Test report

443623-1TRFWL

Date of issue: August 20, 2021

Applicant:
Panduit Corp.

Product:
Network Management Card

Model:
PAN100

FCC ID:
2AVV3-PAN100

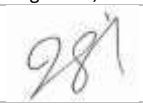
IC certification number:
11688B-PAN100

Specifications:

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

Lab and test locations

Company name	Nemko USA Inc.
Address	2210 Faraday Ave, Suite 150
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	David Hewitt, EMC Specialist
Reviewed by	James Cunningham, EMC/MIL/WL Supervisor
Review date	August 20, 2021
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 NVLAP, NIST, or any agency of the U.S. Government.

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Applicant

Company name	Panduit Corp.
Address	18900 Panduit Drive
City	Tinley Park
Province/State	IL
Postal/Zip code	60487
Country	USA

1.2 Manufacturer

Company name	Panduit Corp.
Address	18900 Panduit Drive
City	Tinley Park
Province/State	IL
Postal/Zip code	60487
Country	USA

1.3 Test specifications

FCC 47 CFR Part 15, Subpart C – §15.247	Operation within the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz
IC RSS-247 Issue 2	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.4 Test methods

ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 DTS Measurement Guidance v03r02 (June 5, 2014)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.5 Exclusions

Variation of power source test could not be performed on the EUT because the EUT receives 5 V_{DC} via USB cable from the support laptop. Adjusting the voltage of the AC mains supply to the support laptop would have been irrelevant to the nature of the test because it would not have changed the supply voltage to the EUT itself.

1.6 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.5 above. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.7 Test report revision history

Table 1.7-1: *Test report revision history*

Revision #	Details of changes made to test report
443623-1TRFWL	Original report issued
Notes:	None

Section 2 Summary of test results

2.1 FCC Part 15 Subpart C, general requirements

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

Notes: EUT is DC powered via micro-USB, and voltage could not be varied.
The antenna is located within the protective cover of EUT

2.2 FCC Part 15.247

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

2.3 IC RSS-247, Issue 2

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

2.4 IC RSS-GEN, Issue 5

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

Section 3 Equipment under test (EUT) details

3.1 Sample information

Receipt date	June 25, 2021
Nemko sample ID number	NEx: 443623

3.2 EUT information

Product name	Network Management Card
Model	irUPS NMC
Serial number	N/A
Part number	ESP32-WROVER-IE

3.3 Technical information

Used IC test site(s) reg. number	2040A
RSS number and issue	RSS-247 issue 2 (February 2017)
Frequency band	2400 – 2483.5 MHz
Minimum frequency (MHz)	2402
Maximum frequency (MHz)	2480
Type of modulation	GFSK
Emission classification	F1D
Power requirements	5 V_{DC}, 0.5 A
Antenna information	TAOGLAS FXP840 antenna 3.6 dBi gain antenna attached via U.FL connector

3.4 EUT exercise and monitoring details

The EUT was controlled by support laptop running ESP_RF_test_tool_v2.5 and set to transmit BLE signals at max power while on the Low, Middle, and High channels—as applicable per test.

Table 3.4-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number	Rev.
--	--	--	--	--

Table 3.4-2: *EUT interface ports*

Description	Qty.
USB micro	1

Table 3.4-3: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
Support Laptop	Dell	Inspiron 5548	20814012794	--

Table 3.4-4: *Inter-connection cables*

Cable description	From	To	Length (m)
USB	Support laptop	EUT	1.0

3.5 EUT setup diagram

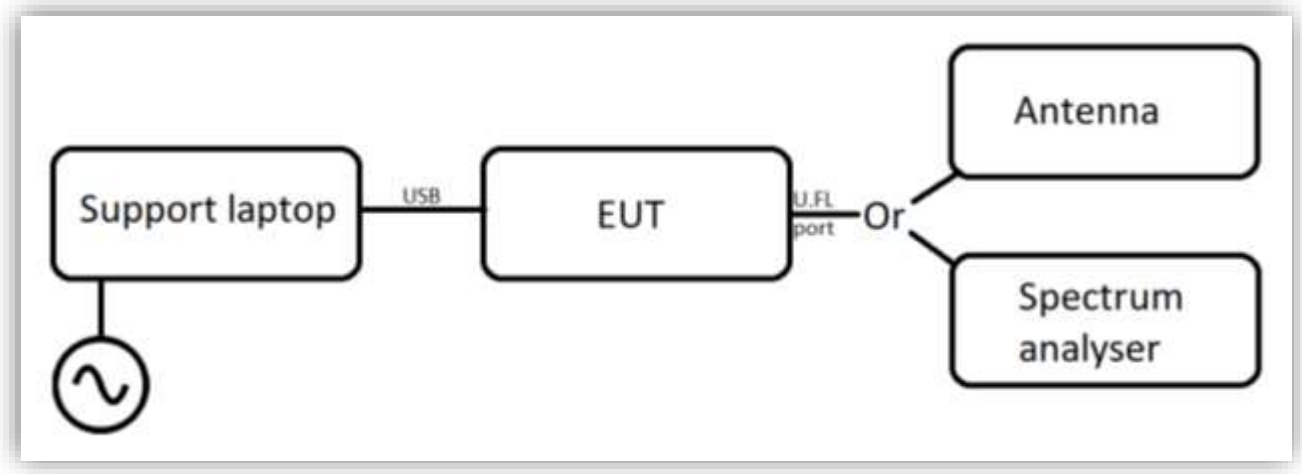


Figure 3.5-1: *Setup diagram*

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5 Test conditions

5.1 Atmospheric conditions

Temperature	15-30 °C
Relative humidity	20-75 %
Air pressure	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

Table 6.1-1: *Test Equipment List*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	1 yr	24 Feb 2022
Transient Limiter	Hewlett-Packard	11947A	681	1 yr	11 Feb 2022
Two Line V-Network	Rohde & Schwarz	ENV216	E1020	1 yr	2 Sep 2022
Signal and spectrum analyzer	Rohde & Schwarz	FSV40	E1120	2 yr	19 Nov 2021
Signal and spectrum analyzer	Rohde & Schwarz	FSW43	E1302	1 yr	18 Sep 2021
Power sensor	ETS Lindgren	7002-006	E1061	1 yr	20 May 2022
Power sensor	ETS Lindgren	7002-006	E1062	1 yr	14 Oct 2021
EMI Test Receiver	Rohde & Schwarz	ESU40	E1121	1 yr	19 May 2022
System Controller	Sunol Sciences	SC104V	E1191	NCR	NCR
Bilog Antenna (30-1000 MHz)	Schaffner	CBL 6111D	1763	2 yr	18 Feb 2022
DRG Horn (1-18 GHz)	ETS-Lindgren	3117-PA	E1160	1 yr	2 Dec 2021
Horn antenna (18-26 GHz)	SAGE	SAR-2309-42-S2	E1143	2 yr	13 Nov 2022
Low noise amplifier	Sage Millimeter, Inc.	SBL-1834034030-KFKF	E1228	VOU	VOU
2.4GHz notch filter	Micro-Tonics	HPM50110-01	E1142	NCR	NCR

Notes: NCR - no calibration required
VOU - verify on use

Table 6.1-2: *Test Software*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.60.10 (AC conducted emissions)
Rohde & Schwarz	EMC 32 V10.60.15 (radiated emissions)

Notes: None

Section 8 Testing data

8.1 FCC 15.207(a) and IC RSS-GEN, Issue 5 8.8 AC power line conducted emissions

8.1.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.207(a)
RSS-Gen → §8.8

For Low-power radio-frequency devices that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). The lower limit applies at the boundary between the frequency ranges.

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	July 22, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1005 mbar
Test location	Ground Plane	Relative humidity	69 %

8.1.3 Notes

Testing was performed with the BLE transmitter operating on a fixed channel at full power. Low, middle, and high channels were tested.

Testing was performed according to ANSI C63.10 §6.2.

8.1.4 Setup details

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

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	– 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

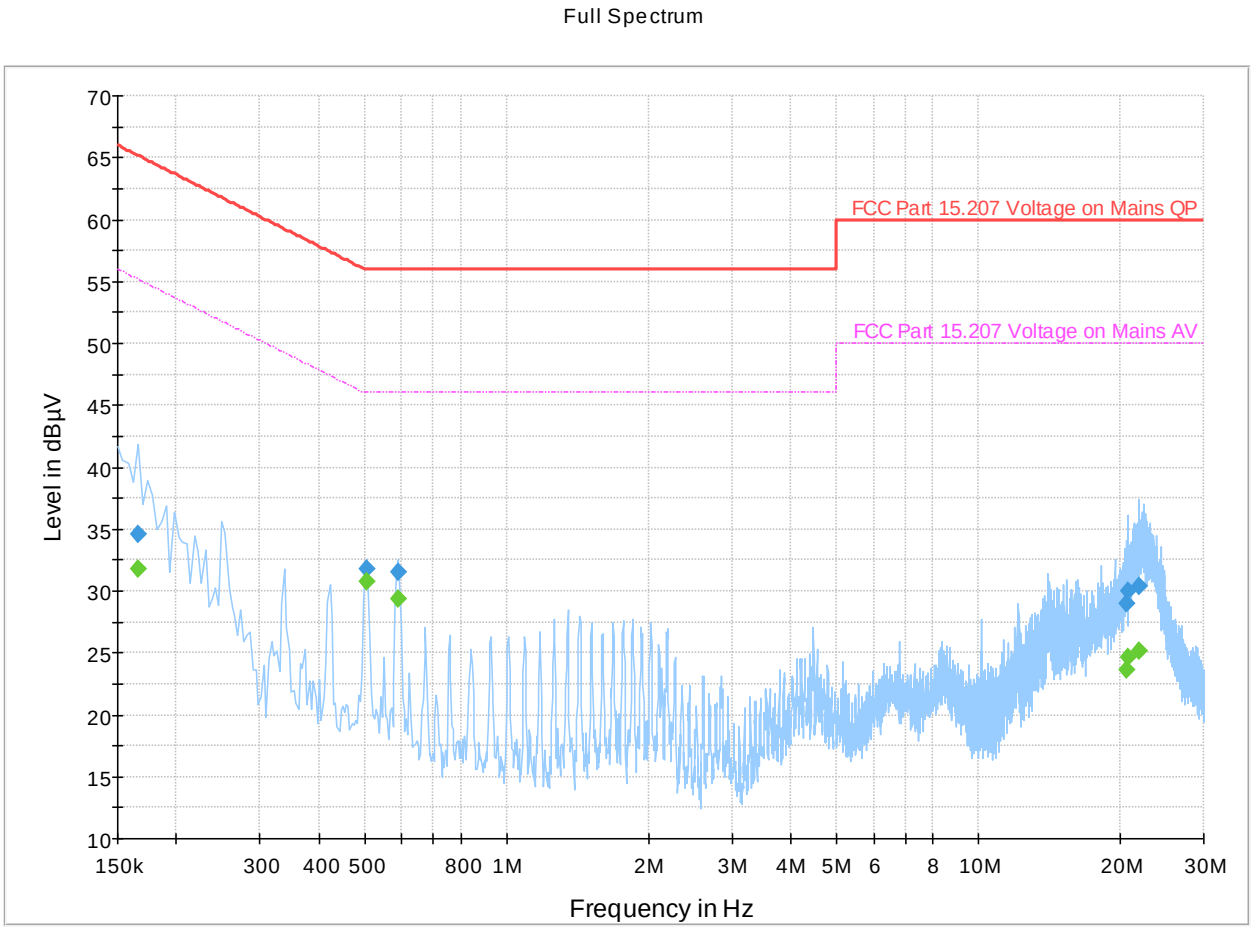


Figure 8.1-1: *AC conducted emissions, BLE Low Channel*

Table 8.1-2: *AC conducted emissions, 150 kHz – 30 MHz, BLE Low Channel*

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.166000	---	31.77	55.16	23.39	5000.0	9.000	N	ON	19.5
0.166000	34.60	---	65.16	30.55	5000.0	9.000	N	ON	19.5
0.506000	---	30.80	46.00	15.20	5000.0	9.000	N	ON	19.4
0.506000	31.83	---	56.00	24.17	5000.0	9.000	N	ON	19.4
0.590000	---	29.33	46.00	16.67	5000.0	9.000	N	ON	19.4
0.590000	31.54	---	56.00	24.46	5000.0	9.000	N	ON	19.4
20.626000	---	23.61	50.00	26.39	5000.0	9.000	N	ON	20.2
20.626000	29.01	---	60.00	30.99	5000.0	9.000	N	ON	20.2
20.750000	---	24.59	50.00	25.41	5000.0	9.000	N	ON	20.1
20.750000	29.97	---	60.00	30.03	5000.0	9.000	N	ON	20.1
21.942000	---	25.12	50.00	24.88	5000.0	9.000	N	ON	20.1
21.942000	30.40	---	60.00	29.60	5000.0	9.000	N	ON	20.1

Notes: Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + transient limiter (dB)

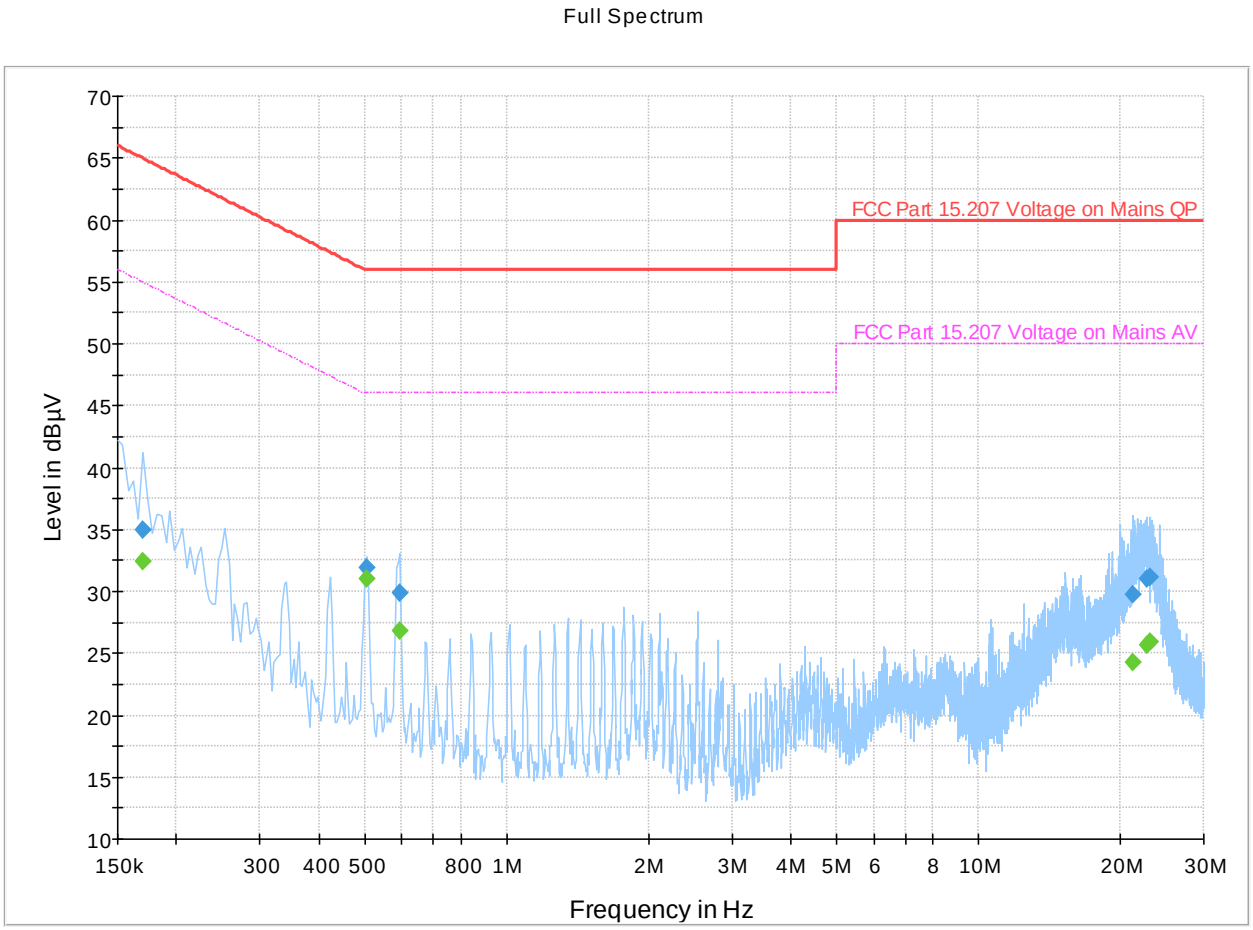


Figure 8.1-2: *AC conducted emissions, BLE Mid Channel*

Table 8.1-3: *AC conducted emissions, 150 kHz – 30 MHz, BLE Mid Channel*

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.170000	**---**	**32.47**	**54.96**	**22.49**	**5000.0**	**9.000**	**N**	**ON**	**19.5**
0.170000	**35.03**	**---**	**64.96**	**29.93**	**5000.0**	**9.000**	**N**	**ON**	**19.5**
0.506000	**---**	**31.06**	**46.00**	**14.94**	**5000.0**	**9.000**	**N**	**ON**	**19.4**
0.506000	**31.97**	**---**	**56.00**	**24.03**	**5000.0**	**9.000**	**N**	**ON**	**19.4**
0.594000	**---**	**26.78**	**46.00**	**19.22**	**5000.0**	**9.000**	**N**	**ON**	**19.4**
0.594000	**29.81**	**---**	**56.00**	**26.19**	**5000.0**	**9.000**	**N**	**ON**	**19.4**
21.194000	**---**	**24.23**	**50.00**	**25.77**	**5000.0**	**9.000**	**N**	**ON**	**20.1**
21.194000	**29.75**	**---**	**60.00**	**30.25**	**5000.0**	**9.000**	**N**	**ON**	**20.1**
22.754000	**---**	**25.72**	**50.00**	**24.28**	**5000.0**	**9.000**	**N**	**ON**	**20.1**
22.754000	**30.96**	**---**	**60.00**	**29.04**	**5000.0**	**9.000**	**N**	**ON**	**20.1**
23.178000	**---**	**25.88**	**50.00**	**24.12**	**5000.0**	**9.000**	**N**	**ON**	**20.0**
23.178000	**31.13**	**---**	**60.00**	**28.87**	**5000.0**	**9.000**	**N**	**ON**	**20.0**

Notes: Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + transient limiter (dB)

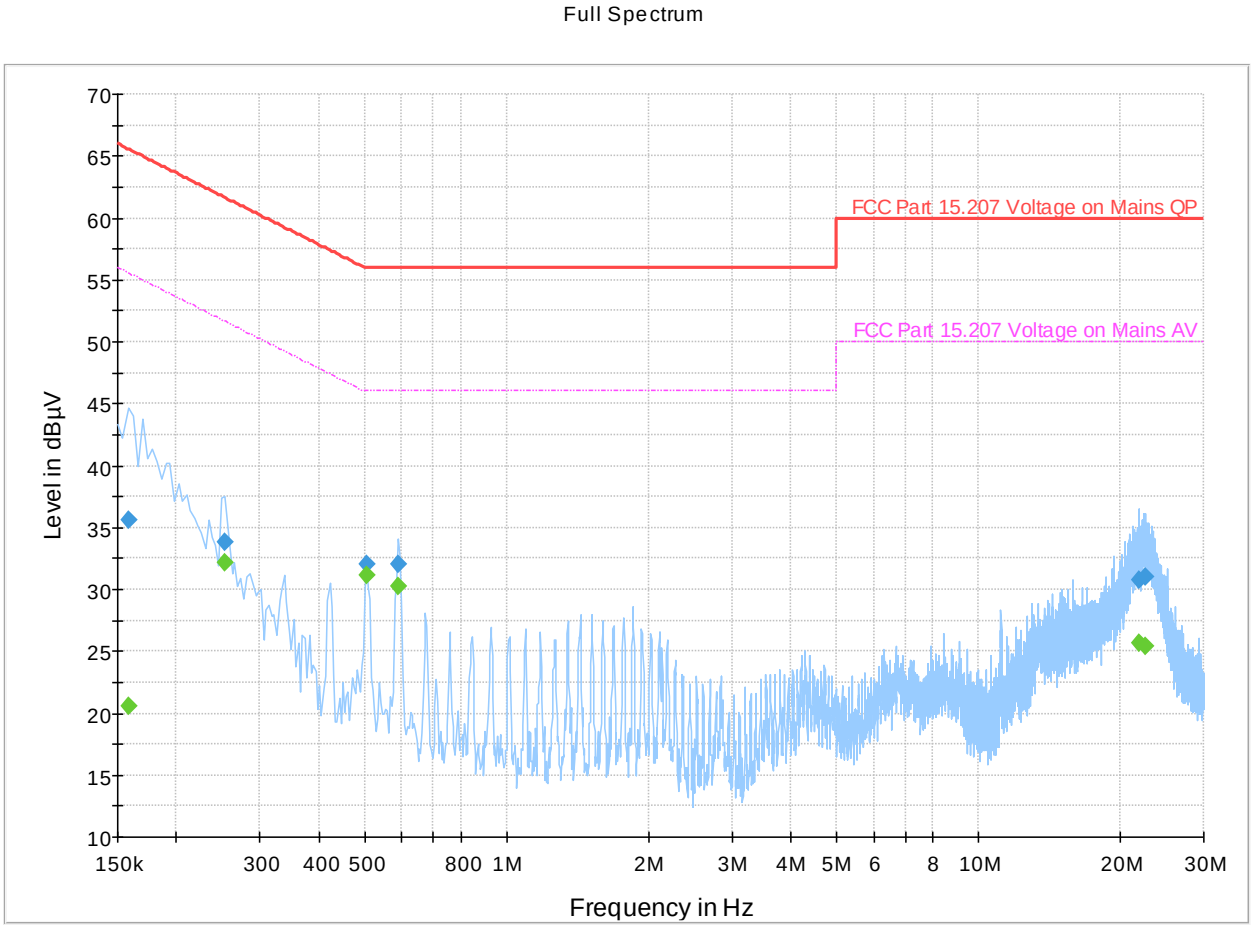


Figure 8.1-3: *AC conducted emissions, BLE High Channel*

Table 8.1-4: *AC conducted emissions, 150 kHz – 30 MHz, BLE High Channel*

Frequency (MHz)	QuasiPeak (dBµV)	CAverage (dBµV)	Limit (dBµV)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Line	Filter	Corr. (dB)
0.158000	---	20.57	55.57	35.00	5000.0	9.000	N	ON	19.5
0.158000	35.58	---	65.57	29.99	5000.0	9.000	N	ON	19.5
0.254000	---	32.21	51.63	19.42	5000.0	9.000	N	ON	19.4
0.254000	33.82	---	61.63	27.80	5000.0	9.000	N	ON	19.4
0.506000	---	31.13	46.00	14.87	5000.0	9.000	N	ON	19.4
0.506000	32.00	---	56.00	24.00	5000.0	9.000	N	ON	19.4
0.590000	---	30.20	46.00	15.80	5000.0	9.000	N	ON	19.4
0.590000	32.00	---	56.00	24.00	5000.0	9.000	N	ON	19.4
21.846000	---	25.68	50.00	24.32	5000.0	9.000	N	ON	20.1
21.846000	30.76	---	60.00	29.24	5000.0	9.000	N	ON	20.1
22.542000	---	25.40	50.00	24.60	5000.0	9.000	N	ON	20.1
22.542000	30.96	---	60.00	29.04	5000.0	9.000	N	ON	20.1

Notes: Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + transient limiter (dB)

8.2 FCC 15.247(a)(2) and RSS-247 5.2(1) Minimum 6 dB bandwidth for systems using digital modulation techniques References

8.2.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(a)(2)
RSS-247 → §5.2(a)

(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.

8.2.2 Test summary

Verdict	Pass		
Test date	July 12, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1003 mbar
Test location	Wireless bench (Conducted)	Relative humidity	60 %

8.2.1 Notes

None

8.2.2 Setup details

EUT setup configuration	Table top
Test facility	Nemko San Diego
Measurement method	558074 D01 DTS Measurement Guidance §8.2 ANSI C63.10 §11.8.1 using built-in marker function of the spectrum analyzer

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

8.2.3 Test data

Table 8.2-1: *6 dB occupied bandwidth test data*

Test Frequency (MHz)	Bandwidth (kHz)	Limit (kHz)	Margin (kHz)
2402	633.9	> 500	133.9
2440	633.9	> 500	133.9
2480	651.2	> 500	151.2

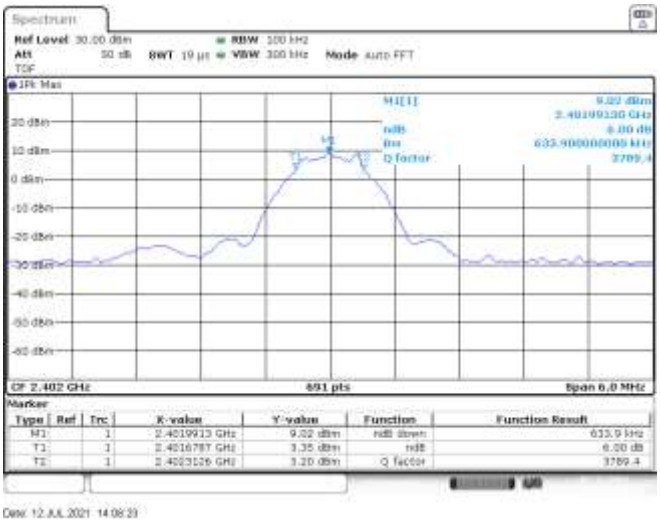


Figure 8.2-1: *6 dB occupied bandwidth, 2402 MHz*

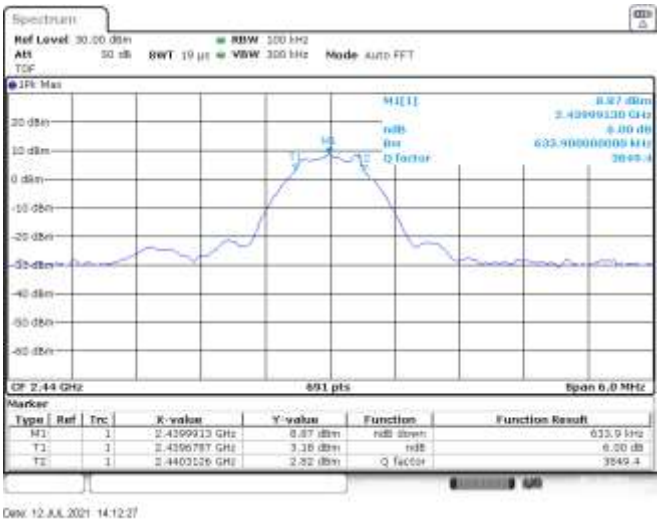


Figure 8.2-2: *6 dB occupied bandwidth, 2440 MHz*

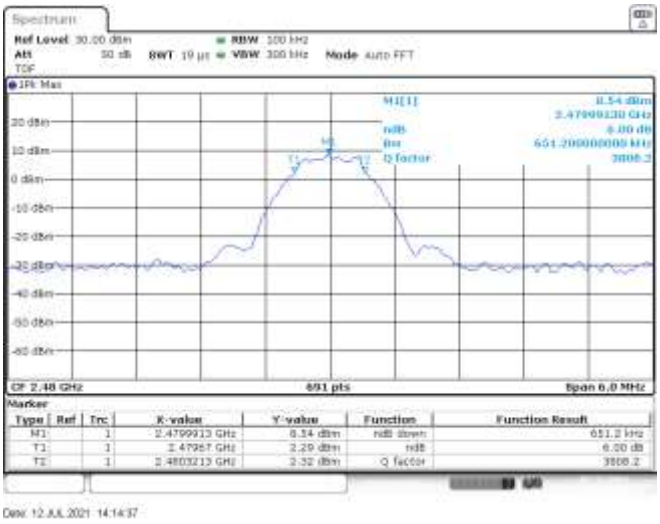


Figure 8.2-3: *6 dB occupied bandwidth, 2480 MHz*

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

8.3.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(b)(2) / (3)

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(3) For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 W (30 dBm). As an alternative to a peak power measurement, compliance with the one-Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

(4) The conducted output power limit specified in paragraph (b) of this Section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this Section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this Section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

RSS-247 → §5.4(d)

(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 e.i.r.p. shall not exceed 4 W, except as provided in 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.

8.3.2 Test summary

Verdict	Pass		
Test date	July 12, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1003 mbar
Test location	Wireless bench (Conducted)	Relative humidity	60 %

8.3.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

The attenuation of the interconnecting cable was included in the power meter software as a correction factor.

The antenna gain is 3.6 dBi per client declaration.

EIRP = Conducted Power + Declared Antenna Gain

8.3.4 Setup details

EUT setup configuration	Table top
Test facility	Nemko San Diego
Measurement method	ANSI C63.10 §11.9.1.3 PKPM1 (Peak Power Meter) method

8.3.5 Test data

Table 8.3-1: *Output power*

Test Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	Conducted Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)
2402	8.03	30.0	3.6	11.63	36.0
2440	7.64	30.0	3.6	11.24	36.0
2480	7.30	30.0	3.6	10.90	36.0

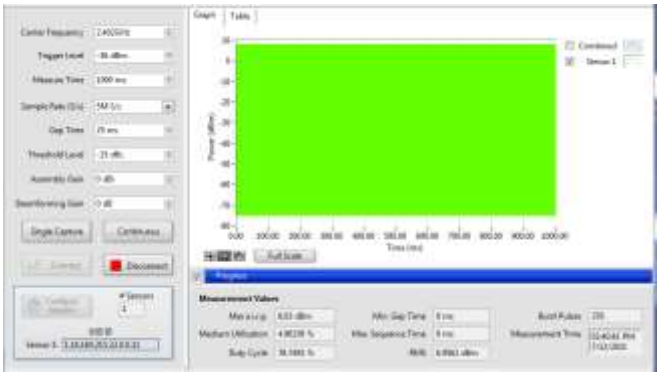


Figure 8.3-1: *Output power, 2402 MHz*

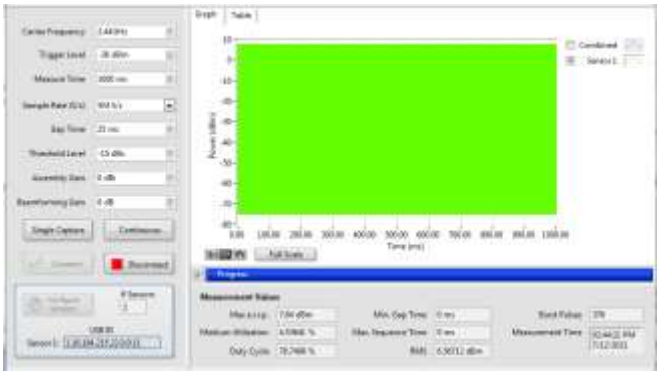


Figure 8.3-2: *Output power, 2440 MHz*

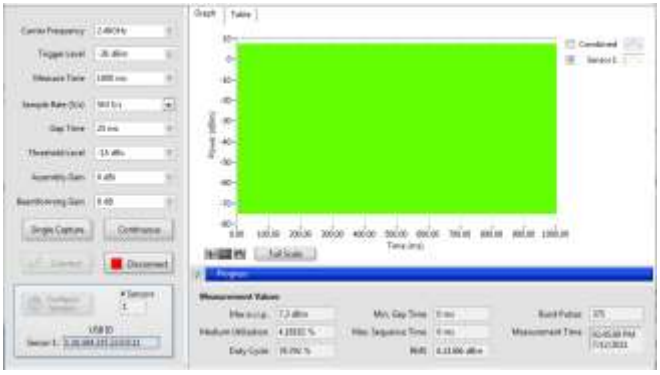


Figure 8.3-3: *Output power, 2480 MHz*

8.4 FCC Part 15.247(d) and RSS-247 5.5 Conducted band-edge spurious emissions

8.4.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(d)

(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.

8.4.2 Test summary

Verdict	Pass		
Test date	July 13, 2021	Temperature	23 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1005 mbar
Test location	Wireless bench (Conducted)	Relative humidity	69 %

8.4.3 Notes

The EUT was configured to transmit continuously at max power on the lowest and highest channels.

For conducted measurements, the loss of the connected cable and attenuator was input into the spectrum analyzer as a transducer factor.

8.4.4 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement details	Conducted band edge measurement performed as per C63.10 §6.10.4

Spectrum analyzer settings for conducted spurious emissions:

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

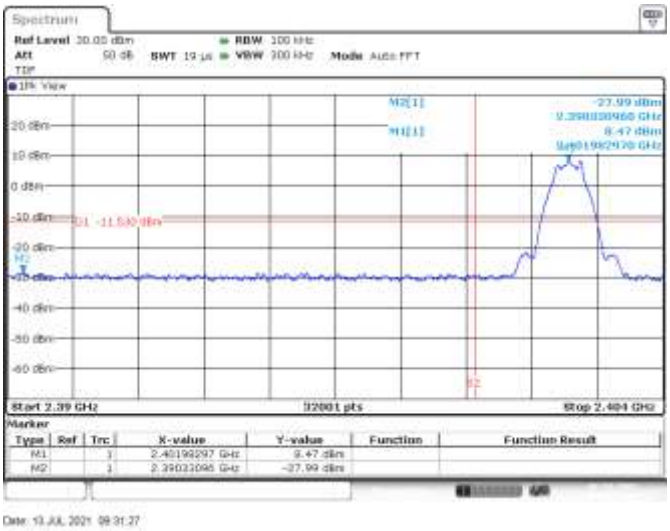


***Figure 8.4-1**: Band edge measurement, 2402 MHz*

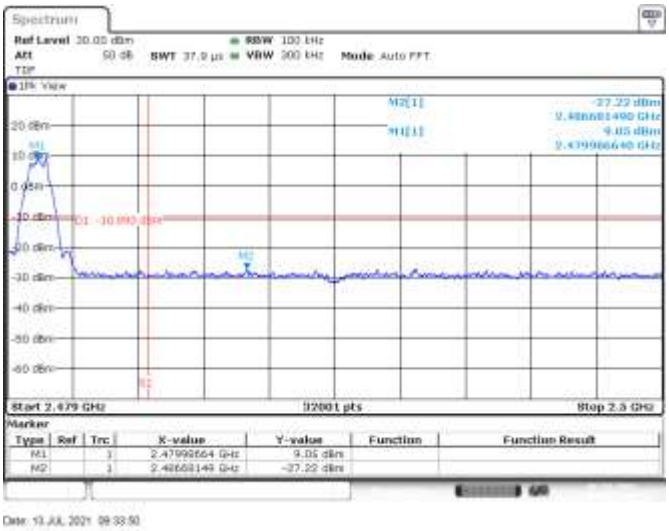


***Figure 8.4-2**: Band edge measurement, 2480 MHz*

8.5 FCC 15.247(d) and RSS-247 5.5 Conducted spurious emissions

8.5.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(d)

(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.

8.5.1 Test summary

Verdict	Pass		
Test date	July 12, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1003 mbar
Test location	Wireless bench (Conducted)	Relative humidity	60 %

8.5.2 Notes

The EUT was configured to transmit continuously at max power on the low, mid, and high channels.

The spectrum was search from 30 MHz to 26 GHz (above the 10th harmonic of the highest transmit frequency of 2480 MHz).

For conducted measurements, the loss of the connected cable and attenuator was input into the spectrum analyzer as a transducer factor.

In each measurement, the limit was derived by subtracting 20 dB from a power spectral density reference measurement.

8.5.3 Setup details

EUT setup configuration	Tabletop
Test facility	Wireless bench
Measurement details	Conducted spurious emissions measurement performed as per C63.10 §11.11.3

Spectrum analyzer settings for conducted spurious emissions:

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

8.5.4 Test data

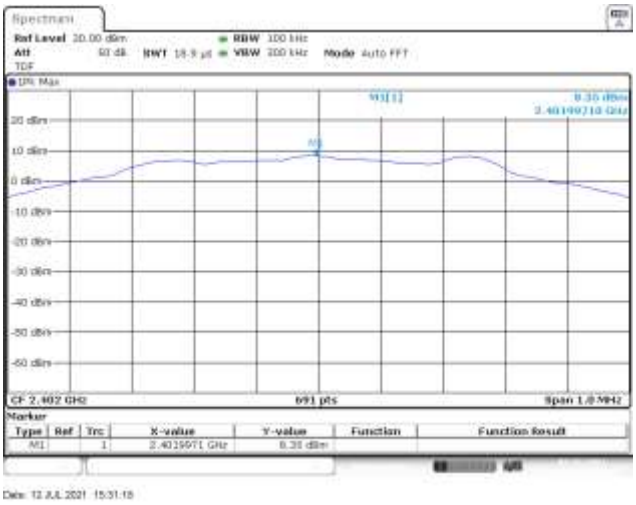


Figure 8.5-1: *Conducted PSD reference, 2402 MHz*

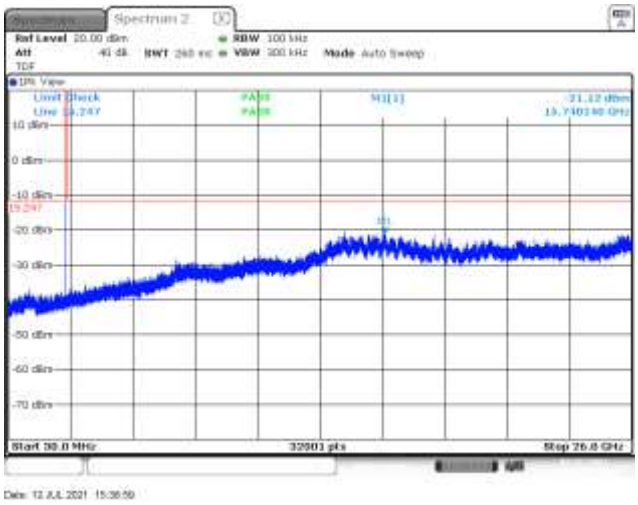


Figure 8.5-2: *Conducted spurious emissions, 2402 MHz*

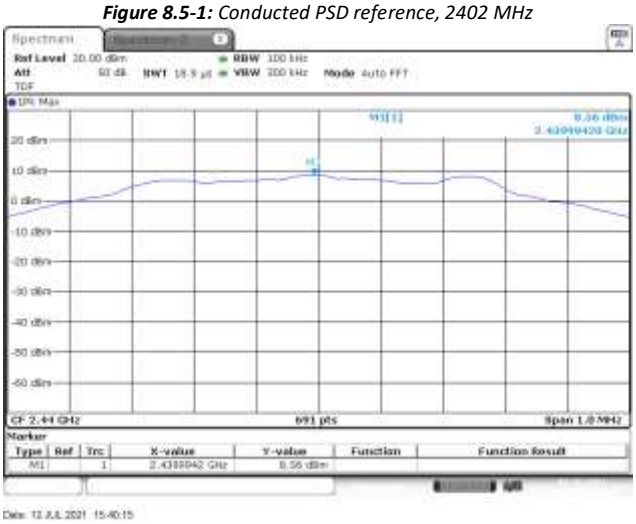


Figure 8.5-3: *Conducted PSD reference, 2440 MHz*

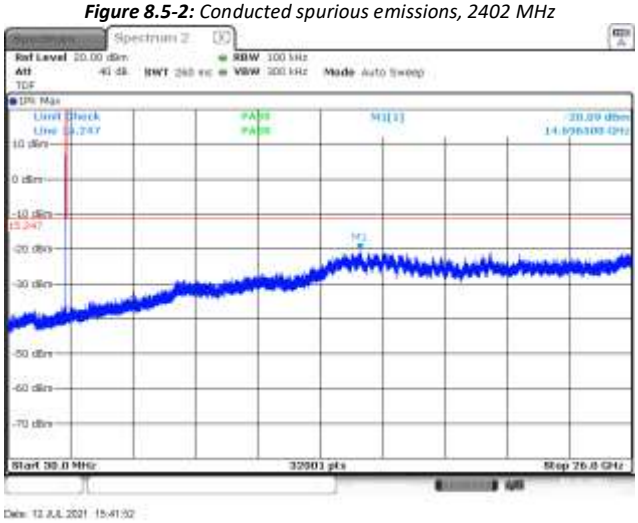


Figure 8.5-4: *Conducted spurious emissions, 2440 MHz*

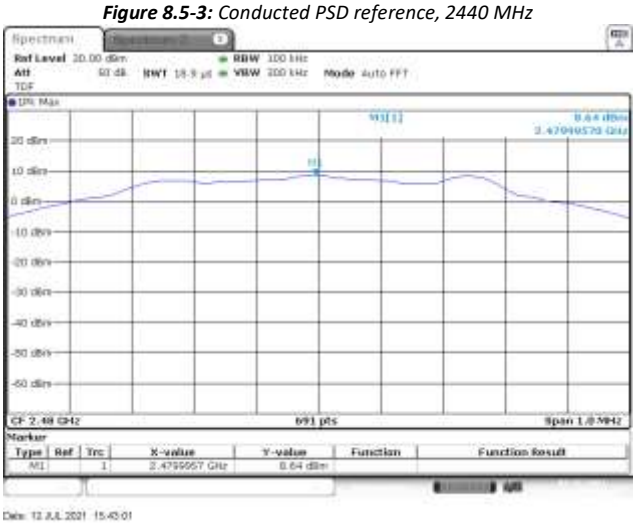


Figure 8.5-5*: Conducted PSD reference, 2480 MHz*

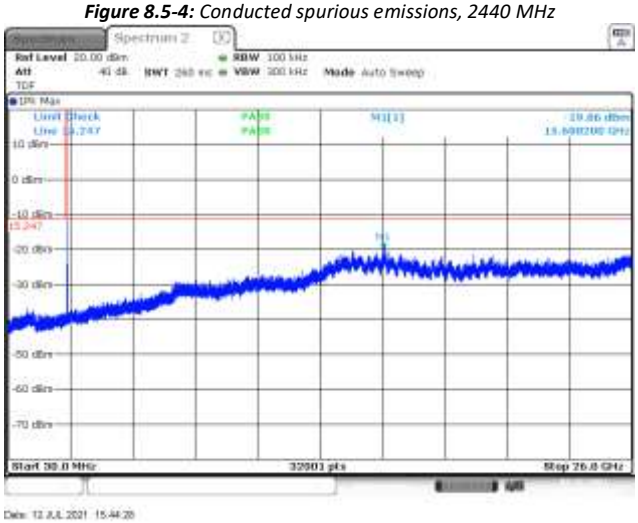


Figure 8.5-6: *Conducted spurious emissions, 2480 MHz*

8.6 FCC 15.247(d) and RSS-247 5.5 Radiated restricted band-edges and spurious emission

8.6.1 Definition and limits

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(d)

(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– 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			

8.6.2 Test summary

Verdict	Pass		
Test date	July 15, 2021	Temperature	23 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1005 mbar
Test location	3m semi-anechoic chamber (Radiated)	Relative humidity	60 %
Test date	July 16, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1006 mbar
Test location	3m semi-anechoic chamber (Radiated)	Relative humidity	64 %
Test date	July 19, 2021	Temperature	23 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber (Radiated)	Relative humidity	60 %
Test date	July 28, 2021	Temperature	23 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1007 mbar
Test location	3m semi-anechoic chamber (Radiated)	Relative humidity	66 %
Test date	July 30, 2021	Temperature	21 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1005 mbar
Test location	3m semi-anechoic chamber (Radiated)	Relative humidity	71 %

8.6.3 Notes

The EUT was configured to transmit continuously at max power on the lowest, middle, and highest channels.

The spectrum was search from 30 MHz to 26 GHz (above the 10th harmonic of the highest transmit frequency of 2480 MHz).

Radiated measurements were performed at a 3 m measurement distance.

8.6.4 Setup details

EUT setup configuration	Tabletop
Test facility	Nemko San Diego
Measurement details	Radiated spurious emissions measurement performed as per C63.10 §11.12

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 CAverage (final measurements)

8.6.5 Test data

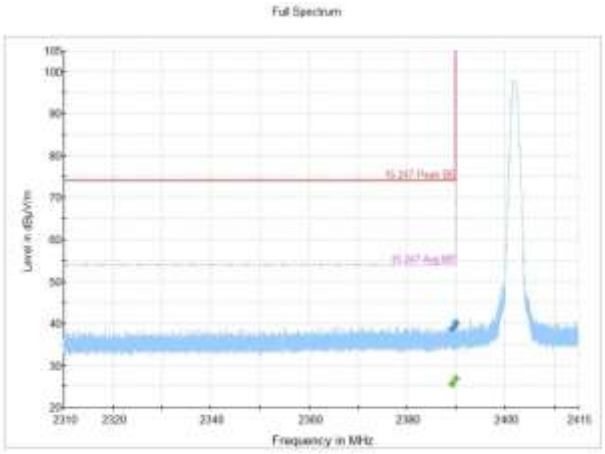


Figure 8.6-1: *Restricted band edge spectral plot, Low channel*

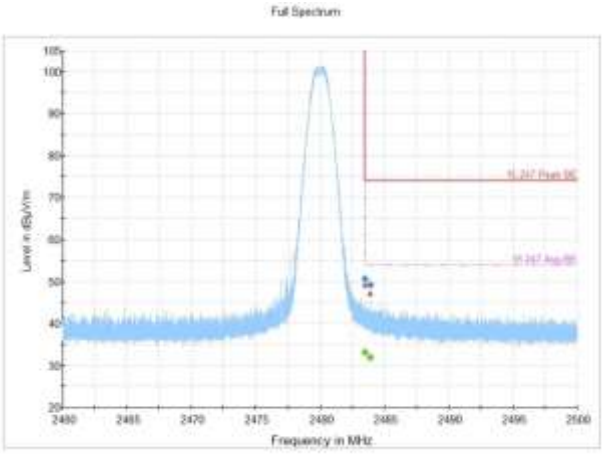


Figure 8.6-2: *Restricted band edge spectral plot, High channel*

Table 8.6-2: *Restricted band edge tabular data, Low channel*

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)
2389.222500	**38.81**	**---**	**73.90**	**35.09**	**5000.0**	**1000.000**	**402.0**	**V**	**240.0**	**-9.1**
2389.222500	**---**	**25.51**	**53.90**	**28.39**	**5000.0**	**1000.000**	**402.0**	**V**	**240.0**	**-9.1**
2390.000000	**40.28**	**---**	**73.90**	**33.62**	**5000.0**	**1000.000**	**302.0**	**H**	**0.0**	**-9.1**
2390.000000	**---**	**26.81**	**53.90**	**27.09**	**5000.0**	**1000.000**	**302.0**	**H**	**0.0**	**-9.1**

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factors = antenna factor ACF (dB) + cable loss (dB) - preamp (dB)

Table 8.6-3: *Restricted band edge tabular data, High channel*

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2483.500000	**---**	**33.21**	**53.90**	**20.69**	**5000.0**	**1000.000**	**322.0**	**H**	**351.0**	**-8.7**
2483.500000	**50.71**	**---**	**73.90**	**23.19**	**5000.0**	**1000.000**	**322.0**	**H**	**351.0**	**-8.7**
2483.904000	**---**	**31.90**	**53.90**	**22.00**	**5000.0**	**1000.000**	**102.0**	**V**	**34.0**	**-8.7**
2483.904000	**49.23**	**---**	**73.90**	**24.67**	**5000.0**	**1000.000**	**102.0**	**V**	**34.0**	**-8.7**

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factors = antenna factor ACF (dB) + cable loss (dB) - preamp (dB)

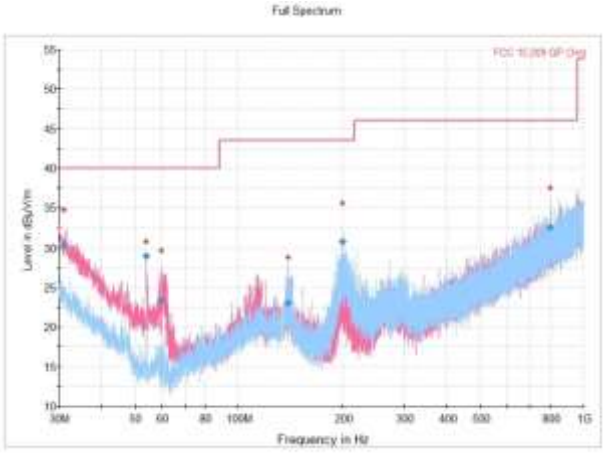


Figure 8.6-3: *Radiated spurious emissions 30-1000 MHz, Low channel*

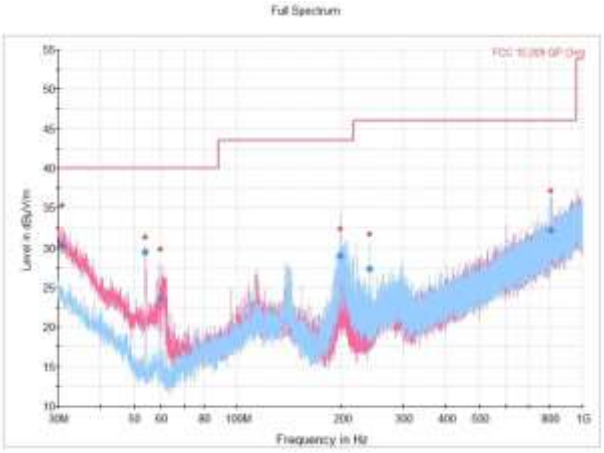


Figure 8.6-4: *Radiated spurious emissions 30-1000 MHz, Mid channel*

Table 8.6-4: *Radiated spurious emissions tabular data, Low channel*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
31.061333	30.32	40.00	9.68	5000.0	120.000	113.0	V	198.0	25.9
54.019000	29.04	40.00	10.96	5000.0	120.000	100.0	V	254.0	14.2
59.509667	23.42	40.00	16.58	5000.0	120.000	134.0	V	210.0	12.7
138.643000	23.09	43.50	20.41	5000.0	120.000	186.0	H	30.0	19.6
199.936667	30.86	43.50	12.64	5000.0	120.000	147.0	H	260.0	17.8
802.637667	32.61	46.00	13.39	5000.0	120.000	313.0	H	33.0	31.8

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

Table 8.6-5: *Radiated spurious emissions tabular data, Mid channel*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.967000	30.33	40.00	9.67	5000.0	120.000	100.0	V	220.0	26.0
54.011333	29.51	40.00	10.49	5000.0	120.000	100.0	V	231.0	14.2
59.578667	23.71	40.00	16.29	5000.0	120.000	135.0	V	252.0	12.7
197.818000	28.97	43.50	14.53	5000.0	120.000	154.0	H	265.0	17.7
239.985000	27.38	46.00	18.62	5000.0	120.000	117.0	H	273.0	19.9
810.043667	32.28	46.00	13.72	5000.0	120.000	398.0	H	91.0	31.9

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

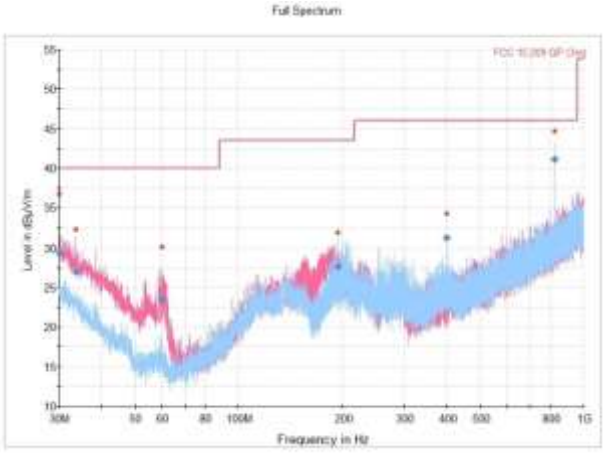


Figure 8.6-5: *Radiated spurious emissions 30-1000 MHz, High channel*

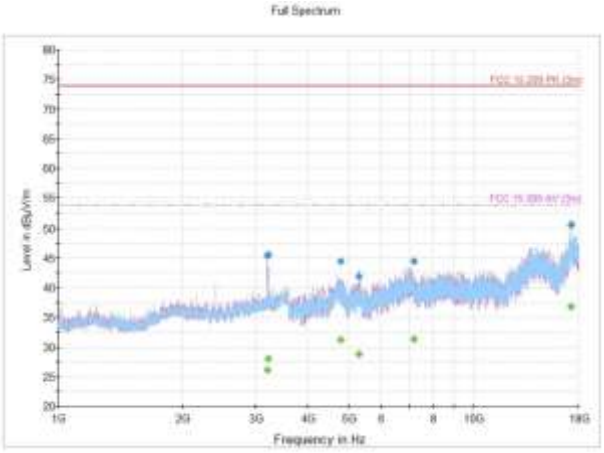


Figure 8.6-6: *Radiated spurious emissions 1-18 GHz, Low channel*

Table 8.6-6: *Radiated spurious emissions tabular data, High channel*

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.220000	29.36	40.00	10.64	5000.0	120.000	108.0	V	0.0	26.4
33.624333	27.03	40.00	12.97	5000.0	120.000	104.0	V	355.0	24.5
59.835667	23.45	40.00	16.55	5000.0	120.000	152.0	V	224.0	12.7
193.082000	27.65	43.50	15.85	5000.0	120.000	104.0	H	254.0	17.4
399.970333	31.29	46.00	14.71	5000.0	120.000	249.0	H	160.0	25.0
826.544000	41.18	46.00	4.82	5000.0	120.000	276.0	H	131.0	32.4

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB)
[3] Limits converted to dBµV/m and an inverse proportionality factor of 20 dB per decade has been used to normalize the specification limit to a measurement distance of 3 meters to determine compliance.

Table 8.6-7: *Radiated spurious emissions tabular data, Low channel*

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)
3208.444444	45.36	---	73.90	28.54	5000.0	1000.000	264.0	V	136.0	-6.3
3208.444444	---	26.09	53.90	27.81	5000.0	1000.000	264.0	V	136.0	-6.3
3229.688889	---	28.08	53.90	25.82	5000.0	1000.000	100.0	V	113.0	-6.2
3229.688889	45.66	---	73.90	28.24	5000.0	1000.000	100.0	V	113.0	-6.2
4803.200000	---	31.19	53.90	22.71	5000.0	1000.000	257.0	H	217.0	-0.8
4803.200000	44.47	---	73.90	29.43	5000.0	1000.000	257.0	H	217.0	-0.8
5309.244444	---	28.80	53.90	25.10	5000.0	1000.000	288.0	V	207.0	-0.7
5309.244444	41.87	---	73.90	32.03	5000.0	1000.000	288.0	V	207.0	-0.7
7205.200000	---	31.40	53.90	22.50	5000.0	1000.000	218.0	V	101.0	1.5
7205.200000	44.43	---	73.90	29.47	5000.0	1000.000	218.0	V	101.0	1.5
17264.211111	50.62	---	73.90	23.28	5000.0	1000.000	162.0	V	160.0	16.4
17264.211111	---	36.83	53.90	17.07	5000.0	1000.000	162.0	V	160.0	16.4

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)

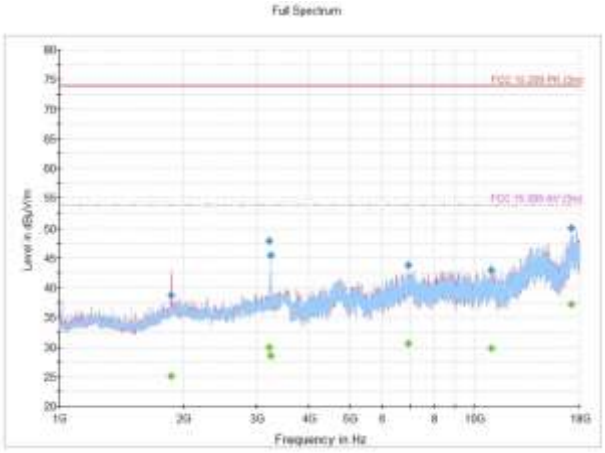


Figure 8.6-7: *Radiated spurious emissions 1-18 GHz, Mid channel*

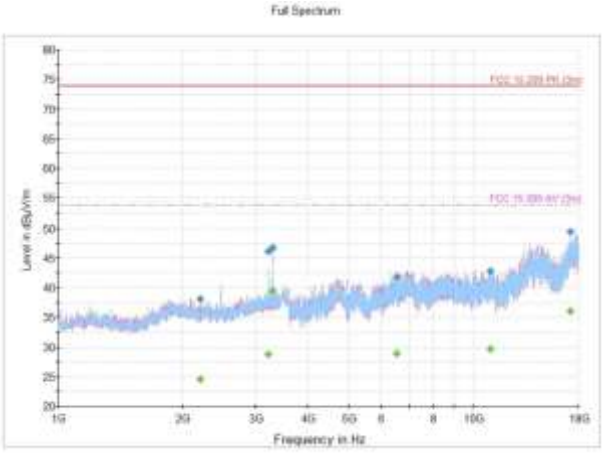


Figure 8.6-8: *Radiated spurious emissions 1-18 GHz, High channel*

Table 8.6-8: *Radiated spurious emissions tabular data, Mid channel*

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)
1868.122222	38.78	---	73.90	35.12	5000.0	1000.000	141.0	V	307.0	-10.3
1868.122222	---	25.14	53.90	28.76	5000.0	1000.000	141.0	V	307.0	-10.3
3229.255556	47.86	---	73.90	26.04	5000.0	1000.000	266.0	H	128.0	-6.2
3229.255556	---	29.90	53.90	24.00	5000.0	1000.000	266.0	H	128.0	-6.2
3255.844444	45.51	---	73.90	28.39	5000.0	1000.000	115.0	H	196.0	-6.1
3255.844444	---	28.50	53.90	25.40	5000.0	1000.000	115.0	H	196.0	-6.1
6948.655556	---	30.52	53.90	23.38	5000.0	1000.000	389.0	V	112.0	1.7
6948.655556	43.87	---	73.90	30.03	5000.0	1000.000	389.0	V	112.0	1.7
11023.500000	42.90	---	73.90	31.00	5000.0	1000.000	382.0	V	316.0	5.3
11023.500000	---	29.86	53.90	24.04	5000.0	1000.000	382.0	V	316.0	5.3
17211.977778	---	37.17	53.90	16.73	5000.0	1000.000	104.0	V	330.0	16.5
17211.977778	50.03	---	73.90	23.87	5000.0	1000.000	104.0	V	330.0	16.5

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)

Table 8.6-9: *Radiated spurious emissions tabular data, High channel*

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)
2212.122222	38.13	---	73.90	35.77	5000.0	1000.000	157.0	V	282.0	-9.9
2212.122222	---	24.60	53.90	29.30	5000.0	1000.000	157.0	V	282.0	-9.9
3229.288889	---	28.81	53.90	25.09	5000.0	1000.000	256.0	V	134.0	-6.2
3229.288889	46.09	---	73.90	27.81	5000.0	1000.000	256.0	V	134.0	-6.2
3306.622222	46.77	---	73.90	27.13	5000.0	1000.000	128.0	V	138.0	-6.0
3306.622222	---	39.52	53.90	14.38	5000.0	1000.000	128.0	V	138.0	-6.0
6538.955556	41.80	---	73.90	32.10	5000.0	1000.000	149.0	V	351.0	1.5
6538.955556	---	28.88	53.90	25.02	5000.0	1000.000	149.0	V	351.0	1.5
11012.344444	42.81	---	73.90	31.09	5000.0	1000.000	312.0	V	0.0	5.4
11012.344444	---	29.64	53.90	24.26	5000.0	1000.000	312.0	V	0.0	5.4
17177.211111	---	36.08	53.90	17.82	5000.0	1000.000	340.0	H	66.0	16.2
17177.211111	49.47	---	73.90	24.43	5000.0	1000.000	340.0	H	66.0	16.2

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)

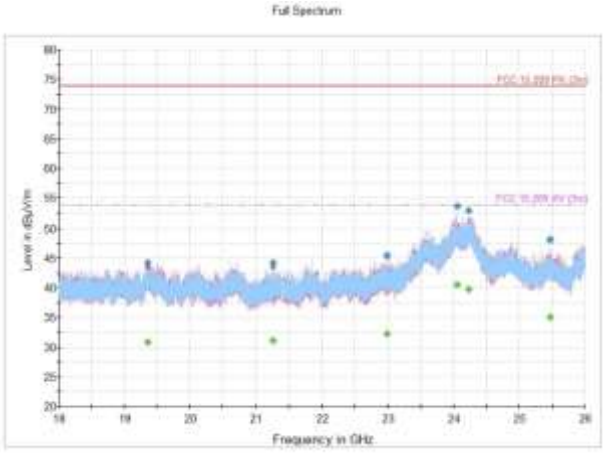


Figure 8.6-9: *Radiated spurious emissions 18-26 GHz, Low channel*

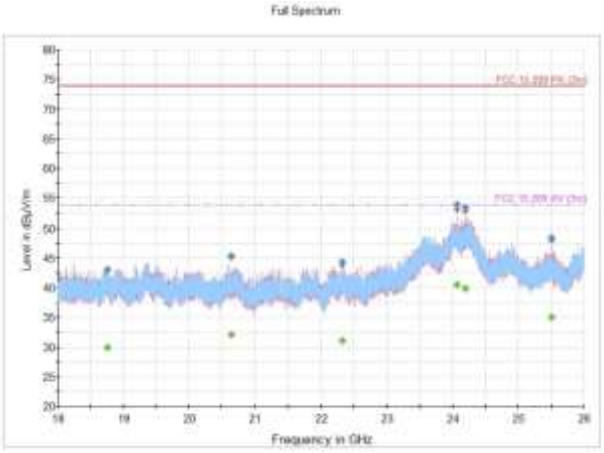


Figure 8.6-10: *Radiated spurious emissions 18-26 GHz, Mid channel*

Table 8.6-10: *Radiated spurious emissions tabular data, Low channel*

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)
19354.966667	---	30.87	53.90	23.03	5000.0	1000.000	402.0	V	314.0	18.5
19354.966667	44.16	---	73.90	29.74	5000.0	1000.000	402.0	V	314.0	18.5
21263.300000	44.23	---	73.90	29.67	5000.0	1000.000	279.0	H	78.0	18.9
21263.300000	---	31.03	53.90	22.87	5000.0	1000.000	279.0	H	78.0	18.9
22993.433333	---	32.27	53.90	21.63	5000.0	1000.000	245.0	H	54.0	21.0
22993.433333	45.42	---	73.90	28.48	5000.0	1000.000	245.0	H	54.0	21.0
24060.166667	---	40.53	53.90	13.37	5000.0	1000.000	312.0	H	106.0	29.7
24060.166667	53.65	---	73.90	20.25	5000.0	1000.000	312.0	H	106.0	29.7
24231.166667	52.86	---	73.90	21.04	5000.0	1000.000	175.0	V	44.0	29.1
24231.166667	---	39.75	53.90	14.15	5000.0	1000.000	175.0	V	44.0	29.1
25470.233333	---	35.00	53.90	18.90	5000.0	1000.000	303.0	V	327.0	24.0
25470.233333	48.11	---	73.90	25.79	5000.0	1000.000	303.0	V	327.0	24.0

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)

Table 8.6-11: *Radiated spurious emissions tabular data, Mid channel*

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)
18763.700000	---	29.94	53.90	23.96	5000.0	1000.000	159.0	V	75.0	17.6
18763.700000	43.02	---	73.90	30.88	5000.0	1000.000	159.0	V	75.0	17.6
20644.900000	45.39	---	73.90	28.51	5000.0	1000.000	391.0	V	322.0	19.6
20644.900000	---	32.14	53.90	21.76	5000.0	1000.000	391.0	V	322.0	19.6
22327.566667	---	31.10	53.90	22.80	5000.0	1000.000	402.0	V	102.0	19.5
22327.566667	44.35	---	73.90	29.55	5000.0	1000.000	402.0	V	102.0	19.5
24068.500000	53.89	---	73.90	20.01	5000.0	1000.000	390.0	V	336.0	29.7
24068.500000	---	40.53	53.90	13.37	5000.0	1000.000	390.0	V	336.0	29.7
24192.366667	53.41	---	73.90	20.49	5000.0	1000.000	205.0	V	86.0	29.2
24192.366667	---	39.85	53.90	14.05	5000.0	1000.000	205.0	V	86.0	29.2
25500.900000	48.41	---	73.90	25.49	5000.0	1000.000	331.0	V	127.0	24.2
25500.900000	---	35.00	53.90	18.90	5000.0	1000.000	331.0	V	127.0	24.2

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)

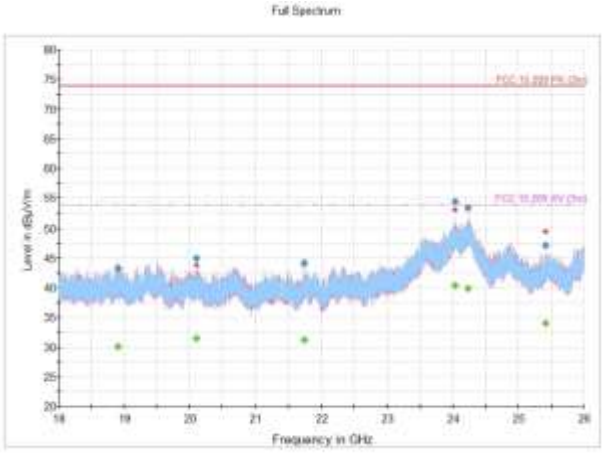


Figure 8.6-11: *Radiated emissions, High channel, 18 – 26 GHz spectral plot*

Table 8.6-12: *Radiated emissions, High channel, 18 – 26 GHz (Peak and CAverage) 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)
18911.966667	43.27	---	73.90	30.63	5000.0	1000.000	402.0	V	170.0	17.5
18911.966667	---	30.09	53.90	23.81	5000.0	1000.000	402.0	V	170.0	17.5
20103.566667	44.93	---	73.90	28.97	5000.0	1000.000	115.0	V	33.0	18.8
20103.566667	---	31.41	53.90	22.49	5000.0	1000.000	115.0	V	33.0	18.8
21732.633333	44.25	---	73.90	29.65	5000.0	1000.000	259.0	V	295.0	19.3
21732.633333	---	31.18	53.90	22.72	5000.0	1000.000	259.0	V	295.0	19.3
24030.300000	54.37	---	73.90	19.53	5000.0	1000.000	365.0	H	201.0	29.7
24030.300000	---	40.33	53.90	13.57	5000.0	1000.000	365.0	H	201.0	29.7
24227.166667	---	39.88	53.90	14.02	5000.0	1000.000	297.0	V	185.0	29.1
24227.166667	53.34	---	73.90	20.56	5000.0	1000.000	297.0	V	185.0	29.1
25418.900000	---	34.04	53.90	19.86	5000.0	1000.000	252.0	H	137.0	23.8
25418.900000	47.11	---	73.90	26.79	5000.0	1000.000	252.0	H	137.0	23.8

Notes: [1] Field strength (dBµV/m) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor = antenna factor ACF (dB) + cable loss (dB) - pre amp (dB)

8.7 FCC 15.247(e) and RSS-247 5.2(b) Power spectral density of digital transmission system

8.7.1 References

Title 47 → Chapter I → Subchapter A → Part 15 → Subpart C → §15.247(e) / ANSI C63.10: 2013

(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(b)

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

8.7.2 Test summary

Verdict	Pass		
Test date	July 12, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1003 mbar
Test location	Wireless bench (Conducted)	Relative humidity	60 %

8.7.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

The EUT antenna port was connected to the spectrum analyzer via low loss cable and a suitable attenuator. The loss of this assembly was corrected for via a transducer factor in the spectrum analyzer.

8.7.4 Setup details

EUT setup configuration	Table top
Test facility	Nemko San Diego
Measurement details	Measurement performed as per C63.10 §11.10.2 (Method PKPSD)

Receiver/spectrum analyzer settings:

Resolution bandwidth	3 kHz
Video bandwidth	10 kHz (≥ 3 x RBW)
Frequency span	1 MHz (1.5 x DTS bandwidth)
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 of DTS*

Transmitter Frequency (MHz)	Measured Level (dBm/3 kHz)	Limit (dBm/3 kHz)
2402	-7.61	8.00
2440	-7.35	8.00
2480	-7.28	8.00

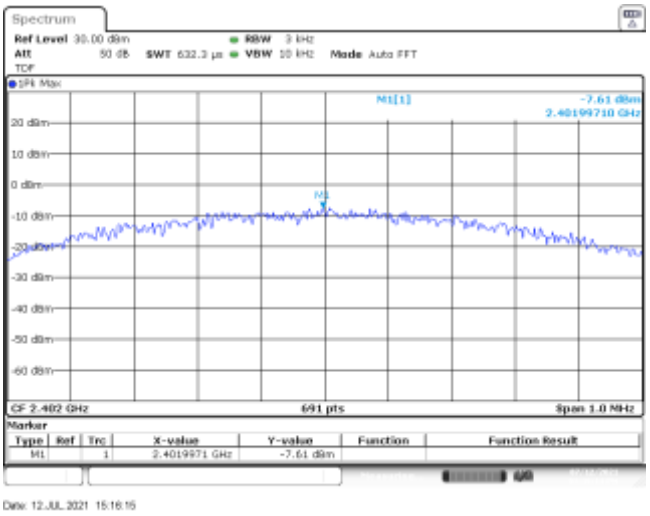


Figure 8.7-1: *Power spectral density of digital transmission system, 2402 MHz*

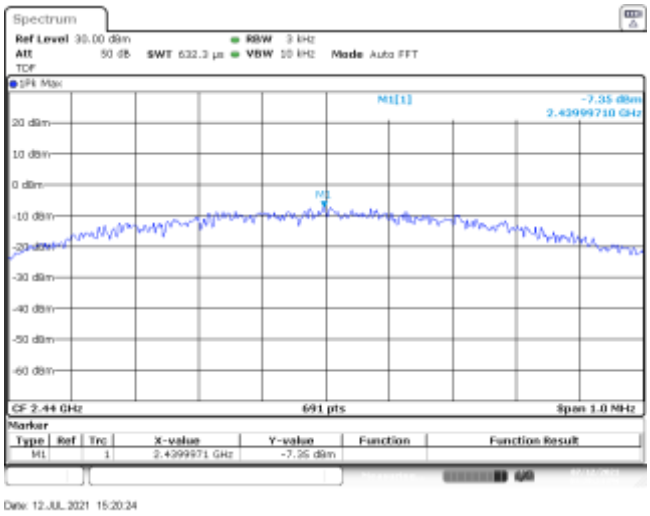


Figure 8.7-2: *Power spectral density of digital transmission system, 2440 MHz*

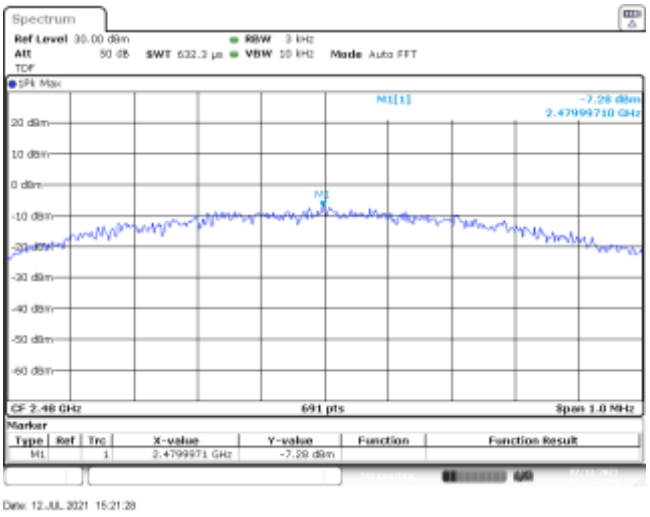


Figure 8.7-3: *Power spectral density of digital transmission system, 2480 MHz*

8.8 RSS-GEN 6.7 Occupied bandwidth (or 99% emission bandwidth)

8.8.1 References

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	July 12, 2021	Temperature	22 °C
Test engineer	David Hewitt, EMC Specialist	Air pressure	1003 mbar
Test location	Wireless bench (Conducted)	Relative humidity	60 %

8.8.3 Notes

Testing was performed in BLE mode and the EUT transmitting on a fixed channel at full power.

8.8.4 Setup details

EUT setup configuration	Tabletop
Test facility	Nemko San Diego
Measurement details	Measurement performed as per C63.10 §6.9.3 using the built-in function of the spectrum analyzer

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

8.8.5 Test data

Table 8.8-1: *99% Occupied bandwidth*

Test Frequency (MHz)	M1 (MHz)	T1 (MHz)	T2 (MHz)	99%Bandwidth (MHz)
2402 (Low channel)	2401.97917	2401.480988	2402.487869	1.006881035
2440 (Mid channel)	2439.97907	2439.285525	2440.487869	1.002343677
2480 (High channel)	2479.97824	2479.481091	2480.486425	1.005334208

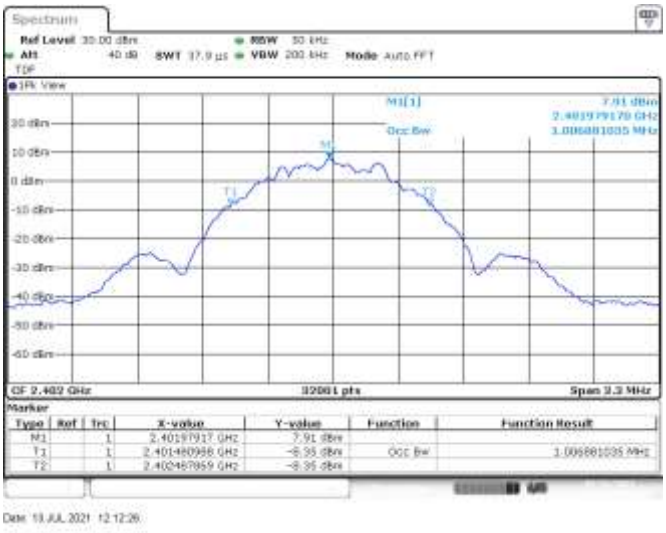


Figure 8.8-1: *99% bandwidth, 2402 MHz*

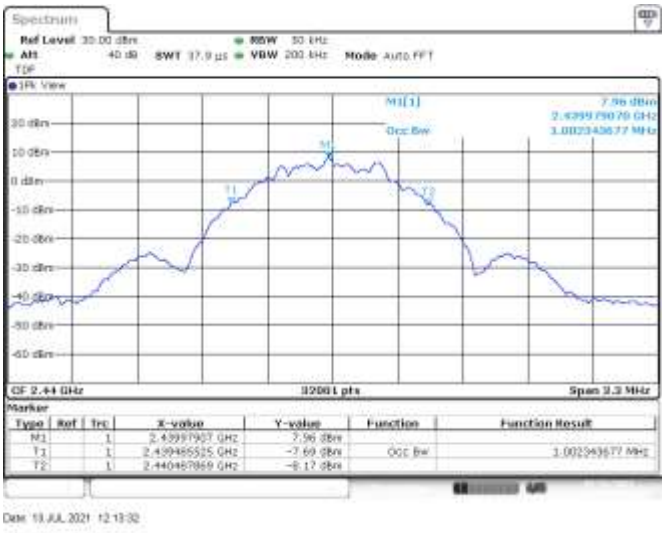


Figure 8.8-2: *99% bandwidth, 2440 MHz*

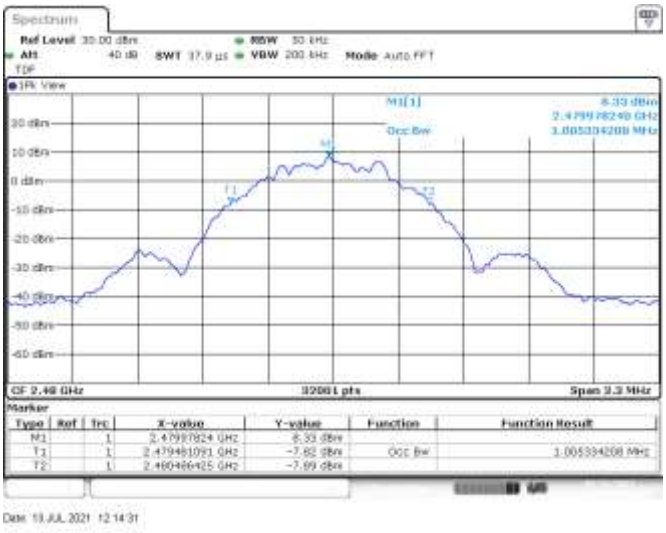


Figure 8.8-3: *99% bandwidth, 2480 MHz*

Section 9 Block diagrams of test set-ups

9.1 Radiated emissions set-up

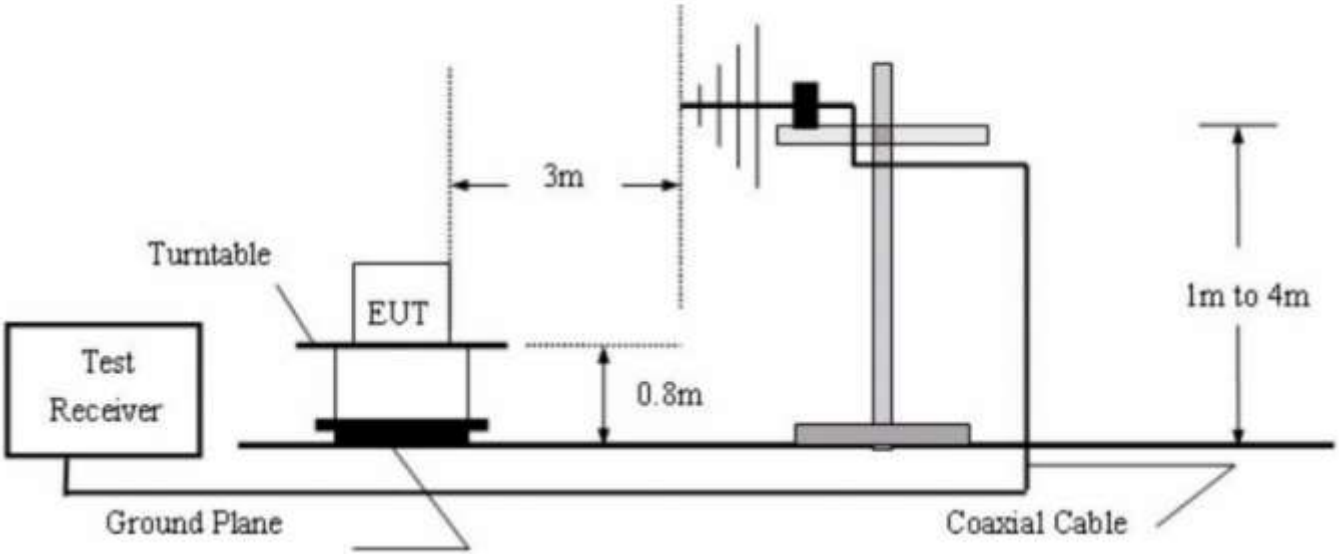


Figure 9.1-1: *30 MHz - 1000 MHz Setup*

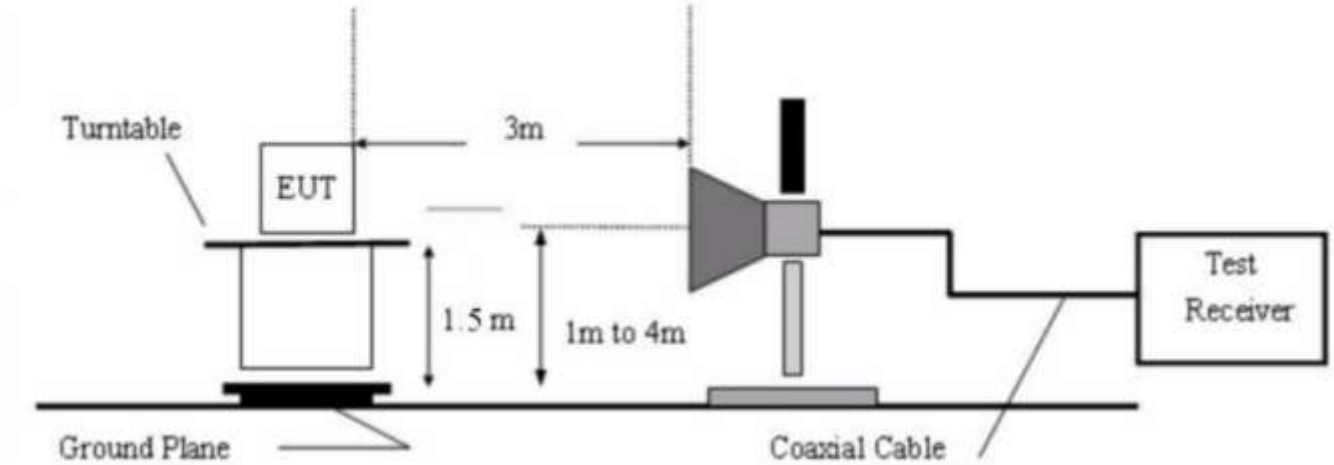


Figure 9.1-2: 1 GHz - 26 GHz Setup

9.2 Conducted emissions set-up

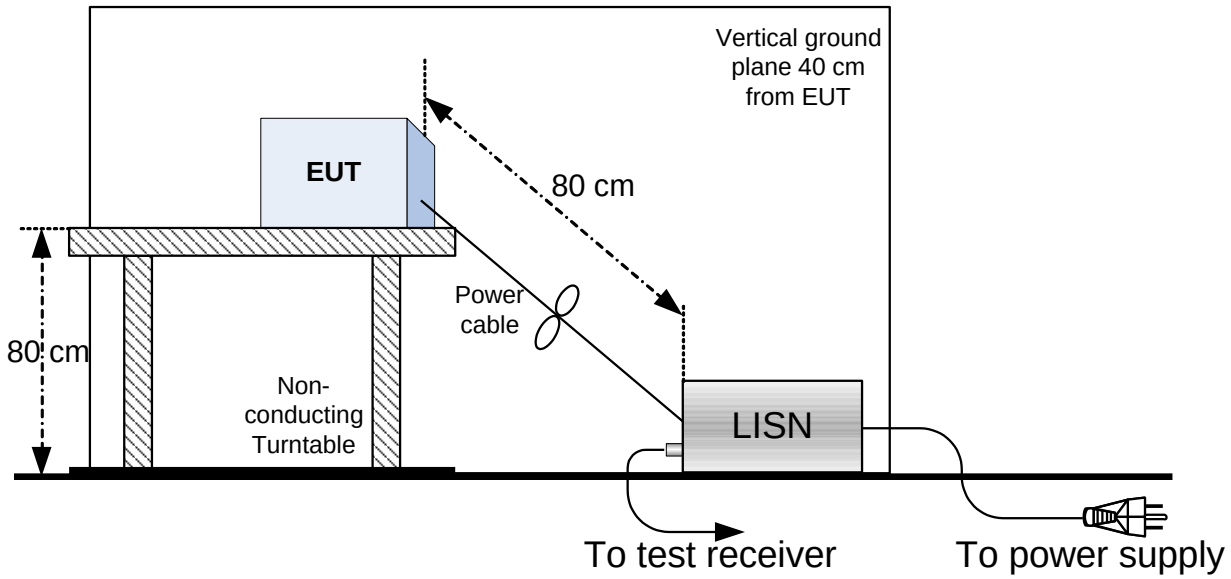


Figure 9.2-1: *150 kHz to 30 MHz Conducted Emissions Setup*