

TEST REPORT

Test Report No.: 1-3692/21-03-03

BNNetzA-CAB-02/21-102

Testing Laboratory

CTC advanced GmbH

Untertürkheimer Straße 6 – 10
66117 Saarbrücken/GERMANY
Phone: + 49 681 5 98 - 0
Fax: + 49 681 5 98 - 9075
Internet: <https://ctcadvanced.com/>
e-mail: mail@ctcadvanced.com

Accredited Testing Laboratory:

The testing laboratory (area of testing) is accredited according to DIN EN ISO/IEC 17025 (2018-03) by the Deutsche Akkreditierungsstelle GmbH (DAkkS). The accreditation is valid for the scope of testing procedures as stated in the accreditation certificate starting with the registration number: D-PL-12076-01.

Applicant

indurad GmbH

Belvedereallee 5
52070 Aachen/GERMANY
Phone: + 49 241 538070-0
Contact: Matthias Rabel
e-mail: matthias.rabel@indurad.com

Manufacturer

indurad GmbH

Belvedereallee 5
52070 Aachen/GERMANY
Phone: + 49 241 538070-0
Contact: Matthias Rabel

Test Standard/s

**FCC - Title 47 CFR
Part 15:
2022-01**

FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices

**ANSI C63.4: 2014-
06**

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

Test Item

Kind of test item: iRTT RechargeUnit
Model name: iRTT-RU

detailed information see chapter 6.1 and 6.2 of this test report



This test report is electronically signed and valid without handwritten signature. The public keys can be requested at the test laboratory to verify the electronic signatures.

Test report authorised:



cn=Uli Kraus, o=CTC advanced GmbH,
ou=KRA-211122,
email=uli.kraus@ctcadvanced.com, c=DE
2022.03.23 10:40:02 +01'00'

Uli Kraus
Head of Department
Electromagnetic Compatibility & Acoustics

Test performed:



cn=Jens Hennemann, o=CTC advanced
GmbH, ou=HMN_211123,
email=jens.hennemann@ctcadvanced.
com, c=DE
2022.03.23 11:00:45 +01'00'

Holger Medrow
Testing Manager
Electromagnetic Compatibility & Acoustics

1 Table of contents

| | | |
|---------|---|----|
| 1 | Table of contents | 2 |
| 2 | General information | 3 |
| 2.1 | Notes and disclaimer..... | 3 |
| 2.2 | Application details | 4 |
| 3 | Test standard/s: | 4 |
| 4 | Test Environment | 4 |
| 5 | Test Laboratories sub-contracted | 4 |
| 6 | Information about Test Conditions..... | 5 |
| 6.1 | Test Item | 5 |
| 6.2 | EUT: Type, S/N etc. and Short Descriptions Used in this Test Report | 5 |
| 6.3 | Auxiliary Equipment (AE): Type, S/N etc. and Short Descriptions | 6 |
| 6.4 | EUT Set-up(s) | 6 |
| 6.5 | EUT Operating Modes | 6 |
| 7 | Summary of Test Results | 7 |
| 7.1 | Emission | 7 |
| 7.2 | Measurement and Test Set-up..... | 8 |
| 7.3 | Measurement uncertainty | 8 |
| 7.4 | Reporting statements of conformity – decision rule | 8 |
| 8 | Detailed test results - Emission | 9 |
| 8.1 | Conducted Emission | 9 |
| 8.2 | Electromagnetic Radiated Emissions (Distance 10 m)..... | 14 |
| 8.3 | Electromagnetic Radiated Emissions (Distance 5 m)..... | 20 |
| 9 | Test equipment and ancillaries used for tests | 26 |
| 10 | Observations | 27 |
| Annex A | Photographs of the test set-up..... | 28 |
| Annex B | Photographs of the EUT | 30 |
| Annex C | Document history | 33 |
| Annex D | Further information | 33 |

2 General information

2.1 Notes and disclaimer

The test results of this test report relate exclusively to the test item specified in this test report. CTC advanced GmbH 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.

The test report may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of CTC advanced GmbH.

The testing service provided by CTC advanced GmbH has been rendered under the current "General Terms and Conditions for CTC advanced GmbH".

CTC advanced GmbH will not be liable for any loss or damage resulting from false, inaccurate, inappropriate or incomplete product information provided by the customer.

Under no circumstances does the CTC advanced GmbH test report include any endorsement or warranty regarding the functionality, quality or performance of any other product or service provided.

Under no circumstances does the CTC advanced GmbH test report include or imply any product or service warranties from CTC advanced GmbH, including, without limitation, any implied warranties of merchantability, fitness for purpose, or non-infringement, all of which are expressly disclaimed by CTC advanced GmbH.

All rights and remedies regarding vendor's products and services for which CTC advanced GmbH has prepared this test report shall be provided by the party offering such products or services and not by CTC advanced GmbH. In no case this test report can be considered as a Letter of Approval.

The present test report can only be used for the sDOC procedure in the USA if the „Responsible Party“ (located in USA) or an official of the responsible party confirms the report in writing, as designated in FCC§2.938.

This test report is electronically signed and valid without handwritten signature. For verification of the electronical signatures, the public keys can be requested at the testing laboratory.

2.2 Application details

Date of receipt of order: 2021-12-21
Date of receipt of test item: 2022-01-04
Start of test¹⁾: 2022-01-19
End of test¹⁾: 2022-01-19
Person(s) present during the test: - / -

¹⁾ Date of each measurement, if not shown in the plot, can be requested. Dates are stored in the measurement software.

3 Test standard/s:

| Test Standard | Test Standard Description |
|--|--|
| FCC - Title 47 CFR Part 15: 2022-01 | FCC - Title 47 of the Code of Federal Regulations; Chapter I; Part 15 - Radio frequency devices |
| ANSI C63.4: 2014-06 | 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 |
| ICES-003, Issue 7: 2020-10 | ICES-003 — Information Technology Equipment (including Digital Apparatus) |

4 Test Environment

Temperature: 15°C – 35°C
Relative humidity content: 30 % - 60 %
Air pressure: 860 – 1060 hPa
Power supply of measurement equipment: 230 V / 50 Hz

5 Test Laboratories sub-contracted

6 Information about Test Conditions

6.1 Test Item

| | | | |
|--|--|------------------|---------------|
| Kind of test item | iRTT RechargeUnit | | |
| Type identification | indurad RadioTransponderTag (iRTT) | | |
| Equipment classification: | Equipment for fixed use | | |
| Environment classification: | Residential, commercial and light industry | | |
| Supply voltage | DC Powered 24V | | |
| Ports (maximum cable lengths declared by manufacturer) | Description | Direction | Length |
| | Signal//power port | In / output | > 3m |
| Is mounting position / usual operating position defined? | | | standing |
| Additional information: | | | |
| - this is a class A digital device: the instructions furnished the user shall include a statement according to §15.105 of the used FCC rules - the build in radioparts are not part of this test and are already tested. | | | |

6.2 EUT: Type, S/N etc. and Short Descriptions Used in this Test Report

| short descrip- tion*) | EUT | Type | S/N serial number | HW hardware status | SW software status |
|-----------------------------|-------------------|---|-------------------------|--------------------------|--------------------------|
| EUT A | iRTT RechargeUnit | indurad Radio Transponder Tag (iRTT) | 67257a | V3 | V0.9 |

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

6.3 Auxiliary Equipment (AE): Type, S/N etc. and Short Descriptions

| AE description*) | Auxiliary equipment | Type | S/N serial number | HW hardware status | SW software status |
|------------------|---------------------|----------------------------|-------------------|--------------------|--------------------|
| AE A | Power supply | goodbay NTS 1500 9-24V EUP | 54799 | - / - | - / - |

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

6.4 EUT Set-up(s)

| EUT set-up no. *) | Combination of EUT and AE | Remarks |
|-------------------|---------------------------|--------------------------|
| set. 1 | EUT A + AE A | setup conducted emission |
| set. 2 | EUT A | setup radiated emission |

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

6.5 EUT Operating Modes

| EUT operating mode no. *) | Description of operating modes | Additional information |
|---------------------------|--------------------------------|------------------------|
| op. 1 | powered | all radio parts idle |

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

7 Summary of Test Results

- ☒ No deviations from the technical specifications were ascertained
☐ There were deviations from the technical specifications ascertained

7.1 Emission

7.1.1 Enclosure

| EMI Phenomenon | Frequency range | Basic standard | Result |
|--------------------------------------|-----------------|---------------------|--------|
| Radiated Interference Field Strength | 30 - 1000 MHz | FCC Part 15 Class A | passed |
| Radiated Interference Field Strength | > 1 GHz | FCC Part 15 Class A | passed |

7.1.2 AC Mains Power Input/Output Ports

| EMI Phenomenon | Frequency range | Basic standard | Result |
|--------------------------------|-----------------|---------------------|--------|
| Conducted interference voltage | 0,15– 30 MHz | FCC Part 15 Class A | passed |

Remarks:

| | |
|-----|---|
| NA1 | Not tested because not required by used standard |
| NA2 | Test not applicable because port does not exists |
| NA3 | Test not applicable because port only for services |
| NA4 | Test not applicable because port lengths not longer than 3m |
| NA5 | Not tested because not required by customer |
| NA6 | Not tested because used frequency < 108 MHz |
| NA7 | Not tested because the device is for vehicular use |

7.2 Measurement and Test Set-up

Note: The test configuration is in accordance with the requirements given in the standards in point 3

7.3 Measurement uncertainty

The uncertainty of the measurement equipment fulfils CISPR 16 and the related European and national standards.

The semi anechoic chamber fulfils the requirements of CISPR 16-1 (ANSI C63.4) for a test volume of 4m Ø.

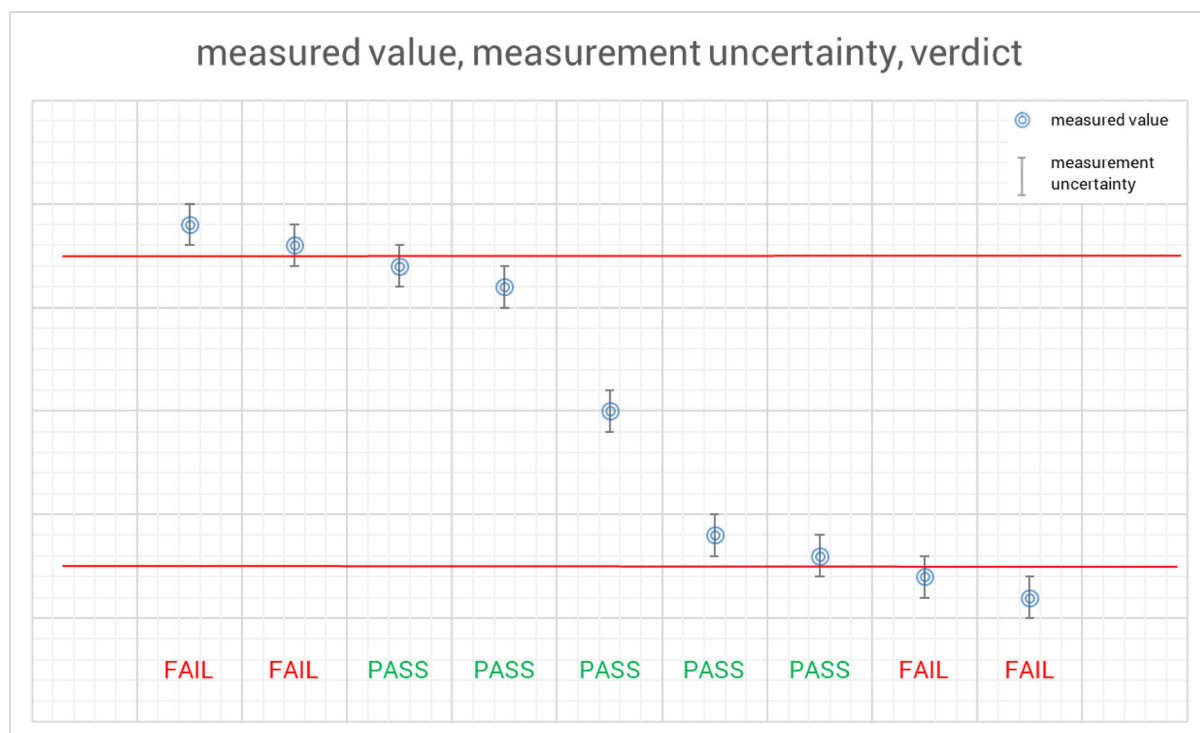
The table below shows the measurement uncertainties for each measurement method. The expended uncertainty (k=2 or 95%) was calculated with worst case values.

| Measurement Method | Frequency area Impulse duration time | Description | Expanded uncertainty (k=2 or 95%) |
|---|---|-------------|--------------------------------------|
| Radiated Emission FCC part 15 B, ANSI C63.4 | 30 MHz – 18 GHz | - / - | ± 4.28 dB |
| Conducted Emission FCC part 15 B, ANSI C63.4 | 9 kHz – 30 MHz | - / - | ± 3.49 dB |

7.4 Reporting statements of conformity – decision rule

Only the measured values related to their corresponding limits will be used to decide whether the equipment under test meets the requirements of the test standards listed in chapter 3.

The measurement uncertainty is mentioned in this test report, see chapter above, but is not taken into account - neither to the limits nor to the measurement results. Measurement results with a smaller margin to the corresponding limits than the measurement uncertainty have a potential risk of more than 5% that the decision might be wrong."



8 Detailed test results - Emission

8.1 Conducted Emission

8.1.1 Instrumentation for Test (see equipment list)

| | | | | | | | | | | | |
|-----|-----|------|--|--|--|--|--|--|--|--|--|
| G 1 | G 2 | F 21 | | | | | | | | | |
|-----|-----|------|--|--|--|--|--|--|--|--|--|

8.1.2 Test Plan

| | | | |
|-----------------------|--------------------|-----------------------|---------------|
| EUT set-up | Set 1 | | |
| Operating mode | Port / Line | Limit | Result |
| op 1 | AC power line | FCC part 15 B Class A | passed |

| | |
|-----------------|--|
| Remark : | Powered by external power supply (115V / 60Hz) |
|-----------------|--|

8.1.3 Conducted Limits (Power-Line)

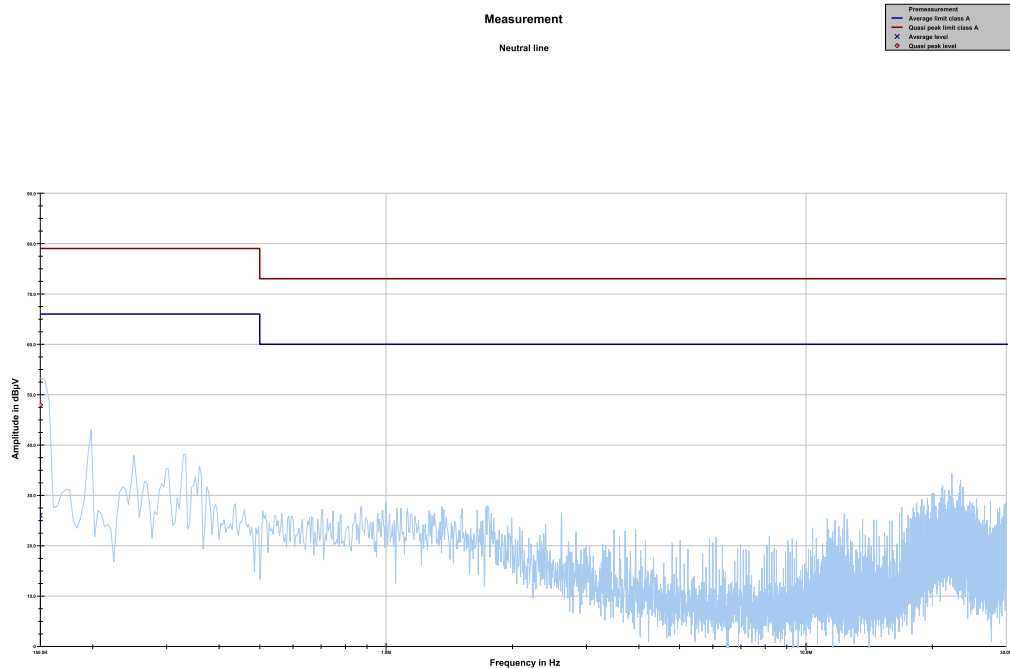
| Frequency- range | FCC part 15 B Class B | | FCC part 15 B Class A | |
|--------------------|-----------------------|----------------|-----------------------|----------------|
| | Quasi-Peak (dBµV) | Average (dBµV) | Quasi-Peak (dBµV) | Average (dBµV) |
| 0,15 MHz – 0,5 MHz | 66-56 | 56-46 | 79 | 66 |
| 0,5 MHz -5 MHz | 56 | 46 | 73 | 60 |
| 5 MHz -30 MHz | 60 | 50 | 73 | 60 |

8.1.4 Calibration Information

| Device | Serial number | Internal Number | Calibration valid until | Calibration interval |
|---------------|---------------|-----------------|-------------------------|----------------------|
| ESCI | 100083 | 3000003312 | 12 / 2022 | 12 month |
| VISN ESH 3-Z5 | 893045/004 | 300000584 | 12 / 2023 | 24 month |

Remarks: All emission components and the shielded room were checked weekly
 Cable loss: 0.6 to 2.4 dB (150kHz to 30 MHz)

8.1.5 Test Results of Main

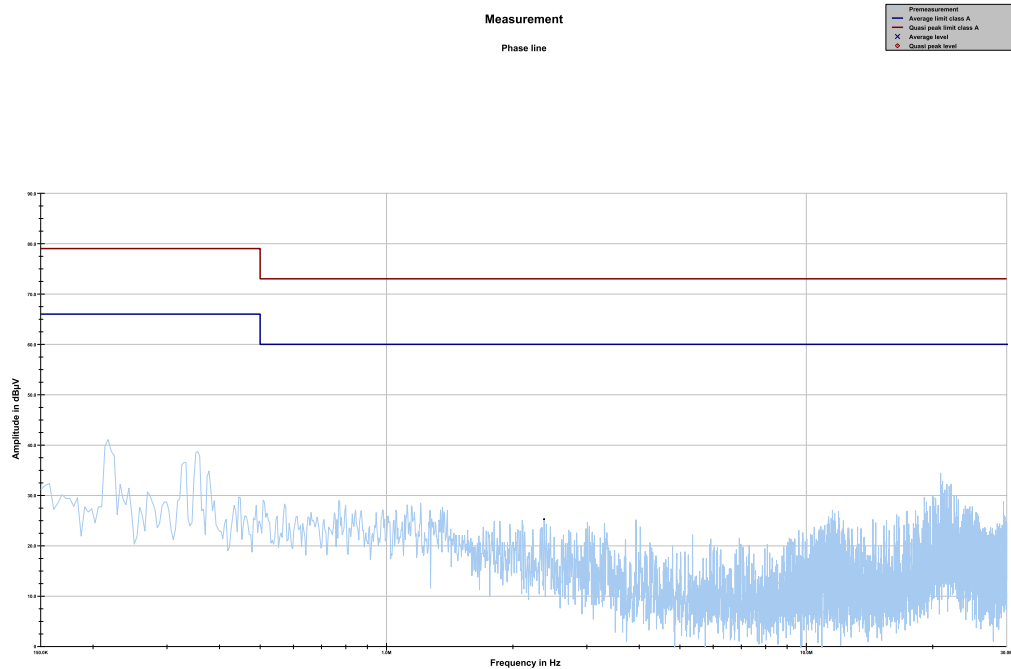


Neutral line tbl
 Project ID: 1-3692/21_03_03

| Frequency | Quasi peak level | Margin quasi peak | Limit QP | Average level | Margin Average | Limit AV |
|-----------|------------------|-------------------|----------|---------------|----------------|----------|
| MHz | dBµV | dB | dBµV | dBµV | dB | dBµV |
| 0.150000 | 47.95 | 31.05 | 79.000 | 26.03 | 39.97 | 66.000 |

Project ID - 1-3692/21_03_03
 EUT - iRTT-RU

Operating mode - powered, all radioparts idle



Phase line tbl
Project ID: 1-3692/21_03_03

| Frequency | Quasi peak level | Margin quasi peak | Limit QP | Average level | Margin average | Limit AV |
|-----------|------------------|-------------------|----------|---------------|----------------|----------|
| MHz | dBµV | dB | dBµV | dBµV | dB | dBµV |
| | | | | | | |

Project ID - 1-3692/21_03_03
EUT - iRTT-RU

Operating mode - powered, all radio parts idle

8.1.6 Signal strength calculation

Calculation formula:

$$SS = UR + CF + VC$$

List of abbreviations:

| | | |
|----|---|---|
| SS | ▶ | signal strength |
| UR | ▶ | voltage at the receiver |
| CF | ▶ | loss of the cable and filter (passband filter 130 kHz – 30 MHz) |
| VC | ▶ | correction factor of the ISN (ESH3-Z5) |

List with correction factors:

| Frequency [MHz] | CF [dB] | VC [dB] |
|-----------------|---------|---------|
| 0,150 | 9,80 | 1,42 |
| 1,000 | 9,80 | 0,41 |
| 5,000 | 9,90 | 0,32 |
| 10,000 | 9,90 | 0,23 |
| 15,000 | 10,00 | 0,39 |
| 20,000 | 10,00 | 1,19 |
| 25,000 | 10,20 | 1,55 |
| 30,000 | 10,30 | 1,31 |

Example calculation:

For example at 10,000 000 MHz the measured Voltage (UR) is 37,62 dBμV, the loss of the cable and filter (CF) is 9,90 dB and the correction factor of the ISN (VC) is 0,23 dB the final result will be calculated:

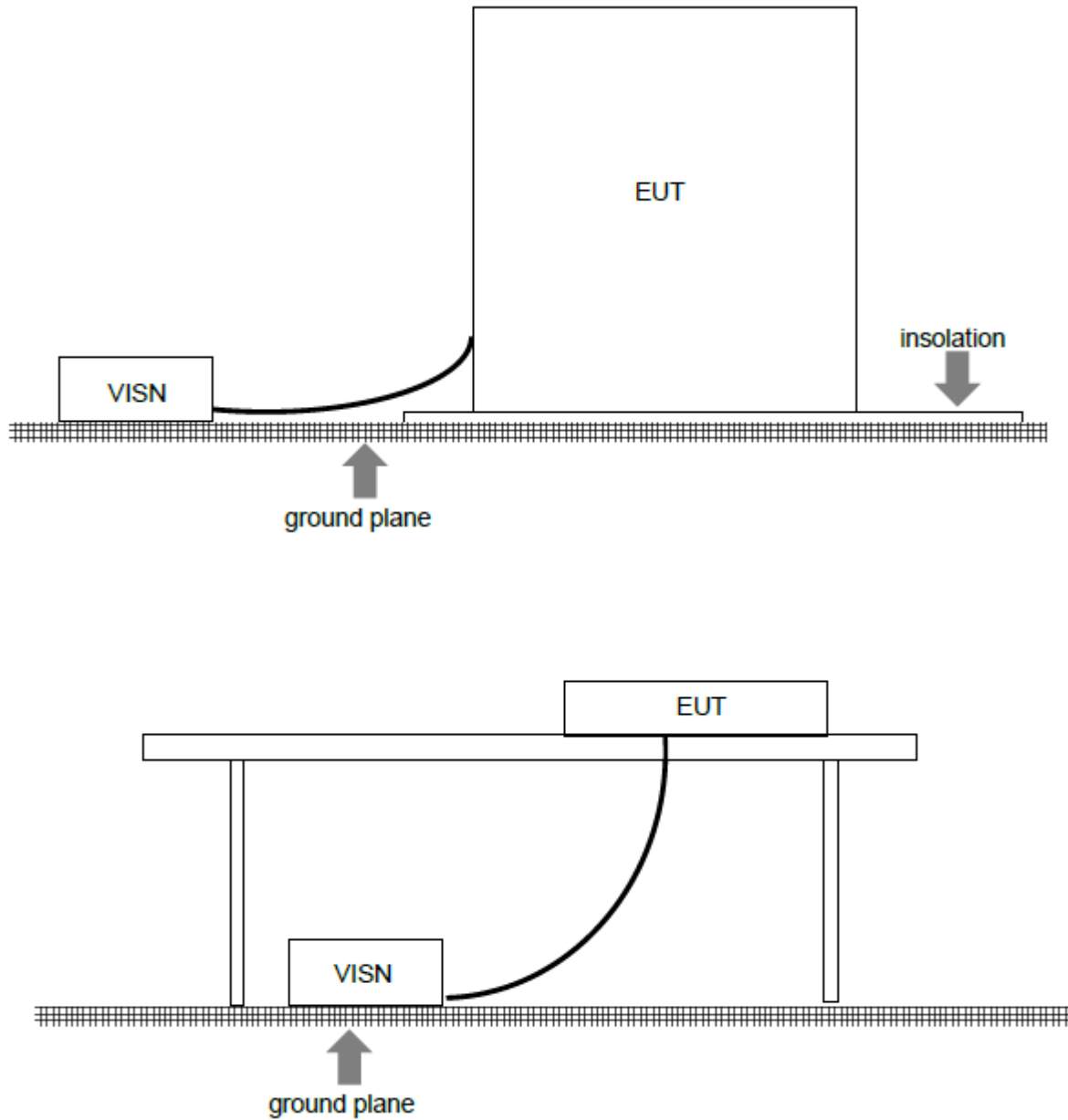
$$SS \text{ [dB}\mu\text{V]} = 37,62 \text{ [dB}\mu\text{V]} + 9,90 \text{ [dB]} + 0,23 \text{ [dB]} = \underline{47,75 \text{ [dB}\mu\text{V]}} \text{ (244, 06 } \mu\text{V)}$$

8.1.7 Version of test software

Software Version: TILE 7.3.0.15

8.1.8 Test Set-up

According to EMC basic standard **ANSI C 63.4**



8.2 Electromagnetic Radiated Emissions (Distance 10 m)

8.2.1 Instrumentation for Test (see equipment list)

| | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|------|--|--|--|--|--|
| F 1 | F 2 | F 5 | F 6 | F 7 | F 8 | F 28 | | | | | |
|-----|-----|-----|-----|-----|-----|------|--|--|--|--|--|

8.2.2 Test Plan

| | | | |
|-----------------------|--------------------|-----------------------|---------------|
| EUT set-up | set 2 | | |
| Operating mode | Application | Limit | Result |
| op 1 | Enclosure | FCC part 15 B Class A | passed |

Remarks: Powered by external power supply DC 24V

8.2.3 Radiated Limits

| Frequency- range | FCC part 15 B Class B | FCC part 15 B Class A |
|-------------------|--|-----------------------|
| 30 MHz – 88 MHz | 30 dB μ V/m | 39,1 dB μ V/m |
| 88 MHz – 216 MHz | 33,5 dB μ V/m | 43,5 dB μ V/m |
| 216 MHz – 960 MHz | 36 dB μ V/m | 46,4 dB μ V/m |
| above 960 MHz | 44 dB μ V/m | 49,5 dB μ V/m |
| | * This values are recalculated from the class B limits at 3 m antenna distance in §15.109 (g 2) of the FCC rules | |

8.2.4 Calibration Information

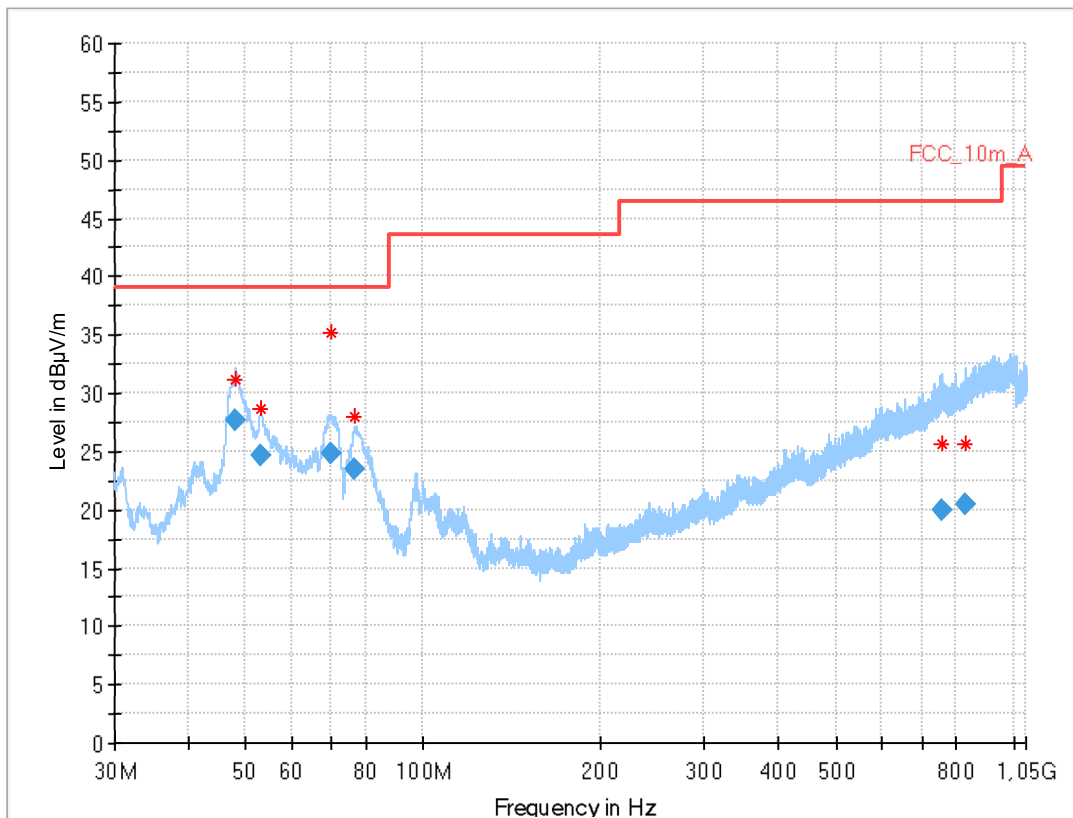
| Device | Serial number | Internal Number | Calibration valid until | Calibration interval |
|-----------------------|------------------------|-----------------|-------------------------|----------------------|
| ESR 3 | 1316.3003K03-102587-ct | 300005771 | 12 / 2022 | 12 month |
| Trilog Antenna | 9163-1029 | 300005379 | 08 / 2023 | 24 month |

Remarks:
System check of all relevant devices and the chamber (weekly)

8.2.5 Test Results

Common Information

EUT: iRTT-RU
 Serial number:
 Test description: FCC part 15 B class A
 Operating condition: powered
 Operator name: SCR
 Comment: DC 24V



Final Result

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|-----------------|--------------------|----------------|-------------|-----------------|-----------------|-------------|-----|---------------|--------------|
| 48.197 | 27.71 | 39.1 | 11.4 | 1000 | 120.0 | 100.0 | V | 106 | 15 |
| 53.069 | 24.66 | 39.1 | 14.4 | 1000 | 120.0 | 112.0 | V | 75 | 15 |
| 69.996 | 24.75 | 39.1 | 14.4 | 1000 | 120.0 | 400.0 | V | 248 | 11 |
| 76.512 | 23.51 | 39.1 | 15.6 | 1000 | 120.0 | 224.0 | V | 183 | 9 |
| 756.049 | 19.90 | 46.4 | 26.5 | 1000 | 120.0 | 184.0 | H | 195 | 24 |
| 830.725 | 20.38 | 46.4 | 26.0 | 1000 | 120.0 | 200.0 | V | 60 | 24 |

8.2.6 Hardware Set-up

Subrange 1

| | |
|--------------------------|--|
| Frequency Range: | 30 MHz - 2 GHz |
| Receiver: | ESR 3 [ESR 3] @ GPIB0 (ADR 20), SN 1316.3003K03/102587, FW 3.46 SP1 |
| Signal Path: | without Notch FW 1.0 |
| Antenna: | VULB 9163 |
| Antenna Tower: | Tower [EMCO 2090 Antenna Tower] @ GPIB0 (ADR 8), FW REV 3.12 |
| Turntable: | Turntable [EMCO Turntable] @ GPIB0 (ADR 9), FW REV 3.12 |
| Software version: | EMC32 V10.59.0 |

8.2.7 Sequence of testing

Setup

- The equipment is set up to simulate normal operation mode as described in the user manual or defined by the manufacturer.
- If the EUT is a tabletop system, a nonconducting table with 0.8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables are positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- Measurement distance is 10 m or 3 m (see ANSI C 63.4) – see test details.
- EUT is set into operation.

Premeasurement

- The turntable rotates from 0° to 315° using 45° steps.
- The antenna is polarized vertical and horizontal.
- The antenna height changes from 1 m to 3 m.
- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement

- The final measurement is performed for at least six highest peaks according to the requirements of the ANSI C63.4.
- Based on antenna and turntable positions at which the peak values are measured the software maximize the peaks by changing turntable position $\pm 45^\circ$ and antenna height between 1 and 4 m.
- The final measurement is done with quasi-peak detector (as described in ANSI C 63.4).
- Final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit are recorded. A plot with the graph of the premeasurement with marked maximum final results and the limit is stored.

8.2.8 Signal strength calculation

Calculation formula:

$$SS = U_R + CL + AF$$

List of abbreviations:

| | | |
|-------|---|-------------------------|
| SS | ▶ | signal strength |
| U_R | ▶ | voltage at the receiver |
| CL | ▶ | loss of the cable |
| AF | ▶ | antenna factor |

List with correction factors:

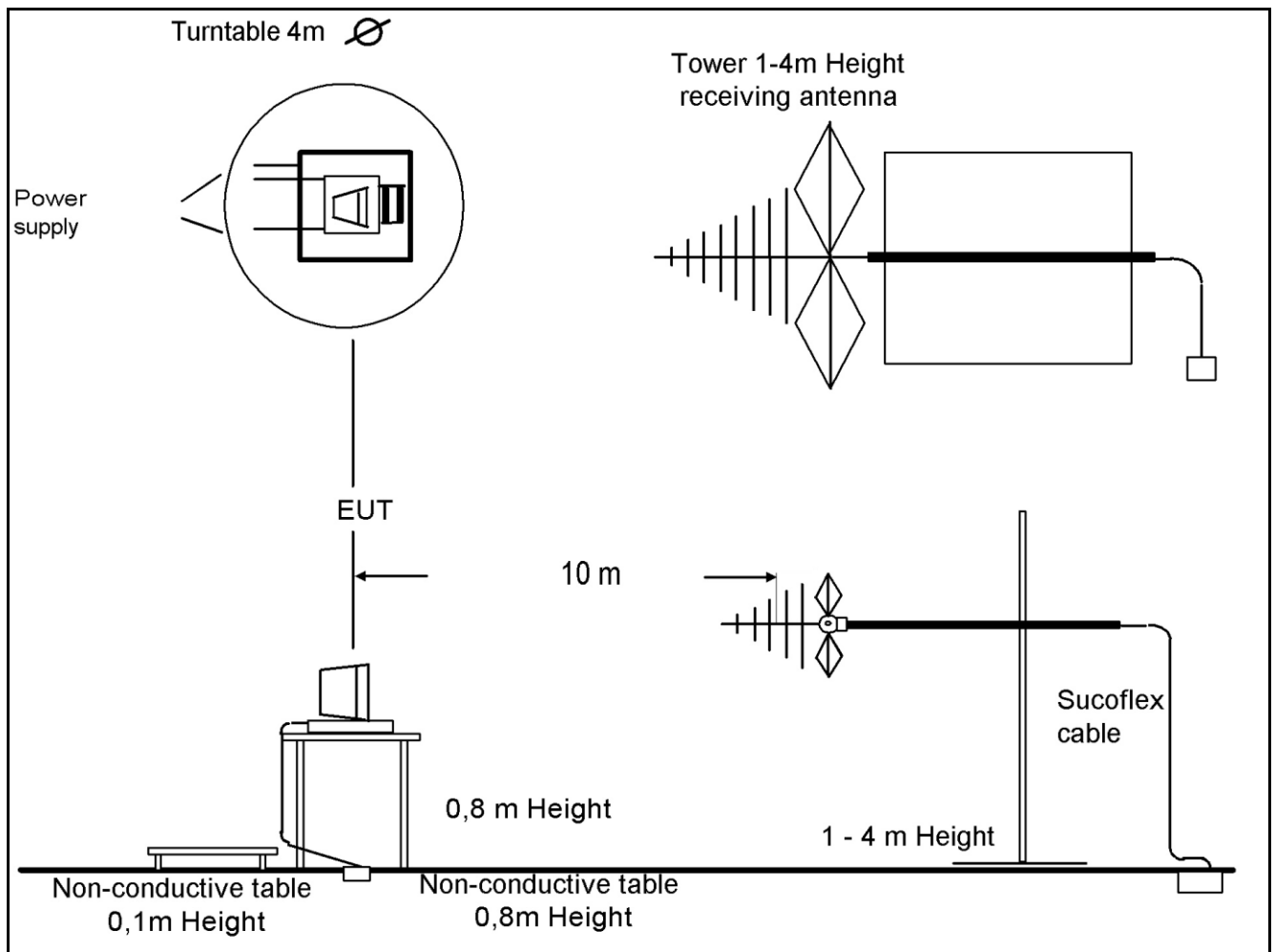
| Frequency [MHz] | CL [dB] | AF [1/m] |
|-----------------|---------|----------|
| 30,000 | 0,20 | 12,30 |
| 100,000 | 0,60 | 11,30 |
| 200,000 | 1,10 | 10,60 |
| 300,000 | 1,30 | 13,20 |
| 400,000 | 1,60 | 15,30 |
| 500,000 | 1,90 | 16,80 |
| 600,000 | 2,00 | 18,80 |
| 700,000 | 2,20 | 20,30 |
| 800,000 | 2,30 | 21,50 |
| 900,000 | 2,40 | 22,80 |
| 1000,000 | 2,50 | 23,30 |

Example calculation:

For example at 500,000 000 MHz the measured Voltage (U_R) is 12,35 dB μ V, the loss of the cable (CL) is 1,90 dB and the antenna factor (AF) is 16,80 dB (m^{-1}) the final result will be calculated:

$$SS [dB\mu V/m] = 12,35 [dB\mu V] + 1,90 [dB] + 16,80 [dB (m^{-1})] = \underline{31,05 [dB\mu V/m]} \quad (35,69 \mu V/m)$$

8.2.9 Test Set-up



8.3 Electromagnetic Radiated Emissions (Distance 5 m)

8.3.1 Instrumentation for Test (see equipment list)

| | | | | | | | | | | | |
|-----|-----|------|------|------|------|--|--|--|--|--|--|
| F 1 | F 6 | F 28 | F 30 | F 32 | F 33 | | | | | | |
|-----|-----|------|------|------|------|--|--|--|--|--|--|

8.3.2 Test Plan

| | | | |
|-----------------------|--------------------|-----------------------|---------------|
| EUT set-up | set 2 | | |
| Operating mode | Application | Limit | Result |
| op 1 | Enclosure | FCC part 15 B Class A | passed |

| | |
|-----------------|--|
| Remarks: | The measured values are recalculated from 5m to 3m distance Powered by external power supply (DC 24V) |
|-----------------|--|

8.3.3 Radiated Limits

| Frequency- range | 47CFR15: (FCC part 15 B) Class B | 47CFR15: (FCC part 15 B) Class A * |
|------------------|----------------------------------|--|
| above 1GHz | 54 dBµV/m | 59,5 dBµV/m |
| | | * This values are recalculated from the class A limits at 10 m antenna distance in §15.109 (g 2) of the FCC rules. |

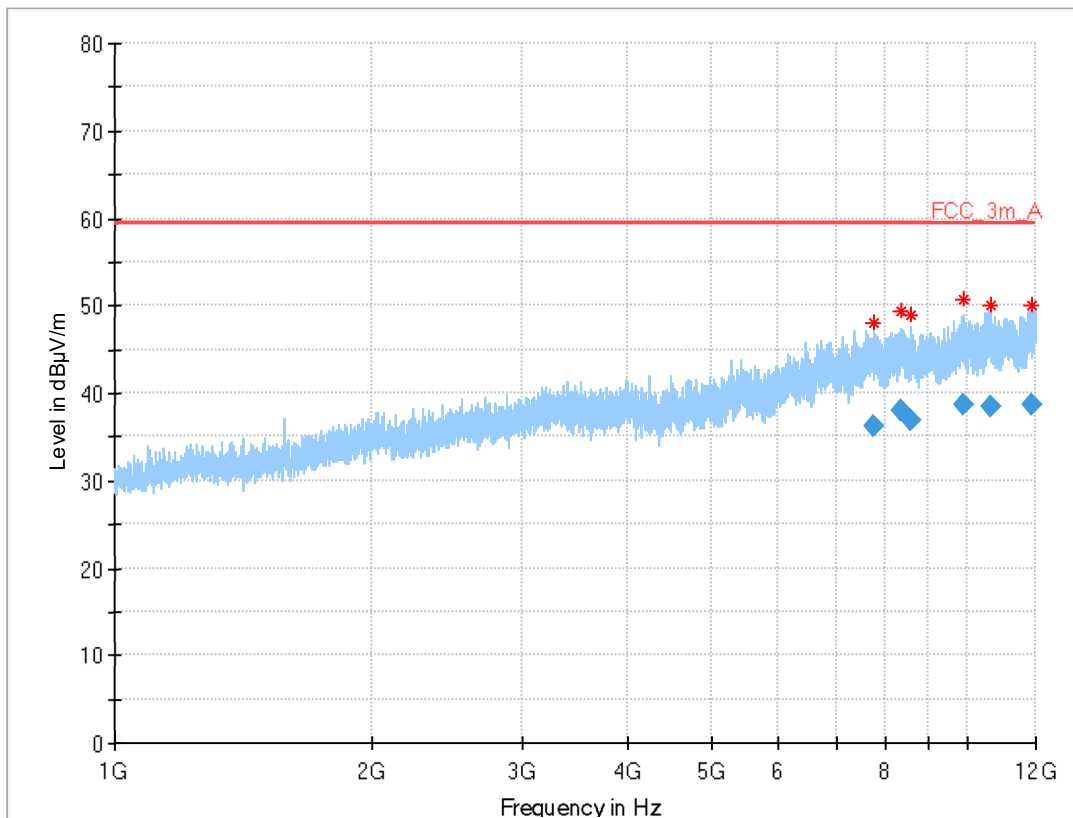
8.3.4 Calibration Information

| Device | Serial number | Internal Number | Calibration valid until | Calibration interval |
|---|---------------|-----------------|-------------------------|----------------------|
| FSU 26 | 200809 | 300003874 | 12/2022 | 12 month |
| Horn Antenna | 9107-3697 | 300001605 | 03/2023 | 24 month |
| Remarks: System check of all relevant devices and the chamber (weekly) | | | | |

8.3.5 Test Results

Common Information

EUT: iRTT-RU
 Serial number:
 Test description: FCC part 15 B class A
 Operating condition: powered
 Operator name: SCR/MAU
 Comment: DC 24V



Final Result

| Frequency (MHz) | Average (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Pol | Azimuth (deg) | Corr. (dB/m) | Comment |
|-----------------|------------------|----------------|-------------|-----------------|-----------------|-----|---------------|--------------|---------|
| 7764.620 | 36.21 | 59.5 | 23.3 | 1000 | 1000.0 | H | 234 | 5 | |
| 8344.251 | 37.91 | 59.5 | 21.6 | 1000 | 1000.0 | H | 165 | 6 | |
| 8579.100 | 36.88 | 59.5 | 22.6 | 1000 | 1000.0 | V | 181 | 6 | |
| 9869.629 | 38.56 | 59.5 | 20.9 | 1000 | 1000.0 | H | 159 | 8 | |
| 10614.125 | 38.33 | 59.5 | 21.2 | 1000 | 1000.0 | H | 142 | 9 | |
| 11873.120 | 38.60 | 59.5 | 20.9 | 1000 | 1000.0 | H | 16 | 10 | |

8.3.6 Hardware Set-up

Subrange 1

Frequency Range:

1 GHz - 18 GHz

Receiver:

FSU 26 [FSU 26]

@ GPIB0 (ADR 17), SN 200809/026, FW 4.71

Signal Path:

1_18_EN

FW 1.0

Antenna:

Horn Antenna EMCO 3115

Turntable:

Turntable [EMCO Turntable]

@ GPIB0 (ADR 9), FW REV 3.12

Software version:

EMC32 V10.59.0

1

8.3.7 Sequence of testing

Setup

- The Equipment was setup to simulate a typical usage like described in the user manual / or described by manufacturer.
- If the EUT is a tabletop system, a nonconducting table with 0,8 m height is used, which is placed on the ground plane.
- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.
- Auxiliary equipment and cables were positioned to simulate normal operation conditions as described in ANSI C 63.4.
- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.
- The measurement distance is: (see ANSI C 63.4)
< 18 GHz = 5 m
The EUT was set into operation.

Premeasurement

- The turntable rotates continuous from 0° to 360°
- The antenna is polarized vertical and horizontal.
- In accordance to the antenna beam and the size of the EUT the antenna height changes in 30 cm steps, start at 1 meter. If it is not possible to tilt the emissions will be checked with a manually tilted antenna from top side.
- The analyzer scans quickly to find the maximum emissions of the EUT

Final measurement

- The final measurement will be performed with minimum the six highest peaks (depends on emissions and number of measured points below 1 GHz)
- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position ($\pm 45^\circ$).
- The final measurement will be done with AV (Average / see ANSI C 63.4) detector
- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit, and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

8.3.8 Signal strength calculation

Calculation formula:

$$SS = U_R + CL + AF + PA + DC$$

List of abbreviations:

| | | |
|-------|---|---|
| SS | ▶ | signal strength |
| U_R | ▶ | voltage at the receiver |
| CL | ▶ | loss of the cable and gain of the preamp |
| AF | ▶ | antenna factor |
| DC | ▶ | distance correction (results measured on 5 m calculated to 3 m) |

List with correction factors: column CL in table contains cable factor and preamplifier correction

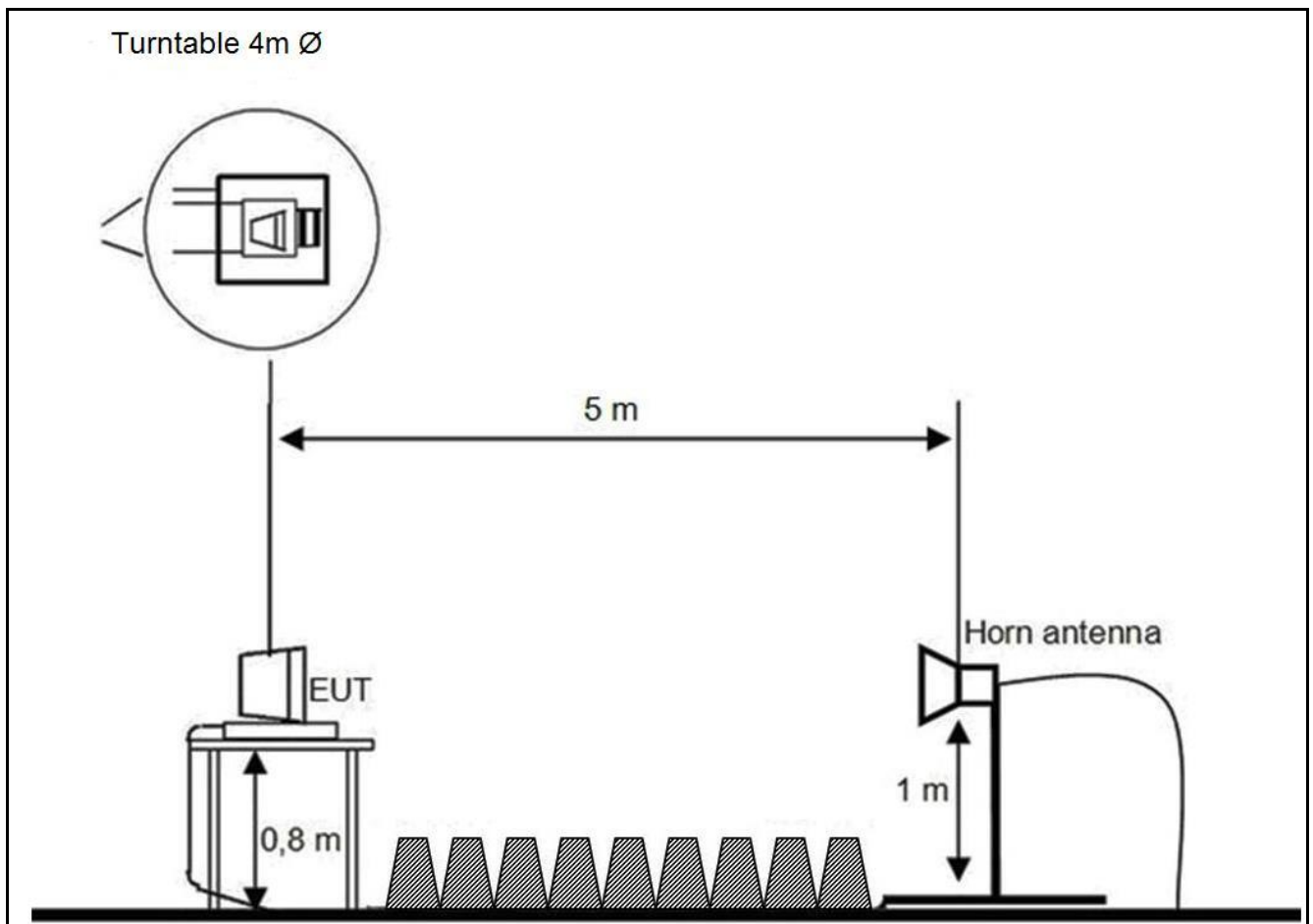
| Frequency [GHz] | CL [dB] | AF [dB1/m] | DC [dB] |
|-----------------|---------|------------|---------|
| 1,000 | -35,50 | 24,40 | 4,40 |
| 1,500 | -35,20 | 25,10 | 4,40 |
| 2,000 | -35,10 | 27,40 | 4,40 |
| 2,500 | -35,00 | 28,50 | 4,40 |
| 3,000 | -34,70 | 30,20 | 4,40 |
| 3,500 | -34,80 | 31,20 | 4,40 |
| 4,000 | -35,00 | 32,60 | 4,40 |
| 4,500 | -34,90 | 32,50 | 4,40 |
| 5,000 | -34,80 | 33,40 | 4,40 |
| 5,500 | -34,35 | 34,10 | 4,40 |
| 6,000 | -34,00 | 34,40 | 4,40 |
| 6,500 | -33,50 | 34,50 | 4,40 |
| 7,000 | -33,10 | 35,50 | 4,40 |
| 7,500 | -33,40 | 36,50 | 4,40 |
| 8,000 | -33,80 | 36,90 | 4,40 |
| 8,500 | -33,75 | 37,20 | 4,40 |
| 9,000 | -33,70 | 37,40 | 4,40 |
| 9,500 | -33,50 | 37,50 | 4,40 |
| 10,000 | -33,40 | 37,90 | 4,40 |
| 11,000 | -35,90 | 38,30 | 4,40 |
| 12,000 | -34,40 | 39,10 | 4,40 |
| 13,000 | -37,30 | 39,30 | 4,40 |
| 14,000 | -36,20 | 41,30 | 4,40 |
| 15,000 | -36,90 | 40,10 | 4,40 |
| 16,000 | -34,90 | 37,60 | 4,40 |
| 17,000 | -35,60 | 40,80 | 4,40 |
| 18,000 | -35,70 | 45,70 | 4,40 |

Example calculation:

For example at 4,000 000 000 GHz the measured Voltage (U_R) is 46,13 dB μ V, the loss of the cable (CL) is -35,00 dB, the antenna factor (AF) is 32,60 dB(m-1) and the distance correction (DC) is 4,40 dB the final result will be calculated:

$$SS \text{ [dB}\mu\text{V/m]} = 46,13 \text{ [dB}\mu\text{V]} + (-35,00) \text{ [dB]} + 32,60 \text{ [dB(m-1)]} + 4,4 \text{ [dB]} = 48,13 \text{ [dB}\mu\text{V/m]} \text{ (202,53 } \mu\text{V/m)}$$

8.3.9 Test Set-up



9 Test equipment and ancillaries used for tests

To simplify the identification of the test equipment and/or ancillaries which were used, the reporting of the relevant test cases only refer to the test item number as specified in the table below.

| No. | Instrument/Ancillary | Manufacturer | Type | Serial-No. | Internal identification |
|--|---|-----------------------|------------------------------------|------------------------|-------------------------|
| Radiated emission in chamber F | | | | | |
| F-1 | Control Computer | F+W | | 2934939v001 | 300005258 |
| F-2 | Trilog-Antenna | Schwarzbeck | VULB 9163 | 9163-1029 | 300005379 |
| F-4b | Switch | Netgear | GS108P | 26V12A3H50336 | 300000368 |
| F-5 | EMI Test receiver | R&S | ESR | 1316.3003K03-102587-ct | 300005771 |
| F-6 | Turntable Interface-Box | EMCO / ETS-LINDGREN | Model 105637 | 44583 | 300003747 |
| F-7 | Tower/Turntable Controller | EMCO / ETS-LINDGREN | Model 2090 | 64672 | 300003746 |
| F-8 | Tower | EMCO / ETS-LINDGREN | Model 2175 | 64762 | 300003745 |
| F-9 | Ultra Notch-Filter Rejected band Ch. 62 | WRCD | | 9 | |
| Radiated immunity in chamber F | | | | | |
| F-10 | Control Computer | F+W | | 2934939v001 | 300005258 |
| F-11 | Signal Generator | R&S | SMB 100A | 1406.6000k02-113856 | 300005266 |
| F-13 | RF-Amplifier | Bonn | BLWA 0860-250/100D | 035491 | 300003210 |
| F-14 | Stacked Logper Antenna | Schwarzbeck | STLP 9129 | 200 | 300006249 |
| F-14a | Bicon-Antenna | EMCO | 3109 | 8906-2309 | 300000575 |
| F-14b | Bicon-Antenna | Schwarzbeck | Balun VHBD 9134 elements BBFA 9146 | 3011 0057 | 300005385 |
| F-15 | RF-Amplifier | ar | 1000LM20 | 20562 | -/- |
| F-16 | Directional Coupler | ar | DC7144A | 312786 | 300003411 |
| F-16a | Directional coupler | emv | DC 2000 | 9401-1677 | 300000592 |
| F-18 | Power Meter | R&S | NRP2 | 104973 | 300005114 |
| F-19 | Power sensor | R&S | NRP-Z91 | 103332 | 300005114-1 |
| F-20 | Power sensor | R&S | NRP-Z91 | 103333 | 300005114-2 |
| F-35 | RF- Amplifier | Bonn | BLMA 2060-5 | 097392A | 300003908 |
| F-36 | Stacked Microwave Log.-Per. Antenna | Schwarzbeck | STLP9149 | 9149-044 | 300003919 |
| Harmonics and flicker in front of chamber F | | | | | |
| F-21 | Flicker and Harmonics Test System | Spitzenberger & Spies | PHE4500/B I PHE4500/B II | B5983 B5984 | 300003314 |
| F-21a | Power Supply | HBS Electronic | ACS-1600-PS | 2002-001247-0 | 300006074 |
| F-28 | Power Supply | Hewlett Packard | 6032 A | 2920 A 04466 | 300000580 |
| Radiated emission in chamber F > 1GHz | | | | | |
| F-29 | Horn antenna | Schwarzbeck | BBHA 9120 B | 188 | 300003896 |
| F-30 | Amplifier | ProNova | 0518C-138 | 005 | F 024 |
| F-31 | Amplifier | Miteq | 42-00502650-28-5A | 1103782 | 300003379 |
| F-32 | Horn antenna | EMCO | 3115 | 9107-3697 | 300001605 |
| F-33 | Spectrum Analyzer | R&S | FSU26 | 200809 | 300003874 |
| F-34 | Loop antenna | EMCO | 6502 | 8905-2342 | 300000256 |

| No. | Instrument/Ancillary | Manufacturer | Type | Serial-No. | Internal identification |
|--|-----------------------------------|-----------------|-------------------|-------------|-------------------------|
| Conducted emission in chamber G | | | | | |
| G-1 | EMI Receiver | R&S | ESCI | 100083 | 300003312 |
| G-2 | V-ISN | Rohde & Schwarz | ESH 3-Z5 | 892475/017 | 300002209 |
| G-2a | V-ISN | Rohde & Schwarz | ESH 2-Z5 | 892602/024 | 300000587 |
| G-3 | 2-Wire ISN | Schaffner | ISN T200 | 19075 | 300003422 |
| G-4 | 4-Wire ISN | Schaffner | ISN T400 | 22325 | 300003423 |
| G-5 | Shielded wire ISN | Schaffner | ISN ST08 | 22583 | 300003433 |
| G-6 | Unshielded 8 wire ISN | Teseq | ISN T800 | 26113 | 300003833 |
| G-7 | Unshielded 8 wire ISN | Teseq | ISN T8-Cat. 6 | 26374 | 300003851 |
| G-8 | RF Current probe | Solar | 9134-1 | 100254 | 300004163 |
| G-9 | V-ISN | Schaffner | ISN PLC-150 | 21579 | 300003318 |
| G-10 | V-ISN | Schaffner | ISN PLC-25-30 | 21584 | 300003319 |
| G 10a | PLC Filter | TESEQ | Filter PLC | 23436 | 300003598 |
| G 10b | Coupling unit 75 Ohm | Fiedler | AC | ---- | 300003272.04 |
| Conducted immunity in chamber G | | | | | |
| G-11 | Signal generator | R&S | SMG | 8610647025 | 300000204.01 |
| G-12 | RF-Amplifier | BONN | BSA 0125-75 | 066502-01 | 300003545 |
| G-13 | Power Meter | R&S | URV 5 | 837723/025 | 300002844.01 |
| G-14 | Power Sensor | R&S | URV 5-Z2 | 832874/021 | 300002239 |
| G-15 | Directional coupler | emv | DC 2000 | 9401-1677 | 300000592 |
| G-16 | Attenuator 6dB | Alan | 50HP6-100 N | 121048 0348 | 300003148 |
| G-17 | EM-Injection Clamp | FCC | 203i | 232 | 300000626 |
| G-18 | CDN | FCC | FCC-801-M3-16 | 237 | 300000627 |
| G-19 | CDN | FCC | FCC-801-T2 | 78 | 300000629 |
| G-20 | CDN | FCC | FCC-801-AF 2 | 62 | 300000630 |
| G-21 | CDN | FCC | FCC-801-AF 4 | 61 | 300000631 |
| G-22 | CDN | FCC | FCC-801-M1 | 2027 | 300002761 |
| G-23 | CDN | TESEQ | CDN M016S | 38741 | 300004847 |
| G-23a | CDN | TESEQ | CDN M516A | 35049 | 300004848 |
| G-24 | transformer for 50Hz Loop Antenna | EM-Test | MC2630 | 0200-10 | 300002659.01 |
| G-25 | 50Hz Loop Antenna | EM-Test | MS 100 | none | 300002659 |
| ESD in chamber G | | | | | |
| G-30 | ESD generator | Schlöder | SESD 30000 | 511333 | 300005097 |
| Emission on bench in chamber G | | | | | |
| G-31 | Absorbing Clamp | R&S | MDS-21 | 832 231/006 | 300000527 |
| generic in chamber G | | | | | |
| G-32 | power supply | Hewlett Packard | 6038A | 2848A06673 | 300001512 |
| Conducted interference in chamber G | | | | | |
| G 33 | Arbitrary Function Generator | 33521B | Keysight | MY52702534 | 300005023 |
| G 34 | Audio amplifier | Crown 5002VZ | MACRO-TECH 5002VZ | 8001641218 | 300004094 |
| G 35 | Shunt | Schwarzbeck | Shunt 9570 | 9570118 | 300004107 |
| G 36 | Coupling network | EM-Test | CN 200N1 | P1322118851 | 300004742 |

10 Observations

No observations, exceeding those reported with the single test cases, have been made.

Annex A Photographs of the test set-up

Photo 1: test setup conducted emission

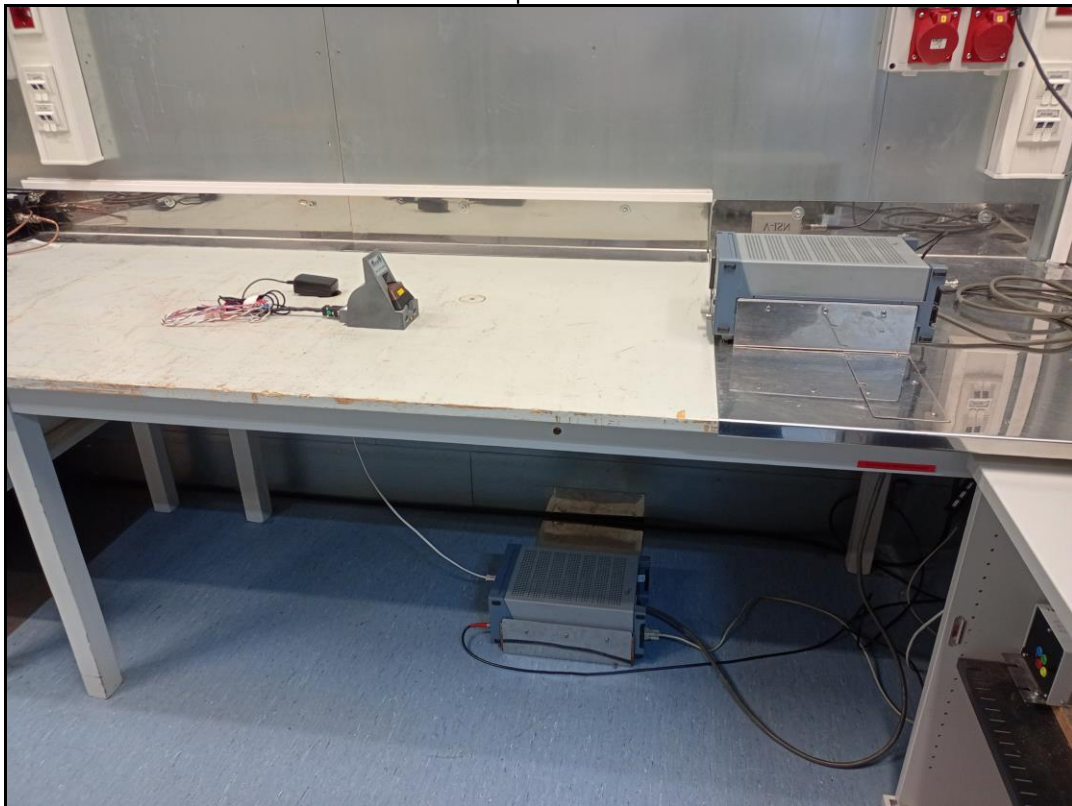


Photo 2: test setup radiated emission

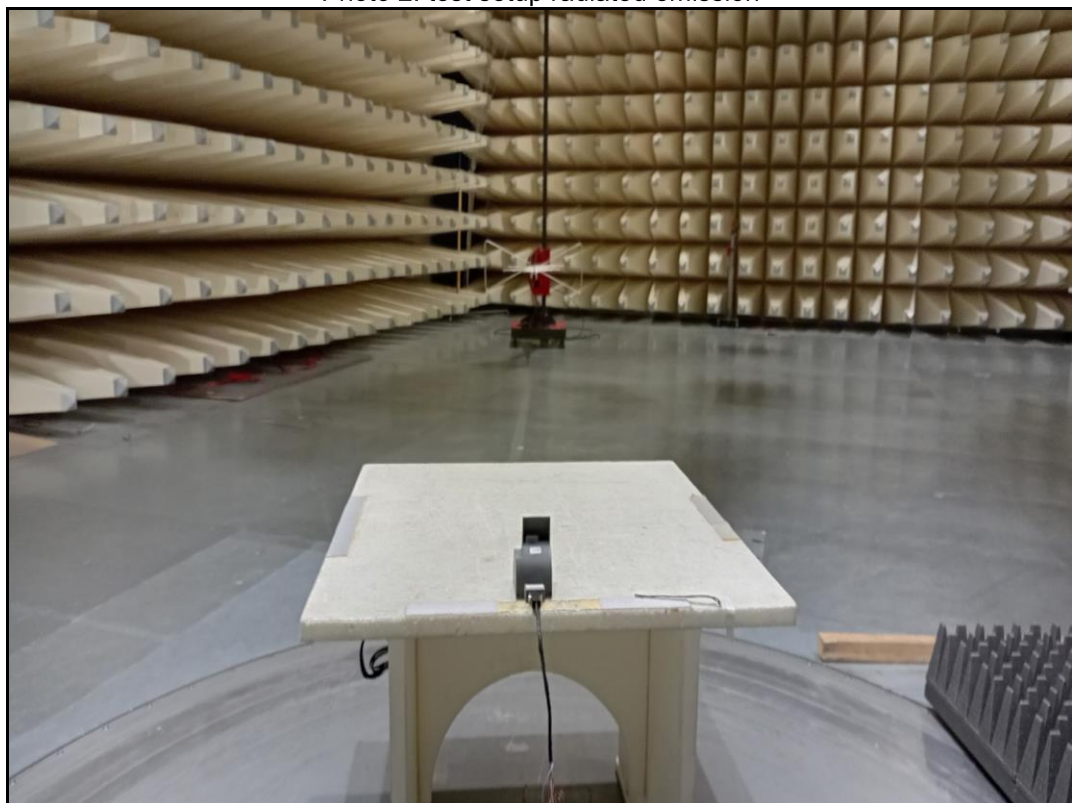


Photo 3: test setup radiated emission



Annex B Photographs of the EUT

Photo 4: Photograph of EUT



Photo 5: Photograph of EUT rear view

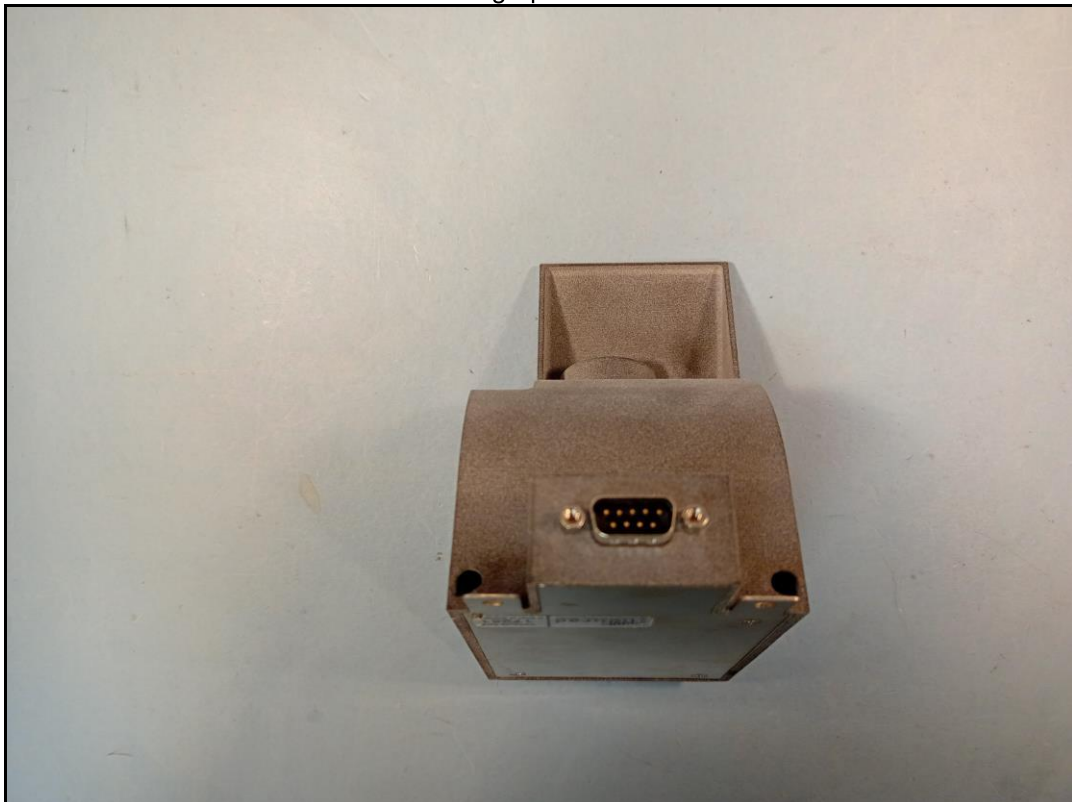


Photo 6: Photograph of EUT downside



Photo 7: Photograph of EUT Side view

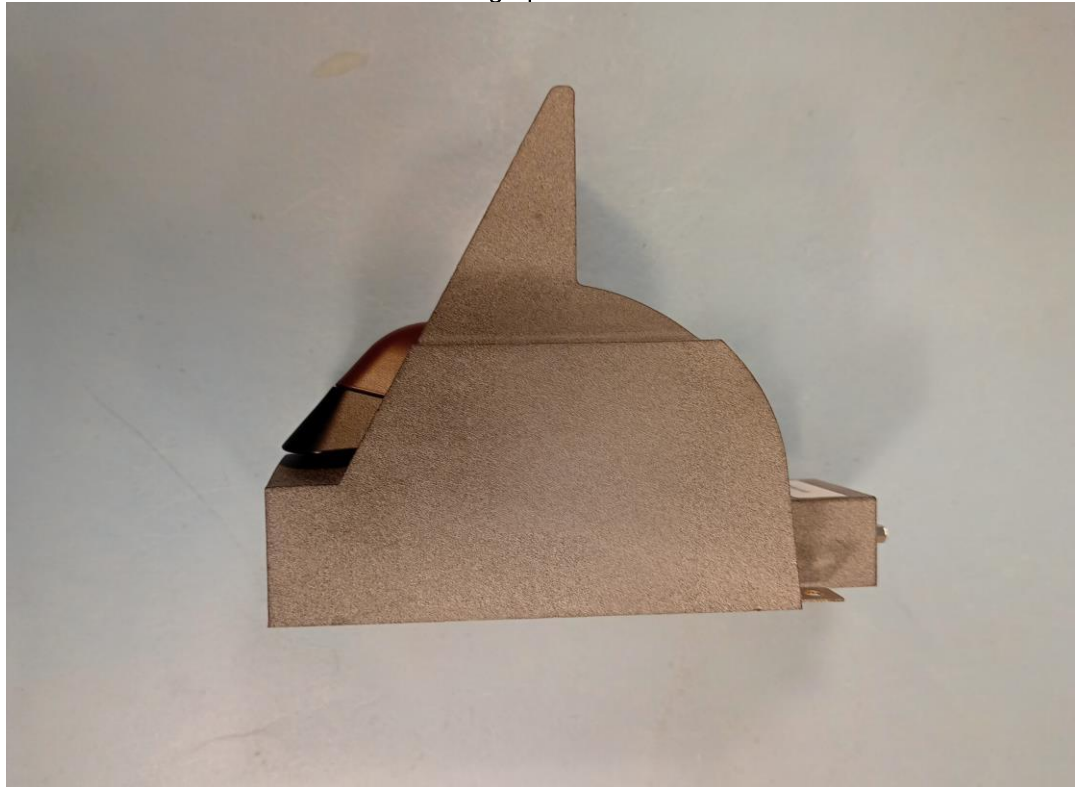


Photo 8: Photograph of AE



Annex C Document history

| Version | Applied changes | Date of release |
|---------|-----------------|-----------------|
| - / - | Initial release | 2022-03-23 |

Annex D Further information**Glossary**

| | | |
|----------|---|----------------------------------|
| DUT | - | Device under Test |
| EMC | - | Electromagnetic Compatibility |
| EUT | - | Equipment under Test |
| FCC | - | Federal Communication Commission |
| FCC ID | - | Company Identifier at FCC |
| HW | - | Hardware |
| IC | - | Industry Canada |
| Inv. No. | - | Inventory number |
| N/A | - | not applicable |
| S/N | - | Serial Number |
| SW | - | Software |