# TEST REPORT # EMCC-040197.1EB, 2021-03-11

**EQUIPMENT UNDER TEST:**

| | |
|---|---|
| Trade Name: | Torque meter |
| Type: | 7HA.03 |
| Serial Number(s): | 201040001 |
| Equipment Class: | Low Power Transceiver |
| FCC ID: | 2ADAT-TJ1S8-2K |
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Address: | Im Tiefen See 45<br>64293 Darmstadt<br>GERMANY |
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**RELEVANT STANDARD(S):** 47 CFR § 15.203, § 15.207, § 15.209, § 15.225

**MEASUREMENT PROCEDURE:** ANSI C63.10-2013

**TEST REPORT PREPARED BY:**

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# 0 REVISION HISTORY

| Project number | Issue date | Chapter | Description |
|---|---|---|---|
| 040197.1EB | 2021-03-11 | n.a. | Initial issue |

# 1 GENERAL INFORMATION

## 1.1 Purpose

The purpose of this report is to show compliance with the 47 CFR § 15.203, § 15.207, § 15.209, § 15.225 requirements applicable to intentional radiators.

## 1.2 Limits and Reservations

The test results in this report apply only to the particular equipment under test (EUT) as declared in this report. This test report shall not be reproduced except in full without the written permission of EMCCons DR. RAŠEK GmbH & Co. KG. Document(s) and/or information, which were provided by the customer, can affect the validity of results.

## 1.3 Test Laboratory

| | |
|---|---|
| Test Laboratory: | EMCCons DR. RAŠEK GmbH & Co. KG |
| Accreditation No.: | D-PL-12067-01-04 |
| FCC Test Firm Registration No.: | 368753 |
| Address of Labs I, II, III and Head Office: | EMCCons DR. RAŠEK GmbH & Co. KG<br>Boelwiese 8<br>91320 Ebermannstadt<br>GERMANY |
| Address of Labs IV and V: | EMCCons DR. RAŠEK GmbH & Co. KG<br>Stoernhofer Berg 15<br>91364 Unterleinleiter<br>GERMANY |
| Phone: | +49 9194 7262-0 |
| Fax: | +49 9194 7262-199 |
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| Web: | www.emcc.de |

## 1.4 Customer

| | |
|---|---|
| Company Name: | Hottinger Brüel & Kjaer GmbH |
| Street: | Im Tiefen See 45 |
| City: | 64293 Darmstadt |
| Country: | GERMANY |
| | |
| Name: | Mr Alexander Ehrhard |
| Phone: | +49 6151 803 8346 |
| Fax: | +49 6151 803 98346 |
| E-Mail: | alexander.ehrhard@hbkworld.com |

## 1.5 Manufacturer

| | |
|---|---|
| Company Name: | Hottinger Brüel & Kjaer GmbH |
| Street: | Im Tiefen See 45 |
| City: | 64293 Darmstadt |
| Country: | Germany |
| Phone: | +49 6151 803 8346 |
| E-Mail: | alexander.ehrhard@hbkworld.com |

## 1.6 Dates and Test Location

| | |
|---|---|
| Date of receipt of EUT: | 2020-11-17, 2021-02-15 |
| Test Date: | CW 47/2020, CW 7/2021 |
| Test Location: | Lab IV |

## 1.7 Ordering Information

| | |
|---|---|
| Purchase Order: | D29-4500741875/2000 |
| Date: | 2020-09-11 |
| Vendor-Number: | 806266 |

## 1.8 Climatic Conditions

| Date | Temperature | Relative Humidity | Air Pressure | Lab | Customer attended tests |
|---|---|---|---|---|---|
| -- | °C | % | hPa | -- | -- |
| 2020-11-19 | 22 | 37 | 979 | IV | No |
| 2020-11-20 | 22 | 34 | 991 | IV | No |
| 2021-02-16 | 21 | 26 | 979 | IV | No |
| 2021-02-17 | 22 | 30 | 978 | IV | No |
| 2021-02-18 | 22 | 29 | 976 | IV | No |

# 2 PRODUCT DESCRIPTION

## 2.1 Equipment under Test (EUT)

The following data is based on customer's information.

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Trade Name: | Torque meter |
| Type: | 7HA.03 |
| Serial No(s): | 201040001 |
| Application: | Low Power Transceiver |
| FCC ID: | 2ADAT-TJ1S8-2K |
| Hardware Version: | Control Unit CH1: Rev.: 1.0<br>Control Unit CH2: Rev.: 2.0<br>Rotor Units: Rev.: 9.0<br>Stator Unit: Rev.: 2.0 |
| Transmit Frequency: | 22 kHz (wireless power transfer)<br>10.7 MHz (wireless data transfer)<br>13.56 MHz (wireless data transfer) |
| Number of RF channels: | 3 |
| Modulation: | CW (22 kHz, wireless power transfer)<br>FM (10.7 MHz + 13.56 MHz wireless data transfer) |
| Highest Internal Frequency | 66 MHz (Rotor Units) |
| Power Supply: | 24 VDC |
| Ports: | Signal and supply – 4 pole Lemo (Type EHG.1B) connector |
| Antenna types: | Integrated loop antenna |
| Remarks: | None |

## 2.2 Intended Use

The following information was delivered by the customer.

| |
|---|
| The EUT is a complete measuring system to measure torque on a rotating shaft. The standard use is inside a test stand. |

## 2.3 EUT Peripherals/Simulators

For all radiated and conducted emission tests the following setup was used:

- Power supply TRIO-PS/1AC/24DC/5 (Phoenix Contact)
- Axon System Control Unit J1 CS10 (10.7 MHz), #36807
- Axon System Control Unit J1 CS13M (13.56 MHz), #41106
- Axon Stator Unit JX-SR70TL, #38235
- Data cable

For frequency stability tests the following dummy setup was used:

- Power supply TRIO-PS/1AC/24DC/5 (Phoenix Contact)
- Axon System Control Unit J1 CS13M (13.56 MHz), #41106
- Axon Stator Unit JX-SR70TL, #38235
- Axon Rotor Unit J1-RD13T_V3, #41385

## 2.4 Mode of operation during testing and test setup

The following information was delivered by the customer.

**Normal operation:**
The EUT is configured to start wireless power supply, measurement and data transfer as soon as supplied by external power.

For the radiated emission test the Axon system control units and the 24VDC power supply were operated outside of the test environment.

For the conducted emission test the EUT was powered with 24 VDC by the AC / DC supply TRIO-PS/1AC/24DC/5 delivered by the customer. The AC/DC power supply was connected to 120 V / 60 Hz.

For the frequency stability tests a dummy setup was used. One Axon system control unit with 13.56 MHz was connected to a dummy magnetic loop antenna. Inside this loop antenna a dummy rotor unit was placed.

Statement of the customer:
“For this dummy setup the input transformer had 1 winding less than the EUT on the primary side. Normal winding ratio 3:78 / dummy setup winding ratio 2:78. The measure affects the input impedance of the transformer to the increased output impedance of the rotor winding.
Deviations of the carrier frequency over temperature are not known. A measurement of the frequency stability over temperature is not necessary from the manufacturer's point of view, since the carrier frequency is not generated analogously but digitally by software.”

## 2.5 Modifications required for compliance

None.

## 3 TEST RESULTS SUMMARY

Summary of test results for the following EUT:

Manufacturer: Hottinger Brüel & Kjaer GmbH
Type: 7HA.03
Serial No.: 201040001

| Requirement | 47 CFR Section | Report Section | Result |
|---|---|---|---|
| Antenna Requirement | § 15.203 | 4 | Passed |
| AC Power Line Conducted Emissions | § 15.207 | 5 | Passed |
| Radiated Emissions 9kHz – 30 MHz | § 15.209<br>§ 15.205 | 6 | Passed |
| Radiated Emissions 30 MHz – 1 GHz | § 15.209<br>§ 15.205 | 7 | Passed |
| Spectrum Mask | § 15.225(a)-(d) | 8 | Passed |
| Carrier Frequency Stability | § 15.225(e) | 9, 10 | Passed |

The client has made the determination that EUT Condition, Characterization, and Mode of Operation are representative of production units and meet the requirements of the specifications referenced herein.
Consistent with Industry practice, measurement and test equipment not directly involved in obtaining measurement results but having an impact on measurements (such as cable loss, antenna factors, etc.) are factored into the "Correction Factor" documented in certain test results. Instrumentation employed for testing meets tolerances consistent with known Industry Standards and Regulations.
The measurements contained in this report were made in accordance with the procedures described in ANSI C63.10-2013 and all applicable Public Notices received prior to the date of testing. All requirements were found to be within the limits outlined in this report.

The test results in this report apply only to the particular equipment under test (EUT) as declared in this report.

Test personnel: Dominik Krüger
Issuance date: 2021-02-25

# 4 ANTENNA REQUIREMENT

Test Requirement: FCC: 47 CFR §15.203

## 4.1 Regulation

**47 CFR § 15.203 Antenna requirement**

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 Part 15C. The manufacturer may design the unit so that the user can replace a broken antenna, 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 Sections 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 Section 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.

## 4.2 Test Procedures

None.

## 4.3 Test Result

The EUT is equipped with a fixed loop antenna.

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test personnel: | Dominik Krüger |

**The EUT meets the requirements of this section.**

# 5 AC POWER LINE CONDUCTED EMISSIONS

Test Requirement: 47 CFR §15.207
Test Procedure: ANSI C63.10-2013

## 5.1 Regulation

**47 CFR § 15.207 Conducted limits**

(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.

| Frequency of emission (MHz) | Conducted limit (dBµV) | |
|---|---|---|
| | Quasi-peak | Average |
| 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.

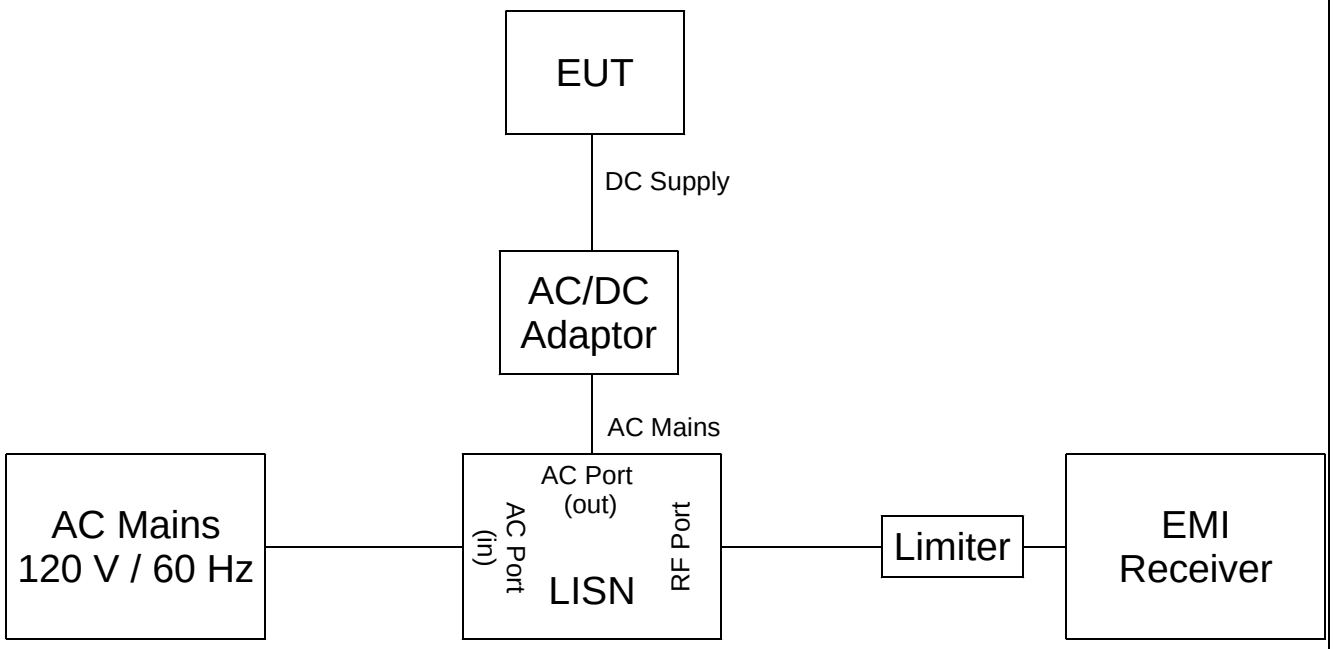
(c) Measurements to demonstrate compliance with the conducted limits are not required for devices which only employ battery power for operation and which do not operate from the AC power lines or contain provisions for operation while connected to the AC power lines. Devices that include, or make provisions 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.

## 5.2 Test Procedures

The EUT was placed on a wooden support above the reference ground plane.
LISN housing, measuring instrument case and reference ground plane were bonded together.

The measurement receiver is connected to the 50 Ω RF port of the LISN.

## 5.3 Test Setup

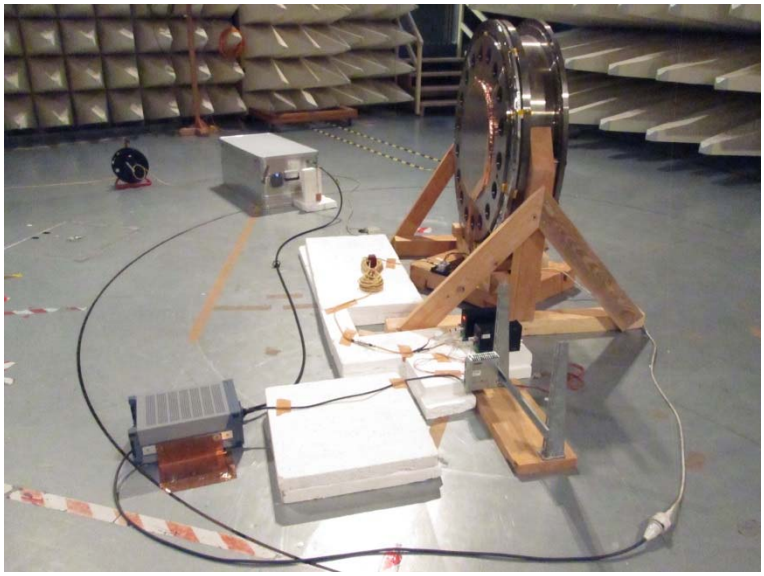



SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.207
Procedure: ANSI C63.10-2013

Power source: #1
Receiver: #3846
LISN: #1470

TEST EQUIPMENT USED:
Refer to chapter 11 of this document.
1, 1470, 1519, 1889, 3846, 4075, 4717, 5392, 5551

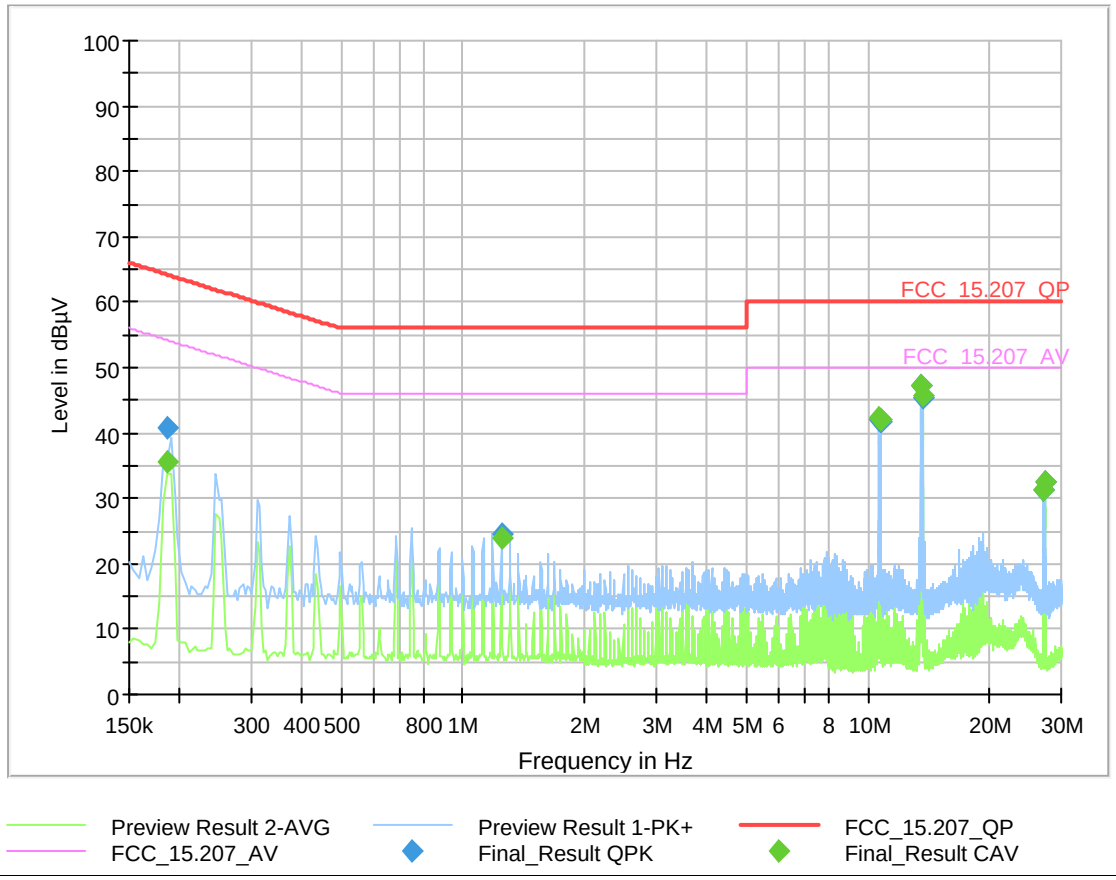


Sample photo of setup

Test on Hottinger Brüel & Kjaer GmbH 7HA.03 to 47 CFR § 15.203, § 15.207, § 15.209, § 15.225

### 5.3.1 Detailed Test Data

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No: | 201040001 |
| Mode: | Normal operation |
| Line: | L and N (max hold) |




Final Results:

| Frequency (MHz) | QuasiPeak (dBµV) | CAverage (dBµV) | Limit (dBµV) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Line | Corr. (dB) |
|---|---|---|---|---|---|---|---|---|
| 0.19 | --- | 35.4 | 54.2 | 18.8 | 1000 | 9.0 | N | 10.0 |
| 0.19 | 40.8 | --- | 64.2 | 23.4 | 1000 | 9.0 | N | 10.0 |
| 1.25 | --- | 23.9 | 46.0 | 22.1 | 1000 | 9.0 | N | 10.0 |
| 1.25 | 24.7 | --- | 56.0 | 31.3 | 1000 | 9.0 | N | 10.0 |
| 10.67 | --- | 42.3 | 50.0 | 7.7 | 1000 | 9.0 | N | 10.0 |
| 10.67 | 42.2 | --- | 60.0 | 17.9 | 1000 | 9.0 | N | 10.0 |
| 10.73 | --- | 42.0 | 50.0 | 8.0 | 1000 | 9.0 | N | 10.0 |
| 10.73 | 41.9 | --- | 60.0 | 18.1 | 1000 | 9.0 | N | 10.0 |
| 13.52 | --- | 47.3 | 50.0 | 2.7 | 1000 | 9.0 | N | 10.0 |
| 13.52 | 47.1 | --- | 60.0 | 12.9 | 1000 | 9.0 | N | 10.0 |
| 13.68 | --- | 45.6 | 50.0 | 4.4 | 1000 | 9.0 | N | 10.0 |
| 13.68 | 45.4 | --- | 60.0 | 14.6 | 1000 | 9.0 | N | 10.0 |
| 27.04 | --- | 31.3 | 50.0 | 18.7 | 1000 | 9.0 | N | 10.0 |
| 27.04 | 31.4 | --- | 60.0 | 28.6 | 1000 | 9.0 | N | 10.0 |
| 27.36 | --- | 32.5 | 50.0 | 17.6 | 1000 | 9.0 | N | 10.0 |
| 27.36 | 32.5 | --- | 60.0 | 27.5 | 1000 | 9.0 | N | 10.0 |

Worst case results listed, only.

## 5.4 Test Result

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test date: | 2021-02-18 |
| Test personnel: | Dominik Krüger |

**The EUT meets the requirements of this section.**

# 6 RADIATED EMISSIONS 9 kHz – 30 MHz

Test requirement: 47 CFR §15.205, §15.209
Test procedure: ANSI C63.10-2013

## 6.1 Regulation

**47 CFR § 15.31**

(f)(2) At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). This paragraph (f) shall not apply to Access BPL devices operating below 30 MHz.

**47CFR § 15.33 Frequency range of radiated measurements**

(a) For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

**47 CFR § 15.35 Measurement detector functions and bandwidths.**

(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrumentation using the CISPR quasi-peak detector can be found in ANSI C63.4-2014, clause 4 (incorporated by reference, see §15.38). As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function as long at the same bandwidth as indicated for CISPR quasi-peak measurements are employed.

**§15.205 Restricted bands of operation.**

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

| MHz | MHz | MHz | 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.
[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.

**47 CFR § 15.209 Radiated emission limits; general requirements.**

(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:

| Frequency (MHz) | Field strength (microvolts/meter) | Measurement distance (meters) |
|---|---|---|
| 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.

(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.

## 6.2 Test Procedures

The measurement was performed in a semi-anechoic room at a test distance of 3 m. A calibrated loop antenna as specified in ANSI C63.10 clause 4.3.2 was positioned with its plane vertical at the test distance from the EUT and rotated about its vertical axis for maximum response at each azimuth about the EUT. The lowest height of the loop antenna was 1 m above the ground.
The EUT was tested on a wooden support on the groundplane.
The EUT was connected to its associated peripherals, with any excess I/O cabling bundled to approximately 1 meter. In certain applications, a remotely located device may be connected to the EUT. In these cases, it is permissible for cabling from the remotely located device to the EUT or accessories to be placed directly on the reference groundplane or, if normally installed beneath the reference groundplane, beneath it. The remotely located device shall be located at a distance sufficient to ensure that it does not contribute to the measured level. This procedure evaluates the interference potential of the EUT, its accessories, and interconnecting cables or wires standing apart from the remotely located device, which in turn shall be evaluated separately, if required.
Measurement initially performed as a pre-scan in the full frequency range in order to find worst case emissions. Final measurement performed at worst-case emission frequencies in a FCC and ISED listed semi-anechoic room at the specified 3 m test distance. Pre-scan and final measurement performed in modulated mode.

Worst case emissions are listed under chapter: Detailed Test Data.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 9 kHz – 30 MHz |
| Test distance | 3 m |
| Test instrumentation resolution bandwidth | 200 Hz (9 kHz - 150 kHz)<br>9 kHz (150 kHz - 30 MHz) |
| Receive antenna height | 1 m |
| Angular steps size during prescan | 90 ° |
| Receive antenna polarization | vertical |
| Measurement chamber | Semi anechoic chamber (SAC) |

* According to Section 15.31 (f)(2): At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). The 40 dB/decade factor was used.

## 6.3 Test Site Correlation for H Field Measurement in Semi-Anechoic Chamber (SAC)

Test procedure following KDB 414788 D01.

The carrier at 22.3 kHz was measured in the semi-anechoic room (SAC) at a test distance of 3 m and at an open field site at a test distance of 3 m and 10 m with the same calibrated loop antenna. This test was done with a set-up consisting of a single turn loop antenna with a diameter of 1.2 m fed by a signal generator. The signal generator was set to a fixed output level with an unmodulated 22.3 kHz sinusoidal signal (documented in test report EMCC-040197V, dated 2018-05-30).

This measurement was used to evaluate a correction of the open field measurement to the semi-anechoic room measurement.

| Freq | Detector | Distance | $F_{SAC}$ | $F_{open}$ | $f_c$ |
|---|---|---|---|---|---|
| [kHz] | | [m] | [dBµV/m] | [dBµV/m] | dB |
| 22.3 | AV | 3 | 109.9 | 107.4 | -2.5 |

Test date: 2018-04-27

$f_C = F_{open} - F_{SAC}$

$f_C$ is correlation factor from SAC to open field site field strength
$F_{open}$ measured field strength at open field site
$F_{SAC}$ measured field strength at SAC

## 6.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits for the band 1.705–30.0 MHz:
µV/m at 30 meters = 30
30 µV/m corresponds with 29.5 dBµV/m.

## 6.5 Field Strength Calculation

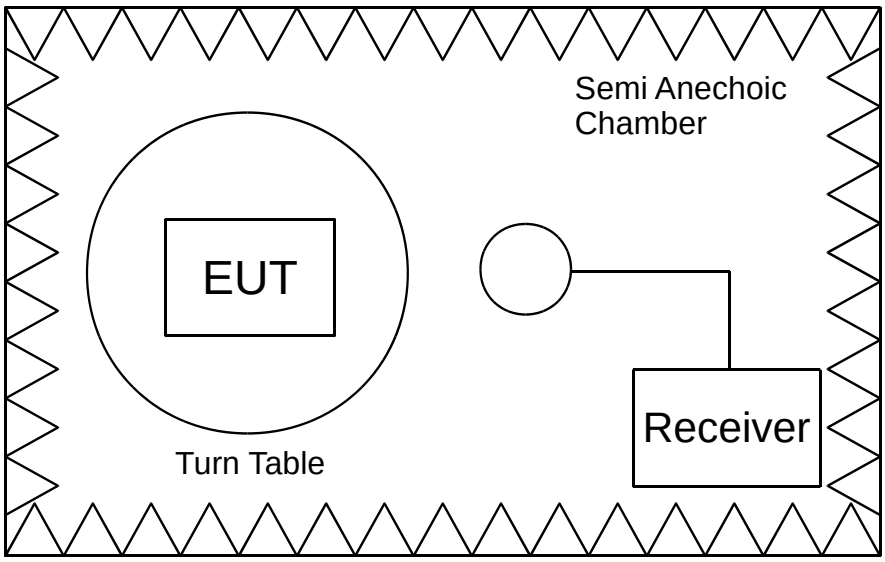
All emission measurements performed using the EMI test program's transducer factor setting capability, i.e. the field strength value measured directly without the necessity of additional correction factors.
For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f)(2) the field strength is calculated by adding additionally an extrapolation factor of 40 dB/decade (inverse linear-distance for field strength measurements). The basic equation with a sample calculation is as follows:

FS = FST + DF
where
FS = Field Strength in dBµV/m
FST = Field Strength at test distance in dBµV/m
DF = Distance Extrapolation Factor in dB,
where DF = 40 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified Distance

Assume the tests performed at a reduced Test Distance of 3 m instead of the Specified Distance of 30 m giving a Distance Extrapolation Factor of DF = 40 log (3 m/30 m) = -40 dB.
Assuming a measured field strength level of 52.5 dBµV/m is obtained. The Distance Factor of -40 dB is added giving a field strength of 12.5 dBµV/m. The 12.5 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 52.5 - 40= 12.5 [dBµV/m]
Level in µV/m = Common Antilogarithm (12.5/20) = 4.2

## 6.6 Test Setup



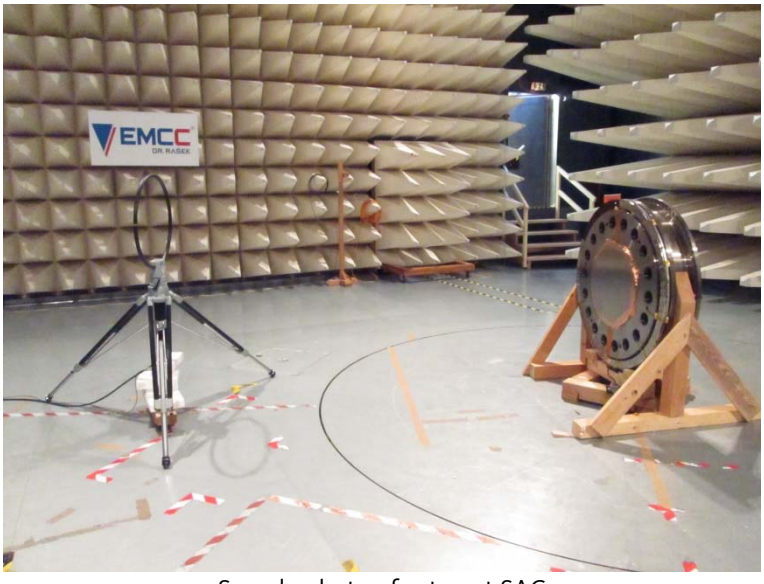

SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.209
Procedure: ANSI C63.10-2013

Receiver: #3846
Antenna: #374

Test distance: 3 m

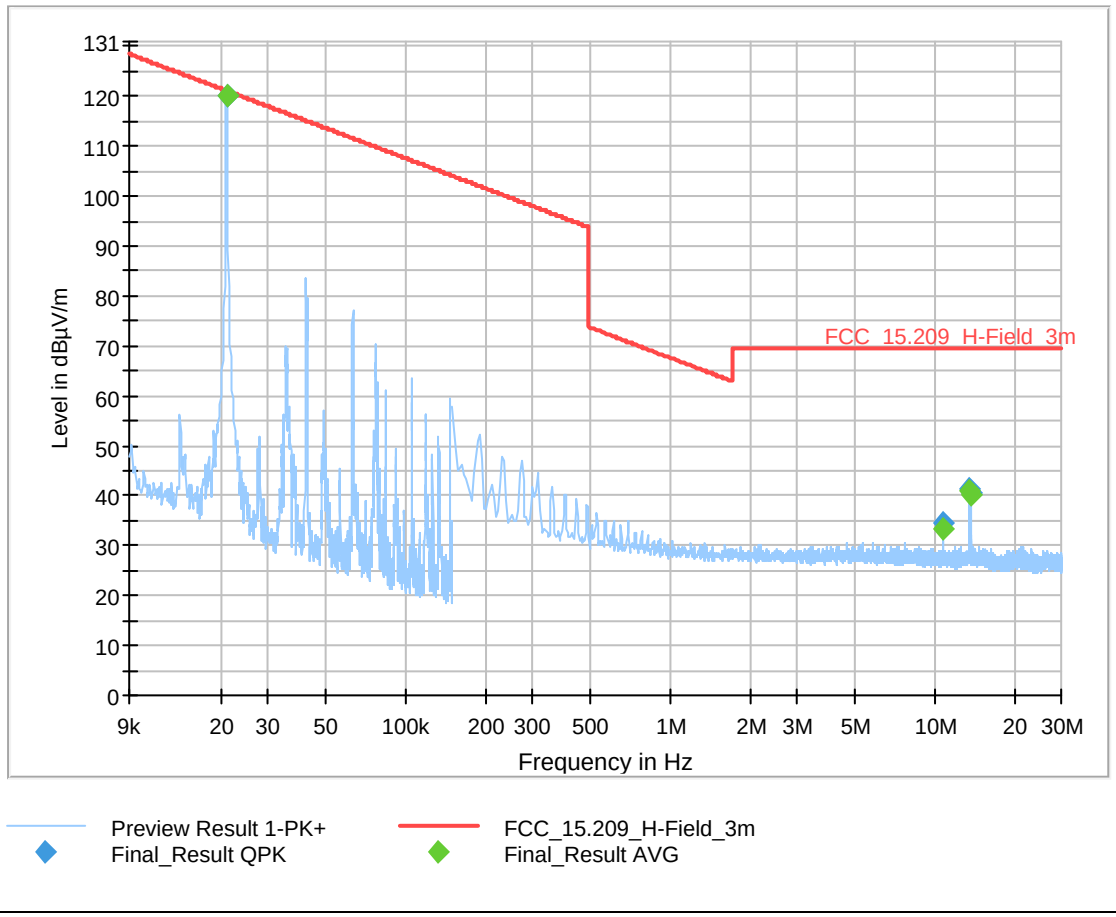
TEST EQUIPMENT USED:
Refer to chapter 11 of this document.
374, 1292, 1416, 1889, 3493, 3846, 4075, 4717, 5392



Sample photo of setup at SAC

### 6.6.1 Detailed Test Data

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No: | 201040001 |
| Mode: | Normal Operation |




Final Result:

| Freq. [MHz] | Detector | 3m_Result [dB(µV/m)] | $f_c$ [dB] | Distance Correction [dB] | 30m_Result [dB(µV/m)] | 30m_Limit [dB(µV/m)] | 300m_Result [dB(µV/m)] | 300m_Limit [dB(µV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|---|---|---|
| 0.022 | AV | 120.4 | -2.5 | -80 | | | 37.9 | 40.6 | 2.7 |
| 10.67 | QP | 34.5 | - | -40 | -5.5 | 29.5 | | | 35 |
| 13.52 | See in chapter 8.6.1 | | | | | | | | |
| 13.68 | | | | | | | | | |

Worst case results listed, only.

Note: The plot shows field strength reading at 3 m distance. In order to compare the 3 m reading with the specified field strength limits a distance correction as described in chapter 6.5 (40 dB/decade) was applied to the limit (represented by the limit line „FCC_15.209_HField_3m“).

## 6.7 Test Result

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test date: | 2021-02-16, 2021-02-17 |
| Test personnel: | Dominik Krüger |

**The EUT meets the requirements of this section.**

# 7 RADIATED EMISSIONS 30 MHz – 1 GHz

Test Requirement: 47 CFR §15.205, §15.209
Test Procedure: ANSI C63.10-2013

## 7.1 Regulation

**§ 15.33 Frequency range of radiated measurements:**
(a) For an intentional radiator, the spectrum shall be investigated from the lowest radio frequency signal generated in the device, without going below 9 kHz, up to at least the frequency shown in this paragraph:
(1) If the intentional radiator operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.
(4) If the intentional radiator contains a digital device, regardless of whether this digital device controls the functions of the intentional radiator or the digital device is used for additional control or function purposes other than to enable the operation of the intentional radiator, the frequency range shall be investigated up to the range specified in paragraphs (a)(1) through (a)(3) of this section or the range applicable to the digital device, as shown in paragraph (b)(1) of this section, whichever is the higher frequency range of investigation.
(b) For unintentional radiators:
(1) Except as otherwise indicated in paragraphs (b)(2) or (b)(3) of this section, for an unintentional radiator, including a digital device, the spectrum shall be investigated from the lowest radio frequency signal generated or used in the device, without going below the lowest frequency for which a radiated emission limit is specified, up to the frequency shown in the following table:

| **Highest frequency generated or used in the device or on which the device operates or tunes** | **Upper frequency of measurement range (MHz)** |
|---|---|
| **[MHz]** | **[MHz]** |
| Below 1.705 | 30 |
| 1.705-108 | 1000 |
| 108-500 | 2000 |
| 500-1000 | 5000 |
| Above 1000 | 5th harmonic of the highest frequency or 40 GHz, whichever is lower. |

**§15.35** Measurement detector functions and bandwidths.
The conducted and radiated emission limits shown in this Part are based on the following, unless otherwise specified elsewhere in this Part:
(a) On any frequency or frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function and related measurement bandwidths, unless otherwise specified. The specifications for the measuring instrument using the CISPR quasi-peak detector can be found in Publication 16 of the International Special Committee on Radio Interference (CISPR) of the International Electrotechnical Commission. As an alternative to CISPR quasi-peak measurements, the responsible party, at its option, may demonstrate compliance with the emission limits using measuring equipment employing a peak detector function, properly adjusted for such factors as pulse desensitization, as long as the same bandwidths as indicated for CISPR quasi-peak measurements are employed.
Note: For pulse modulated devices with a pulse-repetition frequency of 20 Hz or less and for which CISPR quasi-peak measurements are specified, compliance with the regulations shall be demonstrated using measuring equipment employing a peak detector function, properly adjusted for such factors as pulse desensitization, using the same measurement bandwidths that are indicated for CISPR quasi-peak measurements.

**§15.209**(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:

| **Frequency** | **Field Strength** | | **Measurement Distance** |
|---|---|---|---|
| **(MHz)** | **(µV/m)** | **(dB(µV/m))** | **(m)** |
| 30–88 | 100 | 40.0 | 3 |
| 88–216 | 150 | 43.5 | 3 |
| 216-960 | 200 | 46 | 3 |
| Above 960 | 500 | 54 | 3 |

(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.
(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.

## 7.2 Test Procedures

The EUT was tested on a wooden support on the groundplane. In certain applications, a remotely located device may be connected to the EUT. In these cases, it is permissible for cabling from the remotely located device to the EUT or accessories to be placed directly on the reference groundplane or, if normally installed beneath the reference groundplane, beneath it. The remotely located device shall be located at a distance sufficient to ensure that it does not contribute to the measured level. This procedure evaluates the interference potential of the EUT, its accessories, and interconnecting cables or wires standing apart from the remotely located device, which in turn shall be evaluated separately, if required.
With the EUT operating in "worst case" mode, emissions from the unit are maximized by adjusting the polarization and height of the receive antenna and rotating the EUT on the turntable.

Measurement initially performed as a pre-scan in the full frequency range in order to find worst case emissions. Final measurement performed at worst-case emission frequencies in a FCC and ISED listed semi-anechoic room at the specified 3 m test distance. Pre-scan and final measurement performed in modulated mode.
Final measurement performed up to the tenth harmonic of the carrier according to FCC Section 15.33.

Worst case emissions are listed under chapter: test results.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 30 MHz – 660 MHz (tenth harmonic of EUT is 660 MHz) |
| Test distance | 3 m |
| Test instrumentation resolution bandwidth | 120 kHz |
| Receive antenna height | 1 m - 4 m |
| Angular steps size during prescan: | 90 ° |
| Receive antenna polarization | Vertical/Horizontal |
| Measurement location | Semi Anechoic Chamber (SAC) |

* 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 20 dB/decade (inverse linear-distance for field strength measurements; inverse-linear-distance-squared for power density measurements).

## 7.3 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits for frequencies above 88 MHz:

µV/m at 3 meters = 150

150 µV/m corresponds with 43.5 dBµV/m.

## 7.4 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF

Corr. = AF + CF

where
FS = Field Strength in dBµV/m
RA = Receiver Amplitude in dBµV
AF = Antenna Factor in dB (1/m)
CF = Cable Attenuation Factor in dB
Corr = Transducer factor in dB

Assume a receiver reading of 23.4 dBµV is obtained. The Antenna Factor and a Cable Factor are added (Corr. = 13.6 dB), giving a field strength of 37.0 dBµV/m. The 37.0 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

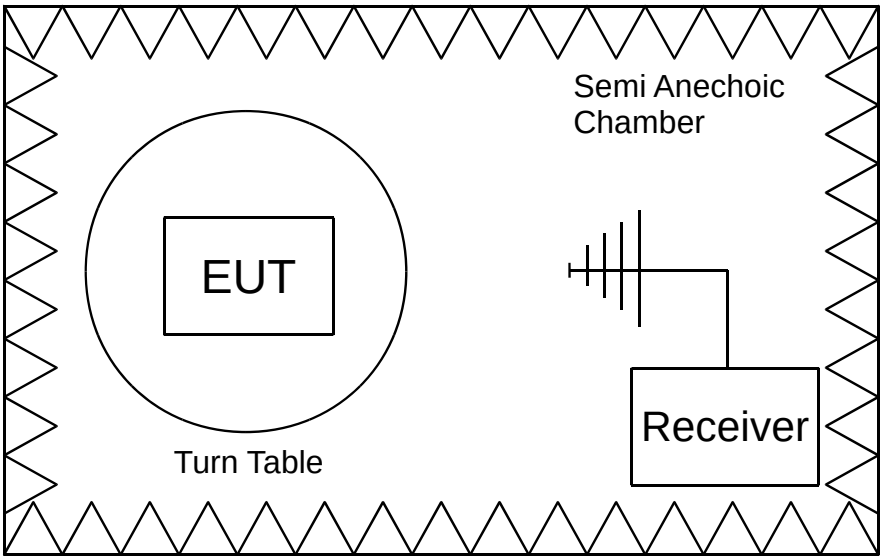
FS = 23.4 + 13.6 = 37.0 [dBµV/m]

Level in µV/m = Common Antilogarithm (37/20) = 70.8

All emission measurements described in this chapter performed using the EMI test program transducer factor setting capability, i.e. the field strength value at the test distance was measured directly without the necessity of additional correction factors. The transducer factor includes both, Antenna Factor and Cable Factor.

Test on Hottinger Brüel & Kjaer GmbH 7HA.03 to 47 CFR § 15.203, § 15.207, § 15.209, § 15.225

## 7.5 Test Setup



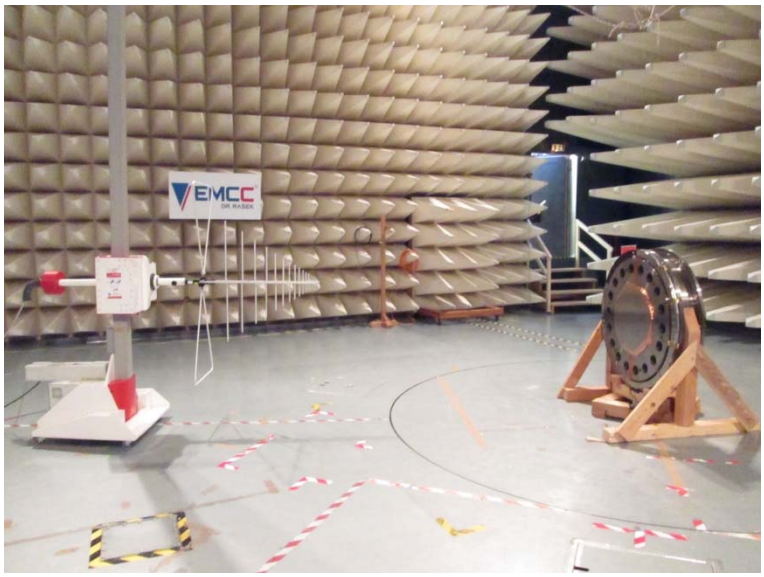

SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.209
Procedure: ANSI C63.10-2013

Receiver: #3846
Antenna: #6041

Test distance: 3 m

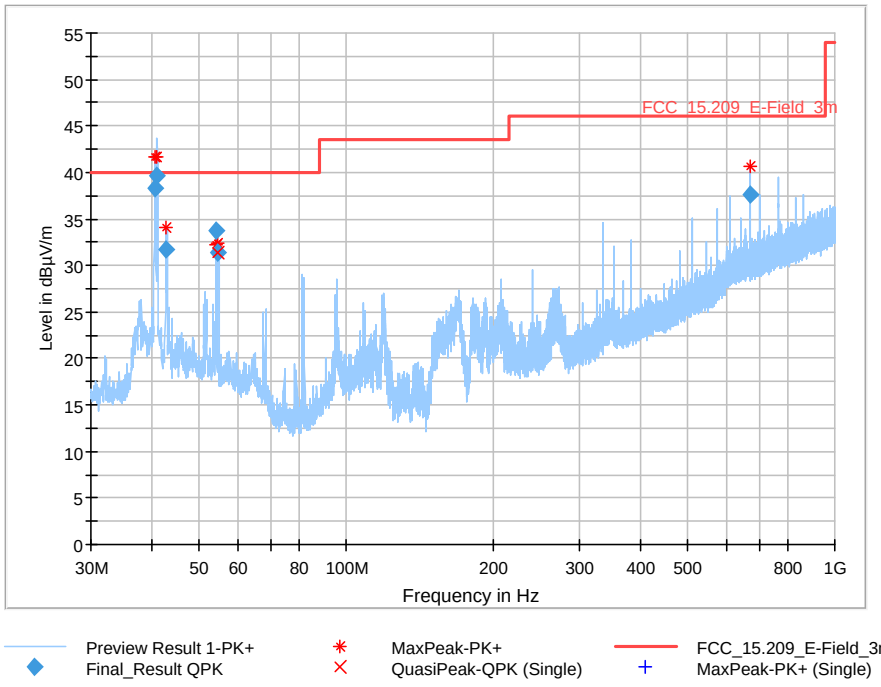
TEST EQUIPMENT USED:
Refer to chapter 11 of this document.
55, 1291, 1292, 1416, 1889, 2648, 2724, 3493, 3846, 4075, 4717, 5392, 6041, 6206



Sample photo of setup

### 7.5.1 Detailed Test Data

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No: | 201040001 |
| Mode: | Normal operation |




Final Result:

| Frequency (MHz) | QuasiPeak (dBµV/m) | Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol | Azimuth (deg) | Corr. (dB/m) |
|---|---|---|---|---|---|---|---|---|---|
| 40.56 | 38.3 | 40.0 | 1.7 | 1000 | 120.0 | 100.0 | V | -90 | 18.9 |
| 41.02 | 39.6 | 40.0 | 0.4 | 1000 | 120.0 | 101.0 | V | 180 | 19.0 |
| 42.66 | 31.7 | 40.0 | 8.3 | 1000 | 120.0 | 100.0 | V | 149 | 19.5 |
| 54.08 | 33.7 | 40.0 | 6.3 | 1000 | 120.0 | 100.0 | V | 97 | 19.5 |
| 54.72 | 31.4 | 40.0 | 8.6 | 1000 | 120.0 | 100.0 | V | -90 | 19.4 |
| 671.98 | 37.7 | 46.0 | 8.3 | 1000 | 120.0 | 113.0 | V | 9 | 28.2 |

Worst case results listed, only.

## 7.6 Test Result

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test date: | 2021-02-17 |
| Test personnel: | Dominik Krüger |

**The EUT meets the requirements of this section.**

# 8 SPECTRUM MASK

Test requirement: 47 CFR §15.225 (a)-(d)
Test procedure: ANSI C63.10-2013

## 8.1 Regulation

**§ 15.225** (a) The field strength of any emissions within the band 13.553–13.567 MHz shall not exceed 15,848 microvolts/ meter at 30 meters.
(b) Within the bands 13.410–13.553 MHz and 13.567–13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.
(c) Within the bands 13.110–13.410 MHz and 13.710–14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.
(d) The field strength of any emissions appearing outside of the 13.110– 14.010 MHz band shall not exceed the general radiated emission limits in§ 15.209.

## 8.2 Test Procedures

The measurement was performed in a semi-anechoic room at a test distance of 3 m. A calibrated loop antenna as specified in ANSI C63.10 clause 4.3.2 was positioned with its plane vertical at the test distance from the EUT and rotated about its vertical axis for maximum response at each azimuth about the EUT. The lowest height of the loop antenna was 1 m above the ground.

The EUT was tested on a wooden support on the groundplane. The EUT was connected to its associated peripherals, with any excess I/O cabling bundled to approximately 1 meter. In certain applications, a remotely located device may be connected to the EUT. In these cases, it is permissible for cabling from the remotely located device to the EUT or accessories to be placed directly on the reference groundplane or, if normally installed beneath the reference groundplane, beneath it. The remotely located device shall be located at a distance sufficient to ensure that it does not contribute to the measured level. This procedure evaluates the interference potential of the EUT, its accessories, and interconnecting cables or wires standing apart from the remotely located device, which in turn shall be evaluated separately, if required.
Measurement initially performed as a pre-scan in the full frequency range in order to find worst case emissions. Final measurement performed at worst-case emission frequencies in a FCC listed semi-anechoic room at the specified 3 m test distance. Pre-scan and final measurement performed in normal operation mode.

Worst case emissions are listed under chapter: Final test results.

## 8.3 Test Site Correlation for H Field Measurement in Semi-Anechoic Chamber (SAC)

Test procedure following KDB 414788

The carrier at 13.56 MHz was measured in the semi-anechoic room (SAC) at a test distance of 3 m and at an open field site at a test distance of 3 m and 10 m with the same calibrated loop antenna The measurement was performed with set-up consisting of a single turn loop antenna with a diameter of 0.85 m, fed by a signal generator. The signal generator was set to a fixed output level with a unmodulated 13.56 MHz sinusoidal signal. In addition a correlation measurement was done with a T12 S6 (documented in the test report EMCC-040197MAE, dated 2016-09-29).

These measurements were used for evaluate a correction of the open field measurement to the semi-anechoic room measurement.

| EUT | Freq | Detector | Distance | $F_{SAC}$ | $F_{open}$ | $f_c$ |
|---|---|---|---|---|---|---|
| | [MHz] | | [m] | [dBµV/m] | [dBµV/m] | dB |
| 0.85 m antenna simulation | 13.56 | QP | 3 | 91.5 | 88.2 | -3.3 |
| T12 S6 | 13.56 | QP | 3 | 71.8 | 68.5 | -3.3 |

| Radiated Emissions Test Characteristics | |
|---|---|
| Frequency range | 13.11 MHz – 14.01 MHz |
| Test distance | 3 m* |
| Test instrumentation resolution bandwidth | 10 kHz (150 kHz - 30 MHz) |
| Receive antenna height | 1 m |
| Receive antenna polarization | Vertical |

* According to Section 15.31 (f)(2): At frequencies below 30 MHz, measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field. Pending the development of an appropriate measurement procedure for measurements performed below 30 MHz, when performing measurements at a closer distance than specified, the results shall be extrapolated to the specified distance by either making measurements at a minimum of two distances on at least one radial to determine the proper extrapolation factor or by using the square of an inverse linear distance extrapolation factor (40 dB/decade). The 40 dB/decade factor was used.

## 8.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits for the band 13.553–13.567 MHz:
µV/m at 30 meters = 15848
15848 µV/m corresponds with 84 dBµV/m.

## 8.5 Field Strength Calculation

All emission measurements performed using the EMI test program's transducer factor setting capability, i.e. the field strength value measured directly without the necessity of additional correction factors.

For test distance other than what is specified, but fulfilling the requirements of Section 15.31 (f)(2) the field strength is calculated by adding additionally an extrapolation factor of 40 dB/decade (inverse linear-distance for field strength measurements). The basic equation with a sample calculation is as follows:

FS = FST + DF + fc

where

FS = Field Strength in dBµV/m

FST = Field Strength at test distance in dBµV/m

fC = correlation factor from SAC to open field site field strength

DF = Distance Extrapolation Factor in dB,

DF = Distance Extrapolation Factor in dB,

where DF = 40 log (Dtest/Dspec) where Dtest = Test Distance and Dspec = Specified Distance

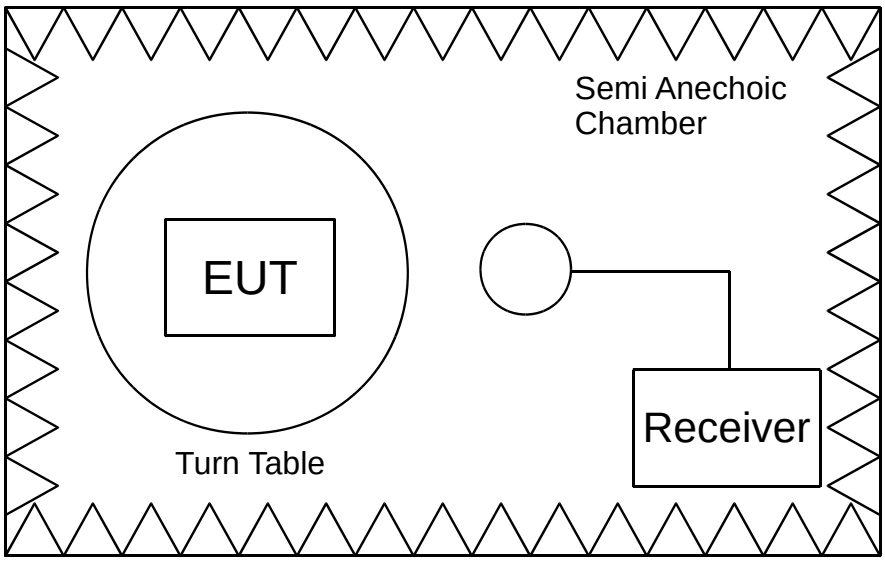
Assume the tests performed at a reduced Test Distance of 3 m instead of the Specified Distance of 30 m giving a Distance Extrapolation Factor of DF = 40 log (3 m/30 m) = -40 dB.

Assuming a measured field strength level of 68.0 dBµV/m is obtained. The Distance Factor of -40 dB and the correlation factor fc of -3.3 dB is added giving a field strength of 20.7 dBµV/m. The 20.7 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 68.0 - 40 - 3.3 = 20.7 [dBµV/m]

Level in µV/m = Common Antilogarithm (20.7.6/20) = 10.8

## 8.6 Test Setup



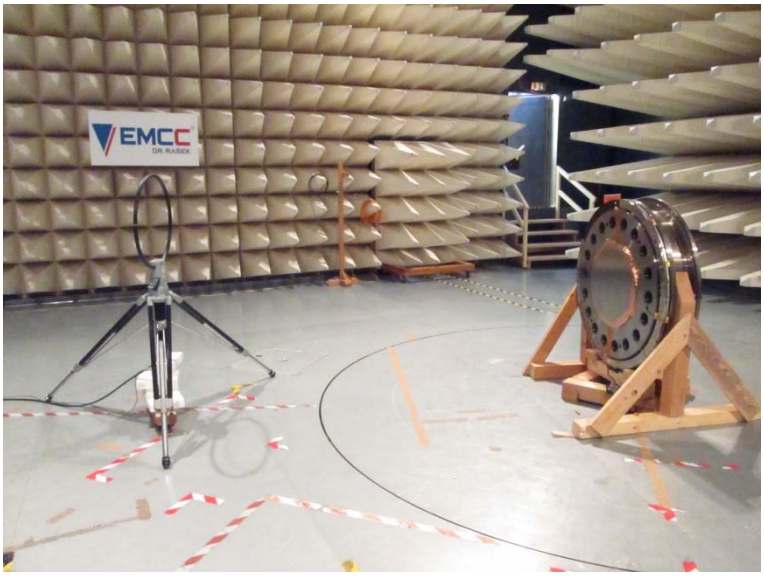

SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.225
Procedure: ANSI C63.10-2013

Receiver: #3846
Antenna: #374

Test distance: 3 m

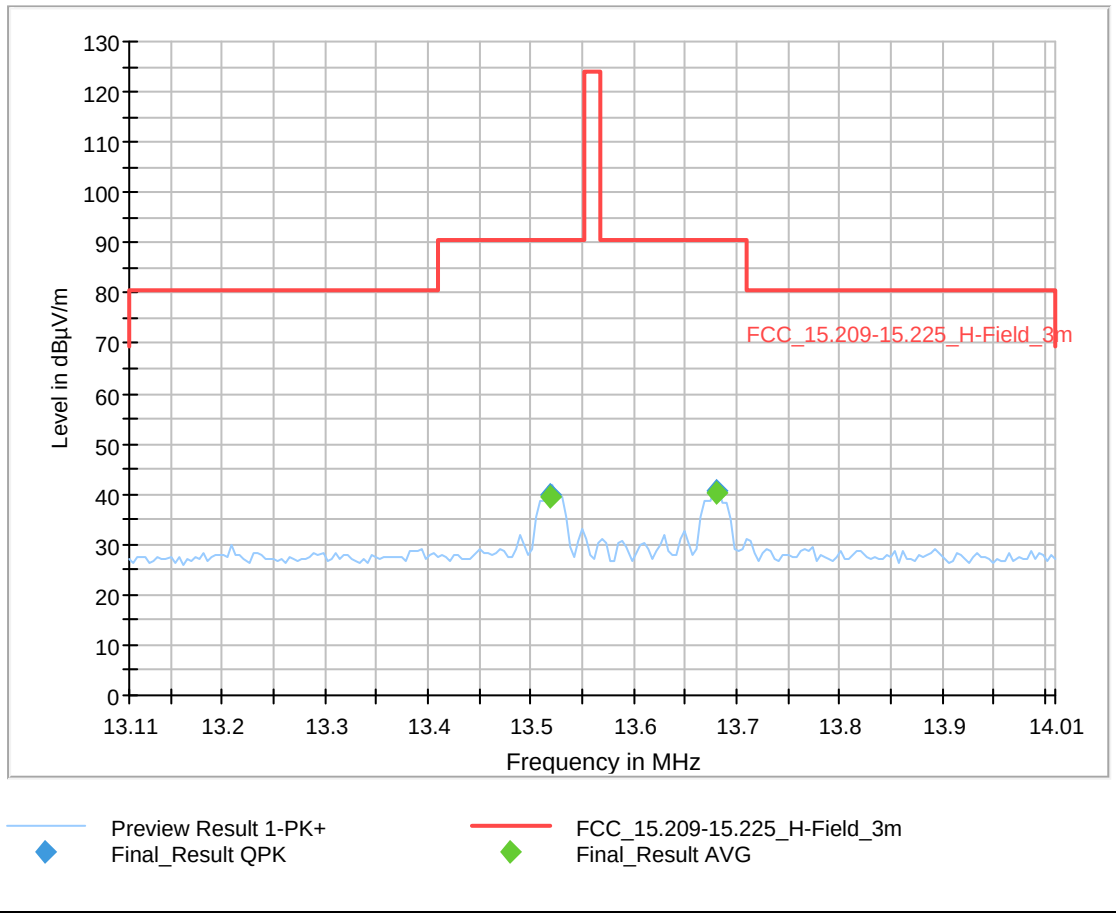
TEST EQUIPMENT USED:
Refer to chapter 11 of this document.
374, 1292, 1416, 1889, 3493, 3846, 4075, 4717, 5392



Sample photo of setup at SAC

### 8.6.1 Detailed Test Data

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No: | 201040001 |
| Mode: | Normal Operation |




Final Result:

| Frequency (MHz) | QuasiPeak (dBµV/m) 3 m result | 3 m Limit (dBµV/m) | Margin (dB) | Meas. Time (ms) | Bandwidth (kHz) | Height (cm) | Pol |
|---|---|---|---|---|---|---|---|
| 13.52 | 39.9 | 90.5 | 50.6 | 1000 | 9.0 | 100.0 | V |
| 13.68 | 40.8 | 90.5 | 49.7 | 1000 | 9.0 | 100.0 | V |

Worst case results listed, only.
Test site correlation not taken into account, since margin is ca. 50 dB.

## 8.7 Test Result

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test date: | 2021-02-17 |
| Test personnel: | Dominik Krüger |

**The EUT meets the requirements of this section.**

# 9 CARRIER FREQUENCY STABILITY VS TEMPERATURE

Test Requirement: FCC 47 CFR §15.225(e)
Test Procedure: ANSI C63.10-2013

## 9.1 Regulation

**47 CFR § 15.225 Operation within the band 13.110–14.010 MHz.**

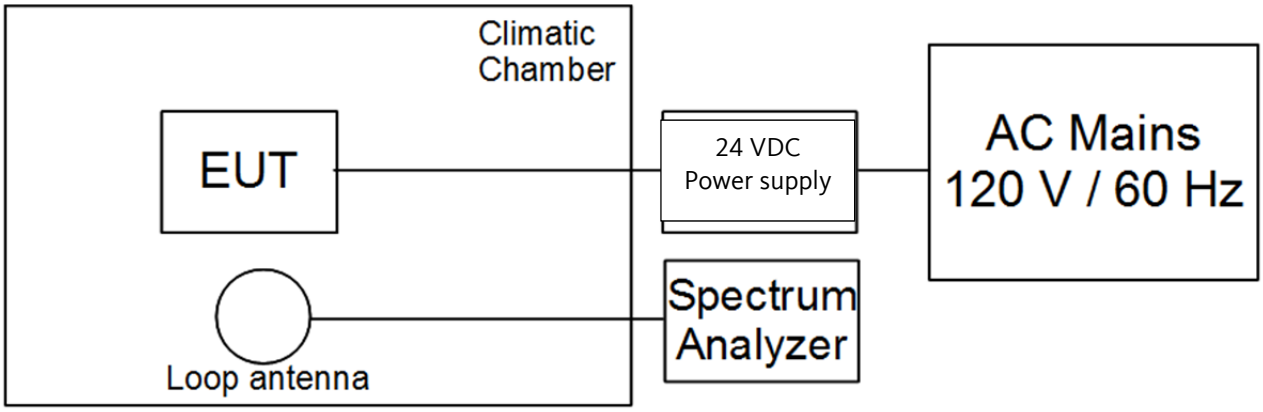
(e) The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of −20 degrees to + 50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

## 9.2 Test Procedures

**Frequency stability with respect to ambient temperature:**
The AC / DC supply of the EUT was supplied with the nominal AC voltage of 120 V at 60 Hz. The radio simulation setup was placed in the centre of the environmental test chamber. The measurement antenna was placed in the environmental test chamber next to the loop antenna and connected to a receiver. It was verified that the receiver had an adequate signal level to allow the measurement.

a) The temperature was set to + 50 °C.
While maintaining a constant temperature inside the environmental chamber, the EUT was turned on and the operating frequency was measured at start-up, two, five and ten minutes after the EUT was energized. Four measurements in total were made.
b) The EUT was switched off.
c) The chamber temperature was lowered by 10 °C and sufficient time was waited until the test chamber and the EUT did stabilize at the temperature.
d) The step a) through step c) were repeated down to the lowest specified temperature.
The highest deviation from the nominal carrier frequency was reported in the test result table.

## 9.3 Test Setup




SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.225
Procedure: ANSI C63.10-2013

Receiver: #3831
Antenna: #1731

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
1, 1731, 2766, 3026, 3831, 4686, 4933, 4955

## 9.4 Test Result

Test conditions: Supply voltage = 120 VAC, 60 Hz
$f_{ref}$ = 13.600550

| Temperature | Time | Frequency | Deviation from reference | | Limit | Lower limit | Upper Limit |
|---|---|---|---|---|---|---|---|
| [°C] | [min] | [MHz] | [Hz] | [ppm] | [ppm] | [MHz] | [MHz] |
| 50 | 0 (start-up) | 13.600550 | 0 | 0.0 | ±100 | 13.5991899 | 13.6019101 |
| 50 | 2 | 13.601100 | 550 | 40.6 | ±100 | 13.5991899 | 13.6019101 |
| 50 | 5 | 13.600550 | 0 | 0.0 | ±100 | 13.5991899 | 13.6019101 |
| 50 | 10 | 13.601150 | 600 | 44.2 | ±100 | 13.5991899 | 13.6019101 |
| 40 | 0 (start-up) | 13.600700 | 150 | 11.1 | ±100 | 13.5991899 | 13.6019101 |
| 40 | 2 | 13.600300 | -250 | 18.4 | ±100 | 13.5991899 | 13.6019101 |
| 40 | 5 | 13.600850 | 300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| 40 | 10 | 13.600400 | -150 | 11.1 | ±100 | 13.5991899 | 13.6019101 |
| 30 | 0 (start-up) | 13.599950 | -600 | 44.2 | ±100 | 13.5991899 | 13.6019101 |
| 30 | 2 | 13.601400 | 850 | 62.7 | ±100 | 13.5991899 | 13.6019101 |
| 30 | 5 | 13.600550 | 0 | 0.0 | ±100 | 13.5991899 | 13.6019101 |
| 30 | 10 | 13.600850 | 300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| 20 | 0 (start-up) | 13.600450 | -100 | 7.4 | ±100 | 13.5991899 | 13.6019101 |
| 20 | 2 | 13.601000 | 450 | 33.2 | ±100 | 13.5991899 | 13.6019101 |
| 20 | 5 | 13.600600 | 50 | 3.7 | ±100 | 13.5991899 | 13.6019101 |
| **20** | **10** | **13.600550** | **0** | **0.0** | **±100** | **13.5991899** | **13.6019101** |
| 10 | 0 (start-up) | 13.600300 | -250 | 18.4 | ±100 | 13.5991899 | 13.6019101 |
| 10 | 2 | 13.600850 | 300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| 10 | 5 | 13.600700 | 150 | 11.1 | ±100 | 13.5991899 | 13.6019101 |
| 10 | 10 | 13.600700 | 150 | 11.1 | ±100 | 13.5991899 | 13.6019101 |
| 0 | 0 (start-up) | 13.600850 | 300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| 0 | 2 | 13.600850 | 300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| 0 | 5 | 13.600550 | 0 | 0.0 | ±100 | 13.5991899 | 13.6019101 |
| 0 | 10 | 13.600450 | -100 | 7.4 | ±100 | 13.5991899 | 13.6019101 |
| -10 | 0 (start-up) | 13.600850 | 300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| -10 | 2 | 13.600400 | -150 | 11.1 | ±100 | 13.5991899 | 13.6019101 |
| -10 | 5 | 13.600000 | -550 | 40.6 | ±100 | 13.5991899 | 13.6019101 |
| -10 | 10 | 13.600550 | 0 | 0.0 | ±100 | 13.5991899 | 13.6019101 |
| -20 | 0 (start-up) | 13.600250 | -300 | 22.1 | ±100 | 13.5991899 | 13.6019101 |
| -20 | 2 | 13.600450 | -100 | 7.4 | ±100 | 13.5991899 | 13.6019101 |
| -20 | 5 | 13.600150 | -400 | 29.5 | ±100 | 13.5991899 | 13.6019101 |
| -20 | 10 | 13.600550 | 0 | 0.0 | ±100 | 13.5991899 | 13.6019101 |

Test performed at nominal supply voltage and within the temperature range of -20 °C up to +50 °C starting at nominal ambient temperature and continuing with the highest specified temperature and proceeding with temperature lowered in 10 degree steps down to the lowest specified.

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test date: | 2020-11-19, 2020-11-20 |
| Test personnel: | Dominik Krüger |

Carrier frequency stability is within the specified limits.

**The EUT meets the requirements of this section.**

# 10 CARRIER FREQUENCY STABILITY VS SUPPLY VOLTAGE

Test Requirement: FCC 47 CFR §15.225(e)
Test Procedure: ANSI C63.10-2013

## 10.1 Regulation

**47 CFR § 15.225 Operation within the band 13.110–14.010 MHz.**

(e) The frequency tolerance of the carrier signal shall be maintained within ±0.01% of the operating frequency over a temperature variation of −20 degrees to + 50 degrees C at normal supply voltage, and for a variation in the primary supply voltage from 85% to 115% of the rated supply voltage at a temperature of 20 degrees C. For battery operated equipment, the equipment tests shall be performed using a new battery.

## 10.2 Test Procedures

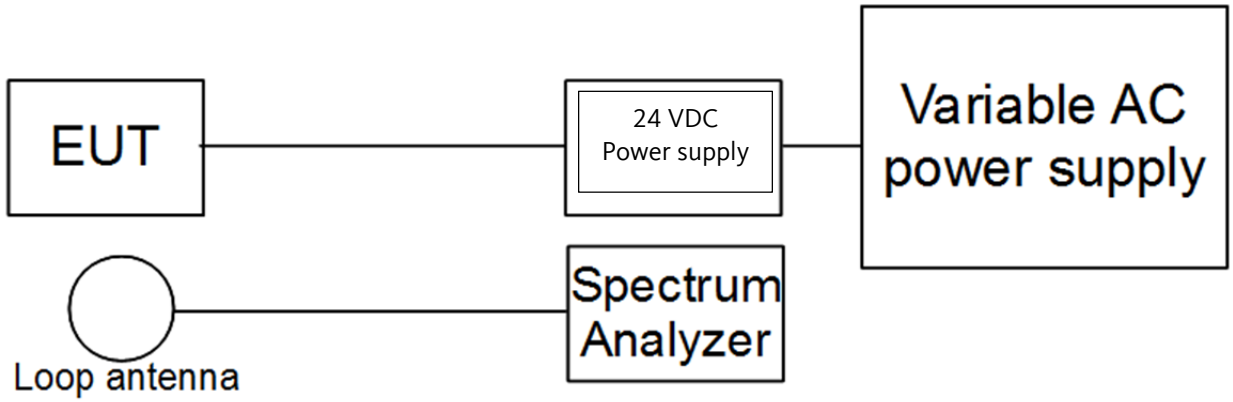
**Frequency stability when varying supply voltage:**

The tests were made at ambient room temperature (+15 °C to +25 °C). The AC / DC supply of the EUT was supplied with the nominal AC voltage of 120 V at 60 Hz. The radio simulation setup was placed in the centre of the environmental test chamber. An antenna was placed next to the loop antenna and connected to a receiver. It was verified that the receiver had an adequate signal level to allow the measurement.

The primary input voltage of the host was set to 120 V / 60 Hz, 102 V / 60 Hz ($U_{nom}$ - 15 %) and
138V / 60 Hz ($U_{nom}$ + 15 %).

The measurement of the centre frequency was measured at each voltage step.

## 10.3 Test Setup




SCHEMATIC TEST SETUP

Requirement: 47 CFR, § 15.225
Procedure: ANSI C63.10-2013

Receiver: #3831
Antenna: #1731

TEST EQUIPMENT USED:
Refer to chapter 5 of this document.
34, 1731, 2766, 3026, 3831, 4686, 4933, 4955

## 10.4 Test Result

Test conditions: Temperature = 20 °C
$f_{ref}$ = 13.600700 MHz

| Supply Voltage | Frequency | Deviation from reference | | Limit | Lower limit | Upper Limit |
|---|---|---|---|---|---|---|
| [V] | [MHz] | [Hz] | [ppm] | [ppm] | [MHz] | [MHz] |
| 102 | 13.600650 | -50 | 3.7 | ±100 | 13.5993399 | 13.6020601 |
| **120** | **13.600700** | **0** | **0.0** | **±100** | **13.5993399** | **13.6020601** |
| 138 | 13.600000 | -700 | 51.6 | ±100 | 13.5993399 | 13.6020601 |

Test performed at normal ambient temperature and within the manufacturer's specified supply voltage range.

| | |
|---|---|
| Manufacturer: | Hottinger Brüel & Kjaer GmbH |
| Type: | 7HA.03 |
| Serial No.: | 201040001 |
| Test date: | 2020-11-20 |
| Test personnel: | Dominik Krüger |

Carrier frequency stability is within the specified limits.

**The EUT meets the requirements of this section.**

## 11 TEST INSTRUMENTS

| Ident# | Instrument | Calibration valid until |
|---|---|---|
| 1 | 60-Hz-Converter | n/a |
| 34 | AC Power Source | n/a |
| 55 | N-Cable N/50 | 2021-10 |
| 374 | Loop Antenna | 2021-02 |
| 1291 | Antenna Mast | n/a |
| 1292 | Multi Device Controller | n/a |
| 1416 | Isolation Transformer | n/a |
| 1470 | V-LISN 50 ohms//(50uH+5ohms) | 2021-10 |
| 1519 | Pulse Limiter | 2021-09 |
| 1731 | Sniffer Loop Probe | n/a |
| 1889 | SR-ULL-01, Semi-Anechoic Chamber (SAC) | n/a |
| 2648 | N-Cable N/50 | 2021-08 |
| 2724 | 5 W Attenuator 6dB | 2021-07 |
| 2766 | DC Power Supply | n/a |
| 3026 | Thermal Chamber | 2021-07 |
| 3493 | DC Power Supply | n/a |
| 3831 | Spectrum Analyzer | 2021-11 |
| 3846 | EMI Test Receiver | 2021-03 |
| 4075 | Workstation | n/a |
| 4686 | TC-Sensor/Type K | 2021-02 |
| 4717 | Web-Thermo-Hygrobarograph | 2021-07 |
| 4933 | Data Logger | 2023-01 |
| 4955 | TC-Sensor/Type K | 2021-02 |
| 5392 | EMC Measurement Software | n/a |
| 5551 | BNC cable | 2021-10 |
| 6041 | TRILOG Broadband Antenna | 2021-10 |
| 6206 | Shielded box | n/a |

**REMARK:** Each piece of measurement and test equipment is identified by its ID number within EMCCons DR. RAŠEK equipment inventory. The ID number allows an unambiguous assignment of each piece of equipment.

The equipment inventory database includes following information for each piece of equipment:

a) Manufacturer and model
b) Serial Number
c) Software version, if applicable
d) Calibration history, if applicable

## 12 MEASUREMENT UNCERTAINTY

| Measurement | Measurement Uncertainty |
|---|---|
| Conducted Emissions, AC mains (150 kHz – 30 MHz) | ±3.5 dB |
| Radiated emissions, H field (9 kHz – 30 MHz) | ± 3.0 dB |
| Radiated Emissions below 1000 MHz | ±5.7 dB |
| RF frequency (25 MHz – 1 GHz) | ± 8.4 * $10^{-8}$ |
| Temperature | ± 1.8° K |
| Humidity | ± 3.1 % |

The reported uncertainty values are based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of 95%.

The given values have been calculated on the basis of the following documents:

CISPR 16-4-2:2011+A1:2014, Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty.

TR 100 028-1 V1.4.1 (2001-12), Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1

TR 100 028-2 V1.4.1 (2001-12), Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2

JCGM 100:2008, Evaluation of measurement data - Guide to the expression of uncertainty in measurement.

## 13 LIST OF ANNEXES

The following annexes are separated parts from this test report.

| Description | Pages |
|---|---|
| Annex 1: Photographs of test setup | 3 |
| Annex 2: External photographs of equipment under test | 3 |
| Annex 3: Photographs of ancillary equipment | 9 |