TEST REPORT

Application No.:	HKEM2308000690PF
Applicant:	ORTechnologies Pty Ltd
Address of Applicant:	Level 1, 70 Trenerry Cres, Abbotsford, Vic 3067
Equipment Under Test (EUT):	
EUT Name:	Sensor Node 3
Model No.:	448-000304 SENSOR NODE 3 WHITE, 448-000374 SENSOR NODE 3 BLACK
Additional Model:	Please refer to section 2 of this report which indicates which item was actually tested and which were electrically identical.
FCC ID:	2BCWQSN3
IC:	31225-SN3
HVIN:	448-000304, 448-000374
Standard(s) :	RSS-247 Issue 3, August 2023 RSS-Gen Issue 5, Amdt 2021 47 CFR Part 15, Subpart C 15.247
Date of Receipt:	2023-10-18
Date of Test:	2023-10-18 to 2023-10-25
Date of Issue:	2023-10-25
Test Result:	The submitted sample was found to comply with the test requirement

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			
Revision No.	**Date**	**Report superseded**	**Remark**

Authorized for issue by:				
		Chan Chun Lok /Project Engineer		Date: 2023-10-25
		Law Man Kit /Reviewer		Date: 2023-10-25

2 Test Summary

IC:

Radio Spectrum Technical Requirement				
Item	**Standard**	**Method**	**Requirement**	**Result**
Antenna Requirement	RSS-247 Issue 3, August 2023	N/A	RSS-Gen Section 6.8	Pass

Radio Spectrum Matter Part				
Item	**Standard**	**Method**	**Requirement**	**Result**
Conducted Emissions at AC Power Line (150kHz-30MHz)	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 6.2	RSS-Gen Section 8.8	Pass
99% Bandwidth	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 6.9.3	RSS-Gen Section 6.7	Pass
Minimum 6dB Bandwidth	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 11.8.1	RSS-247 Section 5.2(a)	Pass
Conducted Peak Output Power	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 11.9.1	RSS-247 Section 5.4(d)	Pass
Power Spectrum Density	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 11.10.2	RSS-247 Clause 5.2(b)	Pass
Conducted Band Edges Measurement	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 11.12	RSS-247 Section 5.5	Pass
Conducted Spurious Emissions	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 11.11	RSS-247 Section 5.5	Pass
Radiated Emissions which fall in the restricted bands	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 6.10.5	Section 3.3 & RSS-Gen Section 8.10	Pass
Radiated Spurious Emissions	RSS-247 Issue 3, August 2023	ANSI C63.10 (2013) Section 6.4&6.5&6.6	Section 3.3 & RSS-Gen Section 8.9	Pass

FCC:

Radio Spectrum Technical Requirement				
Item	**Standard**	**Method**	**Requirement**	**Result**
Antenna Requirement	47 CFR Part 15, Subpart C	N/A	47 CFR Part 15, Subpart C 15.203 & 15.247(b)(4)	Pass

Radio Spectrum Matter Part				
Item	**Standard**	**Method**	**Requirement**	**Result**
Conducted Emissions at AC Power Line (150kHz-30MHz)	47 CFR Part 15, Subpart C 15.247	ANSI C63.10 (2013) Section 6.2	47 CFR Part 15, Subpart C 15.207	Pass
Minimum 6dB Bandwidth	47 CFR Part 15, Subpart C	ANSI C63.10 (2013) Section 11.8.1	47 CFR Part 15, Subpart C a(2)	Pass
Conducted Peak Output Power	47 CFR Part 15, Subpart C	ANSI C63.10 (2013) Section 11.9.1	47 CFR Part 15, Subpart C (b)(3)	Pass
Power Spectrum Density	47 CFR Part 15, Subpart C	ANSI C63.10 (2013) Section 11.10.2	47 CFR Part 15, Subpart C (e)	Pass
Conducted Band Edges Measurement	47 CFR Part 15, Subpart C	ANSI C63.10 (2013) Section 11.13.3.2	47 CFR Part 15, Subpart C (d)	Pass
Conducted Spurious Emissions	47 CFR Part 15, Subpart C	ANSI C63.10 (2013) Section 11.11	47 CFR Part 15, Subpart C (d)	Pass
Radiated Emissions which fall in the restricted bands	47 CFR Part 15, Subpart C	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	ANSI C63.10 (2013) Section 6.4,6.5,6.6	47 CFR Part 15, Subpart C 15.205 & 15.209	Pass

Declaration of EUT Family Grouping:

Item no.: 448-000304 SENSOR NODE 3 WHITE, 448-000374 SENSOR NODE 3 BLACK

According to the confirmation from the applicant, the above models are identical in all electrical aspects in relating to the circuitry design, PCB layout, electrical components used, internal wiring and functions. The differences are only the color and enclosure material.

Therefore, only the model 448-000304 SENSOR NODE 3 WHITE was tested in this report.

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 6

4 GENERAL INFORMATION 8

4.1 DETAILS OF E.U.T. 8
4.2 DESCRIPTION OF SUPPORT UNITS 9
4.3 MODULATION CONFIGURATION 9
4.4 MEASUREMENT UNCERTAINTY 9
4.5 TEST LOCATION 10
4.6 TEST FACILITY 10
4.7 DEVIATION FROM STANDARDS 10
4.8 ABNORMALITIES FROM STANDARD CONDITIONS 10

5 EQUIPMENT LIST 11

6 RADIO SPECTRUM TECHNICAL REQUIREMENT 14

6.1 ANTENNA REQUIREMENT 14
6.1.1 Test Requirement: 14
6.1.2 Conclusion 14

7 RADIO SPECTRUM MATTER TEST RESULTS 15

7.1 CONDUCTED EMISSIONS AT AC POWER LINE (150KHZ-30MHZ) 15
7.1.1 E.U.T. Operation 16
7.1.2 Test Setup Diagram 16
7.1.3 Measurement Procedure and Data 16
7.2 99% BANDWIDTH 19
7.2.1 E.U.T. Operation 19
7.2.2 Test Setup Diagram 19
7.2.3 Measurement Procedure and Data 19
7.3 MINIMUM 6DB BANDWIDTH 20
7.3.1 E.U.T. Operation 20
7.3.2 Test Setup Diagram 20
7.3.3 Measurement Procedure and Data 20
7.4 CONDUCTED PEAK OUTPUT POWER 21
7.4.1 E.U.T. Operation 21
7.4.2 Test Setup Diagram 21
7.4.3 Measurement Procedure and Data 21
7.5 POWER SPECTRUM DENSITY 22
7.5.1 E.U.T. Operation 22
7.5.2 Test Setup Diagram 22
7.5.3 Measurement Procedure and Data 22
7.6 CONDUCTED BAND EDGES MEASUREMENT 23
7.6.1 E.U.T. Operation 23
7.6.2 Test Setup Diagram 23
7.6.3 Measurement Procedure and Data 23
7.7 CONDUCTED SPURIOUS EMISSIONS 24
7.7.1 E.U.T. Operation 24
7.7.2 Test Setup Diagram 24

7.7.3 Measurement Procedure and Data *24*
7.8 RADIATED EMISSIONS WHICH FALL IN THE RESTRICTED BANDS 25
7.8.1 E.U.T. Operation *26*
7.8.2 Test Setup Diagram *26*
7.8.3 Measurement Procedure and Data *27*
7.9 RADIATED SPURIOUS EMISSIONS 28
7.9.1 E.U.T. Operation *28*
7.9.2 Test Setup Diagram *28*
7.9.3 Measurement Procedure and Data *29*
8 PHOTOGRAPHS 33
8.1 EUT CONSTRUCTIONAL DETAILS (EUT PHOTOS) 33
9 APPENDIX 15.247 RSS 247 34
9.1 99% BANDWIDTH 34
9.2 MINIMUM 6DB BANDWIDTH 36
9.3 PEAK CONDUCTED OUTPUT POWER 38
9.4 POWER SPECTRUM DENSITY 39
9.5 CONDUCTED BAND EDGE MEASUREMENT 41
9.6 CONDUCTED SPURIOUS EMISSION 43

4 General Information

4.1 Details of E.U.T.

Power supply:	DC 11.5 V – 22.5 V
Test voltage:	AC 120 V (driver)
Cable:	N/A
Antenna Gain:	0.68 dBi
Antenna Type:	MIFA Antenna
Bluetooth Version:	V5.4 LE
Channel Separation:	2MHz
Modulation Type:	GFSK
Number of Channels:	40
Operation Frequency:	2402MHz to 2480MHz
Series No.:	A1
Firmware Version:	5.1
Hardware Version:	448-000304, 448-00374

Frequency List:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	**2402**	20	2442
1	2404	21	2444
2	2406	22	2446
3	2408	23	2448
4	2410	24	2450
5	2402	25	2452
6	2414	26	2454
7	2416	27	2456
8	2418	28	2458
9	2420	29	2460
10	2422	30	2462
11	2424	31	2464
12	2426	32	2466
13	2428	33	2468
14	2430	34	2470
15	2432	35	2480
16	2434	36	2474
17	2436	37	2476
18	2438	38	2478
19	**2440**	**39**	**2480**

The frequencies under test are bolded.

4.2 Description of Support Units

Description	Manufacturer	Model No.	Serial No.
Laptop	DELL	P75F	475LXQ2
PuTTY.exe	C-MER RainsOptics Limited	N/A	N/A

Note: The laptop and the software PuTTY.exe were for the control of the engineering mode.

4.3 Modulation Configuration

RF software:	PuTTY.exe			
Modulation	**Packet**	**Packet Type**	**Packet Size**	**Power**
GFSK	Default	Default	Default	Pos4dBm
Remark: 1. Pos4dBm value was set in test software as maximum output power setting.				

4.4 Measurement Uncertainty

RF

No.	Item	Measurement Uncertainty
1	Radio Frequency	± 7.25 x 10^{-8}
2	Duty cycle	± 0.37%
3	Occupied Bandwidth	± 3%
4	RF conducted power (30MHz-40GHz)	1.5dB
5	RF power density	1.5dB
6	Conducted Spurious emissions	1.5dB
7	Radiated disturbance (9 kHz - 30MHz)	3.1dB
8	RF Radiated power & Radiated Spurious emission test	4.7dB (30MHz-1GHz)
		4.7dB (1GHz-6GHz)
		4.7dB (6GHz-18GHz)
		5.7dB (18GHz-40GHz)
9	Temperature test	± 1°C
10	Humidity test	± 3%
11	Supply voltages	± 1.5%
12	Time	± 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.

4.5 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.

4.6 Test Facility

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

- **IAS Accreditation (Lab Code: TL-817)**

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.

4.7 Deviation from Standards

None

4.8 Abnormalities from Standard Conditions

None

5 Equipment List

Conducted Emissions at Mains Terminals (150kHz-30MHz)					
Equipment	**Manufacturer**	**Model No**	**Inventory No**	**Cal Date**	**Cal Due Date**
EMI Test Receiver 9kHz to 3.6GHz	Rohde & Schwarz	ESR3 / 102326	E231	2022/11/02	2023/11/01
Artificial Mains Network (LISN)	Schwarzbeck	NSLK 8127 / 8127312	E005	2023/06/13	2024/06/12
Impulse Limiter	Rohde & Schwarz	ESH-3-Z2 / 357881052	E028	2023/07/15	2024/07/14
EMC32 Test software	Rohde & Schwarz	Version 10	N/A	N/A	N/A

99% Bandwidth, 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**
FSV40 SIGNAL ANALYZER 40GHz	Rohde & Schwarz	FSV40	E235	2023/09/26	2024/09/25
OSP-B157W8 OSP-B157W8 PLUS	Rohde & Schwarz	OSP-B157W8	E332	2023/09/26	2024/09/25
Cable	Rohde & Schwarz	J12J103539-00-2	E239	2023/09/17	2024/09/16
WMS32 Test software	Rohde & Schwarz	N/A	Version 11	N/A	N/A

Radiated Emissions which fall in the restricted bands, Radiated Spurious Emissions					
Equipment	**Manufacturer**	**Model No**	**Inventory No**	**Cal Date**	**Cal Due Date**
3m Semi-Anechoic Chamber	ChamPro	N/A	E229	2023/08/09	2024/08/08
Coaxial Cable	SGS	N/A	E167	2023/07/07	2024/07/06
EMI Test Receiver 9kHz to 7GHz	Rohde & Schwarz	ESR7 / 102298	E314	2023/06/13	2024/06/12
Active Loop Antenna 9k-30MHz	Schwarzbeck	FMZB 1513	E327	2022/11/23	2024/11/22
TRILOG Super Broadb. Test Antenna, (25) 30-1000 MHz	Schwarzbeck	VULB 9168	E311	2022/03/08	2024/03/07
EMC32 Test software	Rohde & Schwarz	Version 10	N/A	N/A	N/A
Signal and Spectrum Analyzer 2Hz - 26.5GHz	Rohde & Schwarz	FSW26	E296	2023/09/26	2024/09/25
Horn Antenna 1 - 18GHz	Schwarzbeck	BBHA9120D	E211	2022/03/03	2024/03/02
Preamplifier 33dB, 1 - 18GHz	Schwarzbeck	BBV9718	E214	2023/01/20	2024/01/19
RF cable SMA to SMA 10000mm	HUBER+SUHNER	SF104-26.5/2*11SMA 45	E207	2023/09/17	2024/09/16
Boresight Mast Controller	ChamPro	AM-BS-4500-E	E237	N/A	N/A
Turntable with Controller	ChamPro	EM1000	E238	N/A	N/A

Band Reject Filter 2.4 -2.5GHz	MICRO-TRONICS	BRM50702	E324	2022/09/28	2024/09/27

General used equipment					
Equipment	**Manufacturer**	**Model No**	**Inventory No**	**Cal Date**	**Cal Due Date**
Digital temperature & humidity data logger	SATO	SK-L200TH II	E232	2023/09/21	2024/09/20
Electronic Digital Thermometer with Hygrometer	nil	2074/2075	E159	2023/09/21	2024/09/20
Barometer with digital thermometer	SATO	7612-00	E218	2023/06/29	2024/06/28
Conditional Chamber	Zhong Zhi Testing Instruments	CZ-E-608D	E216	2023/09/26	2024/09/25

6 Radio Spectrum Technical Requirement

6.1 Antenna Requirement

6.1.1 Test Requirement:

RSS-Gen Section 6.8

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

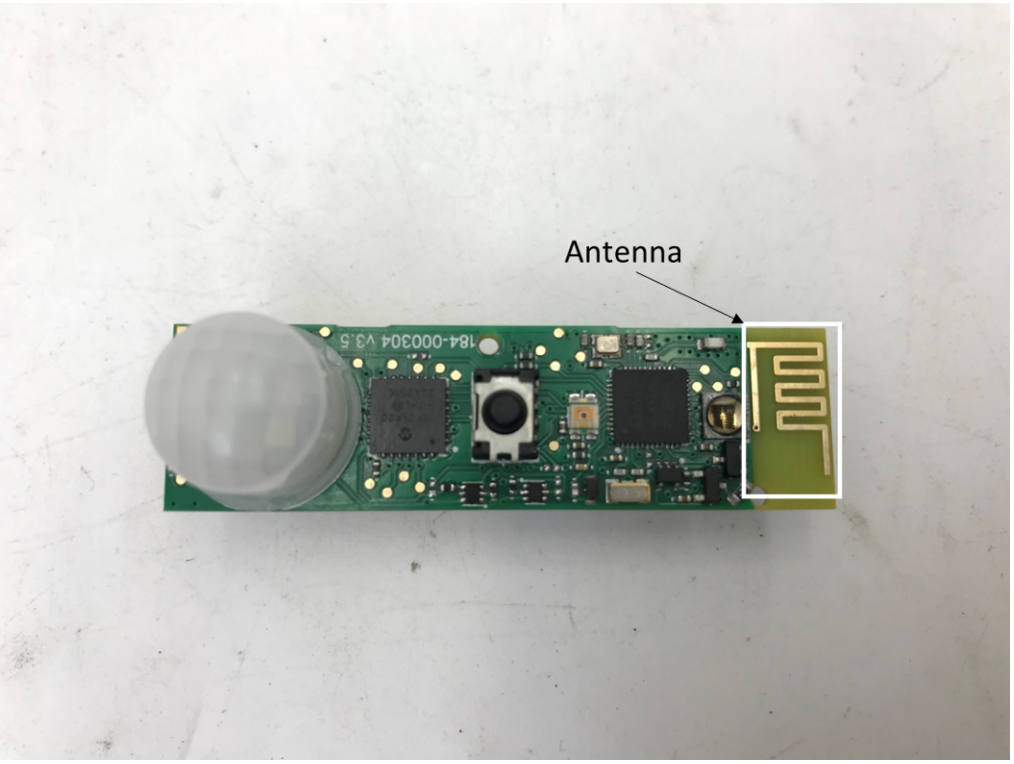
6.1.2 Conclusion

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 0.68 dBi.

Antenna location: Refer to internal photo.

7 Radio Spectrum Matter Test Results

7.1 Conducted Emissions at AC Power Line (150kHz-30MHz)

Test Requirement RSS-Gen Section 8.8
47 CFR Part 15, Subpart C 15.207
Test Method: ANSI C63.10 (2013) Section 6.2
Limit:

Frequency of emission(MHz)	Conducted limit(dBµV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50
*Decreases with the logarithm of the frequency.		

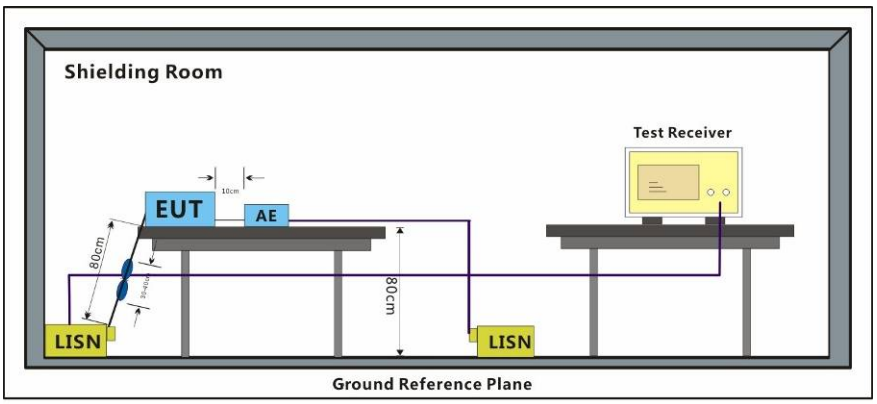
7.1.1 E.U.T. Operation

Operating Environment:

Temperature: 24.7 °C Humidity: 58.4 % RH :

Test mode a: TX mode_Keep the EUT in charging and continuously transmitting mode with GFSK modulation

7.1.2 Test Setup Diagram



7.1.3 Measurement Procedure and Data

1) The mains terminal disturbance voltage test was conducted in a shielded room.

2) The EUT was connected to AC power source through a LISN 1 (Line Impedance Stabilization Network) which provides a 50ohm/50μH + 5ohm linear impedance. The power cables of all other units of the EUT were connected to a second LISN 2, which was bonded to the ground reference plane in the same way as the LISN 1 for the unit being measured. A multiple socket outlet strip was used to connect multiple power cables to a single LISN provided the rating of the LISN was not exceeded.

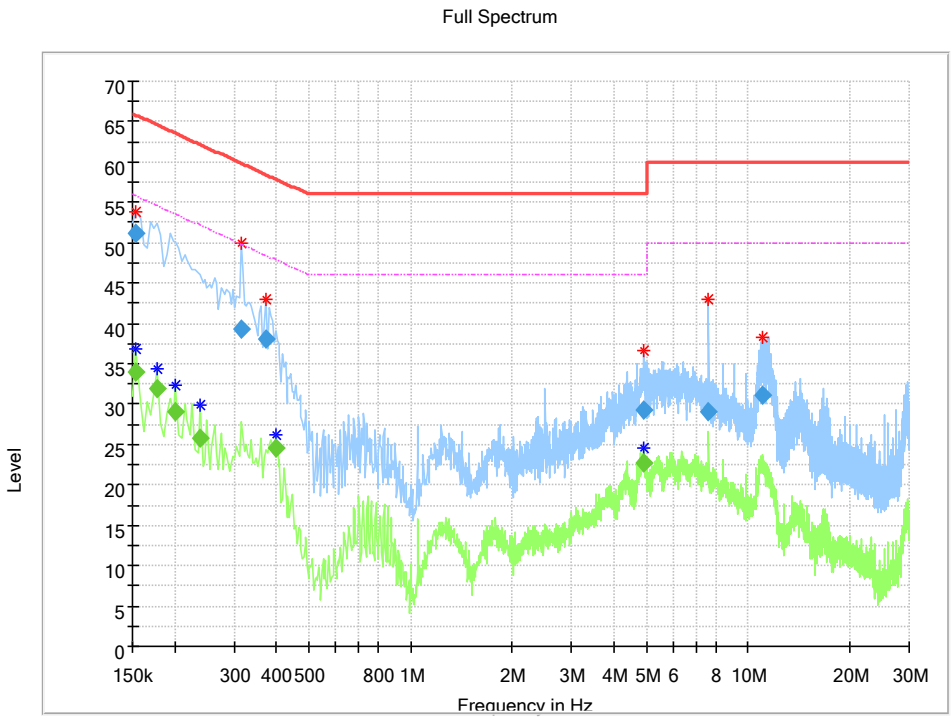
3) The tabletop EUT was placed upon a non-metallic table 0.8m above the ground reference plane. And for floor-standing arrangement, the EUT was placed on the horizontal ground reference plane,

4) The test was performed with a vertical ground reference plane. The rear of the EUT shall be 0.4 m from the vertical ground reference plane. The vertical ground reference plane was bonded to the horizontal ground reference plane. The LISN 1 was placed 0.8 m from the boundary of the unit under test and bonded to a ground reference plane for LISNs mounted on top of the ground reference plane. This distance was between the closest points of the LISN 1 and the EUT. All other units of the EUT and associated equipment was at least 0.8 m from the LISN 2.

5) In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10 on conducted measurement.

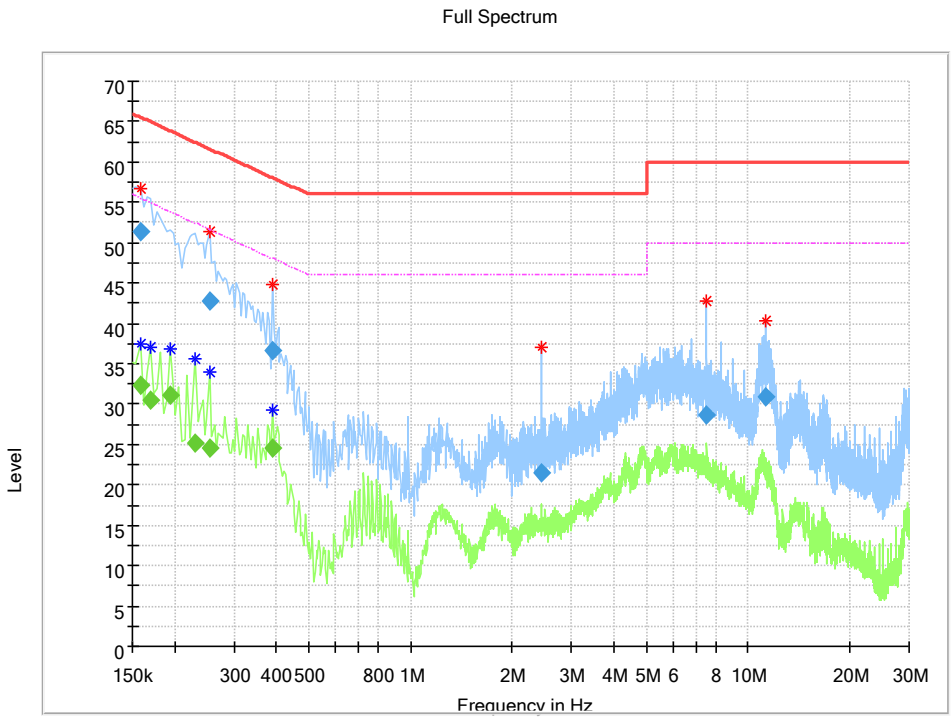
Remark: LISN=Read Level+ Cable Loss+ LISN Factor

Mode:a; Line:Live Line



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Corr. (dB)	Result
0.154000	---	34.0	55.8	21.8	10.0	Pass
0.154000	51.1	---	65.8	14.6	10.0	Pass
0.178000	---	31.8	54.6	22.7	10.0	Pass
0.202000	---	29.1	53.5	24.5	10.0	Pass
0.238000	---	25.7	52.2	26.4	10.0	Pass
0.314000	39.2	---	59.9	20.6	10.0	Pass
0.374000	38.1	---	58.4	20.3	10.0	Pass
0.398000	---	24.5	47.9	23.4	10.0	Pass
4.882000	29.3	---	56.0	26.7	10.2	Pass
4.890000	---	22.7	46.0	23.3	10.2	Pass
7.642000	29.2	---	60.0	30.9	10.3	Pass
11.050000	31.1	---	60.0	28.9	10.3	Pass

Mode:a; Line:Neutral Line



Frequency (MHz)	QuasiPeak (dBµV)	Average (dBµV)	Limit (dBµV)	Margin (dB)	Corr. (dB)	Result
0.158000	---	32.4	55.6	23.2	10.0	Pass
0.158000	51.3	---	65.6	14.2	10.0	Pass
0.170000	---	30.6	55.0	24.4	10.0	Pass
0.194000	---	31.1	53.9	22.7	10.0	Pass
0.230000	---	25.1	52.5	27.3	10.0	Pass
0.254000	42.7	---	61.6	18.9	10.0	Pass
0.254000	---	24.5	51.6	27.1	10.0	Pass
0.390000	36.7	---	58.1	21.4	10.0	Pass
0.390000	---	24.6	48.1	23.4	10.0	Pass
2.442000	21.5	---	56.0	34.5	10.1	Pass
7.558000	28.7	---	60.0	31.3	10.3	Pass
11.234000	30.9	---	60.0	29.1	10.4	Pass

7.2 99% Bandwidth

Test Requirement RSS-Gen Section 6.7

Test Method: ANSI C63.10 (2013) Section 6.9.3

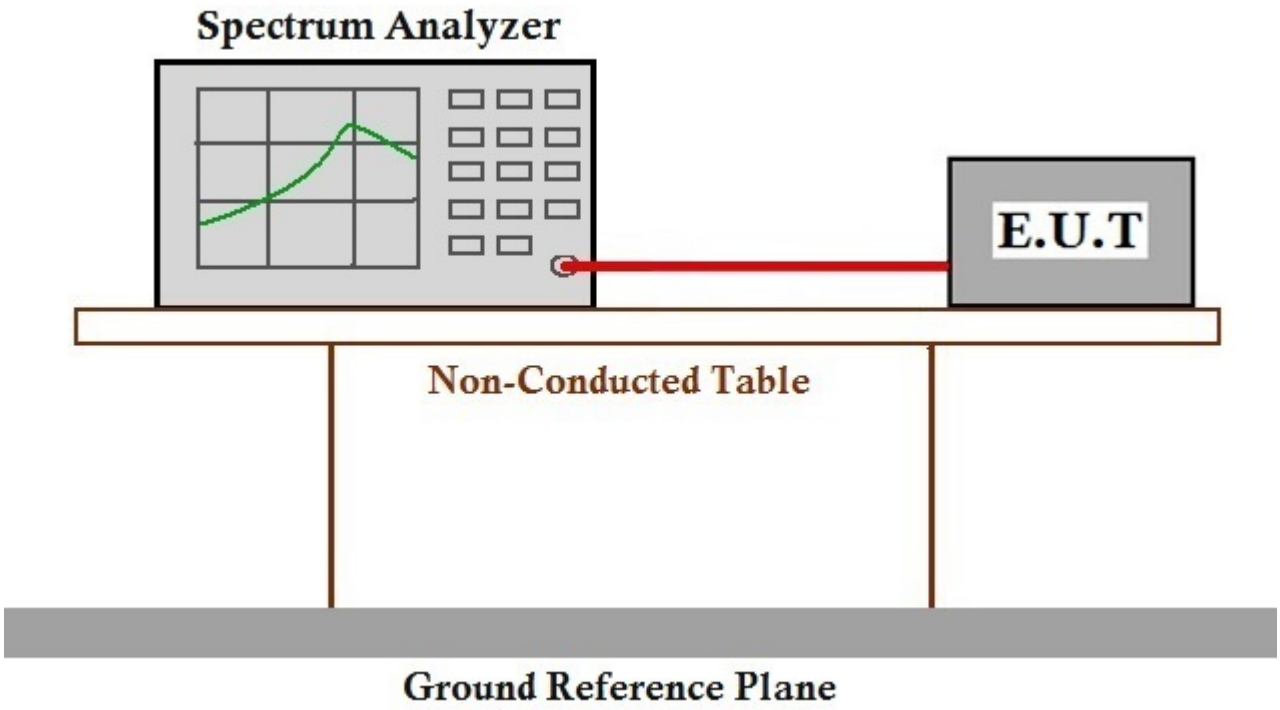
7.2.1 E.U.T. Operation

Operating Environment:

Temperature: 27.6 °C Humidity: 52.8 % RH :

Test mode a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.2.2 Test Setup Diagram



7.2.3 Measurement Procedure and Data

The detailed test data see: Appendix 15.247 RSS 247

7.3 Minimum 6dB Bandwidth

Test Requirement	RSS-247 Section 5.2(a)
	47 CFR Part 15, Subpart C a(2)
Test Method:	ANSI C63.10 (2013) Section 11.8.1
Limit:	⩾500 kHz

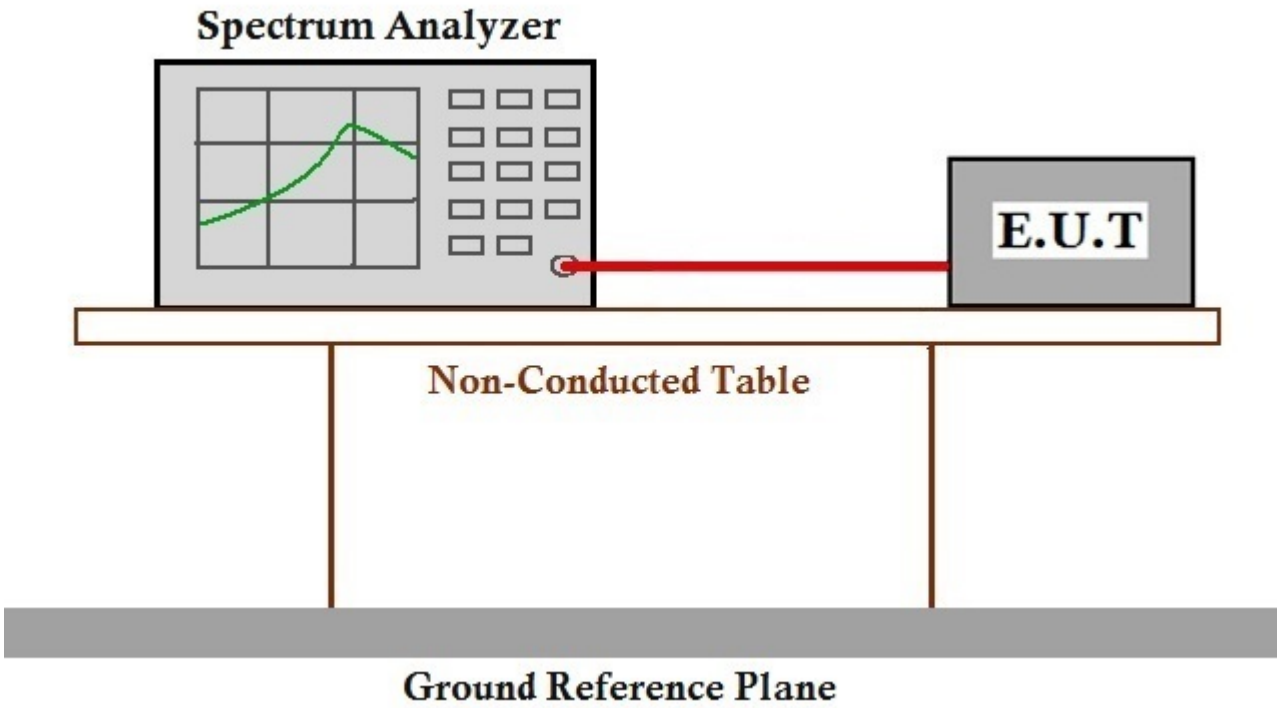
7.3.1 E.U.T. Operation

Operating Environment:

Temperature: 26.7 °C Humidity: 52.7 % RH :

Test mode a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.3.2 Test Setup Diagram



7.3.3 Measurement Procedure and Data

The detailed test data see: Appendix 15.247 RSS 247

7.4 Conducted Peak Output Power

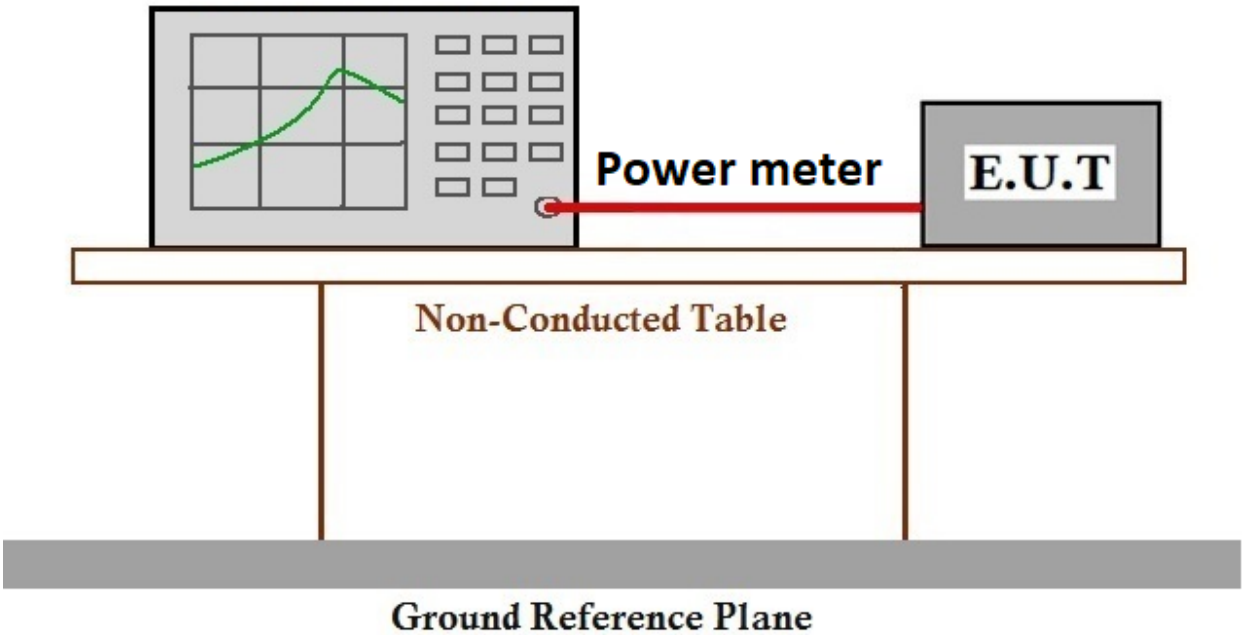
Test Requirement RSS-247 Section 5.4(d)
47 CFR Part 15, Subpart C (b)(3)
Test Method: ANSI C63.10 (2013) Section 11.9.1
Limit:

Frequency range(MHz)	Output power of the intentional radiator(watt)
902-928	1 for ≥50 hopping channels
	0.25 for 25≤ hopping channels <50
	1 for digital modulation
2400-2483.5	1 for ≥75 non-overlapping hopping channels
	0.125 for all other frequency hopping systems
	1 for digital modulation
5725-5850	1 for frequency hopping systems and digital modulation

7.4.1 E.U.T. Operation

Operating Environment:
Temperature: 26.7 °C Humidity: 53.7 % RH :
Test mode a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.4.2 Test Setup Diagram



7.4.3 Measurement Procedure and Data

The detailed test data see: Appendix 15.247 RSS 247

7.5 Power Spectrum Density

Test Requirement	RSS-247 Clause 5.2(b) 47 CFR Part 15, Subpart C (e)
Test Method:	ANSI C63.10 (2013) Section 11.10.2
Limit:	≤8dBm in any 3 kHz band during any time interval of continuous transmission

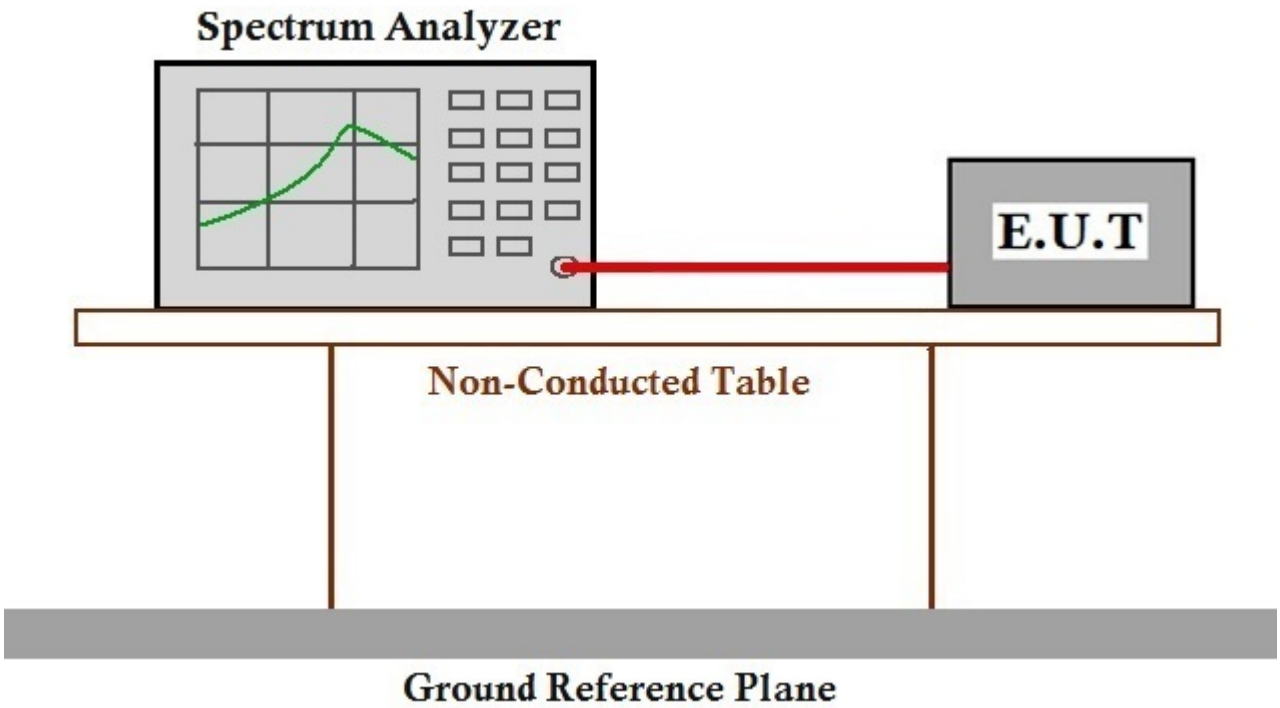
7.5.1 E.U.T. Operation

Operating Environment:

Temperature: 26.8 °C Humidity: 53.8 % RH :

Test mode a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.5.2 Test Setup Diagram



7.5.3 Measurement Procedure and Data

The detailed test data see: Appendix 15.247 RSS 247

7.6 Conducted Band Edges Measurement

Test Requirement	RSS-247 Section 5.5 47 CFR Part 15, Subpart C (d)
Test Method:	ANSI C63.10 (2013) Section 11.13.3.2
Limit:	In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)

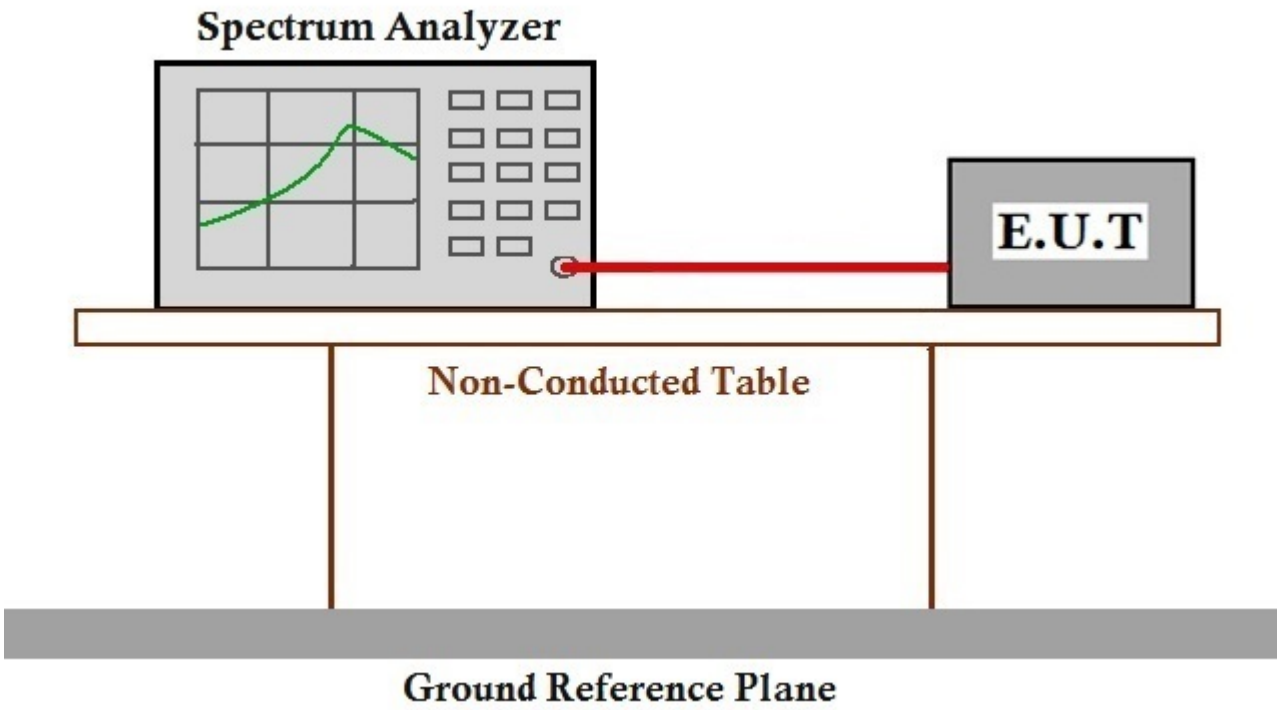
7.6.1 E.U.T. Operation

Operating Environment:

Temperature: 25.8 °C Humidity: 52.9 % RH :

Test mode a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.6.2 Test Setup Diagram



7.6.3 Measurement Procedure and Data

The detailed test data see: Appendix 15.247 RSS 247

7.7 Conducted Spurious Emissions

Test Requirement: RSS-247 Section 5.5
47 CFR Part 15, Subpart C (d)

Test Method: ANSI C63.10 (2013) Section 11.11

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

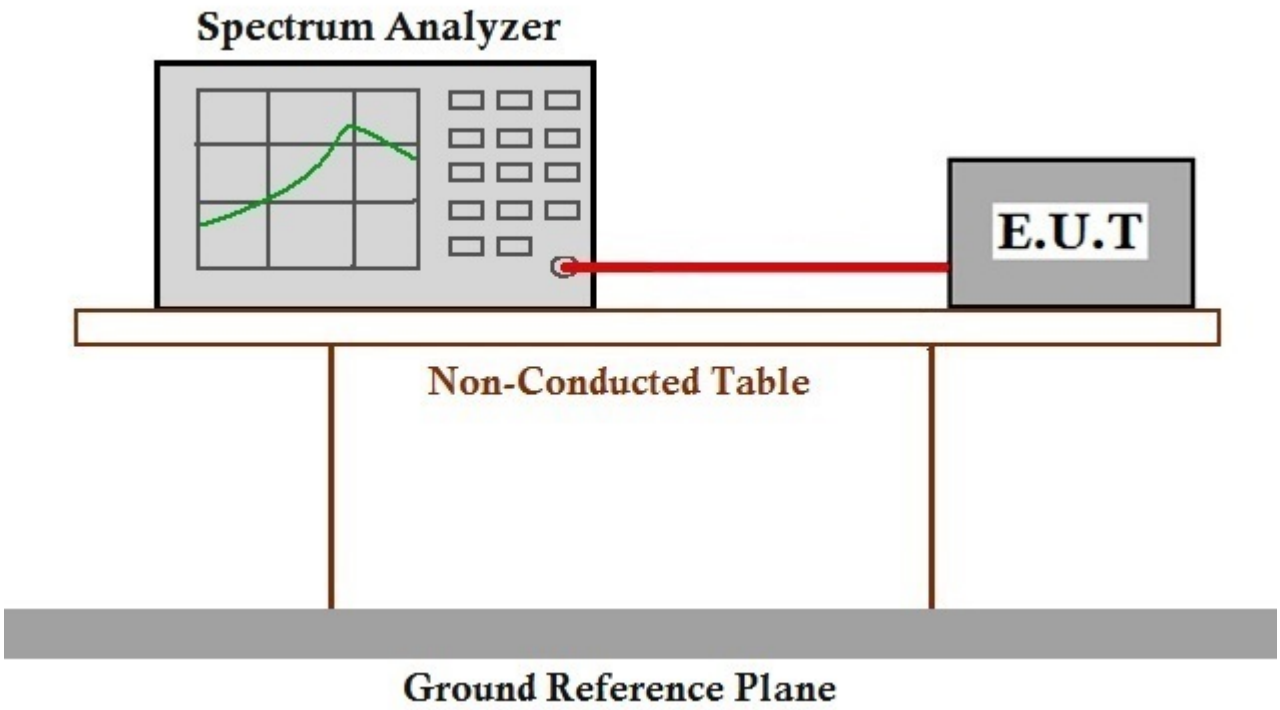
7.7.1 E.U.T. Operation

Operating Environment:

Temperature: 26.7 °C Humidity: 53.8 % RH :

Test mode: a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.7.2 Test Setup Diagram



7.7.3 Measurement Procedure and Data

The detailed test data see: Appendix 15.247 RSS 247

7.8 Radiated Emissions which fall in the restricted bands

Test Requirement Section 3.3 & RSS-Gen Section 8.10
47 CFR Part 15, Subpart C 15.205 & 15.209
Test Method: ANSI C63.10 (2013) Section 6.10.5
Measurement Distance: 3m
Limit:

Frequency(MHz)	Field strength(microvolts/meter)	Measurement distance(meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3
Remark: The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90kHz, 110-490kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector, 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.		

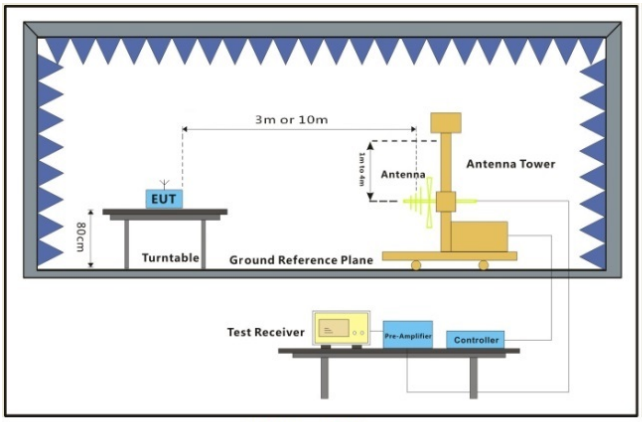
7.8.1 E.U.T. Operation

Operating Environment:

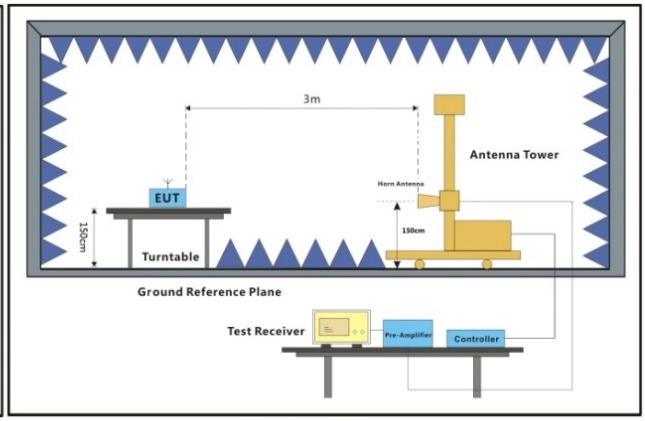
Temperature: 26.7 °C Humidity: 53.8 % RH :

Test mode a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

7.8.2 Test Setup Diagram



30MHz-1GHz



Above 1GHz

7.8.3 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.

Frequency (MHz)	Antenna Polarization	Emission Level (dBµV/m)		Limit (dBµV/m)		Result
		Peak	Average	Peak	Average	
2390.000	H	47.9	29.3	74.0	54.0	Pass
2483.500	H	52.0	28.1	74.0	54.0	Pass
2390.000	V	45.3	28.7	74.0	54.0	Pass
2483.500	V	48.1	31.7	74.0	54.0	Pass

7.9 Radiated Spurious Emissions

Test Requirement Section 3.3 & RSS-Gen Section 8.9
47 CFR Part 15, Subpart C 15.205 & 15.209

Test Method: ANSI C63.10 (2013) Section 6.4,6.5,6.6

Measurement Distance: 3m

Limit:

Frequency(MHz)	Field strength(microvolts/meter)	Measurement distance(meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3
Remark: The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90kHz, 110-490kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector, 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.		

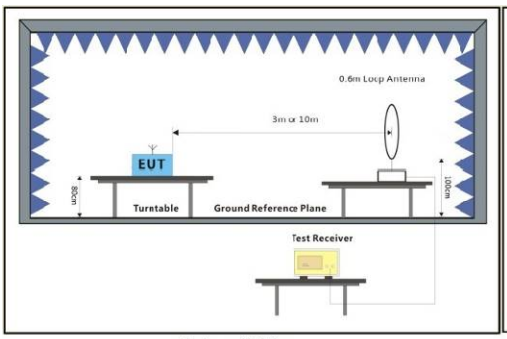
7.9.1 E.U.T. Operation

Operating Environment:

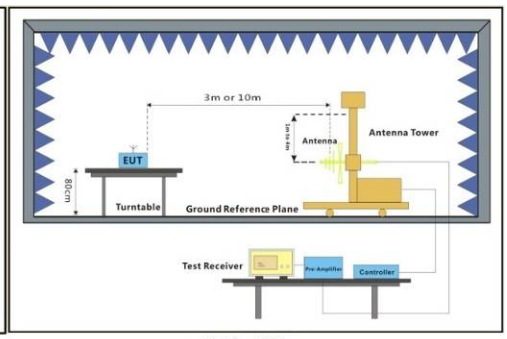
Temperature: 26.6 °C Humidity: 52.8 % RH :

Test a: TX mode_Keep the EUT in continuously transmitting mode with GFSK modulation

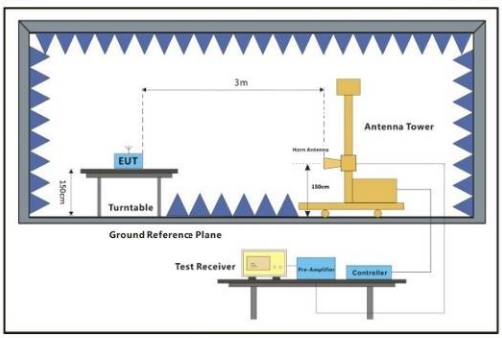
7.9.2 Test Setup Diagram



Below 30MHz



30MHz-1GHz



Above 1GHz

7.9.3 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.

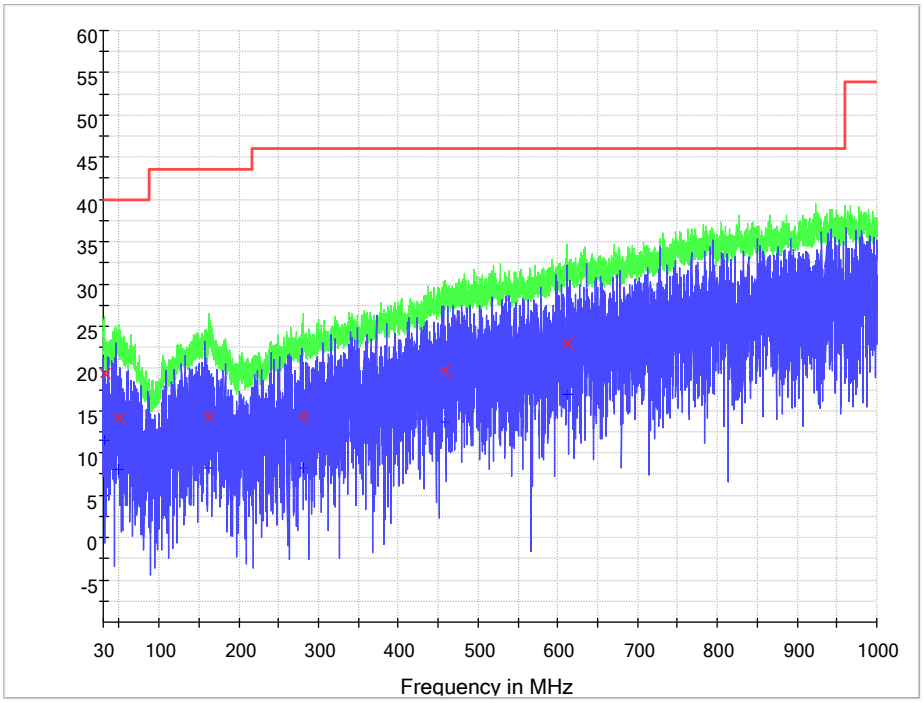
4) For frequencies above 1GHz, the field strength limits are based on average limits. However, the peak field strength of any emission shall not exceed the maximum permitted average limits specified above by more than 20 dB under any condition of modulation. For the emissions whose peak level is lower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

Radiated emission below 30MHz

The measurements with active loop antenna were greater than 20dB below the limit, so the test data were not recorded in the test report.

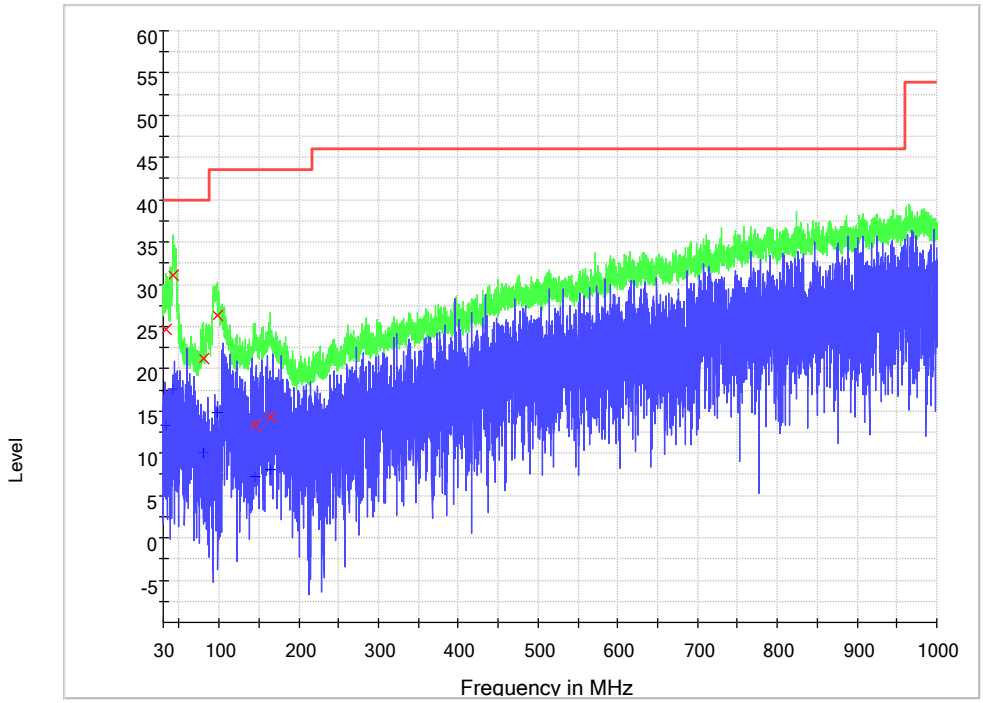
Radiated emission below 1GHz

Mode:a; Polarization:Horizontal; Modulation:GFSK;



Frequency (MHz)	QuasiPeak (dBµV/m)	Pol.	Corr. (dB/m)	Margin (dB)	Limit (dBµV/m)	Result
30.919643	19.5	H	12.9	20.5	40.0	Pass
48.330357	14.2	H	14.3	25.8	40.0	Pass
161.569643	14.2	H	14.6	29.3	43.5	Pass
281.425000	14.3	H	14.4	31.7	46.0	Pass
457.830357	19.8	H	19.6	26.2	46.0	Pass
612.158929	23.1	H	22.4	22.9	46.0	Pass

Mode:a; Polarization:Vertical; Modulation:GFSK;



Frequency (MHz)	QuasiPeak (dBµV/m)	Pol.	Corr. (dB/m)	Margin (dB)	Limit (dBµV/m)	Result
34.262500	24.7	V	13.1	15.4	40.0	Pass
42.758929	31.1	V	14.0	8.9	40.0	Pass
79.669643	21.2	V	10.1	18.8	40.0	Pass
97.080357	26.3	V	8.9	17.2	43.5	Pass
145.273214	13.3	V	14.0	30.2	43.5	Pass
163.728571	14.3	V	14.5	29.2	43.5	Pass

Remark: Only the worst case is shown.

Above 1GHz

Channel: Low

Frequency (MHz)	Antenna Polarization	Emission Level (dBμV/m)		Limit (dBμV/m)		Remark
		Peak	Average	Peak	Average	
4803.750	H	50.1	45.4	74.0	54.0	PASS
7205.000	H	50.8	40.3	74.0	54.0	PASS
9608.000	H	50.1	36.1	74.0	54.0	PASS
4803.750	V	51.0	46.7	74.0	54.0	PASS
7206.000	V	50.8	39.4	74.0	54.0	PASS
9608.000	V	50.7	36.1	74.0	54.0	PASS

Channel: Middle

Frequency (MHz)	Antenna Polarization	Emission Level (dBμV/m)		Limit (dBμV/m)		Remark
		Peak	Average	Peak	Average	
4879.306	H	50.7	43.6	74.0	54.0	PASS
7318.806	H	49.8	38.4	74.0	54.0	PASS
9706.000	H	50.2	36.0	74.0	54.0	PASS
4879.306	V	51.9	44.8	74.0	54.0	PASS
7318.806	V	48.8	36.8	74.0	54.0	PASS
9760.000	V	50.7	36.8	74.0	54.0	PASS

Channel: High

Frequency (MHz)	Antenna Polarization	Emission Level (dBμV/m)		Limit (dBμV/m)		Remark
		Peak	Average	Peak	Average	
4960.528	H	49.7	41.9	74.0	54.0	PASS
7440.639	H	50.9	40.5	74.0	54.0	PASS
9920.000	H	49.9	35.7	74.0	54.0	PASS
4960.056	V	52.8	48.6	74.0	54.0	PASS
7440.000	V	48.6	38.2	74.0	54.0	PASS
12398.500	V	55.5	44.8	74.0	54.0	PASS

8 Photographs

8.1 EUT Constructional Details (EUT Photos)

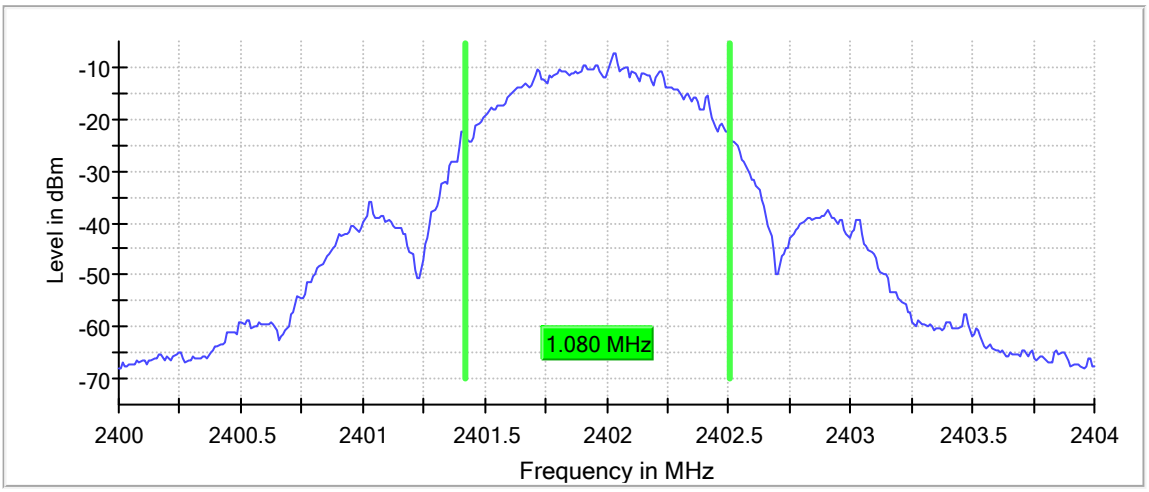
Refer to the appendices external, internal and setup photos.

9 Appendix 15.247 RSS 247

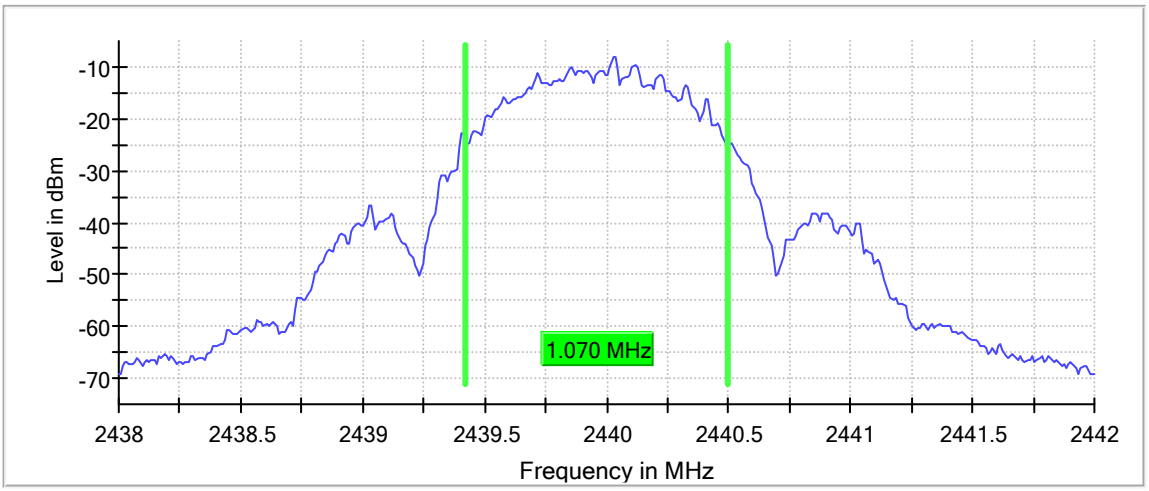
9.1 99% Bandwidth

Frequency (MHz)	Bandwidth (MHz)	Limit (MHz)	Result
2402.000000	1.080000	---	PASS
2440.000000	1.070000	---	PASS
2480.000000	1.080000	---	PASS

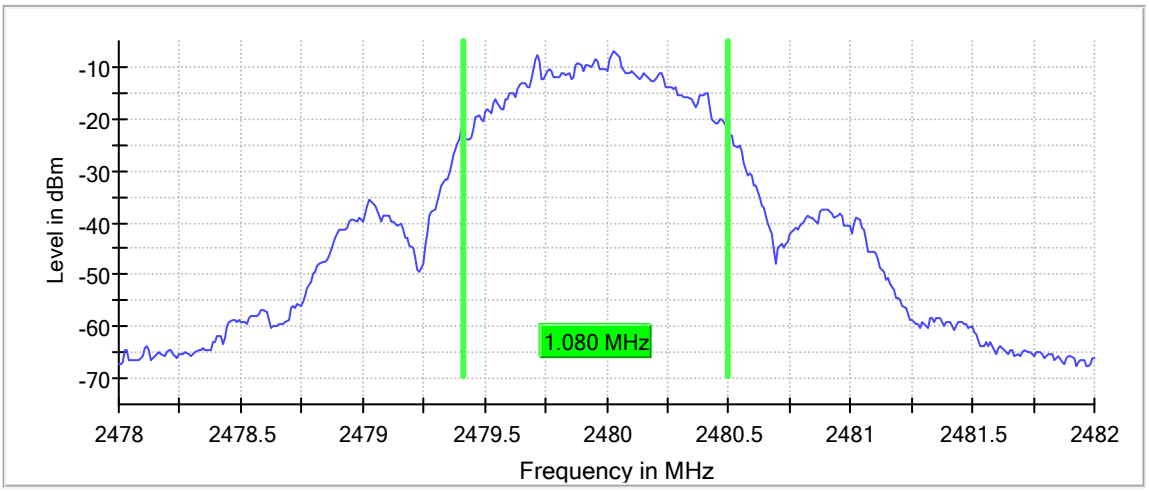
99 % Bandwidth



99 % Bandwidth



99 % Bandwidth



Measurement

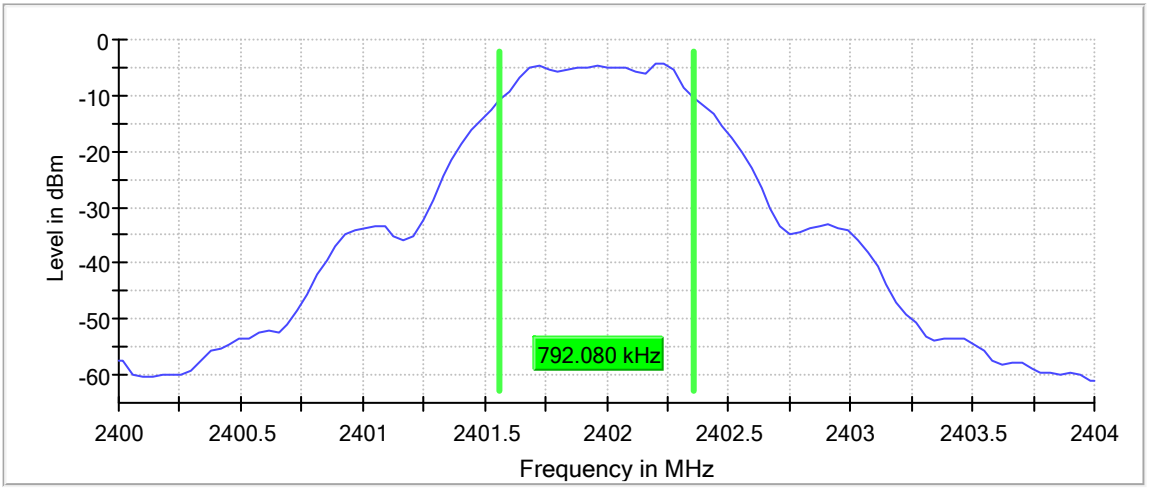
Setting	Instrument Value	Target Value
Start Frequency	2.47800 GHz	2.47800 GHz
Stop Frequency	2.48200 GHz	2.48200 GHz
Span	4.000 MHz	4.000 MHz
RBW	20.000 kHz	>= 20.000 kHz
VBW	100.000 kHz	>= 60.000 kHz
SweepPoints	400	~ 400
Sweeptime	94.824 µs	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.30 dB	0.30 dB
Run	13 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.06 dB	0.30 dB

Remark: Cable loss 0.8dB was considered and set in system configuration.

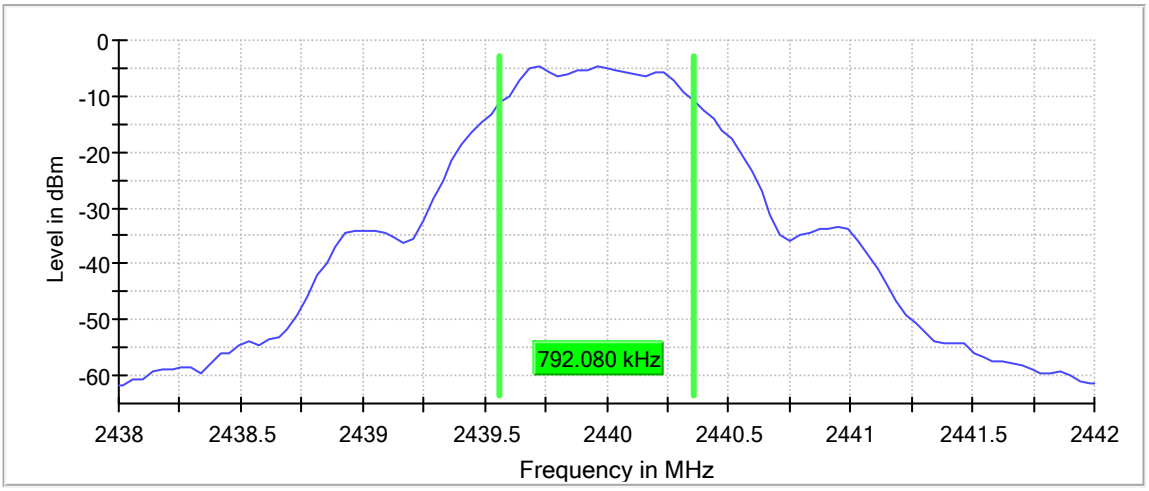
9.2 Minimum 6dB Bandwidth

Frequency (MHz)	Bandwidth (MHz)	Limit Min (MHz)	Result
2402.000000	0.792080	---	PASS
2440.000000	0.792080	---	PASS
2480.000000	0.792080	---	PASS

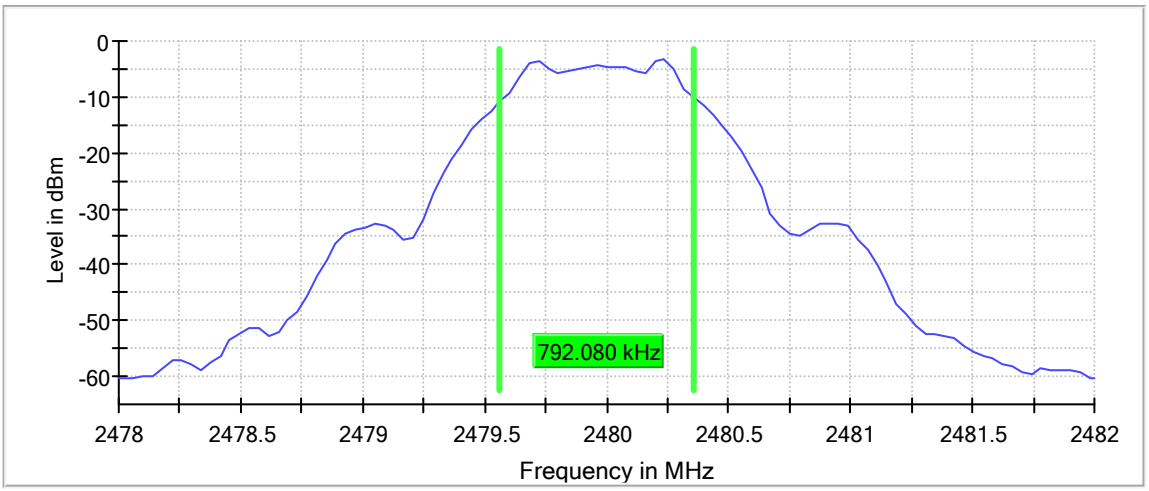
6 dB Bandwidth



6 dB Bandwidth



6 dB Bandwidth



Measurement

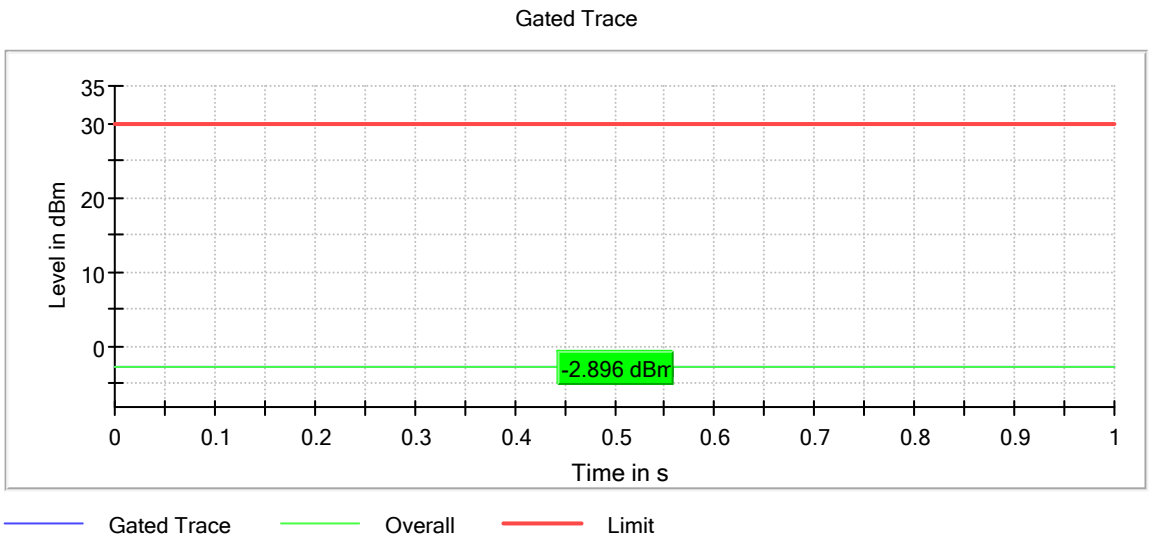
Setting	Instrument Value	Target Value
Start Frequency	2.47800 GHz	2.47800 GHz
Stop Frequency	2.48200 GHz	2.48200 GHz
Span	4.000 MHz	4.000 MHz
RBW	100.000 kHz	~ 100.000 kHz
VBW	300.000 kHz	~ 300.000 kHz
SweepPoints	101	~ 80
Sweeptime	18.938 µs	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	9 / max. 150	max. 150
Stable	5 / 5	5
Max Stable Difference	0.24 dB	0.50 dB

Remark: Cable loss 0.8dB was considered and set in system configuration.

9.3 Peak conducted output power

Frequency (MHz)	Peak Power (dBm)	Limit (dBm)	Result
2402.000000	-3.0	30.0	PASS
2440.000000	-3.7	30.0	PASS
2480.000000	-2.9	30.0	PASS

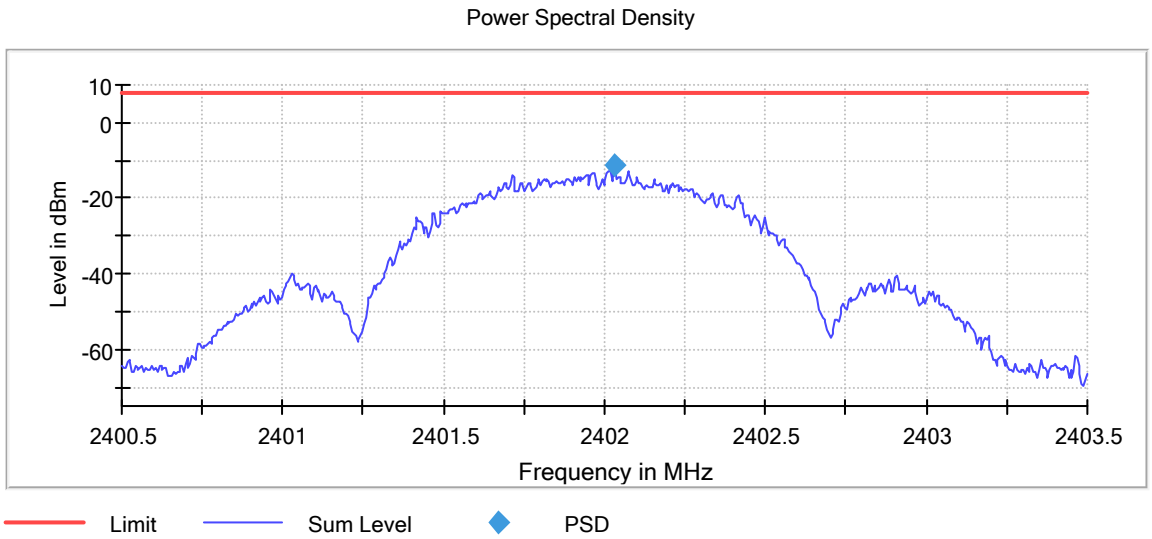
Remark: Antenna gain is 0.68 dBi



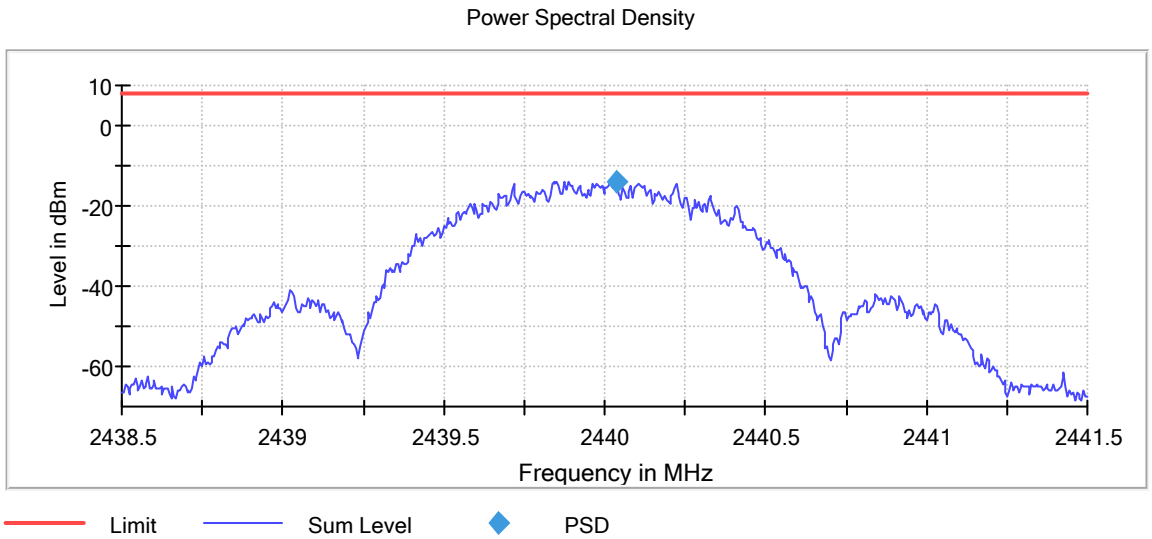
Remark: Cable loss 0.8dB was considered and set in system configuration.

9.4 Power Spectrum Density

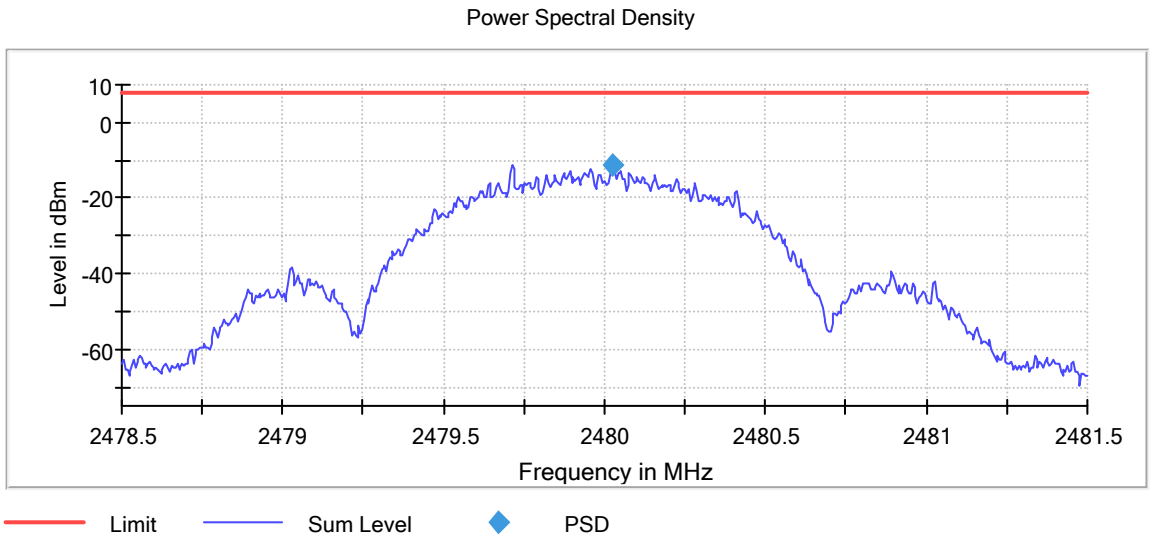
DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2402.000000	2402.032500	-11.449	8.0	PASS



DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2440.000000	2440.037500	-13.779	8.0	PASS



DUT Frequency (MHz)	Frequency (MHz)	PSD (dBm)	Limit Max (dBm)	Result
2480.000000	2480.022500	-11.054	8.0	PASS



Measurement

Setting	Instrument Value	Target Value
Start Frequency	2.47850 GHz	2.47850 GHz
Stop Frequency	2.48150 GHz	2.48150 GHz
Span	3.000 MHz	3.000 MHz
RBW	10.000 kHz	<= 10.000 kHz
VBW	30.000 kHz	>= 30.000 kHz
SweepPoints	600	~ 600
Sweeptime	12.000 ms	12.000 ms
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	RMS	RMS
SweepCount	1	1
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	Sweep
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	59 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

Remark: Cable loss 0.8dB was considered and set in system configuration.

9.5 Conducted Band Edge Measurement

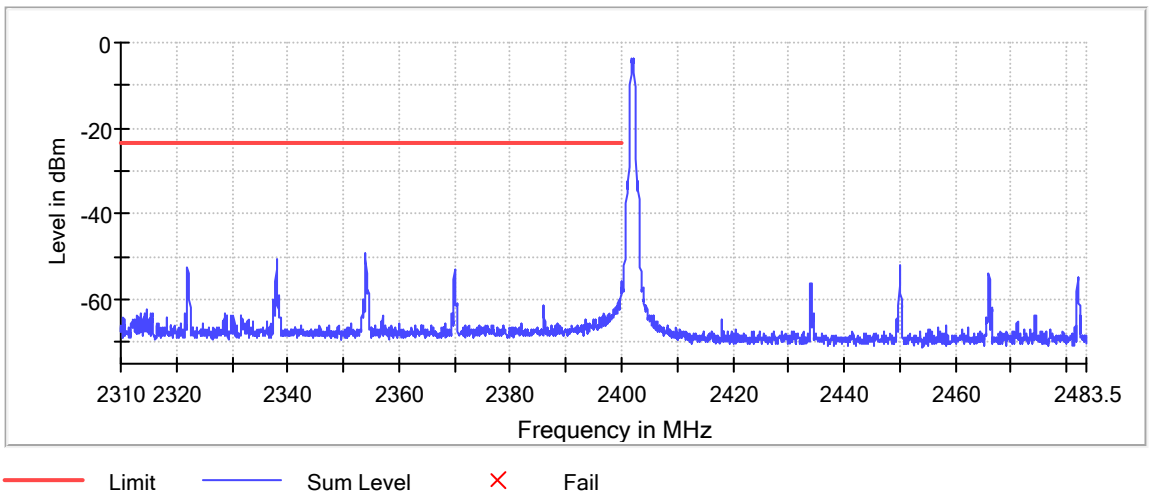
Inband Peak

Frequency (MHz)	Level (dBm)
2402.200000	-3.6
2479.775000	-2.8

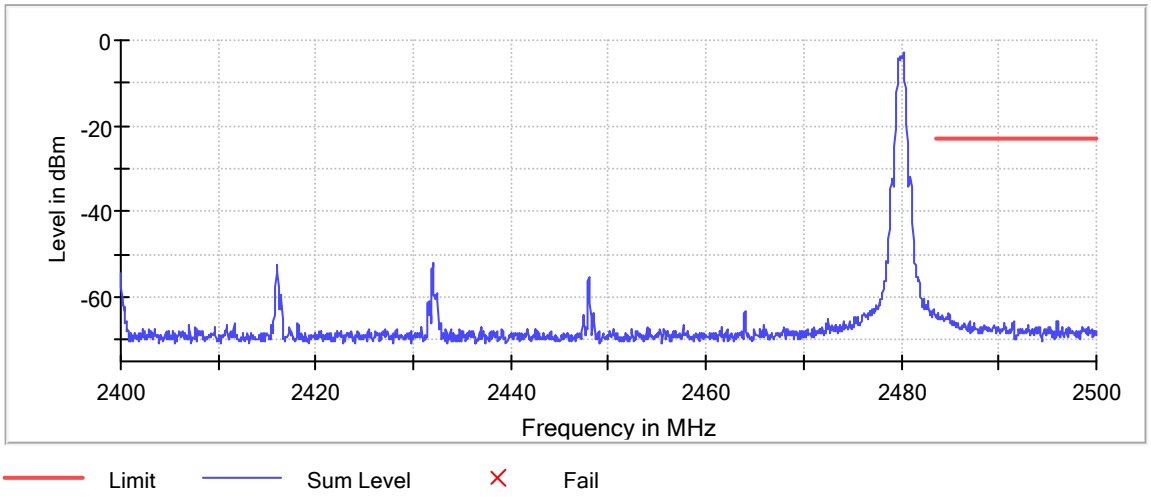
Frequency (MHz)	Level (dBm)	Margin (dB)	Limit (dBm)	Result
2354.025000	-49.4	25.8	-23.6	PASS
2484.875000	-63.9	41.1	-22.8	PASS

Remark: Limit = Inband peak – 20dB
Only the worst case is shown.

Band Edge



Band Edge



Measurement 1

Setting	Instrument Value	Target Value
Start Frequency	2.40000 GHz	2.40000 GHz
Stop Frequency	2.48350 GHz	2.48350 GHz
Span	83.500 MHz	83.500 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	1670	~ 1670
Sweeptime	1.670 ms	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	9 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.07 dB	0.50 dB

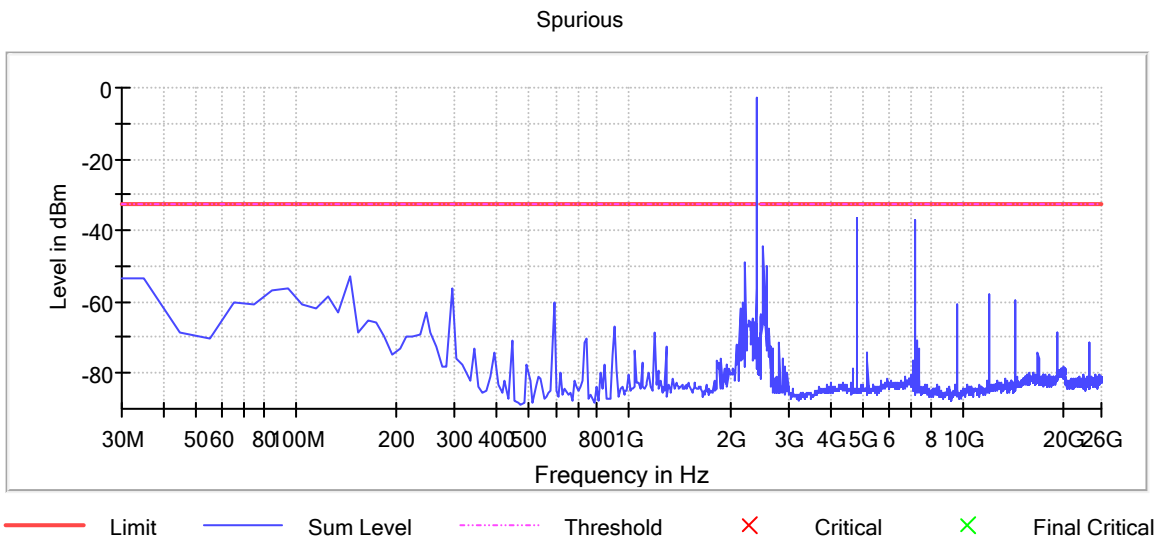
Measurement 2

Setting	Instrument Value	Target Value
Start Frequency	2.48350 GHz	2.48350 GHz
Stop Frequency	2.50000 GHz	2.50000 GHz
Span	16.500 MHz	16.500 MHz
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	330	~ 330
Sweeptime	37.969 µs	AUTO
Reference Level	-10.000 dBm	-10.000 dBm
Attenuation	10.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	100	100
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	FFT	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	4 / max. 150	max. 150
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

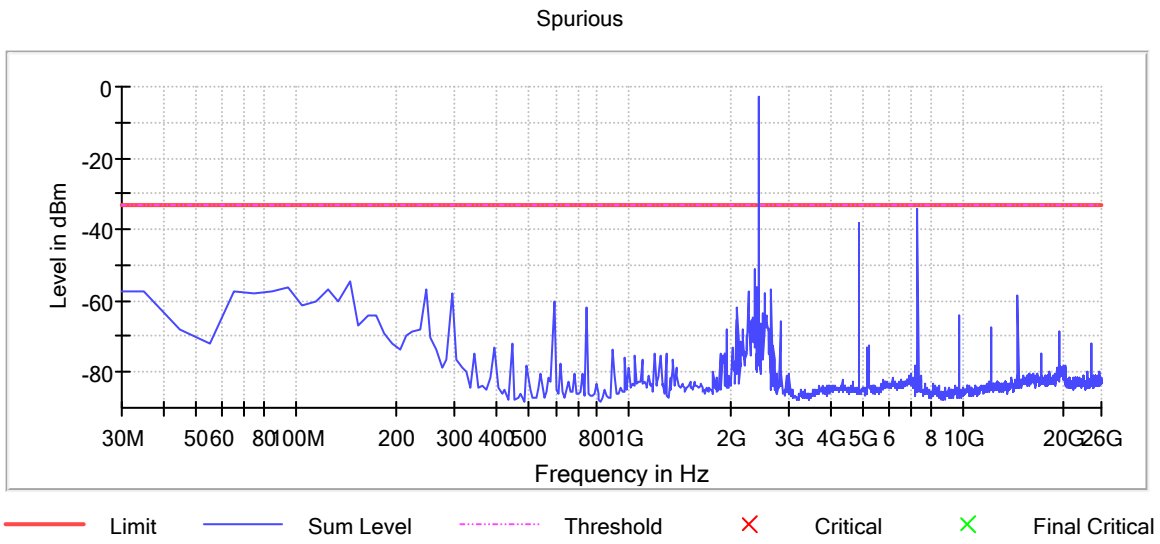
Remark: Cable loss 0.8dB was considered and set in system configuration.

9.6 Conducted spurious emission

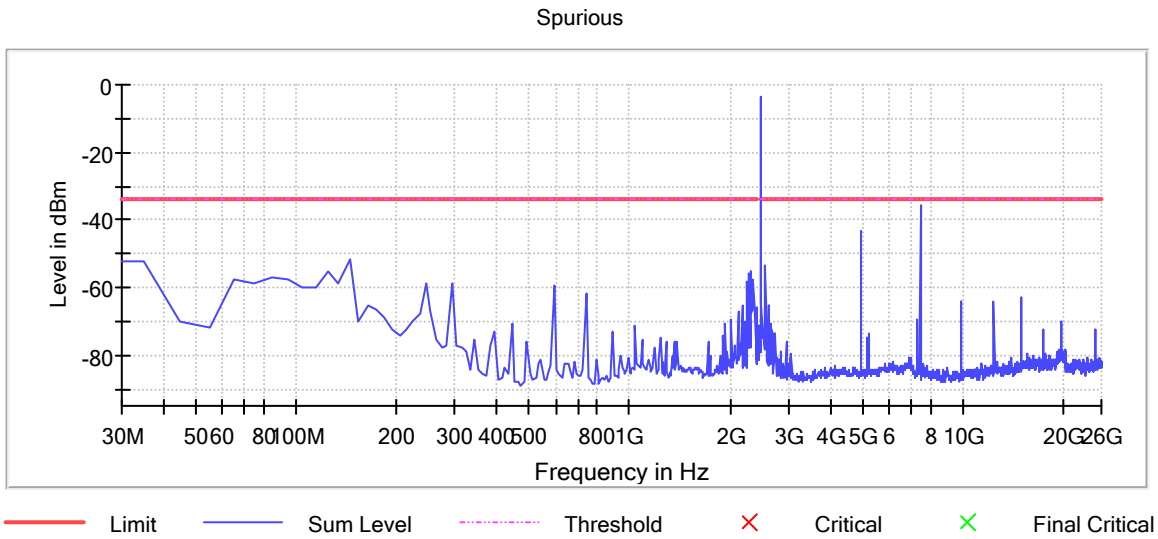
Lowest Channel



Middle Channel



Highest Channel



Pre Measurement 1

Setting	Instrument Value	Target Value
RBW	100.000 kHz	<= 100.000 kHz
VBW	300.000 kHz	>= 300.000 kHz
SweepPoints	238	~ 238
Sweeptime	23.700 ms	AUTO
Reference Level	-30.000 dBm	-30.000 dBm
Attenuation	0.000 dB	AUTO
Detector	MaxPeak	MaxPeak
SweepCount	3	3
Filter	3 dB	3 dB
Trace Mode	Max Hold	Max Hold
Sweeptype	Sweep	AUTO
Preamp	off	off
Stablemode	Trace	Trace
Stablevalue	0.50 dB	0.50 dB
Run	10 / max. 40	max. 40
Stable	3 / 3	3
Max Stable Difference	0.00 dB	0.50 dB

Remark: Cable loss 0.8dB was considered and set in system configuration.

- End of the Report -