

# Test Report

**Test report no.:** 23078986-34194-0

**Date of issue:** 2023-10-12

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

## Applicant

Magna Electronics Inc.

## Manufacturer

Magna Electronics Inc.

## Test Item

MRRICONV03

## 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)

*Karsten Gerald*  
Senior Lab Manager RF

*Gerald*  
signature

Approved by  
(name, function, signature)

*Andreas Bender*  
Deputy Managing Director

*Andreas Bender*  
signature

| Applicant and Test item details |   |
|---------------------------------|---|
| <b>Applicant</b>                | Magna Electronics Inc.<br>2050 Auburn Road<br>Auburn Hills, MI 48326, USA<br>Phone: +1 248 696 6400 |
| <b>Manufacturer</b>             | Magna Electronics Inc.<br>2050 Auburn Road<br>Auburn Hills, MI 48326, USA                           |
| <b>Test item description</b>    | ICON Mid-Range Radar  |
| <b>Model/Type reference</b>     | MRRICONV03  |
| <br>                            |   |
| <b>FCC ID</b>                   | 2A9L3-MRRICONV03  |
| <b>Frequency</b>                | 76.0 GHz to 77.0 GHz  |
| <b>Antenna</b>                  | Plastic Waveguide Antenna (PWG)   |
| <b>Power supply</b>             | 9.0 to 16.0 V DC  |
| <b>Temperature range</b>        | -40 °C to +75 °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 adjected to its use.

#### Decision rule:

Decision rule based on simple acceptance without guard bands, binary statement, based on mutually agreed uncertainty tolerances with expansion factor k=2.

## 1 TABLE OF CONTENTS

|         |  |    |
|---------|--|----|
| 1       | TABLE OF CONTENTS .....  | 3  |
| 2       | GENERAL INFORMATION .....  | 4  |
| 2.1     | Administrative details .....   | 4  |
| 2.2     | Possible test case verdicts .....  | 5  |
| 2.3     | Observations .....   | 5  |
| 2.4     | Opinions and interpretations .....   | 5  |
| 2.5     | Revision history .....   | 5  |
| 2.6     | Further documents .....  | 5  |
| 3       | ENVIRONMENTAL & TEST CONDITIONS .....  | 6  |
| 3.1     | Environmental conditions of test lab .....                                   | 6  |
| 3.2     | Normal and extreme test conditions .....                                     | 6  |
| 4       | TEST STANDARDS AND REFERENCES .....  | 6  |
| 5       | EQUIPMENT UNDER TEST (EUT) .....   | 7  |
| 5.1     | Product description .....  | 7  |
| 5.2     | Description of test item .....   | 7  |
| 5.3     | Technical data of test item .....  | 7  |
| 5.4     | Additional information .....   | 7  |
| 5.5     | Operating conditions .....   | 8  |
| 5.6     | Antenna characteristics .....  | 8  |
| 6       | SUMMARY OF TEST RESULTS .....  | 9  |
| 7       | TEST RESULTS .....   | 10 |
| 7.1     | RF power output (§2.1046 & §95.3367) .....                                   | 10 |
| 7.2     | Modulation characteristics (§2.1047 & KDB 653005 D01 76-81 GHz Radars) ..... | 14 |
| 7.3     | Occupied bandwidth (§2.1049 & §95.3379) .....                                | 15 |
| 7.4     | Field strength of spurious radiation (§2.1053 & §95.3379) .....              | 31 |
| 7.5     | Frequency stability (§2.1055 & §95.3379(b)) .....                            | 50 |
| 8       | Test Setup Description .....   | 52 |
| 8.1     | Semi Anechoic Chamber with Ground Plane .....                                | 53 |
| 8.2     | Fully Anechoic Chamber .....   | 55 |
| 8.3     | Radiated measurements > 18 GHz .....   | 57 |
| 8.4     | Radiated measurements > 50 GHz .....   | 57 |
| 8.5     | Radiated measurements under extreme conditions .....                         | 57 |
| 9       | MEASUREMENT PROCEDURES .....   | 59 |
| 9.1     | Radiated spurious emissions from 9 kHz to 30 MHz .....                       | 59 |
| 9.2     | Radiated spurious emissions from 30 MHz to 1 GHz .....                       | 60 |
| 9.3     | Radiated spurious emissions from 1 GHz to 18 GHz .....                       | 61 |
| 9.4     | Radiated spurious emissions above 18 GHz .....                               | 62 |
| 10      | MEASUREMENT UNCERTAINTIES .....  | 63 |
| Annex 1 | EUT Photographs, external .....  | 64 |
| Annex 2 | EUT Photographs, internal .....  | 67 |
| Annex 3 | Test Setup Photographs .....   | 69 |

## 2 GENERAL INFORMATION

### 2.1 Administrative details

|  |  |  |        |                     |       |                                   |        |                      |                |
|--|--|--|--------|---------------------|-------|-----------------------------------|--------|----------------------|----------------|
| Testing laboratory                     | <b>IBL-Lab GmbH</b><br>Heinrich-Hertz-Allee 7<br>66386 St. Ingbert / Germany<br>Fon: +49 6894 38938-0<br>Fax: +49 6894 38938-99<br>URL: <a href="https://ib-lenhardt.com/">https://ib-lenhardt.com/</a><br>E-Mail: <a href="mailto:info@ib-lenhardt.com">info@ib-lenhardt.com</a>  |  |        |                     |       |                                   |        |                      |                |
| Accreditation / Designation            | The testing laboratory is accredited by Deutsche Akkreditierungsstelle GmbH (DAkkS) in compliance with DIN EN ISO/IEC 17025:2018.<br><br>Scope of testing and registration number:<br><ul style="list-style-type: none"> <li>Attachment to the accreditation certificate <a href="#">D-PL-21375-01-00</a> <ul style="list-style-type: none"> <li>Electronics</li> <li>Electromagnetic Compatibility</li> <li>Radio</li> <li>Electromagnetic Compatibility and Telecommunication (FCC requirements)</li> <li>Telecommunication (TC) and Electromagnetic Compatibility (EMC) for Canadian Standards</li> <li>Automotive EMC</li> </ul> </li> </ul><br>Website DAkkS: <a href="https://www.dakks.de/">https://www.dakks.de/</a><br>The Deutsche Akkreditierungsstelle GmbH (DAkkS) is also a signatory to the <a href="#">ILAC Mutual Recognition Arrangement</a> . <ul style="list-style-type: none"> <li>Designations               <table> <tr> <td>FCC Testing Laboratory Designation No.</td> <td>DE0024</td> </tr> <tr> <td>ISED Company Number</td> <td>27156</td> </tr> <tr> <td>Testing Laboratory CAB Identifier</td> <td>DE0020</td> </tr> <tr> <td>Kraftfahrt-Bundesamt</td> <td>KBA-P 00120-23</td> </tr> </table> </li> </ul> | FCC Testing Laboratory Designation No. | DE0024 | ISED Company Number | 27156 | Testing Laboratory CAB Identifier | DE0020 | Kraftfahrt-Bundesamt | KBA-P 00120-23 |
| FCC Testing Laboratory Designation No. | DE0024   |  |        |                     |       |                                   |        |                      |                |
| ISED Company Number                    | 27156  |  |        |                     |       |                                   |        |                      |                |
| Testing Laboratory CAB Identifier      | DE0020   |  |        |                     |       |                                   |        |                      |                |
| Kraftfahrt-Bundesamt                   | KBA-P 00120-23   |  |        |                     |       |                                   |        |                      |                |
| Testing location                       | <b>IBL-Lab GmbH</b><br>Heinrich-Hertz-Allee 7<br>66386 St. Ingbert / Germany   |  |        |                     |       |                                   |        |                      |                |
| Date of receipt of test samples        | 2023-08-17   |  |        |                     |       |                                   |        |                      |                |
| Start – End of tests                   | 2023-08-17 – 2023-09-07  |  |        |                     |       |                                   |        |                      |                |

## 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

## 2.6 Further documents

List of further applicable documents belonging to the present test report:

– no additional documents –

### 3 ENVIRONMENTAL & TEST CONDITIONS

#### 3.1 Environmental conditions of test lab

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

#### 3.2 Normal and extreme test conditions

|                   | minimum  | normal    | maximum   |
|-------------------|----------|-----------|-----------|
| Temperature       | -40 °C   | 20 °C     | +75 °C    |
| Relative humidity | -/-      | 45 % r.h. | -/-       |
| Power supply      | 9.0 V DC | 13.2 V DC | 16.0 V DC |

### 4 TEST STANDARDS AND REFERENCES

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

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

## 5 EQUIPMENT UNDER TEST (EUT)

### 5.1 Product description

ICON Mid-Range Radar

### 5.2 Description of test item

|                         |               |
|-------------------------|---------------|
| <b>Model name*</b>      | MRRICONV03    |
| <b>Serial number*</b>   | 1B20523700082 |
| <b>Hardware status*</b> | C4            |
| <b>Software status*</b> | 11.7          |

\*: as declared by applicant

### 5.3 Technical data of test item

|                                    |  |
|------------------------------------|--|
| <b>Operational frequency band*</b> | 76.0 GHz to 77.0 GHz                   |
| <b>Type of radio transmission*</b> | modulated carrier                      |
| <b>Modulation type*</b>            | PMCW (Phase Modulated Continuous Wave) |
| <b>Number of channels*</b>         | 1                                      |
| <b>Channel bandwidth*</b>          | < 1 GHz                                |
| <b>Channel spacing*</b>            | N/A                                    |
| <b>Receiver category*</b>          | N/A                                    |
| <b>Receiver bandwidth*</b>         | N/A                                    |
| <b>Duty cycle*</b>                 | Corner: 22.14 %<br>Front: 33.06 %      |
| <b>Antenna*</b>                    | Plastic Waveguide Antenna (PWG)        |
| <b>Rated RF output power*</b>      | < 50 dBm                               |
| <b>Power supply*</b>               | 9.0 to 16.0 V DC                       |
| <b>Temperature range*</b>          | -40 °C to +75 °C                       |

\*: as declared by applicant

### 5.4 Additional information

|  |                           |
|--|---------------------------|
| <b>Model differences</b>                     | -                         |
| <b>Ancillaries tested with</b>               | -                         |
| <b>Additional equipment used for testing</b> | Laptop with test software |

## 5.5 Operating conditions

Please refer to “*Operational Description MRRICONV03\_20230928.pdf*”.

## 5.6 Antenna characteristics

Following information is derived from document “*Operational Description MRRICONV03\_20230928.pdf*”, as provided by applicant.

The radar is typically installed in the positions of the vehicle depicted in Figure 1. The units are mounted behind the front bumper and front and rear corner fascia of the vehicle.

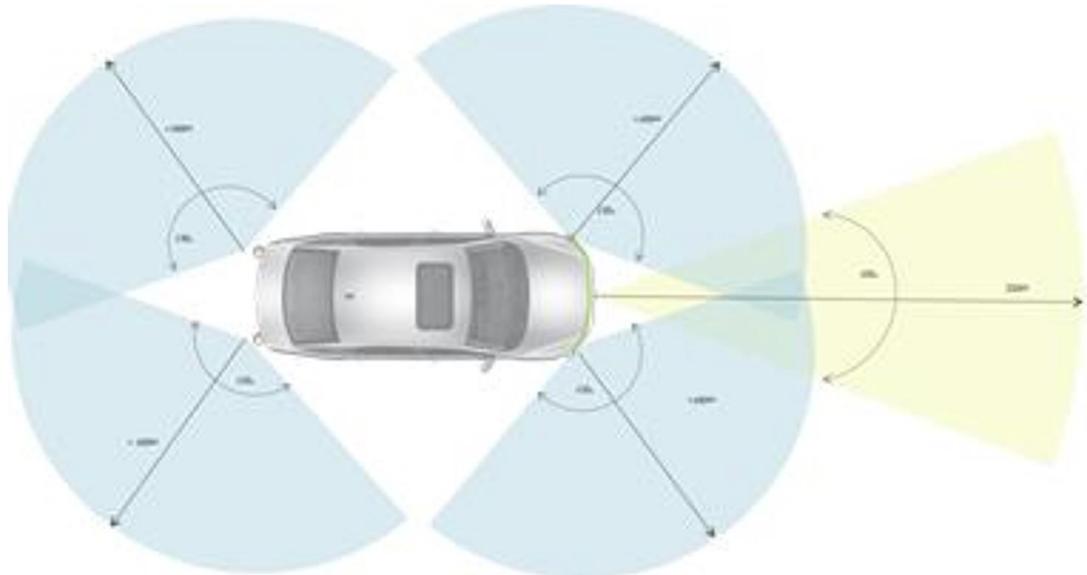


Figure 1: Typical Vehicle Installation

| Number of Antenna Channels          |         |
|-------------------------------------|---------|
| - Transmit                          | 8       |
| - Receive                           | 8       |
| Maximum Realized Antenna Array Gain | 19 dBi  |
| Output Power (=Antenna Input Power) | 6.5 dBm |

## 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<br>§95.3367 (a) (b)                                      | RF power output                         | Nominal            | 23.4 dBm mean<br>18.3 dBm peak | P       |
| §2.1047  | Modulation characteristics              | Nominal            |                                | P       |
| §2.1049<br>§95.3379 (b)  | Occupied bandwidth                      | Nominal            | 468.6 MHz                      | P       |
| §2.1051  | Spurious emissions at antenna terminals | Nominal            | see note                       | N/A     |
| §2.1053<br>§95.3379 (a)(1)<br>§95.3379 (a)(2)<br>§95.3379 (a)(3) | Field strength of spurious radiation    | Nominal            | > limit                        | P       |
| §2.1055<br>§95.3379 (b)  | Frequency stability                     | Nominal<br>Extreme | within band                    | P       |

### Notes

#### FCC's Millimeter Wave Test Procedures:

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

### Comments and observations

None

## 7 TEST RESULTS

### 7.1 RF power output (§2.1046 & §95.3367)

#### Description

§2.1046 Measurements required: RF power output.

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

#### Limits

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

The fundamental radiated emission limits within the 76-81 GHz band are expressed in terms of Equivalent Isotropically Radiated Power (EIRP) and are as follows:

- (a) The maximum power (EIRP) within the 76-81 GHz band shall not exceed 50 dBm based on measurements employing a power averaging detector with a 1 MHz Resolution Bandwidth (RBW).
- (b) The maximum peak power (EIRP) within the 76-81 GHz band shall not exceed 55 dBm based on measurements employing a peak detector with a 1 MHz RBW.

#### Test procedure

##### Mean Power

###### Method with spectrum analyser

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

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

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

###### Method with power meter

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

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

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

**Test procedure**
**Peak Power**
*Method with a spectrum analyser*

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

- Start frequency: lower than the lower edge of the operating frequency range.
- Stop frequency: higher than the upper edge of the operating frequency range.
- Resolution bandwidth: 1 MHz.
- Video bandwidth: 3 MHz.
- Detector mode: Peak detector.
- Display mode: Maxhold.
- Sweep time: EUT cycle time × number of sweep points.
- Measurement is done until trace is stabilised.

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

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

The maximum peak fundamental emission power (EIRP) measurement shall be performed by sweeping over the transmitted occupied bandwidth using a positive peak power detector with peak hold activated, and a 1 MHz RBW. Power integration is not to be used in performing this measurement. The resultant peak power spectral density (maximum in any 1 MHz) data shall be used to demonstrate compliance to the 55 dBm/MHz limit.

Peak power measurements of swept frequency radar implementations (e.g., high sweep rate FMCW) may require a desensitization correction factor to be applied to the measurement results. See relevant Application Note(s) from the measurement instrumentation vendor for details.

ANSI 63.26:

A duty cycle correction factor (DCCF) is added to the mean power, if the DUT is running with a constant duty cycle below 100%.

**Test procedure used:** Method with Spectrum Analyzer

**Test setup:** 8.3

**Test results**

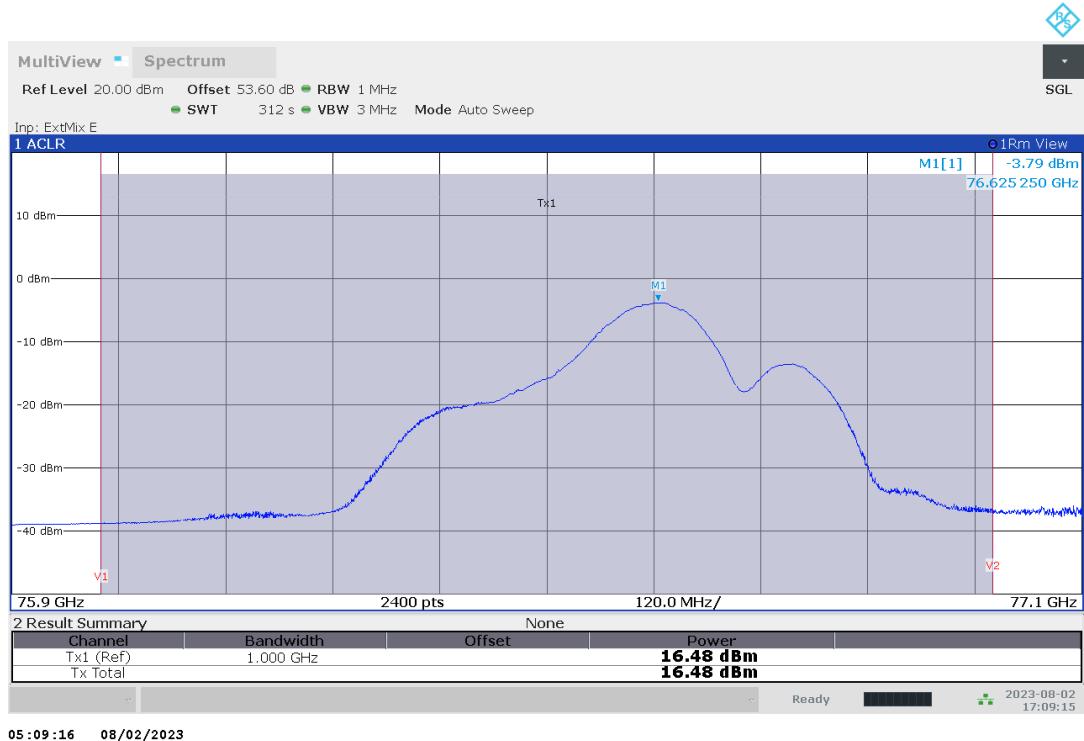
| EUT mode | Test distance | Radiated Mean Power (EIRP) [dBm] | Radiated Mean Power (EIRP) with DCCF [dBm] | Radiated Peak Power (EIRP) [dBm] |
|----------|---------------|----------------------------------|--|----------------------------------|
| Corner   | 1.5 m         | 16.5                             | 23.0                                       | 18.2                             |
| Front    | 1.5 m         | 18.6                             | <b>23.4</b>                                | <b>18.3</b>                      |

**Note:**

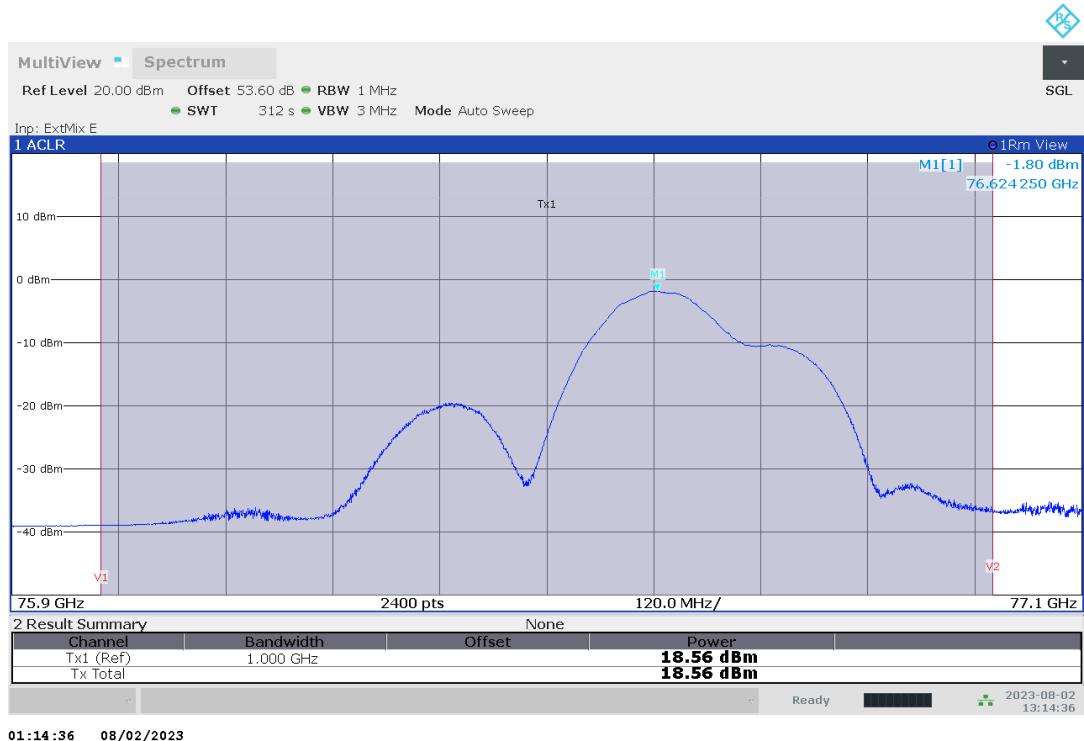
DCCF for Corner mode is:  $10 * \log\left(\frac{1}{0.2214}\right) = 6.55 \text{ dB}$

DCCF for Front mode is:  $10 * \log\left(\frac{1}{0.3306}\right) = 4.81 \text{ dB}$

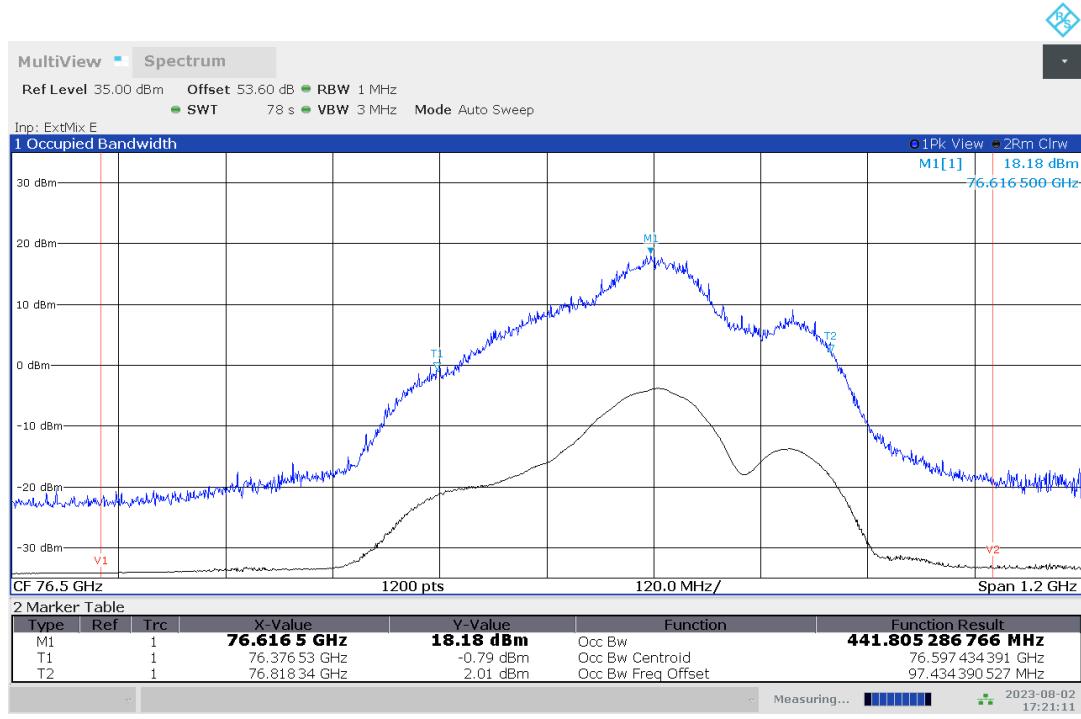
Plot no. 1: Mean Power EIRP, RMS detector / Channel Power, Corner mode



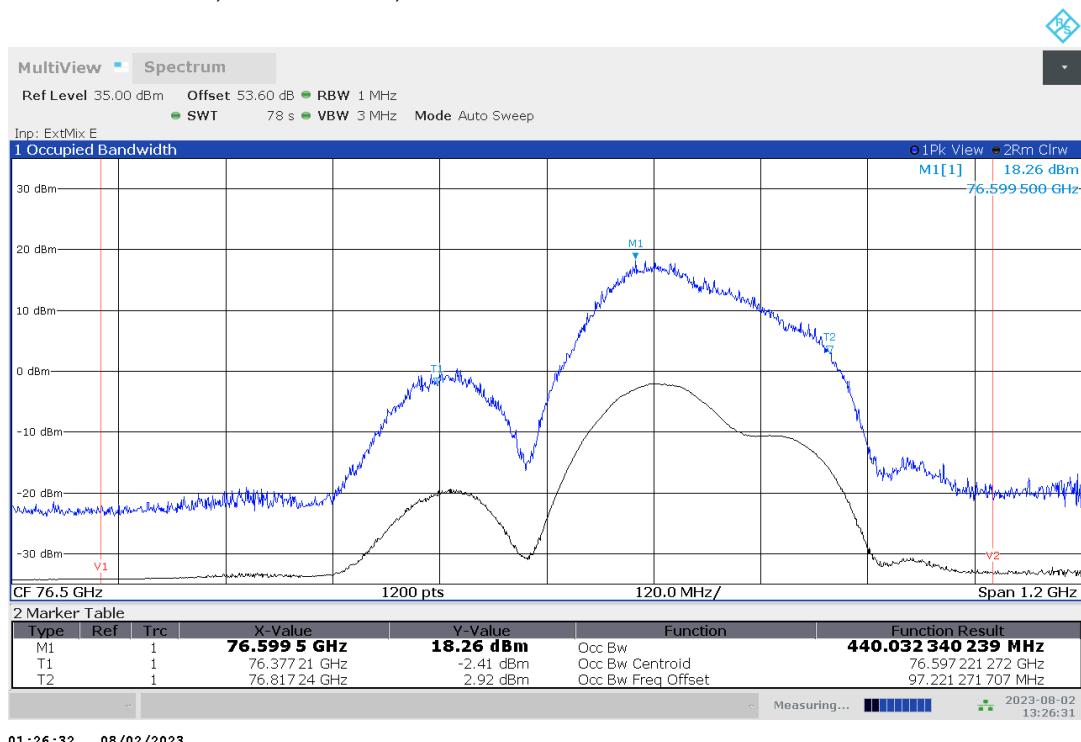
Plot no. 2: Mean Power EIRP, RMS detector / Channel Power, Front mode



Plot no. 3: Peak Power EIRP, Peak detector, Corner mode



Plot no. 4: Peak Power EIRP, Peak detector, Front mode



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

### Description

§2.1047 Modulation characteristics

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

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

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

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

### Statement of applicant / manufacturer concerning modulation characteristics of EUT

See chapter 5.5

## 7.3 Occupied bandwidth (§2.1049 & §95.3379)

### Description

§2.1049 Measurements required: Occupied bandwidth.

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured.

### Limits

§95.3379 (b)

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

### Test procedure

ANSI C63.26, 5.4.4

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

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

- a) The instrument center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be between 1.5 times and 5.0 times the OBW.
- b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW, and VBW shall be approximately three times the RBW, unless otherwise specified by the applicable requirement.
- c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than  $[10 \log (\text{OBW}/\text{RBW})]$  below the reference level. Specific guidance is given in 4.1.5.2.  
Note: Step a) through step c) may require iteration to adjust within the specified tolerances.
- d) Set the detection mode to peak, and the trace mode to max-hold.
- e) If the instrument does not have a 99% OBW function, recover the trace data points and sum directly in linear power terms. Place the recovered amplitude data points, beginning at the lowest frequency, in a running sum until 0.5% of the total is reached. Record that frequency as the lower OBW frequency. Repeat the process until 99.5% of the total is reached and record that frequency as the upper OBW frequency. The 99% power OBW can be determined by computing the difference these two frequencies.
- f) The OBW shall be reported and plot(s) of the measuring instrument display shall be provided with the test report. The frequency and amplitude axis and scale shall be clearly labeled. Tabular data can be reported in addition to the plot(s)

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

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

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

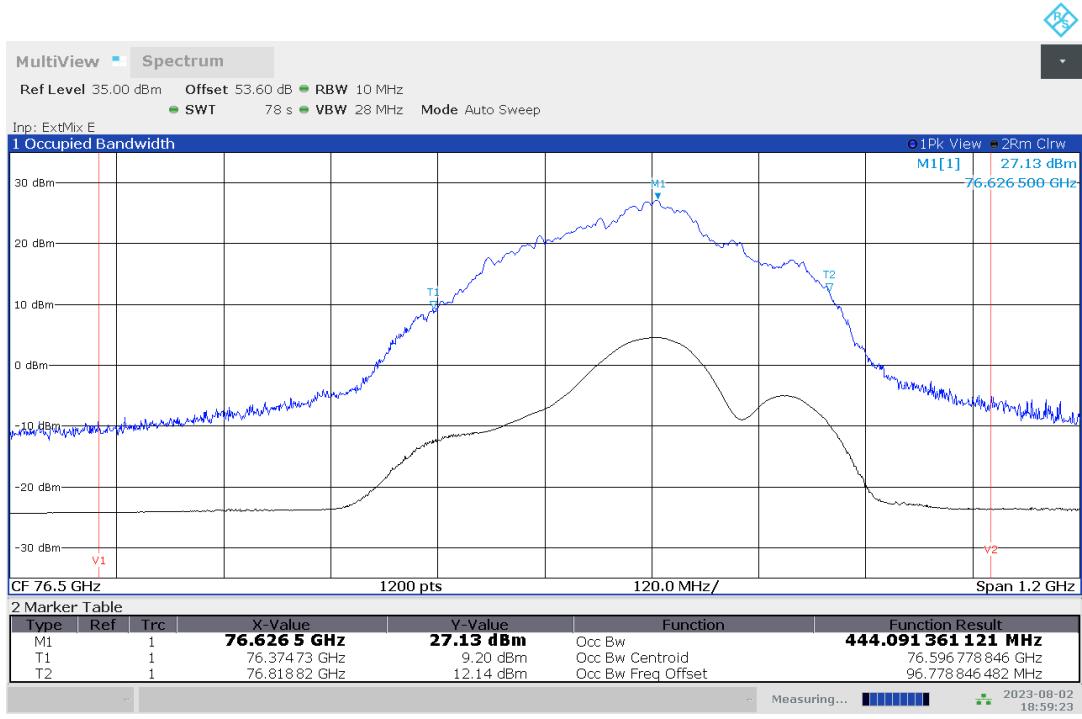
### Note

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

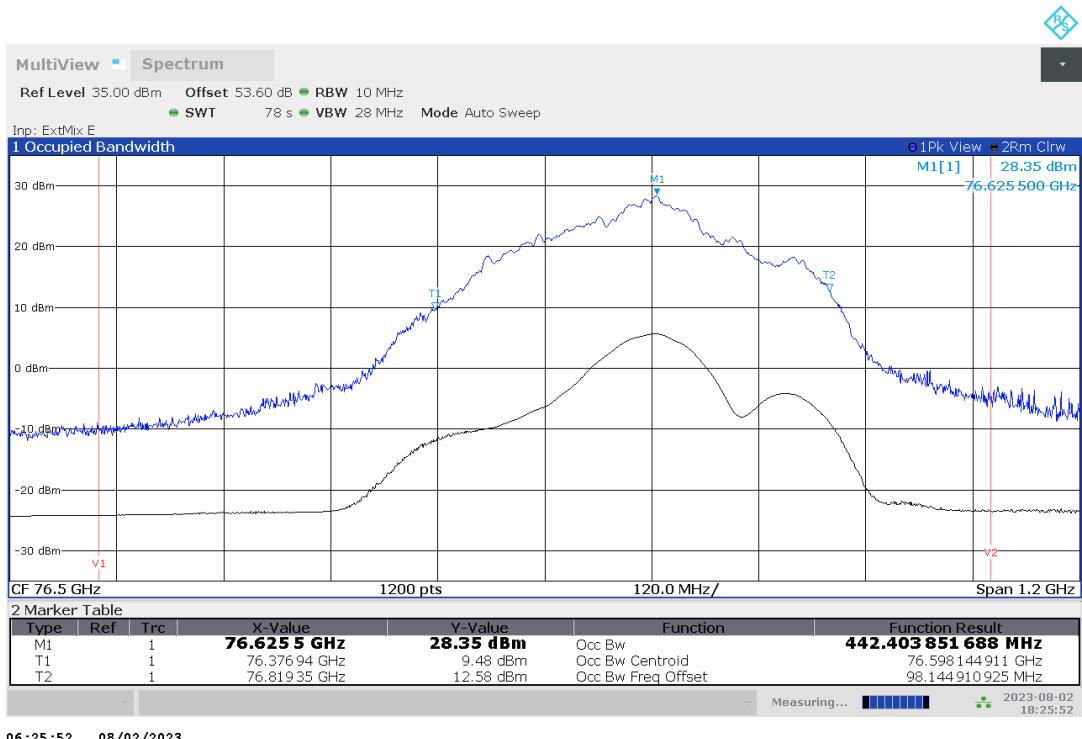
### Test setup: 8.3, 8.4

| <b>Test results</b>  |                        |                            |                            |                      |
|--|------------------------|----------------------------|----------------------------|----------------------|
| <b>EUT mode</b>  | <b>Test conditions</b> | <b>f<sub>L</sub> [GHz]</b> | <b>f<sub>H</sub> [GHz]</b> | <b>99% OBW [MHz]</b> |
| Corner   | 75 °C                  | 76.375                     | 76.819                     | 444.091              |
| Corner   | 50 °C                  | 76.377                     | 76.819                     | 442.404              |
| Corner   | 40 °C                  | 76.377                     | 76.820                     | 442.539              |
| Corner   | 30 °C                  | 76.378                     | 76.820                     | 441.912              |
| Corner   | 20 °C                  | 76.378                     | 76.820                     | 441.391              |
| Corner   | 20 °C                  | 76.378                     | 76.820                     | 442.123              |
| Corner   | 20 °C                  | 76.378                     | 76.820                     | 442.622              |
| Corner   | 10 °C                  | 76.376                     | 76.823                     | 447.006              |
| Corner   | 0 °C                   | 76.372                     | 76.824                     | 452.394              |
| Corner   | -10 °C                 | 76.361                     | 76.825                     | 464.308              |
| Corner   | -20 °C                 | 76.361                     | 76.825                     | 464.275              |
| Corner   | -30 °C                 | 76.359                     | 76.827                     | 467.627              |
| Corner   | -40 °C                 | 76.358                     | 76.827                     | <b>468.575</b>       |
| Front  | 75 °C                  | 76.378                     | 76.819                     | 441.284              |
| Front  | 50 °C                  | 76.378                     | 76.818                     | 440.576              |
| Front  | 40 °C                  | 76.379                     | 76.819                     | 439.923              |
| Front  | 30 °C                  | 76.379                     | 76.819                     | 439.398              |
| Front  | 20 °C                  | 76.381                     | 76.819                     | 438.414              |
| Front  | 20 °C                  | 76.380                     | 76.819                     | 438.801              |
| Front  | 20 °C                  | 76.380                     | 76.819                     | 438.708              |
| Front  | 10 °C                  | 76.383                     | 76.820                     | 436.586              |
| Front  | 0 °C                   | 76.381                     | 76.821                     | 440.218              |
| Front  | -10 °C                 | 76.378                     | 76.822                     | 444.817              |
| Front  | -20 °C                 | 76.370                     | 76.822                     | <b>452.202</b>       |
| Front  | -30 °C                 | 76.373                     | 76.822                     | 448.671              |
| Front  | -40 °C                 | 76.372                     | 76.822                     | 450.464              |
| <b>With voltage variation</b>  |                        |                            |                            |                      |
| Input voltage variation does not affect the transmitted signal (see plots for ambient/normal temperature). |                        |                            |                            |                      |

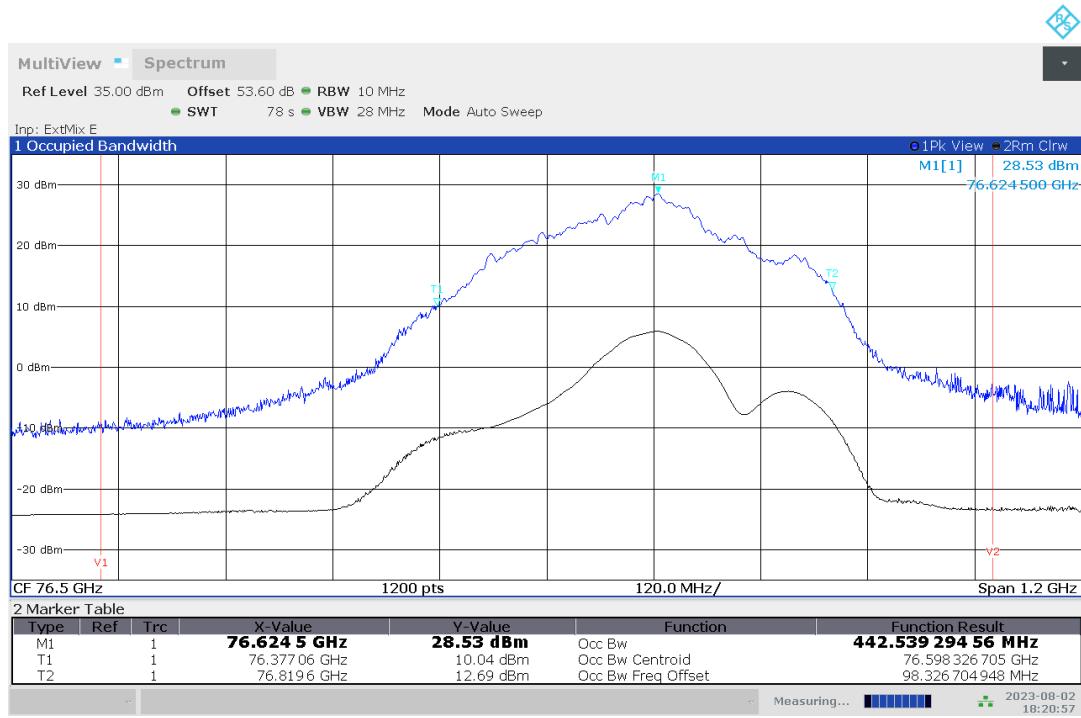
Plot no. 5: 99% OBW, Peak detector, 75 °C, Corner mode



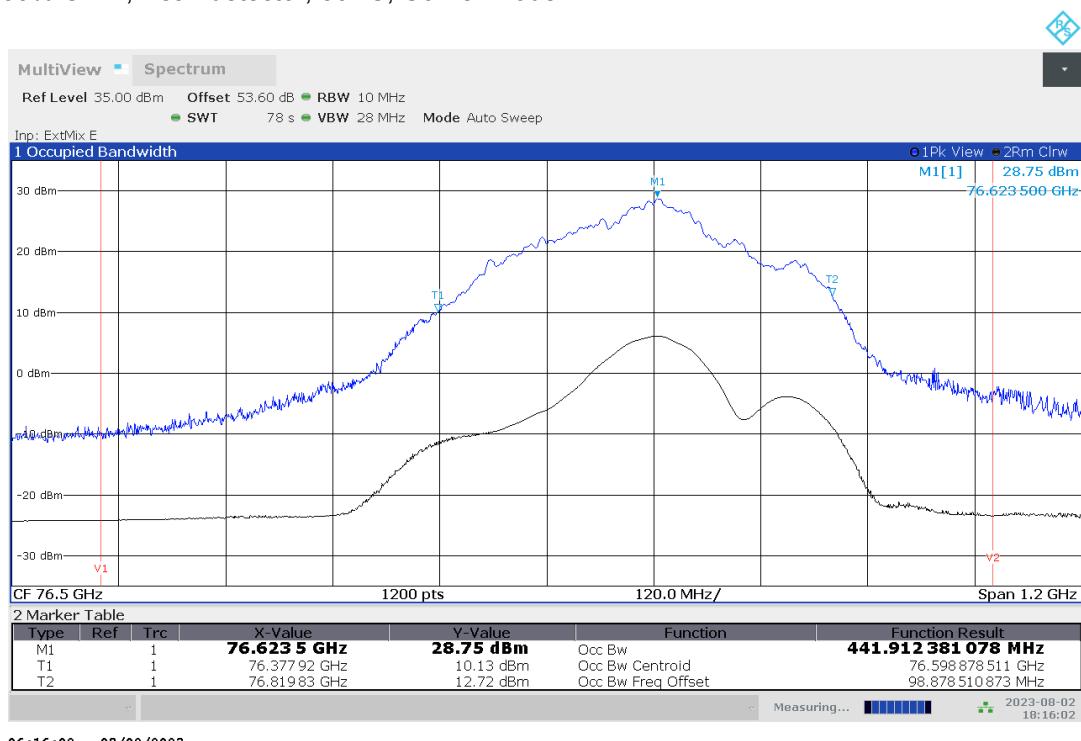
Plot no. 6: 99% OBW, Peak detector, 50 °C, Corner mode

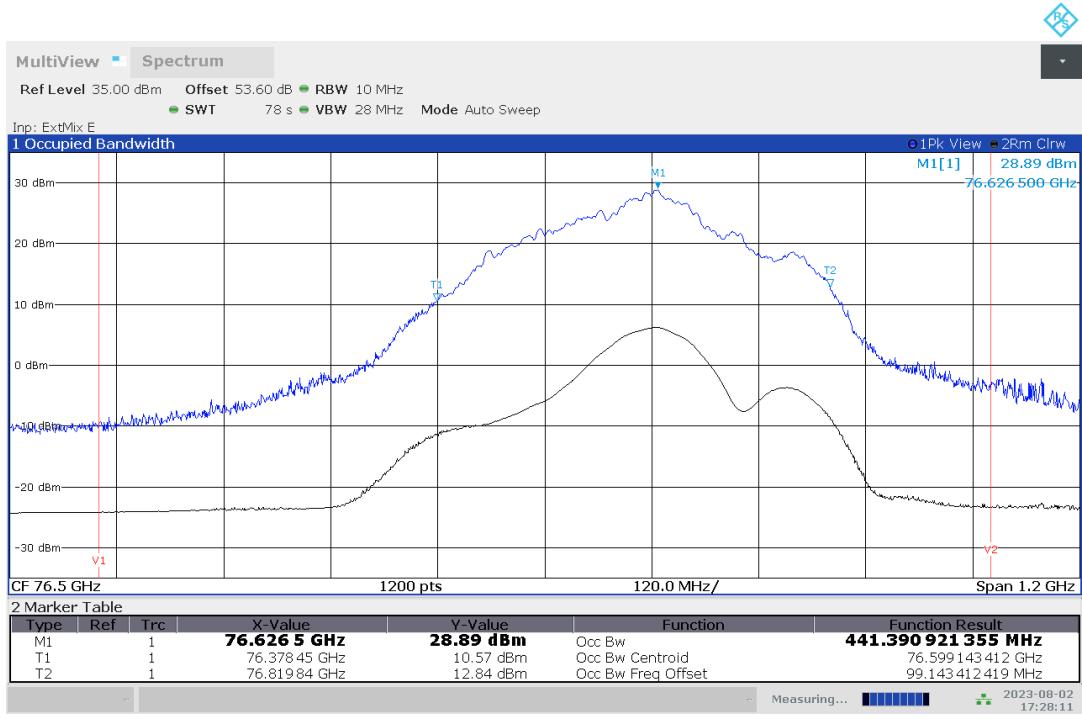
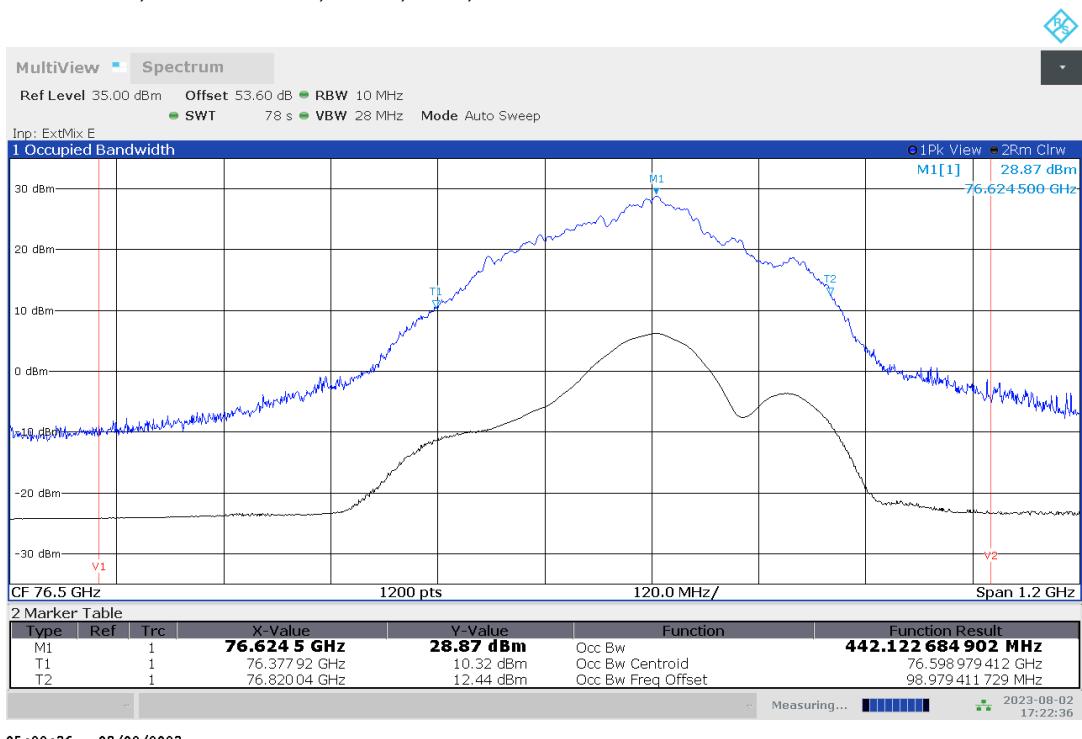


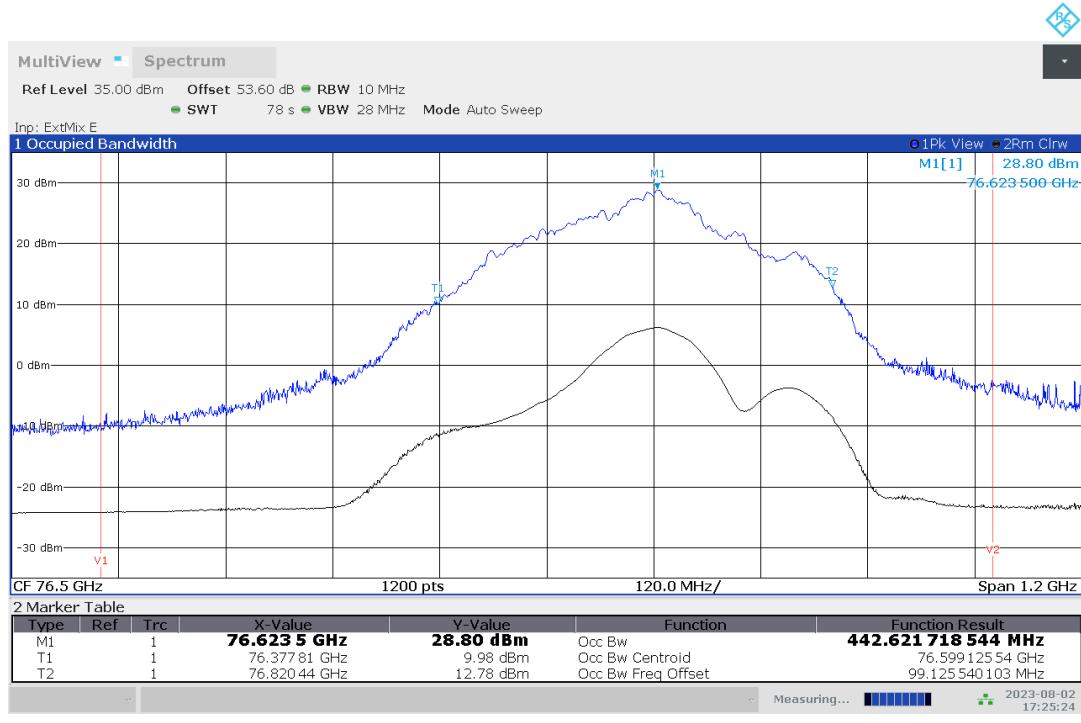
Plot no. 7: 99% OBW, Peak detector, 40 °C, Corner mode



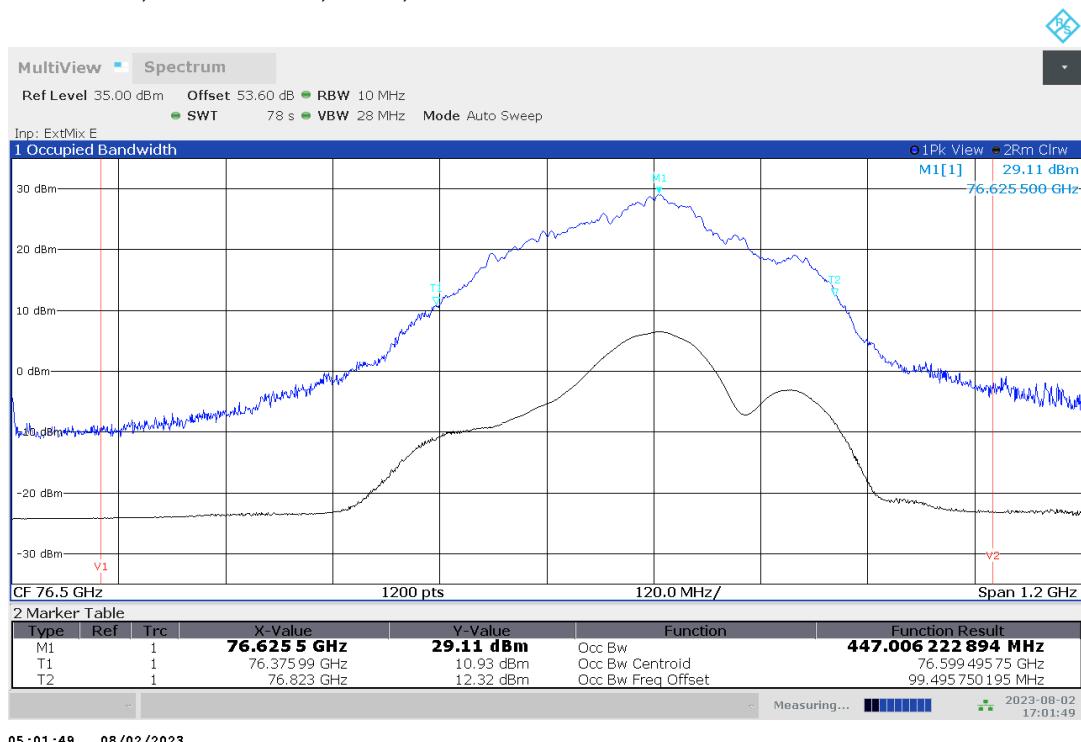
Plot no. 8: 99% OBW, Peak detector, 30 °C, Corner mode



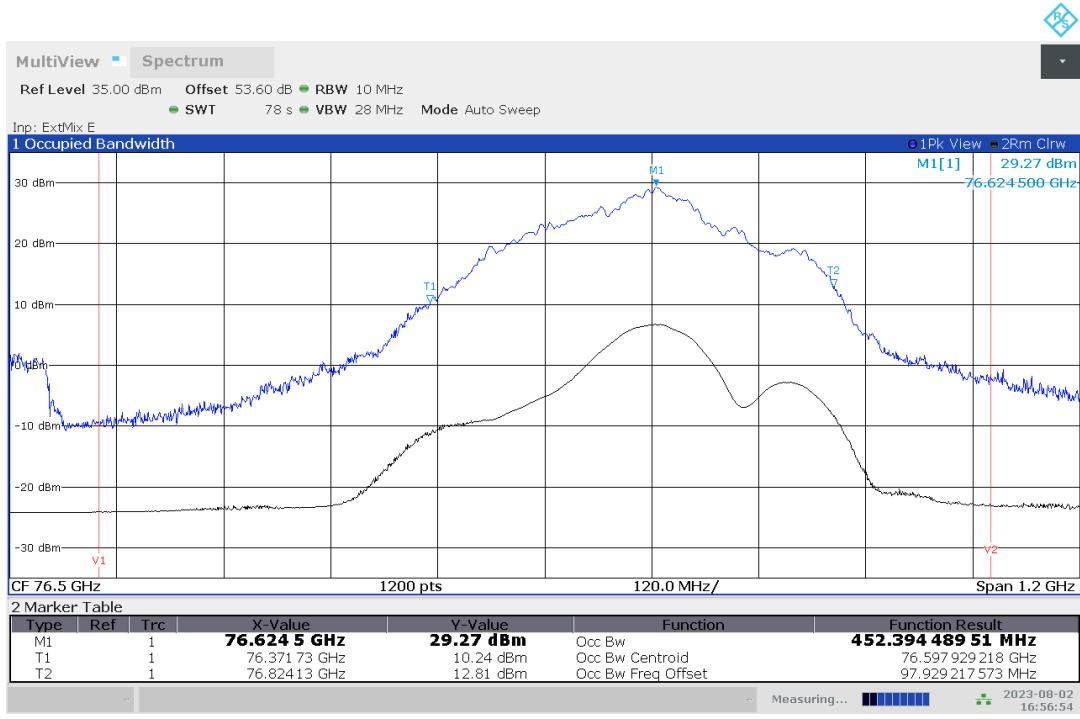
Plot no. 9: 99% OBW, Peak detector, 20 °C, V<sub>max</sub>, Corner modePlot no. 10: 99% OBW, Peak detector, 20 °C, V<sub>nom</sub>, Corner mode

Plot no. 11: 99% OBW, Peak detector, 20 °C, V<sub>min</sub>, Corner mode

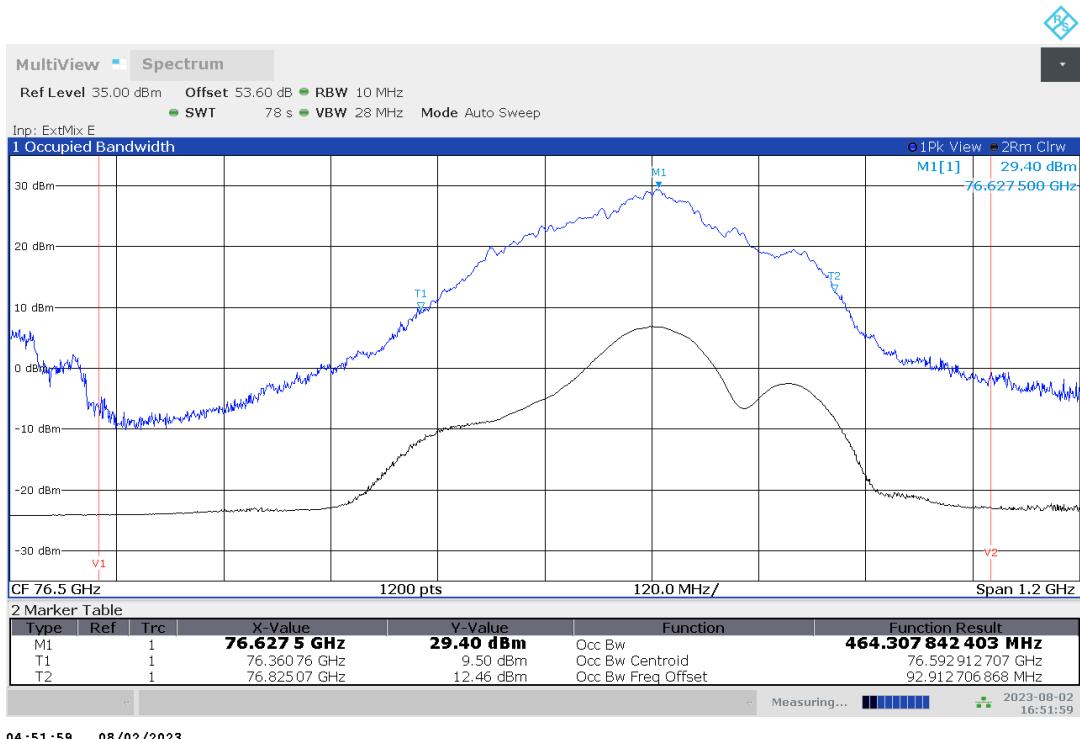
Plot no. 12: 99% OBW, Peak detector, 10 °C, Corner mode



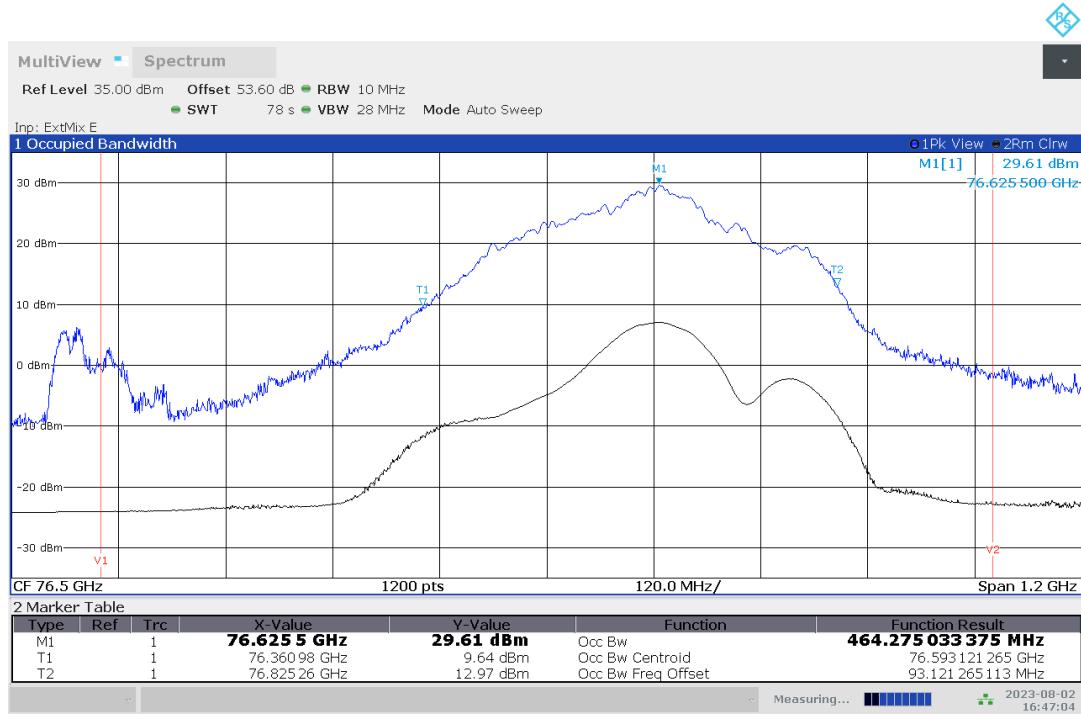
Plot no. 13: 99% OBW, Peak detector, 0 °C, Corner mode



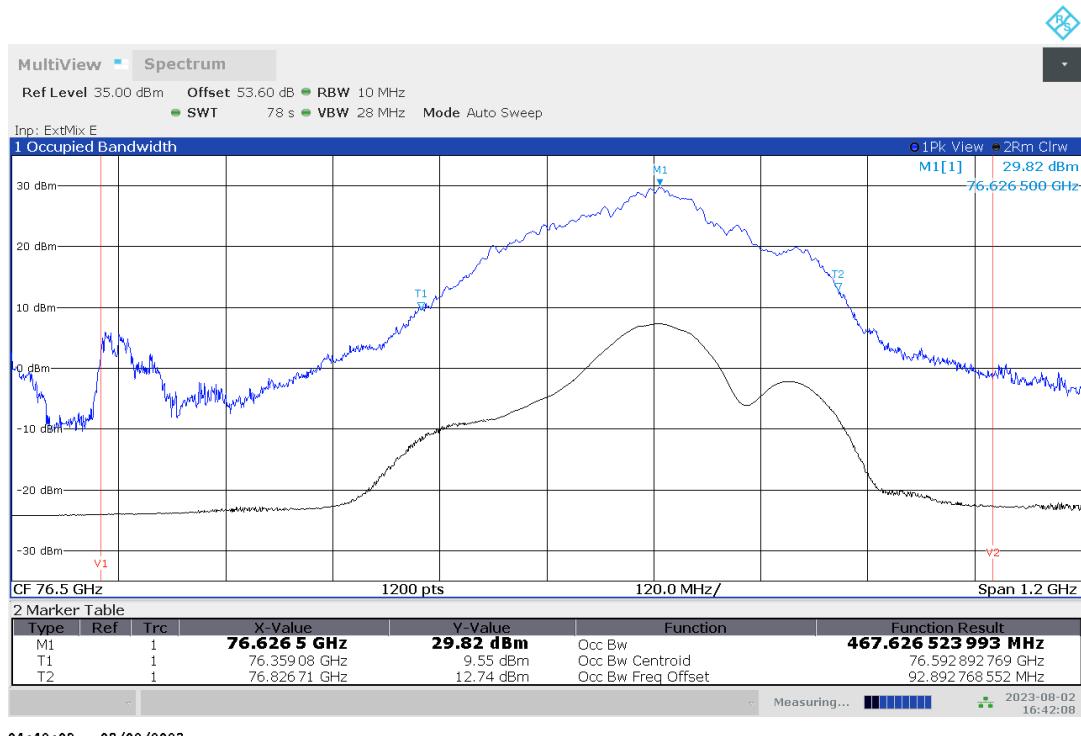
Plot no. 14: 99% OBW, Peak detector, -10 °C, Corner mode



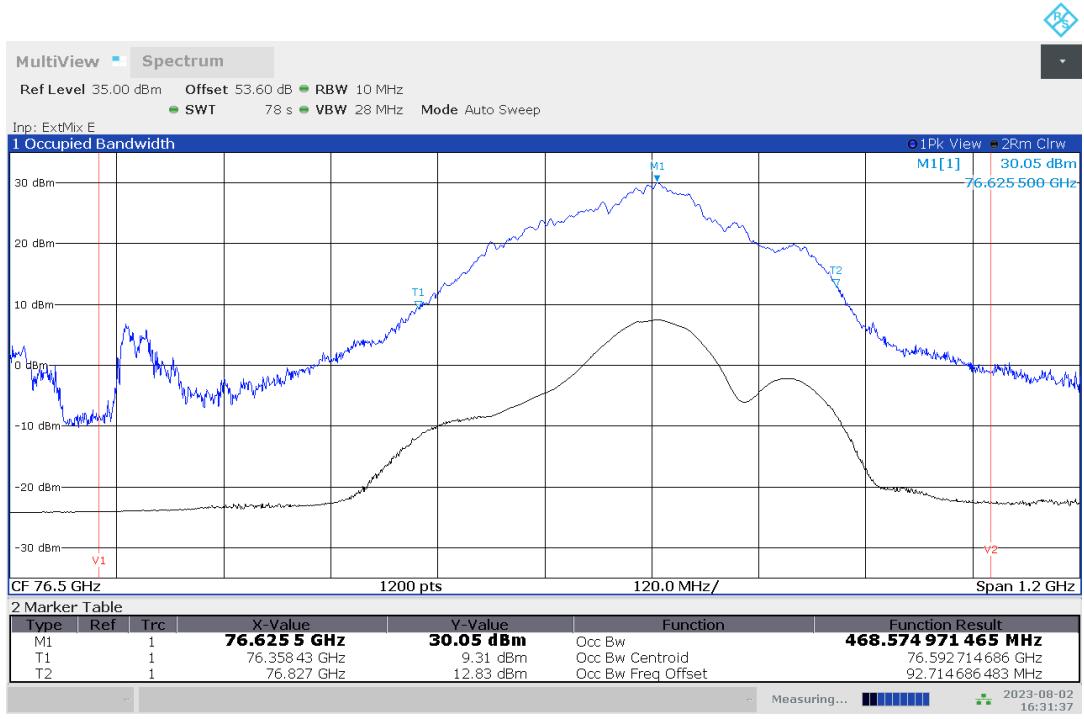
Plot no. 15: 99% OBW, Peak detector, -20 °C, Corner mode



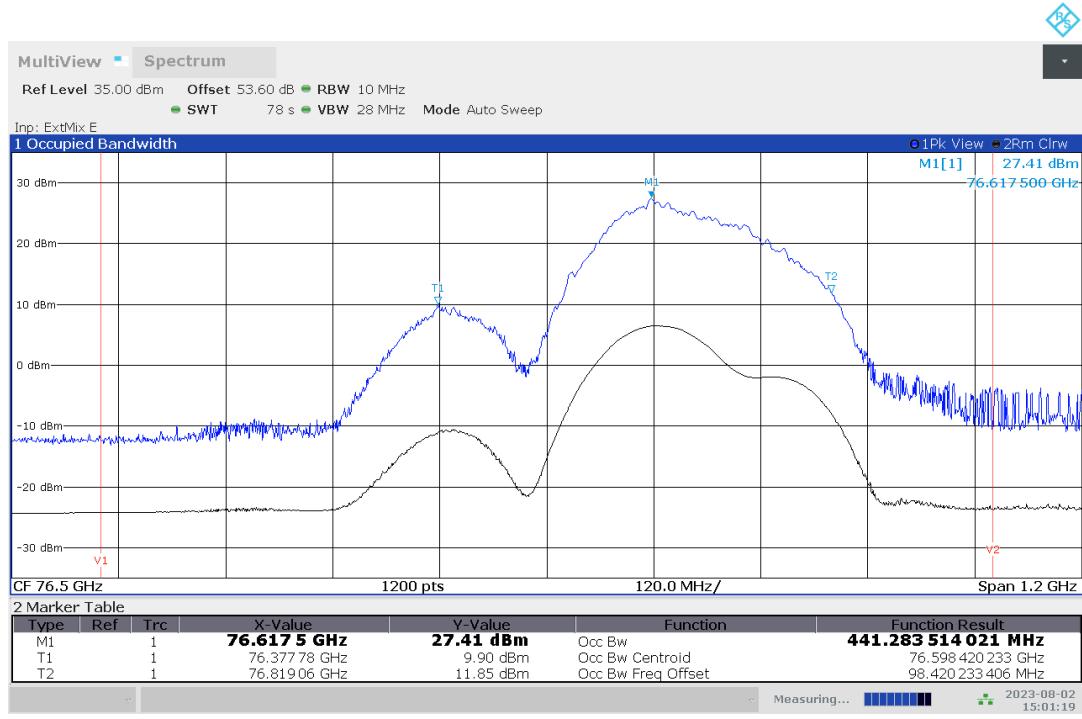
Plot no. 16: 99% OBW, Peak detector, -30 °C, Corner mode



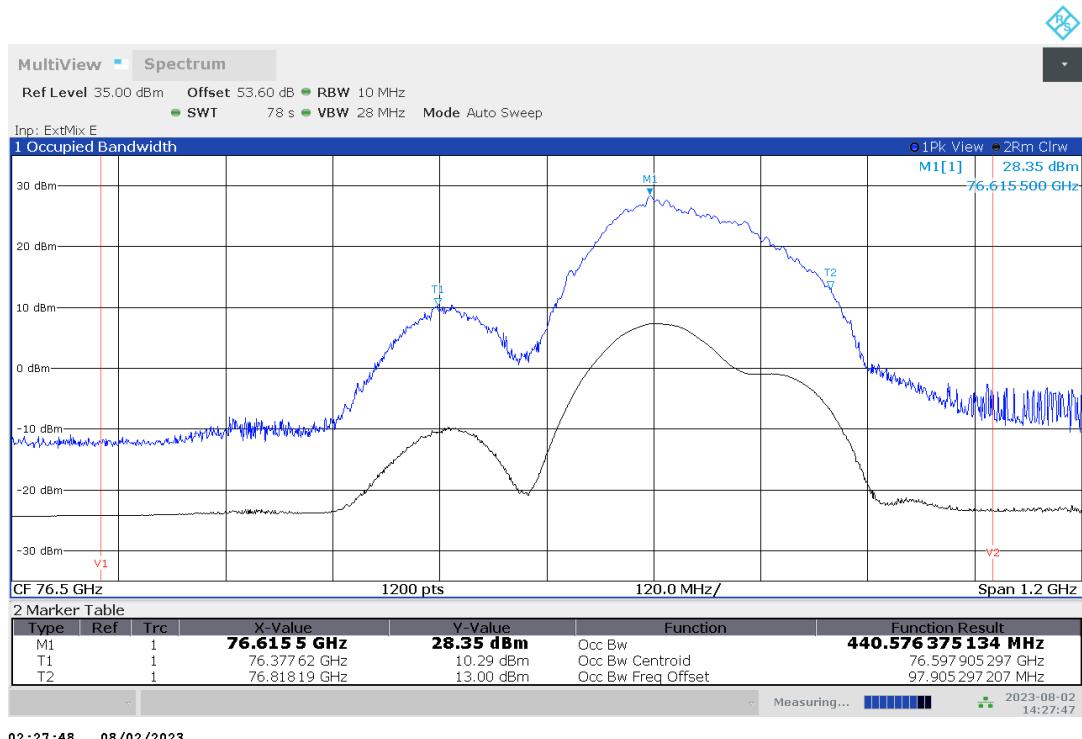
Plot no. 17: 99% OBW, Peak detector, -40 °C, Corner mode



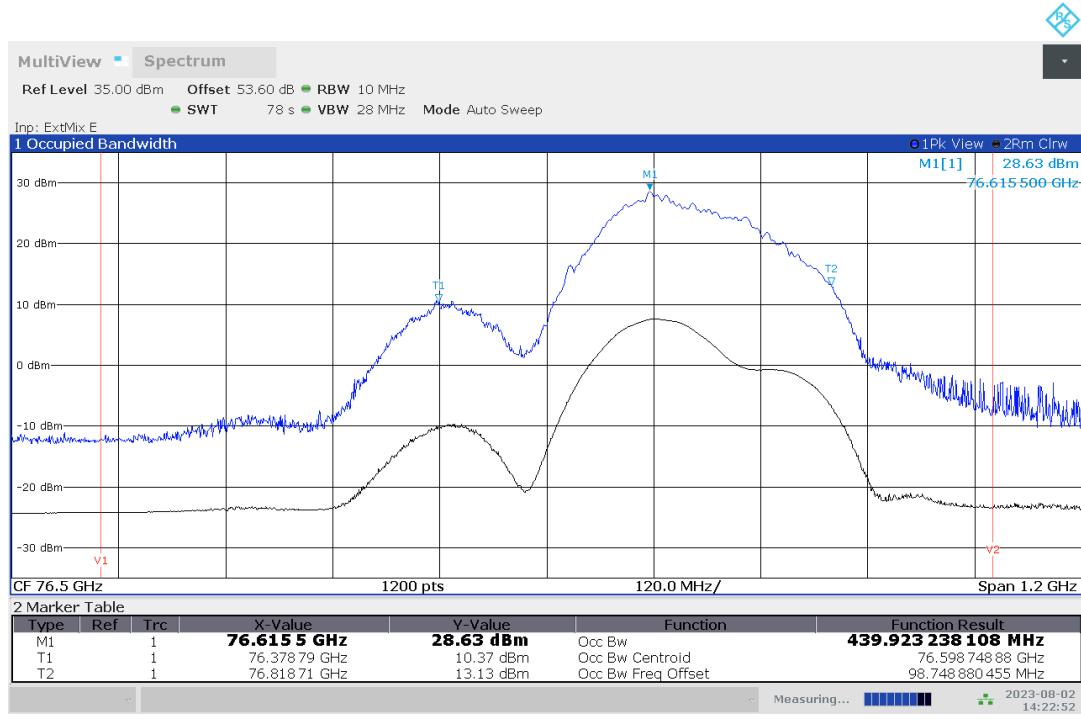
Plot no. 18: 99% OBW, Peak detector, 75 °C, Front mode



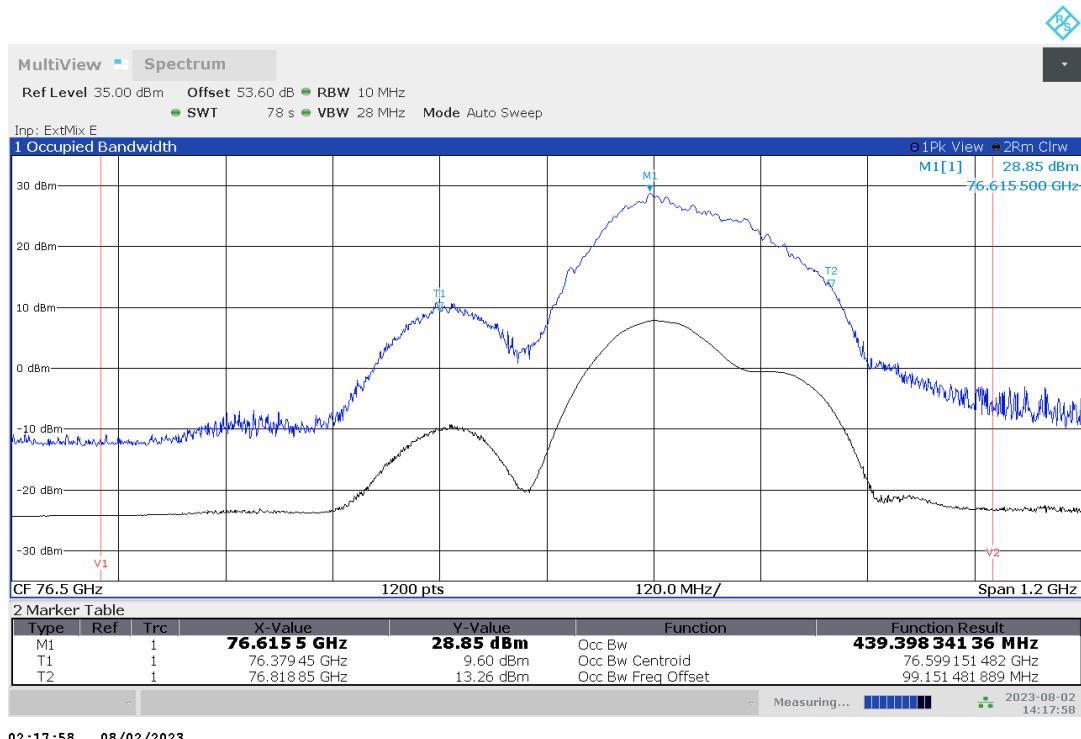
Plot no. 19: 99% OBW, Peak detector, 50 °C, Front mode

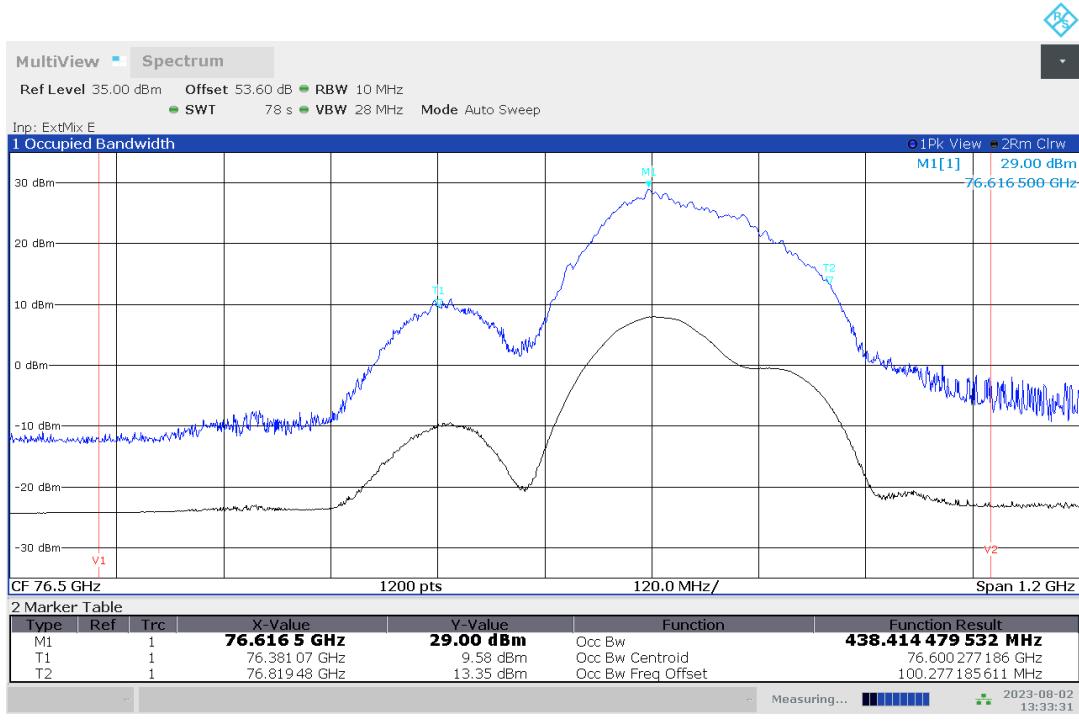
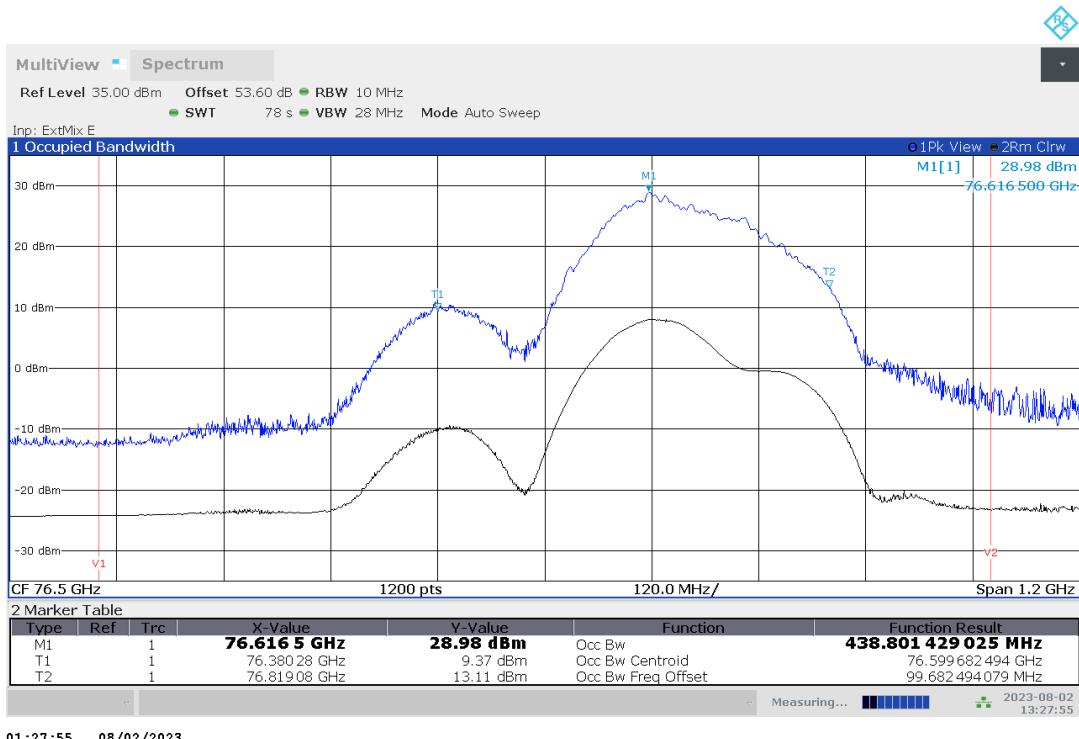


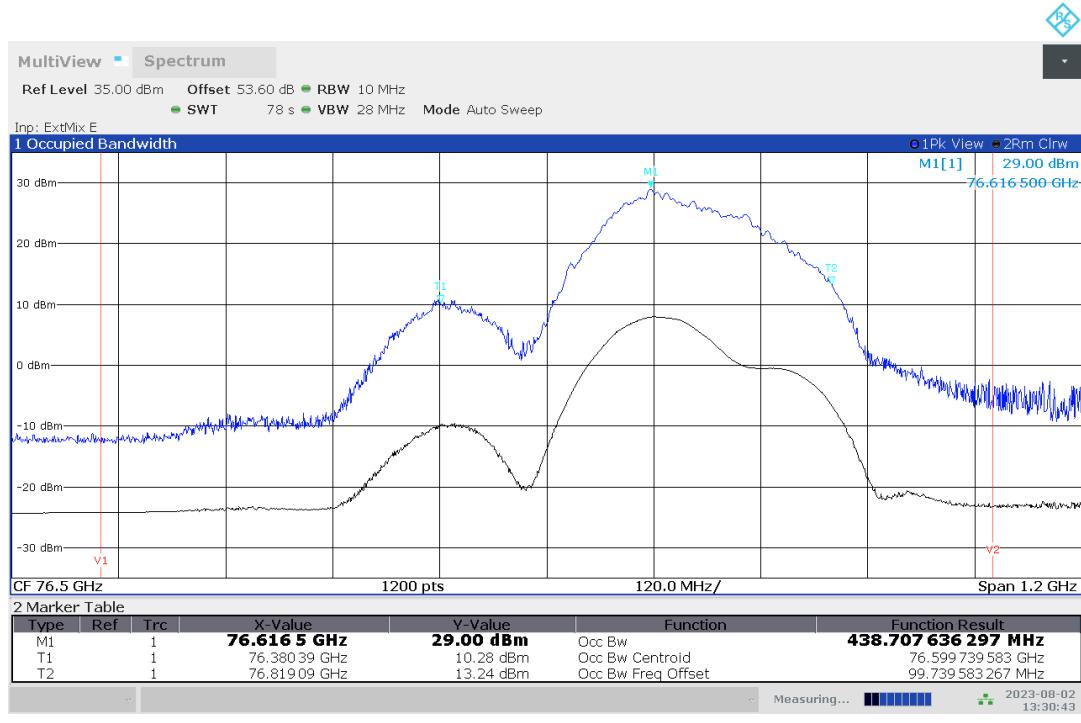
Plot no. 20: 99% OBW, Peak detector, 40 °C, Front mode



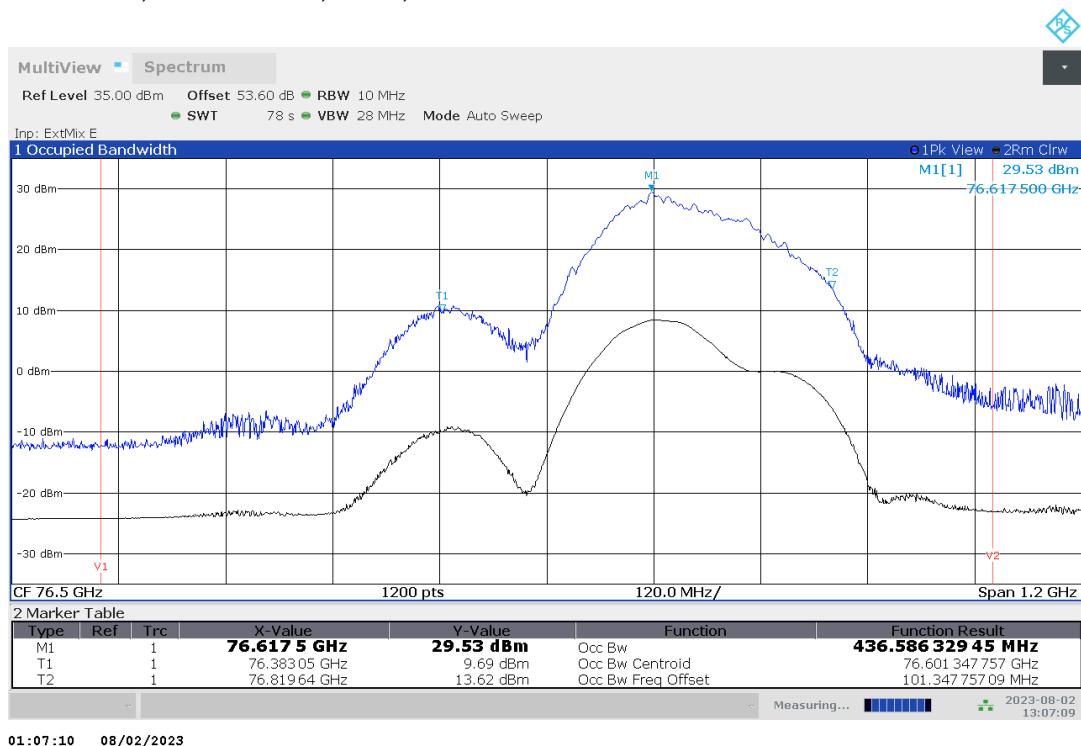
Plot no. 21: 99% OBW, Peak detector, 30 °C, Front mode



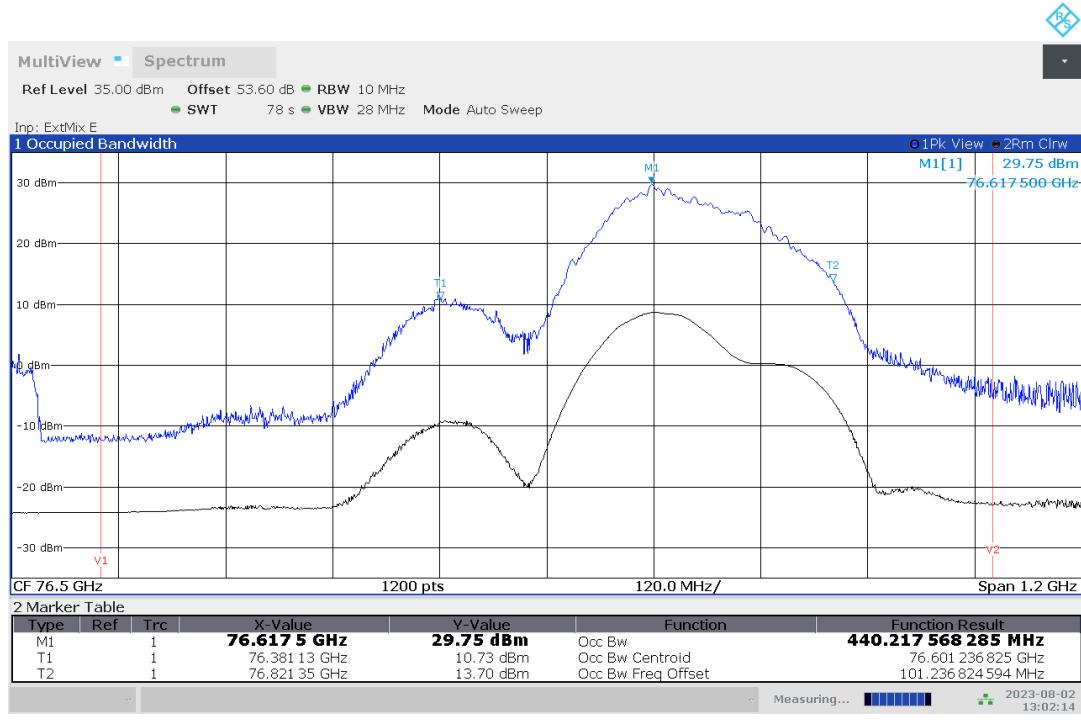
Plot no. 22: 99% OBW, Peak detector, 20 °C, V<sub>max</sub>, Front modePlot no. 23: 99% OBW, Peak detector, 20 °C, V<sub>nom</sub>, Front mode

Plot no. 24: 99% OBW, Peak detector, 20 °C, V<sub>min</sub>, Front mode

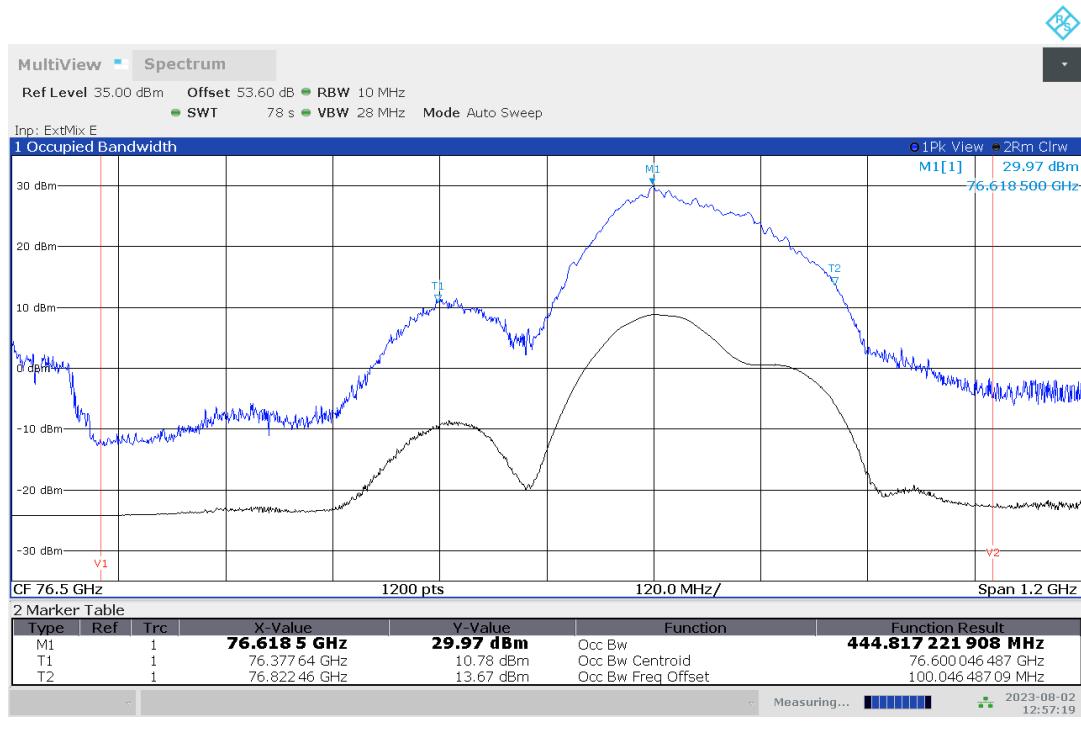
Plot no. 25: 99% OBW, Peak detector, 10 °C, Front mode



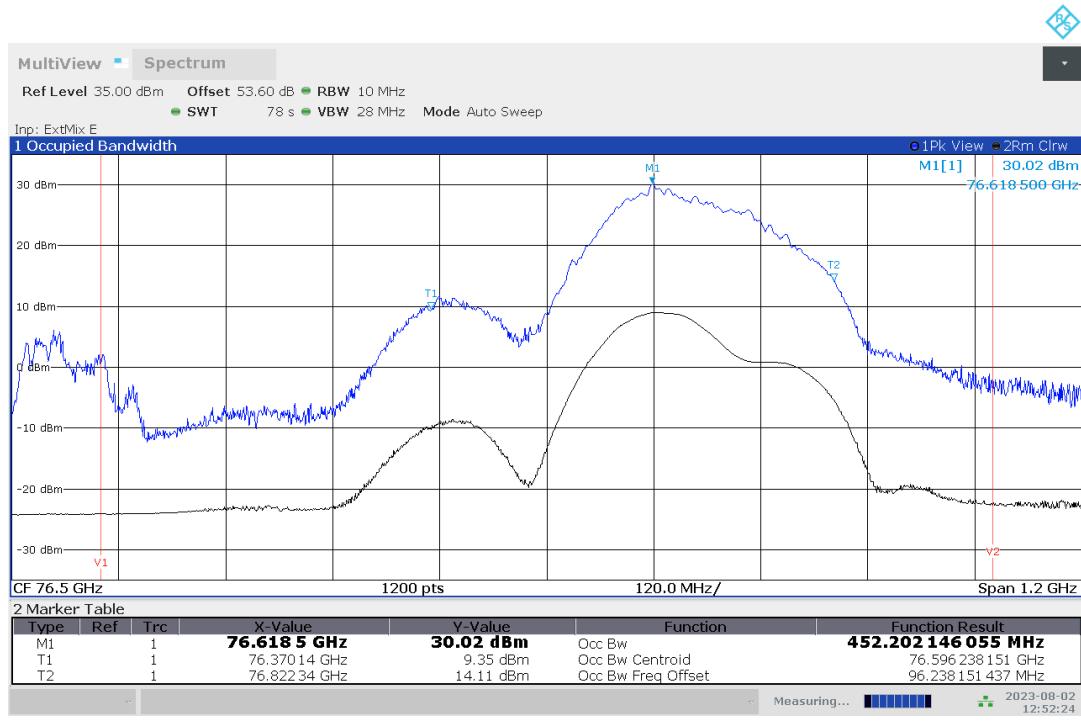
Plot no. 26: 99% OBW, Peak detector, 0 °C, Front mode



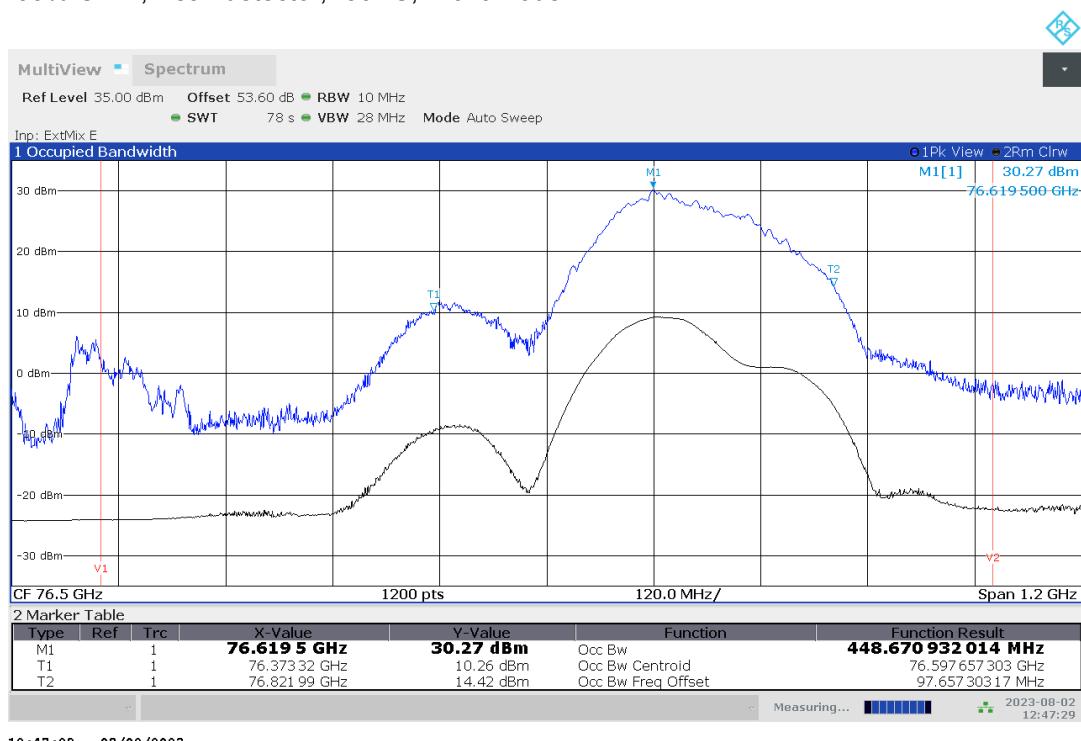
Plot no. 27: 99% OBW, Peak detector, -10 °C, Front mode



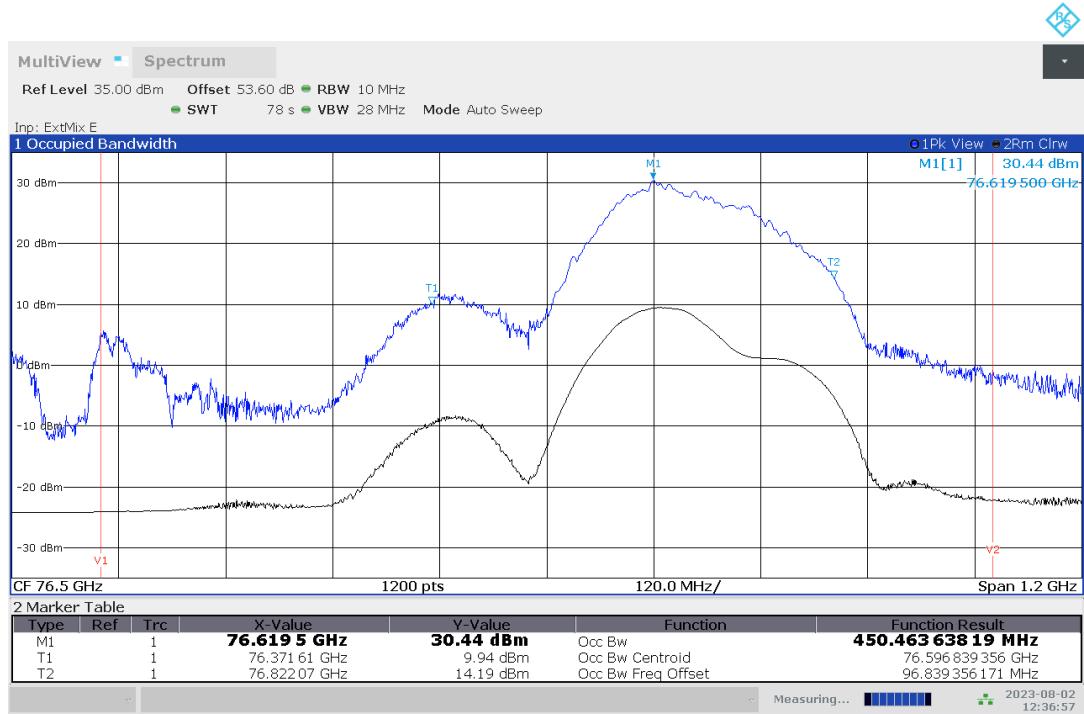
Plot no. 28: 99% OBW, Peak detector, -20 °C, Front mode



Plot no. 29: 99% OBW, Peak detector, -30 °C, Front mode



Plot no. 30: 99% OBW, Peak detector, -40 °C, Front mode



12:36:58 08/02/2023

## 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<br>[MHz] | Field Strength<br>[ $\mu$ V/m] / [dB $\mu$ V/m] | Measurement distance<br>[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<br>[GHz] | Power Density / EIRP               | Measurement distance<br>[m] |
|--------------------|------------------------------------|-----------------------------|
| 40 – 200           | 600 pW/cm <sup>2</sup> → -1.7 dBm  | 3                           |
| 200 – 243          | 1000 pW/cm <sup>2</sup> → +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  $\lambda$  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 <sub>m</sub> [m] |
|--------------|-----------------------|---------|--------------------------------|---------------------------------------|
| 20240-20     | 18.0 – 26.5           | 0.0520  | 26.5                           | 0.478                                 |
| 22240-20     | 26.5 – 40.0           | 0.0342  | 40                             | 0.312                                 |
| 23240-20     | 33.0 – 50.0           | 0.0280  | 50                             | 0.261                                 |
| 24240-20     | 40.0 – 60.0           | 0.0230  | 60                             | 0.212                                 |
| 25240-20     | 50.0 – 75.0           | 0.0185  | 75                             | 0.171                                 |
| 26240-20     | 60.0 – 90.0           | 0.0150  | 90                             | 0.135                                 |
| 27240-20     | 75.0 – 110            | 0.0124  | 110                            | 0.113                                 |
| 28240-20     | 90.0 – 140            | 0.0100  | 140                            | 0.093                                 |
| 29240-20     | 110 – 170             | 0.0085  | 170                            | 0.082                                 |
| 30240-20     | 140 – 220             | 0.0068  | 220                            | 0.068                                 |
| 32240-20     | 220 – 325             | 0.00446 | 243                            | 0.032                                 |

**Used test distances:**

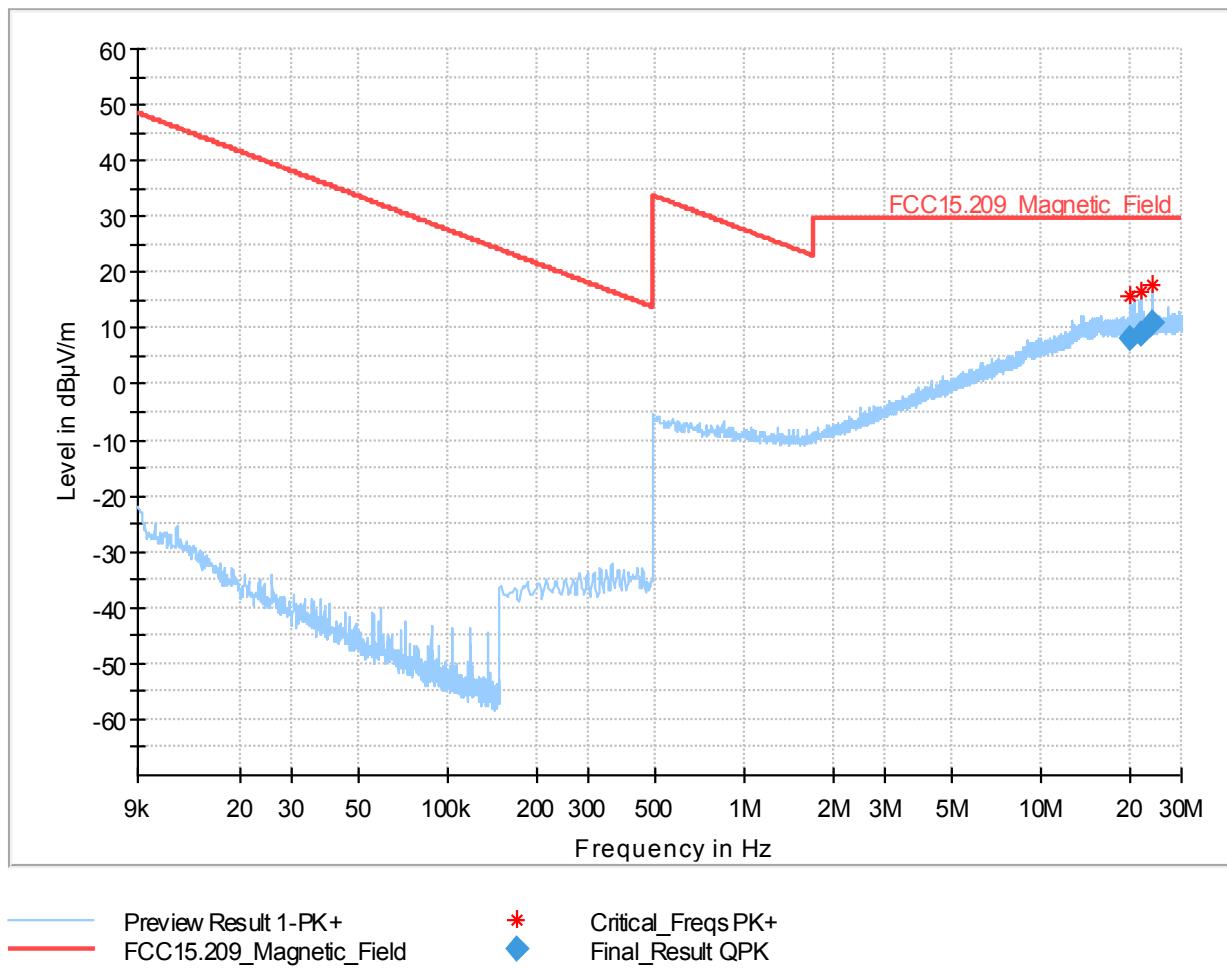
Up to 18 GHz: 3.00 m  
 18 – 40 GHz: 1.00 m  
 40 – 60 GHz: 0.50 m  
 60 – 84 GHz: 1.50 m  
 84 – 110 GHz: 0.25 m  
 110 – 220 GHz: 0.50 m  
 220 – 325 GHz: 1.00 m  
 In-band / OOB: 1.50 m

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

**Test results**

| Channel / Mode                                  | Frequency [GHz] | Detector | Test distance [m] | Level [dB $\mu$ V/dBm] | Limit [dB $\mu$ V/dBm] | Margin [dB] |
|---|-----------------|----------|-------------------|------------------------|------------------------|-------------|
| No critical peaks found. Please refer to plots. |                 |          |                   |                        |                        |             |
|   |                 |          |                   |                        |                        |             |

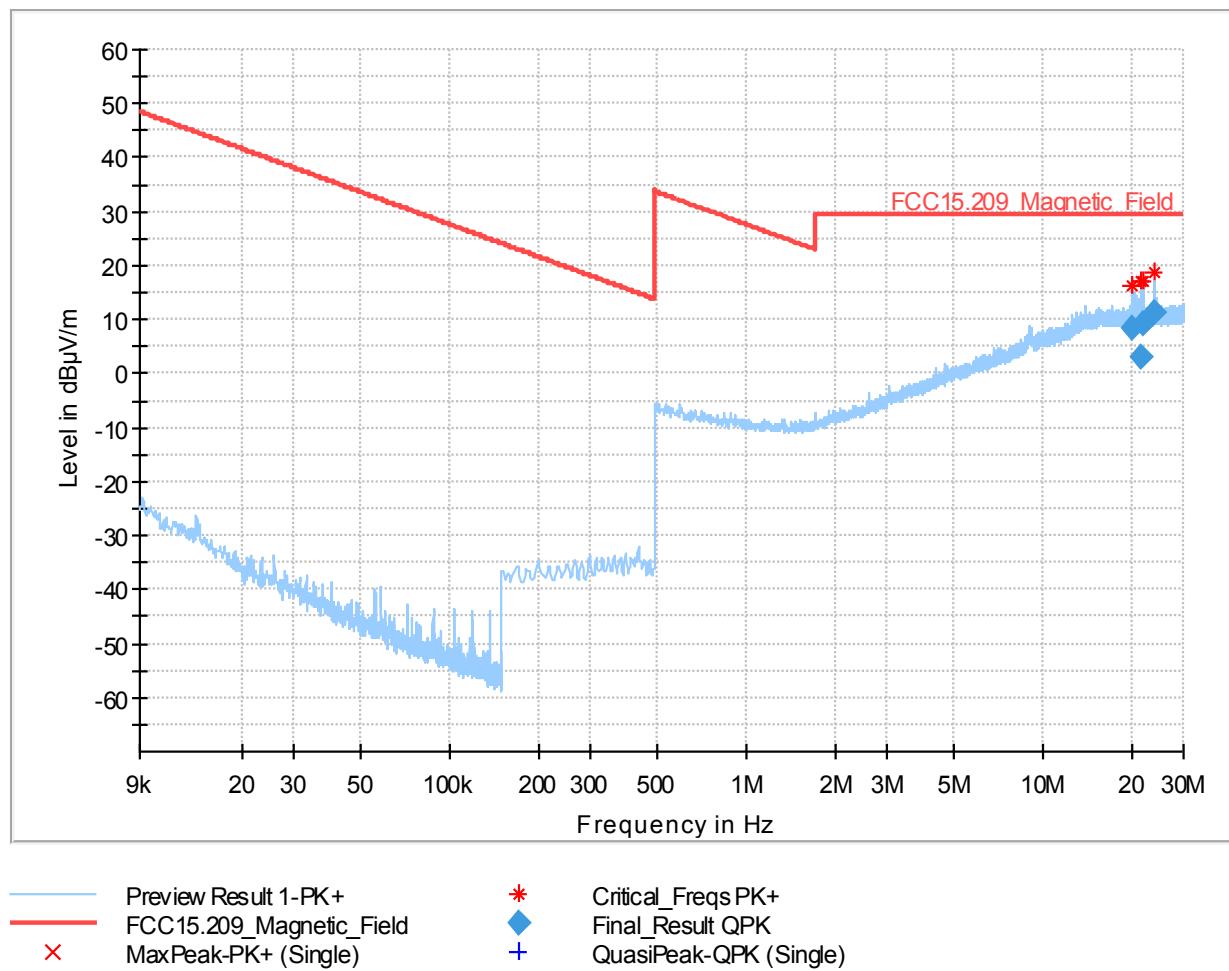
Plot no. 31: radiated emissions 9 kHz – 30 MHz, loop antenna, Corner mode



## Final\_Result

| Frequency (MHz) | QuasiPeak (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Pol | Azimuth (deg) | Corr. (dB) |
|-----------------|--------------------------|----------------------|-------------|-----------------|-----------------|-----|---------------|------------|
| 19.999500       | 8.13                     | 29.54                | 21.41       | 100.0           | 9.000           | V   | 300.0         | 0.5        |
| 21.999750       | 9.07                     | 29.54                | 20.47       | 100.0           | 9.000           | V   | 195.0         | 0.6        |
| 24.000000       | 11.05                    | 29.54                | 18.49       | 100.0           | 9.000           | V   | 319.0         | 0.6        |

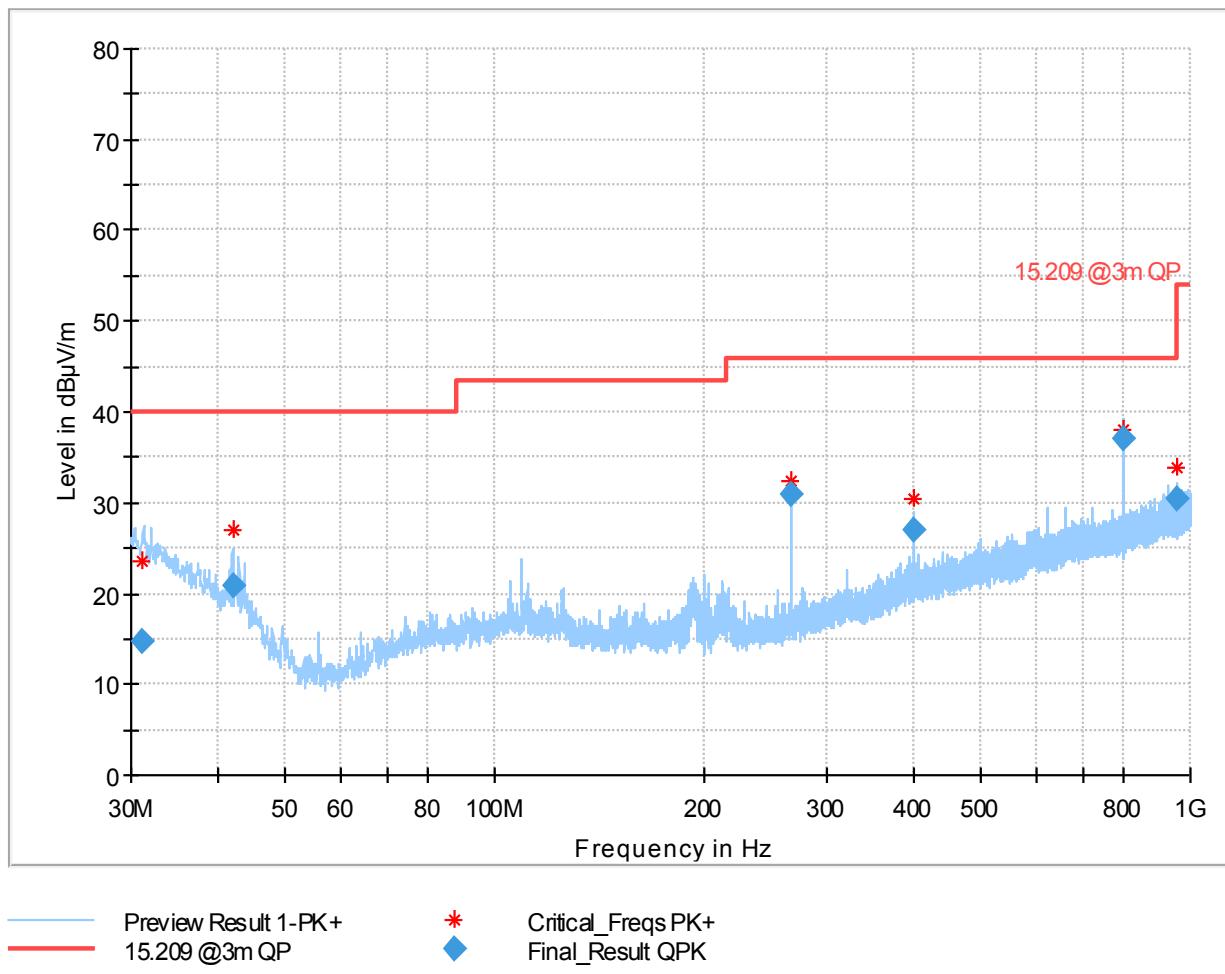
Plot no. 32: radiated emissions 9 kHz – 30 MHz, loop antenna, Front mode



## Final\_Result

| Frequency (MHz) | QuasiPeak (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------------|----------------------|-------------|-----------------|-----------------|-----|---------------|--------------|
| 19.999500       | 8.39                     | 29.54                | 21.15       | 100.0           | 9.000           | V   | 66.0          | 0.5          |
| 21.500250       | 3.11                     | 29.54                | 26.43       | 100.0           | 9.000           | V   | 300.0         | 0.6          |
| 21.999750       | 9.05                     | 29.54                | 20.49       | 100.0           | 9.000           | V   | 300.0         | 0.6          |
| 24.000000       | 11.29                    | 29.54                | 18.25       | 100.0           | 9.000           | V   | 30.0          | 0.6          |

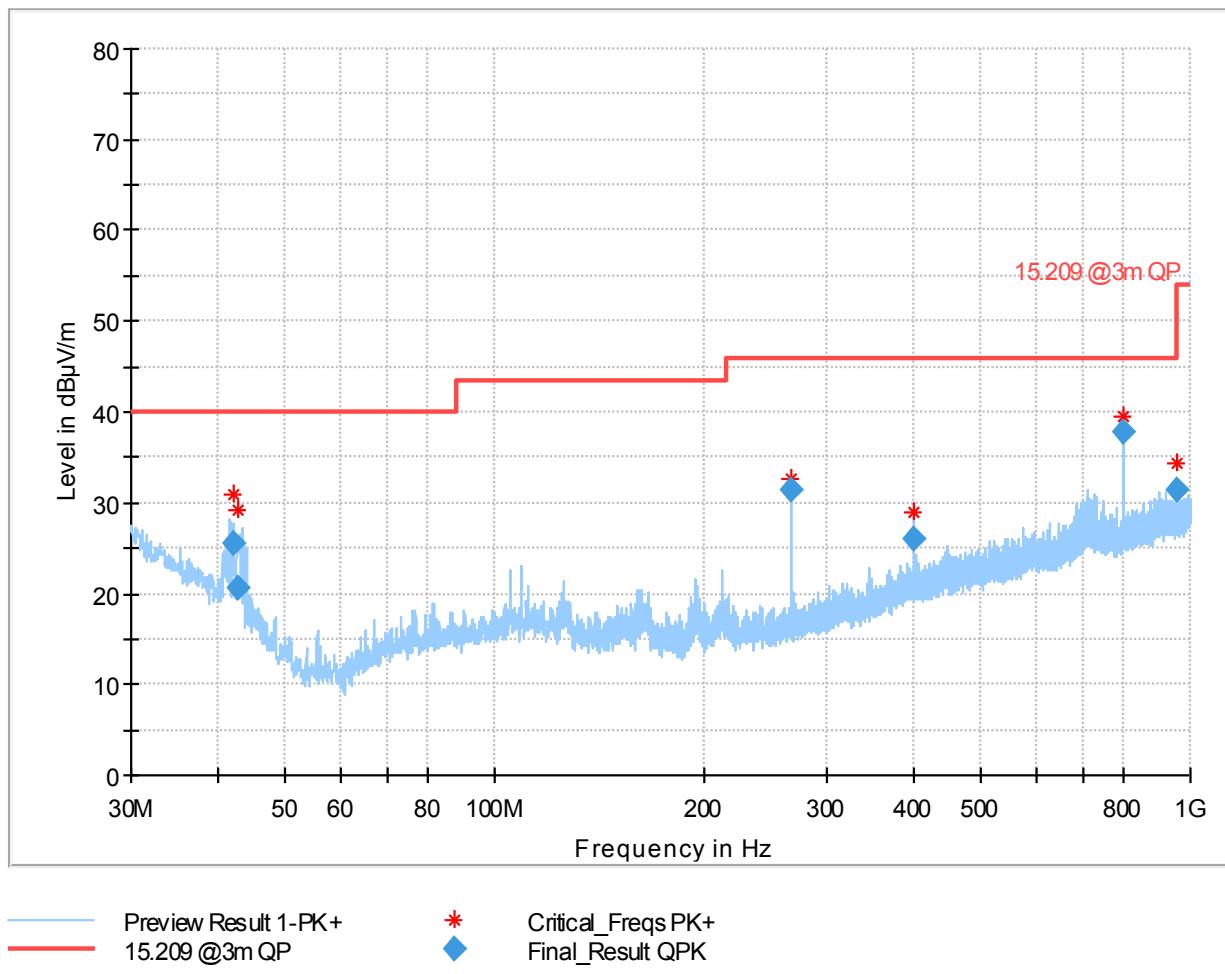
Plot no. 33: radiated emissions 30 MHz – 1 GHz, polarization vertical / horizontal, Corner mode



### Final\_Result

| Frequency (MHz) | QuasiPeak (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|--------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 31.136000       | 14.74                    | 40.00                | 25.26       | 100.0           | 120.000         | 347.0       | V   | 209.0         |
| 42.004500       | 20.86                    | 40.00                | 19.14       | 100.0           | 120.000         | 325.0       | V   | 302.0         |
| 266.656500      | 30.99                    | 46.00                | 15.01       | 100.0           | 120.000         | 103.0       | V   | 323.0         |
| 399.983000      | 27.07                    | 46.00                | 18.93       | 100.0           | 120.000         | 100.0       | V   | 294.0         |
| 799.986000      | 36.95                    | 46.00                | 9.05        | 100.0           | 120.000         | 103.0       | H   | 274.0         |
| 957.489000      | 30.45                    | 46.00                | 15.55       | 100.0           | 120.000         | 103.0       | V   | 2.0           |

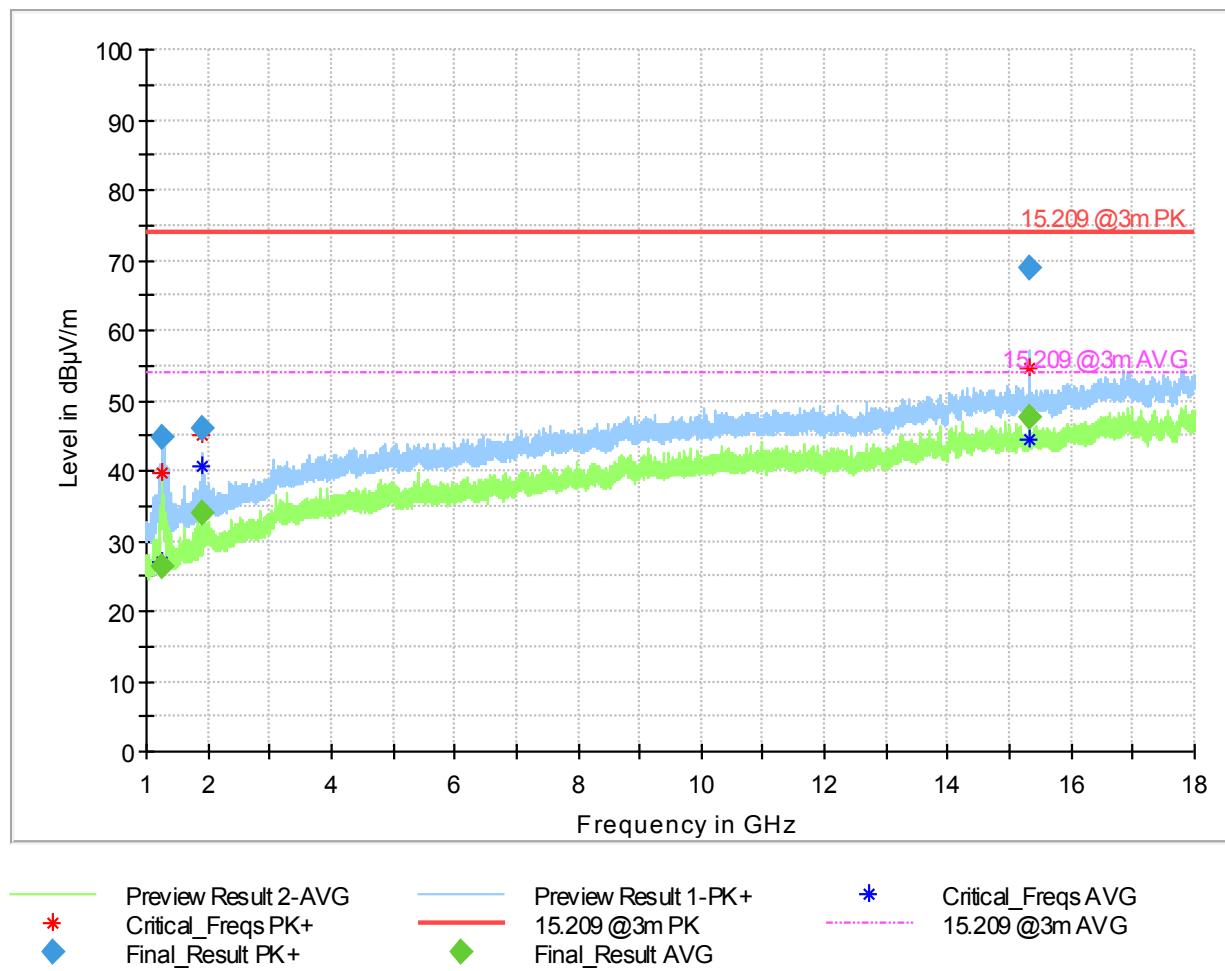
Plot no. 34: radiated emissions 30 MHz – 1 GHz, polarization vertical / horizontal, Front mode



### Final\_Result

| Frequency (MHz) | QuasiPeak (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) |
|-----------------|--------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|---------------|
| 41.990000       | 25.46                    | 40.00                | 14.54       | 100.0           | 120.000         | 100.0       | V   | -2.0          |
| 42.837500       | 20.62                    | 40.00                | 19.38       | 100.0           | 120.000         | 100.0       | V   | 11.0          |
| 266.656500      | 31.49                    | 46.00                | 14.51       | 100.0           | 120.000         | 100.0       | V   | 322.0         |
| 399.981500      | 25.92                    | 46.00                | 20.08       | 100.0           | 120.000         | 103.0       | H   | 209.0         |
| 799.986000      | 37.87                    | 46.00                | 8.13        | 100.0           | 120.000         | 100.0       | H   | 243.0         |
| 957.489000      | 31.46                    | 46.00                | 14.54       | 100.0           | 120.000         | 104.0       | V   | 314.0         |

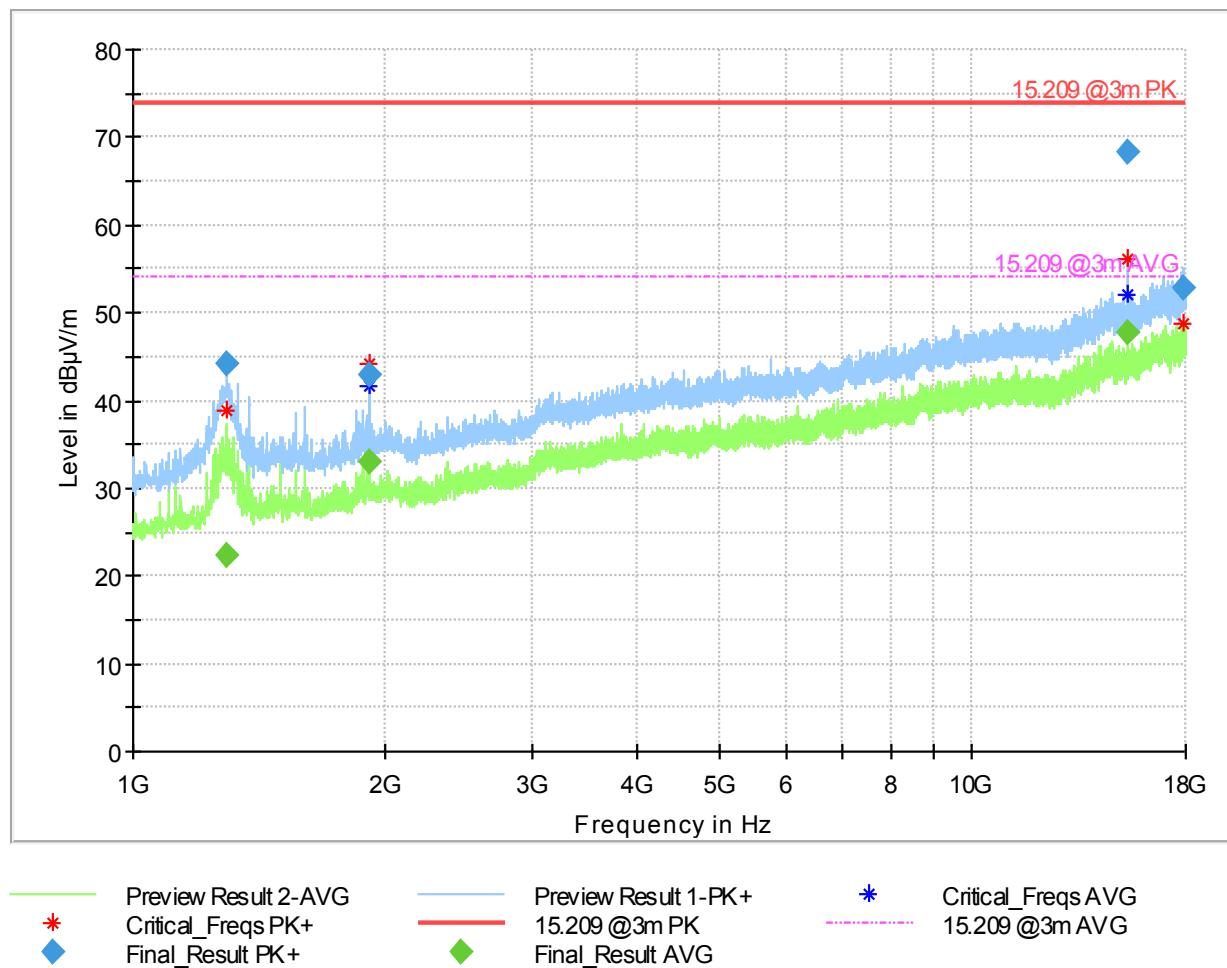
Plot no. 35: radiated emissions 1 GHz – 18 GHz, polarization vertical / horizontal, Corner mode



### Final\_Result

| Frequency (MHz) | MaxPeak (dB $\mu$ V/m) | Average (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|
| 1261.955556     | ---                    | 26.20                  | 54.00                | 27.80       | 100.0           | 1000.000        | 150.0       | H   |
| 1262.405556     | 44.88                  | ---                    | 74.00                | 29.12       | 100.0           | 1000.000        | 150.0       | H   |
| 1914.972222     | ---                    | 33.97                  | 54.00                | 20.03       | 100.0           | 1000.000        | 150.0       | H   |
| 1914.972222     | 46.15                  | ---                    | 74.00                | 27.85       | 100.0           | 1000.000        | 150.0       | V   |
| 15319.711111    | ---                    | 47.53                  | 54.00                | 6.47        | 100.0           | 1000.000        | 150.0       | H   |
| 15319.786111    | 68.85                  | ---                    | 74.00                | 5.15        | 100.0           | 1000.000        | 150.0       | H   |

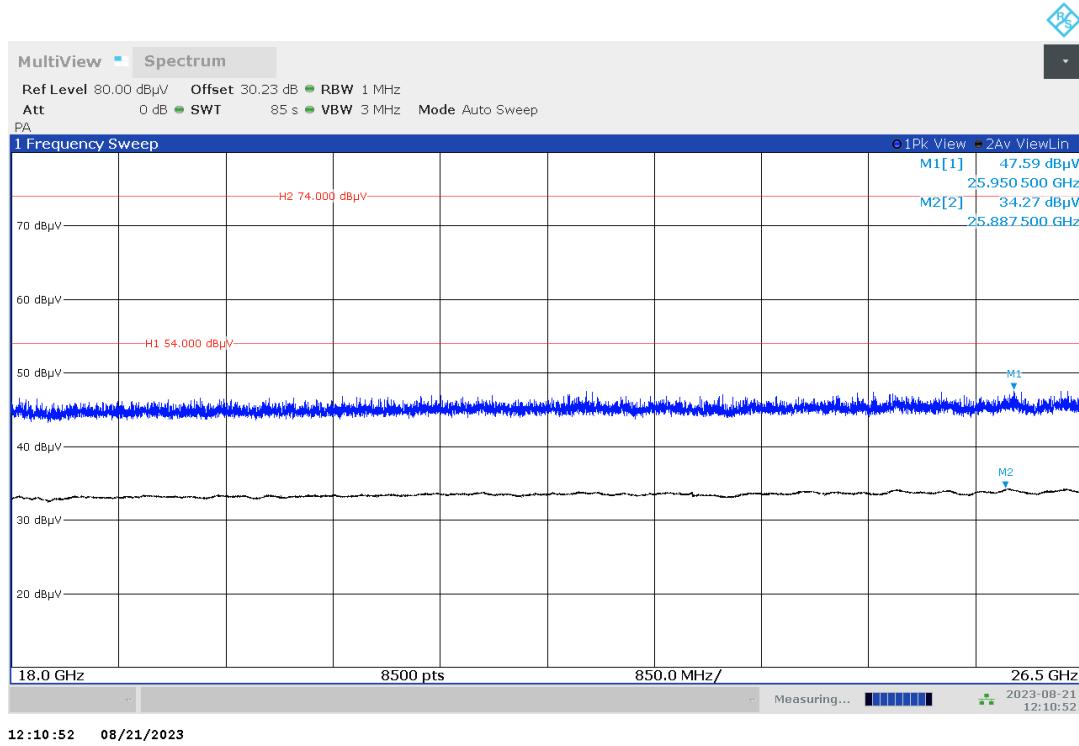
Plot no. 36: radiated emissions 1 GHz – 18 GHz, polarization vertical / horizontal, Front mode



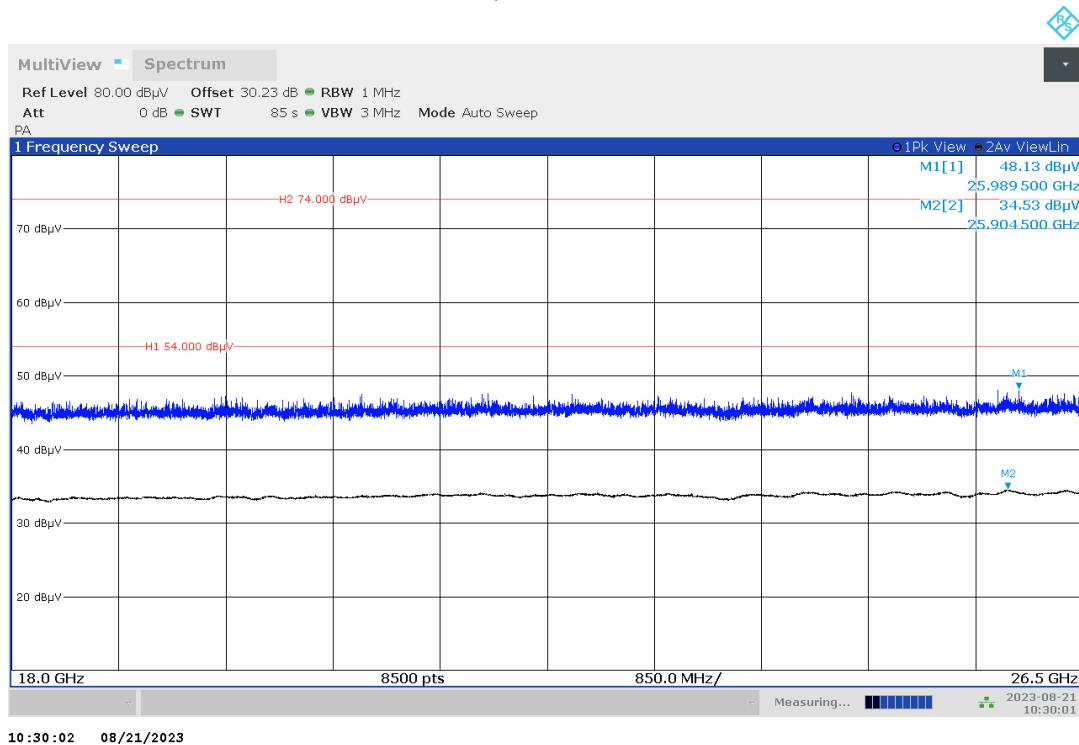
## Final\_Result

| Frequency (MHz) | MaxPeak (dB $\mu$ V/m) | Average (dB $\mu$ V/m) | Limit (dB $\mu$ V/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol |
|-----------------|------------------------|------------------------|----------------------|-------------|-----------------|-----------------|-------------|-----|
| 1293.108333     | ---                    | 22.30                  | 54.00                | 31.70       | 100.0           | 1000.000        | 150.0       | H   |
| 1294.202778     | 44.30                  | ---                    | 74.00                | 29.70       | 100.0           | 1000.000        | 150.0       | H   |
| 1914.897222     | 42.83                  | ---                    | 74.00                | 31.17       | 100.0           | 1000.000        | 150.0       | H   |
| 1914.972222     | ---                    | 32.94                  | 54.00                | 21.06       | 100.0           | 1000.000        | 150.0       | H   |
| 15319.711111    | ---                    | 47.67                  | 54.00                | 6.33        | 100.0           | 1000.000        | 150.0       | H   |
| 15319.741667    | 68.36                  | ---                    | 74.00                | 5.64        | 100.0           | 1000.000        | 150.0       | H   |
| 17870.880556    | 52.82                  | ---                    | 74.00                | 21.18       | 100.0           | 1000.000        | 150.0       | V   |

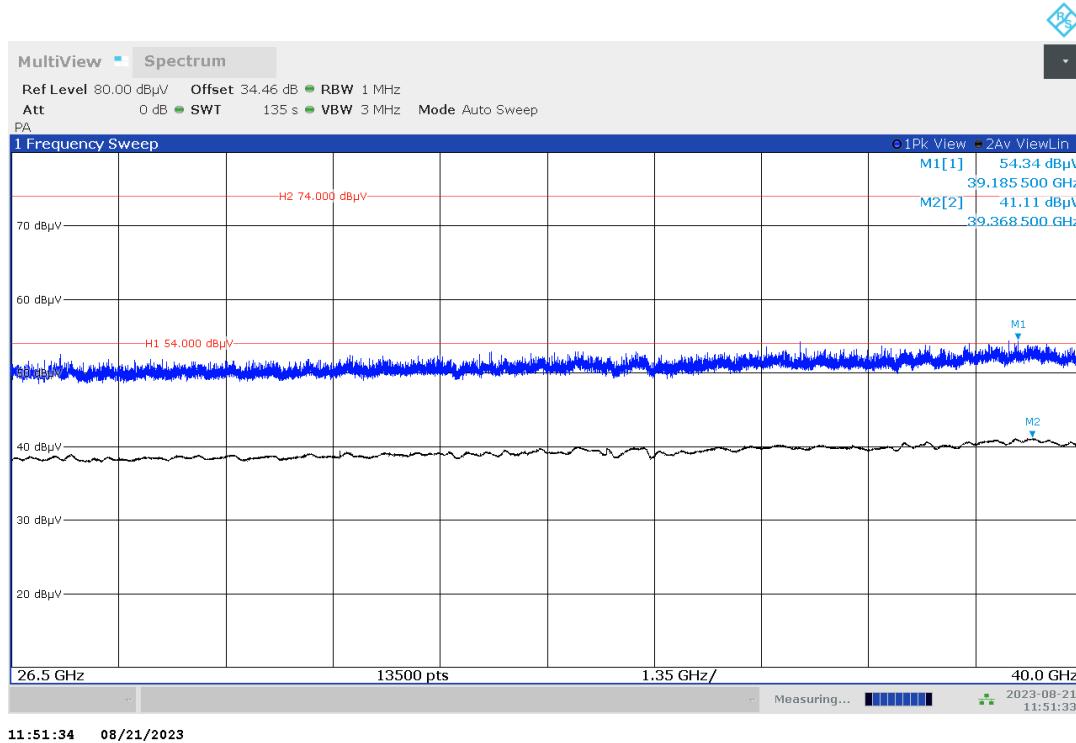
Plot no. 37: radiated emissions 18 GHz – 26.5 GHz, polarization vertical / horizontal, Corner mode



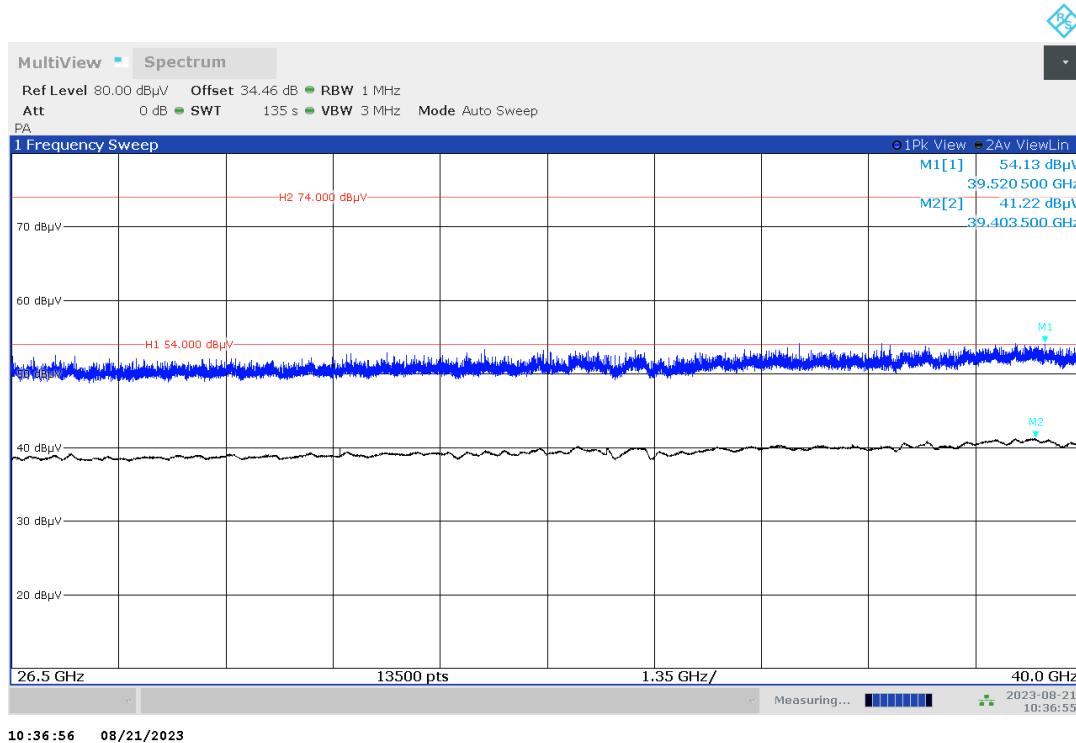
Plot no. 38: radiated emissions 18 GHz – 26.5 GHz, polarization vertical / horizontal, Front mode



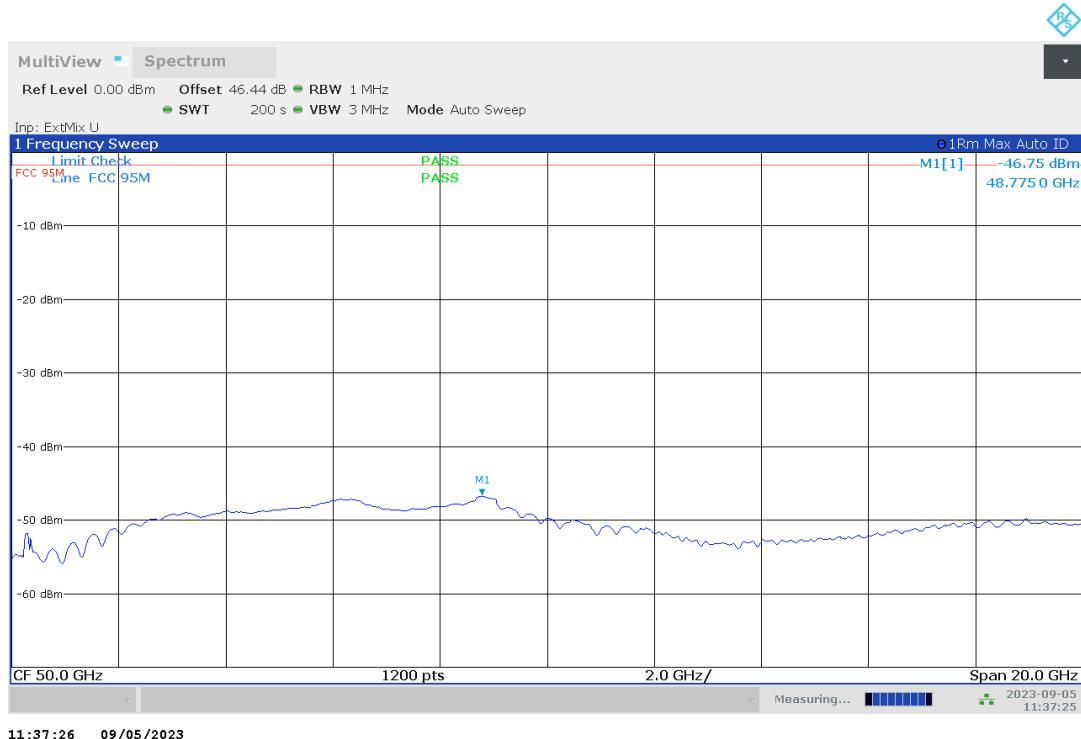
Plot no. 39: radiated emissions 26.5 GHz – 40 GHz, polarization vertical / horizontal, Corner mode



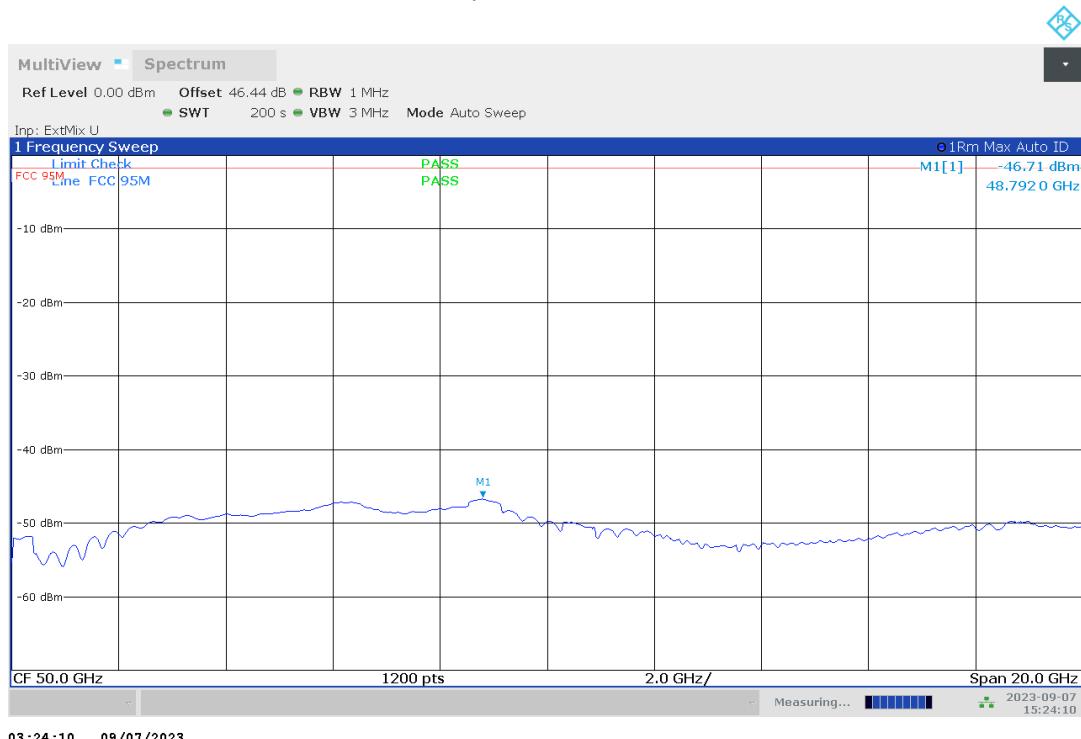
Plot no. 40: radiated emissions 26.5 GHz – 40 GHz, polarization vertical / horizontal, Front mode



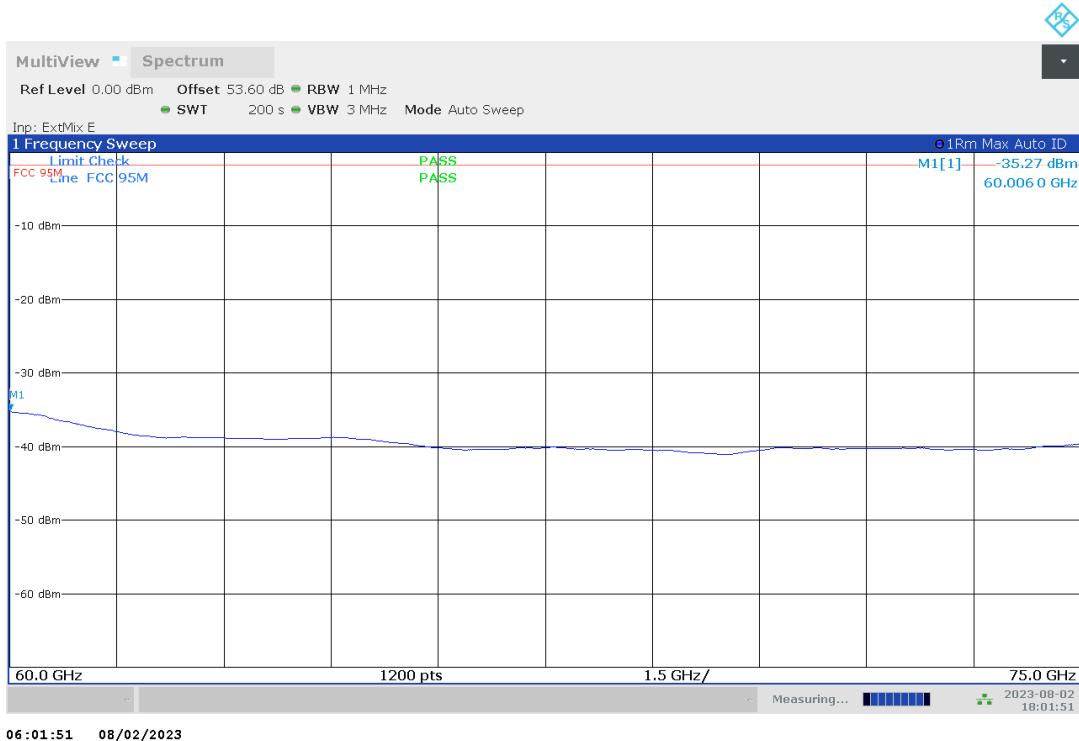
Plot no. 41: radiated emissions 40 GHz – 60 GHz, polarization vertical / horizontal, Corner mode



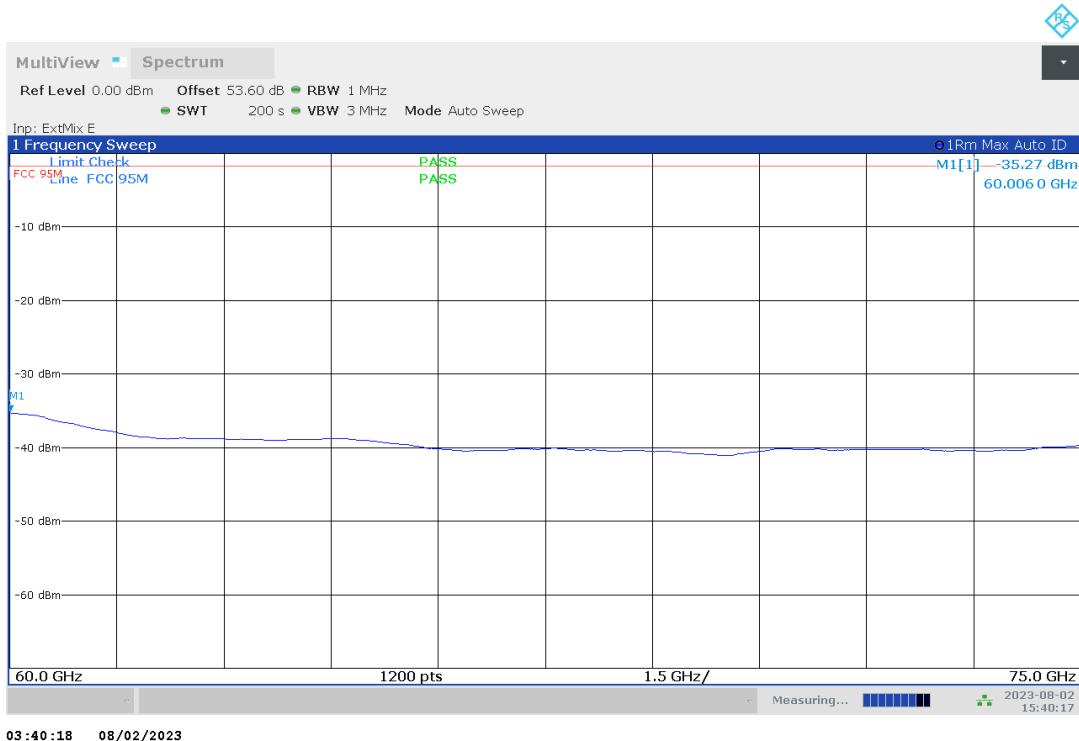
Plot no. 42: radiated emissions 40 GHz – 60 GHz, polarization vertical / horizontal, Front mode



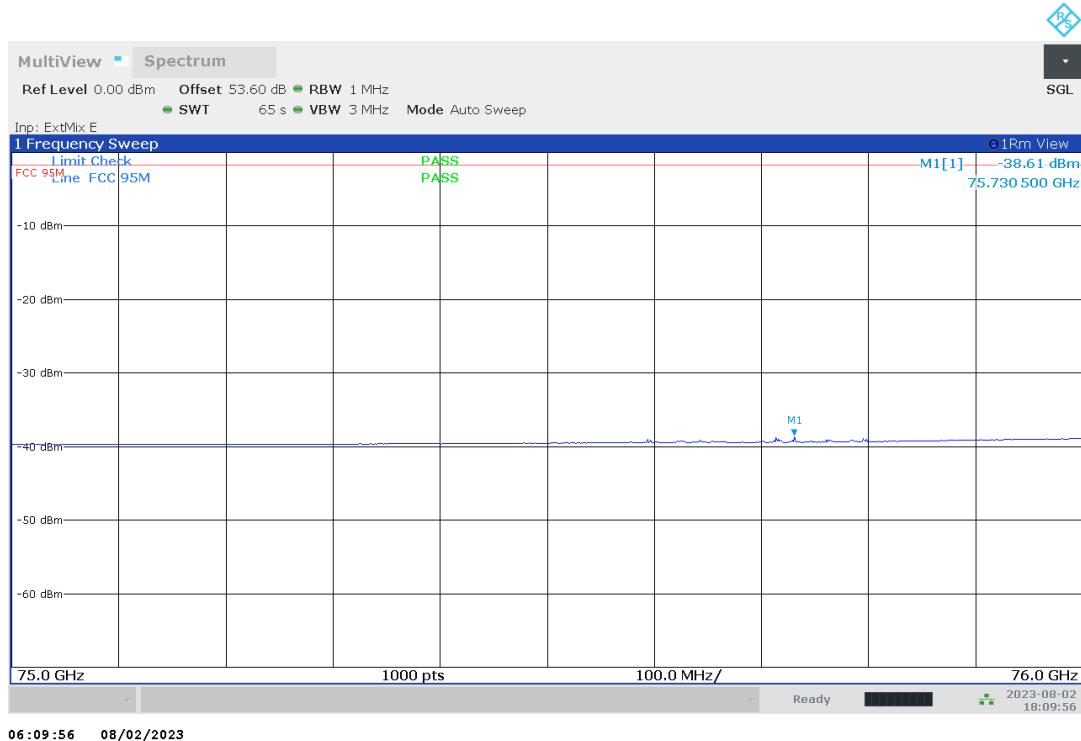
Plot no. 43: radiated emissions 60 GHz – 75 GHz, polarization vertical / horizontal, Corner mode



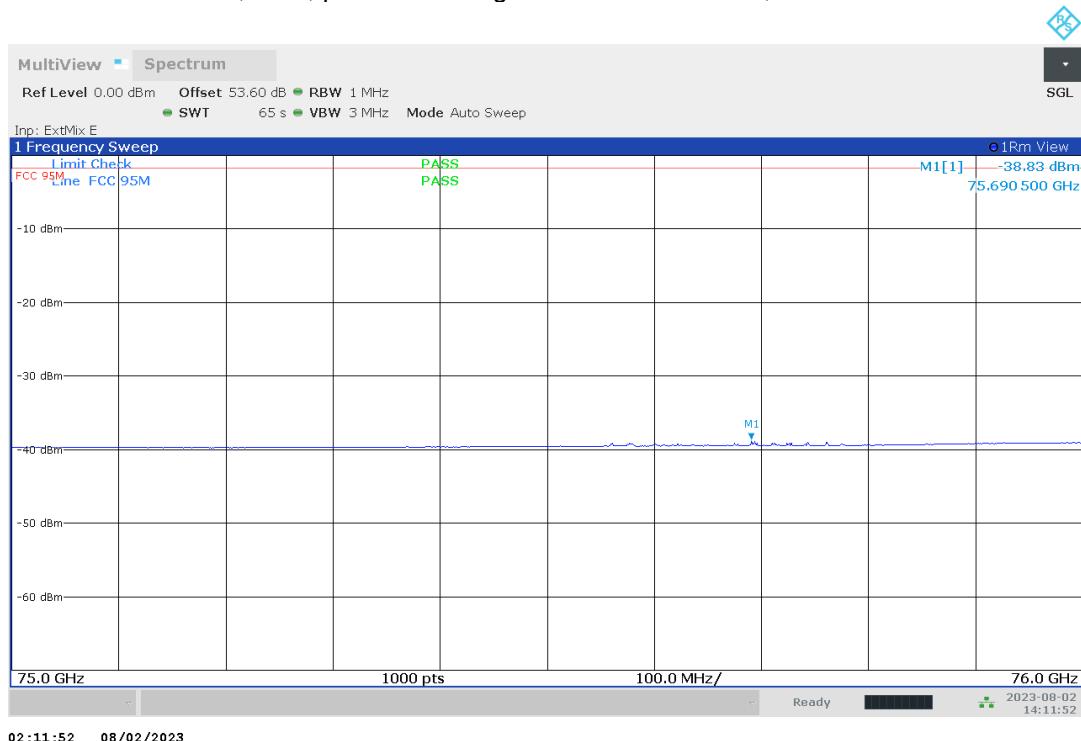
Plot no. 44: radiated emissions 60 GHz – 75 GHz, polarization vertical / horizontal, Front mode



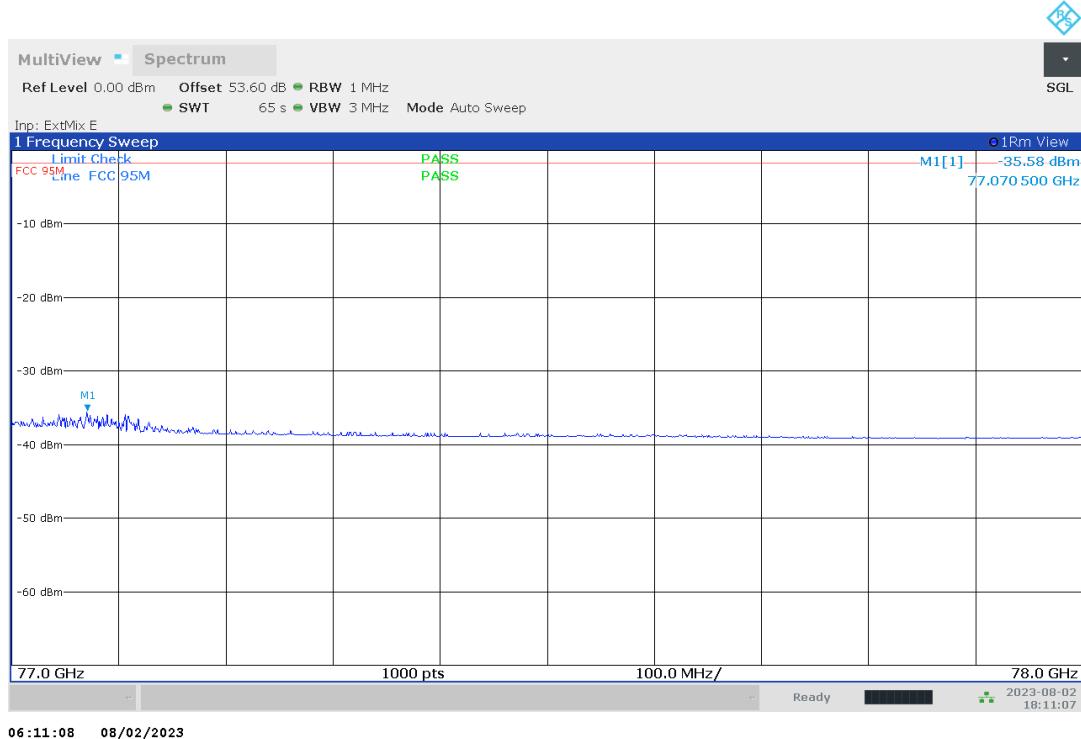
Plot no. 45: radiated emissions, BEC, polarization aligned with radar sensor, Corner mode



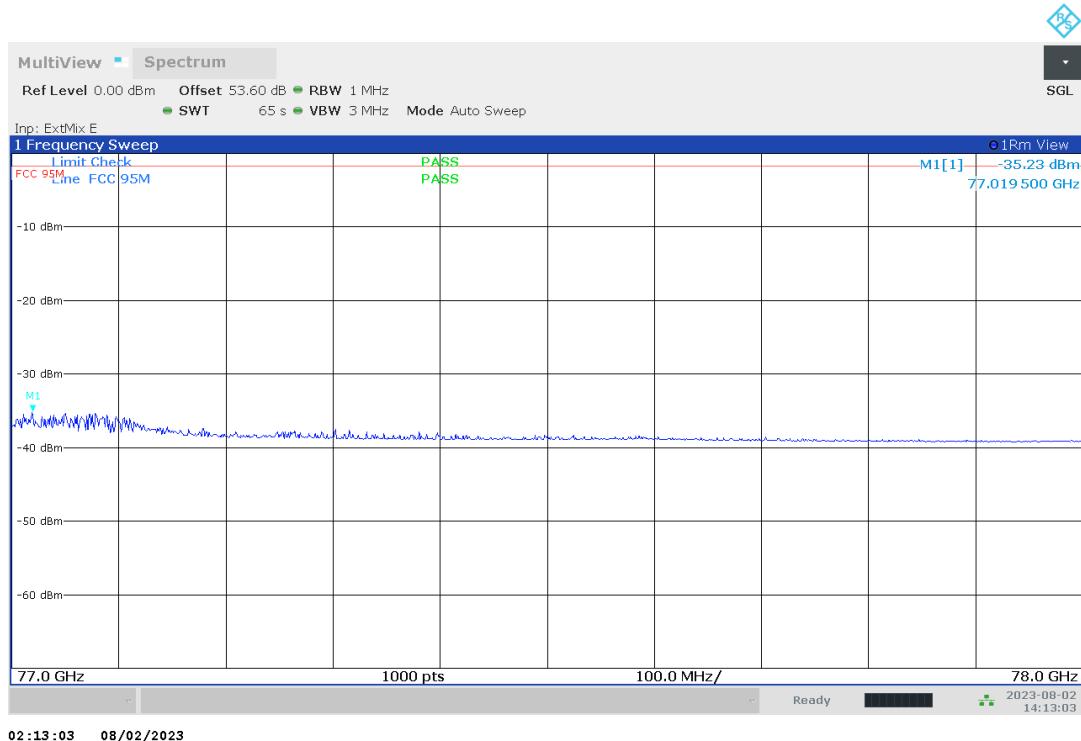
Plot no. 46: radiated emissions, BEC, polarization aligned with radar sensor, Front mode



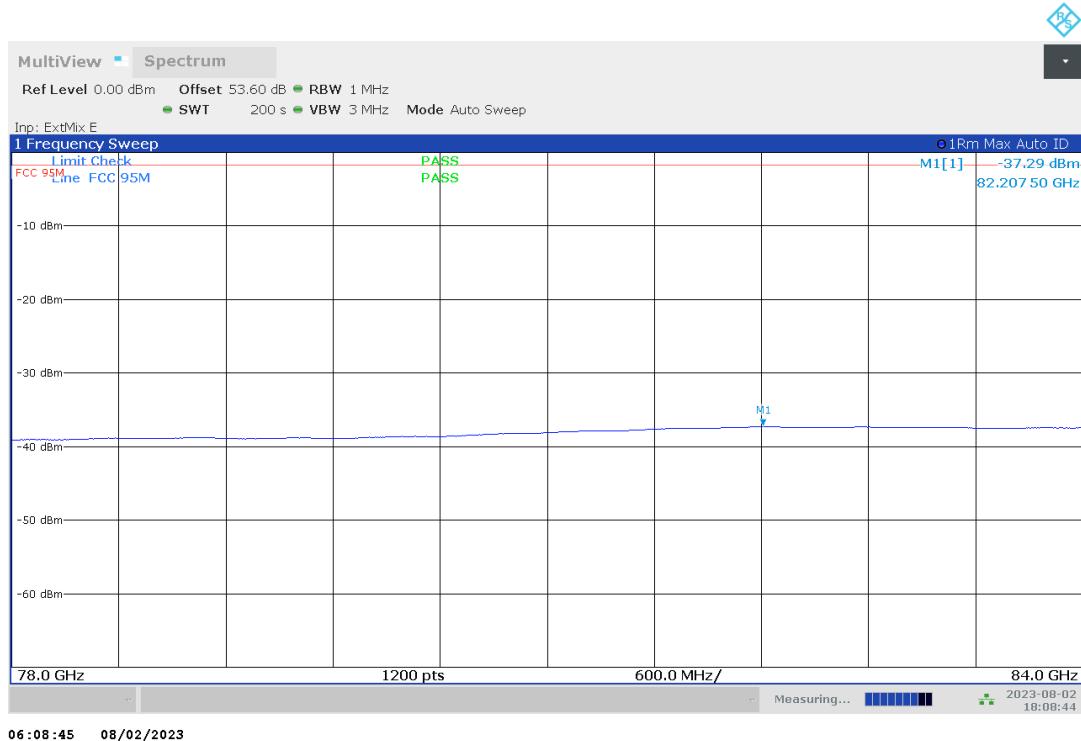
Plot no. 47: radiated emissions 77 GHz – 78 GHz, polarization vertical / horizontal, Corner mode



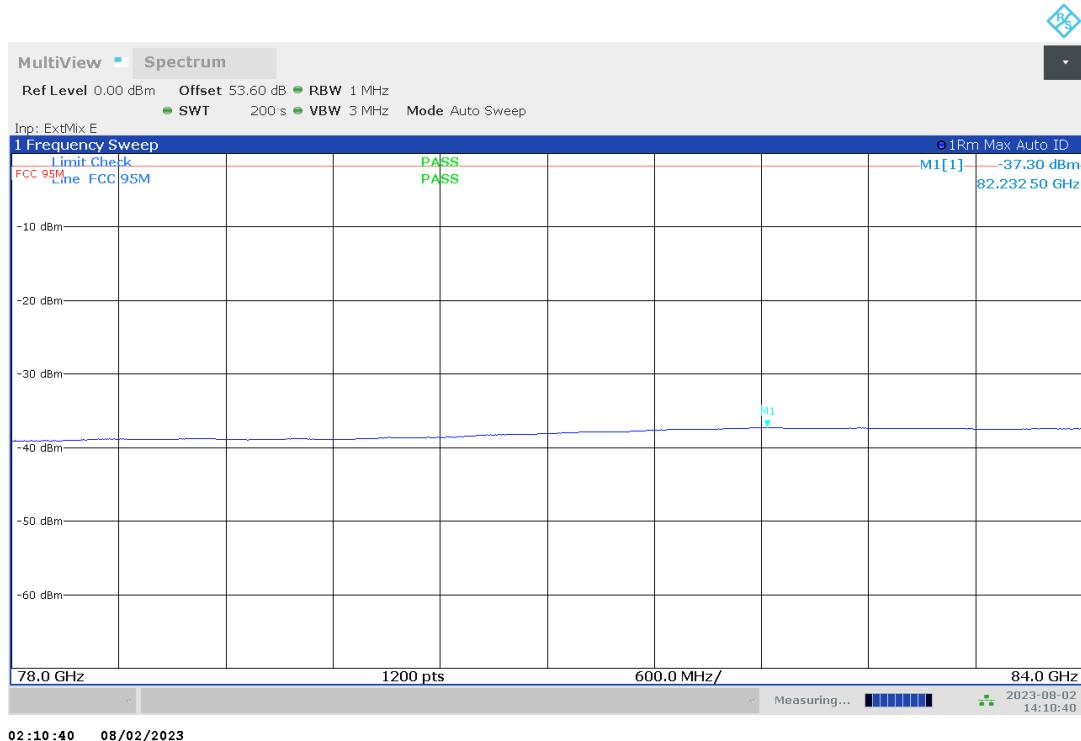
Plot no. 48: radiated emissions 77 GHz – 78 GHz, polarization vertical / horizontal, Front mode



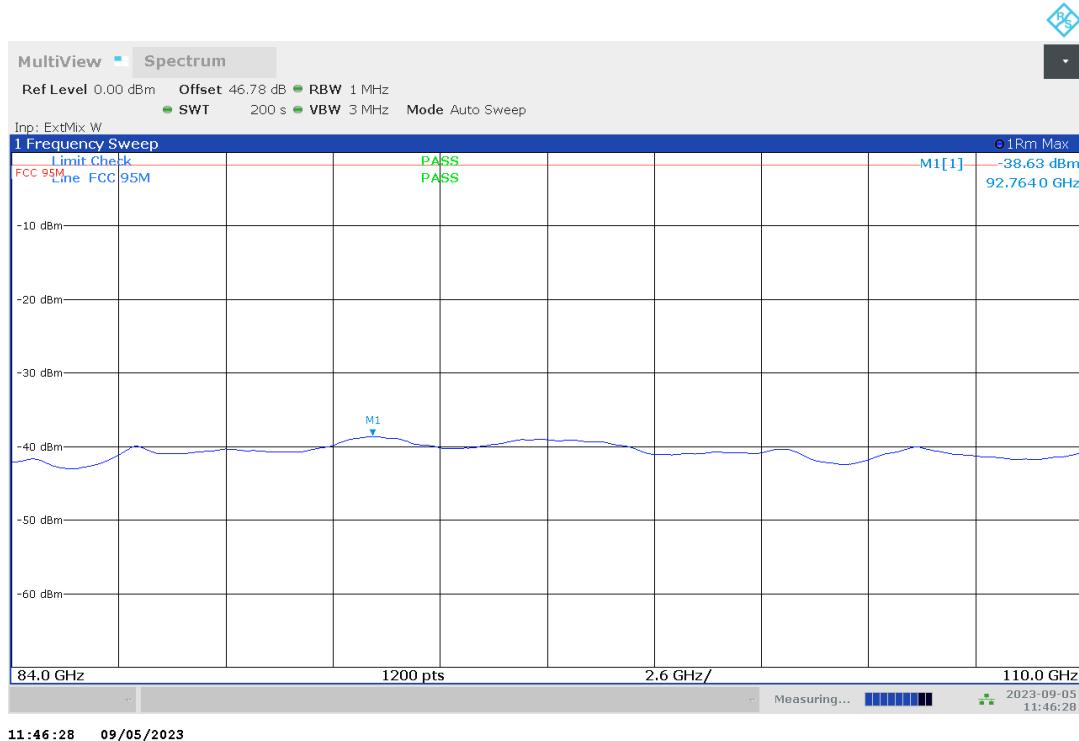
Plot no. 49: radiated emissions 78 GHz – 84 GHz, polarization vertical / horizontal, Corner mode



Plot no. 50: radiated emissions 78 GHz – 84 GHz, polarization vertical / horizontal, Front mode

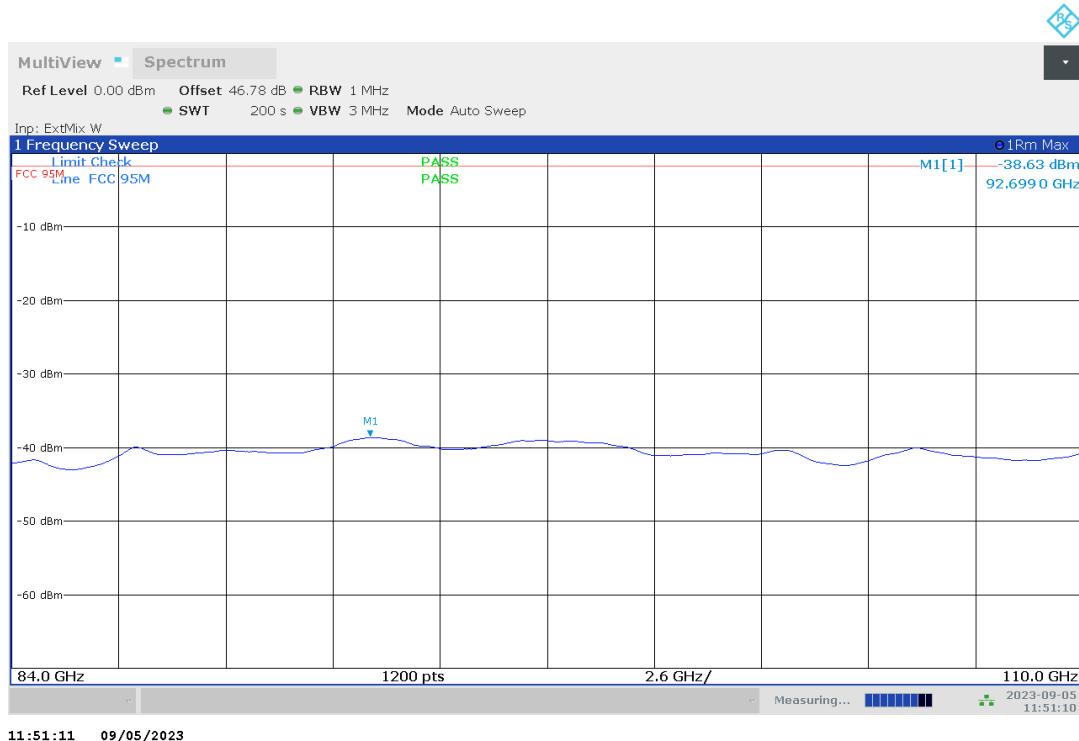


Plot no. 51: radiated emissions 84 GHz – 110 GHz, polarization vertical / horizontal, Corner mode



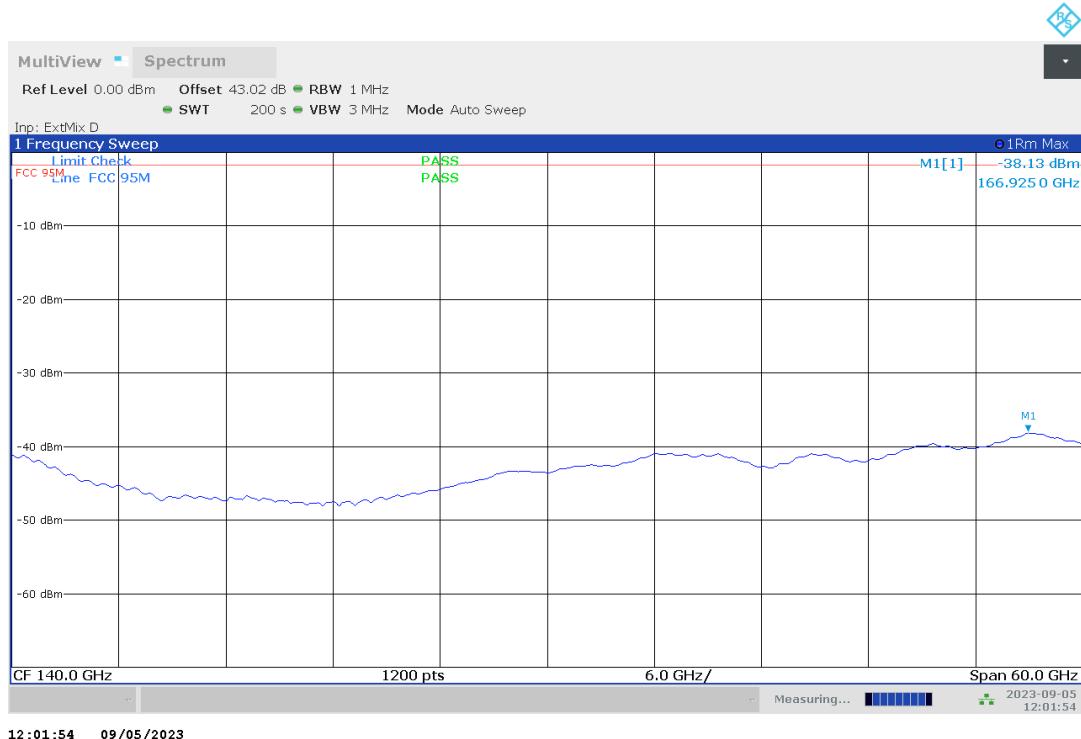
11:46:28 09/05/2023

Plot no. 52: radiated emissions 84 GHz – 110 GHz, polarization vertical / horizontal, Front mode

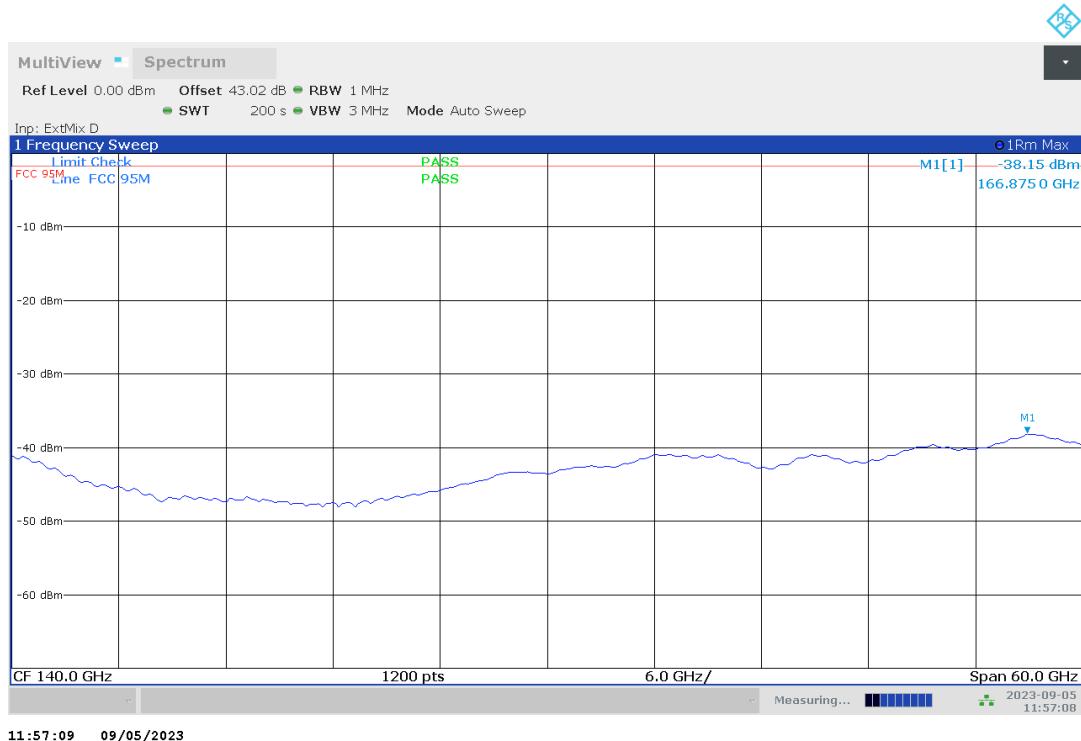


11:51:11 09/05/2023

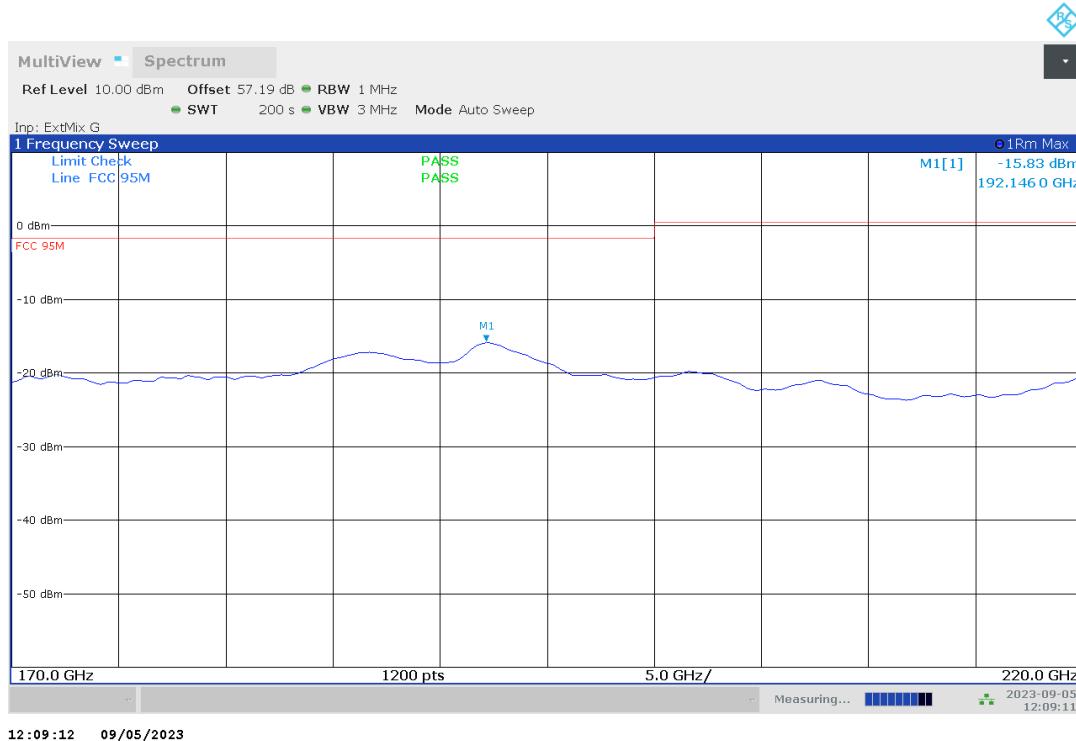
Plot no. 53: radiated emissions 110 GHz – 170 GHz, polarization vertical / horizontal, Corner mode



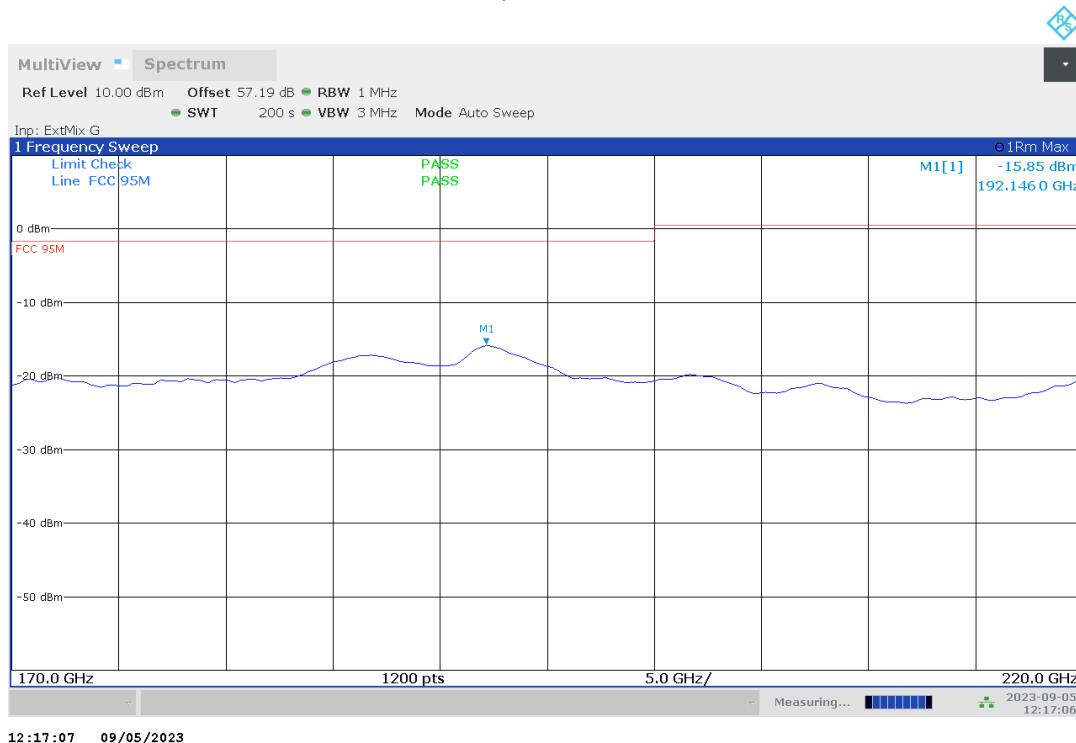
Plot no. 54: radiated emissions 110 GHz – 170 GHz, polarization vertical / horizontal, Front mode



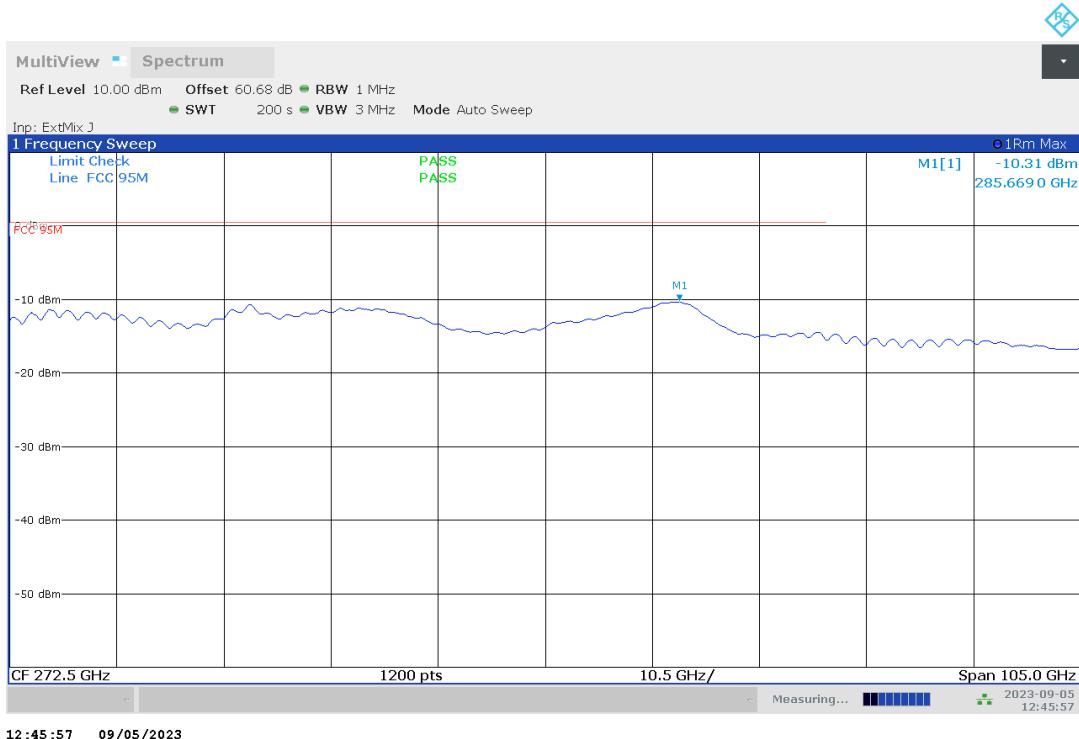
Plot no. 55: radiated emissions 170 GHz – 220 GHz, polarization vertical / horizontal, Corner mode



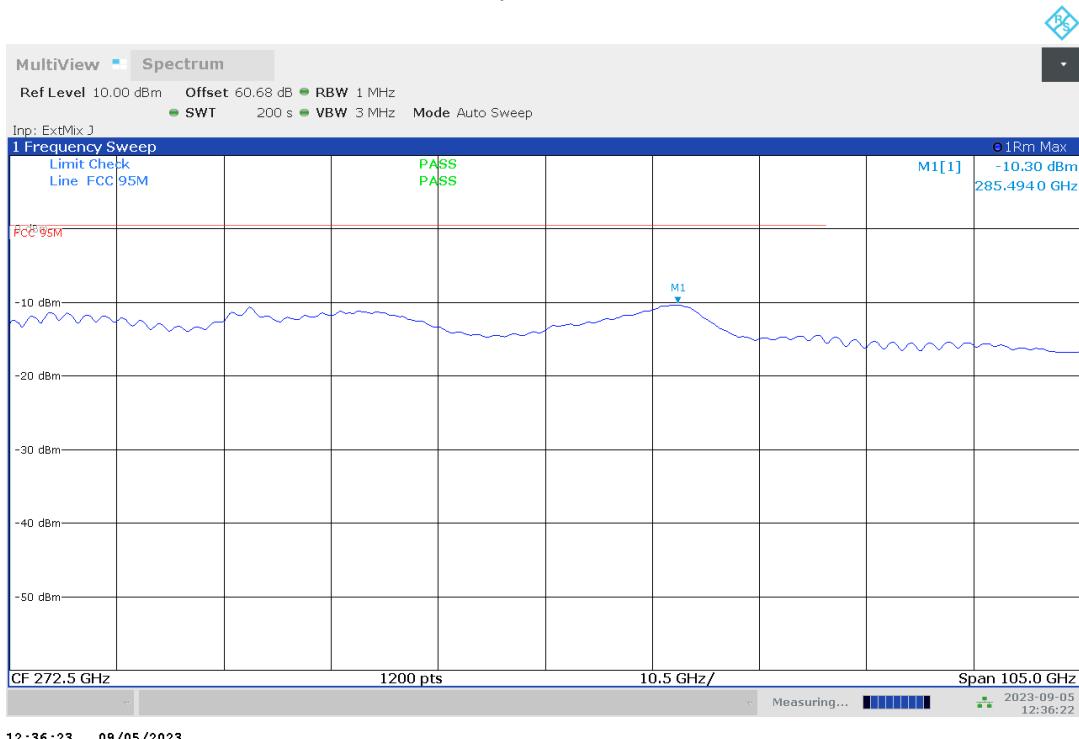
Plot no. 56: radiated emissions 170 GHz – 220 GHz, polarization vertical / horizontal, Front mode



Plot no. 57: radiated emissions 220 GHz – 325 GHz, polarization vertical / horizontal, Corner mode



Plot no. 58: radiated emissions 220 GHz – 325 GHz, polarization vertical / horizontal, Front mode



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

### Description

§2.1055 Measurements required: Frequency stability.

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

(1) From  $-30^{\circ}$  to  $+50^{\circ}$  centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

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

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

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

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

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

### Limits

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

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

### Test procedure

ANSI C63.26, 5.4.4

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

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

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

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

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than  $[10 \log (OBW/RBW)]$  below the reference level. Specific guidance is given in 4.1.5.2.

Note: Step a) through step c) may require iteration to adjust within the specified tolerances.

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

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

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

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

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

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

**Note**

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

**Test setup:** 8.3, 8.4

**Test results / Note**

Please see measurement results for occupied bandwidth.

## 8 Test Setup Description

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

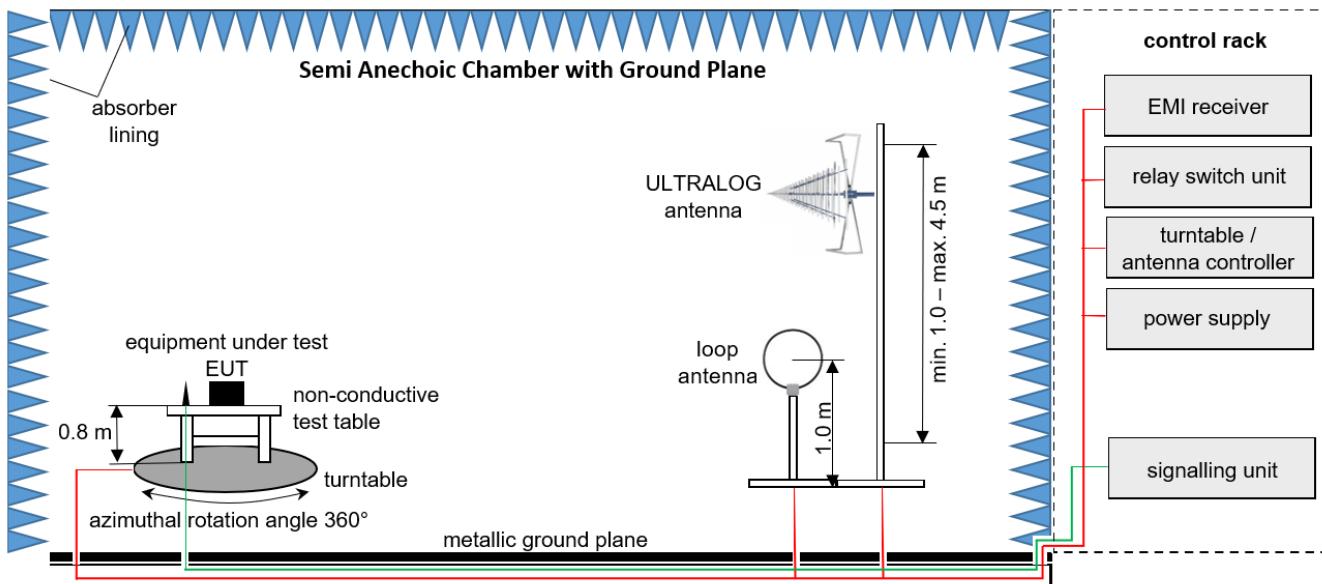
In order to simplify the identification of the equipment used at some special tests, some items of test equipment and ancillaries can be provided with an identifier or number in the equipment list below (Lab/Item).

**Kind of calibration (abbreviations):**

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

## 8.1 Semi Anechoic Chamber with Ground Plane

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



Measurement distance: ULTRALOG antenna at 3 m; loop antenna at 3 m

EMC32 software version: 11.20.00

$$FS = UR + CL + AF$$

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

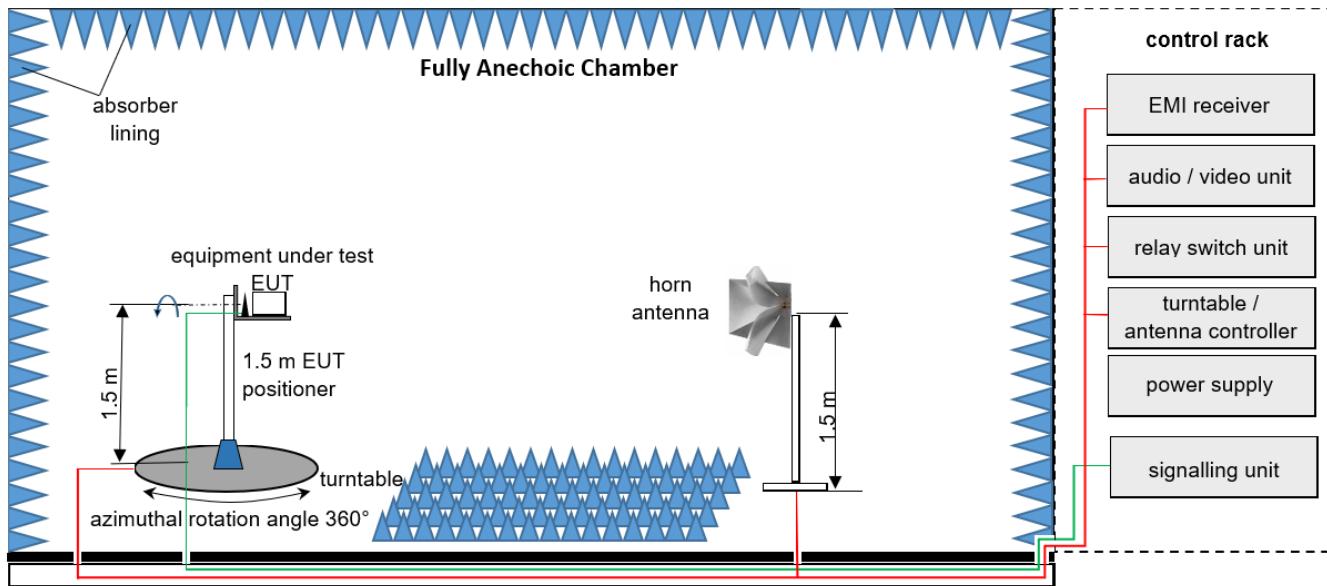
Example calculation:

$$FS [\text{dB}\mu\text{V}/\text{m}] = 12.35 [\text{dB}\mu\text{V}/\text{m}] + 1.90 [\text{dB}] + 16.80 [\text{dB}/\text{m}] = 31.05 [\text{dB}\mu\text{V}/\text{m}] (35.69 \mu\text{V}/\text{m})$$

**List of test equipment used:**

| No. | Equipment                          | Manufacturer                    | Type                           | Serial No.   | IBL No.   | Kind of Calibration | Last / Next Calibration       |
|-----|------------------------------------|---------------------------------|--------------------------------|--------------|-----------|---------------------|-------------------------------|
| 1   | Power Supply                       | Elektro-Automatik GmbH & Co. KG | EA-PSI 9080-40 T               | 2000230001   | LAB000313 | NR                  | –                             |
| 2   | Test table                         | innco systems GmbH              | PT1208-080-RH                  | -            | LAB000306 | NR                  | –                             |
| 3   | Power Supply                       | Chroma                          | 61604                          | 616040005416 | LAB000285 | NR                  | –                             |
| 4   | Positioner                         | maturo GmbH                     | TD 1.5-10KG                    |              | LAB000258 | NR                  | –                             |
| 5   | Compressed Air                     | Implotex                        | 1-850-30                       | -            | LAB000256 | NR                  | –                             |
| 6   | EMI Test Receiver                  | Rohde & Schwarz                 | ESW26                          | 101481       | LAB000236 | C                   | 2023-07-04 → 12M → 2024-07-04 |
| 7   | Semi/Fully Anechoic Chamber (SFAC) | Albatross Projects GmbH         | Babylon 5 (SAC 5)              | 20168.PRB    | LAB000235 | NR                  | –                             |
| 8   | Measurement Software               | Rohde & Schwarz                 | EMC32 V11.20                   |              | LAB000226 | NR                  | –                             |
| 9   | Turntable                          | maturo GmbH                     | TT2.0-2t                       | TT2.0-2t/921 | LAB000225 | NR                  | –                             |
| 10  | Antenna Mast                       | maturo GmbH                     | CAM4.0-P                       | CAM4.0-P/316 | LAB000224 | NR                  | –                             |
| 11  | Antenna Mast                       | maturo GmbH                     | BAM4.5-P                       | BAM4.5-P/272 | LAB000223 | NR                  | –                             |
| 12  | Controller                         | maturo GmbH                     | FCU 3.0                        | 10082        | LAB000222 | NR                  | –                             |
| 13  | Power Supply                       | Elektro-Automatik GmbH & Co. KG | EA-PS 2042-10 B                | 2878350292   | LAB000191 | NR                  | –                             |
| 14  | Pre-Amplifier                      | Schwarzbeck Mess-Elektronik OHG | BBV 9718 C                     | 84           | LAB000169 | NR                  | –                             |
| 15  | Antenna                            | Rohde & Schwarz                 | HF907                          | 102899       | LAB000151 | C                   | 2023-05-15 → 36M → 2026-05-15 |
| 16  | Antenna                            | Rohde & Schwarz                 | HL562E                         | 102005       | LAB000150 | C                   | 2022-12-22 → 36M → 2025-12-22 |
| 17  | Open Switch and Control Platform   | Rohde & Schwarz                 | OSP200 Base Unit 2HU           | 101748       | LAB000149 | NR                  | –                             |
| 18  | Antenna                            | Rohde & Schwarz                 | HF907                          | 102898       | LAB000124 | C                   | 2023-06-13 → 36M → 2026-06-13 |
| 19  | Antenna                            | Rohde & Schwarz                 | HL562E                         | 102001       | LAB000123 | C                   | 2023-04-05 → 36M → 2026-04-05 |
| 20  | Antenna                            | Rohde & Schwarz                 | HFH2-Z2E - Active Loop Antenna | 100954       | LAB000108 | C                   | 2023-05-05 → 36M → 2026-05-05 |

## 8.2 Fully Anechoic Chamber



Measurement distance: horn antenna at 3 m

EMC32 software version: 11.20.00

FS = UR + CA + AF

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

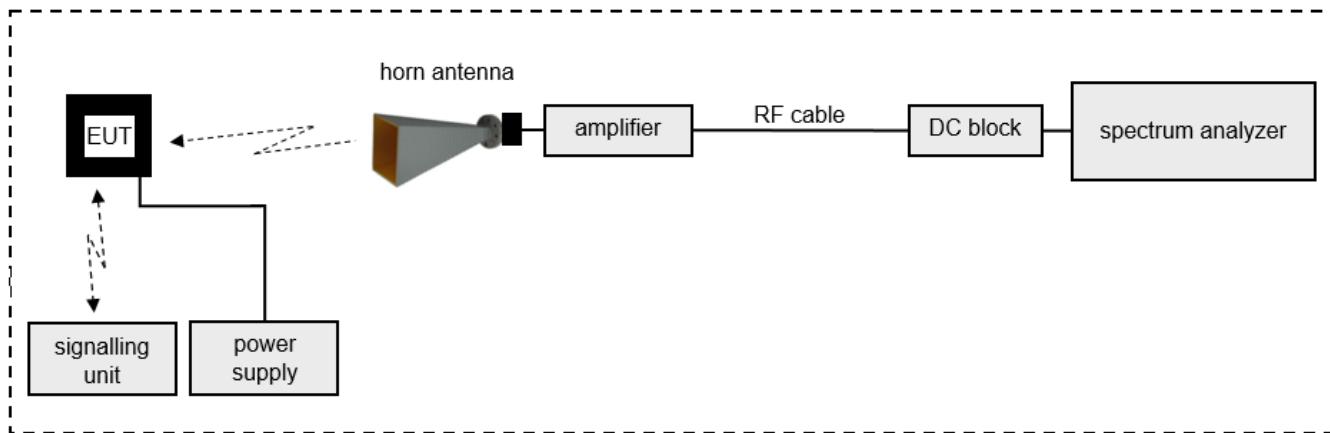
Example calculation:

$$\text{FS [dB}\mu\text{V/m]} = 40.0 \text{ [dB}\mu\text{V/m]} + (-35.8) \text{ [dB]} + 32.9 \text{ [dB/m]} = 37.1 \text{ [dB}\mu\text{V/m]} (71.61 \mu\text{V/m})$$

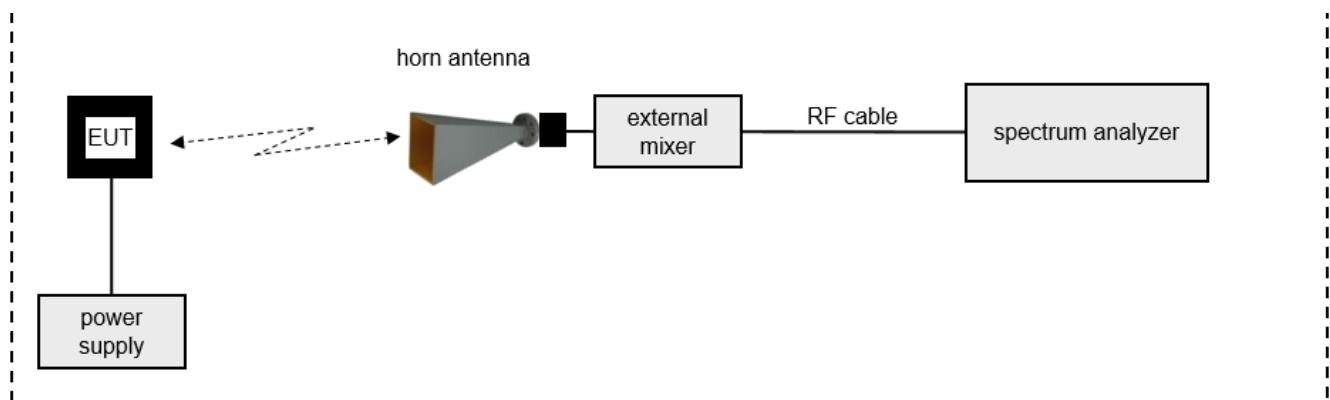
**List of test equipment used:**

| No. | Equipment                          | Manufacturer                    | Type                           | Serial No.   | IBL No.   | Kind of Calibration | Last / Next Calibration       |
|-----|------------------------------------|---------------------------------|--------------------------------|--------------|-----------|---------------------|-------------------------------|
| 1   | Power Supply                       | Elektro-Automatik GmbH & Co. KG | EA-PSI 9080-40 T               | 2000230001   | LAB000313 | NR                  | –                             |
| 2   | Test table                         | innco systems GmbH              | PT1208-080-RH                  | -            | LAB000306 | NR                  | –                             |
| 3   | Power Supply                       | Chroma                          | 61604                          | 616040005416 | LAB000285 | NR                  | –                             |
| 4   | Positioner                         | maturo GmbH                     | TD 1.5-10KG                    |              | LAB000258 | NR                  | –                             |
| 5   | Compressed Air                     | Implotex                        | 1-850-30                       | -            | LAB000256 | NR                  | –                             |
| 6   | EMI Test Receiver                  | Rohde & Schwarz                 | ESW26                          | 101481       | LAB000236 | C                   | 2023-07-04 → 12M → 2024-07-04 |
| 7   | Semi/Fully Anechoic Chamber (SFAC) | Albatross Projects GmbH         | Babylon 5 (SAC 5)              | 20168.PRB    | LAB000235 | NR                  | –                             |
| 8   | Measurement Software               | Rohde & Schwarz                 | EMC32 V11.20                   |              | LAB000226 | NR                  | –                             |
| 9   | Turntable                          | maturo GmbH                     | TT2.0-2t                       | TT2.0-2t/921 | LAB000225 | NR                  | –                             |
| 10  | Antenna Mast                       | maturo GmbH                     | CAM4.0-P                       | CAM4.0-P/316 | LAB000224 | NR                  | –                             |
| 11  | Antenna Mast                       | maturo GmbH                     | BAM4.5-P                       | BAM4.5-P/272 | LAB000223 | NR                  | –                             |
| 12  | Controller                         | maturo GmbH                     | FCU 3.0                        | 10082        | LAB000222 | NR                  | –                             |
| 13  | Power Supply                       | Elektro-Automatik GmbH & Co. KG | EA-PS 2042-10 B                | 2878350292   | LAB000191 | NR                  | –                             |
| 14  | Pre-Amplifier                      | Schwarzbeck Mess-Elektronik OHG | BBV 9718 C                     | 84           | LAB000169 | NR                  | –                             |
| 15  | Antenna                            | Rohde & Schwarz                 | HF907                          | 102899       | LAB000151 | C                   | 2023-05-15 → 36M → 2026-05-15 |
| 16  | Antenna                            | Rohde & Schwarz                 | HL562E                         | 102005       | LAB000150 | C                   | 2022-12-22 → 36M → 2025-12-22 |
| 17  | Open Switch and Control Platform   | Rohde & Schwarz                 | OSP200 Base Unit 2HU           | 101748       | LAB000149 | NR                  | –                             |
| 18  | Antenna                            | Rohde & Schwarz                 | HF907                          | 102898       | LAB000124 | C                   | 2023-06-13 → 36M → 2026-06-13 |
| 19  | Antenna                            | Rohde & Schwarz                 | HL562E                         | 102001       | LAB000123 | C                   | 2023-04-05 → 36M → 2026-04-05 |
| 20  | Antenna                            | Rohde & Schwarz                 | HFH2-Z2E - Active Loop Antenna | 100954       | LAB000108 | C                   | 2023-05-05 → 36M → 2026-05-05 |

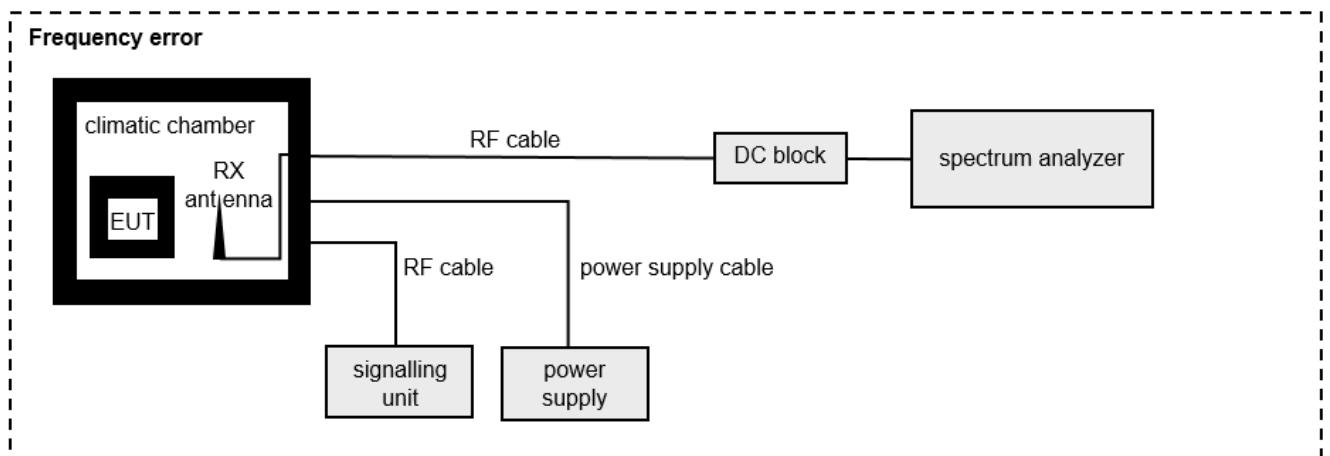
### 8.3 Radiated measurements > 18 GHz



### 8.4 Radiated measurements > 50 GHz



### 8.5 Radiated measurements under extreme conditions



**ROP = AV + D - G**

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

**Example calculation:**

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

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

**List of test equipment used:**

| No. | Equipment         | Manufacturer                    | Type               | Serial No. | IBL No.   | Kind of Calibration | Calibration                   |
|-----|-------------------|---------------------------------|--------------------|------------|-----------|---------------------|-------------------------------|
| 1   | Test table        | innco systems GmbH              | PT0707-RH light    | -          | LAB000303 | NR                  | -                             |
| 2   | Power Supply      | Elektro-Automatik GmbH & Co. KG | EA-PS 2042-10 B    | 2878350255 | LAB000189 | NR                  | -                             |
| 3   | WG-Coax-Adapter   | Flann Microwave Ltd             | 23373-TF30 UG383/U | 273385     | LAB000185 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 4   | WG-Coax-Adapter   | Flann Microwave Ltd             | 22093-TF30 UG599/U | 273263     | LAB000183 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 5   | WG-Coax-Adapter   | Flann Microwave Ltd             | 20093-TF30 UBR220  | 273374     | LAB000181 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 6   | Antenna           | Flann Microwave Ltd             | 30240-20           | 273390     | LAB000178 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 7   | Coaxial Cable     | Huber & Suhner                  | SF101/1.0m         | 503990/1   | LAB000164 | CM                  | 2023-07-17 → 12M → 2024-07-17 |
| 8   | Coaxial Cable     | Rosenberger                     | LU7-022-1000       | 34         | LAB000154 | NR                  | -                             |
| 9   | Coaxial Cable     | Rosenberger                     | LU7-022-1000       | 33         | LAB000153 | NR                  | -                             |
| 10  | Antenna           | Flann Microwave Ltd             | 32240-20           | 273469     | LAB000152 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 11  | Antenna           | Flann Microwave Ltd             | 29240-20           | 273382     | LAB000139 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 12  | Antenna           | Flann Microwave Ltd             | 28240-20           | 273371     | LAB000176 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 13  | Antenna           | Flann Microwave Ltd             | 27240-20           | 273367     | LAB000137 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 14  | Antenna           | Flann Microwave Ltd             | 26240-20           | 273417     | LAB000135 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 15  | Antenna           | Flann Microwave Ltd             | 25240-20           | 272860     | LAB000133 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 16  | Antenna           | Flann Microwave Ltd             | 23240-20           | 273430     | LAB000132 | CM                  | 2022-09-01 → 36M → 2025-09-01 |
| 17  | Antenna           | Flann Microwave Ltd             | 22240-20           | 270448     | LAB000130 | K                   | 2023-07-17 → 12M → 2024-07-17 |
| 18  | Antenna           | Flann Microwave Ltd             | 20240-20           | 266403     | LAB000128 | K                   | 2023-07-17 → 12M → 2024-07-17 |
| 19  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z170            | 100996     | LAB000126 | K                   | 2023-04-26 → 12M → 2024-04-26 |
| 20  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z325            | 101015     | LAB000117 | K                   | 2023-04-11 → 12M → 2024-04-11 |
| 21  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z220            | 101039     | LAB000116 | K                   | 2023-04-06 → 12M → 2024-04-06 |
| 22  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z140            | 101144     | LAB000115 | K                   | 2023-05-23 → 12M → 2024-05-23 |
| 23  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z110            | 102000     | LAB000114 | K                   | 2023-05-02 → 12M → 2024-05-02 |
| 24  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z090            | 102020     | LAB000113 | K                   | 2023-04-06 → 12M → 2024-04-06 |
| 25  | Harmonic Mixer    | Rohde & Schwarz                 | FS-Z075            | 102015     | LAB000112 | K                   | 2023-05-03 → 12M → 2024-05-03 |
| 26  | Spectrum Analyser | Rohde & Schwarz                 | FSW50              | 101450     | LAB000111 | K                   | 2023-07-26 → 12M → 2024-07-26 |
| 27  | Climatic Chamber  | CTS GmbH                        | T-65/50            | 204002     | LAB000110 | CM                  | 2023-05-11 → 12M → 2024-05-11 |
| 28  | Antenna Mast      | Schwarzbeck Mess-Elektronik OHG | AM 9104            | 99         | LAB000109 | NR                  | -                             |

## 9 MEASUREMENT PROCEDURES

### 9.1 Radiated spurious emissions from 9 kHz to 30 MHz

#### Test setup

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

#### Pre-scan

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

#### Final measurement

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

#### Distance correction (extrapolation)

- When performing measurements on test distances other than defined in the rules, the results shall be extrapolated to the specified distance by conservatively presuming that the field strength decays at 40 dB/decade of distance in the region closer than  $\lambda$  in m divided by  $2\pi$  (i.e.,  $\lambda/2\pi$ ), and at 20 dB/decade of distance beyond that, using the measurement of a single point at the radial angle that produces the maximum emission.

This correction is already included in the limit line of corresponding measurement plots.

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

## 9.2 Radiated spurious emissions from 30 MHz to 1 GHz

### Test setup

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

### Pre-scan

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

### Final measurement

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

### Distance correction (extrapolation)

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

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

## 9.3 Radiated spurious emissions from 1 GHz to 18 GHz

### Test setup

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

### Pre-scan

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

### Final measurement

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

### Distance correction (extrapolation)

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

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

## 9.4 Radiated spurious emissions above 18 GHz

### Test setup

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

### Pre-scan

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

### Final measurement

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

### Note

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

### Distance correction (extrapolation)

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

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

## 10 MEASUREMENT UNCERTAINTIES

|                               |                                     |
|-------------------------------|-------------------------------------|
| Radio frequency               | $\leq \pm 10 \text{ ppm}$           |
| Radiated emission             | $\leq \pm 6 \text{ dB}$             |
| Temperature                   | $\leq \pm 1 \text{ }^\circ\text{C}$ |
| Humidity                      | $\leq \pm 5 \text{ \%}$             |
| DC and low frequency voltages | $\leq \pm 3 \text{ \%}$             |

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