



Test report

REP047893-1R2TRFWL

Date of issue: August 13, 2024

Applicant:

Babba Care, Inc.

Product description:

Babba Baby Bottle Cooler and Warmer

Model:

104-0001

Product marketing name(s):

N/A

FCC ID:

2BHFX-1040001

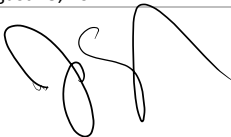
ISED certification number:

32751-1040001

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 3**
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	Chenhao Ma, Wireless Test Technician
Reviewed by	James Cunningham, EMC/WL Manager
Review date	August 13, 2024
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 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 3	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
REP047893-1TRFEMC	July 23, 2024	Original report issued
REP047893-1R1TRFEMC	July 24, 2024	Minor corrections following TCB review
REP047893-1R2TRFEMC	August 13, 2024	Notes added to section 8.6.3

Section 2 Summary of test results

2.1 Sample information

Receipt date	26-Jun-24
Nemko sample ID number	REP047893

2.2 Testing period

Test start date	26-Jun-24
Test end date	28-Jun-24

2.3 Test results

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

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass ¹
§15.31(e)	Variation of power source	Pass

Notes: ¹ EUT is DC powered from dedicated DC source or battery powered. AC conducted emissions tested with representative AC/DC adaptor.

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: ISSED 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	Not applicable
5.4 (c)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (d)	Systems employing digital modulation techniques	Pass
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: ISSED 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	Pass

Notes: ¹ Only 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	Babba Care, Inc.
Address	1974 Amarillo Pl.
City	Escondido
State	CA
Postal/Zip code	92025
Country	United States

3.3 Manufacturer

Company name	Esino USA
Address	No.5 Xifu Street, Lincun, Tangxia Town
City	Dongguan City
State	Guangdong Province
Postal/Zip code	523711
Country	China

3.4 EUT information

Product name	Babba Baby Bottle Cooler and Warmer
Model	104-0001
Variant(s)	N/A
Serial number	1E2425001
Part number	104-0001
Power requirements	Power Adapter: 14V 3A; Battery Pack: 11.1V 3200mAh
Description/theory of operation	Cools and warms fluid inside a baby bottle.
Operational frequencies	2.4 GHz
Software details	Firmware version 6.0.1, Software Engineering Version 4.1

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 type="checkbox"/> 125 kbps operation <input 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	See antenna report (REP041407-1TRFEMC_Antenna gain BLE)
Antenna peak gain	See antenna report (REP041407-1TRFEMC_Antenna gain BLE)

3.6 EUT setup details

Table 3.6-1: EUT sub assemblies

Description	Brand name	Model/Part number	Serial number	Rev.
None				

Table 3.6-2: EUT interface ports

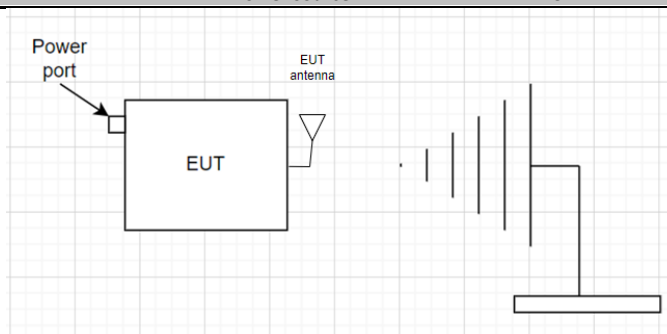
Description	Qty.
Power port	1

Table 3.6-3: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
None				

Table 3.6-4: Inter-connection cables

Cable description	From	To	Length (m)
Power cable	Power source	EUT	0.6

**Figure 3.6-1: Test setup diagram**

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_{cispr} 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_{cispr} then:
 - compliance is deemed to occur is 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_{cispr} then:
 - compliance is deemed to occur is no measured disturbance level, increased by $(U_{\text{lab}} - U_{\text{cispr}})$, exceeds the disturbance limit;
 - non-compliance is deemed to occur if any measured disturbance level, increased by $(U_{\text{lab}} - U_{\text{cispr}})$, 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.
Signal & Spectrum Analyzer 2Hz / 43.5 GHz	Rohde & Schwarz	FSW43	E1302	1 year	Jan-22-2025
EMC Test Receiver	Rohde & Schwarz	ESU 40	E1121	1 year	Aug-23-2024
Antenna, Bilog	Schaffner-Chase	CBL6111C	1763	1 year	July-01-2024
Antenna, Horn	ETS-Lingren	3117-PA	E1160	2 years	Feb-13-2025
Standard Gain Horn Antenna	Eravant	SAZ-2410-2-S1	EW108	1 year	Dec-05-2024
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	1 year	April-17-2025
Transient Limiter (10 dB pad)	Hewlett Packard	11947A	E1159	1 year	March-12-2025
Two Line V-Network	Rohde & Schwarz	ENV216	E1019	1 year	October-03-2024

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 V10.60.10 (AC conducted emissions)
Rohde & Schwarz	EMC 32 V10.60.15 (radiated emissions)

Section 8 Testing data

8.1 Conducted limits / power line conducted emissions limits for licence-exempt radio apparatus

8.1.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.207
- ISSED: RSS-GEN §6.8
- Test method: ANSI C63.10-2020 §6.2

Table 8.1-1: Conducted emissions limit

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

Note: * Decreases with the logarithm of the frequency.

8.1.2 Test summary

Verdict	Pass		
Test date	June 26, 2024	Temperature	23 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
Test location	<input type="checkbox"/> 10m semi anechoic chamber	Relative humidity	55.3 %
	<input type="checkbox"/> 3m semi anechoic chamber		
	<input checked="" type="checkbox"/> Other: Ground plane		

8.1.3 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.

For EUT's supporting multiple modulation schemes and/or data rates, testing is performed with the modulation and data rate that produces the highest transmitter output power.

8.1.4 Setup details

Port under test	Enclosure port
EUT power input during test	120 VAC
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:
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.
Modulation scheme / data rate tested	GFSK/ 2 Mbps

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	– Peak (Preview measurement) – Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 5000 ms (Quasi-peak final measurement) – 5000 ms (CAverage final measurement)

8.1.5 Test data

Full Spectrum

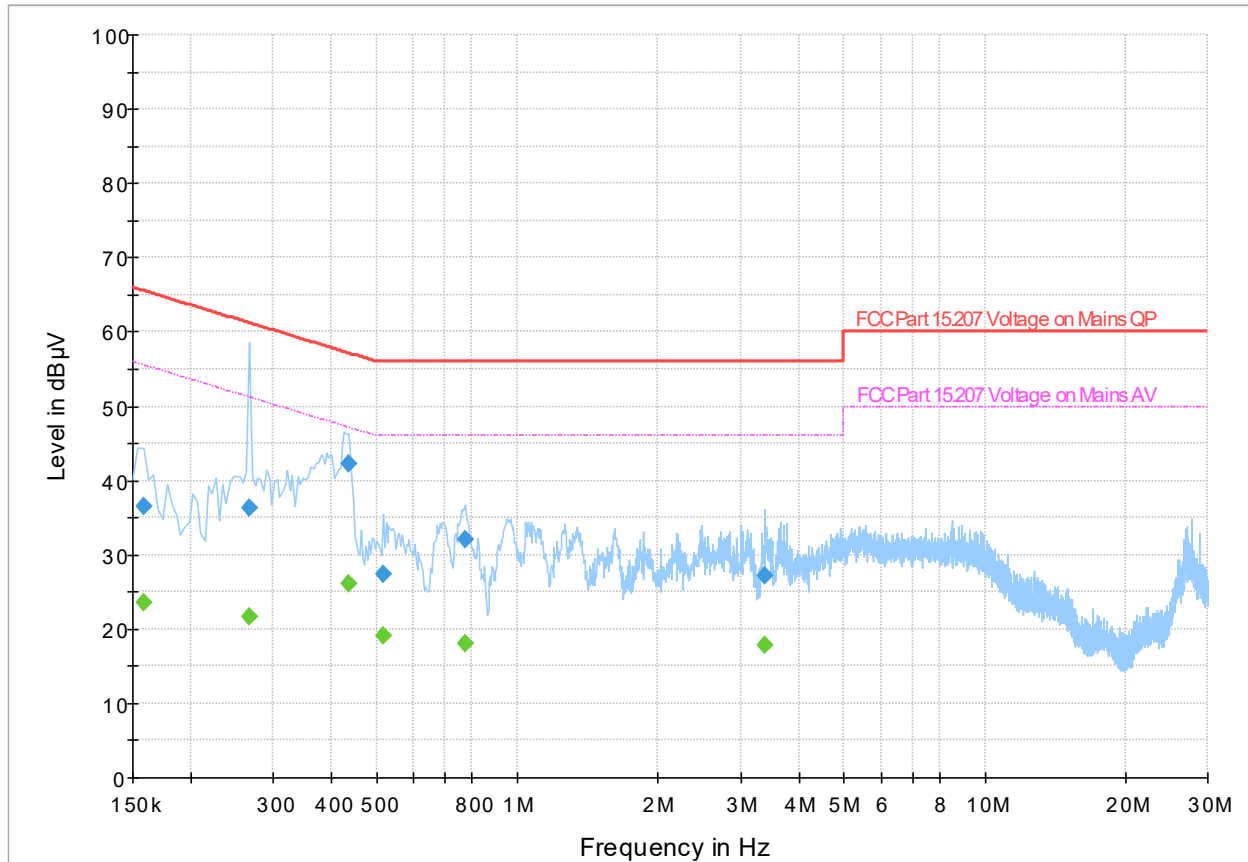


Figure 8.1-1: Conducted emissions at mains port spectral plot (150 kHz - 30 MHz) low channel

Table 8.1-2: Conducted emissions at mains port results

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.158000	---	23.62	55.57	31.95	5000.0	9.000	L1	ON	19.7
0.158000	36.61	---	65.57	28.95	5000.0	9.000	L1	ON	19.7
0.266000	---	21.71	51.24	29.53	5000.0	9.000	N	ON	19.7
0.266000	36.35	---	61.24	24.89	5000.0	9.000	N	ON	19.7
0.434000	---	26.17	47.18	21.00	5000.0	9.000	N	ON	19.7
0.434000	42.33	---	57.18	14.84	5000.0	9.000	N	ON	19.7
0.514000	---	19.05	46.00	26.95	5000.0	9.000	N	ON	19.7
0.514000	27.38	---	56.00	28.62	5000.0	9.000	N	ON	19.7
0.770000	---	18.03	46.00	27.97	5000.0	9.000	N	ON	19.7
0.770000	32.09	---	56.00	23.91	5000.0	9.000	N	ON	19.7
3.390000	---	17.92	46.00	28.08	5000.0	9.000	N	ON	19.8
3.390000	27.08	---	56.00	28.92	5000.0	9.000	N	ON	19.8

Notes:

¹ Result (dBµV) = receiver analyzer value (dBµV) + correction factor (dB).

² Correction factors = LISN factor IL (dB) + cable loss (dB) + transient limiter (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

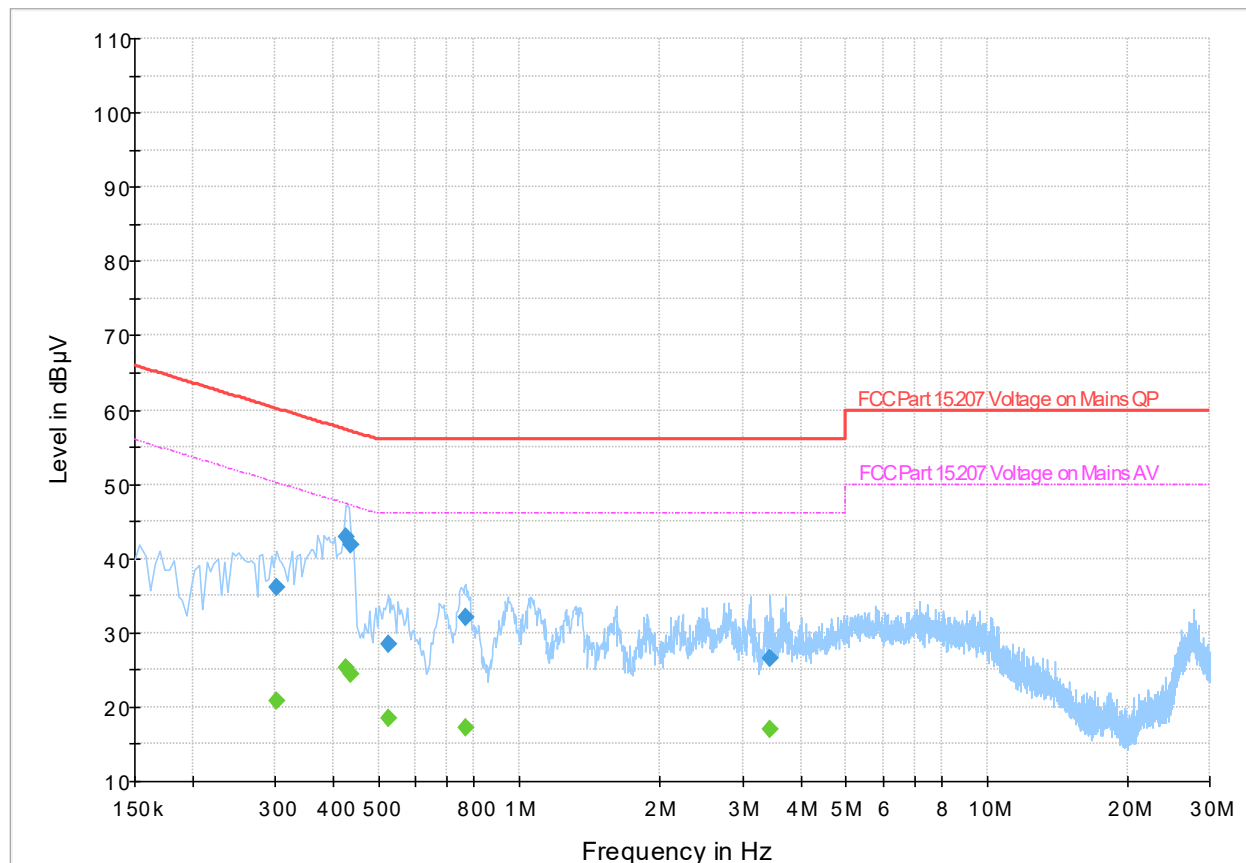


Figure 8.1-2: Conducted emissions at mains port spectral plot (150 kHz - 30 MHz) mid channel

Table 8.1-3: Conducted emissions at mains port results

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.302000	---	20.89	50.19	29.29	5000.0	9.000	N	ON	19.7
0.302000	36.18	---	60.19	24.01	5000.0	9.000	N	ON	19.7
0.426000	---	25.35	47.33	21.98	5000.0	9.000	N	ON	19.7
0.426000	42.88	---	57.33	14.45	5000.0	9.000	N	ON	19.7
0.434000	---	24.54	47.18	22.64	5000.0	9.000	N	ON	19.7
0.434000	41.75	---	57.18	15.43	5000.0	9.000	N	ON	19.7
0.522000	---	18.46	46.00	27.54	5000.0	9.000	N	ON	19.7
0.522000	28.38	---	56.00	27.62	5000.0	9.000	N	ON	19.7
0.766000	---	17.32	46.00	28.68	5000.0	9.000	N	ON	19.7
0.766000	31.98	---	56.00	24.02	5000.0	9.000	N	ON	19.7
3.446000	---	17.08	46.00	28.92	5000.0	9.000	N	ON	19.8
3.446000	26.63	---	56.00	29.37	5000.0	9.000	N	ON	19.8

Notes:

¹ Result (dBµV) = receiver analyzer value (dBµV) + correction factor (dB).

² Correction factors = LISN factor IL (dB) + cable loss (dB) + transient limiter (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

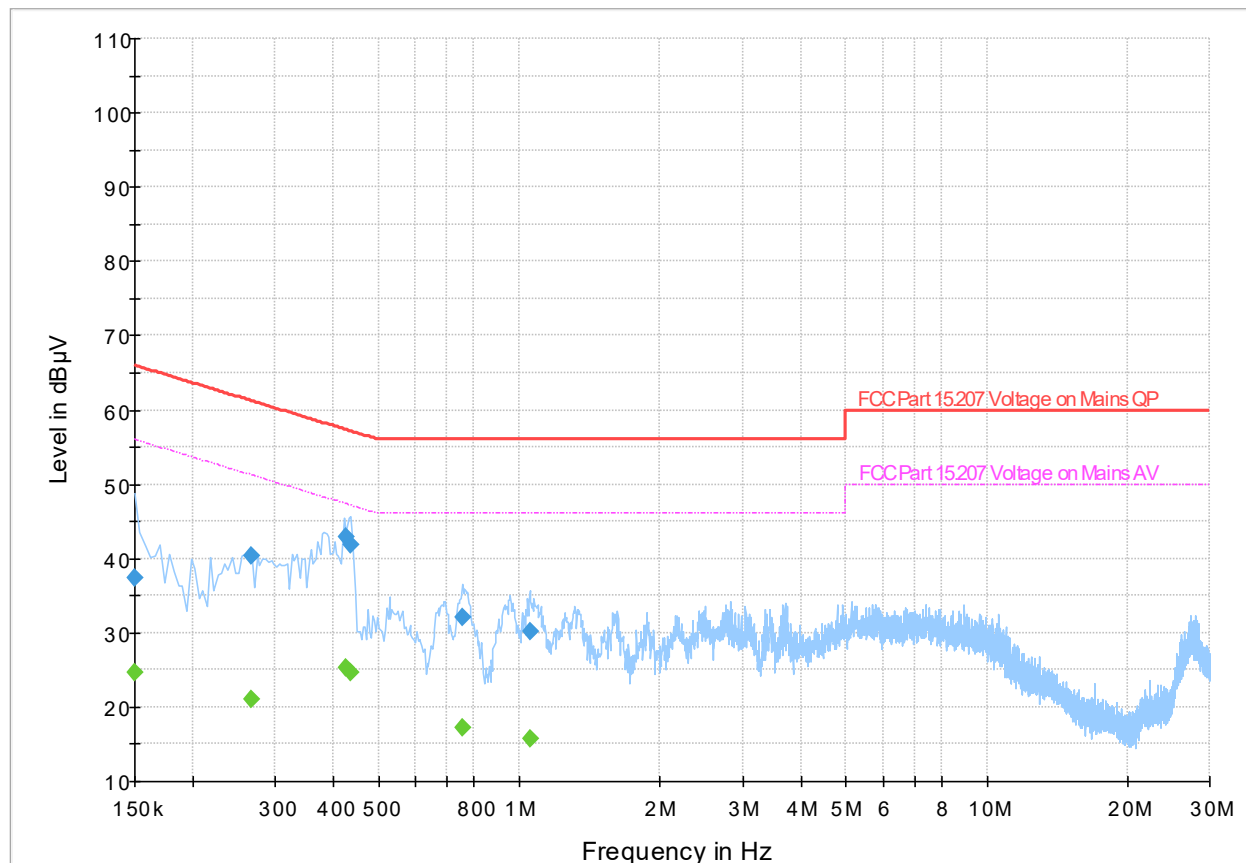


Figure 8.1-3: Conducted emissions at mains port spectral plot (150 kHz - 30 MHz) high channel

Table 8.1-4: Conducted emissions at mains port results

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.150000	---	24.56	56.00	31.44	5000.0	9.000	L1	ON	19.7
0.150000	37.47	---	66.00	28.53	5000.0	9.000	L1	ON	19.7
0.266000	---	20.94	51.24	30.30	5000.0	9.000	N	ON	19.7
0.266000	40.34	---	61.24	20.90	5000.0	9.000	N	ON	19.7
0.426000	---	25.23	47.33	22.10	5000.0	9.000	N	ON	19.7
0.426000	42.86	---	57.33	14.47	5000.0	9.000	N	ON	19.7
0.434000	---	24.58	47.18	22.59	5000.0	9.000	N	ON	19.7
0.434000	41.79	---	57.18	15.38	5000.0	9.000	N	ON	19.7
0.754000	---	17.25	46.00	28.75	5000.0	9.000	N	ON	19.7
0.754000	32.07	---	56.00	23.93	5000.0	9.000	N	ON	19.7
1.054000	---	15.81	46.00	30.19	5000.0	9.000	N	ON	19.7
1.054000	30.12	---	56.00	25.88	5000.0	9.000	N	ON	19.7

Notes:

¹ Result (dBµV) = receiver analyzer value (dBµV) + correction factor (dB).

² Correction factors = LISN factor IL (dB) + cable loss (dB) + transient limiter (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.

8.2 Variation of power source

8.2.1 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.

8.2.2 Test summary

Verdict	Pass		
Test date	June 27, 2024	Temperature	22 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	51.9 %

8.2.3 Notes

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

8.2.4 Setup details

EUT power input during test	Low: 108 V High: 132 V
-----------------------------	------------------------

8.2.5 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.

8.3 Antenna requirement

8.3.1 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	May 10, 2024	Temperature	22 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1003.4 mbar
Test location	<input type="checkbox"/> Wireless bench	Relative humidity	57 %
	<input checked="" type="checkbox"/> Other:3m chamber		

8.3.2 Notes

None

8.3.3 Test data

Antenna part number:	N/A
Technical description:	N/A
Peak gain (dBi):	6.36 dBi
Source of gain data:	<input type="checkbox"/> Declared by client
	<input type="checkbox"/> Antenna data sheet or specification. Document name:
	<input checked="" type="checkbox"/> Antenna gain test report. Document name: REP041407-1TRFEMC_Antenna gain BLE

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

8.4.2 Test summary

Verdict	Pass		
Test date	June 27, 2024	Temperature	22 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	51.9 %

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	Battery
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

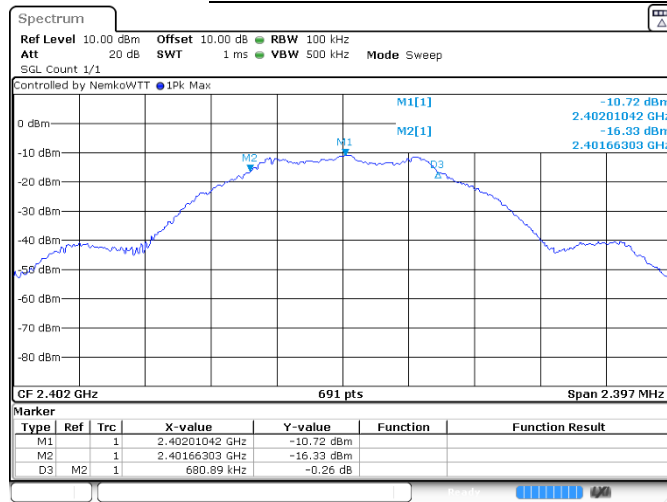
Receiver/spectrum analyzer settings:

Resolution bandwidth	100 kHz
Video bandwidth	500 kHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

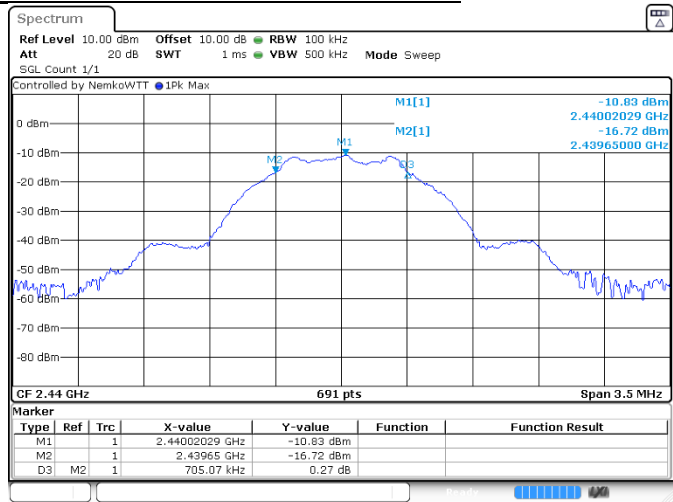
8.4.5 Test data

Table 8.4-1: Minimum 6 dB bandwidth test data

Test Frequency (MHz)	Modulation	DTS Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
2402	GFSK, 1 Mbps	680.89	≥ 500	180.89
2440	GFSK, 1 Mbps	705.07	≥ 500	205.07
2480	GFSK, 1 Mbps	684.36	≥ 500	184.36
2402	GFSK, 2 Mbps	1129.7	≥ 500	629.7
2440	GFSK, 2 Mbps	1135.46	≥ 500	635.46
2480	GFSK, 2 Mbps	1148.03	≥ 500	648.03



DTS bandwidth, TX 2402 MHz, BW: 1MHz, MOD: GFSK



DTS bandwidth, TX 2440 MHz, BW: 1MHz, MOD: GFSK

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

Figure 8.4-2: Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2440 MHz

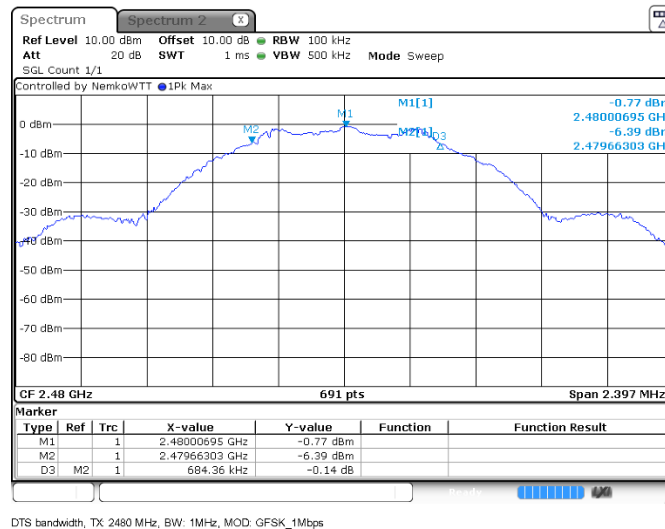
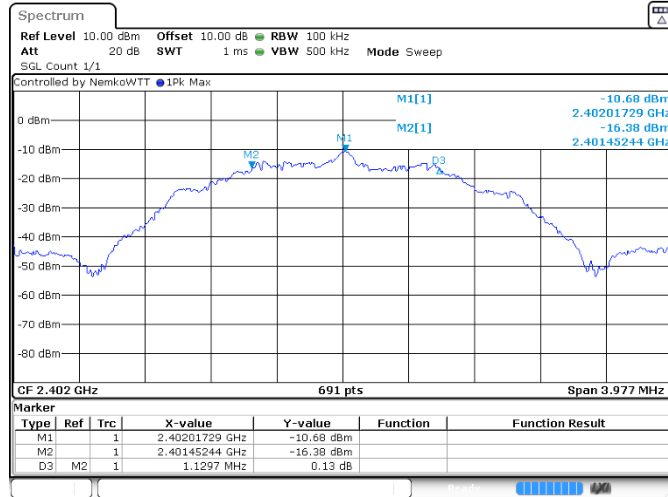


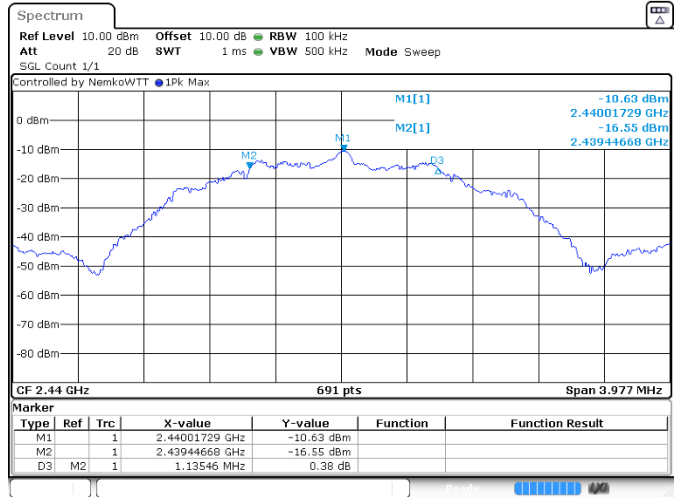
Figure 8.4-3: Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2480 MHz

Section 8
Test name
Specification(s)

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



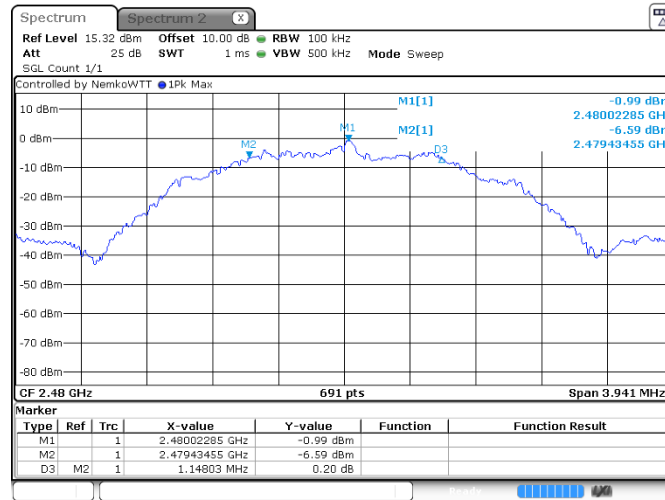
DTS bandwidth, TX 2402 MHz, BW: 2MHz, MOD: GFSK



DTS bandwidth, TX 2440 MHz, BW: 2MHz, MOD: GFSK

Figure 8.4-4: Minimum 6 dB bandwidth, GFSK, 2 Mbps, 2402 MHz

Figure 8.4-5: Minimum 6 dB bandwidth, GFSK, 2 Mbps, 2440 MHz



DTS bandwidth, TX 2480 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.4-6: 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)
- ISSED: RSS-247 5.4(d)
- Test method: ANSI C63.10-2020 §11.9.1.1 (RBW ≥ 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	June 26, 2024	Temperature	23 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	55.3 %

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	Battery
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Receiver/spectrum analyzer settings:

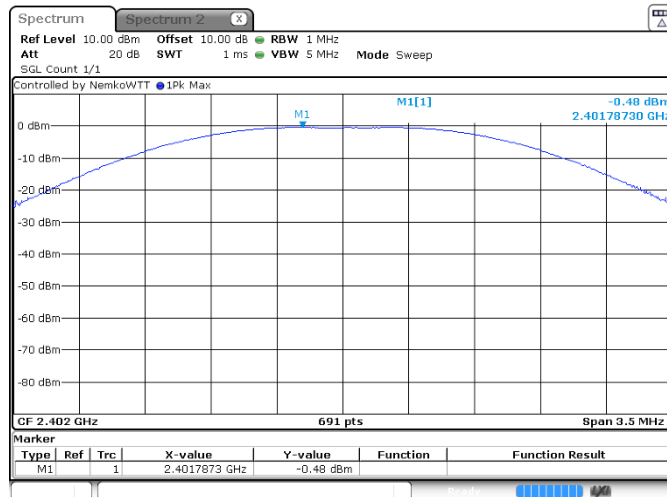
Resolution bandwidth	1 and 2 MHz
Video bandwidth	5 and 10 MHz
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.5.5 Test data

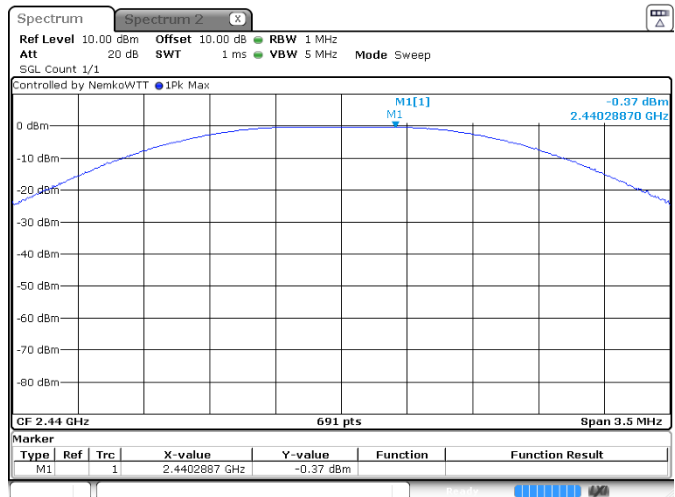
Table 8.5-1: Maximum peak output power test data

Test Frequency (MHz)	Modulation	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	EIRP (dBm) (ISED)
2402	GFSK, 1 Mbps	-0.48	≤ 30	30.48	5.88
2440	GFSK, 1 Mbps	-0.37	≤ 30	30.37	5.99
2480	GFSK, 1 Mbps	-0.64	≤ 30	30.64	5.72
2402	GFSK, 2 Mbps	-0.56	≤ 30	30.56	5.80
2440	GFSK, 2 Mbps	-0.37	≤ 30	30.37	5.99
2480	GFSK, 2 Mbps	-0.65	≤ 30	30.65	5.71

Note: EIRP = conducted power + antenna gain.



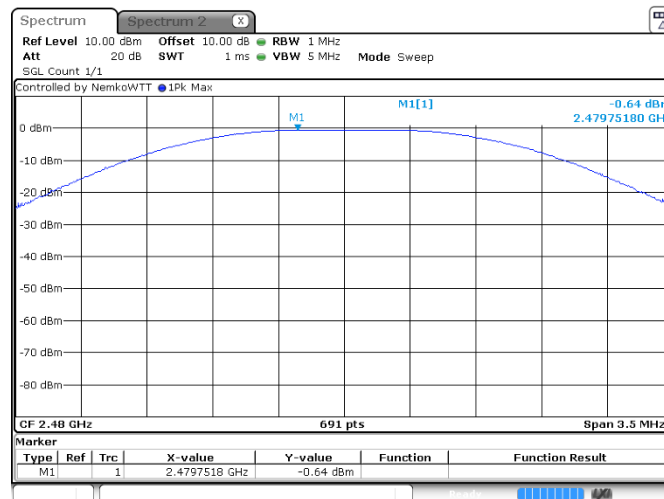
Peak output power, TX 2402 MHz, BW: 1MHz, MOD: GFSK_1Mbps



Peak output power, TX 2440 MHz, BW: 1MHz, MOD: GFSK_1Mbps

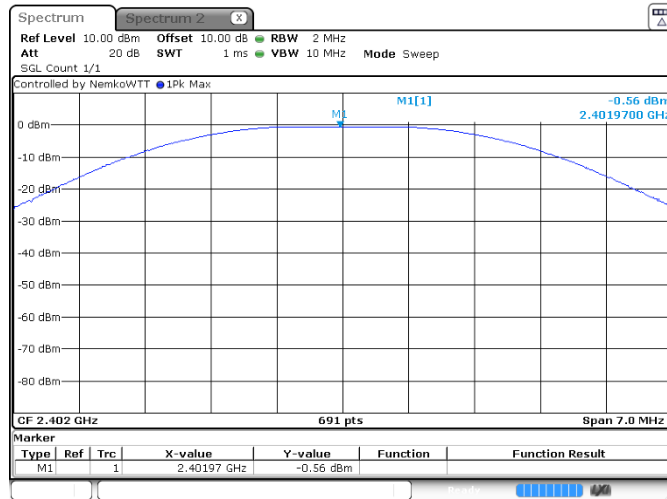
Figure 8.5-1: Maximum peak output power, GFSK, 1 Mbps, 2402 MHz

Figure 8.5-2: Maximum peak output power, GFSK, 1 Mbps, 2440 MHz



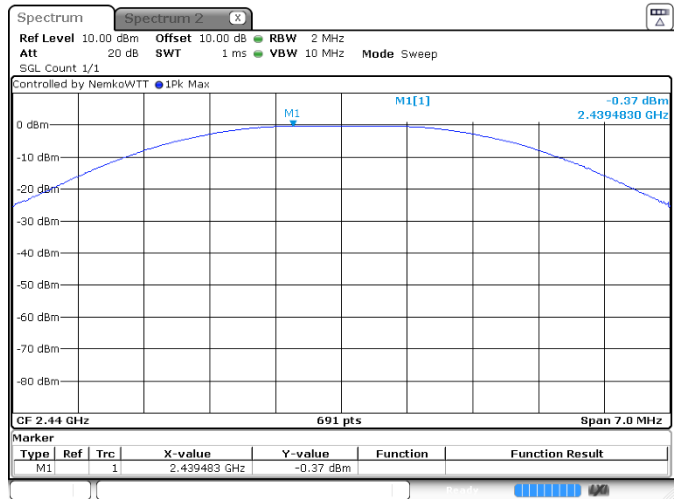
Peak output power, TX 2480 MHz, BW: 1MHz, MOD: GFSK_1Mbps

Figure 8.5-3: Maximum peak output power, GFSK, 1x Mbps, 2480 MHz



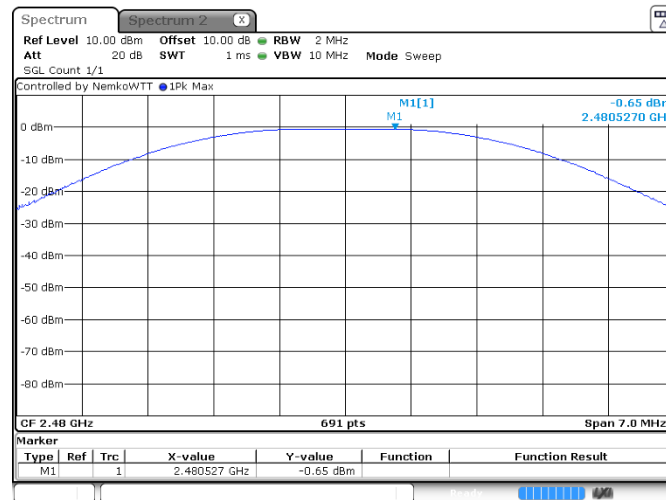
Peak output power, TX 2402 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.5-4: Maximum peak output power, GFSK, 2 Mbps, 2402 MHz



Peak output power, TX 2440 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.5-5: Maximum peak output power, GFSK, 2 Mbps, 2440 MHz



Peak output power, TX 2480 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.5-6: 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	$67.6 - 20 \times \log_{10}(F)$	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 8.6-2: 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: ISSED 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	June 27, 2024	Temperature	22 °C
	June 28, 2024		21 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
			1002.1 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	51.9 %
			53.1 %

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: 2 Mbps.

Note: To enable the EUT to transmit on a fixed channel with highest supported duty cycle, an auxiliary board must be connected to the PCB of the EUT. This auxiliary board interfaces with a laptop PC with software that commands the EUT to operate in the appropriate mode. As such, it was not possible to perform radiated spurious emissions with the final form-factor EUT (including plastic enclosure). Radiated spurious emissions was performed on the EUT PCB without plastic enclosure. Since the enclosure is entirely plastic, it is reasonable that testing the PCB is a worst-case configuration. Note unintentional emissions per Part 15B were performed and passed with the final form factor EUT including plastic enclosure (documented in report REP047893-2TRFEMC).

8.6.4 Setup details

EUT power input during test	Battery power
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)

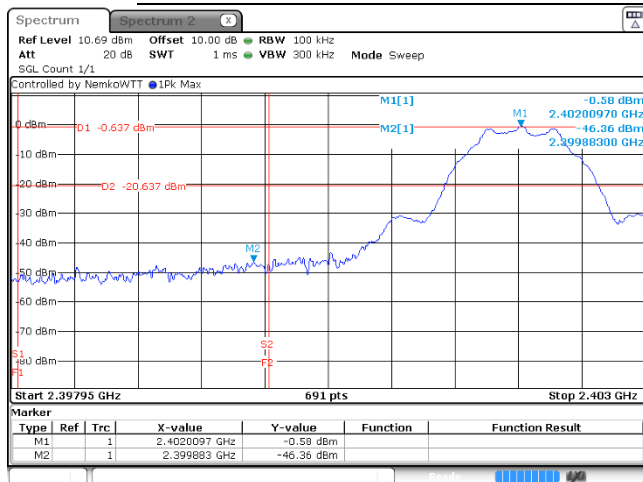
8.6.5 Test data

Antenna port conducted spurious emissions:

- Authorized band edge:

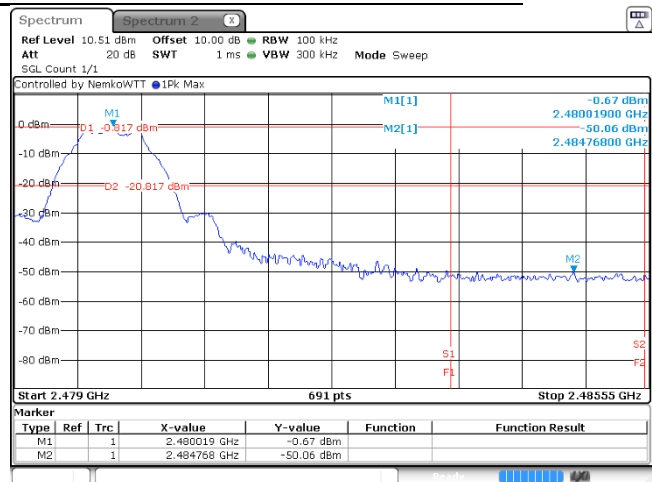
Table 8.6-4: Authorized band edge conducted emissions (antenna port)

Test Frequency (MHz)	Modulation	Frequency of highest emission (MHz)	Amplitude (dBm)	Limit (dBm)	Margin (dB)
2402	GFSK, 1 Mbps	2399.883	-46.36	-20.64	25.72
2480	GFSK, 1 Mbps	2484.768	-50.06	-20.82	29.25
2402	GFSK, 2 Mbps	2399.985	-32.97	-20.67	12.30
2480	GFSK, 2 Mbps	2483.507	-48.66	-20.79	27.87



Authorized band edge, TX: 2402 MHz, BW: 1MHz, MOD: GFSK_1Mbps

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



Authorized band edge, TX: 2480 MHz, BW: 1MHz, MOD: GFSK_1Mbps

Figure 8.6-2: Authorized band-edge emissions, GFSK, 1 Mbps, 2480 MHz

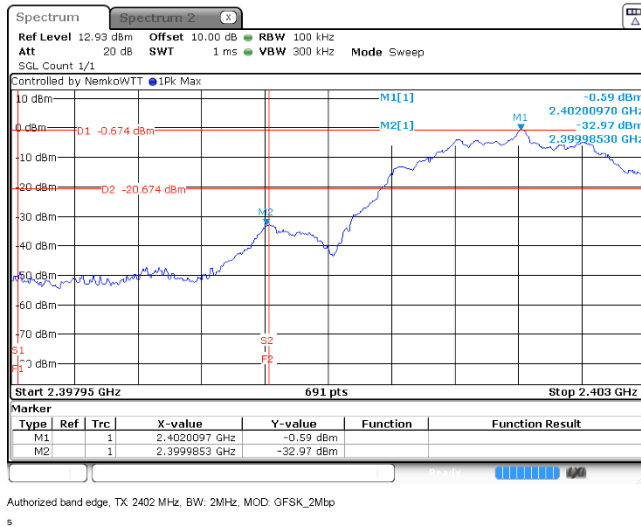


Figure 8.6-3: Authorized band-edge emissions, GFSK, 2 Mbps, 2402 MHz

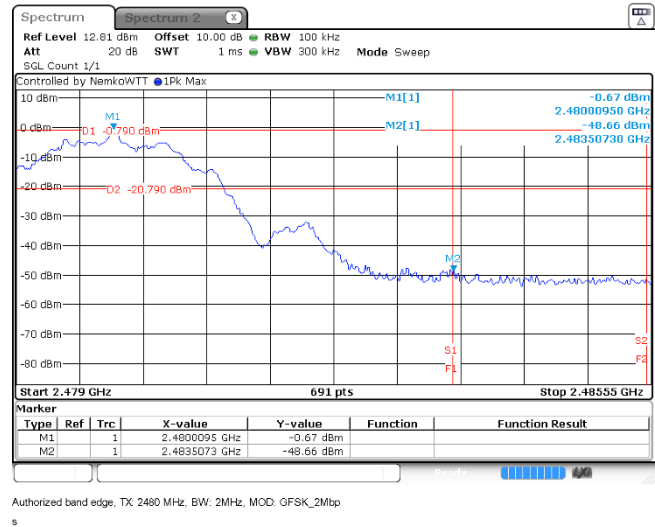
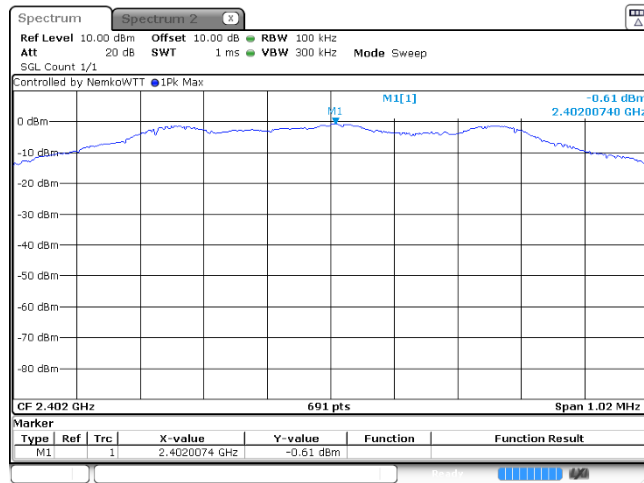


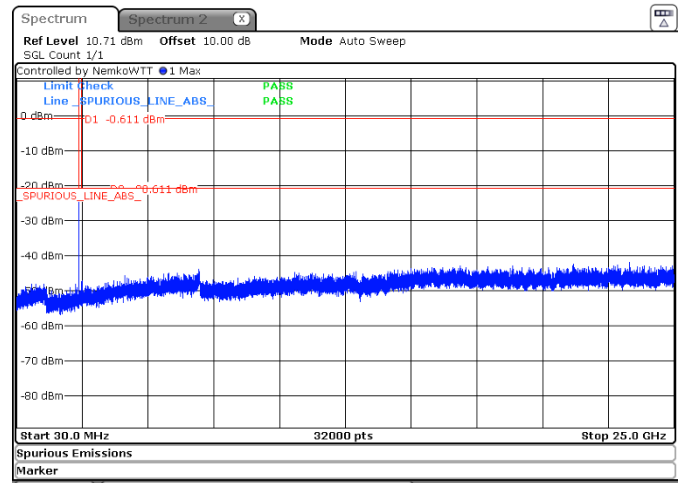
Figure 8.6-4: Authorized band-edge emissions, GFSK, 2 Mbps, 2480 MHz

Antenna port conducted spurious emissions:



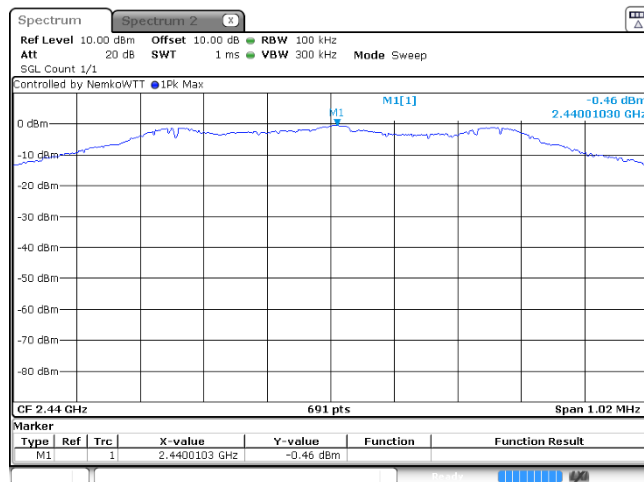
Spurious emission reference level, TX: 2402 MHz, BW: 1 MHz, M
OD: GFSK_1Mbps

Figure 8.6-5: Antenna port conducted spurious emissions, reference level, GFSK, 1 Mbps, 2402 MHz



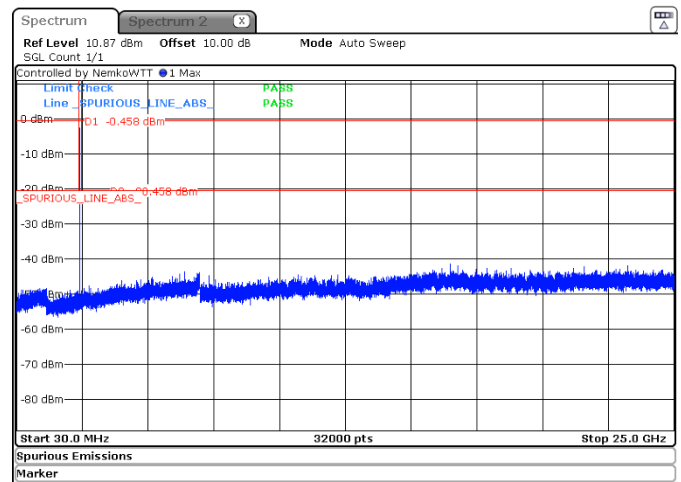
Spurious emissions, TX: 2402 MHz, BW: 1 MHz, MOD: GFSK_1Mbps

Figure 8.6-6: Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2402 MHz



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

Figure 8.6-7: Antenna port conducted spurious emissions, reference level, GFSK, 1 Mbps, 2440 MHz



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

Figure 8.6-8: Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2440 MHz

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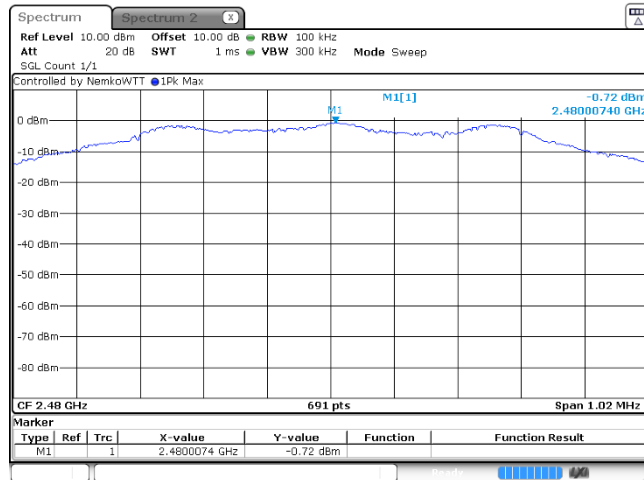
Test name

Specification(s)

Testing data

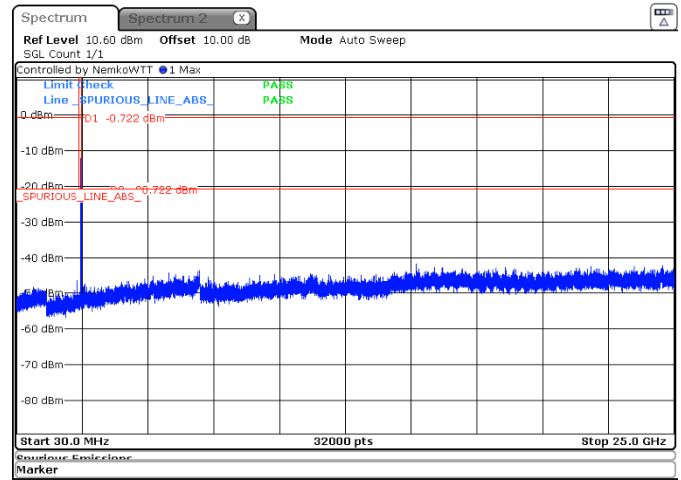
Spurious emissions

FCC 15.247 & RSS-247



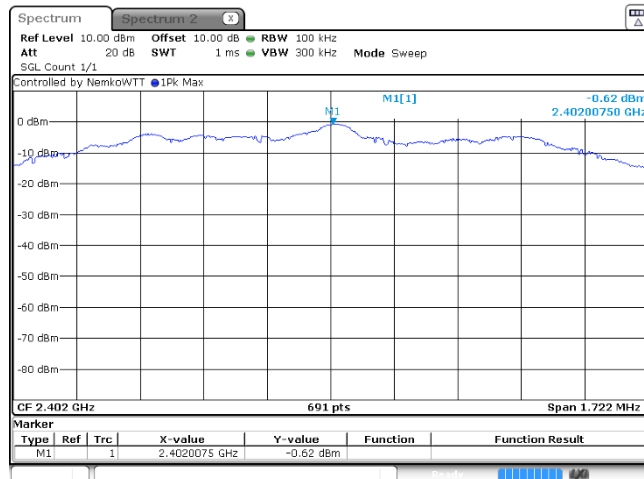
Spurious emission reference level, TX: 2480 MHz, BW: 1MHz, M
OD: GFSK_1Mbps

Figure 8.6-9: Antenna port conducted spurious emissions, reference level, GFSK, 1 Mbps, 2480 MHz



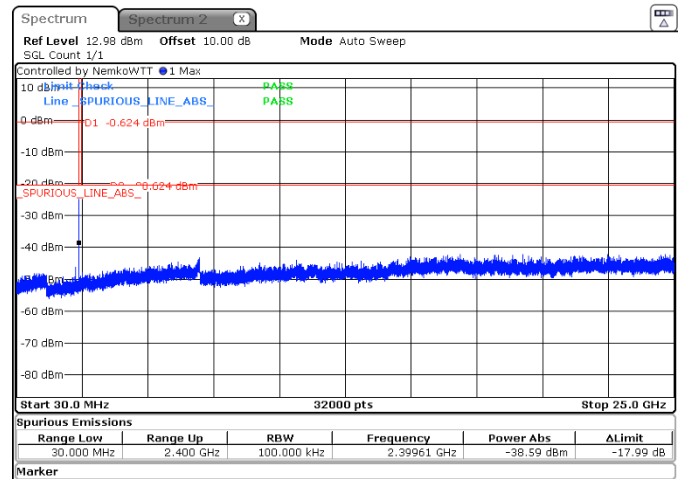
Spurious emissions, TX: 2480 MHz, BW: 1MHz, MOD: GFSK_1Mbps

Figure 8.6-10: Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2480 MHz



Spurious emission reference level, TX: 2402 MHz, BW: 2MHz, M
OD: GFSK_2Mbps

Figure 8.6-11: Antenna port conducted spurious emissions, reference level, GFSK, 2 Mbps, 2402 MHz



Spurious emissions, TX: 2402 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.6-12: Antenna port conducted spurious emissions, GFSK, 2 Mbps, 2402 MHz

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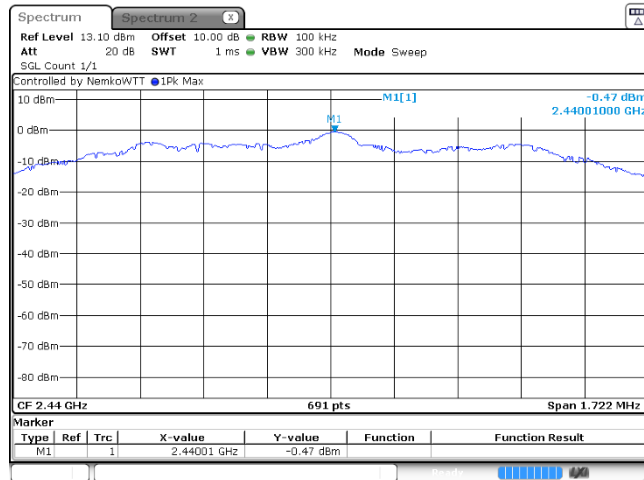
Test name

Specification(s)

Testing data

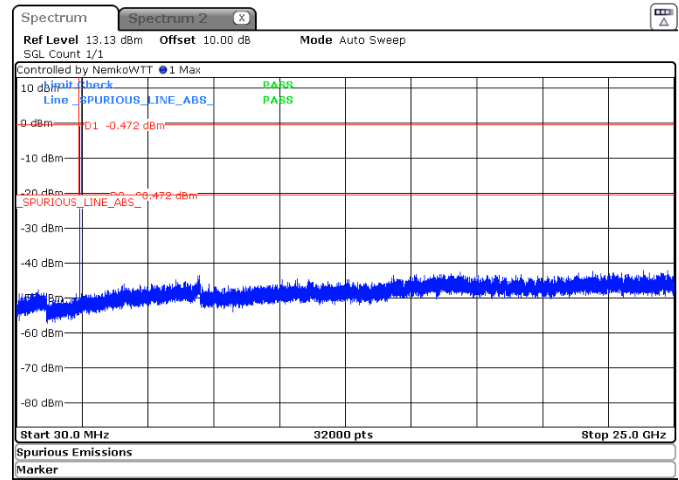
Spurious emissions

FCC 15.247 & RSS-247



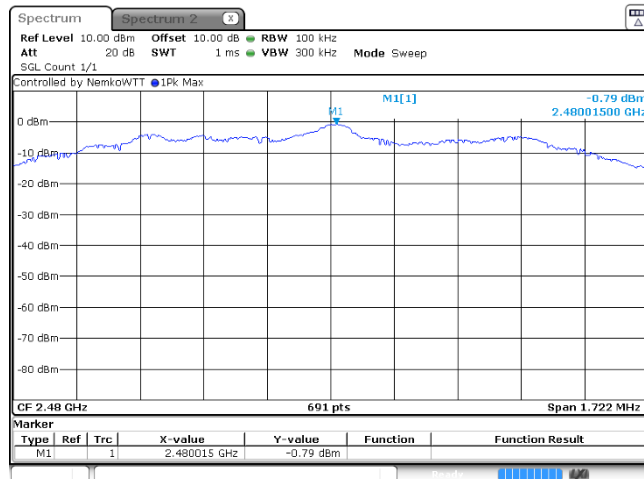
Spurious emission reference level, TX 2440 MHz, BW: 2MHz, M
OD: GFSK_2Mbps

Figure 8.6-13: Antenna port conducted spurious emissions, reference level, GFSK, 2 Mbps, 2440 MHz



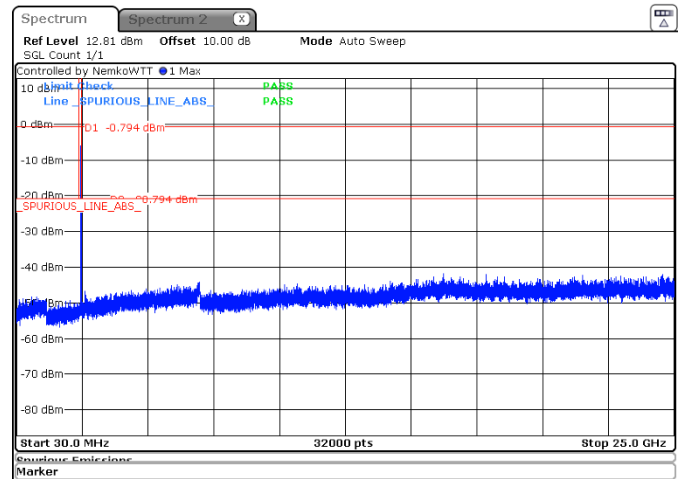
Spurious emissions, TX 2440 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.6-14: Antenna port conducted spurious emissions, GFSK, 2 Mbps, 2440 MHz



Spurious emission reference level, TX 2480 MHz, BW: 2MHz, M
OD: GFSK_2Mbps

Figure 8.6-15: Antenna port conducted spurious emissions, reference level, GFSK, 2 Mbps, 2480 MHz



Spurious emissions, TX 2480 MHz, BW: 2MHz, MOD: GFSK_2Mbps

Figure 8.6-16: Antenna port conducted spurious emissions, GFSK, 2 Mbps, 2480 MHz

Radiated spurious emissions:

- Restricted band edge:

Full Spectrum

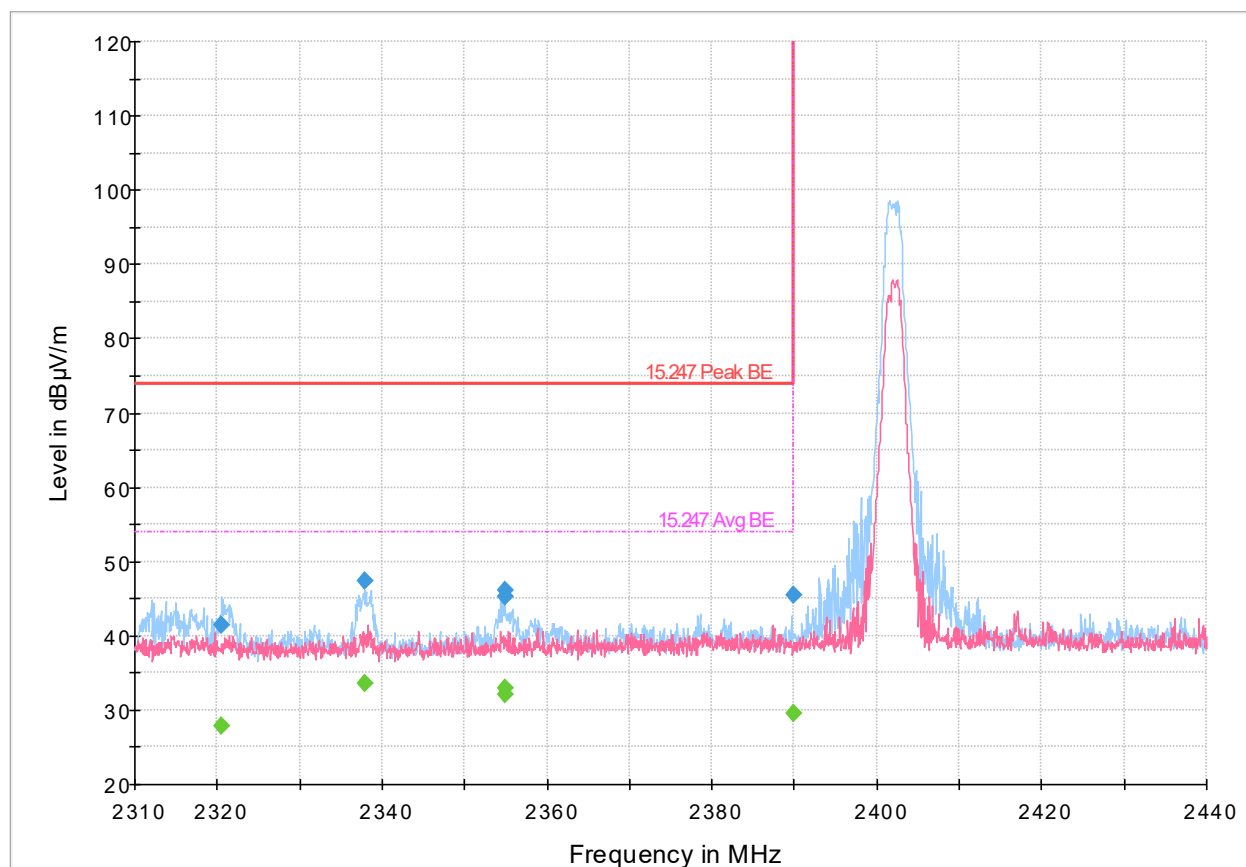


Figure 8.6-17: Radiated emissions spectral plot (2.31 GHz - 2.44 GHz)

Table 8.6-5: 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)
2320.595000	41.35	---	73.90	32.55	5000.0	1000.000	219.0	V	252.0	-5.1
2320.595000	---	27.77	53.90	26.13	5000.0	1000.000	219.0	V	252.0	-5.1
2337.885000	47.47	---	73.90	26.43	5000.0	1000.000	128.0	H	122.0	-4.9
2337.885000	---	33.52	53.90	20.38	5000.0	1000.000	128.0	H	122.0	-4.9
2354.850000	---	32.12	53.90	21.78	5000.0	1000.000	125.0	H	74.0	-4.8
2354.850000	45.27	---	73.90	28.63	5000.0	1000.000	125.0	H	74.0	-4.8
2354.850000	46.17	---	73.90	27.73	5000.0	1000.000	136.0	H	130.0	-4.8
2354.850000	---	32.87	53.90	21.03	5000.0	1000.000	136.0	H	130.0	-4.8
2390.000000	45.41	---	73.90	28.49	5000.0	1000.000	136.0	H	82.0	-4.4
2390.000000	---	29.46	53.90	24.44	5000.0	1000.000	136.0	H	82.0	-4.4

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.

Full Spectrum

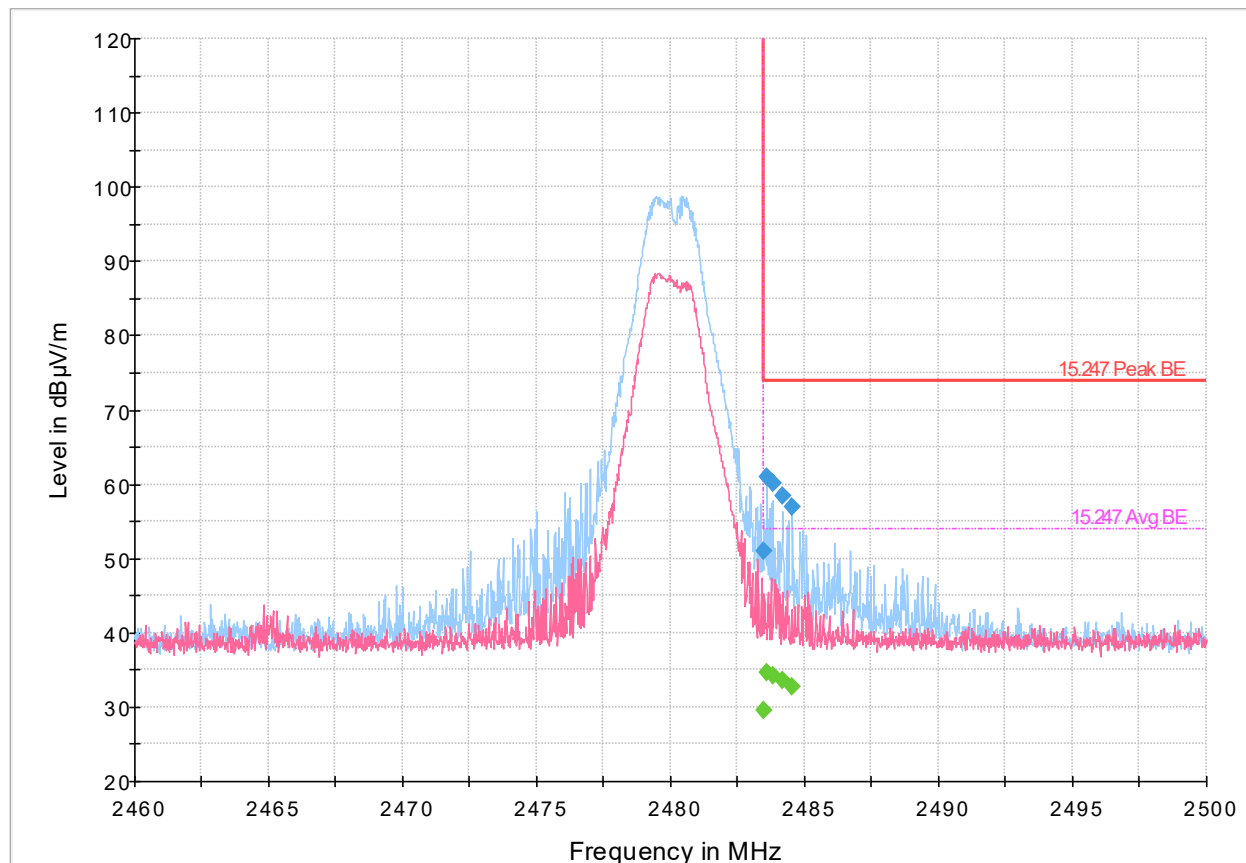


Figure 8.6-18: Radiated emissions spectral plot (2.46 GHz - 2.5 GHz)

Table 8.6-6: 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)
2483.500000	50.91	---	73.90	22.99	5000.0	1000.000	133.0	V	118.0	-4.0
2483.500000	---	29.54	53.90	24.36	5000.0	1000.000	133.0	V	118.0	-4.0
2483.600000	61.04	---	73.90	12.86	5000.0	1000.000	105.0	H	220.0	-4.0
2483.600000	---	34.70	53.90	19.20	5000.0	1000.000	105.0	H	220.0	-4.0
2483.800000	60.09	---	73.90	13.81	5000.0	1000.000	104.0	H	217.0	-4.0
2483.800000	---	34.20	53.90	19.70	5000.0	1000.000	104.0	H	217.0	-4.0
2484.180000	---	33.53	53.90	20.37	5000.0	1000.000	104.0	H	214.0	-4.0
2484.180000	58.40	---	73.90	15.50	5000.0	1000.000	104.0	H	214.0	-4.0
2484.540000	56.95	---	73.90	16.95	5000.0	1000.000	104.0	H	210.0	-4.0
2484.540000	---	32.78	53.90	21.12	5000.0	1000.000	104.0	H	210.0	-4.0

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:

Full Spectrum

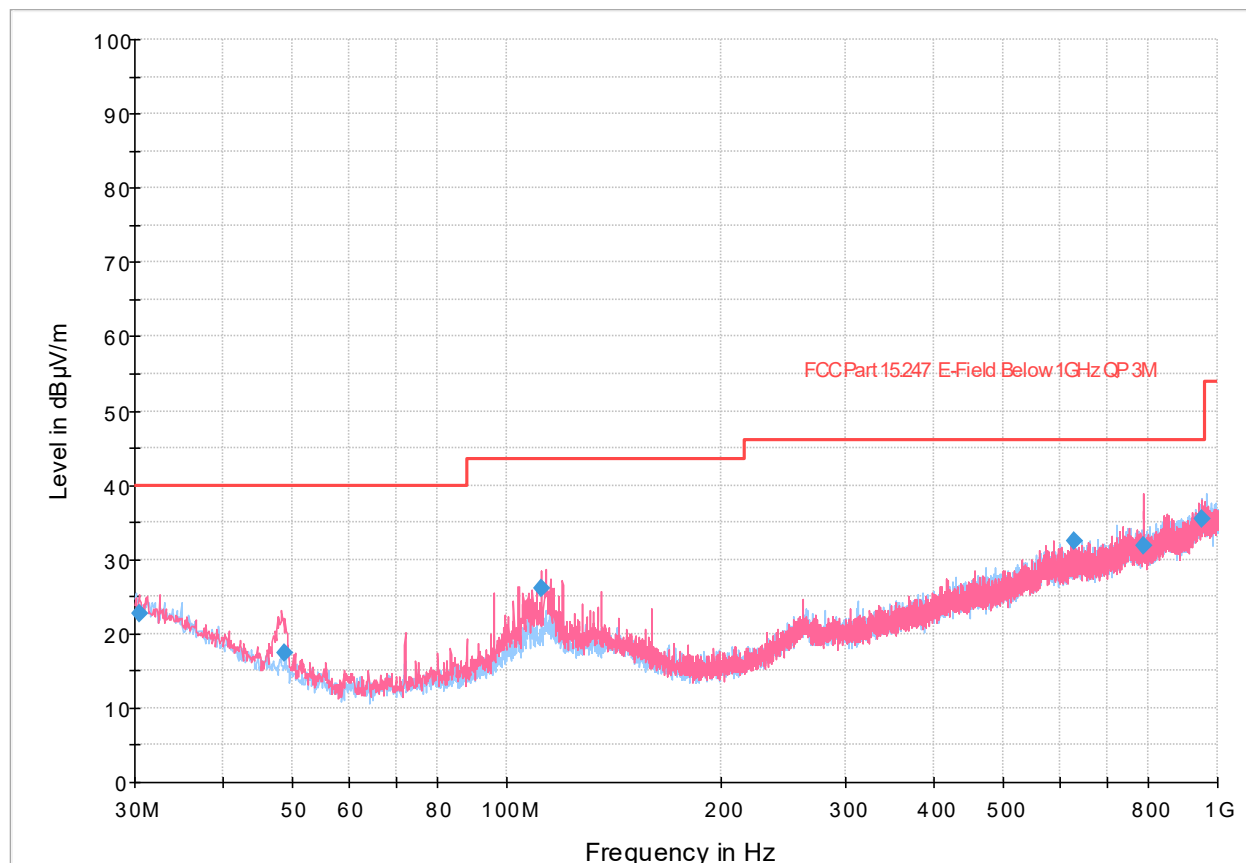


Figure 8.6-19: Radiated emissions spectral plot (30 MHz - 1 GHz) low channel

Table 8.6-7: 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)
30.520000	22.67	40.00	17.33	5000.0	120.000	229.0	H	196.0	25.0
48.716000	17.47	40.00	22.53	5000.0	120.000	144.0	V	65.0	15.0
112.045000	26.18	43.50	17.32	5000.0	120.000	369.0	V	0.0	18.2
630.002000	32.59	46.00	13.41	5000.0	120.000	371.0	V	292.0	30.1
786.173000	31.89	46.00	14.11	5000.0	120.000	107.0	V	32.0	32.0
951.654000	35.55	46.00	10.45	5000.0	120.000	159.0	H	32.0	35.7

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

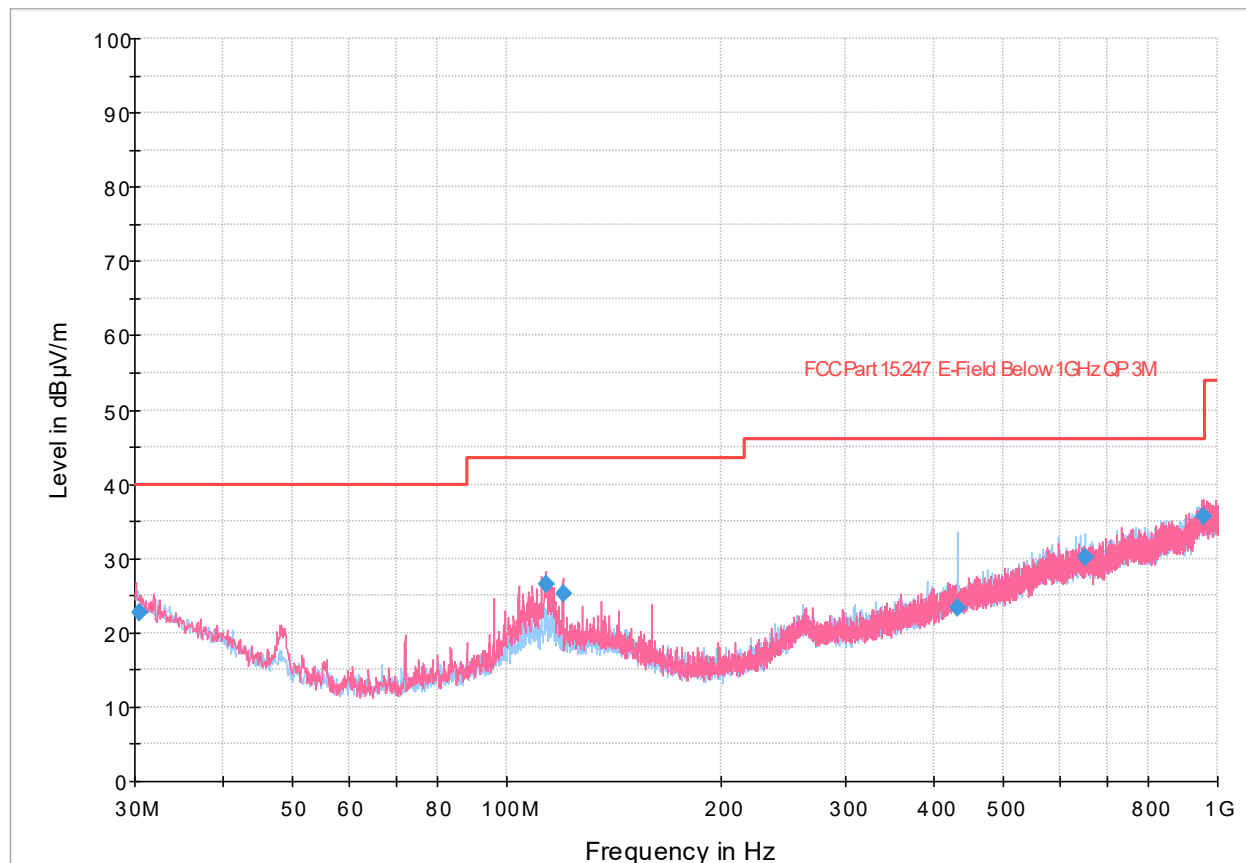


Figure 8.6-20: Radiated emissions spectral plot (30 MHz - 1 GHz) mid channel

Table 8.6-8: 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)
30.400000	22.73	40.00	17.27	5000.0	120.000	244.0	V	144.0	25.1
113.654000	26.62	43.50	16.88	5000.0	120.000	371.0	V	100.0	18.4
120.016000	25.27	43.50	18.23	5000.0	120.000	363.0	V	145.0	18.4
429.833000	23.41	46.00	22.59	5000.0	120.000	154.0	H	273.0	25.4
649.812000	30.05	46.00	15.95	5000.0	120.000	214.0	H	120.0	30.3
957.514000	35.60	46.00	10.40	5000.0	120.000	213.0	V	282.0	35.8

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

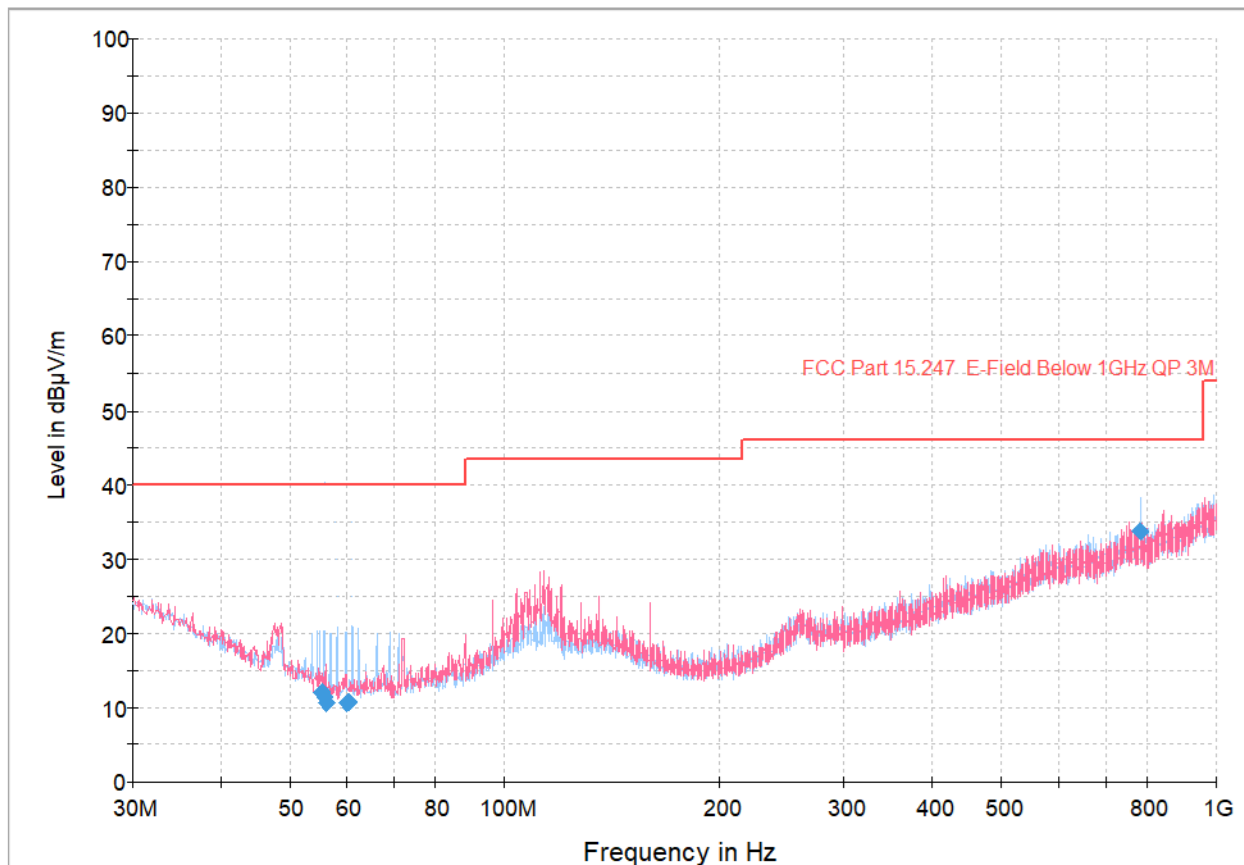


Figure 8.6-21: Radiated emissions spectral plot (30 MHz - 1 GHz) high channel

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)
55.455000	12.09	40.00	27.91	5000.0	120.000	100.0	H	284.0	12.9
56.042000	11.47	40.00	28.53	5000.0	120.000	329.0	H	104.0	12.8
56.326000	10.55	40.00	29.45	5000.0	120.000	246.0	H	153.0	12.7
59.960000	10.63	40.00	29.37	5000.0	120.000	296.0	H	266.0	12.2
60.476000	10.78	40.00	29.22	5000.0	120.000	285.0	H	0.0	12.2
784.375000	33.78	46.00	12.22	5000.0	120.000	316.0	H	244.0	32.0

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

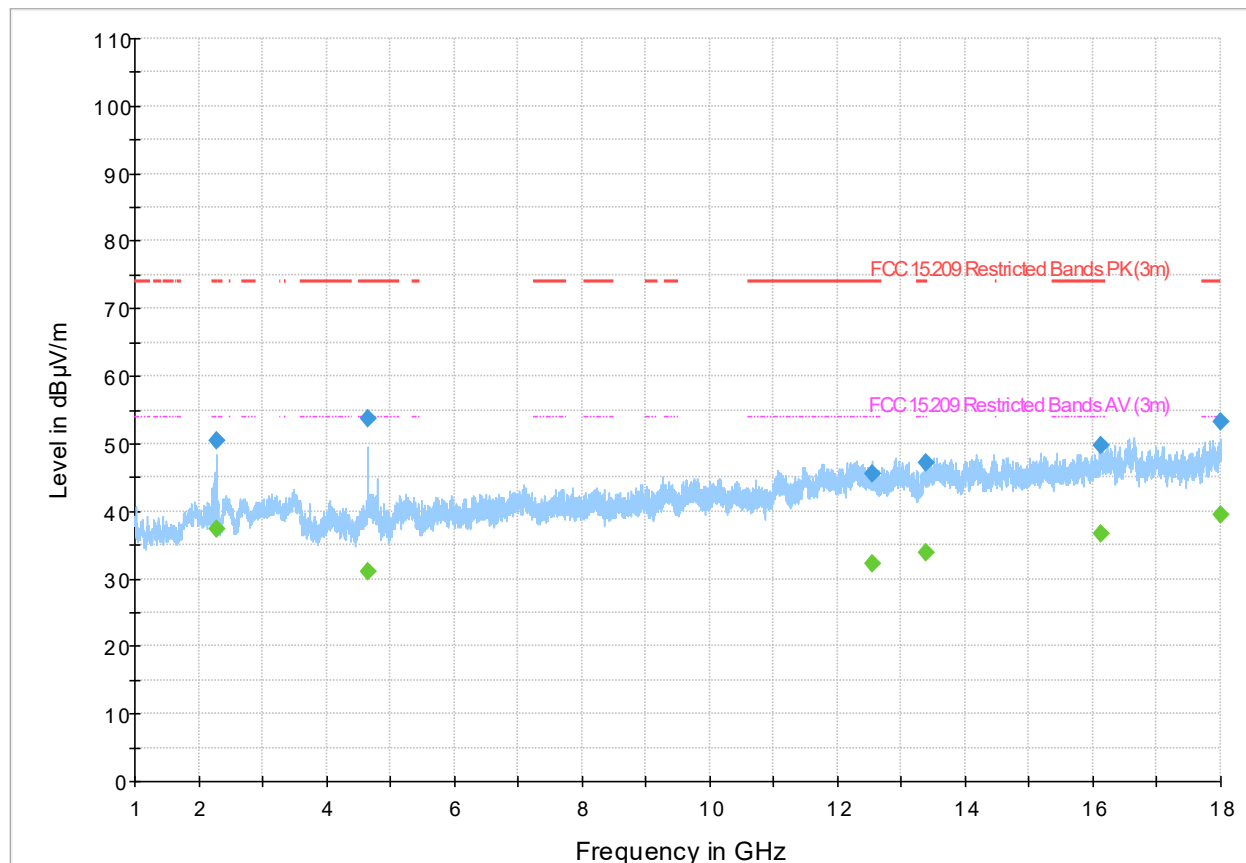


Figure 8.6-22: Radiated emissions spectral plot (1 GHz - 18 GHz) low channel

Table 8.6-10: 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)
2273.950000	50.48	---	73.98	23.50	5000.0	1000.000	123.0	H	210.0	-5.1
2273.950000	---	37.36	53.98	16.62	5000.0	1000.000	123.0	H	210.0	-5.1
4659.050000	53.67	---	73.98	20.31	5000.0	1000.000	138.0	H	0.0	1.9
4659.050000	---	30.96	53.98	23.02	5000.0	1000.000	138.0	H	0.0	1.9
12536.950000	---	32.31	53.98	21.67	5000.0	1000.000	122.0	V	255.0	14.8
12536.950000	45.43	---	73.98	28.55	5000.0	1000.000	122.0	V	255.0	14.8
13383.650000	47.10	---	73.98	26.88	5000.0	1000.000	174.0	H	309.0	16.5
13383.650000	---	33.93	53.98	20.05	5000.0	1000.000	174.0	H	309.0	16.5
16118.600000	49.81	---	73.98	24.17	5000.0	1000.000	283.0	V	315.0	21.6
16118.600000	---	36.65	53.98	17.33	5000.0	1000.000	283.0	V	315.0	21.6
17999.600000	---	39.50	53.98	14.48	5000.0	1000.000	172.0	H	288.0	25.3
17999.600000	53.29	---	73.98	20.69	5000.0	1000.000	172.0	H	288.0	25.3

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.

Full Spectrum

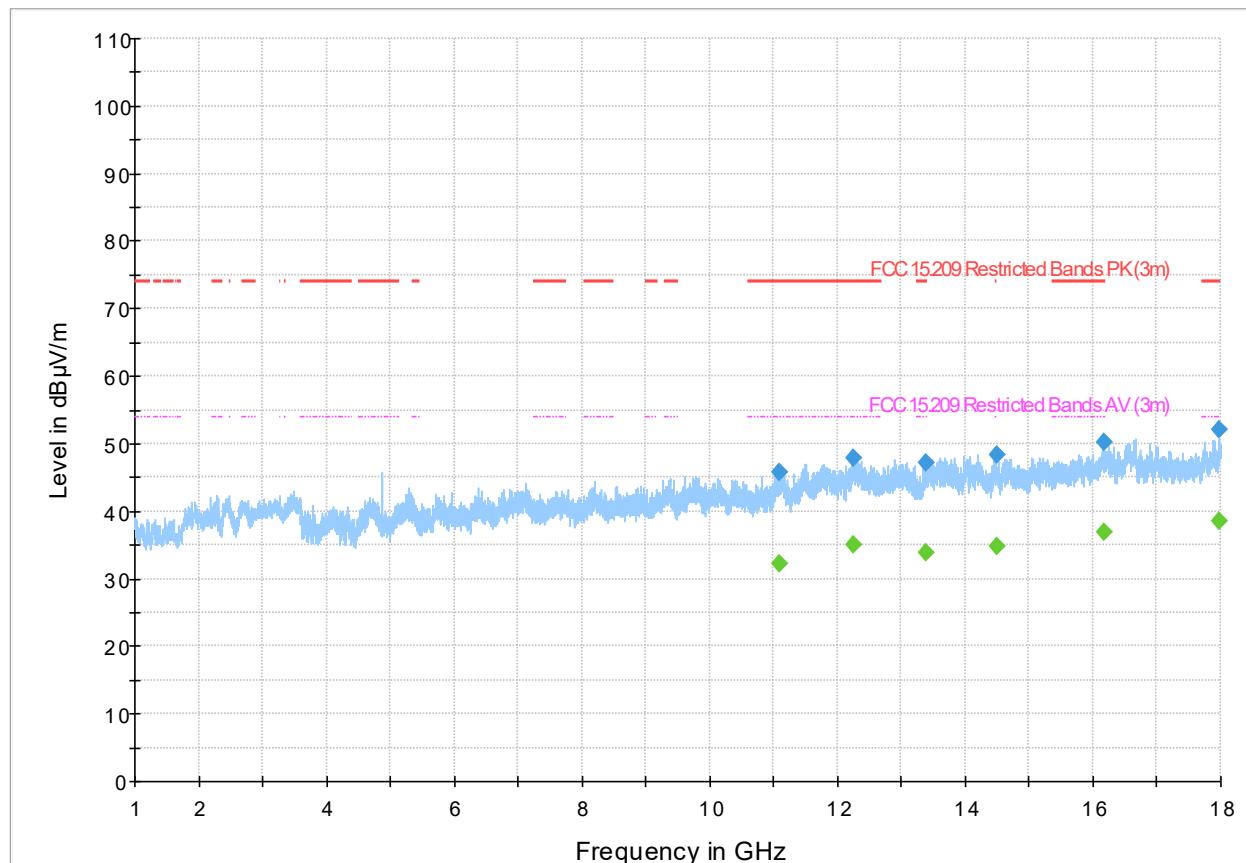


Figure 8.6-23: Radiated emissions spectral plot (1 GHz - 18 GHz) mid channel

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)
11081.200000	45.84	---	73.98	28.14	5000.0	1000.000	312.0	H	148.0	10.8
11081.200000	---	32.25	53.98	21.73	5000.0	1000.000	312.0	H	148.0	10.8
12247.950000	---	35.09	53.98	18.89	5000.0	1000.000	100.0	V	198.0	15.6
12247.950000	47.88	---	73.98	26.10	5000.0	1000.000	100.0	V	198.0	15.6
13383.400000	---	33.88	53.98	20.10	5000.0	1000.000	275.0	H	257.0	16.5
13383.400000	47.11	---	73.98	26.87	5000.0	1000.000	275.0	H	257.0	16.5
14502.150000	---	34.68	---	---	5000.0	1000.000	376.0	V	0.0	16.4
14502.150000	48.25	---	---	---	5000.0	1000.000	376.0	V	0.0	16.4
16173.800000	---	36.86	53.98	17.12	5000.0	1000.000	333.0	V	145.0	22.3
16173.800000	50.30	---	73.98	23.68	5000.0	1000.000	333.0	V	145.0	22.3
17973.150000	52.07	---	73.98	21.91	5000.0	1000.000	172.0	V	62.0	23.6
17973.150000	---	38.53	53.98	15.45	5000.0	1000.000	172.0	V	62.0	23.6

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

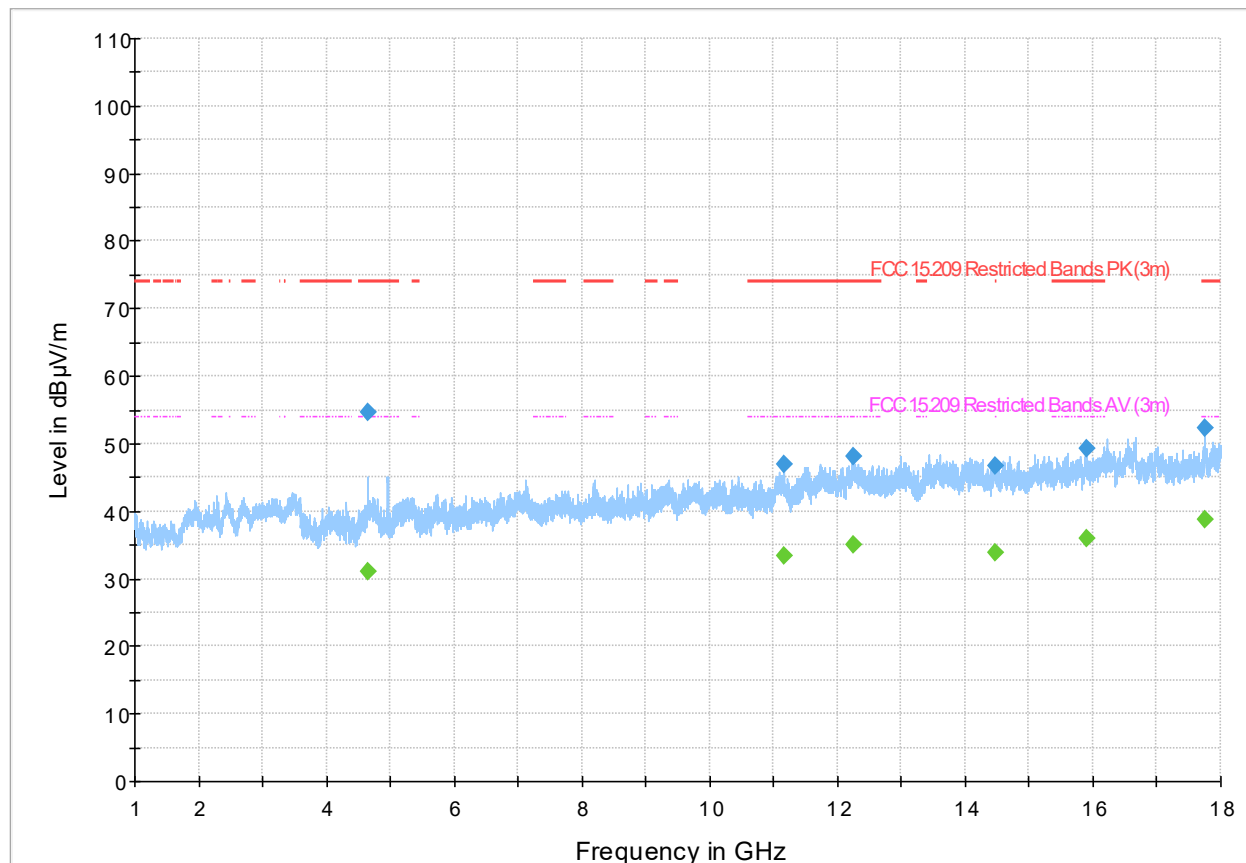


Figure 8.6-24: Radiated emissions spectral plot (1 GHz - 18 GHz) high channel

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)
4659.050000	54.58	---	73.98	19.41	5000.0	1000.000	136.0	H	0.0	1.9
4659.050000	---	30.98	53.98	23.00	5000.0	1000.000	136.0	H	0.0	1.9
11168.050000	46.99	---	73.98	26.99	5000.0	1000.000	156.0	V	20.0	10.9
11168.050000	---	33.33	53.98	20.65	5000.0	1000.000	156.0	V	20.0	10.9
12249.200000	48.05	---	73.98	25.93	5000.0	1000.000	287.0	H	330.0	15.7
12249.200000	---	35.04	53.98	18.94	5000.0	1000.000	287.0	H	330.0	15.7
14481.050000	---	33.80	53.98	20.18	5000.0	1000.000	116.0	H	294.0	16.7
14481.050000	46.81	---	73.98	27.17	5000.0	1000.000	116.0	H	294.0	16.7
15893.450000	49.28	---	73.98	24.70	5000.0	1000.000	362.0	V	330.0	21.7
15893.450000	---	35.92	53.98	18.06	5000.0	1000.000	362.0	V	330.0	21.7
17758.200000	---	38.85	53.98	15.13	5000.0	1000.000	130.0	V	350.0	21.5
17758.200000	52.34	---	73.98	21.64	5000.0	1000.000	130.0	V	350.0	21.5

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

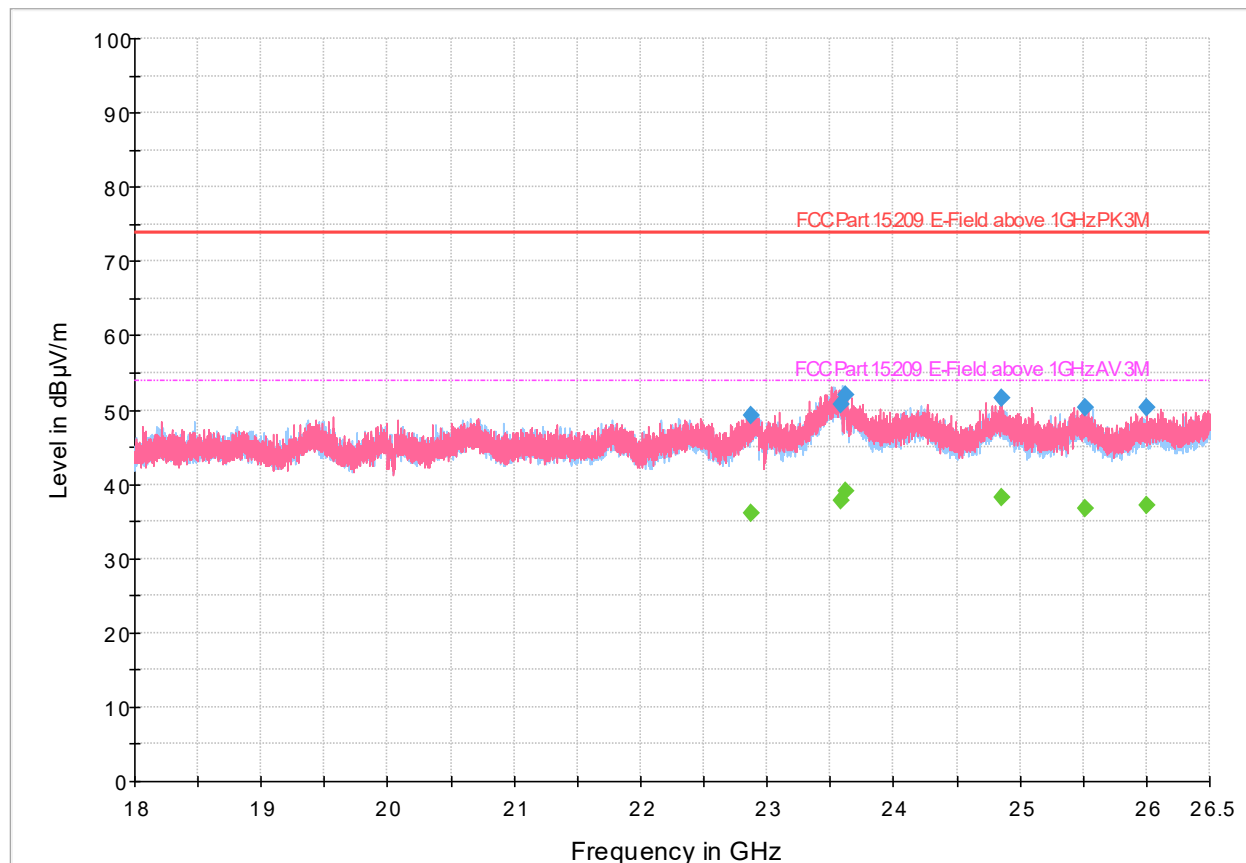


Figure 8.6-25: Radiated emissions spectral plot (18 GHz - 26.5 GHz) low channel

Table 8.6-13: 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)
22879.031250	---	36.13	53.90	17.77	5000.0	1000.000	341.0	V	234.0	29.6
22879.031250	49.36	---	73.90	24.54	5000.0	1000.000	341.0	V	234.0	29.6
23579.937500	50.78	---	73.90	23.12	5000.0	1000.000	222.0	H	201.0	33.1
23579.937500	---	37.72	53.90	16.18	5000.0	1000.000	222.0	H	201.0	33.1
23621.743750	---	39.04	53.90	14.86	5000.0	1000.000	146.0	V	105.0	32.8
23621.743750	52.09	---	73.90	21.81	5000.0	1000.000	146.0	V	105.0	32.8
24848.718750	---	38.15	53.90	15.75	5000.0	1000.000	342.0	V	114.0	30.3
24848.718750	51.69	---	73.90	22.21	5000.0	1000.000	342.0	V	114.0	30.3
25516.731250	50.36	---	73.90	23.54	5000.0	1000.000	220.0	H	86.0	30.5
25516.731250	---	36.63	53.90	17.27	5000.0	1000.000	220.0	H	86.0	30.5
26004.618750	---	37.10	53.90	16.80	5000.0	1000.000	263.0	V	326.0	30.0
26004.618750	50.28	---	73.90	23.62	5000.0	1000.000	263.0	V	326.0	30.0

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

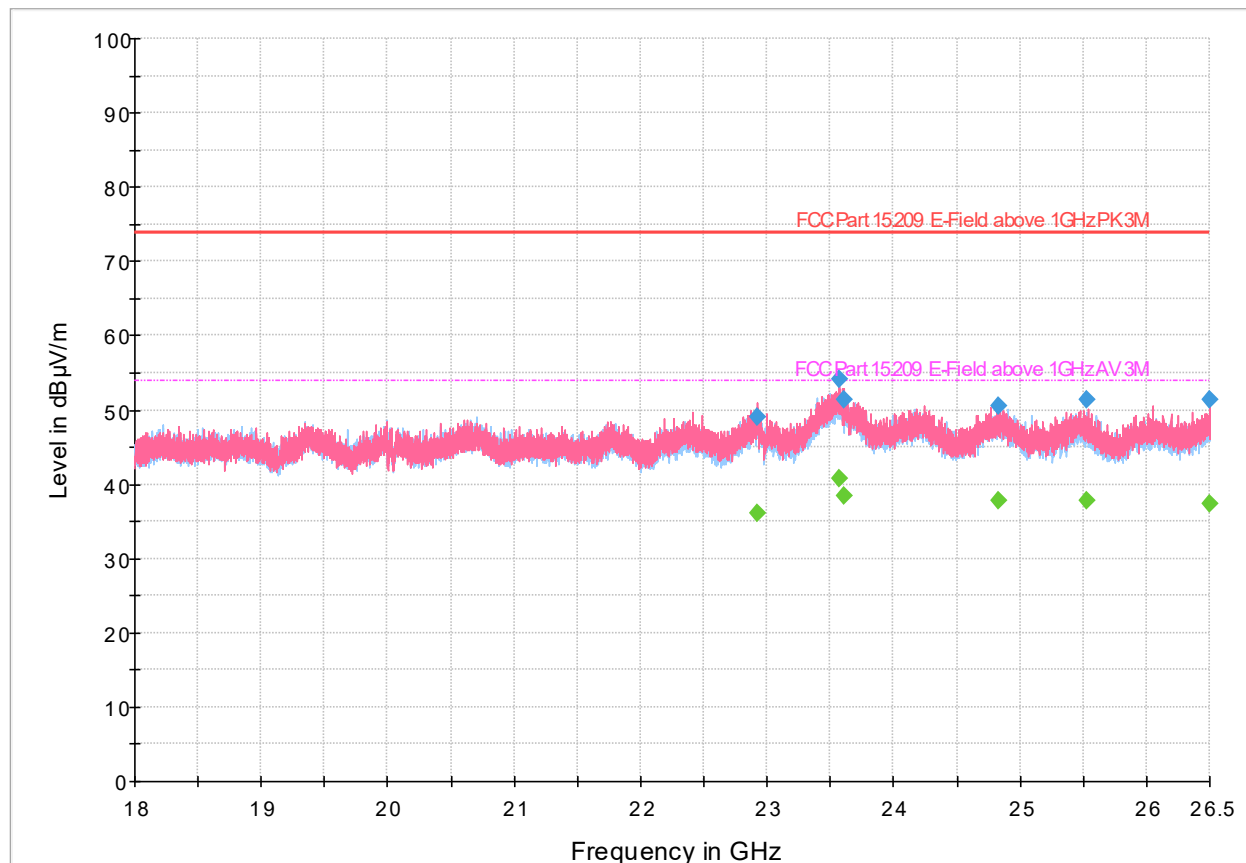


Figure 8.6-26: Radiated emissions spectral plot (18 GHz - 26.5 GHz) mid channel

Table 8.6-14: 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)
22925.175000	---	36.11	53.90	17.79	5000.0	1000.000	400.0	V	162.0	29.5
22925.175000	49.14	---	73.90	24.76	5000.0	1000.000	400.0	V	162.0	29.5
23569.737500	54.13	---	73.90	19.77	5000.0	1000.000	342.0	V	23.0	33.1
23569.737500	---	40.74	53.90	13.16	5000.0	1000.000	342.0	V	23.0	33.1
23606.768750	51.45	---	73.90	22.45	5000.0	1000.000	181.0	V	252.0	32.9
23606.768750	---	38.36	53.90	15.54	5000.0	1000.000	181.0	V	252.0	32.9
24836.012500	---	37.74	53.90	16.16	5000.0	1000.000	376.0	V	281.0	30.3
24836.012500	50.56	---	73.90	23.34	5000.0	1000.000	376.0	V	281.0	30.3
25529.462500	51.31	---	73.90	22.59	5000.0	1000.000	127.0	V	128.0	30.5
25529.462500	---	37.87	53.90	16.03	5000.0	1000.000	127.0	V	128.0	30.5
26494.806250	51.41	---	73.90	22.49	5000.0	1000.000	104.0	V	251.0	31.1
26494.806250	---	37.41	53.90	16.49	5000.0	1000.000	104.0	V	251.0	31.1

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.

Full Spectrum

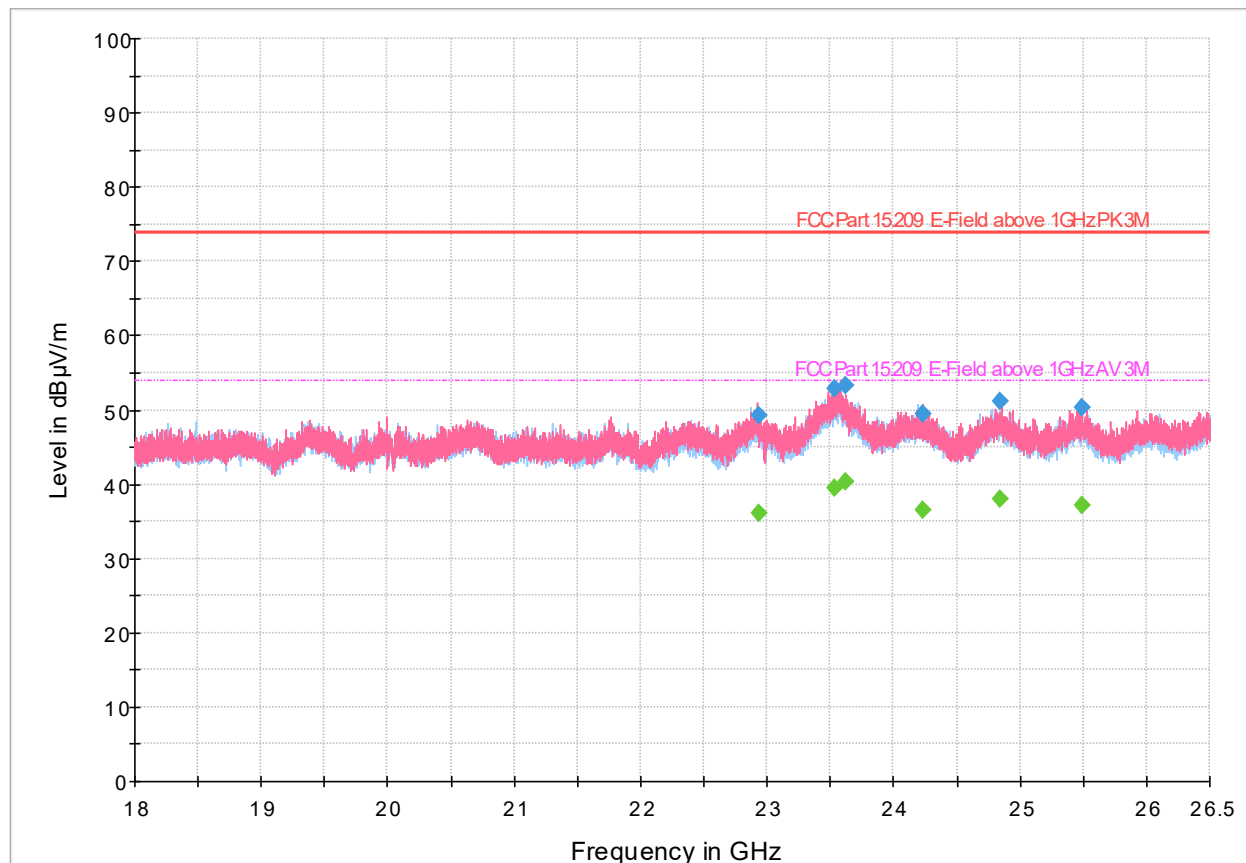


Figure 8.6-27: Radiated emissions spectral plot (18 GHz - 26.5 GHz) high channel

Table 8.6-15: 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)
22931.406250	49.25	---	73.90	24.65	5000.0	1000.000	278.0	V	68.0	29.4
22931.406250	---	36.00	53.90	17.90	5000.0	1000.000	278.0	V	68.0	29.4
23538.431250	52.92	---	73.90	20.98	5000.0	1000.000	120.0	V	190.0	32.9
23538.431250	---	39.57	53.90	14.33	5000.0	1000.000	120.0	V	190.0	32.9
23617.506250	53.25	---	73.90	20.65	5000.0	1000.000	331.0	V	268.0	32.8
23617.506250	---	40.27	53.90	13.63	5000.0	1000.000	331.0	V	268.0	32.8
24230.062500	---	36.52	53.90	17.38	5000.0	1000.000	268.0	V	0.0	30.3
24230.062500	49.49	---	73.90	24.41	5000.0	1000.000	268.0	V	0.0	30.3
24844.031250	51.18	---	73.90	22.72	5000.0	1000.000	227.0	V	0.0	30.3
24844.031250	---	38.06	53.90	15.84	5000.0	1000.000	227.0	V	0.0	30.3
25488.225000	---	37.07	53.90	16.83	5000.0	1000.000	316.0	V	248.0	30.3
25488.225000	50.22	---	73.90	23.68	5000.0	1000.000	316.0	V	248.0	30.3

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.

8.7 Power spectral density

8.7.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(e)
- ISSED: 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	June 27, 2024	Temperature	22 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	51.9 %

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	Battery power
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

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, 1 Mbps	-16.03	≤ 8	24.03
2440	GFSK, 1 Mbps	-15.93	≤ 8	23.93
2480	GFSK, 1 Mbps	-16.18	≤ 8	24.18
2402	GFSK, 2 Mbps	-18.49	≤ 8	26.49
2440	GFSK, 2 Mbps	-18.40	≤ 8	26.40
2480	GFSK, 2 Mbps	-18.74	≤ 8	26.74

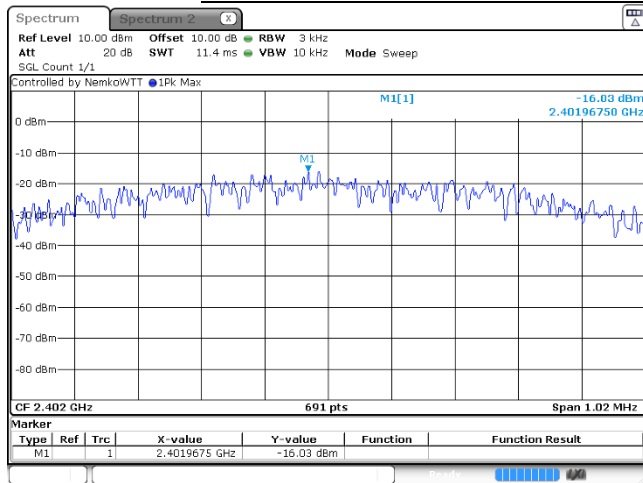


Figure 8.7-1: Power spectral density, GFSK 1 Mbps, 2402 MHz

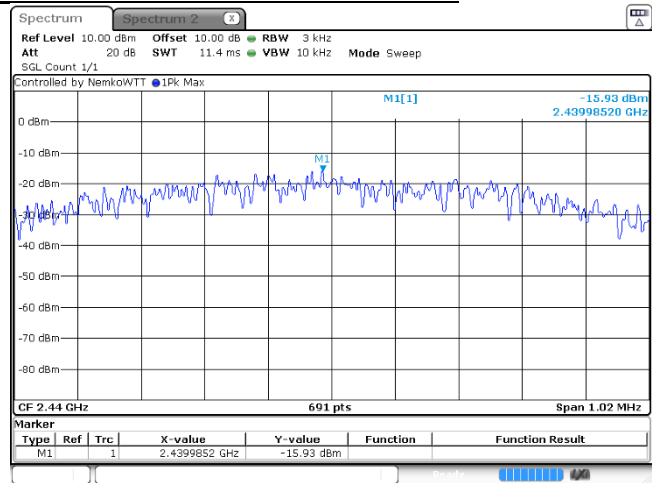


Figure 8.7-2: Power spectral density, GFSK, 1 Mbps, 2440 MHz

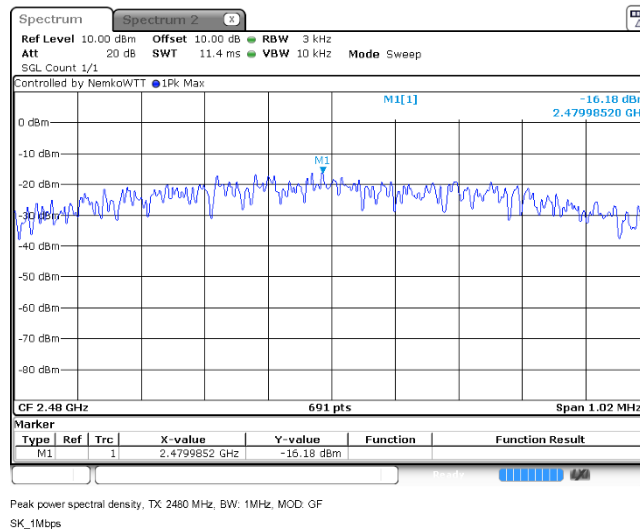
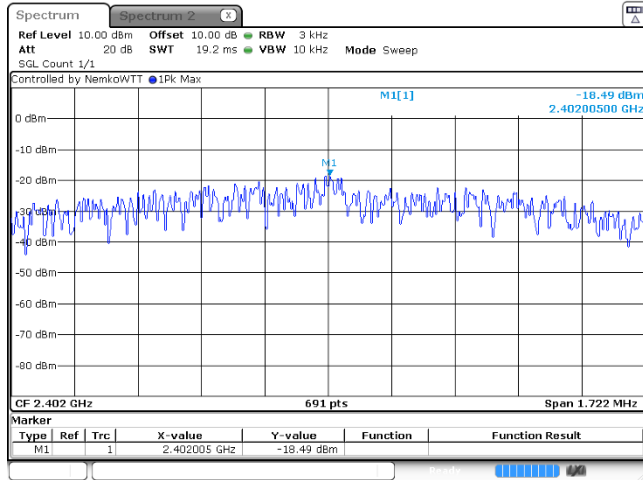
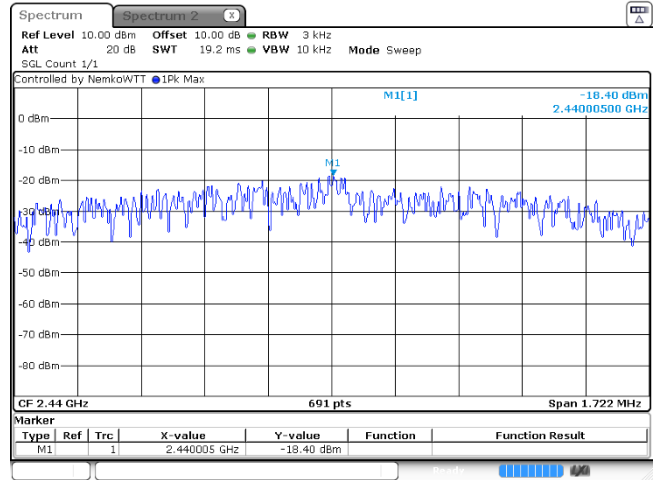


Figure 8.7-3: Power spectral density, GFSK, 1 Mbps, 2480 MHz



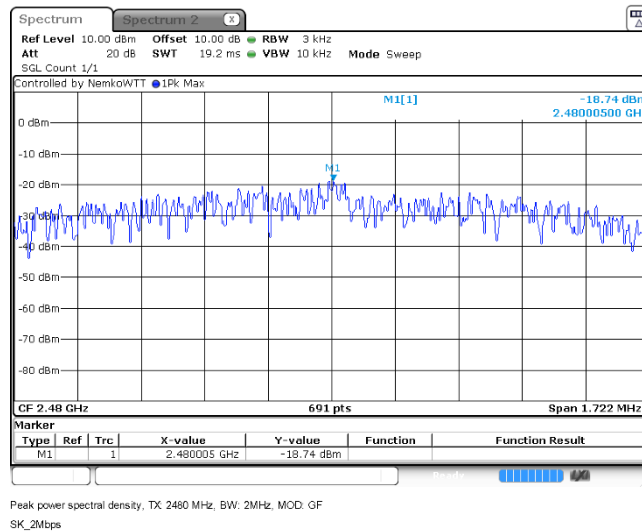
Peak power spectral density, TX 2402 MHz, BW: 2MHz, MOD: GF
SK_2Mbps

Figure 8.7-4: Power spectral density, GFSK, 2 Mbps, 2402 MHz



Peak power spectral density, TX 2440 MHz, BW: 2MHz, MOD: GF
SK_2Mbps

Figure 8.7-5: Power spectral density, GFSK, 2 Mbps, 2440 MHz



Peak power spectral density, TX 2480 MHz, BW: 2MHz, MOD: GF
SK_2Mbps

Figure 8.7-6: Power spectral density, GFSK, 2 Mbps, 2480 MHz

8.8 99% occupied bandwidth

8.8.1 References and limits

- ISSED: 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	June 27, 2024	Temperature	22 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1001.4 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	51.9 %

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	Battery power
EUT setup configuration	<input checked="" type="checkbox"/> Table-top <input type="checkbox"/> Floor standing <input type="checkbox"/> Other:

Receiver settings:

Resolution bandwidth	20, 30 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 _i (MHz)	f _h (MHz)	Limit	Verdict
2402	GFSK, 1 Mbps	1.0358	2401.49855	2402.5369	f _H and f _L within 2400 – 2483.5 MHz	PASS
2440	GFSK, 1 Mbps	1.0358	2439.49855	2440.5369	f _H and f _L within 2400 – 2483.5 MHz	PASS
2480	GFSK, 1 Mbps	1.0536	2479.8842	2480.54197	f _H and f _L within 2400 – 2483.5 MHz	PASS
2402	GFSK, 2 Mbps	2.036	2401.0174	2403.0535	f _H and f _L within 2400 – 2483.5 MHz	PASS
2440	GFSK, 2 Mbps	2.036	2439.0174	2441.0535	f _H and f _L within 2400 – 2483.5 MHz	PASS
2480	GFSK, 2 Mbps	2.067	2478.9971	2481.0637	f _H and f _L within 2400 – 2483.5 MHz	PASS

Section 8

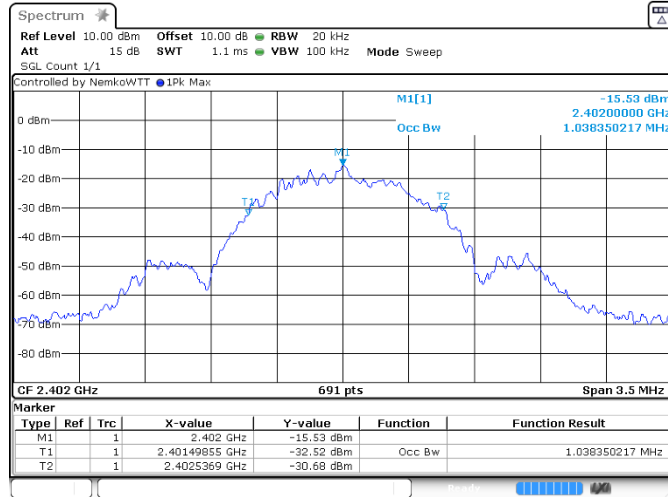
Test name

Specification(s)

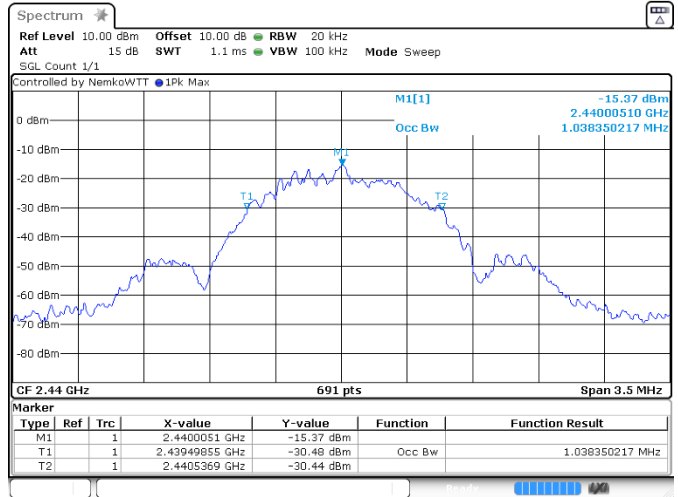
Testing data

99% occupied bandwidth

FCC 15.247 & RSS-247



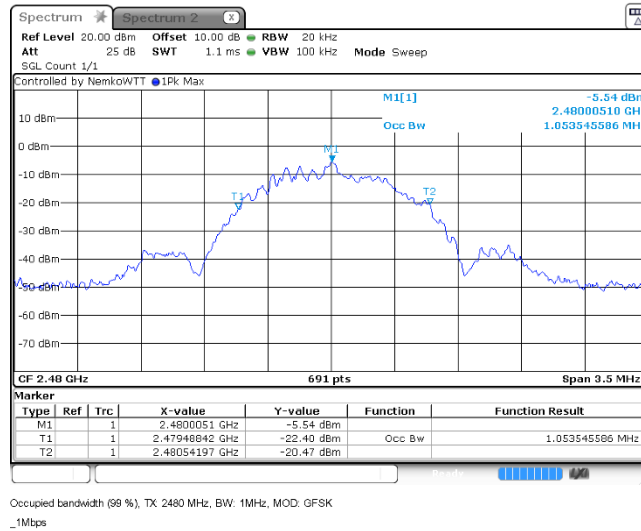
Occupied bandwidth (99 %), TX 2402 MHz, BW: 1MHz, MOD: FHSS



Occupied bandwidth (99 %), TX 2440 MHz, BW: 1MHz, MOD: FHSS

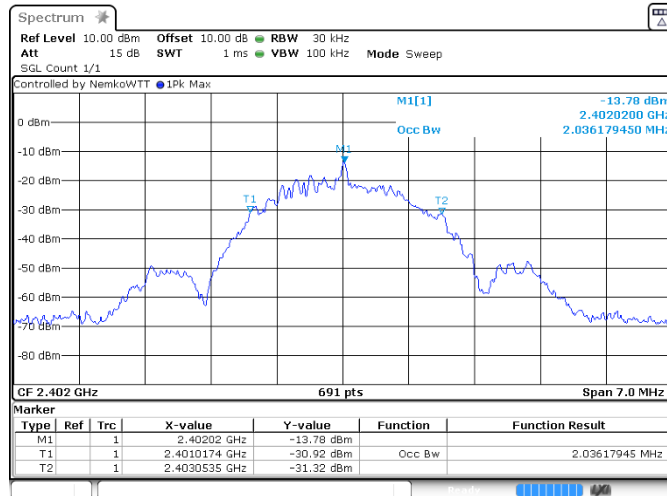
Figure 8.8-1: 99% occupied bandwidth, GFSK, 1 Mbps, 2402 MHz

Figure 8.8-2: 99% occupied bandwidth, GFSK, 1 Mbps, 2440 MHz

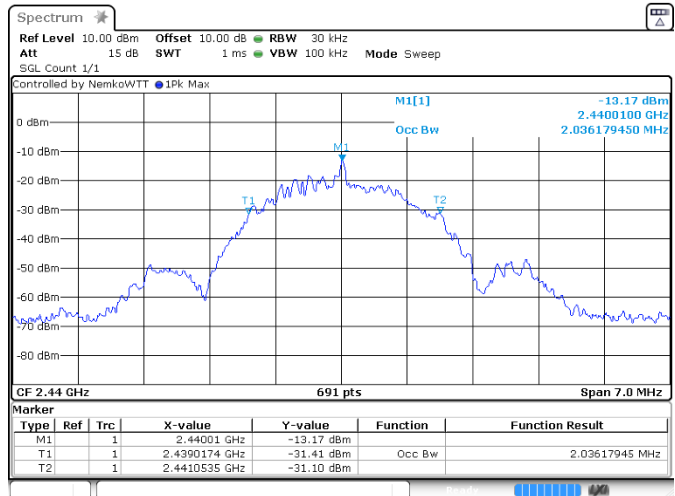


Occupied bandwidth (99 %), TX 2480 MHz, BW: 1MHz, MOD: GFSK
_1Mbps

Figure 8.8-3: 99% occupied bandwidth, GFSK, 1 Mbps, 2480 MHz



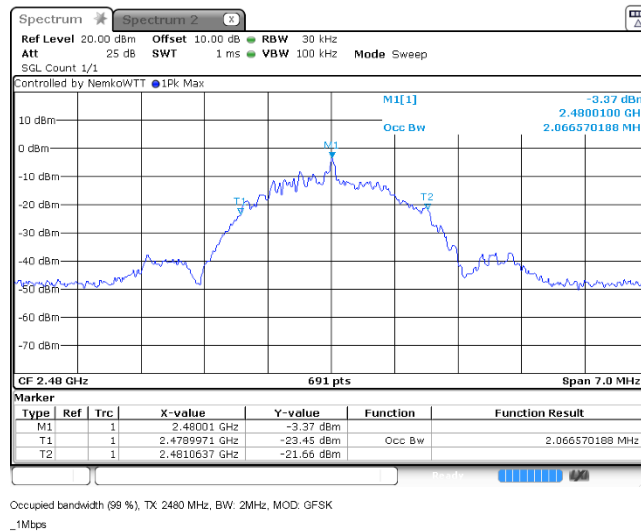
Occupied bandwidth (99 %), TX 2402 MHz, BW: 2MHz, MOD: FHSS



Occupied bandwidth (99 %), TX 2440 MHz, BW: 2MHz, MOD: FHSS

Figure 8.8-4: 99% occupied bandwidth, GFSK, 2 Mbps, 2402 MHz

Figure 8.8-5: 99% occupied bandwidth, GFSK, 2 Mbps, 2440 MHz



Occupied bandwidth (99 %), TX 2480 MHz, BW: 2MHz, MOD: GFSK
_1Mbps

Figure 8.8-6: 99% occupied bandwidth, GFSK, 2 Mbps, 2480 MHz

End of test report