

Test report

385873 - 1TRFWL

Date of issue: October 28, 2019

Applicant:

VIE Technologies Inc

Product:

OPA MOTE

Model:

M01C100R03

Model variant:

N/A

FCC ID:

2AQ6J-M01C100R03

IC Registration number:

24331-M01C100R03

Specifications:

◆ **FCC 47 CFR Part 15 Subpart C, §15.247**


Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz

◆ **RSS-247, Issue 2, February 2017**

Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs)
and License-Exempt Local Area Network (LE-LAN) Devices

Test location

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State	California
Postal code	92008
Country	USA
Telephone	+1 760 444 3500
FCC Site Number	Test Firm Registration Number: 392943 Designation Number: US5058
ISED Test Site	2040B-3

Tested by	Andres Martinez, Wireless Engineer
Reviewed by	Chip Fleury, Wireless and Certification Supervisor
Review date	October 28, 2019
Reviewer signature	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	VIE Technologies
Address	9474 Kearney Villa Road, STE 105
City	San Diego
Province/State	CA
Postal/Zip code	92126
Country	US

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz
RSS-247, Issue 2, February 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
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1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was completed against all relevant requirements of the test standard. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See “Summary of test results” for full details.

1.5 Exclusions

None

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31(e)	Variation of power source	Not applicable ¹
§15.203	Antenna requirement	Pass ²

Notes: ¹ Battery operated, AC conducted emissions provided

² The Antenna is located within the enclosure of EUT and not user accessible.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Pass
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Pass
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Pass
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 5, test results

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable
7.4	Receiver conducted emission limits	Not applicable
8.8	Power Line Conducted Emissions Limits for License-Exempt Radio Apparatus	Pass

Notes: None.

2.4 IC RSS-247, Issue 2, test results

Part	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (1)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (2)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (3)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (4)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (5)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2	Digital Transmission Systems (DTSs)	
5.2 (1)	Minimum 6 dB bandwidth	Pass
5.2 (2)	Maximum power spectral density	Pass
5.3	Hybrid Systems	
5.3 (1)	Digital modulation turned off	Not applicable
5.3 (2)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (1)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (2)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (3)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (4)	Systems employing digital modulation techniques	Pass
5.4 (5)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (6)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	October 24, 2019
Nemko sample ID number	385873



3.2 EUT information

Product name	OPA MOTE
Model	M01C100R03
Model variant	N/A
Serial number	N/A

3.3 Technical information

All used IC test site(s) Reg. number	2040B
RSS number and Issue number	RSS-247 Issue 2, February 2017
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
RF conducted Output power (dBm)	10.11
RF power Max (dBm), EIRP	11.61
Field strength, Units @ distance	N/A
Measured BW (kHz) (6 dB)	2402MHz: 716.8kHz 2440MHz: 674.8kHz 2480MHz: 684.4kHz
Measured BW (kHz) (99% dB)	2402MHz 1027 kHz 2440MHz 1028 kHz 2480MHz 1027 kHz
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	GFSK
Emission classification (F1D, G1D, D1D)	F1D
Transmitter spurious, Units @ distance	49.54dBμV/m (peak) and 36.39 dBμV/m (RMS) @ 3m.
Power requirements	Battery Power.
Antenna information	The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator. Antenna gain: 1.5dBi.

3.4 Product description and theory of operation

This is a battery powered multi-sensor product that communicates wirelessly using the Bluetooth Low Energy standard as defined in Bluetooth 4.0 specification. The hardware includes a non-rechargeable and non-replaceable Lithium battery. The BLE product periodically connects with a BLE gateway within its range to wirelessly transmit and receive sensor and other data. It is intended to use in industry environment for tracking performances of machine and equipment.

3.5 EUT exercise details

Software/Firmware version: SiliconLab BG Stack 2.10.9

Power is set to 8dB at the factory.

Device was set to transmit in continuous mode using a client provided software. EUT was set to three frequencies: 2402MHz, 2440MHz and 2480MHz. All software was preloaded before testing began. The only use of the specialized USB port was by the customer setting the device do permanent battery mode. Which is the mode used will the device is being utilized. There are no transmitter power settings.

3.6 EUT setup diagram

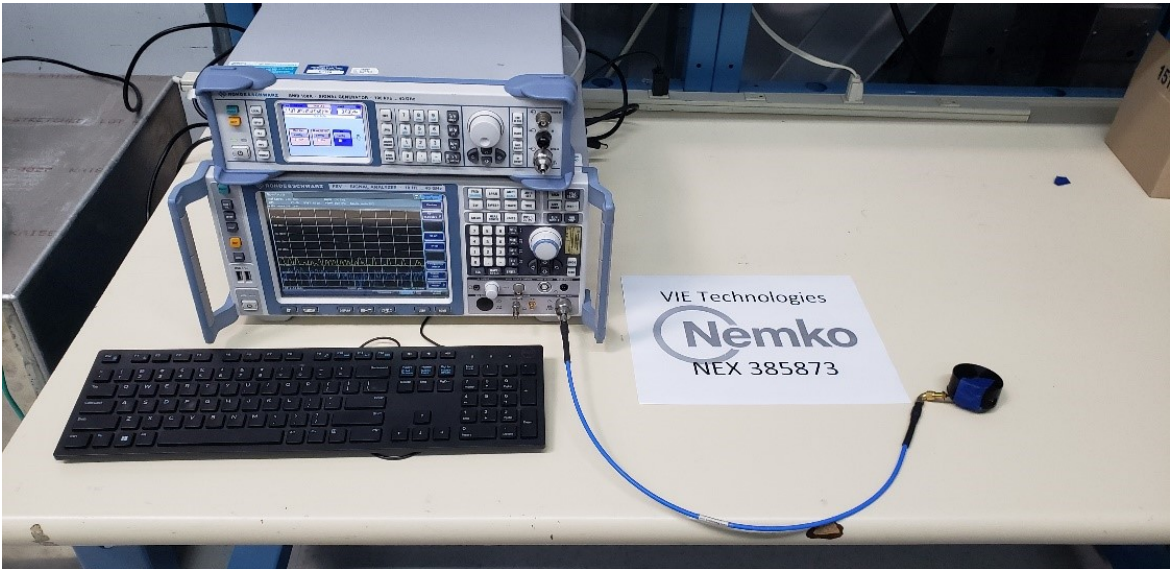


Figure 3.6-1: Setup diagram

3.7 EUT sub assemblies

Table 3.7-1: Support equipment

Description	Brand name	Model/Part number	Serial number
Laptop	DELL	Latitude	7MQRRY1

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

There were no modifications performed to the EUT during this assessment.

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 mbar

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages $\pm 5\%$, for which the equipment was designed.



Section 6. Measurement uncertainty

6.1 Uncertainty of measurement

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of $K = 2$ with 95% certainty.

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	1.38

Section 7. Test equipment

7.1 Test equipment list

Table 7.1-1: Equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receive	Rohde & Schwarz	ESU 40	E1121	2 yr	05-25-2020
EMI Test Receiver 20Hz-40GHz	Rohde&Schwarz	ESU40	E1131	1 yr	05-25-2020
System controller	Sunol Sciences	SC104V	E1191	NCR	NCR
Antenna, Bilog	Schaffner	CBL 6111D	1763	1 yr	01-17-2020
DRG Horn (medium)	ETS-Lindgren	3117-PA	E1139	1 tr	03-21-2020
System Controller 10m Chamber	Sunoc Sciences	SC104V	E1129	NCR	NCR
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	E1120	1 yr	11-24-2020

Note: NCR - no calibration required

Section 8. Testing data

8.1 FCC 15.207(a) and RSS-Gen 5, 8.8 AC power line conducted emissions limits

8.1.1 Definitions and limits

FCC:

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 μ H/50 Ω 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.

IC:

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which 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 table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.1-1: Conducted emissions limit

Frequency of emission, MHz	Conducted limit, dB μ V	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Note: * - The level decreases linearly with the logarithm of the frequency.

** - A linear average detector is required.

8.1.2 Test summary

Test date	March 31, 2020	Temperature	24 °C
Test engineer	Marco Velderrain	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.1.3 Observations, settings and special notes

EUT is battery power.

8.1.4 Setup details

Port under test	AC power mains
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 6 dB or above limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	<ul style="list-style-type: none"> – Peak and Average (Preview measurement) – Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	<ul style="list-style-type: none"> – 100 ms (Peak and Average preview measurement) – 5000 ms (Quasi-peak final measurement) – 5000 ms (CAverage final measurement)

Table 8.1-2: Conducted disturbance at mains port equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	1 yr	29-May-2020
Two Line V-Network	Rohde & Schwarz	ENV216	E1019	1 yr	12-Jul-2020
Transient Limiter (10 dB pad)	Hewlett Packard	11947A	E1159	NCR	NCR
LISN	Solar	9348-50-R-24-BNC	395	1 yr	24-Dec-2020
Variac	Shanghai China	TDGC	S1043	NCR	NCR
Multimeter	Fluke	111	811	1 yr	04-Sep-2020

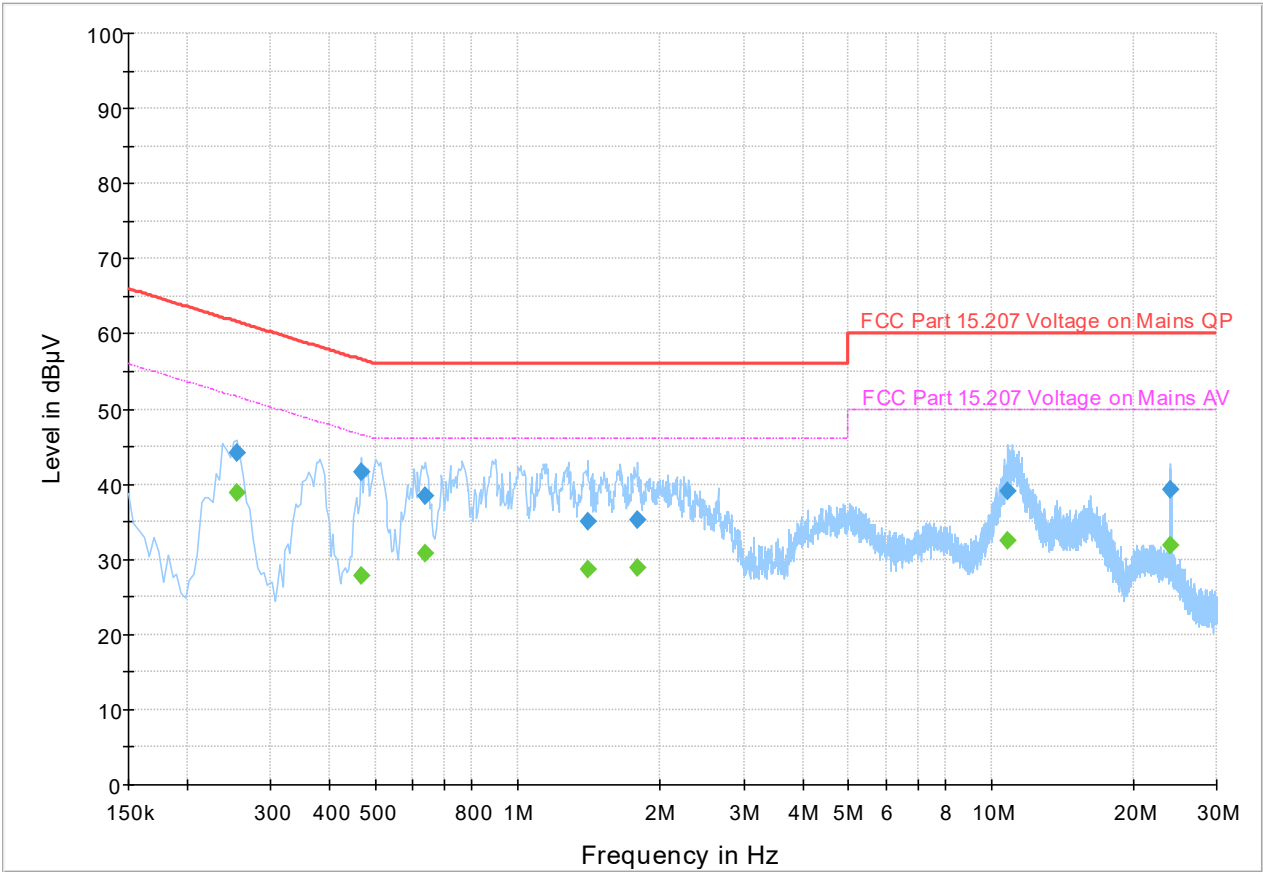
Notes: NCR - no calibration required

Table 8.1-3: Conducted disturbance at mains port test software details

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.20.01

8.1.5 Test data

Full Spectrum



Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.254000	44.26	---	61.63	17.36	5000.0	9.000	N	ON	19.5
0.254000	---	38.78	51.63	12.84	5000.0	9.000	N	ON	19.5
0.466000	41.63	---	56.59	14.96	5000.0	9.000	N	ON	19.4
0.466000	---	27.86	46.59	18.73	5000.0	9.000	N	ON	19.4
0.638000	38.49	---	56.00	17.51	5000.0	9.000	N	ON	19.4
0.638000	---	30.86	46.00	15.14	5000.0	9.000	N	ON	19.4
1.406000	34.93	---	56.00	21.07	5000.0	9.000	N	ON	19.4
1.406000	---	28.64	46.00	17.36	5000.0	9.000	N	ON	19.4
1.786000	35.32	---	56.00	20.68	5000.0	9.000	N	ON	19.4
1.786000	---	28.83	46.00	17.17	5000.0	9.000	N	ON	19.4
10.850000	39.00	---	60.00	21.00	5000.0	9.000	L1	ON	19.7
10.850000	---	32.55	50.00	17.45	5000.0	9.000	L1	ON	19.7
23.994000	---	31.91	50.00	18.09	5000.0	9.000	N	ON	20.1
23.994000	39.35	---	60.00	20.65	5000.0	9.000	N	ON	20.1

8.2 FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques and RSS, 6.7 Occupied bandwidth 99%

8.2.1 Definitions and limits

FCC - 15.247 and IC – RSS.247:

- (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:
- (2) Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

RSS GEN:

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

8.2.2 Test summary

Test date	October 24, 2019	Temperature	24 °C
Test engineer	Andres Martinez	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.2.3 Observations, settings and special notes

Test Procedure ANSI 63.10 2013

6.9.3 Occupied bandwidth – power bandwidth (99%) measurement procedure

11.8 DTS Bandwidth

Spectrum analyzer settings:

Resolution bandwidth	1–5 % of DTS BW (no wider than 100 kHz)
Video bandwidth	≥3 × RBW
Frequency span	30 MHz for 20 MHz channel; 70 MHz for 40 MHz channel
Detector mode	Peak
Trace mode	Max Hold

8.2.4 Test data

Table 8.2-1: 6 dB bandwidth results.

Modulation	Frequency, MHz	6 dB bandwidth, kHz	Limit, kHz	Verdict
GSFK	2402	716.8	500	Pass
	2440	674.8	500	Pass
	2480	684.4	500	Pass

Table 8.2-2: 99% bandwidth results.

Modulation	Frequency, MHz	99% bandwidth, kHz	Verdict
GSFK	2402	1.027MHz	Pass
	2440	1.028MHz	Pass
	2480	1.027MHz	Pass

Section 8

Test name

Specification

Testing data
FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques and RSS, 6.7 Occupied bandwidth 99%
FCC Part 15 Subpart C and RSS-247, Issue 1



Section 8

Test name

Specification

Testing data
FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques and RSS, 6.7 Occupied bandwidth 99%
FCC Part 15 Subpart C and RSS-247, Issue 1

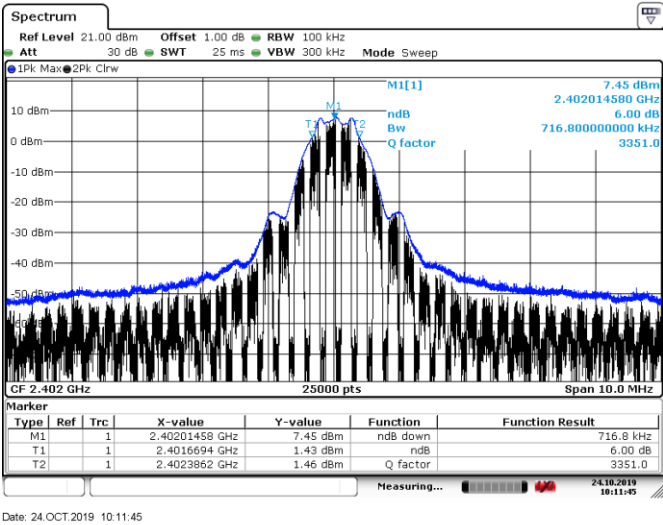


Figure 8.2-1: 6 dB bandwidth on 2402MHz.

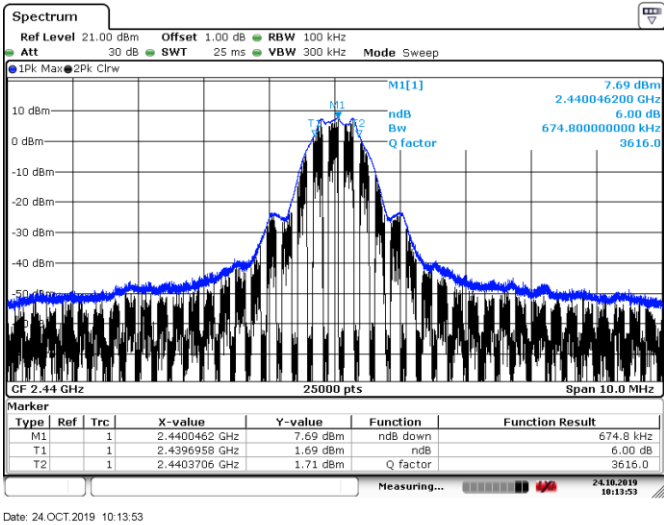


Figure 8.2-2: 6 dB bandwidth on 2440MHz.

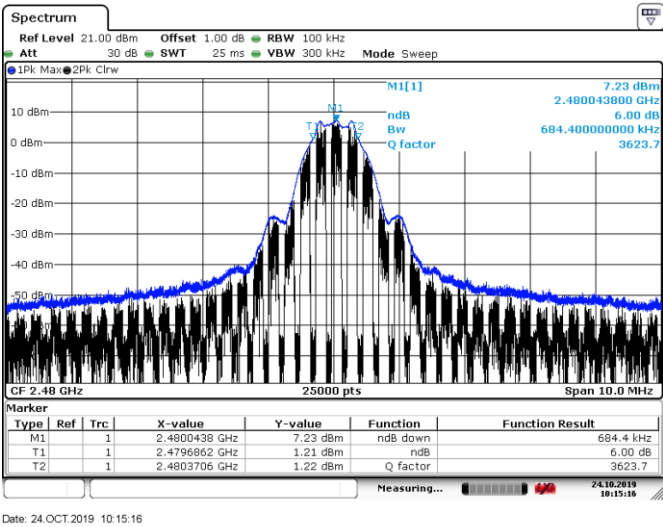


Figure 8.2-3: 6 dB bandwidth on 2480MHz.

Section 8

Test name

Specification

Testing data

FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques and RSS, 6.7 Occupied bandwidth 99%

FCC Part 15 Subpart C and RSS-247, Issue 1

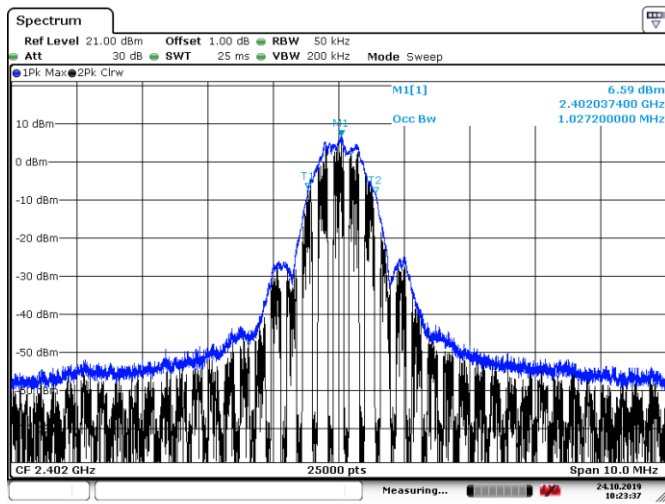


Figure 8.2-4: 99% bandwidth on 2402MHz.

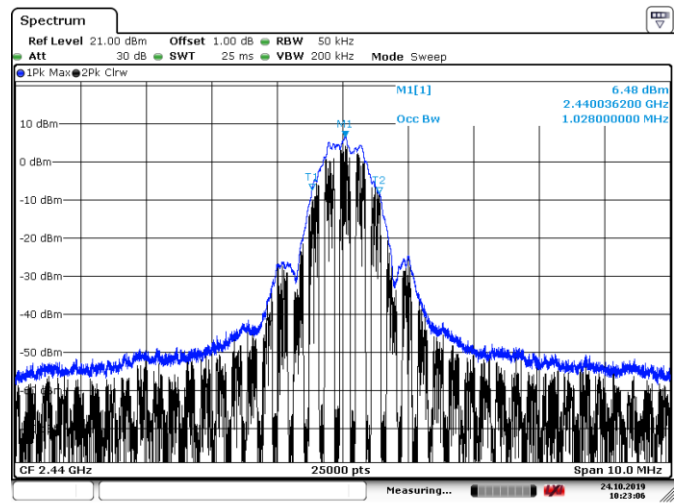


Figure 8.2-5: 99% bandwidth on 2440MHz.

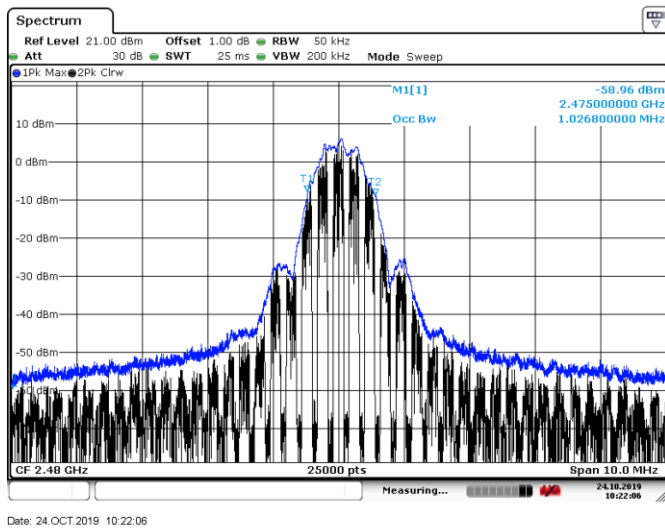


Figure 8.2-6: 99% bandwidth on 2480MHz.

8.3 FCC 15.247(b) and RSS-247 5.4 (4) Transmitter output power and e.i.r.p. requirements

8.3.1 Definitions and limits

FCC 15.247:

- (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:
- (3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.
 - (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.
 - (i) Systems operating in the 2400–2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

- (c) Operation with directional antenna gains greater than 6 dBi.
- (2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:
 - (i) Different information must be transmitted to each receiver.
 - (ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, i.e., the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:
 - (A) The directional gain shall be calculated as the sum of $10 \log$ (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

IC RSS-247:

For DTSs employing digital modulation techniques operating in the bands 902–928 MHz and 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1W. Except as provided in Section 5.4(5), the e.i.r.p. shall not exceed 4 W.

Fixed point-to-point systems in the bands 2400–2483.5 MHz and 5725–5850 MHz are permitted to have an e.i.r.p. higher than 4 W provided that the higher e.i.r.p. is achieved by employing higher gain directional antennas and not higher transmitter output powers. Point-to-multipoint systems, omnidirectional applications and multiple co-located transmitters transmitting the same information are prohibited from exceeding an e.i.r.p. of 4 W.

8.3.2 Test summary

Test date	October 24, 2019	Temperature	24 °C
Test engineer	Andres Martinez	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.3.3 Observations, settings and special notes

Test Procedure ANSI 63.10 2013

11.9.1.1 Maximum Peak conducted output power

Measurement using a spectrum analyzer (SA) at detector mode Peak with the EUT transmitting at full power throughout each sweep.

Offset = Antenna gain + Cable loss. (Antenna gain = 1.5 dBi at 2.4GHz)

8.3.4 Test data

Table 8.3-1: Output power measurements results.

Modulation	Frequency, MHz	Conducted output power, dBm		Verdict	EIRP Output power, dBm		Verdict
		Power	Limit		Power	Limit	
GSFK	2402	10.11	30	Pass	11.61	36	Pass
	2440	9.98	30	Pass	11.48	36	Pass
	2480	9.58	30	Pass	11.08	36	Pass

Note: Offset includes cable loss and antenna gain.

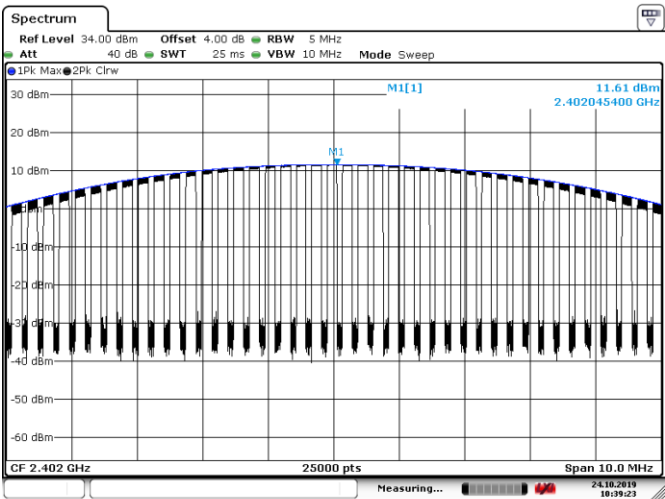


Figure 8.3-1: Output Power Measurement on 2402MHz.

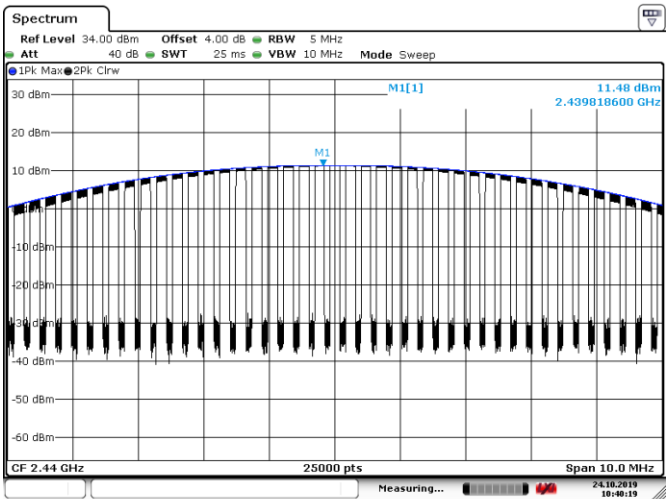
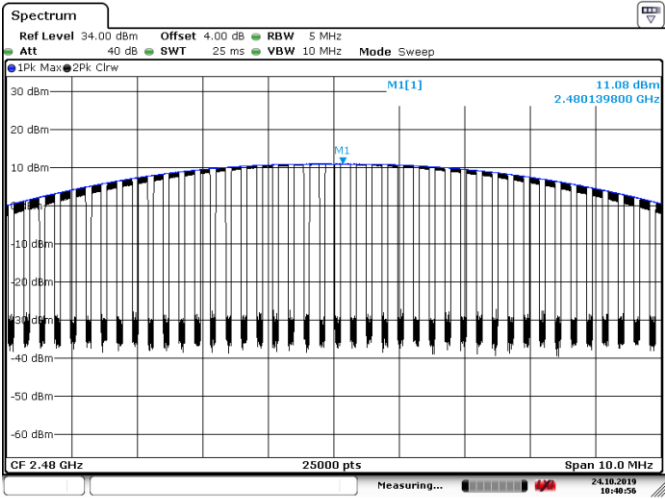


Figure 8.3-2: Output Power Measurement on 2440MHz.

Section 8
Test name
Specification

Testing data
FCC 15.247(b) and RSS-247 5.4 (4) Transmitter output power and e.i.r.p. requirements
FCC Part 15 Subpart C and RSS-247, Issue 2



Date: 24.OCT.2019 10:40:56

Figure 8.3-3: Output Power Measurement on 2480MHz.

8.4 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions

8.4.1 Definitions and limits

FCC 15.247:

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)).

IC RSS-247:

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(4), 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.

Table 8.4-1: FCC §15.209 and RSS-Gen – Radiated emission limits

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

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

For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.4-2: IC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677–5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.4-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.4-3: FCC restricted frequency bands

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.4.2 Test summary

Test date	October 24, 2019	Temperature	25 °C
Test engineer	Andres Martinez	Air pressure	1005 mbar
Verdict	Pass	Relative humidity	45 %

8.4.3 Observations, settings and special notes

Procedure: ANSI C63.10 (2013) – Section 11.12.2.7

The spectrum was searched from 30 MHz to the 10th harmonic.

EUT was set to transmit with 100 % duty cycle.

Radiated measurements were performed at a distance of 3 m, the EUT.

Since fundamental power was tested using average method, the spurious emissions limit is –30 dBc/100 kHz

A notch filter of 2.4 GHz was used.

Spectrum analyzer settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for average radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 Hz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyzer settings for conducted spurious emissions measurements:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.4.4 Test data

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.916000	18.26	40.00	21.74	5000.0	120.000	123.9	V	334.0	22.8
130.548500	15.11	43.50	28.39	5000.0	120.000	132.8	V	120.0	18.7
207.266500	12.85	43.50	30.65	5000.0	120.000	410.0	H	63.0	16.8
300.024500	17.51	46.00	28.49	5000.0	120.000	133.1	V	244.0	21.1
594.006500	34.82	46.00	11.18	5000.0	120.000	403.8	H	-1.0	29.4
884.786500	30.14	46.00	15.86	5000.0	120.000	252.7	H	277.0	33.3

Table 8.4-4: Radiated field strength measurement results, 30MHz to 1GHz, 2402MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
36.322000	17.55	40.00	22.45	5000.0	120.000	214.9	H	16.0	22.0
43.776500	13.95	40.00	26.05	5000.0	120.000	209.0	V	310.0	18.0
134.950000	15.12	43.50	28.38	5000.0	120.000	173.5	H	284.0	18.8
260.264000	18.28	46.00	27.72	5000.0	120.000	191.0	H	136.0	22.1
593.986500	34.20	46.00	11.80	5000.0	120.000	327.6	H	16.0	29.4
956.837500	32.89	46.00	13.11	5000.0	120.000	384.5	V	285.0	35.9

Table 8.4-5: Radiated field strength measurement results, 30MHz to 1GHz, 2440MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
34.373500	18.54	40.00	21.46	5000.0	120.000	402.7	V	104.0	23.1
77.399000	10.08	40.00	29.92	5000.0	120.000	378.4	H	278.0	14.1
131.173500	15.05	43.50	28.45	5000.0	120.000	300.8	H	333.0	18.7
262.485500	18.33	46.00	27.67	5000.0	120.000	348.0	H	0.0	22.1
594.266500	26.14	46.00	19.86	5000.0	120.000	336.8	H	198.0	29.4
954.331000	32.93	46.00	13.07	5000.0	120.000	291.5	H	350.0	35.9

Table 8.4-6: Radiated field strength measurement results, 30MHz to 1GHz, 2480MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	MaxPeak (dBμV/m)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1200.033333	---	32.16	53.90	21.74	5000.0	1000.000	181.0	V	143.0	-14.5
1200.033333	40.18	---	73.90	33.72	5000.0	1000.000	181.0	V	143.0	-14.5
1799.966667	---	34.91	53.90	18.99	5000.0	1000.000	200.0	H	111.0	-12.9
1799.966667	42.27	---	73.90	31.63	5000.0	1000.000	200.0	H	111.0	-12.9
2227.066667	47.52	---	73.90	26.38	5000.0	1000.000	203.0	H	36.0	-11.6
2227.066667	---	26.65	53.90	27.25	5000.0	1000.000	203.0	H	36.0	-11.6
6292.566667	---	30.91	53.90	22.99	5000.0	1000.000	98.0	V	156.0	-0.7
6292.566667	43.15	---	73.90	30.75	5000.0	1000.000	98.0	V	156.0	-0.7
12830.200000	---	35.55	53.90	18.35	5000.0	1000.000	203.0	V	7.0	6.5
12830.200000	47.60	---	73.90	26.30	5000.0	1000.000	203.0	V	7.0	6.5
16301.133333	49.35	---	73.90	24.55	5000.0	1000.000	201.0	V	88.0	10.3
16301.133333	---	36.60	53.90	17.30	5000.0	1000.000	201.0	V	88.0	10.3

Table 8.4-7: Radiated field strength measurement results, 1GHz to 18GHz, 2402MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	MaxPeak (dBμV/m)	RMS (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1263.500000	---	22.94	53.90	30.96	5000.0	1000.000	175.0	V	302.0	-14.7
1263.500000	35.24	---	73.90	38.66	5000.0	1000.000	175.0	V	302.0	-14.7
1799.966667	---	35.83	53.90	18.07	5000.0	1000.000	300.0	H	243.0	-12.9
1799.966667	42.67	---	73.90	31.23	5000.0	1000.000	300.0	H	243.0	-12.9
3521.466667	41.91	---	73.90	31.99	5000.0	1000.000	109.0	V	10.0	-7.0
3521.466667	---	28.90	53.90	25.00	5000.0	1000.000	109.0	V	10.0	-7.0
4872.200000	42.50	---	73.90	31.40	5000.0	1000.000	207.0	V	225.0	-3.2
4872.200000	---	29.76	53.90	24.14	5000.0	1000.000	207.0	V	225.0	-3.2
11954.133333	46.16	---	73.90	27.74	5000.0	1000.000	222.0	V	76.0	3.5
11954.133333	---	33.86	53.90	20.04	5000.0	1000.000	222.0	V	76.0	3.5
16684.900000	48.41	---	73.90	25.49	5000.0	1000.000	118.0	V	243.0	10.9
16684.900000	---	36.57	53.90	17.33	5000.0	1000.000	118.0	V	243.0	10.9

Table 8.4-8: Radiated field strength measurement results, 1GHz to 18GHz, 2440MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Section 8
Test name
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Testing data
FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions
FCC Part 15 Subpart C and RSS-247, Issue 2



Frequency (MHz)	MaxPeak (dBµV/m)	RMS (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
1199.866667	39.75	---	73.90	34.15	5000.0	1000.000	220.0	V	210.0	-14.5
1199.866667	---	31.70	53.90	22.20	5000.0	1000.000	220.0	V	210.0	-14.5
1799.966667	43.00	---	73.90	30.90	5000.0	1000.000	288.0	H	212.0	-12.9
1799.966667	---	35.94	53.90	17.96	5000.0	1000.000	288.0	H	212.0	-12.9
2237.766667	45.42	---	73.90	28.48	5000.0	1000.000	203.0	H	304.0	-11.6
2237.766667	---	26.68	53.90	27.22	5000.0	1000.000	203.0	H	304.0	-11.6
3574.800000	---	29.16	53.90	24.74	5000.0	1000.000	145.0	H	10.0	-6.6
3574.800000	41.94	---	73.90	31.96	5000.0	1000.000	145.0	H	10.0	-6.6
10876.133333	---	32.97	53.90	20.93	5000.0	1000.000	141.0	V	9.0	2.0
10876.133333	45.68	---	73.90	28.22	5000.0	1000.000	141.0	V	9.0	2.0
16306.966667	49.45	---	73.90	24.45	5000.0	1000.000	192.0	H	96.0	10.3
16306.966667	---	36.78	53.90	17.12	5000.0	1000.000	192.0	H	96.0	10.3

Table 8.4-9: Radiated field strength measurement results, 1GHz to 18GHz, 2480MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
23432.183167	49.13	---	73.90	24.77	5000.0	1000.000	107.0	V	294.0	20.0
23432.183167	---	35.88	53.90	18.02	5000.0	1000.000	107.0	V	294.0	20.0
23619.144500	49.47	---	73.90	24.43	5000.0	1000.000	174.0	V	10.0	20.3
23619.144500	---	36.40	53.90	17.50	5000.0	1000.000	174.0	V	10.0	20.3
24627.255167	47.44	---	73.90	26.46	5000.0	1000.000	113.0	V	10.0	18.3
24627.255167	---	34.17	53.90	19.73	5000.0	1000.000	113.0	V	10.0	18.3
25021.253500	---	35.96	53.90	17.94	5000.0	1000.000	125.0	V	56.0	19.1
25021.253500	48.84	---	73.90	25.06	5000.0	1000.000	125.0	V	56.0	19.1
25026.444167	---	35.70	53.90	18.20	5000.0	1000.000	125.0	V	73.0	19.1
25026.444167	49.18	---	73.90	24.72	5000.0	1000.000	125.0	V	73.0	19.1
25613.243167	48.73	---	73.90	25.17	5000.0	1000.000	225.0	V	320.0	19.2
25613.243167	---	35.68	53.90	18.22	5000.0	1000.000	225.0	V	320.0	19.2

Table 8.4-10: Radiated field strength measurement results, 18GHz to 26GHz, 2402MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
19299.775667	46.62	---	73.90	27.28	5000.0	1000.000	155.0	V	181.0	14.9
19299.775667	---	32.87	53.90	21.03	5000.0	1000.000	155.0	V	181.0	14.9
22254.900000	46.31	---	73.90	27.59	5000.0	1000.000	103.0	V	201.0	15.7
22254.900000	---	32.85	53.90	21.05	5000.0	1000.000	103.0	V	201.0	15.7
23349.448833	49.20	---	73.90	24.70	5000.0	1000.000	125.0	V	11.0	19.6
23349.448833	---	36.15	53.90	17.75	5000.0	1000.000	125.0	V	11.0	19.6
23602.946833	49.54	---	73.90	24.36	5000.0	1000.000	140.0	V	13.0	20.4
23602.946833	---	36.39	53.90	17.51	5000.0	1000.000	140.0	V	13.0	20.4
25015.350333	49.38	---	73.90	24.52	5000.0	1000.000	105.0	V	185.0	19.1
25015.350333	---	35.90	53.90	18.00	5000.0	1000.000	105.0	V	185.0	19.1
25999.114667	49.37	---	73.90	24.53	5000.0	1000.000	111.0	V	248.0	20.5
25999.114667	---	36.25	53.90	17.65	5000.0	1000.000	111.0	V	248.0	20.5

Table 8.4-11: Radiated field strength measurement results, 18GHz to 26GHz, 2440MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18635.280833	---	31.91	53.90	21.99	5000.0	1000.000	125.0	V	285.0	14.1
18635.280833	45.07	---	73.90	28.83	5000.0	1000.000	125.0	V	285.0	14.1
19283.116000	---	32.63	53.90	21.27	5000.0	1000.000	125.0	V	3.0	14.8
19283.116000	46.20	---	73.90	27.70	5000.0	1000.000	125.0	V	3.0	14.8
20692.419667	---	32.71	53.90	21.19	5000.0	1000.000	150.0	V	5.0	15.8
20692.419667	46.23	---	73.90	27.67	5000.0	1000.000	150.0	V	5.0	15.8
22095.512833	45.66	---	73.90	28.24	5000.0	1000.000	109.0	V	7.0	15.3
22095.512833	---	31.99	53.90	21.91	5000.0	1000.000	109.0	V	7.0	15.3
23792.422667	---	35.34	53.90	18.56	5000.0	1000.000	110.0	V	352.0	18.7
23792.422667	48.13	---	73.90	25.77	5000.0	1000.000	110.0	V	352.0	18.7
25019.375333	48.97	---	73.90	24.93	5000.0	1000.000	140.0	H	354.0	19.1
25019.375333	---	35.98	53.90	17.92	5000.0	1000.000	140.0	H	354.0	19.1

Table 8.4-12: Radiated field strength measurement results, 18GHz to 26GHz, 2480MHz.

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

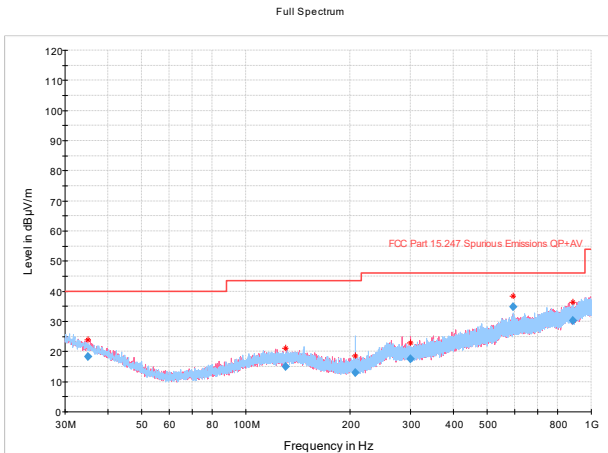


Figure 8.4-1: Radiated spurious emissions, 30MHz to 1GHz, 2402MHz

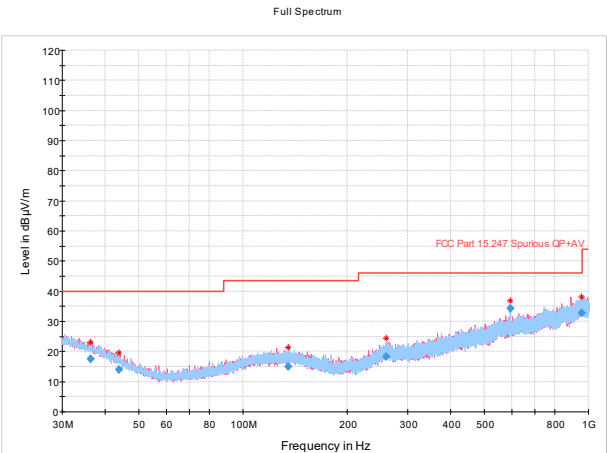


Figure 8.4-2: Radiated spurious emissions, 30MHz to 1GHz, 2440MHz

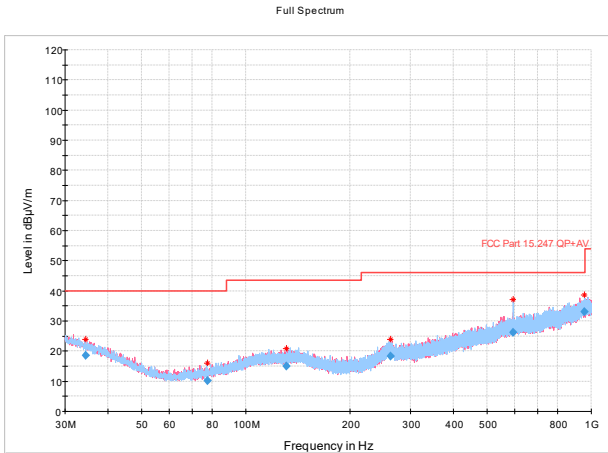


Figure 8.4-3: Radiated spurious emissions, 30MHz to 1GHz, 24080MHz

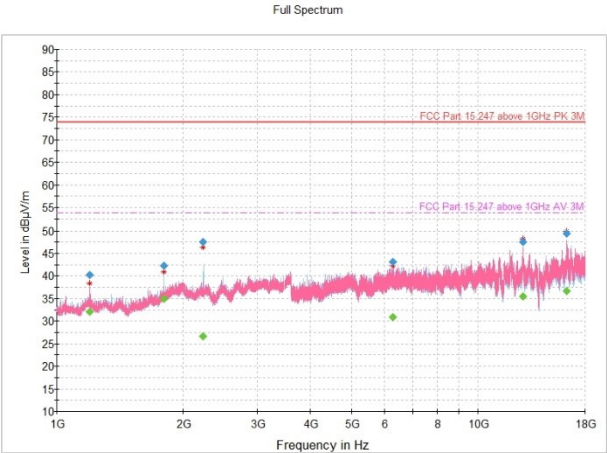


Figure 8.4-4: Radiated spurious emissions, 1GHz to 18GHz, 2402MHz

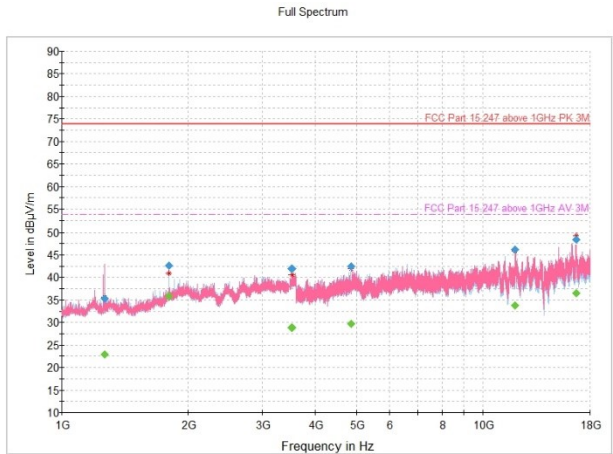


Figure 8.4-5: Radiated spurious emissions, 1GHz to 18GHz, 2440MHz

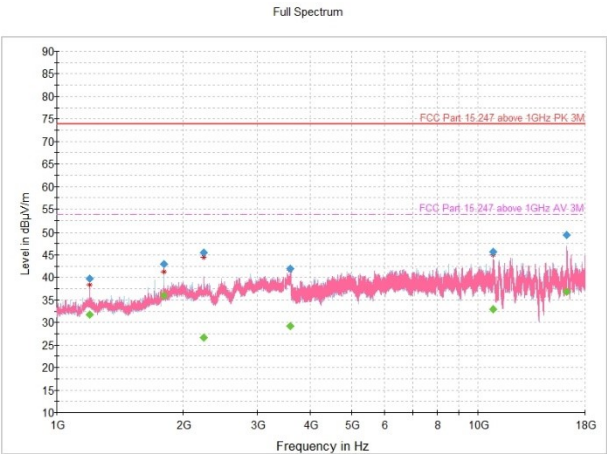


Figure 8.4-6: Radiated spurious emissions, 1GHz to 18GHz, 2480MHz

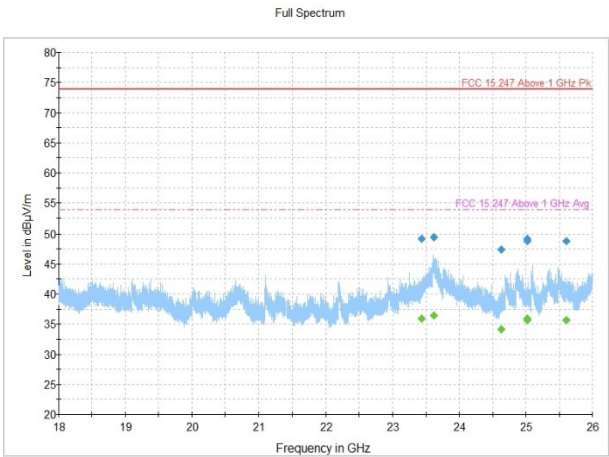


Figure 8.4-7: Radiated spurious emissions, 18GHz to 26GHz, 2402MHz

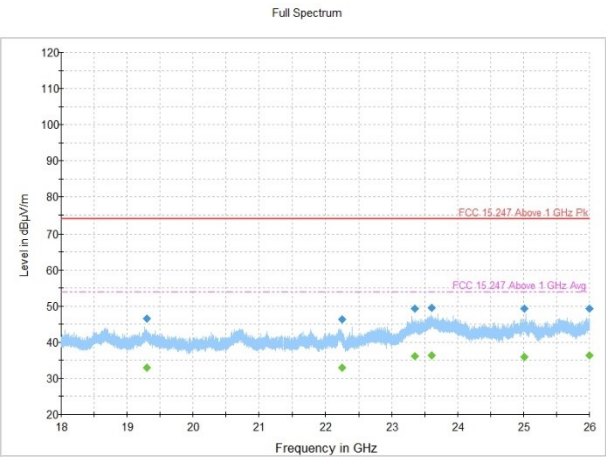


Figure 8.4-8: Radiated spurious emissions, 18GHz to 26GHz, 2440MHz

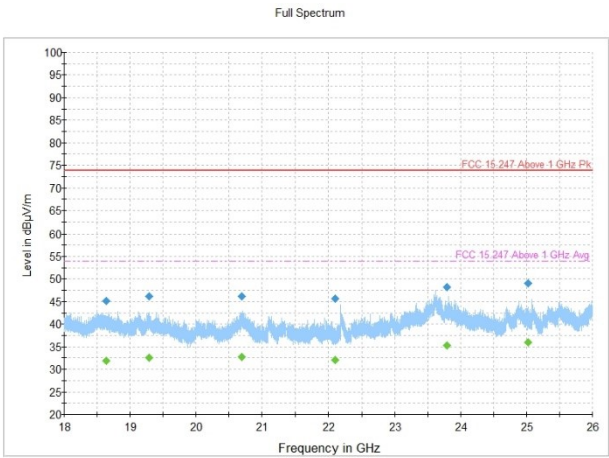


Figure 8.4-9: Radiated spurious emissions, 18GHz to 26GHz, 2480MHz

8.5 FCC 15.247(e) and RSS-247 5.2(2) Power spectral density for digitally modulated devices

8.5.1 Definitions and limits

FCC: 15.247

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. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

IC: RSS-247

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of Section 5.4(4), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.5.2 Test summary

Test date	October 24, 2019	Temperature	24 °C
Test engineer	Andres Martinez	Air pressure	1004 mbar
Verdict	Pass	Relative humidity	45 %

8.5.3 Observations, settings and special notes

Test Procedure: ANSI C63.10 (2013) – 11.10 Maximum power spectral density level in fundamental emission – 11.10.2 Method PKPSD (peak PSD)

Resolution bandwidth:	3 kHz
Video bandwidth:	10 kHz
Frequency span:	3MHz
Detector mode:	Peak
Trace mode:	Peak
Averaging sweeps number:	--

8.5.4 Test data

Table 8.5-1: PSD measurements results for SISO 1 × 1 application

Modulation	Frequency, MHz	PSD, dBm/3kHz	PSD limit, dBm/3kHz	Margin, dB
GSFK	2402	-3.39	8.00	11.95
	2440	-3.55	8.00	11.55
	2480	-3.95	8.00	11.39

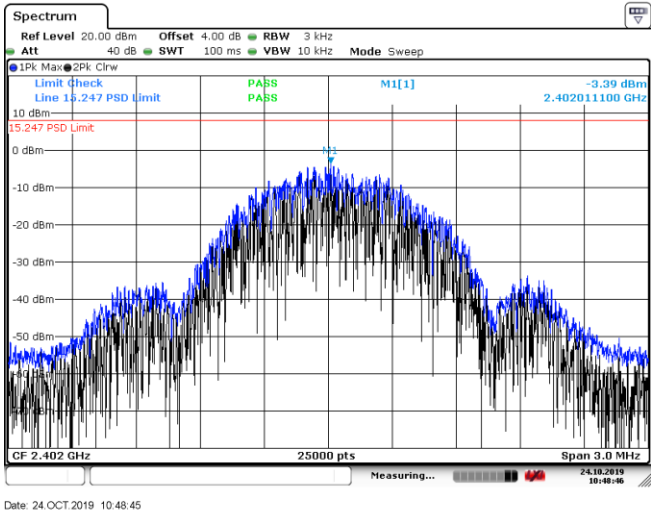


Figure 8.5-1: PSD plot on 2402MHz.

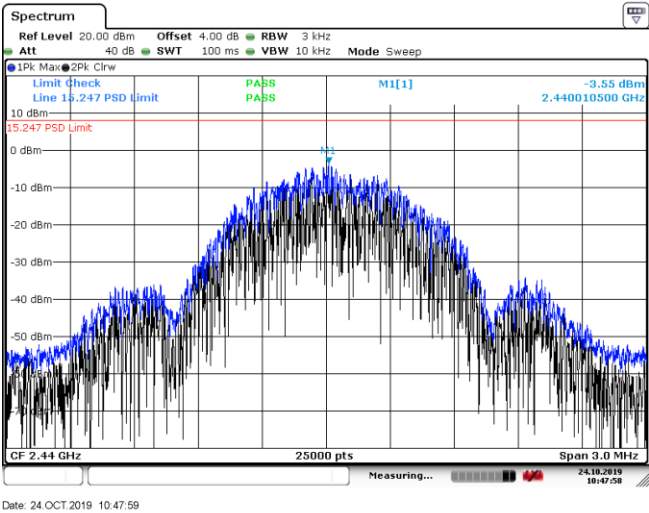


Figure 8.5-2: PSD plot on 2440MHz.

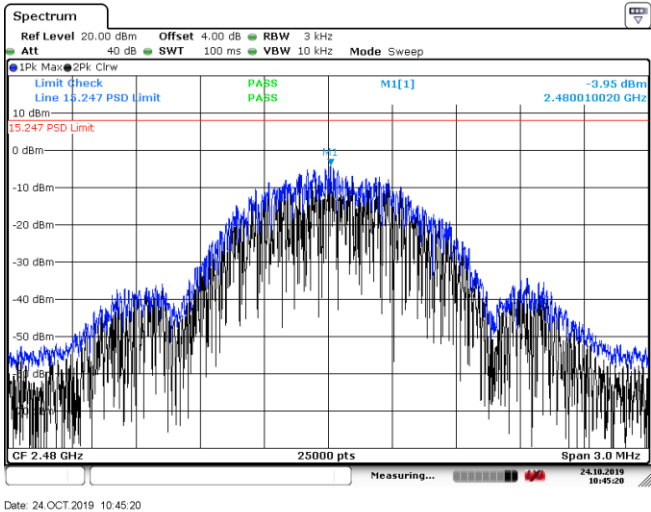
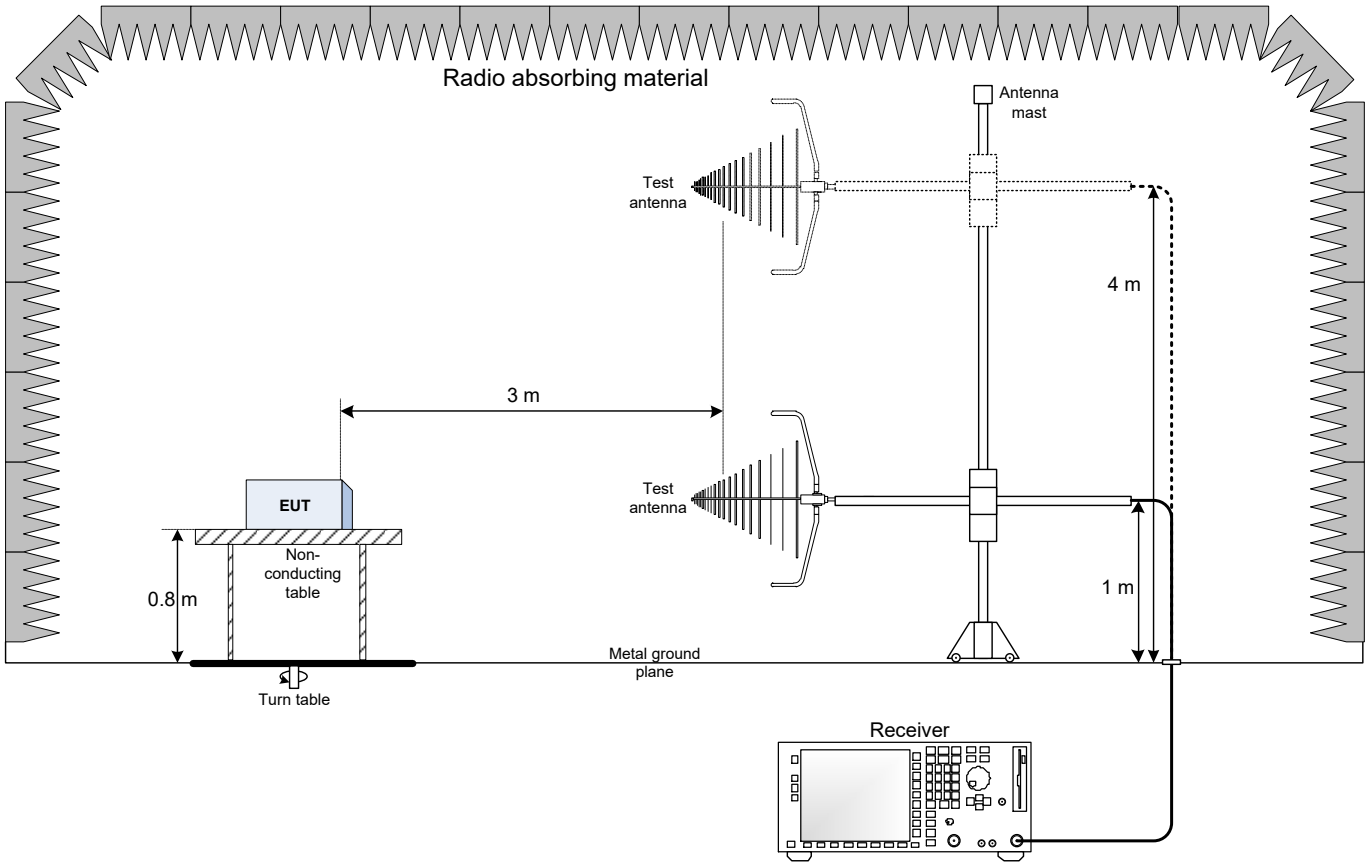


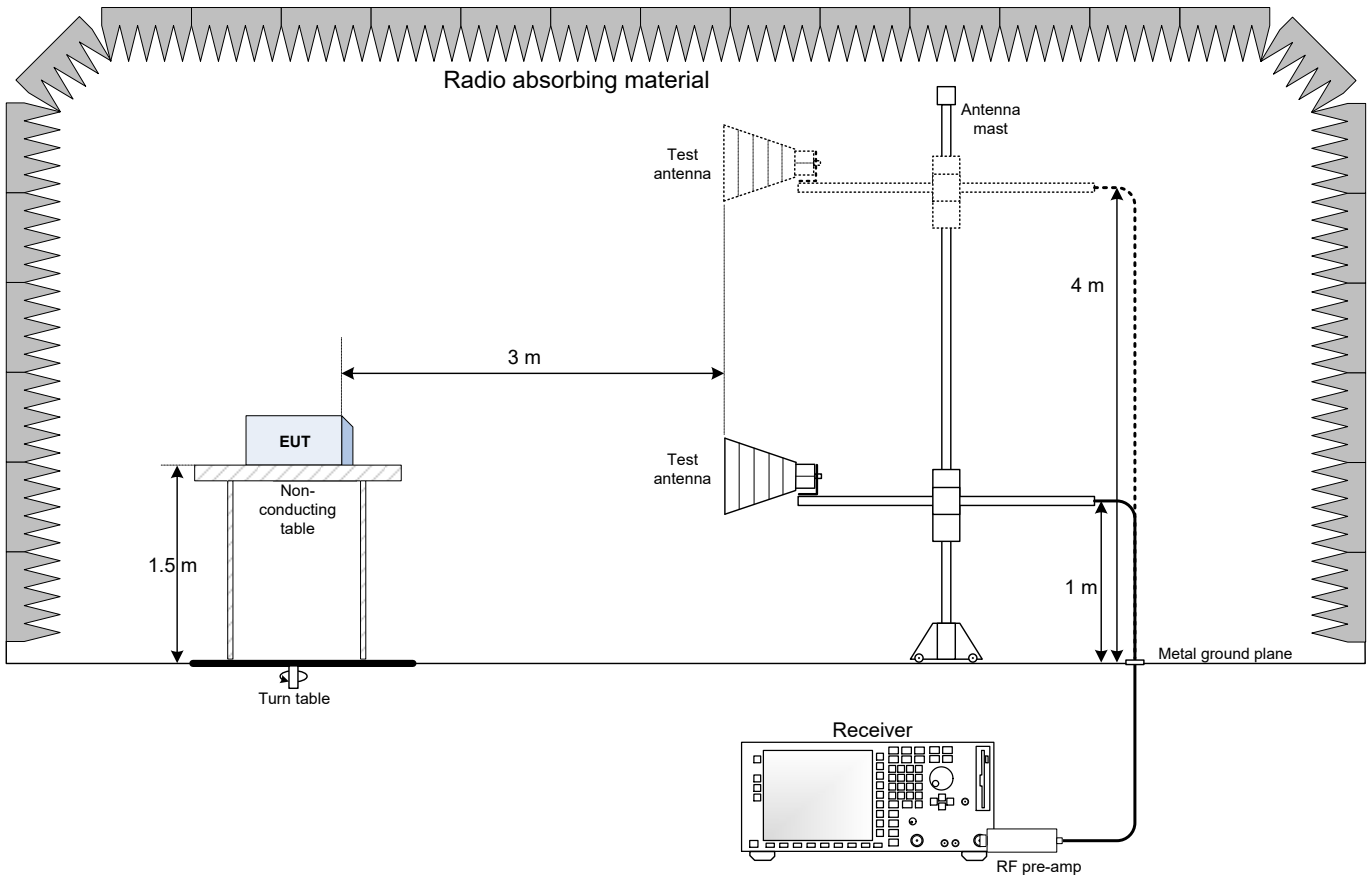
Figure 8.5-3: PSD plot on 2480MHz.

Section 9. Block diagrams of test set-ups

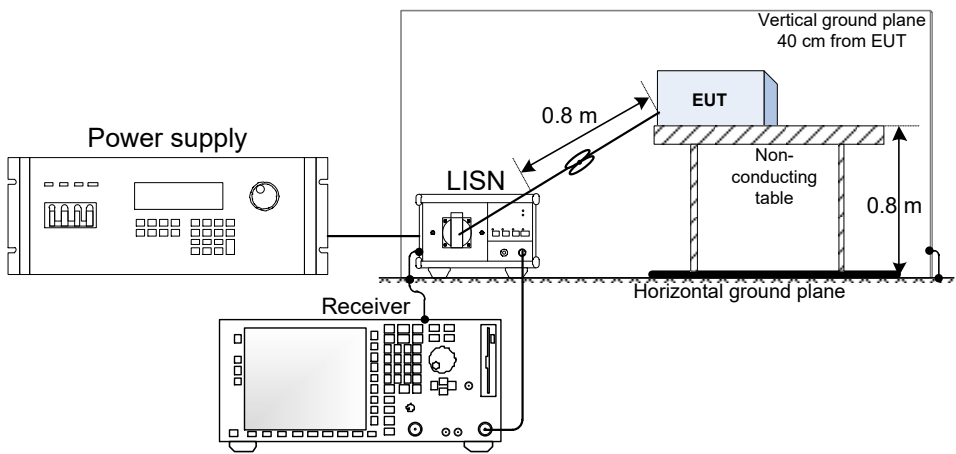
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



9.4 Conducted Port Measurement set-up

Power and or Bandwidth Measurements At Antenna Terminals

