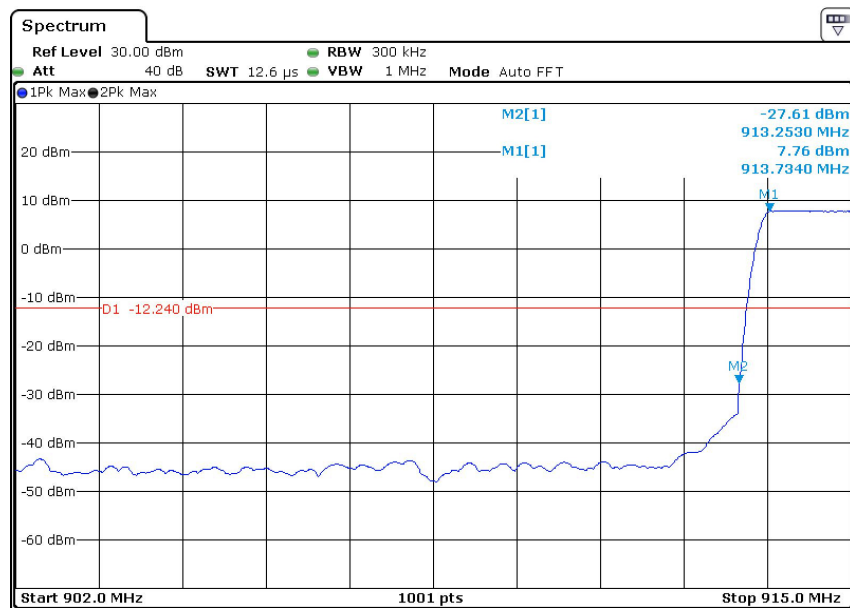
Hopping mode

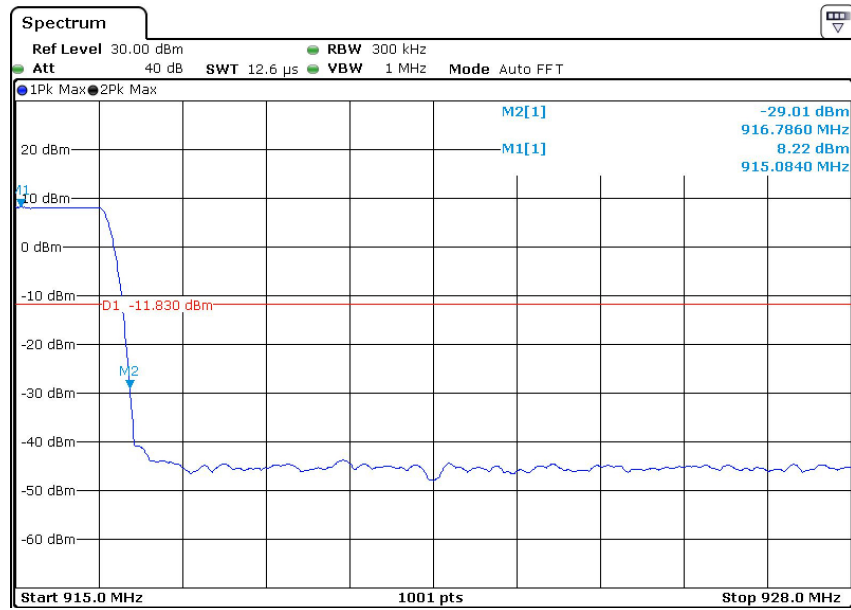
Inband Peak

Frequency (MHz)	Level (dBm)
913.734000	7.76
915.048000	8.22

Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
913.253000	-27.6	-12.2	-15.4	PASS
916.786000	-29.0	-11.8	-17.2	PASS

Remark: Limit = Inband peak – 20dB





6.8 Radiated Emissions which fall in the restricted bands

Test Requirement 47 CFR Part 15, Subpart C 15.209 & 15.247(d), Section 3.3 & RSS-Gen Section 8.10
Test Method: ANSI C63.10 (2013) Section 6.10.5
Limit:

Table 5 – General field strength limits at frequencies above 30 MHz

Frequency (MHz)	Field strength (μ V/m at 3 m)
30 - 88	100
88 - 216	150
216 - 960	200
Above 960	500

Table 6 – General field strength limits at frequencies below 30 MHz

Frequency	Magnetic field strength (H-Field) (μ A/m)	Measurement distance (m)
9 - 490 kHz 1	6.37/F (F in kHz)	300
490 - 1705 kHz	63.7/F (F in kHz)	30
1.705 - 30 MHz	0.08	30

Note 1: The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector.

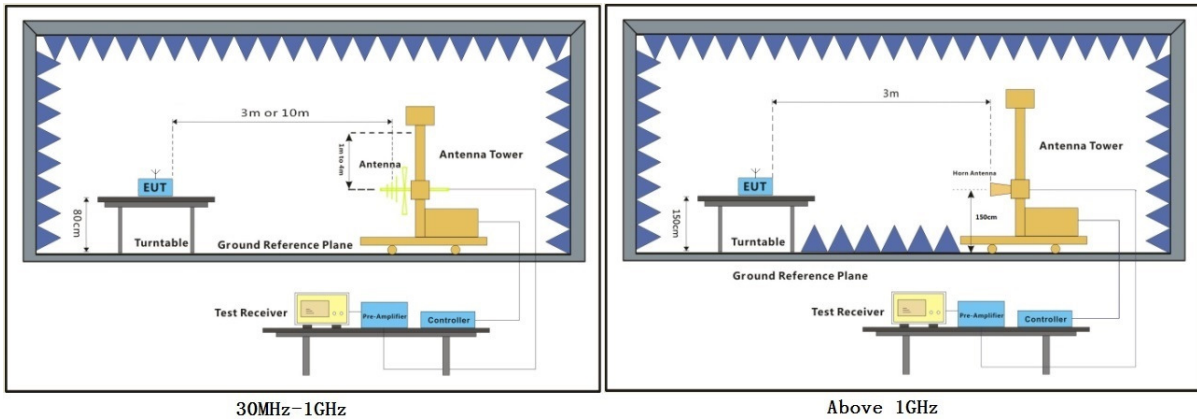
6.8.1 E.U.T. Operation

Operating Environment:

Temperature: 23.1 °C Humidity: 51.4 % RH :

Test mode a:TX Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

6.8.2 Test Setup Diagram



6.8.3 Measurement Procedure and Data

- a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter fully-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- d. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- e. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
- g. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- h. Test the EUT in the lowest channel, the middle channel, the Highest channel.
- i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.
- j. Repeat above procedures until all frequencies measured was complete.

Remark 1: Level= Read Level+ Cable Loss+ Antenna Factor- Preamp Factor

Remark 2: For frequencies above 1GHz, the field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For the emissions whose peak level is lower than the average limit, only the peak measurement is shown in the report.

6.8.4 Measurement Procedure and data

Frequency (MHz)	Antenna Polarization	Emission Level (dBμV/m)		Limit (dBμV/m)		Remark
		Peak	Average	Peak	Average	
902.000	H	31.7	/	74.0	54.0	Pass
928.000	H	31.9	/	74.0	54.0	Pass
902.000	V	26.4	/	74.0	54.0	Pass
928.000	V	27.0	/	74.0	54.0	Pass

6.9 Radiated Spurious Emissions

Test Requirement Section 3.3 & RSS-Gen Section 8.9
Test Method: ANSI C63.10 (2013) Section 6.4&6.5&6.6
Limit:

Table 5 – General field strength limits at frequencies above 30 MHz

Frequency (MHz)	Field strength (μ V/m at 3 m)
30 – 88	100
88 – 216	150
216 – 960	200
Above 960	500

Table 6 – General field strength limits at frequencies below 30 MHz

Frequency	Magnetic field strength (H-Field) (μ A/m)	Measurement distance (m)
9 - 490 kHz 1	6.37/F (F in kHz)	300
490 - 1705 kHz	63.7/F (F in kHz)	30
1.705 - 30 MHz	0.08	30

Note 1: The emission limits for the ranges 9-90 kHz and 110-490 kHz are based on measurements employing a linear average detector.

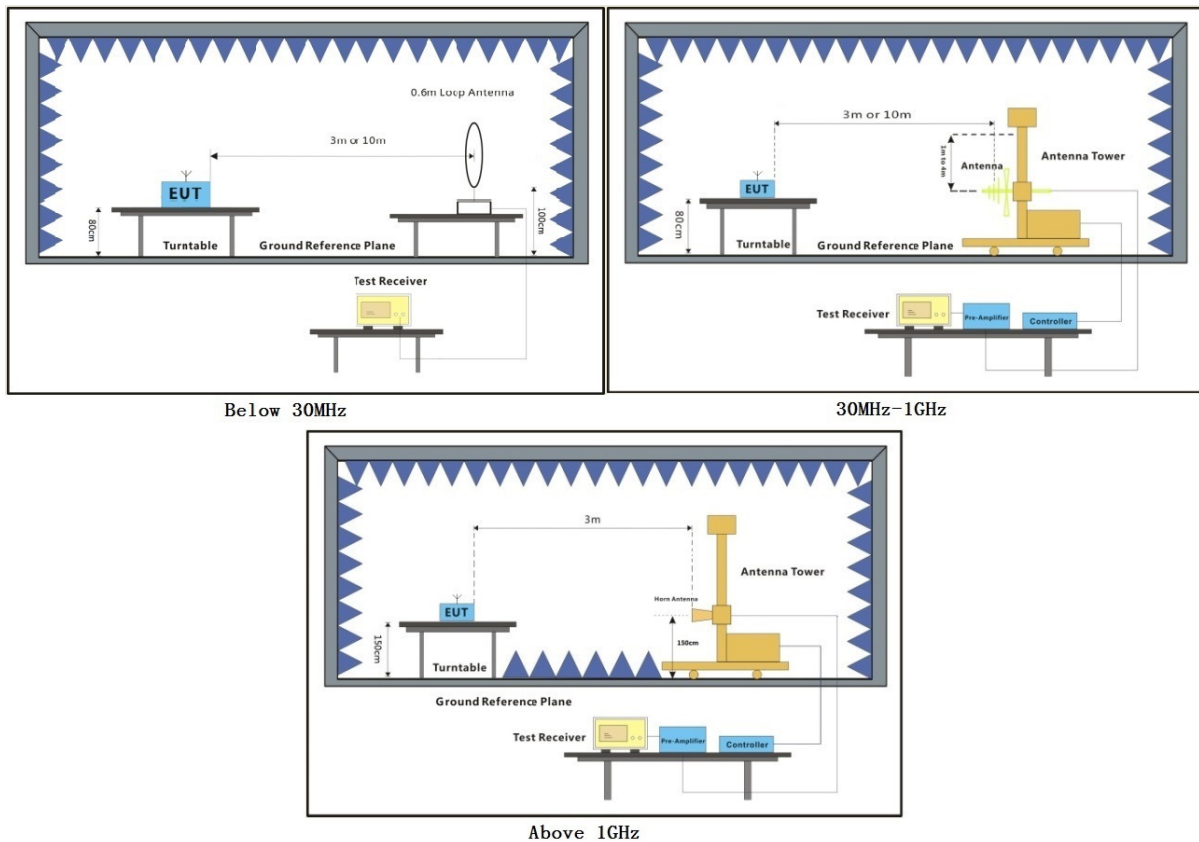
6.9.1 E.U.T. Operation

Operating Environment:

Temperature: 22.3 °C Humidity: 52.3 % RH :

Test mode a:TX Keep the EUT transmitted the continuous modulation test signal at the specific channel(s).

6.9.2 Test Setup Diagram



6.9.3 Measurement Procedure and Data

- a. For below 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 or 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. For above 1GHz, the EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter fully-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- c. The EUT was set 3 or 10 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- d. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- e. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading.
- f. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
- g. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.
- h. Test the EUT in the lowest channel, the middle channel, the Highest channel.
- i. The radiation measurements are performed in X, Y, Z axis positioning for Transmitting mode, and found the X axis positioning which it is the worst case.
- j. Repeat above procedures until all frequencies measured was complete.

Remark:

- 1) For emission below 1GHz, through pre-scan found the worst case is the lowest channel. Only the worst case is recorded in the report.
- 2) The field strength is calculated by adding the Antenna Factor, Cable Factor & Preamplifier. The basic equation with a sample calculation is as follows:
Final Test Level = Receiver Reading + Antenna Factor + Cable Factor – Preamplifier Factor
- 3) Scan from 9kHz to 25GHz, the disturbance above 18GHz and below 30MHz was very low. The points marked on above plots are the highest emissions could be found when testing, so only above points had been displayed. The amplitude of spurious emissions from the radiator which are attenuated more than 20dB below the limit need not be reported.
- 4) For frequencies above 1GHz, the field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For the emissions whose peak level is lower than the average limit, only the peak measurement is shown in the report.

Remark:

1. For radiated emission test: Correction Factor = Antenna Factor + Cable Loss.
2. For conducted emission test: Correction Factor = LISN Factor + Cable Loss.
3. Margin = Limit – Reading
4. Pol = Polarization

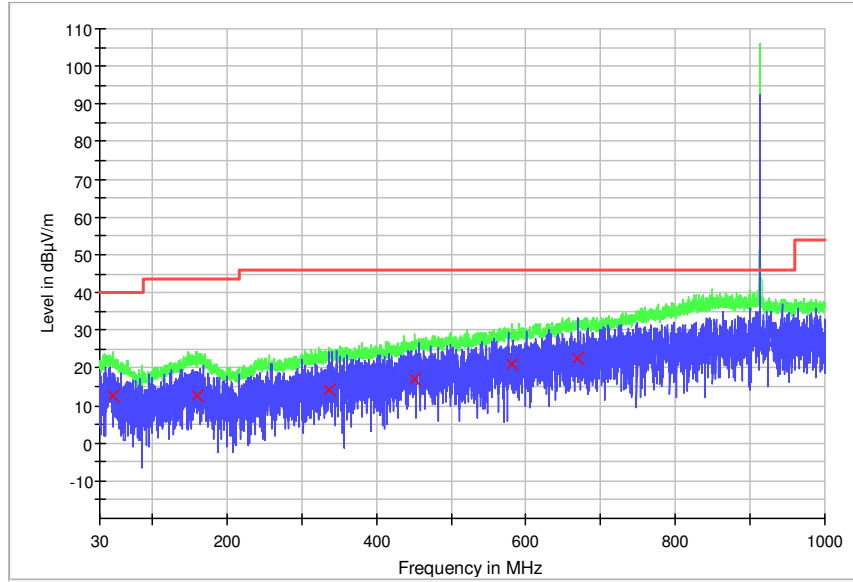
Radiated emission below 1GHz

Mode:a;

913.75MHz

Polarization: Horizontal

Quasi-peak measurement:



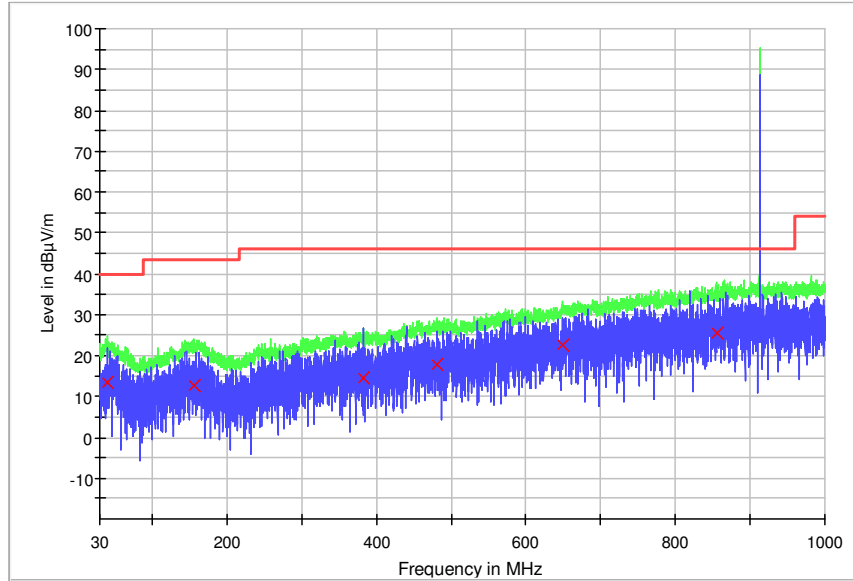
Frequency (MHz)	QuasiPeak (dBμV/m)	Pol.	Corr. (dB/m)	Margin (dB)	Limit (dBμV/m)	Result
47.230000	12.7	H	14.3	27.3	40.0	Pass
160.135000	12.6	H	14.6	30.9	43.5	Pass
337.292500	14.1	H	15.6	32.0	46.0	Pass
451.270000	17.1	H	18.3	28.9	46.0	Pass
580.945000	20.8	H	21.1	25.3	46.0	Pass
668.597500	22.6	H	23.3	23.4	46.0	Pass

Mode:a;

913.75MHz

Polarization: Vertical

Quasi-peak measurement:



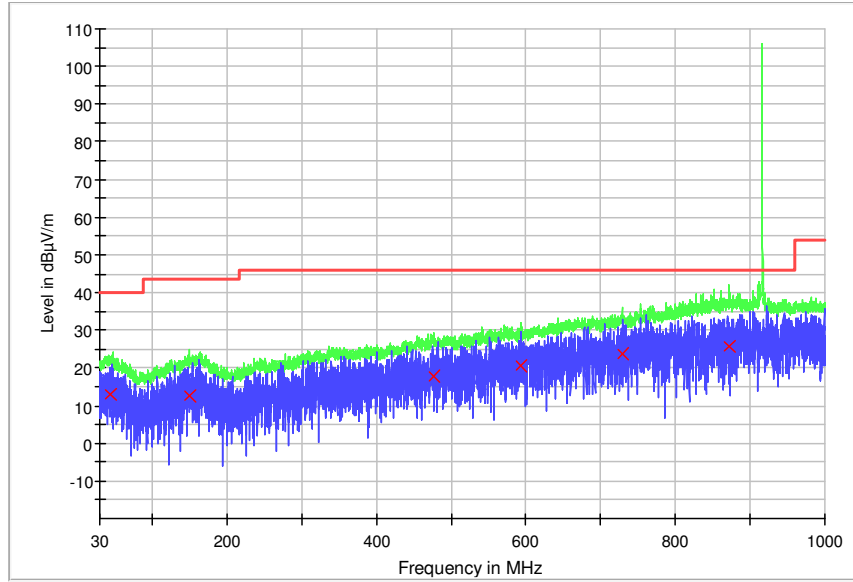
Frequency (MHz)	QuasiPeak (dBμV/m)	Pol.	Corr. (dB/m)	Margin (dB)	Limit (dBμV/m)	Result
39.720000	13.3	V	14.6	26.7	40.0	Pass
156.820000	12.8	V	14.7	30.7	43.5	Pass
382.532500	14.7	V	16.2	31.3	46.0	Pass
480.325000	17.7	V	19.0	28.3	46.0	Pass
649.682500	22.4	V	22.8	23.6	46.0	Pass
854.725000	25.4	V	25.9	20.6	46.0	Pass

Mode:a;

916.30MHz

Polarization: Horizontal

Quasi-peak measurement:



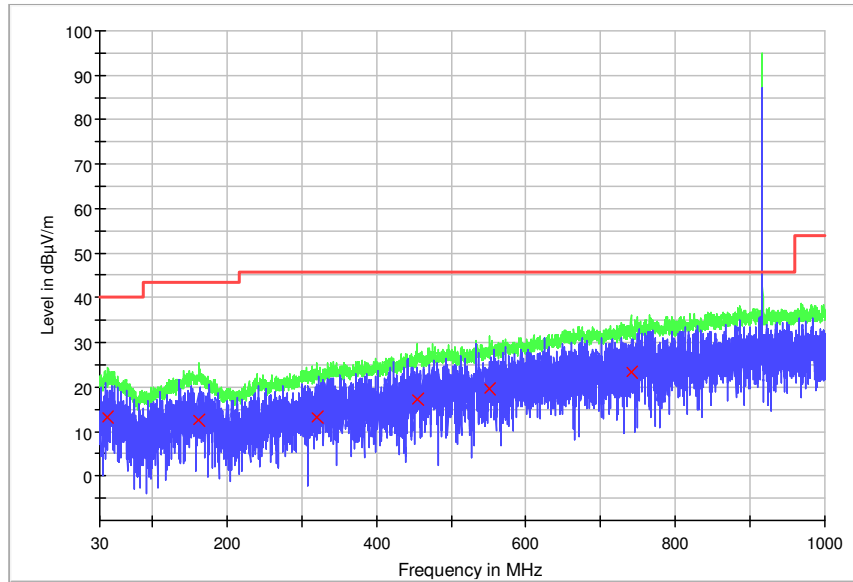
Frequency (MHz)	QuasiPeak (dBμV/m)	Pol.	Corr. (dB/m)	Margin (dB)	Limit (dBμV/m)	Result
43.330000	13.1	H	14.5	26.9	40.0	Pass
150.970000	12.6	H	14.5	30.9	43.5	Pass
477.302500	17.7	H	18.9	28.3	46.0	Pass
592.645000	20.5	H	21.2	25.5	46.0	Pass
728.462500	23.8	H	23.8	22.2	46.0	Pass
871.202500	25.8	H	26.2	20.2	46.0	Pass

Mode:a;

916.30MHz

Polarization: Vertical

Quasi-peak measurement:



Frequency (MHz)	QuasiPeak (dBμV/m)	Pol.	Corr. (dB/m)	Margin (dB)	Limit (dBμV/m)	Result
40.990000	13.1	V	14.4	26.9	40.0	Pass
161.597500	12.7	V	14.5	30.8	43.5	Pass
319.937500	13.2	V	14.9	32.8	46.0	Pass
455.170000	17.2	V	18.4	28.8	46.0	Pass
551.792500	19.7	V	20.4	26.3	46.0	Pass
740.552500	23.1	V	24.1	22.9	46.0	Pass

Above 1GHz

Channel: Low

Frequency (MHz)	Antenna Polarization	Emission Level (dB μ V/m)		Limit (dB μ V/m)		Remark
		Peak	Average	Peak	Average	
1827.250	H	50.3	49.6	74.0	54.0	Pass
2741.500	H	48.5	46.0	74.0	54.0	Pass
3655.000	H	49.6	44.8	74.0	54.0	Pass
3094.000	H	43.2	30.2	74.0	54.0	Pass
5103.000	H	48.5	34.7	74.0	54.0	Pass
6330.500	H	50.7	36.8	74.0	54.0	Pass

Frequency (MHz)	Antenna Polarization	Emission Level (dB μ V/m)		Limit (dB μ V/m)		Remark
		Peak	Average	Peak	Average	
1284.625	V	35.1	21.7	74.0	54.0	Pass
1827.625	V	40.9	36.0	74.0	54.0	Pass
2195.125	V	37.0	23.5	74.0	54.0	Pass
2778.250	V	38.0	24.8	74.0	54.0	Pass
4169.500	V	45.2	31.8	74.0	54.0	Pass
5618.500	V	47.6	34.0	74.0	54.0	Pass

Channel: High

Frequency (MHz)	Antenna Polarization	Emission Level (dB μ V/m)		Limit (dB μ V/m)		Remark
		Peak	Average	Peak	Average	
1364.500	H	35.2	22.2	74.0	54.0	Pass
1832.500	H	59.6	59.1	74.0	54.0	Pass
2749.000	H	49.4	47.2	74.0	54.0	Pass
3665.125	H	50.1	45.3	74.0	54.0	Pass
4583.000	H	46.9	33.7	74.0	54.0	Pass
5497.500	H	47.3	33.5	74.0	54.0	Pass

Frequency (MHz)	Antenna Polarization	Emission Level (dB μ V/m)		Limit (dB μ V/m)		Remark
		Peak	Average	Peak	Average	
1270.375	V	35.3	22.0	74.0	54.0	Pass
1561.375	V	35.7	22.1	74.0	54.0	Pass
1832.125	V	41.7	36.7	74.0	54.0	Pass
2608.000	V	36.9	23.8	74.0	54.0	Pass
3665.500	V	45.7	36.5	74.0	54.0	Pass
5587.000	V	47.6	34.0	74.0	54.0	Pass



Report No.: HKEM200800089502
Page: 45 of 45

7 Photographs

Remark: Photos refer to Appendix: External Photo, Internal Phot, Setup Photo

- End of the Report -