Test report

REP027851-2TRFWL

Date of issue: March 15, 2023

Applicant:

TrellisWare Technologies, Inc

Product:

TW-875 Ghost Radio with battery

Model:

TW-875

Variant(s):

TW-870 Embedded Radio (without internal battery)

FCC ID:

2A6X2-875

IC:

28565-875

Specifications:

- FCC 47 CFR Part 15, Subpart C – §15.247
  Operation within the bands 902 – 928 MHz, 2400 – 2483.5 MHz, 5725 – 5850 MHz
- Industry Canada RSS-247, Issue 2, February 2017
  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	Chenhao Ma, Wireless Test Technician
Reviewed by	James Cunningham, EMC/MIL/WL Supervisor
Review date	March 15, 2023
Reviewer signature	

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.
This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contain in this report are within Nemko USA's ISO/IEC 17025 accreditation.

Copyright notification

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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, 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

1.2 Test methods

ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
558074 D01 DTS Measurement Guidance v05r02 (April 2, 2019)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247

1.3 Exclusions

None.

1.4 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.

1.5 Test report revision history

Table 1.5-1: *Test report revision history*

Revision #	Issue Date	Details of changes made to test report
REP027851-2TRFEMC	March 15, 2023	Original report issued

Section 2 Summary of test results

2.1 FCC Part 15, Subpart C, general requirements

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not applicable [1]
§15.31(e)	Variation of power source	Pass
§15.203	Antenna requirement	Pass [2]
§15.215(c)	20 dB bandwidth	Pass

Note 1: The EUT is DC powered via battery
Note 2: The antenna is connected to the EU using a non-standard connector

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 5275 – 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
6.7	99% Occupied bandwidth	Pass
7.3	Receiver radiated emission limits	Not applicable [1]
7.4	Receiver conducted emission limits	Not applicable [2]
8.8	Power Line Conducted Emissions Limits for License-Exempt Radio Apparatus	Not applicable [3]

Note 1: EUT is neither a stand-alone receiver nor a scanning receiver.
Note 2: The EUT is battery powered

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 Sample information

Receipt date	24-Jan-23
Nemko sample ID number	REP027851

3.3 Testing period

Test start date	24-Jan-23
Test end date	08-Feb-23

3.4 Applicant

Company name	TrellisWare Technologies, Inc
Address	10641 Scripps Summit Court, Ste 100
City	San Diego
State	California
Postal/Zip code	92131
Country	United states

3.5 Manufacturer

Company name	TrellisWare Technologies, Inc
Address	10641 Scripps Summit Court, Ste 100
City	San Diego
State	California
Postal/Zip code	92131
Country	United states

3.6 EUT information

Product name	TW-875 Ghost Radio with battery
Model	TW-875
Variant(s)	TW-870 Embedded Radio (without internal battery)
Serial number	TW-875 = SN-133866, TW-870 = SN-152187
Part number	TW-875 = ASY0750280, TW-870 = ASY0750279
Power requirements	TW-875 uses internal battery, TW-870 uses external battery 8-20 VDC
Description/theory of operation	Handheld MANET radio carries voice, location, and user data. User selectable channel bandwidth of 1.2, 3.6, 10, and 20MHz.
Operational frequencies	2403 – 2478 MHz, depending on bandwidth selected
Software details	Version 6.2.1-b38
Operating band	2400 – 2483.5 MHz
Test frequencies	2403 MHz (1.2 MHz), 2404 MHz (3.6 MHz), 2412 MHz (10 MHz), 2422 MHz (20 MHz), 2442 MHz (20 MHz), 2465 MHz (10 MHz), 2478 MHz (3.6 MHz and 1.2 MHz)
Modulation type(s)	TSM HDR
Antenna type	Omnidirectional antenna
Operating bandwidth(s)	2403 – 2478 MHz, depending on bandwidth selected
Antenna gain (declared)	5 dBi
Nominal channel spacing	1 MHz

3.7 EUT exercise and monitoring details

EUT description of the methods used to exercise the EUT and all relevant ports:

- Radio is fitted with a 5dBi omni-directional antenna. Channel presets are loaded into the radio to cover low, mid, and high frequencies in the range defined above for all four bandwidth settings. Near-constant transmit mode is enabled using the MAC_BERT API function of the radio with burst mode settings based on the selected bandwidth.

EUT setup/configuration rationale:

- The EUT setup in a configuration that was expected to produce the highest amplitude emissions relative to the limit and that satisfy normal operation/installation practice by the end user.
- The type and construction of cables used in the measurement set-up were consistent with normal or typical use. Cables with mitigation features (for example, screening, tighter/more twists per length, ferrite beads) have been noted below:
  - None
- The EUT was setup in a manner that was consistent with its typical arrangement and use. The measurement arrangement of the EUT, local ancillary equipment and associated cabling was representative of normal practice. Any deviations from typical arrangements have been noted below:
  - None

3.8 EUT setup details

Table 3.8-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number	Rev.
TW-875	TSM Ghost Relay with battery	P/N ASY0750280	SN-133866	J
TW-870	TSM Ghost Embedded	P/N ASY0750279	SN-152187	H
TW-1147	Antenna, 1250-2700MHz, 5dBi	TW-1147	None	A

Table 3.8-2: *EUT interface ports*

Description	Qty.
RF Interface = TNC for TW-875, SMA for TW-870	1
GPS Interface = SMA	1
Power = 4 pin ODU circular connector	1
Voice and Data = 12 pin ODU circular connector	1

Table 3.8-3: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
Test Laptop	Dell	Latitude 7430	None	None
12V marine battery for TW-870	Interstate	Model 14	None	None

Table 3.8-4: *Inter-connection cables*

Cable description	From	To	Length (m)
USB to 12 pin ODU connector	Control computer	DUT	1
Banana to 4-pin ODU connector power for TW-870 only	12V battery	DUT	1

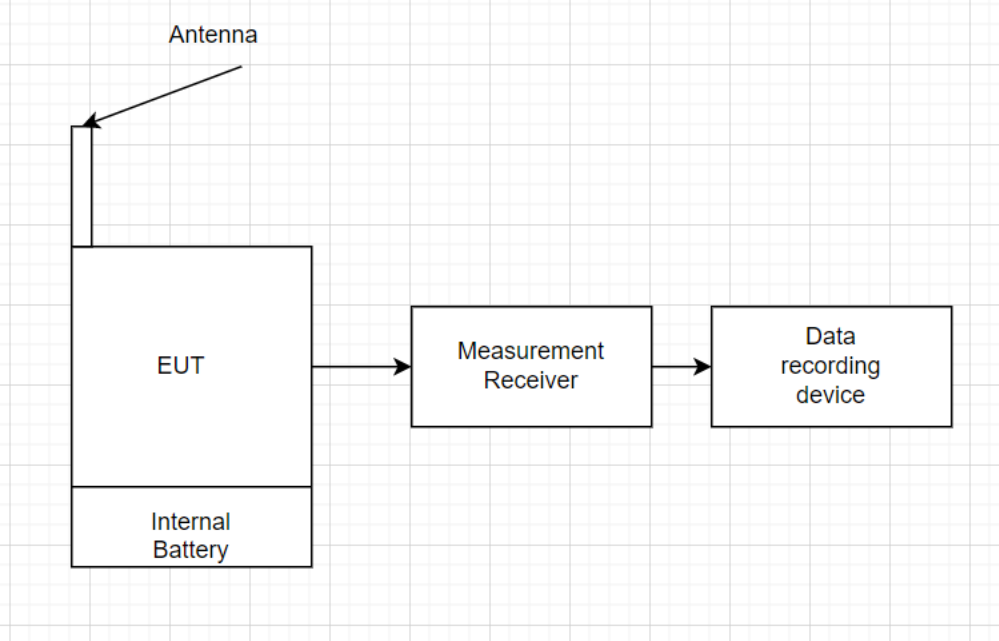

Figure 3.8-1: Test setup diagram

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

None.

4.2 Technical judgement

None.

4.3 Deviations from laboratory test procedures

None.

Section 5 Test conditions

5.1 Atmospheric conditions

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

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

5.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages ±5 %, for which the equipment was designed.

Section 6 Measurement uncertainty

6.1 Uncertainty of measurement

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

Table 6.1-1: *Measurement uncertainty calculations*

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

Notes: Compliance assessment:

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

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

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

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

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

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: *Test equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
EMI Test Receiver	Rohde & Schwarz	ESCI 7	E1026	1 year	03/22/2023
Standard Gain Horn Antenna	Eravant	SAZ-2410-42-S1	EW107	2 years	11/22/2023
Signal & Spectrum Analyzer	Rohde & Schwarz	FSW43	E1302	1 year	10/20/2023
20 dB attenuator	Centric RF	C407-20	E1201	NCR	NCR
10 dB attenuator	Centric RF	C407-10	E1198	NCR	NCR
Transient Limiter	Hewlett-Packard	11947A	E1159	1 year	02/18/2023
Two Line V-Network	Rohde & Schwarz	ENV216	E1019	1 year	09/30/2023
EMI Test Receiver	Rohde & Schwarz	ESU40	E1121	1 year	05/31/2023
System Controller	Sunol Sciences	SC104V	E1129	NCR	NCR
Bilog Antenna	Schaffner	CBL 6111D	1763	2 years	04/01/2024
DRG Horn	ETS-Lindgren	3117-PA	E1139	2 years	04/19/2023
Pre-Amp as part of DRG Horn	ETS-Lindgren	3117-PA	Part of E1139	2 years	04/19/2023

Notes: N/A – not applicable
NCR – no calibration required
VOU – verify on use

Table 7.1-2: T*est software details*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.60.15 (Radiated emissions)
Rohde & Schwarz	EMC 32 V10.20.01 (AC conducted emissions)

Notes: None

Section 8 Testing data

8.1 Minimum 6 dB bandwidth for systems using digital modulation techniques

8.1.1 References and limits

- FCC 47 CFR Part 15, Subpart B: §15.247(a)(2)
- RSS-247: §5.2(a)
- Test method: 558074 D01 DTS Measurement Guidance §8.2 and ANSI C63.10 §11.8.2 (using built-in marker function of the spectrum analyzer)

§15.247:
(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:
(2) Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

RSS-247:
5.2 DTSs include systems that employ digital modulation techniques resulting in spectral characteristics similar to direct sequence systems. The following applies to the bands 902-928 MHz and 2400-2483.5 MHz:
(a) The minimum 6 dB bandwidth shall be 500 kHz.

8.1.2 Test summary

Verdict	Pass		
Test date	February 6, 2023	Temperature	19.77 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	997.1 mbar
Test location	☒ Wireless bench ☐ Other:	Relative humidity	44.1 %

8.1.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power. Low, middle and high channels were tested.
Because of high power, use 10dBm attenuate.

8.1.4 Setup details

EUT power input during test	12 VDC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ Other:

Receiver settings:

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

8.1.5 Test data

Table 8.1-1: *TSM Bandwidth 1.2MHz 6dB DTS bandwidth test data*

Test frequency (MHz)	Bandwidth (kHz)	Limit
2403	1070	≥ 500 kHz
2442	1110	≥ 500 kHz
2478	1070	≥ 500 kHz

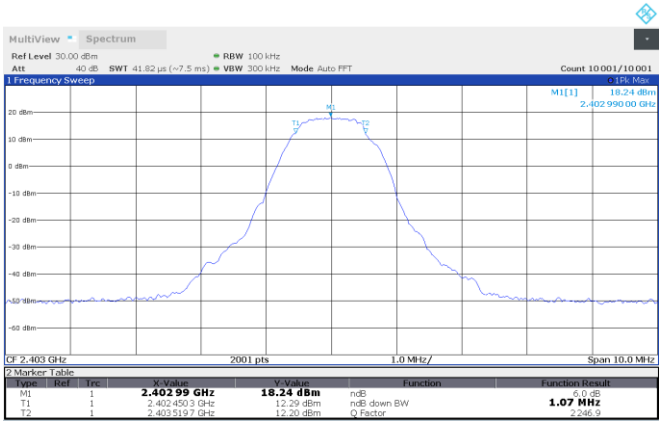

Figure 8.1-1: *TSM Bandwidth 1.2MHz 6dB DTS bandwidth, 2403 MHz*

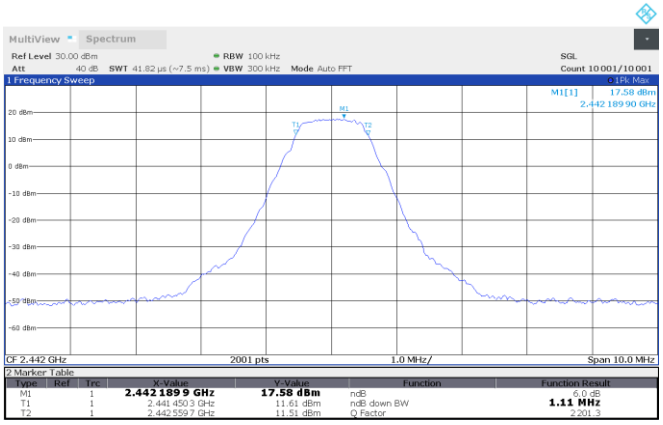

Figure 8.1-2: *TSM Bandwidth 1.2MHz 6dB DTS bandwidth, 2442 MHz*

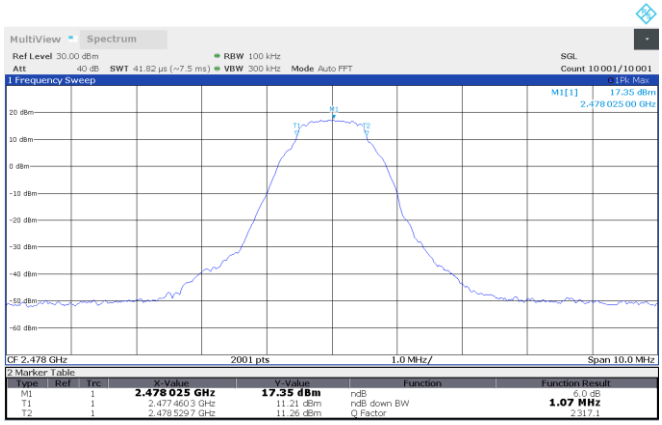

Figure 8.1-3: *TSM Bandwidth 1.2MHz 6dB DTS bandwidth, 2478 MHz*

Table 8.1-2: *TSM Bandwidth 3.6MHz 6dB DTS bandwidth test data*

Test frequency (MHz)	Bandwidth (kHz)	Limit
2404	2300	≥ 500 kHz
2442	2420	≥ 500 kHz
2478	2450	≥ 500 kHz

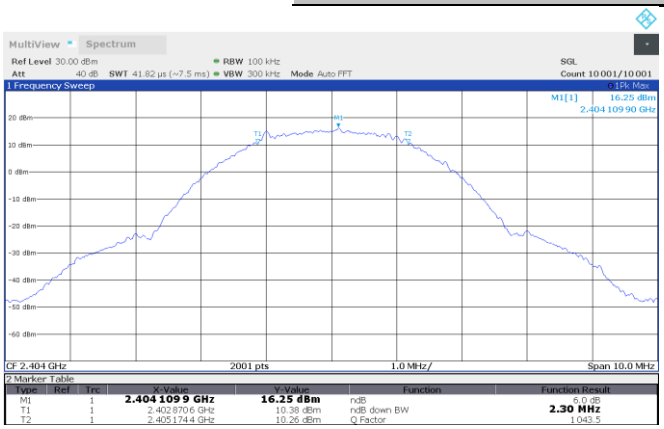

Figure 8.1-4: *TSM Bandwidth 3.6MHz 6dB DTS bandwidth, 2404 MHz*

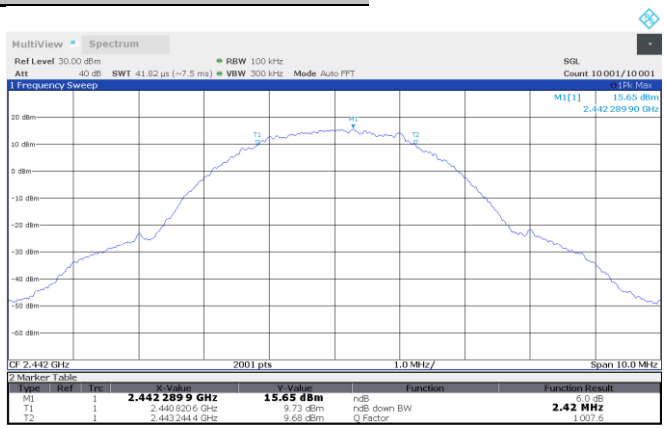

Figure 8.1-5: *TSM Bandwidth 3.6MHz 6dB DTS bandwidth, 2442 MHz*

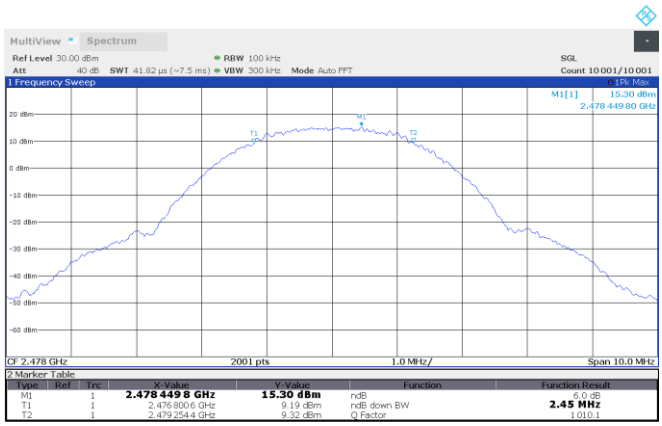

Figure 8.1-6: *TSM Bandwidth 3.6MHz 6dB DTS bandwidth, 2478 MHz*

Table 8.1-3: *TSM Bandwidth 10MHz 6dB DTS bandwidth test data*

Test frequency (MHz)	Bandwidth (kHz)	Limit
2412	6270	≥ 500 kHz
2442	5420	≥ 500 kHz
2465	5200	≥ 500 kHz

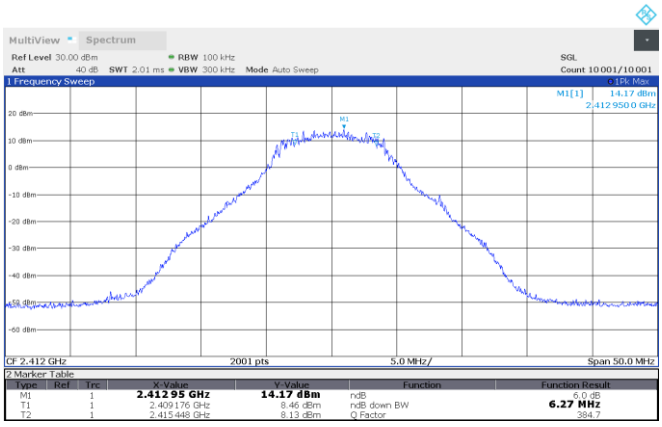

Figure 8.1-7: *TSM Bandwidth 10MHz 6dB DTS bandwidth, 2412 MHz*

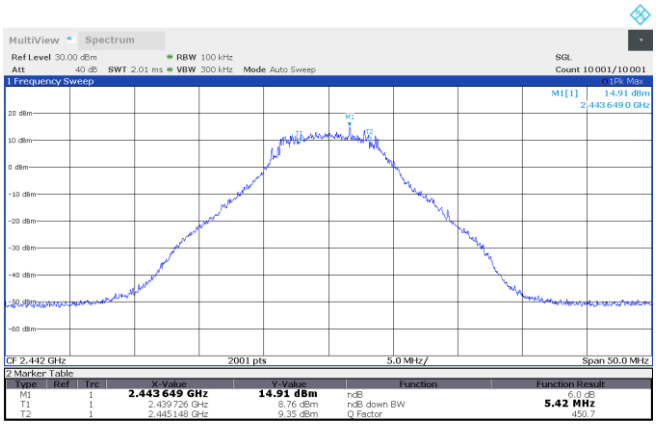

Figure 8.1-8: *TSM Bandwidth 10MHz 6dB DTS bandwidth, 2442 MHz*

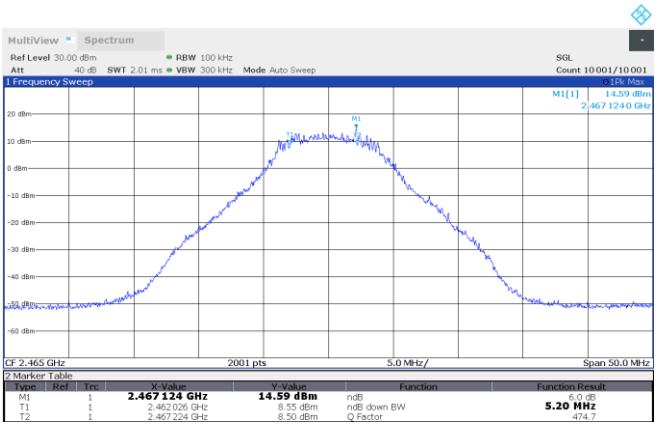

Figure 8.1-9: *TSM Bandwidth 10MHz 6dB DTS bandwidth, 2465 MHz*

Table 8.1-4: *TSM Bandwidth 20MHz 6dB DTS bandwidth test data*

Test frequency (MHz)	Bandwidth (kHz)	Limit
2422	18590	≥ 500 kHz
2442	17966	≥ 500 kHz

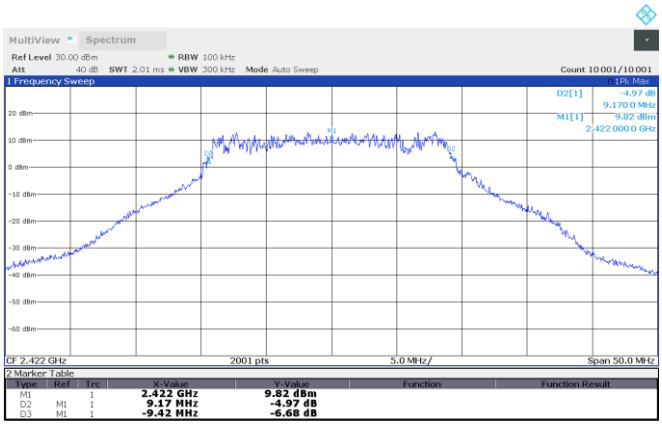

Figure 8.1-10: *TSM Bandwidth 20MHz 6dB DTS bandwidth, 2412 MHz*

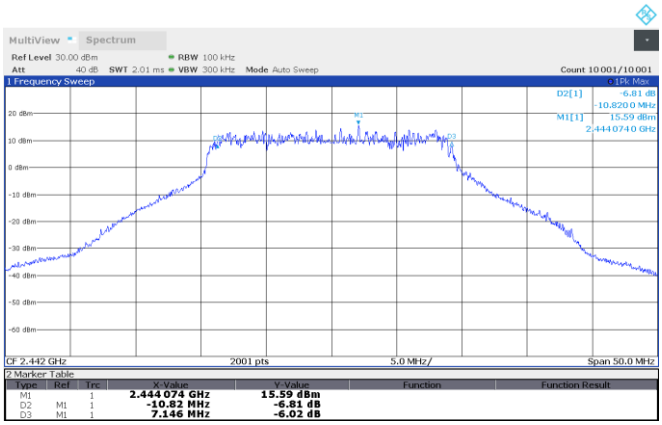

Figure 8.1-11: *TSM Bandwidth 20MHz 6dB DTS bandwidth, 2442 MHz*

Table 8.1-5: *HDR-Bandwidth 20MHz 6dB DTS bandwidth test data*

Test frequency (MHz)	Bandwidth (kHz)	Limit
2422	17920	≥ 500 kHz
2442	18070	≥ 500 kHz

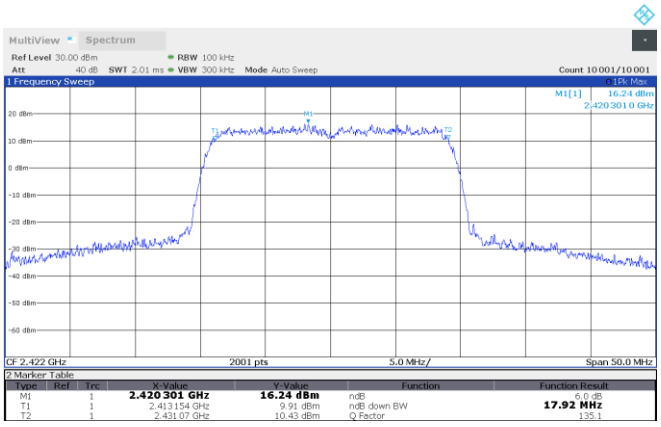

Figure 8.1-12: *HDR Bandwidth 20MHz 6dB DTS bandwidth, 2422 MHz*

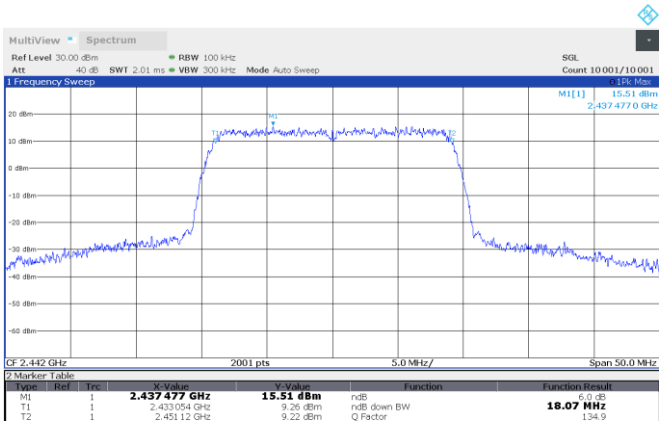

Figure 8.1-13: *HDR Bandwidth 20MHz 6dB DTS bandwidth, 2442 MHz*

8.2 Transmitter output power and EIRP requirements

8.2.1 References and limits

- FCC 47 CFR Part 15, Subpart B: §15.247(b)(3)
- RSS-247: §5.4(d)
- Test method: ANSI C63.10 §11.9.2.2.2 (Method AVGSA-1)
- Test method: ANSI C63.10 §11.9.2.2.6 (Method AVGSA-3)

§15.247:

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

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

RSS-247:

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

(d) For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The EIRP shall not exceed 4 W, except as provided in RSS 247 section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

8.2.2 Test summary

Verdict	Pass		
Test date	February 8, 2023	Temperature	19.74 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	1002.4 mbar
Test location	☒ Wireless bench ☐ Other:	Relative humidity	39.98 %

8.2.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power. Low, middle and high channels were tested. EIRP = conducted power + declared antenna gain.
Use method AVGSA-3 for testing.

8.2.4 Setup details

EUT power input during test	12 VDC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ Other:

Receiver settings:

Resolution bandwidth	See plots
Video bandwidth	See plots
Detector mode	RMS
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.2.5 Test data

Table 8.2-1: *TSM-Bandwidth 1.2MHz Transmitter output power and EIRP test data*

Test frequency (MHz)	Peak conducted output power (dBm)	Conducted limit (dBm)	Antenna Gain (declared) (dBi)	EIRP (dBm)	EIRP limit (dBm)
2403	27.32	30.0	5	32.32	36.0
2442	27.30	30.0	5	32.30	36.0
2478	26.97	30.0	5	31.97	36.0

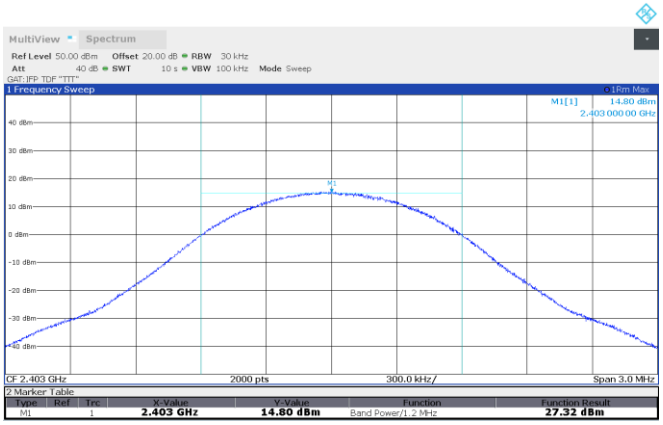

Figure 8.2-1: *TSM-Bandwidth 1.2MHz Conducted output power, 2403 MHz*

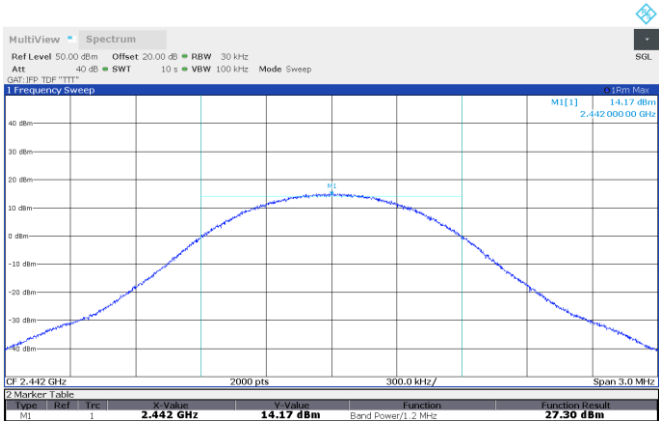

Figure 8.2-2: *TSM-Bandwidth 1.2MHz Conducted output power, 2442 MHz*

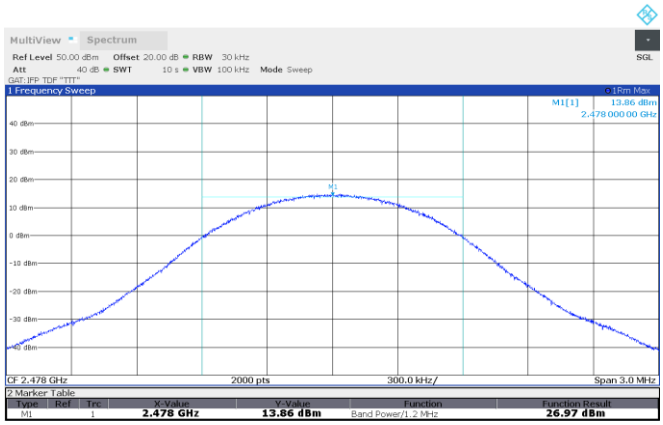

Figure 8.2-3: *TSM-Bandwidth 1.2MHz Conducted output power, 2478 MHz*

Table 8.2-2: *TSM-Bandwidth 3.6MHz Transmitter output power and EIRP test data*

Test frequency (MHz)	Peak conducted output power (dBm)	Conducted limit (dBm)	Antenna Gain (declared) (dBi)	EIRP (dBm)	EIRP limit (dBm)
2404	27.36	30.0	5	32.36	36.0
2442	27.12	30.0	5	32.12	36.0
2478	26.77	30.0	5	31.77	36.0

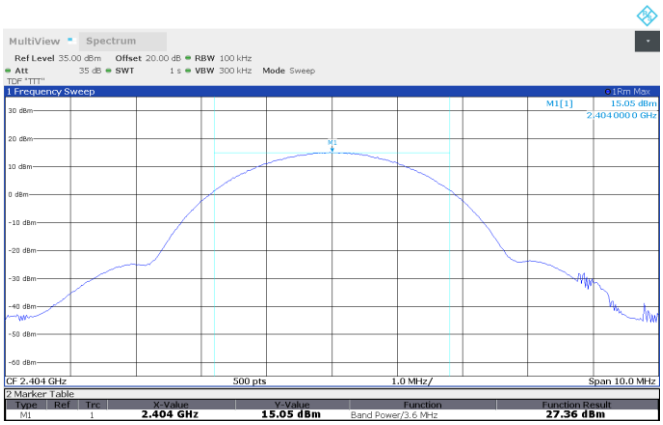

Figure 8.2-4: *TSM-Bandwidth 3.6MHz Conducted output power, 2404 MHz*

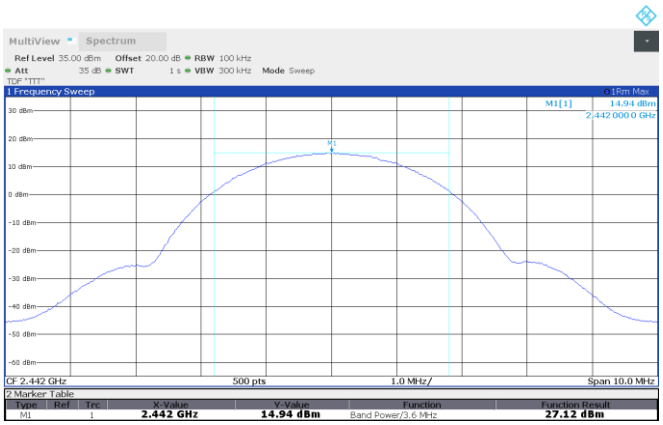

Figure 8.2-5: *TSM-Bandwidth 3.6MHz Conducted output power, 2442 MHz*

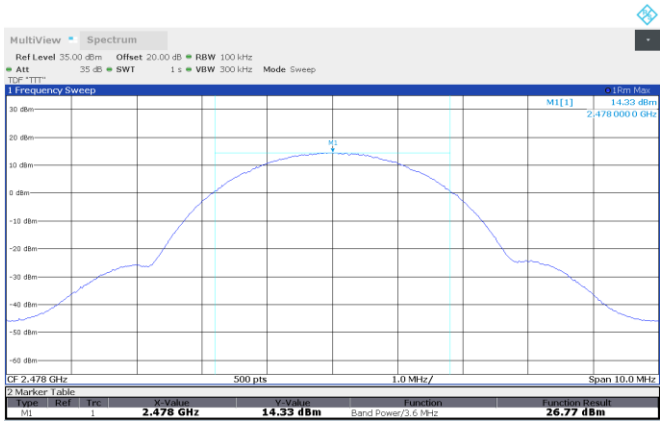

Figure 8.2-6: *TSM-Bandwidth 3.6MHz Conducted output power, 2478 MHz*

Table 8.2-3: *TSM-Bandwidth 10MHz Transmitter output power and EIRP test data*

Test frequency (MHz)	Peak conducted output power (dBm)	Conducted limit (dBm)	Antenna Gain (declared) (dBi)	EIRP (dBm)	EIRP limit (dBm)
2412	27.30	30.0	5	32.30	36.0
2442	27.18	30.0	5	32.18	36.0
2465	27.06	30.0	5	32.06	36.0

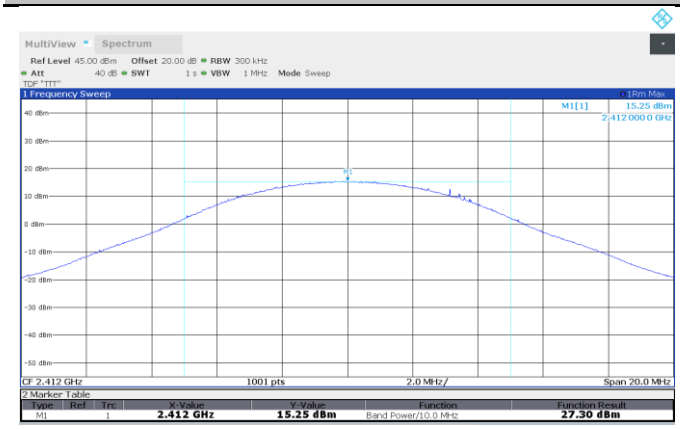

Figure 8.2-7: *TSM-Bandwidth 10MHz Conducted output power, 2412 MHz*

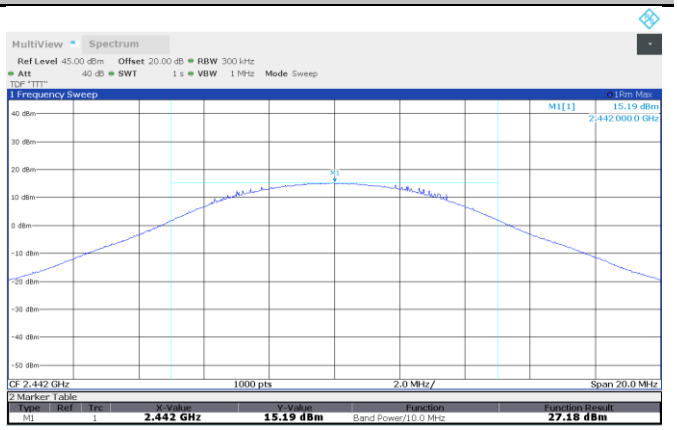

Figure 8.2-8: *TSM-Bandwidth 10MHz Conducted output power, 2442 MHz*

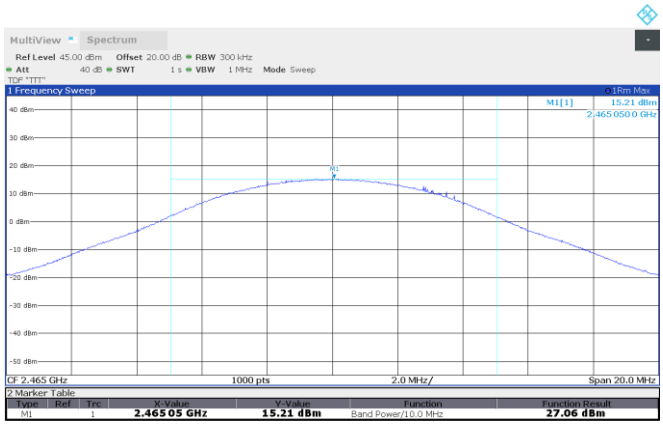

Figure 8.2-9: *TSM-Bandwidth 10MHz Conducted output power, 2465 MHz*

Table 8.2-4: *TSM-Bandwidth 20MHz Transmitter output power and EIRP test data*

Test frequency (MHz)	Peak conducted output power (dBm)	Conducted limit (dBm)	Antenna Gain (declared) (dBi)	EIRP (dBm)	EIRP limit (dBm)
2422	27.65	30.0	5	32.65	36.0
2442	27.92	30.0	5	32.92	36.0

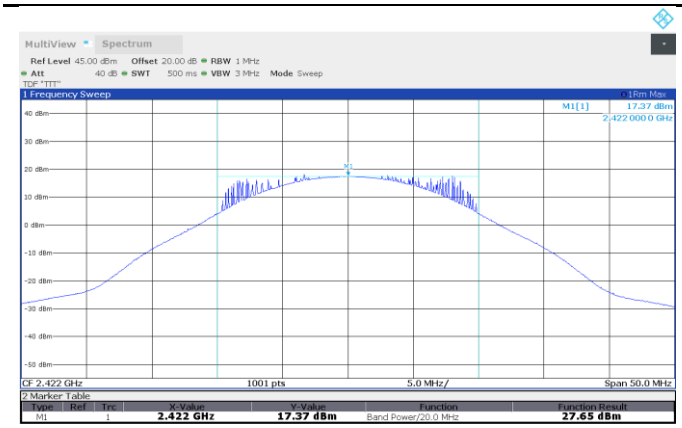

Figure 8.2-10: *TSM-Bandwidth 20MHz Conducted output power, 2422 MHz*

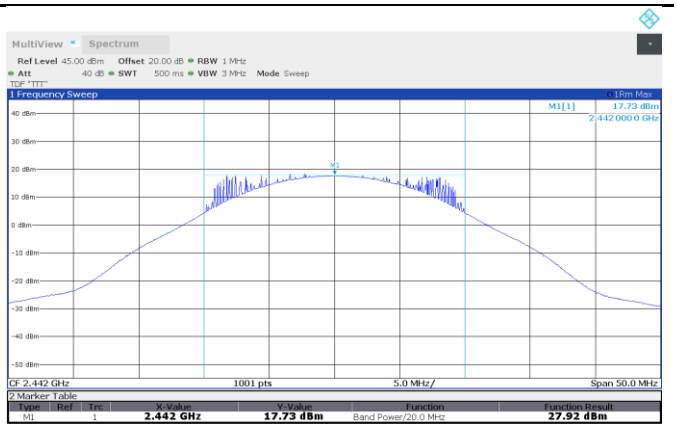

Figure 8.2-11: *TSM-Bandwidth 20MHz Conducted output power, 2442 MHz*

Table 8.2-5: *HDR-Bandwidth 20MHz Transmitter output power and EIRP test data*

Test frequency (MHz)	Peak conducted output power (dBm)	Conducted limit (dBm)	Antenna Gain (declared) (dBi)	EIRP (dBm)	EIRP limit (dBm)
2422	23.88	30.0	5	28.88	35.0
2442	23.83	30.0	5	28.83	35.0

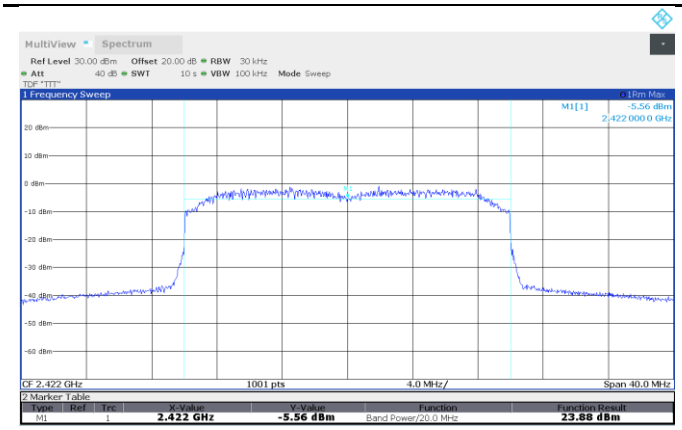

Figure 8.2-12: *HDR-Bandwidth 20MHz Conducted output power, 2422 MHz*

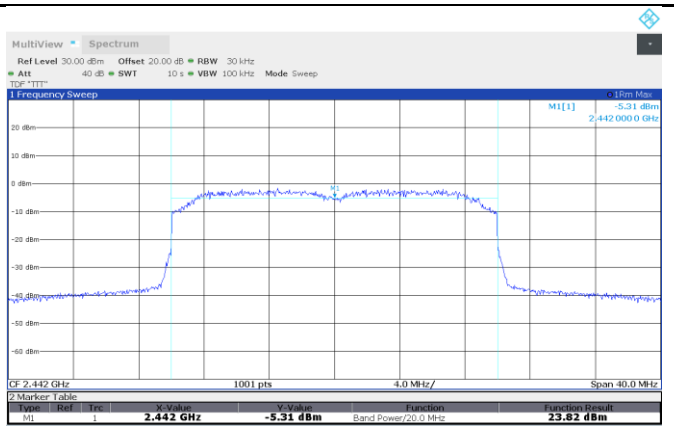

Figure 8.2-13: *HDR-Bandwidth 20MHz Conducted output power, 2442 MHz*

8.3 Spurious emissions

8.3.1 References and limits

- FCC 47 CFR Part 15, Subpart B: §15.247(d)
- RSS-247: §5.5
- Test method: ANSI C63.10-2014 §6.10.4 (authorized band edge)
- Test method: ANSI C63.10-2014 §6.7 (antenna port conducted spurious emissions)
- Test method: ANSI C63.10-2014 §11.13 (radiated restricted band edge)
- Test method: ANSI C63.10-2014 §6.5, 6.6 (radiated emissions in restricted bands)

§15.247:

(d) In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

RSS-247:

5.4 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 8.3-1: *FCC §15.209– Radiated emission limits*

Frequency, MHz	Field strength of emissions µV/m	Field strength of emissions dBµV/m	Measurement distance, 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 8.3-2: *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			

8.3.2 Test summary

Verdict	Pass		
Test date	February 6, 2023	Temperature	19.77 °C
Test engineer	Chenhao Ma, Wireless Test Technician	Air pressure	997.1 mbar
Test location	☒ Wireless bench ☐ 10 m semi-anechoic chamber ☒ 3 m semi-anechoic chamber ☐ Other:	Relative humidity	44.1 %

8.3.3 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. All operating modes were assessed with only data for only the worst case bandwidth (3.6 MHz) presented below.

NOTE: Since transmitter output power and power spectral density were measured using average detector methods, the required attenuation of spurious emissions below the highest in-band power in 100 kHz bandwidth is 30 dB. The spectral plots below illustrate a line at 20 dB however there is sufficient margin to see that no emissions exceed the 30 dB attenuation requirement.

8.3.4 Setup details

EUT power input during test	12 VDC
EUT setup configuration	☒ Table-top ☐ Floor standing ☐ Other:

Spectrum analyzer settings (conducted emissions):

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

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

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

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

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

8.3.5 Test data

Authorized band edge conducted emissions

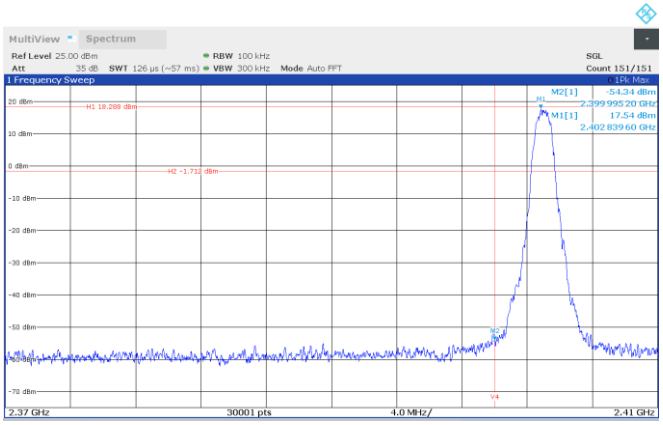

Figure 8.3-1: *TSM Bandwidth 1.2MHz Authorized band edge emissions, 2403 MHz*

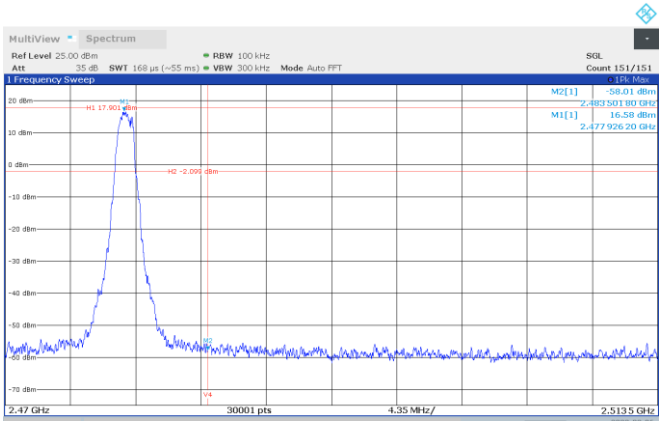

Figure 8.3-2: *TSM Bandwidth 1.2MHz Authorized band edge emissions, 2478 MHz*

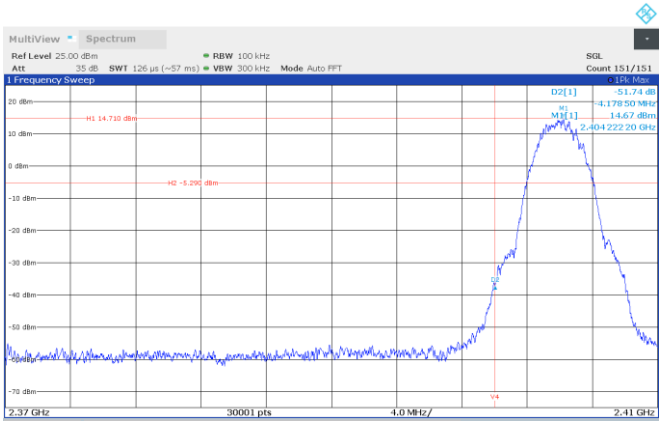

Figure 8.3-3: *TSM Bandwidth 3.6MHz Authorized band edge emissions, 2404 MHz*

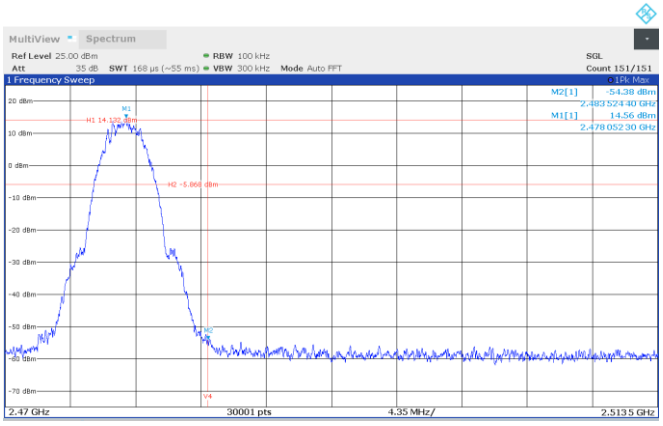

Figure 8.3-4: *TSM Bandwidth 3.6MHz Authorized band edge emissions, 2478 MHz*

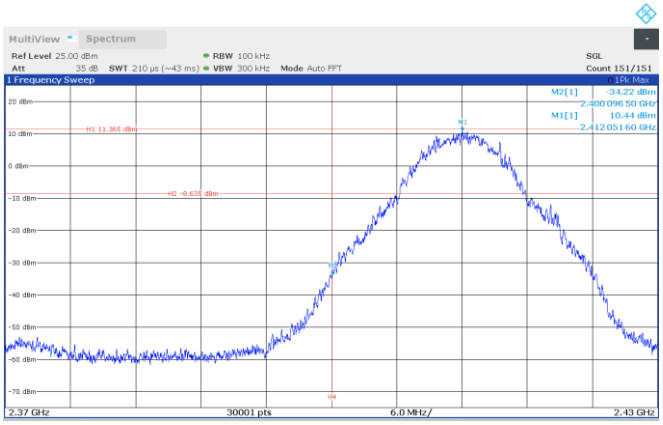

Figure 8.3-5: *TSM Bandwidth 10MHz Authorized band edge emissions, 2412MHz*

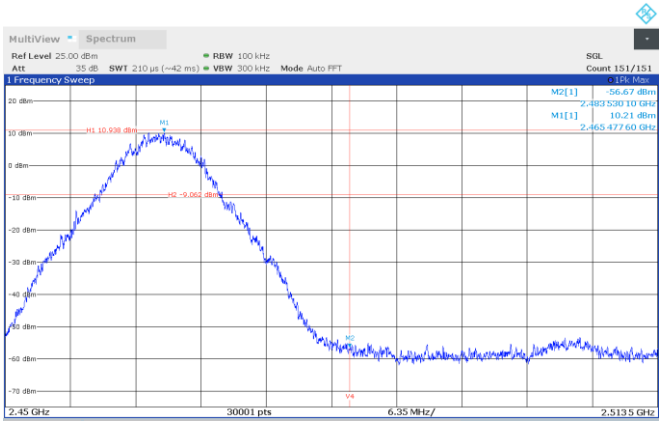

Figure 8.3-6: *TSM Bandwidth 10MHz Authorized band edge emissions, 2465MHz*

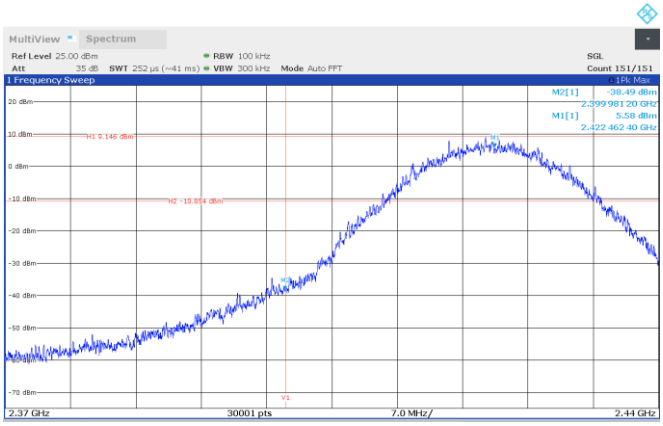

Figure 8.3-7: *TSM Bandwidth 20MHz Authorized band edge emissions, 2422MHz*

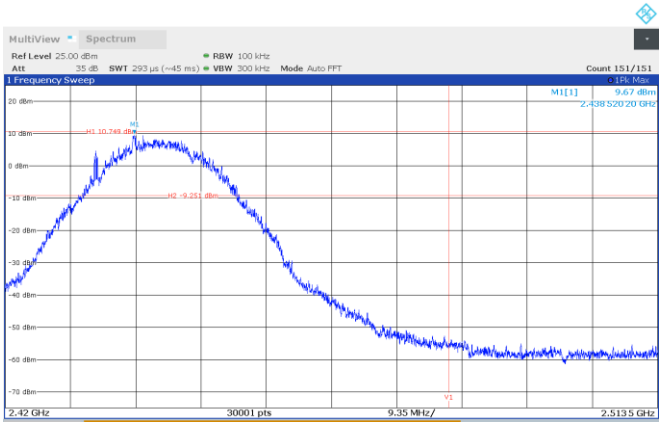

Figure 8.3-8: *TSM Bandwidth 20MHz Authorized band edge emissions, 2442MHz*

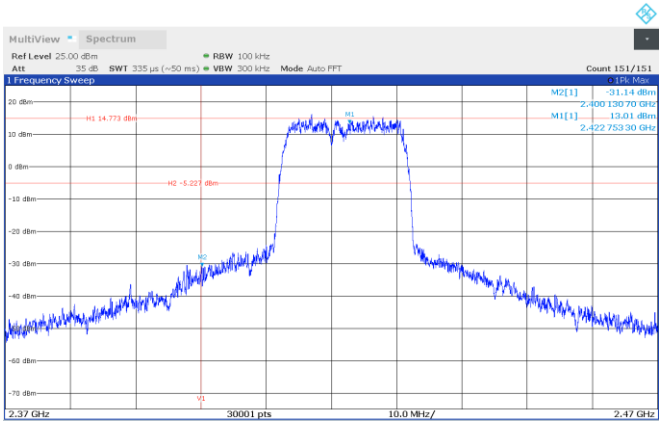

Figure 8.3-9: *HDR Bandwidth 20MHz Authorized band edge emissions, 2422MHz*

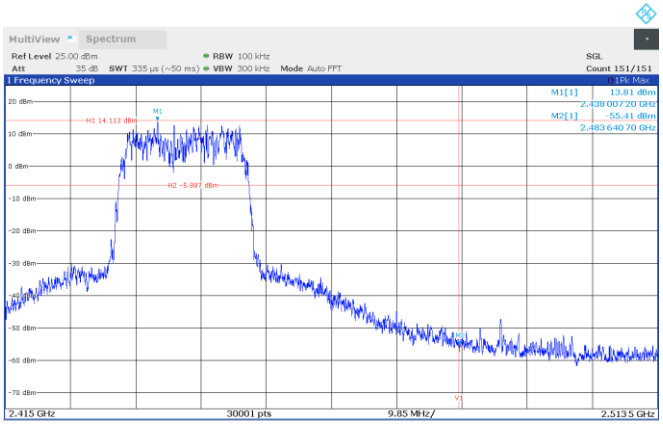

Figure 8.3-10: *HDR Bandwidth 20MHz Authorized band edge emissions, 2442MHz*

Antenna port conducted spurious emissions

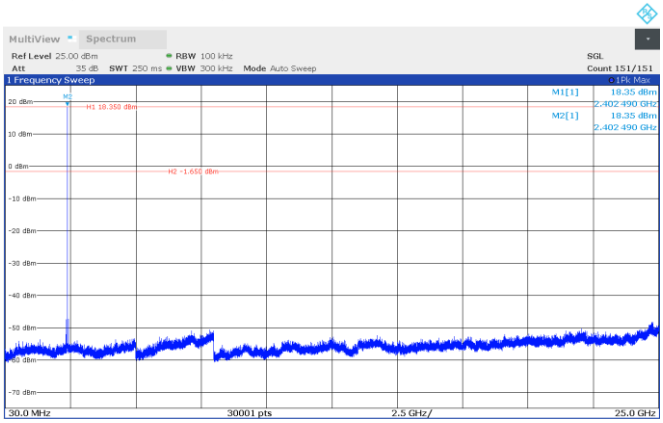

Figure 8.3-11: *TSM-Bandwidth 1.2MHz conducted spurious emission, 2403 MHz*

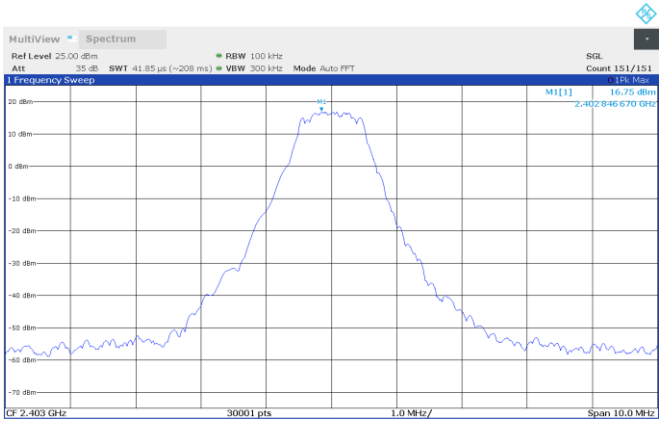

Figure 8.3-12: *TSM-Bandwidth 1.2MHz conducted spurious emission reference level, 2403 MHz*

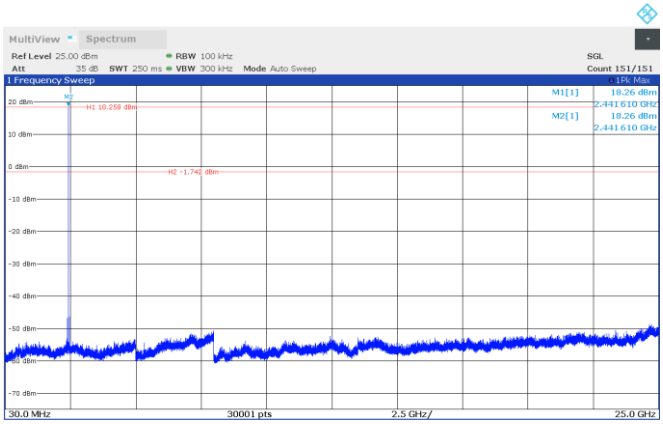

Figure 8.3-13: *TSM-Bandwidth 1.2MHz conducted spurious emission, 2442 MHz*

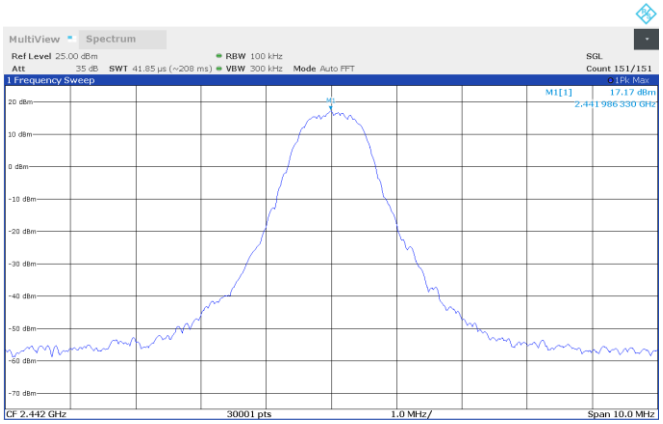

Figure 8.3-14: *TSM-Bandwidth 1.2MHz conducted spurious emission reference level, 2442 MHz*

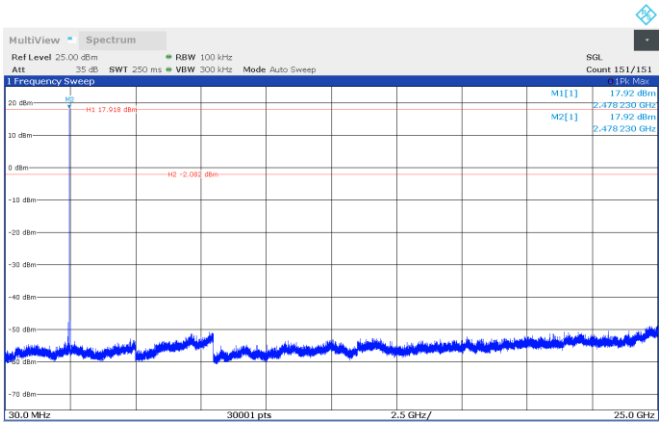

Figure 8.3-15: *TSM-Bandwidth 1.2MHz conducted spurious emission, 2478 MHz*

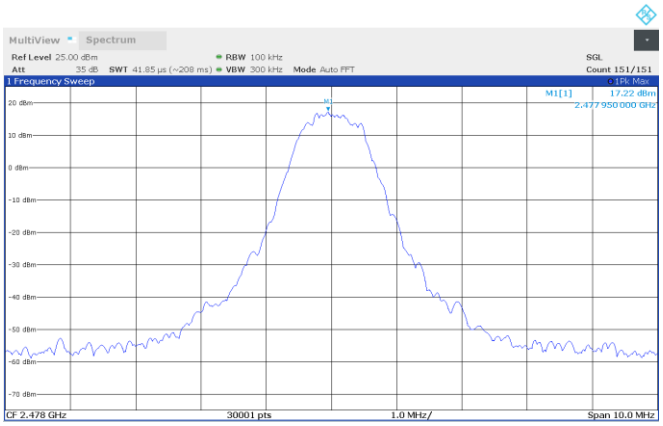

Figure 8.3-16: *TSM-Bandwidth 1.2MHz conducted spurious emission reference level, 2478 MHz*

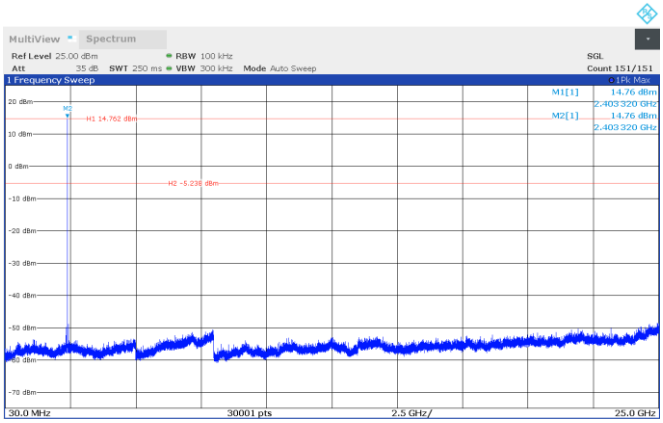

Figure 8.3-17: *TSM-Bandwidth 3.6MHz conducted spurious emission, 2404 MHz*

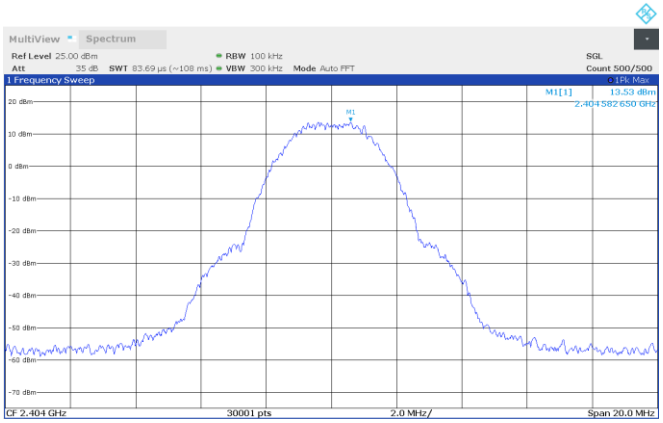

Figure 8.3-18: *TSM-Bandwidth 3.6MHz conducted spurious emission reference level, 2404 MHz*

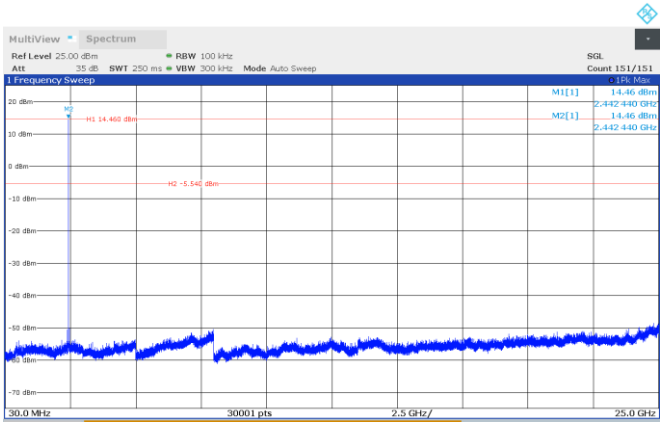

Figure 8.3-19: *TSM-Bandwidth 3.6MHz conducted spurious emission, 2442 MHz*

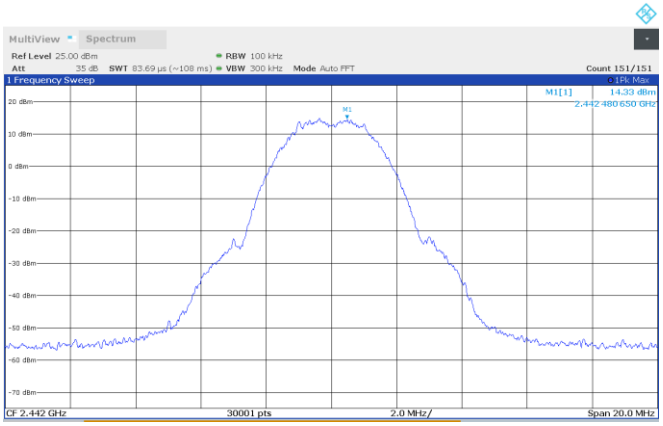

Figure 8.3-20: *TSM-Bandwidth 3.6MHz conducted spurious emission reference level, 2442 MHz*

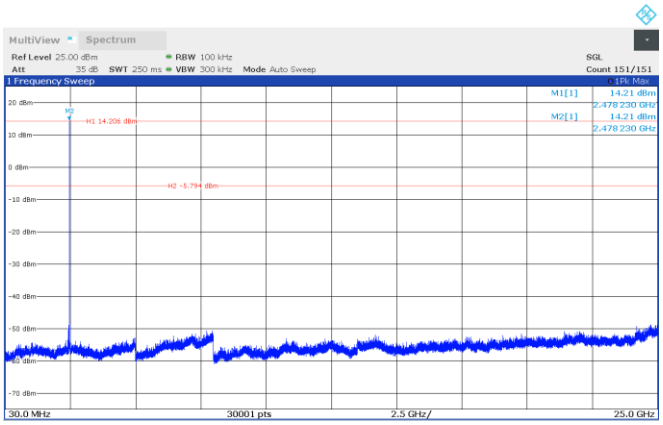

Figure 8.3-21: *TSM-Bandwidth 3.6MHz conducted spurious emission 2478 MHz*

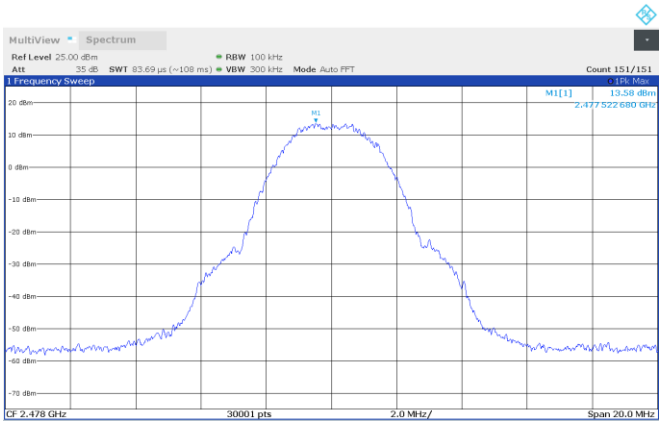

Figure 8.3-22: *TSM-Bandwidth 3.6MHz conducted spurious emission reference level, 2478 MHz*

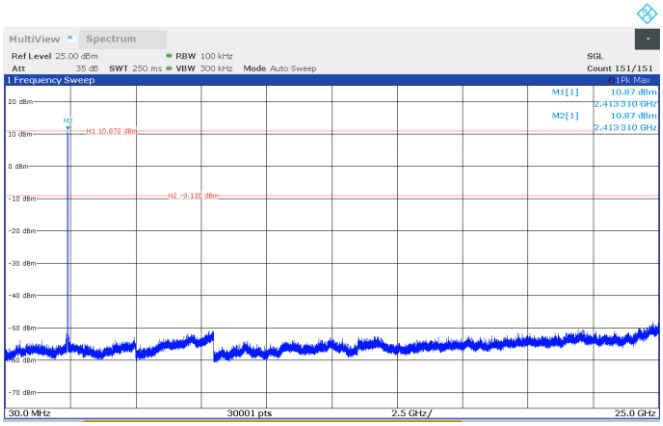

Figure 8.3-23: *TSM-Bandwidth 10MHz conducted spurious emission, 2412 MHz*

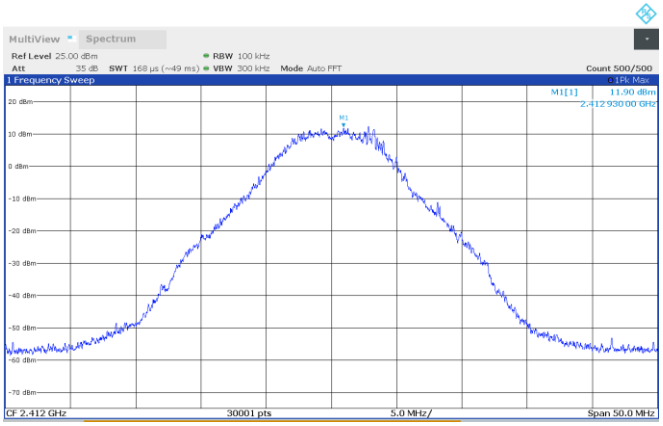

Figure 8.3-24: *TSM-Bandwidth 10MHz conducted spurious emission reference level, 2412 MHz*

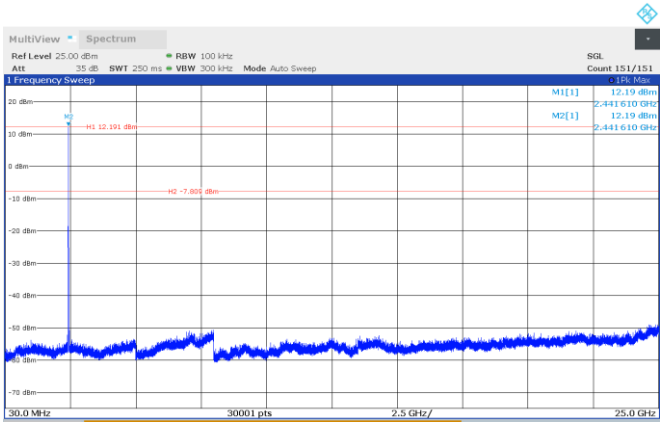

Figure 8.3-25: *TSM-Bandwidth 10MHz conducted spurious emission, 2442 MHz*

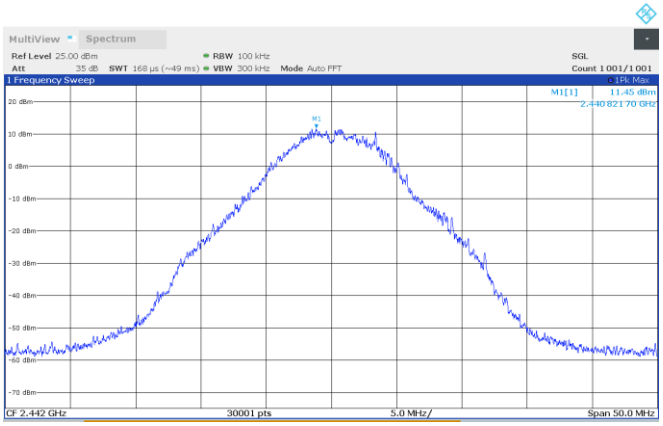

Figure 8.3-26: *TSM-Bandwidth 10MHz conducted spurious emission reference level, 2442 MHz*

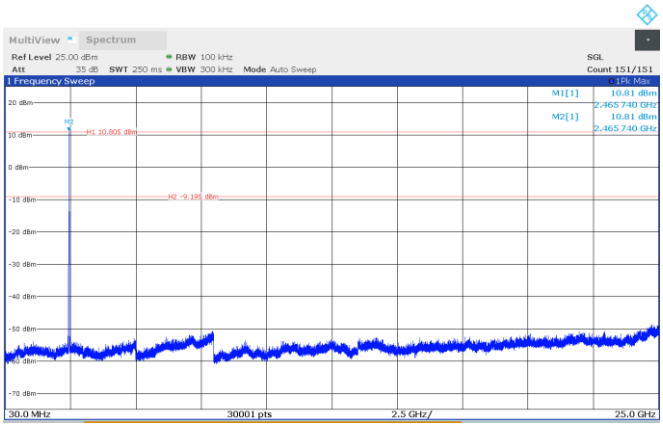

Figure 8.3-27: *TSM-Bandwidth 10MHz conducted spurious emission, 2465 MHz*

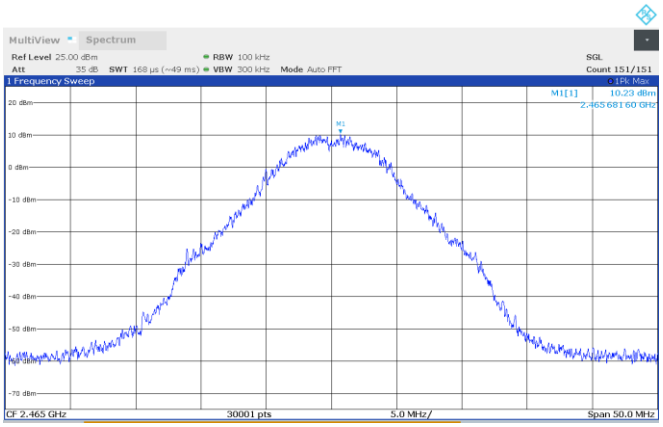

Figure 8.3-28: *TSM-Bandwidth 10MHz conducted spurious emission reference level, 2465 MHz*

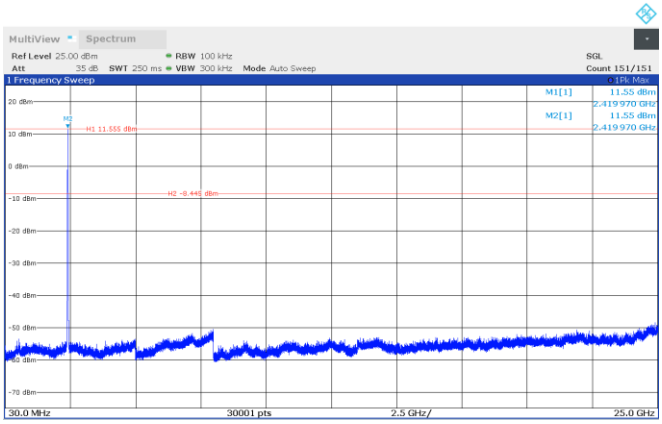

Figure 8.3-29: *TSM-Bandwidth 20MHz conducted spurious emission, 2422 MHz*

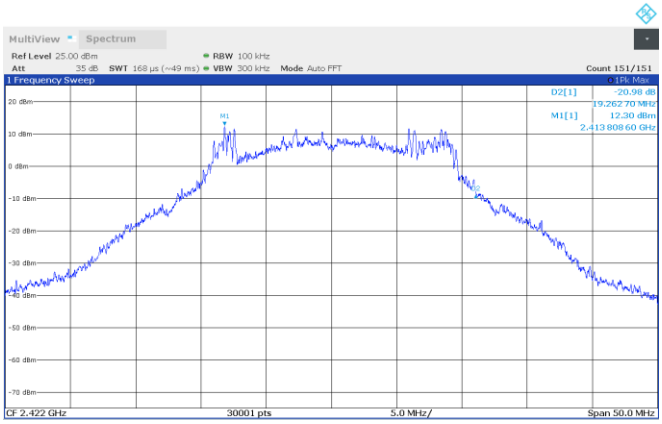

Figure 8.3-30: *TSM-Bandwidth 20MHz conducted spurious emission reference level, 2422 MHz*

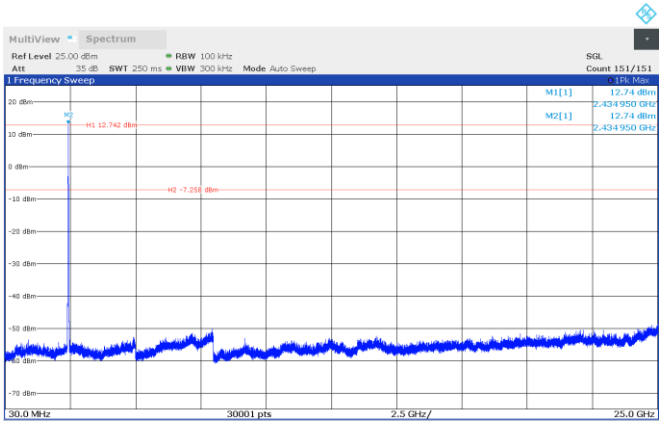

Figure 8.3-31: *TSM-Bandwidth 20MHz conducted spurious emission, 2442 MHz*

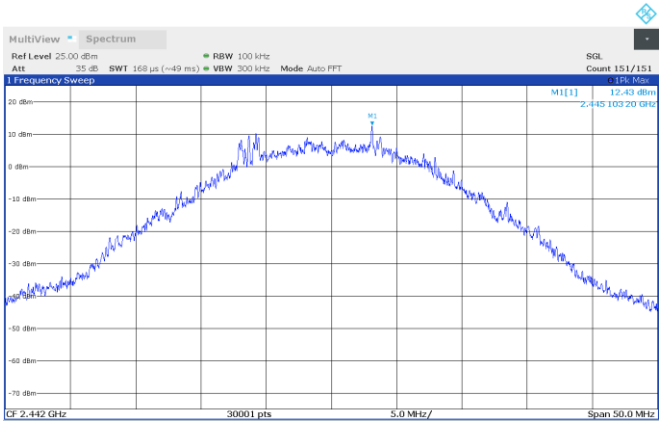

Figure 8.3-32: *TSM-Bandwidth 20MHz conducted spurious emission reference level, 2442 MHz*

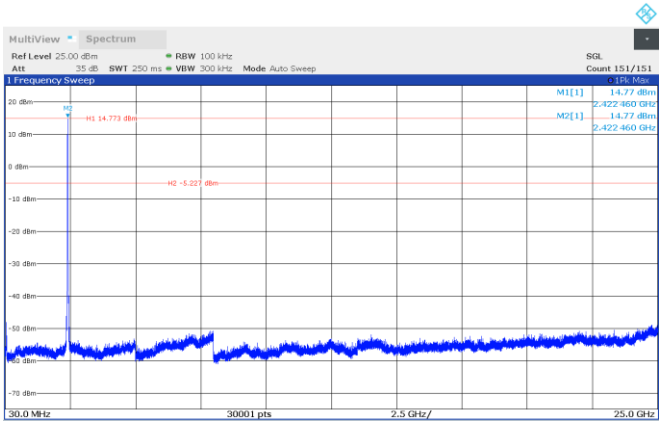

Figure 8.3-33: *HDR-Bandwidth 20MHz conducted spurious emission, 2422 MHz*

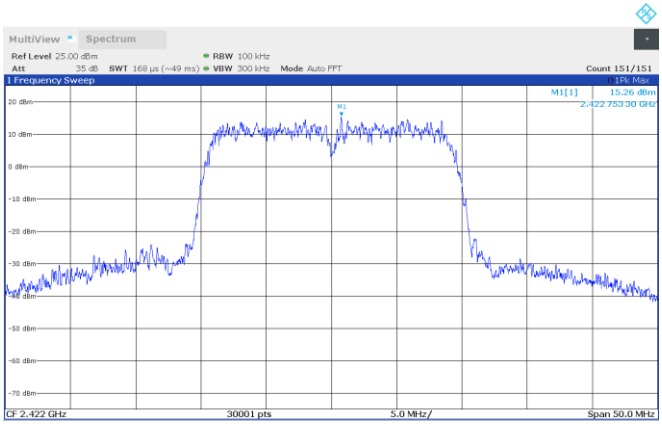

Figure 8.3-34: *HDR-Bandwidth 20MHz conducted spurious emission reference level, 2422 MHz*