D-PL-21375-01-03

BNetzA-CAB-21/21-21

Test Report

Test report no.: 22026895-25799-1
Date of issue: 2022-07-06

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

Applicant
ZF Autocruise France S.A.S.

Manufacturer
ZF Autocruise France S.A.S.

Test Item
FRGen21

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)	*Andreas Bender* *Deputy Managing Director*	signature

Applicant and Test item details	
Applicant	ZF Autocruise France S.A.S. 760 Avenue du Technopôle 29280, PLOUZANE, France
Manufacturer	ZF Autocruise France S.A.S. 760 Avenue du Technopôle 29280, PLOUZANE, France
Test item description	Automotive Radar
Model/Type reference	FRGen21
FCC ID	S9I
Frequency	76.0 GHz to 77.0 GHz
Antenna	integrated patch antenna
Power supply	8.0 to 16.0 V DC
Temperature range	-40 °C to +85 °C

Disclaimer and Notes

The content of this test report relates to the mentioned test sample(s) only.
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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:
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 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	2022-06-24
Start – End of tests	2022-06-24 – 2022-06-29

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:
Emission designator added, calibration date of anechoic chamber corrected

This test report 22026895-25799-1 replaces the previous test report 22026895-25799-0
Utilisation, publication and control of previous report editions is under responsibility of the applicant.

2.6 Further documents

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

3 ENVIRONMENTAL & TEST CONDITIONS

3.1 Environmental conditions

Temperature	20°C ± 5°C
Relative humidity	25-75% r.H.
Barometric Pressure	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	8.0 V DC	13.5 V DC	16 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
KDB653005 D01, V01, R01	Equipment Authorization Guidance for 76-81 GHz Radar Devices

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

Automotive Radar

5.2 Description of test item

Model name*	FRGen21
Serial number*	FR22129AND60062
Hardware status*	C1
Software status*	XA_R12a04

*: 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
Emission designator*	F0N
Number of channels*	1
Channel bandwidth*	< 1 GHz
Channel spacing*	N/A
Receiver category*	N/A
Receiver bandwidth*	N/A
Duty cycle*	Low speed mode: 42.09 % Mid speed mode: 42.09 % High speed mode: 42.09 %
Antenna*	integrated patch antenna
Rated RF output power*	< 50 dBm
Power supply*	8.0 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, a network converter 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
"ZF FRGen21 Product Data Sheet v2–1632751721.pdf"

3 Detection Performance

The FRGen21 radar sensor features three modes of operation - long range, mid-range and short range. These range modes are defined as:

- Short range: < 15km/h
- Mid-range: > 15km/h and < 65km/h
- Long range: > 65km/h

There is just one single antenna, but the range resolution is dynamically adjusted to the own speed

The table below depicts the specification for the radar in all three modes (long range, mid-range and short range). The following paragraphs further describe the parameters.

Parameter		Long Range High Speed	Mid-Range Med. Speed	Short Range Low Speed
Range	FoV	350m	200m	100m
	Resolution	~0.7m	~ 0.4m	~ 0.2m
	Accuracy	~ 0.1m	~ 0.05m	~ 0.02m
Velocity	FoV	-70 .... +70 m/s		
	Resolution	0.1 m/s		
	Accuracy	0.01 m/s		
Azimuth	FoV (+/-) Incl. misalignment compensation	20° (@ ≤ 300m)	45° (@ ≤ 150m)	60° (@ ≤ 80m)
	Resolution	1.5° @ +/-20° 0.8° @ +/-20° (due to high resolution methods)		
Elevation	FoV (+/-) Incl. misalignment compensation	10° @ 300m - 15° @ ≤ 200m		
	Resolution	1.5° @ +/-15°		
Auxiliary	Cycle Time	60ms		
	Frequency Bandwidth	195MHz (eff)	365MHz (eff)	720MHz (eff)
	Power Consumption	21W		
	Heater Interface	max. 70w		

Term definition:

FoV: All values are defined for 10dBm² target RCS
Resolution: Separation capability of two targets if all other 3 coordinates are the same
Accuracy: Measurement accuracy on single target

Azimuth and elevation FoV:

- Includes tilt compensation range
- FoV is specified after automatic compensation of up to ±5° in elevation and azimuth.
- FoV is defined for each angular direction at the maximum tilt in the other direction (e.g. azimuth FoV at elevation ±15°)

4.3.2 Modulation

We use a modulation scheme based on a coherent train of linearly frequency modulated pulses, also known as fast chirp-sequence modulation, which is illustrated in Figure 3.

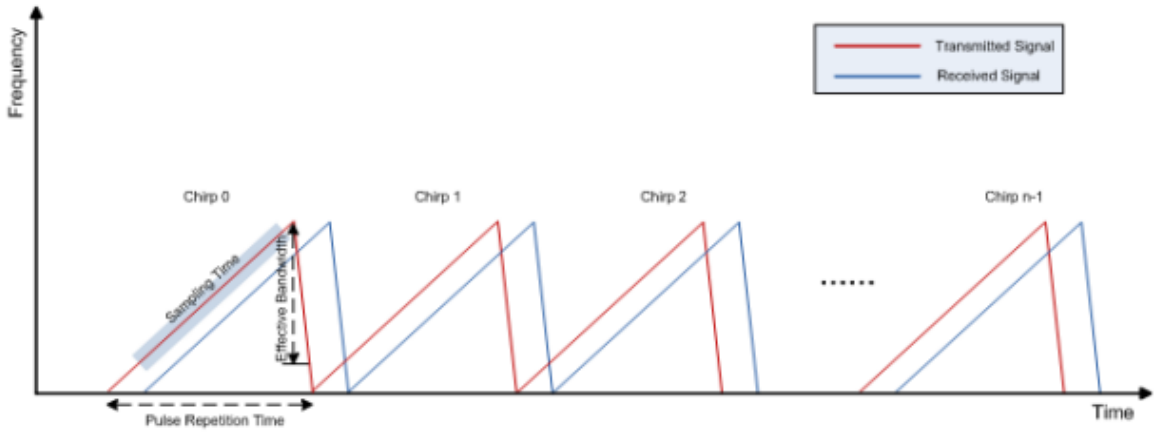


Figure 3: Chirp timing

5.6 Antenna characteristics

Antenna Gain was declared by customer: 23.1 dBi
The following information is derived from the provided document
“Antenna Specification−1635241422.pdf”

FRGen21 – Antenna Information

Radar Model : FRGen21

We ZF Autocruise France S.A.S.
760 Avenue du Technopôle
29280 PLOUZANE
FRANCE

hereby declare under our sole responsibility, that the indicated antenna gain of 15.1 dBi for the product FRGen21 corresponds to the antenna gain activated (operating) during the conformity measurement scenario, required for type approval in Japan. The integral Duty cycle has been evaluated at 42.09%.

Antenna gain and duty cycle are required for calculating the corresponding conducted antenna power and have been estimated with the following characteristics:

- The FRGen21 radar cycle is 60ms
- The transmission time is 25.25ms
- Duty cycle is estimated at 42.09%
- FRGen21 has 12 identical transmit antennas that will transmit simultaneously, resulting in one bigger antenna with a higher gain, when measuring EIRP. Therefore, the total simulated gain of the combined antennas (to be used for EIRP measurement) has a maximum gain of 23.1 dBi.
- The indicated antenna gain results of 3D electromagnetic simulation with CST MICROWAVE STUDIO software, performed by Dr. Christophe CALVEZ, RF HW team lead.

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	27.77 dBm mean 39.43 dBm peak	P
§2.1047	Modulation characteristics	Nominal	-	P
§2.1049	Occupied bandwidth	Nominal	873.908 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: Pulse repetition time x number of sweep points
- Measurement is done until trace is stabilised

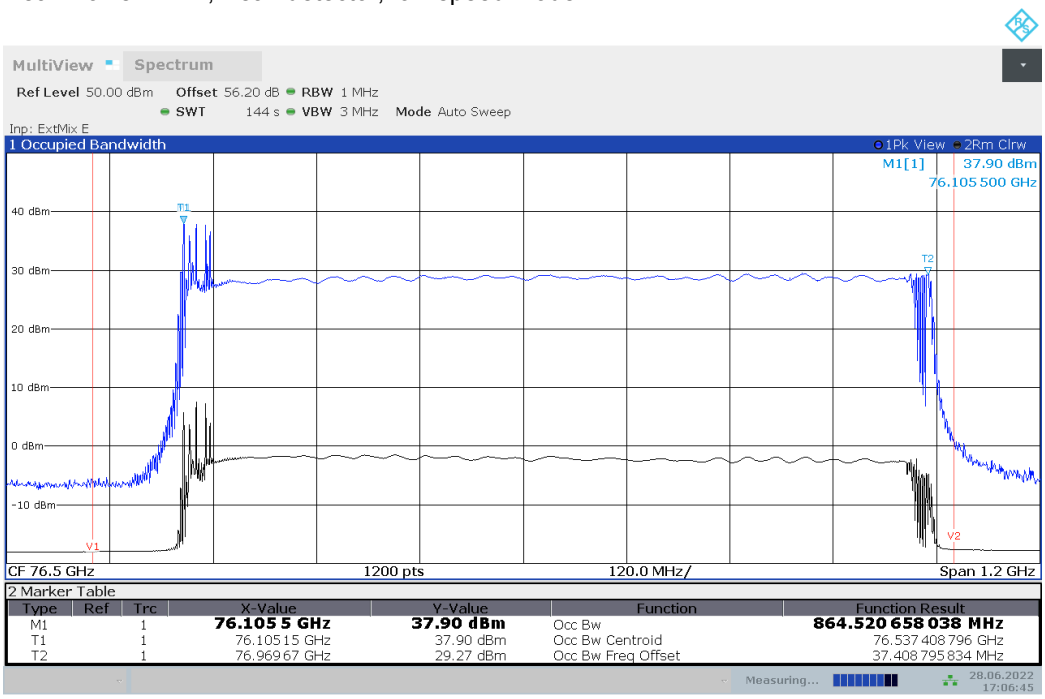
The peak power to be considered is the maximum value recorded.

Test setup: 8.3			
Test results:			
EUT mode	**Test distance**	**Radiated Mean Power (EIRP) [dBm]**	**Radiated Peak Power (EIRP) [dBm]**
Low speed	2.0 m	27.68	37.90
Mid speed	2.0 m	**27.77**	**39.43**
High speed	2.0 m	27.72	37.75

Plot no. 1: Mean Power EIRP, RMS detector / Channel Power, low speed mode

17:15:16 23.06.2022

Plot no. 2: Peak Power EIRP, Peak detector, low speed mode



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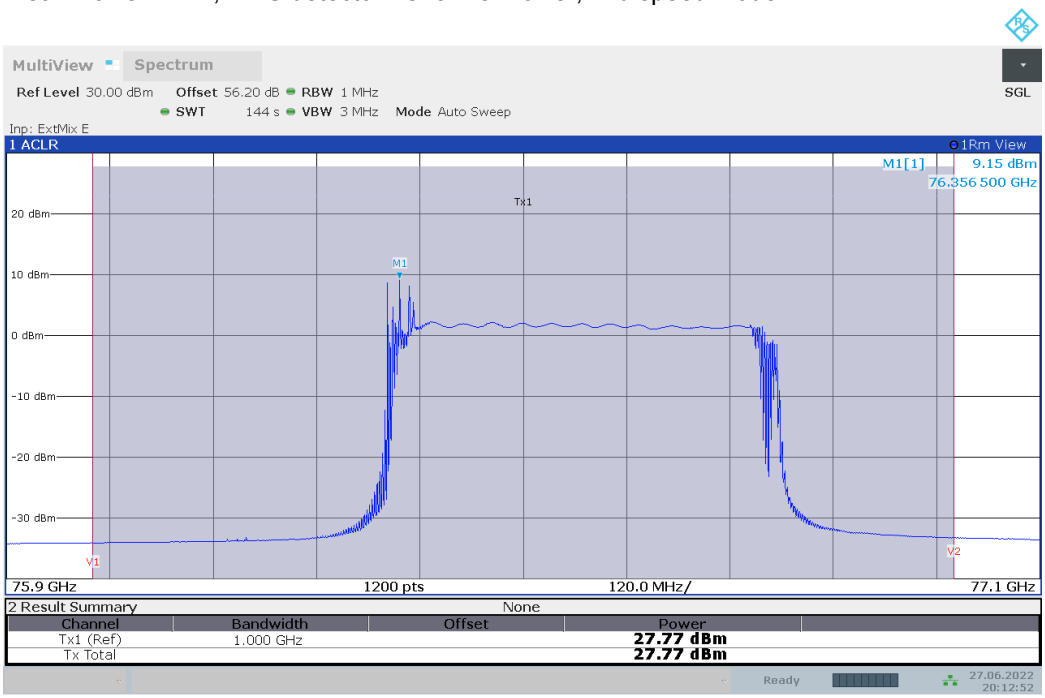
Plot no. 3: Mean Power EIRP, RMS detector / Channel Power, mid speed mode



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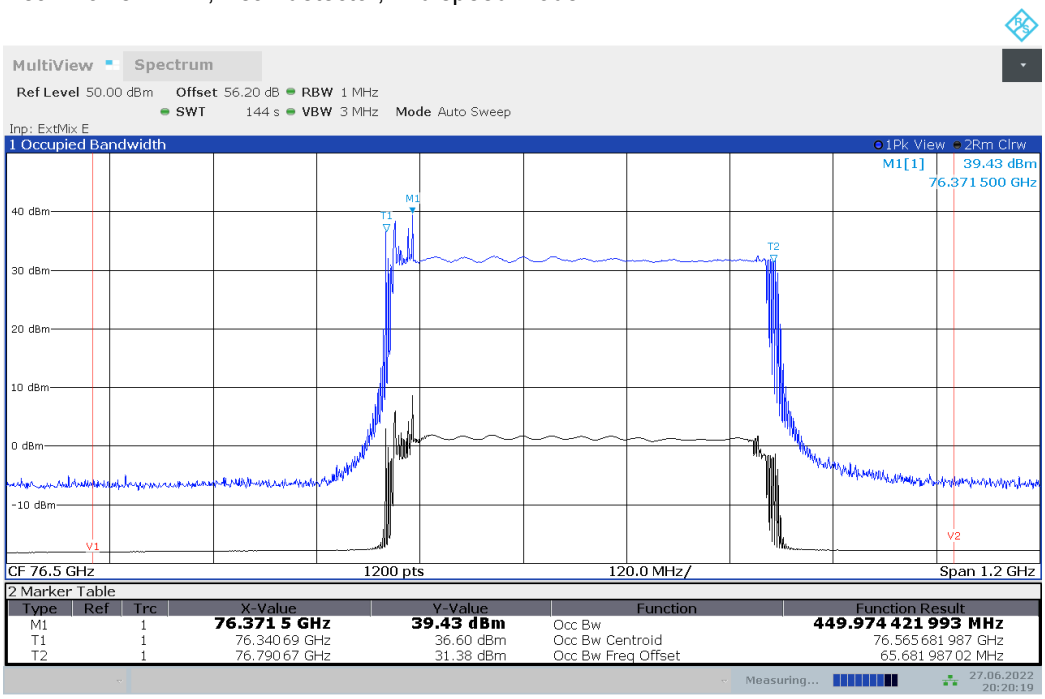
Plot no. 4: Peak Power EIRP, Peak detector, mid speed mode



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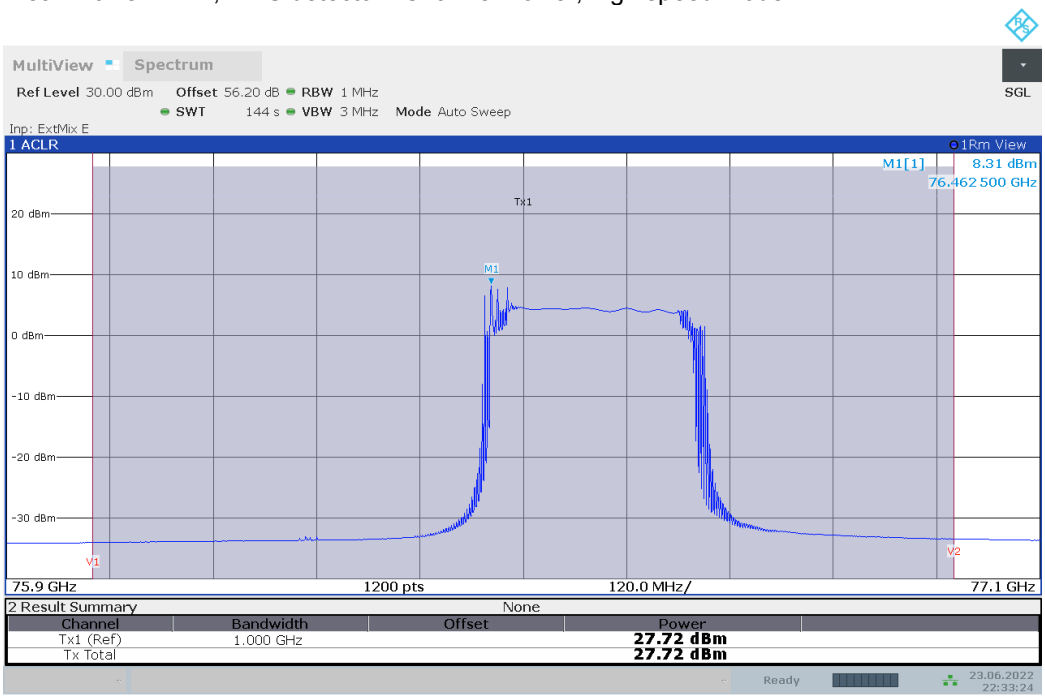
Plot no. 5: Mean Power EIRP, RMS detector / Channel Power, high speed mode



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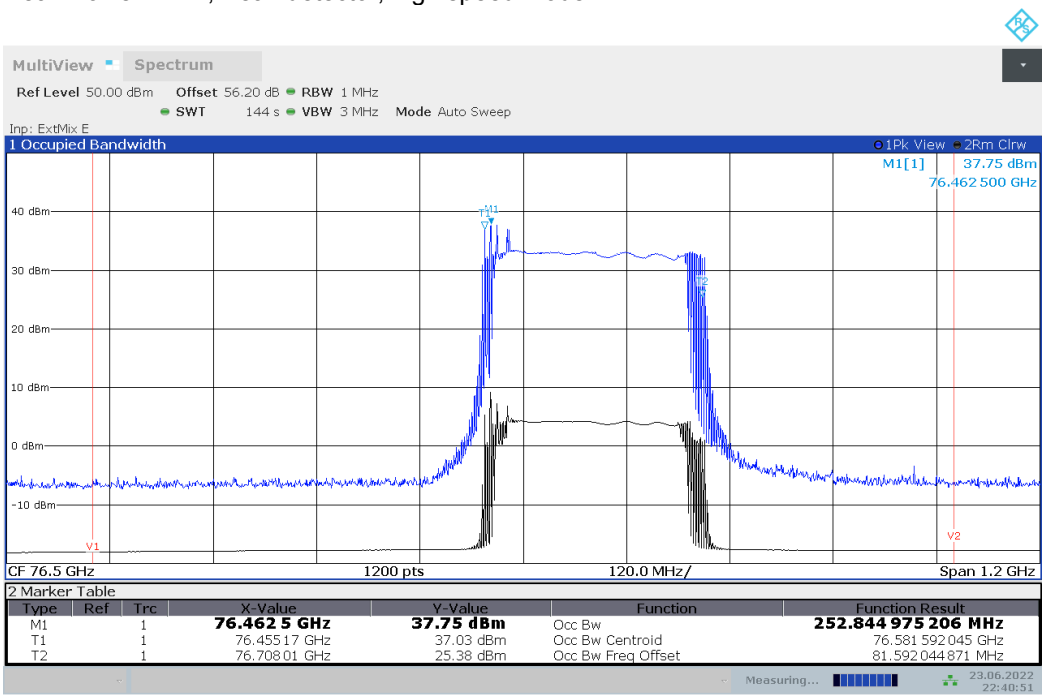
Plot no. 6: Peak Power EIRP, Peak detector, high speed mode



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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 C63.10, 6.9.3

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.

d) Step a) through step c) might require iteration to adjust within the specified range.

e) Video averaging is not permitted. Where practical, a sample detection and single sweep mode shall be used. Otherwise, peak detection and max hold mode (until the trace stabilizes) shall be used.

f) Use the 99% power bandwidth function of the instrument (if available) and report the measured bandwidth.

g) If the instrument does not have a 99% power bandwidth function, then the trace data points are recovered and directly summed in linear power terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached; that frequency is recorded as the lower frequency. The process is repeated until 99.5% of the total is reached; that frequency is recorded as the upper frequency. The 99% power bandwidth is the difference between these two frequencies.

h) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).

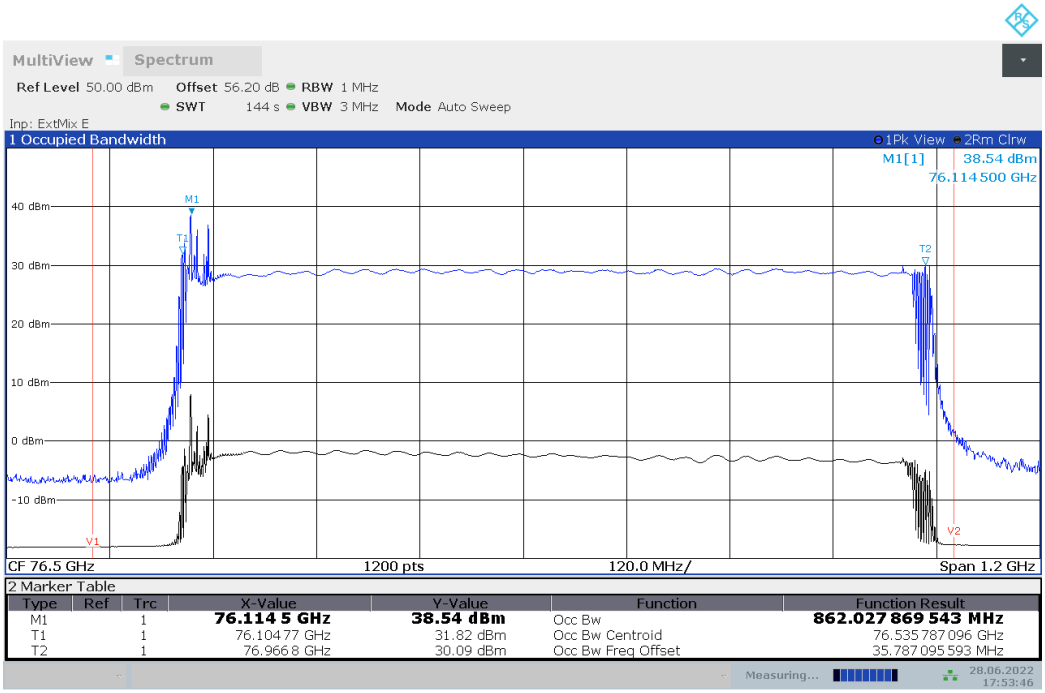
Note

Measurements with the peak detector are 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 C63.10).

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]**
Low speed mode	85 °C	76.105	76.967	862.028
Low speed mode	50 °C	76.103	76.971	868.055
Low speed mode	40 °C	76.101	76.974	**873.908**
Low speed mode	30 °C	76.104	76.972	867.580
Low speed mode	20 °C / V_{min}	76.104	76.974	869.999
Low speed mode	20 °C / V_{nom}	76.105	76.970	864.521
Low speed mode	20 °C / V_{max}	76.104	76.972	867.668
Low speed mode	10 °C	76.104	76.976	872.057
Low speed mode	0 °C	76.103	76.976	873.159
Low speed mode	-10 °C	76.107	76.974	866.610
Low speed mode	-20 °C	76.107	76.973	865.727
Low speed mode	-30 °C	76.106	76.976	870.559
Low speed mode	-40 °C	76.108	76.968	859.455
Mid speed mode	85 °C	76.336	76.799	463.205
Mid speed mode	50 °C	76.337	76.797	460.126
Mid speed mode	40 °C	76.338	76.797	459.349
Mid speed mode	30 °C	76.339	76.798	459.116
Mid speed mode	20 °C / V_{min}	76.339	76.799	459.563
Mid speed mode	20 °C / V_{nom}	76.340	76.801	461.141
Mid speed mode	20 °C / V_{max}	76.339	76.799	459.659
Mid speed mode	10 °C	76.339	76.800	460.639
Mid speed mode	0 °C	76.339	76.800	461.216
Mid speed mode	-10 °C	76.340	76.800	460.149
Mid speed mode	-20 °C	76.339	76.803	463.739
Mid speed mode	-30 °C	76.340	76.801	460.857
Mid speed mode	-40 °C	76.340	76.801	460.621
High speed mode	85 °C	76.447	76.718	271.288
High speed mode	50 °C	76.447	76.718	270.911
High speed mode	40 °C	76.448	76.719	271.226
High speed mode	30 °C	76.444	76.720	276.153
High speed mode	20 °C / V_{min}	76.448	76.721	272.959
High speed mode	20 °C / V_{nom}	76.445	76.719	274.209
High speed mode	20 °C / V_{max}	76.447	76.720	273.511
High speed mode	10 °C	76.446	76.720	273.498
High speed mode	0 °C	76.448	76.723	274.797
High speed mode	-10 °C	76.450	76.721	271.946
High speed mode	-20 °C	76.448	76.722	273.284
High speed mode	-30 °C	76.450	76.724	273.361
High speed mode	-40 °C	76.448	76.722	273.473
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 low speed



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Plot no. 8: 99% OBW, Peak detector, 50 °C, Test mode low speed

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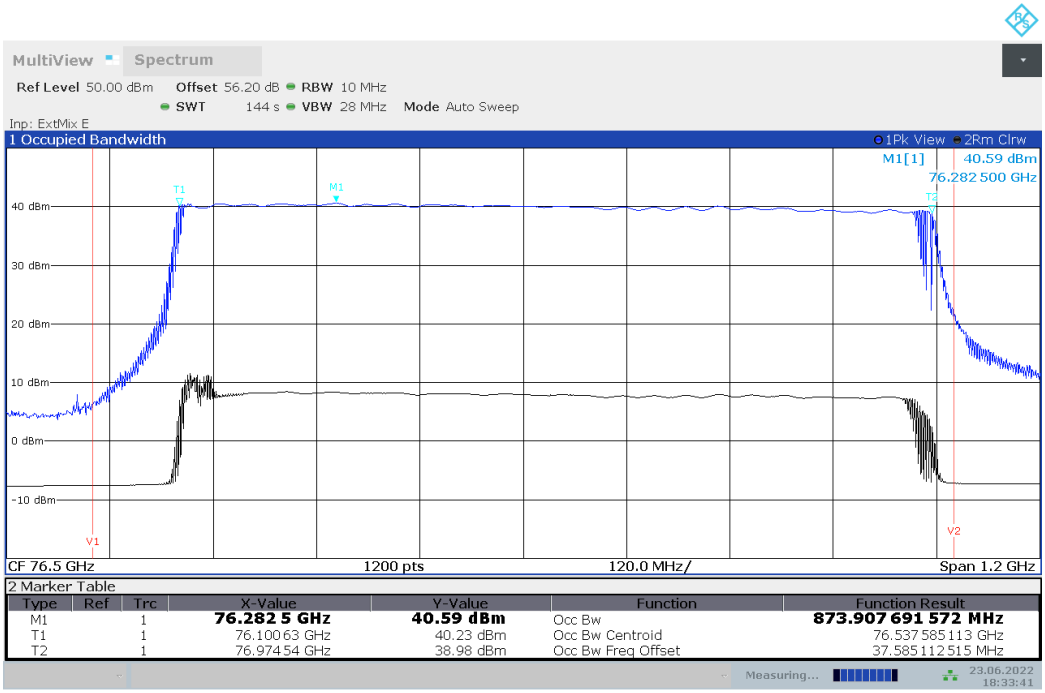
Plot no. 9: 99% OBW, Peak detector, 40 °C, Test mode low speed



18:33:42 23.06.2022

Plot no. 10: 99% OBW, Peak detector, 30 °C, Test mode low speed

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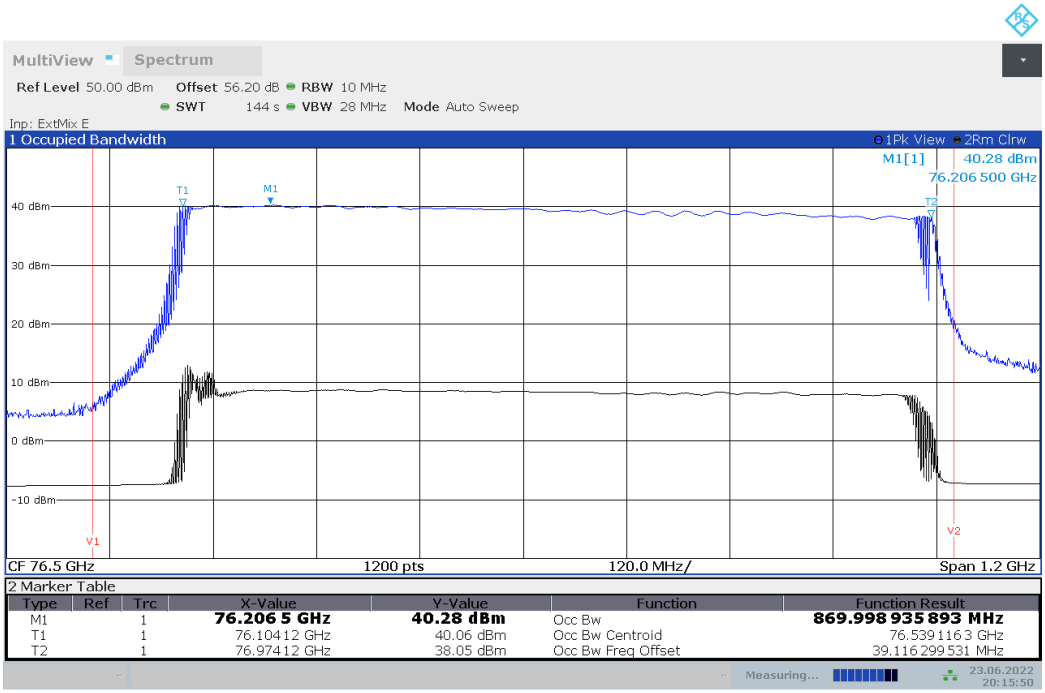
Plot no. 11: 99% OBW, Peak detector, 20 °C, V_{min}, Test mode low speed



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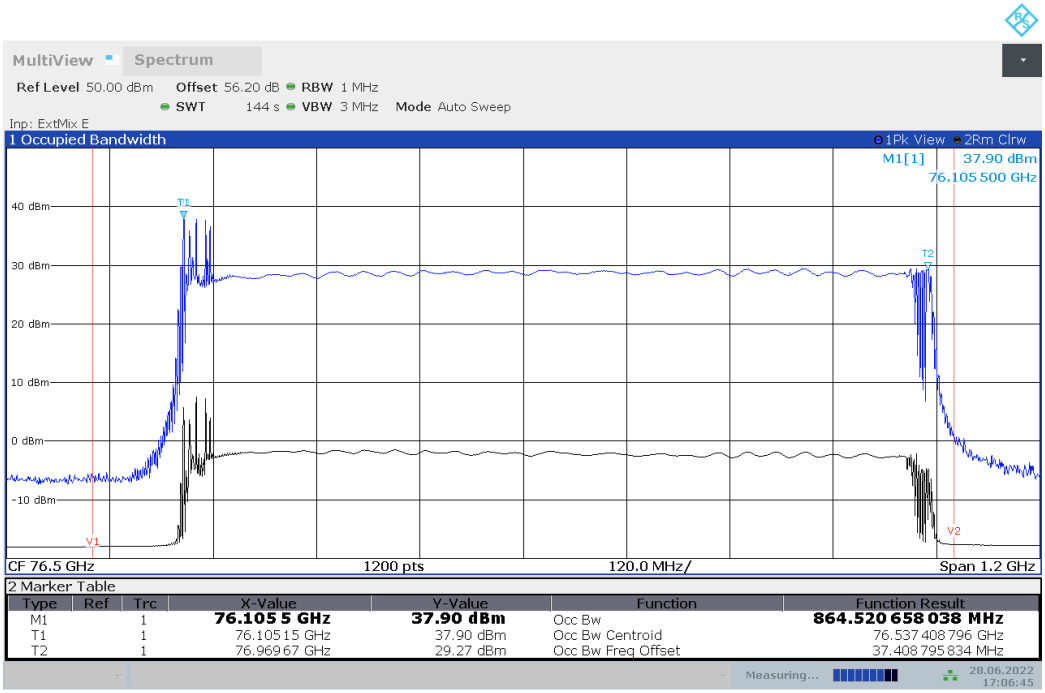
Plot no. 12: 99% OBW, Peak detector, 20 °C, V_{nom}, Test mode low speed



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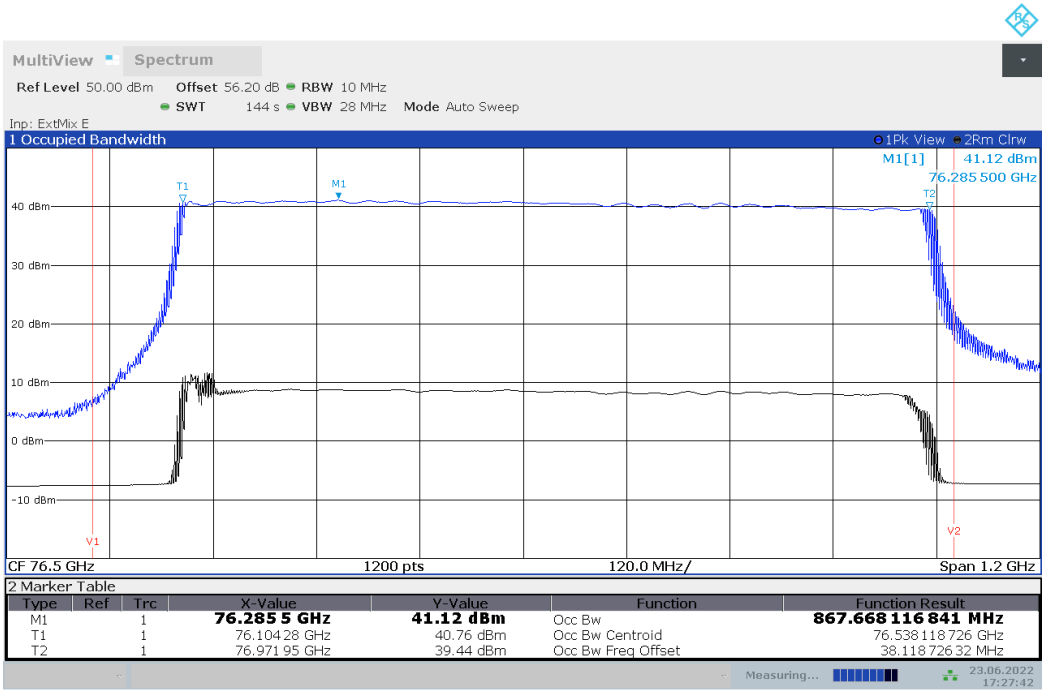
Plot no. 13: 99% OBW, Peak detector, 20 °C, V_{max}, Test mode low speed



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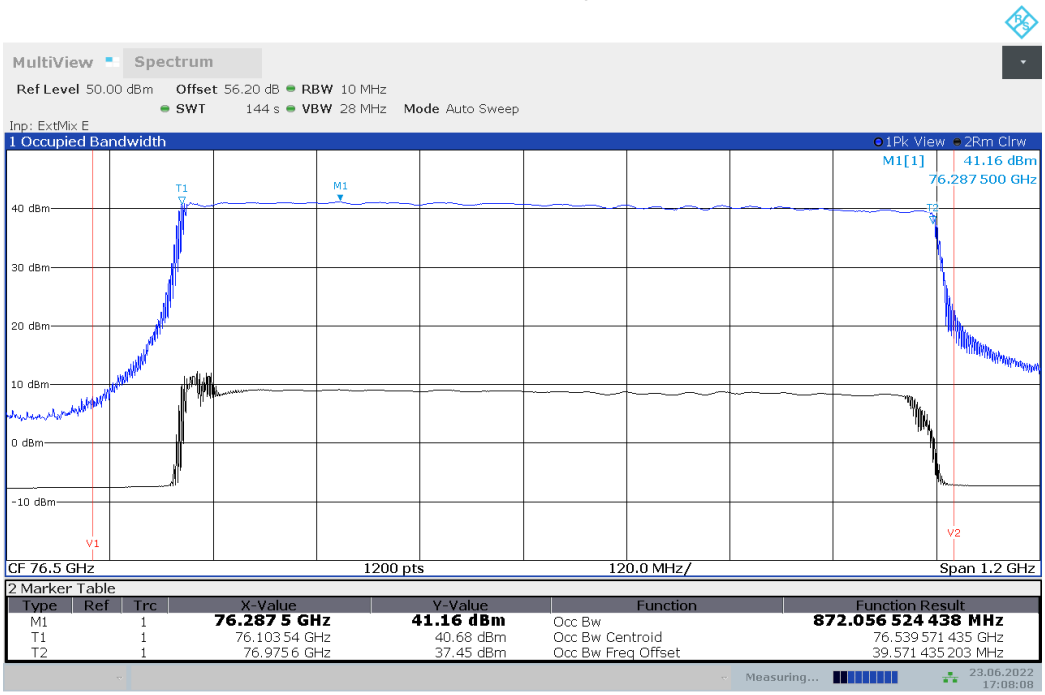
Plot no. 14: 99% OBW, Peak detector, 10 °C, Test mode low speed



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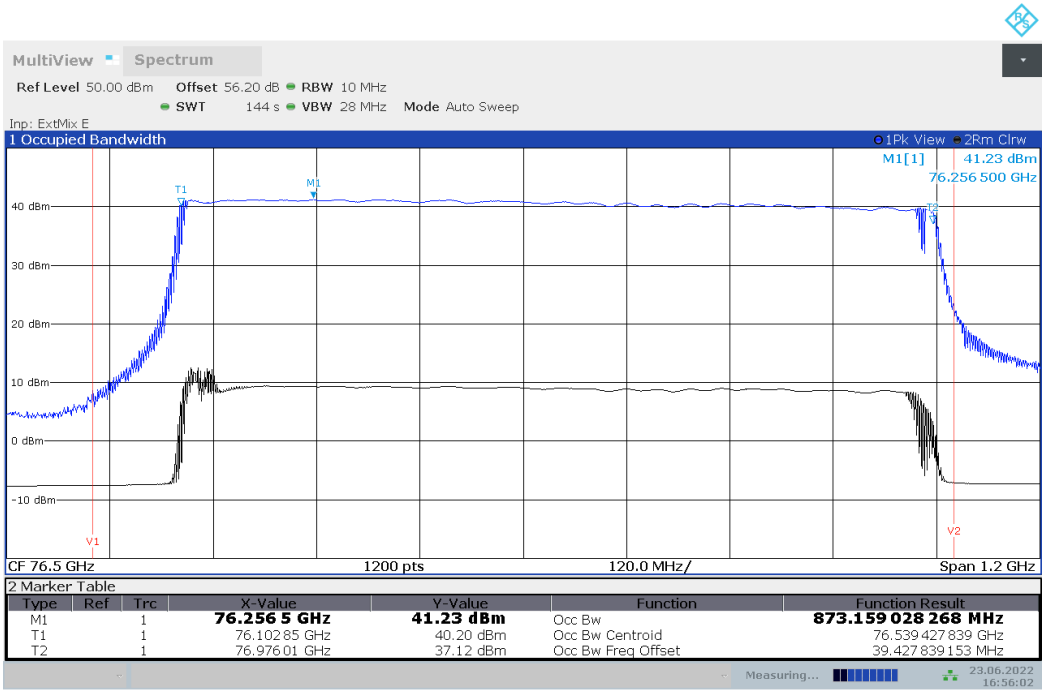
Plot no. 15: 99% OBW, Peak detector, 0 °C, Test mode low speed



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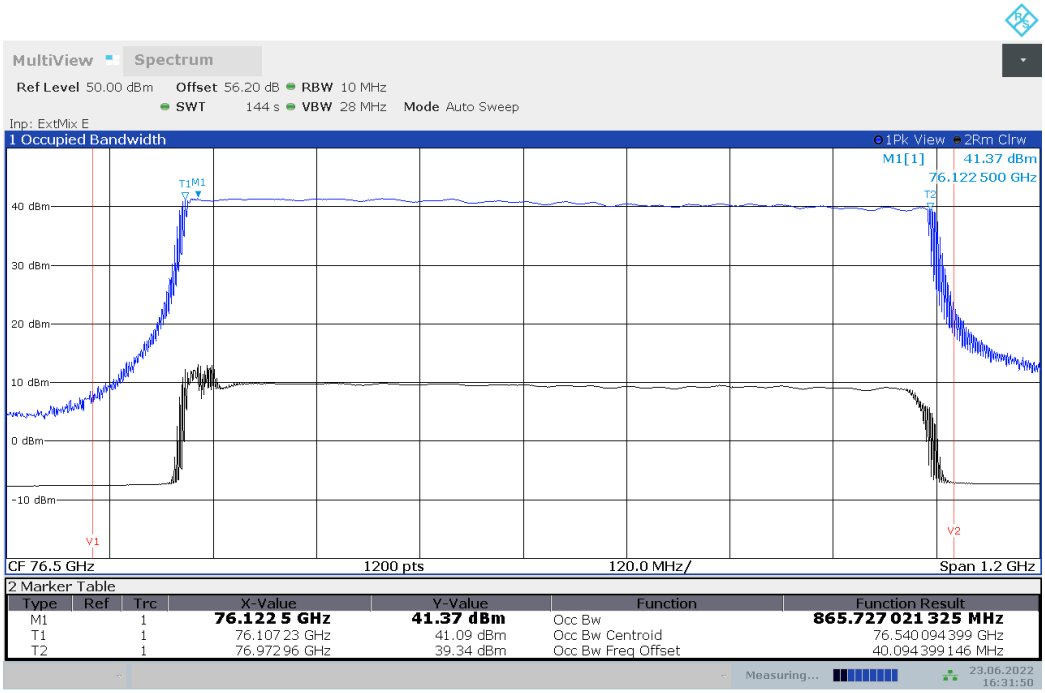
Plot no. 16: 99% OBW, Peak detector, -10 °C, Test mode low speed

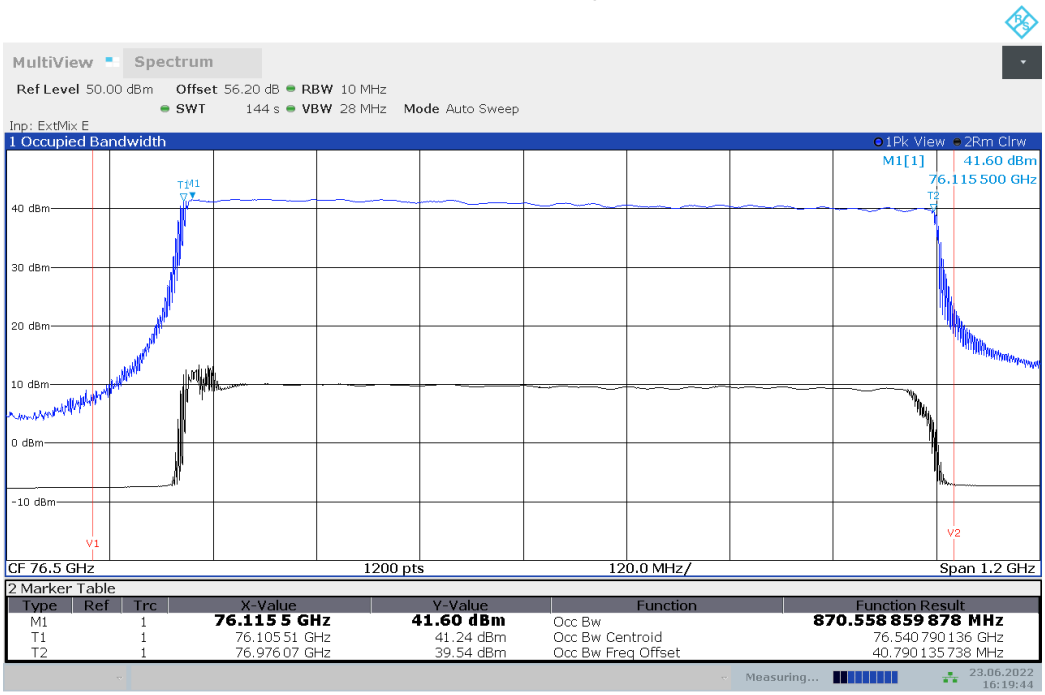
16:43:57 23.06.2022

Plot no. 17: 99% OBW, Peak detector, -20 °C, Test mode low speed



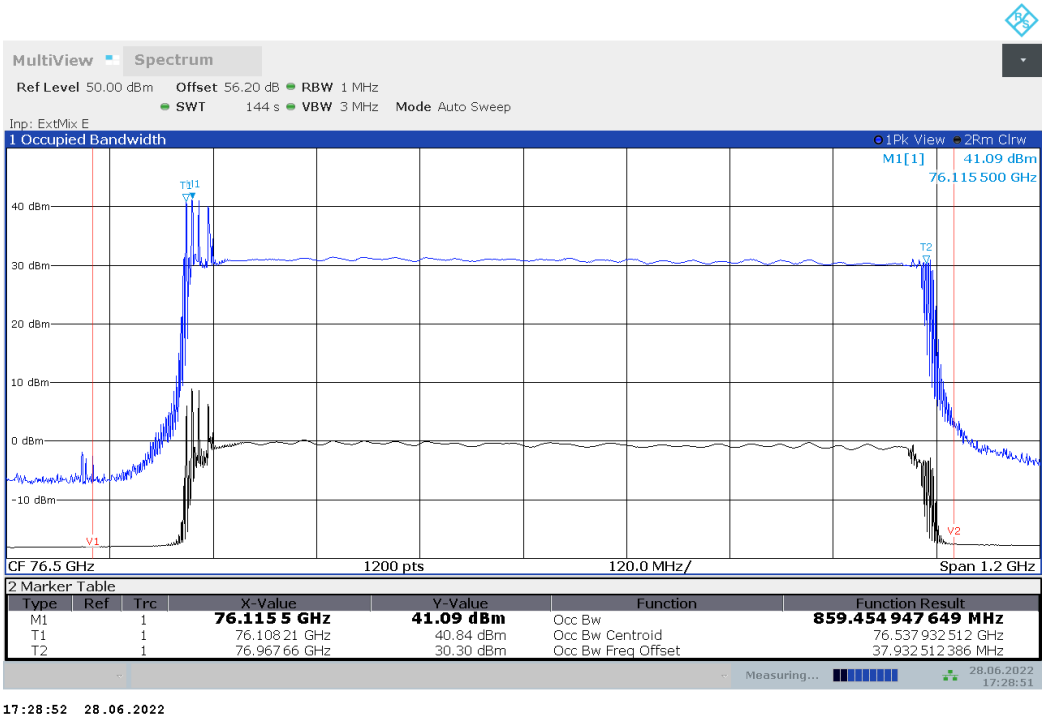
16:31:51 23.06.2022

Plot no. 18: 99% OBW, Peak detector, -30 °C, Test mode low speed

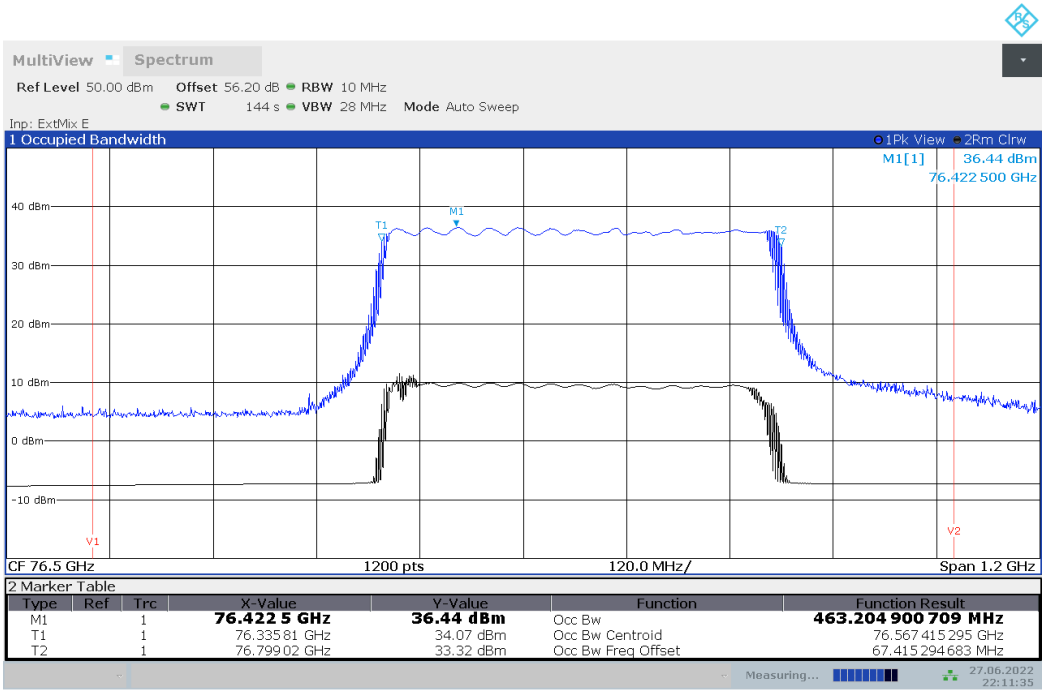


16:19:44 23.06.2022

Plot no. 19: 99% OBW, Peak detector, -40 °C, Test mode low speed

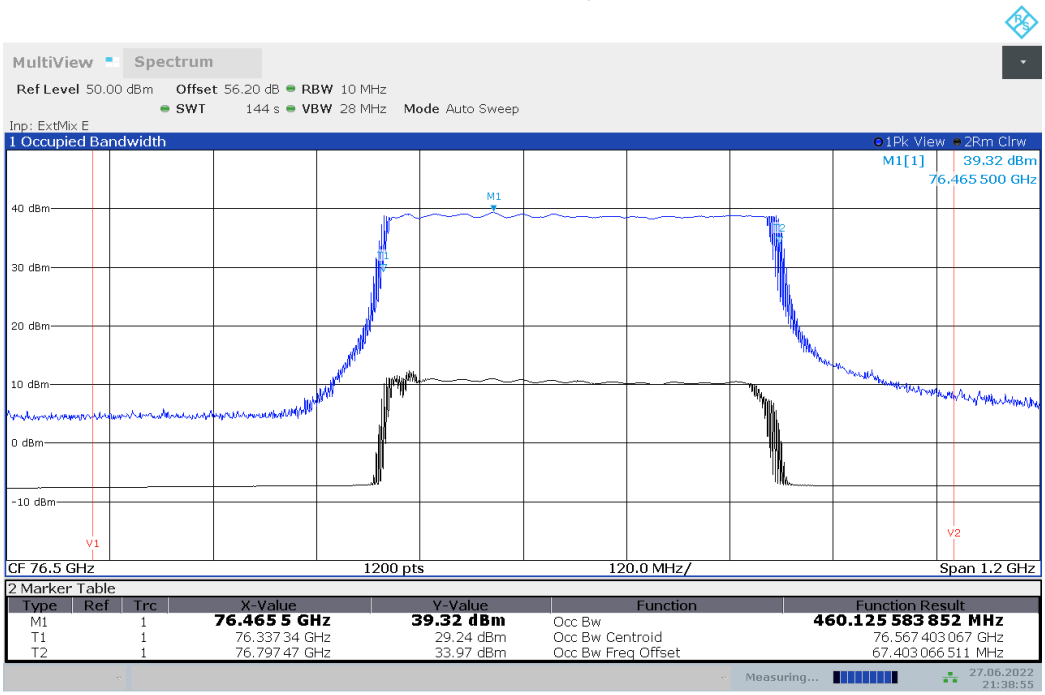


Plot no. 20: 99% OBW, Peak detector, 85 °C, Test mode mid speed



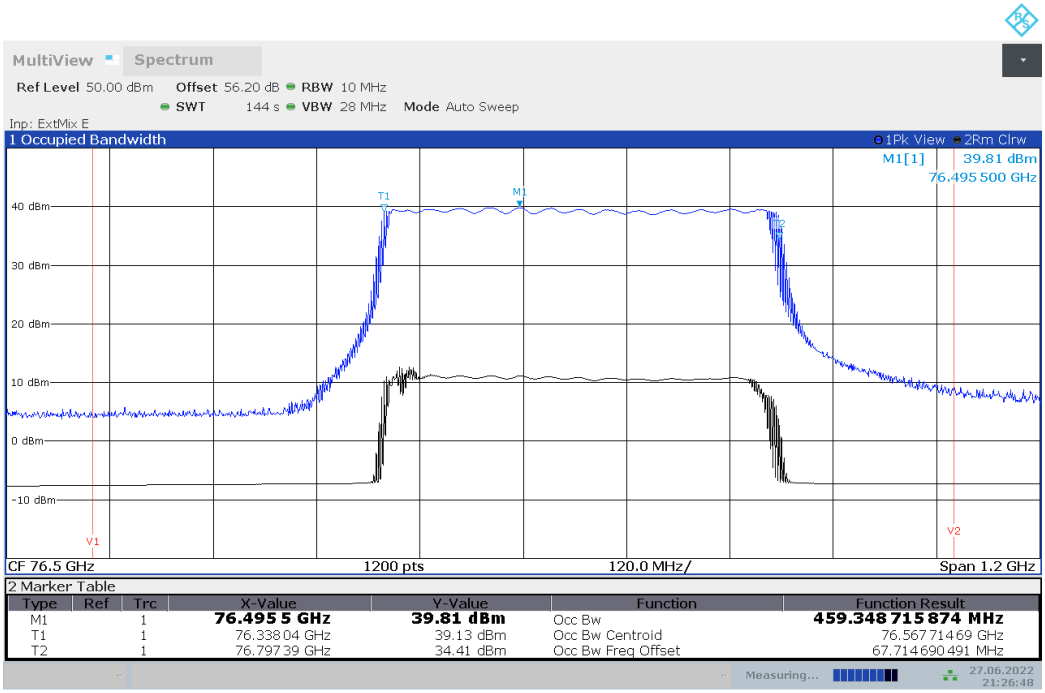
22:11:36 27.06.2022

Plot no. 21: 99% OBW, Peak detector, 50 °C, Test mode mid speed



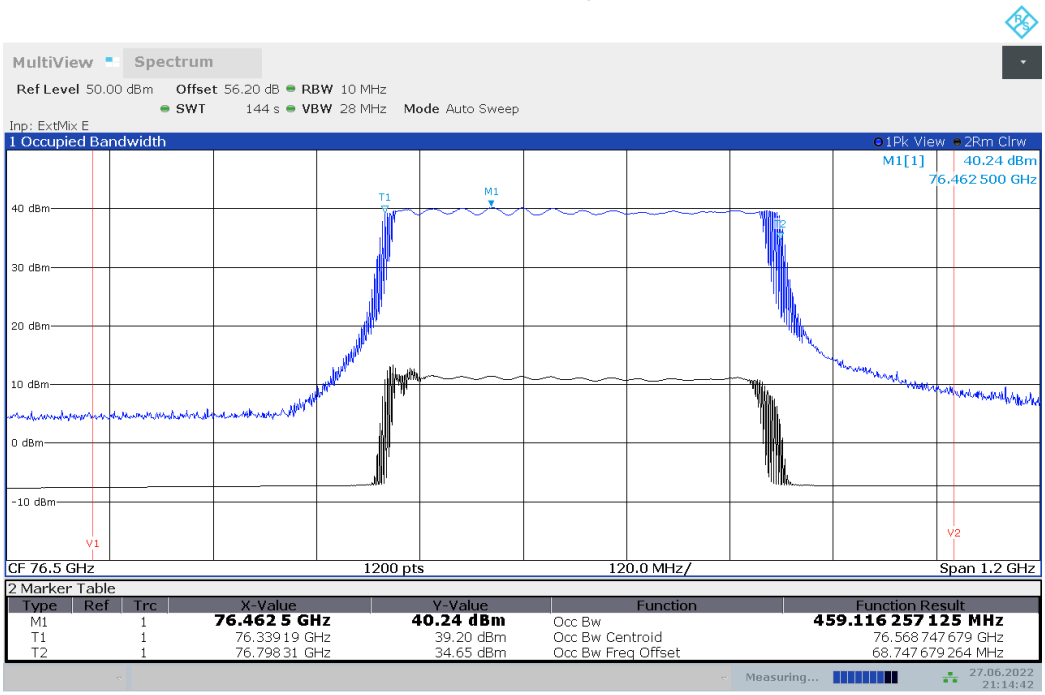
21:38:56 27.06.2022

Plot no. 22: 99% OBW, Peak detector, 40 °C, Test mode mid speed



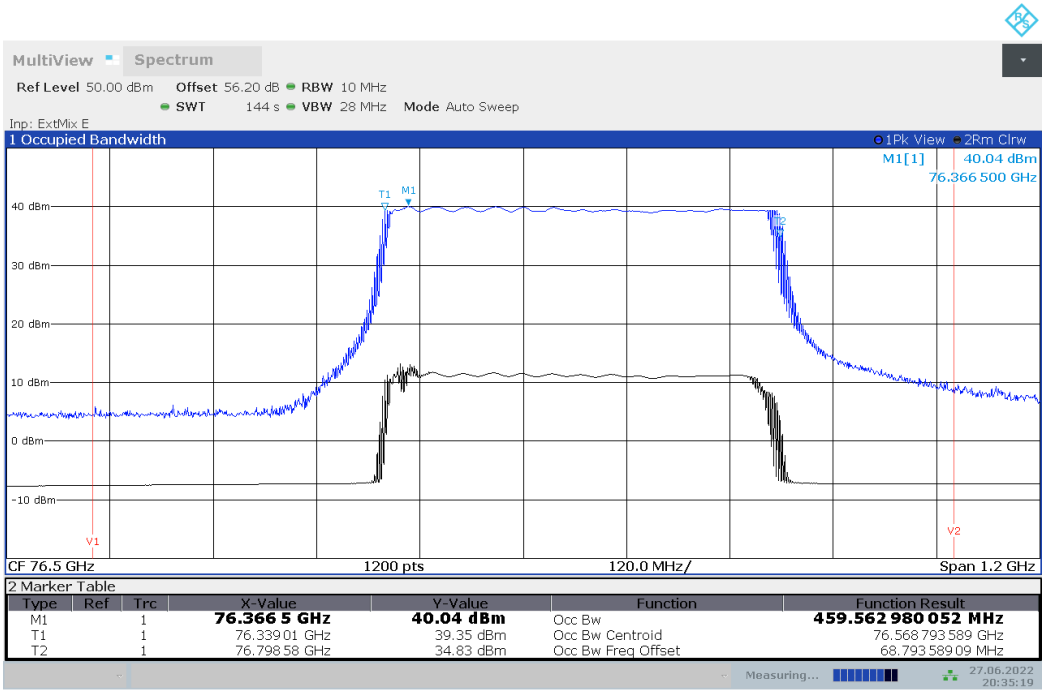
21:26:49 27.06.2022

Plot no. 23: 99% OBW, Peak detector, 30 °C, Test mode mid speed



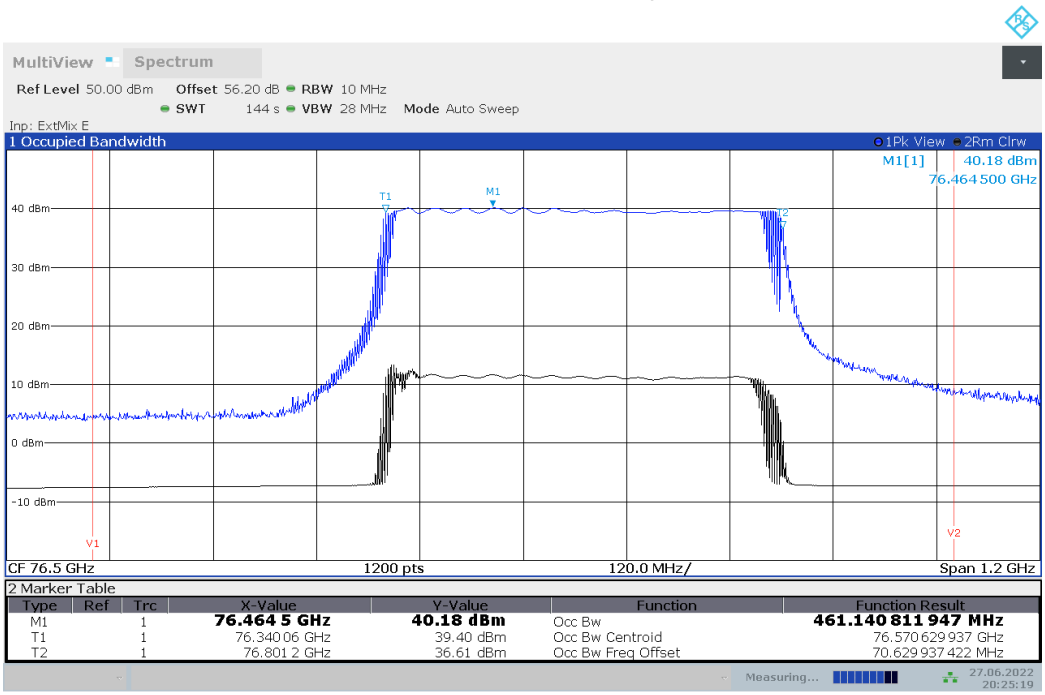
21:14:42 27.06.2022

Plot no. 24: 99% OBW, Peak detector, 20 °C, V_{min}, Test mode mid speed



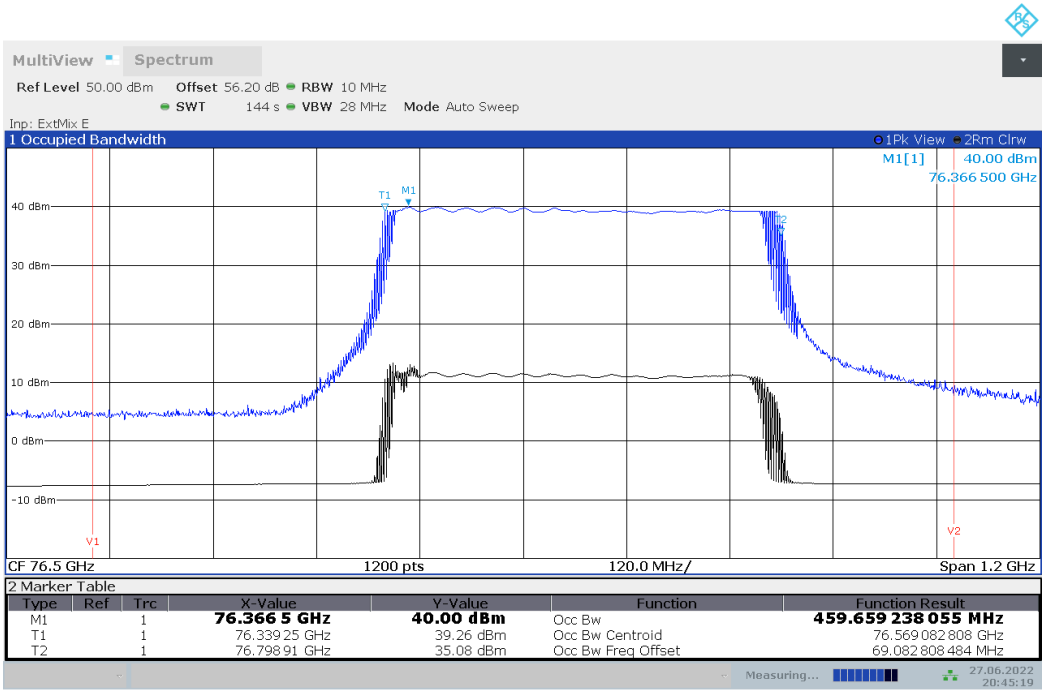
20:35:20 27.06.2022

Plot no. 25: 99% OBW, Peak detector, 20 °C, V_{nom}, Test mode mid speed



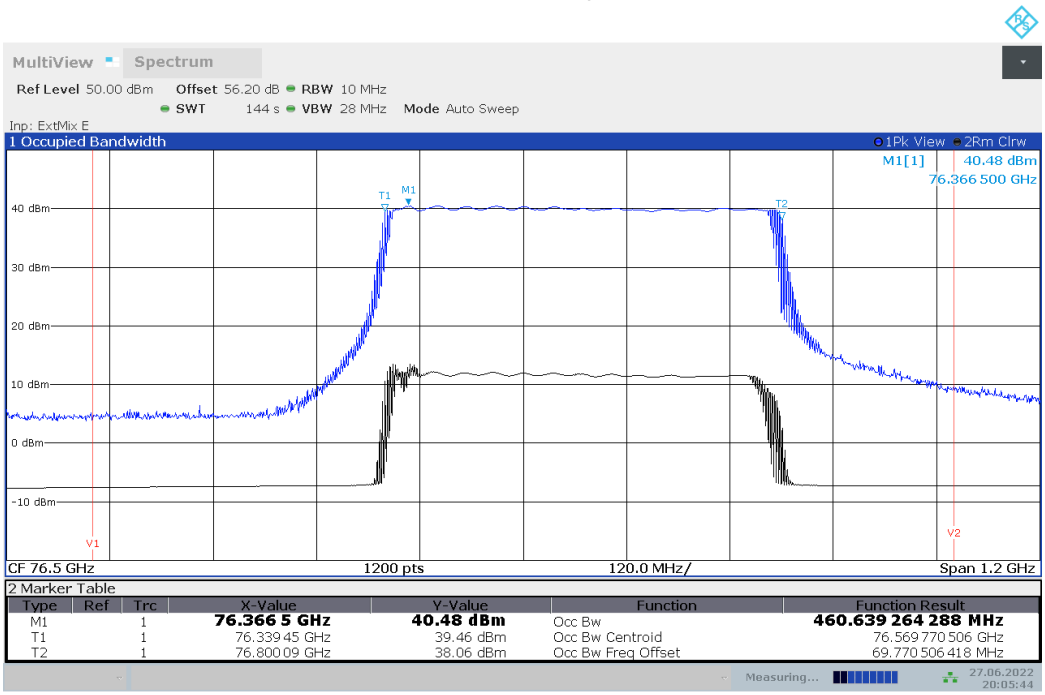
20:25:20 27.06.2022

Plot no. 26: 99% OBW, Peak detector, 20 °C, V_{max}, Test mode mid speed



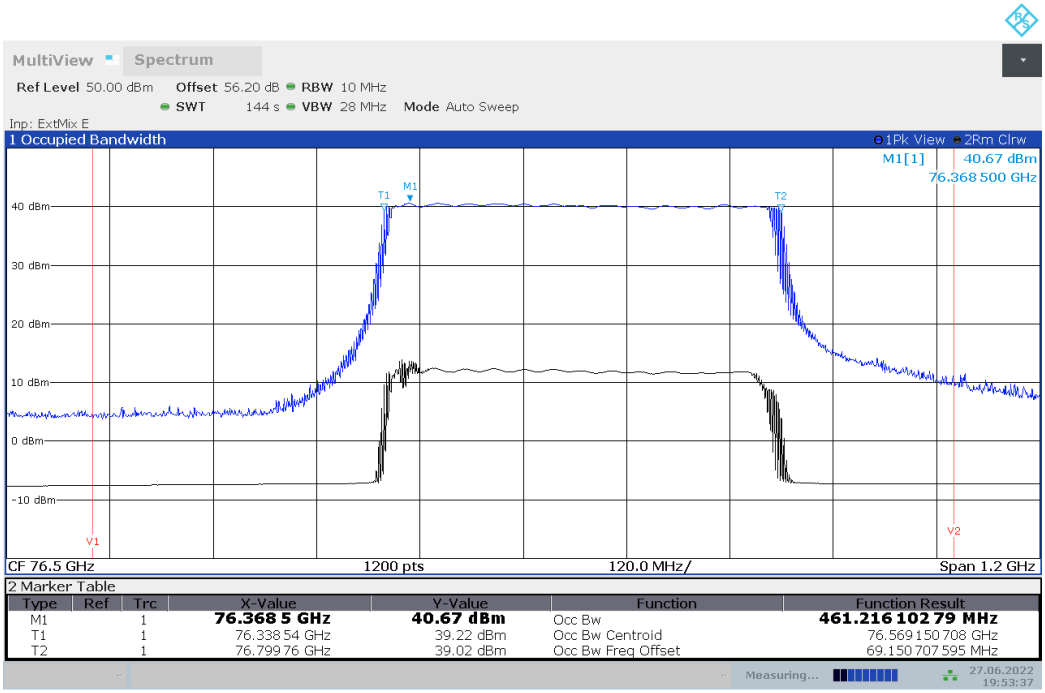
20:45:20 27.06.2022

Plot no. 27: 99% OBW, Peak detector, 10 °C, Test mode mid speed



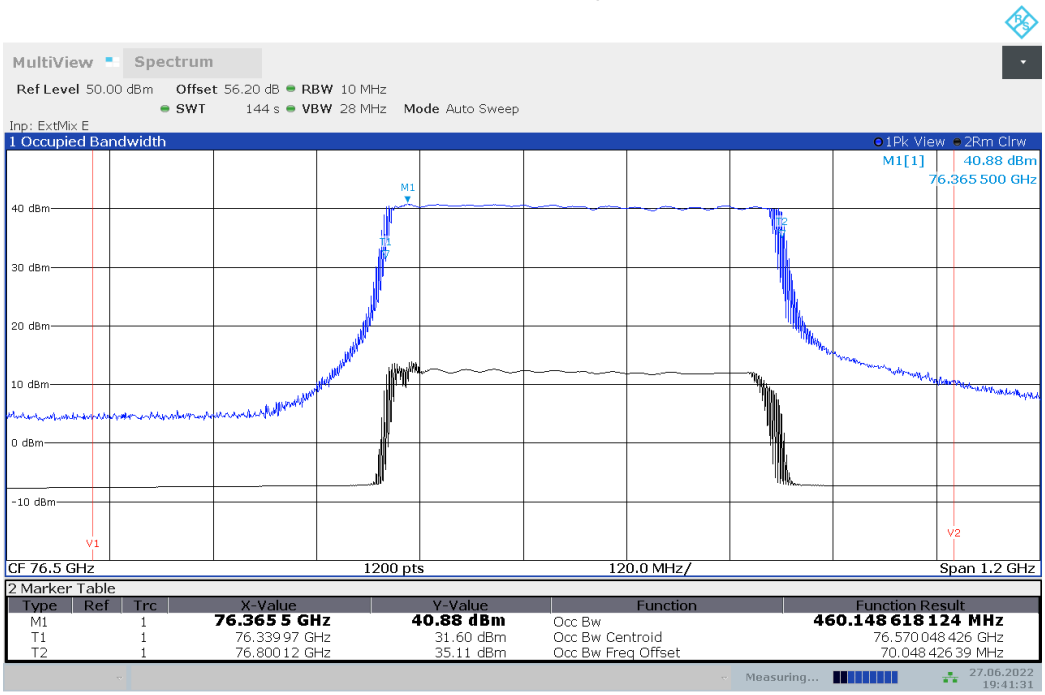
20:05:45 27.06.2022

Plot no. 28: 99% OBW, Peak detector, 0 °C, Test mode mid speed



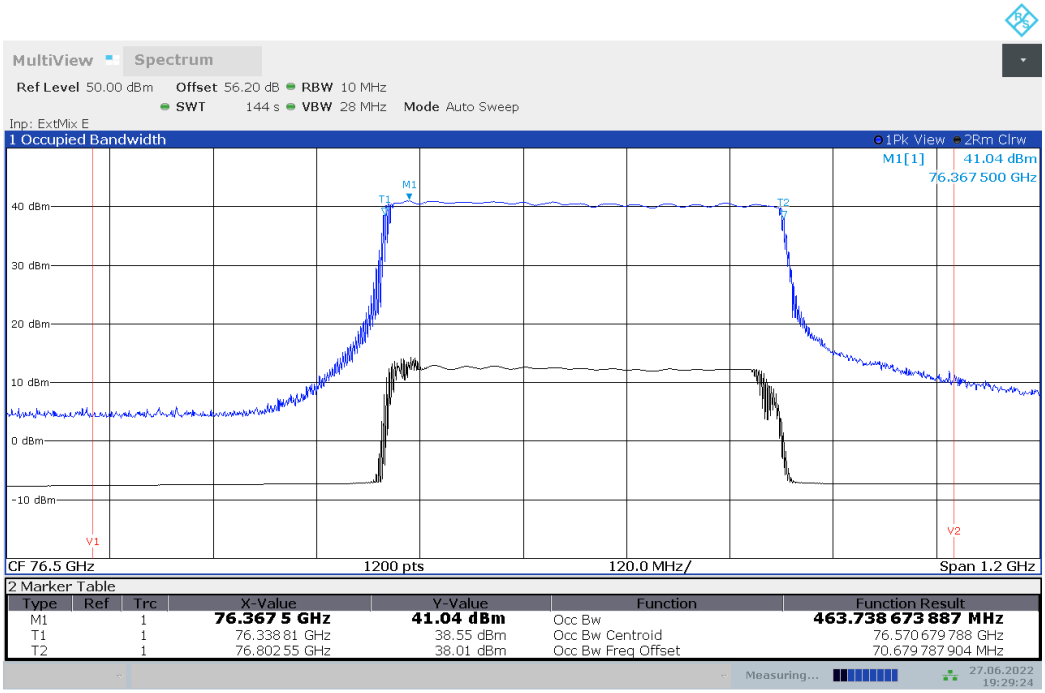
19:53:38 27.06.2022

Plot no. 29: 99% OBW, Peak detector, -10 °C, Test mode mid speed



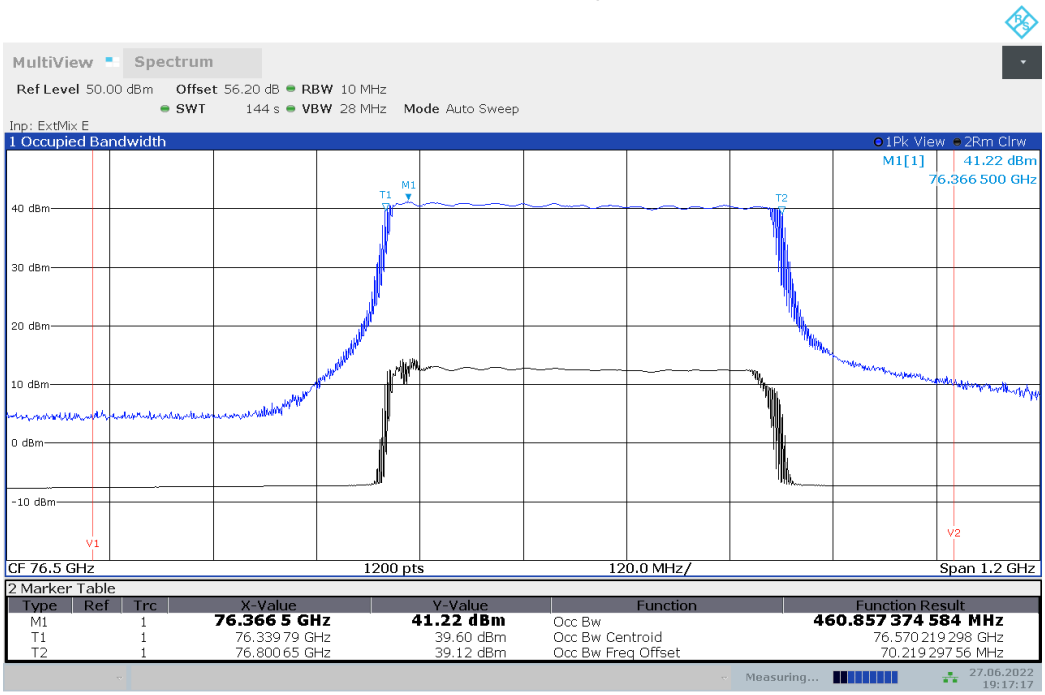
19:41:31 27.06.2022

Plot no. 30: 99% OBW, Peak detector, -20 °C, Test mode mid speed



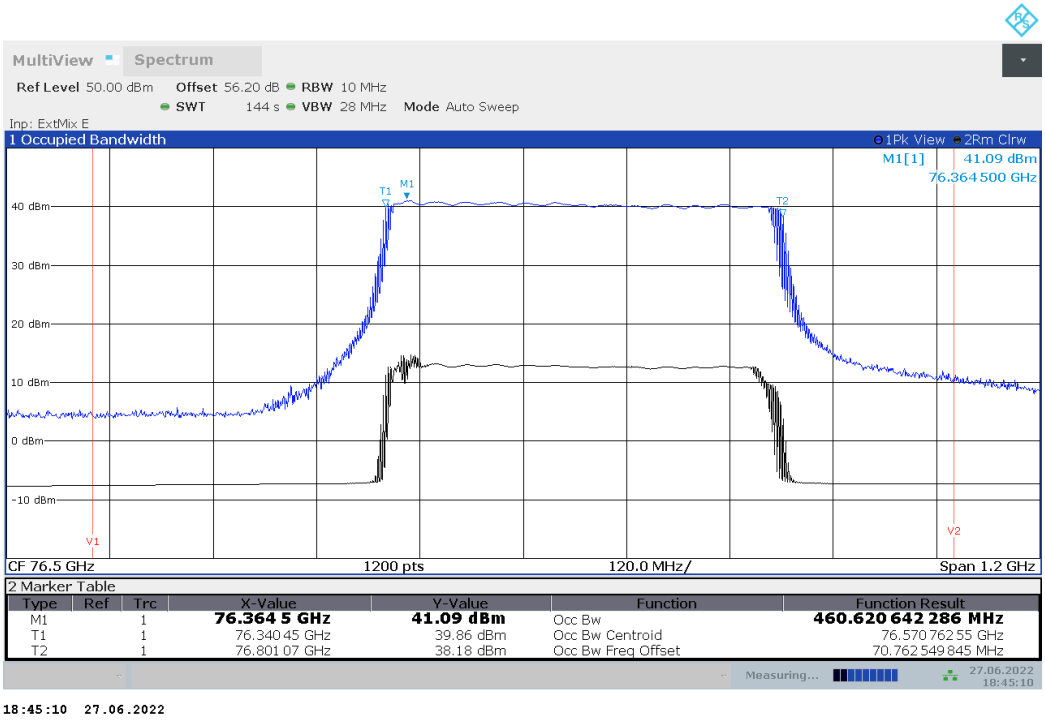
19:29:24 27.06.2022

Plot no. 31: 99% OBW, Peak detector, -30 °C, Test mode mid speed

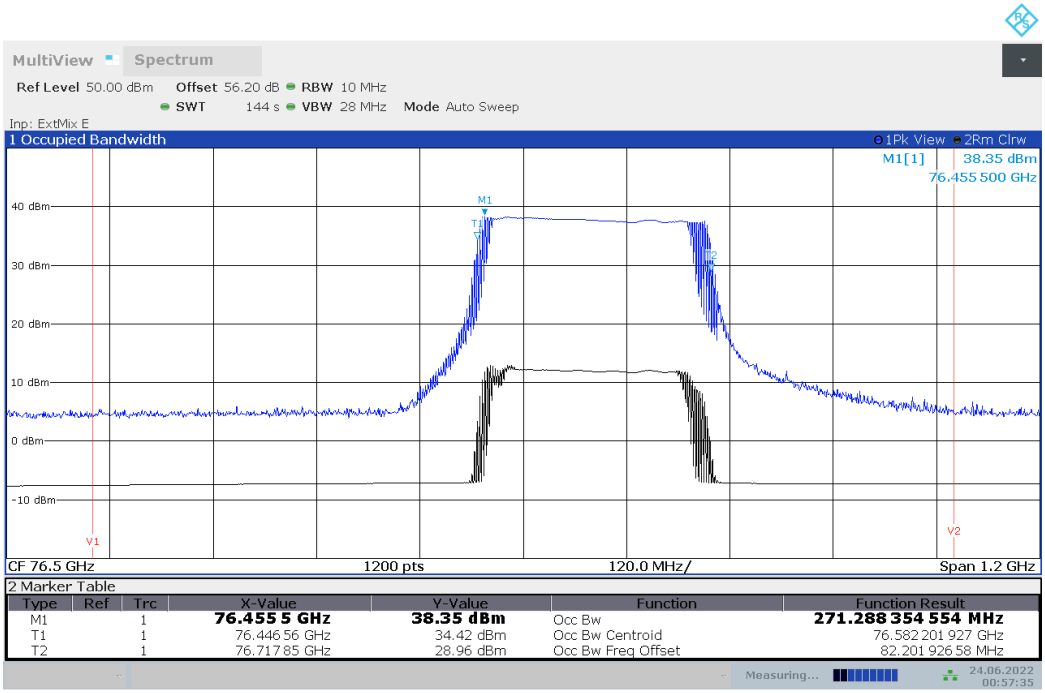


19:17:17 27.06.2022

Plot no. 32: 99% OBW, Peak detector, -40 °C, Test mode mid speed

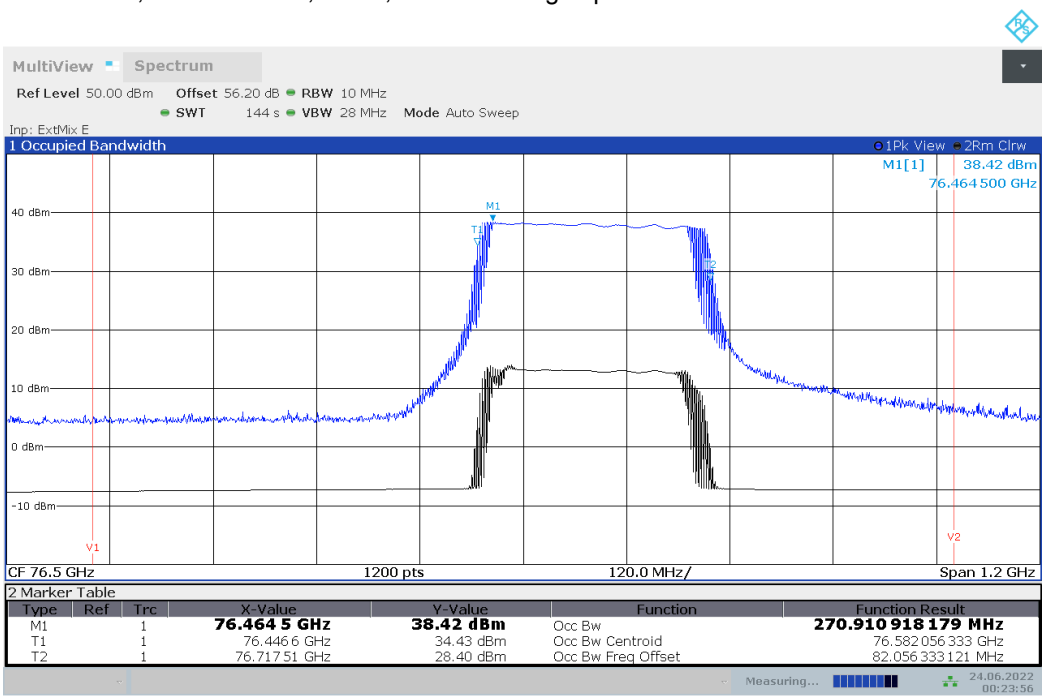


Plot no. 33: 99% OBW, Peak detector, 85 °C, Test mode high speed



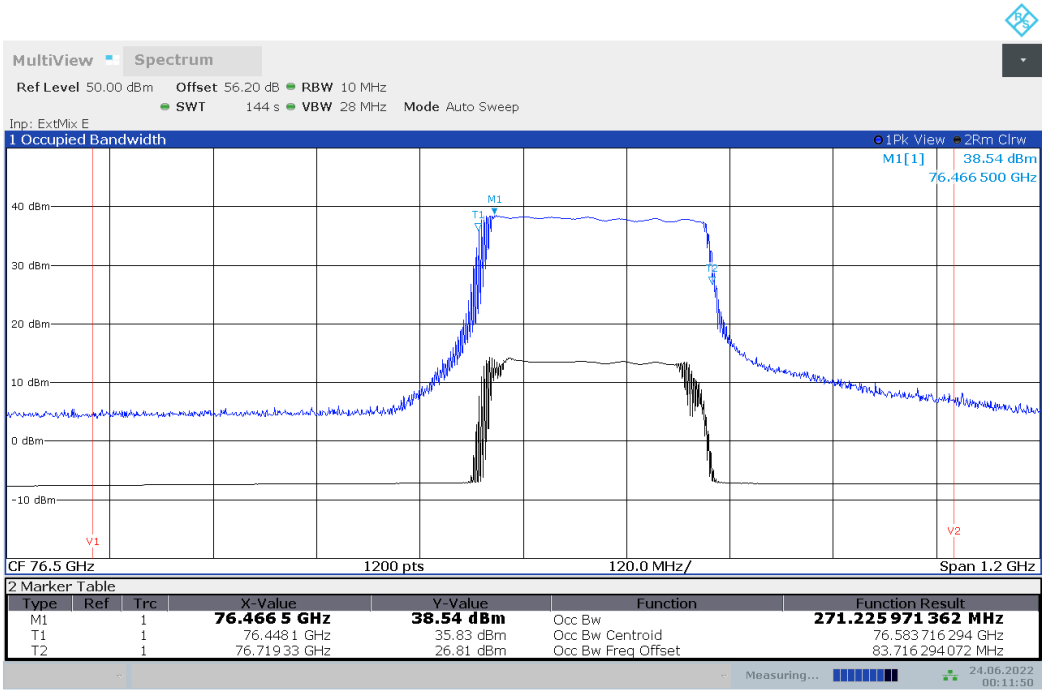
00:57:36 24.06.2022

Plot no. 34: 99% OBW, Peak detector, 50 °C, Test mode high speed



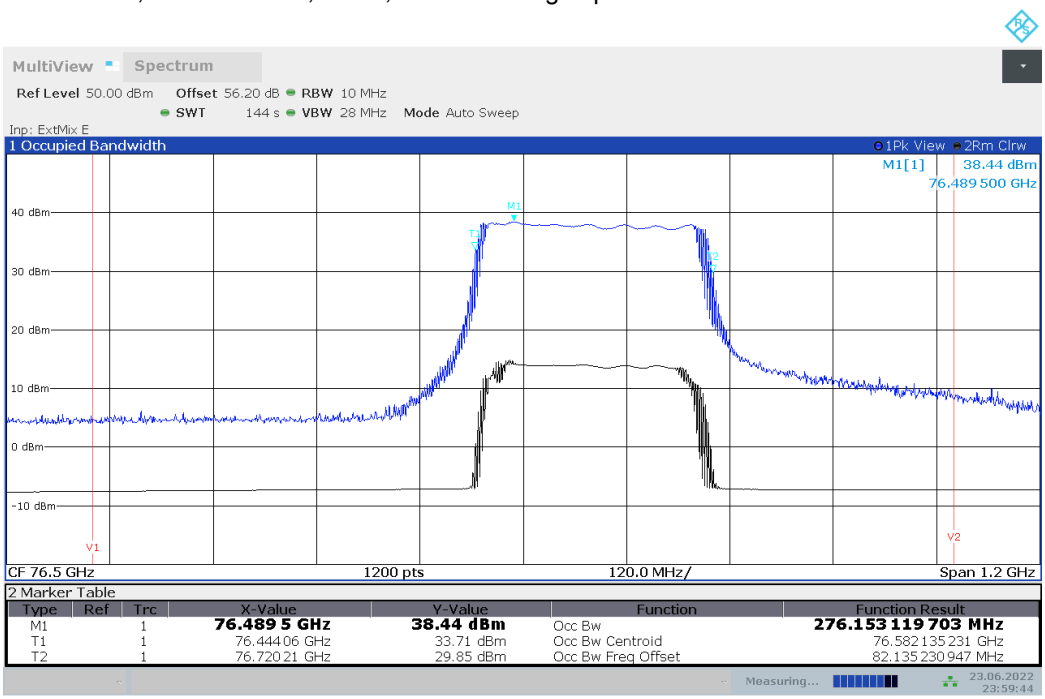
00:23:56 24.06.2022

Plot no. 35: 99% OBW, Peak detector, 40 °C, Test mode high speed



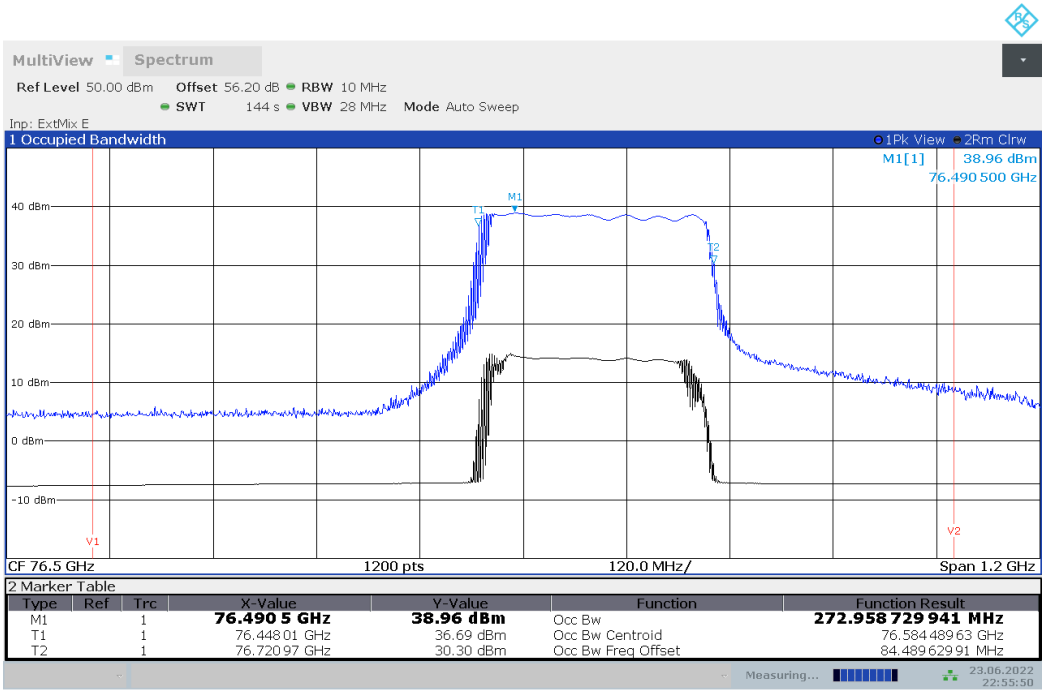
00:11:50 24.06.2022

Plot no. 36: 99% OBW, Peak detector, 30 °C, Test mode high speed



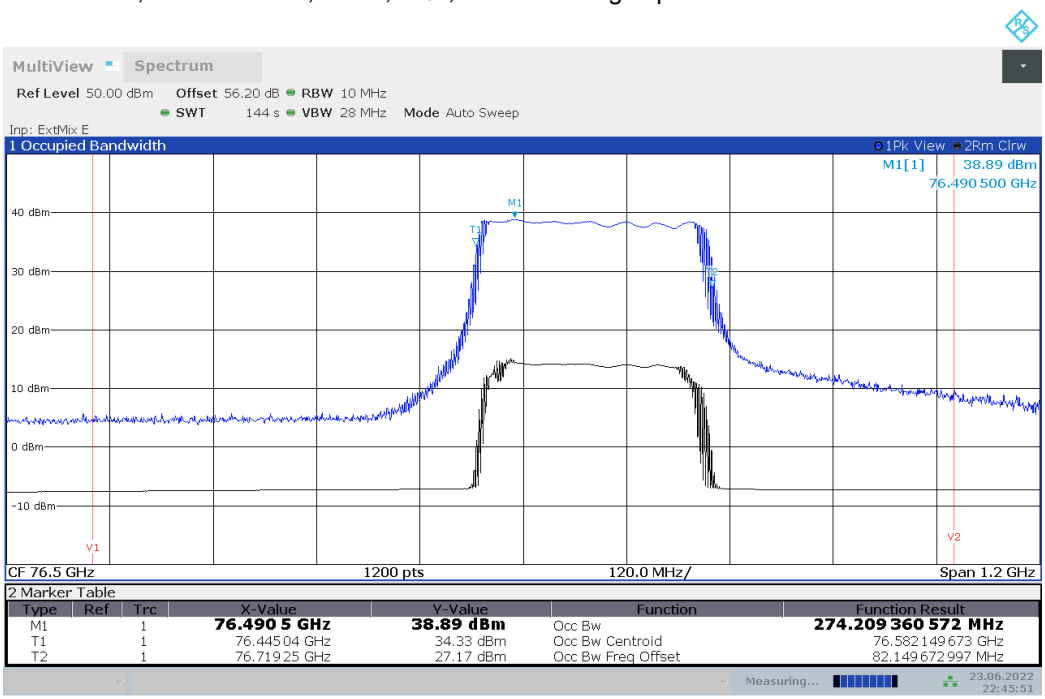
23:59:44 23.06.2022

Plot no. 37: 99% OBW, Peak detector, 20 °C, V_{min}, Test mode high speed



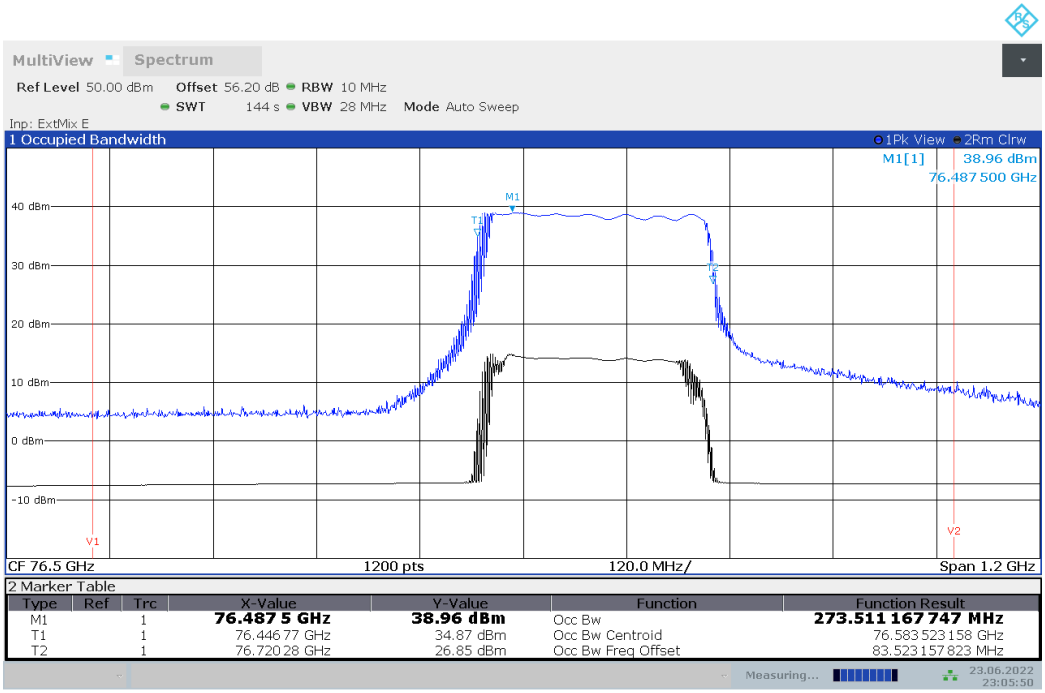
22:55:51 23.06.2022

Plot no. 38: 99% OBW, Peak detector, 20 °C, V_{nom}, Test mode high speed



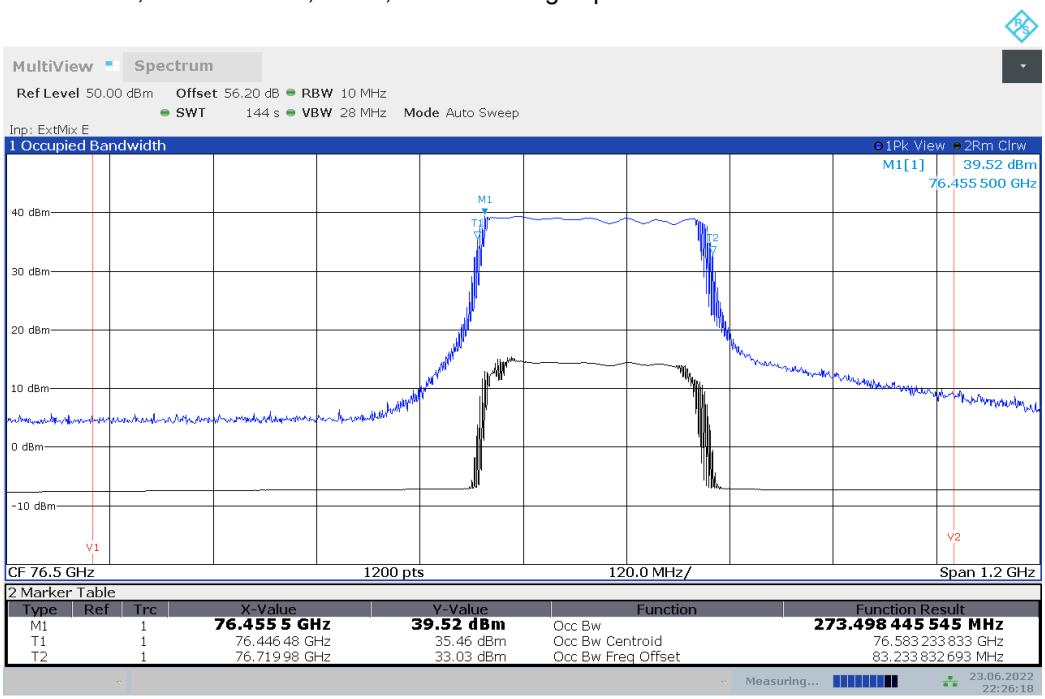
22:45:51 23.06.2022

Plot no. 39: 99% OBW, Peak detector, 20 °C, V_{max}, Test mode high speed



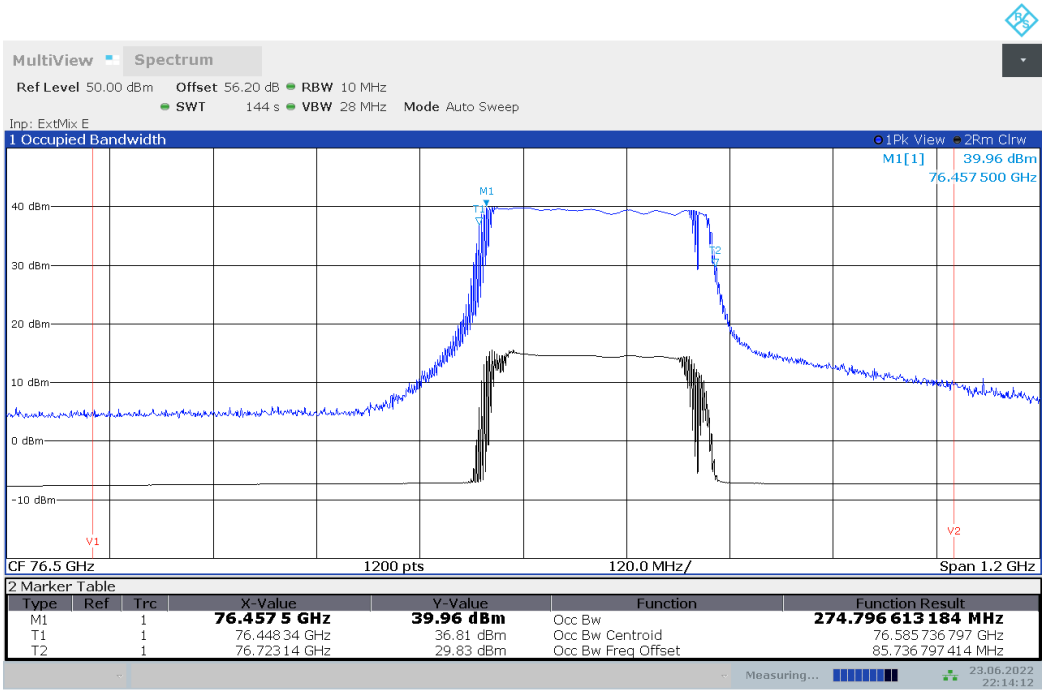
23:05:51 23.06.2022

Plot no. 40: 99% OBW, Peak detector, 10 °C, Test mode high speed



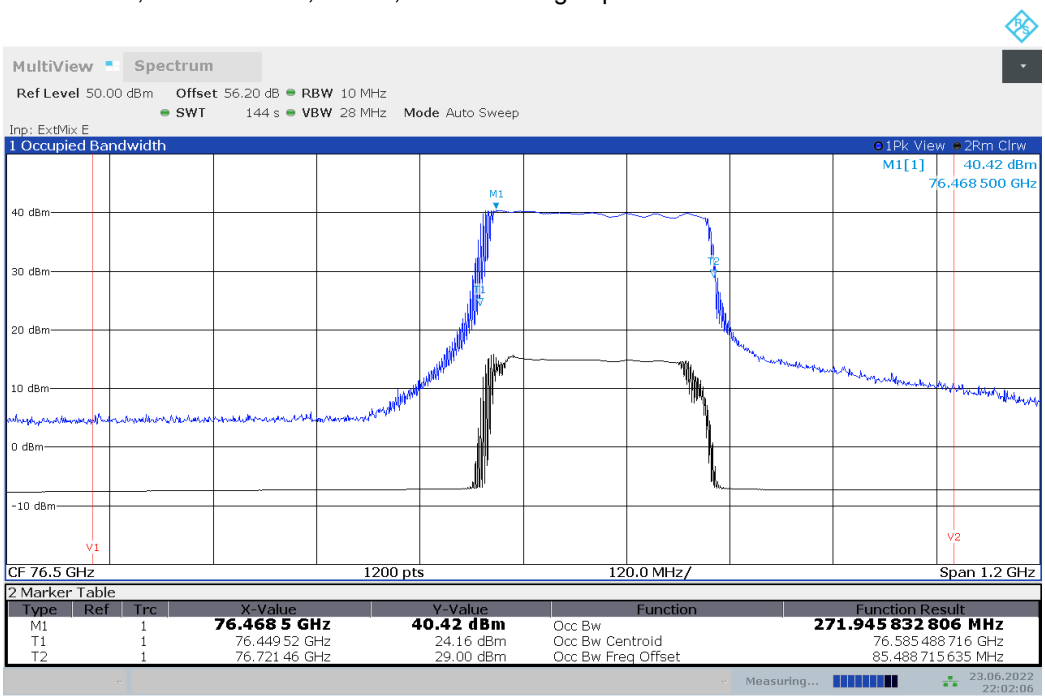
22:26:18 23.06.2022

Plot no. 41: 99% OBW, Peak detector, 0 °C, Test mode high speed



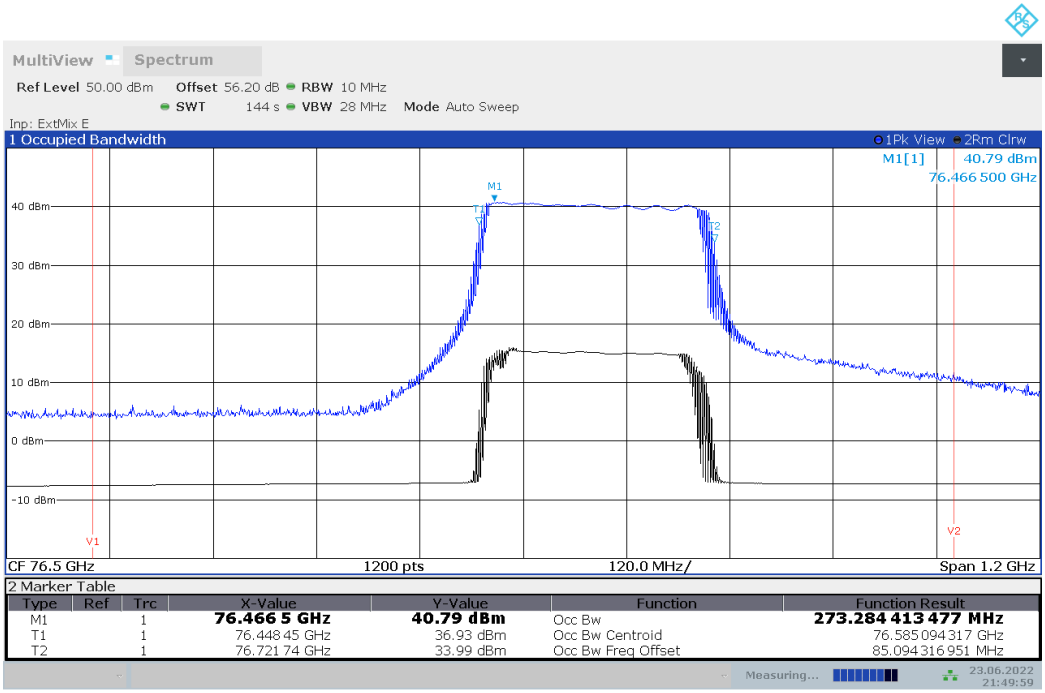
22:14:13 23.06.2022

Plot no. 42: 99% OBW, Peak detector, -10 °C, Test mode high speed



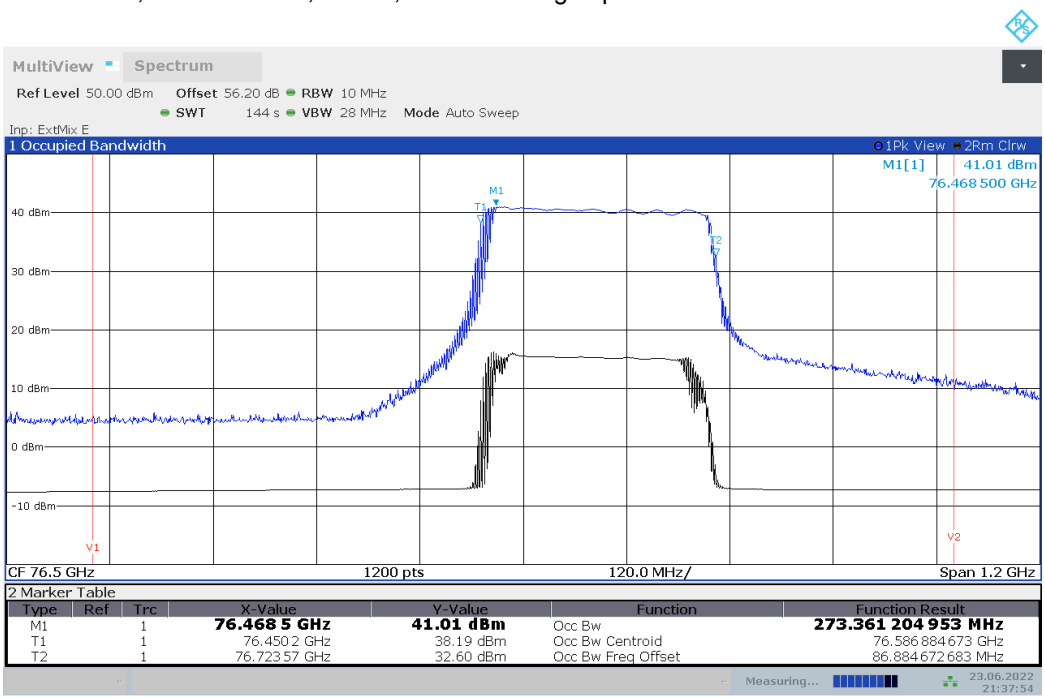
22:02:07 23.06.2022

Plot no. 43: 99% OBW, Peak detector, -20 °C, Test mode high speed



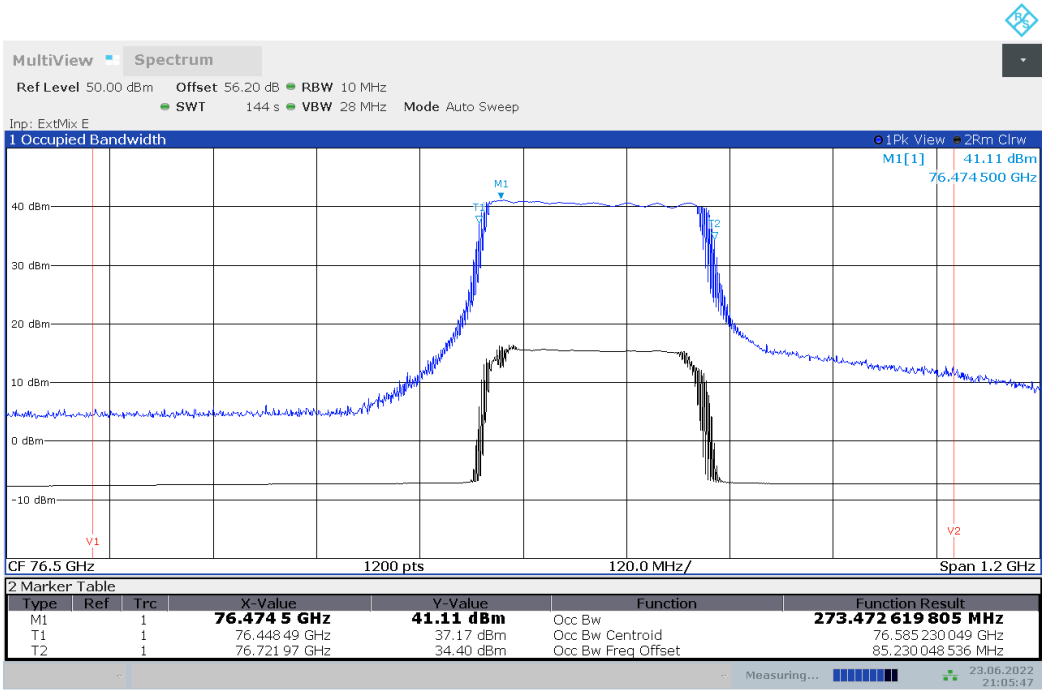
21:50:00 23.06.2022

Plot no. 44: 99% OBW, Peak detector, -30 °C, Test mode high speed



21:37:54 23.06.2022

Plot no. 45: 99% OBW, Peak detector, -40 °C, Test mode high speed



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 C63.10).

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

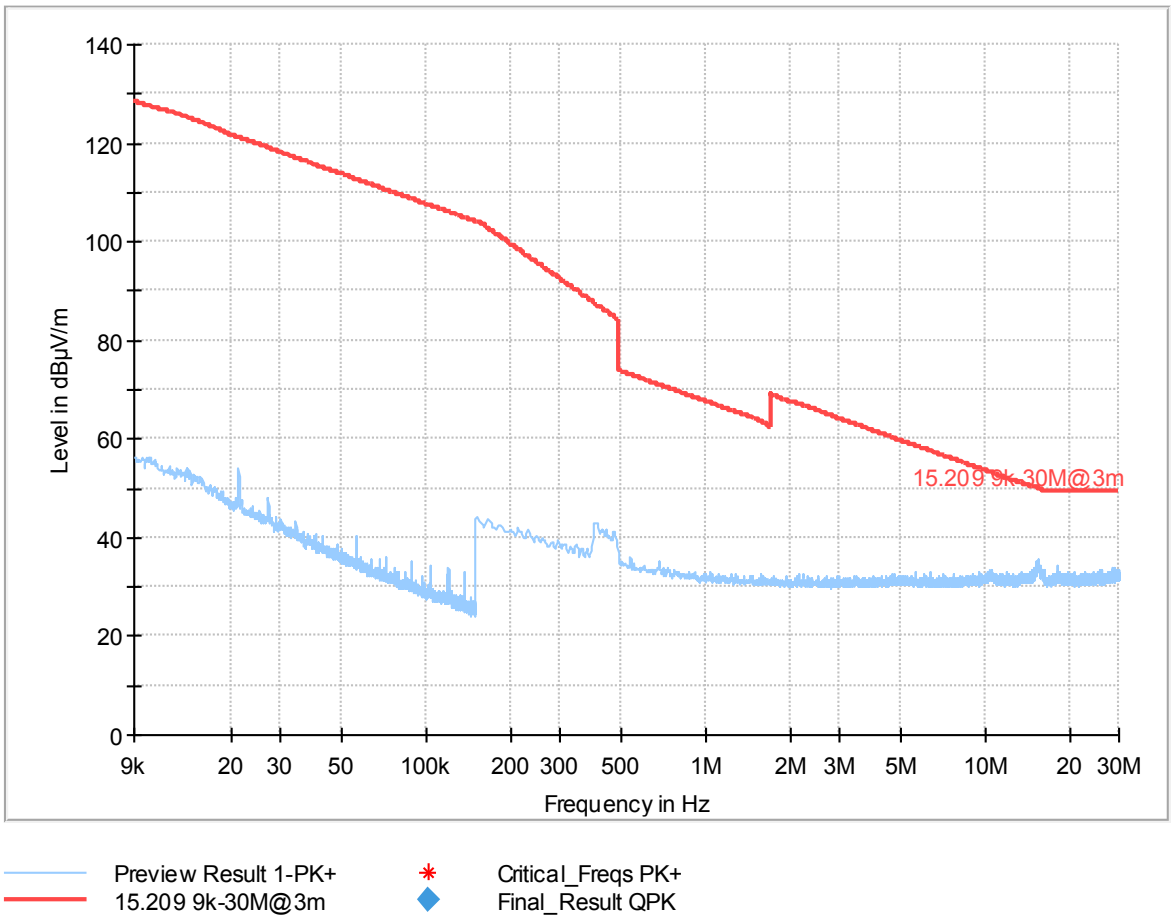
Used test distances
Up to 18 GHz: 3.00 m
18 – 40 GHz: 1.00 m
40 – 60 GHz: 0.50 m
60 – 84 GHz: 2.00 m
84 – 110 GHz: 0.50 m
110 – 170 GHz: 0.25 m
145 – 220 GHz: 0.50 m
220 – 330 GHz: 1.00 m
In-band / OOB measurements: 2.00 m

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)

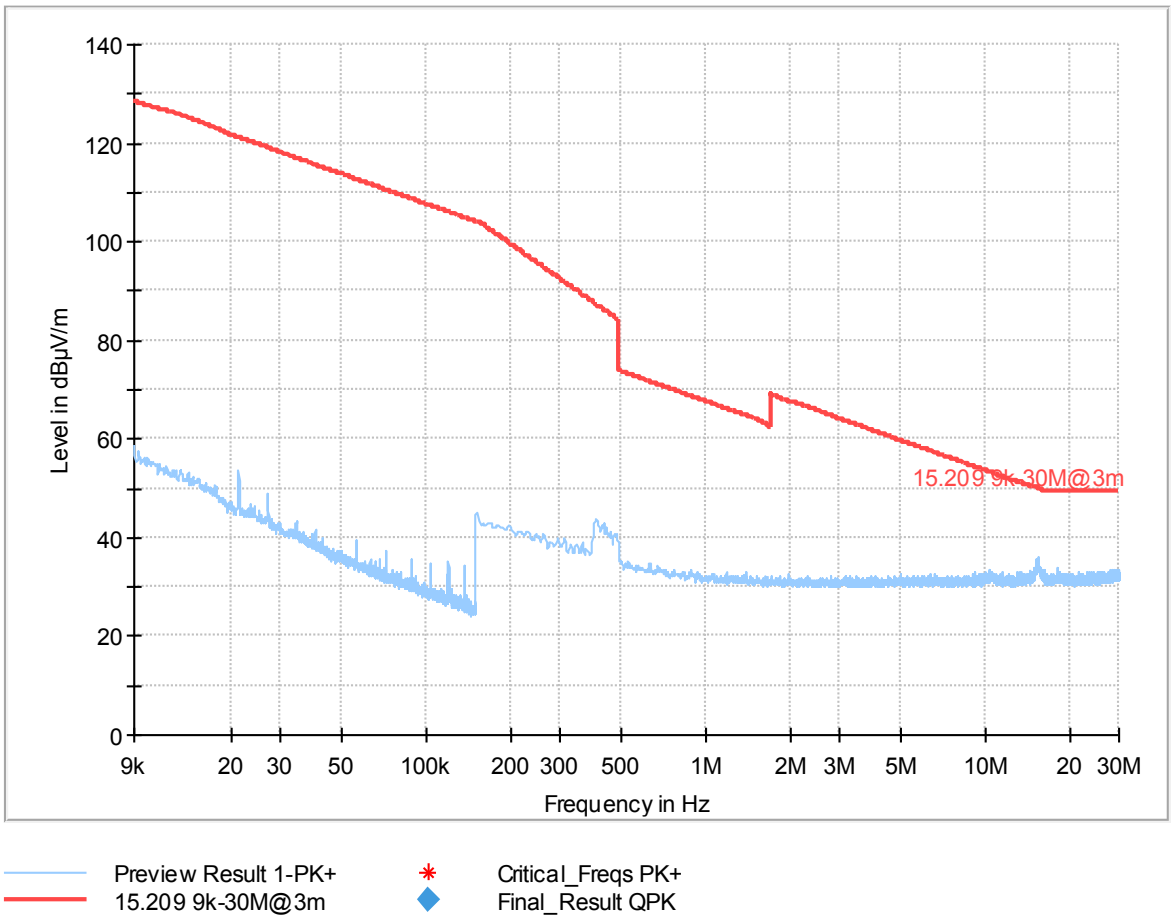
Test results:

Channel / Mode	Frequency [GHz]	Detector	Test distance [m]	Level [dBµV/dBm]	Limit [dBµV/dBm]	Margin [dB]
No critical emissions found. For further details see plots.						

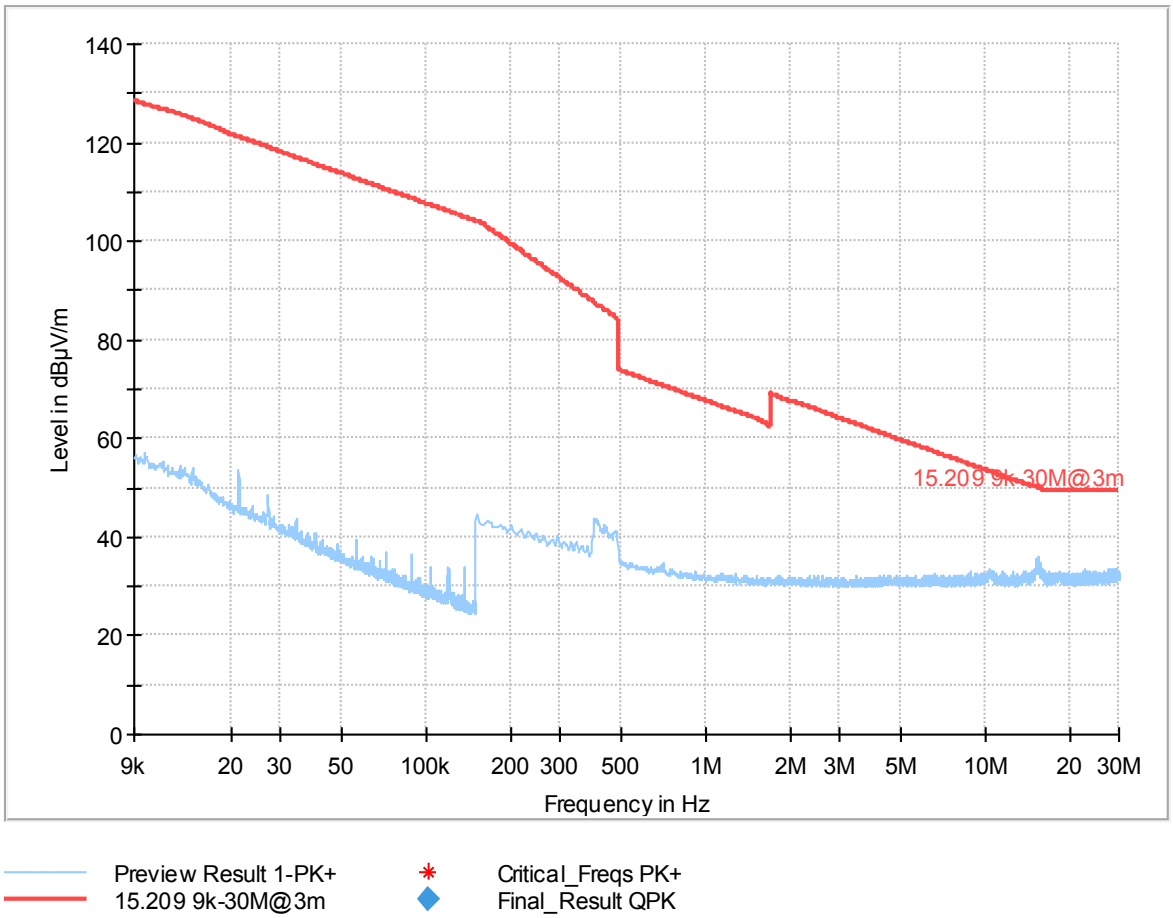
Plot no. 46: radiated emissions 9 kHz – 30 MHz, low speed mode , loop antenna



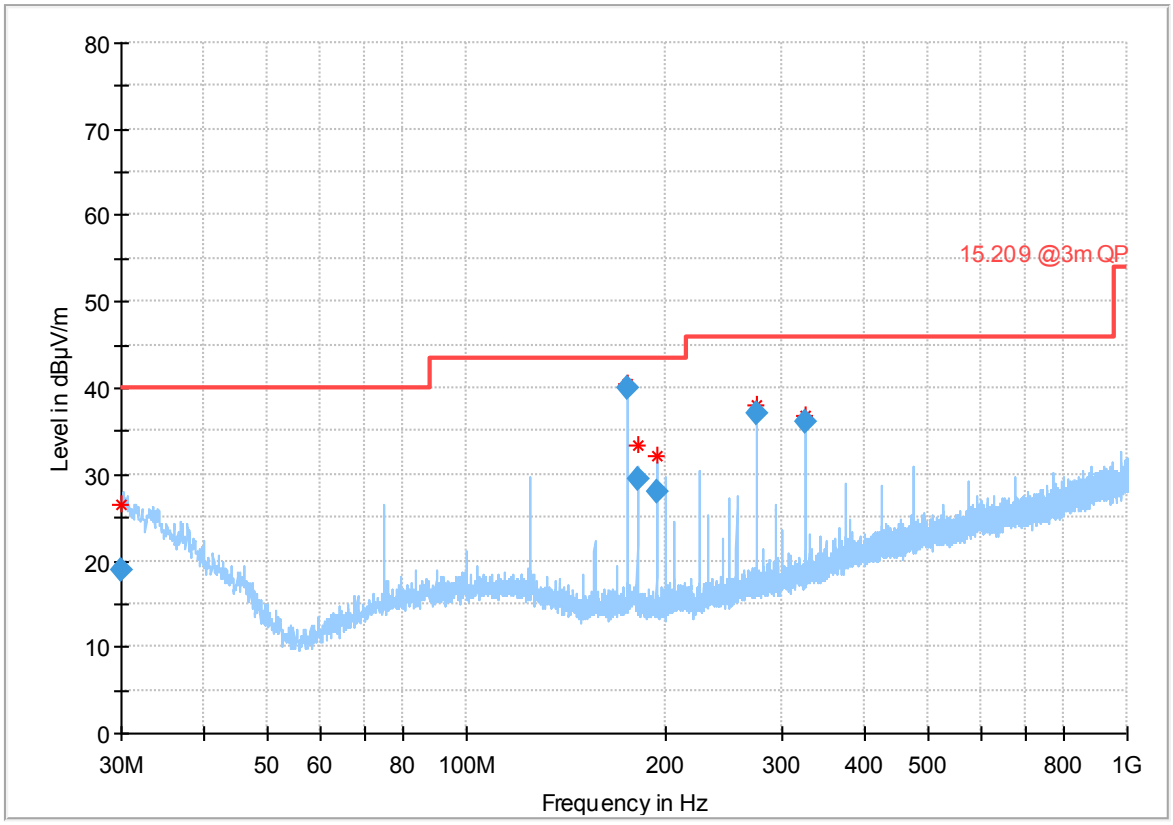
Plot no. 47: radiated emissions 9 kHz – 30 MHz, mid speed mode, loop antenna



Plot no. 48: radiated emissions 9 kHz – 30 MHz, high speed mode, loop antenna



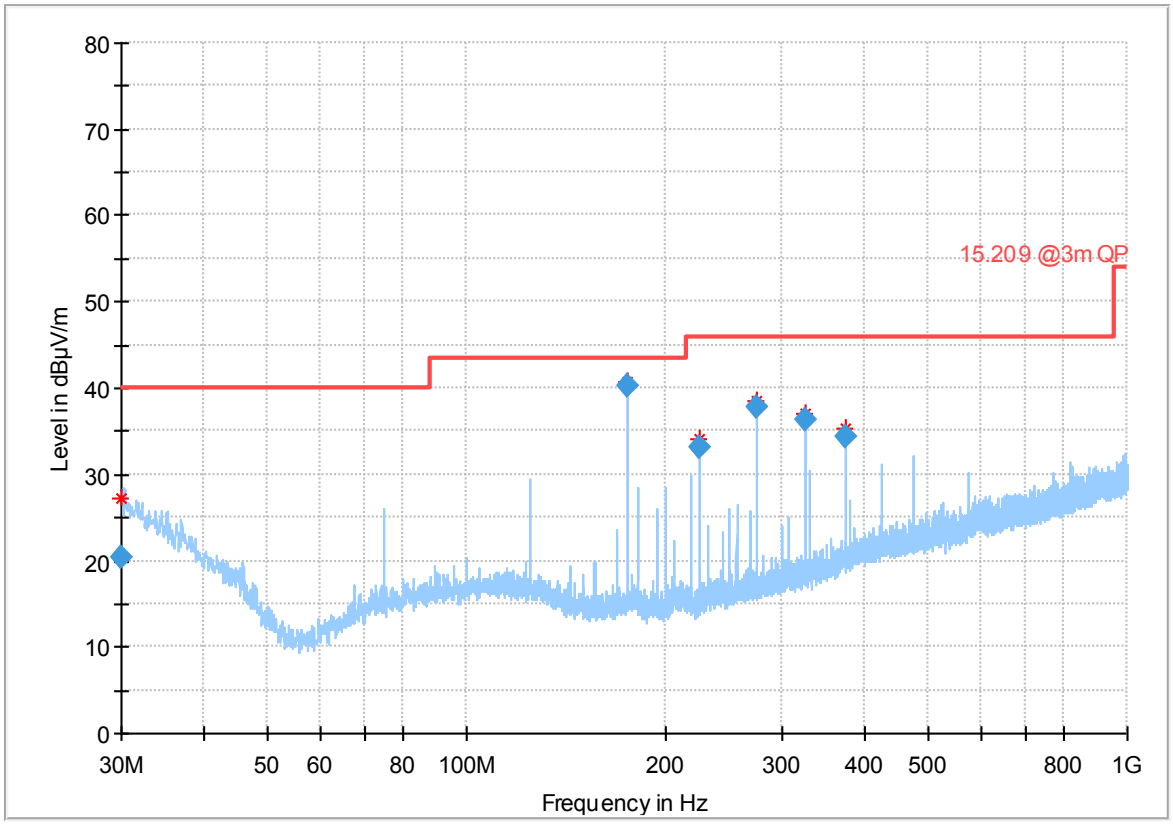
Plot no. 49: radiated emissions 30 MHz – 1 GHz, low speed mode, polarization vertical / horizontal



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.075000	18.94	40.00	21.06	100.0	120.000	100.0	V	197.0
174.991500	39.97	43.50	3.53	100.0	120.000	153.0	H	241.0
181.249500	29.38	43.50	14.12	100.0	120.000	184.0	H	91.0
193.761000	27.86	43.50	15.64	100.0	120.000	150.0	H	4.0
274.998500	37.14	46.00	8.86	100.0	120.000	100.0	H	116.0
325.002000	36.01	46.00	9.99	100.0	120.000	100.0	H	65.0

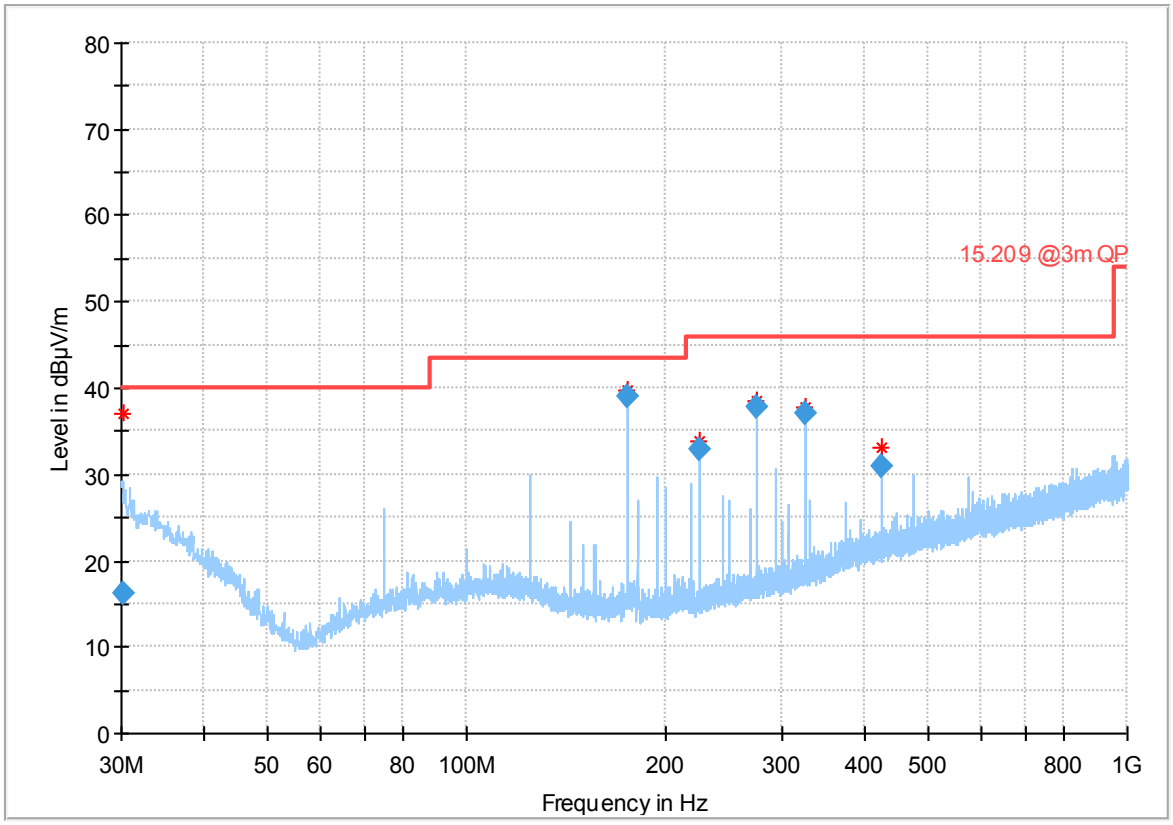
Plot no. 50: radiated emissions 30 MHz – 1 GHz, mid speed mode, polarization vertical / horizontal



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.000000	20.26	40.00	19.74	100.0	120.000	100.0	V	92.0
174.991500	40.31	43.50	3.19	100.0	120.000	153.0	H	246.0
224.993500	33.21	46.00	12.79	100.0	120.000	104.0	H	207.0
274.998500	37.87	46.00	8.13	100.0	120.000	100.0	H	210.0
325.002000	36.27	46.00	9.73	100.0	120.000	100.0	H	124.0
375.005500	34.28	46.00	11.72	100.0	120.000	100.0	H	79.0

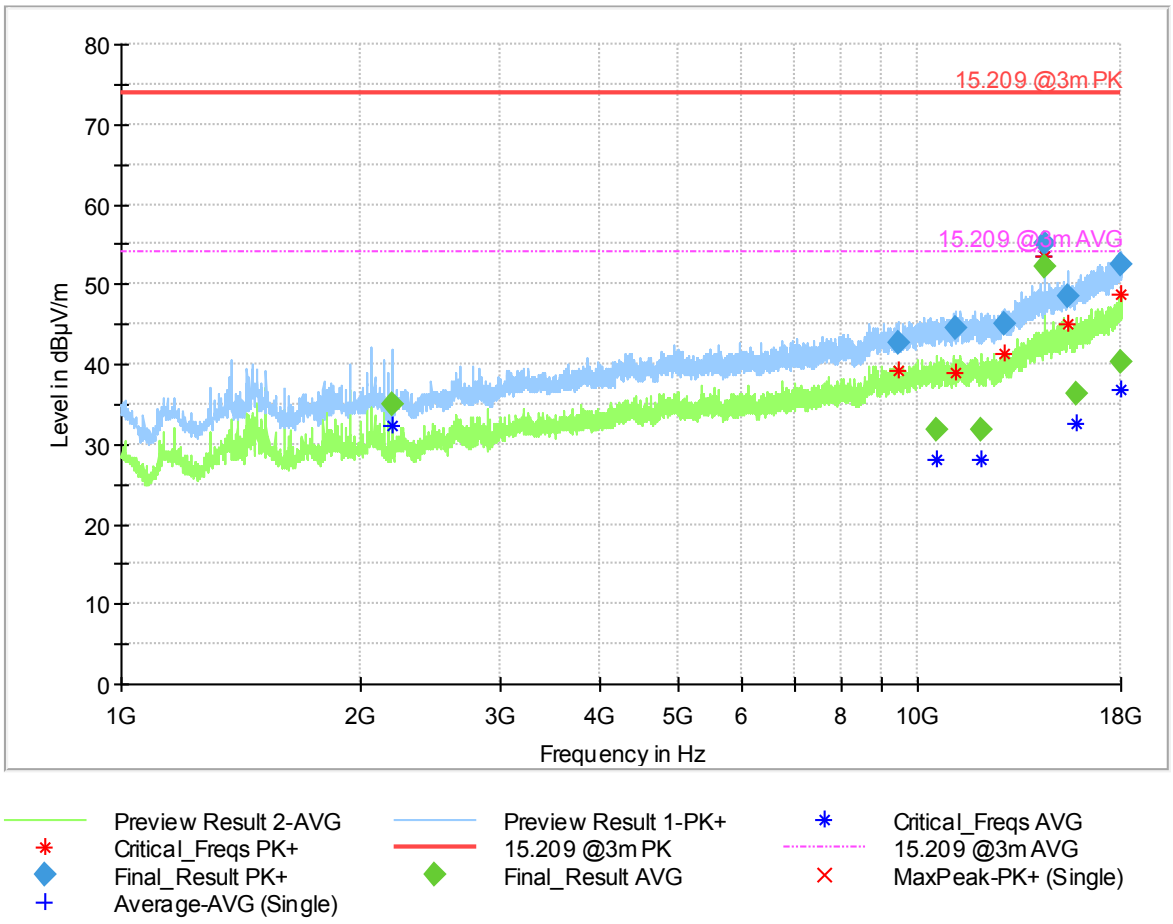
Plot no. 51: radiated emissions 30 MHz – 1 GHz, high speed mode, polarization vertical / horizontal



Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.200000	16.16	40.00	23.84	100.0	120.000	348.0	H	59.0
174.991500	39.14	43.50	4.36	100.0	120.000	154.0	H	257.0
224.993500	32.84	46.00	13.16	100.0	120.000	119.0	H	212.0
274.998500	37.75	46.00	8.25	100.0	120.000	100.0	H	210.0
325.002000	37.10	46.00	8.90	100.0	120.000	100.0	H	120.0
424.984000	30.85	46.00	15.15	100.0	120.000	182.0	H	79.0

Plot no. 52: radiated emissions 1 GHz – 18 GHz, low speed mode, 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
2187.616667	---	34.90	54.00	19.10	100.0	1000.000	150.0	V
9440.275000	42.74	---	74.00	31.26	100.0	1000.000	150.0	V
10552.666667	---	31.79	54.00	22.21	100.0	1000.000	150.0	V
11151.444444	44.60	---	74.00	29.40	100.0	1000.000	150.0	V
11993.588889	---	31.66	54.00	22.34	100.0	1000.000	150.0	H
12861.383333	45.00	---	74.00	29.00	100.0	1000.000	150.0	V
14399.702778	---	52.09	54.00	1.91	100.0	1000.000	150.0	H
14399.777778	55.00	---	74.00	19.00	100.0	1000.000	150.0	H
15405.655556	48.50	---	74.00	25.50	100.0	1000.000	150.0	V
15830.055556	---	36.16	54.00	17.84	100.0	1000.000	150.0	H
17974.980556	---	40.22	54.00	13.78	100.0	1000.000	150.0	V
17999.655556	52.56	---	74.00	21.44	100.0	1000.000	150.0	H