

Ambient Recording GmbH  
Schleissheimer Str. 181c  
80797 München  
Tel.: +49 89 360 55 10-0

200503-AU01+W05

Ambient Recording GmbH  
Modular card  
LockitModule

15.247

RSS-247

**Note:**

- Element Materials Technology Straubing GmbH is the legal successor of EMV Testhaus GmbH. Therefore, until the ongoing procedure for renaming the conformity assessment body applied for at German Accreditation Body DAkkS is completed, the certificates and appropriate annexes of EMV Testhaus GmbH are referred to.

**Accreditation:**

FCC test firm accreditation expiration date: 2021-05-30  
MRA US-EU, FCC designation number: DE0010  
FCC registration number: 97268  
BnetzA-CAB-02/21-02/5 Valid until 2023-11-26



Recognized on March 14<sup>th</sup>, 2019 by the  
Department of Innovation, Science and Economic Development (ISED) Canada  
as a wireless testing laboratory  
CAB identifier: DE0011  
ISED#: 3472A

**Location of Testing:**

Element Materials Technology Straubing GmbH  
Tel.: +49 9421 56868-0  
Fax: +49 9421 56868-100  
Email: [info.straubing@element.com](mailto:info.straubing@element.com)  
Gustav-Hertz-Straße 35  
94315 Straubing, Germany

The technical accuracy is guaranteed through the quality management of  
Element Materials Technology Straubing GmbH.

This document may be reproduced only in its entirety and without change.  
The results contained in this document relate only to the item(s) tested

---

## Table of contents

|     |                                                                           |    |
|-----|---------------------------------------------------------------------------|----|
| 1   | Summary of test results .....                                             | 6  |
| 2   | Referenced publications .....                                             | 8  |
| 3   | Equipment under test (EUT) .....                                          | 9  |
| 3.1 | General information .....                                                 | 9  |
| 3.2 | Radio specifications .....                                                | 10 |
| 3.3 | Photo documentation .....                                                 | 11 |
| 4   | Test configuration and mode of operation .....                            | 12 |
| 4.1 | Test configuration .....                                                  | 12 |
| 4.2 | Mode of operation .....                                                   | 13 |
| 5   | Test procedures .....                                                     | 14 |
| 5.1 | General specifications .....                                              | 14 |
| 5.2 | Antenna-port conducted measurements .....                                 | 15 |
| 5.3 | AC powerline conducted emissions .....                                    | 15 |
| 5.4 | Radiated emissions below 30 MHz .....                                     | 17 |
| 5.5 | Radiated emissions from 30 MHz to 1 GHz .....                             | 19 |
| 5.6 | Radiated emissions above 1 GHz .....                                      | 21 |
| 5.7 | Bandwidth measurements .....                                              | 24 |
| 5.8 | Maximum peak conducted output power .....                                 | 25 |
| 5.9 | Power spectral density .....                                              | 25 |
| 6   | Test results .....                                                        | 26 |
| 6.1 | AC powerline conducted emissions .....                                    | 27 |
| 6.2 | 6 dB bandwidth .....                                                      | 31 |
| 6.3 | Occupied bandwidth .....                                                  | 35 |
| 6.4 | Conducted output power .....                                              | 39 |
| 6.5 | Power spectral density .....                                              | 43 |
| 6.6 | Antenna-port conducted measurements .....                                 | 47 |
| 6.7 | Radiated emissions below 30 MHz .....                                     | 53 |
| 6.8 | Radiated emissions from 30 MHz to 1 GHz .....                             | 56 |
| 6.9 | Radiated emissions from 1 GHz to 25 GHz (10 <sup>th</sup> harmonic) ..... | 59 |
| 7   | Equipment calibration status .....                                        | 68 |
| 8   | Measurement uncertainties .....                                           | 69 |
| 9   | Revision history .....                                                    | 70 |

## List of figures

|                                                                                                                                                  |    |
|--------------------------------------------------------------------------------------------------------------------------------------------------|----|
| Figure 1: Setup for antenna-port conducted measurements.....                                                                                     | 15 |
| Figure 2: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz .....                                                          | 16 |
| Figure 3: Setup for radiated emissions test below 30 MHz.....                                                                                    | 18 |
| Figure 4: Setup for radiated emissions test from 30 MHz to 1 GHz.....                                                                            | 20 |
| Figure 5: Setup for radiated emissions test above 1 GHz.....                                                                                     | 23 |
| Figure 6: Chart of AC powerline conducted emissions on L1 .....                                                                                  | 29 |
| Figure 7: Chart of AC powerline conducted emissions on N.....                                                                                    | 30 |
| Figure 8: Chart of 6 dB bandwidth test on lowest channel .....                                                                                   | 33 |
| Figure 9: Chart of 6 dB bandwidth test on middle channel .....                                                                                   | 33 |
| Figure 10: Chart of 6 dB bandwidth test on highest channel .....                                                                                 | 34 |
| Figure 11: Chart of occupied bandwidth test on lowest channel.....                                                                               | 37 |
| Figure 12: Chart of occupied bandwidth test on middle channel .....                                                                              | 37 |
| Figure 13: Chart of occupied bandwidth test on highest channel .....                                                                             | 38 |
| Figure 14: Chart of conducted output power on lowest channel .....                                                                               | 41 |
| Figure 15: Chart of conducted output power on middle channel.....                                                                                | 41 |
| Figure 16: Chart of conducted output power on highest channel.....                                                                               | 42 |
| Figure 17: Chart of power spectral density on lowest channel.....                                                                                | 45 |
| Figure 18: Chart of power spectral density on middle channel .....                                                                               | 45 |
| Figure 19: Chart of power spectral density on highest channel .....                                                                              | 46 |
| Figure 20: Chart of emissions test from 9 kHz to 25 GHz on lowest channel, PK-detector.....                                                      | 50 |
| Figure 21: Chart of emissions test from 9 kHz to 25 GHz on lowest channel, RMS-detector .....                                                    | 50 |
| Figure 22: Chart of emissions test from 9 kHz to 25 GHz on middle channel, PK-detector .....                                                     | 51 |
| Figure 23: Chart of emissions test from 9 kHz to 25 GHz on middle channel, RMS-detector .....                                                    | 51 |
| Figure 24: Chart of emissions test from 9 kHz to 25 GHz on highest channel, PK-detector .....                                                    | 52 |
| Figure 25: Chart of emissions test from 9 kHz to 25 GHz on highest channel, AV-detector .....                                                    | 52 |
| Figure 26: Chart of emissions test below 30 MHz on lowest channel, EUT position X, antenna parallel to the EUT.....                              | 55 |
| Figure 27: Chart of emissions test from 30 MHz to 1 GHz on lowest channel, EUT position Z, antenna polarization vertical.....                    | 58 |
| Figure 28: Chart of emissions test from 1 GHz to 3 GHz on lowest channel with band edges, EUT position Z, antenna polarization horizontal .....  | 62 |
| Figure 29: Chart of emissions test from 1 GHz to 18 GHz on lowest channel, EUT position Z, antenna polarization horizontal.....                  | 62 |
| Figure 30: Chart of exploratory emission test from 18 GHz to 25 GHz on lowest channel at 0.5 m.....                                              | 63 |
| Figure 31: Chart of emissions test from 1 GHz to 18 GHz on middle channel, EUT position Z, antenna polarization horizontal.....                  | 64 |
| Figure 32: Chart of exploratory emission test from 18 GHz to 25 GHz on middle channel at 0.5 m .....                                             | 64 |
| Figure 33: Chart of emissions test from 1 GHz to 3 GHz on highest channel with band edges, EUT position Z, antenna polarization horizontal ..... | 66 |
| Figure 34: Chart of emissions test from 1 GHz to 18 GHz on highest channel, EUT position Z, antenna polarization horizontal.....                 | 66 |
| Figure 35: Chart of exploratory emission test from 18 GHz to 25 GHz on highest channel at 0.5 m .....                                            | 67 |

## List of tables

|                                                                                       |    |
|---------------------------------------------------------------------------------------|----|
| Table 1: Radio specifications of EUT .....                                            | 11 |
| Table 2: Tested channel(s).....                                                       | 11 |
| Table 3: EUT used for testing.....                                                    | 12 |
| Table 4: Support equipment used for testing .....                                     | 12 |
| Table 5: Ports of EUT and appropriate cables .....                                    | 12 |
| Table 6: Bandwidth and detector type for AC power-line conducted emissions test ..... | 15 |
| Table 7: Sample calculation .....                                                     | 16 |
| Table 8: Recalculation factors for extrapolation .....                                | 17 |
| Table 9: Bandwidth and detector type for radiated emissions test below 30 MHz.....    | 17 |

---

|                                                                                                            |    |
|------------------------------------------------------------------------------------------------------------|----|
| Table 10: Sample calculation .....                                                                         | 18 |
| Table 11: Bandwidth and detector type for radiated emissions test from 30 MHz to 1 GHz .....               | 19 |
| Table 12: Sample calculation .....                                                                         | 19 |
| Table 13: Sample calculation .....                                                                         | 21 |
| Table 14: Bandwidth and trace settings for exploratory radiated emissions test above 1 GHz.....            | 21 |
| Table 15: Bandwidth and detector type for final radiated emissions test above 1 GHz.....                   | 22 |
| Table 16: Limits for AC powerline conducted emissions according to 15.207(a) and RSS-Gen, section 8.8 .    | 28 |
| Table 17: Results of AC powerline conducted emissions on N.....                                            | 30 |
| Table 18: Results of 6 dB bandwidth test.....                                                              | 34 |
| Table 19: Results of occupied bandwidth test.....                                                          | 38 |
| Table 20: Results of conducted output power .....                                                          | 42 |
| Table 21: Results of conducted power spectral density .....                                                | 46 |
| Table 22: General radiated emission limits from 9 kHz to 25 GHz according to §15.209 .....                 | 48 |
| Table 23: General radiated emission limits from 9 kHz to 30 MHz according to RSS-Gen section 8.9 .....     | 48 |
| Table 24: General radiated emission limits from 30 MHz to 25 GHz according to RSS-Gen section 8.9 .....    | 48 |
| Table 25: Results of emissions test from 9 kHz to 25 GHz on lowest channel.....                            | 50 |
| Table 26: Results of emissions test from 9 kHz to 25 GHz on middle channel .....                           | 51 |
| Table 27: Results of emissions test from 9 kHz to 25 GHz on highest channel .....                          | 52 |
| Table 28: General radiated emission limits up to 30 MHz according to §15.209.....                          | 54 |
| Table 29: General radiated emission limits from 9 kHz to 30 MHz according to RSS-Gen section 8.9 .....     | 54 |
| Table 30: General radiated emission limits $\geq$ 30 MHz according to §15.209 and RSS-Gen section 8.9..... | 57 |
| Table 31: General radiated emission limits above 960 MHz according to §15.209 and RSS-Gen .....            | 60 |
| Table 32: Results of emissions test from 1 GHz to 25 GHz on lowest channel.....                            | 63 |
| Table 33: Results of emissions test from 1 GHz to 25 GHz on middle channel .....                           | 65 |
| Table 34: Results of emissions test from 1 GHz to 25 GHz on highest channel .....                          | 67 |

## 1 Summary of test results

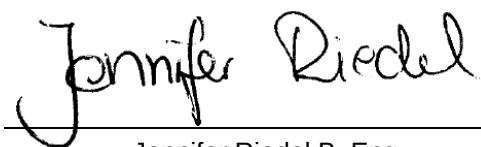
System type: Digital transmission system (DTS)

| 47 CFR part and section | Test                                                    | Equivalent to IC radio standard(s) | Page | Result             | Note(s) |
|-------------------------|---------------------------------------------------------|------------------------------------|------|--------------------|---------|
| 15.207                  | AC power line conducted emissions<br>150 kHz to 30 MHz  | RSS-Gen,<br>section 8.8            | 27   | Passed             | 1       |
| 15.247(a)(2)            | 6 dB bandwidth                                          | RSS-247,<br>section 5.2(a)         | 31   | Passed             | ---     |
| ---                     | Occupied bandwidth                                      | RSS-Gen,<br>section 6.7            | 35   | For reference only | ---     |
| 15.247(b)               | Conducted output power                                  | RSS-247,<br>section 5.4            | 39   | Passed             | ---     |
| 15.247(e)               | Power spectral density                                  | RSS-247,<br>section 5.2(b)         | 43   | Passed             | ---     |
| 15.247(d)               | Antenna-port conducted measurements                     | RSS-247,<br>section 5.5            | 47   | Passed             | 2       |
| 15.247(d)               | Radiated emissions below 30 MHz                         | RSS-247,<br>section 5.5            | 53   | Passed             | ---     |
| 15.247(d)               | Radiated emissions from 30 MHz to 1 GHz                 | RSS-247,<br>section 5.5            | 56   | Passed             | ---     |
| 15.247(d)               | Radiated emissions from 1 GHz to 25 GHz (10th harmonic) | RSS-247,<br>section 5.5            | 59   | Passed             | ---     |
| 15.247(i)               | Radio frequency radiation exposure                      | RSS-Gen, Section 3.4               | ---  | Not performed      | 3       |

Notes (for information about EUT see clause 3):

- 1 Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions for, the use of battery chargers which permit operating while charging, AC adapters or battery eliminators or that connect to the AC power lines indirectly, obtaining their power through another device which is connected to the AC power lines, shall be tested to demonstrate compliance with the conducted limits.
- 2 If antenna port conducted tests cannot be performed (e.g. for portable or handheld devices with integral antenna), then radiated tests are performed for demonstrating compliance to the conducted emission requirements (see "Spurious radiated emissions 9 kHz to 10<sup>th</sup> harmonic").
- 3 Radio frequency radiation exposure is in consideration in another test report.

Straubing, January 26, 2021



---

Jennifer Riedel B. Eng.  
Radio Test Engineer



---

Konrad Graßl  
Department Manager Radio

## 2 Referenced publications

| <i>Publication</i>                             | <i>Title</i>                                                                                                                                                                                                    |
|------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CFR 47 Part 2<br>October 2019                  | Code of Federal Regulations, Title 47 (Telecommunication), Part 2 (Frequency allocation and radio treaty matters; General rules and regulations) of the Federal Communication Commission (FCC)                  |
| CFR 47 Part 15<br>October 2019                 | Code of Federal Regulations, Title 47 (Telecommunication), Part 15 (Radio Frequency Devices) of the Federal Communication Commission (FCC)                                                                      |
| KDB Publication no. 412172<br>August 7, 2015   | Guidelines for determining the Effective Radiated Power (ERP) and Equivalent Isotropically Radiated Power (EIRP) of an RF transmitting system                                                                   |
| KDB Publication no. 558074<br>April 02, 2019   | Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS), Frequency Hopping Spread Spectrum Sytem, and Hybrid System Devices Operating Under §15.247 of the FCC Rules              |
| KDB Publication no. 662911<br>October 31, 2013 | Emissions Testing of Transmitters with Multiple Outputs in the Same Band (e.g., MIMO, Smart Antenna, etc)                                                                                                       |
| ANSI C63.10<br>June 2013                       | American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices                                                                                                                  |
| RSS-Gen, Issue 5<br>March 2019                 | Spectrum Management and Telecommunications -<br>Radio Standards Specification -<br>General Requirements for Compliance of Radio Apparatus                                                                       |
| RSS-247, Issue 2<br>February 2017              | Spectrum Management and Telecommunications -<br>Radio Standards Specification -<br>Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices |



### 3 Equipment under test (EUT)

All Information in this clause is declared by customer.

#### 3.1 General information

|                           |                                                                                                                                                                                                              |                                 |                                |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------------|
| Product type:             | Modular card                                                                                                                                                                                                 |                                 |                                |
| Model name:               | LockitModule                                                                                                                                                                                                 |                                 |                                |
| Serial number(s):         | NLa01289                                                                                                                                                                                                     |                                 |                                |
| Manufacturer:             | Ambient Recording GmbH                                                                                                                                                                                       |                                 |                                |
| Version:                  | Hardware:                                                                                                                                                                                                    | Rev B                           |                                |
|                           | Software:                                                                                                                                                                                                    | 6.20                            |                                |
| Short description:        | EUT is a modular card that transmits its data to devices using the same core technology on a single selectable frequency on ISM 2.45 GHz, Ch. 11 (2405 MHz) through 26 (2480MHz) according to IEEE 802.15.4. |                                 |                                |
| Additional modifications: | None                                                                                                                                                                                                         |                                 |                                |
| FCC ID:                   | PDZ-LM                                                                                                                                                                                                       |                                 |                                |
| IC registration number:   | 27202-LM                                                                                                                                                                                                     |                                 |                                |
| Emission classification:  | 2M39G7D                                                                                                                                                                                                      |                                 |                                |
| Power supply:             | DC supply                                                                                                                                                                                                    |                                 |                                |
|                           | Nominal voltage:                                                                                                                                                                                             | 3.3 V                           |                                |
| Device type:              | <input checked="" type="checkbox"/> Portable                                                                                                                                                                 | <input type="checkbox"/> Mobile | <input type="checkbox"/> Fixed |

## 3.2 Radio specifications

|                             |                                   |                                              |                                                  |
|-----------------------------|-----------------------------------|----------------------------------------------|--------------------------------------------------|
| System type (Note 1):       | Digital transmission system (DTS) |                                              |                                                  |
| Application frequency band: | 2400.0 MHz - 2483.5 MHz           |                                              |                                                  |
| Number of RF channels:      | 15                                |                                              |                                                  |
| Nominal bandwidth:          | 5 MHz                             |                                              |                                                  |
| Modulation(s):              | QPSK                              |                                              |                                                  |
| Antenna:                    | Type:                             | 2.4G & 2db RP SMA male antenna               |                                                  |
|                             | Gain:                             | 2 dBi (maximum)                              |                                                  |
|                             | Connector:                        | <input checked="" type="checkbox"/> external | <input type="checkbox"/> internal                |
|                             |                                   | <input type="checkbox"/> temporary           | <input type="checkbox"/> none (integral antenna) |

Note(s):

1. "DTS" is the equipment class for digital transmission systems, "DSS" for all other Part 15 spread spectrum transmitters as used for equipment authorization system form 731.

| <i>Channel no.</i> | <i>Operating frequency (MHz)</i> |
|--------------------|----------------------------------|
| 11                 | 2405 MHz                         |
| 12                 | 2410 MHz                         |
| 13                 | 2415 MHz                         |
| 14                 | 2420 MHz                         |
| 15                 | 2425 MHz                         |
| 16                 | 2430 MHz                         |
| 17                 | 2435 MHz                         |
| 18                 | 2440 MHz                         |
| 19                 | 2445 MHz                         |
| 20                 | 2450 MHz                         |
| 21                 | 2455 MHz                         |
| 22                 | 2460 MHz                         |
| 23                 | 2465 MHz                         |
| 24                 | 2470 MHz                         |
| 25                 | 2475 MHz                         |
| 26                 | 2480 MHz                         |

Table 1: Radio specifications of EUT

| <i>Channel</i> | <i>Frequency (MHz)</i> |
|----------------|------------------------|
| Low            | 2405                   |
| Middle         | 2440                   |
| High           | 2480                   |

Table 2: Tested channel(s)

### 3.3 Photo documentation

For internal photos of the EUT see annex C.  
Photos taken during testing including EUT positions can be found in annex A.

## 4 Test configuration and mode of operation

### 4.1 Test configuration

| <i>Device</i> | <i>Type designation</i> | <i>Serial or inventory no.</i> | <i>Manufacturer</i>    |
|---------------|-------------------------|--------------------------------|------------------------|
| Modular card  | LockitModule            | NLa01289                       | Ambient Recording GmbH |

Table 3: EUT used for testing

| <i>Device</i>           | <i>Type designation</i> | <i>Serial or inventory no.</i> | <i>Manufacturer</i>    |
|-------------------------|-------------------------|--------------------------------|------------------------|
| Evaluation board        | NLM Carrier             | ADN18051701                    | Ambient Recording GmbH |
| Laptop                  | Lifebook A531           | E001053                        | FUJITSU                |
| Power supply for laptop | AC adapter              | E001053                        | FUJITSU                |

Table 4: Support equipment used for testing

| <i>Port</i>  | <i>Classification</i>       |
|--------------|-----------------------------|
| U.FL         | Antenna cable               |
| Socket board | DC power and Signal/control |

Table 5: Ports of EUT and appropriate cables

## **4.2 Mode of operation**

The EUT was DC supplied by the evaluation board and connected to the laptop via USB.

### **4.2.1 Test software used for all tests**

The test software YAT was used to set the appropriate parameter, e.g. channel. The modulated signal was set with the button "PRBV mode".

### **4.2.2 Test modes applied**

For the measurements the testing mode "PRBV" for modulated TX carrier is used with the carrier frequency set to the appropriate channel using "Ch = 11", "Ch = 18" or "Ch = 26", as applicable. For further details see clause 4.2.1.

## **5 Test procedures**

### **5.1 General specifications**

#### **5.1.1 Test setups**

Tabletop devices are placed on a non-conductive table with a height of 0.8 m. In case of AC power-line conducted emissions test, the rear of the EUT is located 40 cm to the vertical wall of the RF-shielded (screened) room which is used as vertical conducting plane. For radiated emission measurements above 1 GHz, tabletop devices are placed at a height of 1.5 m above the floor using a support made of styrene placed on top of the non-conductive table.

All other surfaces of tabletop or floor-standing EUTs are at least 80 cm from any other grounded conducting surface. This includes the case or cases of one or more LISNs when performing an AC power-line conducted emissions test.

Radiated emission measurements of equipment that can be used in multiple orientations (e.g. portable or handheld devices) are performed with the EUT in each of three orthogonal axis positions.

#### **5.1.2 Conversion to conducted test results**

If test procedures described herein are based on the use of an antenna-port conducted test configuration, but the EUT cannot provide such a configuration (e.g., portable or handheld devices with integral antenna), radiated tests are performed for demonstrating compliance to the conducted requirements.

If a radiated test configuration has to be used, then the measured power or field strength levels are converted to equivalent conducted power levels for comparison to the applicable limit. For this purpose, at first the radiated field strength or power levels are converted to EIRP as described in annex G of ANSI C63.10 and KDB Publication 412172, document D01. The equivalent conducted power is then determined by subtracting the EUT transmit antenna gain from the EIRP (assuming logarithmic representation).

For devices utilizing multiple antenna technologies, KDB Publication 662911 applies.

## 5.2 Antenna-port conducted measurements

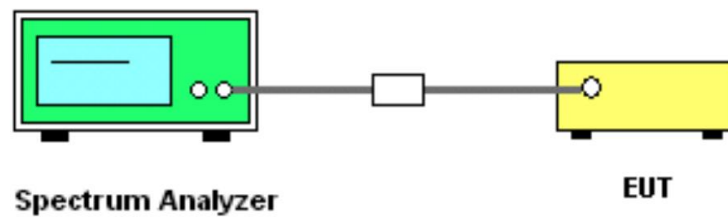


Figure 1: Setup for antenna-port conducted measurements

The RF signal of the EUT is measured conducted at the antenna port. In case of no permanent antenna connector available, a temporary antenna connector should be supplied by the manufacturer. The specific insertion loss of the signal path, which is matched to 50 Ohm, is determined. The test receiver is set to analyzer mode with pre-selector activated. The measurement readings on the test receiver are corrected by the signal path loss.

For frequency hopping systems (FHSS) and digital transmission systems (DTS) the settings as specified by KDB Publication 558074, document D01, are used.

If a radiated test configuration has to be used, conversion to conducted test results is performed according to clause 5.1.2.

## 5.3 AC powerline conducted emissions

AC power-line conducted emissions are measured according to clause 6.2 of ANSI C63.10 over the frequency range from 150 kHz to 30 MHz to determine the line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network. The tests are performed in a shielded room.

If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements are made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.

For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an “off-the-shelf” unmodified ac power adapter is used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

| Frequency ( <i>f</i> )      | Measurement receiver bandwidth | Step size | Detector type |                     |                     |
|-----------------------------|--------------------------------|-----------|---------------|---------------------|---------------------|
|                             |                                |           | Prescan       | Prescan with FFT    | Final scan          |
| 150 kHz ≤ <i>f</i> < 30 MHz | 9 kHz                          | ≤ 4.5 kHz | Peak, Average | Quasi-peak, Average | Quasi-peak, Average |

Table 6: Bandwidth and detector type for AC power-line conducted emissions test

The AC power-line conducted emissions test is performed in the following steps:

- The EUT is arranged as tabletop or floor-standing equipment, as applicable, and connected to a line impedance stabilization network (LISN) with 50 μH / 50 Ω. If required, a second LISN of the same type and terminated by 50 Ω is used for peripheral devices. The EUT is switched on.
- The measurement equipment is connected to the LISN for the EUT and set-up according to the specifications of the test (see table 6). At the LISN, the neutral line is selected to be tested.

- c) The prescan is performed with both detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescan, but not for final scan.
- d) When the prescan is completed, maximum levels with less margin than 10 dB or exceeding the limit are determined and collected in a list.
- e) With the first frequency of the list selected, a frequency zoom over a range of ten times of the measurement receiver bandwidth around this frequency is performed. If the EUT has no significant drift in frequency, the frequency zoom can be skipped.
- f) For final scan, the emission level is measured and the maximum is recorded.
- g) Steps e) to f) are repeated for all other frequencies in the list. At least the six highest EUT emissions relative to the limit have to be recorded.
- h) Steps c) to g) are repeated for all current-carrying conductors of all of the power cords of EUT, i.e. all phase and (if used) neutral line(s).

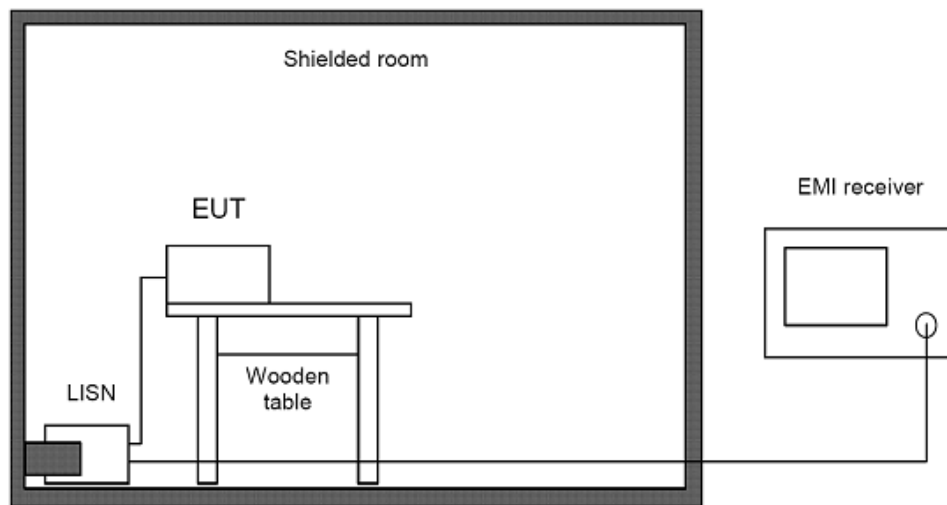


Figure 2: Setup for AC power-line conducted emissions test from 150 kHz to 30 MHz

| Phase | Frequency<br>(MHz) | Reading<br>value<br>(dB $\mu$ V) | AMN<br>correction<br>(dB) | Cable<br>attenuation<br>+ 10 dB<br>attenuator<br>(dB) | Correction<br>factor (Corr.)<br>(dB) | Level<br>(dB $\mu$ V/m) |
|-------|--------------------|----------------------------------|---------------------------|-------------------------------------------------------|--------------------------------------|-------------------------|
| L 1   | 10                 | 10                               | 0.6                       | 10.9                                                  | 11.5                                 | 21.5                    |
| N     | 10                 | 10                               | 1.0                       | 10.9                                                  | 11.9                                 | 21.9                    |

Table 7: Sample calculation

Correction factor = Artificial mains network correction + Cable attenuation + 10 dB

Level = Reading value + Correction factor = 10 dB $\mu$ V + 11.5 dB = 21.5 dB $\mu$ V

Prescans are performed with all detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans. If no limit is specified for certain detectors, final scan measurement with these detectors may be omitted.



## 5.4 Radiated emissions below 30 MHz

Radiated emissions below 30 MHz are measured according to clause 6.4 of ANSI C63.10 using an inductive shielded loop antenna. As this antenna measures the magnetic field only, its antenna factors are converted to electric field strength values assuming a free space impedance of  $377 \Omega$  as described in clause 4.3.1 of ANSI C63.10. This results in an additional correction of 51.53 dB.

According to clause 6.4.3 of ANSI C63.10, at frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the requirements. In this case, the results are extrapolated to the specified distance by using a recalculation factor determined according to one of the methods described in clause 6.4.4 of ANSI C63.10, provided that the maximum dimension of the device is equal to or less than 0.625 times the wavelength at the frequency being measured. As the minimum wavelength is 10 meters corresponding to the maximum frequency of 30 MHz, this requirement is fulfilled if the maximum dimension of the device is equal to or less than 6.25 meters.

Unless otherwise stated, the recalculation factor is determined according to clause 6.4.4.2 “Extrapolation from the measurement of a single point” of ANSI C63.10:

$$\begin{aligned} d_{\text{near field}} &= 47.77 / f_{\text{MHz}}, \text{ or} \\ f_{\text{MHz}} &= 47.77 / d_{\text{near field}} \end{aligned}$$

The frequency  $f_{\text{MHz}}$  at which the near field distance is equal to the limit and/or test distance is important for selection of the right formula to determine the recalculation factor:

$$\begin{aligned} f_{\text{MHz}}(300 \text{ m}) &\approx 0.159 \text{ MHz} \\ f_{\text{MHz}}(30 \text{ m}) &\approx 1.592 \text{ MHz} \\ f_{\text{MHz}}(3 \text{ m}) &\approx 15.923 \text{ MHz} \end{aligned}$$

Based on the test distances for the general radiated emission limits as specified in §15.209 of 47 CFR Part 15 or RSS-Gen, the following formulas are used to determine the recalculation factor:

| Frequency (f)                                                 | $d_{\text{limit}}$ | $d_{\text{measure}}$ | Formula for recalculation factor                                                                           |
|---------------------------------------------------------------|--------------------|----------------------|------------------------------------------------------------------------------------------------------------|
| 9 kHz $\leq$ f $\leq$ 159 kHz<br>490 kHz < f $\leq$ 1.592 MHz | 300 m<br>30 m      | 3 m                  | $-40 \log(d_{\text{limit}} / d_{\text{measure}})$                                                          |
| 159 kHz < f $\leq$ 490 kHz<br>1.592 MHz < f $\leq$ 15.923 MHz | 300 m<br>30 m      | 3 m                  | $-40 \log(d_{\text{near field}} / d_{\text{measure}}) - 20 \log(d_{\text{limit}} / d_{\text{near field}})$ |
| f > 15.923 MHz                                                | 30 m               | 3 m                  | $-20 \log(d_{\text{limit}} / d_{\text{measure}})$                                                          |

Table 8: Recalculation factors for extrapolation

Prescans for radiated measurements below 30 MHz are performed in a fully anechoic room (called “CDC”). The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 9.

| Frequency (f)             | Measurement receiver bandwidth | Step size      | Detector type |                          |                          |
|---------------------------|--------------------------------|----------------|---------------|--------------------------|--------------------------|
|                           |                                |                | Prescan       | Prescan with FFT         | Final scan               |
| 9 kHz $\leq$ f < 150 kHz  | 200 Hz                         | $\leq$ 100 Hz  | Peak, Average | Peak Quasi-peak, Average | Peak Quasi-peak, Average |
| 150 kHz $\leq$ f < 30 MHz | 9 kHz                          | $\leq$ 4.5 kHz | Peak, Average | Peak Quasi-peak, Average | Peak Quasi-peak, Average |

Table 9: Bandwidth and detector type for radiated emissions test below 30 MHz

| Frequency<br>(MHz) | Reading value<br>(dB $\mu$ V) | Antenna<br>correction<br>(dB/m) | Cable<br>attenuation<br>(dB) | Correction<br>factor (Corr.)<br>(dB) | Level<br>(dB $\mu$ V/m) |
|--------------------|-------------------------------|---------------------------------|------------------------------|--------------------------------------|-------------------------|
| 10                 | 20.00                         | 19.59                           | 0.33                         | 19.92                                | 39.92                   |

Table 10: Sample calculation

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 20 dB $\mu$ V + 19.92 dB = 39.92 dB $\mu$ V/m

Prescans are performed with all detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans. If no limit is specified for certain detectors, final scan measurement with these detectors may be omitted.

The radiated emissions test below 30 MHz is performed in the following steps:

- The loop antenna is positioned with its plane perpendicular to the ground with the lowest height of the antenna 1 m above the ground.
- The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
- The measurement equipment is connected to the loop antenna and set-up according to the specifications of the test (see table 9).
- The EUT is turned to a position likely to get the maximum and the test antenna is rotated to detect the maximum of the fundamental in this EUT position.
- Then the EUT is rotated in a horizontal plane through 360° in steps of 45°. Starting at 0°, at each table position the spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the current table position is noted as the maximum position.
- After the last prescan, the significant maximum emissions and their table positions are determined and collected in a list.
- With the test receiver set to the first frequency of the list, the EUT is rotated by  $\pm 45^\circ$  around the table position found during prescans while measuring the emission level continuously. For final scan, the worst-case table position is set and the maximum emission level is recorded.
- Step g) is repeated for all other frequencies in the list.
- Finally, for frequencies with critical emissions the loop antenna is rotated again to find the maximum of emission. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to i) are repeated in two other orthogonal positions. If the EUT may be used in one position only, steps a) to i) are repeated in one orthogonal position.

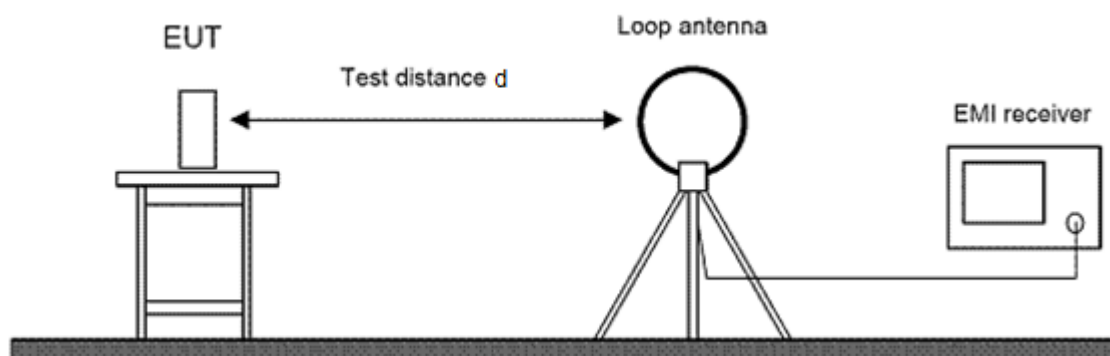


Figure 3: Setup for radiated emissions test below 30 MHz

## 5.5 Radiated emissions from 30 MHz to 1 GHz

Radiated emissions in the frequency range 30 MHz to 1 GHz are measured according to clause 6.5 of ANSI C63.10 using a semi-anechoic chamber (SAC) with a ground plane on the floor. The measurement distance is 3 meters. The emissions of the EUT are recorded with an EMI test receiver configured as described in table 11.

| Frequency (f)              | Measurement receiver bandwidth | Step size     | Detector type |                  |            |
|----------------------------|--------------------------------|---------------|---------------|------------------|------------|
|                            |                                |               | Prescan       | Prescan with FFT | Final scan |
| 30 MHz $\leq f \leq$ 1 GHz | 120 kHz                        | $\leq$ 60 kHz | Peak          | Quasi-peak       | Quasi-peak |

Table 11: Bandwidth and detector type for radiated emissions test from 30 MHz to 1 GHz

| Frequency<br>(MHz) | Reading value<br>(dB $\mu$ V) | Antenna correction<br>(dB/m) | Cable attenuation<br>(dB) | Correction factor (Corr.)<br>(dB) | Level<br>(dB $\mu$ V/m) |
|--------------------|-------------------------------|------------------------------|---------------------------|-----------------------------------|-------------------------|
| 100                | 30.00                         | 11.71                        | 1.06                      | 12.77                             | 42.77                   |

Table 12: Sample calculation

Correction factor = Antenna correction + Cable attenuation

Level = Reading value + Correction factor = 30 dB $\mu$ V + 12.77 dB = 42.77 dB $\mu$ V/m

The measurement antenna is a combination of a biconical antenna and a logarithmic-periodic dipole array antenna. It is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and in a height between 1 m and 4 m above the ground plane.

If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans.

The radiated emissions test from 30 MHz to 1 GHz is performed in the following steps:

- The measurement antenna is oriented initially for vertical polarization.
- The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
- The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 11).
- The table position is set to 0°.
- The antenna height is set to 1 m.
- The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
- The antenna height is increased to 4 m in steps of 50 cm. At each height, step f) is repeated.
- The polarization of the measurement antenna is changed to horizontal.
- The antenna height is decreased from 4 m to 1 m in steps of 50 cm. At each height, step f) is repeated.
- The EUT is rotated in a horizontal plane through 360° in steps of 60°. At each table position, steps e) to i) are repeated.
- After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
- With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
- The antenna is moved by  $\pm 50$  cm around this height and the EUT is rotated by  $\pm 60^\circ$  around this table position while measuring the emission level continuously.
- For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
- Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to o) are repeated in two other orthogonal positions.

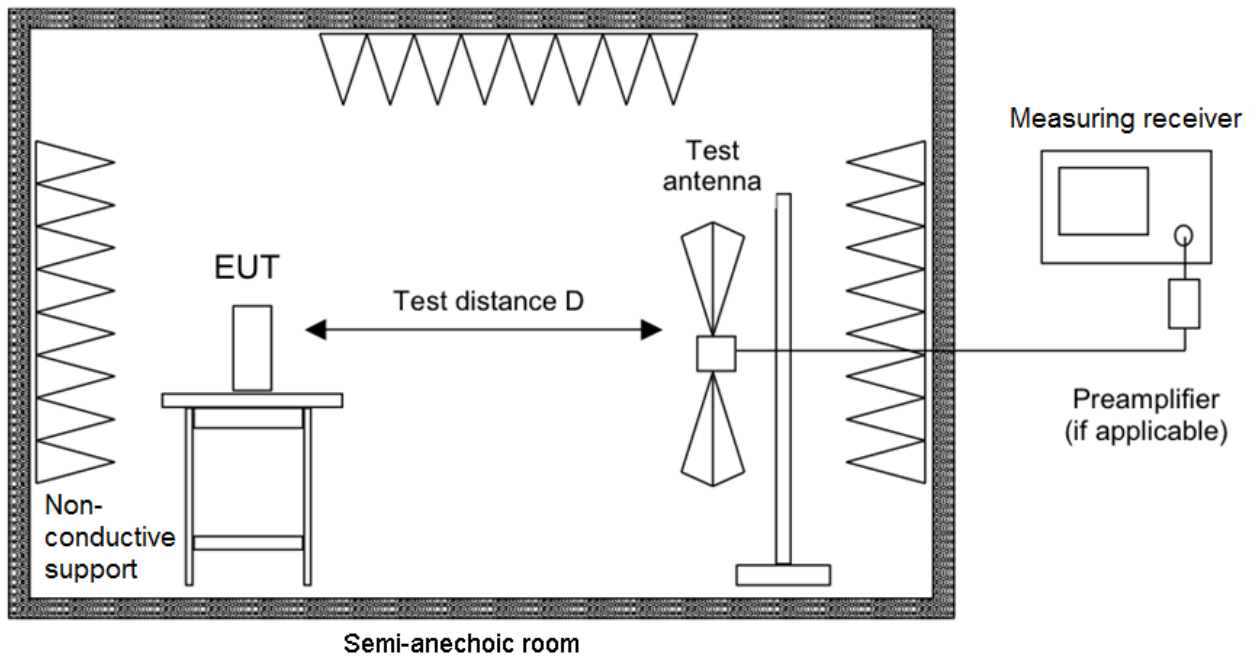


Figure 4: Setup for radiated emissions test from 30 MHz to 1 GHz

## 5.6 Radiated emissions above 1 GHz

Radiated emissions above 1 GHz are measured according to clause 6.6 of ANSI C63.10 by conducting exploratory and final radiated emission tests. According to clause 6.6.4.1 of ANSI C63.10, measurements may be performed at a distance closer than that specified in the requirements. However, an attempt shall be made to avoid making final measurements in the near field of both the measurement antenna and the EUT.

For measurement of radiated emissions above 1 GHz, horn antennas are used.

| Test chamber | Frequency (MHz) | Reading value (dBμV) | Antenna correction (dB/m) | Correction pre-amplifier (dB) | Cable attenuation (dB) | Correction factor (Corr.) (dB) | Level (dBμV/m) |
|--------------|-----------------|----------------------|---------------------------|-------------------------------|------------------------|--------------------------------|----------------|
| SAC3         | 2400            | 50.00                | 27.76                     | -47.91                        | 5.24                   | -14.92                         | 35.08          |
| FS-SAC       | 2400            | 50.00                | 27.76                     | -34.57                        | 3.51                   | -3.30                          | 46.70          |

Table 13: Sample calculation

Correction factor = Antenna correction + Correction pre-amplifier + Cable attenuation

SAC3:

Level = Reading value + Correction factor = 50.00 dBμV - 14.92 dB/m = 35.08 dBμV/m

FS-SAC:

Level = Reading value + Correction factor = 50.00 dBμV - 3.30 dB/m = 46.70 dBμV/m

### 5.6.1 Exploratory radiated emissions measurements

Exploratory radiated emissions above 1 GHz are measured in a semi-anechoic chamber with RF absorbing material on the floor or a fully anechoic room. They are performed by moving the receiving antenna over all sides of the EUT at a closer distance (e.g. 0.5 or 1 m) while observing the display of the test receiver to find the emissions to be re-tested during final radiated emission measurements.

According to clause 5.3.3 of ANSI C63.10, when performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade of distance (inverse of linear distance for field-strength measurements). To simplify testing and documentation, the limits are increased accordingly instead of decreasing the results.

The emissions of the EUT are displayed and recorded with an EMI test receiver operating in the spectrum analyzer mode using the settings as described in table 14.

| Frequency (f)          | Resolution bandwidth | Video bandwidth | Sweep time | Trace detector(s) | Trace mode(s) | Test      |
|------------------------|----------------------|-----------------|------------|-------------------|---------------|-----------|
| $f \geq 1 \text{ GHz}$ | 1 MHz                | 3 MHz           | AUTO       | Max Peak, Average | Clear Write   | Searching |
|                        |                      |                 |            |                   | Max Hold      | Recording |

Table 14: Bandwidth and trace settings for exploratory radiated emissions test above 1 GHz

If during exploratory radiated emissions measurements no levels to be re-tested are found, the final radiated emissions measurement may be omitted. In this case, the chart of the exploratory radiated emissions measurements has to be reported.

## 5.6.2 Final radiated emissions measurements

Final radiated emissions above 1 GHz are measured in the semi-anechoic chamber (SAC3) or Free space semi-anechoic chamber (FS-SAC) with RF absorbing material on the floor between measurement antenna and EUT. The measurement distance is 3 meters in the semi-anechoic chamber (SAC3) or 1.5 m in the Free space semi-anechoic chamber (FS-SAC). The emissions of the EUT are recorded with an EMI test receiver configured as described in table 15.

| Frequency (f)          | Measurement receiver bandwidth | Step size              | Detector type |               |
|------------------------|--------------------------------|------------------------|---------------|---------------|
|                        |                                |                        | Prescan       | Final scan    |
| $f \geq 1 \text{ GHz}$ | 1 MHz                          | $\leq 500 \text{ kHz}$ | Peak, Average | Peak, Average |

Table 15: Bandwidth and detector type for final radiated emissions test above 1 GHz

Prescans are performed with both detectors activated at the same time. If the test receiver is capable of FFT analysis, it is used for prescans, but not for final scans.

The horn antenna is mounted on a support capable of allowing the antenna to be used in either horizontal or vertical polarization and to be moved in a scan height range between 1 m and the scan height upper range defined in clause 6.6.3.3 of ANSI C63.10. When the EUT is manipulated through three different orientations, the scan height upper range for the measurement antenna is limited to 2.5 m above the ground plane.or 0.5 m above the top of the EUT, whichever is higher. Otherwise, the scan height upper range is 4 m above the ground plane.

To keep the emission signal within the illumination area of the 3 dB beamwidth of the measurement antenna, the automatic tilt function of the antenna support device is used to point the antenna at an angle toward the source of the emission.

The final radiated emissions test above 1 GHz is performed in the following steps:

- The measurement antenna is oriented initially for vertical polarization.
- The EUT is placed in its standard position on a turntable capable of rotation through 360° in the horizontal plane and arranged as tabletop or floor-standing equipment, as applicable. The EUT is switched on.
- The measurement equipment is connected to the measurement antenna and set-up according to the specifications of the test (see table 15).
- The table position is set to 0°.
- The antenna height is set to 1 m.
- The spectrum for the full frequency range is recorded. If the emission at a certain frequency is higher than the levels already recorded, the polarization and height of the measurement antenna as well as the current table position are noted as the maximum position.
  - The antenna height is increased to the scan height upper range in steps of 50 cm. At each height, step f) is repeated.
- The polarization of the measurement antenna is changed to horizontal.
- The antenna height is decreased from the scan height upper range to 1 m in steps of 50 cm. At each height, step f) is repeated.
- The EUT is rotated in a horizontal plane through 360° in steps of 30°. At each table position, steps e) to i) are repeated.
- After the last prescan, the significant maximum emissions with their polarizations and heights of the measurement antenna as well as their table positions are determined and collected in a list.
- With the test receiver set to the first frequency of the list, the measurement antenna is set to the polarization and height and the table is moved to the position as determined during prescans.
- The antenna is moved by  $\pm 50 \text{ cm}$  around this height and the EUT is rotated by  $\pm 30^\circ$  around this table position while measuring the emission level continuously.
- For final scan, the worst-case positions of antenna and table are set and the maximum emission level is recorded.
- Steps l) to n) are repeated for all other frequencies in the list. At least, frequency and level of the six highest emissions relative to the limit have to be recorded. However, emissions more than 20 dB below the limit do not need to be reported.

If the EUT may be used in various positions, steps a) to o) are repeated in two other orthogonal positions.

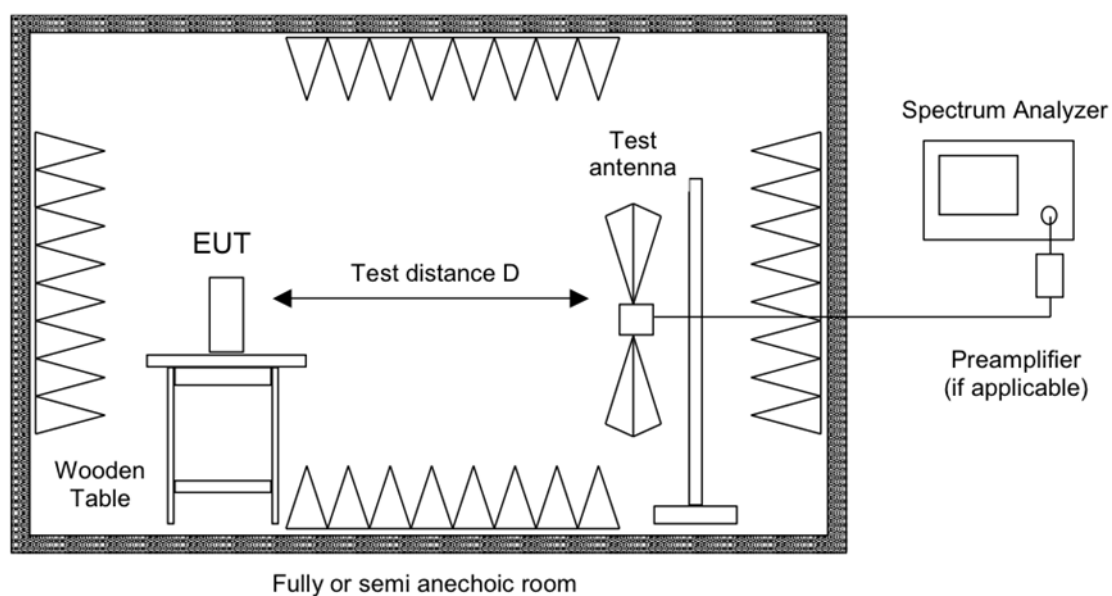


Figure 5: Setup for radiated emissions test above 1 GHz



## 5.7 Bandwidth measurements

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

### 5.7.1 6 dB bandwidth (DTS bandwidth)

The 6 dB bandwidth or DTS bandwidth is measured according to clause 8.0 of KDB Publication 558074, document D01, using the following settings:

- a) Resolution bandwidth RBW = 100 kHz
- b) Video bandwidth (VBW)  $\geq 3 \times$  RBW
- c) Detector = Peak
- d) Trace mode = max hold
- e) Sweep = auto couple

After the trace is stabilized, the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

If using the automatic bandwidth measurement capability of the test instrument (6 dB down function), care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be  $\geq 6$  dB. In addition, it has to be checked that this function delivers the two outermost amplitude points.

### 5.7.2 99 % occupied bandwidth

According to section 6.7 of RSS-Gen, the occupied bandwidth (OBW) is defined as the 99 % emission bandwidth.

The span of the spectrum analyzer is set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

The resolution bandwidth is in the range of 1 % to 5 % of the occupied bandwidth and the video bandwidth is not smaller than three times the resolution bandwidth. Video averaging is not permitted.

If possible, the detector of the spectrum analyzer is set to "Sample". However, if the device is not transmitting continuously, a peak, or peak hold is used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement).

To measure the 99 % emission bandwidth, the OBW function of the test receiver is used with the power bandwidth set to 99 %. This function indicates the lowest frequency (starting from the left side of the span) and the highest frequency (starting from the right side of the span) where 0.5% of the total sum is reached. The difference between the two frequencies is the 99 % occupied bandwidth.



## 5.8 Maximum peak conducted output power

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

The maximum conducted output power test method for digital transmission systems (DTS) refers to section 8.3.1.1 of KDB Publication 558074, document D01.

The spectrum analyzer settings are as follows:

- a) Span  $\geq 3 \times \text{RBW}$ , centered on a channel
- b) RBW  $\geq$  DTS bandwidth
- c) VBW  $\geq 3 \times \text{RBW}$
- d) Sweep time = auto coupled
- e) Detector function = peak
- f) Trace mode = max hold
- g) Reference level = more than  $10 \cdot \log(\text{OBW}/\text{RBW})$  dB above peak of spectral envelope

After the trace is stabilized, the marker-to-peak function is used to set the marker to the peak of the emission. The indicated level is the maximum peak conducted output power.

## 5.9 Power spectral density

The power spectral density test method for DTS systems refers to section 8.4 of KDB Publication 558074, document D01.

The spectrum analyzer settings are as follows:

- a) Span = 1.5 times the DTS bandwidth, centered on a channel
- b) RBW:  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$
- c) VBW  $\geq 3 \times \text{RBW}$
- d) Sweep time = auto coupled or  $\geq \text{span}/\text{RBW}$  in seconds, whichever is greater
- e) Detector function = peak
- f) Trace mode = max hold
- g) Reference level = more than  $10 \cdot \log(\text{OBW}/\text{RBW})$  dB above peak of spectral envelope

After the trace is stabilized, the marker-to-peak function is used to set the marker to the peak of the emission. The indicated level is the power spectral density.

In case of antenna-port conducted tests as described in clause 5.2 cannot be performed, according to section 3.0 of KDB 558074 D01, results of radiated tests are used for demonstrating compliance to the conducted emission requirements. For details about conversion see clause 5.1.2

---

## 6 Test results

This clause gives details about the test results as collected in the summary of test results on page 6.

For information about measurement uncertainties see page 69.

The climatic conditions are recorded during the tests. It is ensured that the climatic conditions are within the following ranges:

| <i>Ambient temperature</i> | <i>Ambient humidity</i> | <i>Ambient pressure</i> |
|----------------------------|-------------------------|-------------------------|
| 15°C to 35°C               | 30 % to 75 %            | 86 kPa to 106 kPa       |

## 6.1 AC powerline conducted emissions

|                               |                 |                         |
|-------------------------------|-----------------|-------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s): | 15.207(a)               |
|                               | Reference(s)    | ANSI C63.10, clause 6.2 |
| Section(s) in RSS:            | Requirement(s): | RSS-Gen, section 8.8    |
|                               | Reference(s):   | ANSI C63.10, clause 6.2 |

|               |                                                                                          |                  |                  |
|---------------|------------------------------------------------------------------------------------------|------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                                                                  | Date(s) of test: | January 22, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed <input type="checkbox"/> Test not passed |                  |                  |

### 6.1.1 Test equipment

| Type                     | Designation                      | Manufacturer                                       | Inventory no.              |
|--------------------------|----------------------------------|----------------------------------------------------|----------------------------|
| Shielded room            | P92007                           | Siemens Matsushita                                 | E00107                     |
| EMI test receiver        | ESR 7                            | Rohde & Schwarz                                    | E00739                     |
| Cable set shielded room  | RG 223/U<br>RG 223/U<br>RG 223/U | AME HF-Technik<br>AME HF-Technik<br>AME HF-Technik | E01307<br>E00026<br>E00918 |
| Artificial mains network | ESH2-Z5                          | Rohde & Schwarz                                    | E00004                     |
| Attenuator (10 dB)       | 50FHB-010-10                     | JFW Industries                                     | E00471                     |
| Test software            | EMC32-EB (V10.35)                | Rohde & Schwarz                                    | E00777                     |

### 6.1.2 Limits

According to 15.207(a) and RSS-Gen section 8.8:

For intentional radiators that are designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in Table 16.

| <i>Frequency of emission<br/>(MHz)</i> | <i>Conducted limit (dB<math>\mu</math>V)</i> |                |
|----------------------------------------|----------------------------------------------|----------------|
|                                        | <i>Quasi-peak</i>                            | <i>Average</i> |
| 0.15-0.5                               | 66 to 56*                                    | 56 to 46*      |
| 0.5-5                                  | 56                                           | 46             |
| 5-30                                   | 60                                           | 50             |

Table 16: Limits for AC powerline conducted emissions according to 15.207(a) and RSS-Gen, section 8.8

\*Decreases with the logarithm of the frequency

### 6.1.3 Test procedure

The AC powerline conducted emissions are measured using the test procedure as described in clause 5.3.

## 6.1.4 Test results

Note(s):

1 The test was performed at 120 V and 60 Hz.

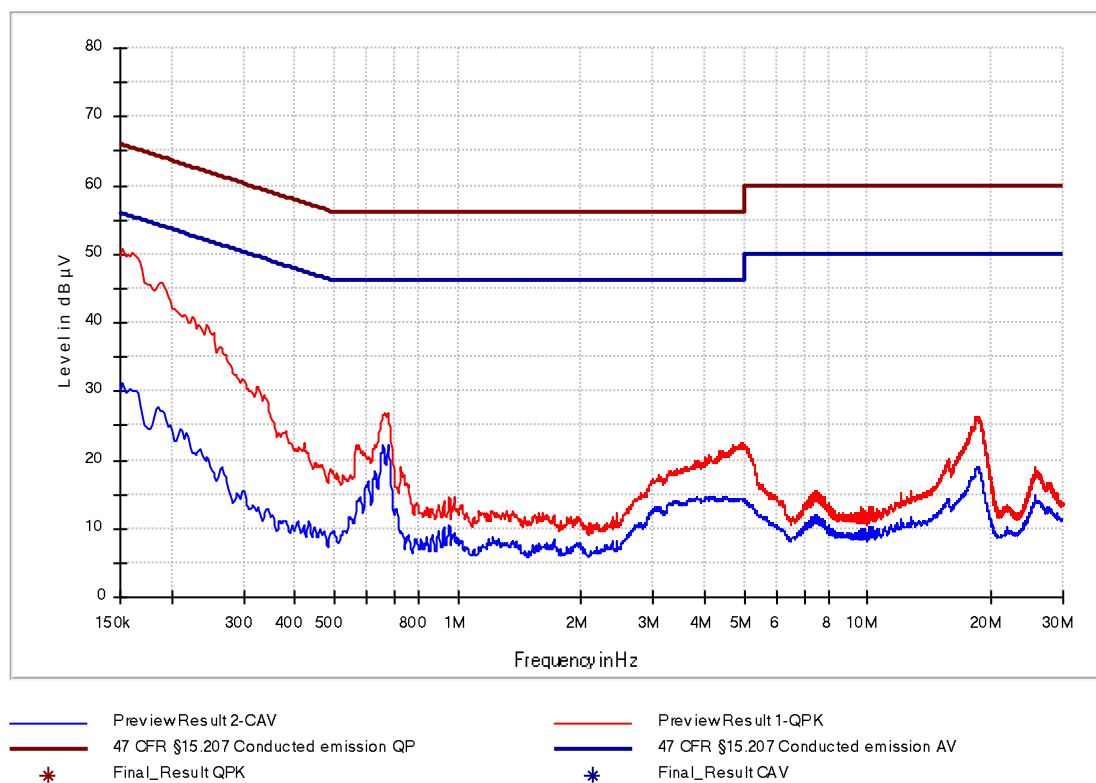


Figure 6: Chart of AC powerline conducted emissions on L1

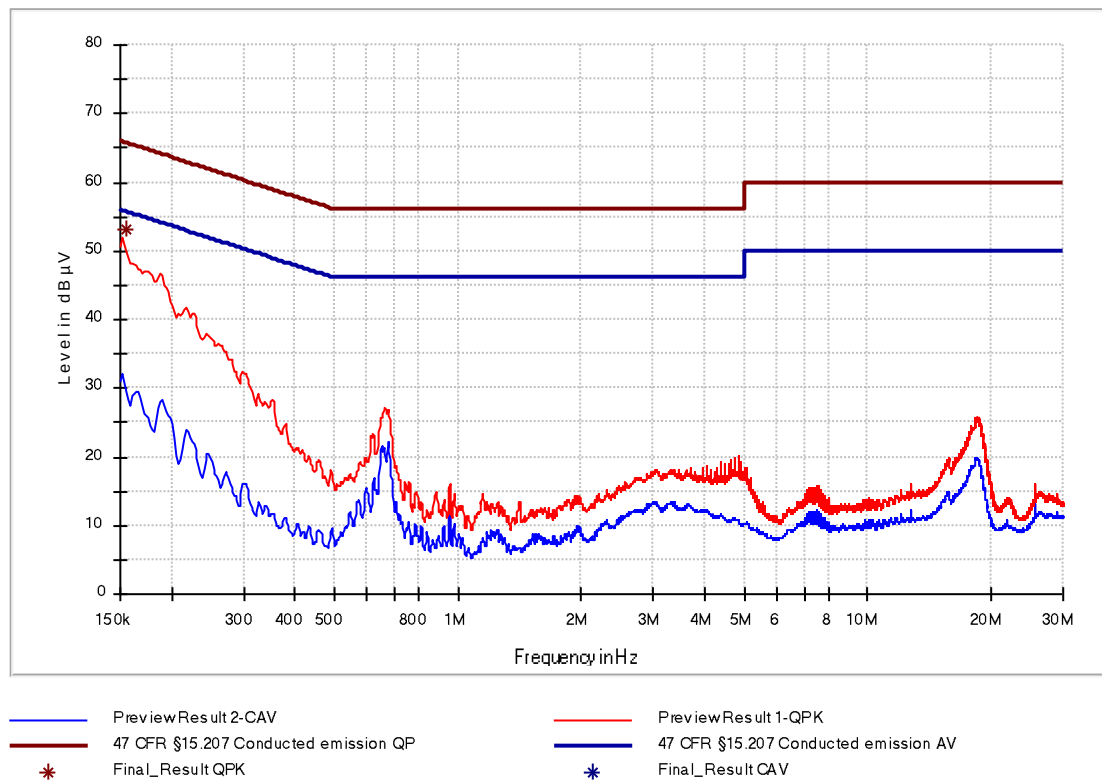


Figure 7: Chart of AC powerline conducted emissions on N

| Frequency (MHz) | QuasiPeak (dB $\mu$ V) | Average (dB $\mu$ V) | Limit (dB $\mu$ V) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE  | Corr. (dB) |
|-----------------|------------------------|----------------------|--------------------|-------------|-----------------|-----------------|------|-----|------------|
| 0.154500        | 53.22                  | ---                  | 65.75              | 12.53       | 1000.0          | 9.000           | N    | GND | 10.1       |

Table 17: Results of AC powerline conducted emissions on N

## 6.2 6 dB bandwidth

|                               |                 |                           |
|-------------------------------|-----------------|---------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s): | 15.247(a)(2)              |
|                               | Reference(s):   | KDB558074 D01, clause 8.2 |
| Section(s) in RSS:            | Requirement(s): | ANSI C63.10, clause 11.8  |
|                               | Reference(s):   | RSS-247, section 5.2(a)   |
|                               |                 | KDB558074 D01, clause 8.2 |
|                               |                 | ANSI C63.10, clause 11.8  |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 19, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.2.1 Test equipment

| Type              | Designation | Manufacturer    | Inventory no. |
|-------------------|-------------|-----------------|---------------|
| EMI test receiver | ESU 26      | Rohde & Schwarz | W00002        |

## **6.2.2 Limits**

According to §15.247(a)(2) and RSS-247 section 5.2(a):

Systems using digital modulation techniques (DTS) may operate in the 2400-2483.5 MHz band. The minimum 6 dB bandwidth shall be at least 500 kHz.

## **6.2.3 Test procedure**

The 6 dB bandwidth is measured using the test procedure as described in clause 5.7.1 and referring to the

- ☒ test method for conducted measurements as described in clause 5.2.
- ☐ test method for radiated measurements as described in clause 5.6.



## 6.2.4 Test results

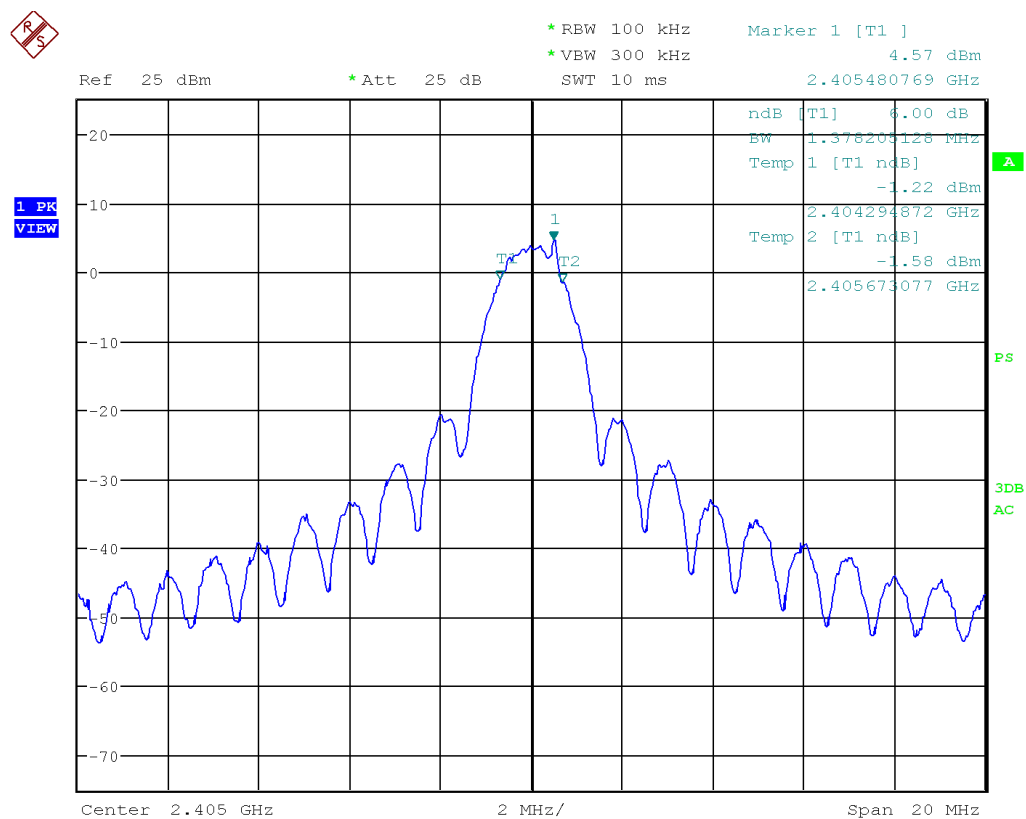


Figure 8: Chart of 6 dB bandwidth test on lowest channel

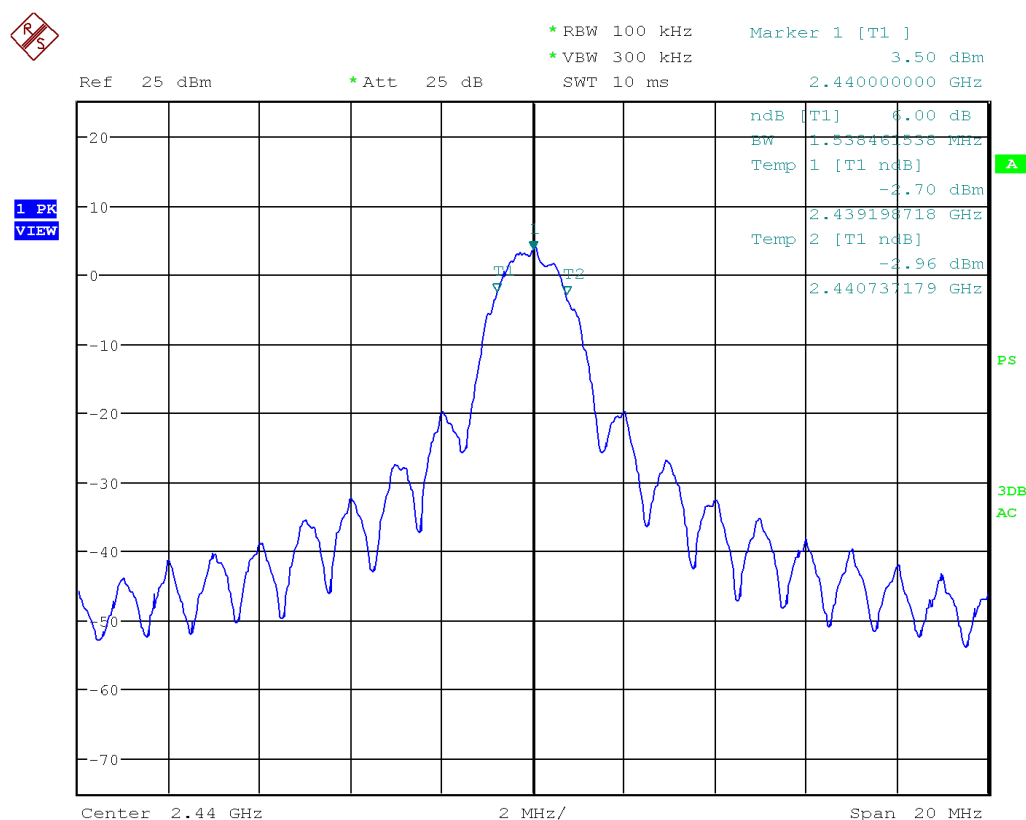


Figure 9: Chart of 6 dB bandwidth test on middle channel

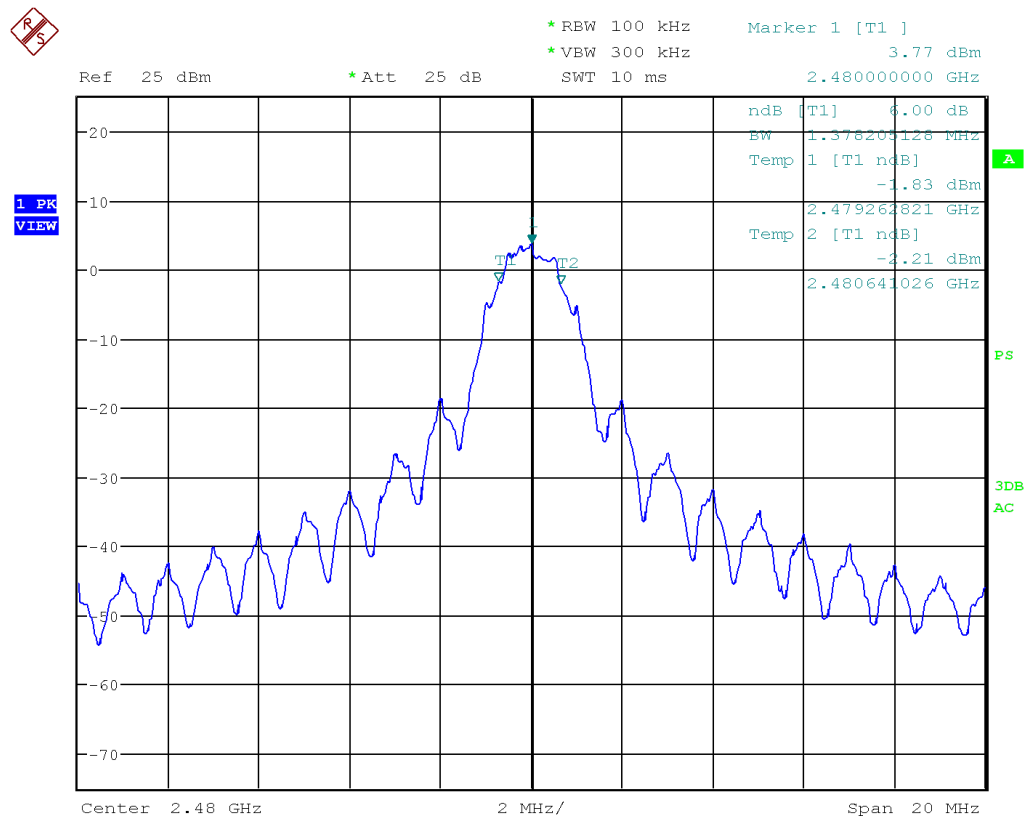


Figure 10: Chart of 6 dB bandwidth test on highest channel

| Channel | 6 dB bandwidth (kHz) | Bandwidth limit (kHz) | Lower frequency of bandwidth (MHz) | Lower frequency of designated band (MHz) | Upper frequency of bandwidth (MHz) | Upper frequency of designated band (MHz) | Result |
|---------|----------------------|-----------------------|------------------------------------|------------------------------------------|------------------------------------|------------------------------------------|--------|
| low     | 1378.21              | ≥ 500                 | 2404.295                           | 2400.000                                 | 2405.673                           | 2483.500                                 | Passed |
| middle  | 1538.46              | ≥ 500                 | 2439.200                           | 2400.000                                 | 2440.737                           | 2483.500                                 | Passed |
| high    | 1378.21              | ≥ 500                 | 2479.263                           | 2400.000                                 | 2480.641                           | 2483.500                                 | Passed |

Table 18: Results of 6 dB bandwidth test

### 6.3 Occupied bandwidth

|                               |                                  |                                                                                |
|-------------------------------|----------------------------------|--------------------------------------------------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s):<br>Reference(s): | ---<br>KDB 558074 D01, section 5.2                                             |
| Section(s) in RSS:            | Requirement(s):<br>Reference(s): | RSS-Gen, section 6.7<br>KDB 558074 D01, section 5.2<br>ANSI C63.10, clause 6.9 |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 19, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

#### 6.3.1 Test equipment

| Type              | Designation | Manufacturer    | Inventory no. |
|-------------------|-------------|-----------------|---------------|
| EMI test receiver | ESU 26      | Rohde & Schwarz | W00002        |

### **6.3.2 Limits**

According to section 5.2 of KDB Publication 558074, document D01:

The 99 % occupied bandwidth is necessary for setting the proper reference level and input attenuation.

According to RSS-Gen, section 6.7:

The occupied bandwidth or the “99% emission bandwidth” has to be reported for all equipment in addition to the specified bandwidth required in RSS-247.

### **6.3.3 Test procedure**

The occupied bandwidth is measured using the test procedure as described in clause 5.7.2 and referring to the

- ☒ test method for conducted measurements as described in clause 5.2.
- ☐ test method for radiated measurements as described in clause 5.6.

### 6.3.4 Test results

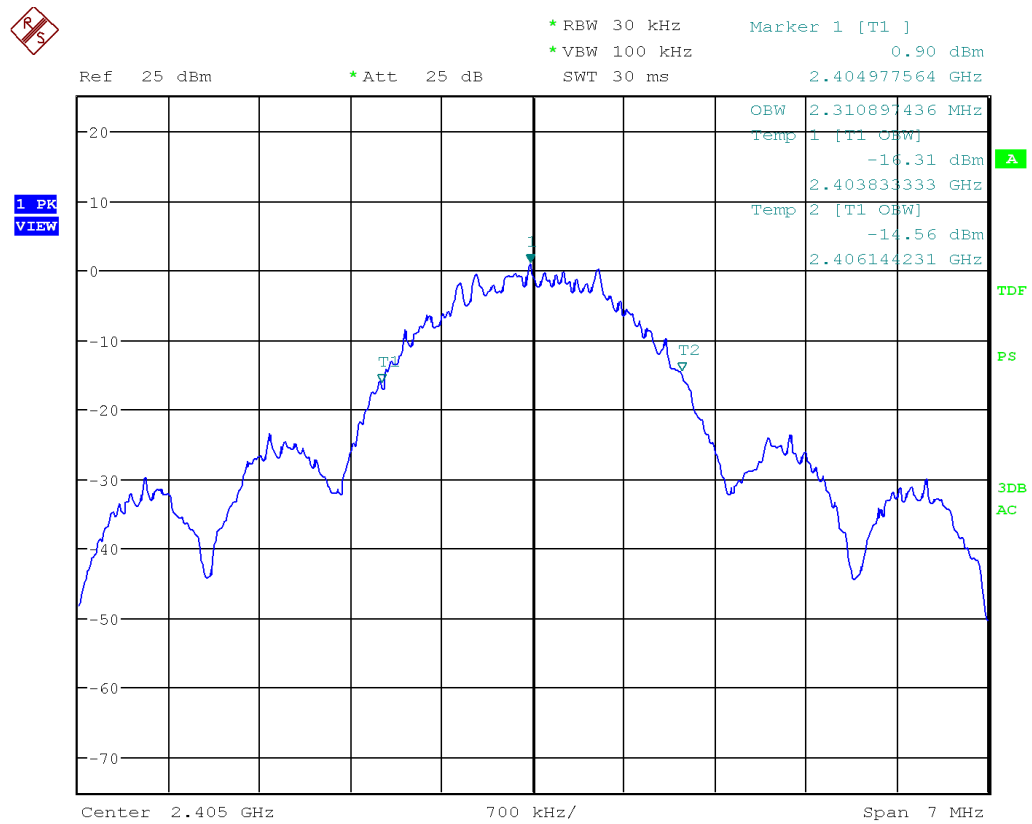


Figure 11: Chart of occupied bandwidth test on lowest channel

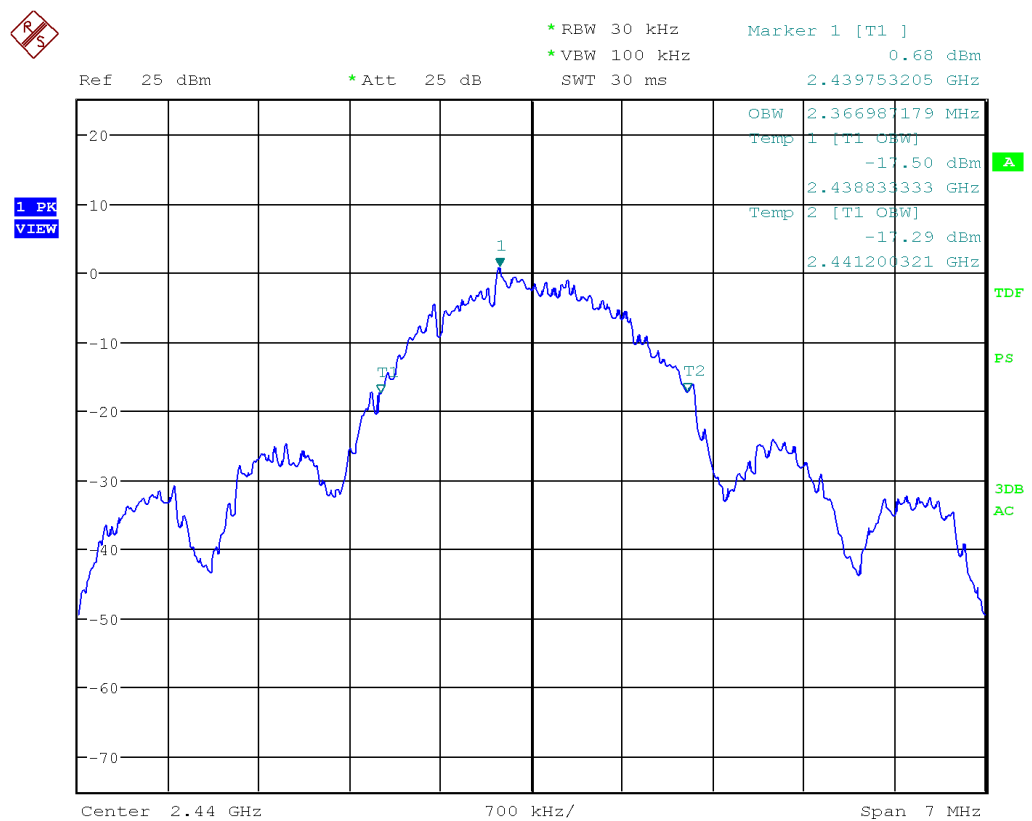


Figure 12: Chart of occupied bandwidth test on middle channel

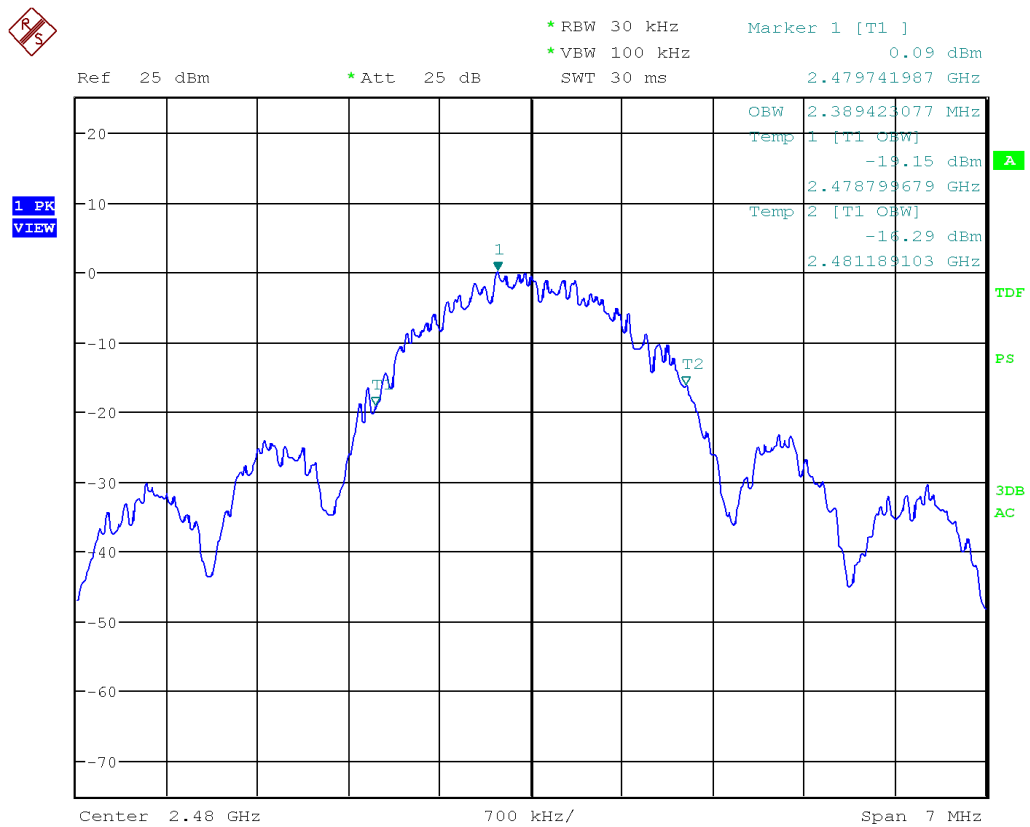


Figure 13: Chart of occupied bandwidth test on highest channel

| Channel | 99 % occupied bandwidth (kHz) | Result   |
|---------|-------------------------------|----------|
| low     | 2310.897                      | Recorded |
| middle  | 2366.987                      | Recorded |
| high    | 2389.423                      | Recorded |

Table 19: Results of occupied bandwidth test

## 6.4 Conducted output power

|                               |                                  |                                                                                   |
|-------------------------------|----------------------------------|-----------------------------------------------------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s):<br>Reference(s): | 15.247(b)<br>KDB 558074 D01, clause 8.3<br>ANSI C63.10, clause 11.9               |
| Section(s) in RSS:            | Requirement(s):<br>Reference(s): | RSS-247, section 5.4(d)<br>KDB 558074 D01, clause 8.3<br>ANSI C63.10, clause 11.9 |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 19, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.4.1 Test equipment

| Type              | Designation | Manufacturer    | Inventory no. |
|-------------------|-------------|-----------------|---------------|
| EMI test receiver | ESU 26      | Rohde & Schwarz | W00002        |

## 6.4.2 Limits

According to §15.247(b)(3):

For systems using digital modulation in the 2400-2483.5 MHz band: 1 Watt (30 dBm).

As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

According to §15.247(b)(4):

The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

According to RSS-247, section 5.4(d):

For DTSs employing digital modulation techniques operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

## 6.4.3 Test procedure

The maximum peak conducted output power is measured using the test procedure as described in clause 5.8 and referring to the

- ☒ test method for conducted measurements as described in clause 5.2.
- ☐ test method for radiated measurements as described in clause 5.6.



## 6.4.4 Test results

Note(s):

1. The gain of the antenna is below 6 dBi, therefore a reduction of the conducted limit was not applied.

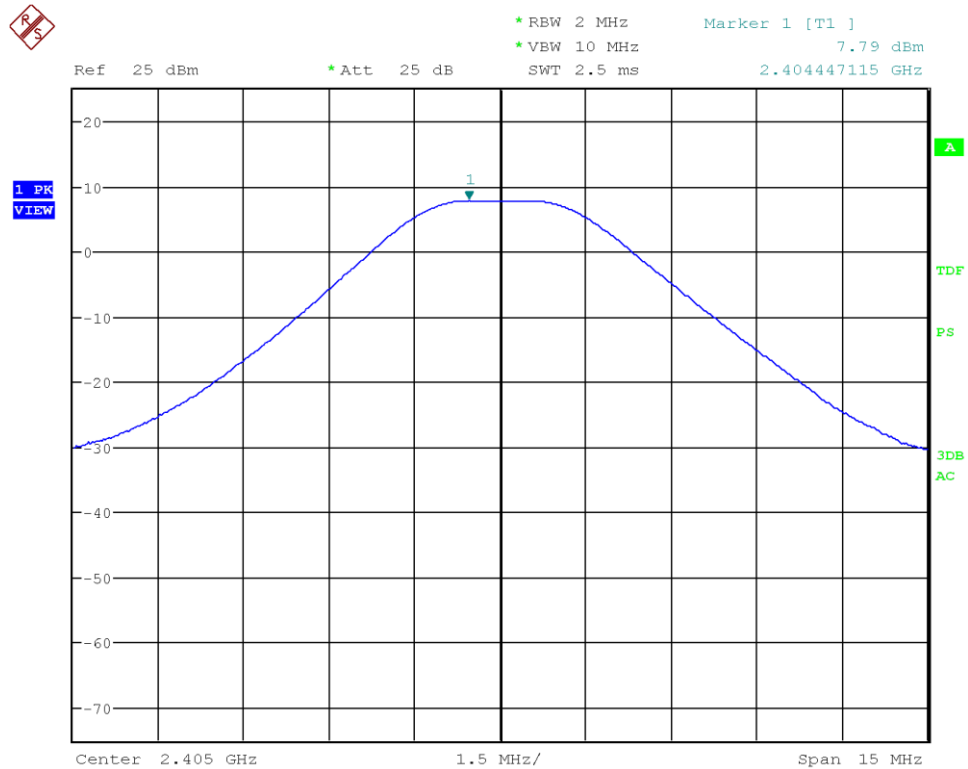


Figure 14: Chart of conducted output power on lowest channel

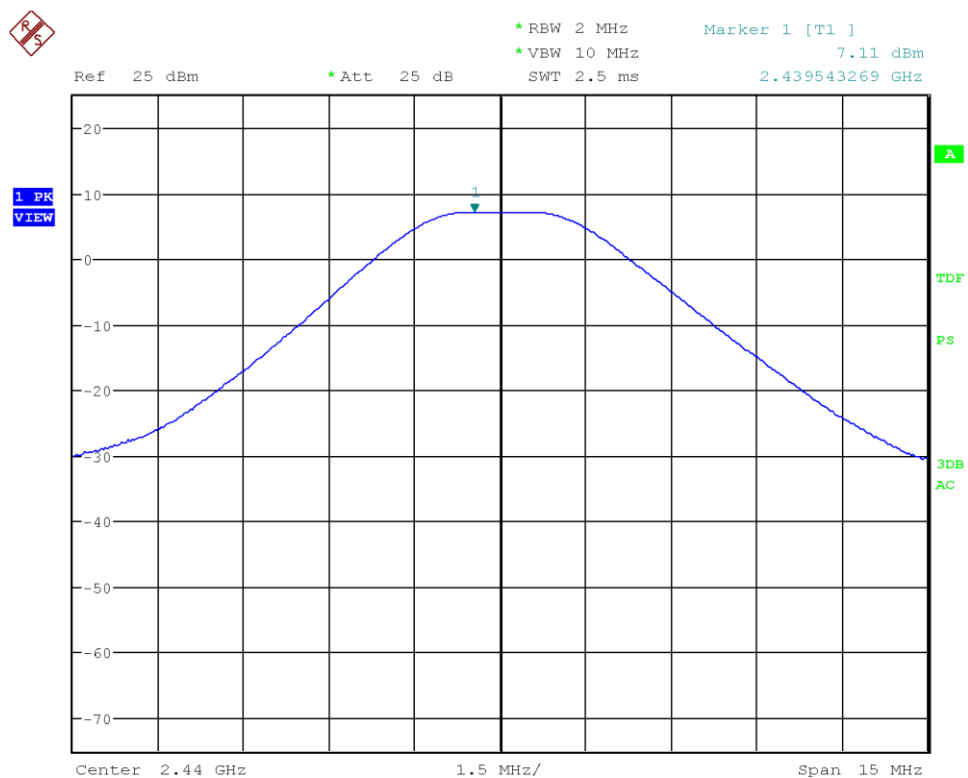


Figure 15: Chart of conducted output power on middle channel

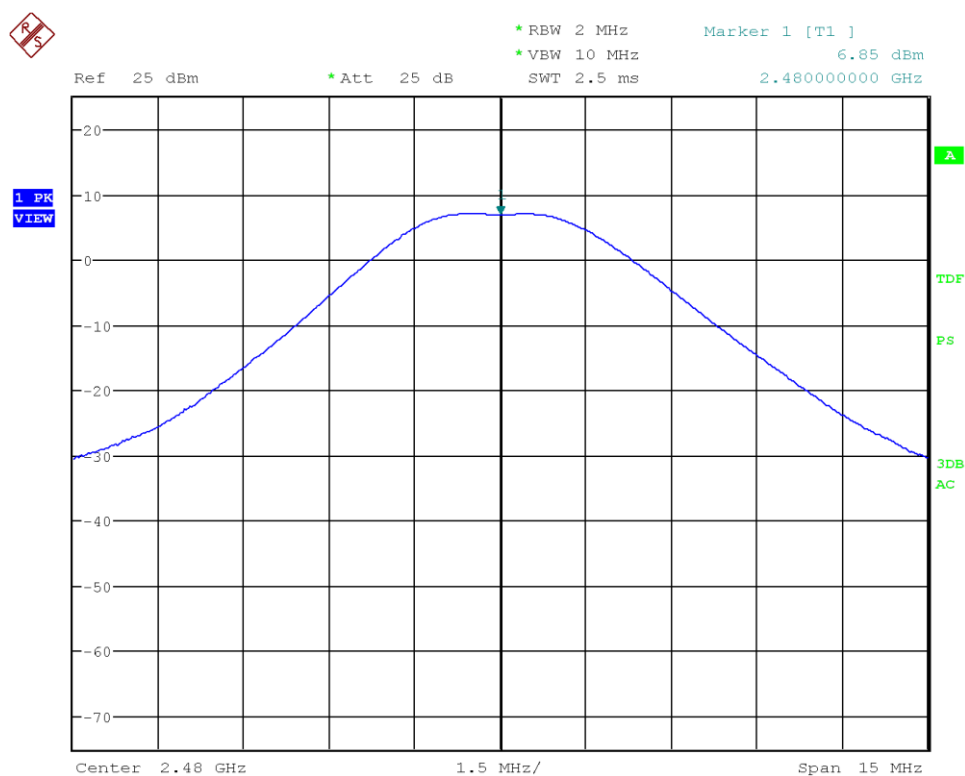


Figure 16: Chart of conducted output power on highest channel

| Channel | Conducted output power (dBm) | Limit (dBm) | Margin (dB) | Results |
|---------|------------------------------|-------------|-------------|---------|
| low     | 7.79                         | 30.00       | 22.21       | Passed  |
| middle  | 7.11                         | 30.00       | 22.89       | Passed  |
| high    | 6.85                         | 30.00       | 23.15       | Passed  |

Table 20: Results of conducted output power

## 6.5 Power spectral density

|                               |                                  |                                                                                    |
|-------------------------------|----------------------------------|------------------------------------------------------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s):<br>Reference(s): | 15.247(e)<br>KDB 558074 D01, clause 8.4<br>ANSI C63.10, clause 11.10               |
| Section(s) in RSS:            | Requirement(s):<br>Reference(s): | RSS-247, section 5.2(b)<br>KDB 558074 D01, clause 8.4<br>ANSI C63.10, clause 11.10 |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 19, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.5.1 Test equipment

| Type              | Designation | Manufacturer    | Inventory no. |
|-------------------|-------------|-----------------|---------------|
| EMI test receiver | ESU 26      | Rohde & Schwarz | W00002        |

## 6.5.2 Limits

According to §15.247(e) and RSS-247 section 5.2(b):

For digitally modulated systems (DTS), the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

The same method of determining the conducted output power shall be used to determine the power spectral density.

## 6.5.3 Test procedure

The power spectral density is measured using the test procedure as described in clause 5.9 and referring to the

- ☒ test method for conducted measurements as described in clause 5.2.
- ☐ test method for radiated measurements as described in clause 5.6.

## 6.5.4 Test results

Note(s):

1. The gain of the antenna is below 6 dBi, therefore a reduction of the conducted limit was not applied.

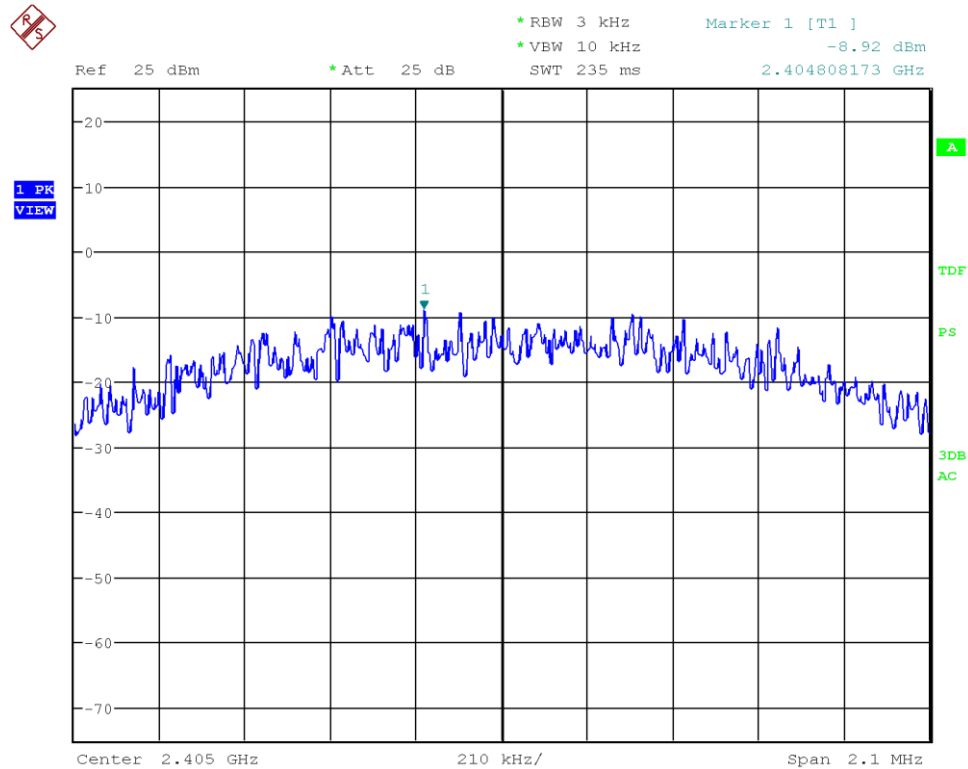


Figure 17: Chart of power spectral density on lowest channel

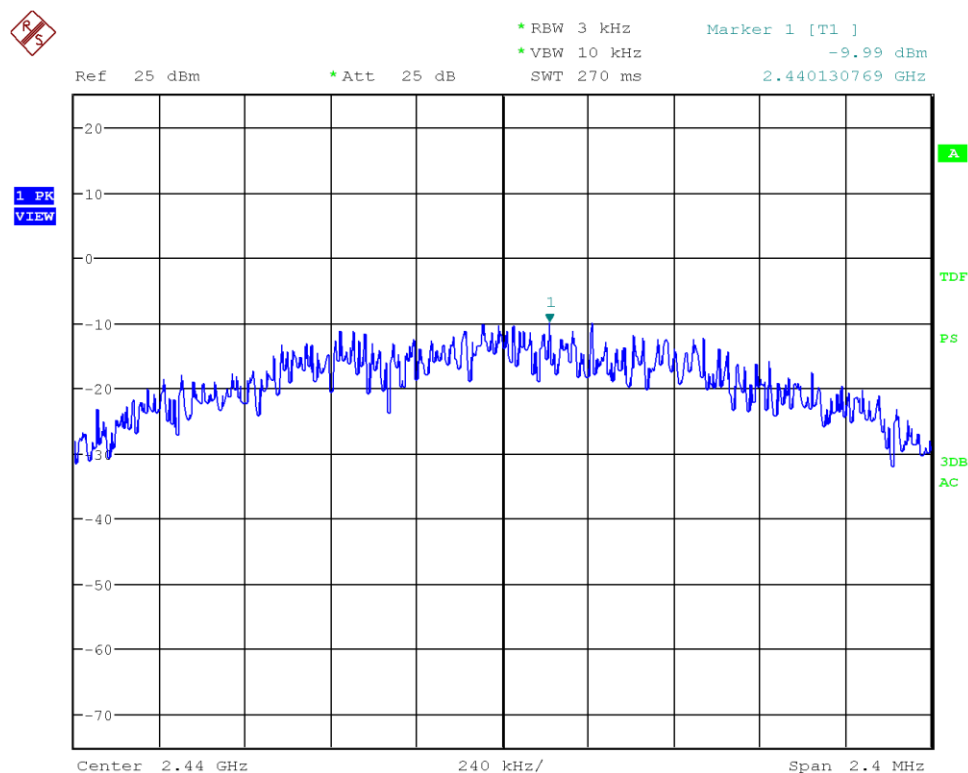


Figure 18: Chart of power spectral density on middle channel

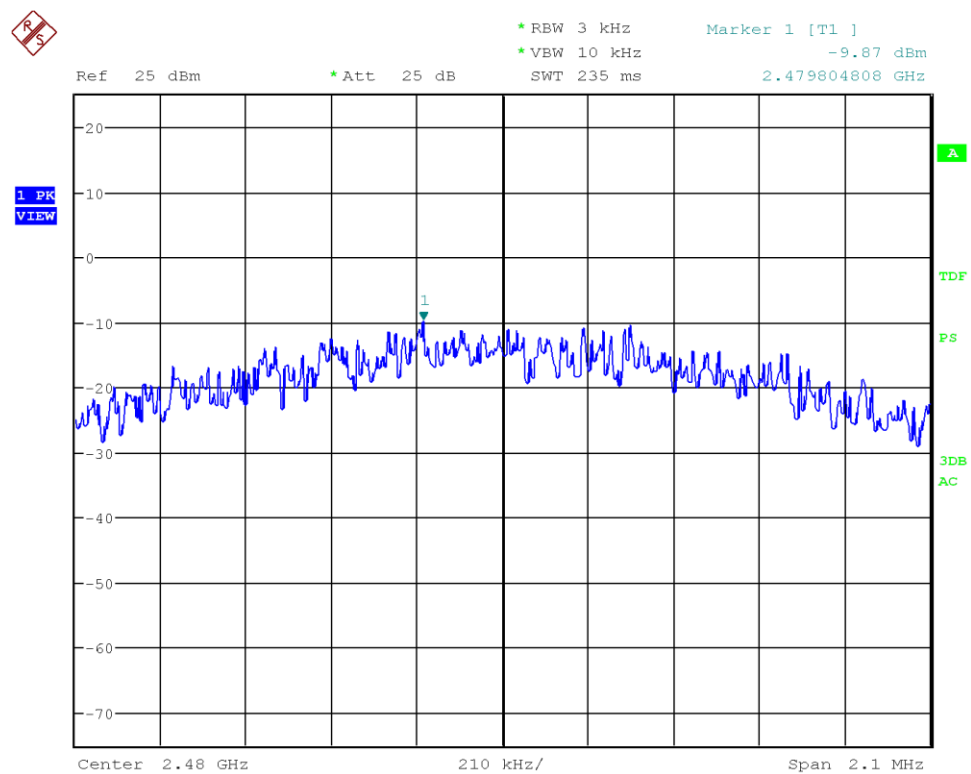


Figure 19: Chart of power spectral density on highest channel

| Channel | Power spectral density<br>(dBm/3 kHz) | Limit<br>(dBm/3 kHz) | Margin<br>(dB) | Results |
|---------|---------------------------------------|----------------------|----------------|---------|
| low     | -8.92                                 | 8.00                 | 16.92          | Passed  |
| middle  | -9.99                                 | 8.00                 | 17.99          | Passed  |
| high    | -9.87                                 | 8.00                 | 17.87          | Passed  |

Table 21: Results of conducted power spectral density

## 6.6 Antenna-port conducted measurements

|                               |                 |                                                            |
|-------------------------------|-----------------|------------------------------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s): | 15.247(d)                                                  |
|                               | Reference(s):   | KDB 558074 D01, clauses 8.6<br>ANSI C63.10, clause 11.12.2 |
| Section(s) in RSS:            | Requirement(s): | RSS-247, section 5.5                                       |
|                               | Reference(s):   | KDB 558074 D01, clauses 8.6<br>ANSI C63.10, clause 11.12.2 |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 19, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.6.1 Test equipment

| Type              | Designation | Manufacturer    | Inventory no. |
|-------------------|-------------|-----------------|---------------|
| EMI test receiver | ESU 26      | Rohde & Schwarz | W00002        |

## 6.6.2 Limits

According to §15.247(d) and RSS-247 section 5.5:

In any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits specified in §15.209(a) and RSS-Gen section 8.10.

| Frequency<br>(MHz) | Field strength                  |                       | Measurement distance<br>(m) |
|--------------------|---------------------------------|-----------------------|-----------------------------|
|                    | ( $\mu\text{V/m}$ )             | (dB $\mu\text{V/m}$ ) |                             |
| 0.009 – 0.490      | 2400/F(kHz)<br>(266.67 – 4.90)  | 48.52 – 13.80         | 300                         |
| 0.490 – 1.705      | 24000/F(kHz)<br>(48.98 – 14.08) | 33.80 – 22.97         | 30                          |
| 1.705 – 30         | 30                              | 29.54                 | 30                          |
| 30 – 88            | 100                             | 40.00                 | 3                           |
| 88 – 216           | 150                             | 43.52                 | 3                           |
| 216 - 960          | 200                             | 46.02                 | 3                           |
| Above 960          | 500                             | 53.98                 | 3                           |

Table 22: General radiated emission limits from 9 kHz to 25 GHz according to §15.209

| Frequency<br>(MHz) | Magnetic field strength |                       | Measurement distance<br>(m) |
|--------------------|-------------------------|-----------------------|-----------------------------|
|                    | ( $\mu\text{A/m}$ )     | (dB $\mu\text{A/m}$ ) |                             |
| 0.009 – 0.490      | 6.37/F(kHz)             | -2.999 – -37.721      | 300                         |
| 0.490 – 1.705      | 63.7/F(kHz)             | -17.721 – -28.636     | 30                          |
| 1.705 – 30         | 0.08                    | -21.94                | 30                          |

Table 23: General radiated emission limits from 9 kHz to 30 MHz according to RSS-Gen section 8.9

| Frequency<br>(MHz) | Field strength      |                       | Measurement distance<br>(m) |
|--------------------|---------------------|-----------------------|-----------------------------|
|                    | ( $\mu\text{V/m}$ ) | (dB $\mu\text{V/m}$ ) |                             |
| 30 – 88            | 100                 | 40.00                 | 3                           |
| 88 – 216           | 150                 | 43.52                 | 3                           |
| 216 - 960          | 200                 | 46.02                 | 3                           |
| Above 960          | 500                 | 53.98                 | 3                           |

Table 24: General radiated emission limits from 30 MHz to 25 GHz according to RSS-Gen section 8.9

In case of measurements are performed at other distances than that specified in the requirements, the limits in the charts and tables reported with the test results are derived from the general radiated emission limits as listed in table 28 using the recalculation factor as described in clause 5.3.



### 6.6.3 Test procedure

The emissions from 9 kHz to 25 GHz are measured using the

- ☒ test procedure for conducted measurements as described in clause 5.2.
- ☐ test procedure for radiated measurements as described in clause 5.3.

## 6.6.4 Test results

### Note(s)

- 1 The power limit lines in all charts are calculated from the field strength limits at 3 m measurement distance with an antenna gain of 0 dBi. The maximum antenna gain is 2 dBi. According to ANSI C63.10 clause 11.12.2.6, the gain of the transmitting antenna must be added to the measured output power, either the maximum in-band gain of the antenna across all operating bands or 2 dBi, whichever is greater.
- 2 The operating frequency band from 2400 MHz to 2483.5 MHz is not shown in the charts because it is not in consideration in this clause.

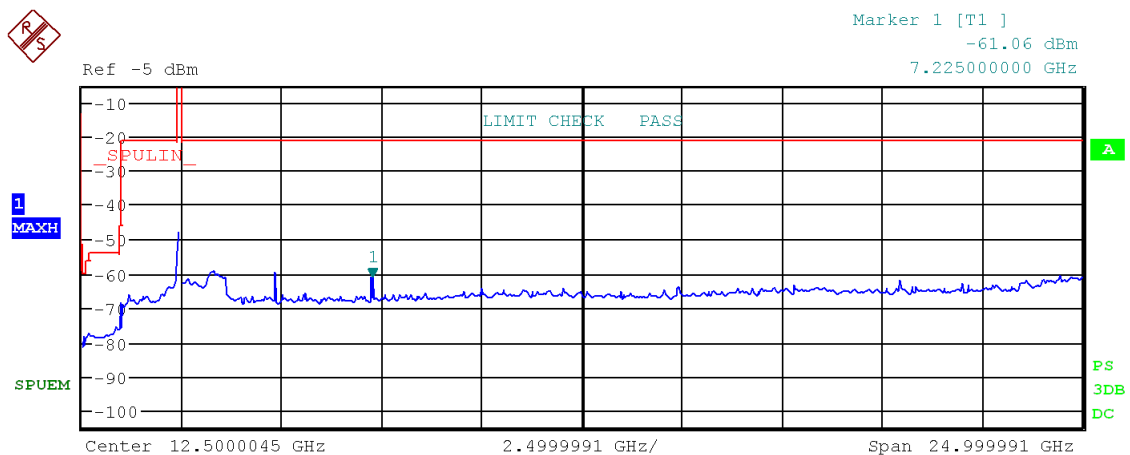


Figure 20: Chart of emissions test from 9 kHz to 25 GHz on lowest channel, PK-detector

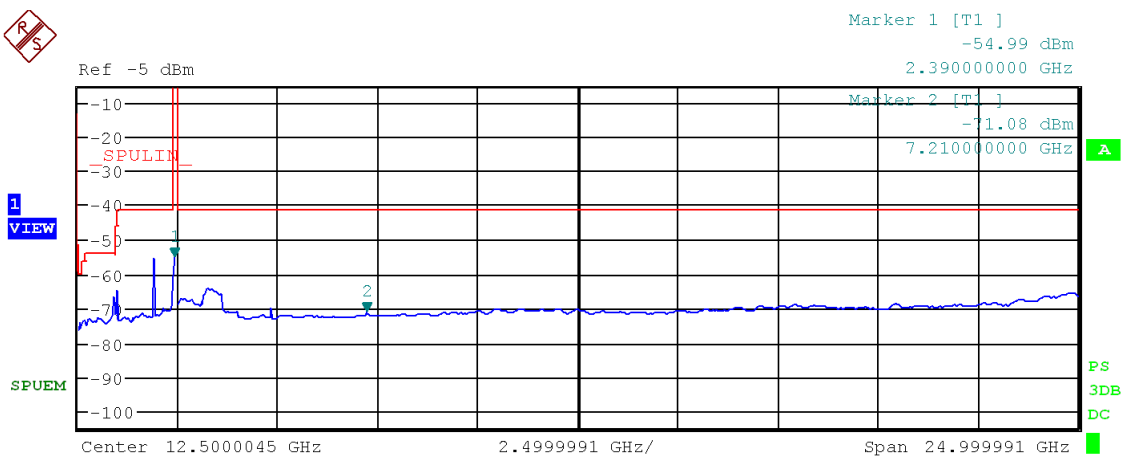


Figure 21: Chart of emissions test from 9 kHz to 25 GHz on lowest channel, RMS-detector

| Frequency (MHz) | Level (dBm) | Detector | Limit (dBm) | Margin (dB) |
|-----------------|-------------|----------|-------------|-------------|
| 1897.477        | -53.63      | RMS      | -41.20      | 12.43       |
| 4810.000        | -57.88      | PK       | -21.20      | 36.68       |
| 4810.000        | -68.03      | RMS      | -41.20      | 26.83       |
| 7225.000        | -59.06      | PK       | -21.20      | 37.86       |
| 7210.000        | -69.08      | RMS      | -41.20      | 27.88       |

Table 25: Results of emissions test from 9 kHz to 25 GHz on lowest channel

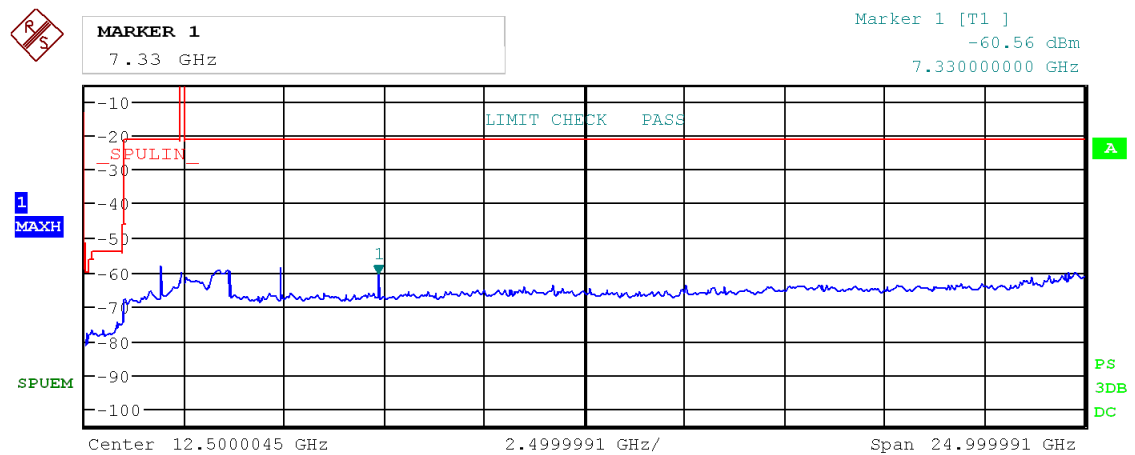


Figure 22: Chart of emissions test from 9 kHz to 25 GHz on middle channel, PK-detector

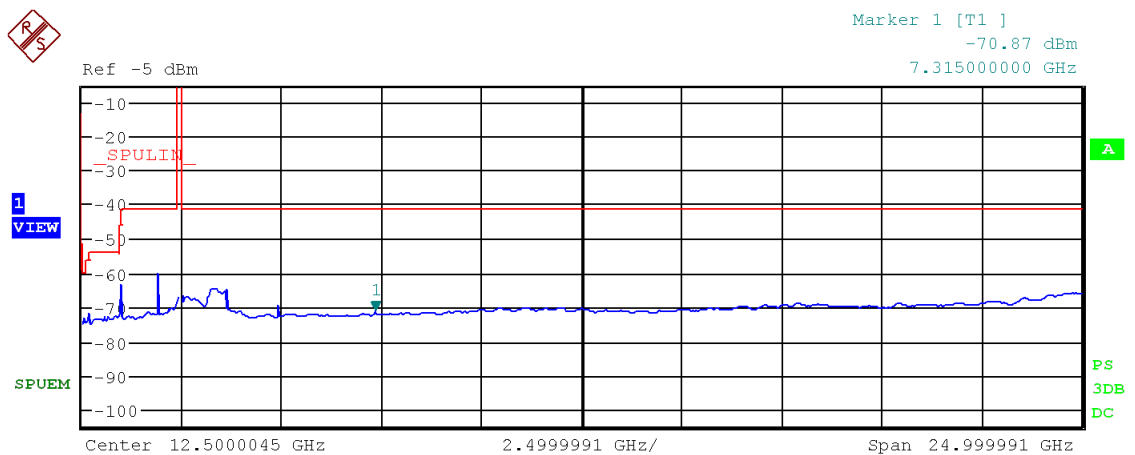


Figure 23: Chart of emissions test from 9 kHz to 25 GHz on middle channel, RMS-detector

| Frequency (MHz) | Level (dBm) | Detector | Limit (dBm) | Margin (dB) |
|-----------------|-------------|----------|-------------|-------------|
| 1883.113        | -56.13      | PK       | -21.20      | 34.93       |
| 1881.260        | -57.98      | RMS      | -41.20      | 16.78       |
| 4870.000        | -56.83      | PK       | -21.20      | 35.63       |
| 4870.000        | -67.68      | RMS      | -41.20      | 26.48       |
| 7330.000        | -58.56      | PK       | -21.20      | 37.36       |
| 7315.000        | -68.87      | RMS      | -41.20      | 27.67       |

Table 26: Results of emissions test from 9 kHz to 25 GHz on middle channel

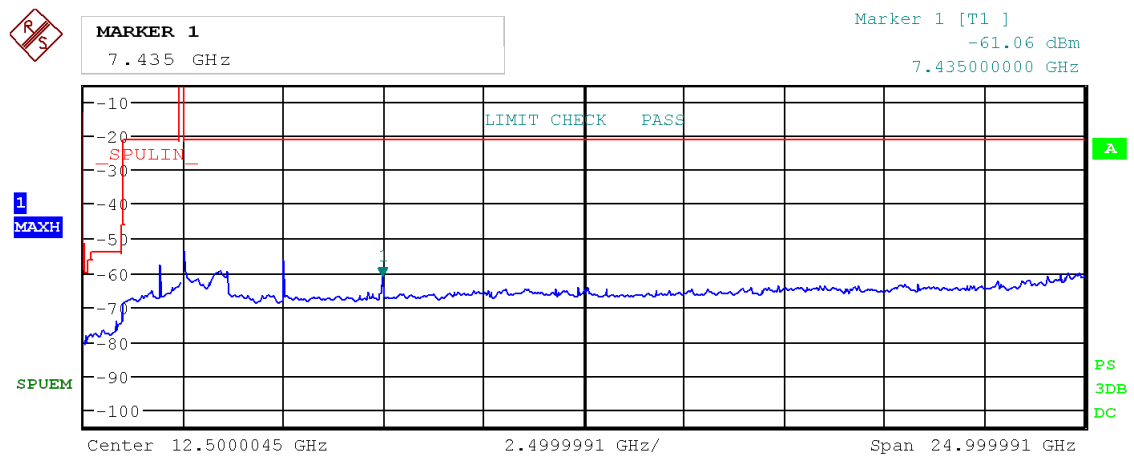


Figure 24: Chart of emissions test from 9 kHz to 25 GHz on highest channel, PK-detector

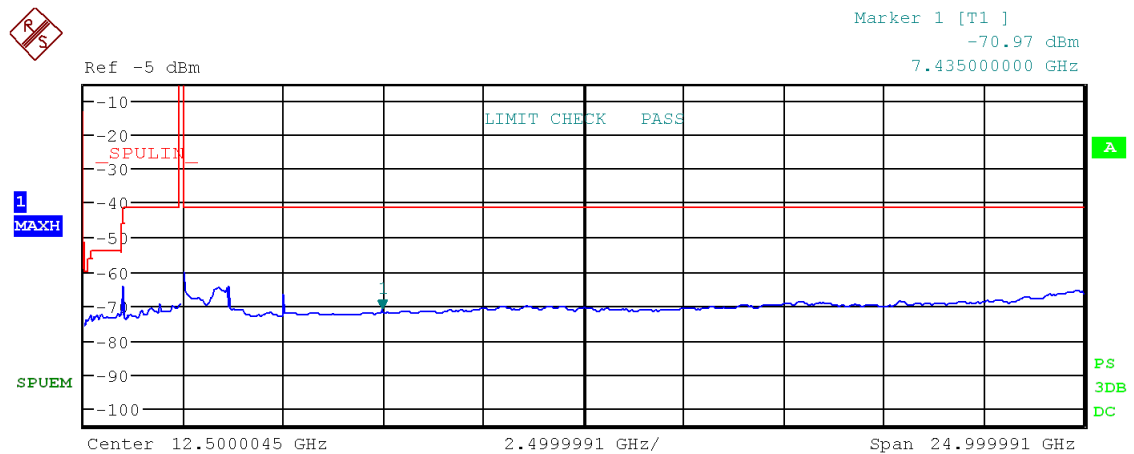


Figure 25: Chart of emissions test from 9 kHz to 25 GHz on highest channel, AV-detector

| Frequency (MHz) | Level (dBm) | Detector | Limit (dBm) | Margin (dB) |
|-----------------|-------------|----------|-------------|-------------|
| 1881.260        | -55.82      | PK       | -21.20      | 34.62       |
| 1883.113        | -67.50      | RMS      | -41.20      | 26.30       |
| 4960.000        | -54.51      | PK       | -21.20      | 33.31       |
| 4960.000        | -64.85      | RMS      | -41.20      | 23.65       |
| 7435.000        | -59.06      | PK       | -21.20      | 37.86       |
| 7435.000        | -68.97      | RMS      | -41.20      | 27.77       |

Table 27: Results of emissions test from 9 kHz to 25 GHz on highest channel

## 6.7 Radiated emissions below 30 MHz

|                               |                                  |                                                                                        |
|-------------------------------|----------------------------------|----------------------------------------------------------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s):<br>Reference(s): | 15.247(d)<br>KDB 558074 D01, clauses 8.5 and 8.6<br>ANSI C63.10, clause 6.4            |
| Section(s) in RSS:            | Requirement(s):<br>Reference(s): | RSS-247, section 5.5<br>KDB 558074 D01, clauses 8.5 and 8.6<br>ANSI C63.10, clause 6.4 |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 21, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.7.1 Test equipment

| Type                             | Designation        | Manufacturer                                                | Inventory no.                        |
|----------------------------------|--------------------|-------------------------------------------------------------|--------------------------------------|
| Compact Diagnostic Chamber (CDC) | VK041.0174         | Albatross Projects                                          | E00026                               |
| EMI test receiver                | ESR 7              | Rohde & Schwarz                                             | E00739                               |
| Loop antenna                     | HFH2-Z2            | Rohde & Schwarz                                             | E00060                               |
| Cable set CDC                    | RF cable(s)        | Huber + Suhner<br>AME HF-Technik<br>AME HF-Technik<br>Stabo | E00446<br>E00920<br>E00921<br>E01215 |
| Test software                    | EMC32-MEB (V10.35) | Rohde & Schwarz                                             | E01073                               |

## 6.7.2 Limits

According to §15.247(d) and RSS-247 section 5.5:

In any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits specified in §15.209(a) and RSS-Gen section 8.10.

For the frequency range 9 kHz to 30 MHz, these limits are shown in table 28 and Table 29.

| Frequency<br>(MHz) | Field strength                  |                              | Measurement distance<br>(m) |
|--------------------|---------------------------------|------------------------------|-----------------------------|
|                    | ( $\mu\text{V/m}$ )             | ( $\text{dB}\mu\text{V/m}$ ) |                             |
| 0.009 – 0.490      | 2400/F(kHz)<br>(266.67 – 4.90)  | 48.52 – 13.80                | 300                         |
| 0.490 – 1.705      | 24000/F(kHz)<br>(48.98 – 14.08) | 33.80 – 22.97                | 30                          |
| 1.705 – 30         | 30                              | 29.54                        | 30                          |

Table 28: General radiated emission limits up to 30 MHz according to §15.209

| Frequency<br>(MHz) | Magnetic field strength |                              | Measurement distance<br>(m) |
|--------------------|-------------------------|------------------------------|-----------------------------|
|                    | ( $\mu\text{A/m}$ )     | ( $\text{dB}\mu\text{A/m}$ ) |                             |
| 0.009 – 0.490      | 6.37/F(kHz)             | -2.999 – -37.721             | 300                         |
| 0.490 – 1.705      | 63.7/F(kHz)             | -17.721 – -28.636            | 30                          |
| 1.705 – 30         | 0.08                    | -21.94                       | 30                          |

Table 29: General radiated emission limits from 9 kHz to 30 MHz according to RSS-Gen section 8.9

In case of measurements are performed at other distances than that specified in the requirements, the limits in the charts and tables reported with the test results are derived from the general radiated emission limits as listed in table 28 using the recalculation factor as described in clause 5.3.

## 6.7.3 Test procedure

The emissions below 30 MHz are measured using the

- ☐ test procedure for conducted measurements as described in clause 5.2.
- ☒ test procedure for radiated measurements as described in clause 5.3.

The following parameters are set:

| Frequency range  | IF Bandwidth | Preamplifier |
|------------------|--------------|--------------|
| 9 kHz – 150 kHz  | 200 Hz       | Off          |
| 150 kHz – 30 MHz | 9 kHz        | Off          |

## 6.7.4 Test results

|                    |                                                 |                                                |                                                |
|--------------------|-------------------------------------------------|------------------------------------------------|------------------------------------------------|
| Test distance:     | <input checked="" type="checkbox"/> 3 m         | <input type="checkbox"/> 10 m                  | <input type="checkbox"/> ..... m               |
| Antenna alignment: | <input checked="" type="checkbox"/> in parallel | <input checked="" type="checkbox"/> in line    | <input type="checkbox"/> angle ..... °         |
| EUT position:      | <input checked="" type="checkbox"/> Position X  | <input checked="" type="checkbox"/> Position Y | <input checked="" type="checkbox"/> Position Z |

Note(s):

- 1 Premeasurements were performed to declare the worst case which is documented below.
- 2 No assessable emissions could be detected.
- 3 Premeasurements have shown that there are no differences between the tested channels below 30 MHz, so the final measurement was only performed on channel low.
- 4 The limits in CFR 47, Part 15, Subpart C, paragraph 15.209(a), are identical to those in RSS-Gen section 8.9, Table 6, since the measurements are performed in terms of magnetic field strength and converted to electric field strength levels (as reported in the table) using the free space impedance of 377 Ohms. For example, the measurement at frequency X kHz resulted in a level of Y dBuV/m, which is equivalent to  $Y - 51.5 = Z$  dBuA/m, which has the same margin, W dB, to the corresponding RSS-210 limit as it has to 15.209(a) limit.

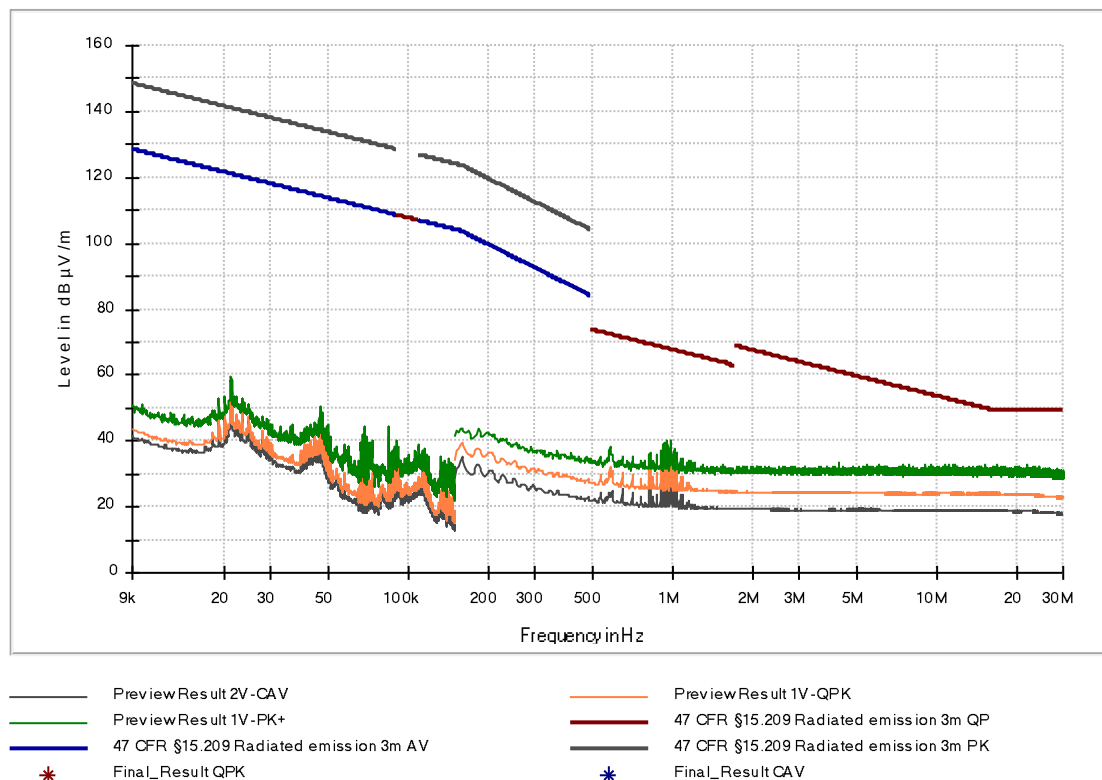


Figure 26: Chart of emissions test below 30 MHz on lowest channel, EUT position X, antenna parallel to the EUT

## 6.8 Radiated emissions from 30 MHz to 1 GHz

|                               |                 |                                     |
|-------------------------------|-----------------|-------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s): | 15.247(d)                           |
|                               | Reference(s):   | KDB 558074 D01, clauses 8.4 and 8.5 |
|                               |                 | ANSI C63.10, clause 6.5             |
| Section(s) in RSS:            | Requirement(s): | RSS-247, section 5.5                |
|                               | Reference(s):   | KDB 558074 D01, clauses 8.4 and 8.5 |
|                               |                 | ANSI C63.10, clause 6.5             |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 21, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.8.1 Test equipment

| Type                           | Designation       | Manufacturer       | Inventory no.              |
|--------------------------------|-------------------|--------------------|----------------------------|
| Semi-anechoic chamber (SAC)    | SAC3              | Albatross Projects | E00716                     |
| EMI test receiver              | ESW 44            | Rohde & Schwarz    | E00895                     |
| TRILOG broadband antenna (SAC) | VULB 9162         | Schwarzbeck        | E00643                     |
| Cable set SAC                  | RF cable(s)       | Huber + Suhner     | E00755<br>E01033<br>E01034 |
| Test software                  | EMC32-EB (V10.35) | Rohde & Schwarz    | E00777                     |



## 6.8.2 Limits

According to §15.247(d) and RSS-247 section 5.5:

In any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits specified in §15.209(a) and RSS-Gen section 8.10.

For frequencies equal to and above 30 MHz, these limits are shown in table 30.

| <i>Frequency<br/>(MHz)</i> | <i>Field strength</i>        |                                | <i>Measurement distance<br/>(m)</i> |
|----------------------------|------------------------------|--------------------------------|-------------------------------------|
|                            | <i>(<math>\mu</math>V/m)</i> | <i>(dB<math>\mu</math>V/m)</i> |                                     |
| 30 – 88                    | 100                          | 40.00                          | 3                                   |
| 88 – 216                   | 150                          | 43.52                          | 3                                   |
| 216 - 960                  | 200                          | 46.02                          | 3                                   |
| Above 960                  | 500                          | 53.98                          | 3                                   |

Table 30: General radiated emission limits  $\geq$  30 MHz according to §15.209 and RSS-Gen section 8.9

## 6.8.3 Test procedure

The emissions from 30 MHz to 1 GHz are measured using the

- ☐ test procedure for conducted measurements as described in clause 5.2.
- ☒ test procedure for radiated measurements as described in clause 5.5.

The following parameters are set:

| <i>Frequency range</i> | <i>IF Bandwidth</i> | <i>Preamplifier</i> |
|------------------------|---------------------|---------------------|
| 30 MHz – 1 GHz         | 120 kHz             | 20 dB               |

## 6.8.4 Test results

|                |                                                |                                                |                                                |
|----------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| Test distance: | <input checked="" type="checkbox"/> 3 m        | <input type="checkbox"/> 10 m                  | <input type="checkbox"/> ..... m               |
| Polarization:  | <input checked="" type="checkbox"/> horizontal | <input checked="" type="checkbox"/> vertical   |                                                |
| EUT position:  | <input checked="" type="checkbox"/> Position X | <input checked="" type="checkbox"/> Position Y | <input checked="" type="checkbox"/> Position Z |

### Note(s)

- 1 Premeasurements were performed to declare the worst case which is documented below.
- 2 No assessable emissions could be detected.
- 3 Premeasurements have shown that there are no differences between the tested channels in the range of 30 MHz to 1 GHz, so the final measurement was only performed on lowest channel.

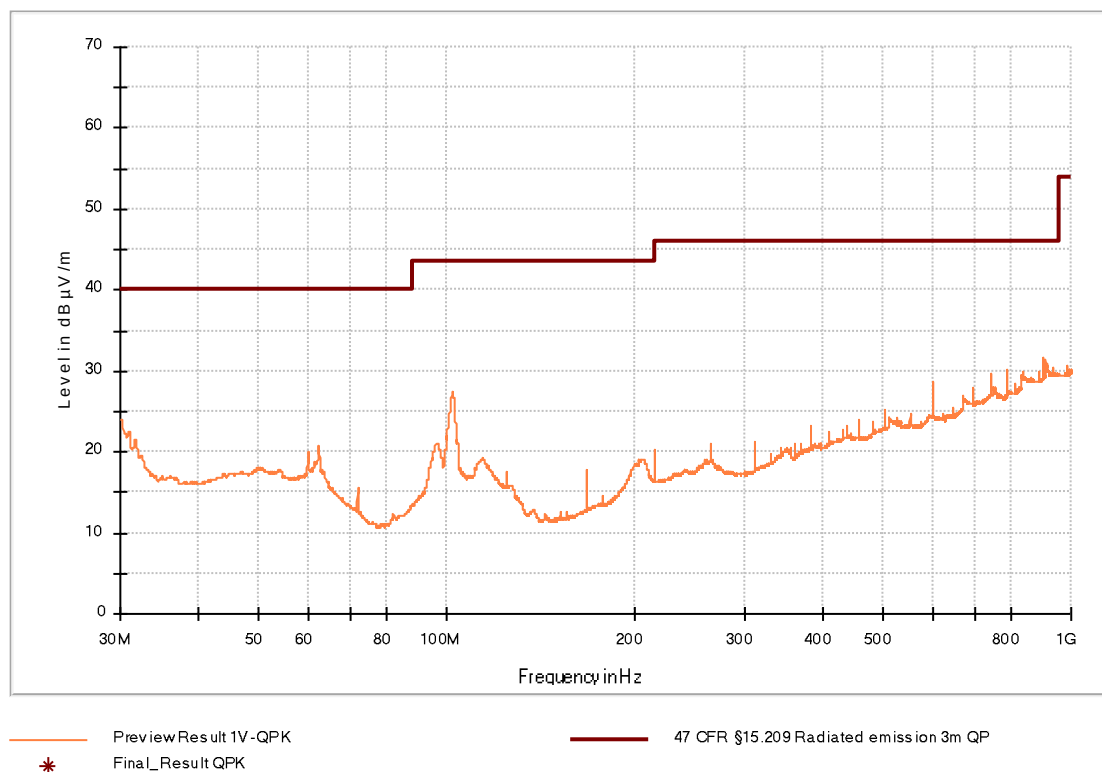


Figure 27: Chart of emissions test from 30 MHz to 1 GHz on lowest channel, EUT position Z, antenna polarization vertical

## 6.9 Radiated emissions from 1 GHz to 25 GHz (10<sup>th</sup> harmonic)

|                               |                                  |                                                                                        |
|-------------------------------|----------------------------------|----------------------------------------------------------------------------------------|
| Section(s) in 47 CFR Part 15: | Requirement(s):<br>Reference(s): | 15.247(d)<br>KDB 558074 D01, clauses 8.4 and 8.5<br>ANSI C63.10, clause 6.6            |
| Section(s) in RSS:            | Requirement(s):<br>Reference(s): | RSS-247, section 5.5<br>KDB 558074 D01, clauses 8.4 and 8.5<br>ANSI C63.10, clause 6.6 |

|               |                                                 |                                          |                  |
|---------------|-------------------------------------------------|------------------------------------------|------------------|
| Performed by: | Jennifer Riedel B. Eng.                         | Date(s) of test:                         | January 20, 2021 |
| Result:       | <input checked="" type="checkbox"/> Test passed | <input type="checkbox"/> Test not passed |                  |

### 6.9.1 Test equipment

| Type                                      | Designation | Manufacturer                                             | Inventory no.              |
|-------------------------------------------|-------------|----------------------------------------------------------|----------------------------|
| Free space semi-anechoic chamber (FS-SAC) | FS-SAC      | ELEMENT STRAUBING                                        | E00100                     |
| EMI test receiver                         | ESU 26      | Rohde & Schwarz                                          | W00002                     |
| Preamplifier (0.5 GHz - 18 GHz)           | BBV 917 B   | Schwarzbeck                                              | W01325                     |
| Preamplifier (18 GHz – 40 GHz)            | BBV 9721    | Schwarzbeck                                              | W01350                     |
| Horn antenna                              | BBHA 9120D  | Schwarzbeck                                              | W00053                     |
| Horn antenna                              | BBHA 9170   | Schwarzbeck                                              | W00055                     |
| Cable set FS-SAC                          | RF cable(s) | Teledyne Reynolds<br>Huber + Suhner<br>Teledyne Reynolds | E00435<br>E00307<br>E00433 |

## 6.9.2 Limits

According to §15.247(d) and RSS-247 section 5.5:

In any 100 kHz bandwidth outside of the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.

In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits specified in §15.209(a) and RSS-Gen section 8.10.

For frequencies above 960 MHz, these limits are shown in table 31.

| <i>Frequency<br/>(MHz)</i> | <i>Field strength</i>        |                                | <i>Measurement distance<br/>(m)</i> |
|----------------------------|------------------------------|--------------------------------|-------------------------------------|
|                            | <i>(<math>\mu</math>V/m)</i> | <i>(dB<math>\mu</math>V/m)</i> |                                     |
| Above 960                  | 500                          | 53.98                          | 3                                   |

Table 31: General radiated emission limits above 960 MHz according to §15.209 and RSS-Gen

## 6.9.3 Test procedure

The emissions from 1 GHz to 25 GHz are measured using the

- ☐ test procedure for conducted measurements as described in clause 5.2.
- ☒ test procedure for radiated measurements as described in clause 5.6.

The following parameters are set:

| <i>Frequency range</i> | <i>IF Bandwidth</i> | <i>Preamplifier</i> |
|------------------------|---------------------|---------------------|
| 1 GHz – 25 GHz         | 1 MHz               | External            |

#### 6.9.4 Test results

|                |                                                |                                                |                                                |
|----------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| Test distance: | Exploratory tests:                             | <input type="checkbox"/> 1 m                   | <input checked="" type="checkbox"/> 0.5 m      |
|                | Final tests:                                   | <input type="checkbox"/> 3 m                   | <input checked="" type="checkbox"/> 1.5 m      |
| EUT position:  | <input checked="" type="checkbox"/> Position X | <input checked="" type="checkbox"/> Position Y | <input checked="" type="checkbox"/> Position Z |

##### Note(s):

- 1 The measurements from 1 GHz to 18 GHz are made at a measurement distance of 1.5 m. However, the limit lines for these tests are referenced to the limit lines at a measurement distance of 3 m (Offset – 6 dB).
- 2 The exploratory measurements from 18 GHz to 25 GHz are made at a measurement distance of 0.5 m. However, the limit lines for these tests are referenced to the limit lines at a measurement distance of 3 m (Offset – 15.6 dB).
- 3 Premeasurements were performed to declare the worst case which is documented below. The table results are the final measurements of the emissions detected in the premeasurements which are shown in this test report.
- 4 According to ANSI C63.10 clause 6.6.4.3 note 1, if the maximized peak measured value complies with the average limit, then it is unnecessary to perform an average measurement.

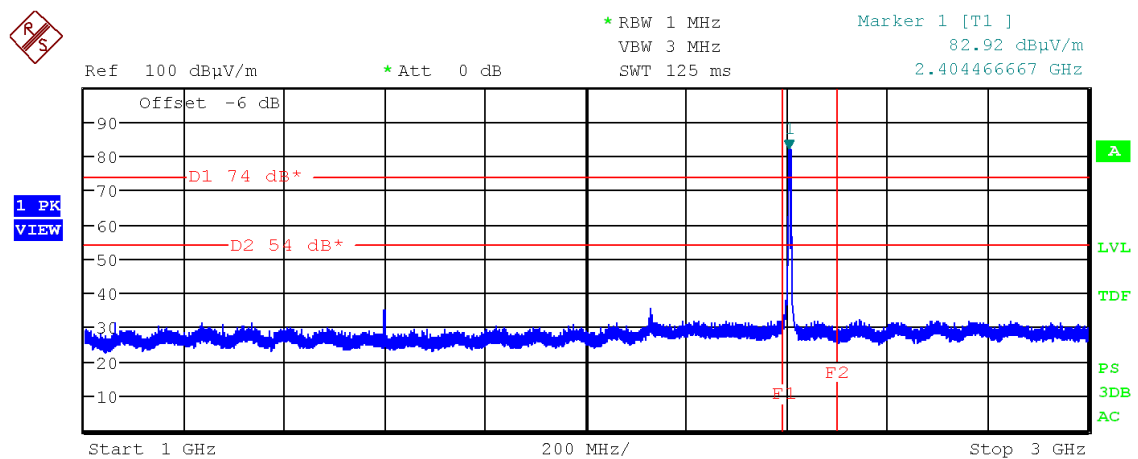


Figure 28: Chart of emissions test from 1 GHz to 3 GHz on lowest channel with band edges, EUT position Z, antenna polarization horizontal

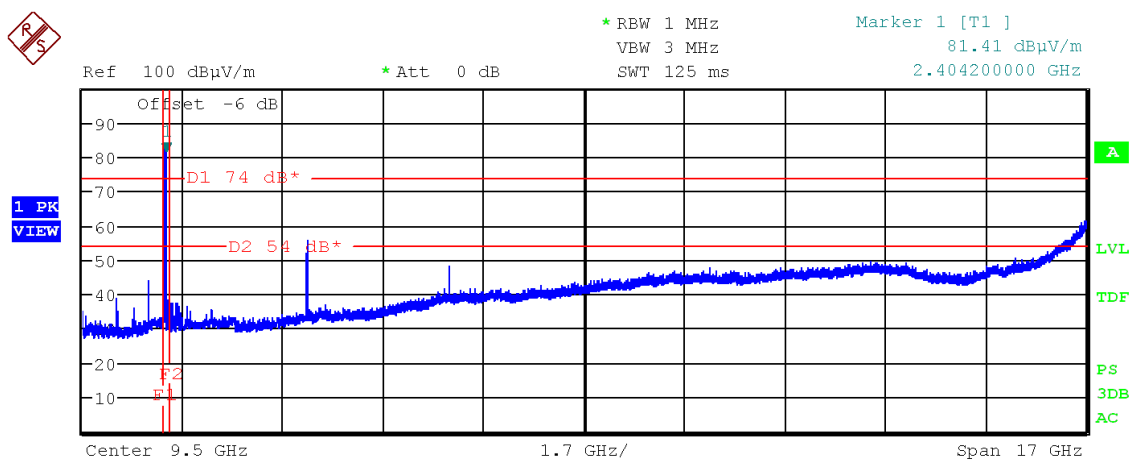


Figure 29: Chart of emissions test from 1 GHz to 18 GHz on lowest channel, EUT position Z, antenna polarization horizontal

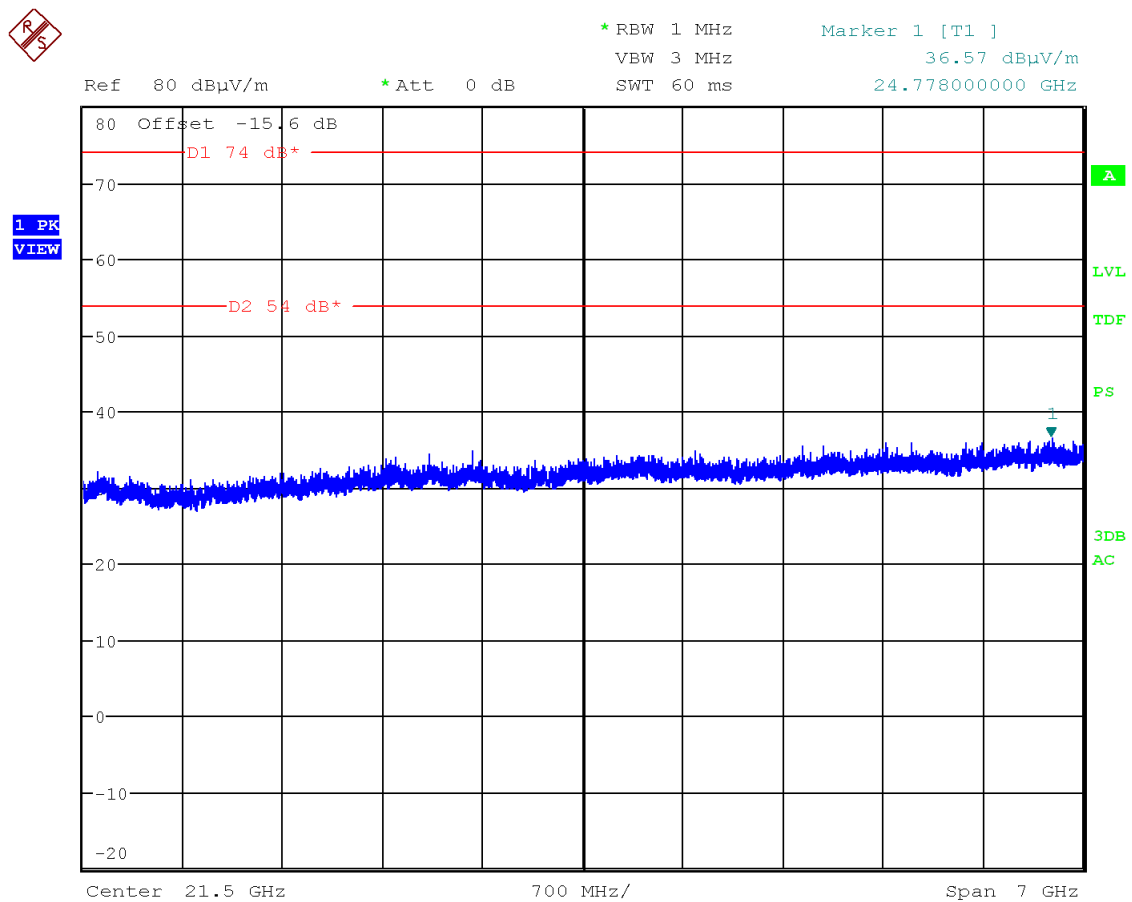


Figure 30: Chart of exploratory emission test from 18 GHz to 25 GHz on lowest channel at 0.5 m

| Frequency (MHz) | EUT Pos. | Level (dBμV/m) | Detector | Limit (dBμV/m) | Margin (dB) | Height (cm) | Pol. | Azimuth (deg) | Corr. (dB/m) |
|-----------------|----------|----------------|----------|----------------|-------------|-------------|------|---------------|--------------|
| 4810.994        | Z        | 56.95          | PK       | 74.00          | 17.05       | 177.00      | H    | 71.00         | 1.2          |
| 4810.833        | Z        | 51.06          | AV       | 54.00          | 2.94        | 177.00      | H    | 71.00         | 1.2          |
| 7216.410        | Z        | 50.23          | PK       | 74.00          | 23.77       | 200.00      | H    | 50.00         | 8.9          |
| 17975.179       | Z        | 61.59          | PK       | 74.00          | 12.41       | 150.00      | H    | 50.00         | 18.3         |
| 17975.788       | Z        | 47.60          | AV       | 74.00          | 26.40       | 150.00      | H    | 50.00         | 18.3         |

Table 32: Results of emissions test from 1 GHz to 25 GHz on lowest channel

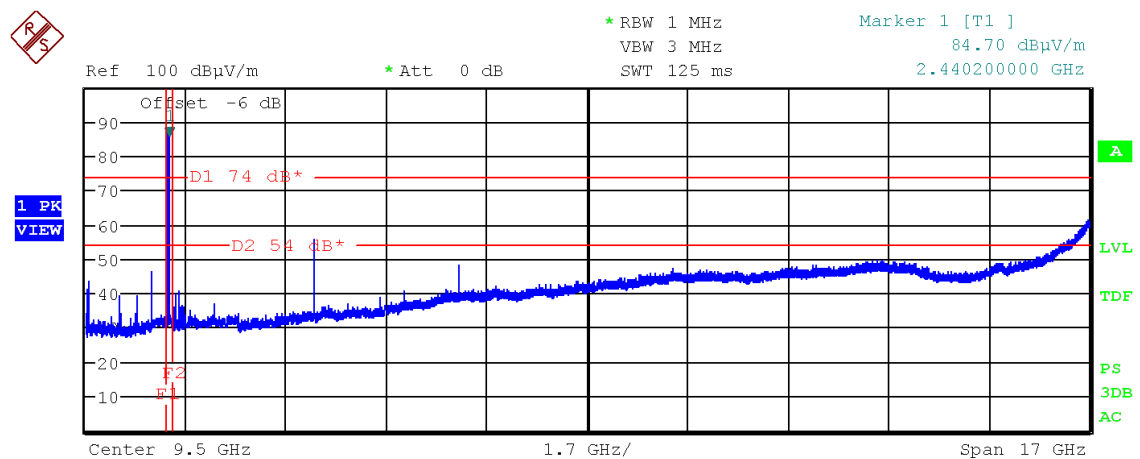


Figure 31: Chart of emissions test from 1 GHz to 18 GHz on middle channel, EUT position Z, antenna polarization horizontal

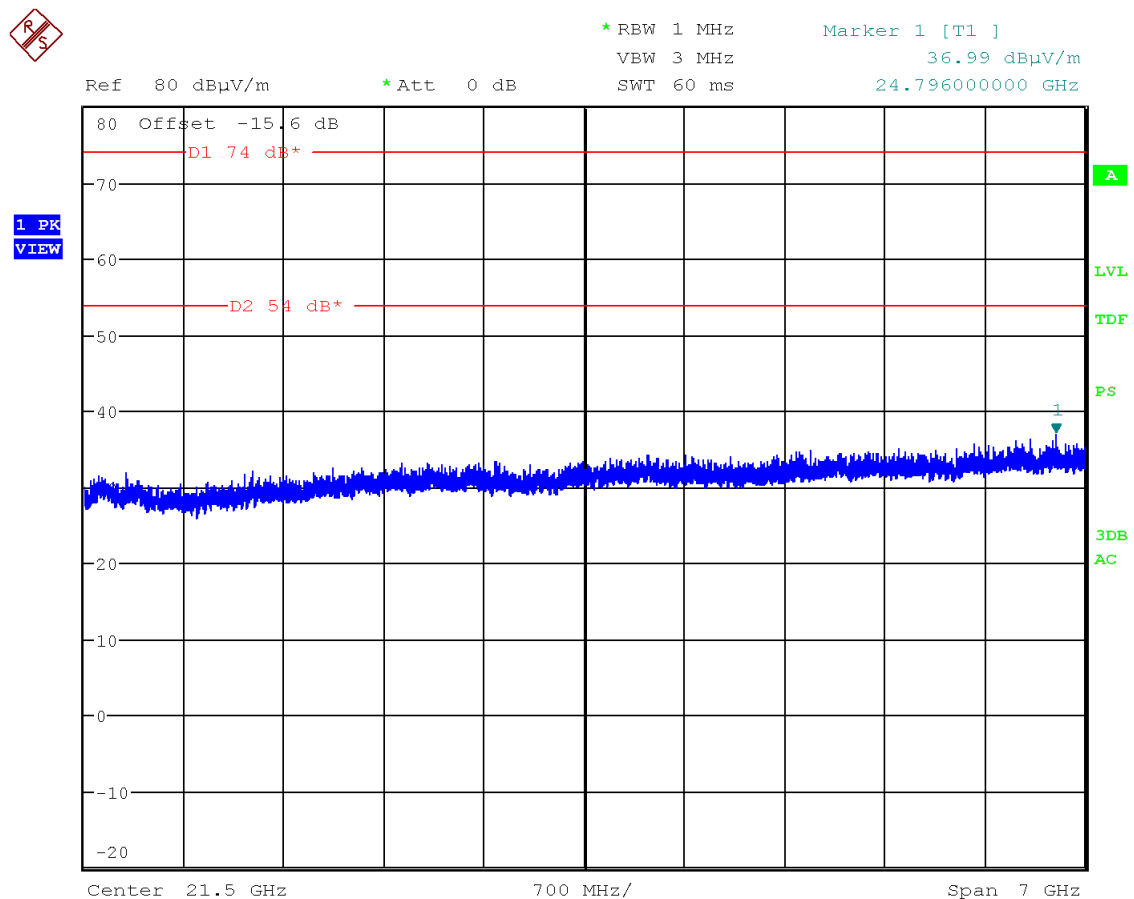


Figure 32: Chart of exploratory emission test from 18 GHz to 25 GHz on middle channel at 0.5 m



| <i>Frequency<br/>(MHz)</i> | <i>EUT<br/>Pos.</i> | <i>Level<br/>(dB<math>\mu</math>V/m)</i> | <i>Detec-<br/>tor</i> | <i>Limit<br/>(dB<math>\mu</math>V/m)</i> | <i>Margin<br/>(dB)</i> | <i>Height<br/>(cm)</i> | <i>Pol.</i> | <i>Azimuth<br/>(deg)</i> | <i>Corr.<br/>(dB/m)</i> |
|----------------------------|---------------------|------------------------------------------|-----------------------|------------------------------------------|------------------------|------------------------|-------------|--------------------------|-------------------------|
| 4879.071                   | Z                   | 56.05                                    | PK                    | 74.00                                    | 17.95                  | 180.00                 | H           | 68.00                    | 0.9                     |
| 4880.865                   | Z                   | 49.79                                    | AV                    | 54.00                                    | 4.21                   | 180.00                 | H           | 68.00                    | 0.9                     |
| 7321.474                   | Z                   | 49.05                                    | PK                    | 74.00                                    | 24.95                  | 200.00                 | H           | 53.00                    | 8.7                     |
| 17984.859                  | Z                   | 61.14                                    | PK                    | 74.00                                    | 12.86                  | 200.00                 | H           | 0                        | 18.5                    |
| 17865.577                  | Z                   | 47.56                                    | AV                    | 54.00                                    | 6.44                   | 200.00                 | H           | 0                        | 18.5                    |

Table 33: Results of emissions test from 1 GHz to 25 GHz on middle channel

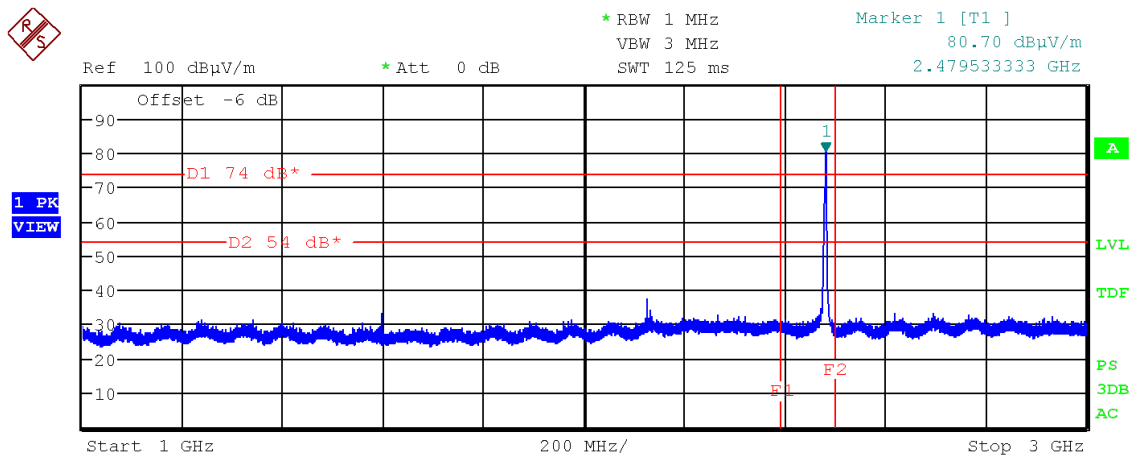


Figure 33: Chart of emissions test from 1 GHz to 3 GHz on highest channel with band edges, EUT position Z, antenna polarization horizontal

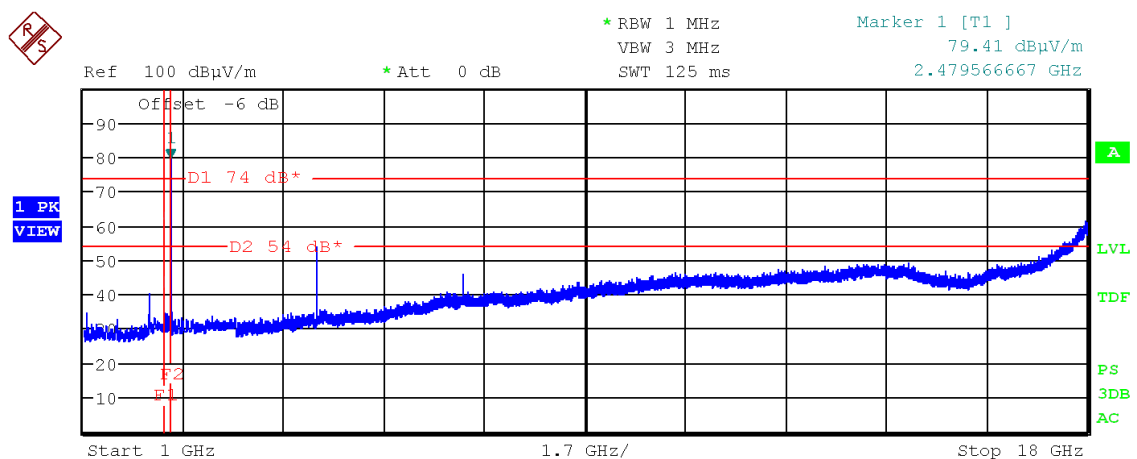


Figure 34: Chart of emissions test from 1 GHz to 18 GHz on highest channel, EUT position Z, antenna polarization horizontal

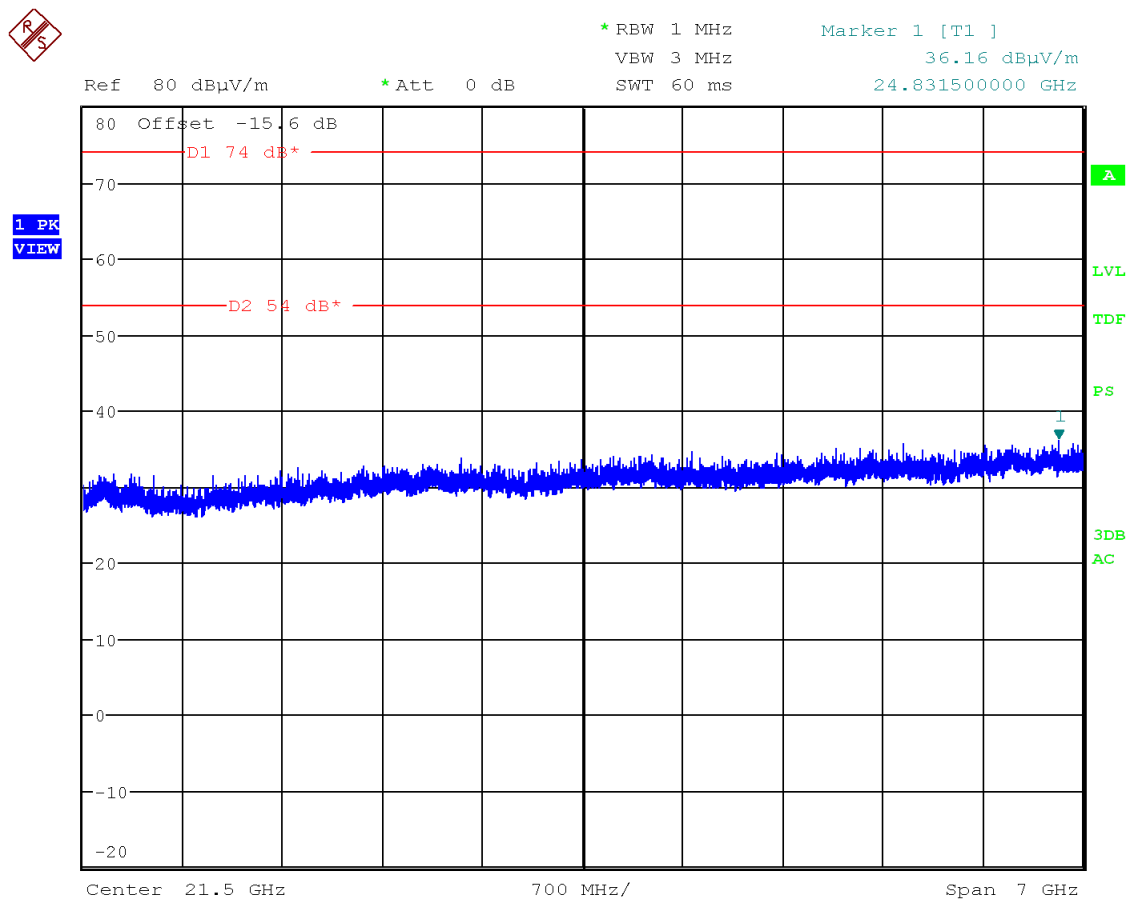


Figure 35: Chart of exploratory emission test from 18 GHz to 25 GHz on highest channel at 0.5 m

| Frequency (MHz) | EUT Pos. | Level (dBμV/m) | Detector | Limit (dBμV/m) | Margin (dB) | Height (cm) | Pol. | Azimuth (deg) | Corr. (dB/m) |
|-----------------|----------|----------------|----------|----------------|-------------|-------------|------|---------------|--------------|
| 4959.327        | Z        | 55.20          | PK       | 74.00          | 18.80       | 176.00      | H    | 65.00         | 1.3          |
| 4960.769        | Z        | 48.46          | AV       | 54.00          | 5.54        | 176.00      | H    | 65.00         | 1.3          |
| 7438.333        | Z        | 49.34          | PK       | 74.00          | 24.66       | 202.00      | H    | 50.00         | 9.3          |
| 17995.590       | Z        | 61.16          | PK       | 74.00          | 12.84       | 200.00      | H    | 51.00         | 18.5         |
| 17994.627       | Z        | 47.69          | AV       | 54.00          | 6.31        | 200.00      | H    | 51.00         | 18.5         |

Table 34: Results of emissions test from 1 GHz to 25 GHz on highest channel

## 7 Equipment calibration status

| Description                                      | Modell number                  | Serial number           | Inventory number(s) | Last calibration | Next calibration |
|--------------------------------------------------|--------------------------------|-------------------------|---------------------|------------------|------------------|
| EMI test receiver                                | ESW44                          | 101538                  | E00895              | 2020-08          | 2022-08          |
| EMI test receiver                                | ESU26                          | 100026                  | W00002              | 2020-06          | 2022-06          |
| EMI test receiver                                | ESR7                           | 101059                  | E00739              | 2019-08          | 2021-08          |
| EMI test receiver                                | ESCI3                          | 100328                  | E00552              | 2020-10          | 2022-10          |
| EMI test receiver                                | ESCI3                          | 100013                  | E00001              | 2020-05          | 2022-05          |
| Preamplifier (1 GHz - 18 GHz)                    | BBV 9718 B                     | 00032                   | W01325              | 2020-09          | 2021-09          |
| Preamplifier (18 GHz - 40 GHz)                   | BBV 9721                       | 43                      | W01350              | 2020-11          | 2021-11          |
| Preamplifier (1 GHz - 18 GHz)                    | ALS05749                       | 001                     | W01007              | 2021-01          | 2022-01          |
| Loop antenna                                     | HFH2-Z2                        | 871398/0050             | E00060              | 2020-10          | 2021-10          |
| LISN                                             | ESH2-Z5                        | 881362/037              | E00004              | Note 1           |                  |
| LISN                                             | ESH2-Z5                        | 893406/009              | E00005              | 2020-10          | 2021-10          |
| Field probe                                      | RF-R 400-1                     | 02-2030                 | E00270              | Note 2           |                  |
| TRILOG broadband antenna (SAC3)                  | VULB 9162                      | 9162-041                | E00643              | 2018-03          | 2021-03          |
| Horn antenna                                     | BBHA 9120D                     | 9120D-592               | W00053              | 2020-04          | 2023-04          |
| Horn antenna                                     | BBHA 9170                      | 9170-332                | W00055              | 2020-04          | 2023-04          |
| Shielded room                                    | P92007                         | B 83117 C 1109 T 211    | E00107              | N/A              |                  |
| Compact diagnostic chamber (CDC)                 | VK041.0174                     | D62128-A502-A69-2-0006  | E00026              | N/A              |                  |
| Semi-anechoic chamber (SAC) with floor absorbers | FS-SAC                         | ---                     | E00100              | 2018-03          | 2021-03          |
| Semi-anechoic chamber (SAC)                      | SAC3                           | C62128-A520-A643-x-0006 | E00716              | 2018-03          | 2021-03          |
| Cable set CDC                                    | RG214/U                        | ---                     | E00446              | 2020-04          | 2021-04          |
|                                                  | LCF12-50J                      | ---                     | E01215              | 2020-04          | 2021-04          |
|                                                  | LMR400                         | 1718020006              | E00920              | 2021-01          | 2022-01          |
|                                                  | RG214 Hiflex                   | 171802007               | E00921              | 2021-01          | 2022-01          |
| Cable set anechoic chamber                       | 262-0942-1500                  | 005                     | E00435              | 2020-10          | 2021-10          |
|                                                  | SF104EA/2x11PC 35-42/5m        | 11144/4EA               | E00307              | 2020-12          | 2021-12          |
|                                                  | 262-0942-1500                  | 003                     | E00433              | 2020-10          | 2021-10          |
| Cable set of semi-anechoic chamber SAC3          | SF104EA/11PC35/11PC35/10000M M | 501347/4EA              | E00755              | 2020-12          | 2021-12          |
|                                                  | SF104E/11PC35/1 1PC35/2000MM   | 507410/4E               | E01035              | 2020-12          | 2021-12          |
|                                                  | SF104E/11PC35/1 1PC35/2000MM   | 507411/4E               | E01034              | 2020-09          | 2021-09          |

Note(s)

1. Only used for decoupling of support equipment.
2. Only used for relative measurements.

## 8 Measurement uncertainties

| Description                                | Uncertainty  | $U_{Limit}$  | Note(s)  | k= |
|--------------------------------------------|--------------|--------------|----------|----|
| AC power line conducted emission           | $\pm 3.0$ dB | $\pm 3.4$ dB | 2b), 3b) | 2  |
| Carrier frequency separation               | $\pm 1.5$ %  | $\pm 5$ %    | 2a), 3a) | 2  |
| Number of hopping frequencies              | $\pm 1.5$ %  | $\pm 5$ %    | 2a), 3a) | 2  |
| Time of occupancy (dwell time)             | $\pm 1.5$ %  | $\pm 5$ %    | 2a), 3a) | 2  |
| Bandwidth tests                            | $\pm 2.0$ %  | $\pm 5$ %    | 2a), 3a) | 2  |
| Maximum conducted output power (conducted) | $\pm 2.9$ dB | $\pm 3.0$ dB | 2a), 3a) | 2  |
| Power spectral density (conducted)         | $\pm 2.9$ dB | $\pm 3.0$ dB | 2a), 3a) | 2  |
| Conducted spurious emissions               | $\pm 2.9$ dB | $\pm 3.0$ dB | 2a), 3a) | 2  |
| Radiated emissions                         |              |              |          |    |
| from 9 kHz to 30 MHz                       | $\pm 3.8$ dB | $\pm 4.0$ dB | 2b), 3b) | 2  |
| from 30 MHz to 1 GHz                       | $\pm 6.1$ dB | $\pm 6.3$ dB | 2b), 3b) | 2  |
| from 1 GHz to 6 GHz                        | $\pm 4.6$ dB | $\pm 5.2$ dB | 2b), 3b) | 2  |
| from 6 GHz to 18 GHz                       | $\pm 5.0$ dB | $\pm 5.5$ dB | 2b), 3b) | 2  |
| from 18 GHz to 26.5 GHz                    | $\pm 5.4$ dB | $\pm 6.0$ dB | 2b), 3c) | 2  |
| from 26.5 GHz to 40 GHz                    | $\pm 6.2$ dB | $\pm 6.5$ dB | 2b), 3c) | 2  |

### Note(s):

- The uncertainty stated is the expanded uncertainty obtained by multiplying the standard uncertainty by the coverage factor k. For a confidence level of 95 % the coverage factor k is 2.
- The values of the measurement uncertainty as listed above are calculated according to
  - ETSI TR 100 028-1 V1.4.1 and ETSI TR 100 028-2 V1.4.1
  - CISPR 16-4-2:2011-06 + A1:2014-02 + A2:2018-08
- The limits for the measurement uncertainty as listed above are
  - derived from ETSI EN 300 328 V2.1.1
  - equal to  $U_{CISPR}$  taken from CISPR 16-4-2:2011-06 + A1:2014-02 + A2:2018-08
  - defined by the test laboratory
- Simple acceptance is applied as the decision rule while keeping the specified limits ( $U_{Limit}$ ) for the expanded measurement uncertainty (i.e. Test Uncertainty Ratio  $TUR \geq 1:1$ ). That means, compliance is based on the recorded level by the lab irrespective of the expanded measurement uncertainty value but with a limitation to it.
- All used test instruments as well as the test accessories are calibrated at regular intervals.

---

## 9 Revision history

| <i>Revision</i> | <i>Date</i> | <i>Issued by</i>        | <i>Description of modifications</i> |
|-----------------|-------------|-------------------------|-------------------------------------|
| 0               | 2021-01-26  | Jennifer Riedel B. Eng. | First edition                       |

Template: RF\_15.247\_RSS-247\_V1.1