Test report

REP0030760-2R1TRFWL

Date of issue: May 26, 2023

Applicant:

Echodyne Corporation

Product:

Ku Band Radar

Model:

EchoShield 700025-200

Variant(s):

N/A

FCC ID:

2ANLB-MESA00054

Specifications:

- FCC CFR 47 Part 90
  Private land mobile radio services – radiolocation service
- FCC CFR 47 Part 2
  Frequency Allocations and Radio Treaty Matters, General Rules and Regulations

Lab and test locations

Company name	Nemko USA Inc.
Address	2210 Faraday Ave, Suite 150
City	Carlsbad
State	California
Postal code	92008
Country	USA
Telephone	+1 760 444 3500
Website	www.nemko.com
FCC Site Number	Test Firm Registration Number: 392943; Designation Number: US5058
ISED Test Site	2040B-3

Tested by	Martha Espinoza, Wireless Test Engineer
Reviewed by	James Cunningham, EMC/Wireless Manager
Review date	May 26, 2023
Reviewer signature	

Limits of responsibility

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

Copyright notification

Table of Contents

Section 1 Report summary

1.1 Test specifications

FCC CFR 47 Part 2	Frequency Allocations and Radio Treaty Matters General Rules and Regulations
FCC 47 CFR Part 90	Private land mobile radio services

1.2 Test methods

ANSI C63.26-2015	American National Standard of Procedures for Compliance Testing of Transmitters Used in Licensed Radio Services

1.3 Exclusions

None.

1.4 Statement of compliance

Testing was performed against all relevant requirements of the test standard(s).

Results obtained indicate that the product under test complies in full with the tested requirements.

The test results relate only to the item(s) tested.

See “Section 2 Summary of test results” for full details.

1.5 Test report revision history

Table 1.5-1: *Test report revision history*

Revision #	Issue Date	Details of changes made to test report
REP0030760-2TRFEMC	May 8, 2023	Original report issued
REP0030760-2R1TRFEMC	May 26, 2023	Test method typo: C63.10 was replaced by C63.26 (pages 22, 28,39). Calculation added at page 22.

Section 2 Summary of test results

2.1 FCC Part 2 and Part 90 test results

Part	Test description	Verdict
§90.205	Power and antenna heigh limits	Pass
§90.207	Types of emissions	Pass
§90.209	Bandwidth limitations (99% OBW)	Pass
§90.209	Frequency stability	Pass
§90.210	Emission masks: Emission limitations	Pass
§90.210	Emission masks: Transmitter spurious emissions	Pass

Note: None

Section 3 Equipment under test (EUT) details

3.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

3.2 Sample information

Receipt date	24-Mar-23
Nemko sample ID number	REP0030760

3.3 Testing period

Test start date	27-Mar-23
Test end date	06-Apr-23

3.4 Applicant

Company name	Echodyne Corporation
Address	12112 115th Ave NE
City	Kirkland
State	WA
Postal/Zip code	98034
Country	United States of America

3.5 Manufacturer

Company name	Echodyne Corporation
Address	12112 115th Ave NE
City	Kirkland
State	WA
Postal/Zip code	98034
Country	United States of America

3.6 EUT information

Product name	Ku Band Radar
Model	EchoShield 700025-200
Variant(s)	N/A
Serial number	N/A
Part number	N/A
Power requirements	28 VDC
Description/theory of operation	Ground-based location and navigation radar
Software details	N/A
Operating band	Ku Band: 15.7 GHz - 17.3 GHz
Operational frequencies	15.75 GHz – 16.15 GHz – 16.55 GHz (25 MHz BW); 15.80 GHz – 16.15 GHz – 16.50 GHz (50 MHz BW); 15.85 GHz – 16.15 GHz – 16.45 GH (100 MHz BW); 15.90 GHz – 16.15 GHz – 16.40 GHz (200 MHz BW).
Antenna type	AESA (Active Electronically Scanned Array)
Antenna gain (declared)	27 dBi

3.7 EUT exercise and monitoring details

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

- EUT was configured with a channel frequency and bandwidth fixed via ethernet port using a computer (via client's software).

EUT setup/configuration rationale:

- The EUT was set up in a configuration that was expected to produce the highest amplitude emissions.

3.8 EUT setup details

Table 3.8-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number	Rev.
N/A	N/A	N/A	N/A	N/A

Table 3.8-2: *EUT interface ports*

Description	Qty.
1G Base-T Ethernet.	1

Table 3.8-3: *Support equipment*

Description	Brand name	Model/Part number	Serial number	Rev.
Control PC	ThinkPad	N/A	N/A	N/A
Universal AC/DC Power supply	Echodyne	N/A	N/A	--
Junction Box (1 Channel)	Echodyne	N/A	N/A	--

Table 3.8-4: *Inter-connection cables*

Cable description	From	To	Length (m)
Primary radar cable	EUT	Junction Box (1 CH)	2
CAT5e 1G Ethernet cable	Junction Box (1 CH)	Control PC	5
DC Power cable	Junction Box (1 CH)	Universal AC/DC Power supply	2
NEMA 5-15P Cable	AC Outlet	Universal AC/DC Power supply	1

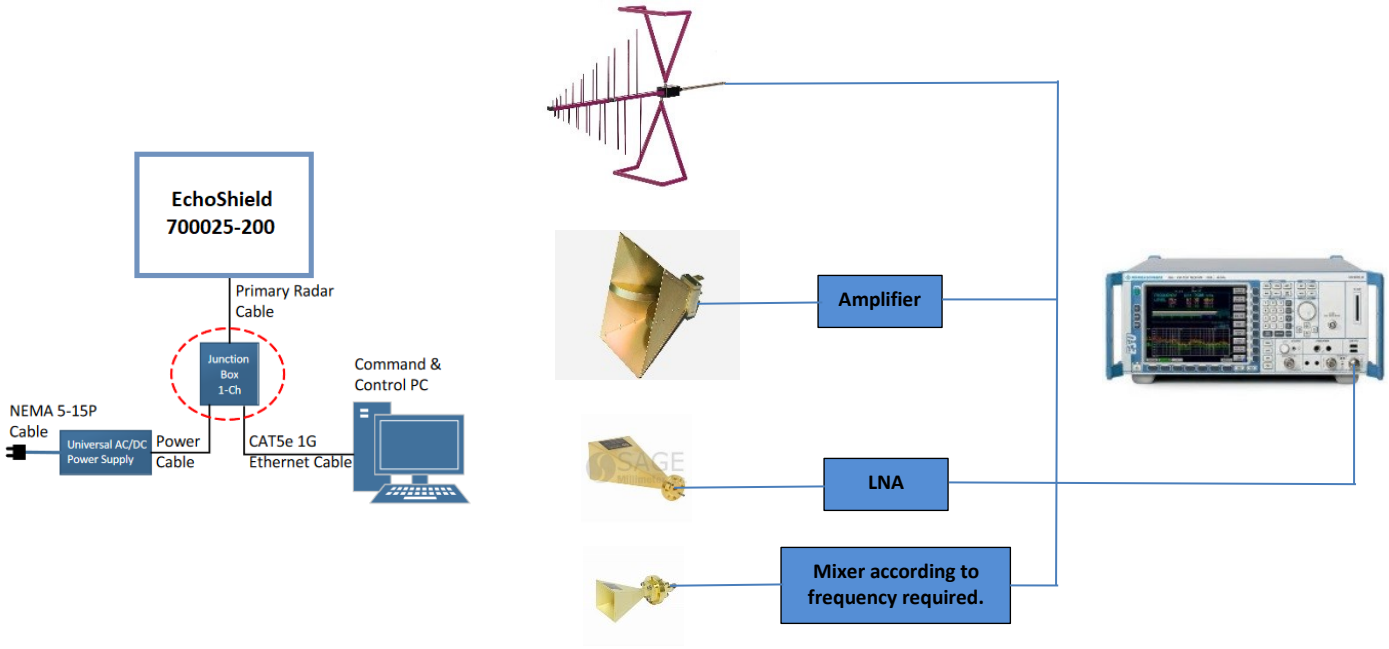

Figure 3.8-1: Test setup diagram

Section 4 Engineering considerations

4.1 Modifications incorporated in the EUT

None.

4.2 Technical judgement

None.

4.3 Deviations from laboratory test procedures

None.

Section 5 Test conditions

5.1 Atmospheric conditions

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

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

5.2 Power supply range

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

Section 6 Measurement uncertainty

6.1 Uncertainty of measurement

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

Table 6.1-1: *Measurement uncertainty calculations*

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

Notes: Compliance assessment:

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

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

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

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

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

Section 7 Test equipment

7.1 Test equipment list

Table 7.1-1: *Test equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
Signal & Spectrum Analyzer 2Hz / 43.5 GHz	Rohde & Schwarz	FSW43	E1302	1 year	Oct-20-2023
Antenna Horn	EMCO	3115	1033	2 years	Nov-02-2024
EMC Test Receiver	Rohde & Schwarz	ESU 40	E1121	1 year	May-31-2023
Antenna, Bilog	Schaffner-Chase	CBL6111C	1480	1 year	Feb-21-2024
Antenna, Horn	ETS-Lingren	3117-PA	E1139	2 years	April-19-2023
Standard Gain Horn Antenna	Eravant	SAZ-2410-42-S1	EW107	1 year	Nov-22-2023
Standard Gain Horn Antenna	Eravant	SAZ-2410-2-S1	EW108	1 year	Nov-22-2023
Low Noise Amplifier	Sage Millimeter	SBL-1834034030-KFKF-SI	E1228	NCR	NCR
Antenna, Horn	Sage Millimeter	SAR-2309-19-S2	E1144	NCR	NCR
Mixer	Rohde & Schwarz	FS-Z60	E1138	VOU	VOU
Antenna, Horn	Sage Millimeter	SAR-2408-15-S2	E1152	NCR	NCR
Mixer	Rohde & Schwarz	FS-Z75	E1149	VOU	VOU
Antenna, Horn	Sage Millimeter	SAR-2507-10-S2	E1146	NCR	NCR
Mixer	Rohde & Schwarz	FS-Z110	E1154	VOU	VOU
Environmental chamber	Cincinnati Sub-Zero	ZPH-32-2-2-H/ACa	S1179	1 year	Aug-29-2023
Low pass filter	RF-Lambda	RLPF13G14	PBC	VOU	VOU
High pass filter	Anatech Electronics	AE18000SSH6616	PBC	VOU	VOU
High pass filter	Anatech Electronics	AE18000SSH6615	PBC	VOU	VOU

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

Table 7.1-2: *Test software details*

Manufacturer of Software	Details
Rohde & Schwarz	EMC 32 V10.60.15

Notes: None

Section 8 Testing data

8.1 Bandwidth of emission (99%)

8.1.1 References and limits

- FCC 47 CFR Part 90: §90.209
- Test method: ANSI C63.26-2014 (5.4.4)

Each authorization issued to a station licensed under this part will show an emission designator representing the class of emission authorized. The designator will be prefixed by a specified necessary bandwidth. This number does not necessarily indicate the bandwidth occupied by the emission at any instant. In those cases where § 2.202 of this chapter does not provide a formula for the computation of necessary bandwidth, the occupied bandwidth, as defined in part 2 of this chapter, may be used in lieu of the necessary bandwidth.

8.1.2 Test summary

Verdict	Pass		
Test date	March 29, 2023; March 30, 2023; March 31, 2023; April 3, 2023	Temperature	19°C; 20°C; 18°C; 20°C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003mbar; 1005mbar; 1006mbar; 1001mbar
Test location	☐ Wireless bench ☒ Other: 3M Chamber	Relative humidity	58%; 59%; 56%; 57%

8.1.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power.
Two modes related to the width of the radar pulse were tested and the summary of the time duration of each pulse is described in the following table:

Frequency	Bandwidth declared	Type of pulse	Time duration
15.75 GHz	25 MHz	Longest pulse	30 µs
16.15 GHz	25 MHz	Longest pulse	30 µs
16.55 GHz	25 MHz	Longest pulse	30 µs
15.80 GHz	50 MHz	Longest pulse	30 µs
16.15 GHz	50 MHz	Longest pulse	30 µs
16.50 GHz	50 MHz	Longest pulse	30 µs
15.85 GHz	100 MHz	Longest pulse	30 µs
16.15 GHz	100 MHz	Longest pulse	30 µs
16.45 GHz	100 MHz	Longest pulse	30 µs
15.90 GHz	200 MHz	Longest pulse	28.494 µs
16.15 GHz	200 MHz	Longest pulse	28.494 µs
16.40 GHz	200 MHz	Longest pulse	28.494 µs
15.75 GHz	25 MHz[1]	Shortest pulse	2 µs
16.15 GHz	25 MHz[1]	Shortest pulse	1 µs
16.55 GHz	25 MHz[1]	Shortest pulse	2 µs
15.80 GHz	50 MHz[1]	Shortest pulse	5 µs
16.15 GHz	50 MHz[1]	Shortest pulse	500 ns
16.50 GHz	50 MHz[1]	Shortest pulse	5 µs
15.85 GHz	100 MHz[1]	Shortest pulse	5 µs
16.15 GHz	100 MHz[1]	Shortest pulse	500 ns
16.45 GHz	100 MHz[1]	Shortest pulse	5 µs
15.90 GHz	200 MHz[1]	Shortest pulse	15 µs
16.15 GHz	200 MHz[1]	Shortest pulse	500 ns
16.40 GHz	200 MHz[1]	Shortest pulse	15 µs

Note 1: These bandwidths are declared only as reference, the real number is shown in table 8.1-2 of this section.

Table 8.1-1: *Pulse description table*.

Testing was done at 3 meters with the antenna and turntable fixed. A maximization of the signal was done to define the position of the max power:
Antenna heigh: 150 cm
Turntable: 4.5 Degrees

8.1.4 Setup details

EUT power input during test	28 V DC
EUT setup configuration	☐ Table-top ☐ Floor standing ☒ Other: Tripod mounted (1.5 m)

Receiver settings:

Resolution bandwidth	Approximately 1-5 % of the emission bandwidth
Video bandwidth	Approximately 3 x resolution bandwidth
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.1.5 Test data

Frequency	Bandwidth	Type of pulse	Time duration
15.75 GHz	24.566 MHz	Longest pulse	30 µs
16.15 GHz	24.741 MHz	Longest pulse	30 µs
16.55 GHz	24.567 MHz	Longest pulse	30 µs
15.80 GHz	48.316 MHz	Longest pulse	30 µs
16.15 GHz	48.541 MHz	Longest pulse	30 µs
16.50 GHz	48.457 MHz	Longest pulse	30 µs
15.85 GHz	97.556 MHz	Longest pulse	30 µs
16.15 GHz	97.820 MHz	Longest pulse	30 µs
16.45 GHz	97.132 MHz	Longest pulse	30 µs
15.90 GHz	193.589 MHz	Longest pulse	28.494 µs
16.15 GHz	193.791 MHz	Longest pulse	28.494 µs
16.40 GHz	193.061 MHz	Longest pulse	28.494 µs
15.75 GHz	27.328 MHz	Shortest pulse	2 µs
16.15 GHz	28.783 MHz	Shortest pulse	1 µs
16.55 GHz	27.181 MHz	Shortest pulse	2 µs
15.80 GHz	49.022 MHz	Shortest pulse	5 µs
16.15 GHz	57.745 MHz	Shortest pulse	500 ns
16.50 GHz	49.049 MHz	Shortest pulse	5 µs
15.85 GHz	97.763 MHz	Shortest pulse	5 µs
16.15 GHz	105.705 MHz	Shortest pulse	500 ns
16.45 GHz	97.407 MHz	Shortest pulse	5 µs
15.90 GHz	193.505 MHz	Shortest pulse	15 µs
16.15 GHz	194.452 MHz	Shortest pulse	500 ns
16.40 GHz	192.795 MHz	Shortest pulse	15 µs

Table 8.1-2: *99% OBW results*.

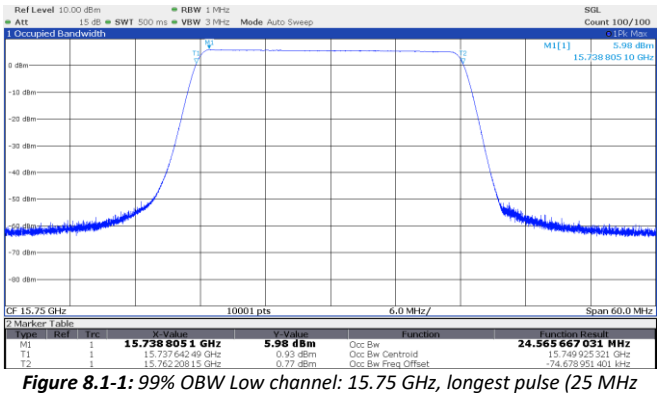

Figure 8.1-1: *99% OBW Low channel: 15.75 GHz, longest pulse (25 MHz BW)*

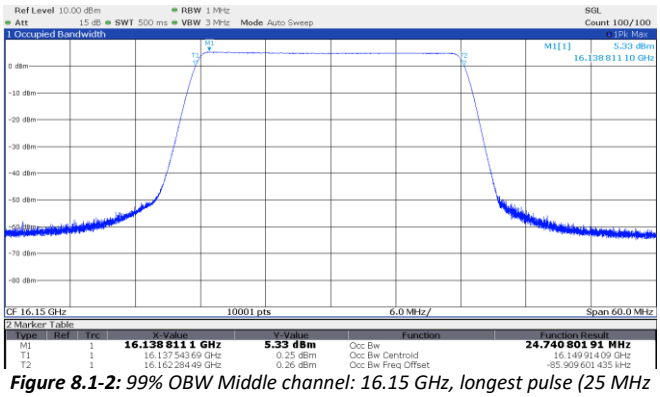

Figure 8.1-2: *99% OBW Middle channel: 16.15 GHz, longest pulse (25 MHz BW)*

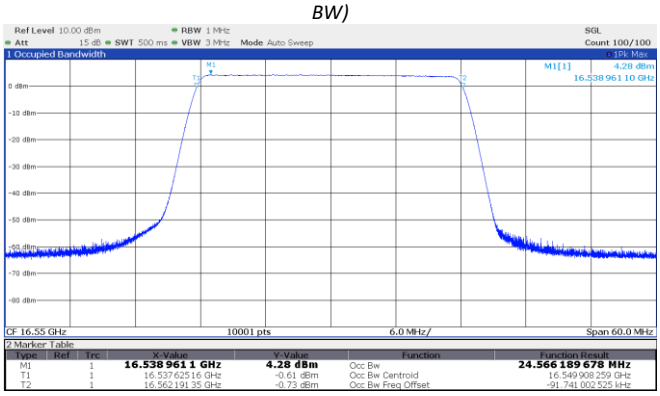

Figure 8.1-3: *99% OBW High channel: 16.55 GHz, longest pulse (25 MHz BW)*

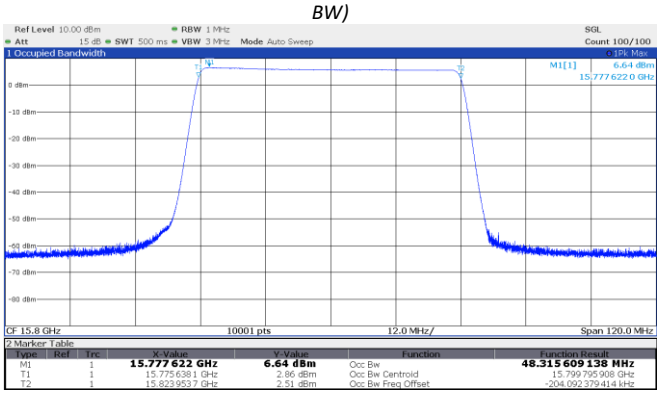

Figure 8.1-4: *99% OBW Low channel: 15.80 GHz, longest pulse (50 MHz BW)*

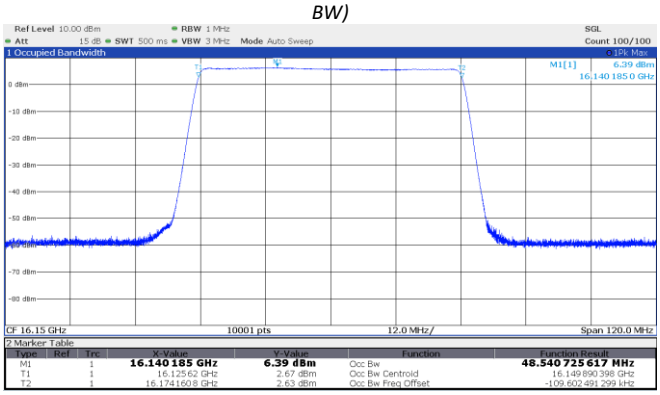

Figure 8.1-5: *99% OBW Middle channel: 16.15 GHz, longest pulse (50 MHz BW)*

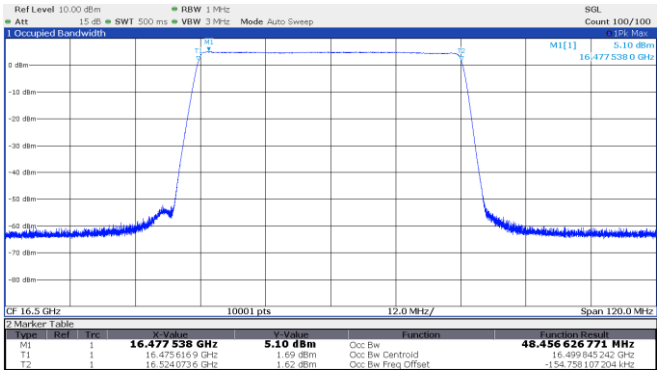

Figure 8.1-6: *99% OBW High channel: 16.50 GHz, longest pulse (50 MHz BW)*

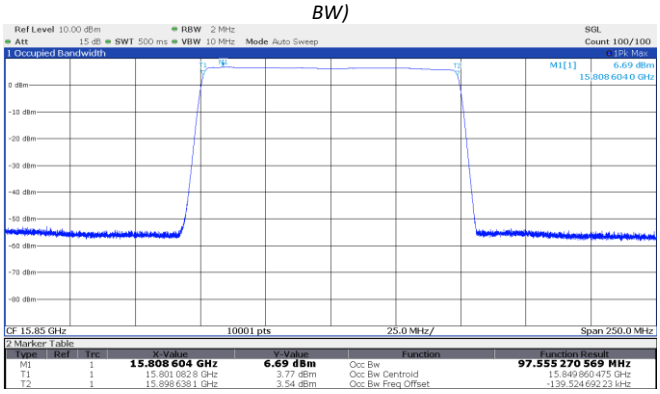

Figure 8.1-7: *99% OBW Low channel: 15.85 GHz, longest pulse (100 MHz BW)*

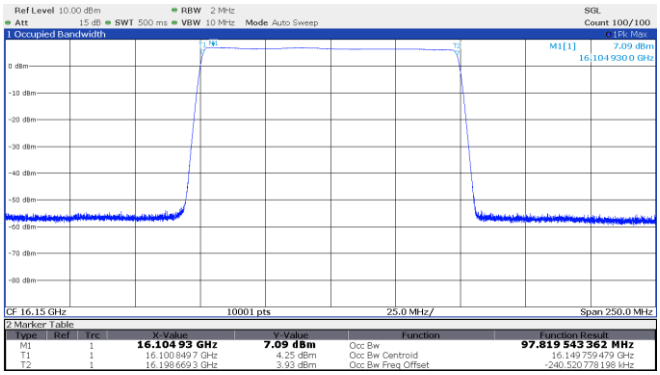

Figure 8.1-8: *99% OBW Middle channel: 16.15 GHz, longest pulse (100 MHz BW)*

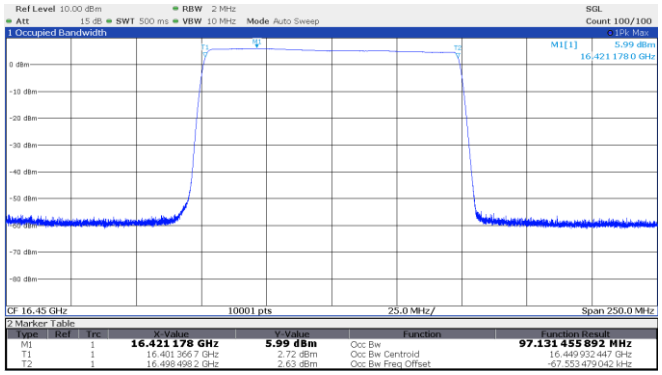

Figure 8.1-9: *99% OBW High channel: 16.45 GHz, longest pulse (100 MHz BW)*

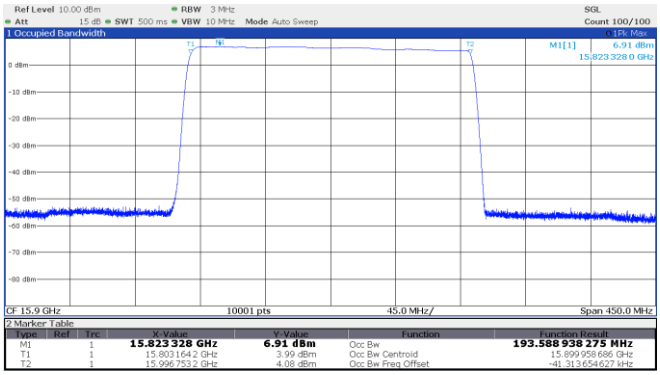

Figure 8.1-10: *99% OBW Low channel: 15.90 GHz, longest pulse (200 MHz BW)*

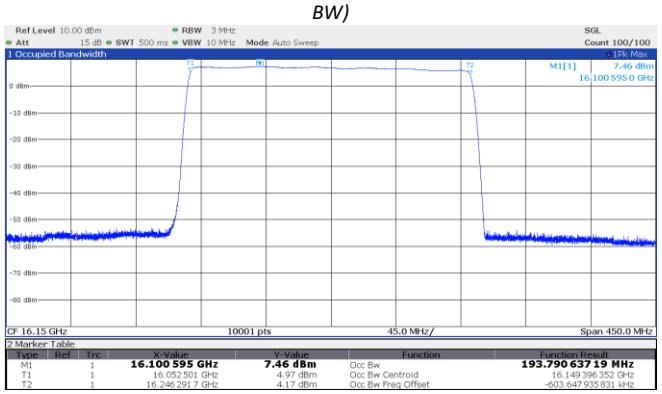

Figure 8.1-11: *99% OBW Middle channel: 16.15 GHz, longest pulse (200 MHz BW)*

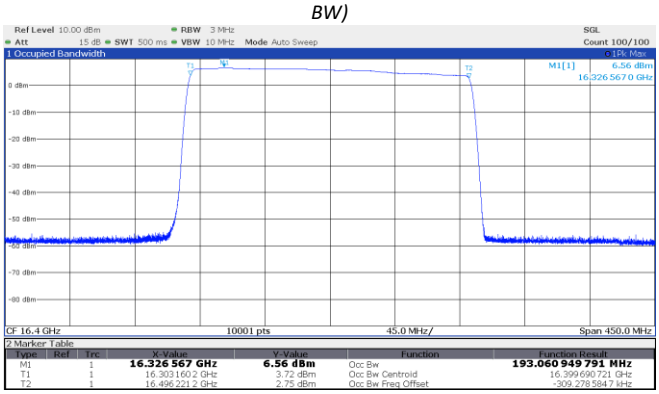

Figure 8.1-12: *99% OBW High channel: 16.40 GHz, longest pulse (200 MHz BW)*

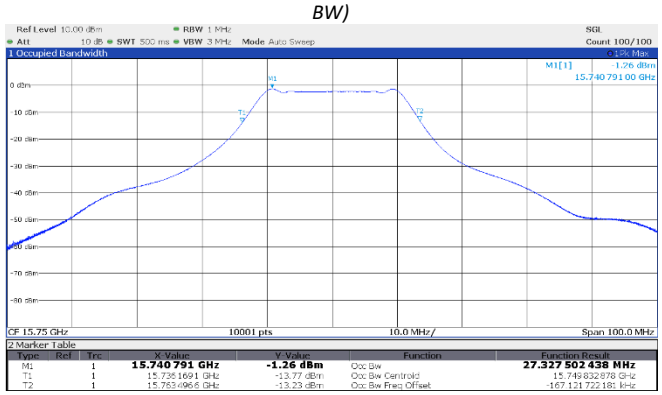

Figure 8.1-13: *99% OBW Low channel: 15.75 GHz, shortest pulse (25 MHz BW)*

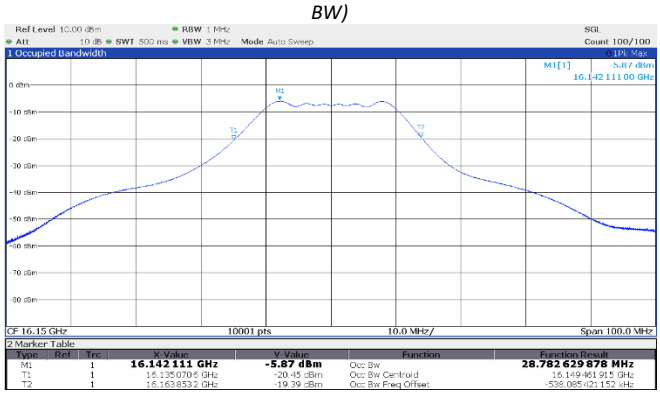

Figure 8.1-14: *99% OBW Middle channel: 16.15 GHz, shortest pulse (25 MHz BW)*

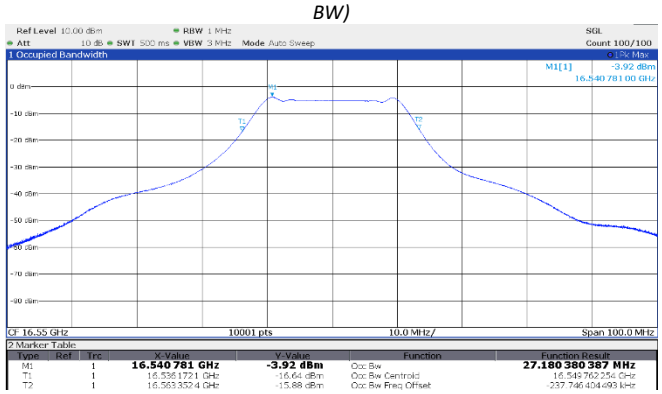

Figure 8.1-15: *99% OBW High channel: 16.55 GHz, shortest pulse (25 MHz BW)*

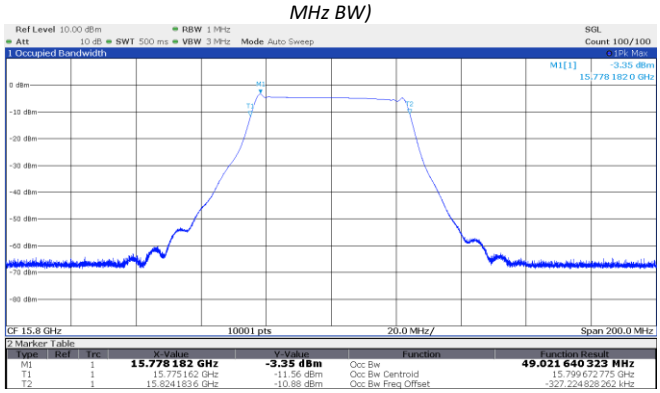

Figure 8.1-16: *99% OBW Low channel: 15.80 GHz, shortest pulse (50 MHz BW)*

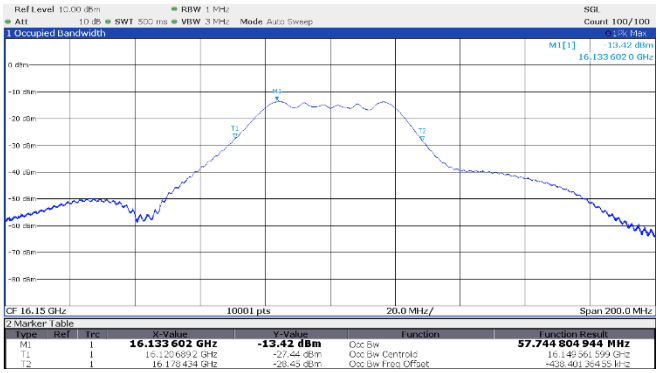

Figure 8.1-17: *99% OBW Middle channel: 16.15 GHz, shortest pulse (50 MHz BW)*

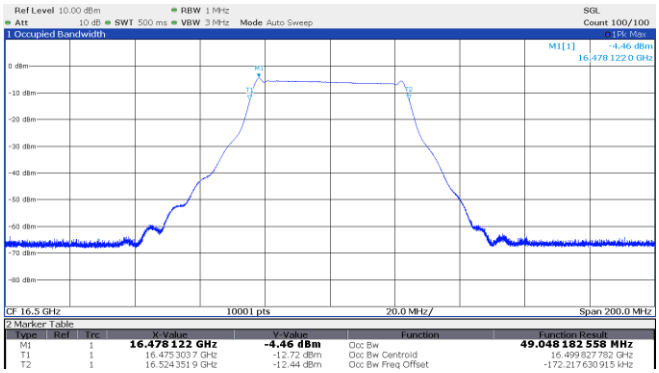

Figure 8.1-18: *99% OBW High channel: 16.50 GHz, shortest pulse (50 MHz BW)*

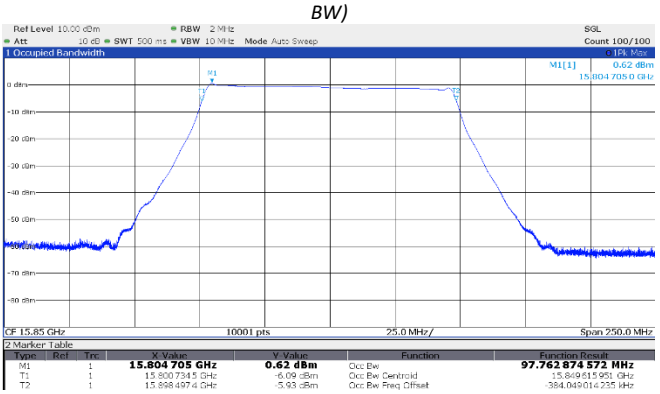

Figure 8.1-19: *99% OBW Low channel: 15.85 GHz, shortest pulse (100 MHz BW)*

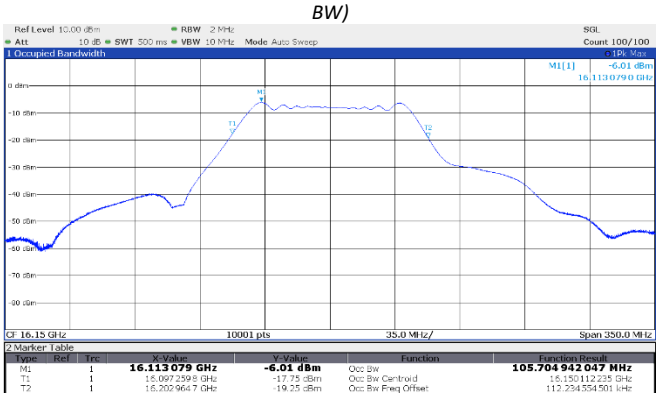

Figure 8.1-20: *99% OBW Middle channel: 16.15 GHz, shortest pulse (100 MHz BW)*

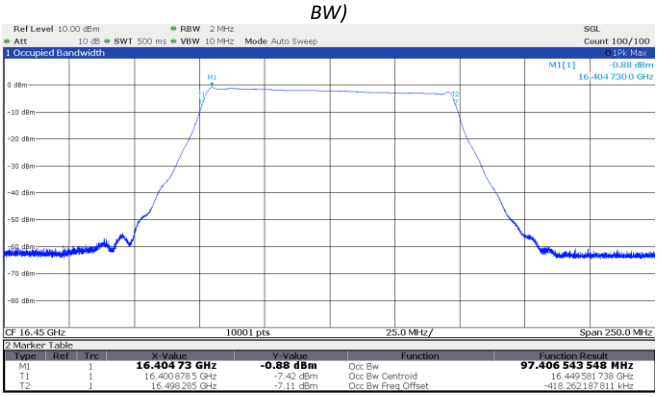

Figure 8.1-21: *99% OBW High channel: 16.45 GHz, shortest pulse (100 MHz BW)*

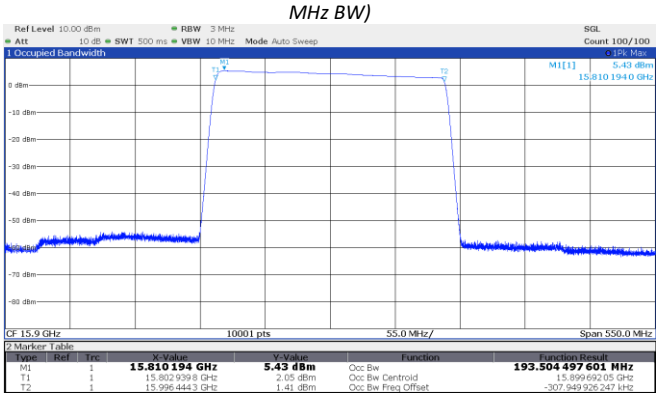

Figure 8.1-22: *99% OBW Low channel: 15.90 GHz, shortest pulse (200 MHz BW)*

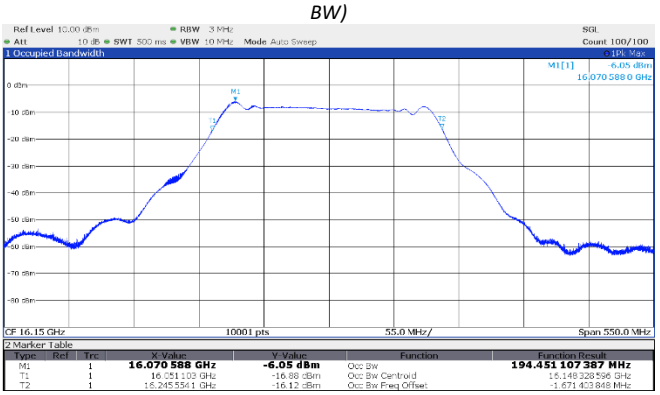

Figure 8.1-23: *99% OBW Middle channel: 16.15 GHz, shortest pulse (200 MHz BW)*

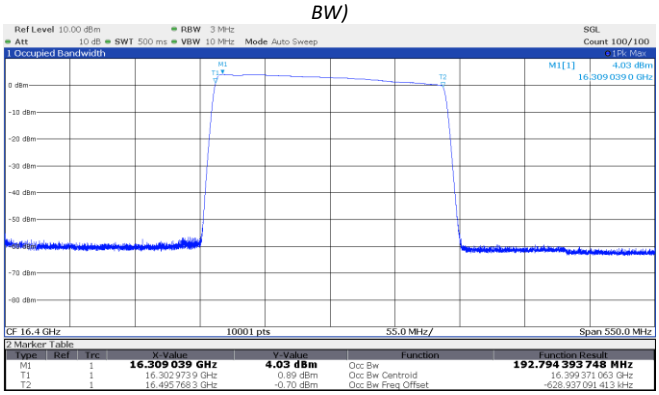

Figure 8.1-24: *99% OBW High channel: 16.40 GHz, shortest pulse (200 MHz BW)*

8.2 Bandwidth of emission (26 dB)

8.2.1 References and limits

- Test method: ANSI C63.26-2014 (5.4.3)

8.2.2 Test summary

Verdict	Pass		
Test date	March 29, 2023; March 30, 2023; March 31, 2023; April 3, 2023	Temperature	19°C; 20°C; 18°C; 20°C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003mbar; 1005mbar; 1006mbar; 1001mbar
Test location	☐ Wireless bench ☒ Other: 3M Chamber	Relative humidity	58%; 59%; 56%; 57%

8.2.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power following the cases shown on table 8.1-1 from section 8.1.3 of this document. This measurement is not a requirement, but it is used for the mask calculation shown on section 8.4 of this document.

Testing was done at 3 meters with the antenna and turntable fixed. A maximization of the signal was done to define the position of the max power:
Antenna heigh: 150 cm Turntable: 4.5 Degrees

8.2.4 Setup details

EUT power input during test	28 V DC
EUT setup configuration	☐ Table-top ☐ Floor standing ☒ Other: Tripod mounted (1.5 m)

Receiver settings:

Resolution bandwidth	Approximately 1-5 % of the emission bandwidth
Video bandwidth	Approximately 3 x resolution bandwidth
Detector mode	Peak
Trace mode	Max Hold
Measurement time	Long enough for trace to stabilize

8.2.5 Test data

Frequency	Bandwidth	Type of pulse	Time duration
15.75 GHz	27.45 MHz	Longest pulse	30 µs
16.15 GHz	**27.62 MHz**[1]	Longest pulse	30 µs
16.55 GHz	27.41 MHz	Longest pulse	30 µs
15.80 GHz	52.29 MHz	Longest pulse	30 µs
16.15 GHz	**52.64 MHz**[1]	Longest pulse	30 µs
16.50 GHz	52.58 MHz	Longest pulse	30 µs
15.85 GHz	104.34 MHz	Longest pulse	30 µs
16.15 GHz	**104.54 MHz**[1]	Longest pulse	30 µs
16.45 GHz	103.74 MHz	Longest pulse	30 µs
15.90 GHz	**204.69 MHz**[1]	Longest pulse	28.494 µs
16.15 GHz	204.37 MHz	Longest pulse	28.494 µs
16.40 GHz	203.92 MHz	Longest pulse	28.494 µs
15.75 GHz	**38.50 MHz**[3]	Shortest pulse	2 µs
16.15 GHz	**41.09 MHz**[2]	Shortest pulse	1 µs
16.55 GHz	37.79 MHz	Shortest pulse	2 µs
15.80 GHz	59.69 MHz	Shortest pulse	5 µs
16.15 GHz	**80.23 MHz**[2]	Shortest pulse	500 ns
16.50 GHz	**62.09 MHz**[3]	Shortest pulse	5 µs
15.85 GHz	**115.29 MHz**[3]	Shortest pulse	5 µs
16.15 GHz	**159.09 MHz**[2]	Shortest pulse	500 ns
16.45 GHz	114.64 MHz	Shortest pulse	5 µs
15.90 GHz	**205.84 MHz**[3]	Shortest pulse	15 µs
16.15 GHz	**243.24 MHz**[2]	Shortest pulse	500 ns
16.40 GHz	205.18 MHz	Shortest pulse	15 µs

Table 8.2-1: *26 dB OBW results.*

Note 1: 26 dB bandwidth selected from the three channels under investigation to be used as common mask for the three cases.
Note 2: Single case.
Note 3: 26 dB bandwidth selected from the two channels with the same pulse width under investigation to be used as common mask for the two cases.

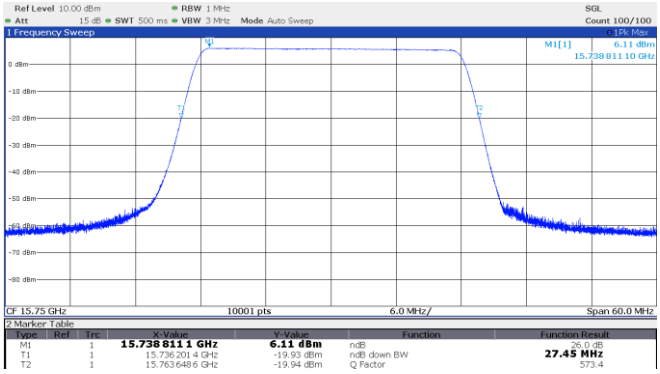

Figure 8.2-1: *26 dB OBW Low channel: 15.75 GHz, longest pulse (25 MHz BW)*

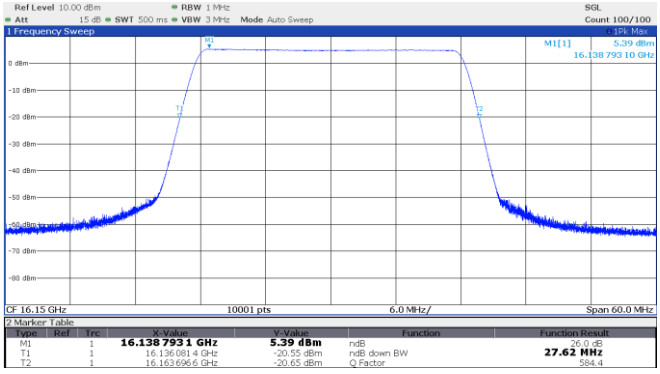

Figure 8.2-2: *26 dB OBW Middle channel: 16.15 GHz, longest pulse (25 MHz BW)*

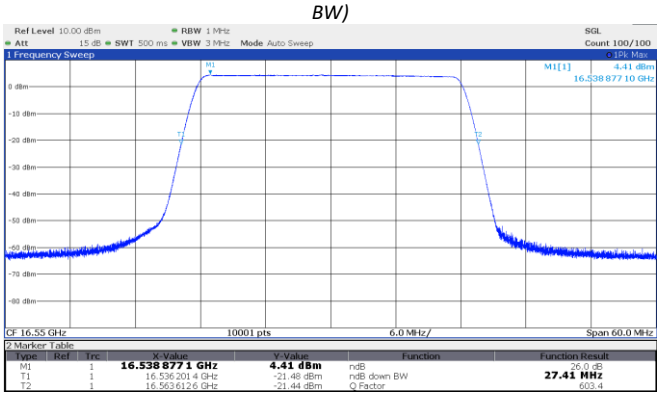

Figure 8.2-3: *26 dB OBW High channel: 16.55 GHz, longest pulse (25 MHz BW)*

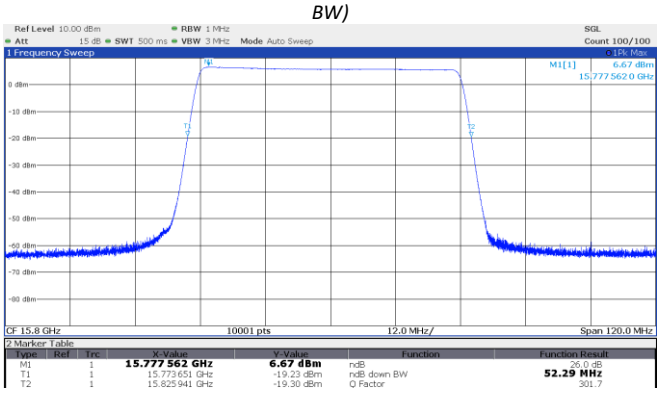

Figure 8.2-4: *26 dB OBW Low channel: 15.80 GHz, longest pulse (50 MHz BW)*

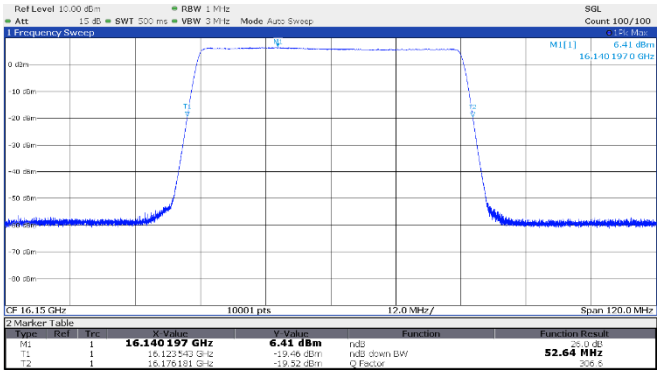

Figure 8.2-5: *26 dB OBW Middle channel: 16.15 GHz, longest pulse (50 MHz BW)*

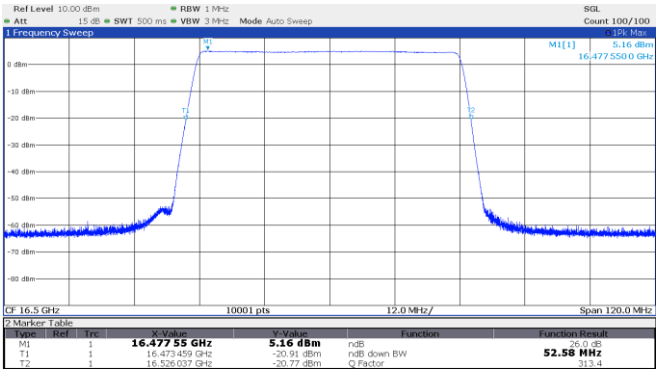

Figure 8.2-6: *26 dB OBW High channel: 16.50 GHz, longest pulse (50 MHz BW)*

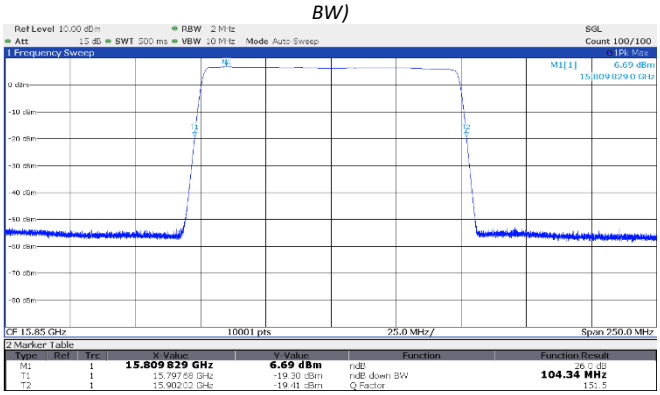

Figure 8.2-7: *26 dB OBW Low channel: 15.85 GHz, longest pulse (100 MHz BW)*

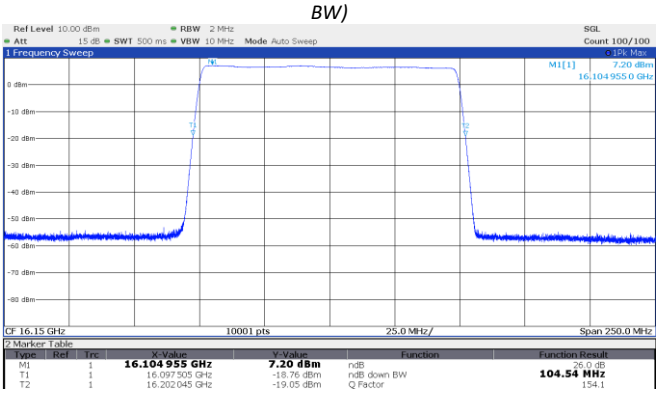

Figure 8.2-8: *26 dB OBW Middle channel: 16.15 GHz, longest pulse (100 MHz BW)*

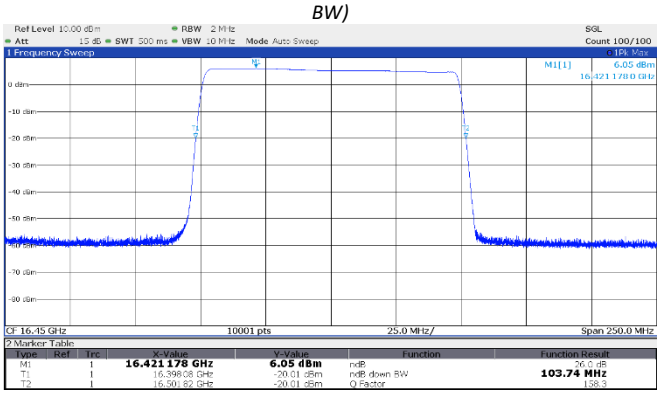

Figure 8.2-9: *26 dB OBW High channel: 16.45 GHz, longest pulse (100 MHz BW)*

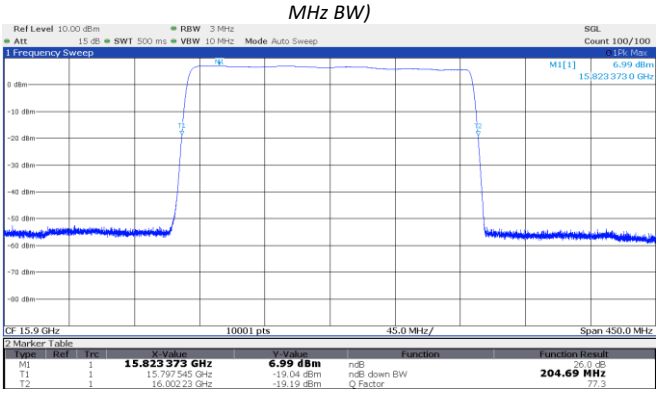

Figure 8.2-10: *26 dB OBW Low channel: 15.90 GHz, longest pulse (200 MHz BW)*

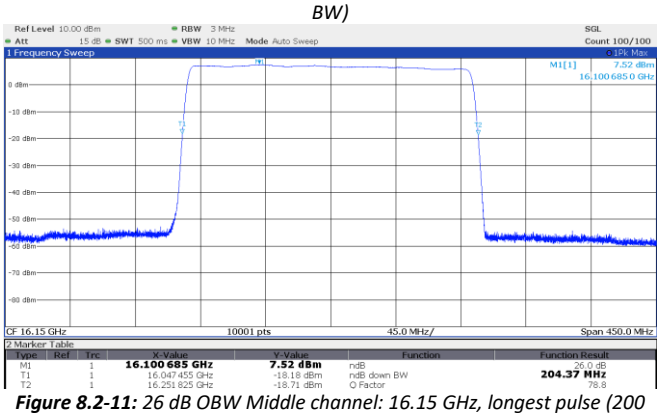

Figure 8.2-11: *26 dB OBW Middle channel: 16.15 GHz, longest pulse (200 MHz BW)*

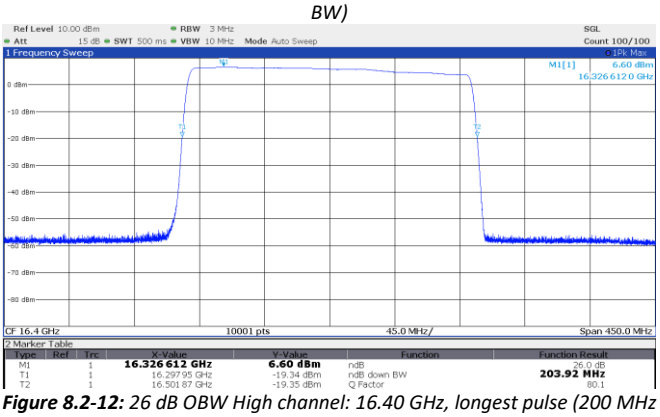

Figure 8.2-12: *26 dB OBW High channel: 16.40 GHz, longest pulse (200 MHz BW)*

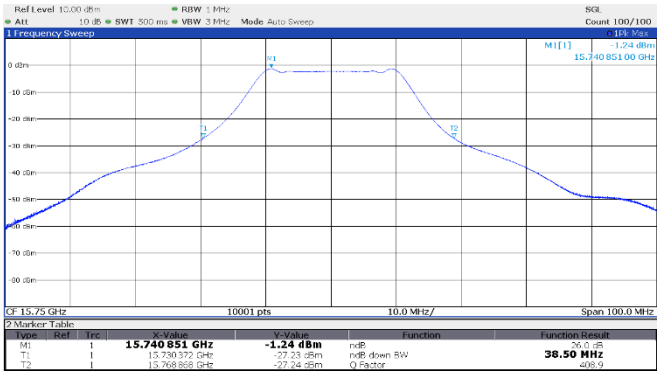

Figure 8.2-13: *26 dB OBW Low channel: 15.75 GHz, shortest pulse (25 MHz BW)*

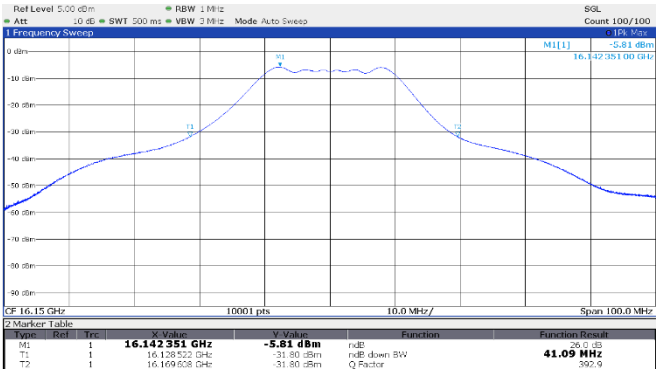

Figure 8.2-14: *26 dB OBW Middle channel: 16.15 GHz, shortest pulse (25 MHz BW)*

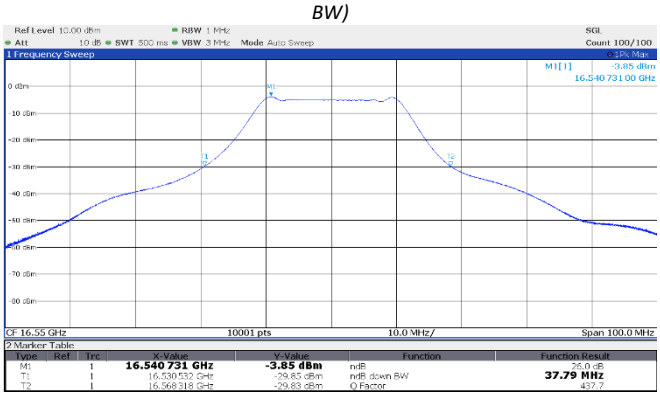

Figure 8.2-15: *26 dB OBW High channel: 16.55 GHz, shortest pulse (25 MHz BW)*

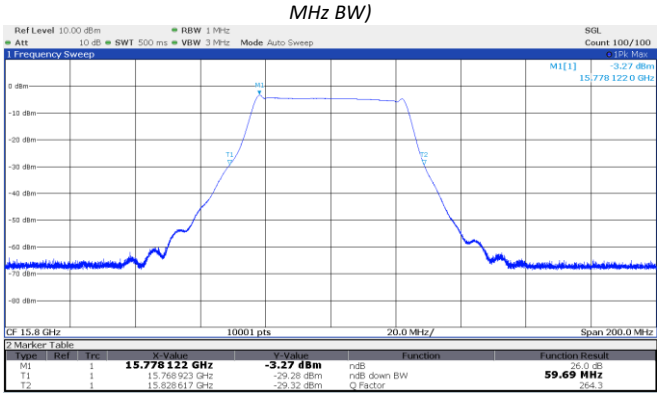

Figure 8.2-16: *26 dB OBW Low channel: 15.80 GHz, shortest pulse (50 MHz BW)*

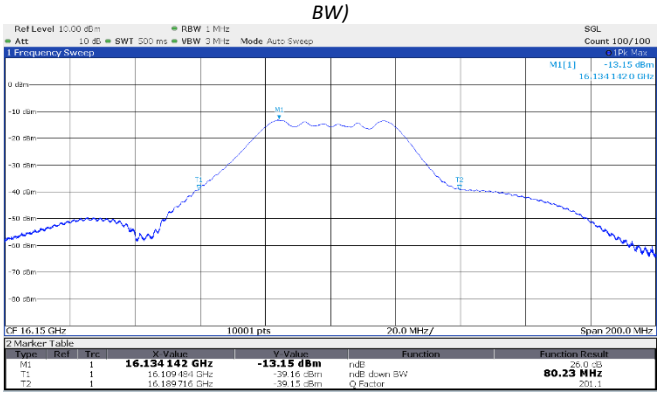

Figure 8.2-17: *26 dB OBW Middle channel: 16.15 GHz, shortest pulse (50 MHz BW)*

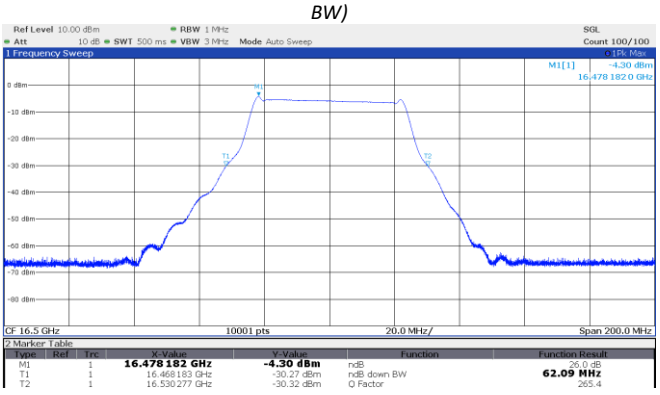

Figure 8.2-18: *26 dB OBW High channel: 16.50 GHz, shortest pulse (50 MHz BW)*

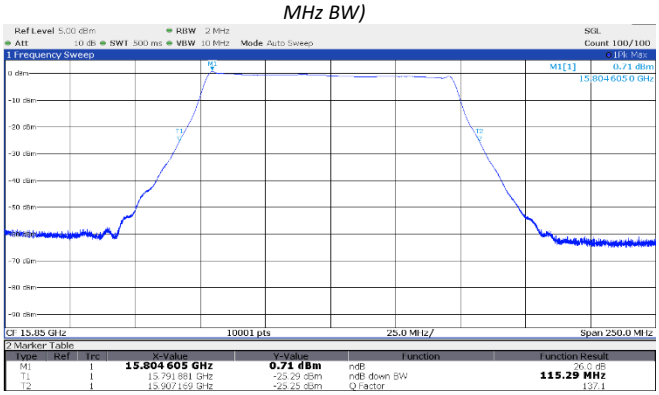

Figure 8.2-19: *26 dB OBW Low channel: 15.85 GHz, shortest pulse (100 MHz BW)*

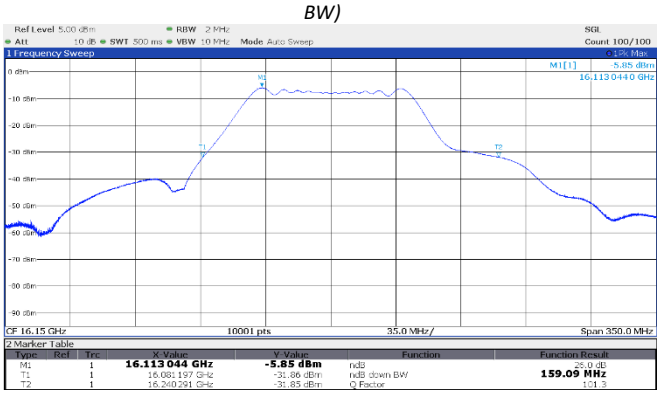

Figure 8.2-20: *26 dB OBW Middle channel: 16.15 GHz, shortest pulse (100 MHz BW)*

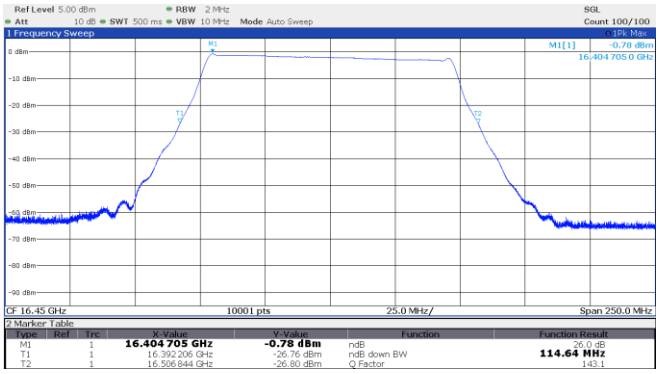

Figure 8.2-21: *26 dB OBW High channel: 16.45 GHz, shortest pulse (100 MHz BW)*

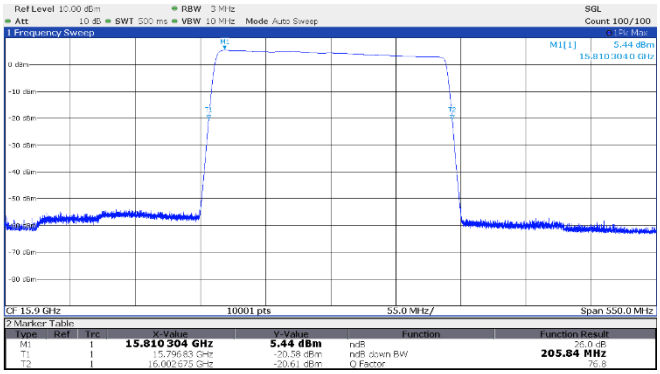

Figure 8.2-22: *26 dB OBW Low channel: 15.90 GHz, shortest pulse (200 MHz BW)*

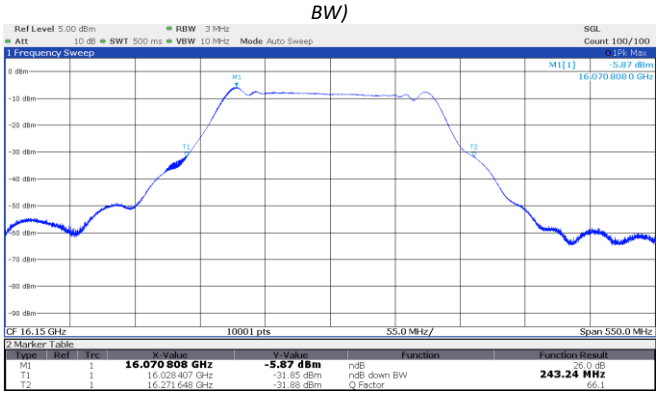

Figure 8.2-23: *26 dB OBW Middle channel: 16.15 GHz, shortest pulse (200 MHz BW)*

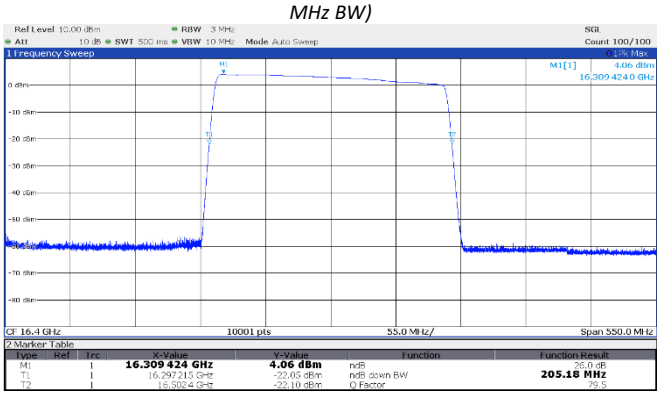

Figure 8.2-24: *26 dB OBW High channel: 16.40 GHz, shortest pulse (200 MHz BW)*

8.3 Power and antenna height limits

8.3.1 References and limits

- FCC 47 CFR Part 90: §90.205
- Test method: ANSI C63.26-2014 (5.2.4.4.2)

Applicants for licenses must request and use no more power than the actual power necessary for satisfactory operation. Except where otherwise specifically provided for, the maximum power that will be authorized to applicants whose license applications for new stations are filed after August 18, 1995, is as follows:

(r) All other frequency bands. Requested transmitter power will be considered and authorized on a case by case basis.

8.3.2 Test summary

Verdict	Pass		
Test date	March 29, 2023; March 30, 2023; March 31, 2023; April 3, 2023	Temperature	19°C; 20°C; 18°C; 20°C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003mbar; 1005mbar; 1006mbar; 1001mbar
Test location	☐ Wireless bench ☒ Other: 3M Chamber	Relative humidity	58%; 59%; 56%; 57%

8.3.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power following the cases shown on table 8.1-1 from section 8.1.3 of this document. All correction factors corresponding cables losses, receiving antenna gain, and air path losses were compensated to get the real EIRP value of the product. Both polarizations were evaluated, horizontal and vertical (linear polarization per client declaration) and only the worst case (max power) was taken for the testing purposes: horizontal polarization. The duty cycle correction factor was added according to each frequency channel tested. Table 8.3-1 shows the constant duty cycle corresponding to each case.

The equation to calculate the total correction factor corresponding to each frequency tested is given by the following expression as well as the table with the corresponding duty cycle to each case:

$$E.I.R.P = P_r - G_r - 20\log_{10}\left(\frac{\lambda}{4\pi d}\right)$$

Adding cable losses and duty cycle correction factors (absolute values):

$$E.I.R.P = P_r - G_r - 20\log_{10}\left(\frac{\lambda}{4\pi d}\right) + L_{cable} + 10\log_{10}\left(\frac{1}{Duty\ cycle}\right)$$

Where:
P_r = Power received in the spectrum analyzer
λ = Wavelength of the signal
L_{cable} = Losses corresponding to interconnexion cables
d = Measuring distance (3 meters)
G_r = Receiving antenna gain
DC = Duty cycle declared

Example:

$$E.I.R.P = P_r - 16.389 - 20\log_{10}\left(\frac{\frac{299792458}{15750000000}}{4\pi(3)}\right) + 19.434 + 10\log_{10}\left(\frac{1}{0.15}\right)$$

$$E.I.R.P = P_r - 16.389 - (-65.935) + 19.388 + 8.239 = P_r + 77.174 \text{ (offset)}$$

DC = Duty cycle declared

Testing was done at 3 meters with the antenna and turntable fixed. A maximization of the signal was done to define the position of the max power:
Antenna heigh: 150 cm
Turntable: 4.5 Degrees

8.3.3 Notes, continued

Frequency	Type of pulse	Time duration	Duty cycle
15.75 GHz	Longest pulse	30 µs	15%
16.15 GHz	Longest pulse	30 µs	15%
16.55 GHz	Longest pulse	30 µs	15%
15.80 GHz	Longest pulse	30 µs	15%
16.15 GHz	Longest pulse	30 µs	15%
16.50 GHz	Longest pulse	30 µs	15%
15.85 GHz	Longest pulse	30 µs	15%
16.15 GHz	Longest pulse	30 µs	15%
16.45 GHz	Longest pulse	30 µs	15%
15.90 GHz	Longest pulse	28.494 µs	15%
16.15 GHz	Longest pulse	28.494 µs	15%
16.40 GHz	Longest pulse	28.494 µs	15%
15.75 GHz	Shortest pulse	2 µs	10%
16.15 GHz	Shortest pulse	1 µs	10%
16.55 GHz	Shortest pulse	2 µs	10%
15.80 GHz	Shortest pulse	5 µs	10%
16.15 GHz	Shortest pulse	500 ns	10%
16.50 GHz	Shortest pulse	5 µs	10%
15.85 GHz	Shortest pulse	5 µs	10%
16.15 GHz	Shortest pulse	500 ns	10%
16.45 GHz	Shortest pulse	5 µs	10%
15.90 GHz	Shortest pulse	15 µs	10%
16.15 GHz	Shortest pulse	500 ns	10%
16.40 GHz	Shortest pulse	15 µs	10%

Table 8.3-1: *Duty cycle table*.

8.3.4 Setup details

EUT power input during test	28 V DC
EUT setup configuration	☐ Table-top ☐ Floor standing ☒ Other: Tripod mounted (1.5 m)

Receiver settings:

Resolution bandwidth	Approximately 1-5 % of the emission bandwidth
Video bandwidth	Approximately 3 x resolution bandwidth
Detector mode	RMS
Trace mode	Average (at least 100 traces)
Measurement points	≥ (2xspan)/RBW
Span	2 times or 3 times the 99% OBW

8.3.5 Test data

Frequency	Type of pulse	Time duration	Power (EIRP)
15.75 GHz	Longest pulse	30 µs	74.41 dBm
16.15 GHz	Longest pulse	30 µs	74.72 dBm
16.55 GHz	Longest pulse	30 µs	74.97 dBm
15.80 GHz	Longest pulse	30 µs	75.43 dBm
16.15 GHz	Longest pulse	30 µs	76.39 dBm
16.50 GHz	Longest pulse	30 µs	76.15 dBm
15.85 GHz	Longest pulse	30 µs	75.38 dBm
16.15 GHz	Longest pulse	30 µs	**76.68 dBm**[1]
16.45 GHz	Longest pulse	30 µs	76.11 dBm
15.90 GHz	Longest pulse	28.494 µs	75.37 dBm
16.15 GHz	Longest pulse	28.494 µs	76.11 dBm
16.40 GHz	Longest pulse	28.494 µs	75.79 dBm
15.75 GHz	Shortest pulse	2 µs	73.52 dBm
16.15 GHz	Shortest pulse	1 µs	72.70 dBm
16.55 GHz	Shortest pulse	2 µs	72.99 dBm
15.80 GHz	Shortest pulse	5 µs	73.81 dBm
16.15 GHz	Shortest pulse	500 ns	70.79 dBm
16.50 GHz	Shortest pulse	5 µs	74.88 dBm
15.85 GHz	Shortest pulse	5 µs	71.74 dBm
16.15 GHz	Shortest pulse	500 ns	74.81 dBm
16.45 GHz	Shortest pulse	5 µs	72.12 dBm
15.90 GHz	Shortest pulse	15 µs	74.00 dBm
16.15 GHz	Shortest pulse	500 ns	70.82 dBm
16.40 GHz	Shortest pulse	15 µs	73.61 dBm

Note 1: Max power measured (worst case)

Table 8.3-2: *Power results (EIRP.).*

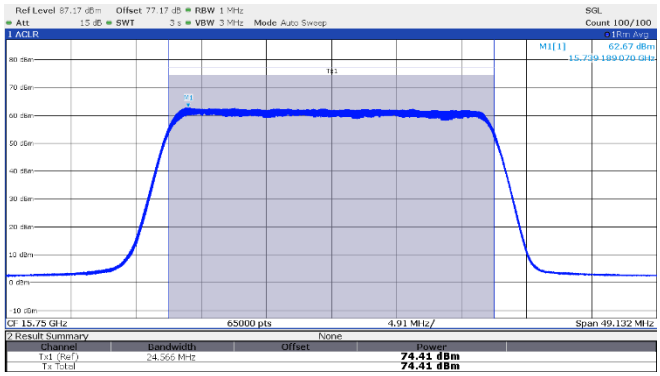

Figure 8.3-1: *EIRP Power, Low channel: 15.75 GHz, longest pulse (25 MHz BW)*

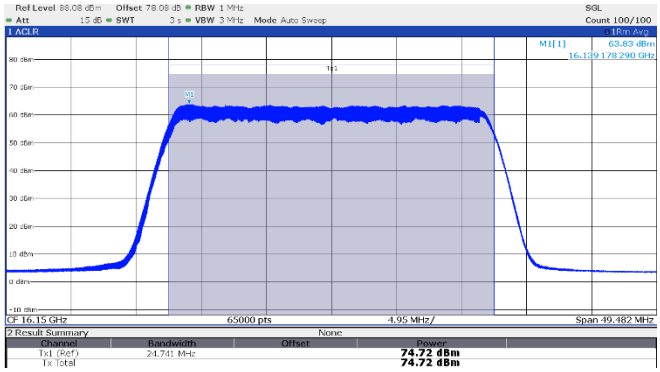

Figure 8.3-2: *EIRP Power, Middle channel: 16.15 GHz, longest pulse (25 MHz BW)*

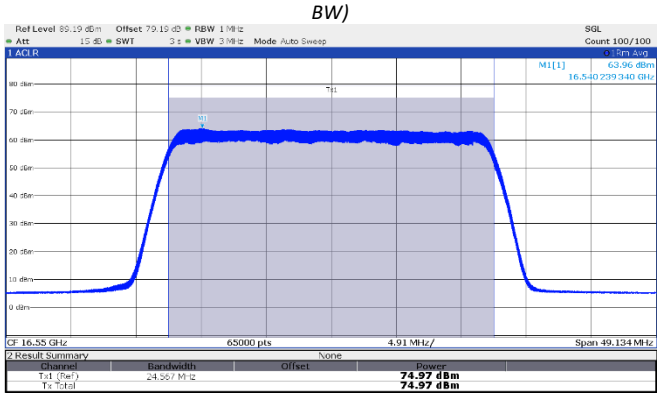

Figure 8.3-3: *EIRP Power, High channel: 16.55 GHz, longest pulse (25 MHz BW)*

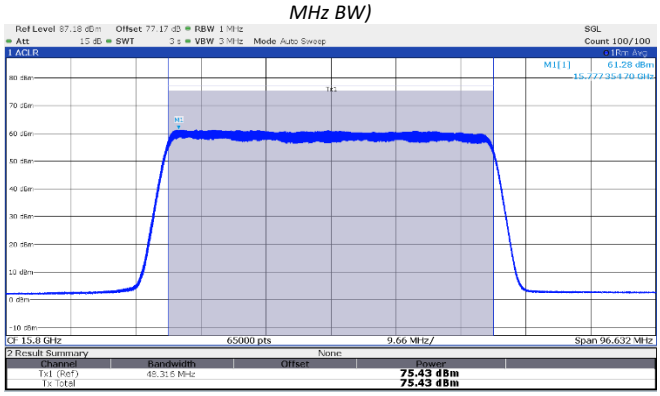

Figure 8.3-4: *EIRP Power, Low channel: 15.80 GHz, longest pulse (50 MHz BW)*

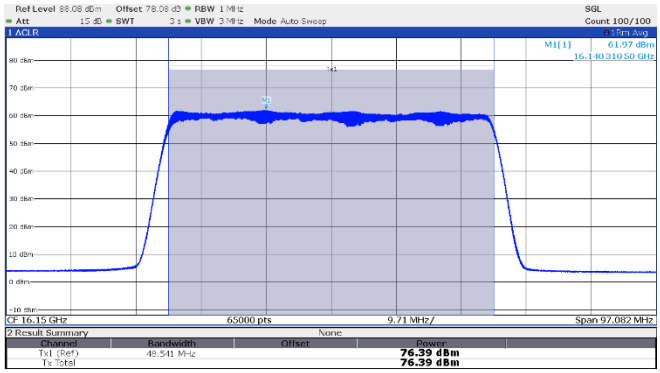

Figure 8.3-5: *EIRP Power, Middle channel: 16.15 GHz, longest pulse (50 MHz BW)*

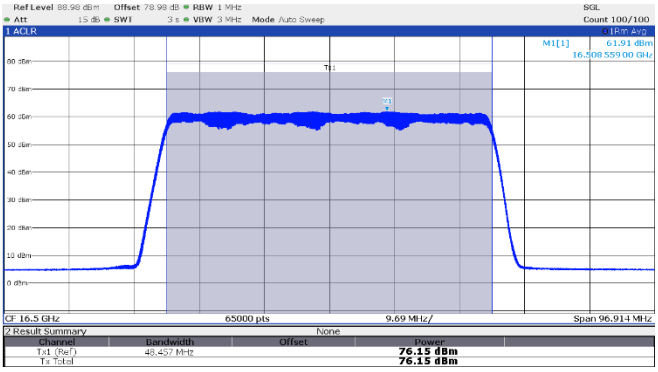

Figure 8.3-6: *EIRP Power, High channel: 16.50 GHz, longest pulse (50 MHz BW)*

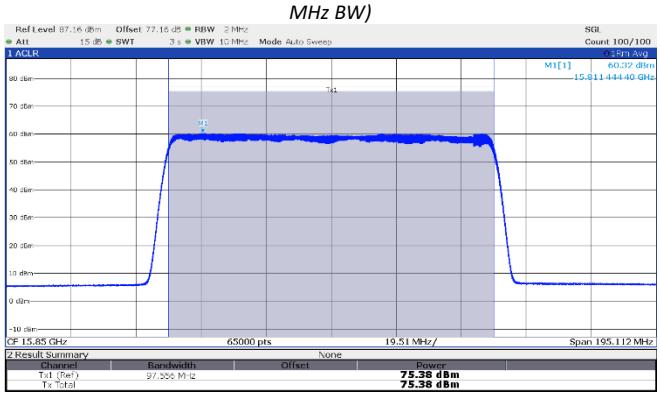

Figure 8.3-7: *EIRP Power, Low channel: 15.85 GHz, longest pulse (100 MHz BW)*

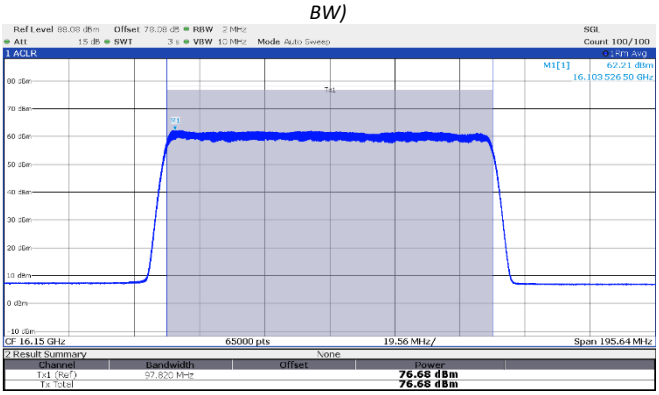

Figure 8.3-8: *EIRP Power, Middle channel: 16.15 GHz, longest pulse (100 MHz BW)*

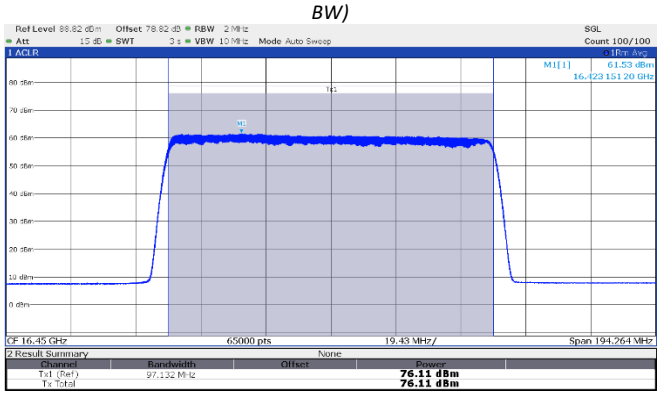

Figure 8.3-9: *EIRP Power, High channel: 16.45 GHz, longest pulse (100 MHz BW)*

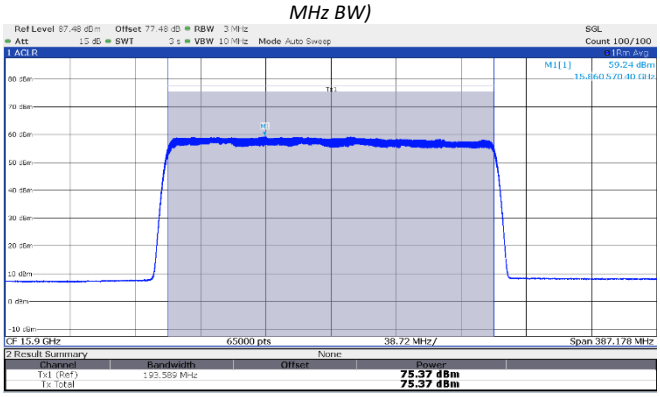

Figure 8.3-10: *EIRP Power, Low channel: 15.90 GHz, longest pulse (200 MHz BW)*

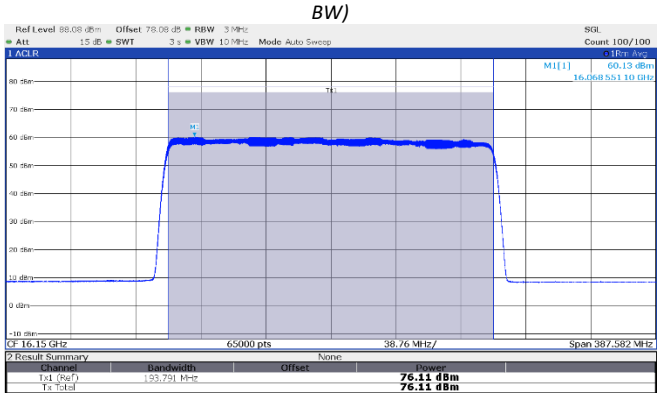

Figure 8.3-11: *EIRP Power, Middle channel: 16.15 GHz, longest pulse (200 MHz BW)*

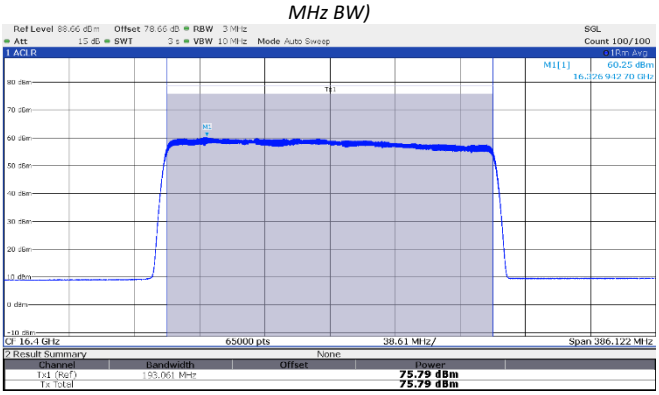

Figure 8.3-12: *EIRP Power, High channel: 16.40 GHz, longest pulse (200 MHz BW)*

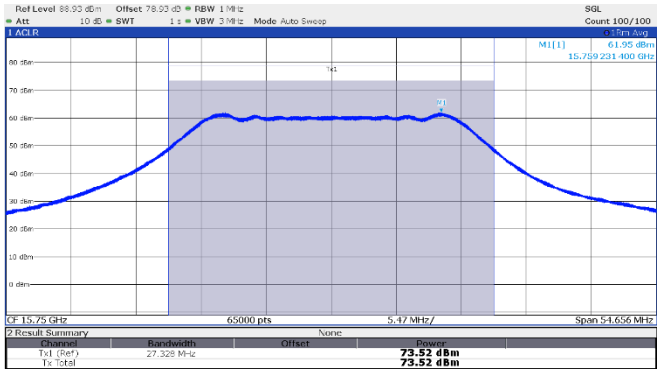

Figure 8.3-13: *EIRP Power, Low channel: 15.75 GHz, shortest pulse (25 MHz BW)*

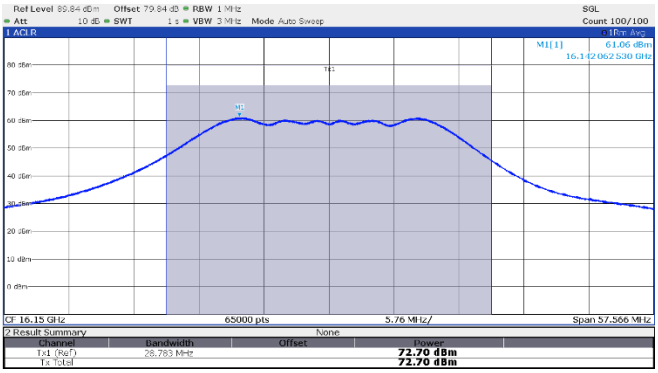

Figure 8.3-14: *EIRP Power, Middle channel: 16.15 GHz, shortest pulse (25 MHz BW)*

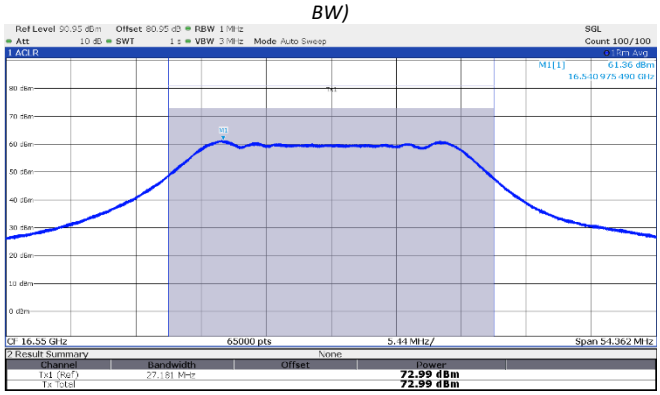

Figure 8.3-15: *EIRP Power, High channel: 16.55 GHz, shortest pulse (25 MHz BW)*

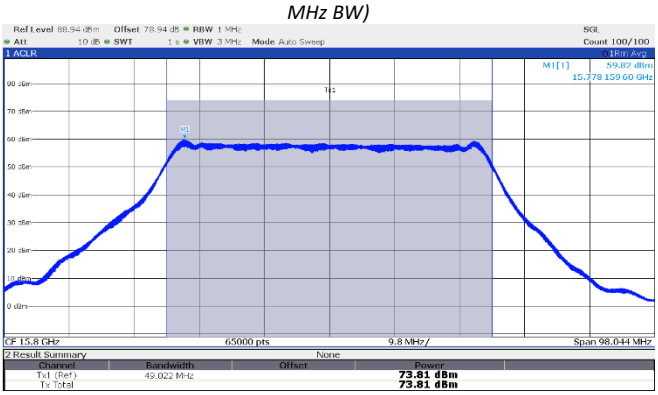

Figure 8.3-16: *EIRP Power, Low channel: 15.80 GHz, shortest pulse (50 MHz BW)*

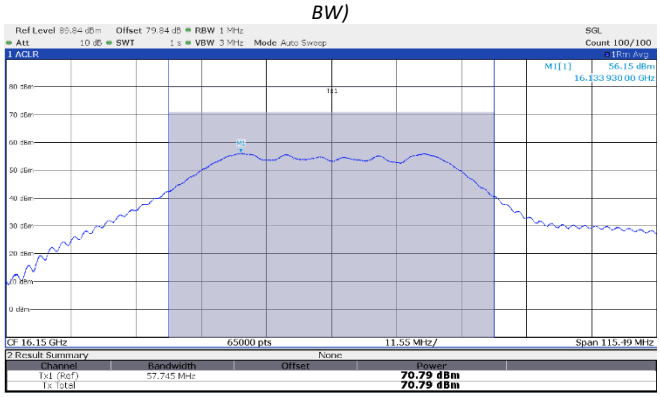

Figure 8.3-17: *EIRP Power, Middle channel: 16.15 GHz, shortest pulse (50 MHz BW)*

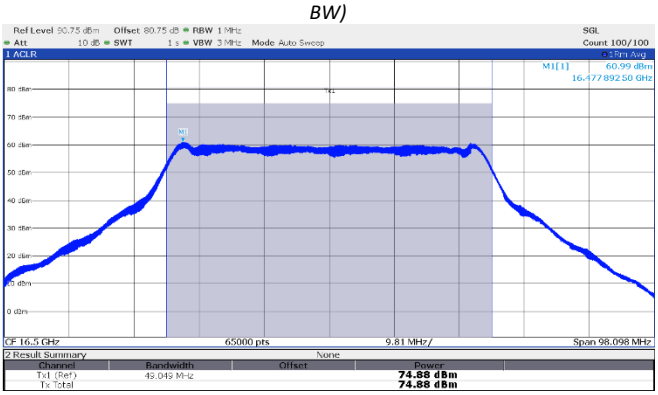

Figure 8.3-18: *EIRP Power, High channel: 16.50 GHz, shortest pulse (50 MHz BW)*

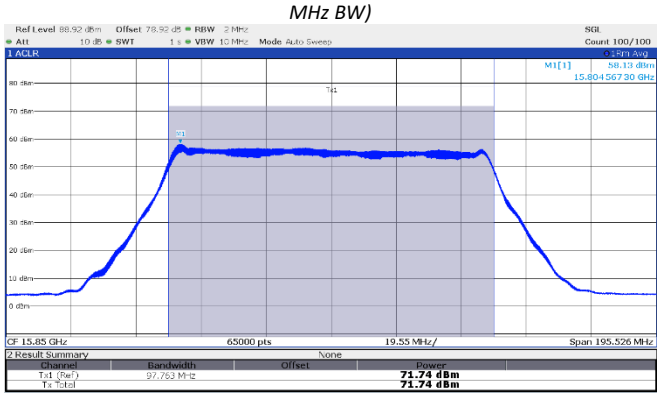

Figure 8.3-19: *EIRP Power, Low channel: 15.85 GHz, shortest pulse (100 MHz BW)*

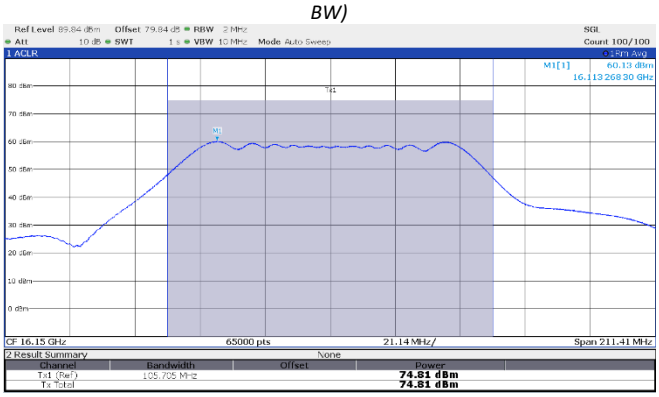

Figure 8.3-20: *EIRP Power, Middle channel: 16.15 GHz, shortest pulse (100 MHz BW)*

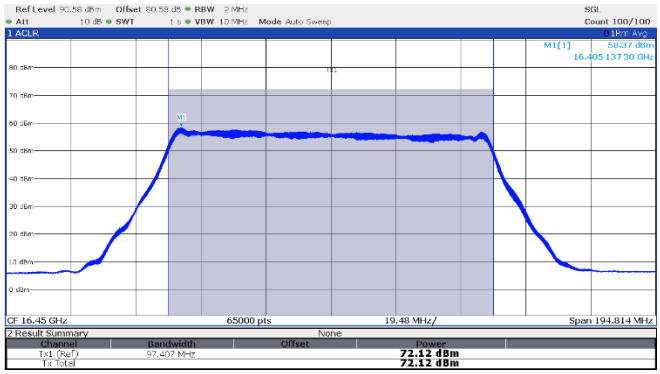

Figure 8.3-21: *EIRP Power, High channel: 16.45 GHz, shortest pulse (100 MHz BW)*

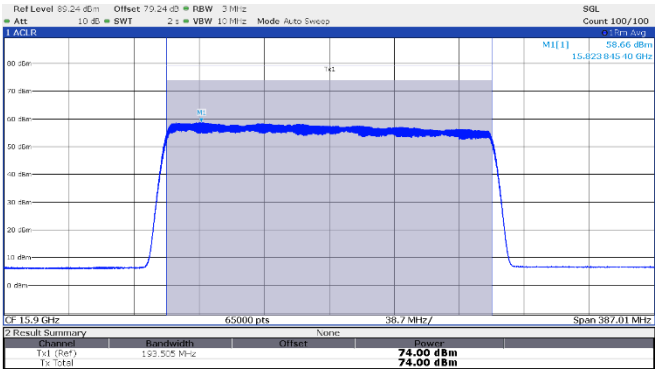

Figure 8.3-22: *EIRP Power, Low channel: 15.90 GHz, shortest pulse (200 MHz BW)*

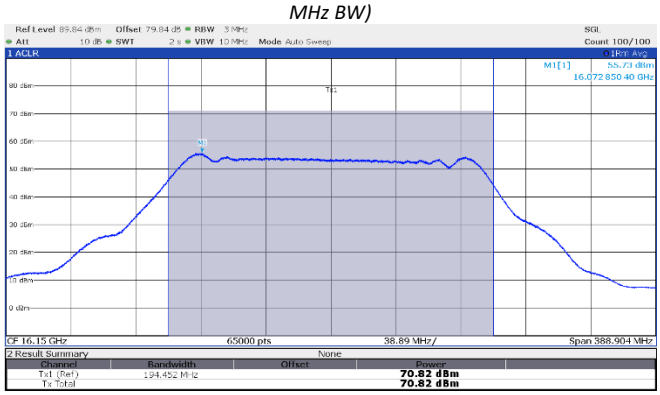

Figure 8.3-23: *EIRP Power, Middle channel: 16.15 GHz, shortest pulse (200 MHz BW)*

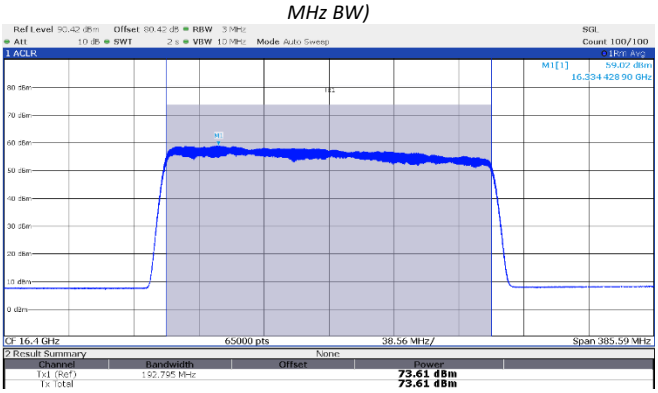

Figure 8.3-24: *EIRP Power, High channel: 16.40 GHz, shortest pulse (200 MHz BW)*

8.4 Emission mask

8.4.1 References and limits

- FCC 47 CFR Part 90: §90.210
- Test method: ANSI C63.26-2014 (5.5)

(b) Emission Mask B. For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:
(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.
(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.
(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

8.4.2 Test summary

Verdict	Pass		
Test date	March 29, 2023; March 30, 2023; March 31, 2023; April 3, 2023	Temperature	19°C; 20°C; 18°C; 20°C
Test engineer	Martha Espinoza, Wireless Test Engineer	Air pressure	1003mbar; 1005mbar; 1006mbar; 1001mbar
Test location	☐ Wireless bench ☒ Other: 3M Chamber	Relative humidity	58%; 59%; 56%; 57%

8.4.3 Notes

Testing was performed with the transmitter operating on a fixed channel at full power following the cases shown on table 8.1-1 from section 8.1.3 of this document. The width of the mask was defined according to the 26 dB bandwidth widest results (one measured bandwidth selected for each declared bandwidth and each pulse width) shown in table 8.2-1 from section 8.2.5 of this document.

The emission mask was separated into two sections of this document: section 8.4, range from 14 GHz to 18 GHz (including the frequency of operation within ±250% from occupied bandwidth) and section 8.5 which considered the emissions before 14 GHz and after 18 GHz.

The range between the ±250% is a relative limit, therefore, no correction factors were added. For the frequency range beyond ±250% the limit is an absolute value (-13 dBm), which means the corrections factors corresponding to air path losses and interconnexion cables were added as an offset in the spectrum analyzer.

In this section, for the middle channel, 16.15 GHz, 25 MHz declared BW, shortest pulse (1 µs), the middle channel, 16.15 GHz, 50 MHz declared BW, shortest pulse (500 ns), the low channel, 15.80 GHz, 50 MHz declared BW, shortest pulse (5 µs) and the high channel, 16.50 GHz, 50 MHz declared BW, shortest pulse (5 µs), a frequency offset equivalent to RBW/2 in the edges of these channels was applied, according to the basic guidelines described on C63.26 (5.7.2). In the other cases, the mask was applied without frequency offset.

8.4.4 Setup details

EUT power input during test	28 V DC
EUT setup configuration	☐ Table-top ☐ Floor standing ☒ Other: Tripod mounted (1.5 m)

Receiver settings:

Resolution bandwidth	Approximately 1-5 % of the emission bandwidth
Video bandwidth	Approximately 3 x resolution bandwidth
Detector mode	RMS
Trace mode	Average (at least 100 traces)
Span	Enough to see the spectrum under investigation

8.4.5 Test data

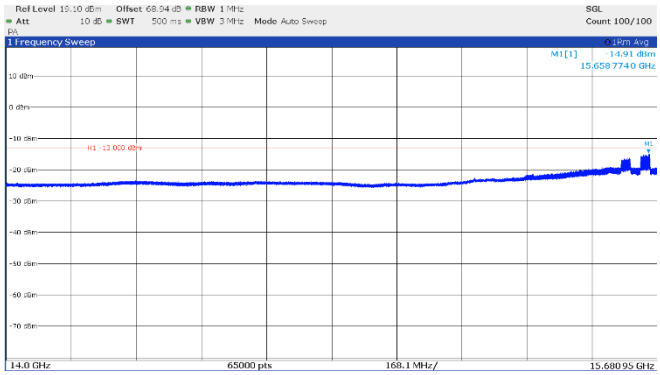

Figure 8.4-1: *Emission mask, beyond ±250% of BW (low frequency range), Low channel: 15.75 GHz, longest pulse. (25 MHz BW)*

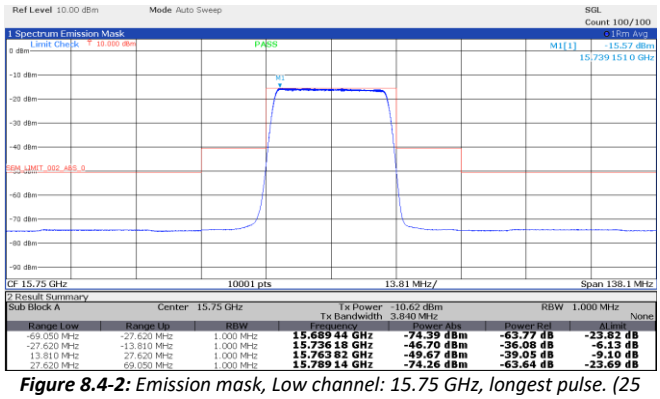

Figure 8.4-2: *Emission mask, Low channel: 15.75 GHz, longest pulse. (25 MHz BW)*

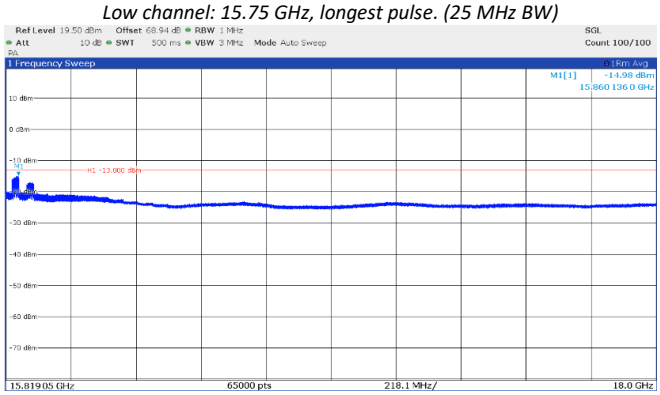

Figure 8.4-3: *Emission mask, beyond ±250% of BW (high frequency range), Low channel: 15.75 GHz, longest pulse. (25 MHz BW)*

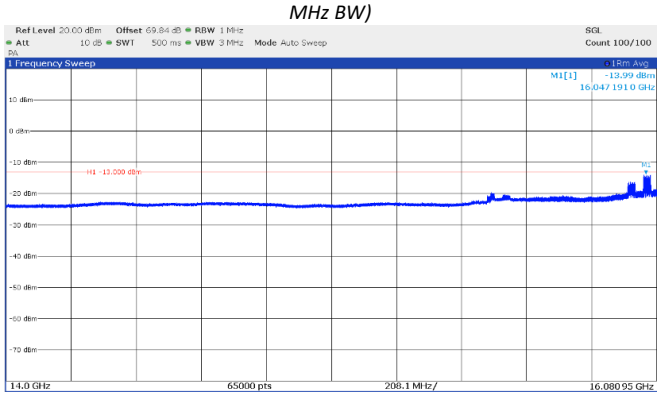

Figure 8.4-4: *Emission mask, beyond ±250% of BW (low frequency range), Middle channel: 16.15 GHz, longest pulse. (25 MHz BW)*

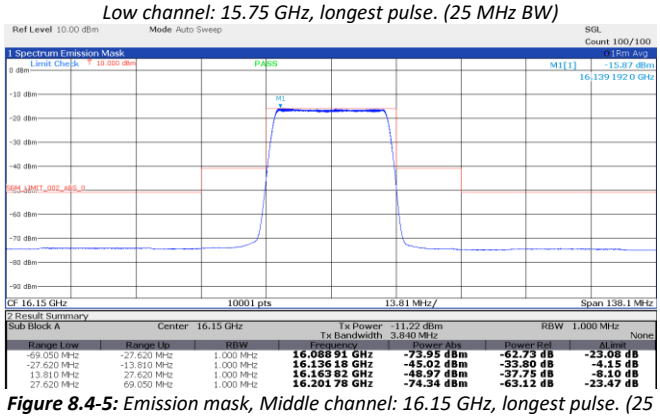

Figure 8.4-5: *Emission mask, Middle channel: 16.15 GHz, longest pulse. (25 MHz BW)*

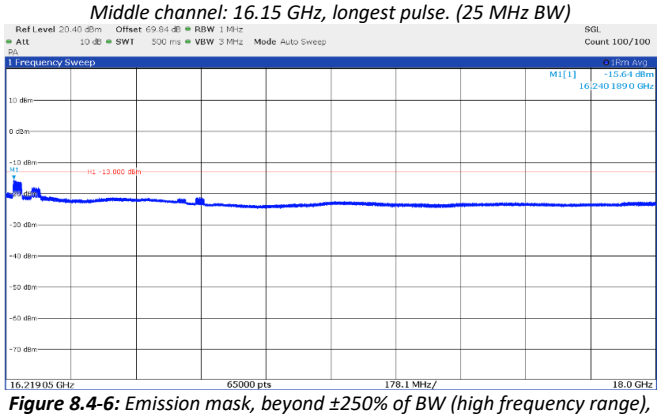

Figure 8.4-6: *Emission mask, beyond ±250% of BW (high frequency range), Middle channel: 16.15 GHz, longest pulse. (25 MHz BW)*

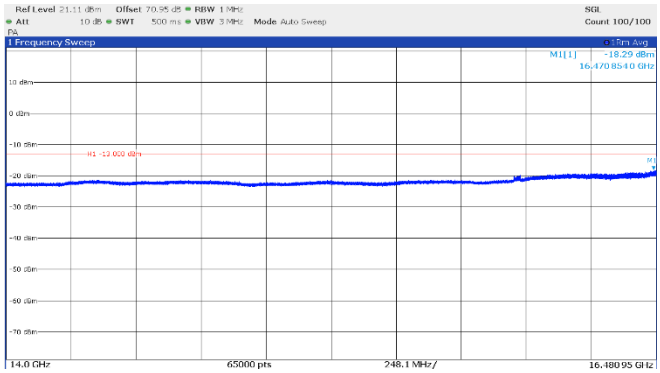

Figure 8.4-7: *Emission mask, beyond ±250% of BW (low frequency range), High channel: 16.55 GHz, longest pulse. (25 MHz BW)*

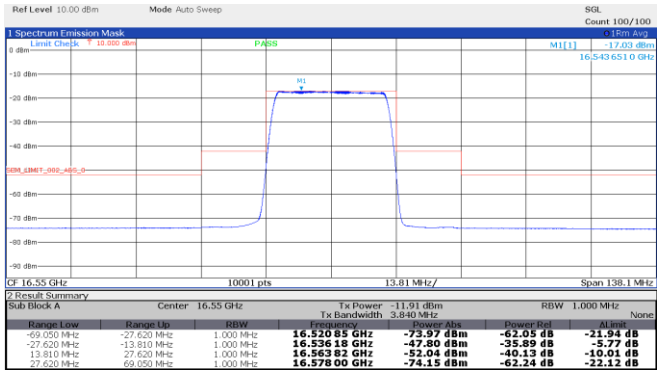

Figure 8.4-8: *Emission mask, High channel: 16.55 GHz, longest pulse. (25 MHz BW)*

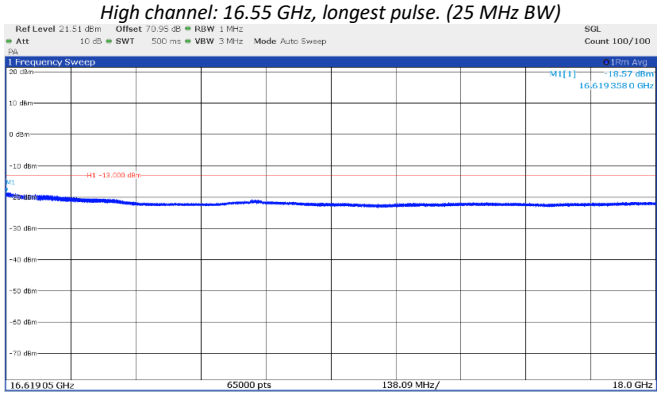

Figure 8.4-9: *Emission mask, beyond ±250% of BW (high frequency range), High channel: 16.55 GHz, longest pulse. (25 MHz BW)*

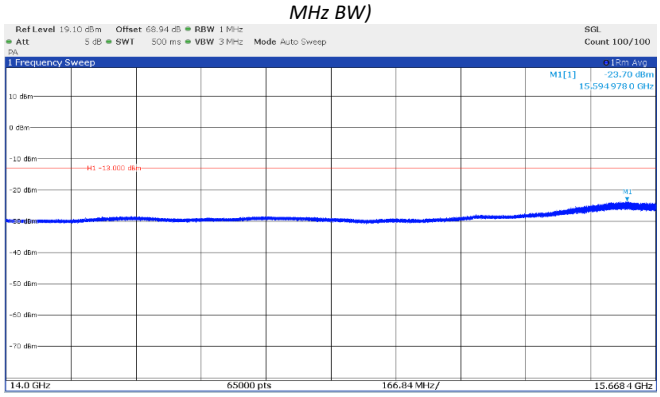

Figure 8.4-10: *Emission mask, beyond ±250% of BW (low frequency range), Low channel: 15.80 GHz, longest pulse. (50 MHz BW)*

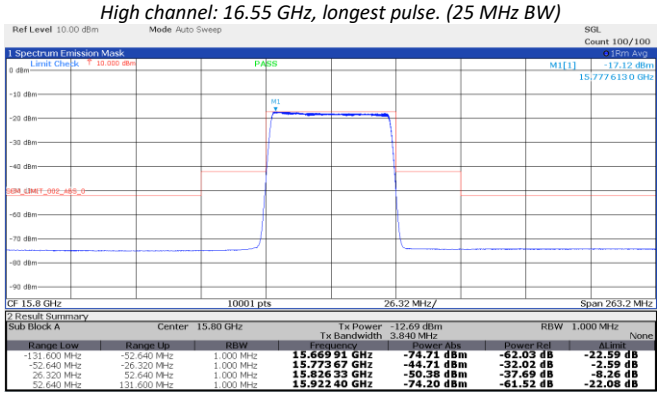

Figure 8.4-11: *Emission mask, Low channel: 15.80 GHz, longest pulse. (50 MHz BW)*

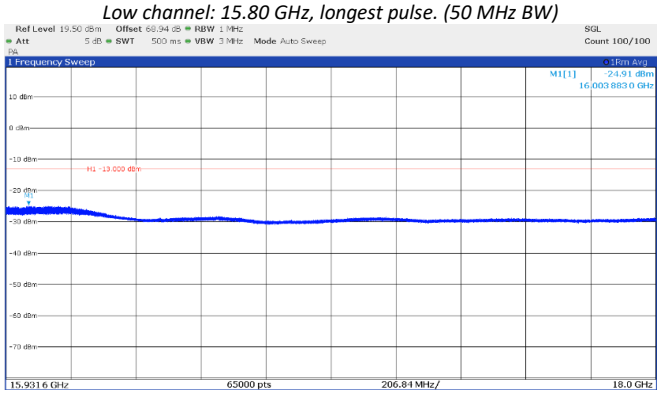

Figure 8.4-12: *Emission mask, beyond ±250% of BW (high frequency range), Low channel: 15.80 GHz, longest pulse. (50 MHz BW)*

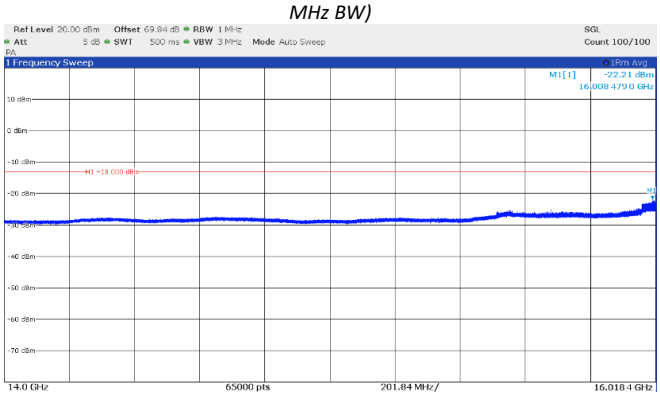

Figure 8.4-13: *Emission mask, beyond ±250% of BW (low frequency range), Middle channel: 16.15 GHz, longest pulse. (50 MHz BW)*

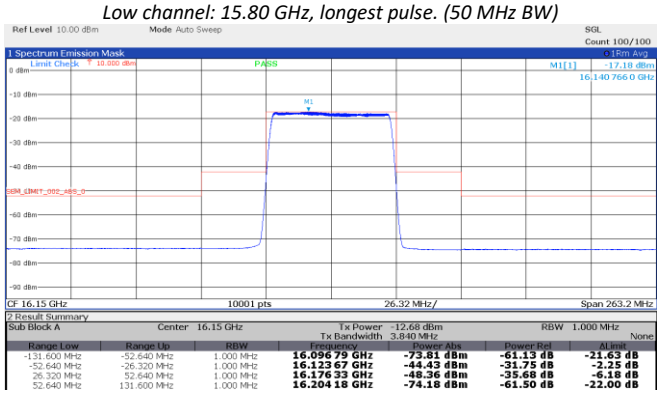

Figure 8.4-14: *Emission mask, Middle channel: 16.15 GHz, longest pulse. (50 MHz BW)*

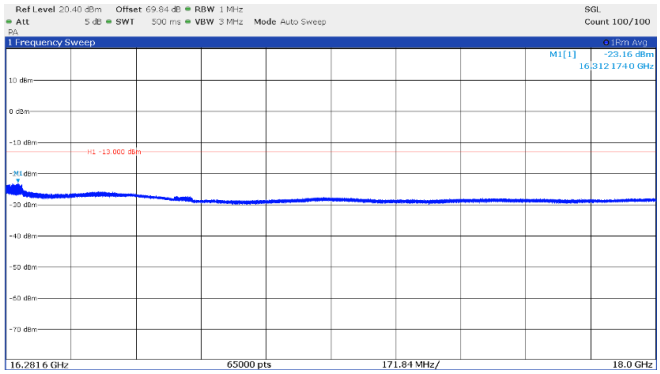

Figure 8.4-15: *Emission mask, beyond ±250% of BW (high frequency range), Middle channel: 16.15 GHz, longest pulse. (50 MHz BW)*

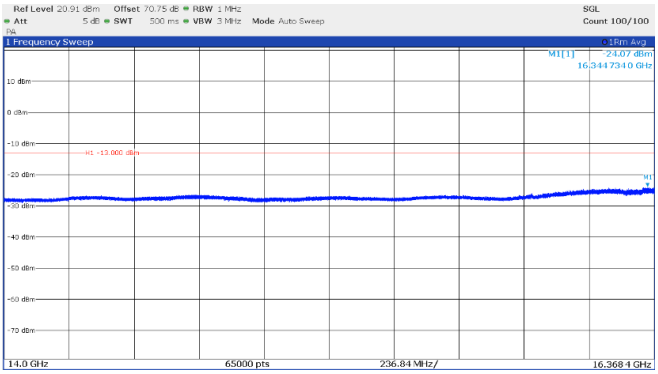

Figure 8.4-16: *Emission mask, beyond ±250% of BW (low frequency range), High channel: 16.50 GHz, longest pulse. (50 MHz BW)*

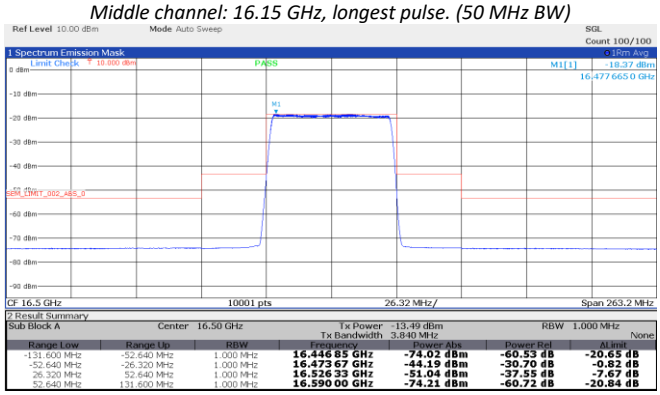

Figure 8.4-17: *Emission mask, High channel: 16.50 GHz, longest pulse. (50 MHz BW)*

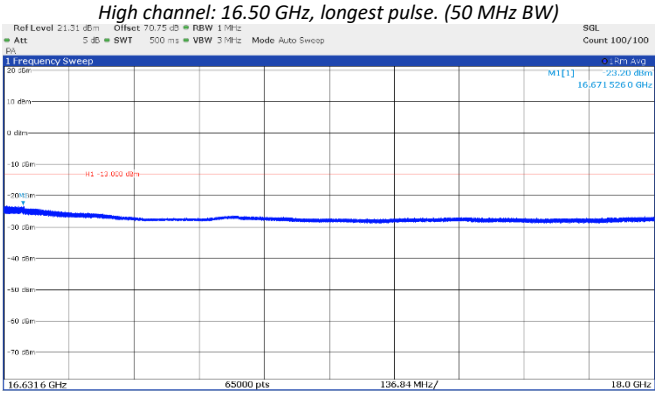

Figure 8.4-18: *Emission mask, beyond ±250% of BW (high frequency range), High channel: 16.50 GHz, longest pulse. (50 MHz BW)*

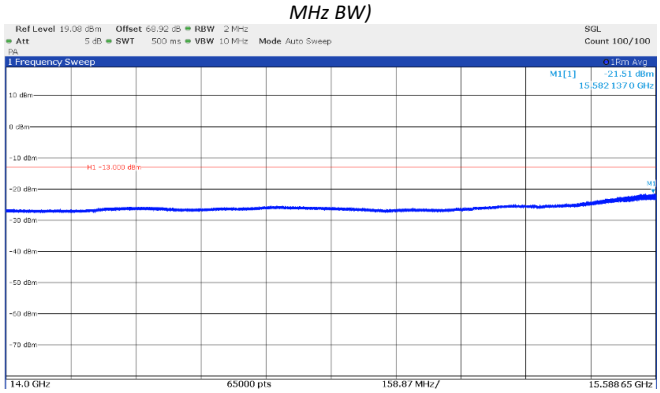

Figure 8.4-19: *Emission mask, beyond ±250% of BW (low frequency range), Low channel: 15.85 GHz, longest pulse. (100 MHz BW)*

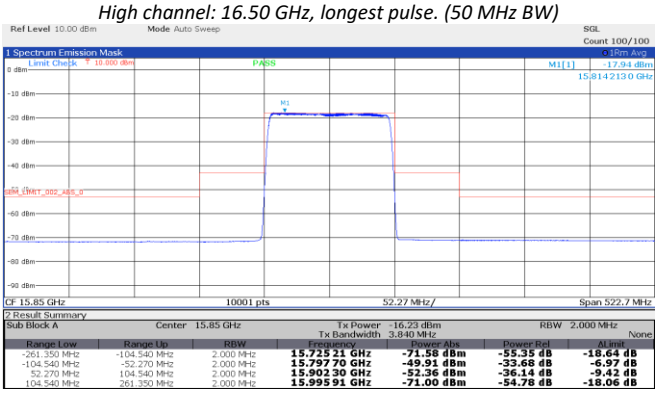

Figure 8.4-20: *Emission mask, Low channel: 15.85 GHz, longest pulse. (100 MHz BW)*

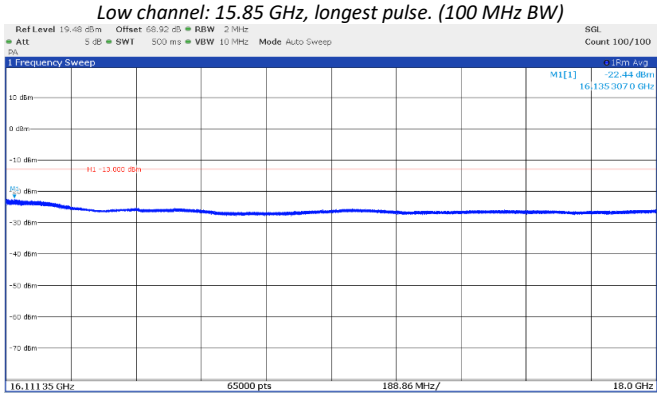

Figure 8.4-21: *Emission mask, beyond ±250% of BW (high frequency range), Low channel: 15.85 GHz, longest pulse. (100 MHz BW)*

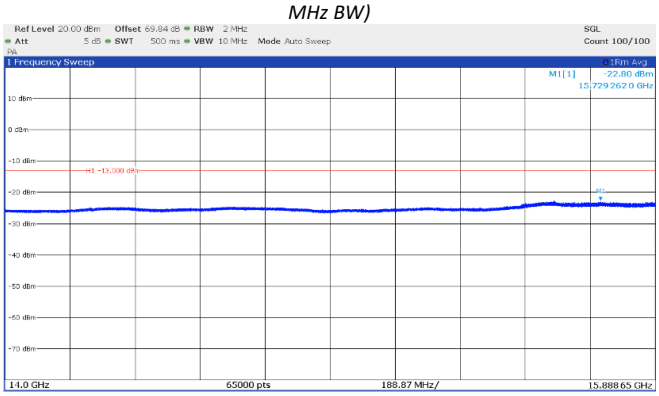

Figure 8.4-22: *Emission mask, beyond ±250% of BW (low frequency range), Middle channel: 16.15 GHz, longest pulse. (100 MHz BW)*