DAkkS Deutsche Akkreditierungsstelle D-PL-21375-01-00

INGENIEURBÜRO LENHARDT

Bundesnetzagentur

BNetzA-CAB-21/21-21

Test Report

Test report no.: 23028383-31512-1
Date of issue: 2023-06-07

Test result: The test item **- passed - and complies** with below listed standards.

Applicant

Valeo Schalter und Sensoren GmbH

Manufacturer

Valeo Schalter und Sensoren GmbH

Test Item

MCR1

RF-Spectrum Testing according to:

FCC 47 CFR Part 95
Personal radio services,
Subpart M - The 76-81 GHz Band Radar Service

Tested by (name, function, signature)	*Sebastian Janoschka* *Head of Department Radio*	signature
Approved by (name, function, signature)	*Karsten Geraldy* *Lab Manager RF*	signature

Applicant and Test item details	
Applicant	Valeo Schalter und Sensoren GmbH Laiernstraße 12 74321, Bietigheim-Bissingen, Germany Phone: +420 225355470
Manufacturer	Valeo Schalter und Sensoren GmbH Laiernstraße 12 74321, Bietigheim-Bissingen, Germany
Test item description	Automotive radar sensor
Model/Type reference	MCR1
FCC ID	VE2-60913793
Frequency	76.0 GHz to 77.0 GHz
Antenna	integrated patch antenna
Power supply	9.0 to 16.0 V DC
Temperature range	-40 °C to +85 °C

Disclaimer and Notes

Within this test report, a ☒ point / ☐ comma is used as a decimal separator.
If otherwise, a detailed note is added adjected to its use.

IBL-Lab GmbH does not take test samples. The samples used for testing are provided by the applicant.

Decision rule:
Decision rule based on simple acceptance without guard bands, binary statement, based on mutually agreed uncertainty tolerances with expansion factor k=2 according to ILAC-G8:09/2019

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2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: https://ib-lenhardt.com/ E-Mail: info@ib-lenhardt.com
Accreditation / Designation	The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018. Scope of testing and registration number: • Attachment to the accreditation certificate D-PL-21375-01-00 ○ Electronics ○ Electromagnetic Compatibility ○ Radio ○ Electromagnetic Compatibility and Telecommunication (FCC requirements) ○ Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards ○ Automotive EMC Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the ILAC Mutual Recognition Arrangement. • Designations ○ FCC Testing Laboratory Designation Number DE0024 ○ ISED ISED Company Number 27156 Testing Laboratory CAB Identifier DE0020 ○ Kraftfahrt-Bundesamt KBA-P 00120-23
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2023-03-10
Start – End of tests	2023-03-10 – 2020-03-24

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS)
Test sample does not meet the requirements	F (FAIL)
Test case does not apply to the test sample	N/A (Not applicable)
Test case not performed	N/P (Not performed)

2.3 Observations

No additional observations other than the reported observations within this test report have been made.

2.4 Opinions and interpretations

No appropriate opinions or interpretations according ISO/IEC 17025:2017 clause 7.8.7 are within this test report.

2.5 Revision history

-0 Initial Version

-1 Revision:	Reference for operating conditions and antenna characteristics added. Naming scheme of DUT changed accordingly to operational description

This test report 23028383-31512-1 replaces the previous test report 23028383-31512-0
Utilisation, publication and control of previous report editions is under responsibility of the applicant.

2.6 Further documents

List of further applicable documents belonging to the present test report:
– no additional documents –

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75% r.H.
Barometric Pressure	860-1060 mbar
Power supply	230 V AC ± 5%

3.2 Normal and extreme test conditions

	minimum	normal	maximum
Temperature	-40 °C	20 °C	+85 °C
Relative humidity	-/-	45 % r.h.	-/-
Power supply	9.0 V DC	13.2 V DC	16.0 V DC

4 TEST STANDARDS AND REFERENCES

Test standard (accredited)	**Description**
FCC 47 CFR Part 95	Personal radio services, Subpart M - The 76-81 GHz Band Radar Service

Reference	**Description**
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
KDB 653005 D01, V01, R02	Equipment Authorization Guidance for 76-81 GHz Radar Devices

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

Automotive radar sensor

5.2 Description of test item

Model name*	MCR1
Serial number*	DUT 1 (other variant with front beam) normal operating mode: 2302150000041 DUT 2 (with corner beam 1: 2302150000011 DUT 3 (with corner beam 2: 2302150000012 DUT 4 (with corner beams) normal operating mode: 2302150000006
Hardware status*	bb60913/bb60793
Software status*	40.1.- 41.1

*: as declared by applicant

5.3 Technical data of test item

Operational frequency band*	76.0 GHz to 77.0 GHz
Type of radio transmission*	modulated carrier
Modulation type*	FMCW
Number of channels*	1
Channel bandwidth*	< 1 GHz
Channel spacing*	N/A
Receiver category*	N/A
Receiver bandwidth*	N/A
Duty cycle*	MCR1 ~42.4% MCR1 other variant ~21.2%
Antenna*	integrated patch antenna
Rated RF output power*	< 50 dBm
Power supply*	9.0 to 16.0 V DC
Temperature range*	-40 °C to +85 °C

*: as declared by applicant

5.4 Additional information

Model differences	*2 Variants of the MCR1 are measured:* *MCR1 will be used as a corner sensor with two alternating beamforms within it's band,* *MCR1 other variant will be used as a front sensor with one central beam in terms of azimuth and elevation.* *According to the statement of our customer, the difference in hard and software between those two is the feed to the same pcb-antenna as well as software related steering of these beams in terms of angle and burst.* *Two of the MCR1 samples were specially prepared, so that only one beam (no beamsteering or alternating of those) was continuously used for testing purposes in terms of carrier measurement.*
Ancillaries tested with	-
Additional equipment used for testing	-

5.5 Operating conditions

Operating conditions are described in "*MCR1-Operational Description*", provided by applicant.

5.6 Antenna characteristics

Antenna characteristics are described in "*MCR1-Operational Description*", provided by applicant.

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 95 – Subpart M

Clause	Requirement / Test case	Test Conditions	Result / Remark	Verdict
§2.1046 §95.3367 (a) (b)	RF power output	Nominal	30.16 dBm mean 35.84 dBm peak	P
§2.1047	Modulation characteristics	Nominal		P
§2.1049 §95.3379 (b)	Occupied bandwidth	Nominal	565.402 MHz	P
§2.1051	Spurious emissions at antenna terminals	Nominal	see note	N/A
§2.1053 §95.3379 (a)(1) §95.3379 (a)(2) §95.3379 (a)(3)	Field strength of spurious radiation	Nominal	< limit	P
§2.1055 §95.3379 (b)	Frequency stability	Nominal Extreme	within band	P

Notes
FCC's Millimeter Wave Test Procedures: I. A radiated method of measurements in order to demonstrate compliance with the various regulatory requirements has been chosen in consideration of test equipment availability and the limitations of many external harmonic mixers. A conducted method of measurement could be employed if EUT and mixer waveguides both are accessible and of the same type (WG number) and if waveguide sections and transitions can be found. Another potential problem is that the peak power output may exceed the +20 dBm input power limit of many commercially available mixers. For these reasons a radiated method is preferred.

Comments and observations
-none

7 TEST RESULTS

7.1 RF power output (§2.1046 & §95.3367)

Description

§2.1046 Measurements required: RF power output.

(a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in §2.1033(c)(8). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

Limits

§95.3367 76-81 GHz Band Radar Service radiated power limits

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.

Test procedure

Mean Power

Method with spectrum analyser

A spectrum analyser with the following settings is used as measuring receiver in the test set-up:

- Start frequency: lower than the lower edge of the operating frequency range.
- Stop frequency: higher than the upper edge of the operating frequency range.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: 3 MHz.
- Detector mode: RMS.
- Display mode: clear write.
- Averaging time: larger than one EUT cycle time.
- Sweep time: averaging time × number of sweep points.

Channel Power function needs to be used to calculate the average power. Boundaries for the calculation needs to be defined. This is typically the operating frequency range.

Method with power meter

The power meter shall be connected to the measurement antenna. The frequency correction factor shall be taken into account. The power meter shall be a true RMS power meter. The measurement time shall be equal or longer than the EUT cycle time.

KDB 653005 D01 76-81 GHz Radars v01r02, 4. b)

The maximum fundamental emission power (EIRP) shall be measured using a power averaging (rms) detector with a 1 MHz resolution bandwidth (RBW) and integrated over the full 99% occupied bandwidth (OBW) to obtain the data necessary to demonstrate compliance to the 50 dBm limit.

Test procedure

Peak Power

Method with a spectrum analyser

A spectrum analyser with the following settings is used as measuring receiver in the test set-up:
• Start frequency: lower than the lower edge of the operating frequency range.
• Stop frequency: higher than the upper edge of the operating frequency range.
• Resolution bandwidth: 1 MHz.
• Video bandwidth: 3 MHz.
• Detector mode: Peak detector.
• Display mode: Maxhold.
• Sweep time: EUT cycle time × number of sweep points.
• Measurement is done until trace is stabilised.
The peak power to be considered is the maximum value recorded.

KDB 653005 D01 76-81 GHz Radars v01r02, 4. c)
The maximum peak fundamental emission power (EIRP) measurement shall be performed by sweeping over the transmitted occupied bandwidth using a positive peak power detector with peak hold activated, and a 1 MHz RBW. Power integration is not to be used in performing this measurement. The resultant peak power spectral density (maximum in any 1 MHz) data shall be used to demonstrate compliance to the 55 dBm/MHz limit.
Peak power measurements of swept frequency radar implementations (e.g., high sweep rate FMCW) may require a desensitization correction factor to be applied to the measurement results. See relevant Application Note(s) from the measurement instrumentation vendor for details.

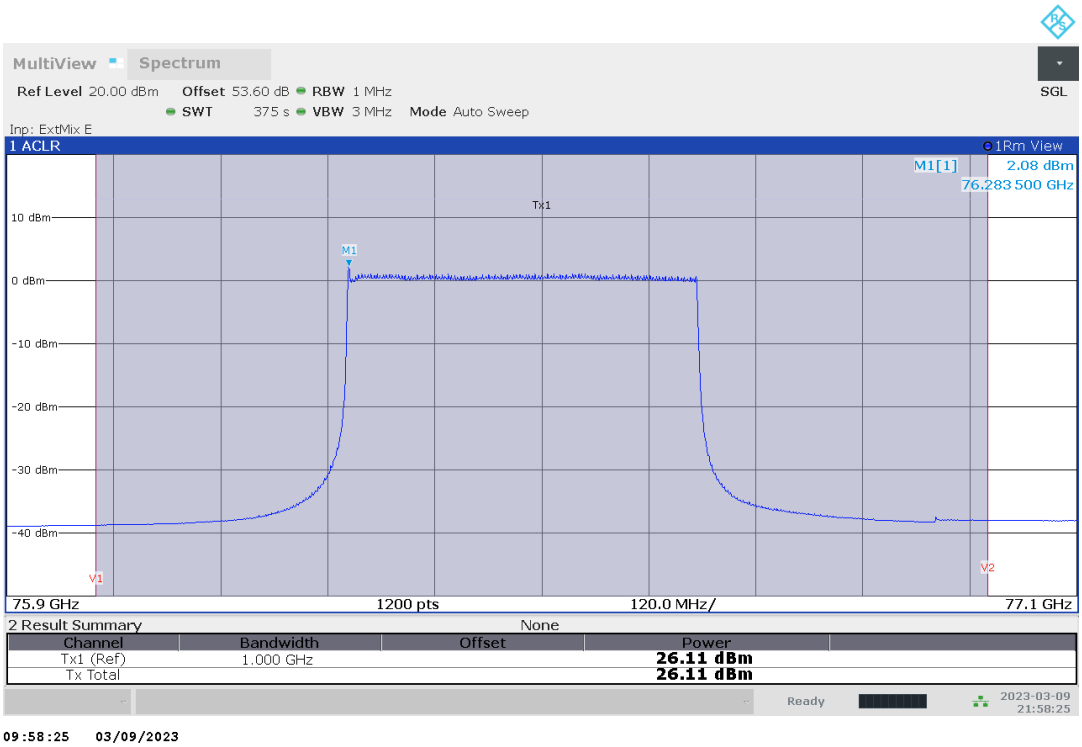
Test procedure used: Method with Spectrum Analyzer

Test setup: 8.3

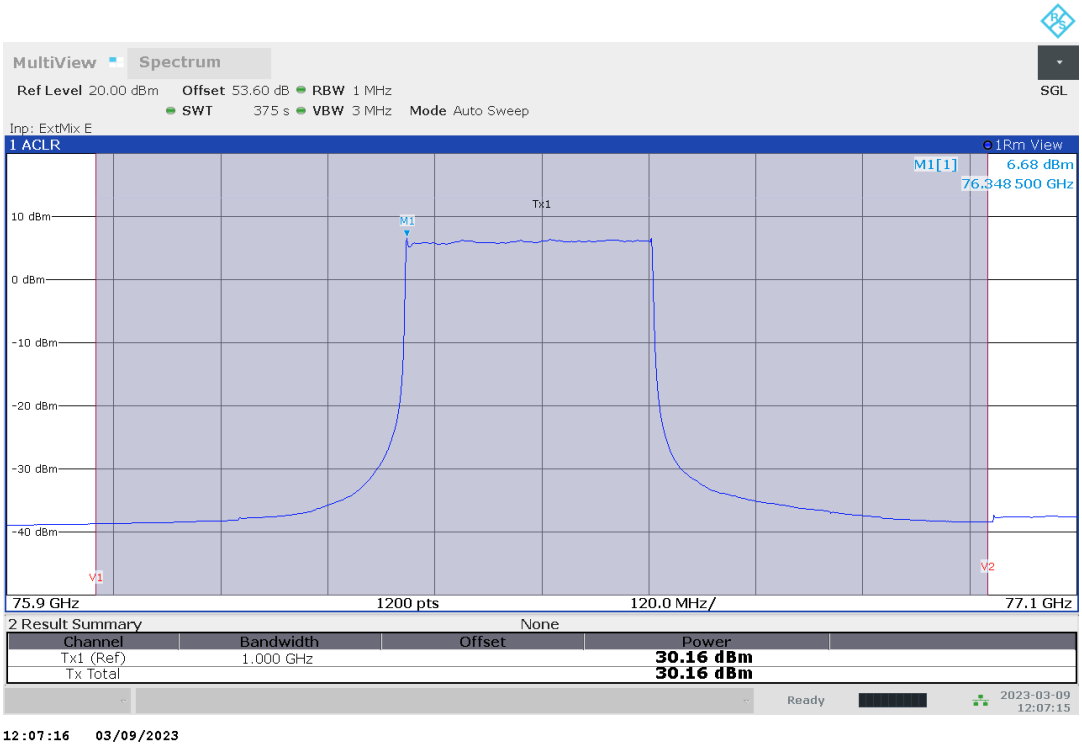
Test results

DUT & Test mode	Test distance	Mean power (EIRP) [dBm]	Radiated Peak Power (EIRP) [dBm]
1 normal	1.5 m	26.11	35.84
2 beam 1	1.5 m	30.16	32.46
3 beam 2	1.5 m	20.00	20.50

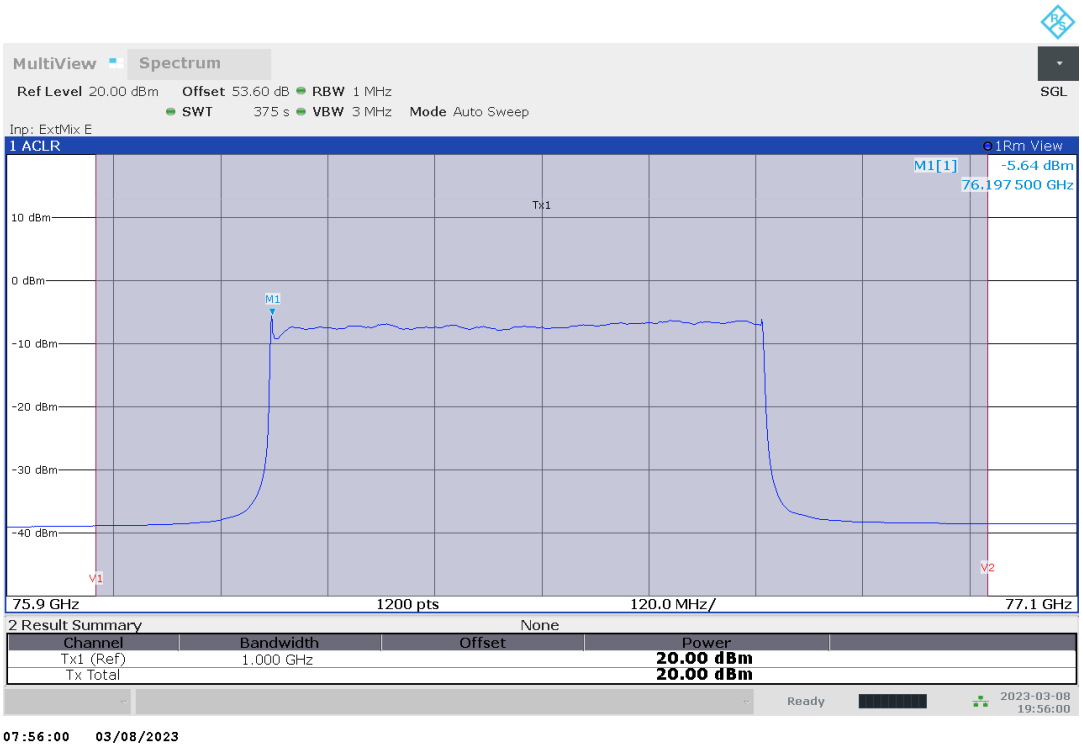
Plot no. 1: Mean Power EIRP, RMS detector / Channel Power, DUT 1 normal mode, T_{nom}, V_{nom}



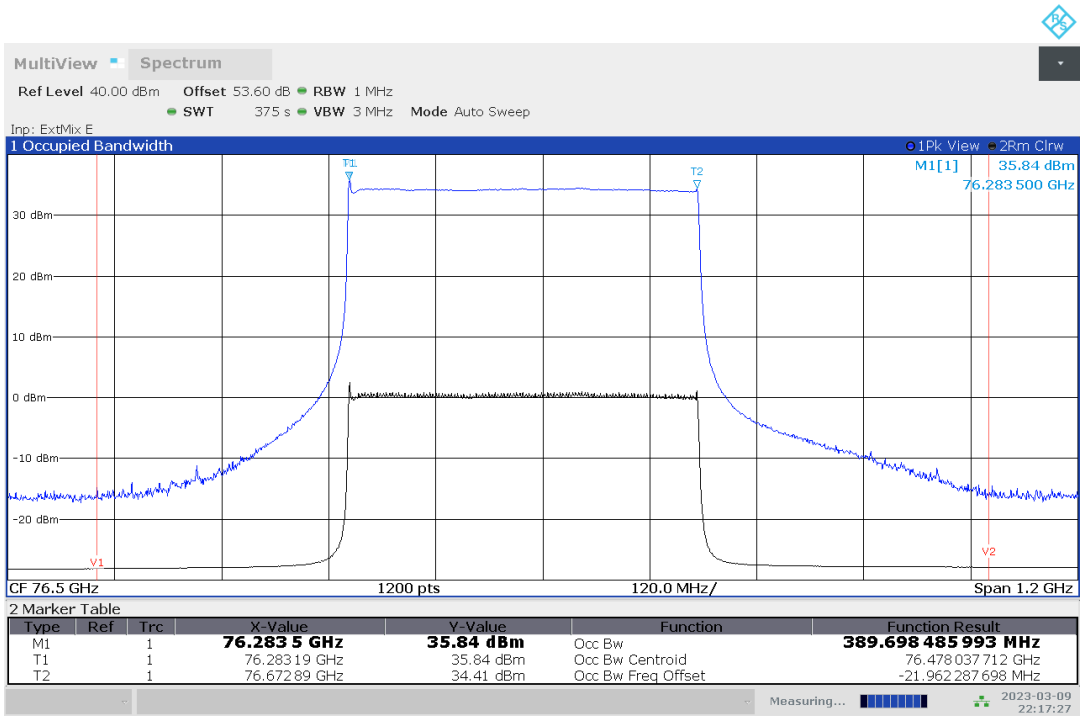
Plot no. 2: Mean Power EIRP, RMS detector / Channel Power, DUT 2 beam 1, T_{nom}, V_{nom}



Plot no. 3: Mean Power EIRP, RMS detector / Channel Power, DUT 3 beam 2, T_{nom}, V_{nom}



Plot no. 4: Peak Power EIRP, DUT 1 normal mode, T_{nom}, V_{nom}



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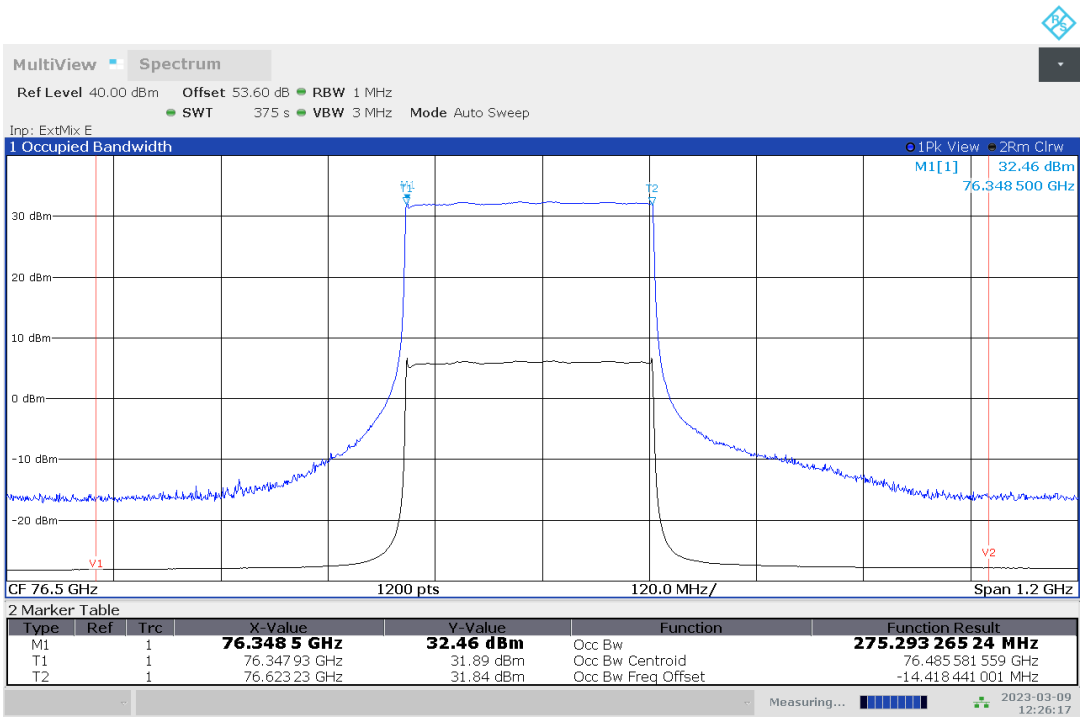
Plot no. 5: Peak Power EIRP, DUT 2 beam 1, T_{nom}, V_{nom}



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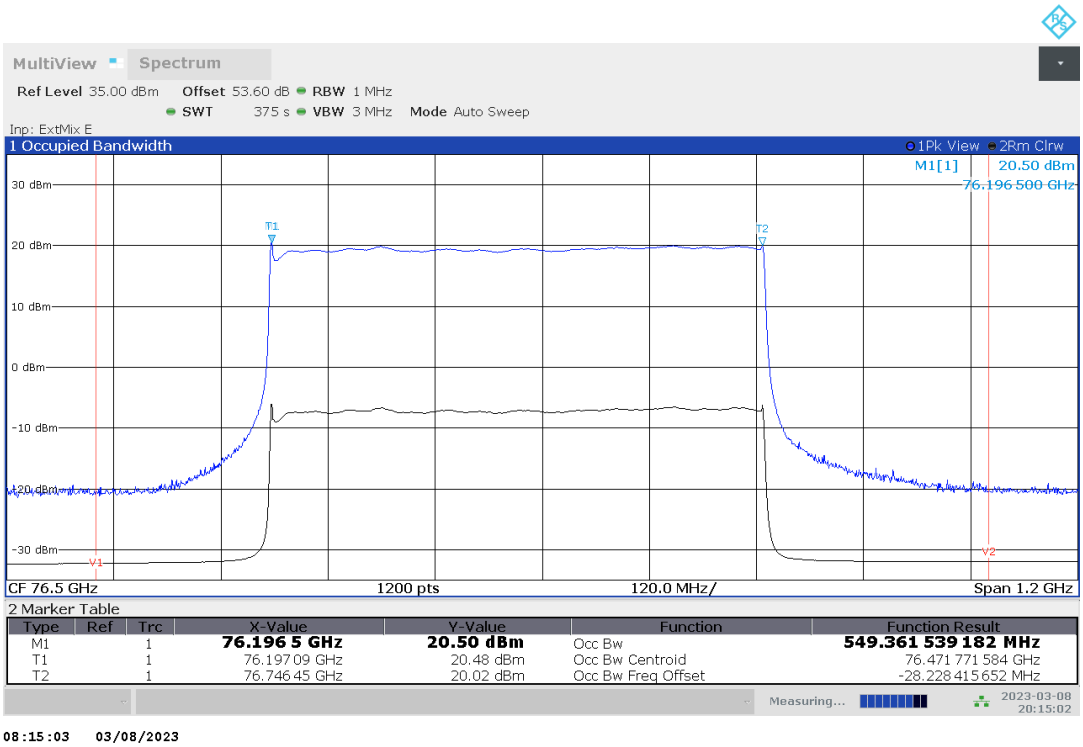
Plot no. 6: Peak Power EIRP, DUT 3 beam 2, T_{nom}, V_{nom}



7.2 Modulation characteristics (§2.1047 & KDB 653005 D01 76-81 GHz Radars)

Description

§2.1047 Modulation characteristics

(d) Other types of equipment. A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.

KDB 653005 D01 76-81 GHz Radars v01r02, 3. g)

Concerning the Section 2.1047 modulation characteristics requirement, the following information should be provided:

1) Pulsed radar: pulse width and pulse repetition frequency (if PRF is variable, then report maximum and minimum values).
2) Non-pulsed radar (*e.g.,* FMCW): modulation type (i.e., sawtooth, sinusoid, triangle, or square wave) and sweep characteristics (sweep bandwidth, sweep rate, sweep time).

Statement of applicant / manufacturer concerning modulation characteristics of EUT

Please refer to chapter 5

7.3 Occupied bandwidth (§2.1049 & §95.3379)

Description

§2.1049 Measurements required: Occupied bandwidth.

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.

Limits

§95.3379 (b)

Fundamental emissions (i.e. 99% emission bandwidth) must be contained within the frequency bands specified in this section during all conditions of operation.

Test procedure

ANSI C63.26, 5.4.4

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.

The following procedure shall be used for measuring 99% power bandwidth:

a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level. Specific guidance is given in 4.1.5.2.
Note: Step a) through step c) may require iteration to adjust within the specified tolerances.

d) Set the detection mode to peak, and the trace mode to max-hold.

e) If the instrument does not have a 99% OBW function, recover the trace data points and sum directly in linear power terms. Place the recovered amplitude data points, beginning at the lowest frequency, in a running sum until 0.5% of the total is reached. Record that frequency as the lower OBW frequency. Repeat the process until 99.5% of the total is reached and record that frequency as the upper OBW frequency. The 99% power OBW can be determined by computing the difference these two frequencies.

f) The OBW shall be reported and plot(s) of the measuring instrument display shall be provided with the test report. The frequency and amplitude axis and scale shall be clearly labeled. Tabular data can be reported in addition to the plot(s)

KDB 653005 D01 76-81 GHz Radars v01r02, 4. d)

The occupied bandwidth of the radar device shall be measured, reported, and shown to be fully contained within the designated 76-81 GHz frequency band under normal operating conditions as well as under those extreme ambient temperature and input voltage conditions as described in Section 2.1057.

The OBW measurement of an FMCW radar shall be performed with the transmitter operating in normal mode (i.e., with frequency sweep or step active).

Note

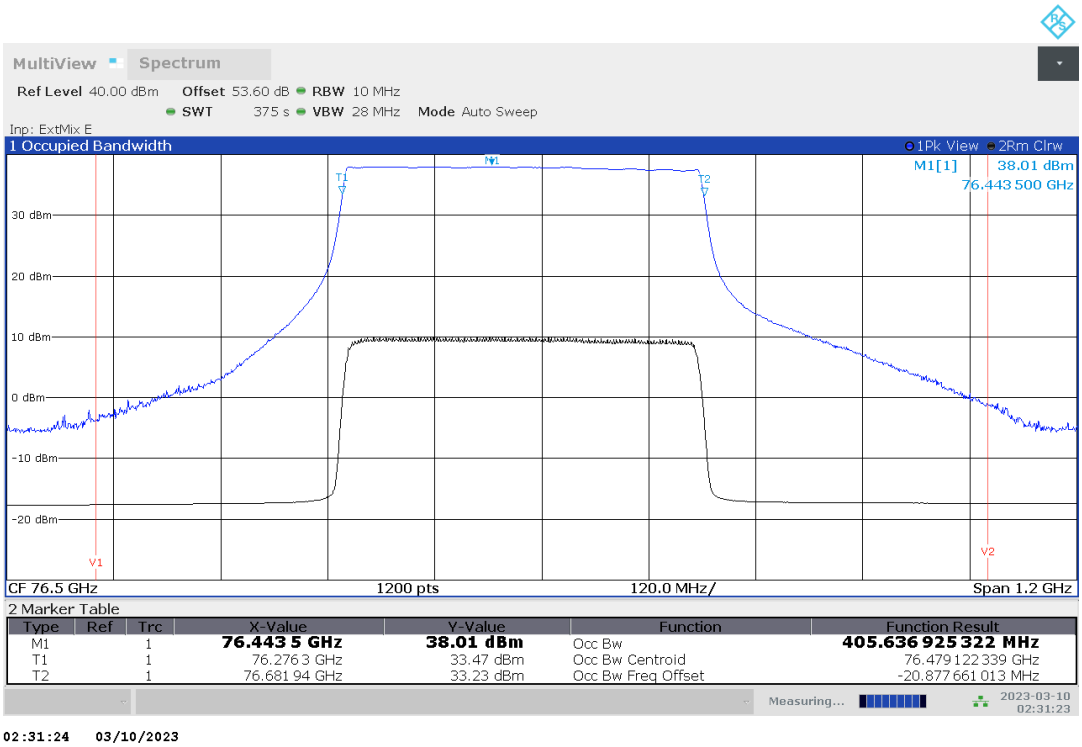
Measurements with the peak detector are also suitable to demonstrate compliance of an EUT, as long as the required resolution bandwidth is used, because peak detection will yield amplitudes equal to or greater than amplitudes measured with RMS detector. The measurement data from a spectrum analyser peak detector will represent the worst-case results (see ANSI C63.26, chapter D2: general considerations).

Test setup: 8.3, 8.4

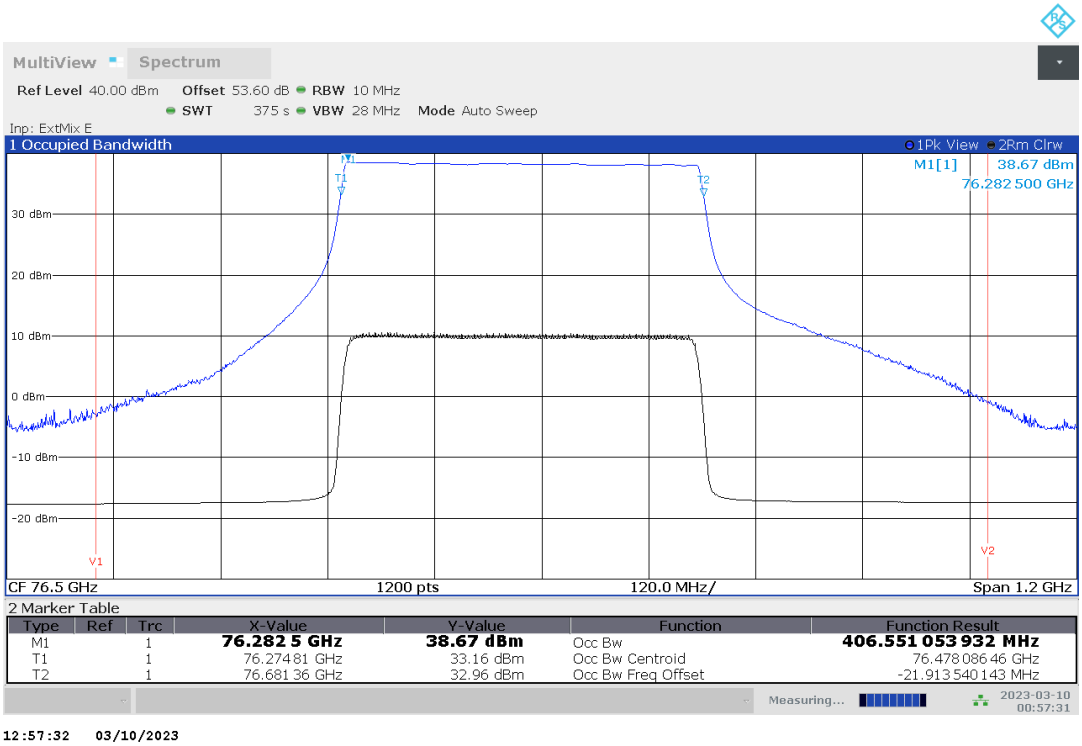
Test results				
EUT mode	**Test conditions**	**f_L [GHz]**	**f_H [GHz]**	**99% OBW [MHz]**
DUT 1 normal	85 °C	76.276	76.681	405.637
DUT 1 normal	50 °C	76.275	76.681	406.551
DUT 1 normal	40 °C	76.275	76.682	406.685
DUT 1 normal	30 °C	76.275	76.682	406.867
DUT 1 normal	20 °C V_{max}	76.275	76.682	406.948
DUT 1 normal	20 °C V_{nom}	76.275	76.682	406.943
DUT 1 normal	20 °C V_{min}	76.275	76.682	406.989
DUT 1 normal	10 °C	76.275	76.682	407.343
DUT 1 normal	0 °C	76.275	76.682	407.485
DUT 1 normal	-10 °C	76.276	76.683	407.652
DUT 1 normal	-20 °C	76.275	76.683	408.230
DUT 1 normal	-30 °C	76.275	76.684	408.551
DUT 1 normal	-40 °C	76.274	76.683	408.596
DUT 2 Beam 1	85 °C	76.337	76.633	296.578
DUT 2 Beam 1	50 °C	76.337	76.633	296.440
DUT 2 Beam 1	40 °C	76.337	76.634	296.540
DUT 2 Beam 1	30 °C	76.338	76.634	296.360
DUT 2 Beam 1	20 °C V_{max}	76.338	76.635	296.452
DUT 2 Beam 1	20 °C V_{nom}	76.338	76.635	296.377
DUT 2 Beam 1	20 °C V_{min}	76.388	76.635	296.932
DUT 2 Beam 1	10 °C	76.339	76.635	296.259
DUT 2 Beam 1	0 °C	76.339	76.636	296.233
DUT 2 Beam 1	-10 °C	76.340	76.636	296.017
DUT 2 Beam 1	-20 °C	76.340	76.636	296.299
DUT 2 Beam 1	-30 °C	76.340	76.634	296.533
DUT 2 Beam 1	-40 °C	76.340	76.637	296.776
DUT 3 Beam 2	85 °C	76.190	76.754	563.883
DUT 3 Beam 2	50 °C	76.190	76.754	563.956
DUT 3 Beam 2	40 °C	76.190	76.754	563.450
DUT 3 Beam 2	30 °C	76.191	76.754	562.955
DUT 3 Beam 2	20 °C V_{max}	76.912	76.754	562.950
DUT 3 Beam 2	20 °C V_{nom}	76.191	76.755	563.019
DUT 3 Beam 2	20 °C V_{min}	76.192	76.754	562.941
DUT 3 Beam 2	10 °C	76.192	76.755	563.441
DUT 3 Beam 2	0 °C	76.192	76.756	563.894
DUT 3 Beam 2	-10 °C	76.191	76.756	564.535
DUT 3 Beam 2	-20 °C	76.192	76.757	564.980
DUT 3 Beam 2	-30 °C	76.191	76.757	565.402
DUT 3 Beam 2	-40 °C	76.192	76.757	565.141

With voltage variation
Input voltage variation does not affect the transmitted signal (see plots for ambient/normal temperature).

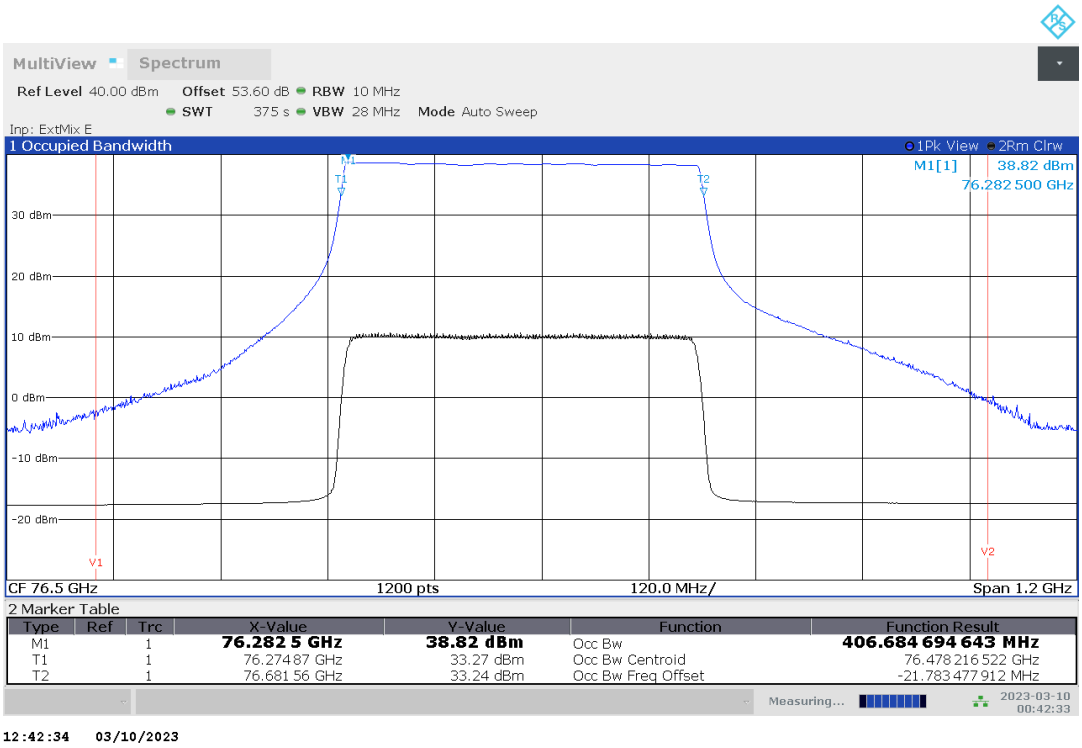
Plot no. 7: 99% OBW, Peak detector, 85 °C, DUT 1 normal



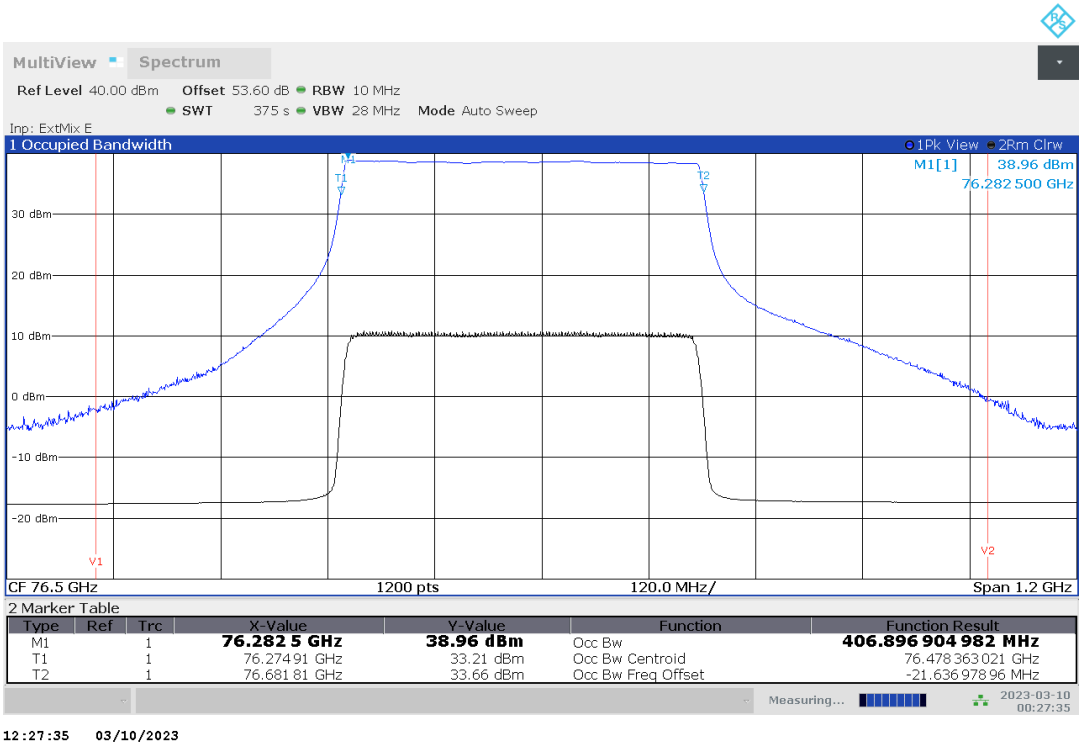
Plot no. 8: 99% OBW, Peak detector, 50 °C, DUT 1 normal



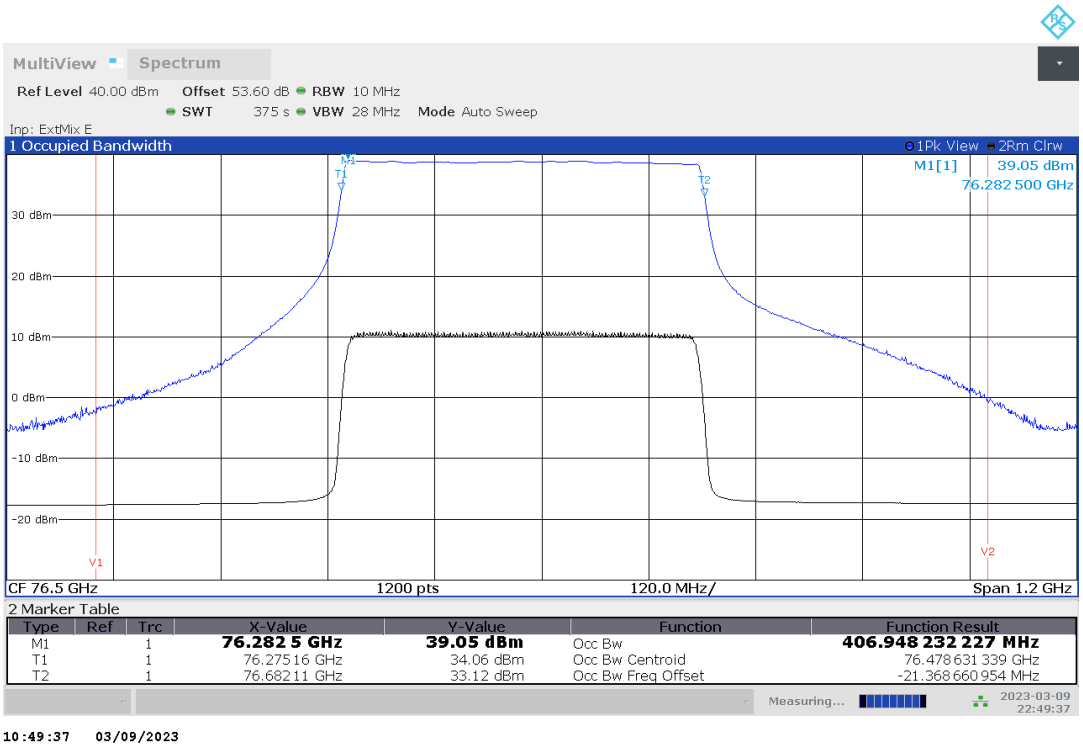
Plot no. 9: 99% OBW, Peak detector, 40 °C, DUT 1 normal



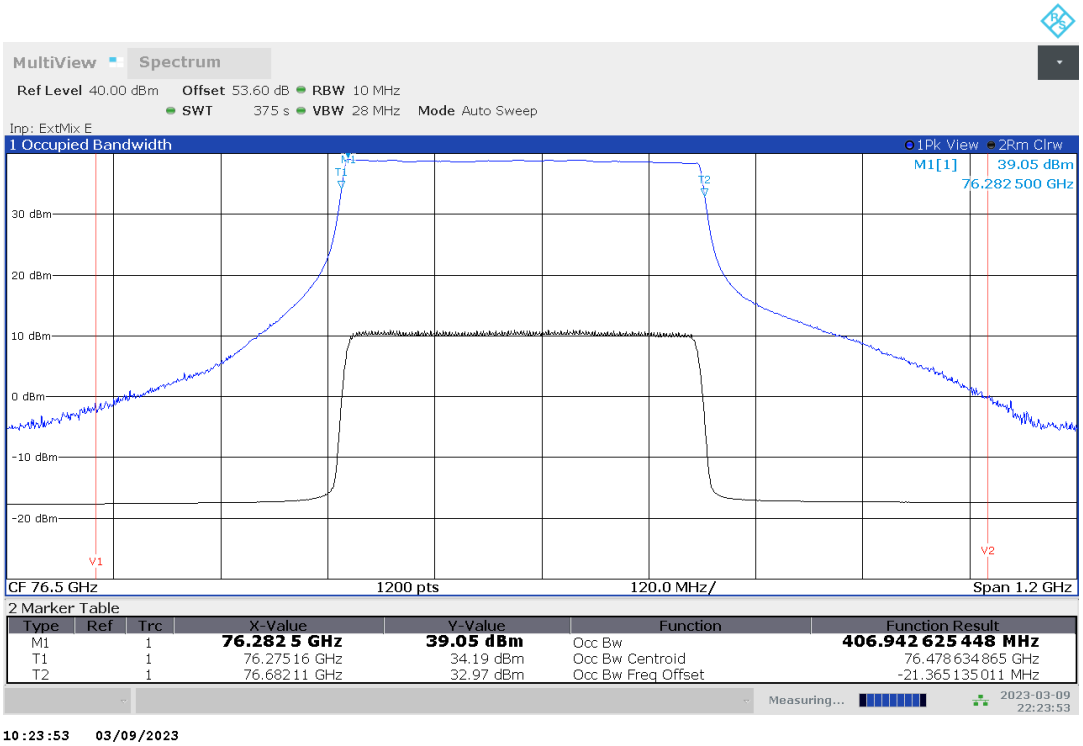
Plot no. 10: 99% OBW, Peak detector, 30 °C, DUT 1 normal



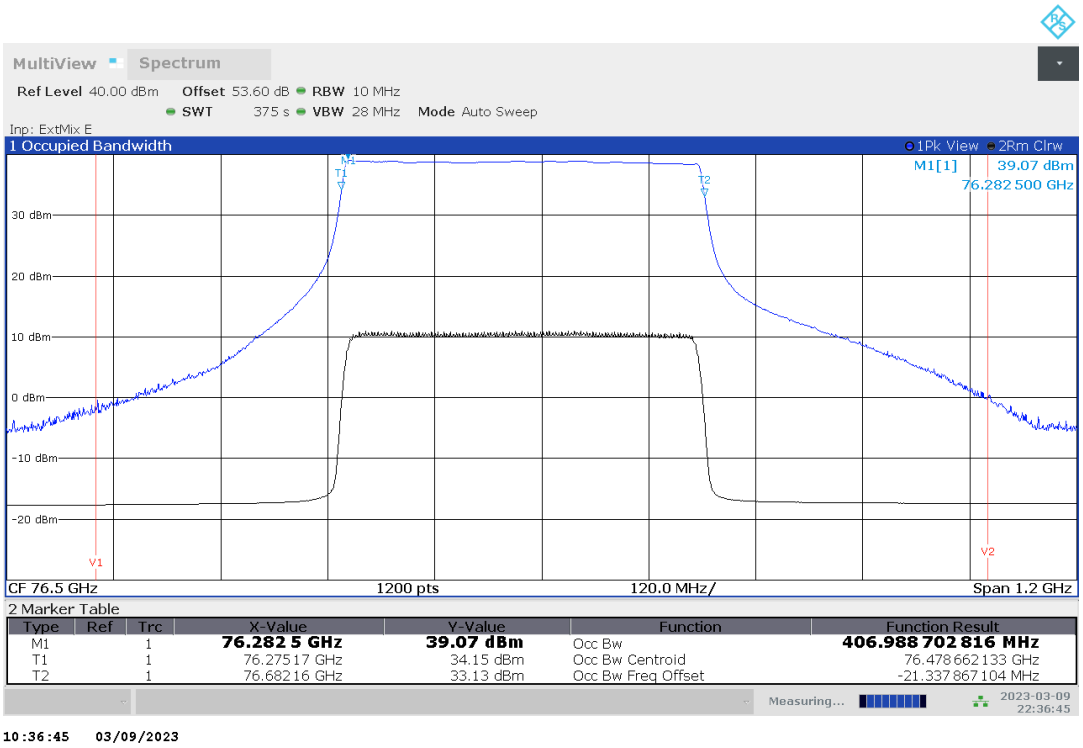
Plot no. 11: 99% OBW, Peak detector, 20 °C, V_{max}, DUT 1 normal



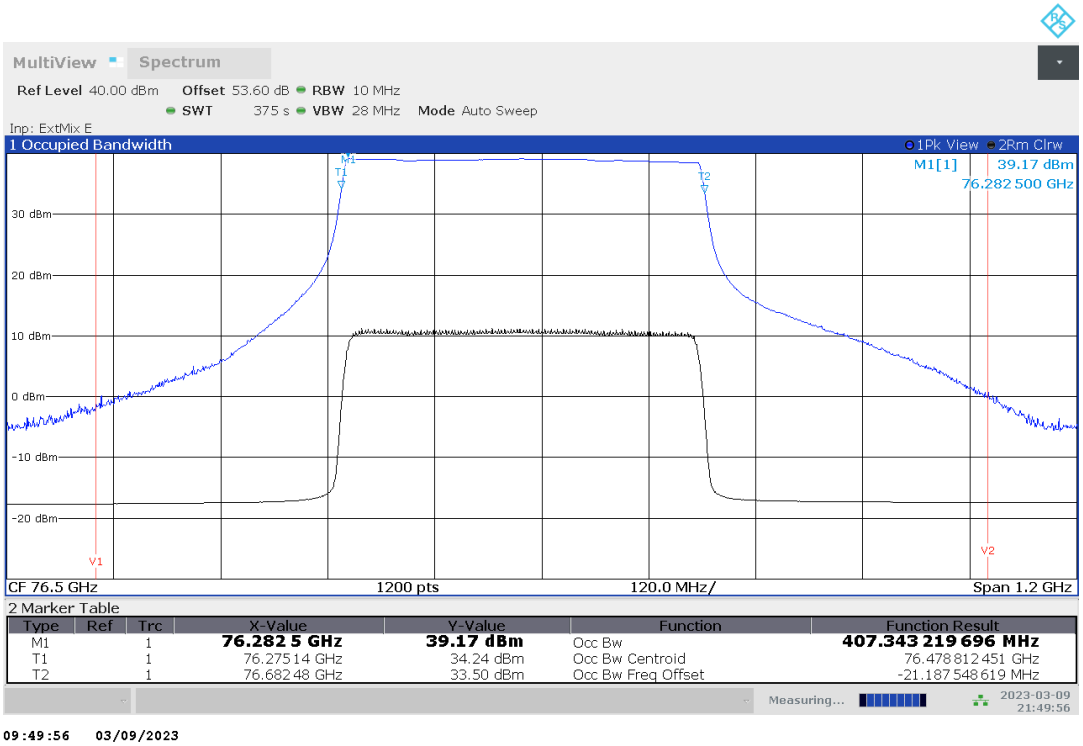
Plot no. 12: 99% OBW, Peak detector, 20 °C, V_{nom}, DUT 1 normal



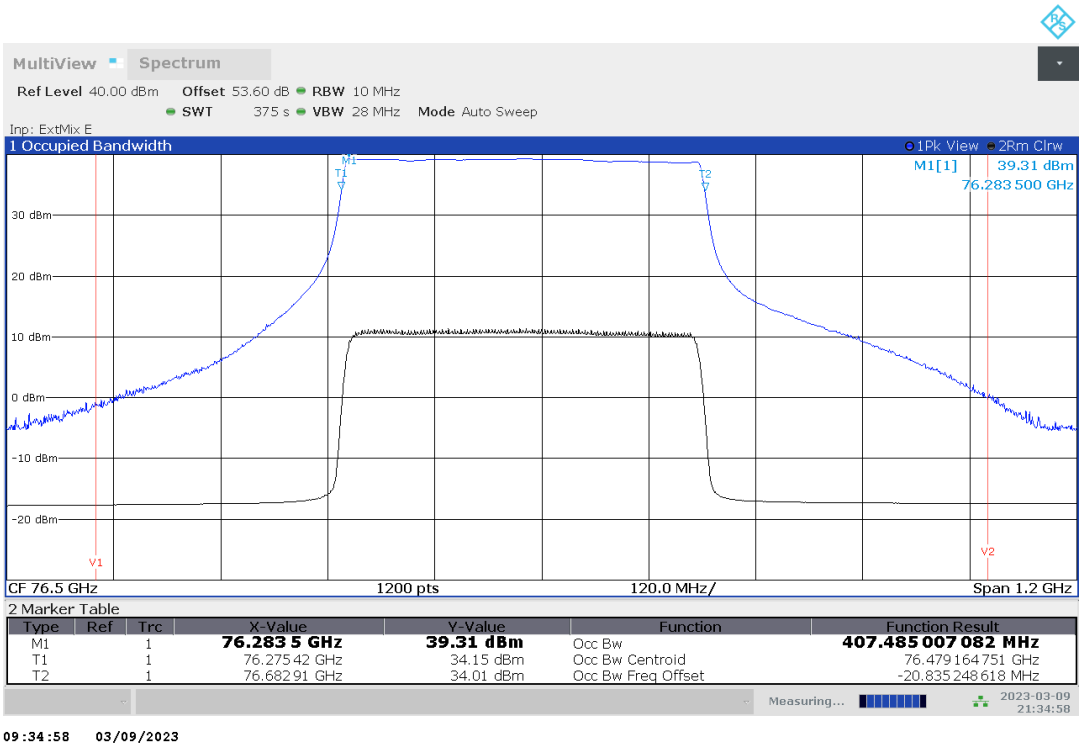
Plot no. 13: 99% OBW, Peak detector, 20 °C, V_{min}, DUT 1 normal



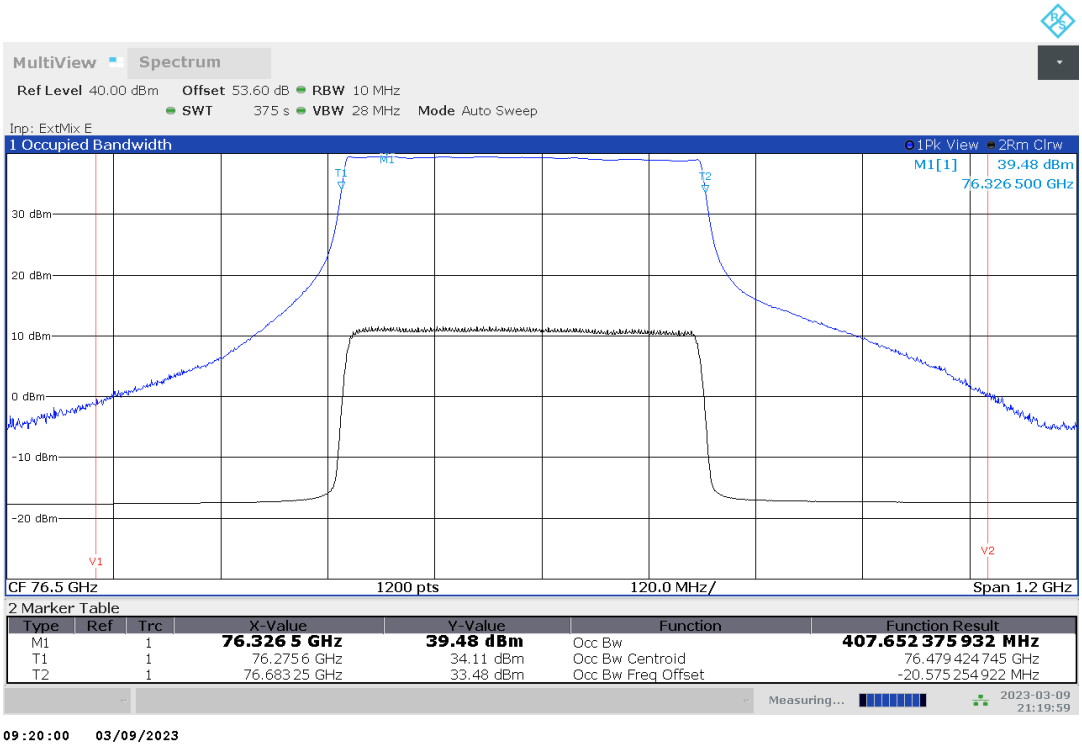
Plot no. 14: 99% OBW, Peak detector, 10 °C, DUT 1 normal



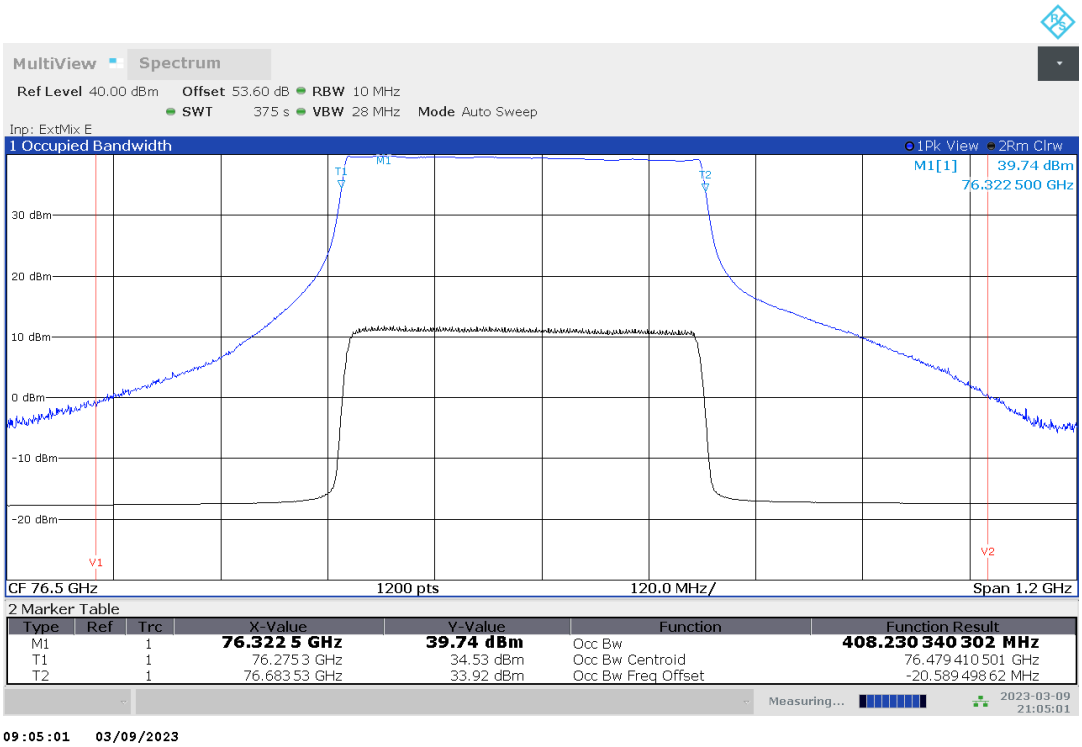
Plot no. 15: 99% OBW, Peak detector, 0 °C, DUT 1 normal



Plot no. 16: 99% OBW, Peak detector, -10 °C, DUT 1 normal

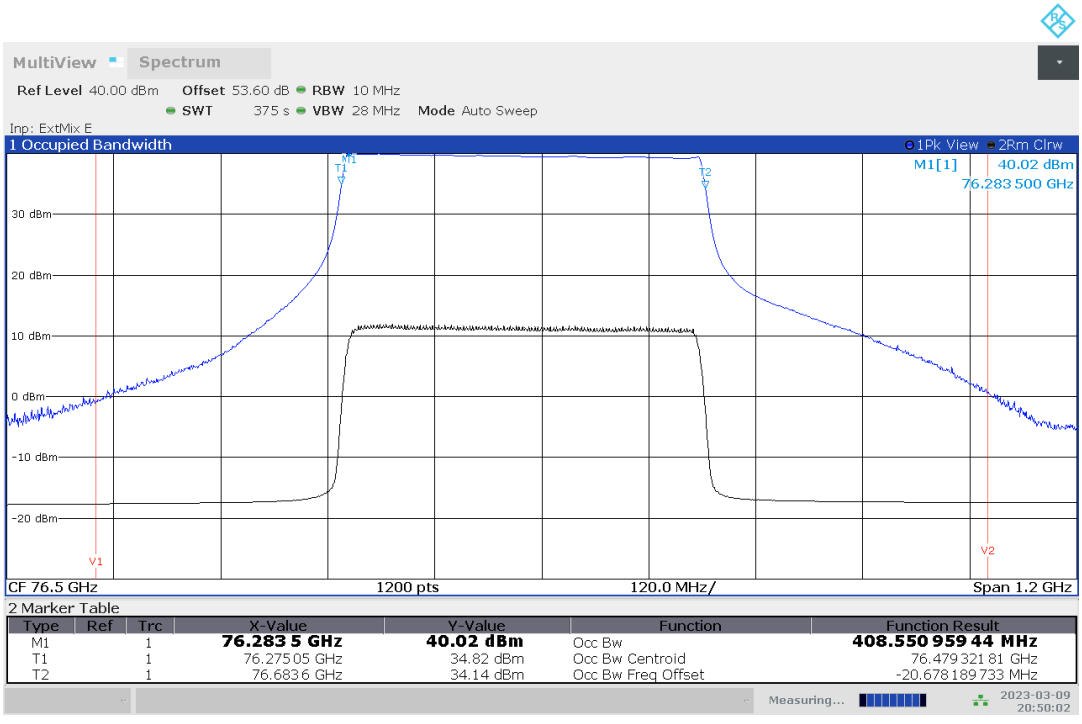


Plot no. 17: 99% OBW, Peak detector, -20 °C, DUT 1 normal



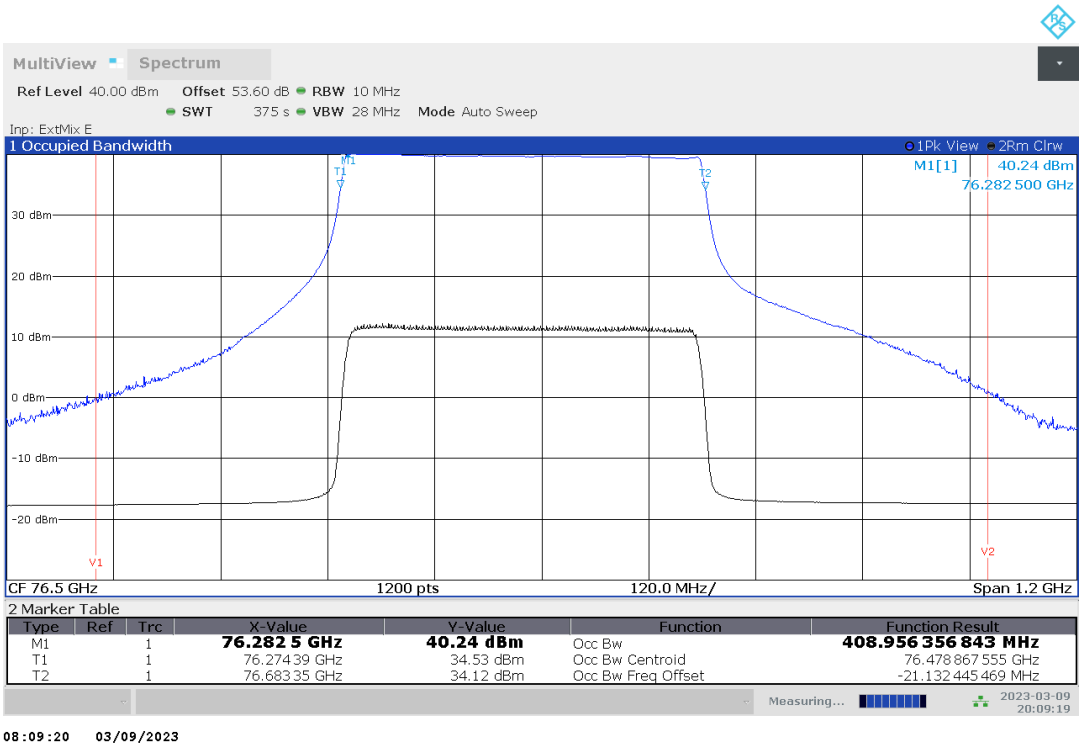
09:05:01 03/09/2023

Plot no. 18: 99% OBW, Peak detector, -30 °C, DUT 1 normal

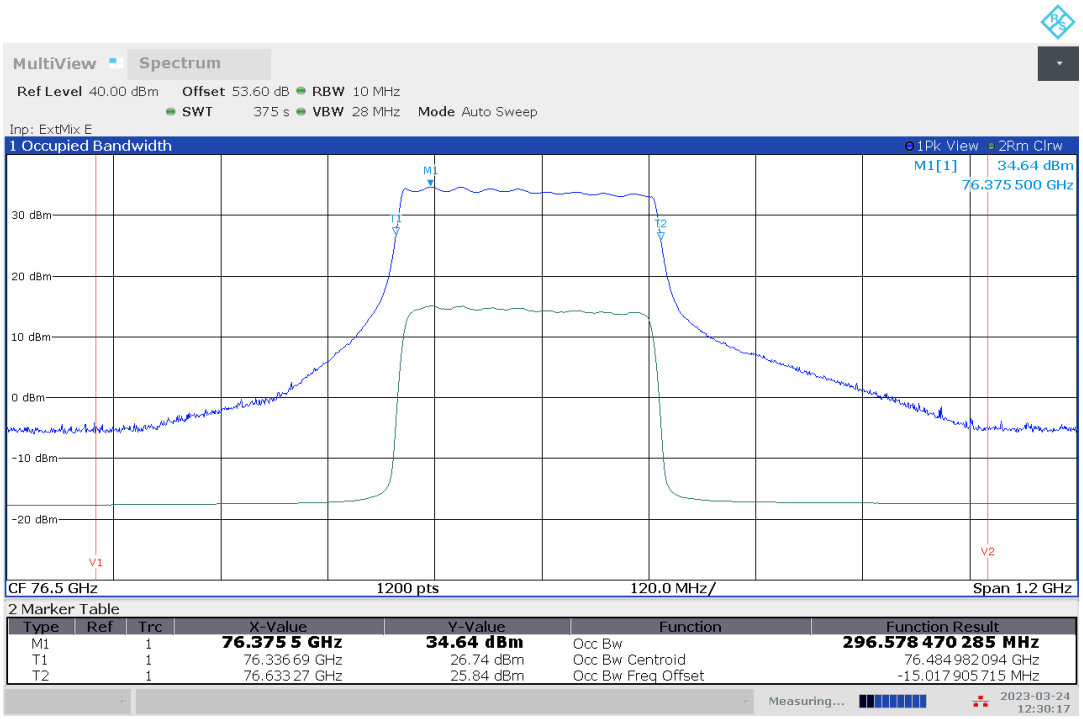


08:50:02 03/09/2023

Plot no. 19: 99% OBW, Peak detector, -40 °C, DUT 1 normal

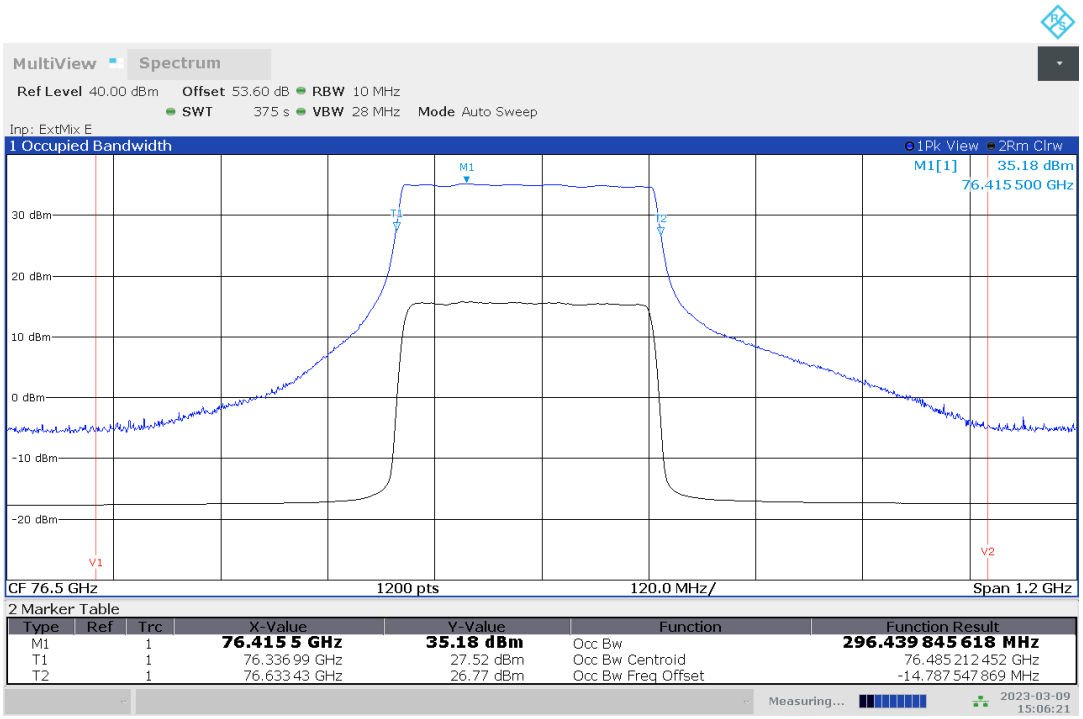


Plot no. 20: 99% OBW, Peak detector, 85 °C, DUT 2 Beam 1



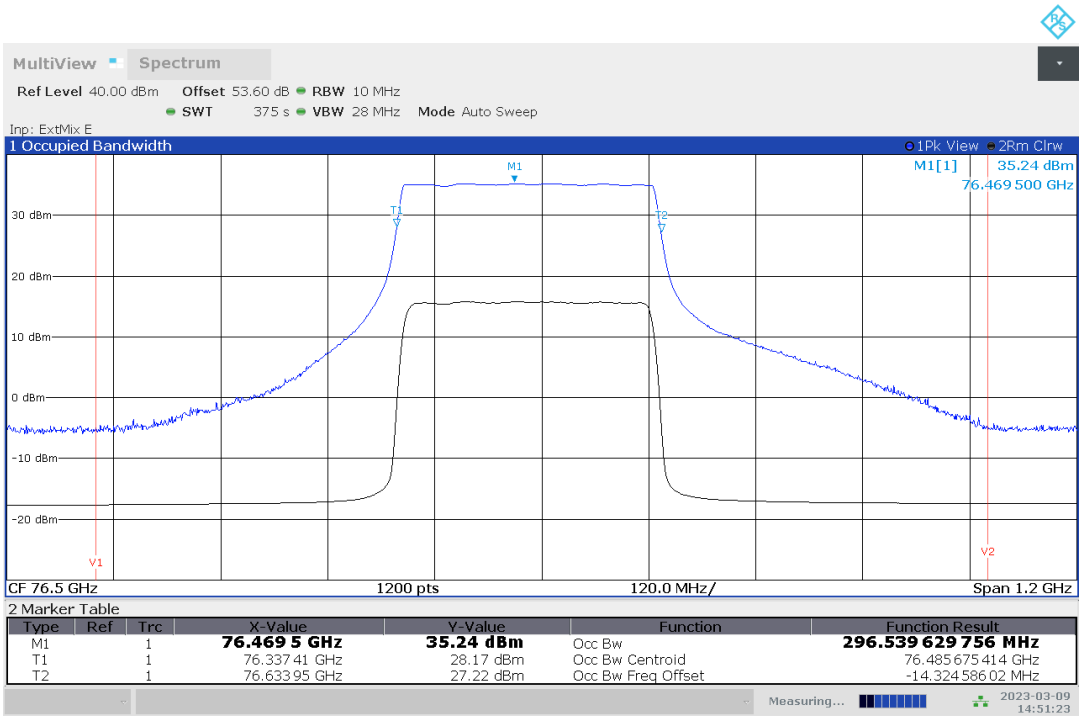
12:30:17 03/24/2023

Plot no. 21: 99% OBW, Peak detector, 50 °C, DUT 2 Beam 1

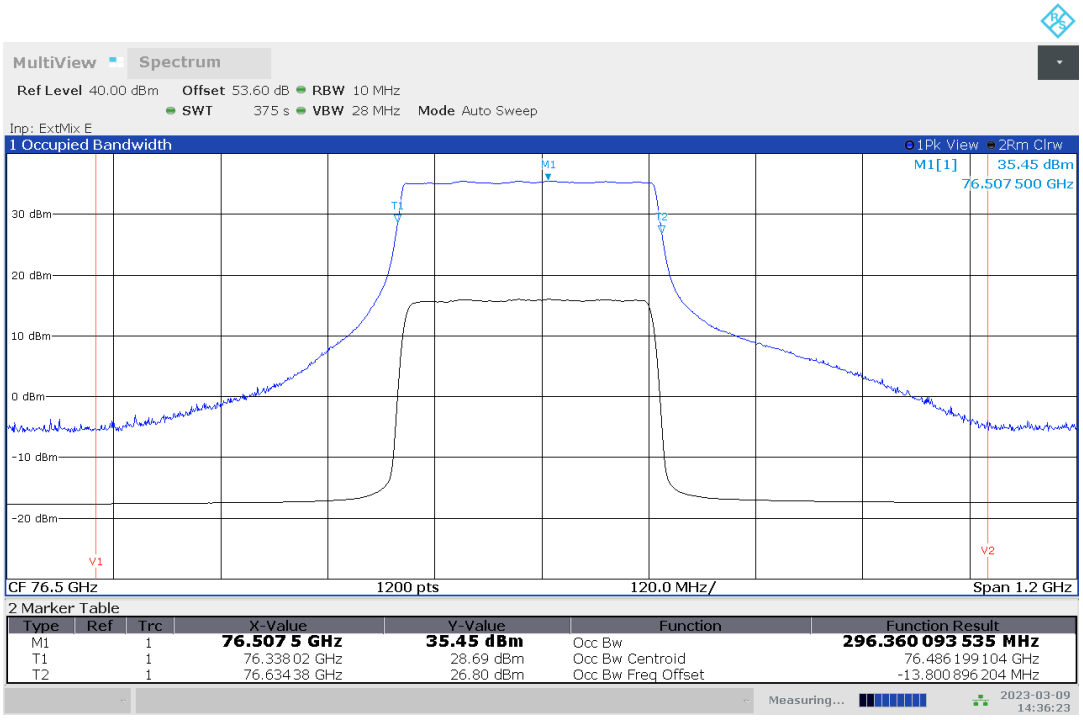


03:06:22 03/09/2023

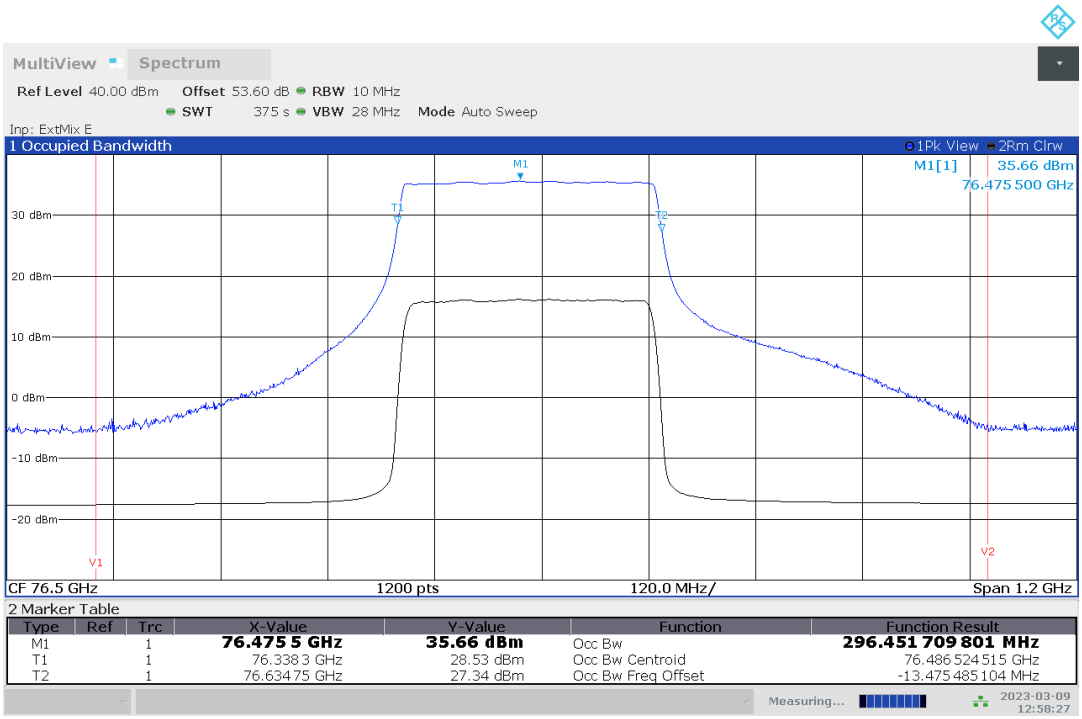
Plot no. 22: 99% OBW, Peak detector, 40 °C, DUT 2 Beam 1



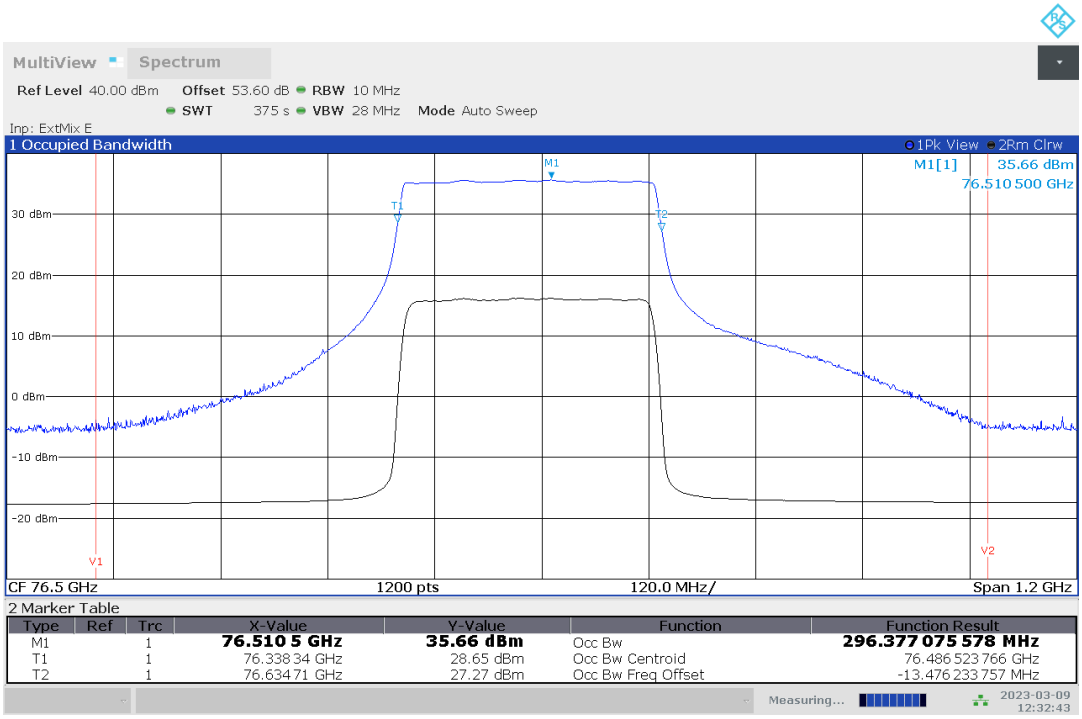
Plot no. 23: 99% OBW, Peak detector, 30 °C, DUT 2 Beam 1



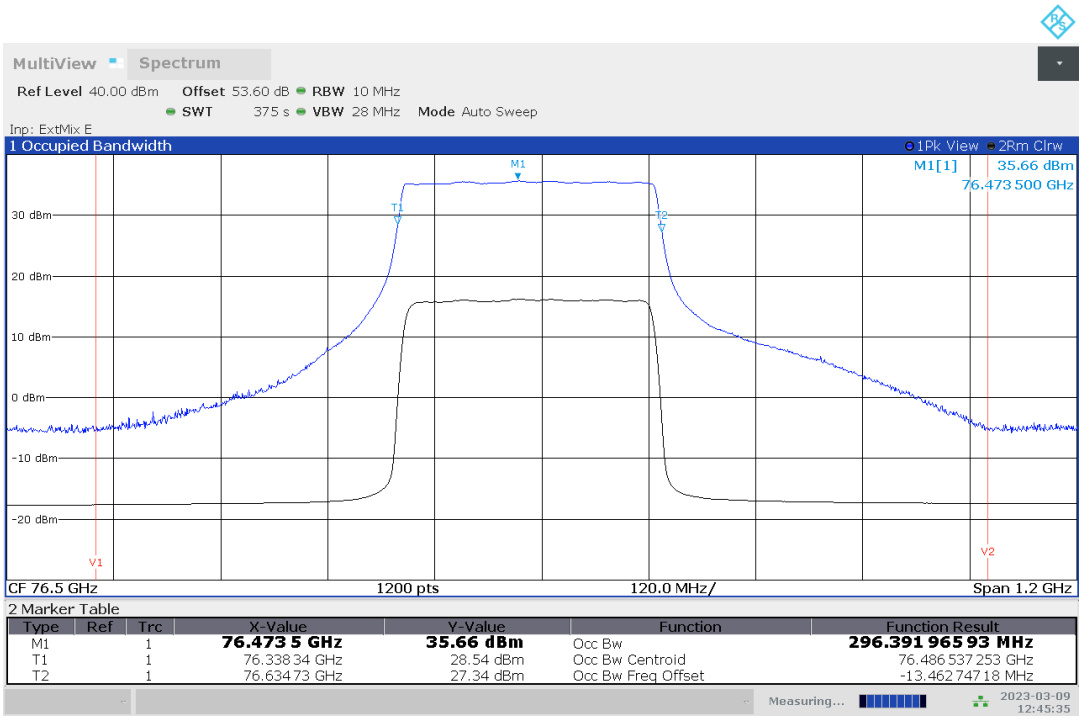
Plot no. 24: 99% OBW, Peak detector, 20 °C, V_{max}, DUT 2 Beam 1



Plot no. 25: 99% OBW, Peak detector, 20 °C, V_{nom} DUT 2 Beam 1

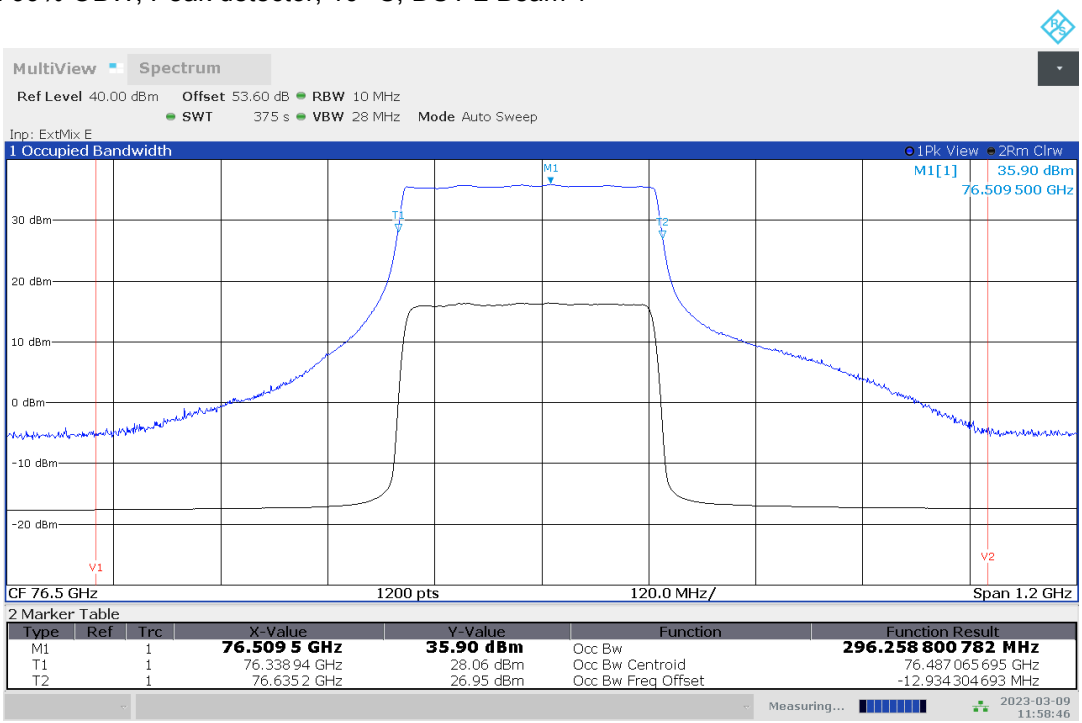


Plot no. 26: 99% OBW, Peak detector, 20 °C, V_{min} ,DUT 2 Beam 1



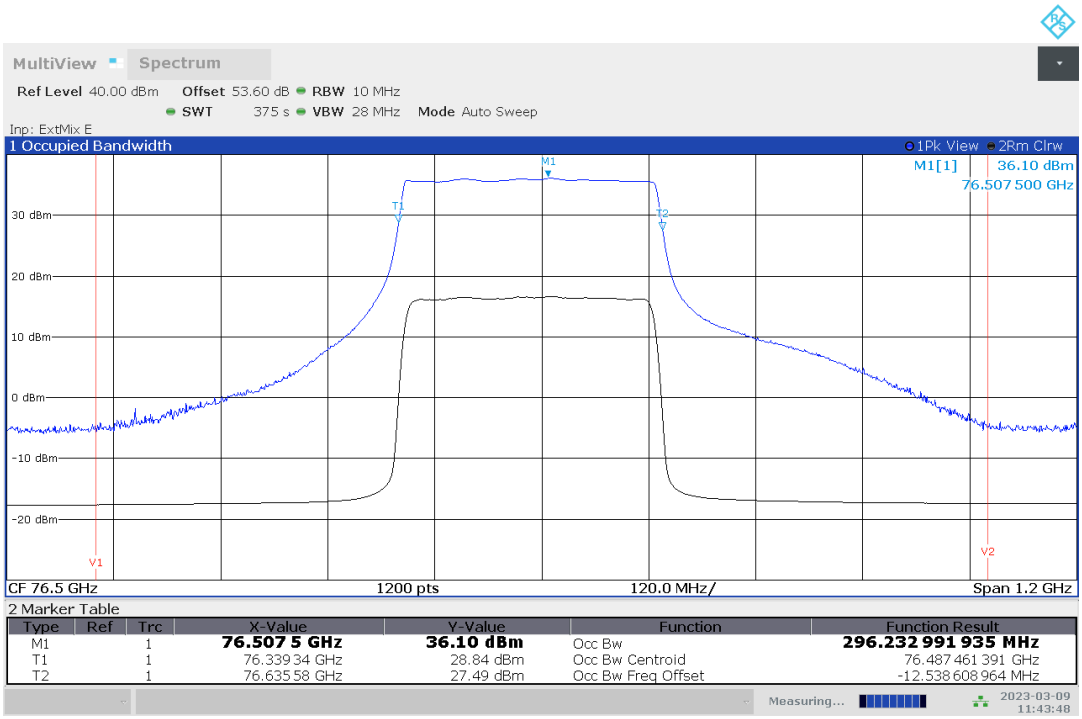
12:45:36 03/09/2023

Plot no. 27: 99% OBW, Peak detector, 10 °C, DUT 2 Beam 1

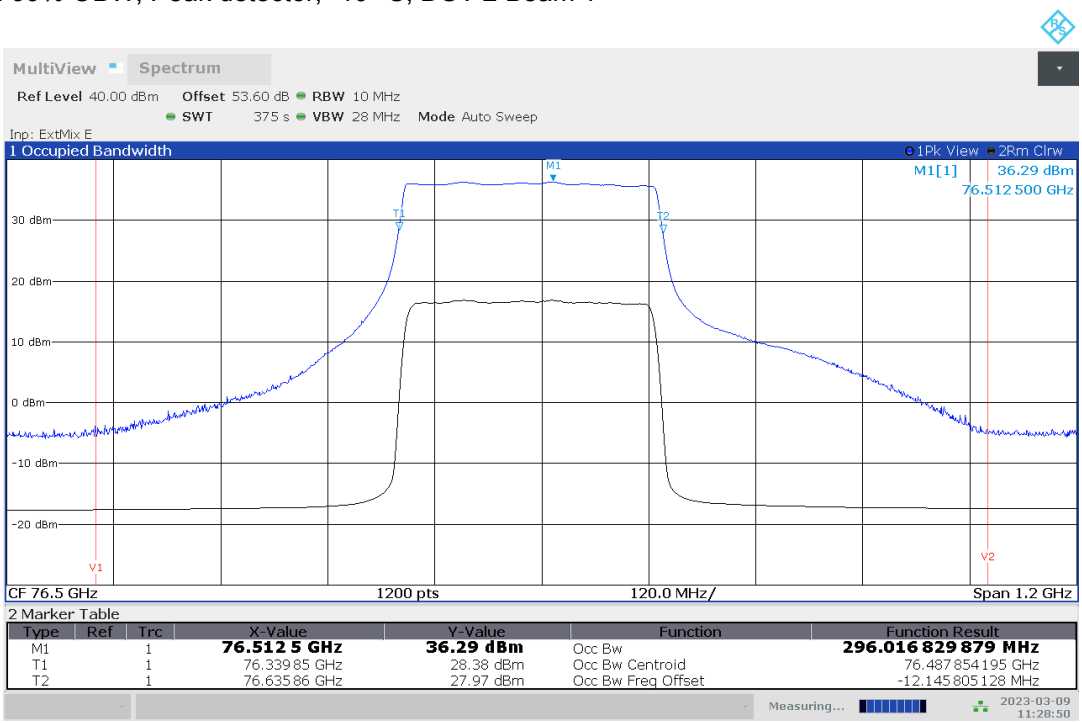


11:58:47 03/09/2023

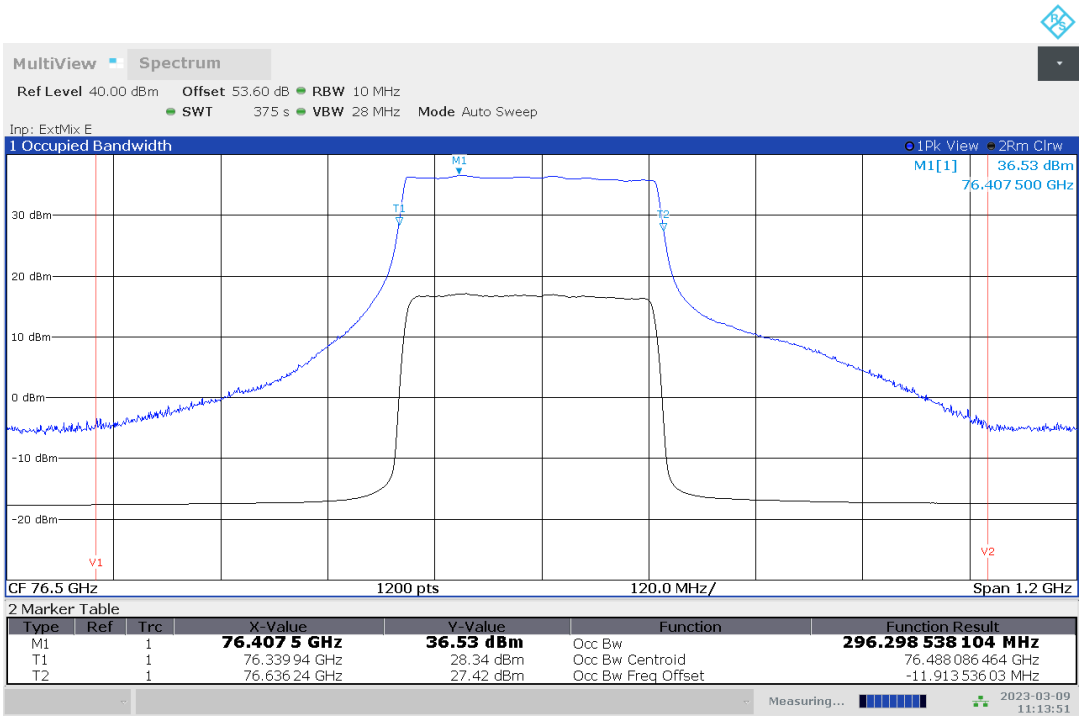
Plot no. 28: 99% OBW, Peak detector, 0 °C, DUT 2 Beam 1



Plot no. 29: 99% OBW, Peak detector, -10 °C, DUT 2 Beam 1

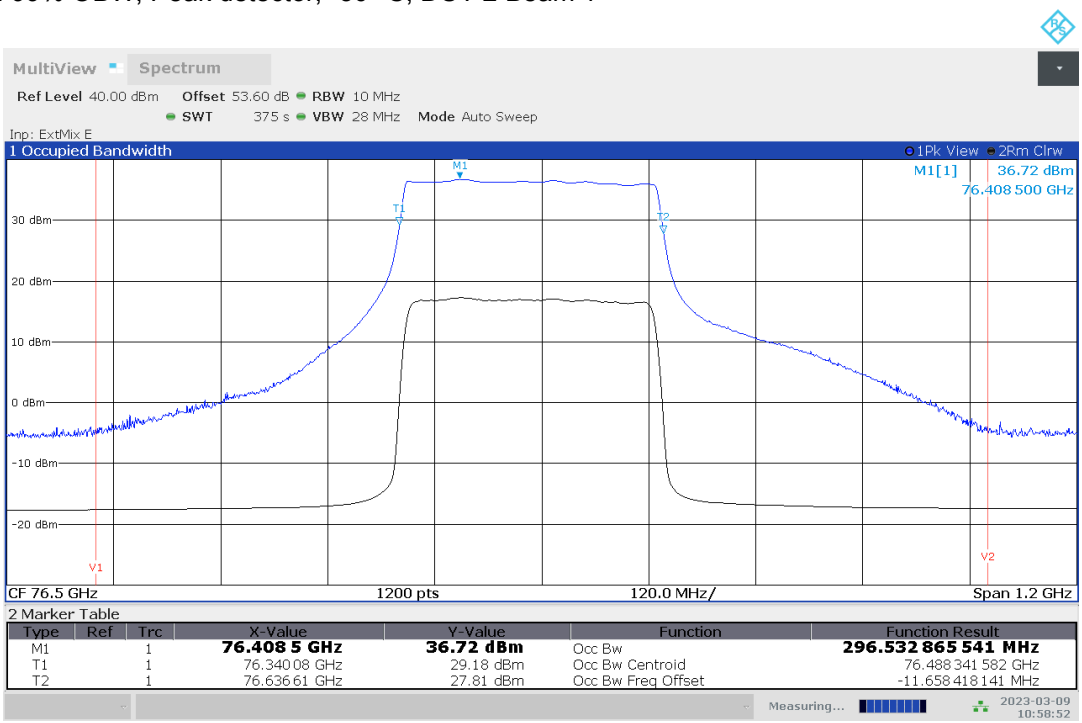


Plot no. 30: 99% OBW, Peak detector, -20 °C, DUT 2 Beam 1



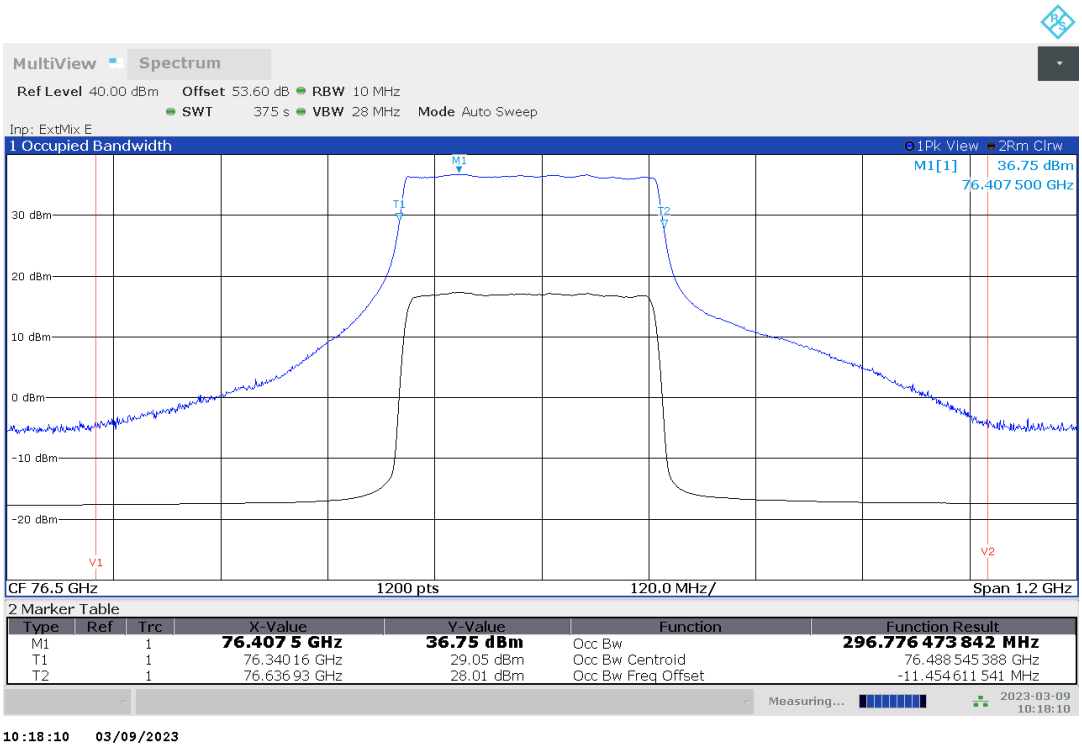
11:13:51 03/09/2023

Plot no. 31: 99% OBW, Peak detector, -30 °C, DUT 2 Beam 1

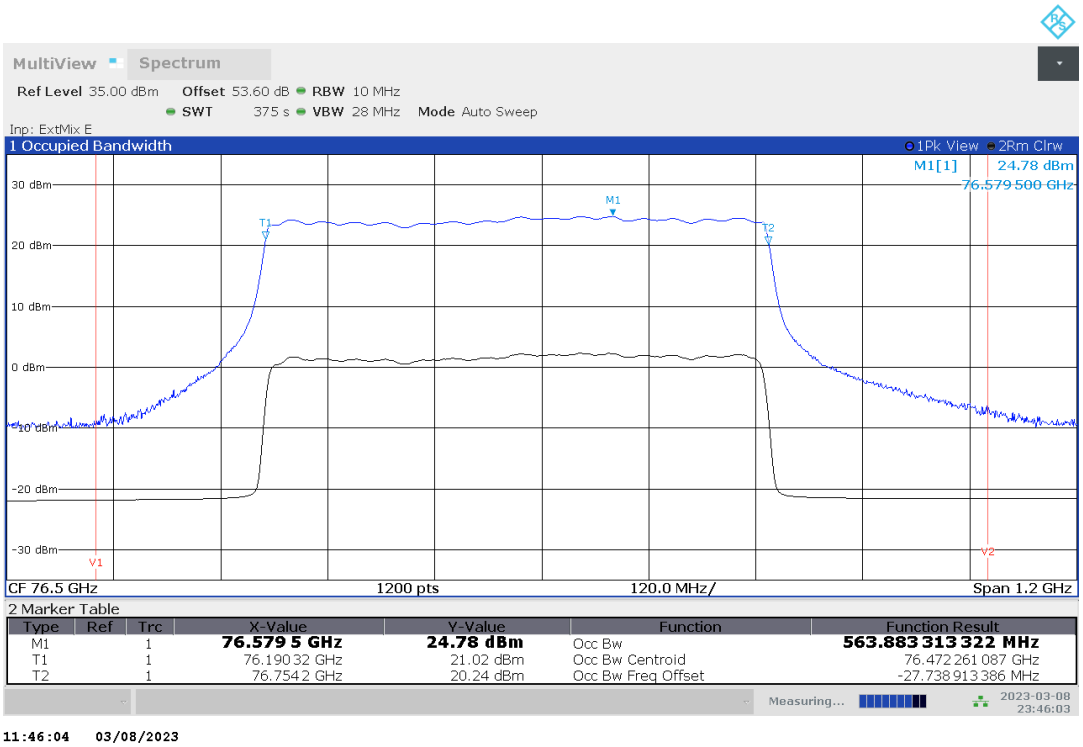


10:58:53 03/09/2023

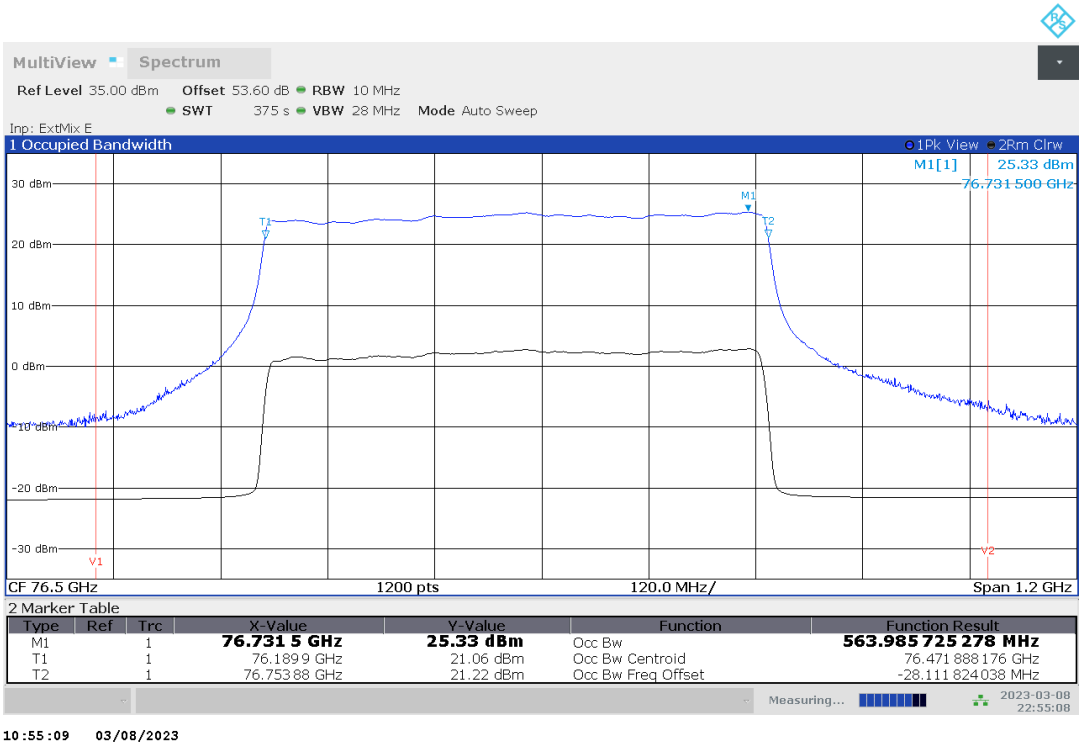
Plot no. 32: 99% OBW, Peak detector, -40 °C, DUT 2 Beam 1



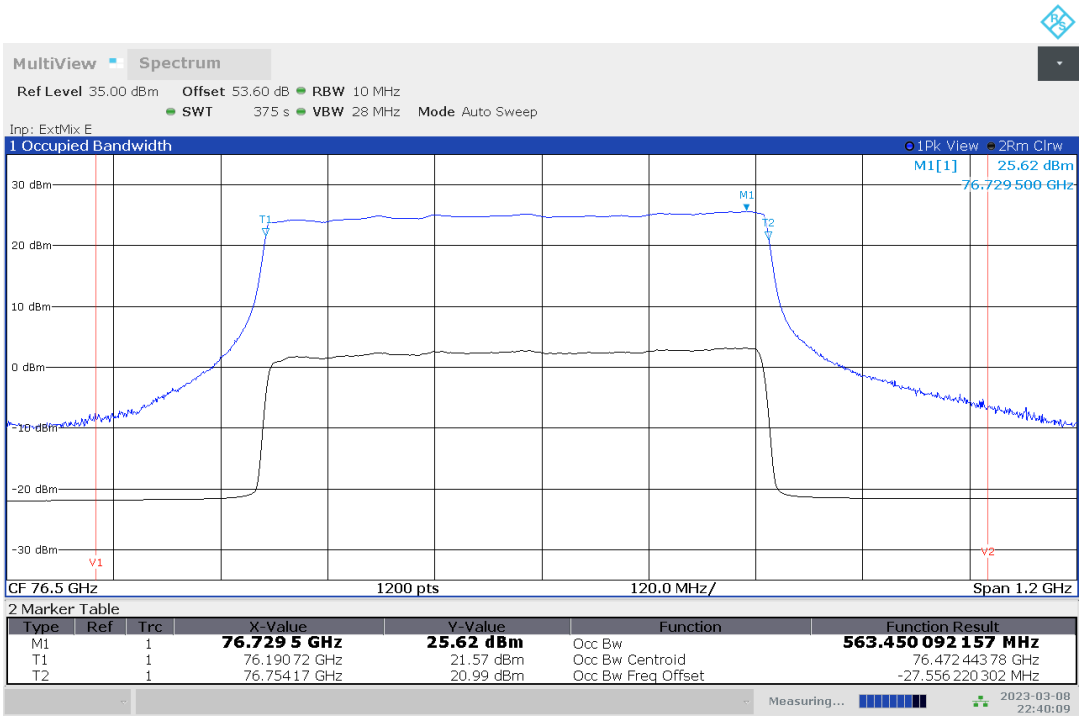
Plot no. 33: 99% OBW, Peak detector, 85 °C, DUT 3 Beam 2



Plot no. 34: 99% OBW, Peak detector, 50 °C, DUT 3 Beam 2

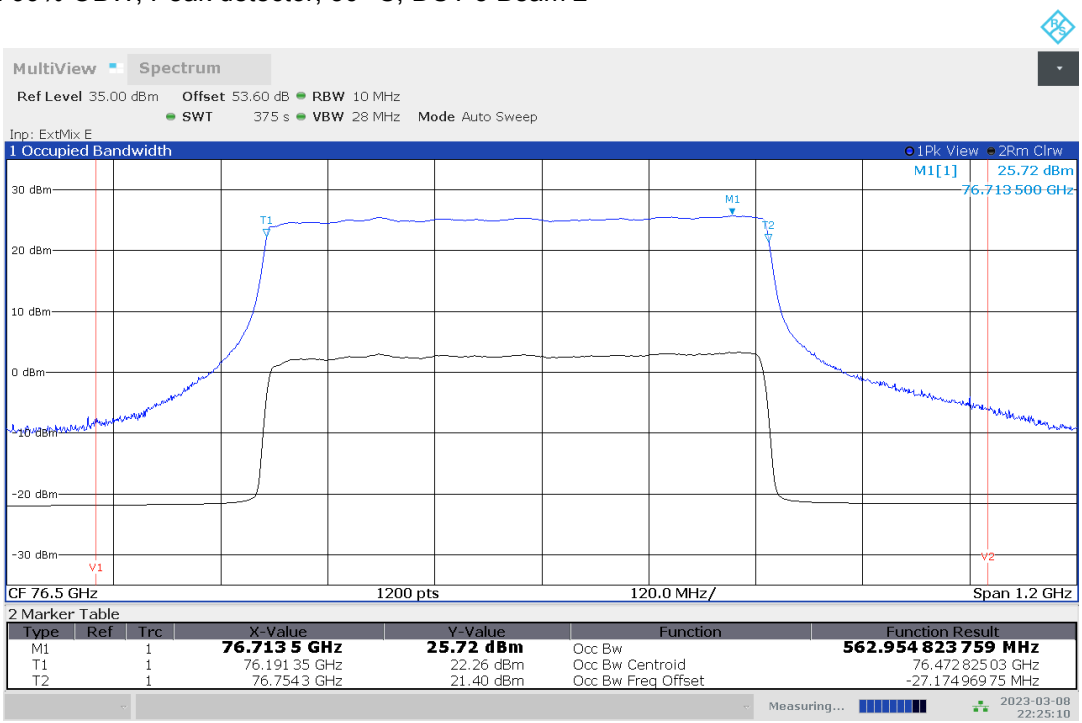


Plot no. 35: 99% OBW, Peak detector, 40 °C, DUT 3 Beam 2



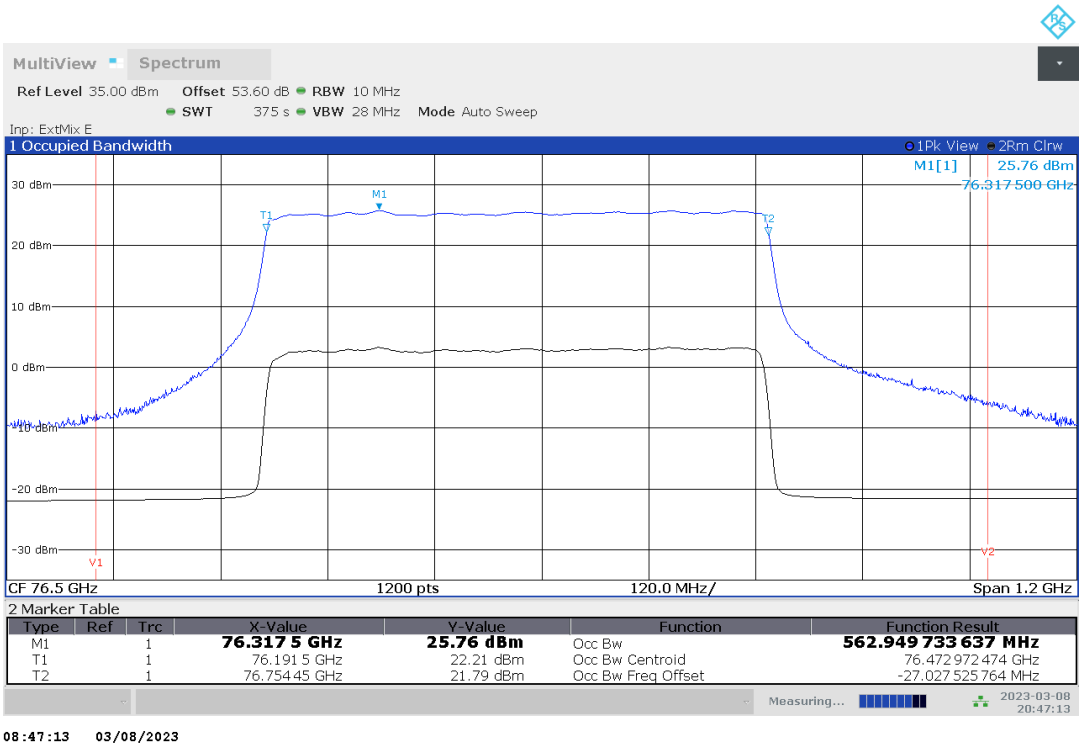
10:40:10 03/08/2023

Plot no. 36: 99% OBW, Peak detector, 30 °C, DUT 3 Beam 2

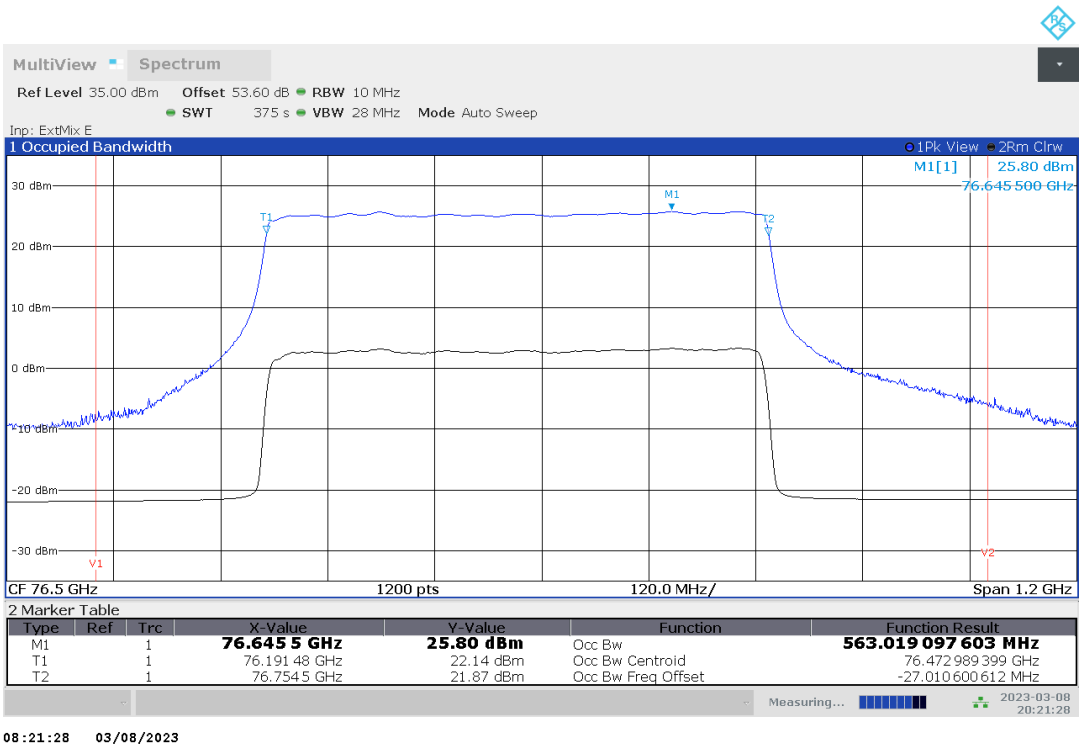


10:25:11 03/08/2023

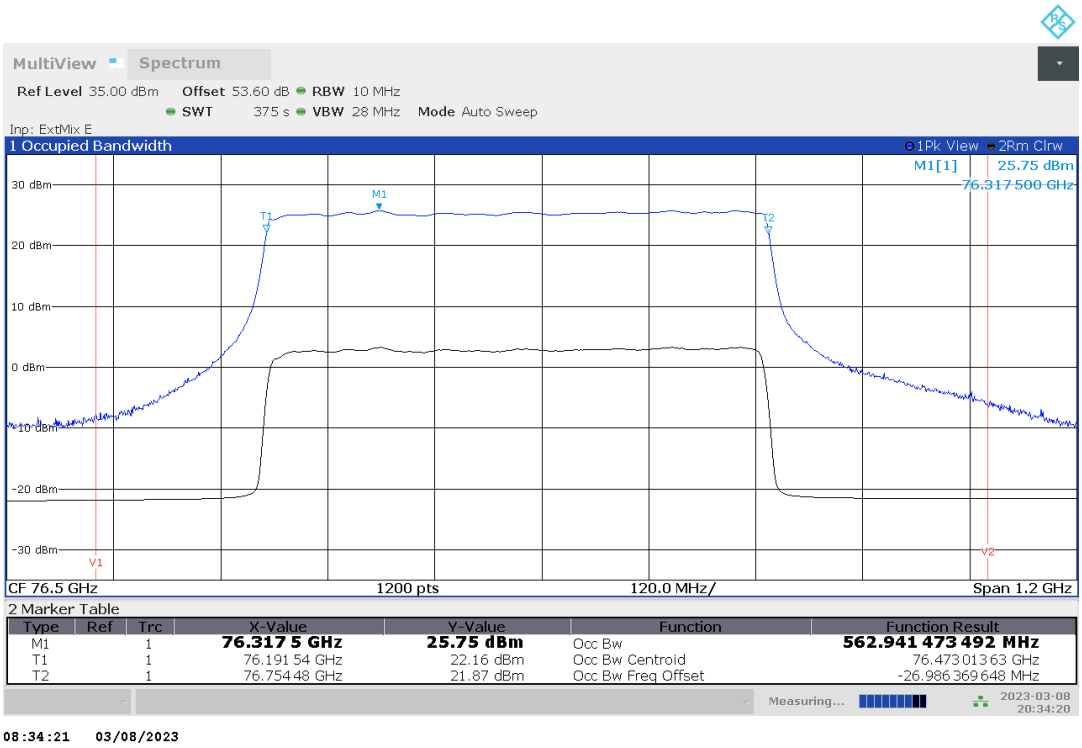
Plot no. 37: 99% OBW, Peak detector, 20 °C, V_{max}, DUT 3 Beam 2



Plot no. 38: 99% OBW, Peak detector, 20 °C, V_{nom}, DUT 3 Beam 2

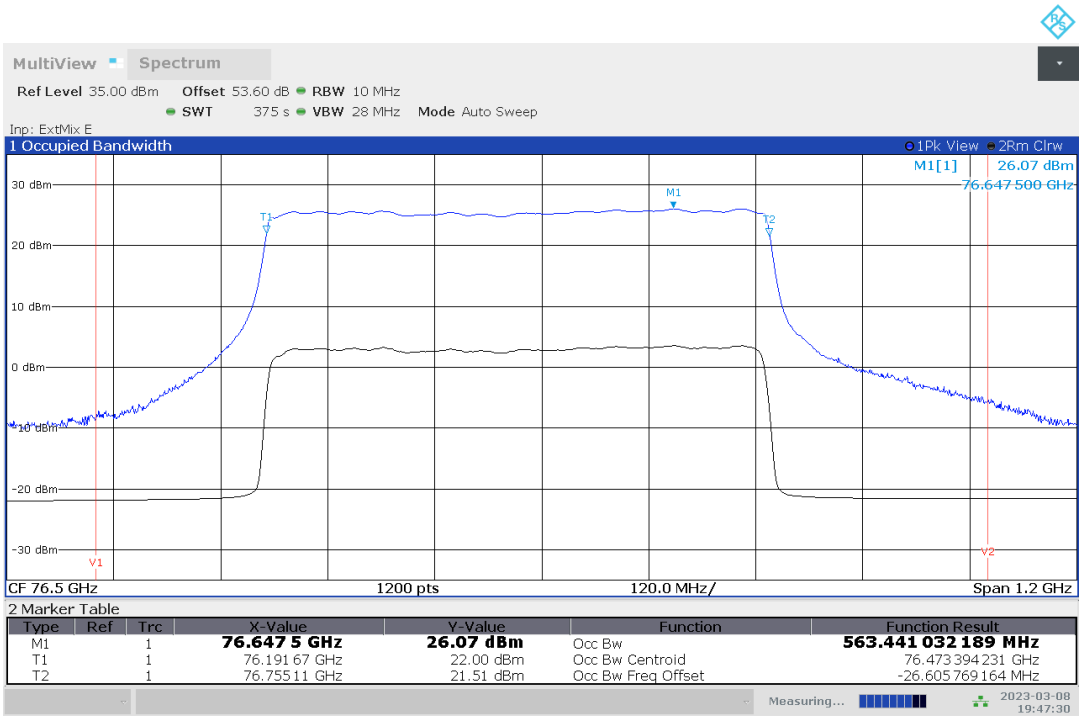


Plot no. 39: 99% OBW, Peak detector, 20 °C, V_{min}, DUT 3 Beam 2



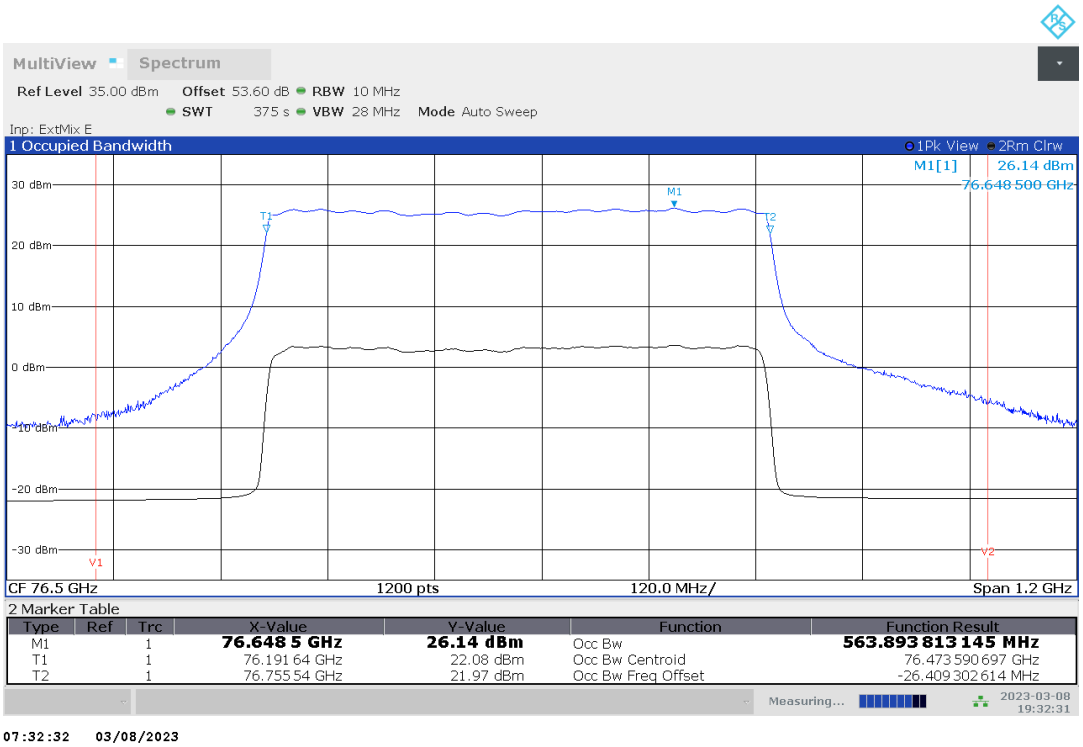
08:34:21 03/08/2023

Plot no. 40: 99% OBW, Peak detector, 10 °C, DUT 3 Beam 2

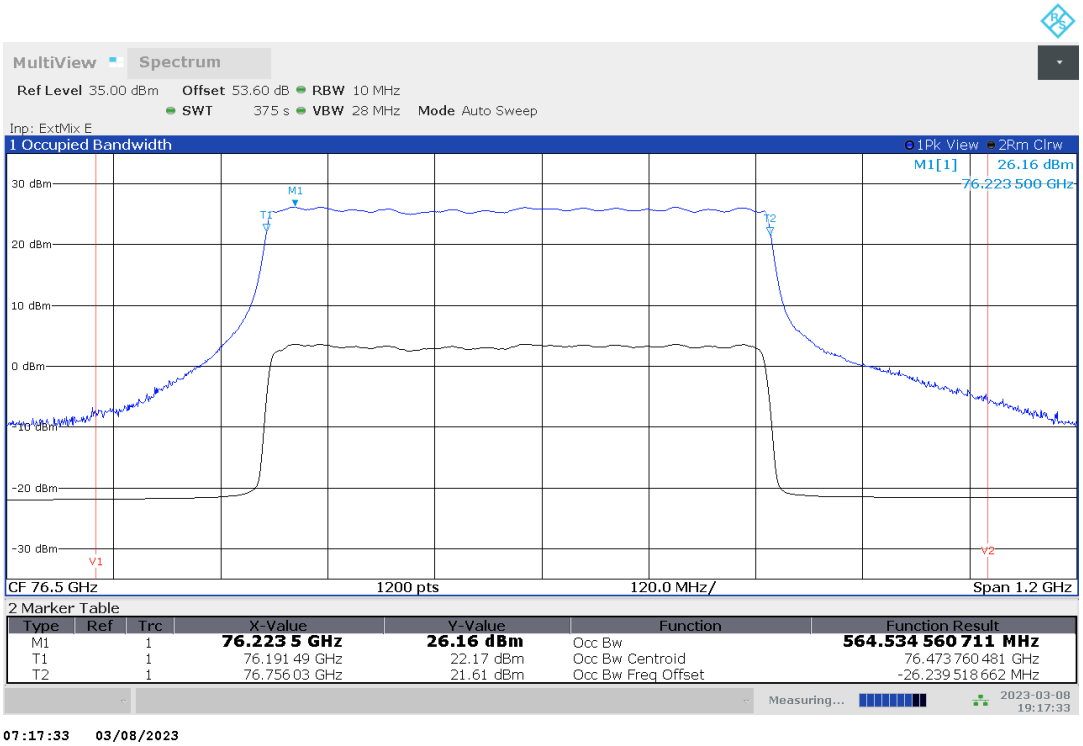


07:47:31 03/08/2023

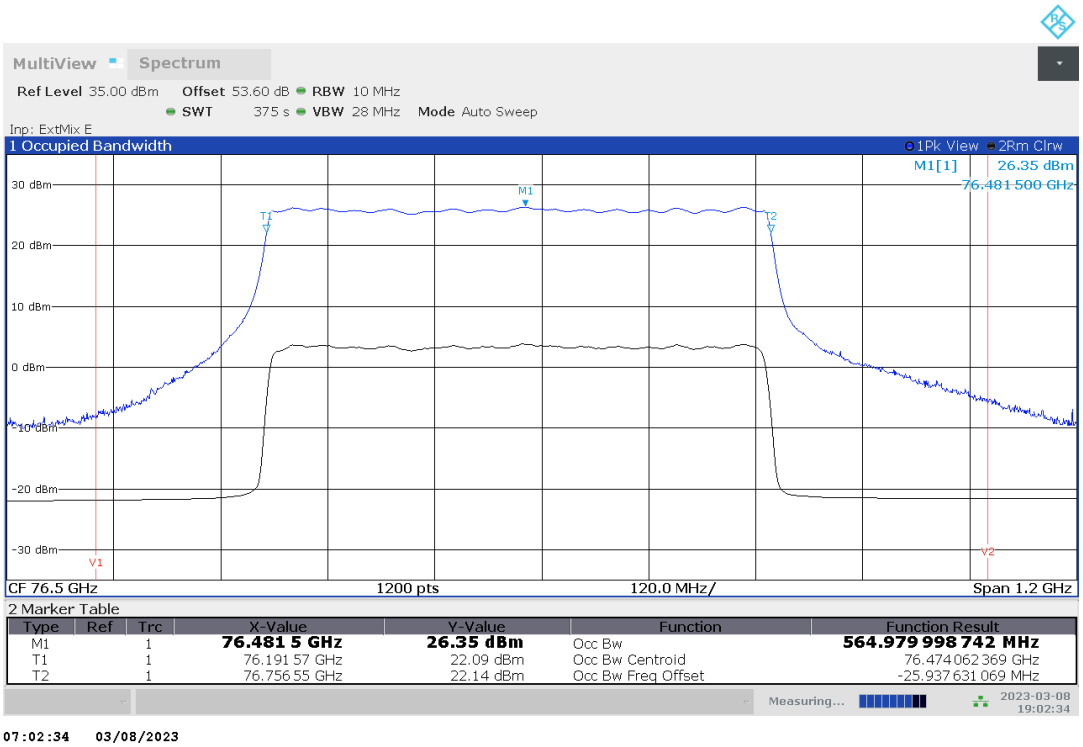
Plot no. 41: 99% OBW, Peak detector, 0 °C, DUT 3 Beam 2



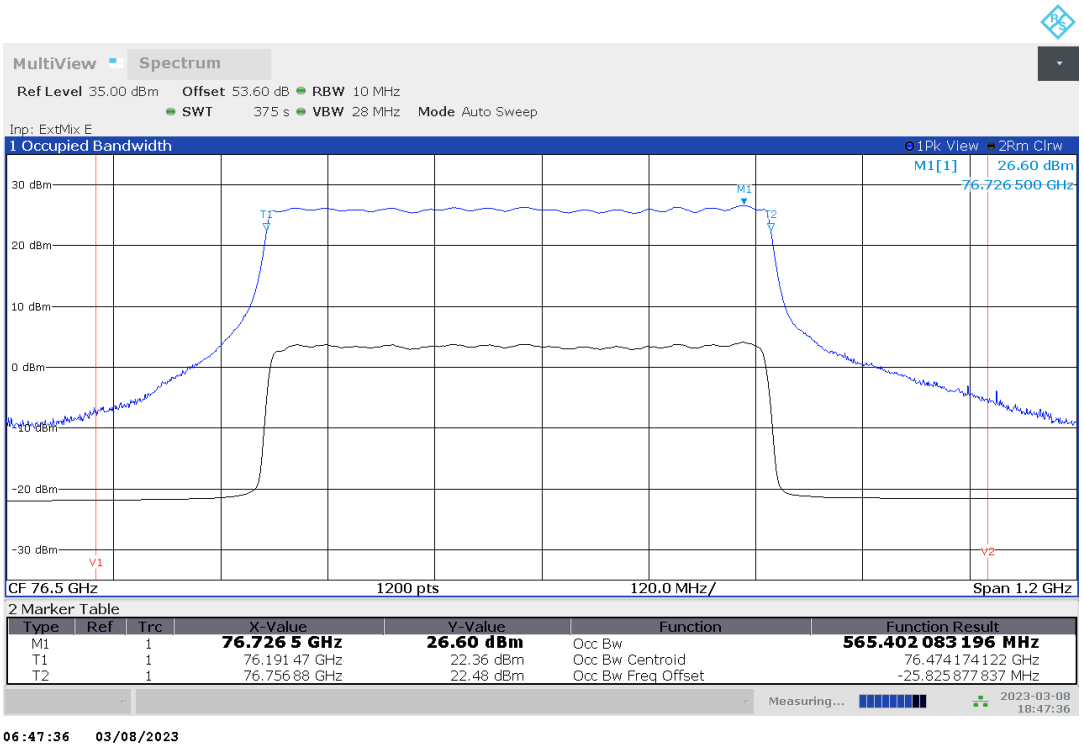
Plot no. 42: 99% OBW, Peak detector, -10 °C, DUT 3 Beam 2



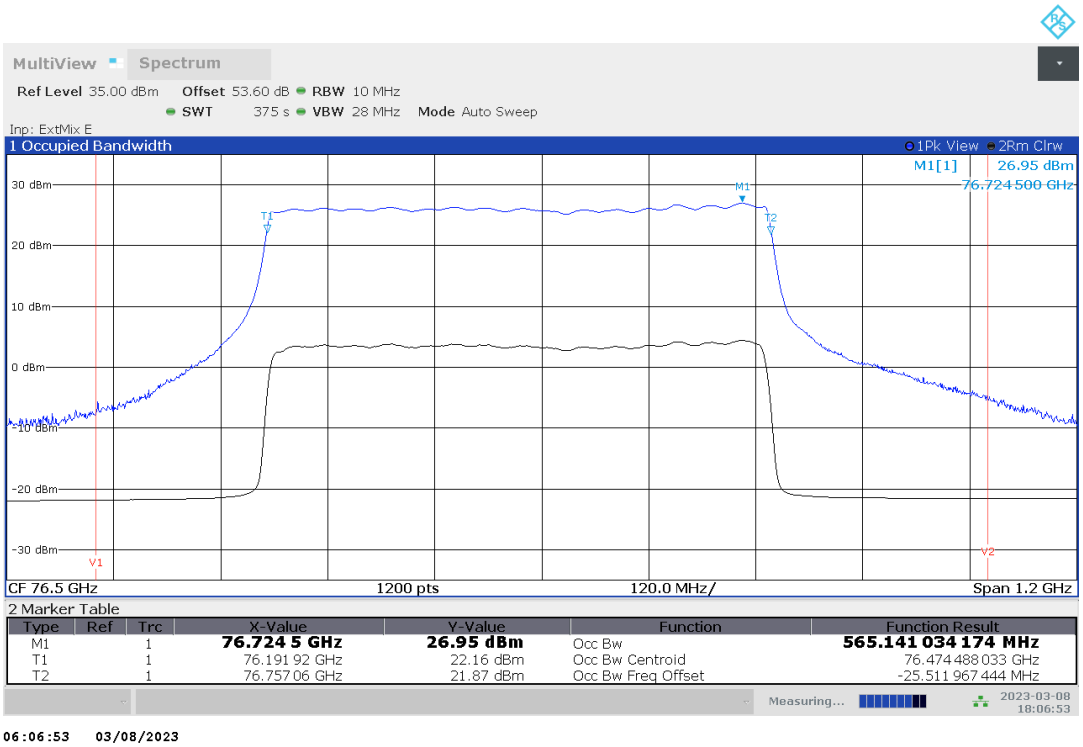
Plot no. 43: 99% OBW, Peak detector, -20 °C, DUT 3 Beam 2



Plot no. 44: 99% OBW, Peak detector, -30 °C, DUT 3 Beam 2



Plot no. 45: 99% OBW, Peak detector, -40 °C, DUT 3 Beam 2



7.4 Field strength of spurious radiation (§2.1053 & §95.3379)

Description

§2.1053 Measurements required: Field strength of spurious radiation.

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

Limits

§95.3379 76-81 GHz Band Radar Service unwanted emissions limits.

(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.

Frequency [MHz]	Field Strength [µV/m] / [dBµV/m]	Measurement distance [m]
0.009 – 0.490	2400/F[kHz]	300
0.490 – 1.705	24000/F[kHz]	30
1.705 – 30.0	30.0 / 29.5	30
30 – 88	100 / 40.0	3
88 – 216	150 / 43.5	3
216 – 960	200 / 46.0	3
960 – 40 000	500 / 54.0	3

(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:

Frequency [GHz]	Power Density / EIRP	Measurement distance [m]
40 – 200	600 pW/cm^2 → -1.7 dBm	3
200 – 243	1000 pW/cm^2 → +0.5 dBm	3

Note

Measurements with the peak detector are also suitable to demonstrate compliance of an EUT, as long as the required resolution bandwidth is used, because peak detection will yield amplitudes equal to or greater than amplitudes measured with RMS detector. The measurement data from a spectrum analyser peak detector will represent the worst-case results (see ANSI C63.26, chapter D2: general considerations).

Calculation of the far field distance (Rayleigh distance):
The aperture dimensions of these horn antennas shall be small enough so that the measurement distance in meters is equal to or greater than the Rayleigh distance (i.e. $R_m = 2D^2 / \lambda$), where D is the largest linear dimension (i.e. width or height) of the antenna aperture in m and λ is the free-space wavelength in meters at the frequency of measurement.

Antenna type	Frequency range [GHz]	D [m]	Highest frequency in use [GHz]	Far field distance R_m [m]
20240-20	18.0 – 26.5	0.0520	26.5	0.478
22240-20	26.5 – 40.0	0.0342	40	0.312
23240-20	33.0 – 50.0	0.0280	50	0.261
24240-20	40.0 – 60.0	0.0230	60	0.212
25240-20	50.0 – 75.0	0.0185	75	0.171
26240-20	60.0 – 90.0	0.0150	90	0.135
27240-20	75.0 – 110	0.0124	110	0.113
28240-20	90.0 – 140	0.0100	140	0.093
29240-20	110 – 170	0.0085	170	0.082
30240-20	140 – 220	0.0068	220	0.068
32240-20	220 – 325	0.00446	243	0.032

Used test distances

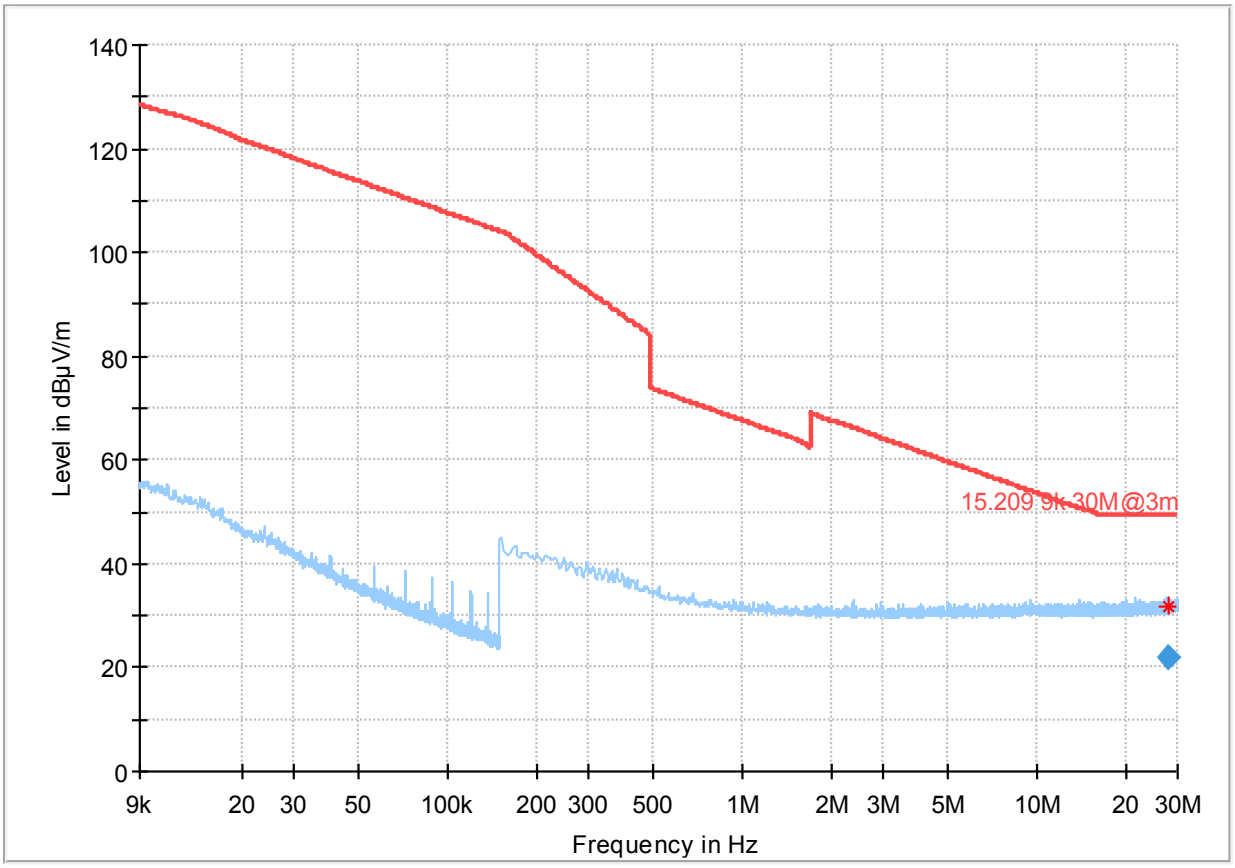
Up to 18 GHz: 3.00 m
18 – 60 GHz: 1.00 m
60 – 84 GHz: 1.50 m
84 – 110 GHz: 0.50 m
110 – 170 GHz: 0.25 m
170 – 220 GHz: 1.00 m
220 – 325 GHz: 1.00 m
In-band / OOB: 1.50 m

Test setup: 8.1 – 8.4 (in case of field strength measurements below 40 GHz: test distance correction factor of 20dB/decade is already considered in the plots / test result table)

Test results

Channel / Mode	Frequency [GHz]	Detector	Test distance [m]	Level [dBµV/dBm]	Limit [dBµV/dBm]	Margin [dB]
No critical peaks found. Please refer to plots.						

Plot no. 46: radiated emissions 9 kHz – 30 MHz, loop antenna, DUT 4 normal



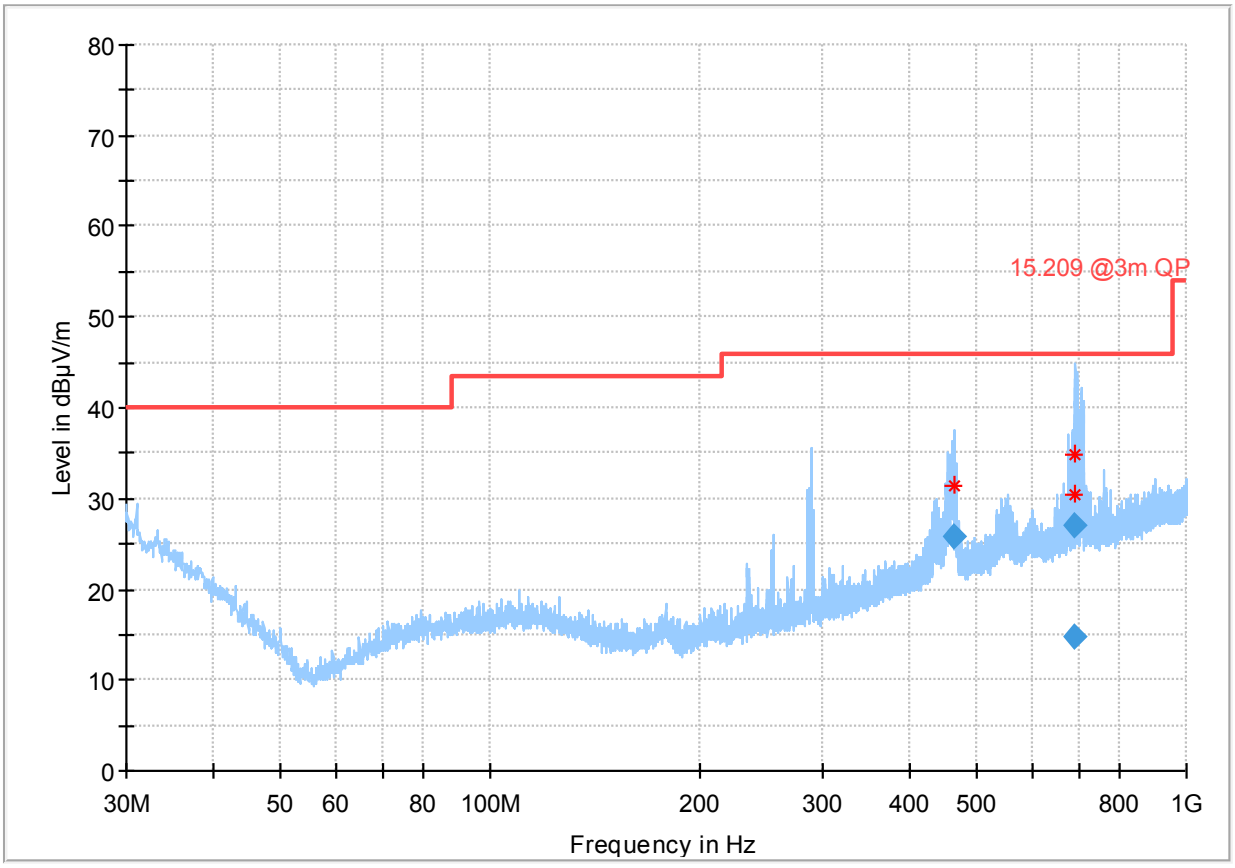
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
27.791250	21.81	49.54	27.73	100.0	9.000	V	156.0	20.8

(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Comment
27.791250	11:29:31 - 10.03.2023

Plot no. 47: radiated emissions 30 MHz – 1 GHz, polarization vertical / horizontal, DUT 4 normal



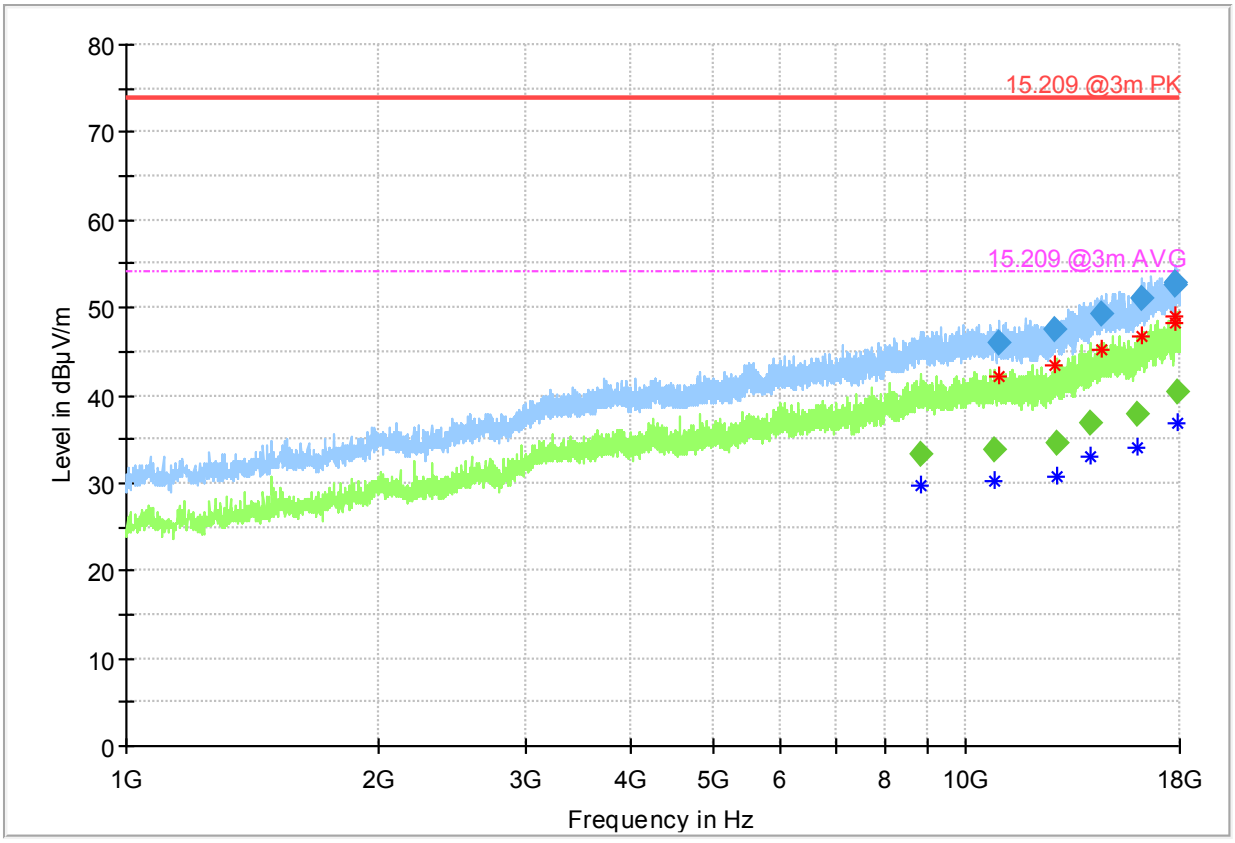
Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
463.069500	25.84	46.00	20.16	100.0	120.000	100.0	V	35.0
691.749000	26.93	46.00	19.07	100.0	120.000	100.0	V	246.0
693.468000	14.63	46.00	31.37	100.0	120.000	100.0	V	-3.0

(continuation of the "Final_Result" table from column 15 ...)

Frequency (MHz)	Corr. (dB/m)	Comment
463.069500	17.4	10:43:21 - 10.03.2023
691.749000	20.7	10:45:20 - 10.03.2023
693.468000	20.8	10:41:36 - 10.03.2023

Plot no. 48: radiated emissions 1 GHz – 18 GHz, polarization vertical / horizontal, DUT 4 normal



Preview Result 2-AVG
Critical_Freqs PK+
Final_Result PK+
Preview Result 1-PK+
15.209 @3m PK
Final_Result AVG
Critical_Freqs AVG
15.209 @3m AVG

Final_Result

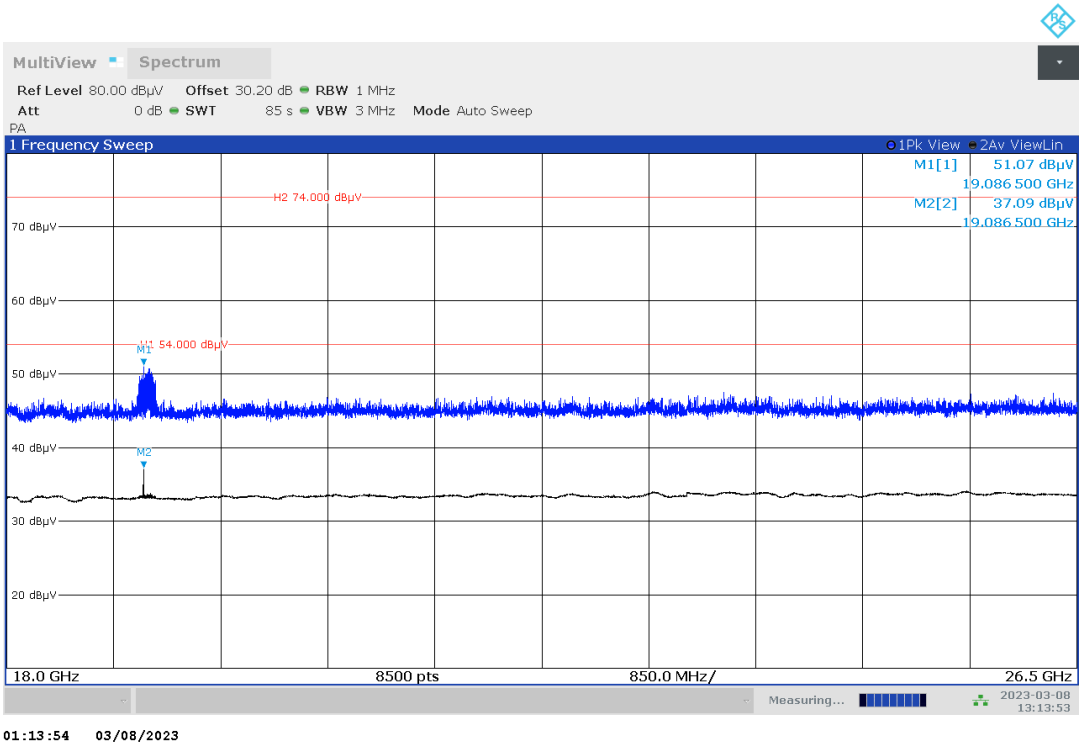
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8857.388889	---	33.22	54.00	20.78	100.0	1000.000	150.0	V
10845.369444	---	33.80	54.00	20.21	100.0	1000.000	150.0	V
10971.488889	45.86	---	74.00	28.14	100.0	1000.000	150.0	V
12810.608333	47.49	---	74.00	26.51	100.0	1000.000	150.0	H
12886.388889	---	34.44	54.00	19.56	100.0	1000.000	150.0	V
14125.769444	---	36.71	54.00	17.29	100.0	1000.000	150.0	V
14498.869444	49.37	---	74.00	24.63	100.0	1000.000	150.0	V
15982.277778	---	37.73	54.00	16.27	100.0	1000.000	150.0	H
16216.858333	51.09	---	74.00	22.91	100.0	1000.000	150.0	H
17799.327778	52.73	---	74.00	21.27	100.0	1000.000	150.0	H
17800.602778	52.58	---	74.00	21.42	100.0	1000.000	150.0	H
17927.608333	---	40.42	54.00	13.58	100.0	1000.000	150.0	V

(continuation of the "Final_Result" table from column 14 ...)

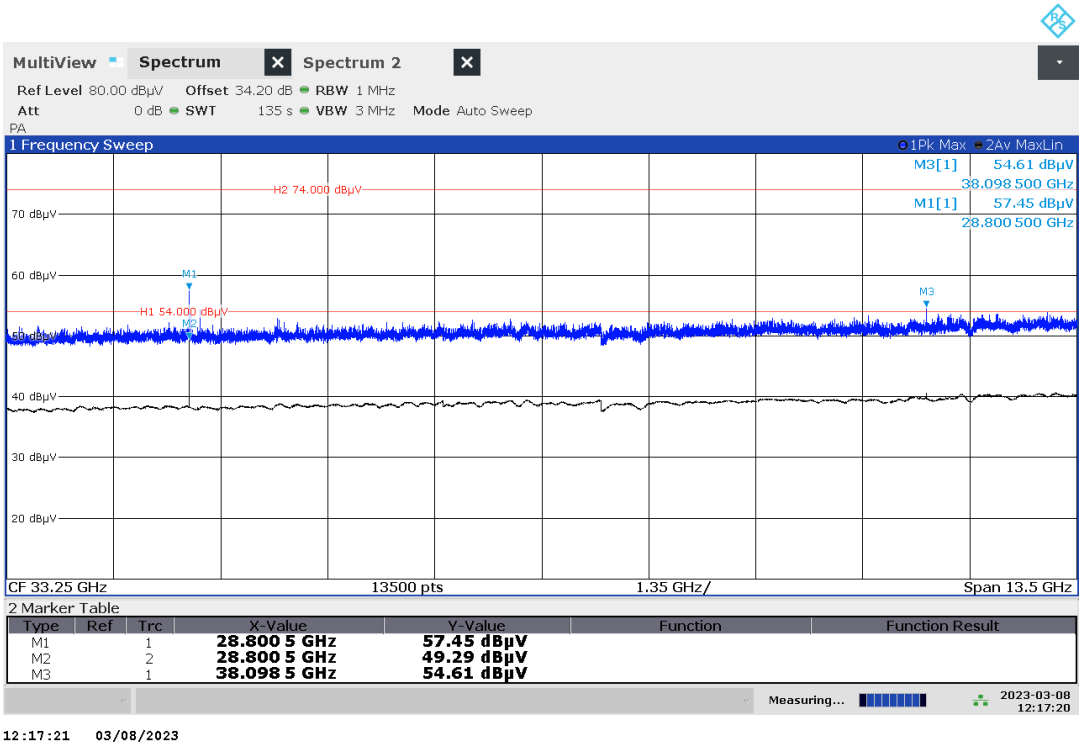
Frequency (MHz)	Azimuth (deg)	Elevation (deg)	Corr. (dB/m)	Comment
8857.388889	188.0	39.0	12.2	12:20:19 - 10.03.2023
10845.369444	8.0	39.0	15.4	12:18:22 - 10.03.2023
10971.488889	28.0	45.0	15.3	12:11:06 - 10.03.2023
12810.608333	94.0	52.0	14.9	12:09:14 - 10.03.2023
12886.388889	30.0	98.0	14.9	12:24:14 - 10.03.2023

14125.769444	**139.0**	**-6.0**	**17.3**	**12:14:36 - 10.03.2023**
14498.869444	**44.0**	**93.0**	**17.9**	**12:12:45 - 10.03.2023**
15982.277778	**40.0**	**39.0**	**17.7**	**12:16:35 - 10.03.2023**
16216.858333	**86.0**	**60.0**	**18.2**	**12:07:38 - 10.03.2023**
17799.327778	**286.0**	**10.0**	**21.6**	**12:05:45 - 10.03.2023**
17800.602778	**288.0**	**6.0**	**21.7**	**12:04:07 - 10.03.2023**
17927.608333	**304.0**	**58.0**	**22.4**	**12:22:08 - 10.03.2023**

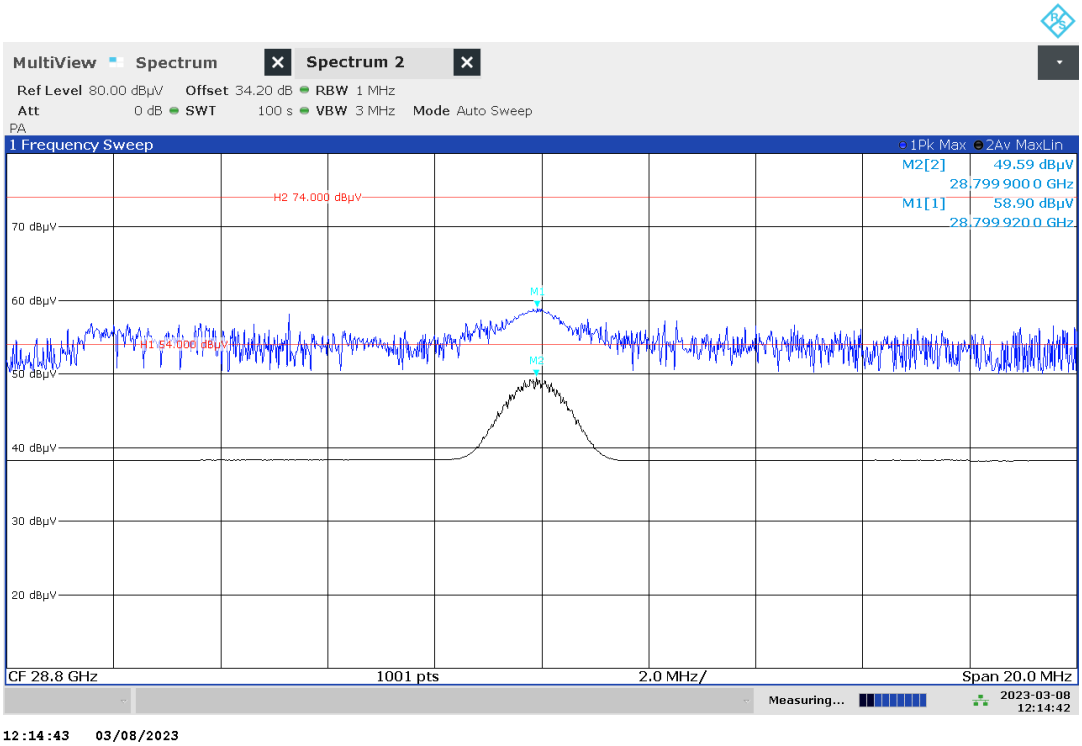
Plot no. 49: radiated emissions 18 GHz – 26.5 GHz, polarization vertical / horizontal, DUT 4 normal



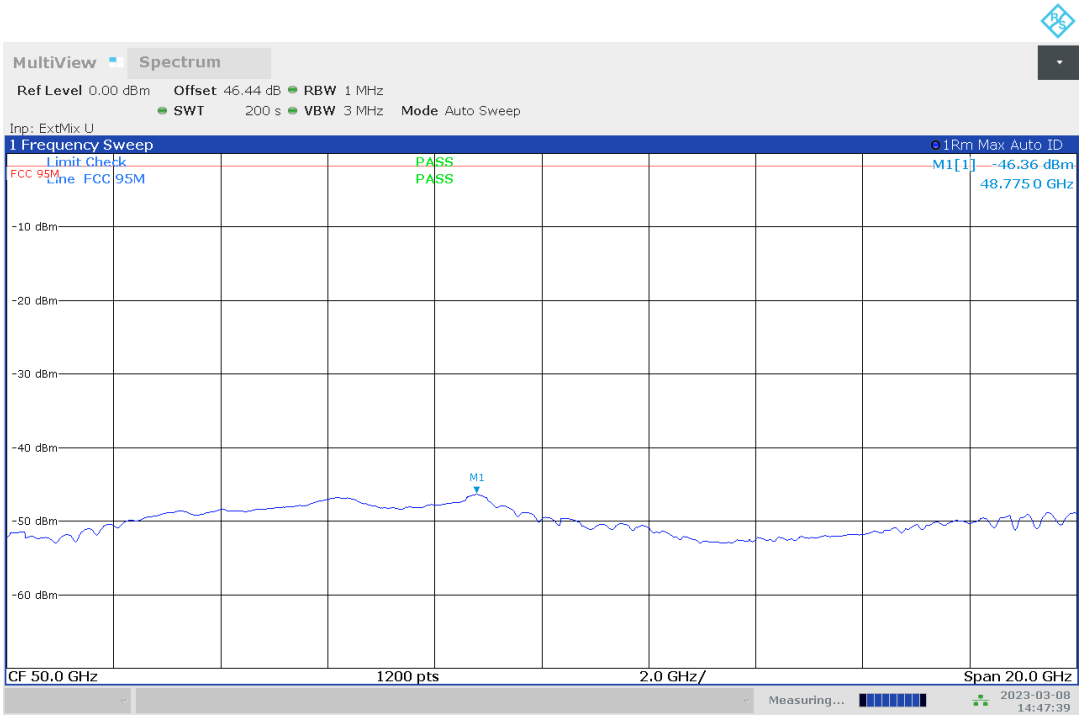
Plot no. 50: radiated emissions 26.5 GHz – 40 GHz, polarization vertical / horizontal, DUT 4 normal



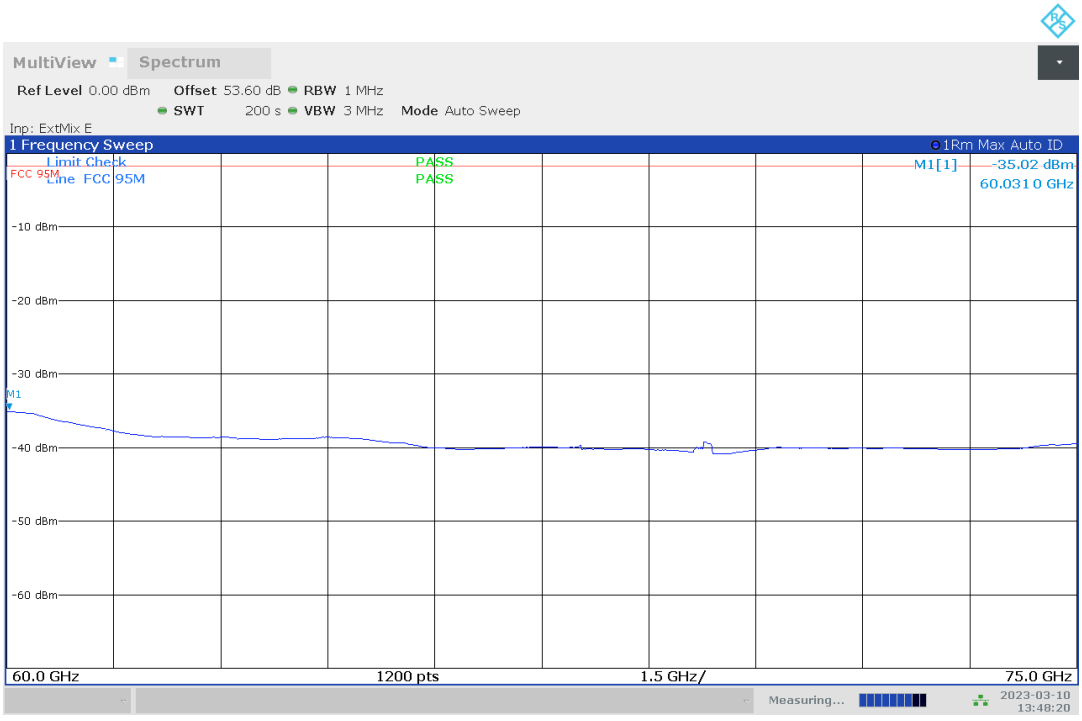
Plot no. 51: radiated emissions zoomed in on 28.8 GHz emission, polarization vertical / horizontal, DUT 4 normal



Plot no. 52: radiated emissions 40 GHz – 60 GHz, polarization vertical / horizontal, DUT 4 normal

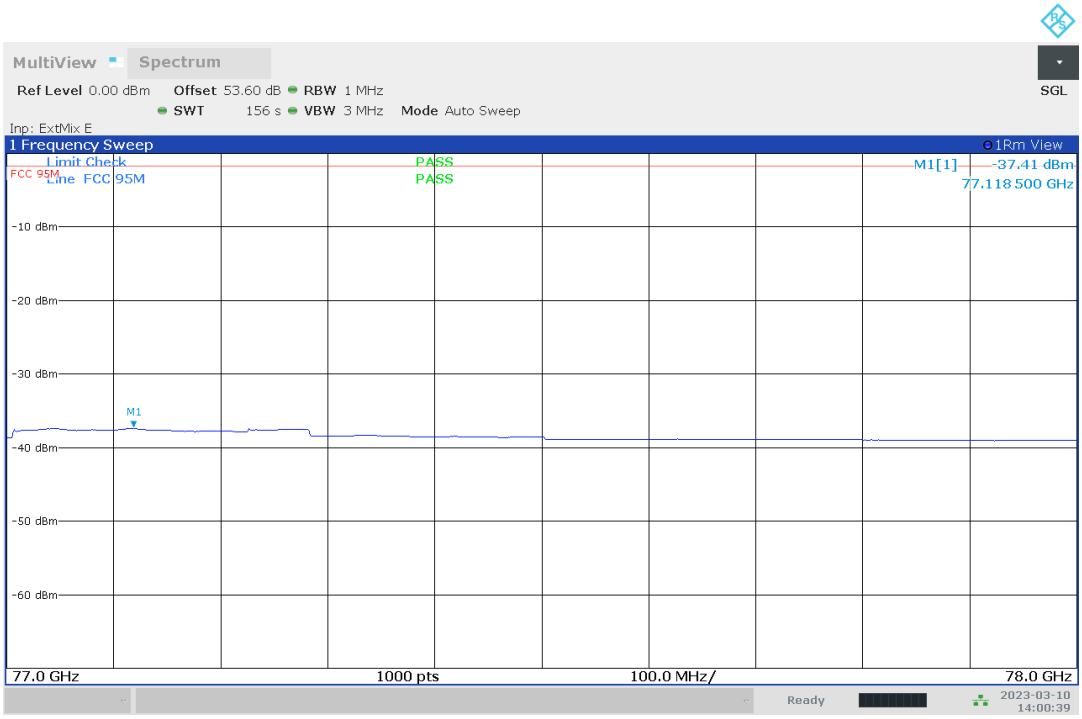


Plot no. 53: radiated emissions 60 GHz – 75 GHz, polarization vertical / horizontal, DUT 4 normal

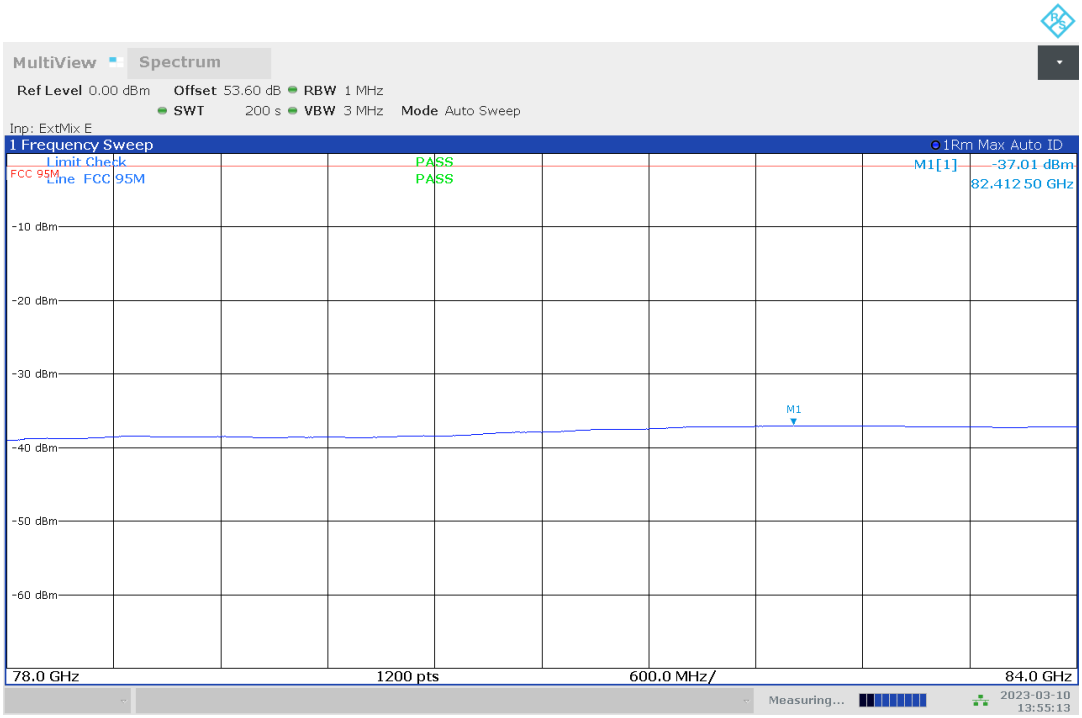


Plot no. 54: radiated emissions 75 GHz – 76 GHz, BEC, polarization aligned with radar sensor, DUT 4 normal

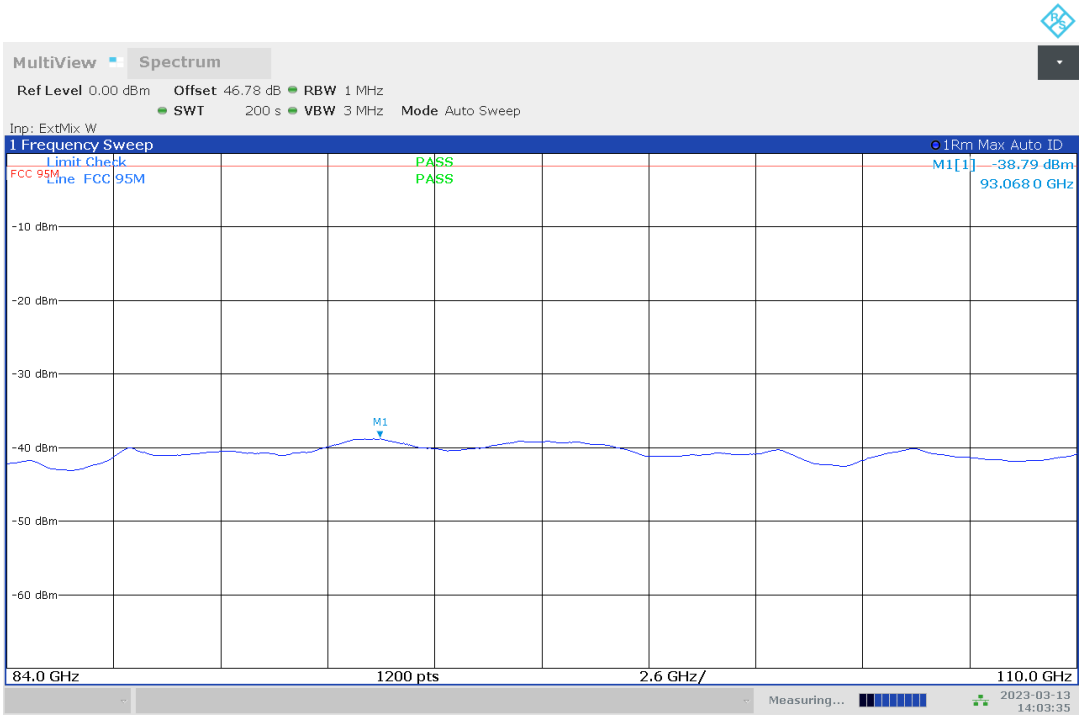
Plot no. 55: radiated emissions 77 GHz – 78 GHz, BEC, polarization aligned with radar sensor, DUT 4 normal



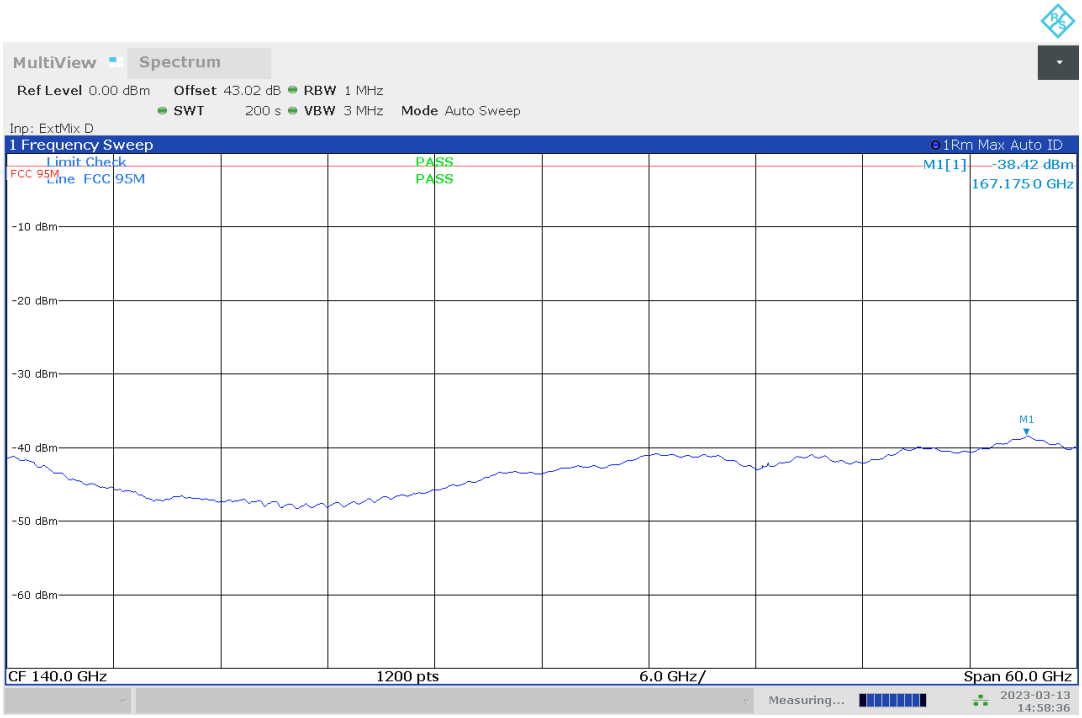
Plot no. 56: radiated emissions 78 GHz – 84 GHz, polarization vertical / horizontal, DUT 4 normal



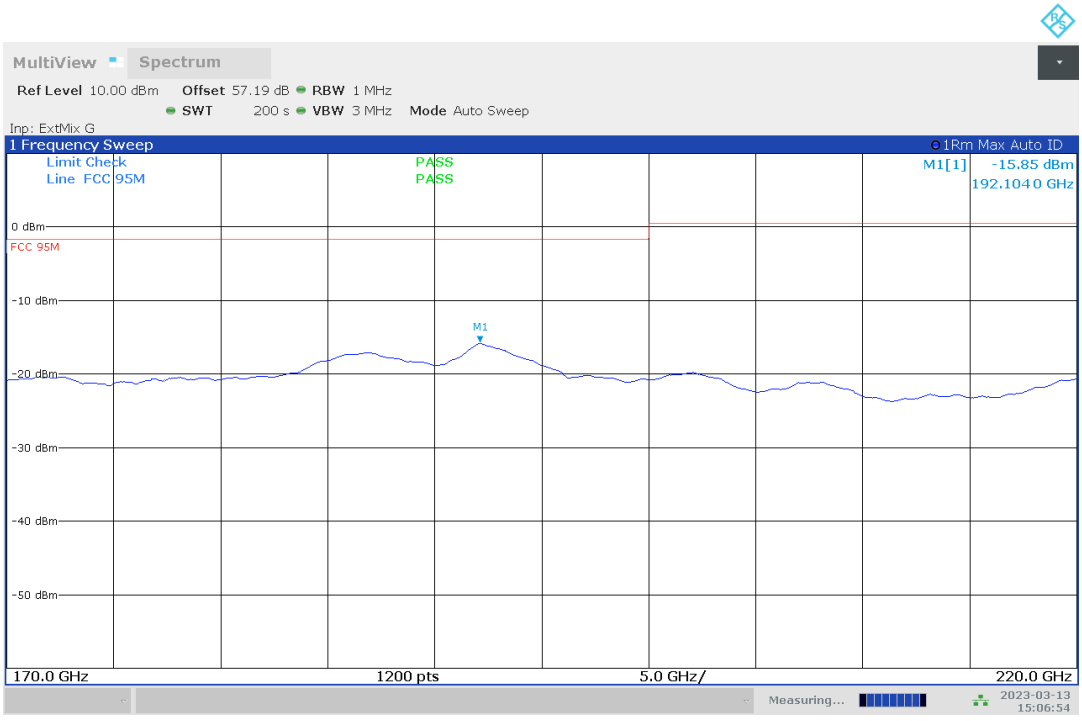
Plot no. 57: radiated emissions 84 GHz – 110 GHz, polarization vertical / horizontal, DUT 4 normal



Plot no. 58: radiated emissions 110 GHz – 170 GHz, polarization vertical / horizontal, DUT 4 normal



Plot no. 59: radiated emissions 170 GHz – 220 GHz, polarization vertical / horizontal, DUT 4 normal



Plot no. 60: radiated emissions 220 GHz – 325 GHz, polarization vertical / horizontal, DUT 4 normal