Test report

REP019799-1R2TRFWL

Date of issue: January 11, 2024

Applicant:

Carol Cole Company dba NuFace

Product description:

NuFACE® Fix+ Line Smoothing

Model:

10800

Product marketing name(s):

NuFACE® Fix+

FCC ID:

2AGNA-10800

ISED certification number:

25861-10800

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

Company name	Nemko USA Inc.
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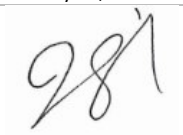
City	Carlsbad
State	California
Postal code	92008
Country	USA
Telephone	+1 760 444 3500
Website	www.nemko.com
FCC Site Number	Test Firm Registration Number: 392943; Designation Number: US5058
ISED Test Site	2040B-3

Tested by	Martha Espinoza, Wireless Test Engineer Chenhao Ma, Wireless Test Technician
Reviewed by	James Cunningham, EMC/WL Manager
Review date	January 11, 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.
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.

Copyright notification

Table of Contents

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
REP019799-1TRFEMC	January 9, 2024	Original report issued
REP019799-1R1TRFEMC	January 10, 2024	Updated following TCB feedback
REP019799-1R2TRFEMC	January 11, 2024	Minor correction

Section 2 Summary of test results

2.1 Sample information

Receipt date	01-Dec-23
Nemko sample ID number	REP019799

2.2 Testing period

Test start date	04-Dec-23
Test end date	21-Dec-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	Pass [1]
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass

Notes: [1] EUT is charged via USB 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: *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	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: *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	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	Carol Cole Company dba NuFace
Address	1325 Sycamore Ave
City	Vista
State	CA
Postal/Zip code	92081
Country	USA

3.3 Manufacturer

Company name	Carol Cole Company dba NuFace
Address	1325 Sycamore Ave
City	Vista
State	CA
Postal/Zip code	92081
Country	USA

3.4 EUT information

Product name	NuFACE® Fix+ Line Smoothing
Model	10800
Variant(s)	N/A
Serial number	761-XA1-0001; 761-XA1-0002; 761-XA1-0003; Samples in TX mode. 761-XA1-0005; 761-XA1-0006; 761-XA1-0019; Samples in RX mode.
Part number	N/A
Power requirements	3.7 V DC battery, charged via USB AC/DC Adapter

3.5 Transmitter Information

Frequency band	2400 – 2483.5 MHz
Transmitter type	☐ Frequency hopping spread spectrum (FHSS) ☒ Digital transmission system (DTS) ☐ Hybrid FHSS / DTS
Minimum frequency (MHz)	2402
Maximum frequency (MHz)	2480
Type of modulation	GFSK
Data rate	☐ 125 kbps operation ☐ 500 kbps operation ☒ 1 Mbps operation ☐ 2 Mbps operation
Tested frequencies	2402 MHz (low), 2441 MHz (middle), and 2480 MHz (high)
Antenna type	Chip antenna
Antenna peak gain	2.21 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.
DC power port	1

Table 3.6-3: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
DC power supply	Topward	3303D	NSN	---

Table 3.6-4: *Inter-connection cables*

Cable description	From	To	Length (m)
DC cable	DC power supply	EUT	0.5

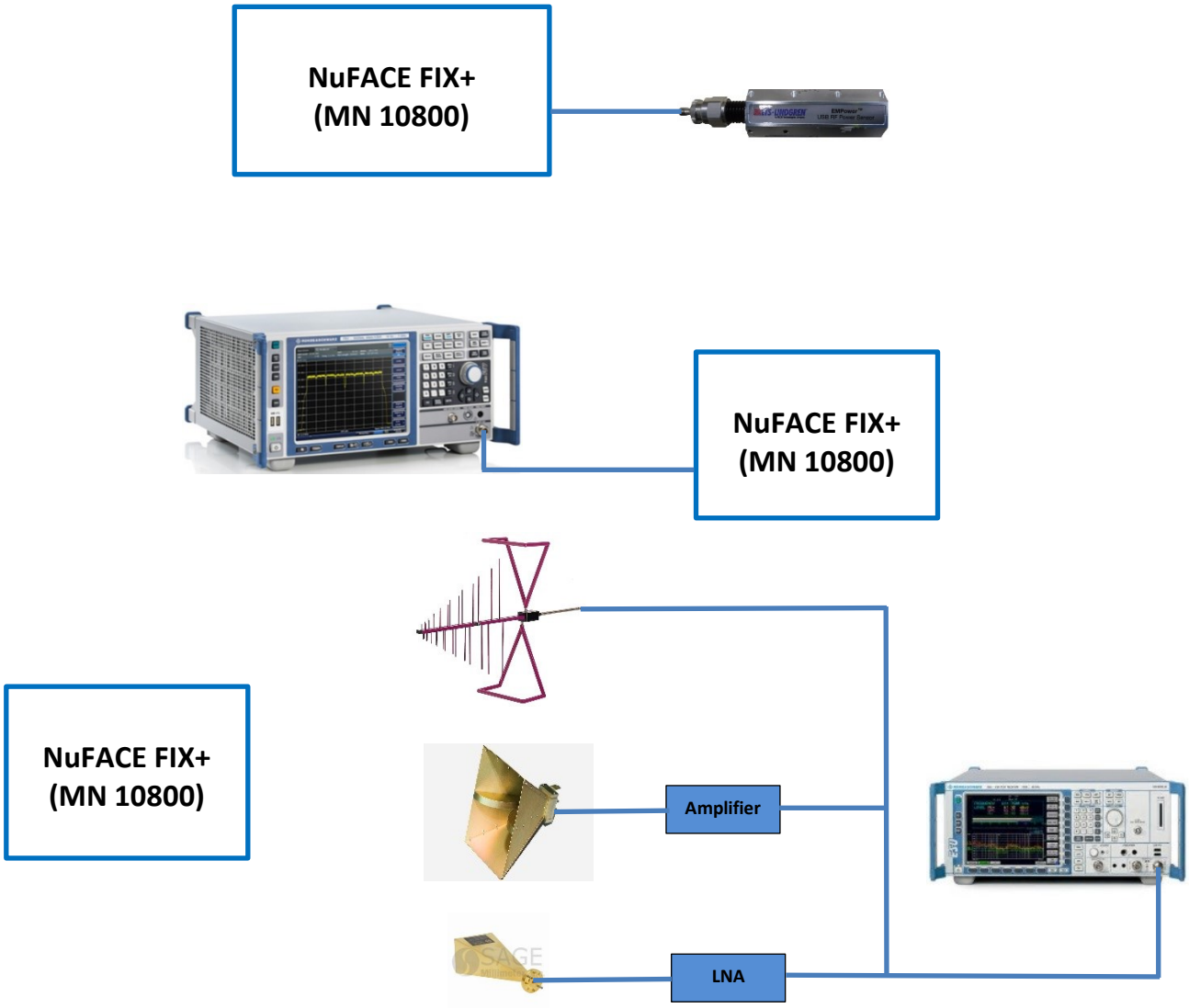


Figure 3.6-1: Test setup diagram

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 ±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_{lab} - U_{cispr}), exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance level, increased by (U_{lab} - U_{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.
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	1 year	17-04-2024
Transient Limiter	Hewlett-Packard	11947A	E1159	1 year	28-02-2024
Two Line V-Network	Rohde & Schwarz	ENV216	E1020	1 year	01-02-2024
Signal and spectrum analyzer	Rohde & Schwarz	FSV3030	E1321	1 year	26-09-2024
Power sensor	ETS Lindgren	7002-006	E1061	1 year	27-07-2024
DC Power Supply	Topward	3303D	E1264	NCR	NCR
EMI Test Receiver	Rohde & Schwarz	ESU40	E1131	1 year	03-02-2024
System Controller	Sunol Sciences	SC104V	E1191	NCR	NCR
Bilog Antenna (30-1000 MHz)	Schaffner	CBL 6111D	1763	2 years	04-01-2024
DRG Horn (1-18 GHz)	ETS-Lindgren	3117-PA	E1139	VOU	VOU
Horn antenna (18-26 GHz)	Eravant	SAZ-2410-42-S1	EW107	1 year	05-12-2024
Low noise amplifier	Sage Millimeter, Inc.	SBL-1834034030-KFKF	E1228	VOU	VOU

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
- ISED: 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	December 8, 2023	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003 mbar
Test location	☐ 10m semi anechoic chamber ☐ 3m semi anechoic chamber ☒ Other: Ground plane	Relative humidity	53 %

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	AC mains port of AC/DC adapter
EUT power input during test	120 VAC / 60 Hz
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ 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, 1 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

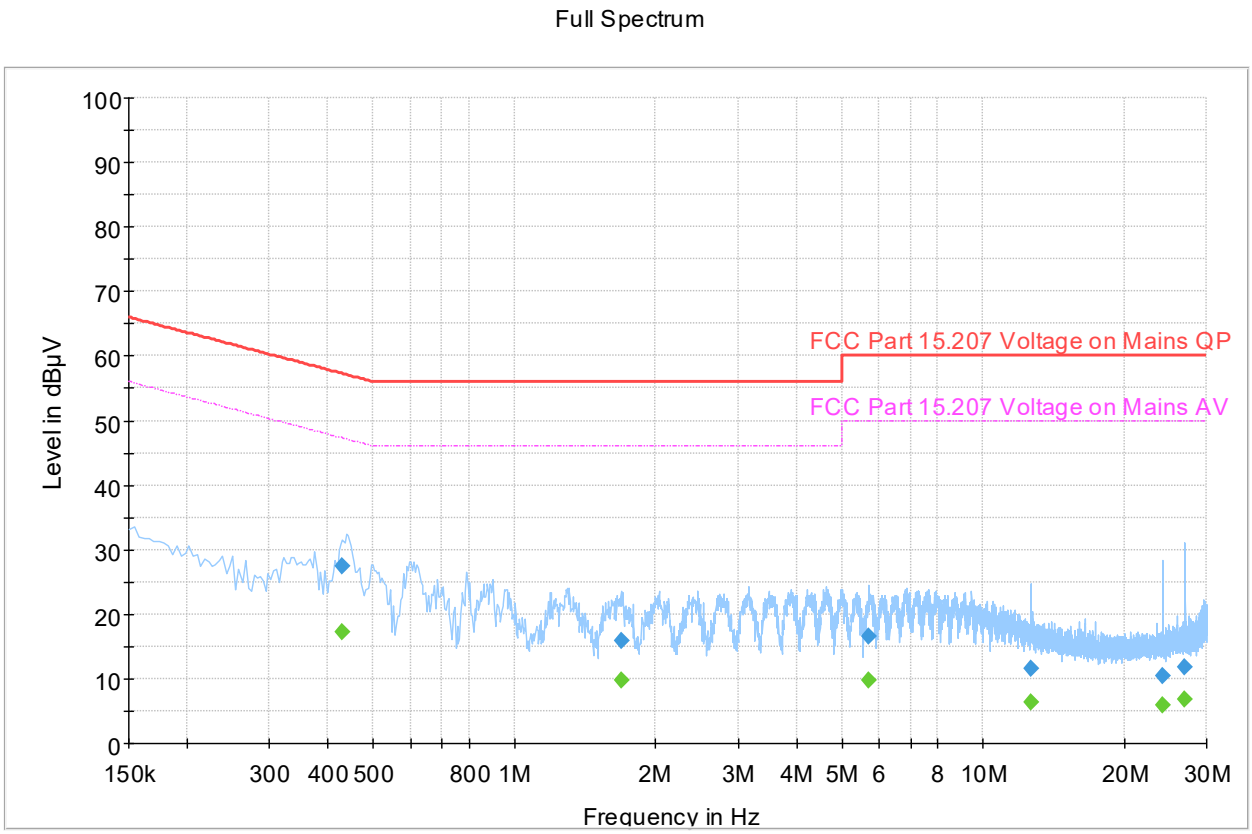


Figure 8.1-1: *Conducted emissions at mains port spectral plot (150 kHz - 30 MHz), 2402 MHz operation*

Table 8.1-2*: Conducted emissions at mains port results, 2402 MHz operation*

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.430000	---	17.21	47.25	30.04	5000.0	9.000	L1	ON	19.5
0.430000	27.49	---	57.25	29.76	5000.0	9.000	L1	ON	19.5
1.686000	---	9.80	46.00	36.20	5000.0	9.000	L1	ON	19.6
1.686000	15.89	---	56.00	40.11	5000.0	9.000	L1	ON	19.6
5.698000	---	9.79	50.00	40.21	5000.0	9.000	L1	ON	19.7
5.698000	16.64	---	60.00	43.36	5000.0	9.000	L1	ON	19.7
12.670000	---	6.31	50.00	43.69	5000.0	9.000	L1	ON	20.0
12.670000	11.50	---	60.00	48.50	5000.0	9.000	L1	ON	20.0
24.182000	10.48	---	60.00	49.52	5000.0	9.000	N	ON	20.4
24.182000	---	5.86	50.00	44.14	5000.0	9.000	N	ON	20.4
27.026000	11.84	---	60.00	48.16	5000.0	9.000	L1	ON	20.4
27.026000	---	6.73	50.00	43.27	5000.0	9.000	L1	ON	20.4

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.

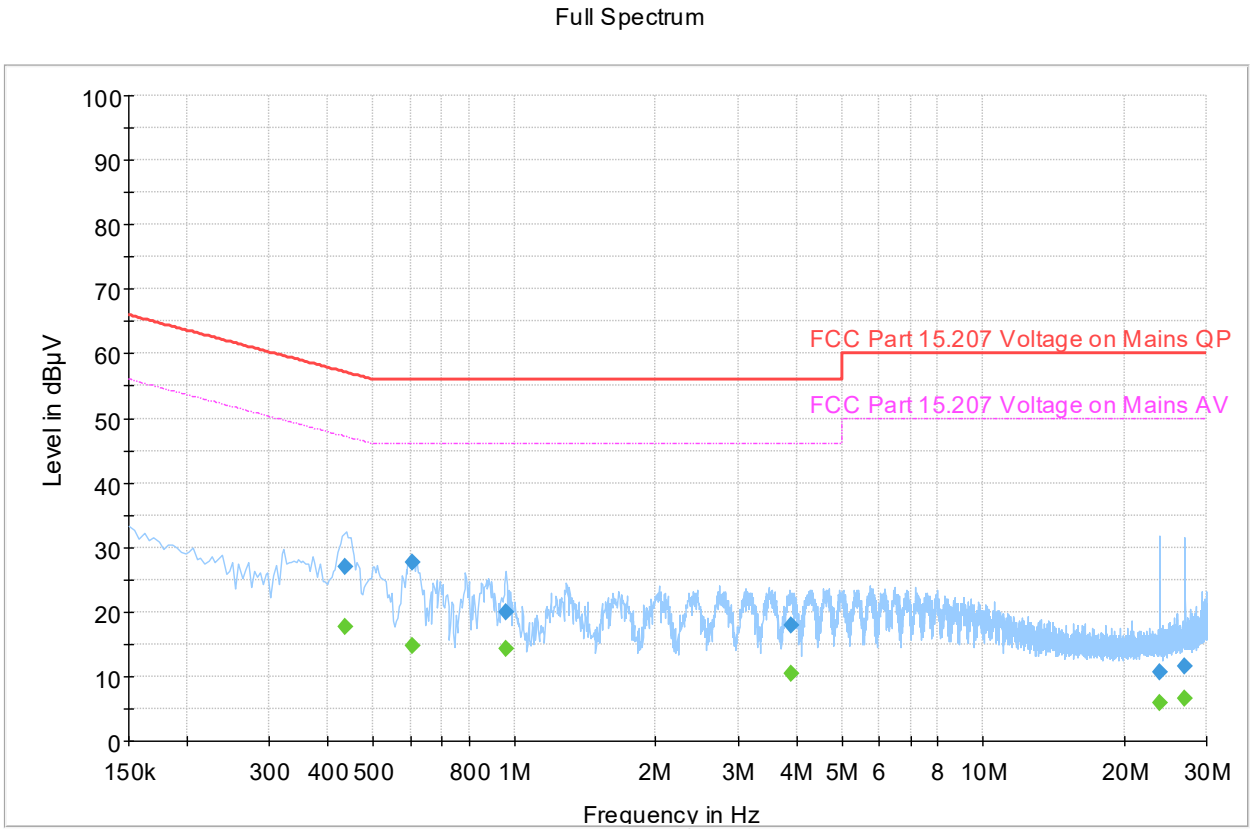


Figure 8.1-2: *Conducted emissions at mains port spectral plot (150 kHz - 30 MHz), 2441 MHz operation*

Table 8.1-3*: Conducted emissions at mains port results, 2441 MHz operation*

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.434000	---	17.65	47.18	29.52	5000.0	9.000	L1	ON	19.5
0.434000	26.98	---	57.18	30.19	5000.0	9.000	L1	ON	19.5
0.606000	---	14.74	46.00	31.26	5000.0	9.000	L1	ON	19.5
0.606000	27.69	---	56.00	28.31	5000.0	9.000	L1	ON	19.5
0.958000	---	14.32	46.00	31.68	5000.0	9.000	L1	ON	19.5
0.958000	19.99	---	56.00	36.01	5000.0	9.000	L1	ON	19.5
3.906000	---	10.34	46.00	35.66	5000.0	9.000	L1	ON	19.6
3.906000	17.89	---	56.00	38.11	5000.0	9.000	L1	ON	19.6
23.866000	10.65	---	60.00	49.35	5000.0	9.000	N	ON	20.4
23.866000	---	5.83	50.00	44.17	5000.0	9.000	N	ON	20.4
27.026000	11.62	---	60.00	48.38	5000.0	9.000	L1	ON	20.4
27.026000	---	6.61	50.00	43.39	5000.0	9.000	L1	ON	20.4

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.

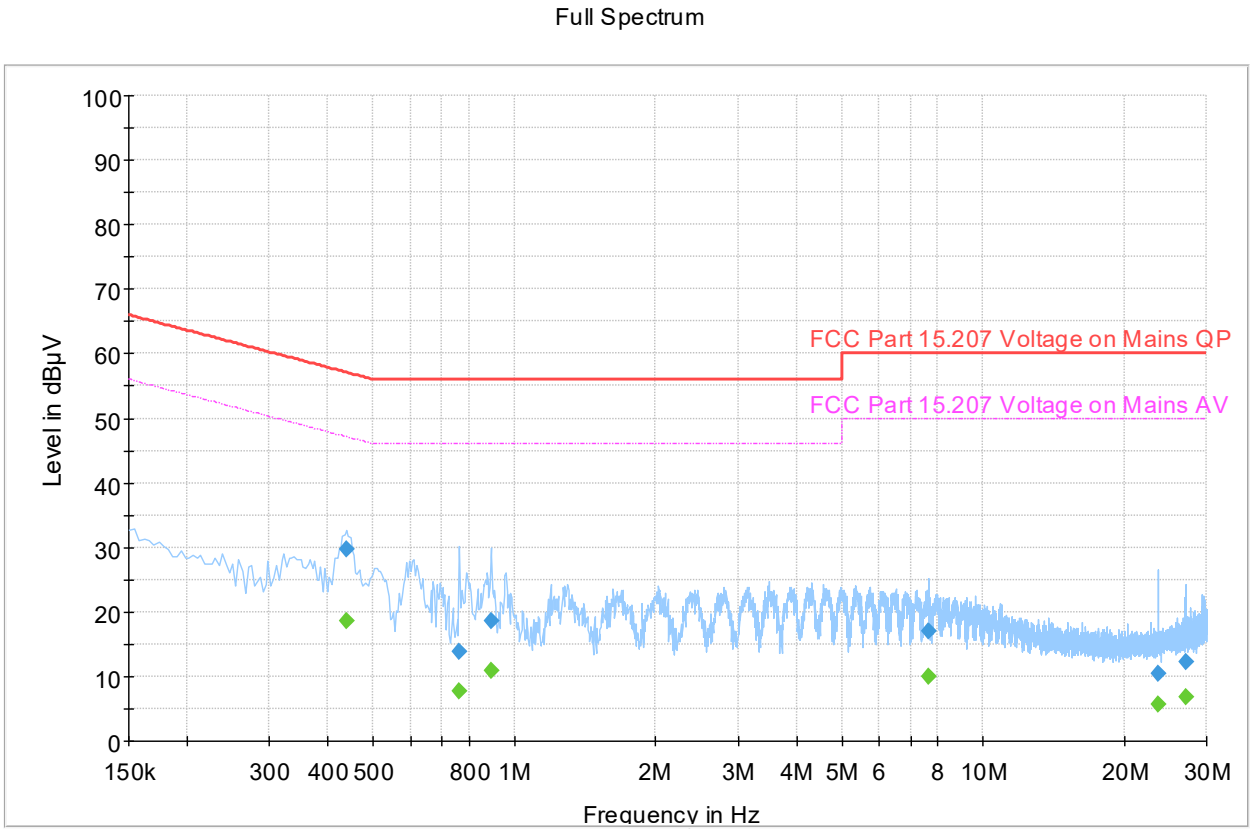


Figure 8.1-3: *Conducted emissions at mains port spectral plot (150 kHz - 30 MHz), 2480 MHz operation*

Table 8.1-4*: Conducted emissions at mains port results, 2480 MHz operation*

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.438000	---	18.50	47.10	28.60	5000.0	9.000	L1	ON	19.5
0.438000	29.64	---	57.10	27.46	5000.0	9.000	L1	ON	19.5
0.762000	---	7.78	46.00	38.22	5000.0	9.000	L1	ON	19.5
0.762000	13.86	---	56.00	42.14	5000.0	9.000	L1	ON	19.5
0.890000	---	10.78	46.00	35.22	5000.0	9.000	L1	ON	19.5
0.890000	18.69	---	56.00	37.31	5000.0	9.000	L1	ON	19.5
7.642000	---	10.08	50.00	39.92	5000.0	9.000	L1	ON	19.8
7.642000	17.09	---	60.00	42.91	5000.0	9.000	L1	ON	19.8
23.686000	10.44	---	60.00	49.56	5000.0	9.000	N	ON	20.4
23.686000	---	5.77	50.00	44.23	5000.0	9.000	N	ON	20.4
27.146000	12.21	---	60.00	47.79	5000.0	9.000	L1	ON	20.4
27.146000	---	6.73	50.00	43.27	5000.0	9.000	L1	ON	20.4

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	December 8, 2023	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003 mbar
Test location	☐ 10m semi anechoic chamber ☐ 3m semi anechoic chamber ☒ Other: Ground plane	Relative humidity	53 %

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	DC 3.7 V +/- 15%

8.2.5 Test data

☐	EUT is battery operated. Therefore, all tests performed with a new fully charged battery
☒	EUT power supply voltage varied across supported range. No variation in transmitter output power observed therefore all tests performed at nominal power supply voltage.
☐	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	December 8, 2023	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003 mbar
Test location	☐ 10m semi anechoic chamber ☐ 3m semi anechoic chamber ☒ Other: Ground plane	Relative humidity	53 %

8.3.2 Notes

None

8.3.3 Test data

Antenna part number:	ANT1005LL14R2400A
Technical description:	2.4 GHz chip antenna
Peak gain (dBi):	2.21 dBi
Source of gain data:	☐ Declared by client ☒ Antenna data sheet or specification. Document name: Technical Data Sheet – 1005 2.4G Chip Antenna ☐ Antenna gain test report. Document name:

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	December 4, 2023	Temperature	19 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1005 mbar
Test location	☒ Wireless bench ☐ 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	3.7 V DC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ 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)
2402	GFSK, 1 Mbps	744.83	≥ 500
2441	GFSK, 1 Mbps	728.03	≥ 500
2480	GFSK, 1 Mbps	739.73	≥ 500

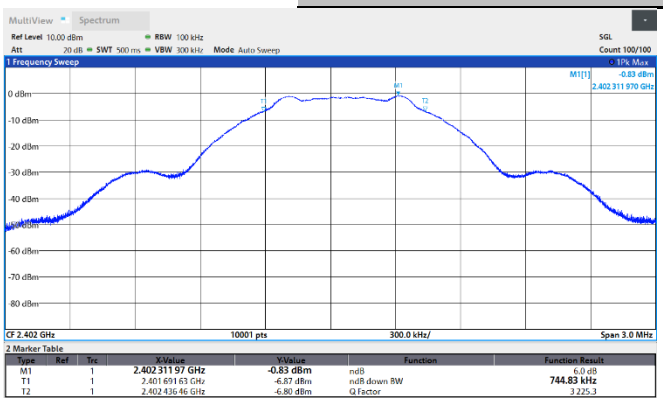


Figure 8.4-1: *Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2402 MHz*

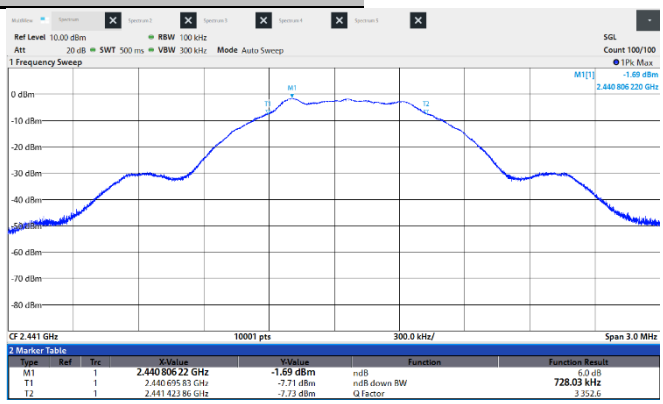


Figure 8.4-2: *Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2441 MHz*

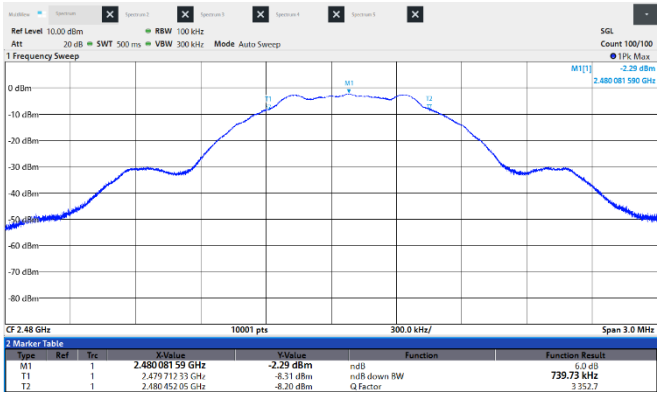


Figure 8.4-3: *Minimum 6 dB bandwidth, GFSK, 1 Mbps, 2480 MHz*

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 §11.9.1.3 (Peak power meter)

§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	December 4, 2023	Temperature	19 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1005 mbar
Test location	☒ Wireless bench ☐ 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.

EIRP (dBi) = Conducted Power (dBm) + Antenna Gain (dBi). For example, at 2402 MHz:
EIRP = 0.45 dBm + 2.21 dBi = 2.66 dBm.

8.5.4 Setup details

EUT power input during test	3.7 V DC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ Other:

8.5.5 Test data

Table 8.5-1: *Maximum peak output power test data*

Test Frequency (MHz)	Modulation	Conducted Power (dBm)	Limit (dBm)	EIRP (dBm) (ISED)	EIRP Limit (dBm) (ISED)
2402	GFSK, 1 Mbps	0.45	≤ 30	2.66	36
2441	GFSK, 1 Mbps	-0.42	≤ 30	1.79	36
2480	GFSK, 1 Mbps	-0.93	≤ 30	1.28	36

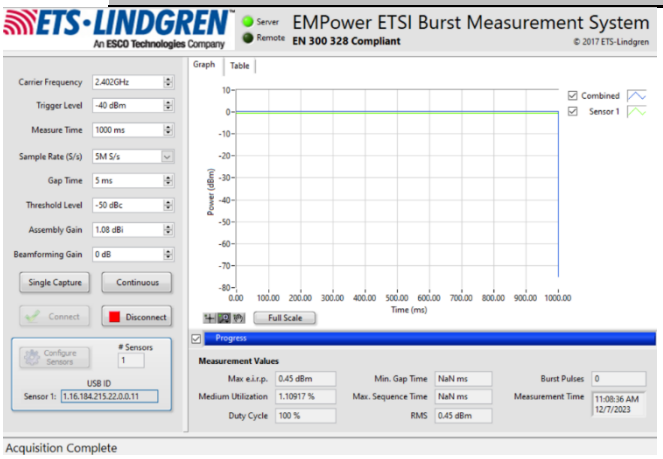


Figure 8.5-1: *Maximum peak output power, GFSK, 1 Mbps, 2402 MHz*

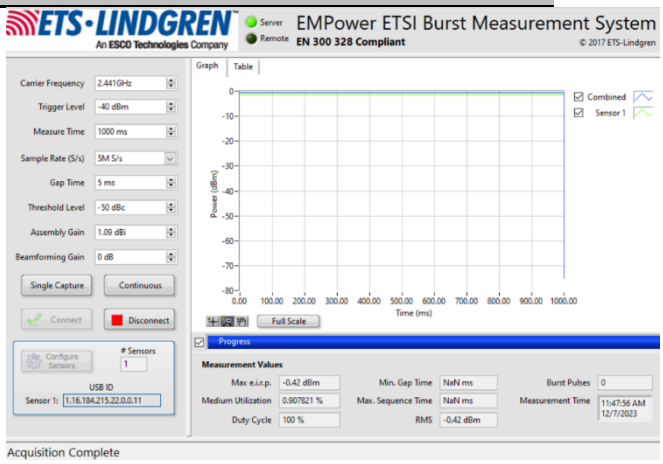


Figure 8.5-2: *Maximum peak output power, GFSK, 1 Mbps, 2441 MHz*

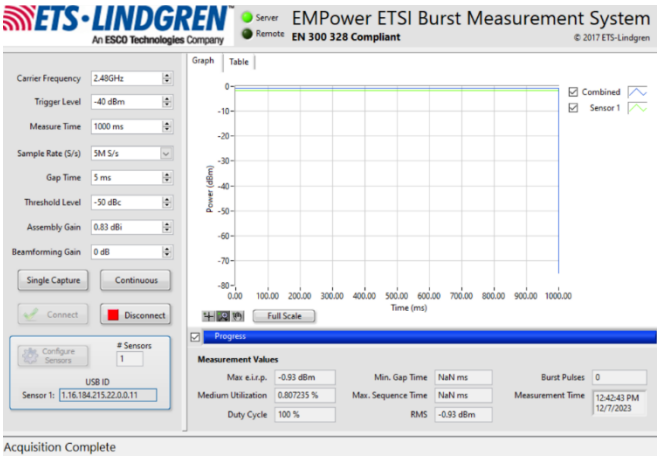


Figure 8.5-3: *Maximum peak output power, GFSK, 1 Mbps, 2480 MHz*

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: *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	December 4, 2023 December 5, 2023 December 20, 2023 December 21, 2023	Temperature	19 °C 20 °C 19 °C 20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1005 mbar 1002 mbar 1001 mbar 1006 mbar
Test location	☒ Wireless bench (conducted tests) ☐ 10 m semi-anechoic chamber (radiated tests) ☒ 3 m semi-anechoic chamber (radiated tests) ☐ Other:	Relative humidity	53 % 56 % 55 % 58 %

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, 1 Mbps.

8.6.4 Setup details

EUT power input during test	3.7 V DC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ 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:**

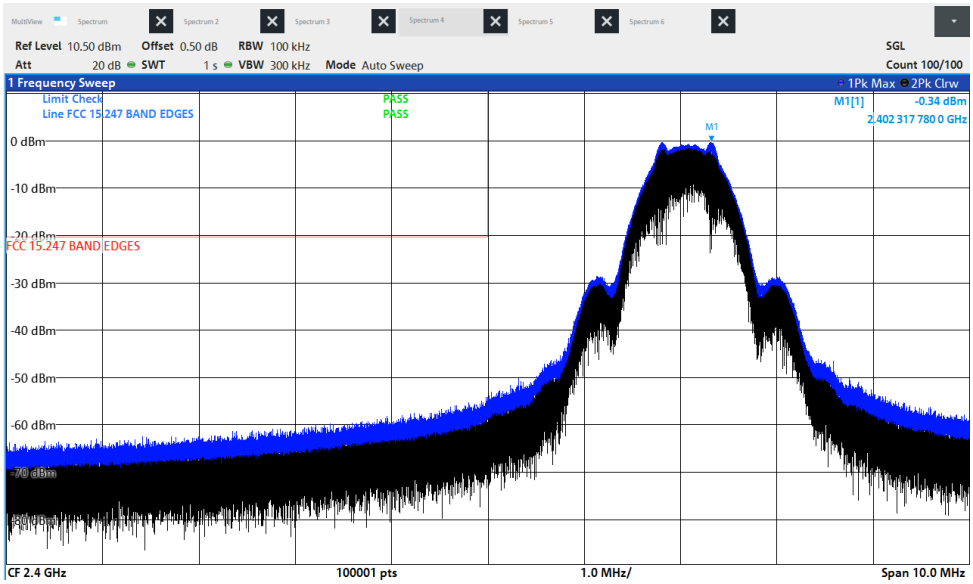


Figure 8.6-1: *Authorized band-edge emissions, GFSK, 1 Mbps, 2402 MHz*

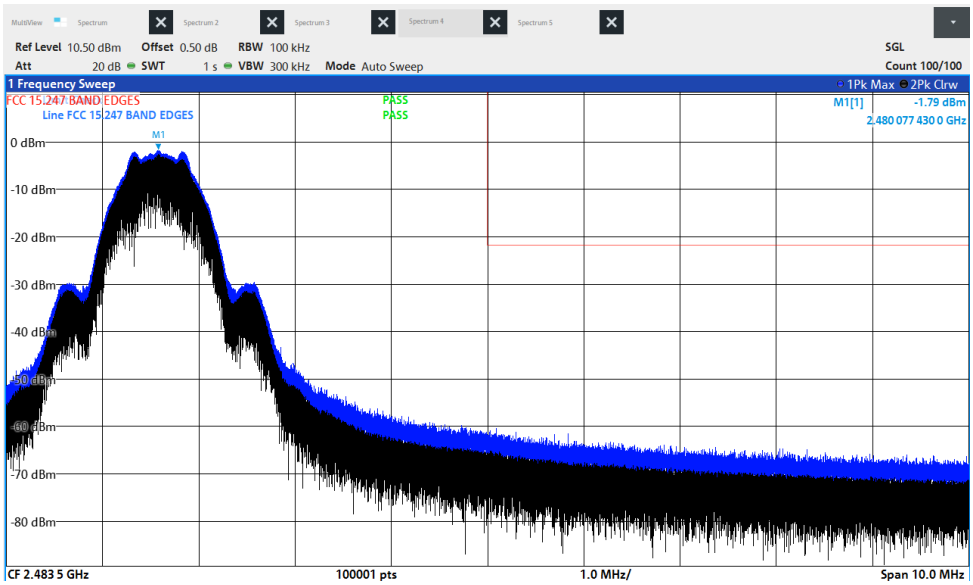


Figure 8.6-2: *Authorized band-edge emissions, GFSK, 1 Mbps, 2480 MHz*

- **Antenna port conducted spurious emissions:**

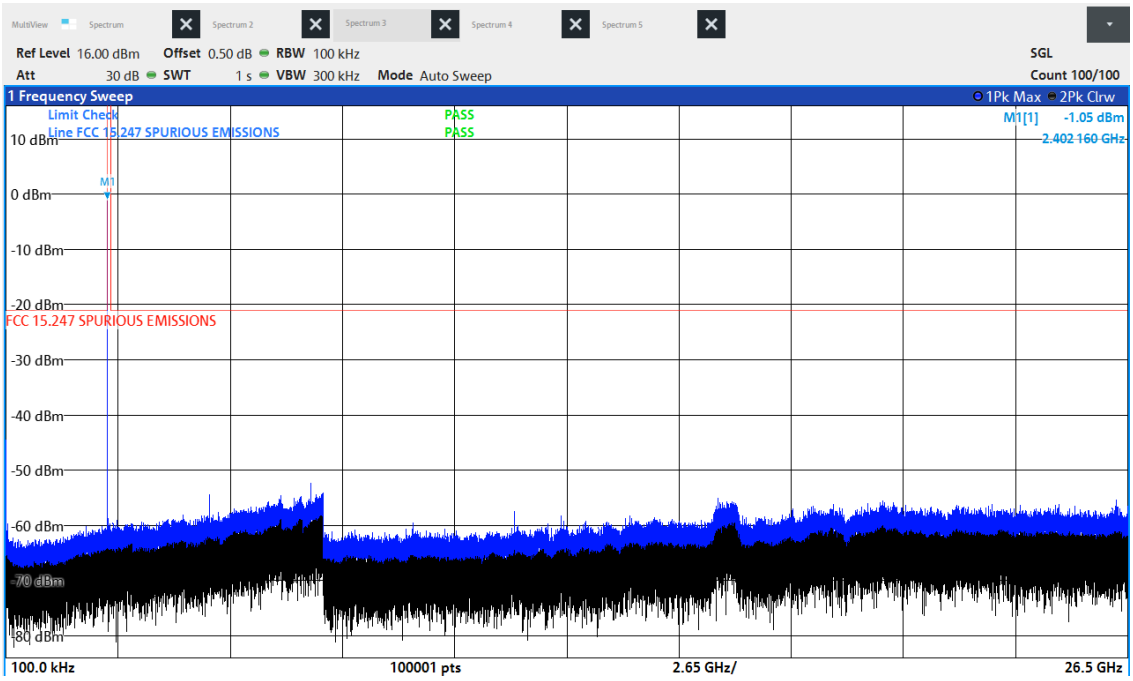


Figure 8.6-3: *Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2402 MHz*

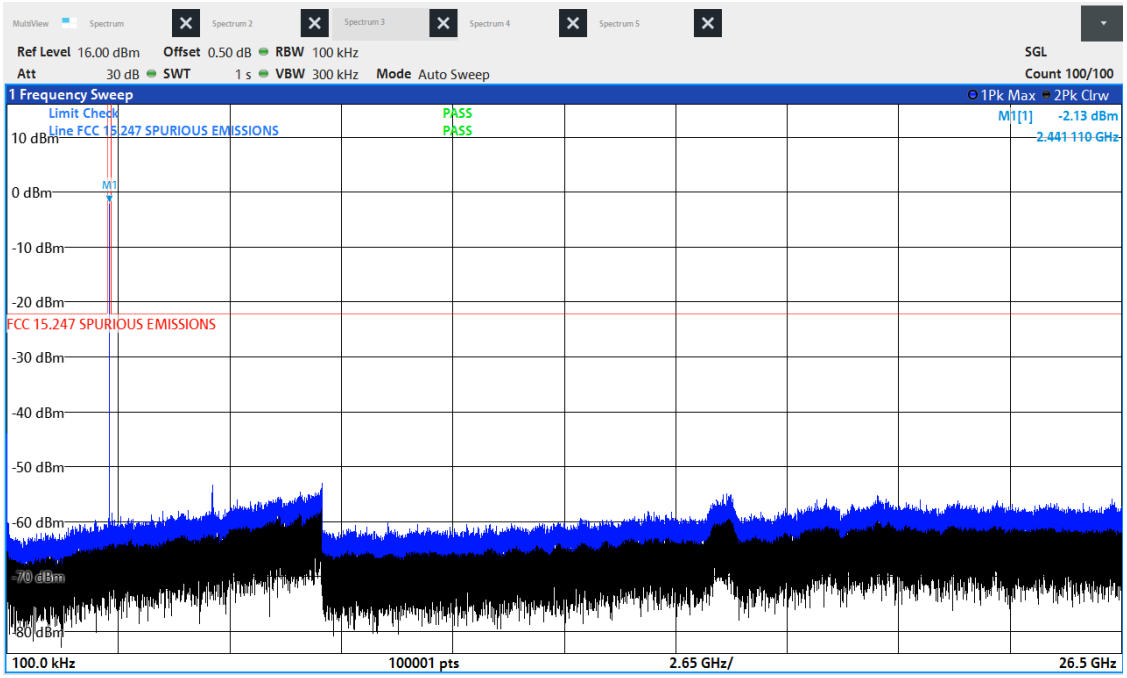


Figure 8.6-4: *Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2441 MHz*

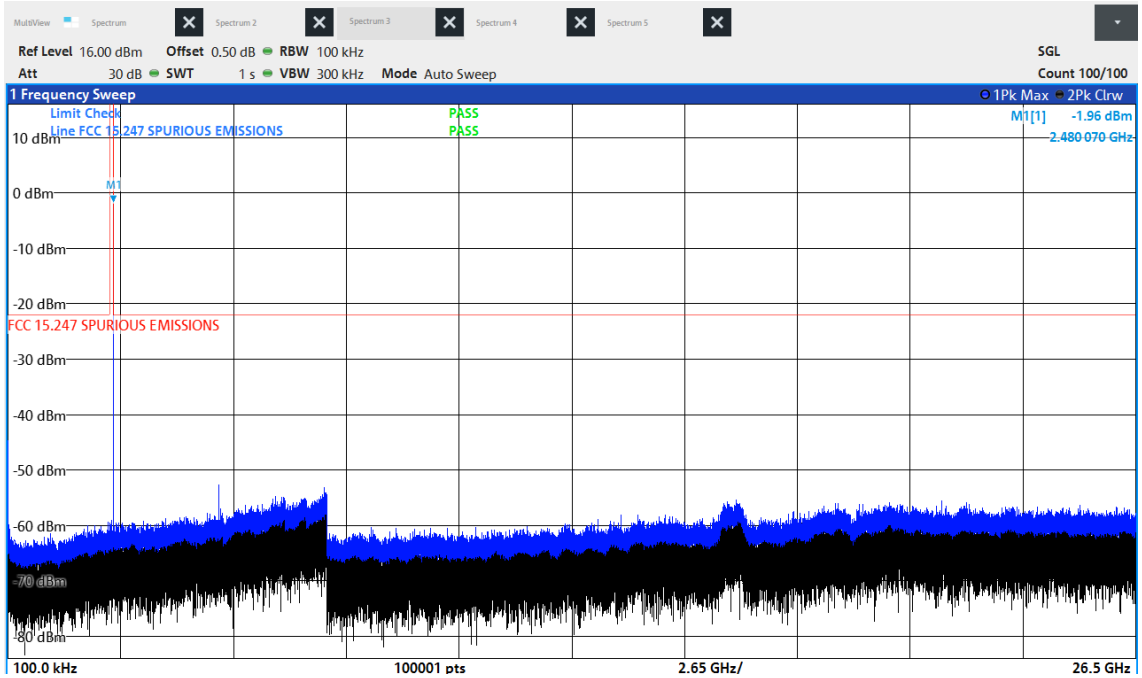


Figure 8.6-5: *Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2480 MHz*

Radiated spurious emissions:

- **Restricted band edge:**

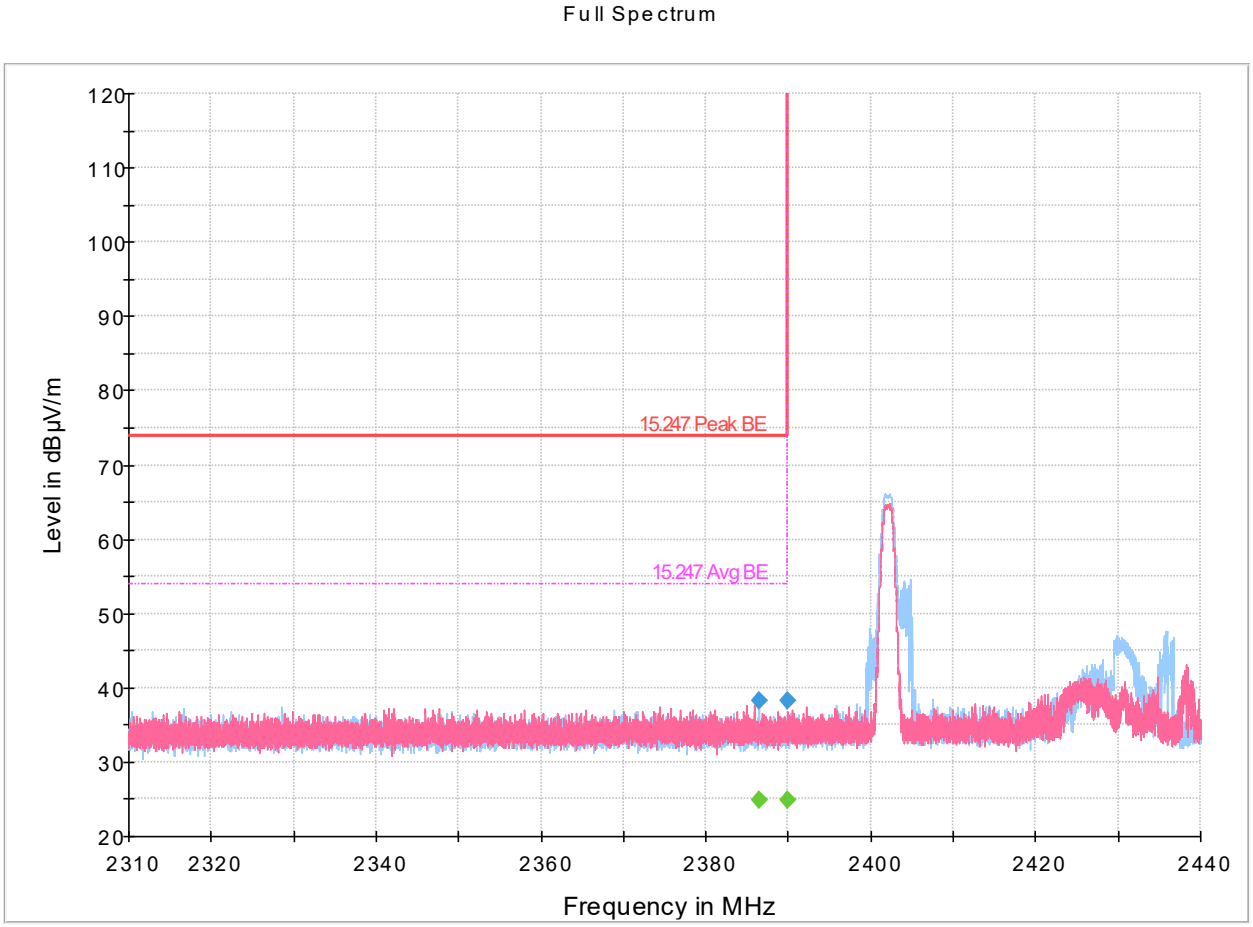


Figure 8.6-6: *Radiated emissions spectral plot (2.31 GHz - 2.44 GHz)*

Table 8.6-4*: 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)
2386.418333	38.35	---	73.90	35.55	5000.0	1000.000	171.0	V	21.0	-10.0
2386.418333	---	24.86	53.90	29.04	5000.0	1000.000	171.0	V	21.0	-10.0
2390.000000	38.32	---	73.90	35.58	5000.0	1000.000	286.0	H	64.0	-10.0
2390.000000	---	24.96	53.90	28.94	5000.0	1000.000	286.0	H	64.0	-10.0

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.

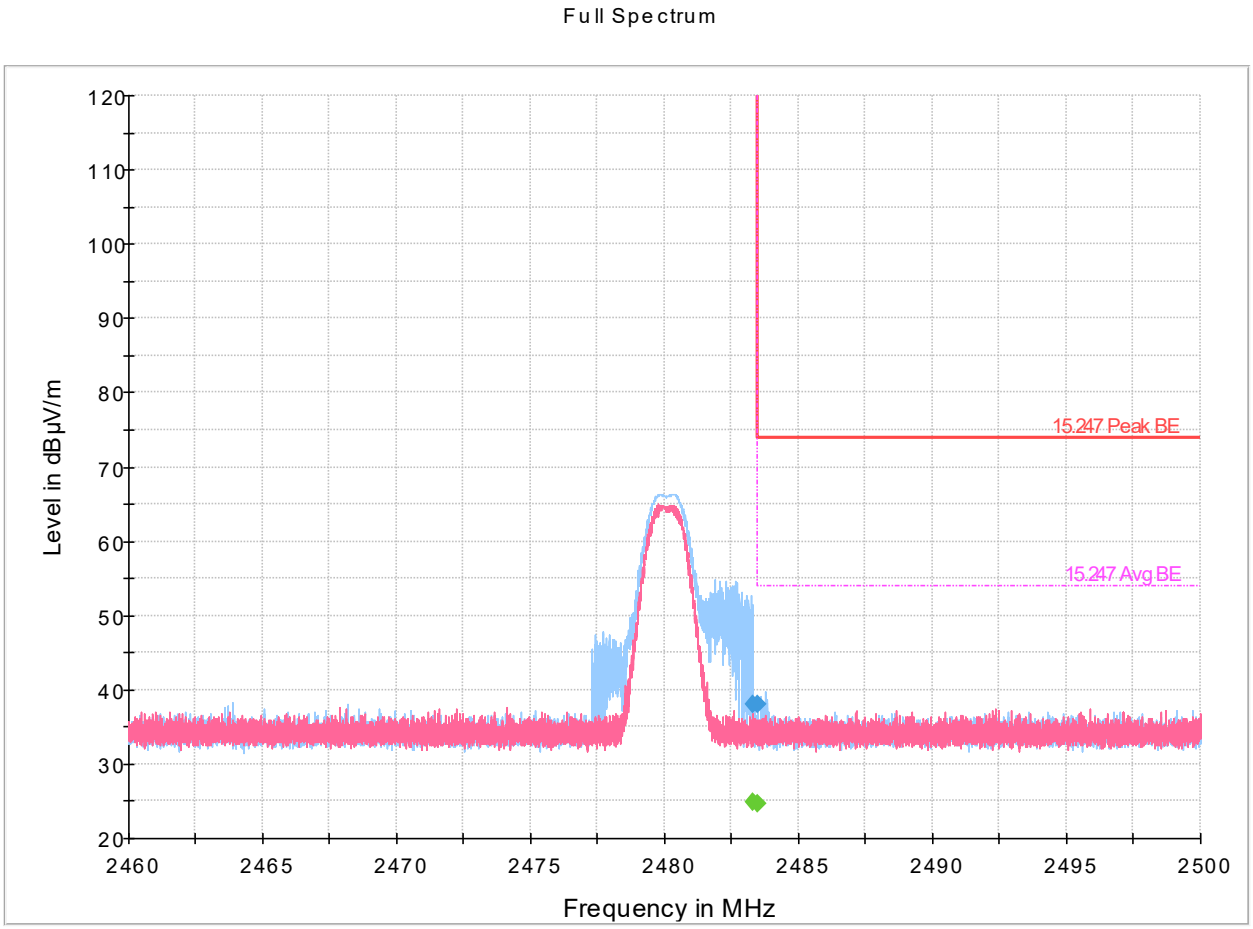


Figure 8.6-7: *Radiated emissions spectral plot (2.46 GHz - 2.5 GHz)*

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)
2483.300000	---	24.78	131.20	106.42	5000.0	1000.000	284.0	H	126.0	-9.7
2483.300000	38.07	---	151.20	113.13	5000.0	1000.000	284.0	H	126.0	-9.7
2483.500000	---	24.74	53.90	29.16	5000.0	1000.000	211.0	V	178.0	-9.7
2483.500000	38.02	---	73.90	35.88	5000.0	1000.000	211.0	V	178.0	-9.7

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.

- **Radiated spurious emissions, restricted bands:**

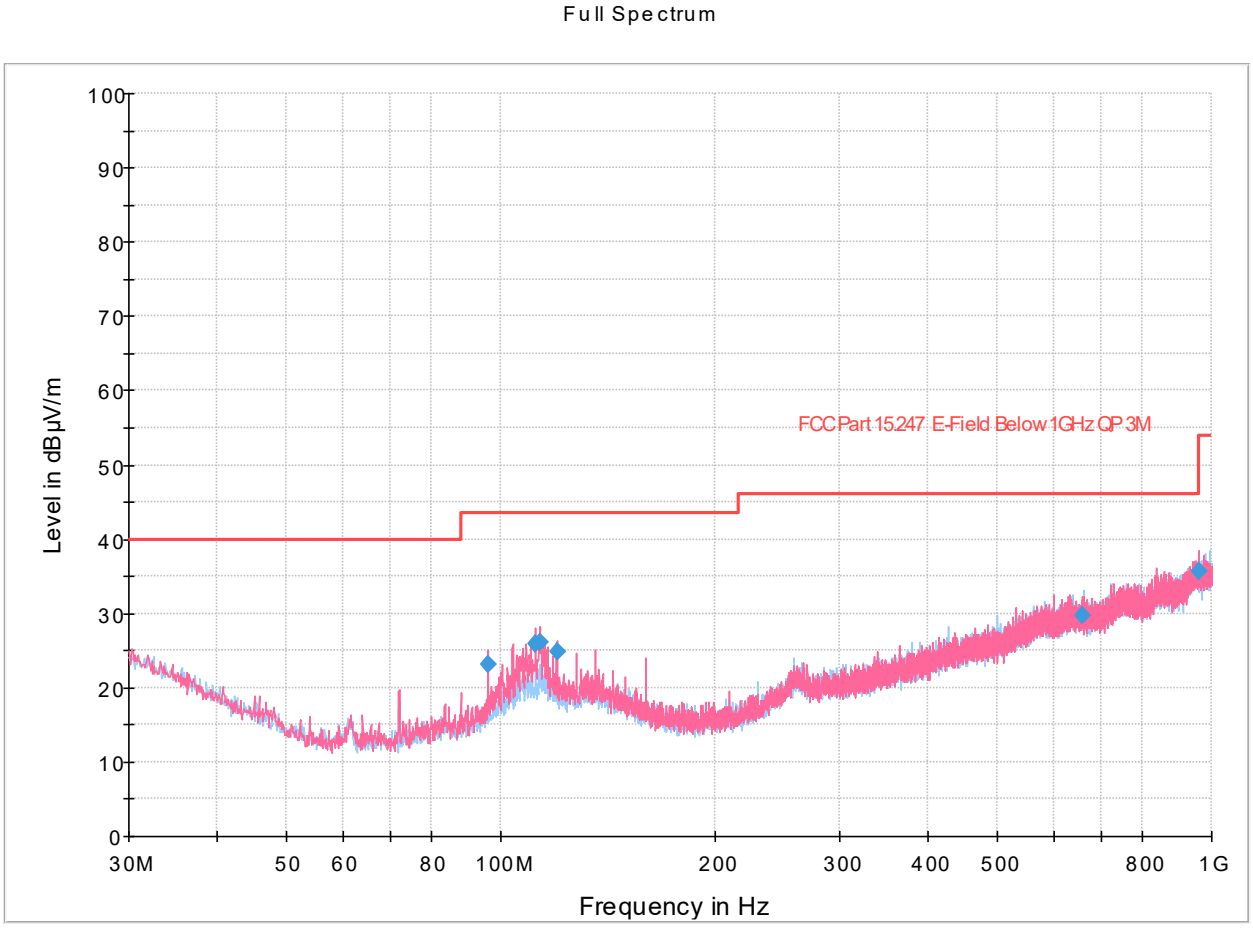


Figure 8.6-8: *Radiated emissions spectral plot (30 MHz - 1 GHz), 2402 MHz operation*

Table 8.6-6*: Radiated emissions results, 2402 MHz operation*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
96.000000	23.04	43.50	20.46	5000.0	120.000	380.0	V	20.0	16.1
112.045000	25.88	43.50	17.62	5000.0	120.000	400.0	V	0.0	18.2
113.654000	26.10	43.50	17.40	5000.0	120.000	399.0	V	0.0	18.4
120.016000	24.75	43.50	18.75	5000.0	120.000	373.0	V	180.0	18.4
658.975000	29.82	46.00	16.18	5000.0	120.000	393.0	H	181.0	30.2
960.551000	35.56	53.90	18.34	5000.0	120.000	196.0	V	221.0	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

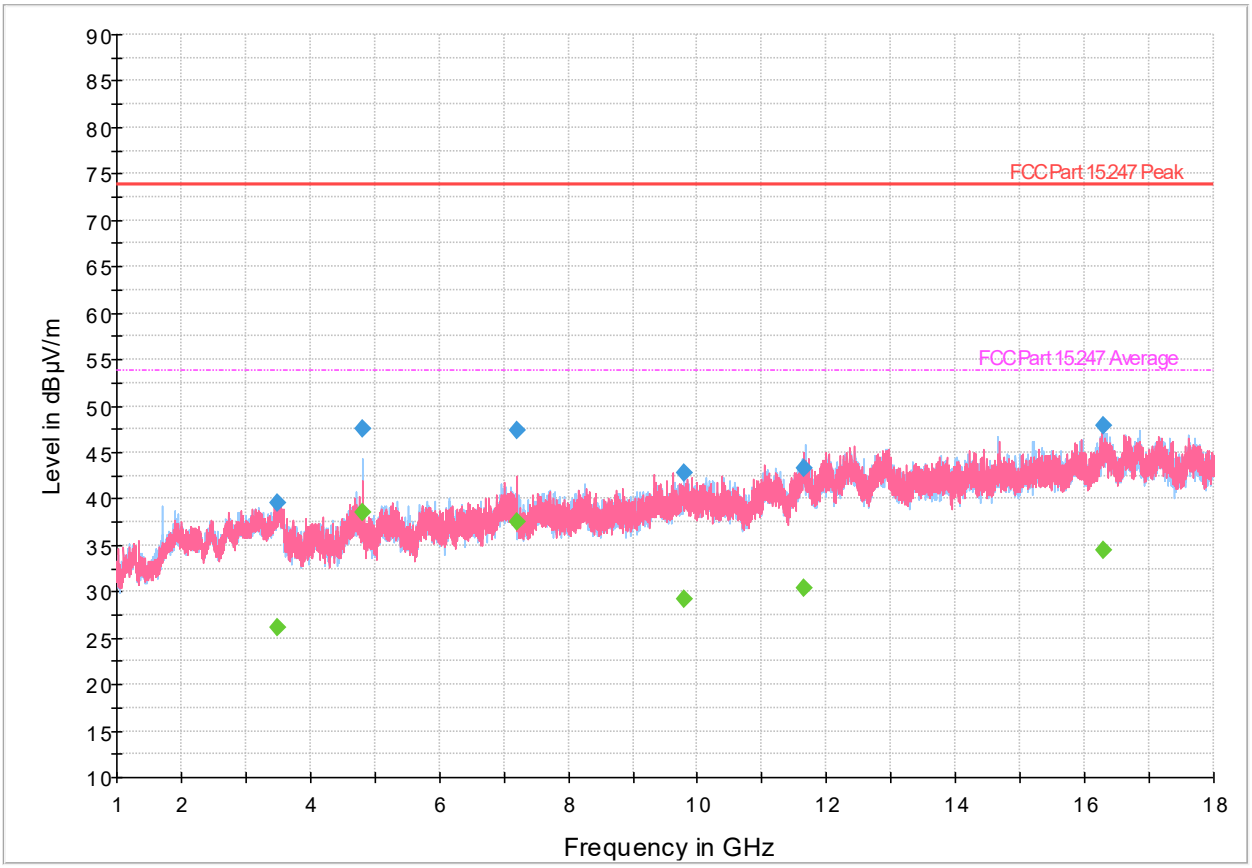


Figure 8.6-9: *Radiated emissions spectral plot (1 GHz - 18 GHz), 2402 MHz operation*

Table 8.6-7*: Radiated emissions results, 2402 MHz operation*

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)
3502.411111	39.53	---	73.90	34.37	5000.0	1000.000	374.0	H	0.0	-6.4
3502.411111	---	26.20	53.90	27.70	5000.0	1000.000	374.0	H	0.0	-6.4
4804.622222	47.61	---	73.90	26.29	5000.0	1000.000	175.0	H	84.0	-2.3
4804.622222	---	38.51	53.90	15.39	5000.0	1000.000	175.0	H	84.0	-2.3
7206.888889	47.44	---	73.90	26.46	5000.0	1000.000	120.0	V	328.0	0.4
7206.888889	---	37.48	53.90	16.42	5000.0	1000.000	120.0	V	328.0	0.4
9800.666667	---	29.27	53.90	24.63	5000.0	1000.000	104.0	H	327.0	3.6
9800.666667	42.77	---	73.90	31.13	5000.0	1000.000	104.0	H	327.0	3.6
11657.466667	43.26	---	73.90	30.64	5000.0	1000.000	154.0	H	257.0	5.1
11657.466667	---	30.30	53.90	23.60	5000.0	1000.000	154.0	H	257.0	5.1
16288.422222	---	34.42	53.90	19.48	5000.0	1000.000	203.0	H	0.0	13.3
16288.422222	47.79	---	73.90	26.11	5000.0	1000.000	203.0	H	0.0	13.3

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.
The fundamental emission at 2402 MHz was suppressed with a 2.4 GHz notch filter.

Full Spectrum

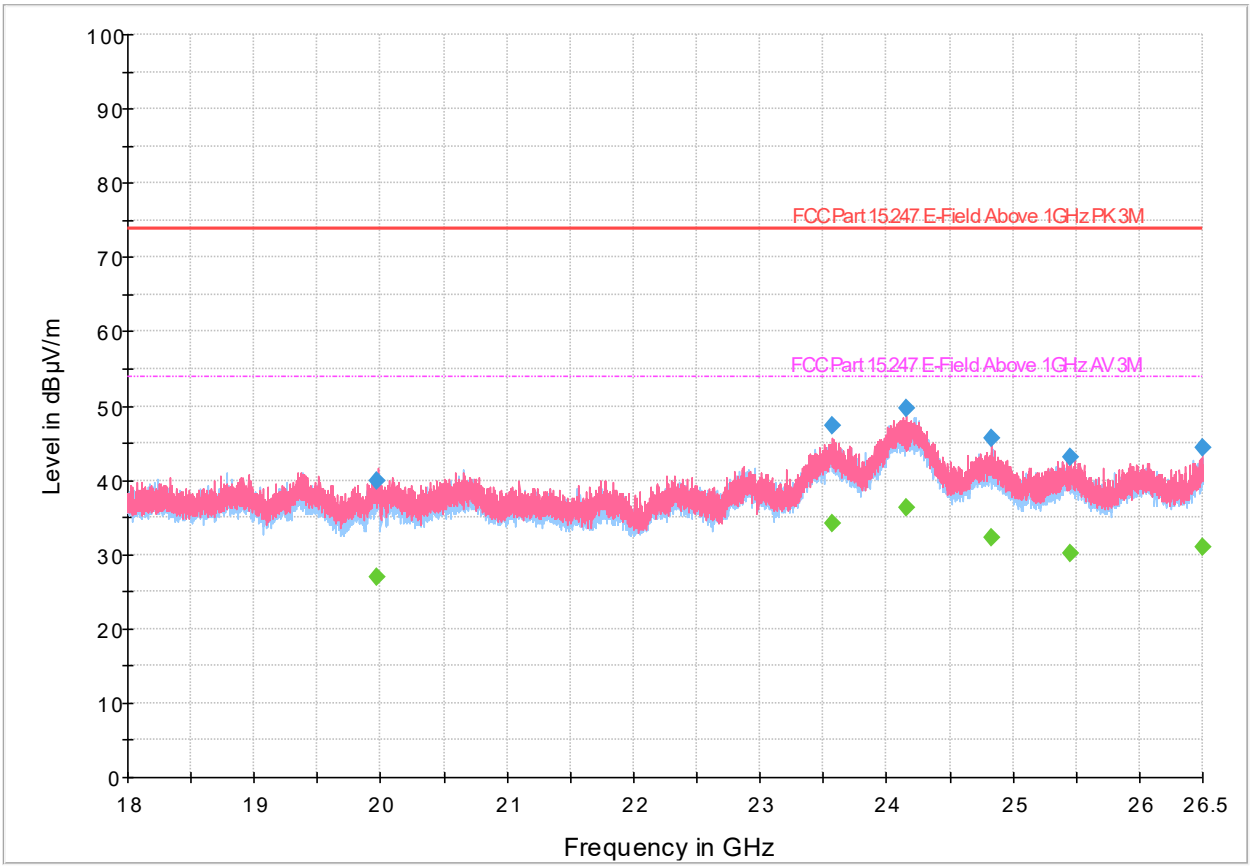


Figure 8.6-10: *Radiated emissions spectral plot (18 GHz - 26.5 GHz), 2402 MHz operation*

Table 8.6-8*: Radiated emissions results, 2402 MHz operation*

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)
19965.450000	39.87	---	73.90	34.03	5000.0	1000.000	333.0	V	88.0	16.3
19965.450000	---	26.96	53.90	26.94	5000.0	1000.000	333.0	V	88.0	16.3
23574.656250	47.40	---	73.90	26.50	5000.0	1000.000	292.0	V	117.0	23.9
23574.656250	---	34.10	53.90	19.80	5000.0	1000.000	292.0	V	117.0	23.9
24162.381250	---	36.40	53.90	17.50	5000.0	1000.000	335.0	V	118.0	27.2
24162.381250	49.74	---	73.90	24.16	5000.0	1000.000	335.0	V	118.0	27.2
24834.162500	45.66	---	73.90	28.24	5000.0	1000.000	399.0	V	55.0	22.3
24834.162500	---	32.34	53.90	21.56	5000.0	1000.000	399.0	V	55.0	22.3
25448.337500	43.12	---	73.90	30.78	5000.0	1000.000	397.0	V	337.0	21.7
25448.337500	---	30.16	53.90	23.74	5000.0	1000.000	397.0	V	337.0	21.7
26494.900000	---	30.99	53.90	22.91	5000.0	1000.000	392.0	V	174.0	23.4
26494.900000	44.41	---	73.90	29.49	5000.0	1000.000	392.0	V	174.0	23.4

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

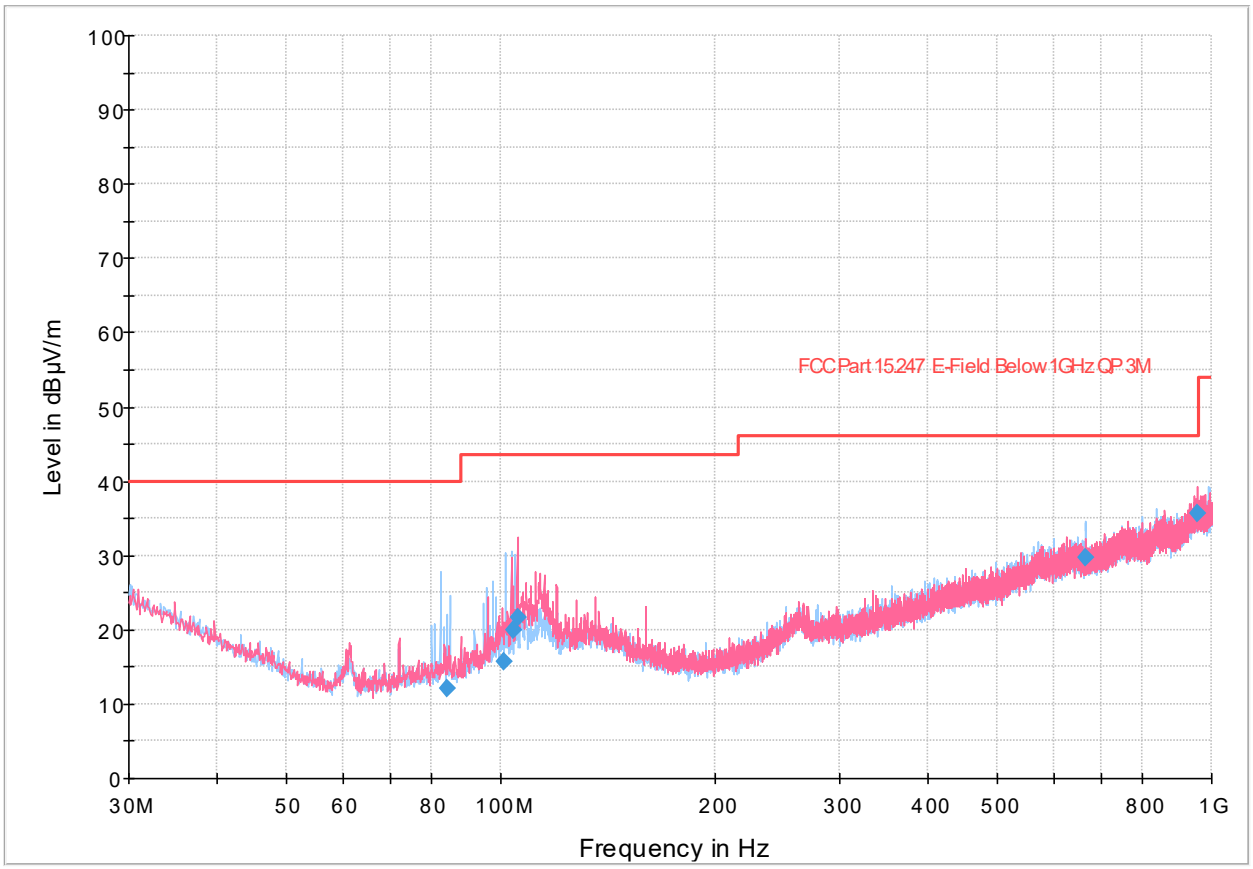


Figure 8.6-11: *Radiated emissions spectral plot (30 MHz - 1 GHz), 2441 MHz operation*

Table 8.6-9*: Radiated emissions results, 2441 MHz operation*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
84.020000	12.20	40.00	27.80	5000.0	120.000	159.0	H	116.0	14.3
101.026000	15.62	43.50	27.88	5000.0	120.000	291.0	H	147.0	17.1
103.983000	19.90	43.50	23.60	5000.0	120.000	272.0	H	78.0	17.6
105.580000	21.56	43.50	21.94	5000.0	120.000	387.0	V	19.0	17.8
665.253000	29.68	46.00	16.32	5000.0	120.000	270.0	H	67.0	30.1
954.497000	35.60	46.00	10.40	5000.0	120.000	145.0	V	66.0	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

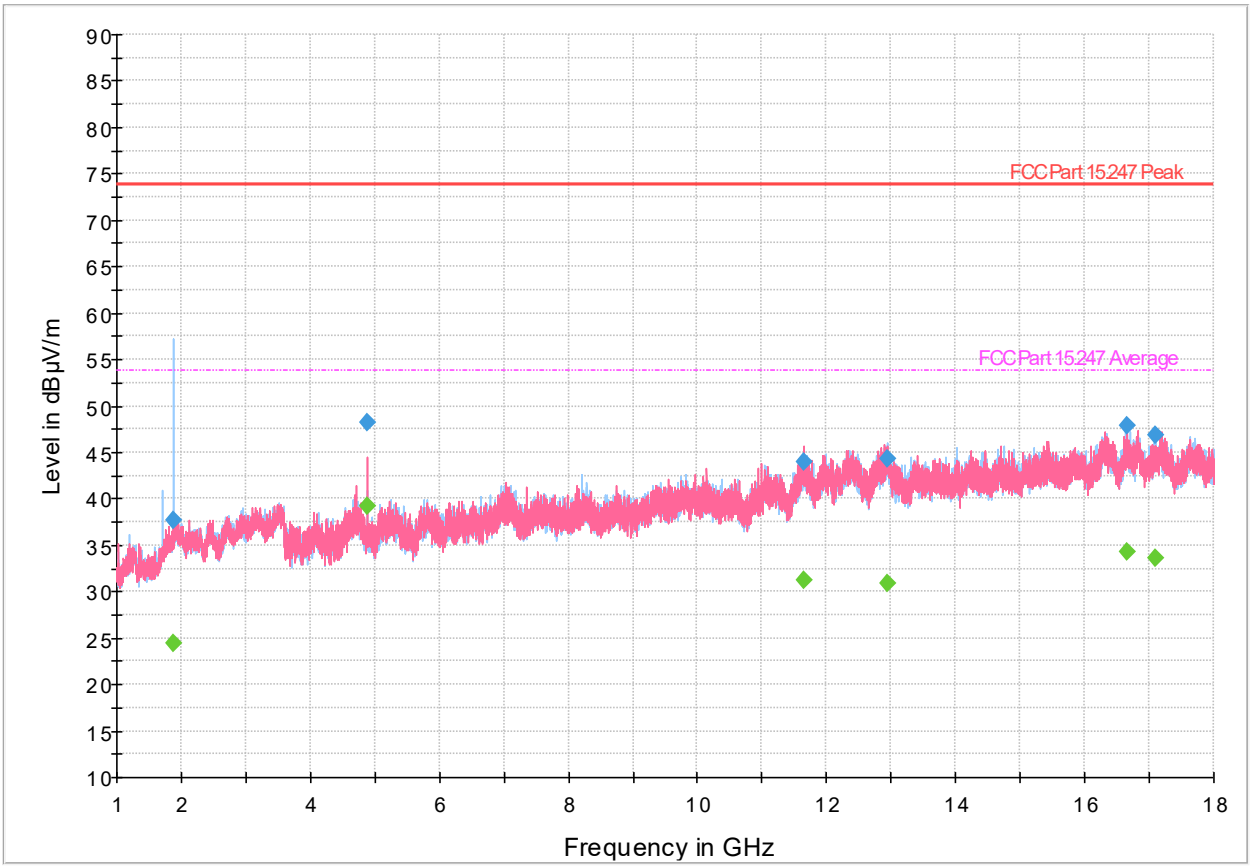


Figure 8.6-12: *Radiated emissions spectral plot (1 GHz - 18 GHz), 2441 MHz operation*

Table 8.6-10*: Radiated emissions results, 2441 MHz operation*

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)
1888.655556	---	24.44	53.90	29.46	5000.0	1000.000	104.0	H	216.0	-10.8
1888.655556	37.66	---	73.90	36.24	5000.0	1000.000	104.0	H	216.0	-10.8
4881.666667	---	39.18	53.90	14.72	5000.0	1000.000	117.0	V	126.0	-2.3
4881.666667	48.27	---	73.90	25.63	5000.0	1000.000	117.0	V	126.0	-2.3
11641.888889	43.91	---	73.90	29.99	5000.0	1000.000	390.0	V	254.0	4.9
11641.888889	---	31.31	53.90	22.59	5000.0	1000.000	390.0	V	254.0	4.9
12936.611111	---	30.90	53.90	23.00	5000.0	1000.000	400.0	H	286.0	8.6
12936.611111	44.33	---	73.90	29.57	5000.0	1000.000	400.0	H	286.0	8.6
16653.511111	---	34.37	53.90	19.53	5000.0	1000.000	276.0	H	88.0	14.1
16653.511111	47.84	---	73.90	26.06	5000.0	1000.000	276.0	H	88.0	14.1
17102.855556	46.78	---	73.90	27.12	5000.0	1000.000	322.0	H	205.0	13.5
17102.855556	---	33.65	53.90	20.25	5000.0	1000.000	322.0	H	205.0	13.5

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.
The fundamental emission at 2441 MHz was suppressed with a 2.4 GHz notch filter.

Full Spectrum

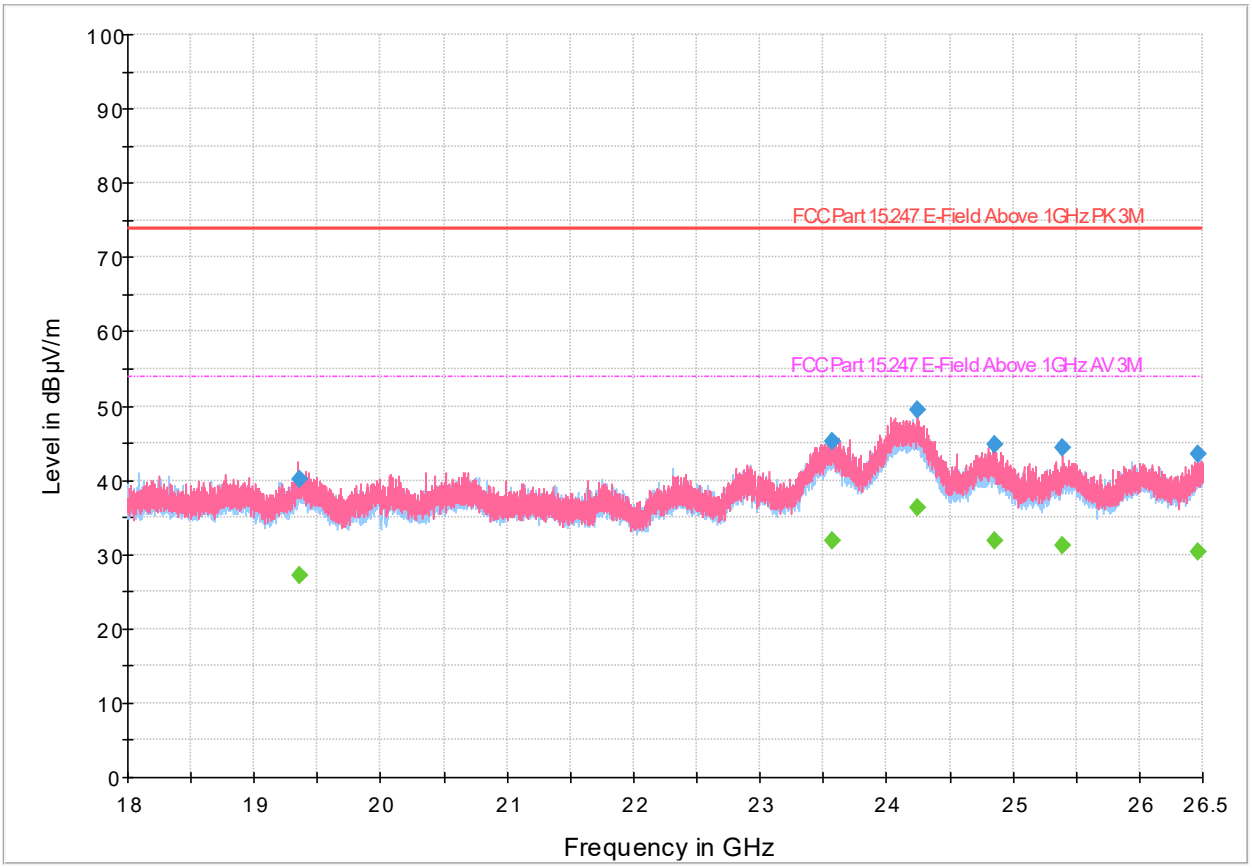


Figure 8.6-13: *Radiated emissions spectral plot (18 GHz - 26.5 GHz), 2441 MHz operation*

Table 8.6-11*: Radiated emissions results, 2441 MHz operation*

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)
19353.968750	40.14	---	73.90	33.76	5000.0	1000.000	308.0	V	23.0	16.7
19353.968750	---	27.12	53.90	26.78	5000.0	1000.000	308.0	V	23.0	16.7
23569.606250	45.27	---	73.90	28.63	5000.0	1000.000	142.0	H	285.0	23.9
23569.606250	---	31.84	53.90	22.06	5000.0	1000.000	142.0	H	285.0	23.9
24250.200000	49.45	---	73.90	24.45	5000.0	1000.000	315.0	V	86.0	26.9
24250.200000	---	36.22	53.90	17.68	5000.0	1000.000	315.0	V	86.0	26.9
24854.856250	44.82	---	73.90	29.08	5000.0	1000.000	391.0	V	23.0	22.3
24854.856250	---	31.89	53.90	22.01	5000.0	1000.000	391.0	V	23.0	22.3
25393.725000	44.33	---	73.90	29.57	5000.0	1000.000	370.0	V	10.0	21.5
25393.725000	---	31.12	53.90	22.78	5000.0	1000.000	370.0	V	10.0	21.5
26461.768750	43.59	---	73.90	30.31	5000.0	1000.000	247.0	V	268.0	23.2
26461.768750	---	30.30	53.90	23.60	5000.0	1000.000	247.0	V	268.0	23.2

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

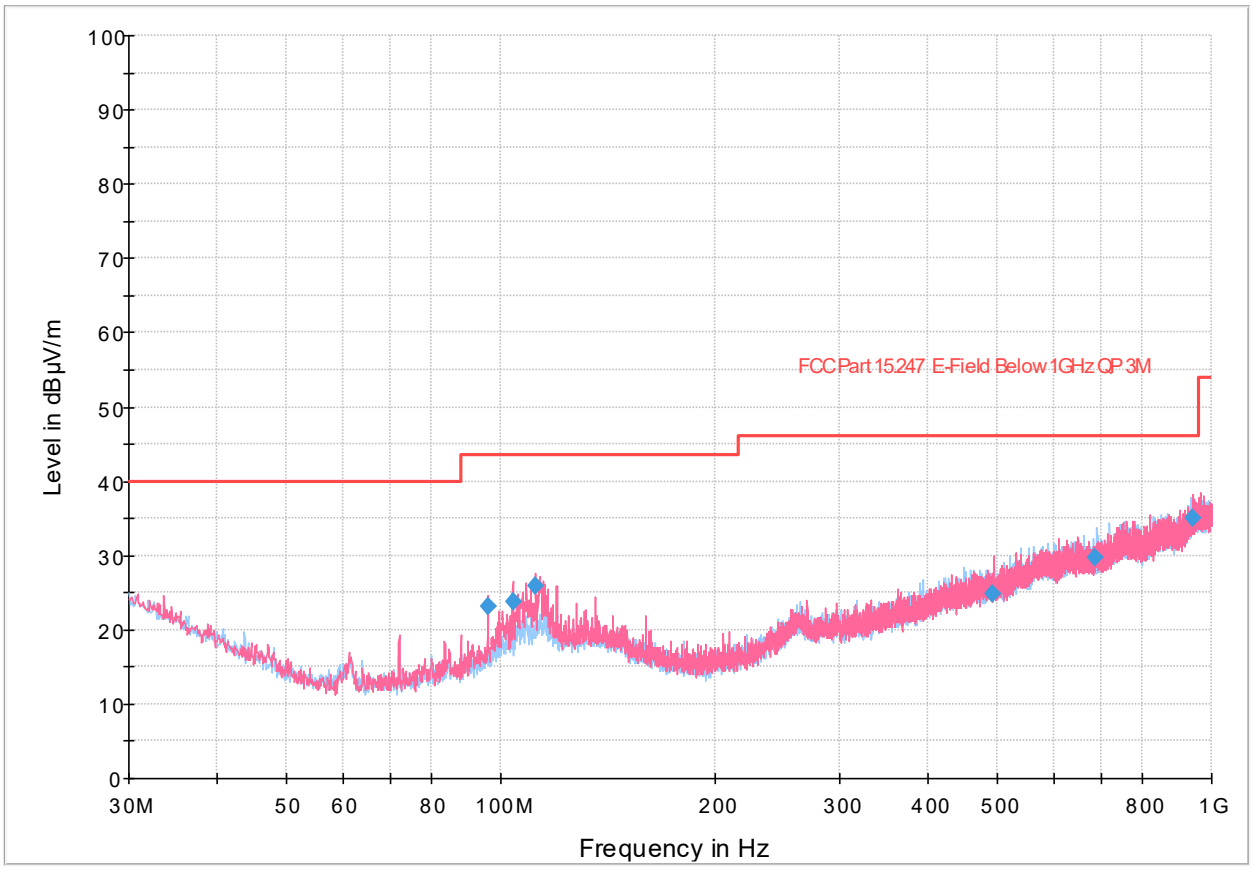


Figure 8.6-14: *Radiated emissions spectral plot (30 MHz - 1 GHz), 2480 MHz operation*

Table 8.6-12*: Radiated emissions results, 2480 MHz operation*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
96.017000	23.23	43.50	20.27	5000.0	120.000	358.0	V	230.0	16.1
104.051000	23.87	43.50	19.63	5000.0	120.000	400.0	V	293.0	17.6
112.045000	25.81	43.50	17.69	5000.0	120.000	383.0	V	154.0	18.2
492.391000	24.89	46.00	21.11	5000.0	120.000	164.0	V	168.0	26.5
687.180000	29.82	46.00	16.18	5000.0	120.000	147.0	H	171.0	30.2
939.609000	35.11	46.00	10.89	5000.0	120.000	183.0	V	269.0	35.2

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

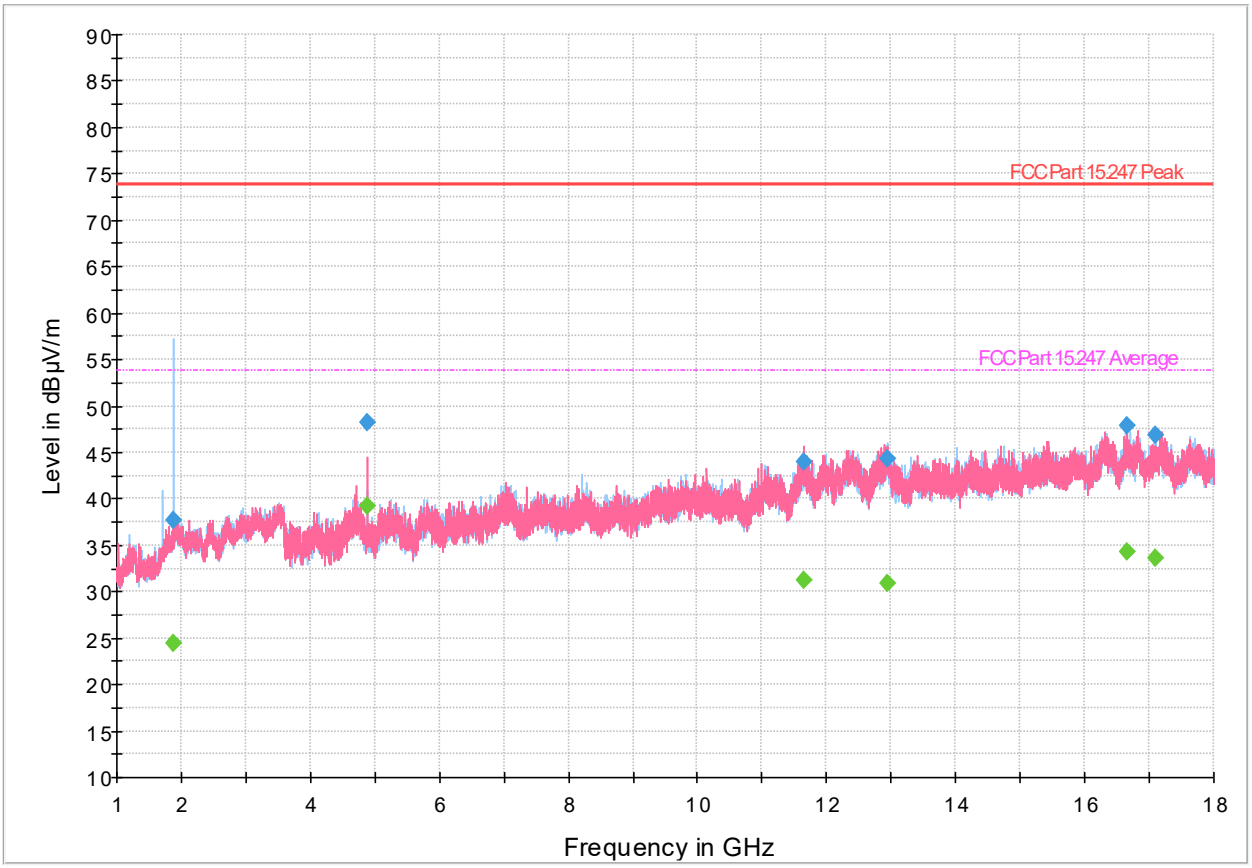


Figure 8.6-15: *Radiated emissions spectral plot (1 GHz - 18 GHz), 2480 MHz operation*

Table 8.6-13*: Radiated emissions results, 2480 MHz operation*

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)
1888.655556	---	24.44	53.90	29.46	5000.0	1000.000	104.0	H	216.0	-10.8
1888.655556	37.66	---	73.90	36.24	5000.0	1000.000	104.0	H	216.0	-10.8
4881.666667	---	39.18	53.90	14.72	5000.0	1000.000	117.0	V	126.0	-2.3
4881.666667	48.27	---	73.90	25.63	5000.0	1000.000	117.0	V	126.0	-2.3
11641.888889	43.91	---	73.90	29.99	5000.0	1000.000	390.0	V	254.0	4.9
11641.888889	---	31.31	53.90	22.59	5000.0	1000.000	390.0	V	254.0	4.9
12936.611111	---	30.90	53.90	23.00	5000.0	1000.000	400.0	H	286.0	8.6
12936.611111	44.33	---	73.90	29.57	5000.0	1000.000	400.0	H	286.0	8.6
16653.511111	---	34.37	53.90	19.53	5000.0	1000.000	276.0	H	88.0	14.1
16653.511111	47.84	---	73.90	26.06	5000.0	1000.000	276.0	H	88.0	14.1
17102.855556	46.78	---	73.90	27.12	5000.0	1000.000	322.0	H	205.0	13.5
17102.855556	---	33.65	53.90	20.25	5000.0	1000.000	322.0	H	205.0	13.5

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.
The fundamental emission at 2480 MHz was suppressed with a 2.4 GHz notch filter.

Full Spectrum

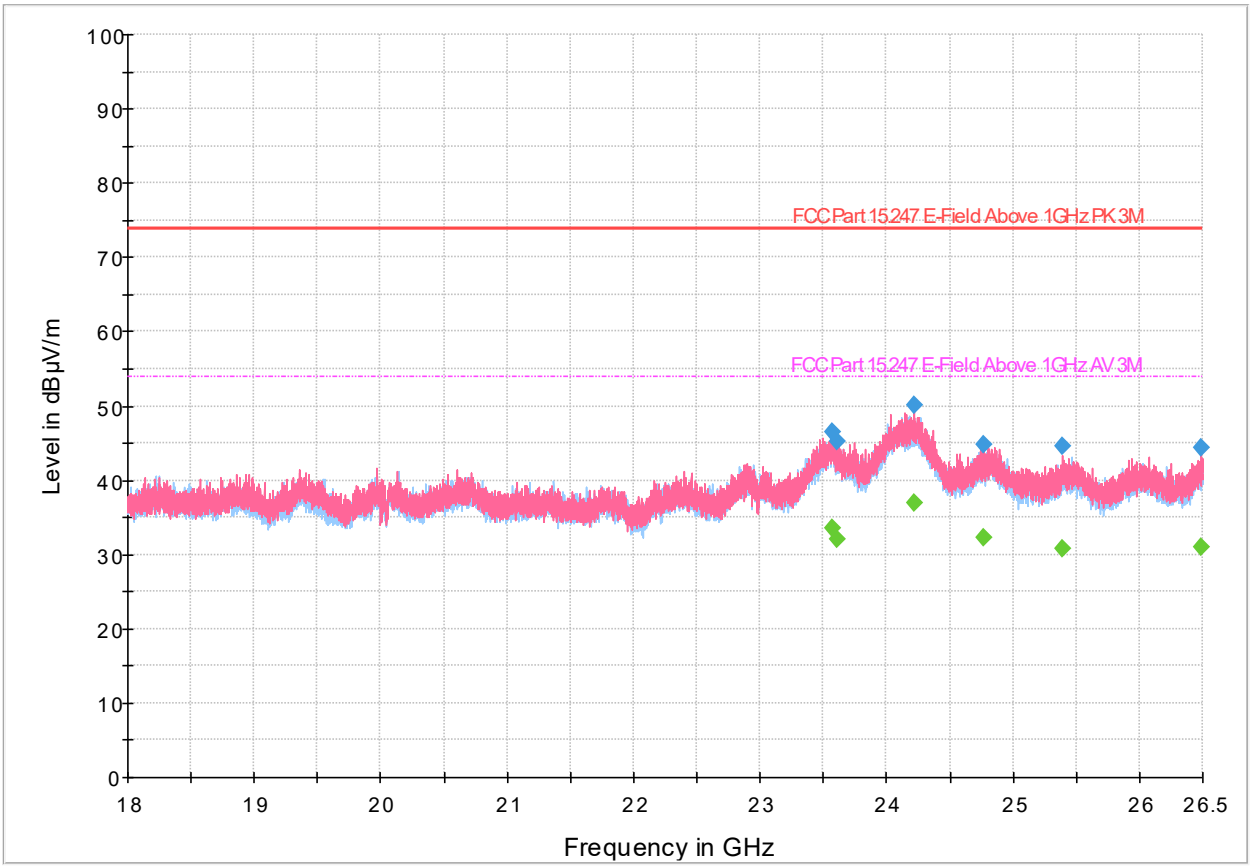


Figure 8.6-16: *Radiated emissions spectral plot (18 GHz - 26.5 GHz), 2480 MHz operation*

Table 8.6-14*: Radiated emissions results, 2480 MHz operation*

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)
23565.325000	46.48	---	73.90	27.42	5000.0	1000.000	309.0	V	339.0	23.8
23565.325000	---	33.50	53.90	20.40	5000.0	1000.000	309.0	V	339.0	23.8
23608.650000	---	32.08	53.90	21.82	5000.0	1000.000	397.0	H	345.0	23.8
23608.650000	45.19	---	73.90	28.71	5000.0	1000.000	397.0	H	345.0	23.8
24223.400000	---	36.91	53.90	16.99	5000.0	1000.000	291.0	V	237.0	27.0
24223.400000	50.11	---	73.90	23.79	5000.0	1000.000	291.0	V	237.0	27.0
24772.281250	44.76	---	73.90	29.14	5000.0	1000.000	330.0	V	11.0	22.3
24772.281250	---	32.17	53.90	21.73	5000.0	1000.000	330.0	V	11.0	22.3
25392.131250	---	30.80	53.90	23.10	5000.0	1000.000	165.0	V	145.0	21.5
25392.131250	44.57	---	73.90	29.33	5000.0	1000.000	165.0	V	145.0	21.5
26486.437500	---	31.01	53.90	22.89	5000.0	1000.000	381.0	V	0.0	23.4
26486.437500	44.30	---	73.90	29.60	5000.0	1000.000	381.0	V	0.0	23.4

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.

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	December 5, 2023	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1002 mbar
Test location	☒ Wireless bench ☐ Other:	Relative humidity	56 %

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	3.7 V DC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ 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)
2402	GFSK, 1 Mbps	-12.89	≤ 8
2441	GFSK, 1 Mbps	-12.69	≤ 8
2480	GFSK, 1 Mbps	-14.26	≤ 8

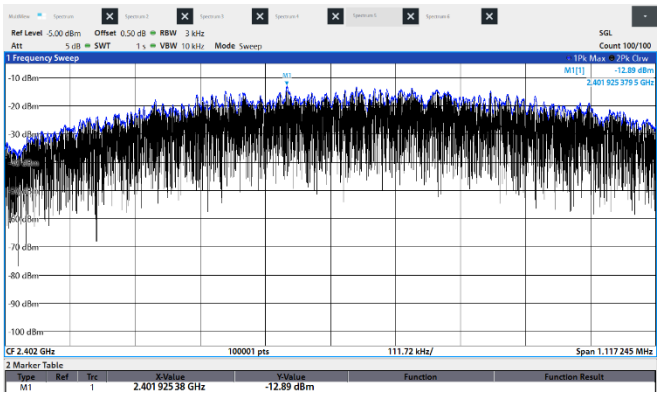


Figure 8.7-1: *Power spectral density, GFSK, 1 Mbps, 2402 MHz*

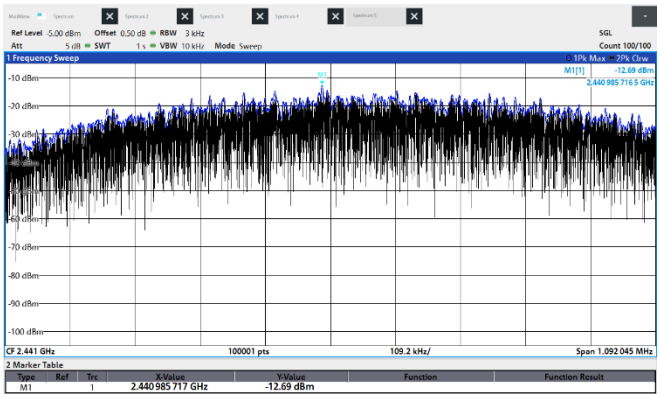


Figure 8.7-2: *Power spectral density, GFSK, 1 Mbps, 2441 MHz*

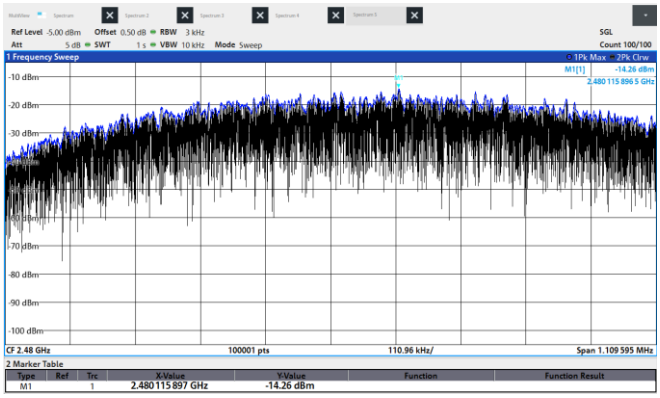


Figure 8.7-3: *Power spectral density, GFSK, 1 Mbps, 2480 MHz*

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	December 5, 2023	Temperature	20 °C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1002 mbar
Test location	☒ Wireless bench ☐ Other:	Relative humidity	56 %

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	3.7 V DC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ Other:

Receiver settings:

Resolution bandwidth	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_l (MHz)	f_h (MHz)	Limit
2402	GFSK, 1 Mbps	1.067	2401.531	2402.597	f_H and f_L within 2400 – 2483.5 MHz
2441	GFSK, 1 Mbps	1.071	2440.808	2441.600	f_H and f_L within 2400 – 2483.5 MHz
2480	GFSK, 1 Mbps	1.068	2479.545	2480.612	f_H and f_L within 2400 – 2483.5 MHz

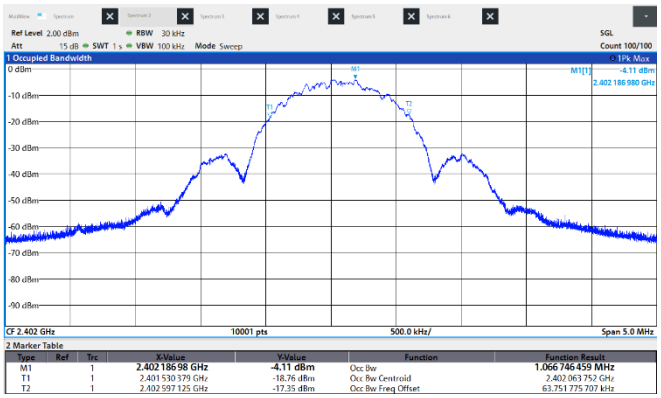


Figure 8.8-1: *99% occupied bandwidth, GFSK, 1 Mbps, 2402 MHz*

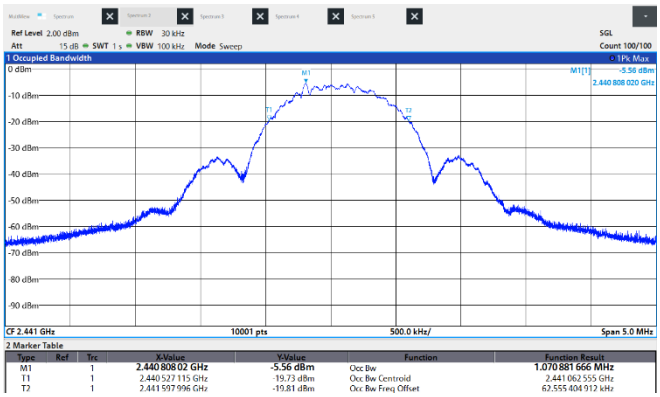


Figure 8.8-2: *99% occupied bandwidth, GFSK, 1 Mbps, 2441 MHz*

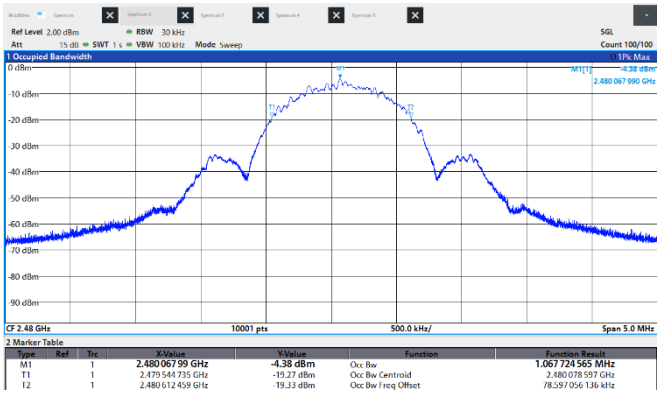


Figure 8.8-3: *99% occupied bandwidth, GFSK, 1 Mbps, 2480 MHz*

End of test report