# Test Report acc. to FCC Title 47 CFR Part 15
## relating to
## Feig Electronic GmbH
## ID ISC.MRMU102-A

**Title 47 – Telecommunication**
**Part 15 - Radio Frequency Devices**
**Subpart C – Intentional Radiators**
**Measurement Procedure:**
**ANSI C63.4-2014**
**ANSI C63.10-2013**

ilac-MRA DAkkS Deutsche Akkreditierungsstelle D-PL-12053-01-03



**TÜV NORD Hochfrequenztechnik GmbH & Co. KG** **Tel.: +49 221 8888950**
**LESKANPARK, Gebäude 10, Waltherstr. 49-51, 51069 Köln, Germany**

| MANUFACTURER | |
|---|---|
| Manufacturer name | **Feig Electronic** |
| Manufacturer’s grantee code | **PJM** |
| Manufacturer’s address | Lange Str. 4, 35781 Weilburg, Germany |
| Phone | +49 6471 30 09 428 |
| Fax | +49 6471 30 09 99 |
| Email | reinhard.monno@feig.de |

| TESTING LABORATORY | |
|---|---|
| Test engineer | Mr. Ralf Trepper |
| Testing laboratory name | TÜV NORD Hochfrequenztechnik GmbH & Co. KG |
| Testing laboratory address | LESKANPARK, Gebäude 10 |
| | Walterstr. 49-51, 51069 Köln, Germany |
| Phone | +49 221 8888950 |
| Email | rtrepper@tuev-nord.de |

| RELEVANT STANDARD | |
|---|---|
| Title | **47 - Telecommunication** |
| Part | **15 - Radio Frequency Devices** |
| Subpart | **Subpart C – Intentional Radiators - Section 15.247** |
| Measurement procedure | **ANSI C63.4-2014 & ANSI C63.10-2013** |

| EQUIPMENT UNDER TEST (EUT) | |
|---|---|
| Equipment category | RFID Reader |
| Trade name | Feig Electronic |
| Type designation | **ID ISC.MRMU102-A** |
| Serial no. | 7693060 |
| Variants | ID ISC.MRMU102-A<br>ID ISC.MRU102-A<br>ID ISC.MRU102-USB<br>ID ISC.MRU102-PoE<br>ID ISC.MRU102-PoE-LED |

## Test result summary

| Test report Clause | FCC section | Requirements headline | Test result | | |
|---|---|---|---|---|---|
| 8.1 | §15.203 | Antenna requirement | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.2 | §15.207 (a) | AC power line conducted limits | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.3 | §15.205, §15.209, §15.247 (d) | Restricted bands of operation | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.4 | §15.205, §15.209, §15.247 (d) | Radiated emission limits, general requirements | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.5 | §15.247 (a) (1) | Bandwidth | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.6 | §15.247 (a) (1) | Carrier frequency separation | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.7 | §15.247 (a) (1) | Number of hopping channels | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.8 | §15.247 (a) (1) | Average time of occupancy | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.9 | §15.247 (b) (2) | Peak output power | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.10 | §15.247 (d) | Out of band emissions | **Pass** | ~~Fail~~ | ~~N.t.*~~ |
| 8.11 | §1.1310 §2.1091 | Radio frequency hazard | **Pass** | ~~Fail~~ | ~~N.t.*~~ |

* Not tested

As far as in this report statements on conformity are made, decision rules according to DIN EN ISO/IEC 17025:2018, 7.8.6 have been applied. If the report does not state otherwise, procedure 1 according to IEC Guide 115 ed.1.0 2007 (uncertainty of measurement calculated) has been applied on measurement and test procedures which are the base of this report.

| **The equipment passed all the conducted tests** | **Yes** | ~~No~~ |
|---|---|---|

| | | |
|---|---|---|
| **Signature** | TÜV NORD Digital unterschrieben von Shrestha Anup Datum: 2021.06.30 11:42:06 +02'00' | TÜV NORD Digital unterschrieben von Trepper Ralf Datum: 2021.06.30 11:42:49 +02'00' |
| **Name** | **Mr. Anup Shrestha** | **Mr. Ralf Trepper** |
| **Designation** | **RF Test Engineer** | **Deputy Laboratory Manager** |
| **Date of issue** | **2021-06-24** | **2021-06-24** |

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## 1. Table of contents

| Revision | Date of issue | Creator | Content of change |
|---|---|---|---|
| 00 | 24.06.21 | AS | Initial release |
| --- | --- | --- | --- |
| --- | --- | --- | --- |

Table 0-1: Table of contents

Note: If the document has been changed by revision number, all previous documents are no longer valid and must be destroyed.

## 2. Introduction

This test report **is not an expert opinion** and consists of:

- Test result summary
- List of contents
- Introduction and further information
- Performance assessment
- Detailed test information

All pages have been numbered consecutively and bear the TÜV NORD Hochfrequenztechnik GmbH & Co. KG logo, the test report number, the date, the test specification in its current version as well as the type designation of the EUT. The total numbers of pages in this report is **64**.

The tests were carried out in a representative assembly and in accordance with the test methods and/or requirements stated in:

**FCC Title 47 CFR Part 15 Subpart C Section 15.247, ANSI C63.4-2014 & ANSI C63.10-2013**

The sample of the product was received on:

**- 2021-06-04**

The tests were carried out in the following period of time:

**- 2021-06-07 - 2021-06-23**

## 3. Testing laboratory

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LESKANPARK, Gebäude 10
Waltherstr. 49-51
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Germany

Phone: +49 221 8888950

**FCC Registration Number: 763407**

Accredited by:

**DAkkS Deutsche Akkreditierungsstelle GmbH**
**DAkkS accreditation number: D-PL-12053-01-03**

## 4. Applicant

| | |
|---|---|
| Company name | : FEIG ELECTRONIC GmbH |
| Address | : Lange Str. 4 |
| | 35781 Weilburg |
| Country | : Germany |
| Telephone | : +49 6471 30 09 428 |
| Fax | : +49 6471 30 09 99 |
| Email | : reinhard.monno@feig.de |
| Date of order | : 2021-04-21 |
| References | : Mr. Rainhard Monno |

## 5. Product

Sample of the following apparatus was submitted for testing:

| | |
|---|---|
| Manufacturer | : Feig Electronic |
| Trademark | : Feig Electronic |
| Type designation | : **ID ISC.MRMU102-A** |
| Serial number | : 7693060 |
| Hardware version | : FE10996 |
| Variants | : ID ISC.MRMU102-A, ID ISC.MRU102-A, ID ISC.MRU102-USB, |
| | ID ISC.MRU102-PoE, ID ISC.MRU102-PoE-LED |
| Software release | : RF-Stack V1.00 |
| Type of equipment | : RFID Reader |
| Power used | : 12.0 – 24.0V DC (nominal 12.0V DC) |
| Frequency used | : 902.75 MHz – 927.25 MHz (50 channels with 500 kHz channel spacing) |
| Generated or used frequencies | : 902.75 MHz - 927.25 MHz (Carrier frequencies) |
| | 20.0 MHz, 25.0 MHz (Crystals) |
| ITU emission class | : 98KA7D |
| FCC ID | : PJMMRU102A |

For issuing this report the following product documentation was used:

| Title | Description | Version |
|---|---|---|
| INSTALLATION MANUAL | INSTALLATION MANUAL<br>ID ISC.MRMU102-A<br>UHF Mid Range Reader Module | M21112-4e-ID-B |

For issuing this report the following product documentation was used:

| Description | Date | Identifications |
|---|---|---|
| External photographs of the **E**quipment **U**nder **T**est (EUT) | 2021-06-24 | Annex no. 1 |
| Internal photographs of the **E**quipment **U**nder **T**est (EUT) | 2021-06-24 | Annex no. 2 |
| Channel occupancy / bandwidth | 2021-06-24 | Annex no. 3 |
| Label sample | 2021-06-24 | Annex no. 4 |
| Functional description / User Manual | 2021-06-24 | Annex no. 5 |
| Test setup photos | 2021-06-24 | Annex no. 6 |
| Block diagram | 2021-06-24 | Annex no. 7 |
| Operational description | 2021-06-24 | Annex no. 8 |
| Schematics | 2021-06-24 | Annex no. 9 |
| Parts list | 2021-06-24 | Annex no. 10 |
| Test Results | 2021-06-24 | Annex no. 11 |

## 6. Conclusions, observations and comments

The test report will be filed at TÜV NORD Hochfrequenztechnik GmbH & Co. KG for a period of 10 years following the issue of this report. It may only be reproduced or published in full. Reproduction or publication of extracts from the report requires the prior written approval of TÜV NORD Hochfrequenztechnik GmbH & Co. KG.

The results of the tests as stated in this report are exclusively applicable to the EUT as identified in this report.
TÜV NORD Hochfrequenztechnik GmbH & Co. KG cannot be held liable for properties of the EUT that have not been observed during these tests.

TÜV NORD Hochfrequenztechnik GmbH & Co. KG assumes the sample to comply with the requirements of FCC Title 47 CFR Part 15 for the respective test sector, if the test results turn out positive.

**Comments:**

**There are three SMA antenna connectors (ANT1, ANT2 and ANT3) on the PCB board of the EUT which can be connected up to three external UHF antennas to achieve long reader range. The output power from all the three SMA antenna connectors are same. For our test, we have used ANT1 and other two antenna connectors were terminated with 50 ohm terminators.**

**All RFID Readers ID ISC.MRMU102-A, ID ISC.MRU102-A, ID ISC.MRU102-USB, ID ISC.MRU102-PoE, ID ISC.MRU102-PoE LED, have identical innternal antenna and identical RF connectors. All Versions use the same printed circuit board.**


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# 7. Operational description

## 7.1 EUT details

The EUT is a small, compact and with internal antenna RFID reader operating at UHF (902 MHz – 928 MHz) in a frequency hopping mode. The EUT is available in three device variants with Ethernet, USB or RS232. The EUT has three SMA antenna connectors such that it can be connected up to three external UHF antennas to achieve long reader ranges. The RFID reader has an output power level of 500 mW. The RFID reader can be supplied with 12.0 – 24.0V DC via a separate power supply or via Power over Ethernet (type PoE).

## 7.2 EUT configuration

The EUT is powered up as soon as it is connected to 12.0V DC voltage (nominal) or via PoE. With the test software “CPRStart” on a controller PC, the EUT could be configured at different power levels, frequencies and hoping modes. The test was performed at maximum output power with continuous transmission mode at lower, upper and middle frequencies as well as at frequency hopping modes.

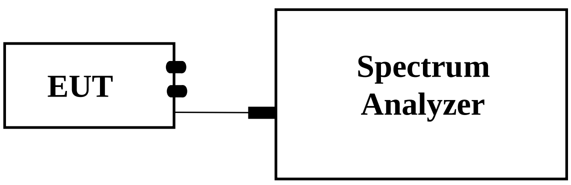
The following configurations were set during the test:

Output power: +27 dBm
Frequency hopping in the band: 902 MHz – 928 MHz
Channel spacing: 500 kHz
Single frequency operation at: 902.75 MHz, 914.75 MHz, 927.25 MHz
Changes in the modulation: none

## 7.3 EUT measurement description

<u>Conducted measurements at antenna port</u>

Among three SMA Antenna connectors, ANT1 of the the EUT was connected to the spectrum analyser via a RF cable as shown in the test setup block diagram. ANT2 and ANT3 were terminated with 50 Ohm terminators. The reading of the spectrum analyser was corrected with a RF cable loss, Blocking capacitor and a 20 dB Attenuator.



Radiated measurements

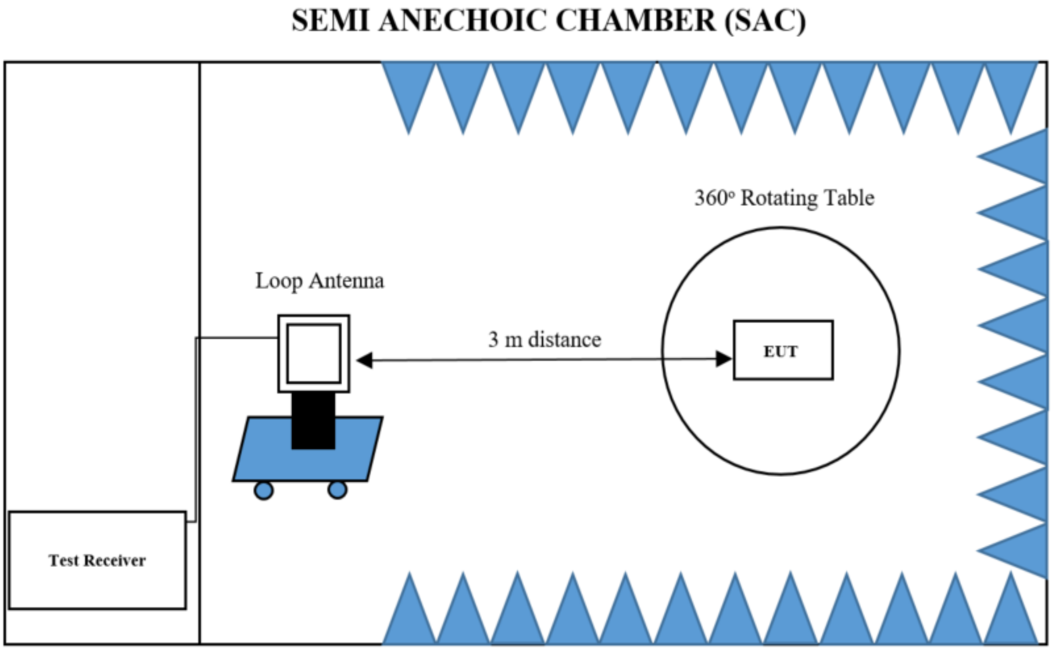
The EUT was tested in a typical fashion. During preliminary emission tests, the EUT was operated in the continuous measuring mode for worst-case emission mode investigation. Therefore, the final qualification testing was completed with the EUT operated in continuous measuring mode. All tests were performed in a semi-anechoic chamber (SAC) with the EUT's typical voltage: 12.0V DC.

In order to establish the maximum radiation, firstly, there have been viewed all orthogonal adjustments of the test samples, secondly the test ample have been rotated at all adjustments around the own axis between 0° and 360°, and thirdly, the antenna polarization between horizontal and vertical had been varied.

Radiated measurements from 9 kHz – 30 MHz, 30MHz – 1 GHz and above 1 GHz were performed using a small loop antenna, Linear polarized Logarithmic Periodic Broadband Antenna and stacked Logarithmic-Periodic Broadband Antenna for linear polarized respectively with a measuring distance of 3 m inside SAC.

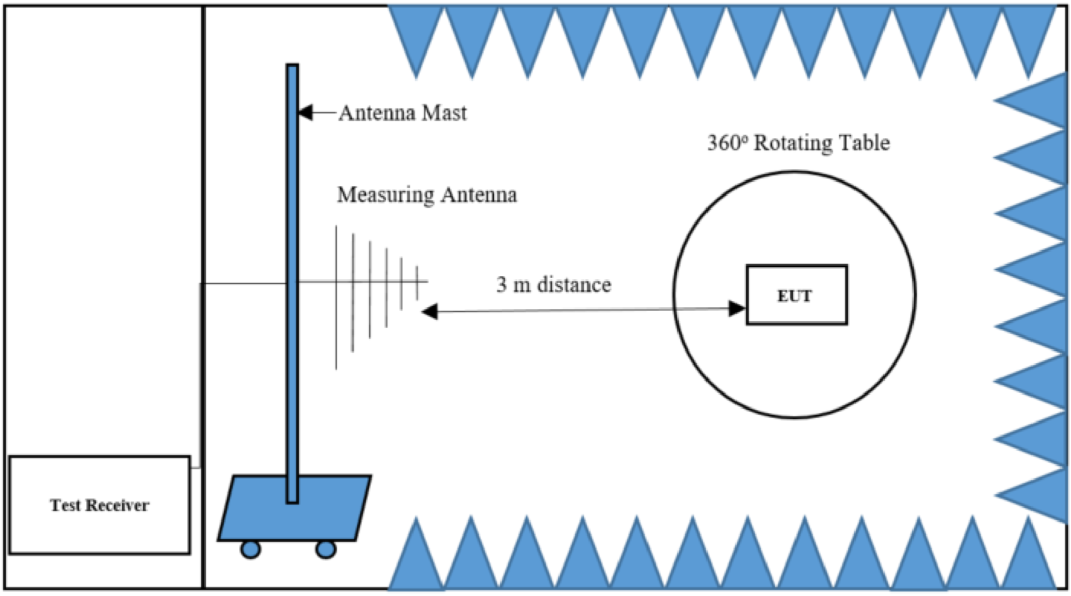
Radiated measurements above 1 GHz is made by placing loose-laid RF absorber material on the ground plane. Additionally, radiated emission measurements above 1 GHz are made using calibrated linearly polarized antennas, which may have a smaller beam width (main lobe) than do the antennas used for frequencies below 1 GHz. The measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal.

Radiated measurements setup (9 kHz – 30 MHz)



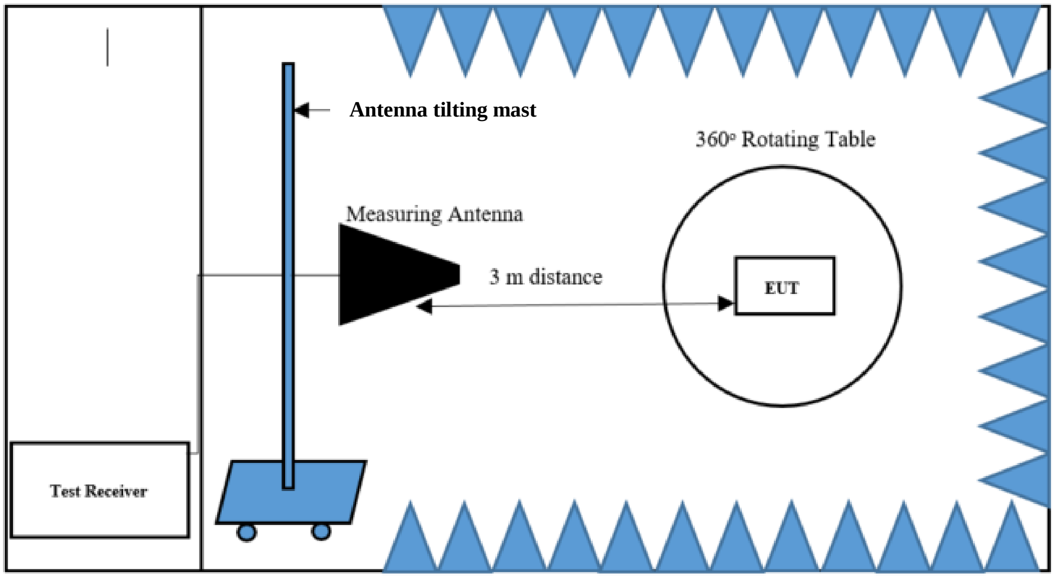
Radiated measurements setup (30 MHz – 1 GHz)

**SEMI ANECHOIC CHAMBER (SAC)**




Radiated measurements setup above 1 GHz

**SEMI ANECHOIC CHAMBER (SAC)**



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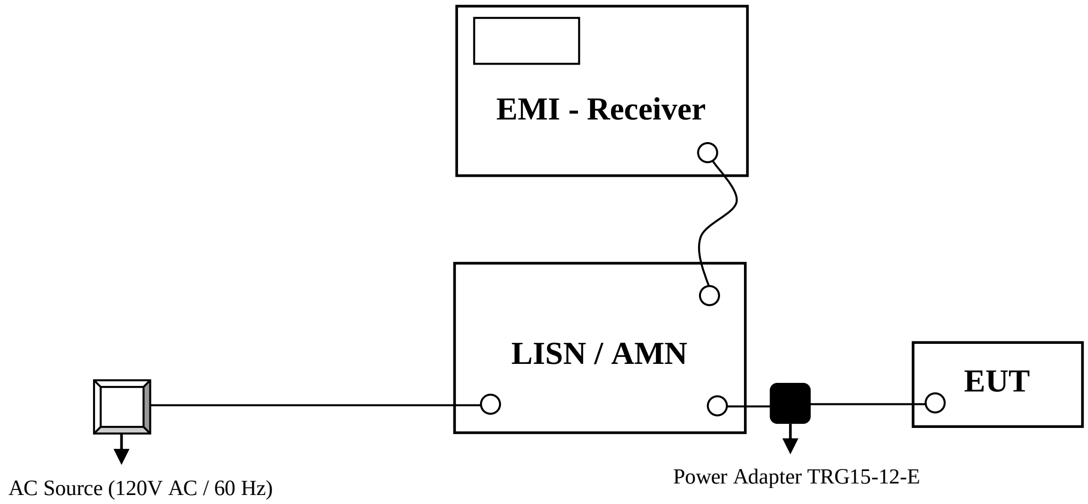
AC Powerline Conducted measurements

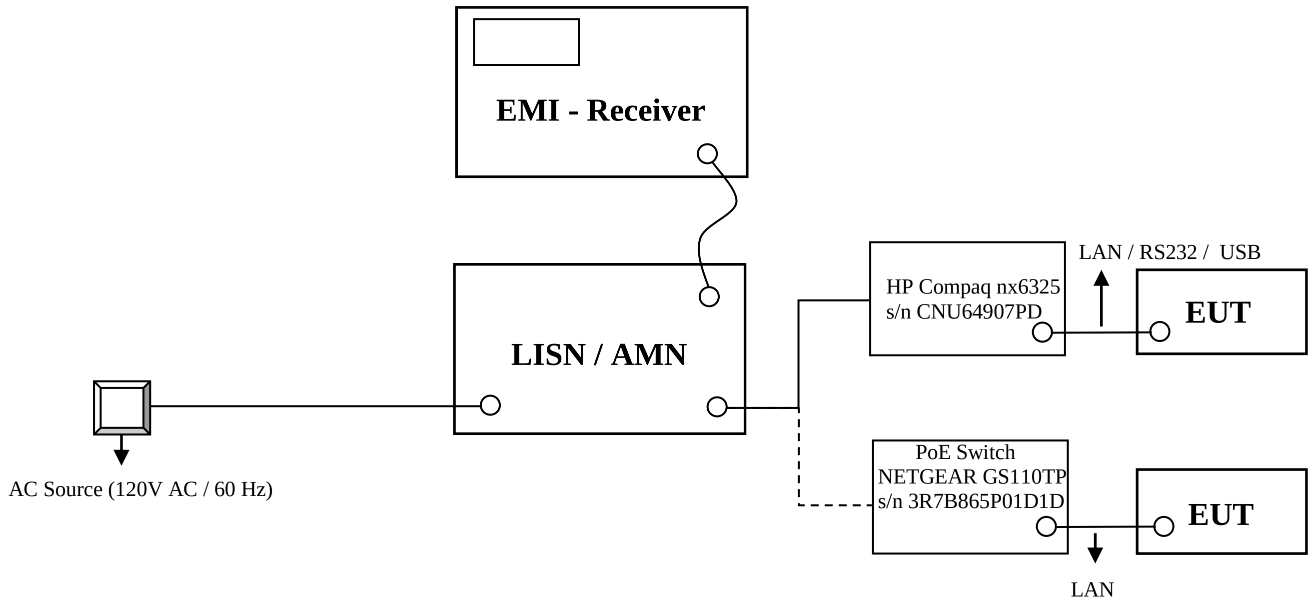
AC powerline conducted measurements were performed on four available RFID reader types (ID ISC.MRU102-A, ID ISC.MRU102-USB, ID ISC.MRU102-PoE and ID ISC.MRU102-PoE-LED) connected via serial, USB, LAN and AC ports to the artificial mains network. The measurements was also performed on the EUT MRU102 without outer casing. It has been tested in four steps:

1. Test laptop with inactive EUT
2. Test laptop with active EUT connected via serial and USB ports to the artificial mains network
3. Only with active EUT connected via PoE (LAN-port) to the artificial mains network
4. Test laptop with active EUT (without outer casing) connected via USB and serial ports to the artificial mains network

## AC Port




## RS232 / LAN / USB Port



## 8.1 Antenna requirement

### 8.1.1 Regulation

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

### 8.1.2 Result

| Antenna Type | Antenna description | Frequency | Gain |
|---|---|---|---|
| **Integrated** | Integrated internal circular polarized antenna | **902.0 – 928.0 MHz** | **-7.0 dBic** |
| **ID ISC.ANT.U170/170** | External UHF RFID circular polarized antenna | **902.0 – 928.0 MHz** | **4.0 dBic** |
| **ID ISC.ANT.U270/270** | External UHF RFID circular polarized antenna | **902.0 – 928.0 MHz** | **9.0 dBic** |
| **ID ISC.ANT.U600/270** | External UHF RFID circular polarized antenna | **902.0 – 928.0 MHz** | **11.0 dBic** |
| **ID ISC.ANT.U290/290** | External UHF RFID circular polarized antenna | **902.0 – 928.0 MHz** | **9.0 dBic** |
| **ID ISC.ANT.U580/290** | External UHF RFID circular polarized antenna | **902.0 – 928.0 MHz** | **11.0 dBic** |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no .: 2 |

## 8.2 Conducted limits

### 8.2.1 Regulation

§15.207 (a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is 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 the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

| Conducted Limits | | |
|---|---|---|
| **Frequency of Emission** | **Quasi-Peak (QP)** | **Average (AV)** |
| **MHz** | **dBµV** | **dBµV** |
| 0.15 - 0.5 | 66 to 56* | 56 to 46* |
| 0.5 - 5 | 56 | 46 |
| 5 -30 | 60 | 50 |
| *Decreases with the logarithm of the frequency | | |

(b) The limit shown in paragraph (a) of this section shall not apply to carrier current systems operating as intentional radiators on frequencies below 30 MHz. In lieu thereof, these carrier current systems shall be subject to the following standards:

1) For carrier current system containing their fundamental emission within the frequency band 535–1705 kHz and intended to be received using a standard AM broadcast receiver: no limit on conducted emissions.

(2) For all other carrier current systems: 1000 µV within the frequency band 535–1705 kHz, as measured using a 50 µH/50 ohms LISN.

(3) Carrier current systems operating below 30 MHz are also subject to the radiated emission limits in §15.205, §15.209, §15.221, §15.223, or §15.227, as appropriate.

(c) 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.

### 8.2.2 Test procedures

The EUT and the additional equipment (if required) are connected to the main power through a line impedance stabilization network (LISN). The LISN must be appropriate to ANSI C63.4-2014 Section 7.
Additional equipment must also be connected to a second LISN with the same specifications described in the above section (if required).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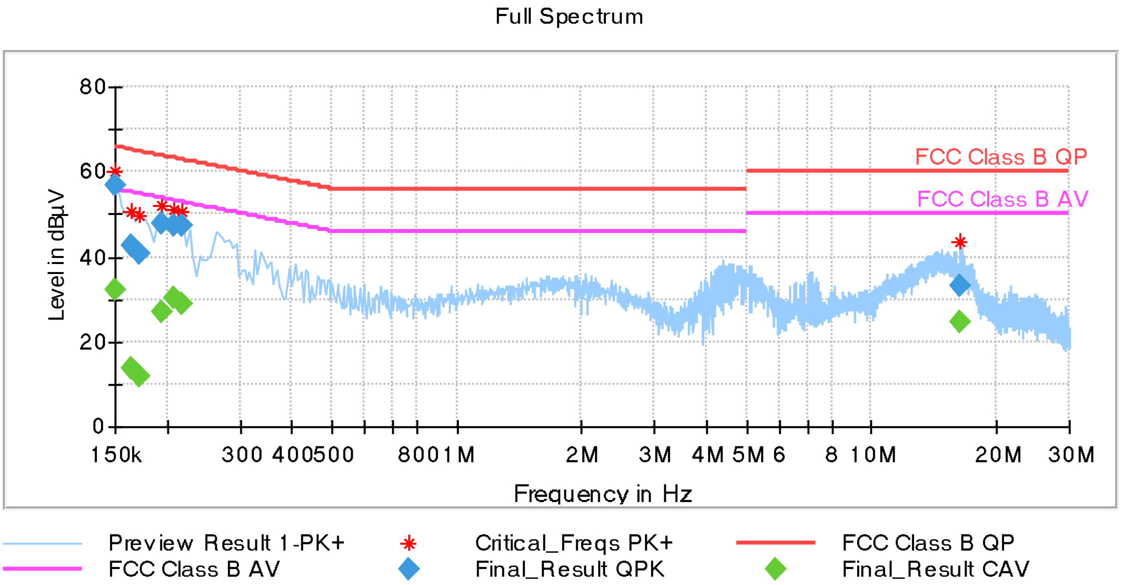
### 8.2.3 Result

– **<u>Test laptop with inactive EUT (ID ISC.MRMU102-A):</u>**




| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.150000 | 56.73 | --- | 66.00 | 9.27 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.150000 | --- | 32.41 | 56.00 | 23.59 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.163500 | --- | 13.64 | 55.28 | 41.64 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.163500 | 42.68 | --- | 65.28 | 22.60 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.172500 | --- | 11.80 | 54.84 | 43.04 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.172500 | 40.75 | --- | 64.84 | 24.09 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.195000 | 47.89 | --- | 63.82 | 15.93 | 1000.0 | 9.000 | L1 | GND | 20.1 |
| 0.195000 | --- | 26.99 | 53.82 | 26.83 | 1000.0 | 9.000 | L1 | GND | 20.1 |
| 0.208500 | --- | 30.11 | 53.27 | 23.15 | 1000.0 | 9.000 | L1 | GND | 20.1 |
| 0.208500 | 47.44 | --- | 63.27 | 15.83 | 1000.0 | 9.000 | L1 | GND | 20.1 |
| 0.217500 | 47.25 | --- | 62.91 | 15.66 | 1000.0 | 9.000 | N | GND | 20.1 |
| 0.217500 | --- | 28.74 | 52.91 | 24.17 | 1000.0 | 9.000 | N | GND | 20.1 |
| 16.422000 | 32.99 | --- | 60.00 | 27.01 | 1000.0 | 9.000 | L1 | GND | 21.0 |
| 16.422000 | --- | 24.59 | 50.00 | 25.41 | 1000.0 | 9.000 | L1 | GND | 21.0 |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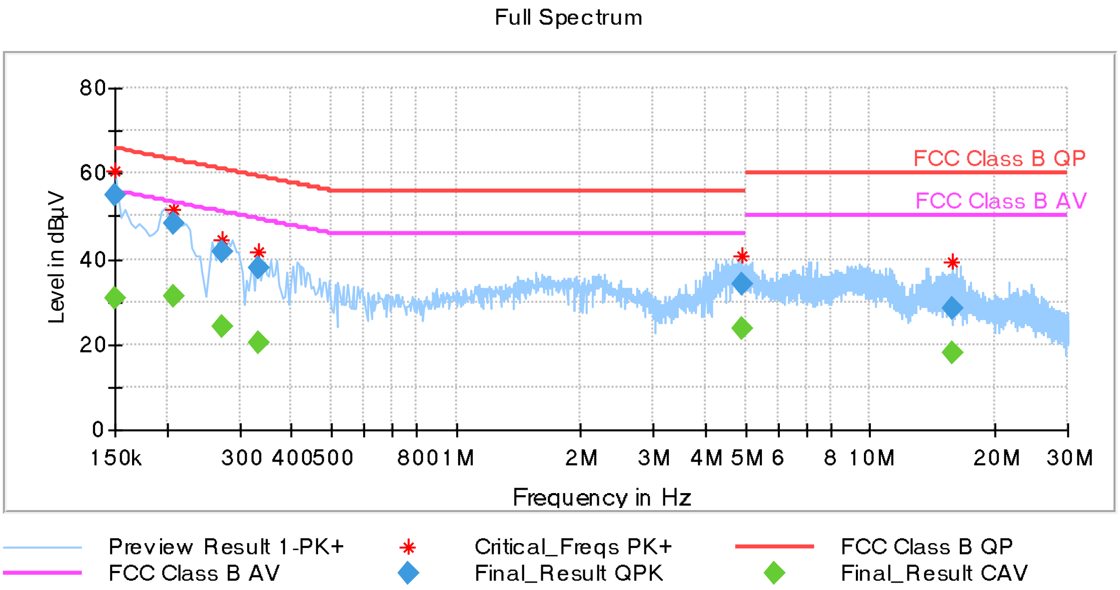
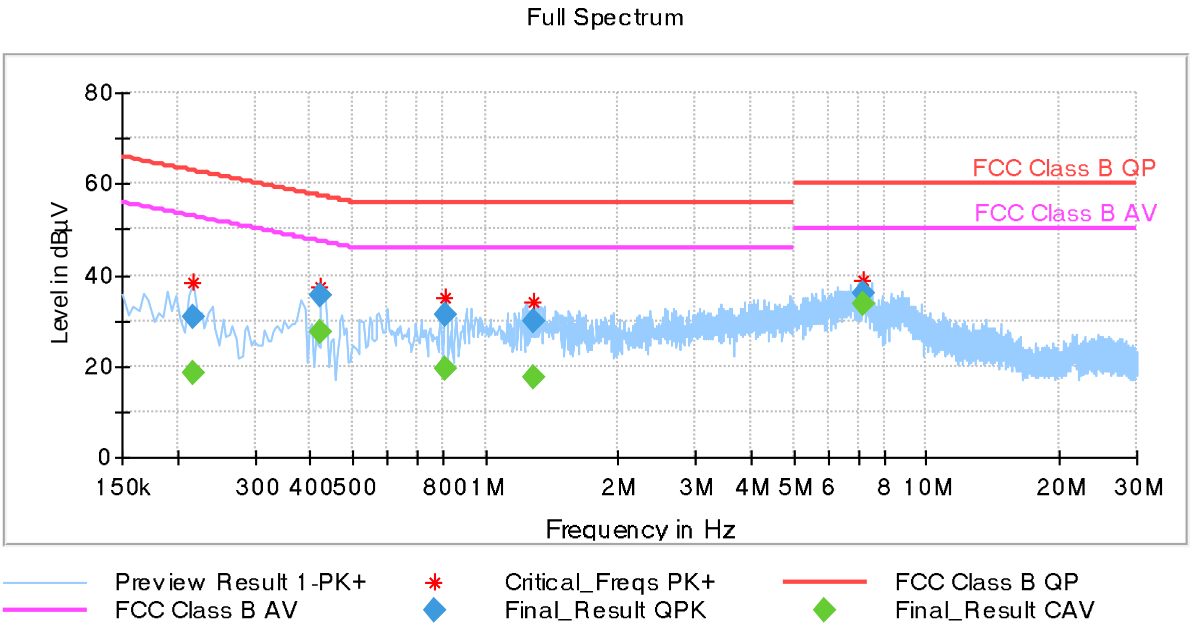
– **Test laptop with active EUT (ID ISC.MRU102-A) - RS232 port:**



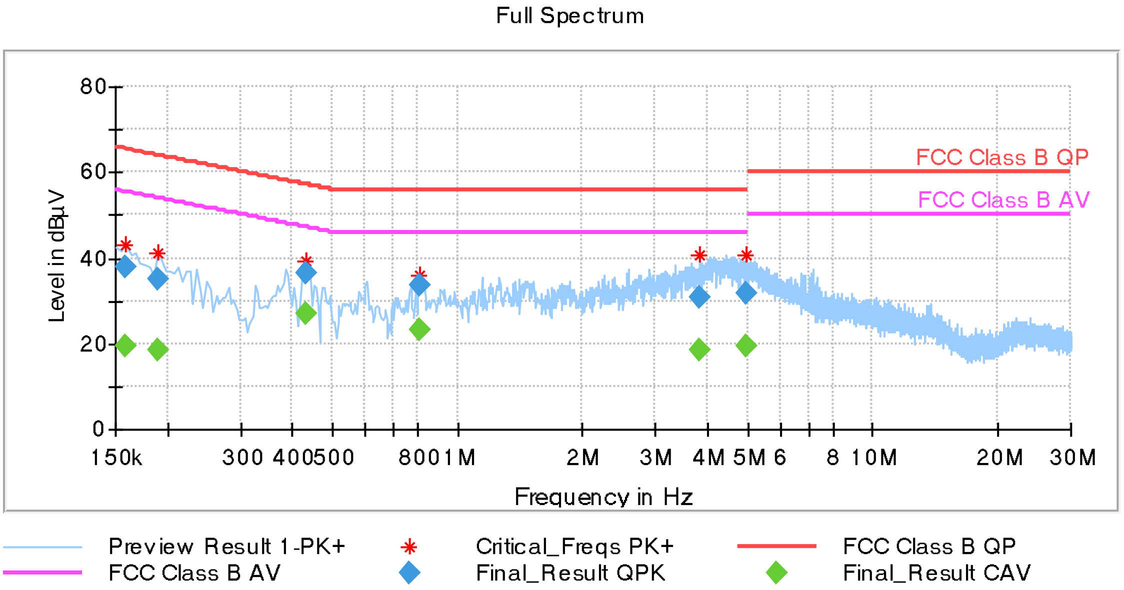

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.150 | 55.14 | --- | 66.00 | 10.86 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.150 | --- | 30.96 | 56.00 | 25.04 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.2085 | 48.19 | --- | 63.27 | 15.07 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.2085 | --- | 31.12 | 53.27 | 22.14 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.2715 | 41.76 | --- | 61.07 | 19.31 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.2715 | --- | 24.04 | 51.07 | 27.03 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.3345 | 37.96 | --- | 59.34 | 21.38 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.3345 | --- | 20.54 | 49.34 | 28.80 | 1000.0 | 9.0 | N | GND | 20.3 |
| 4.9155 | --- | 23.80 | 46.00 | 22.20 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 4.9155 | 34.02 | --- | 56.00 | 21.98 | 1000.0 | 9.0 | L1 | GND | 21.0 |
| 15.7875 | --- | 17.87 | 50.00 | 32.13 | 1000.0 | 9.0 | L1 | GND | 21.0 |
| 15.7875 | 28.19 | --- | 60.00 | 31.81 | 1000.0 | 9.0 | L1 | GND | 20.1 |

- **Test with ext. power adapter (TRG1512-E) with active EUT (ID ISC.MRU102-A) - AC port:**



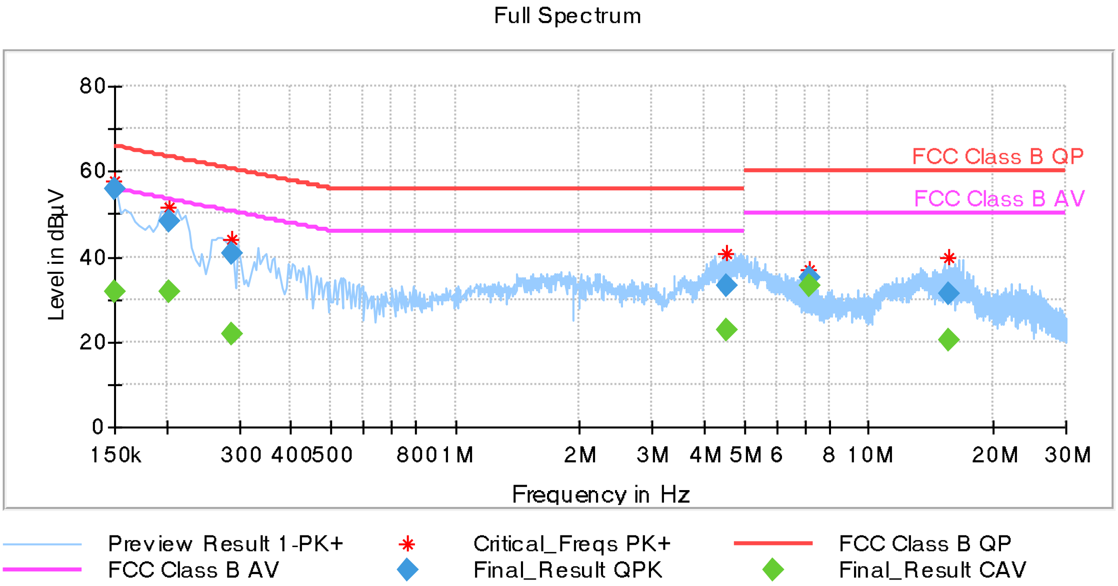

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.217500 | --- | 18.37 | 52.91 | 34.54 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.217500 | 30.80 | --- | 62.91 | 32.11 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.424500 | --- | 27.24 | 47.36 | 20.12 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.424500 | 35.52 | --- | 57.36 | 21.83 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.811500 | --- | 19.64 | 46.00 | 26.36 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.811500 | 31.38 | --- | 56.00 | 24.62 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 1.288500 | 29.77 | --- | 56.00 | 26.23 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 1.288500 | --- | 17.72 | 46.00 | 28.28 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 7.215000 | 35.90 | --- | 60.00 | 24.10 | 1000.0 | 9.0 | L1 | GND | 20.4 |
| 7.215000 | --- | 33.39 | 50.00 | 16.61 | 1000.0 | 9.0 | L1 | GND | 20.4 |

- **Test laptop with active EUT (MRU102-USB) - AC port:**



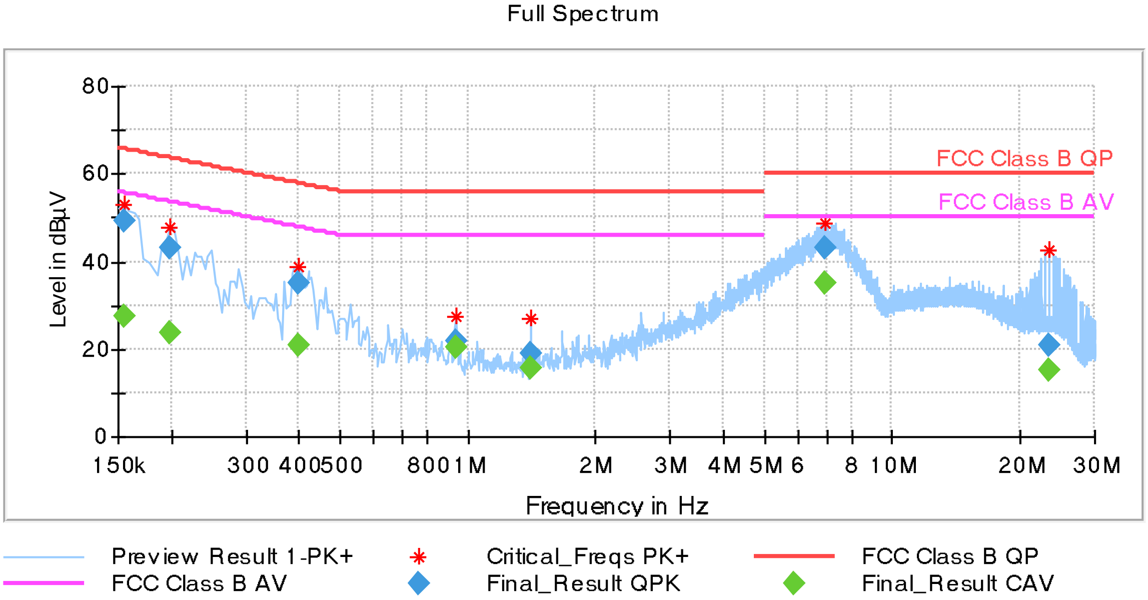

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.159000 | 38.01 | --- | 65.52 | 27.51 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.159000 | --- | 19.47 | 55.52 | 36.05 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.190500 | 35.07 | --- | 64.02 | 28.95 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.190500 | --- | 18.62 | 54.02 | 35.39 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.433500 | 36.54 | --- | 57.19 | 20.65 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.433500 | --- | 26.91 | 47.19 | 20.28 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.811500 | 33.41 | --- | 56.00 | 22.59 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.811500 | --- | 23.16 | 46.00 | 22.84 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 3.817500 | --- | 18.59 | 46.00 | 27.41 | 1000.0 | 9.0 | N | GND | 20.2 |
| 3.817500 | 30.66 | --- | 56.00 | 25.34 | 1000.0 | 9.0 | N | GND | 20.2 |
| 4.983000 | --- | 19.55 | 46.00 | 26.45 | 1000.0 | 9.0 | N | GND | 20.2 |
| 4.983000 | 31.83 | --- | 56.00 | 24.17 | 1000.0 | 9.0 | N | GND | 20.2 |

– **Test laptop with active EUT (MRU102-USB) - USB port:**



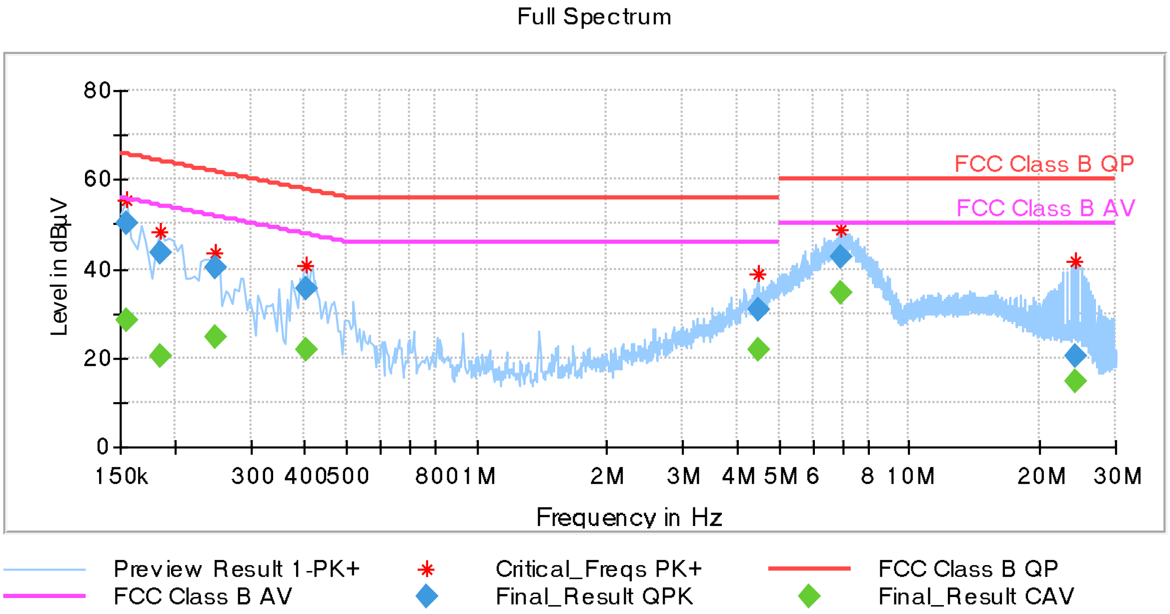

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.150000 | --- | 31.86 | 56.00 | 24.14 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.150000 | 55.91 | --- | 66.00 | 10.09 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.204000 | 48.47 | --- | 63.45 | 14.97 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.204000 | --- | 31.55 | 53.45 | 21.90 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.289500 | 40.89 | --- | 60.54 | 19.65 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.289500 | --- | 21.99 | 50.54 | 28.55 | 1000.0 | 9.0 | N | GND | 20.1 |
| 4.510500 | 32.92 | --- | 56.00 | 23.08 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 4.510500 | --- | 22.81 | 46.00 | 23.19 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 7.210500 | --- | 32.93 | 50.00 | 17.07 | 1000.0 | 9.0 | N | GND | 20.4 |
| 7.210500 | 34.90 | --- | 60.00 | 25.10 | 1000.0 | 9.0 | N | GND | 20.4 |
| 15.612000 | 31.30 | --- | 60.00 | 28.70 | 1000.0 | 9.0 | L1 | GND | 21.0 |
| 15.612000 | --- | 20.48 | 50.00 | 29.52 | 1000.0 | 9.0 | L1 | GND | 21.0 |

- **With active EUT (MRU102-PoE) - LAN port:**



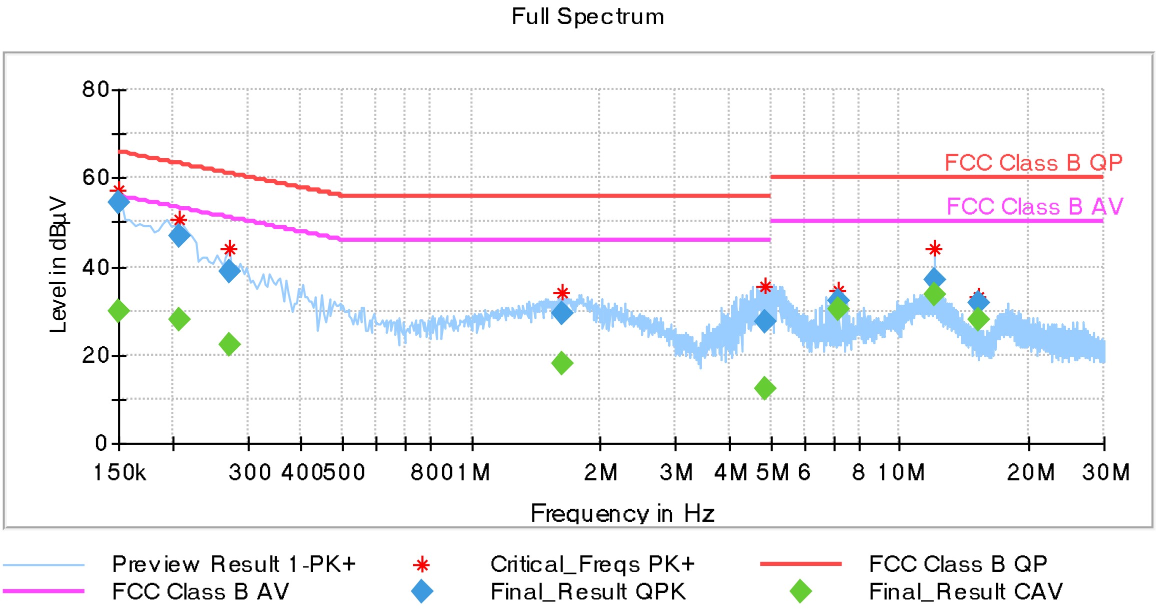

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.154500 | --- | 27.26 | 55.75 | 28.49 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.154500 | 49.37 | --- | 65.75 | 16.39 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.199500 | --- | 23.82 | 53.63 | 29.81 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.199500 | 43.08 | --- | 63.63 | 20.56 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.397500 | --- | 20.95 | 47.91 | 26.96 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.397500 | 34.80 | --- | 57.91 | 23.10 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.937500 | 21.73 | --- | 56.00 | 34.27 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.937500 | --- | 20.26 | 46.00 | 25.74 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 1.405500 | 18.70 | --- | 56.00 | 37.30 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 1.405500 | --- | 15.60 | 46.00 | 30.40 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 6.981000 | --- | 35.24 | 50.00 | 14.76 | 1000.0 | 9.0 | N | GND | 20.4 |
| 6.981000 | 43.15 | --- | 60.00 | 16.85 | 1000.0 | 9.0 | N | GND | 20.4 |
| 23.442000 | --- | 14.95 | 50.00 | 35.05 | 1000.0 | 9.0 | N | GND | 21.3 |
| 23.442000 | 20.66 | --- | 60.00 | 39.34 | 1000.0 | 9.0 | N | GND | 21.3 |

– **With active EUT (MRU102-PoE-LED) - LAN port:**



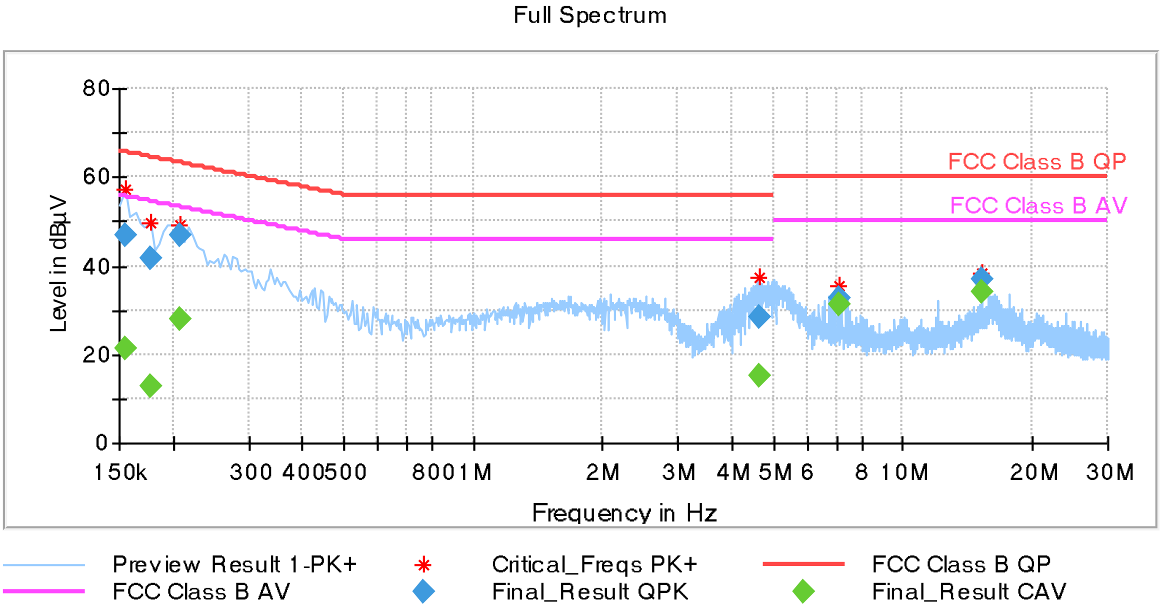

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.154500 | --- | 28.31 | 55.75 | 27.44 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.154500 | 50.13 | --- | 65.75 | 15.63 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.186000 | --- | 20.47 | 54.21 | 33.75 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.186000 | 43.70 | --- | 64.21 | 20.51 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.249000 | 40.19 | --- | 61.79 | 21.60 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.249000 | --- | 24.85 | 51.79 | 26.94 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.402000 | 35.55 | --- | 57.81 | 22.26 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.402000 | --- | 21.56 | 47.81 | 26.25 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 4.461000 | 30.77 | --- | 56.00 | 25.23 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 4.461000 | --- | 21.58 | 46.00 | 24.42 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 6.967500 | 42.73 | --- | 60.00 | 17.27 | 1000.0 | 9.0 | N | GND | 20.4 |
| 6.967500 | --- | 34.78 | 50.00 | 15.22 | 1000.0 | 9.0 | N | GND | 20.4 |
| 24.121500 | 20.51 | --- | 60.00 | 39.49 | 1000.0 | 9.0 | N | GND | 21.3 |
| 24.121500 | --- | 14.60 | 50.00 | 35.40 | 1000.0 | 9.0 | N | GND | 21.3 |

– **Test laptop with active EUT (MRMU102-without outer casing) - USB port:**




| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.150000 | 54.31 | --- | 66.00 | 11.69 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.150000 | --- | 30.03 | 56.00 | 25.97 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.208500 | 47.00 | --- | 63.27 | 16.27 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.208500 | --- | 28.06 | 53.27 | 25.20 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.271500 | --- | 22.25 | 51.07 | 28.82 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.271500 | 38.93 | --- | 61.07 | 22.15 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 1.626000 | 29.46 | --- | 56.00 | 26.54 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 1.626000 | --- | 18.02 | 46.00 | 27.98 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 4.866000 | --- | 12.49 | 46.00 | 33.51 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 4.866000 | 27.63 | --- | 56.00 | 28.37 | 1000.0 | 9.0 | L1 | GND | 20.3 |
| 7.224000 | 32.15 | --- | 60.00 | 27.85 | 1000.0 | 9.0 | N | GND | 20.4 |
| 7.224000 | --- | 30.10 | 50.00 | 19.90 | 1000.0 | 9.0 | N | GND | 20.4 |
| 12.003000 | 36.78 | --- | 60.00 | 23.22 | 1000.0 | 9.0 | L1 | GND | 20.8 |
| 12.003000 | --- | 33.72 | 50.00 | 16.28 | 1000.0 | 9.0 | L1 | GND | 20.8 |
| 15.342000 | 31.76 | --- | 60.00 | 28.24 | 1000.0 | 9.0 | L1 | GND | 21.0 |
| 15.342000 | --- | 27.80 | 50.00 | 22.20 | 1000.0 | 9.0 | L1 | GND | 21.0 |

– **Test laptop with active EUT (MRMU102-without outer casing) – RS232 port:**




| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | PE | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|---|
| 0.154500 | 46.67 | --- | 65.75 | 19.08 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.154500 | --- | 21.37 | 55.75 | 34.38 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.177000 | --- | 12.66 | 54.63 | 41.97 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.177000 | 41.83 | --- | 64.63 | 22.79 | 1000.0 | 9.0 | N | GND | 20.1 |
| 0.208500 | 46.96 | --- | 63.27 | 16.31 | 1000.0 | 9.0 | L1 | GND | 20.1 |
| 0.208500 | --- | 27.90 | 53.27 | 25.36 | 1000.0 | 9.0 | L1 | GND | 20.2 |
| 4.641000 | --- | 14.96 | 46.00 | 31.04 | 1000.0 | 9.0 | N | GND | 20.2 |
| 4.641000 | 28.31 | --- | 56.00 | 27.69 | 1000.0 | 9.0 | N | GND | 20.4 |
| 7.116000 | --- | 31.39 | 50.00 | 18.61 | 1000.0 | 9.0 | N | GND | 20.4 |
| 7.116000 | 32.71 | --- | 60.00 | 27.29 | 1000.0 | 9.0 | N | GND | 21.0 |
| 15.342000 | --- | 34.30 | 50.00 | 15.70 | 1000.0 | 9.0 | N | GND | 21.0 |
| 15.342000 | 37.09 | --- | 60.00 | 22.91 | 1000.0 | 9.0 | N | GND | 20.1 |

| | |
|---|---|
| Test cables used | KISN2 |
| Test equipment used | 272, 551, 665 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6 |

## 8.3 Restricted bands of operation

### 8.3.1 Regulation

§15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

| Restricted bands of operation | | | |
|---|---|---|---|
| **Frequency Band MHz** | **Frequency Band MHz** | **Frequency Band MHz** | **Frequency Band GHz** |
| 0.090-0.110 | 16.42-16.423 | 399.9-410 | 4.5-5.15 |
| [1]0.495-0.505 | 16.69475-16.69525 | 608-614 | 5.35-5.46 |
| 2.1735-2.1905 | 16.80425-16.80475 | 960-1240 | 7.25-7.75 |
| 4.125-4.128 | 25.5-25.67 | 1300-1427 | 8.025-8.5 |
| 4.17725-4.17775 | 37.5-38.25 | 1435-1626.5 | 9.0-9.2 |
| 4.20725-4.20775 | 73-74.6 | 1645.5-1646.5 | 9.3-9.5 |
| 6.215-6.218 | 74.8-75.2 | 1660-1710 | 10.6-12.7 |
| 6.26775-6.26825 | 108-121.94 | 1718.8-1722.2 | 13.25-13.4 |
| 6.31175-6.31225 | 123-138 | 2200-2300 | 14.47-14.5 |
| 8.291-8.294 | 149.9-150.05 | 2310-2390 | 15.35-16.2 |
| 8.362-8.366 | 156.52475-156.52525 | 2483.5-2500 | 17.7-21.4 |
| 8.37625-8.38675 | 156.7-156.9 | 2690-2900 | 22.01-23.12 |
| 8.41425-8.41475 | 162.0125-167.17 | 3260-3267 | 23.6-24.0 |
| 12.29-12.293 | 167.72-173.2 | 3332-3339 | 31.2-31.8 |
| 12.51975-12.52025 | 240-285 | 3345.8-3358 | 36.43-36.5 |
| 12.57675-12.57725 | 322-335.4 | 3600-4400 | ([2]) |
| 13.36-13.41 | --- | --- | --- |
| **[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.<br>[2] Above 38.6** | | | |

(b) Except as provided in paragraphs (d) and (e) of this section, the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

(c) Except as provided in paragraphs (d) and (e) of this section, regardless of the field strength limits specified elsewhere in this subpart, the provisions of this section apply to emissions from any intentional radiator.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(d) The following devices are exempt from the requirements of this section:

(1) Swept frequency field disturbance sensors operating between 1.705 and 37 MHz provided their emissions only sweep through the bands listed in paragraph (a) of this section, the sweep is never stopped with the fundamental emission within the bands listed in paragraph (a) of this section, and the fundamental emission is outside of the bands listed in paragraph (a) of this section more than 99% of the time the device is actively transmitting, without compensation for duty cycle.

(2) Transmitters used to detect buried electronic markers at 101.4 kHz which are employed by telephone companies.

(3) Cable locating equipment operated pursuant to §15.213.

(4) Any equipment operated under the provisions of §15.253, 15.255, and 15.256 in the frequency band 75-85 GHz, or §15.257 of this part.

(5) Biomedical telemetry devices operating under the provisions of §15.242 of this part are not subject to the restricted band 608-614 MHz but are subject to compliance within the other restricted bands.

(6) Transmitters operating under the provisions of subparts D or F of this part.

(7) Devices operated pursuant to §15.225 are exempt from complying with this section for the 13.36-13.41 MHz band only.

(8) Devices operated in the 24.075-24.175 GHz band under §15.245 are exempt from complying with the requirements of this section for the 48.15-48.35 GHz and 72.225-72.525 GHz bands only, and shall not exceed the limits specified in §15.245(b).

(9) Devices operated in the 24.0-24.25 GHz band under §15.249 are exempt from complying with the requirements of this section for the 48.0-48.5 GHz and 72.0-72.75 GHz bands only, and shall not exceed the limits specified in §15.249(a).

(10) White space devices operating under subpart H of this part are exempt from complying with the requirements of this section for the 608-614 MHz band.

(e) Harmonic emissions appearing in the restricted bands above 17.7 GHz from field disturbance sensors operating under the provisions of §15.245 shall not exceed the limits specified in §15.245(b).

### 8.3.2 Result

| | |
|---|---|
| Test Cables used | K60, K101, K119 |
| Test equipment used | 23, 406, 445a, 660, 665, 451, 452 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes**** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |

**All emissions that falls under the restricted bands of operations are included in clause 8.4 and are maked blue.

## 8.4 Radiated emission limits, general requirements

### 8.4.1 Regulation

(a) Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

| **Intentional radiator- radiated emission limits** | | |
|---|---|---|
| **Frequency** | **Field Strength** | **Measurement distance** |
| **MHz** | **µV / m** | **m** |
| 0.009-0.490 | 2400/F(kHz) | 300 |
| 0.490-1.705 | 24000/F(kHz) | 30 |
| 1.705-30.0 | 30 | 30 |
| 30-88 | 100** | 3 |
| 88-216 | 150** | 3 |
| 216-960 | 200** | 3 |
| above 960 | 500 | 3 |
| Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permItted under other sections of this part, e.g., §§15.231 and 15.241. | | |

(b) In the emission table above, the tighter limit applies at the band edges.

(c) The level of any unwanted emissions from an intentional radiator operating under these general provisions shall not exceed the level of the fundamental emission. For intentional radiators which operate under the provisions of other sections within this part and which are required to reduce their unwanted emissions to the limits specified in this table, the limits in this table are based on the frequency of the unwanted emission and not the fundamental frequency. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.

(d) The emission limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.

(e) The provisions in §§15.31, 15.33, and 15.35 for measuring emissions at distances other than the distances specified in the above table, determining the frequency range over which radiated emissions are to be measured, and limiting peak emissions apply to all devices operated under this part.

(f) In accordance with §15.33(a), in some cases the emissions from an intentional radiator must be measured to beyond the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator because of the incorporation of a digital device. If measurements above the tenth harmonic are so required, the radiated emissions above the tenth harmonic shall comply with the general radiated emission limits applicable to the incorporated digital device, as shown in §15.109 and as based on the frequency of the emission being measured, or, except for emissions contained in the restricted frequency bands shown in §15.205, the limit on spurious emissions specified for the intentional radiator, whichever is the higher limit. Emissions which must be measured above the tenth harmonic of the highest fundamental frequency designed to be emitted by the intentional radiator and which fall within the restricted bands shall comply with the general radiated emission limits in §15.109 that are applicable to the incorporated digital device.

(g) Perimeter protection systems may operate in the 54-72 MHz and 76-88 MHz bands under the provisions of this section. The use of such perimeter protection systems is limited to industrial, business and commercial applications.

### 8.4.2 Test procedure

The EUT and this peripheral (when additional equipment exists) are placed on a turn table which is 0.8 m above the ground. The turn table would be allowed to rotate 360° to determine the position of the maximum emission level. The test distance between the EUT and the receiving antenna are 3m. To find the maximum emission, the polarization of the receiving antenna is changed in horizontal and vertical polarization; the position of the EUT was changed in different orthogonal determinations.

ANSI C63.4-2014 Section 8 "Radiated Emissions Testing"

Measurement procedures for electric field radiated emissions from 9kHz - 1 GHz & 1 GHz - 40 GHz are covered in Clause 8 of ANSI C63.4-2014. The ANSI C63.4-2014 measurement procedure consists of both an exploratory test and a final measurement. The exploratory test is critical to determine the frequency of all significant emissions. For each mode of operation required to be tested, the frequency spectrum is monitored. Variations in antenna height, antenna orientation, antenna polarization, EUT azimuth, and cable or wire placement is explored to produce the emission that has the highest amplitude relative to the limit.

The final measurements are made based on the findings in the exploratory testing. When making exploratory and final measurements it is necessary to maximize the measured radiated emission. Sub clause 8.3.2 of ANSI C63.4-2014 states that the measurement is to be made "while keeping the antenna in the 'cone of radiation' from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response." We consider the "cone of radiation" to be the 3 dB beam width of the measurement antenna.

While the "bore-sighting" technique is not explicitly mentioned in ANSI C63.4-2014, it is a useful technique for measurements using a directional antenna, such as a double-ridged waveguide antenna. Several precautions must be observed, including: knowledge of the beam width of the antenna and the resulting illumination area relative to the size of the EUT, estimation for source of the emission and general location within larger EUTs, measuring system sensitivity, etc.

ANSI C63.4-2014 requires that the measurement antenna is kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. That means that if the directional radiation pattern of the EUT results in a maximum emission at an upwards angle from the EUT, when a directional antenna is used to make the measurement it will be necessary for it to be pointed towards the source of the emission within the EUT. This can be done by either pointing the antenna at an angle towards the source of the emission, or by rotating the EUT, in both height and polarization, to maximize the measured emission. The emission must be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured.

| **Radiated emissions test characteristics** | |
|---|---|
| Test distance | 3 m* |
| Test instrumentation resolution bandwidth | 9 kHz (Below 30 MHz) |
| | 120 kHz (30 MHz - 1,000 MHz) |
| | 1 MHz (Above 1000 MHz) |
| Receive antenna scan height | 1 m - 4 m |
| Receive antenna polarization | Vertical/horizontal |

* According to Section 15.31 (f) (1): At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the

measurement equipment. Measurements shall not be performed at a distance greater than 30 meters unless it can be further demonstrated that measurements at a distance of 30 meters or less are impractical. 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 (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

### 8.4.3 Calculation of the field strength

The field strength is calculated by the following calculation:

Corrected Level = Receiver Level + Correction Factor (without the use of a pre-amplifier)

Corrected Level = Receiver Level + Correction Factor – Pre-amplifier (with the use of a pre-amplifier)

Receiver Level : Receiver reading without correction factors
Correction Factor : Antenna factor + cable loss

For example:
The receiver reading is 32.7 dBµV. The antenna factor for the measured frequency is +2.5 dB (1/m) and the cable factor for the measured frequency is 0.71 dB, giving a field strength of 35.91dBµV/m.
The 35.91 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

Level in µV/m = Common Antilogarithm (35.91/20) = 62.44

For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f) (1) the field strength is calculated by adding additionally an extrapolation factor of 20 dB/decade (inverse linear distance for field strength measurements).


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### 8.4.4 Result

**<u>Radiated Emissions from EUT (ID ISC.MRMU102-A)</u>**

*Lower Channel @ 902.75 MHz*

| **Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Pol V / H** | **Azimuth (deg)** |
| 0.009 - 30 | ** | ** | --- | --- | --- | --- | --- |
| **No emissions detected | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Middle Channel @ 914.75 MHz*

| **Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Pol V / H** | **Azimuth (deg)** |
| 0.009 - 30 | ** | ** | --- | --- | --- | --- | --- |
| **No emissions detected | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Higher Channel @ 927.25 MHz*

| **Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Pol V / H** | **Azimuth (deg)** |
| 0.009 - 30 | ** | ** | --- | --- | --- | --- | --- |
| **No emissions detected | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

| | |
|---|---|
| Test cables used | K60, K101, K119 |
| Test equipment used | 23, 665, 660 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.*~~ |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |

*Lower Channel @ 902.75 MHz*

| Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **240.01** | **18.94** | 46.0 | **27.1** | 120.0 | 104.0 | H | 128.0 |
| **360.00** | **25.82** | 46.0 | **20.2** | 120.0 | 100.0 | H | 333.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Blue marked: restricted bands*

*Middle Channel @ 914.75 MHz*

| Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **30 - 1000** | ** | --- | --- | --- | --- | --- | --- |
| ****No emissions detected** | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Blue marked: restricted bands*

*Higher Channel @ 927.25 MHz*

| Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **30 - 1000** | ** | --- | --- | --- | --- | --- | --- |
| ****No emissions detected** | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Blue marked: restricted bands*

| | |
|---|---|
| Test cables used | K60, K101, K119 |
| Test equipment used | 406, 660, 665 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.*~~ |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |

*Lower Channel @ 902.75 MHz*

| Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **MaxPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **1805.375*** | **55.51** | --- | --- | --- | 1000.0 | 116.0 | H | 224.0 |
| **1805.375*** | --- | **63.05** | --- | --- | 1000.0 | 116.0 | H | 224.0 |
| **2708.125** | **53.61** | --- | 54.00 | **0.39** | 1000.0 | 164.0 | H | 204.0 |
| **2708.125** | --- | **61.93** | 74.00 | **12.07** | 1000.0 | 164.0 | H | 204.0 |
| **3610.875** | --- | **53.16** | 74.00 | **20.84** | 1000.0 | 247.0 | V | 57.0 |
| **3610.875** | **43.93** | --- | 54.00 | **10.07** | 1000.0 | 247.0 | V | 57.0 |
| **4513.625** | **47.37** | --- | 54.00 | **6.63** | 1000.0 | 165.0 | H | 113.0 |
| **4513.625** | --- | **56.20** | 74.00 | **17.80** | 1000.0 | 165.0 | H | 113.0 |
| **5416.375** | --- | **54.83** | 74.00 | **19.17** | 1000.0 | 104.0 | V | 119.0 |
| **5416.375** | **44.70** | --- | 54.00 | **9.30** | 1000.0 | 104.0 | V | 119.0 |
| **6319.125** | --- | **55.93** | 74.00 | **18.07** | 1000.0 | 199.0 | H | 91.0 |
| **6319.125** | **46.18** | --- | 54.00 | **7.82** | 1000.0 | 199.0 | H | 91.0 |
| **7221.875** | **42.10** | --- | 54.00 | **11.90** | 1000.0 | 190.0 | H | 124.0 |
| **7221.875** | --- | **54.32** | 74.00 | **19.68** | 1000.0 | 190.0 | H | 124.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | | |
| *** This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!** | | | | | | | | |

*Blue marked: restricted bands*

*Middle Channel @ 914.75 MHz*

| Transmitter Spurious Radiation (1 GHz – 10 GHz) , (Section 15.205, 15.209) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **MaxPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **1829.375*** | **56.63** | --- | --- | --- | 1000.0 | 135.0 | H | 149.0 |
| **1829.375*** | --- | **64.34** | --- | --- | 1000.0 | 135.0 | H | 149.0 |
| **2744.125** | **52.17** | --- | 54.00 | **1.83** | 1000.0 | 204.0 | H | 206.0 |
| **2744.125** | --- | **60.33** | 74.00 | **13.67** | 1000.0 | 204.0 | H | 206.0 |
| **3658.875** | --- | **58.97** | 74.00 | **15.03** | 1000.0 | 104.0 | V | 191.0 |
| **3658.875** | **49.98** | --- | 54.00 | **4.02** | 1000.0 | 104.0 | V | 191.0 |
| **4573.625** | --- | **56.45** | 74.00 | **17.55** | 1000.0 | 218.0 | H | 118.0 |
| **4573.625** | **46.22** | --- | 54.00 | **7.78** | 1000.0 | 218.0 | H | 118.0 |
| **5488.375** | **43.95** | --- | 54.00 | **10.05** | 1000.0 | 111.0 | V | 131.0 |
| **5488.375** | --- | **54.60** | 74.00 | **19.40** | 1000.0 | 111.0 | V | 131.0 |
| **6403.125** | --- | **60.28** | 74.00 | **13.72** | 1000.0 | 193.0 | H | 103.0 |
| **6403.125** | **48.87** | --- | 54.00 | **5.13** | 1000.0 | 193.0 | H | 103.0 |
| **7317.875** | **40.98** | --- | 54.00 | **13.02** | 1000.0 | 185.0 | H | 123.0 |
| **7317.875** | --- | **53.19** | 74.00 | **20.81** | 1000.0 | 185.0 | H | 123.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | | |
| *** This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!** | | | | | | | | |

*Blue marked: restricted bands*


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*Higher Channel @ 902.75 MHz*

| **Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209)** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **MaxPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **1854.375*** | **57.00** | --- | --- | --- | 1000.0 | 160.0 | H | 142.0 |
| **1854.375*** | --- | **65.01** | --- | --- | 1000.0 | 160.0 | H | 142.0 |
| **2781.625** | --- | **59.06** | 74.00 | **14.94** | 1000.0 | 100.0 | H | 242.0 |
| **2781.625** | **50.20** | --- | 54.00 | **3.80** | 1000.0 | 100.0 | H | 242.0 |
| **3708.875** | **50.24** | --- | 54.00 | **3.76** | 1000.0 | 100.0 | V | 142.0 |
| **3708.875** | --- | **59.11** | 74.00 | **14.89** | 1000.0 | 100.0 | V | 142.0 |
| **4636.125** | --- | **53.08** | 74.00 | **20.92** | 1000.0 | 200.0 | H | 142.0 |
| **4636.125** | **43.19** | --- | 54.00 | **10.81** | 1000.0 | 200.0 | H | 142.0 |
| **5563.375** | **43.58** | --- | 54.00 | **10.42** | 1000.0 | 130.0 | H | 226.0 |
| **5563.375** | --- | **54.18** | 74.00 | **19.82** | 1000.0 | 130.0 | H | 226.0 |
| **6490.625** | **51.41** | --- | 54.00 | **2.59** | 1000.0 | 208.0 | H | 98.0 |
| **6490.625** | --- | **61.63** | 74.00 | **12.37** | 1000.0 | 208.0 | H | 98.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | | |
| *** This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!** | | | | | | | | |

*Blue marked: restricted bands*

| | |
|---|---|
| Test cables used | K60, K101, K119 |
| Test equipment used | 445a, 660, 665 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |

## Radiated Emissions from EUT (MRU102-PoE-LED)

*Lower Channel @ 902.75 MHz*

| Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Pol V / H** | **Azimuth (deg)** |
| **0.116590** | --- | **37.8** | 106.3 | **68.6** | 0.2 | H | 14.0 |
| **24.971250** | **54.8** | --- | 69.5 | **14.7** | 9.0 | V | 265.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Blue marked: restricted bands*

*Middle Channel @ 914.75 MHz*

| Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Pol V / H** | **Azimuth (deg)** |
| **24.954250** | **53.9** | --- | 69.5 | **15.6** | 9.0 | V | 242.0 |
| ****No emissions detected** | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Blue marked: restricted bands*

*Higher Channel @ 927.25 MHz*

| Transmitter Spurious Radiation below 30 MHz, (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **QuasiPeak (dBµV/m)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Pol V / H** | **Azimuth (deg)** |
| **24.489750** | **54.2** | --- | 69.5 | **15.3** | 9.0 | V | 286.0 |
| ****No emissions detected** | | | | | | | |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |

*Blue marked: restricted bands*

| | |
|---|---|
| Test cables used | K60, K101, K119 |
| Test equipment used | 23, 665, 660 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |



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*Lower Channel @ 902.75 MHz*

| Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **34.52** | **30.5** | 40.0 | **10.5** | 120.0 | 100.0 | V | 159.0 |
| **57.99*** | **40.5** | --- | --- | 120.0 | 100.0 | V | 4.0 |
| **66.25** | **38.2** | 40.0 | **1.8** | 120.0 | 100.0 | V | 180.0 |
| **124.98** | **36.2** | 43.5 | **7.3** | 120.0 | 100.0 | V | 206.0 |
| **225.00** | **39.1** | 46.0 | **5.9** | 120.0 | 100.0 | V | 85.0 |
| **275.01** | **37.6** | 46.0 | **8.4** | 120.0 | 100.0 | V | 298.0 |
| **324.99** | **42.9** | 46.0 | **3.1** | 120.0 | 100.0 | H | 107.0 |
| **399.99** | **36.9** | 46.0 | **9.1** | 120.0 | 100.0 | H | 92.0 |
| **500.01** | **36.6** | 46.0 | **9.4** | 120.0 | 104.0 | V | 79.0 |
| **750.00** | **40.0** | 46.0 | **6.0** | 120.0 | 100.0 | H | 187.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |
| *** This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!** | | | | | | | |

*Blue marked: restricted bands*

*Middle Channel @ 914.75 MHz*

| Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **34.98** | **32.4** | 40.0 | **7.6** | 120.0 | 100.0 | V | 5.0 |
| **57.52*** | **40.5** | --- | --- | 120.0 | 100.0 | V | 25.0 |
| **64.41** | **38.2** | 40.0 | **1.8** | 120.0 | 100.0 | V | -25.0 |
| **124.98** | **27.3** | 43.5 | **16.2** | 120.0 | 104.0 | V | 196.0 |
| **225.00** | **40.5** | 46.0 | **5.5** | 120.0 | 100.0 | V | 105.0 |
| **324.99** | **44.0** | 46.0 | **2.0** | 120.0 | 100.0 | H | 121.0 |
| **399.99** | **36.4** | 46.0 | **9.6** | 120.0 | 100.0 | H | 78.0 |
| **750.00** | **39.9** | 46.0 | **5.1** | 120.0 | 100.0 | H | 187.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |
| *** This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!** | | | | | | | |

*Blue marked: restricted band*

*Higher Channel @ 927.25 MHz*

| **Transmitter Spurious Radiation (30 MHz – 1 GHz), (Section 15.205, 15.209)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **35.45** | **31.8** | 40.0 | **9.2** | 120.0 | 100.0 | V | 239.0 |
| **58.00*** | **40.1** | --- | **---** | 120.0 | 100.0 | V | -25.0 |
| **64.91** | **38.5** | 40.0 | **1.5** | 120.0 | 100.0 | V | -39.0 |
| **124.98** | **33.9** | 43.5 | **9.1** | 120.0 | 100.0 | V | 193.0 |
| **225.00** | **42.5** | 46.0 | **3.5** | 120.0 | 100.0 | V | 109.0 |
| **275.01** | **41.8** | 46.0 | **5.2** | 120.0 | 100.0 | V | 325.0 |
| **425.01** | **34.6** | 46.0 | **11.4** | 120.0 | 100.0 | V | 129.0 |
| **800.01** | **38.7** | 46.0 | **7.3** | 120.0 | 100.0 | H | 187.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | |
| *** This frequency is not listed in the restricted bands of operation (section FCC 15.205), therefore does not require to follow the limits according to section FCC 15.209!** | | | | | | | |

*Blue marked: restricted bands*

*Lower Channel @ 902.75 MHz*

| Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **MaxPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **1805.375** | **50.60** | --- | 54.00 | **3.40** | 1000.0 | 192.0 | H | 204.0 |
| **1805.375** | --- | **63.32** | 74.00 | **10.68** | 1000.0 | 192.0 | H | 204.0 |
| **2019.375** | **34.36** | --- | 54.00 | **19.64** | 1000.0 | 160.0 | H | 12.0 |
| **2019.375** | --- | **47.28** | 74.00 | **26.72** | 1000.0 | 160.0 | H | 12.0 |
| **2708.125** | **46.97** | --- | 54.00 | **7.03** | 1000.0 | 100.0 | V | 161.0 |
| **2708.125** | --- | **59.17** | 74.00 | **14.83** | 1000.0 | 100.0 | V | 161.0 |
| **3610.875** | --- | **56.66** | 74.00 | **17.34** | 1000.0 | 192.0 | H | 258.0 |
| **3610.875** | **43.62** | --- | 54.00 | **10.38** | 1000.0 | 192.0 | H | 258.0 |
| **4513.625** | **39.14** | --- | 54.00 | **14.86** | 1000.0 | 149.0 | H | 209.0 |
| **4513.625** | --- | **52.05** | 74.00 | **21.95** | 1000.0 | 149.0 | H | 209.0 |
| **5416.375** | --- | **52.68** | 74.00 | **21.32** | 1000.0 | 117.0 | V | 232.0 |
| **5416.375** | **39.50** | --- | 54.00 | **14.50** | 1000.0 | 117.0 | V | 232.0 |
| **6319.125** | **41.41** | --- | 54.00 | **12.59** | 1000.0 | 138.0 | H | 236.0 |
| **6319.125** | --- | **54.16** | 74.00 | **19.84** | 1000.0 | 138.0 | H | 236.0 |
| **7222.125** | **38.56** | --- | 54.00 | **15.44** | 1000.0 | 110.0 | H | 91.0 |
| **7222.125** | --- | **51.55** | 74.00 | **22.45** | 1000.0 | 110.0 | H | 91.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | | |

*Blue marked: restricted bands*

*Middle Channel @ 914.75 MHz*

| Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **MaxPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **1829.375** | **49.08** | --- | 54.00 | **4.92** | 1000.0 | 111.0 | H | 206.0 |
| **1829.375** | --- | **61.84** | 74.00 | **12.16** | 1000.0 | 111.0 | H | 206.0 |
| **2019.375** | --- | **47.56** | 74.00 | **26.44** | 1000.0 | 188.0 | H | 5.0 |
| **2019.375** | **33.19** | --- | 54.00 | **20.81** | 1000.0 | 188.0 | H | 5.0 |
| **2744.125** | **45.24** | --- | 54.00 | **8.76** | 1000.0 | 190.0 | V | 168.0 |
| **2744.125** | --- | **57.90** | 74.00 | **16.10** | 1000.0 | 190.0 | V | 168.0 |
| **3658.875** | --- | **58.87** | 74.00 | **15.13** | 1000.0 | 116.0 | V | 176.0 |
| **3658.875** | **45.95** | --- | 54.00 | **8.05** | 1000.0 | 116.0 | V | 176.0 |
| **4573.625** | --- | **51.39** | 74.00 | **22.61** | 1000.0 | 118.0 | H | 232.0 |
| **4573.625** | **38.37** | --- | 54.00 | **15.63** | 1000.0 | 118.0 | H | 232.0 |
| **5488.375** | --- | **54.01** | 74.00 | **19.99** | 1000.0 | 129.0 | V | 256.0 |
| **5488.375** | **40.43** | --- | 54.00 | **13.57** | 1000.0 | 129.0 | V | 256.0 |
| **6403.125** | --- | **55.05** | 74.00 | **18.95** | 1000.0 | 324.0 | H | 237.0 |
| **6403.125** | **41.23** | --- | 54.00 | **12.77** | 1000.0 | 324.0 | H | 237.0 |
| **7317.875** | --- | **51.90** | 74.00 | **22.10** | 1000.0 | 162.0 | H | 237.0 |
| **7317.875** | **38.29** | --- | 54.00 | **15.71** | 1000.0 | 162.0 | H | 237.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | | |

*Blue marked: restricted bands*

*Higher Channel @ 927.25 MHz*

| Transmitter Spurious Radiation (1 GHz – 10 GHz), (Section 15.205, 15.209) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency (MHz)** | **Average (dBµV/m)** | **MaxPeak (dBµV/m)** | **Limit (dBµV/m)** | **Margin (dB)** | **Bandwidth (kHz)** | **Height (cm)** | **Pol V / H** | **Azimuth (deg)** |
| **1854.375** | --- | **61.19** | 74.00 | **12.81** | 1000.0 | 167.0 | H | 138.0 |
| **1854.375** | **48.53** | --- | 54.00 | **5.47** | 1000.0 | 167.0 | H | 138.0 |
| **2019.375** | **32.14** | --- | 54.00 | **21.86** | 1000.0 | 194.0 | V | 157.0 |
| **2019.375** | --- | **46.36** | 74.00 | **27.64** | 1000.0 | 194.0 | V | 157.0 |
| **2781.625** | **46.01** | --- | 54.00 | **7.99** | 1000.0 | 162.0 | V | 167.0 |
| **2781.625** | --- | **58.88** | 74.00 | **15.12** | 1000.0 | 162.0 | V | 167.0 |
| **3708.875** | **45.01** | --- | 54.00 | **8.99** | 1000.0 | 116.0 | V | 191.0 |
| **3708.875** | --- | **57.94** | 74.00 | **16.06** | 1000.0 | 116.0 | V | 191.0 |
| **4636.125** | --- | **51.37** | 74.00 | **22.63** | 1000.0 | 176.0 | V | 164.0 |
| **4636.125** | **37.89** | --- | 54.00 | **16.11** | 1000.0 | 176.0 | V | 164.0 |
| **5563.375** | **41.48** | --- | 54.00 | **12.52** | 1000.0 | 217.0 | H | 251.0 |
| **5563.375** | --- | **54.61** | 74.00 | **19.39** | 1000.0 | 217.0 | H | 251.0 |
| **6490.625** | **43.43** | --- | 54.00 | **10.57** | 1000.0 | 137.0 | H | 239.0 |
| **6490.625** | --- | **56.07** | 74.00 | **17.93** | 1000.0 | 137.0 | H | 239.0 |
| **7417.875** | **38.62** | --- | 54.00 | **15.38** | 1000.0 | 201.0 | H | 235.0 |
| **7417.875** | --- | **51.57** | 74.00 | **22.43** | 1000.0 | 201.0 | H | 235.0 |
| Measurement uncertainty: Conducted ± 1 dB / ERP ± 4 dB | | | | | | | | |

*Blue marked: restricted bands*

| | |
|---|---|
| Test cables used | K60, K101, K119 |
| Test equipment used | 445a, 660, 665, 406, 451, 452 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |

## 8.5 Bandwidth

### 8.5.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.


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### 8.5.2 Result

| Operating Frequency | Minimum Measured 20 dB Bandwidth |
|---|---|
| MHz | kHz |
| 902.75 | 97.7 |
| 914.75 | 97.9 |
| 927.25 | 97.4 |

| Operating Frequency | Maximum Measured 99 % Bandwidth |
|---|---|
| MHz | kHz |
| 902.75 | 95.9 |
| 914.75 | 94.4 |
| 927.25 | 93.9 |

| | |
|---|---|
| Test Cables used | K121 |
| Test equipment used | 356, 502, 226, 571, 594, 493 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 3 |

## 8.6 Carrier frequency separation

### 8.6.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.


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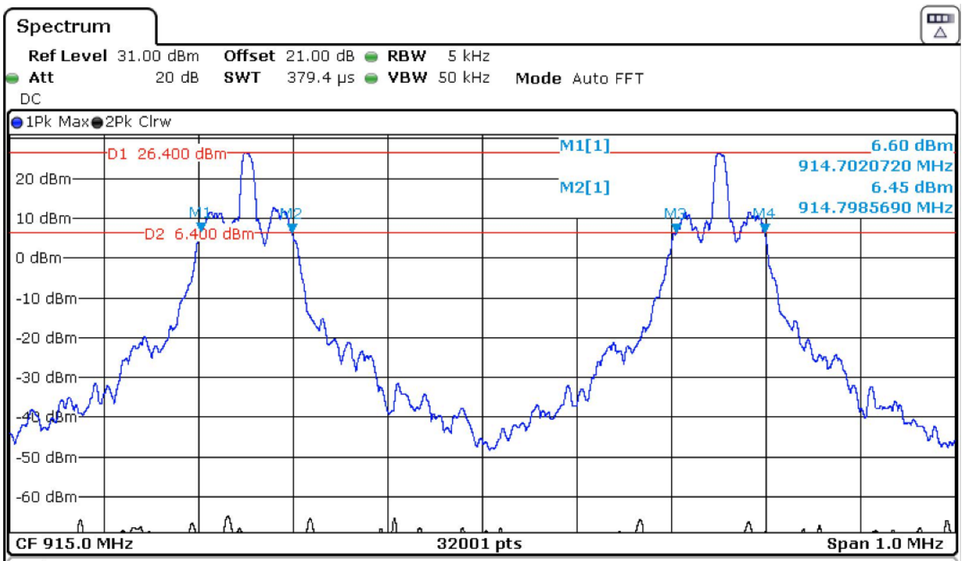
### 8.6.2 Result

**Plot of channel separation measurement**




| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 914.702072 MHz | 6.60 dBm | | |
| M2 | | 1 | 914.798569 MHz | 6.45 dBm | | |
| M3 | | 1 | 915.204681 MHz | 6.32 dBm | | |
| M4 | | 1 | 915.298209 MHz | 6.24 dBm | | |

| | 20 dBc frequencies MHz | | Calculated centre frequencies MHz | | Calculated channel separation kHz |
|---|---|---|---|---|---|
| **Operating Frequency 1** | $F1_L$ | **914.702072** | **F1** | **914.7503205** | **501.1245** |
| | $F1_H$ | **914.798569** | | | |
| **Operating Frequency 2** | $F2_L$ | **915.204681** | **F2** | **915.251445** | |
| | $F2_H$ | **915.298209** | | | |

**$F1 = F1_H - F1_L$** **$F2 = F2_H - F2_L$** **channel separation = F2 – F1**

| | |
|---|---|
| Test Cables used | K121 |
| Test equipment used | 356, 502, 226, 571, 594, 493 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~**No**~~ | ~~**N.t.**~~* |
| Test setup photos / test results are attached | ~~**Yes**~~ | **No** | Annex no.: |

## 8.7 Number of hopping channels

### 8.7.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.



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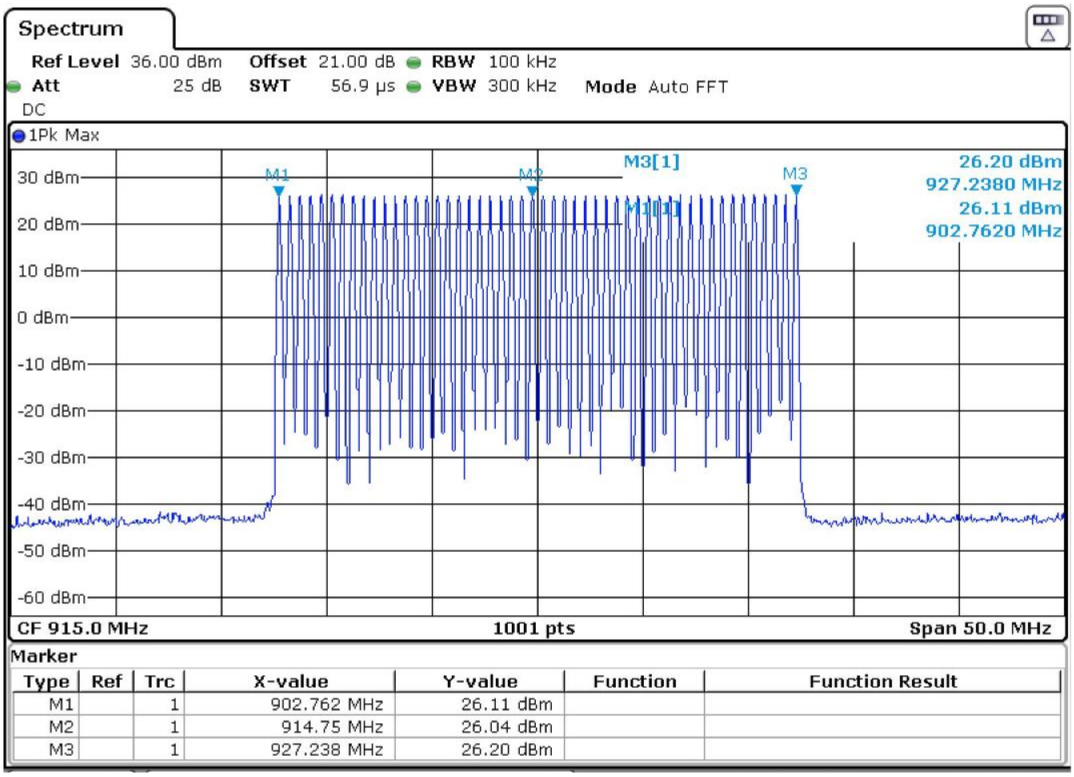
### 8.7.2 Result

**Plot of number of hopping channels**




| Operating Frequency Band | Number of hopping channels Measured | Number of hopping channels Limit |
|---|---|---|
| **902 - 928** | **50** | **50** |

| | |
|---|---|
| Test Cables used | K121 |
| Test equipment used | 356, 502, 226, 571, 594, 493 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | ~~Yes~~ | **No** | Annex no.: |

## 8.8 Average time of occupancy

### 8.8.1 Regulation

Section 15.247 (a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

(ii) Frequency hopping systems operating in the 5725-5850 MHz band shall use at least 75 hopping frequencies. The maximum 20 dB bandwidth of the hopping channel is 1 MHz. The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 30 second period.

(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.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### 8.8.2 Result

| Operating Frequency MHz | | Duration of a single transmission ms | Number of transmissions | Average time of occupancy ms | Limit ms |
|---|---|---|---|---|---|
| $F_{Low}$ | 902.75 | 321 | 1 | 321 | 400 |
| $F_{Middle}$ | 914.75 | 321 | 1 | 321 | 400 |
| $F_{High}$ | 927.25 | 321 | 1 | 321 | 400 |

| | |
|---|---|
| Test Cables used | K121 |
| Test equipment used | 356, 502, 226, 571, 594, 493 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | ~~Yes~~ | **No** | Annex no.: |

## 8.9 Peak output power

### 8.9.1 Regulation

Section 15.247 (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

(2) For frequency hopping systems operating in the 902-928 MHz band: 1 watt for systems employing at least 50 hopping channels; and, 0.25 watts for systems employing less than 50 hopping channels, but at least 25 hopping channels, as permitted under paragraph (a)(1)(i) of this section.

(3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. 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.

(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.

(c) Operation with directional antenna gains greater than 6 dBi.

(1) Fixed point-to-point operation:

(i) Systems operating in the 2400-2483.5 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter conducted output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (c)(1)(i) and (c)(1)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum or digitally modulated intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

(2) In addition to the provisions in paragraphs (b)(1), (b)(3), (b)(4) and (c)(1)(i) of this section, transmitters operating in the 2400-2483.5 MHz band that emit multiple directional beams, simultaneously or sequentially, for

the purpose of directing signals to individual receivers or to groups of receivers provided the emissions comply with the following:

(i) Different information must be transmitted to each receiver.

(ii) If the transmitter employs an antenna system that emits multiple directional beams but does not do emit multiple directional beams simultaneously, the total output power conducted to the array or arrays that comprise the device, *i.e.*, the sum of the power supplied to all antennas, antenna elements, staves, etc. and summed across all carriers or frequency channels, shall not exceed the limit specified in paragraph (b)(1) or (b)(3) of this section, as applicable. However, the total conducted output power shall be reduced by 1 dB below the specified limits for each 3 dB that the directional gain of the antenna/antenna array exceeds 6 dBi. The directional antenna gain shall be computed as follows:

(A) The directional gain shall be calculated as the sum of 10 log (number of array elements or staves) plus the directional gain of the element or stave having the highest gain.

(B) A lower value for the directional gain than that calculated in paragraph (c)(2)(ii)(A) of this section will be accepted if sufficient evidence is presented, e.g., due to shading of the array or coherence loss in the beamforming.

(iii) If a transmitter employs an antenna that operates simultaneously on multiple directional beams using the same or different frequency channels, the power supplied to each emission beam is subject to the power limit specified in paragraph (c)(2)(ii) of this section. If transmitted beams overlap, the power shall be reduced to ensure that their aggregate power does not exceed the limit specified in paragraph (c)(2)(ii) of this section. In addition, the aggregate power transmitted simultaneously on all beams shall not exceed the limit specified in paragraph (c)(2)(ii) of this section by more than 8 dB.

(iv) Transmitters that emit a single directional beam shall operate under the provisions of paragraph (c)(1) of this section.



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### 8.9.2 Test procedure

The EUT and this peripheral (when additional equipment exists) are placed on a turn table which is 0.8 m above the ground. The turn table would be allowed to rotate 360° to determine the position of the maximum emission level. The test distance between the EUT and the receiving antenna are 3m. To find the maximum emission, the polarization of the receiving antenna is changed in horizontal and vertical polarization; the position of the EUT was changed in different orthogonal determinations.

ANSI C63.4-2014 Section 8 “Radiated Emissions Testing”

Measurement procedures for electric field radiated emissions from 9kHz - 1 GHz & 1 GHz - 40 GHz are covered in Clause 8 of ANSI C63.4-2014. The ANSI C63.4-2014 measurement procedure consists of both an exploratory test and a final measurement. The exploratory test is critical to determine the frequency of all significant emissions. For each mode of operation required to be tested, the frequency spectrum is monitored. Variations in antenna height, antenna orientation, antenna polarization, EUT azimuth, and cable or wire placement is explored to produce the emission that has the highest amplitude relative to the limit.

The final measurements are made based on the findings in the exploratory testing. When making exploratory and final measurements it is necessary to maximize the measured radiated emission. Sub clause 8.3.2 of ANSI C63.4-2014 states that the measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” We consider the “cone of radiation” to be the 3 dB beam width of the measurement antenna.

While the “bore-sighting” technique is not explicitly mentioned in ANSI C63.4-2014, it is a useful technique for measurements using a directional antenna, such as a double-ridged waveguide antenna. Several precautions must be observed, including: knowledge of the beam width of the antenna and the resulting illumination area relative to the size of the EUT, estimation for source of the emission and general location within larger EUTs, measuring system sensitivity, etc.

ANSI C63.4-2014 requires that the measurement antenna is kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. That means that if the directional radiation pattern of the EUT results in a maximum emission at an upwards angle from the EUT, when a directional antenna is used to make the measurement it will be necessary for it to be pointed towards the source of the emission within the EUT. This can be done by either pointing the antenna at an angle towards the source of the emission, or by rotating the EUT, in both height and polarization, to maximize the measured emission. The emission must be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured.


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| **Radiated emissions test characteristics** | |
|---|---|
| Test distance | 10m, 3 m* |
| Test instrumentation resolution bandwidth | 9 kHz (Below 30 MHz) |
| | 120 kHz (30 MHz - 1000 MHz) |
| | 1 MHz (Above 1000 MHz) |
| Receive antenna scan height | 1 m (Below 30 MHz) |
| | 1 m - 4 m (30 MHz - 15000 MHz) |
| | 1 m – 2.5 m (18000 MHz - 40000 MHz) |
| | 1 m (Above 40000 MHz) |
| Receive antenna polarization | 0° or 90° (Below 30 MHz) |
| | vertical/horizontal (Above 30 MHz) |

*According to Section 15.31 (f) (1): At frequencies at or above 30 MHz, measurements may be performed at a distance other than what is specified provided: measurements are not made in the near field except where it can be shown that near field measurements are appropriate due to the characteristics of the device; and it can be demonstrated that the signal levels needed to be measured at the distance employed can be detected by the measurement equipment. When performing measurements at a distance other than that specified, the results shall be extrapolated to the specified distance using an extrapolation factor of 20dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

### 8.9.3 Calculation of the peak power (radiated)

The field strength is calculated by the following calculation:

Corrected Level = Receiver Level + Correction Factor (without the use of a pre-amplifier)

Corrected Level = Receiver Level + Correction Factor – Pre-Amplifier (with the use of a pre-amplifier)

Receiver Level : Receiver reading without correction factors
Correction Factor : field attenuation + cable loss

For example:
The receiver reading is +1.0 dBm. The field attenuation for the measured frequency is +19.5 dB and the cable factor for the measured frequency is 2.1 dB, giving a power of +22.6 dBm.
The +22.6dBm value can be mathematically converted to its corresponding level in W.

+22.6 dBm = 0.182 W = 182 mW


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## 8.9.4 Result

| Peak output power at antenna port (Section 15.247 (b)(2)) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **f** | **Detct** | **BW*** | **Rx Level** | **CF** | **LC** | **Limit** | **Margin** |
| **MHz** | **Type** | **kHz** | **dBm** | **dB** | **dBm** | **dBm** | **dB** |
| **902.75** | PK | 100 | **---** | --- | **26.5** | 30.0 | **3.5** |
| **914.75** | PK | 100 | **---** | --- | **26.3** | 30.0 | **3.7** |
| **927.25** | PK | 100 | **---** | --- | **26.6** | 30.0 | **3.4** |
| Measurement uncertainty: ± 3 dB | | | | | | | |
| **f: Frequency \| Detct : Detector type \| BW: Bandwidth \| Rx Level : Receiver level \| CF : Correction factor \| LC : Level corrected** | | | | | | | |

BW* = the measuring receiver bandwidth

| Max. radiated peak output power e.i.r.p. Calculated (Section 15.247 (b)(2)) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Antenna Type** | **f** | **Rx Level** | **Antenna gain** | **e.i.r.p. LC (cable 2m)** | **e.i.r.p. LC (cable 6m)** | **e.i.r.p. Limit** | **Margin Cable 2m** | **Margin Cable 6m** |
| **Internal / External** | **(MHz)** | **dBm** | **dBi** | **dBm** | **dBm** | **dBm** | **dB** | |
| **Internal** | **902.75** | **26.5** | **-10** | **16.0** | **14.9** | 36* | **21.1** | **20.0** |
| | **914.75** | **26.3** | **-10** | **15.8** | **14.7** | 36* | **21.3** | **20.2** |
| | **927.25** | **26.6** | **-10** | **16.1** | **15.0** | 36* | **19.9** | **21.0** |
| **ID ISC.ANT.U170/170** | **902.75** | **26.5** | **1** | **27.0** | **25.9** | 36* | **9.0** | **10.1** |
| | **914.75** | **26.3** | **1** | **26.8** | **25.7** | 36* | **9.2** | **10.3** |
| | **927.25** | **26.6** | **1** | **27.5** | **26.0** | 36* | **8.5** | **10.0** |
| **ID ISC.ANT.U270/270** | **902.75** | **26.5** | **6** | **32.0** | **30.9** | 36* | **4.0** | **5.1** |
| | **914.75** | **26.3** | **6** | **31.8** | **30.7** | 36* | **4.2** | **5.3** |
| | **927.25** | **26.6** | **6** | **32.1** | **31.0** | 36* | **3.9** | **5.0** |
| **ID ISC.ANT.U600/270** | **902.75** | **26.5** | **8** | **34.0** | **32.9** | 36* | **2.0** | **3.1** |
| | **914.75** | **26.3** | **8** | **33.8** | **32.7** | 36* | **2.2** | **3.3** |
| | **927.25** | **26.6** | **8** | **34.1** | **33.0** | 36* | **1.9** | **3.0** |
| **ID ISC.ANT.U290/290** | **902.75** | **26.5** | **6** | **27.0** | **30.9** | 36* | **4.0** | **5.1** |
| | **914.75** | **26.3** | **6** | **26.8** | **30.7** | 36* | **4.2** | **5.3** |
| | **927.25** | **26.6** | **6** | **27.5** | **31.0** | 36* | **3.9** | **5.0** |
| **ID ISC.ANT.U580/290** | **902.75** | **26.5** | **8** | **34.0** | **32.9** | 36* | **2.0** | **3.1** |
| | **914.75** | **26.3** | **8** | **33.8** | **32.7** | 36* | **2.2** | **3.3** |
| | **927.25** | **26.6** | **8** | **34.1** | **33.0** | 36* | **1.9** | **3.0** |
| Measurement uncertainty: ± 0.5 dB | | | | | | | | |
| **f: Frequency \| Rx Level : Receiver \| e.i.r.p. LC : Corrected e.i.r.p Level \|*e.i.r.p. Limit = 30 dBm + 6 dBi (antenna gain) = 4 Watt** | | | | | | | | |
| **Max. Peak output power (radiated) = Noted receiver level + Antenna gain - Coax cable attenuation<br>Coax cable attenuation (length - 2m) = 0.5 dB ; Coax cable attenuation (length - 6m) = 1.6 dB** | | | | | | | | |

| | |
|---|---|
| Test Cables used | K121 |
| Test equipment used | 356, 502, 226, 571, 594, 493 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.~~* |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 11 |

## 8.10 Out of band emission

### 8.10.1 Regulation

Section 15.247 (d) In any 100 kHz bandwidth outside 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, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

### 8.10.2 Calculation of the "Out of band emissions"

The field strength is calculated by the following calculation:

Corrected Level = Receiver Level + Correction Factor (without the use of a pre-amplifier)

Corrected Level = Receiver Level + Correction Factor – Pre-Amplifier (with the use of a pre-amplifier)

| | |
|---|---|
| Receiver Level | : Receiver reading without correction factors |
| Correction Factor | : field attenuation + cable loss |

For example:
The receiver reading in a 100 kHz bandwidth is -45.0 dBm. The field attenuation for the measured frequency is +10.5 dB and the cable factor for the measured frequency is 1.5 dB, giving a power of -33.0 dBm.
The measured peak power in a 100 kHz bandwidth is +3.6dBm. Therefore the Attenuation can be calculated as follows:

Attenuation = measured peak power – out of band emission receiver reading = +3.6 dBm – (-33.0 dBm) =36.6 dB


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### 8.10.3 Test procedure

The EUT and this peripheral (when additional equipment exists) are placed on a turn table which is 0.8 m above the ground. The turn table would be allowed to rotate 360° to determine the position of the maximum emission level. The test distance between the EUT and the receiving antenna are 3m. To find the maximum emission, the polarization of the receiving antenna is changed in horizontal and vertical polarization; the position of the EUT was changed in different orthogonal determinations.

ANSI C63.4-2014 Section 8 “Radiated Emissions Testing”

Measurement procedures for electric field radiated emissions from 9kHz - 1 GHz & 1 GHz - 40 GHz are covered in Clause 8 of ANSI C63.4-2014. The ANSI C63.4-2014 measurement procedure consists of both an exploratory test and a final measurement. The exploratory test is critical to determine the frequency of all significant emissions. For each mode of operation required to be tested, the frequency spectrum is monitored. Variations in antenna height, antenna orientation, antenna polarization, EUT azimuth, and cable or wire placement is explored to produce the emission that has the highest amplitude relative to the limit.

The final measurements are made based on the findings in the exploratory testing. When making exploratory and final measurements it is necessary to maximize the measured radiated emission. Sub clause 8.3.2 of ANSI C63.4-2014 states that the measurement is to be made “while keeping the antenna in the ‘cone of radiation’ from that area and pointed at the area both in azimuth and elevation, with polarization oriented for maximum response.” We consider the “cone of radiation” to be the 3 dB beam width of the measurement antenna.

While the “bore-sighting” technique is not explicitly mentioned in ANSI C63.4-2014, it is a useful technique for measurements using a directional antenna, such as a double-ridged waveguide antenna. Several precautions must be observed, including: knowledge of the beam width of the antenna and the resulting illumination area relative to the size of the EUT, estimation for source of the emission and general location within larger EUTs, measuring system sensitivity, etc.

ANSI C63.4-2014 requires that the measurement antenna is kept pointed at the source of the emission both in azimuth and elevation, with the polarization of the antenna oriented for maximum response. That means that if the directional radiation pattern of the EUT results in a maximum emission at an upwards angle from the EUT, when a directional antenna is used to make the measurement it will be necessary for it to be pointed towards the source of the emission within the EUT. This can be done by either pointing the antenna at an angle towards the source of the emission, or by rotating the EUT, in both height and polarization, to maximize the measured emission. The emission must be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured.

### 8.10.4 Result

- **EUT (ID ISC.MRMU102-A)**

*Lower Channel @ 902.75 MHz*

| Spurious Emissions - conducted (Transmitter), (Section 15.247 (d)) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **frequency** | **Detector** | **BW** | **Rx Level** | **CF** | **LC** | **Limit** | **Margin** |
| **MHz** | **Type** | **kHz** | **dBm** | **dB** | **dBm** | **dBm*** | **dB** |
| 119.4 | PK | 100 | --- | --- | -54.8 | 6.19 | 61.0 |
| 392.1 | PK | 100 | --- | --- | -51.5 | 6.19 | 57.7 |
| 1804.9 | PK | 100 | --- | --- | -33.5 | 6.4 | 39.9 |
| 2707.0 | PK | 100 | --- | --- | -39.9 | 6.4 | 46.3 |
| 6950.5 | PK | 100 | --- | --- | -50.4 | 6.4 | 56.8 |
| Measurement uncertainty: ± 3 dB | | | | | | | |
| *** 20 dB below the carrier peak level<br>** All other emissions lower than the noise level of the measuring equipment!** | | | | | | | |
| **BW: meas. receiver Bandwidth \| Rx Level : Receiver level \| CF : Correction factor \| LC : Level corrected** | | | | | | | |

*Middle Channel @ 914.75 MHz*

| Spurious Emissions - conducted (Transmitter), (Section 15.247 (d)) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **frequency** | **Detector** | **BW** | **Rx Level** | **CF** | **LC** | **Limit** | **Margin** |
| **MHz** | **Type** | **kHz** | **dBm** | **dB** | **dBm** | **dBm*** | **dB** |
| 130.4 | PK | 100 | --- | --- | -55.4 | 6.35 | 61.8 |
| 377.1 | PK | 100 | --- | --- | -51.9 | 6.35 | 58.3 |
| 1830.1 | PK | 100 | --- | --- | -33.3 | 6.52 | 39.8 |
| 2744.8 | PK | 100 | --- | --- | -38.8 | 6.52 | 45.3 |
| Measurement uncertainty: ± 3 dB | | | | | | | |
| *** 20 dB below the carrier peak level<br>** All other emissions lower than the noise level of the measuring equipment!** | | | | | | | |
| **BW: meas. receiver Bandwidth \| Rx Level : Receiver level \| CF : Correction factor \| LC : Level corrected** | | | | | | | |


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*Higher Channel @ 927.25 MHz*

| **Spurious Emissions - conducted (Transmitter)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| **frequency** | **Detector** | **BW** | **Rx Level** | **CF** | **LC** | **Limit** | **Margin** |
| **MHz** | **Type** | **kHz** | **dBm** | **dB** | **dBm** | **dBm*** | **dB** |
| 142.4 | PK | 100 | --- | --- | -54.8 | 6.56 | 61.4 |
| 363.1 | PK | 100 | --- | --- | -52.0 | 6.56 | 58.6 |
| 1855.2 | PK | 100 | --- | --- | -33.3 | 6.57 | 39.9 |
| 2782.5 | PK | 100 | --- | --- | -38.4 | 6.57 | 45.0 |
| 6725.8 | PK | 100 | --- | --- | -51.1 | 6.57 | 57.7 |
| Measurement uncertainty: ± 3 dB | | | | | | | |
| *** 20 dB below the carrier peak level<br>** All other emissions lower than the noise level of the measuring equipment!** | | | | | | | |
| **BW: meas. receiver Bandwidth \| Rx Level : Receiver level \| CF : Correction factor \| LC : Level corrected** | | | | | | | |

| | |
|---|---|
| Test cables used | K121 |
| Test equipment used | 356, 502, 226, 571, 594, 493 |

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.*~~ |

| | | | |
|---|---|---|---|
| Test setup photos / test results are attached | **Yes** | ~~No~~ | Annex no.: 6, 11 |

## 8.11 Radio Frequency hazard

### 8.11.1 Regulation

Section 15.247 (i)
According to § 1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

### 8.11.2 Result

MPE calculation method

These equations are generally accurate in the far field of an antenna but will over predict power density in the near field, where they could be used for making a "worst case" prediction.

$S = PG/4\pi R^2$

where S = power density ( in appropriate units, e.g. $mW/cm^2$)
P = power input to the antenna (in appropriate units e.g. mW)
G = power gain of the antenna in the direction of interest relative to the isotropic radiator
R = distance to the center of radiation of the antenna (appropriate units e.g. cm)

OR, $S = EIRP/(4\pi R^2)$

Where, EIRP = equivalent isotropically radiated power

| MPE Calculations | | | |
|---|---|---|---|
| Operating Frequency | Calculated EIRP | Power density (S) @ 20 cm | |
| | | Calculated | Limit |
| kHz / MHz | mW | $mW/cm^2$ | |
| Channel 1 : 902.75 | 2511.9 | 0.49 | 0.6 |
| Channel 2 : 914.75 | 2398.8 | 0.47 | 0.6 |
| Channel 3 : 927.25 | 2570.4 | 0.51 | 0.6 |

**Limit:**

**0.60 $mW/cm^2$ is the reference level for general public exposure according to the OET Bulletin 65, Edition 97-01 Table 1.**

| | | | |
|---|---|---|---|
| The equipment passed the conducted tests | **Yes** | ~~No~~ | ~~N.t.*~~ |
| Test setup photos / test results are attached | ~~Yes~~ | **No** | Annex no.: |

## 9. Additional information to the test report

| Remarks | Description |
|---|---|
| N.t.[1] | Not tested, because the antenna is part of the PCB |
| N.t.[2] | Not tested, because the EUT is directly battery powered |
| N.t.[3] | Not tested, because not applicable to the EUT |
| N.t.[4] | Not tested, because not ordered |

## 10. List of test equipment

| State<br>Jun. 23, 2021 | | | | | |
|---|---|---|---|---|---|
| **Marking** | **Manufacturer** | **SW/Type/Serial-No.** | **Last Cal./Val.** | **Next Cal./Val.** | **No.** |
| ***1 Measuring Instruments*** | | | | | |
| Attenuator | Radiall | --- | *Nov 19* | *Nov 22* | *62* |
| Attenuator 3dB | Suhner | 6803/17 | *Nov 19* | *Nov 22* | *137* |
| Attenuator 3dB / 18 GHz | Suhner | 3dB/18GHz | *Nov 19* | *Nov 22* | *299* |
| Terminator | Texcan | --- | *Nov 19* | *Nov 22* | *304* |
| Attenuator 6dB / 18 GHz | Suhner | 6dB/18GHz | *Nov 19* | *Nov 22* | *344* |
| Attenuator 20dB / 20GHz | Parzich | 40AH-20 | *Nov 19* | *Nov 22* | *354* |
| Terminator | KDI | T173CS | *Nov 19* | *Nov 22* | *490* |
| Variable transformer | RFT | LS 002 | --- | --- | *154a* |
| Variable transformer | Schunt+Ben | --- | --- | --- | *155* |
| Power sensor | Marconi | 6914 | *Sep 20* | *Sep 22* | *258* |
| Power sensor | Marconi | 6913 | *Aug 19* | *Aug 21* | *286* |
| Power sensor | Rohde & Schwarz | NRP18SN | *Nov 19* | *Nov 21* | *651* |
| 3-Path Diode Power Sensor<br>10 MHz to 8 GHz | Rohde & Schwarz | NRP8S | *Oct 20* | *Oct 22* | *663* |
| 3-Path Diode Power Sensor<br>10 MHz to 18 GHz | Rohde & Schwarz | NRP18S-20 | *Oct 20* | *Oct 22* | *664* |
| Coaxial Directional Coupler | Narda | 3003-20 | *Jan 21* | *Jan 24* | *370/342* |
| Coaxial directional coupler | Mini Circuits | ZFDC-20-5 | *Mar 20* | *Mar 22* | *434* |
| Coaxial directional coupler | Narda+Suhner | --- | *Mar 20* | *Mar 23* | *472/492* |
| Coaxial High Pass Filter | Mini circuits | NHP-700 | *Apr 21* | *Apr 24* | *435* |
| Coaxial High Pass Filter | Mini circuits | NHP-200 | *Apr 21* | *Apr 24* | *405* |
| Coaxial High Pass Filter | Mini circuits | NHP-25+ | *Apr 21* | *Apr 24* | *455* |
| High Pass Filter | Mini circuits | VHF-3500+ | *Apr 21* | *Apr 24* | *451* |
| High Pass Filter | Mini circuits | VHF-1200+ | *Apr 21* | *Apr 24* | *452* |
| Bandpass Filter | Schomandl | BN86871 | *Nov 18* | *Nov 21* | *66* |
| Bandpass Filter | Schomandl | BN68673 | *Nov 18* | *Nov 21* | *67* |
| Low Pass Filter | Mini circuits | SLP550 | *Apr 21* | *Apr 24* | *273* |
| Low Pass Filter | Mini circuits | SLP550 | *Apr 21* | *Apr 24* | *274* |
| RF Current Probe 9 kHz – 30 MHz | Rohde & Schwarz | ESH2-Z1 | *Jun 18* | *Jun 21* | *42* |
| Passive Test Probe – 9 kHz – 30 MHz | TÜV NORD | VDE 0876 | *Apr 21* | *Apr 24* | *45* |
| Coaxial Fixed Attenuator DC – 1 GHz | Texscan | HFP50/10 | *Jul 20* | *Jul 23* | *60* |
| 8 Wire Impedance Stabilisation Network | Schwarzbeck | CAT5 8158 | *Nov 19* | *Nov 21* | *71a* |
| T-Section - 50 W | Rohde & Schwarz | BN 42441/50 | *Aug 18* | *Aug 21* | *93* |
| RF Current Injection Clamp 0.15 – 1GHz | Lüthi GmbH | EM 101 | *Nov 19* | *Nov 22* | *156* |
| Absorbing Clamp MDS 30MHz – 1GHz | Lüthi GmbH | MDS-21 | *Nov 19* | *Nov 22* | *160* |
| Insertion Unit | Rohde & Schwarz | URV5-Z4 | *Mai 19* | *Mai 22* | *162* |
| Coaxial RF Termination - 0 – 1000 MHz | Telewave Inc. | TWL 35 | *Nov 18* | *Nov 21* | *164* |
| Coaxial RF Termination - 0 – 1000 MHz | Telewave Inc. | TWL 60 | *Nov 18* | *Nov 21* | *165* |
| Fixed Attenuator - DC – 1.5GHz | Bird | Mod/ 8343-060 | *Apr. 20* | *Apr. 23* | *177* |
| Rotary Step Attenuator DC – 2 GHz | Texscan | TA – 50 | *Mar20* | *Mar 22* | *184* |
| CDN up to 230 MHz | MEB | KEN-M 2 /M 3 | *Nov 19* | *Nov 21* | *264* |
| Impulse limiter 10 dB | Rohde & Schwarz | ESH3 Z2 | *Mai 19* | *Mai 22* | *272* |
| Fixed Attenuator - DC – 18 GHz \| 30 dB | MTS | --- | *Nov 20* | *Nov 23* | *275* |
| Fixed Attenuator - DC – 18 GHz \| 30 dB | MTS | --- | *Mar 20* | *Mar 22* | *276* |
| Passive Probe - 9 kHz – 30 MHz \| 2.5 kΩ | RFT | TK 121 | *Jun 20* | *Jun 23* | *302* |
| Passive probe 1.5kΩ | Schwarzbeck | TK 9416 | *Oct 20* | *Oct 23* | *621* |
| Termination Resistor 50 W | Radiall | 404011 | *Nov 18* | *Nov 21* | *309* |
| Branching device (4x) 50W | Rohde & Schwarz | 892228/20 | *Sep 19* | *Sep 22* | *320* |
| Dummy-Load - 2 – 18 GHz | Narda | MODEL 367NF | *Nov 19* | *Nov 22* | *343* |

| | | | | | |
|---|---|---|---|---|---|
| DC Block Adapter - 0.045 – 26.5 GHz | Hewlett-Packard | 11742A | *Apr 21* | *Apr 24* | *356* |
| Insertion Unit 10V \| 9 kHz 1000 MHz | Rohde & Schwarz | URV 5-Z2 | *Mai 19* | *Mai 22* | *367* |
| RF Probe 0.02 – 1000 MHz | Rohde & Schwarz | 395.2680.02 | *Mai 19* | *Mai 22* | *368* |
| 150W attenuator | Weinschel | 49-20-33 | *Oct 19* | *Oct 22* | *374* |
| Fixed Coaxial Attenuator - DC – 18 GHz | Weinschel | 23-6-34 | *Feb 20* | *Feb 23* | *375* |
| Insertion Unit 9 kHz – 2000 MHz | Rohde & Schwarz | URY-Z2 | *Oct 19* | *Oct 22* | *416* |
| Panoramic Adapter (Monitoring) | Schwarzbeck | PAN1550 | --- | --- | *429* |
| DC-BLOCK - DC – 6.0 GHz \|50 W | Mini Circuits | BLK-6-N+ | *Aug 18* | *Aug 21* | *462* |
| Terminating resistor 50Ω SMA | --- | --- | *Nov 19* | *Nov 22* | *493* |
| Terminating resistor 50Ω SMA | --- | SC 60-601-0000-31 | *Nov 19* | *Nov 22* | *497* |
| Fixed Attenuator –0 – 40 GHz | Anritsu | 41KC-10 | *Nov 19* | *Nov 22* | *504* |
| Fixed Attenuator – 0 – 40 GHz | Anritsu | 41KC-10 | *Nov 19* | *Nov 22* | *505* |
| Fixed Attenuator – 0 – 40 GHz | Anritsu | 41KC-6 | *Nov 19* | *Nov 22* | *506* |
| Fixed Attenuator – 0 – 40 GHz | Anritsu | 41KC-3 | *Nov 19* | *Nov 22* | *507* |
| Electric Dummy Load | RA-NAV Lab. | DA-75U | --- | --- | *526* |
| Power Splitter / Combiner | Mini Circuits | ZESC-2-11 | *Nov 19* | *Nov 22* | *527* |
| 3 Way Power Splitter / Combiner | Mini Circuits | ZFSC-3-1 | *Mar 20* | *Mar 23* | *529* |
| 3 Way Power Splitter / Combiner | Mini Circuits | ZFSC-3-1 | *Mar 20* | *Mar 23* | *530* |
| RF-Attenuator - 6 dB | Haefely | --- | *Mar 20* | *Mar 23* | *540* |
| RF-Attenuator - 1– 120 MHz \| 12 dB | Haefely | --- | *Mar 20* | *Mar 23* | *541* |
| RF-Attenuator - 1– 120 MHz \| 39 dB | Haefely | --- | *Mar 20* | *Mar 23* | *542* |
| LISN 9kHz – 30 MHz | Schwarzbeck | NNLA 8120 | *Aug 20* | *Aug 22* | *551* |
| HV Probe P6013A | Tektronix | P6013A | *Mai 19* | *Mai 22* | *559* |
| VLISN 5µH | Schwarzbeck | 8125-1944 | *Nov 19* | *Nov 21* | *585* |
| VLISN 5µH | Schwarzbeck | 8125-1945 | *Nov 19* | *Nov 21* | *586* |
| 20dB Attenuator, up to 18 GHz | Mini Circuit | BW-N20W5+ | *Nov 19* | *Nov 22* | *594* |
| Step Attenuator - DC-18 GHz \| 0 to 11 dB | Hewlett-Packard | 8494B | *Nov 19* | *Nov 22* | *604* |
| Analyser Reference System | Spitzenberger & Spies | ARS 16/1 | *Jan 20* | *Jan 22* | *606a/b/c* |
| Capacitive Coupling Clamp 5 kV | Schlöder | SFT 415 | *Mai 20* | *Mai 23* | *608* |
| RF Probes for 50 Ω Receivers | Schwarzbeck | TK 9416 | --- | --- | *612* |
| Current probe TRMS | BEHA APROB | CHB35 | *Oct 19* | *Oct 22* | *652* |
| Semi Anechoic Chamber | COMTEST | SAC-3m | *Apr 21* | *Apr 23* | *660* |
| Maturo Turntable | Maturo | TT2.0SI<br>(SN: TT2.05SI/817<br>SW: 1.0.0.4473) | --- | --- | *667* |
| Maturo Antenna Mast | Maturo | TAM4.5-E-10kg<br>(SN: 10011/216/2588.01) | --- | --- | *668* |
| Maturo Controller | Maturo | FCU3.0/009/2588.01<br>(SN: 10014/2019) | --- | --- | *669* |
| Current probe 20 Hz – 100 MHz | Rohde & Schwarz | EZ-17 (0816.2063.03) | *Mar 20* | *Mar 23* | *670* |
| Coupling Decoupling Network | AMETEK | CDN ST08A | *Aug 20* | *Aug 23* | *762* |
| BONN HF Switch Matrix DC – 8 GHz | BONN Elektronik | BAS 0080-3 | --- | --- | *682* |
| External Directional Coupler | BONN Elektronik | BDC 1060-40/500 | *Dec 20* | *Dec 22* | *683* |
| BI-Directional Coax. Coup. 50-1000 MHz | Narda | 3020A | *Jan 18* | *Jan 22* | *141* |
| Vertical coupling plate | TÜV NORD HFT | --- | --- | --- | *265* |
| Measuring table | TÜV NORD HFT | --- | --- | --- | *106* |
| Data line coupling network | EM Test AG | CNV 504/ 508 | --- | --- | 285 |
| ***2 Generators*** | | | | | |
| EFT/Burst Generator | Schlöder | SFT 1400 | *Mai 20* | *Mai 22* | *46a* |
| Hybrid Generator | Schlöder | CWG1500 | *Nov 19* | *Nov 21* | *522* |
| ESD Generator | Schlöder | SESD 216 | *Oct 19* | *Oct 21* | *653* |
| Signal Generator | Rohde & Schwarz | SMB100A | *Jul 20* | *Jul 22* | *571* |
| RF Generator | Rohde & Schwarz | SGT100A | *Apr 20* | *Apr 22* | *636* |


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| | | | | | |
|---|---|---|---|---|---|
| Signal Generator | Rohde & Schwarz | SMG | *Jun 21* | *Jun 23* | *136* |
| Signal Generator | Marconi | 2042 | *Mai 20* | *Mai 22* | *6* |
| Signal Generator | Marconi | 2024 | *Mai 20* | *Mai 22* | *213* |
| Puls Generator | EM Test | MPG 200 | *Cal. before use* | *Cal. before use* | *181* |
| Surge Generator | H+H | MIG063 IN S-T | *Apr 21* | *Apr 23* | *561* |
| ***3. Antennas*** | | | | | |
| Loop Ant. 9kHz-30MHz | Schwarzbeck | FMZB1516 | *Sep 19* | *Sep 21* | *23* |
| Biconical Ant. 30-300 MHz | Schwarzbeck | VHA9103/BBA9106 | *Apr 20* | *Apr 22* | *80/616* |
| Double Ridged Horn | Schwarzbeck | BBHA9120C | *Oct 19* | *Oct 21* | *169* |
| Double Ridged Horn | Schwarzbeck | BBHA 9120A | *Apr 20* | *Apr 22* | *284* |
| Tri-Log Broadband | Schwarzbeck | VULB9168 | *Mai 21* | *Mai 23* | *406* |
| Broadband Horn 14-40 GHz | Schwarzbeck | BBHA9170 | *Nov 19* | *Nov 21* | *442* |
| Log Per Antenna 0.7-20 GHz | Schwarzbeck | STLP9148 | *Mai 21* | *Mai 23* | *445a* |
| Bilog Ant. | Schwarzbeck | CBL6111 | *Cal. before use* | *Cal. before use* | *167* |
| Balun with biconical BBA9106 (TX) | Schwarzbeck [only for NSA] | VHBB9124 | *Nov 19* | *Nov 21* | *0796* |
| Balun with biconical BBA9106 (RX) | Schwarzbeck [only for NSA] | VHBA9123 | *Nov 19* | *Nov 21* | *9758* |
| Log periodic Ant (TX) | Schwarzbeck [only for NSA] | UHALP9108 | *Nov 19* | *Nov 21* | *9002* |
| Log periodic Ant (RX) | Schwarzbeck [only for NSA] | UHALP9108 | *Nov 19* | *Nov 21* | *9003* |
| Spectrum analyser Mixer 220 – 325 GHz | Radiometer Physics | SAM325 | *Aug 19* | *Aug 21* | *591* |
| Dual Mode Potter Horn 220-325 GHz | Radiometer Physics | 325-WR2 | --- | --- | *592* |
| Dual Mode Potter Horn 75-110 GHz | Radiometer Physics | --- | --- | --- | *649* |
| Gain Horn Antenna 50-75 GHz | Dorado | GH-15-20 | --- | --- | *511* |
| Standard Gain Horn 1.7 – 2.6 GHz | Narda | 645 | --- | --- | *514* |
| W-band active Sextupler with input drive amplifier | Spacek Labs Inc. | AW-6XW-0 | --- | --- | *221a* |
| 60 to 65 GHz active frequency quadrupler | Spacek Labs Inc. | A625-4XW-0 | --- | --- | *222a* |
| Harmonic Mixer 40-60 GHz | Rohde & Schwarz | FS-Z60 | *Jul 19* | *Jul 21* | *515* |
| Gain Horn Antenna 40-60 GHz | Dorado | GH-19-20 | --- | --- | *518* |
| Spectrum analyser Mixer 90-140 GHz | Radiometer Physics | SAM140 | *Aug 19* | *Aug 21* | *545* |
| Dual Mode Potter Horn 90-140 GHz | Radiometer Physics | 140-WR8 | --- | --- | *547* |
| Spectrum analyser Mixer 140-220GHz | Radiometer Physics | SAM220 | *Aug 19* | *Aug 21* | *450* |
| Dual Mode Potter Horn 140-220 GHz | Radiometer Physics | 220-WR5.1 | --- | --- | *548* |
| Harmonic Mixer 60-90 GHz | Rohde & Schwarz | FS-Z90 | *Jul 19* | *Jul 21* | *501* |
| Dual Mode Potter Horn 60-90 GHz | Radiometer Physics | 90-W12 | --- | --- | *549* |
| Gain Horn 33-55 GHz | Dorado | --- | --- | --- | *383* |
| Gain Horn 50-75 GHz | Dorado | --- | --- | --- | *384* |
| Gain Horn 75-110 GHz | Dorado | --- | --- | --- | *385* |
| Standard Gain Ant. 26.5-40 GHz | Maury Microwave | U211C | --- | --- | *532/628* |
| Waveguide Harmonic Mixer 50 – 75 GHz | Keysight | M1971V | *Oct 19* | *Oct 21* | *763* |
| Waveguide Harmonic Mixer 75 – 110 GHz | Keysight | M1971W | *Oct 19* | *Oct 21* | *764* |
| Stacked Log.-Per. Antenna 70 MHz – 10 GHz | Schwarzbeck | STLP 9129 | --- | --- | *662* |
| ***4. Amplifier*** | | | | | |
| RF-Power Amplifier 250 kHz – 150 MHz | ENI | 3100LA | --- | --- | --- |
| RF pre-amplifier 100kHz-1.3GHz | HP | 8447E | *Aug 20* | *Aug 22* | *166a* |
| Mitteq amplifier 26.5-40 GHz | Mitteq | --- | *Mar 20* | *Mar 22* | *223a* |
| RF pre-amplifier 1-18GHz | Narda | --- | *Mar 20* | *Mar 22* | *345* |
| Mitteq Amplifier 18-26GHz | Mitteq | --- | *Apr 20* | *Apr 22* | *433* |
| Microwave amplifier 12-18GHz | Schwarzbeck | BBV9719 | *Mar 20* | *Mar 22* | *443* |
| Microwave amplifier 0.5-18GHz | Schwarzbeck | BBV9718 | *Apr 21* | *Apr 23* | *444* |
| RF-Power Amplifier 10kHz-1000 MHz | Poetschke | 8100 (Band 1) BHED (Band 2) | --- | --- | *684* |



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| | | | | | |
|---|---|---|---|---|---|
| | | BHED (Band 3) | | | |
| RF-Power Amplifier 800 MHz – 4,2 GHz | Amplifier Research | 10S1G4 | --- | --- | *685* |
| RF-Power Amplifier 4 GHz – 8 GHz | Amplifier Research | 35S4G8A | --- | --- | *686* |
| ***5. Power supplies*** | | | | | |
| Programmable Power Supply | Fluke | PM 2813 | --- | --- | *28a* |
| Power Supply | HP | --- | --- | --- | *125* |
| Power Supply | Sorensen | LM 30-6 | --- | --- | *134a* |
| Power Supply | HP | 6034L | --- | --- | *226* |
| Regulated Power Supply | Farnell | AP60-50 | --- | --- | *408* |
| Power Supply | EA | PSI 8080-40-DT | --- | --- | *560* |
| Power Supply | HP | 6032A | --- | --- | *644* |
| ***6. Meters*** | | | | | |
| Microwave Frequency Counter | Hewlett-Packard | 5351B | *Nov 20* | *Nov 22* | *432* |
| Temperature test cabinet | Heraeus Vötsch | VMT04/35 | --- | --- | *102a* |
| Temperature test cabinet | Brabender | TTE 32/40 H | --- | --- | *87* |
| Digital-Hygro-Thermometer | Greisinger | GFTH95 | *Nov 19* | *Nov 21* | *57a* |
| Volt & RF Power Meter | Rohde & Schwarz | URV35 | *Cal. before use* | *Cal. before use* | *161* |
| Spectrum Analyzer - 9 kHz – 18 GHz | Rohde & Schwarz | FSL18 | *Jul 20* | *Jul 22* | *171a* |
| Multimeter | Gossen Metrawatt | Metrahit pro | *Nov 19* | *Nov 21* | *215a* |
| Humidity/Temperature Measuring device | TESTO | Testo 625 | *Oct 19* | *Oct 21* | *259a* |
| Volt & RF Power Meter | Rohde & Schwarz | URV35 | *Nov 19* | *Nov 21* | *271* |
| Multimeter | Gossen Metrawatt | Metrahit 26S | *Sep 20* | *Sep 22* | *313* |
| Level and Power Meter - 9 kHz – 3 GHz | Rohde & Schwarz | URY | *Mar 20* | *Mar 22* | *307* |
| Temperature test device | Ahlhorn | Almemo 2390-5 PT100 | *Mar 20* | *Mar 23* | *401/402* |
| Signal & Spectrum Analyser 10 Hz-30 GHz | Rohde & Schwarz | FSV-30 | *Jul 19* | *Jul 21* | *502* |
| Digital-Vacuum-/Barometer | Greisinger | GDH12AN | *Oct 19* | *Oct 21* | *558* |
| Temperature test cabinet | Weiß Umwelttechnik | WKL 34/40 | *Aug 18* | *Aug 21* | *562* |
| Digital Storage Oscilloscope | Tektronix | TDS 2012C | *Oct 19* | *Oct 21* | *568* |
| Miniature Flat, Zero-Biased Schottky Detector –0.1– 18 GHz | Narda | 4503A-03 | *Val. bevor use* | *Val. bevor use* | *613* |
| Digital-Vacuum-/Barometer | Greisinger | GDH-200-14 | *Oct 19* | *Oct 21* | *632* |
| EMI Test receiver ESW26 | Rohde & Schwarz | R&S ESW26 (SN: 101383/26 SW: R&S ESW1.61)) | *Nov 19* | *Nov 21* | *665* |
| Signal analyser Keysight 50GHz | Keysight | UXA N9040B (SN: MY57213006 SW: A.24.58/2019.0702) | *Nov 19* | *Nov 21* | *666* |
| ***7. test/control software*** | | | | | |
| EMC32 | Rohde & Schwarz | V10.60.20 | --- | --- | --- |
| Maturo mcApp | Maturo | SW: V3.4.9.4537 (19.04.04) | --- | --- | --- |
| SPS EMC | Spitzenberger & Spies | SW: V4.1.3 | --- | --- | --- |
| EMV-Soft | Schlöder GmbH | SW: V11.95 | --- | --- | --- |
| ISMISO | EM Test AG | SW:V3.63 | --- | --- | --- |


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## 11. List of test cables

| Internal Cable Number | Connector Type | Frequency Range (MHz) | Cable Length (m) | Manufacturer |
|---|---|---|---|---|
| 3 | N | 0,5 - 8000 | 3 | Cellflex |
| 4 | N | 0,5 - 8000 | 3 | Cellflex |
| 4a | BNC | 10 – 1500 | 0.50 | Telemeter |
| 14a | BNC | 10 – 1000 | 1.00 | Telemeter |
| 17a | APC3.5 | 10 – 26500 | 2.13 | Huber + Suhner |
| 18a | APC3.5 | 10 – 26500 | 2.13 | Huber + Suhner |
| 22 | BNC | 10 – 1000 | 1.50 | --- |
| 27 | BNC | 10 – 1000 | 1.00 | Fabrica Milanese Cond. |
| 40 | BNC | --- | 0.50 | Aircell |
| 43 | SMA | 10 – 18000 | 0.50 | Rosenberger |
| 44 | SMA | --- | 0.50 | Huber + Suhner |
| 45 | SMA | 10 – 18000 | 0.50 | Huber + Suhner |
| 48 | SMA | | 0.50 | Huber + Suhner |
| 49 | N | 10 – 18000 | 1.00 | Huber + Suhner |
| 50 | N | 10 – 18000 | 1.00 | Huber + Suhner |
| 51 | N | 10 – 18000 | 1.00 | Huber + Suhner |
| 52 | N | 10 – 18000 | 1.00 | Huber + Suhner |
| 54 | BNC | 10 – 3500 | 1.00 | Aircell |
| 58 | N | 10 – 18000 | 2.00 | Huber + Suhner |
| 59 | N | 10 – 18000 | 1.00 | Huber + Suhner |
| 60 | N | 10 – 18000 | 2.00 | Huber + Suhner |
| 61 | N | 10 – 18000 | 1.00 | Huber + Suhner |
| 62 | SMA | --- | 0.50 | Huber + Suhner |
| 63 | SMA | 10 – 18000 | 0.50 | Huber + Suhner |
| 64 | SMA | 10 – 18000 | 0.50 | Huber + Suhner |
| 65 | APC3.5 | 10 – 26500 | 0.60 | --- |
| 66 | APC3.5 | 10 – 26500 | 0.60 | --- |
| 67 | APC3.5 | 10 – 26500 | 0.60 | --- |
| 68 | APC3.5 | 10 – 26500 | 0.60 | --- |
| 72 | BNC | --- | 0.40 | --- |
| 73 | BNC | --- | 0.40 | --- |
| 76 | SMA | 10 – 30000 | 3.00 | Gore |
| 79 | BNC/N | 10 – 1000 | 5.00 | --- |
| 80 | SMA | --- | 0.25 | Huber + Suhner |
| 87 | SMA | 10 – 18000 | 0.15 | Huber + Suhner |
| 88 | SMA | 10 – 18000 | 0.15 | Huber + Suhner |
| 89 | SMA | 10 – 18000 | 0.15 | Huber + Suhner |
| 90 | SMA | 10 – 18000 | 0.15 | Huber + Suhner |
| 91 | SMA | --- | 1.50 | Huber + Suhner |
| 94 | BNC | --- | 1.10 | --- |
| 95 | BNC | --- | 0.80 | --- |
| 96 | BNC | --- | 0.80 | --- |
| 100 | N | 10 – 26500 | 6.00 | Rosenberg |
| 101 | N | 10 – 18000 | 2.90 | Huber + Suhner |
| 102 | SMA | 10 – 18000 | 2.00 | Huber + Suhner |
| 111 | BNC | 10 – 1000 | 0.50 | --- |
| 112 | BNC | 10 – 1000 | 0.50 | --- |
| 114 | SMA | 10 – 18000 | 0.25 | Huber + Suhner |
| 116 | SMA | 10 – 18000 | 0.25 | Huber + Suhner |
| 119 | N | 10 – 20000 | 8.00 | Jyebao |
| 121 | SMA | 10 – 18000 | 1.50 | Huber + Suhner |
| 122 | SMA | 10 – 18000 | 2.00 | Huber + Suhner |
| 123 | SMA | 10 – 18000 | 2.00 | Huber + Suhner |


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| Internal Cable Number | Connector Type | Frequency Range (MHz) | Cable Length (m) | Manufacturer |
|---|---|---|---|---|
| 145 | SMA | 10 – 26500 | 8.00 | Huber + Suhner |
| 147 | APC3.5 | 10 – 40000 | 1.50 | Jyebao |
| 148 | APC3.5 | 10 – 40000 | 3.00 | Jyebao |
| 151 | SMA | 10 – 18000 | 0.50 | Rosenberger |
| 152 | SMA | 10 – 18000 | 0.50 | Rosenberger |
| 154 | BNC | 10 – 1000 | 1.00 | --- |
| 155 | N/BNC | --- | 0.85 | --- |
| 157 | BNC | --- | 0.50 | --- |
| 158 | SMA | 10 – 26500 | 2.00 | Huber + Suhner |
| 160 | SMA | 10 – 18000 | 0.40 | Nortel Networks |
| 161 | SMA | 10 – 18000 | 1.00 | Huber + Suhner |
| 162 | APC35 | 10 – 26500 | 2.00 | Huber + Suhner |
| 163 | APC3.5 | 10 - 26500 | 2.00 | Huber + Suhner |
| 164 | APC3.5 | 10 – 26500 | 2.00 | Huber + Suhner |
| 165 | APC2.9 | 10 – 26500 | 2.00 | Huber + Suhner |
| 166 | APC3.5 | 10 – 40000 | --- | --- |
| 167 | APC3.5 | 10 – 40000 | 1.00 | Jyebao |
| 168 | APC3.5 | 10 – 40000 | 1.00 | Jyebao |
| 169 | APC3.5 | 10 – 40000 | 1.00 | Jyebao |
| 170 | APC3.5 | 10 – 40000 | 1.00 | Jyebao |
| 171 | APC3.5 | 10 – 40000 | 1.00 | Jyebao |
| 172 | SAM | --- | 0.90 | Huber + Suhner |
| 173 | APC | 10 – 26500 | 2.00 | Huber + Suhner |
| 174 | APC | 10 – 26500 | --- | Huber + Suhner |
| 175 | SMA | 10 – 18000 | 0.40 | Huber + Suhner |
| 176 | N-SMA | 10 – 18000 | 0.50 | Huber + Suhner |
| 188 | N | 10 – 18000 | 5.00 | Huber + Suhner |
| EMV 1 | BNC | --- | 2.00 | Henn |
| EMV 2 | BNC | 10 – 1000 | 2.00 | Henn |
| EMV 4 | BNC | --- | 9.70 | Henn |
| EMV 5 | BNC | --- | 3.80 | Henn |
| EMV 6 | BNC/N | 10 – 1000 | 5.00 | Lüthi |
| EMV 7 | BNC | 10 – 1000 | 1.50 | Henn |
| EMV 8 | BNC | 10 – 1500 | 1.70 | Henn |
| EMV 9 | BNC | 10 – 1000 | 1.70 | Henn |
| EMV 11 | BNC | --- | 5.20 | Hasselt |
| EMV 12 | BNC | 10 – 1000 | 2.40 | Hasselt |
| EMV 13 | BNC | 10 – 1000 | 4.10 | Hasselt |
| EMV 14 | BNC | 10 – 1000 | 2.50 | Hasselt |
| EMV 15 | BNC | --- | 0.90 | Henn |
| EMV 16 | Fischer | --- | 2.00 | --- |
| EMV 18a | Fischer | --- | 1.00 | --- |
| EMV 19a | Fischer | --- | 1.50 | --- |
| KISN2 | BNC | 10 – 2000 | 4.80 | --- |


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# End of test report



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