DAkkS Deutsche Akkreditierungsstelle D-PL-21375-01-03

INGENIEURBÜRO LENHARDT

Bundesnetzagentur

BNetzA-CAB-21/21-21

Test Report

Test report no.: 21096300-23127-1
Date of issue: 2021-12-20

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

Applicant
Robert Bosch GmbH

Manufacturer
Robert Bosch GmbH

Test Item
FR5CUEC

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* *Lab Manager RF*	signature
Approved by (name, function, signature)	*Dr.-Ing. Harald Ansorge* *Managing Director*	signature

Applicant and Test item details	
Applicant	Robert Bosch GmbH Daimlerstrasse 6 71229, Leonberg, Germany Phone: +49 711 400 40990 Fax: +49 711 400 40999
Manufacturer	Robert Bosch GmbH Daimlerstrasse 6 71229, Leonberg, Germany
Test item description	Automotive radar sensor
Model/Type reference	FR5CUEC
FCC ID	NF3-FR5CUEC
Frequency	76.0 GHz to 77.0 GHz
Antenna	integrated patch antenna
Power supply	7.0 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 samples. The samples used for testing are provided by the applicant.

Decision rule: Binary Statement for Simple Acceptance Rule according ILAC-G8:09/2019

1 TABLE OF CONTENTS

2 GENERAL INFORMATION

2.1 Administrative details

Testing laboratory	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 Sankt Ingbert / Germany Fon: +49 6894 38938-0 Fax: +49 6894 38938-99 URL: www.ib-lenhardt.de E-Mail: info@ib-lenhardt.de
Accreditation	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: • Electronics D-PL-21375-01-01 • Electromagnetic Compatibility D-PL-21375-01-02 • Electromagnetic Compatibility and Telecommunication (FCC requirements) D-PL-21375-01-03 • Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards D-PL-21375-01-04 • ISED Company Number 27156 • Testing Laboratory CAB Identifier DE0020 • Telecommunication (TC) D-PL-21375-01-05 Website DAkkS: https://www.dakks.de/ The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the ILAC Mutual Recognition Arrangement
Testing location	**IBL-Lab GmbH** Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2021-12-10
Start – End of tests	2021-12-10 – 2021-12-20

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: Equipment list updated; database issue led to wrong expiration date. Fixed

This test report 21096300-23127-1 **replaces the previous test report 21096300-23127-0.**
Utilisation, publication 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	940-1060 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	7 V DC	12 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 C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
KDB653005 D01, V01, R01	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*	FR5CUEC
Serial number*	0000081505C0100000000061210215127510236 8
PCB identifier*	0265B62849 -01
Hardware status*	C1
Software status*	1037609312 / 1037609313

*: 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*	~42%
Antenna*	integrated patch antenna
Rated RF output power*	< 50 dBm
Power supply*	7.0 to 16.0 V DC
Temperature range*	-40 °C to +85 °C

*: as declared by applicant

5.4 Additional information

Model differences	-/-
Ancillaries tested with	-/-
Additional equipment used for testing	*A notebook, 2 CAN converters and special test software was used, to change the running mode of the EUT*

5.5 Operating conditions

The following information is derived from the provided document “Technical_Descripion_V1.pdf”

5 Modulation description

The sensor modulation mode depends on vehicle speed:

Vehicle speed	Modulation mode	Active TX channels
up to 65km/h	DMP01	TX1, TX2, TX3, TX4, TX5, TX6, TX7, TX8
65km/h – 115 km/h	DMP02	TX1, TX2, TX3, TX4, TX5, TX6, TX7, TX8
above 115 km/h	DMP04	TX1, TX2, TX3, TX4, TX5, TX6, TX7, TX8

All modulations use the same basic principle:
The sensor emits a series of fast FMCW chirps. The chirps are grouped in sequence and sequences are grouped in bursts.
A single sequence consists of 12 chirps around constant centre frequency. Each chirp is emitted on different TX channel and takes 44,32µs. In between chirps transmitter is turned off. In first sequence, 3 chirps are emitted on TX1 antenna, 3 chirps on TX2, 1 chirps on TX3, 1 chirps on TX4, 1 chirps on TX5, 1 chirps on TX6, 1 chirps on TX7 and 1 chirps on TX8. In second sequence, 1 chirps are emitted on TX1 antenna, 1 chirps on TX2, 1 chirps on TX3, 1 chirps on TX4, 1 chirps on TX5, 1 chirps on TX6, 3 chirps on TX7 and 3 chirps on TX8.

A burst takes 23,9 ms and consists of 32 sequences (384 chirps). Centre frequency of each sequence is shifted slightly. Once burst emission is completed, transmitter is turned off until end of cycle.
A single cycle takes 66ms.

5.1 DMP01 modulation

Chirp frequency span: 229 MHz
Burst frequency span: 850 MHz
Occupied bandwidth: 860 MHz

5.2 DMP02 modulation

Chirp frequency span: 172 MHz
Burst frequency span: 688 MHz
Occupied bandwidth: 700 MHz

5.3 DMP04 modulation

Chirp frequency span: 114 MHz
Burst frequency span: 456 MHz
Occupied bandwidth: 470 MHz

5.4 Information: Duty Cycle

Cycle length: T_{Total} = 66 ms
Burst length: T_{Burst} = 23,9 ms
Monitoring signals: T_{Mon} = 1,207 ms(Master)+2,325 ms(Slave) = 3,532 ms
On-Time: $T_{On} = T_{Burst} + T_{Mon}$ = 23,9 ms + 3,532 ms = 27,432 ms
Duty Cycle = T_{On} / T_{Total} = 27,432 ms / 66 ms = 0,46

Duty Cycle: **3,81 dB**

5.6 Antenna characteristics

The following information is derived from the provided document “Technical_Descripion_V1.pdf”

4.2 Antenna gain

The table provides the simulation results for the antennas of the sensor FR5CUEC

Antenna No.	Gain (dBi)	G_{numTx}	Activation distribution per sequence
TX1	15	31,62	1
TX2	15	31,62	1
TX3	14,8	30,20	1
TX4	14,7	29,51	1
TX5	14,8	30,20	1
TX6	15	31,62	1
TX7	14,9	30,90	3
TX8	15	31,62	3

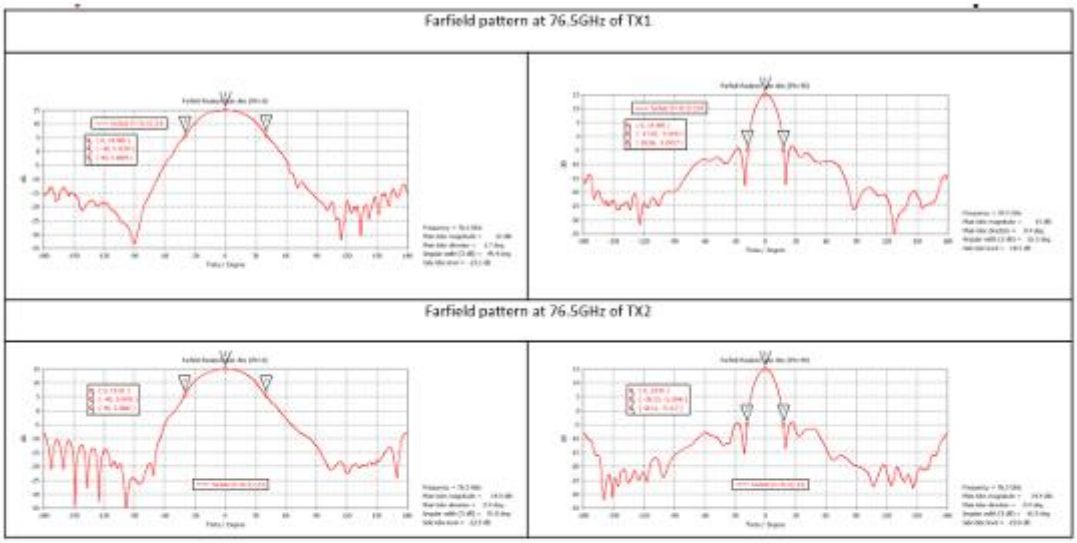
$G_{,numTx} = 10^{G(dBi)/10}$

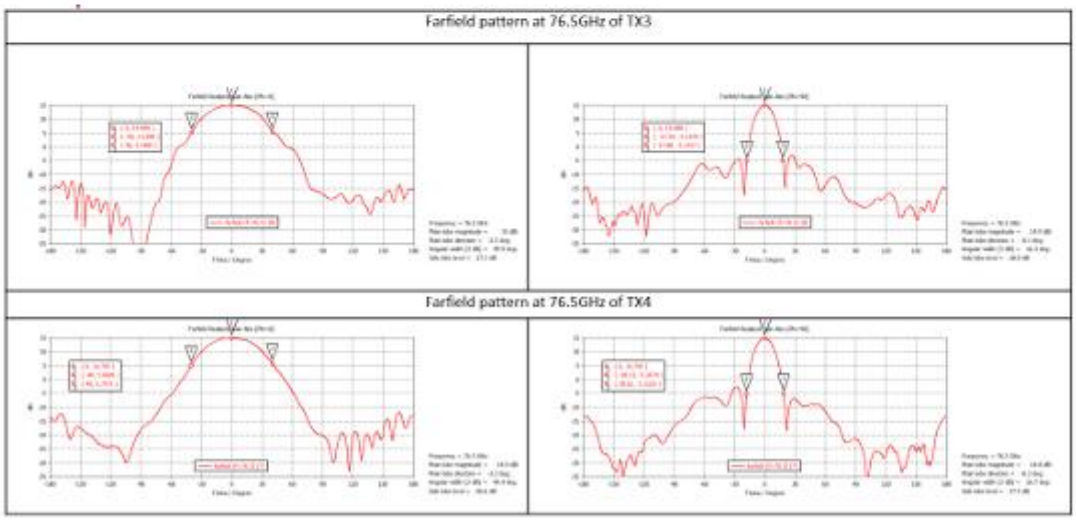
One antenna sequence consists of 12 antenna activations:
1xTX1 + 1xTX2 + 1xTX3 + 1xTX4+ 1xTX5+ 1xTX6+ 3xTX7+ 3xTX8

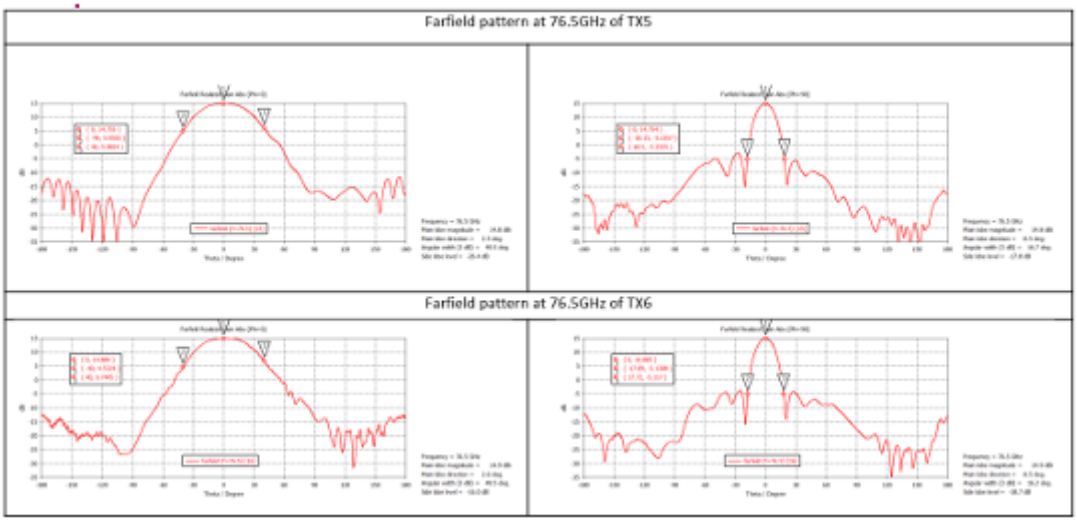
$G_{ANTtotal,num}$ =
$(1xG_{numTX1}+1xG_{numTX2}+1xG_{numTX3}+1xG_{numTX4}+1xG_{numTX5}+1xG_{numTX6}+3xG_{numTX7}+3xG_{numTX8})/12$
= (1x31,62+1x31,62+1x30,20+1x29,51+1x30,20+1x31,62+3x30,90+3x31,61)/12
= 31,03

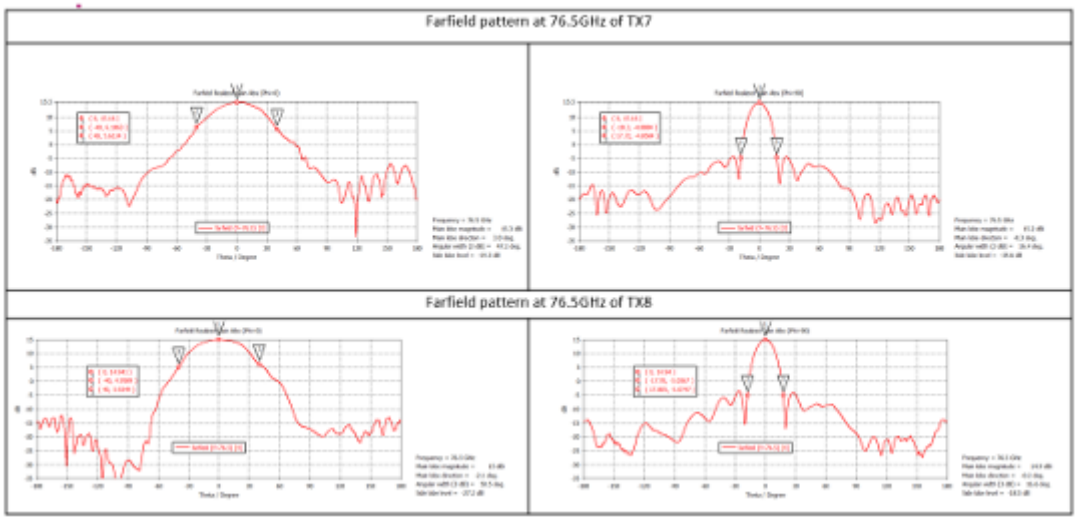
$G_{ANTtotal,dBi}$ = 10xLog($G_{ANTtotal,num}$)= 10xLog(31,03) = **14,92 dBi**

4.3 Antenna gain simulation results FR5CUEC






Farfield pattern at 76.5GHz of TX5
Farfield pattern at 76.5GHz of TX6


Farfield pattern at 76.5GHz of TX7
Farfield pattern at 76.5GHz of TX8

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	21.42 dBm mean 37.40 dBm peak	P
§2.1047	Modulation characteristics	Nominal		N/P
§2.1049	Occupied bandwidth	Nominal	863.112 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

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.

Test procedure

Peak Power

Method with a spectrum analyser

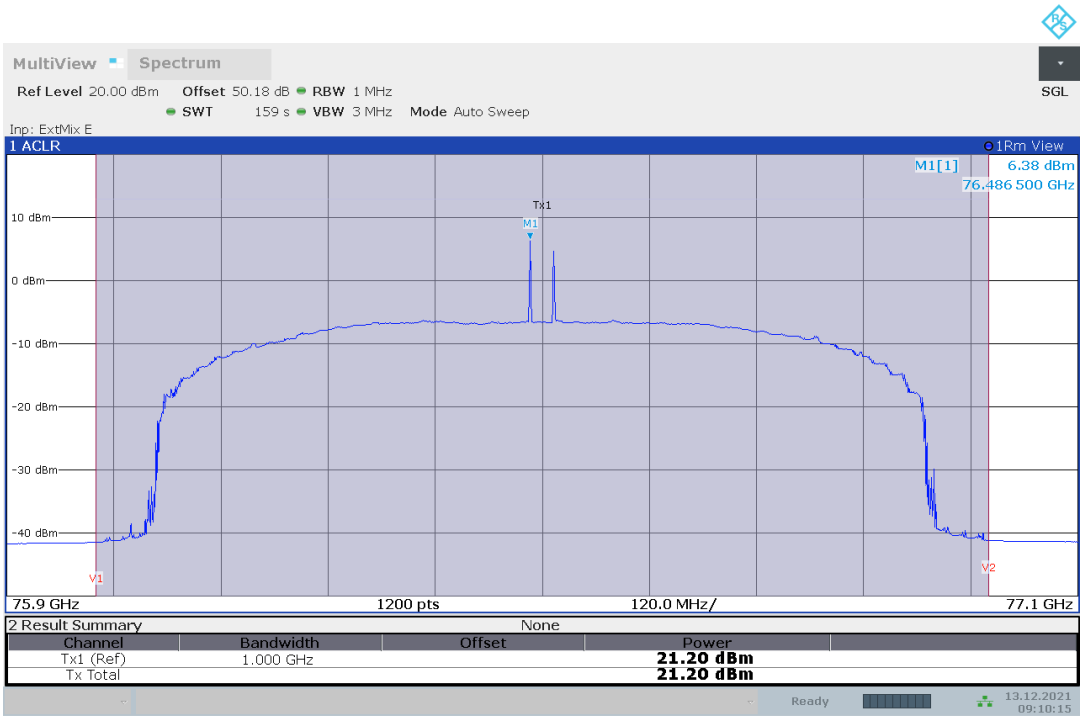
A spectrum analyser with the following settings is used as measuring receiver in the test set-up:

- 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.
- Averaging time: none, due to peak detector
- Sweep time: auto
- Measurement is done until trace is stabilised

The peak power to be considered is the maximum value recorded.

Test setup: 8.3			
Test results:			
EUT mode	**Test distance**	**Radiated Mean Power (EIRP) [dBm]**	**Radiated Peak Power (EIRP) [dBm]**
1	1 m	21.20	36.81
2	1 m	21.41	**37.40**
4	1 m	**21.42**	37.05

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



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Plot no. 2: Mean Power EIRP, RMS detector / Channel Power, EUT Mode 2

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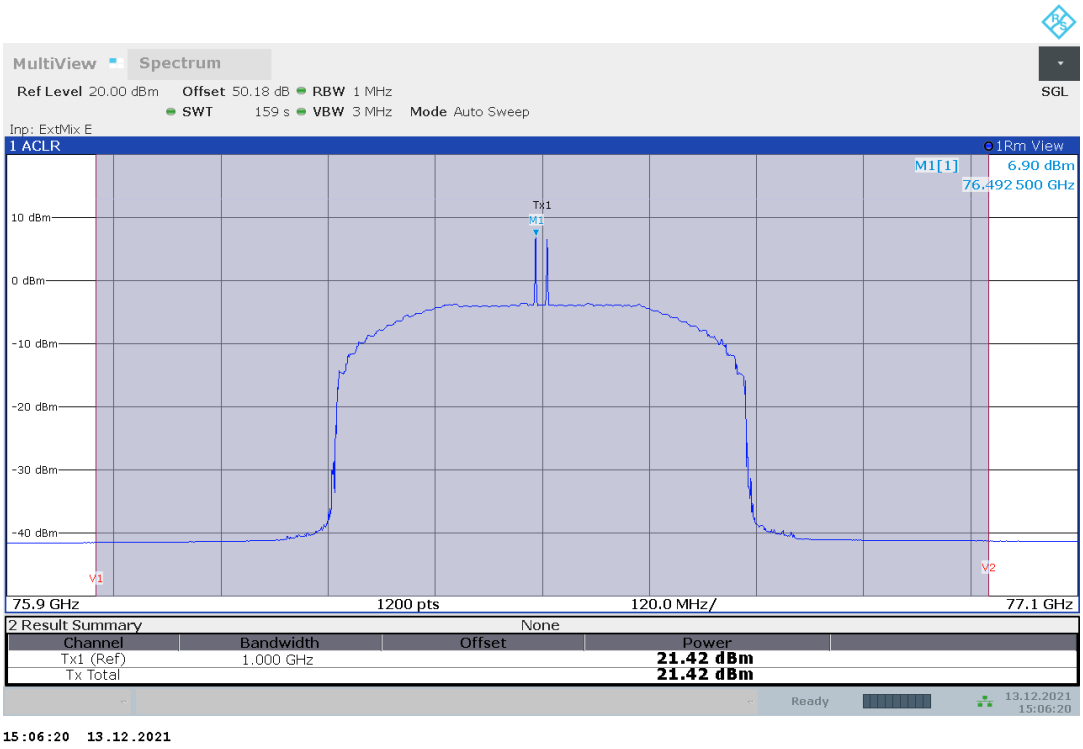
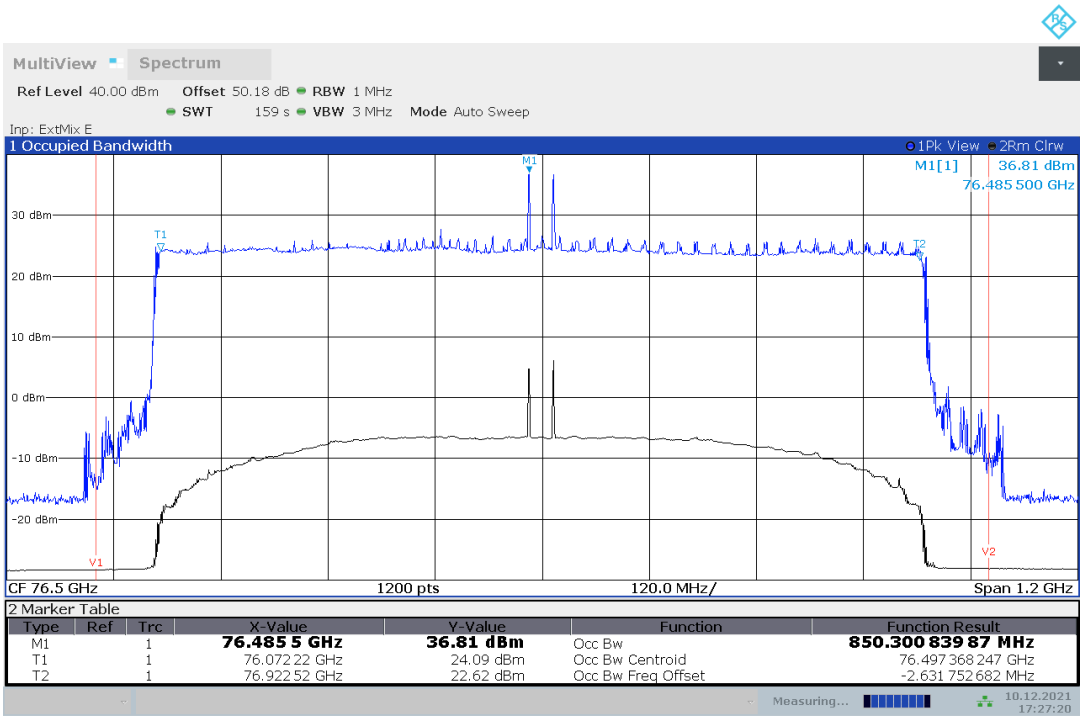
Plot no. 3: Mean Power EIRP, RMS detector / Channel Power, EUT Mode 4



Plot no. 4: Peak Power EIRP, Peak detector, EUT Mode 1



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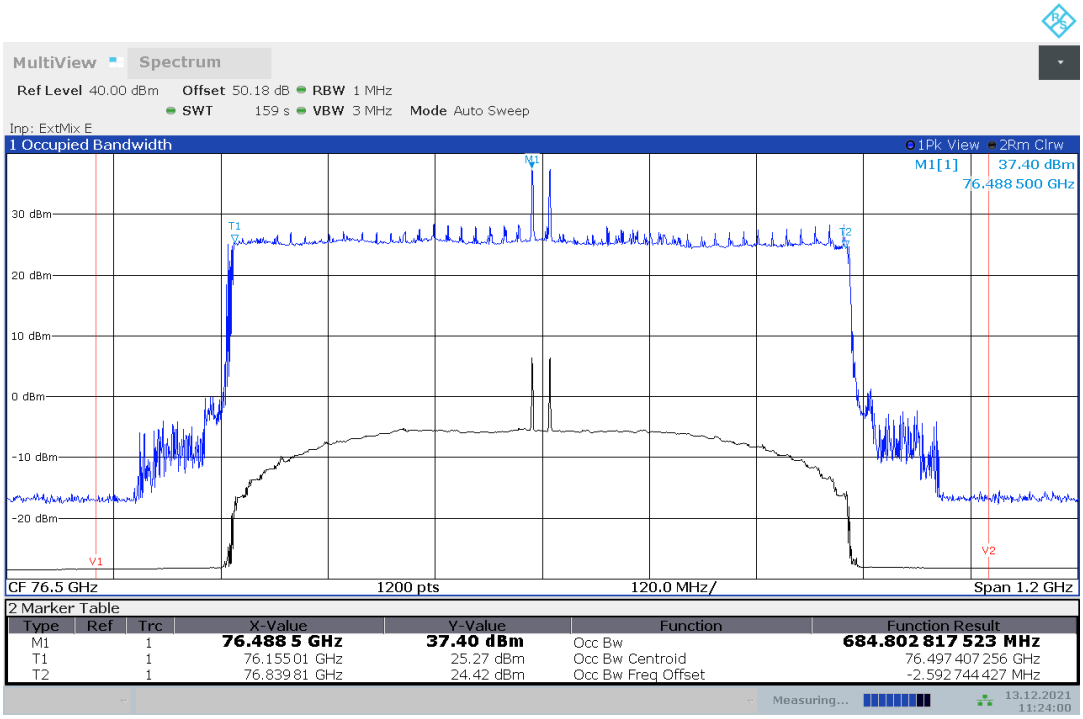
Plot no. 5: Peak Power EIRP, Peak detector, EUT Mode 2



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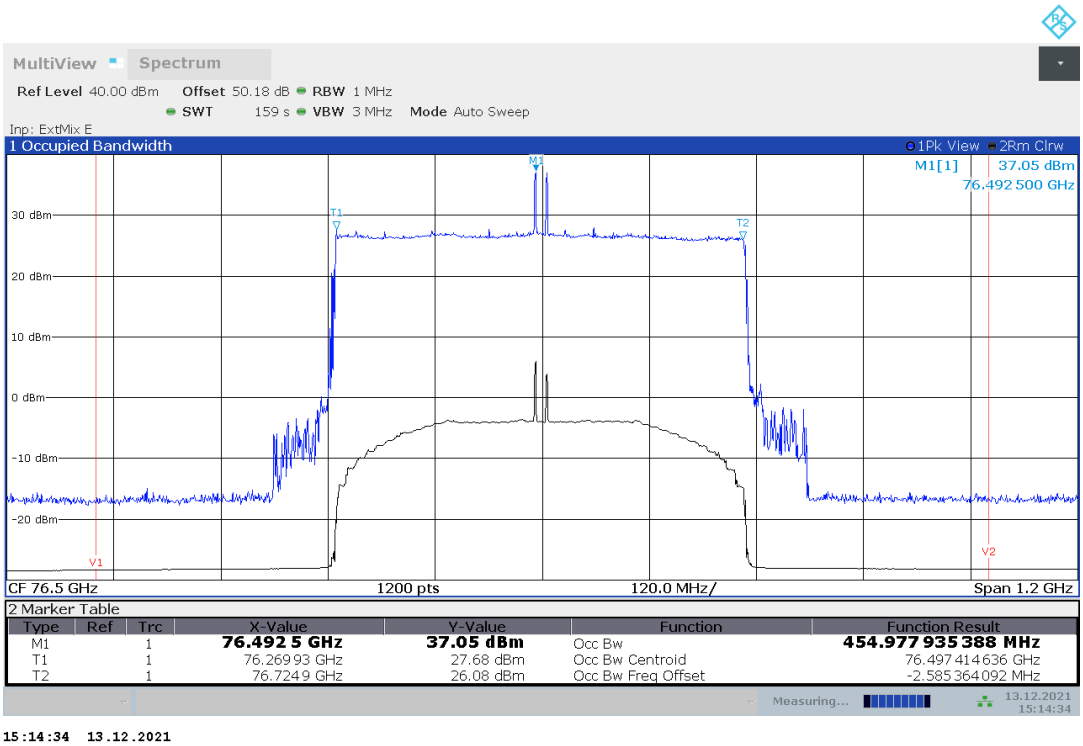
Plot no. 6: Peak Power EIRP, Peak detector, EUT Mode 4



7.2 Modulation characteristics (§2.1047 & KDB 653005 D01 76-81 GHz Radars v01r01)

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 V01r01:

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 5.5

7.3 Occupied bandwidth (§2.1049)

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

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

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) ay 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)

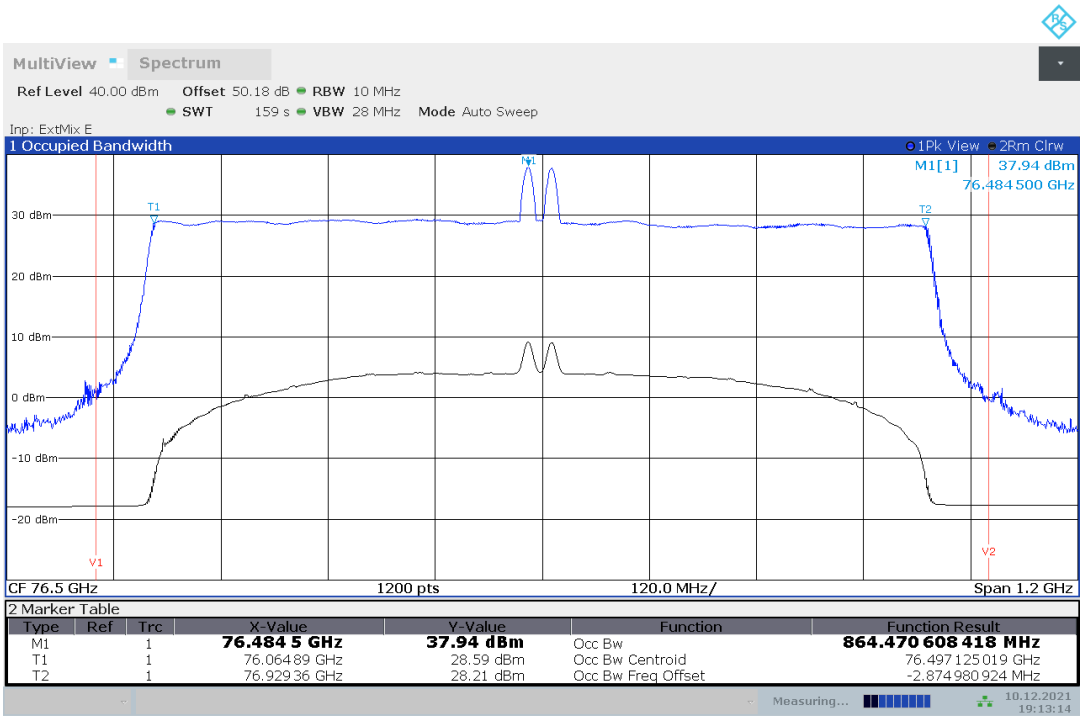
Note

-none

Test setup: 8.3, 8.4

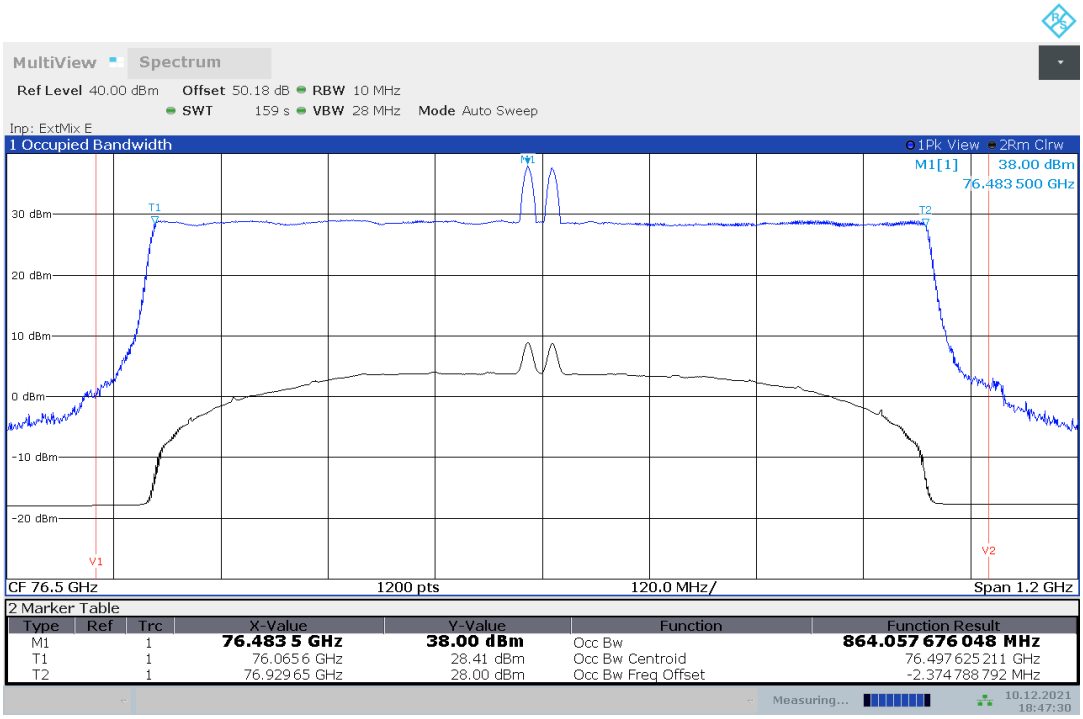
Test results under normal and extreme test conditions:				
EUT mode	**Test conditions**	**f_L [GHz]**	**f_H [GHz]**	**99% OBW [MHz]**
1	85 °C	76.065	76.929	864.470
1	50 °C	76.065	76.929	864.057
1	40 °C	76.065	76.931	865.687
1	30 °C	76.066	76.930	864.499
1	20 °C / V_{min}	76.066	76.930	863.425
1	20 °C / V_{nom}	76.067	76.930	863.112
1	20 °C / V_{max}	76.066	76.930	864.248
1	10 °C	76.067	76.933	865.683
1	0 °C	76.067	76.931	863.169
1	-10 °C	76.067	76.932	864.991
1	-20 °C	76.068	76.933	865.516
1	-30 °C	76.068	76.933	864.285
1	-40 °C	76.068	76.932	864.364
2	85 °C	76.146	76.846	700.044
2	50 °C	76.147	76.844	697.281
2	40 °C	76.147	76.845	698.271
2	30 °C	76.147	76.846	699.081
2	20 °C / V_{min}	76.148	76.846	698.561
2	20 °C / V_{nom}	76.148	76.849	701.653
2	20 °C / V_{max}	76.147	76.847	700.079
2	10 °C	76.148	76.848	699.685
2	0 °C	76.148	76.847	699.156
2	-10 °C	76.147	76.848	700.520
2	-20 °C	76.149	76.849	699.881
2	-30 °C	76.150	76.849	699.113
2	-40 °C	76.150	76.848	697.935
4	85 °C	76.262	76.729	467.185
4	50 °C	76.262	76.730	467.672
4	40 °C	76.263	76.731	467.562
4	30 °C	76.263	76.731	467.557
4	20 °C / V_{min}	76.263	76.731	467.401
4	20 °C / V_{nom}	76.264	76.731	467.544
4	20 °C / V_{max}	76.263	76.731	467.608
4	10 °C	76.264	76.732	467.299
4	0 °C	76.265	76.732	467.252
4	-10 °C	76.266	76.733	467.157
4	-20 °C	76.265	76.733	468.253
4	-30 °C	76.266	76.733	467.881
4	-40 °C	76.265	76.733	468.118
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, Test Mode 1



19:13:15 10.12.2021

Plot no. 8: 99% OBW, Peak detector, 50 °C, Test Mode 1



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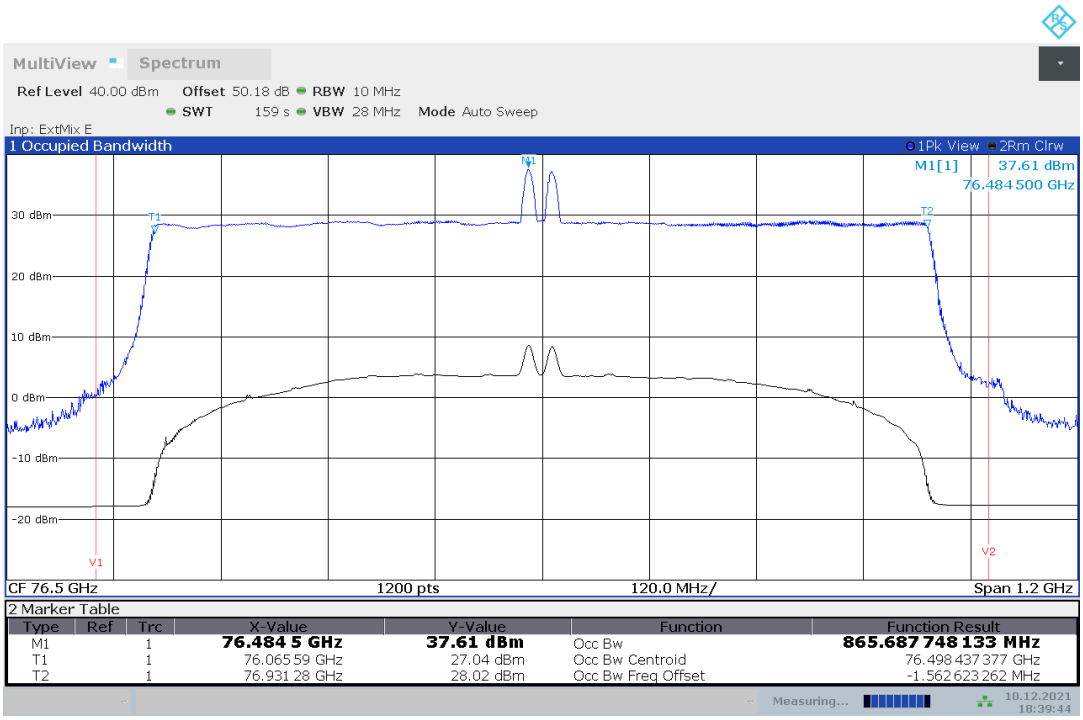
Plot no. 9: 99% OBW, Peak detector, 40 °C, Test Mode 1



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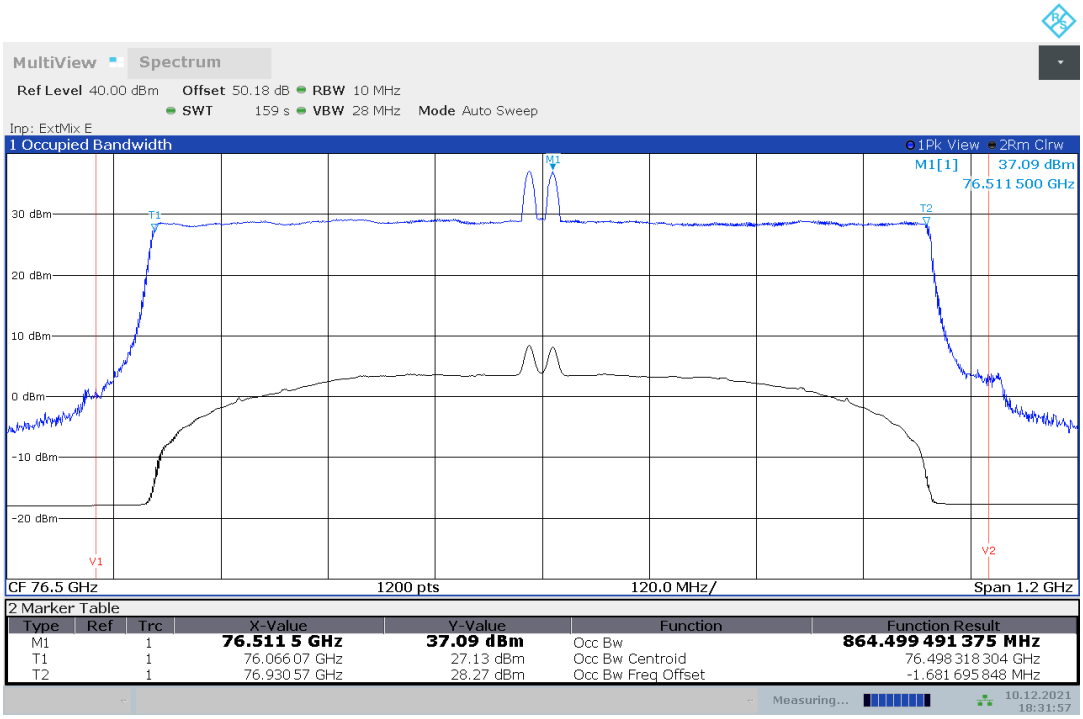
Plot no. 10: 99% OBW, Peak detector, 30 °C, Test Mode 1



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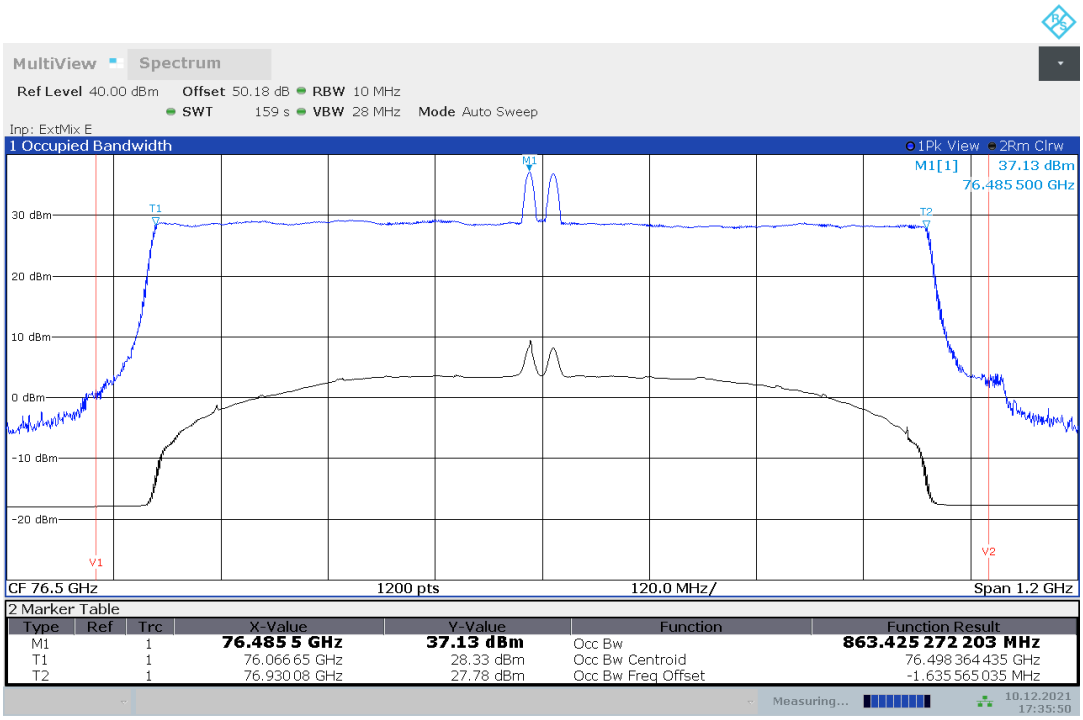
Plot no. 11: 99% OBW, Peak detector, 20 °C, V_{min}, Test Mode 1



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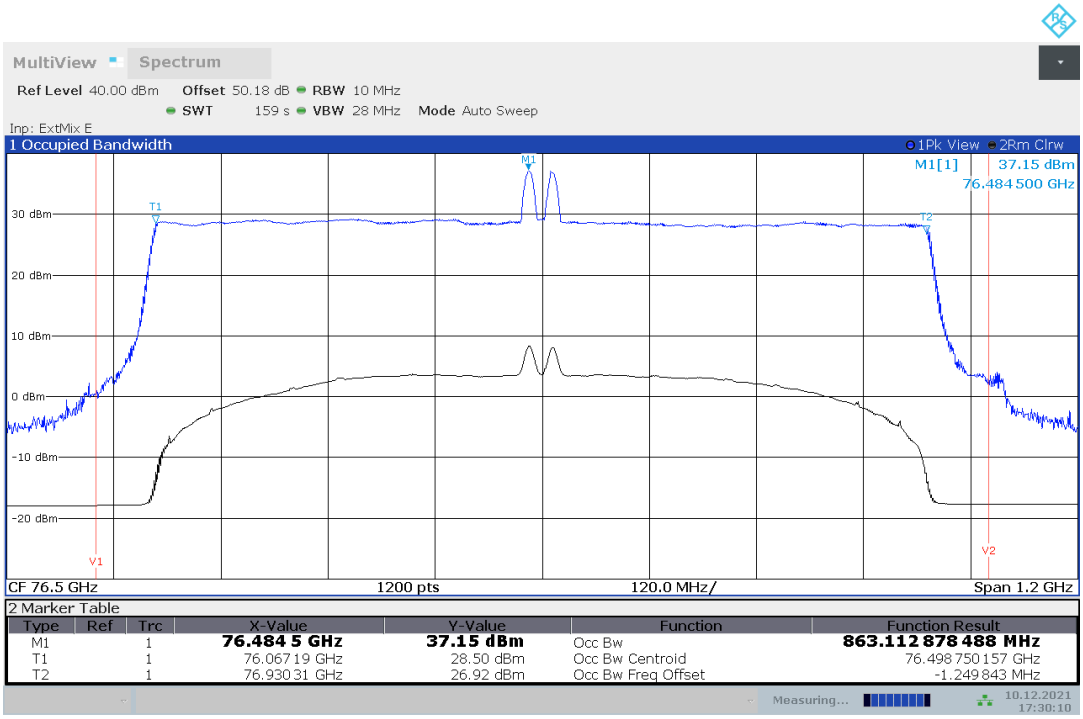
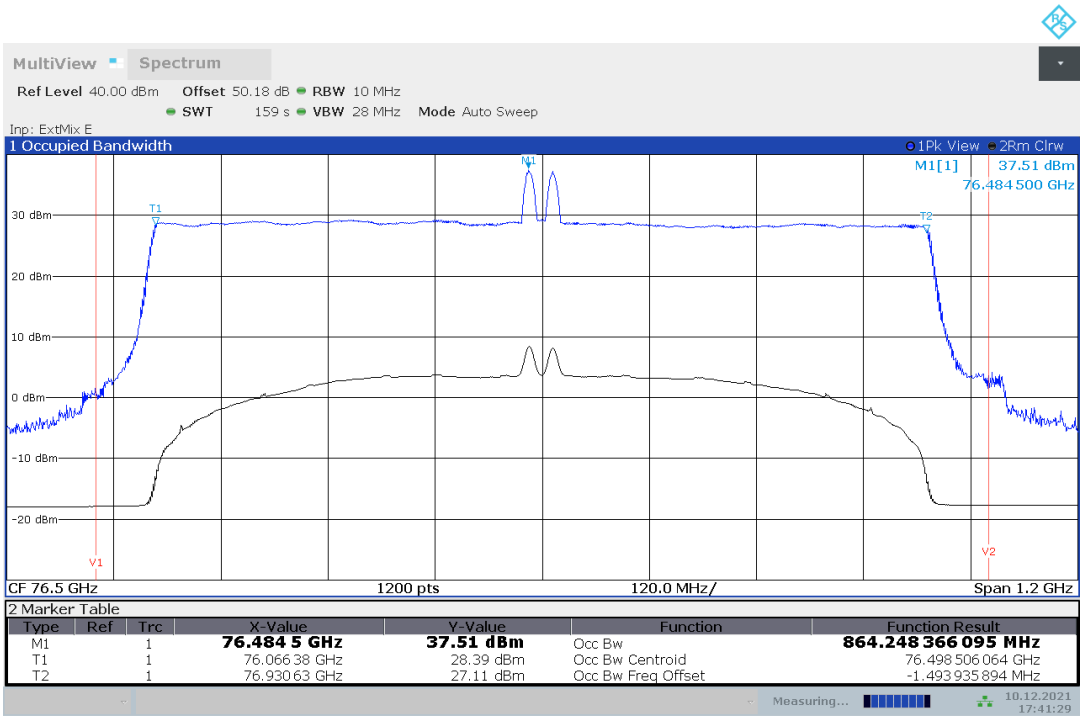
Plot no. 12: 99% OBW, Peak detector, 20 °C, V_{nom}, Test Mode 1



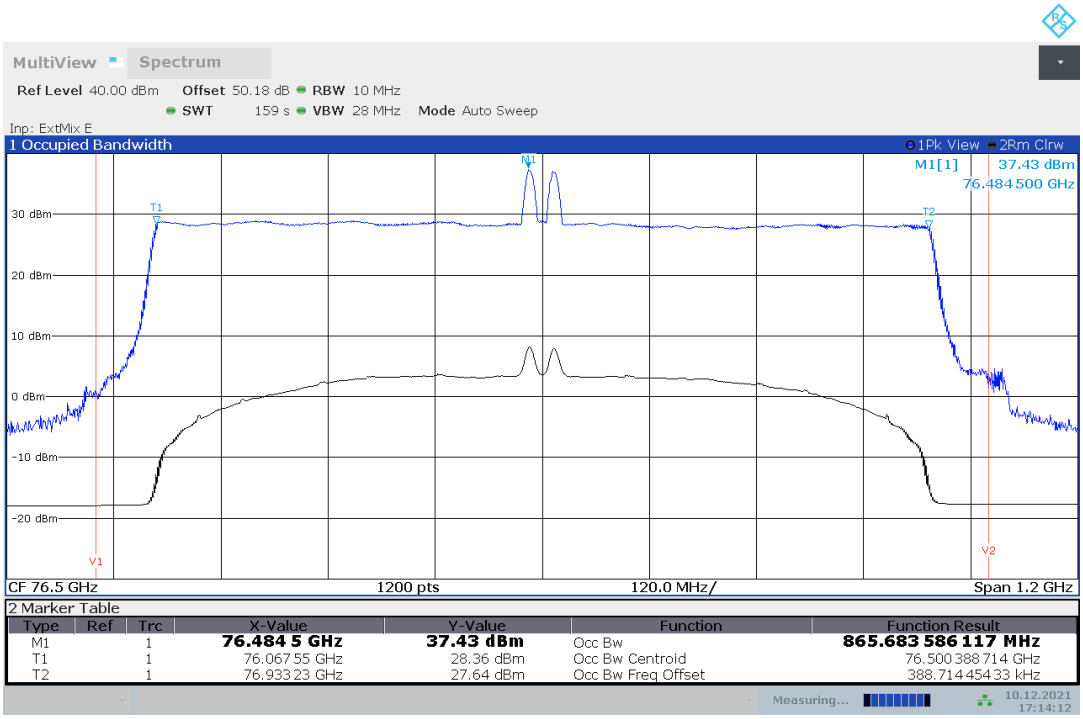
17:30:10 10.12.2021

Plot no. 13: 99% OBW, Peak detector, 20 °C, V_{max}, Test Mode 1



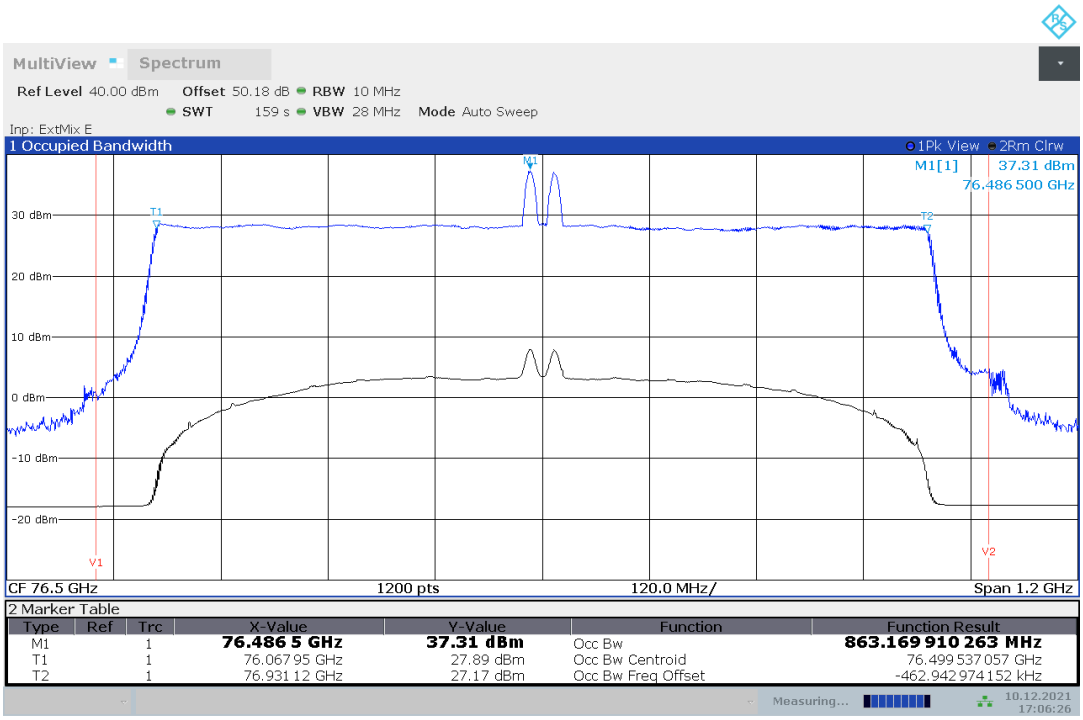
17:41:29 10.12.2021

Plot no. 14: 99% OBW, Peak detector, 10 °C, Test Mode 1



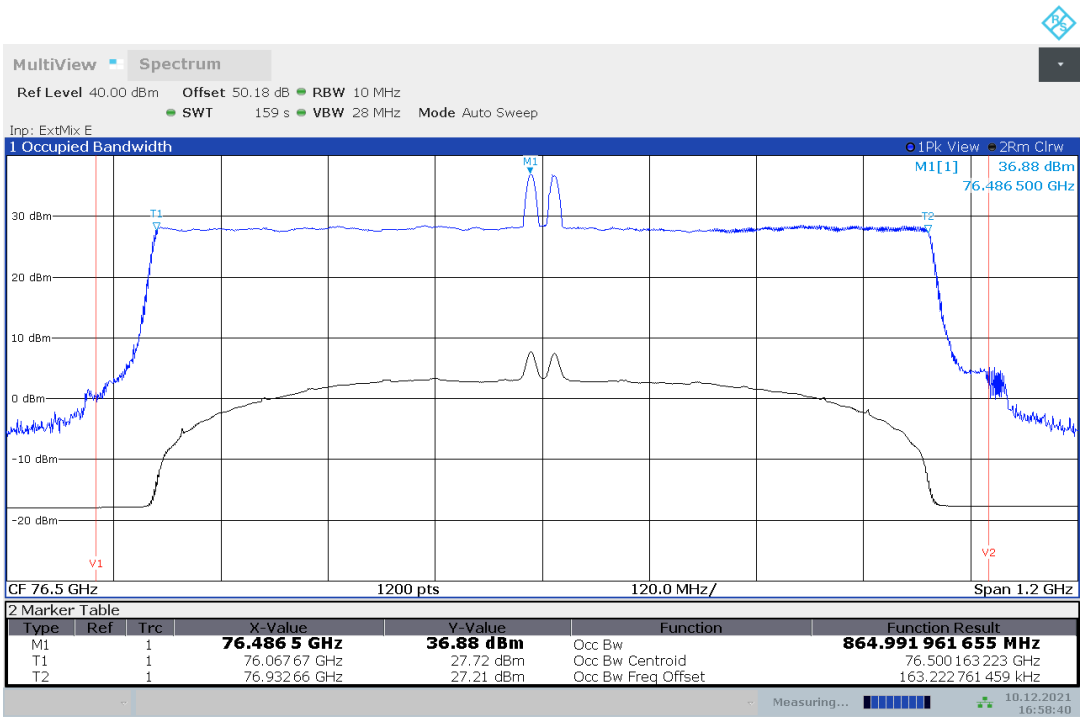
17:14:13 10.12.2021

Plot no. 15: 99% OBW, Peak detector, 0 °C, Test Mode 1



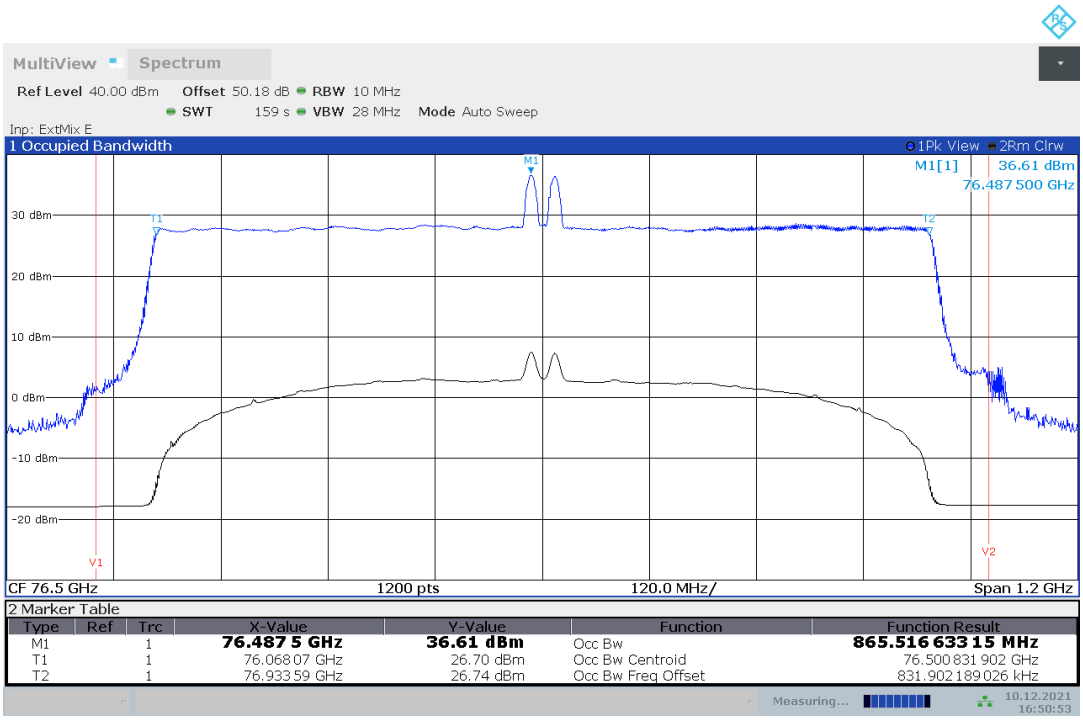
17:06:27 10.12.2021

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



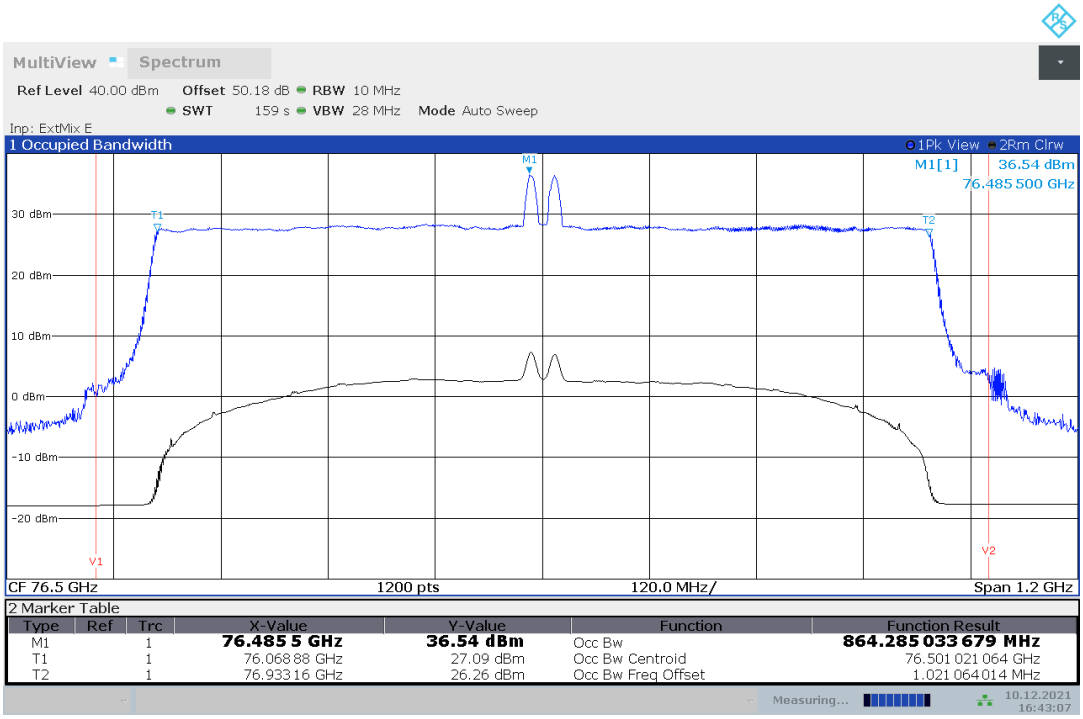
16:58:41 10.12.2021

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



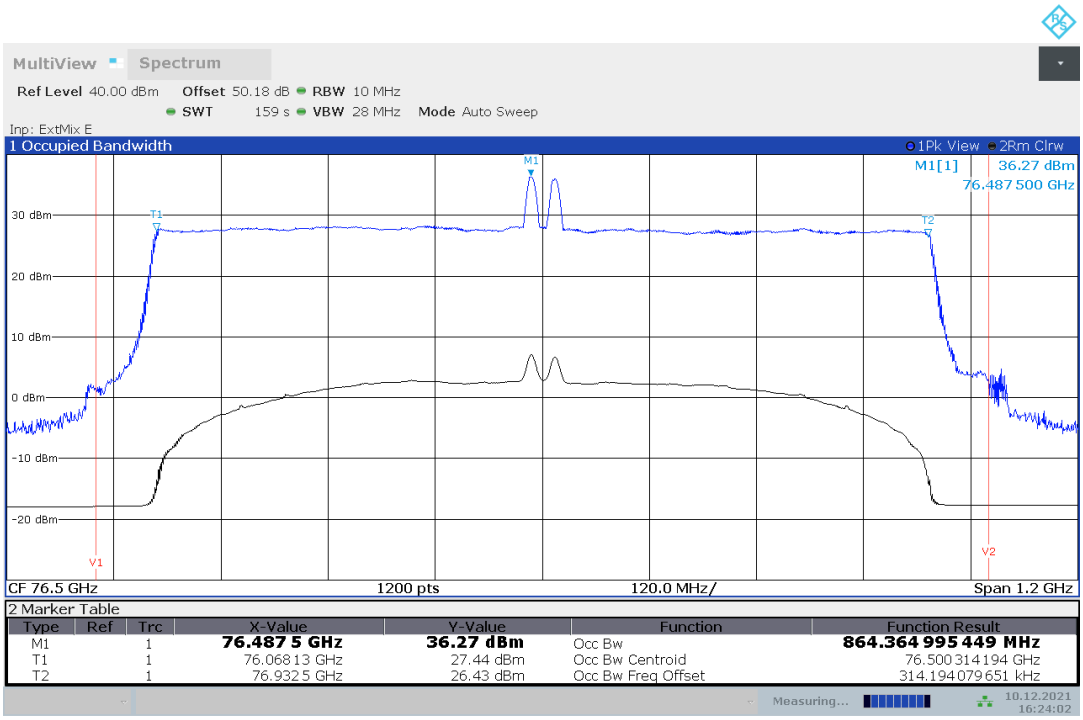
16:50:54 10.12.2021

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

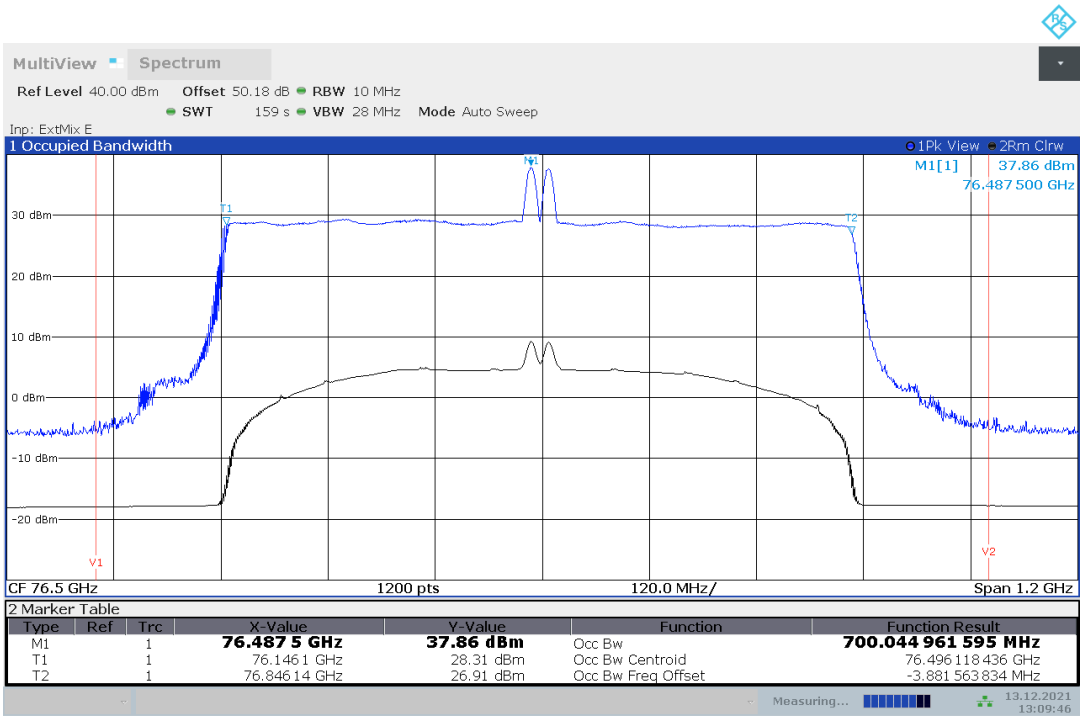


16:43:08 10.12.2021

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

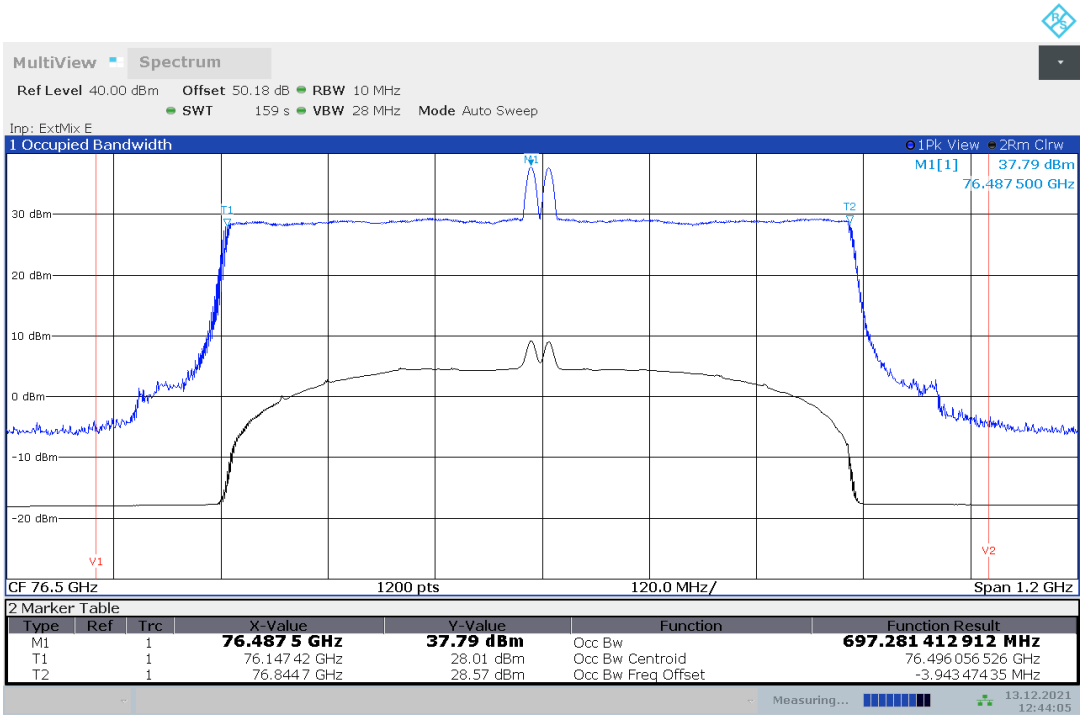


Plot no. 20: 99% OBW, Peak detector, 85 °C, Test Mode 2



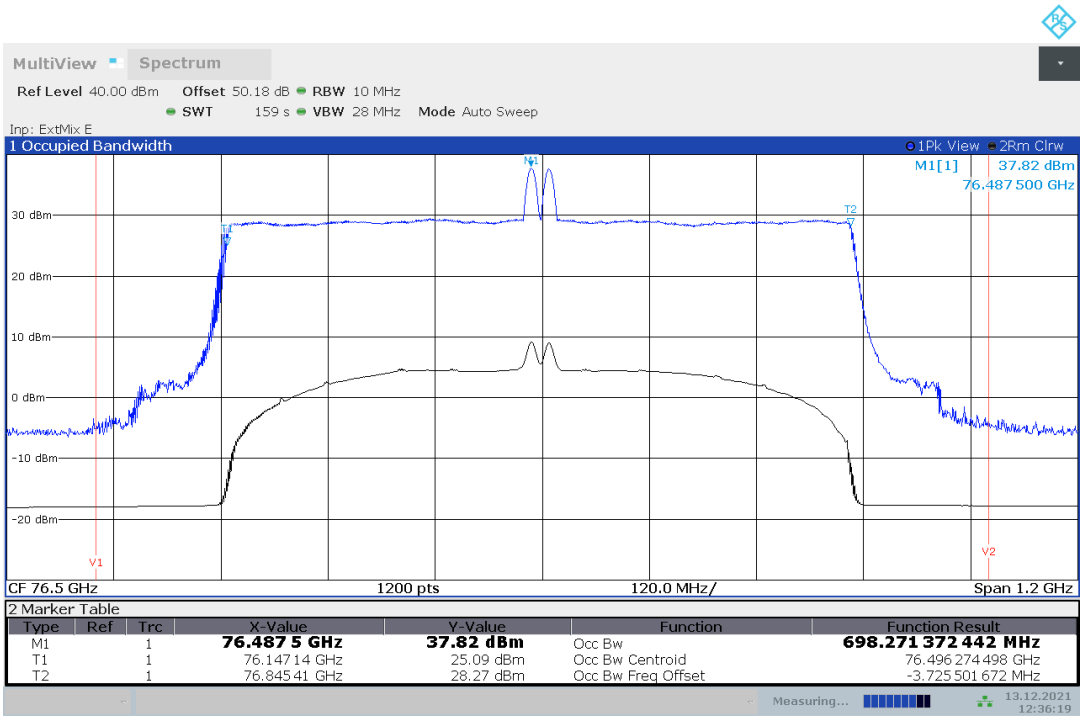
13:09:47 13.12.2021

Plot no. 21: 99% OBW, Peak detector, 50 °C, Test Mode 2



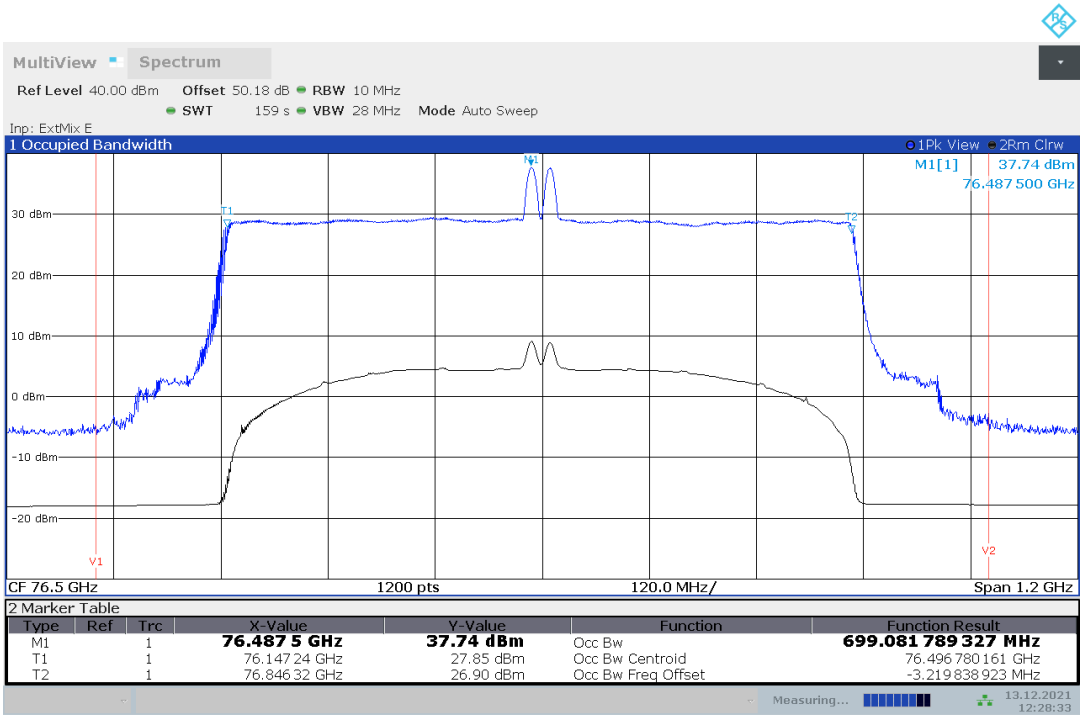
12:44:06 13.12.2021

Plot no. 22: 99% OBW, Peak detector, 40 °C, Test Mode 2



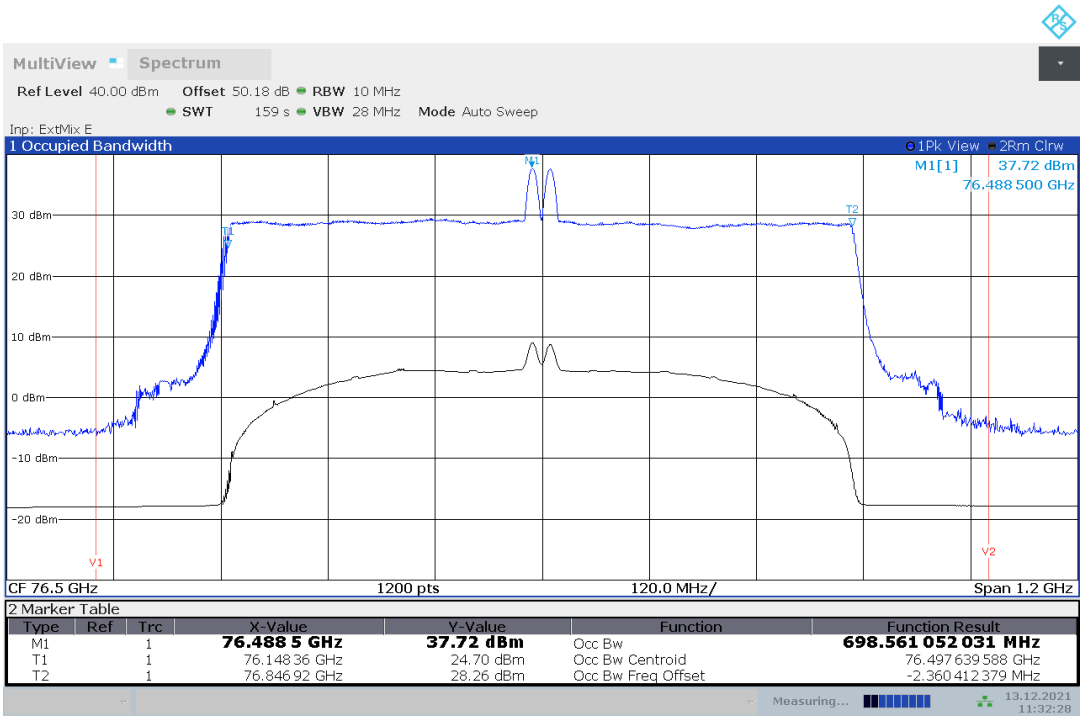
12:36:20 13.12.2021

Plot no. 23: 99% OBW, Peak detector, 30 °C, Test Mode 2



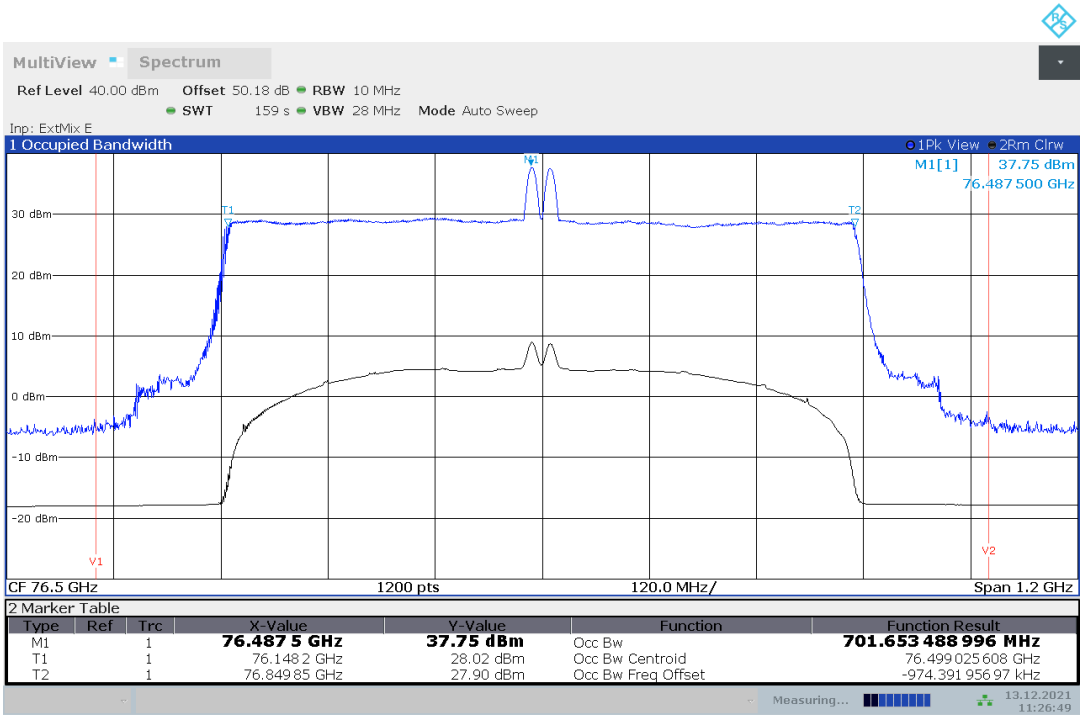
12:28:34 13.12.2021

Plot no. 24: 99% OBW, Peak detector, 20 °C, V_{min}, Test Mode 2



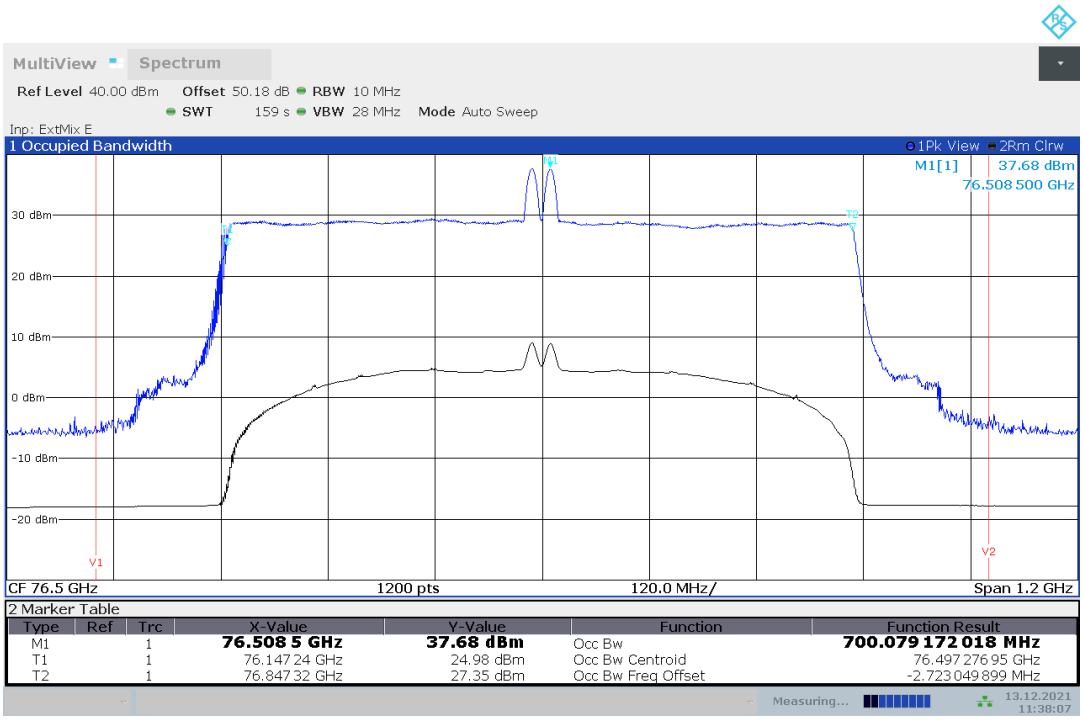
11:32:28 13.12.2021

Plot no. 25: 99% OBW, Peak detector, 20 °C, V_{nom}, Test Mode 2



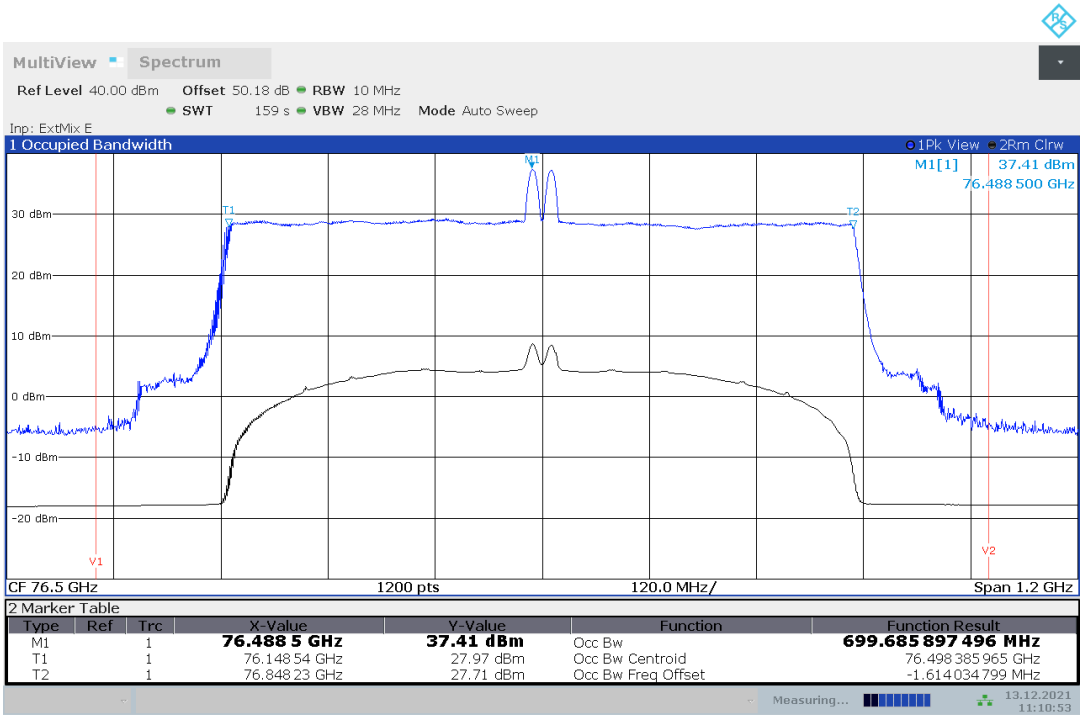
11:26:49 13.12.2021

Plot no. 26: 99% OBW, Peak detector, 20 °C, V_{max}, Test Mode 2



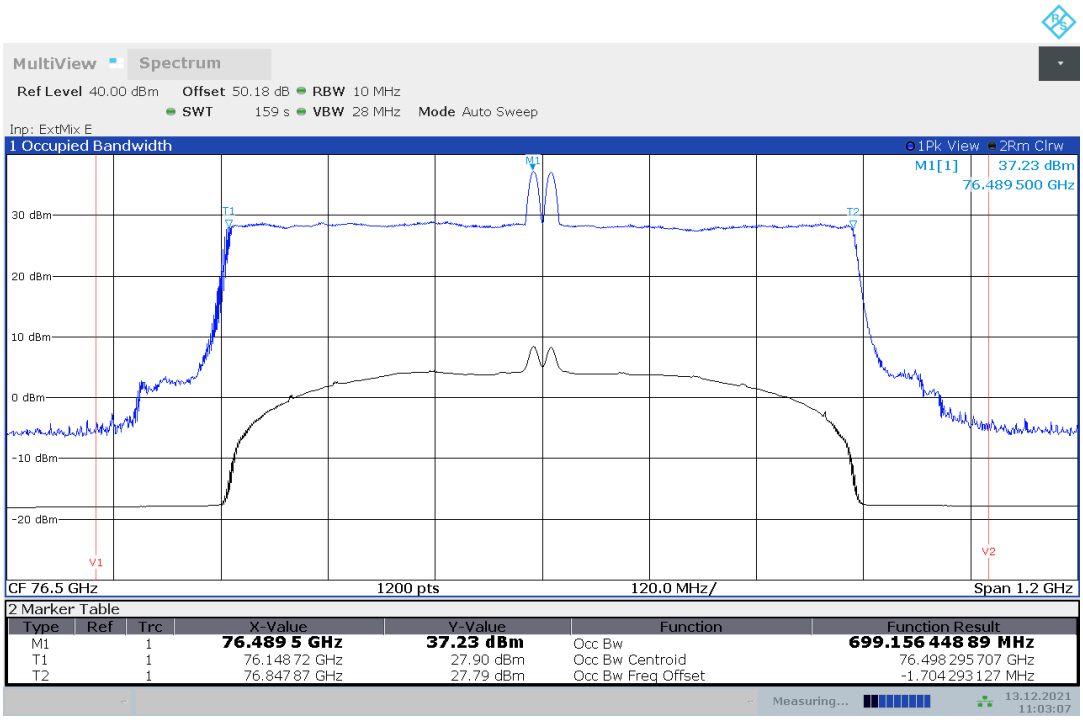
11:38:07 13.12.2021

Plot no. 27: 99% OBW, Peak detector, 10 °C, Test Mode 2



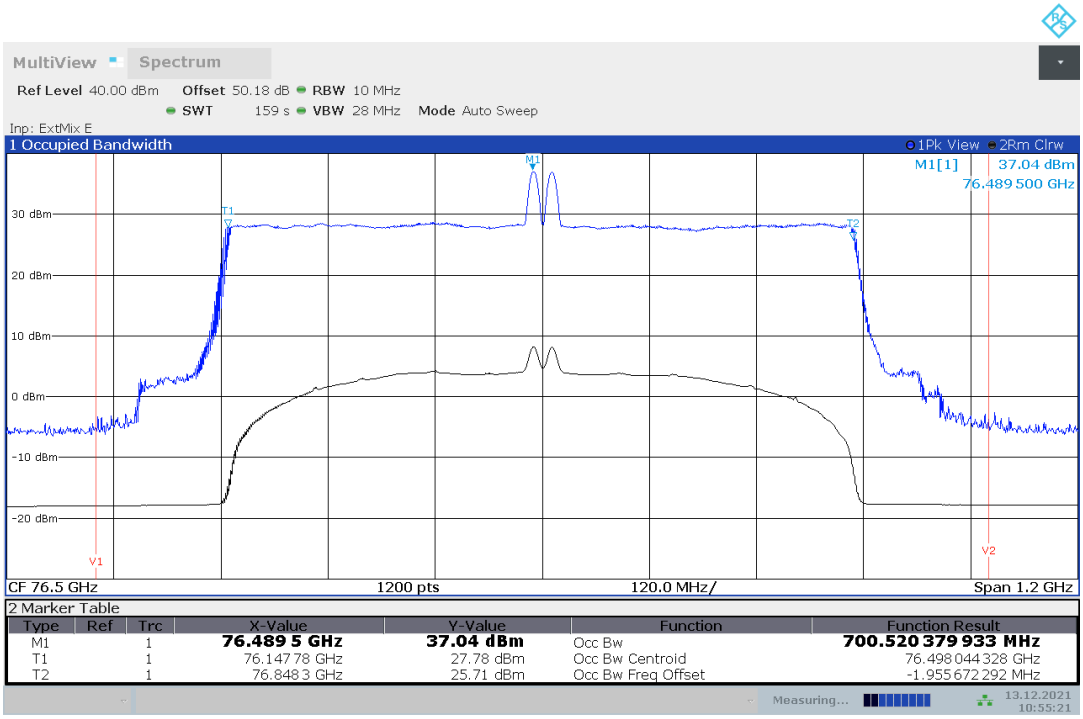
11:10:54 13.12.2021

Plot no. 28: 99% OBW, Peak detector, 0 °C, Test Mode 2



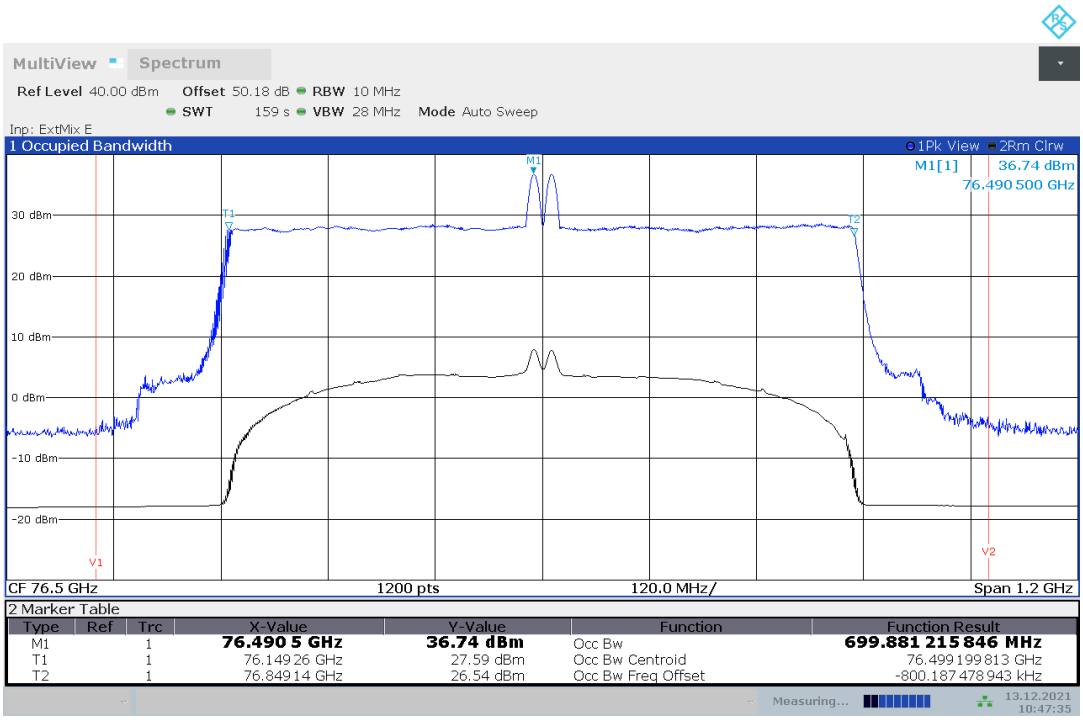
11:03:08 13.12.2021

Plot no. 29: 99% OBW, Peak detector, -10 °C, Test Mode 2



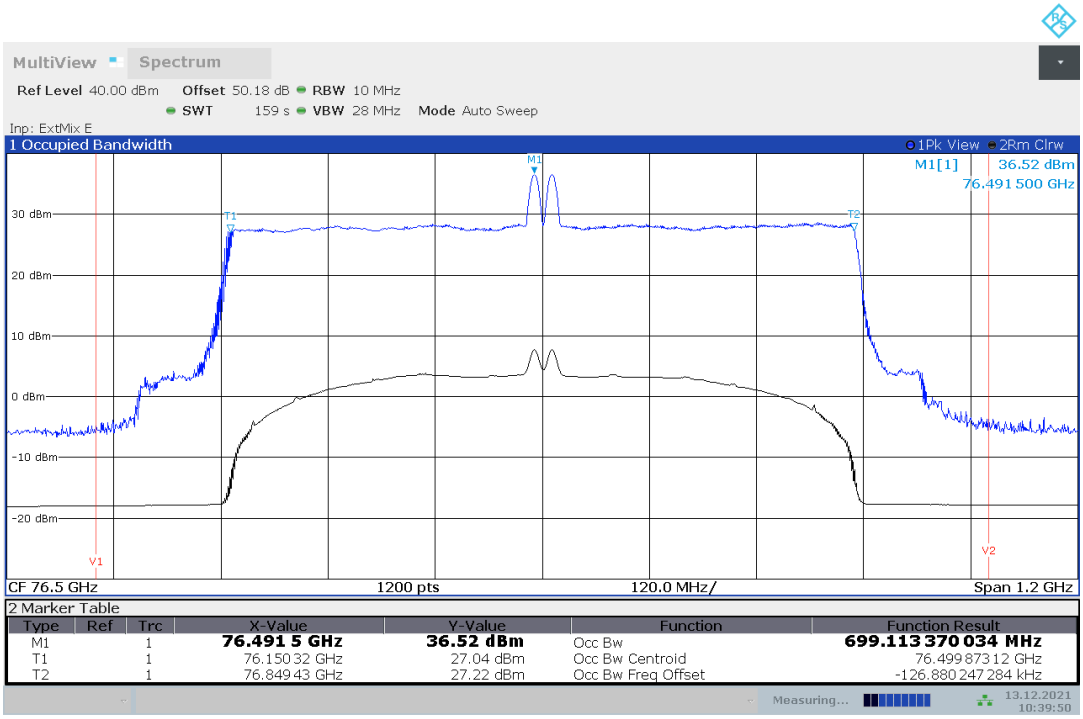
10:55:22 13.12.2021

Plot no. 30: 99% OBW, Peak detector, -20 °C, Test Mode 2



10:47:36 13.12.2021

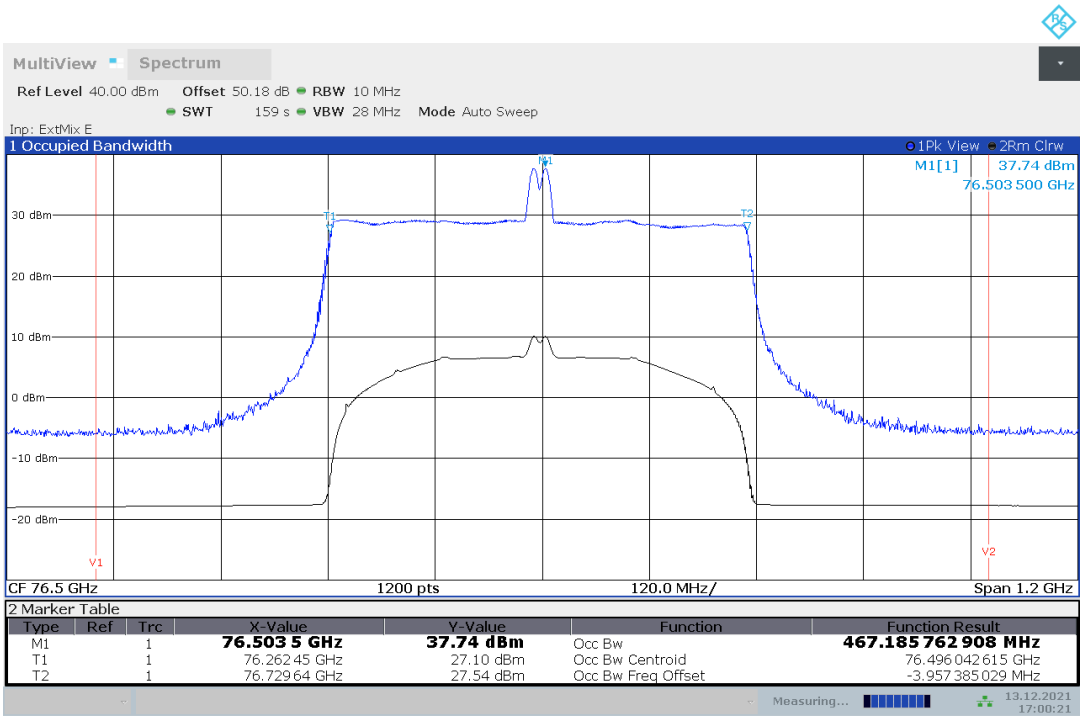
Plot no. 31: 99% OBW, Peak detector, -30 °C, Test Mode 2



10:39:50 13.12.2021

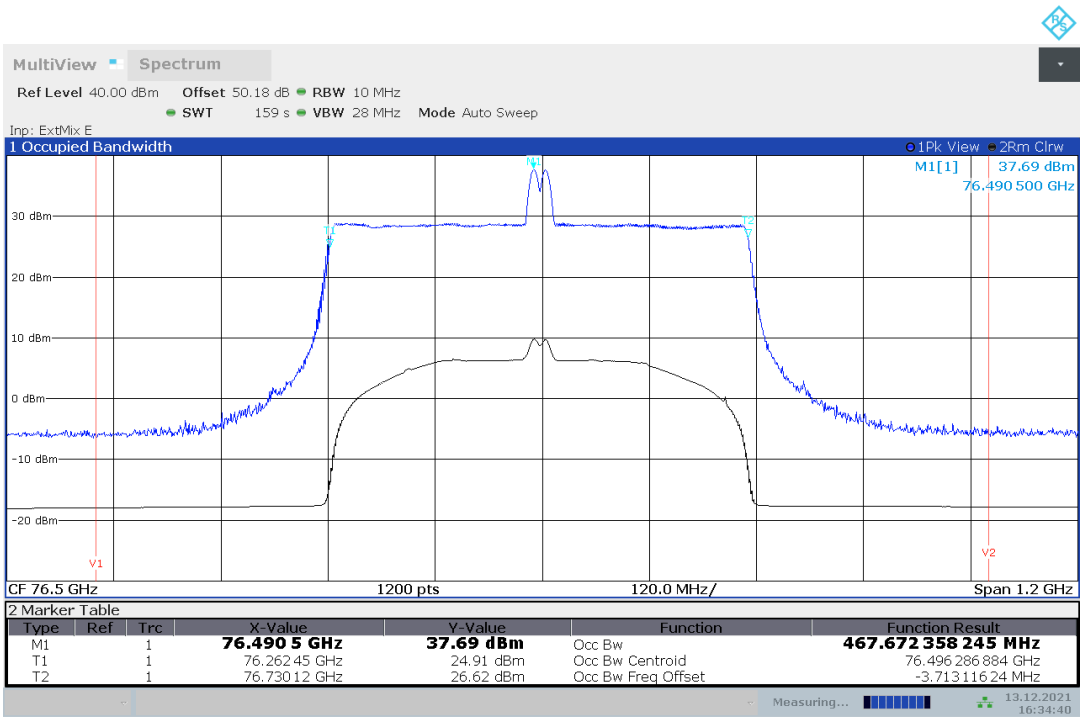
Plot no. 32: 99% OBW, Peak detector, -40 °C, Test Mode 2

Plot no. 33: 99% OBW, Peak detector, 85 °C, Test Mode 4



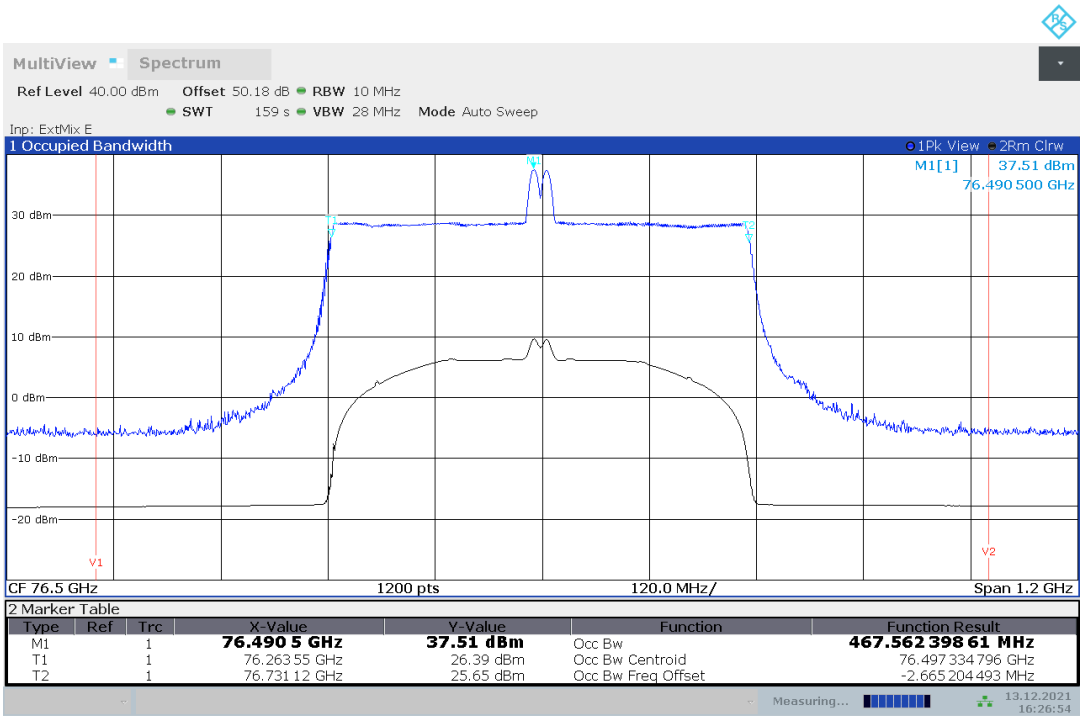
17:00:22 13.12.2021

Plot no. 34: 99% OBW, Peak detector, 50 °C, Test Mode 4



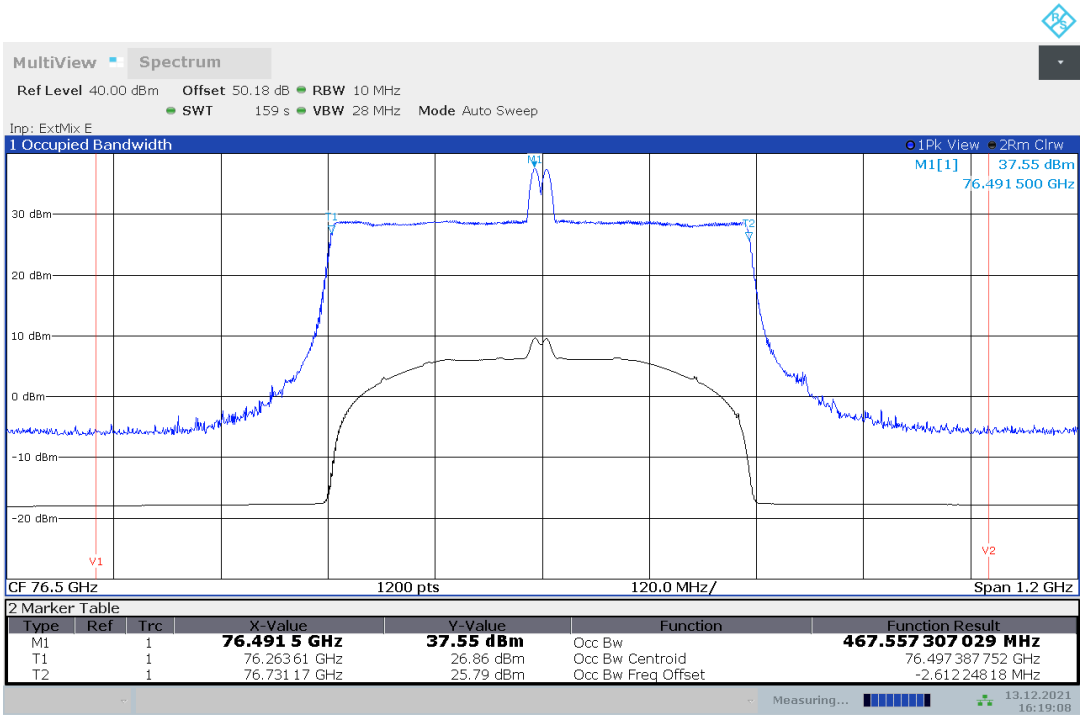
16:34:41 13.12.2021

Plot no. 35: 99% OBW, Peak detector, 40 °C, Test Mode 4



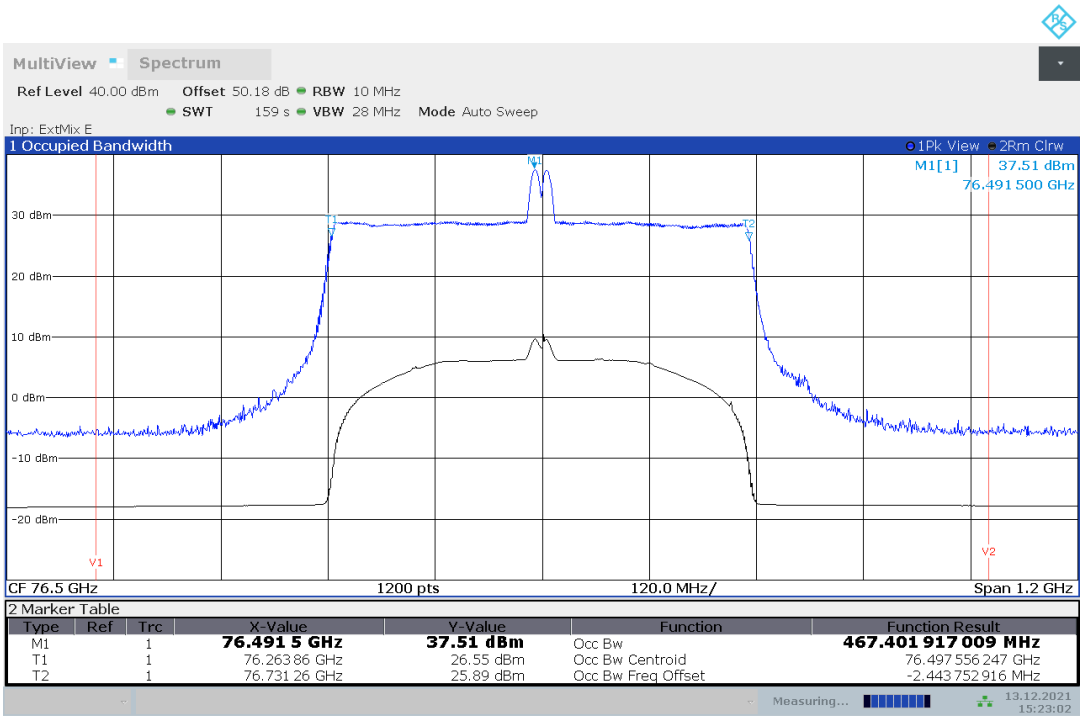
16:26:55 13.12.2021

Plot no. 36: 99% OBW, Peak detector, 30 °C, Test Mode 4



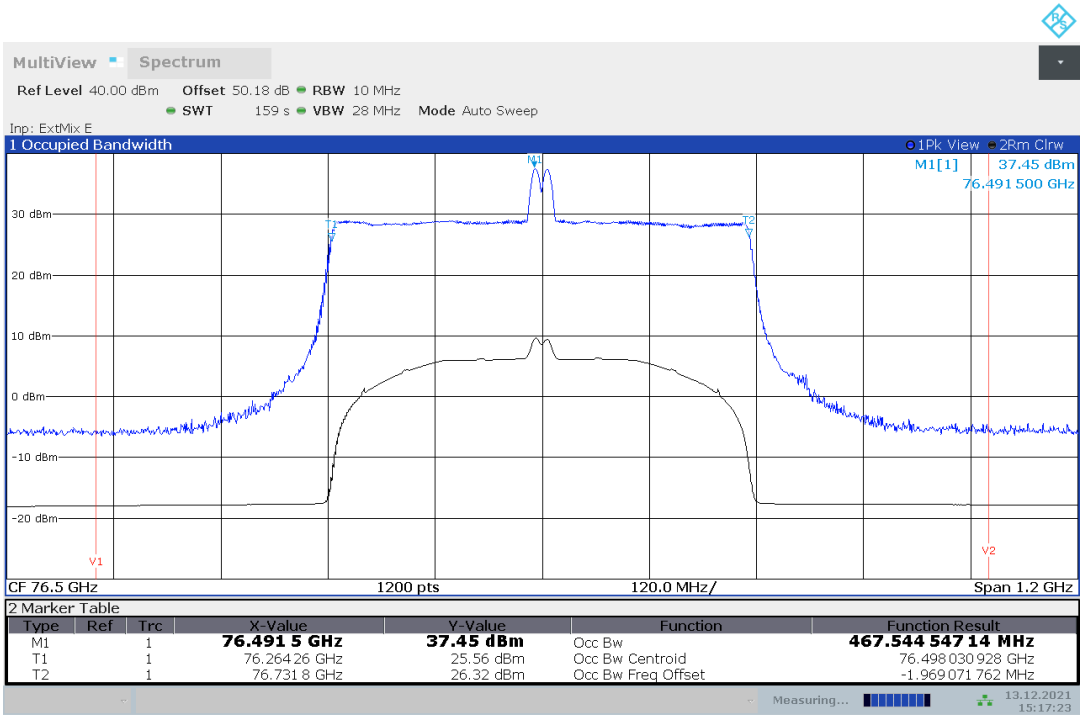
16:19:09 13.12.2021

Plot no. 37: 99% OBW, Peak detector, 20 °C, V_{min}, Test Mode 4



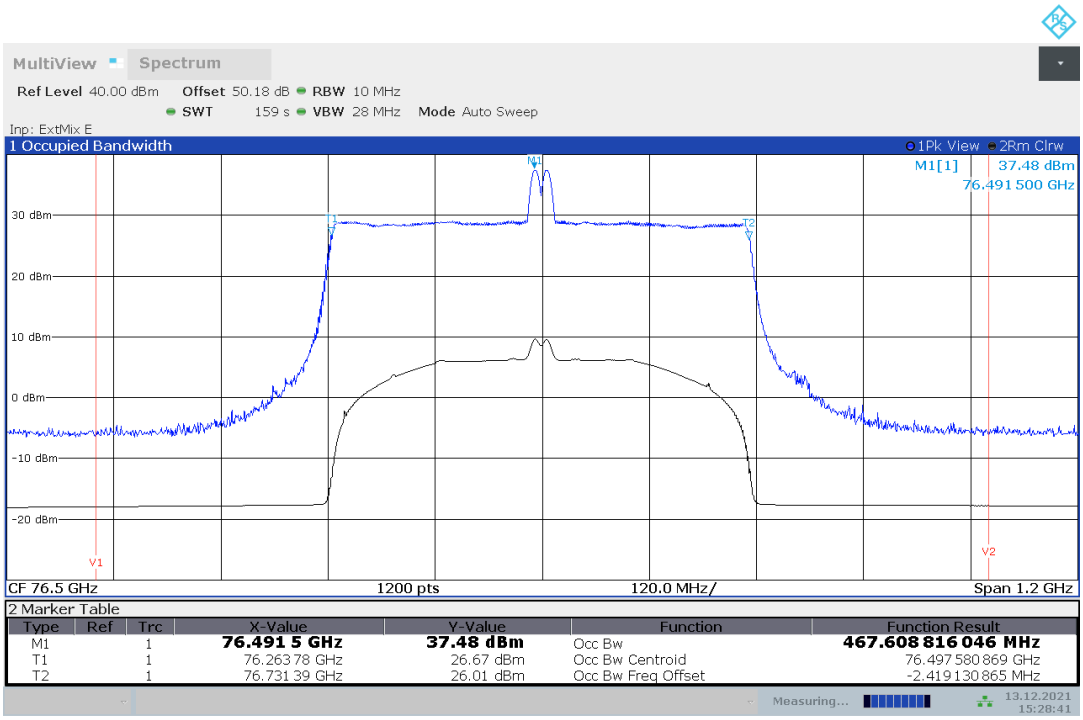
15:23:02 13.12.2021

Plot no. 38: 99% OBW, Peak detector, 20 °C, V_{nom}, Test Mode 4



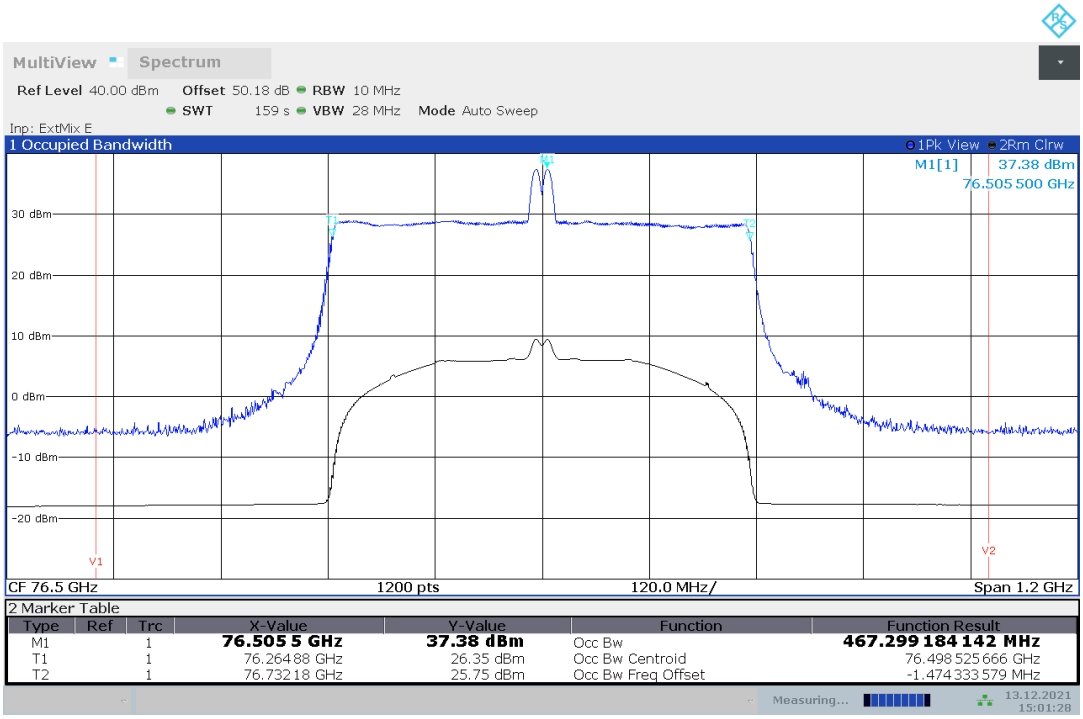
15:17:24 13.12.2021

Plot no. 39: 99% OBW, Peak detector, 20 °C, V_{max}, Test Mode 4



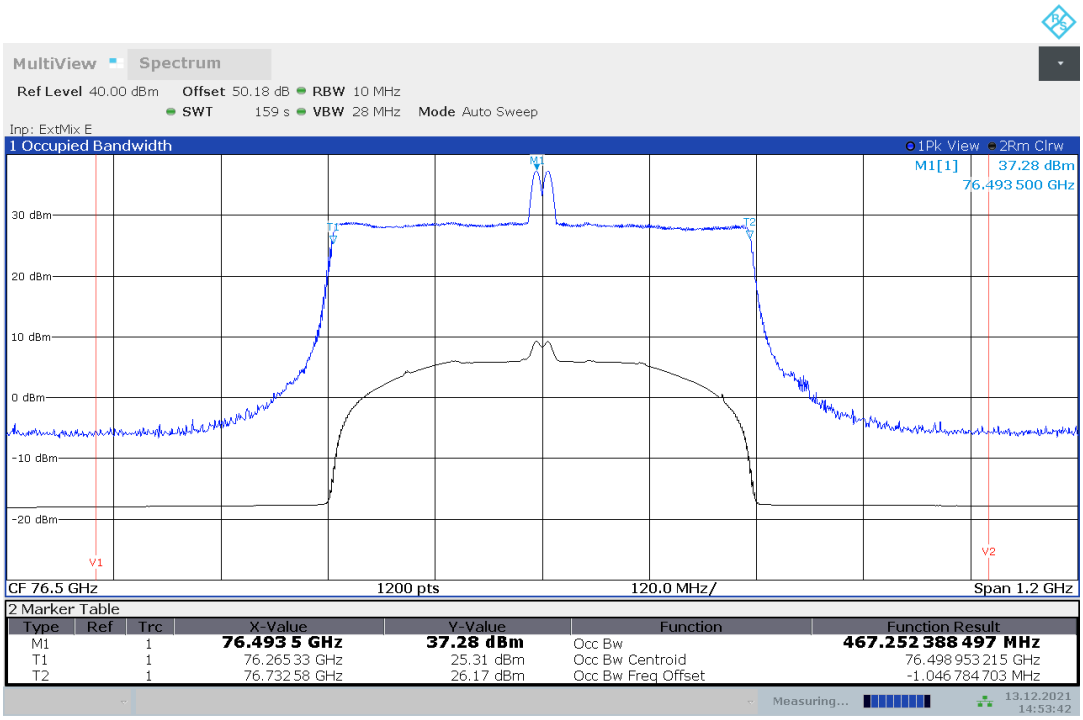
15:28:41 13.12.2021

Plot no. 40: 99% OBW, Peak detector, 10 °C, Test Mode 4



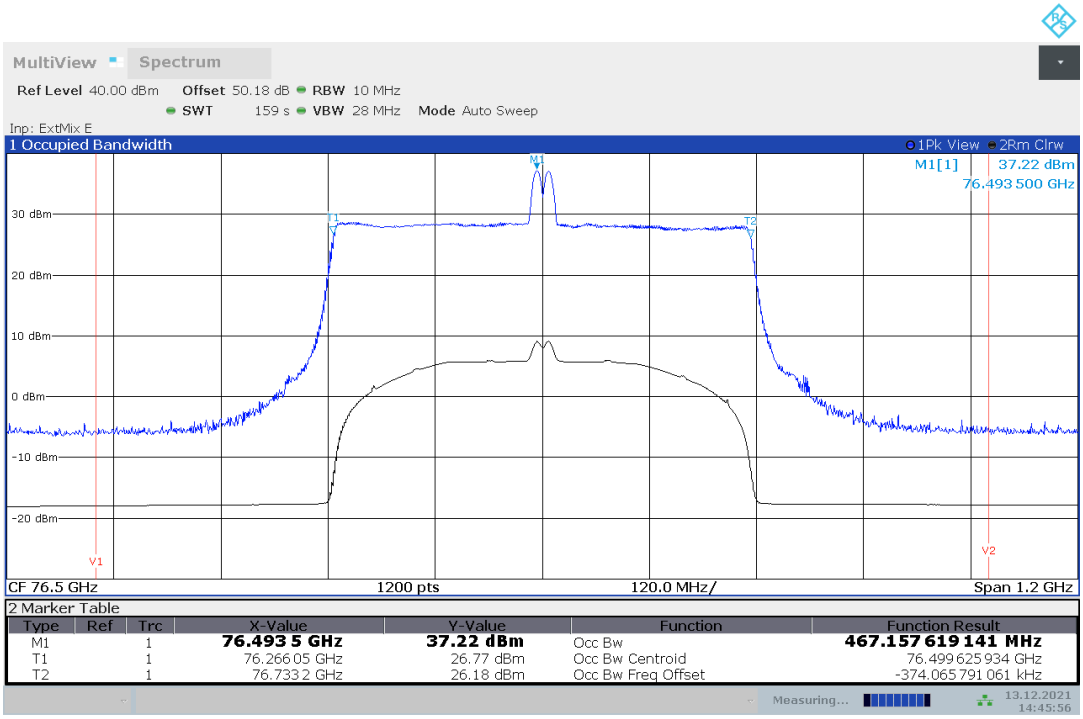
15:01:28 13.12.2021

Plot no. 41: 99% OBW, Peak detector, 0 °C, Test Mode 4



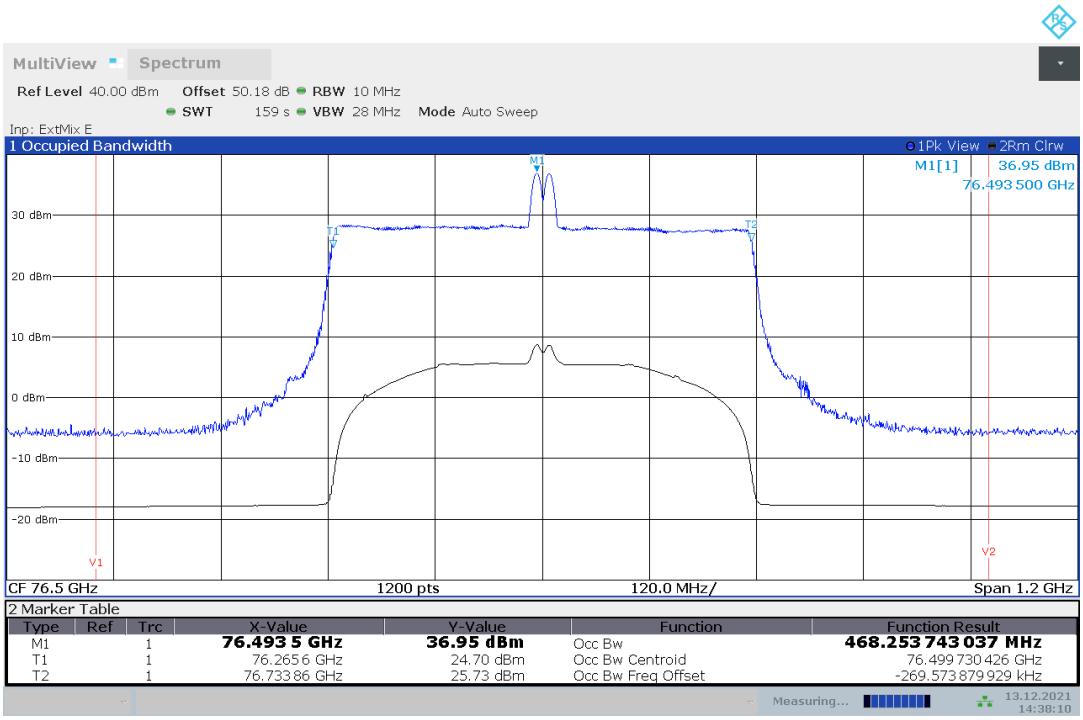
14:53:42 13.12.2021

Plot no. 42: 99% OBW, Peak detector, -10 °C, Test Mode 4



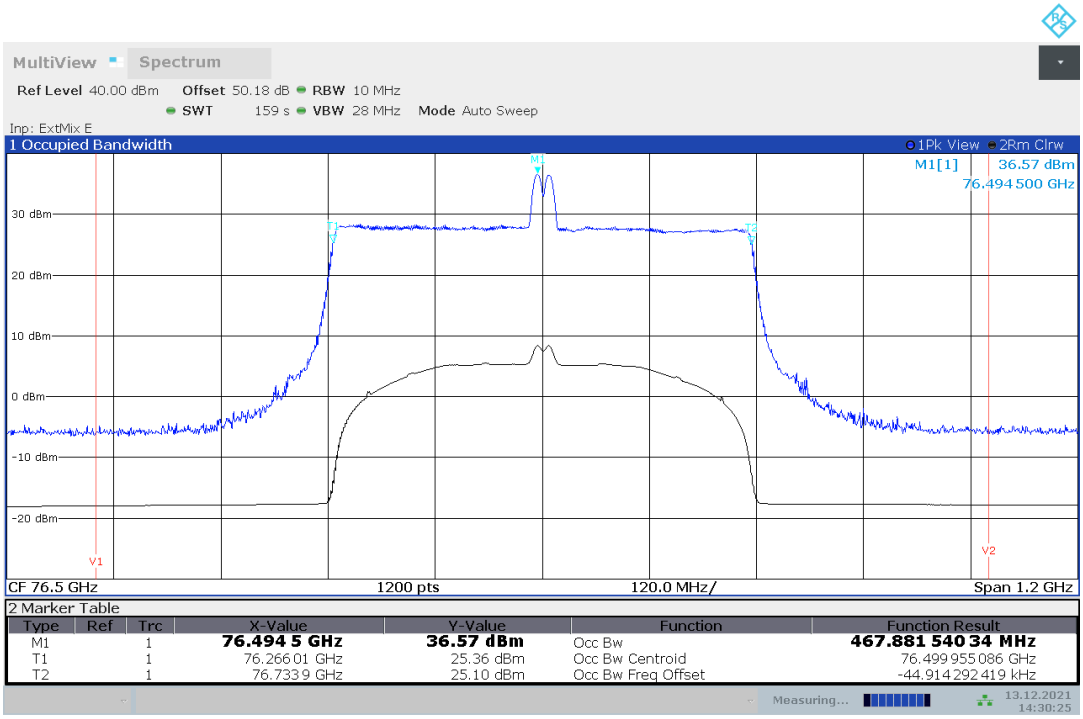
14:45:57 13.12.2021

Plot no. 43: 99% OBW, Peak detector, -20 °C, Test Mode 4



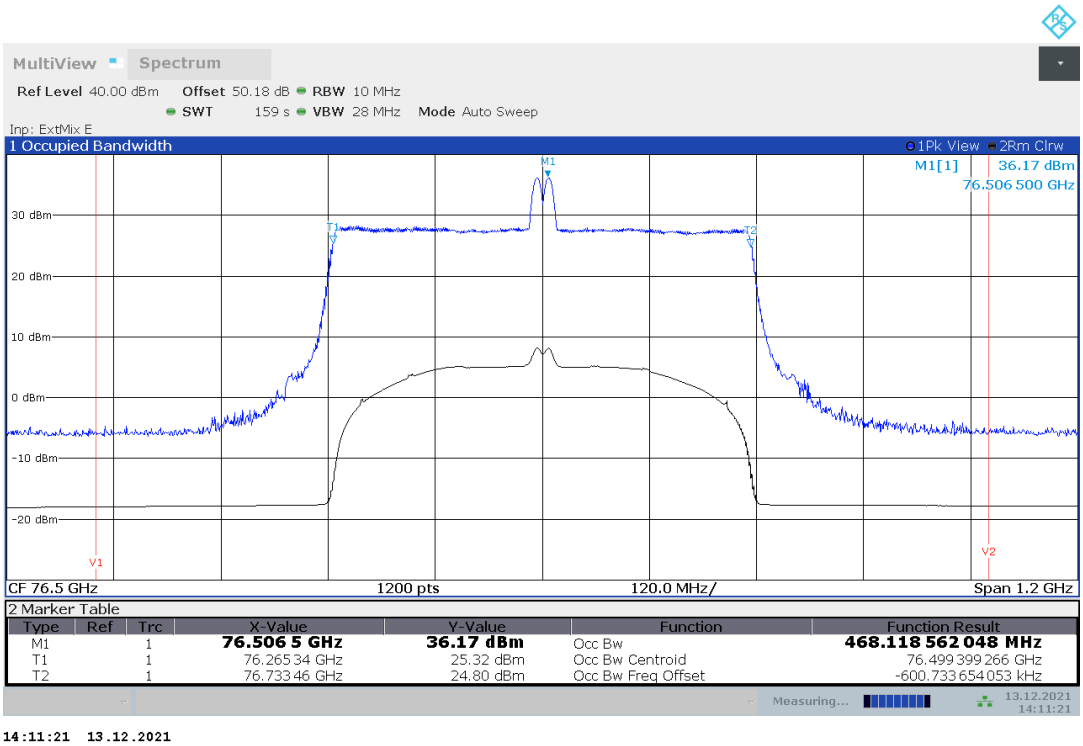
14:38:11 13.12.2021

Plot no. 44: 99% OBW, Peak detector, -30 °C, Test Mode 4



14:30:25 13.12.2021

Plot no. 45: 99% OBW, Peak detector, -40 °C, Test Mode 4



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	17.6 – 26.7	0.0520	26.5	0.478
22240-20	26.4 – 40.1	0.0342	40	0.312
23240-20	33.0 – 50.1	0.0280	50	0.261
24240-20	39.3 – 59.7	0.0230	60	0.212
25240-20	49.9 – 75.8	0.0185	75	0.171
26240-20	60.5 – 91.5	0.0150	90	0.135
27240-20	73.8 – 112	0.0124	110	0.113
29240-20	114 – 173	0.0085	170	0.082
30240-20	145 – 220	0.0068	220	0.068
32240-20	217 – 330	0.00446	243	0.032

Used test distances

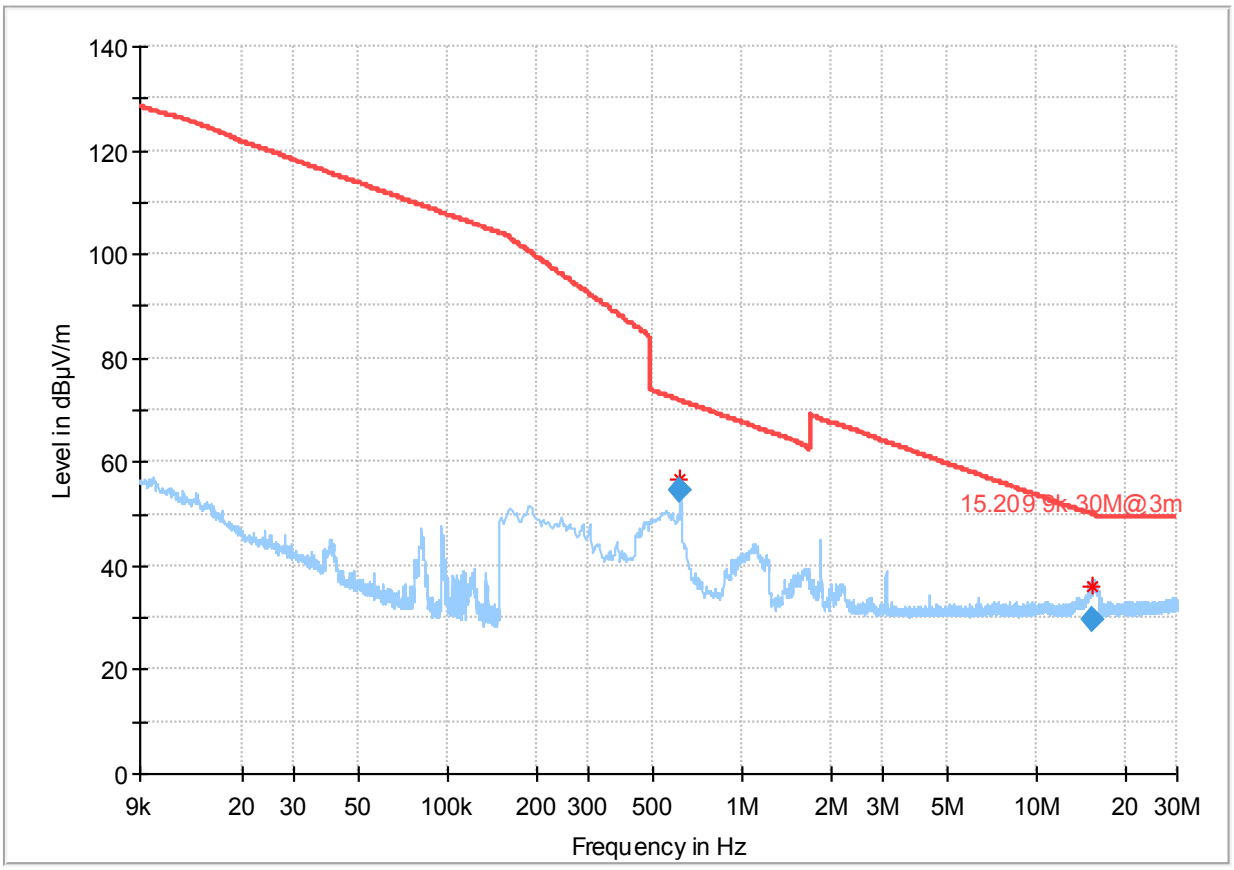
Up to 18 GHz:	3.00 m	In-band / OOB:	1.00 m
18 – 40 GHz:	1.00 m	110 – 170 GHz:	0.25 m
40 – 60 GHz:	0.50 m	170 – 220 GHz:	1.00 m
60 – 84 GHz:	1.00 m	220 – 325 GHz:	1.00 m
84 – 110 GHz:	0.50 m		

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.						

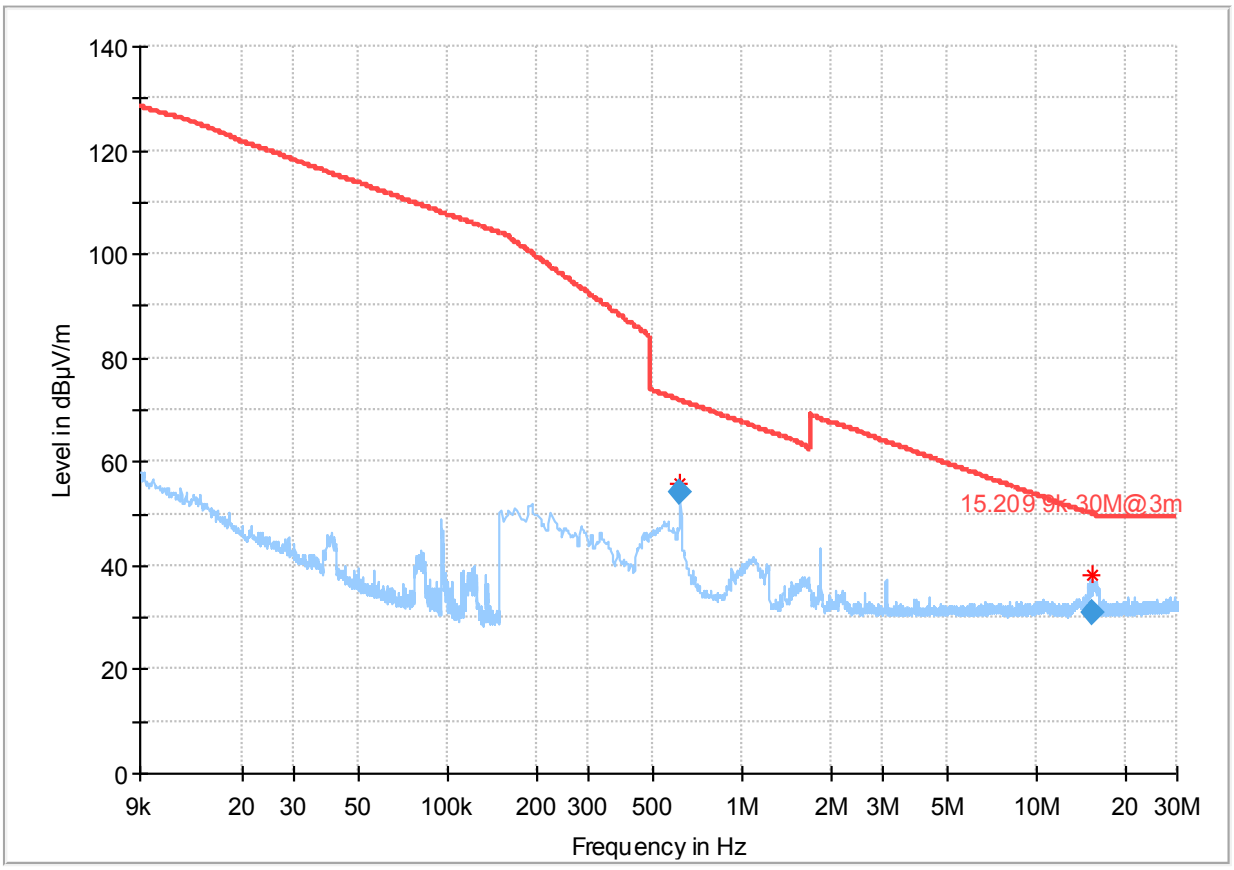
Plot no. 46: radiated emissions 9 kHz – 30 MHz, Mode 1, loop antenna



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.615750	54.75	71.83	17.08	100.0	9.000	H	156.0	20.4
15.560250	29.60	50.03	20.43	100.0	9.000	H	240.0	20.5

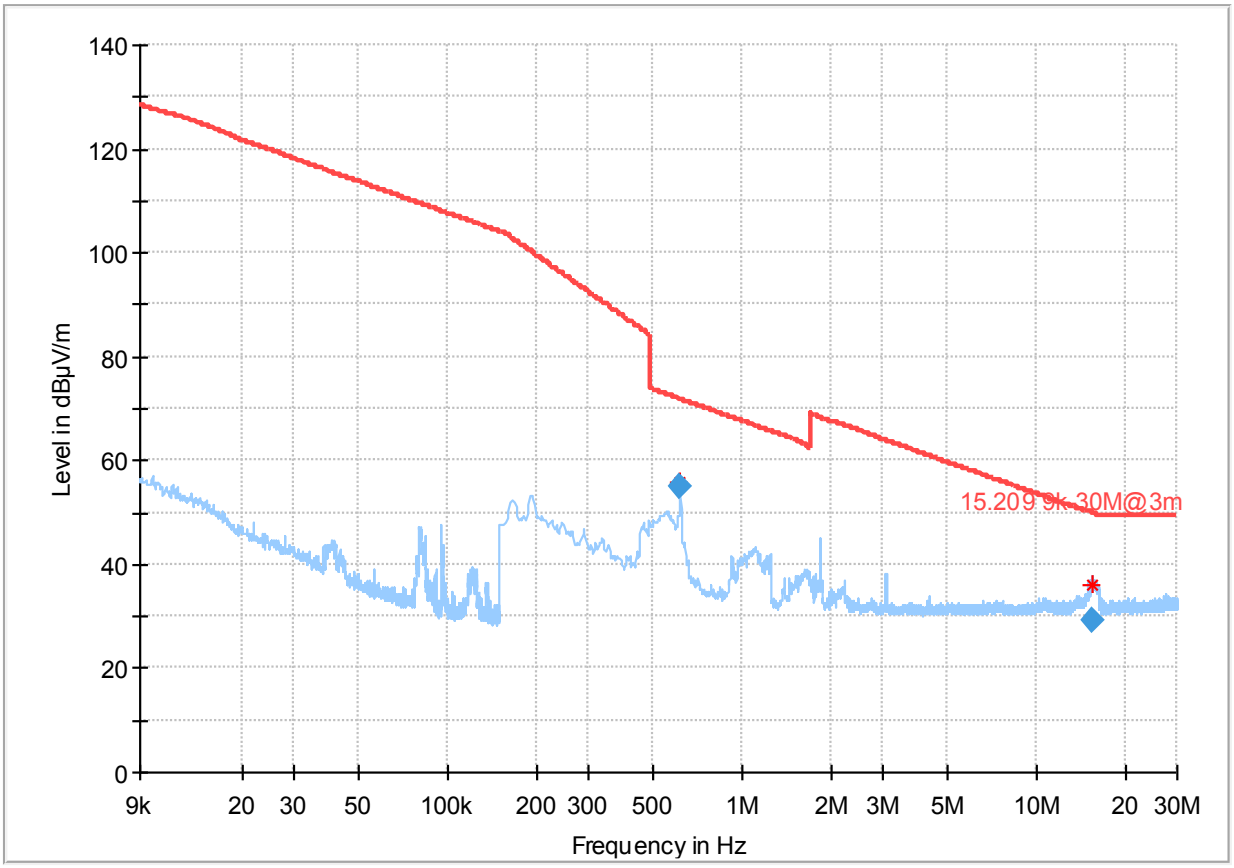
Plot no. 47: radiated emissions 9 kHz – 30 MHz, Mode 2, loop antenna



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.615750	54.02	71.83	17.81	100.0	9.000	H	156.0	20.4
15.528750	31.08	50.03	18.95	100.0	9.000	V	30.0	20.5

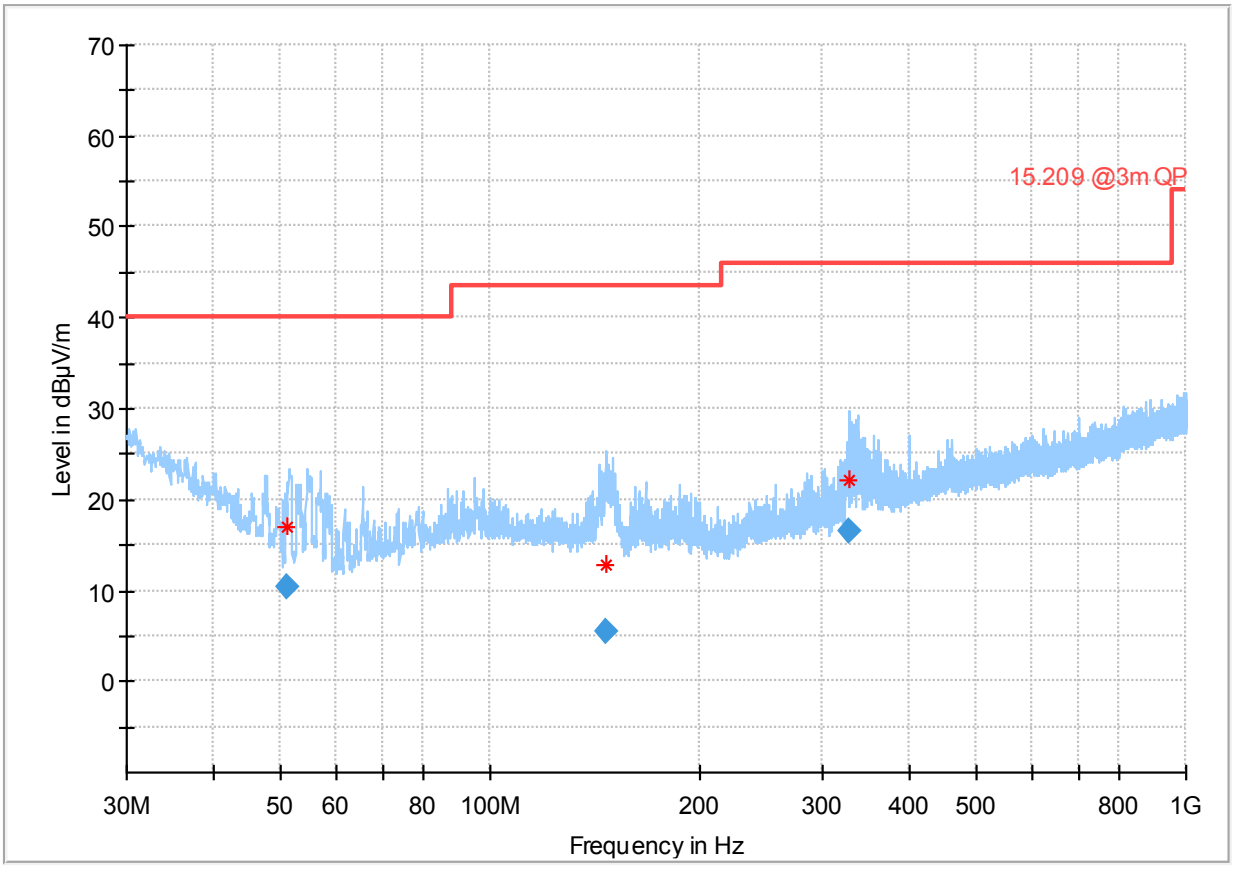
Plot no. 48: radiated emissions 9 kHz – 30 MHz, Mode 4, loop antenna



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
0.615750	54.99	71.83	16.84	100.0	9.000	H	156.0	20.4
15.553500	29.33	50.03	20.70	100.0	9.000	H	300.0	20.5

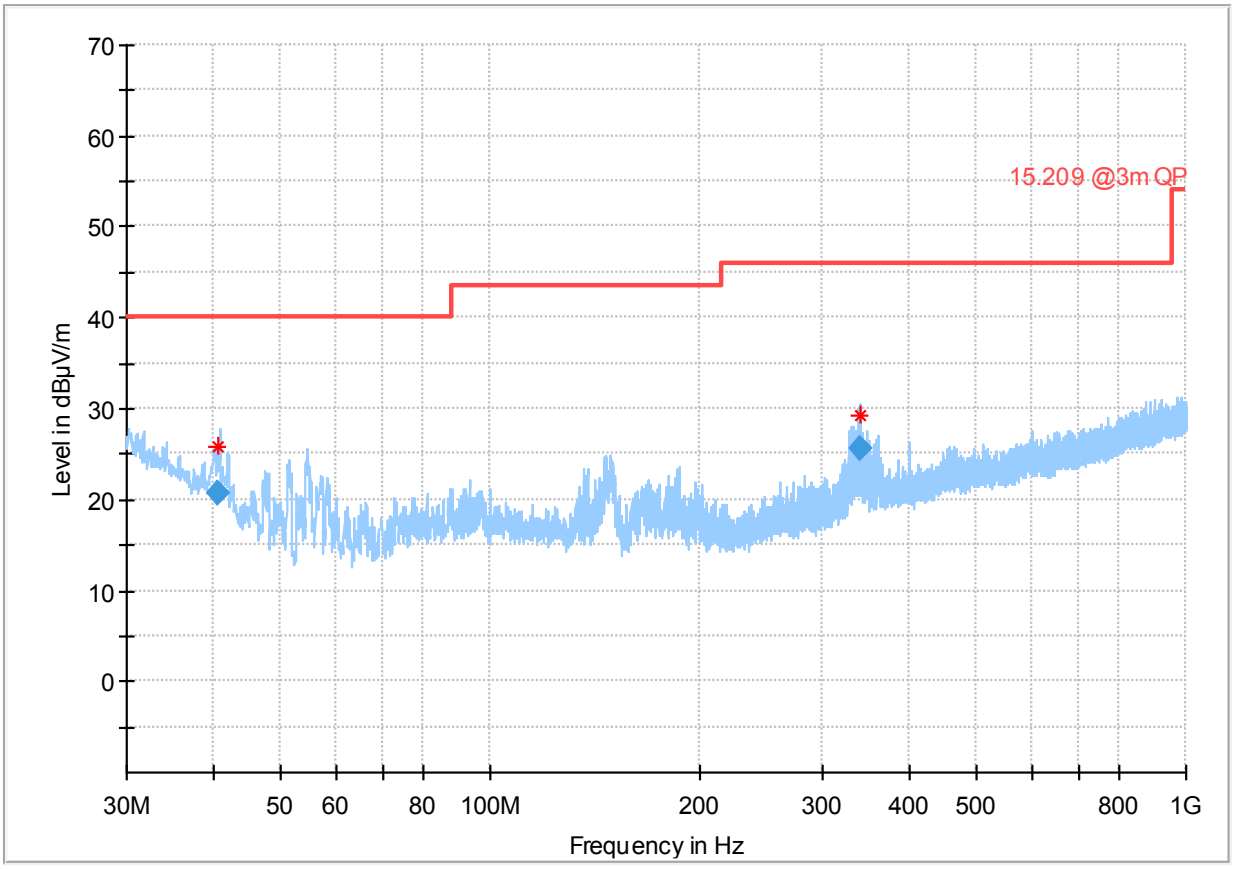
Plot no. 49: radiated emissions 30 MHz – 1 GHz, Mode 1, polarization vertical / horizontal



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
50.937000	10.46	40.00	29.54	100.0	120.000	100.0	V	325.0
146.958500	5.39	43.50	38.11	100.0	120.000	150.0	V	349.0
326.915500	16.48	46.00	29.52	100.0	120.000	142.0	H	93.0

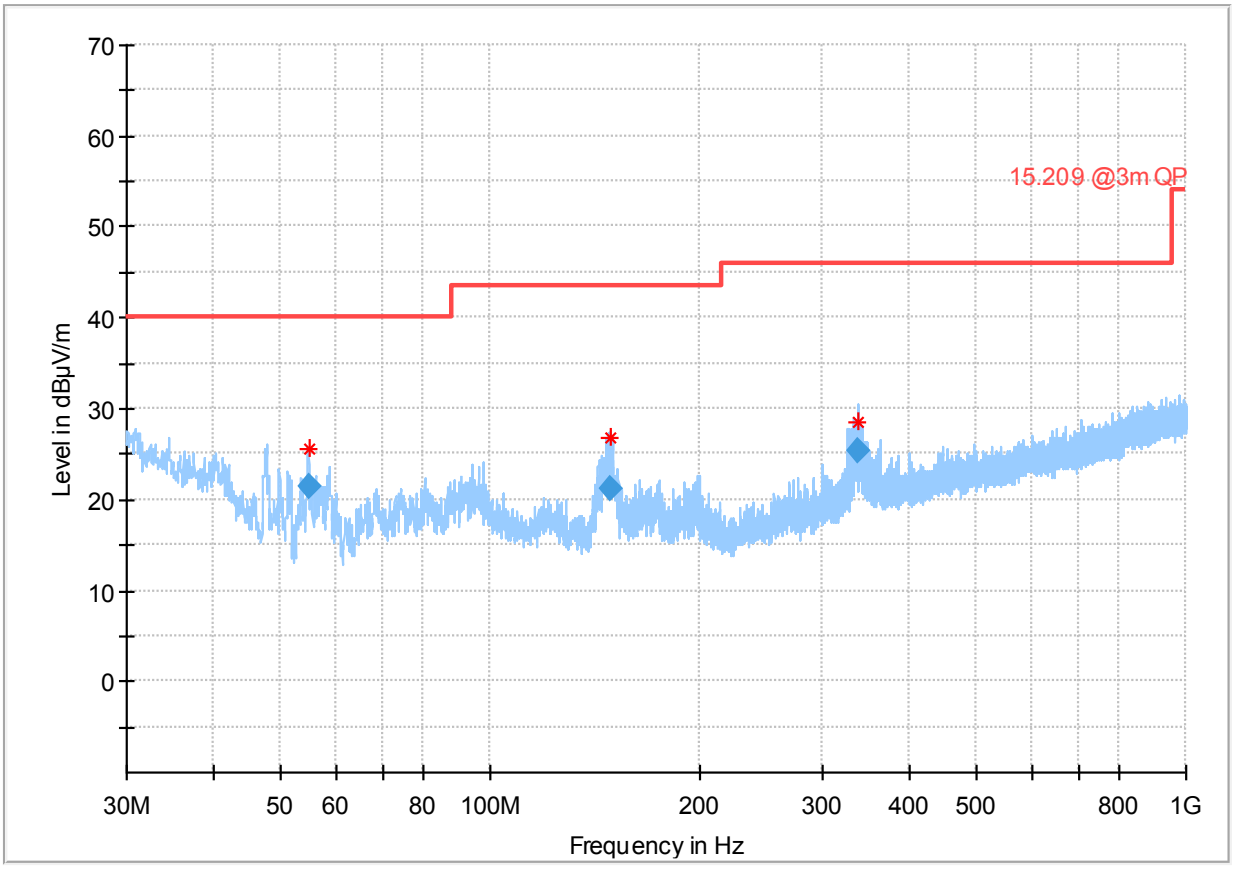
Plot no. 50: radiated emissions 30 MHz – 1 GHz, Mode 2, polarization vertical / horizontal



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
40.514000	20.77	40.00	19.23	100.0	120.000	100.0	V	236.0
339.209500	25.53	46.00	20.47	100.0	120.000	100.0	H	75.0

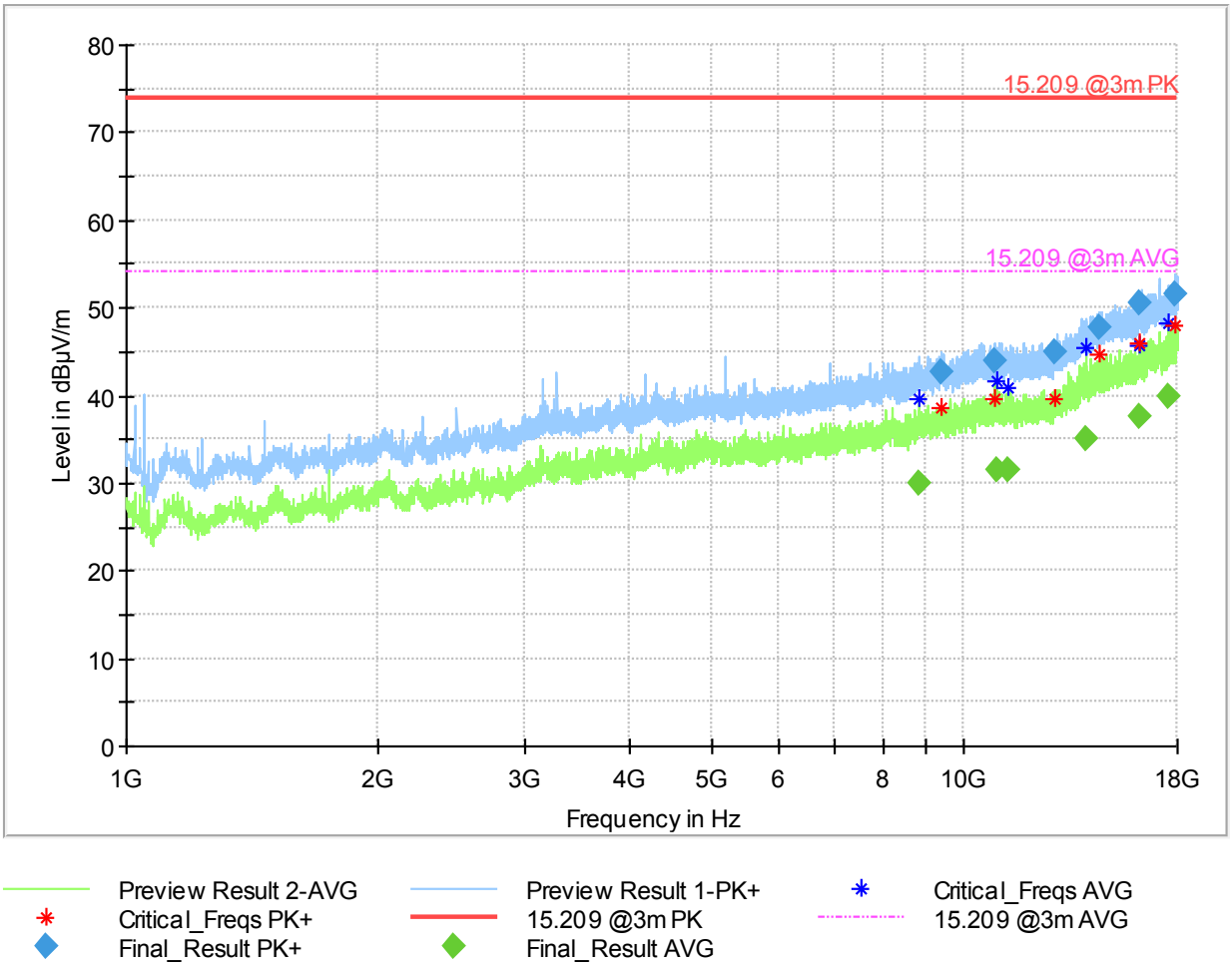
Plot no. 51: radiated emissions 30 MHz – 1 GHz, Mode 4, polarization vertical / horizontal



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
54.810000	21.33	40.00	18.67	100.0	120.000	131.0	V	290.0
149.175000	21.06	43.50	22.44	100.0	120.000	150.0	V	190.0
337.218000	25.35	46.00	20.65	100.0	120.000	100.0	H	83.0

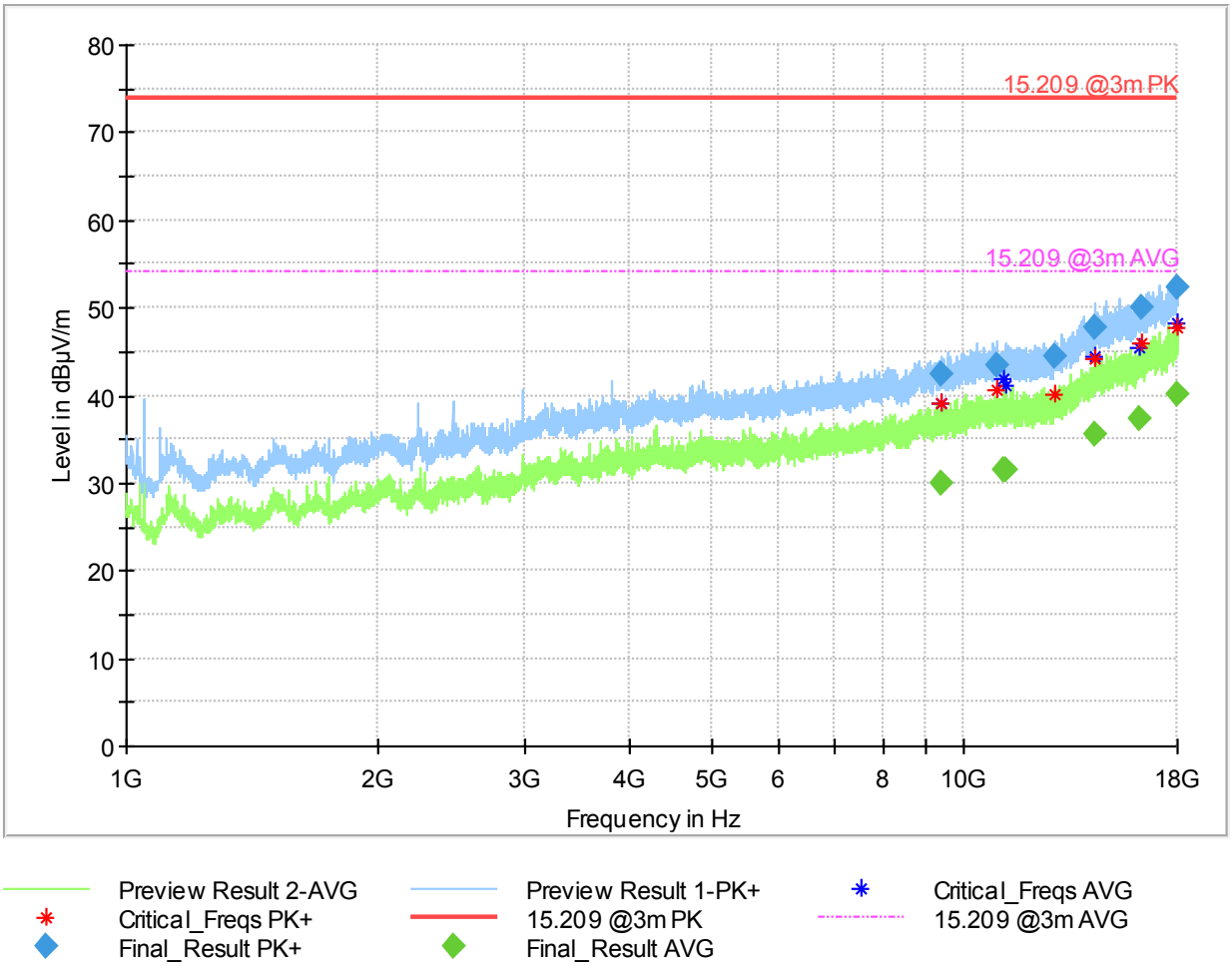
Plot no. 52: radiated emissions 1 GHz – 18 GHz, Mode 1, polarization vertical / horizontal



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8854.944444	---	30.09	54.00	23.91	100.0	1000.000	150.0	V
9423.305556	42.71	---	74.00	31.29	100.0	1000.000	150.0	V
10920.519444	43.99	---	74.00	30.01	100.0	1000.000	150.0	H
10942.166667	---	31.61	54.00	22.39	100.0	1000.000	150.0	H
11328.444444	---	31.37	54.00	22.63	100.0	1000.000	150.0	V
12816.125000	44.87	---	74.00	29.13	100.0	1000.000	150.0	V
13996.500000	---	35.11	54.00	18.89	100.0	1000.000	150.0	V
14516.333333	47.80	---	74.00	26.20	100.0	1000.000	150.0	V
16238.566667	50.56	---	74.00	23.44	100.0	1000.000	150.0	H
16249.944444	---	37.66	54.00	16.34	100.0	1000.000	150.0	V
17610.888889	---	39.77	54.00	14.23	100.0	1000.000	150.0	V
17899.994444	51.45	---	74.00	22.55	100.0	1000.000	150.0	V

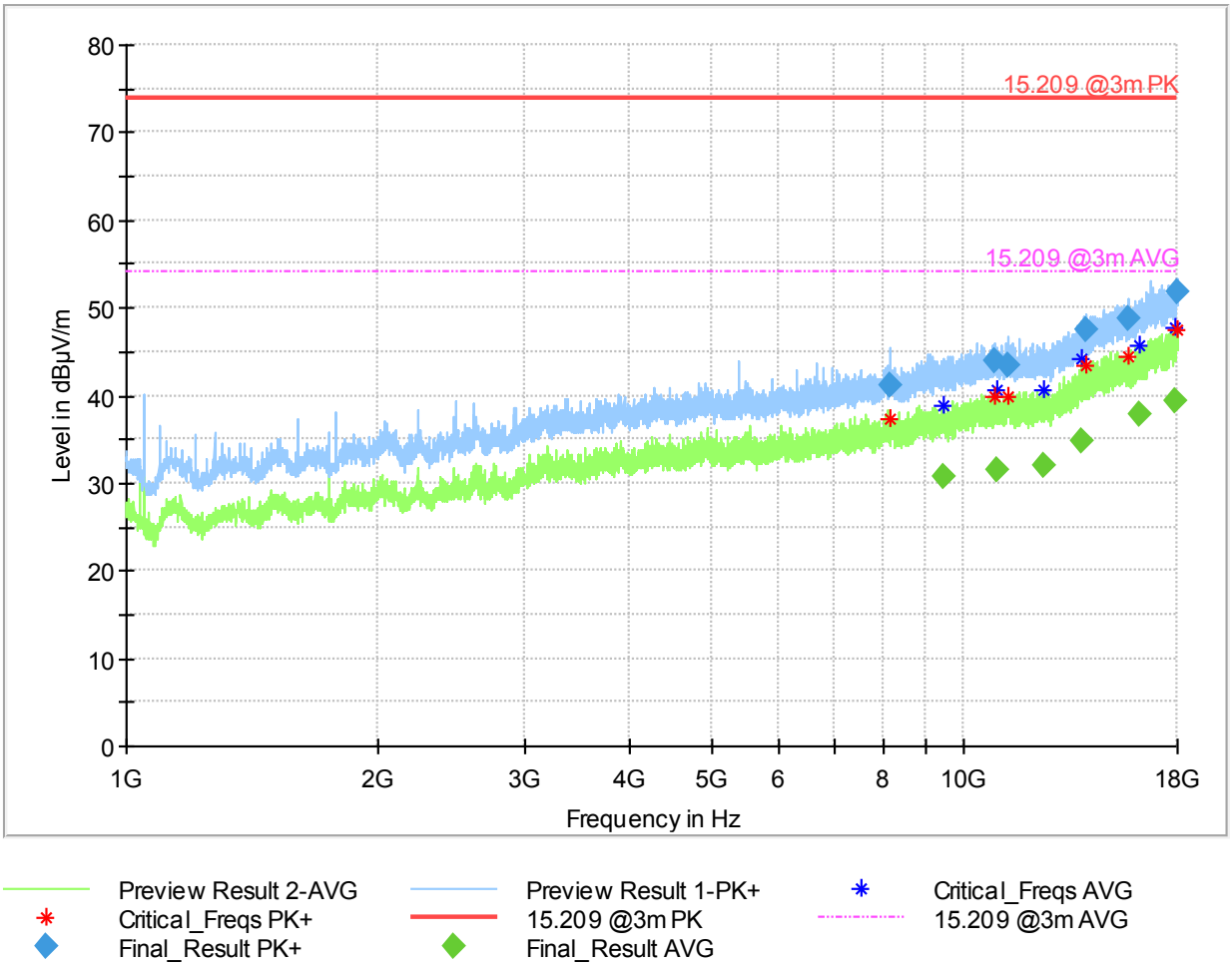
Plot no. 53: radiated emissions 1 GHz – 18 GHz, Mode 2, polarization vertical / horizontal



Final_Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
9390.444444	---	30.05	54.00	23.95	100.0	1000.000	150.0	V
9423.575000	42.49	---	74.00	31.51	100.0	1000.000	150.0	H
10954.113889	43.55	---	74.00	30.45	100.0	1000.000	150.0	V
11143.333333	---	31.40	54.00	22.60	100.0	1000.000	150.0	H
11259.500000	---	31.46	54.00	22.54	100.0	1000.000	150.0	H
12825.058333	44.47	---	74.00	29.53	100.0	1000.000	150.0	H
14365.777778	---	35.50	54.00	18.50	100.0	1000.000	150.0	V
14372.958333	47.68	---	74.00	26.32	100.0	1000.000	150.0	H
16171.555556	---	37.27	54.00	16.73	100.0	1000.000	150.0	V
16283.525000	50.02	---	74.00	23.98	100.0	1000.000	150.0	V
17963.511111	52.19	---	74.00	21.81	100.0	1000.000	150.0	V
17997.166667	---	40.16	54.00	13.84	100.0	1000.000	150.0	V

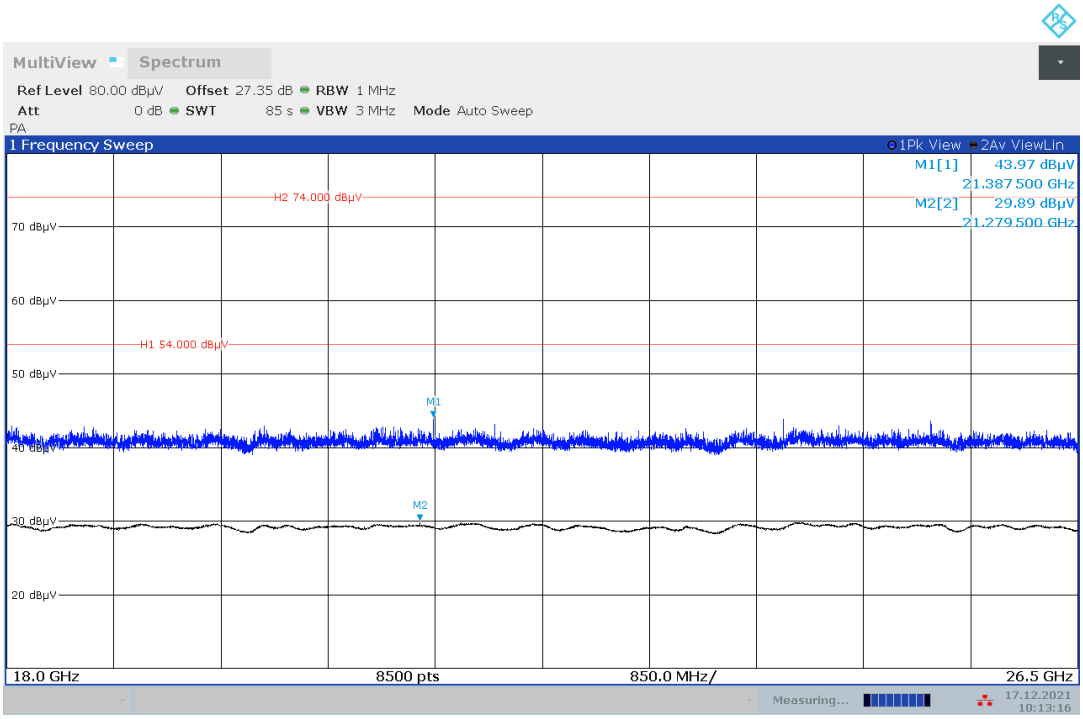
Plot no. 54: radiated emissions 1 GHz – 18 GHz, Mode 4, polarization vertical / horizontal



Final_Result

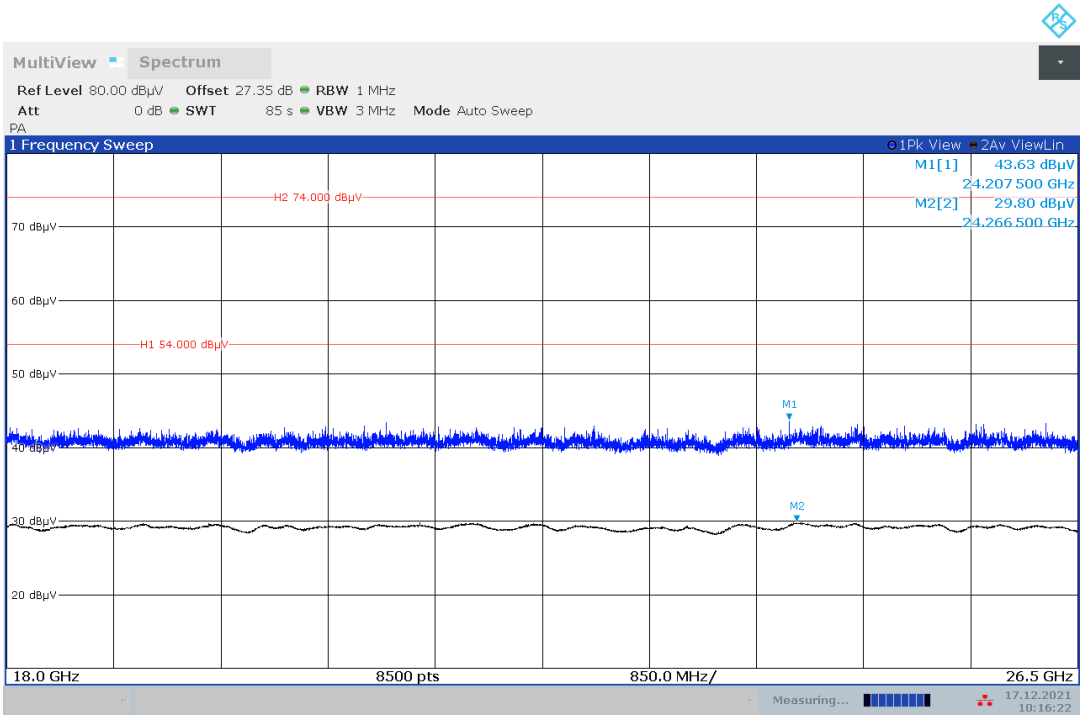
Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
8171.930556	41.27	---	74.00	32.73	100.0	1000.000	150.0	H
9441.444444	---	30.73	54.00	23.27	100.0	1000.000	150.0	V
10925.991667	43.87	---	74.00	30.13	100.0	1000.000	150.0	H
10949.722222	---	31.53	54.00	22.47	100.0	1000.000	150.0	H
11286.019444	43.48	---	74.00	30.52	100.0	1000.000	150.0	V
12455.166667	---	32.09	54.00	21.91	100.0	1000.000	150.0	H
13844.444444	---	34.76	54.00	19.24	100.0	1000.000	150.0	H
14022.825000	47.38	---	74.00	26.63	100.0	1000.000	150.0	V
15704.850000	48.65	---	74.00	25.35	100.0	1000.000	150.0	V
16214.055556	---	37.76	54.00	16.24	100.0	1000.000	150.0	H
17862.111111	---	39.39	54.00	14.61	100.0	1000.000	150.0	V
17977.183333	51.91	---	74.00	22.09	100.0	1000.000	150.0	V

Plot no. 55: radiated emissions 18 GHz – 26.5 GHz, Mode 1, polarization vertical / horizontal



10:13:17 17.12.2021

Plot no. 56: radiated emissions 18 GHz – 26.5 GHz, Mode 2, polarization vertical / horizontal



10:16:23 17.12.2021