

RADIO TEST REPORT – 400316-2R1TRFWL

Type of assessment:

Class II Permissive Change

Applicant:

Redline Communications

Product:

Broad-band wireless infrastructure product

Model:

RDL-3100-RMA

FCC ID:

QC8-RDL3100RMA

Specifications:

- ◆ **FCC 47 CFR Part 15 Subpart E, §15.407**

Date of issue: July 29, 2020

Andrey Adelberg, Senior EMC/RF Specialist

Tested by



Signature

David Duchesne, EMC/RF Lab Manager

Reviewed by



Signature

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Lab locations

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	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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Section 1 Report summary

1.1 Test specifications

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

Due to C2PC only limited subset of testing was perform in order to make sure continued compliance with added 3 channel bandwidths: 0.875 MHz, 5 MHz and 45 MHz.

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	July 9, 2020	Original report issued
R1TRF	July 29, 2020	Internal photographs of the EUT were removed

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 decided to perform the following:

1. RF power output: on one channel for each modulation/additional bandwidth.
2. Power Spectral Density: on one channel for each modulation/additional bandwidth.
3. Occupied bandwidth: at additional bandwidths 0.875 MHz, 5 MHz, and 45 MHz.
4. Band edge spurious emissions: upper and lower band edge with both additional bandwidths
5. Out-of-band spurious emissions: spurious emissions up to 10x fundamental TX frequency on one frequency for one of the additional bandwidths.

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 $\pm 5\%$, 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, \pm 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
Manufacture name	Same as applicant
Manufacture address	Same as applicant

5.3 EUT information

Product name	Broad-band wireless infrastructure product
Model	RDL-3100-RMA
Serial number	318SC16300082
Power supply requirements	48 V _{DC} PoE via 120 V _{AC} , 60 Hz
Product description and theory of operation	The EUT is a 2x2 MIMO point-to-multipoint (PMP) and 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	<input checked="" type="checkbox"/>	Outdoor access point
	<input type="checkbox"/>	Indoor access point
	<input type="checkbox"/>	Fixed point-to-point access point
	<input type="checkbox"/>	Client device
	<input type="checkbox"/>	Device installed in vehicles
Frequency band	5150–5250 MHz (U-NII-1)	
Channel sizes (MHz)	0.875, 5, 45	
Type of modulation	OFDM using 256-QAM, 128-QAM, 64-QAM, 16-QAM, QPSK and BPSK modulation for sub-carriers	
Antenna information	10 dBi Redline AOD-DB-0512-02 omnidirectional antenna 10 dBi L-Com, HG5158DP-10U, omnidirectional antenna 24 dBi Dual Polarization Antenna 4.9–6.1 GHz, Redline 30-00362-00 32 dBi Redline A3FT3204LTPD Parabolic Antenna, 4.9–5.8 GHz, 4 degree, dual polarity	

Channel sizes:	0.875 MHz	5 MHz	45 MHz
Frequency Min (MHz)	5151.0	5155.0	5175.0
Frequency Max (MHz)	5249.5	5247.5	5227.5
RF power Max (W), Conducted	0.055 (17.43 dBm)	0.144 (21.58 dBm)	0.310 (24.91 dBm)
Measured BW (kHz), 99% OBW	723	4115	41091
Emission classification	723KW7D	4M12W7D	41M1W7D
Transmitter spurious, dBμV/m @ 3 m	53.69 at 5150 MHz	53.98 at 5150 MHz	53.96 at 1550 MHz

5.5 EUT setup details

5.5.1 Radio exercise details

Operating conditions	Software version used: 3.12.6
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: <code>dbg txloop 1 0 95</code>

EUT setup configuration, continued

Table 5.5-1: Support equipment

Description	Brand name	Model, Part number, Serial number, Revision level
Power over Ethernet adapter	Microsemi	PN: PD-9001GR/AT/AC

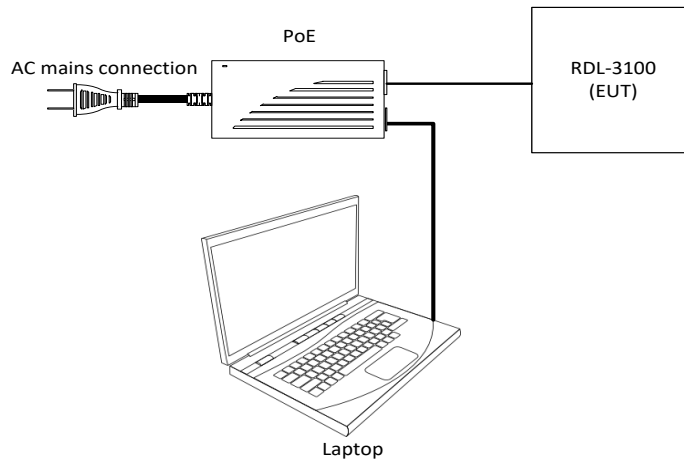


Figure 5.5-1: Setup block diagram

Section 6 Summary of test results

6.1 Testing location

Test location (s) Ottawa

6.2 Testing period

Test start date June 15, 2020 Test end date June 30, 2020

6.3 Sample information

Receipt date June 12, 2020 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	Not tested
§15.31l	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: Only limited subset of testing was performed

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	Not applicable
§15.407(a)(1)	Power and density limits within 5.15–5.25 GHz band	Pass
§15.407(a)(2)	Power and density limits within 5.25–5.35 GHz and 5.47–5.725 GHz bands	Not applicable
§15.407(a)(3)	Power and density limits within 5.725–5.85 GHz band	Not applicable
§15.407(b)(1)	Undesirable emission limits for 5.15–5.25 GHz band	Pass
§15.407(b)(2)	Undesirable emission limits for 5.25–5.35 GHz band	Not applicable
§15.407(b)(3)	Undesirable emission limits for 5.47–5.725 GHz bands	Not applicable
§15.407(b)(4)	Undesirable emission limits for 5.725–5.85 GHz band	Not applicable
§15.407(b)(6)	Conducted limits for U-NII devices using an AC power line	Not tested
§15.407(e)	Minimum 6 dB bandwidth of U-NII devices within the 5.725–5.85 GHz band	Not applicable
§15.407(g)	Frequency stability	Not tested
§15.407(h)(1) ¹	Transmit power control (TPC)	Not applicable
§15.407(h)(2) ¹	Dynamic Frequency Selection (DFS)	Not applicable

Notes: ¹DFS and TPC requirements are only applicable to 5.25–5.35 GHz and 5.47–5.725 GHz bands
Only limited subset of testing was performed

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.
3 m EMI test chamber	TDK	SAC-3	FA002047	1 year	January 24, 2021
Flush mount turntable	Sunol	FM2022	FA002082	—	NCR
Controller	Sunol	SC104V	FA002060	—	NCR
Antenna mast	Sunol	TLT2	FA002061	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	November 8, 2020
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	October 31, 2020
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	October 31, 2020
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002873	1 year	November 4, 2020
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	November 7, 2020
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU

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

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	Andrey Adelberg	Test date	June 15, 2020

8.1.3 Observations, settings and special notes

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

- 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.
- For devices, where operating at a supply voltage deviating $\pm 15\%$ 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.
- 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.
- 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:	<input checked="" type="checkbox"/> AC	<input type="checkbox"/> DC	<input type="checkbox"/> Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO	<input type="checkbox"/> N/A
If EUT is battery operated, was the testing performed using fresh batteries?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	<input type="checkbox"/> YES	<input type="checkbox"/> NO	<input checked="" type="checkbox"/> 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	Andrey Adelberg	Test date	June 15, 2020

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:

- 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.
- 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.
- 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:

- 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).
- 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).
- 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	Mid channel, MHz	High channel, MHz
0.875	5150	5250	100	5151.0	5200.0	5249.5
5	5150	5250	100	5155.0	5200.0	5247.5
45	5150	5250	100	5175.0	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	Andrey Adelberg	Test date	June 15, 2020

8.3.3 Observations, settings and special notes

None

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
Omnidirectional	Redline	AOD-DB-0512-02	10 dBi	N-type
Omnidirectional	L-Com	HG5158DP-10U	10 dBi	N-type
Dual Polarization	Redline	30-00362-00	24 dBi	MCX
Parabolic	Redline	A3FT3204LTPD	32 dBi	N-type

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	Andrey Adelberg	Test date	June 23, 2020

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	5200	0.829	0.824
0.875	256QAM	5200	0.819	0.829
5	BPSK	5200	4.670	4.690
5	256QAM	5200	4.740	4.630
45	BPSK	5200	46.050	46.450
45	256QAM	5200	45.950	46.350

Test data, continued

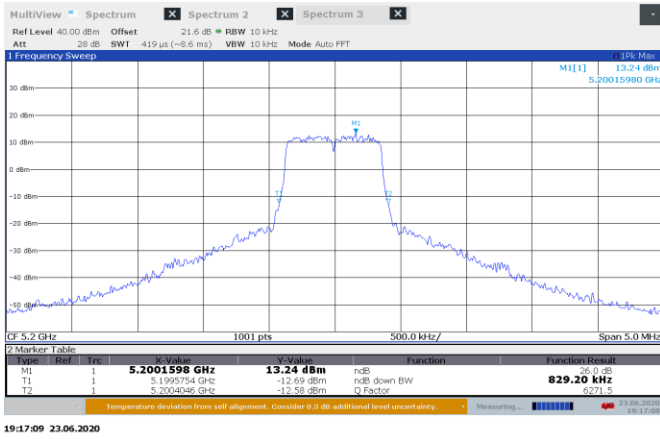


Figure 8.4-1: 26 dB bandwidth on 0.875 MHz channel, sample plot

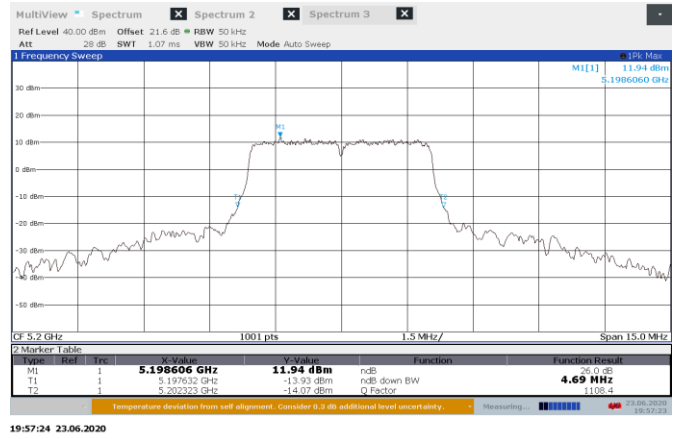


Figure 8.4-2: 26 dB bandwidth on 5 MHz channel, sample plot

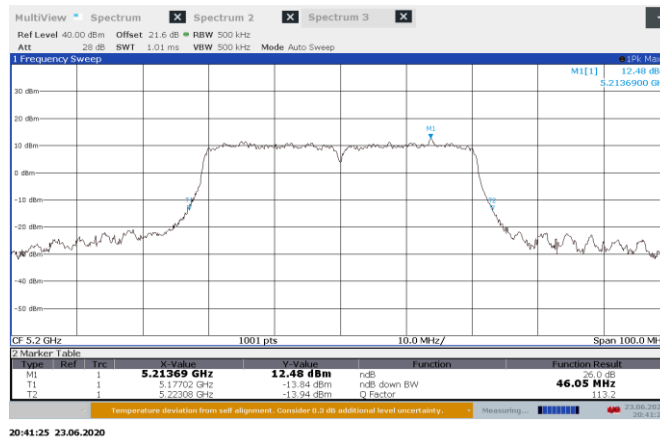


Figure 8.4-3: 26 dB bandwidth on 45 MHz channel, sample plot

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	Andrey Adelberg	Test date	June 23, 2020

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 % of span
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	5200	0.723	0.720
0.875	256QAM	5200	0.723	0.723
5	BPSK	5200	4.099	4.114
5	256QAM	5200	4.115	4.107
45	BPSK	5200	41.089	41.072
45	256QAM	5200	41.091	41.058

Test data, continued

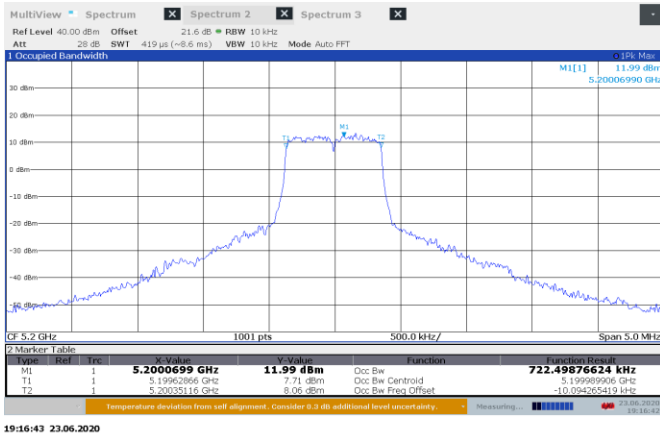


Figure 8.5-1: 99% bandwidth on 0.875 MHz channel, sample plot

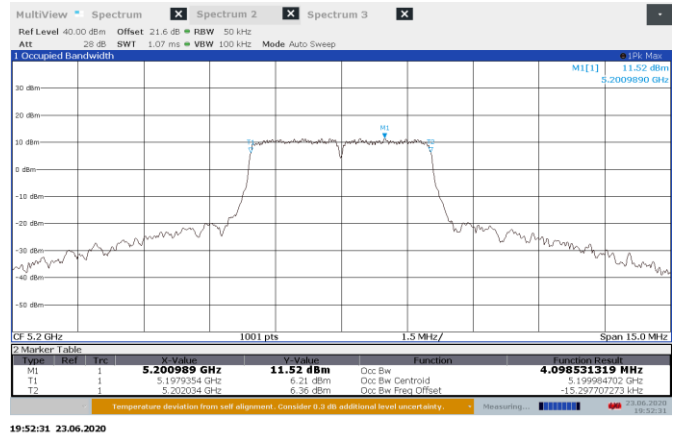


Figure 8.5-2: 99% bandwidth on 0.875 MHz channel, sample plot

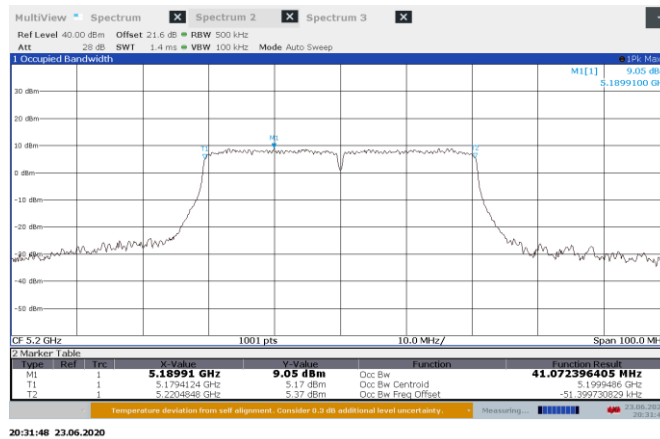


Figure 8.5-3: 99% bandwidth on 0.875 MHz channel, sample plot

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	Andrey Adelberg	Test date	June 25, 2020

8.6.3 Observations, settings and special notes

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

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

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

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

For antennas with the directional gain greater than 6 dBi, the maximum FCC output power limit was calculated as follows:

30 dBm – (Maximum antenna gain – 6 dBi)

For 10 dBi antenna with 0.7 dB cable loss: Limit = 30 dBm – (9.3 dBi – 6 dBi) = 26.7 dBm

For 24 dBi antenna with 0.7 dB cable loss: Limit = 30 dBm – (23.3 dBi – 6 dBi) = 12.7 dBm

For 32 dBi antenna with 0.7 dB cable loss: Limit = 30 dBm – (31.3 dBi – 6 dBi) = 4.7 dBm

For antennas with the directional gain greater than 6 dBi, the maximum power spectral density limit was calculated as follows:

17 dBm/MHz – (Maximum antenna gain – 6 dBi)

For 10 dBi antenna with 0.7 dB cable loss: Limit = 17 dBm/MHz – (9.3 dBi – 6 dBi) = 13.7 dBm/MHz

For 24 dBi antenna with 0.7 dB cable loss: Limit = 17 dBm/MHz – (23.3 dBi – 6 dBi) = –0.3 dBm/MHz

For 32 dBi antenna with 0.7 dB cable loss: Limit = 17 dBm/MHz – (31.3 dBi – 6 dBi) = –8.3 dBm/MHz

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

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	10 kHz to 1 MHz
Video bandwidth	≥ 3 MHz
Frequency span	Enough to encompass the entire 26 dB EBW or 99% OBW of the signal
Detector mode	RMS
Trace mode	Max Hold
Power aggregation	Over 26 dB EBW or 99% OBW

8.6.4 Test data

Table 8.6-1: Output power measurements results for 0.875 MHz channel with 10 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	13.67	15.06	17.43	26.70	9.27	9.30	26.73	36.00	9.27
256QAM	5200	13.69	13.91	16.81	26.70	9.89	9.30	26.11	36.00	9.89



Test data, continued

Table 8.6-2: PPSD measurements results for 0.875 MHz channel with 10 dBi antenna

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	5200	10.63	10.69	13.67	13.70	0.03
256QAM	5200	10.76	10.54	13.66	13.70	0.04

Table 8.6-3: Output power measurements results for 0.875 MHz channel with 24 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	-0.52	0.51	3.04	12.70	9.66	23.30	26.34	36.00	9.66
256QAM	5200	-0.58	-0.35	2.55	12.70	10.15	23.30	25.85	36.00	10.15

Table 8.6-4: PPSD measurements results for 0.875 MHz channel with 24 dBi antenna

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	5200	-3.24	-3.41	-0.31	-0.30	0.01
256QAM	5200	-3.27	-3.49	-0.37	-0.30	0.07

Table 8.6-5: Output power measurements results for 0.875 MHz channel with 32 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	-8.65	-7.47	-5.01	4.70	9.71	31.30	26.29	36.00	9.71
256QAM	5200	-8.74	-8.54	-5.63	4.70	10.33	31.30	25.67	36.00	10.33

Table 8.6-6: PPSD measurements results for 0.875 MHz channel with 32 dBi antenna

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	5200	-11.39	-11.27	-8.32	-8.30	0.02
256QAM	5200	-11.33	-11.31	-8.31	-8.30	0.01

Test data, continued

Table 8.6-7: Output power measurements results for 5 MHz channel with 10 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	18.47	18.49	21.49	26.70	5.21	9.30	30.79	36.00	5.21
256QAM	5200	18.55	18.59	21.58	26.70	5.12	9.30	30.88	36.00	5.12

Table 8.6-8: PPSD measurements results for 5 MHz channel with 10 dBi antenna

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	5200	10.67	10.67	13.68	13.70	0.02
256QAM	5200	10.64	10.69	13.68	13.70	0.02

Table 8.6-9: Output power measurements results for 5 MHz channel with 24 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	4.39	4.43	7.42	12.70	5.28	23.30	30.72	36.00	5.28
256QAM	5200	4.32	4.42	7.38	12.70	5.32	23.30	30.68	36.00	5.32

Table 8.6-10: PPSD measurements results for 5 MHz channel with 24 dBi antenna

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	5200	-3.31	-3.61	-0.45	-0.30	0.15
256QAM	5200	-3.23	-3.56	-0.38	-0.30	0.08

Table 8.6-11: Output power measurements results for 5 MHz channel with 32 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	-3.65	-3.60	-0.61	4.70	5.31	31.30	30.69	36.00	5.31
256QAM	5200	-3.55	-3.66	-0.59	4.70	5.29	31.30	30.71	36.00	5.29

Table 8.6-12: PPSD measurements results for 5 MHz channel with 32 dBi antenna

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	5200	-11.61	-11.41	-8.50	-8.30	0.20
256QAM	5200	-11.44	-11.22	-8.32	-8.30	0.02



Test data, continued

Table 8.6-13: Output power measurements results for 45 MHz channel with 10 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	21.76	22.03	24.91	26.70	1.79	9.30	34.21	36.00	1.79
256QAM	5200	21.61	21.85	24.74	26.70	1.96	9.30	34.04	36.00	1.96

Table 8.6-14: PPSD measurements results for 45 MHz channel with 10 dBi antenna

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	5200	6.41	6.81	9.62	13.70	4.08
256QAM	5200	6.42	6.73	9.59	13.70	4.11

Table 8.6-15: Output power measurements results for 45 MHz channel with 24 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	10.02	9.12	12.60	12.70	0.10	23.30	35.90	36.00	0.10
256QAM	5200	10.16	9.12	12.68	12.70	0.02	23.30	35.98	36.00	0.02

Table 8.6-16: PPSD measurements results for 45 MHz channel with 24 dBi antenna

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	5200	-5.24	-6.08	-2.63	-0.30	2.33
256QAM	5200	-5.04	-6.03	-2.50	-0.30	2.20

Table 8.6-17: Output power measurements results for 45 MHz channel with 32 dBi antenna

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	Total antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dBm
BPSK	5200	1.99	1.12	4.59	4.70	0.11	31.30	35.89	36.00	0.11
256QAM	5200	2.00	0.84	4.47	4.70	0.23	31.30	35.77	36.00	0.23

Table 8.6-18: PPSD measurements results for 45 MHz channel with 32 dBi antenna

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	5200	-13.40	-14.20	-10.77	-8.30	2.47
256QAM	5200	-13.23	-14.25	-10.70	-8.30	2.40

Test data, continued

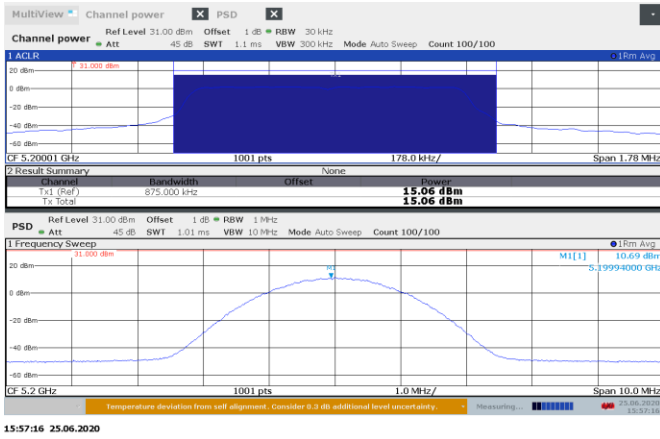


Figure 8.6-1: Sample plot for power and PPSD on 0.875 MHz channel

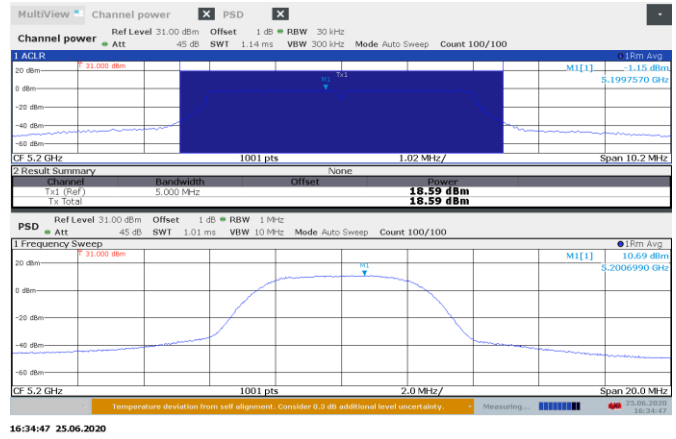


Figure 8.6-2: Sample plot for power and PPSD on 5 MHz channel

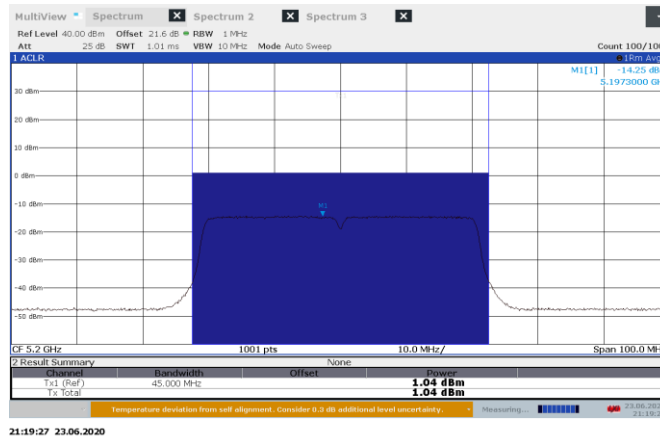


Figure 8.6-3: Sample plot for power and PPSD on 45 MHz channel

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 and RSS-Gen – Radiated emission limits

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

Notes: In the emission table above, the tighter limit applies at the band edges.
 For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test.

Table 8.7-2: 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	Andrey Adelberg	Test date	June 16, 2020

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).

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: Radiated field strength within restricted bands worst case measurement results

Channel width, MHz	Antenna gain, dBi	Channel	Emission frequency, MHz	Peak Field strength, dB μ V/m			Average Field strength, dB μ V/m		
				Measured	Limit	Margin, dB	Measured	Limit	Margin, dB
0.875	10	Low	5150	62.04	74.00	11.96	53.69	54.00	0.31
0.875	24	Low	5150	55.46	74.00	18.54	46.57	54.00	7.43
0.875	32	Low	5150	61.00	74.00	13.00	52.03	54.00	1.97
5	10	Low	5150	62.26	74.00	11.74	53.88	54.00	0.12
5	24	Low	5150	57.58	74.00	16.42	48.85	54.00	5.15
5	32	Low	5150	61.92	74.00	12.08	53.98	54.00	0.02
45	10	Low	5150	61.63	74.00	12.37	53.78	54.00	0.22
45	24	Low	5150	61.99	74.00	12.01	53.92	54.00	0.08
45	32	Low	5150	61.35	74.00	12.65	53.96	54.00	0.04

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

The rest of the radiated spurious emissions were more than 15 dB below the limits.

Test data, continued

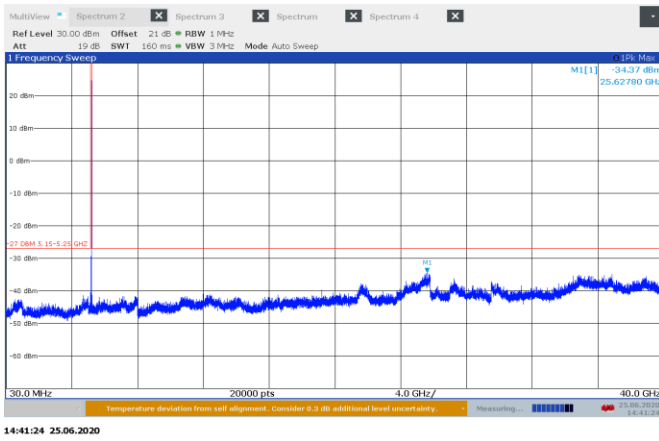


Figure 8.7-1: Conducted spurious emissions up to 40 GHz, 0.875 MHz channel at ch0

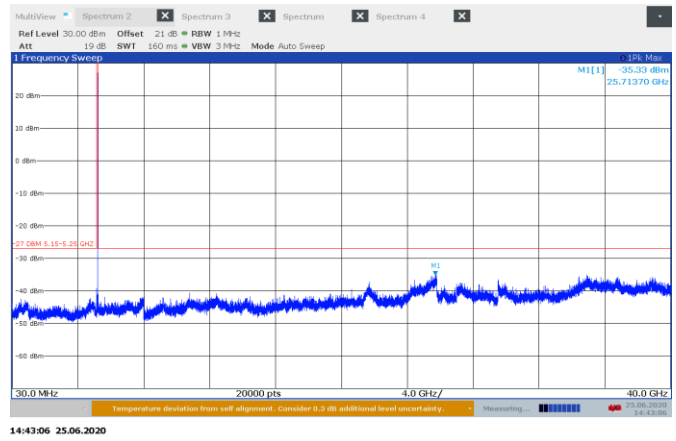


Figure 8.7-2: Conducted spurious emissions up to 40 GHz, 0.875 MHz channel at ch1

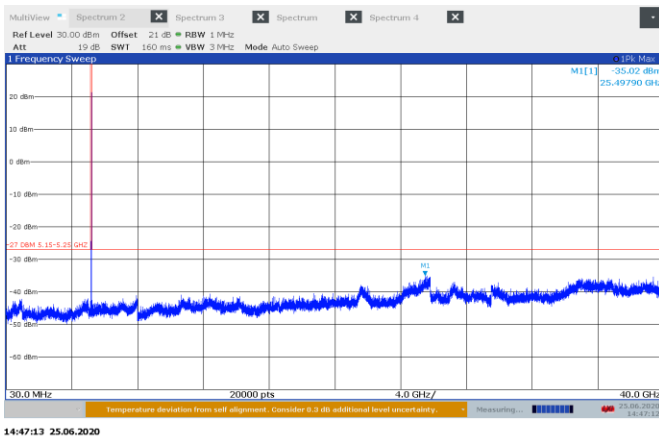


Figure 8.7-3: Conducted spurious emissions up to 40 GHz, 5 MHz channel at ch0

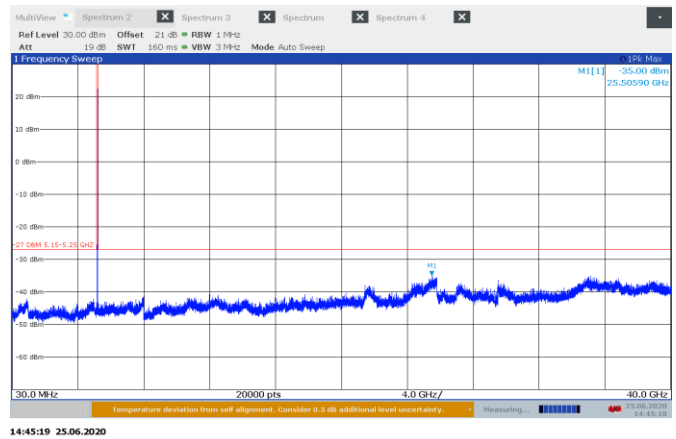


Figure 8.7-4: Conducted spurious emissions up to 40 GHz, 5 MHz channel at ch1

Test data, continued

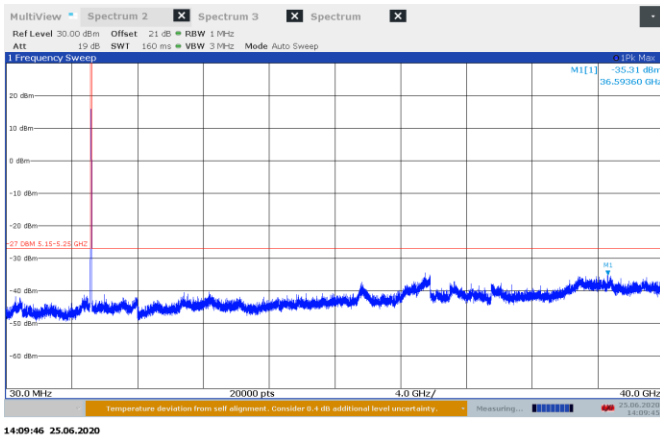


Figure 8.7-5: Conducted spurious emissions up to 40 GHz, 45 MHz channel at ch0

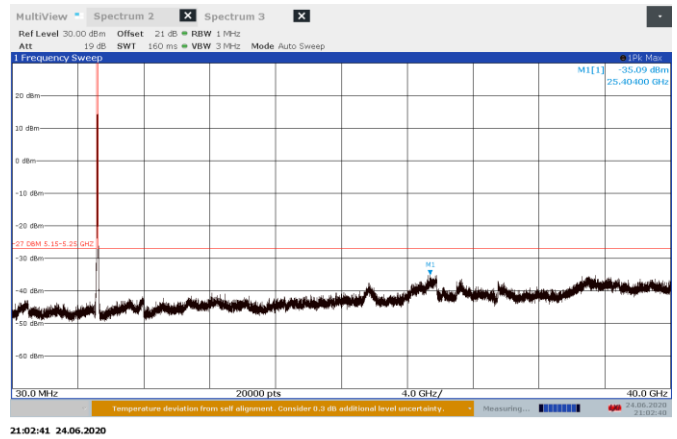


Figure 8.7-6: Conducted spurious emissions up to 40 GHz, 45 MHz channel at ch1

End of the test report