

Test Report

Test report no.: 21055526-20547-2

Date of issue: 2022-03-07

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

Applicant

Robert Bosch GmbH

Manufacturer

Robert Bosch GmbH

Test Item

F5CP12

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)

B.Sc. Piotr Sardyko
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Approved by
(name, function, signature)

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Deputy Managing Director


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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	Radar Sensor
Model/Type reference	F5CP12
FCC ID	NF3-F5CP12
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

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Within this test report, a point / comma is used as a decimal separator.
If otherwise, a detailed note is added adjoined 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	<p>The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkKS) in compliance with DIN EN ISO/IEC 17025:2018.</p> <p>Scope of testing and registration number:</p> <ul style="list-style-type: none"> • 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 <p>Website DAkKS: https://www.dakks.de/</p> <p>The Deutsche Akkreditierungsstelle GmbH (DAkKS) is also a signatory to the ILAC Mutual Recognition Arrangement</p>
Testing location	IBL-Lab GmbH Heinrich-Hertz-Allee 7 66386 St. Ingbert / Germany
Date of receipt of test samples	2022-01-17
Start – End of tests	2022-01-17 – 2022-01-29

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:

Page 16: description of Duty cycle calculation was deleted from Antenna characteristics Chapter
Page 19: description of Radiated Mean Power (EIRP) measurement method was added

-2:

Page 16: description of estimated output power was deleted from Antenna characteristics Chapter, description of Duty cycle calculation was added

This test report 21055526-20547-2 replaces the previous test report 21055526-20547-0 and 21055526-20547-1.

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	7.0 V DC	12.0 V DC	16.0 V DC

4 TEST STANDARDS AND REFERENCES

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

Reference	Description
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
KDB653005 D01, V01, R01	Equipment Authorization Guidance for 76-81 GHz Radar Devices

5 EQUIPMENT UNDER TEST (EUT)

5.1 Product description

Radar Sensor

5.2 Description of test item

Model name*	F5CP12
Serial number*	1100010991500421509301010321225569931969
PCB identifier*	0265.D65.923-02
Hardware status*	C35.3; 0203.3BB.069-01 (back connector) 0203.3BB.070-01 side connector)
Software status*	1037609608_pre

*: 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*	DMP 7-9: 25.5 %
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	<p>Several EUT's were made available for testing purposes. The first EUT (eg. labelled no.1) was used for testing.</p> <p>The EUT's differ considering the connector, 2 versions are made available:</p> <p>As stated in the Declaration of similarity:</p> <p>"The model F5CP12 has two connector variants:</p> <ol style="list-style-type: none"> variant 0203.3BB.069-01; with housing P/N: 1275.101.969 (connector on the back of the sensor) variant 0203.3BB.070-01; with housing P/N: 1275.101.968 (connector on the side of the sensor) <p>Difference between the 0203.3BB.069-01 and 0203.3BB.070-01 is only mechanical direction of the connector. All other components are identical."</p>
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 Documentation F5CP12”

4.3 Modulation description

The F5CP12 sensor modulation mode depends on vehicle speed.

Vehicle speed	Modulation mode	Active TX channels
up to 65km/h	DMP7	TX1, TX2, TX3
65km/h – 115 km/h	DMP8	TX1, TX2, TX3
above 115 km/h	DMP9	TX1, TX2, TX3

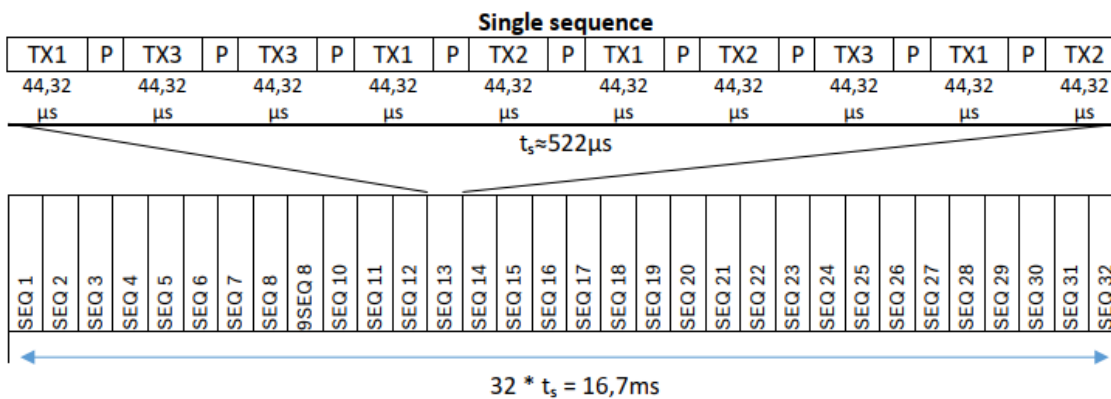
All modulations use the same basic principle:

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

A single sequence takes 522µs and consists of 10 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 every sequence, 4 chirps are emitted on TX1 antenna, 3 chirps on TX2 and 3 chirps on TX3.

A burst takes 16,7ms and consists of 32 sequences (320 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.



4.3.1 DMP07 modulation

Chirp frequency span: 228MHz

Burst frequency span: 618MHz

Occupied bandwidth: 846 MHz

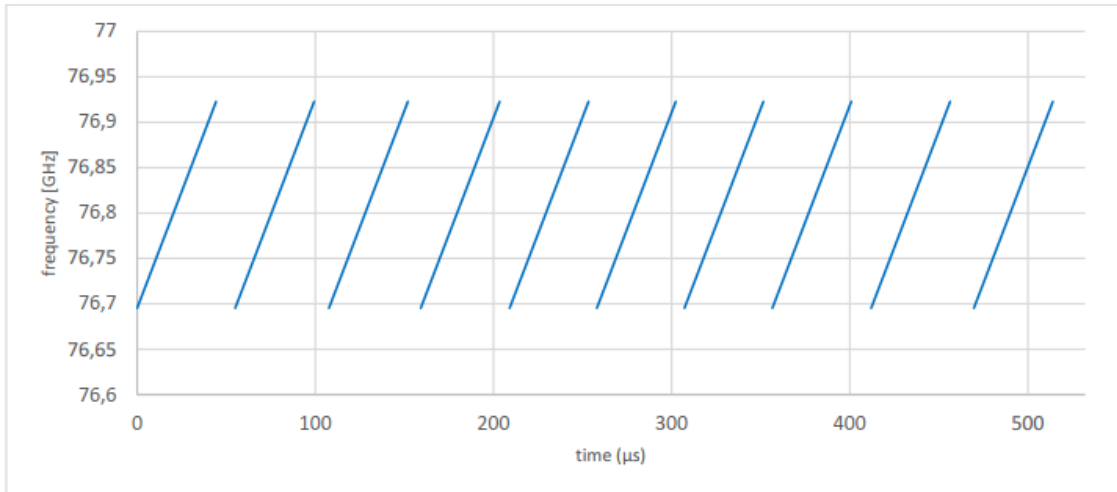


Figure 6: DMP07 single sequence

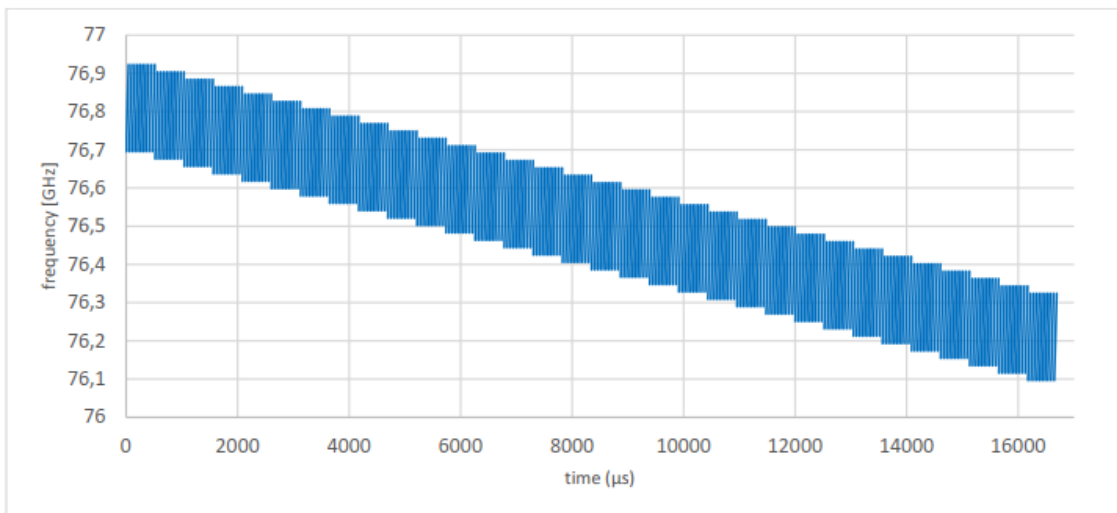


Figure 7: DMP07 single burst

4.3.2 DMP08 modulation

Chirp frequency span: 190 MHz

Burst frequency span: 570 MHz

Occupied bandwidth: 760 MHz

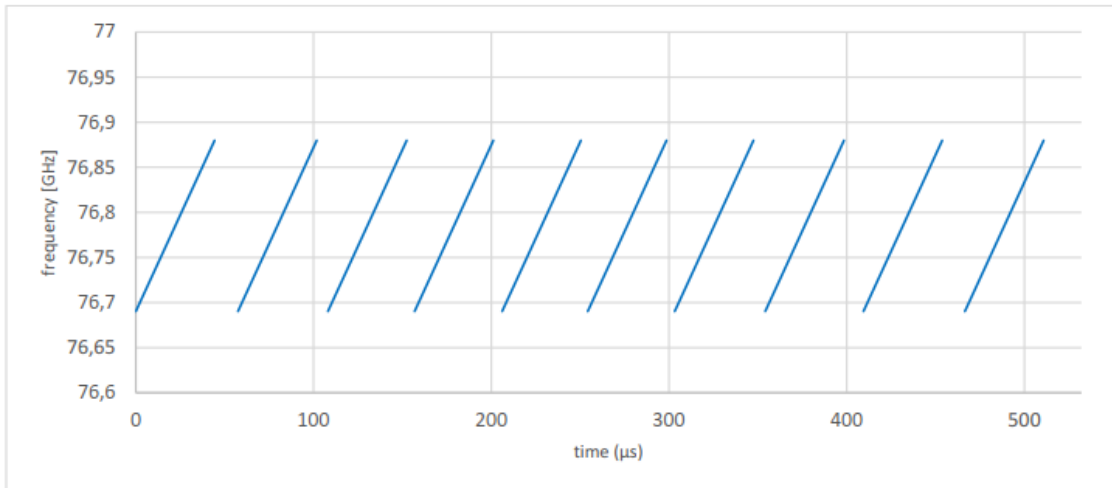


Figure 8: DMP08 single sequence

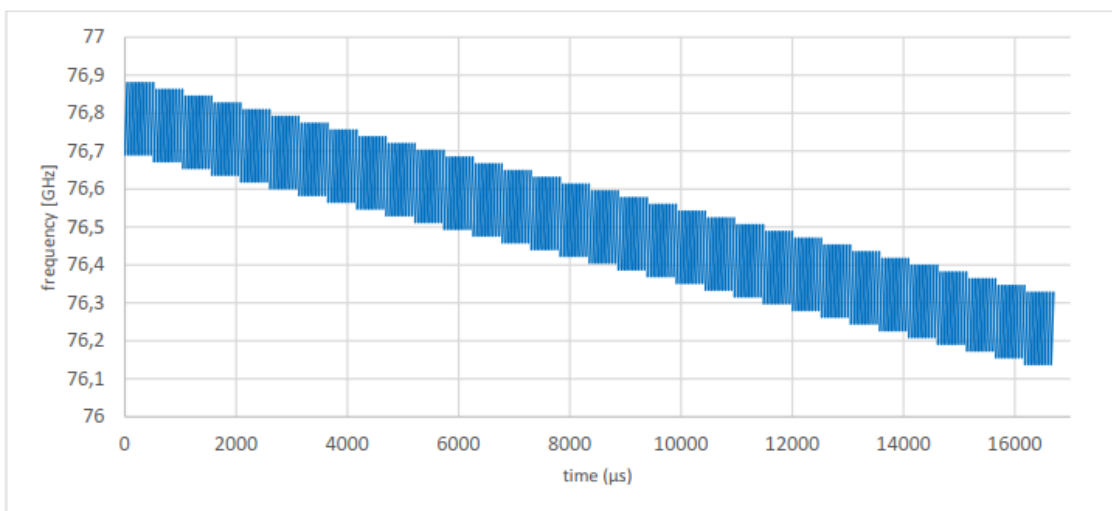


Figure 9: DMP08 single burst

4.3.3 DMP09 modulation

Chirp frequency span: 163 MHz

Burst frequency span: 489 MHz

Occupied bandwidth: 652 MHz

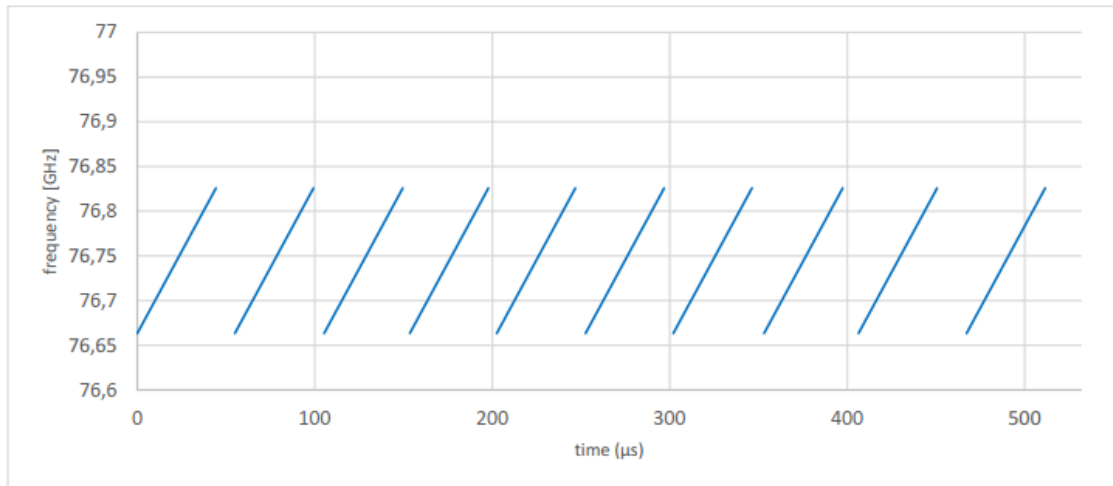


Figure 10: DMP09 single sequence

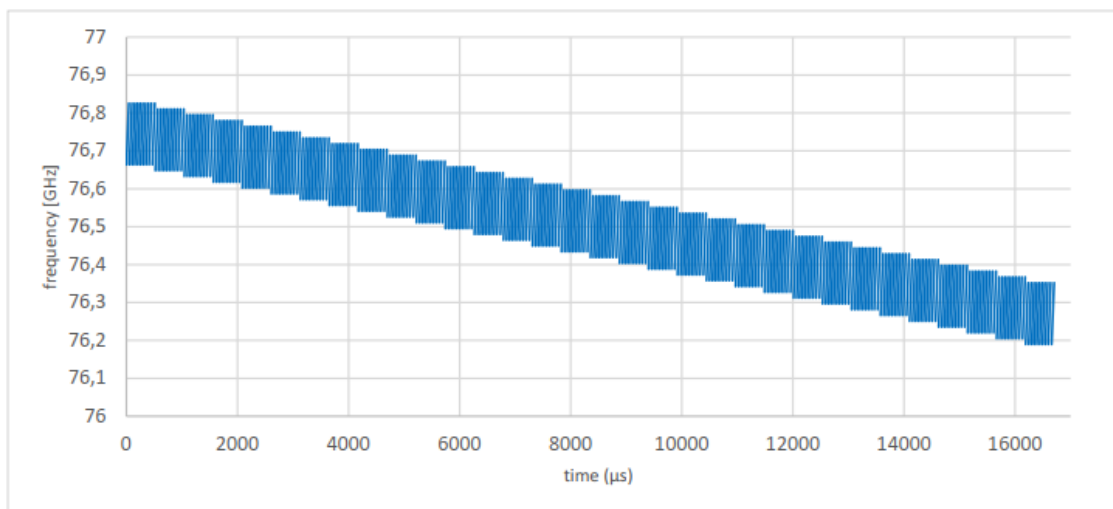
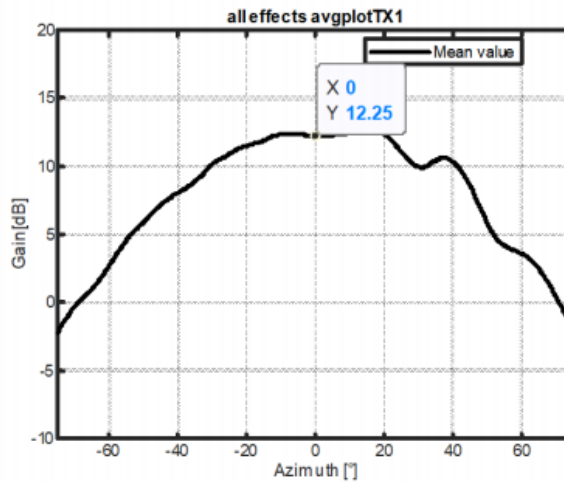


Figure 11: DMP09 single burst

5.6 Antenna characteristics

4.2.1 TX1 antenna characteristic

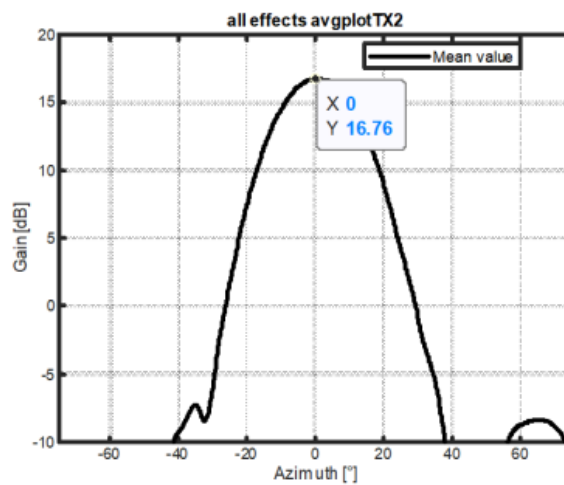
Simulation result of TX1 azimuth antenna characteristic is presented below:



Maximum gain is 12,25dBi

4.2.2 TX2 antenna characteristics

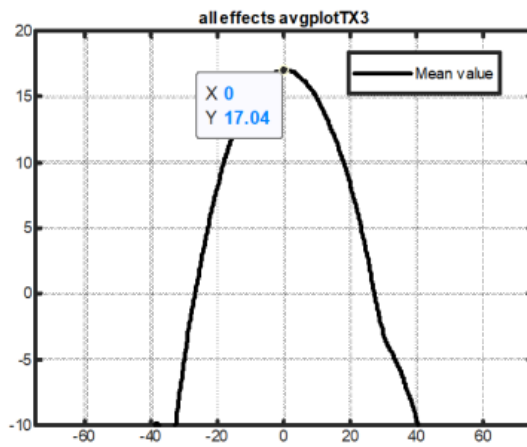
Simulation result of TX2 azimuth antenna characteristic is presented below:



Maximum gain is 16,76dBi.

4.2.3 TX3 antenna characteristics

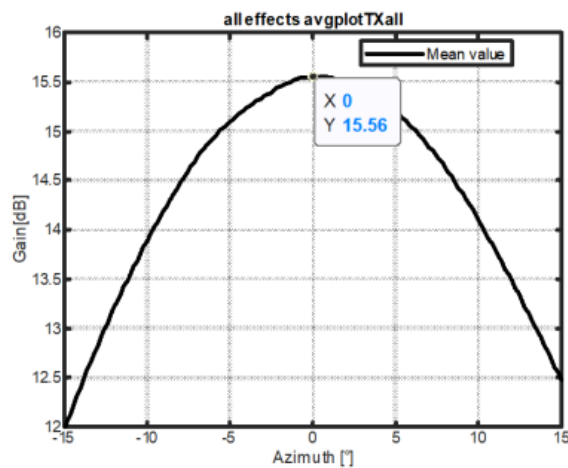
Simulation result of TX3 azimuth antenna characteristic is presented below:



Maximum gain is 17,04dBi.

4.2.4 TXall antenna characteristics

Simulation result of all channels (TX1, TX2, TX3) combined azimuth antenna characteristic is presented below:



Maximum gain is 15,56dBi at distance 1m.

4.4 Duty Cycle

Total duration of a single F5CP12 cycle is always 66ms. Within this time, the sensor transmits a single burst of 16,7ms. Additionally, every 2nd cycle, sensor emits a monitoring signal, which takes 0,29ms.

Therefore, sensor duty cycle:

$$\text{Duty_cycle} = \frac{\text{burst_length} + \frac{\text{monitoring_length}}{2}}{\text{cycle_length}} * 100$$

Modulation mode	Burst length	Duty cycle
DMP07; DMP08; DMP09	16,7ms	25,5%

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	20.04 dBm mean 30.16 dBm peak	P
§2.1047	Modulation characteristics	Nominal		N/P
§2.1049	Occupied bandwidth	Nominal	893.944 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.

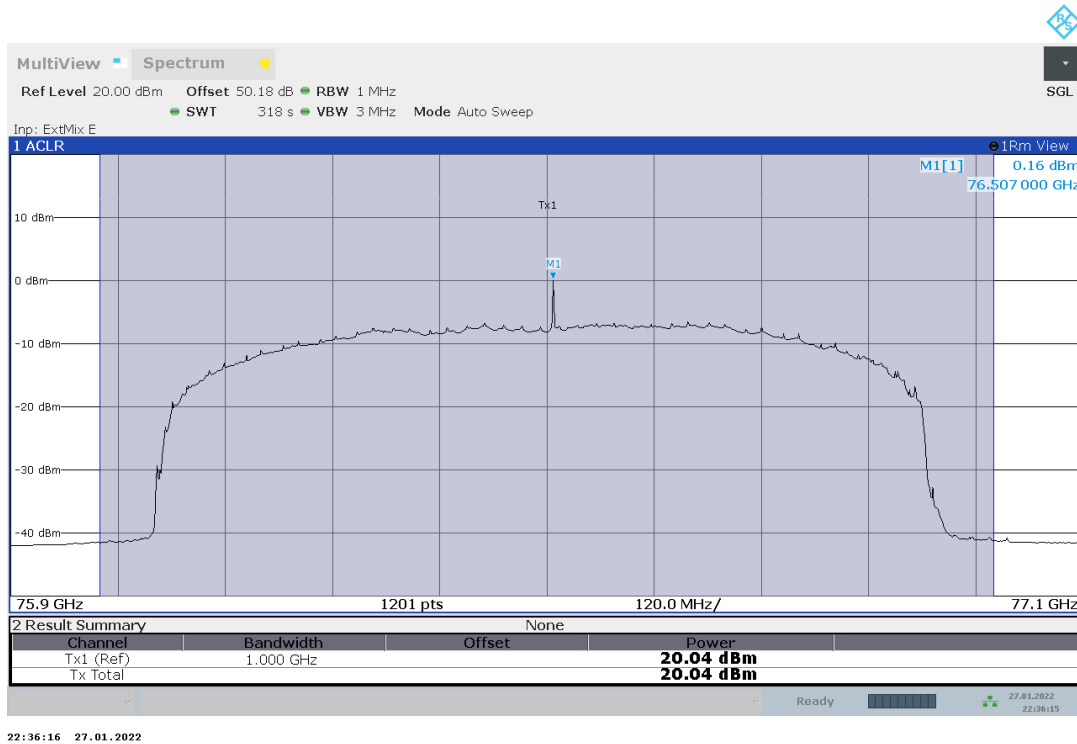
Test setup: 8.3**Test results:**

EUT mode	Test distance	Radiated Mean Power (EIRP)* [dBm]	Radiated Peak Power (EIRP) [dBm]
7	1 m	20.04	29.85
8	1 m	19.98	30.16
9	1 m	20.00	30.05

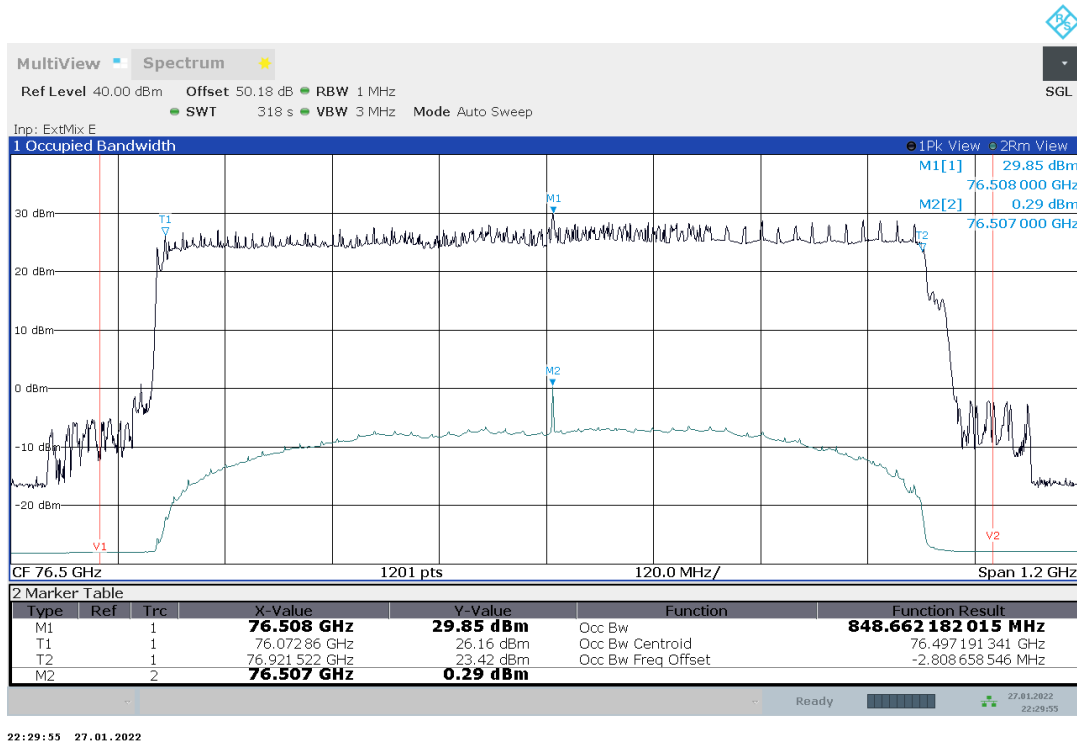
* Radiated Mean Power (EIRP) was measured with spectrum analyzer with channel power function. Please see plots below.

*

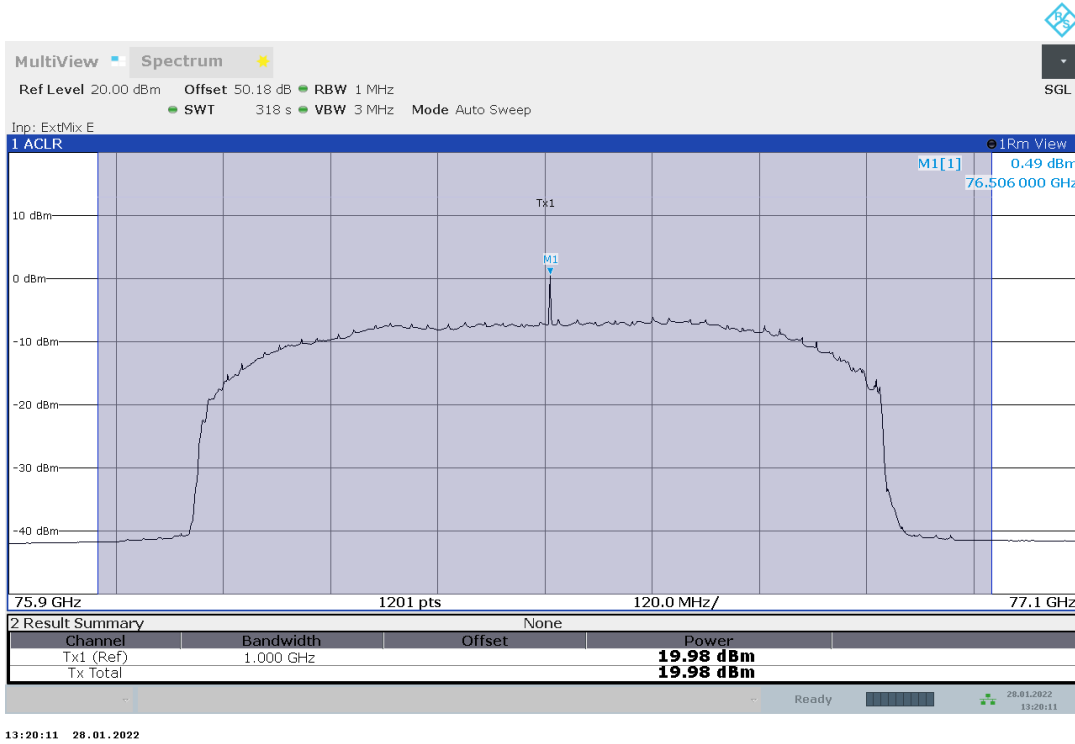
Plot no. 1: Mean Power EIRP, RMS detector / Channel Power, EUT Mode 7



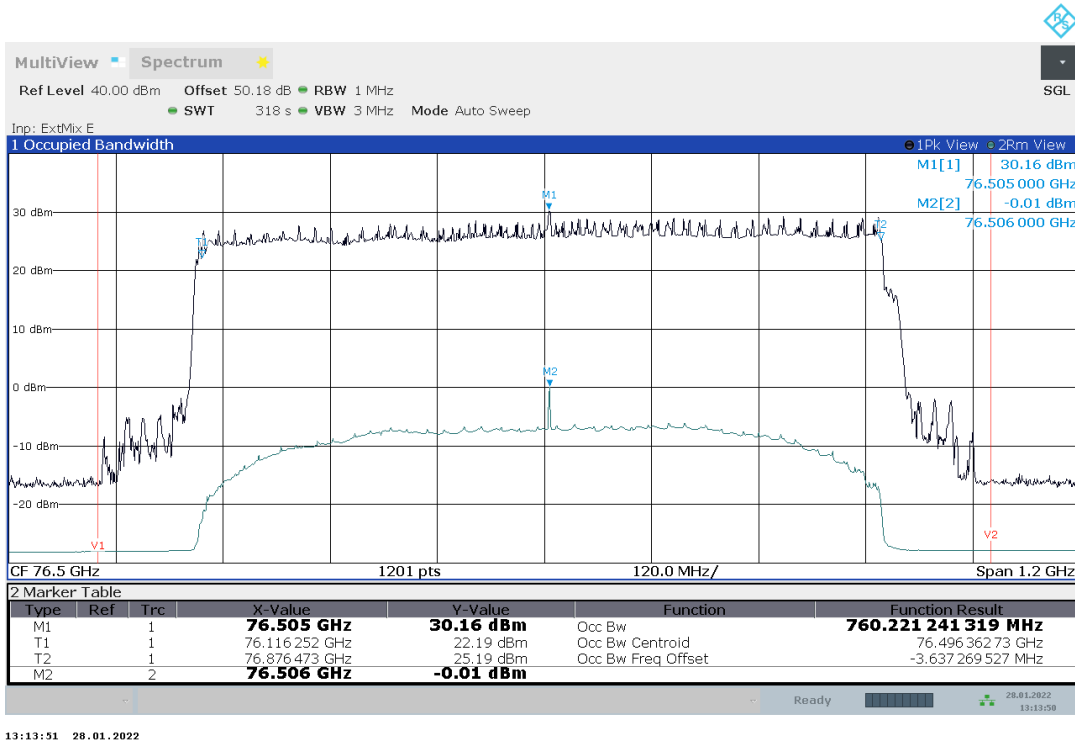
Plot no. 2: Peak Power EIRP, Peak detector, EUT Mode 7



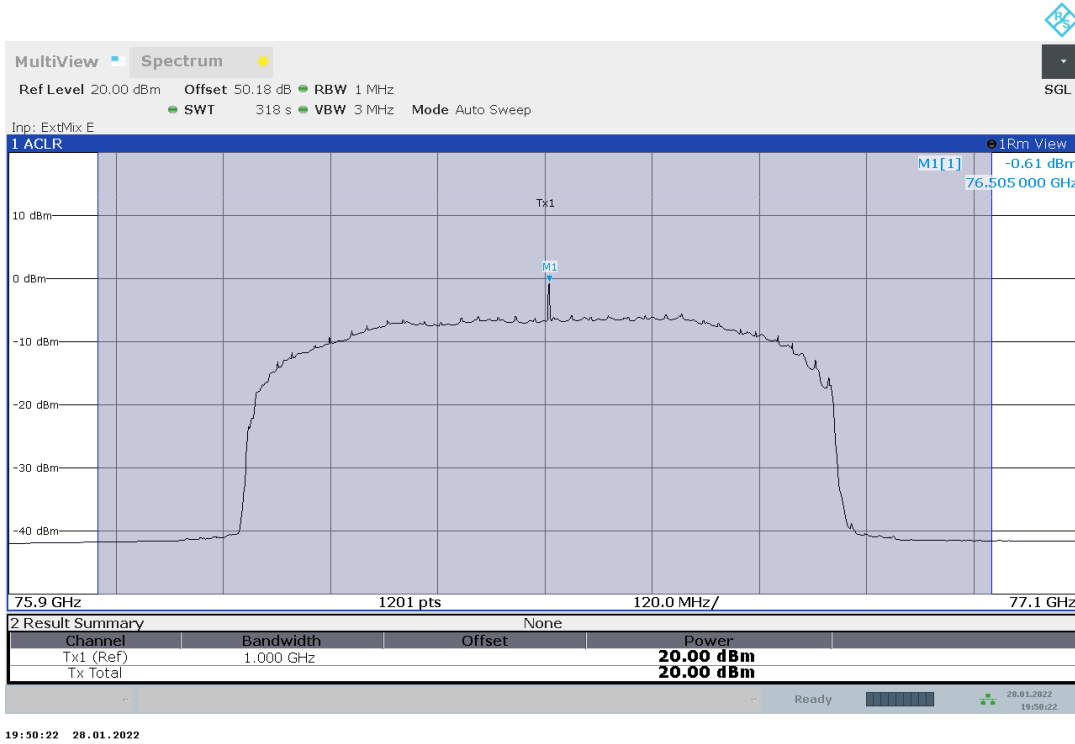
Plot no. 3: Mean Power EIRP, RMS detector / Channel Power, EUT Mode 8



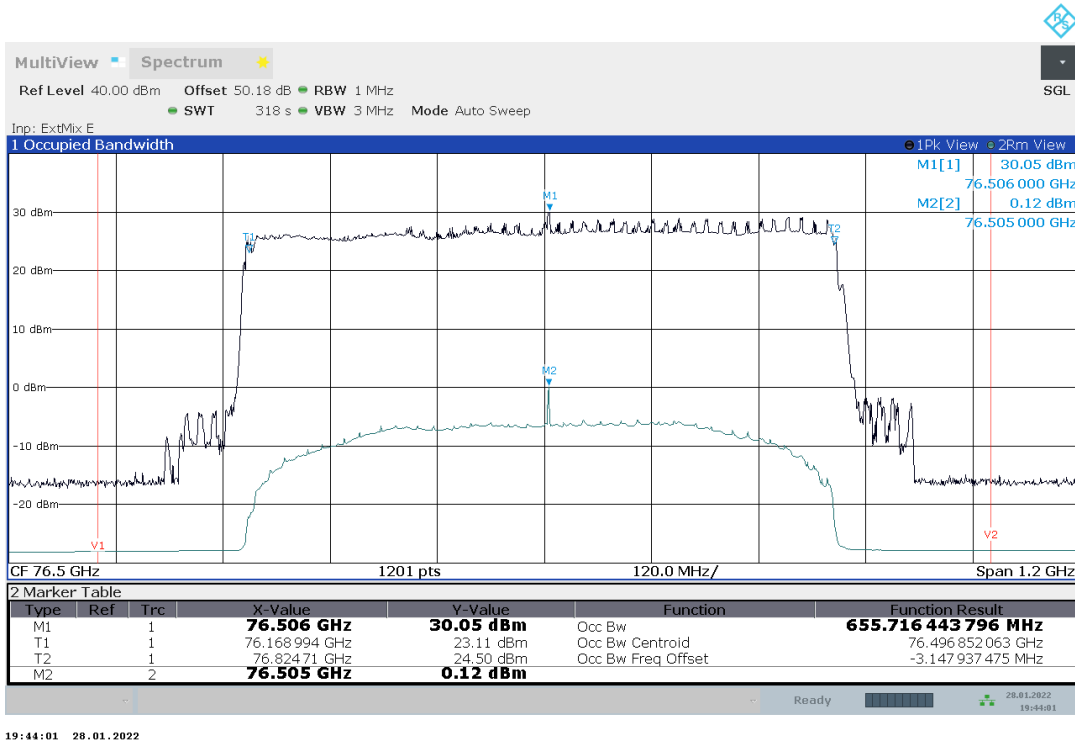
Plot no. 4: Peak Power EIRP, Peak detector, EUT Mode 8



Plot no. 5: Mean Power EIRP, RMS detector / Channel Power, EUT Mode 9



Plot no. 6: Peak Power EIRP, Peak detector, EUT Mode 9



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

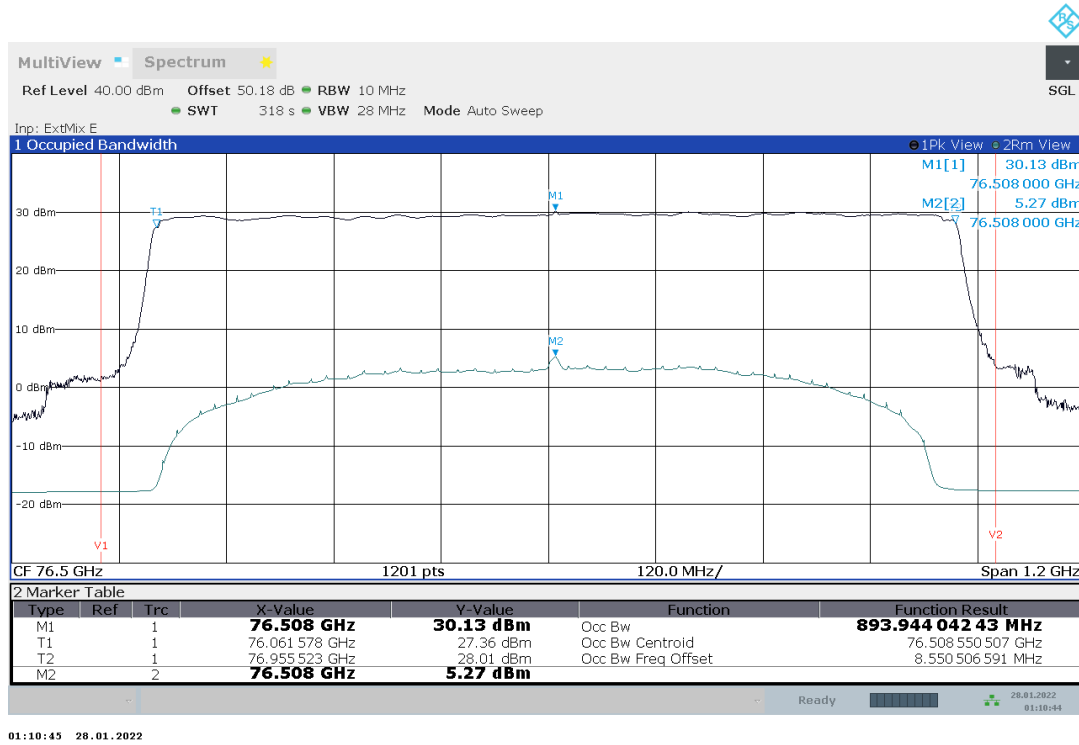
7.3 Occupied bandwidth (§2.1049)
<p>Description</p> <p>§2.1049 Measurements required: Occupied bandwidth. The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.</p>
<p>Limits</p> <p>The radar device's occupied bandwidth (i.e. 99% emission bandwidth) shall be contained in the 76-81GHz frequency band.</p>
<p>Test procedure</p> <p>ANSI C63.26, 5.4.4</p> <p>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:</p> <p>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.</p> <p>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.</p> <p>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.</p> <p>d) Set the detection mode to peak, and the trace mode to max-hold.</p> <p>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.</p> <p>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)</p>
<p>Note</p> <p>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 C63.26 general considerations).</p>
<p>Test setup: 8.3, 8.4</p>

Test results under normal and extreme test conditions:				
EUT mode	Test conditions	f_L [MHz]	f_H [MHz]	99% OBW [MHz]
7	85 °C	76061.578	76955.523	893.944
7	50 °C	76060.828	76946.532	885.703
7	40 °C	76062.242	76942.658	880.417
7	30 °C	76063.230	76946.255	883.025
7	20 °C / V_{min}	76061.968	76947.375	885.408
7	20 °C / V_{nom}	76063.565	76949.162	885.597
7	20 °C / V_{max}	76063.321	76950.404	887.083
7	10 °C	76063.290	76949.716	886.426
7	0 °C	76066.613	76951.683	885.070
7	-10 °C	76065.432	76954.309	888.876
7	-20 °C	76067.828	76955.314	887.486
7	-30 °C	76068.724	76951.458	882.734
7	-40 °C	76067.533	76952.091	884.558
8	85 °C	76111.656	76904.385	792.728
8	50 °C	76106.404	76897.746	791.342
8	40 °C	76106.320	76893.799	787.479
8	30 °C	76106.721	76898.999	792.277
8	20 °C / V_{min}	76106.662	76893.338	786.676
8	20 °C / V_{nom}	76106.731	76896.477	789.746
8	20 °C / V_{max}	76105.979	76897.148	791.169
8	10 °C	76107.292	76900.146	792.854
8	0 °C	76107.774	76901.853	794.079
8	-10 °C	76109.341	76902.340	792.999
8	-20 °C	76110.545	76905.015	794.471
8	-30 °C	76110.581	76900.231	789.651
8	-40 °C	76111.025	76903.349	792.324
9	85 °C	76162.974	76845.039	682.065
9	50 °C	76160.065	76845.870	685.805
9	40 °C	76159.345	76840.083	680.739
9	30 °C	76159.720	76839.076	679.355
9	20 °C / V_{min}	76159.607	76837.153	677.545
9	20 °C / V_{nom}	76160.102	76838.820	678.718
9	20 °C / V_{max}	76159.410	76838.671	679.260
9	10 °C	76160.592	76840.594	680.002
9	0 °C	76161.579	76841.873	680.294
9	-10 °C	76162.648	76840.079	677.431
9	-20 °C	76163.585	76845.144	681.559
9	-30 °C	76164.586	76842.901	678.315
9	-40 °C	76164.758	76843.143	678.385
With voltage variation				
Input voltage variation does not affect the transmitted signal (see plots for ambient/normal temperature).				

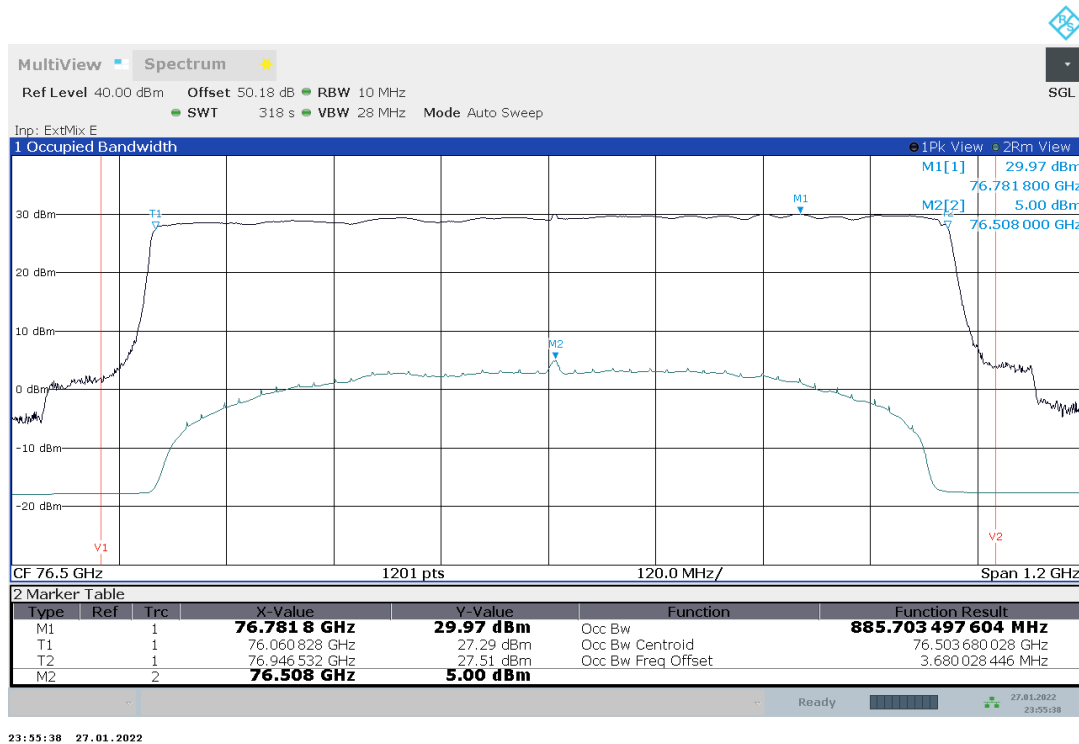
TR no.: 2105526-20547-2

2022-03-07

Plot no. 7: 99% OBW, Peak detector, 85 °C, Test Mode 7



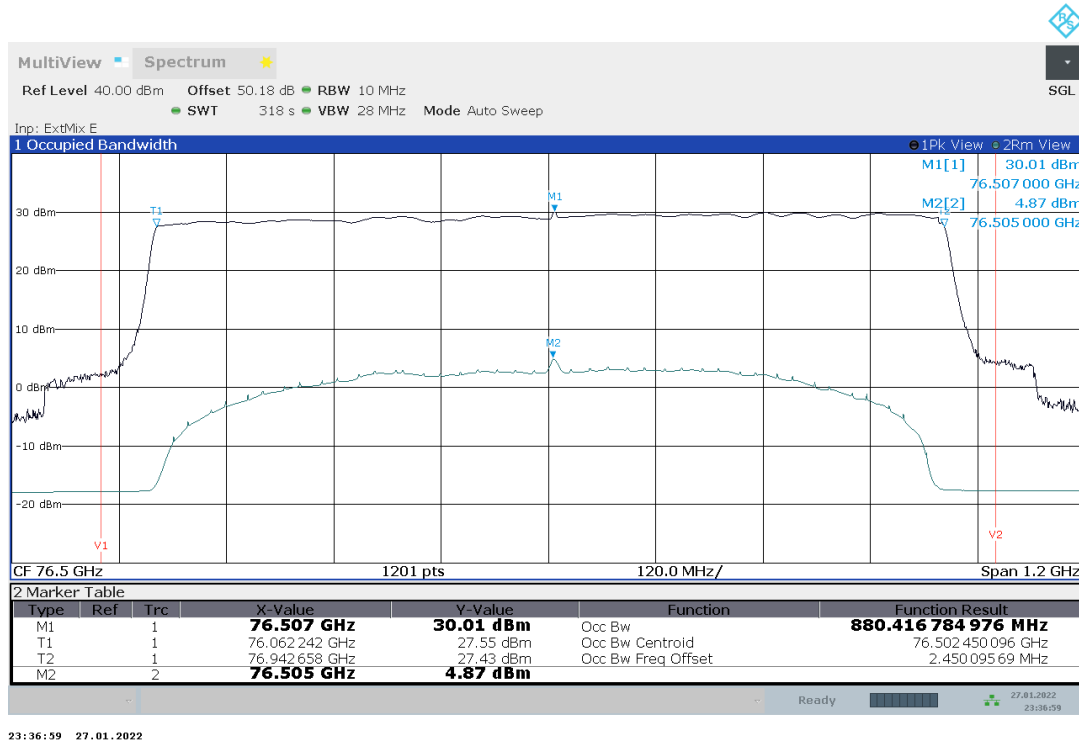
Plot no. 8: 99% OBW, Peak detector, 50 °C, Test Mode 7



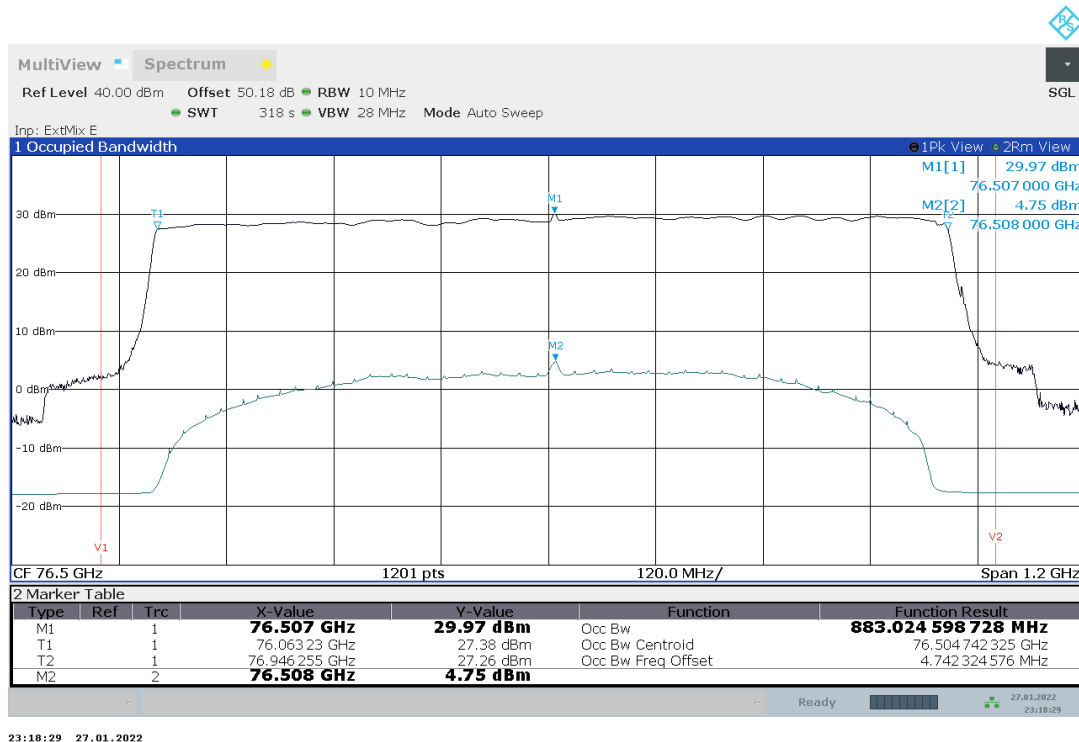
TR no.: 2105526-20547-2

2022-03-07

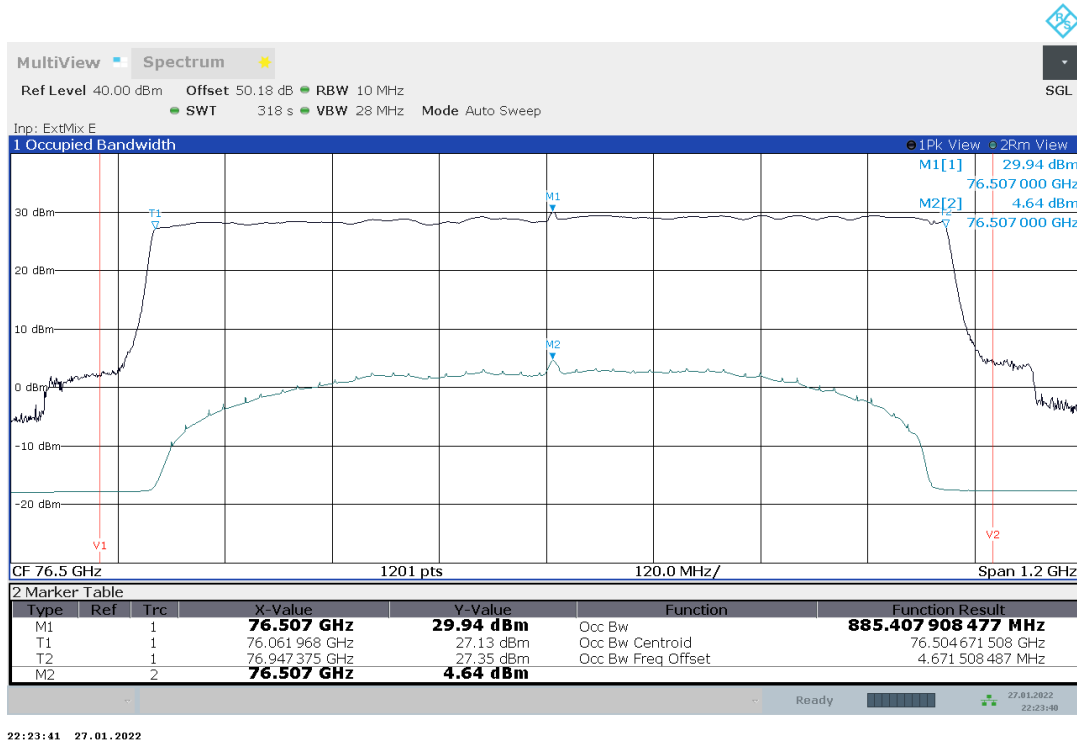
Plot no. 9: 99% OBW, Peak detector, 40 °C, Test Mode 7



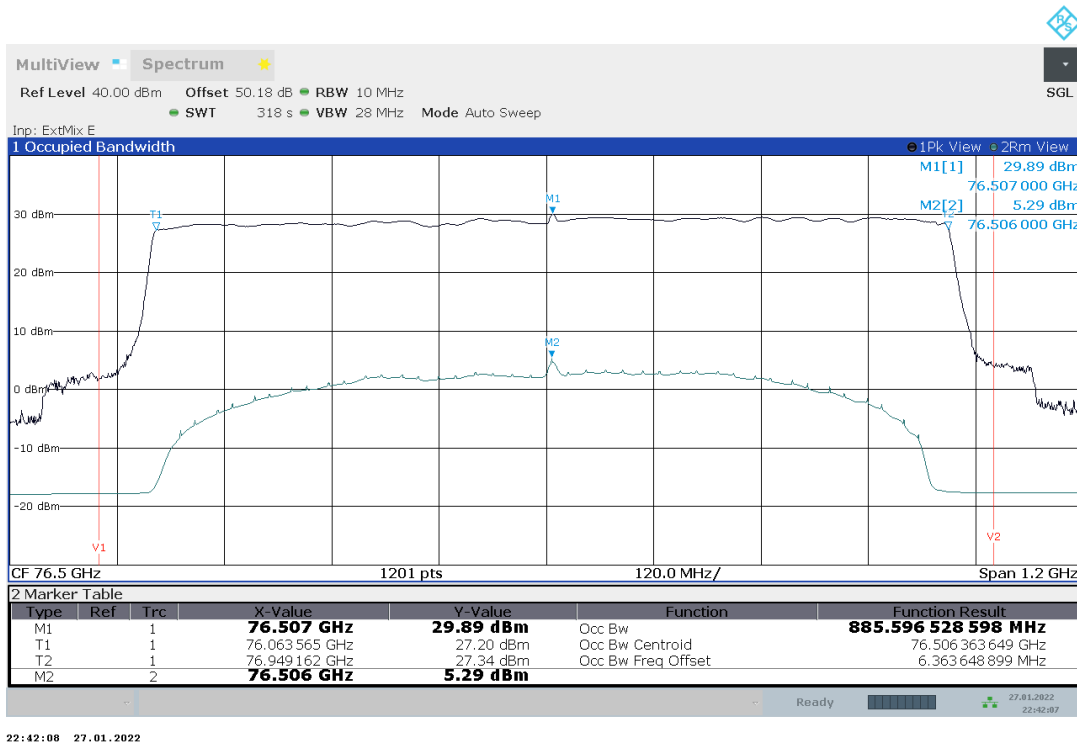
Plot no. 10: 99% OBW, Peak detector, 30 °C, Test Mode 7



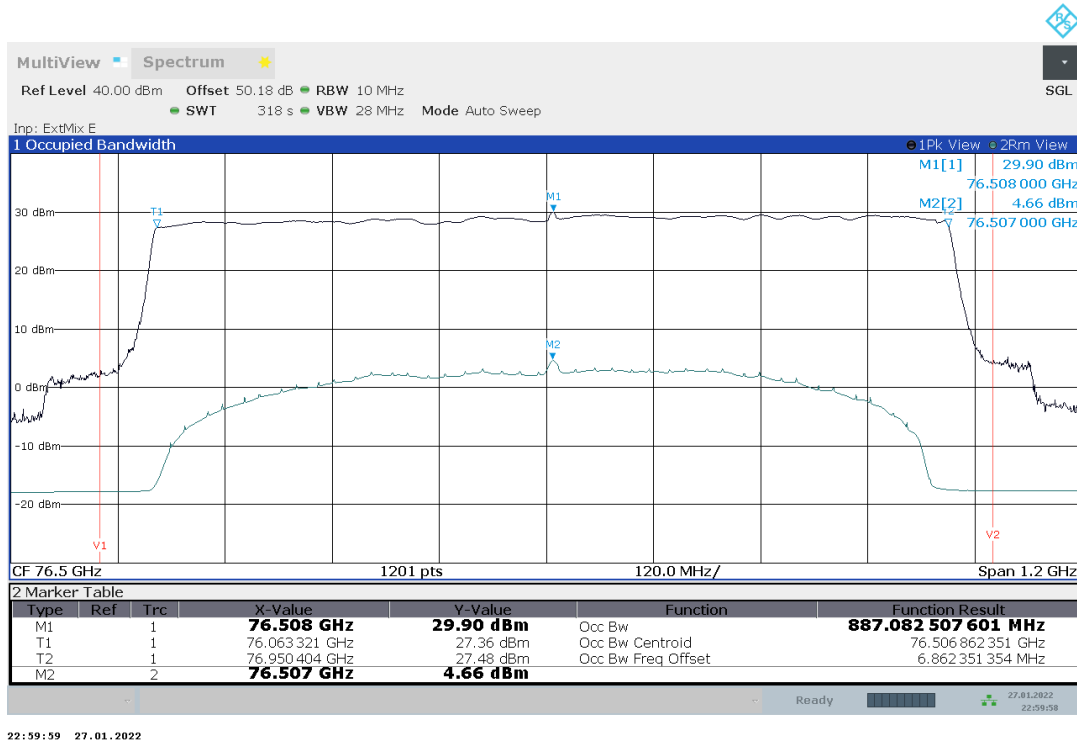
Plot no. 11: 99% OBW, Peak detector, 20 °C, V_{min}, Test Mode 7



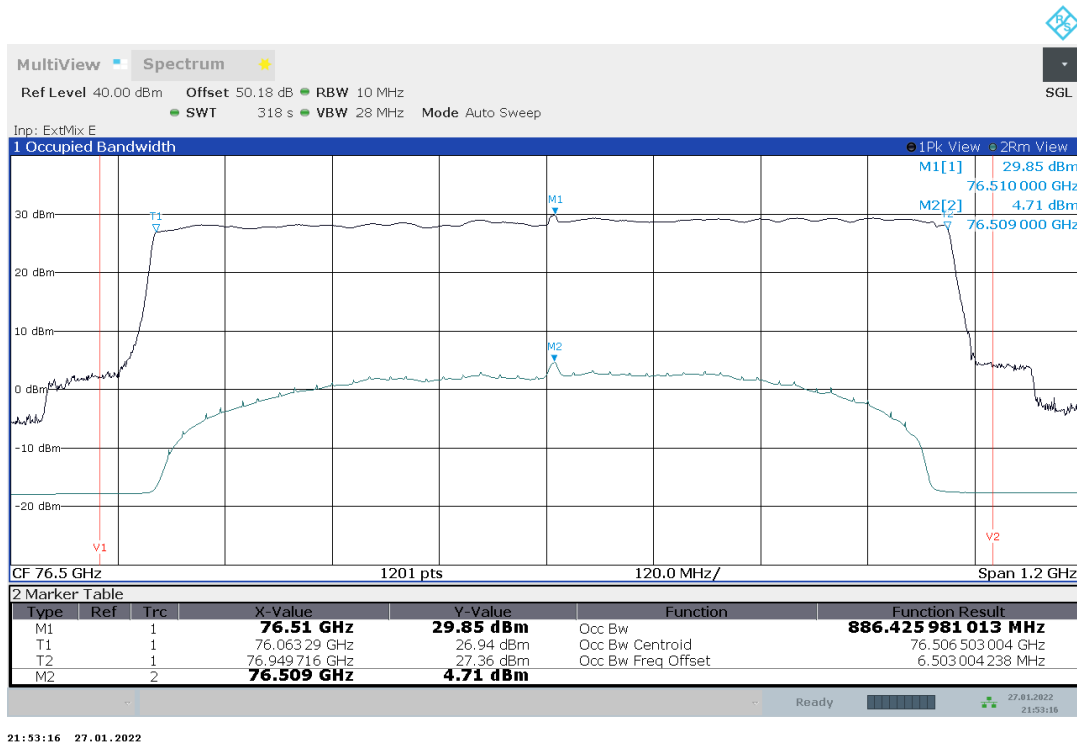
Plot no. 12: 99% OBW, Peak detector, 20 °C, V_{nom}, Test Mode 7



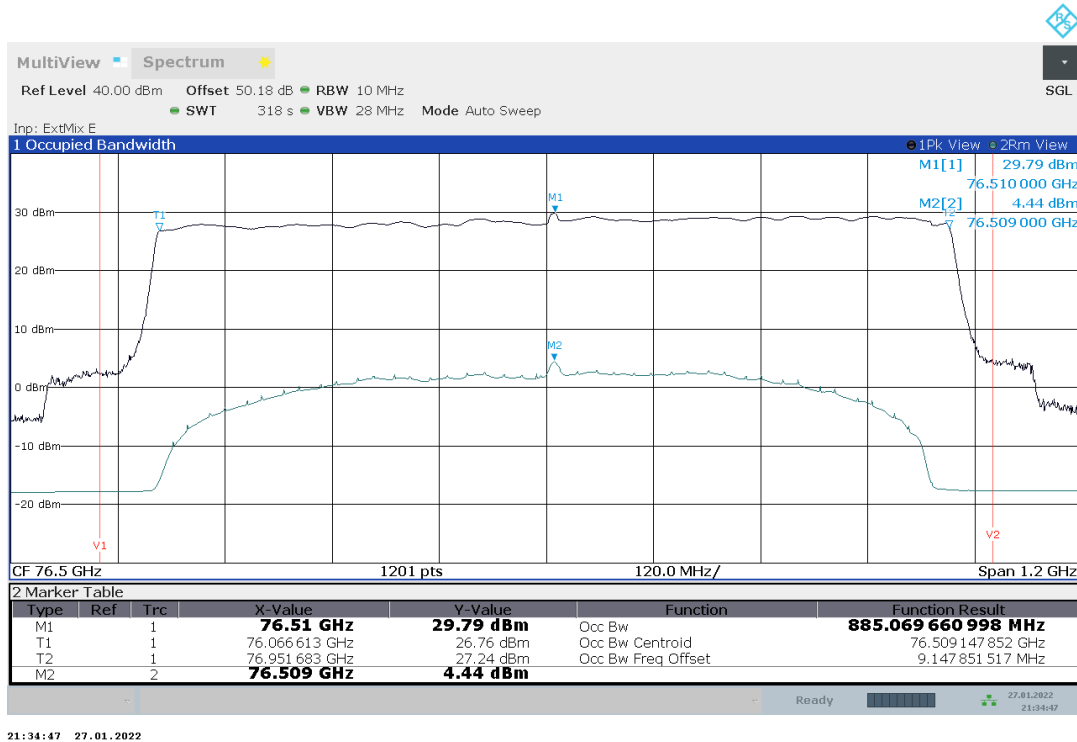
Plot no. 13: 99% OBW, Peak detector, 20 °C, V_{max}, Test Mode 7



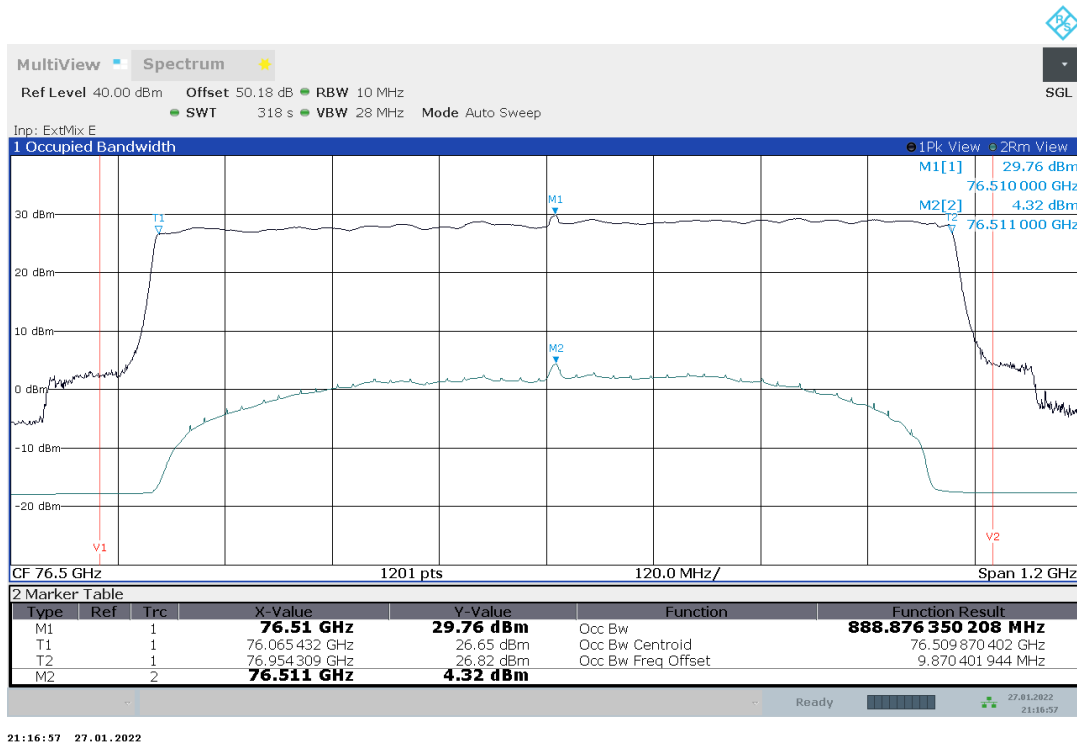
Plot no. 14: 99% OBW, Peak detector, 10 °C, Test Mode 7



Plot no. 15: 99% OBW, Peak detector, 0 °C, Test Mode 7



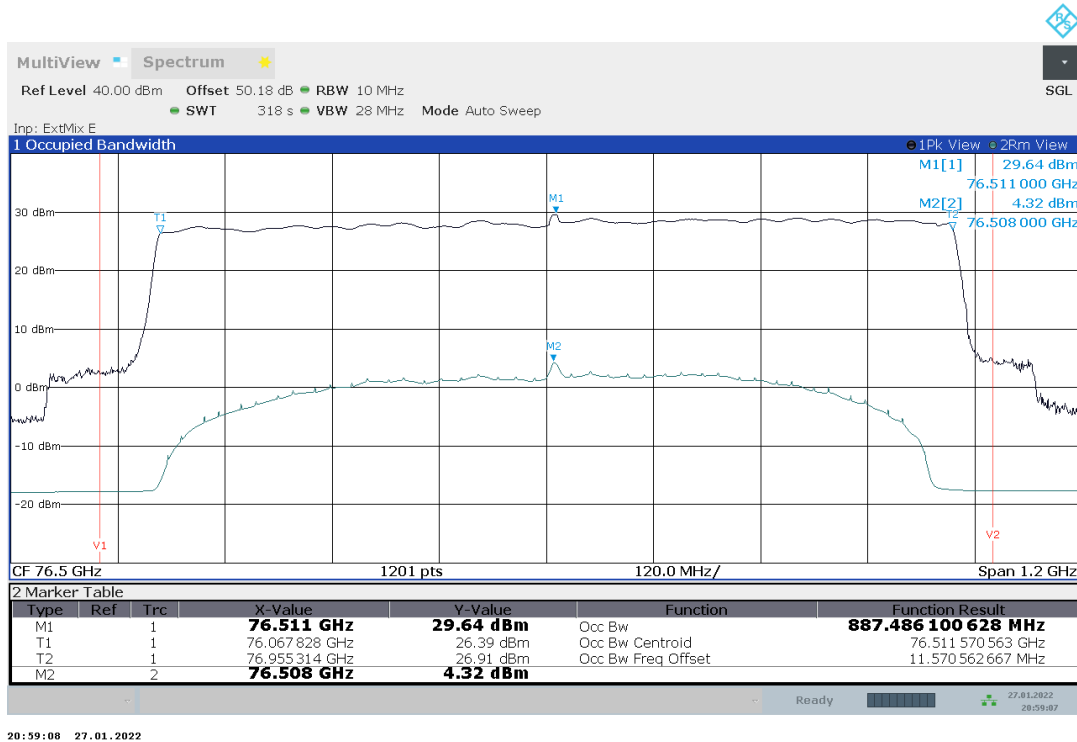
Plot no. 16: 99% OBW, Peak detector, -10 °C, Test Mode 7



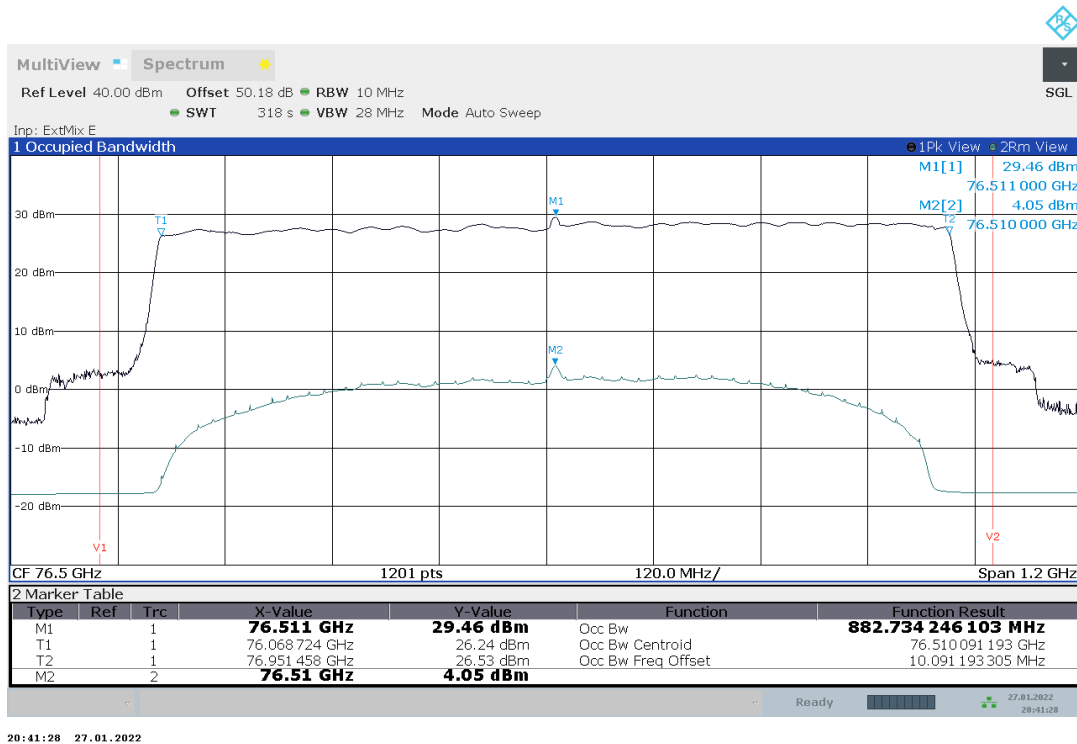
TR no.: 21055526-20547-2

2022-03-07

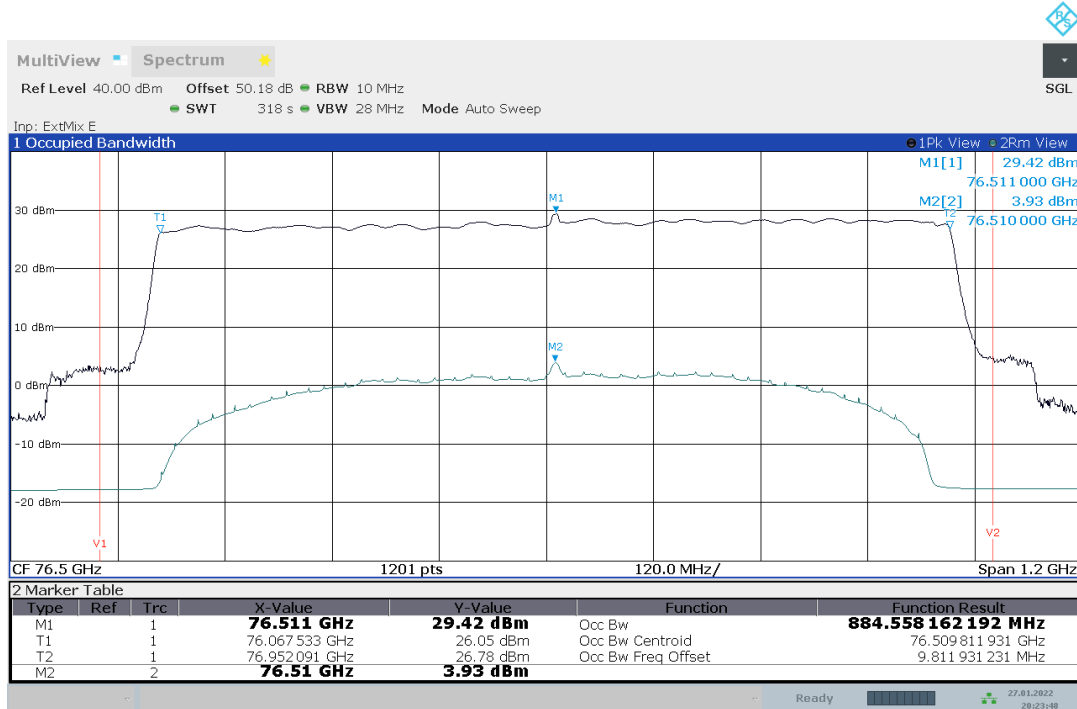
Plot no. 17: 99% OBW, Peak detector, -20 °C, Test Mode 7



Plot no. 18: 99% OBW, Peak detector, -30 °C, Test Mode 7



Plot no. 19: 99% OBW, Peak detector, -40 °C, Test Mode 7

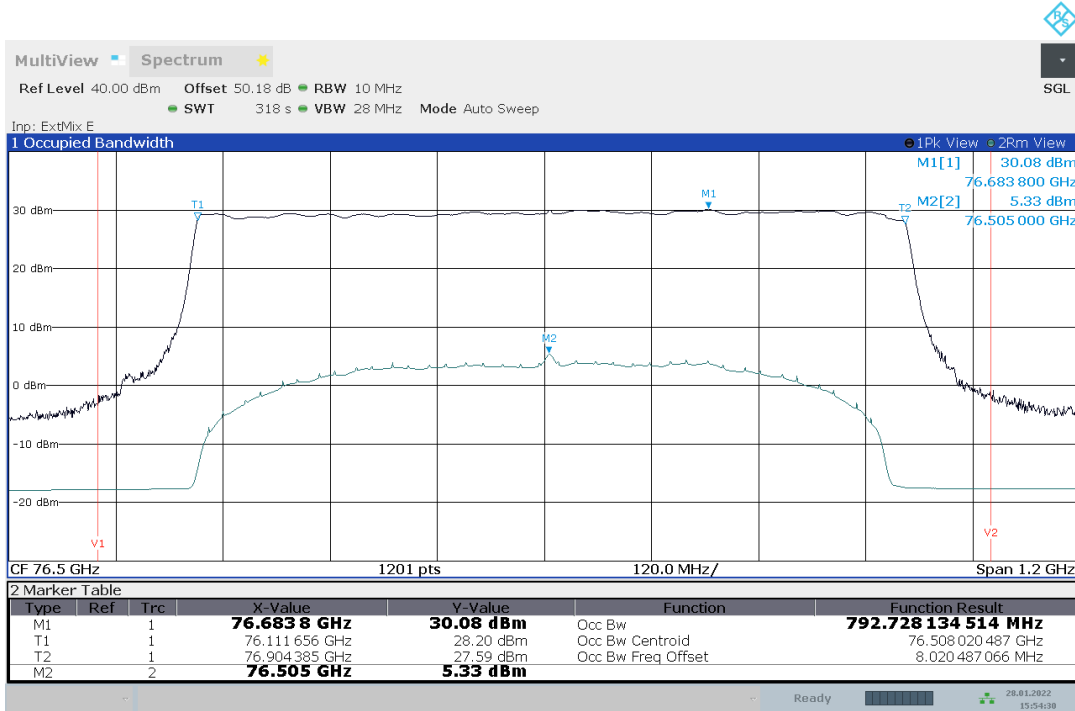


20:23:49 27.01.2022

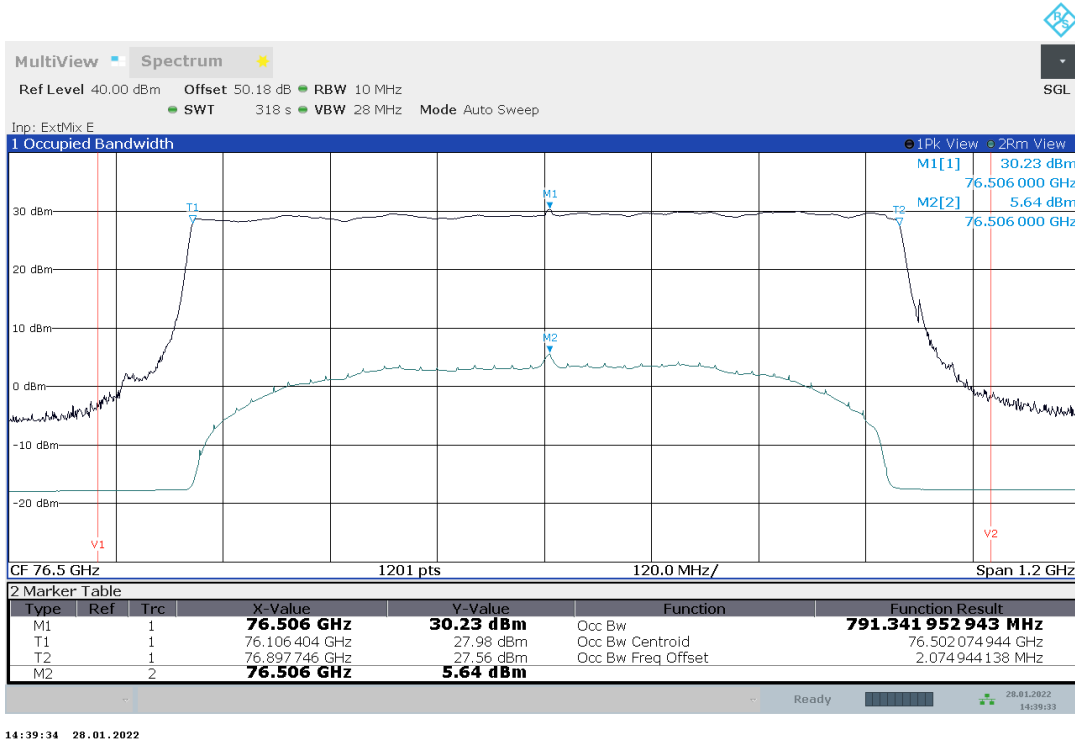
TR no.: 2105526-20547-2

2022-03-07

Plot no. 20: 99% OBW, Peak detector, 85 °C, Test mode 8



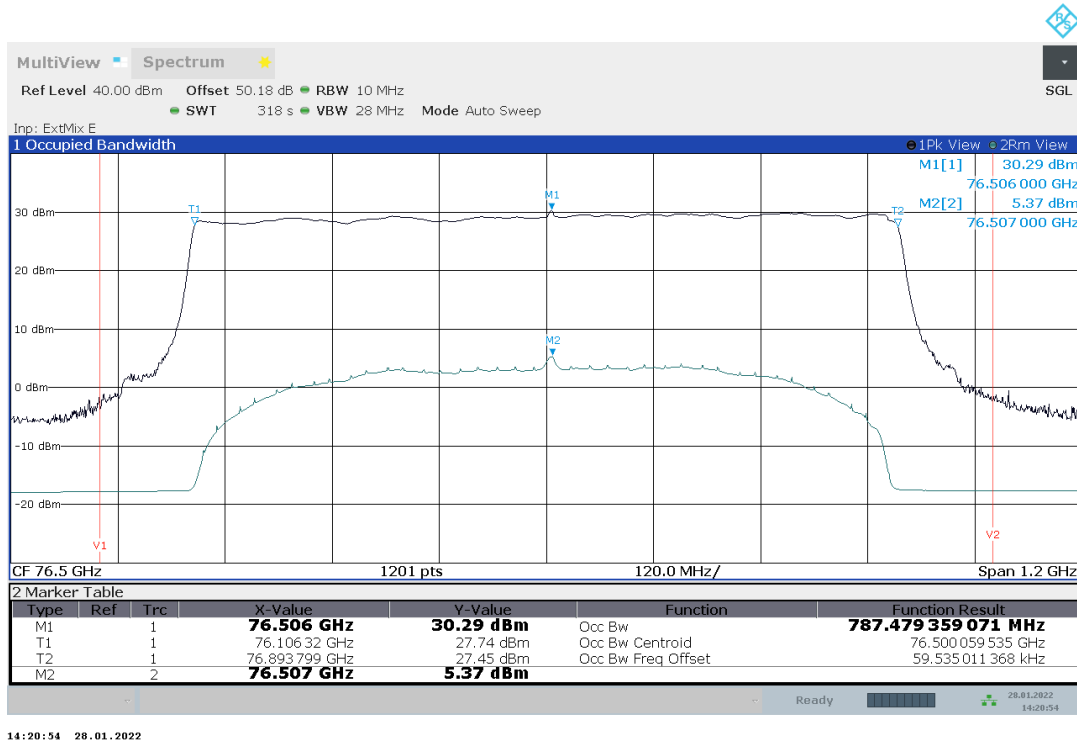
Plot no. 21: 99% OBW, Peak detector, 50 °C, Test mode 8



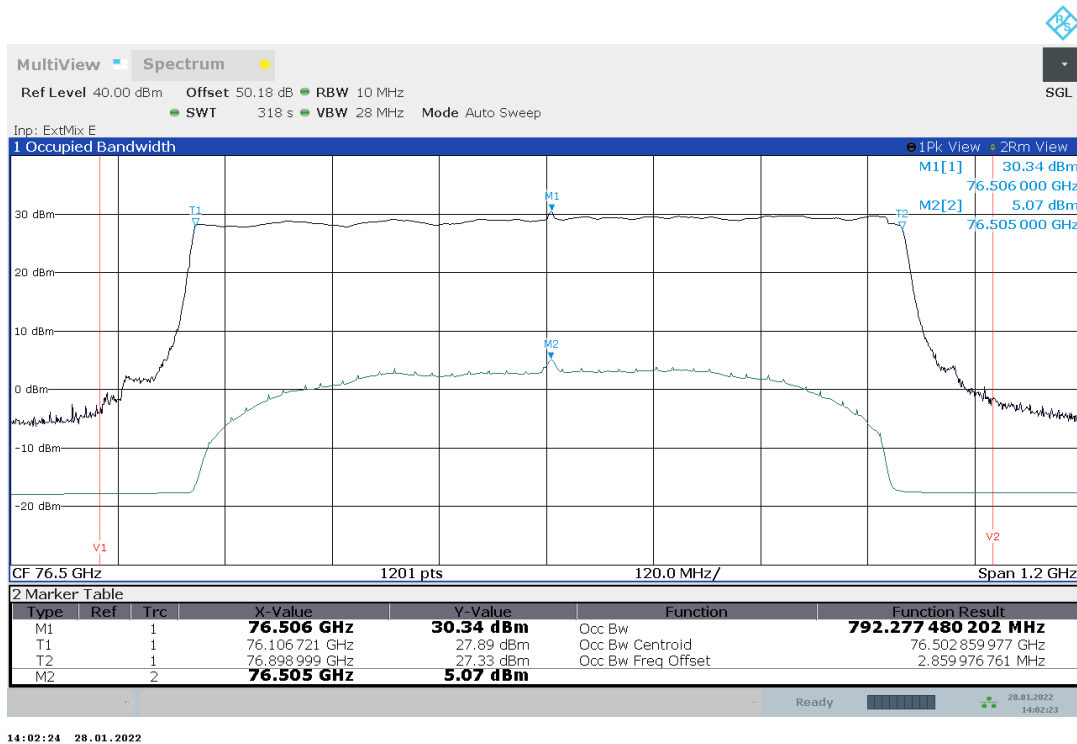
TR no.: 21055526-20547-2

2022-03-07

Plot no. 22: 99% OBW, Peak detector, 40 °C, Test mode 8



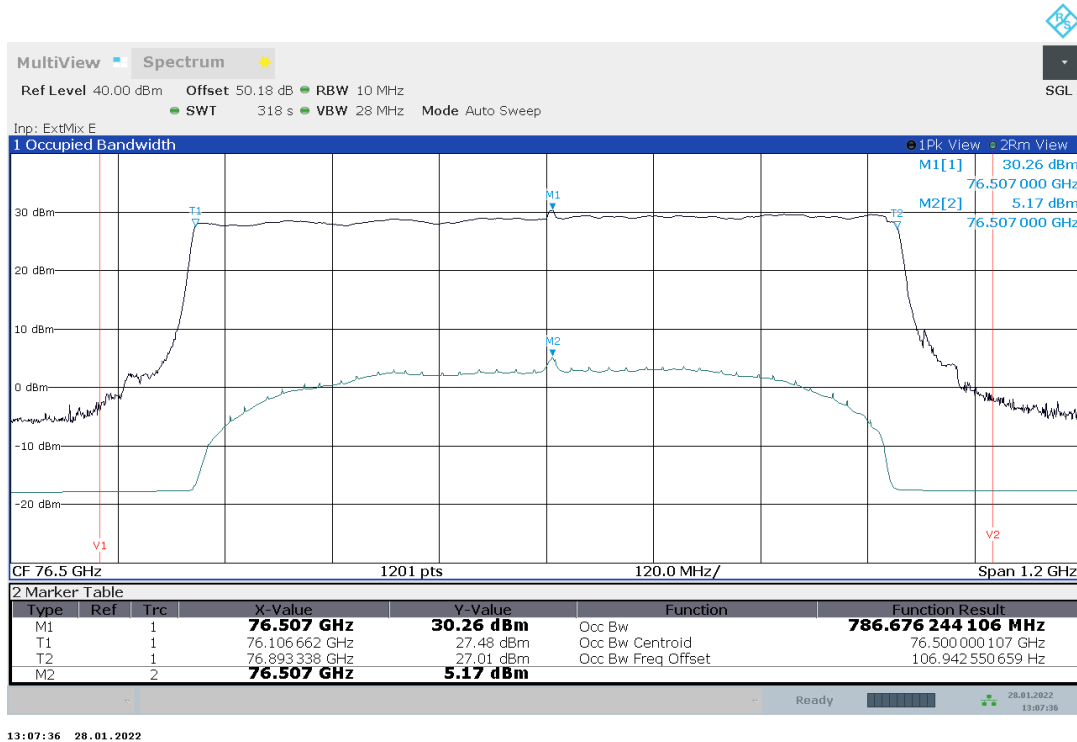
Plot no. 23: 99% OBW, Peak detector, 30 °C, Test mode 8



TR no.: 2105526-20547-2

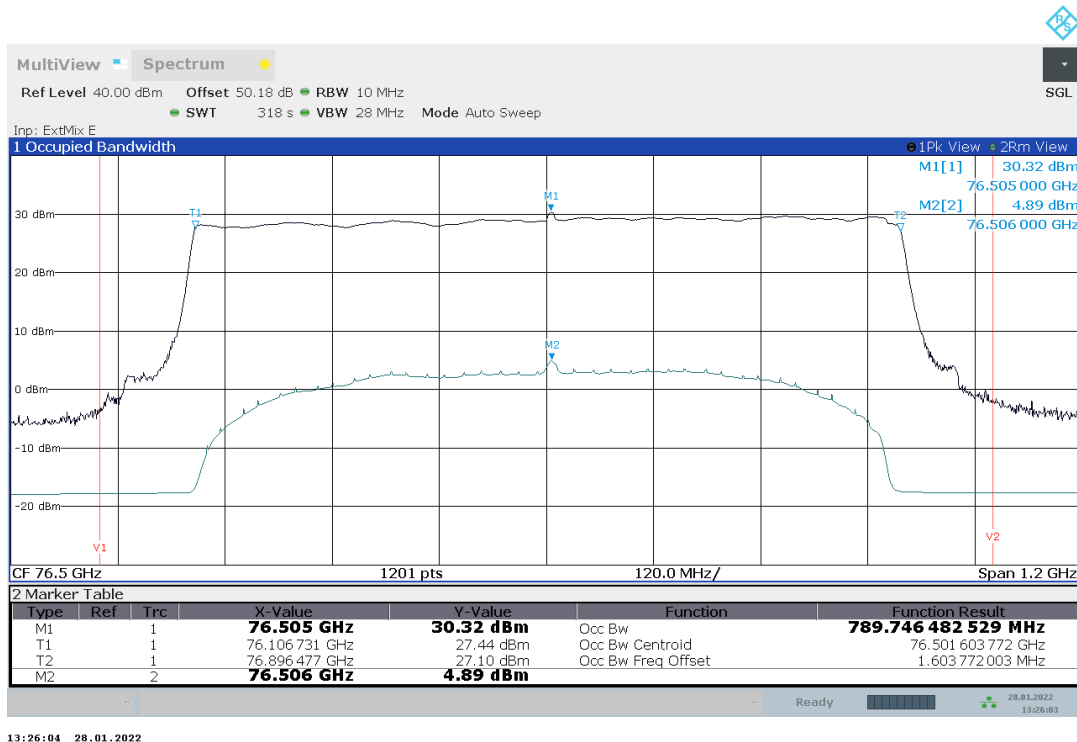
2022-03-07

Plot no. 24: 99% OBW, Peak detector, 20 °C, V_{min}, Test mode 8



13:07:36 28.01.2022

Plot no. 25: 99% OBW, Peak detector, 20 °C, V_{nom}, Test mode 8

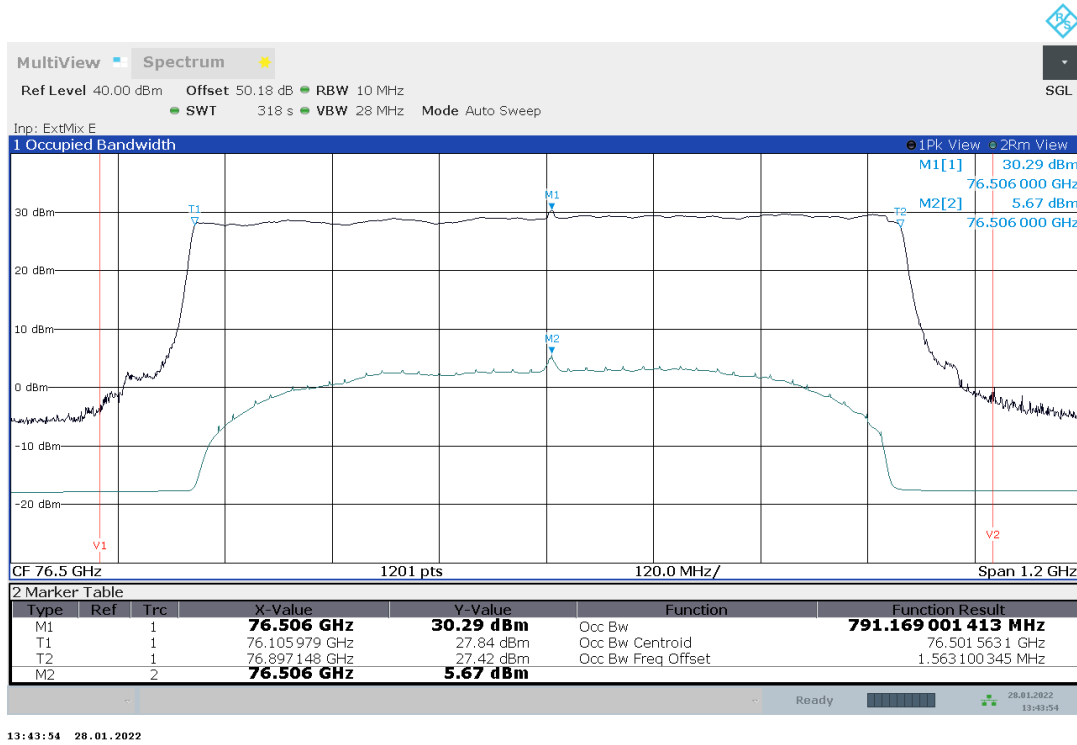


13:26:04 28.01.2022

TR no.: 21055526-20547-2

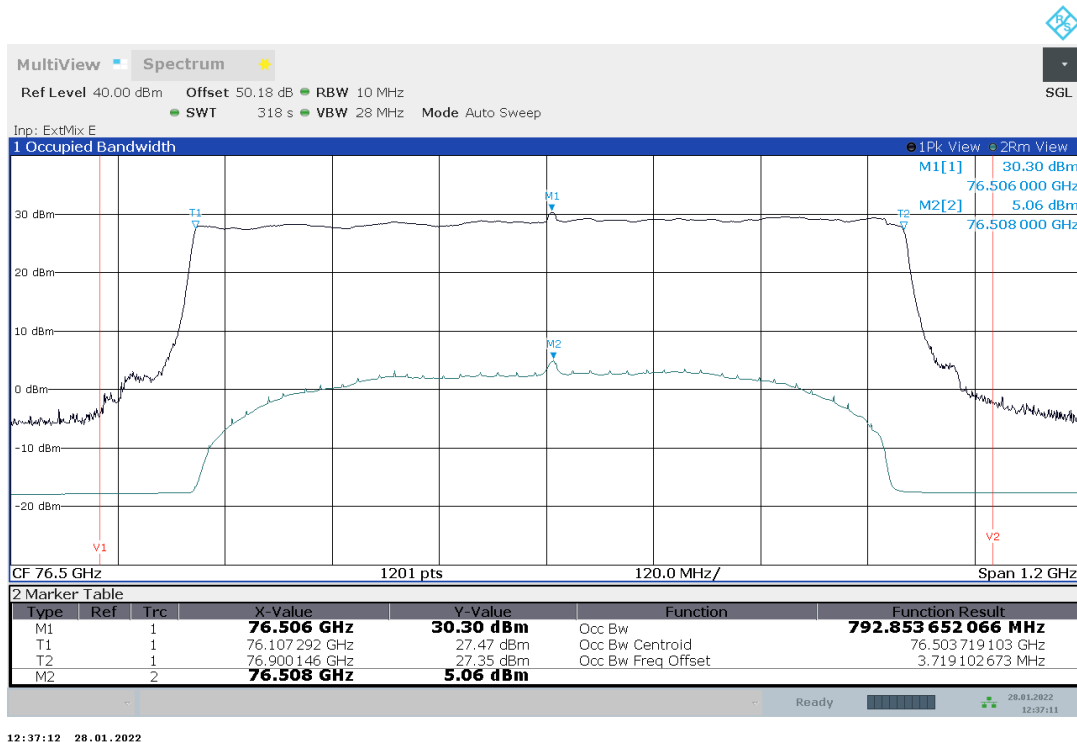
2022-03-07

Plot no. 26: 99% OBW, Peak detector, 20 °C, V_{max}, Test mode 8



13:43:54 28.01.2022

Plot no. 27: 99% OBW, Peak detector, 10 °C, Test mode 8

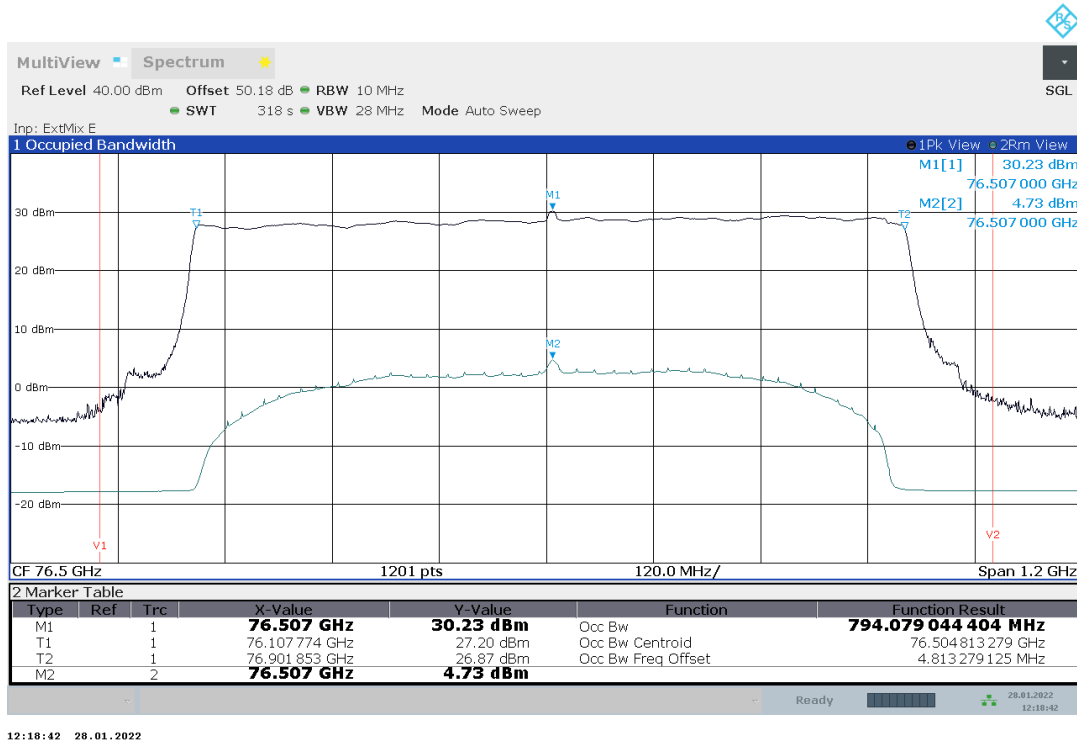


12:37:12 28.01.2022

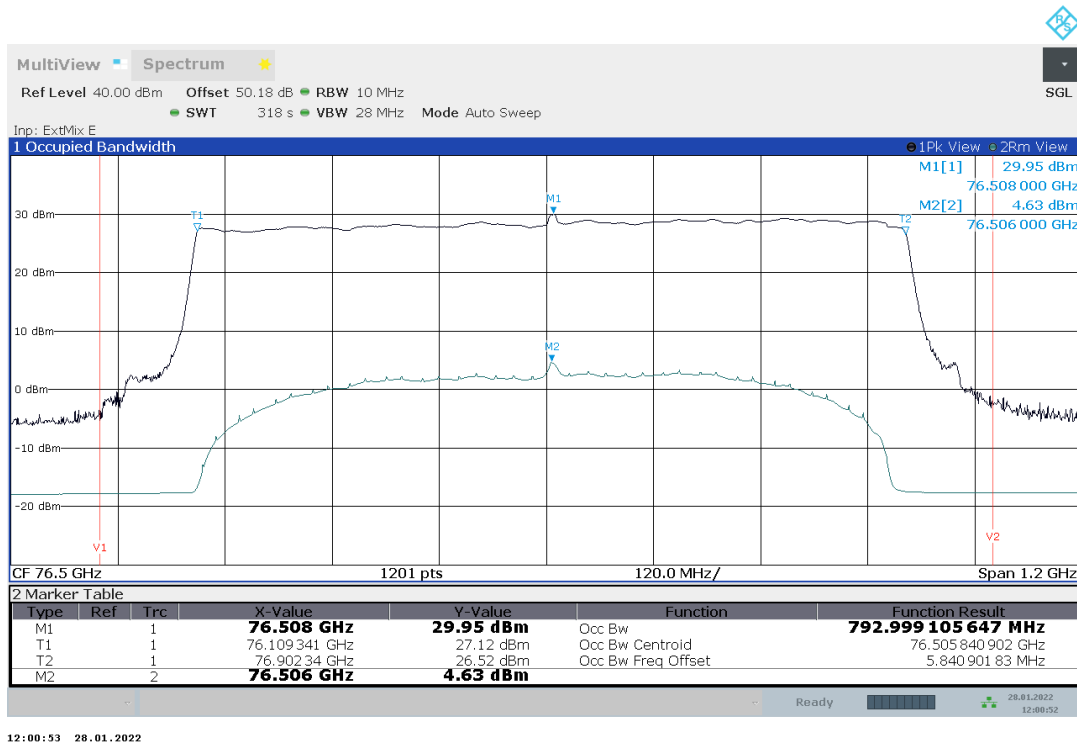
TR no.: 2105526-20547-2

2022-03-07

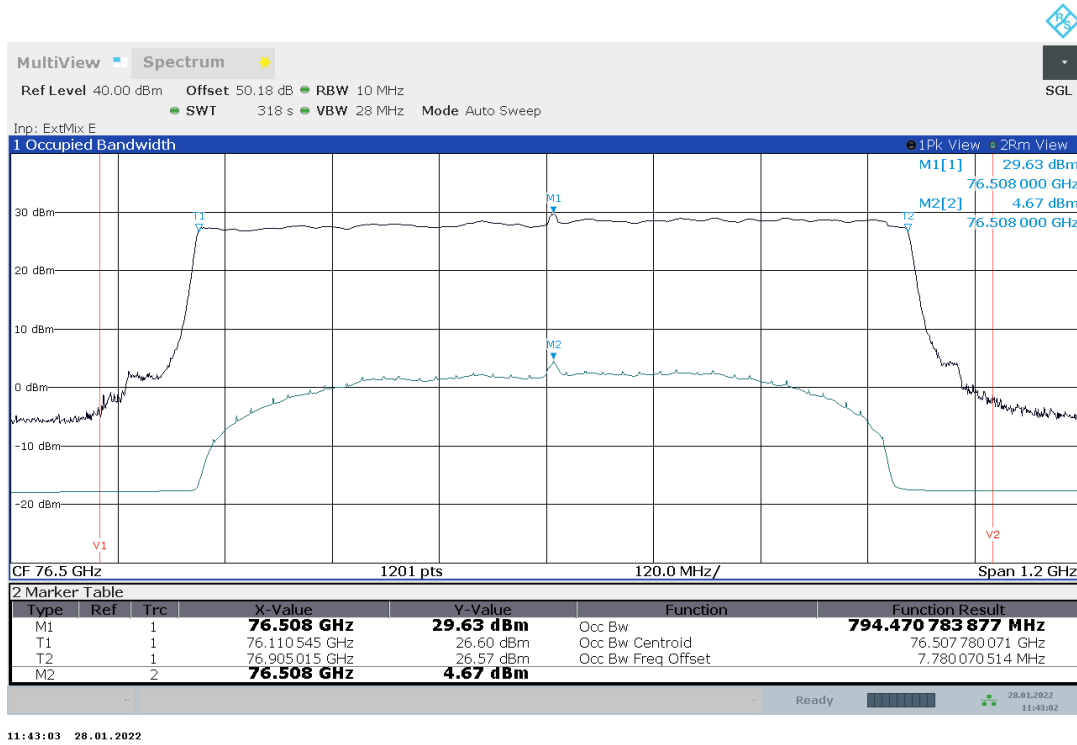
Plot no. 28: 99% OBW, Peak detector, 0 °C, Test mode 8



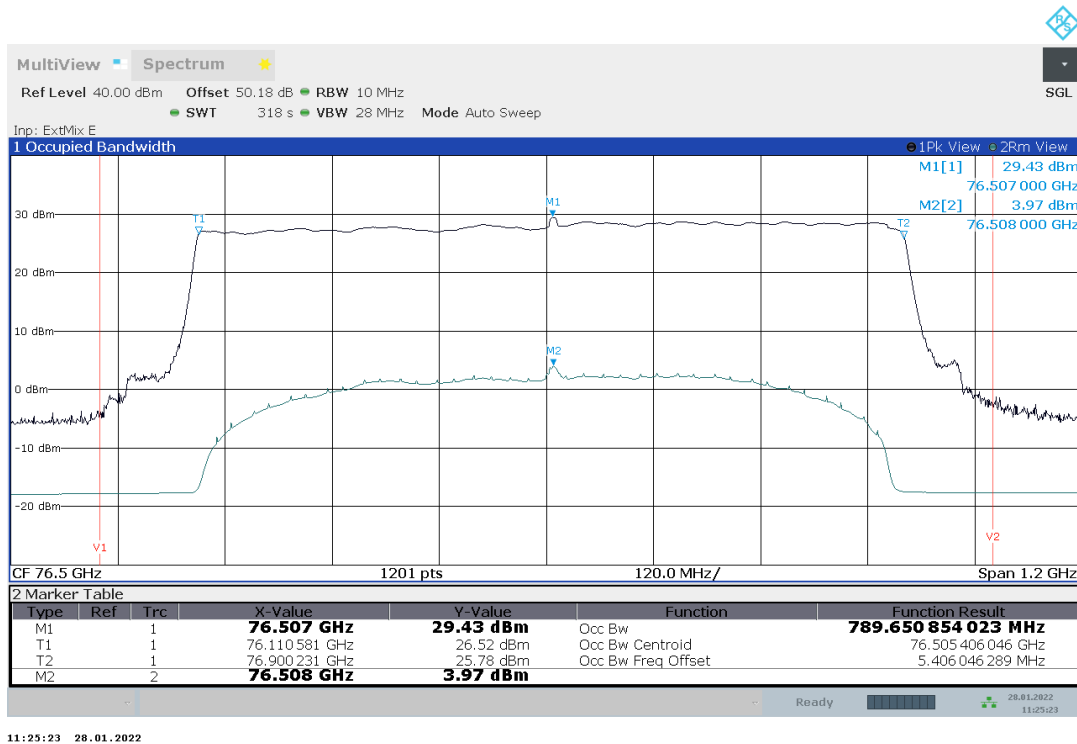
Plot no. 29: 99% OBW, Peak detector, -10 °C, Test mode 8



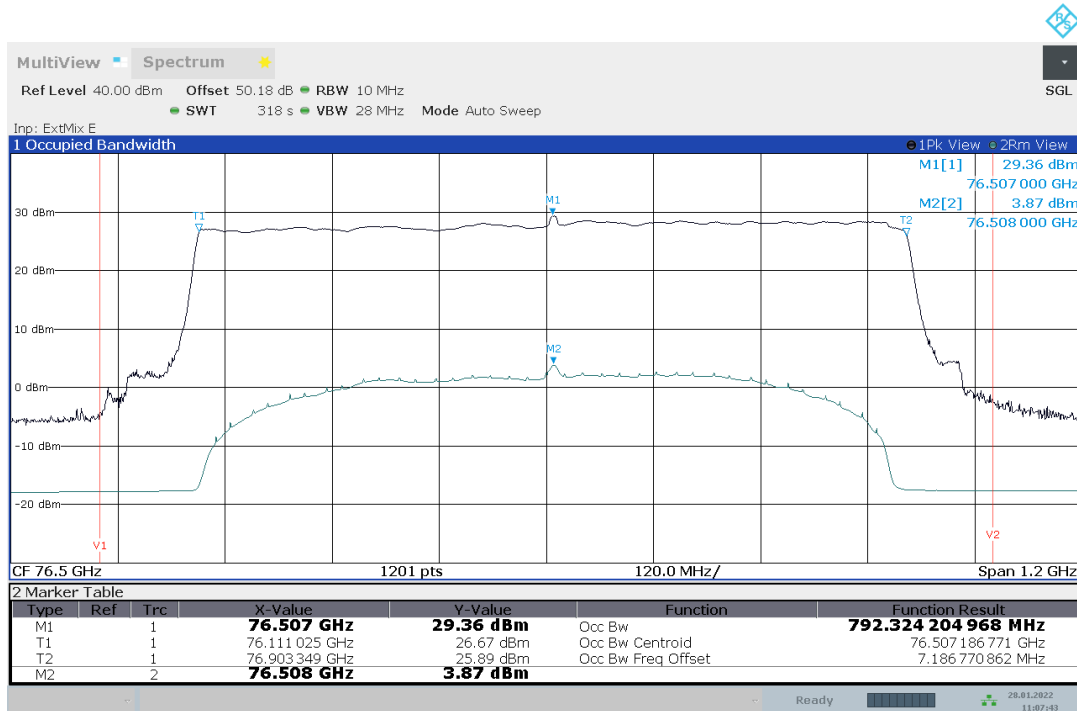
Plot no. 30: 99% OBW, Peak detector, -20 °C, Test mode 8



Plot no. 31: 99% OBW, Peak detector, -30 °C, Test mode 8



Plot no. 32: 99% OBW, Peak detector, -40 °C, Test mode 8

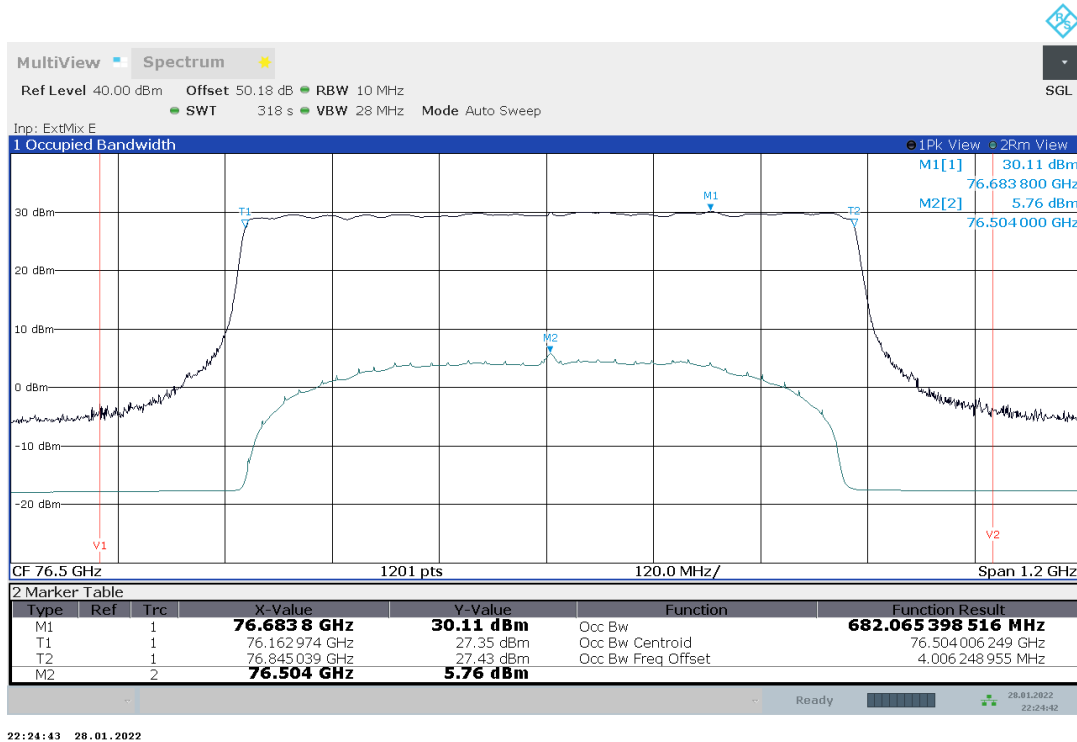


11:07:43 28.01.2022

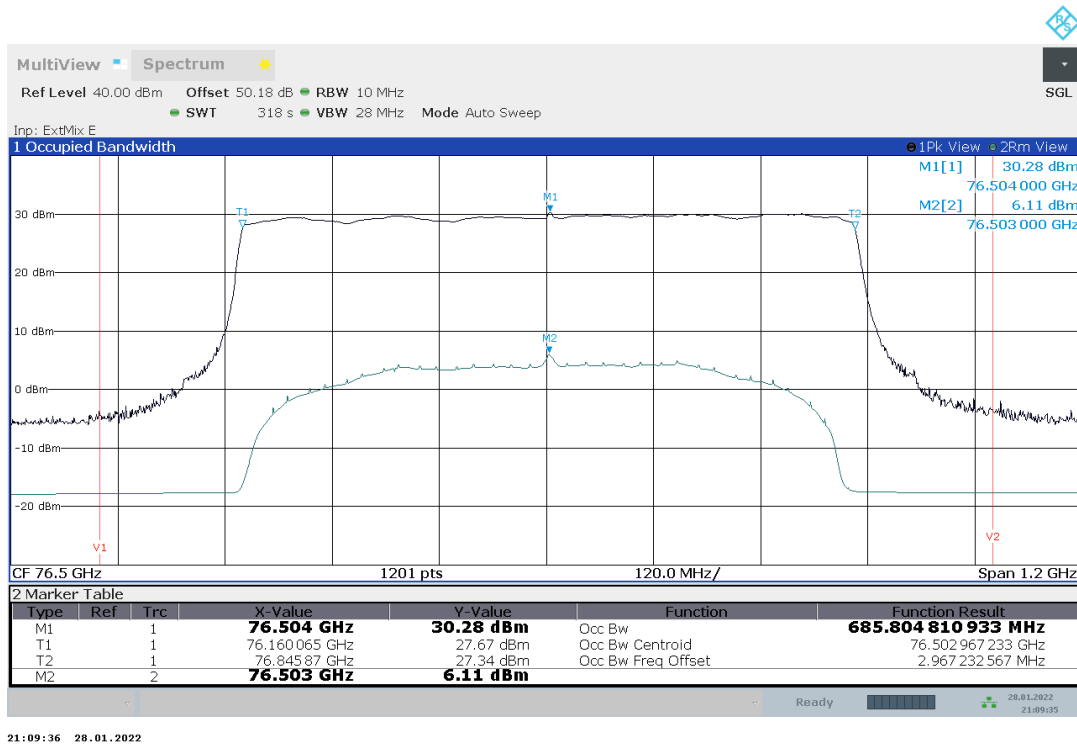
TR no.: 2105526-20547-2

2022-03-07

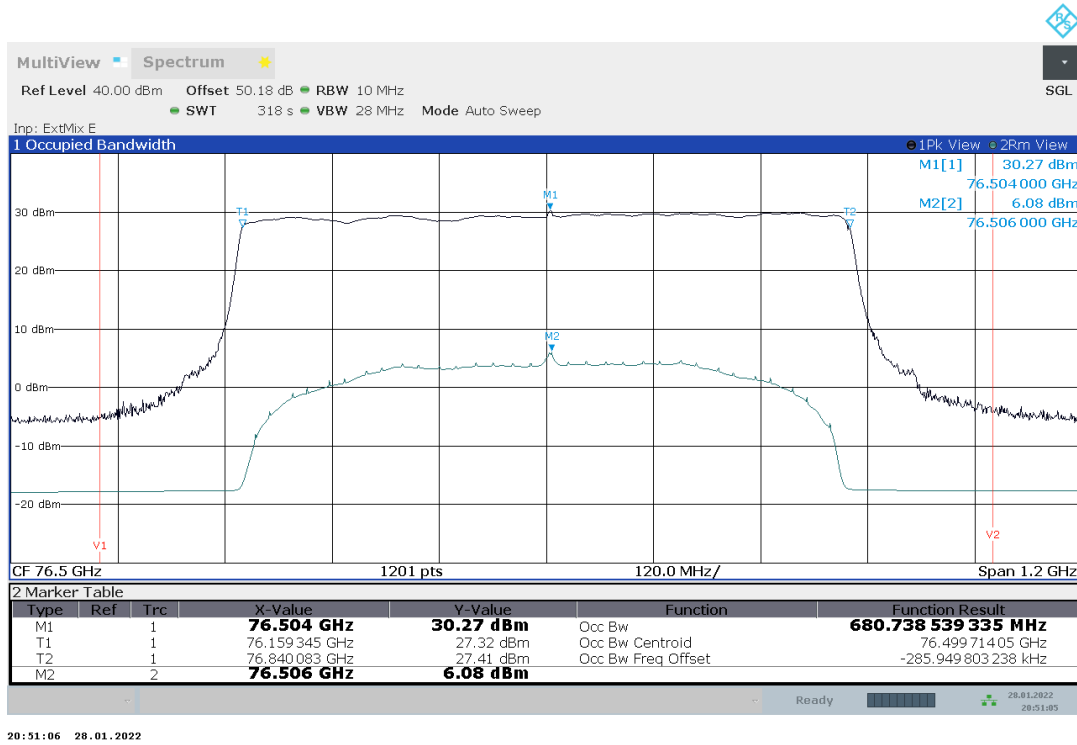
Plot no. 33: 99% OBW, Peak detector, 85 °C, Test Mode 9



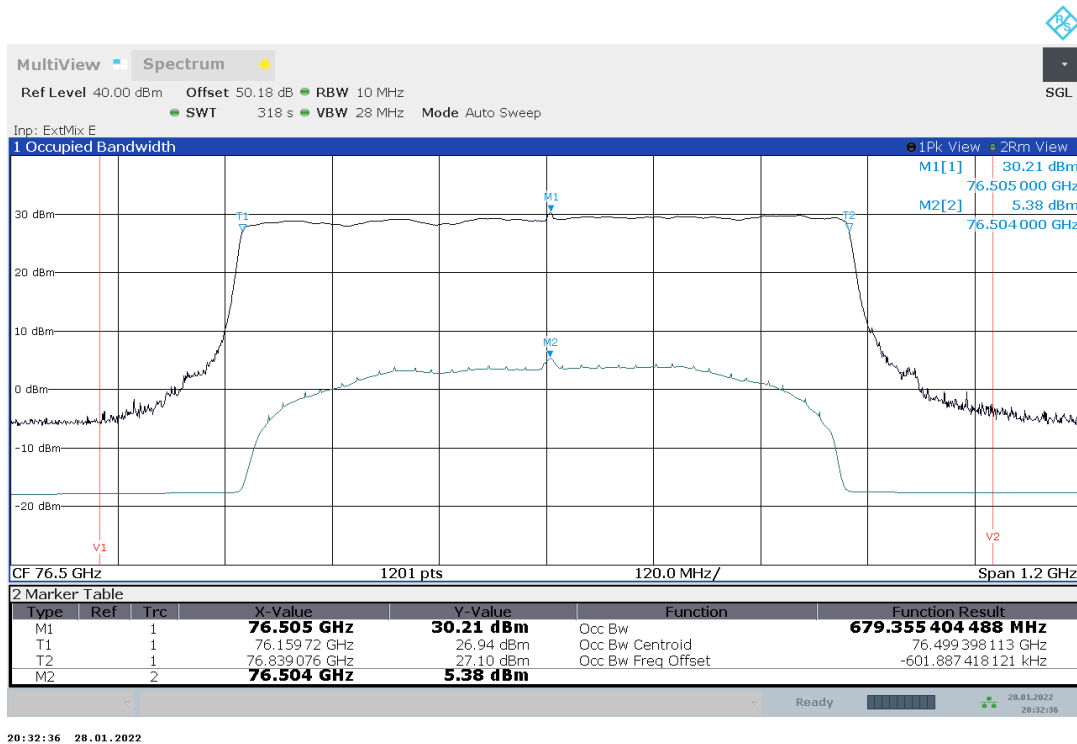
Plot no. 34: 99% OBW, Peak detector, 50 °C, Test Mode 9



Plot no. 35: 99% OBW, Peak detector, 40 °C, Test Mode 9



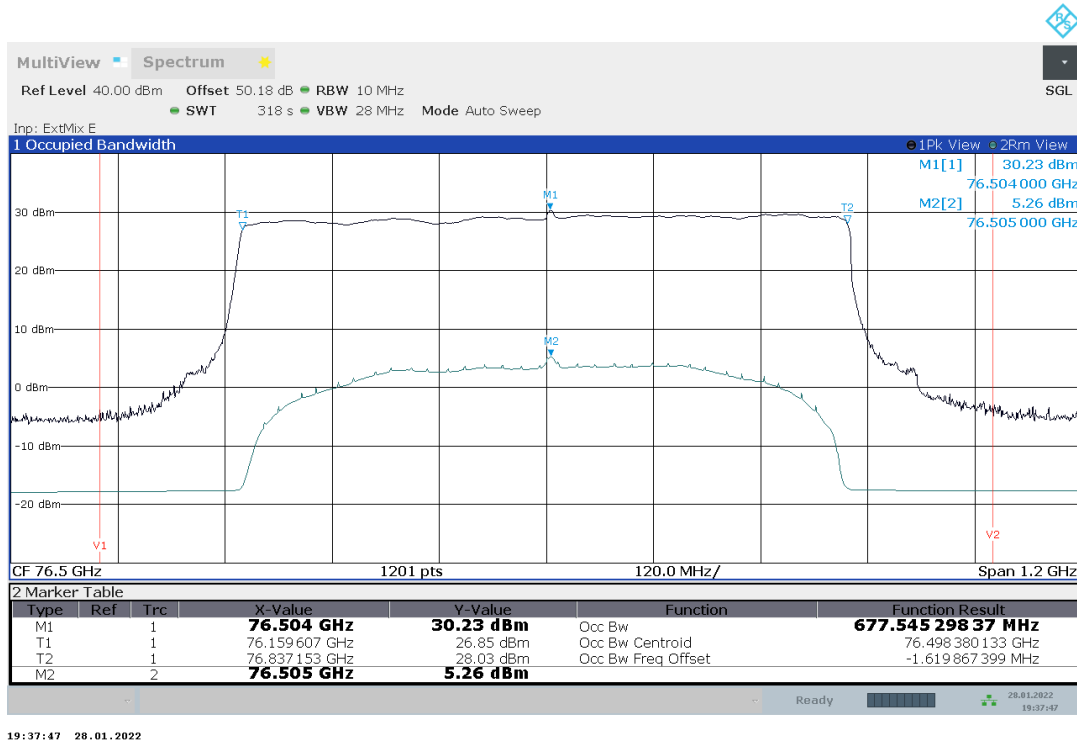
Plot no. 36: 99% OBW, Peak detector, 30 °C, Test Mode 9



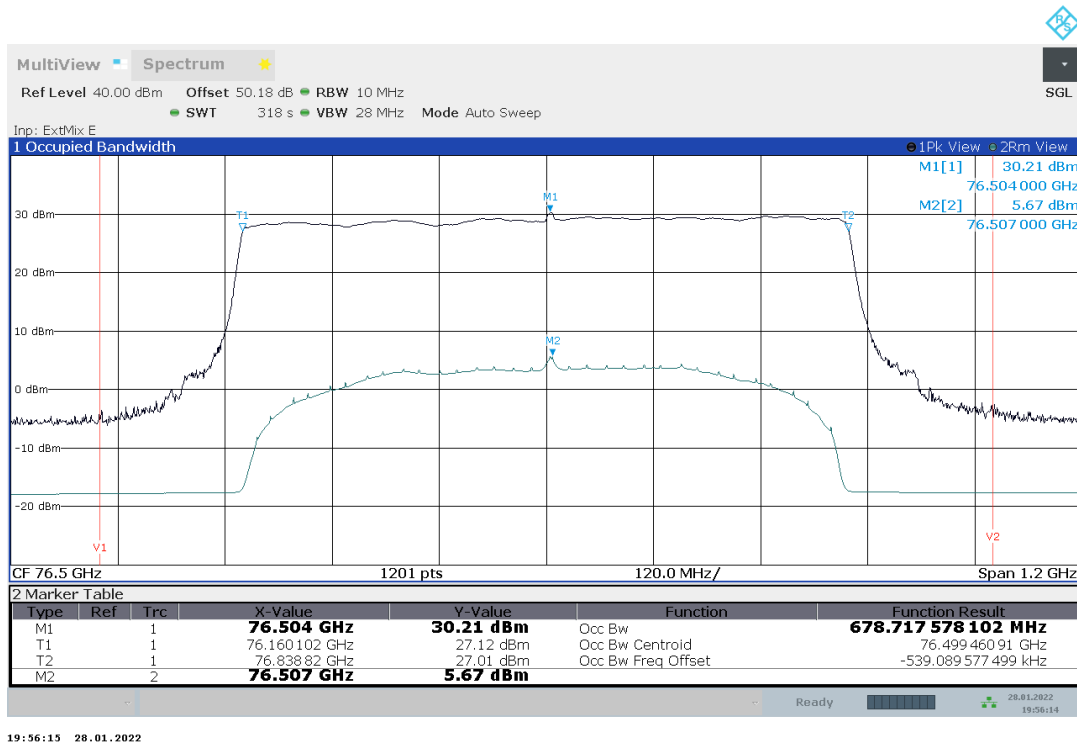
TR no.: 21055526-20547-2

2022-03-07

Plot no. 37: 99% OBW, Peak detector, 20 °C, V_{min}, Test Mode 9



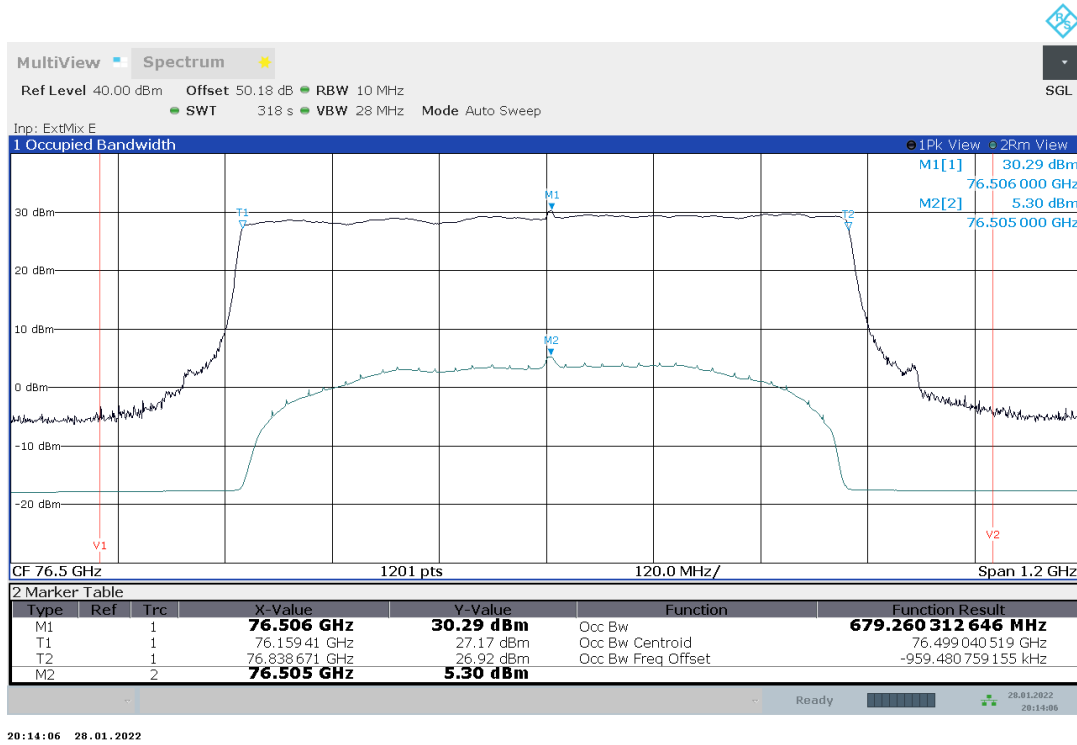
Plot no. 38: 99% OBW, Peak detector, 20 °C, V_{nom}, Test Mode 9



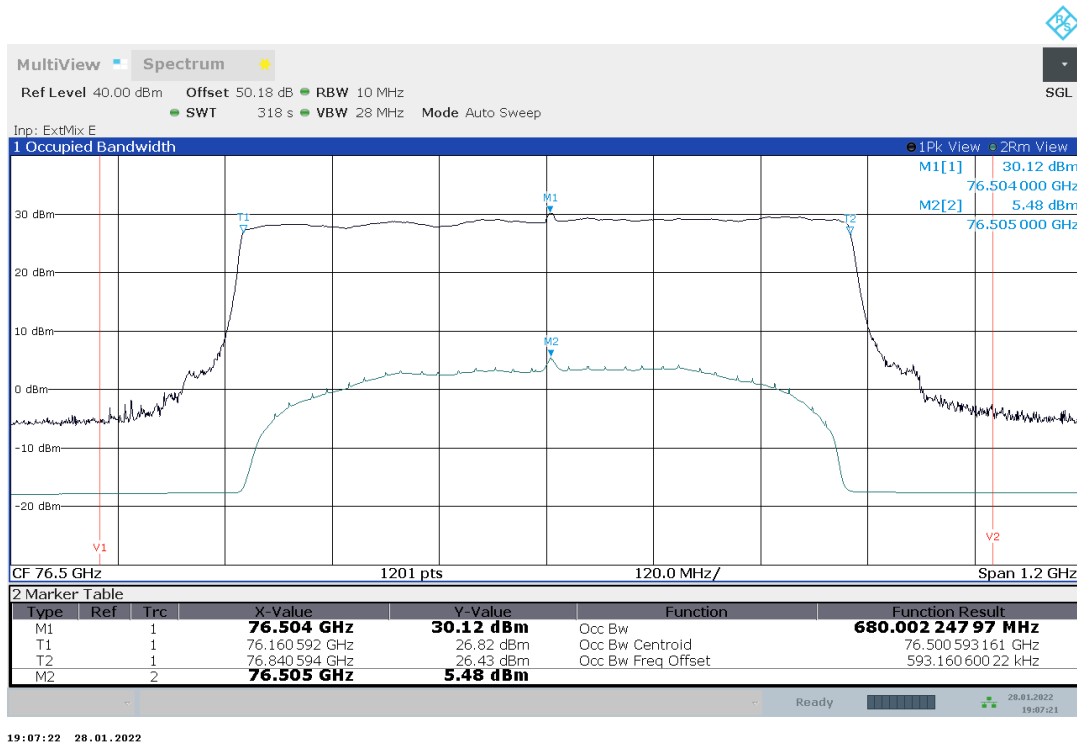
TR no.: 21055526-20547-2

2022-03-07

Plot no. 39: 99% OBW, Peak detector, 20 °C, V_{max}, Test Mode 9



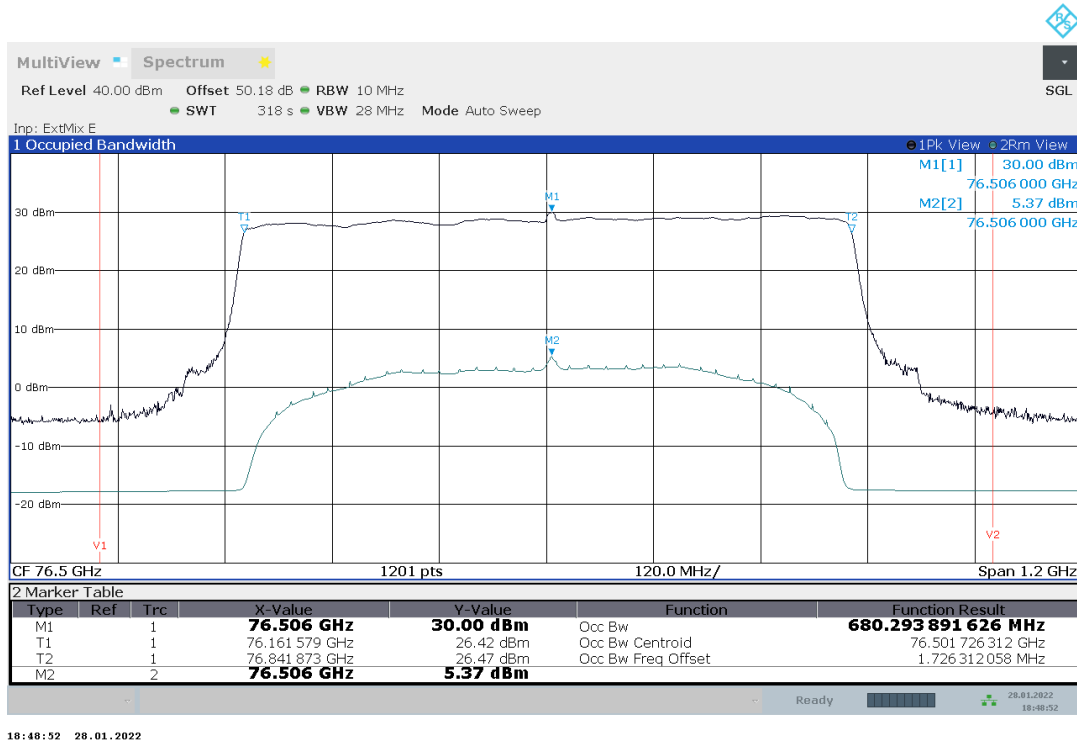
Plot no. 40: 99% OBW, Peak detector, 10 °C, Test Mode 9



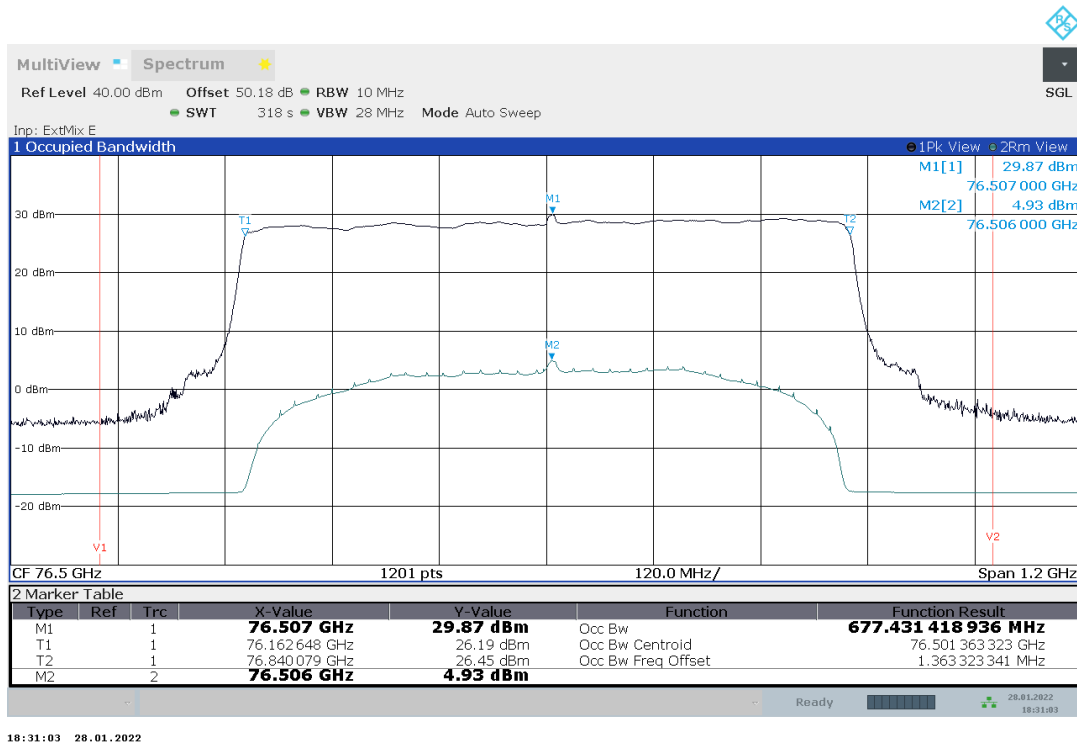
TR no.: 2105526-20547-2

2022-03-07

Plot no. 41: 99% OBW, Peak detector, 0 °C, Test Mode 9



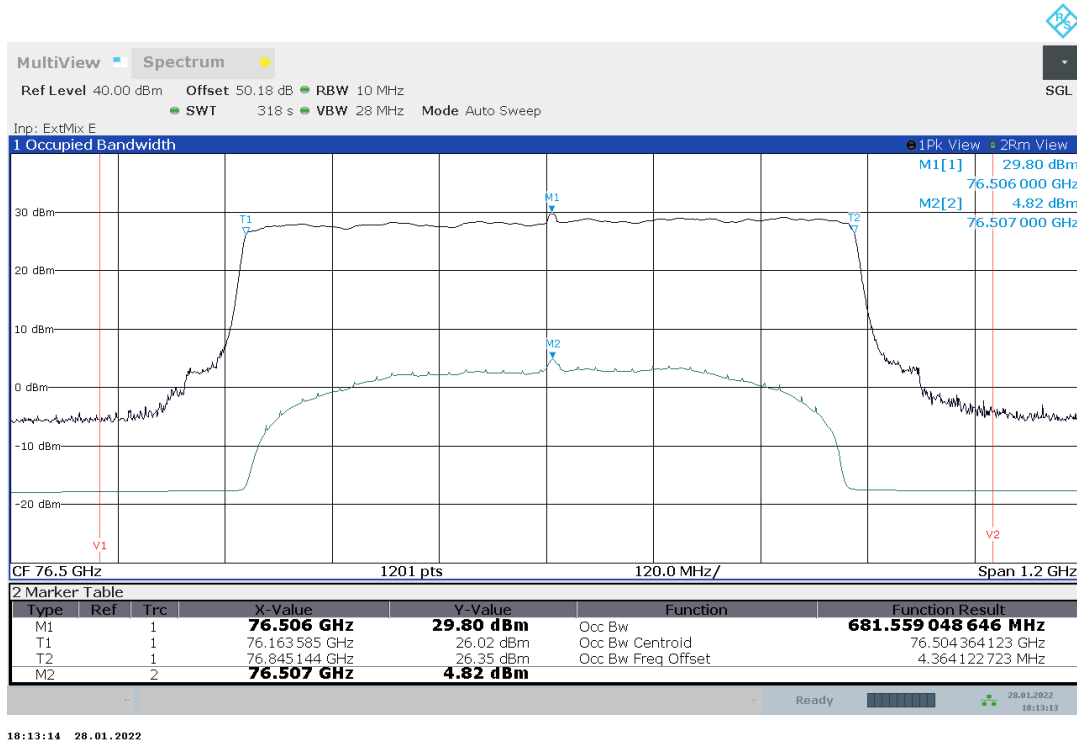
Plot no. 42: 99% OBW, Peak detector, -10 °C, Test Mode 9



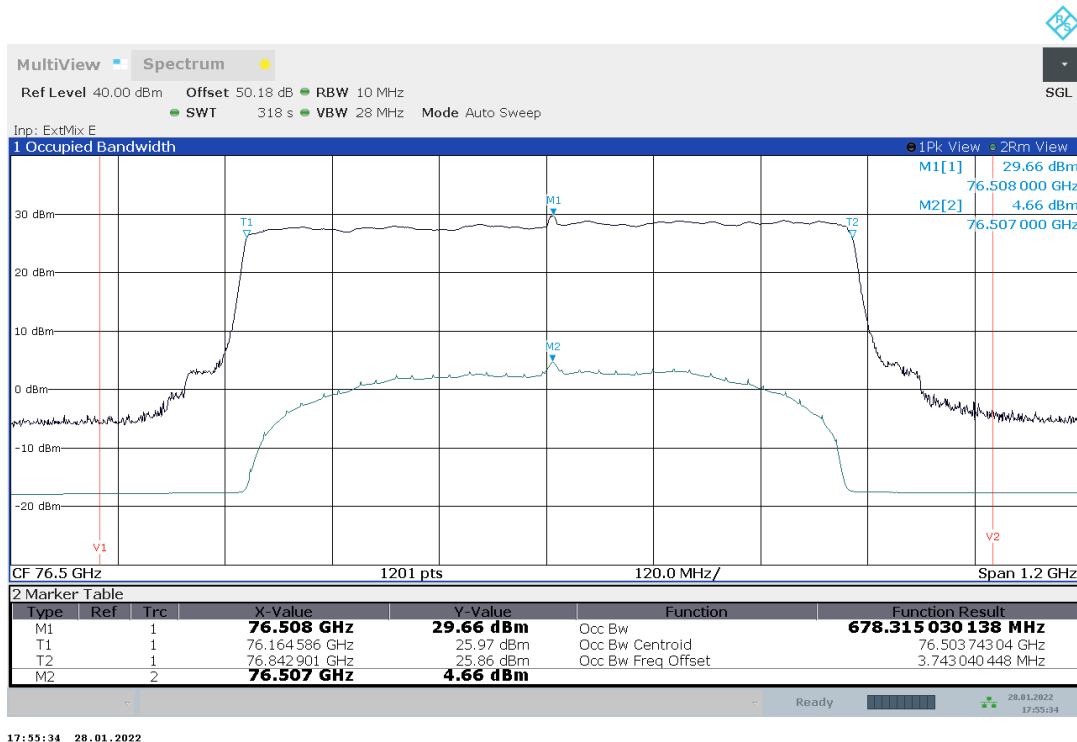
TR no.: 2105526-20547-2

2022-03-07

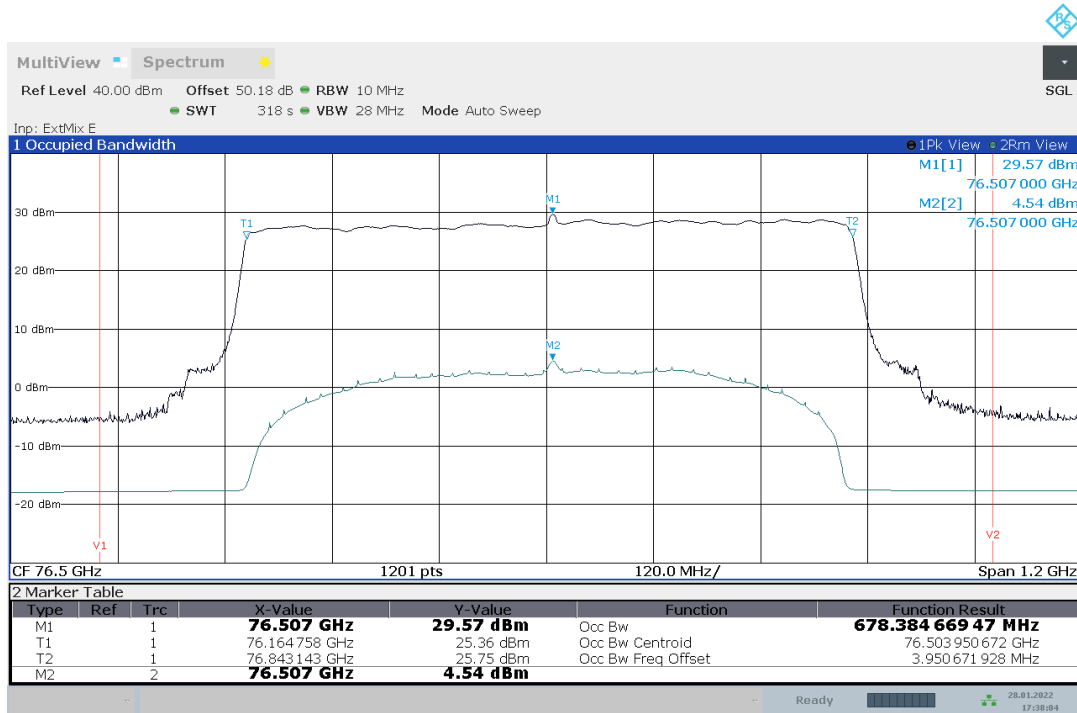
Plot no. 43: 99% OBW, Peak detector, -20 °C, Test Mode 9



Plot no. 44: 99% OBW, Peak detector, -30 °C, Test Mode 9



Plot no. 45: 99% OBW, Peak detector, -40 °C, Test Mode 9



17:38:05 28.01.2022

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 [$\mu\text{V}/\text{m}$] / [dB $\mu\text{V}/\text{m}$]	Measurement distance [m]
0.009 – 0.490	2400/F[kHz]	300
0.490 – 1.705	24000/F[kHz]	30
1.705 – 30.0	30.0 / 29.5	30
30 – 88	100 / 40.0	3
88 – 216	150 / 43.5	3
216 – 960	200 / 46.0	3
960 – 40 000	500 / 54.0	3

(2) The power density of radiated emissions outside the 76-81 GHz band above 40.0 GHz shall not exceed the following, based on measurements employing an average detector with a 1 MHz RBW:

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

Note

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

Calculation of the far field distance (Rayleigh distance):

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

Antenna type	Frequency range [GHz]	D [m]	Highest frequency in use [GHz]	Far field distance R_m [m]
20240-20	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

Typical test distances

Up to 18 GHz: 3.00 m
 18 – 50 GHz: 0.50 m
 50 – 110 GHz: 0.25 m
 110 – 170 GHz: 0.10 m
 In-band / OOB: 1.00 m

Used test distances

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

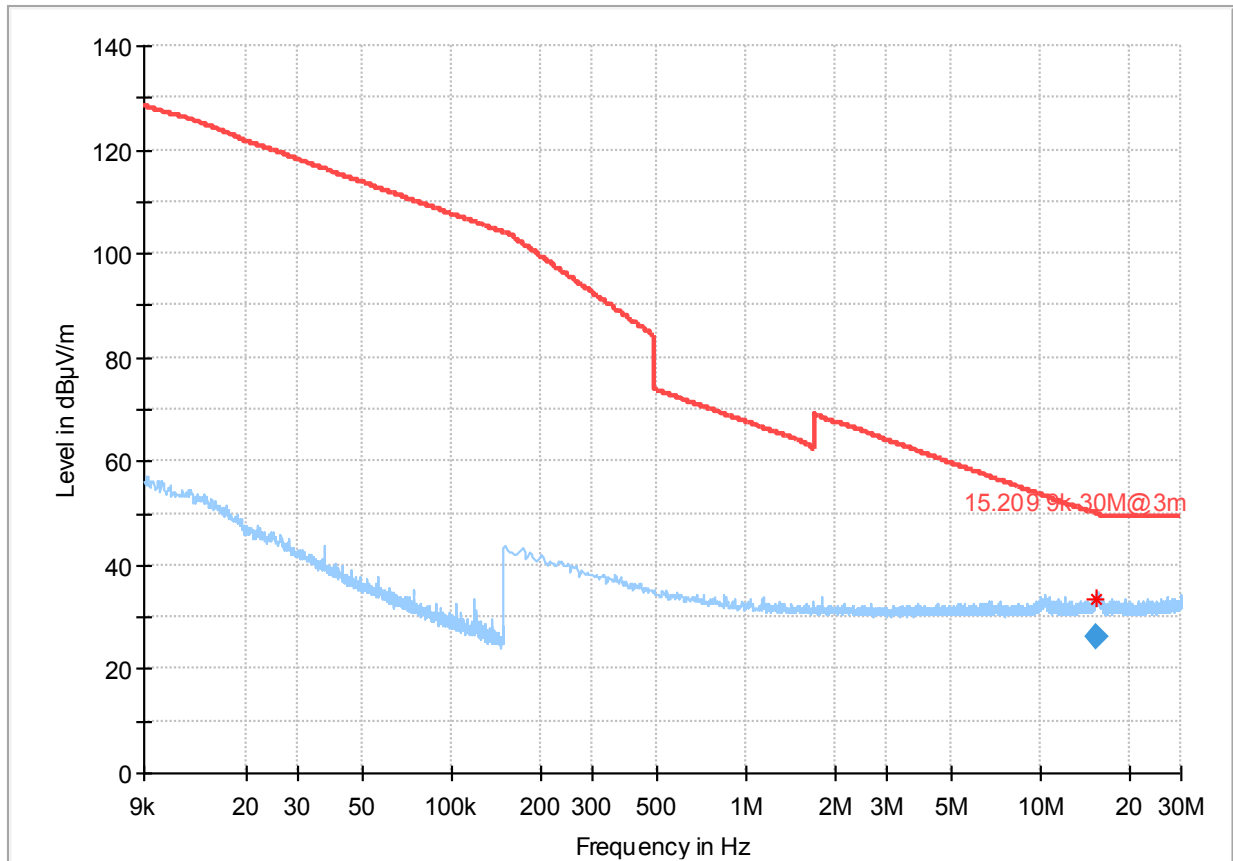
Test setup: 8.1 – 8.4 (in case of field strength measurements below 40 GHz: test distance correction factor of 20dB/decade is already considered in the plots / test result table)

Test results:

Channel / Mode	Frequency [GHz]	Detector	Test distance [m]	Level [dBµV/dBm]	Limit [dBµV/dBm]	Margin [dB]
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No critical emissions found. Some plots for measurements made with harmonic mixers may include image signals and mixer products (here Plots 61-66, 73-75). The amplitude of these mixing products is below the limit. Each mixer product was checked separately with Signal ID function whether it is a real signal or a mixer product. For further details see plots.

Plot no. 46: radiated emissions 9 kHz – 30 MHz, Mode 7, loop antenna

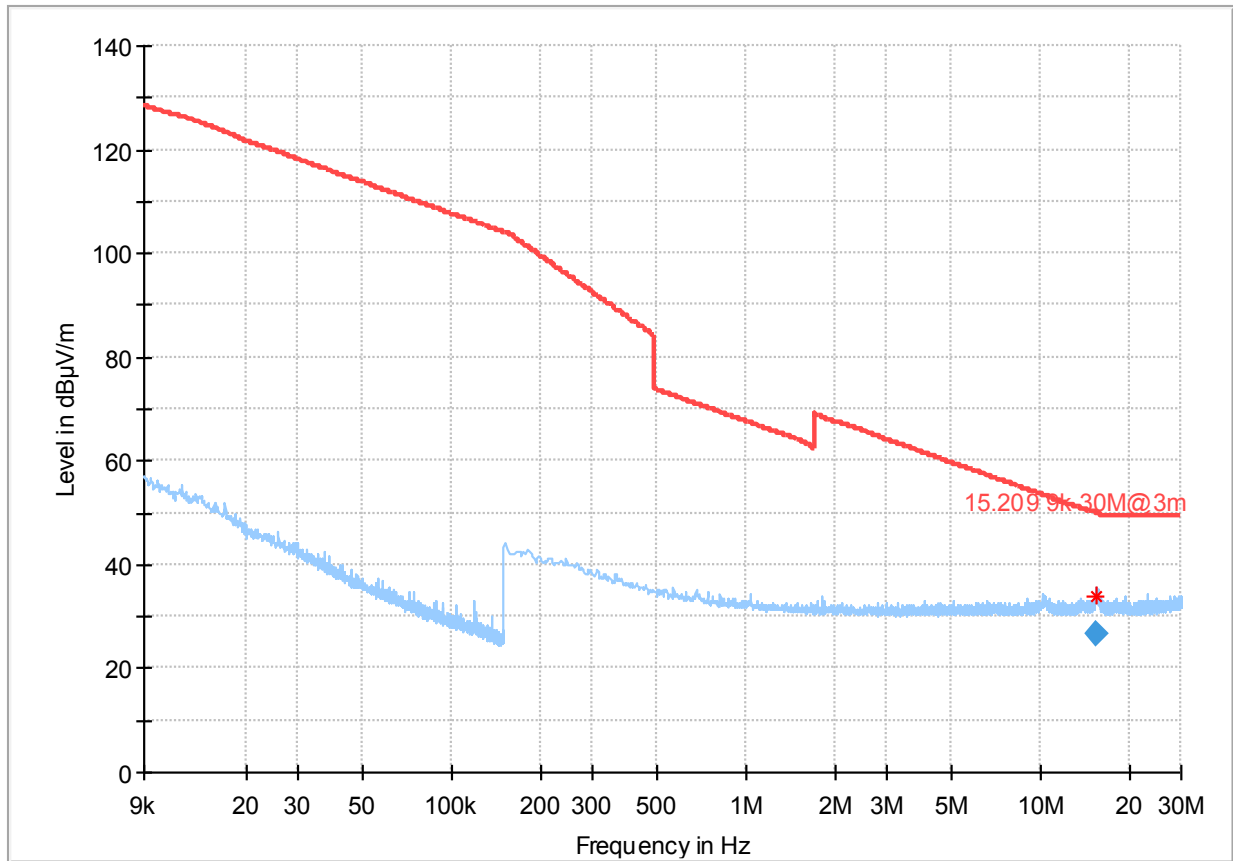


— Preview Result 1-PK+ * Critical_Freqs PK+
— 15.209 9k-30M@3m ◆ Final_Result QPK

Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
15.567000	26.37	50.03	23.66	100.0	9.000	V	240.0	20.5

Plot no. 47: radiated emissions 9 kHz – 30 MHz, mode 8, loop antenna

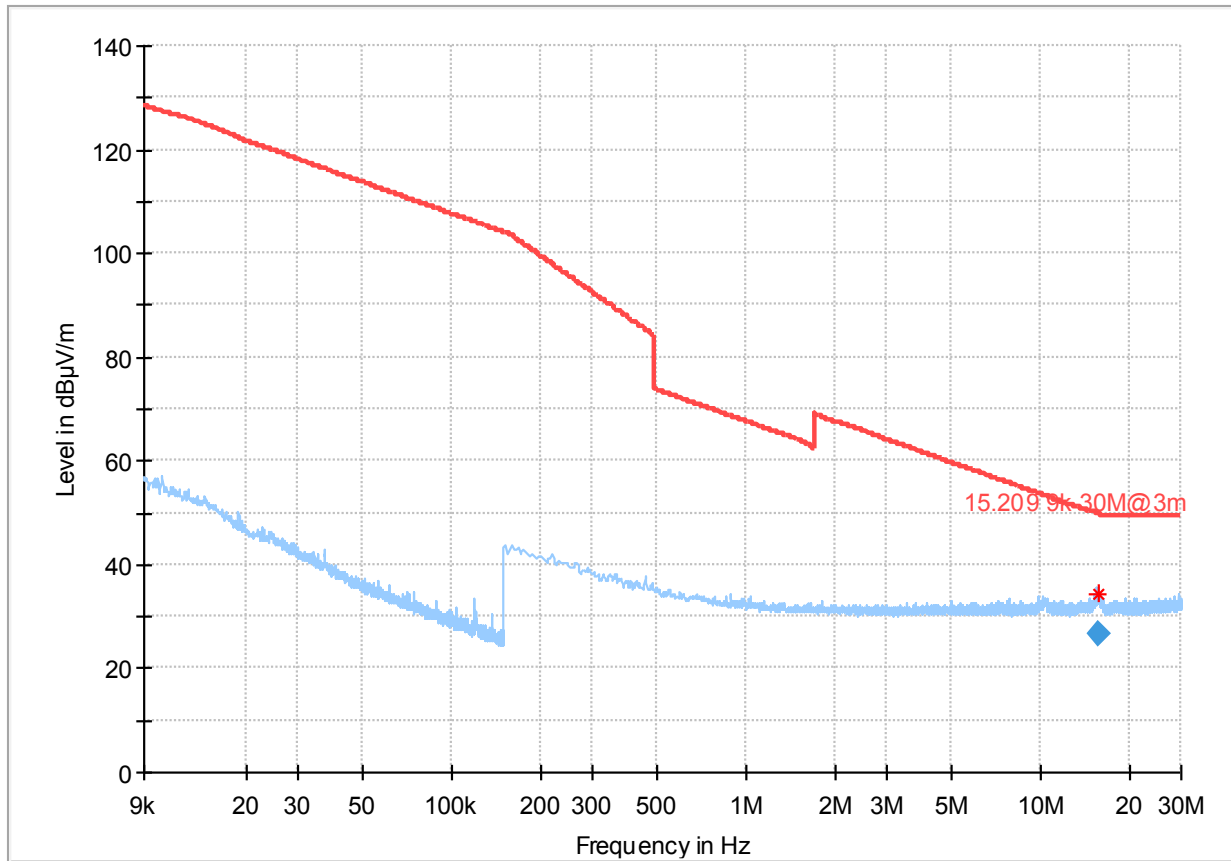


— Preview Result 1-PK+ * Critical_Freqs PK+
— 15.209 9k-30M@3m ◆ Final_Result QPK

Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
15.524250	26.52	50.03	23.51	100.0	9.000	V	300.0	20.5

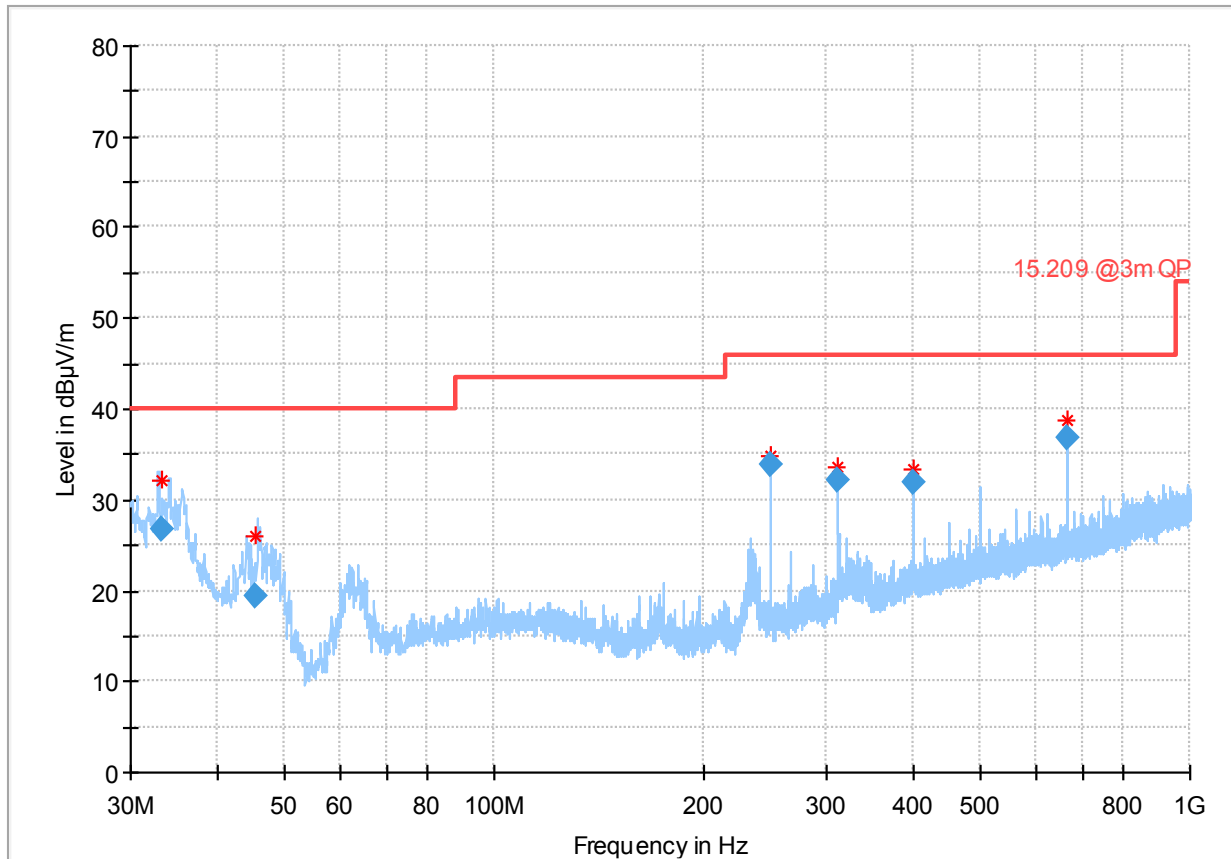
Plot no. 48: radiated emissions 9 kHz – 30 MHz, Mode 9, loop antenna



— Preview Result 1-PK+ * Critical_Freqs PK+
— 15.209 9k-30M@3m ◆ Final_Result QPK

Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Pol	Azimuth (deg)	Corr. (dB/m)
15.670500	26.56	50.02	23.46	100.0	9.000	V	30.0	20.5

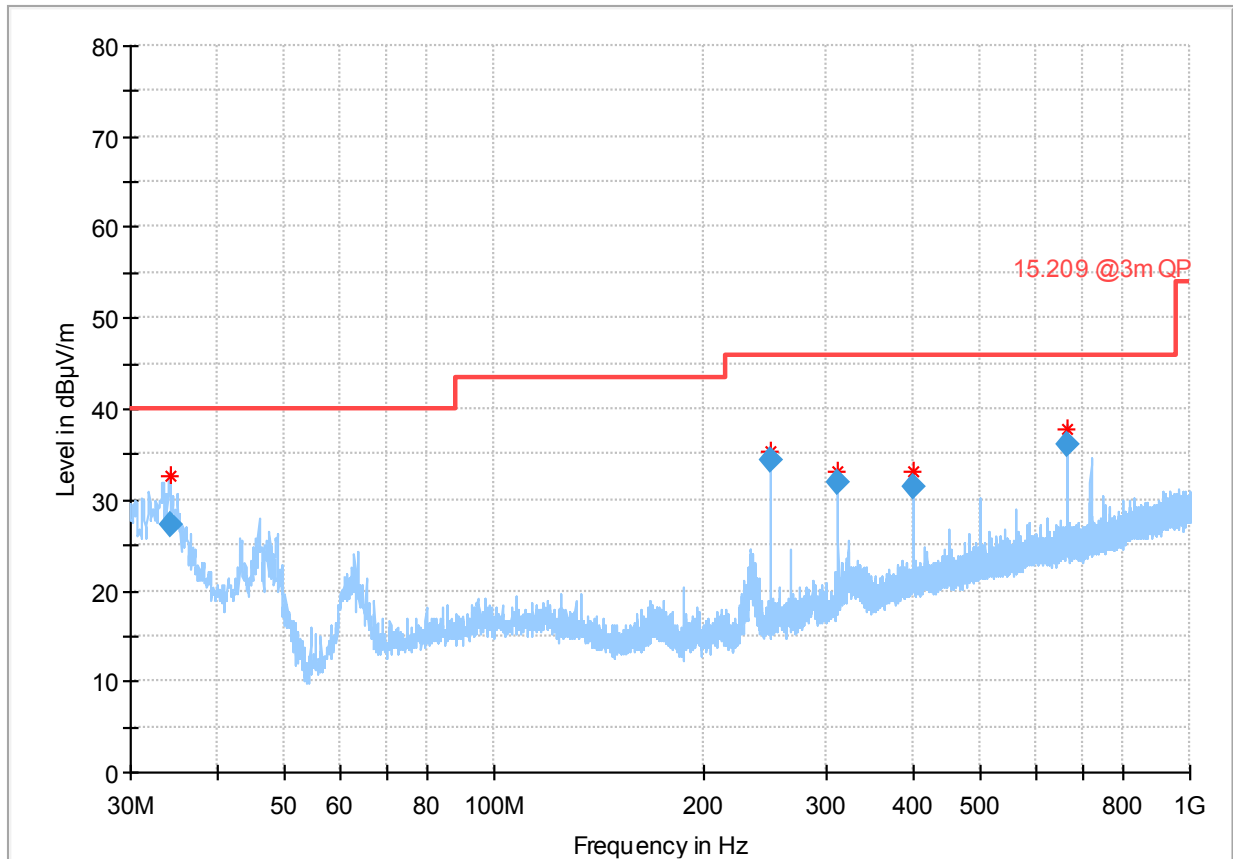


— Preview Result 1-PK+ * Critical_Freqs PK+
— 15.209 @3m QP ◆ Final_Result QPK

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
33.310000	26.64	40.00	13.36	100.0	120.000	100.0	V	147.0
45.462500	19.39	40.00	20.61	100.0	120.000	187.0	V	109.0
249.996000	33.77	46.00	12.23	100.0	120.000	148.0	V	243.0
312.512500	32.05	46.00	13.95	100.0	120.000	100.0	V	249.0
400.006500	31.80	46.00	14.20	100.0	120.000	100.0	V	240.0
666.659500	36.76	46.00	9.24	100.0	120.000	103.0	V	294.0

Plot no. 50: radiated emissions 30 MHz – 1 GHz, mode 8, polarization vertical / horizontal

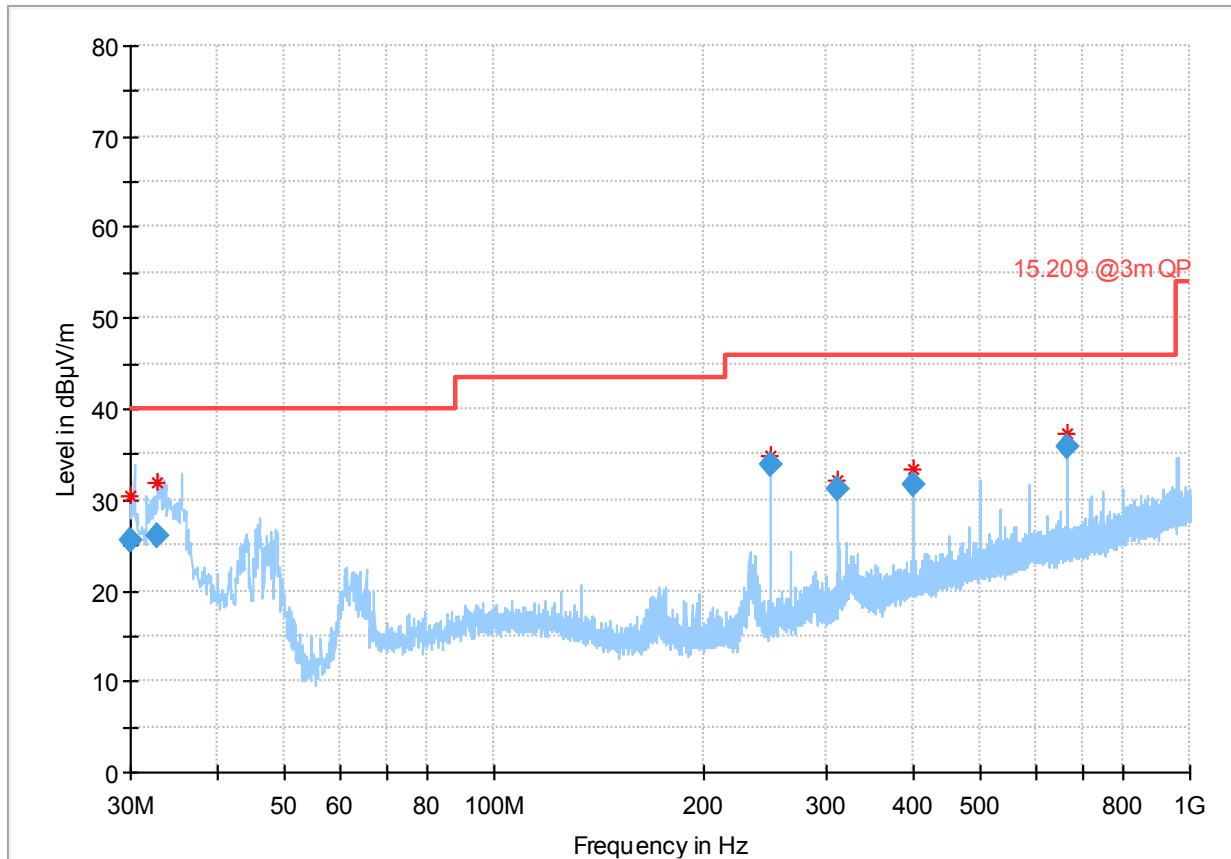


— Preview Result 1-PK+ * Critical_Freqs PK+
— 15.209 @3m QP ◆ Final_Result QPK

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
34.196000	27.28	40.00	12.72	100.0	120.000	100.0	V	30.0
249.996000	34.26	46.00	11.74	100.0	120.000	150.0	V	237.0
312.489000	31.94	46.00	14.06	100.0	120.000	100.0	V	224.0
399.981500	31.37	46.00	14.63	100.0	120.000	100.0	V	234.0
666.659500	35.97	46.00	10.03	100.0	120.000	103.0	V	294.0

Plot no. 51: radiated emissions 30 MHz – 1 GHz, Mode 9, polarization vertical / horizontal

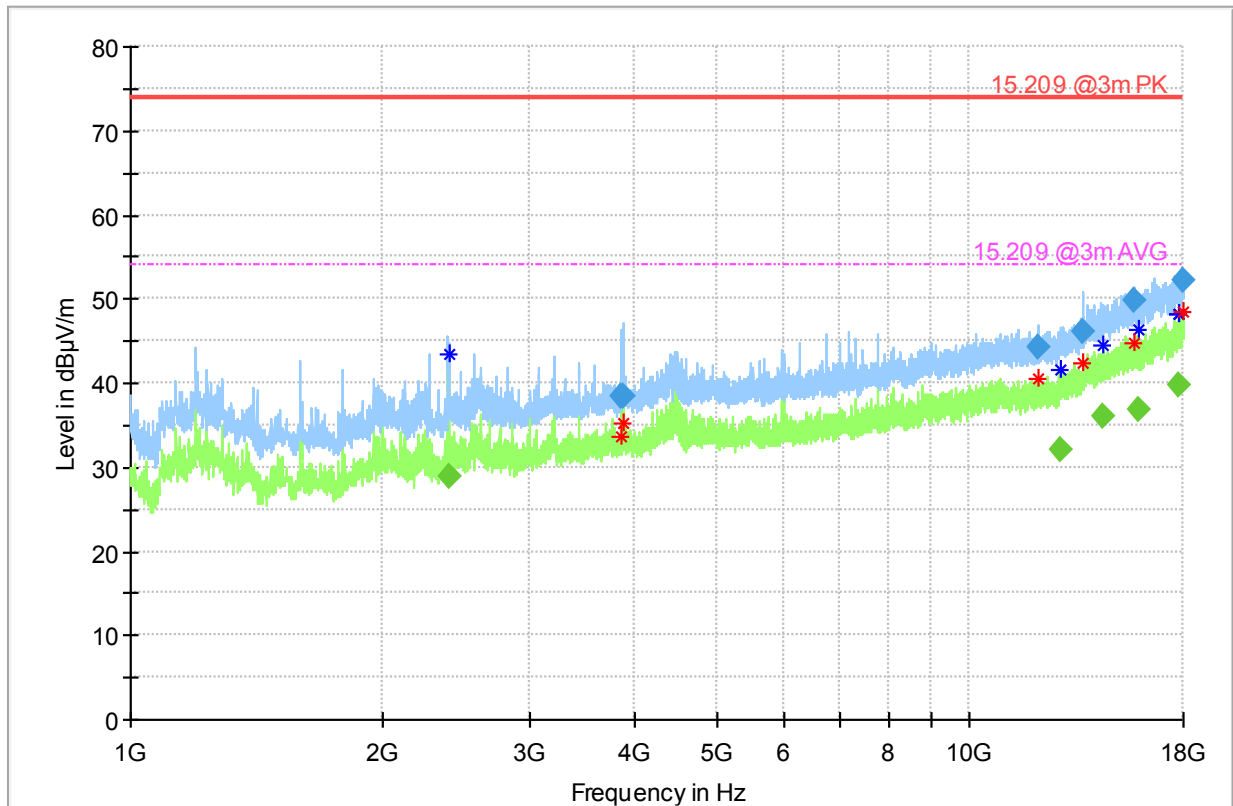


— Preview Result 1-PK+ * Critical_Freqs PK+
— 15.209 @3m QP ◆ Final_Result QPK

Final_Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)
30.000000	25.43	40.00	14.57	100.0	120.000	103.0	V	326.0
32.836500	26.13	40.00	13.87	100.0	120.000	153.0	V	342.0
249.996000	33.77	46.00	12.23	100.0	120.000	138.0	V	230.0
312.487500	31.24	46.00	14.76	100.0	120.000	103.0	V	230.0
400.006500	31.55	46.00	14.45	100.0	120.000	104.0	V	241.0
666.658000	35.87	46.00	10.13	100.0	120.000	104.0	V	291.0

Plot no. 52: radiated emissions 1 GHz – 18 GHz, Mode 7, polarization vertical / horizontal

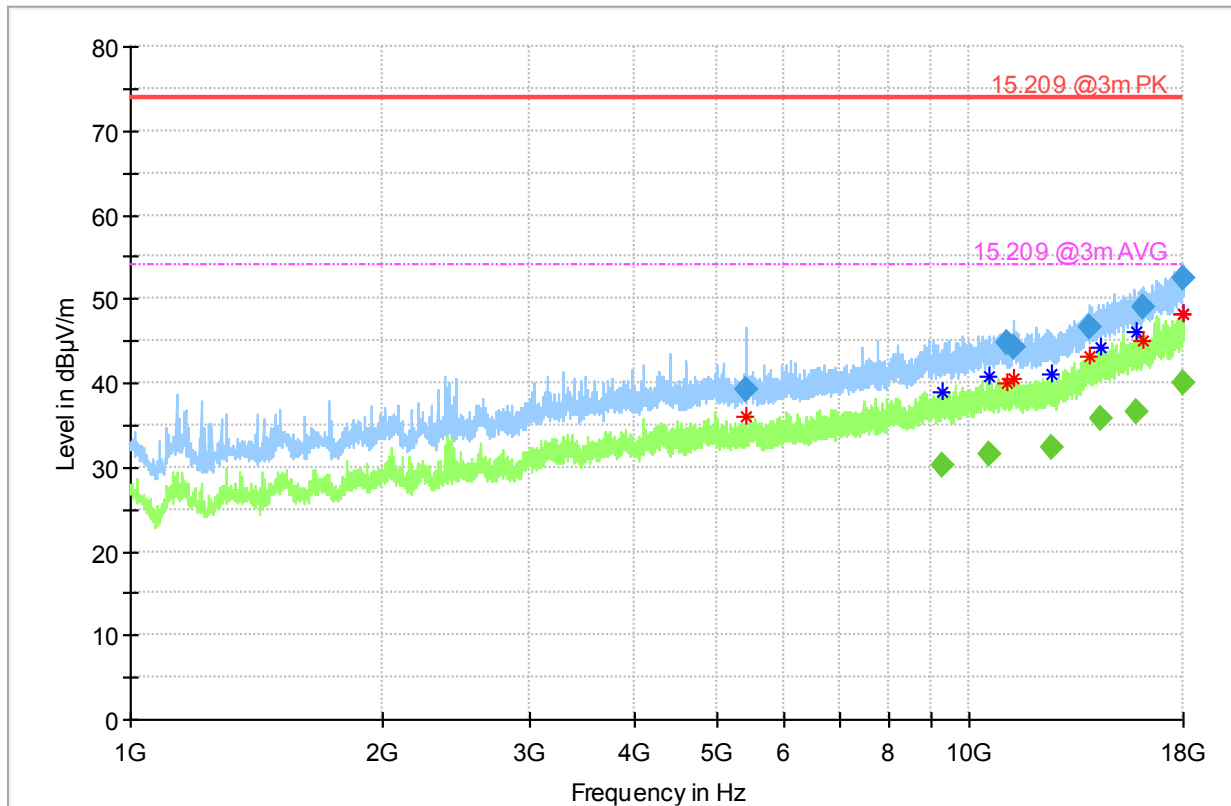


- Preview Result 2-AVG
- Preview Result 1-PK+
- * Critical_Freqs PK+
- 15.209 @3m PK
- * Critical_Freqs AVG
- ◆ Final_Result PK+
- ◆ Final_Result AVG
- x MaxPeak-PK+ (Single)
- + Average-AVG (Single)

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
2394.000000	---	28.83	54.00	25.17	100.0	1000.000	150.0	V
3848.908333	38.53	---	74.00	35.47	100.0	1000.000	150.0	H
3874.558333	38.43	---	74.00	35.57	100.0	1000.000	150.0	H
12073.205556	44.35	---	74.00	29.65	100.0	1000.000	150.0	V
12853.722222	---	32.08	54.00	21.92	100.0	1000.000	150.0	V
13679.286111	46.02	---	74.00	27.98	100.0	1000.000	150.0	H
14427.166667	---	36.00	54.00	18.00	100.0	1000.000	150.0	V
15742.297222	49.85	---	74.00	24.15	100.0	1000.000	150.0	V
15915.611111	---	36.77	54.00	17.23	100.0	1000.000	150.0	V
17766.722222	---	39.72	54.00	14.28	100.0	1000.000	150.0	H
17984.708333	52.15	---	74.00	21.85	100.0	1000.000	150.0	V

Plot no. 53: radiated emissions 1 GHz – 18 GHz, mode 8, polarization vertical / horizontal

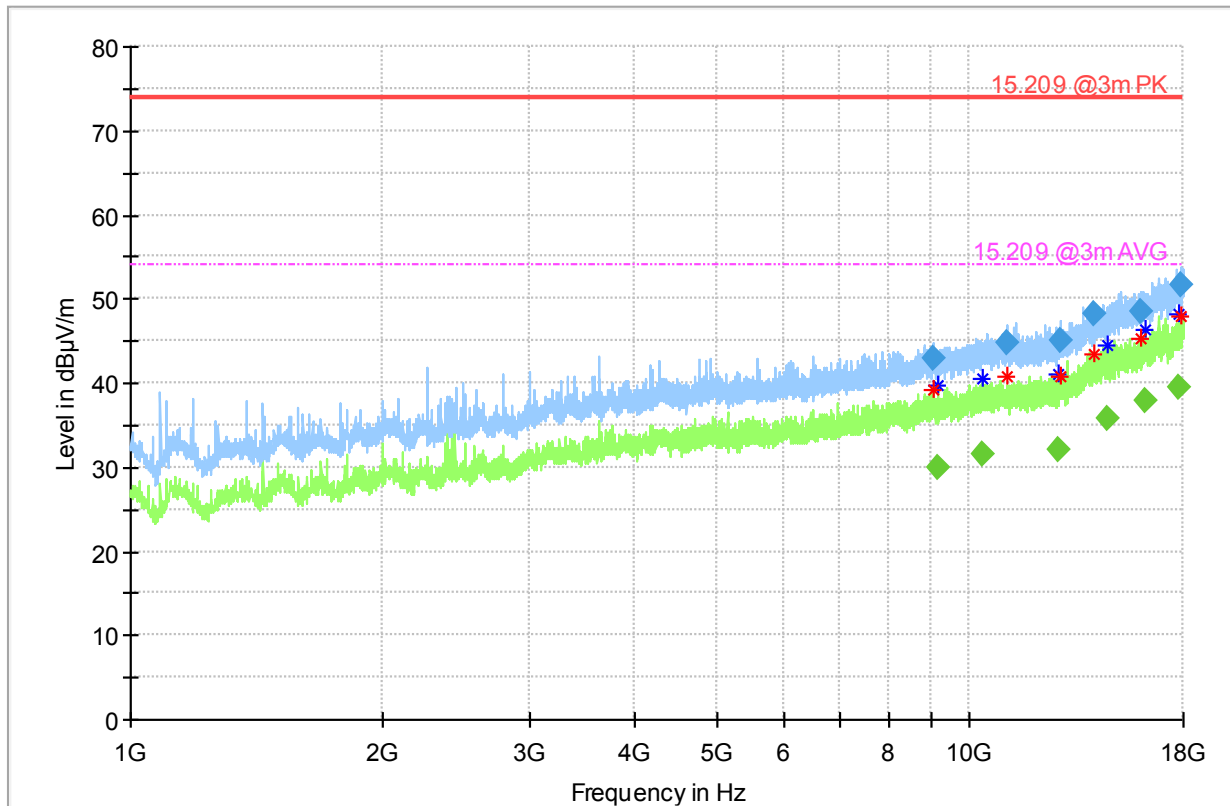


- Preview Result 2-AVG
- Preview Result 1-PK+
- * Critical_Freqs PK+
- 15.209 @3m PK
- * Critical_Freqs AVG
- ◆ Final_Result PK+
- ◆ Final_Result AVG
- - - 15.209 @3m AVG
- + Average-AVG (Single)
- × MaxPeak-PK+ (Single)

Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
5432.891667	39.21	---	74.00	34.79	100.0	1000.000	150.0	H
9288.444444	---	30.14	54.00	23.86	100.0	1000.000	150.0	V
10566.277778	---	31.48	54.00	22.52	100.0	1000.000	150.0	H
11128.416667	44.69	---	74.00	29.31	100.0	1000.000	150.0	H
11297.008333	44.18	---	74.00	29.82	100.0	1000.000	150.0	H
12565.666667	---	32.25	54.00	21.75	100.0	1000.000	150.0	V
13933.641667	46.73	---	74.00	27.27	100.0	1000.000	150.0	V
14383.722222	---	35.70	54.00	18.30	100.0	1000.000	150.0	V
15807.000000	---	36.66	54.00	17.34	100.0	1000.000	150.0	H
16115.113889	49.11	---	74.00	24.89	100.0	1000.000	150.0	H
17963.166667	---	39.91	54.00	14.09	100.0	1000.000	150.0	V
17966.150000	52.52	---	74.00	21.48	100.0	1000.000	150.0	H

Plot no. 54: radiated emissions 1 GHz – 18 GHz, Mode 9, polarization vertical / horizontal



- Preview Result 2-AVG
- Preview Result 1-PK+
- * Critical_Freqs PK+
- 15.209 @3m PK
- * Critical_Freqs AVG
- ◆ Final_Result PK+
- ◆ Final_Result AVG
- - - 15.209 @3m AVG
- + Average-AVG (Single)
- × MaxPeak-PK+ (Single)

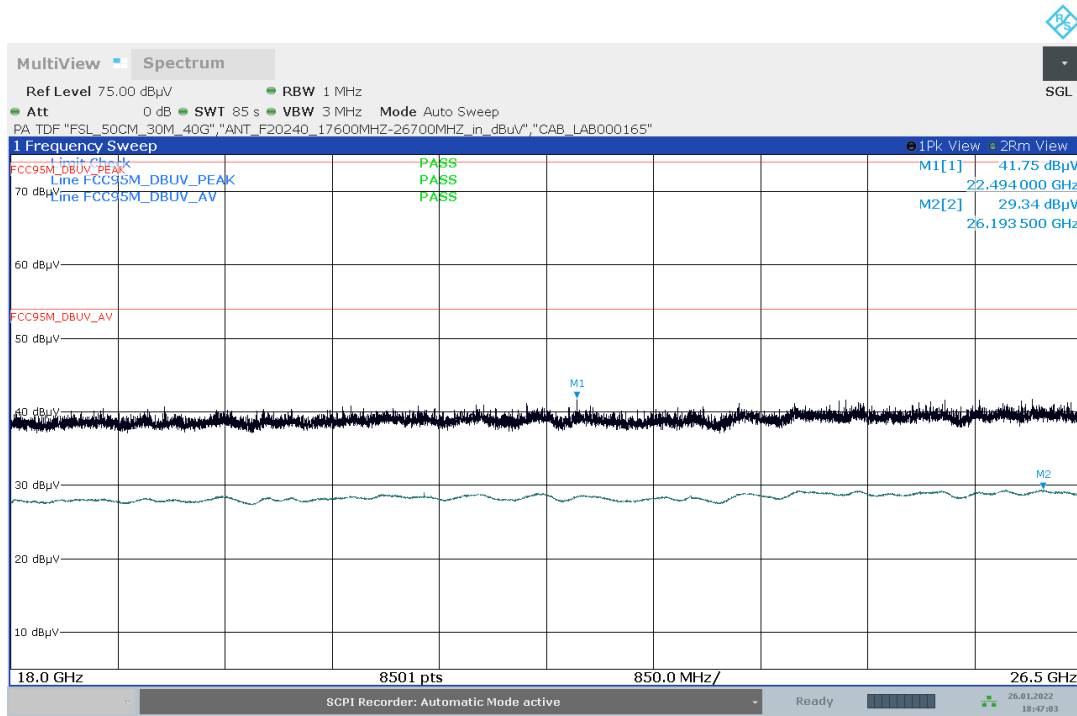
Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol
9090.486111	43.00	---	74.00	31.00	100.0	1000.000	150.0	H
9203.444444	---	29.96	54.00	24.04	100.0	1000.000	150.0	H
10369.833333	---	31.43	54.00	22.57	100.0	1000.000	150.0	V
11066.833333	44.72	---	74.00	29.28	100.0	1000.000	150.0	H
12803.666667	---	32.05	54.00	21.95	100.0	1000.000	150.0	V
12870.227778	45.10	---	74.00	28.90	100.0	1000.000	150.0	V
14047.694444	48.29	---	74.00	25.71	100.0	1000.000	150.0	V
14595.277778	---	35.80	54.00	18.20	100.0	1000.000	150.0	H
16027.461111	48.50	---	74.00	25.50	100.0	1000.000	150.0	H
16249.000000	---	37.79	54.00	16.21	100.0	1000.000	150.0	H
17779.000000	---	39.48	54.00	14.52	100.0	1000.000	150.0	H
17931.475000	51.56	---	74.00	22.44	100.0	1000.000	150.0	H

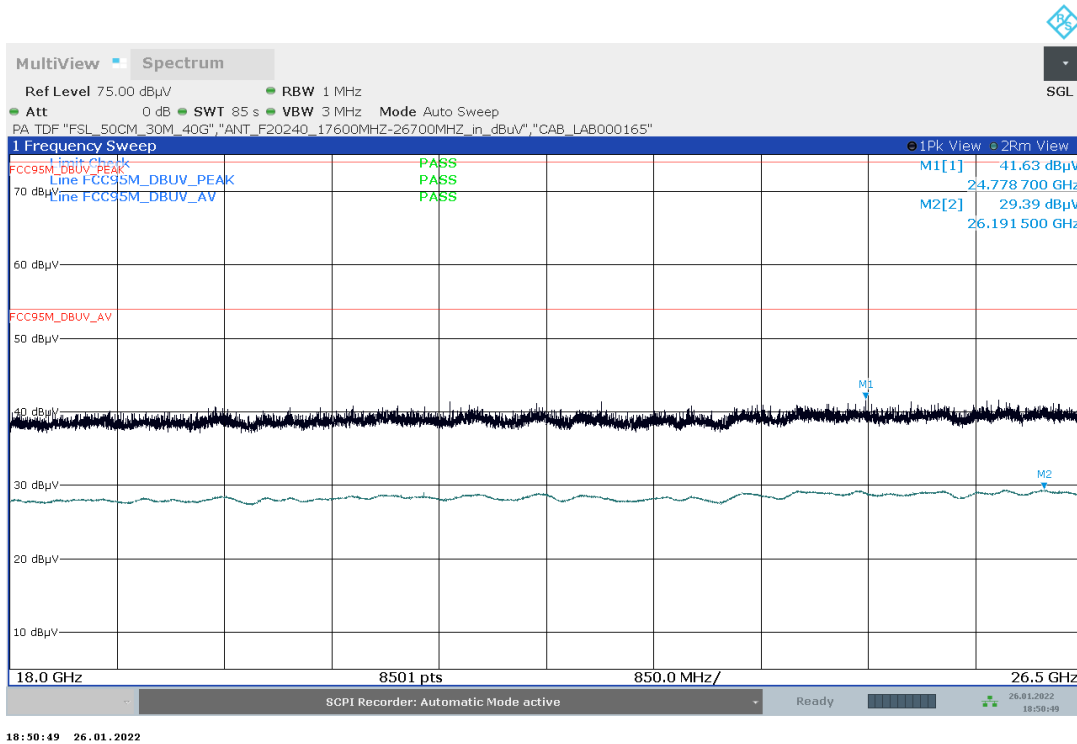
TR no.: 21055526-20547-2

2022-03-07

Plot no. 55: radiated emissions 18 GHz – 26.5 GHz, Mode 7, polarization vertical / horizontal



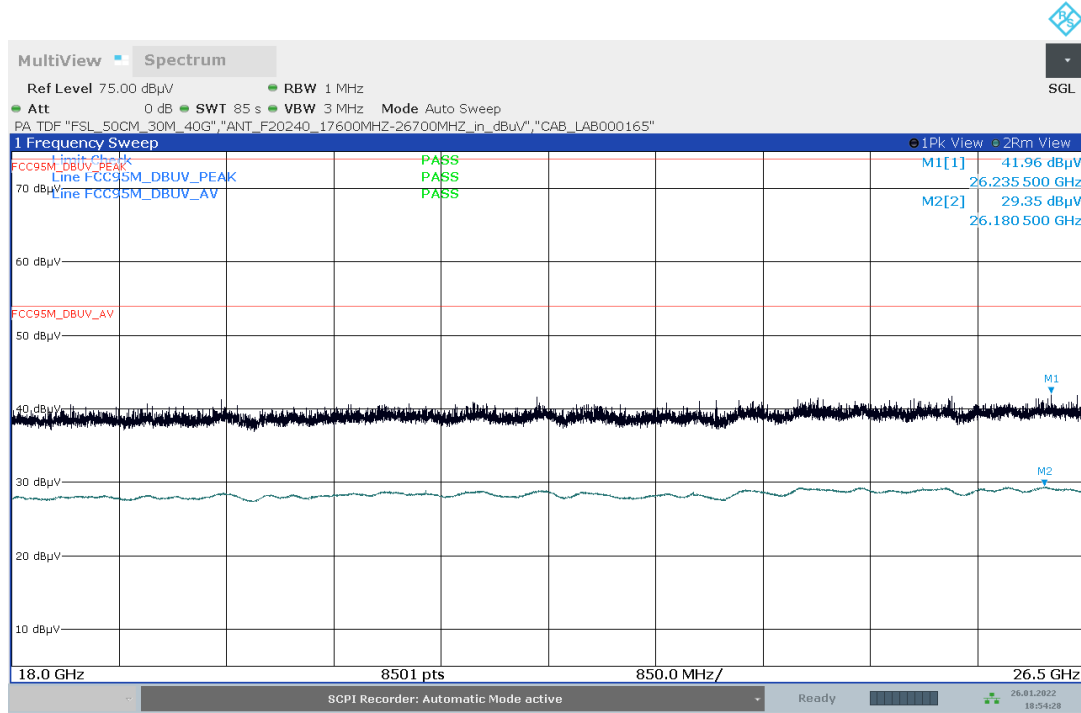
Plot no. 56: radiated emissions 18 GHz – 26.5 GHz, mode 8, polarization vertical / horizontal



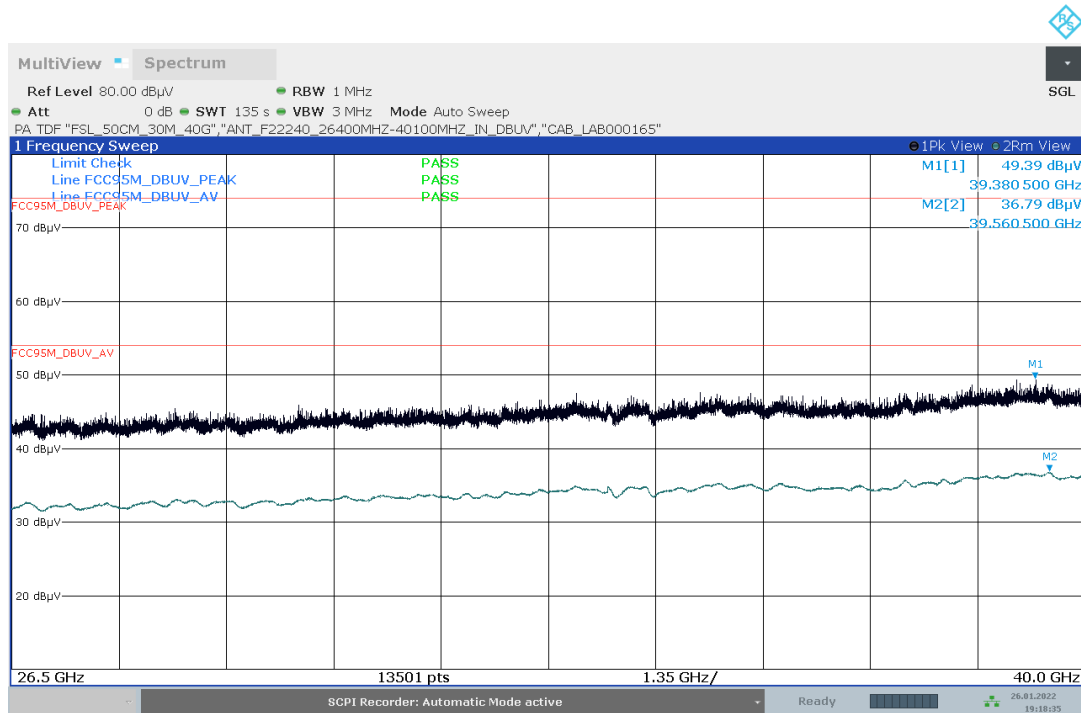
TR no.: 21055526-20547-2

2022-03-07

Plot no. 57: radiated emissions 18 GHz – 26.5 GHz, Mode 9, polarization vertical / horizontal



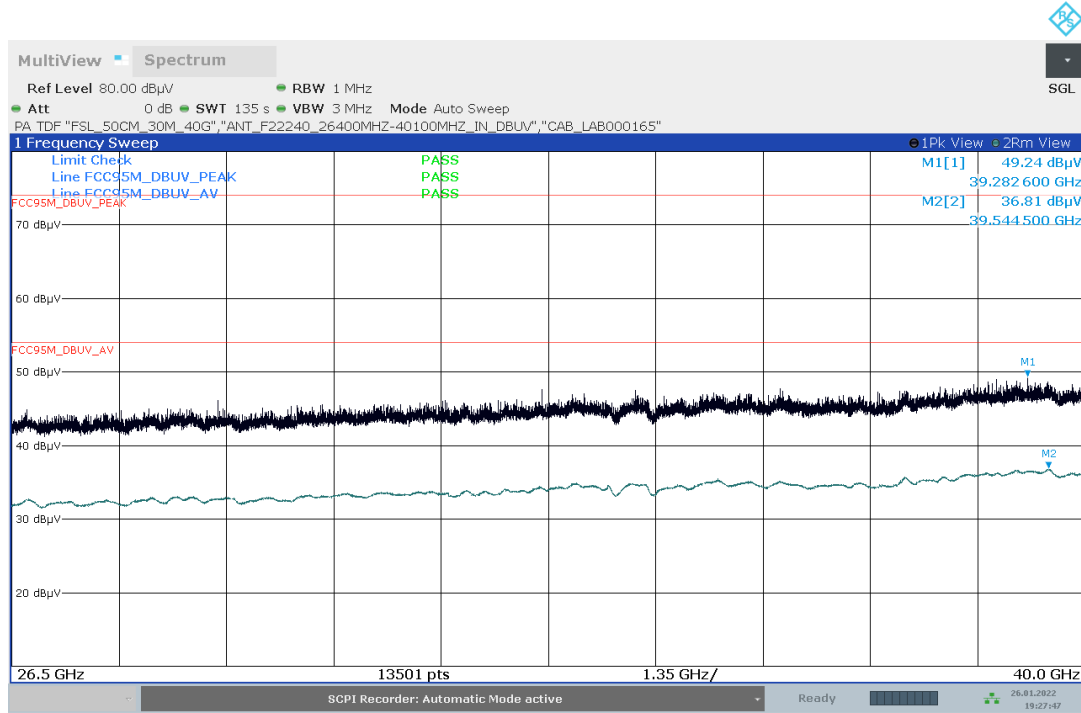
Plot no. 58: radiated emissions 26.5 GHz – 40 GHz, Mode 7, polarization vertical / horizontal



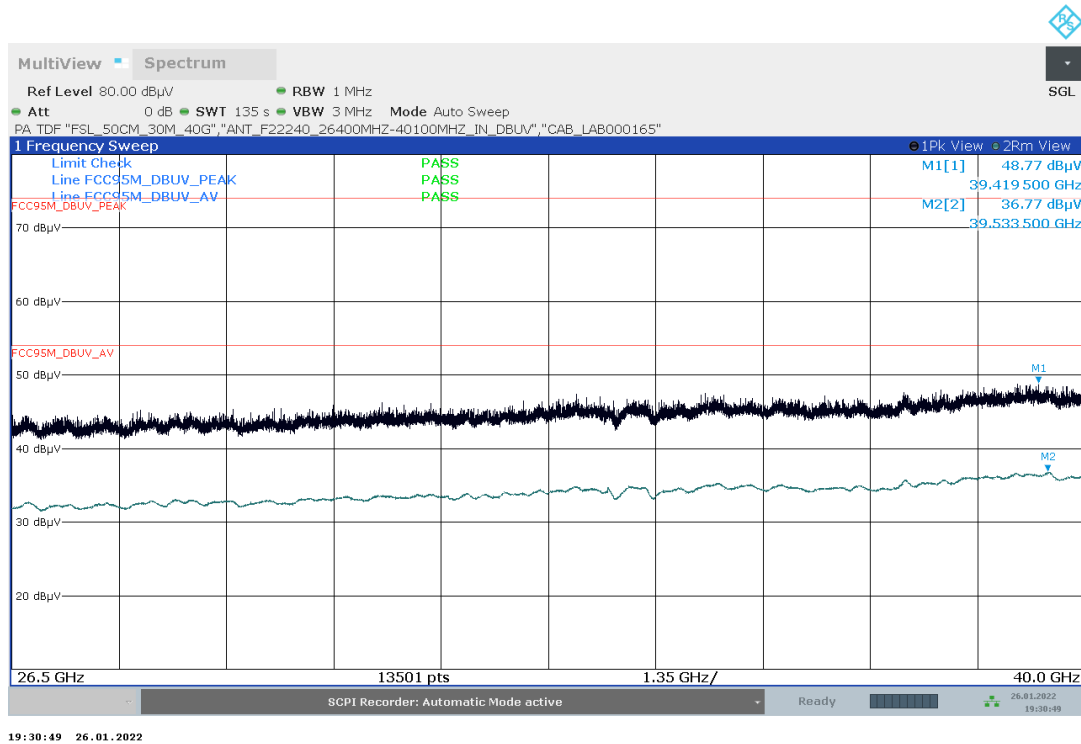
TR no.: 21055526-20547-2

2022-03-07

Plot no. 59: radiated emissions 26.5 GHz – 40 GHz, mode 8, polarization vertical / horizontal



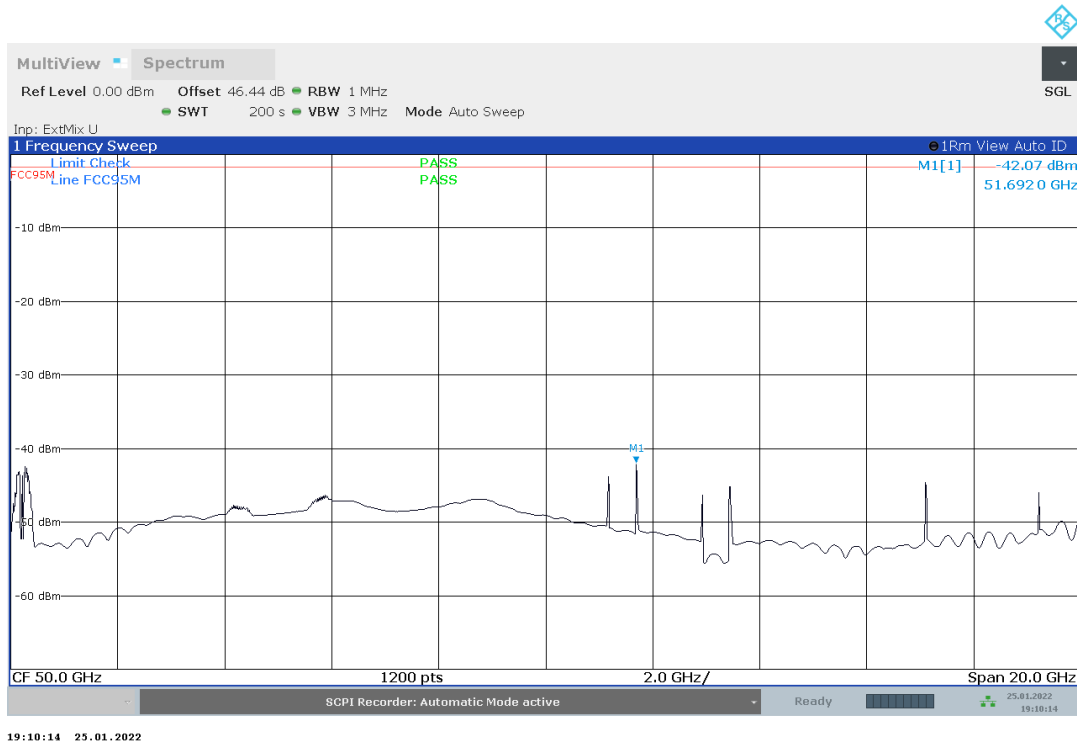
Plot no. 60: radiated emissions 26.5 GHz – 40 GHz, Mode 9, polarization vertical / horizontal



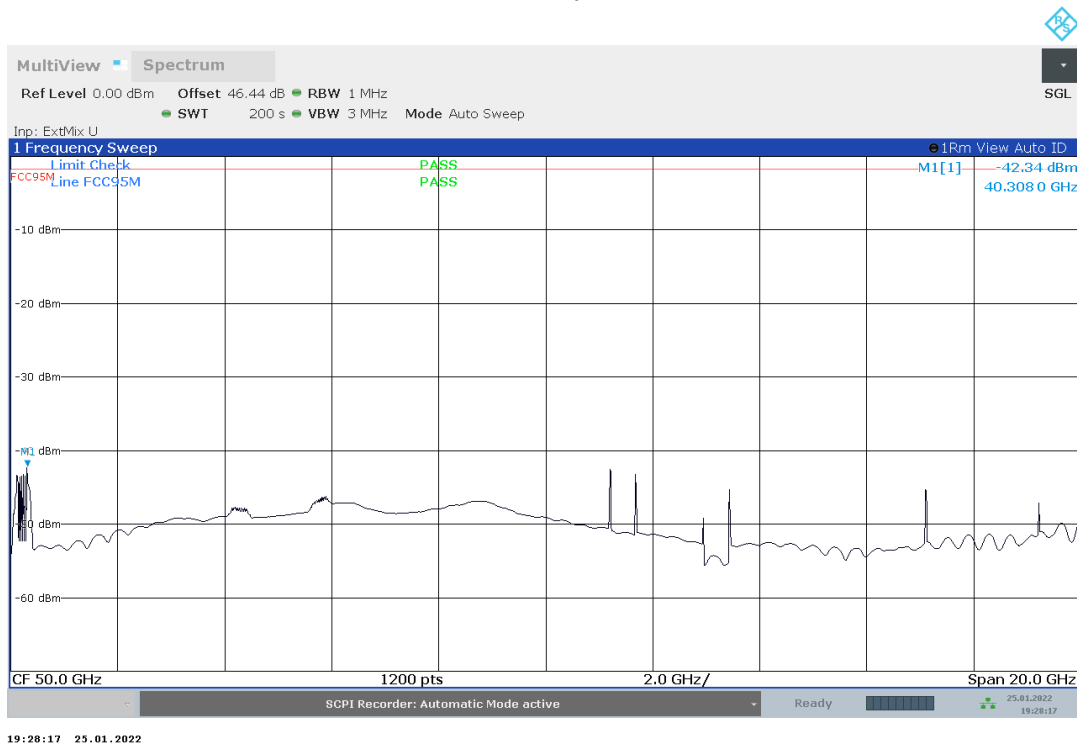
TR no.: 2105526-20547-2

2022-03-07

Plot no. 61: radiated emissions 40 GHz – 60 GHz, Mode 7, polarization vertical / horizontal



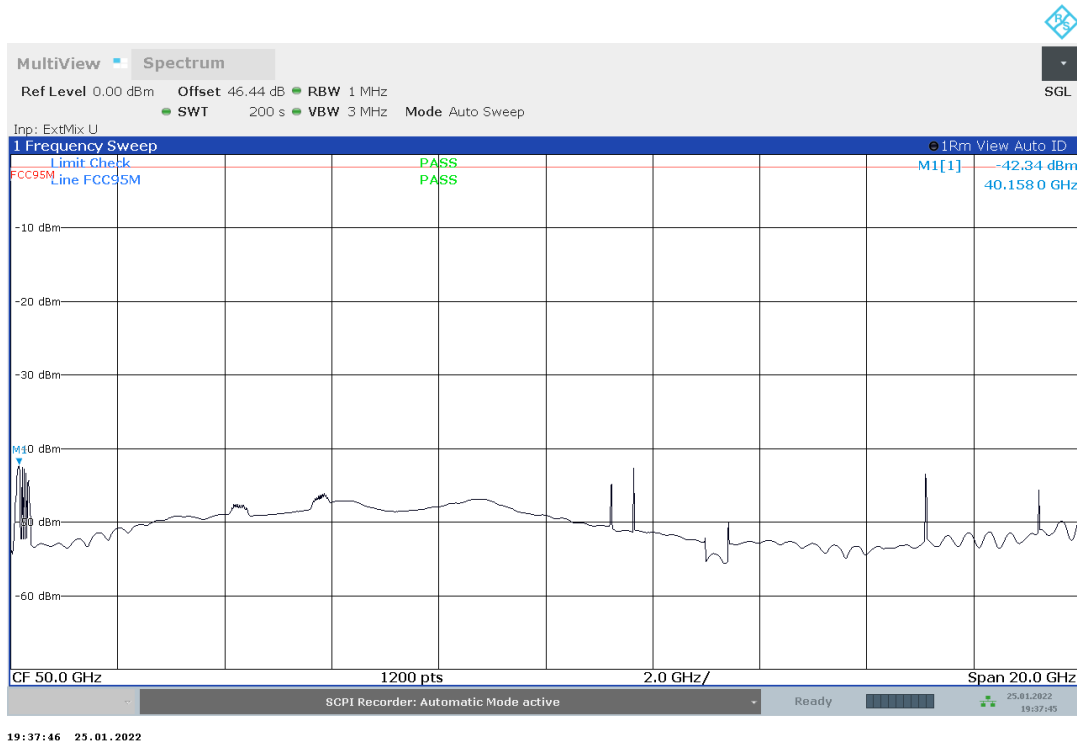
Plot no. 62: radiated emissions 40 GHz – 60 GHz, mode 8, polarization vertical / horizontal



TR no.: 2105526-20547-2

2022-03-07

Plot no. 63: radiated emissions 40 GHz – 60 GHz, Mode 9, polarization vertical / horizontal



Plot no. 64: radiated emissions 60 GHz – 75 GHz, Mode 7, polarization vertical / horizontal

