Hearing Aid Compatibility (HAC) TEST REPORT

<For RF-Emission Measurement>

Model No.(EUT):	5059S
Company Name	TCL Communication Ltd.
Company Address	7/F, Block F4, TCL Communication Technology Building, TCL International E City, Zhong Shan Yuan Road, Nanshan District, Shenzhen, Guangdong, P.R. China 518052
FCC ID	2ACCJH102
Date of receive	Dec. 11, 2018
Date of test	Dec. 13, 2018
Date of Issue	Dec. 24, 2018

Standards:

ANSI C63.19-2011

FCC RULE PART(S): 47 CFR PART 20.19(B)
HAC CATEGORY: M3 (M Category)

In the configuration tested, the EUT complied with the standards specified above.

Remarks:

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

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Signed on behalf of SGS

Sr. Engineer	**Asst. Manager**
Matt Kuo	John Yeh
Matt Kuo	**John Yeh**
Date: Dec. 24, 2018	**Date: Dec. 24, 2018**

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Revision History

Report Number	Revision	Description	Issue Date
E5/2018/C0010	Rev.00	Initial creation of document	Dec. 24, 2018

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Table of Contents

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1. Introduction

The purpose of the Hearing Aid Compatibility is to enable measurements of the near electric fields generated by wireless communication devices in the region controlled for use by a hearing aid in accordance with ANSI-C63.19-2011

The purpose of this standard is to establish categories for hearing aids and for WD (wireless communications devices) that can indicate to health care practitioners and hearing aid users which hearing aids are compatible with which WD, and to provide tests that can be used to assess the electromagnetic characteristics of hearing aids and WD and assign them to these categories. The various parameters required, in order to demonstrate compatibility and accessibility are measured. The design of the standard is such that when a hearing aid and WD achieve one of the categories specified, as measured by the methodology of this standard, the indicated performance is realized.

In order to provide for the usability of a hearing aid with a WD, several factors must be coordinated:
a) Radio frequency (RF) measurements of the near-field electric fields emitted by a WD to categorize these emissions for correlation with the RF immunity of a hearing aid.

Hence, the following are measurements made for the WD:
RF E-Field emissions

The measurement plane is parallel to, and 1.5cm in front of, the reference plane.

Applications for certification of equipment operation under part 20, that a manufacturer is seeking to certify as hearing aid compatible, as set forth in §20.19 of that part, shall include a statement indication compliance with the test requirements of §20.19 and indicating the appropriate U-rating for the equipment. The manufacturer of the equipment shall be responsible for maintaining the test results.

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2. Testing Laboratory

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3. Details of Applicant

Applicant Name	TCL Communication Ltd.
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4. Description of EUT

Model No.	5059S	
FCC ID	2ACCJH102	
Mode of Operation	☒GSM ☒GPRS ☒EDGE ☒WCDMA ☒LTE FDD ☒Bluetooth ☒WLAN802.11b/g/n/(20M/40M)	
Duty Cycle	GSM (DTM multi class B)	1/8.3
	GPRS (support multi class 12 max)	1/2 (1Dn4UP) 1/2.76 (1Dn3UP) 1/4.1 (1Dn2UP) 1/8.3 (1Dn1UP)
	EDGE (support multi class 12 max)	1/2 (1Dn4UP) 1/2.76 (1Dn3UP) 1/4.1 (1Dn2UP) 1/8.3 (1Dn1UP)
	WCDMA	1
	LTE FDD	1
	WLAN802.11b/g/n(20M/40M)	1
	Bluetooth	1
TX Frequency Range (MHz)	GSM850	824 – 849
	GSM1900	1850 – 1910
	WCDMA Band II	1850 – 1910
	WCDMA Band V	824 – 849
	LTE FDD Band 2	1850 – 1910
	LTE FDD Band 4	1710 – 1755
	LTE FDD Band 5	824 – 849
	LTE FDD Band 13	777 – 787
	LTE FDD Band 66	1710 – 1780
	WLAN802.11 b/g/n(20M)	2412 – 2462
	WLAN802.11 n(40M)	2422 – 2452
	Bluetooth	2402 – 2480

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Channel Number (ARFCN)	GSM850	128	–	251
	GSM1900	512	–	810
	WCDMA Band II	9262	–	9538
	WCDMA Band V	4132	–	4233
	LTE FDD Band 2	18607	–	19193
	LTE FDD Band 4	19957	–	20393
	LTE FDD Band 5	20407	–	20643
	LTE FDD Band 13	23205	–	23255
	LTE FDD Band 66	131979	–	132665
	WLAN802.11 b/g/n(20M)	1	–	11
	WLAN802.11 n(40M)	3	–	9
	Bluetooth	0	–	78

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5. Air Interfaces and Bands

Air Interface	Band (MHz)	Type	ANSI C63.19 Tested	Simultaneous Transmitter	Name of Voice Service	Power Reduction
GSM	850	VO	Yes	BT and Wi-Fi	CMRS Voice	NA
	1900					
	GPRS/EDGE	DT	No		NA	
WCDMA	850	VO	Yes (Note 1.)	BT and Wi-Fi	CMRS Voice	NA
	1900					
	HSPA	DT	No		NA	
LTE	Band 2/4/5/13/66	VD	Yes (Note 1.)	BT and Wi-Fi	VoLTE	NA
Wi-Fi	2450	VD	Yes (Note 1.)	BT and GSM,WCDMA, LTE	Wi-Fi calling	NA
BT	2450	DT	NA	Wi-Fi and GSM,WCDMA, LTE	NA	NA

VO: Legacy Cellular Voice Service from Table 7.1 in 7.4.2.1 of ANSI C63.19-2011
DT: Digital Transport (no voice)
VD: IP Voice Service over Digital Transport

Note
1. It applies the low power exemption based on ANSI C63.19-2011

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6. Test Environment

Ambient Temperature	21.7° C
Relative Humidity	<80 %

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7. Description of test system

7.1 Measurement system Diagram for SPEAG Robotic

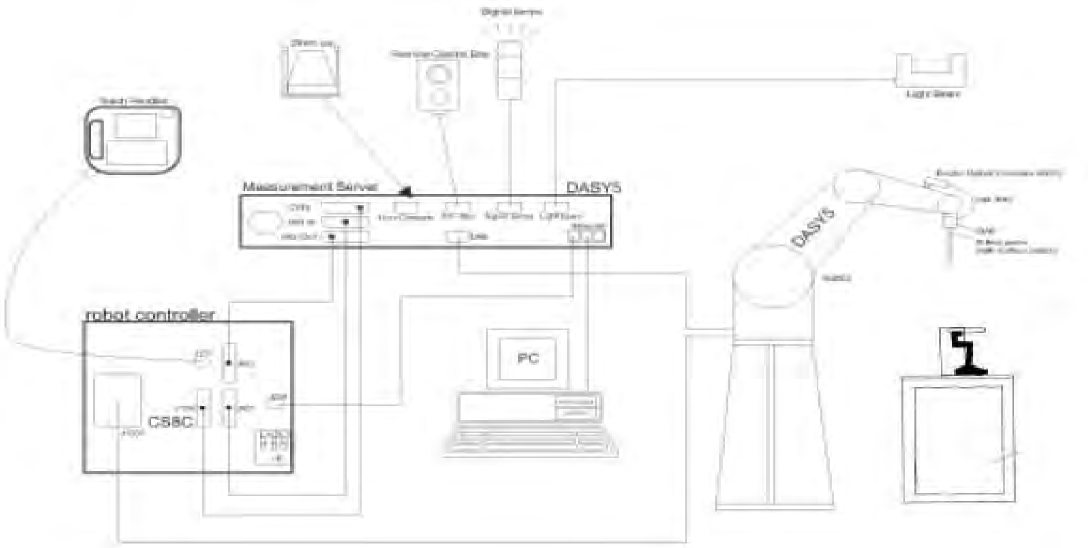

Fig.1 The SPEAG Robotic Diagram

The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Staubli RX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
- E Field probe.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.

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- A computer operating Windows 7.
- DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The Test Arch phantom.
- The device holder for handheld mobile phones.
- Validation dipole kits allowing to validate the proper functioning of the system.

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7.2 E Field Probe

Construction	One dipole parallel, two dipoles normal to probe axis Built-in shielding against static charges PEEK enclosure material	 ER3DV6 E-Field Probe
Calibration	In air from 100 MHz to 3.0 GHz (absolute accuracy ±6.0%, k=2)	
Frequency	(extended to 20 MHz for MRI), Linearity: ± 0.2 dB (100 MHz to 3 GHz)	
Directivity	± 0.2 dB in air (rotation around probe axis) ± 0.4 dB in air (rotation normal to probe axis)	
Dynamic Range	2 V/m to > 1000 V/m; Linearity: ± 0.2 dB	
Dimensions	Tip diameter: 8 mm Distance from probe tip to dipole centers: 2.5 mm	

7.3 Test Arch

Description	Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.	 Test Arch
Dimensions	length: 370 mm width: 370 mm height: 370 mm	

7.4 Phone Holder

Description	Supports accurate and reliable positioning of any phone Effect on near field <+/- 0.5 dB	 Phone Holder

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8. Test Procedure

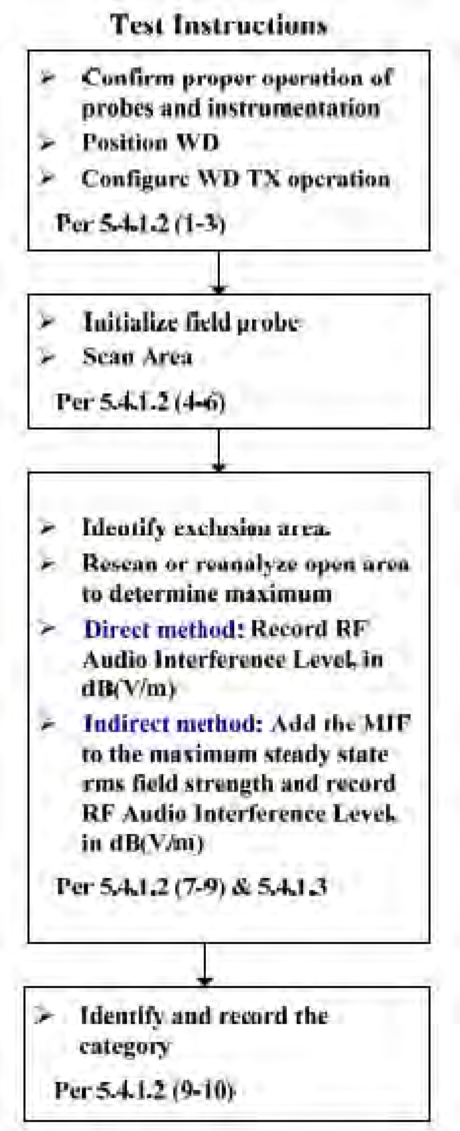

Fig.2 RF emission flow chart

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The following illustrate a typical RF emissions test scan over a wireless communications device (Indirect method):

1. Proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed.
2. WD is positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.
3. The WD operation for maximum rated RF output power was configured and confirmed with the base station simulator, at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test.
4. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The WD audio output was positioned tangent (as physically possible) to the measurement plane.
5. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the HAC Phantom.
6. The measurement system measured the field strength at the reference location.
7. Measurements at 5mm increments in the 5 × 5 cm region were performed and recorded. A 360° rotation about the azimuth axis at the maximum interpolated position was measured. For the worst-case condition, the peak reading from this rotation was used in re-evaluating the HAC category.
8. The system performed a drift evaluation by measuring the field at the reference location.

Note.

Per KDB 285076 D01 v05 2.c) 1), handsets that have the ability to support concurrent connections using simultaneous transmissions shall be independently tested for each air interface/band given in ANSI C63.19-2011. At the present time ANSI C63.19 does not provide simultaneous transmission test procedures.

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9. System Verification

A dipole antenna meeting the requirements given in ANSI C63.19-2011 was placed in the position normally occupied by the WD.
The length of the dipole was scanned by E-field probes and the maximum values for each were recorded.

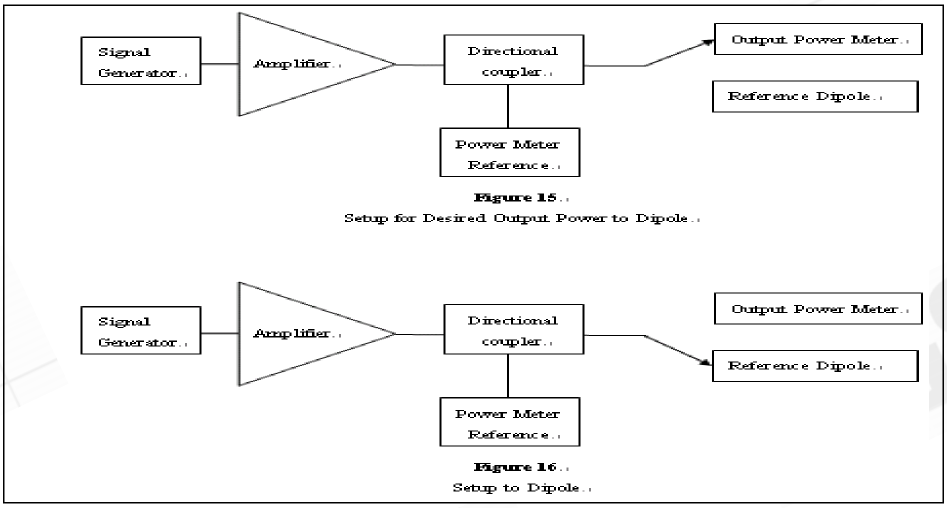

Fig.3 System verification

For E-Field Scan

Mode	Frequency(MHz)	Input Power(dBm)	E-Field 1 (V/m)	E-Field 2(V/m)	Target Value(V/m)	Deviation	Measured Date
CW	835	20	105.7	120.2	110.3	2.40%	Dec. 13, 2018
CW	1880	20	92.08	94.66	88.8	5.15%	Dec. 13, 2018

Note:
For E-Field, the deviation is [(E-Field 1 + E-Field 2) / 2 – Target value] / Target value x 100%

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10. Modulation Interference Factor

For any specific fixed and repeatable modulated signal, a modulation interference factor (MIF, expressed in dB) may be developed that relates its interference potential to its steady-state rms signal level or average power level. This factor is a function only of the audio-frequency amplitude modulation characteristics of the signal and is the same for field-strength and conducted power measurements. It is important to emphasize that the MIF is valid only for a specific repeatable audio-frequency amplitude modulation characteristic. Any change in modulation characteristic requires determination and application of a new MIF

The MIF may be determined using a radiated RF field or a conducted RF signal,

b) Using RF illumination or conducted coupling, apply the specific modulated signal in question to the measurement system at a level within its confirmed operating dynamic range.

c) Measure the steady-state rms level at the output of the fast probe or sensor.

d) Measure the steady-state average level at the weighting output.

e) Without changing the square-law detector or weighting system, and using RF illumination or conducted coupling, substitute for the specific modulated signal a 1 kHz, 80% amplitude modulated carrier at the same frequency and adjust its strength until the level at the weighting output equals the step d) measurement.

f) Without changing the carrier level from step e), remove the 1 kHz modulation and again measure the steady-state rms level indicated at the output of the fast probe or sensor.

g) The MIF for the specific modulation characteristic is provided by the ratio of the step f) measurement to the step c) measurement, expressed in dB (20 × log(step f))/step c)).

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Based on the KDB285076D01v05, the handset can also use the MIF values predetermined by the test equipment manufacturer, and the following table lists the MIF values evaluated by DASY manufacturer (SPEAG), and the test result will be calculated with the MIF parameter automatically.

SPEAG UID	UID version	Communication system	MIF(dB)
10011	CAB (9.25.2018)	UMTS-FDD (WCDMA)	-27.23
10021	DAC (9.25.2018)	GSM-FDD (TDMA, GMSK)	3.63
10061	CAB (9.25.2018)	IEEE 802.11b WiFi 2.4 GHz	-2.02
10077	CAB (9.25.2018)	IEEE 802.11g WiFi 2.4 GHz	0.12
10170	CAE (9.25.2018)	LTE-FDD (SC-FDMA,1RB, 20MHz,16-QAM)	-9.76
10176	CAG (9.25.2018)	LTE-FDD (SC-FDMA,1RB, 10MHz,16-QAM)	-9.76
10178	CAG (9.25.2018)	LTE-FDD (SC-FDMA,1RB, 5MHz,16-QAM)	-9.76
10182	CAE (9.25.2018)	LTE-FDD (SC-FDMA,1RB, 15MHz,16-QAM)	-9.76
10185	CAE (9.25.2018)	LTE-FDD (SC-FDMA,1RB, 3MHz,16-QAM)	-9.76
10188	CAF (9.25.2018)	LTE-FDD (SC-FDMA,1RB, 1.4MHz,16-QAM)	-9.76
10591	AAB (9.25.2018)	IEEE 802.11n(20MHz)	-5.59
10599	AAB (9.25.2018)	IEEE 802.11n(40MHz)	-5.59

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11. Justification of held to ear modes tested

I. Analysis of RF air interface technologies

Based on ANSI. C63.19-2011. 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. If a device supports multiple RF air interfaces, each RF air interface shall be evaluated individually.

The MIF plus the worst case average power for all modes are investigated below to determine the testing requirements for this device.

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II. Low power exemption

Air interference	Maximum Average Antenna input power (dBm)	Worst case MIF (dB)	Maximum Average Antenna input power + MIF (dBm)	Low power exemption
GSM850	33	3.63	36.63	No
GSM1900	29.5	3.63	33.13	No
WCDMA Band II	23.2	-27.23	-4.03	Yes
WCDMA Band V	23.5	-27.23	-3.73	Yes
LTE B2	23	-9.76	13.24	Yes
LTE B4	23.8	-9.76	14.04	Yes
LTE B5	23.5	-9.76	13.74	Yes
LTE B13	23.6	-9.76	13.84	Yes
LTE B66	23.8	-9.76	14.04	Yes
WLAN 802.11b	16.6	-2.02	14.58	Yes
WLAN 802.11g	13.5	0.12	13.62	Yes
WLAN 802.11n20	11.5	-5.59	5.91	Yes
WLAN 802.11n40	8	-5.59	2.41	Yes

We used the predetermined MIF to evaluate the low power exemption.

Based on ANSI C63.19-2011, RF emission testing for WCDMA/LTE/WLAN is exempted.

Based on ANSI C63.19-2011, WCDMA/LTE/WLAN that is exempted from testing shall be rated as M4.

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11. ANSI C63.19-2011 performance and categories

The measurements were performed to ensure compliance to the ANSI C63.19-2011 standard,

Category	E-Field Emissions dB(V/m) < 960MHz
M1	50-55
M2	45-50
M3	40-45
M4	<40

Category	E-Field Emissions dB(V/m) > 960MHz
M1	40-45
M2	35-40
M3	30-35
M4	<30

WD RF audio interference level categories in logarithmic units

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12. Instruments List

Manufacturer	Device	Type	Serial number	Date of last calibration	Date of next calibration
Schmid & Partner Engineering AG	E-Field Probe	ER3DV6	2306	Mar.22,2018	Mar.21,2019
Schmid & Partner Engineering AG	System Validation Dipole	CD835V3	1052	Mar.14,2018	Mar.13,2019
		CD1880V3	1044	Mar.14,2018	Mar.13,2019
Schmid & Partner Engineering AG	Data acquisition Electronics	DAE4	1336	Aug.06,2018	Aug.05,2019
Schmid & Partner Engineering AG	Software	DASY52 52.8.8	N/A	Calibration not required	Calibration not required
Agilent	Dielectric Probe Kit	85070D	US01440168	Calibration not required	Calibration not required
Agilent	Dual-directional coupler	778D	MY52180302	Jul.05,2018	Jul.04,2019
Agilent	RF Signal Generator	N5181A	MY50144143	Mar.15,2018	Mar.14,2019
Schmid & Partner Engineering AG	Test Arch SD HAC	P01	1047	Calibration not required	Calibration not required
Agilent	Power Meter	E4417A	MY52240003	Dec.21,2017	Dec.20,2018
Agilent	Power Sensor	E9301H	MY52200003	Dec.21,2017	Dec.20,2018
			MY52200004	Dec.21,2017	Dec.20,2018
R&S	Radio Communication Teser	CMU200	113505	Dec.20,2017	Dec.19,2018

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13. Summary of Results

E-Field

E-Field Emission	Channel	Modulation Interference Factor	Power Drift(dB)	Audio Interference Level dB(V/m)	RESULT	Excl Blocks per 4.3.1.2.2
GSM 850	128	3.63	-0.08	35.15	M4	236
	190	3.63	-0.11	34.48	M4	236
	251	3.63	-0.03	34.85	M4	236
E-Field Emission	**Channel**	**Modulation Interference Factor**	**Power Drift(dB)**	**Audio Interference Level dB(V/m)**	**RESULT**	**Excl Blocks per 4.3.1.2.2**
GSM 1900	512	3.63	0.01	29.04	M4	236
	661	3.63	-0.02	30.06	M3	236
	810	3.63	0.01	29.72	M4	689

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14. Measurement Data

Date: 2018/12/13

HAC-RF-EMISSION_GSM 850_CH 128

Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 824.2 MHz; Duty Cycle: 1:8.6896
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:

- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Device E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 43.40 V/m; Power Drift = -0.08 dB
Applied MIF = 3.63 dB
RF audio interference level = 35.15 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **32.86 dBV/m**	Grid 2 **M4** **35.07 dBV/m**	Grid 3 **M4** **35.08 dBV/m**
Grid 4 **M4** **32.9 dBV/m**	Grid 5 **M4** **35.15 dBV/m**	Grid 6 **M4** **35.17 dBV/m**
Grid 7 **M4** **32.69 dBV/m**	Grid 8 **M4** **34.68 dBV/m**	Grid 9 **M4** **34.69 dBV/m**

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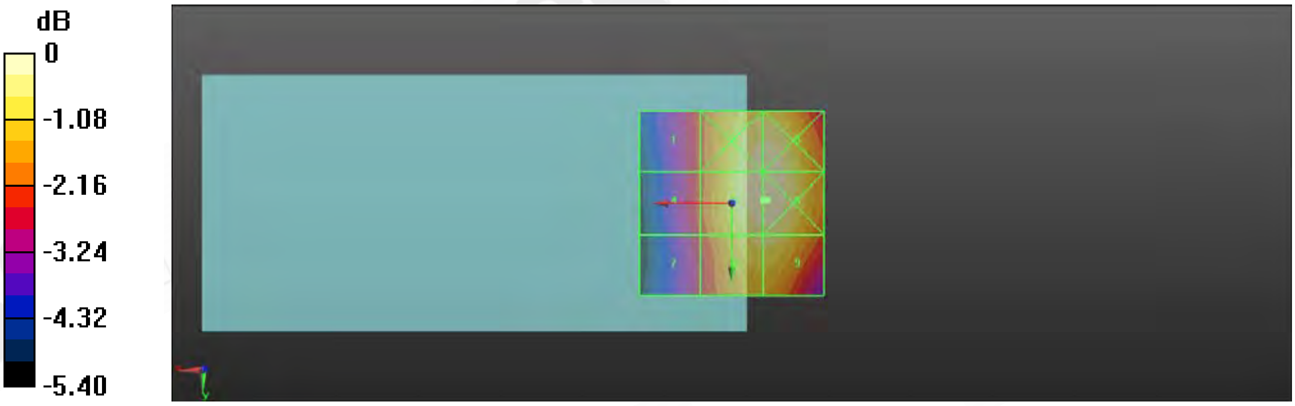

0 dB = 57.31 V/m = 35.17 dBV/m

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Date: 2018/12/13

HAC-RF-EMISSION_GSM 850_CH 190

Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 836.6 MHz; Duty Cycle: 1:8.6896
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:

- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Device E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 40.67 V/m; Power Drift = -0.11 dB
Applied MIF = 3.63 dB
RF audio interference level = 34.48 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **32.2 dBV/m**	Grid 2 **M4** **34.45 dBV/m**	Grid 3 **M4** **34.49 dBV/m**
Grid 4 **M4** **32.23 dBV/m**	Grid 5 **M4** **34.48 dBV/m**	Grid 6 **M4** **34.5 dBV/m**
Grid 7 **M4** **32.05 dBV/m**	Grid 8 **M4** **33.94 dBV/m**	Grid 9 **M4** **33.95 dBV/m**

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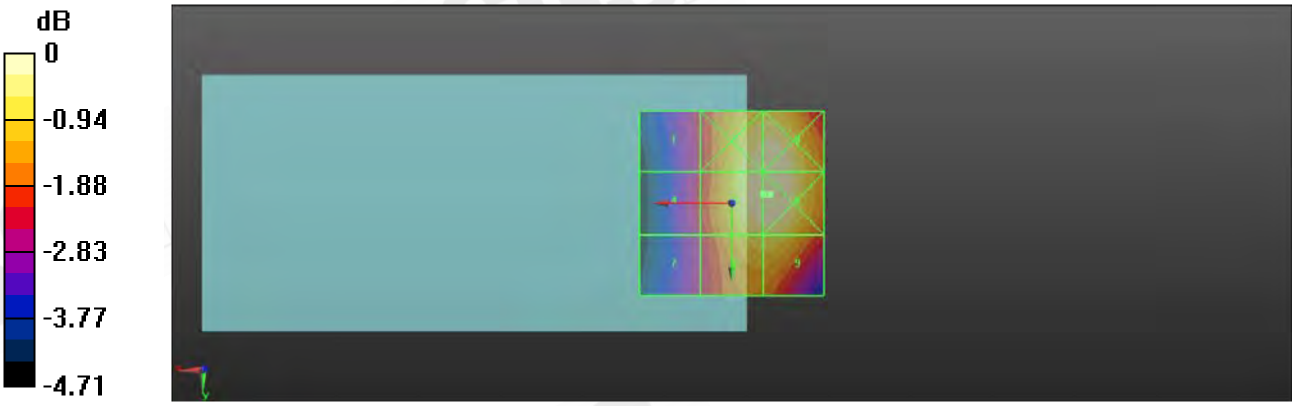

0 dB = 53.11 V/m = 34.50 dBV/m

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Date: 2018/12/13

HAC-RF-EMISSION_GSM 850_CH 251
Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 848.6 MHz; Duty Cycle: 1:8.6896
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:
- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Device E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 46.06 V/m; Power Drift = -0.03 dB
Applied MIF = 3.63 dB
RF audio interference level = 34.85 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **33.07 dBV/m**	Grid 2 **M4** **34.65 dBV/m**	Grid 3 **M4** **34.66 dBV/m**
Grid 4 **M4** **33.31 dBV/m**	Grid 5 **M4** **34.85 dBV/m**	Grid 6 **M4** **34.86 dBV/m**
Grid 7 **M4** **33.48 dBV/m**	Grid 8 **M4** **34.65 dBV/m**	Grid 9 **M4** **34.56 dBV/m**

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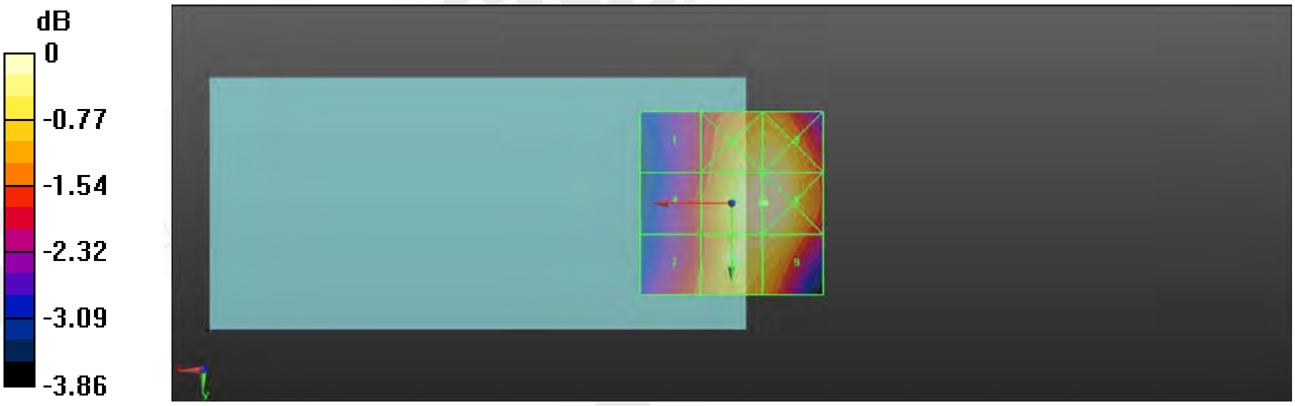

0 dB = 55.32 V/m = 34.86 dBV/m

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Date: 2018/12/13

HAC-RF-EMISSION_GSM 1900_CH 512
Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 1850.2 MHz; Duty Cycle: 1:8.6896
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:

- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Device E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 20.19 V/m; Power Drift = 0.01 dB
Applied MIF = 3.63 dB
RF audio interference level = 29.04 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **26.79 dBV/m**	Grid 2 **M4** **29.05 dBV/m**	Grid 3 **M4** **29.05 dBV/m**
Grid 4 **M4** **26.34 dBV/m**	Grid 5 **M4** **29.04 dBV/m**	Grid 6 **M4** **29.04 dBV/m**
Grid 7 **M4** **24.59 dBV/m**	Grid 8 **M4** **28.24 dBV/m**	Grid 9 **M4** **28.26 dBV/m**

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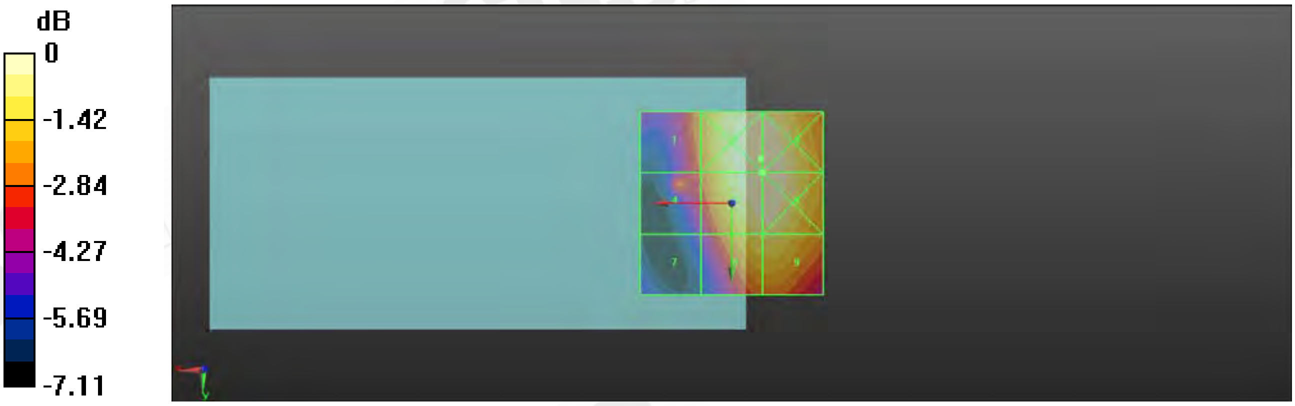

0 dB = 28.36 V/m = 29.05 dBV/m

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Date: 2018/12/13

HAC-RF-EMISSION_GSM 1900_CH 661
Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 1880 MHz; Duty Cycle: 1:8.6896
Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 1000 kg/m^3
Phantom section: RF Section

DASY5 Configuration:
- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Device E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 22.52 V/m; Power Drift = -0.02 dB
Applied MIF = 3.63 dB
RF audio interference level = 30.06 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 **M4** **27.46 dBV/m**	Grid 2 **M4** **29.93 dBV/m**	Grid 3 **M4** **29.93 dBV/m**
Grid 4 **M4** **27.11 dBV/m**	Grid 5 **M3** **30.06 dBV/m**	Grid 6 **M3** **30.08 dBV/m**
Grid 7 **M4** **26.18 dBV/m**	Grid 8 **M4** **29.85 dBV/m**	Grid 9 **M4** **29.91 dBV/m**

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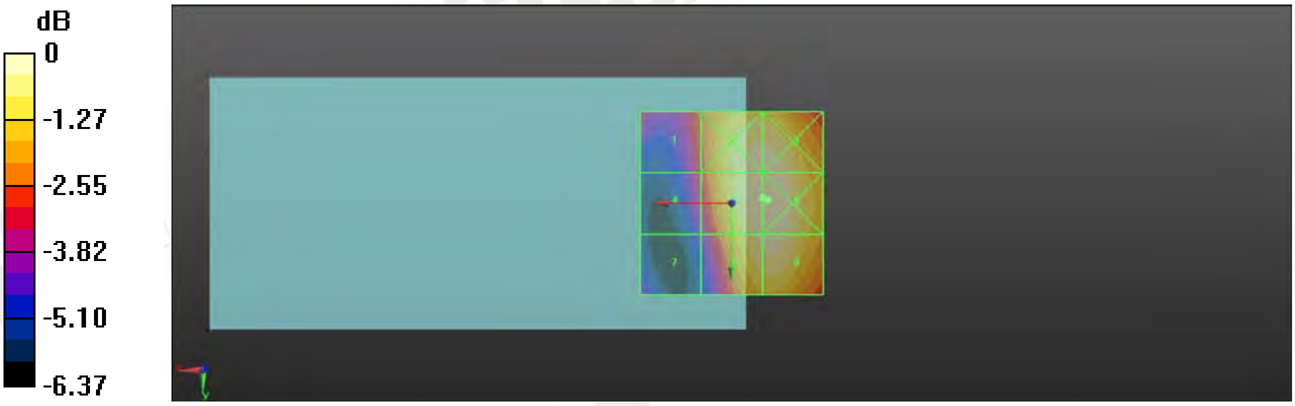

0 dB = 31.92 V/m = 30.08 dBV/m

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Date: 2018/12/13

HAC-RF-EMISSION_GSM 1900_CH 810

Communication System: UID 10021 - DAC, GSM-FDD (TDMA, GMSK); Frequency: 1909.8 MHz; Duty Cycle: 1:8.6896
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:

- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Device E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 22.11 V/m; Power Drift = 0.01 dB
Applied MIF = 3.63 dB
RF audio interference level = 29.72 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **26.79 dBV/m**	Grid 2 **M4** **29.56 dBV/m**	Grid 3 **M4** **29.56 dBV/m**
Grid 4 **M4** **26.55 dBV/m**	Grid 5 **M4** **29.72 dBV/m**	Grid 6 **M4** **29.73 dBV/m**
Grid 7 **M4** **26 dBV/m**	Grid 8 **M4** **29.61 dBV/m**	Grid 9 **M4** **29.63 dBV/m**

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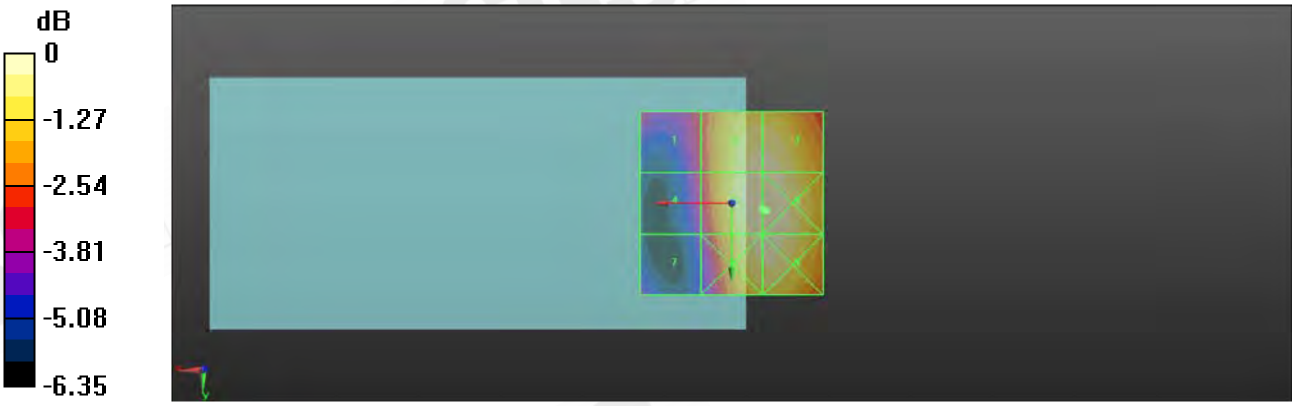

0 dB = 30.65 V/m = 29.73 dBV/m

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15. System Verification

Date: 2018/12/13

Dipole CD835V3_SN_1052
Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:

- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 124.8 V/m; Power Drift = -0.04 dB
PMR not calibrated. PMF = 1.000 is applied.
E-field emissions = 105.7 V/m
Near-field category: M4 (AWF 0 dB)

PMF scaled E-field

Grid 1 **M4** **86.88 V/m**	Grid 2 **M4** **101.7 V/m**	Grid 3 **M4** **105.7 V/m**
Grid 4 **M4** **66.67 V/m**	Grid 5 **M4** **66.67 V/m**	Grid 6 **M4** **63.39 V/m**
Grid 7 **M4** **120.2 V/m**	Grid 8 **M4** **118.3 V/m**	Grid 9 **M4** **104.4 V/m**

Cursor:
Total = 120.2 V/m
E Category: M4
Location: 7, 72.5, 9.7 mm

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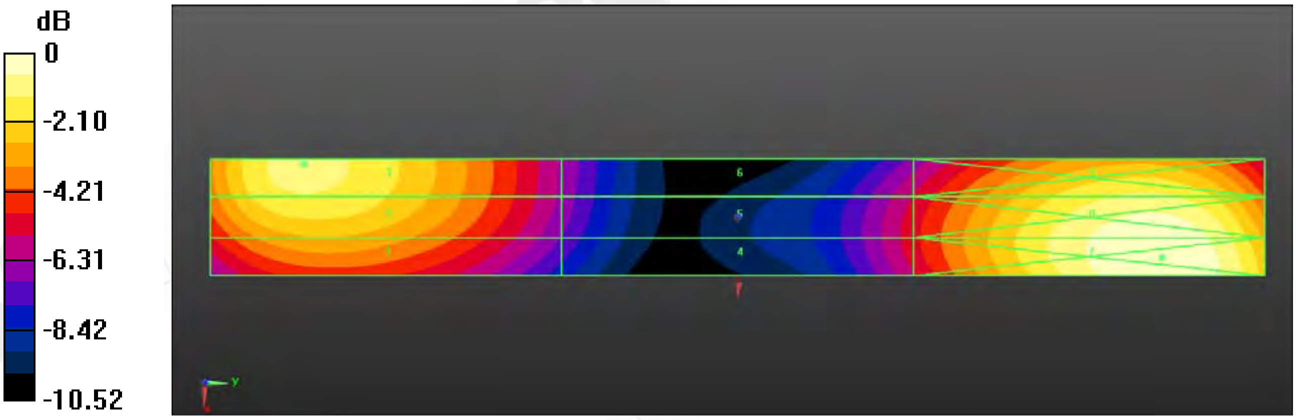

0 dB = 120.2 V/m = 41.60 dBV/m

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Date: 2018/12/13

Dipole CD1880V3_SN_1044
Communication System: CW; Frequency: 1880 MHz; Duty Cycle: 1:1
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section

DASY5 Configuration:

- Probe: ER3DV6 - SN2306; ConvF(1, 1, 1); Calibrated: 2018/3/22
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/8/6
- Phantom: HAC Test Arch; ;
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole E-Field measurement /E Scan: Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 164.8 V/m; Power Drift = 0.01 dB
PMR not calibrated. PMF = 1.000 is applied.
E-field emissions = 92.08 V/m
Near-field category: M3 (AWF 0 dB)

PMF scaled E-field

Grid 1 **M3** **93.33 V/m**	Grid 2 **M3** **94.66 V/m**	Grid 3 **M3** **93.06 V/m**
Grid 4 **M3** **72.54 V/m**	Grid 5 **M3** **72.99 V/m**	Grid 6 **M3** **71.72 V/m**
Grid 7 **M3** **90.82 V/m**	Grid 8 **M3** **92.08 V/m**	Grid 9 **M3** **90.31 V/m**

Cursor:
Total = 94.66 V/m
E Category: M3
Location: 0, -32.5, 9.7 mm

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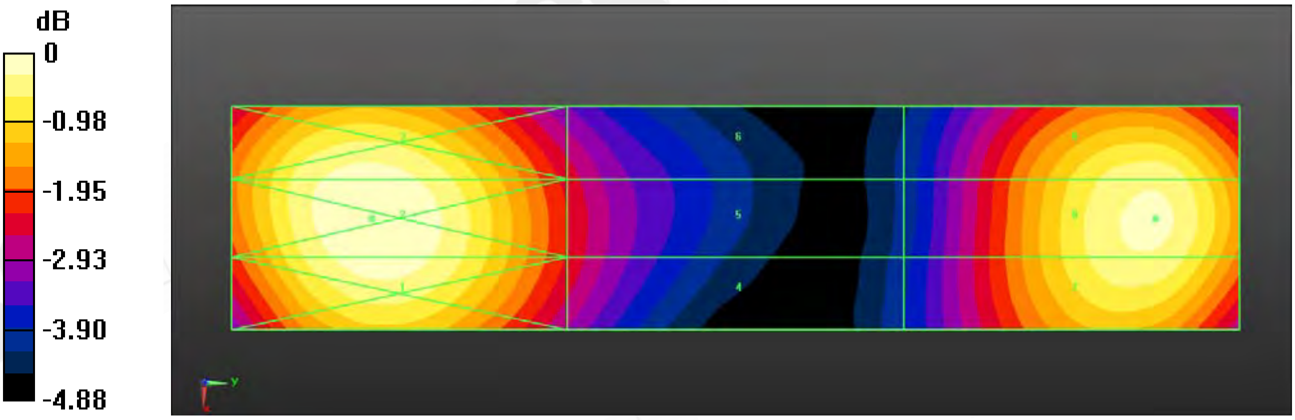

0 dB = 94.66 V/m = 39.52 dBV/m

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16. DAE & Probe Calibration Certificate

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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client SGS-TW (Auden)

Certificate No: DAE4-1336_Aug18

CALIBRATION CERTIFICATE

Object: DAE4 - SD 000 D04 BM - SN: 1336

Calibration procedure(s): QA CAL-06.v29
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: August 06, 2018

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
Keithley Multimeter Type 2001	SN: 0810278	31-Aug-17 (No:21092)	Aug-18
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	04-Jan-18 (in house check)	In house check: Jan-19
Calibrator Box V2.1	SE UMS 006 AA 1002	04-Jan-18 (in house check)	In house check: Jan-19

	Name	Function	Signature
Calibrated by:	Dominique Steffen	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	i.V.

Issued: August 6, 2018

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Certificate No: DAE4-1336_Aug18 Page 1 of 5

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Glossary

DAE	data acquisition electronics
Connector angle	information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
  - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
  - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
  - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
  - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
  - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
  - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
  - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
  - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
  - *Power consumption:* Typical value for information. Supply currents in various operating modes.

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DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1µV , full range = -100...+300 mV

Low Range: 1LSB = 61nV , full range = -1.......+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Calibration Factors	X	Y	Z
High Range	403.344 ± 0.02% (k=2)	403.624 ± 0.02% (k=2)	403.107 ± 0.02% (k=2)
Low Range	3.95102 ± 1.50% (k=2)	3.98703 ± 1.50% (k=2)	3.99683 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	287.0 ° ± 1 °

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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	200042.98	3.65	0.00
Channel X	+ Input	20006.34	1.11	0.01
Channel X	- Input	-20005.65	-0.58	0.00
Channel Y	+ Input	200034.32	0.12	0.00
Channel Y	+ Input	20003.47	-1.57	-0.01
Channel Y	- Input	-20006.39	-1.21	0.01
Channel Z	+ Input	200032.22	-2.05	-0.00
Channel Z	+ Input	20002.78	-2.14	-0.01
Channel Z	- Input	-20007.34	-2.09	0.01

Low Range		Reading (µV)	Difference (µV)	Error (%)
Channel X	+ Input	2001.47	0.30	0.01
Channel X	+ Input	201.92	0.79	0.39
Channel X	- Input	-198.26	0.59	-0.30
Channel Y	+ Input	2001.55	0.37	0.02
Channel Y	+ Input	200.97	-0.11	-0.05
Channel Y	- Input	-199.34	-0.43	0.22
Channel Z	+ Input	2001.12	0.04	0.00
Channel Z	+ Input	200.15	-0.88	-0.44
Channel Z	- Input	-200.14	-1.15	0.58

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Common mode Input Voltage (mV)	High Range Average Reading (µV)	Low Range Average Reading (µV)
Channel X	200	6.04	4.72
	- 200	-4.13	-4.79
Channel Y	200	-3.65	-3.78
	200	2.68	2.45
Channel Z	200	22.40	22.16
	- 200	-24.83	-25.10

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	Input Voltage (mV)	Channel X (µV)	Channel Y (µV)	Channel Z (µV)
Channel X	200	-	6.12	-1.64
Channel Y	200	9.19	-	6.46
Channel Z	200	8.44	6.31	-

Certificate No: DAE4-1336_Aug18 Page 4 of 5

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4. AD-Converter Values with inputs shorted
DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

	High Range (LSB)	Low Range (LSB)
Channel X	15666	16509
Channel Y	15907	15587
Channel Z	15855	15507

5. Input Offset Measurement
DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.87	-0.00	2.62	0.36
Channel Y	3.53	2.67	4.59	0.34
Channel Z	-0.18	-1.34	1.53	0.54

6. Input Offset Current
Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

	Zeroing (kOhm)	Measuring (MOhm)
Channel X	200	200
Channel Y	200	200
Channel Z	200	200

8. Low Battery Alarm Voltage (Typical values for information)

Typical values	Alarm Level (VDC)
Supply (+ Vcc)	+7.9
Supply (- Vcc)	-7.6

9. Power Consumption (Typical values for information)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.01	+6	+14
Supply (- Vcc)	-0.01	-8	-9

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Accreditation No.: **SCS 0108**

Client **SGS-TW (Auden)**

Certificate No: **ER3-2306_Mar18**

CALIBRATION CERTIFICATE

Object	ER3DV6 - SN:2306
Calibration procedure(s)	QA CAL-02.v8, QA CAL-25.v6 Calibration procedure for E-field probes optimized for close near field evaluations in air
Calibration date:	March 22, 2018

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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02525)	Apr-18
Reference 20 dB Attenuator	SN: S5277 (20x)	07-Apr-17 (No. 217-02528)	Apr-18
Reference Probe ER3DV6	SN: 2328	10-Oct-17 (No. ER3-2328_Oct17)	Oct-18
DAE4	SN: 789	2-Aug-17 (No. DAE4-789_Aug17)	Aug-18
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 22, 2018

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Certificate No: ER3-2306_Mar18 Page 1 of 11

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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).

Certificate No: ER3-2305_Mar18 Page 2 of 11

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Probe ER3DV6

SN:2306

Manufactured: December 17, 2002
Calibrated: March 22, 2018

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

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DASY/EASY - Parameters of Probe: ER3DV6 - SN:2306

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)	1.06	1.10	1.21	± 10.1 %
DCP (mV)[B]	103.2	101.7	105.2	

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	209.1	±3.0 %
		Y	0.0	0.0	1.0		166.9	
		Z	0.0	0.0	1.0		212.3	
10010-CAA	SAR Validation (Square, 100ms, 10ms)	X	0.43	50.9	4.8	10.00	36.5	±1.4 %
		Y	0.40	50.0	2.9		37.7	
		Z	0.46	51.5	4.8		36.2	
10021-DAC	GSM-FDD (TDMA, GMSK)	X	3.16	72.2	16.8	9.39	149.3	±1.9 %
		Y	2.31	66.9	14.0		123.3	
		Z	4.08	75.8	18.1		136.1	
10061-CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)	X	3.40	72.3	21.2	3.60	146.7	±1.4 %
		Y	2.69	67.9	19.2		114.8	
		Z	4.55	78.2	23.7		148.8	
10077-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)	X	9.60	69.3	24.4	11.00	122.3	±3.0 %
		Y	9.64	69.7	24.9		131.0	
		Z	9.66	69.7	24.6		122.4	
10173-CAD	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	5.99	71.3	25.0	9.48	112.5	±3.0 %
		Y	5.94	71.6	25.4		119.7	
		Z	6.19	71.6	24.7		115.0	
10226-CAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM)	X	5.98	71.3	25.0	9.48	112.3	±3.0 %
		Y	5.94	71.5	25.3		120.0	
		Z	6.16	71.4	24.6		114.9	
10229-CAB	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM)	X	5.99	71.3	25.0	9.48	112.4	±3.0 %
		Y	5.97	71.8	25.5		119.8	
		Z	6.19	71.5	24.7		114.9	
10232-CAD	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	5.99	71.3	25.0	9.48	112.2	±3.0 %
		Y	5.98	71.8	25.5		119.9	
		Z	6.17	71.4	24.6		115.0	
10235-CAD	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	5.98	71.3	25.0	9.48	112.0	±3.0 %
		Y	5.95	71.6	25.4		119.9	
		Z	6.19	71.5	24.7		115.2	

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10238-CAD	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM)	X	5.88	71.3	25.0	9.48	112.2	±3.0 %
		Y	5.94	71.6	25.4		119.0	
		Z	6.20	71.6	24.7		114.9	
10295-AAB	CDMA2000, RC1, SO3, 1/8th Rate 25 fr.	X	5.71	71.0	27.1	12.49	78.3	±1.9 %
		Y	5.39	70.0	26.9		82.0	
		Z	5.74	70.7	26.4		78.4	

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%.

[E] 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.

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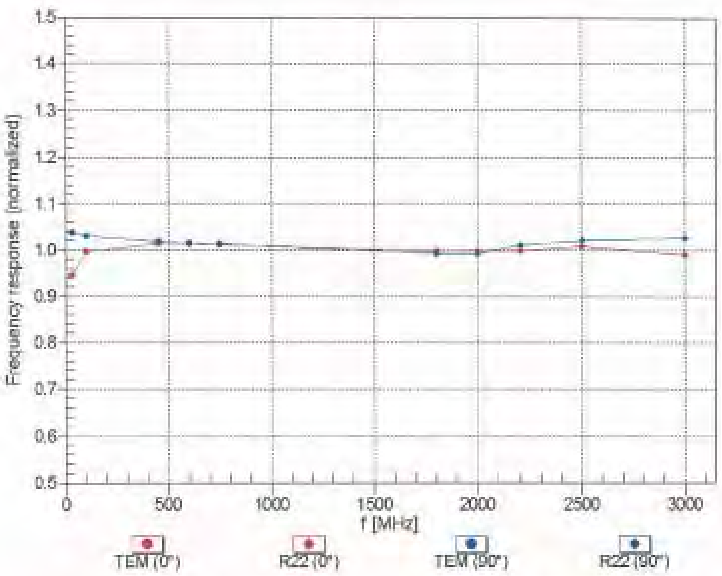
Frequency Response of E-Field

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



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

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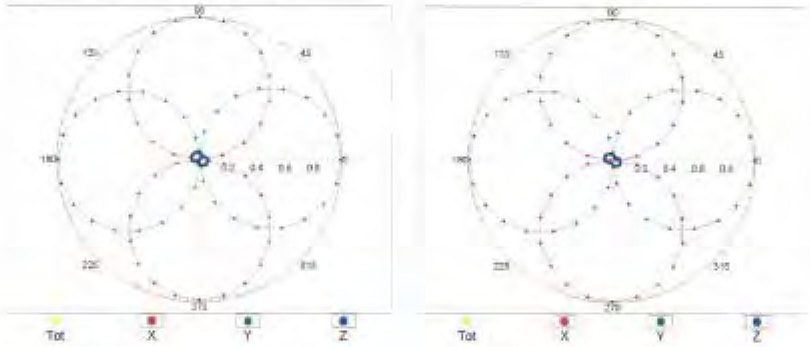
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0°

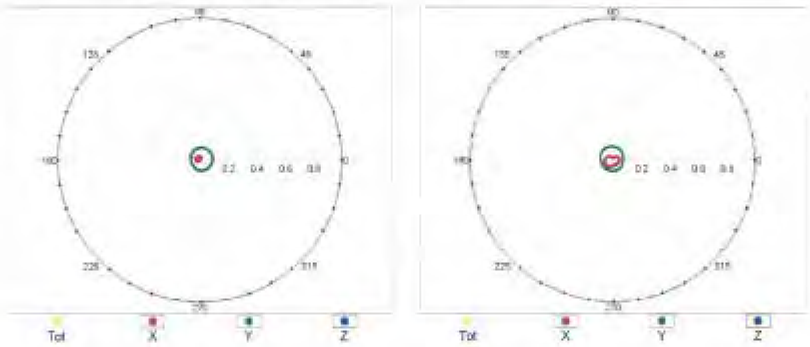
f=2500 MHz,R22,0°



Receiving Pattern (ϕ), ϑ = 90°

f=600 MHz,TEM,90°

f=2500 MHz,R22,90°



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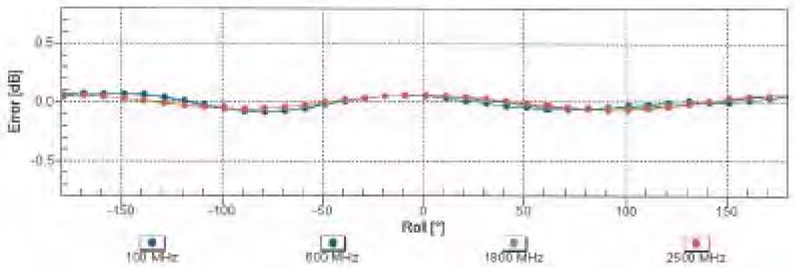
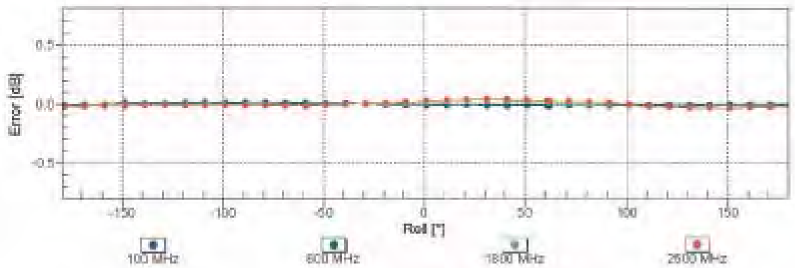
Receiving Pattern (ϕ), ϑ = 0°



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

Receiving Pattern (ϕ), ϑ = 90°



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

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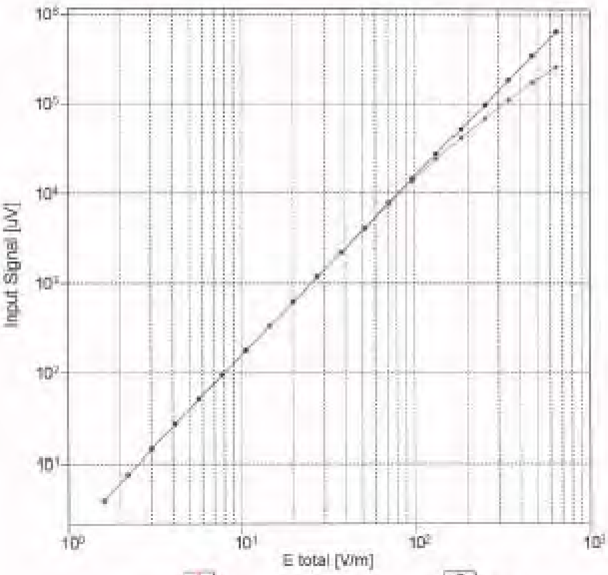
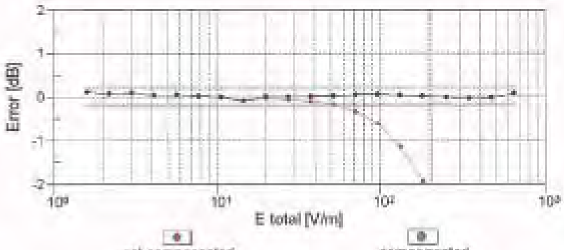
ER3DV6 – SN:2306 March 22, 2018

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





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

Certificate No: ER3-2306_Mar18 Page 9 of 11

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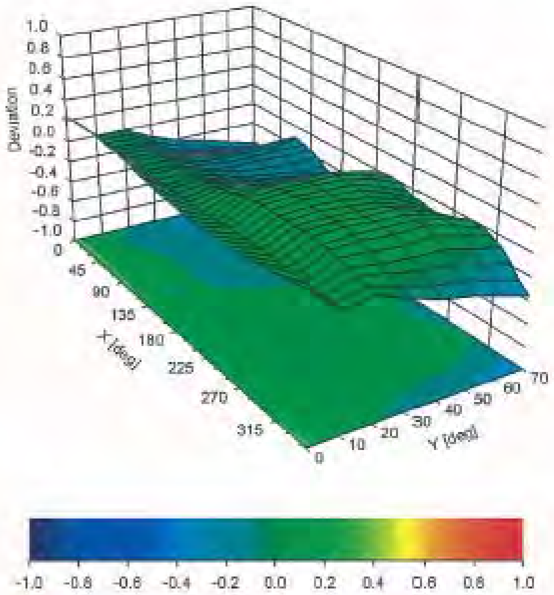
Deviation from Isotropy in Air

Error (ϕ, ϑ), f = 900 MHz



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

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DASY/EASY - Parameters of Probe: ER3DV6 - SN:2306

Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	131.1
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

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17. Uncertainty Budget

HAC Uncertainty Budget
According to ANSI C63.19 [1], [2]

Error Description	Uncert. value	Prob. Dist.	Div.	(c_i) E	(c_i) H	Std. Unc. E	Std. Unc. H
Measurement System							
Probe Calibration	±5.1 %	N	1	1	1	±5.1 %	±5.1 %
Axial Isotropy	±4.7 %	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %
Sensor Displacement	±16.5 %	R	$\sqrt{3}$	1	0.145	±9.5 %	±1.4 %
Boundary Effects	±2.4 %	R	$\sqrt{3}$	1	1	±1.4 %	±1.4 %
Phantom Boundary Effect	±7.2 %	R	$\sqrt{3}$	1	0	±4.1 %	±0.0 %
Linearity	±4.7 %	R	$\sqrt{3}$	1	1	±2.7 %	±2.7 %
Scaling with PMR calibration	±10.0 %	R	$\sqrt{3}$	1	1	±5.8 %	±5.8 %
System Detection Limit	±1.0 %	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %
Readout Electronics	±0.3 %	N	1	1	1	±0.3 %	±0.3 %
Response Time	±0.8 %	R	$\sqrt{3}$	1	1	±0.5 %	±0.5 %
Integration Time	±2.6 %	R	$\sqrt{3}$	1	1	±1.5 %	±1.5 %
RF Ambient Conditions	±3.0 %	R	$\sqrt{3}$	1	1	±1.7 %	±1.7 %
RF Reflections	±12.0 %	R	$\sqrt{3}$	1	1	±6.9 %	±6.9 %
Probe Positioner	±1.2 %	R	$\sqrt{3}$	1	0.67	±0.7 %	±0.5 %
Probe Positioning	±4.7 %	R	$\sqrt{3}$	1	0.67	±2.7 %	±1.8 %
Extrap. and Interpolation	±1.0 %	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %
Test Sample Related							
Device Positioning Vertical	±4.7 %	R	$\sqrt{3}$	1	0.67	±2.7 %	±1.8 %
Device Positioning Lateral	±1.0 %	R	$\sqrt{3}$	1	1	±0.6 %	±0.6 %
Device Holder and Phantom	±2.4 %	R	$\sqrt{3}$	1	1	±1.4 %	±1.4 %
Power Drift	±5.0 %	R	$\sqrt{3}$	1	1	±2.9 %	±2.9 %
Phantom and Setup Related							
Phantom Thickness	±2.4 %	R	$\sqrt{3}$	1	0.67	±1.4 %	±0.9 %
Combined Std. Uncertainty						±16.3 %	±12.3 %
Expanded Std. Uncertainty on Power						**±32.6 %**	**±24.6 %**
Expanded Std. Uncertainty on Field						**±16.3 %**	**±12.3 %**

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18. System Validation from Original Equipment Supplier

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
S 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 **SGS-TW (Auden)**

Certificate No: **CD835V3-1052_Mar18**

CALIBRATION CERTIFICATE

Object	CD835V3 - SN: 1052
Calibration procedure(s)	QA CAL-20.v6 Calibration procedure for dipoles in air
Calibration date:	March 14, 2018

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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Probe EF3DV3	SN: 4013	05-Mar-18 (No. EF3-4013_Mar18)	Mar-19
DAE4	SN: 781	17-Jan-18 (No. DAE4-781_Jan18)	Jan-19

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-17)	In house check: Oct-20
Power sensor HP E4412A	SN: US38485102	05-Jan-10 (in house check Oct-17)	In house check: Oct-20
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-17)	In house check: Oct-20
RF generator R&S SMT-06	SN: 832283/011	27-Aug-12 (in house check Oct-17)	In house check: Oct-20
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

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

Issued: March 15, 2018

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Certificate No: CD835V3-1052_Mar18 Page 1 of 5

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Accreditation No.: **SCS 0108**

References

[1] 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 15 mm 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], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 15 mm (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.

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%.

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Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Phantom	HAC Test Arch	
Distance Dipole Top - Probe Center	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

E-field 15 mm above dipole surface	condition	**Interpolated maximum**
Maximum measured above high end	100 mW input power	110.6 V/m = 40.87 dBV/m
Maximum measured above low end	100 mW input power	109.9 V/m = 40.82 dBV/m
Averaged maximum above arm	100 mW input power	**110.3 V/m ± 12.8 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

Frequency	Return Loss	Impedance
800 MHz	15.8 dB	41.1 Ω - 11.9 jΩ
835 MHz	29.3 dB	52.6 Ω + 2.4 jΩ
880 MHz	17.1 dB	61.2 Ω - 10.7 jΩ
900 MHz	17.4 dB	52.4 Ω - 13.7 jΩ
945 MHz	22.6 dB	46.7 Ω + 6.4 jΩ

3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

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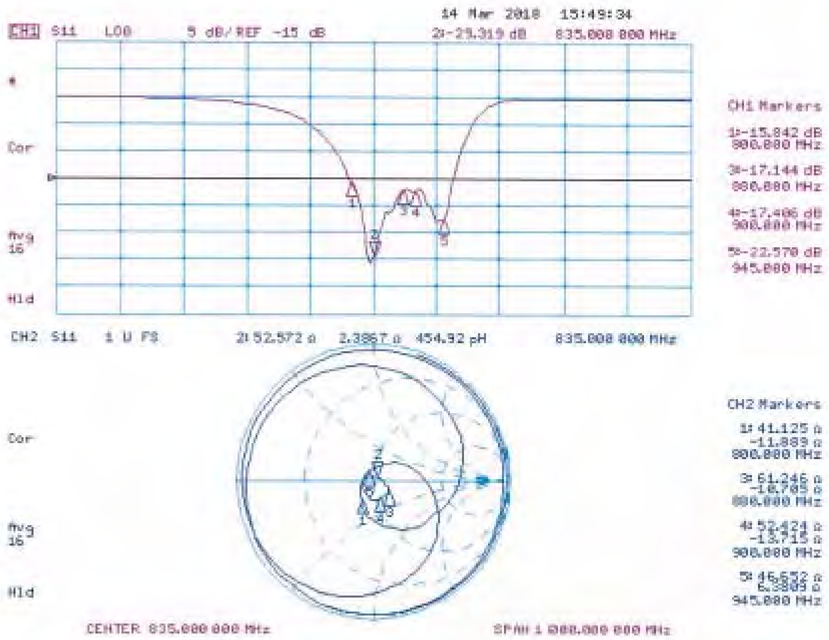
Impedance Measurement Plot



Certificate No: CD835V3-1052_Mar18 Page 4 of 5

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DASY5 E-field Result

Date: 14.03.2018

Test Laboratory: SPEAG Lab2

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: CD835V3 - SN: 1052

Communication System: UID 0 - CW ; Frequency: 835 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

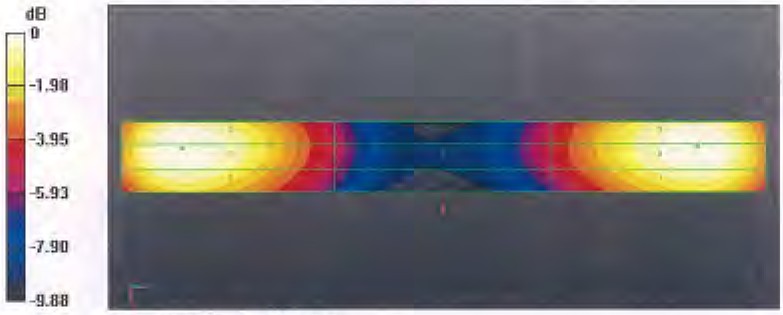
DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1); Calibrated: 05.03.2018;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 17.01.2018
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole E-Field measurement @ 835MHz/E-Scan - 835MHz d=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 = 129.8 V/m; Power Drift = -0.00 dB
Applied MIF = 0.00 dB
RF audio interference level = 40.87 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 M3 40.3 dBV/m	Grid 2 M3 40.87 dBV/m	Grid 3 M3 40.85 dBV/m
Grid 4 M4 35.56 dBV/m	Grid 5 M4 36.05 dBV/m	Grid 6 M4 36.05 dBV/m
Grid 7 M3 40.29 dBV/m	Grid 8 M3 40.82 dBV/m	Grid 9 M3 40.81 dBV/m



0 dB = 110.6 V/m = 40.88 dBV/m

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Accreditation No.: SCS 0108

Client SGS-TW (Auden)

Certificate No: CD1880V3-1044_Mar18

CALIBRATION CERTIFICATE

Object: CD1880V3 - SN: 1044

Calibration procedure(s): QA CAL-20.v6
Calibration procedure for dipoles in air

Calibration date: March 14, 2018

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	04-Apr-17 (No. 217-02521/02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Probe EF3DV3	SN: 4013	05-Mar-18 (No. EF3-4013_Mar18)	Mar-19
DAE4	SN: 781	17-Jan-18 (No. DAE4-781_Jan18)	Jan-19

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-17)	In house check: Oct-20
Power sensor HP E4412A	SN: US38485102	05-Jan-10 (in house check Oct-17)	In house check: Oct-20
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-17)	In house check: Oct-20
RF generator R&S SMT-06	SN: 832283/011	27-Aug-12 (in house check Oct-17)	In house check: Oct-20
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

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

Issued: March 15, 2018

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[1] 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 15 mm 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], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 15 mm (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.

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%.

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Measurement Conditions

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

DASY Version	DASY5	V52.10.0
Phantom	HAC Test Arch	
Distance Dipole Top - Probe Center	15 mm	
Scan resolution	dx, dy = 5 mm	
Frequency	1880 MHz ± 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 1880 MHz

E-field 15 mm above dipole surface	condition	**Interpolated maximum**
Maximum measured above high end	100 mW input power	88.9 V/m = 38.98 dBV/m
Maximum measured above low end	100 mW input power	88.6 V/m = 38.95 dBV/m
Averaged maximum above arm	100 mW input power	**88.8 V/m ± 12.8 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

Frequency	Return Loss	Impedance
1730 MHz	23.4 dB	53.7 Ω + 5.9 jΩ
1880 MHz	20.1 dB	58.7 Ω + 6.4 jΩ
1900 MHz	20.8 dB	59.4 Ω + 3.3 jΩ
1950 MHz	27.9 dB	53.4 Ω - 2.4 jΩ
2000 MHz	21.4 dB	46.2 Ω + 7.3 jΩ

3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

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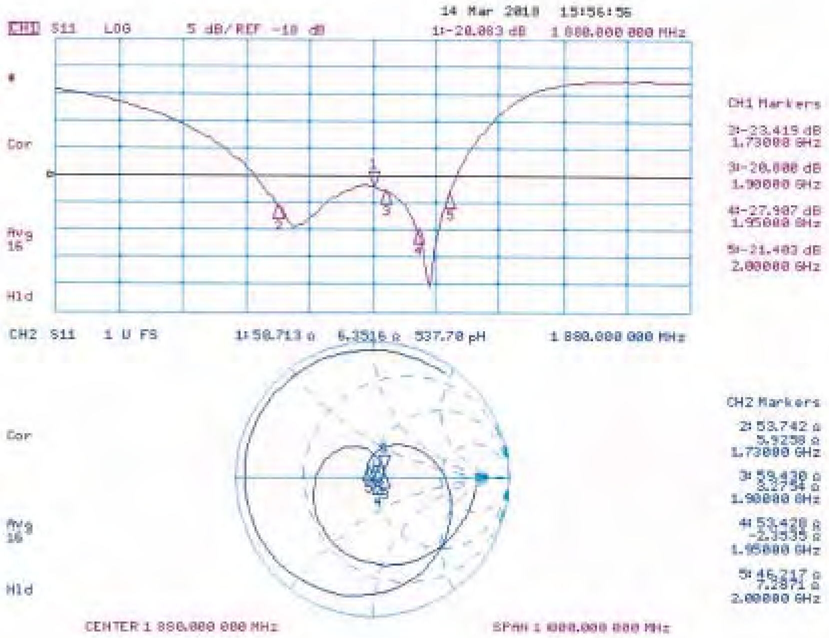
Impedance Measurement Plot



Certificate No: CD1880V3-1044_Mar18 Page 4 of 5

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DASY5 E-field Result

Date: 14.03.2018

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: CD1880V3 - SN: 1044

Communication System: UID 0 - CW ; Frequency: 1880 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Phantom section: RF Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

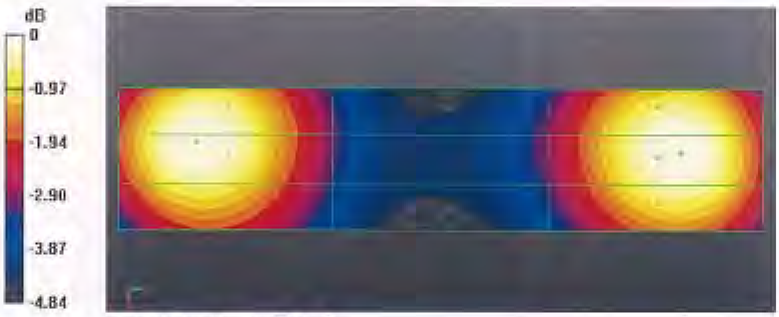
DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1); Calibrated: 05.03.2018;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 17.01.2018
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=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 = 160.7 V/m; Power Drift = 0.00 dB
Applied MIF = 0.00 dB
RF audio interference level = 38.98 dBV/m
Emission category: M2

MIF scaled E-field

Grid 1 M2 38.41 dBV/m	Grid 2 M2 38.95 dBV/m	Grid 3 M2 38.93 dBV/m
Grid 4 M2 35.89 dBV/m	Grid 5 M2 36.09 dBV/m	Grid 6 M2 36.07 dBV/m
Grid 7 M2 38.67 dBV/m	Grid 8 M2 38.98 dBV/m	Grid 9 M2 38.91 dBV/m



0 dB = 88.87 V/m = 38.98 dBV/m

Certificate No: CD1880V3-1044_Mar18 Page 5 of 5

End of report

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