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

LENHARDT
WORLDWIDE | TESTING | CERTIFICATION

Bundesnetzagentur
BNetzA-CAB-21/21-21

Test Report

Test report no.: 23109360-40963-0
Date of issue: 2025-05-20

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

Applicant
Robert Bosch GmbH

Manufacturer
Robert Bosch GmbH

Test Item
F6AA0

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 RF*	signature
Approved by (name, function, signature)	*Karsten Geraldy* *Lab Manager RF*	signature

Applicant and Test item details	
Applicant	Robert Bosch GmbH Renningen 70465, Stuttgart, Germany
Manufacturer	Robert Bosch GmbH Renningen 70465, Stuttgart, Germany
Test item description	Automotive radar sensor
Model/Type reference	F6AA0
Standard specific information	
FCC ID	NF3-F6AA0
Technology	Automotive radar device
Frequency	76.0 GHz to 77.0 GHz
Antenna	3D-waveguide antenna
Power supply	6.7 to 19.0 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.

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	2025-03-18
Start – End of tests	2025-03-19 – 2025-05-07

2.2 Possible test case verdicts

Test sample meets the requirements	P (PASS) – the measured value is below the acceptance limit, AL = TL
Test sample does not meet the requirements	F (FAIL) – the measured value is above the acceptance limit, AL = TL
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

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 of test laboratory

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	6.7 V DC	13.2 V DC	19.0 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*	F6AA0	
Serial number*	Molex - back: AK2 – side:	10751075107546611111101501241504222610036 0322031203101500101000100124360085151044
Hardware status*	Molex - back: AK2 – side:	0203.3BB06K-80 0203.3BB0F8-01
Software status*	All EUTs:	02033B8125

*: 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*	N/A
Channel bandwidth*	< 1 GHz
Channel spacing*	N/A
Receiver category*	N/A
Receiver bandwidth*	N/A
Duty cycle*	28.8%
Antenna Gain*	21.97 dBi
Antenna*	3D-waveguide antenna
Power supply*	6.7 to 19.0 V DC
Temperature range*	-40 °C to +85 °C

*: as declared by applicant

5.4 Additional information

Model differences	In general, the EUT has two connector orientations: connector on the back of the sensor and connector on the side of the sensor. Difference is the mechanical direction of the connector. All other components are identical. (as declared by the manufacturer) Two different devices are tested: one device with the Molex-connector on EUT's back side and another one with the AK2-connector directed straight to the side. Full testing is performed for EUT with Molex-connector on its back side and test modes DMP01, DMP02 and DMP03. Additional radiated spurious test are performed for EUT with AK2-connector straight to the side and DMP01-Mode only.
Ancillaries tested with	N/A
Additional equipment used for testing	A laptop with specialized software as well as a CAN converter were used to change the running mode of the EUT

5.5 Operating conditions

Following information is derived from document "*F6AA0 Technical Description V2.0*", provided by applicant.

4.3 Modulation description

The F6AA0 sensor modulation mode depends on vehicle speed.

Vehicle speed	Modulation mode	Occupied Bandwidth	Active TX channels
up to 65km/h	DMP01	850 MHz	TX1, TX2, TX3, TX4
65km/h – 115 km/h	DMP02	850 MHz	TX1, TX2, TX3, TX4
above 115 km/h	DMP03	850 MHz	TX1, TX2, TX3, TX4

Basic modulation principle:

The sensor emits a series of fast FMCW chirps. The chirps are grouped in sequence and sequences are grouped in bursts.

Each chirp takes on average 19 µs. 4 chirps are emitted within a sequence on a single transmit frequency. A burst consists of 128 sequences, each sequency transmitted on a different frequency. The sequences are transmitted time shifted on different TX channels, resulting in a burst length of 14,40 ms. Once burst emission is completed, transmitter is turned off until end of cycle. A single cycle takes 50ms.

4.4 Duty Cycle

Total duration of a single F6AA0 cycle is 50ms. Within this time, the sensor transmits a single burst of 14,40 ms. Therefore, the sensor duty cycle is 14,40ms/50ms = 0,288.

$$Duty\_cycle = \frac{burst\_length}{cycle\_length} * 100$$

Modulation mode	Burst length	Duty cycle	Factor
DMP01; DMP02; DMP03	14,40 ms	28,8 %	5,40 dB

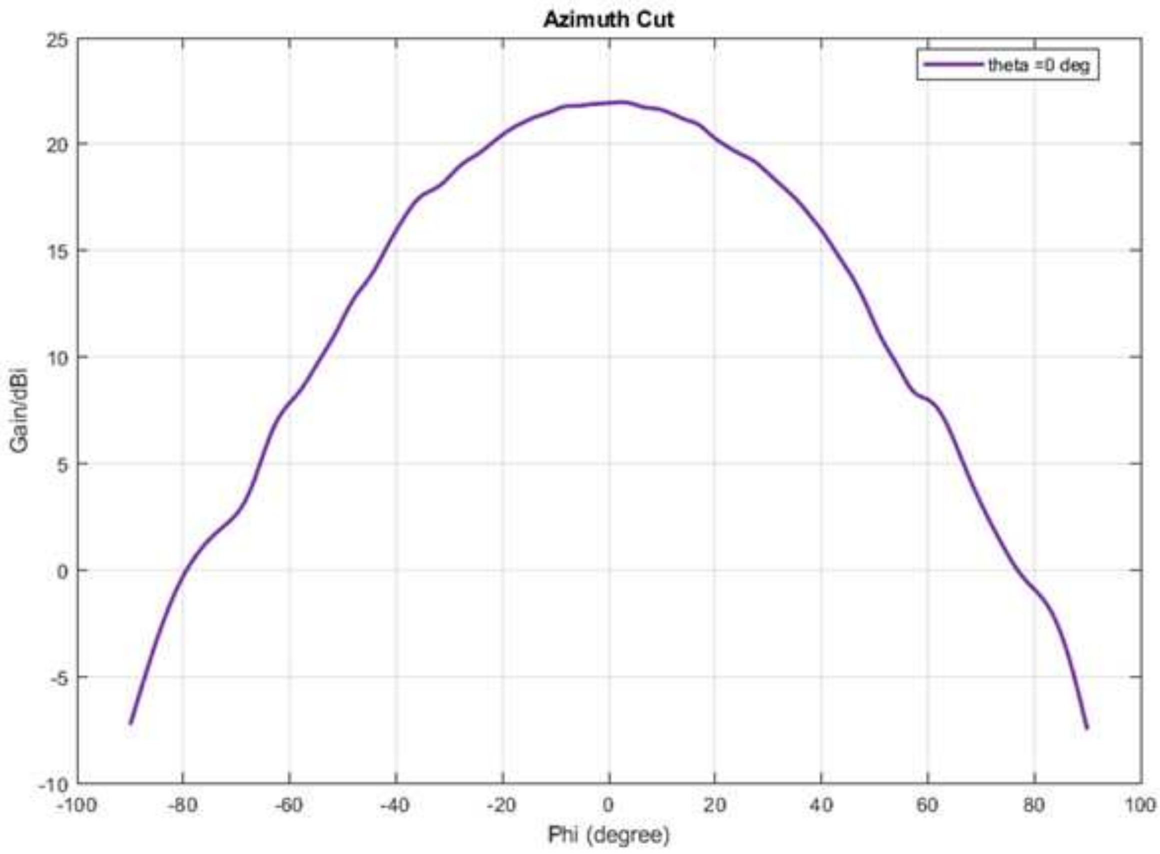
5.6 Antenna characteristics

Following information is derived from document "*F6AA0 Technical Description V2.0*", provided by applicant.

4.2 Antenna characteristics

4.2.1 TX all antenna characteristics

Simulation result of all channels combined azimuth antenna characteristic:



Maximum gain is 21,97 dBi.

6 SUMMARY OF TEST RESULTS

Test specification
FCC 47 CFR Part 95 – Subpart M

FCC-Clause	Requirement / Test case	Test Conditions	Result / Remark	Verdict
§2.1046 §95.3367 (a) (b)	RF power output	Nominal	27.40 dBm mean 38.62 dBm peak	**- PASS -**
§2.1047	Modulation characteristics	Nominal		**- PASS -**
§2.1049 §95.3379 (b)	Occupied bandwidth	Nominal	860.9 MHz	**- PASS -**
§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	**- PASS -**
§2.1055 §95.3379 (b)	Frequency stability	Nominal Extreme	within band	**- PASS -**

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.

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.

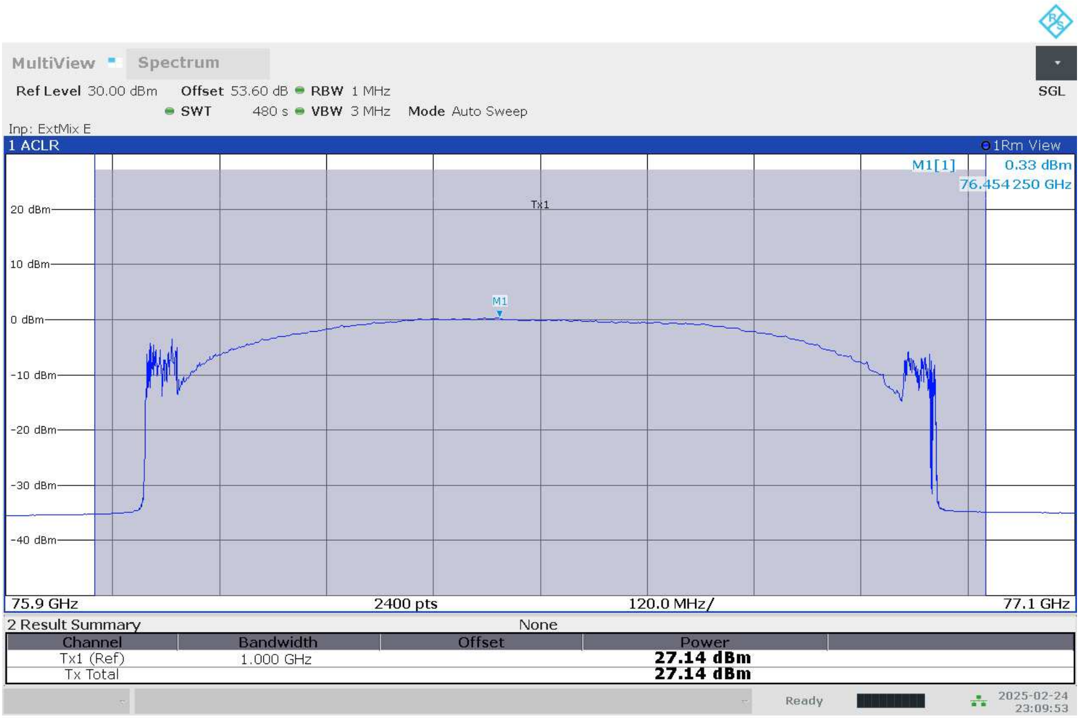
Test procedure used: Method with Spectrum Analyzer

Test setup: 8.3

Test results

EUT mode	Test distance [m]	Radiated Mean Power (EIRP) [dBm]	Radiated Peak Power (EIRP) [dBm]
DMP01	1.5	27.14	**38.62**
DMP02	1.5	26.97	**38.62**
DMP03	1.5	**27.40**	38.28

Plot no. 1: Mean Power EIRP, RMS detector / Channel Power, EUT DMP01



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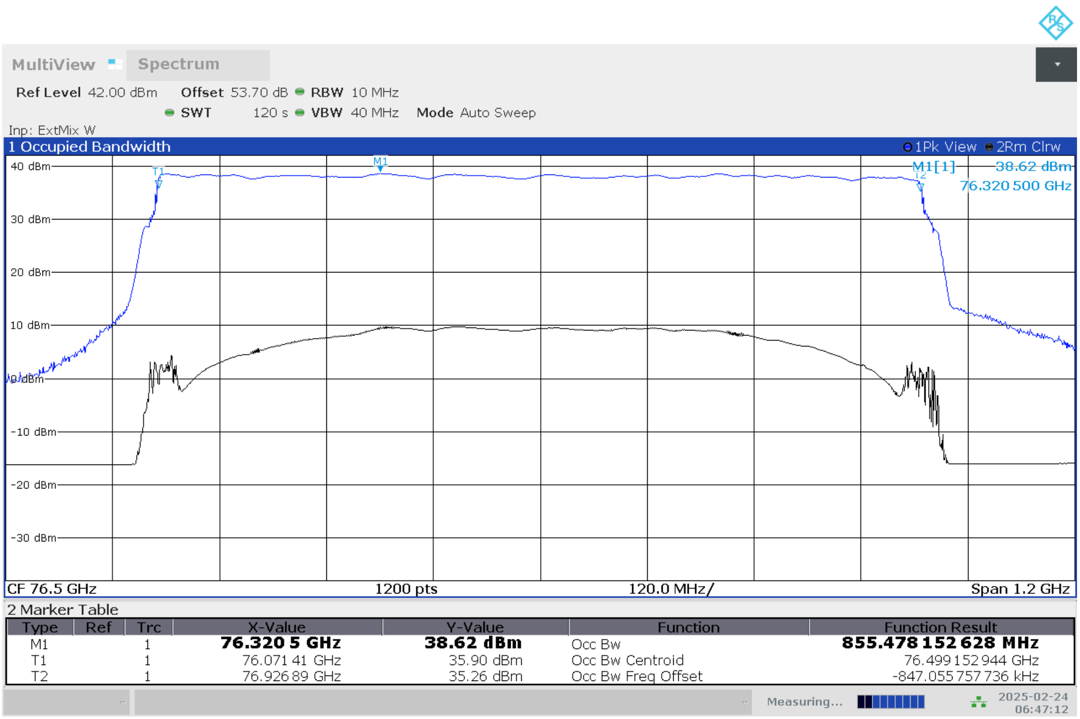
Plot no. 2: Peak Power EIRP, Peak detector, EUT DMP01



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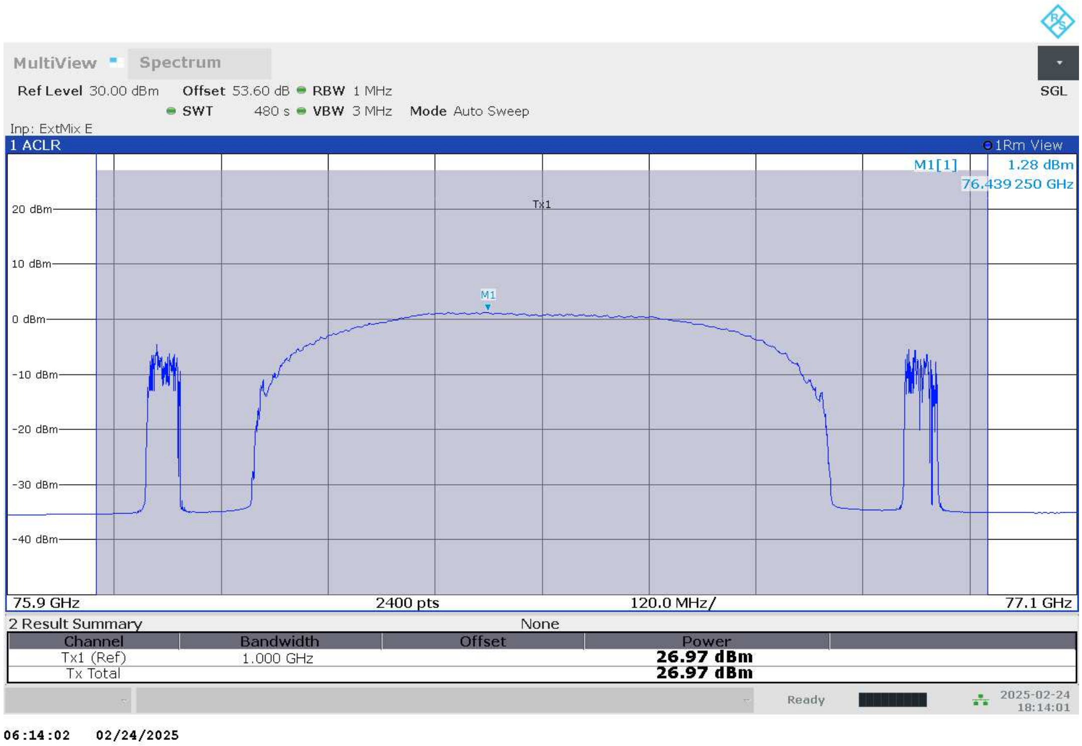
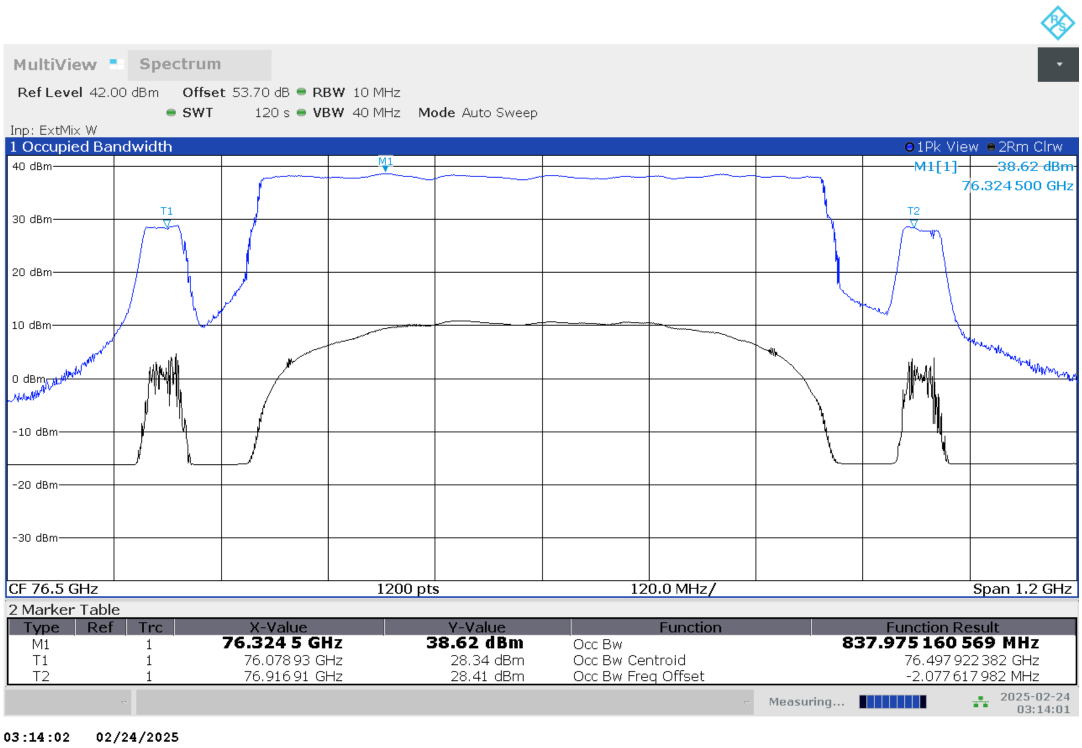
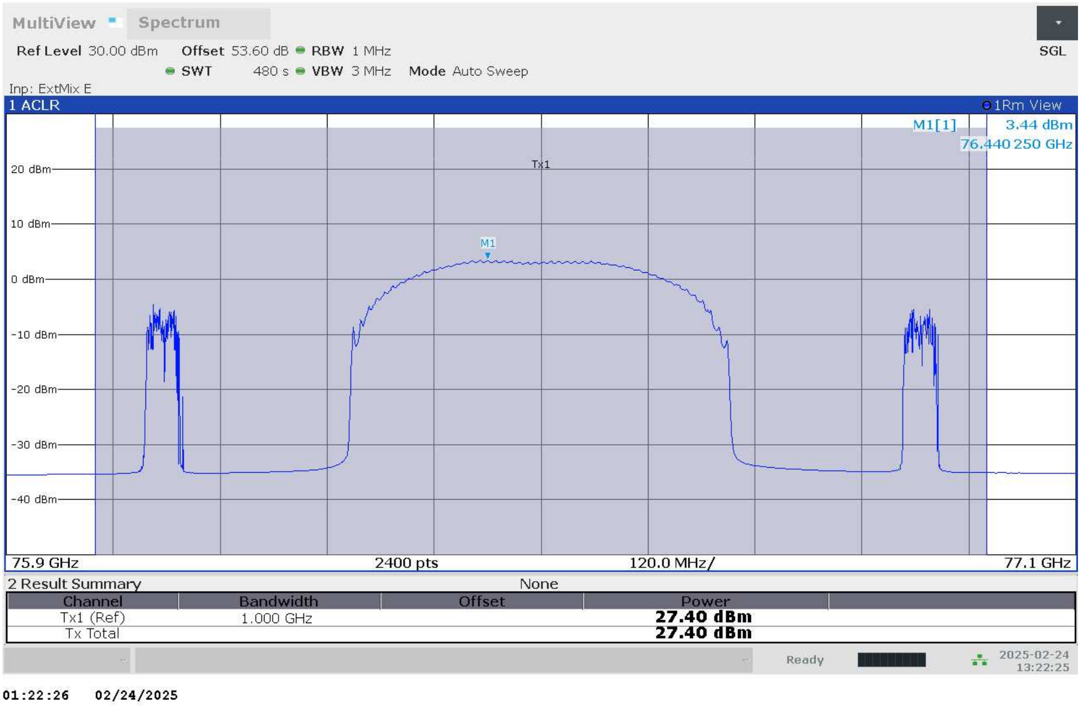
Plot no. 3: Mean Power EIRP, RMS detector / Channel Power, EUT DMP02



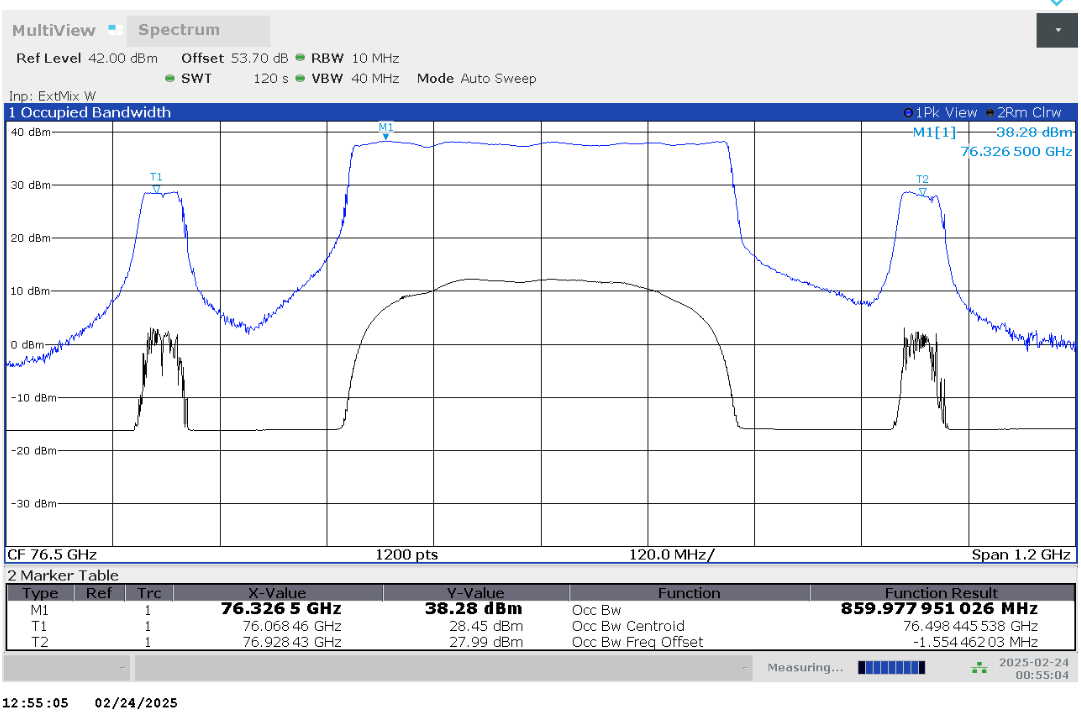
Plot no. 4: Peak Power EIRP, Peak detector, EUT DMP02



Plot no. 5: Mean Power EIRP, RMS detector / Channel Power, EUT DMP03



Plot no. 6: Peak Power EIRP, Peak detector, EUT DMP03



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

Modulation characteristics derived from provided document, please refer to chapter 5.5

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).

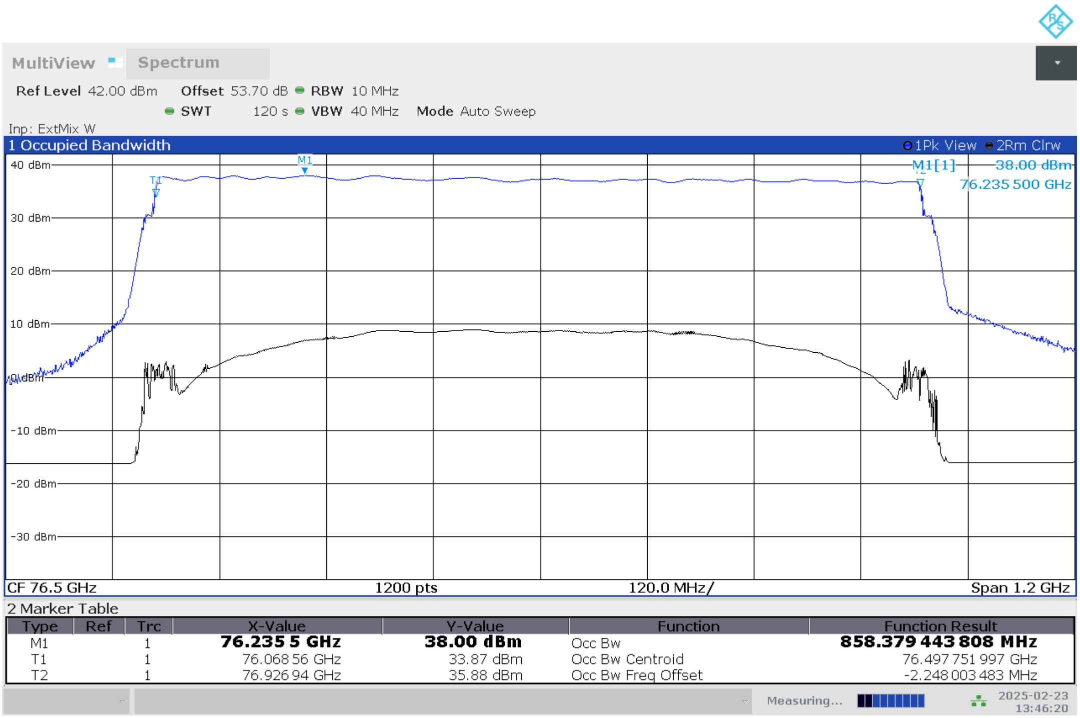
Test setup: 8.3, 8.4

Test results				
EUT mode	**Test conditions**	**f_L [GHz]**	**f_H [GHz]**	**99% OBW [MHz]**
DMP01	85 °C	76.069	76.927	858.379
DMP01	60 °C	76.07	76.924	853.936
DMP01	50 °C	76.07	76.925	854.882
DMP01	40 °C	76.07	76.925	854.656
DMP01	30 °C	76.071	76.926	855.394
DMP01	20 °C / V_{max}	76.071	76.927	855.356
DMP01	20 °C / V_{nom}	76.071	76.927	855.478
DMP01	20 °C / V_{min}	76.071	76.927	855.442
DMP01	10 °C	76.072	76.928	855.636
DMP01	0 °C	76.073	76.929	856.223
DMP01	-10 °C	76.074	76.930	856.560
DMP01	-20 °C	76.075	76.931	856.458
DMP01	-30 °C	76.074	76.932	857.389
DMP01	-40 °C	76.074	76.934	860.115
DMP02	85 °C	76.085	76.914	828.876
DMP02	60 °C	76.082	76.912	829.930
DMP02	50 °C	76.082	76.912	830.095
DMP02	40 °C	76.081	76.913	831.729
DMP02	30 °C	76.079	76.916	836.896
DMP02	20 °C / V_{max}	76.078	76.917	838.549
DMP02	20 °C / V_{nom}	76.079	76.917	837.975
DMP02	20 °C / V_{min}	76.078	76.917	839.446
DMP02	10 °C	76.081	76.919	838.331
DMP02	0 °C	76.081	76.92	839.071
DMP02	-10 °C	76.082	76.921	838.844
DMP02	-20 °C	76.084	76.922	838.354
DMP02	-30 °C	76.081	76.922	840.937
DMP02	-40 °C	76.080	76.921	841.025
DMP03	85 °C	76.068	76.925	856.925
DMP03	60 °C	76.07	76.925	854.760
DMP03	50 °C	76.071	76.924	853.526
DMP03	40 °C	76.069	76.925	855.908
DMP03	30 °C	76.067	76.927	860.336
DMP03	20 °C / V_{max}	76.068	76.929	860.953
DMP03	20 °C / V_{nom}	76.068	76.928	859.978
DMP03	20 °C / V_{min}	76.068	76.928	860.338
DMP03	10 °C	76.07	76.929	859.158
DMP03	0 °C	76.073	76.930	857.384
DMP03	-10 °C	76.073	76.930	857.296
DMP03	-20 °C	76.073	76.931	858.323
DMP03	-30 °C	76.072	76.932	860.378
DMP03	-40 °C	76.072	76.933	**860.880**

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, DMP01



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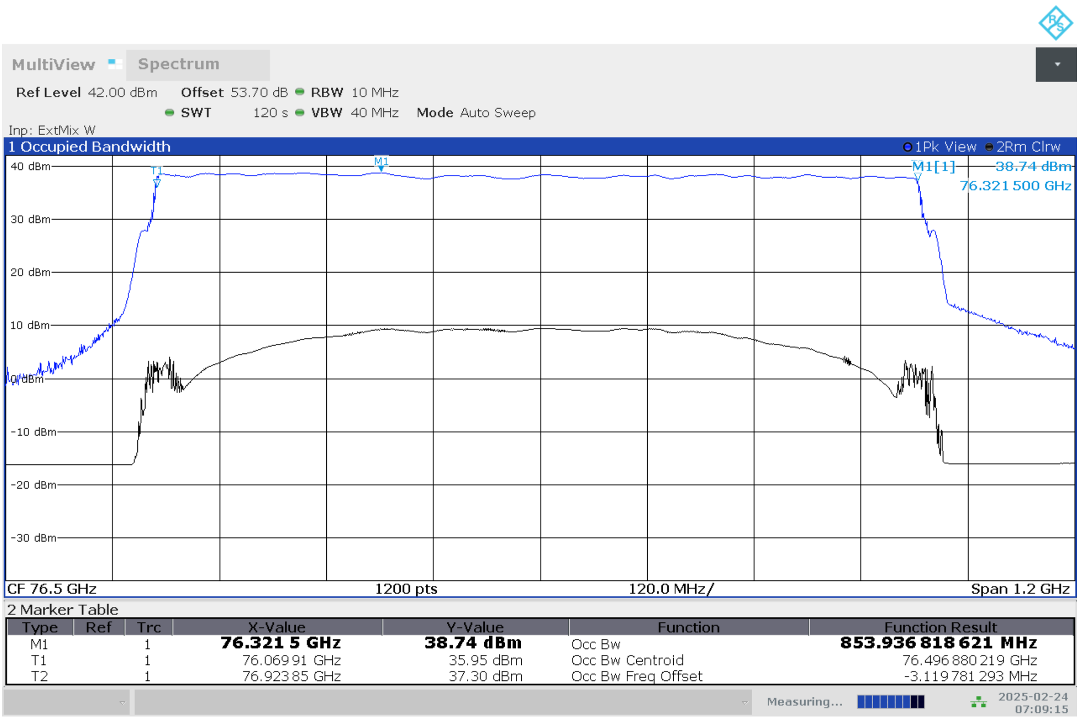
Plot no. 8: 99% OBW, Peak detector, 60 °C, DMP01



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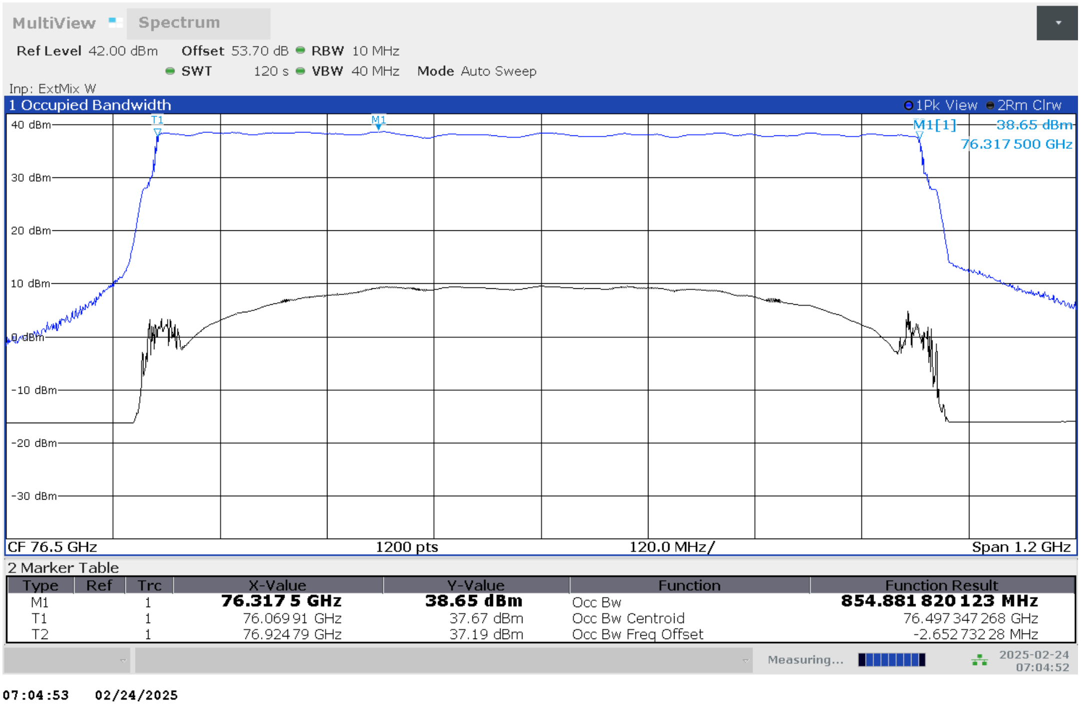
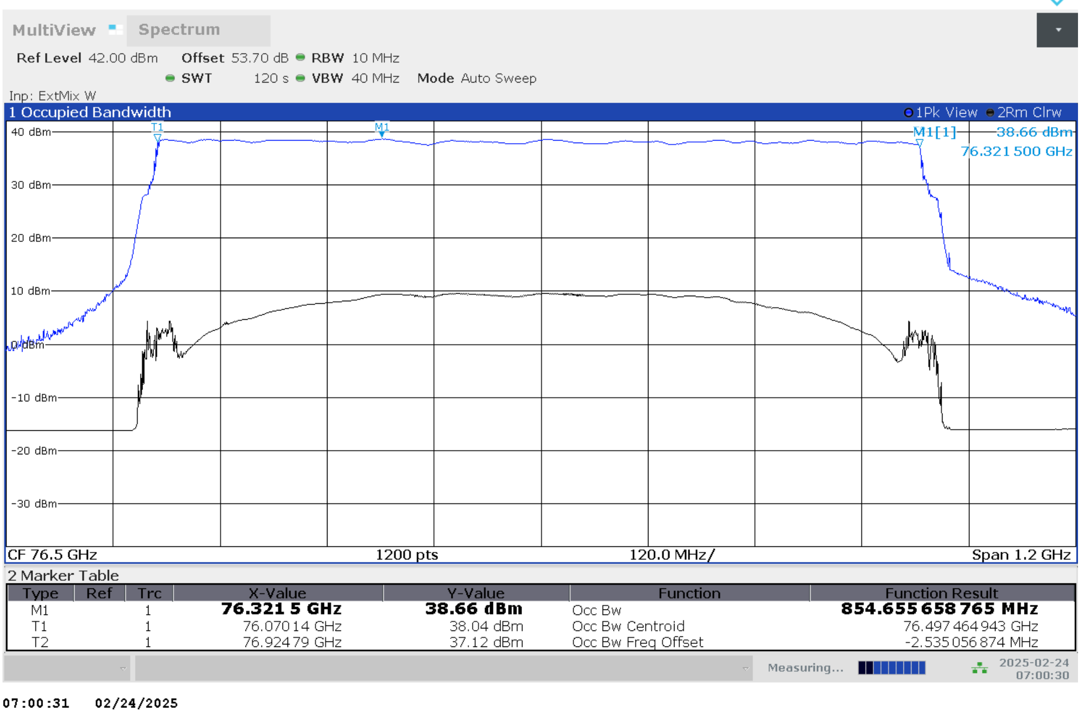
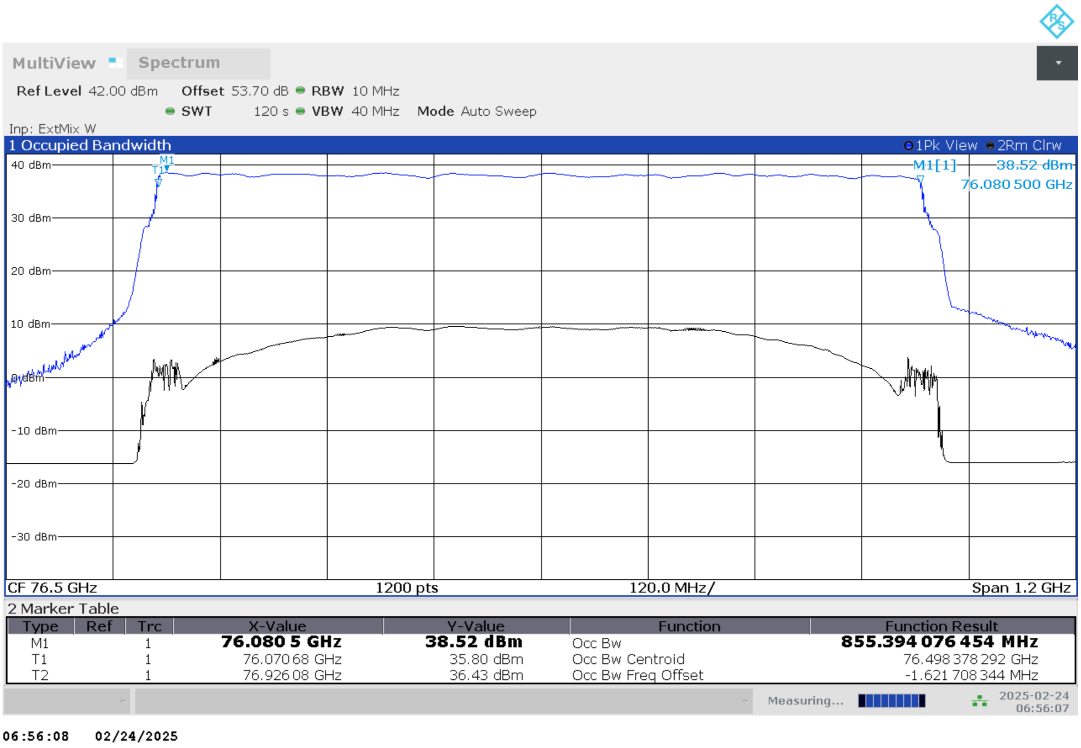
Plot no. 9: 99% OBW, Peak detector, 50 °C, DMP01



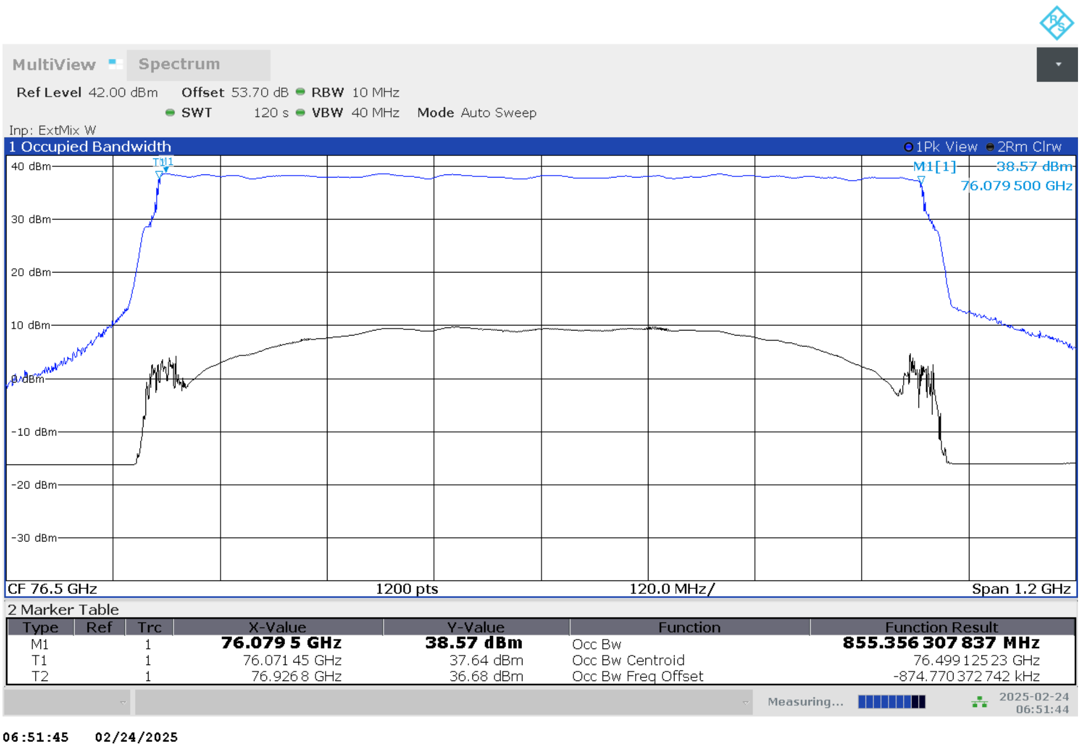
Plot no. 10: 99% OBW, Peak detector, 40 °C, DMP01



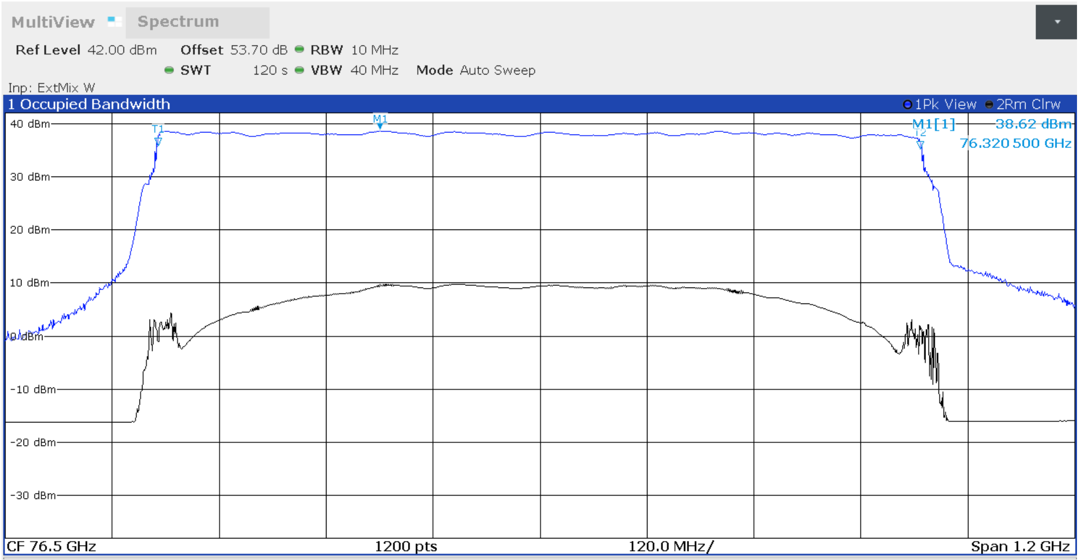
Plot no. 11: 99% OBW, Peak detector, 30 °C, DMP01



Plot no. 12: 99% OBW, Peak detector, 20 °C, V_{max}, DMP01



Plot no. 13: 99% OBW, Peak detector, 20 °C, V_{nom}, DMP01



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**76.320 5 GHz**	**38.62 dBm**	Occ Bw	**855.478 152 628 MHz**
T1		1	76.071 41 GHz	35.90 dBm	Occ Bw Centroid	76.499 152 944 GHz
T2		1	76.926 89 GHz	35.26 dBm	Occ Bw Freq Offset	-847.055 757 736 kHz

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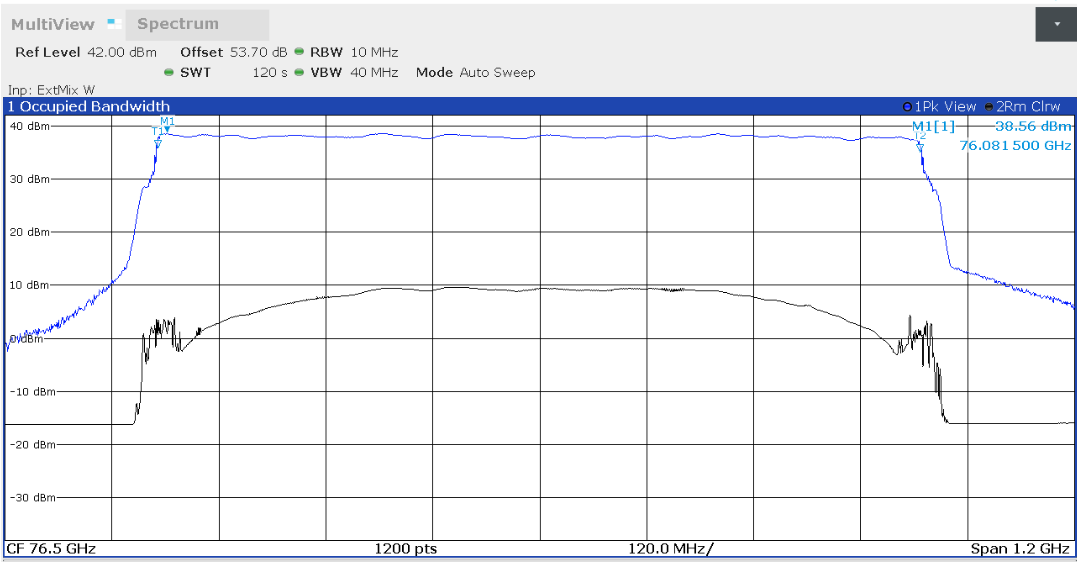
Plot no. 14: 99% OBW, Peak detector, 20 °C, V_{min}, DMP01



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**76.081 5 GHz**	**38.56 dBm**	Occ Bw	**855.441 570 142 MHz**
T1		1	76.071 41 GHz	35.78 dBm	Occ Bw Centroid	76.499 131 009 GHz
T2		1	76.926 85 GHz	35.04 dBm	Occ Bw Freq Offset	-868.990 710 602 kHz

Measuring... 2025-02-24 06:49:28

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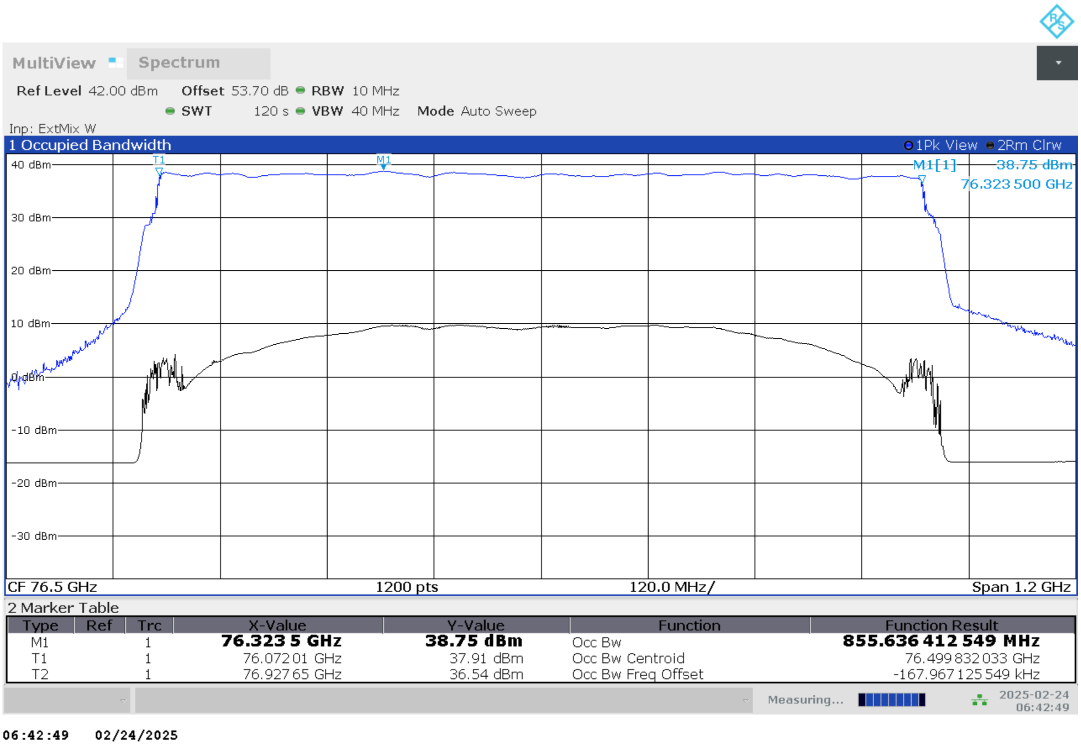
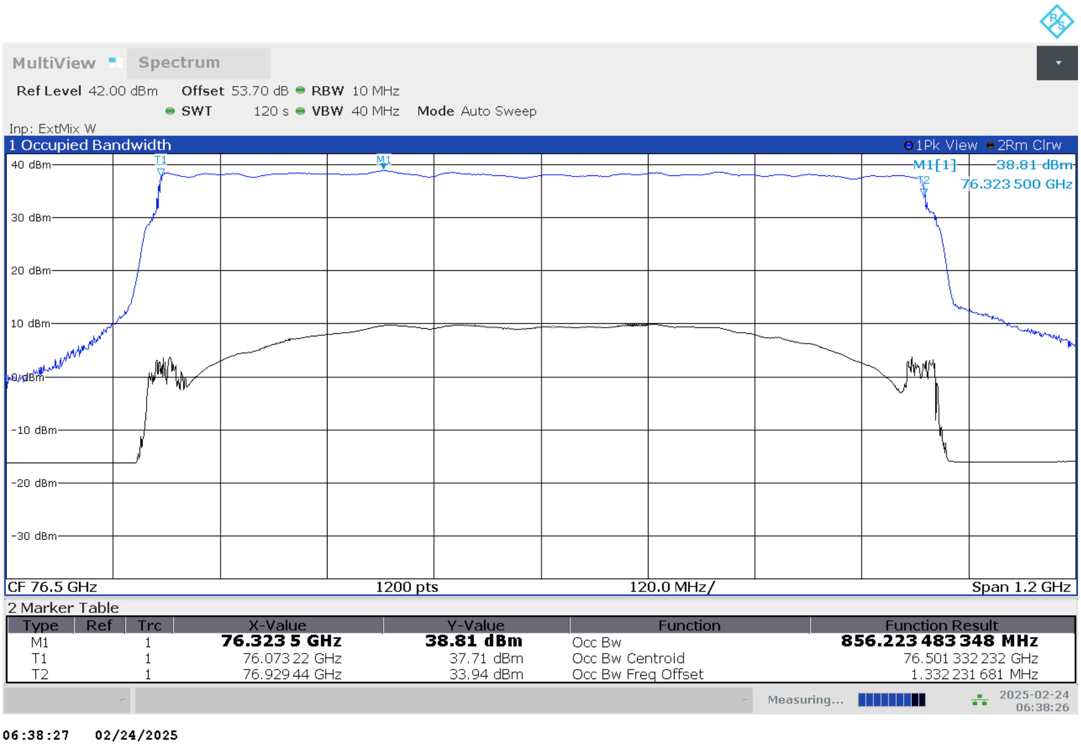
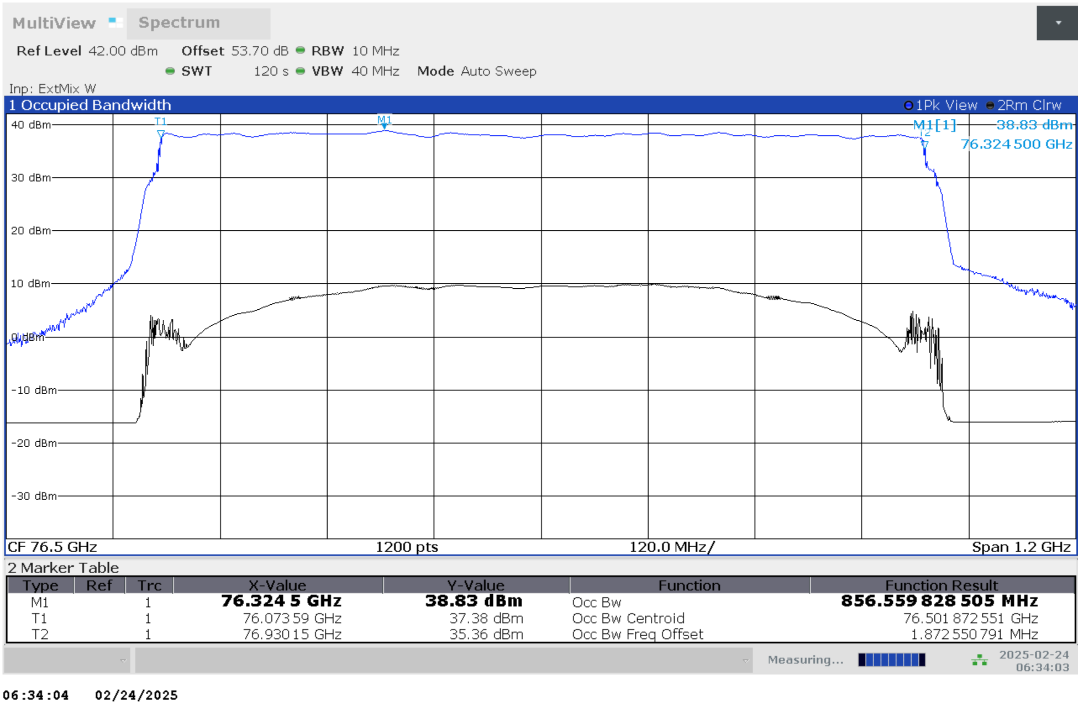
Plot no. 15: 99% OBW, Peak detector, 10 °C, DMP01



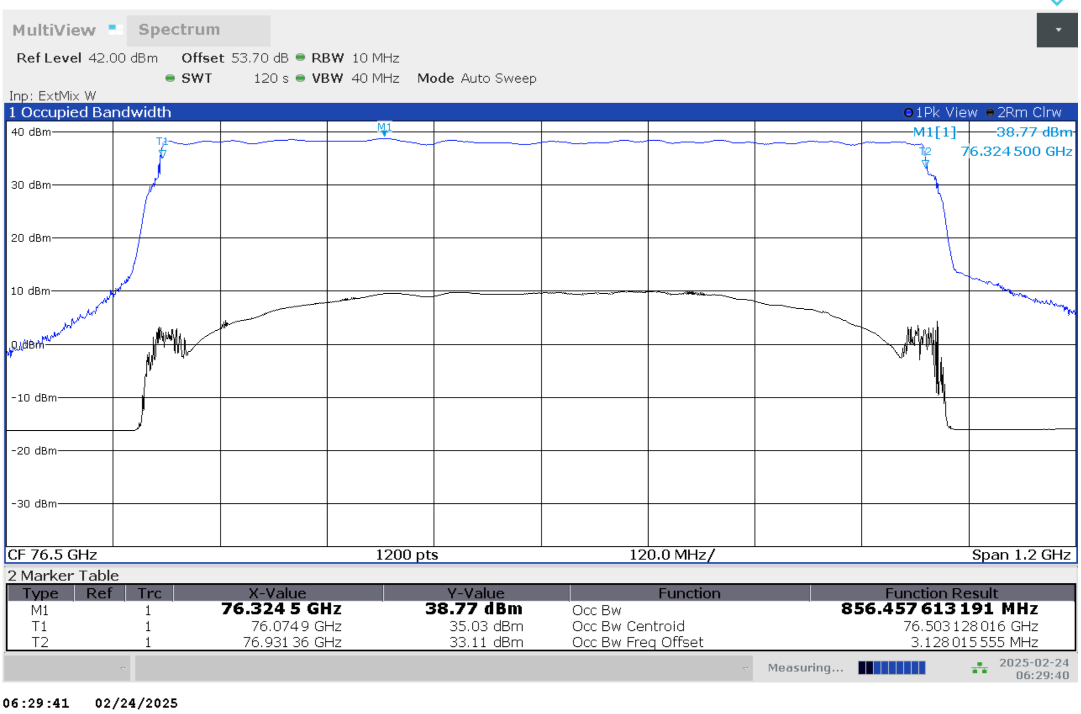
Plot no. 16: 99% OBW, Peak detector, 0 °C, DMP01



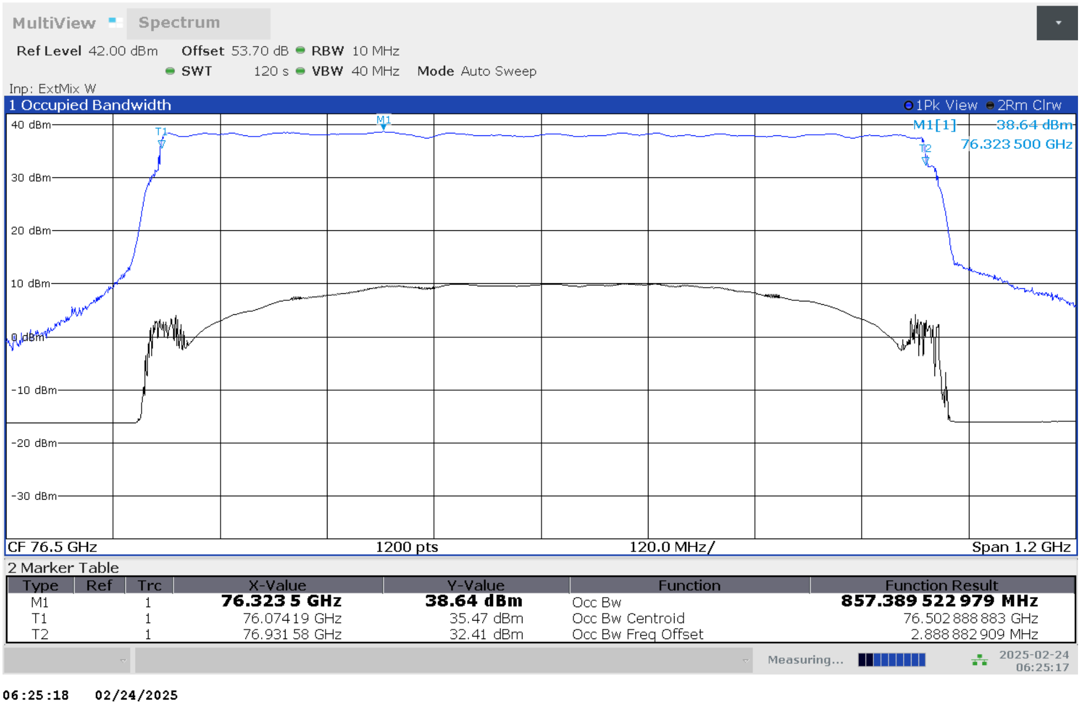
Plot no. 17: 99% OBW, Peak detector, -10 °C, DMP01



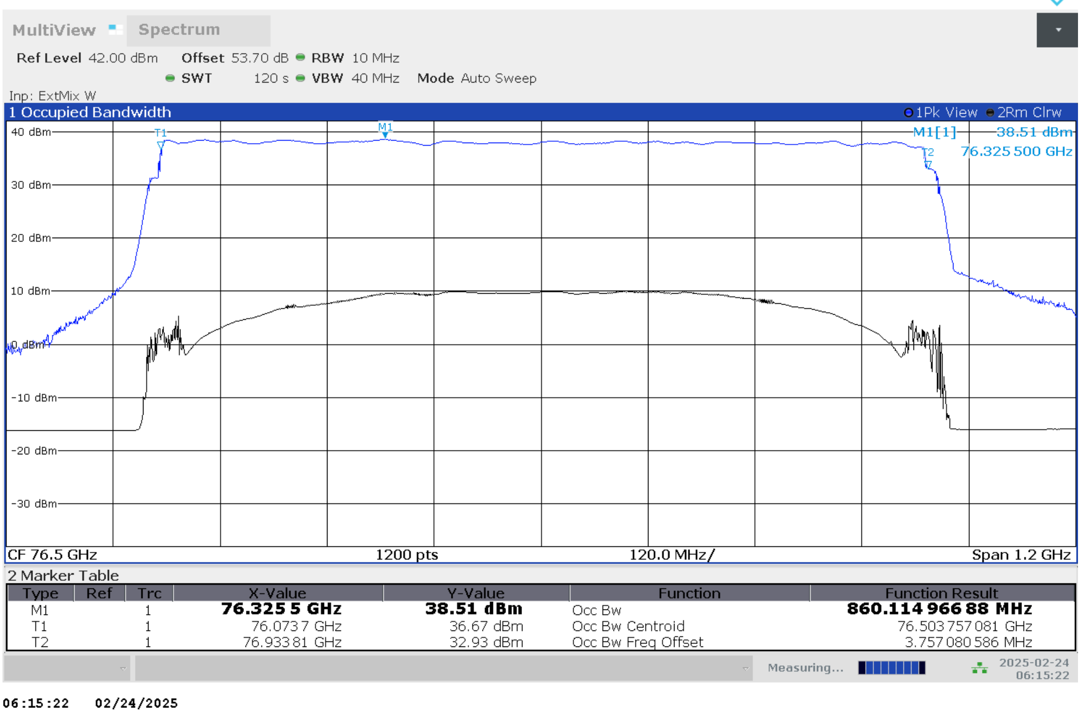
Plot no. 18: 99% OBW, Peak detector, -20 °C, DMP01



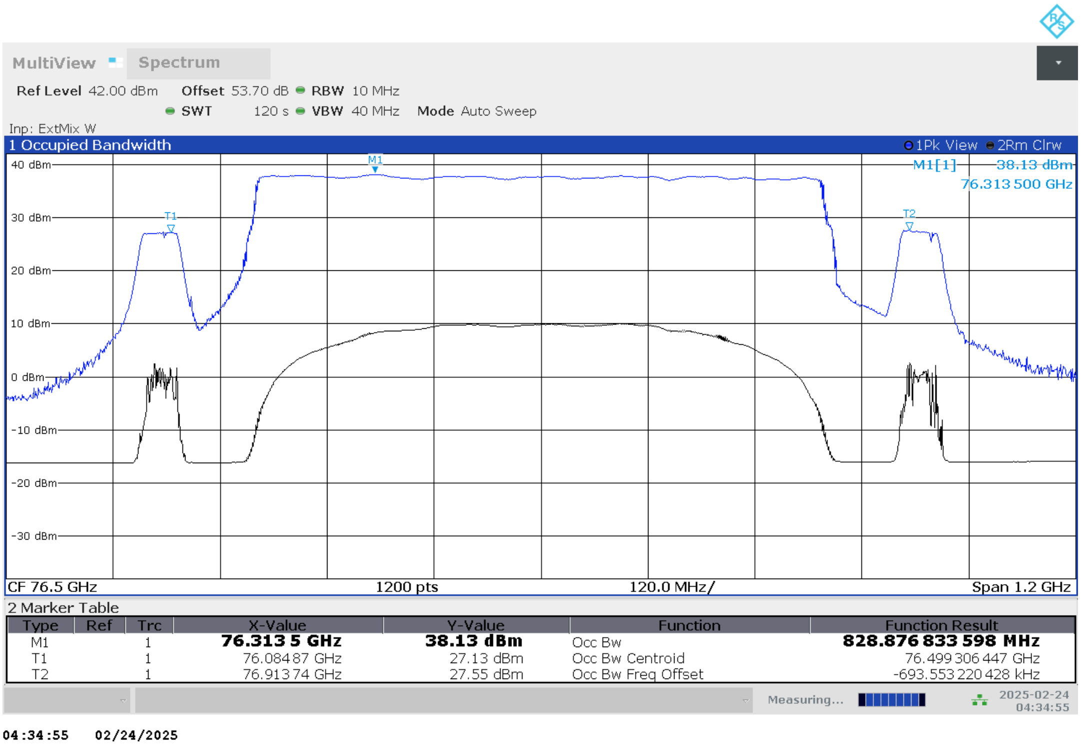
Plot no. 19: 99% OBW, Peak detector, -30 °C, DMP01



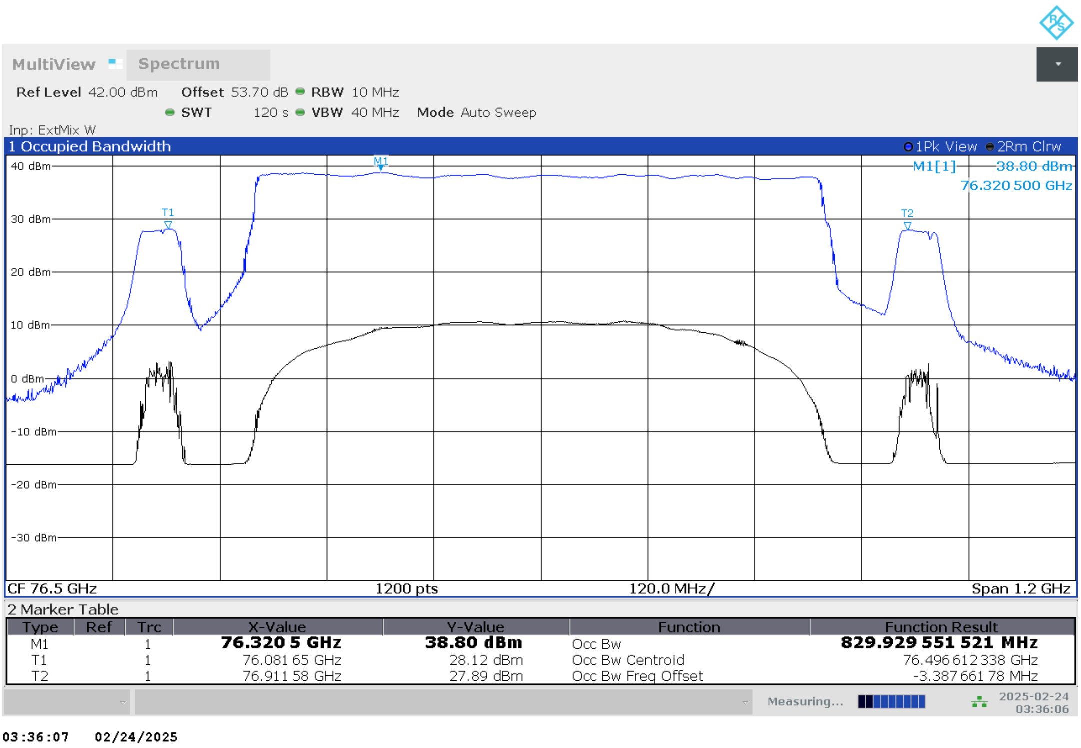
Plot no. 20: 99% OBW, Peak detector, -40 °C, DMP01



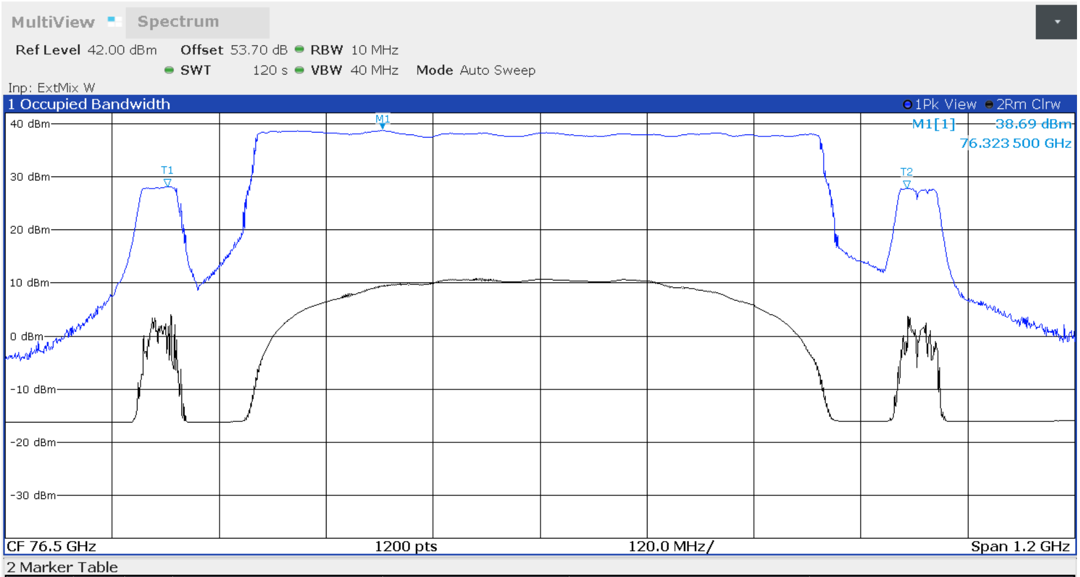
Plot no. 21: 99% OBW, Peak detector, 85 °C, DMP02



Plot no. 22: 99% OBW, Peak detector, 60 °C, DMP02



Plot no. 23: 99% OBW, Peak detector, 50 °C, DMP02



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**76.323 5 GHz**	**38.69 dBm**	Occ Bw	**830.094 731 496 MHz**
T1		1	76.081 84 GHz	28.10 dBm	Occ Bw Centroid	76.496 891 985 GHz
T2		1	76.911 94 GHz	27.73 dBm	Occ Bw Freq Offset	-3.108 015 278 MHz

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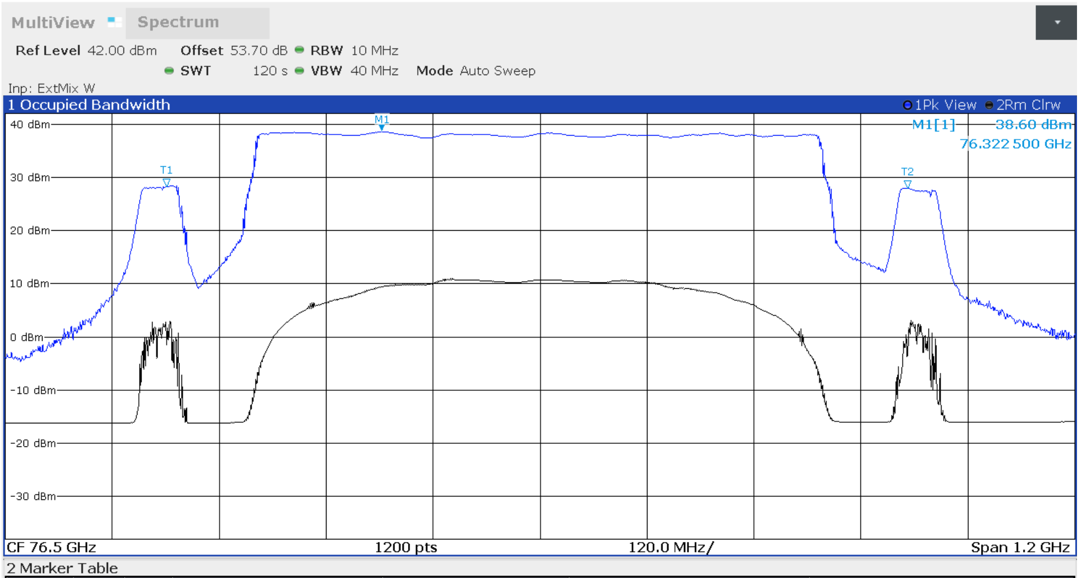
Plot no. 24: 99% OBW, Peak detector, 40 °C, DMP02



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**76.322 5 GHz**	**38.60 dBm**	Occ Bw	**831.728 899 077 MHz**
T1		1	76.080 87 GHz	28.25 dBm	Occ Bw Centroid	76.496 735 249 GHz
T2		1	76.912 6 GHz	27.90 dBm	Occ Bw Freq Offset	-3.264 750 861 MHz

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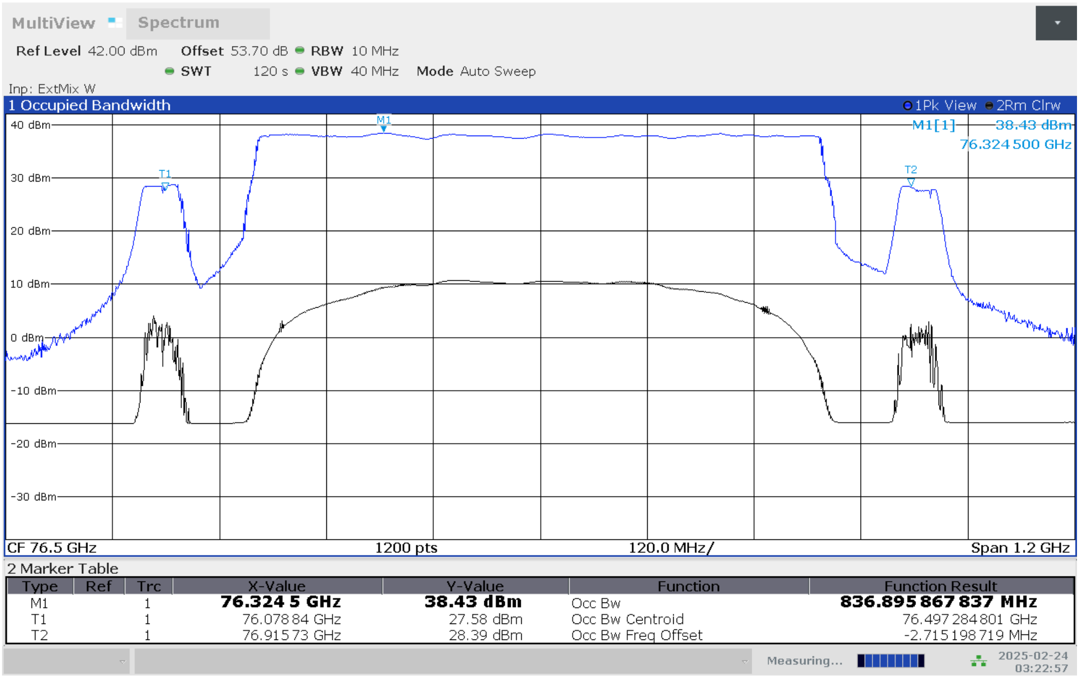
Plot no. 25: 99% OBW, Peak detector, 30 °C, DMP02



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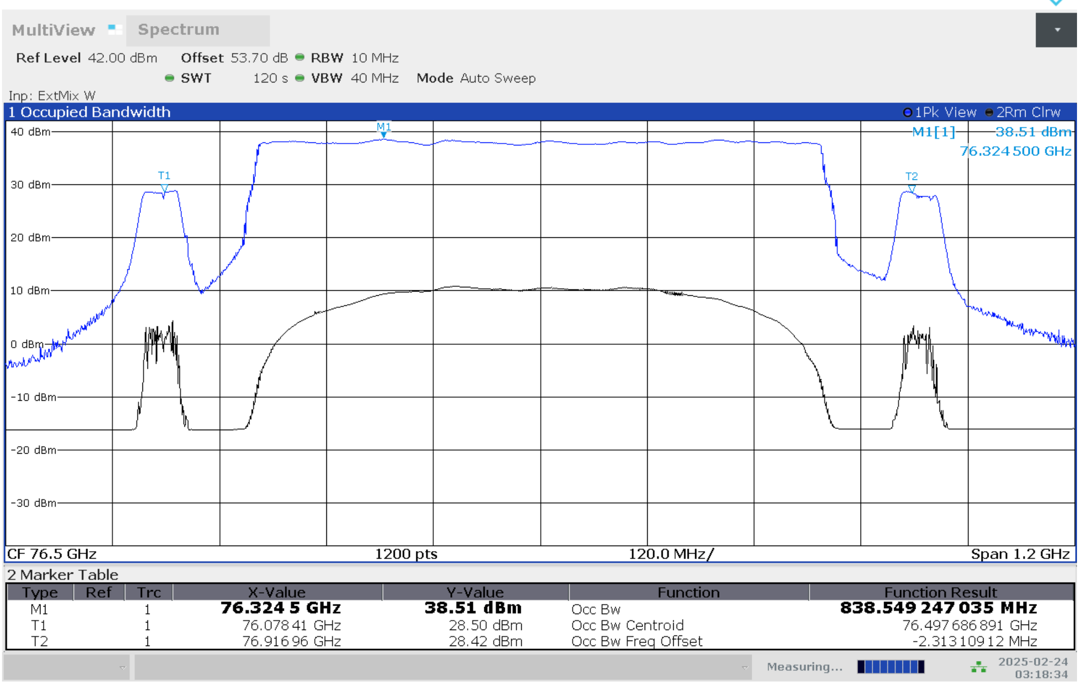
Plot no. 26: 99% OBW, Peak detector, 20 °C, V_{max}, DMP02



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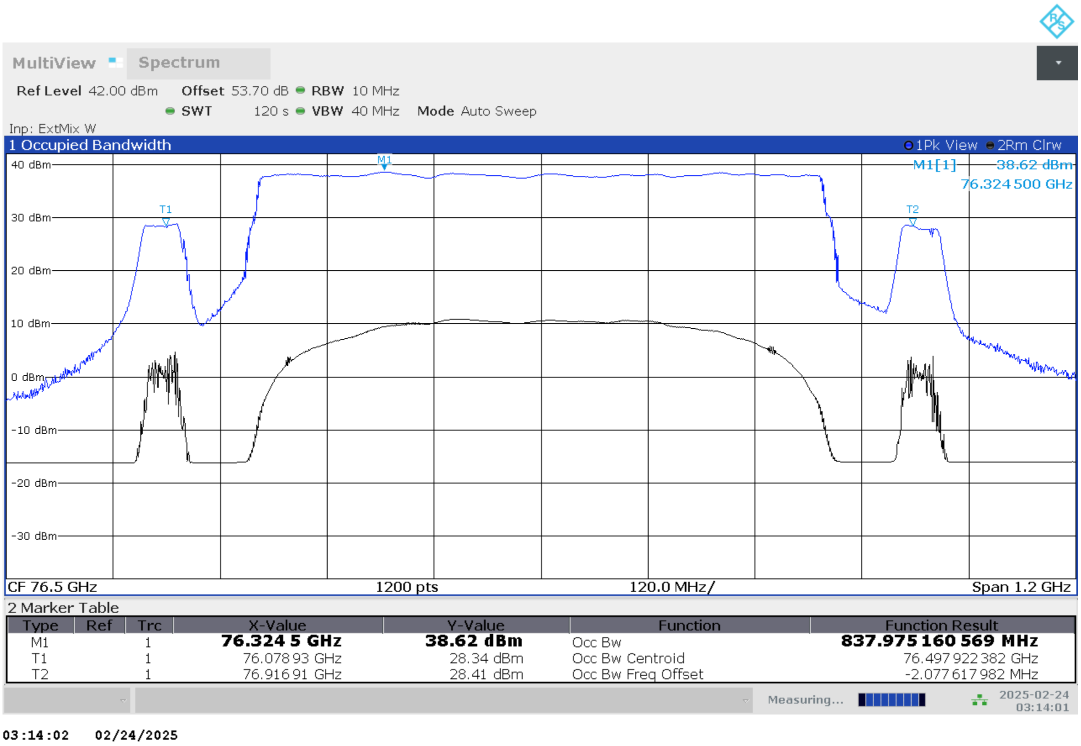
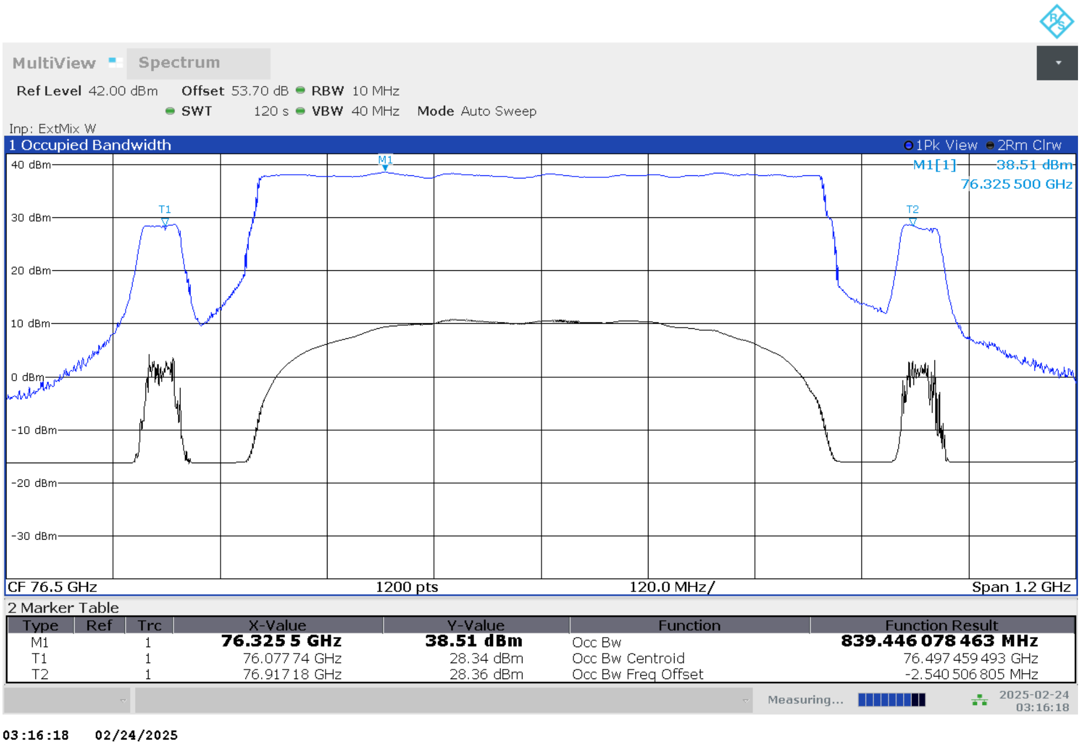
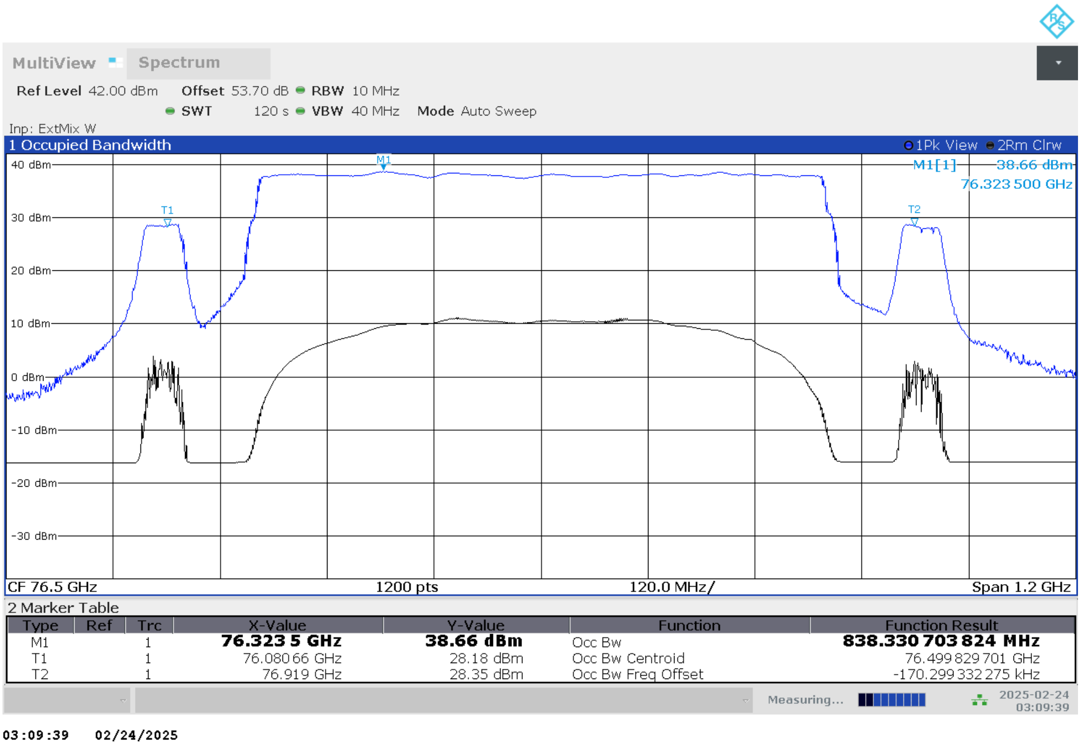
Plot no. 27: 99% OBW, Peak detector, 20 °C, V_{nom}, DMP02



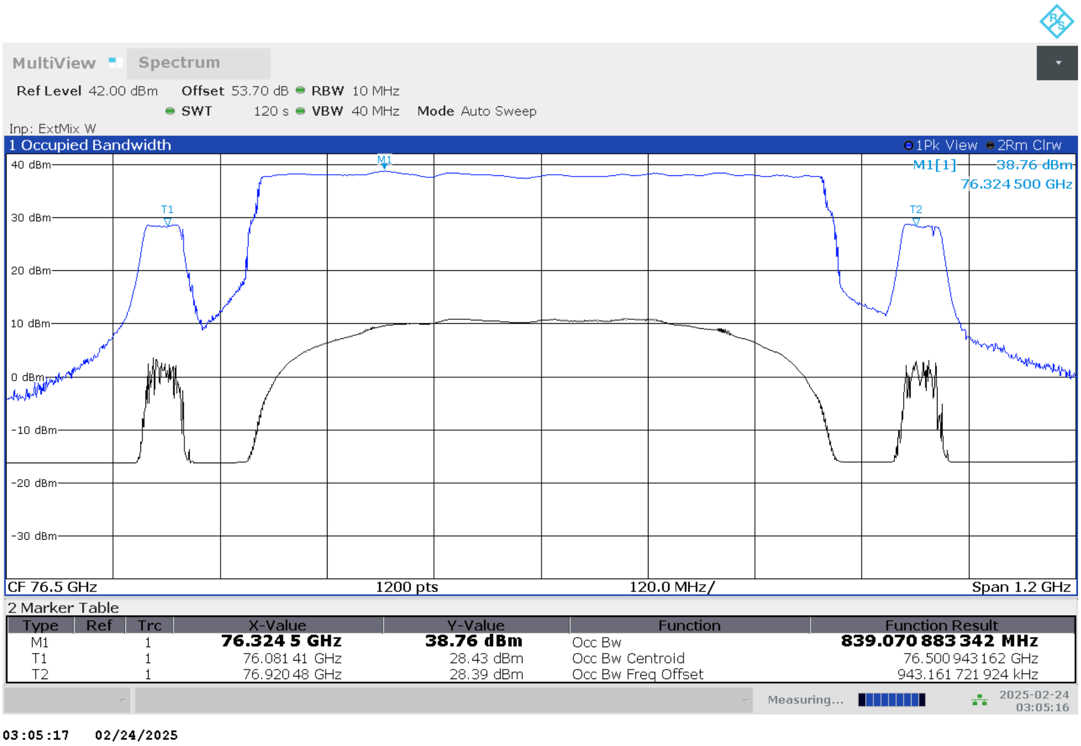
Plot no. 28: 99% OBW, Peak detector, 20 °C, V_{min}, DMP02



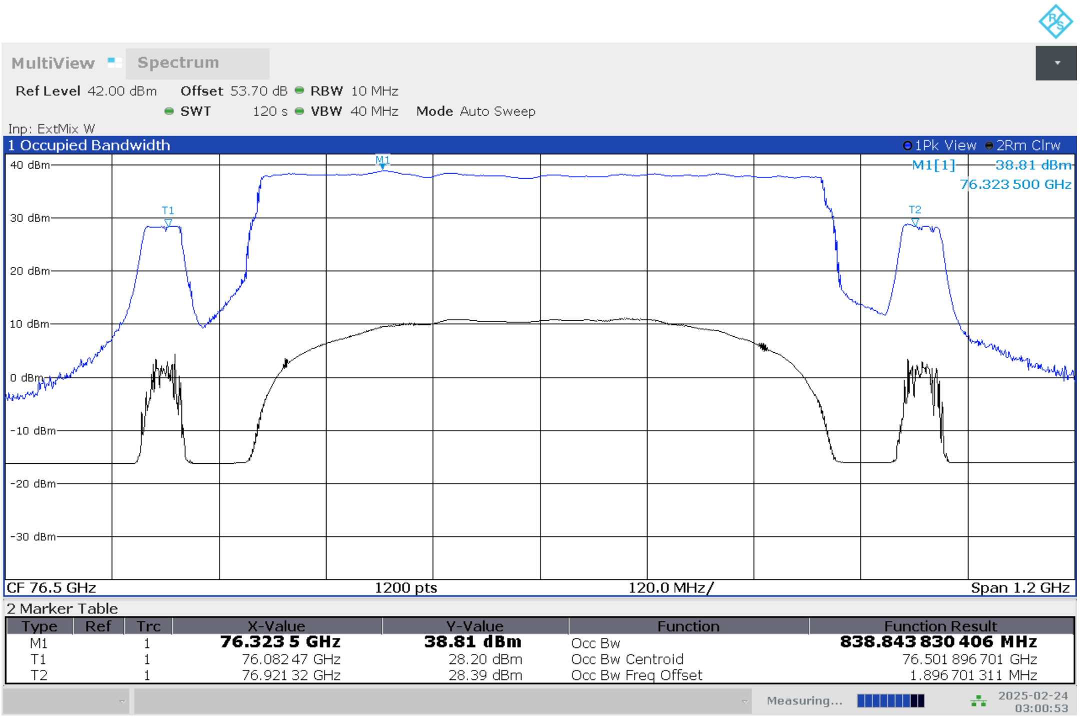
Plot no. 29: 99% OBW, Peak detector, 10 °C, DMP02



Plot no. 30: 99% OBW, Peak detector, 0 °C, DMP02



Plot no. 31: 99% OBW, Peak detector, -10 °C, DMP02



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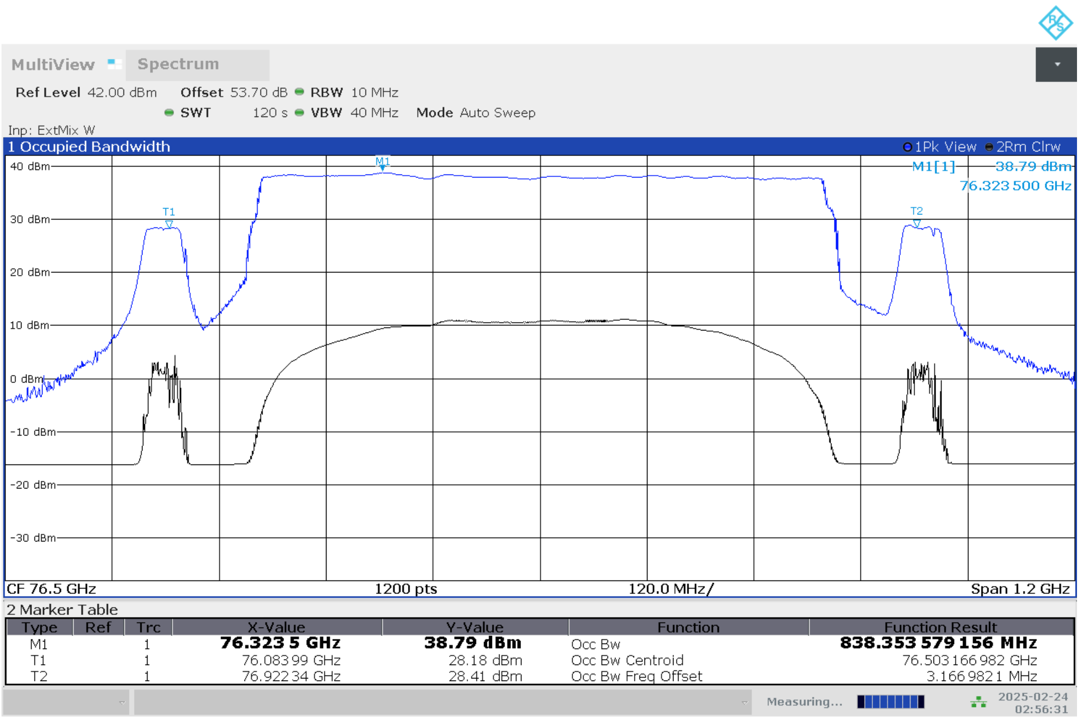
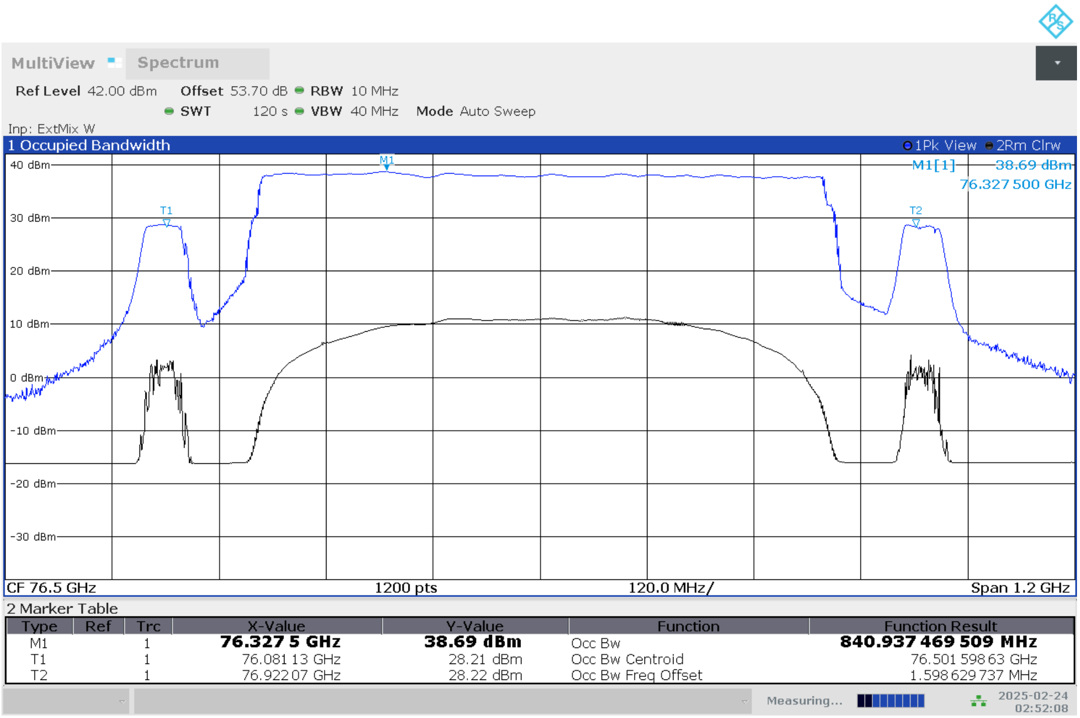
Plot no. 32: 99% OBW, Peak detector, -20 °C, DMP02



02:56:31 02/24/2025

Plot no. 33: 99% OBW, Peak detector, -30 °C, DMP02



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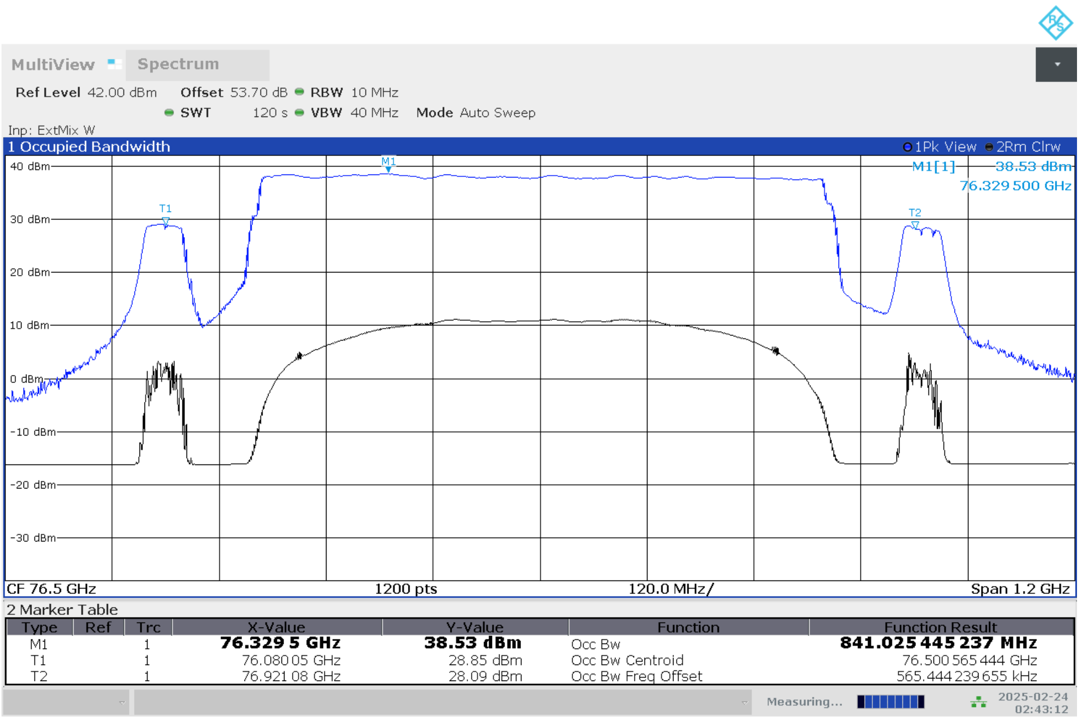
Plot no. 34: 99% OBW, Peak detector, -40 °C, DMP02



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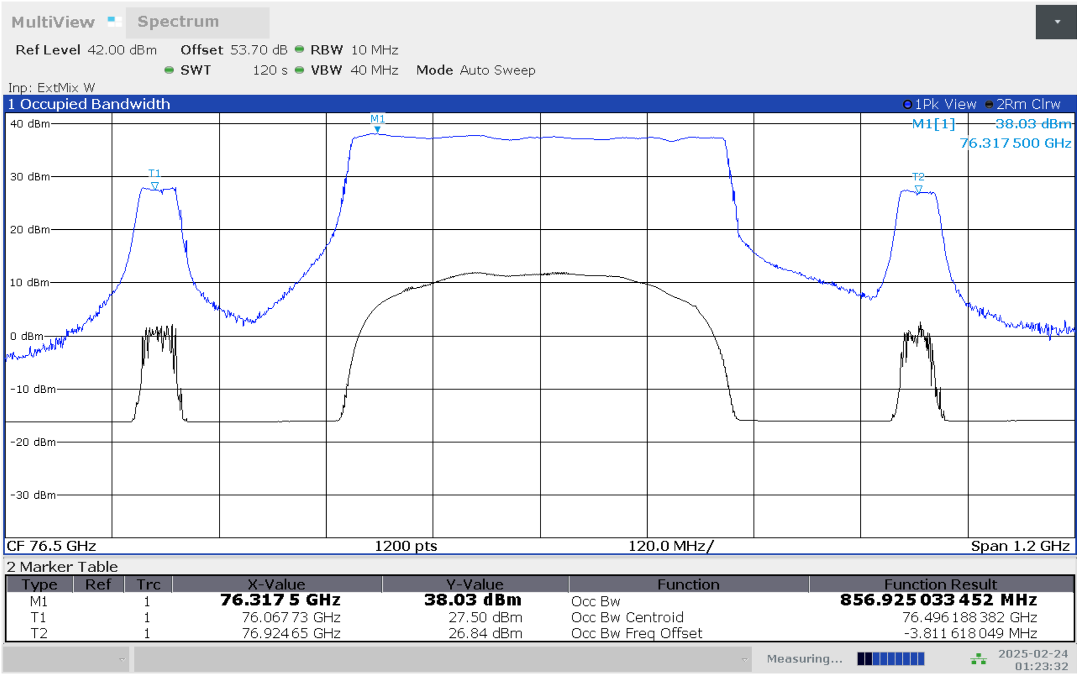
Plot no. 35: 99% OBW, Peak detector, 85 °C, DMP03



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**76.317 5 GHz**	**38.03 dBm**	Occ Bw	**856.925 033 452 MHz**
T1		1	76.067 73 GHz	27.50 dBm	Occ Bw Centroid	76.496 188 382 GHz
T2		1	76.924 65 GHz	26.84 dBm	Occ Bw Freq Offset	-3.811 618 049 MHz

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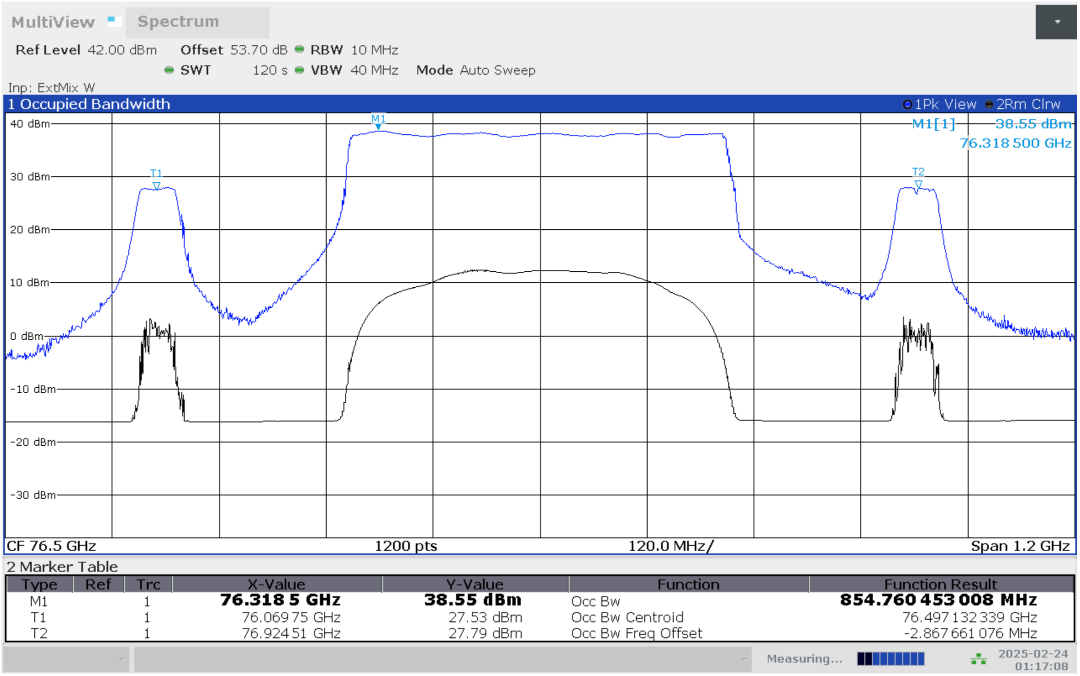
Plot no. 36: 99% OBW, Peak detector, 60 °C, DMP03



Type	Ref	Trc	X-Value	Y-Value	Function	Function Result
M1		1	**76.318 5 GHz**	**38.55 dBm**	Occ Bw	**854.760 453 008 MHz**
T1		1	76.069 75 GHz	27.53 dBm	Occ Bw Centroid	76.497 132 339 GHz
T2		1	76.924 51 GHz	27.79 dBm	Occ Bw Freq Offset	-2.867 661 076 MHz

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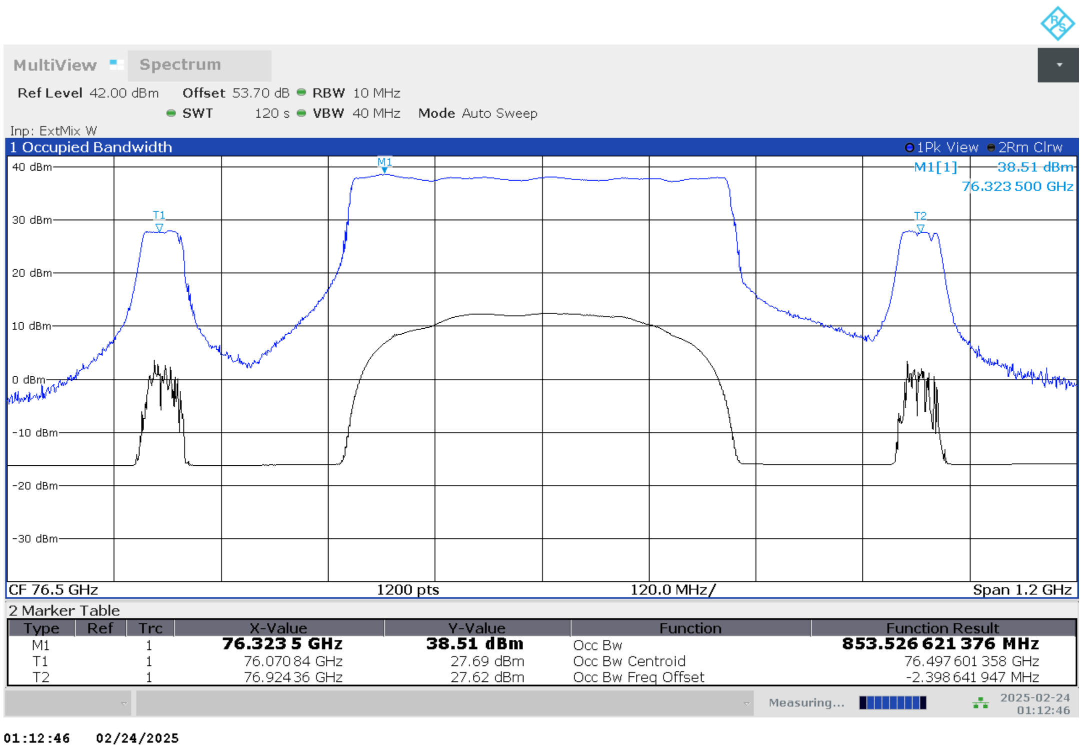
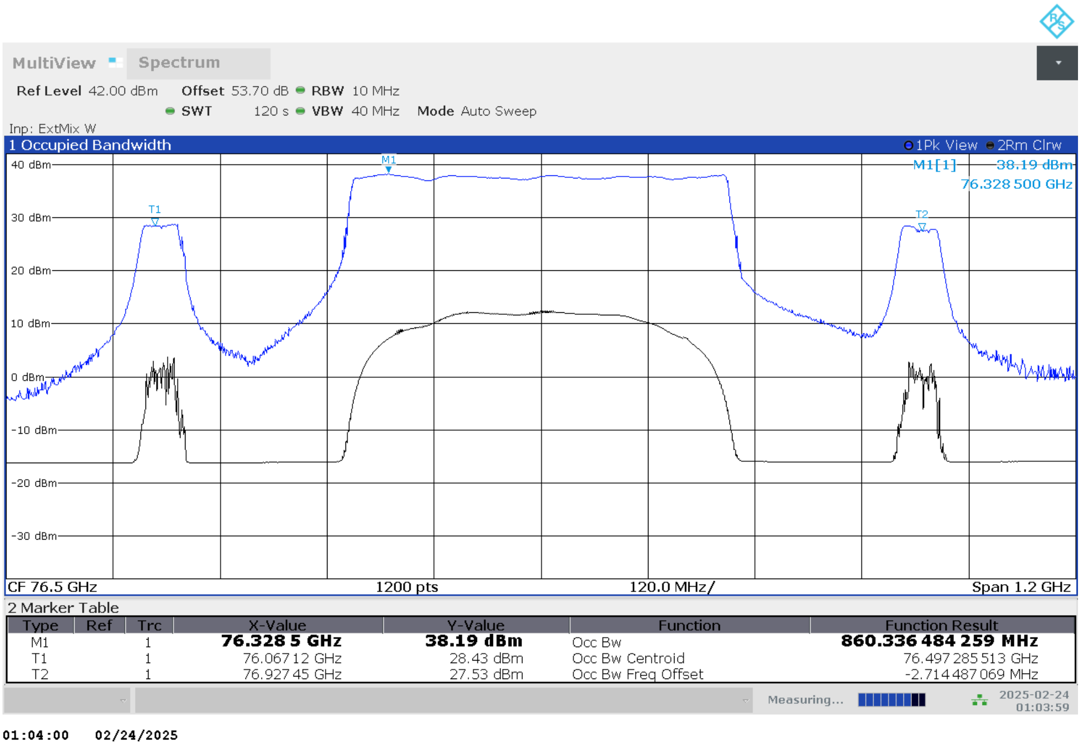
Plot no. 37: 99% OBW, Peak detector, 50 °C, DMP03

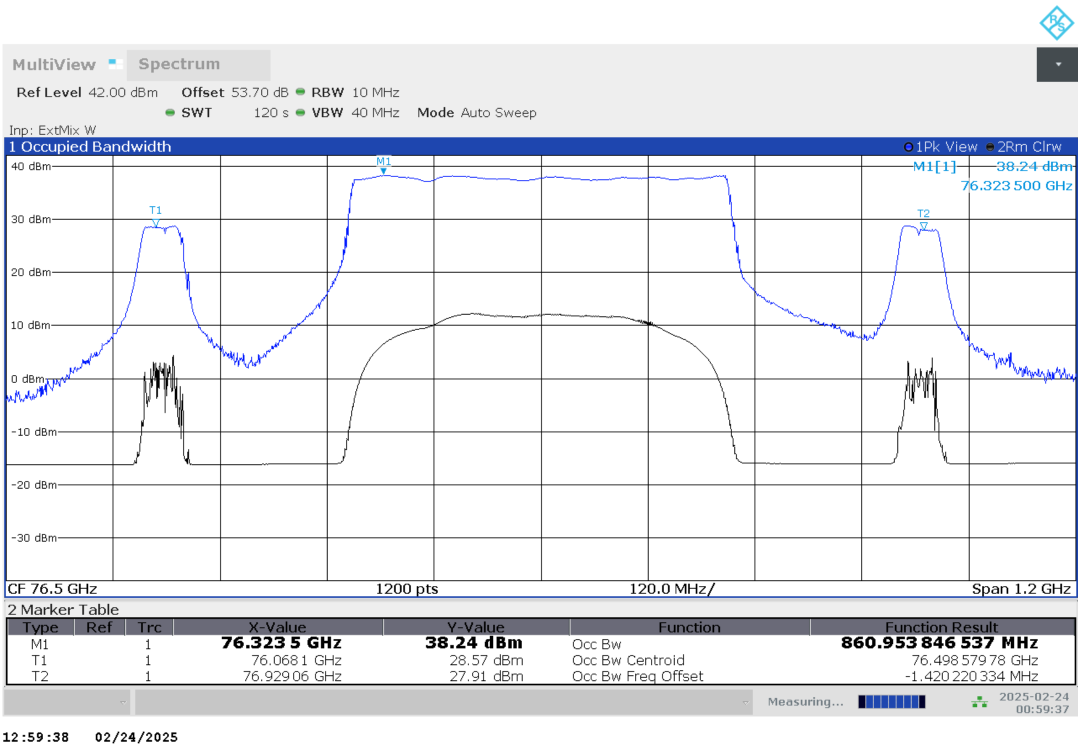


Plot no. 38: 99% OBW, Peak detector, 40 °C, DMP03

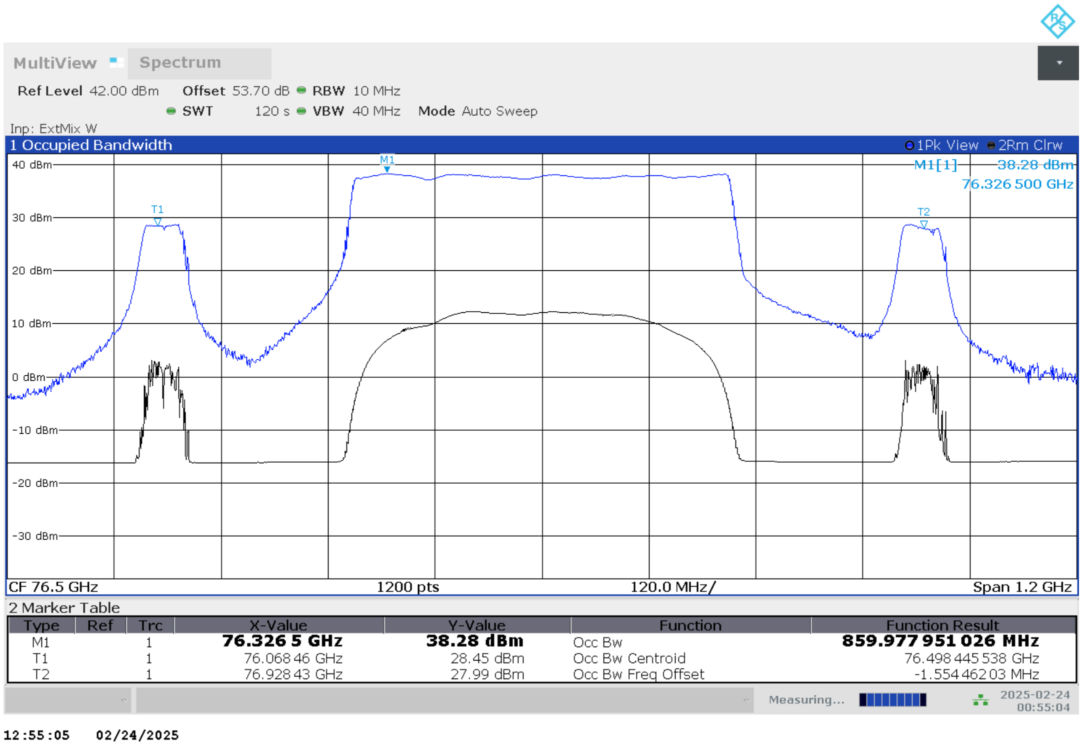
Plot no. 39: 99% OBW, Peak detector, 30 °C, DMP03



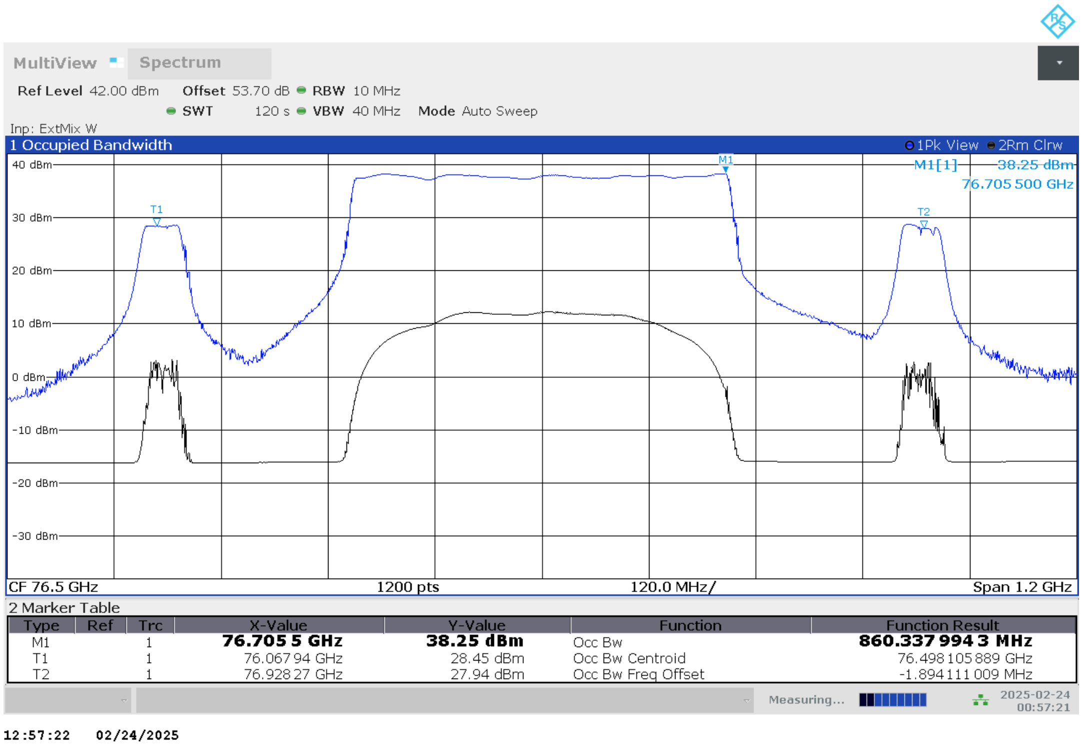
Plot no. 40: 99% OBW, Peak detector, 20 °C, V_{max}, DMP03



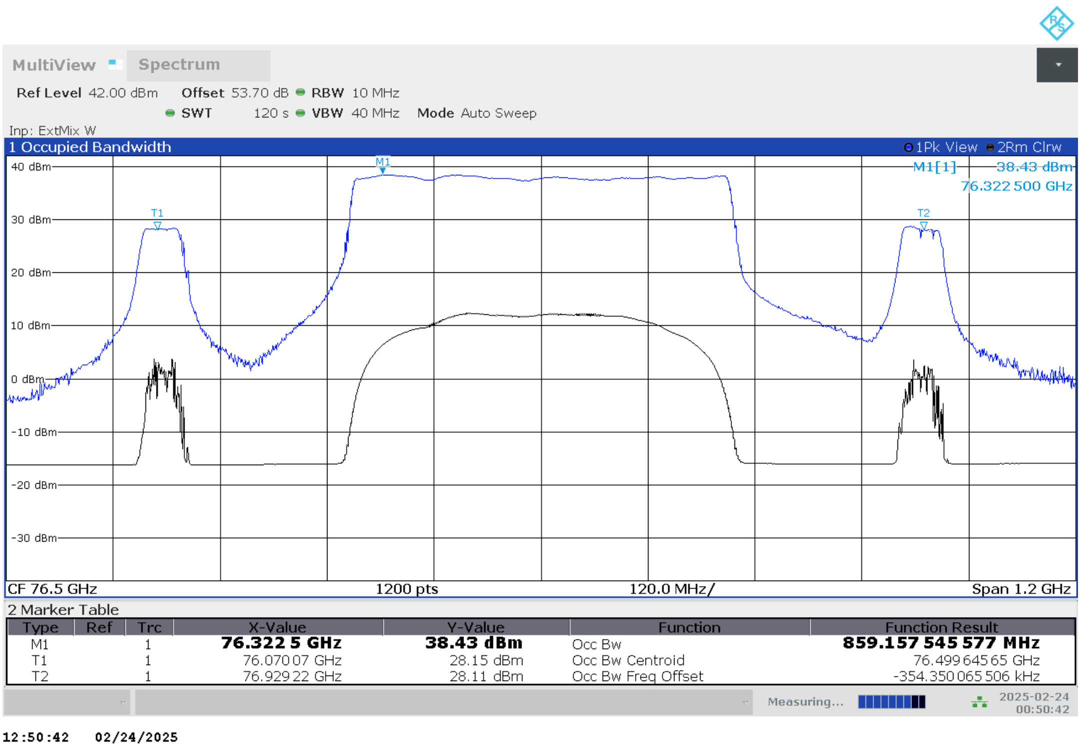
Plot no. 41: 99% OBW, Peak detector, 20 °C, V_{nom}, DMP03



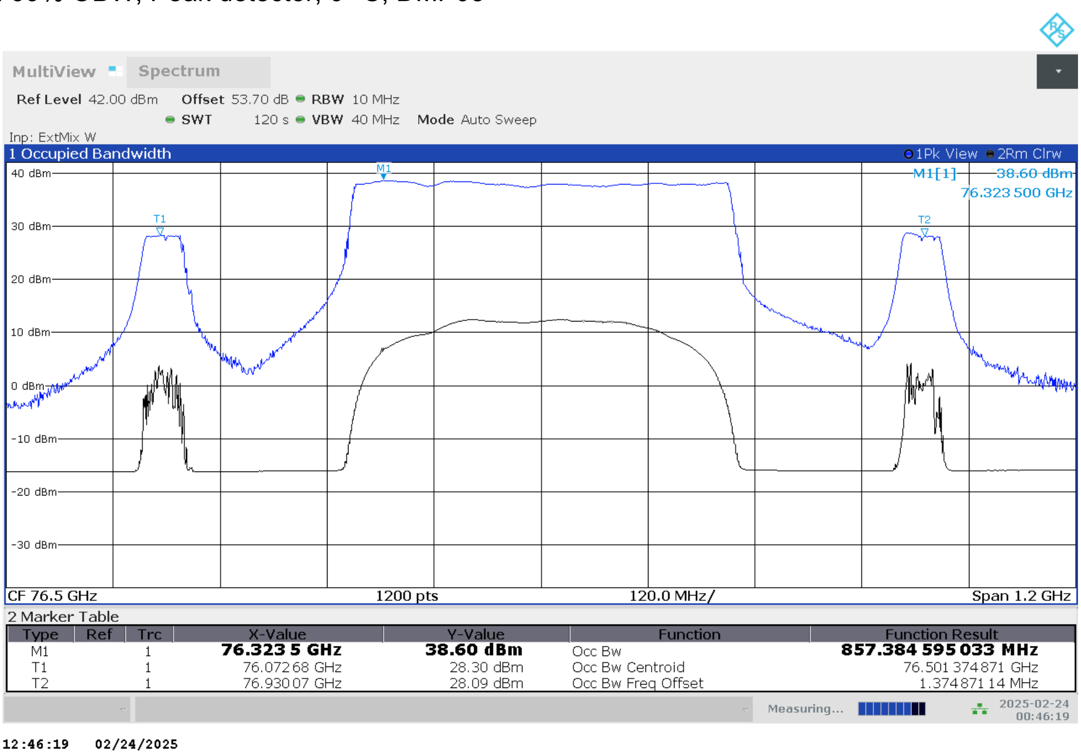
Plot no. 42: 99% OBW, Peak detector, 20 °C, V_{min}, DMP03



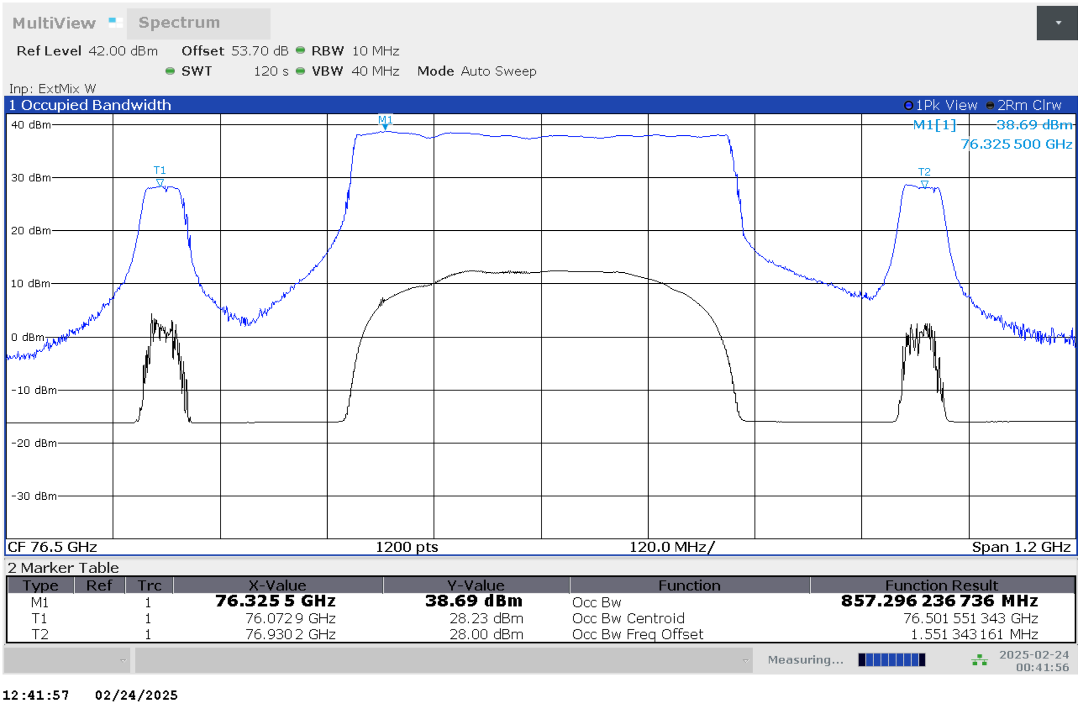
Plot no. 43: 99% OBW, Peak detector, 10 °C, DMP03



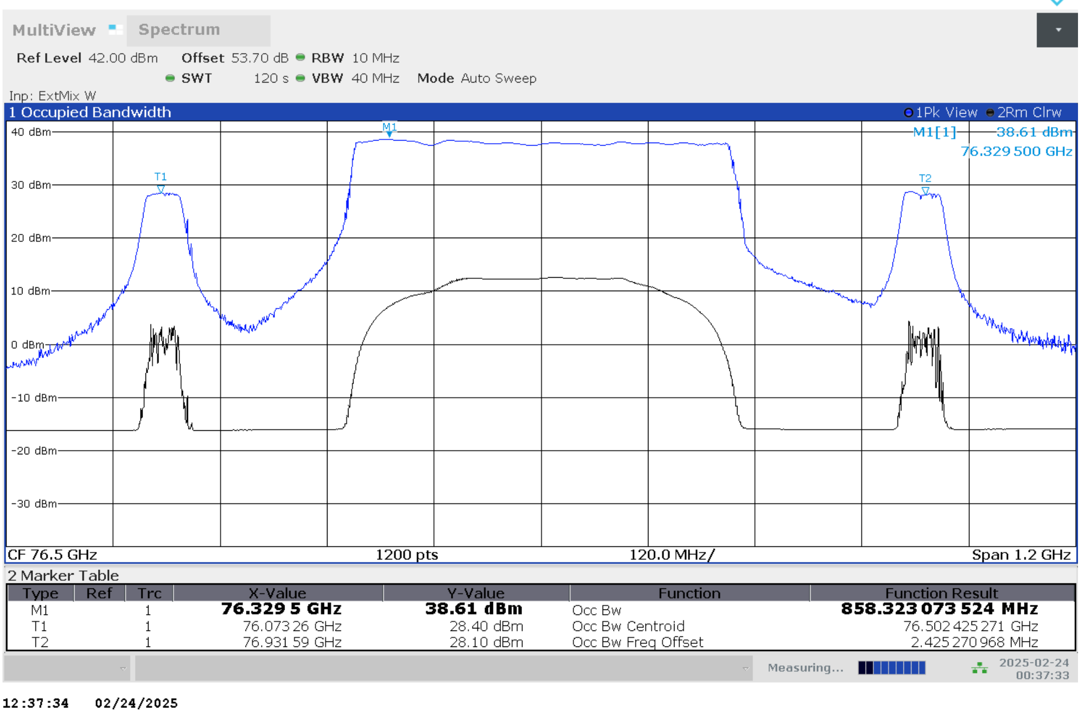
Plot no. 44: 99% OBW, Peak detector, 0 °C, DMP03



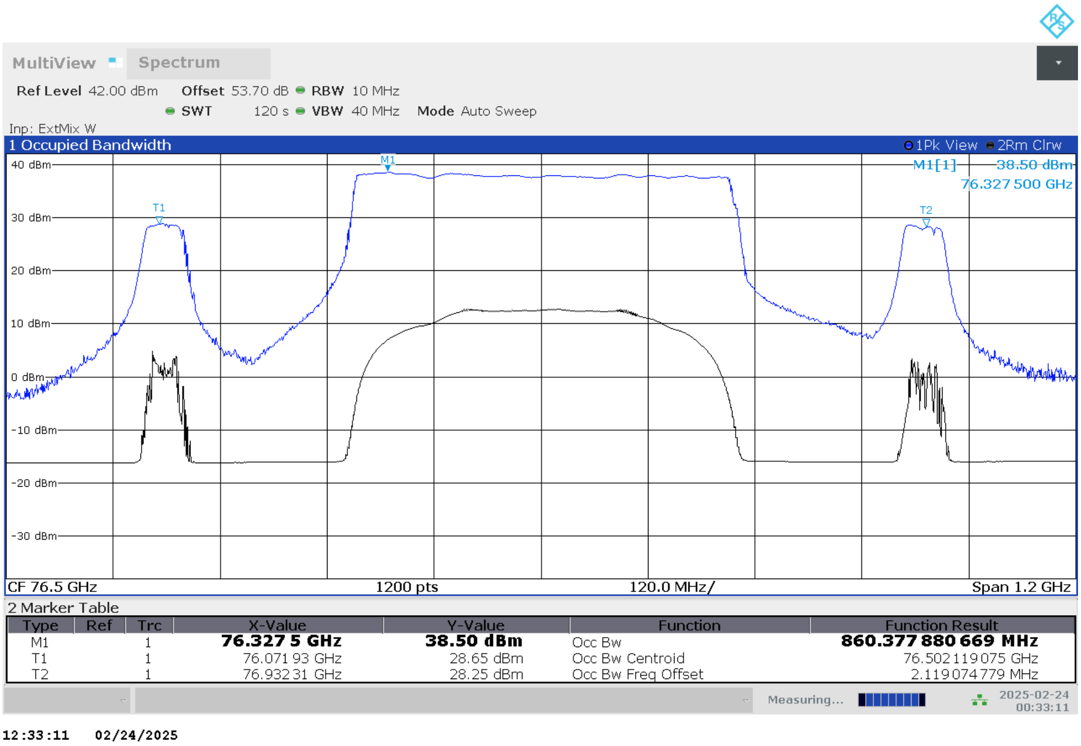
Plot no. 45: 99% OBW, Peak detector, -10 °C, DMP03



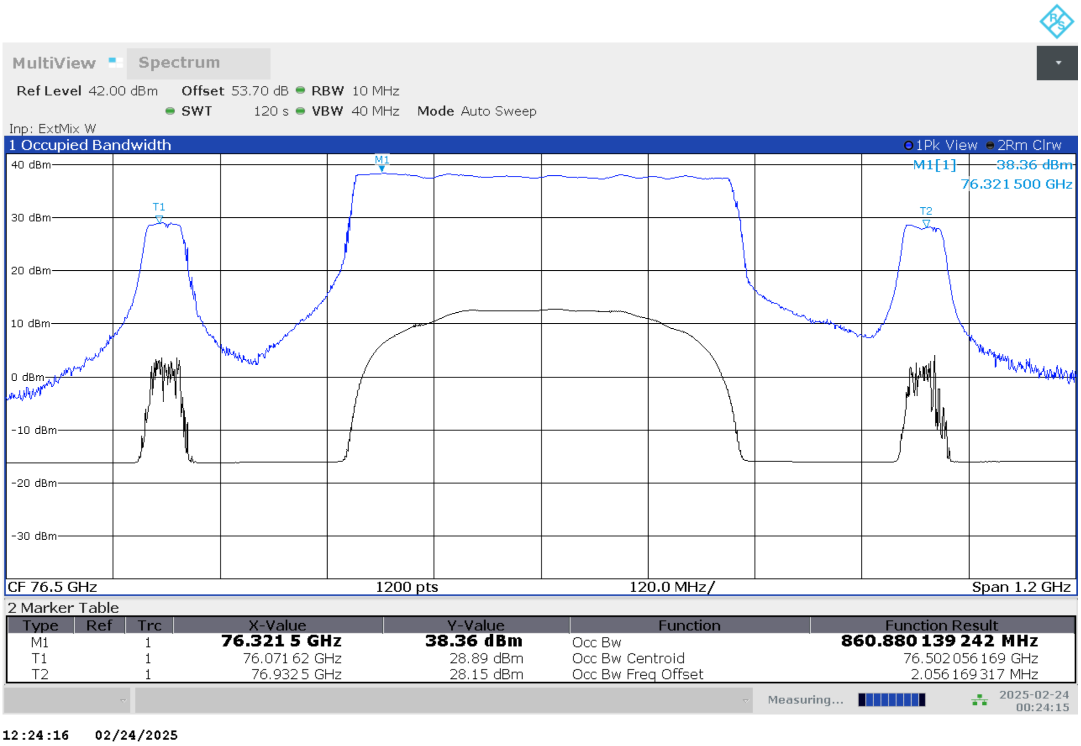
Plot no. 46: 99% OBW, Peak detector, -20 °C, DMP03



Plot no. 47: 99% OBW, Peak detector, -30 °C, DMP03



Plot no. 48: 99% OBW, Peak detector, -40 °C, DMP03



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/cm² → -1.7 dBm	3
200 – 243	1000 pW/cm² → +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 – 325 GHz:	1.00 m
In-band / OOB:	1.50 m

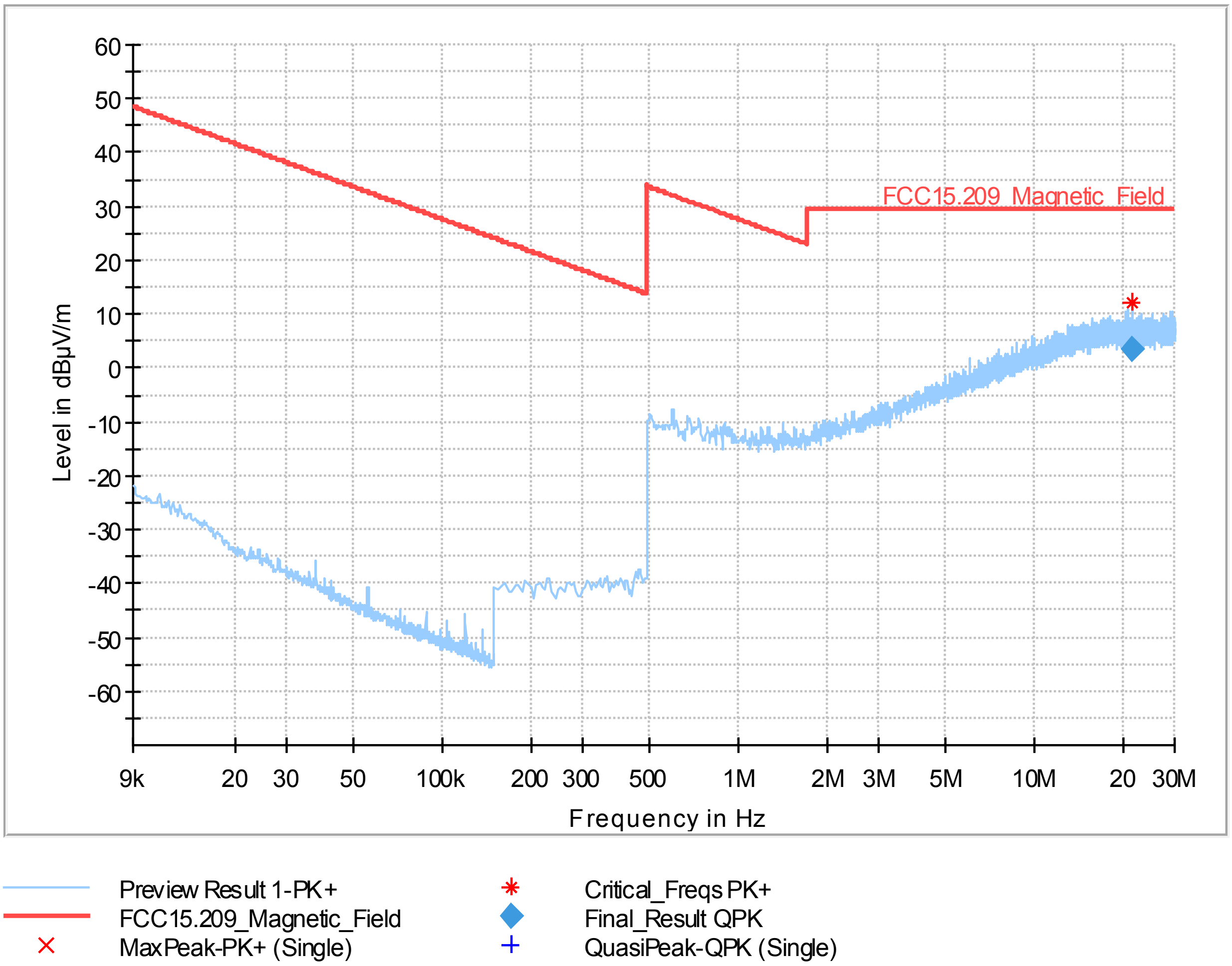
Test setup: 8.1 – 8.4 (in case of field strength measurements below 40 GHz: test distance correction factor of 20dB/decade is already considered in the plots / test result table)

Test results

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

Note:
LD = Limit Distance of 300m / 30m / 3m depending on frequency range, see limit table

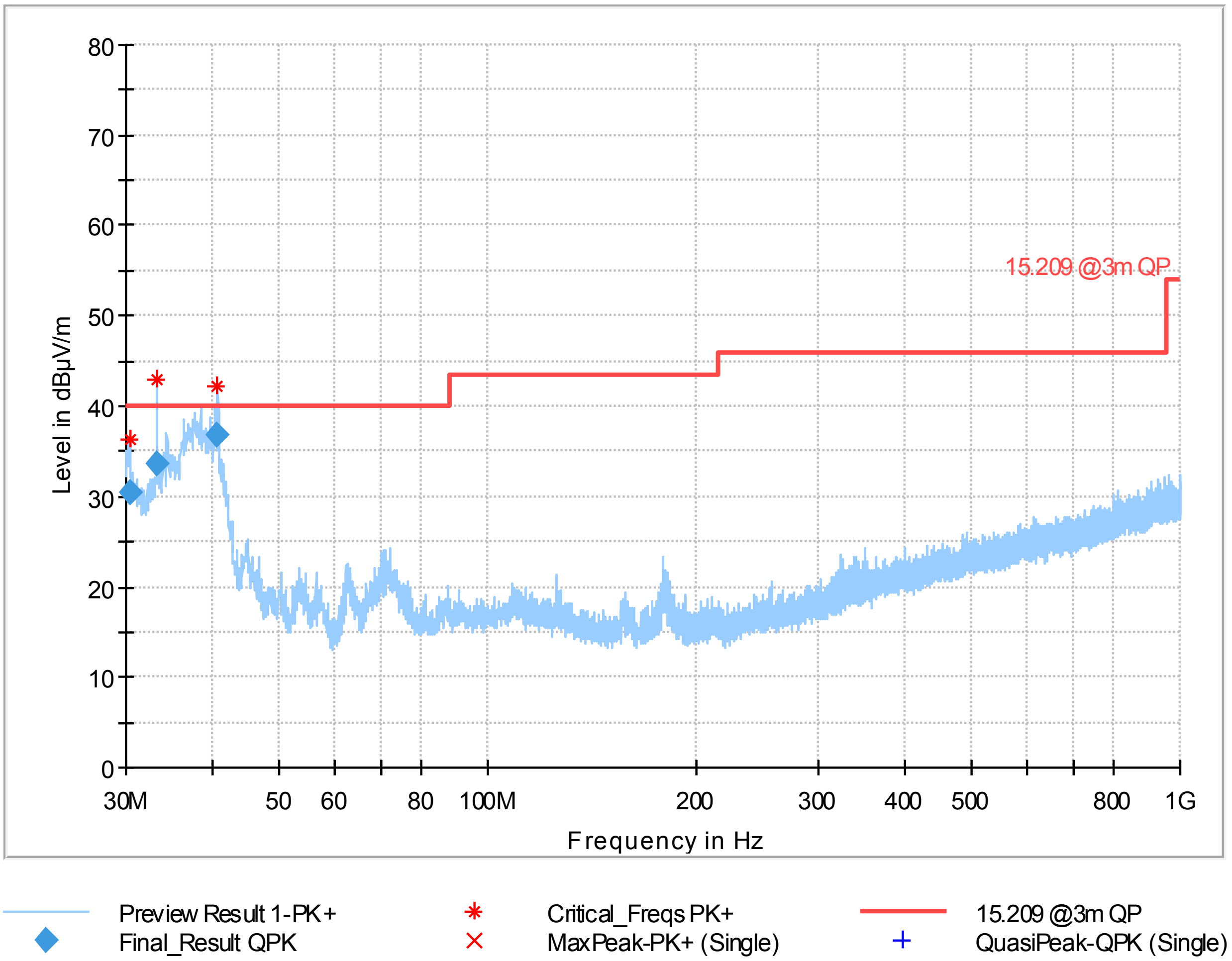
Plot no. 49: radiated emissions 9 kHz – 30 MHz, loop antenna polarization vertical / horizontal, DMP01



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
21.431955	3.51	29.54	26.03	100.0	9.000	V	238.0	0.6

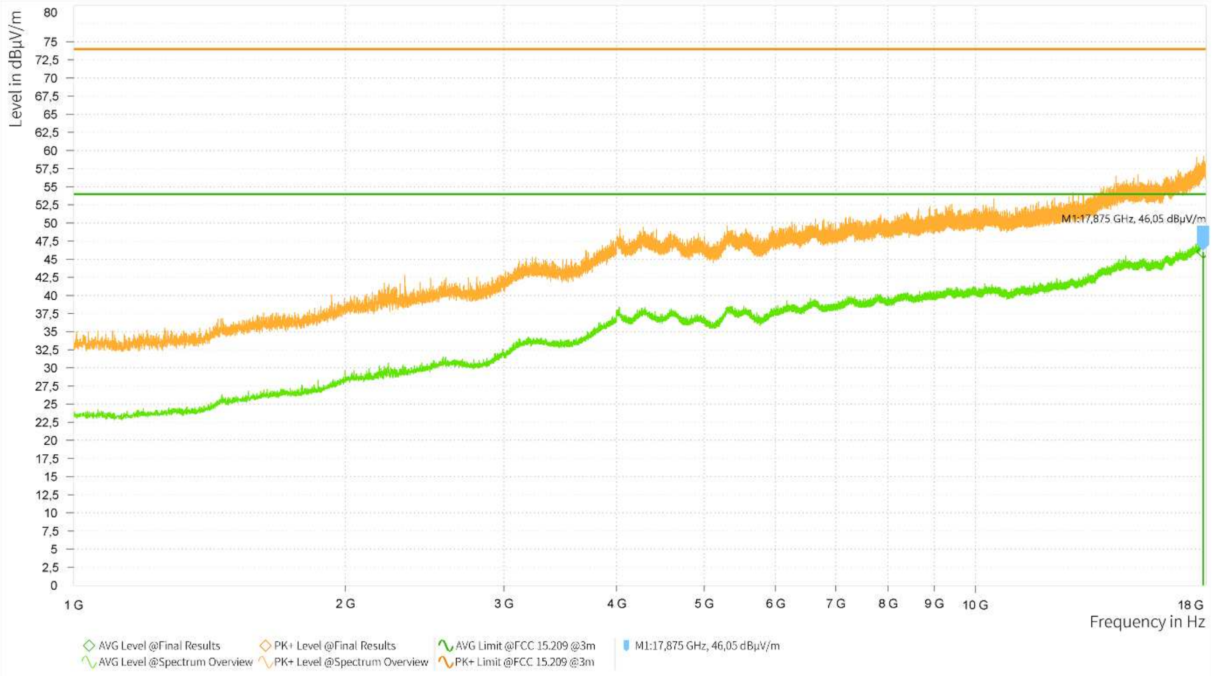
Plot no. 50: radiated emissions 30 MHz – 1 GHz, polarization vertical / horizontal, DMP01



Final_Result

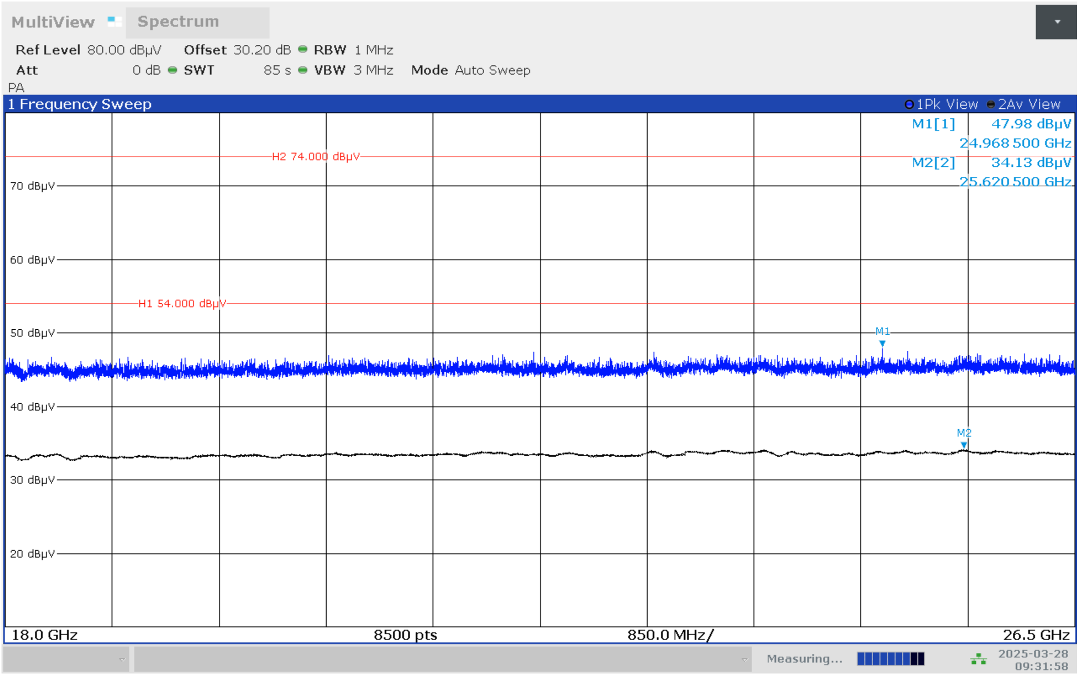
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.450000	30.32	40.00	9.68	100.0	120.000	103.0	V	204.0
33.328000	33.57	40.00	6.43	100.0	120.000	103.0	V	229.0
40.688500	36.84	40.00	3.16	100.0	120.000	103.0	V	51.0

Plot no. 51: radiated emissions 1 GHz – 18 GHz, polarization vertical / horizontal, DMP01



Rg	Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Elevation [deg]	Azimuth [deg]	Antenna Height [m]	Time of Meas.
1	17.875,375				46,05	54,00	7,95	44,14	75	40,7	1,50	16:05:56
1	17.901,350				46,03	54,00	7,97	44,20	105	191,9	1,50	16:07:22

Plot no. 52: radiated emissions 18 GHz – 26.5 GHz, polarization vertical / horizontal, DMP01



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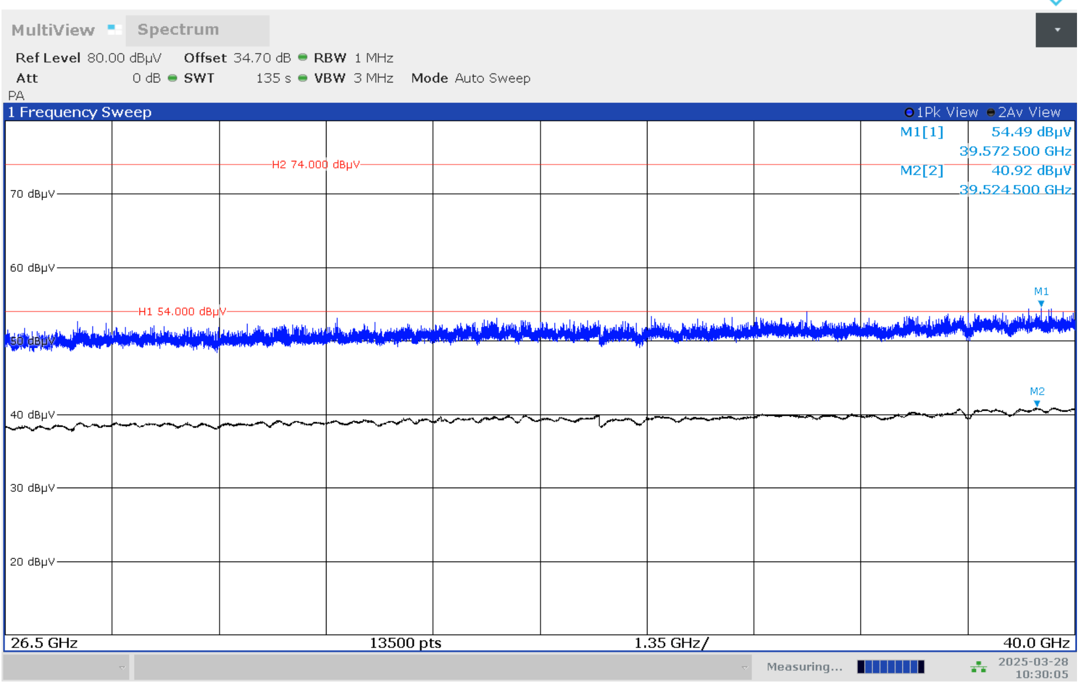
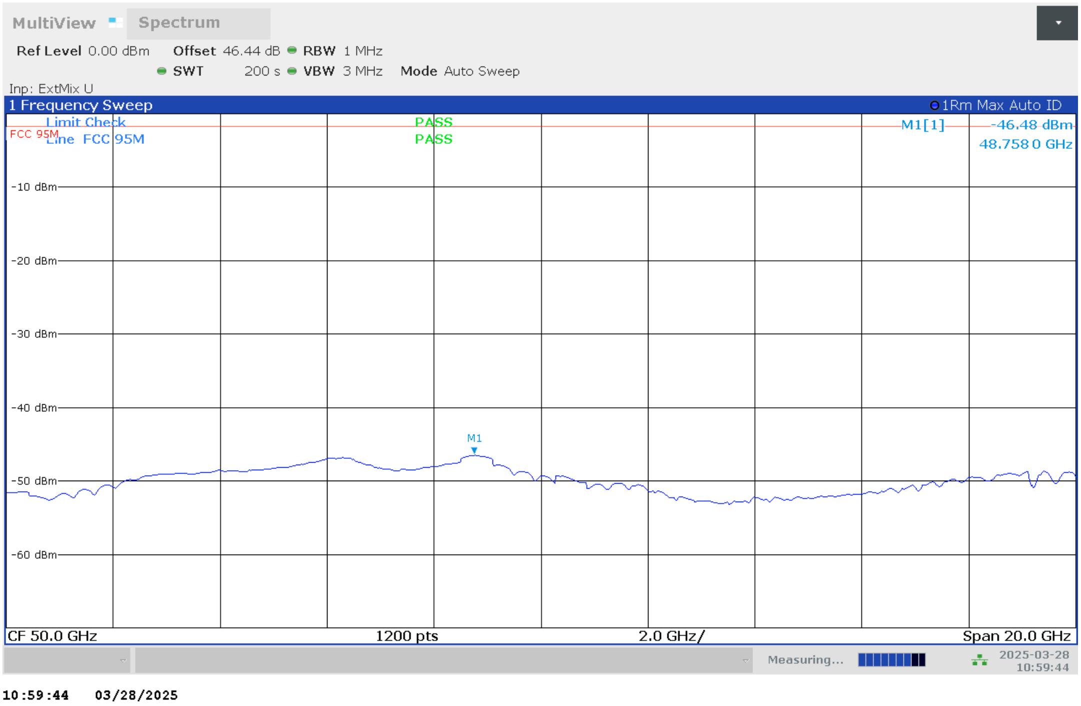
Plot no. 53: radiated emissions 26.5 GHz – 40 GHz, polarization vertical / horizontal, DMP01

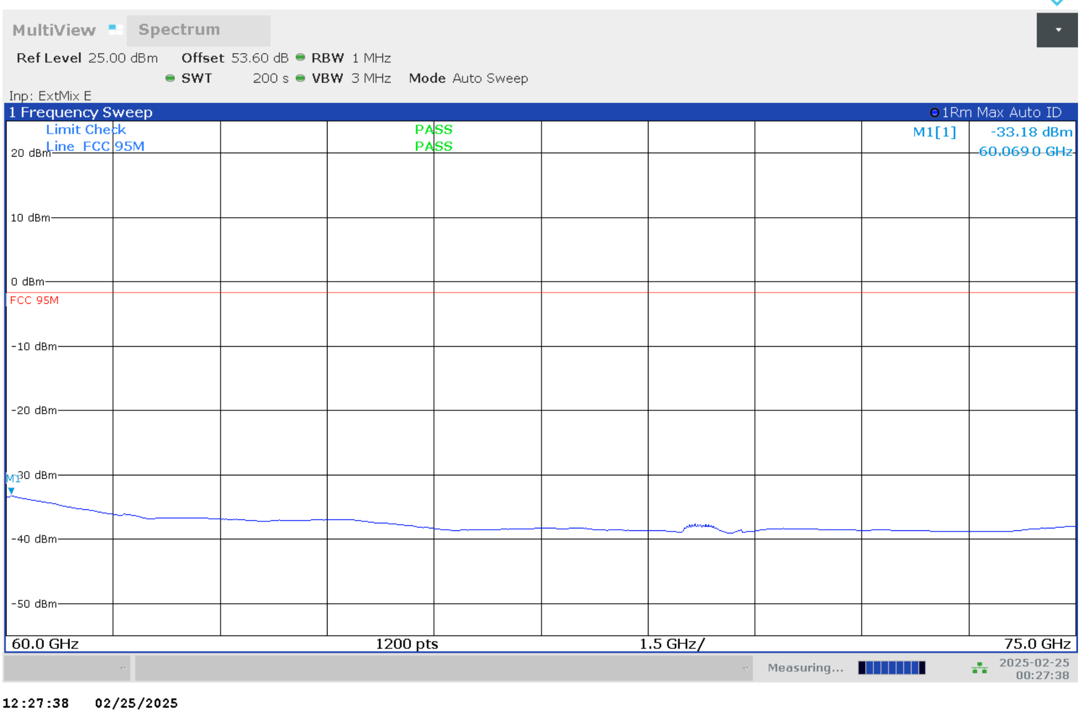


10:30:06 03/28/2025

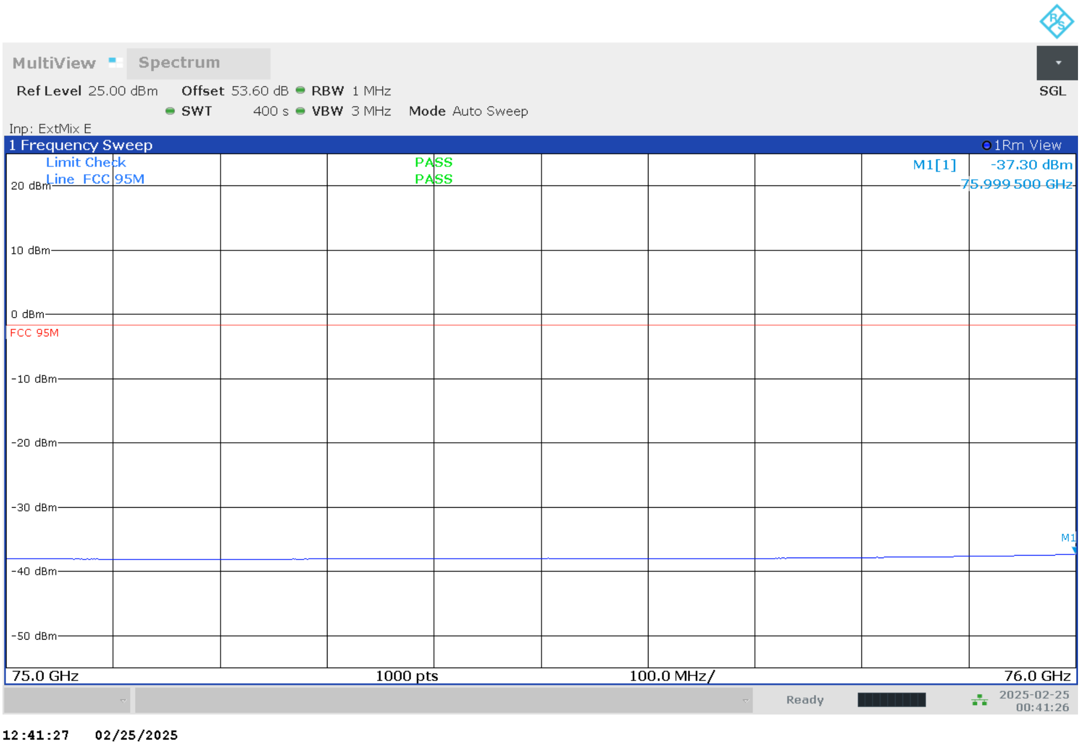
Plot no. 54: radiated emissions 40 GHz – 60 GHz, polarization vertical / horizontal, DMP01



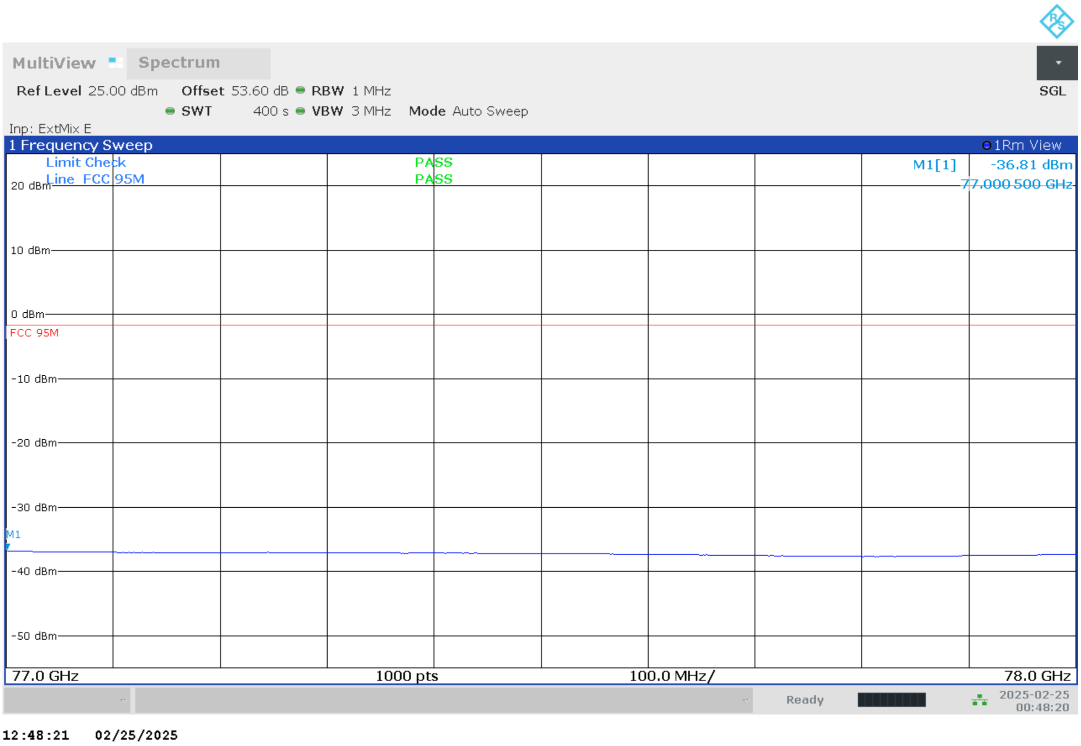
Plot no. 55: radiated emissions 60 GHz – 75 GHz, polarization vertical / horizontal, DMP01



Plot no. 56: radiated emissions 75.0 GHz – 76.0 GHz, band edge, DMP01

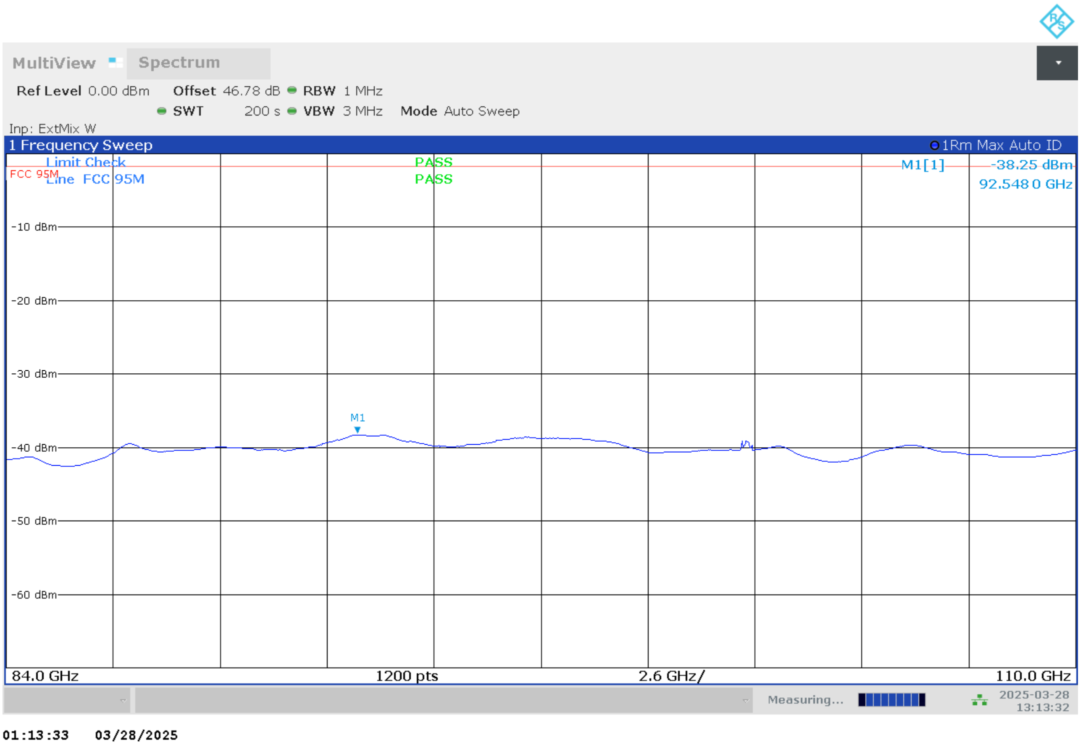


Plot no. 57: radiated emissions 77 GHz – 78 GHz, polarization vertical / horizontal, DMP01

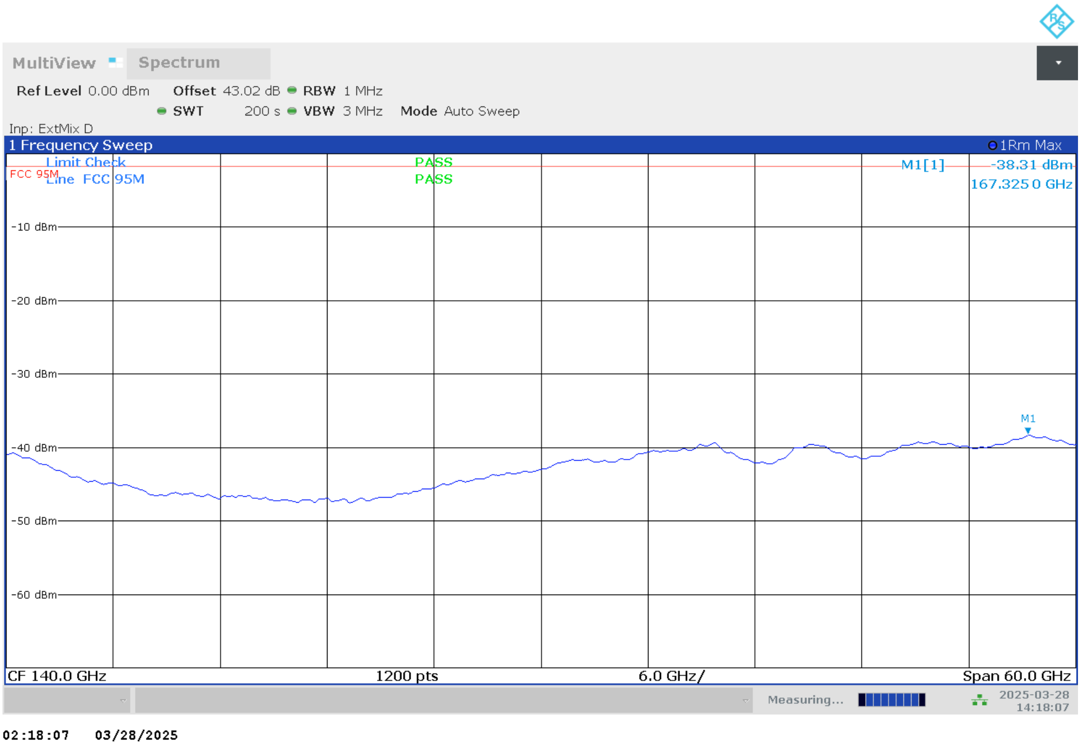


Plot no. 58: radiated emissions 78 GHz – 84 GHz, polarization vertical / horizontal, DMP01

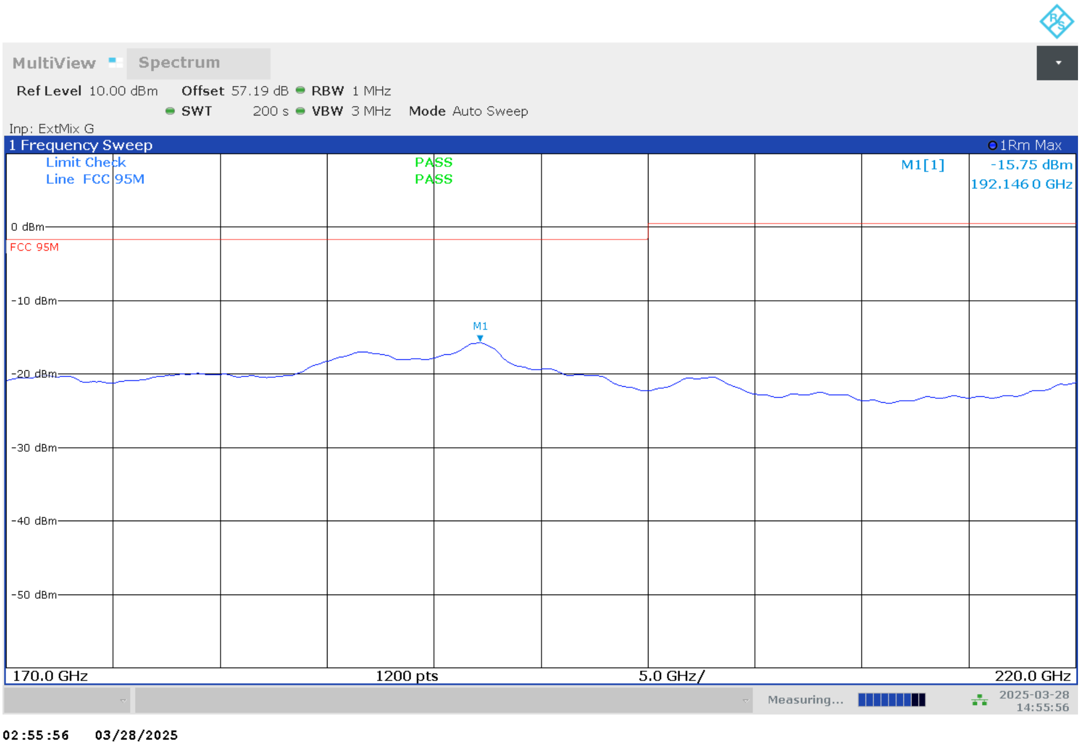
Plot no. 59: radiated emissions 84 GHz – 110 GHz, polarization vertical / horizontal, DMP01



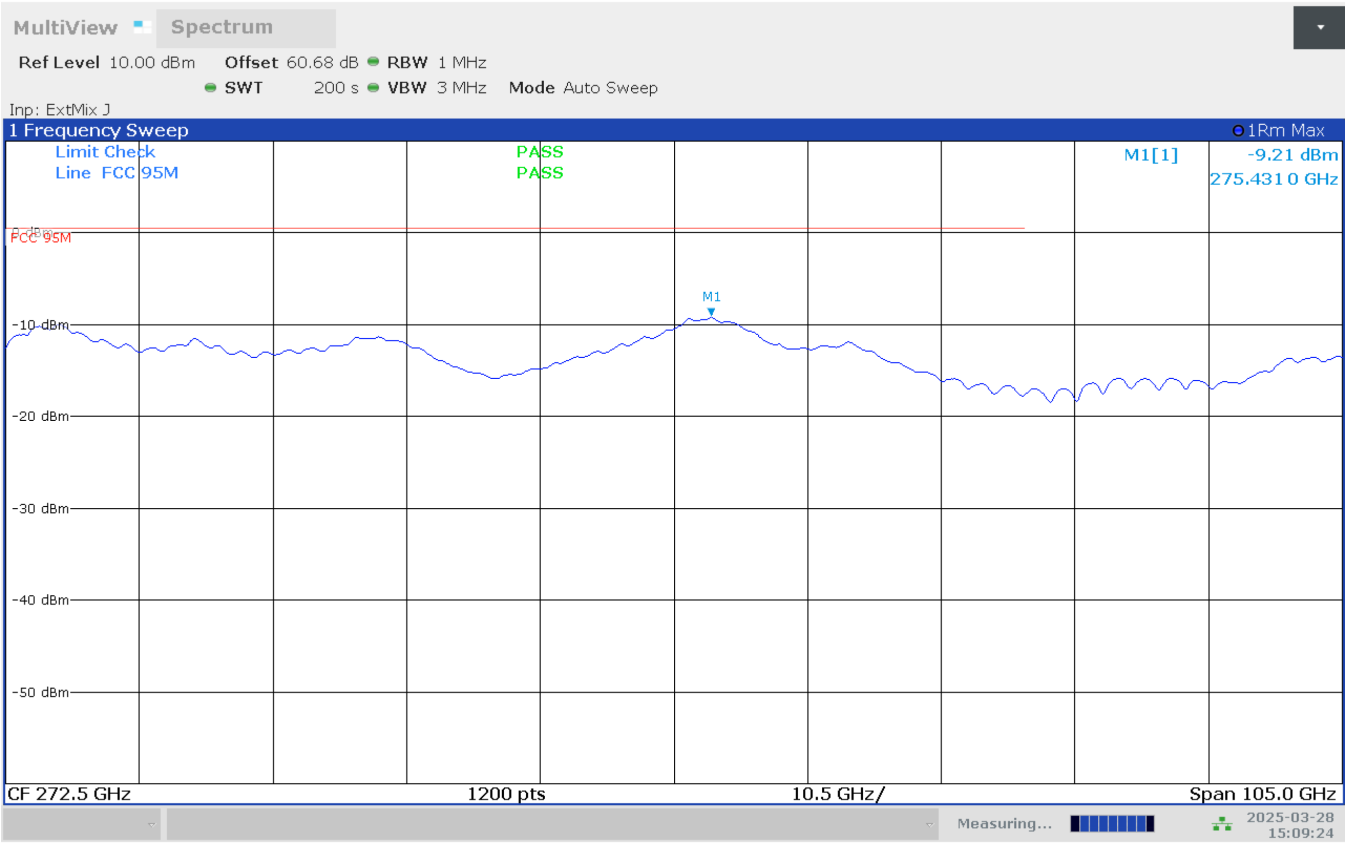
Plot no. 60: radiated emissions 110 GHz – 170 GHz, polarization vertical / horizontal, DMP01



Plot no. 61: radiated emissions 170 GHz – 220 GHz, polarization vertical / horizontal, DMP01

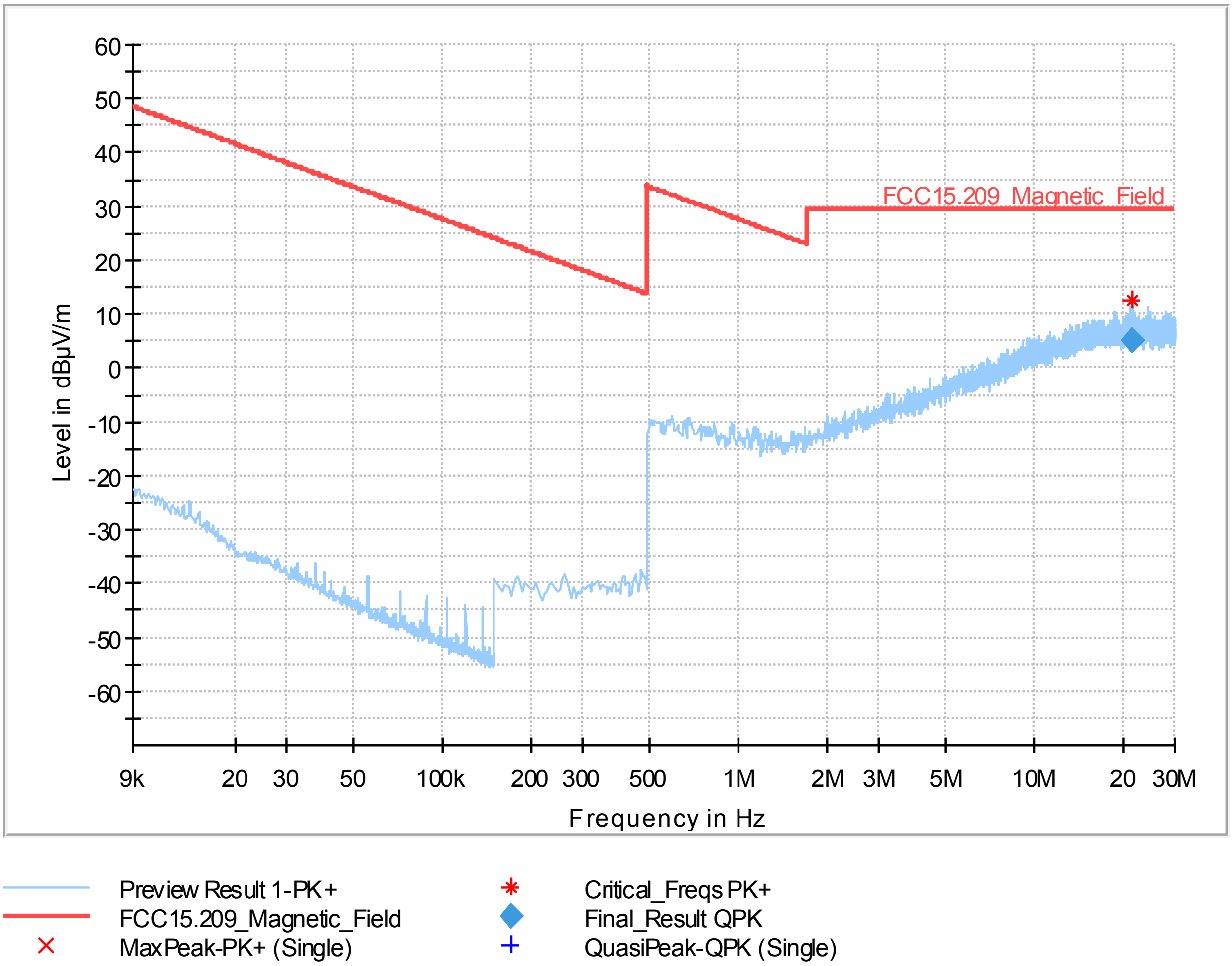


Plot no. 62: radiated emissions 220 GHz – 325 GHz, polarization vertical / horizontal, DMP01



03:09:25 03/28/2025

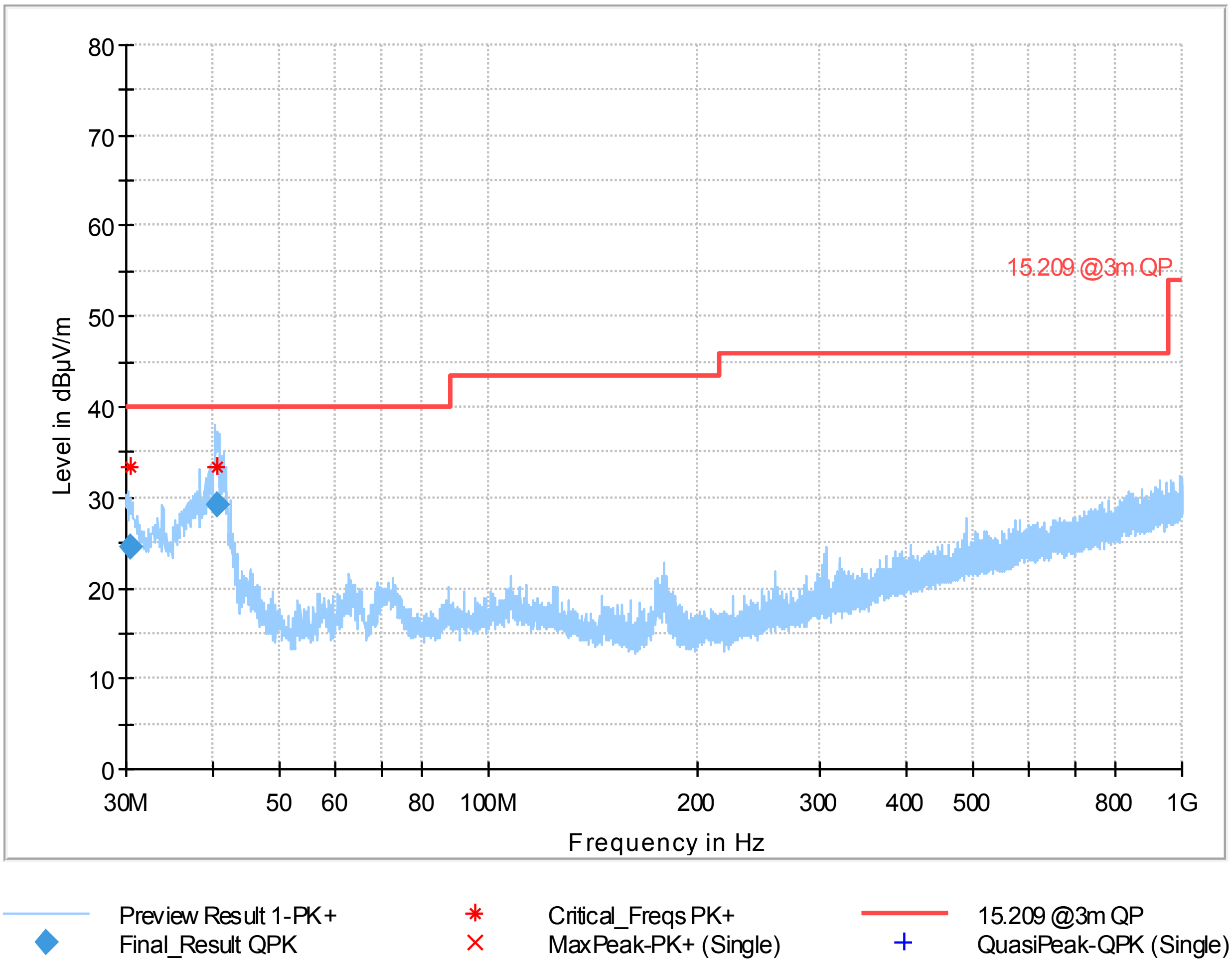
Plot no. 63: radiated emissions 9 kHz – 30 MHz, loop antenna polarization vertical / horizontal, DMP02



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
21.612864	5.31	29.54	24.23	100.0	9.000	V	257.0	0.6

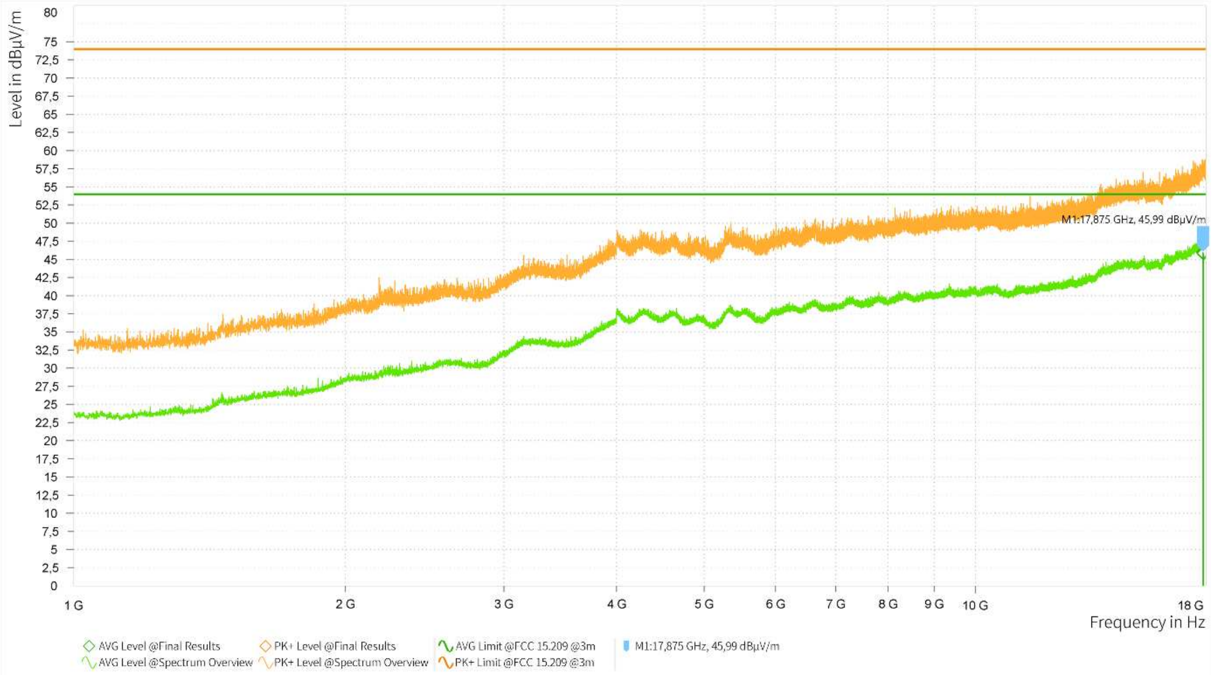
Plot no. 64: radiated emissions 30 MHz – 1 GHz, polarization vertical / horizontal, DMP02



Final_Result

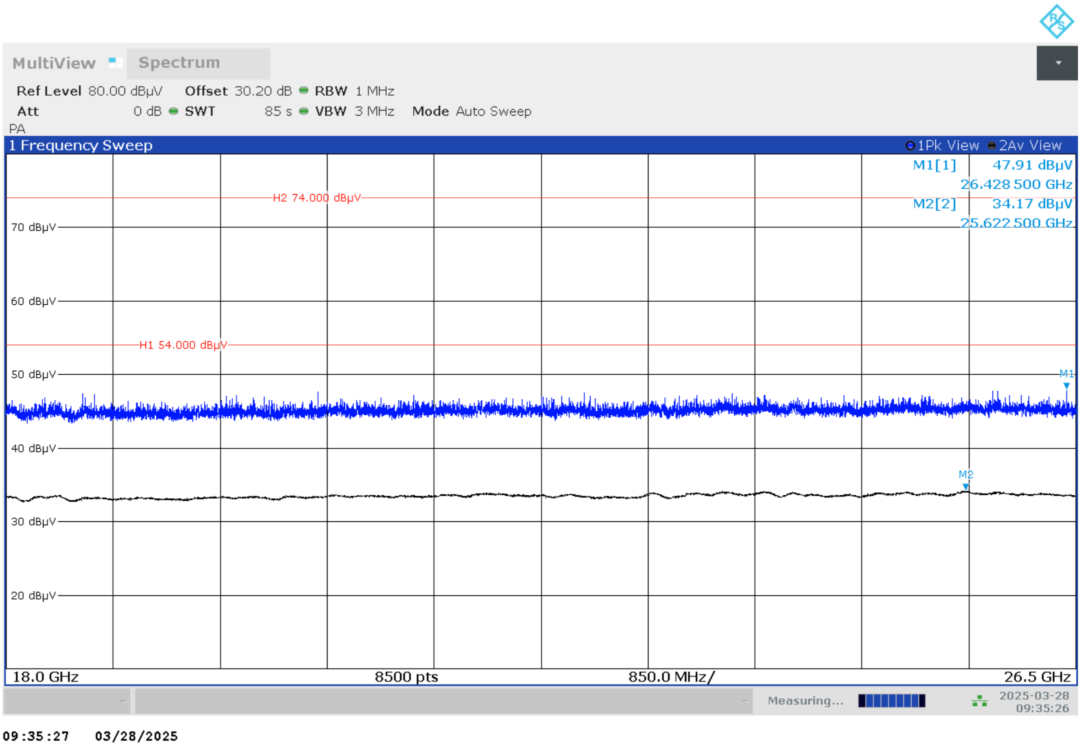
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.480000	24.43	40.00	15.57	100.0	120.000	365.0	V	68.0
40.469000	29.20	40.00	10.80	100.0	120.000	100.0	V	18.0

Plot no. 65: radiated emissions 1 GHz – 18 GHz, polarization vertical / horizontal, DMP02

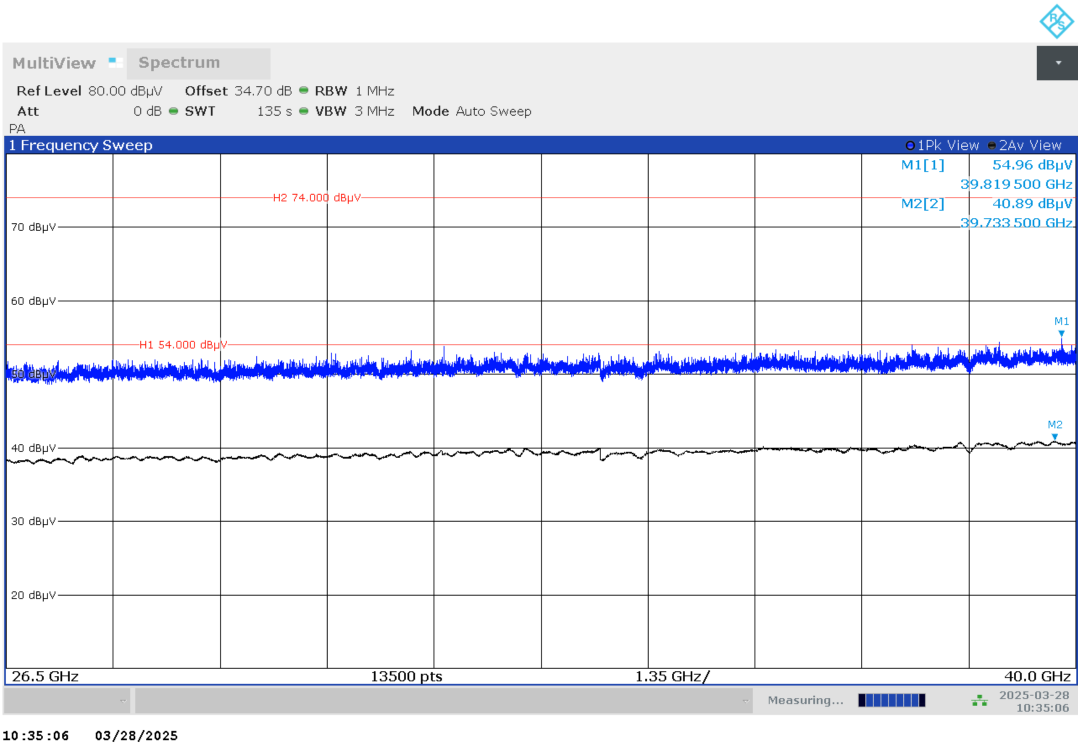


Rg	Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Elevation [deg]	Azimuth [deg]	Antenna Height [m]	Time of Meas.
1	17.875,450				45,99	54,00	8,01	44,14	81	353,6	1,50	15:35:30
1	17.900,575				45,83	54,00	8,17	44,20	80,1	391,9	1,50	15:36:47

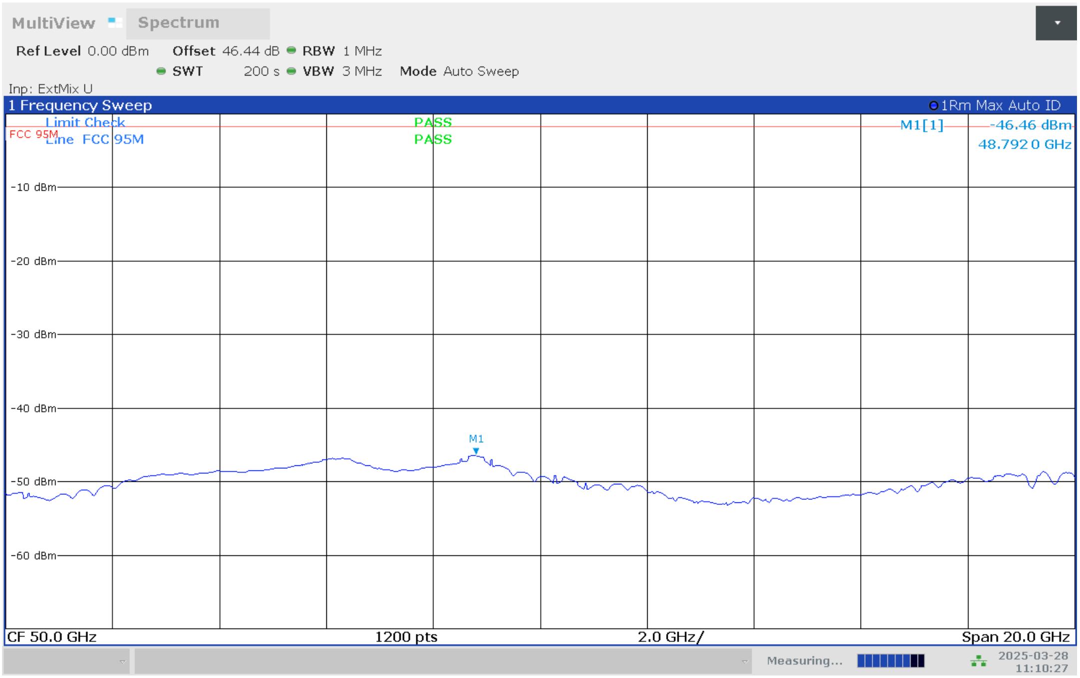
Plot no. 66: radiated emissions 18 GHz – 26.5 GHz, polarization vertical / horizontal, DMP02



Plot no. 67: radiated emissions 26.5 GHz – 40 GHz, polarization vertical / horizontal, DMP02

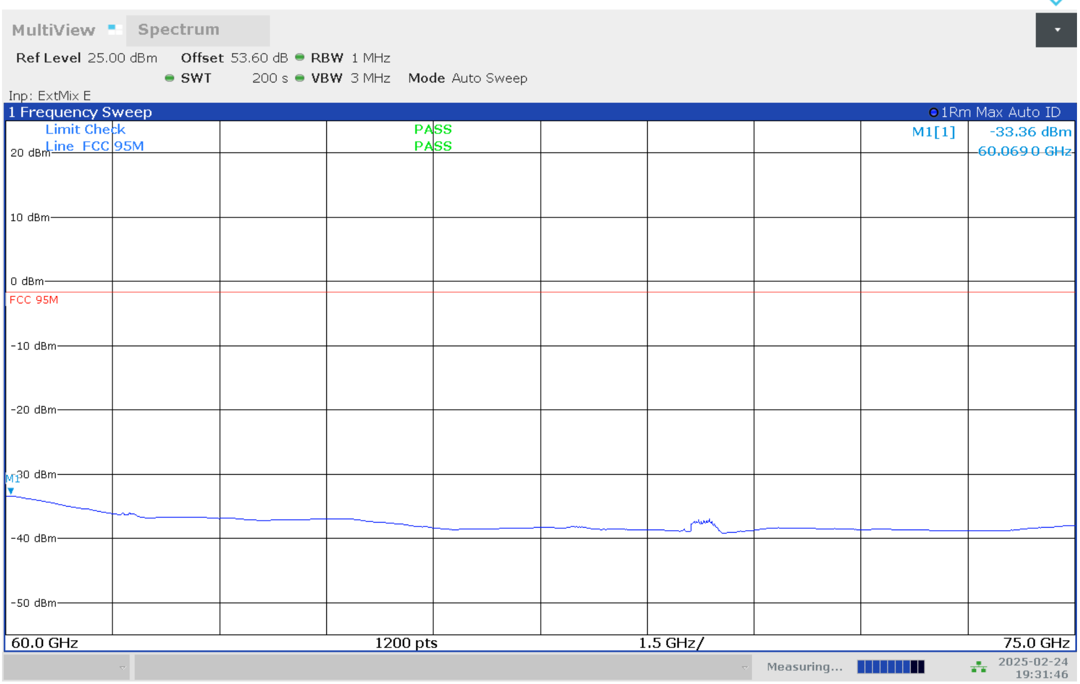


Plot no. 68: radiated emissions 40 GHz – 60 GHz, polarization vertical / horizontal, DMP02



11:10:27 03/28/2025

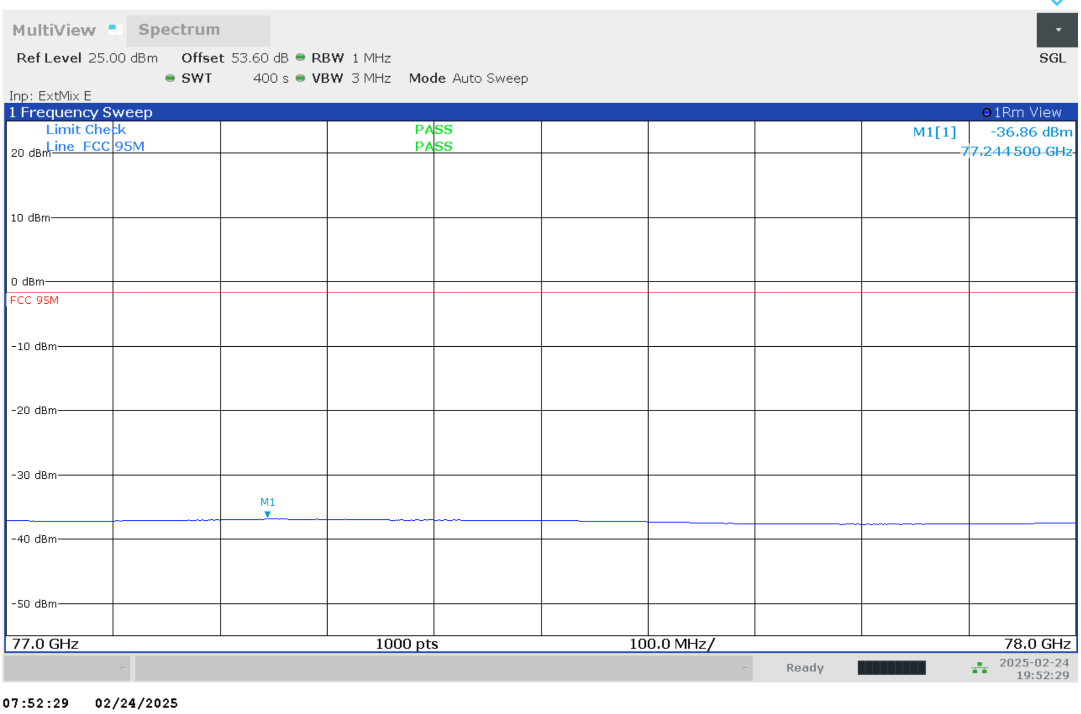
Plot no. 69: radiated emissions 60 GHz – 75 GHz, polarization vertical / horizontal, DMP02



07:31:47 02/24/2025

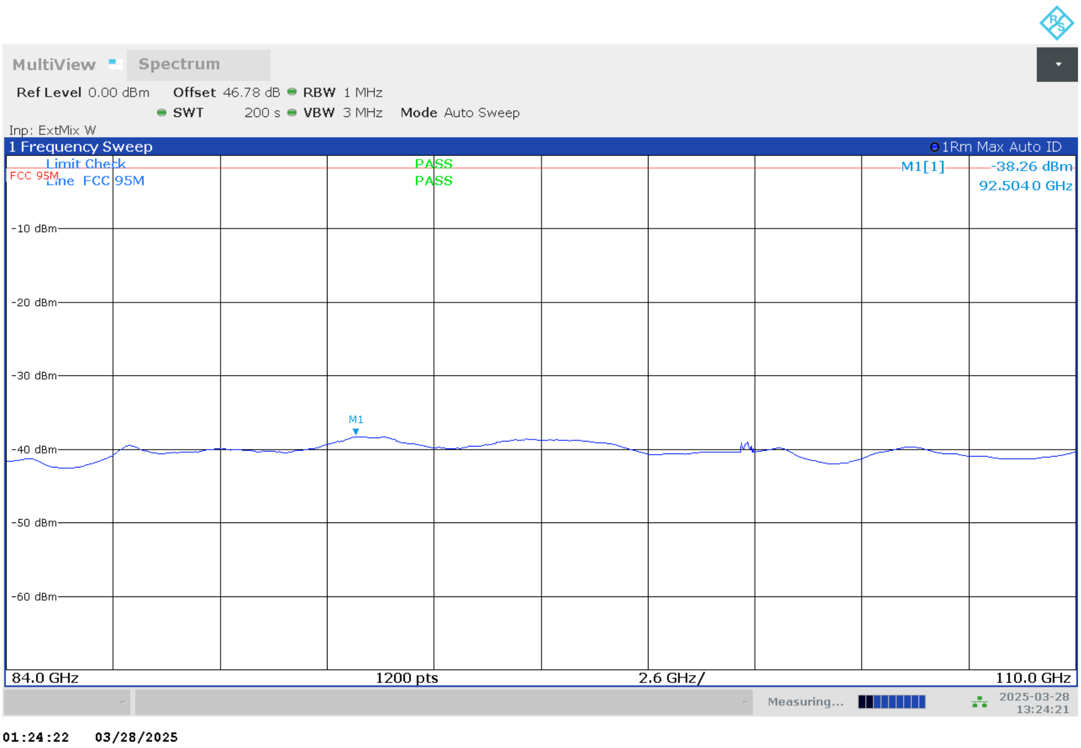
Plot no. 70: radiated emissions 75 GHz – 76GHz, band edge, DMP02

Plot no. 71: radiated emissions 77 GHz – 78 GHz, polarization vertical / horizontal, DMP02

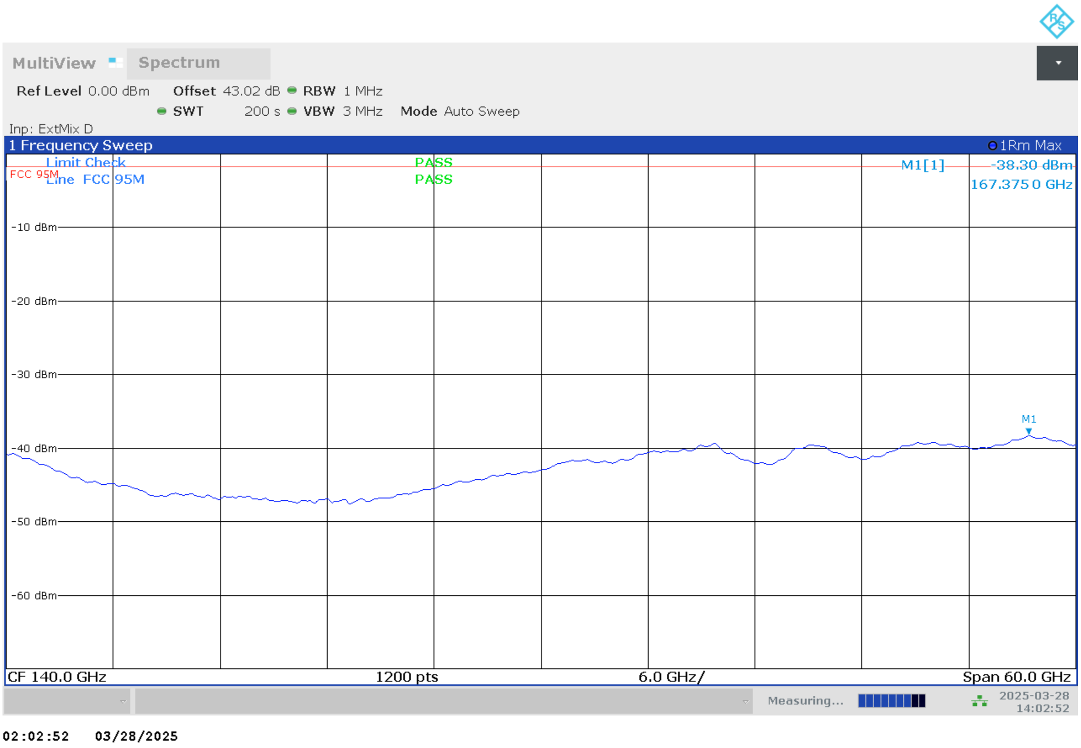


Plot no. 72: radiated emissions 78 GHz – 84 GHz, polarization vertical / horizontal, DMP02

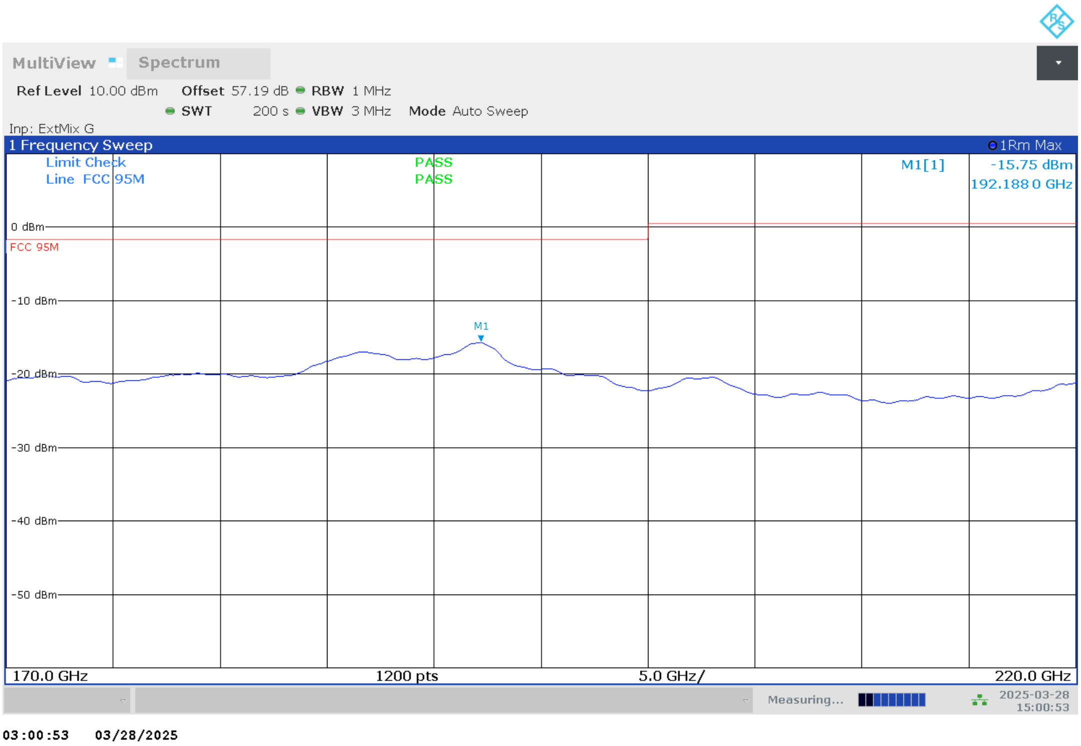
Plot no. 73: radiated emissions 84 GHz – 110 GHz, polarization vertical / horizontal, DMP02



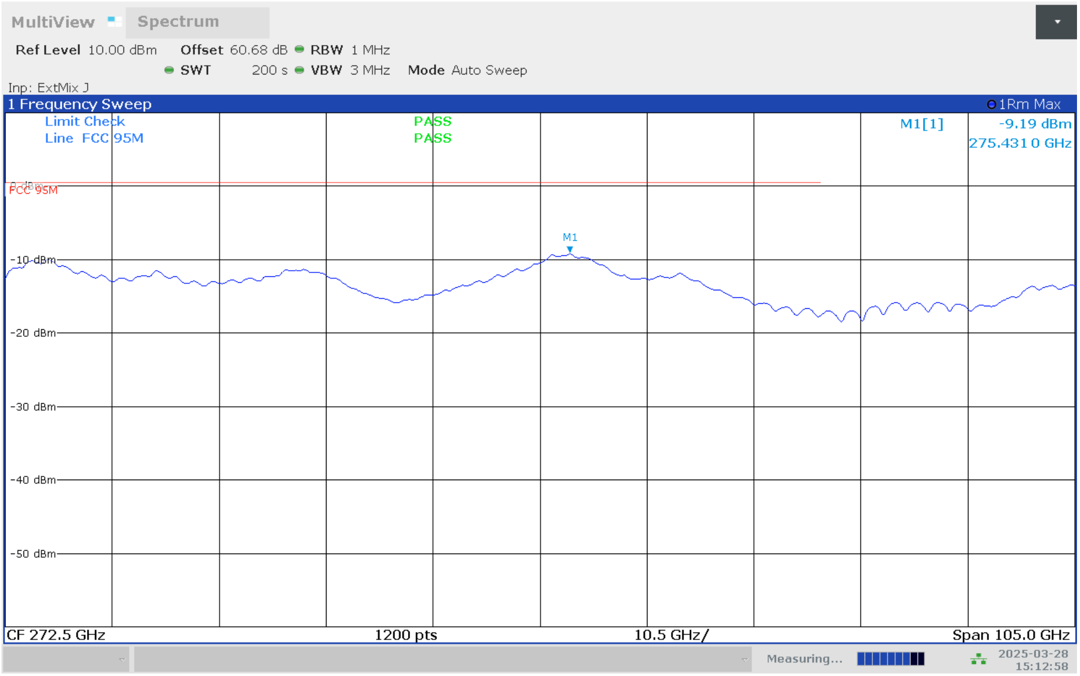
Plot no. 74: radiated emissions 110 GHz – 170 GHz, polarization vertical / horizontal, DMP02



Plot no. 75: radiated emissions 170 GHz – 220 GHz, polarization vertical / horizontal, DMP02

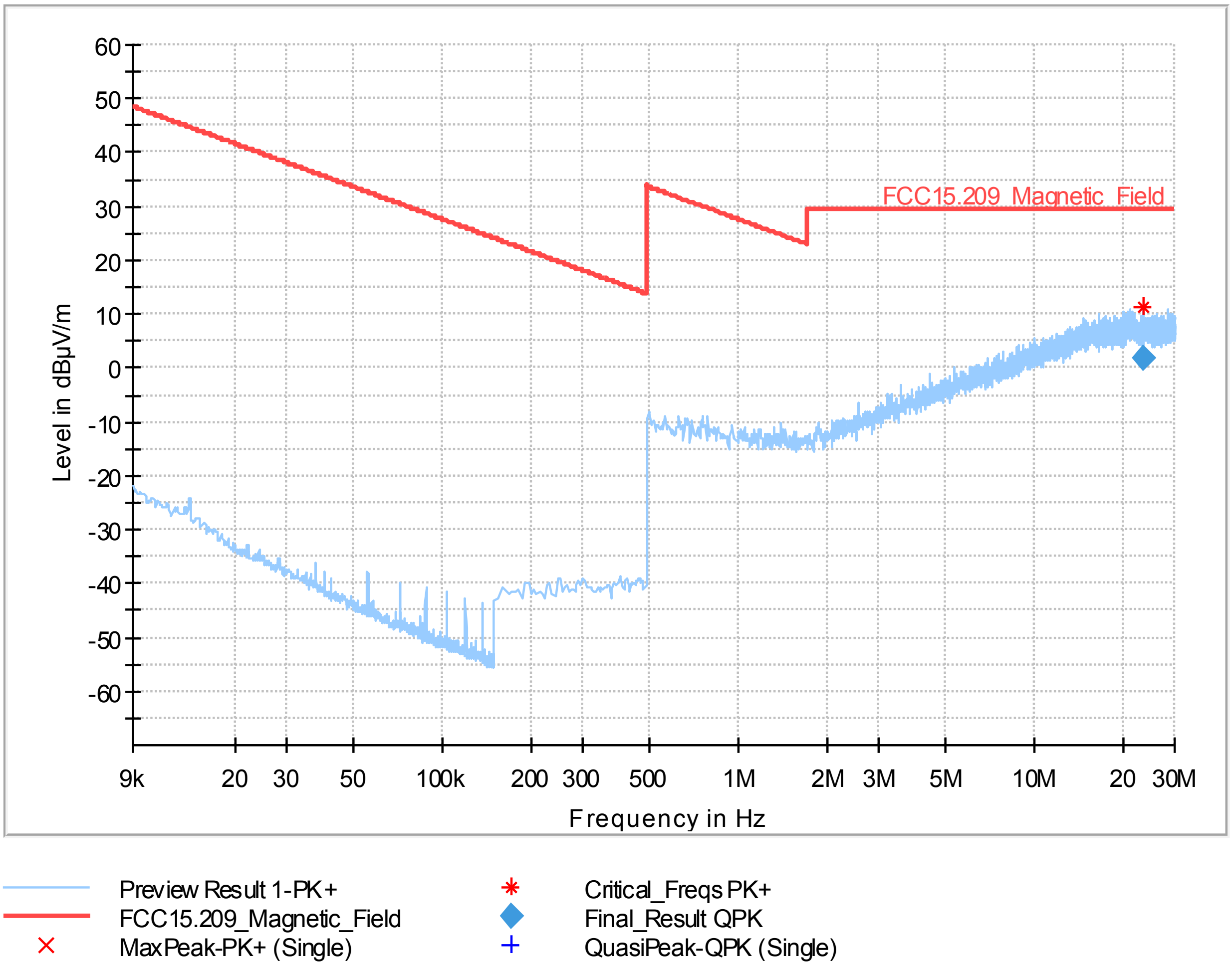


Plot no. 76: radiated emissions 220 GHz – 325 GHz, polarization vertical / horizontal, DMP02



03:12:58 03/28/2025

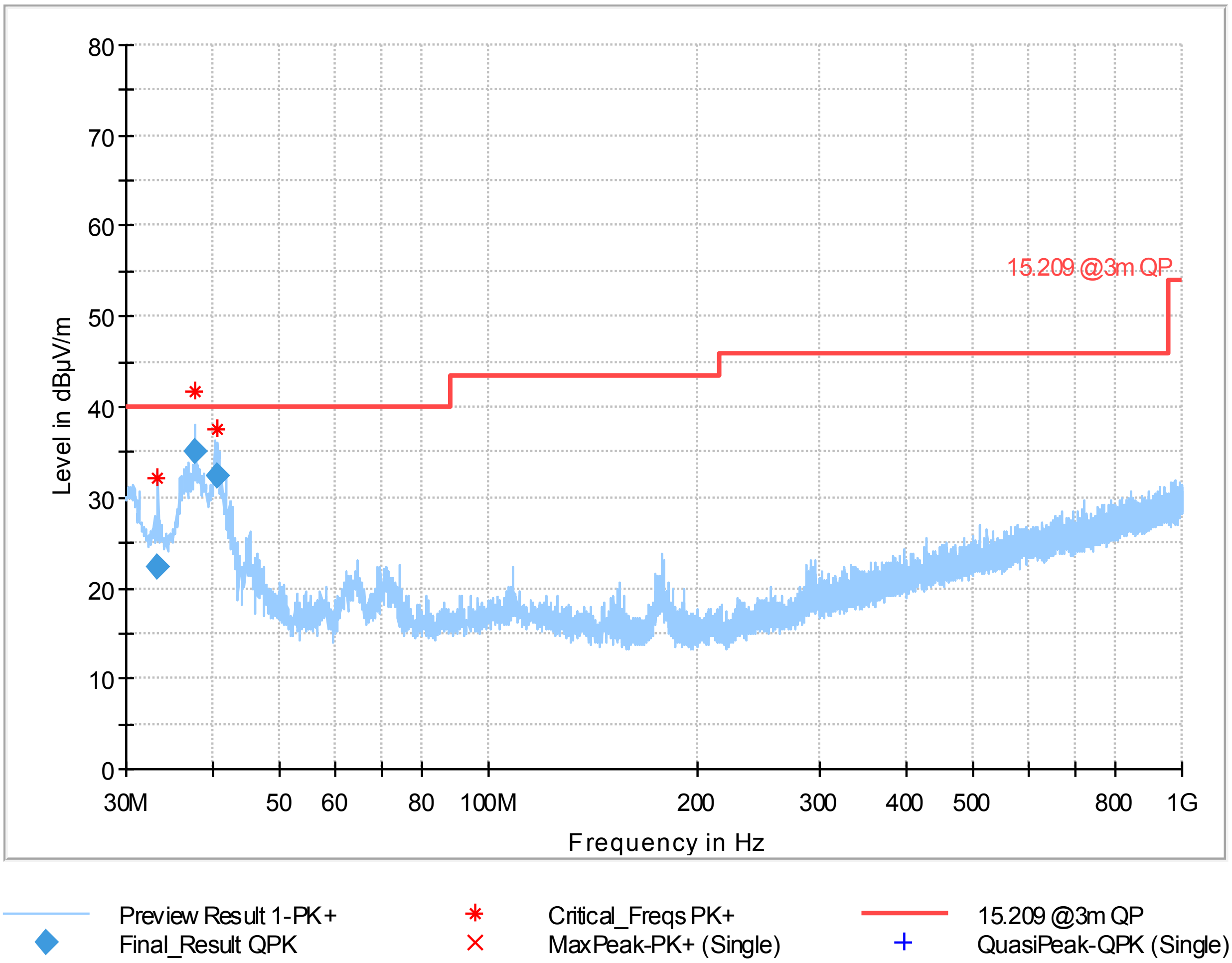
Plot no. 77: radiated emissions 9 kHz – 30 MHz, loop antenna polarization vertical / horizontal, DMP03



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
23.629932	1.68	29.54	27.86	100.0	9.000	V	246.0	0.6

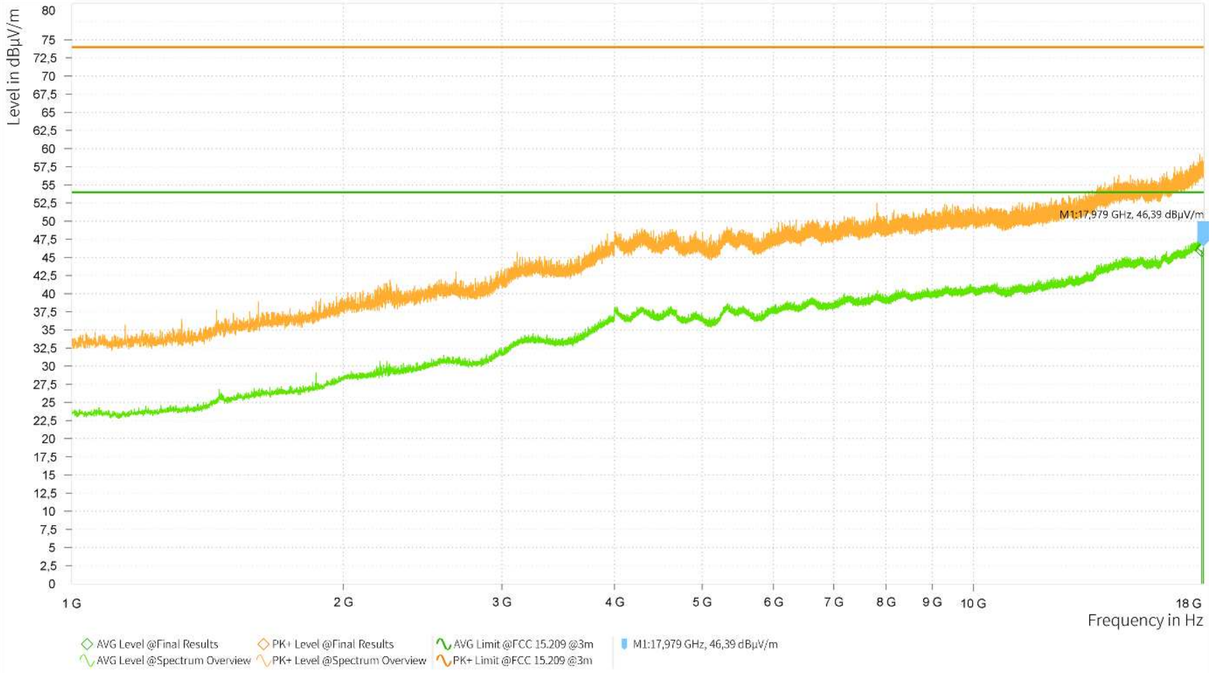
Plot no. 78: radiated emissions 30 MHz – 1 GHz, polarization vertical / horizontal, DMP03



Final_Result

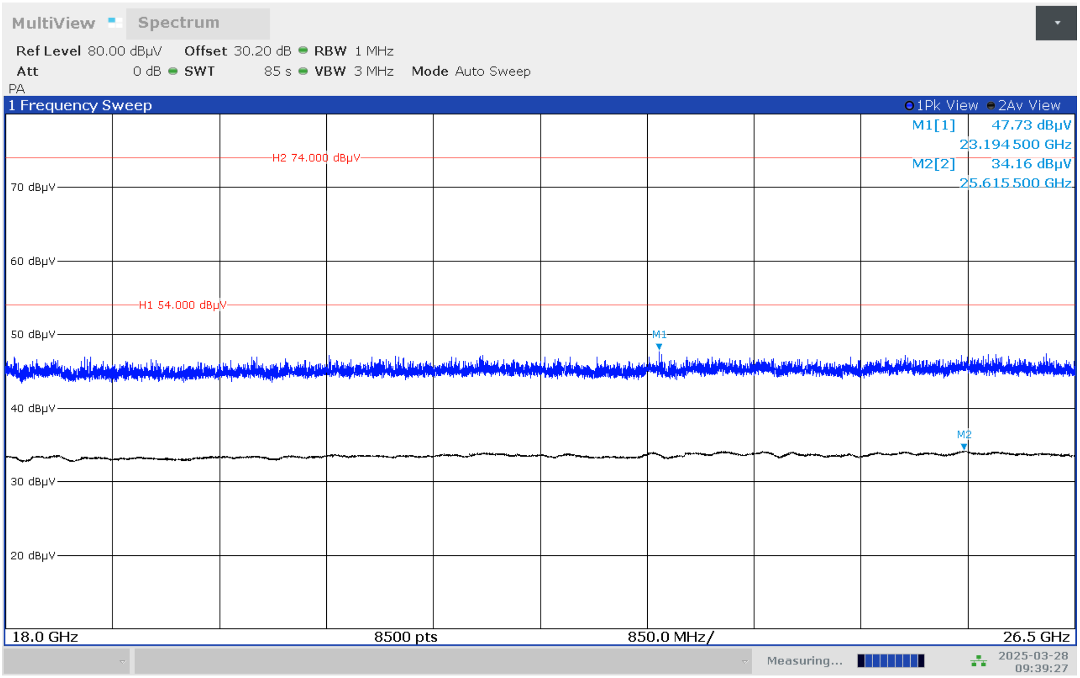
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
33.256500	22.23	40.00	17.77	100.0	120.000	165.0	V	270.0
37.730000	35.09	40.00	4.91	100.0	120.000	104.0	V	343.0
40.697500	32.28	40.00	7.72	100.0	120.000	100.0	V	6.0

Plot no. 79: radiated emissions 1 GHz – 18 GHz, polarization vertical / horizontal, DMP03



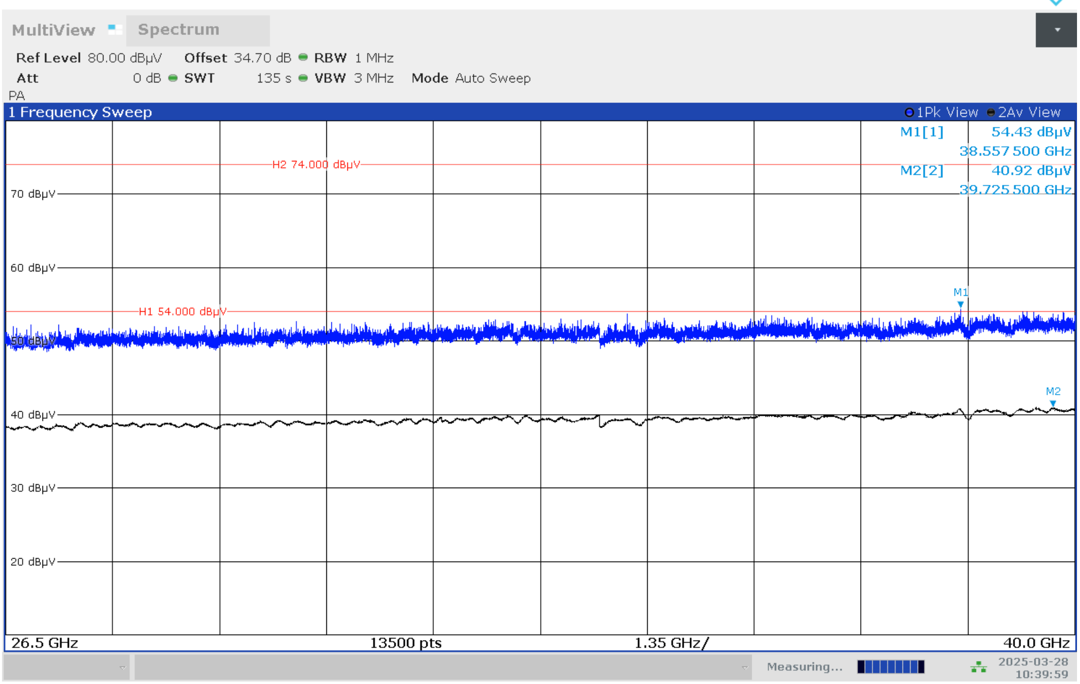
Rg	Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Elevation [deg]	Azimuth [deg]	Antenna Height [m]	Time of Meas.
1	17.905,400				46,00	54,00	8,00	44,22	105	334,7	1,50	16:26:52
1	17.978,700				46,39	54,00	7,61	44,44	82	162,5	1,50	16:25:20

Plot no. 80: radiated emissions 18 GHz – 26.5 GHz, polarization vertical / horizontal, DMP03



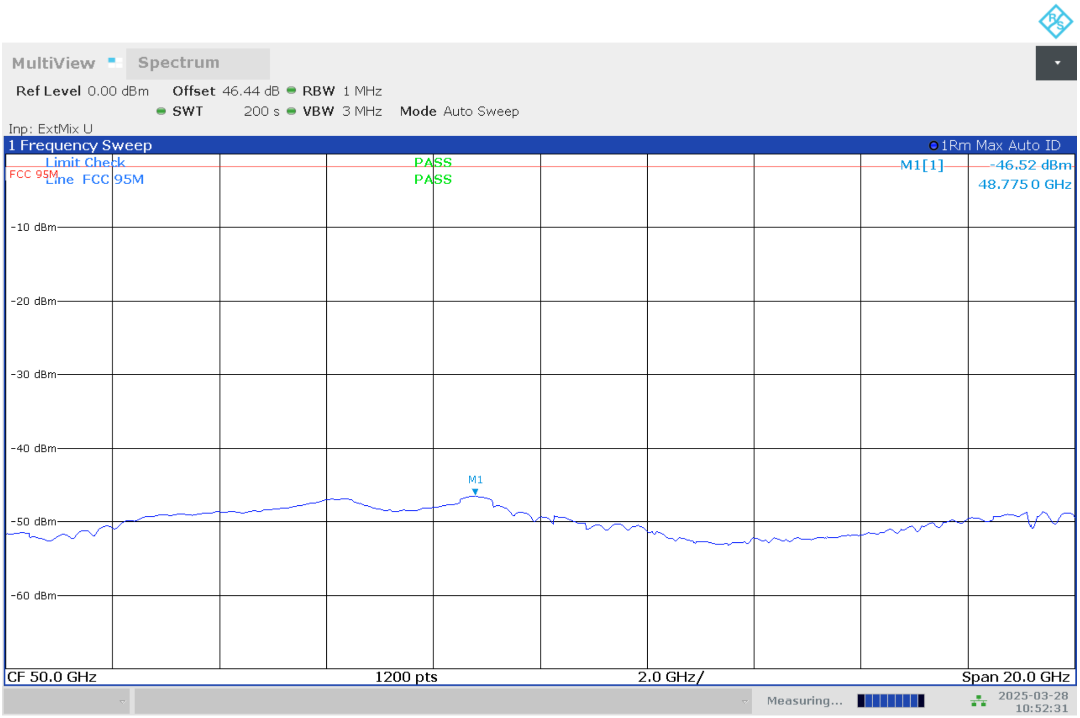
09:39:28 03/28/2025

Plot no. 81: radiated emissions 26.5 GHz – 40 GHz, polarization vertical / horizontal, DMP03



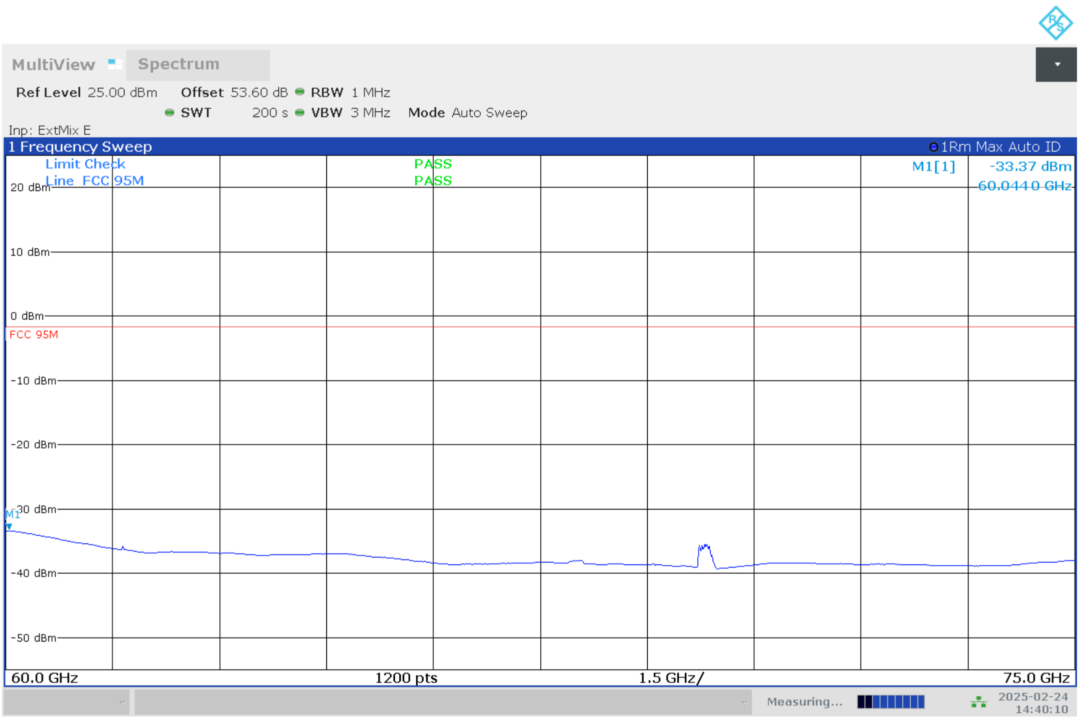
10:39:59 03/28/2025

Plot no. 82: radiated emissions 40 GHz – 60 GHz, polarization vertical / horizontal, DMP03



10:52:32 03/28/2025

Plot no. 83: radiated emissions 60 GHz – 75 GHz, polarization vertical / horizontal, DMP03

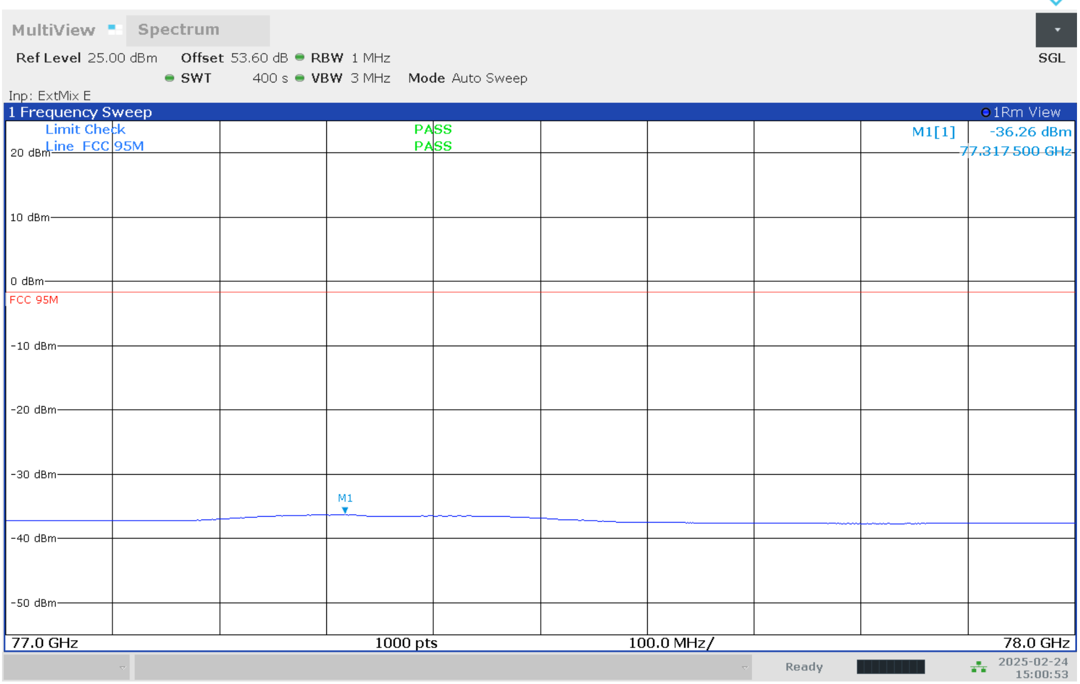


02:40:10 02/24/2025

Plot no. 84: radiated emissions 75 GHz – 76 GHz, band edge, DMP03

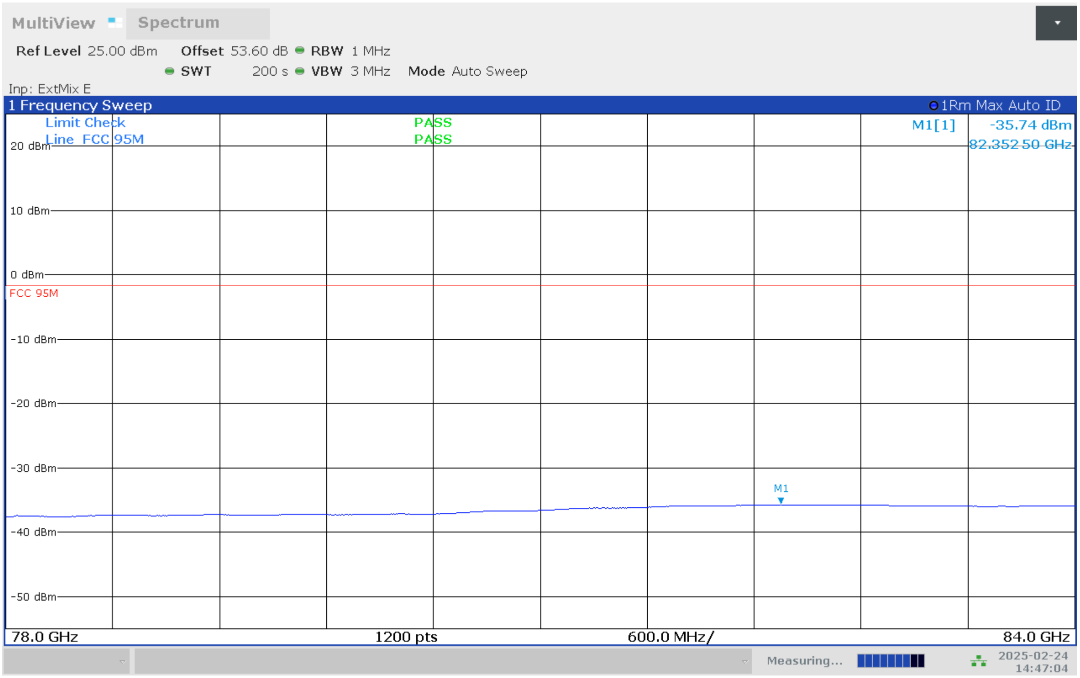
02:53:59 02/24/2025

Plot no. 85: radiated emissions 77 GHz – 78 GHz, polarization vertical / horizontal, DMP03



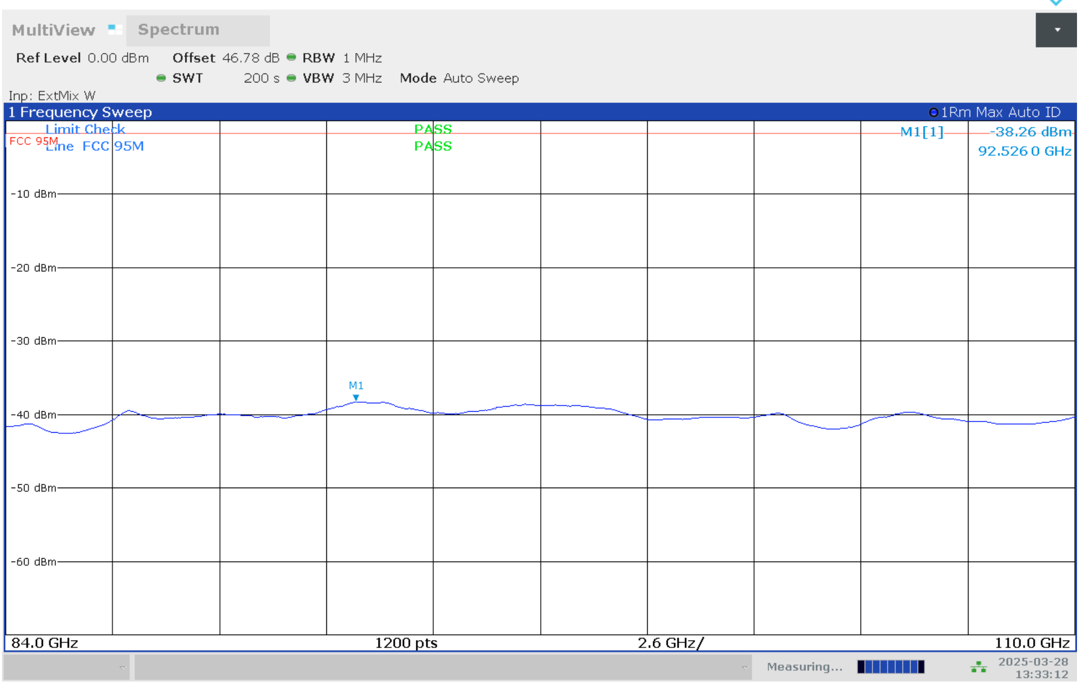
03:00:53 02/24/2025

Plot no. 86: radiated emissions 78 GHz – 84 GHz, polarization vertical / horizontal, DMP03



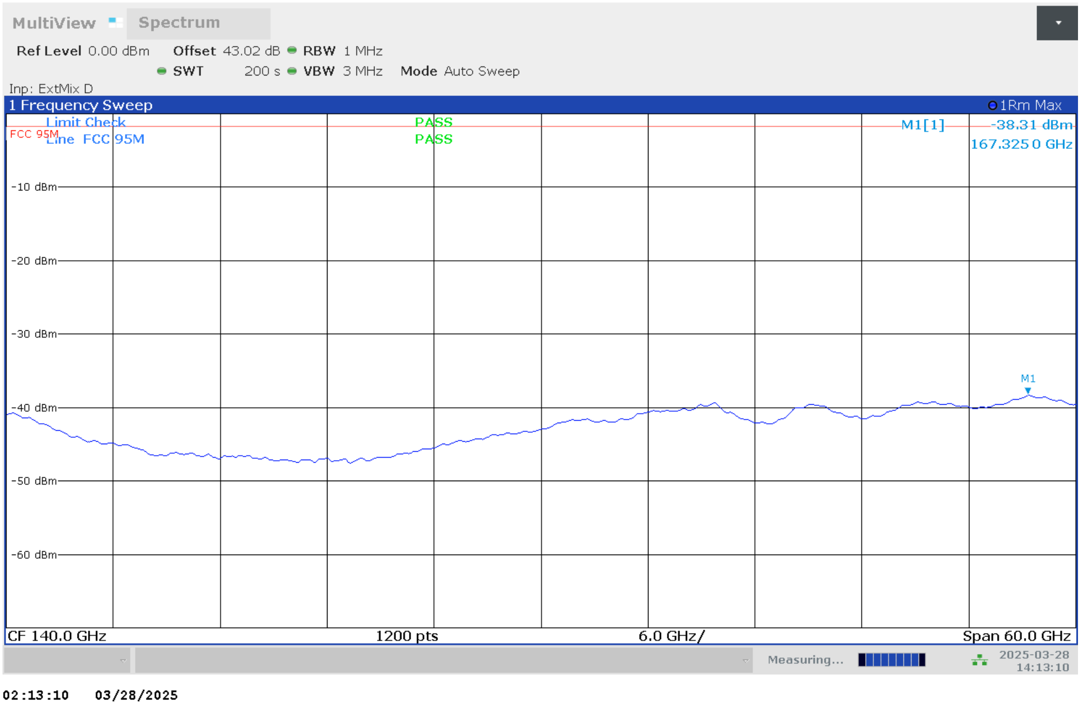
02:47:05 02/24/2025

Plot no. 87: radiated emissions 84 GHz – 110 GHz, polarization vertical / horizontal, DMP03

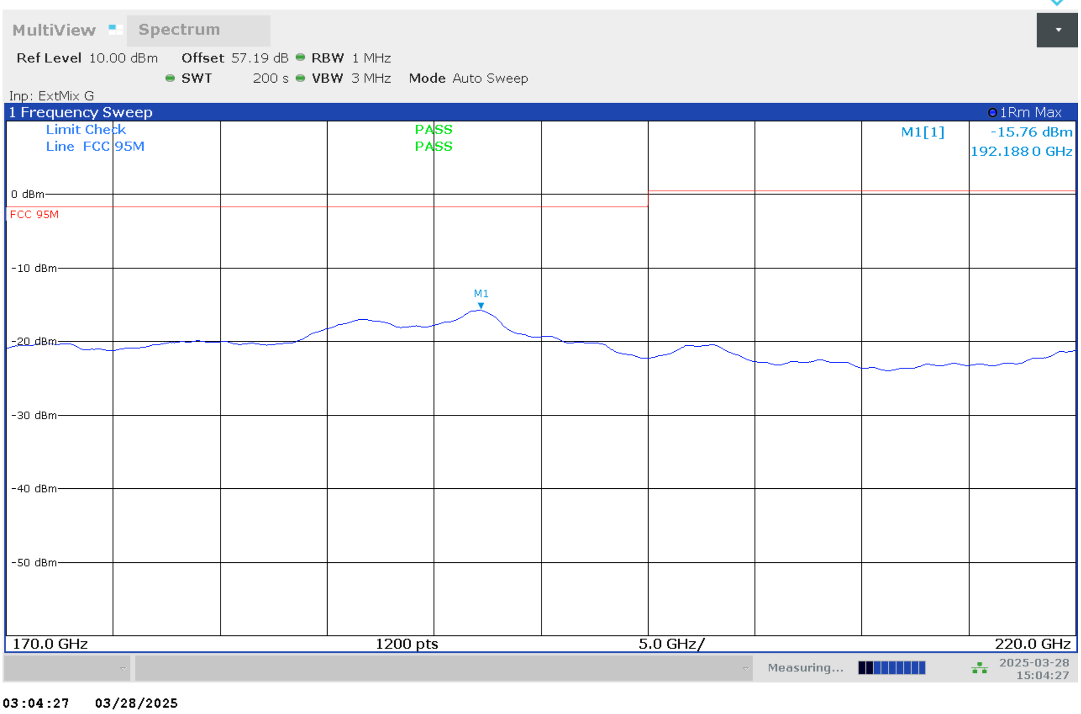


01:33:12 03/28/2025

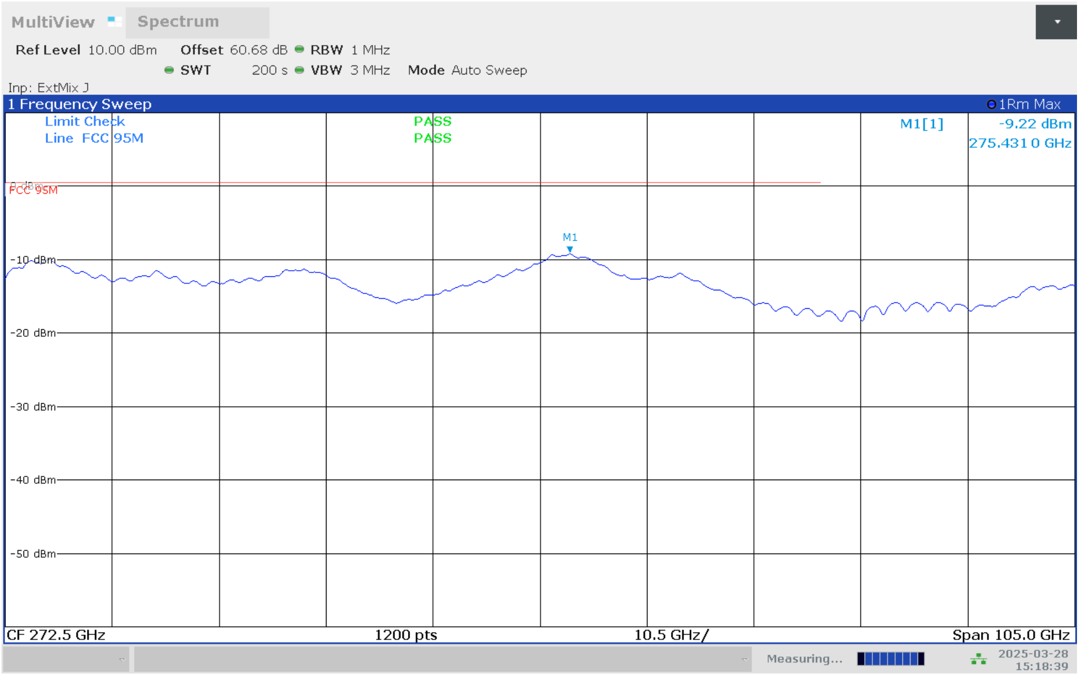
Plot no. 88: radiated emissions 110 GHz – 170 GHz, polarization vertical / horizontal, DMP03



Plot no. 89: radiated emissions 170 GHz – 220 GHz, polarization vertical / horizontal, DMP03

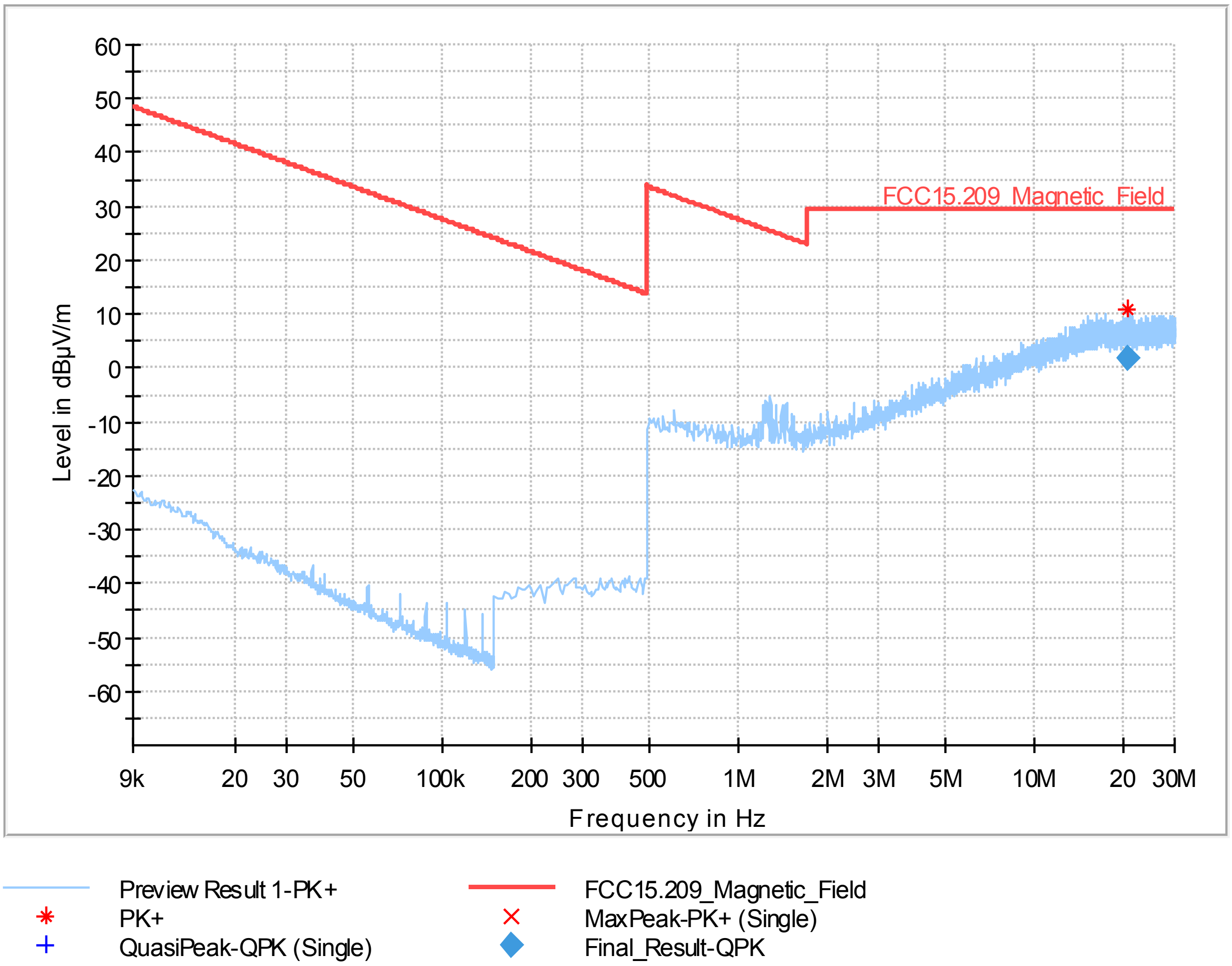


Plot no. 90: radiated emissions 220 GHz – 325 GHz, polarization vertical / horizontal, DMP03



03:18:40 03/28/2025

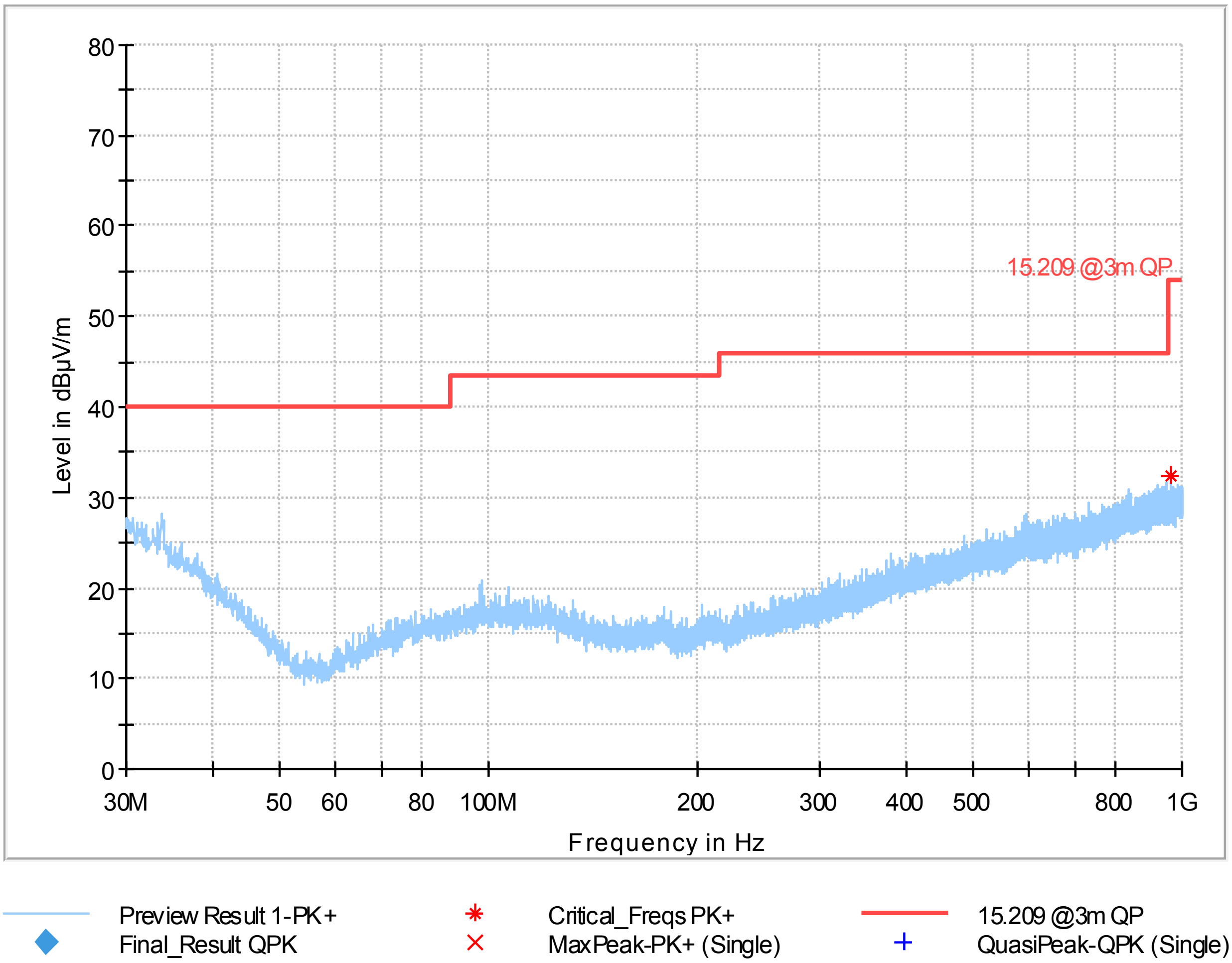
Plot no. 91: EUT with AK2-connector, rad. emissions 9 kHz – 30 MHz, polarization vertical / horizontal, DMP01



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB)
20.895727	1.82	29.54	27.72	100.0	9.000	V	116.0	0.6

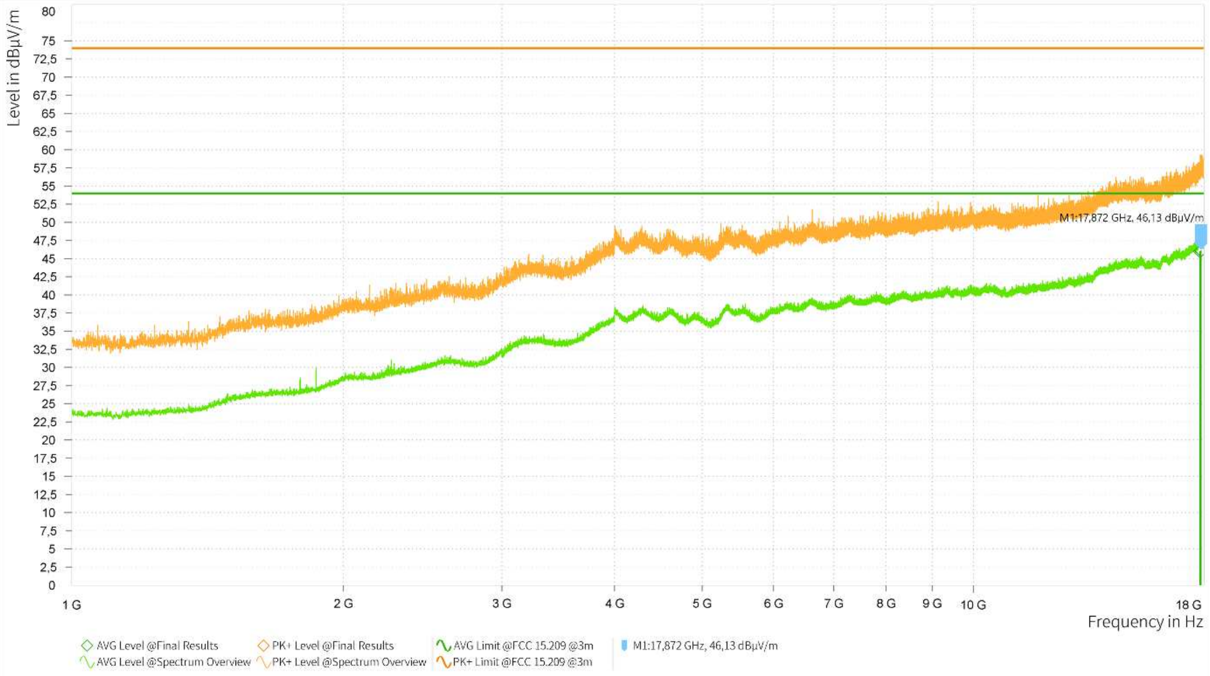
Plot no. 92: EUT with AK2-connector, rad. emissions 30 MHz – 1 GHz, polarization vertical / horizontal, DMP01



Critical_Freqs

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
960.909000	32.39	54.00	21.61	---	---	300.0	H	250.0

Plot no. 93: EUT with AK2-connector, rad. emissions 1 GHz – 18 GHz, polarization vertical / horizontal, DMP01



Rg	Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Elevation [deg]	Azimuth [deg]	Antenna Height [m]	Time of Meas.
1	17.829,400				45,99	54,00	8,01	44,03	15	389,6	1,50	13:39:42
1	17.872,000				46,13	54,00	7,87	44,13	80,7	138,5	1,50	13:41:12

7.5 Frequency stability (§2.1055 & §95.3379(b))

Description

§2.1055 Measurements required: Frequency stability.

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(1) From -30° to + 50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

Limits

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

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

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 / Note **Please see measurement results for occupied bandwidth.**

8 Test Setup Description

Typically, the calibrations of the test apparatus are commissioned to and performed by an accredited calibration laboratory. The calibration intervals are determined in accordance with the DIN EN ISO/IEC 17025. In addition to the external calibrations, the laboratory executes comparison measurements with other calibrated test systems or effective verifications. Cyclic chamber inspections and range calibrations are performed. Where possible, RF generating and signalling equipment as well as measuring receivers and analysers are connected to an external high-precision 10 MHz reference (GPS-based or rubidium frequency standard).

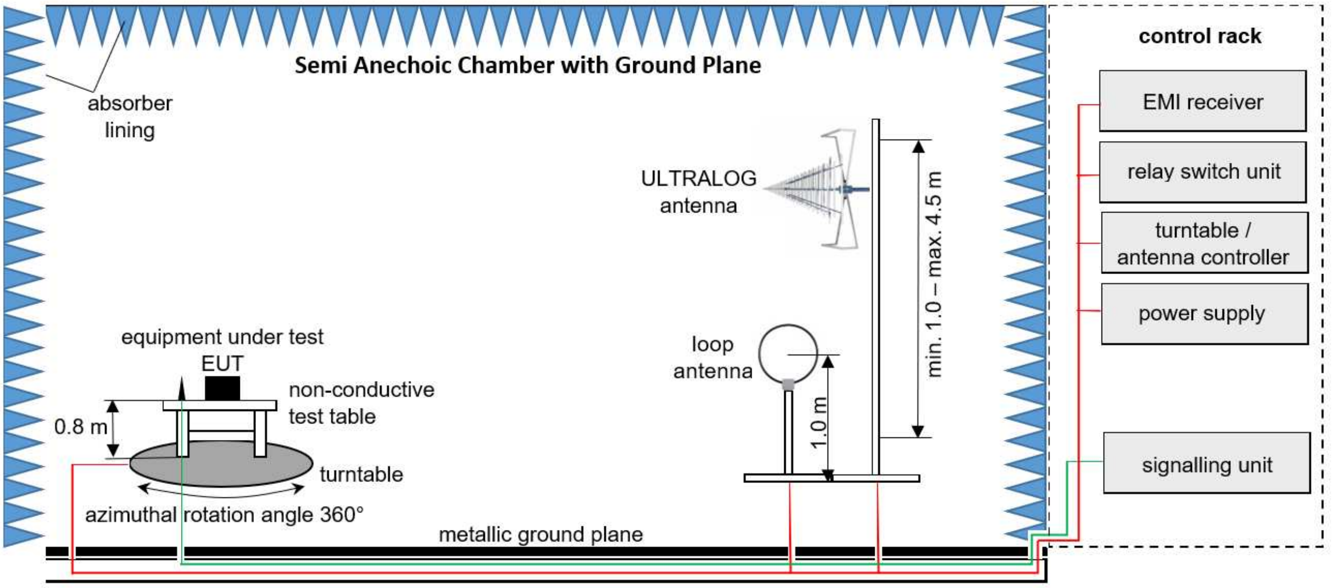
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

Kind of calibration (abbreviations):

C = calibrated
CM = cyclic maintenance
NR = not required
L = locked

8.1 Semi Anechoic Chamber with Ground Plane

Radiated measurements are performed in vertical and horizontal plane in the frequency range 30 MHz to 1 GHz in a Semi Anechoic Chamber with a metallic ground plane. The EUT is positioned on a non-conductive test table with a height of 0.80 m above the metallic ground plane that covers the whole chamber. The receiving antennas conform to specification ANSI C63.26-2015, American National Standard for Testing Unlicensed Wireless Devices. These antennas can be moved over the height range between 1.0 m and 4.5 m in order to search for maximum field strength emitted from the EUT. The measurement distances between EUT and receiving antennas are indicated in the test setups for the various frequency ranges. For each measurement, the EUT is rotated in all three axes until the maximum field strength is received. The wanted and unwanted emissions are received by a spectrum analyzer where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: ULTRALOG antenna at 3 m; loop antenna at 3 m
EMC32 software version: 11.20.00

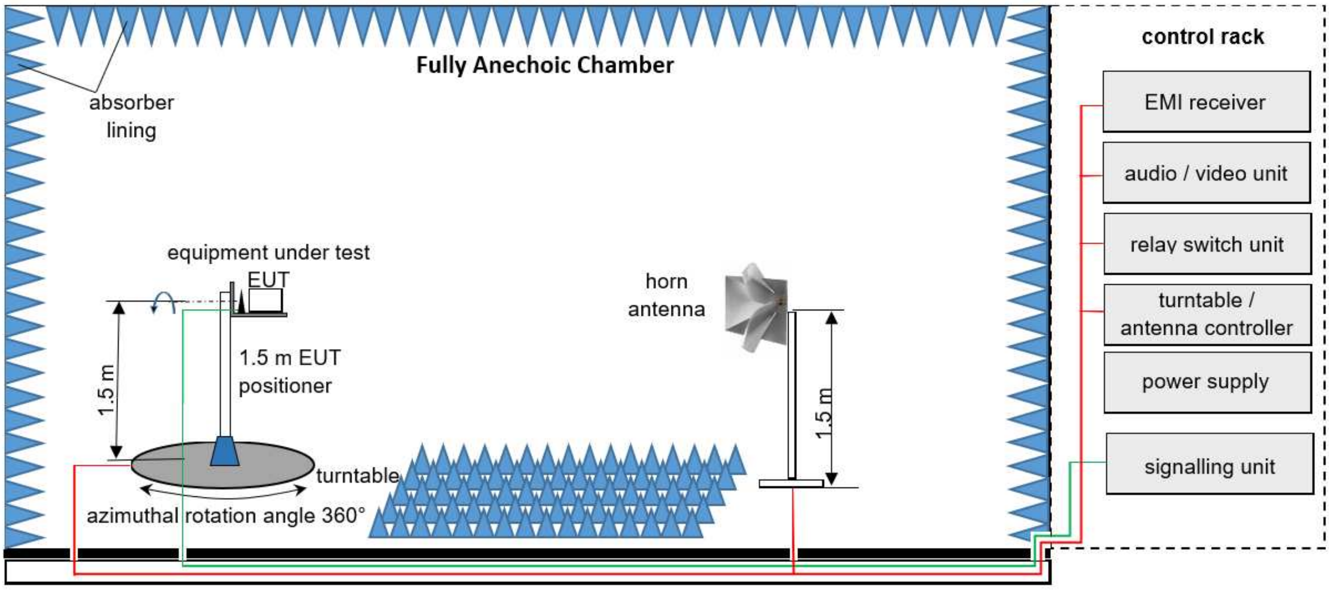
FS = UR + CL + AF
(FS-field strength; UR-voltage at the receiver; CL-loss of the cable; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 12.35 [dBµV/m] + 1.90 [dB] + 16.80 [dB/m] = 31.05 [dBµV/m] (35.69 µV/m)

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Rohde & Schwarz	IN 600	101554	LAB000824	NR	–
2	Antenna	Rohde & Schwarz	HL562E	102173	LAB000673	C	2022-10-17 → 36M → 2025-10-17
3	Power Supply	Chroma	61602		LAB000507	NR	–
4	EMI Test Receiver	Rohde & Schwarz	ESW26	101517	LAB000363	C	2025-01-10 → 12M → 2026-01-10
5	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
6	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
7	Antenna Mast	Berlebach	Tripod HFH2-Z8 & -Z9	101762	LAB000292	NR	–
8	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
9	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
10	Semi/Fully Anechoic Chamber	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	CM	2025-03-18 → 36M → 2028-03-18
11	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
12	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
13	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
14	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
15	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
16	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
17	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	CM	2022-05-31 → 36M → 2025-05-31
18	Open Switch and Control Platform	Rohde & Schwarz	OSP220 Base Unit 2HU	101748	LAB000149	NR	–
19	Antenna	Rohde & Schwarz	HFH2-Z2E	100954	LAB000108	C	2023-05-05 → 36M → 2026-05-05

8.2 Fully Anechoic Chamber



Measurement distance: horn antenna at 3 m
EMC32 software version: 11.20.00

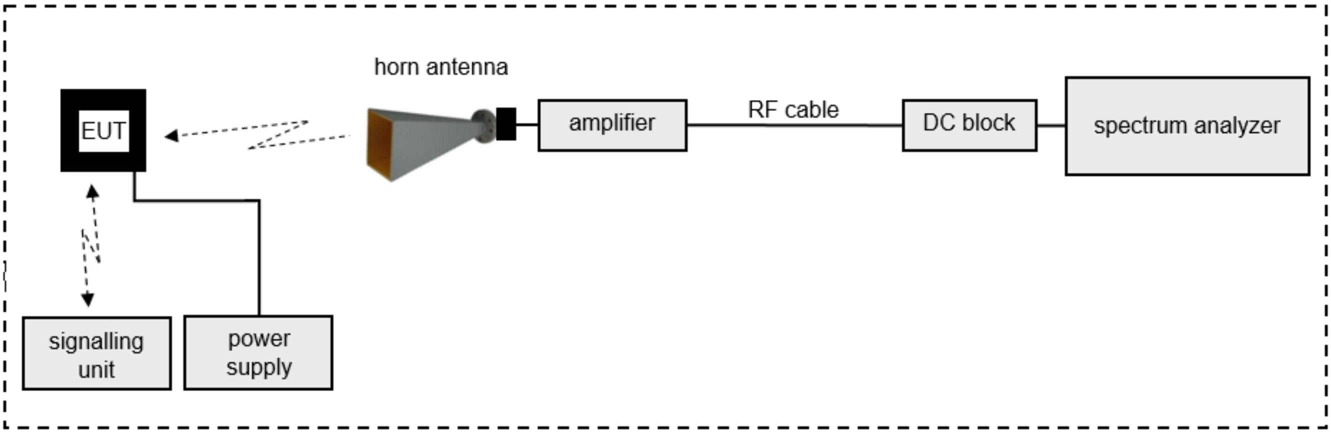
FS = UR + CA + AF
(FS-field strength; UR-voltage at the receiver; CA-loss of the signal path; AF-antenna factor)

Example calculation:
FS [dBµV/m] = 40.0 [dBµV/m] + (-35.8) [dB] + 32.9 [dB/m] = 37.1 [dBµV/m] (71.61 µV/m)

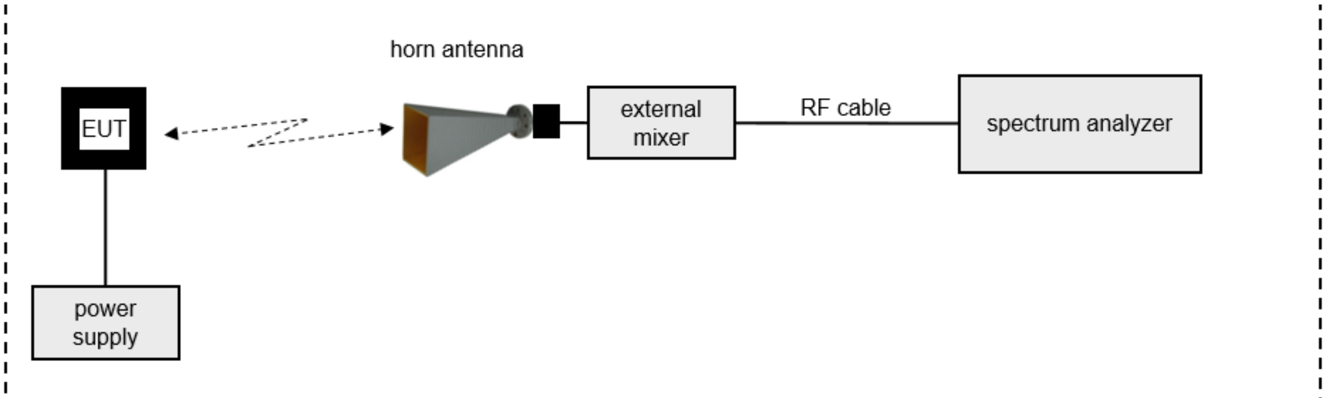
List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Power Supply	Rohde & Schwarz	IN 600	101554	LAB000824	NR	–
2	Power Supply	Chroma	61602		LAB000507	NR	–
3	EMI Test Receiver	Rohde & Schwarz	ESW26	101517	LAB000363	C	2025-01-10 → 12M → 2026-01-10
4	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PSI 9080-40 T	2000230001	LAB000313	NR	–
5	Test table	innco systems GmbH	PT1208-080-RH	-	LAB000306	NR	–
6	Antenna Mast	Berlebach	Tripod HFH2-Z8 & -Z9	101762	LAB000292	NR	–
7	Positioner	maturo GmbH	TD 1.5-10KG		LAB000258	NR	–
8	Compressed Air	Implotex	1-850-30	-	LAB000256	NR	–
9	Semi/Fully Anechoic Chamber	Albatross Projects GmbH	Babylon 5 (SAC 5)	20168.PRB	LAB000235	CM	2025-03-18 → 36M → 2028-03-18
10	Measurement Software	Rohde & Schwarz	EMC32 V11.20		LAB000226	NR	–
11	Turntable	maturo GmbH	TT2.0-2t	TT2.0-2t/921	LAB000225	NR	–
12	Antenna Mast	maturo GmbH	CAM4.0-P	CAM4.0-P/316	LAB000224	NR	–
13	Antenna Mast	maturo GmbH	BAM4.5-P	BAM4.5-P/272	LAB000223	NR	–
14	Controller	maturo GmbH	FCU 3.0	10082	LAB000222	NR	–
15	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350292	LAB000191	NR	–
16	Pre-Amplifier	Schwarzbeck Mess-Elektronik OHG	BBV 9718 C	84	LAB000169	CM	2022-05-31 → 36M → 2025-05-31
17	Antenna	Rohde & Schwarz	HF907	102899	LAB000151	C	2023-05-15 → 36M → 2026-05-15
18	Open Switch and Control Platform	Rohde & Schwarz	OSP220 Base Unit 2HU	101748	LAB000149	NR	–

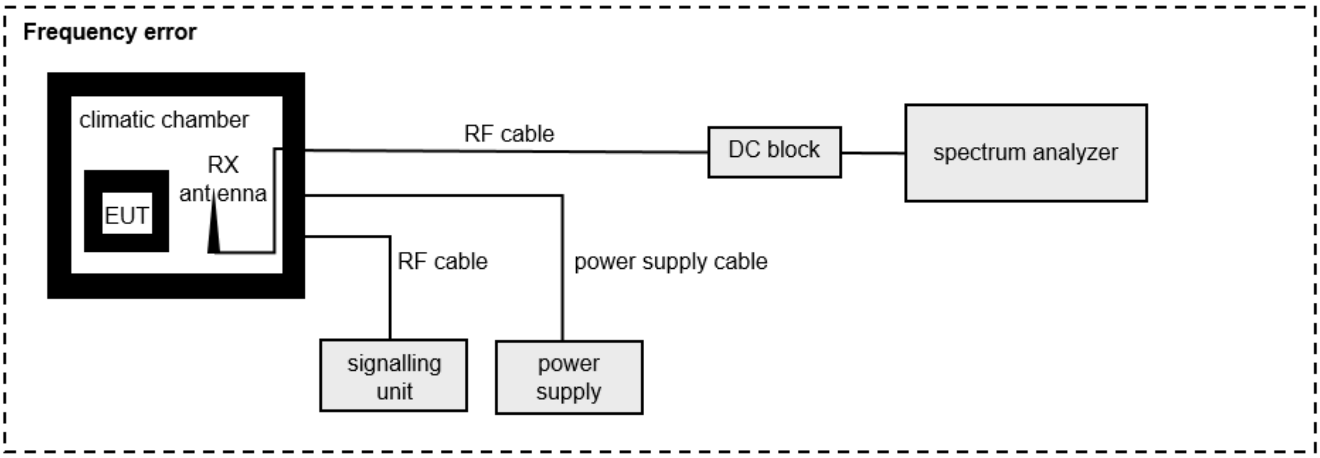
8.3 Radiated measurements > 18 GHz



8.4 Radiated measurements > 50 GHz



8.5 Radiated measurements under extreme conditions



ROP = AV + D - G
(ROP-rad. output power; AV-analyzer value; D-free field attenuation of measurement distance; G-antenna gain)

Example calculation:
ROP [dBm] = -54.0 [dBm] + 64.0 [dB] - 20.0 [dBi] = -10 [dBm] (100 µW)

Note: conversion loss of mixer is already included in analyzer value.

List of test equipment used:

No.	Equipment	Manufacturer	Type	Serial No.	IBL No.	Kind of Calibration	Last / Next Calibration
1	Antenna	Flann Microwave Ltd	24240-20 (40.0-60.0 GHz)	275176	LAB000376	CM	2024-07-16 → 12M → 2025-07-16
2	Harmonic Mixer	Rohde & Schwarz	FS-Z060	101350	LAB000375	C	2025-04-15 → 12M → 2026-04-15
3	Absorber	Telemeter Electronic	EPP 12	-	LAB000327	NR	–
4	Test table	innco systems GmbH	PT0707-RH light	-	LAB000303	NR	–
5	Filter (Coax/WG, LPF, HPF, Band)	TTE	10-WHPF-84.5-UG387	-	LAB000299	NR	–
6	Power Supply	Elektro-Automatik GmbH & Co. KG	EA-PS 2042-10 B	2878350255	LAB000189	NR	–
7	WG-Coax-Adapter	Flann Microwave Ltd	23373-TF30 UG383/U	273384	LAB000184	CM	2024-07-16 → 12M → 2025-07-16
8	WG-Coax-Adapter	Flann Microwave Ltd	22093-TF30 UG599/U	273263	LAB000183	CM	2024-07-16 → 12M → 2025-07-16
9	WG-Coax-Adapter	Flann Microwave Ltd	20093-TF30 UBR220	273373	LAB000180	CM	2024-07-16 → 12M → 2025-07-16
10	Antenna	Flann Microwave Ltd	30240-20 (140-220 GHz)	273390	LAB000178	CM	2024-07-16 → 12M → 2025-07-16
11	Antenna	Flann Microwave Ltd	28240-20 (90.0-140 GHz)	273371	LAB000176	CM	2024-07-16 → 12M → 2025-07-16
12	Coaxial Cable	Huber & Suhner	SF101/1.0m	503989/1	LAB000163	CM	2024-07-17 → 12M → 2025-07-17
13	Coaxial Cable	Rosenberger	LU7-022-1000	34	LAB000154	CM	2024-07-17 → 12M → 2025-07-17
14	Coaxial Cable	Rosenberger	LU7-022-1000	33	LAB000153	CM	2024-07-17 → 12M → 2025-07-17
15	Antenna	Flann Microwave Ltd	32240-20 (220-325 GHz)	273469	LAB000152	CM	2024-07-16 → 12M → 2025-07-16
16	Antenna	Flann Microwave Ltd	29240-20 (110-170 GHz)	273382	LAB000139	CM	2024-07-16 → 12M → 2025-07-16
17	Antenna	Flann Microwave Ltd	27240-20 (75.0-110 GHz)	273367	LAB000137	CM	2024-07-16 → 12M → 2025-07-16
18	Antenna	Flann Microwave Ltd	26240-20 (60.0-90.0 GHz)	273417	LAB000135	CM	2024-07-16 → 12M → 2025-07-16
19	Antenna	Flann Microwave Ltd	25240-20 (50.0-75.0 GHz)	272860	LAB000133	CM	2024-07-16 → 12M → 2025-07-16
20	Antenna	Flann Microwave Ltd	23240-20 (33.0-50.0 GHz)	273431	LAB000131	CM	2024-07-16 → 12M → 2025-07-16
21	Antenna	Flann Microwave Ltd	22240-20 (26.5-40.0 GHz)	270448	LAB000130	CM	2024-07-16 → 12M → 2025-07-16
22	Antenna	Flann Microwave Ltd	20240-20 (18.0-26.5 GHz)	266402	LAB000127	CM	2024-07-16 → 12M → 2025-07-16
23	Harmonic Mixer	Rohde & Schwarz	FS-Z170	100996	LAB000126	C	0000-00-00 → 12M → 2026-03-27
24	Harmonic Mixer	Rohde & Schwarz	FS-Z325	101015	LAB000117	C	2025-04-09 → 12M → 2026-04-09
25	Harmonic Mixer	Rohde & Schwarz	FS-Z220	101039	LAB000116	C	0000-00-00 → 12M → 2026-03-27
26	Harmonic Mixer	Rohde & Schwarz	FS-Z140	101144	LAB000115	C	2025-04-09 → 12M → 2026-04-09
27	Harmonic Mixer	Rohde & Schwarz	FS-Z110	102000	LAB000114	C	0000-00-00 → 12M → 2026-03-27
28	Harmonic Mixer	Rohde & Schwarz	FS-Z090	102020	LAB000113	C	2025-04-16 → 12M → 2026-04-16
29	Harmonic Mixer	Rohde & Schwarz	FS-Z075	102015	LAB000112	C	0000-00-00 → 12M → 2026-03-27
30	Spectrum Analyser	Rohde & Schwarz	FSW50	101450	LAB000111	C	2024-07-25 → 12M → 2025-07-25
31	Climatic Chamber	CTS GmbH	T-65/50	204002	LAB000110	CM	2024-06-07 → 12M → 2025-06-07
32	Antenna Mast	Schwarzbeck Mess-Elektronik OHG	AM 9104	99	LAB000109	NR	–
33	Multimeter	Keysight	U1242B	MY59110034	LAB000009	C	2024-08-06 → 12M → 2025-08-06

9 MEASUREMENT PROCEDURES

9.1 Radiated spurious emissions from 9 kHz to 30 MHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 360° continuously.
- For each turntable position the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software by rotating the turntable from 0° to 360°.
- Loop antenna is rotated with special 3D adapter set to find maximum level of emissions.
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade of distance in the region closer than λ in m divided by 2π (i.e., λ/2π), and at 20 dB/decade of distance beyond that, using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the limit line of corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

9.2 Radiated spurious emissions from 30 MHz to 1 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 360° continuously.
- Antenna polarisation is changed (H-V / V-H) and antenna height is changed from 1 meter to 4 meters.
- For each turntable position / antenna polarisation / antenna height the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

9.3 Radiated spurious emissions from 1 GHz to 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- In case of floor standing equipment, it is placed in the middle of the turn table.
  In case of tabletop equipment it is placed on a non-conductive table with a height of 80 cm.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- Interface cables, e.g. power supply, network, … are connected to the connection box in the turn table.
- EUT is powered on and set into operation.

Pre-scan

- Turntable performs an azimuthal rotation from 0° to 360° continuously.
- Antenna polarisation is changed (H-V / V-H).
- For each turntable position and antenna polarisation the EMI-receiver/spectrum analyser performs a positive-peak/max-hold sweep (=worst-case). Data is transferred to EMI-software and recorded. EMI-software will show the maximum level of all single sweeps as the final result for the pre-scan.

Final measurement

- Significant emissions found during the pre-scan will be maximized by the EMI-software based on evaluated data during the pre-scan by rotating the turntable and changing antenna height and polarisation.
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C6.4).
- Plot of the pre-scan with frequencies of identified emissions including levels, correction factors, turn table position, antenna polarisation and settings of measuring equipment is recorded.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

9.4 Radiated spurious emissions above 18 GHz

Test setup

- The EUT is set up according to its intended use, as described in the user manual or as defined by the manufacturer.
- Additional equipment, cables, … necessary for testing, are positioned like under normal operation.
- EUT is powered on and set into operation.
- Test distance depends on EUT size and test antenna size (farfield conditions shall be met).

Pre-scan

- The test antenna is handheld and moved carefully over the EUT to cover the EUT's whole sphere and for different polarizations of the antenna.

Final measurement

- Significant emissions found during the pre-scan will be maximized, i.e. position and antenna orientation causing the highest emissions with Peak and RMS detector
- Final measurement will be performed with measuring equipment settings as defined in the applicable test standards (e.g. ANSI C63.4 / C63.26).
- Final plot showing measurement data, levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit is recorded.

Note

- In case of measurements with external harmonic mixers (e.g. above 50 GHz) special care is taken to avoid possible overloading of the external mixer's input.
- As external harmonic mixers may generate false images, care is taken to ensure that any emission measured by the spectrum analyzer is indeed radiated from the EUT and not internally generated by the external harmonic mixer. Signal identification feature of spectrum analyzer is used to eliminate/reduce images of the external harmonic mixer.

Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 20 dB/decade of distance beyond the region λ in m divided by 2π (i.e., λ/2π), using the measurement of a single point at the radial angle that produces the maximum emission.
  This correction is already included in the corresponding measurement plots.

Detailed requirements can be found in e.g. ANSI C63.4 / C63.26

10 MEASUREMENT UNCERTAINTIES

Radio frequency	≤ ± 10 ppm
Radiated emission	≤ ± 6 dB
Temperature	≤ ± 1 °C
Humidity	≤ ± 5 %
DC and low frequency voltages	≤ ± 3 %

The indicated expanded measurement uncertainty corresponds to the standard measurement uncertainty for the measurement results multiplied by the coverage factor k = 2. It was determined in accordance with EA-4/01 m:2013. The true value is located in the corresponding interval with a probability of 95 %.

End of Test Report