



Test report

REP015384-8TRFWL

Date of issue: December 11, 2023

Applicant:

Alarm.com, Inc

Product description:

Video Doorbell

Model:

ADC-VDB755P

Product marketing name(s):

PoE Video Doorbell

FCC ID:

YL6VDB755P

ISED certification number:

9111A-VDB755P

Specifications:

- ◆ **FCC 47 CFR Part 15, Subpart C – §15.247**
Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5727 – 5850 MHz
- ◆ **Industry Canada RSS-247, Issue 2**
Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Lab and test locations

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FCC Site Number	Test Firm Registration Number: 392943; Designation Number: US5058
ISED Test Site	2040B-3
Tested by	Lan Sayasane, EMC Test Engineer
Reviewed by	James Cunningham, EMC/WL Manager
Review date	December 11, 2023
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 contained in this report are within Nemko USA's ISO/IEC 17025 accreditation.

This report must not be used by the client to claim product certification, approval, or endorsement by ANAB, NIST, or any agency of the U.S. Government.

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Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 15, Subpart C – §15.247	Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5727 – 5850 MHz
Industry Canada RSS-247, Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.2 Exclusions

None.

1.3 Statement of compliance

Testing was performed against all relevant requirements of the test standard(s).

Results obtained indicate that the product under test complies in full with the tested requirements.

The test results relate only to the item(s) tested.

See "Section 2 Summary of test results" for full details.

1.4 Test report revision history

Table 1.4-1: Test report revision history

Revision #	Issue Date	Details of changes made to test report
REP015384-8TRFEMC	December 11, 2023	Original report issued

Section 2 Summary of test results

2.1 Sample information

Receipt date	12-Sep-23
Nemko sample ID number	REP015384

2.2 Testing period

Test start date	25-Sep-23
Test end date	21-Nov-23

2.3 Test results

Table 2.3-1: FCC 47 CFR Part 15, Subpart B & C, general requirements

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable ¹
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass
§15.231(c)	20 dB bandwidth	Pass

Notes: ¹ EUT is powered via PoE

Table 2.3-2: FCC 47 CFR Part 15, Subpart C, §15.247 requirements

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(b)(4)	Transmitting antennas of directional gain greater than 6 dBi	Not applicable
§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

Table 2.3-3: ISED RSS-247 requirements

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (b)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (c)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (e)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2 (a)	Minimum 6 dB bandwidth	Pass
5.2 (b)	Maximum power spectral density	Pass
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4 (a)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Pass
5.4 (c)	Frequency hopping systems operating in the 5725–5850 MHz	Pass
5.4 (d)	Systems employing digital modulation techniques	Not applicable
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

Table 2.3-4: ISED RSS-GEN requirements

Part	Test description	Verdict
6.7	Occupied bandwidth (99%)	Pass
7.3	Receiver radiated emission limits	Not applicable ¹
7.4	Receiver conducted emission limits	Not applicable ¹
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Not applicable

Notes: ¹Only applicable to scanner receivers or stand-alone receivers operating in the band 30-960 MHz

Section 3 Equipment under test (EUT) details

3.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

3.2 Applicant

Company name	Alarm.com, Inc
Address	8281 Greensboro Drive Suite 100
City	Tysons
State	Virginia
Postal/Zip code	22102
Country	United States

3.3 Manufacturer

Company name	Alarm.com, Inc
Address	8281 Greensboro Drive Suite 100
City	Tysons
State	Virginia
Postal/Zip code	22102
Country	United States

3.4 EUT information

Product name	Video Doorbell
Model	ADC-VDB755P
Variant(s)	PoE Video Doorbell
Serial number	N/A
Part number	N/A
Power requirements	POE; 48VDC, 50/60Hz, 0.15A, 5W
Description/theory of operation	Bluetooth Low Energy (BLE) v5.0
Operational frequencies	2402 - 2480 MHz
Software details	N/A

3.5 Transmitter Information

Frequency band	2400 – 2483.5 MHz
Transmitter type	<input type="checkbox"/> Frequency hopping spread spectrum (FHSS) <input checked="" type="checkbox"/> Digital transmission system (DTS) <input type="checkbox"/> Hybrid FHSS / DTS
Minimum frequency (MHz)	2402
Maximum frequency (MHz)	2480
Type of modulation	GFSK
Data rate	<input checked="" type="checkbox"/> 125 kbps operation <input checked="" type="checkbox"/> 500 kbps operation <input checked="" type="checkbox"/> 1 Mbps operation <input checked="" type="checkbox"/> 2 Mbps operation
Tested frequencies	2402 MHz (low), 2440 MHz (middle), and 2480 MHz (high)
Antenna type	Multilayer antenna
Antenna peak gain	2.5 dBi

3.6 EUT setup details

Table 3.6-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number	Rev.
N/A				

Table 3.6-2: EUT interface ports

Description	Qty.
Ethernet	1

Table 3.6-3: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
Laptop PC PoE injector	POE-48i	N/A	112013870D	N/A

Table 3.6-4: Inter-connection cables

Cable description	From	To	Length (m)
Ethernet	EUT	PoE injector	1
Ethernet	PoE injector	Laptop	1

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

None.

4.2 Technical judgement

None.

4.3 Deviations from laboratory test procedures

None.

Section 5 Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	86–106 kPa

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

Nemko USA Inc. has calculated measurement uncertainty and is documented in EMC/MUC/001 "Uncertainty in EMC measurements." Measurement uncertainty was calculated using the methods described in CISPR 16-4-2 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics, and limit modelling – Measurement instrumentation uncertainty. The expression of Uncertainty in EMC testing. Measurement uncertainty calculations assume a coverage factor of K=2 with 95% certainty.

Table 6.1-1: Measurement uncertainty calculations

Measurement		U_{cisp} dB	U_{lab} dB
Conducted disturbance at AC mains and other port power using a V-AMN	9 kHz to 150 kHz	3.8	2.9
	150 kHz to 30 MHz	3.4	2.3
Conducted disturbance at telecommunication port using AAN	150 kHz to 30 MHz	5.0	4.3
Conducted disturbance at telecommunication port using CVP	150 kHz to 30 MHz	3.9	2.9
Conducted disturbance at telecommunication port using CP	150 kHz to 30 MHz	2.9	1.4
Conducted disturbance at telecommunication port using CP and CVP	150 kHz to 30 MHz	4.0	3.1
Radiated disturbance (electric field strength in a SAC)	30 MHz to 1 GHz	6.3	5.5
Radiated disturbance (electric field strength in a FAR)	1 GHz to 6 GHz	5.2	4.7
Radiated disturbance (electric field strength in a FAR)	6 GHz to 18 GHz	5.5	5.0

Notes: Compliance assessment:

If U_{lab} is less than or equal to U_{cisp} then:

- 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

If U_{lab} is greater than U_{cisp} then:

- compliance is deemed to occur if no measured disturbance level, increased by $(U_{lab} - U_{cisp})$, exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance level, increased by $(U_{lab} - U_{cisp})$, exceeds the disturbance limit

V-AMN: V type artificial mains network
 AAN: Asymmetric artificial network
 CP: Current probe
 CVP: Capacitive voltage probe
 SAC: Semi-anechoic chamber
 FAR: Fully anechoic room

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: Test Equipment List

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESU26	E1353	1 year	14-Nov-2024
System controller	Sunol Sciences	SC104V	E1129	NCR	NCR
Bilog Antenna (30-1000MHz)	Schaffner-Chase	CBL 6111D	1763	2 years	01-Apr-2024
DRG Horn (medium)	ETS-Lindgren	3117-PA	E1160	1 year	13-Feb-2024
Standard Gain Horn Antenna	Eravant	SAZ-2410-42-S1	EW107	1 year	22-Nov-2023
Signal and Spectrum Analyzer	Rohde & Schwarz	FSW43	E1302	1 year	20-Oct-2023
Signal and Spectrum Analyzer	Rohde & Schwarz	FSV40	E1120	2 years	28-Aug-2025

Notes: NCR: no calibration required
VBU: verify before use

7.2 Test software list

Table 7.2-1: Test Software

Manufacturer	Details
Rohde & Schwarz	EMC 32 V10.60.15 (radiated emissions)

Section 8 Testing data

8.1 Variation of power source

8.1.1 References and limits

- FCC 47 CFR Part 15, Subpart A: §15.31(e)
- Test method: ANSI C63.10-2020 §5.13

§15.31(e):

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test summary

Verdict	Pass		
Test date	September 25, 2023	Temperature	21 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	53 %

8.1.3 Notes

Testing was performed with the transmitter operating on a fixed channel (middle) at maximum output power.

8.1.4 Setup details

EUT power input during test PoE 48V varied between 85 – 115 %

8.1.5 Test data

<input type="checkbox"/>	EUT is battery operated. Therefore, all tests performed with a new fully charged battery
<input checked="" type="checkbox"/>	EUT power supply voltage varied across supported range. No variation in transmitter output power observed therefore all tests performed at nominal power supply voltage.
<input type="checkbox"/>	EUT power supply voltage varied across supported range. Transmitter output power variation was observed. All tests performed with the EUT operated at the worst-case operating voltage with respect to transmitter output power: V.

8.2 Antenna requirement

8.2.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.203

§15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. Test summary

Verdict	Pass
Test date	September 25, 2023
Test engineer	Lan Sayasane, EMC Test Engineer
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:

8.2.2 Notes

None

8.2.3 Test data

Antenna part number:	ANT016008LCS2442MA2
Technical description:	Multilayer antenna
Peak gain (dBi):	2.5 dBi
Source of gain data:	<input type="checkbox"/> Declared by client <input checked="" type="checkbox"/> Antenna data sheet or specification. Document name: rf_ant_ant016008lcs2442ma2_summary_en <input type="checkbox"/> Antenna gain test report. Document name:

8.3 20 dB bandwidth

8.3.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.215(c)
- Test method: ANSI C63.4-2020: §6.9.2

§15.215:

(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated.

8.3.2 Test summary

Verdict	Pass		
Test date	September 25, 2023	Temperature	21 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	53 %

8.3.3 Notes

Testing was performed with the transmitter operating on a fixed channel (lowest, middle, and highest) at maximum output power.

The spectral plots within this section have been corrected with all relevant transducer factors.

8.3.4 Setup details

EUT power input during test	48V DC PoE
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Receiver/spectrum analyzer settings:

Resolution bandwidth	20 kHz
Video bandwidth	100 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.3.5 Test data

Table 8.3-1: 20 dB bandwidth test data

Test frequency (MHz)	Modulation	Bandwidth (MHz)	Measured f_L (MHz)	Measured f_H (MHz)	Limit	Verdict
2402	GFSK, 0.125 Mbps	1.078	2401.895	2402.973	f_H and f_L within 2400 – 2483.5 MHz	PASS
2440	GFSK, 0.125 Mbps	1.085	2439.902	2440.987	f_H and f_L within 2400 – 2483.5 MHz	PASS
2480	GFSK, 0.125 Mbps	1.071	2479.916	2480.987	f_H and f_L within 2400 – 2483.5 MHz	PASS
2402	GFSK, 0.500 Mbps	1.089	2401.899	2402.987	f_H and f_L within 2400 – 2483.5 MHz	PASS
2440	GFSK, 0.500 Mbps	1.092	2439.902	2440.994	f_H and f_L within 2400 – 2483.5 MHz	PASS
2480	GFSK, 0.500 Mbps	1.127	2479.892	2481.019	f_H and f_L within 2400 – 2483.5 MHz	PASS
2402	GFSK, 1 Mbps	1.124	2401.874	2402.998	f_H and f_L within 2400 – 2483.5 MHz	PASS
2440	GFSK, 1 Mbps	1.117	2439.885	2441.001	f_H and f_L within 2400 – 2483.5 MHz	PASS
2480	GFSK, 1 Mbps	1.120	2479.892	2481.012	f_H and f_L within 2400 – 2483.5 MHz	PASS
2402	GFSK, 2 Mbps	2.165	2401.362	2403.527	f_H and f_L within 2400 – 2483.5 MHz	PASS
2440	GFSK, 2 Mbps	2.131	2439.393	2441.525	f_H and f_L within 2400 – 2483.5 MHz	PASS
2480	GFSK, 2 Mbps	2.169	2479.373	2481.542	f_H and f_L within 2400 – 2483.5 MHz	PASS

Section 8

Test name

Specification(s)

Testing data
20 dB bandwidth
FCC 15.247 & RSS-247



Figure 8.3-1: 20 dB bandwidth, GFSK, 0.125 Mbps, 2402 MHz



Figure 8.3-2: 20 dB bandwidth, GFSK, 0.125 Mbps, 2440 MHz



Figure 8.3-3: 20 dB bandwidth, GFSK, 0.125 Mbps, 2480 MHz



Figure 8.3-4: 20 dB bandwidth, GFSK, 0.500 Mbps, 2402 MHz

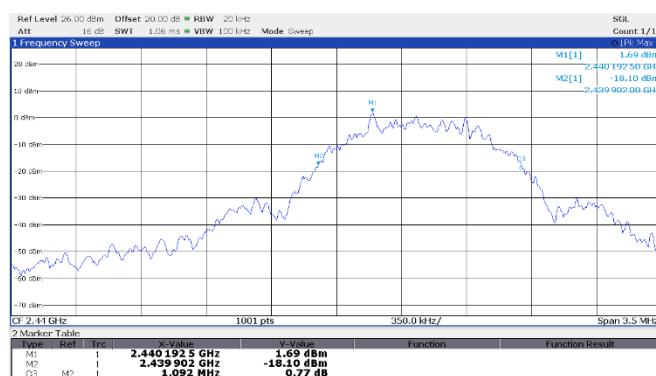


Figure 8.3-5: 20 dB bandwidth, GFSK, 0.500 Mbps, 2440 MHz



Figure 8.3-6: 20 dB bandwidth, GFSK, 0.500 Mbps, 2480 MHz

Section 8
Test name
Testing data
20 dB bandwidth
Specification(s)
FCC 15.247 & RSS-247

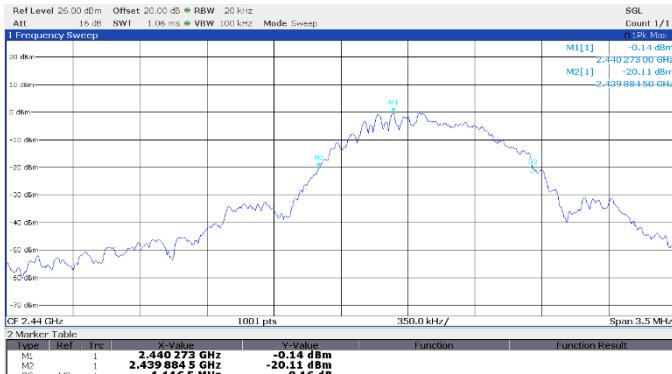
Figure 8.3-7: 20 dB bandwidth, GFSK, 1 Mbps, 2402 MHz

Figure 8.3-8: 20 dB bandwidth, GFSK, 1 Mbps, 2440 MHz

Figure 8.3-9: 20 dB bandwidth, GFSK, 1 Mbps, 2480 MHz

Figure 8.3-10: 20 dB bandwidth, GFSK, 2 Mbps, 2402 MHz

Figure 8.3-11: 20 dB bandwidth, GFSK, 2 Mbps, 2440 MHz

Figure 8.3-12: 20 dB bandwidth, GFSK, 2 Mbps, 2480 MHz

Section 8
Test name
Specification(s)

Testing data
20 dB bandwidth
FCC 15.247 & RSS-247



8.4 Minimum 6 dB bandwidth

8.4.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(a)(2)
- ISED: RSS-247 5.2(a)
- Test method: ANSI C63.10-2020 §11.8.1

§15.247:

(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-247:

5.2 DTs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

(a) The minimum 6 dB bandwidth shall be 500 kHz.

8.4.2 Test summary

Verdict	Pass		
Test date	September 25, 2023	Temperature	21 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	53 %

8.4.3 Notes

Testing was performed with the transmitter operating on a fixed channel (lowest, middle, and highest) at maximum output power.

The spectral plots within this section have been corrected with all relevant transducer factors.

8.4.4 Setup details

EUT power input during test	48V DC PoE
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Receiver/spectrum analyzer settings:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.4.5 Test data

Table 8.4-1: Minimum 6 dB bandwidth test data

Test Frequency (MHz)	Modulation	DTS Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
2402	GFSK, 0.125 Mbps	621.810	≥ 500	121.810
2440	GFSK, 0.125 Mbps	621.585	≥ 500	121.585
2480	GFSK, 0.125 Mbps	628.425	≥ 500	128.425
2402	GFSK, 0.500 Mbps	665.616	≥ 500	165.616
2440	GFSK, 0.500 Mbps	662.090	≥ 500	162.090
2480	GFSK, 0.500 Mbps	672.672	≥ 500	172.672
2402	GFSK, 1 Mbps	707.000	≥ 500	207.000
2440	GFSK, 1 Mbps	717.500	≥ 500	217.500
2480	GFSK, 1 Mbps	717.500	≥ 500	217.500
2402	GFSK, 2 Mbps	1162.000	≥ 500	662.000
2440	GFSK, 2 Mbps	1169.000	≥ 500	669.000
2480	GFSK, 2 Mbps	1179.500	≥ 500	679.500

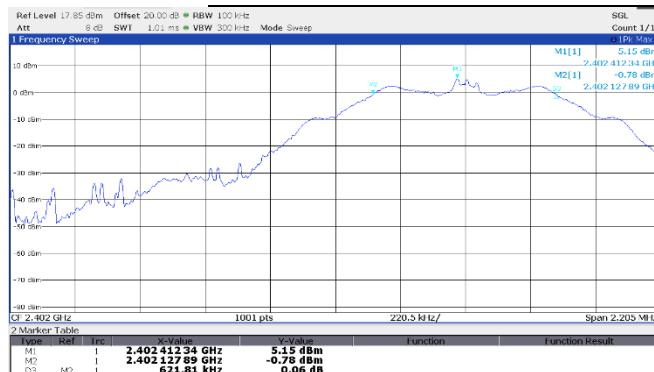


Figure 8.4-1: Minimum 6 dB bandwidth, GFSK, 0.125 Mbps, 2402 MHz

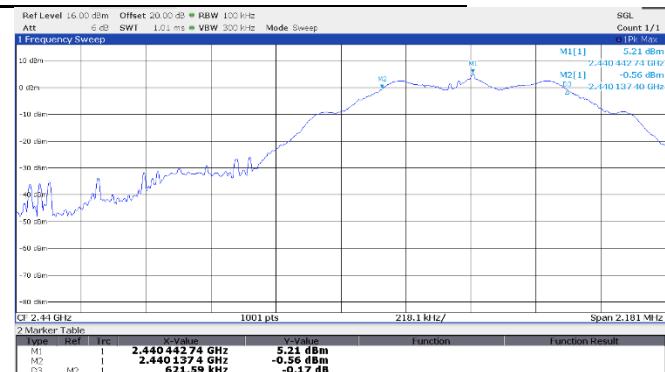


Figure 8.4-2: Minimum 6 dB bandwidth, GFSK, 0.125 Mbps, 2440 MHz

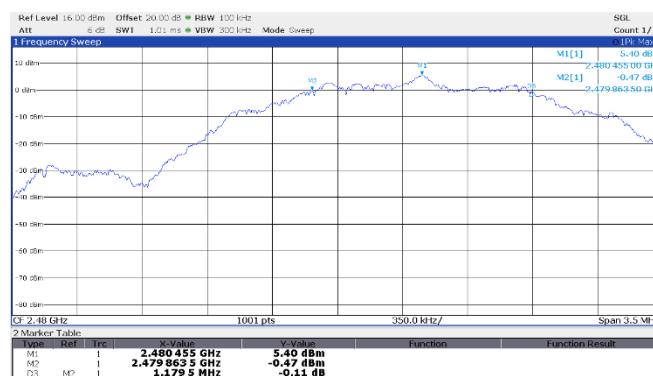


Figure 8.4-3: Minimum 6 dB bandwidth, GFSK, 0.125 Mbps, 2480 MHz

Section 8

Test name

Specification(s)

Testing data
Minimum 6 dB bandwidth
FCC 15.247 & RSS-247



Figure 8.4-4: Minimum 6 dB bandwidth, GFSK, 0.500 Mbps, 2402 MHz



Figure 8.4-5: Minimum 6 dB bandwidth, GFSK, 0.500 Mbps, 2440 MHz

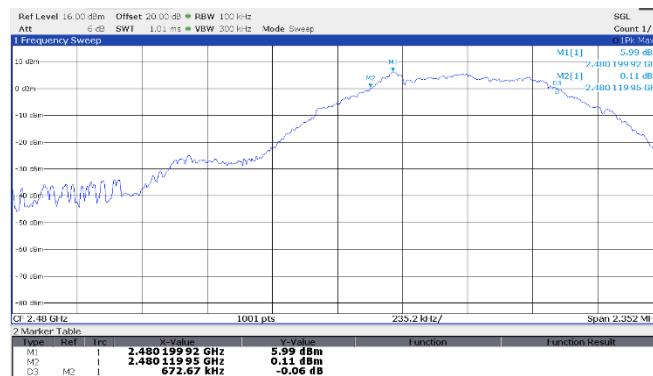


Figure 8.4-6: Minimum 6 dB bandwidth, GFSK, 0.500 Mbps, 2480 MHz

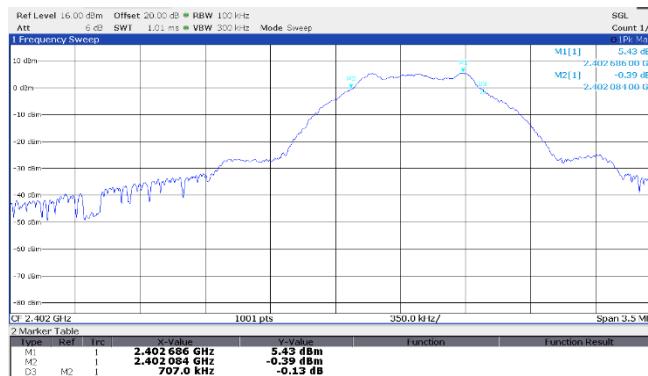


Figure 8.4-7: Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2402 MHz

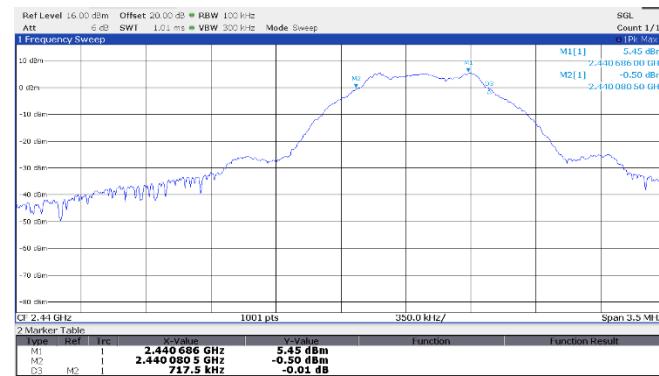


Figure 8.4-8: Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2440 MHz



Figure 8.4-9: Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2480 MHz

Section 8

Test name

Specification(s)

Testing data
Minimum 6 dB bandwidth
FCC 15.247 & RSS-247

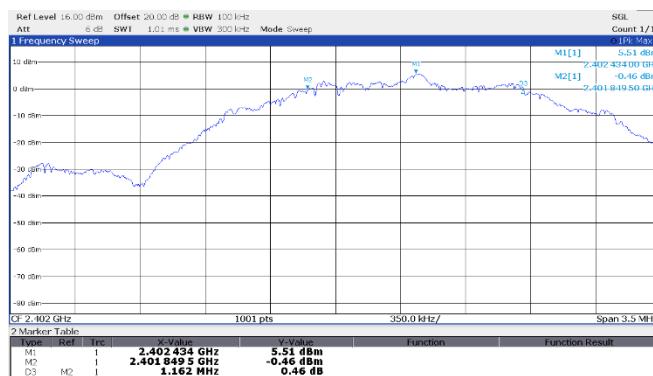


Figure 8.4-10: Minimum 6 dB bandwidth, GFSK, 2 Mbps, 2402 MHz

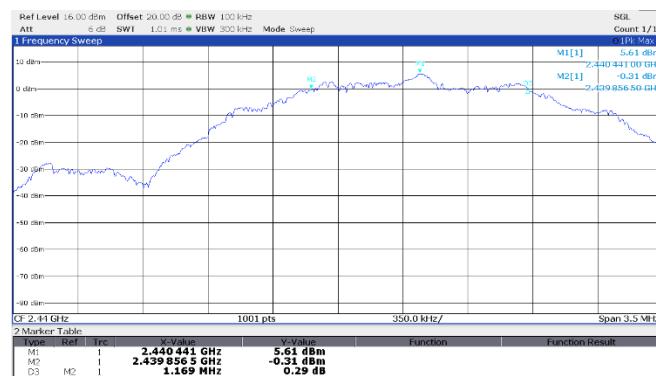


Figure 8.4-11: Minimum 6 dB bandwidth, GFSK, 2 Mbps, 2440 MHz



Figure 8.4-12: Minimum 6 dB bandwidth, GFSK, 2 Mbps, 2480 MHz

8.5 Maximum peak output power

8.5.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(b)(3)
- ISED: RSS-247 5.4(d)
- Test method: ANSI C63.10-2020 §11.9.1.1 (RBW \geq DTS BW)

§15.247:

(b) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. 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.

RSS-247:

5.4 Devices shall comply with the following requirements, where applicable:

(d) 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 1 W. The EIRP shall not exceed 4 W, except as provided in RSS 247 section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling 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 transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

8.5.2 Test summary

Verdict	Pass		
Test date	September 25, 2023	Temperature	21 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	53 %

8.5.3 Notes

Testing was performed with the transmitter operating on a fixed channel (lowest, middle, and highest) at maximum output power.

The spectral plots within this section have been corrected with all relevant transducer factors.

8.5.4 Setup details

EUT power input during test	48V DC PoE
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

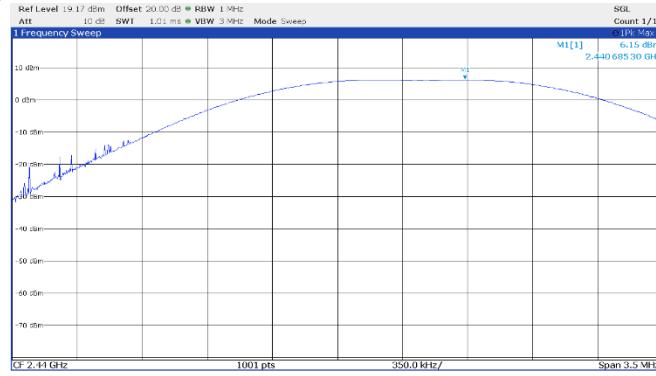
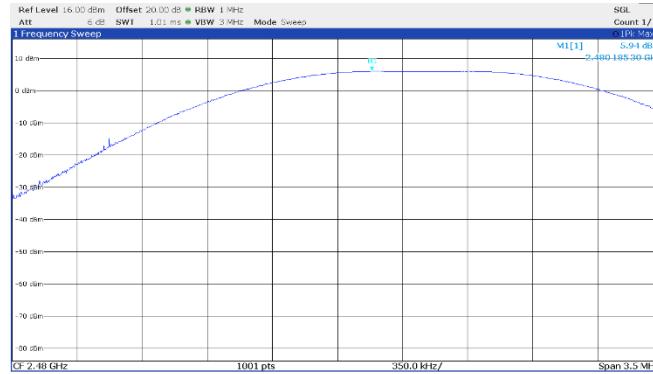
Receiver/spectrum analyzer settings:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

Section 8**Test name****Specification(s)****Testing data****Maximum peak output power****FCC 15.247 & RSS-247****8.5.5 Test data****Table 8.5-1: Maximum peak output power test data**

Test Frequency (MHz)	Modulation	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	EIRP (dBm) (ISED)
2402	GFSK, 0.125 Mbps	6.19	≤ 30	23.81	8.69
2440	GFSK, 0.125 Mbps	6.15	≤ 30	23.85	8.65
2480	GFSK, 0.125 Mbps	5.94	≤ 30	24.06	8.44
2402	GFSK, 0.500 Mbps	6.22	≤ 30	23.78	8.72
2440	GFSK, 0.500 Mbps	6.13	≤ 30	23.87	8.63
2480	GFSK, 0.500 Mbps	5.96	≤ 30	24.04	8.46
2402	GFSK, 1 Mbps	6.24	≤ 30	23.76	8.74
2440	GFSK, 1 Mbps	6.17	≤ 30	23.83	8.67
2480	GFSK, 1 Mbps	5.98	≤ 30	24.02	8.48
2402	GFSK, 2 Mbps	6.40	≤ 30	23.6	8.9
2440	GFSK, 2 Mbps	6.33	≤ 30	23.67	8.83
2480	GFSK, 2 Mbps	6.18	≤ 30	23.82	8.68

Note: EIRP (dBm) = Measured Conducted Power (dBm) + Declared Peak Antenna Gain (dBi)

**Figure 8.5-1: Maximum peak output power, GFSK, 0.125 Mbps, 2402 MHz****Figure 8.5-2: Maximum peak output power, GFSK, 0.125 Mbps, 2440 MHz****Figure 8.5-3: Maximum peak output power, GFSK, 0.125 Mbps, 2480 MHz**

Section 8

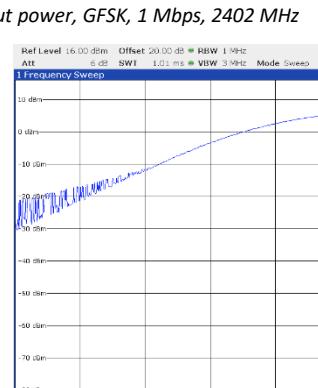
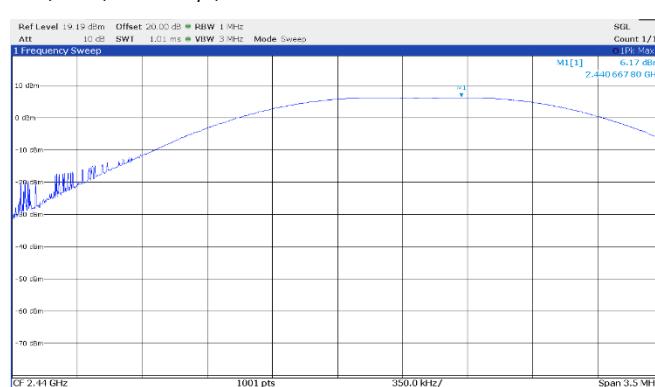
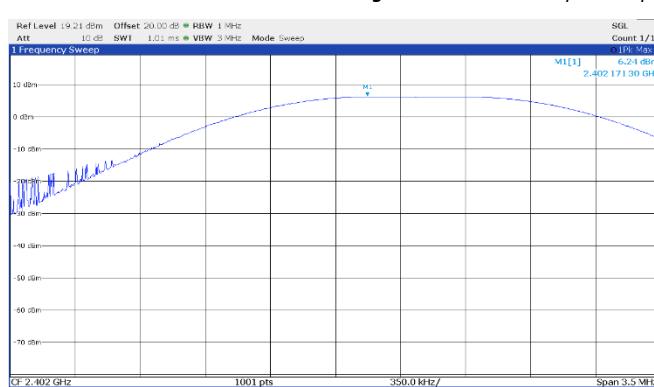
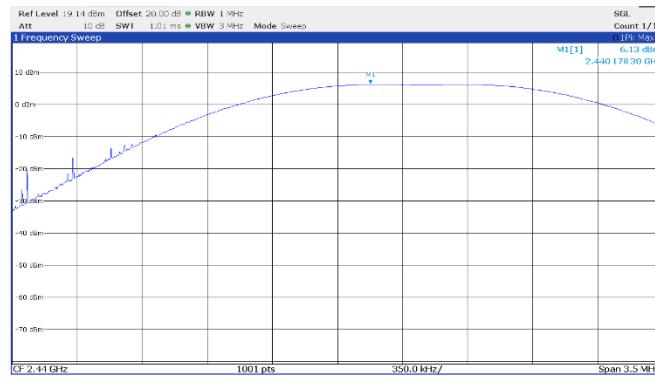
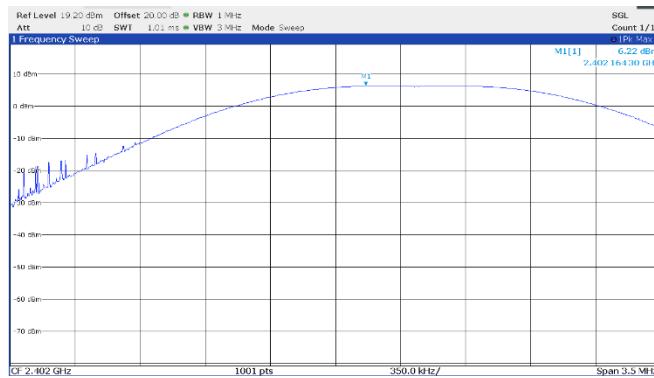
Test name

Specification(s)

Testing data

Maximum peak output power

FCC 15.247 & RSS-247



Section 8

Test name

Specification(s)

Testing data
Maximum peak output power
FCC 15.247 & RSS-247

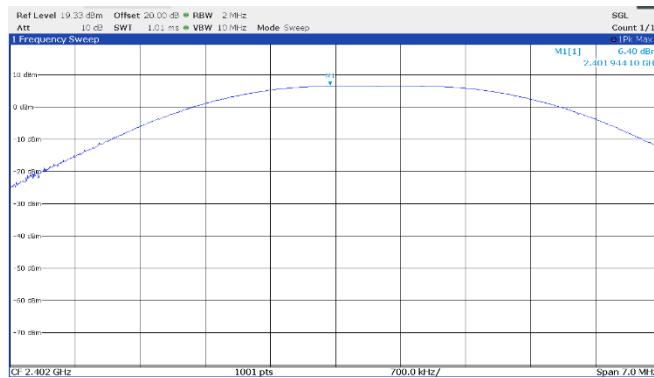


Figure 8.5-10: Maximum peak output power, GFSK, 2 Mbps, 2402 MHz

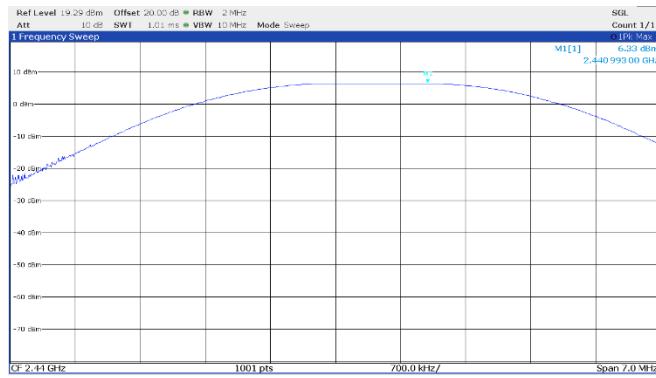


Figure 8.5-11: Maximum peak output power, GFSK, 2 Mbps, 2440 MHz

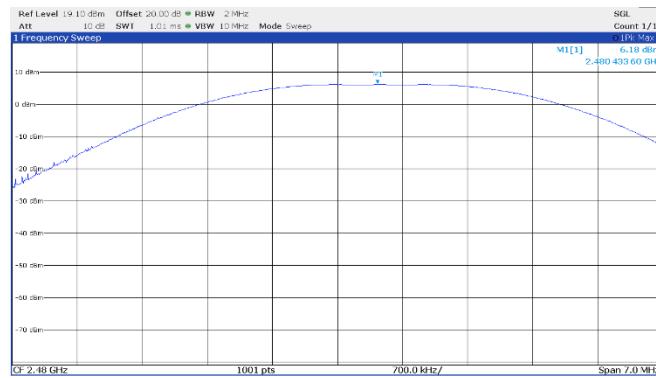


Figure 8.5-12: Maximum peak output power, GFSK, 2 Mbps, 2480 MHz

8.6 Spurious emissions

8.6.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(d)
- RSS-247: §5.5
- Test method: ANSI C63.10-2020 §6.10.4 (authorized band edge)
- Test method: ANSI C63.10-2020 §11.11 (antenna port conducted spurious emissions)
- Test method: ANSI C63.10-2020 §11.12.3 (radiated restricted band edge)
- Test method: ANSI C63.10-2020 §6.5, 6.6 (radiated emissions in restricted bands)

§15.247:

(d) 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)).

RSS-247:

5.5 In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.6-1: FCC §15.209 / RSS-GEN §8.9 – 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 × log ₁₀ (F)	300
0.490–1.705	24000/F	87.6 – 20 × 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 8.6-2: 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			

Table 8.6-3: ISED RSS-GEN restricted frequency bands

MHz	MHz	GHz
090 - 0.110	149.9 - 150.05	9.0 - 9.2
0.495 - 0.505	156.52475 - 156.52525	9.3 - 9.5
2.1735 - 2.1905	156.7 - 156.9	10.6 - 12.7
3.020 - 3.026	162.0125 - 167.17	13.25 - 13.4
4.125 - 4.128	167.72 - 173.2	14.47 - 14.5
4.17725 - 4.17775	240 - 285	15.35 - 16.2
4.20725 - 4.20775	322 - 335.4	17.7 - 21.4
5.677 - 5.683	399.9 - 410	22.01 - 23.12
6.215 - 6.218	608 - 614	23.6 - 24.0
6.26775 - 6.26825	960 - 1427	31.2 - 31.8
6.31175 - 6.31225	1435 - 1626.5	36.43 - 36.5
8.291 - 8.294	1645.5 - 1646.5	Above 38.6
8.362 - 8.366	1660 - 1710	
8.37625 - 8.38675	1718.8 - 1722.2	
8.41425 - 8.41475	2200 - 2300	
12.29 - 12.293	2310 - 2390	
12.51975 - 12.52025	2483.5 - 2500	
12.57675 - 12.57725	2655 - 2900	
13.36 - 13.41	3260 - 3267	
16.42 - 16.423	3332 - 3339	
16.69475 - 16.69525	3345.8 - 3358	
16.80425 - 16.80475	3500 - 4400	
25.5 - 25.67	4500 - 5150	
37.5 - 38.25	5350 - 5460	
73 - 74.6	7250 - 7750	
74.8 - 75.2	8025 - 8500	
108 - 138		

8.6.2 Test summary

Verdict	Pass		
Test date	September 26, 2023 September 28, 2023	Temperature	21 °C 22 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar 1006 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench (conducted tests) <input type="checkbox"/> 10 m semi-anechoic chamber (radiated tests) <input checked="" type="checkbox"/> 3 m semi-anechoic chamber (radiated tests) <input type="checkbox"/> Other:	Relative humidity	51 % 45 %

8.6.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power. Low, middle, and high channels were tested. The spectrum was searched from 30 MHz to 26 GHz (above the 10th harmonic of the highest transmit frequency).

For radiated measurements, the EUT was investigated to identify the worst-case orientation with respect to the fundamental transmitter power. All measurements were performed with the EUT in that worst-case orientation.

The spectral plots within this section have been corrected with all relevant transducer factors.

Radiated emissions are reported for the modulation / data rate settings that produced the highest transmitter output power as a worst-case. For this EUT, the worst-case modulation / data rate setting used was: GFSK, 2 Mbps.

8.6.4 Setup details

EUT power input during test	48 V PoE
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Spectrum analyzer settings (conducted emissions):

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

Receiver settings for radiated measurements within restricted bands below 1 GHz:

Resolution bandwidth	120 kHz
Video bandwidth	300 kHz
Detector mode	Peak (preview measurements) Quasi-Peak (final measurements)

Receiver settings for radiated measurements within restricted bands above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak (preview measurements) Peak and average (final measurements)

8.6.5 Test data

Antenna port conducted spurious emissions:

- Authorized band edge:

Table 8.6-4: Authorized band edge conducted emissions (antenna port)

Test Frequency (MHz)	Modulation	Frequency of highest emission (MHz)	Amplitude (dBm)	Limit (dBm)	Margin (dB)
2402	GFSK, 0.125 Mbps	2399.925	-43.70	-15.69	28.01
2480	GFSK, 0.125 Mbps	2483.767	-50.23	-15.09	35.14
2402	GFSK, 0.500 Mbps	2399.955	-43.00	-13.88	29.12
2480	GFSK, 0.500 Mbps	2483.747	-48.77	-14.04	34.73
2402	GFSK, 1 Mbps	2399.996	-42.98	-14.71	28.27
2480	GFSK, 1 Mbps	2483.531	-47.85	-14.85	33.00
2402	GFSK, 2 Mbps	2399.426	-42.00	-14.44	27.56
2480	GFSK, 2 Mbps	2483.499	-41.33	-14.58	26.75

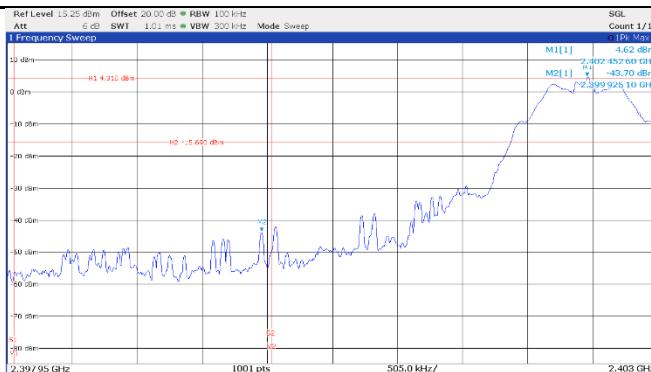


Figure 8.6-1: Authorized band-edge emissions, GFSK, 0.125 Mbps, 2402 MHz



Figure 8.6-2: Authorized band-edge emissions, GFSK, 0.125 Mbps, 2480 MHz

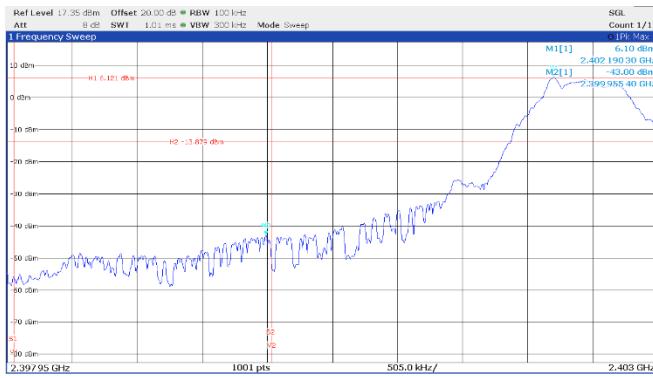


Figure 8.6-3: Authorized band-edge emissions, GFSK, 0.500 Mbps, 2402 MHz

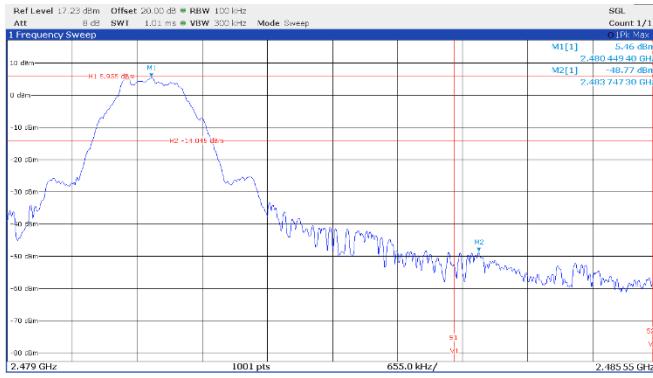


Figure 8.6-4: Authorized band-edge emissions, GFSK, 0.500 Mbps, 2480 MHz



Figure 8.6-5: Authorized band-edge emissions, GFSK, 1 Mbps, 2402 MHz



Figure 8.6-6: Authorized band-edge emissions, GFSK, 1 Mbps, 2480 MHz



Figure 8.6-7: Authorized band-edge emissions, GFSK, 2 Mbps, 2402 MHz

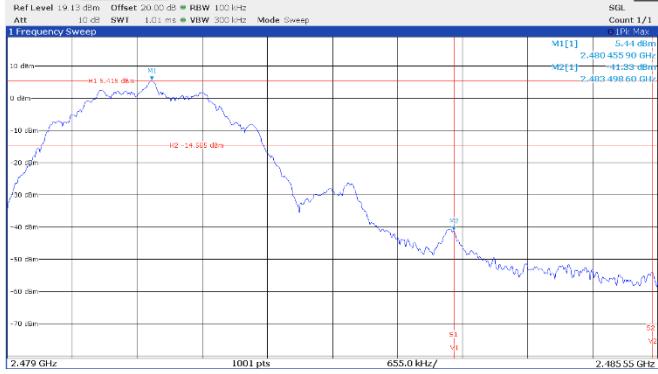


Figure 8.6-8: Authorized band-edge emissions, GFSK, 2 Mbps, 2480 MHz

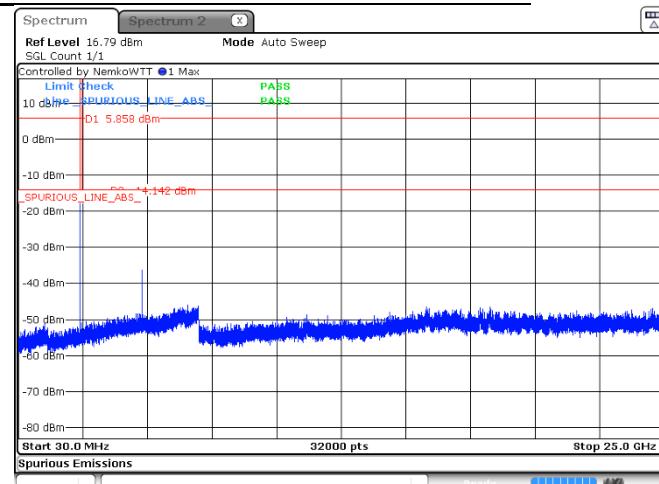
- **Antenna port conducted spurious emissions:**

Table 8.6-5: Antenna port conducted spurious emissions

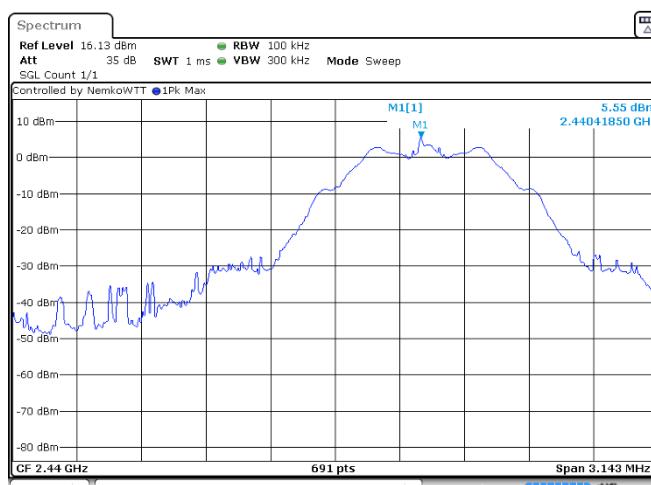
Test Frequency (MHz)	Modulation	Frequency of highest emission (MHz)	Amplitude (dBm)	Limit (dBm)	Margin (dB)
2402	GFSK, 0.125 Mbps			No significant emissions	
2440	GFSK, 0.125 Mbps			No significant emissions	
2480	GFSK, 0.125 Mbps			No significant emissions	
2402	GFSK, 0.500 Mbps			No significant emissions	
2440	GFSK, 0.500 Mbps			No significant emissions	
2480	GFSK, 0.500 Mbps			No significant emissions	
2402	GFSK, 1 Mbps			No significant emissions	
2440	GFSK, 1 Mbps			No significant emissions	
2480	GFSK, 1 Mbps			No significant emissions	
2402	GFSK, 2 Mbps			No significant emissions	
2440	GFSK, 2 Mbps			No significant emissions	
2480	GFSK, 2 Mbps			No significant emissions	



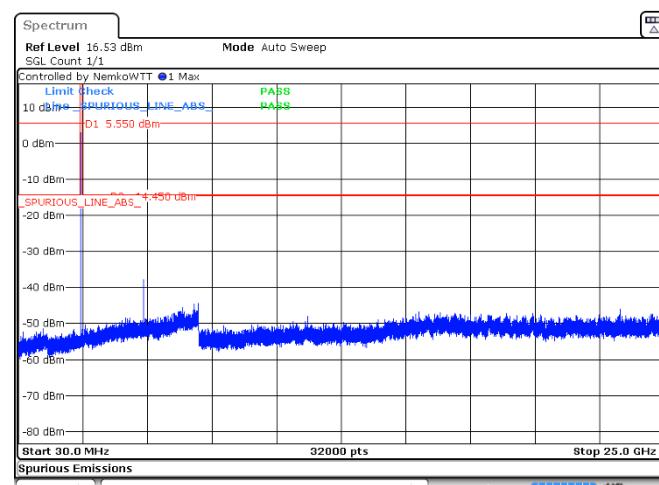
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OD: GFSK_0125Mbps



Spurious emissions, TX 2402 MHz, BW 1MHz, MOD: GFSK_0.125
bps



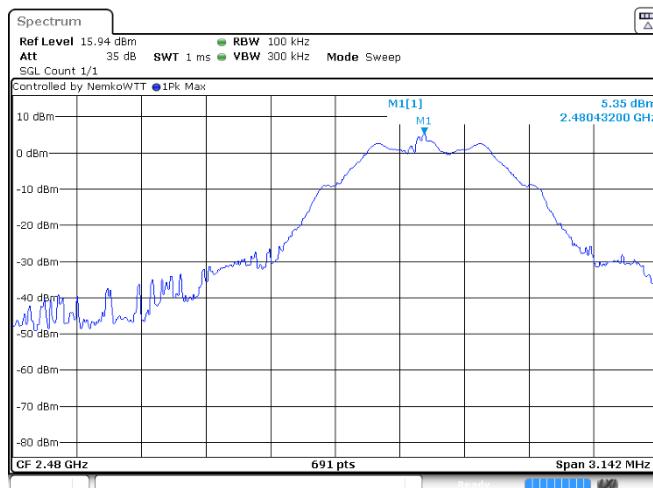
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OD: GFSK_0125Mbps



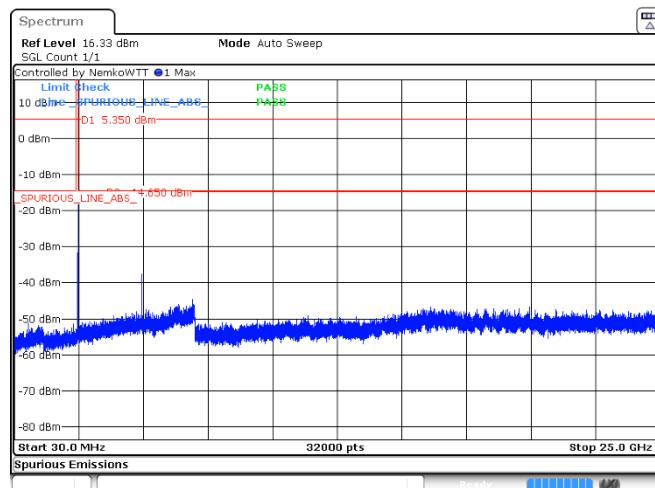
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bps

Section 8**Test name**

Testing data
Spurious emissions
Specification(s)
FCC 15.247 & RSS-247

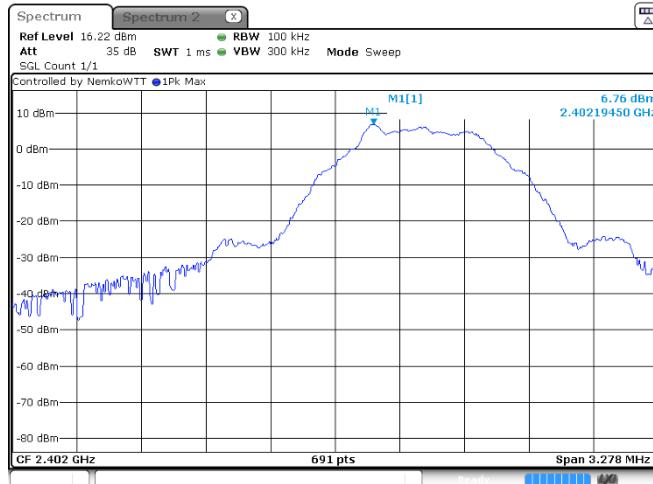


Spurious emission reference level, TX 2480 MHz, BW 1MHz, M
OD GFSK_0125Mbps



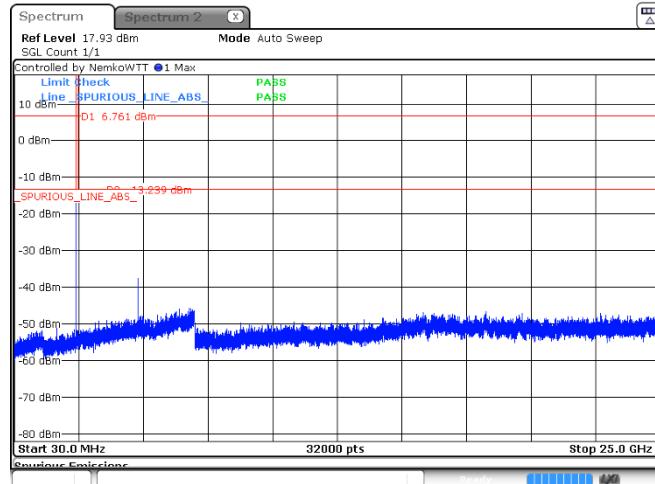
Spurious emission reference level, TX 2480 MHz, BW 1MHz, M

OD GFSK_0125Mbps



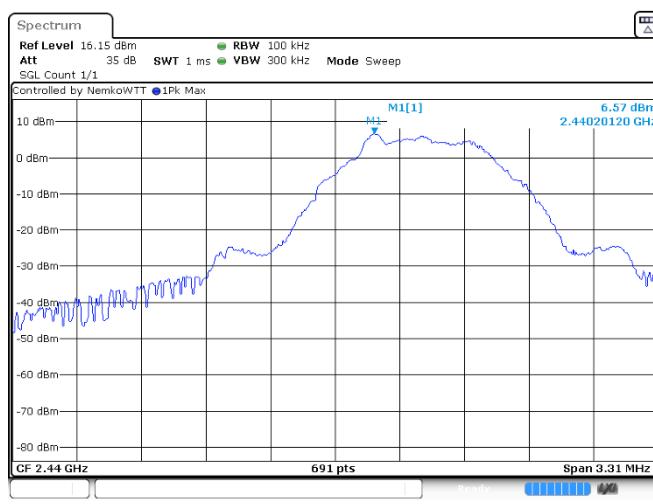
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OD GFSK_0500Mbps



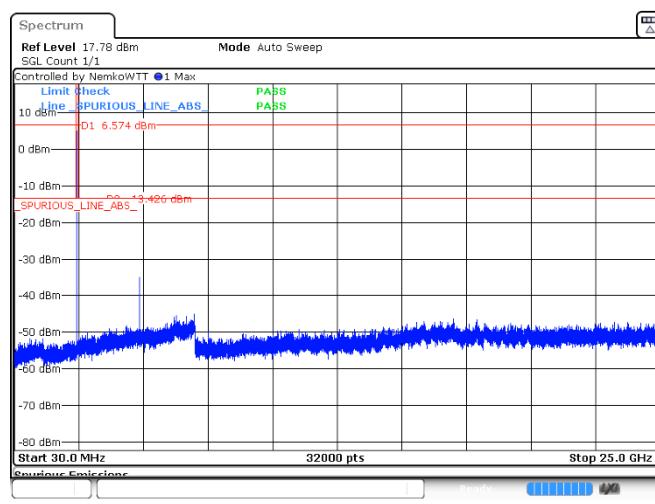
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OD GFSK_0500Mbps



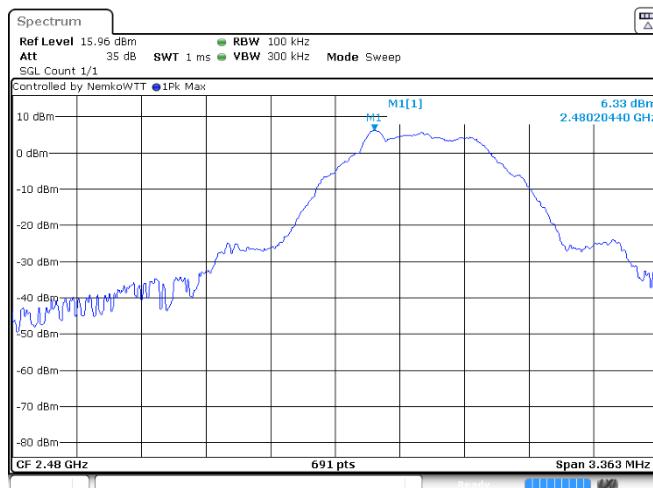
Spurious emission reference level, TX 2440 MHz, BW 1MHz, M

OD GFSK_0500Mbps

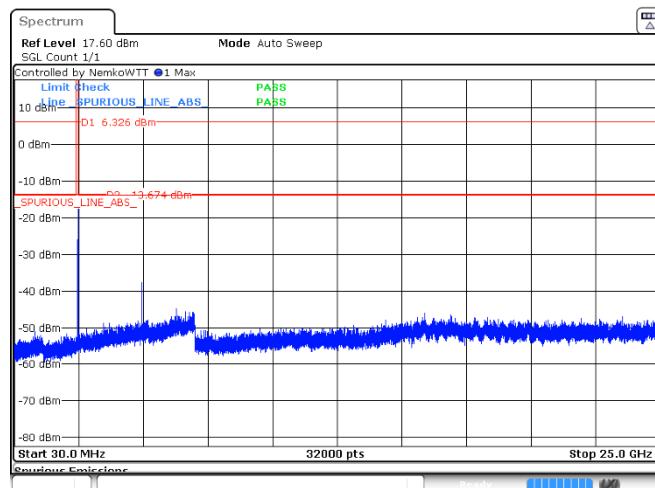


Spurious emission reference level, TX 2440 MHz, BW 1MHz, M

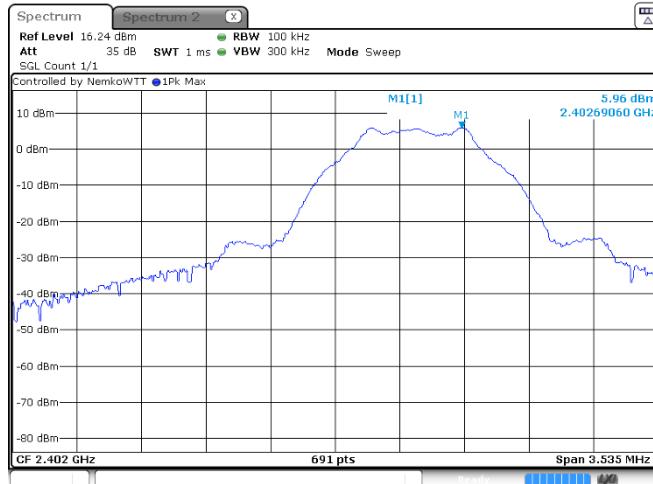
OD GFSK_0500Mbps

Section 8**Test name****Testing data****Specification(s)****Spurious emissions****FCC 15.247 & RSS-247**

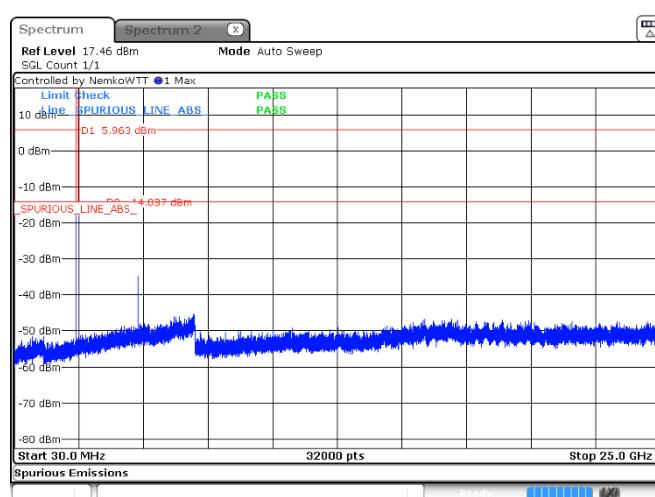
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OD GFSK_0.500Mbps



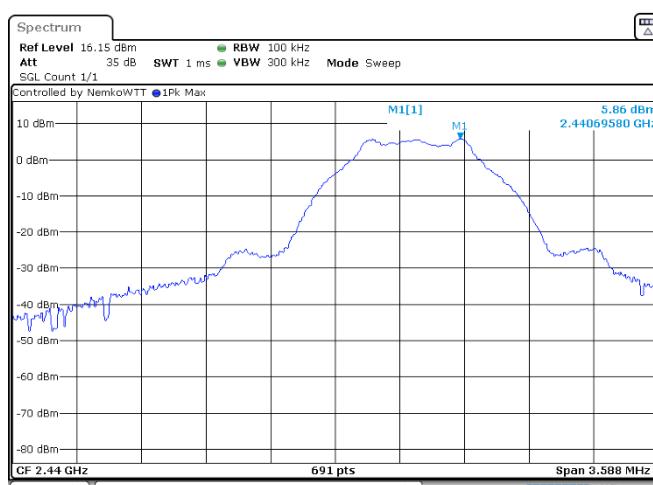
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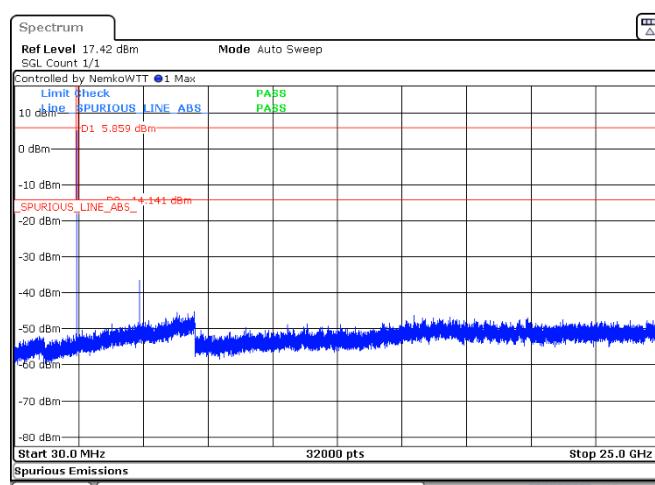
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OD GFSK_1Mbps



Spurious emissions, TX 2402 MHz, BW 1MHz, MOD GFSK_1Mbps



Spurious emission reference level, TX 2440 MHz, BW 1MHz, M
OD GFSK_1Mbps



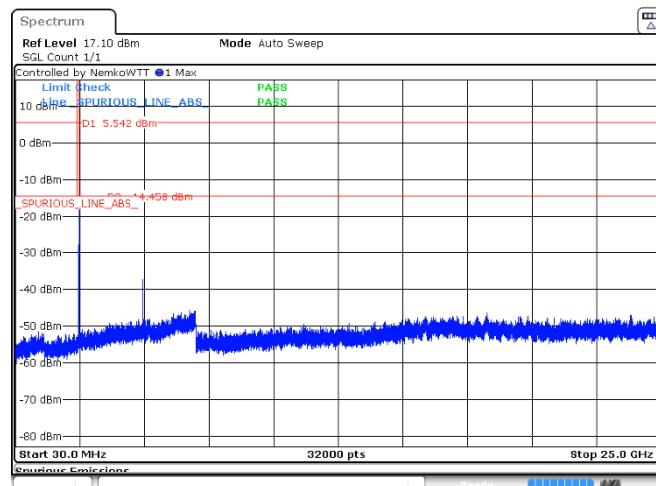
Spurious emissions, TX 2440 MHz, BW 1MHz, MOD GFSK_1Mbps

Section 8
Test name
Specification(s)

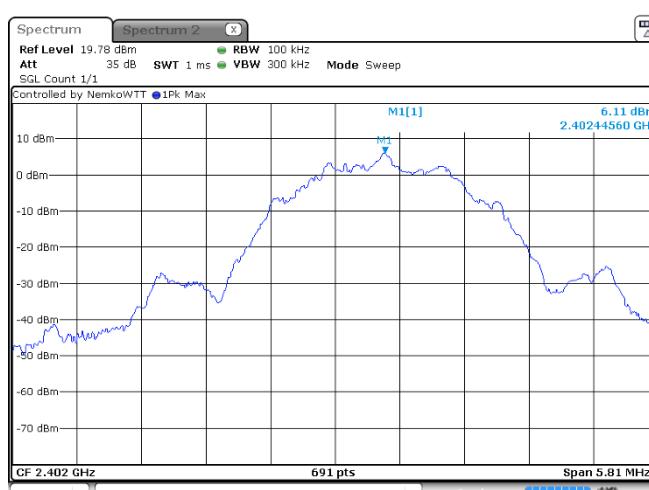
Testing data
Spurious emissions
FCC 15.247 & RSS-247



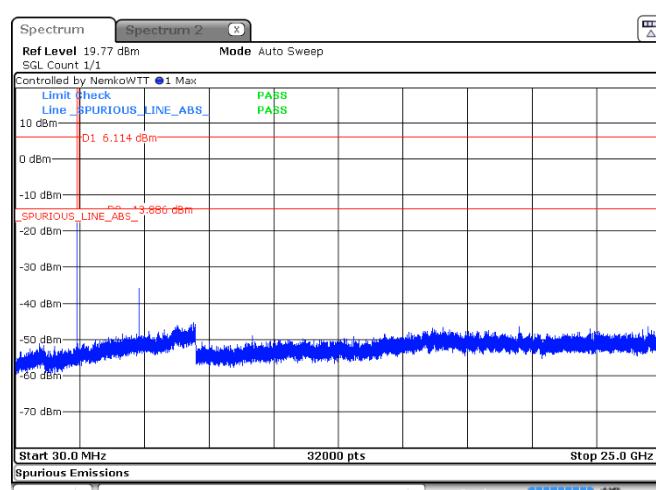
Spurious emission reference level, TX 2480 MHz, BW 1MHz, M
OD GFSK_1Mbps



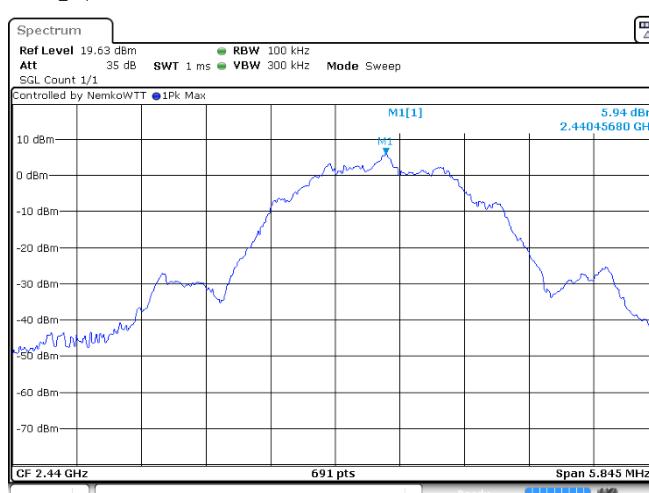
Spurious emissions, TX 2480 MHz, BW 1MHz, MOD. GFSK_1Mbps



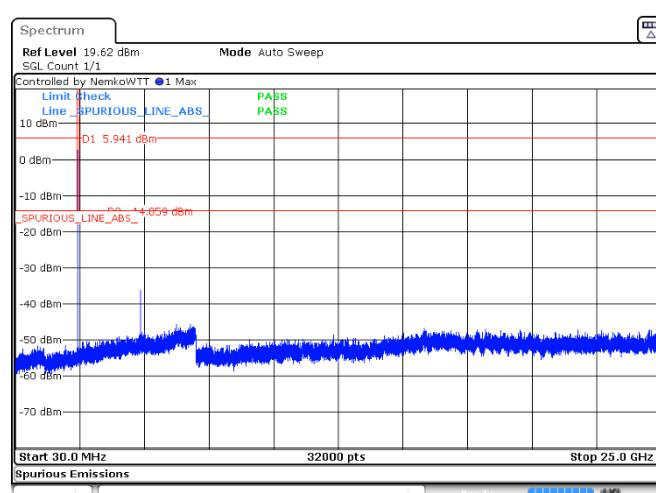
Spurious emission reference level, TX 2402 MHz, BW 1MHz, M
OD GFSK_2Mbps



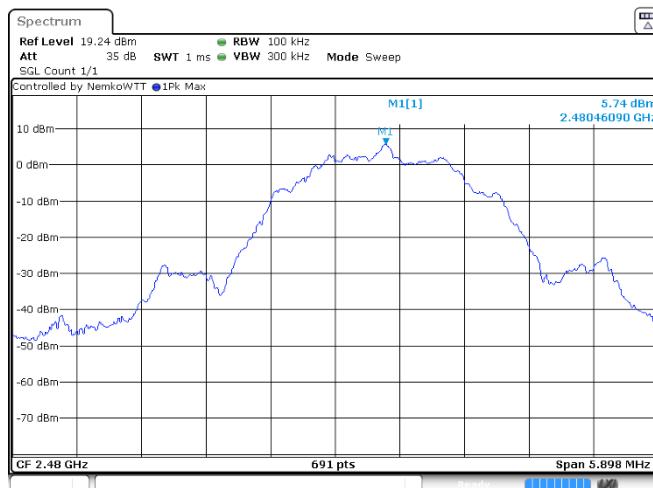
Spurious emissions, TX 2402 MHz, BW 1MHz, MOD. GFSK_2Mbps



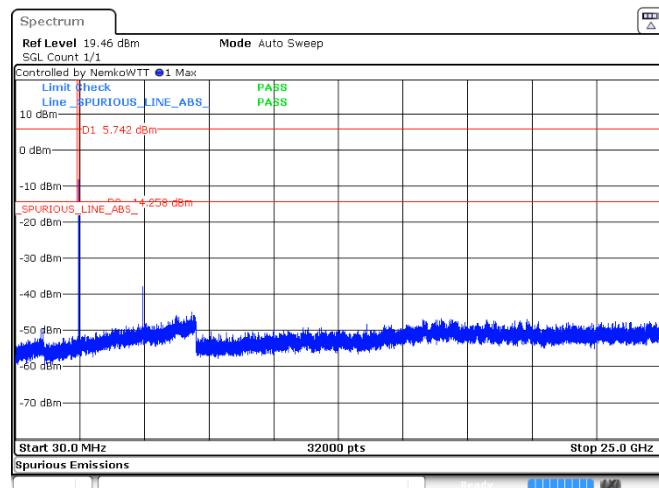
Spurious emission reference level, TX 2440 MHz, BW 1MHz, M
OD GFSK_2Mbps



Spurious emissions, TX 2440 MHz, BW 1MHz, MOD. GFSK_2Mbps

Section 8**Test name****Specification(s)****Testing data****Spurious emissions****FCC 15.247 & RSS-247**

Spurious emission reference level, TX 2480 MHz, BW 1MHz, M
 CO GFSK_2Mbps



Radiated spurious emissions:

- **Restricted band edge:**

Full Spectrum

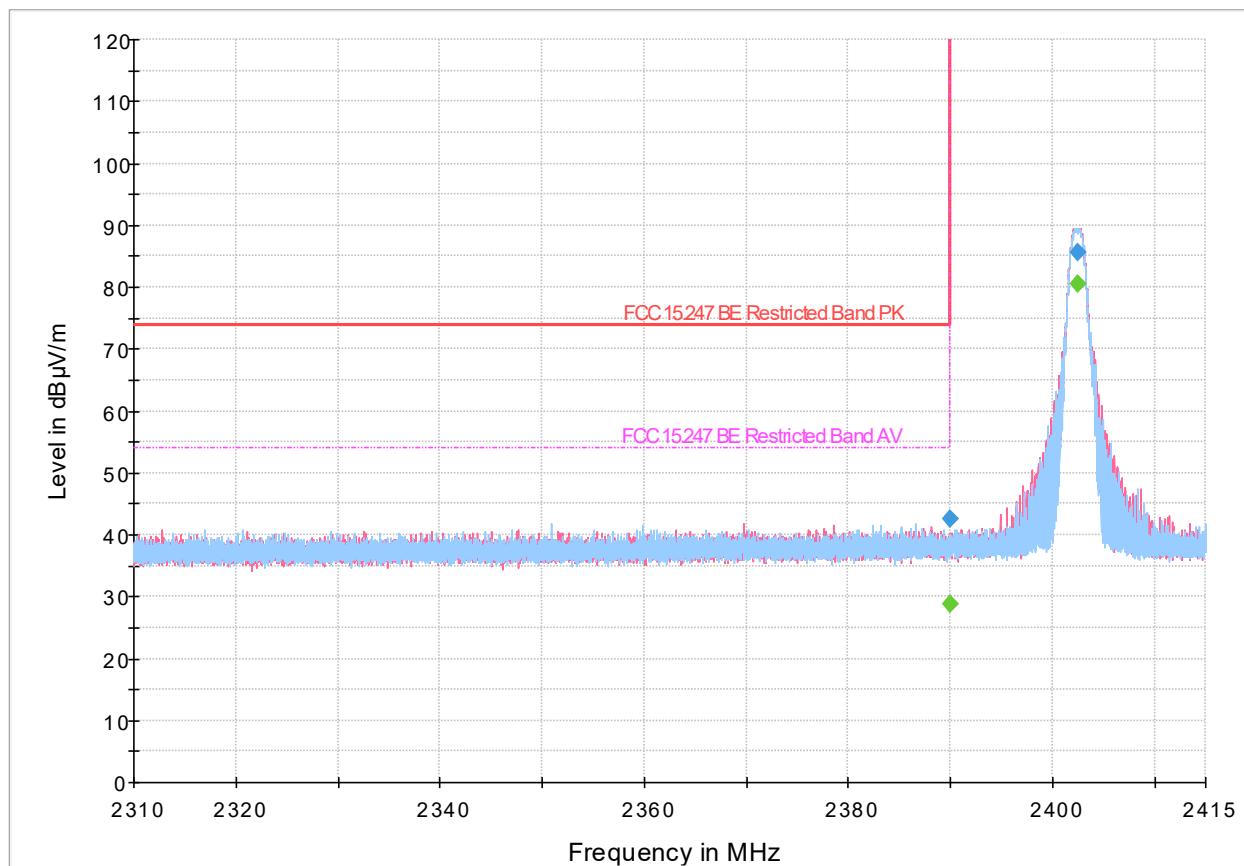


Figure 8.6-9: Radiated emissions spectral plot (2.31 GHz - 2.415 GHz)

Table 8.6-6: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2390.000000	---	28.75	53.90	25.15	5000.0	1000.000	106.0	H	44.0	-5.3
2390.000000	42.44	---	73.90	31.46	5000.0	1000.000	106.0	H	44.0	-5.3
2402.463000	---	80.55	150.00	69.45	5000.0	1000.000	165.0	V	190.0	-5.3
2402.463000	85.49	---	150.00	64.51	5000.0	1000.000	165.0	V	190.0	-5.3

Notes:

¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Full Spectrum

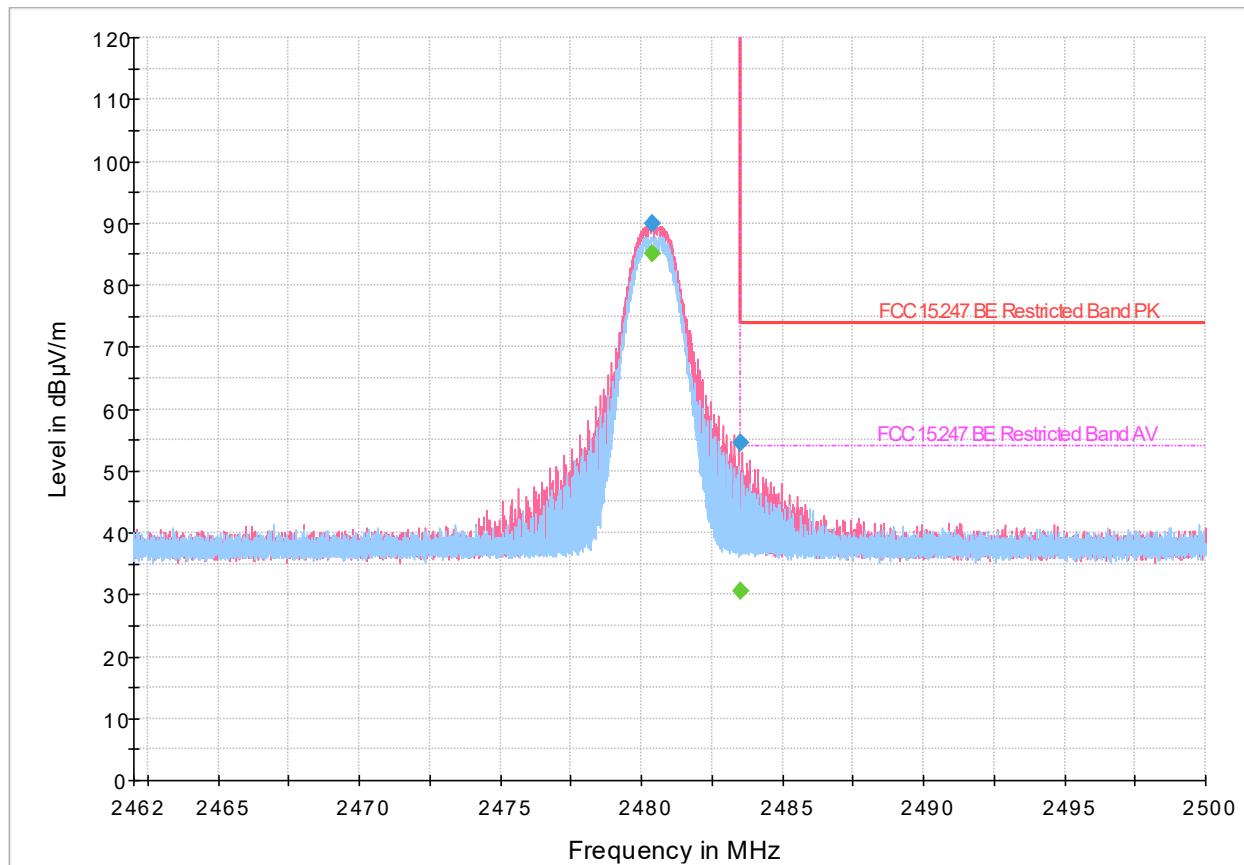


Figure 8.6-10: Radiated emissions spectral plot (2.462 GHz - 2.5 GHz)

Table 8.6-7: Radiated emissions results

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)
2480.378700	---	85.05	150.00	64.95	5000.0	1000.000	98.0	V	219.0	-5.1
2480.378700	89.91	---	150.00	60.09	5000.0	1000.000	98.0	V	219.0	-5.1
2483.500000	---	30.58	53.90	23.32	5000.0	1000.000	98.0	V	226.0	-5.1
2483.500000	54.40	---	73.90	19.50	5000.0	1000.000	98.0	V	226.0	-5.1

Notes:

¹ Field strength (dBμV/m) = receiver/spectrum analyzer value (dBμV) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

- Radiated spurious emissions, restricted bands:

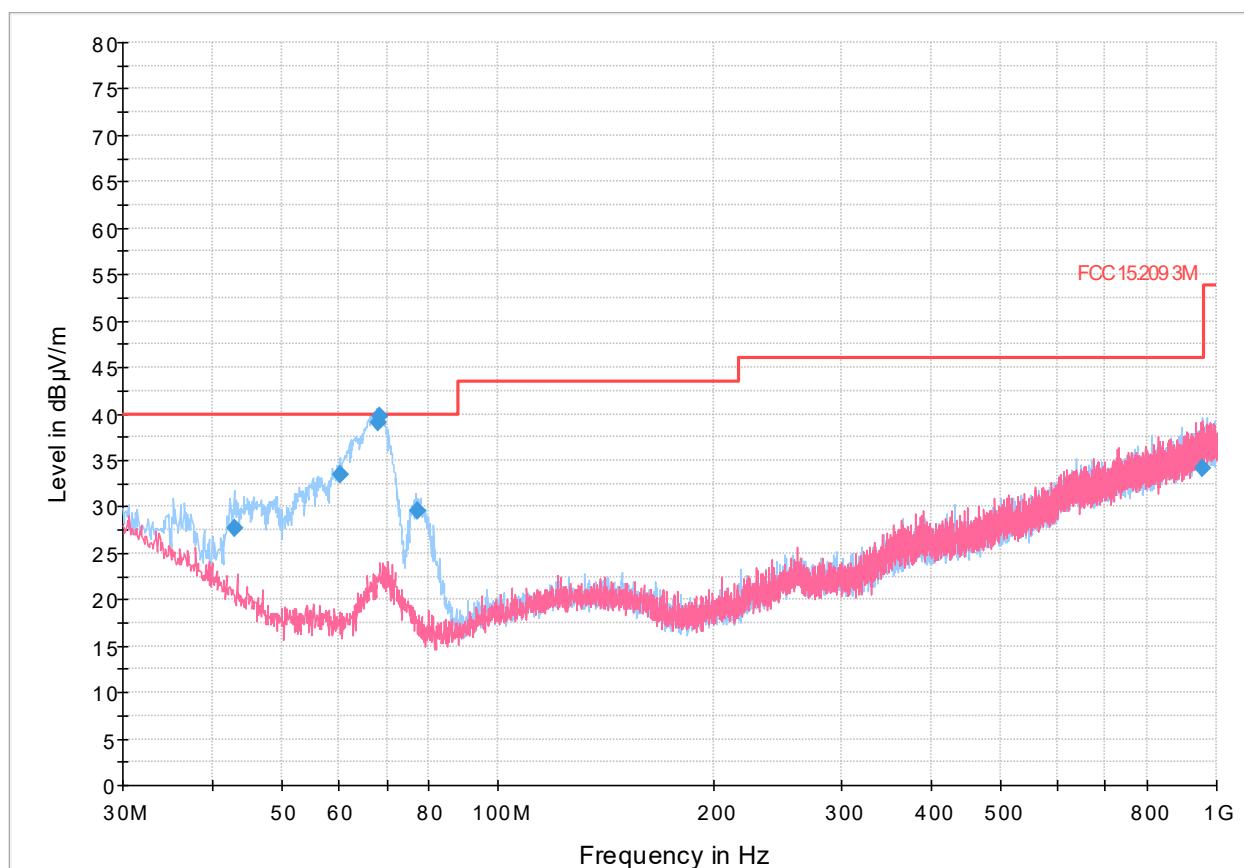


Figure 8.6-11: Radiated emissions spectral plot (30 MHz - 1 GHz), 2402 MHz, 2MBps

Table 8.6-8: Radiated emissions results

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
42.961000	27.61	40.00	12.39	5000.0	120.000	131.0	H	78.0	19.5
60.307000	33.52	40.00	6.48	5000.0	120.000	98.0	H	230.0	12.6
68.033000	39.03	40.00	0.97	5000.0	120.000	108.0	H	298.0	13.3
68.221000	39.66	40.00	0.34	5000.0	120.000	98.0	H	0.0	13.3
77.271000	29.51	40.00	10.49	5000.0	120.000	98.0	H	271.0	14.6
953.825000	34.19	46.00	11.81	5000.0	120.000	137.0	H	275.0	34.2

Notes: ¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Full Spectrum

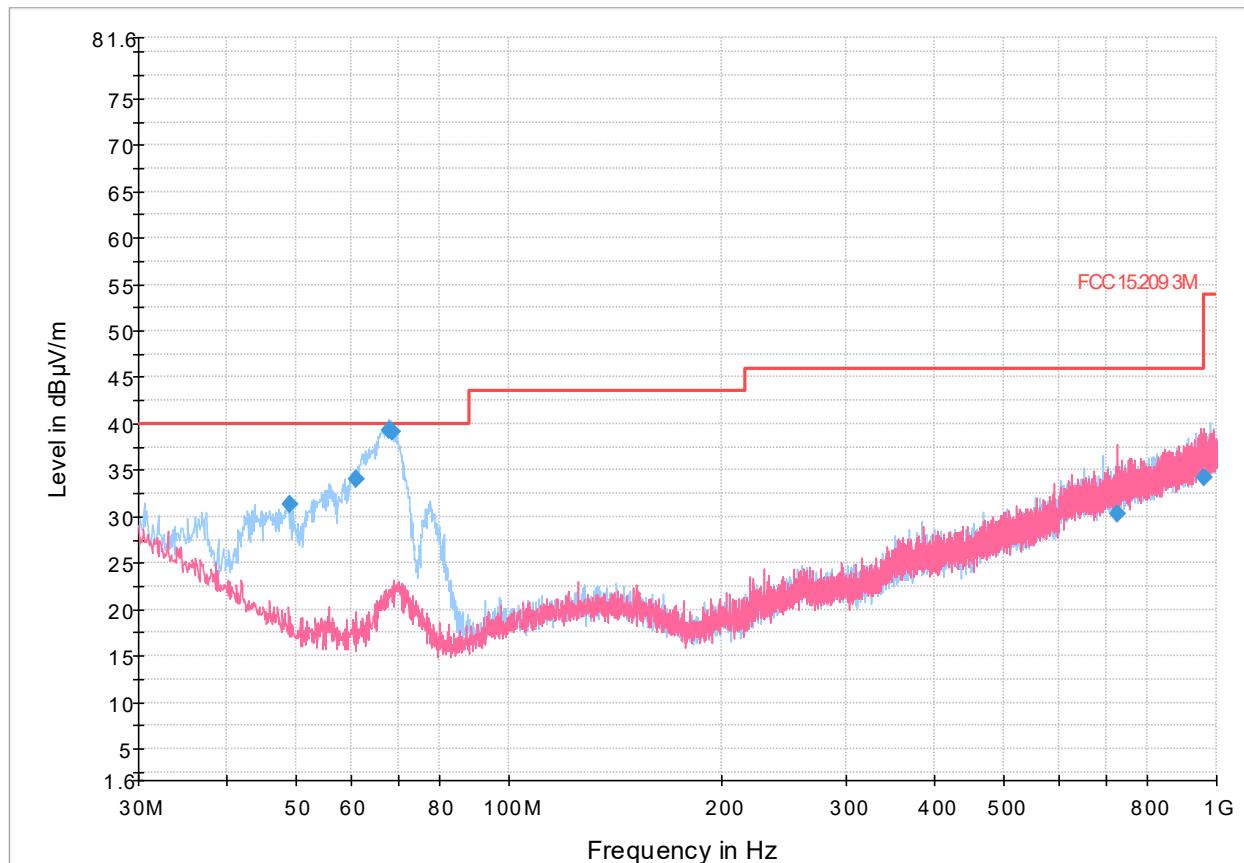


Figure 8.6-12: Radiated emissions spectral plot (30 MHz - 1 GHz), 2440 MHz, 2 MBps

Table 8.6-9: Radiated emissions results

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
49.101000	31.30	40.00	8.70	5000.0	120.000	98.0	H	124.0	16.3
60.787000	33.97	40.00	6.03	5000.0	120.000	103.0	H	0.0	12.6
67.907000	39.26	40.00	0.74	5000.0	120.000	102.0	H	11.0	13.2
68.341000	39.21	40.00	0.79	5000.0	120.000	98.0	H	32.0	13.3
725.459000	30.24	46.00	15.76	5000.0	120.000	132.0	V	102.0	30.5
958.035000	34.23	46.00	11.77	5000.0	120.000	191.0	V	0.0	34.2

Notes:

¹ Field strength (dBμV/m) = receiver/spectrum analyzer value (dBμV) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Full Spectrum

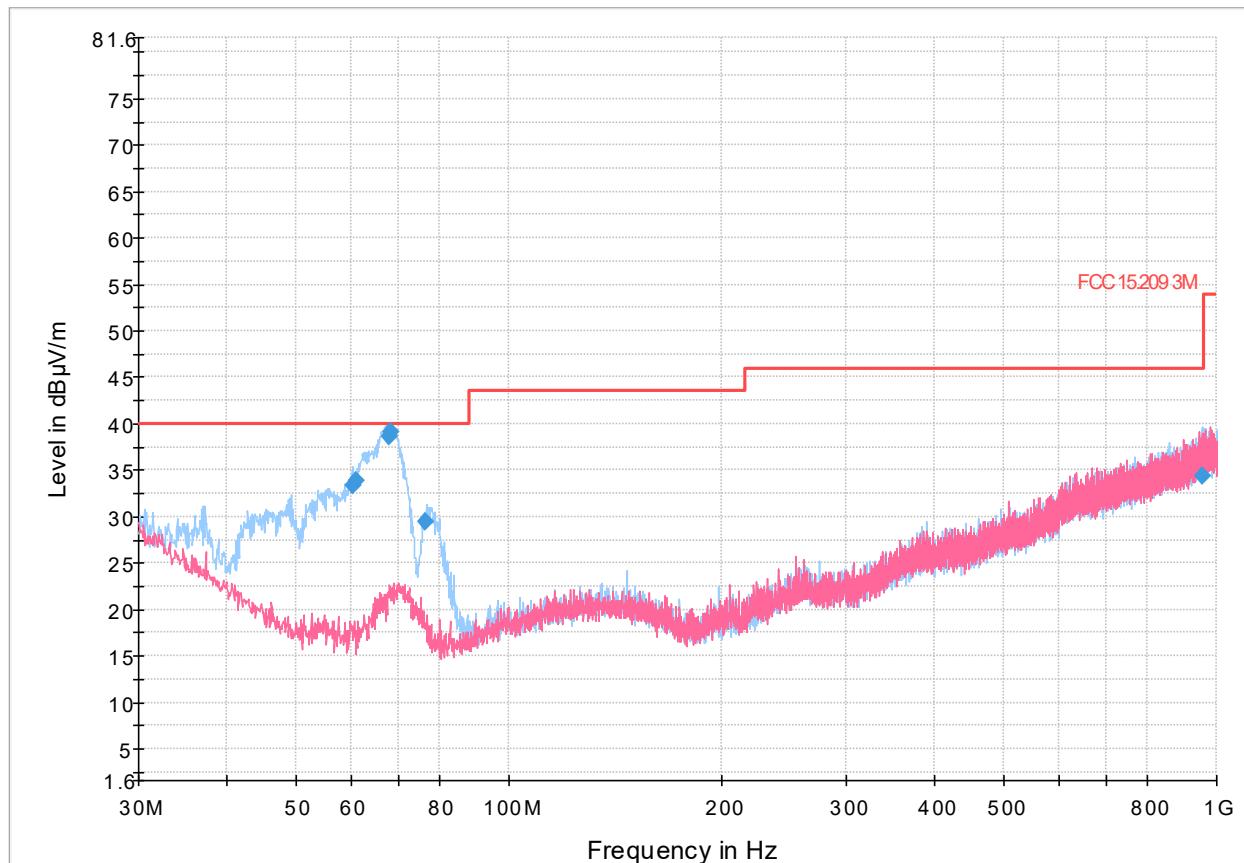


Figure 8.6-13: Radiated emissions spectral plot (30 MHz - 1 GHz), 2480 MHz, 2 Mbps

Table 8.6-10: Radiated emissions results

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
60.187000	33.38	40.00	6.62	5000.0	120.000	116.0	H	20.0	12.6
61.021000	33.87	40.00	6.13	5000.0	120.000	98.0	H	324.0	12.6
67.895000	38.57	40.00	1.43	5000.0	120.000	106.0	H	0.0	13.2
68.130000	39.10	40.00	0.90	5000.0	120.000	105.0	H	10.0	13.3
76.323000	29.44	40.00	10.56	5000.0	120.000	98.0	H	338.0	14.5
956.696000	34.33	46.00	11.67	5000.0	120.000	107.0	H	282.0	34.2

Notes:

¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Full Spectrum

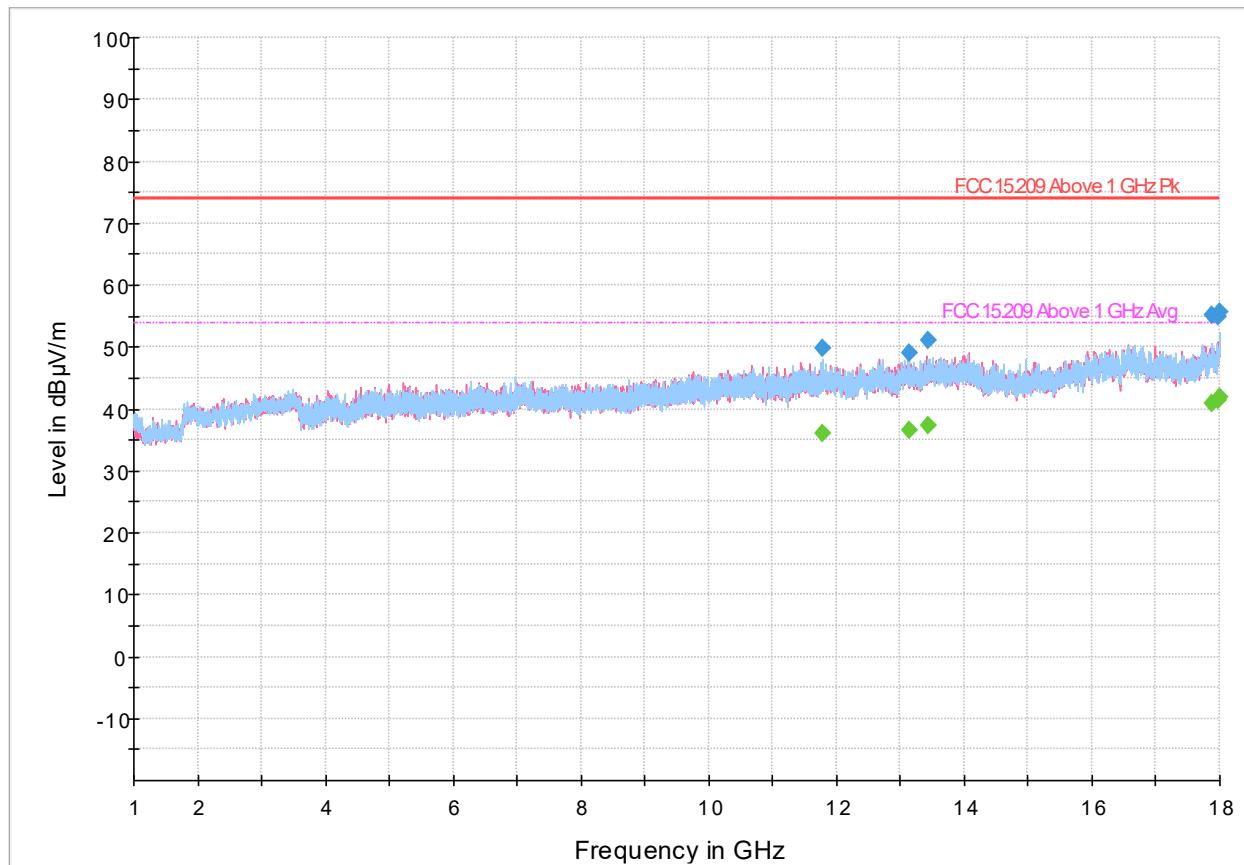


Figure 8.6-14: Radiated emissions spectral plot (1 GHz - 18 GHz), 2402 MHz, 2 Mbps

Table 8.6-11: Radiated emissions results

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)
11771.950000	49.72	---	73.90	24.18	5000.0	1000.000	226.0	H	100.0	11.1
11771.950000	---	36.05	53.90	17.85	5000.0	1000.000	226.0	H	100.0	11.1
13132.450000	---	36.45	53.90	17.45	5000.0	1000.000	317.0	H	268.0	12.7
13132.450000	49.12	---	73.90	24.78	5000.0	1000.000	317.0	H	268.0	12.7
13445.800000	---	37.29	53.90	16.61	5000.0	1000.000	244.0	H	46.0	13.7
13445.800000	51.08	---	73.90	22.82	5000.0	1000.000	244.0	H	46.0	13.7
17878.950000	---	40.83	53.90	13.07	5000.0	1000.000	231.0	V	35.0	18.7
17878.950000	55.05	---	73.90	18.85	5000.0	1000.000	231.0	V	35.0	18.7
17985.450000	---	41.28	53.90	12.62	5000.0	1000.000	106.0	V	252.0	19.6
17985.450000	54.84	---	73.90	19.06	5000.0	1000.000	106.0	V	252.0	19.6
17998.750000	55.63	---	73.90	18.27	5000.0	1000.000	295.0	H	353.0	20.4
17998.750000	---	41.95	53.90	11.95	5000.0	1000.000	295.0	H	353.0	20.4

Notes: ¹ Field strength (dBμV/m) = receiver/spectrum analyzer value (dBμV) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

A notch filter was used to suppress the fundamental emission.

Full Spectrum

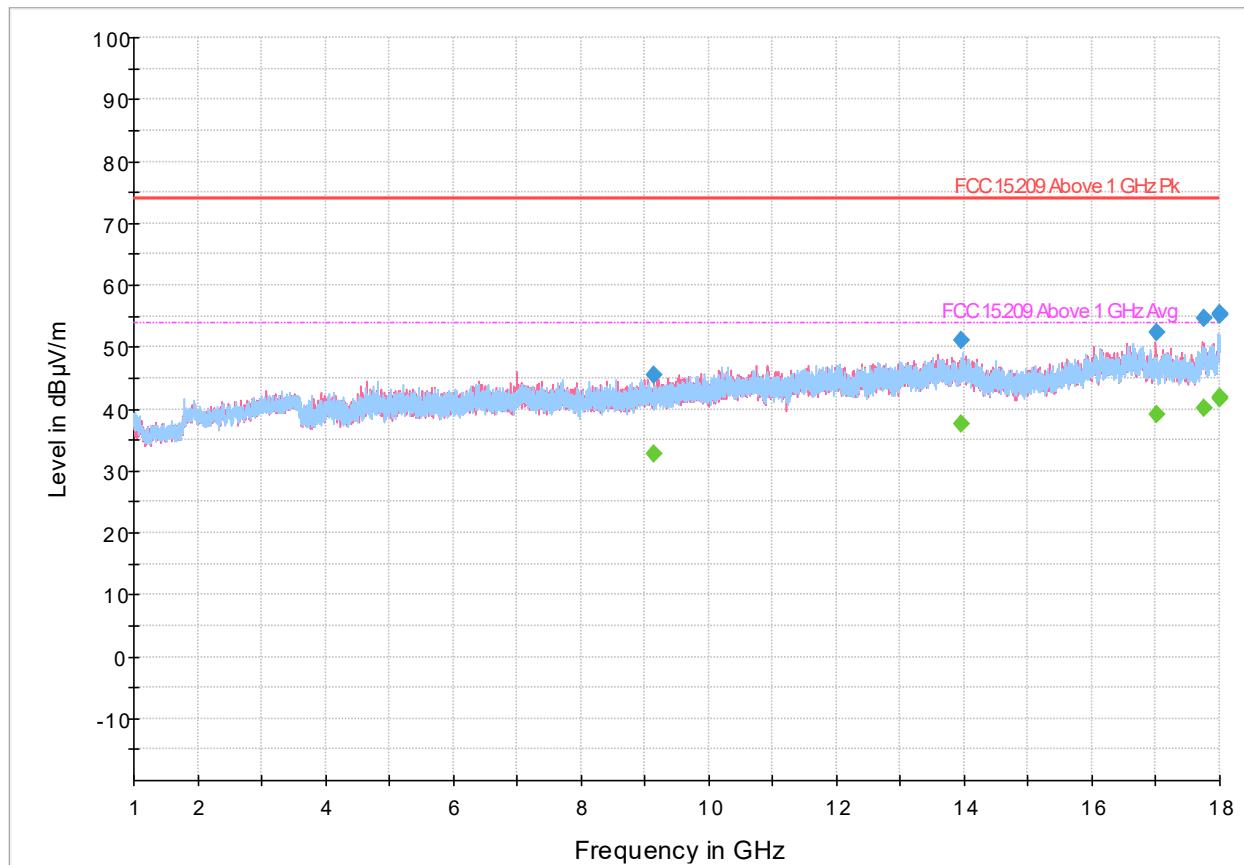


Figure 8.6-15: Radiated emissions spectral plot (1 GHz - 18 GHz), 2440 MHz, 2 Mbps

Table 8.6-12: Radiated emissions results

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)
9148.500000	45.52	---	73.90	28.38	5000.0	1000.000	164.0	V	355.0	5.8
9148.500000	---	32.73	53.90	21.17	5000.0	1000.000	164.0	V	355.0	5.8
13960.900000	51.19	---	73.90	22.71	5000.0	1000.000	315.0	H	290.0	14.6
13960.900000	---	37.69	53.90	16.21	5000.0	1000.000	315.0	H	290.0	14.6
17001.400000	---	39.05	53.90	14.85	5000.0	1000.000	349.0	V	214.0	15.4
17001.400000	52.29	---	73.90	21.61	5000.0	1000.000	349.0	V	214.0	15.4
17744.800000	---	40.19	53.90	13.71	5000.0	1000.000	337.0	V	330.0	17.0
17744.800000	54.75	---	73.90	19.15	5000.0	1000.000	337.0	V	330.0	17.0
17995.000000	55.17	---	73.90	18.73	5000.0	1000.000	344.0	H	340.0	20.1
17995.000000	---	41.74	53.90	12.16	5000.0	1000.000	344.0	H	340.0	20.1
17998.700000	55.34	---	73.90	18.56	5000.0	1000.000	98.0	H	204.0	20.3
17998.700000	---	41.94	53.90	11.96	5000.0	1000.000	98.0	H	204.0	20.3

Notes: ¹ Field strength (dBμV/m) = receiver/spectrum analyzer value (dBμV) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

A notch filter was used to suppress the fundamental emission.

Full Spectrum

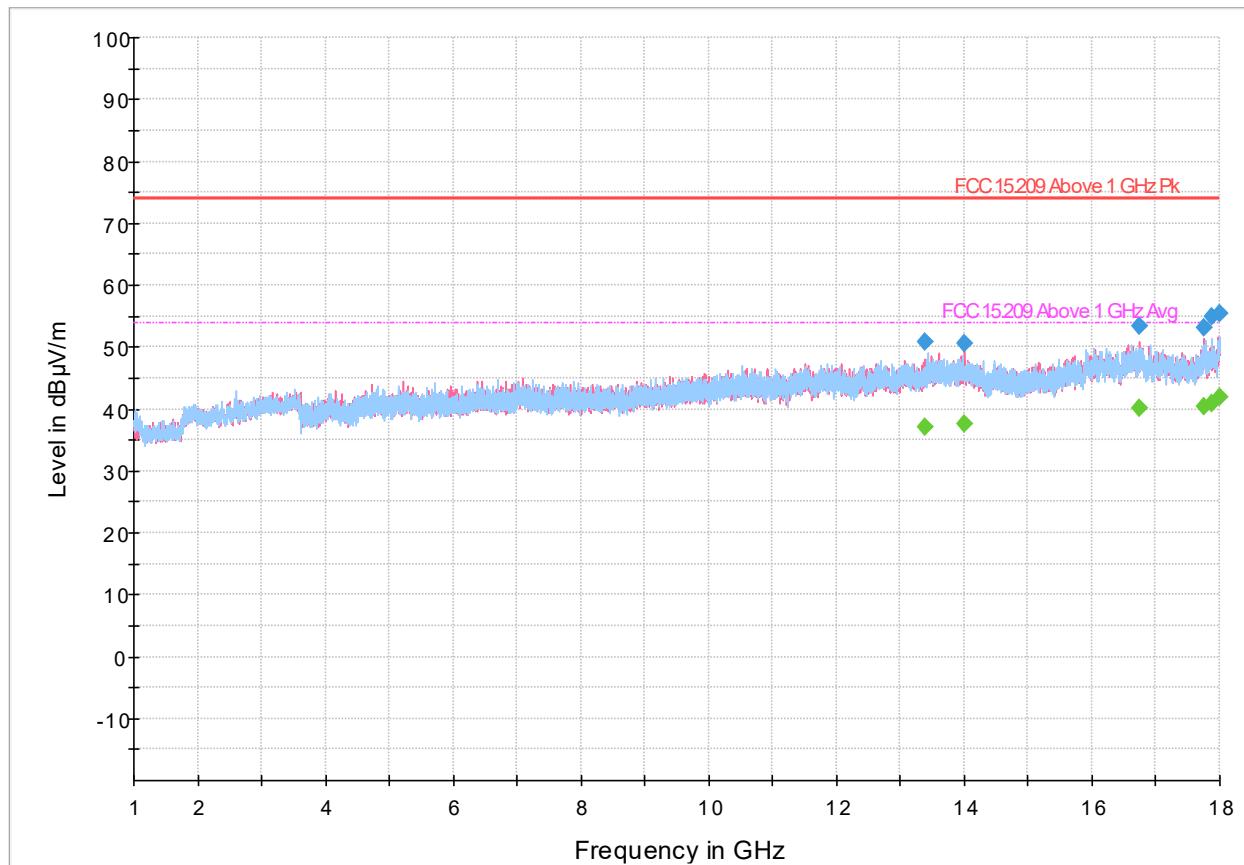


Figure 8.6-16: Radiated emissions spectral plot (1 GHz - 18 GHz), 2480 MHz, 2 Mbps

Table 8.6-13: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
13386.150000	50.71	---	73.90	23.19	5000.0	1000.000	197.0	V	162.0	13.3
13386.150000	---	36.96	53.90	16.94	5000.0	1000.000	197.0	V	162.0	13.3
13996.200000	50.56	---	73.90	23.34	5000.0	1000.000	165.0	V	268.0	14.5
13996.200000	---	37.55	53.90	16.35	5000.0	1000.000	165.0	V	268.0	14.5
16748.950000	53.32	---	73.90	20.58	5000.0	1000.000	284.0	V	239.0	18.2
16748.950000	---	40.04	53.90	13.86	5000.0	1000.000	284.0	V	239.0	18.2
17755.000000	53.16	---	73.90	20.74	5000.0	1000.000	232.0	V	276.0	17.1
17755.000000	---	40.30	53.90	13.60	5000.0	1000.000	232.0	V	276.0	17.1
17864.900000	---	40.87	53.90	13.03	5000.0	1000.000	339.0	H	11.0	18.4
17864.900000	55.01	---	73.90	18.89	5000.0	1000.000	339.0	H	11.0	18.4
17998.150000	---	41.96	53.90	11.94	5000.0	1000.000	128.0	H	11.0	20.3
17998.150000	55.32	---	73.90	18.58	5000.0	1000.000	128.0	H	11.0	20.3

Notes: ¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

A notch filter was used to suppress the fundamental emission.

Full Spectrum

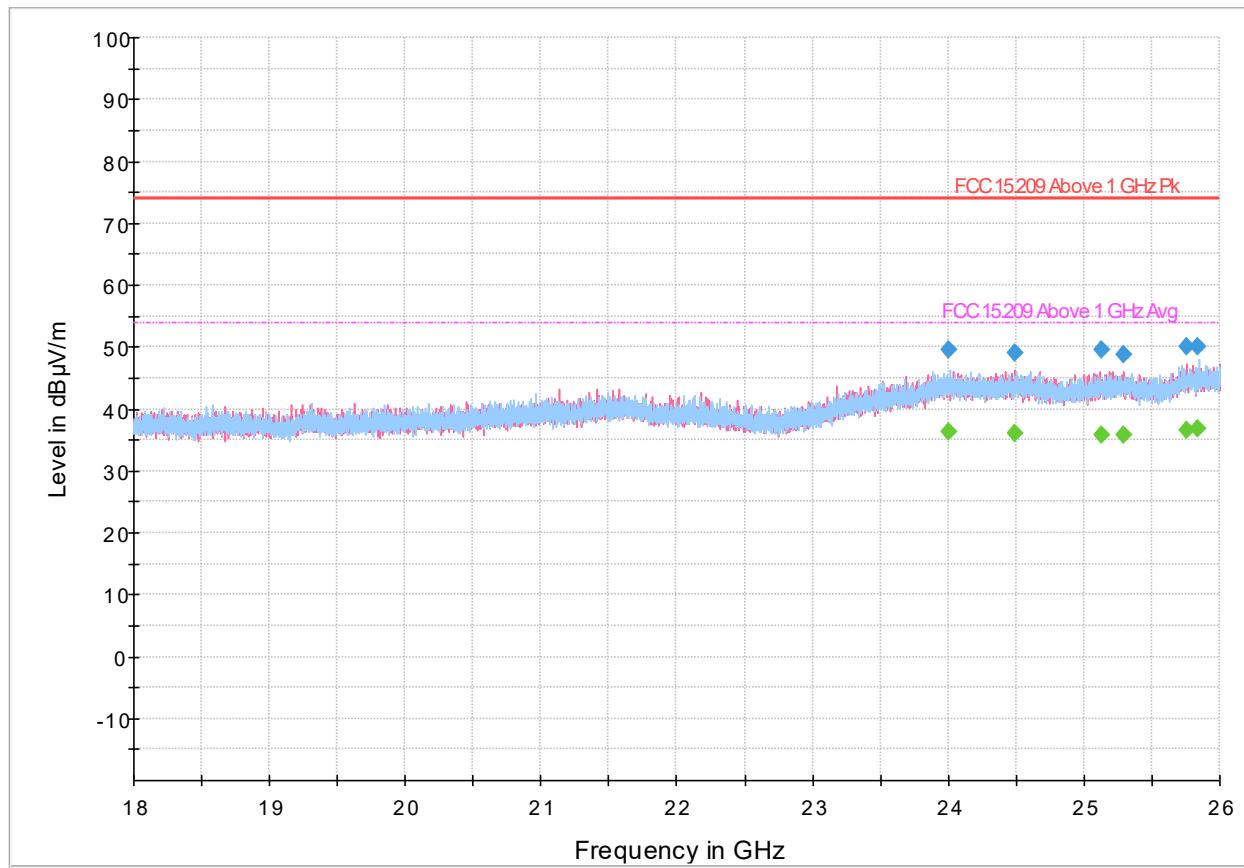


Figure 8.6-17: Radiated emissions spectral plot (18 GHz - 26 GHz), 2402 MHz, 2 Mbps

Table 8.6-14: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
24003.000000	49.51	---	73.90	24.39	5000.0	1000.000	364.0	H	289.0	18.6
24003.000000	---	36.33	53.90	17.57	5000.0	1000.000	364.0	H	289.0	18.6
24493.800000	---	36.04	53.90	17.86	5000.0	1000.000	363.0	V	244.0	17.7
24493.800000	49.03	---	73.90	24.87	5000.0	1000.000	363.0	V	244.0	17.7
25125.800000	49.51	---	73.90	24.39	5000.0	1000.000	185.0	V	294.0	17.1
25125.800000	---	35.72	53.90	18.18	5000.0	1000.000	185.0	V	294.0	17.1
25286.600000	---	35.88	53.90	18.02	5000.0	1000.000	146.0	V	232.0	17.2
25286.600000	48.80	---	73.90	25.10	5000.0	1000.000	146.0	V	232.0	17.2
25761.400000	50.07	---	73.90	23.83	5000.0	1000.000	230.0	V	0.0	17.7
25761.400000	---	36.60	53.90	17.30	5000.0	1000.000	230.0	V	0.0	17.7
25840.600000	50.10	---	73.90	23.80	5000.0	1000.000	268.0	H	323.0	17.7
25840.600000	---	36.73	53.90	17.17	5000.0	1000.000	268.0	H	323.0	17.7

Notes: ¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Full Spectrum

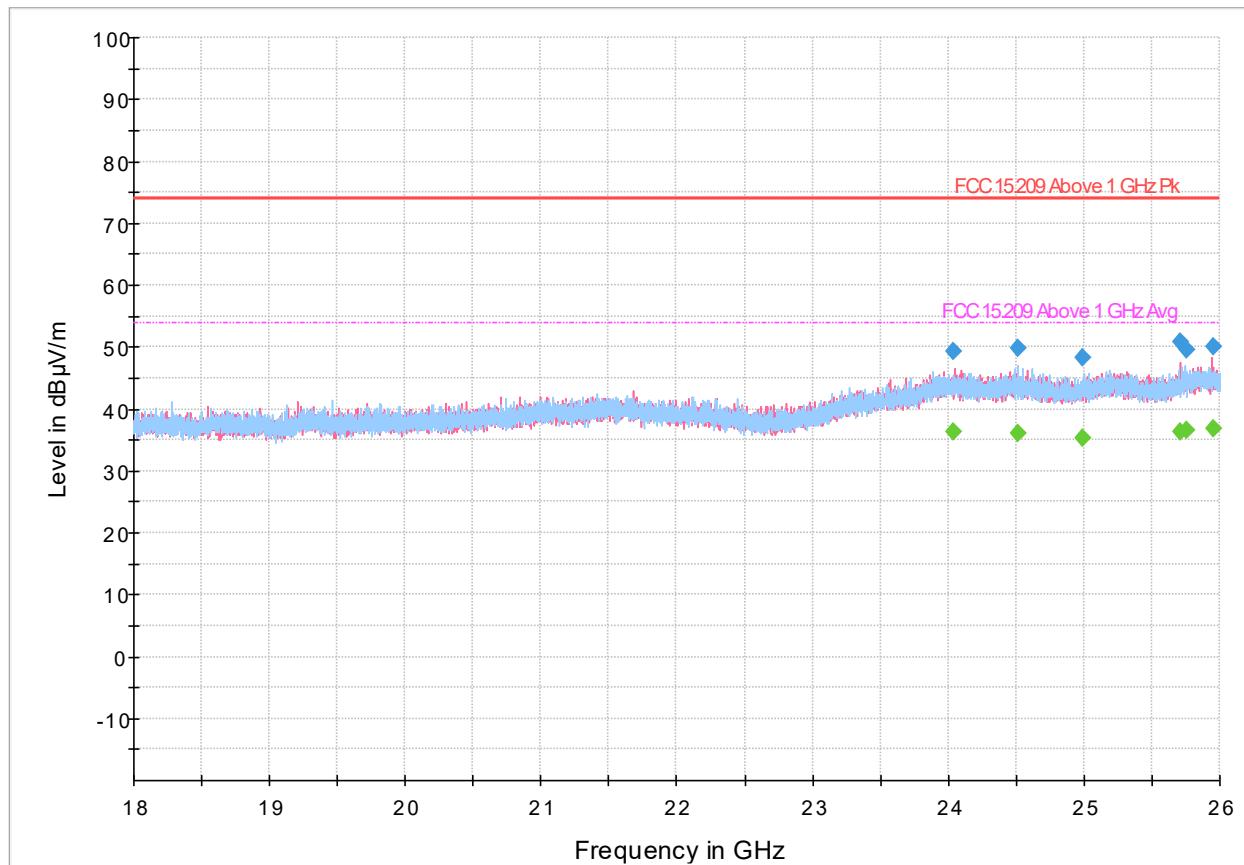


Figure 8.6-18: Radiated emissions spectral plot (18 GHz - 26 GHz), 2440 MHz, 2 Mbps

Table 8.6-15: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
24041.400000	---	36.31	53.90	17.59	5000.0	1000.000	401.0	V	55.0	18.5
24041.400000	49.36	---	73.90	24.54	5000.0	1000.000	401.0	V	55.0	18.5
24510.600000	49.77	---	73.90	24.13	5000.0	1000.000	317.0	H	293.0	17.7
24510.600000	---	36.00	53.90	17.90	5000.0	1000.000	317.0	H	293.0	17.7
24991.800000	---	35.30	53.90	18.60	5000.0	1000.000	360.0	H	92.0	17.1
24991.800000	48.37	---	73.90	25.53	5000.0	1000.000	360.0	H	92.0	17.1
25714.200000	---	36.37	53.90	17.53	5000.0	1000.000	287.0	V	86.0	17.7
25714.200000	50.82	---	73.90	23.08	5000.0	1000.000	287.0	V	86.0	17.7
25753.400000	---	36.57	53.90	17.33	5000.0	1000.000	229.0	H	135.0	17.7
25753.400000	49.60	---	73.90	24.30	5000.0	1000.000	229.0	H	135.0	17.7
25948.200000	50.10	---	73.90	23.80	5000.0	1000.000	272.0	V	102.0	17.7
25948.200000	---	36.78	53.90	17.12	5000.0	1000.000	272.0	V	102.0	17.7

Notes: ¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Full Spectrum

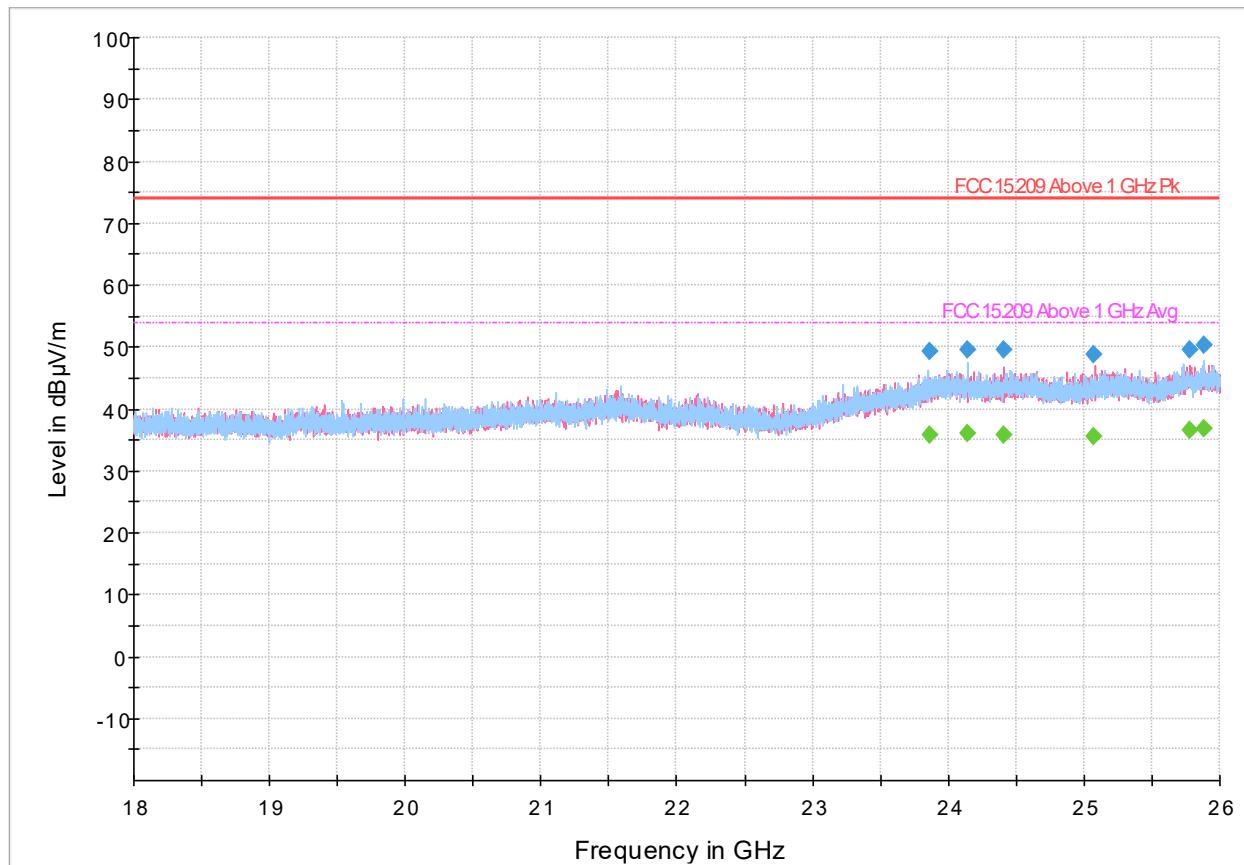


Figure 8.6-19: Radiated emissions spectral plot (18 GHz - 26 GHz), 2480 MHz, 2 Mbps

Table 8.6-16: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
23866.200000	49.28	---	73.90	24.62	5000.0	1000.000	260.0	H	187.0	18.0
23866.200000	---	35.77	53.90	18.13	5000.0	1000.000	260.0	H	187.0	18.0
24140.200000	---	36.07	53.90	17.83	5000.0	1000.000	353.0	H	0.0	18.3
24140.200000	49.63	---	73.90	24.27	5000.0	1000.000	353.0	H	0.0	18.3
24413.000000	---	35.90	53.90	18.00	5000.0	1000.000	110.0	V	341.0	17.8
24413.000000	49.58	---	73.90	24.32	5000.0	1000.000	110.0	V	341.0	17.8
25076.600000	---	35.54	53.90	18.36	5000.0	1000.000	373.0	V	86.0	17.1
25076.600000	48.69	---	73.90	25.21	5000.0	1000.000	373.0	V	86.0	17.1
25773.800000	49.58	---	73.90	24.32	5000.0	1000.000	326.0	V	0.0	17.7
25773.800000	---	36.64	53.90	17.26	5000.0	1000.000	326.0	V	0.0	17.7
25883.400000	---	36.85	53.90	17.05	5000.0	1000.000	204.0	H	353.0	17.7
25883.400000	50.29	---	73.90	23.61	5000.0	1000.000	204.0	H	353.0	17.7

Notes: ¹ Field strength (dB μ V/m) = receiver/spectrum analyzer value (dB μ V) + correction factor (dB)

² Correction factors = antenna factor ACF (dB) + cable loss (dB)

³ Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

8.7 Power spectral density

8.7.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(e)
- ISED: RSS-247: §5.2(b)
- Test method: ANSI C63.10-2020 §11.10.2.1 (Method PKPSD)

§15.247:

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

RSS-247:

5.2 DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:

(b) 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(d), (i.e., the power spectral density shall be determined using the same method as is used to determine the conducted output power).

8.7.2 Test summary

Verdict	Pass		
Test date	September 25, 2023	Temperature	21 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	53 %

8.7.3 Notes

Testing was performed with the transmitter operating on a fixed channel (lowest, middle, and highest) at maximum output power.

The spectral plots within this section have been corrected with all relevant transducer factors.

8.7.4 Setup details

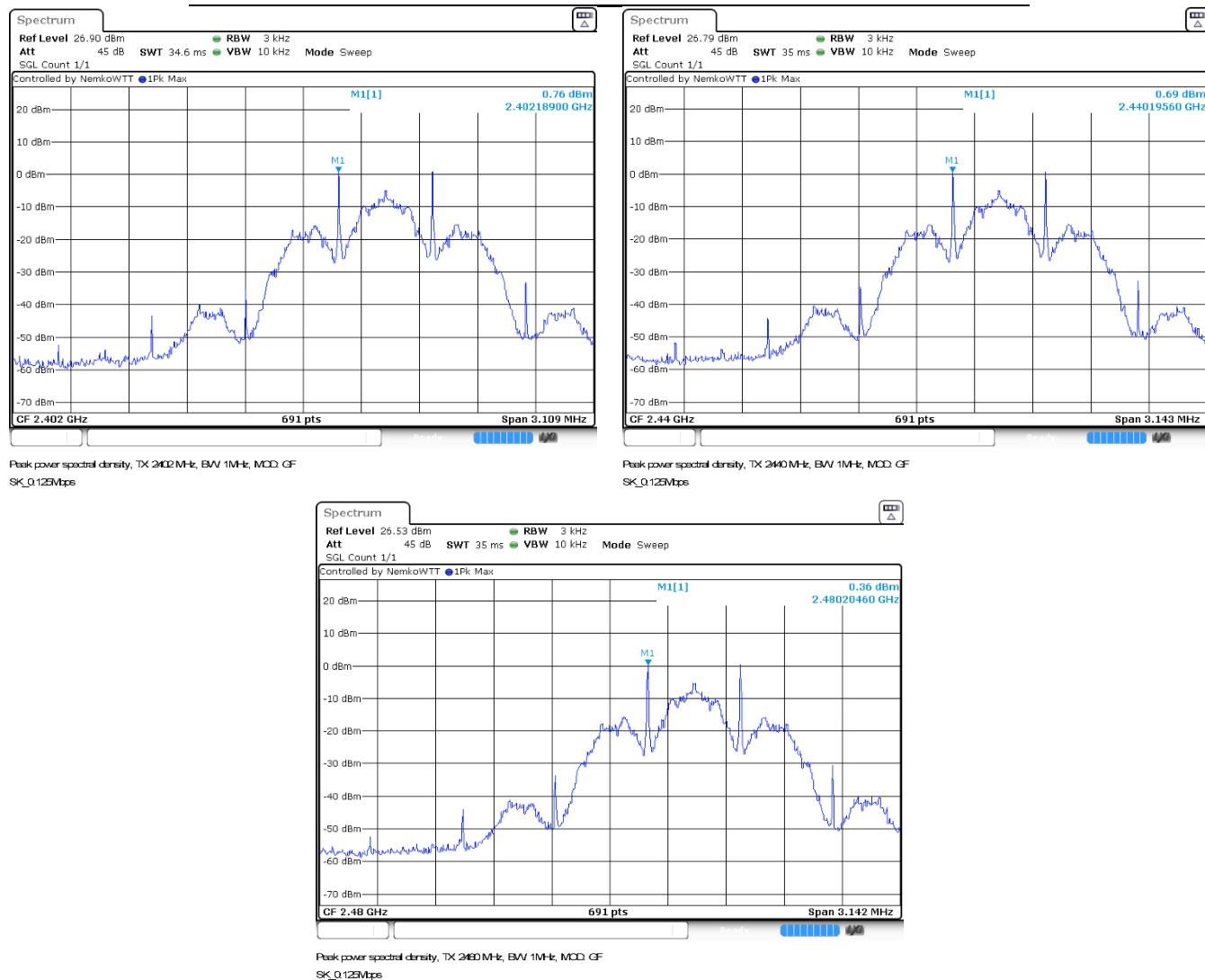
EUT power input during test	48 VDC PoE
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Spectrum analyzer settings:

Resolution bandwidth	3 kHz
Video bandwidth	10 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

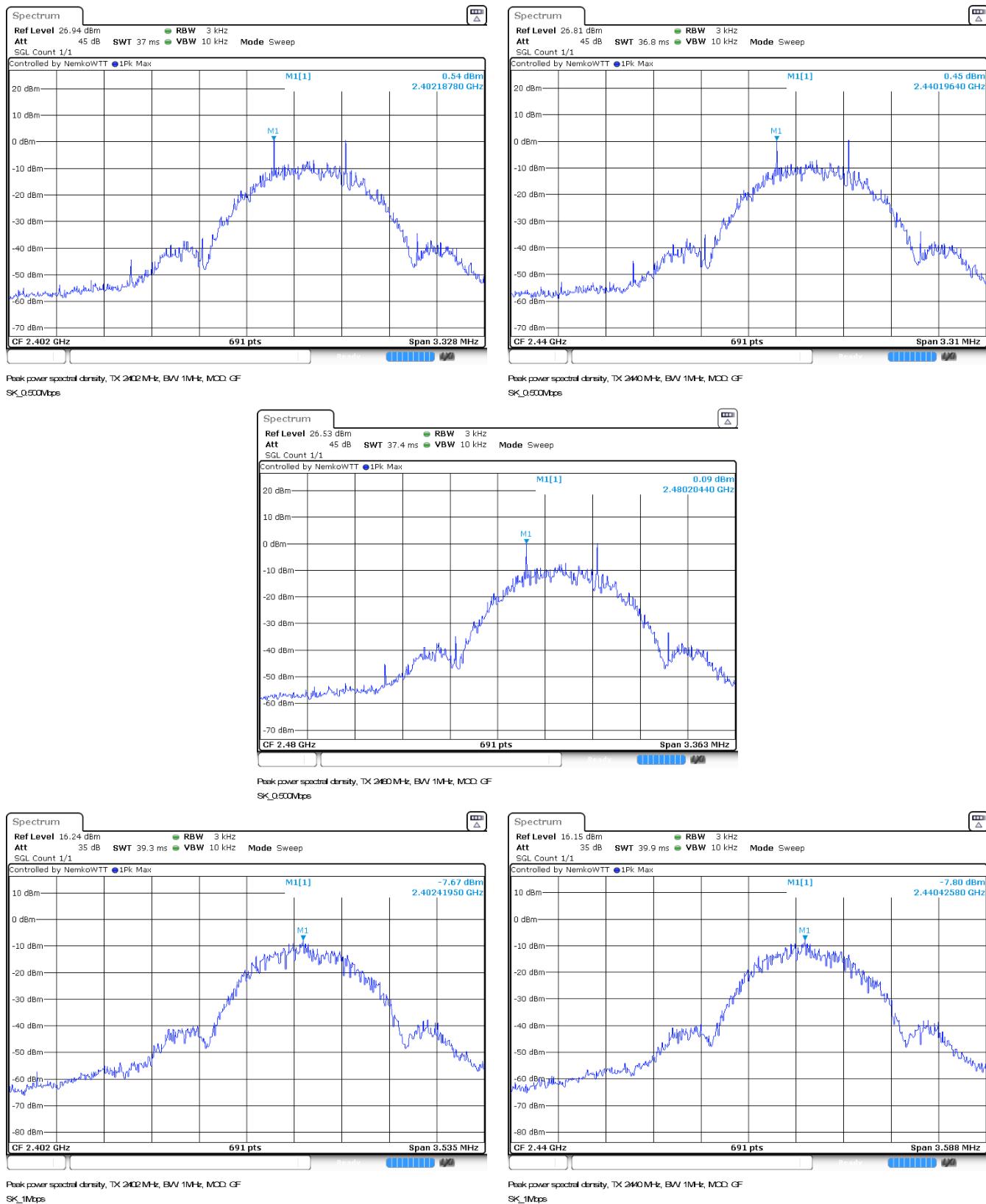
Section 8**Test name****Specification(s)****Testing data****Power spectral density****FCC 15.247 & RSS-247****8.7.5 Test data****Table 8.7-1: Power spectral density test data**

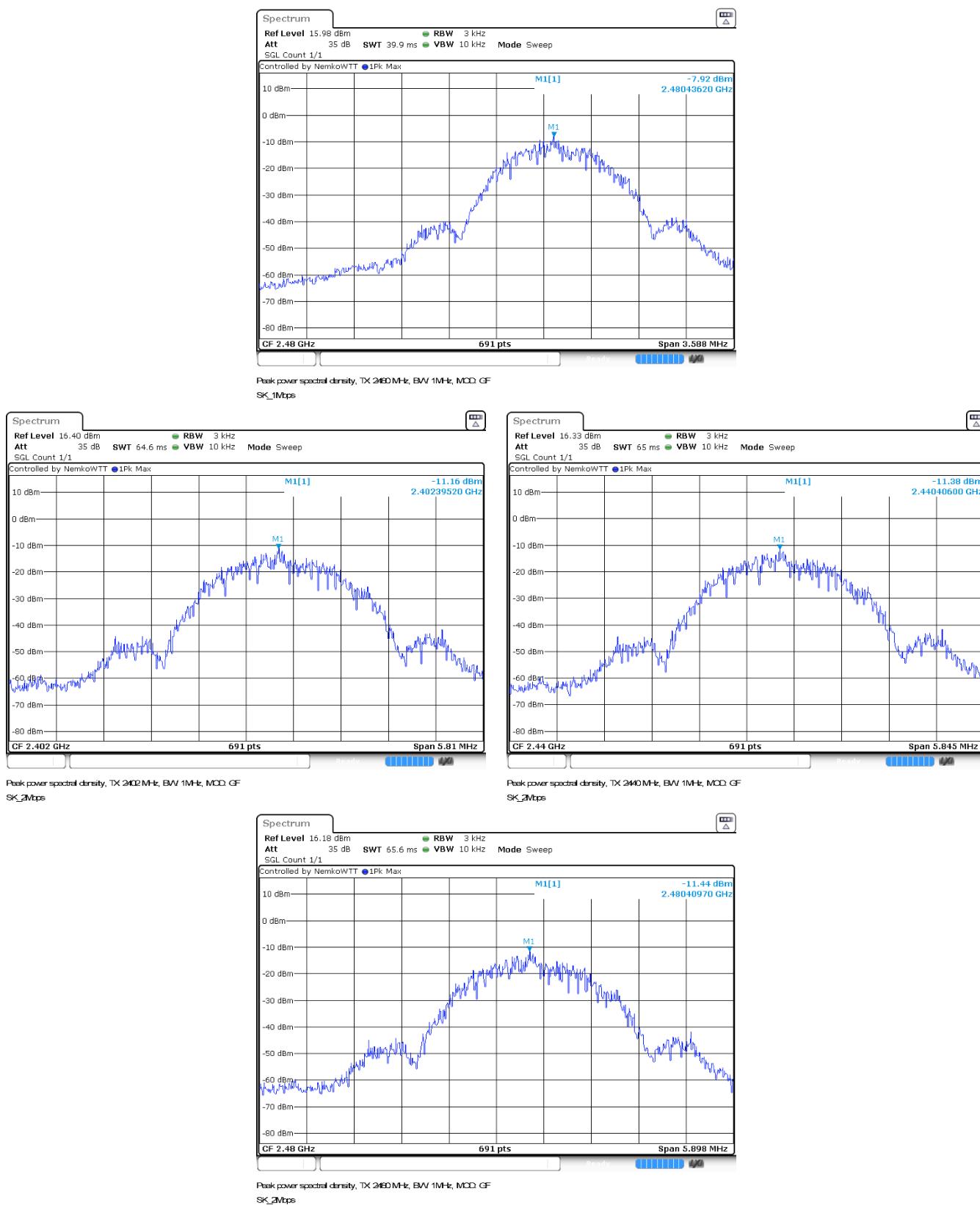
Test Frequency (MHz)	Modulation	Power Density (dBm/3 kHz)	Limit (dBm)	Margin (dB)
2402	GFSK, 0.125 Mbps	0.76	≤ 8	8.11
2440	GFSK, 0.125 Mbps	0.69	≤ 8	8.24
2480	GFSK, 0.125 Mbps	0.36	≤ 8	8.35
2402	GFSK, 0.500 Mbps	0.54	≤ 8	8.30
2440	GFSK, 0.500 Mbps	0.45	≤ 8	8.46
2480	GFSK, 0.500 Mbps	0.09	≤ 8	8.65
2402	GFSK, 1 Mbps	-7.67	≤ 8	16.24
2440	GFSK, 1 Mbps	-7.80	≤ 8	16.63
2480	GFSK, 1 Mbps	-7.92	≤ 8	16.59
2402	GFSK, 2 Mbps	-11.16	≤ 8	19.87
2440	GFSK, 2 Mbps	-11.38	≤ 8	20.23
2480	GFSK, 2 Mbps	-11.44	≤ 8	20.11



Section 8**Test name****Specification(s)****Testing data****Power spectral density**

FCC 15.247 & RSS-247





8.8 99% occupied bandwidth

8.8.1 References and limits

- ISED: RSS-Gen: §6.7
- Test method: ANSI C63.4-2020: §6.9.2

RSS-GEN:

6.7 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.

8.8.2 Test summary

Verdict	Pass		
Test date	September 25, 2023	Temperature	21 °C
Test engineer	Lan Sayasane, EMC Test Engineer	Air pressure	1007 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	53 %

8.8.3 Notes

Testing was performed with the transmitter operating on a fixed channel (lowest, middle, and highest) at maximum output power.

The spectral plots within this section have been corrected with all relevant transducer factors.

8.8.4 Setup details

EUT power input during test	48 V DC PoE
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Receiver settings:

Resolution bandwidth	20 kHz
Video bandwidth	100 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.8.5 Test data

Table 8.8-1: 99% occupied bandwidth test data

Test Frequency (MHz)	Modulation	99% BW (MHz)	f _l (MHz)	f _h (MHz)	Limit	Verdict
2402	GFSK, 0.125 Mbps	1.046	2401.914	2402.960	f _h and f _l within 2400 – 2483.5 MHz	PASS
2440	GFSK, 0.125 Mbps	1.046	2439.919	2440.965	f _h and f _l within 2400 – 2483.5 MHz	PASS
2480	GFSK, 0.125 Mbps	1.038	2479.931	2480.969	f _h and f _l within 2400 – 2483.5 MHz	PASS
2402	GFSK, 0.500 Mbps	1.018	2401.933	2402.951	f _h and f _l within 2400 – 2483.5 MHz	PASS
2440	GFSK, 0.500 Mbps	1.022	2439.938	2440.960	f _h and f _l within 2400 – 2483.5 MHz	PASS
2480	GFSK, 0.500 Mbps	1.022	2479.946	2480.968	f _h and f _l within 2400 – 2483.5 MHz	PASS
2402	GFSK, 1 Mbps	1.027	2401.935	2402.962	f _h and f _l within 2400 – 2483.5 MHz	PASS
2440	GFSK, 1 Mbps	1.029	2439.940	2440.969	f _h and f _l within 2400 – 2483.5 MHz	PASS
2480	GFSK, 1 Mbps	1.026	2479.950	2480.976	f _h and f _l within 2400 – 2483.5 MHz	PASS
2402	GFSK, 2 Mbps	2.034	2401.444	2403.477	f _h and f _l within 2400 – 2483.5 MHz	PASS
2440	GFSK, 2 Mbps	2.037	2439.450	2441.487	f _h and f _l within 2400 – 2483.5 MHz	PASS
2480	GFSK, 2 Mbps	2.033	2479.458	2481.492	f _h and f _l within 2400 – 2483.5 MHz	PASS

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Figure 8.8-1: 99% occupied bandwidth, GFSK, 0.125 Mbps, 2402 MHz



Figure 8.8-2: 99% occupied bandwidth, GFSK, 0.125 Mbps, 2440 MHz



Figure 8.8-3: 99% occupied bandwidth, GFSK, 0.125 Mbps, 2480 MHz



Figure 8.8-4: 99% occupied bandwidth, GFSK, 0.500 Mbps, 2402 MHz



Figure 8.8-5: 99% occupied bandwidth, GFSK, 0.500 Mbps, 2440 MHz



Figure 8.8-6: 99% occupied bandwidth, GFSK, 0.500 Mbps, 2480 MHz

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Figure 8.8-7: 99% occupied bandwidth, GFSK, 1 Mbps, 2402 MHz

Figure 8.8-8: 99% occupied bandwidth, GFSK, 1 Mbps, 2440 MHz

Figure 8.8-9: 99% occupied bandwidth, GFSK, 1 Mbps, 2480 MHz

Figure 8.8-10: 99% occupied bandwidth, GFSK, 2 Mbps, 2402 MHz

Figure 8.8-11: 99% occupied bandwidth, GFSK, 2 Mbps, 2440 MHz

Figure 8.8-12: 99% occupied bandwidth, GFSK, 2 Mbps, 2480 MHz

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End of test report