

## Test Report

### 23-1-0086301T004a-C2

|                                                  |                                                                                                                                                                                                                                                                                                |                 |                     |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|---------------------|
| Number of pages:                                 | 32                                                                                                                                                                                                                                                                                             | Date of Report: | 2025-Jun-12         |
| Testing company:                                 | <p>cetecom advanced GmbH<br/>Untertuerkheimer Str. 6-10<br/>66117 Saarbruecken<br/>GERMANY</p>                                                                                                                                                                                                 | Applicant:      | <p>indurad GmbH</p> |
| Product:                                         | 1D Radar                                                                                                                                                                                                                                                                                       |                 |                     |
| Model:                                           | iLDR-M-G5                                                                                                                                                                                                                                                                                      |                 |                     |
| FCC ID:                                          | 2AJRSILDRG5                                                                                                                                                                                                                                                                                    |                 |                     |
| Testing has been carried out in accordance with: | <p><b>FCC Regulations</b><br/><b>Title 47 CFR, Chapter I, Subchapter D, Part 95</b><br/><b>Subpart M</b><br/><b>The 76-81 GHz Band Radar Service</b><br/>§ 95.3367 76-81 GHz Band Radar Service radiated power limits<br/>§ 95.3379 76-81 GHz Band Radar Service unwanted emissions limits</p> |                 |                     |
| Tested Technology:                               | Radar (76G – 81GHz)                                                                                                                                                                                                                                                                            |                 |                     |
| Test Results:                                    | <p><input checked="" type="checkbox"/> <b>The EUT complies with the requirements in respect of all parameters subject to the test.</b><br/>The test results relate only to devices specified in this document</p>                                                                              |                 |                     |

The current version of Test Report 23-1-0086301T004a-C2 replaces the test report 23-1-0086301T004a-C1, dated 2025-Jun-04. The replaced test report is herewith invalid.

#### Signatures:

|                                                                                     |                                                                                                                                                                                    |                                                                                       |                                                                                                                                                               |
|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| Christian Lorenz<br>Lab Manager<br>Authorization of test report                     |                                                                                                                                                                                    | on behalf of                                                                          | Al-Amin Hossain<br>Lab Manager<br>Responsible of test report                                                                                                  |

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# 1 General information

## 1.1 Disclaimer and Notes

The test results of this test report relate exclusively to the test item specified in this test report as specified in chapter 2.7. cetecom advanced does not assume responsibility for any conclusions and generalizations drawn from the test results with regard to other specimens or samples of the type of the equipment represented by the test item.

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Also we refer on special conditions which the applicant should fulfill according §2.927 to §2.948, special focus regarding modification of the equipment and availability of sample equipment for market surveillance tests.

## 1.2 Summary of Test Results

The EUT integrates a Radar transmitter. Other implemented wireless technologies were not considered within this test report.

| Test specification clause                                        | Test case                               | Temperature conditions | Power source voltages | Pass                                | Fail                     | NA                       | NP                                  | Remark      |
|------------------------------------------------------------------|-----------------------------------------|------------------------|-----------------------|-------------------------------------|--------------------------|--------------------------|-------------------------------------|-------------|
| §2.1046<br>§95.3367 (a) / (b)                                    | Radiated power                          | Nominal                | Nominal               | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | complies    |
| §2.1047                                                          | Modulation characteristics              | -/-                    | -/-                   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | See Annex 5 |
| §2.1049                                                          | Occupied bandwidth (99% bandwidth)      | Nominal                | Nominal               | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | complies    |
| §2.1051                                                          | Spurious emissions at antenna terminals | Nominal                | Nominal               | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | complies    |
| §2.1053<br>§95.3379 (a)(1)<br>§95.3379 (a)(2)<br>§95.3379 (a)(3) | Unwanted emissions (radiated spurious)  | Nominal                | Nominal               | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | complies    |
| §2.1055<br>§95.3379 (b)                                          | Frequency stability                     | Nominal and Extreme    | Nominal and Extreme   | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/>            | complies    |

Note: C = Compliant; NC = Not compliant; NA = Not applicable; NP = Not performed

See 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 of devices operating under Sections 15.253 and 15.255 may exceed the +20 dBm input power limit of many commercially available mixers. For these reasons a radiated method is preferred.

Decision Rule: cetecom advanced GmbH follows [ILAC G8:2019 chapter 4.2.1 \(Simple Acceptance Rule\)](#).

## 1.3 Summary of Test Methods

| Guidance             | Version | Description                                                                                                                                                         |
|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ANSI C63.4-2014      | -/-     | American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz |
| ANSI C63.26-2015     | -/-     | American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services                                                                   |
| 76-81 GHz Radars KDB | v01r02  | 653005 D01 76-81 GHz Radars v01r02: EQUIPMENT AUTHORIZATION GUIDANCE FOR 76-81 GHz RADAR DEVICES                                                                    |

## 2 Administrative Data

### 2.1 Identification of the Testing Laboratory

|                                     |                                                             |  |                                  |
|-------------------------------------|-------------------------------------------------------------|--|----------------------------------|
| Company name:                       | cetekom advanced GmbH                                       |  |                                  |
| Address:                            | Untertuerkheimer Str. 6-10<br>66117 Saarbruecken<br>Germany |  |                                  |
| Responsible for testing laboratory: | Dipl.-Ing. (FH) Andreas Luckenbill M.Sc.                    |  |                                  |
| Accreditation scope:                | DAkkS Webpage: <a href="#">FCC</a> <a href="#">ISED</a>     |  |                                  |
| Lab company recognition no.:        | Location Essen-Laboratory<br>DE0003                         |  | Location SB Laboratory<br>DE0002 |
| Test location 1:                    | Im Teelbruch 116; 45219 Essen                               |  |                                  |
| Test location 2:                    | Untertuerkheimer Str. 6-10; 66117 Saarbruecken              |  |                                  |

### 2.2 General limits for environmental conditions

|                     |           |
|---------------------|-----------|
| Temperature:        | 22±2 °C   |
| Relative. humidity: | 45±15% rH |

### 2.3 Test Laboratories sub-contracted

|               |    |
|---------------|----|
| Company name: | -- |
|---------------|----|

### 2.4 Organizational Items

|                           |                            |
|---------------------------|----------------------------|
| Responsible test manager: | Al-Amin Hossain            |
| Receipt of EUT:           | 2023-Aug-01                |
| Date(s) of test:          | 2023-Aug-01 to 2024-Jan-30 |
| Version of template:      | 24.0101                    |

### 2.5 Applicant's details

|                         |                                                                      |
|-------------------------|----------------------------------------------------------------------|
| Applicant's name:       | indurad GmbH                                                         |
| Address:                | Belvederealle 5<br>52070 Aachen<br>North Rhine-Westphalia<br>Germany |
| Contact Person:         | Matthias Rabel                                                       |
| Contact Person's Email: | matthias.rabel@indurad.com                                           |

### 2.6 Manufacturer's details

|                      |                                            |
|----------------------|--------------------------------------------|
| Manufacturer's name: | indurad GmbH                               |
| Address:             | Belvederealle 5<br>52070 Aachen<br>Germany |

## 2.7 EUT: Type, S/N etc. and short descriptions used in this test report

| Short description*) | PMT Sample No.    | Product  | Model     | Type            | S/N | HW status | SW status |
|---------------------|-------------------|----------|-----------|-----------------|-----|-----------|-----------|
| EUT 1               | 23-1-00863S03_C01 | 1D Radar | iLDR-M-G5 | iLDR-M-G5-DN100 | --  | G5        | E5        |

\*) EUT short description is used to simplify the identification of the EUT in this test report.

## 2.8 Untested Variant (VAR)

| VAR No. *) | Sample No. | Product  | Model     | Type           | SN | HW | SW |
|------------|------------|----------|-----------|----------------|----|----|----|
| --         | --         | 1D Radar | iLDR-M-G5 | iLDR-M-G5-DN50 | -- | G5 | E5 |
| --         | --         | 1D Radar | iLDR-M-G5 | iLDR-M-G5-DN80 | -- | G5 | E5 |

\*) The listed additional untested model variant(s) (VAR) is/are not object of evaluation of compliance. For further information please see Annex 5: Declaration of applicant of model differences.

If the table above does not show any other line than the headline, no untested variants are available.

## 2.9 Auxiliary Equipment (AE): Type, S/N etc. and short descriptions

| Short description*) | PMT Sample No.    | Auxiliary Equipment | Type     | S/N               | HW status | SW status         |
|---------------------|-------------------|---------------------|----------|-------------------|-----------|-------------------|
| AE 1                | 23-1-00863S09_C01 | Laptop              | ThinkPad | heineken 77-81GHz | -         | run iDat solution |

\*) AE short description is used to simplify the identification of the auxiliary equipment in this test report.

## 2.10 Connected cables

| Short description*) | PMT Sample No.    | Cable type    | Connectors | Length |
|---------------------|-------------------|---------------|------------|--------|
| CAB 01              | 23-1-00863S06_C01 | Cable harness | --         | N/A    |
| CAB 02              | --                | LAN Cable     | --         | N/A    |

\*) CAB short description is used to simplify the identification of the connected cables in this test report.

## 2.11 Software

| Short description*) | PMT Sample No. | Software | Type | S/N | HW status | SW status |
|---------------------|----------------|----------|------|-----|-----------|-----------|
| -                   | -              | -        | -    | -   | -         | -         |

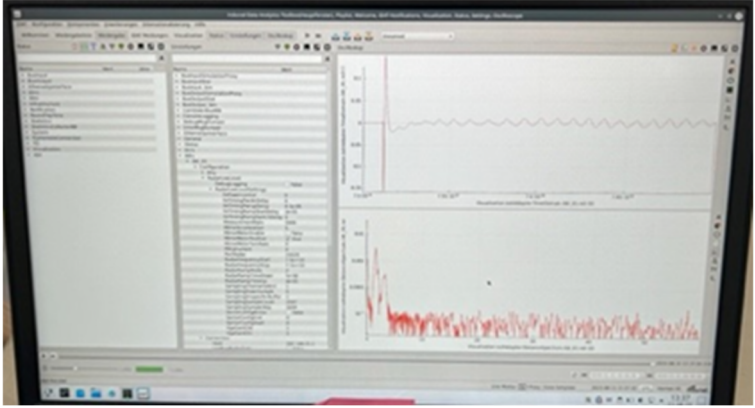
\*) SW short description is used to simplify the identification of the used software in this test report.

## 2.12 EUT set-ups

| set-up no. *) | Combination of EUT and AE    | Description                                            |
|---------------|------------------------------|--------------------------------------------------------|
| Set. 1        | EUT 1 + AE 1 + CAB 1 + CAB 2 | This setup has been used for all radiated measurements |

\*) EUT set-up no. is used to simplify the identification of the EUT set-up in this test report.

## 2.13 EUT operation modes

| EUT operating mode no. *) | Operating modes                                                                                           | Additional information                                                                                                                                                                                                                                                          |
|---------------------------|-----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| op. 1                     | <p>EUT set to Normal mode(76G to 81GHz),<br/>RADAR is Active,</p> <p>EUT in Transmit and Receive mode</p> | <ul style="list-style-type: none"> <li>➤ AE 1 + CAB 2 have been used to set the EUT in operation mode</li> <li>➤ Customer provided tool has been used to set the EUT in operation</li> </ul>  |

\*) EUT operating mode no. is used to simplify the test report.

### 3 Equipment under test (EUT)

#### 3.1 General Data of Main EUT as Declared by Applicant

|                                                                                  |                                                      |                              |                                                                        |
|----------------------------------------------------------------------------------|------------------------------------------------------|------------------------------|------------------------------------------------------------------------|
| Product name                                                                     | 1D Radar                                             |                              |                                                                        |
| Kind of product                                                                  | iLDR-M-G5                                            |                              |                                                                        |
| Firmware                                                                         | <input type="checkbox"/> for normal use              |                              | <input checked="" type="checkbox"/> Special version for test execution |
| Power supply                                                                     | <input type="checkbox"/> AC Mains                    | -                            |                                                                        |
|                                                                                  | <input checked="" type="checkbox"/> DC Mains         | 24 V DC via banana Connector |                                                                        |
|                                                                                  | <input type="checkbox"/> Battery                     | --                           |                                                                        |
| Operational conditions                                                           | T <sub>nom</sub> = 20 °C                             | T <sub>min</sub> = -40 °C    | T <sub>max</sub> = +70 °C                                              |
|                                                                                  | V <sub>nom</sub> = 24 V                              | V <sub>min</sub> = 10 V      | V <sub>max</sub> = 35 V                                                |
| EUT sample type                                                                  | Pre-Production                                       |                              |                                                                        |
| Weight                                                                           | 3.3 kg                                               |                              |                                                                        |
| Size [LxWxH]                                                                     | 100 x 100 x 215 mm                                   |                              |                                                                        |
| Interfaces                                                                       | Gbit Ethernet (requires indurad RadarProcessingUnit) |                              |                                                                        |
| For further details refer Applicants Declaration & following technical documents |                                                      |                              |                                                                        |
| Refer section 3.2                                                                |                                                      |                              |                                                                        |

#### 3.2 Detailed Technical data of Main EUT as Declared by Applicant

|                                                                                  |                                                                |                                                           |                                      |
|----------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------|--------------------------------------|
| TX Frequency range                                                               | 76 GHz to 81 GHz                                               |                                                           |                                      |
| Type of modulation used                                                          | FMCW                                                           |                                                           |                                      |
| Antenna polarization                                                             | Vertical (Worst-case)                                          |                                                           |                                      |
| Bandwidth                                                                        | < 5000 MHz                                                     |                                                           |                                      |
| Emission classification                                                          | F3N (FMCW)                                                     |                                                           |                                      |
| Coaxial antenna connector available                                              | <input checked="" type="checkbox"/> No connector               | <input type="checkbox"/> Only for testing purpose         | <input type="checkbox"/> Regular use |
| Antenna Type                                                                     | <input type="checkbox"/> Integrated – microstrip patch array   |                                                           |                                      |
|                                                                                  | <input checked="" type="checkbox"/> External, no RF- connector |                                                           |                                      |
|                                                                                  | <input type="checkbox"/> External, separate RF-connector       |                                                           |                                      |
| Single TX antenna gain                                                           | 31 dBi                                                         | <input checked="" type="checkbox"/> Declared by applicant | <input type="checkbox"/> Measured    |
| Total effective gain of 3 TX antenna                                             | --                                                             | <input type="checkbox"/> Declared by applicant            | <input type="checkbox"/> Measured    |
| For further details refer Applicants Declaration & following technical documents |                                                                |                                                           |                                      |
| Description of Reference Document (supplied by applicant)                        |                                                                | Version                                                   | Total Pages                          |
| 2023-05_indurad_LinearDynamicRadar-Premium_iLDR-M_Data-Sheet_en_V01.02jsg        |                                                                | V01.04                                                    | 2                                    |
| 2023-08-03_iLDR_iSDR-G5-platform_CTC_V1mrl                                       |                                                                | CTC Version 1                                             | 7                                    |

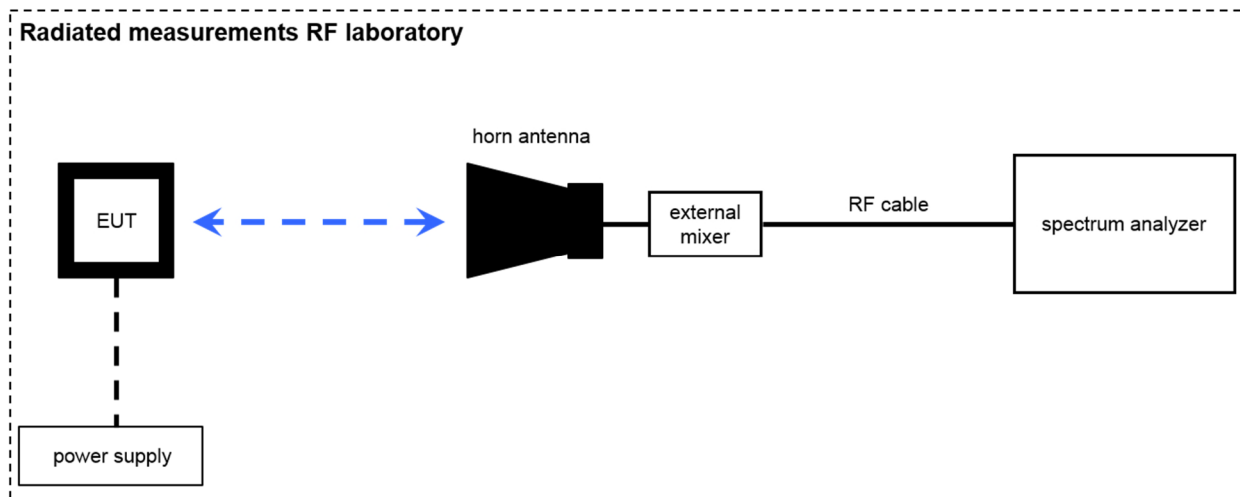
#### 3.3 Modifications on Test sample

|                                    |    |
|------------------------------------|----|
| Additions/deviations or exclusions | -- |
|------------------------------------|----|

## 4 Measurements

### 4.1 The maximum peak power EIRP / peak EIRP spectral density. The maximum power EIRP/ average EIRP.

Schematic:



$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;  
G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:

$$OP \text{ [dBm]} = -65.0 \text{ [dBm]} + 50.0 \text{ [dB]} - 20.0 \text{ [dBi]} + 5.0 \text{ [dB]} = -30 \text{ [dBm]} (1 \mu\text{W})$$

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

Testing method:

All the measurements are done according to standards and rules listed in subsection 5.1.2. The measured power is EIRP\*.

The EUT is ON and set to default mode: FMCW modulation. EUT is tested under nominal condition.

For the maximum peak power EIRP / peak EIRP spectral density test function Signal-ID is activated to exclude ghost signals (product of the mixer).

\*EIRP: Equivalent Isotropic Radiated Power

#### 4.1.1 Measurement Location

|           |                                    |
|-----------|------------------------------------|
| Test site | 120907 - FAC2 - Radiated Emissions |
|-----------|------------------------------------|

#### 4.1.2 Limit

| Average [dBm] | Peak [dBm] |
|---------------|------------|
| 50            | 55         |

## Description:

### §95.3367:

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

## Limits:

FCC §95.3367 (a) (b)

| Frequency       | Limit (eirp)      |
|-----------------|-------------------|
| 76.0 - 81.0 GHz | 50 dBm (Average)  |
| 76.0 - 81.0 GHz | 55 dBm/MHz (PEAK) |

## Measurement: Average Power

| Measurement parameter |          |
|-----------------------|----------|
| Detector:             | RMS      |
| Resolution bandwidth: | 1 MHz    |
| Video bandwidth:      | 3 MHz    |
| Trace-Mode:           | Max Hold |

## Measurement: Peak Power

| Measurement parameter |          |
|-----------------------|----------|
| Detector:             | Pos-Peak |
| Resolution bandwidth: | 10 MHz   |
| Video bandwidth:      | 28 MHz   |
| Trace-Mode:           | Max Hold |

### Note: KDB 653005 D01 v01r02 / §4.(c)(1)

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.

### Consequence:

Worst case measurement, the peak power measurement is performed with a greater resolution bandwidth to solve the problem with the desensitization.

## 4.1.3 Result

| Mode        | Peak detector, max peak search (marker) [dBm] | max peak search (marker frequency) [GHz] | RMS detector, channel power measurement [dBm] | Voltage [V] | Temperature [°C] | Result |
|-------------|-----------------------------------------------|------------------------------------------|-----------------------------------------------|-------------|------------------|--------|
| Normal mode | 37.51                                         | 76.423                                   | 22.90                                         | 24 DC       | 22               | Passed |

Remark: for more information and graphical plot see annex, TR23-1-0086301T004a-A6

## 4.2 Modulation characteristics

### Description:

§2.1047 (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, section 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).

For this measurement, please check customer provided document in Annex 5.

### 4.3 Occupied bandwidth

#### Description:

§2.1049 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.

#### Limits:

| FCC                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------|
| FCC §95.3379 (b)                                                                                                                |
| The occupied bandwidth from intentional radiators operated within the specified frequency band shall comply with the following: |
| Frequency range                                                                                                                 |
| 76 GHz – 81 GHz                                                                                                                 |

#### Measurement:

| Parameters            |          |
|-----------------------|----------|
| Detector:             | Pos-Peak |
| Resolution bandwidth: | 10 MHz   |
| Video bandwidth:      | 28 MHz   |
| Trace-Mode:           | Max Hold |

#### Results:

| EUT   | Temperature [°C] | Voltage [V] | $f_L$ in GHz | $f_H$ in GHz | Occupied Bandwidth (99%) in GHz |
|-------|------------------|-------------|--------------|--------------|---------------------------------|
| EUT 1 | 20(Tnom)         | 24(Vnom)    | 76.0528      | 80.9191      | 4.8663                          |

Remark: for more information and graphical plot see annex TR23-1-0086301T004a-A6 (Page 7-8)

| EUT   | Temperature [°C] | Voltage [V] | $f_L$ in GHz | $f_H$ in GHz | 20dB Occupied Bandwidth in GHz |
|-------|------------------|-------------|--------------|--------------|--------------------------------|
| EUT 1 | 20(Tnom)         | 24(Vnom)    | 76.02900     | 80.97100     | 4.94200                        |

Remark: for more information and graphical plot see annex TR23-1-0086301T004a-A6 (Page 10-11)

## 4.4 Field strength of emissions (band edge)

### Testing method:

For low and high band edge see "Field strength of emission (radiated spurious)" in the corresponding frequency range.

### 4.4.1 Measurement Location

|           |                                    |
|-----------|------------------------------------|
| Test site | 120907 - FAC2 - Radiated Emissions |
|-----------|------------------------------------|

#### Description:

Investigation of the emission limits at the band edge.

#### Limits:

FCC §95.3379 (a) (2) (i) + (ii) / ANSI C63.10-2013 / 6.10

| Frequency Range [GHz] | Measurement distance | Power Density                     |
|-----------------------|----------------------|-----------------------------------|
| 40 – 76 and 81 – 200  | 3.0 m                | 600 pW/cm <sup>2</sup> → -1.7 dBm |

FCC §95.3367 (a) (b)

| Frequency Range [GHz] | Power Density        |
|-----------------------|----------------------|
| 76 - 81               | 50 dBm/MHz (e.i.r.p) |

#### Measurement:

| Parameters            |          |
|-----------------------|----------|
| Detector:             | RMS      |
| Resolution bandwidth: | 1 MHz    |
| Video bandwidth:      | 3 MHz    |
| Trace-Mode:           | Max Hold |

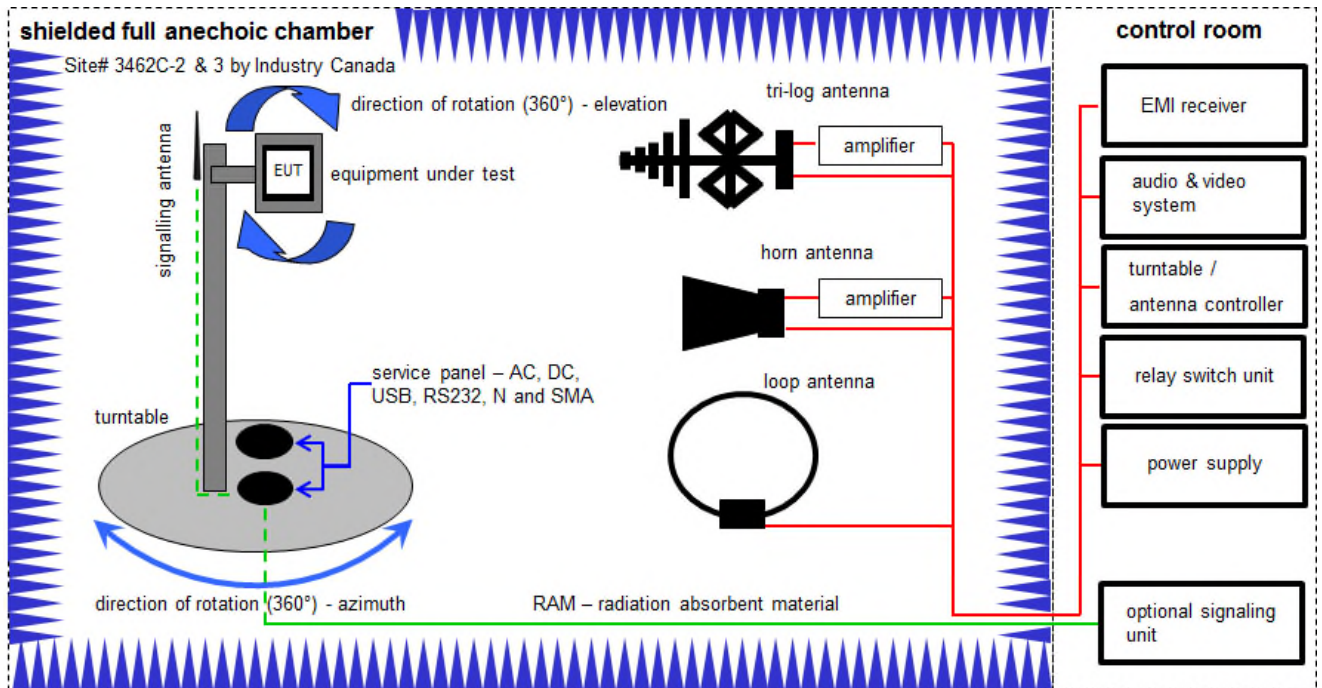
### 4.4.2 Result

- Remark: for more information and graphical plot see annex, **TR23-1-0086301T004a-A1**
- Overview about results are included in chapter 4.8

## 4.5 Radiated field strength emissions below 30 MHz

### 4.5.1 Description of the general test setup and methodology, see below example:

Schematic:



Measurement distance: tri-log antenna 3 meter and horn antenna 3 meter; loop antenna 3 meter.

$$FS = UR + CA + AF$$

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

Example calculation:

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

$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;

G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:

$$OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 \mu W)$$

**FCC §95.3379**

(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.

| FCC                                                 |                                    |                          |
|-----------------------------------------------------|------------------------------------|--------------------------|
| CFR Part 95.3379 (a) (1) / CFR Part 95.3379 (a) (3) |                                    |                          |
| Radiated unwanted emissions                         |                                    |                          |
| Frequency (MHz)                                     | Field Strength ( $\mu\text{V/m}$ ) | Measurement distance (m) |
| 0.009 – 0.490                                       | $2400/F[\text{kHz}]$               | 300                      |
| 0.490 – 1.705                                       | $24000/F[\text{kHz}]$              | 30                       |
| 1.705 – 30.0                                        | 30                                 | 30                       |
| 30 – 88                                             | 100                                | 3                        |
| 88 – 216                                            | 150                                | 3                        |
| 216 – 1000                                          | 200                                | 3                        |
| 1000 – 18 000                                       | 500                                | 3                        |
| 18 000 – 40 000                                     | 500                                | 3                        |

(i) In the emissions table in paragraph (a)(1) of this section, the tighter limit applies at the band edges.

(ii) The limits in the table in paragraph (a)(1) of this section are based on the frequency of the unwanted emissions and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(iii) The emissions limits shown in the table in paragraph (a)(1) of this section are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9.0-90.0 kHz, 110.0-490.0 kHz, and above 1000 MHz. Radiated emissions limits in these three bands are based on measurements employing an average detector with a 1 MHz RBW

(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:

(i) For radiated emissions outside the 76-81 GHz band between 40 GHz and 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 600 pW/cm<sup>2</sup> at a distance of 3 meters from the exterior surface of the radiating structure.

(ii) For radiated emissions above 200 GHz from field disturbance sensors and radar systems operating in the 76-81 GHz band: 1000 pW/cm<sup>2</sup> at a distance of 3 meters from the exterior surface of the radiating structure.

| Frequency Range (GHz) | Power Density                | EIRP     |
|-----------------------|------------------------------|----------|
| 40 – 200              | 600 pW/cm <sup>2</sup> @ 3m  | -1.7 dBm |
| 200 – 243             | 1000 pW/cm <sup>2</sup> @ 3m | +0.5 dBm |

(3) For field disturbance sensors and radar systems operating in the 76-81 GHz band, the spectrum shall be investigated up to 231.0 GHz.

**Limit conversion (ANSI C63.10-2013 9.6):**

$$\text{EIRP[dBm]} = 10 \times \log(4 \times \pi \times d^2 \times \text{PD}[\text{W/m}^2])$$

- Power density at the distance specified by the limit: PD [W/m<sup>2</sup>]
- Equivalent isotropically radiated power: EIRP [dBm]
- Distance at which the power density limit is specified: d [m]

According to this formula, an emission limit of PD = 600 pW/cm<sup>2</sup> at a distance of d = 3 m corresponds to an equivalent isotropically radiated power of EIRP = -1.7 dBm.

**Measurement:**

| Measurement parameter |                                        |
|-----------------------|----------------------------------------|
| Detector:             | Quasi Peak / Pos-Peak / LinAV / RMS    |
| Resolution bandwidth: | F < 1 GHz: 100 kHz<br>F > 1 GHz: 1 MHz |
| Video bandwidth:      | F < 1 GHz: 300 kHz<br>F > 1 GHz: 3 MHz |
| Trace-Mode:           | Max Hold                               |

**4.5.2 Measurement Location**

|           |             |
|-----------|-------------|
| Test site | Halle C, SB |
|-----------|-------------|

**4.5.3 Result**

| Diagram | Operation Mode | Maximum Level [dBμV/m]<br>Frequency Range 0.009 – 30 MHz | Result |
|---------|----------------|----------------------------------------------------------|--------|
| 2-01_B  | 1              | No critical frequency found                              | Passed |

Remark: for more information and graphical plot see annex A1 **TR23-1-0086301T004a-A1**

**Equipment table (Chamber C):**

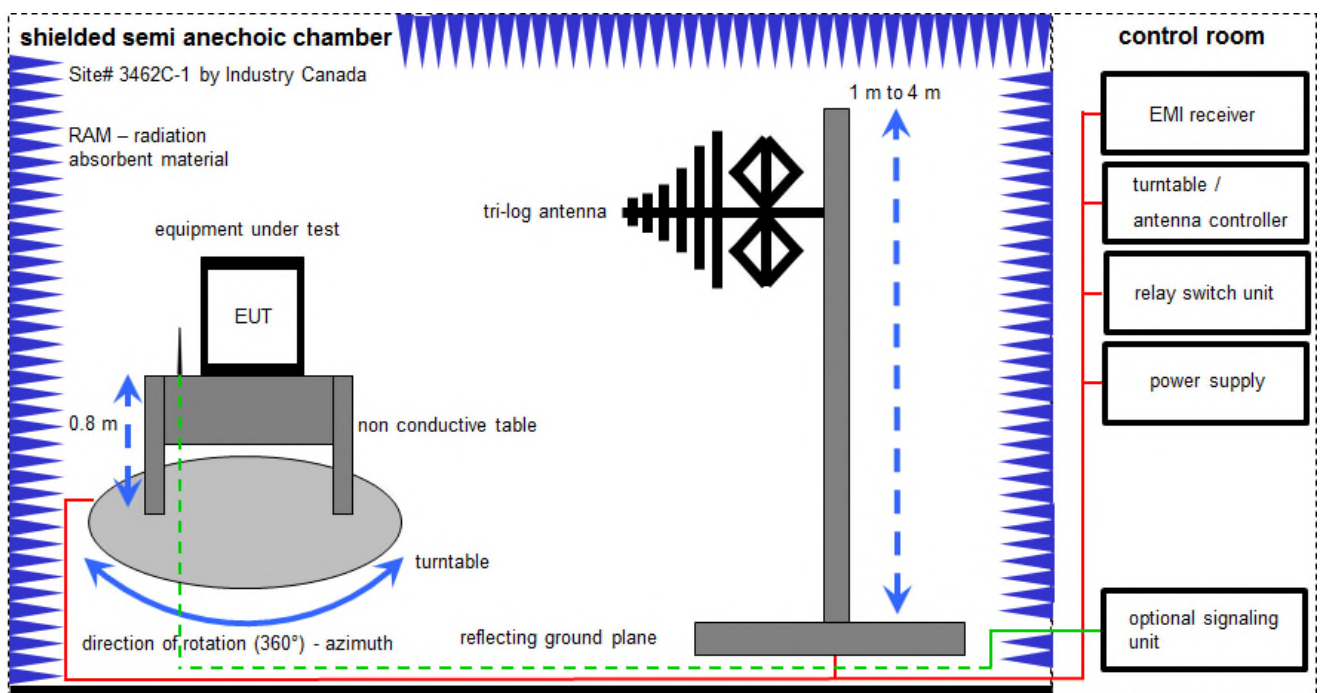
| No. | Lab / Item | Equipment                                      | Type                                          | Manufacturer                  | Serial No. | INV. No.  | Kind of Calibration | Last Calibration         | Next Calibration         |
|-----|------------|------------------------------------------------|-----------------------------------------------|-------------------------------|------------|-----------|---------------------|--------------------------|--------------------------|
| 1   | A,B,C      | DC power supply, 60Vdc, 50A, 1200 W            | 6032A                                         | HP                            | 2818A03450 | 300001040 | vKI!                | 09.12.2020               | 08.12.2023               |
| 2   | A,B,C      | Anechoic chamber                               | FAC 3/5m                                      | MWB / TDK                     | 87400/02   | 300000996 | ev                  | -/-                      | -/-                      |
| 3   | A,B,C      | Switch / Control Unit                          | 3488A                                         | HP                            | *          | 300000199 | ne                  | -/-                      | -/-                      |
| 4   | A,B,C      | Variable isolating transformer                 | MPL IEC625 Bus Variable isolating transformer | Erfi                          | 91350      | 300001155 | ne                  | -/-                      | -/-                      |
| 5   | A,B,C      | EMI Test Receiver 20Hz- 26,5GHz                | ESU26                                         | R&S                           | 100037     | 300003555 | k                   | 11.12.2023               | 31.12.2024               |
| 6   | A,B,C      | 4U RF Switch Platform                          | L4491A                                        | Agilent Technologies          | MY50000037 | 300004509 | ne                  | -/-                      | -/-                      |
| 7   | A,B,C      | NEXIO EMV-Software                             | BAT EMC V2022.0.32.0                          | EMCO                          |            | 300004682 | ne                  | -/-                      | -/-                      |
| 8   | A,B,C      | PC                                             | ExOne                                         | F+W                           |            | 300004703 | ne                  | -/-                      | -/-                      |
| 9   | B,C        | MXG Microwave Analog Signal Generator          | NS183A                                        | Agilent Technologies          | MY47420220 | 300003813 | vKI!                | 07.12.2022               | 31.12.2025               |
| 10  | B          | Highpass Filter                                | WHKX7.0/18G-8SS                               | Wainwright                    | 19         | 300003790 | ne                  | -/-                      | -/-                      |
| 11  | B          | Broadband Amplifier 0.5-18 GHz                 | CBLU5184540                                   | CERNEX                        | 22049      | 300004481 | ev                  | -/-                      | -/-                      |
| 12  | B          | RF-Amplifier                                   | AMF-6F06001800-30-10P-R                       | NARDA-MITEQ Inc               | 2011572    | 300005241 | ev                  | -/-                      | -/-                      |
| 13  | B          | Double-Ridged Waveguide Horn Antenna 1-18.0GHz | 3115                                          | EMCO                          | 8812-3089  | 300000307 | vKI!                | 11.02.2022               | 29.02.2024               |
| 14  | C          | TRILOG Broadband Test-Antenna 30 MHz - 3 GHz   | VULB9163                                      | Schwarzbeck Mess - Elektronik | 318        | 300003696 | vKI!                | 31.01.2024               | 30.01.2026               |
| 15  | A          | Active Loop Antenna 9 kHz to 30 MHz            | 6502                                          | EMCO                          | 8905-2342  | 300000256 | vKI!                | 17.06.2021<br>19.07.2023 | 30.06.2023<br>31.07.2025 |

Remark: valid for period of measurements

## 4.6 Radiated field strength emissions 30 MHz – 1000 MHz

### 4.6.1 Description of the general test setup and methodology, see below example:

The radiated measurements are performed in vertical and horizontal plane in the frequency range from 30 MHz to 1 GHz in semi-anechoic chambers. The EUT is positioned on a non-conductive support with a height of 0.80 m above a conductive ground plane that covers the whole chamber. The receiving antennas are conform to specifications ANSI C63. These antennas can be moved over the height range between 1.0 m and 4.0 m in order to search for maximum field strength emitted from 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 spectrum analyzers where the detector modes and resolution bandwidths over various frequency ranges are set according to requirement ANSI C63.



Measurement distance: tri-log antenna 10 meter

$$FS = UR + CL + AF$$

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

Example calculation:

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

#### 4.6.2 Measurement Location

|           |             |
|-----------|-------------|
| Test site | Halle F, SB |
|-----------|-------------|

#### 4.6.3 Limit

| Radiated emissions limits (3 meters) |                                  |                                           |            |                 |
|--------------------------------------|----------------------------------|-------------------------------------------|------------|-----------------|
| Frequency Range [MHz]                | Limit [ $\mu\text{V}/\text{m}$ ] | Limit [ $\text{dB}\mu\text{V}/\text{m}$ ] | Detector   | RBW / VBW [kHz] |
| 30 - 88                              | 100                              | 40.0                                      | Quasi peak | 100 / 300       |
| 88 - 216                             | 150                              | 43.5                                      | Quasi peak | 100 / 300       |
| 216 - 960                            | 200                              | 46.0                                      | Quasi peak | 100 / 300       |
| 960 - 1000                           | 500                              | 54.0                                      | Quasi peak | 100 / 300       |

#### 4.6.4 Result

| Diagram | Operation Mode | Maximum Level [ $\text{dB}\mu\text{V}/\text{m}$ ]<br>Frequency Range 30M – 1000 MHz | Result |
|---------|----------------|-------------------------------------------------------------------------------------|--------|
| 3.01    | 1              | 32.62dB $\mu\text{V}/\text{m}$ @724.106MHz                                          | Passed |

Remark: for more information and graphical plot see annex A1 **TR23-1-0086301T004a-A1**

#### Equipment table (Chamber F):

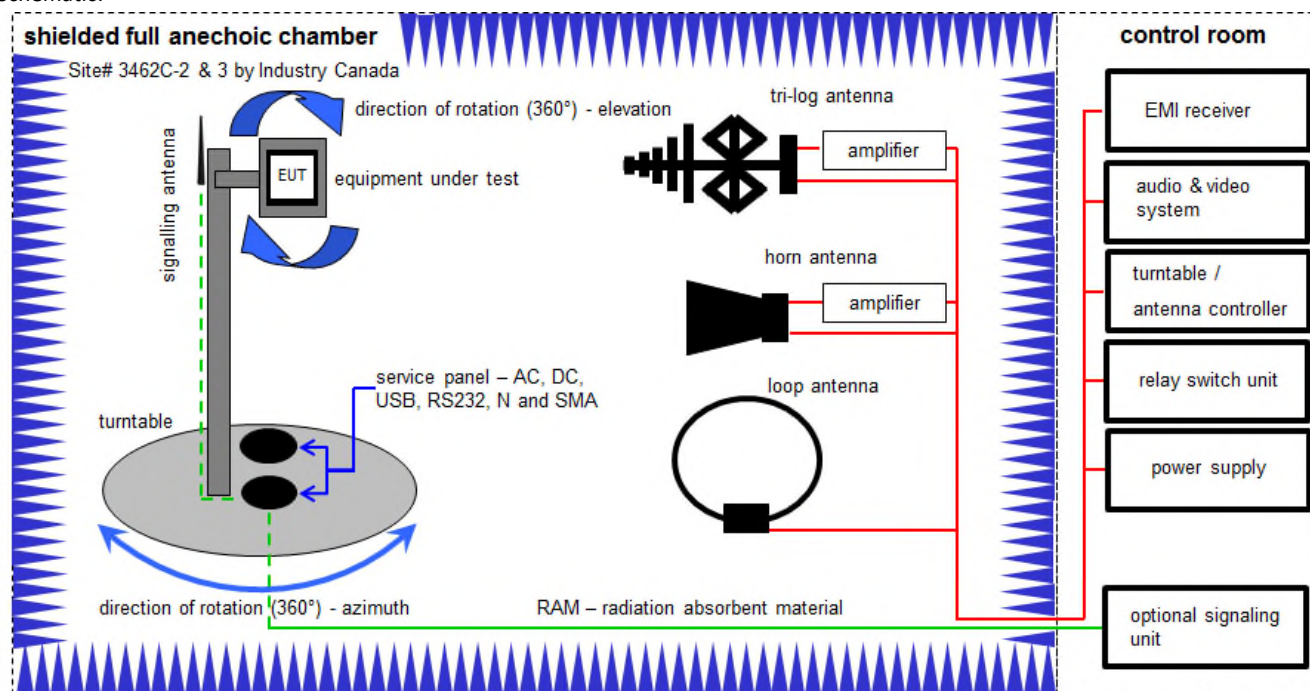
| No. | Lab / Item | Equipment                                    | Type         | Manufacturer                  | Serial No. | INV. No.  | Kind of Calibration | Last Calibration         | Next Calibration         |
|-----|------------|----------------------------------------------|--------------|-------------------------------|------------|-----------|---------------------|--------------------------|--------------------------|
| 1   | n. a.      | Switch-Unit                                  | 3488A        | HP                            | 2719A14505 | 300000368 | ev                  | -/-                      | -/-                      |
| 2   | n. a.      | DC power supply, 60Vdc, 50A, 1200 W          | 6032A        | HP                            | 2920A04466 | 300000580 | ne                  | -/-                      | -/-                      |
| 3   | n. a.      | Semi anechoic chamber                        | 300023       | MWB AG                        | -/-        | 300000551 | ne                  | -/-                      | -/-                      |
| 4   | n. a.      | Antenna Tower                                | Model 2175   | ETS-Lindgren                  | 64762      | 300003745 | izw                 | -/-                      | -/-                      |
| 5   | n. a.      | Positioning Controller                       | Model 2090   | ETS-Lindgren                  | 64672      | 300003746 | izw                 | -/-                      | -/-                      |
| 6   | n. a.      | Turntable Interface-Box                      | Model 105637 | ETS-Lindgren                  | 44583      | 300003747 | izw                 | -/-                      | -/-                      |
| 7   | n. a.      | EMI Test Receiver                            | ESR3         | Rohde & Schwarz               | 102587     | 300005771 | k                   | 09.12.2022<br>06.12.2023 | 31.12.2023<br>31.12.2024 |
| 8   | n. a.      | PC                                           | TecLine      | F+W                           | -/-        | 300004388 | ne                  | -/-                      | -/-                      |
| 9   | n. a.      | TRILOG Broadband Test-Antenna 30 MHz - 3 GHz | VULB9163     | Schwarzbeck Mess - Elektronik | 295        | 300003787 | vKI!                | 12.04.2021<br>23.05.2023 | 30.04.2023<br>31.05.2025 |

Remark: valid for period of measurements

## 4.7 Radiated field strength emissions 1GHz – 18 GHz

### 4.7.1 Description of the general test setup and methodology, see below example:

Schematic:



Measurement distance: tri-log antenna 3 meter and horn antenna 3 meter; loop antenna 3 meter.

$$FS = UR + CA + AF$$

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

Example calculation:

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

$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;  
G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:

$$OP [dBm] = -65.0 [dBm] + 50 [dB] - 20 [dBi] + 5 [dB] = -30 [dBm] (1 \mu W)$$

### 4.7.2 Measurement Location

|           |             |
|-----------|-------------|
| Test site | Halle C, SB |
|-----------|-------------|

#### 4.7.3 Measurement distance

| Frequency Range [GHz] | Measurement distance [m] |
|-----------------------|--------------------------|
| 1 - 8                 | 3                        |
| 8 - 18                | 3                        |

#### 4.7.4 Result

| Diagram | Operation Mode | Frequency Range | Maximum Level [dBμV/m]<br>Frequency Range 1G – 40 GHz       | Result |
|---------|----------------|-----------------|-------------------------------------------------------------|--------|
| D127_B  | 1              | 1G – 18GHz      | Max Peak: 53dBuV/m @<br>12500GHz,<br>47.7 dBuV/m @ 12500GHz | Passed |

Remark: for more information and graphical plot see annex A1 **TR23-1-0086301T004a-A1**

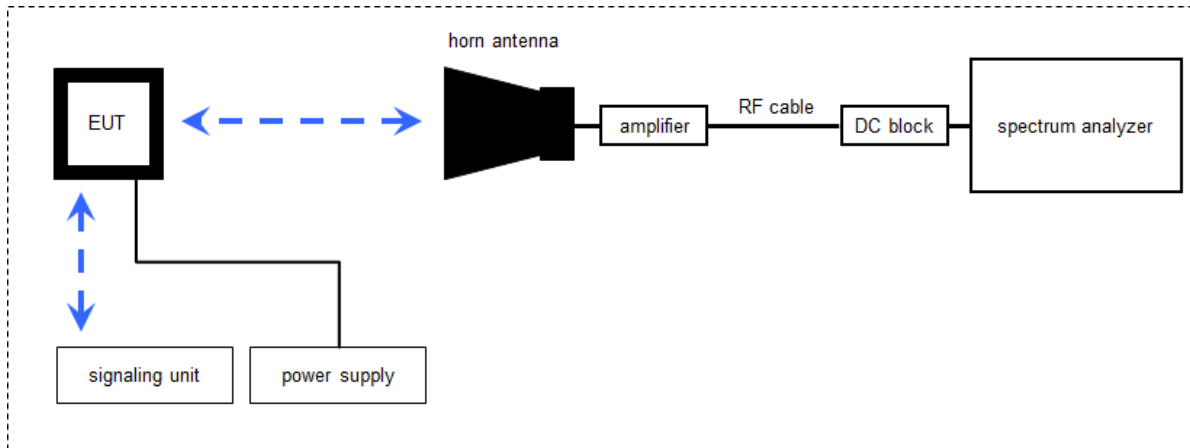
#### Equipment table (Chamber C):

| No. | Lab / Item | Equipment                                      | Type                                             | Manufacturer                  | Serial No. | INV. No.  | Kind of Calibration | Last Calibration         | Next Calibration         |
|-----|------------|------------------------------------------------|--------------------------------------------------|-------------------------------|------------|-----------|---------------------|--------------------------|--------------------------|
| 1   | A,B,C      | DC power supply, 60Vdc, 50A, 1200 W            | 6032A                                            | HP                            | 2818A03450 | 300001040 | vKI!                | 09.12.2020               | 08.12.2023               |
| 2   | A,B,C      | Anechoic chamber                               | FAC 3/5m                                         | MWB / TDK                     | 87400/02   | 300000996 | ev                  | -/-                      | -/-                      |
| 3   | A,B,C      | Switch / Control Unit                          | 3488A                                            | HP                            | *          | 300000199 | ne                  | -/-                      | -/-                      |
| 4   | A,B,C      | Variable isolating transformer                 | MPL IEC625 Bus<br>Variable isolating transformer | Erfi                          | 91350      | 300001155 | ne                  | -/-                      | -/-                      |
| 5   | A,B,C      | EMI Test Receiver 20Hz- 26,5GHz                | ESU26                                            | R&S                           | 100037     | 300003555 | k                   | 11.12.2023               | 31.12.2024               |
| 6   | A,B,C      | 4U RF Switch Platform                          | L4491A                                           | Agilent Technologies          | MY50000037 | 300004509 | ne                  | -/-                      | -/-                      |
| 7   | A,B,C      | NEXIO EMV-Software                             | BAT EMC V2022.0.32.0                             | EMCO                          |            | 300004682 | ne                  | -/-                      | -/-                      |
| 8   | A,B,C      | PC                                             | ExOne                                            | F+W                           |            | 300004703 | ne                  | -/-                      | -/-                      |
| 9   | B,C        | MXG Microwave Analog Signal Generator          | NS183A                                           | Agilent Technologies          | MY47420220 | 300003813 | vKI!                | 07.12.2022               | 31.12.2025               |
| 10  | B          | Highpass Filter                                | WHKX7.0/18G-8SS                                  | Wainwright                    | 19         | 300003790 | ne                  | -/-                      | -/-                      |
| 11  | B          | Broadband Amplifier 0.5-18 GHz                 | CBLU5184540                                      | CERNEX                        | 22049      | 300004481 | ev                  | -/-                      | -/-                      |
| 12  | B          | RF-Amplifier                                   | AMF-6F06001800-30-10P-R                          | NARDA-MITEQ Inc               | 2011572    | 300005241 | ev                  | -/-                      | -/-                      |
| 13  | B          | Double-Ridged Waveguide Horn Antenna 1-18.0GHz | 3115                                             | EMCO                          | 8812-3089  | 300000307 | vKI!                | 11.02.2022               | 29.02.2024               |
| 14  | C          | TRILOG Broadband Test-Antenna 30 MHz - 3 GHz   | VULB9163                                         | Schwarzbeck Mess - Elektronik | 318        | 300003696 | vKI!                | 31.01.2024               | 30.01.2026               |
| 15  | A          | Active Loop Antenna 9 kHz to 30 MHz            | 6502                                             | EMCO                          | 8905-2342  | 300000256 | vKI!                | 17.06.2021<br>19.07.2023 | 30.06.2023<br>31.07.2025 |

Remark: valid for period of measurements

## 4.8 Radiated field strength emissions, above 18 GHz

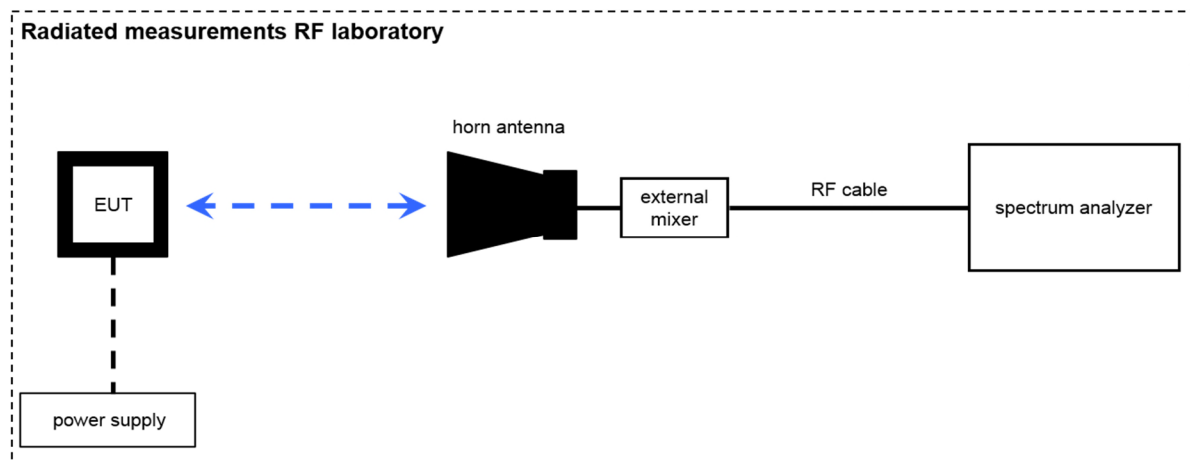
Schematic:



## 4.9 Radiated field strength emissions, above 50/85 GHz

### 4.9.1 Description of the general test setup and methodology, see below example:

Schematic:



$$OP = AV + D - G + CA$$

(OP-radiated output power; AV-analyzer value; D-free field attenuation of measurement distance;

G-antenna gain+amplifier gain; CA-loss signal path)

Example calculation:

$$OP [dBm] = -65.0 [dBm] + 50.0 [dB] - 20.0 [dBi] + 5.0 [dB] = -30 [dBm] (1 \mu W)$$

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

Testing method:

All the measurements are done according to standards and rules listed in subsection 5.1.2. The measured power is EIRP\*.

The EUT is ON and set to default mode: FMCW modulation. EUT is tested under nominal condition.

For the maximum peak power EIRP / peak EIRP spectral density test function Signal-ID is activated to exclude ghost signals (product of the mixer).

\*EIRP: Equivalent Isotropic Radiated Power

## 4.9.2 Measurement Location

|           |                                     |
|-----------|-------------------------------------|
| Test site | SYS 13 + SYS 14, SB<br>18G – 162GHz |
|           | FAC 2, ESS<br>162G – 243GHz         |

### Equipment table :

| ID    | Description                                       | Manufacturer                                   | SerNo       | CheckType | Last Check                           | Interval             | Next Check                           |
|-------|---------------------------------------------------|------------------------------------------------|-------------|-----------|--------------------------------------|----------------------|--------------------------------------|
|       | 120907 - FAC2 - Radiated Emissions                |                                                |             | chk       |                                      |                      |                                      |
| 20005 | AC - LISN 50 Ohm/50µH ESH2-Z5                     | Rohde & Schwarz Messgerätebau GmbH / Memmingen | 861741/005  | cal       | chk: 2023-Feb-21<br>cal: 2023-May-25 | chk: 12M<br>cal: 12M | chk: 2024-Feb-21<br>cal: 2024-May-25 |
| 20133 | Horn Antenna 3115 (Meas 1)                        | EMCO Elektronik GmbH / Gilching                | 9012-3629   | cal       | cal: 2023-May-22                     | cal: 36M             | cal: 2026-May-22                     |
| 20302 | Horn Antenna BBHA9170 (Meas 1)                    | Schwarzbeck Mess-Elektronik OHG / Schönaun     | 155         | cpu       | chk: 2020-Apr-15                     | chk: 12M             |                                      |
| 20303 | Horn Antenna BBHA9170 (Subst 1)                   | Schwarzbeck Mess-Elektronik OHG                | 156         | cpu       |                                      | chk: 12M             |                                      |
| 20354 | DC - Power Supply 40A NGPE 40/40                  |                                                | 448         | cpu       |                                      |                      |                                      |
| 20729 | FS-Z140                                           | Rohde & Schwarz Messgerätebau GmbH / Memmingen | 101004      | cal       | cal: 2023-Jun-16                     | cal: 36M             | cal: 2026-Jun-16                     |
| 20730 | FS-Z110                                           | Rohde & Schwarz Messgerätebau GmbH / Memmingen | 101468      | cal       | cal: 2023-Jun-02                     | cal: 36M             | cal: 2026-Jun-02                     |
| 20731 | FS-Z75                                            | Rohde & Schwarz Messgerätebau GmbH / Memmingen | 101022      | cal       | cal: 2022-May-18                     | cal: 36M             | cal: 2025-May-18                     |
| 20732 | Signal- and Spectrum Analyzer FSW67               | Rohde & Schwarz Messgerätebau GmbH / Memmingen | 104023      | cal       | cal: 2023-May-25                     | cal: 12M             | cal: 2024-May-25                     |
| 20733 | Harmonic Mixer FS-Z220                            | RPG-Radiometer Physics GmbH                    | 101009      | cal       | cal: 2021-May-27                     | cal: 36M             | cal: 2024-May-27                     |
| 20734 | Harmonic Mixer FS-Z325                            | RPG-Radiometer Physics GmbH / Meckenheim       | 101005      | cal       | cal: 2021-May-27                     | cal: 36M             | cal: 2024-May-27                     |
| 20765 | Pickett-Potter Horn Antenna FH-PP 40-60           | RPG-Radiometer Physics GmbH / Meckenheim       | 010001      | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |
| 20767 | Pickett-Potter Horn Antenna FH-PP 140-220         | RPG-Radiometer Physics GmbH / Meckenheim       | 010011      | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |
| 20811 | Horn Antenna ASY-SGH-124-SMA                      | Antenna Systems Solutions S.L                  | 29F14182337 | cal       | cal: 2021-Oct-20                     | cal: 36M             | cal: 2024-Oct-20                     |
| 20812 | Pickett-Potter Horn Antenna FH-PP-325             | RPG-Radiometer Physics GmbH / Meckenheim       | 10024       | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |
| 20813 | Pickett-Potter Horn Antenna FH-PP 075             | RPG-Radiometer Physics GmbH / Meckenheim       | 10006       | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |
| 20814 | Pickett-Potter Horn Antenna FH-PP 140             | RPG-Radiometer Physics GmbH / Meckenheim       | 10008       | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |
| 20815 | Pickett-Potter Horn Antenna FH-PP 110             | RPG-Radiometer Physics GmbH / Meckenheim       | 10014       | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |
| 20817 | Waveguide Rectangular Horn Antenna SAR-2309-22-S2 | ERAVANT / Torrance                             | 13254-01    | chk       | chk: 2023-Oct-20                     | chk: 12M             | chk: 2024-Oct-20                     |

Remark: valid for period of measurements

| No. | Lab / Item | Equipment                               | Type          | Manufacturer         | Serial No.    | INV. No.  | Kind of Calibration | Last Calibration         | Next Calibration         |
|-----|------------|-----------------------------------------|---------------|----------------------|---------------|-----------|---------------------|--------------------------|--------------------------|
| 1   | n. a.      | Spectrum Analyzer                       | FSW50         | Rohde & Schwarz      | 101332        | 300005935 | k                   | 20.01.2022<br>07.12.2023 | 31.01.2023<br>31.12.2024 |
| 2   | n. a.      | Spectrum Analyzer<br>2 Hz - 85 GHz      | FSW85         | R&S                  | 101333        | 300005568 | k                   | 11.07.2022<br>02.08.2023 | 31.07.2023<br>31.08.2024 |
| 3   | n. a.      | Temperature Test Chamber                | T-40/50       | CTS GmbH             | 064023        | 300003540 | ev                  | 09.05.2022               | 08.05.2024               |
| 4   | n. a.      | DC Power Supply,<br>60V, 10A            | 6038A         | HP                   | 2848A07027    | 300001174 | vKI!                | 08.12.2020               | 07.12.2023               |
| 5   | n. a.      | Power supply                            | N5767A        | Agilent Technologies | US14J1569P    | 300004851 | vKI!                | 08.12.2020               | 31.12.2023               |
| 6   | n. a.      | Broadband LNA<br>18-50 GHz              | CBL18503070PN | CERNEX               | 25240         | 300004948 | ev                  | 09.03.2022               | 08.03.2024               |
| 7   | n. a.      | Horn Antenna 18,0-40,0 GHz              | LHAF180       | Microw.Devel         | 39180-103-021 | 300001747 | vKI!                | 17.01.2022<br>24.01.2024 | 31.01.2024<br>31.01.2026 |
| 8   | n. a.      | Std. Gain Horn Antenna<br>18.0-26.5 GHz | 638           | Narda                |               | 300000486 | vKI!                | 17.01.2022               | 31.01.2024               |
| 9   | n. a.      | Std. Gain Horn Antenna<br>26.5-40.0 GHz | V637          | Narda                | 82-16         | 300000510 | vKI!                | 17.01.2022               | 31.01.2024               |

|    |       |                                            |           |                            |        |           |    |                          |                          |
|----|-------|--------------------------------------------|-----------|----------------------------|--------|-----------|----|--------------------------|--------------------------|
| 10 | n. a. | Std. Gain Horn<br>Antenna 33.0-50.1<br>GHz | 2324-20   | Flann                      | 57     | 400000683 | ne | -/-                      | -/-                      |
| 11 | n. a. | Std. Gain Horn<br>Antenna<br>49.9-75.8 GHz | 2524-20   | Flann                      | *      | 300001983 | ne | -/-                      | -/-                      |
| 12 | n. a. | Harmonic Mixer 3-<br>Port, 50-75 GHz       | FS-Z75    | Rohde & Schwarz            | 101578 | 300005788 | k  | 07.07.2022<br>19.07.2023 | 31.07.2024               |
| 13 | n. a. | Std. Gain Horn<br>Antenna 60-90 GHz        | COR 60_90 | Thomson CSF                |        | 300000814 | ev | -/-                      | -/-                      |
| 14 | n. a. | Harmonic Mixer 3-<br>Port, 60-90 GHz       | FS-Z90    | R&S                        | 101555 | 300004691 | k  | 21.07.2022<br>25.08.2023 | 31.07.2023<br>31.08.2024 |
| 15 | n. a. | Std. Gain Horn<br>Antenna<br>73.8-112 GHz  | 2724-20   | Flann                      | *      | 300001988 | ne | -/-                      | -/-                      |
| 16 | n. a. | Harmonic Mixer 3-<br>Port, 75-110 GHz      | FS-Z110   | R&S                        | 101411 | 300004959 | k  | 07.07.2022<br>17.07.2023 | 31.07.2023<br>31.07.2024 |
| 17 | n.a.  | Std. Gain Horn<br>Antenna 92.3-140<br>GHz  | 2824-20   | Flann                      |        | 300001993 | ne | -/-                      | -/-                      |
| 18 | n.a.  | Harmonic Mixer 3-<br>port, 90-140 GHz      | FS-Z140   | Rohde & Schwarz            | 101119 | 300005581 | k  | 20.07.2022<br>03.08.2023 | 31.07.2023<br>31.08.2024 |
| 19 | n. a. | Std. Gain Horn<br>Antenna<br>114-173 GHz   | 2924-20   | Flann                      | *      | 300001999 | ne | -/-                      | -/-                      |
| 20 | n. a. | Harmonic Mixer 3-<br>Port, 110-170 GHz     | FS-Z170   | Radiometer Physics<br>GmbH | 100014 | 300004156 | k  | 01.07.2022<br>21.07.2023 | 31.07.2023<br>31.07.2024 |
| 21 | n. a. | Std. Gain Horn<br>Antenna<br>145-220 GHz   | 3024-20   | Flann                      | *      | 300002000 | ne | -/-                      | -/-                      |
| 22 | n. a. | Harmonic Mixer 3-<br>Port, 140-220 GHz     | SAM-220   | Radiometer Physics<br>GmbH | 200001 | 300004157 | k  | 21.07.2022<br>01.08.2023 | 31.07.2023<br>31.08.2024 |

Remark: valid for period of measurements

### Calculation of the boundary near/far field:

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

| Antenna range [GHz] | D [m]   | Highest frequency in the measurement [GHz] | Lowest wavelength $\lambda$ in the measurement [m] | Boundary for near/far field [m] |
|---------------------|---------|--------------------------------------------|----------------------------------------------------|---------------------------------|
| 162-220             | 0.01070 | 220                                        | 0.001362693                                        | 0.17                            |
| 220-243             | 0.00705 | 243                                        | 0.001297803                                        | 0.08                            |

### Transducer factor TF

| Mixer: 50 - 75 GHz (FS-Z75, S/N 101578)           |                 |                     |                              |
|---------------------------------------------------|-----------------|---------------------|------------------------------|
| Distance [m]                                      | Frequency [GHz] | TF [dB] (for power) | TF [dB] (for field strength) |
| 0,10                                              | 50-75           | /                   | /                            |
| 0,15                                              | 50-75           | /                   | /                            |
| 0,25                                              | 50-75           | 36,12               | 24,36                        |
| 0,50                                              | 50-75           | 42,14               | 30,38                        |
| 0,75                                              | 50-75           | 45,66               | 33,90                        |
| 1,00                                              | 50-75           | 48,16               | 36,40                        |
| 1,50                                              | 50-75           | 51,68               | 39,92                        |
| 2,00                                              | 50-75           | 54,18               | 42,42                        |
| 2,50                                              | 50-75           | 56,12               | 44,36                        |
| 3,00                                              | 50-75           | 57,71               | 45,94                        |
| Far field distance of antenna (@ max. frequency): |                 |                     | 17.2 cm                      |
| Mixer: 75-110 GHz (FS-Z110, S/N 101411)           |                 |                     |                              |
| Distance [m]                                      | Frequency [GHz] | TF [dB] (for power) | TF [dB] (for field strength) |
| 0,10                                              | 75-110          | /                   | /                            |
| 0,15                                              | 75-110          | 34,95               | 23,19                        |
| 0,25                                              | 75-110          | 39,39               | 27,63                        |
| 0,50                                              | 75-110          | 45,41               | 33,65                        |
| 0,75                                              | 75-110          | 48,93               | 37,17                        |
| 1,00                                              | 75-110          | 51,43               | 39,67                        |
| 1,50                                              | 75-110          | 54,95               | 43,19                        |
| 2,00                                              | 75-110          | 57,45               | 45,69                        |
| 2,50                                              | 75-110          | 59,39               | 47,63                        |
| 3,00                                              | 75-110          | 60,97               | 49,21                        |
| Far field distance of antenna (@ max. frequency): |                 |                     | 11.3 cm                      |
| Mixer: 110-170 GHz (FS-Z170, S/N 100014)          |                 |                     |                              |
| Distance [m]                                      | Frequency [GHz] | TF [dB] (for power) | TF [dB] (for field strength) |
| 0,10                                              | 110-170         | 34,55               | 22,79                        |
| 0,15                                              | 110-170         | 38,07               | 26,31                        |
| 0,25                                              | 110-170         | 42,51               | 30,75                        |
| 0,50                                              | 110-170         | 48,53               | 36,77                        |
| 0,75                                              | 110-170         | 52,05               | 40,29                        |
| 1,00                                              | 110-170         | 54,55               | 42,76                        |
| 1,50                                              | 110-170         | 58,07               | 46,31                        |
| 2,00                                              | 110-170         | 60,57               | 48,81                        |
| 2,50                                              | 110-170         | 62,51               | 50,75                        |
| 3,00                                              | 110-170         | 64,09               | 52,33                        |
| Far field distance of antenna (@ max. frequency): |                 |                     | 8.2 cm                       |

| Mixer: 60 - 90 GHz (FS-Z90, S/N 101555, ThomsonCOR6090) |                 |                         |                              |
|---------------------------------------------------------|-----------------|-------------------------|------------------------------|
| Distance [m]                                            | Frequency [GHz] | TF [dB] (for power)     | TF [dB] (for field strength) |
| 0,15                                                    | 60 70 80 90     | /                       | /                            |
| 0,25                                                    | 60 70 80 90     | /                       | /                            |
| 0,50                                                    | 60 70 80 90     | 41,78 42,93 44,19 45,52 | 30,02 31,17 32,43 33,76      |
| 0,75                                                    | 60 70 80 90     | 45,30 46,45 47,71 49,05 | 33,54 34,69 35,95 37,28      |
| 1,00                                                    | 60 70 80 90     | 47,80 48,95 50,21 51,55 | 36,04 37,19 38,45 39,78      |
| 1,50                                                    | 60 70 80 90     | 51,33 52,47 53,73 55,07 | 39,56 40,71 41,97 43,30      |
| 2,00                                                    | 60 70 80 90     | 53,82 54,97 56,23 57,57 | 42,06 43,21 44,47 45,80      |
| 2,50                                                    | 60 70 80 90     | 55,76 56,91 58,17 59,50 | 44,00 45,15 46,41 47,74      |
| 3,00                                                    | 60 70 80 90     | 57,35 58,49 59,75 61,09 | 45,58 46,73 48,00 49,32      |
| Far field distance of antenna (@ max. frequency):       |                 |                         | 44.5 cm                      |

#### Measurement distance\_SYS13\_SYS14\_SB:

| Measurement frequency range: | Measurement distance [m] | Boundary for near/far field [m] |
|------------------------------|--------------------------|---------------------------------|
| 76 GHz – 81 GHz              | 1.50                     | 0.445                           |
| 81 GHz – 85 GHz              | 0.50                     | 0.445                           |
| 85 GHz – 90 GHz              | 0.50                     | 0.113                           |
| 90 GHz – 110 GHz             | 0.50                     | 0.113                           |
| 110 GHz – 115 GHz            | 0.25                     | 0.082                           |
| 115 GHz – 162 GHz            | 0.50                     | 0.082                           |

#### Measurement distance\_FAC2\_ESS:

| Measurement frequency range: | Measurement distance [m] | Boundary for near/far field [m] |
|------------------------------|--------------------------|---------------------------------|
| 162 GHz – 220 GHz            | 1                        | 0.17                            |
| 220 GHz – 243 GHz            | 0.5                      | 0.08                            |

#### 4.9.3 Limit

| FCC Frequency [GHz]                  | FCC EIRP [dBm]                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ISED Frequency [GHz] | ISED EIRP [dBm] |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------|
| 40 - 200                             | 600 pW/cm2 ~ -1.7                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 40 - 162             | -30             |
| 200 - 243                            | 1000 pW/cm2 ~ 0.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 73.5 - 76            | 0               |
| Limit conversion<br>(pW/cm2 to dBm): | $P[dBm] = 10 \cdot \log(4 \cdot \pi \cdot d^2 \cdot P[W/m^2])$ <p>d- distance of the limit defined in W/m2. Here: 3 m.</p> <hr/> <p>600 pW/cm2: <math>P[dBW] = 10 \cdot \log(4 \cdot \pi \cdot (3m)^2 \cdot 6 \cdot 10^{-6} W/m^2)</math><br/> 600 pW/cm2: <math>P[dBW] = -31.7 \text{ dBW}</math><br/> <math>P[dBm] = P[dBW] + 30</math><br/> 600 pW/cm2: <math>P[dBm] = -31.7 \text{ dBW} + 30</math><br/> 600 pW/cm2: <math>P[dBm] = -1.7 \text{ dBm}</math></p> <hr/> <p>1000 pW/cm2: <math>P[dBW] = 10 \cdot \log(4 \cdot \pi \cdot (3m)^2 \cdot 1 \cdot 10^{-5} W/m^2)</math><br/> 1000 pW/cm2: <math>P[dBW] = -29.5 \text{ dBW}</math><br/> <math>P[dBm] = P[dBW] + 30</math><br/> 1000 pW/cm2: <math>P[dBm] = -29.5 \text{ dBW} + 30</math><br/> 1000 pW/cm2: <math>P[dBm] = +0.5 \text{ dBm}</math></p> |                      |                 |

#### 4.9.4 Spectrum-Analyzer Settings

|                            |                                          |
|----------------------------|------------------------------------------|
| Resolution Bandwidth (RBW) | 1 MHz                                    |
| Video Bandwidth (VBW)      | Minimum 3 times the resolution bandwidth |
| Detector                   | RMS detector.                            |
| Trace-Mode:                | Maxhold                                  |

#### 4.9.5 Result

| Diagram | Operation Mode | Frequency Range | Maximum Level [dBm]<br>Frequency Range 40G – 231 GHz | Result |
|---------|----------------|-----------------|------------------------------------------------------|--------|
| D129_01 | 1              | 18G – 26.5GHz   | No critical frequency found                          | Passed |
| D129_02 | 1              | 26.5G – 40GHz   | No critical frequency found                          | Passed |
|         |                |                 |                                                      |        |
| D131    | 1              | 40G – 50GHz     | No critical frequency found                          | Passed |
| D132    | 1              | 50G – 76GHz     | No critical frequency found                          | Passed |
| --      | --             | 76G – 81GHz     | <b>Note-2</b>                                        | --     |
| D134_01 | 1              | 81G – 85GHz     | No critical frequency found                          | Passed |
| D135    | 1              | 85G – 90GHz     | -39.17dBm@87.498GHz                                  | Passed |
| D137    | 1              | 90G – 110GHz    | No critical frequency found                          | Passed |
| D139    | 1              | 110G – 115GHz   | No critical frequency found                          | Passed |
| D141    | 1              | 115G – 162GHz   | No critical frequency found                          | Passed |
| D143_01 | 1              | 162G – 200GHz   | No critical frequency found                          | Passed |
| D143_02 | 1              | 200G – 220GHz   | No critical frequency found                          | Passed |
| D145    | 1              | 220G – 243GHz   | No critical frequency found                          | Passed |

Note-1: for more information and graphical plot see annex **TR23-1-0086301T004a-A1**

Note-2: 76G – 81GHz, In Band Measurements, check chapter 4.1, 4.3.

Note-3: Only worst measurement antenna polarization noted in this table, for other results see annex A1

## 4.10 Frequency stability

### Description:

§95.3379 (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.

### Limits:

| FCC                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------------------------|
| FCC §95.3379 (b)                                                                                                                |
| The occupied bandwidth from intentional radiators operated within the specified frequency band shall comply with the following: |
| Frequency range                                                                                                                 |
| 76 GHz – 81 GHz                                                                                                                 |

### Measurement:

| Parameters            |          |
|-----------------------|----------|
| Detector:             | Pos-Peak |
| Resolution bandwidth: | 10 MHz   |
| Video bandwidth:      | 28 MHz   |
| Trace-Mode:           | Max Hold |

### Measurement results 99% Occupied Bandwidth:

| Test condition     | Frequency $f_L$ [MHz]   | Frequency $f_H$ [MHz] | Bandwidth [MHz] |
|--------------------|-------------------------|-----------------------|-----------------|
| -20 °C / $V_{nom}$ | 76044.25                | 80906.91              | 4862.6          |
| -10 °C / $V_{nom}$ | 76045.90                | 80904.89              | 4858.9          |
| 0 °C / $V_{nom}$   | 76047.94                | 80910.75              | 4862.8          |
| 10 °C / $V_{nom}$  | 76049.03                | 80914.84              | 4865.8          |
| 20 °C / $V_{nom}$  | See chapter 4.3 results |                       |                 |
| 20 °C / $V_{min}$  | 76050.86                | 80917.07              | 4866.2          |
| 20 °C / $V_{max}$  | 76051.06                | 80917.26              | 4866.1          |
| 30 °C / $V_{nom}$  | 76049.01                | 80908.46              | 4859.4          |
| 40 °C / $V_{nom}$  | 76050.22                | 80909.85              | 4859.6          |
| 50 °C / $V_{nom}$  | 76050.27                | 80914.91              | 4864.6          |

### Note:

- The EUT is measured in the temperature range from -20°C to 50°C specified by §95.3379 (b).

**Result: Passed**

#### 4.10.1 Calibration legend

| Note / remarks | Interval of calibration & Verification |
|----------------|----------------------------------------|
| 12M            | 12 months                              |
| 24M            | 24 months                              |
| 36M            | 36 months                              |
| 10Y            | 10 Years                               |

| Abbreviation Check Type | Description                                          |
|-------------------------|------------------------------------------------------|
| K<br>(cal)              | calibration / calibrated                             |
| Ne<br>(cnn)             | not required (k, ev, izw, zw not required)           |
| Ev<br>(chk)             | periodic self verification                           |
| Ve                      | long-term stability recognized                       |
| vlkl!                   | Attention: extended calibration interval             |
| NK!                     | Attention: not calibrated                            |
| EK                      | limited calibration                                  |
| zw                      | cyclical maintenance (external cyclical maintenance) |
| izw                     | internal cyclical maintenance                        |
| g                       | blocked for accredited testing                       |
| cpu                     | Verification before usage                            |
| *)                      | next calibration ordered / currently in progress     |

## 5 Results from external laboratory

|      |   |
|------|---|
| None | - |
|------|---|

## 6 Opinions and interpretations

|      |   |
|------|---|
| None | - |
|------|---|

## 7 List of abbreviations

|      |   |
|------|---|
| None | - |
|------|---|

## 8 Measurement Uncertainty valid for conducted/radiated measurements

The reported uncertainties are calculated based on the standard uncertainty multiplied with the appropriate coverage factor **k**, such that a confidence level of approximately 95% is achieved. For uncertainty determination, each component used in the concrete measurement set-up was taken in account and its contribution to the overall uncertainty according its statistical distribution calculated.

### Measurement Uncertainty Location Essen

| Issue No. | Measurement type                                         | References       | Frequency range of measurement |            | Calculated Uncertainty based on confidence level of 95,54% | Remarks                                                                        |
|-----------|----------------------------------------------------------|------------------|--------------------------------|------------|------------------------------------------------------------|--------------------------------------------------------------------------------|
|           |                                                          |                  | Start [MHz]                    | Stop [MHz] |                                                            |                                                                                |
| 1         | Magnetic field strength                                  | EN/FCC/ISED/JP   | 0,009                          | 30         | 4,86                                                       | Magnetic loop antenna, Pre-amp on                                              |
| 2         | RF-Output power (eirp)<br>Unwanted emissions (eirp) [dB] | EN,FCC/ISED, JP  | 30                             | 100        | 4,57                                                       | without Pre-Amp                                                                |
|           |                                                          |                  | 30                             | 100        | 4,91                                                       | with PreAmp                                                                    |
|           |                                                          |                  | 100                            | 1000       | 4,02                                                       | without Pre-Amp                                                                |
|           |                                                          |                  | 100                            | 1000       | 4,26                                                       | with PreAmp                                                                    |
|           |                                                          |                  | 1000                           | 18000      | 4,36                                                       | without Pre-Amp                                                                |
|           |                                                          |                  | 1000                           | 18000      | 5,23                                                       | with PreAmp                                                                    |
|           |                                                          |                  | 18000                          | 33000      | 4,92                                                       | Schwarzbeck BBHA9170 (#20302) Antenna set-up non-mixer set-up)                 |
|           |                                                          |                  | 33000                          | 50000      | 4,17                                                       | Set-up for Q-Band (WR-22), non-mixer set-up                                    |
|           |                                                          |                  | 40000                          | 60000      | 4,69                                                       | Set-up U-Band (WR-19), non-mixer set-up                                        |
|           |                                                          |                  | 50000                          | 75000      | 4,06                                                       | External Mixer set-up V-Band (WR-15)                                           |
|           |                                                          |                  | 75000                          | 110000     | 4,17                                                       | External Mixer set-up W-Band (WR-6)                                            |
|           |                                                          |                  | 90000                          | 140000     | 5,49                                                       | External Mixer set-up F-Band (WR-8)                                            |
|           |                                                          |                  | 140000                         | 225000     | 6,22                                                       | External Mixer set-up G-Band (WR-5)                                            |
|           |                                                          |                  | 225000                         | 325000     | 7,04                                                       | External Mixer set-up (WR-3)                                                   |
|           |                                                          |                  | 325000                         | 500000     | 8,84                                                       | External Mixer set-up (WR-2.2)                                                 |
| 3         | Radiated Blocking [dB]                                   | EN               | 1000                           | 18000      | 2,85                                                       | Typical set-up with microwave generator and antenna, value for 7GHz calculated |
|           |                                                          |                  | 18000                          | 33000      | 4,66                                                       | Typical set-up with microwave generator and antenna                            |
|           |                                                          |                  | 33000                          | 50000      | 3,48                                                       | WR-22 set-up                                                                   |
|           |                                                          |                  | 50000                          | 75000      | 3,73                                                       | WR-15 set-up                                                                   |
|           |                                                          |                  | 75000                          | 110000     | 4,26                                                       | WR-6 set-up                                                                    |
| 4         | Frequency Error UWB/FMCW [kHz]                           | EN, FCC,JP, ISED | 116000                         | 123000     | 279,87                                                     | Calculated for 123GHz carrier (FMCW)                                           |
|           |                                                          |                  | 40000                          | 77000      | 276,19                                                     | calculated for 77 GHz (FMCW) carrier                                           |
|           |                                                          |                  | 6000                           | 7000       | 33,92                                                      | calculated for 6.5GHz UWB Ch.5                                                 |
|           | Frequency error [Hz]                                     |                  | 11                             | 14         | 20,76                                                      | calculated for 13.56MHz carrier                                                |
| 6         | Conducted emissions AC-mains                             | EN/FCC/ISED      | 0,009                          | 30         | 3,57                                                       | general EMI-measurements on AC/DC ports                                        |

### Measurement Uncertainty Location Saarbrücken

| Test case                                                          | Uncertainty                                             |
|--------------------------------------------------------------------|---------------------------------------------------------|
| Equivalent isotropically radiated power (e.i.r.p.)                 | Conducted value $\pm 1$ dB<br>Radiated value $\pm 3$ dB |
| Permitted range of operating frequencies                           | $\pm 100$ kHz                                           |
| Conducted unwanted emissions in the spurious domain (up to 18 GHz) | $\pm 1$ dB                                              |
| Radiated unwanted emissions in the spurious domain (up to 18 GHz)  | $\pm 3$ dB                                              |
| Conducted unwanted emissions in the spurious domain (18 to 40 GHz) | $\pm 4$ dB                                              |
| Radiated unwanted emissions in the spurious domain (18 to 40 GHz)  | $\pm 4$ dB                                              |
| Conducted unwanted emissions in the spurious domain (40 to 50 GHz) | $\pm 4,5$ dB                                            |
| Radiated unwanted emissions in the spurious domain (40 to 50 GHz)  | $\pm 4,5$ dB                                            |
| Conducted unwanted emissions in the spurious domain (above 50 GHz) | $\pm 5$ dB                                              |
| Radiated unwanted emissions in the spurious domain (above 50 GHz)  | $\pm 5$ dB                                              |
| DC and low frequency voltages                                      | $\pm 3$ %                                               |
| Temperature                                                        | $\pm 1$ °C                                              |
| Humidity                                                           | $\pm 3$ %                                               |

## 9 Versions of test reports (change history)

| Version | Applied changes                                                                                                                                                                  | Date of release |
|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| --      | ➤ Initial release                                                                                                                                                                | 2025-Jan-17     |
| C1      | ➤ Annex-5 has been added on page 3,<br>➤ Summary of test result for modulation characteristics on page 5 has been updated,<br>➤ Chapter 2.8 (untested variant) has been updated. | 2025-Jun-04     |
| C2      | ➤ Annex 5 mentioned on page 12, ANSI C63.10 deleted, Antenna gain                                                                                                                | 2025-Jun-12     |
| --      | --                                                                                                                                                                               | --              |

**End Of Test Report**