# HAC RF TESTREPORT

## No. I16Z42454-SEM03

**For**

**TCL Communication Ltd.**

**GSM Quad-band/HSPA-UMTS Six-band/LTE 19 band mobile phone**

**Modelname: BBB100-1**

**With**

**Hardware Version: 05**

**Software Version: AAJ048**

**FCC ID: 2ACCJN016**

**Results Summary: M Category = M4**

**Issued Date: 2017-2-22**

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TESTING
CNAS L0570

**Note:**

The test results in this test report relate only to the devices specified in this report. This report shall not be reproduced except in full without the written approval of CTTL.

**Test Laboratory:**

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## REPORT HISTORY

| Report Number | Revision | Issue Date | Description |
|---|---|---|---|
| I16Z42454-SEM03 | Rev.0 | 2017-2-22 | Initial creation of test report |

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# 1 Test Laboratory

## 1.1 Testing Location

| | |
|---|---|
| CompanyName: | CTTL(Shouxiang) |
| Address: | No. 51 Shouxiang Science Building, Xueyuan Road, Haidian District, Beijing, P. R. China100191 |

## 1.2 Testing Environment

| | |
|---|---|
| Temperature: | 18°C~25°C, |
| Relative humidity: | 30%~ 70% |
| Ground system resistance: | < 0.5 Ω |
| Ambient noise is checked and found very low and in compliance with requirement of standards. Reflection of surrounding objects is minimized and in compliance with requirement of standards | |

## 1.3 Project Data

| | |
|---|---|
| Project Leader: | Qi Dianyuan |
| Test Engineer: | Lin Hao |
| Testing Start Date: | January 17, 2017 |
| Testing End Date: | January 17, 2017 |

## 1.4 Signature

**Lin Xiaojun**

**(Prepared this test report)**

**Qi Dianyuan**

**(Reviewed this test report)**

**Lu Bingsong**

**Deputy Director of the laboratory**

**(Approved this test report)**

# 2 Client Information

## 2.1 Applicant Information

| | |
|---|---|
| Company Name: | TCL Communication Ltd. |
| Address /Post: | 5F, C building, No. 232, Liang Jing Road ZhangJiang High-Tech Park, Pudong Area Shanghai, P.R. China. 201203 |
| City: | Shanghai |
| Postal Code: | 201203 |
| Country: | P.R.China |
| Contact: | Gong Zhizhou |
| Email: | zhizhou.gong@tcl.com |
| Telephone: | 0086-21- 31363544 |
| Fax: | 0086-21-61460602 |

## 2.2 Manufacturer Information

| | |
|---|---|
| Company Name: | TCL Communication Ltd. |
| Address /Post: | 5F, C building, No. 232, Liang Jing Road ZhangJiang High-Tech Park, Pudong Area Shanghai, P.R. China. 201203 |
| City: | Shanghai |
| Postal Code: | 201203 |
| Country: | P.R.China |
| Contact: | Gong Zhizhou |
| Email: | zhizhou.gong@tcl.com |
| Telephone: | 0086-21- 31363544 |
| Fax: | 0086-21-61460602 |

# 3 Equipment Under Test (EUT) and Ancillary Equipment (AE)

## 3.1 About EUT

| | |
|---|---|
| Description: | GSM Quad-band/HSPA-UMTS Six-band/LTE 19 band mobile phone |
| Model name: | BBB100-1 |
| Operating mode(s): | GSM 850/900/1800/1900, UMTS FDD 1/2/4/5/6/8, BT, Wi-Fi<br>LTE Band 1/2/3/4/5/7/8/12/13/17/19/20/28/29/30/38/39/40/41 |

## 3.2 Internal Identification of EUT used during the test

| EUT ID* | IMEI | HW Version | SW Version |
|---|---|---|---|
| EUT1 | 004402243183278 | 05 | AAJ048 |
| EUT2 | 004402243180936 | 05 | AAJ048 |

*EUT ID: is used to identify the test sample in the lab internally.

**Note:** It is performed to test HAC with the EUT1 and conducted power with the EUT2.

## 3.3 Internal Identification of AE used during the test

| AE ID* | Description | Model | SN | Manufacturer |
|---|---|---|---|---|
| AE1 | Battery | BAT-63108-003 | CAC3440001C3 | ATL |
| AE2 | Battery | TLp034E1 | CAC3440003C1 | BYD |

*AE ID: is used to identify the test sample in the lab internally.

**Note:** It is performed to test HAC with the AE1.

## 3.4 Air Interfaces / Bands Indicating Operating Modes

| Air-interface | Band(MHz) | Type | C63.19/tested | Simultaneous Transmissions | OTT | Power Reduction |
|---|---|---|---|---|---|---|
| GSM | 850 | VO | Yes | BT, WLAN | NA | NA |
| | 1900 | | | | | |
| GPRS/EDGE | 850 | DT | NA | | | No |
| | 1900 | | | | | |
| WCDMA (UMTS) | 850 | VO | Yes | BT, WLAN | NA | NA |
| | 1700 | | | | | |
| | 1900 | | | | | |
| | HSPA | DT | NA | | | |
| LTE | Band 1/2/3/4/5/7/8/12/ 13/17/19/20/28/29 30/38/39/40/41 | V/D. | NA | BT, WLAN | NA | NA |
| BT | 2450 | DT | NA | GSM, WCDMA, LTE | NA | NA |
| WLAN | 2450 | DT | NA | GSM, WCDMA, LTE | NA | NA |

VO: Voice CMRS/PSTN Service Only V/D: Voice CMRS/PSTN and Data Service DT: Digital Transport

* HAC Rating was not based on concurrent voice and data modes, Non current mode was found to represent worst case rating for both M and T rating

Note:1.= No Associated T-Coil measurement has been made in accordance with 285076 D02 T-Coil testing for CMRS IP

# 4 CONDUCTED OUTPUT POWER MEASUREMENT

## 4.1 Summary

During the process of testing, the EUT was controlled via Agilent Digital Radio Communication tester (E5515C) to ensure the maximum power transmission and proper modulation. This result contains conducted output power for the EUT. In all cases, the measured output power should be greater and within 5% than EMI measurement.

## 4.2 Conducted Power

| | | | |
|---|---|---|---|
| **GSM 850MHz** | **Conducted Power (dBm)** | | |
| | **Channel 251(848.8MHz)** | **Channel 190(836.6MHz)** | **Channel 128(824.2MHz)** |
| | 31.54 | 31.51 | 31.50 |
| **GSM 1900MHz** | **Conducted Power(dBm)** | | |
| | **Channel 810(1909.8MHz)** | **Channel 661(1880MHz)** | **Channel 512(1850.2MHz)** |
| | 29.32 | 29.32 | 29.39 |
| **WCDMA 850MHz** | **Conducted Power (dBm)** | | |
| | **Channel 4233(846.6MHz)** | **Channel 4182(836.4MHz)** | **Channel 4132(826.4MHz)** |
| | 23.50 | 23.23 | 23.35 |
| **WCDMA 1700MHz** | **Conducted Power (dBm)** | | |
| | **Channel 1513 (1752.6MHz)** | **Channel 1412 (1732.4MHz)** | **Channel 1312 (1712.4MHz)** |
| | 23.14 | 23.22 | 23.22 |
| **WCDMA 1900MHz** | **Conducted Power (dBm)** | | |
| | **Channel 9538(1907.6MHz)** | **Channel 9400(1880MHz)** | **Channel 9262(1852.4MHz)** |
| | 23.93 | 23.72 | 23.76 |
| **LTE Band2 QPSK** | **Conducted Power (dBm)** | | |
| | **Channel 19100(1900MHz)** | **Channel18900(1880MHz)** | **Channel 18700(1860MHz)** |
| | 24.12 | 24.02 | 24.08 |
| **LTE Band4 QPSK** | **Conducted Power (dBm)** | | |
| | **Channel 20300(1745MHz)** | **Channel20175(1732.5MHz)** | **Channel 20050(1720MHz)** |
| | 23.62 | 23.55 | 23.58 |
| **LTE Band5 QPSK** | **Conducted Power (dBm)** | | |
| | **Channel 20600(844MHz)** | **Channel 20525(836.5MHz)** | **Channel20450(829MHz)** |
| | 23.66 | 23.44 | 23.72 |
| **LTE Band7 QPSK** | **Conducted Power (dBm)** | | |
| | **Channel 21350(2560MHz)** | **Channel21100(2535MHz)** | **Channel 20850(2510MHz)** |
| | 22.68 | 23.03 | 23.02 |
| **LTE Band12 QPSK** | **Conducted Power (dBm)** | | |
| | **Channel 23130(711MHz)** | **Channel 23095(707.5MHz)** | **Channel23060(704MHz)** |
| | 23.14 | 23.30 | 23.16 |
| **LTE Band13 QPSK** | **Conducted Power (dBm)** | | |
| | **Channel 23230(782MHz)** | | |
| | 23.40 | | |

| | | | |
|---|---|---|---|
| **LTE** | **Conducted Power (dBm)** | | |
| **Band30** | **Channel 27710(2310MHz)** | | |
| **QPSK** | 23.46 | | |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band41** | **Channel 41490(2680MHz)** | **Channel 40620(2593MHz)** | **Channel 39750(2506MHz)** |
| **QPSK** | 23.00 | 23.19 | 23.43 |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band2** | **Channel 19100(1900MHz)** | **Channel18900(1880MHz)** | **Channel 18700(1860MHz)** |
| **16-QAM** | 23.30 | 23.22 | 23.20 |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band4** | **Channel 20300(1745MHz)** | **Channel20175(1732.5MHz)** | **Channel 20050(1720MHz)** |
| **16-QAM** | 22.89 | 22.81 | 22.77 |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band5** | **Channel 20600(844MHz)** | **Channel 20525(836.5MHz)** | **Channel20450(829MHz)** |
| **16-QAM** | 22.90 | 22.81 | 22.87 |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band7** | **Channel 21350(2560MHz)** | **Channel21100(2535MHz)** | **Channel 20850(2510MHz)** |
| **16-QAM** | 21.90 | 22.23 | 22.19 |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band12** | **Channel 23130(711MHz)** | **Channel 23095(707.5MHz)** | **Channel23060(704MHz)** |
| **16-QAM** | 22.43 | 22.56 | 22.46 |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band13** | **Channel 23230(782MHz)** | | |
| **16-QAM** | 23.09 | | |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band30** | **Channel 27710(2310MHz)** | | |
| **16-QAM** | 23.02 | | |
| **LTE** | **Conducted Power (dBm)** | | |
| **Band41** | **Channel 41490(2680MHz)** | **Channel 40620(2593MHz)** | **Channel 39750(2506MHz)** |
| **16-QAM** | 21.79 | 22.18 | 22.65 |

# 5 Reference Documents

## 5.1 Reference Documents for testing

The following document listed in this section is referred for testing.

| Reference | Title | Version |
|---|---|---|
| ANSI C63.19-2011 | American National Standard for Methods of Measurement of Compatibility between Wireless Communication Devices and Hearing Aids | 2011 Edition |
| FCC 47 CFR §20.19 | Hearing Aid Compatible Mobile Headsets | 2015 Edition |
| KDB 285076 D01 | Equipment Authorization Guidance for Hearing Aid Compatibility | v04 |

# 6 OPERATIONAL CONDITIONS DURING TEST

## 6.1 HAC MEASUREMENT SET-UP

These measurements are performed using the DASY5 NEO automated dosimetric assessment system. It is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland. It consists of high precision robotics system (Stäubli), robot controller, Intel Core2 computer, near-field probe, probe alignment sensor. The robot is a six-axis industrial robot performing precise movements. A cell controller system contains the power supply, robot controller, teach pendant (Joystick),and remote control, is used to drive the robot motors. The PC consists of the HP Intel Core21.86 GHz computer with Windows XP system and HAC Measurement Software DASY5 NEO, A/D interface card, monitor, mouse, and keyboard. The Stäubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE)circuit performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

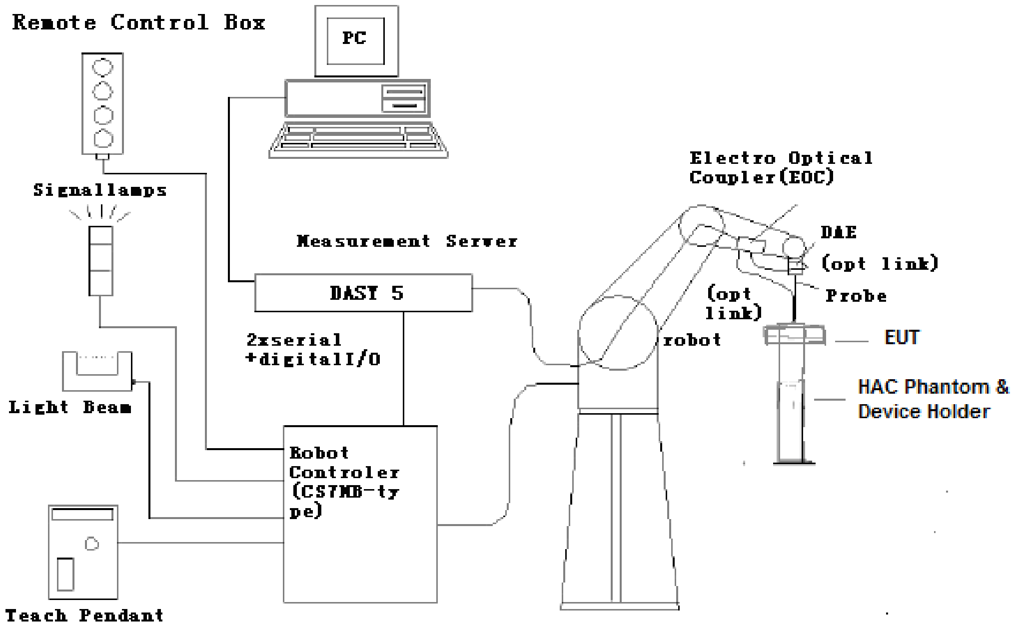
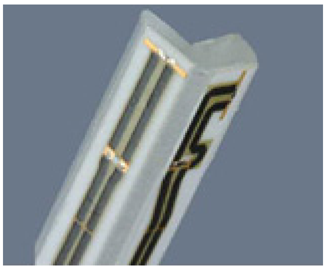



**Fig. 1 HAC Test Measurement Set-up**

The DAE4 consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts. They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer.

## 6.2 Probe Specification

E-Field Probe Description



[ER3DV6]

| | |
|---|---|
| Construction | One dipole parallel, two dipoles normal to probe axis<br>Built-in shielding against static charges<br>PEEK enclosure material |
| Calibration | In air from 100 MHz to 3.0 GHz (absolute accuracy ±6.0%, k=2) |
| Frequency | 40 MHz to > 6 GHz (can be extended to < 20 MHz)<br>Linearity: ± 0.2 dB (100 MHz to 3 GHz) |
| Directivity | ± 0.2 dB in air (rotation around probe axis)<br>± 0.4 dB in air (rotation normal to probe axis) |
| Dynamic Range | 2 V/m to > 1000 V/m; Linearity: ± 0.2 dB |
| Dimensions | Overall length: 330 mm (Tip: 16 mm)<br>Tip diameter: 8 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 2.5 mm |
| Application | General near-field measurements up to 6 GHz<br>Field component measurements<br>Fast automatic scanning in phantoms |

### 6.3Test Arch Phantom &Phone Positioner

The Test Arch phantom should be positioned horizontally on a stable surface. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. It enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot (Dimensions: 370 x 370 x 370 mm).

The Phone Positioner supports accurate and reliable positioning of any phone with effect on near field <±0.5 dB.

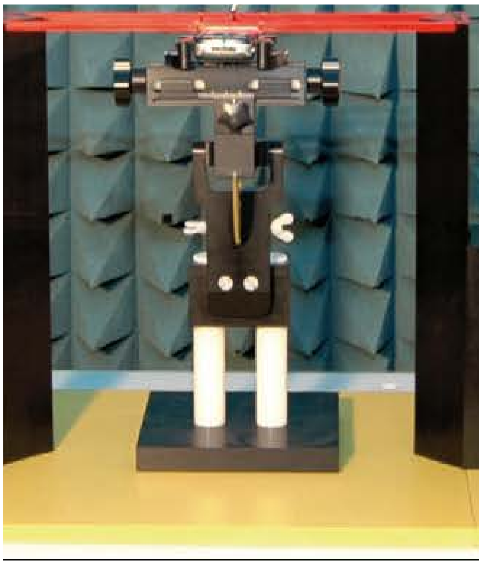


**Fig. 2 HAC Phantom & Device Holder**

### 6.4Robotic System Specifications

**Specifications**

**Positioner:** Stäubli Unimation Corp. Robot Model: RX160L

**Repeatability:** ±0.02 mm

**No. of Axis:** 6

**Data Acquisition Electronic (DAE) System**

**Cell Controller**

**Processor:** Intel Core2

**Clock Speed:** 1.86GHz

**Operating System:** Windows XP

**Data Converter**

**Features:**Signal Amplifier, multiplexer, A/D converter, and control logic

**Software:** DASY5 software

**Connecting Lines:** Optical downlink for data and status info.

Optical uplink for commands and clock

# 7 EUT ARRANGEMENT

## 7.1 WD RF Emission Measurements Reference and Plane

Figure 4 illustrates the references and reference plane that shall be used in the WD emissions measurement.

- The grid is 5 cm by 5 cm area that is divided into 9 evenly sized blocks or sub-grids.
- The grid is centered on the audio frequency output transducer of the WD (speaker or T-coil).
- The grid is located by reference to a reference plane. This reference plane is the planar area that contains the highest point in the area of the WD that normally rests against the user's ear
- The measurement plane is located parallel to the reference plane and 15 mm from it, out from the phone. The grid is located in the measurement plane.

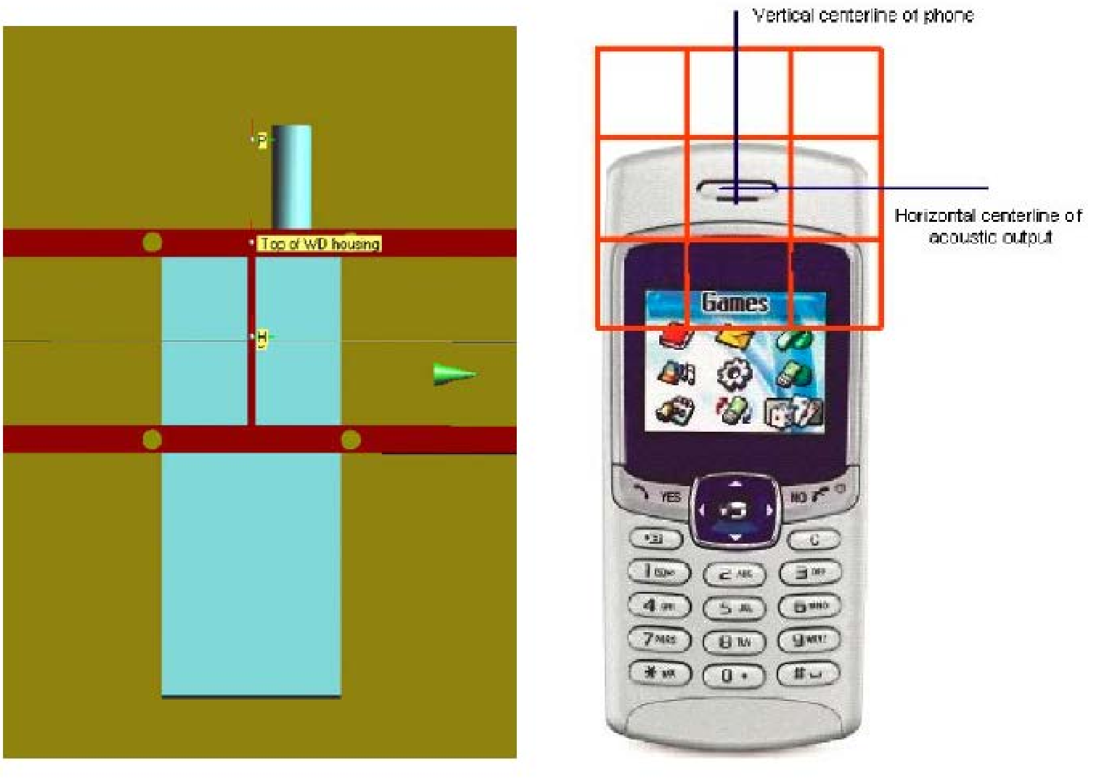



**Fig. 3 WD reference and plane for RF emission measurements**

# 8 SYSTEM VALIDATION

## 8.1 Validation Procedure

Place a dipole antenna meeting the requirements given in ANSI C63.19 in the position normally occupied by the WD. The dipole antenna serves as a known source for an electrical output. Position the E-field probes so that:

•The probes and their cables are parallel to the coaxial feed of the dipole antenna

•The probe cables and the coaxial feed of the dipole antenna approach the measurement area from opposite directions

• The center point of the probe element(s) are 15 mm from the closest surface of the dipole elements.

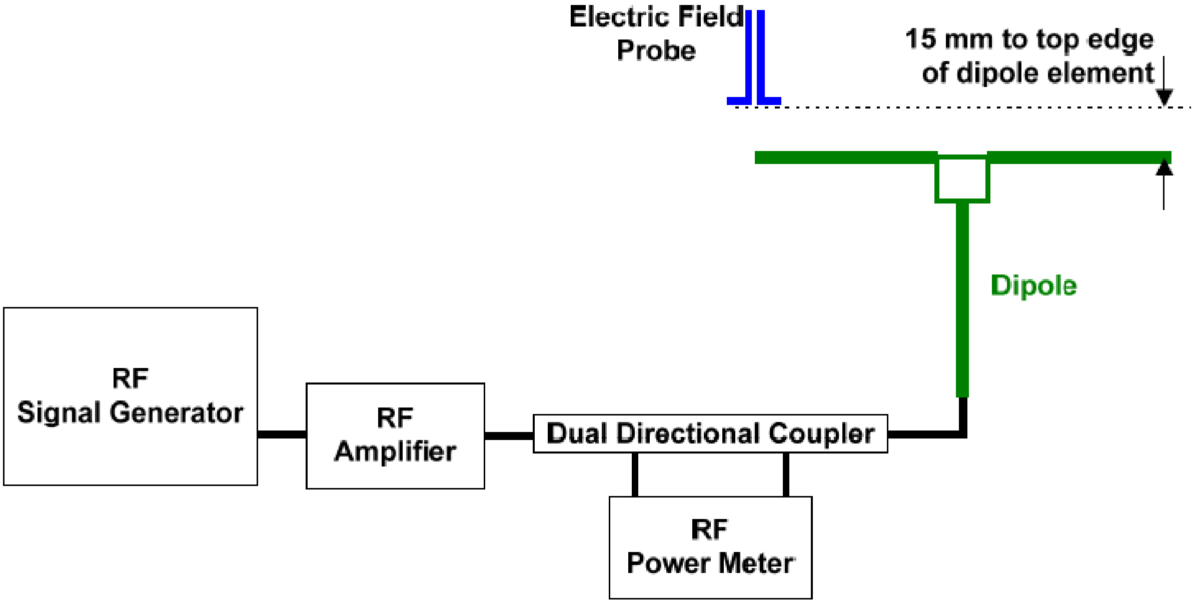



**Fig. 4 Dipole Validation Setup**

## 8.2 Validation Result

| E-Field Scan | | | | | | |
|---|---|---|---|---|---|---|
| **Mode** | **Frequency (MHz)** | **Input Power (mW)** | **Measured[1] Value(dBV/m)** | **Target[2] Value(dBV/m)** | **Deviation[3] (%)** | **Limit[4] (%)** |
| CW | 835 | 100 | 40.48 | 40.54 | -0.69 | ±25 |
| CW | 1880 | 100 | 39.47 | 39.35 | 1.39 | ±25 |

Notes:

1. Please refer to the attachment for detailed measurement data and plot.

2. Target value is provided by SPEAD in the calibration certificate of specific dipoles.

3. Deviation (%) = 100 * (Measured value minus Target value) divided by Target value.

4. ANSI C63.19 requires values within ± 25% are acceptable, of which 12% is deviation and 13% is measurement uncertainty. Values independently validated for the dipole actually used in the measurements should be used, when available.

# 9 Evaluation of MIF

## 9.1 Introduction

The MIF (Modulation Interference Factor) is used to classify E-field emission to determine Hearing Aid Compatibility (HAC). It scales the power-averaged signal to the RF audio interference level and is characteristic to a modulation scheme. The HAC standard preferred "indirect" measurement method is based on average field measurement with separate scaling by the MIF. With an Audio Interference Analyzer (AIA) designed by SPEAG specifically for the MIF measurement, these values have been verified by practical measurements on an RF signal modulated with each of the waveforms. The resulting deviations from the simulated values are within the requirements of the HAC standard.

The AIA (Audio Interference Analyzer) is an USB powered electronic sensor to evaluate signals in the frequency range 698MHz - 6 GHz. It contains RMS detector and audio frequency circuits for sampling of the RF envelope.

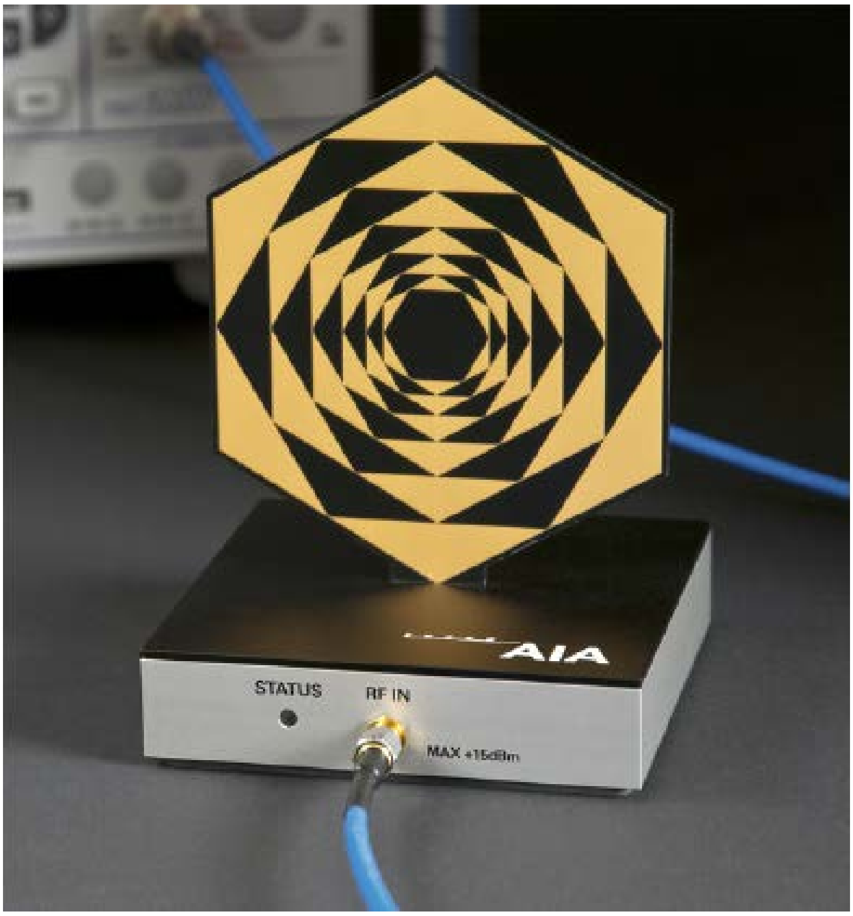



**Fig. 5 AIA Front View**

## 9.2 MIF measurement with the AIA

The MIF is measured with the AIA as follows:

1. Connect the AIA via USB to the DASY5 PC and verify the configuration settings.
2. Couple the RF signal to be evaluated to an AIA via cable or antenna.
3. Generate a MIF measurement job for the unknown signal and select the measurement port and timing settings.
4. Document the results via the post processor in a report.

## 9.3 Test equipment for the MIF measurement

| No. | Name | Type | Serial Number | Manufacturer |
|---|---|---|---|---|
| 01 | Signal Generator | E4438C | MY49071430 | Agilent |
| 02 | AIA | SE UMS 170 CB | 1029 | SPEAG |
| 03 | BTS | E5515C | MY50263375 | Agilent |

## 9.4 Test signal validation

The signal generator (E4438C) is used to generate a 1GHz signal with different modulation in the below table based on the ANSI C63.19-2011. The measured MIF with AIA are compared with the target values given in ANSI C63.19-2011 table D.3, D.4 and D5.

| **Pulse modulation** | **Target MIF** | **Measured MIF** | **Deviation** |
|---|---|---|---|
| 0.5ms pulse, 1000Hz repetition rate | -0.9 dB | -0.9 dB | 0 dB |
| 1ms pulse, 100Hz repetition rate | +3.9 dB | +3.7 dB | 0.2 dB |
| 0.1ms pulse, 100Hz repetition rate | +10.1 dB | +10.0 dB | 0.1 dB |
| 10ms pulse, 10Hz repetition rate | +1.6 dB | +1.7 dB | 0.1 dB |
| **Sine-wave modulation** | **Target MIF** | **Measured MIF** | **Deviation** |
| 1 kHz, 80% AM | -1.2 dB | -1.3 dB | 0.1 dB |
| 1 kHz, 10% AM | -9.1 dB | -9.0 dB | 0.1 dB |
| 1 kHz, 1% AM | -19.1 dB | -18.9 dB | 0.2 dB |
| 100 Hz, 10% AM | -16.1 dB | -16.0 dB | 0.1 dB |
| 10 kHz, 10% AM | -21.5 dB | -21.6 dB | 0.1 dB |
| **Transmission protocol** | **Target MIF** | **Measured MIF** | **Deviation** |
| GSM; full-rate version 2; speech codec/handset low | +3.5 dB | +3.47 dB | 0.03 dB |
| WCDMA; speech; speech codec low; AMR 12.2 kb/s | -20.0 dB | -19.8 dB | 0.2 dB |
| CDMA; speech; SO3; RC3; full frame rate; 8kEVRC | -19.0 dB | -19.1 dB | 0.1 dB |
| CDMA; speech; SO3; RC1; 1/8$^{th}$ frame rate; 8kEVRC | +3.3 dB | +3.44 dB | 0.14 dB |

### 9.5 DUT MIF results

| **Typical MIF levels in ANSI C63.19-2011** | |
|---|---|
| Transmission protocol | Modulation interference factor |
| GSM; full-rate version 2; speech codec/handset low | +3.5 dB |
| WCDMA; speech; speech codec low; AMR 12.2 kb/s | -20.0 dB |
| LTE-FDD (SC-FDMA, 1RB, 20MHz, QPSK) | -15.63 dB |
| LTE-FDD (SC-FDMA, 1RB, 20MHz, 16QAM) | -9.76 dB |
| LTE-TDD (SC-FDMA, 1RB, 20MHz, QPSK) | -1.62 dB |
| LTE-TDD (SC-FDMA, 1RB, 20MHz, 16QAM) | -1.44 dB |

| **Measured MIF levels** | | |
|---|---|---|
| Band | Channel | Modulation interference factor |
| GSM 850 | 251 | +3.48 dB |
| | 190 | +3.50 dB |
| | 128 | +3.49 dB |
| GSM 1900 | 810 | +3.41 dB |
| | 661 | +3.47 dB |
| | 512 | +3.48 dB |
| WCDMA 850 | 4233 | -19.71 dB |
| | 4182 | -19.66 dB |
| | 4132 | -19.64 dB |
| WCDMA 1700 | 1513 | -19.58 dB |
| | 1412 | -19.59 dB |
| | 1312 | -19.61 dB |
| WCDMA 1900 | 9538 | -19.63 dB |
| | 9400 | -19.63 dB |
| | 9262 | -19.65 dB |
| LTE Band2 QPSK | 19100 | -15.04 dB |
| | 18900 | -14.82 dB |
| | 18700 | -14.19 dB |
| LTE Band4 QPSK | 20300 | -15.05 dB |
| | 20175 | -14.64 dB |
| | 20050 | -15.11 dB |
| LTE Band5 QPSK | 20600 | -14.36 dB |
| | 20525 | -14.81 dB |
| | 20450 | -14.80 dB |
| LTE Band7 QPSK | 21350 | -14.89 dB |
| | 21100 | -14.77 dB |
| | 20850 | -15.13 dB |
| LTE Band12 QPSK | 23130 | -14.57 dB |
| | 23095 | -14.80 dB |
| | 23060 | -13.90 dB |

| | | |
|---|---|---|
| LTE Band13 QPSK | 23230 | -14.36 dB |
| LTE Band17 QPSK | 23800 | -14.26 dB |
| | 23790 | -14.58 dB |
| | 23780 | -14.71 dB |
| LTE Band30 QPSK | 27710 | -14.88 dB |
| LTE Band41 QPSK | 41490 | -1.83 dB |
| | 40620 | -1.75 dB |
| | 39750 | -1.69 dB |
| LTE Band2 16QAM | 19100 | -10.42 dB |
| | 18900 | -10.96 dB |
| | 18700 | -11.11 dB |
| LTE Band4 16QAM | 20300 | -10.95 dB |
| | 20175 | -11.10 dB |
| | 20050 | -10.32 dB |
| LTE Band5 16QAM | 20600 | -11.03 dB |
| | 20525 | -10.34 dB |
| | 20450 | -9.63 dB |
| LTE Band7 16QAM | 21350 | -10.82 dB |
| | 21100 | -10.52 dB |
| | 20850 | -10.47 dB |
| LTE Band12 16QAM | 23130 | -10.07 dB |
| | 23095 | -11.12 dB |
| | 23060 | -10.85 dB |
| LTE Band13 16QAM | 23230 | -10.79 dB |
| LTE Band17 16QAM | 23800 | -11.21 dB |
| | 23790 | -10.38 dB |
| | 23780 | -9.87 dB |
| LTE Band30 16QAM | 27710 | -10.26 dB |
| LTE Band41 16QAM | 41490 | -1.73 dB |
| | 40620 | -1.54 dB |
| | 39750 | -1.45 dB |

# 10 Evaluation for low-power exemption

## 10.1 Product testing threshold

There are two methods for exempting an RF air interface technology from testing. The first method requires evaluation of the MIF for the worst-case operating mode. An RF air interface technology of a device is exempt from testing when its average antenna input power plus its MIF is≤17 dBm for any of its operating modes. The second method does not require determination of the MIF. The RF emissions testing exemption shall be applied to an RF air interface technology in a device whose peak antenna input power, averaged over intervals ≤50 μs20, is ≤23 dBm. An RF air interface technology that is exempted from testing by either method shall be rated as M4.
The first method is used to be exempt from testing for the RF air interface technology in this report.

## 10.2 Conducted power

| Band | Average power (dBm) | MIF (dB) | Sum (dBm) |
|---|---|---|---|
| GSM 850 | 31.54 | 3.50 | 35.04 |
| GSM 1900 | 29.39 | 3.48 | 32.87 |
| WCDMA 850 | 23.50 | -19.64 | 3.86 |
| WCDMA 1700 | 23.22 | -19.58 | 3.64 |
| WCDMA 1900 | 23.93 | -19.63 | 4.30 |

## 10.3 Conclusion

According to the above table, the sums of average power and MIF for UMTS are less than 17dBm. So it is only measured for GSM bands. The UMTS bands are exempt from testing and rated as M4.

# 11 RF TEST PROCEDUERES

**The evaluation was performed with the following procedure:**

1) Confirm proper operation of the field probe, probe measurement system and other instrumentation and the positioning system.

2) Position the WD in its intended test position. The gauge block can simplify this positioning.

3) Configure the WD normal operation for maximum rated RF output power, at the desired channel and other operating parameters (e.g., test mode), as intended for the test.

4) The center sub-grid shall centered on the center of the T-Coil mode axial measurement point or the acoustic output, as appropriate. Locate the field probe at the initial test position in the50 mm by 50 mm grid, which is contained in the measurement plane. If the field alignment method is used, align the probe for maximum field reception.

5) Record the reading.

6) Scan the entire 50 mm by 50 mm region in equally spaced increments and record the reading at each measurement point. The distance between measurement points shall be sufficient to assure the identification of the maximum reading.

7) Identify the five contiguous sub-grids around the center sub-grid whose maximum reading is the lowest of all available choices. This eliminates the three sub-grids with the maximum readings. Thus, the six areas to be used to determine the WD's highest emissions are identified.

8) Identify the maximum field reading within the non-excluded sub-grids identified in Step 7)

9) Evaluate the MIF and add to the maximum steady-state rms field-strength reading to obtain the RF audio interference level..

10) Compare this RF audio interference level with the categories and record the resulting WD category rating.

## 12 Measurement Results (E-Field)

| Frequency | | Measured Value(dBV/m) | Power Drift (dB) | Category |
|---|---|---|---|---|
| MHz | Channel | | | |
| **GSM 850** | | | | |
| 848.8 | 251 | 28.68 | -0.01 | **M4** (see Fig B.1) |
| 836.6 | 190 | 30.30 | -0.00 | **M4** (see Fig B.2) |
| 824.2 | 128 | 31.78 | -0.05 | **M4** (see Fig B.3) |
| **GSM 1900** | | | | |
| 1909.8 | 810 | 28.25 | 0.14 | **M4** (see Fig B.4) |
| 1880 | 661 | 28.06 | -0.01 | **M4** (see Fig B.5) |
| 1850.2 | 512 | 28.86 | -0.14 | **M4** (see Fig B.6) |

## 13 ANSIC 63.19-2011 LIMITS

**WD RF audio interference level categories in logarithmic units**

| **Emission categories** | **< 960 MHz** | |
|---|---|---|
| | **E-field emissions** | |
| Category M1 | 50 to 55 | dB (V/m) |
| Category M2 | 45 to 50 | dB (V/m) |
| Category M3 | 40 to 45 | dB (V/m) |
| Category M4 | < 40 | dB (V/m) |
| **Emission categories** | **>960 MHz** | |
| | **E-field emissions** | |
| Category M1 | 40 to 45 | dB (V/m) |
| Category M2 | 35 to 40 | dB (V/m) |
| Category M3 | 30 to 35 | dB (V/m) |
| Category M4 | < 30 | dB (V/m) |

## 14 MEASUREMENT UNCERTAINTY

| No. | Error source | Type | Uncertainty Value(%) | Prob. Dist. | k | $c_i$E | Standard Uncertainty (%) $u_i'$ (%)E | Degree of freedom $V_{eff}$ or $v_i$ |
|---|---|---|---|---|---|---|---|---|
| **Measurement System** | | | | | | | | |
| 1 | Probe Calibration | B | 5. | N | 1 | 1 | 5.1 | ∞ |
| 2 | Axial Isotropy | B | 4.7 | R | $\sqrt{3}$ | 1 | 2.7 | ∞ |
| 3 | Sensor Displacement | B | 16.5 | R | $\sqrt{3}$ | 1 | 9.5 | ∞ |
| 4 | Boundary Effects | B | 2.4 | R | $\sqrt{3}$ | 1 | 1.4 | ∞ |
| 5 | Linearity | B | 4.7 | R | $\sqrt{3}$ | 1 | 2.7 | ∞ |
| 6 | Scaling to Peak Envelope Power | B | 2.0 | R | $\sqrt{3}$ | 1 | 1.2 | ∞ |
| 7 | System Detection Limit | B | 1.0 | R | $\sqrt{3}$ | 1 | 0.6 | ∞ |
| 8 | Readout Electronics | B | 0.3 | N | 1 | 1 | 0.3 | ∞ |
| 9 | Response Time | B | 0.8 | R | $\sqrt{3}$ | 1 | 0.5 | ∞ |
| 10 | Integration Time | B | 2.6 | R | $\sqrt{3}$ | 1 | 1.5 | ∞ |
| 11 | RF Ambient Conditions | B | 3.0 | R | $\sqrt{3}$ | 1 | 1.7 | ∞ |
| 12 | RF Reflections | B | 12.0 | R | $\sqrt{3}$ | 1 | 6.9 | ∞ |
| 13 | Probe Positioner | B | 1.2 | R | $\sqrt{3}$ | 1 | 0.7 | ∞ |
| 14 | Probe Positioning | A | 4.7 | R | $\sqrt{3}$ | 1 | 2.7 | ∞ |
| 15 | Extra. And Interpolation | B | 1.0 | R | $\sqrt{3}$ | 1 | 0.6 | ∞ |
| **Test Sample Related** | | | | | | | | |
| 16 | Device Positioning Vertical | B | 4.7 | R | $\sqrt{3}$ | 1 | 2.7 | ∞ |
| 17 | Device Positioning Lateral | B | 1.0 | R | $\sqrt{3}$ | 1 | 0.6 | ∞ |
| 18 | Device Holder and Phantom | B | 2.4 | R | $\sqrt{3}$ | 1 | 1.4 | ∞ |
| 19 | Power Drift | B | 5.0 | R | $\sqrt{3}$ | 1 | 2.9 | ∞ |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 20 | AIA measurement | B | 12 | R | $\sqrt{3}$ | 1 | 6.9 | ∞ |
| **Phantom and Setup related** | | | | | | | | |
| 21 | Phantom Thickness | B | 2.4 | R | $\sqrt{3}$ | 1 | 1.4 | ∞ |
| Combined standard uncertainty(%) | | | | | | | 16.2 | |
| Expanded uncertainty (confidence interval of 95 %) | | $u_e = 2u_c$ | | N | k=2 | | 32.4 | |

## 15 MAIN TEST INSTRUMENTS

**Table 1: List of Main Instruments**

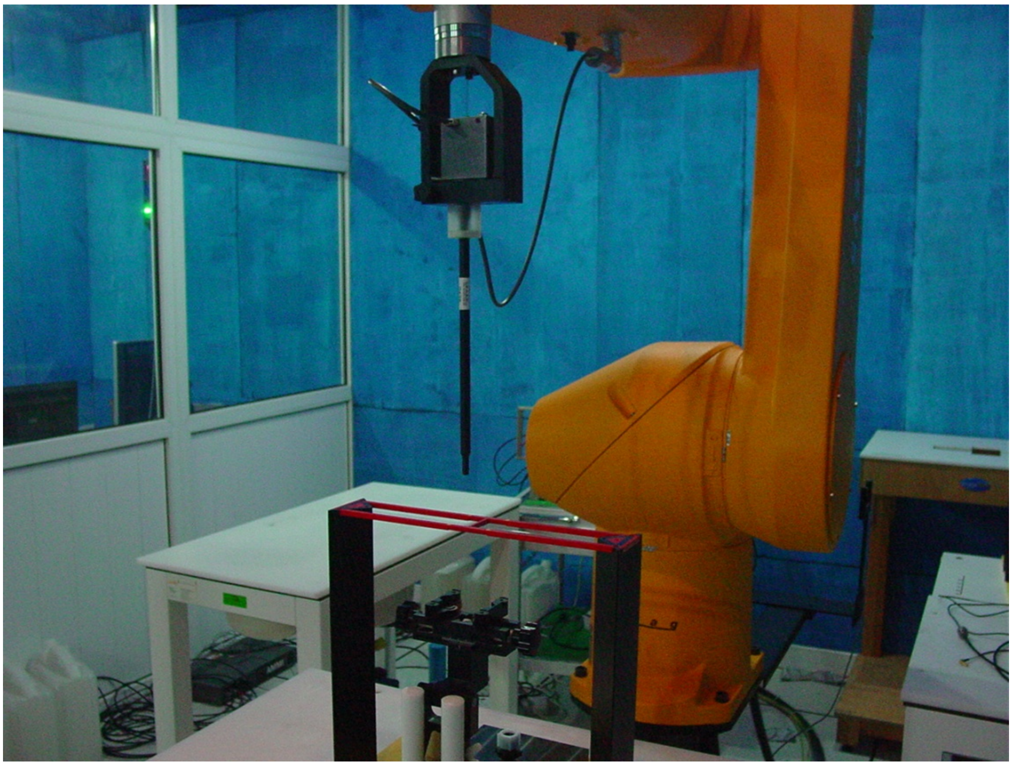
| No. | Name | Type | Serial Number | Calibration Date | Valid Period |
|---|---|---|---|---|---|
| 01 | Signal Generator | E4438C | MY49071430 | February 01,2016 | One Year |
| 02 | Power meter | NRVD | 102196 | March 03,2016 | One year |
| 03 | Power sensor | NRV-Z5 | 100596 | | |
| 04 | Amplifier | 60S1G4 | 0331848 | No Calibration Requested | |
| 05 | E-Field Probe | ER3DV6 | 2272 | January 19, 2016 | One year |
| 06 | HAC Dipole | CD835V3 | 1023 | August 31, 2016 | One year |
| 07 | HAC Dipole | CD1880V3 | 1018 | August 31, 2016 | One year |
| 08 | BTS | E5515C | MY50263375 | January 30, 2016 | One year |
| 09 | DAE | SPEAG DAE4 | 777 | August 22, 2016 | One year |
| 10 | AIA | SE UMS 170 CB | 1029 | No Calibration Requested | |

## 16 CONCLUSION

The HAC measurement indicates that the EUT complies with the HAC limits of the ANSIC63.19-2011. The total M-rating is **M4.**

***END OF REPORT BODY***

# ANNEX A TEST LAYOUT



Picture A1:HAC RF System Layout

## ANNEX B TEST PLOTS

### HAC RF E-Field GSM 850 High

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$

Ambient Temperature: 22.0$^{o}$C

Communication System: GSM 850; Frequency: 848.8 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device/Hearing Aid Compatibility Test (101x101x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 22.60 V/m; Power Drift = -0.01 dB

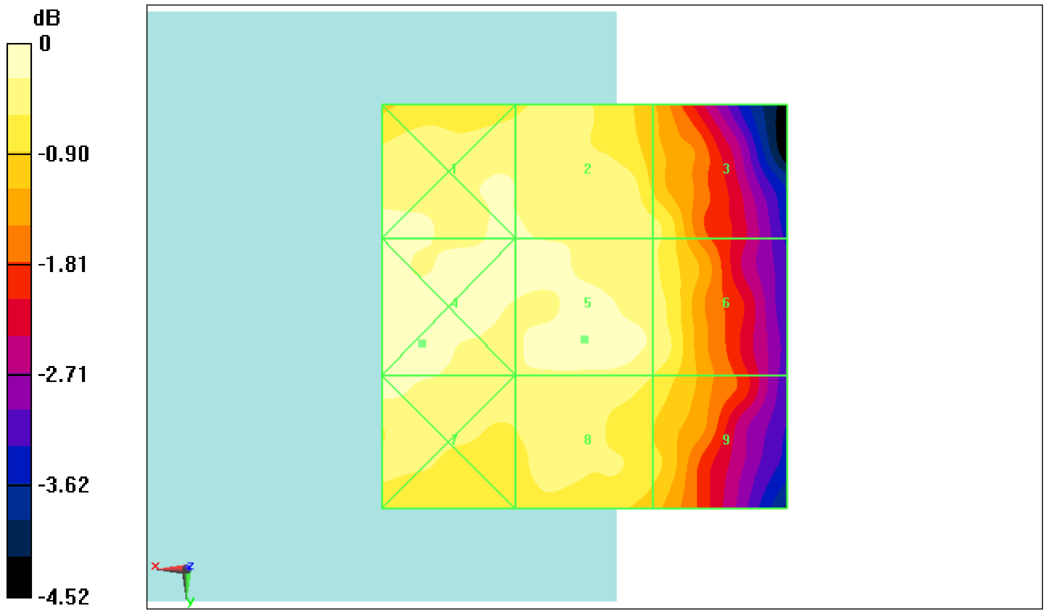
Applied MIF = 3.48 dB

RF audio interference level = 28.68 dBV/m

**Emission category: M4**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1 **M4** **28.61 dBV/m** | Grid 2 **M4** **28.53 dBV/m** | Grid 3 **M4** **28.26 dBV/m** |
| Grid 4 **M4** **28.77 dBV/m** | Grid 5 **M4** **28.68 dBV/m** | Grid 6 **M4** **28.43 dBV/m** |
| Grid 7 **M4** **28.6 dBV/m** | Grid 8 **M4** **28.45 dBV/m** | Grid 9 **M4** **28.17 dBV/m** |




0 dB = 27.44 V/m = 28.77 dBV/m

**Fig B.1 HAC RF E-Field GSM 850 High**

## HAC RF E-Field GSM 850 Middle

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: σ = 0 mho/m, $\varepsilon_r = 1$; ρ = 1000 kg/m$^3$

Ambient Temperature: 22.0$^o$C

Communication System: GSM 850; Frequency: 836.6 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 2/Hearing Aid Compatibility Test (101x101x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 27.34 V/m; Power Drift = -0.00 dB

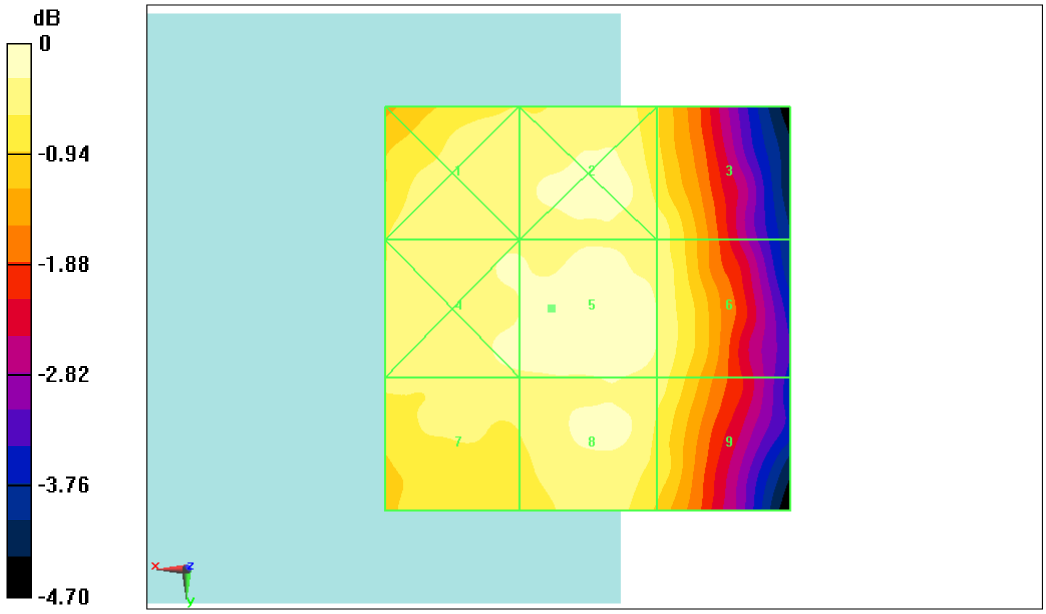
Applied MIF = 3.50 dB

RF audio interference level = 30.30 dBV/m

**Emission category: M4**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1 **M4** **29.93 dBV/m** | Grid 2 **M4** **30.1 dBV/m** | Grid 3 **M4** **29.85 dBV/m** |
| Grid 4 **M4** **30.07 dBV/m** | Grid 5 **M4** **30.3 dBV/m** | Grid 6 **M4** **30 dBV/m** |
| Grid 7 **M4** **29.95 dBV/m** | Grid 8 **M4** **30.08 dBV/m** | Grid 9 **M4** **29.83 dBV/m** |




0 dB = 32.73 V/m = 30.30 dBV/m

**Fig B.2 HAC RF E-Field GSM 850 Middle**

## HAC RF E-Field GSM 850 Low

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$

Ambient Temperature: 22.0$^o$C

Communication System: GSM 850; Frequency: 824.2 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 3/Hearing Aid Compatibility Test (101x101x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 32.84 V/m; Power Drift = -0.05 dB

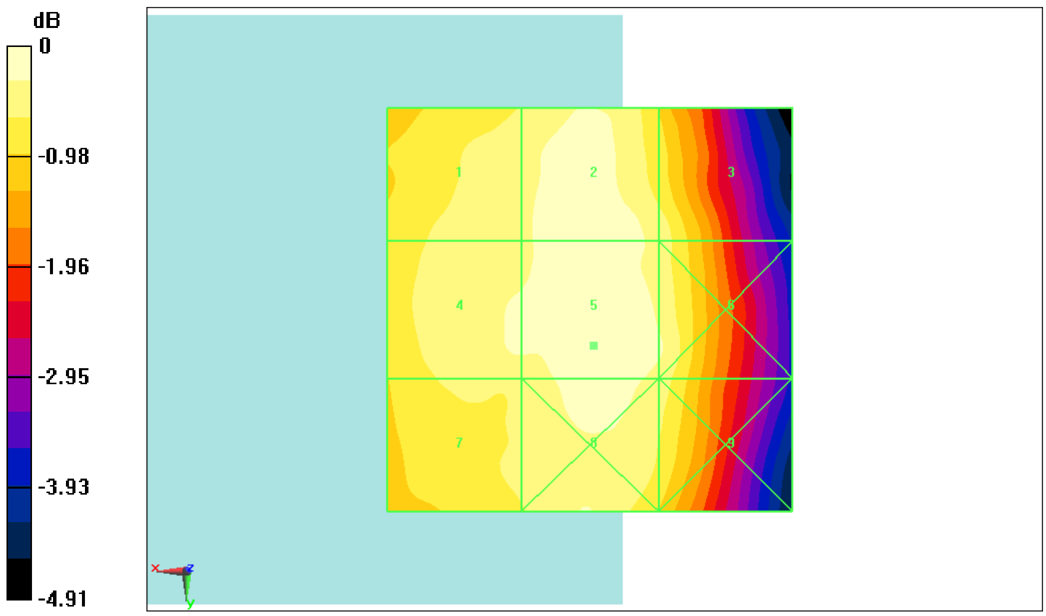
Applied MIF = 3.49 dB

RF audio interference level = 31.78 dBV/m

**Emission category: M4**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1 **M4** **31.4 dBV/m** | Grid 2 **M4** **31.62 dBV/m** | Grid 3 **M4** **31.33 dBV/m** |
| Grid 4 **M4** **31.53 dBV/m** | Grid 5 **M4** **31.78 dBV/m** | Grid 6 **M4** **31.5 dBV/m** |
| Grid 7 **M4** **31.27 dBV/m** | Grid 8 **M4** **31.69 dBV/m** | Grid 9 **M4** **31.34 dBV/m** |




0 dB = 38.83 V/m = 31.78 dBV/m

**Fig B.3 HAC RF E-Field GSM 850 Low**

## HAC RF E-Field GSM 1900 High

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$

Ambient Temperature: 22.0$^o$C

Communication System: DCS 1900; Frequency: 1909.8 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device/Hearing Aid Compatibility Test (101x101x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 18.29 V/m; Power Drift = 0.14 dB

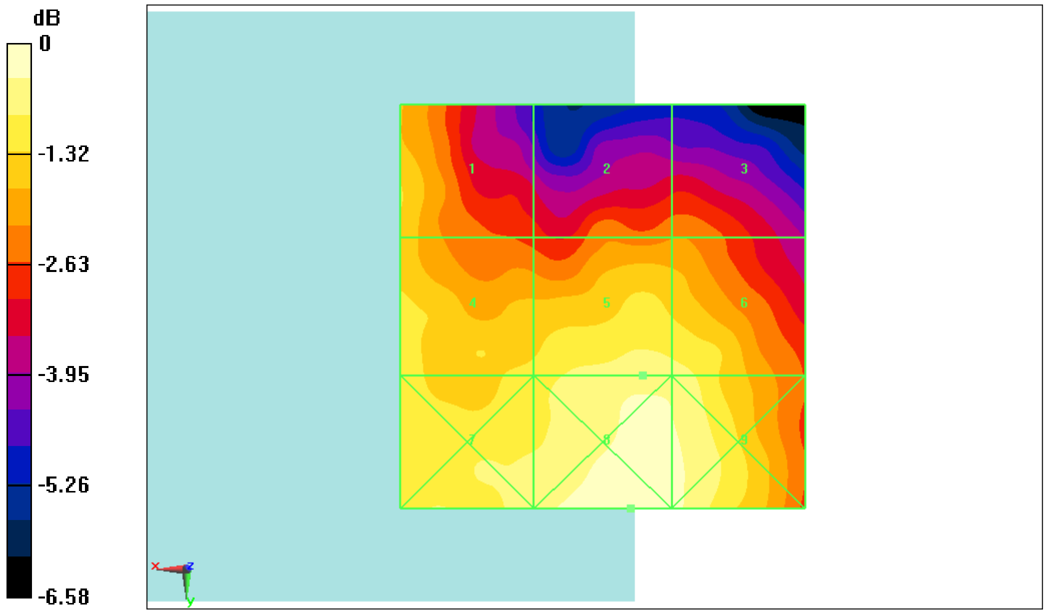
Applied MIF = 3.41 dB

RF audio interference level = 28.25 dBV/m

**Emission category: M4**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1 **M4** **27.58 dBV/m** | Grid 2 **M4** **26.65 dBV/m** | Grid 3 **M4** **26.68 dBV/m** |
| Grid 4 **M4** **27.73 dBV/m** | Grid 5 **M4** **28.25 dBV/m** | Grid 6 **M4** **28.19 dBV/m** |
| Grid 7 **M4** **28.24 dBV/m** | Grid 8 **M4** **28.85 dBV/m** | Grid 9 **M4** **28.55 dBV/m** |




0 dB = 27.69 V/m = 28.85 dBV/m

**Fig B.4 HAC RF E-Field GSM 1900 High**

## HAC RF E-Field GSM 1900 Middle

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$

Ambient Temperature: 22.0°C

Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 2/Hearing Aid Compatibility Test (101x101x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 17.11 V/m; Power Drift = -0.01 dB

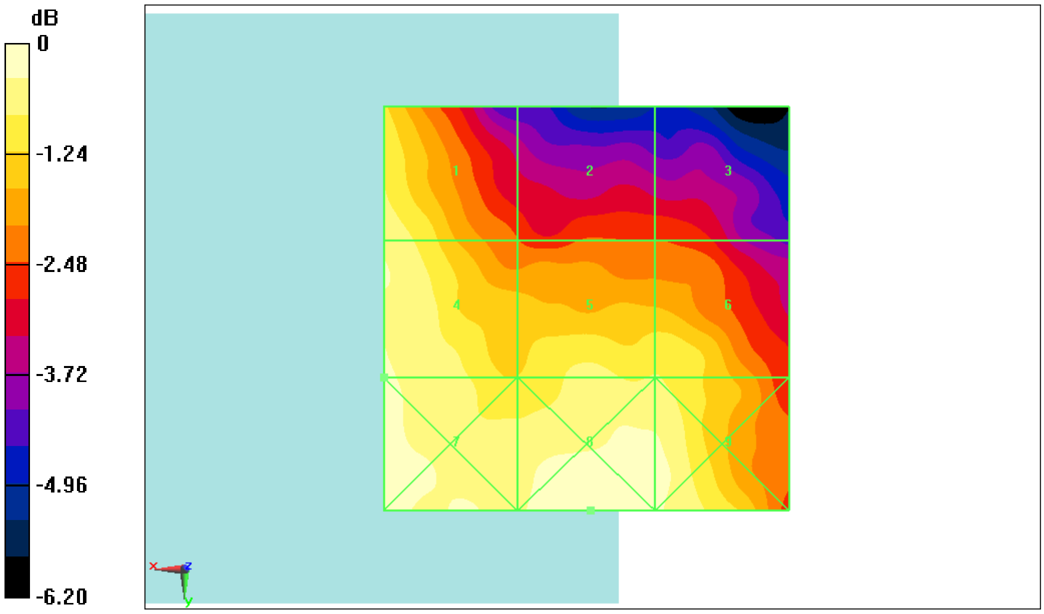
Applied MIF = 3.47 dB

RF audio interference level = 28.06 dBV/m

**Emission category: M4**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1 **M4** **27.86 dBV/m** | Grid 2 **M4** **25.96 dBV/m** | Grid 3 **M4** **25.92 dBV/m** |
| Grid 4 **M4** **28.06 dBV/m** | Grid 5 **M4** **27.8 dBV/m** | Grid 6 **M4** **27.58 dBV/m** |
| Grid 7 **M4** **28.32 dBV/m** | Grid 8 **M4** **28.39 dBV/m** | Grid 9 **M4** **28.13 dBV/m** |




0 dB = 26.28 V/m = 28.39 dBV/m

**Fig B.5 HAC RF E-Field GSM 1900 Middle**

**HAC RF E-Field GSM 1900 Low**

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$

Ambient Temperature: 22.0°C

Communication System: DCS 1900; Frequency: 1850.2 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 3/Hearing Aid Compatibility Test (101x101x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 19.66 V/m; Power Drift = -0.14 dB

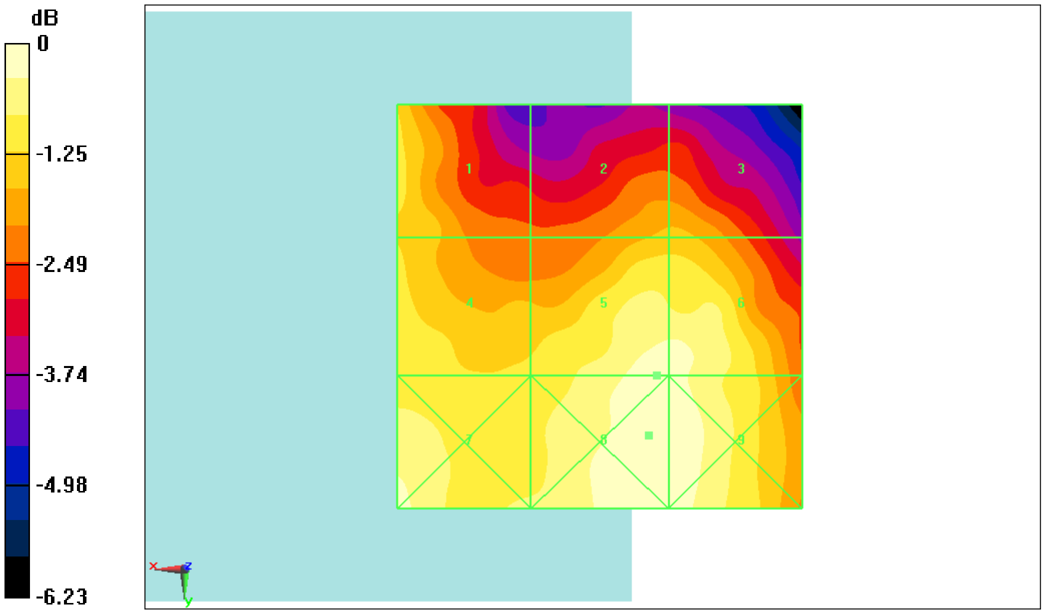
Applied MIF = 3.48 dB

RF audio interference level = 28.86 dBV/m

**Emission category: M4**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1 **M4** **28.16 dBV/m** | Grid 2 **M4** **27.65 dBV/m** | Grid 3 **M4** **27.65 dBV/m** |
| Grid 4 **M4** **28.16 dBV/m** | Grid 5 **M4** **28.86 dBV/m** | Grid 6 **M4** **28.83 dBV/m** |
| Grid 7 **M4** **28.96 dBV/m** | Grid 8 **M4** **29.14 dBV/m** | Grid 9 **M4** **29.07 dBV/m** |




0 dB = 28.64 V/m = 29.14 dBV/m

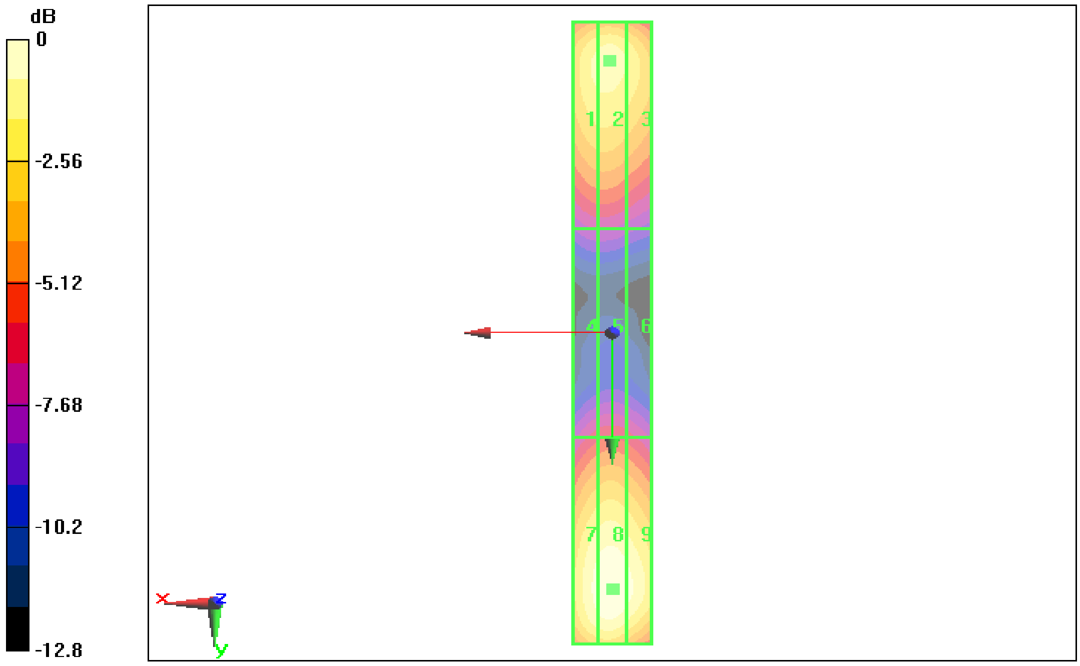
**Fig B.6 HAC RF E-Field GSM 1900 Low**

## ANNEX C SYSTEM VALIDATION RESULT

**E SCAN of Dipole 835 MHz**
**Date: 2017-1-17**
Electronics: DAE4 Sn777
Medium: Air
Medium parameters used: σ = 0 mho/m, εr = 1; ρ = 1000 kg/m3
Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1
Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)
**E Scan - measurement distance from the probe sensor center to CD835 Dipole = 15mm/Hearing Aid Compatibility Test (41x361x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 105.7 V/m; Power Drift = -0.06 dB
Applied MIF = 0.00 dB
RF audio interference level = 40.48 dBV/m
**Emission category: M3**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1**M3** **40.28 dBV/m** | Grid 2**M3** **40.48 dBV/m** | Grid 3**M3** **40.36 dBV/m** |
| Grid 4 **M4** **35.47 dBV/m** | Grid 5 **M4** **35.78 dBV/m** | Grid 6 **M4** **35.77 dBV/m** |
| Grid 7 **M3** **39.89 dBV/m** | Grid 8 **M3** **40.19 dBV/m** | Grid 9 **M3** **40.12 dBV/m** |




0 dB = 40.48 dBV/m

**E SCAN of Dipole 1880 MHz**

**Date: 2017-1-17**

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m$^3$

Communication System: CW; Frequency: 1880 MHz; Duty Cycle: 1:1

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

**E Scan - measurement distance from the probe sensor center to CD1880 Dipole = 15mm/Hearing Aid Compatibility Test (41x181x1):** Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 94.1 V/m; Power Drift = -0.09 dB

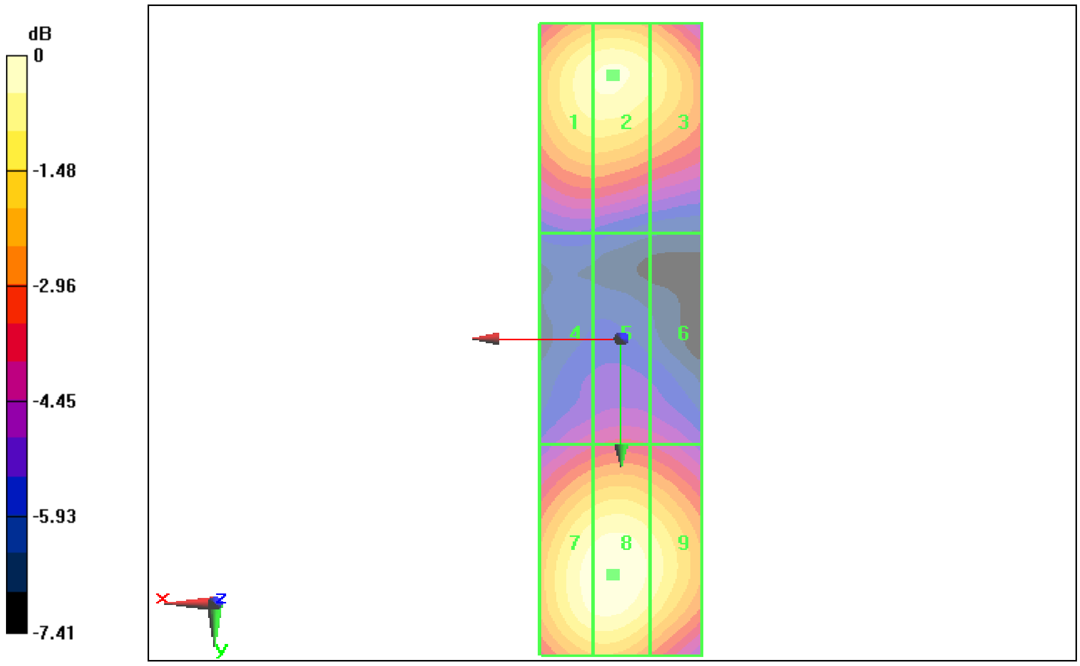
Applied MIF = 0.00 dB

RF audio interference level = 39.47 dBV/m

**Emission category: M2**

MIF scaled E-field

| | | |
|---|---|---|
| Grid 1**M2** **39.24 dBV/m** | Grid 2**M2** **39.47 dBV/m** | Grid 3**M2** **39.34 dBV/m** |
| Grid 4**M2** **36.91 dBV/m** | Grid 5**M2** **37.09 dBV/m** | Grid 6**M2** **37.02 dBV/m** |
| Grid 7**M2** **39.27 dBV/m** | Grid 8**M2** **39.41 dBV/m** | Grid 9**M2** **39.31 dBV/m** |




0 dB = 39.47 dBV/m

# ANNEX D PROBE CALIBRATION CERTIFICATE

**E_Probe ER3DV6**

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** Schweizerischer Kalibrierdienst
**C** Service suisse d'étalonnage
**S** Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

**Client** CTTL (Auden)

**Certificate No: ER3-2272_Jan16**

## CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | ER3DV6 - SN:2272 |
| Calibration procedure(s) | QA CAL-02.v8, QA CAL-25.v6<br>Calibration procedure for E-field probes optimized for close near field evaluations in air |
| Calibration date: | January 19, 2016 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter E4419B | GB41293874 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Power sensor E4412A | MY41498087 | 01-Apr-15 (No. 217-02128) | Mar-16 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 01-Apr-15 (No. 217-02129) | Mar-16 |
| Reference 20 dB Attenuator | SN: S5277 (20x) | 01-Apr-15 (No. 217-02132) | Mar-16 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 01-Apr-15 (No. 217-02133) | Mar-16 |
| Reference Probe ER3DV6 | SN: 2328 | 12-Oct-15 (No. ER3-2328_Oct15) | Oct-16 |
| DAE4 | SN: 789 | 16-Mar-15 (No. DAE4-789_Mar15) | Mar-16 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-13) | In house check: Apr-16 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Michael Weber | Laboratory Technician | M.Weber |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 20, 2016

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

## Glossary:

| | |
|---|---|
| NORMx,y,z | sensitivity in free space |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C, D | modulation dependent linearization parameters |
| Polarization φ | φ rotation around probe axis |
| Polarization ϑ | ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis |
| Connector Angle | information used in DASY system to align probe sensor X to the robot coordinate system |

## Calibration is Performed According to the Following Standards:

a) IEEE Std 1309-2005, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005
b) CTIA Test Plan for Hearing Aid Compatibility, Rev 3.0, November 2013

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 for XY sensors and ϑ = 90 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart).
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z*: *A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide setup.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

# Probe ER3DV6

## SN:2272

Manufactured: November 29, 2001
Calibrated: January 19, 2016

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ER3DV6 - SN:2272

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm (µV/(V/m)$^2$) | 1.66 | 1.71 | 1.78 | ± 10.1 % |
| DCP (mV)[B] | 100.4 | 99.4 | 100.7 | |

## Modulation Calibration Parameters

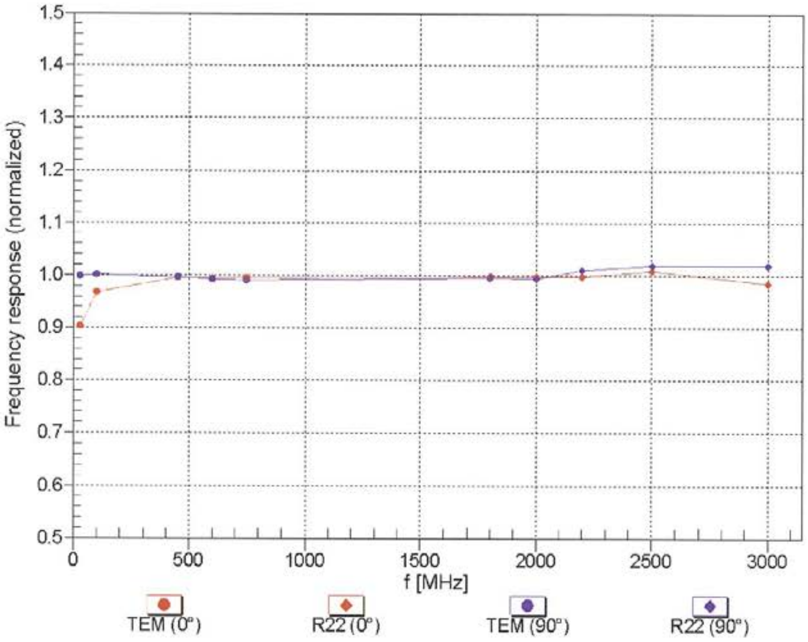
| UID | Communication System Name | | A dB | B dB√µV | C | D dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | X | 0.0 | 0.0 | 1.0 | 0.00 | 198.9 | ±3.8 % |
| | | Y | 0.0 | 0.0 | 1.0 | | 165.5 | |
| | | Z | 0.0 | 0.0 | 1.0 | | 196.7 | |

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

# Frequency Response of E-Field

**(TEM-Cell:ifi110 EXX, Waveguide: R22)**

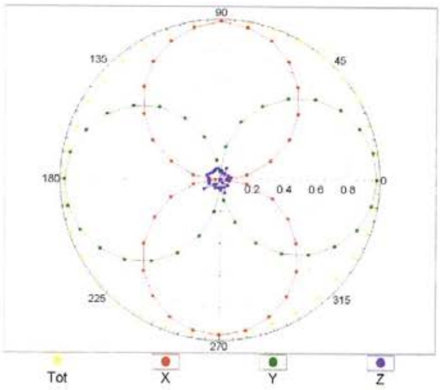



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

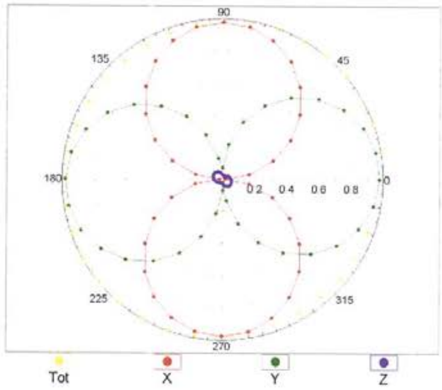
ER3DV6 – SN:2272 January 19, 2016

## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0°

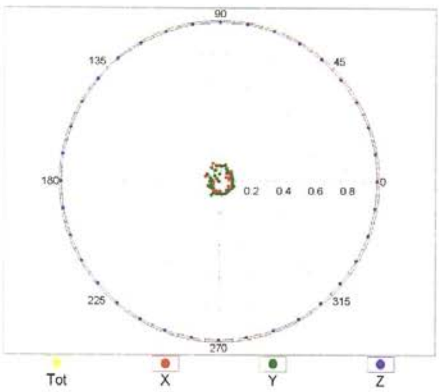



f=2500 MHz,R22,0°

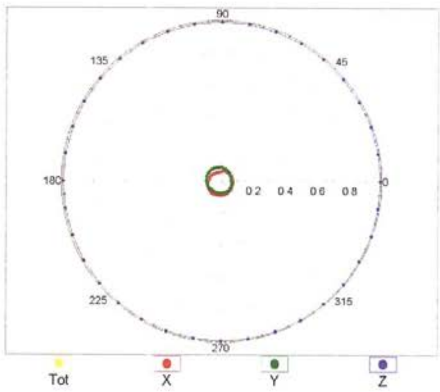



## Receiving Pattern (ϕ), ϑ = 90°

f=600 MHz,TEM,90°

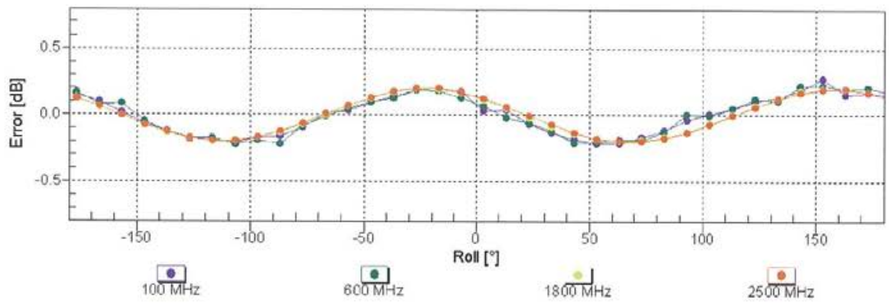



f=2500 MHz,R22,90°



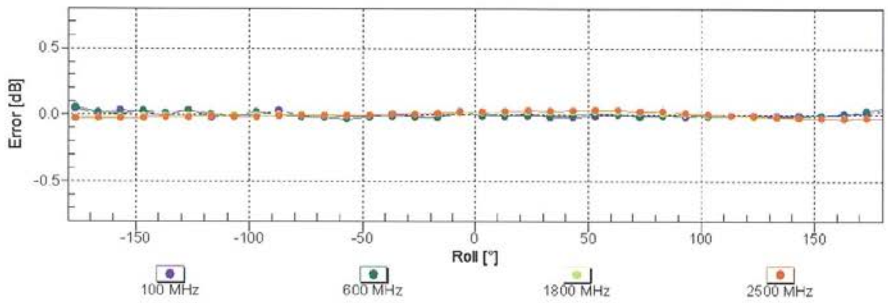
ER3DV6 – SN:2272 January 19, 2016

## Receiving Pattern (ϕ), ϑ = 0°



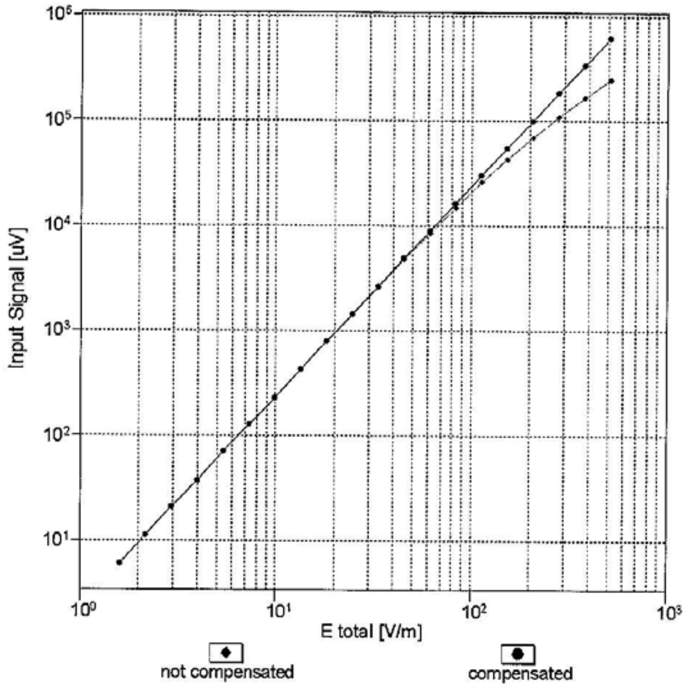

**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

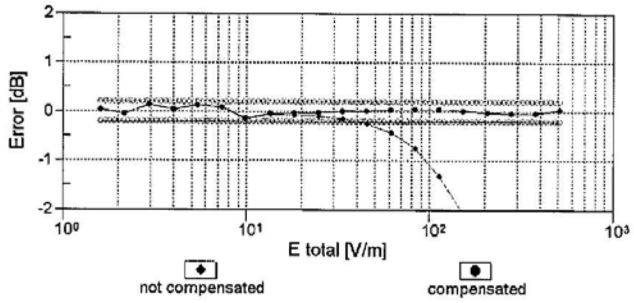
## Receiving Pattern (ϕ), ϑ = 90°




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

# Dynamic Range f(E-field)
**(TEM cell , f = 900 MHz)**

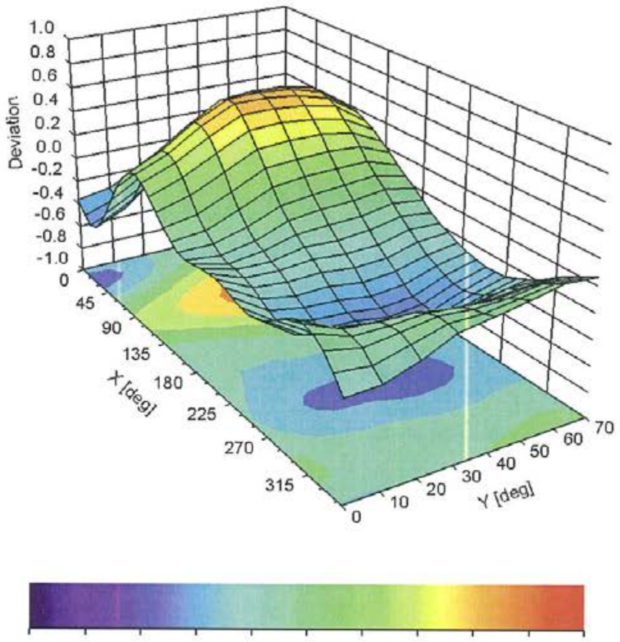



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

# Deviation from Isotropy in Air

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ER3DV6 - SN:2272

**Other Probe Parameters**

| | |
|---|---|
| Sensor Arrangement | Rectangular |
| Connector Angle (°) | 113.1 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 8 mm |
| Probe Tip to Sensor X Calibration Point | 2.5 mm |
| Probe Tip to Sensor Y Calibration Point | 2.5 mm |
| Probe Tip to Sensor Z Calibration Point | 2.5 mm |

# ANNEX E DIPOLE CALIBRATION CERTIFICATE

**Dipole 835 MHz**

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

Accreditation No.: **SCS 0108**

Client **CTTL-BJ (Auden)**

Certificate No: **CD835V3-1023_Aug16**

## CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | CD835V3 - SN: 1023 |
| Calibration procedure(s) | QA CAL-20.v6<br>Calibration procedure for dipoles in air |
| Calibration date: | August 31, 2016 |

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards | ID # | Cal Date (Certificate No.) | Scheduled Calibration |
|---|---|---|---|
| Power meter NRP | SN: 104778 | 06-Apr-16 (No. 217-02288/02289) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103244 | 06-Apr-16 (No. 217-02288) | Apr-17 |
| Power sensor NRP-Z91 | SN: 103245 | 06-Apr-16 (No. 217-02289) | Apr-17 |
| Reference 20 dB Attenuator | SN: 5058 (20k) | 05-Apr-16 (No. 217-02292) | Apr-17 |
| Type-N mismatch combination | SN: 5047.2 / 06327 | 05-Apr-16 (No. 217-02295) | Apr-17 |
| Probe ER3DV6 | SN: 2336 | 31-Dec-15 (No. ER3-2336_Dec15) | Dec-16 |
| Probe H3DV6 | SN: 6065 | 31-Dec-15 (No. H3-6065_Dec15) | Dec-16 |
| DAE4 | SN: 781 | 04-Sep-15 (No. DAE4-781_Sep15) | Sep-16 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| Power meter Agilent 4419B | SN: GB42420191 | 09-Oct-09 (in house check Sep-14) | In house check: Oct-17 |
| Power sensor HP E4412A | SN: US38485102 | 05-Jan-10 (in house check Sep-14) | In house check: Oct-17 |
| Power sensor HP 8482A | SN: US37295597 | 09-Oct-09 (in house check Sep-14) | In house check: Oct-17 |
| RF generator R&S SMT-06 | SN: 832283/011 | 27-Aug-12 (in house check Oct-15) | In house check: Oct-17 |
| Network Analyzer HP 8753E | SN: US37390585 | 18-Oct-01 (in house check Oct-15) | In house check: Oct-16 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Leif Klysner | Laboratory Technician | Leif Klysner |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: September 1, 2016

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

**Calibration Laboratory of**
Schmid & Partner
Engineering AG
**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**S** **Schweizerischer Kalibrierdienst**
**C** **Service suisse d'étalonnage**
**S** **Servizio svizzero di taratura**
**Swiss Calibration Service**

Accredited by the Swiss Accreditation Service (SAS)
**The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates**

**Accreditation No.: SCS 0108**

**References**

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[2] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

**Methods Applied and Interpretation of Parameters:**

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm (15 mm for [2]) above the top metal edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections.
It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY5 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminating by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E-field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1] and [2], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (15 mm for [2]) (in z) above the metal top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, in the plane above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

## Measurement Conditions

DASY system configuration, as far as not given on page 1.

| | | |
|---|---|---|
| **DASY Version** | DASY5 | V52.8.8 |
| **Phantom** | HAC Test Arch | |
| **Distance Dipole Top - Probe Center** | 10, 15 mm | |
| **Scan resolution** | dx, dy = 5 mm | |
| **Frequency** | 835 MHz ± 1 MHz | |
| **Input power drift** | < 0.05 dB | |

## Maximum Field values at 835 MHz

| **H-field 10 mm above dipole surface** | condition | **interpolated maximum** |
|---|---|---|
| Maximum measured | 100 mW input power | **0.450 A/m ± 8.2 % (k=2)** |

| **E-field 10 mm above dipole surface** | condition | **Interpolated maximum** |
|---|---|---|
| Maximum measured above high end | 100 mW input power | 166.0 V/m = 44.40 dBV/m |
| Maximum measured above low end | 100 mW input power | 159.9 V/m = 44.08 dBV/m |
| Averaged maximum above arm | 100 mW input power | **162.9 V/m ± 12.8 % (k=2)** |

| **E-field 15 mm above dipole surface** | condition | **Interpolated maximum** |
|---|---|---|
| Maximum measured above high end | 100 mW input power | 106.4 V/m = 40.54 dBV/m |
| Maximum measured above low end | 100 mW input power | 104.5 V/m = 40.38 dBV/m |
| Averaged maximum above arm | 100 mW input power | **105.5 V/m ± 12.8 % (k=2)** |