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RADIO TEST REPORT – 454155-2TRFWL

Type of assessment:
Final product testing

Applicant:
Redline Communications Inc.

Product:
Outdoor Wireless TCP/IP Transport

Model:
RDL-3211 XC

FCC ID:
QC8-RDL3211XC

IC Registration number:
4310A-RDL3211XC

Specification:
FCC 47 CFR Part 15 Subpart E, §15.407

Date of issue: March 23, 2022

Mark Libbrecht, EMC/RF Specialist	Mark Libbrecht
Tested by	Signature
Andrey Adelberg, Senior EMC/RF Specialist	Adelberg
Reviewed by	Signature

Nemko Canada Inc., a testing laboratory, is accredited by the Standards Council of Canada.
The tests included in this report are within the scope of this accreditation

Lab locations

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Test site identifier	**Organization**	**Ottawa/Almonte**	**Montreal**	**Cambridge**
	FCC:	CA2040	CA2041	**CA0101**
	ISED:	2040A-4	2040G-5	**24676**
Website	www.nemko.com			

Limits of responsibility

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

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 15, Subpart E, Clause 15.407	Unlicensed National Information Infrastructure Devises

1.2 Test methods

789033 D02 General U-NII Test Procedures New Rules v02r01 (December 14, 2017)	Guidelines for Compliance Testing of Unlicensed National Information Infrastructure (U-NII) Devices Part 15, Subpart E
662911 D01 Multiple Transmitter Output v02r01 (October 31, 2013)	Emissions Testing of Transmitters with Multiple Outputs in the Same Band
662911 D02 MIMO with Cross Polarized Antenna v01 (October 25, 2011)	Emissions testing of transmitters with multiple outputs in the same band (MIMO) with Cross Polarized Antenna
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

1.3 Exclusions

None

1.4 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 1.3 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.

1.5 Test report revision history

Table 1.5-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	March 23, 2022	Original report issued

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

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

2.2 Technical judgment

It was verified that the worst-case results were observed when EUT was operating with BPSK modulation (MCS: 0), therefore all the measurement results in this report are based on this modulation.

2.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3 Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

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.

3.2 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 4 Measurement uncertainty

4.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada, Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products.

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Table 4.1-1: *Measurement uncertainty calculations*

Test name	Measurement uncertainty, ±dB
All antenna port measurements	0.55
Occupied bandwidth	4.45
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78

Section 5 Information provided by the applicant

5.1 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 contained 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.

5.2 Applicant/Manufacture

Applicant name	Redline Communications
Applicant address	302 Town Center Blvd., Markham, Ontario L3R 0E8, Canada
Manufacturer name	Same as applicant
Manufacturer address	Same as applicant

5.3 EUT information

Product name	Outdoor Wireless TCP/IP Transport
Model	RDL-3211 XC
Serial number	477RM21450003
Part Number	13-00509-50
Power supply requirements	PoE 48 V_{DC} 0.280 A (via external 100–240 V_{AC}, 50/60 Hz Adapter)
Product description and theory of operation	The EUT is a 2×2 MIMO point-to-point (PTP) carrier grade broadband wireless infrastructure product, designed to operate in the U-NII-1 WLAN band.

5.4 Radio technical information

Device type	☐	Outdoor access point
	☐	Indoor access point
	☒	Fixed point-to-point access point
	☐	Client device
	☐	Device installed in vehicles
Frequency band	5150–5250 MHz (U-NII-1)	
Channel sizes (MHz)	0.875, 5, 10, 20, 40, 45	
Type of modulation	OFDM using 256-QAM, 128-QAM, 64-QAM, 16-QAM, QPSK and BPSK modulation for sub-carriers	
Antenna information	2×2 MIMO: 25 dBi Dual Polarization Antenna 4.9–6.1 GHz, Redline 30-00399-00	

Channel sizes:	0.875 MHz	5 MHz	10 MHz	20 MHz	40 MHz	45 MHz
Frequency Min (MHz)	5151.0	5155.0	5160.0	5170.0	5190.0	5190.0
Frequency Max (MHz)	5249.5	5247.5	5245.0	5240.0	5230.0	5227.5
RF power Max (W), EIRP	6.546	19.588	38.815	40.832	20.277	12.942
Measured BW (MHz), 99% OBW	0.735	4.16	8.28	16.64	33.30	41.33
Emission designation	725KW7D	4M16W7D	8M28W7D	16M6W7D	33M3W7D	41M3W7D
Transmitter spurious, dBµV/m @ 3 m	53.67	53.90	53.89	53.78	53.87	53.51

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	Test software: 1.90.0-106
Transmitter state	The EUT was controlled to transmit at desired frequency and modulation from laptop using web interface at IP address: 192.168.25.2. In addition, Telnet session was used to force 95% duty cycle with the following command: *dbg txloop 1 0 95* Power settings are made to attain maximum output allowed in power tables shown in section 8.6

EUT setup configuration, continued

Table 5.5-1: *Support equipment*

Description	Brand name	Model, Part number, Serial number, Revision level
PoE	Microsemi	PN: PD-9501GR/AC, SN: C19296230000004019

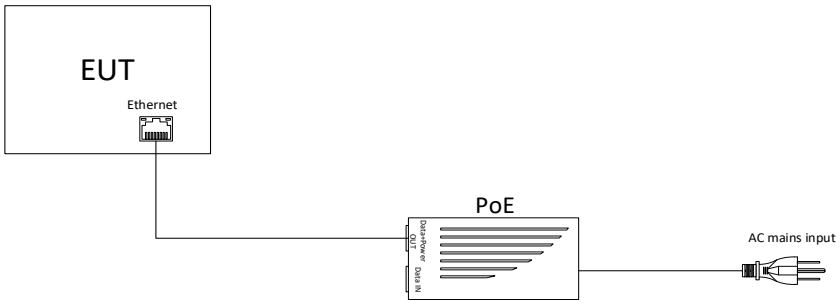


Figure 5.5-1: *Setup block diagram*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Cambridge

6.2 Testing period

Test start date	January 13, 2022	Test end date	March 1, 2022

6.3 Sample information

Receipt date	December 17, 2021	Nemko sample ID number(s)	1

6.4 FCC Part 15 Subpart A and C, general requirements test results

Table 6.4-1: *FCC general requirements results*

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass
§15.31I	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: [1]EUT is powered via PoE adapter @ 48V DC

6.5 FCC Part §15.407 test results

Table 6.5-1: *FCC §15.407 requirements results*

Part	Test description	Verdict
§15.403(i)	Emission bandwidth	Pass
§15.407(a)(1)	Power and density limits within 5.15–5.25 GHz band	Pass
§15.407(b)(1)	Undesirable emission limits for 5.15–5.25 GHz band	Pass
§15.407(b)(6)	Conducted limits for U-NII devices using an AC power line	Pass
§15.407(g)	Frequency stability	Pass
§15.407(h)(1)[1]	Transmit power control (TPC)	Not applicable
§15.407(h)(2)[1]	Dynamic Frequency Selection (DFS)	Not applicable

Notes [1]DFS and TPC requirements are only applicable to 5.25–5.35 GHz and 5.47–5.725 GHz bands

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	November 30, 2022
Spectrum analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	November 30, 2022
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	April 12, 2022
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	April 28, 2022
Horn antenna (1–18 GHz)	ETS-Lindgren	3117	FA002911	1 year	April 21, 2022
Preamp (1–18 GHz)	ETS-Lindgren	124334	FA002956	1 year	April 5, 2022
50 Ω coax cable	Huber + Suhner	None	FA003043	1 year	July 13, 2022
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	July 13, 2022
Horn antenna (18–40 GHz)	EMCO	3116B	FA002948	1 year	January 23, 2023
Preamp 18-40 GHz	None	None	FA003323	1 year	April 5, 2022
Notch filter 2400-2483.5 MHz	Microwave Circuits	N0324413	FA003027	1 year	April 23, 2022
Notch filter 5150 - 5350 MHz	Microwave Circuits	N0452501	FA003030	1 year	April 23, 2022

Notes: NCR - no calibration required

Section 8 Testing data

8.1 Variation of power source

8.1.1 References, definitions and limits

FCC §15.31 (e):

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 13, 2022

8.1.3 Observations, settings and special notes

The testing was performed as per ANSI C63.10 Section 5.13.

a) Where the device is intended to be powered from an external power adapter, the voltage variations shall be applied to the input of the adapter provided with the device at the time of sale. If the device is not marketed or sold with a specific adapter, then a typical power adapter shall be used.
b) For devices, where operating at a supply voltage deviating ±15% from the nominal rated value may cause damages or loss of intended function, test to minimum and maximum allowable voltage per manufacturer's specification and document in the report.
c) For devices with wide range of rated supply voltage, test at 15% below the lowest and 15% above the highest declared nominal rated supply voltage.
d) For devices obtaining power from an input/output (I/O) port (USB, firewire, etc.), a test jig is necessary to apply voltage variation to the device from a support power supply, while maintaining the functionalities of the device.

For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

8.1.4 Test data

EUT Power requirements:	☒ AC	☐ DC	☐ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☒ NO	☐ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☐ YES	☐ NO	☒ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☐ YES	☐ NO	☒ N/A

8.2 Number of frequencies

8.2.1 References, definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table.

Table 8.2-1: *Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Notes: "near" means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 13, 2022

8.2.3 Observations, settings and special notes

ANSI C63.10, Clause 5.6.2.1:

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

a) For each operating mode, if the measured channel bandwidth on the middle channel is at least 150% of the minimum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

b) For multiple-input multiple-output (MIMO) systems, if the measured channel bandwidth on testing the middle channel exceeds the minimum permitted bandwidth by more than 50% on one transmit chain, then it is not necessary to repeat testing on the other chains.

c) If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

ANSI C63.10, Clause 5.6.2.2:

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

a) Band edge requirements—Measurements on the mode with the widest bandwidth can be used to cover the same channel (center frequency) on modes with narrower bandwidth that have the same or lower output power for each modulation family (e.g., OFDM and direct sequence spread spectrum).

b) Spurious emissions—Measure the mode with the highest output power and the mode with the highest output power spectral density for each modulation family (e.g., OFDM and direct sequence spread spectrum).

c) In-band PSD—Measurements on the mode with the narrowest bandwidth can be used to cover all modes within the same modulation family of an equal or lower output power provided the result is less than 50% of the limit.

8.2.4 Test data

Table 8.2-2: *Test channels selection*

Channel bandwidth, MHz	Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	2nd Low channel, MHz	Mid channel, MHz	High channel, MHz
0.875	5150	5250	100	5151.0	5160.0	5200.0	5249.5
5	5150	5250	100	5155.0	5160.0	5200.0	5247.5
10	5150	5250	100	5160.0	5170.0	5200.0	5245.0
20	5150	5250	100	5170.0	5190.0	5200.0	5240.0
40	5150	5250	100	5190.0	N/A	5200.0	5230.0
45	5150	5250	100	5190.0	N/A	5200.0	5227.5

8.3 Antenna requirement

8.3.1 References, definitions and limits

FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

8.3.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 13, 2022

8.3.3 Observations, settings and special notes

EUT utilizes 2 × 2 MIMO antenna configuration, which are cross polarized in orientation.

8.3.4 Test data

Must the EUT be professionally installed?	☒ YES	☐ NO	
Does the EUT have detachable antenna(s)?	☒ YES	☐ NO	
If detachable, is the antenna connector(s) non-standard?	☒ YES	☐ NO	☐ N/A

Table 8.3-1: *Antenna information*

Antenna type	Manufacturer	Model number	Maximum gain	Connector type
Dual Polarization	Redline	30-00399-00	25 dBi	MCX

8.4 Emission bandwidth

8.4.1 References, definitions and limits

FCC §15.403:

(i) For purposes of this subpart the emission bandwidth shall be determined by measuring the width of the signal between two points, one below the carrier center frequency and one above the carrier center frequency, that are 26 dB down relative to the maximum level of the modulated carrier. Determination of the emissions bandwidth is based on the use of measurement instrumentation employing a peak detector function with an instrument resolution bandwidth approximately equal to 1.0 percent of the emission bandwidth of the device under measurement.

8.4.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 13, 2022

8.4.3 Observations, settings and special notes

The emission bandwidth was tested per ANSI C63.10, Clause 12.4 and KDB 789033 D02, Clause II(C)(1). Spectrum analyser settings:

Resolution bandwidth	approximately 1% of the emission bandwidth
Video bandwidth	> RBW
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: *26 dB bandwidth results*

Channel bandwidth, MHz	Modulation	Frequency, MHz	26 dB bandwidth at ch0, MHz	26 dB bandwidth at ch1, MHz
0.875	BPSK	5151.0	817.20	827.20
0.875	BPSK	5152.0	825.20	827.20
0.875	BPSK	5200.0	829.20	825.20
0.875	BPSK	5249.5	821.20	821.20
5	BPSK	5155.0	4.71	4.68
5	BPSK	5160.0	4.70	4.71
5	BPSK	5200.0	4.68	4.74
5	BPSK	5247.5	4.70	4.74
10	BPSK	5160.0	9.35	9.45
10	BPSK	5170.0	9.39	9.41
10	BPSK	5200.0	9.33	9.41
10	BPSK	5245.0	9.39	9.45
20	BPSK	5170.0	18.54	18.62
20	BPSK	5190.0	18.50	18.74
20	BPSK	5200.0	18.54	18.62
20	BPSK	5240.0	18.58	18.66
40	BPSK	5190.0	37.90	38.11
40	BPSK	5200.0	37.83	37.97
40	BPSK	5230.0	37.62	38.04
45	BPSK	5190.0	46.75	47.07
45	BPSK	5200.0	46.67	47.15
45	BPSK	5227.5	46.75	47.23

Test data, continued

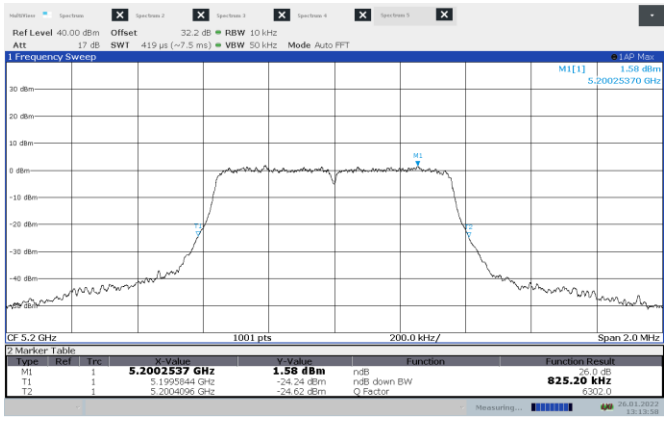


Figure 8.4-1: *26 dB bandwidth on 0.875 MHz channel, sample plot*

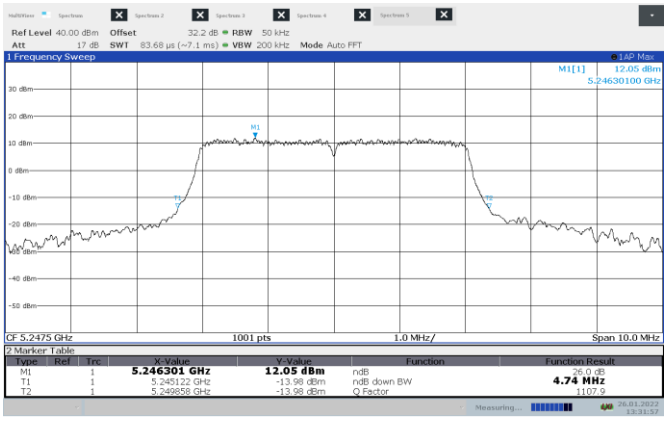


Figure 8.4-2: *26 dB bandwidth on 5 MHz channel, sample plot*

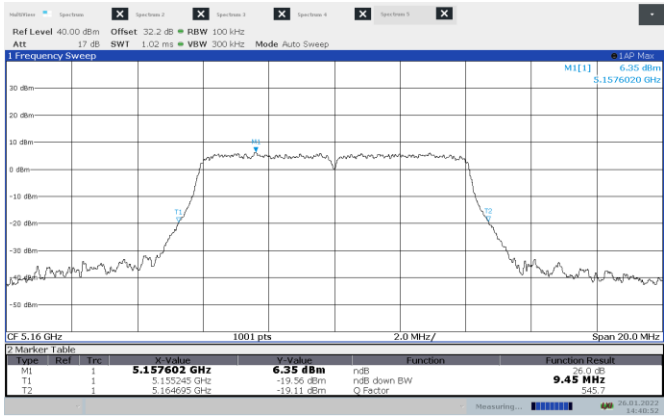


Figure 8.4-3: *26 dB bandwidth on 10 MHz channel, sample plot*

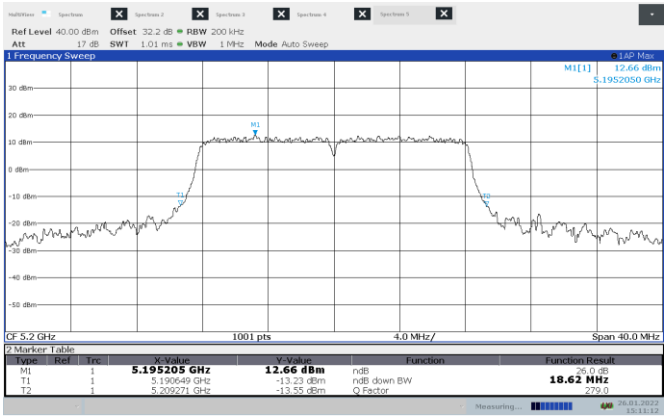


Figure 8.4-4: *26 dB bandwidth on 20 MHz channel, sample plot*

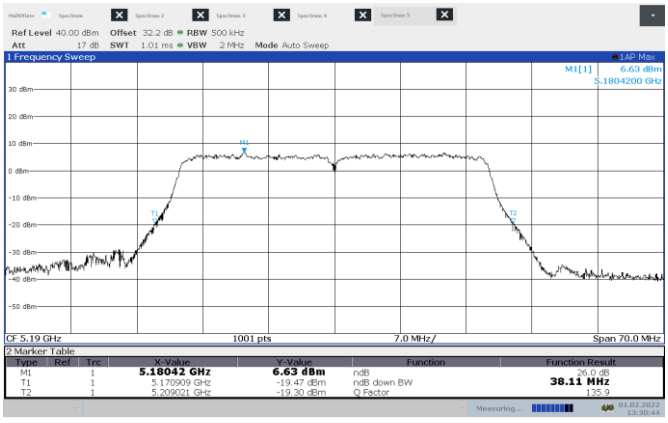


Figure 8.4-5: *26 dB bandwidth on 40 MHz channel, sample plot*

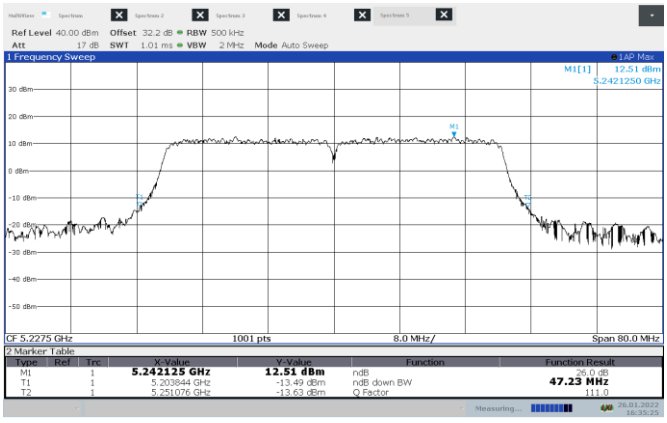


Figure 8.4-6: *26 dB bandwidth on 45 MHz channel, sample plot*

8.5 Occupied bandwidth

8.5.1 References, definitions and limits

ANSI C63.10-2013, Clause 6.9.3:

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

8.5.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 13, 2022

8.5.3 Observations, settings and special notes

The emission bandwidth was tested per ANSI C63.10, Clause 6.9.3 and KDB 789033 D02, Clause II(D). Spectrum analyser settings:

Resolution bandwidth:	1–5 % of OBW
Video bandwidth:	≥3 × RBW
Detector mode:	Peak
Trace mode:	Max Hold

8.5.4 Test data

Table 8.5-1: *99% bandwidth results*

Channel bandwidth, MHz	Modulation	Frequency, MHz	99% bandwidth at ch0, MHz	99% bandwidth at ch1, MHz
0.875	BPSK	5151.0	0.734	0.731
0.875	BPSK	5152.0	0.732	0.735
0.875	BPSK	5200.0	0.735	0.734
0.875	BPSK	5249.5	0.735	0.734
5	BPSK	5155.0	4.11	4.12
5	BPSK	5160.0	4.13	4.14
5	BPSK	5200.0	4.16	4.13
5	BPSK	5247.5	4.13	4.13
10	BPSK	5160.0	8.25	8.26
10	BPSK	5170.0	8.27	8.28
10	BPSK	5200.0	8.26	8.27
10	BPSK	5245.0	8.26	8.27
20	BPSK	5170.0	16.60	16.58
20	BPSK	5190.0	16.63	16.64
20	BPSK	5200.0	16.63	16.61
20	BPSK	5240.0	16.62	16.61
40	BPSK	5190.0	33.23	33.24
40	BPSK	5200.0	33.29	33.26
40	BPSK	5230.0	33.30	33.29
45	BPSK	5190.0	41.31	41.27
45	BPSK	5200.0	41.25	41.28
45	BPSK	5227.5	41.32	41.33

Test data, continued

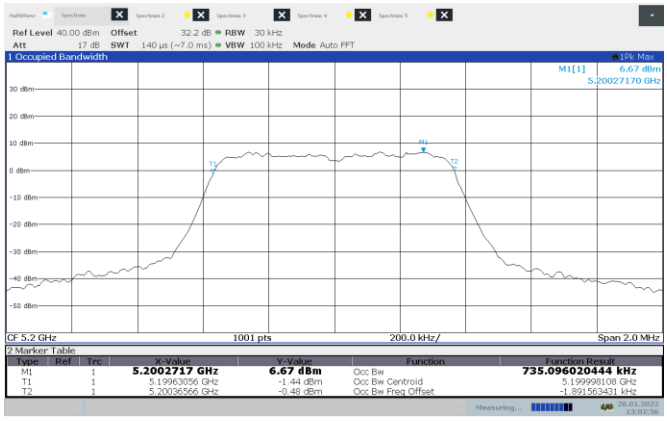


Figure 8.5-1: *99% bandwidth on 0.875 MHz channel, sample plot*

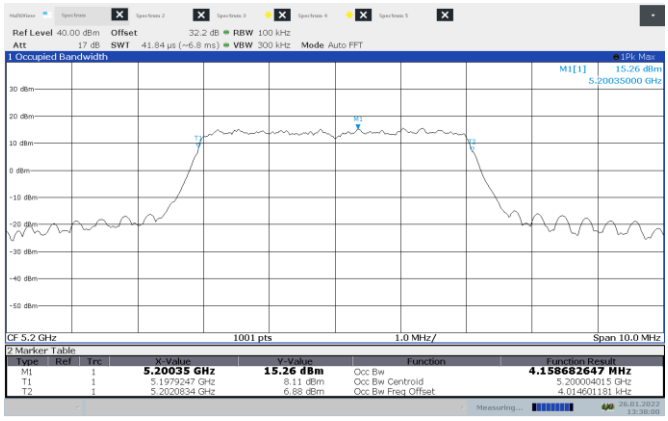


Figure 8.5-2: *99% bandwidth on 5 MHz channel, sample plot*

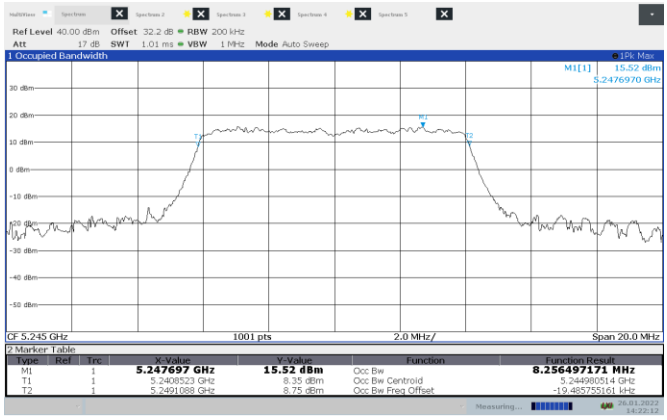


Figure 8.5-3: *99% bandwidth on 10 MHz channel, sample plot*

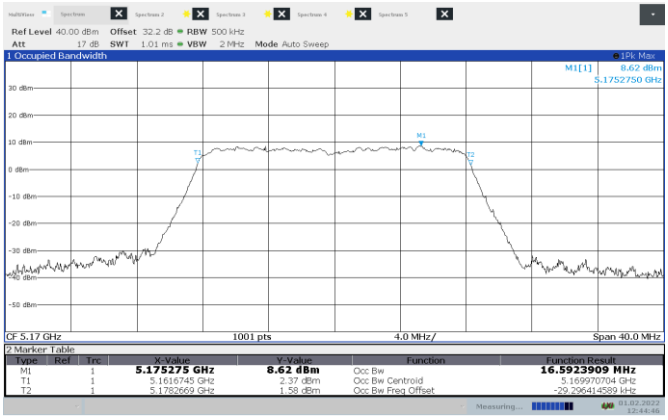


Figure 8.5-4: *99% bandwidth on 20 MHz channel, sample plot*

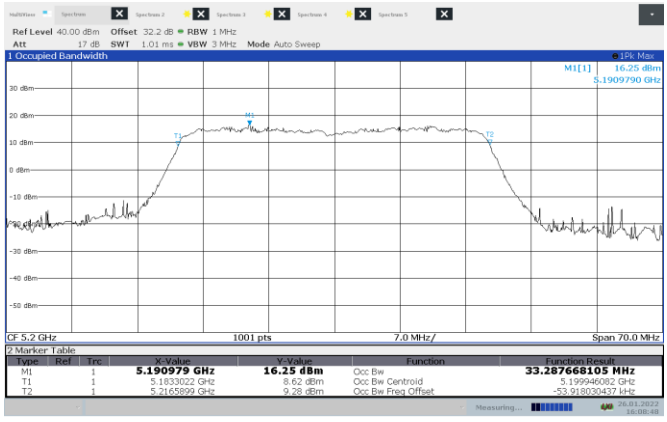


Figure 8.5-5: *99% bandwidth on 40 MHz channel, sample plot*

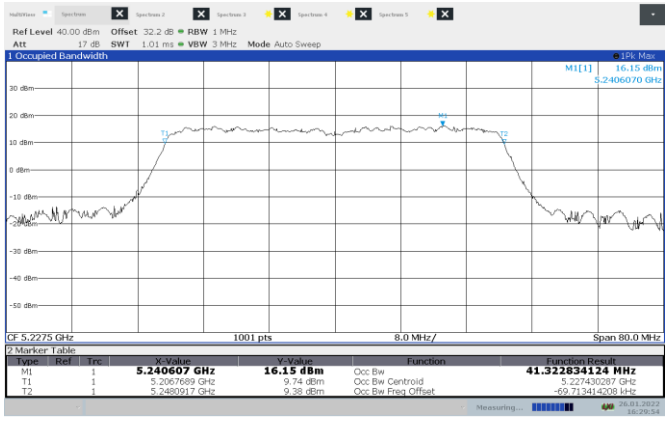


Figure 8.5-6: *99% bandwidth on 45 MHz channel, sample plot*

8.6 Transmitter output power and e.i.r.p. requirements for 5150–5250 MHz band

8.6.1 References, definitions and limits

FCC §15.407:

(a) Power limits:

(1) For the band 5.15–5.25 GHz.

(i) For an outdoor access point operating in the band 5.15–5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi. The maximum e.i.r.p. at any elevation angle above 30 degrees as measured from the horizon must not exceed 125 mW (21 dBm).

(ii) For an indoor access point operating in the band 5.15–5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(iii) For fixed point-to-point access points operating in the band 5.15–5.25 GHz, the maximum conducted output power over the frequency band of operation shall not exceed 1 W. In addition, the maximum power spectral density shall not exceed 17 dBm in any 1 megahertz band. Fixed point-to-point U-NII devices may employ antennas with directional gain up to 23 dBi without any corresponding reduction in the maximum conducted output power or maximum power spectral density. For fixed point-to-point transmitters that employ a directional antenna gain greater than 23 dBi, a 1 dB reduction in maximum conducted output power and maximum power spectral density is required for each 1 dB of antenna gain in excess of 23 dBi. Fixed, point-to-point operations exclude the use of point-to-multipoint systems, omnidirectional applications, and multiple collocated transmitters transmitting the same information. The operator of the U-NII device, or if the equipment is professionally installed, the installer, is responsible for ensuring that systems employing high gain directional antennas are used exclusively for fixed, point-to-point operations.

(iv) For client devices in the 5.15–5.25 GHz band, the maximum conducted output power over the frequency band of operation shall not exceed 250 mW provided the maximum antenna gain does not exceed 6 dBi. In addition, the maximum power spectral density shall not exceed 11 dBm in any 1 megahertz band. If transmitting antennas of directional gain greater than 6 dBi are used, both the maximum conducted output power and the maximum power spectral density shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

(4) The maximum conducted output power must be measured over any interval of continuous transmission using instrumentation calibrated in terms of an rms-equivalent voltage.

(5) The maximum power spectral density is measured as a conducted emission by direct connection of a calibrated test instrument to the equipment under test. If the device cannot be connected directly, alternative techniques acceptable to the Commission may be used. Measurements in the 5.15–5.25 GHz, 5.25–5.35 GHz, and the 5.47–5.725 GHz bands are made over a bandwidth of 1 MHz or the 26 dB emission bandwidth of the device, whichever is less. A narrower resolution bandwidth can be used, provided that the measured power is integrated over the full reference bandwidth.

8.6.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 13, 2022

8.6.3 Observations, settings and special notes

Combined average output power was calculated as follows: $P_{combined} = 10 \times log_{10}\left(\left(10^{P_{ch0}/10}\right) + \left(10^{P_{ch1}/10}\right)\right)$

EIRP was calculated as follows: $EIRP = P_{combined} + antenna\ gain$

Combined PPSD was calculated as follows: $PPSD_{combined} = 10 \times log_{10}\left(\left(10^{PSD_{ch0}/10}\right) + \left(10^{PSD_{ch1}/10}\right)\right)$

No summation of directional gain is needed for cross-polarized antennas as per manufacturer's definition of the cross-polarized MIMO type.

For fixed point-to -point access points antennas with the directional gain greater than 23 dBi, the maximum FCC output power limit was calculated as follows:

30 dBm – (Maximum antenna gain – 23 dBi)

For 25 dBi antenna with 0.7 dB cable loss: Limit = 30 dBm – (24.3 dBi – 23 dBi) = 28.7 dBm

Antenna gain for elevation angle above 30 degree is 8 dBi.

Conducted output power was tested per ANSI C63.10, Clause 12.3 and 789033 D02, Clause II(E) using method SA-1 or SA-1 Alternative (averaging with the EUT transmitting at full power throughout each sweep).

Spectrum analyser settings:

Resolution bandwidth	>1 % of BW
Video bandwidth	≥ 3 × RBW
Frequency span	1 – 5 × OBW
Detector mode	RMS
Trace mode	Average Power
Power integration	Over 26 dB EBW
Sweep counts	> 100

For fixed point-to -point access points antennas with the directional gain greater than 23 dBi, the maximum power spectral density limit was calculated as follows:

17 dBm/MHz – (Maximum antenna gain – 23 dBi)

For 25 dBi antenna with 0.7 dB cable loss: Limit = 17 dBm/MHz – (24.3 dBi – 23 dBi) = 15.7 dBm/MHz

Power spectral density was tested per ANSI C63.10, Clause 12.5 and 789033 D02, Clause II(F).

Spectrum analyser settings:

Resolution bandwidth	1 MHz
Video bandwidth	≥ 3 × RBW
Frequency span	1 – 5 × OBW
Detector mode	RMS
Trace mode	Average Power
Sweep counts	> 100

8.6.4 Test data

Table 8.6-1: *Output power measurements results for 0.875 MHz channel*

Modulation	Frequency, MHz	Conducted output power at ch0, dBm	Conducted output power at ch1, dBm	Combined output power, dBm	Power limit, dBm	Power margin, dB	Antenna gain, dBi	EIRP, dBm
BPSK	5151.0	-9.43	-9.33	-6.37	28.70	35.07	24.30	17.93
BPSK	5160.0	10.83	10.86	13.86	28.70	14.84	24.30	38.16
BPSK	5200.0	10.53	10.59	13.57	28.70	15.13	24.30	37.87
BPSK	5249.5	10.36	10.54	13.46	28.70	15.24	24.30	37.76

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB), EIRP (dBm) = Combined output power, dBm + Antenna Gain, dBi

Table 8.6-2: *PPSD measurements results for 0.875 MHz channel*

Modulation	Frequency, MHz	PPSD at ch0, dBm/MHz	PPSD at ch1, dBm/MHz	Combined PPSD, dBm/MHz	PPSD limit, dBm/MHz	PPSD margin, dB
BPSK	5151.0	-9.63	-10.05	-6.82	15.7	22.52
BPSK	5160.0	9.88	10.51	13.22	15.7	2.48
BPSK	5200.0	10.03	10.22	13.14	15.7	2.56
BPSK	5249.5	10.33	10.33	13.34	15.7	2.36

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB),

Table 8.6-3: *Output power measurements results for 5 MHz channel*

Modulation	Frequency, MHz	Conducted output power at ch0, dBm	Conducted output power at ch1, dBm	Combined output power, dBm	Power limit, dBm	Power margin, dB	Antenna gain, dBi	EIRP, dBm
BPSK	5155.0	0.35	0.52	3.45	28.70	25.25	24.3	27.75
BPSK	5160.0	11.81	11.76	14.80	28.70	13.90	24.3	39.10
BPSK	5200.0	15.58	15.64	18.62	28.70	10.08	24.3	42.92
BPSK	5247.5	15.41	15.59	18.51	28.70	10.19	24.3	42.81

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB), EIRP (dBm) = Combined output power, dBm + Antenna Gain, dBi

Table 8.6-4: *PPSD measurements results for 5 MHz channel*

Modulation	Frequency, MHz	PPSD at ch0, dBm/MHz	PPSD at ch1, dBm/MHz	Combined PPSD, dBm/MHz	PPSD limit, dBm/MHz	PPSD margin, dB
BPSK	5155.0	-5.59	-5.24	-2.40	15.7	18.10
BPSK	5160.0	5.74	5.84	8.80	15.7	6.90
BPSK	5200.0	9.94	9.73	12.85	15.7	2.85
BPSK	5247.5	9.66	9.59	12.64	15.7	3.06

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB)

Test data, continued

Table 8.6-5: *Output power measurements results for 10 MHz channel*

Modulation	Frequency, MHz	Conducted output power at ch0, dBm	Conducted output power at ch1, dBm	Combined output power, dBm	Power limit, dBm	Power margin, dB	Antenna gain, dBi	EIRP, dBm
BPSK	5160.0	2.48	2.69	5.60	28.70	23.10	24.3	29.90
BPSK	5170.0	10.42	10.71	13.58	28.70	15.12	24.3	37.88
BPSK	5200.0	18.61	18.54	21.59	28.70	7.11	24.3	45.89
BPSK	5245.0	18.57	18.51	21.55	28.70	7.15	24.3	45.85

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB), EIRP (dBm) = Combined output power, dBm + Antenna Gain, dBi

Table 8.6-6: *PPSD measurements results for 10 MHz channel*

Modulation	Frequency, MHz	PPSD at ch0, dBm/MHz	PPSD at ch1, dBm/MHz	Combined PPSD, dBm/MHz	PPSD limit, dBm/MHz	PPSD margin, dB
BPSK	5160.0	-6.27	-6.12	-3.18	15.7	18.88
BPSK	5170.0	1.50	2.20	4.87	15.7	10.83
BPSK	5200.0	9.68	9.96	12.83	15.7	2.87
BPSK	5245.0	9.68	9.98	12.84	15.7	2.86

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB)

Table 8.6-7: *Output power measurements results for 20 MHz channel*

Modulation	Frequency, MHz	Conducted output power at ch0, dBm	Conducted output power at ch1, dBm	Combined output power, dBm	Power limit, dBm	Power margin, dB	Antenna gain, dBi	EIRP, dBm
BPSK	5170.0	3.61	3.93	6.78	28.70	21.92	24.3	31.08
BPSK	5190.0	12.64	12.81	15.74	28.70	12.96	24.3	40.04
BPSK	5200.0	18.83	18.76	21.81	28.70	6.89	24.3	46.11
BPSK	5240.0	18.56	18.86	21.72	28.70	6.98	24.3	46.02

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB), EIRP (dBm) = Combined output power, dBm + Antenna Gain, dBi

Table 8.6-8: *PPSD measurements results for 20 MHz channel*

Modulation	Frequency, MHz	PPSD at ch0, dBm/MHz	PPSD at ch1, dBm/MHz	Combined PPSD, dBm/MHz	PPSD limit, dBm/MHz	PPSD margin, dB
BPSK	5170.0	-8.24	-7.86	-5.04	15.70	20.74
BPSK	5190.0	0.90	0.89	3.91	15.70	11.79
BPSK	5200.0	7.18	7.02	10.11	15.70	5.59
BPSK	5240.0	6.82	6.93	9.89	15.70	5.81

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB)

Test data, continued

Table 8.6-9: *Output power measurements results for 40 MHz channel*

Modulation	Frequency, MHz	Conducted output power at ch0, dBm	Conducted output power at ch1, dBm	Combined output power, dBm	Power limit, dBm	Power margin, dB	Antenna gain, dBi	EIRP, dBm
BPSK	5190.0	5.29	5.35	8.33	28.70	20.37	24.3	32.63
BPSK	5200.0	11.61	11.70	14.67	28.70	14.03	24.3	38.97
BPSK	5230.0	15.67	15.85	18.77	28.70	9.93	24.3	43.07

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB), EIRP (dBm) = Combined output power, dBm + Antenna Gain, dBi

Table 8.6-10: *PPSD measurements results for 40 MHz channel*

Modulation	Frequency, MHz	PPSD at ch0, dBm/MHz	PPSD at ch1, dBm/MHz	Combined PPSD, dBm/MHz	PPSD limit, dBm/MHz	PPSD margin, dB
BPSK	5190.0	-9.51	-9.31	-6.40	15.70	22.10
BPSK	5200.0	-3.05	-3.14	-0.08	15.70	15.78
BPSK	5230.0	0.87	1.20	4.05	15.70	11.65

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB)

Table 8.6-11: *Output power measurements results for 45 MHz channel*

Modulation	Frequency, MHz	Conducted output power at ch0, dBm	Conducted output power at ch1, dBm	Combined output power, dBm	Power limit, dBm	Power margin, dB	Antenna gain, dBi	EIRP, dBm
BPSK	5190.0	1.27	1.34	4.32	28.70	24.38	24.3	28.62
BPSK	5200.0	5.34	5.44	8.40	28.70	20.30	24.3	32.70
BPSK	5227.5	13.82	13.80	16.82	28.70	11.88	24.3	41.12

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB), EIRP (dBm) = Combined output power, dBm + Antenna Gain, dBi

Table 8.6-12: *PPSD measurements results for 45 MHz channel*

Modulation	Frequency, MHz	PPSD at ch0, dBm/MHz	PPSD at ch1, dBm/MHz	Combined PPSD, dBm/MHz	PPSD limit, dBm/MHz	PPSD margin, dB
BPSK	5190.0	-14.26	-14.28	-11.26	15.70	26.96
BPSK	5200.0	-10.30	-10.12	-7.20	15.70	22.90
BPSK	5227.5	-2.45	-1.53	1.04	15.70	14.66

Note: Antenna gain, dBi = peak gain (25 dBi) – cable loss (0.7 dB)

Test data, continued

Table 8.6-13: *Output power measurements results for 0.875 MHz channel for elevation angle above 30 degrees*

Modulation	Frequency, MHz	Port Number	Conducted output power , dBm	Antenna gain, dBi	EIRP power, dBm	EIRP limit, dB	Margin, dB
BPSK	5151.0	0	-9.43	7.30	-2.13	21.00	23.13
		1	-9.33	7.30	-2.03	21.00	23.03
BPSK	5160.0	0	10.83	7.30	18.13	21.00	2.87
		1	10.86	7.30	18.16	21.00	2.84
BPSK	5200.0	0	10.53	7.30	17.83	21.00	3.17
		1	10.59	7.30	17.89	21.00	3.11
BPSK	5249.5	0	10.36	7.30	17.66	21.00	3.34
		1	10.54	7.30	17.84	21.00	3.16

Note: Antenna gain, dBi = peak gain (8 dBi) – cable loss (0.7 dB), EIRP (dBm) = Individual port output power, dBm + Antenna Gain, dBi

Table 8.6-14: *Output power measurements results for 5 MHz channel for elevation angle above 30 degrees*

Modulation	Frequency, MHz	Port Number	Conducted output power , dBm	Antenna gain, dBi	EIRP power, dBm	EIRP limit, dB	Margin, dB
BPSK	5155.0	0	0.35	7.30	7.65	21.00	13.35
		1	0.52	7.30	7.82	21.00	13.18
BPSK	5160.0	0	11.81	7.30	19.11	21.00	1.89
		1	11.76	7.30	19.06	21.00	1.94
BPSK	5200.0	0	13.52	7.30	20.82	21.00	0.18
		1	12.93	7.30	20.23	21.00	0.77
BPSK	5247.5	0	13.62	7.30	20.92	21.00	0.08
		1	13.37	7.30	20.67	21.00	0.33

Note: Antenna gain, dBi = peak gain (8 dBi) – cable loss (0.7 dB), EIRP (dBm) = Individual port output power, dBm + Antenna Gain, dBi

Table 8.6-15: *Output power measurements results for 10 MHz channel for elevation angle above 30 degrees*

Modulation	Frequency, MHz	Port Number	Conducted output power , dBm	Antenna gain, dBi	EIRP power, dBm	EIRP limit, dB	Margin, dB
BPSK	5160.0	0	2.48	7.30	9.78	21.00	11.22
		1	2.69	7.30	9.99	21.00	11.01
BPSK	5170.0	0	10.42	7.30	17.72	21.00	3.28
		1	10.71	7.30	18.01	21.00	2.99
BPSK	5200.0	0	13.59	7.30	20.89	21.00	0.11
		1	13.49	7.30	20.79	21.00	0.21
BPSK	5245.0	0	13.32	7.30	20.62	21.00	0.38
		1	13.47	7.30	20.77	21.00	0.23

Note: Antenna gain, dBi = peak gain (8 dBi) – cable loss (0.7 dB), EIRP (dBm) = Individual port output power, dBm + Antenna Gain, dBi

Test data, continued

Table 8.6-16: *Output power measurements results for 20 MHz channel for elevation angle above 30 degrees*

Modulation	Frequency, MHz	Port Number	Conducted output power , dBm	Antenna gain, dBi	EIRP power, dBm	EIRP limit, dB	Margin, dB
BPSK	5170.0	0	3.61	7.30	10.91	21.00	10.09
		1	3.93	7.30	11.23	21.00	9.77
BPSK	5190.0	0	12.64	7.30	19.94	21.00	1.06
		1	12.81	7.30	20.11	21.00	0.89
BPSK	5200.0	0	13.55	7.30	20.85	21.00	0.15
		1	13.63	7.30	20.93	21.00	0.07
BPSK	5240.0	0	13.54	7.30	20.84	21.00	0.16
		1	13.58	7.30	20.88	21.00	0.12

Note: Antenna gain, dBi = peak gain (8 dBi) – cable loss (0.7 dB), EIRP (dBm) = Individual port output power, dBm + Antenna Gain, dBi

Table 8.6-17: *Output power measurements results for 40 MHz channel for elevation angle above 30 degrees*

Modulation	Frequency, MHz	Port Number	Conducted output power , dBm	Antenna gain, dBi	EIRP power, dBm	EIRP limit, dB	Margin, dB
BPSK	5190.0	0	5.29	7.30	12.59	21.00	8.41
		1	5.35	7.30	12.65	21.00	8.35
BPSK	5200.0	0	11.61	7.30	18.91	21.00	2.09
		1	11.70	7.30	19.00	21.00	2.00
BPSK	5230.0	0	13.16	7.30	20.46	21.00	0.54
		1	13.52	7.30	20.82	21.00	0.18

Note: Antenna gain, dBi = peak gain (8 dBi) – cable loss (0.7 dB), EIRP (dBm) = Individual port output power, dBm + Antenna Gain, dBi

Table 8.6-18: *Output power measurements results for 45 MHz channel for elevation angle above 30 degrees*

Modulation	Frequency, MHz	Port Number	Conducted output power , dBm	Antenna gain, dBi	EIRP power, dBm	EIRP limit, dB	Margin, dB
BPSK		0	1.27	7.30	8.57	21.00	12.43
		1	1.34	7.30	8.64	21.00	12.36
BPSK		0	5.34	7.30	12.64	21.00	8.36
		1	5.44	7.30	12.74	21.00	8.26
BPSK		0	13.13	7.30	20.43	21.00	0.57
		1	13.57	7.30	20.87	21.00	0.13

Note: Antenna gain, dBi = peak gain (8 dBi) – cable loss (0.7 dB), EIRP (dBm) = Individual port output power, dBm + Antenna Gain, dBi

Test data, continued

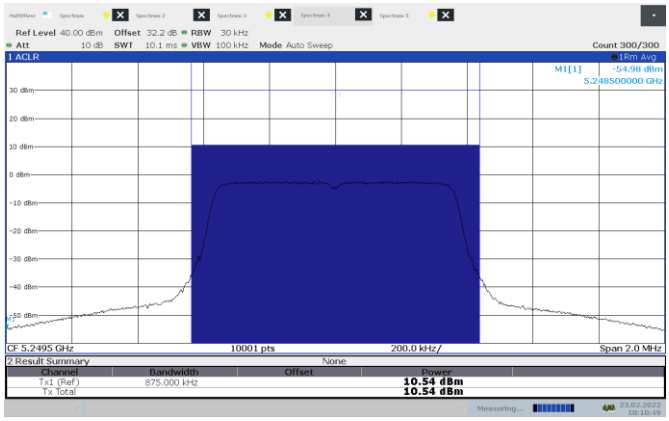


Figure 8.6-1: *Sample plot for power on 0.875 MHz channel*

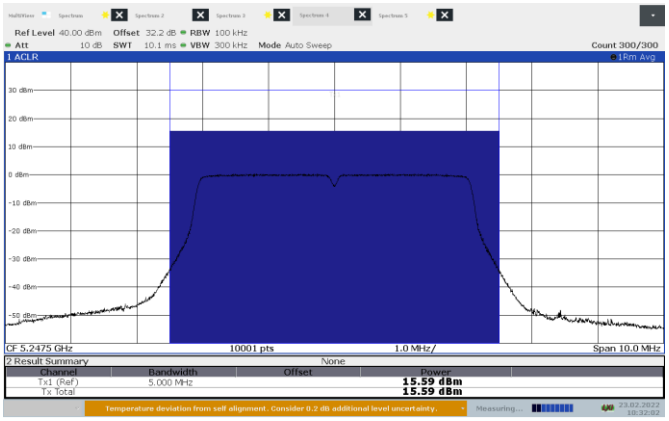


Figure 8.6-2: *Sample plot for power on 5 MHz channel*

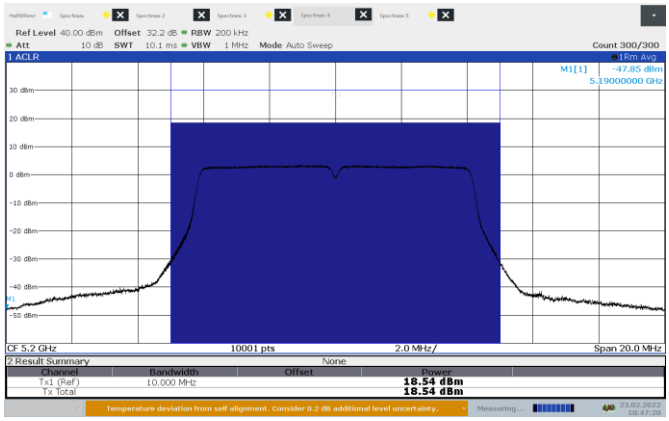


Figure 8.6-3: *Sample plot for power on 10 MHz channel*

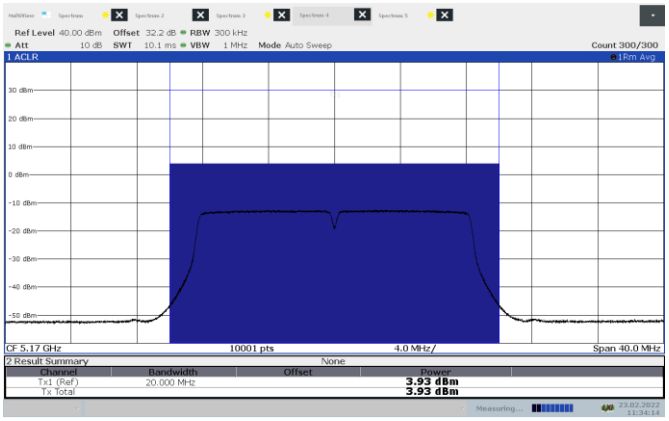


Figure 8.6-4: *Sample plot for power on 20 MHz channel*

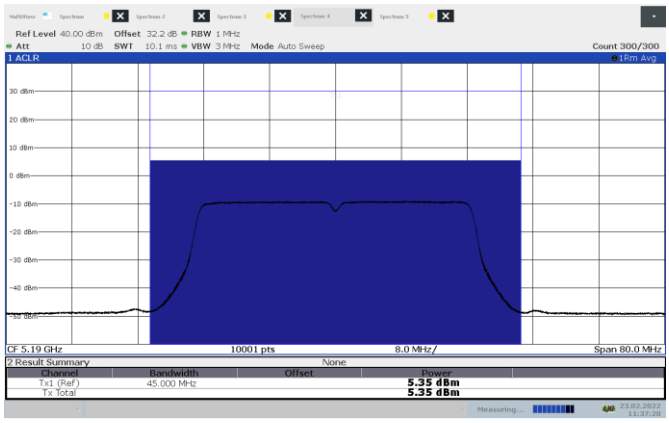


Figure 8.6-5: *Sample plot for power on 40 MHz channel*

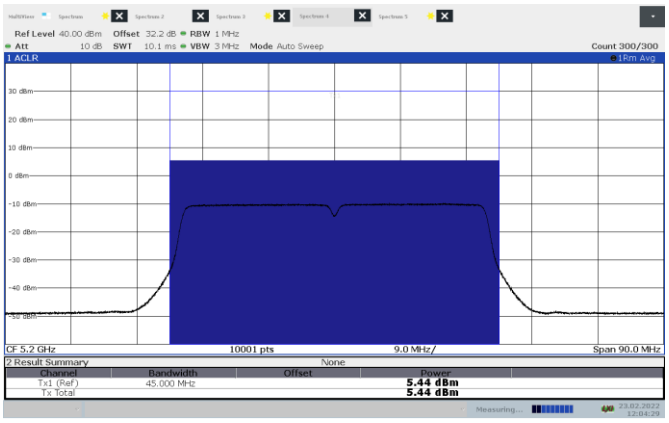


Figure 8.6-6: *Sample plot for power on 45 MHz channel*

Test data, continued

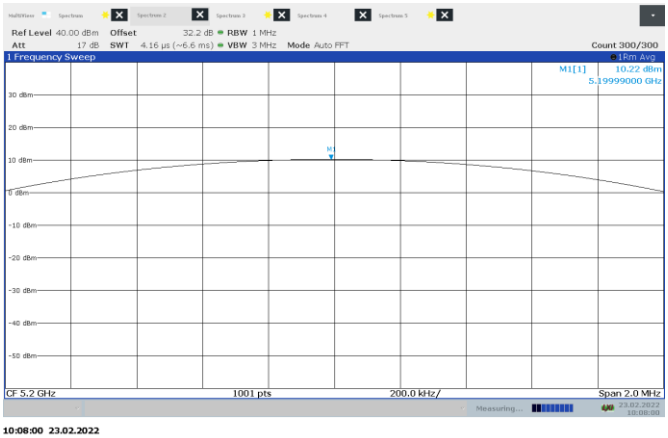


Figure 8.6-7: *Sample plot for PSD on 0.875 MHz channel*

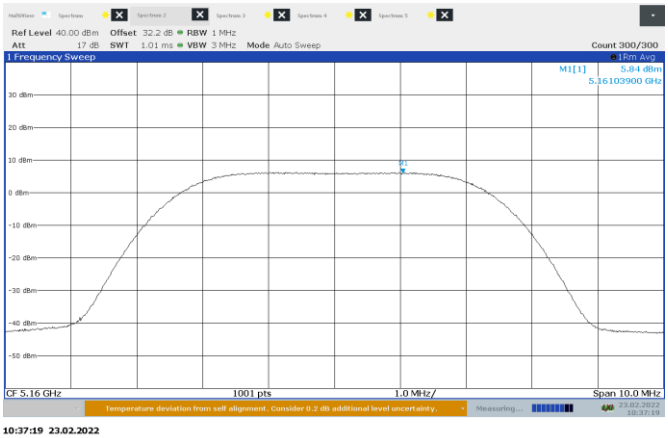


Figure 8.6-8: *Sample plot for PSD on 5 MHz channel*

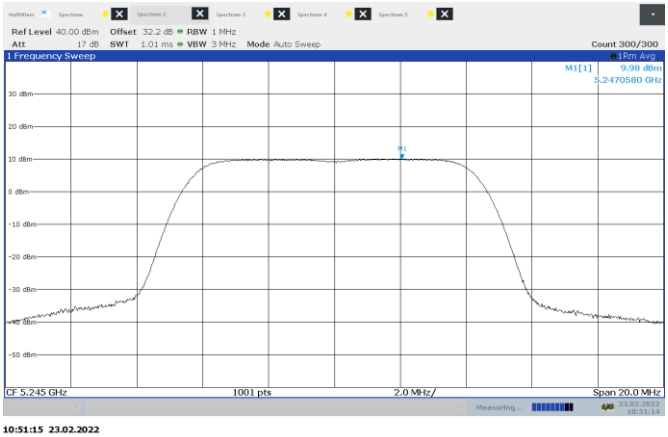


Figure 8.6-9: *Sample plot for PSD on 10 MHz channel*

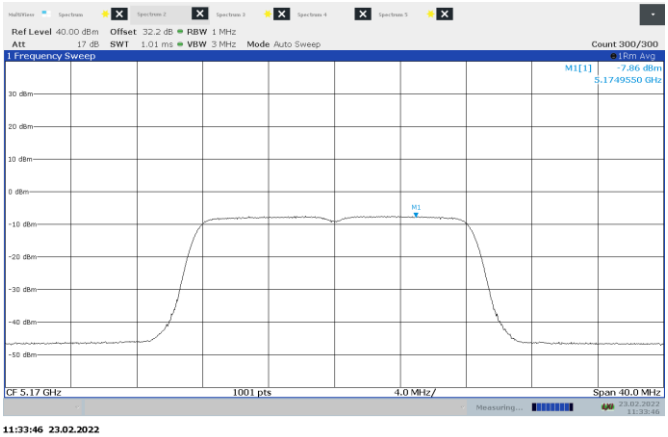


Figure 8.6-10: *Sample plot for PSD on 20 MHz channel*

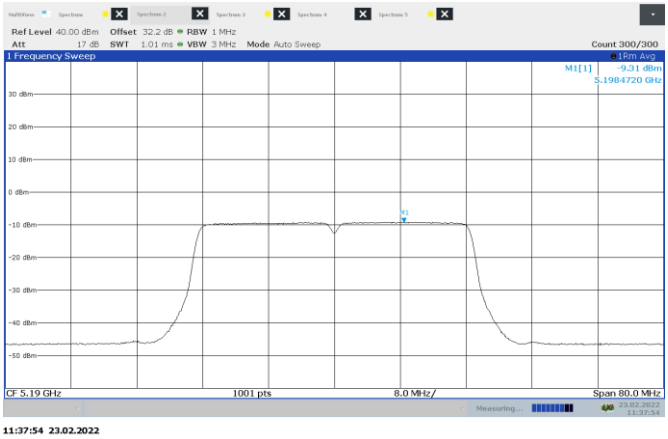


Figure 8.6-11: *Sample plot for PSD on 40 MHz channel*

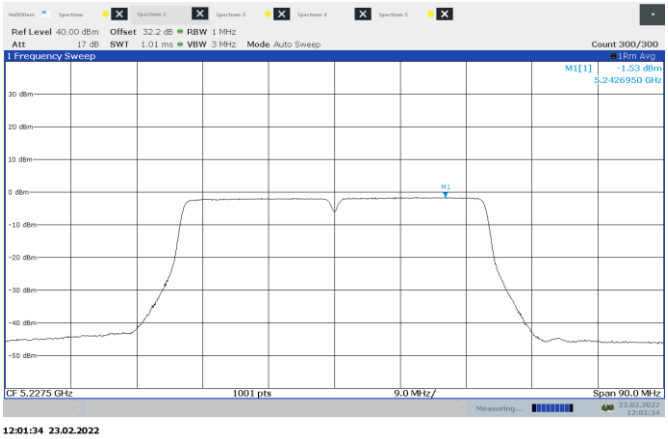


Figure 8.6-12: *Sample plot for PSD on 45 MHz channel*

8.7 Spurious unwanted (undesirable) emissions

8.7.1 References, definitions and limits

FCC §15.407:

(b) Undesirable emission limits.
Except as shown in paragraph (b)(7) of this section, the maximum emissions outside of the frequency bands of operation shall be attenuated in accordance with the following limits:

(1) For transmitters operating in the 5.15–5.25 GHz band: All emissions outside of the 5.15–5.35 GHz band shall not exceed an e.i.r.p. of −27 dBm/MHz.

(5) The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

(6) Unwanted emissions below 1 GHz must comply with the general field strength limits set forth in §15.209.

(7) The provisions of §15.205 apply to intentional radiators operating under this section.

(8) When measuring the emission limits, the nominal carrier frequency shall be adjusted as close to the upper and lower frequency band edges as the design of the equipment permits.

Table 8.7-1: *FCC §15.209 – Radiated emission limits*

	Field strength of emissions		
Frequency, MHz	**µV/m**	**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 8.7-2: *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			

8.7.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 31, 2022

8.7.3 Observations, settings and special notes

- As part of the current assessment, the test range of 9 kHz to 40 GHz has been fully considered and compared to the actual frequencies utilized within the EUT. Since the EUT contains a transmitter in the GHz range, the EUT has been deemed compliant without formal testing in the 9 kHz to 30 MHz test range, therefore formal test results (tabular data and/or plots) are not provided within this test report.
- EUT was set to transmit with 95 % duty cycle. The EUT was transmitting on both MIMO chains simultaneously
- Radiated measurements were performed at a distance of 3 m up to 18 GHz, at 1 m above 18 GHz (with added distance correction factor).
- The spurious emission was tested per ANSI C63.10, Clause 12.7 and 789033 D02, Clause II(G).
- As per KDB 789033 D02 III B) a) (i) As a practical matter, the 99% bandwidth may be used in lieu of the 26 dB bandwidth to show the emission does not intentionally extend into the 5250–5350 MHz band of operation.
- The most stringent peak spurious emission limit is −27 dBm/MHz EIRP = −27 – (25 – 0.7) = −51.3 dBm/MHz
- Conducted average restricted limit calculated as follows:
  54 dBµV/m − 95.2 dB – (Antenna gain – path loss) = 54 dBµV/m – 95.2 – (25.0 – 0.7) = −65.5 dBm/MHz
- Radiated cabinet spurious is completed using 10 MHz BW mid channel.
- The transmitter output signals are completely uncorrelated as defined in KDB 662911 D01

Spectrum analyser for peak conducted measurements within restricted bands below 1 GHz:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser for peak conducted measurements within restricted bands above 1 GHz:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser for average conducted measurements within restricted bands above 1 GHz for frequencies where peak results were above the average limit:

Resolution bandwidth:	1 MHz
Video bandwidth:	10 MHz
Detector mode:	RMS
Trace mode:	Power average
Number of averaging traces:	100

Spectrum analyser for peak conducted measurements outside restricted bands:

Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.7.4 Test data

Table 8.7-3: *Field strength within restricted bands worst case measurement results, average*

Channel width, MHz	Antenna gain, dBi	Channel	Emission frequency, MHz	Measured conducted Average Field strength, dBm		Conducted Average Limit, dBm	Margin, dBm
				Ch 0	Ch 1		
0.875	24.3	Low	5151	-65.93	-65.83	-65.5	0.33
0.875	24.3	2nd Low	5160	-66.26	-66.36	-65.5	0.76
0.875	24.3	Mid	5200	-70.87	-70.95	-65.5	5.37
5	24.3	Low	5155	-66.24	-66.53	-65.5	0.74
5	24.3	Low	5160	-65.85	-65.60	-65.5	0.10
5	24.3	Low	5200	-67.18	-67.32	-65.5	1.68
10	24.3	Low	5160	-67.63	-67.03	-65.5	1.53
10	24.3	2nd Low	5170	-66.64	-66.19	-65.5	0.69
10	24.3	Mid	5200	-65.61	-65.68	-65.5	0.11
20	24.3	Low	5170	-67.53	-65.72	-65.5	0.22
20	24.3	2nd Low	5190	-66.39	-66.12	-65.5	0.62
20	24.3	Mid	5200	-66.01	-66.01	-65.5	0.51
20	24.3	High	5240	-65.80	-65.85	-65.5	0.30
40	24.3	Low	5190	-67.10	-65.63	-65.5	0.13
40	24.3	Mid	5200	-66.03	-65.96	-65.5	0.46
40	24.3	High	5230	-66.87	-66.48	-65.5	0.98
45	24.3	Low	5190	-67.63	-65.99	-65.5	0.49
45	24.3	Mid	5200	-67.50	-66.08	-65.5	0.58
45	24.3	High	5227.5	-67.19	-66.79	-65.5	1.29

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.
Conducted restricted band average Limit, dBm = 54 dBµV/m – 95.2 – (Antenna gain – Path Loss) = 54 – 95.2 – (25 – 0.7) = −65.5 dBm

Test data, continued

Table 8.7-4: *Conducted band edge within 5150 MHz bands worst case measurement results, peak*

Channel width, MHz	Antenna gain, dBi	Channel	Emission frequency, MHz	Measured conducted Peak Field strength, dBm/MHz		Conducted band edge Peak Limit, dBm/MHz	Margin, dBm
				Ch 0	Ch 1		
0.875	24.3	Low	5151	-52.78	-52.96	-51.3	1.48
0.875	24.3	2nd Low	5160	-53.42	-53.61	-51.3	2.12
0.875	24.3	Mid	5200	-58.01	-58.96	-51.3	6.71
5	24.3	Low	5155	-54.61	-53.24	-51.3	1.94
5	24.3	Low	5160	-54.92	-52.28	-51.3	0.98
5	24.3	Low	5200	-51.64	-52.00	-51.3	0.34
10	24.3	Low	5160	-52.00	-53.65	-51.3	0.70
10	24.3	2nd Low	5170	-53.57	-52.95	-51.3	1.65
10	24.3	Mid	5200	-52.59	-52.15	-51.3	0.85
20	24.3	Low	5170	-55.37	-53.53	-51.3	2.23
20	24.3	2nd Low	5190	-54.62	-55.61	-51.3	3.32
20	24.3	Mid	5200	-52.49	-53.32	-51.3	1.19
20	24.3	High	5240	-53.20	-52.68	-51.3	1.38
40	24.3	Low	5190	-55.32	-53.46	-51.3	2.16
40	24.3	Mid	5200	-54.61	-54.90	-51.3	3.31
40	24.3	High	5230	-55.21	-55.44	-51.3	3.91
45	24.3	Low	5190	-56.12	-54.81	-51.3	3.51
45	24.3	Mid	5200	-56.77	-54.14	-51.3	2.84
45	24.3	High	5227.5	-55.36	-54.47	-51.3	3.17

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.
Conducted band edge peak limit, dBm = −27 dBm/MHz EIRP = −27 – (25.0 – 0.7) = −51.3 dBm/MHz

Test data, continued

Table 8.7-5: *Upper band edge 5250 MHz 99% bandwidth results*

Channel bandwidth, MHz	Modulation	Frequency, MHz	Upper 99% bandwidth, MHz	Limit, MHz	Margin, MHz
0.875	BPSK	5249.5	5249.87	5250.00	0.13
5	BPSK	5247.5	5249.56	5250.00	0.44
10	BPSK	5245.0	5249.11	5250.00	0.89
20	BPSK	5240.0	5248.27	5250.00	1.73
40	BPSK	5230.0	5246.58	5250.00	3.42
45	BPSK	5227.5	5248.09	5250.00	1.91

Table 8.7-6: *Radiated field strength within 5350 MHz restricted bands worst case measurement results, average*

Channel width, MHz	Antenna gain, dBi	Channel	Emission frequency, MHz	Measured conducted Average Field strength, dBm		Average Field strength, dBµV/m @ 3 m	Average Limit, dBµV/m @ 3 m	Margin, dBµV/m @ 3 m
				Ch 0	Ch 1			
0.875	24.3	high	5249.5	-56.21	-55.95	39.25	54.00	14.75
5	24.3	high	5247.5	-55.59	-55.73	39.61	54.00	14.39
10	24.3	high	5245	-55.72	-55.59	39.61	54.00	14.39
20	24.3	high	5240	-55.69	-55.63	39.57	54.00	14.43
40	24.3	high	5230	-55.61	-55.75	39.59	54.00	14.41
45	24.3	high	5227.5	-55.49	-55.29	39.91	54.00	14.09

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Table 8.7-7: *Radiated field strength within 5350 MHz restricted bands worst case measurement results, Peak*

Channel width, MHz	Antenna gain, dBi	Channel	Emission frequency, MHz	Measured conducted Peak Field strength, dBm		Peak Field strength, dBµV/m @ 3 m	Peak Limit, dBµV/m @ 3 m	Margin, dBµV/m @ 3 m
				Ch 0	Ch 1			
0.875	24.3	high	5249.5	-48.58	-47.03	48.17	74.00	25.83
5	24.3	high	5247.5	-48.53	-47.59	47.61	74.00	26.39
10	24.3	high	5245	-48.44	-48.45	46.76	74.00	27.24
20	24.3	high	5240	-47.87	-48.16	47.33	74.00	26.67
40	24.3	high	5230	-47.67	-47.94	47.53	74.00	26.47
45	24.3	high	5227.5	-47.29	-47.86	47.91	74.00	26.09

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Test data, continued

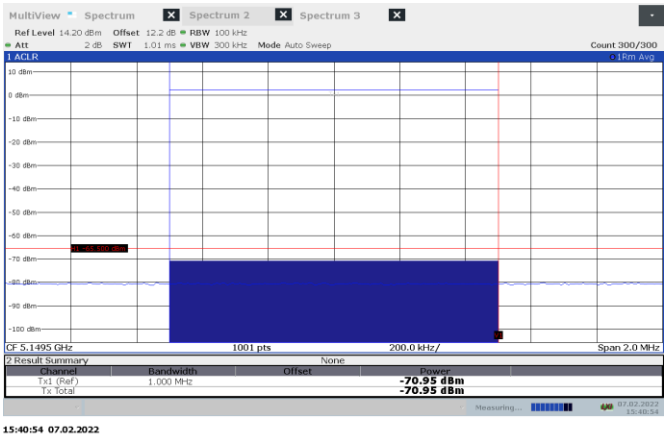


Figure 8.7-1: *Conducted average restricted band edge emissions@5150 MHz, 0.875 MHz sample plot*

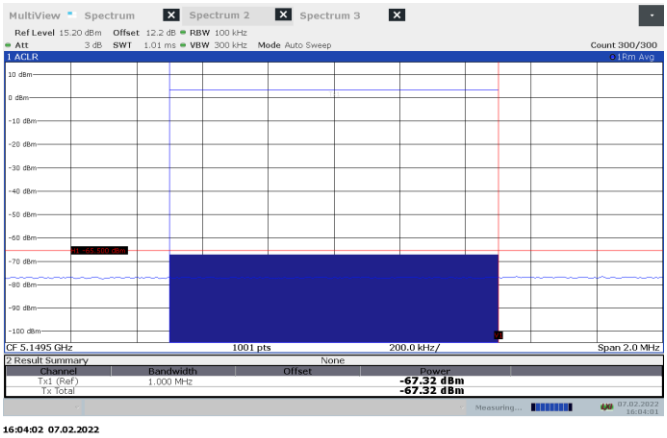


Figure 8.7-2: *Conducted average restricted band edge emissions@5150 MHz, 5 MHz sample plot*

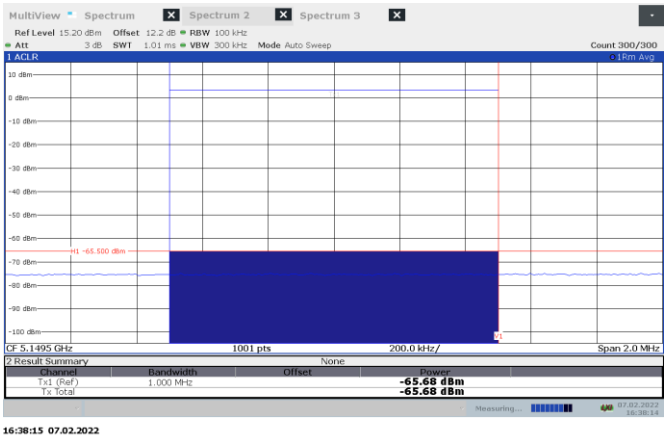


Figure 8.7-3: *Conducted average restricted band edge emissions @5150 MHz, 10 MHz sample plot*

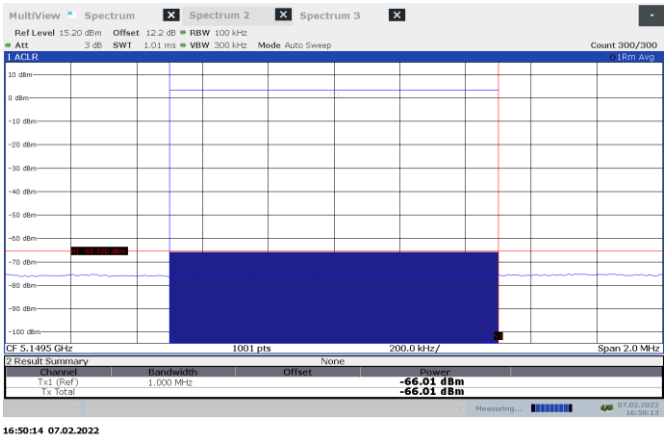


Figure 8.7-4: *Conducted average restricted band edge emissions @5150 MHz, 20 MHz sample plot*

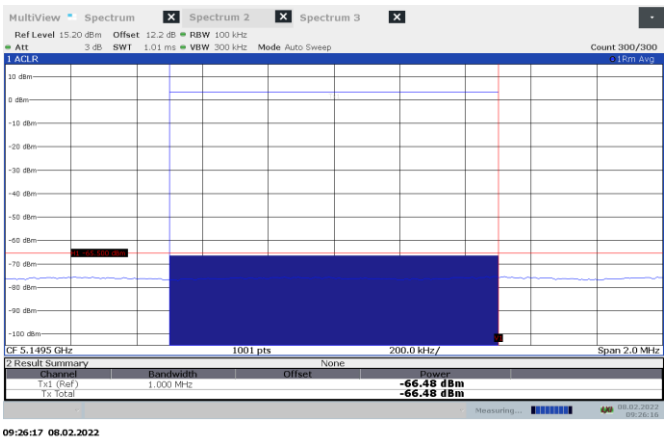


Figure 8.7-5: *Conducted average restricted band edge emissions @5150 MHz, 40 MHz sample plot*

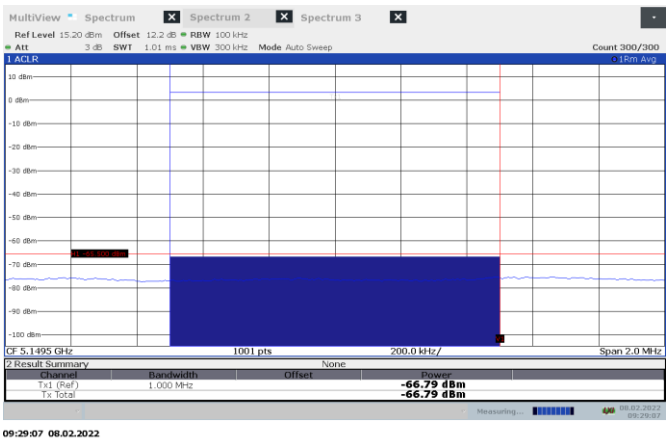


Figure 8.7-6: *Conducted average restricted band edge emissions @5150 MHz, 45 MHz sample plot*

Test data, continued

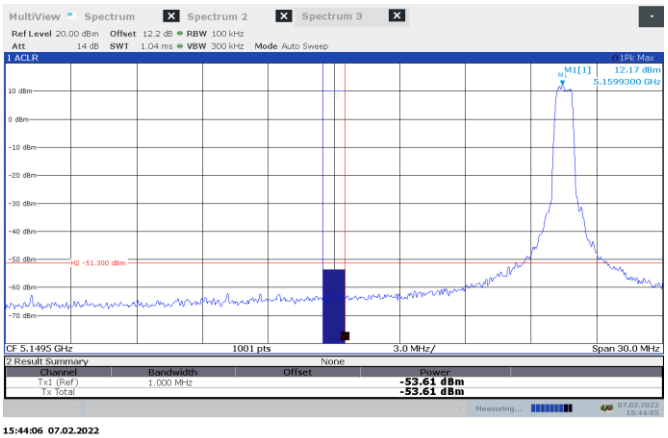


Figure 8.7-7: *Conducted peak band edge emissions, 0.875 MHz sample plot*

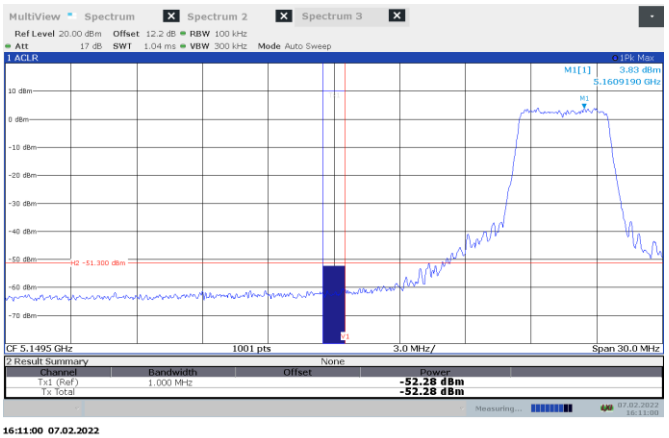


Figure 8.7-8: *Conducted peak band edge emissions, 5 MHz sample plot*

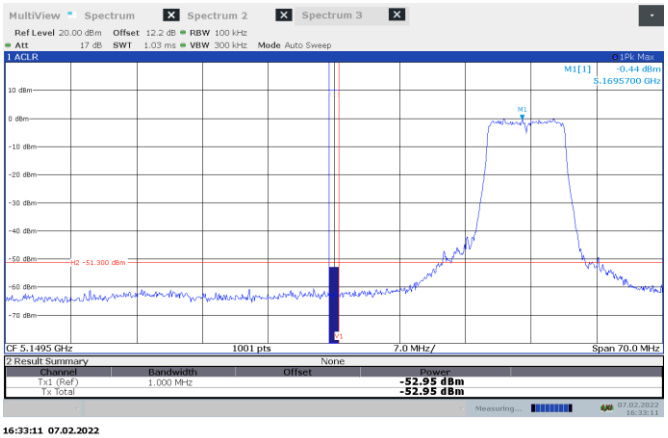


Figure 8.7-9: *Conducted peak band edge emissions, 10 MHz sample plot*

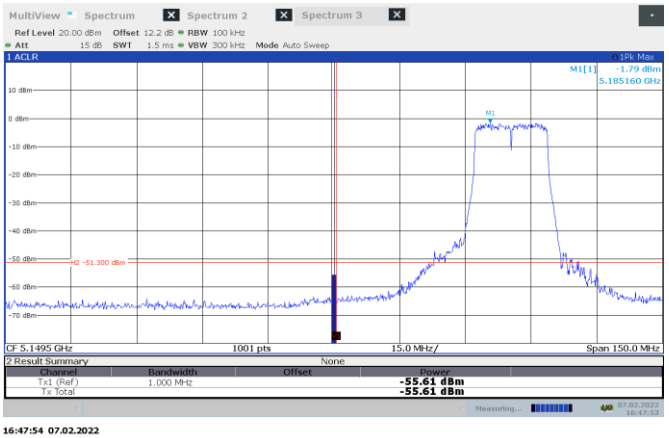


Figure 8.7-10: *Conducted peak band edge emissions, 20 MHz sample plot*

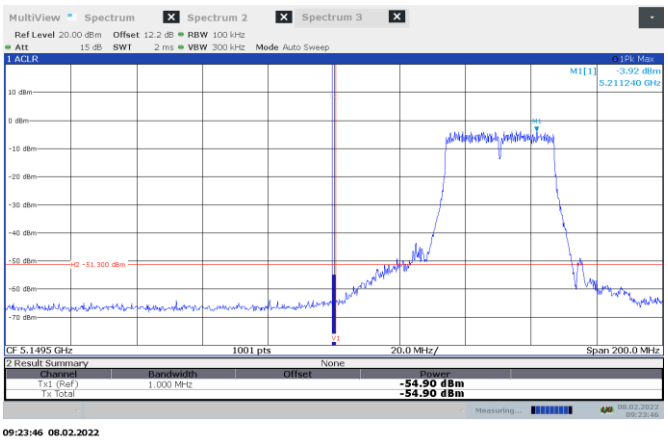


Figure 8.7-11: *Conducted peak band edge emissions, 40 MHz sample plot*

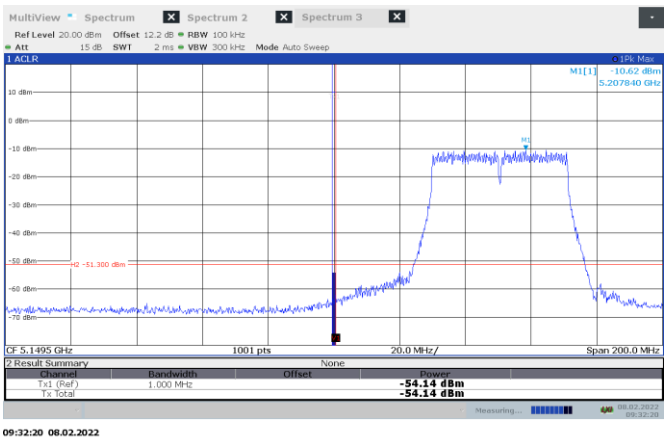
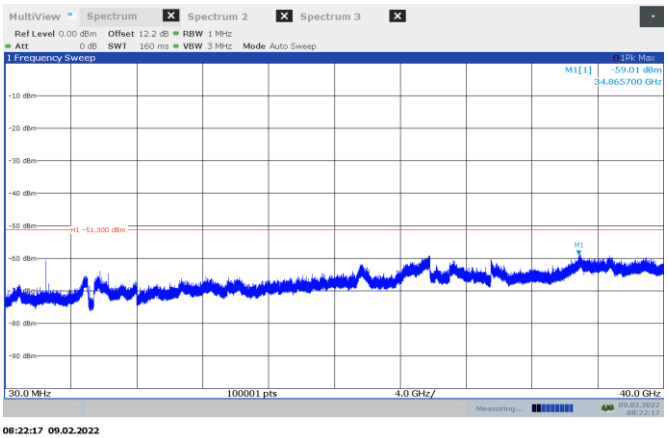


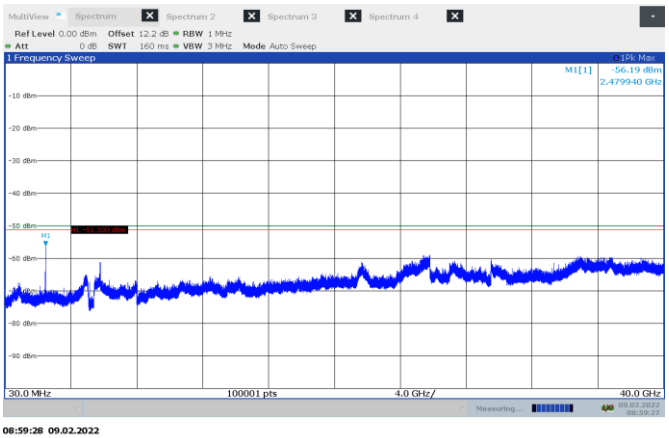
Figure 8.7-12: *Conducted peak band edge emissions, 45 MHz sample plot*

Test data, continued



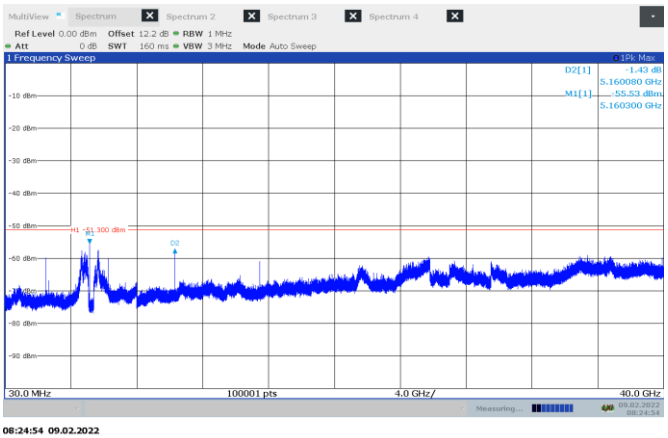
08:22:17 09.02.2022

Figure 8.7-13: *Conducted spurious emissions up to 40 GHz, 0.875 MHz low channel at ch0*



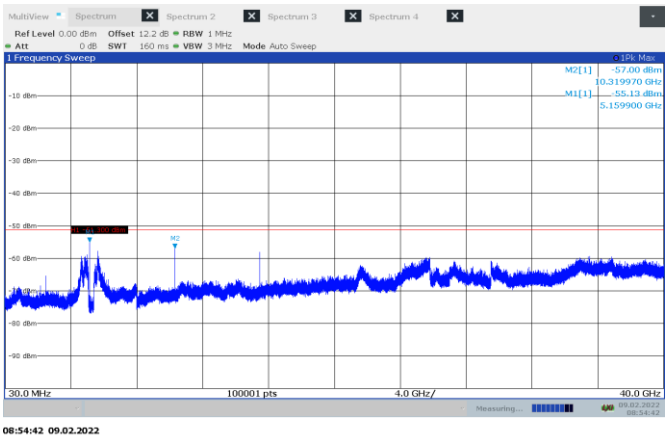
08:59:28 09.02.2022

Figure 8.7-14: *Conducted spurious emissions up to 40 GHz, 0.875 MHz low channel at ch1*



08:24:54 09.02.2022

Figure 8.7-15: *Conducted spurious emissions up to 40 GHz, 0.875 MHz 2nd low channel at ch0*



08:54:42 09.02.2022

Figure 8.7-16: *Conducted spurious emissions up to 40 GHz, 0.875 MHz 2nd low channel at ch1*

Test data, continued

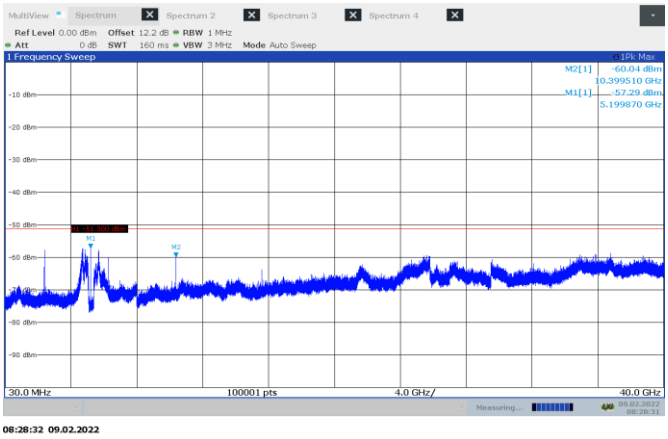


Figure 8.7-17: *Conducted spurious emissions up to 40 GHz, 0.875 MHz mid channel at ch0*

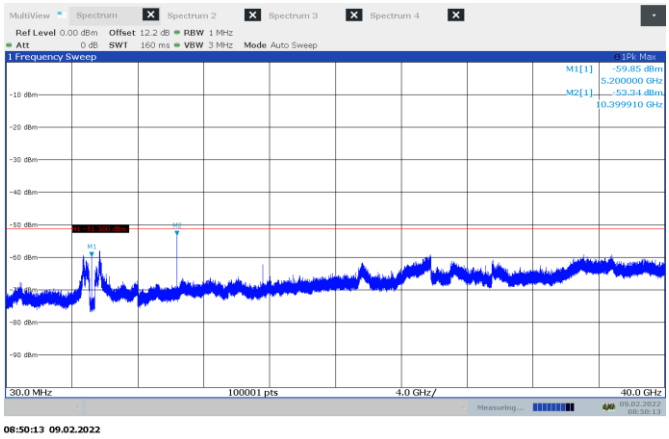


Figure 8.7-18: *Conducted spurious emissions up to 40 GHz, 0.875 MHz mid channel at ch1*

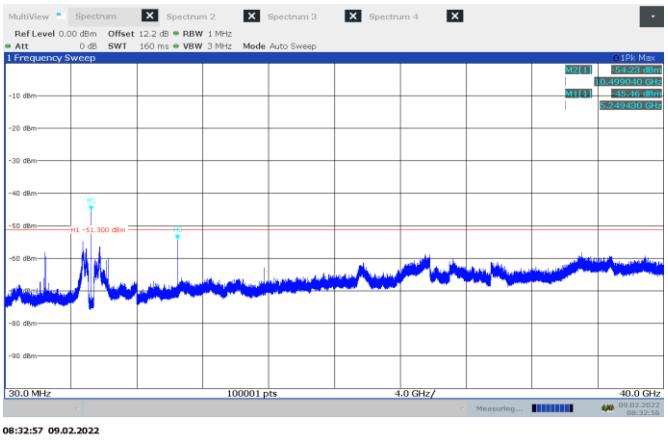


Figure 8.7-19: *Conducted spurious emissions up to 40 GHz, 0.875 MHz high channel at ch0*

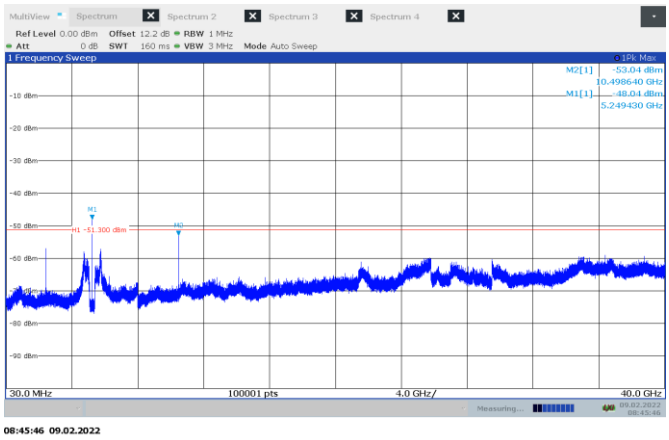


Figure 8.7-20: *Conducted spurious emissions up to 40 GHz, 0.875 MHz high channel at ch1*

Test data, continued

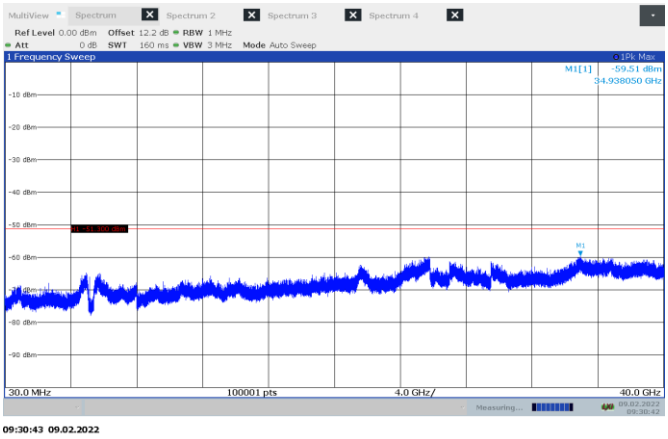


Figure 8.7-21: *Conducted spurious emissions up to 40 GHz, 5 MHz low channel at ch0*

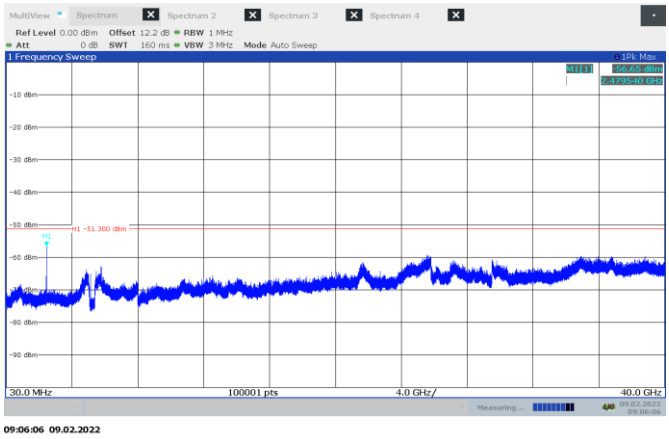


Figure 8.7-22: *Conducted spurious emissions up to 40 GHz, 5 MHz low channel at ch1*

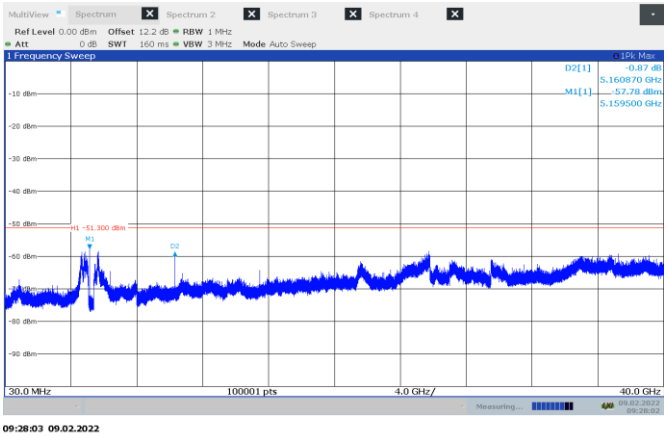


Figure 8.7-23: *Conducted spurious emissions up to 40 GHz, 5 MHz 2nd low channel at ch0*

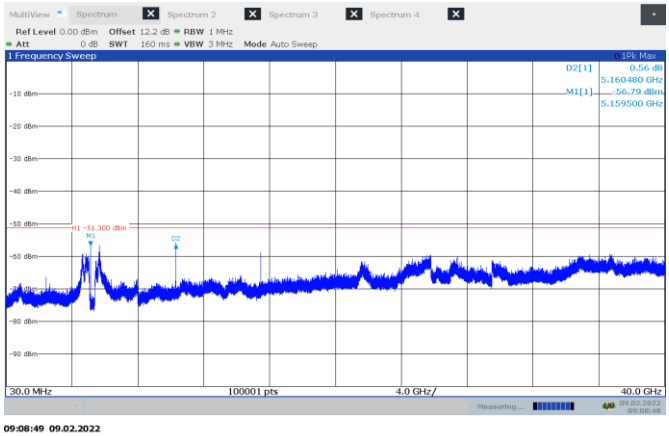


Figure 8.7-24: *Conducted spurious emissions up to 40 GHz, 5 MHz 2nd low channel at ch1*

Test data, continued

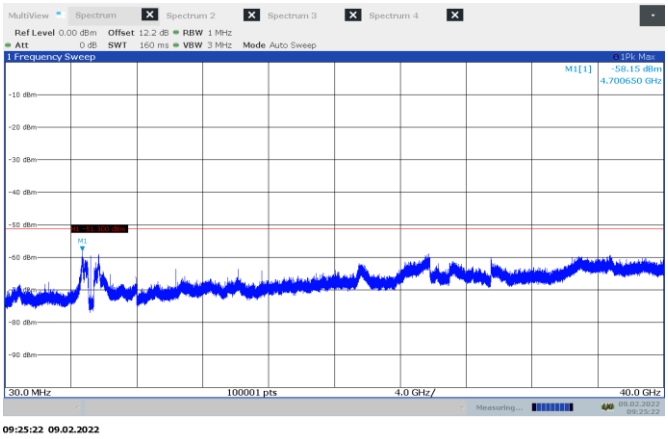


Figure 8.7-25: *Conducted spurious emissions up to 40 GHz, 5 MHz mid channel at ch0*

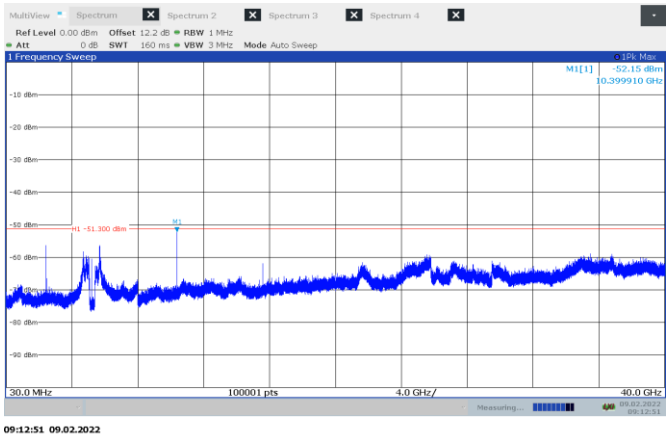


Figure 8.7-26: *Conducted spurious emissions up to 40 GHz, 5 MHz mid channel at ch1*

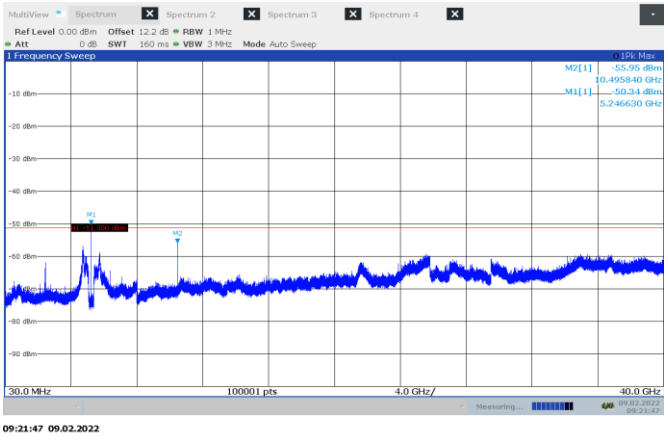


Figure 8.7-27: *Conducted spurious emissions up to 40 GHz, 5 MHz high channel at ch0*

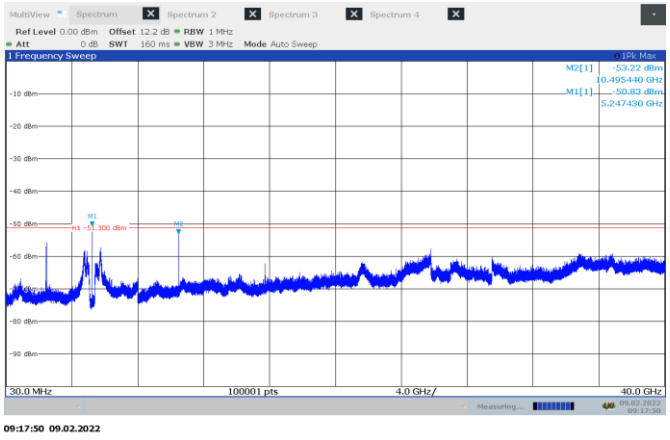


Figure 8.7-28: *Conducted spurious emissions up to 40 GHz, 5 MHz high channel at ch1*

Test data, continued

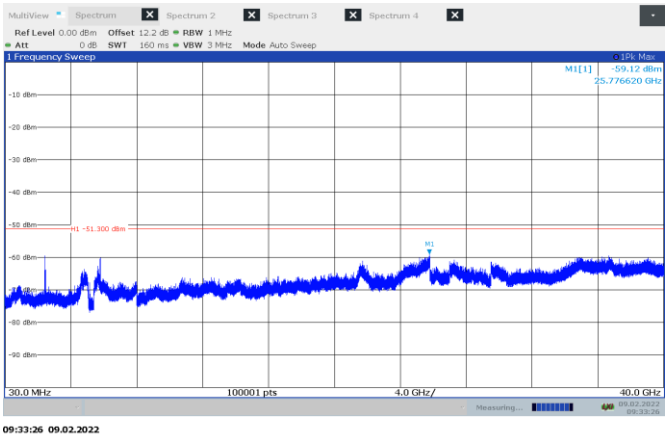


Figure 8.7-29: *Conducted spurious emissions up to 40 GHz, 10 MHz low channel at ch0*

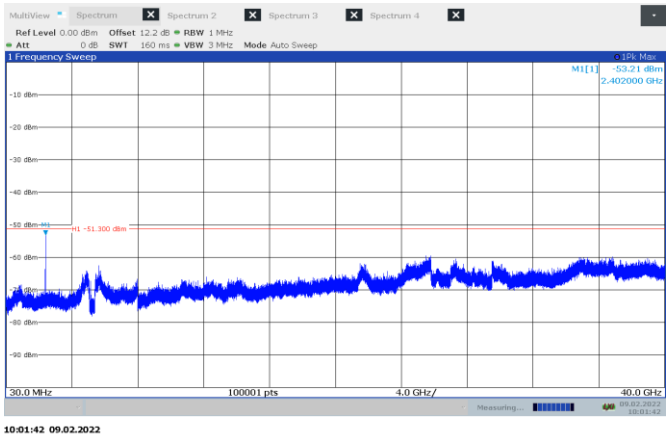


Figure 8.7-30: *Conducted spurious emissions up to 40 GHz, 10 MHz low channel at ch1*

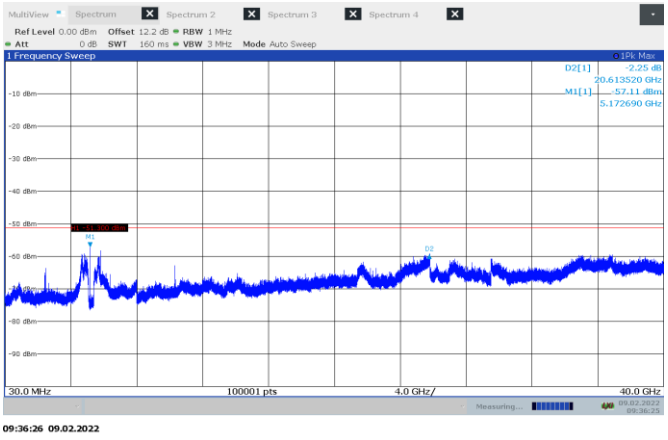


Figure 8.7-31: *Conducted spurious emissions up to 40 GHz, 10 MHz 2nd low channel at ch0*

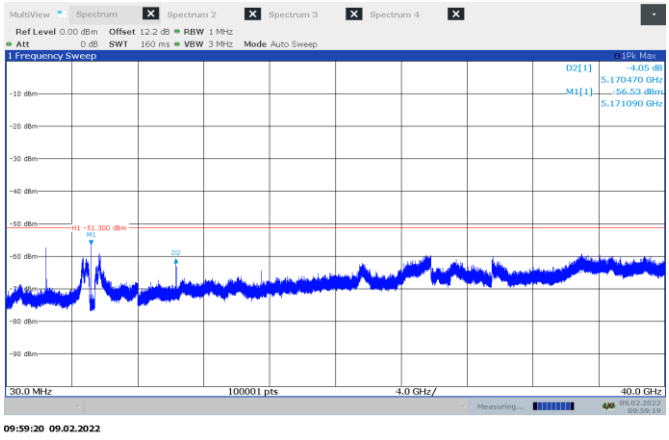


Figure 8.7-32: *Conducted spurious emissions up to 40 GHz, 10 MHz 2nd low channel at ch1*

Test data, continued

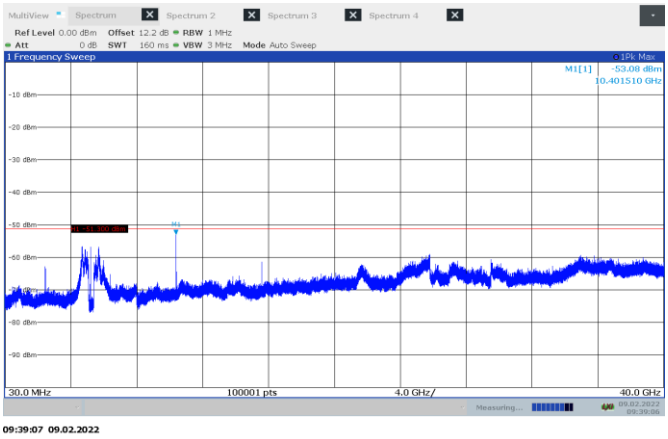


Figure 8.7-33: *Conducted spurious emissions up to 40 GHz, 10 MHz mid channel at ch0*

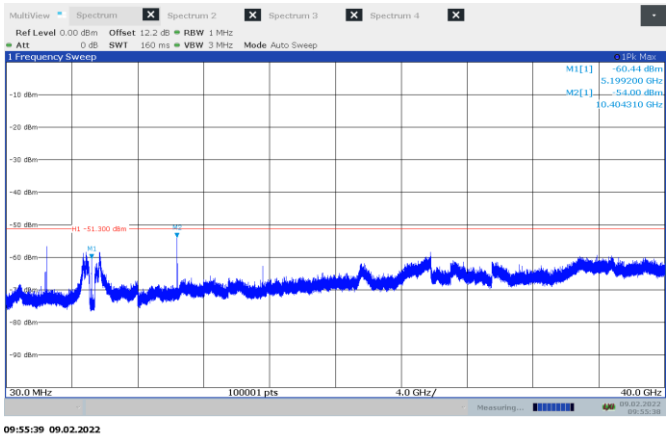


Figure 8.7-34: *Conducted spurious emissions up to 40 GHz, 10 MHz mid channel at ch1*

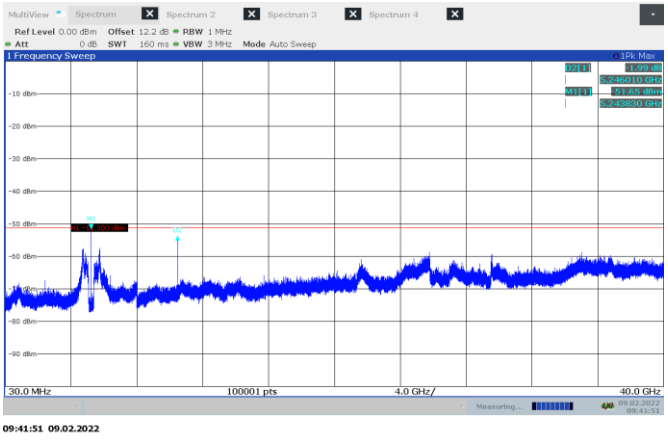


Figure 8.7-35: *Conducted spurious emissions up to 40 GHz, 10 MHz high channel at ch0*

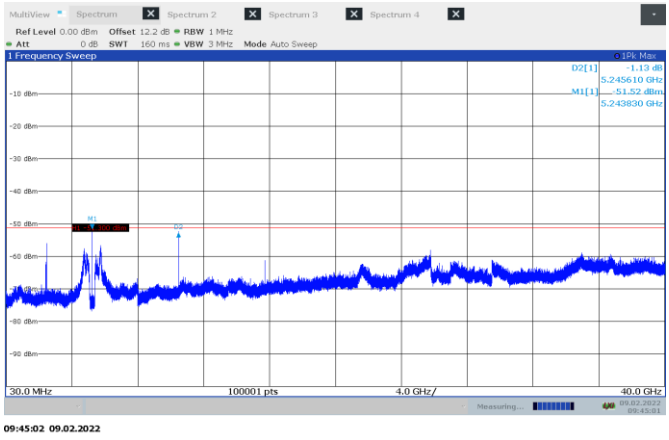


Figure 8.7-36: *Conducted spurious emissions up to 40 GHz, 10 MHz high channel at ch1*

Test data, continued

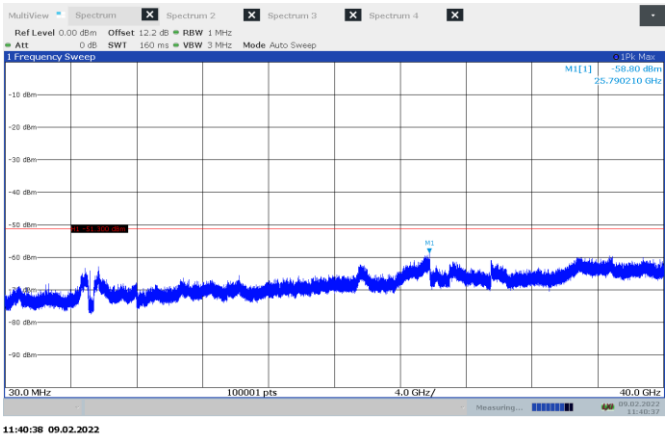


Figure 8.7-37: *Conducted spurious emissions up to 40 GHz, 20 MHz low channel at ch0*

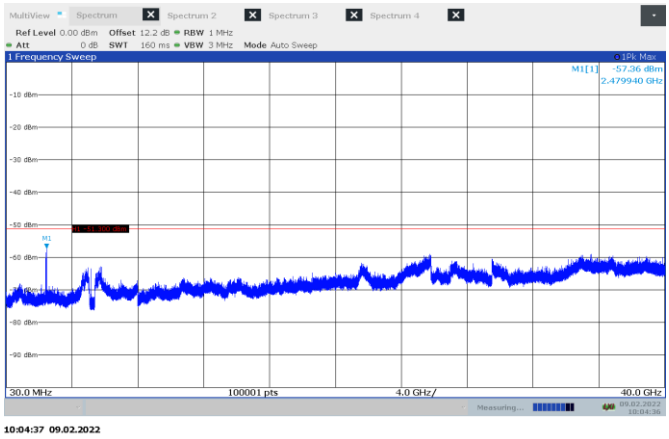


Figure 8.7-38: *Conducted spurious emissions up to 40 GHz, 20 MHz low channel at ch1*

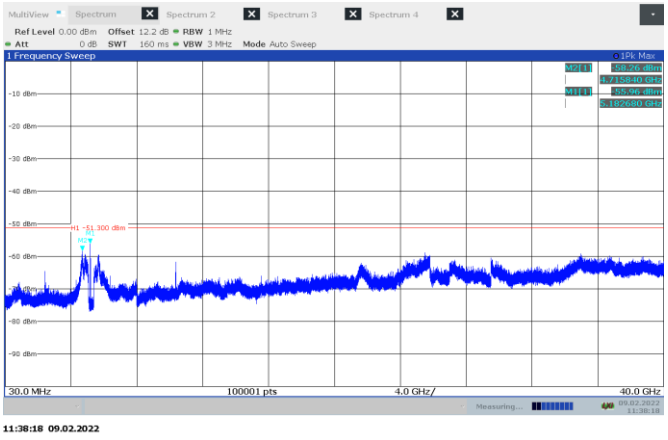


Figure 8.7-39: *Conducted spurious emissions up to 40 GHz, 20 MHz 2nd low channel at ch0*

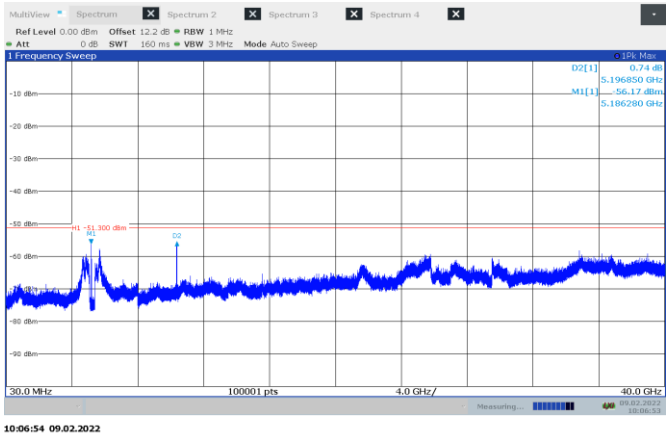


Figure 8.7-40: *Conducted spurious emissions up to 40 GHz, 20 MHz 2nd low channel at ch1*

Test data, continued

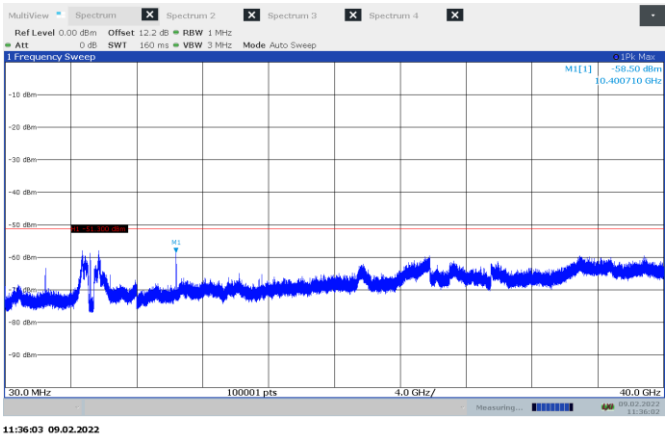


Figure 8.7-41: *Conducted spurious emissions up to 40 GHz, 20 MHz mid channel at ch0*

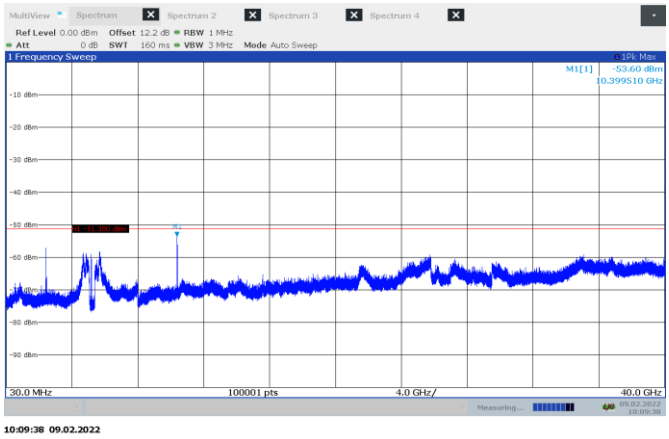


Figure 8.7-42: *Conducted spurious emissions up to 40 GHz, 20 MHz mid channel at ch1*

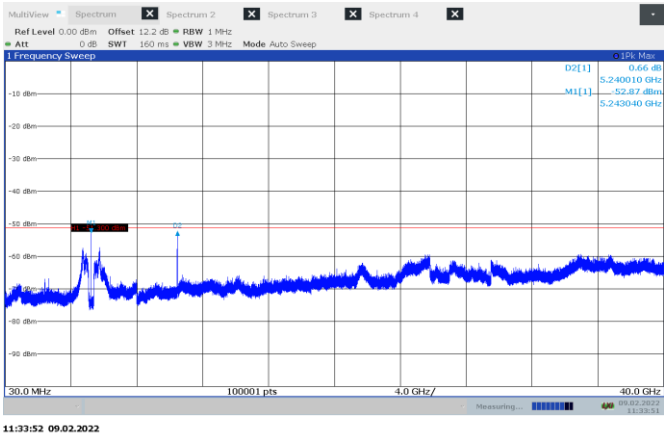


Figure 8.7-43: *Conducted spurious emissions up to 40 GHz, 20 MHz high channel at ch0*

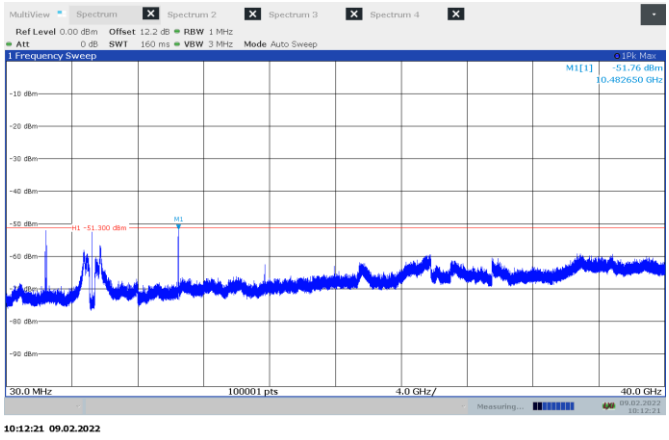


Figure 8.7-44: *Conducted spurious emissions up to 40 GHz, 20 MHz high channel at ch1*

Test data, continued

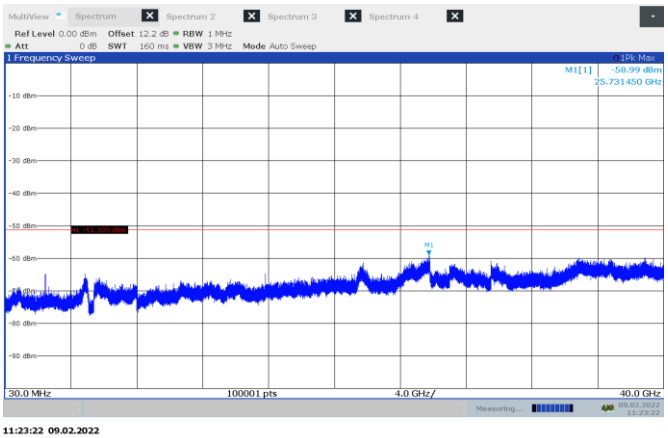


Figure 8.7-45: *Conducted spurious emissions up to 40 GHz, 40 MHz low channel at ch0*

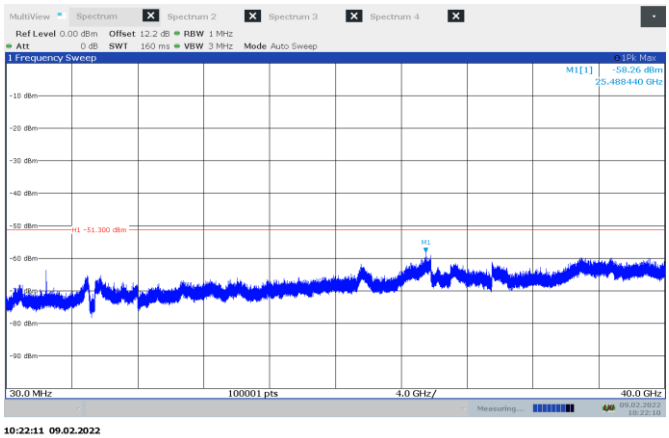


Figure 8.7-46: *Conducted spurious emissions up to 40 GHz, 40 MHz low channel at ch1*

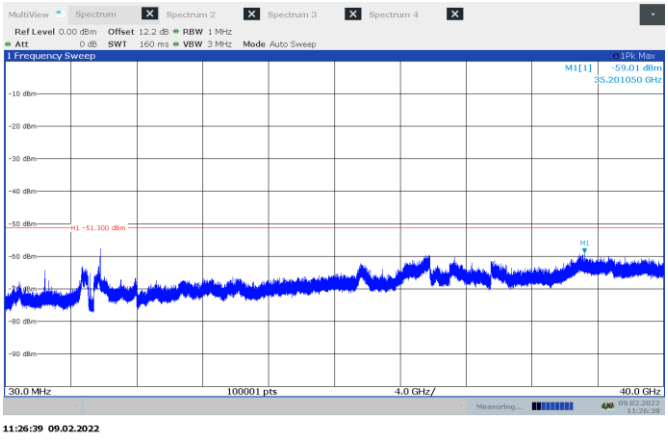


Figure 8.7-47: *Conducted spurious emissions up to 40 GHz, 40 MHz 2nd low channel at ch0*

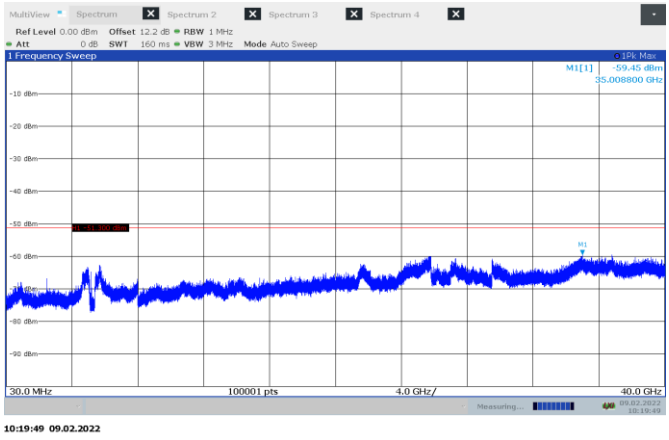


Figure 8.7-48: *Conducted spurious emissions up to 40 GHz, 40 MHz 2nd low channel at ch1*

Test data, continued

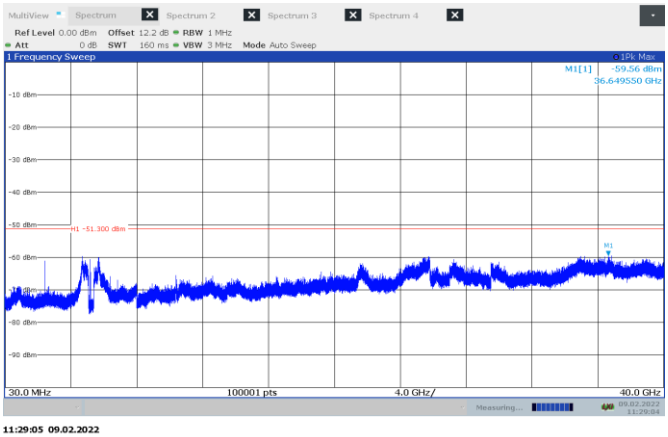


Figure 8.7-49: *Conducted spurious emissions up to 40 GHz, 40 MHz mid channel at ch0*

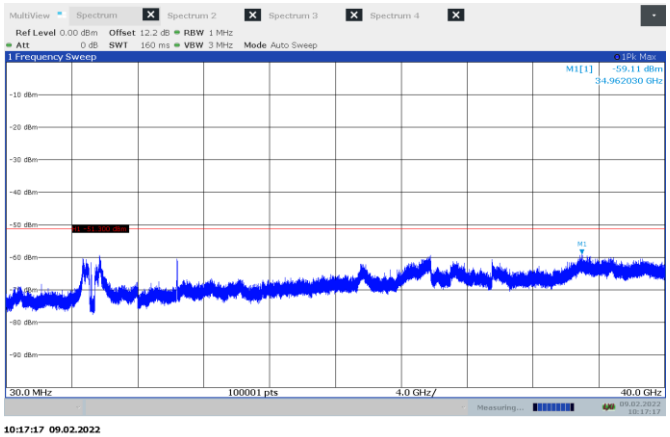


Figure 8.7-50: *Conducted spurious emissions up to 40 GHz, 40 MHz mid channel at ch1*

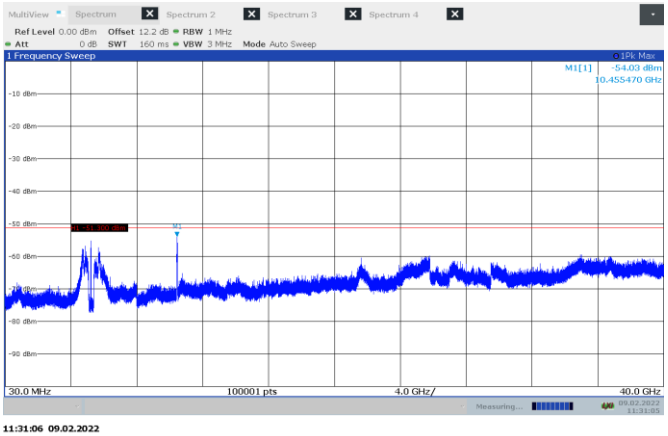


Figure 8.7-51: *Conducted spurious emissions up to 40 GHz, 40 MHz high channel at ch0*

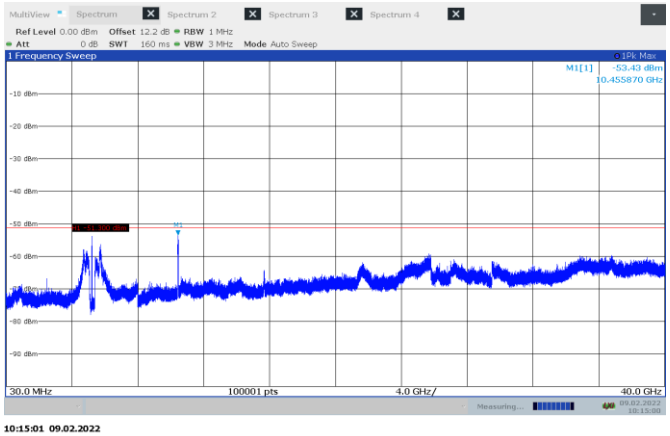


Figure 8.7-52: *Conducted spurious emissions up to 40 GHz, 40 MHz high channel at ch1*

Test data, continued

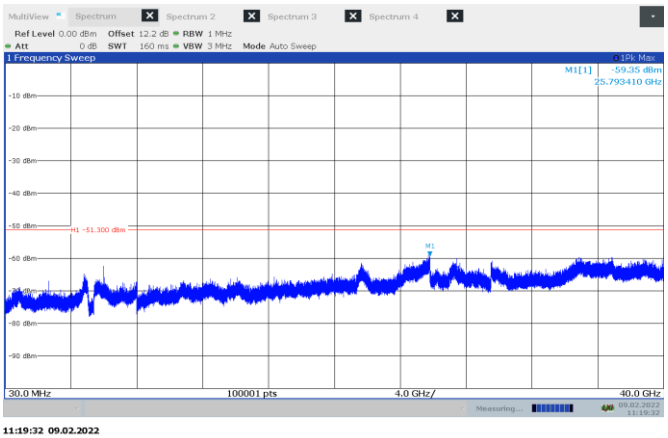


Figure 8.7-53: *Conducted spurious emissions up to 40 GHz, 45 MHz low channel at ch0*

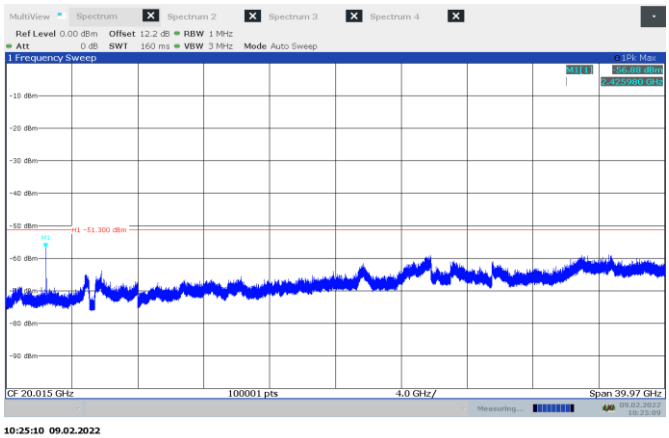


Figure 8.7-54: *Conducted spurious emissions up to 40 GHz, 45 MHz low channel at ch1*

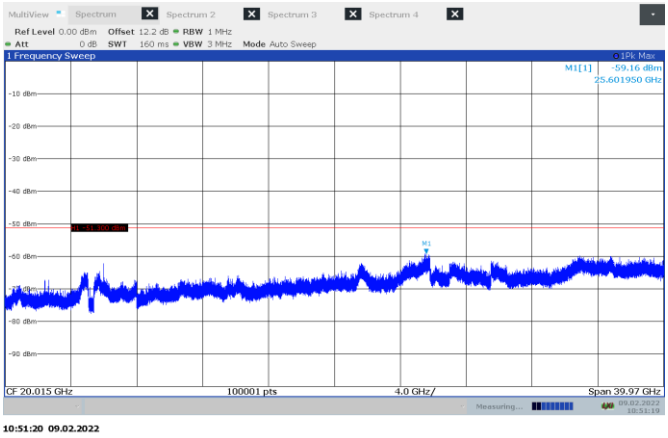


Figure 8.7-55: *Conducted spurious emissions up to 40 GHz, 45 MHz 2nd low channel at ch0*

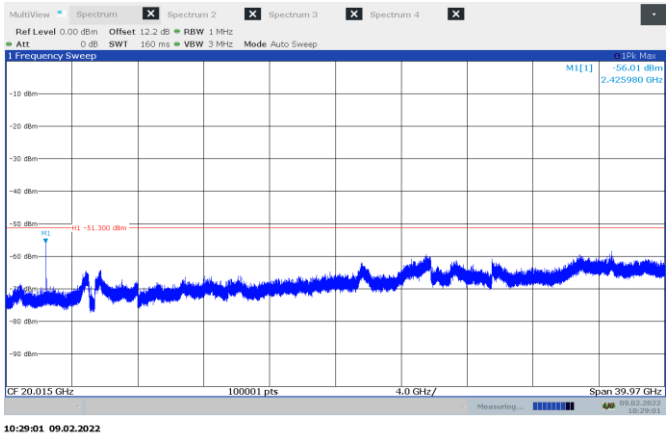


Figure 8.7-56: *Conducted spurious emissions up to 40 GHz, 45 MHz 2nd low channel at ch1*

Test data, continued

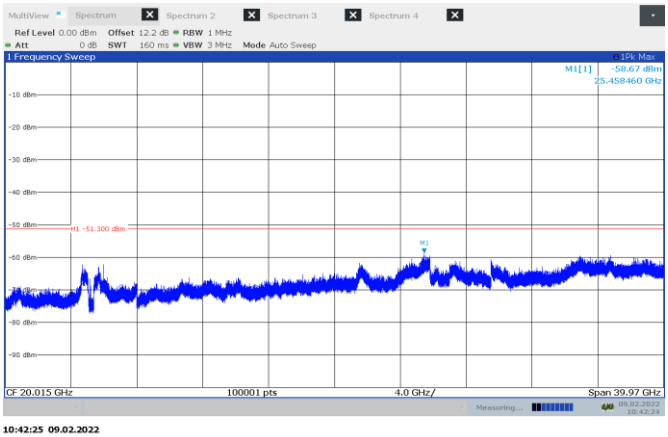


Figure 8.7-57: *Conducted spurious emissions up to 40 GHz, 45 MHz mid channel at ch0*

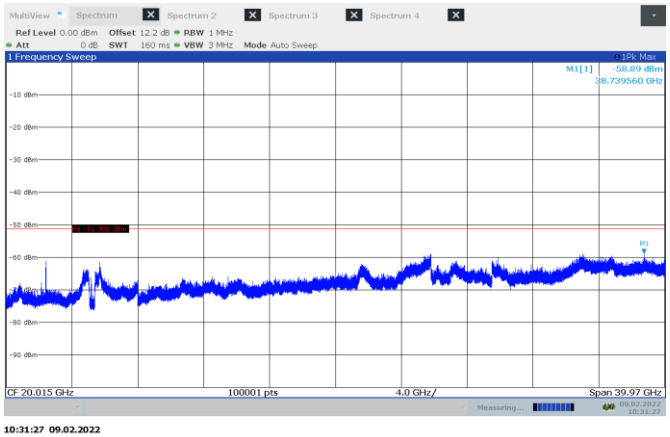


Figure 8.7-58: *Conducted spurious emissions up to 40 GHz, 45 MHz mid channel at ch1*

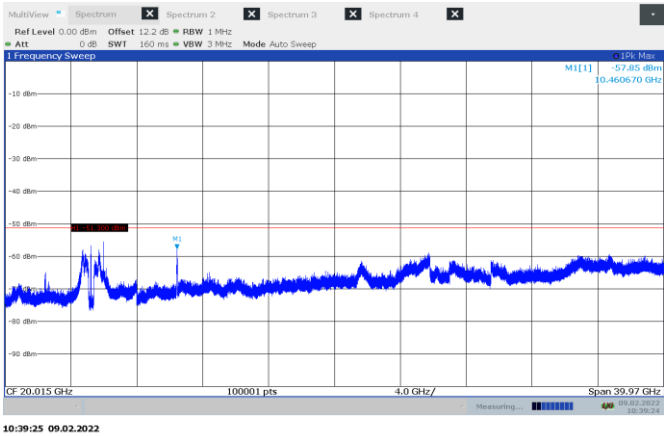


Figure 8.7-59: *Conducted spurious emissions up to 40 GHz, 45 MHz high channel at ch0*

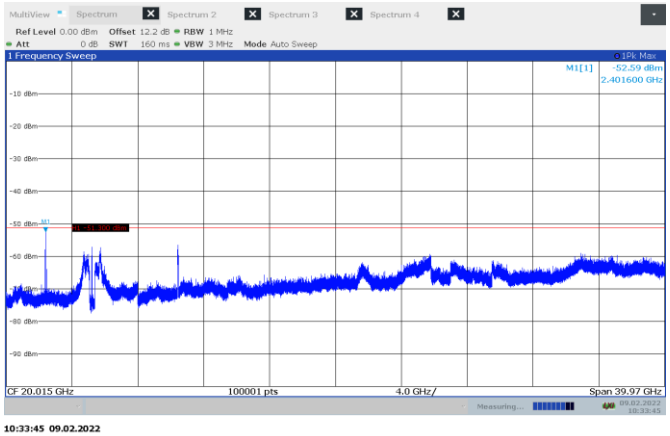


Figure 8.7-60: *Conducted spurious emissions up to 40 GHz, 45 MHz high channel at ch1*

Test data, continued

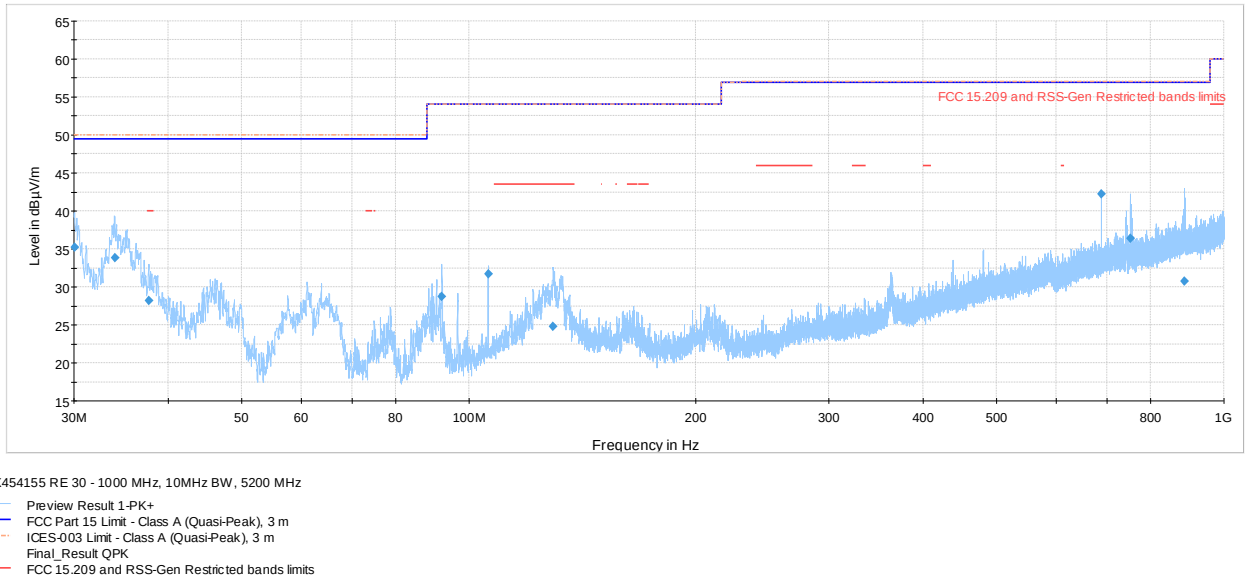


Figure 8.7-61: *Radiated cabinet spurious emissions 30 – 1000 MHz*

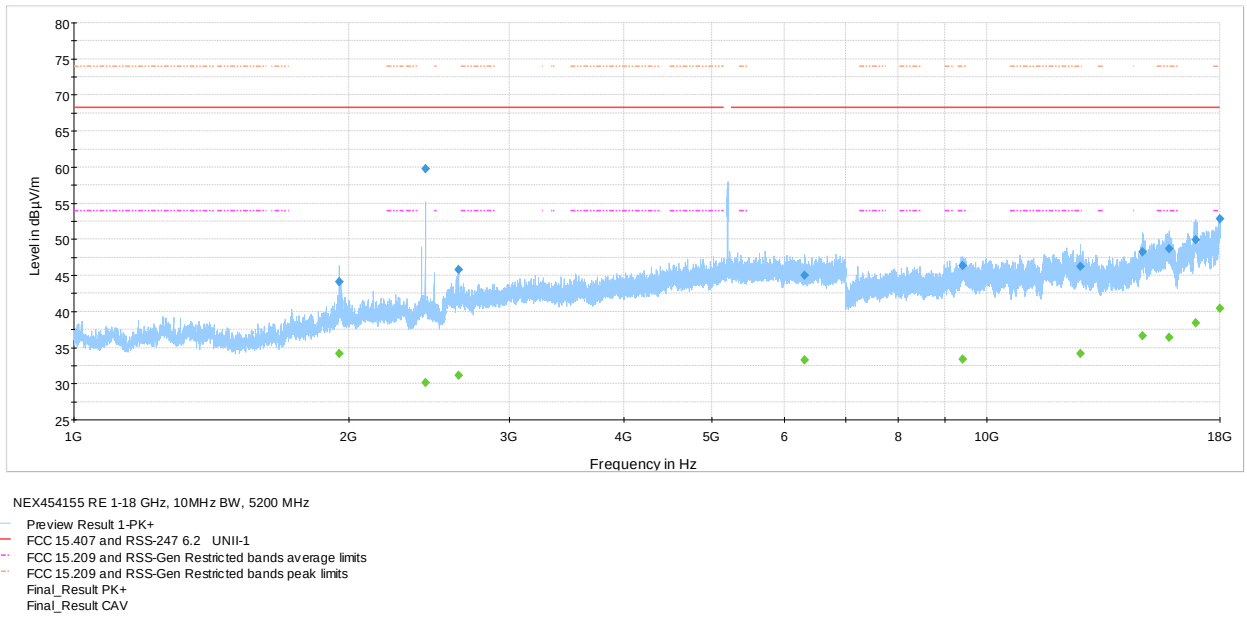


Figure 8.7-62: *Radiated cabinet spurious emissions 1 – 18 GHz*

Test data, continued

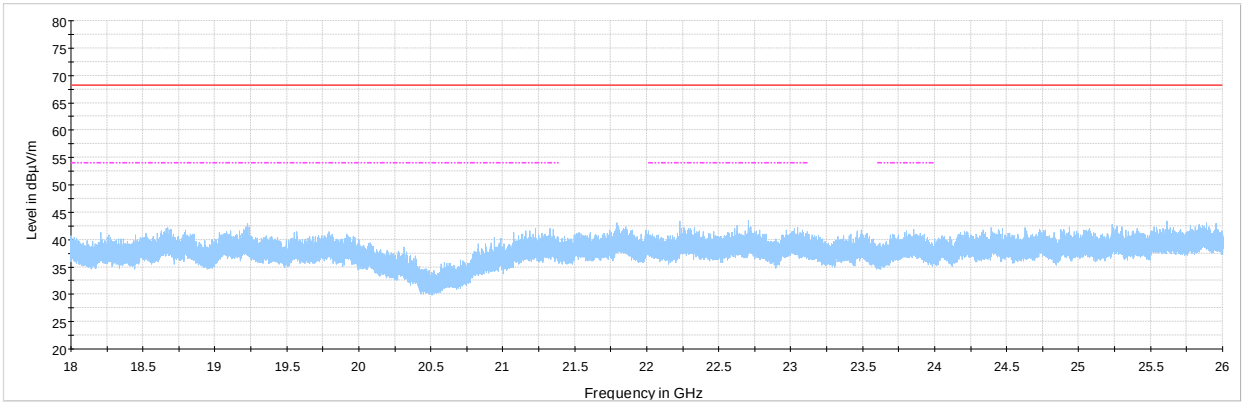


Figure 8.7-63: *Radiated cabinet spurious emissions 18 – 26 GHz*

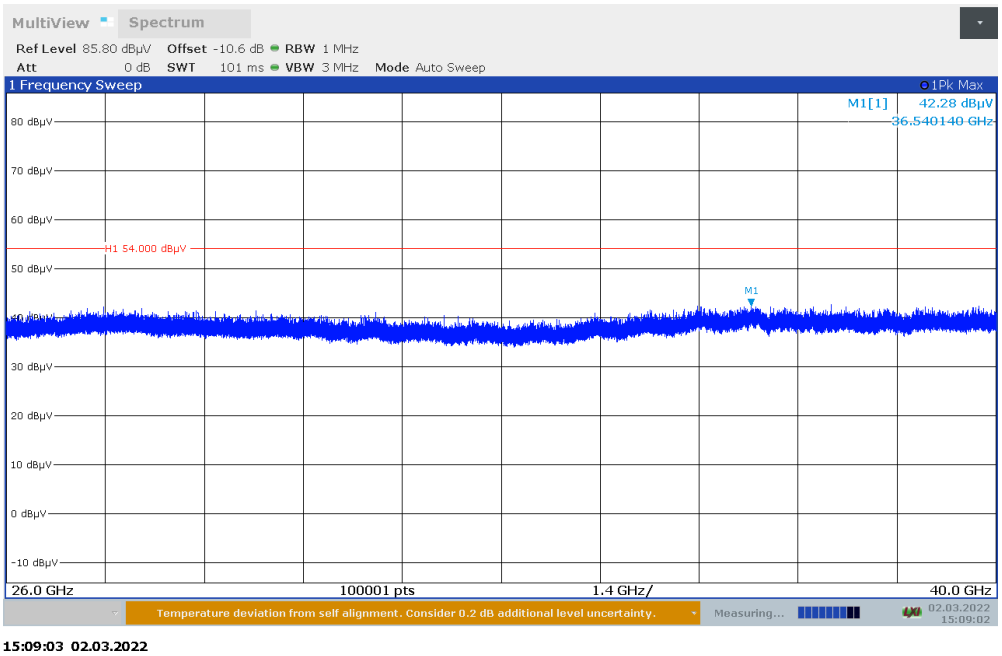


Figure 8.7-64: *Radiated cabinet spurious emissions 26 – 40 GHz*

8.8 AC power line conducted emissions limits

8.8.1 Definitions and limits

FCC §15.407(6)(b):

Any U-NII devices using an AC power line are required to comply also with the conducted limits set forth in §15.207

FCC §15.207(a):
Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator 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). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Table 8.8-1: *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: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.8.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	March 1, 2022

8.8.3 Observations, settings and special notes

The EUT was set up as tabletop configuration.

The spectral scan has been corrected with transducer factors (i.e. cable loss, LISN factors, and attenuators) for determination of compliance.

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.

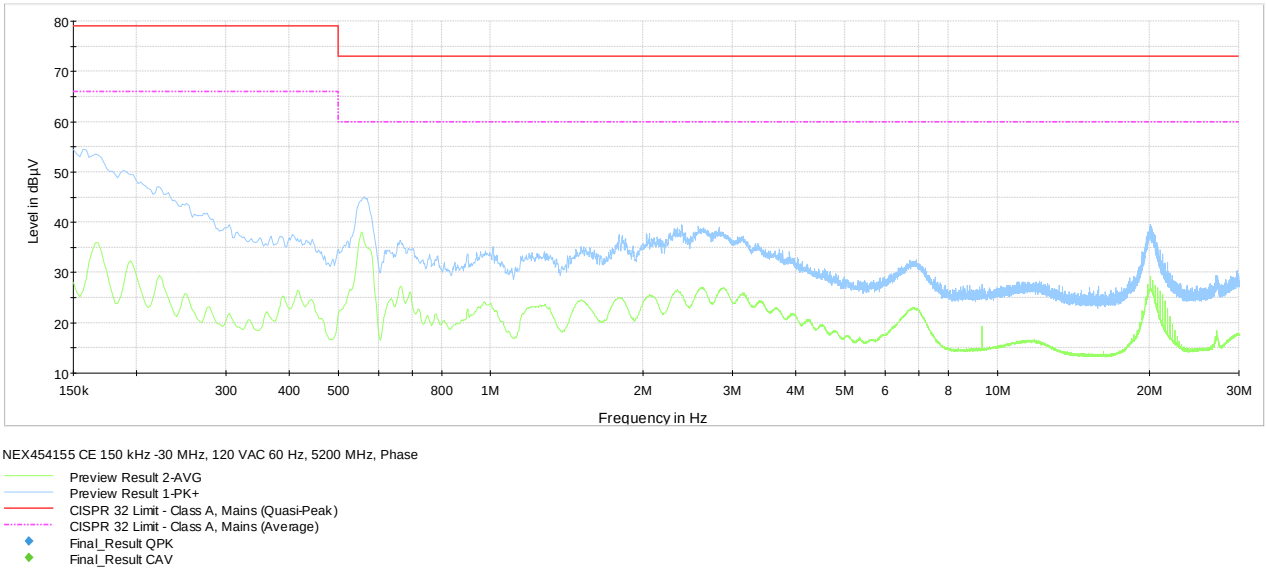
Receiver settings for preview measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average
Trace mode	Max Hold
Measurement time	100 ms

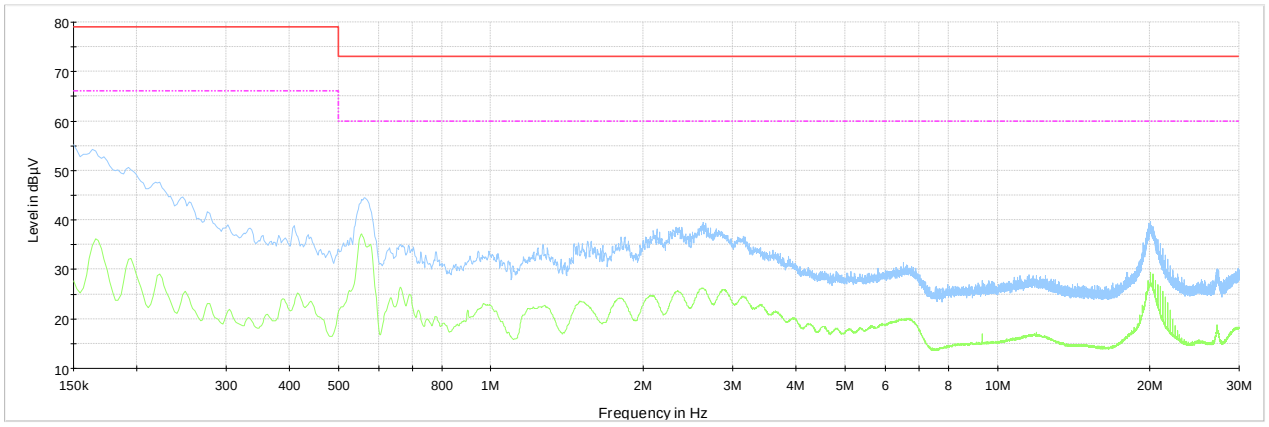
Receiver settings for final measurements:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Quasi-Peak and Average
Trace mode	Max Hold
Measurement time	100 ms

8.8.4 Test data



Plot 8.8-1: *Conducted emissions on phase line*



Plot 8.8-2: *Conducted emissions on neutral line*

8.9 Frequency stability

8.9.1 Definitions and limits

Manufacturers of U-NII devices are responsible for ensuring frequency stability such that an emission is maintained within the band of operation under all conditions of normal operation as specified in the user's manual.

8.9.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	February 28, 2022

8.9.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold

8.9.4 Test data

Table 8.9-1: *Frequency drift measurement*

Test conditions	Frequency, GHz	Drift, Hz
+70 °C, Nominal	5.199994688	449
+60 °C, Nominal	5.199996544	-1407
+50 °C, Nominal	5.199997994	-2857
+40 °C, Nominal	5.199990803	4334
+30 °C, Nominal	5.199997633	-2496
+20 °C, +15 %	5.199998162	-3025
+20 °C, Nominal	5.199995137	***Reference***
+20 °C, −15 %	5.199990016	5121
+10 °C, Nominal	5.199997862	-2725
0 °C, Nominal	5.200000263	-5126
−10 °C, Nominal	5.199996265	-1128
−20 °C, Nominal	5.199994960	177
−30 °C, Nominal	5.199999124	-3987
−40 °C, Nominal	5.200001683	-6546

8.9.4 Test data, continued

Table 8.9-2: *Lower band edge drift calculation*

Bandwidth, MHz	−26 dBc lower cross point, GHz	Max negative drift, Hz	Drifted lower cross point, GHz	Band edge, GHz	Margin, MHz
0.875	5.1505824	-6546	5.150575854	**5.15**	0.576
5	5.1526520	-6546	5.152645454	**5.15**	2.645
10	5.1552450	-6546	5.155238454	**5.15**	5.238
20	5.1606490	-6546	5.160642454	**5.15**	10.642
40	5.1508390	-6546	5.150832454	**5.15**	0.832
45	5.1514240	-6546	5.151417454	**5.15**	1.417

Notes: Drifted lower cross point = −26 dBc lower cross point – max negative drift.

Table 8.9-3: *Upper band edge drift calculation*

Bandwidth, MHz	99% OBW upper cross point, GHz	Max positive drift, Hz	Drifted upper cross point, GHz	Band edge, GHz	Margin, MHz
0.875	5.249663800	5121	5.249668921	**5.25**	0.331
5	5.249562300	5121	5.249567421	**5.25**	0.433
10	5.249128500	5121	5.249133621	**5.25**	0.866
20	5.248288900	5121	5.248294021	**5.25**	1.706
40	5.246628000	5121	5.246633121	**5.25**	3.367
45	5.248166900	5121	5.248172021	**5.25**	1.828

Notes: Drifted upper cross point = 99% OBW upper cross point + max positive drift.

End of the test report