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RADIO TEST REPORT – 454155-1R1TRFWL

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

Specifications:

- FCC 47 CFR Part 90, Subpart Y
- RSS-111 Issue 5, September 2014

Date of issue: March 31, 2022

Mark Libbrecht, EMC/RF Specialist
Tested by

Signature

Andrey Adelberg, Senior EMC/RF Specialist
Reviewed by

Signature

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.

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Table of Contents

Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 90, Subpart Y	Regulations governing licensing and use of frequencies in the 4940–4990 MHz band
RSS-111 Issue 5, September 4, 2014	Broadband Public Safety Equipment Operating in the Band 4940–4990 MHz

1.2 Test methods

ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
RSS-102, Issue 5, March 19, 2015	Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
SP-4940, June 2006	Spectrum Utilization Policy, Technical and Licensing Requirements for Broadband Public Safety in the Band 4940–4990 MHz
FCC 47 CFR Part 2, Subpart J	Equipment authorization procedures
RSS-Gen Issue 5, March 2019	General Requirements for Compliance of Radio Apparatus

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
R1TRF	March 31, 2022	Edited section 5.5.1 radio exercise details

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 for Radio*

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-multipoint (PMP), and point-to-point (PTP) carrier grade broadband wireless infrastructure product, designed to operate in the 4940-4990 MHz band.

5.4 Technical information

Frequency band	4940–4990 MHz
Channel sizes*	0.875 MHz, 5 MHz, 10 MHz and 20 MHz
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

Note: None

Channel sizes:	0.875 MHz	5 MHz	10 MHz	20 MHz
Frequency Min (MHz)	4940.5	4942.5	4945.0	4950.0
Power setting	16	22	22	22
Frequency Max (MHz)	4989.5	4987.5	4985.0	4980.0
RF power Max (W), Conducted	0.098 (19.91 dBm)	0.362 (25.59 dBm)	0.356 (25.51 dBm)	0.369 (25.67 dBm)
Measured BW (MHz), 99% OBW	0.726	4.090	8.030	16.670
Emission classification	726KW7D	4M09W7D	8M03W7D	16M7W7D
Transmitter spurious, dBm	-37.38	-33.02	-37.63	-38.07

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 table are assigned accordingly to attain power level tables show in section 8.2

5.5.2 EUT setup configuration

Table 5.5-1: *Support equipment*

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

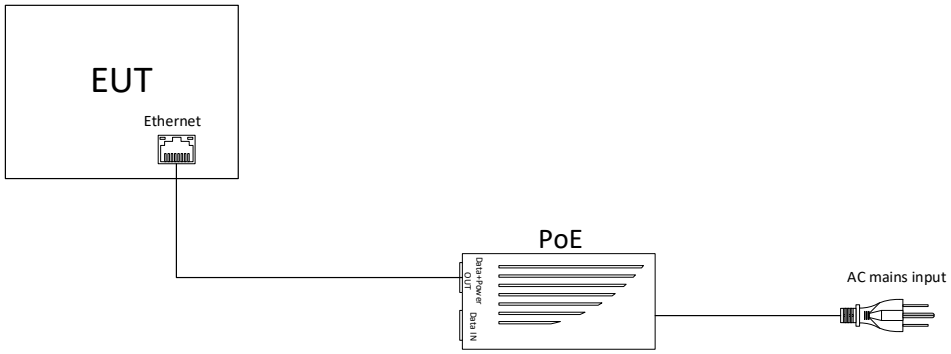


Figure 5.5-1: *Setup block diagram*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Cambridge

6.2 Testing period

Test start date	January 10, 2022	Test end date	March 2, 2022

6.3 Sample information

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

6.4 FCC Part 2 and 90 Subpart Y test requirements results

Table 6.4-1: *FCC requirements results*

Paragraph	Test description	Verdict
§90.1215(d)	Occupied bandwidth	Pass
§90.1215(a)	Peak output power	Pass
§90.1215(b)	Peak power spectral density	Pass
§90.210(m)	Spurious emissions at the antenna terminals	Pass
§90.210(m)(6)	Radiated spurious emissions	Pass
§90.213(a)	Frequency stability	Pass

Note: None

6.5 ISED RSS-111, Issue 5 and RSS-Gen, Issue 5 test requirements results

Table 6.5-1: *ISED requirements results*

Section	Test description	Verdict
RSS-111, 5.1	Types of modulation	Pass[1]
RSS-111, 5.2	Transmitter frequency stability	Pass
RSS-111, 5.3	Equipment's transmit output power and channel bandwidth	Pass
RSS-111, 5.4	Transmitter peak-to-average power ratio	Pass
RSS-111, 5.5	Transmitter unwanted emissions	Pass
RSS-Gen, 6.7	Occupied bandwidth	Pass

Notes: [1]The EUT utilizes OFDM method of encoding digital modulations such as BPSK, QPSK, 16-QAM, 64-QAM, 128-QAM, and 256-QAM

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 26,2023
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

Notes: NCR - no calibration required

Section 8 Testing data

8.1 Number of frequencies

8.1.1 References, definitions and limits

ANSI C63.26, Clause 5.1.2:

Measurements of transmitters shall be performed and, if required, reported for each frequency band in which the EUT can be operated with the device transmitting at the number of frequencies in each band specified in table below.

RSS-Gen, Clause 6.9:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.1-1: *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.

8.1.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 10, 2022

8.1.3 Observations, settings and special notes

None

8.1.4 Test data

Table 8.1-2: *Test channels selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Channel size, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
4940	4990	50	0.875	4940.5	4965.0	4989.5
			5.000	4942.5	4965.0	4987.5
			10.000	4945.0	4965.0	4985.0
			20.000	4950.0	4965.0	4980.0

8.2 Transmitter Output Power

8.2.1 References, definitions and limits

FCC §90.1215:

The transmitting power of stations operating in the 4940–4990 MHz band must not exceed the maximum limits in this section.

(a)(1) The maximum conducted output power should not exceed limits in the table below

(2) High power devices are also limited to a peak power spectral density of 21 dBm per one MHz. High power devices using channel bandwidths other than those listed above are permitted; however, they are limited to peak power spectral density of 21 dBm/MHz. If transmitting antennas of directional gain greater than 9 dBi are used, both the maximum conducted output power and the peak power spectral density should be reduced by the amount in decibels that the directional gain of the antenna exceeds 9 dBi. However, high power point-to-point and point-to-multipoint operations (both fixed and temporary-fixed rapid deployment) may employ transmitting antennas with directional gain up to 26 dBi without any corresponding reduction in the maximum conducted output power or spectral density. Corresponding reduction in the maximum conducted output power and peak power spectral density should be the amount in decibels that the directional gain of the antenna exceeds 26 dBi.

(b) Low power devices are also limited to a peak power spectral density of 8 dBm per one MHz. Low power devices using channel bandwidths other than those listed above are permitted; however, they are limited to a peak power spectral density of 8 dBm/MHz. If transmitting antennas of directional gain greater than 9 dBi are used, both the maximum conducted output power and the peak power spectral density should be reduced by the amount in decibels that the directional gain of the antenna exceeds 9 dBi.

RSS-111, Clause 5.3:

Equipment is classified as either a low-power or high-power device according to its maximum transmitted power and its channel bandwidth as described in the section below. The equipment's occupied bandwidth shall not exceed its channel bandwidth. The transmitted power of low-power and high-power devices shall not exceed the maximum limits corresponding to the equipment type given in table below

Table 8.2-1: *Channel bandwidth and power limits*

Channel bandwidth, MHz	Output power (P) for low-power device, dBm	Output power (P) for high-power device, dBm
1	P ≤ 7	7 < P ≤ 20
5	P ≤ 14	14 < P ≤ 27
10	P ≤ 17	17 < P ≤ 30
15	P ≤ 18.8	18.8 < P ≤ 31.8
20	P ≤ 20	20 < P ≤ 33

High- and low-power devices are also limited to a maximum power spectral density of 21 dBm/MHz and 8 dBm/MHz respectively. Devices using channel bandwidths other than those listed in Table 1 are permitted; however, the channel bandwidth shall not exceed 20 MHz and the devices shall comply with the maximum power spectral density limits of 21 dBm/MHz for high-power transmitters and 8 dBm/MHz for low-power transmitters. See SP 4940 MHz for antenna gain limits and operational restrictions for the device.

For low-power devices, if a directional antenna is used and its gain exceeds 9 dBi, the transmit power shall be reduced by the same amount that the antenna gain is exceeded.

For high-power fixed point-to-point and point-to-multipoint operations, if the directional antenna gain exceeds 26 dBi, the transmit power shall be reduced by same amount that the antenna gain is exceeded.

SP-4940, Clause 7:

7.1 Radiated Power Limits

The following section specifies the technical requirements for the authorization of public safety systems operating in the band 4940–4990 MHz.

7.1.1 Mobile and Fixed Operations

The transmitting power of stations operating in the band 4940–4990 MHz must not exceed the maximum limits specified below. However all systems should be limited to the power necessary to provide adequate coverage.

References, definitions and limits, continued

7.1.2 Limits for Operation of High-power Devices

Table 8.2-2: *Channel bandwidth and power limits for High-power Devices*

Channel bandwidth, MHz	High power maximum conducted output power, dBm
1	20
5	27
10	30
15	31.8
20	33

Devices may use other channel bandwidths, however high-power devices are limited to a peak power spectral density of 21 dBm per 1 MHz. If a directional gain greater than 9 dBi is used, both the peak transmit power and the peak power spectral density should be reduced by the equivalent amount.

For high-power fixed point-to-point and point-to-multipoint operation, a directional gain up to 26 dBi may be used, however if it exceeds 26 dBi, both the peak transmit power and the peak power spectral density should be reduced by the equivalent amount.

7.1.3 Limits for Operation of Low-power Devices

Table 8.2-3: *Channel bandwidth and power limits for Low-power Devices*

Channel bandwidth, MHz	Low power maximum conducted output power, dBm
1	7
5	14
10	17
15	18.8
20	20

Devices may use other channel bandwidths, however low-power devices are limited to a peak power spectral density of 8 dBm per 1 MHz. If a directional gain greater than 9 dBi is used, both the peak transmit power and the peak power spectral density should be reduced by the equivalent amount.

8.2.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 10, 2022

8.2.3 Observations, settings and special notes

EUT is a high-power device, therefore higher limits apply.
This test was performed as per ANSI C63.26, subclause 5.2.4
Measurement of output power and PSD was performed with the following spectrum analyser settings:

Resolution bandwidth	1 MHz
Video bandwidth	≥ 3 × RBW
Frequency span	≥ 2 × OBW
Detector mode	RMS
Trace mode	Averaging over ≥ 100 sweeps
Power integration	Over the channel BW

8.2.4 Test data

Table 8.2-4: *Transmitter power results for 0.875 MHz with 25 dBi antenna*

Frequency, MHz	Power on ch0, dBm	Power on ch1, dBm	Combined power, dBm	Power limit, dBm	Margin, dB
4940.5	16.46	17.14	19.82	20.00	0.18
4965.0	16.46	17.29	19.91	20.00	0.09
4989.5	16.39	17.13	19.79	20.00	0.21

Table 8.2-5: *Transmitter power results for 5 MHz channel with 25 dBi antenna*

Frequency, MHz	Power on ch0, dBm	Power on ch1, dBm	Combined power, dBm	Power limit, dBm	Margin, dB
4942.5	22.29	22.86	25.59	27.00	1.41
4965.0	22.09	22.75	25.44	27.00	1.56
4987.5	22.21	22.74	25.49	27.00	1.51

Table 8.2-6: *Transmitter power results for 10 MHz channel with 25 dBi antenna*

Frequency, MHz	Power on ch0, dBm	Power on ch1, dBm	Combined power, dBm	Power limit, dBm	Margin, dB
4945.0	22.17	22.81	25.51	30.00	4.49
4965.0	22.20	22.68	25.46	30.00	4.54
4985.0	22.10	22.66	25.40	30.00	4.60

Table 8.2-7: *Transmitter power results for 20 MHz channel with 25 dBi antenna*

Frequency, MHz	Power on ch0, dBm	Power on ch1, dBm	Combined power, dBm	Power limit, dBm	Margin, dB
4950.0	22.32	22.98	25.67	33.00	7.33
4965.0	22.14	22.87	25.53	33.00	7.47
4980.0	22.29	22.86	25.59	33.00	7.41

Test data, continued

Table 8.2-8: *Transmitter power spectral density results for 0.875 MHz channel with 25 dBi antenna*

Frequency, MHz	PSD on ch0, dBm/MHz	PSD on ch1, dBm/MHz	Combined PSD, dBm/MHz	PSD limit, dBm/MHz	Margin, dB
4940.5	16.18	16.72	19.47	21.00	1.53
4965.0	16.07	16.91	19.52	21.00	1.48
4989.5	16.06	16.70	19.40	21.00	1.60

Table 8.2-9: *Transmitter power spectral density results for 5 MHz channel with 25 dBi antenna*

Frequency, MHz	PSD on ch0, dBm/MHz	PSD on ch1, dBm/MHz	Combined PSD, dBm/MHz	PSD limit, dBm/MHz	Margin, dB
4942.5	16.49	17.03	19.78	21.00	1.22
4965.0	16.35	17.03	19.71	21.00	1.29
4987.5	16.45	16.89	19.69	21.00	1.31

Table 8.2-10: *Transmitter power spectral density results for 10 MHz channel with 25 dBi antenna*

Frequency, MHz	PSD on ch0, dBm/MHz	PSD on ch1, dBm/MHz	Combined PSD, dBm/MHz	PSD limit, dBm/MHz	Margin, dB
4945.0	13.43	14.03	16.75	21.00	4.25
4965.0	13.58	13.99	16.80	21.00	4.20
4985.0	13.37	13.92	16.66	21.00	4.34

Table 8.2-11: *Transmitter power spectral density results for 20 MHz channel with 25 dBi antenna*

Frequency, MHz	PSD on ch0, dBm/MHz	PSD on ch1, dBm/MHz	Combined PSD, dBm/MHz	PSD limit, dBm/MHz	Margin, dB
4950.0	10.89	10.95	13.93	21.00	7.07
4965.0	10.79	11.16	13.99	21.00	7.01
4980.0	10.63	11.21	13.94	21.00	7.06

Test data, continued

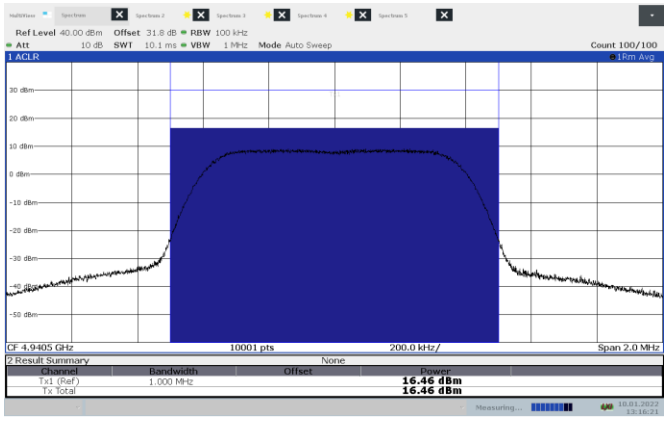


Figure 8.2-1: *Output power 0.875 MHz channel, sample plot*

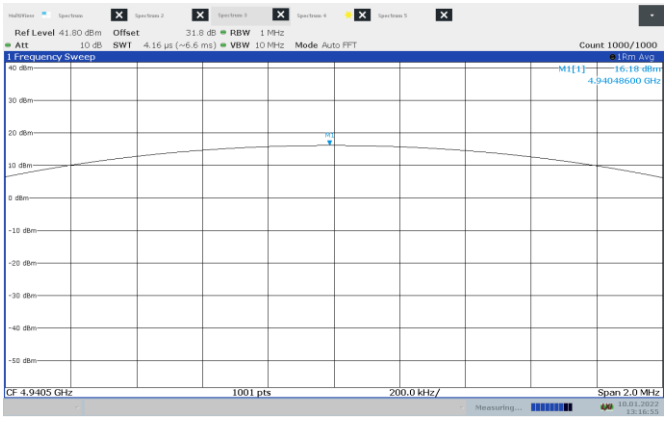


Figure 8.2-2: *PSD on 0.875 MHz channel, sample plot*

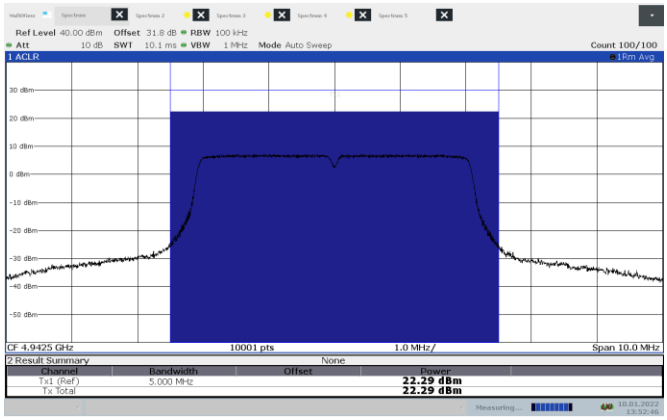


Figure 8.2-3: *Output power 5 MHz channel, sample plot*

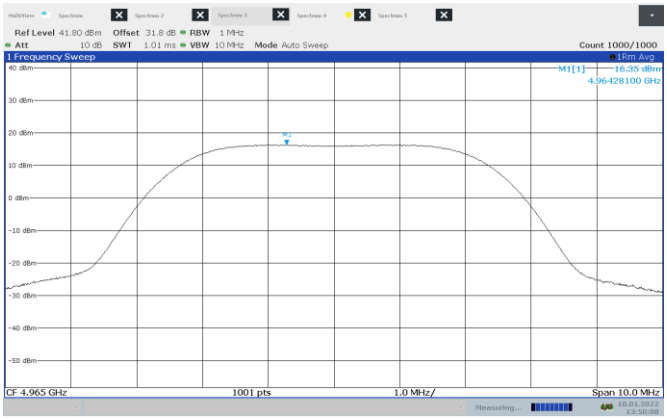


Figure 8.2-4: *PSD on 5 MHz channel, sample plot*

Test data, continued

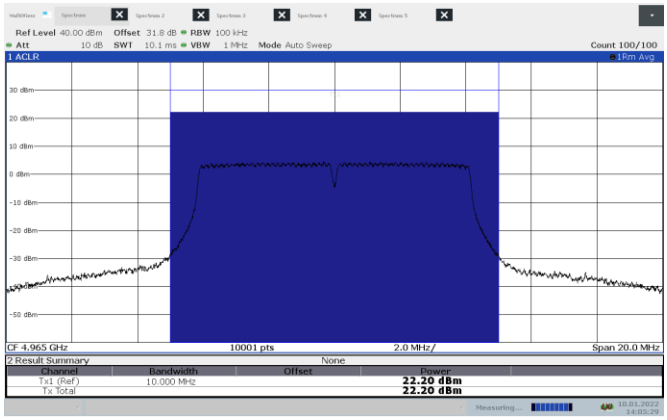


Figure 8.2-5: *Output power 10 MHz channel, sample plot*

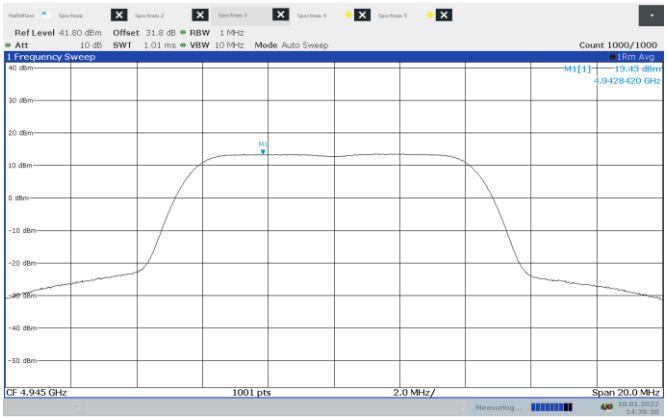


Figure 8.2-6: *PSD on 10 MHz channel, sample plot*

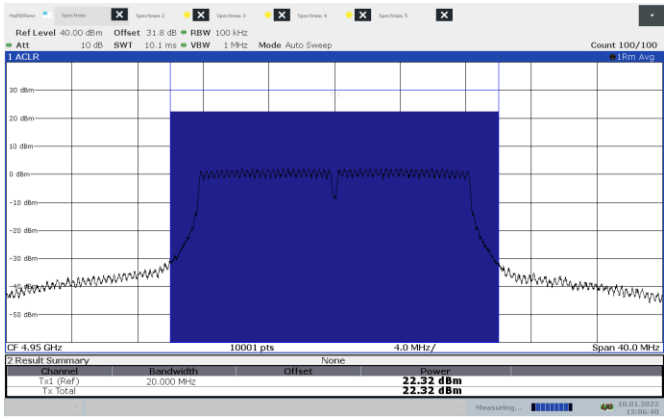


Figure 8.2-7: *Output power 20 MHz channel, sample plot*

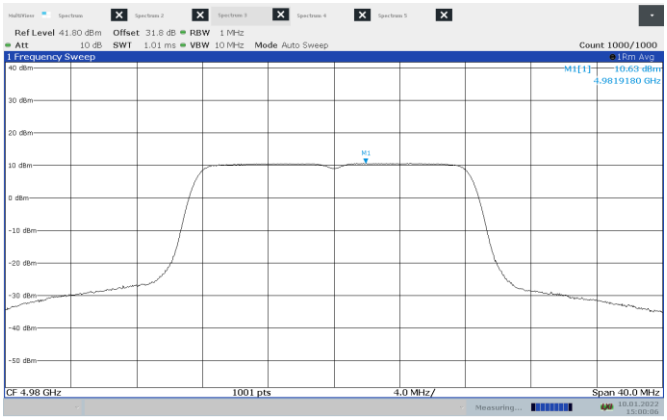


Figure 8.2-8: *PSD on 20 MHz channel, sample plot*

8.3 Transmitter Peak to Average Power Ratio (PAPR)

8.3.1 References, definitions and limits

FCC §90.1215:

The transmitting power of stations operating in the 4940–4990 MHz band must not exceed the maximum limits in this section.

(e) The ratio of the peak excursion of the modulation envelope (measured using a peak hold function) to the maximum conducted output power shall not exceed 13 dB across any 1 MHz bandwidth or the emission bandwidth whichever is less.

RSS-111, Clause 5.4:

The PAPR of the equipment shall not exceed 13 dB for more than 0.1% of the time, using a signal that corresponds to the highest PAPR during periods of continuous transmission.

8.3.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 10, 2022

8.3.3 Observations, settings and special notes

This test was performed as per ANSI C63.26, subclause 5.2.6
Measurement of CCDF was performed with the following spectrum analyser settings:

Analysis bandwidth	> 26 dB BW, or greatest setting
Number of samples	Enough to stabilize trace

8.3.4 Test data

Table 8.3-1: *PAPR measurements results for 0.875 MHz channel*

Frequency, MHz	Antenna port	Ratio, dB	Limit, dB	Margin, dB
4940.5	Ch0	8.42	13.00	4.58
4965.0	Ch0	8.42	13.00	4.58
4989.5	Ch0	8.44	13.00	4.56
4940.5	Ch1	8.40	13.00	4.60
4965.0	Ch1	8.42	13.00	4.58
4989.5	Ch1	8.46	13.00	4.54

Table 8.3-2: *PAPR measurements results for 5 MHz channel*

Frequency, MHz	Antenna port	Ratio, dB	Limit, dB	Margin, dB
4942.5	Ch0	8.14	13.00	4.86
4965.0	Ch0	8.22	13.00	4.78
4987.5	Ch0	8.18	13.00	4.82
4942.5	Ch1	7.68	13.00	5.32
4965.0	Ch1	7.82	13.00	5.18
4987.5	Ch1	7.88	13.00	5.12

Table 8.3-3: *PAPR measurements results for 10 MHz channel*

Frequency, MHz	Antenna port	Ratio, dB	Limit, dB	Margin, dB
4945.0	Ch0	8.16	13.00	4.84
4965.0	Ch0	8.18	13.00	4.82
4985.0	Ch0	8.22	13.00	4.78
4945.0	Ch1	7.70	13.00	5.30
4965.0	Ch1	7.86	13.00	5.14
4985.0	Ch1	7.92	13.00	5.08

Table 8.3-4: *PAPR measurements results for 20 MHz channel*

Frequency, MHz	Antenna port	Ratio, dB	Limit, dB	Margin, dB
4950.0	Ch0	8.38	13.00	4.62
4965.0	Ch0	8.44	13.00	4.56
4980.0	Ch0	8.46	13.00	4.54
4950.0	Ch1	8.26	13.00	4.74
4965.0	Ch1	8.30	13.00	4.70
4980.0	Ch1	8.32	13.00	4.68

Test data, continued

Figure 8.3-1: *PAPR on 0.875 MHz channel, sample plot*

Figure 8.3-2: *PAPR on 5 MHz channel, sample plot*

Figure 8.3-3: *PAPR on 10 MHz channel, sample plot*

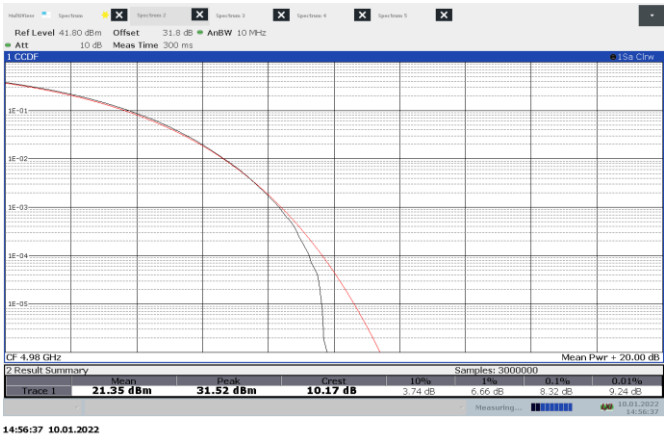


Figure 8.3-4: *PAPR on 20 MHz channel, sample plot*

8.4 Occupied bandwidth

8.4.1 References, definitions and limits

FCC §90.1215:

(d) The peak power spectral density is measured as 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 are made over a bandwidth of one MHz or the 26 dB emission bandwidth of the device, whichever is less. A resolution bandwidth less than the measurement bandwidth can be used, provided that the measured power is integrated to show total power over the measurement bandwidth. If the resolution bandwidth is approximately equal to the measurement bandwidth, and much less than the emission bandwidth of the equipment under test, the measured results shall be corrected to account for any difference between the resolution bandwidth of the test instrument and its actual noise bandwidth.

RSS-Gen, Clause 6.7:

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

8.4.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 10, 2022

8.4.3 Observations, settings and special notes

The Occupied Bandwidth test was performed as per ANSI C63.26, subclause 5.4.4.
Spectrum analyser settings:

Resolution bandwidth	1 – 5% OBW
Video bandwidth	≥3 × RBW
Frequency span	~1.5 × OBW
Detector mode	Peak
Trace mode	Max Hold

The 26 dB Bandwidth test was performed as per ANSI C63.26, subclause 5.4.3
Spectrum analyser settings:

Resolution bandwidth	1 -5 % OBW
Video bandwidth	≥3 × RBW
Frequency span	~1.5 × OBW
Detector mode	Peak
Trace mode	Max Hold

8.4.4 Test data

Table 8.4-1: *Occupied bandwidth results for 0.875 MHz channel*

Antenna port	Frequency, MHz	99% occupied bandwidth, kHz	26 dB bandwidth, kHz
Ch0	4940.5	722.58	825.20
Ch0	4965.0	723.81	819.20
Ch0	4989.5	723.34	819.20
Ch1	4940.5	723.57	825.20
Ch1	4965.0	723.86	831.20
Ch1	4989.5	726.26	835.20

Table 8.4-2: *Occupied bandwidth results for 5 MHz channel*

Antenna port	Frequency, MHz	99% occupied bandwidth, MHz	26 dB bandwidth, MHz
Ch0	4942.5	4.09	4.70
Ch0	4965.0	4.09	4.70
Ch0	4987.5	4.09	4.67
Ch1	4942.5	4.09	4.70
Ch1	4965.0	4.09	4.71
Ch1	4987.5	4.09	4.71

Table 8.4-3: *Occupied bandwidth results for 10 MHz channel*

Antenna port	Frequency, MHz	99% occupied bandwidth, MHz	26 dB bandwidth, MHz
Ch0	4945.0	8.26	9.39
Ch0	4965.0	8.24	9.37
Ch0	4985.0	8.25	9.39
Ch1	4945.0	8.30	9.39
Ch1	4965.0	8.27	9.43
Ch1	4985.0	8.23	9.41

Table 8.4-4: *Occupied bandwidth results for 20 MHz channel*

Antenna port	Frequency, MHz	99% occupied bandwidth, MHz	26 dB bandwidth, MHz
Ch0	4950.0	16.62	18.54
Ch0	4965.0	16.62	18.54
Ch0	4980.0	16.63	18.54
Ch1	4950.0	16.67	18.70
Ch1	4965.0	16.65	18.62
Ch1	4980.0	16.65	18.62

Test data, continued

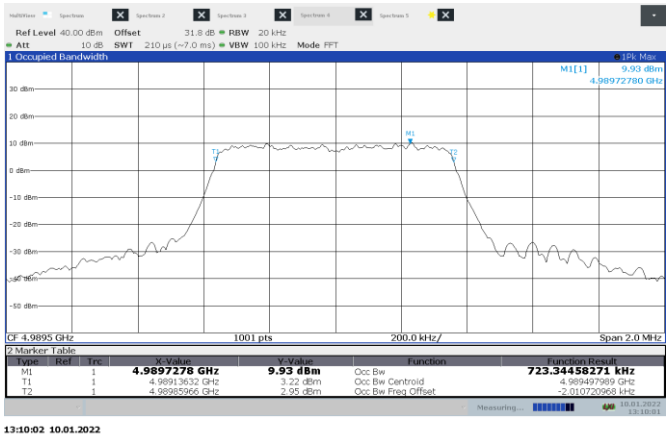


Figure 8.4-1: *99% occupied bandwidth on 0.875 MHz channel, sample plot*

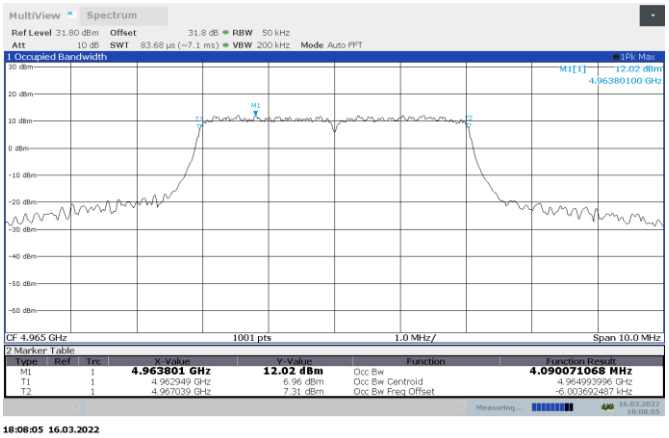


Figure 8.4-2: *99% occupied bandwidth on 5 MHz channel, sample plot*

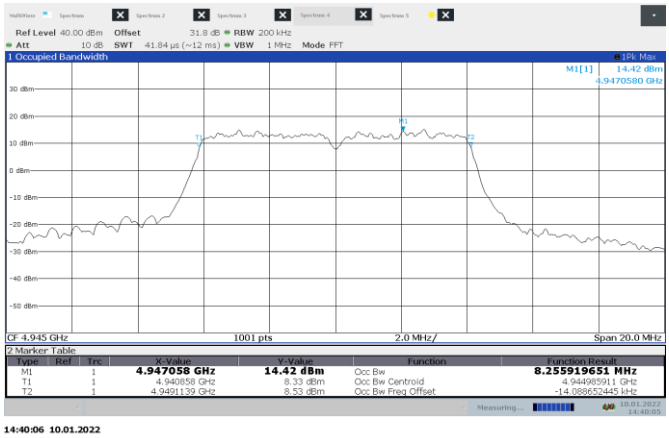


Figure 8.4-3: *99% occupied bandwidth on 10 MHz channel, sample plot*

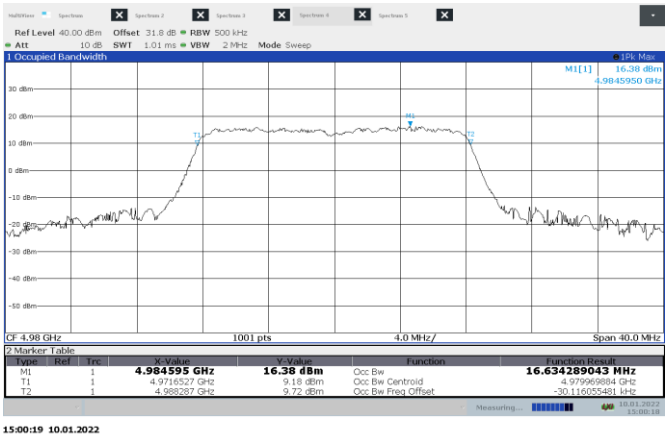


Figure 8.4-4: *99% occupied bandwidth on 20 MHz channel, sample plot*

Test data, continued

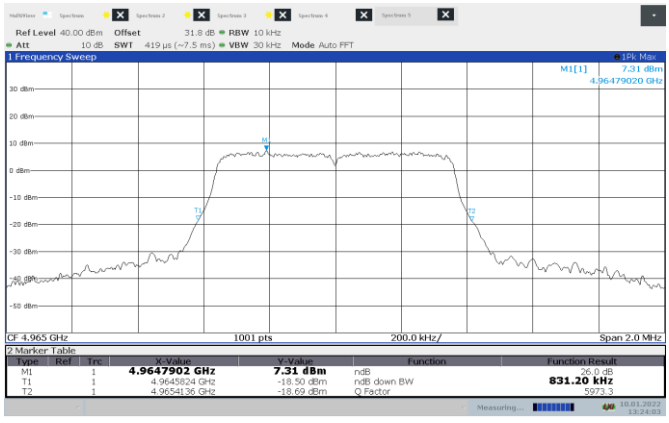


Figure 8.4-5: *26 dB bandwidth on 0.875 MHz channel, sample plot*

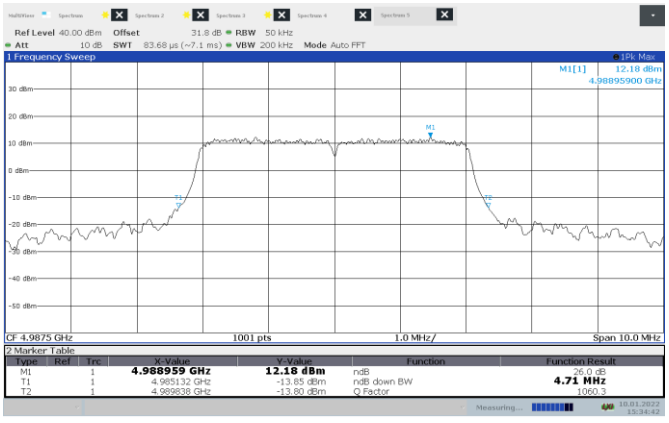


Figure 8.4-6: *26 dB bandwidth on 5 MHz channel, sample plot*

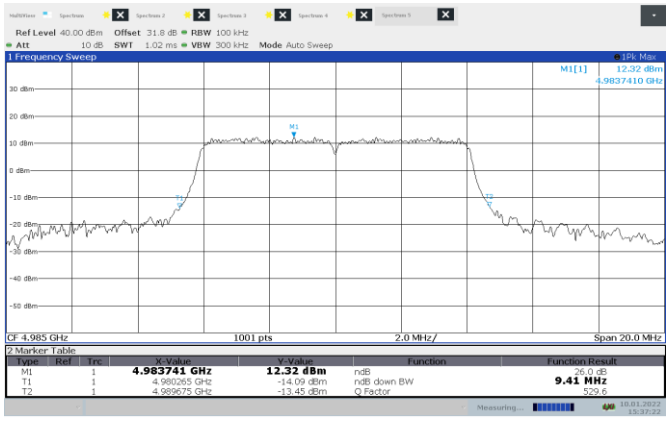


Figure 8.4-7: *26 dB bandwidth on 10 MHz channel, sample plot*

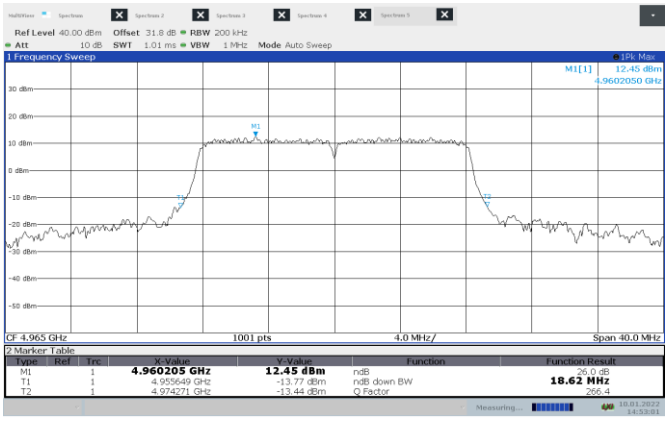


Figure 8.4-8: *26 dB bandwidth on 20 MHz channel, sample plot*

8.5 Spectrum mask and spurious emissions

8.5.1 References, definitions and limits

FCC §90.210:

Except as indicated elsewhere in this part, transmitters used in the radio services governed by this part must comply with the emission masks outlined in this section. Unless otherwise stated, per paragraphs (d)(4), (e)(4), and (o) of this section, measurements of emission power can be expressed in either peak or average values provided that emission powers are expressed with the same parameters used to specify the unmodulated transmitter carrier power. For transmitters that do not produce a full power unmodulated carrier, reference to the unmodulated transmitter carrier power refers to the total power contained in the channel bandwidth. Unless indicated elsewhere in this part, the table in this section specifies the emission masks for equipment operating under this part.

Table 8.5-1: *Applicable Emission Masks*

Frequency band, MHz	Mask for equipment with audio low pass filter	Mask for equipment with audio low pass filter
4940–4990	L or M	L or M

(l) **Emission Mask L.** For low power transmitters (20 dBm or less) operating in the 4940-4990 MHz frequency band, the power spectral density of the emissions must be attenuated below the output power of the transmitter as follows

(1) On any frequency removed from the assigned frequency between 0-45% of the authorized bandwidth (BW): 0 dB.

(2) On any frequency removed from the assigned frequency between 45-50% of the authorized bandwidth: 219 log (% of (BW)/45) dB.

(3) On any frequency removed from the assigned frequency between 50-55% of the authorized bandwidth: 10 + 242 log (% of (BW)/50) dB.

(4) On any frequency removed from the assigned frequency between 55-100% of the authorized bandwidth: 20 + 31 log (% of (BW)/55) dB attenuation.

(5) On any frequency removed from the assigned frequency between 100-150% of the authorized bandwidth: 28 + 68 log (% of (BW)/100) dB attenuation.

(6) On any frequency removed from the assigned frequency above 150% of the authorized bandwidth: 40 dB.

(7) The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz. The power spectral density is the power measured within the resolution bandwidth of the measurement device divided by the resolution bandwidth of the measurement device. Emission levels are also based on the use of measurement instrumentation employing a resolution bandwidth of at least one percent of the occupied bandwidth.

(m) **Emission Mask M.** For high power transmitters (greater that 20 dBm) operating in the 4940–4990 MHz frequency band, the power spectral density of the emissions must be attenuated below the output power of the transmitter as follows:

(1) On any frequency removed from the assigned frequency between 0–45% of the authorized bandwidth (BW): 0 dB.

(2) On any frequency removed from the assigned frequency between 45–50% of the authorized bandwidth: 568 log (% of (BW)/45) dB.

(3) On any frequency removed from the assigned frequency between 50–55% of the authorized bandwidth: 26 + 145 log (% of BW/50) dB.

(4) On any frequency removed from the assigned frequency between 55–100% of the authorized bandwidth: 32 + 31 log (% of (BW)/55) dB.

(5) On any frequency removed from the assigned frequency between 100–150% of the authorized bandwidth: 40 + 57 log (% of (BW)/100) dB.

(6) On any frequency removed from the assigned frequency between above 150% of the authorized bandwidth: 50 dB or 55 + 10 log (P) dB, whichever is the lesser attenuation.

(7) The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz. The power spectral density is the power measured within the resolution bandwidth of the measurement device divided by the resolution bandwidth of the measurement device. Emission levels are also based on the use of measurement instrumentation employing a resolution bandwidth of at least one percent of the occupied bandwidth.

References, definitions and limits, continued

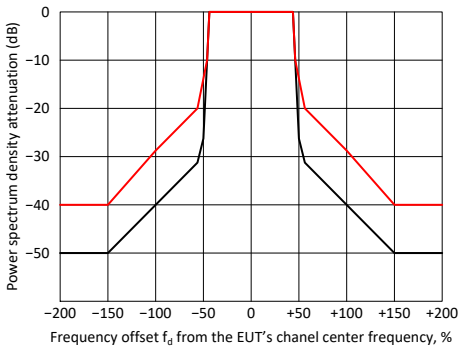
RSS-119, Clause 5.5:

On any frequency f, offset from the channel centre frequency fc by a separation fd (expressed as a percentage of the channel bandwidth), the power spectral density of the unwanted emissions for low- and high-power transmitters shall comply with the limits specified in Table 8.5 2. Figure 8.5–1 shows the emission mask for low- and high-power transmitters. For equipment with multiple transmitters, the unwanted emissions of each transmitter shall comply with the emission limits based on the output power of the transmitter regardless of the total output power of the equipment (i.e. total output power from all the transmitters).

Table 8.5-2: *Emission mask for low- and high-power transmitters*

Offset Frequency f_d (% of the equipment's channel bandwidth)	**Minimum attenuation low-power transmitter, dB**	**Minimum attenuation high-power transmitter, dB**
$0 < f_d \leq 45$	0	0
$45 < f_d \leq 50$	$219 \times \log_{10} (f_d / 45)$	$568 \times \log_{10} (f_d / 45)$
$50 < f_d \leq 55$	$10 + 242 \times \log_{10} (f_d / 50)$	$26 + 145 \times \log_{10} (f_d / 50)$
$55 < f_d \leq 100$	$20 + 31 \times \log_{10} (f_d / 55)$	$32 + 31 \times \log_{10} (f_d / 55)$
$100 < f_d \leq 150$	$28 + 68 \times \log_{10} (f_d / 100)$	$40 + 57 \times \log_{10} (f_d / 100)$
$f_d > 150$	40	whichever is less stringent: 50 dBc or −25 dBm

Notes: * - Where: f_d (%) = ((f − f_c) / channel bandwidth) × 100



Note: Red line is for Low-power transmitter, Black line is for High-power transmitter

Figure 8.5-1: *Unwanted emission mask for low- and high-power transmitters*

8.5.2 Test summary

Verdict	Pass		
Tested by	Mark Libbrecht	Test date	January 12, 2022

8.5.3 Observations, settings and special notes

- Cabinet spurious measurements were performed at a distance of 3 m This test was performed at the antenna ports and radiated with both antennas terminated with 50 Ohm load.
- The radiated spurious emission was tested per ANSI C63.26, subclause 5.5.3.

Spectrum analyzer settings for frequencies below 1000 MHz:

Detector mode	Peak or Quasi-Peak
Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Trace mode	Max Hold

Spectrum analyzer settings for peak measurements at the frequencies above 1000 MHz:

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

Spectrum analyzer settings for average measurements at the frequencies above 1000 MHz:

Detector mode	Peak
Resolution bandwidth	1 MHz
Video bandwidth	10 Hz
Trace mode	Max Hold

Conducted spurious emissions tests was performed as per ANSI C63.26 subclause 5.7.3
Spectrum analyser settings for conducted spectrum mask:

Resolution bandwidth:	≥ 1% channel bandwidth
Video bandwidth:	30 kHz
Detector mode:	RMS
Trace mode:	Max Hold

Spectrum analyser settings for conducted spurious emissions:

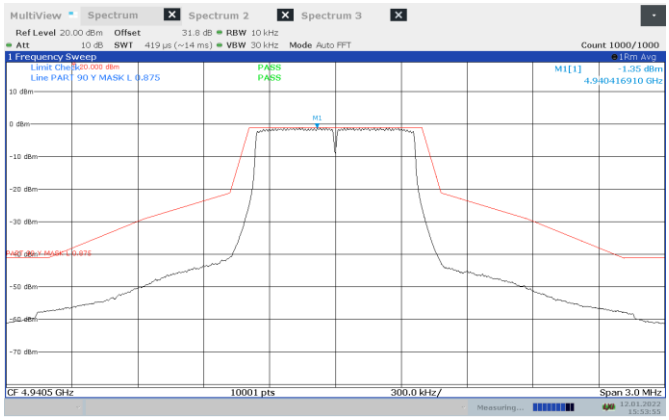
Resolution bandwidth:	1 MHz
Video bandwidth:	3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

−50 dBc is a more stringent limit than −25 dBm; therefore all plots reference -25 dBm spurious limit. The low power emission mask (*l)* is applicable for 0.875 MHz channels up to ±150% of channel bandwidth. The High power emission Mask (*m)* is applicable 5 MHz, 10 MHz and 20 MHz up to ±150% of channel bandwidth:

Radiated spurious was completed on the 5 MHz channel bandwidth, as it has the maximum power and PSD measured amongst the different bandwidths

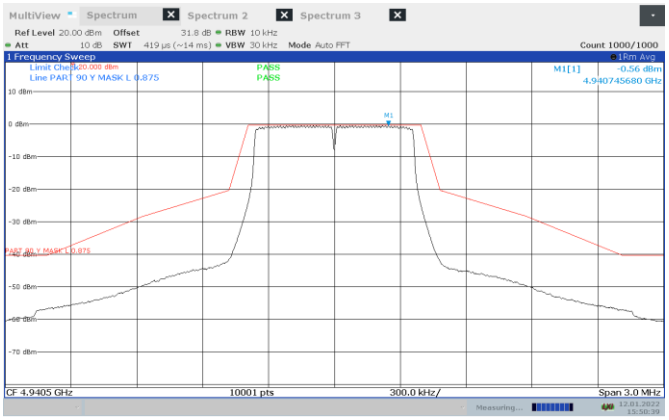
Radiated cabinet spurious limit calculated as follows:
Limit dBµV/m @ 3 m = -25 dBm + 95.23 dB
Limit dBµV/m @ 3 m = 70.23 dBµV/m

8.5.4 Test data



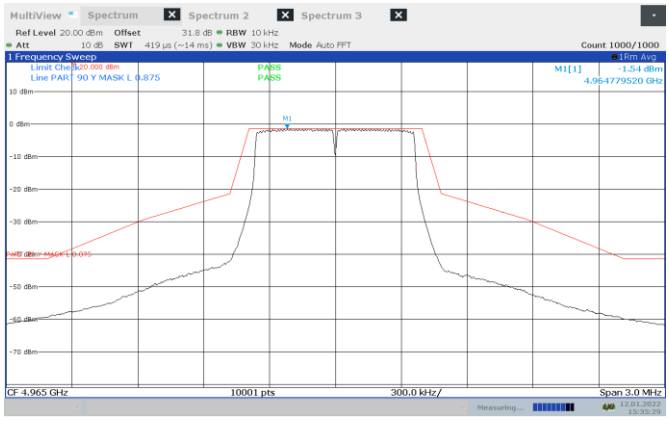
15:53:56 12.01.2022

Figure 8.5-2: *Emission mask for 0.875 MHz low channel at ch0*



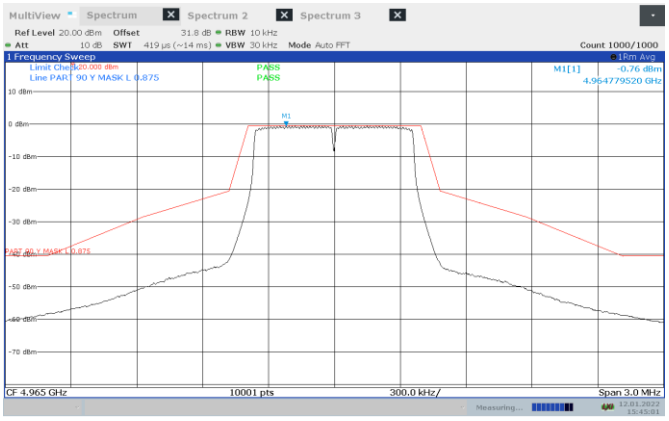
15:50:39 12.01.2022

Figure 8.5-3: *Emission mask for 0.875 MHz low channel at ch1*



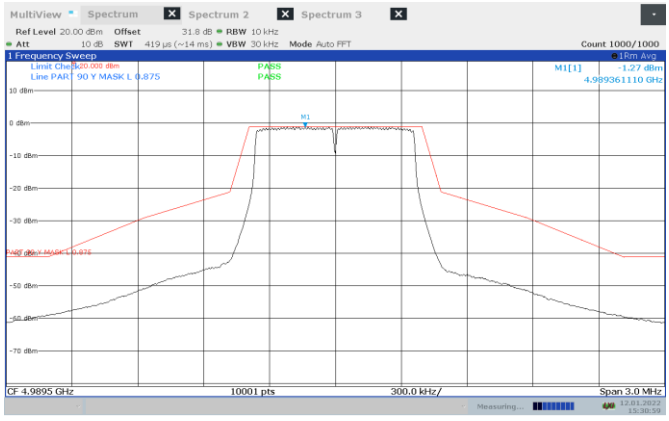
15:35:30 12.01.2022

Figure 8.5-4: *Emission mask for 0.875 MHz mid channel at ch0*



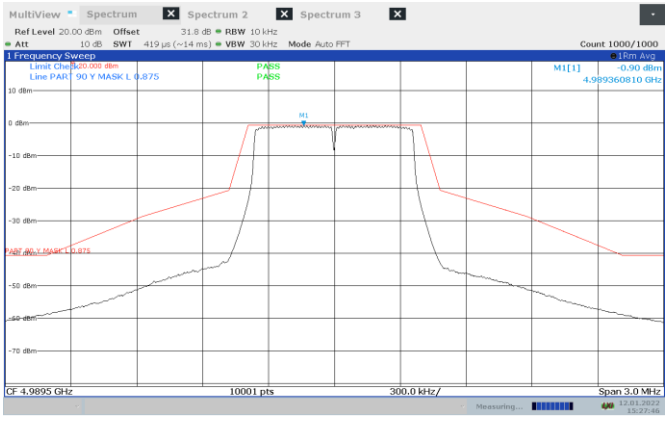
15:45:02 12.01.2022

Figure 8.5-5: *Emission mask for 0.875 MHz mid channel at ch1*



15:31:00 12.01.2022

Figure 8.5-6: *Emission mask for 0.875 MHz high channel at ch0*



15:27:46 12.01.2022

Figure 8.5-7: *Emission mask for 0.875 MHz high channel at ch1*

Test data, continued

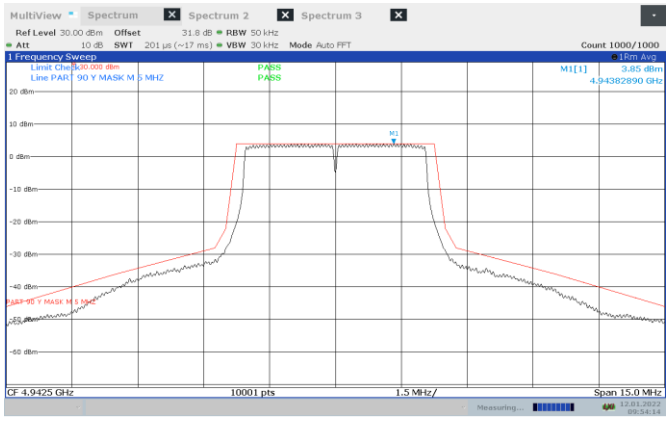


Figure 8.5-8: *Emission mask for 5 MHz low channel at ch0*

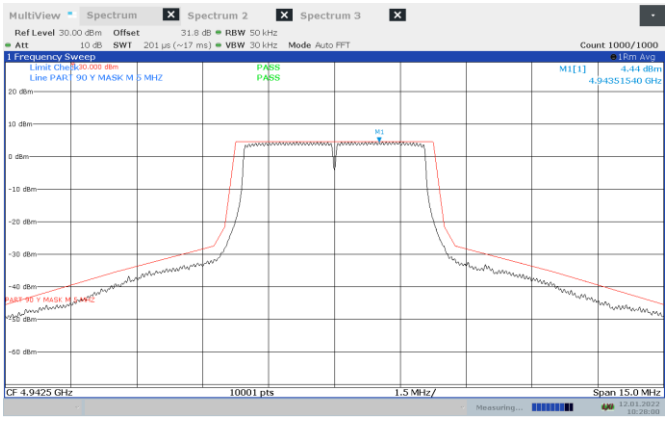


Figure 8.5-9: *Emission mask for 5 MHz low channel at ch1*

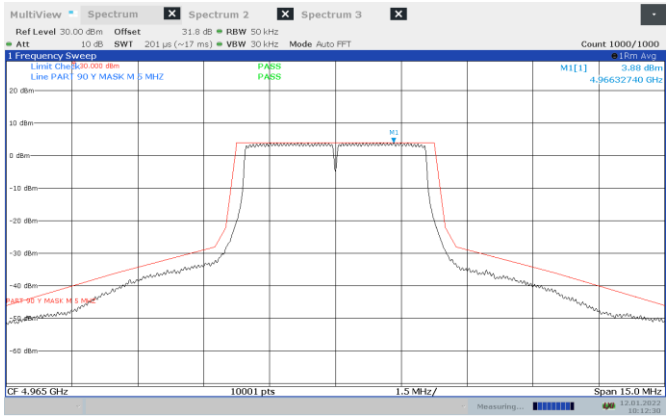


Figure 8.5-10: *Emission mask for 5 MHz mid channel at ch0*

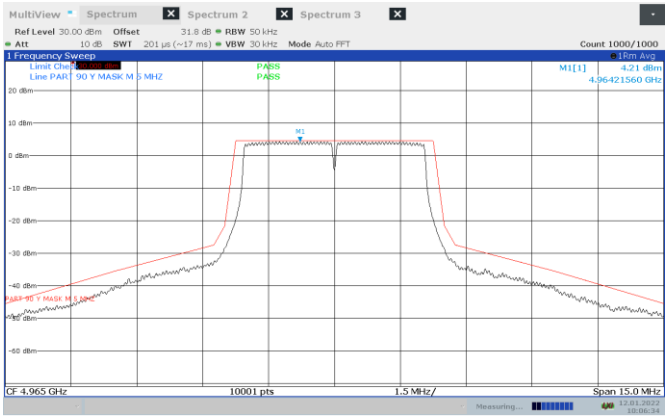


Figure 8.5-11: *Emission mask for 5 MHz mid channel at ch1*

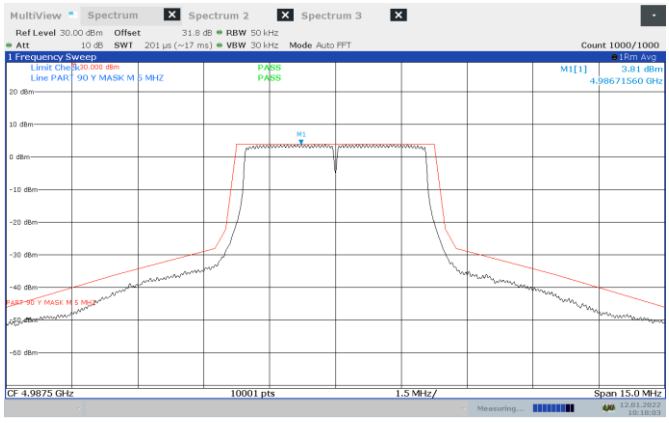


Figure 8.5-12: *Emission mask for 5 MHz high channel at ch0*

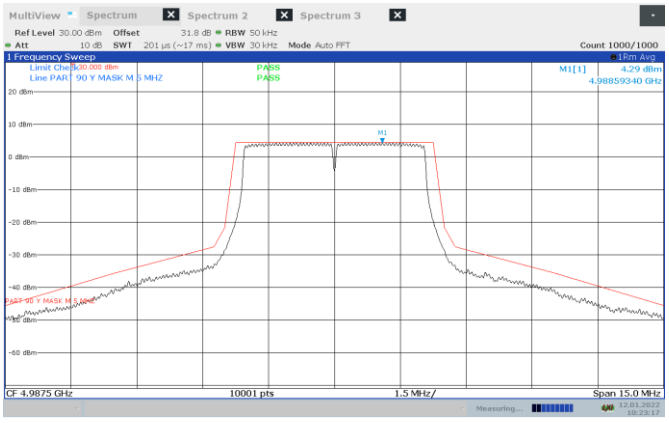


Figure 8.5-13: *Emission mask for 5 MHz high channel at ch1*

Test data, continued

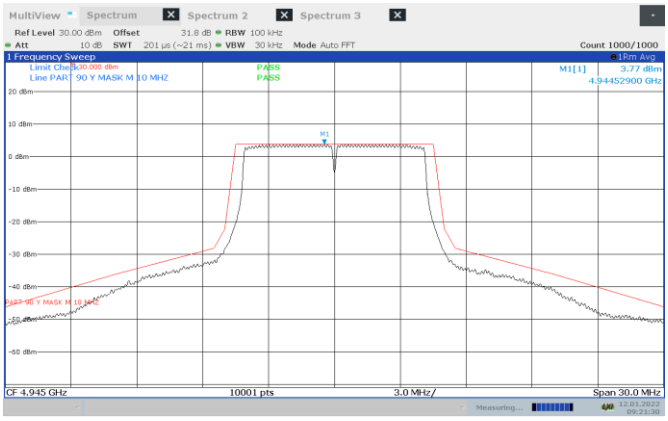


Figure 8.5-14: *Emission mask for 10 MHz low channel at ch0*

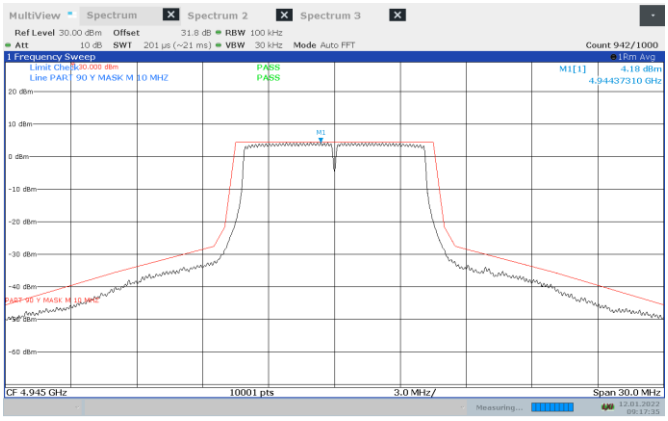


Figure 8.5-15: *Emission mask for 10 MHz low channel at ch1*

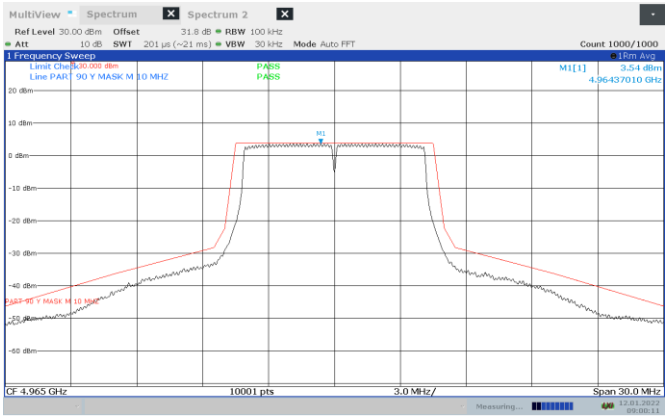


Figure 8.5-16: *Emission mask for 10 MHz mid channel at ch0*

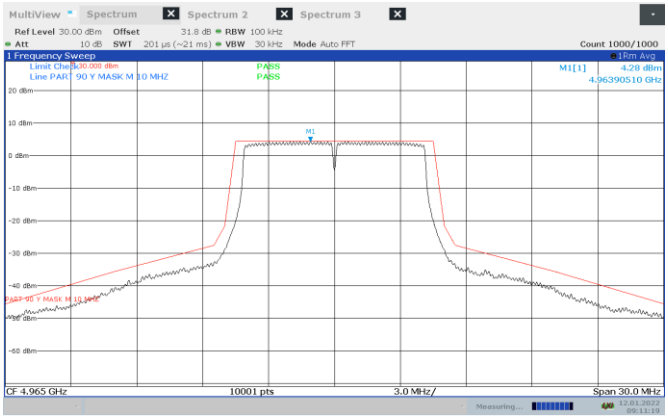


Figure 8.5-17: *Emission mask for 10 MHz mid channel at ch1*

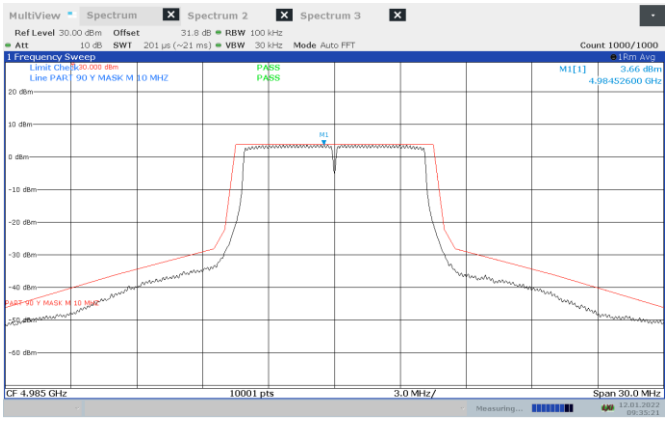


Figure 8.5-18: *Emission mask for 10 MHz high channel at ch0*

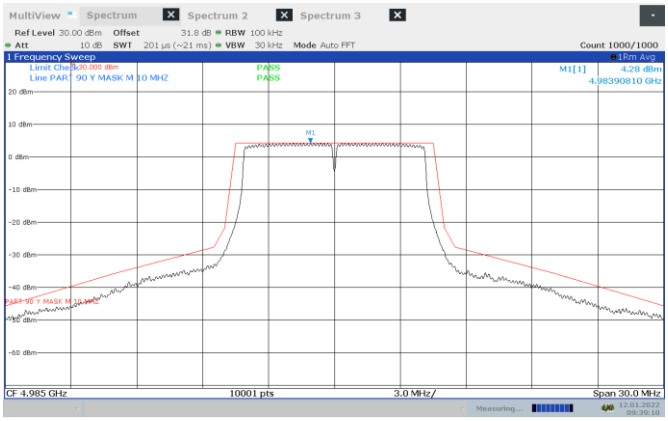


Figure 8.5-19: *Emission mask for 10 MHz high channel at ch1*

Test data, continued

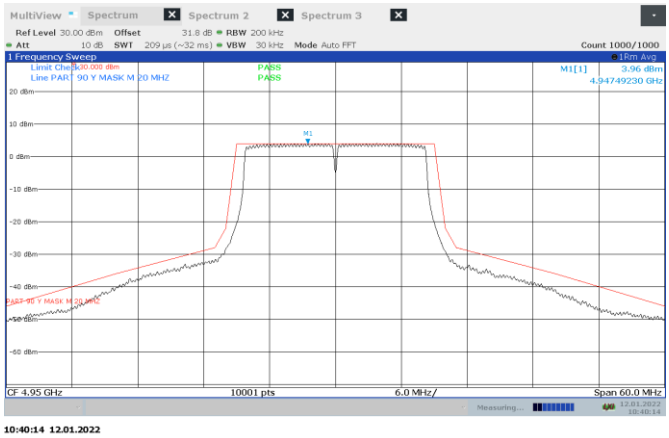


Figure 8.5-20: *Emission mask for 20 MHz low channel at ch0*

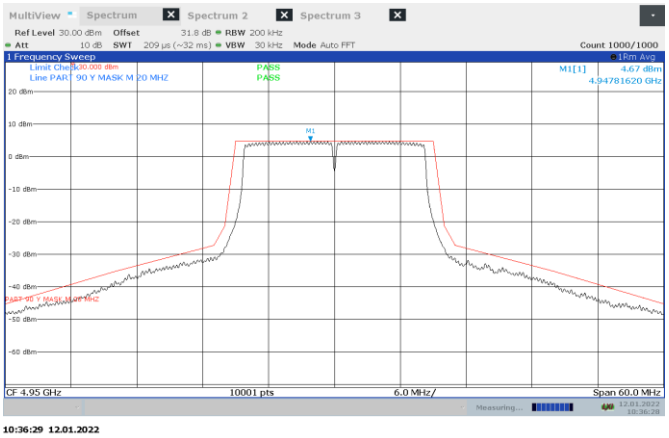


Figure 8.5-21: *Emission mask for 20 MHz low channel at ch1*

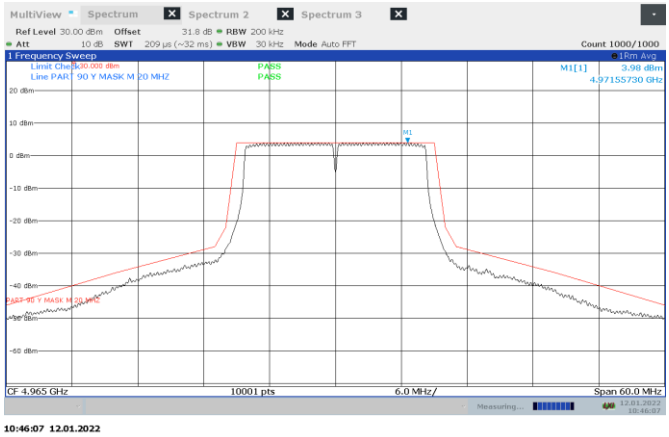


Figure 8.5-22: *Emission mask for 20 MHz mid channel at ch0*

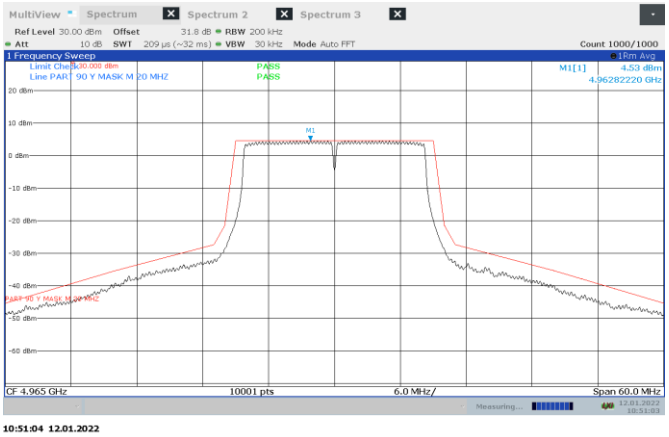


Figure 8.5-23: *Emission mask for 20 MHz mid channel at ch1*

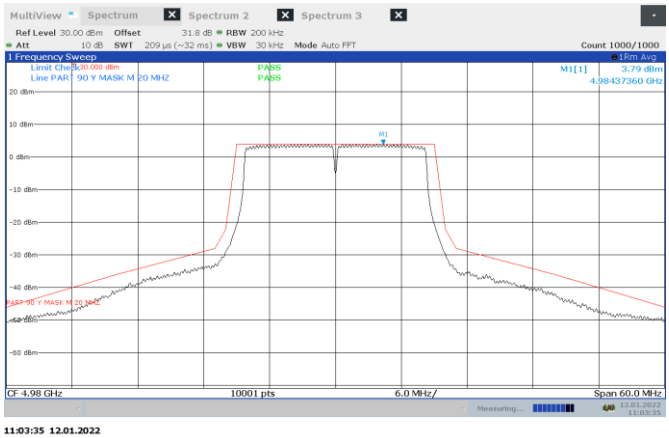


Figure 8.5-24: *Emission mask for 20 MHz high channel at ch0*

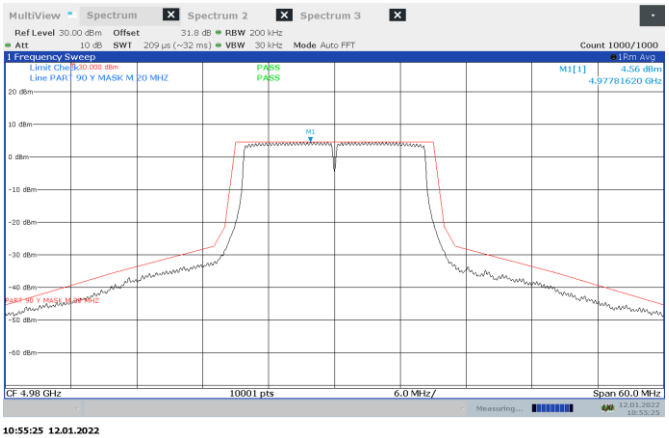


Figure 8.5-25: *Emission mask for 20 MHz high channel at ch1*

Test data, continued

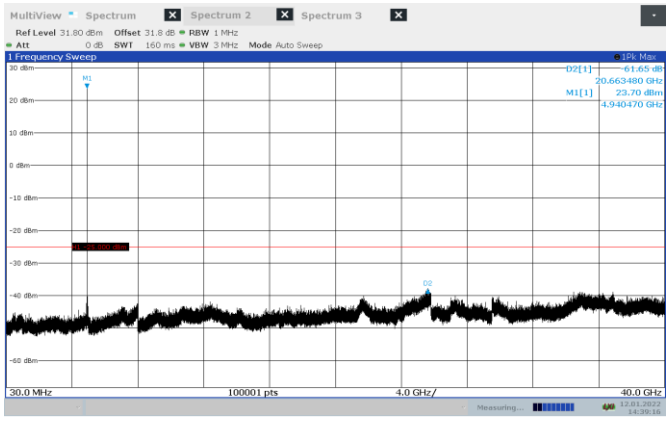


Figure 8.5-26: *Conducted spurious emissions for 0.875 MHz low channel at ch0*

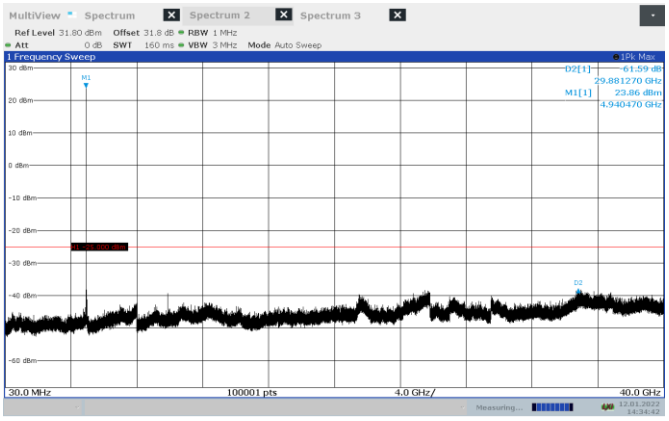


Figure 8.5-27: *Conducted spurious emissions for 0.875 MHz low channel at ch1*

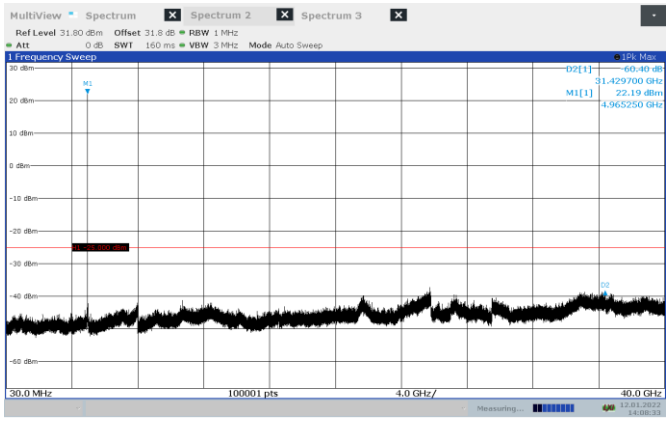


Figure 8.5-28: *Conducted spurious emissions for 0.875 MHz mid channel at ch0*

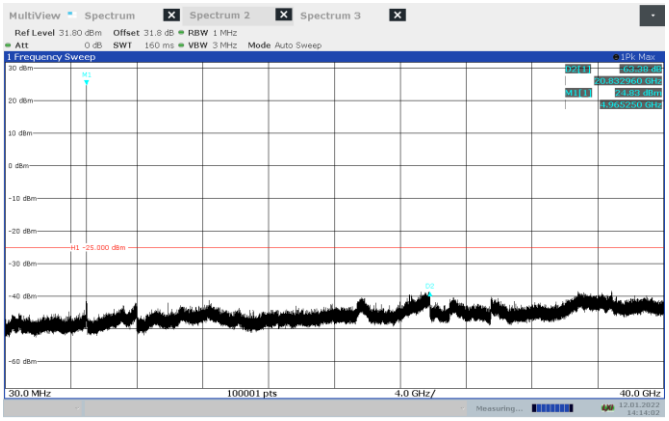


Figure 8.5-29: *Conducted spurious emissions for 0.875 MHz mid channel at ch1*

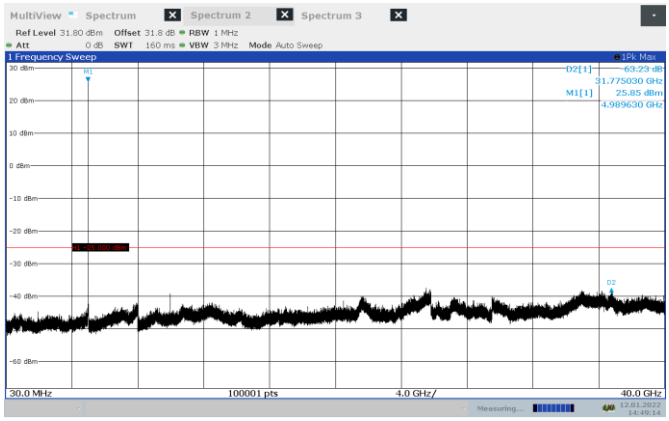


Figure 8.5-30: *Conducted spurious emissions for 0.875 MHz high channel at ch0*

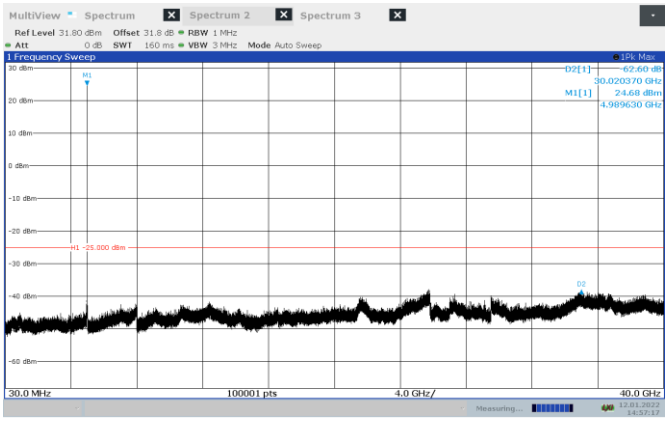


Figure 8.5-31: *Conducted spurious emissions for 0.875 MHz high channel at ch1*

Test data, continued

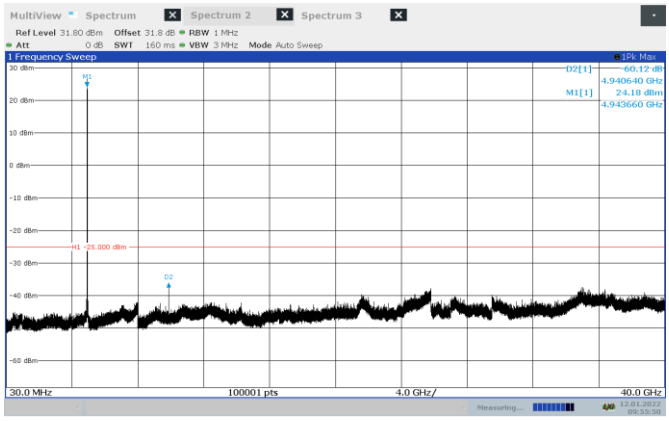


Figure 8.5-32: *Conducted spurious emissions for 5 MHz low channel at ch0*

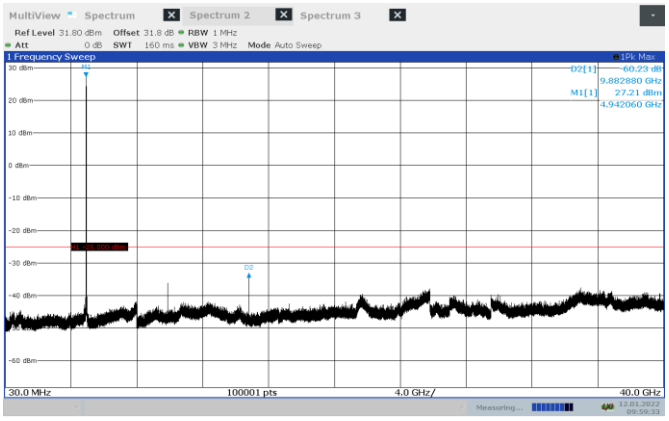


Figure 8.5-33: *Conducted spurious emissions for 5 MHz low channel at ch1*

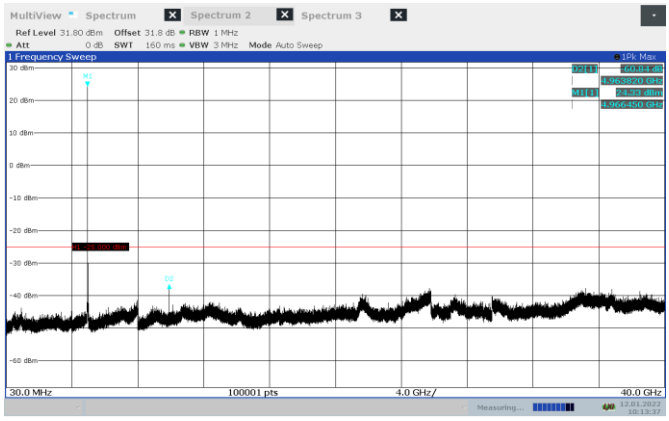


Figure 8.5-34: *Conducted spurious emissions for 5 MHz mid channel at ch0*

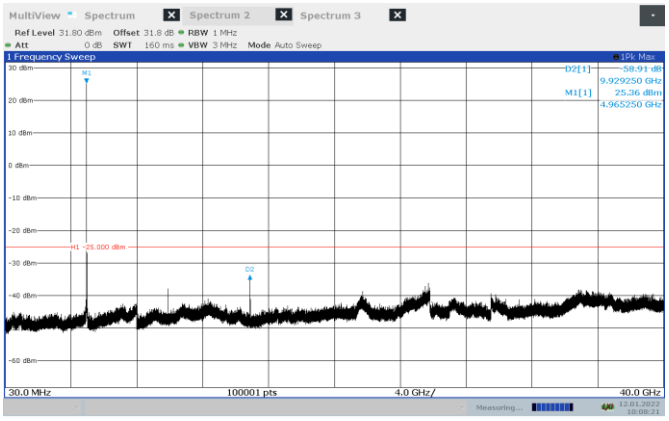


Figure 8.5-35: *Conducted spurious emissions for 5 MHz mid channel at ch1*

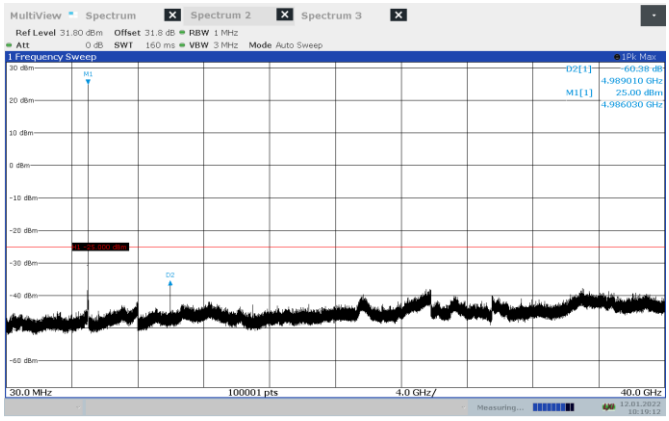


Figure 8.5-36: *Conducted spurious emissions for 5 MHz high channel at ch0*

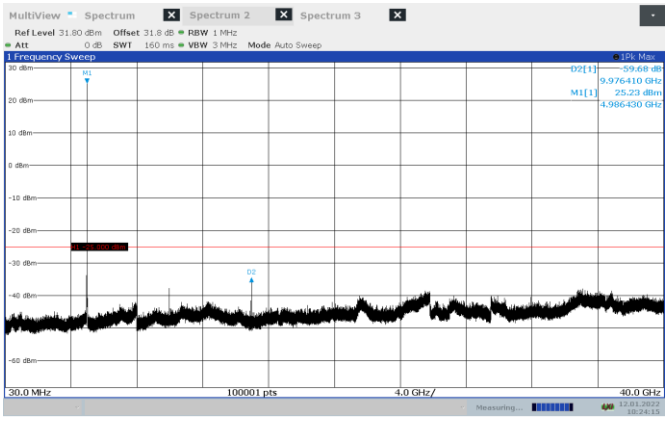


Figure 8.5-37: *Conducted spurious emissions for 5 MHz high channel at ch1*

Test data, continued

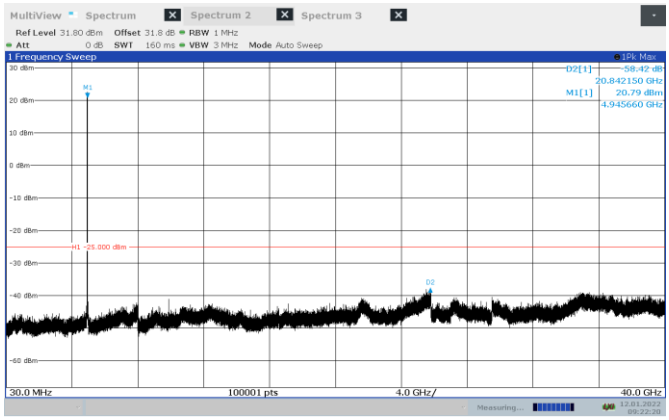


Figure 8.5-38: *Conducted spurious emissions for 10 MHz low channel at ch0*

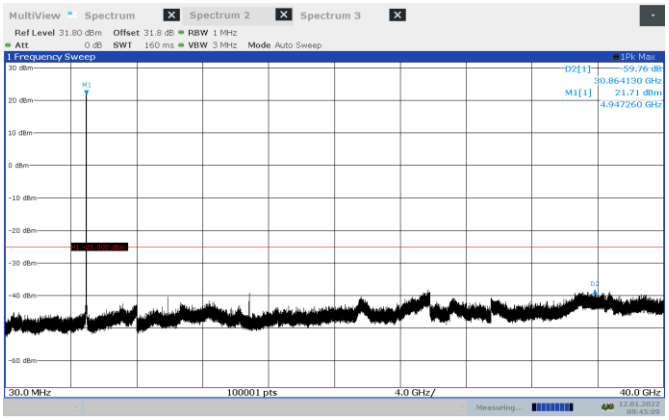


Figure 8.5-39: *Conducted spurious emissions for 10 MHz low channel at ch1*

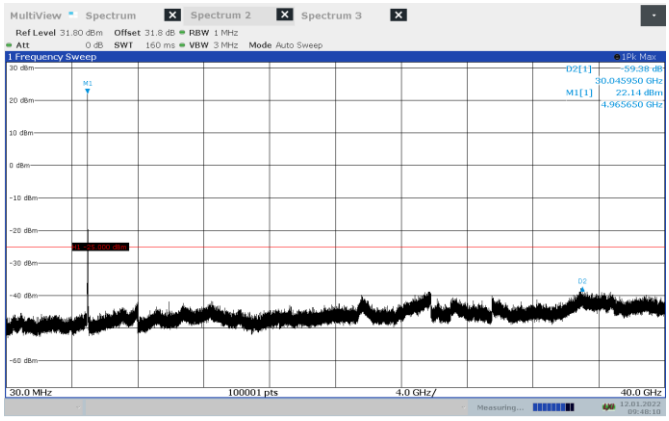


Figure 8.5-40: *Conducted spurious emissions for 10 MHz mid channel at ch0*

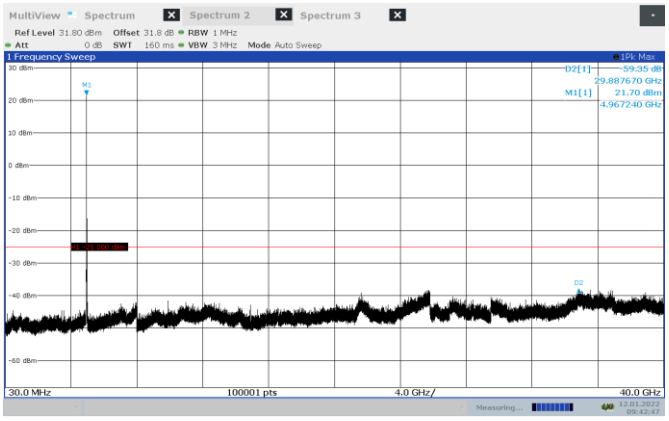


Figure 8.5-41: *Conducted spurious emissions for 10 MHz mid channel at ch1*

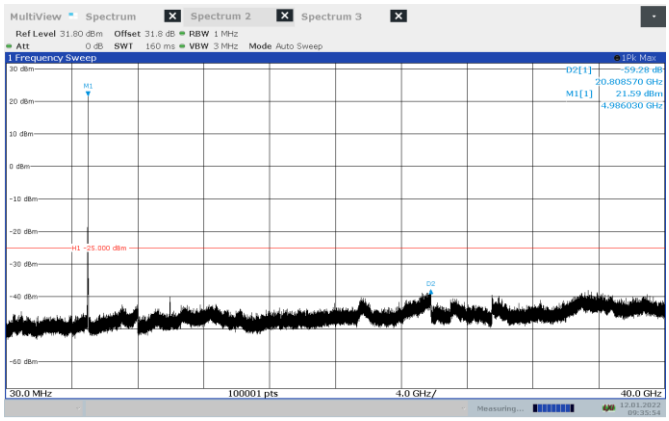


Figure 8.5-42: *Conducted spurious emissions for 10 MHz high channel at ch0*

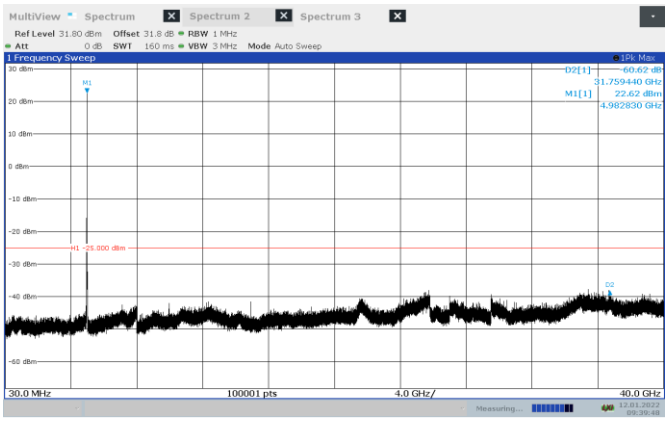


Figure 8.5-43: *Conducted spurious emissions for 10 MHz high channel at ch1*

Test data, continued

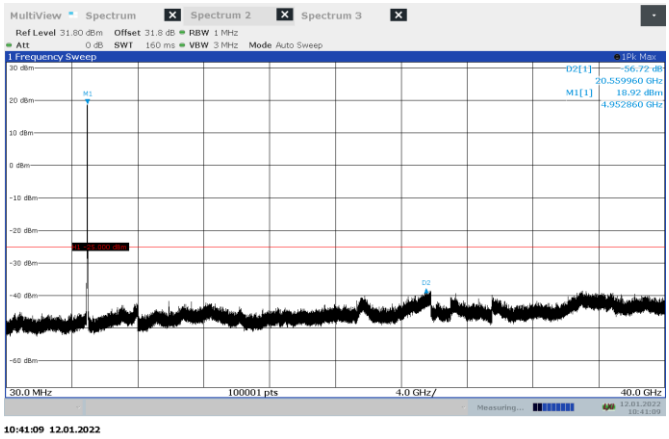


Figure 8.5-44: *Conducted spurious emissions for 20 MHz low channel at ch0*

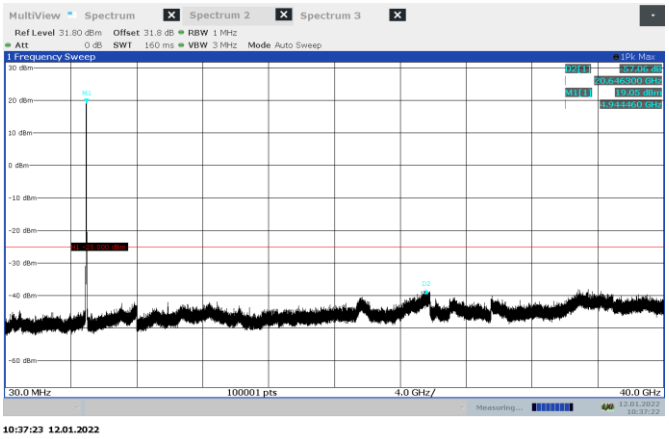


Figure 8.5-45: *Conducted spurious emissions for 20 MHz low channel at ch1*

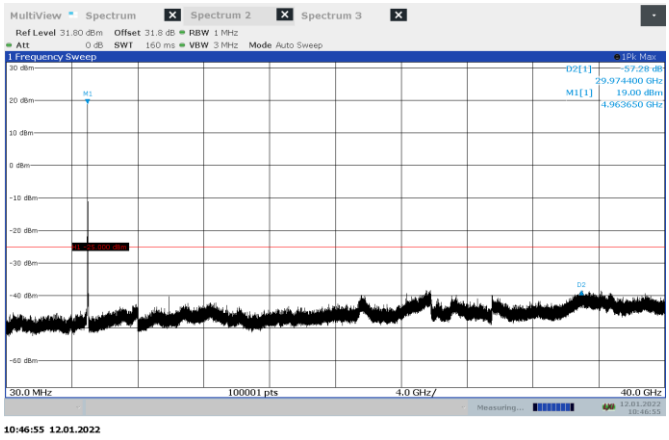


Figure 8.5-46: *Conducted spurious emissions for 20 MHz mid channel at ch0*

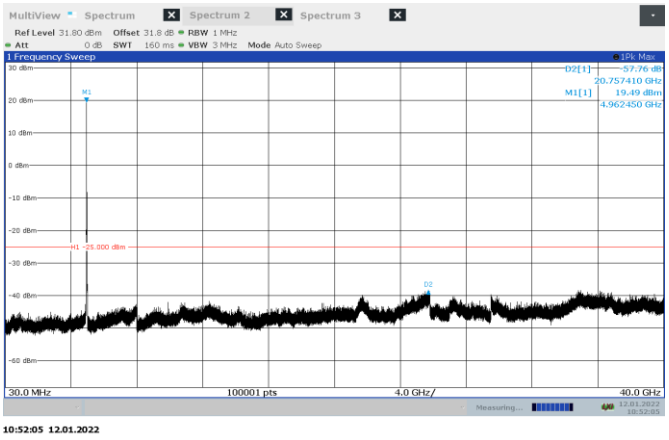


Figure 8.5-47: *Conducted spurious emissions for 20 MHz mid channel at ch1*

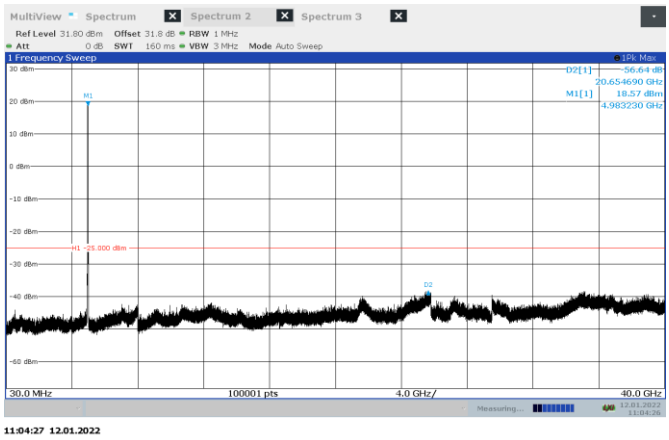


Figure 8.5-48: *Conducted spurious emissions for 20 MHz high channel at ch0*

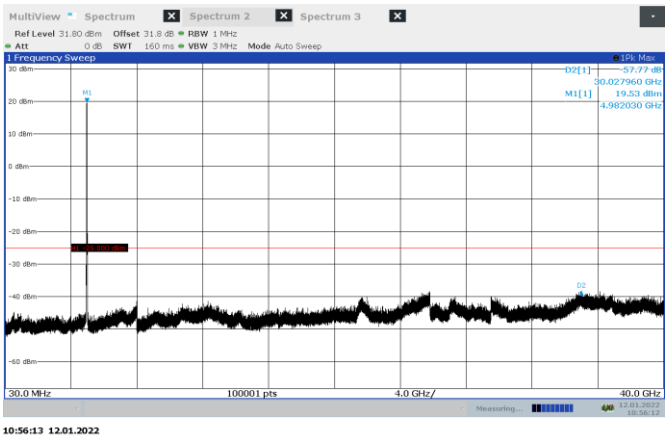
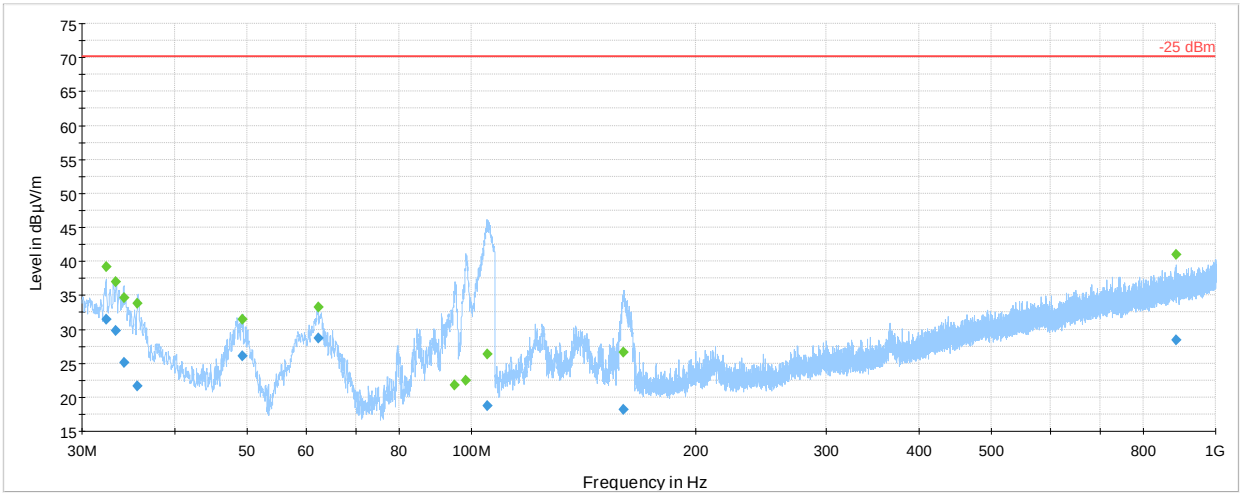


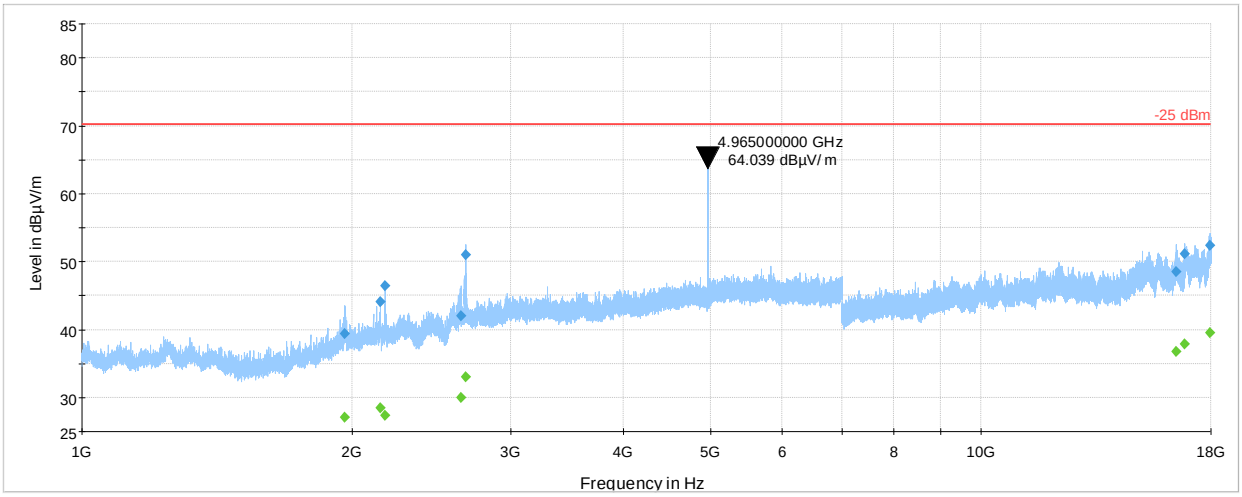
Figure 8.5-49: *Conducted spurious emissions for 20 MHz high channel at ch1*

Test data, continued



NEX-454155 RE 30-1000 MHz, 4.9 GHz mid, 5MHz BW
Preview Result 1-PK+
-25 dBm
Final_Result QPK
Final_Result PK+

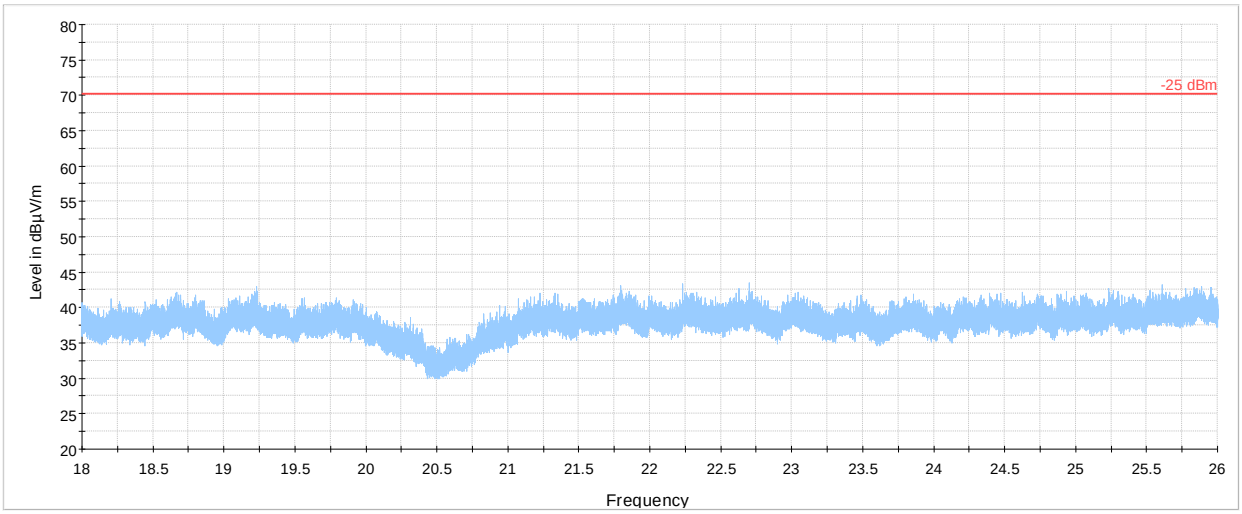
Figure 8.5-50: *Radiated cabinet spurious emissions below 1 GHz*



NEX-454155 RE 1-18 GHz, 4.9 GHz mid, 5MHz BW
Preview Result 1-PK+
-25 dBm
Final_Result PK+
Final_Result CAV

Figure 8.5 42: *Radiated cabinet spurious emissions 1-18 GHz*

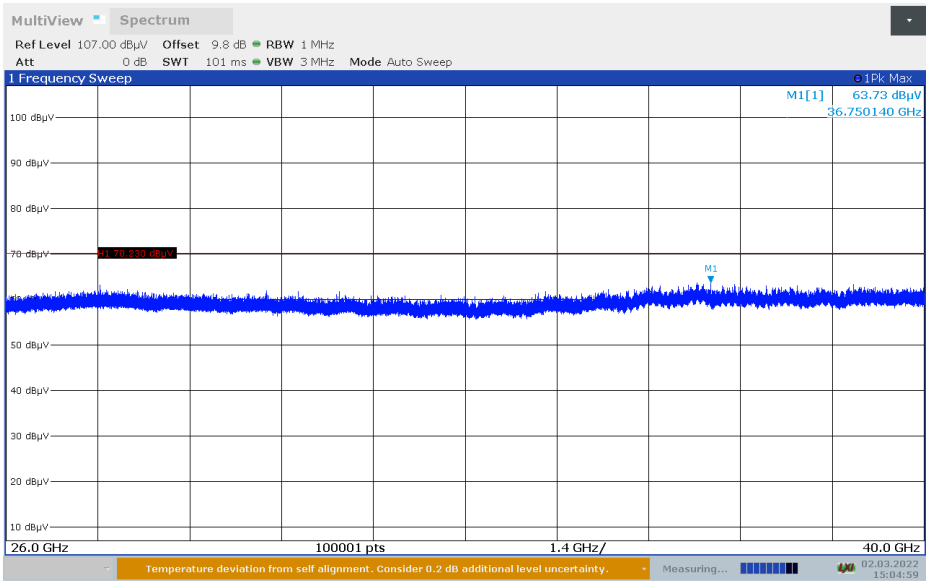
Test data, continued



NEX454155 RE 18-26 GHz, 5MHz BW, 4.9 GHz

Preview Result 1-PK+
-25 dBm
Final_Result PK+

Figure 8.5-51: *Radiated cabinet spurious emissions 18-26 GHz*



15:04:59 02.03.2022

Figure 8.5-52: *Radiated cabinet spurious emissions 26-40 GHz*

8.6 Frequency stability

8.6.1 References, definitions and limits

FCC Part 90.213:

(a) Unless noted elsewhere, transmitters used in the services governed by this part must have a minimum frequency stability as specified in the following table:

Table 8.6-1: *Minimum frequency stability*

Frequency range (MHz)	Fixed and base stations (±ppm)	Mobile stations (±ppm)	
		Over 2 watts output power	2 watts or less output power
Below 25	100	100	200
25–50	20	20	50
72–76	5		50
150–174	5	5	50
216–220	1.0		1.0
220–222	0.1	1.5	1.5
421–512	2.5	5	5
806–809	1.0	1.5	1.5
809–824	1.5	2.5	2.5
851–854	1.0	1.5	1.5
854–869	1.5	2.5	2.5
896–901	0.1	1.5	1.5
902–928	2.5	2.5	2.5
929–930	1.5		
935–940	0.1	1.5	1.5
1427–1435	300	300	300
Above 2450			

RSS-111 Sub clause 5.2:

The applicant shall ensure frequency stability by showing that the occupied bandwidth is maintained within the band of operation when tested at the temperature and supply voltage variations specified for the frequency stability measurement in RSS-Gen.

8.6.2 Test summary

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

8.6.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth:	1-5 %of OBW
Video bandwidth:	3 X RBW
Detector mode:	Peak
Trace mode:	Max Hold

8.6.4 Test data

Table 8.6-2: *Frequency drift measurement*

Test conditions	Frequency, GHz	Drift, Hz
+60 °C, Nominal	4.964993421	-1664
+50 °C, Nominal	4.964984105	-10980
+40 °C, Nominal	4.964997062	1977
+30 °C, Nominal	4.964992837	-2248
+20 °C, +15 %	4.964995060	-25
+20 °C, Nominal	4.964995085	*Reference*
+20 °C, −15 %	4.964994210	-874
+10 °C, Nominal	4.964996118	1033
0 °C, Nominal	4.964996046	961
−10 °C, Nominal	4.965004186	9101
−20 °C, Nominal	4.964997272	2187
−30 °C, Nominal	4.964994869	-216
−40 °C, Nominal	4.964995594	509

Table 8.6-3: *Lower band edge drift calculation*

Bandwidth, MHz	lower cross point F_L, GHz	Max negative drift, Hz	Drifted lower cross point, GHz	Band edge, GHz	Margin, MHz
0.875	4.9407318	10980	4.94072082	4.940	0.72
5	4.9404527	10980	4.94044172	4.940	0.44
10	4.9408580	10980	4.94084702	4.940	0.84
20	4.9416535	10980	4.94164252	4.940	1.64

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

Table 8.6-4: *Upper band edge drift calculation*

Bandwidth, MHz	upper cross point F_H, GHz	Max positive drift, Hz	Drifted upper cross point, GHz	Band edge, GHz	Margin, MHz
0.875	4.9898597	9101	4.98986880	4.990	0.13
5	4.9895408	9101	4.98954990	4.990	0.45
10	4.9891120	9101	4.98912110	4.990	0.88
20	4.9882870	9101	4.98829610	4.990	1.70

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

End of the test report