



Test report

REP026818-1R1TRFWL

Date of issue: April 25, 2024

Applicant:

Murphy's Bowl LLC

Product description:

Murphy's Bowl Access Portal (MBAP)

Model:

IDAP v1.0, IDAP nUWB x1.0

Variants:

None

FCC ID:

2BE69-MBAP01

Specifications:

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

Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5727 – 5850 MHz

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	April 25, 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 contained 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

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
REPO26818-1TRFWL	March 30, 2024	Original report issued
REPO26818-1R1TRFWL	April 25, 2024	Updated following TCB feedback

Section 2 Summary of test results

2.1 Sample information

Receipt date	06-Feb-24
Nemko sample ID number	REP026818

2.2 Testing period

Test start date	09-Feb-24
Test end date	23-Feb-24

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
§15.231(c)	20 dB bandwidth	Pass

Notes: ¹ EUT is directly or indirectly powered via AC mains

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

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	Murphy's Bowl LLC
Address	10400 NE 4th Street, Suite 3600,
City	Bellevue
State	WA
Postal/Zip code	98004
Country	United States

3.3 Manufacturer

Company name	Schippers and Crew, Inc.
Address	5309 Shilshole Ave NW, Suite 100
City	Seattle
State	WA
Postal/Zip code	98107
Country	United States

3.4 EUT information

Product name	Murphy's Bowl Access Portal (MBAP)
Model	IDAP v1.0, IDAP nUWB x1.0
Variant(s)	None
Serial number	None
Part number	None
Power requirements	48v DC or PoE
Description/theory of operation	None
Operational frequencies	2402-2480MHz
Software details	None

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 type="checkbox"/> 2 Mbps operation
Tested frequencies	2402 MHz (low), 2440 MHz (middle), and 2480 MHz (high)
Antenna type	Integrated antenna
Antenna peak gain	0.65 dBi

3.6 EUT setup details

Table 3.6-1: EUT sub assemblies

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

Table 3.6-2: EUT interface ports

Description	Qty.
USB	2
Ethernet	3
Power	1

Table 3.6-3: Support equipment

Description	Brand name	Model/Part number	Serial number	Rev.
Laptop	HP	Latitude 5420	None	None
Network switch	Netgear	MS108EUP	6R52285WA0057	None

Table 3.6-4: Inter-connection cables

Cable description	From	To	Length (m)
Ethernet cable	Network switch	EUT	4m

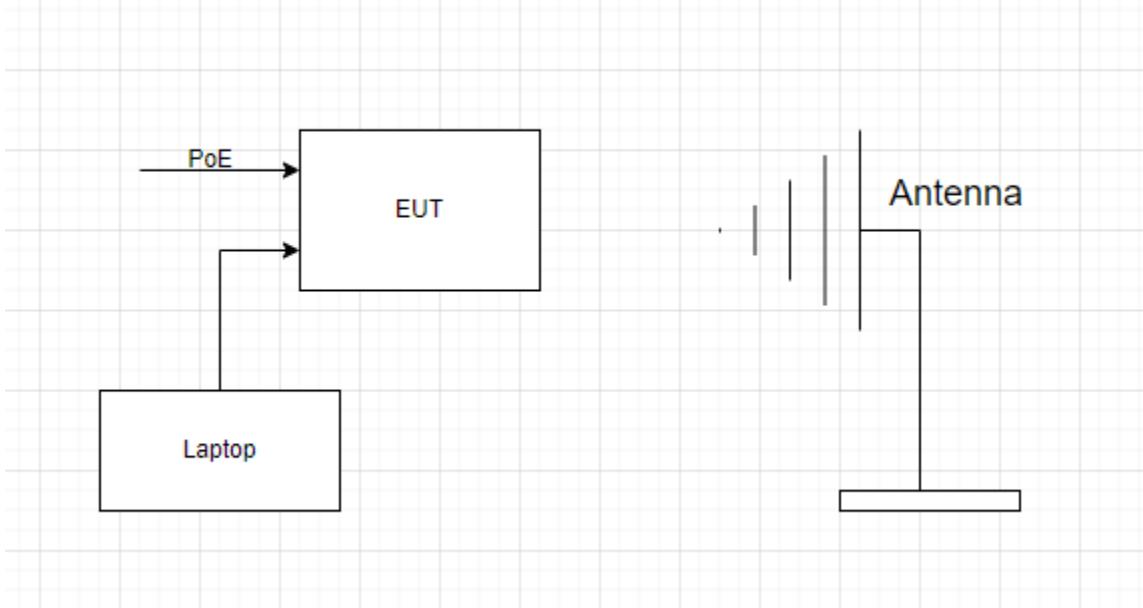


Figure 3.6-1: Test setup diagram

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

Notes: Compliance assessment:

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

- compliance is deemed to occur if no measured disturbance level exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance level exceeds the disturbance limit

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

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

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

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: Test Equipment List

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESU40	E1121	08-23-2023	08-23-2024
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	04-15-2023	04-17-2024
Antenna, DRWG	EMCO	3115	1033	11-02-2022	11-02-2024
Standard Gain Horn Antenna	Eravant	SAZ-2410-42-S1	EW107	12-05-2023	12-05-2024
10dB transmit limiter	HP	11947A	E1159	02-27-2023	02-27-2024
Two Line V-Network	Rohde & Schwarz	ENV216	E1020	10-02-2023	10-02-2024
DRG Horn	ETS-Lindgren	3117-PA	E1160	03-13-2023	03-13-2024

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
- Test method: ANSI C63.10-2020 §6.2

Table 8.1-1: Conducted emissions limit

Frequency of emission, MHz	Quasi-peak	Conducted limit, dB μ V	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	February 22, 2024	Temperature	22 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1002.3 mbar
Test location	<input type="checkbox"/> 10m semi anechoic chamber <input type="checkbox"/> 3m semi anechoic chamber <input checked="" type="checkbox"/> Other: Ground plane	Relative humidity	54 %

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 to 48VDC
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.

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

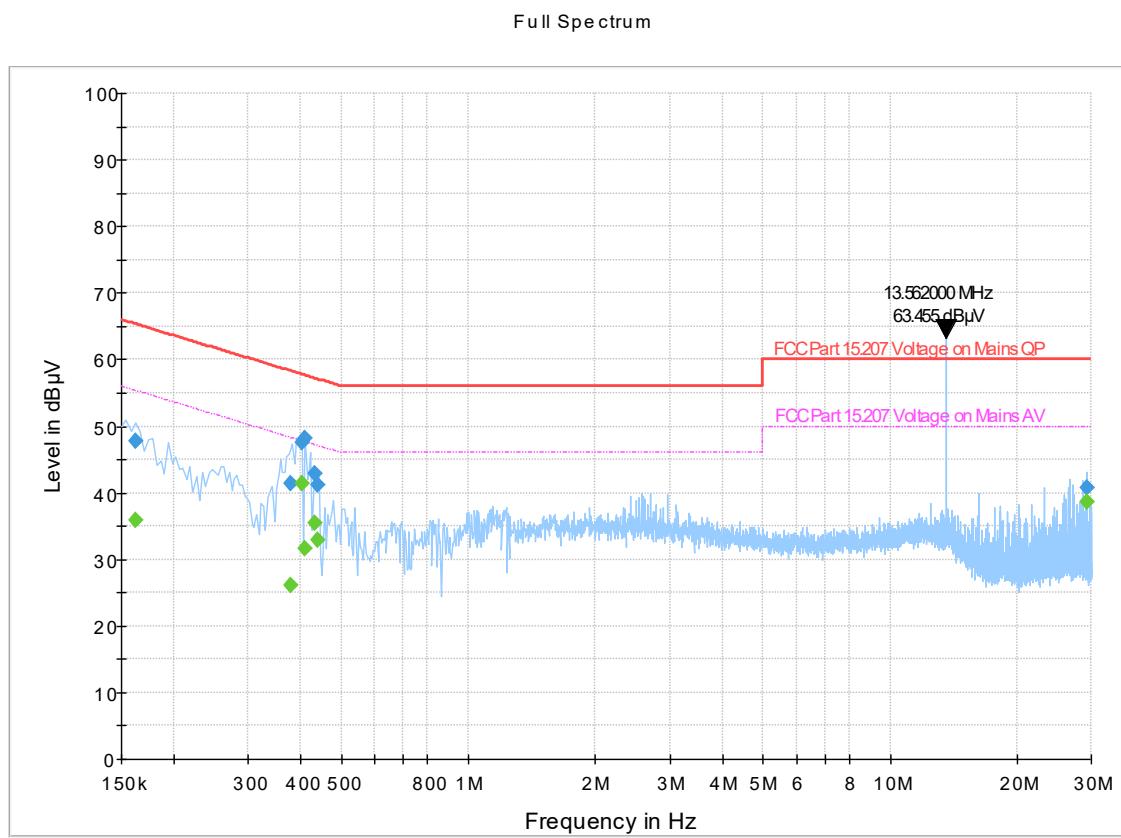


Figure 8.1-1: Conducted emissions at mains port spectral plot (150 kHz - 30 MHz)

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)
0.162000	---	35.79	55.36	19.57	5000.0	9.000	L1	ON	19.6
0.162000	47.76	---	65.36	17.60	5000.0	9.000	L1	ON	19.6
0.378000	41.36	---	58.32	16.96	5000.0	9.000	N	ON	19.5
0.378000	---	26.17	48.32	22.15	5000.0	9.000	N	ON	19.5
0.402000	47.53	---	57.81	10.28	5000.0	9.000	N	ON	19.5
0.402000	---	41.42	47.81	6.39	5000.0	9.000	N	ON	19.5
0.410000	48.20	---	57.65	9.45	5000.0	9.000	L1	ON	19.5
0.410000	---	31.60	47.65	16.05	5000.0	9.000	L1	ON	19.5
0.430000	42.90	---	57.25	14.36	5000.0	9.000	L1	ON	19.5
0.430000	---	35.51	47.25	11.74	5000.0	9.000	L1	ON	19.5
0.438000	---	32.89	47.10	14.21	5000.0	9.000	N	ON	19.5
0.438000	41.14	---	57.10	15.96	5000.0	9.000	N	ON	19.5
29.238000	---	38.54	50.00	11.46	5000.0	9.000	N	ON	20.6
29.238000	40.80	---	60.00	19.20	5000.0	9.000	N	ON	20.6

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.

Emission marked at 13.56 MHz is the intentional NFC radiator which could not be disabled. The emission is not evaluated against the limits.

8.2 Antenna requirement

8.2.1 References and limits

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

§15.203:

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

Verdict	Pass		
Test date	March 6, 2024	Temperature	22 °C
Test engineer	Chenhai Ma, Wireless Test Technician	Air pressure	1002.7 mbar
Test location	<input type="checkbox"/> Wireless bench <input checked="" type="checkbox"/> Other: 3m anechoic chamber	Relative humidity	56 %

8.2.2 Notes

None

8.2.3 Test data

Antenna part number:	None
Technical description:	None
Peak gain (dBi):	0.65 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: REP026818-9TRFEMC_Antenna gain BLE

8.3 20 dB bandwidth

8.3.1 References and limits

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

§15.215:

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

8.3.2 Test summary

Verdict	Pass		
Test date	February 6, 2024	Temperature	22 °C
Test engineer	Chenaho Ma, Wireless Test Technician	Air pressure	1003.2 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	49.6 %

8.3.3 Notes

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

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

8.3.4 Setup details

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

Receiver/spectrum analyzer settings:

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

8.3.5 Test data

Table 8.3-1: 20 dB bandwidth test data

Test frequency (MHz)	Modulation	Bandwidth (MHz)	Measured f_L (MHz)	Measured f_H (MHz)	Limit	Verdict
2402	GFSK, 1 Mbps	1.2215	2401.384	2402.606	f_H and f_L within 2400 – 2483.5 MHz	Pass
2440	GFSK, 1 Mbps	1.225	2439.388	2440.613	f_H and f_L within 2400 – 2483.5 MHz	Pass
2480	GFSK, 1 Mbps	1.2285	2479.384	2480.613	f_H and f_L within 2400 – 2483.5 MHz	Pass

Section 8

Test name

Testing data
20 dB bandwidth

Specification(s)

FCC 15.247



Occupied bandwidth (20 dB), TX: 2402 MHz, BW: 1MHz, MOD: GFSK_1Mbps

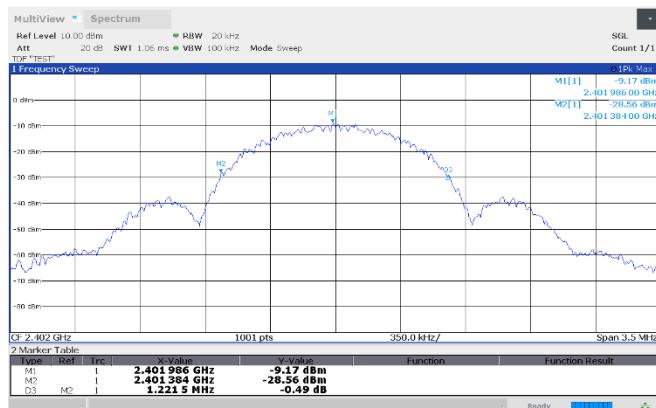


Figure 8.3-1: 20 dB bandwidth, GFSK, 1 Mbps, 2402 MHz

Occupied bandwidth (20 dB), TX: 2440 MHz, BW: 1MHz, MOD: GFSK_1Mbps

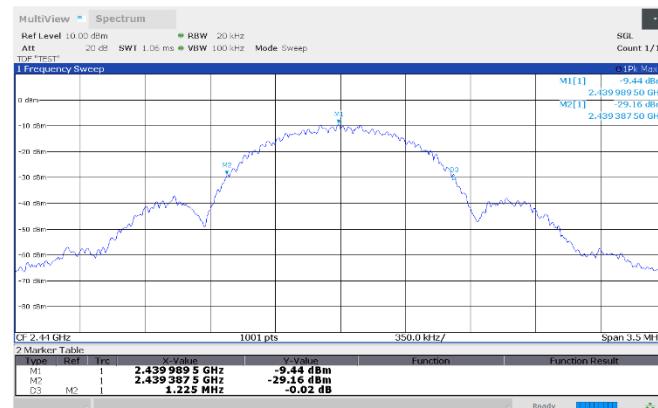


Figure 8.3-2: 20 dB bandwidth, GFSK, 1 Mbps, 2440 MHz

Occupied bandwidth (20 dB), TX: 2480 MHz, BW: 1MHz, MOD: GFSK_1Mbps

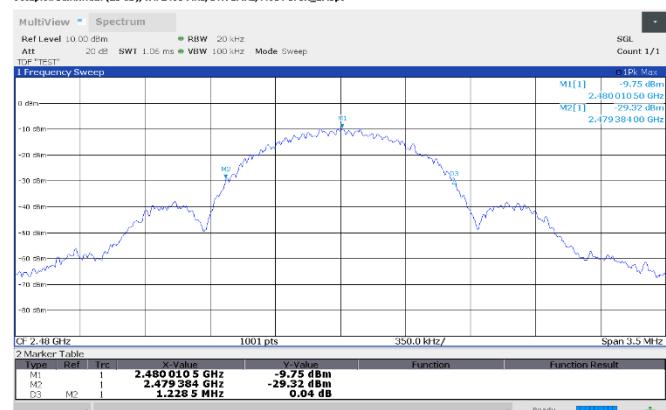


Figure 8.3-3: 20 dB bandwidth, GFSK, 1 Mbps, 2480 MHz

8.4 Minimum 6 dB bandwidth

8.4.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(a)(2)
- 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.

8.4.2 Test summary

Verdict	Pass		
Test date	February 6, 2024	Temperature	22 °C
Test engineer	Chenhai Ma, Wireless Test Technician	Air pressure	1003.2 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	49.6 %

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

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

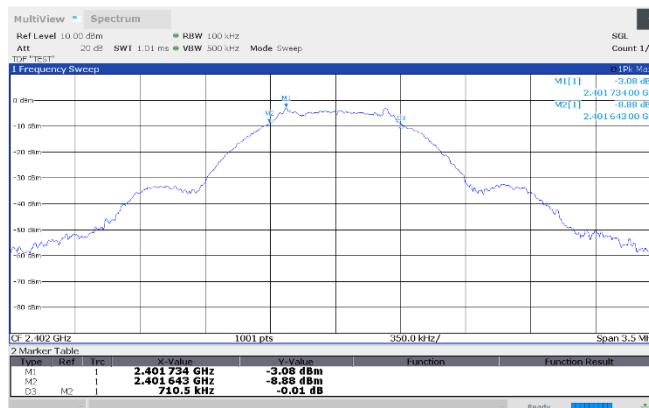
Section 8**Test name**

Testing data
Minimum 6 dB bandwidth
Specification(s)
FCC 15.247

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	710.5	≥ 500	Pass
2440	GFSK, 1 Mbps	713.24	≥ 500	Pass
2480	GFSK, 1 Mbps	697.27	≥ 500	Pass

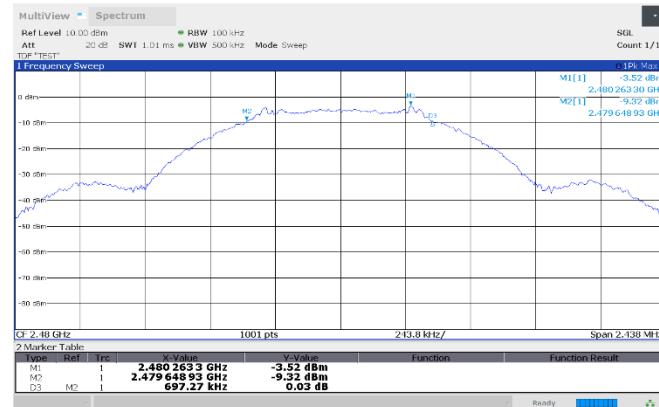
DTS bandwidth, TX: 2402 MHz, BW: 1MHz, MOD: GFSK_1Mbps

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

DTS bandwidth, TX: 2440 MHz, BW: 1MHz, MOD: GFSK_1Mbps

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

DTS bandwidth, TX: 2480 MHz, BW: 1MHz, MOD: GFSK_1Mbps

**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)
- Test method: ANSI C63.10-2020 §11.9.1.1 (RBW \geq DTS BW)

§15.247:

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

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

8.5.2 Test summary

Verdict	Pass		
Test date	February 6, 2024	Temperature	22 °C
Test engineer	Chenaho Ma, Wireless Test Technician	Air pressure	1003.2 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	49.6 %

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

Receiver/spectrum analyzer settings:

Resolution bandwidth	1 MHz
Video bandwidth	5 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)
2402	GFSK, 1 Mbps	-2.66	≤ 30
2440	GFSK, 1 Mbps	-3.11	≤ 30
2480	GFSK, 1 Mbps	-3.18	≤ 30

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

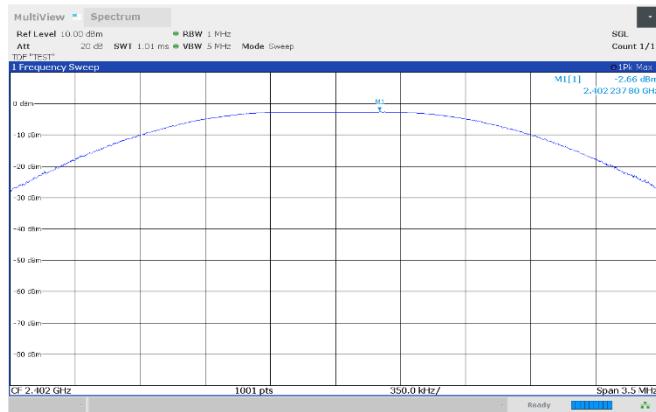


Figure 8.5-1: Maximum peak output power, GFSK, 1 Mbps, 2402 MHz

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

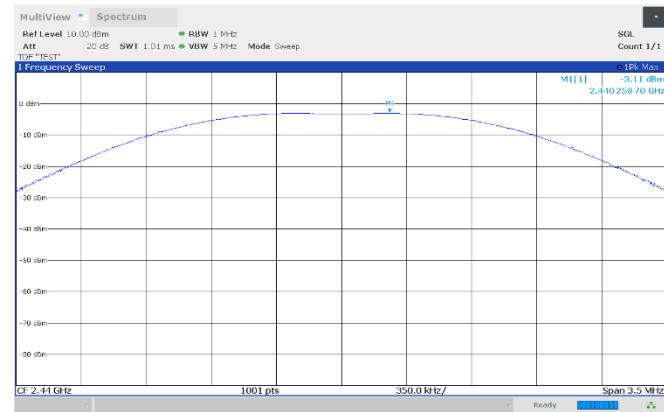


Figure 8.5-2: Maximum peak output power, GFSK, 1 Mbps, 2440 MHz

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

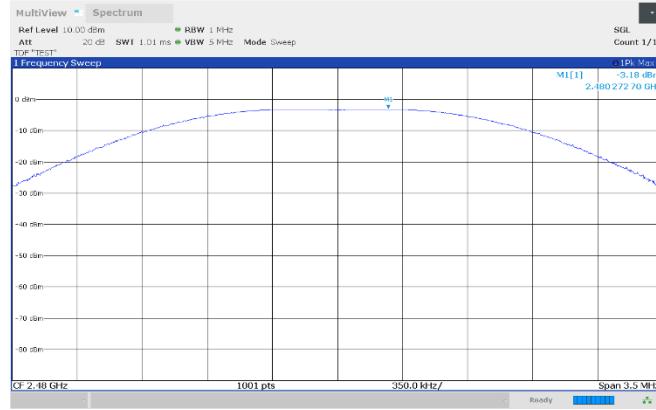


Figure 8.5-3: Maximum peak output power, GFSK, 1 Mbps, 2480 MHz

8.6 Spurious emissions

8.6.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(d)
- 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)).

Table 8.6-1: FCC §15.209 – Radiated emission limits

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

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

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

Table 8.6-2: FCC restricted frequency bands

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

8.6.2 Test summary

Verdict	Pass		
Test date	February 9, 2024	Temperature	21 °C
Test engineer	Chenhai Ma, Wireless Test Technician	Air pressure	1002.4 mbar
Test location	<input 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	53 %

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.

8.6.4 Setup details

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

Spectrum analyzer settings (conducted emissions):

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

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

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

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

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

8.6.5 Test data

Antenna port conducted spurious emissions:

- Authorized band edge:

Table 8.6-3: 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	2399.925	-57.97	-23.018	34.952
2480	GFSK, 1 Mbps	2483.871	-64.66	-23.507	41.153

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

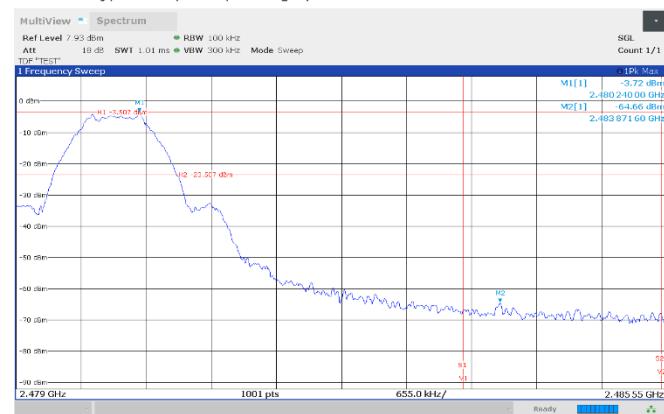


Figure 8.6-2: Authorized band-edge emissions, GFSK, 1 Mbps, 2480MHz

- Antenna port conducted spurious emissions:

Table 8.6-4: Antenna port conducted spurious emissions.

Test Frequency (MHz)	Modulation	Verdict
2402	GFSK, 1 Mbps	Pass
2440	GFSK, 1 Mbps	Pass
2480	GFSK, 1 Mbps	Pass

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

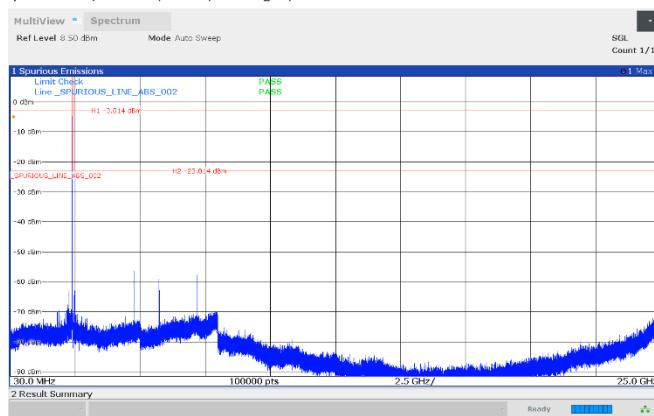


Figure 8.6-3: Antenna port conducted spurious emissions, reference level, GFSK, 1 Mbps, 2402 MHz

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

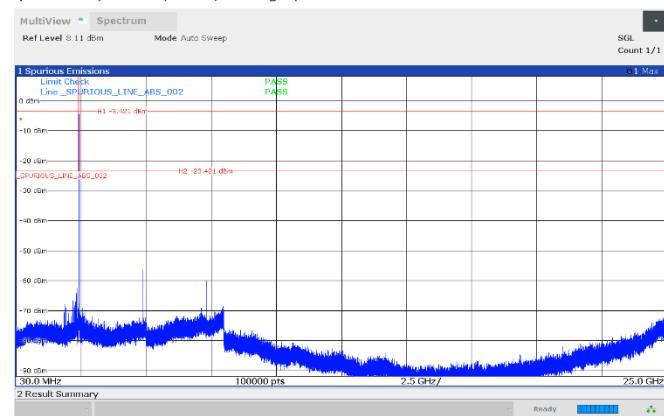


Figure 8.6-4: Antenna port conducted spurious emissions, GFSK, 1 Mbps, 2402 MHz

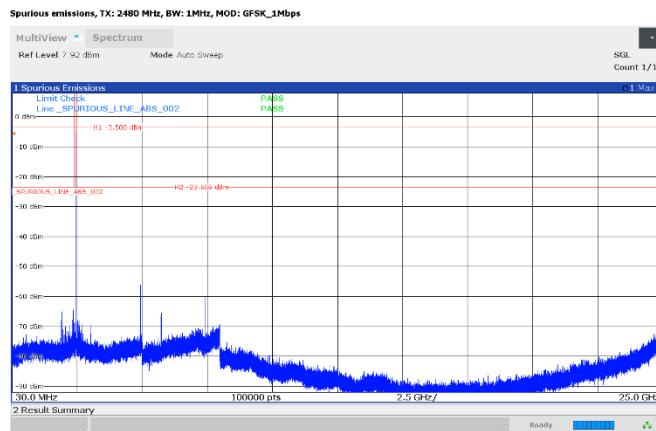


Figure 8.6-5: Antenna port conducted spurious emissions, reference level, GFSK, 1 Mbps, 2440 MHz

Radiated spurious emissions:

- Restricted band edge:

Full Spectrum

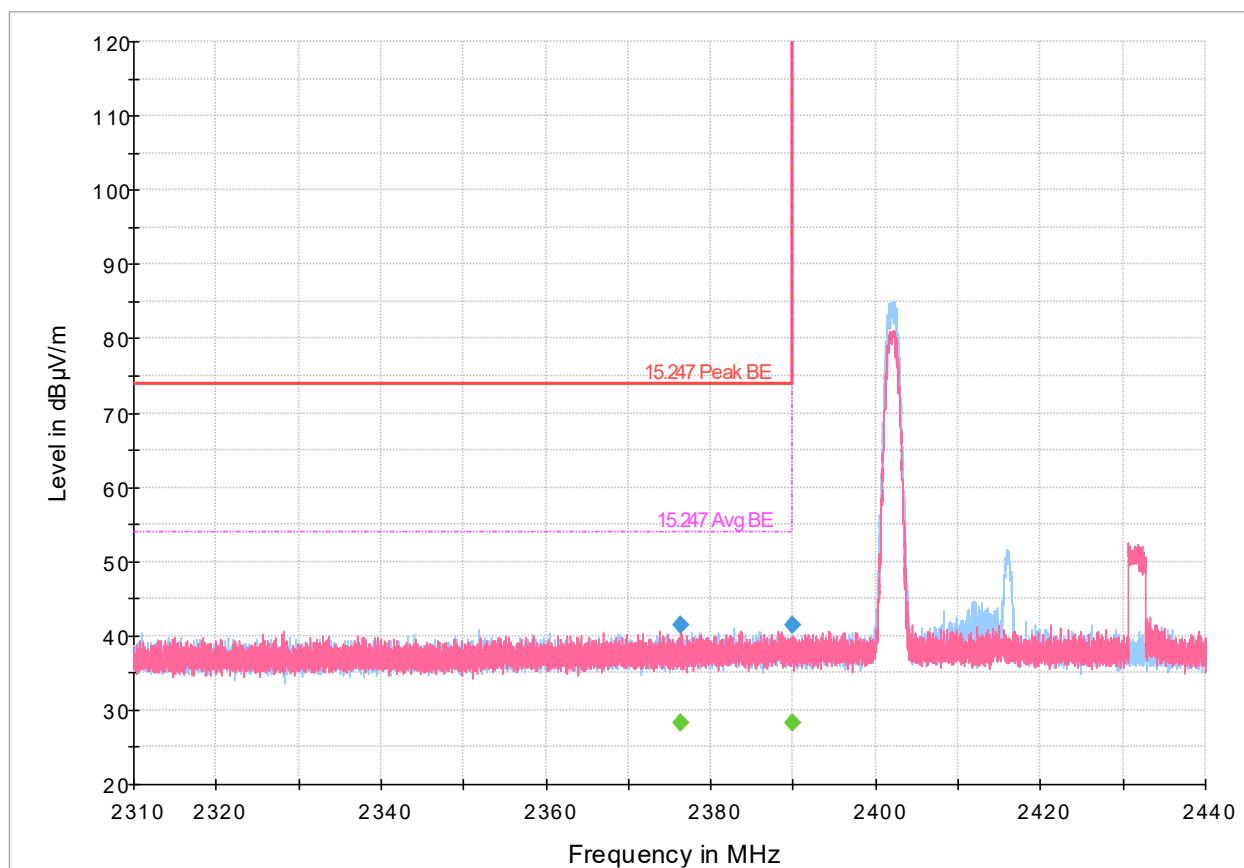


Figure 8.6-6: Radiated emissions spectral plot (2.31 GHz - 2.44 GHz)

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)
2376.278333	---	28.18	53.90	25.72	5000.0	1000.000	400.0	H	98.0	-4.5
2376.278333	41.38	---	73.90	32.52	5000.0	1000.000	400.0	H	98.0	-4.5
2390.000000	---	28.32	53.90	25.58	5000.0	1000.000	251.0	H	78.0	-4.4
2390.000000	41.38	---	73.90	32.52	5000.0	1000.000	251.0	H	78.0	-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

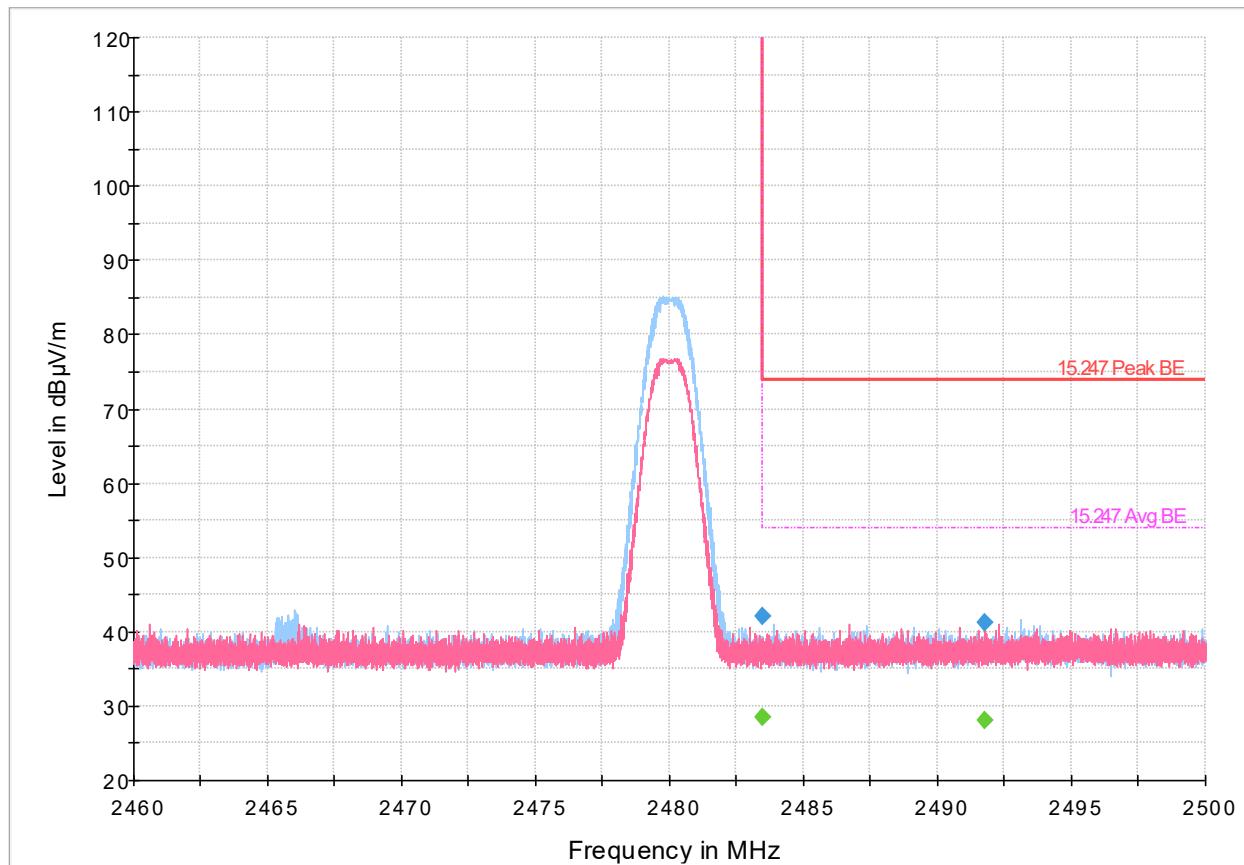


Figure 8.6-7: Radiated emissions spectral plot (2.46 GHz - 2.5 GHz)

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)
2483.50000	42.17	---	73.90	31.73	5000.0	1000.000	173.0	H	169.0	-4.0
2483.50000	---	28.39	53.90	25.51	5000.0	1000.000	173.0	H	169.0	-4.0
2491.77333	41.23	---	73.90	32.67	5000.0	1000.000	381.0	H	138.0	-4.0
2491.77333	---	28.06	53.90	25.84	5000.0	1000.000	381.0	H	138.0	-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,**

Full Spectrum

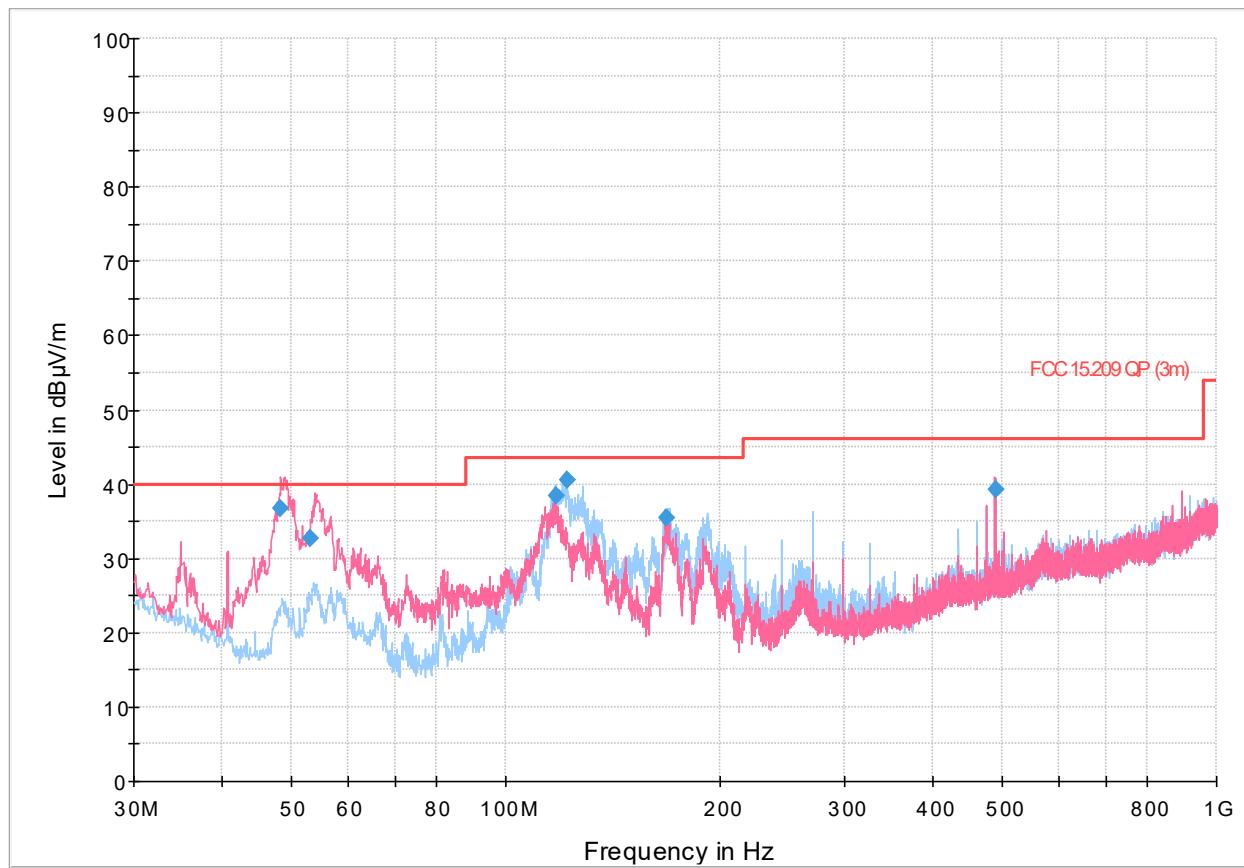


Figure 8.6-8: Radiated emissions spectral plot (30 MHz - 1 GHz) low channel 2402MHz

Table 8.6-7: Radiated emissions results

Frequency (MHz)	QuasiPeak (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
48.293000	36.81	40.00	3.19	5000.0	120.000	117.0	V	349.0	15.1
53.262000	32.77	40.00	7.23	5000.0	120.000	114.0	V	327.0	13.5
118.065000	38.49	43.50	5.01	5000.0	120.000	258.0	H	190.0	18.5
122.053000	40.54	43.50	2.96	5000.0	120.000	223.0	H	208.0	18.4
168.828000	35.39	43.50	8.11	5000.0	120.000	133.0	H	112.0	16.9
488.171000	39.26	46.00	6.74	5000.0	120.000	137.0	V	148.0	26.4

Notes:

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

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

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

Full Spectrum

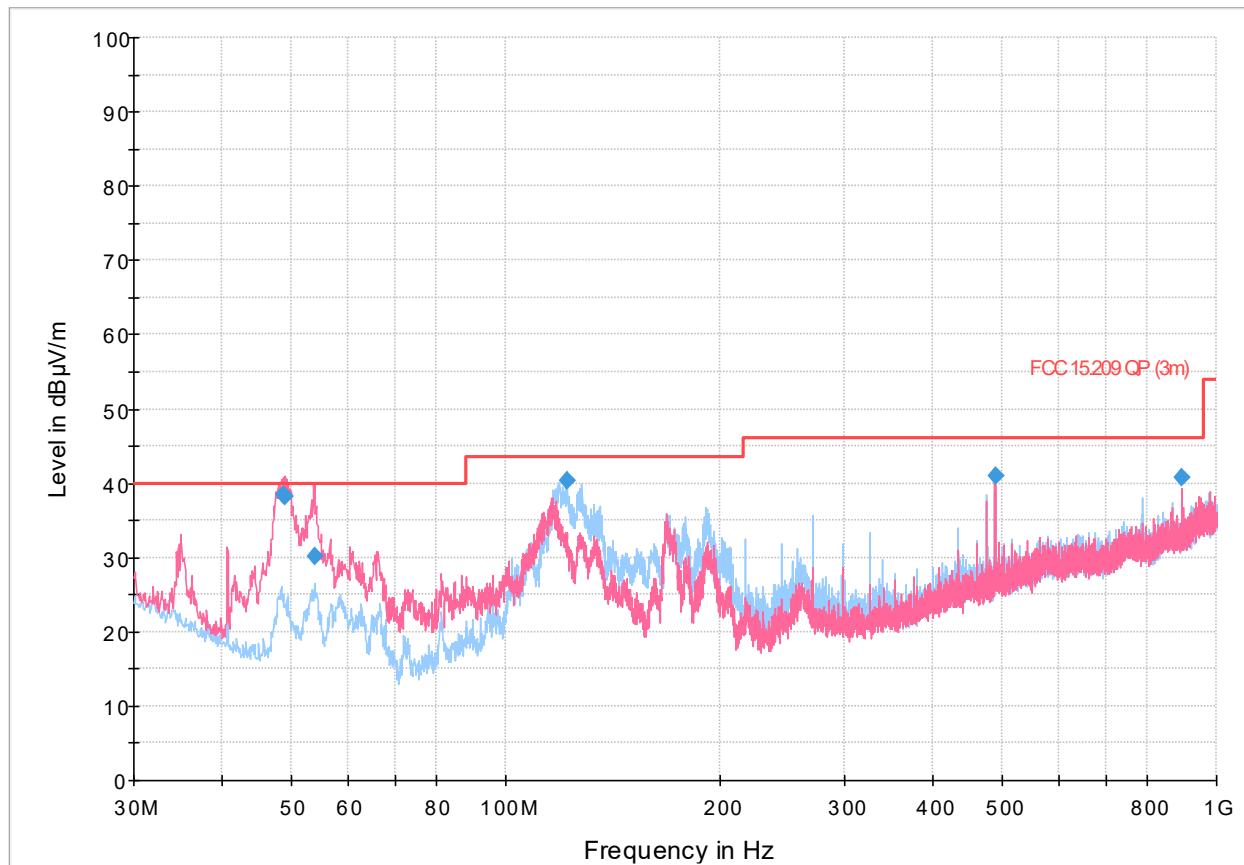


Figure 8.6-9: Radiated emissions spectral plot (30 MHz - 1 GHz) mid channel 2440MHz

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)
48.820000	38.45	40.00	1.55	5000.0	120.000	120.0	V	351.0	14.9
49.012000	38.27	40.00	1.73	5000.0	120.000	134.0	V	11.0	14.9
53.908000	30.25	40.00	9.75	5000.0	120.000	114.0	V	0.0	13.3
122.053000	40.28	43.50	3.22	5000.0	120.000	237.0	H	212.0	18.4
488.171000	40.91	46.00	5.09	5000.0	120.000	100.0	V	90.0	26.4
895.006000	40.85	46.00	5.15	5000.0	120.000	100.0	V	160.0	33.3

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

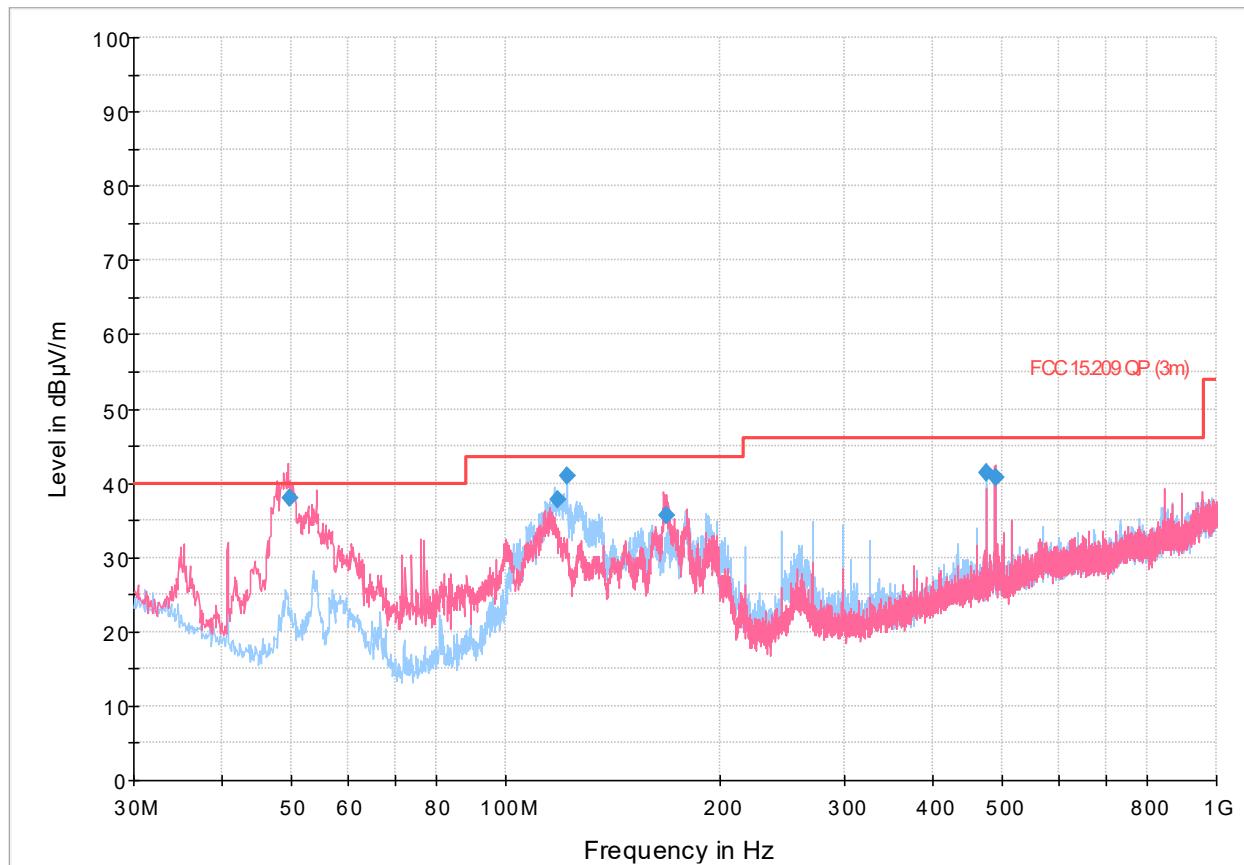


Figure 8.6-10: Radiated emissions spectral plot (30 MHz - 1 GHz) high channel 2480MHz

Table 8.6-9: Radiated emissions results

Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
49.817000	37.95	40.00	2.05	5000.0	120.000	104.0	V	274.0	14.6
118.529000	37.81	43.50	5.69	5000.0	120.000	235.0	H	193.0	18.5
122.053000	40.88	43.50	2.62	5000.0	120.000	246.0	H	216.0	18.4
168.301000	35.58	43.50	7.92	5000.0	120.000	100.0	V	333.0	16.9
474.711000	41.30	46.00	4.70	5000.0	120.000	168.0	H	284.0	26.2
488.188000	40.79	46.00	5.21	5000.0	120.000	100.0	V	100.0	26.4

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

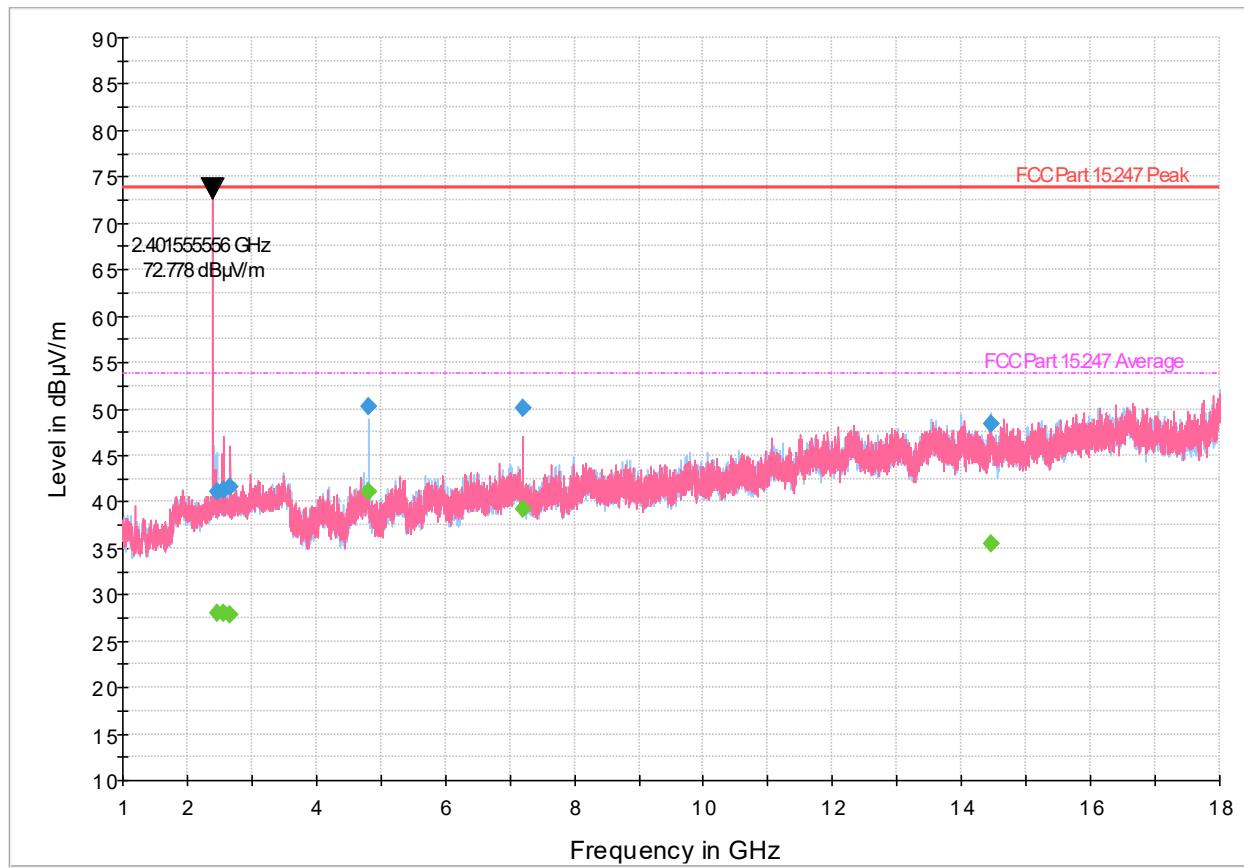


Figure 8.6-11: Radiated emissions spectral plot (1 GHz - 18 GHz) low channel 2402MHz

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)
2466.611111	41.13	---	73.90	32.77	5000.0	1000.000	323.0	H	0.0	-4.0
2466.611111	---	27.99	53.90	25.91	5000.0	1000.000	323.0	H	0.0	-4.0
2562.544444	41.32	---	73.90	32.58	5000.0	1000.000	338.0	V	65.0	-3.8
2562.544444	---	27.99	53.90	25.91	5000.0	1000.000	338.0	V	65.0	-3.8
2672.611111	---	27.80	53.90	26.10	5000.0	1000.000	171.0	V	357.0	-3.6
2672.611111	41.55	---	73.90	32.35	5000.0	1000.000	171.0	V	357.0	-3.6
4804.477778	---	41.06	53.90	12.84	5000.0	1000.000	259.0	H	168.0	2.0
4804.477778	50.24	---	73.90	23.66	5000.0	1000.000	259.0	H	168.0	2.0
7205.144444	---	39.16	53.90	14.74	5000.0	1000.000	168.0	V	44.0	5.2
7205.144444	50.06	---	73.90	23.84	5000.0	1000.000	168.0	V	44.0	5.2
14456.700000	---	35.50	53.90	18.40	5000.0	1000.000	381.0	H	272.0	17.2
14456.700000	48.40	---	73.90	25.50	5000.0	1000.000	381.0	H	272.0	17.2

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.

Marked emission at 2402 MHz is the intentional BLE transmitter and is not evaluated against the limits.

Full Spectrum

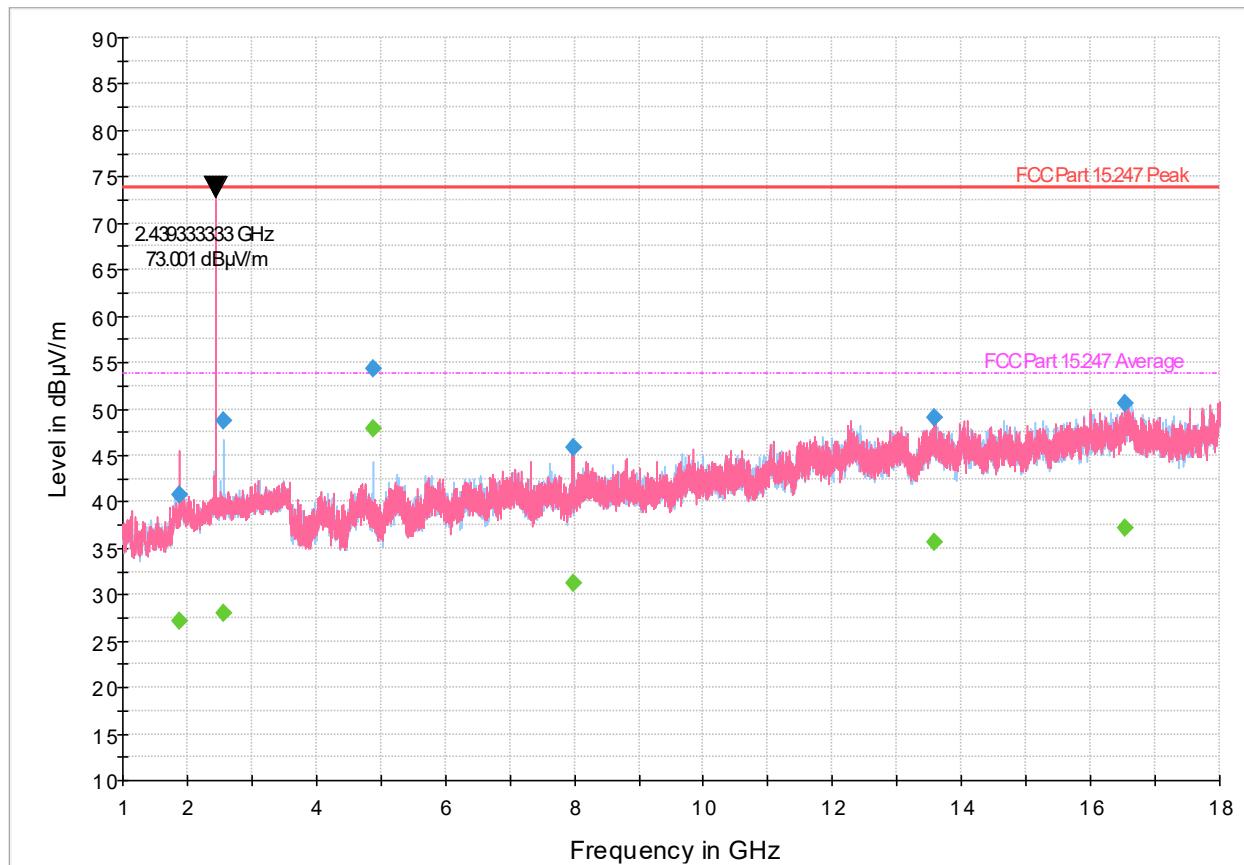


Figure 8.6-12: Radiated emissions spectral plot (1 GHz - 18 GHz) mid channel 2440MHz

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)
1875.866667	---	27.11	53.90	26.79	5000.0	1000.000	198.0	V	355.0	-6.1
1875.866667	40.78	---	73.90	33.12	5000.0	1000.000	198.0	V	355.0	-6.1
2566.544444	---	27.98	53.90	25.92	5000.0	1000.000	308.0	H	56.0	-3.8
2566.544444	48.69	---	73.90	25.21	5000.0	1000.000	308.0	H	56.0	-3.8
4879.633333	54.40	---	73.90	19.50	5000.0	1000.000	285.0	H	192.0	1.5
4879.633333	---	47.84	53.90	6.06	5000.0	1000.000	285.0	H	192.0	1.5
7979.088889	45.84	---	73.90	28.06	5000.0	1000.000	219.0	V	56.0	6.7
7979.088889	---	31.18	53.90	22.72	5000.0	1000.000	219.0	V	56.0	6.7
13582.366667	48.99	---	73.90	24.91	5000.0	1000.000	389.0	V	32.0	16.8
13582.366667	---	35.63	53.90	18.27	5000.0	1000.000	389.0	V	32.0	16.8
16532.111111	50.64	---	73.90	23.26	5000.0	1000.000	286.0	V	260.0	22.4
16532.111111	---	37.22	53.90	16.68	5000.0	1000.000	286.0	V	260.0	22.4

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.

Marked emission at 2440 MHz is the intentional BLE transmitter and is not evaluated against the limits.

Full Spectrum

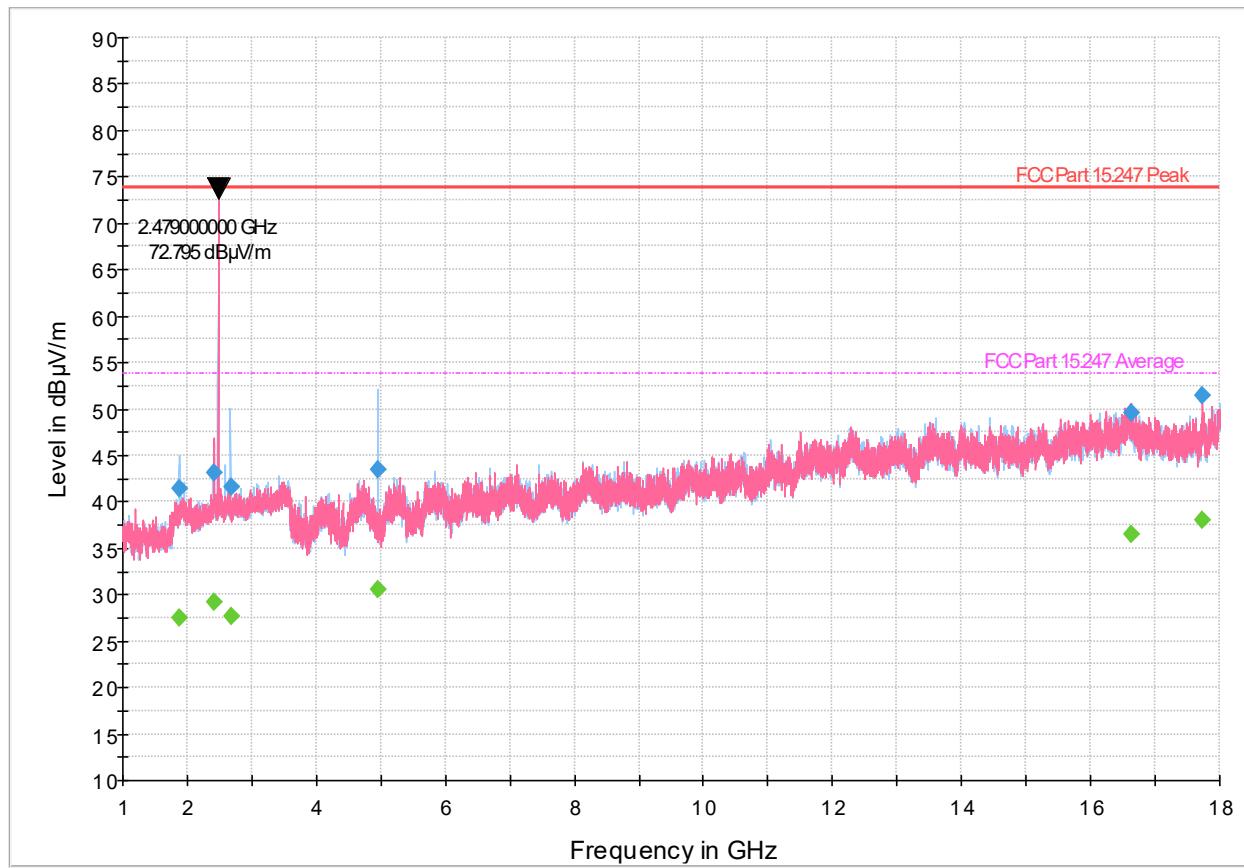


Figure 8.6-13: Radiated emissions spectral plot (1 GHz - 18 GHz) high channel 2480MHz

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)
1888.255556	41.45	---	73.90	32.45	5000.0	1000.000	330.0	H	180.0	-6.0
1888.255556	---	27.50	53.90	26.40	5000.0	1000.000	330.0	H	180.0	-6.0
2411.388889	---	29.27	53.90	24.63	5000.0	1000.000	342.0	V	323.0	-4.2
2411.388889	43.07	---	73.90	30.83	5000.0	1000.000	342.0	V	323.0	-4.2
2677.411111	41.62	---	73.90	32.28	5000.0	1000.000	274.0	H	145.0	-3.6
2677.411111	---	27.68	53.90	26.22	5000.0	1000.000	274.0	H	145.0	-3.6
4963.766667	---	30.56	53.90	23.34	5000.0	1000.000	367.0	H	87.0	1.3
4963.766667	43.53	---	73.90	30.37	5000.0	1000.000	367.0	H	87.0	1.3
16641.388889	---	36.54	53.90	17.36	5000.0	1000.000	399.0	V	122.0	23.3
16641.388889	49.62	---	73.90	24.28	5000.0	1000.000	399.0	V	122.0	23.3
17741.222222	51.39	---	73.90	22.51	5000.0	1000.000	319.0	V	249.0	21.3
17741.222222	---	38.05	53.90	15.85	5000.0	1000.000	319.0	V	249.0	21.3

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.

Marked emission at 2479 MHz is the intentional BLE transmitter and is not evaluated against the limits.

Full Spectrum

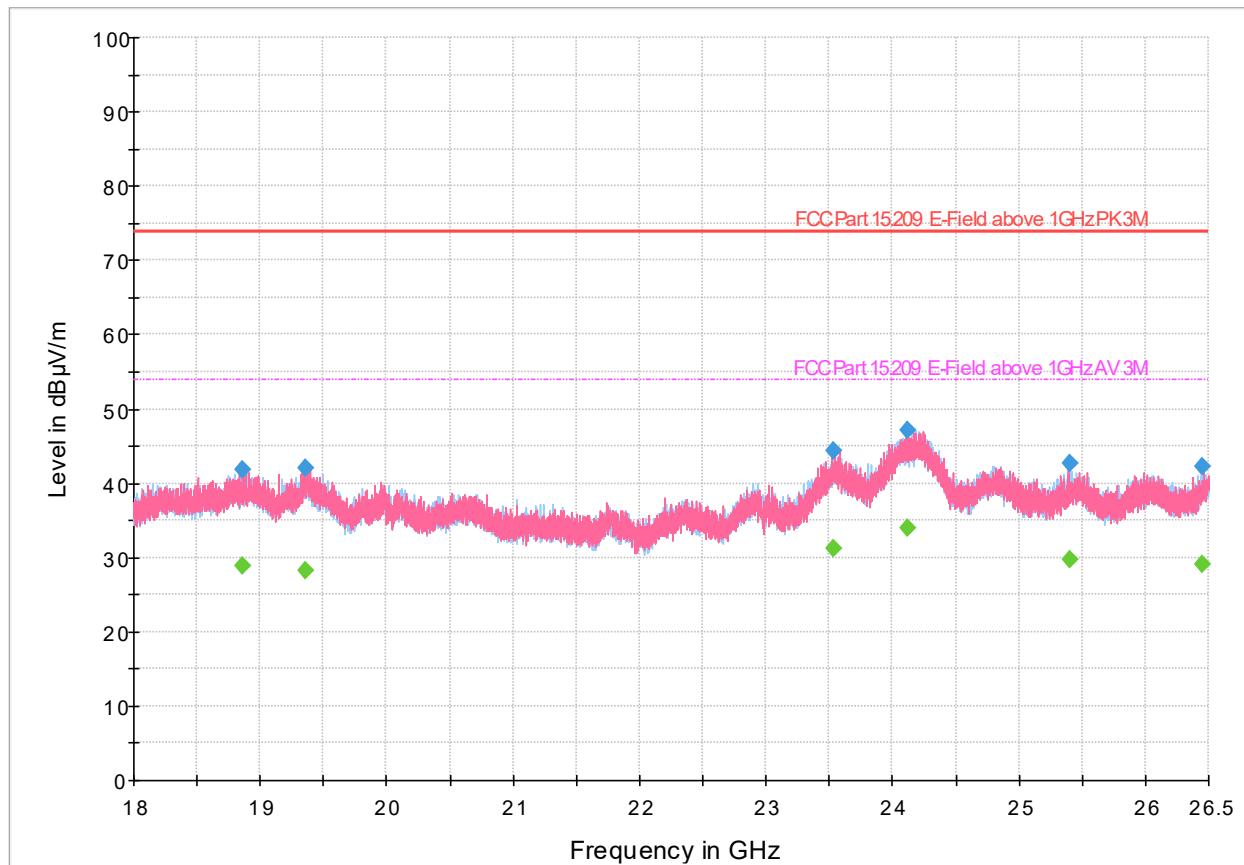


Figure 8.6-14: Radiated emissions spectral plot (18 GHz - 26.5 GHz) low channel 2402MHz

Table 8.6-13: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
18858.068750	---	28.77	53.90	25.13	5000.0	1000.000	313.0	V	58.0	15.9
18858.068750	41.86	---	73.90	32.04	5000.0	1000.000	313.0	V	58.0	15.9
19358.481250	---	28.23	53.90	25.67	5000.0	1000.000	355.0	V	272.0	16.7
19358.481250	42.04	---	73.90	31.86	5000.0	1000.000	355.0	V	272.0	16.7
23530.618750	---	31.15	53.90	22.75	5000.0	1000.000	196.0	H	161.0	23.4
23530.618750	44.41	---	73.90	29.49	5000.0	1000.000	196.0	H	161.0	23.4
24113.937500	---	33.89	53.90	20.01	5000.0	1000.000	301.0	H	0.0	27.4
24113.937500	47.10	---	73.90	26.80	5000.0	1000.000	301.0	H	0.0	27.4
25405.300000	---	29.71	53.90	24.19	5000.0	1000.000	377.0	H	313.0	21.6
25405.300000	42.72	---	73.90	31.18	5000.0	1000.000	377.0	H	313.0	21.6
26453.068750	---	29.12	53.90	24.78	5000.0	1000.000	398.0	V	150.0	23.2
26453.068750	42.26	---	73.90	31.64	5000.0	1000.000	398.0	V	150.0	23.2

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

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

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

Full Spectrum

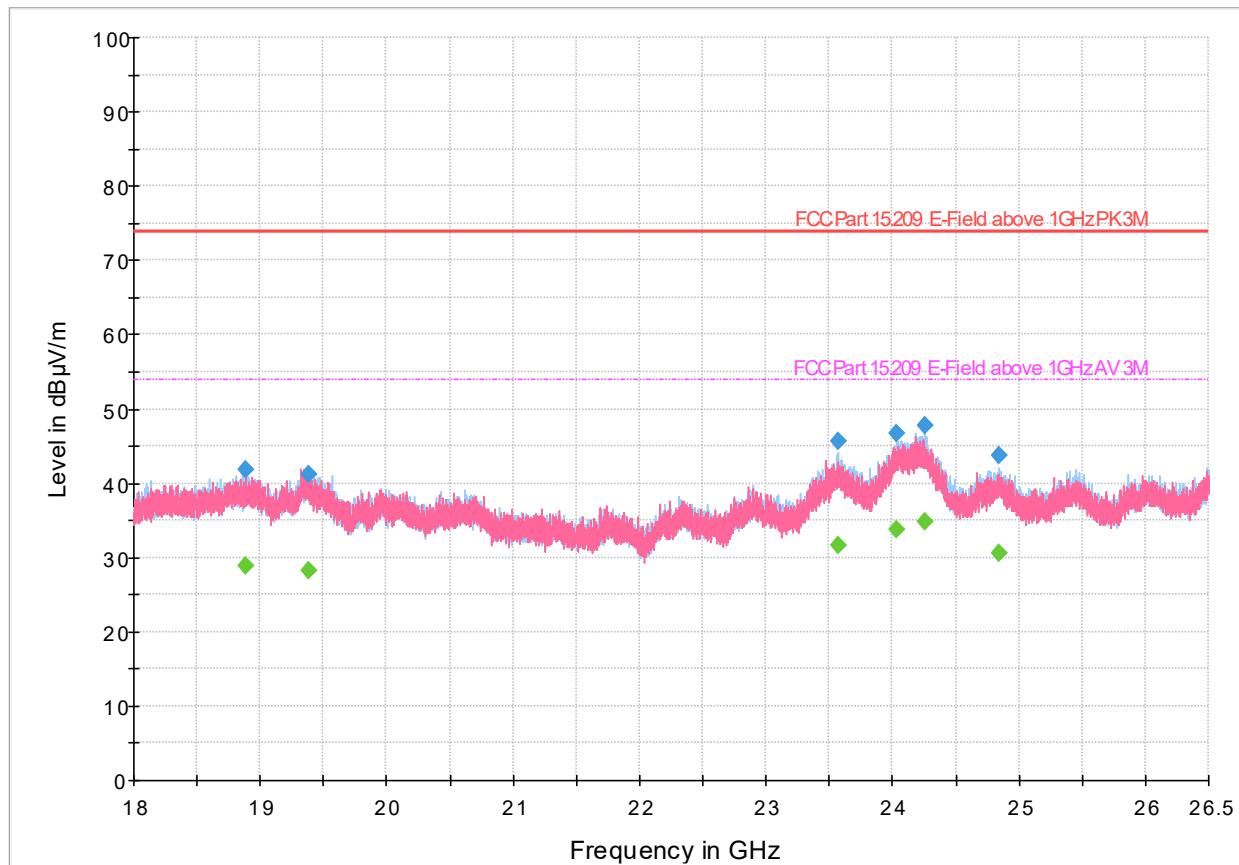


Figure 8.6-15: Radiated emissions spectral plot (18 GHz - 26.5 GHz) mid channel 2440MHz

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)
18887.262500	41.85	---	73.90	32.05	5000.0	1000.000	335.0	H	11.0	15.9
18887.262500	---	28.84	53.90	25.06	5000.0	1000.000	335.0	H	11.0	15.9
19377.243750	---	28.24	53.90	25.66	5000.0	1000.000	184.0	V	40.0	16.6
19377.243750	41.28	---	73.90	32.62	5000.0	1000.000	184.0	V	40.0	16.6
23567.868750	45.55	---	73.90	28.35	5000.0	1000.000	400.0	H	159.0	23.8
23567.868750	---	31.58	53.90	22.32	5000.0	1000.000	400.0	H	159.0	23.8
24037.956250	46.73	---	73.90	27.17	5000.0	1000.000	134.0	H	131.0	27.6
24037.956250	---	33.74	53.90	20.16	5000.0	1000.000	134.0	H	131.0	27.6
24251.550000	---	34.73	53.90	19.17	5000.0	1000.000	276.0	H	347.0	26.9
24251.550000	47.77	---	73.90	26.13	5000.0	1000.000	276.0	H	347.0	26.9
24837.787500	43.71	---	73.90	30.19	5000.0	1000.000	294.0	H	39.0	22.3
24837.787500	---	30.50	53.90	23.40	5000.0	1000.000	294.0	H	39.0	22.3

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

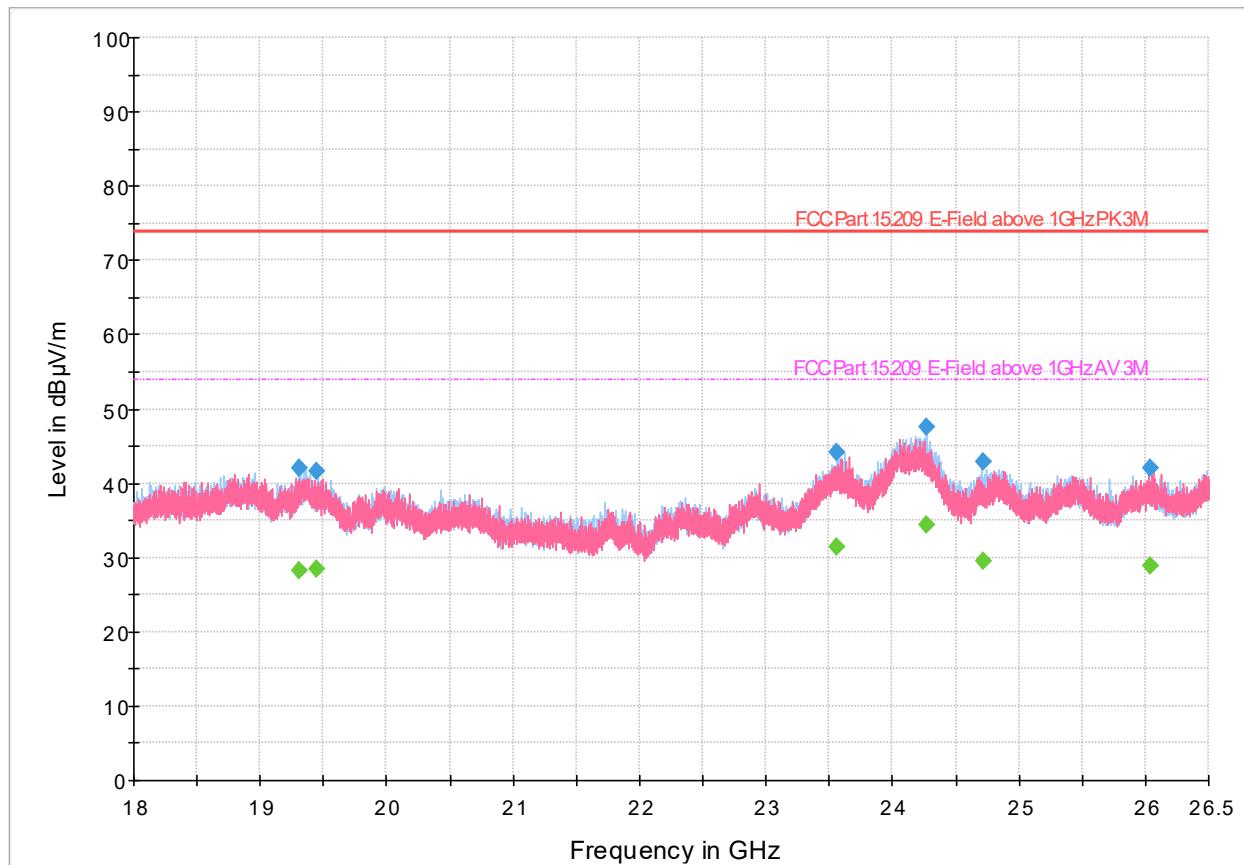


Figure 8.6-16: Radiated emissions spectral plot (18 GHz - 26.5 GHz) high channel 2480MHz

Table 8.6-15: Radiated emissions results

Frequency (MHz)	MaxPeak (dB μ V/m)	CAverage (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
19307.156250	---	28.19	53.90	25.71	5000.0	1000.000	134.0	H	192.0	16.7
19307.156250	41.97	---	73.90	31.93	5000.0	1000.000	134.0	H	192.0	16.7
19449.075000	41.59	---	73.90	32.31	5000.0	1000.000	100.0	H	283.0	16.5
19449.075000	---	28.45	53.90	25.45	5000.0	1000.000	100.0	H	283.0	16.5
23558.700000	44.26	---	73.90	29.64	5000.0	1000.000	246.0	H	178.0	23.7
23558.700000	---	31.44	53.90	22.46	5000.0	1000.000	246.0	H	178.0	23.7
24274.656250	---	34.39	53.90	19.51	5000.0	1000.000	304.0	H	252.0	26.6
24274.656250	47.63	---	73.90	26.27	5000.0	1000.000	304.0	H	252.0	26.6
24714.300000	---	29.58	53.90	24.32	5000.0	1000.000	254.0	H	314.0	22.4
24714.300000	42.86	---	73.90	31.04	5000.0	1000.000	254.0	H	314.0	22.4
26037.131250	---	28.87	53.90	25.03	5000.0	1000.000	194.0	V	121.0	21.8
26037.131250	41.97	---	73.90	31.93	5000.0	1000.000	194.0	V	121.0	21.8

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

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

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

8.7 Power spectral density

8.7.1 References and limits

- FCC 47 CFR Part 15, Subpart C: §15.247(e)
- 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.

8.7.2 Test summary

Verdict	Pass		
Test date	February 6, 2024	Temperature	22 °C
Test engineer	Chenhai Ma, Wireless Test Technician	Air pressure	1003.2 mbar
Test location	<input checked="" type="checkbox"/> Wireless bench <input type="checkbox"/> Other:	Relative humidity	49.6 %

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

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/3 kHz)
2402	GFSK, 1 Mbps	-17.64	≤ 8
2440	GFSK, 1 Mbps	-18.17	≤ 8
2480	GFSK, 1 Mbps	-18.39	≤ 8

Peak power spectral density, TX: 2402 MHz, BW: 1MHz, MOD: GFSK_1Mbps

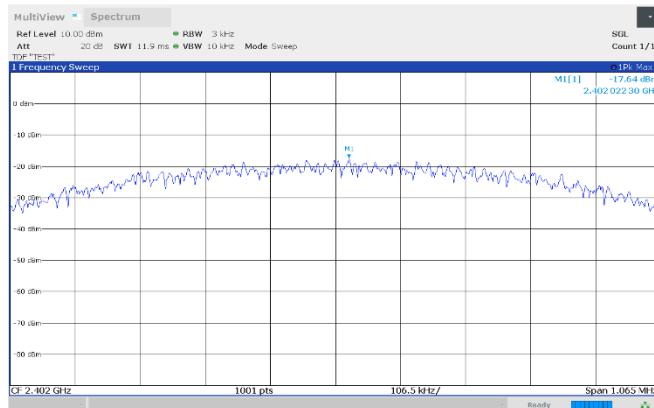


Figure 8.7-1: Power spectral density, GFSK, 1 Mbps, 2402 MHz

Peak power spectral density, TX: 2440 MHz, BW: 1MHz, MOD: GFSK_1Mbps

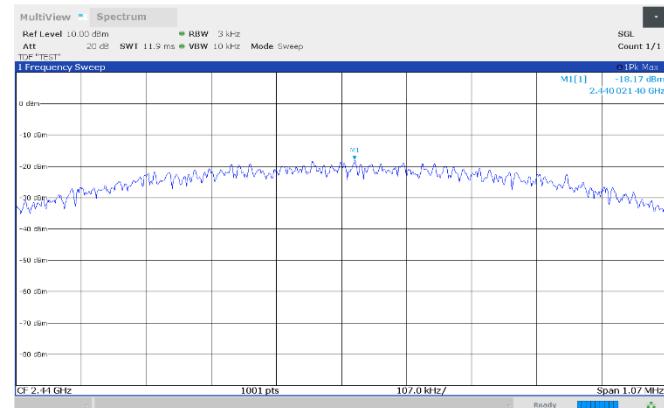


Figure 8.7-2: Power spectral density, GFSK, 1, 2440 MHz

Peak power spectral density, TX: 2480 MHz, BW: 1MHz, MOD: GFSK_1Mbps

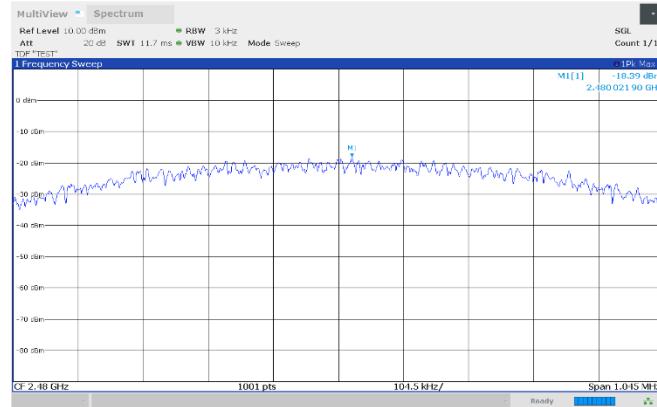


Figure 8.7-3: Power spectral density, GFSK, 1, 2480 MHz

End of test report