# TEST REPORT # EMCC-150530A, 2016-04-25

**EQUIPMENT UNDER TEST:**

| | |
|---|---|
| Device: | AG501 |
| Serial Number: | 03-12-10-24 |
| Application: | Articulograph |
| Manufacturer: | Carstens Medizinelektronik GmbH |
| Address: | Nelkenweg 8<br>37120 Bovenden<br>Germany |
| Phone: | +49 5593 1697 |
| Fax: | +49 5593 8791 |

**RELEVANT STANDARD(S):** 47 CFR §§ 15.207, 15.209

**MEASUREMENT PROCEDURE:**

☒ ANSI C63.10-2013 ☐ RSS-Gen Issue 4 ☐ Other

**TEST REPORT PREPARED BY:**

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**TEST PERSONNEL:**

Daniel Mayle

**HEAD OF COMMERCIAL EMC AND RADIO DEPT.:**

Wolfgang Döring

# CONTENTS

# 1 GENERAL INFORMATION

## 1.1 Purpose

The purpose of this report is to show compliance with the FCC regulations for a licence-exempt intentional radiator operating under subpart C of part 15 of the Code of Federal Regulations title 47.

## 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.

## 1.3 Test Location

| | |
|---|---|
| Test Laboratory: | EMCCons DR. RAŠEK GmbH & Co. KG |
| Accreditation No.: | D-PL-12067-01-00 |
| 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 |
| Laboratory: | Test Laboratory IV<br>The 3 m & 10 m semi-anechoic chamber site has been fully described in a report submitted to the FCC and accepted in the letter dated December 24, 2013, Registration Number 878769. |
| Phone: | +49 9194 7262-0 |
| Fax: | +49 9194 7262-199 |
| E-Mail: | emc.cons@emcc.de |
| Web: | www.emcc.de |

## 1.4 Manufacturer

| | |
|---|---|
| Company Name: | Carstens Medizinelektronik GmbH |
| Street: | Nelkenweg 8 |
| City: | 37120 Bovenden |
| Country: | Germany |

## 1.5 Applicant

| | |
|---|---|
| Company Name: | Carstens Medizinelektronik GmbH |
| Street: | Nelkenweg 8 |
| City: | 37120 Bovenden |
| Country: | Germany |
| | |
| Name for contact purposes: | Mr Bahne Carstens |
| Phone: | +49 5593 1697 |
| Fax: | +49 5593 8791 |
| E-Mail: | bahne@articulograph.de |

## 1.6 Dates and Test Location

| | |
|---|---|
| Date of Receipt of EUT: | 2016-02-12 |
| Test Date: | CW 06/2016 |
| Test Location: | Lab IV |

## 1.7 Ordering Information

Purchase Order and Date: E-Mail dated 2016-02-08

## 1.8 Climatic Conditions

| Date | Temperature [°C] | Relative Humidity [%] | Air Pressure [hPa] | Lab | Customer attended tests |
|---|---|---|---|---|---|
| 2016-02-12 | 24 | 28 | 961 | IV | Yes, Mr and Mrs Carstens |
| 2016-02-15 | 23 | 31 | 968 | IV | No |

# 2 PRODUCT DESCRIPTION

## 2.1 Equipment Under Test (EUT)

| | |
|---|---|
| Trade Name: | AG501 |
| Serial Number: | 03-12-10-24 |
| FCC ID: | 2AHFP-AG501 |
| Application: | Articulograph |
| Power Supply: | 115VAC / 60 Hz |
| Highest internally generated or used frequency: | 660 MHz |
| Ports: | 1x Ethernet |
| Variants: | None |
| Remarks: | None |

## 2.2 Intended Use

The following information was delivered by the customer:

The 9 transmitter coils generate an alternating magnetic field which induce voltage within the sensor coils. From the registered voltages the position (x; y; z) and the two angles of orientation (phi;theta) are calculated 1250 times per second for each sensor. Therefore, the movement of the sensors can be defined in the real time.

## 2.3 EUT Peripherals/Simulators

The equipment under test (EUT) was tested being connected via an Ethernet to customer's notebook.

## 2.4 Mode of Operation During Testing and Test Setup

The following information was delivered by the customer:

Mode "Diagnose Modus":
The diagnostic mode is similar to the operational mode with only one difference that the data are collected continuously. In fact in the diagnostic mode as well as the operational mode the transmitters are switched on, the amplitudes are read, statically collected and shown on display.

## 2.5 Modifications required for Compliance

The following modification was applied to the EUT before all measurements reported in this document:

1) Application of two ferrites (Würth 742 711 31) at the endings of the Ethernet cable.

Refer to Annex 3 for detailed pictures of the modification 1).

# 3 TEST RESULTS SUMMARY

Summary of test results for the following EUT:

Manufacturer: Carstens Medizinelektronik GmbH
Device: AG501
Serial No: 03-12-10-24

| Requirement | 47 CFR Section | Report Section | Result |
|---|---|---|---|
| Conducted AC Power Line Emissions 150 kHz – 30 MHz | 15.207(a) | 4 | Passed |
| Radiated Emissions 9 kHz – 30 MHz | 15.209(a) | 5 | Passed |
| Radiated Emissions 30 MHz – 1000 MHz | 15.209(a) | 6 | Passed |
| Radiated Emissions 1 GHz – 5 GHz | 15.209(a) | 7 | Passed |

N.A. – not applicable; N.T. – Not tested acc. to applicant's order.

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. 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: Daniel Mayle
Issuance Date: 2016-04-25

# 4 POWER LINE CONDUCTED EMISSIONS TEST

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

## 4.1 Regulation

**§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.

## 4.2 Test Equipment

| Type | Manufacturer/ Model No. | EMCC Ident No. | Last Calibration | Next Calibration |
|---|---|---|---|---|
| 60-Hz-Converter | AEG / DAMK4/DAGK4 | 1 | n.a. | n.a. |
| Pulse Limiter | R&S / ESH3-Z2 | 1519 | 2015-09-21 | 2017-09-21 |
| V-LISN 50 ohms (50 uH + 5 ohms) | R&S / ESH2-Z5 | 1901 | 2015-09-22 | 2017-09-22 |
| EMI Test Receiver | R&S / ESU8 | 3846 | 2015-08 | 2016-08 |
| Digital Multimeter | Agilent / U1241A | 2719 | 2015-01 | 2015-01 |
| V-LISN 50 ohms (50 μH + 5 ohms) | Schwarzbeck/ NNLA8119(mod) | 1469 | 2015-11 | 2017-11 |

## 4.3 Test Procedures

**ANSI C63.10-2013, 6.2.3.3.1 General requirements**

Where a floor-standing EUT is typically installed with its base in direct electrical contact with, or connected to, a grounded metal floor or grid, the EUT shall be connected to, or placed directly on, the test site (or turntable) reference ground plane in a manner representative of this contact or connection.

Where floor-standing equipment is not typically installed with its base in direct electrical contact with, or connected to, a metal floor or grid, the EUT shall not be placed in direct electrical contact with the test site (or turntable) reference ground plane. If necessary to prevent direct metallic contact of the EUT and the reference ground plane, insulating material (up to 12 mm thick) shall be placed under the EUT.

To represent typical raised/false floor installation of EUTs more explicitly, the base of the EUT may be raised but in no case exceed 34 cm above the reference ground plane. If the EUT elevation that is not representative of a typical installation is used for testing, the reason for the variation shall be explained in the test report. However, the preferred method shall be measurements made at elevations that are representative of actual applications.

Floor-standing equipment can be interconnected with cabling either lying on the floor, under the floor (to simulate a raised floor installation), or overhead, according to normal installation. The material used to raise the EUT shall be nonconductive and shall not adversely affect the measurements. Test arrangements for floor-standing equipment are shown in Figure 6. Normally, tests shall be performed with the equipment standing on the reference ground plane, with or without an insulating surface, as appropriate.

**ANSI C63.10-2013, 6.2.3.3.2 Placement of floor-standing accessories**

Accessories that are part of a floor-standing system shall be placed in one typical arrangement with typical spacing between equipment cabinets or enclosures.

## 4.4 Test Result

Mode: Diagnose Modus

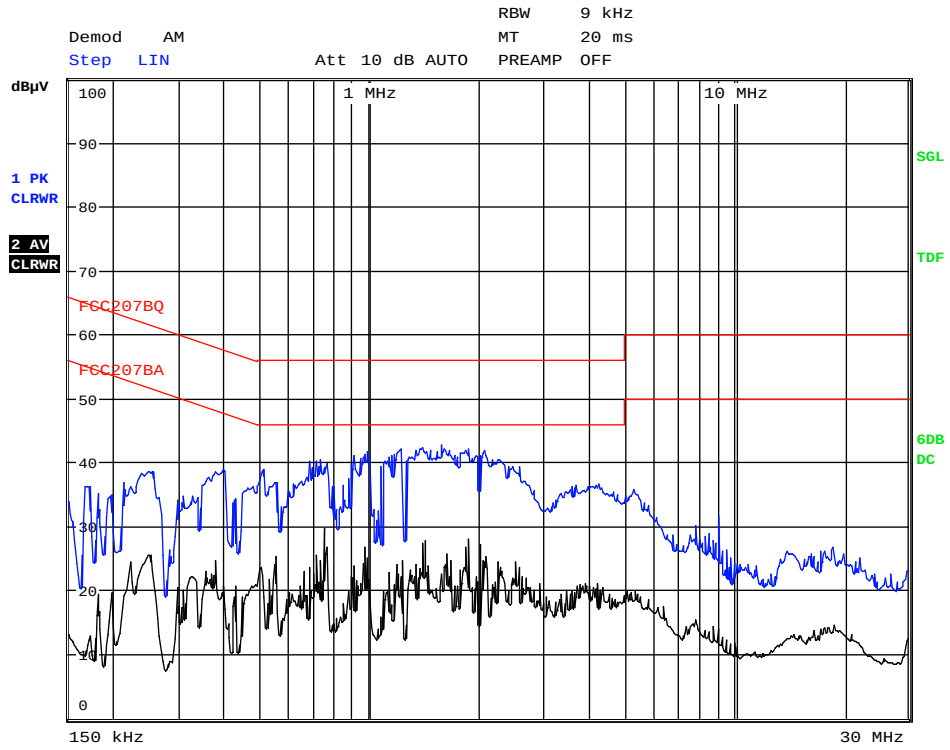
| Line: L | | | |
|---|---|---|---|
| **Freq. [MHz]** | **Detector** | **Result [dBµV]** | **Margin [dB]** |
| 0.75 | CISPR AV | 29.7 | 16.3 |
| 0.97 | CISPR AV | 26.8 | 19.2 |
| 1.22 | PK | 42.1 | 13.9 |
| 1.4 | PK | 42.3 | 13.7 |
| 1.4 | CISPR AV | 27.4 | 18.6 |
| 1.42 | CISPR AV | 27.8 | 18.2 |
| 1.47 | PK | 41.9 | 14.1 |
| 1.58 | PK | 42.8 | 13.2 |
| 1.83 | CISPR AV | 26.7 | 19.3 |
| 1.87 | CISPR AV | 28.1 | 17.9 |
| 1.87 | PK | 42.1 | 13.9 |
| 2.07 | PK | 41.9 | 14.1 |

| Line: N | | | |
|---|---|---|---|
| **Freq. [MHz]** | **Detector** | **Result [dBµV]** | **Margin [dB]** |
| 0.38 | CISPR AV | 29.5 | 18.8 |
| 0.4 | PK | 44.6 | 13.3 |
| 0.52 | CISPR AV | 28.3 | 17.7 |
| 0.52 | PK | 41.9 | 14.1 |
| 0.7 | PK | 43.4 | 12.6 |
| 0.9 | PK | 43.4 | 12.6 |
| 0.99 | CISPR AV | 27.3 | 18.7 |
| 1.01 | CISPR AV | 31 | 15 |
| 1.14 | PK | 44 | 12 |
| 1.42 | CISPR AV | 29.1 | 16.9 |
| 1.49 | PK | 42.5 | 13.5 |
| 2.11 | CISPR AV | 27.2 | 18.8 |

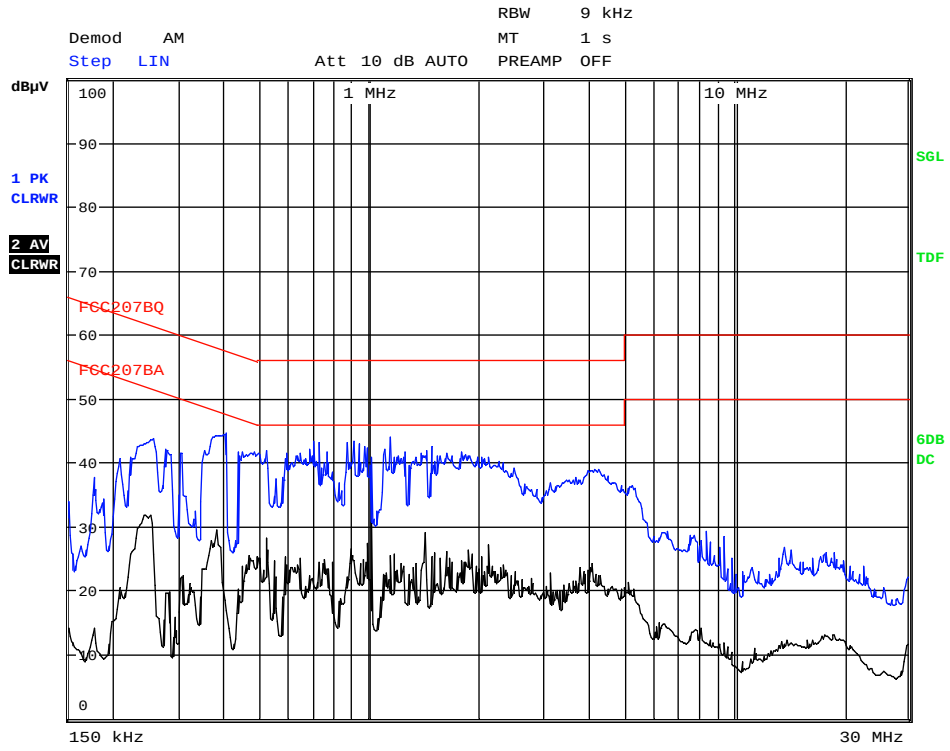
Manufacturer: Carstens Medizinelektronik GmbH
Device: AG501
Serial No: 03-12-10-24
Test Date: 2016-02-15

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

## 4.5 Measurement Plots




Mode: normal operation; 115V/60Hz; Line: L
Date: 15.FEB.2016




Mode: normal operation; 115V/60Hz; Line: N
Date: 15.FEB.2016

# 5 RADIATED EMISSIONS 9 kHz – 30 MHz

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

## 5.1 Regulation

**§ 15.209 Radiated emission limits**

(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 of emission [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 |

(b) In the emission table above, the tighter limit applies at the band edges. Sections 15.33 and 15.35 which specify the frequency range over which radiated emissions are to be measured and the detector functions and other measurement standards apply

(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.

**§ 15.33 Frequency range of radiated measurements**

(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 (MHz) | Upper frequency of measurement range (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.

## 5.2 Test Equipment

| Type | Manufacturer/ Model No. | EMCC Ident No. | Last Calibration | Next Calibration |
|---|---|---|---|---|
| 60-Hz-Converter | AEG / DAMK4/DAGK4 | 1 | n.a. | n.a. |
| EMI Test Receiver | R&S / ESU 8 | 3846 | 2015-08 | 2016-08 |
| AutoGager - EMI Software | EMCC | 3866 | n.a. | n.a. |
| Digital Multimeter | Agilent / U1241A | 2719 | 2015-01 | 2017-01 |
| Arbitrary/Function Gen. | Stanford DS345 | 3 | 2015-02 | 2017-02 |
| Loop Antenna | R&S / HFH 2-Z2 | 374 | 2014-06 | 2016-06 |
| Loop Antenna | MAG 20-0.15R | 4750 | 2014-11 | 2016-11 |

## 5.3 Test Procedures

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 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. For certain applications, the loop antenna may also need to be positioned horizontally at the specified distance from the EUT. Instead of changing the loop antenna polarization to horizontal the EUT antenna was rotated by 90 degrees. I.e. tests performed for 2 EUT antenna polarizations. The center of the loop antenna was 1 m above the ground.
The EUT was tested on a ground plane as it is a floorstanding equipment. The ancillary equipment was placed on a 0.8m high tabletop.
The EUT is connected to its associated peripherals, with any excess I/O cabling bundled.
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 ground plane or, if normally installed beneath the reference ground plane, 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 semi-anechoic room at the specified 3 m test distance.
Worst case emissions are listed under chapter: Final test results.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 9 kHz - 30 MHz |
| Test distance | 3 m* |
| Test instrumentation resolution bandwidth | 200 Hz (9 kHz - 150 kHz) |
| | 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.

## 5.4 Reference Measurement at open field site

The measurement was performed with set-up consisting of a single turn loop antenna with a diameter of 0.15 m, feeded by a signal generator. The loop dimension was chosen to simulate the EUT as far as possible. The signal generator was set to a fixed output level with an unmodulated 10 kHz and 14 kHz sinusoidal signal.

The radiated H fieldstrength at 10 kHz and 14 kHz generated by this set-up was measured with the same test setup as used in the SAC in 3 m distance first, and then repeated at the open field site in 3 m and 10 m distance

### 5.4.1 Measurement in SAC

The measurement was performed in the semi-anechoic chamber 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 field generating loop antenna and rotated about its vertical axis for maximum response at each azimuth about the field generating loop antenna. The center of the calibrated loop antenna was 1 m above the ground.
The field generating loop antenna was fixed on a styrofoam support on the ground plane at a height similar to the EUT position. The loop plane was vertical.

The measurement was performed at the maximum of the radiated field of the 10 kHz and 14 kHz signal. The maximum obtained for a parallel orientation of both antennas.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 10 kHz, 14 kHz |
| Test distance | 3 m, 10 m |
| Test instrumentation resolution bandwidth | 200 Hz |
| Receive antenna height | 1 m |

**Results SAC**

| Frequency | Detector | Distance | Result |
|---|---|---|---|
| [kHz] | - | [m] | [dBµV/m] |
| 10.0 | AV | 3 | 95.6 |
| 14.0 | AV | 3 | 95.6 |

## 5.4.2 Measurements at open field site

The measurement was performed at an open field site at a test distance of 3 m and 10 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 field generating loop antenna and rotated about its vertical axis for maximum response at each azimuth about the field generating loop antenna. The center of the calibrated loop antenna was 1 m above the ground.
The field generating loop antenna was fixed on a styrofoam support at a height similar to the EUT position in the SAC. The loop plane was vertical.

The measurement was performed for each distance at the maximum of the radiated field of the 10 kHz and 14 kHz signal. The maximum obtained for a parallel orientation of both antennas.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 10 kHz, 14 kHz |
| Test distance | 3 m, 10 m |
| Test instrumentation resolution bandwidth | 200 Hz |
| Receive antenna height | 1 m |

**Results OATS**

| Frequency | Detector | Distance | Result |
|---|---|---|---|
| [kHz] | - | [m] | [dBµV/m] |
| 10.0 | AV | 3 | 92.7 |
| 14.0 | AV | 3 | 92.8 |

## 5.4.3 Correlation of SAC and open field site

**FCC 15.31** Measurement standards

(d) Field strength measurements shall be made, to the extent possible, on an open field site. Test sites other than open field sites may be employed if they are properly calibrated so that the measurement results correspond to what would be obtained from an open field site.

**KDB 937606:**

…Test sites other than open field sites, such as anechoic chambers, may be employed only if calibrated so that the measurements correspond to those obtained on an open field site. Since there are no standards for validation of test sites below 30 MHz, calibration must be obtained by other means such as performing measurements at an alternate test site and comparing to measurements obtained on an open field site. Statistical analysis of the measurement data from several similar devices may be required to show correlation between the measurements from the alternate test site and an open field test site. The limit distance below 30 MHz is 30 meters or more and in most anechoic chambers it is not possible to perform measurements at such distances. This may make it difficult to show correlation between measurements made on an open field site at distances greater than the dimensions of the anechoic chamber and measurements made at the same distance in the anechoic chamber without further analysis and comprehensive testing. …

The difference of the radiated emission measurement from the open field site and the SAC at 3 m is the correlation factor $f_C$.

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

$f_C$ 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
Results

| Frequency | Detector | Distance | $F_{SAC}$ | $F_{open}$ | $f_C$ |
|---|---|---|---|---|---|
| [kHz] | | [m] | [dBµV/m] | [dBµV/m] | dB |
| 10.0 | AV | 3 | 95.6 | 92.7 | 2.9 |
| 14.0 | AV | 3 | 95.6 | 92.8 | 2.8 |

The correlation of the SAC and open field site measurement results at 10 kHz/14 kHz and 3 m distance shows that the SAC measurement result is slightly higher (2.9 dB) than the result of the open field site measurement, obviously caused by the presence of the ground plane.

## 5.5 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.

## 5.6 Field Strength Calculation

All emission measurements performed using the test receiver'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 + $f_C$

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 58.8 dBµV/m is obtained. The Distance Factor of -40 dB is added, giving a field strength of 18.8 dBµV/m. The 18.8 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 58.8 - 40 = 18.8 [dBµV/m]

Level in µV/m = Common Antilogarithm (18.8/20) = 8.7

## 5.7 Final Test Results

Mode: Diagnose Modus

| Frequency [kHz] | 3m Result [dB(µV/m)] | Distance Correction [dB] | fc [dB] | 300m / 30m Result [dB(µV/m)] | 300m / 30m Limit [dB(µV/m)] | Margin [dB] |
|---|---|---|---|---|---|---|
| 10.5 | 106.4 | -80 | -2.9 | 23.5 | 47.2 | 23.7 |
| 11 | 109.9 | -80 | -2.9 | 27.0 | 46.8 | 19.8 |
| 13.5 | 107.5 | -80 | -2.8 | 24.7 | 45.0 | 20.3 |
| 585 | 58.2 | -40 | 0 | 18.2 | 32.3 | 14.1 |
| 625 | 50.1 | -40 | 0 | 10.1 | 31.7 | 21.6 |
| 1350 | 44.9 | -40 | 0 | 4.9 | 25.0 | 20.1 |

*All tests performed at 3 m distance. The table above contains worst-case emissions, only. For further details refer to the pre-scan test plots.*

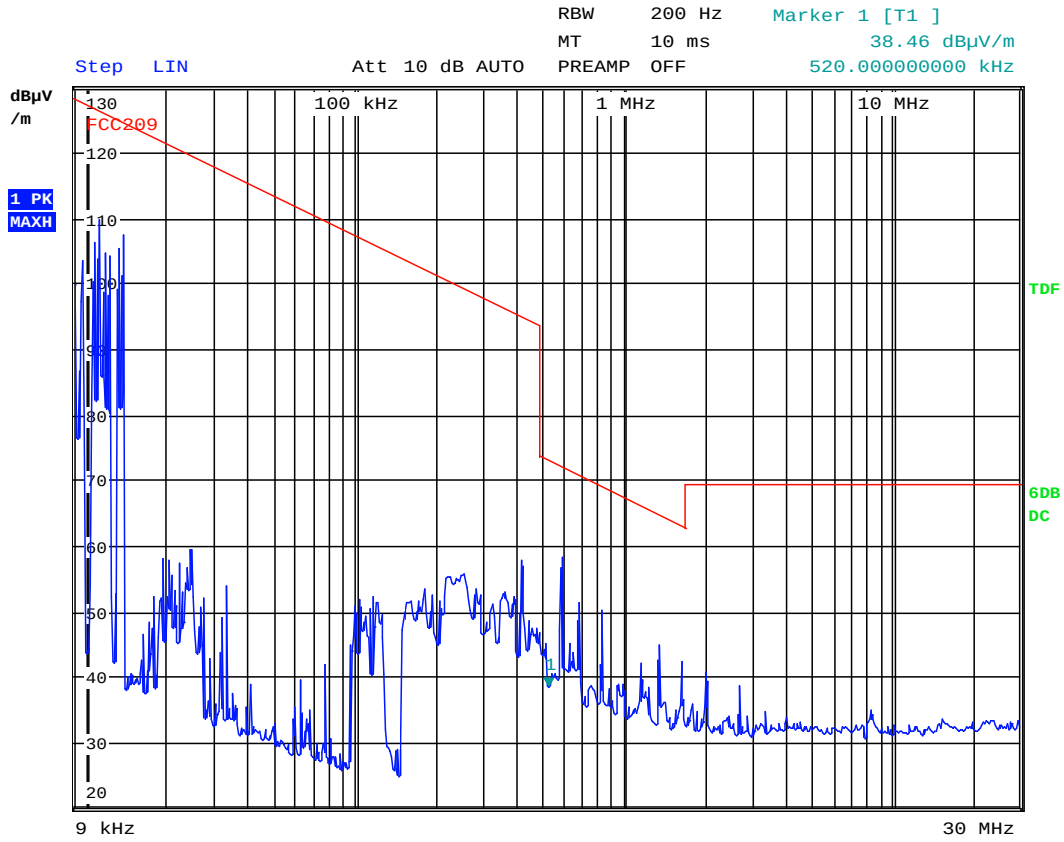
Manufacturer: Carstens Medizinelektronik GmbH
Device: AG501
Serial No: 03-12-10-24
Test Date: 2016-02-15

All measured emissions in the range 9 kHz to 30 MHz are below the specified limits.

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

## 5.8 Measurement Prescan-Plots

Frequency Range: 9kHz – 30 MHz; Ant.: hor. & ver.




EUT: AG501, H-antenna 2 directions, EUT 4 directions

Date: 12.FEB.2016 17:13:43

Mode: normal operation, 115V/60Hz
Date: 12.FEB.2016

# 6 RADIATED EMISSIONS 30 MHz – 1000 MHz

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

## 6.1 Regulation

**§ 15.209 Radiated emission limits**

(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 of emission [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 |

(c) In the emission tables above, the tighter limit applies at the band edges. Sections 15.33 and 15.35 which specify the frequency range over which radiated emissions are to be measured and the detector functions and other measurement standards apply.

**§ 15.33 Frequency range of radiated measurements**

(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 (MHz) | Upper frequency of measurement range (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.

## 6.2 Test Equipment

| Type | Manufacturer/ Model No. | EMCC Ident No. | Last Calibration | Next Calibration |
|---|---|---|---|---|
| 60-Hz-Converter | AEG / DAMK4/DAGK4 | 1 | n.a. | n.a. |
| EMI/RFI Test Receiver | R&S / ESS | 303 | 2015-03 | 2016-03 |
| VHF Test Dipole RX | Schwarzbeck / VHA 9103 | 1983 | 2015-05 | 2017-05 |
| Log Per. Antenna | Schwarzbeck / VUSLP 9111B | 3203 | 2015-05 | 2017-05 |
| AutoGager - EMI Software | EMCC | 3866 | n.a. | n.a. |
| Digital Multimeter | Agilent / U1241A | 2719 | 2015-01 | 2017-01 |

## 6.3 Test Procedures

The EUT was tested on a ground plane.
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 ground plane or, if normally installed beneath the reference ground plane, 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. Manipulating the system cables also maximizes EUT emissions. All tests performed with the EUT placed in both vertical and horizontal polarizations on the nonconductive table.

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

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 30 MHz – 1000 MHz |
| Test distance | 3 m |
| Test instrumentation resolution bandwidth | 120 kHz |
| Receive antenna height | 1 m - 4 m |
| Receive antenna polarization | Vertical/Horizontal |

## 6.4 Calculation of Field Strength Limits

E.g. radiated emissions field strength limits for the frequency band 88 - 216 MHz:

150 µV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log ( E_{\mu V/m} )$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 150 µV/m corresponds with 43.5 dBµV/m.

## 6.5 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
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

Assume a receiver reading of 23.5 dBµV is obtained. The Antenna Factor of 7.4 dB(1/m) and a Cable Factor of 1.1 dB are added, giving a field strength of 32 dBµV/m. The 32 dBµV/m value can be mathematically converted to its corresponding level in µV/m.

FS = 23.5 + 7.4 + 1.1 = 32 [dBµV/m]

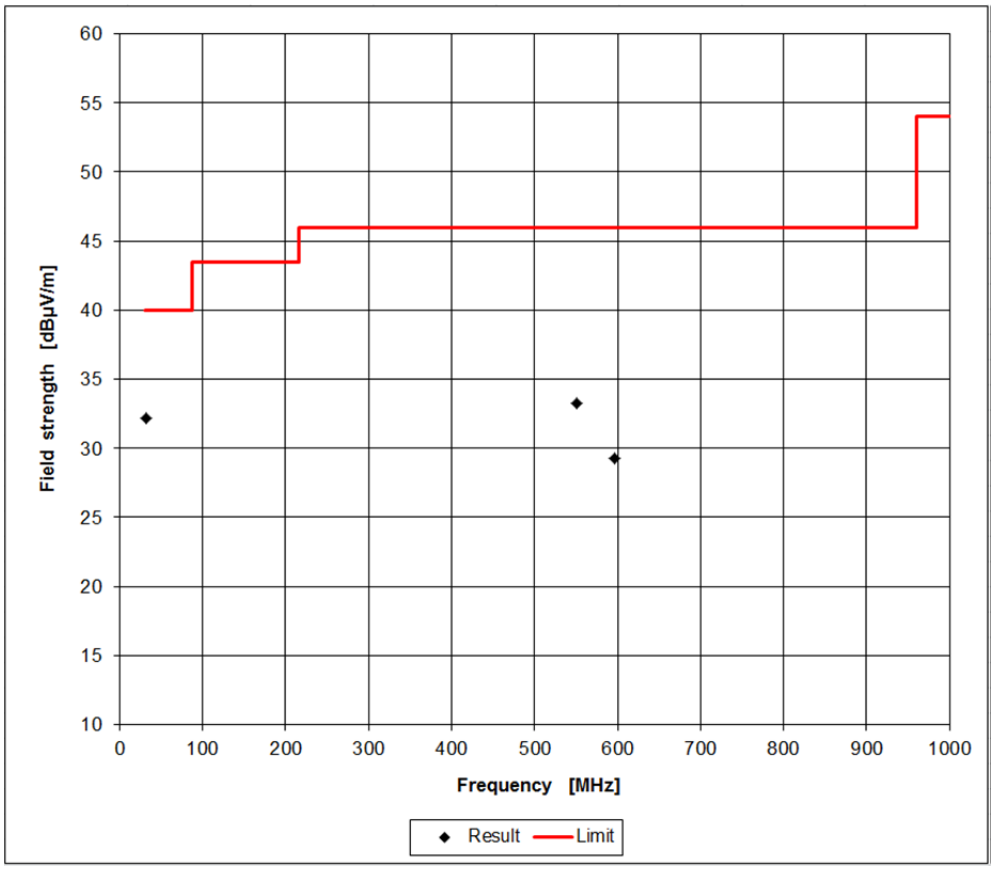
Level in µV/m = Common Antilogarithm (32/20) = 39.8

## 6.6 Final Test Results

Mode: Diagnose Modus

| Frequency [MHz] | RA [dB(µV)] | AF + CF [dB(1/m)] | Result [dB(µV/m)] | Limit [dB(µV/m)] | Margin [dB] | Polarisation h / v |
|---|---|---|---|---|---|---|
| 32.42 | 13.6 | 18.6 | 32.2 | 40 | 7.8 | v |
| 549.99 | 10.5 | 22.7 | 33.2 | 46 | 12.8 | h |
| 596.84 | 5.1 | 24.2 | 29.3 | 46 | 16.7 | h |

*All tests performed at 3 m distance. The table above contains worst-case emissions, only. For further details refer to the pre-scan test plots.*




Manufacturer: Carstens Medizinelektronik GmbH
Device: AG501
Serial No: 03-12-10-24
Test Date: 2016-02-12

All measured emissions in the range 30 MHz to 1000 MHz are below the specified limits.

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

## 6.7 Measurement Prescan-Plots

Frequency Range: 30 – 300 MHz; Ant.: hor. & ver.

EMCC DR. RASEK 12. Feb 16 14:54

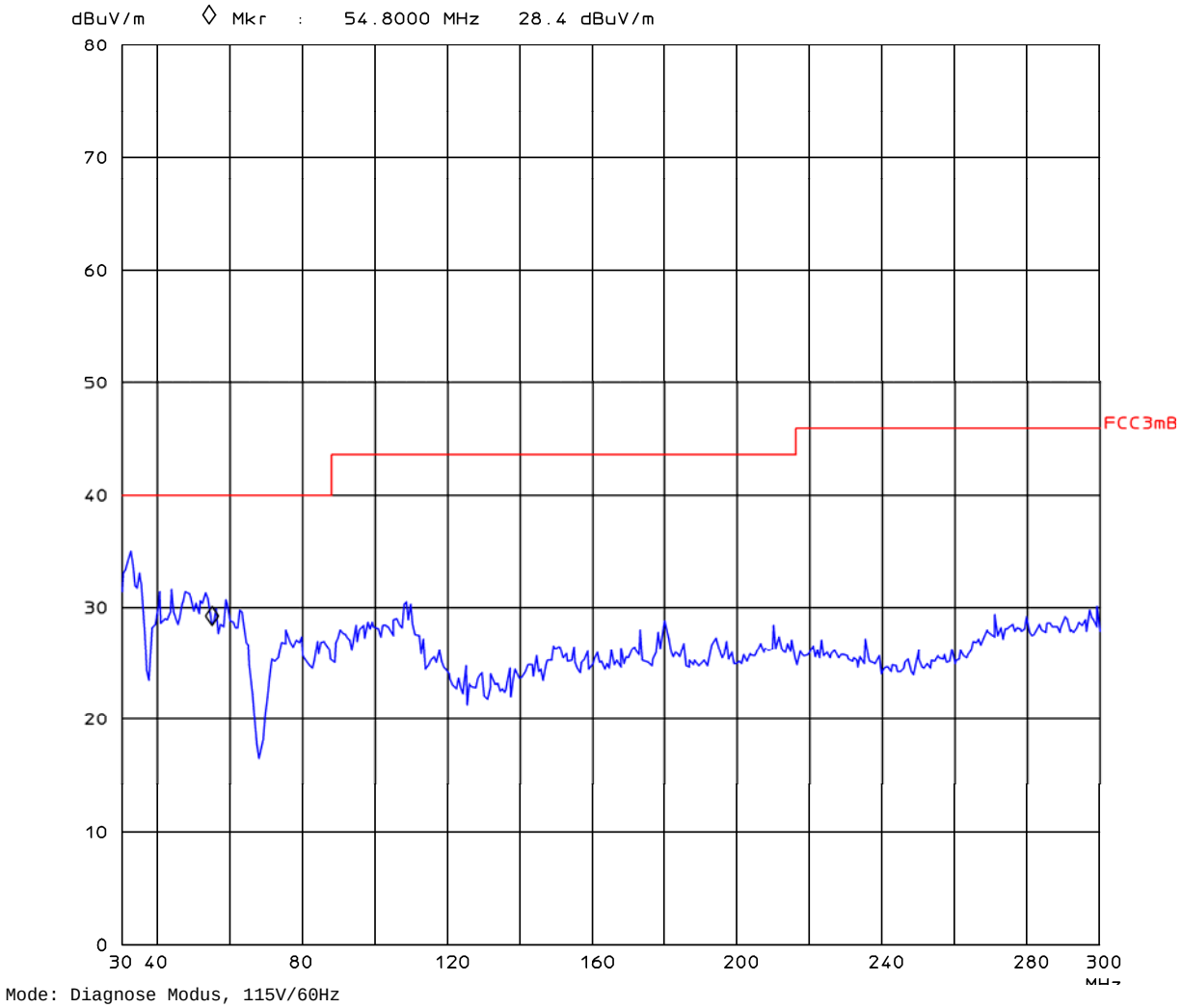
Radiated Emissions Prescan in SAR, d=3m

EUT: Articulograph
Manuf: Carstens
Op Cond: Diagnose Modus
Operator: D. Mayle
Test Spec: FCC
Comment: 4 sides, ant. pol. hor + vert, 3,4 heights

Fast Scan Settings (1 Range)

| Start | Stop | Step | IF BW | Detector | M-Time | Atten | Preamp | OpRge |
|---|---|---|---|---|---|---|---|---|
| 30M | 300M | 40k | 120k | PK | 0.10ms | 0dBLN | ON | 60dB |

| Transducer No. | Start | Stop | Name |
|---|---|---|---|
| 21 | 30M | 300M | 89926k3 |




Mode: Diagnose Modus, 115V/60Hz
Date: 12.FEB.2016

Frequency Range: 300 – 1000 MHz; Ant.: hor. & ver.

EMCC DR. RASEK 12. Feb 16 15:38

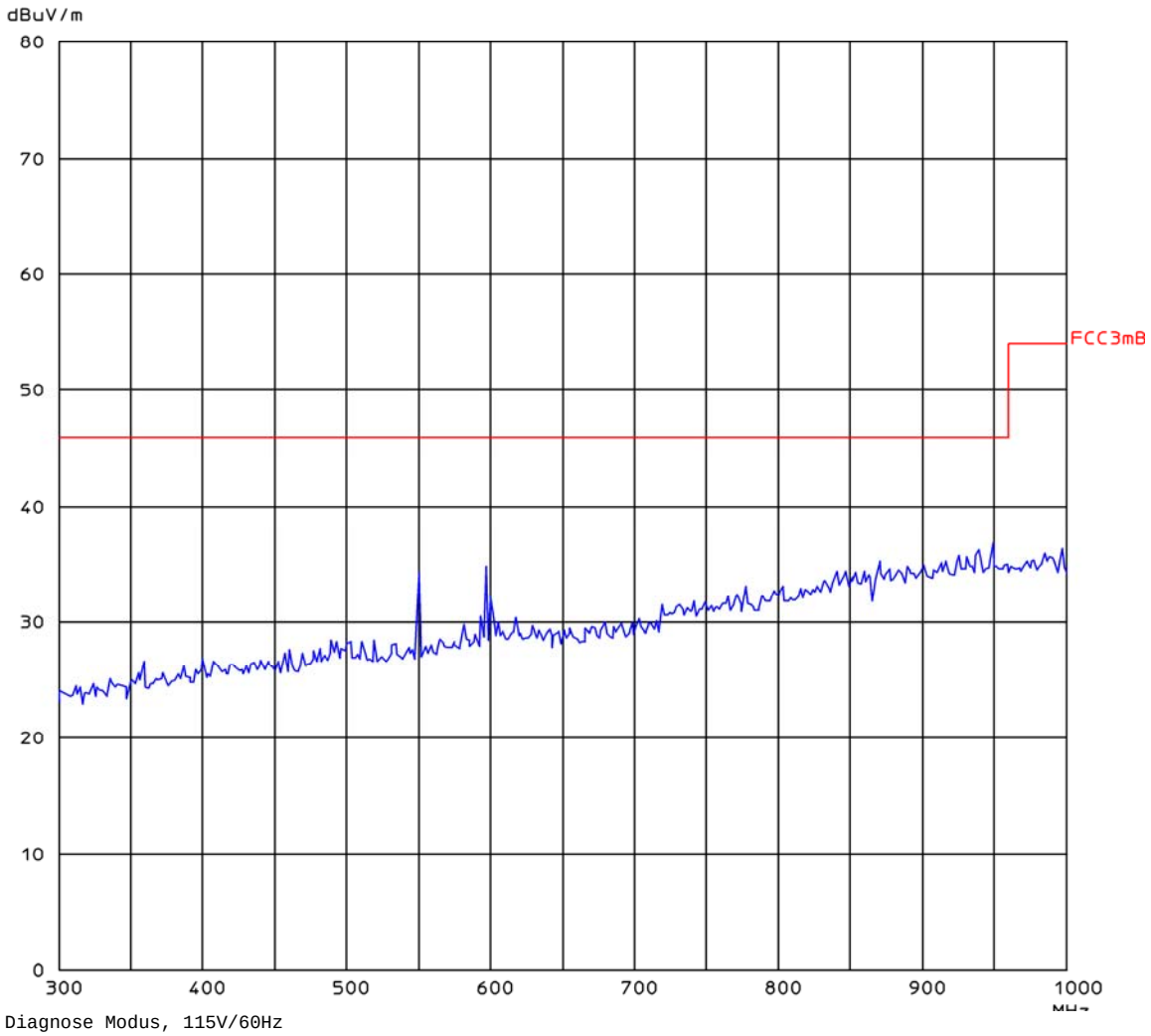
Radiated Emissions Prescan in SAR, d=3m

EUT: Articulograph
Manuf: Carstens
Op Cond: Diagnose Modus
Operator: D. Mayle
Test Spec: FCC
Comment: 4 sides, ant. pol. hor & ver, 3,4 heights

Fast Scan Settings (1 Range)

| Frequencies | | | Receiver Settings | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | Stop | Step | IF BW | Detector | M-Time | Atten | Preamp | OpRge |
| 300M | 1000M | 40k | 120k | PK | 0.10ms | 0dBLN | ON | 60dB |

| Transducer | No. | Start | Stop | Name |
|---|---|---|---|---|
| | 22 | 300M | 1000M | 320326k3 |




Mode: Diagnose Modus, 115V/60Hz
Date: 12.FEB.2016

# 7 RADIATED EMISSIONS 1 GHz – 5 GHz

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

## 7.1 Regulation

**§ 15.209 Radiated emission limits**

(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 of emission | Field strength |
|---|---|
| [MHz] | [microvolts/meter] |
| 0.009-0.490 | 2400/F(kHz) |
| 0.490-1.705 | 24000/F(kHz) |
| 1.705-30.0 | 30 |
| 30-88 | 100 |
| 88-216 | 150 |
| 216-960 | 200 |
| Above 960 | 500 |

(c) In the emission tables above, the tighter limit applies at the band edges. Sections 15.33 and 15.35 which specify the frequency range over which radiated emissions are to be measured and the detector functions and other measurement standards apply

**§ 15.33 Frequency range of radiated measurements**

(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 (MHz) | Upper frequency of measurement range (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.

(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.

## 7.2 Test Equipment

| Type | Manufacturer/ Model No. | EMCC Ident No. | Last Calibration | Next Calibration |
|---|---|---|---|---|
| 60-Hz-Converter | AEG / DAMK4/DAGK4 | 1 | n.a. | n.a. |
| Double Ridged Guide Ant. | Schwarzbeck / BBHA 9120D | 3236 | 2015-06 | 2017-06 |
| EMI Test Receiver | R&S / ESU8 | 3846 | 2015-08 | 2016-08 |
| AutoGager - EMI Software | EMCC | 3866 | n.a. | n.a. |
| Digital Multimeter | Agilent / U1241A | 2719 | 2015-01 | 2017-01 |
| HF-Cable | IW / NPS-2801N-2756-NPS | 4391 | 2015-07 | 2016-07 |

## 7.3 Test Procedures

**ANSI C63.10-2013, 6.6.2 Antenna selection, location, and measuring distance**

Radiated emission measurements in the frequency range above 1 GHz shall be made on a test site meeting the requirements in 5.2 particularly for measurements above 1 GHz, and at a measurement distance specified in 5.3 (typically 3 m) using antenna(s) specified in 4.3.4. Because some EUTs can have an electrical size larger than the 3 dB beamwidth of the antenna at the specified measurement distance, and because the source of emissions is generally limited to relatively small-angle cones of radiation, the measurement antenna beamwidth shall be known so that when emissions from EUTs are measured, the area of coverage across the EUT can be determined.

**ANSI C63.10-2013, 6.6.4.1 General**

Subclauses 6.6.4.2 and 6.6.4.3 describe the procedures that shall be used for making exploratory and final radiated emission tests for frequencies above 1 GHz. Measurements may be performed at a distance closer than that specified in the requirements; however, an attempt shall be made to avoid making measurements in the near field of both the measurement antenna and the EUT for final measurements.

In performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity does not provide a noise floor more than 6 dB below the limit, then low-noise preamplifiers, closer test distances, higher gain antennas, or narrower bandwidths might be required. If closer measurement distances are used, then the beamwidth of the measurement antenna versus the size of the EUT shall be taken into account. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used [see item b) of 4.1.3]. The effects of using bandwidths different from those specified shall also be determined (see also 6.3). Any changes from the specific measurement conditions shall be described in the report of the measurements (see also Annex E).

Install an appropriate filter at the input of the measurement system power amplifier. This filter shall attenuate the fundamental emission of the EUT and allow an accurate measurement of the associated harmonics and spurious emissions. The filter shall be characterized, and any attenuation/loss factors shall be accounted for in the measurement results.

Data shall be recorded in peak and average detection up to the highest measurement frequency required (unless stated otherwise in the applicable requirements).

**ANSI C63.10-2013, 6.6.4.2 Exploratory radiated emissions measurements**

Exploratory radiated measurements shall be performed at the measurement distance or at a closer distance than that specified for compliance to determine the emission characteristics of the EUT and, if applicable, the EUT configuration that produces the maximum level of emissions. The frequencies of maximum emission may be determined by manually positioning the antenna close to the EUT, and then moving the antenna over all sides of the EUT while observing a spectral display. It is advantageous to have prior knowledge of the frequencies of emissions, although this may be determined from such a near-field scan. The near-field scan shall only be used to determine the frequency but not the amplitude of the emissions. Where exploratory measurements are not adequate to determine the worst-case operating modes and are used only to identify the frequencies of the highest emissions, additional preliminary tests can be required.

Preliminary tests shall be performed following the procedures in 6.3 on a site meeting the requirements of 5.2. For emissions from the EUT, the maximum level shall be determined by rotating the EUT and its antenna through 0° to 360°. For each mode of operation required to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

Broadband antennas and a spectrum analyzer or a radio-noise meter with a panoramic display are often useful in this type of test. If either antenna height or EUT azimuth are not fully measured

during exploratory testing, then complete testing can be required at the OATS or semi-anechoic chamber when the final full spectrum testing is performed.

**ANSI C63.10-2013, 6.6.4.3 Final radiated emissions measurements**

The final measurements are performed on a site meeting the requirements of 5.2. Using the orientation and equipment arrangement of the EUT based on the measurement results found during the preliminary (exploratory) measurements per 6.6.4.2, the EUT arrangement, appropriate modulation, and modes of operation that produce the emissions that have the highest amplitude relative to the limit shall be selected for the final measurement. The final measurement shall follow all the procedures in 6.3 with the EUT operating on frequencies per 5.6. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), as well as the frequency and amplitude of the six highest spurious emissions relative to the limit. Emissions more than 20 dB below the limit do not need to be reported.

Measurements are performed with the EUT rotated from 0° to 360°; the antenna height scanned in accordance with 6.6.3.1, 6.6.3.2, or 6.6.3.3, as appropriate; and the antenna rotated to repeat the measurements for both the horizontal and vertical antenna polarizations. Variations in cable or wire placement shall be explored to maximize the measured emissions.

The emission signal shall be kept within the illumination area of the 3 dB beamwidth of the antenna so that the maximum emission from the EUT is measured. This may be achieved by either pointing the antenna at an angle toward the source of the emission or by testing the EUT as described in 6.6.3.3.

If the emission is pulsed, then refer to Annex C for guidelines on selecting bandwidth and determining pulse desensitization factors, as necessary.

As noted in 6.6.4.1, when performing these measurements, the sensitivity of the complete measurement system relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, then low-noise preamplifiers, closer measurement distances, higher gain antennas, or narrower

bandwidths may be used. If closer measurement distances or higher gain antennas are used, then the beamwidth of the measurement antenna versus the physical size of the EUT shall be taken into account, so that the physical sizes of the EUT dimensions are encompassed by the beamwidth of the measurement antenna. Also, measurement system overload protection shall be determined to be adequate when preamplifiers are used. The effects on the measured emission value using bandwidths different from those specified shall be determined if such bandwidth changes are made. Any changes from the specific measurement conditions shall be described in the report of the measurements.

Unless specified otherwise by the regulatory authority, the instrumentation, detector functions, and bandwidths specified in 4.1.4.2.1 and 4.1.4.2.2 shall be used. For pulsed emissions, the procedure in 4.1.4.2.4 shall be used.

| **Radiated Emissions Test Characteristics** | |
|---|---|
| Frequency range | 1 GHz – 5 GHz |
| Test distance | 3 m |
| Test instrumentation resolution bandwidth | 1 MHz |
| Receive antenna height | 1 m |
| Receive antenna polarization | Vertical/Horizontal |

## 7.4 Calculation of Field Strength Limits

E.g. radiated spurious emissions field strength limits for the band above 960 MHz:

500 µV/m at 3 meters

Using the equation:

$E_{dB\mu V/m} = 20 * \log ( E_{\mu V/m} )$

where

$E_{dB\mu V/m}$ = Field Strength in logarithmic units (dBµV/m)

$E_{\mu V/m}$ = Field Strength in linear units (µV/m)

A field strength limit of 500 µV/m corresponds with 46 dBµV/m.

## 7.5 Field Strength Calculation

All emission measurements performed using the test receiver's transducer factor setting capability, i.e. the field strength value measured directly without the necessity of additional correction factors. The transducer factor is calculated by adding the Antenna Factor and Cable Factor:

TF = AF + CF
where
TF = Transducer Factor in dB(1/m)
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB

## 7.6 Final Test Results

Mode: Diagnose Modus

| Frequency [GHz] | Meas. [PK / AV] | Result [dB(µV/m)] | AV Limit [dB(µV/m)] | Margin [dB] | Orientation h / v |
|---|---|---|---|---|---|
| 2.27 | PK | 35.2 | 54 | 18.8 | v |

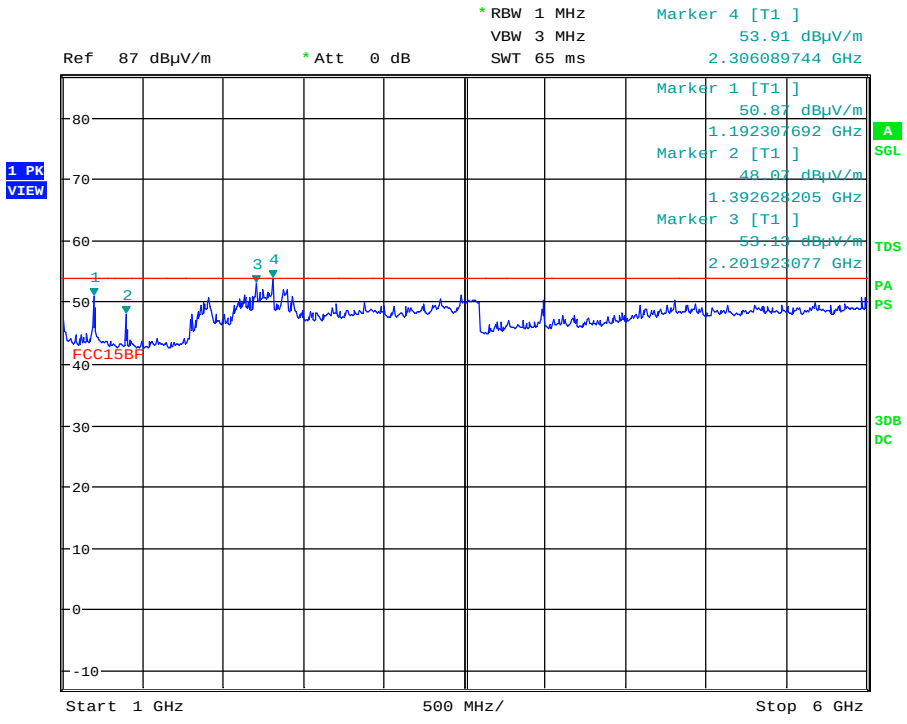
*All tests performed at 3 m distance. The table above contains worst-case emissions, only. For further details refer to the pre-scan test plots.*

Manufacturer: Carstens Medizinelektronik GmbH
Device: AG501
Serial No: 03-12-10-24
Test Date: 2016-02-12

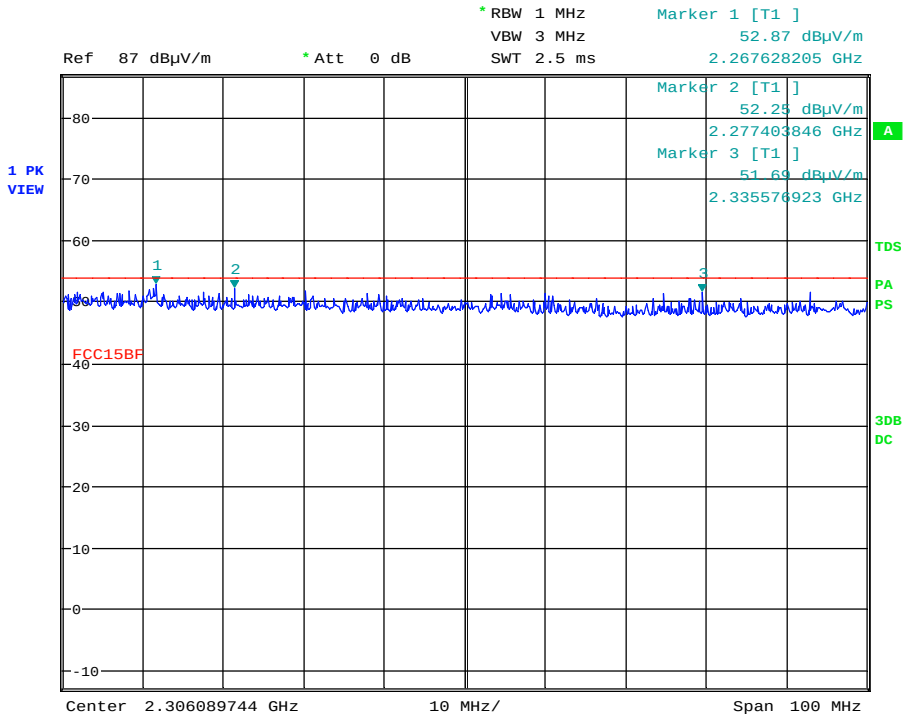
All measured emissions in the range 1 GHz to 6 GHz are below the specified limits.

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

## 7.7 Measurement Prescan-Plots

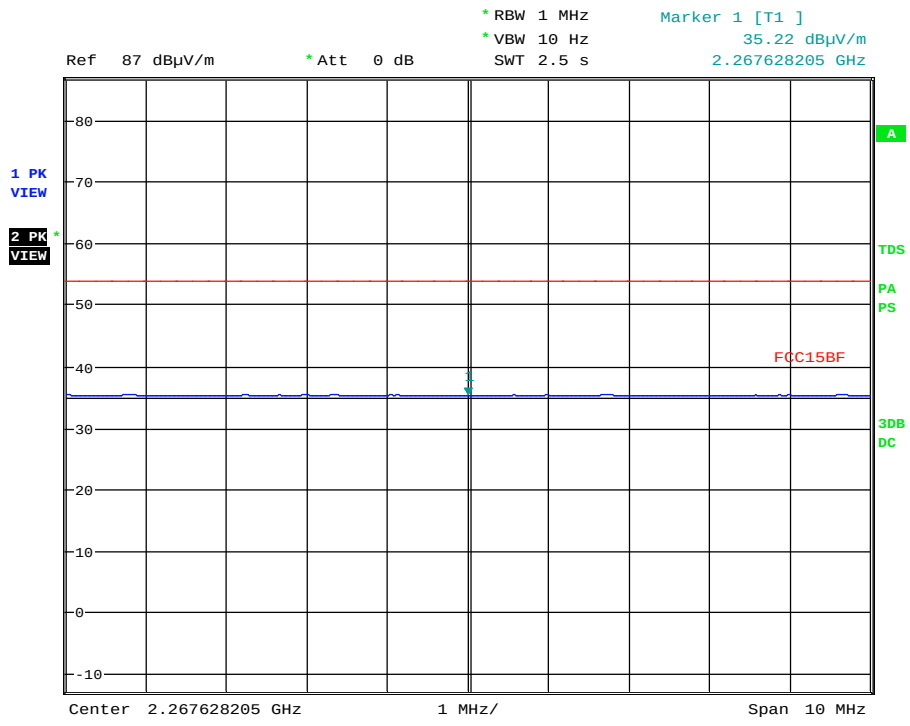



Mode: normal operation, 115V/60Hz
Date: 12.FEB.2016




Mode: normal operation; 115V/60Hz; Line: N
Date: 15.FEB.2016

## 7.8 Measurement Final-Plot




Mode: normal operation, 115V/60Hz
Date: 12.FEB.2016

# 8 LIST OF ANNEXES

Following annexes are separated parts from this test report.

| Description | Pages |
|---|---|
| Annex 1: Photographs of test set-up | 4 |
| Annex 2: External photographs of equipment under test (EUT) | 3 |
| Annex 3: Photographs of modifications of equipment under test (EUT) | 2 |