RADIO TEST REPORT

Project Number:
PRJ0030546

Report number:
REP008007

Type of assessment:
Final product testing

Applicant:
Define Design Deploy Corp. dba D3

Product:
AWR1843 AOP Module

Model Number:
RS-1843AOP

FCC ID:
2ASVZ-01

ISED Certification number:
IC: 30644-01

Specifications:
FCC 47 CFR Part 95, Subpart M
RSS-251 Issue 2, July 2018

Date of issue: July 15, 2024

Hossein Zamani Zardehsavari, EMC/RF Specialist
Tested by

Signature

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Reviewed by

Signature

Lab locations

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Test site registration	**Organization**	**Recognition numbers and location**		
	FCC/ISED	FCC: CA2040; IC: 2040A-4 (Ottawa/Almonte); FCC: CA2041; IC: 2040G-5 (Montreal); CA0101 (Cambridge)		
Website	www.nemko.com			

Limits of responsibility

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

Copyright notification

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Section 1 Report summary

1.1 Test specifications

FCC 47 CFR Part 95, Subpart M	The 76–81 GHz Band Radar Service
RSS-251 Issue 2, July 2018	Vehicular Radar and Airport Fixed or Mobile Radar in the 76–81 GHz Frequency Band

1.2 Test methods

ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
FCC 47 CFR Part 2, Subpart J	Equipment authorization procedures
KDB 653005 D01	76–81 GHz Radars v01r02.

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*

Report ID.	Date of issue	Details of changes made to test report
REP008007	July 15, 2024	Original report issued

Section 2 Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

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

2.2 Technical judgment

None

2.3 Model variant declaration

There were no model variants declared by the applicant.

2.4 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
Radiated spurious emissions (30 MHz to 1GHz)	3.78
Radiated spurious emissions (1 GHz to 6 GHz)	4.65
Radiated spurious emissions (6 GHz to 18 GHz)	4.94
Radiated spurious emissions (18 GHz to 26 GHz)	4.37
Radiated spurious emissions (18 GHz to 40 GHz)	4.61
Radiated spurious emissions (40 GHz to 220 GHz)	5.81

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

Name	Define Design Deploy Corp. dba D3
Address	150 Lucius Gordon Dr, West Henrietta, NY 14586

5.3 EUT information

Product name	AWR1843 AOP Module
Model	RS-1843AOP
Serial number	None
Part number	PCA-00C019017
Power supply requirements	5 V_{DC} (from host)
Product description and theory of operation	The primary component is a radar front-end and post processing device. The chip has a full analog RF front end which synthesizes a radar transmission starting at 77 GHz and ramping up to 81 GHz. This transmission is repeated to capture angle and velocity information from the scene. Internal ADC, FFT, and processing cores are used to post process the data and output messages over UART or CAN for an external processor.

5.4 Technical information

System type	Base/Fixed point-to-point system
Frequency band	76–81 GHz
Frequency Min	77 GHz
Frequency Max	81 GHz
RF power Max, EIRP	3.23 W (35.09 dBm)
Measured BW, 99% OBW	4.055 GHz
Type of modulation	FMCW
Emission classification	Analog: F3E
Antenna information	Type – Patch Antenna Manufacturer – Texas Instruments (TI) Model – 1843 Antenna On Package (AOP) Gain: 4 dBi
FMCW specifications	The mmWave SOC is used to detect objects by emitting FMCW mmWave chirps from one or more of its TX antennas. This emission is of type 4G06F0N (4.06 GHz FM with no modulation, carrying no information). The transmitters are swept over the entire 4 GHz bandwidth from 77 to 81 GHz in a sawtooth pattern. The chirp used has 16 repeated sawtooths with a slope of 20 MHz/µs for 200 µs each such that the entire 4 GHz is swept.

5.5 EUT setup details

5.5.1 Radio exercise details

The Module was preinstalled in the typical Host for the testing purposes. The Host model is RS-1843AOPC (referenced as EUT on the diagram below).

Transmitter state	EUT was energized and continuous transmission commenced
Receiver state	EUT was energized and continuous reception commenced

5.5.2 EUT setup configuration

Table 5.5-1: *EUT interface ports*

Description	Qty.
4 pins connector	1

Table 5.5-2: *Support equipment*

Description	Brand name	Model, Part number, Serial number, Revision level
PCAN-USB FD Adapter	Peak system	MN: IPEH-004022 SN: 79959956243
Laptop	Lenovo	SN: PF08X9G6, MN: 80LO

Table 5.5-3: *Inter-connection cables*

Cable description	From	To	Length (m)
4 pins	EUT	PCAN-USB FD Adapter	0.5
USB	PCAN-USB FD Adapter	Laptop	0.5

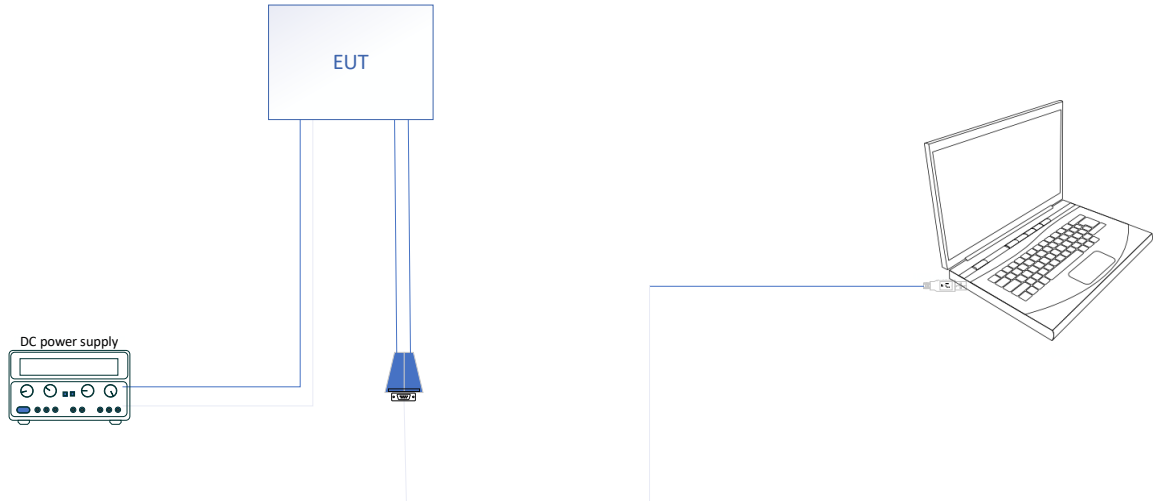

Figure 5.5-1: *Radiated testing block diagram*

Section 6 Summary of test results

6.1 Testing location

Test location (s)	Montreal

6.2 Testing period

Test start date	March 1, 2023	Test end date	October 11, 2023

6.3 Sample information

Receipt date	February 23, 2023	Nemko sample ID number(s)	PRJ00305460001

6.4 FCC Part 2 and 95 Subpart M test requirements results

Table 6.4-1: *FCC requirements results*

Part	Test description	Verdict
§2.1049	Occupied Bandwidth	Pass
§2.1046, §95.3367	Transmitter output power	Pass
§2.1053, §95.3379	Unwanted emissions	Pass
§2.1055(d), §95.3379	Transmitter frequency stability	Pass

Notes: None

6.5 ISED test requirements results

Table 6.5-1: *ISED RSS-Gen results*

Part	Test description	Verdict
6.7	Occupied bandwidth	Pass
7.1	Receiver radiated emission limits	Not applicable[1]
7.2	Receiver conducted emission limits	Not applicable[1]
7.3	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Not applicable[2]

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

[2] Module gets DC power from the host battery

Table 6.5-2: *ISED RSS-251 results*

Part	Test description	Verdict
7	Occupied bandwidth	Pass
8	Average equivalent isotropically radiated power (e.i.r.p.)	Pass
9	Peak e.i.r.p. spectral density	Pass
10	Unwanted emissions	Pass
11	Frequency stability	Pass

Notes: None

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 (Emissions)	TDK	SAC-3	FA002532e	1 year	April 1, 2023
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
Power Meter	HIOKI	PW3337	FA002727	—	NCR
DC Power Supply	Sorensen	SGA80X125C-AAA	FA002738	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	March 3, 2024
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	March 24, 2023
Horn antenna (1–18 GHz)	EMCO	3115	FA001451	1 year	March 10, 2023
Pre-amplifier (18–40 GHz)	Com-Power	PAM-840	FA002508	—	NCR
Signal and Spectrum Analyzer	Rhode&Schwarz	FSW50	FA003267	1 year	December 8, 2023
Hamonic mixer (75-110 GHz)	Rohde & Schwarz	FS-Z110	FA003262	3years	March 2, 2024
Hamonic mixer (50-75 GHz)	Rohde & Schwarz	FS-Z75	FA003263	3years	September 24, 2023
Hamonic mixer (140-220 GHz)	Rohde & Schwarz	FS-Z220	FA003269	3years	December 15, 2023
Hamonic mixer (110-170 GHz)	Rohde & Schwarz	FS-Z170	FA003296	3years	February 18, 2024
Standard gain horn (50-75 GHz)	Mi-Wave	261V-25/385	FA003270	NCR	NCR
Standard gain horn (75-110 GHz)	Mi-Wave	261W-25/387	FA003271	NCR	NCR
Standard gain horn (110-170 GHz)	Mi-Wave	261D-25/387	FA003272	NCR	NCR
Standard gain horn (140-220 GHz)	Mi-Wave	261G-25/385	FA003273	NCR	NCR
Standard gain horn (33-50 GHz)	Mi-Wave	261B-25/383	FA003274	NCR	NCR
Temperature and humidity monitor (EMC/Chamber)	Elpro	RTH1i US	FA003281	3 years	April 2, 2024

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

Section 8 Testing data

8.1 Transmitter Output Power

8.1.1 References, definitions and limits

FCC §95.3367

The fundamental radiated emission limits within the 76-81 GHz band are expressed in terms of Equivalent Isotropically Radiated Power (EIRP) and are as follows:

(a) The maximum power (EIRP) within the 76-81 GHz band shall not exceed 50 dBm based on measurements employing a power averaging detector with a 1 MHz Resolution Bandwidth (RBW).

(b) The maximum peak power (EIRP) within the 76-81 GHz band shall not exceed 55 dBm based on measurements employing a peak detector with a 1 MHz RBW.

$$EIRP = E_{meas} + 20\log(d_{meas}) - 104.7$$

where E_{meas} is measured electric field at distance of d_{meas}

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8.1 The average e.i.r.p. measurement shall be performed using a power averaging detector with a 1 MHz resolution bandwidth (RBW). The power shall be integrated over the occupied bandwidth.

8.2 The radar device's total average e.i.r.p. shall not exceed 50 dBm over the occupied bandwidth.

9.1 The peak e.i.r.p. measurement shall be performed by sweeping the transmitted occupied bandwidth with a positive peak power detector, using a peak hold display mode, and a 1 MHz resolution bandwidth. The power integration is not to be used in performing this measurement.

9.2 The radar device's peak e.i.r.p. spectral density shall not exceed 55 dBm/MHz.

8.1.2 Test summary

Verdict	Pass		
Tested by	Hossein Zamani	Test date	October 11, 2023

8.1.3 Observations, settings and special notes

Duty Cycle Correction Factor (DCCF) = 10 × Log_{10} [T_{on}/(T_{on}+T_{off})] = 10 × Log_{10} (8.9 µs / (8.9 µs + 195 µs)) = −13.6 dB
Measurement of peak power was performed per ANSI C63.26 subclause 5.2.3.3.

Spectrum analyser settings:

Resolution bandwidth	1 MHz
Video bandwidth	≥ 3 × RBW
Frequency span	≥ 2 × OBW
Detector mode	Peak, and RMS
Trace mode	Peak Max Hold, and RMS average
Sweep time	≥ 10 × (number of points in sweep) × (transmission symbol period)

8.1.4 Test data

Table 8.1-1: *Transmitter total power results FCC and ISED*

Frequency, GHz	EIRP, dBm/OBW	Detector type	DCCF, dB	Corrected EIRP/OBW	Limit type	Limit, dBm/OBW	Margin, dB
77.09790	35.09	RMS (e.r.i.p)	-13.6	21.49	Average	50.00	28.51

Table 8.1-2: *Transmitter power results FCC and ISED*

Frequency, GHz	EIRP, dBm/MHz	Detector type	Limit type	Limit, dBm/MHz	Margin, dB
77.09790	9.00	RMS (e.r.i.p)	Average	50.00	41.00
77.09790	15.24	Peak (e.r.i.p)	Peak	55.00	53.36

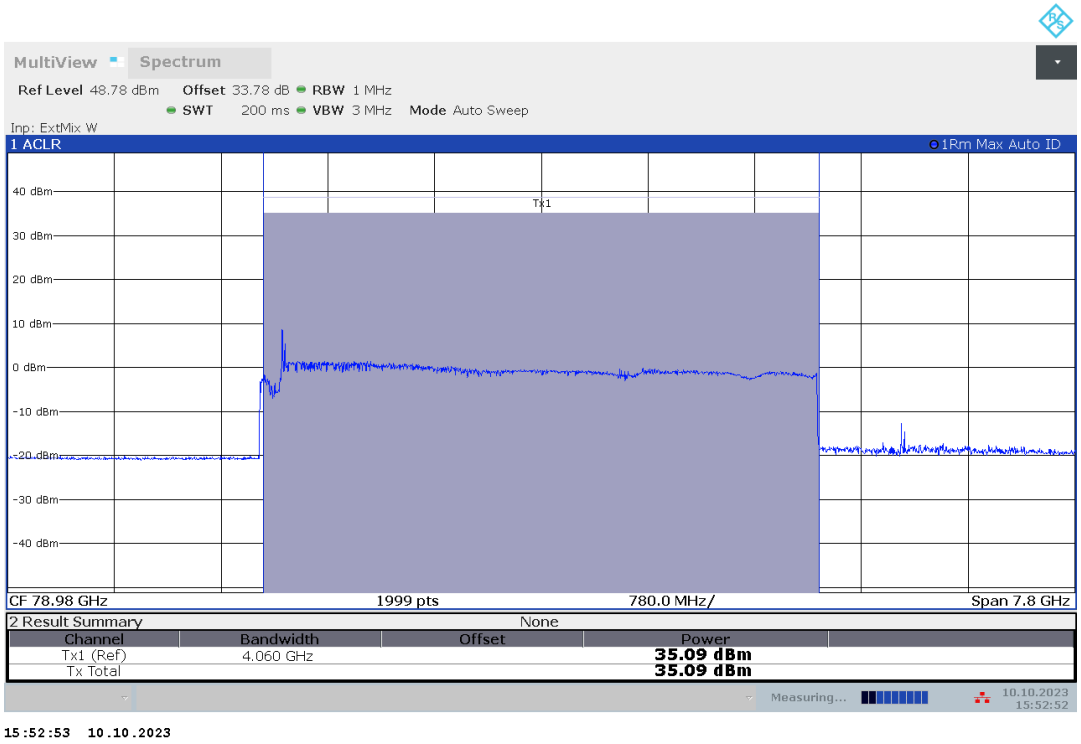

Figure 8.1-1: *EIRP for FCC and ISED (RMS detector)*

Note: [1]ERIP(dBm)= $E_{meas+20log(d_{meas})-95.23}$

[2]Offset(dB)=-9.54 dB (distance offset from 3m to 1m) + 43.32 dB/m (Antenna factor)

Test data, continued

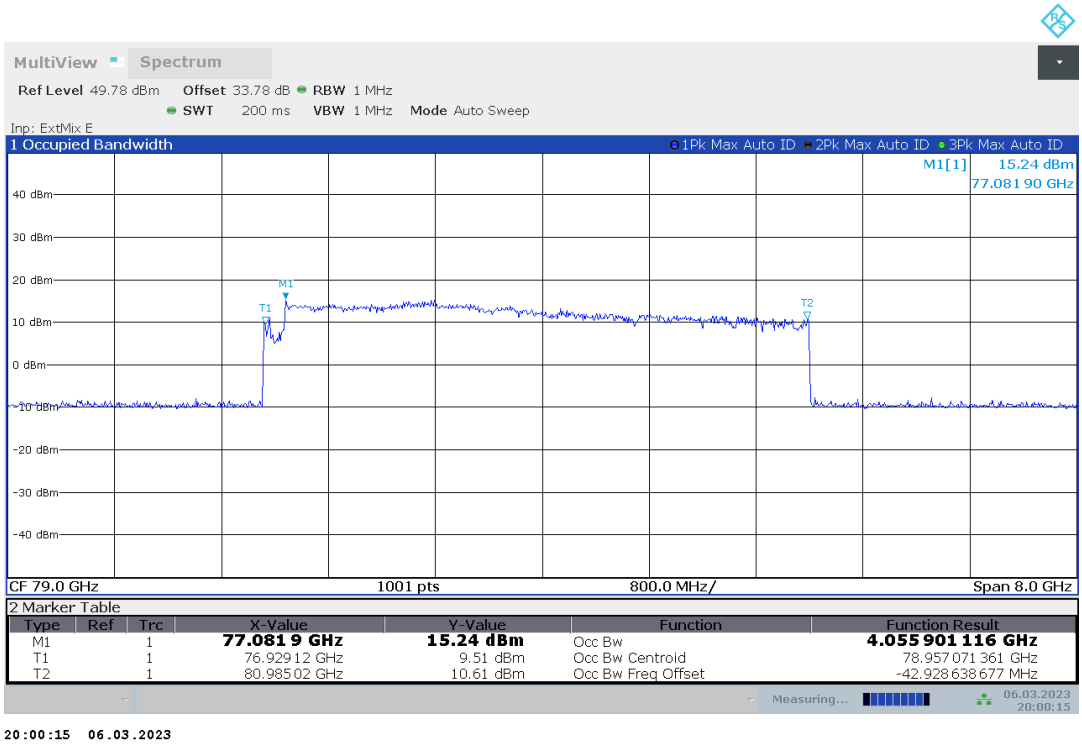

Figure 8.1-2: *EIRP for FCC and ISED (Peak detector)*

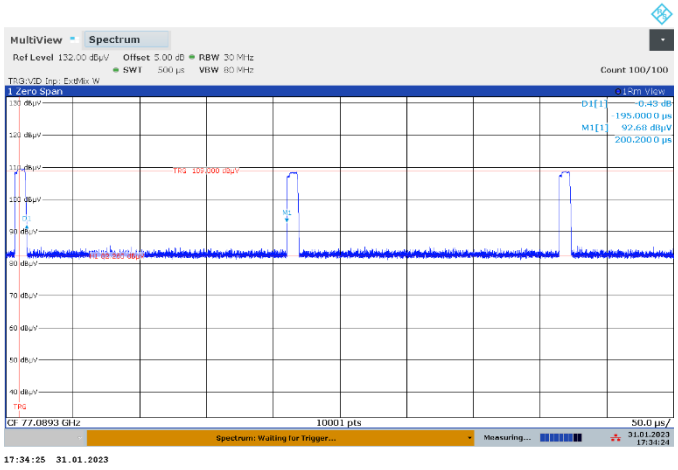

Figure 8.1-3: *pulse off time*

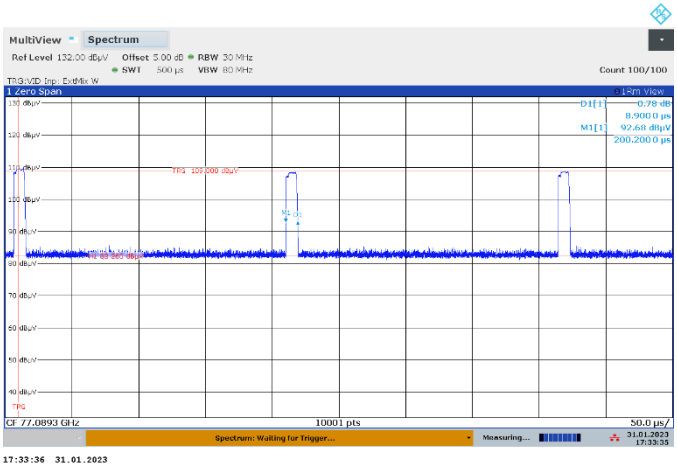

Figure 8.1-4: *pulse on time*

Note: Duty Cycle Correction Factor (DCCF) = 10 × Log_{10} [T_{on}/(T_{on}+T_{off})] = 10 × Log_{10} (8.9 µs / (8.9 µs + 195 µs)) = −13.6 dB

8.2 Occupied Bandwidth

8.2.1 References, definitions and limits

FCC §2.1049 and § 95.3361

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured

RSS-Gen, Clause 6.7:

7.2 The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be contained in the 76-81 GHz frequency band.

8.2.2 Test summary

Verdict	Pass		
Tested by	Hossein Zamani	Test date	March 6, 2023

8.2.3 Observations, settings and special notes

The test was performed as per ANSI C63.26, subclause 5.4.4.

Spectrum analyser settings:

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

8.2.4 Test data

Table 8.2-1: *Occupied Bandwidth limit*

Frequency min, GHz	Frequency min limit GHz	Frequency min, margin, GHz	Frequency max, GHz	Frequency max limit, GHz	Frequency min, margin GHz
77.0819	76	1.09790	80.98502	81	0.01498

Table 8.2-2: *99% occupied bandwidth results*

Modulation	Frequency range, GHz	99% occupied bandwidth, GHz
FMCW	77–81	4.055901116

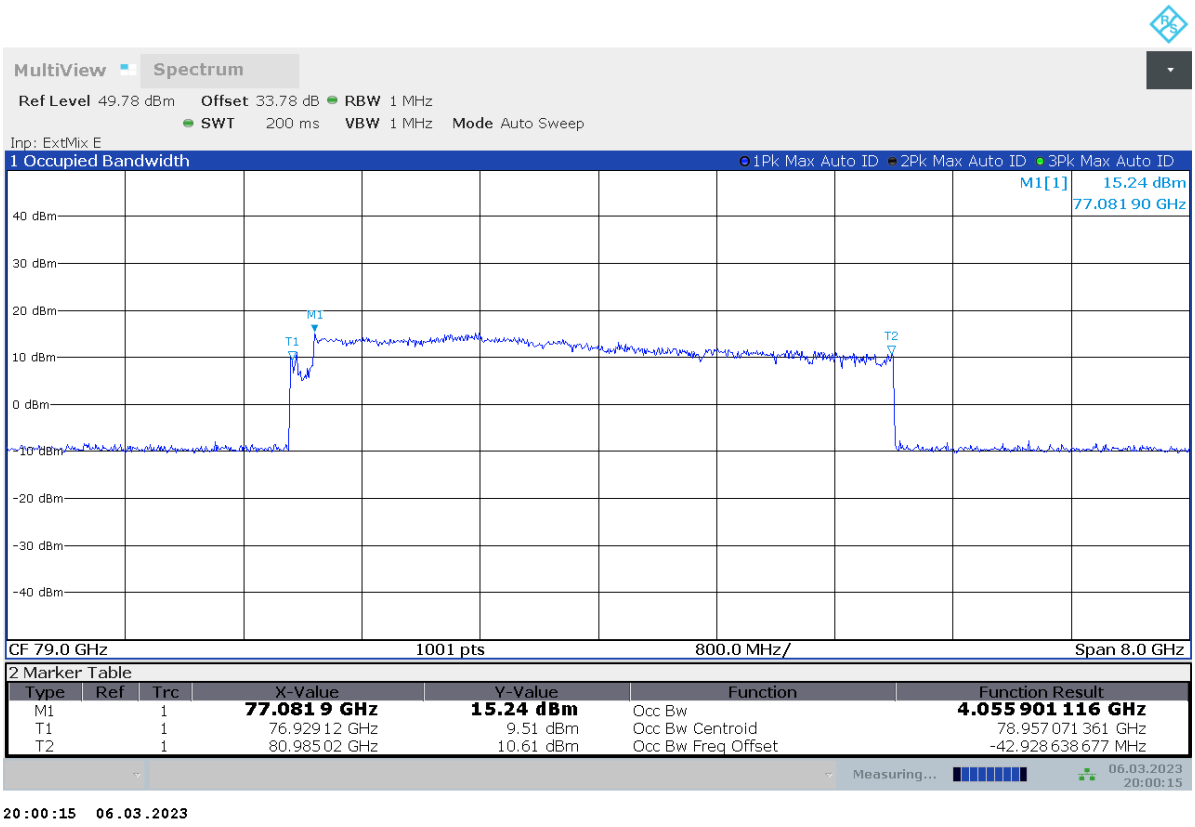

Figure 8.2-1: *Occupied Bandwidth*

8.3 Spurious emissions

8.3.1 References, definitions and limits

FCC §95.3379

(a) The power density of any emissions outside the 76-81 GHz band shall consist solely of spurious emissions and shall not exceed the following:

(1) Radiated emissions below 40 GHz shall not exceed the field strength as shown in the following emissions table

Table 8.3-1: *15.209 and RSS-Gen emissions field strength limits*

Frequency, MHz	Field strength of emissions µV/m	dBµV/m	Measurement distance, m
0.009–0.490	2400/F	67.6 – 20 × $\log_{10}$(F)	300
0.490–1.705	24000/F	Section 9 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

(2) The power density of radiated emissions outside the 76-81 GHz band above 40.0 GHz shall not exceed the following, based on measurements employing an average detector with a 1 MHz RBW:

(i) For radiated emissions outside the 76-81 GHz band between 40 GHz and 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 600 pW/cm^2 at a distance of 3 meters from the exterior surface of the radiating structure.

(ii) For radiated emissions above 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 1000 pW/cm^2 at a distance of 3 meters from the exterior surface of the radiating structure.

(3) For field disturbance sensors and radar systems operating in the 76-81 GHz band, the spectrum shall be investigated up to 231.0 GHz.

(b) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

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10.1 In addition to the requirements specified in RSS-Gen and the method of measurement of ANSI C63.10, the spectrum shall be investigated up to 162 GHz.

10.2 The radar device's unwanted emissions outside the 76-81 GHz frequency band shall comply with the limits in table 1, below.

Table 8.3-2: *Unwanted emissions limits outside the 76-81 GHz frequency band*

Frequency, MHz	Field strength of emissions dBm/MHz	dBµV/MHz	Applicable detector
Below 40 GHz	RSS-Gen general field strength limits for licence-exempt radio apparatus		
40-162 GHz	-30	65.23	RMS detector

Notes: For radar devices that operate solely in the 76-77 GHz band (i.e. the occupied bandwidth is entirely contained in the 76-77 GHz band), an unwanted emissions limit of 0 dBm/MHz shall apply for the unwanted emission that fall in the 73.5-76 GHz band. Outside of the 73.5-76 GHz band, the unwanted emission limits prescribed in table 1 shall apply.

8.3.2 Test summary

Verdict	Pass		
Tested by	Hossein Zamani	Test date	March 6, 2023

8.3.3 Observations, settings and special notes

Spectrum analyser settings for spurious emissions:

Resolution bandwidth:	100kHz (below 1 GHz); 1 MHz (above 1 GHz)
Video bandwidth:	> RBW
Detector mode:	Peak
Trace mode:	Max Hold
Distance	3 m (30 MHz to 18 GHz), 1 m (18 GHz to 110 GHz), 30 cm (above 110 GHz)

Equations to calculate power density:

Convert the EIRP in dBm to the EIRP in watts using:

$$EIRPLinear = 10^{[(EIRPLog - 30)/10]}$$

Where, EIRP Linear is the equivalent isotropically radiated power, in watts and EIRP Log is the equivalent isotropically radiated power, in dBm

Calculate the power density at the distance specified by the limit from the EIRP in watts using Equation:

$$PD = EIRPLinear / 4\pi d^2$$

Where, PD is the power density at the distance specified by the limit, in W/m^2 and EIRPLinear is the equivalent isotropically radiated power, in watts

d is the distance at which the power density limit is specified, in m.

According to FCC §95.3379(2)(i), the radiated emission limit outside the 76–81 GHz band between 40 GHz and 200 GHz is 600 pW/cm^2 at a distance of 3 meters from the exterior surface of the radiating structure. As per above equation

$$EIRPLinear = PD \times 4\pi d^2 = 0.000006 * 4 * \pi * 9 = 0.0006786\ W$$

$$EIRPdBm = -1.69$$

$$EIRPdB\mu V/m = 93.54$$

According to FCC §95.3379 (2) (ii), the radiated emission limit outside the 76–81 GHz band above 200 GHz is 1000 pW/cm^2 at a distance of 3 meters from the exterior surface of the radiating structure. As per above equation

$$EIRPLinear = PD \times 4\pi d^2 = 0.00001 * 4 * \pi * 9 = 0.001131\ W$$

$$EIRPdBm = 0.53$$

$$EIRPdB\mu V/m = 93.86$$

8.3.4 Test data

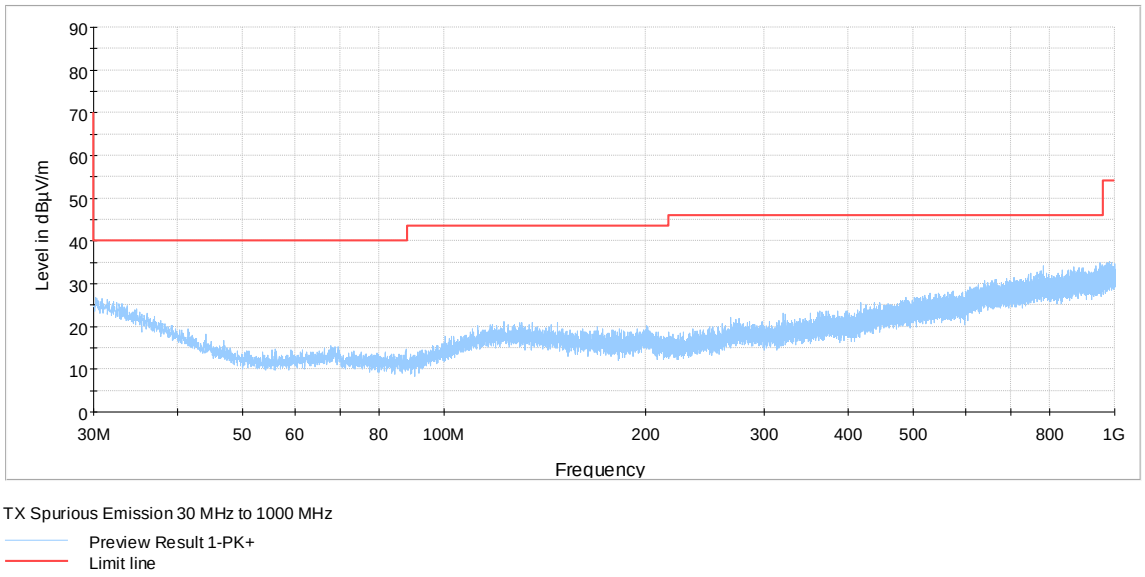

Figure 8.3-1: *Radiated spurious emissions within 30 to 1000 MHz*

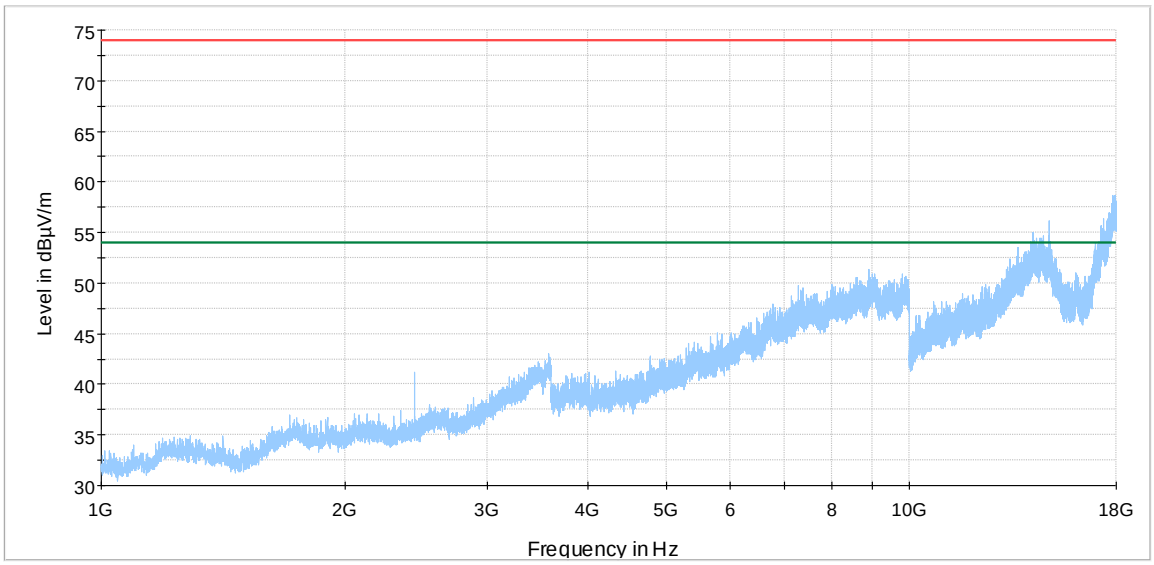

Figure 8.3-2: *Radiated spurious emissions within 1 to 18 GHz*

Note: At the frequencies where the noise floor exceeds the limit, the spectrum was verified and all those exceeding levels are of the noise floor.

8.3.4 Test data, continued

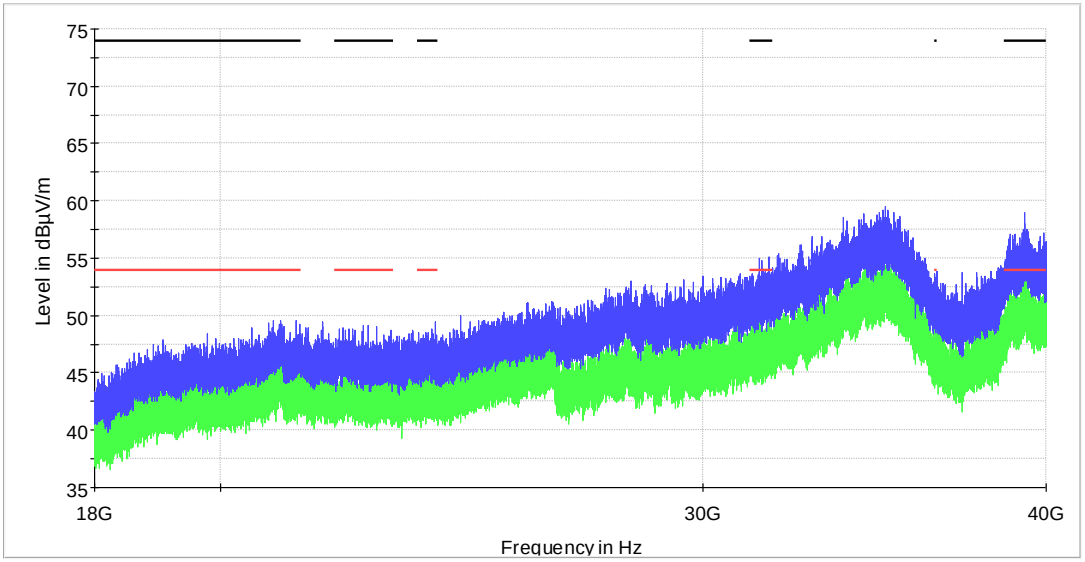

Figure 8.3-3: *Radiated spurious emissions within 18 to 40 GHz*

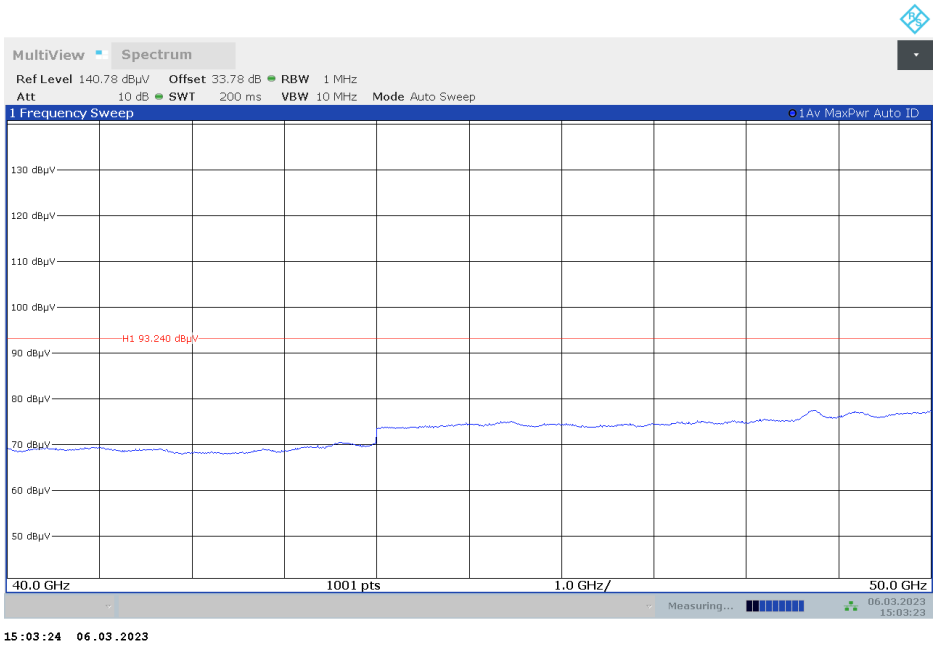

Figure 8.3-4: *Radiated spurious emissions within 40 to 50 GHz (FCC limit line)*

8.3.4 Test data, continued

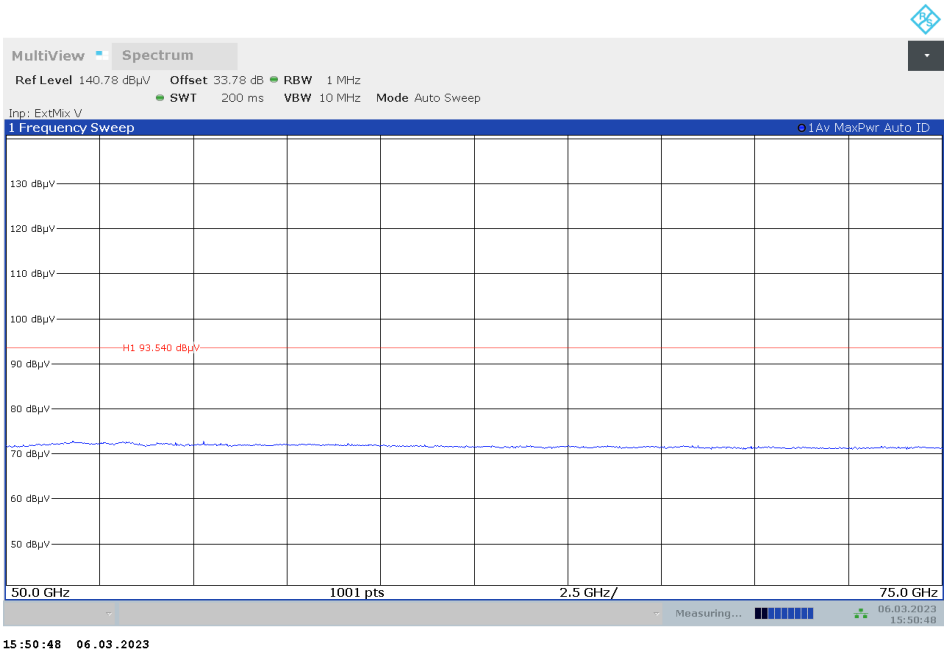

Figure 8.3-5: *Radiated spurious emissions within 50 to 75 GHz (FCC limit line)*

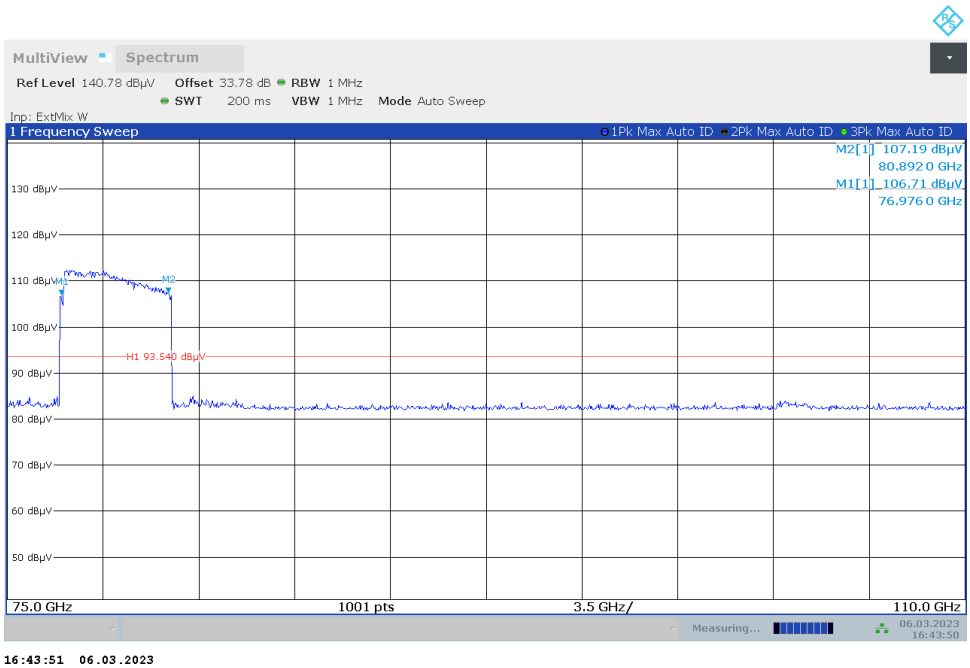

Figure 8.3-6: *Radiated spurious emissions within 75 to 110 GHz (FCC limit line)*

8.3.4 Test data, continued

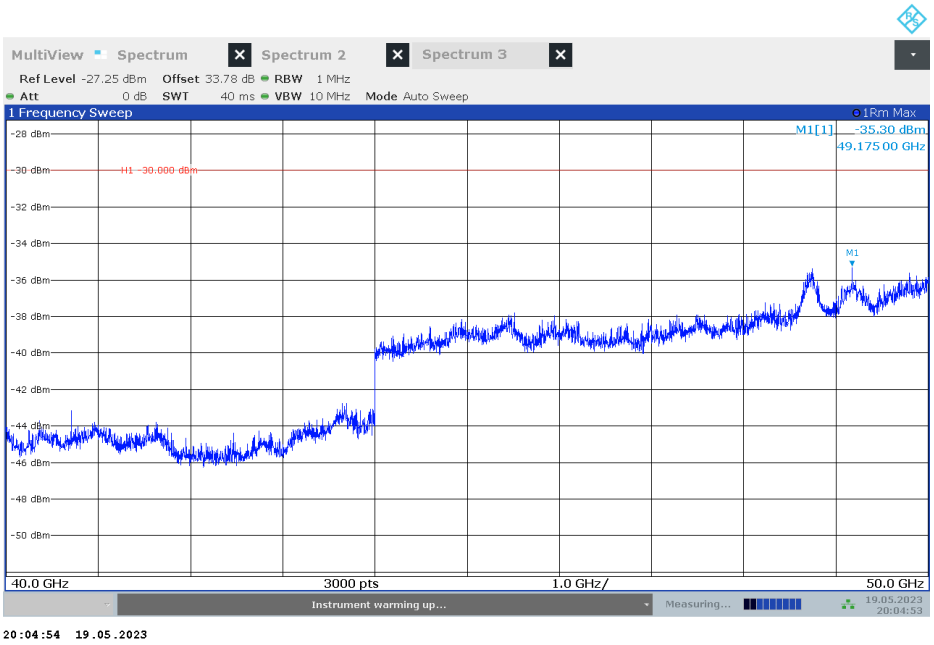

Figure 8.3-7: *Radiated spurious emissions within 40 to 50 GHz (RSS limit line)*

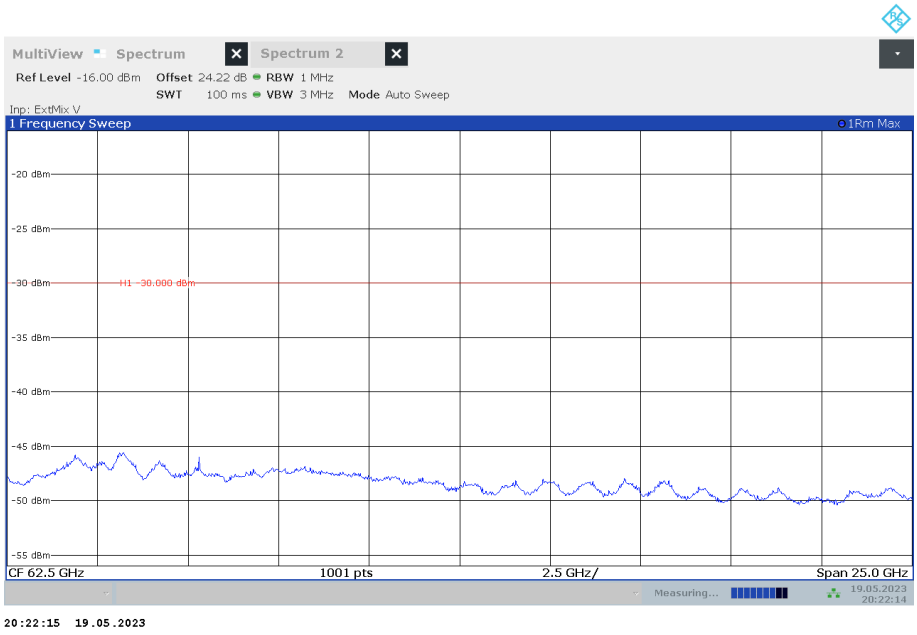

Figure 8.3-8: *Radiated spurious emissions within 50 to 75 GHz (RSS limit line)*

8.3.4 Test data, continued

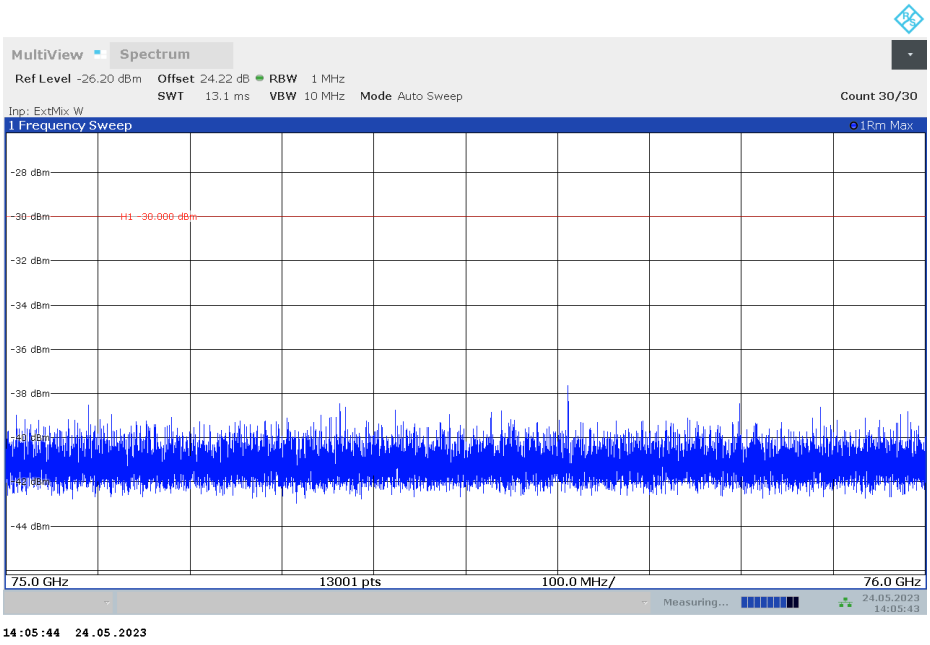

Figure 8.3-9: *Radiated spurious emissions within 75 to 76 GHz (RSS limit line)*

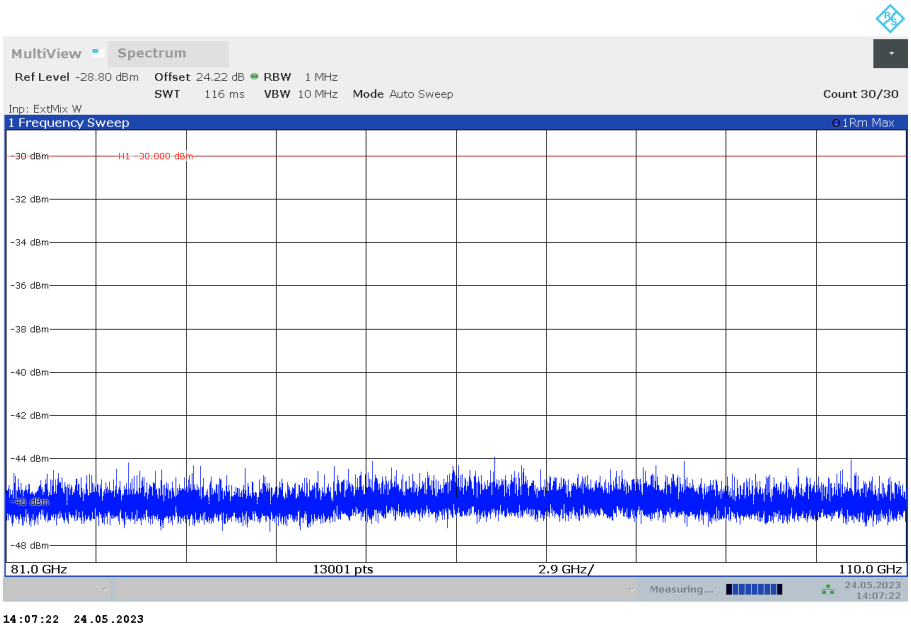

Figure 8.3-10: *Radiated spurious emissions within 81 to 110 GHz (RSS limit line)*

Note: No emission are observed above 110 GHz.

8.4 Transmitter frequency stability

8.4.1 References, definitions and limits

FCC§2.1055 (d), §95.3379

(b) Fundamental emissions must be contained within the frequency bands specified in this section during all conditions of operation. Equipment is presumed to operate over the temperature range −20 to +50 degrees Celsius with an input voltage variation of 85% to 115% of rated input voltage, unless justification is presented to demonstrate otherwise.

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(b) Fundamental emissions shall be contained within the 76-81 GHz frequency band during all conditions of operation when tested at the temperature and voltage variations specified for the frequency stability measurement in RSS-Gen.

8.4.2 Test summary

Verdict	Pass		
Tested by	Hossein Zamani	Test date	March 6, 2023

8.4.3 Observations, settings and special notes

Test was performed on supply voltage variations as per client rated, no frequency deviation was observed.

8.4.3 Test data

Table 8.4-1: *Transmitter frequency stability results*

Test conditions	Frequency, GHz	Limit GHz
+50 °C, Nominal	76.9395	76
+40 °C, Nominal	76.9337	76
+30 °C, Nominal	76.9309	76
+20 °C, Nominal	76.9557	Reference
+10 °C, Nominal	76.9466	76
0 °C, Nominal	76.9052	76
−10 °C, Nominal	76.9324	76
−20 °C, Nominal	76.9537	76
20 °C, 85%	76.9545	76
20 °C, 115%	76.9326	76

Table8.4-2: *Transmitter frequency stability results*

Test conditions	Frequency, GHz	Limit GHz
+50 °C, Nominal	80.96512	81
+40 °C, Nominal	80.96443	81
+30 °C, Nominal	80.93561	81
+20 °C, Nominal	80.97661	Reference
+10 °C, Nominal	80.97544	81
0 °C, Nominal	80.96323	81
−10 °C, Nominal	80.96214	81
−20 °C, Nominal	80.97415	81
20 °C, 85%	80.96478	81
20 °C, 115%	80.96265	81