

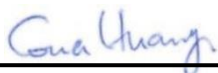
HEARING AID COMPATIBILITY RF EMISSIONS TEST REPORT

FCC ID : UZ7TC57HO
Equipment : Touch Computer
Brand Name : Zebra
Model Name : TC57HO
M-Rating : M3
Applicant : Zebra Technologies Corporation
1 Zebra Plaza Holtsville, NY 11742
Manufacturer : Zebra Technologies Corporation
1 Zebra Plaza Holtsville, NY 11742
Standard : FCC 47 CFR §20.19
ANSI C63.19-2011

The product was received on Sep. 04, 2018 and testing was started from Sep. 13, 2018 and completed on Sep. 14, 2018. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The report must not be used by the client to claim product certification, approval, or endorsement by TAF or any agency of government.

The test results in this variant report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.



Approved by: Cona Huang / Deputy Manager

SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory
No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)



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History of this test report

Report No.	Version	Description	Issued Date
HA882724A	Rev. 01	Initial issue of report	Oct. 15, 2018

**1. General Information**

Product Feature & Specification	
Applicant Name	Zebra Technologies Corporation
Equipment Name	Touch Computer
Brand Name	Zebra
Model Name	TC57HO
FCC ID	UZ7TC57HO
HW Version	DV
SW Version	91-10-03.00-OG-U00-STD
FW Version	FUSION_QA_2_1.0.0.030_O
MFD	30-Jul-18
EUT Stage	Engineering sample
Date Tested	2018/09/13 ~ 2018/09/14
Frequency Band	GSM850: 824.2 MHz ~ 848.8 MHz GSM1900: 1850.2 MHz ~ 1909.8 MHz WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz WCDMA Band IV: 1712.4 MHz ~ 1752.6 MHz WCDMA Band V: 826.4 MHz ~ 846.6 MHz LTE Band 2: 1850.7 MHz ~ 1909.3 MHz LTE Band 4: 1710.7 MHz ~ 1754.3 MHz LTE Band 5: 824.7 MHz ~ 848.3 MHz LTE Band 7: 2502.5 MHz ~ 2567.5 MHz LTE Band 12: 699.7 MHz ~ 715.3 MHz LTE Band 13: 779.5 MHz ~ 784.5 MHz LTE Band 14: 790.5 MHz ~ 795.5 MHz LTE Band 17: 706.5 MHz ~ 713.5 MHz LTE Band 25: 1850.7 MHz ~ 1914.3 MHz LTE Band 26: 814.7 MHz ~ 848.3 MHz LTE Band 66: 1710.7 MHz ~ 1779.3 MHz LTE Band 38: 2572.5 MHz ~ 2617.5 MHz LTE Band 41: 2498.5 MHz ~ 2687.5 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5720 MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz Bluetooth: 2402 MHz ~ 2480 MHz NFC: 13.56 MHz
Mode	GSM/GPRS/EGPRS/DTM AMR / RMC 12.2Kbps HSDPA HSUPA DC-HSDPA LTE: QPSK, 16QAM, 64QAM 802.11a/b/g/n/ac HT20/HT40/VHT20/VHT40/VHT80 Bluetooth BR/EDR/LE NFC:ASK

Reviewed by: Jason Wang**Report Producer: Daisy Peng**

Specification of Accessories				
Adapter	Brand Name	Zebra	Part Number	PWR-WUA5V12W0US
Battery 1	Brand Name	Zebra	Part Number	BT-000314-50
Battery 2	Brand Name	Zebra	Part Number	BT-000314-01
USB cable	Brand Name	Zebra	Part Number	CBL-TC51-USB1-01
Headset Jumper 1	Brand Name	Zebra	Part Number	CBL-TC51-HDST25-01
Headset Jumper 2	Brand Name	Zebra	Part Number	CBL-TC51-HDST35-01
2.5mm Earphone	Brand Name	Zebra	Part Number	HDST-25MM-PTVP-01
3.5mm Earphone	Brand Name	Zebra	Part Number	HDST-35MM-PTVP-01
Exoskeleton	Brand Name	Zebra	Part Number	SG-TC51-EX01-01
Trigger Handle 1	Brand Name	Zebra	Part Number	TRG-TC51-SNP1-01
Soft Holster	Brand Name	Zebra	Part Number	SG-TC51-HLSTR1-01
Hand strap	Brand Name	Zebra	Part Number	SG-TC51-BHDSTP1-03
USB-C Adaptor	Brand Name	Zebra	Part Number	ADPTR-TC56-USBC-01
USB Type C cable	Brand Name	Zebra	Part Number	N/A

Remark:

1. There are two battery options, for RF emission evaluation is selected battery1 as the main test, battery2 choose worst air interface to be tested.



2. Testing Location

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 1190) and the FCC designation No. TW1190 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC test.

Testing Laboratory	
Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.) TEL: +886-3-327-3456 FAX: +886-3-328-4978
Test Site No.	Sporton Site No.: SAR04-HY

3. Applied Standards

- FCC CFR47 Part 20.19
- ANSI C63.19-2011
- FCC KDB 285076 D01 HAC Guidance v05
- FCC KDB 285076 D02 T Coil testing v03
- FCC KDB 285076 D03 HAC FAQ v01

4. RF Audio Interference Level

FCC wireless hearing aid compatibility rules ensure that consumers with hearing loss are able to access wireless communications services through a wide selection of handsets without experiencing disabling radio frequency (RF) interference or other technical obstacles.

To define and measure the hearing aid compatibility of handsets, in CFR47 part 20.19 ANSI C63.19 is referenced. A handset is considered hearing aid-compatible for acoustic coupling if it meets a rating of at least M3 under ANSI C63.19, and A handset is considered hearing aid compatible for inductive coupling if it meets a rating of at least T3. According to ANSI C63.19 2011 version, for acoustic coupling, the RF electric field emissions of wireless communication devices should be measured and rated according to the emission level as below.

Emission Categories	E-field emissions	
	<960Mhz	>960Mhz
M1	50 to 55 dB (V/m)	40 to 45 dB (V/m)
M2	45 to 50 dB (V/m)	35 to 40 dB (V/m)
M3	40 to 45 dB (V/m)	30 to 35 dB (V/m)
M4	<40 dB (V/m)	<30 dB (V/m)

Table 5.1 Telephone near-field categories in linear units



5. Air Interface and Operating Mode

Air Interface	Band MHz	Type	C63.19 Tested	Simultaneous Transmitter	Name of Voice Service	Power Reduction
GSM	GSM850	VO	Yes	WLAN, BT	CMRS Voice	No
	GSM1900			WLAN, BT		No
	EDGE850	VD	Yes	WLAN, BT	Google Duo ⁽¹⁾ / WFC ^(1,2)	No
	EDGE1900			WLAN, BT		
WCDMA	850	VO	No ⁽¹⁾	WLAN, BT	CMRS Voice	No
	1750			WLAN, BT		No
	1900			WLAN, BT		No
	HSPA	VD	No ⁽¹⁾	WLAN, BT	Google Duo ⁽¹⁾ / WFC ^(1,2)	No
LTE (FDD)	Band 2	VD	No ⁽¹⁾	WLAN, BT	VoLTE / Google Duo ⁽¹⁾ / WFC ^(1,2)	No
	Band 4			WLAN, BT		No
	Band 5			WLAN, BT		No
	Band 7			WLAN, BT		No
	Band 12			WLAN, BT		No
	Band 13			WLAN, BT		No
	Band 14			WLAN, BT		No
	Band 17			WLAN, BT		No
	Band 25			WLAN, BT		No
	Band 26			WLAN, BT		No
	Band 66			WLAN, BT		No
LTE (TDD)	Band 38	VD	Yes	WLAN, BT	VoLTE / Google Duo ⁽¹⁾ / WFC ^(1,2)	No
	Band 41			WLAN, BT		No
Wi-Fi	2450	VD	No ⁽¹⁾	GSM,WCDMA,LTE	Google Duo ⁽¹⁾ / WFC ^(1,2)	No
	5200			GSM,WCDMA,LTE		No
	5300			GSM,WCDMA,LTE		No
	5500			GSM,WCDMA,LTE		No
	5800			GSM,WCDMA,LTE		No
BT	2450	DT	No	GSM,WCDMA,LTE	NA	No

Type Transport:

VO= Voice only

DT= Digital Transport only (no voice)

VD= CMRS and IP Voice Service over Digital Transport

Remark:

- The air interface is exempted from testing by low power exemption that its average antenna input power plus its MIF is ≤ 17 dBm, and is rated as M4.
- The Workforce Connect (WFC) is an over-the-top (OTT) – voice services operating over IP, and this voice application was development and pre-installed on a wireless handset by the Zebra Technologies Corporation.

6. Measurement System Specification

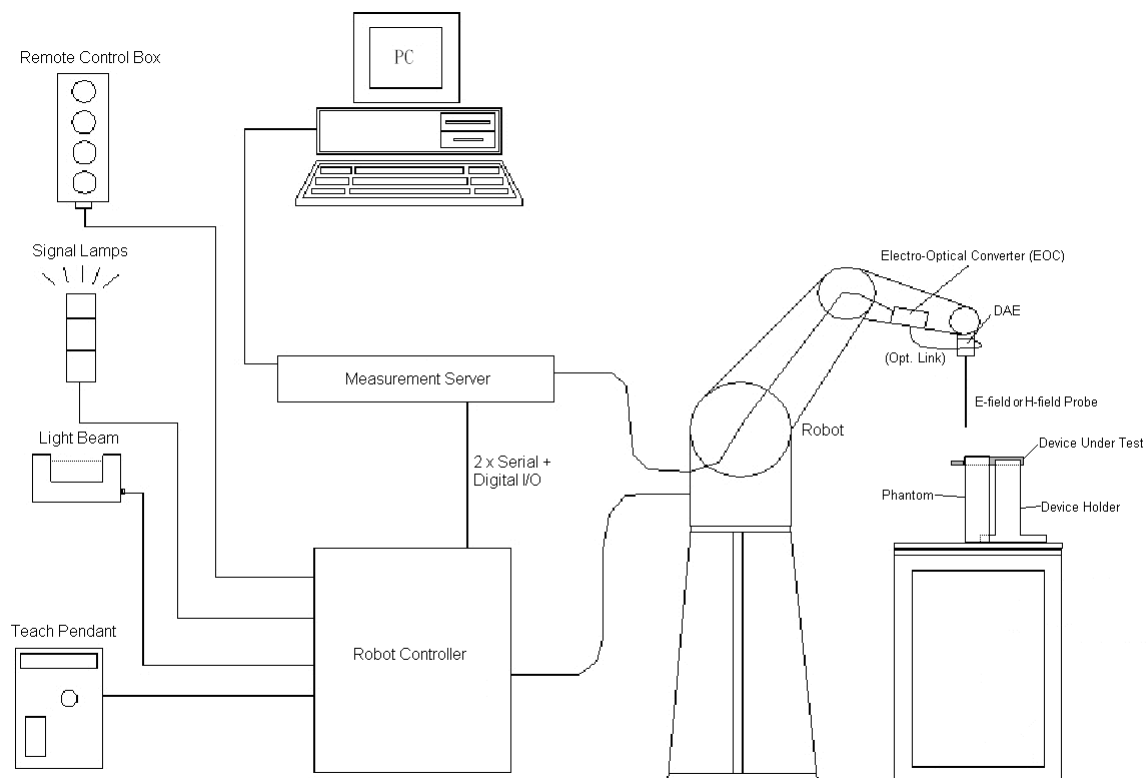


Fig 5.1 System Configurations

6.1 E-Field Probe System

E-Field Probe Specification

<ER3DV6>

Construction	One dipole parallel, two dipoles normal to probe axis Built-in shielding against static charges
Calibration	In air from 100 MHz to 3.0 GHz (absolute accuracy $\pm 6.0\%$, $k=2$)
Frequency	100 MHz to 6 GHz; Linearity: ± 2.0 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 (M3 or better device readings fall well below diode compression point)
Linearity	± 0.2 dB
Dimensions	Overall length: 330 mm (Tip: 16 mm) Tip diameter: 8 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.5 mm



Fig 5.2 Photo of E-field Probe

Probe Tip Description:

HAC field measurements take place in the close near field with high gradients. Increasing the measuring distance from the source will generally decrease the measured field values (in case of the validation dipole approx. 10% per mm).

6.2 Data Storage and Evaluation

The DASYS software stores the assessed data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all the necessary software parameters for the data evaluation (probe calibration data, and device frequency and modulation data) in measurement files.

Probe parameters :	- Sensitivity	Norm _i , a _{i0} , a _{i1} , a _{i2}
	- Conversion factor	ConvF _i
	- Diode compression point	dcp _i
Device parameters :	- Frequency	f
	- Crest factor	cf
Media parameters :	- Conductivity	σ
	- Density	ρ

The formula for each channel can be given as :

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with V_i = compensated signal of channel i, (i = x, y, z)
 U_i = input signal of channel i, (i = x, y, z)
 cf = crest factor of exciting field (DASY parameter)
 dcp_i = diode compression point (DASY parameter)

From the compensated input signals, the primary field data for each channel can be evaluated :

$$\text{E-field Probes : } E_i = \sqrt{\frac{V_i}{\text{Norm}_i \cdot \text{ConvF}}}$$

with V_i = compensated signal of channel i, (i = x, y, z)
 Norm_i = sensor sensitivity of channel i, (i = x, y, z), $\mu\text{V}/(\text{V/m})^2$ for E-field Probes
 ConvF = sensitivity enhancement in solution
 f = carrier frequency [GHz]
 E_i = electric field strength of channel i in V/m

The RSS value of the field components gives the total field strength (Hermitian magnitude) :

$$E_{\text{tot}} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.



7. RF Emissions Test Procedure

Referenced from ANSI C63.19 -2011 section 5.5.1

- a. Confirm the proper operation of the field probe, probe measurement system, and other instrumentation and the positioning system.
- b. Position the WD in its intended test position.
- c. Set the WD to transmit a fixed and repeatable combination of signal power and modulation characteristic that is representative of the worst case (highest interference potential) encountered in normal use. Transiently occurring start-up, changeover, or termination conditions, or other operations likely to occur less than 1% of the time during normal operation, may be excluded from consideration.
- d. The center sub-grid shall be centered on the T-Coil mode perpendicular measurement point or the acoustic output, as appropriate. Locate the field probe at the initial test position in the 50 mm by 50 mm grid, which is contained in the measurement plane, refer to illustrated in Figure 8.2. If the field alignment method is used, align the probe for maximum field reception.
- e. Record the reading at the output of the measurement system.
- f. Scan the entire 50 mm by 50 mm region in equality 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.
- g. 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.
- h. Identify the maximum reading within the non-excluded sub-grids identified in step g).
- i. Indirect measurement method
- j. The RF audio interference level in dB (V/m) is obtained by adding the MIF (in dB) to the maximum steady-state rms field-strength reading, in dB (V/m)
- k. Compare this RF audio interference level with the categories in ANSI C63.19-2011 clause 8 and record the resulting WD category rating.
- l. For the T-Coil perpendicular measurement location is ≥ 5.0 mm from the center of the acoustic output, then two different 50 mm by 50 mm areas may need to be scanned, the first for the microphone mode assessment and the second for the T-Coil assessment.
- m. The second for the T-Coil assessment, with the grid shifted so that it is centered on the perpendicular measurement point. Record the WD category rating.

Test Instructions

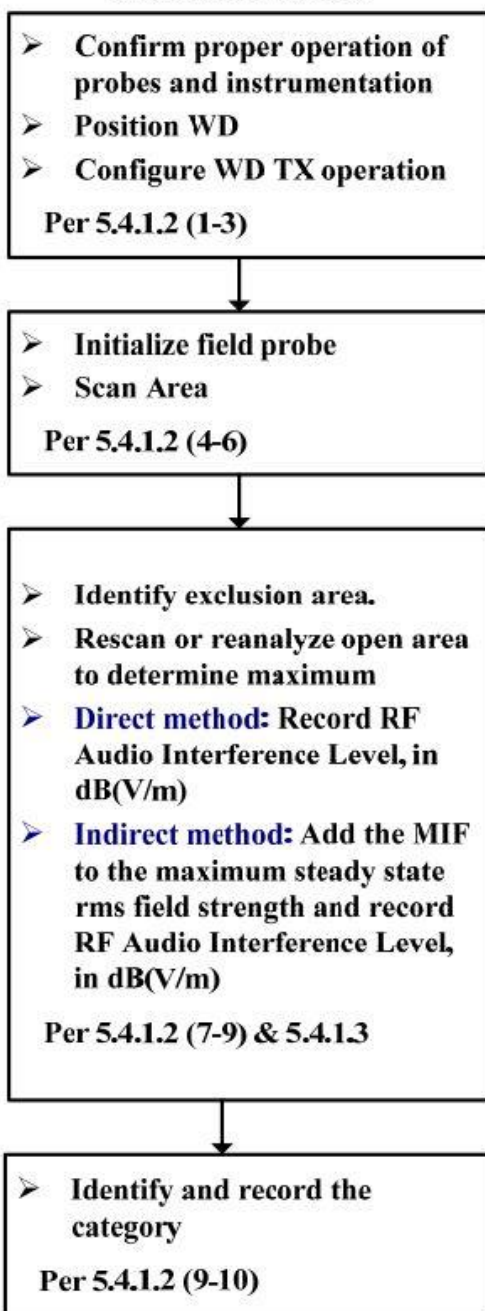


Figure 8.1 RF Emissions Flow Chart

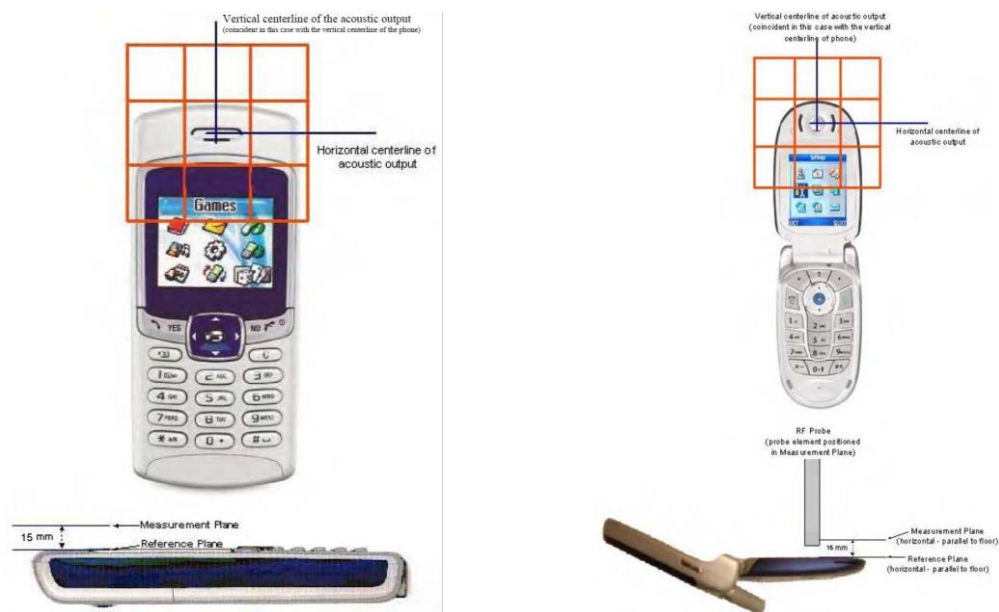


Fig 8.2 EUT reference and plane for HAC RF emission measurements

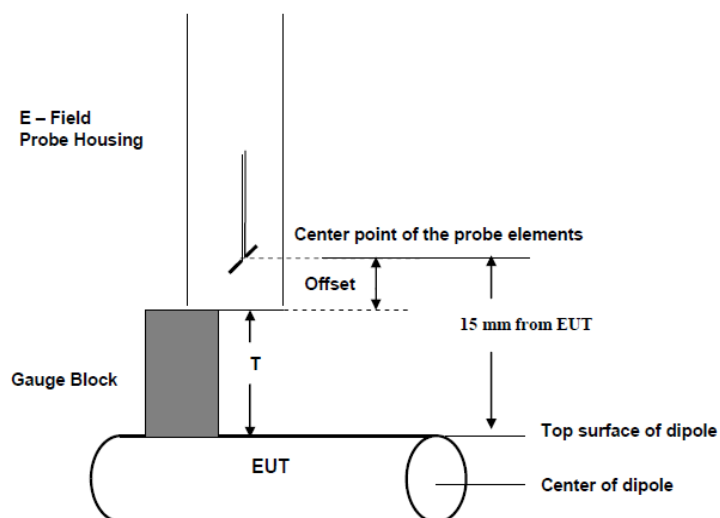


Fig. 8.3 Gauge block with E-field probe

**8. Test Equipment List**

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	835MHz Calibration Dipole	CD835V3	1045	Sep. 27, 2017	Sep. 26, 2018
SPEAG	1880MHz Calibration Dipole	CD1880V3	1038	Sep. 27, 2017	Sep. 26, 2018
SPEAG	2450MHz Calibration Dipole	CD2450V3	1186	Jan. 09, 2018	Jan. 08, 2019
SPEAG	2600Mhz Calibration Dipole	CD2600V3	1010	Nov. 22, 2017	Nov. 21, 2018
SPEAG	Data Acquisition Electronics	DAE4	910	Jun. 21, 2018	Jun. 20, 2019
SPEAG	Isotropic E-Field Probe	ER3DV6	2358	Jan. 19, 2018	Jan. 18, 2019
SPEAG	Isotropic E-Field Probe	EF3DV3	4053	Mar. 19, 2018	Mar. 18, 2019
RCPTWN	Thermometer	HTC-1	TM685-1	Mar. 16, 2018	Mar. 15, 2019
RCPTWN	Thermometer	HTC-1	TM281-1	Mar. 16, 2018	Mar. 15, 2019
SPEAG	Test Arch Phantom	N/A	N/A	NCR	NCR
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR
Anritsu	Power Meter	ML2495A	1419002	May. 18, 2018	May. 19, 2019
Anritsu	Power Sensor	MA2411B	1339124	May. 18, 2018	May. 19, 2019
R&S	Base Station	CMW500	115793	May. 24, 2018	May. 23, 2019
R&S	Base Station	CMU200	116457	May. 30, 2018	May. 29, 2019
ATM	Dual Directional Coupler	C122H-10	P610410z-02	NCR	NCR
Woken	Attenuator	WK0602-XX	N/A	NCR	NCR
Mini-Circuits	Power Amplifier	ZVE-8G+	6382	Aug. 09, 2018	Aug. 08, 2019
Mini-Circuits	Power Amplifier	ZHL-42W+	15542	Aug. 09, 2018	Aug. 08, 2019

Note:

1. NCR: "No-Calibration Required"

9. Measurement System Validation

Each DASY system is equipped with one or more system validation kits. These units, together with the predefined measurement procedures within the DASY software, enable the user to conduct the system performance check and system validation. System validation kit includes a dipole, tripod holder to fix it underneath the test Arch and a corresponding distance holder.

The system performance check verifies that the system operates within its specifications. System and operator errors can be detected and corrected. It is recommended that the system performance check be performed prior to any usage of the system in order to guarantee reproducible results. The system performance check uses normal HAC measurements in a simplified setup with a well characterized source. This setup was selected to give a high sensitivity to all parameters that might fail or vary over time. The system check does not intend to replace the calibration of the components, but indicates situations where the system uncertainty is exceeded due to drift or failure.

<Test Setup>

1. In the simplified setup for system evaluation, the EUT is replaced by a calibrated dipole and the power source is replaced by a continuous wave which comes from a signal generator.
2. The center point of the probe element(s) is 15mm from the closest surface of the dipole elements.
3. The calibrated dipole must be placed beneath the arch phantom. The equipment setup is shown below:
4. The output power on dipole port must be calibrated to 20dBm (100mW) before dipole is connected.

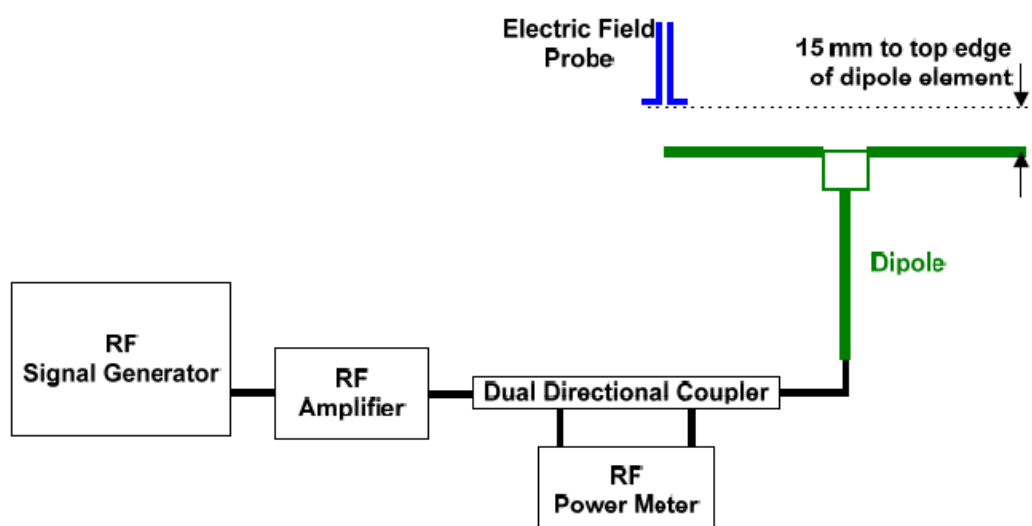


Fig. 7.1 Setup Diagram

<Validation Results>

Comparing to the original E-field value provided by SPEAG, the verification data should be within its specification of 25 %. Table 6.1 shows the target value and measured value. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to appendix A of this report.

Deviation = ((Average E-field Value) - (Target value)) / (Target value) * 100%

Frequency (MHz)	Input Power (dBm)	Target Value (V/m)	E-Field above high end (V/m)	E-Field above low end (V/m)	Average Value (V/m)	Deviation (%)	Date
835	20	106.8	109.3	107.3	108.3	1.40	Sep 13, 2018
1880	20	90	88.77	84.5	86.635	-3.74	Sep 13, 2018
2450	20	87.3	88.75	90.56	89.655	2.70	Sep 14, 2018
2600	20	85.4	84.22	92.14	88.18	3.26	Sep 13, 2018

10. Modulation Interference Factor

The HAC Standard ANSI C63.19-2011 defines a new scaling using the Modulation Interference Factor (MIF). 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 Modulation Interference factor (MIF, in dB) is added to the measured average E-field (in dBV/m) and converts it to the RF Audio Interference level (in dBV/m). This level considers the audible amplitude modulation components in the RF E-field. CW fields without amplitude modulation are assumed to not interfere with the hearing aid electronics. Modulations without time slots and low fluctuations at low frequencies have low MIF values, TDMA modulations with narrow transmission and repetition rates of few 100 Hz have high MIF values and give similar classifications as ANSI C63.19-2011.

ER3D, EF3D and EU2D E-field probes have a bandwidth <10 kHz and can therefore not evaluate the RF envelope in the full audio band. DASY52 is therefore using the indirect measurement method according to ANSI C63.19-2011 which is the primary method. These near field probes read the averaged E-field measurement. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by PMR calibration in order to not overestimate the field reading. Probe Modulation Response (PMR) calibration linearizes the probe response over its dynamic range for specific modulations which are characterized by their UID and result in an uncertainty specified in the probe calibration certificate. The MIF is characteristic for a given waveform envelope and can be used as a constant conversion factor if the probe has been PMR calibrated.

The evaluation method for the MIF is defined in ANSI C63.19-2011 section D.7. An RMS demodulated RF signal is fed to a spectral filter (similar to an A weighting filter) and forwarded to a temporal filter acting as a quasi-peak detector. The averaged output of these filtering is scaled to a 1 kHz 80% AM signal as reference. MIF measurement requires additional instrumentation and is not well suited for evaluation by the end user with reasonable uncertainty. It may alternatively be determined through analysis and simulation, because it is constant and characteristic for a communication signal. DASY52 uses well-defined signals for PMR calibration. The MIF of these signals has been determined by simulation and it is automatically applied.

The MIF measurement uncertainty is estimated as follows, declared by HAC equipment provider SPEAG, for modulation frequencies from slotted waveforms with fundamental frequency and at least 2 harmonics within 10 kHz:

1. 0.2 dB for MIF: -7 to +5 dB
2. 0.5 dB for MIF: -13 to +11 dB
3. 1 dB for MIF: > -20 dB

MIF values applied in this test report were provided by the HAC equipment provider of SPEAG, and the worst values for all air interface are listed below to determine the Low-power Exemption.

UID	Communication System Name	MIF(dB)
10021	GSM-FDD(TDMA,GMSK)	3.63
10025	EDGE-FDD (TDMA, 8PSK, TN 0)	3.75
10460	UMTS-FDD(WCDMA, AMR)	-25.43
10225	UMTS-FDD (HSPA+)	-20.39
10170	LTE-FDD(SC-FDMA,1RB,20MHz,16-QAM)	-9.76
10172	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	-1.62
10173	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	-1.44
10174	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 64-QAM)	-1.54
10061	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)	-2.02
10077	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)	0.12
10427	IEEE 802.11n (HT Greenfield, 150 Mbps, 64-QAM)	-13.44
10069	IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps)	-3.15
10616	IEEE 802.11ac WiFi (40MHz, MCS0, 90pc duty cycle)	-5.57

11. Low-power Exemption

<Max Tune-up Limit>

Frequency Band			Average Power (dBm)
GSM	GSM850		33.50
	EDGE850		28.00
	GSM1900		30.50
	EDGE1900		27.00
WCDMA	Band V		25.00
	Band IV		25.00
	Band II		25.00
	HSPA		24.00
FDD LTE	Band 2		25.00
	Band 4		25.00
	Band 5		24.50
	Band 7		23.50
	Band 12		25.00
	Band 13		24.50
	Band 14		24.50
	Band 17		25.00
	Band 25		25.00
	Band 26		24.50
Band 66		25.00	
TDD LTE	Band 38	QPSK	25.00
		16QAM	24.00
		64QAM	23.00
	Band 41	QPSK	24.00
		16QAM	23.00
		64QAM	22.00
2.4GHz WLAN Ant 1	802.11b		16.00
	802.11g		16.00
	802.11n-HT20		16.00
	802.11n-HT40		16.00
	802.11ac-VHT20		16.00
	802.11ac-VHT40		16.00
5GHz WLAN Ant 1	802.11a		18.50
	802.11n-HT20		18.50
	802.11n-HT40		18.50
	802.11ac-VHT20		18.50
	802.11ac-VHT40		18.50
	802.11ac-VHT80		17.00
2.4GHz WLAN Ant 2	802.11b		19.50
	802.11g		17.00
	802.11n-HT20		17.50
	802.11n-HT40		17.00
	802.11ac-VHT20		17.50
	802.11ac-VHT40		17.00
5GHz WLAN Ant 2	802.11a		18.00
	802.11n-HT20		18.00
	802.11n-HT40		18.00
	802.11ac-VHT20		18.00
	802.11ac-VHT40		18.00
	802.11ac-VHT80		18.00

<Low Power Exemption>

Air Interface		Max Average Antenna Input Power (dBm)	Worst Case MIF (dB)	Power + MIF(dB)	C63.19 test required
GSM850		33.50	3.63	37.13	Yes
EDGE850		28.00	3.75	31.75	Yes ⁽¹⁾
GSM1900		30.50	3.63	34.13	Yes
EDGE1900		27.00	3.75	30.75	Yes ⁽¹⁾
WCDMA		25.00	-25.43	-0.43	No
WCDMA - HSPA		24.00	-20.39	3.61	No
LTE - FDD		25.00	-9.76	15.24	No
LTE – TDD Band 38	QPSK	25.00	-1.62	23.38	Yes
	16QAM	24.00	-1.44	22.56	Yes ⁽¹⁾
	64QAM	23.00	-1.54	21.46	Yes ⁽¹⁾
LTE – TDD Band 41	QPSK	24.00	-1.62	22.38	Yes
	16QAM	23.00	-1.44	21.56	Yes ⁽¹⁾
	64QAM	22.00	-1.54	20.46	Yes ⁽¹⁾
2.4GHz WLAN Ant 1	802.11b	16.00	-2.02	13.98	No
	802.11g	16.00	0.12	16.12	No
	802.11n-HT20	16.00	-13.44	2.56	No
	802.11n-HT40	16.00	-13.44	2.56	No
	802.11ac-VHT20	16.00	-5.57	10.43	No
	802.11ac-VHT40	16.00	-5.57	10.43	No
5GHz WLAN Ant 1	802.11a	18.50	-3.15	15.35	No
	802.11n-HT20	18.50	-13.44	5.06	No
	802.11n-HT40	18.50	-13.44	5.06	No
	802.11ac-VHT20	18.50	-5.57	12.93	No
	802.11ac-VHT40	18.50	-5.57	12.93	No
	802.11ac-VHT80	17.00	-5.57	11.43	No
2.4GHz WLAN Ant 2	802.11b	19.50	-2.02	17.48	Yes
	802.11g	17.00	0.12	17.12	Yes ⁽¹⁾
	802.11n-HT20	17.50	-13.44	4.06	No
	802.11n-HT40	17.00	-13.44	3.56	No
	802.11ac-VHT20	17.50	-5.57	11.93	No
	802.11ac-VHT40	17.00	-5.57	11.43	No
5GHz WLAN Ant 2	802.11a	18.00	-3.15	14.85	No
	802.11n-HT20	18.00	-13.44	4.56	No
	802.11n-HT40	18.00	-13.44	4.56	No
	802.11ac-VHT20	18.00	-5.57	12.43	No
	802.11ac-VHT40	18.00	-5.57	12.43	No
	802.11ac-VHT80	18.00	-5.57	12.43	No

General Note:

- EDGE data modes and LTE TDD 16QAM/64QAM is not necessary due the GSM Voice mode and TDD QPSK is the worst case; 2.4GHz WLAN Ant 2 11g mode is not necessary due 11b is the worst case.
- According to ANSI C63.19 2011-version, for the 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.
- HAC RF rating is M4 for the air interface which meets the low power exemption.

12. Conducted RF Output Power (Unit: dBm)

<GSM>

Average Antenna Input Power(dBm)						
Band	GSM850			GSM1900		
Channel	128	189	251	512	661	810
Frequency (MHz)	824.2	836.4	848.8	1850.2	1880.0	1909.8
GSM (GMSK, 1 Tx slot)	32.61	32.21	32.09	29.45	29.05	29.06

<TDD LTE Band 38>

BW [MHz]	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Middle Ch. / Freq.	Power High Ch. / Freq.
Channel				37850	38000	38150
Frequency (MHz)				2580	2595	2610
20	QPSK	1	0	24.07	24.19	24.25

<TDD LTE Band 41>

BW [MHz]	Modulation	RB Size	RB Offset	Power Low Ch. / Freq.	Power Low Middle Ch. / Freq.	Power Middle Ch. / Freq.	Power High Middle Ch. / Freq.	Power High Ch. / Freq.
Channel				39750	40185	40620	41055	41490
Frequency (MHz)				2506	2549.5	2593	2636.5	2680
20	QPSK	1	0	23.40	23.41	23.35	23.25	23.13

<2.4GHz WLAN Ant 2>

2.4GHz WLAN	Mode	Channel	Frequency (MHz)	Average power (dBm)
	802.11b 1Mbps	1	2412	19.14
		6	2437	19.46
		11	2462	19.49

**13. HAC RF Emission Test Results**

Plot No.	Air Interface	Mode	Channel	Battery	Transmit Ant.	Average Antenna Input Power (dBm)	MIF	E-Field (dBV/m)	Margin to FCC M3 limit (dB)	E-Field M Rating
1	GSM850	GSM Voice	128	Battery 1	-	32.61	3.63	37.95	7.05	M4
2	GSM850	GSM Voice	189	Battery 1	-	32.21	3.63	38.22	6.78	M4
3	GSM850	GSM Voice	251	Battery 1	-	32.09	3.63	39.00	6.00	M4
4	GSM1900	GSM Voice	512	Battery 1	-	29.45	3.63	32.30	2.70	M3
5	GSM1900	GSM Voice	512	Battery 2	-	29.45	3.63	32.23	2.77	M3
6	GSM1900	GSM Voice	661	Battery 1	-	29.05	3.63	30.94	4.06	M3
7	GSM1900	GSM Voice	810	Battery 1	-	29.06	3.63	29.84	5.16	M4
8	LTE Band 38	20M_QPSK_1RB_Offset	37850	Battery 1	-	24.07	-1.62	29.34	5.66	M4
9	LTE Band 38	20M_QPSK_1RB_Offset	38000	Battery 1	-	24.19	-1.62	28.68	6.32	M4
10	LTE Band 38	20M_QPSK_1RB_Offset	38150	Battery 1	-	24.25	-1.62	29.06	5.94	M4
11	LTE Band 41	20M_QPSK_1RB_Offset	39750	Battery 1	-	23.40	-1.62	29.11	5.89	M4
12	LTE Band 41	20M_QPSK_1RB_Offset	40185	Battery 1	-	23.41	-1.62	28.73	6.27	M4
13	LTE Band 41	20M_QPSK_1RB_Offset	40620	Battery 1	-	23.35	-1.62	27.73	7.27	M4
14	LTE Band 41	20M_QPSK_1RB_Offset	41055	Battery 1	-	23.25	-1.62	28.55	6.45	M4
15	LTE Band 41	20M_QPSK_1RB_Offset	41490	Battery 1	-	23.13	-1.62	27.95	7.05	M4
16	WLAN2.4GHz	802.11b 1Mbps	1	Battery 1	Ant 2	19.14	-2.02	26.82	8.18	M4
17	WLAN2.4GHz	802.11b 1Mbps	6	Battery 1	Ant 2	19.46	-2.02	29.05	5.95	M4
18	WLAN2.4GHz	802.11b 1Mbps	11	Battery 1	Ant 2	19.49	-2.02	28.31	6.69	M4

Remark:

1. The HAC measurement system applies MIF value onto the measured RMS E-field, which is indirect method in ANSI C63.19 2011 version, and reports the RF audio interference level.
2. Phone Condition: Mute on; Backlight off; Max Volume

Test Engineer : Nick Yu.

14. Uncertainty Assessment

The component of uncertainty may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainty by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances. Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is showed in Table 12.1.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (E)	Standard Uncertainty (E)
Measurement System					
Probe Calibration	5.1	Normal	1	1	± 5.1 %
Axial Isotropy	4.7	Rectangular	$\sqrt{3}$	1	± 2.7 %
Sensor Displacement	16.5	Rectangular	$\sqrt{3}$	1	± 9.5 %
Boundary Effects	2.4	Rectangular	$\sqrt{3}$	1	± 1.4 %
Phantom Boundary Effects	7.2	Rectangular	$\sqrt{3}$	1	± 4.1 %
Linearity	4.7	Rectangular	$\sqrt{3}$	1	± 2.7 %
Scaling with PMR Calibration	10.0	Rectangular	$\sqrt{3}$	1	± 5.77 %
System Detection Limit	1.0	Rectangular	$\sqrt{3}$	1	± 0.6 %
Readout Electronics	0.3	Normal	1	1	± 0.3 %
Response Time	0.8	Rectangular	$\sqrt{3}$	1	± 0.5 %
Integration Time	2.6	Rectangular	$\sqrt{3}$	1	± 1.5 %
RF Ambient Conditions	3.0	Rectangular	$\sqrt{3}$	1	± 1.7 %
RF Reflections	12.0	Rectangular	$\sqrt{3}$	1	± 6.9 %
Probe Positioner	1.2	Rectangular	$\sqrt{3}$	1	± 0.7 %
Probe Positioning	4.7	Rectangular	$\sqrt{3}$	1	± 2.7 %
Extrap. and Interpolation	1.0	Rectangular	$\sqrt{3}$	1	± 0.6 %
Test Sample Related					
Device Positioning Vertical	4.7	Rectangular	$\sqrt{3}$	1	± 2.7 %
Device Positioning Lateral	1.0	Rectangular	$\sqrt{3}$	1	± 0.6 %
Device Holder and Phantom	2.4	Rectangular	$\sqrt{3}$	1	± 1.4 %
Power Drift	5.0	Rectangular	$\sqrt{3}$	1	± 2.9 %
Phantom and Setup Related					
Phantom Thickness	2.4	Rectangular	$\sqrt{3}$	1	± 1.4 %
Combined Standard Uncertainty					± 16.30 %
Coverage Factor for 95 %					K = 2
Expanded Std. Uncertainty on Power					± 32.6 %
Expanded Std. Uncertainty on Field					± 16.3 %

Table 12.1 Uncertainty Budget of HAC free field assessment
Remark:

Worst-Case uncertainty budget for HAC free field assessment according to ANSI C63.19 [1], [2]. The budget is valid for the frequency range 700 MHz - 3 GHz and represents a worst case analysis.



15. References

- [1] ANSI C63.19-2011, "American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", 27 May 2011.
- [2] FCC KDB 285076 D01v05, "Equipment Authorization Guidance for Hearing Aid Compatibility", Sep 2017
- [3] FCC KDB 285076 D02v03, "Guidance for performing T-Coil tests for air interfaces supporting voice over IP (e.g., LTE and WiFi) to support CMRS based telephone services", Sep 2017
- [4] FCC KDB 285076 D03v01, "Hearing aid compatibility frequently asked questions", Sep 2017
- [5] SPEAG DASY System Handbook



Appendix A. Plots of System Performance Check

The plots are shown as follows.

HAC_E_Dipole_835

DUT: HAC-Dipole 835 MHz

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - measurement distance from the probe sensor center to CD835 = 10mm & 15mm/Hearing Aid Compatibility Test at 15mm distance (41x361x1): Interpolated grid:

dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 123.0 V/m; Power Drift = -0.07 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 109.3 V/m

Average value of Total=(109.3+107.3) / 2 = 108.3 V/m

PMF scaled E-field

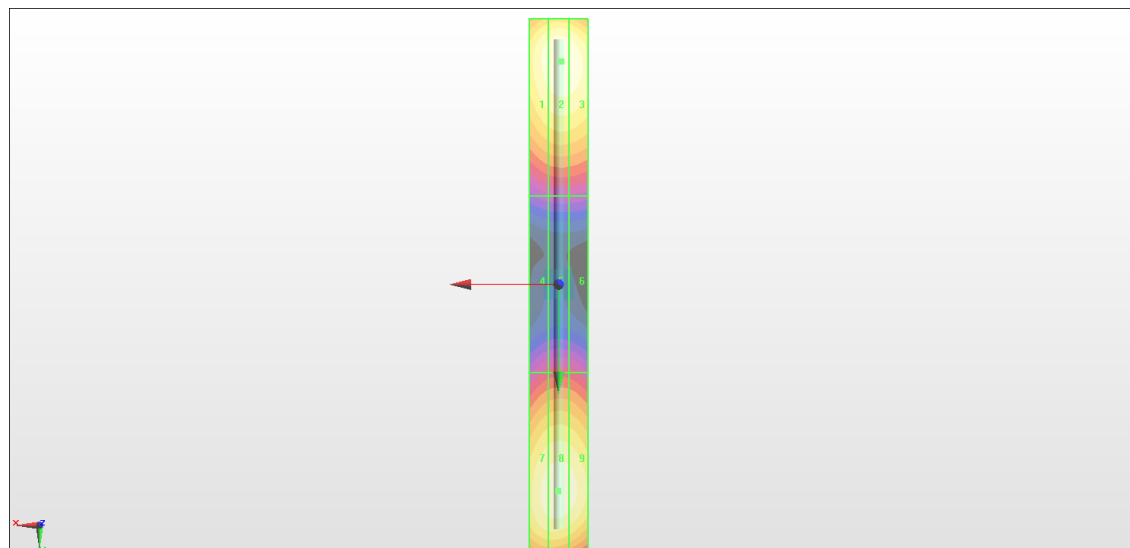
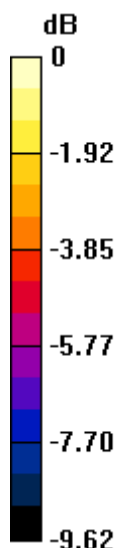
Grid 1 M4 105.7 V/m	Grid 2 M4 109.3 V/m	Grid 3 M4 108.0 V/m
Grid 4 M4 62.51 V/m	Grid 5 M4 63.56 V/m	Grid 6 M4 62.89 V/m
Grid 7 M4 105.7 V/m	Grid 8 M4 107.3 V/m	Grid 9 M4 105.6 V/m

Cursor:

Total = 109.3 V/m

E Category: M4

Location: -1, -75.5, 9.7 mm



0 dB = 109.3 V/m = 40.77 dBV/m

HAC_E_Dipole_1880**DUT: HAC Dipole 1880 MHz**

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

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - measurement distance from the probe sensor center to CD1880 = 10mm & 15mm/Hearing Aid Compatibility Test at 15mm distance (41x181x1): Interpolated grid:

$dx=0.5000$ mm, $dy=0.5000$ mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 147.2 V/m; Power Drift = 0.01 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 88.77 V/m

Average value of Total = $(88.77 + 84.5) / 2 = 86.635$ V/m

PMF scaled E-field

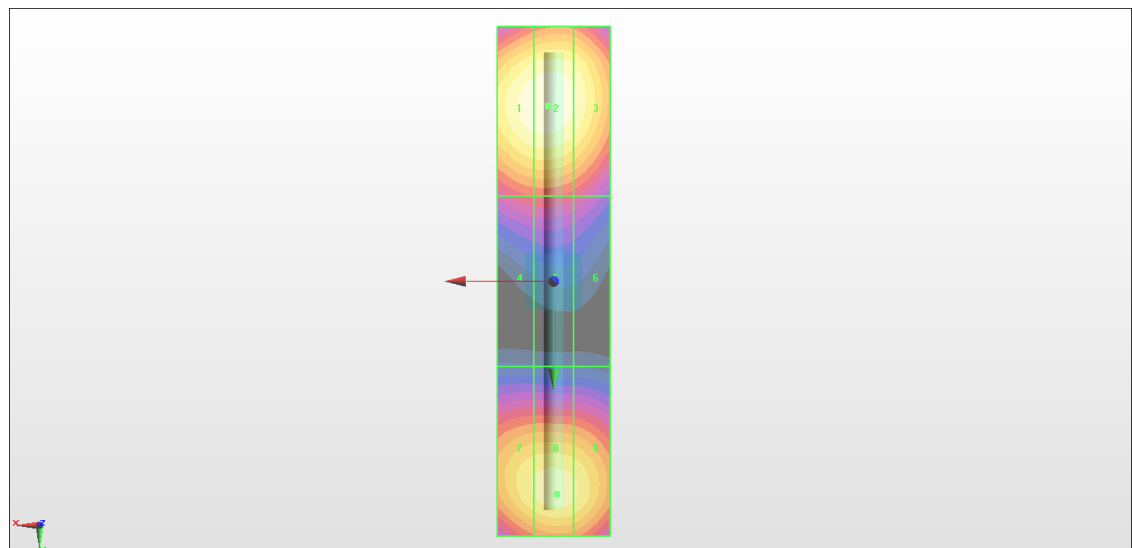
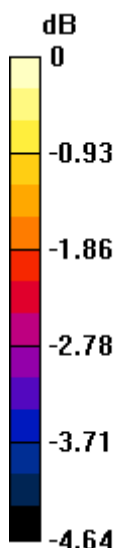
Grid 1 M3 88.09 V/m	Grid 2 M3 88.77 V/m	Grid 3 M3 86.29 V/m
Grid 4 M3 69.40 V/m	Grid 5 M3 69.59 V/m	Grid 6 M3 67.75 V/m
Grid 7 M3 83.12 V/m	Grid 8 M3 84.50 V/m	Grid 9 M3 83.48 V/m

Cursor:

Total = 88.77 V/m

E Category: M3

Location: 1, -31, 9.7 mm



0 dB = 88.77 V/m = 38.97 dBV/m

HAC_E_Dipole_2450**DUT: HAC Dipole 2450 MHz**

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: EF3DV3 - SN4053; ConvF(1, 1, 1); Calibrated: 2018/3/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - measurement distance from the probe sensor center to CD2450 = 10mm & 15mm
2/Hearing Aid Compatibility Test at 15mm distance (41x181x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 76.03 V/m; Power Drift = 0.01 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 90.56 V/m

Average value of Total=(88.75+90.56) / 2 = 89.655 V/m

PMF scaled E-field

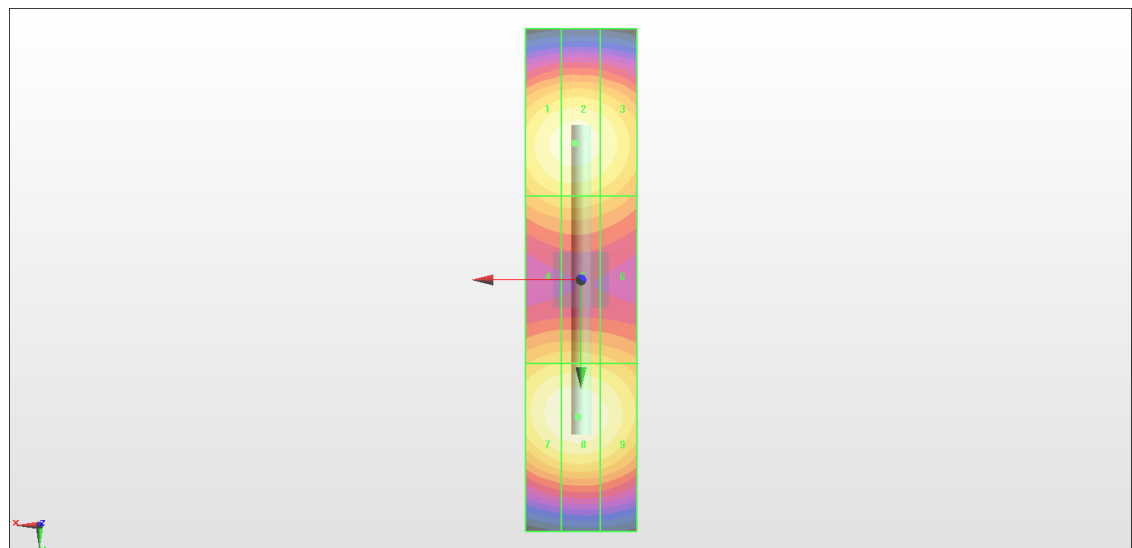
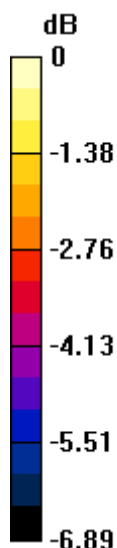
Grid 1 M3 88.04 V/m	Grid 2 M3 88.75 V/m	Grid 3 M3 85.98 V/m
Grid 4 M3 77.84 V/m	Grid 5 M3 78.04 V/m	Grid 6 M3 76.20 V/m
Grid 7 M3 89.60 V/m	Grid 8 M3 90.56 V/m	Grid 9 M3 87.68 V/m

Cursor:

Total = 90.56 V/m

E Category: M3

Location: 0.5, 24.5, 9.7 mm



0 dB = 90.56 V/m = 39.14 dBV/m

HAC_E_Dipole_2600**DUT: HAC Dipole 2600 MHz**

Communication System: CW ; Frequency: 2600 MHz; Duty Cycle: 1:1

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - measurement distance from the probe sensor center to CD2600 = 10mm & 15mm/Hearing Aid Compatibility Test at 15mm distance (41x181x1): Interpolated grid:

$dx=0.5000$ mm, $dy=0.5000$ mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 72.46 V/m; Power Drift = 0.01 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 92.14 V/m

Average value of Total=(84.22+92.14) / 2 = 88.18 V/m

PMF scaled E-field

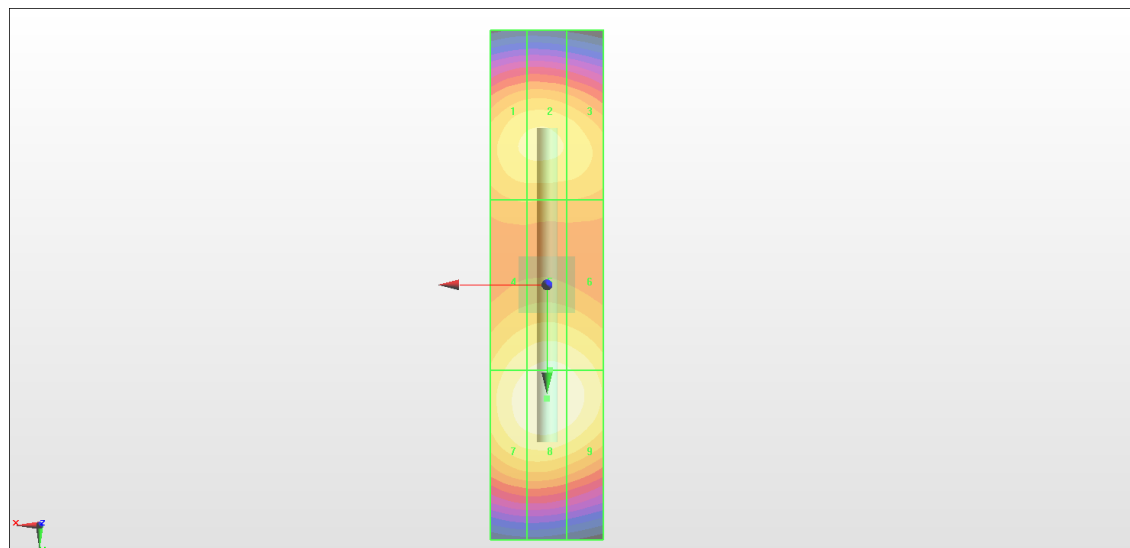
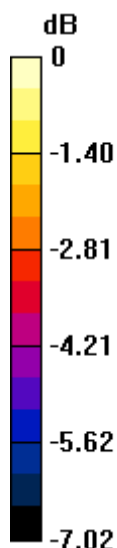
Grid 1 M3 83.71 V/m	Grid 2 M3 84.22 V/m	Grid 3 M3 82.43 V/m
Grid 4 M3 87.34 V/m	Grid 5 M3 89.03 V/m	Grid 6 M3 87.99 V/m
Grid 7 M3 90.54 V/m	Grid 8 M3 92.14 V/m	Grid 9 M3 90.72 V/m

Cursor:

Total = 92.14 V/m

E Category: M3

Location: 0, 20, 9.7 mm



0 dB = 92.14 V/m = 39.29 dBV/m



Appendix B. Plots of RF Emission Measurement

The plots are shown as follows.

#01_HAC_E_GSM850_GSM Voice_Ch128

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 824.2 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 62.93 V/m; Power Drift = -0.06 dB

Applied MIF = 3.63 dB

RF audio interference level = 37.95 dBV/m

Emission category: M4

MIF scaled E-field

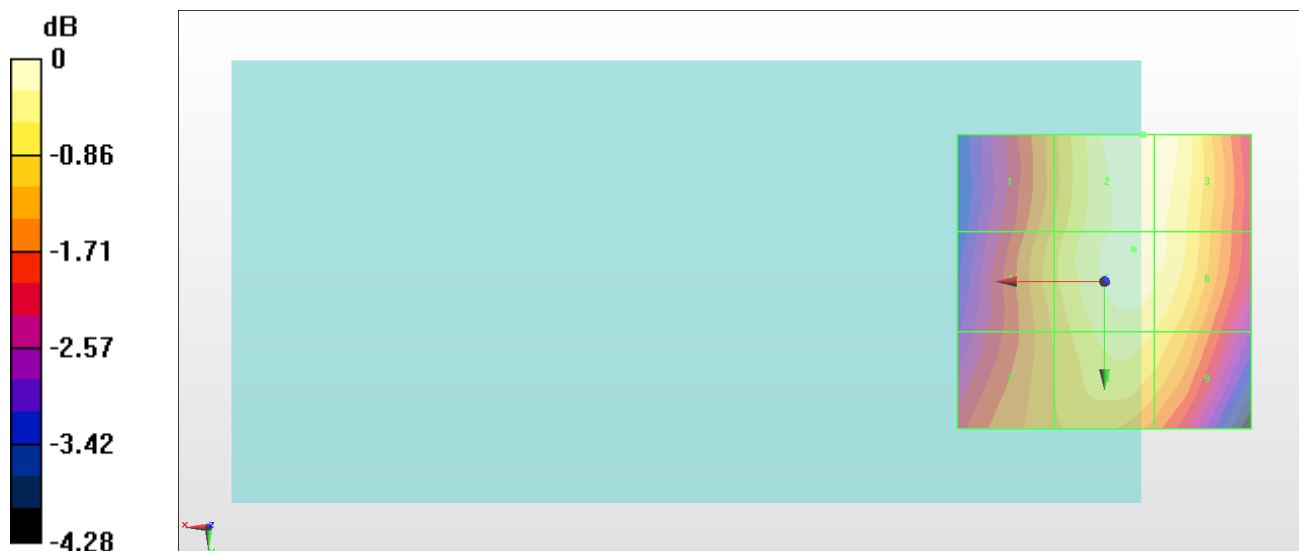
Grid 1 M4 36.89 dBV/m	Grid 2 M4 37.95 dBV/m	Grid 3 M4 37.93 dBV/m
Grid 4 M4 37.05 dBV/m	Grid 5 M4 37.85 dBV/m	Grid 6 M4 37.79 dBV/m
Grid 7 M4 36.87 dBV/m	Grid 8 M4 37.53 dBV/m	Grid 9 M4 37.38 dBV/m

Cursor:

Total = 37.95 dBV/m

E Category: M4

Location: -6.5, -25, 8.7 mm



#02_HAC_E_GSM850_GSM Voice_Ch189

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 836.4 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 66.44 V/m; Power Drift = -0.01 dB

Applied MIF = 3.63 dB

RF audio interference level = 38.22 dBV/m

Emission category: M4

MIF scaled E-field

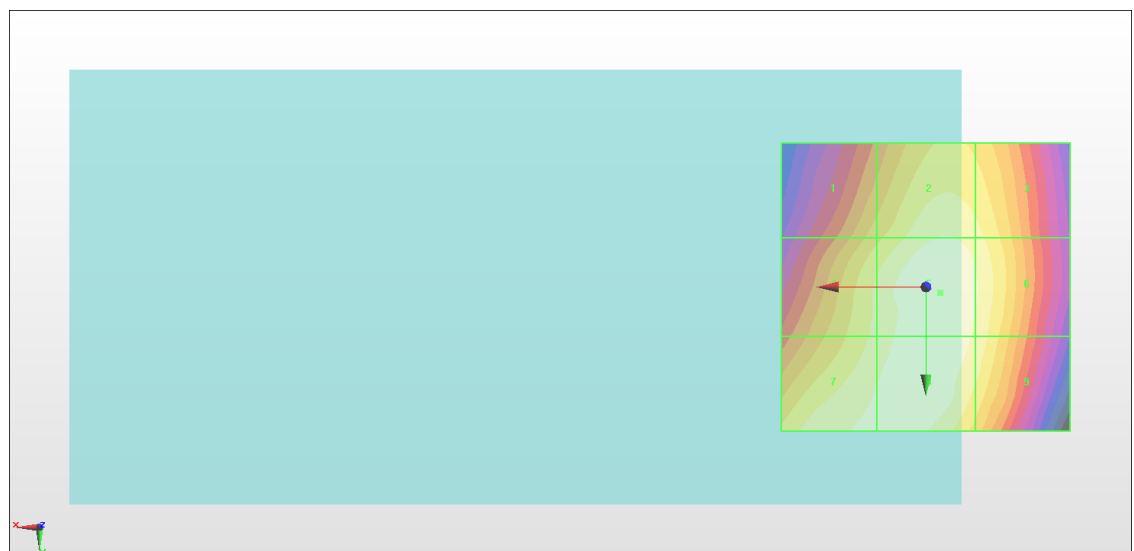
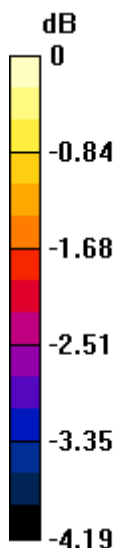
Grid 1 M4 37.31 dBV/m	Grid 2 M4 37.96 dBV/m	Grid 3 M4 37.79 dBV/m
Grid 4 M4 37.76 dBV/m	Grid 5 M4 38.22 dBV/m	Grid 6 M4 37.98 dBV/m
Grid 7 M4 38.02 dBV/m	Grid 8 M4 38.17 dBV/m	Grid 9 M4 37.89 dBV/m

Cursor:

Total = 38.22 dBV/m

E Category: M4

Location: -2.5, 1, 8.7 mm



0 dB = 81.45 V/m = 38.22 dBV/m

#03_HAC_E_GSM850_GSM Voice_Ch251

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 848.8 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 73.32 V/m; Power Drift = -0.03 dB

Applied MIF = 3.63 dB

RF audio interference level = 39.00 dBV/m

Emission category: M4

MIF scaled E-field

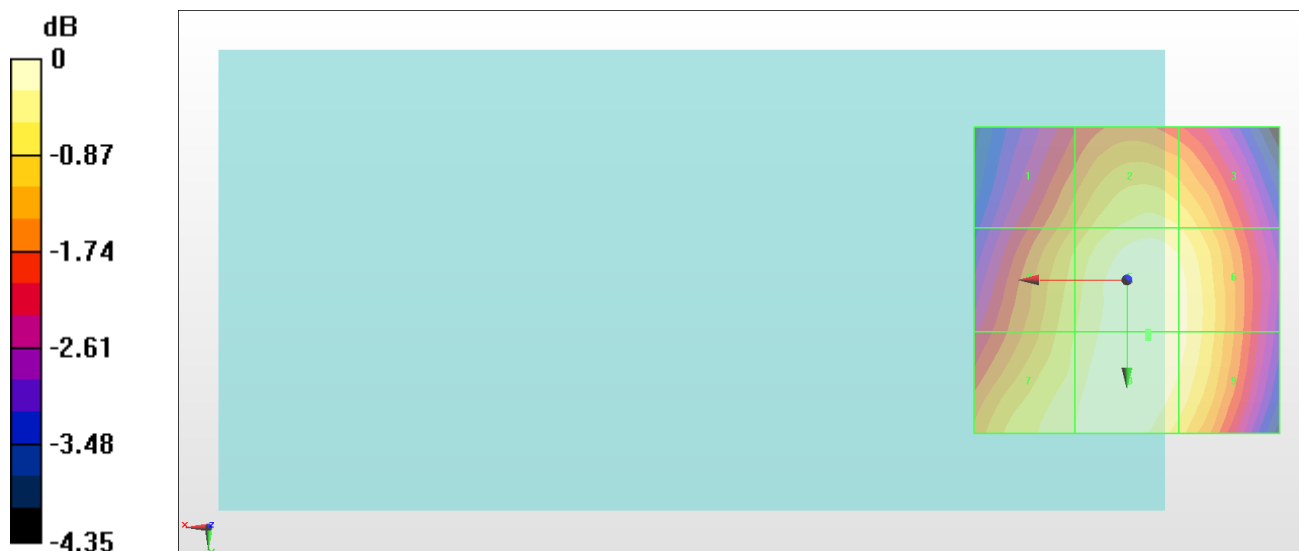
Grid 1 M4 37.87 dBV/m	Grid 2 M4 38.59 dBV/m	Grid 3 M4 38.45 dBV/m
Grid 4 M4 38.42 dBV/m	Grid 5 M4 39 dBV/m	Grid 6 M4 38.83 dBV/m
Grid 7 M4 38.71 dBV/m	Grid 8 M4 39 dBV/m	Grid 9 M4 38.82 dBV/m

Cursor:

Total = 39.00 dBV/m

E Category: M4

Location: -3.5, 9.5, 8.7 mm



0 dB = 89.16 V/m = 39.00 dBV/m

#04_HAC_E_GSM1900_GSM Voice_Ch512

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 1850.2 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 29.37 V/m; Power Drift = -0.08 dB

Applied MIF = 3.63 dB

RF audio interference level = 32.30 dBV/m

Emission category: M3

MIF scaled E-field

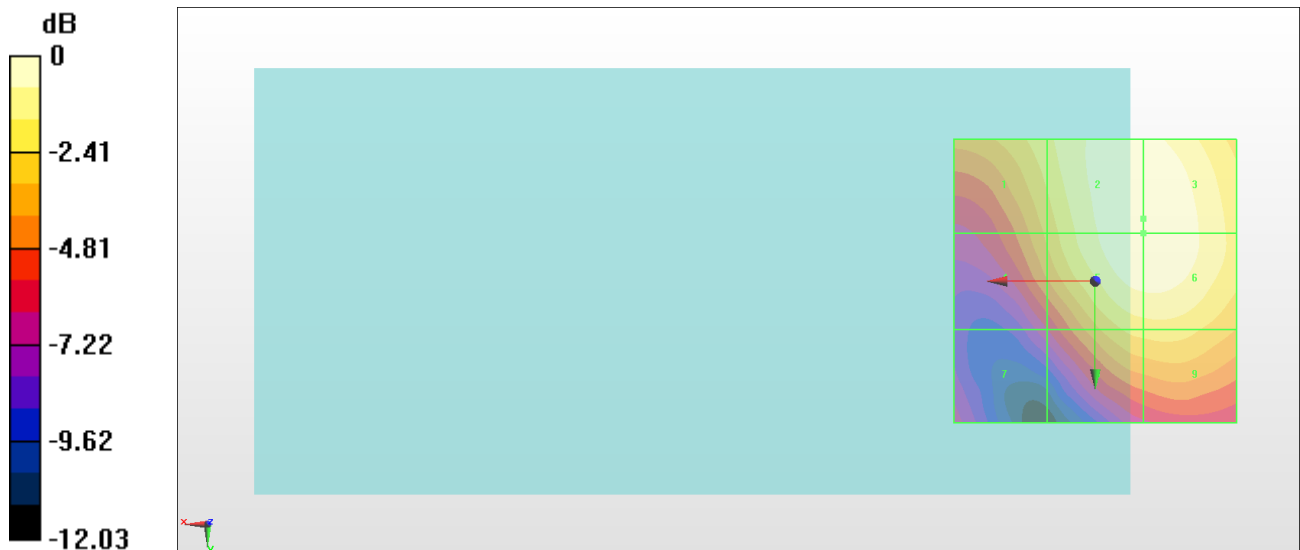
Grid 1 M3 30.49 dBV/m	Grid 2 M3 32.3 dBV/m	Grid 3 M3 32.3 dBV/m
Grid 4 M4 29.3 dBV/m	Grid 5 M3 32.28 dBV/m	Grid 6 M3 32.28 dBV/m
Grid 7 M4 25.87 dBV/m	Grid 8 M3 30.26 dBV/m	Grid 9 M3 30.36 dBV/m

Cursor:

Total = 32.30 dBV/m

E Category: M3

Location: -8.5, -11, 8.7 mm



0 dB = 41.22 V/m = 32.30 dBV/m

#05_HAC_E_GSM1900_GSM Voice_Ch512

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 1850.2 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.8 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 29.02 V/m; Power Drift = -0.08 dB

Applied MIF = 3.63 dB

RF audio interference level = 32.23 dBV/m

Emission category: M3

MIF scaled E-field

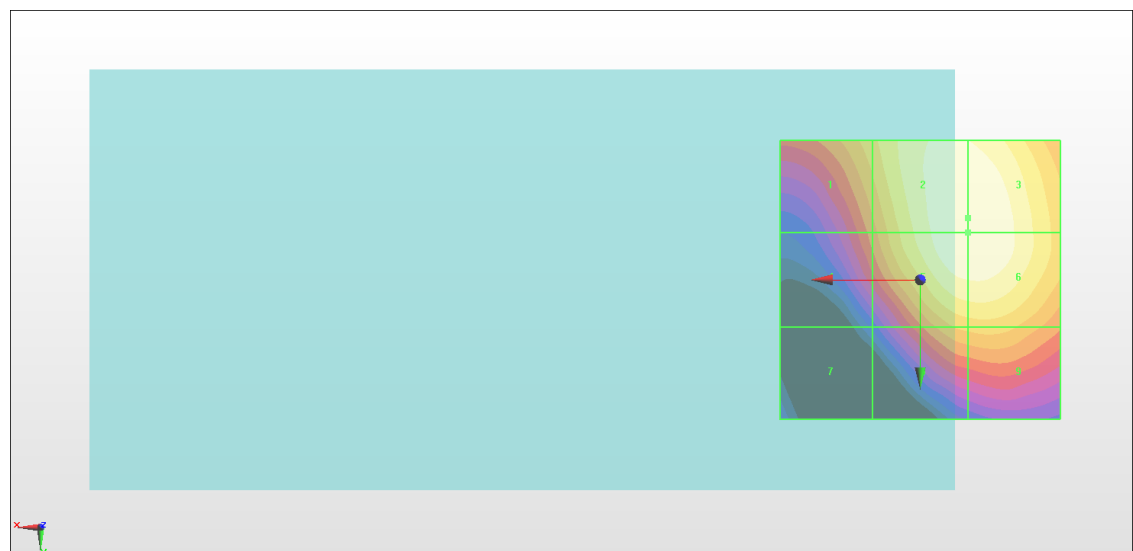
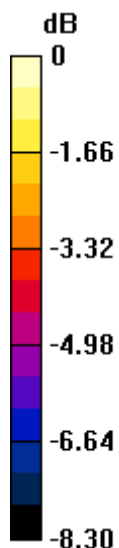
Grid 1 M3 30.36 dBV/m	Grid 2 M3 32.23 dBV/m	Grid 3 M3 32.23 dBV/m
Grid 4 M4 29.25 dBV/m	Grid 5 M3 32.21 dBV/m	Grid 6 M3 32.19 dBV/m
Grid 7 M4 25.64 dBV/m	Grid 8 M3 30.22 dBV/m	Grid 9 M3 30.33 dBV/m

Cursor:

Total = 32.23 dBV/m

E Category: M3

Location: -8.5, -11, 8.7 mm



0 dB = 40.89 V/m = 32.23 dBV/m

#06_HAC_E_GSM1900_GSM Voice_Ch661

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 1880 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 24.56 V/m; Power Drift = -0.05 dB

Applied MIF = 3.63 dB

RF audio interference level = 30.94 dBV/m

Emission category: M3

MIF scaled E-field

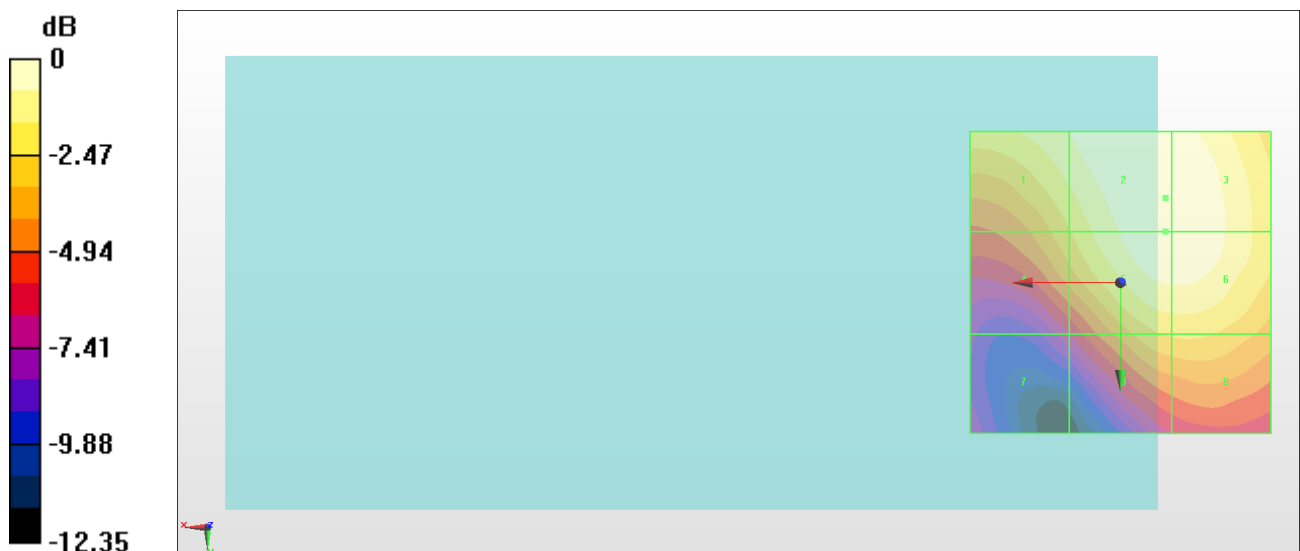
Grid 1 M3 30.14 dBV/m	Grid 2 M3 30.94 dBV/m	Grid 3 M3 30.92 dBV/m
Grid 4 M4 28.41 dBV/m	Grid 5 M3 30.86 dBV/m	Grid 6 M3 30.85 dBV/m
Grid 7 M4 24.32 dBV/m	Grid 8 M4 28.59 dBV/m	Grid 9 M4 28.66 dBV/m

Cursor:

Total = 30.94 dBV/m

E Category: M3

Location: -7.5, -14, 8.7 mm



#07_HAC_E_GSM1900_GSM Voice_Ch810

Communication System: GSM-FDD (TDMA, GMSK); Frequency: 1909.8 MHz; Duty Cycle: 1:8.6896

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 17.00 V/m; Power Drift = -0.12 dB

Applied MIF = 3.63 dB

RF audio interference level = 29.84 dBV/m

Emission category: M4

MIF scaled E-field

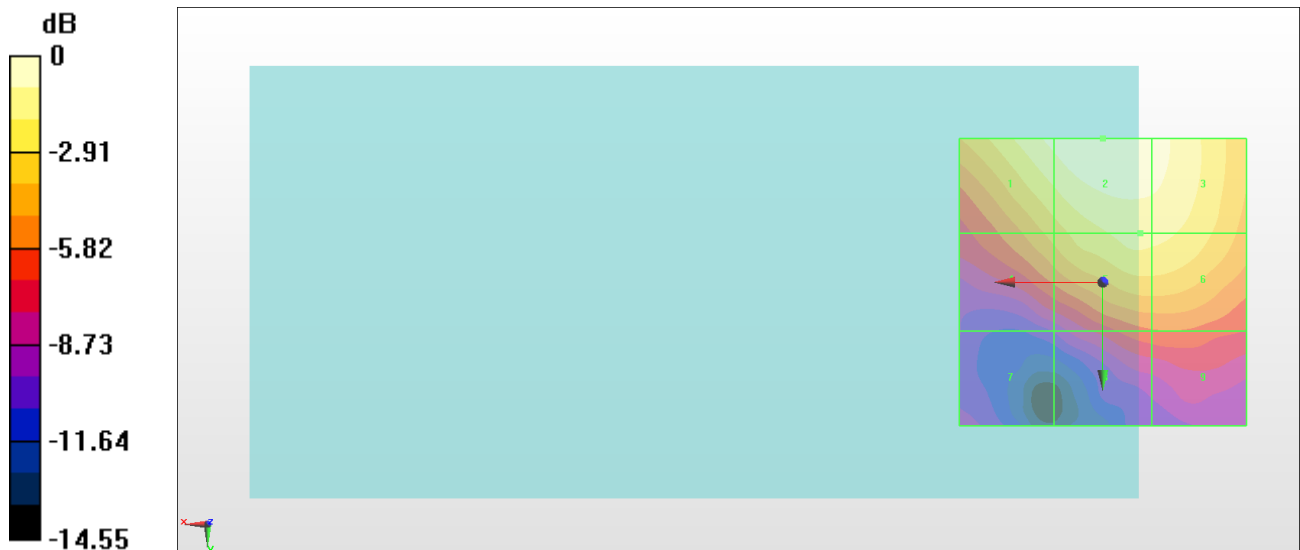
Grid 1 M4 29.19 dBV/m	Grid 2 M4 29.84 dBV/m	Grid 3 M4 29.3 dBV/m
Grid 4 M4 26.39 dBV/m	Grid 5 M4 28.24 dBV/m	Grid 6 M4 28.19 dBV/m
Grid 7 M4 20.78 dBV/m	Grid 8 M4 23.91 dBV/m	Grid 9 M4 24.02 dBV/m

Cursor:

Total = 29.84 dBV/m

E Category: M4

Location: 0, -25, 8.7 mm



#08_HAC_E_LTE Band 38_20M_QPSK_1_0_Ch37850

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2580 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 26.77 V/m; Power Drift = -0.06 dB

Applied MIF = -1.62 dB

RF audio interference level = 29.34 dBV/m

Emission category: M4

MIF scaled E-field

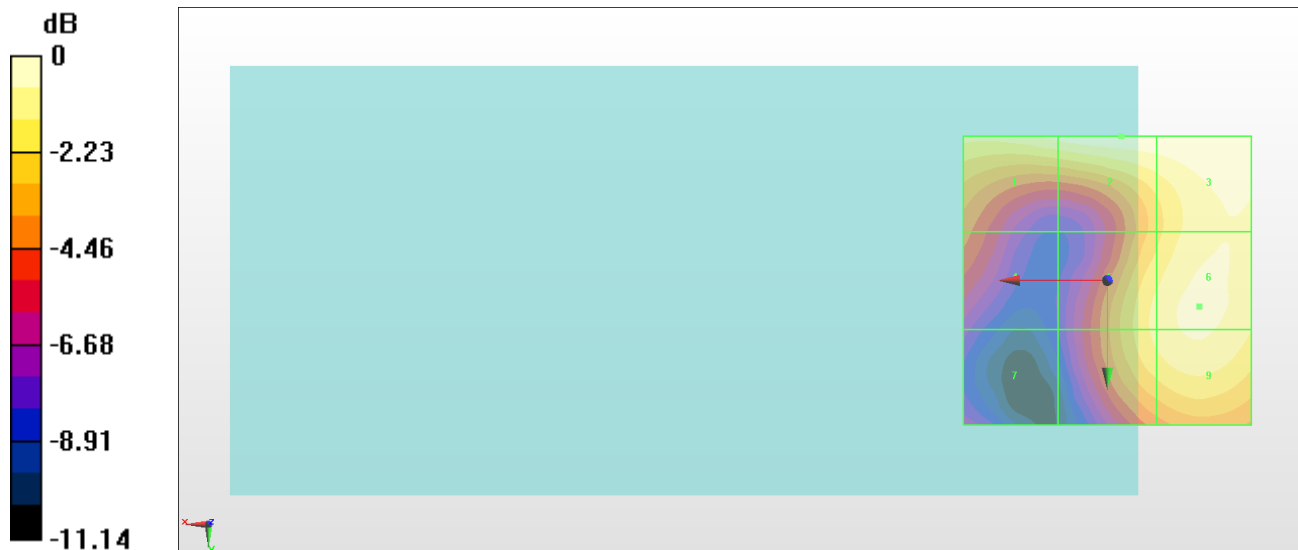
Grid 1 M4 28.91 dBV/m	Grid 2 M4 29.34 dBV/m	Grid 3 M4 29.31 dBV/m
Grid 4 M4 25.22 dBV/m	Grid 5 M4 28.09 dBV/m	Grid 6 M4 28.81 dBV/m
Grid 7 M4 22.57 dBV/m	Grid 8 M4 28.07 dBV/m	Grid 9 M4 28.7 dBV/m

Cursor:

Total = 29.34 dBV/m

E Category: M4

Location: -2.5, -25, 8.7 mm



#09_HAC_E_LTE Band 38_20M_QPSK_1_0_Ch38000

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2595 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 24.52 V/m; Power Drift = -0.03 dB

Applied MIF = -1.62 dB

RF audio interference level = 28.68 dBV/m

Emission category: M4

MIF scaled E-field

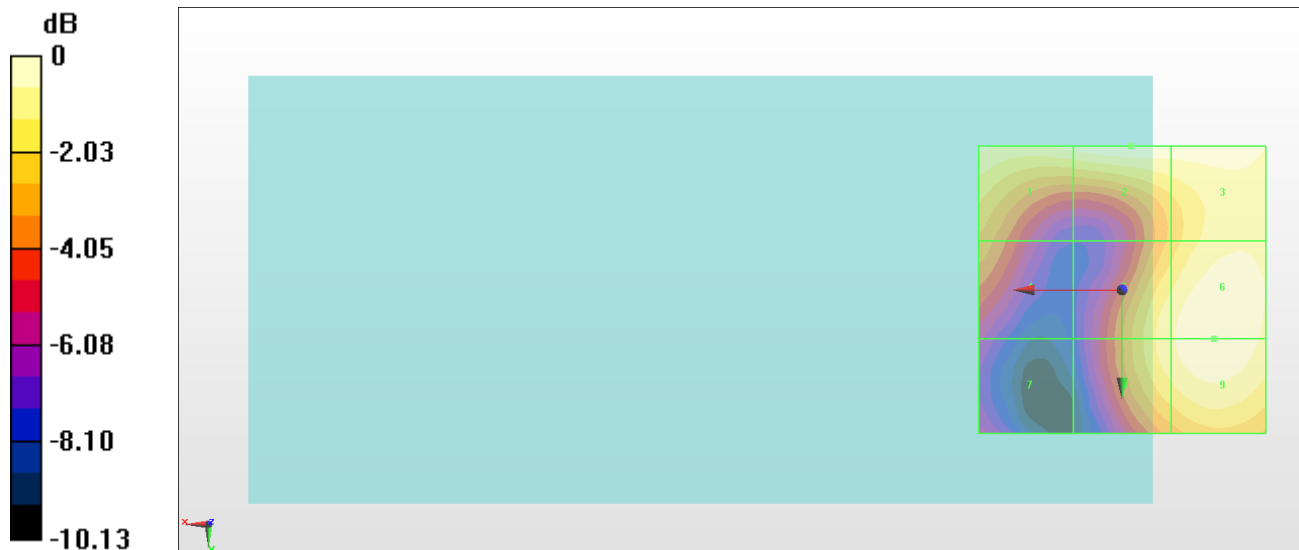
Grid 1 M4 28.3 dBV/m	Grid 2 M4 28.68 dBV/m	Grid 3 M4 28.54 dBV/m
Grid 4 M4 25.87 dBV/m	Grid 5 M4 27.88 dBV/m	Grid 6 M4 28.6 dBV/m
Grid 7 M4 23 dBV/m	Grid 8 M4 27.87 dBV/m	Grid 9 M4 28.58 dBV/m

Cursor:

Total = 28.68 dBV/m

E Category: M4

Location: -1.5, -25, 8.7 mm



#10_HAC_E_LTE Band 38_20M_QPSK_1_0_Ch38150

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2595 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 23.65 V/m; Power Drift = -0.05 dB

Applied MIF = -1.62 dB

RF audio interference level = 29.06 dBV/m

Emission category: M4

MIF scaled E-field

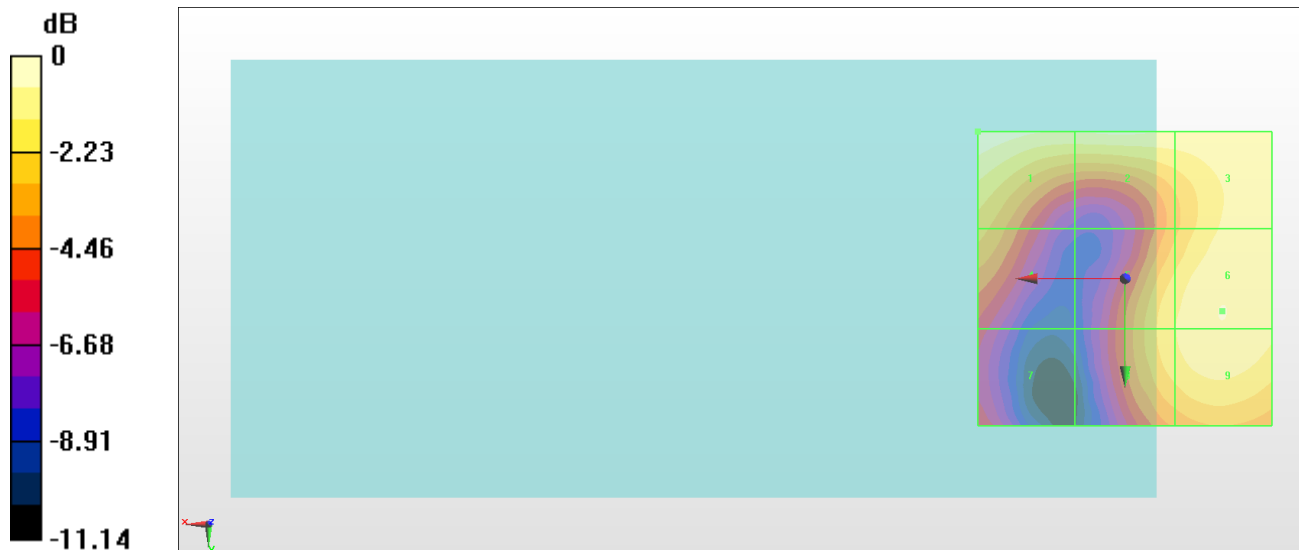
Grid 1 M4 29.06 dBV/m	Grid 2 M4 28.5 dBV/m	Grid 3 M4 28.29 dBV/m
Grid 4 M4 26.4 dBV/m	Grid 5 M4 27.55 dBV/m	Grid 6 M4 28.33 dBV/m
Grid 7 M4 23.84 dBV/m	Grid 8 M4 27.55 dBV/m	Grid 9 M4 28.3 dBV/m

Cursor:

Total = 29.06 dBV/m

E Category: M4

Location: 25, -25, 8.7 mm



#11_HAC_E_LTE Band 41_20M_QPSK_1_0_Ch39750

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2506 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 28.07 V/m; Power Drift = -0.03 dB

Applied MIF = -1.62 dB

RF audio interference level = 29.11 dBV/m

Emission category: M4

MIF scaled E-field

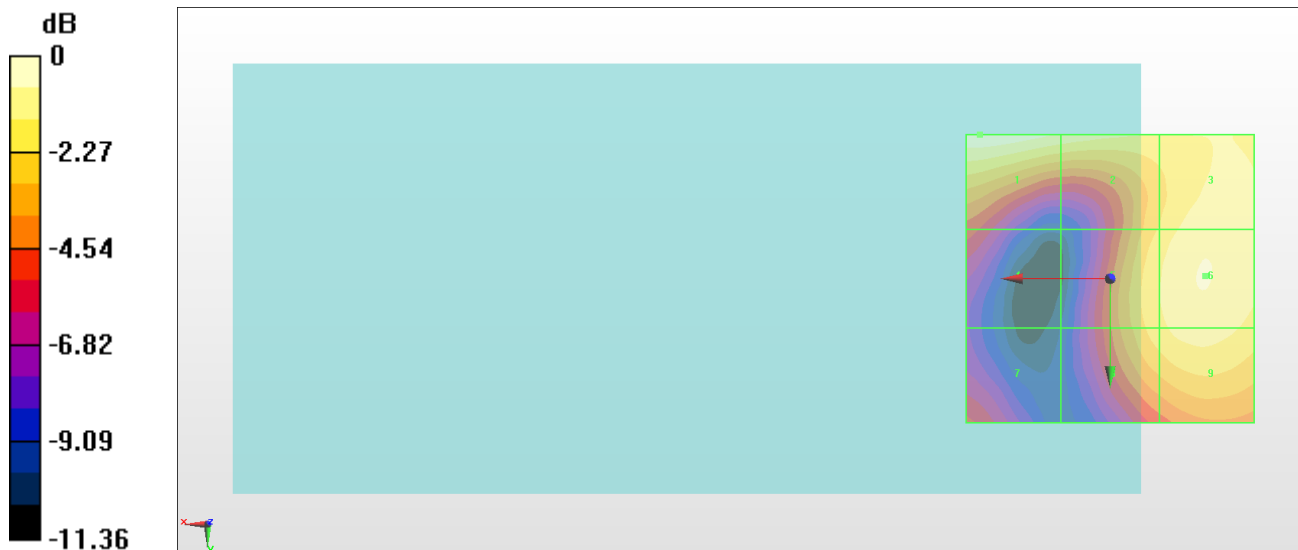
Grid 1 M4 29.11 dBV/m	Grid 2 M4 28.33 dBV/m	Grid 3 M4 28.11 dBV/m
Grid 4 M4 24.25 dBV/m	Grid 5 M4 27.6 dBV/m	Grid 6 M4 28.39 dBV/m
Grid 7 M4 24.08 dBV/m	Grid 8 M4 27.33 dBV/m	Grid 9 M4 27.97 dBV/m

Cursor:

Total = 29.11 dBV/m

E Category: M4

Location: 22.5, -25, 8.7 mm



0 dB = 28.54 V/m = 29.11 dBV/m

#12_HAC_E_LTE Band 41_20M_QPSK_1_0_Ch40185

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2549.5 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 26.74 V/m; Power Drift = -0.01 dB

Applied MIF = -1.62 dB

RF audio interference level = 28.73 dBV/m

Emission category: M4

MIF scaled E-field

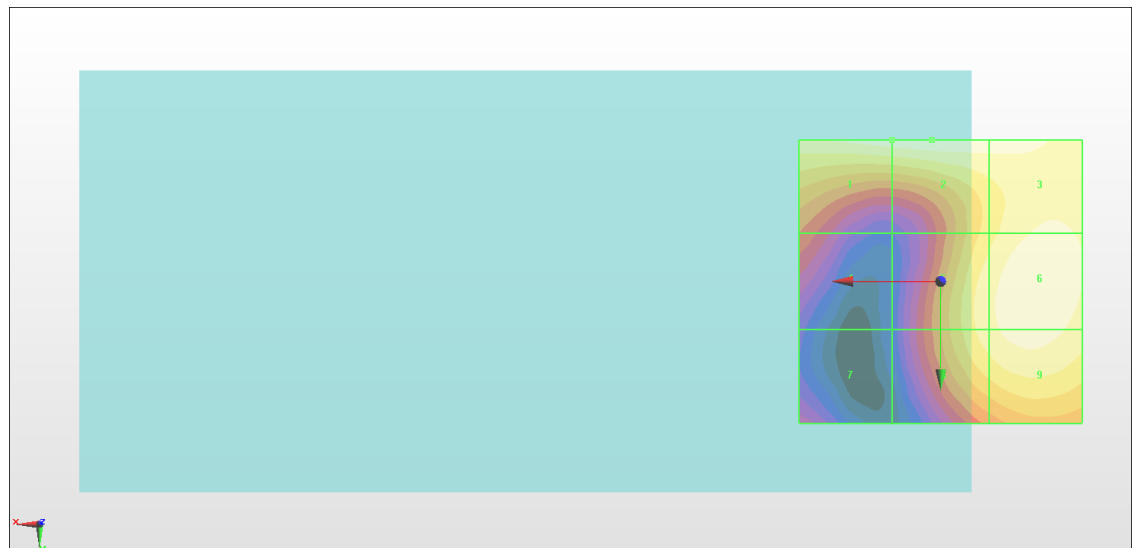
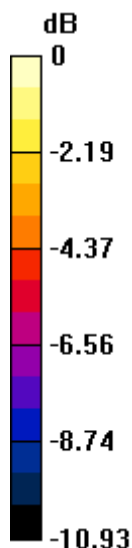
Grid 1 M4 28.52 dBV/m	Grid 2 M4 28.73 dBV/m	Grid 3 M4 28.49 dBV/m
Grid 4 M4 24.37 dBV/m	Grid 5 M4 27.82 dBV/m	Grid 6 M4 28.53 dBV/m
Grid 7 M4 22.74 dBV/m	Grid 8 M4 27.71 dBV/m	Grid 9 M4 28.33 dBV/m

Cursor:

Total = 28.73 dBV/m

E Category: M4

Location: 1.5, -25, 8.7 mm



0 dB = 27.33 V/m = 28.73 dBV/m

#13_HAC_E_LTE Band 41_20M_QPSK_1_0_Ch40620

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2593 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 22.90 V/m; Power Drift = 0.01 dB

Applied MIF = -1.62 dB

RF audio interference level = 27.73 dBV/m

Emission category: M4

MIF scaled E-field

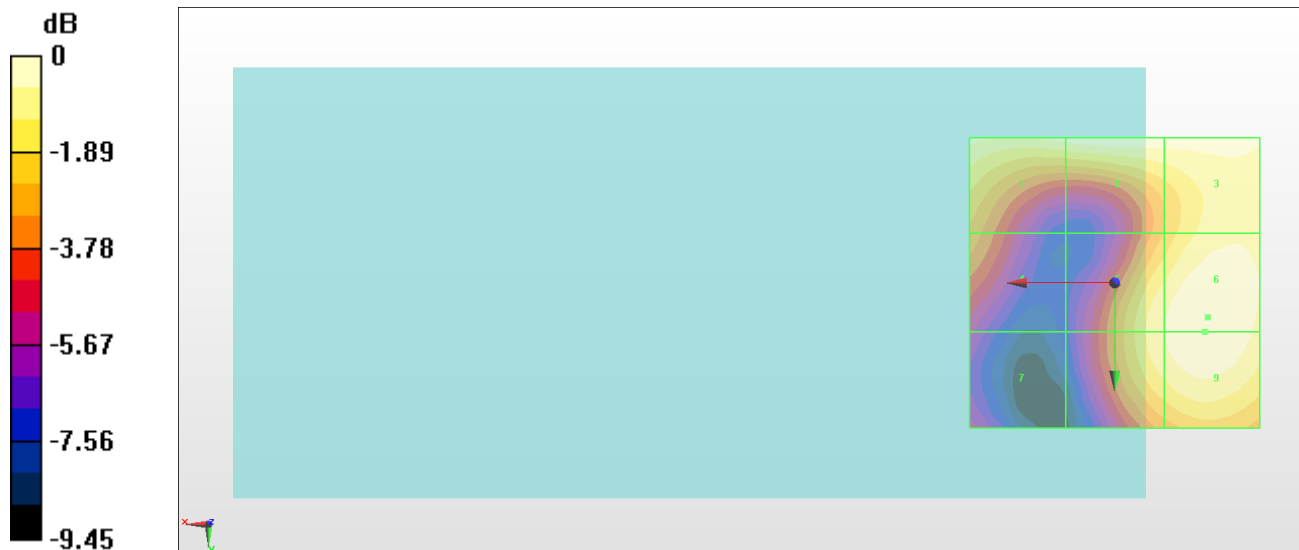
Grid 1 M4 27.38 dBV/m	Grid 2 M4 27.71 dBV/m	Grid 3 M4 27.55 dBV/m
Grid 4 M4 25 dBV/m	Grid 5 M4 27.1 dBV/m	Grid 6 M4 27.73 dBV/m
Grid 7 M4 22.47 dBV/m	Grid 8 M4 27.09 dBV/m	Grid 9 M4 27.7 dBV/m

Cursor:

Total = 27.73 dBV/m

E Category: M4

Location: -16, 6, 8.7 mm



#14_HAC_E_LTE Band 41_20M_QPSK_1_0_Ch41055

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2636.5 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 20.65 V/m; Power Drift = 0.11 dB

Applied MIF = -1.62 dB

RF audio interference level = 28.55 dBV/m

Emission category: M4

MIF scaled E-field

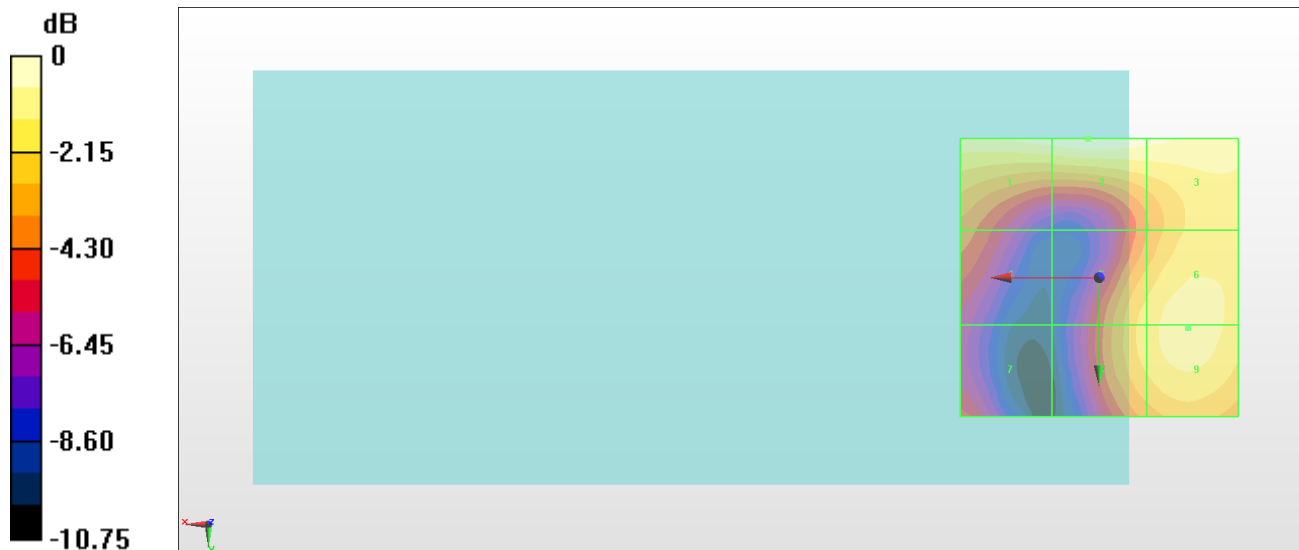
Grid 1 M4 28.32 dBV/m	Grid 2 M4 28.55 dBV/m	Grid 3 M4 28.17 dBV/m
Grid 4 M4 24.73 dBV/m	Grid 5 M4 26.74 dBV/m	Grid 6 M4 27.49 dBV/m
Grid 7 M4 23.95 dBV/m	Grid 8 M4 26.75 dBV/m	Grid 9 M4 27.49 dBV/m

Cursor:

Total = 28.55 dBV/m

E Category: M4

Location: 2, -25, 8.7 mm



#15_HAC_E_LTE Band 41_20M_QPSK_1_0_Ch41490

Communication System: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK); Frequency: 2680 MHz; Duty Cycle: 1:8.33681

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: ER3DV6 - SN2358; ConvF(1, 1, 1); Calibrated: 2018/1/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 16.90 V/m; Power Drift = -0.04 dB

Applied MIF = -1.62 dB

RF audio interference level = 27.95 dBV/m

Emission category: M4

MIF scaled E-field

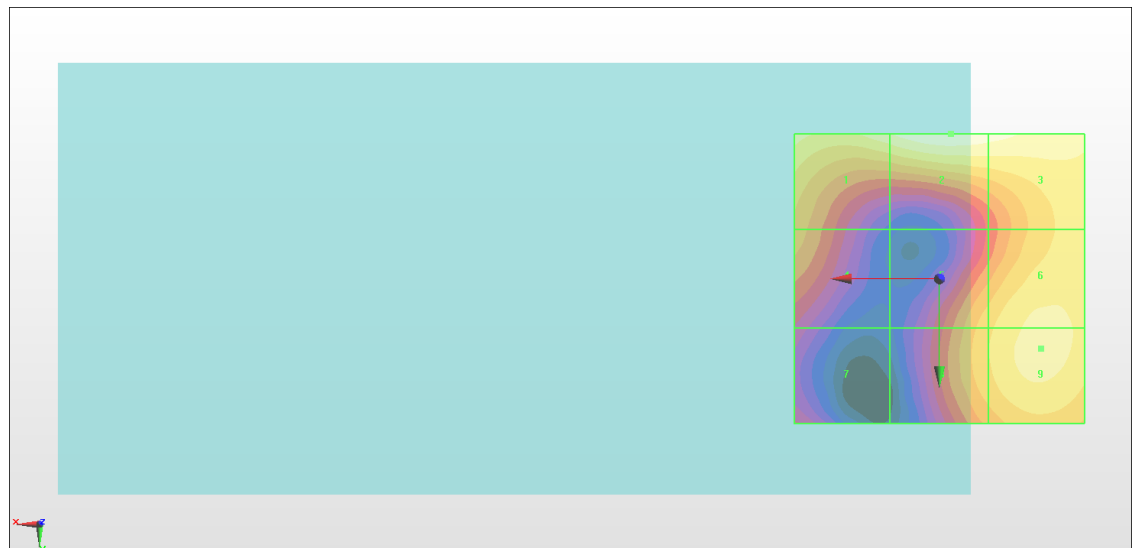
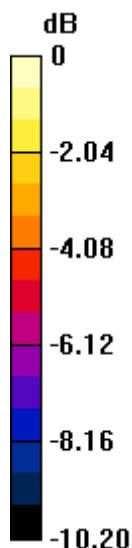
Grid 1 M4 27.24 dBV/m	Grid 2 M4 27.95 dBV/m	Grid 3 M4 27.63 dBV/m
Grid 4 M4 24.98 dBV/m	Grid 5 M4 25.74 dBV/m	Grid 6 M4 26.8 dBV/m
Grid 7 M4 22.8 dBV/m	Grid 8 M4 25.91 dBV/m	Grid 9 M4 26.85 dBV/m

Cursor:

Total = 27.95 dBV/m

E Category: M4

Location: -2, -25, 8.7 mm



0 dB = 24.97 V/m = 27.95 dBV/m

#16_HAC_E_WLAN2.4GHz_802.11b 1Mbps_Ch1

Communication System: IEEE 802.11b; Frequency: 2412 MHz; Duty Cycle: 1:2.29087

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: EF3DV3 - SN4053; ConvF(1, 1, 1); Calibrated: 2018/3/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 34.46 V/m; Power Drift = -0.04 dB

Applied MIF = -2.02 dB

RF audio interference level = 26.82 dBV/m

Emission category: M4

MIF scaled E-field

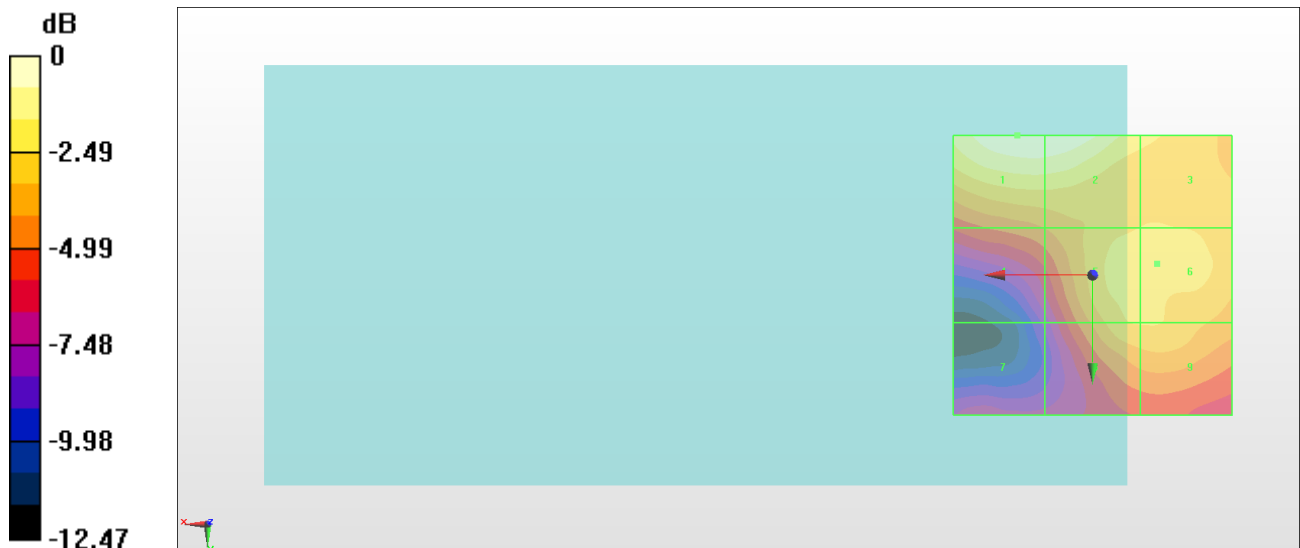
Grid 1 M4 26.82 dBV/m	Grid 2 M4 26.81 dBV/m	Grid 3 M4 24.78 dBV/m
Grid 4 M4 22.72 dBV/m	Grid 5 M4 25.04 dBV/m	Grid 6 M4 25.08 dBV/m
Grid 7 M4 20.06 dBV/m	Grid 8 M4 24.4 dBV/m	Grid 9 M4 24.41 dBV/m

Cursor:

Total = 26.82 dBV/m

E Category: M4

Location: 13.5, -25, 8.7 mm



0 dB = 21.93 V/m = 26.82 dBV/m

#17_HAC_E_WLAN2.4GHz_802.11b 1Mbps_Ch6

Communication System: 802.11b; Frequency: 2437 MHz; Duty Cycle: 1:2.29087

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: EF3DV3 - SN4053; ConvF(1, 1, 1); Calibrated: 2018/3/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 41.09 V/m; Power Drift = 0.11 dB

Applied MIF = -2.02 dB

RF audio interference level = 29.05 dBV/m

Emission category: M4

MIF scaled E-field

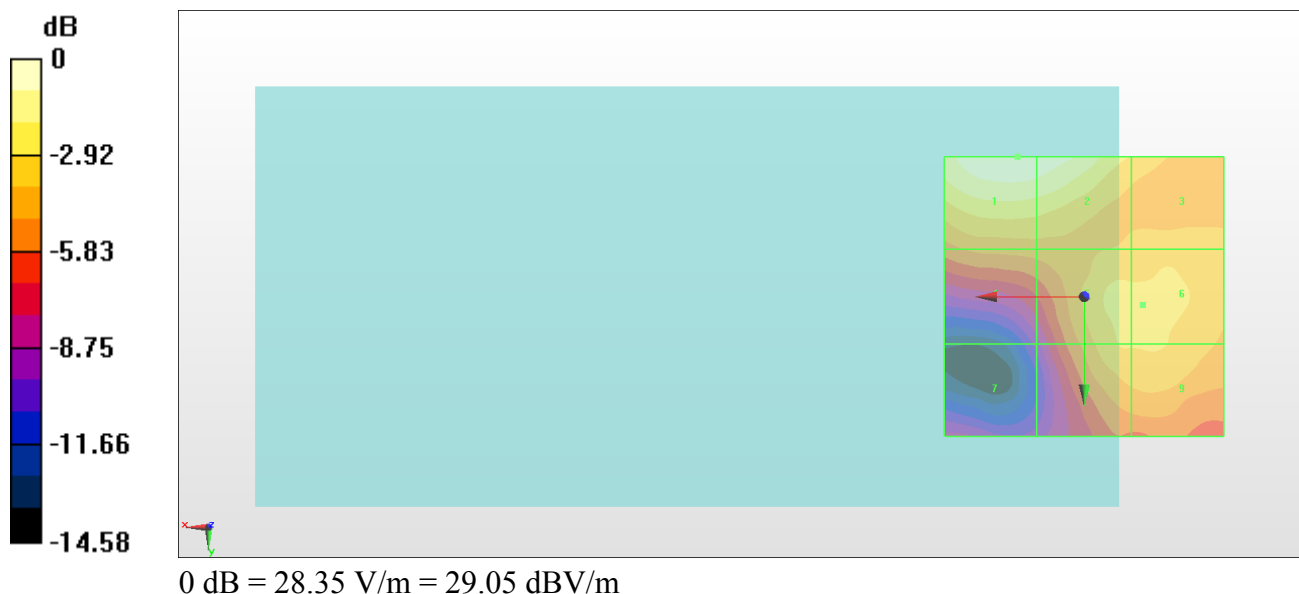
Grid 1 M4 29.05 dBV/m	Grid 2 M4 28.88 dBV/m	Grid 3 M4 26.11 dBV/m
Grid 4 M4 24.69 dBV/m	Grid 5 M4 26.7 dBV/m	Grid 6 M4 26.75 dBV/m
Grid 7 M4 20.76 dBV/m	Grid 8 M4 26.23 dBV/m	Grid 9 M4 26.28 dBV/m

Cursor:

Total = 29.05 dBV/m

E Category: M4

Location: 12, -25, 8.7 mm



#18_HAC_E_WLAN2.4GHz_802.11b 1Mbps_Ch11

Communication System: 802.11b; Frequency: 2462 MHz; Duty Cycle: 1:2.29087

Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³

Ambient Temperature : 23.6 °C

DASY5 Configuration:

- Probe: EF3DV3 - SN4053; ConvF(1, 1, 1); Calibrated: 2018/3/19;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

E Scan - ER3D: 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 = 37.22 V/m; Power Drift = 0.02 dB

Applied MIF = -2.02 dB

RF audio interference level = 28.31 dBV/m

Emission category: M4

MIF scaled E-field

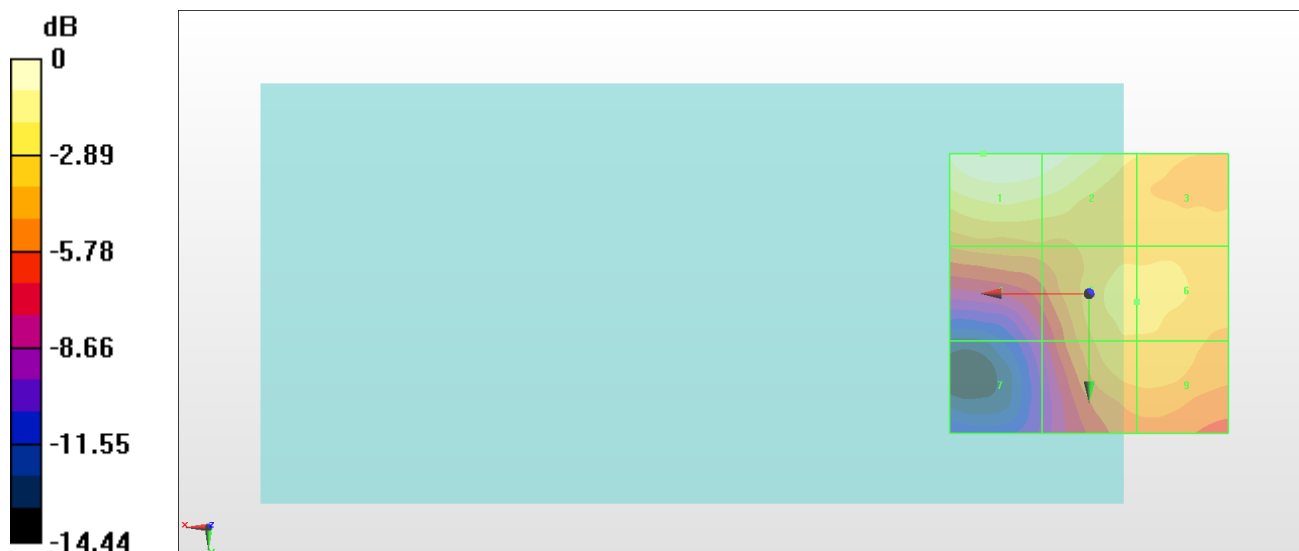
Grid 1 M4 28.31 dBV/m	Grid 2 M4 28.07 dBV/m	Grid 3 M4 25.54 dBV/m
Grid 4 M4 24.24 dBV/m	Grid 5 M4 25.98 dBV/m	Grid 6 M4 25.98 dBV/m
Grid 7 M4 20.06 dBV/m	Grid 8 M4 25.36 dBV/m	Grid 9 M4 25.22 dBV/m

Cursor:

Total = 28.31 dBV/m

E Category: M4

Location: 19, -25, 8.7 mm



0 dB = 26.02 V/m = 28.31 dBV/m



Appendix C. DASY Calibration Certificate

The DASY calibration certificates are shown as follows.



Accredited by the Swiss Accreditation Service (SAS)
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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Sporton (Auden)**

Certificate No: **CD835V3-1045_Sep17**

CALIBRATION CERTIFICATE

Object **CD835V3 - SN: 1045**

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

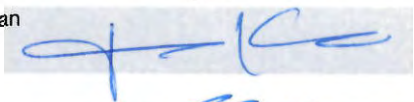
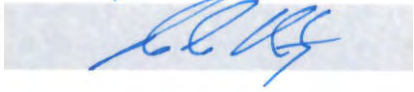
Calibration date: **September 27, 2017**

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 ER3DV6	SN: 2336	30-Dec-16 (No. ER3-2336_Dec16)	Dec-17
Probe H3DV6	SN: 6065	30-Dec-16 (No. H3-6065_Dec16)	Dec-17
DAE4	SN: 781	13-Jul-17 (No. DAE4-781_Jul17)	Jul-18
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-16)	In house check: Oct-17

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

Issued: September 28, 2017

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



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-C63.19-2011
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%.

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 $\pm$ 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	107.9 V/m = 40.66 dBV/m
Maximum measured above low end	100 mW input power	105.8 V/m = 40.49 dBV/m
Averaged maximum above arm	100 mW input power	106.8 V/m $\pm$ 12.8 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

Frequency	Return Loss	Impedance
800 MHz	16.5 dB	41.7 Ω - 11.1 j Ω
835 MHz	32.7 dB	49.0 Ω + 2.0 j Ω
900 MHz	18.8 dB	48.2 Ω - 11.2 j Ω
950 MHz	17.6 dB	53.4 Ω + 13.3 j Ω
960 MHz	12.8 dB	66.8 Ω + 21.4 j Ω

3.2 Antenna Design and Handling

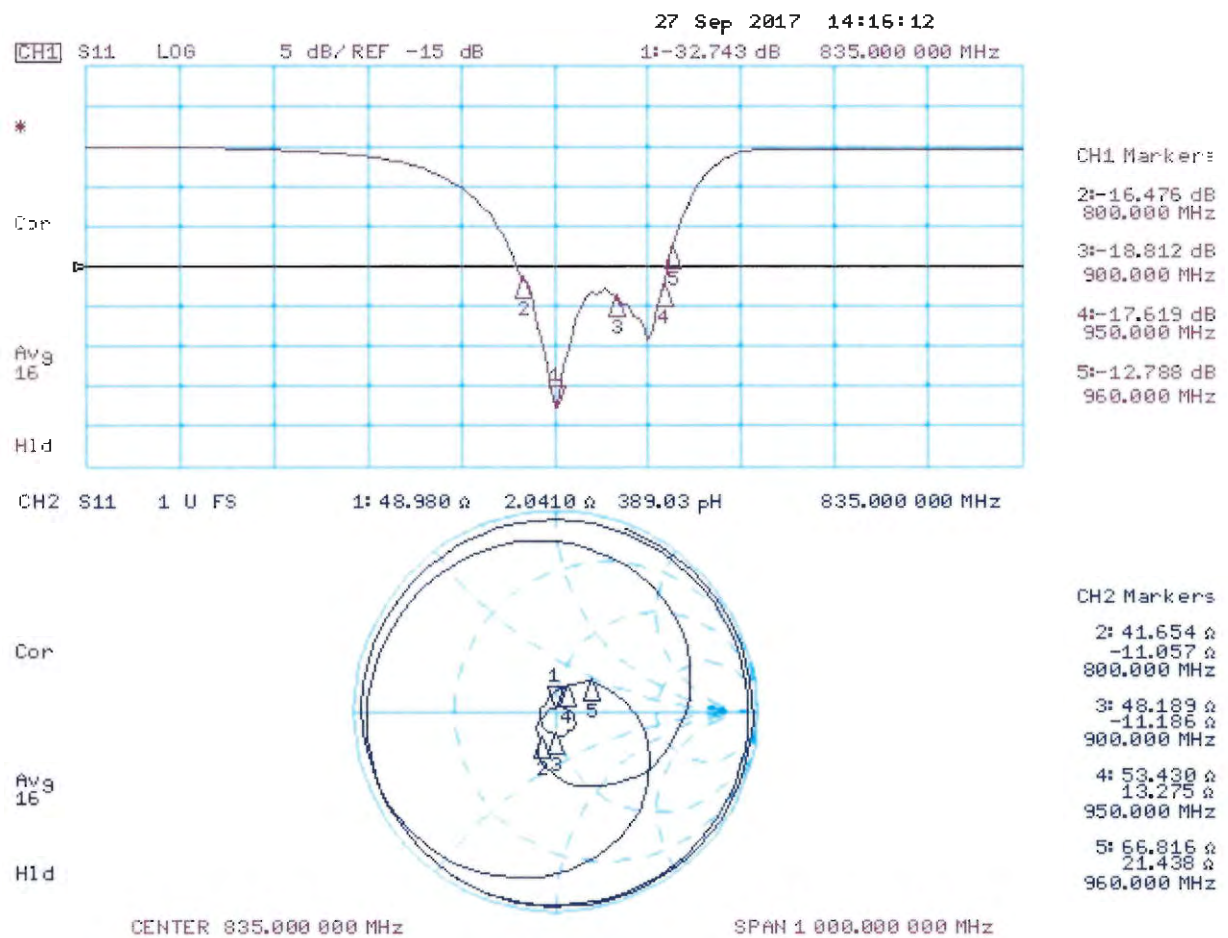
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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.

Impedance Measurement Plot



DASY5 E-field Result

Date: 27.09.2017

Test Laboratory: SPEAG Lab2

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: CD835V3 - SN: 1045

Communication System: UID 0 - CW ; Frequency: 835 MHz

Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 1000$ kg/m³

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 30.12.2016;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 13.07.2017
- 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 = 109.3 V/m; Power Drift = 0.00 dB

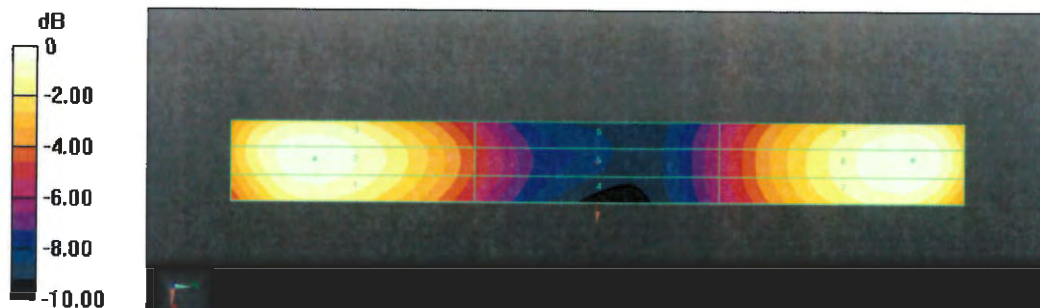
Applied MIF = 0.00 dB

RF audio interference level = 40.66 dBV/m

Emission category: M3

MIF scaled E-field

Grid 1 M3	Grid 2 M3	Grid 3 M3
40.28 dBV/m	40.49 dBV/m	40.42 dBV/m
Grid 4 M4	Grid 5 M4	Grid 6 M4
35.86 dBV/m	36.03 dBV/m	35.91 dBV/m
Grid 7 M3	Grid 8 M3	Grid 9 M3
40.48 dBV/m	40.66 dBV/m	40.59 dBV/m



0 dB = 107.9 V/m = 40.66 dBV/m



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

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Multilateral Agreement for the recognition of calibration certificates

Client **Sporton (Auden)**

Certificate No: **CD1880V3-1038_Sep17**

CALIBRATION CERTIFICATE

Object **CD1880V3 - SN: 1038**

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

Calibration date: **September 27, 2017**

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 ER3DV6	SN: 2336	30-Dec-16 (No. ER3-2336_Dec16)	Dec-17
Probe H3DV6	SN: 6065	30-Dec-16 (No. H3-6065_Dec16)	Dec-17
DAE4	SN: 781	13-Jul-17 (No. DAE4-781_Jul17)	Jul-18
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-16)	In house check: Oct-17

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

Issued: September 28, 2017

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



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-C63.19-2011
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 eliminated 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%.

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	1730 MHz $\pm$ 1 MHz 1880 MHz $\pm$ 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 1730 MHz

E-field 15 mm above dipole surface	condition	Interpolated maximum
Maximum measured above high end	100 mW input power	96.3 V/m = 39.67 dBV/m
Maximum measured above low end	100 mW input power	95.6 V/m = 39.61 dBV/m
Averaged maximum above arm	100 mW input power	96.0 V/m $\pm$ 12.8 % (k=2)

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	91.8 V/m = 39.26 dBV/m
Maximum measured above low end	100 mW input power	88.2 V/m = 38.91 dBV/m
Averaged maximum above arm	100 mW input power	90.0 V/m $\pm$ 12.8 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

Nominal Frequencies

Frequency	Return Loss	Impedance
1730 MHz	21.9 dB	$56.0 \Omega + 6.1 j\Omega$
1880 MHz	22.0 dB	$58.2 \Omega + 2.5 j\Omega$
1900 MHz	22.2 dB	$58.4 \Omega - 0.4 j\Omega$
1950 MHz	26.9 dB	$50.8 \Omega - 4.5 j\Omega$
2000 MHz	20.5 dB	$43.5 \Omega + 6.0 j\Omega$

3.2 Antenna Design and Handling

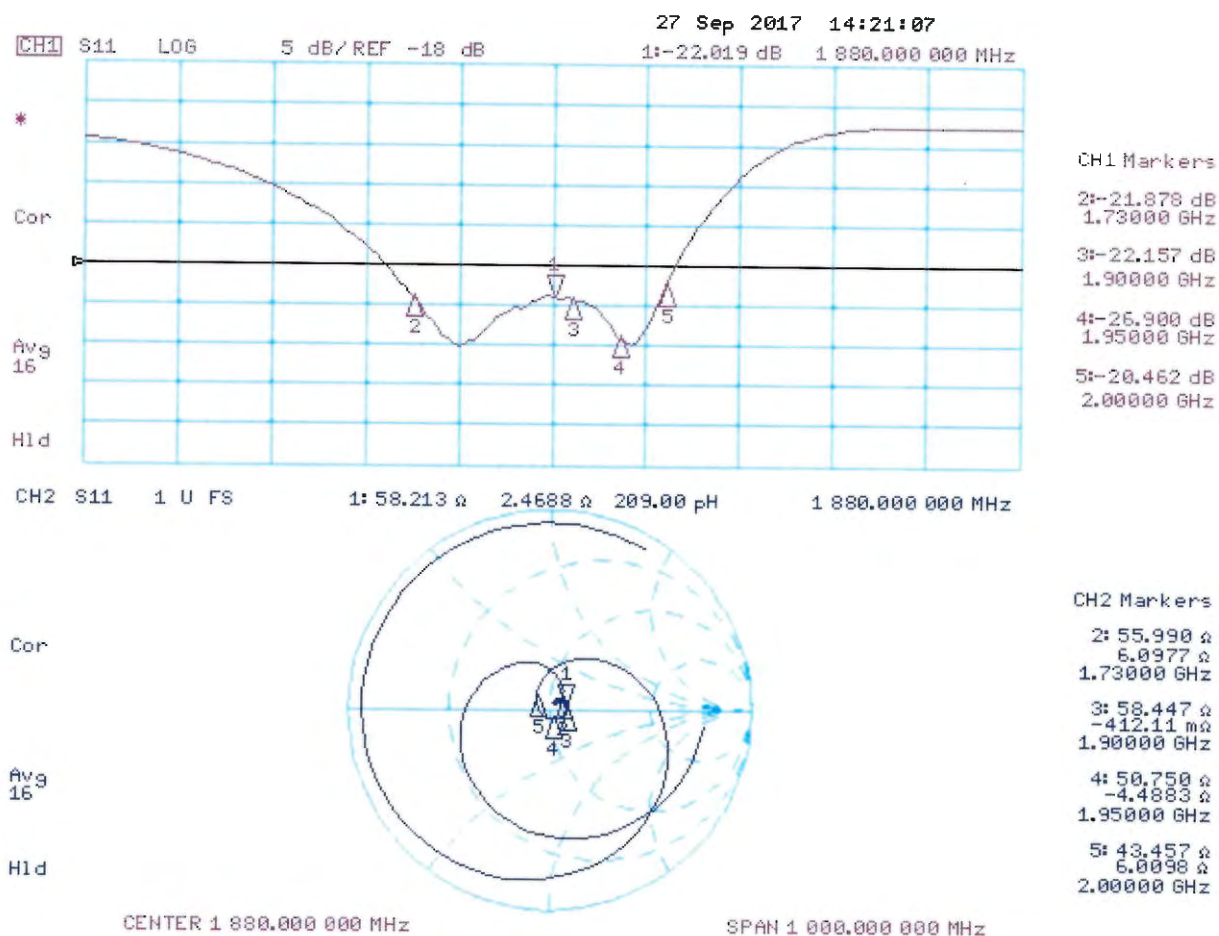
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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.

Impedance Measurement Plot



DASY5 E-field Result

Date: 27.09.2017

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: CD1880V3 - SN: 1038

Communication System: UID 0 - CW ; Frequency: 1880 MHz

Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 1000$ kg/m³

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 30.12.2016;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 13.07.2017
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Reference 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 = 158.0 V/m; Power Drift = 0.00 dB

Applied MIF = 0.00 dB

RF audio interference level = 39.26 dBV/m

Emission category: M2

MIF scaled E-field

Grid 1 M2 39.02 dBV/m	Grid 2 M2 39.26 dBV/m	Grid 3 M2 39.18 dBV/m
Grid 4 M2 36.98 dBV/m	Grid 5 M2 37.13 dBV/m	Grid 6 M2 37.02 dBV/m
Grid 7 M2 38.73 dBV/m	Grid 8 M2 38.91 dBV/m	Grid 9 M2 38.90 dBV/m

Dipole E-Field measurement @ 1880MHz/E-Scan - 1730MHz 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 = 170.3 V/m; Power Drift = 0.01 dB

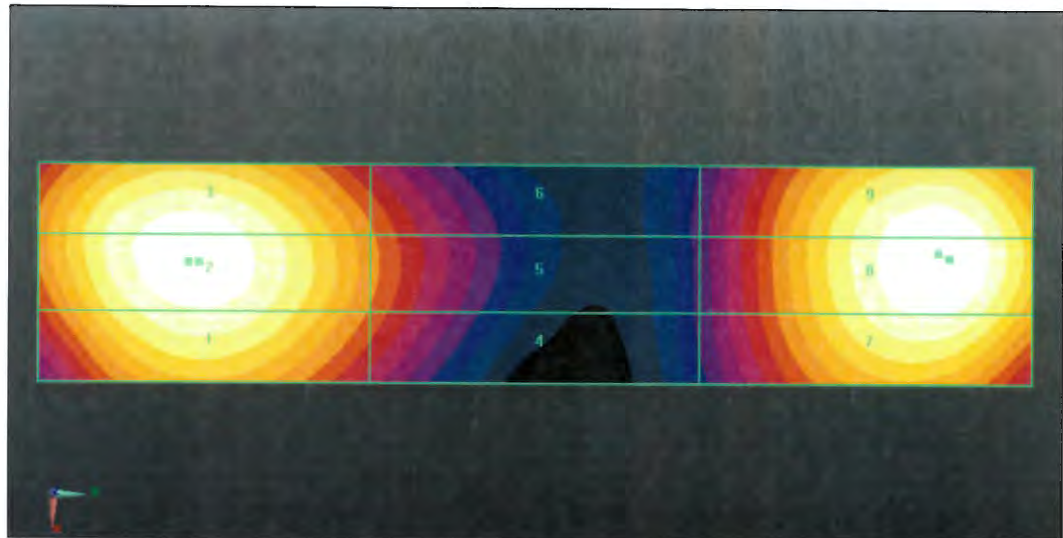
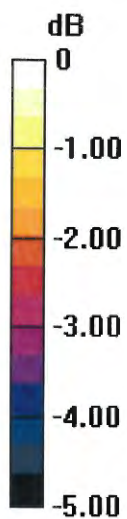
Applied MIF = 0.00 dB

RF audio interference level = 39.67 dBV/m

Emission category: M2

MIF scaled E-field

Grid 1 M2	Grid 2 M2	Grid 3 M2
39.45 dBV/m	39.67 dBV/m	39.58 dBV/m
Grid 4 M2	Grid 5 M2	Grid 6 M2
37.65 dBV/m	37.83 dBV/m	37.72 dBV/m
Grid 7 M2	Grid 8 M2	Grid 9 M2
39.3 dBV/m	39.61 dBV/m	39.58 dBV/m



0 dB = 91.84 V/m = 39.26 dBV/m



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 **Sporton (Auden)**

Certificate No: **CD2450V3-1186_Jan18**

CALIBRATION CERTIFICATE

Object **CD2450V3 - SN: 1186**

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

Calibration date: **January 09, 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	14-Jun-17 (No. EF3-4013_Jun17)	Jun-18
DAE4	SN: 781	13-Jul-17 (No. DAE4-781_Jul17)	Jul-18

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

Calibrated by: **Leif Klysner** **Leif Klysner** **Leif Klysner**
 Name Function Signature
 Laboratory Technician

Approved by: **Katja Pokovic** **Katja Pokovic** **Katja Pokovic**
 Name Function Signature
 Technical Manager

Issued: January 10, 2018

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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%.

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	2450 MHz $\pm$ 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 2450 MHz

E-field 15 mm above dipole surface	condition	Interpolated maximum
Maximum measured above high end	100 mW input power	87.8 V/m = 38.86 dBV/m
Maximum measured above low end	100 mW input power	86.8 V/m = 38.77 dBV/m
Averaged maximum above arm	100 mW input power	87.3 V/m $\pm$ 12.8 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

Frequency	Return Loss	Impedance
2250 MHz	16.3 dB	65.7 Ω + 8.2 j Ω
2350 MHz	26.1 dB	54.2 Ω - 3.0 j Ω
2450 MHz	31.6 dB	52.4 Ω - 1.3 j Ω
2550 MHz	39.2 dB	50.9 Ω + 0.7 j Ω
2650 MHz	16.6 dB	67.1 Ω - 3.0 j Ω

3.2 Antenna Design and Handling

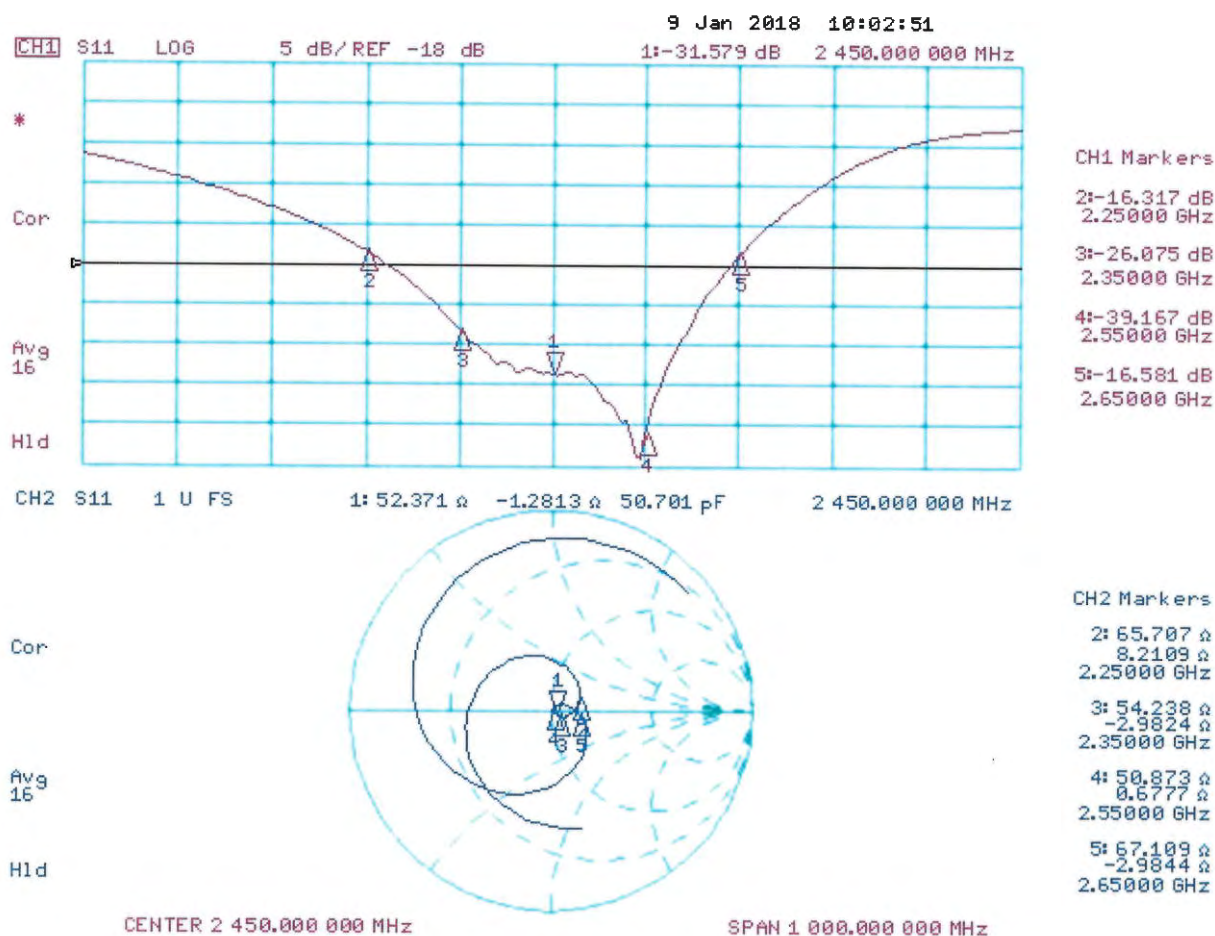
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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.

Impedance Measurement Plot



DASY5 E-field Result

Date: 09.01.2018

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 2450 MHz; Type: CD2450V3; Serial: CD2450V3 - SN: 1186

Communication System: UID 0 - CW ; Frequency: 2450 MHz

Medium parameters used: $\sigma = 0 \text{ S/m}$, $\epsilon_r = 1$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1); Calibrated: 14.06.2017;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 13.07.2017
- 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 @ 2450MHz/E-Scan - 2450MHz d=15mm/Hearing Aid Compatibility Test (41x181x1):

Interpolated grid: $dx=0.5000 \text{ mm}$, $dy=0.5000 \text{ mm}$

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 77.23 V/m; Power Drift = -0.02 dB

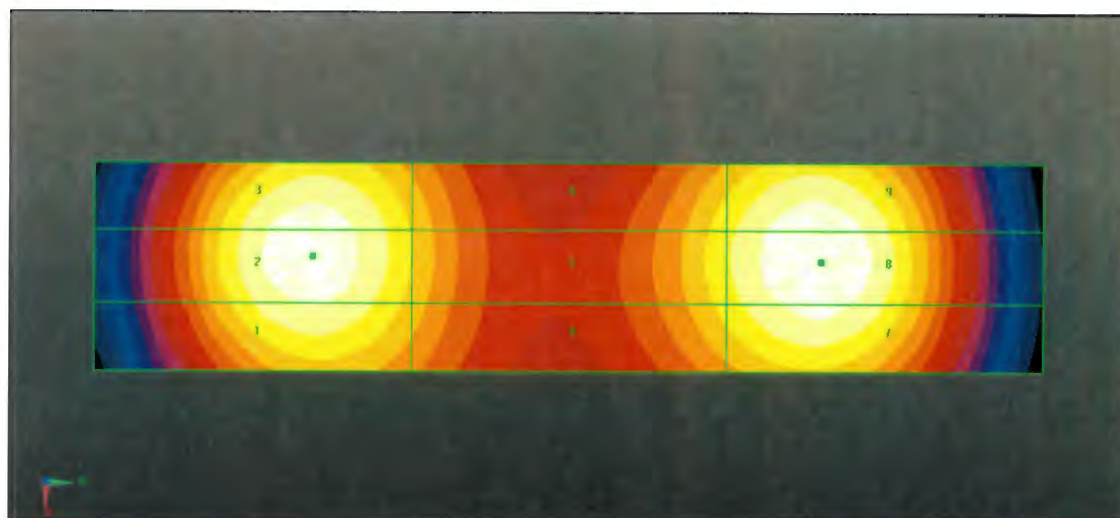
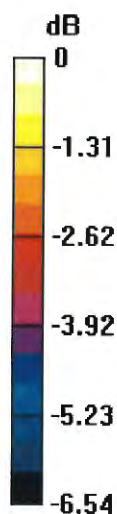
Applied MIF = 0.00 dB

RF audio interference level = 38.86 dBV/m

Emission category: M2

MIF scaled E-field

Grid 1 M2	Grid 2 M2	Grid 3 M2
38.46 dBV/m	38.77 dBV/m	38.7 dBV/m
Grid 4 M2	Grid 5 M2	Grid 6 M2
37.75 dBV/m	37.94 dBV/m	37.87 dBV/m
Grid 7 M2	Grid 8 M2	Grid 9 M2
38.6 dBV/m	38.86 dBV/m	38.76 dBV/m



0 dB = 87.75 V/m = 38.86 dBV/m



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Accreditation No.: **SCS 0108**

Client **Sporton-TW (Auden)**

Certificate No: **CD2600V3-1010_Nov17**

CALIBRATION CERTIFICATE

Object **CD2600V3 - SN: 1010**

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

Calibration date: **November 22, 2017**

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	14-Jun-17 (No. EF3-4013_Jun17)	Jun-18
DAE4	SN: 781	13-Jul-17 (No. DAE4-781_Jul17)	Jul-18

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

Calibrated by: **Leif Klysner** Name: **Leif Klysner** Function: **Laboratory Technician**

Approved by: **Katja Pokovic** Name: **Katja Pokovic** Technical Manager

Signature

Issued: November 23, 2017

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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 eliminated 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%.

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	2600 MHz $\pm$ 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 2600 MHz

E-field 15 mm above dipole surface	condition	Interpolated maximum
Maximum measured above high end	100 mW input power	85.8 V/m = 38.67 dBV/m
Maximum measured above low end	100 mW input power	84.9 V/m = 38.58 dBV/m
Averaged maximum above arm	100 mW input power	85.4 V/m $\pm$ 12.8 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

Frequency	Return Loss	Impedance
2450 MHz	23.6 dB	44.6 Ω - 3.3 j Ω
2550 MHz	29.4 dB	52.0 Ω + 2.8 j Ω
2600 MHz	26.8 dB	54.7 Ω - 0.7 j Ω
2650 MHz	25.3 dB	53.5 Ω - 4.4 j Ω
2750 MHz	19.4 dB	45.4 Ω - 9.2 j Ω

3.2 Antenna Design and Handling

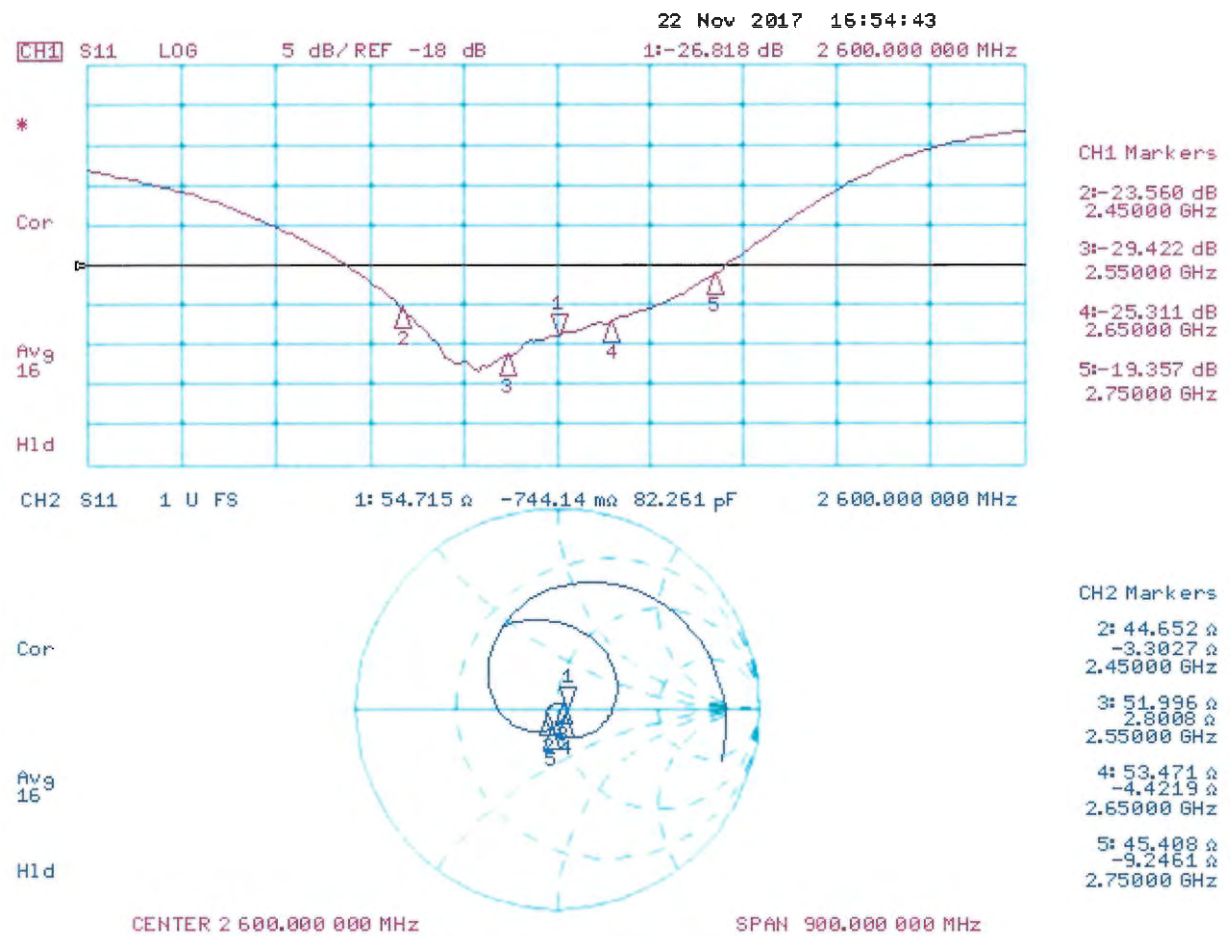
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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.

Impedance Measurement Plot



DASY5 E-field Result

Date: 21.11.2017

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 2600 MHz; Type: CD2600V3; Serial: CD2600V3 - SN: 1010

Communication System: UID 0 - CW ; Frequency: 2600 MHz

Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 1000$ kg/m³

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1); Calibrated: 14.06.2017;
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 13.07.2017
- 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 @ 2600MHz - with EF_4013/E-Scan - 2600MHz 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 = 64.99 V/m; Power Drift = -0.04 dB

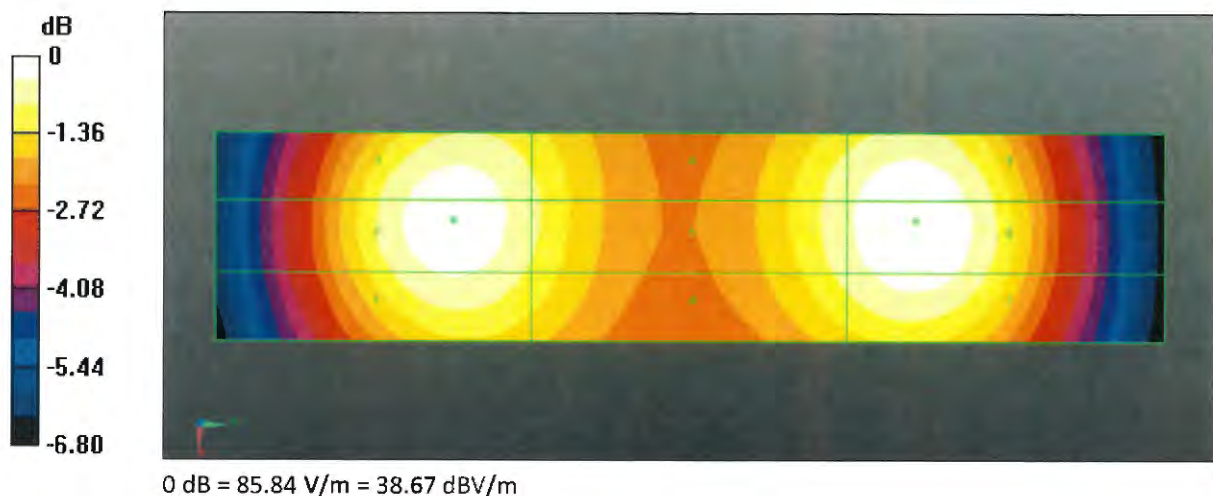
Applied MIF = 0.00 dB

RF audio interference level = 38.67 dBV/m

Emission category: M2

MIF scaled E-field

Grid 1 M2 38.26 dBV/m	Grid 2 M2 38.58 dBV/m	Grid 3 M2 38.53 dBV/m
Grid 4 M2 37.93 dBV/m	Grid 5 M2 38.15 dBV/m	Grid 6 M2 38.12 dBV/m
Grid 7 M2 38.42 dBV/m	Grid 8 M2 38.67 dBV/m	Grid 9 M2 38.61 dBV/m





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Accreditation No.: **SCS 0108**

Client **Auden**

Certificate No: **DAE4-910_Jun18**

CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BK - SN: 910**

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

Calibration date: **June 21, 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 $(22 \pm 3)^{\circ}\text{C}$ 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

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

Issued: June 21, 2018

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Accreditation No.: **SCS 0108**

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.

DC Voltage Measurement

A/D - Converter Resolution nominal

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

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

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

Calibration Factors	X	Y	Z
High Range	403.316 $\pm$ 0.02% (k=2)	402.740 $\pm$ 0.02% (k=2)	403.223 $\pm$ 0.02% (k=2)
Low Range	3.98189 $\pm$ 1.50% (k=2)	3.94034 $\pm$ 1.50% (k=2)	3.94948 $\pm$ 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	270.0 ° $\pm$ 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	200036.85	-0.57	-0.00
Channel X + Input	20007.13	1.21	0.01
Channel X - Input	-20003.15	2.23	-0.01
Channel Y + Input	200035.57	-4.86	-0.00
Channel Y + Input	20005.66	-0.36	-0.00
Channel Y - Input	-20005.78	-0.47	0.00
Channel Z + Input	200031.43	-6.16	-0.00
Channel Z + Input	20004.85	-0.87	-0.00
Channel Z - Input	-20006.04	-0.58	0.00

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2001.67	0.16	0.01
Channel X + Input	201.92	0.42	0.21
Channel X - Input	-198.17	0.31	-0.16
Channel Y + Input	2001.38	-0.14	-0.01
Channel Y + Input	201.49	-0.03	-0.01
Channel Y - Input	-198.91	-0.42	0.21
Channel Z + Input	2002.08	0.66	0.03
Channel Z + Input	199.86	-1.52	-0.75
Channel Z - Input	-200.22	-1.73	0.87

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	-12.45	-14.44
	- 200	16.44	14.50
Channel Y	200	6.37	5.97
	- 200	-7.85	-7.73
Channel Z	200	-11.52	-12.01
	- 200	10.51	10.13

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	-	4.62	-2.89
Channel Y	200	9.63	-	4.93
Channel Z	200	10.63	7.69	-

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	16196	17184
Channel Y	15388	15032
Channel Z	16713	16294

5. Input Offset Measurement

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

Input 10M Ω

	Average (μ V)	min. Offset (μ V)	max. Offset (μ V)	Std. Deviation (μ V)
Channel X	1.84	0.59	3.46	0.62
Channel Y	1.42	0.15	2.77	0.52
Channel Z	-0.96	-2.82	0.61	0.60

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 Sporton (Auden)

Certificate No: ER3-2358_Jan18

CALIBRATION CERTIFICATE

Object ER3DV6 - SN:2358

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: January 19, 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

Calibrated by:	Name Michael Weber	Function Laboratory Technician	Signature
Approved by:	Katja Pokovic	Technical Manager	

Issued: January 24, 2018

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Glossary:

NORM _{x,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., $\vartheta = 0$ 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:

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

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ for XY sensors and $\vartheta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- NORM(f)_{x,y,z}** = NORM_{x,y,z} * frequency_response (see Frequency Response Chart).
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 NORM_x (no uncertainty required).

Probe ER3DV6

SN:2358

Manufactured: July 7, 2005
Calibrated: January 19, 2018

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

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2358

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$)	1.66	1.51	1.54	$\pm 10.1 \%$
DCP (mV) ^B	99.2	100.2	100.5	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	226.7	$\pm 3.3 \%$
		Y	0.0	0.0	1.0		199.5	
		Z	0.0	0.0	1.0		190.1	
10021-DAC	GSM-FDD (TDMA, GMSK)	X	19.82	99.3	27.8	9.39	121.6	$\pm 2.2 \%$
		Y	14.37	93.3	26.1		106.4	
		Z	12.91	89.7	24.8		137.0	
10172-CAD	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	10.00	85.0	32.5	9.21	147.1	$\pm 2.2 \%$
		Y	8.48	79.0	29.0		126.2	
		Z	7.90	75.6	26.6		117.5	
10173-CAD	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	10.28	85.1	32.5	9.48	147.0	$\pm 2.2 \%$
		Y	8.76	79.2	29.0		125.8	
		Z	8.31	76.5	27.1		117.3	
10174-CAD	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 64-QAM)	X	10.72	84.7	33.4	10.25	147.7	$\pm 2.5 \%$
		Y	9.41	79.5	30.2		126.5	
		Z	8.84	76.3	27.8		117.9	
10295-AAB	CDMA2000, RC1, SO3, 1/8th Rate 25 fr.	X	14.87	99.4	41.3	12.49	110.4	$\pm 1.9 \%$
		Y	15.41	99.6	41.0		95.8	
		Z	11.45	87.5	34.5		87.4	

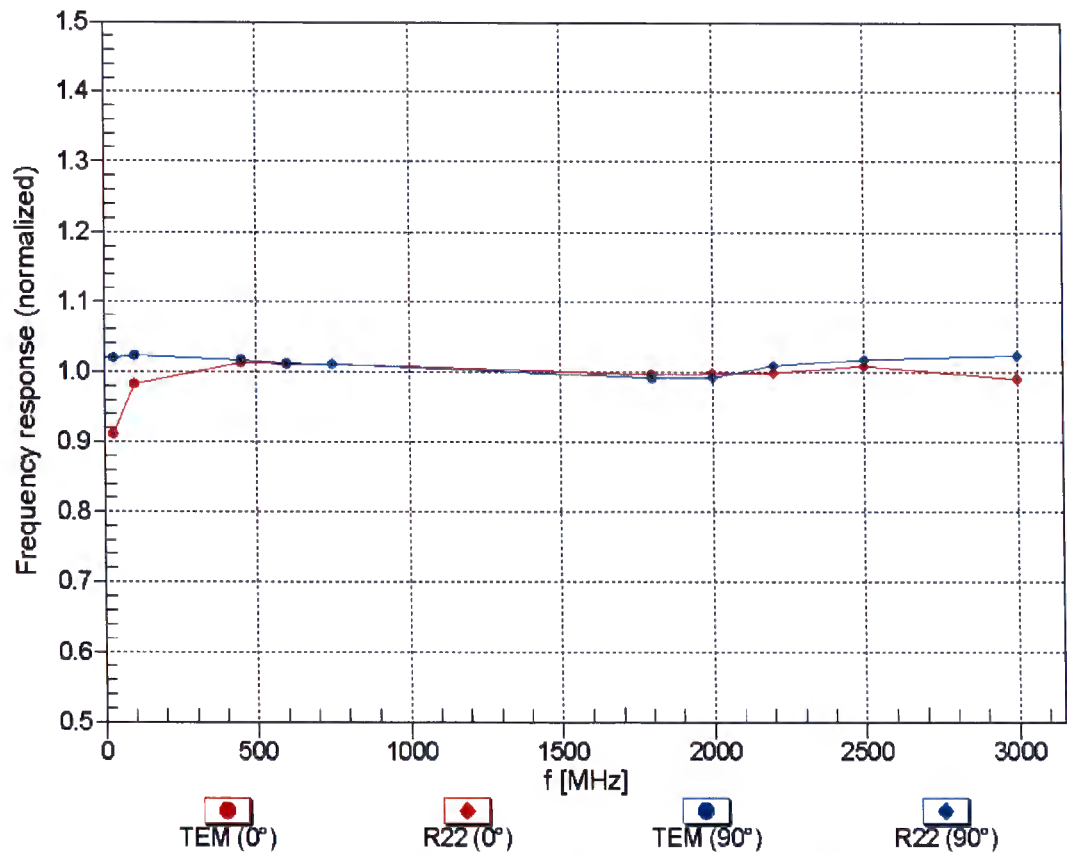
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^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.

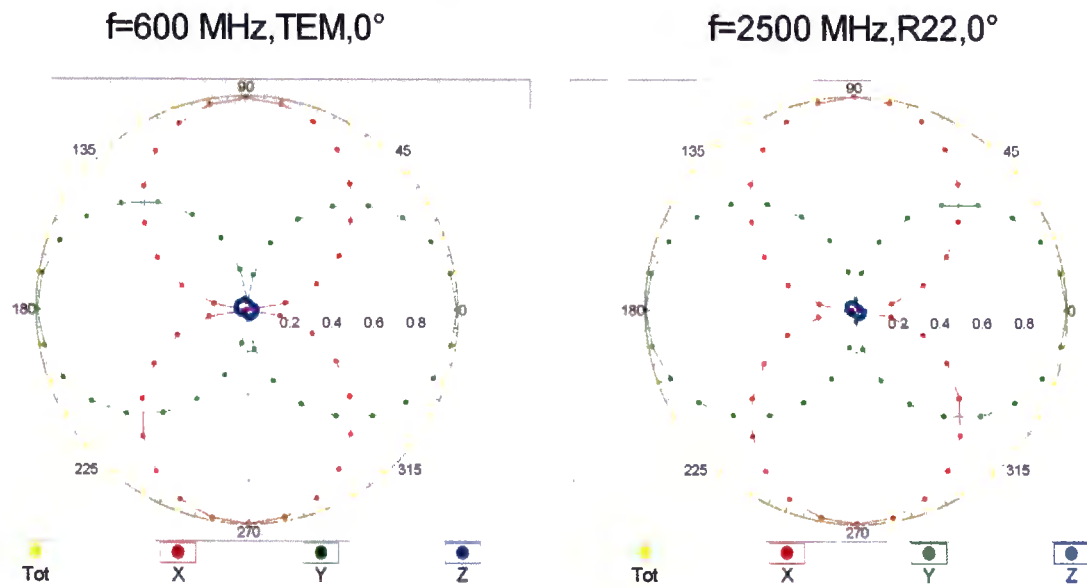
Frequency Response of E-Field

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

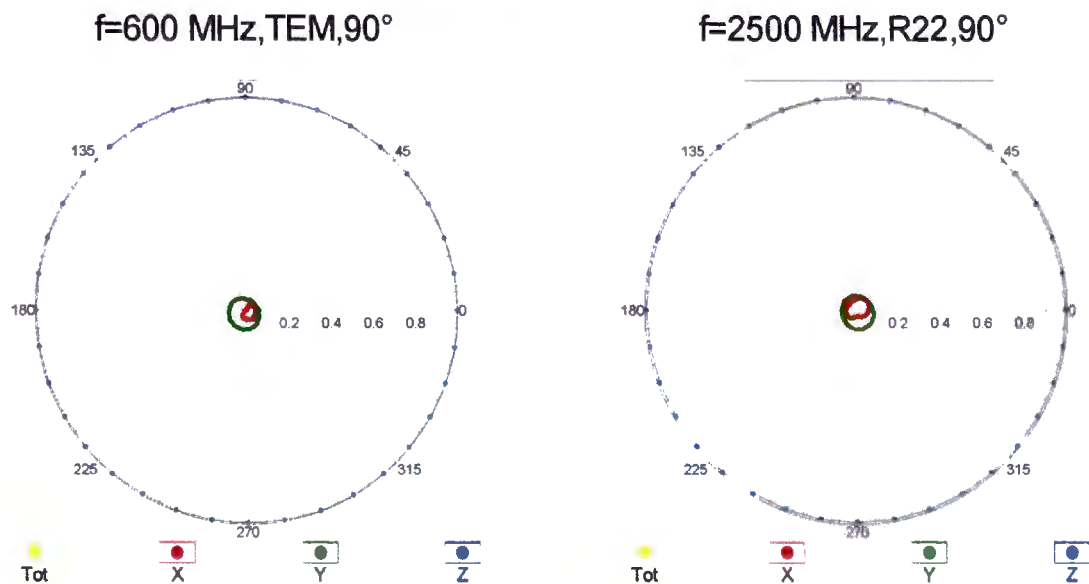


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

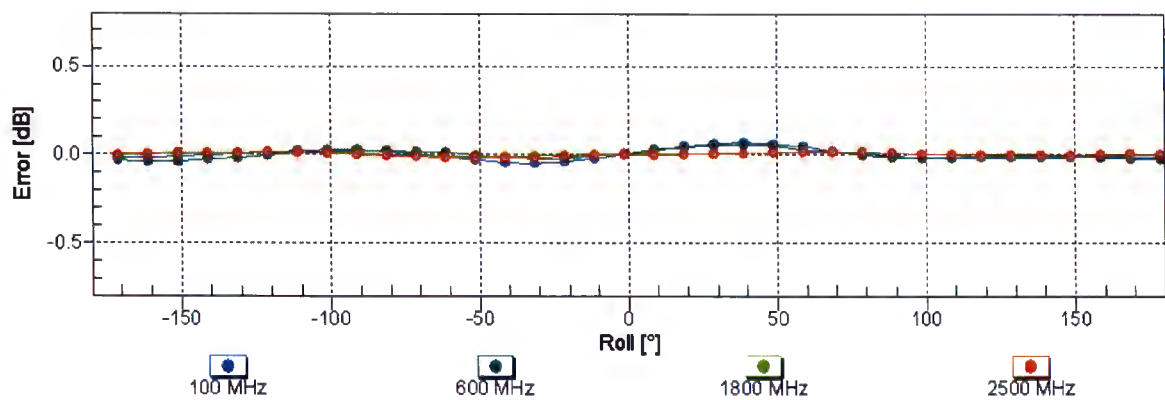
Receiving Pattern (ϕ), $\vartheta = 0^\circ$



Receiving Pattern (ϕ), $\vartheta = 90^\circ$

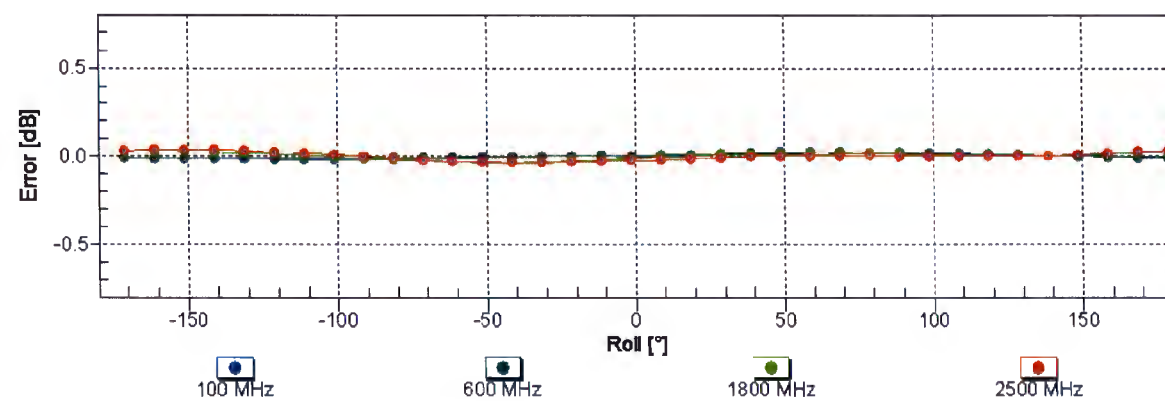


Receiving Pattern (ϕ), $\vartheta = 0^\circ$



Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

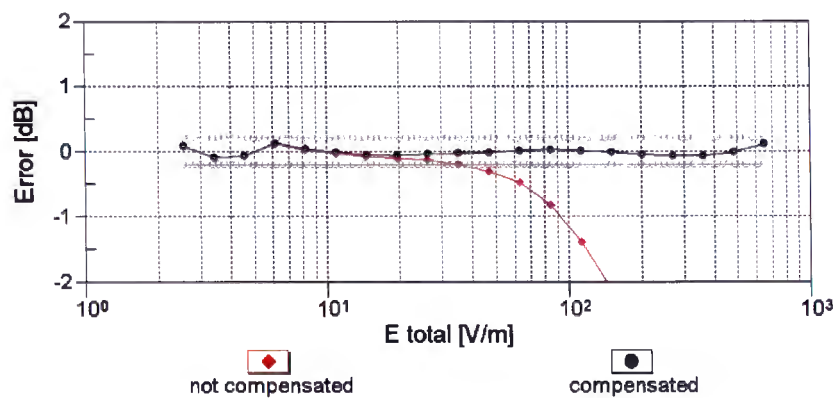
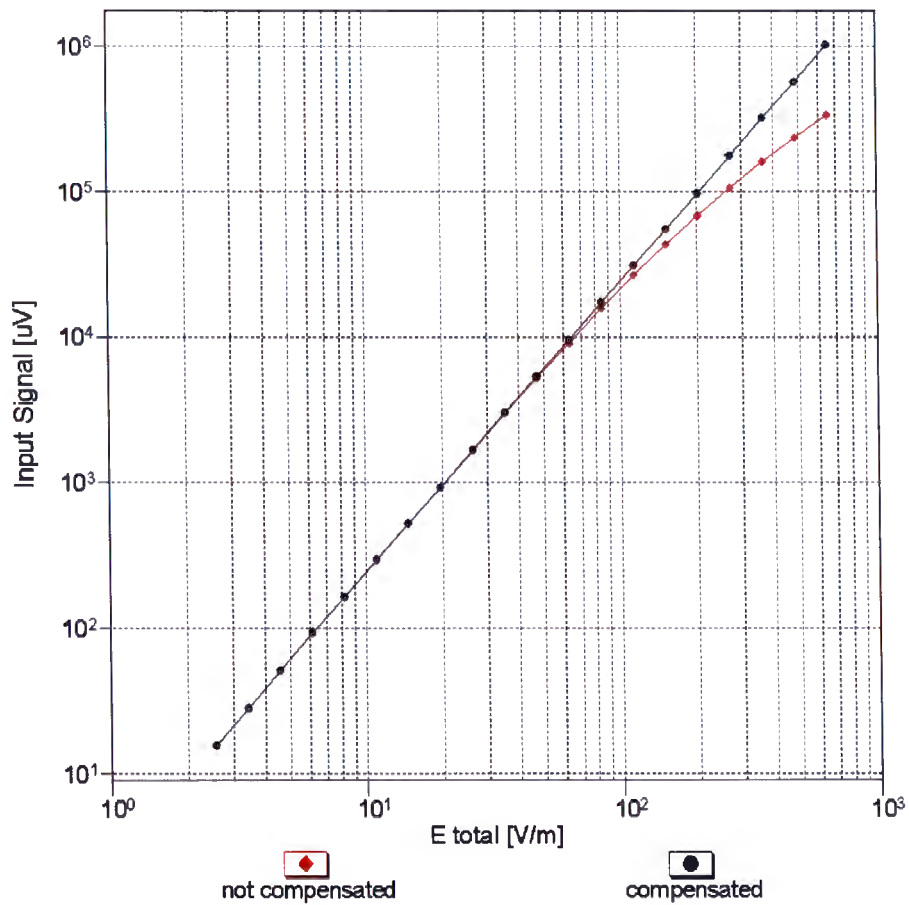
Receiving Pattern (ϕ), $\vartheta = 90^\circ$



Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

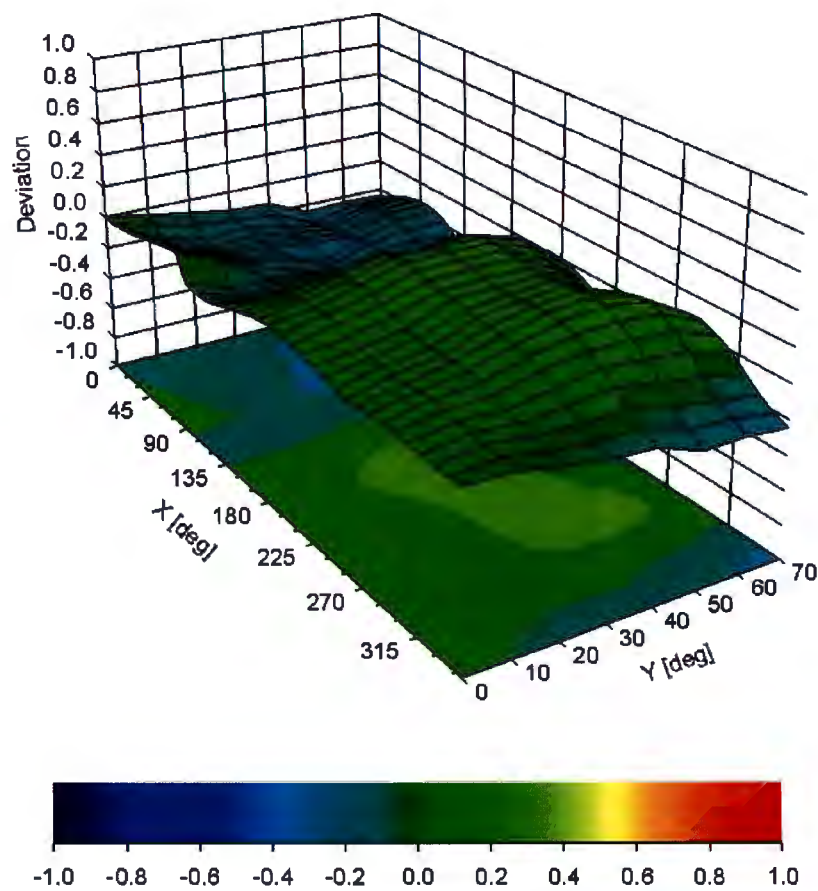
Dynamic Range f(E-field)

(TEM cell , f = 900 MHz)



Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

Deviation from Isotropy in Air
Error (ϕ , ϑ), $f = 900\text{ MHz}$



Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ ($k=2$)

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2358

Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	118.7
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



Accreditation No.: **SCS 0108**

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

Client

Sporton (Auden)

Certificate No: **EF3-4053_Mar18**

CALIBRATION CERTIFICATE

Object

EF3DV3 - SN:4053

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 19, 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

Calibrated by:

Name

Jeton Kastrati

Function

Laboratory Technician

Signature

Approved by:

Katja Pokovic

Technical Manager

Issued: March 19, 2018

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



Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA
 Multilateral Agreement for the recognition of calibration certificates

Glossary:

NORM _{x,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., $\vartheta = 0$ 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:

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

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\vartheta = 0$ for XY sensors and $\vartheta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- NORM(f)_{x,y,z}** = NORM_{x,y,z} * frequency_response (see Frequency Response Chart).
- DCP_{x,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
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,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 NORM_x (no uncertainty required).

Probe EF3DV3

SN:4053

Manufactured: May 24, 2016
Calibrated: March 19, 2018

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

DASY/EASY - Parameters of Probe: EF3DV3 - SN:4053

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$)	0.74	0.72	1.30	$\pm 10.1 \%$
DCP (mV) ^B	98.7	95.3	97.0	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu\text{V}}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	173.0	$\pm 2.5 \%$
		Y	0.0	0.0	1.0		166.2	
		Z	0.0	0.0	1.0		135.1	
10021-DAC	GSM-FDD (TDMA, GMSK)	X	1.89	64.8	11.5	9.39	134.7	$\pm 2.2 \%$
		Y	3.13	72.7	17.0		136.9	
		Z	3.02	72.4	16.7		149.1	
10061-CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)	X	3.01	70.1	19.9	3.60	117.5	$\pm 0.7 \%$
		Y	3.14	69.4	19.5		115.6	
		Z	3.68	73.5	21.9		127.3	
10069-CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps)	X	10.45	69.2	23.6	10.56	115.6	$\pm 2.7 \%$
		Y	10.99	69.7	23.9		119.4	
		Z	11.40	70.9	24.8		135.6	
10077-CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)	X	10.11	70.8	25.3	11.00	136.1	$\pm 3.3 \%$
		Y	10.60	71.2	25.5		139.0	
		Z	10.19	69.7	24.6		112.9	
10172-CAD	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	5.84	71.7	25.0	9.21	122.2	$\pm 3.3 \%$
		Y	6.24	71.2	24.6		125.2	
		Z	6.46	72.8	25.9		137.3	
10173-CAD	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	6.15	72.8	25.5	9.48	120.1	$\pm 3.3 \%$
		Y	6.59	72.2	25.1		124.0	
		Z	6.87	74.0	26.4		136.3	
10295-AAB	CDMA2000, RC1, SO3, 1/8th Rate 25 fr.	X	5.56	69.6	25.5	12.49	103.3	$\pm 1.2 \%$
		Y	5.88	69.6	26.0		104.5	
		Z	6.11	71.1	27.2		115.3	

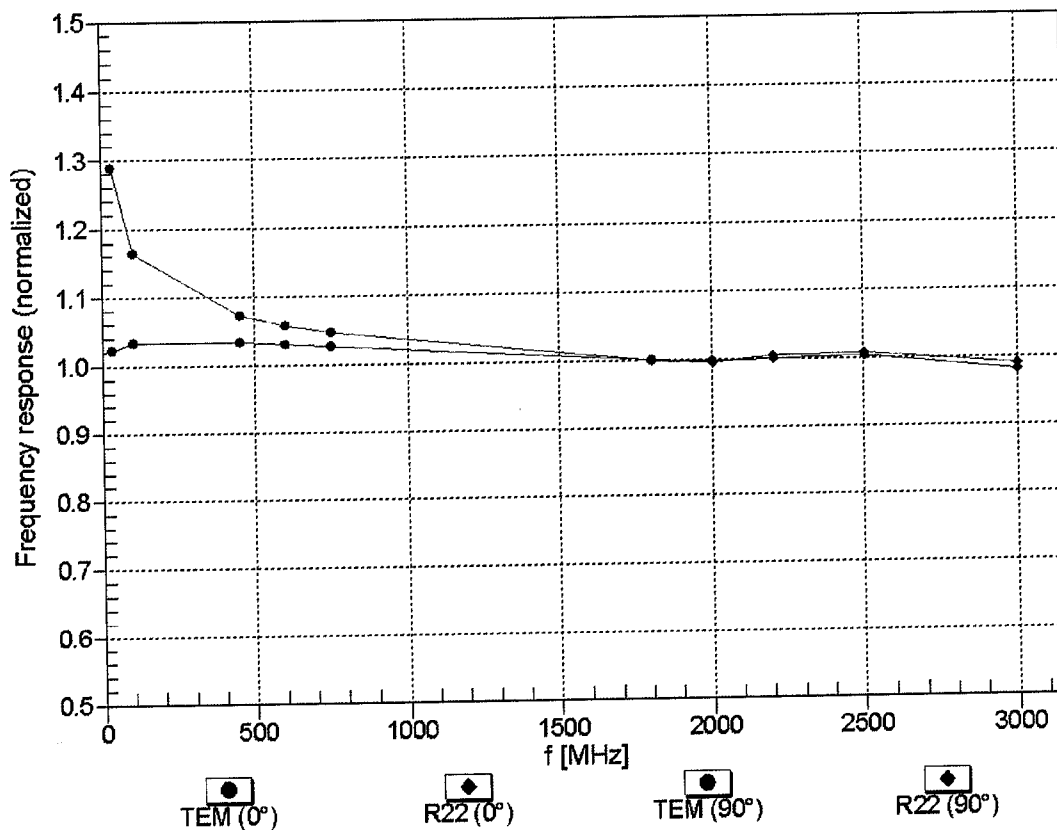
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^B Numerical linearization parameter: uncertainty not required.

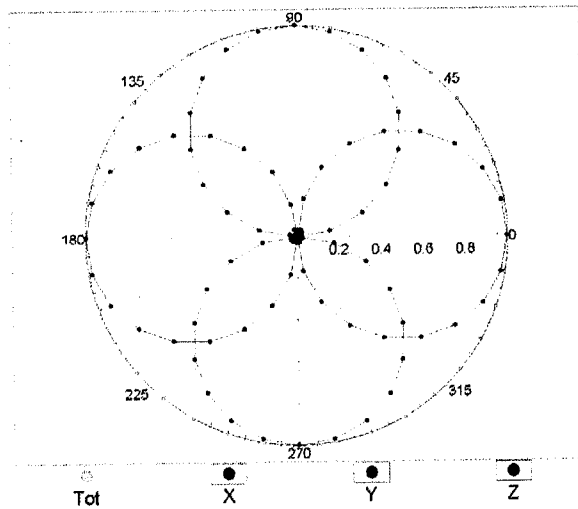
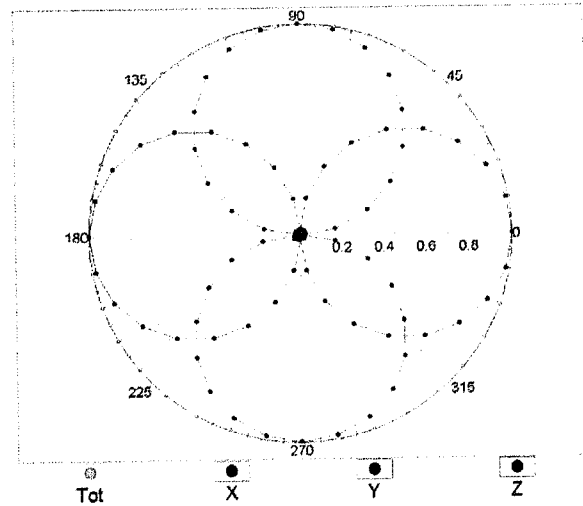
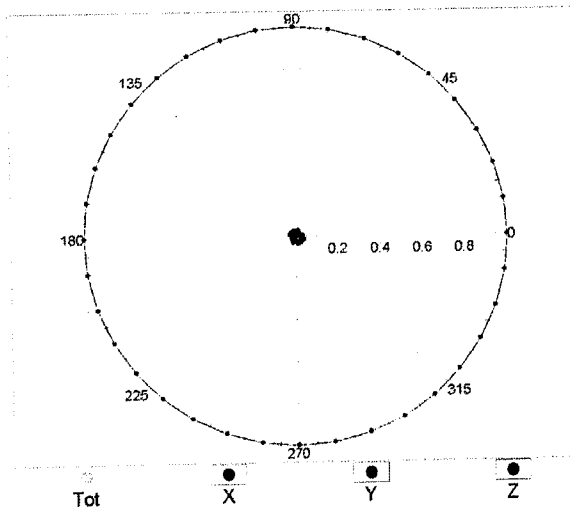
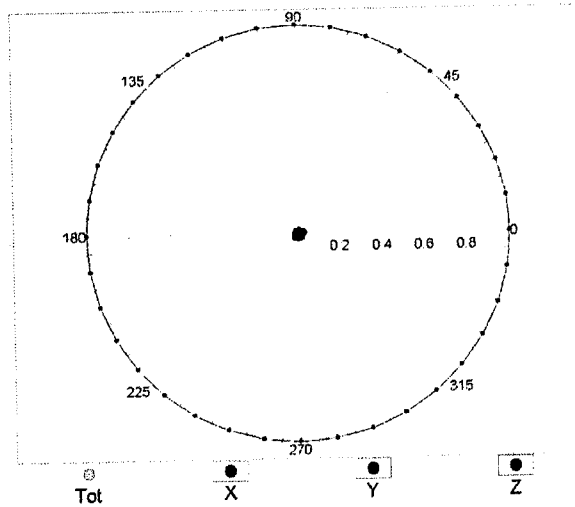
^E Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Frequency Response of E-Field

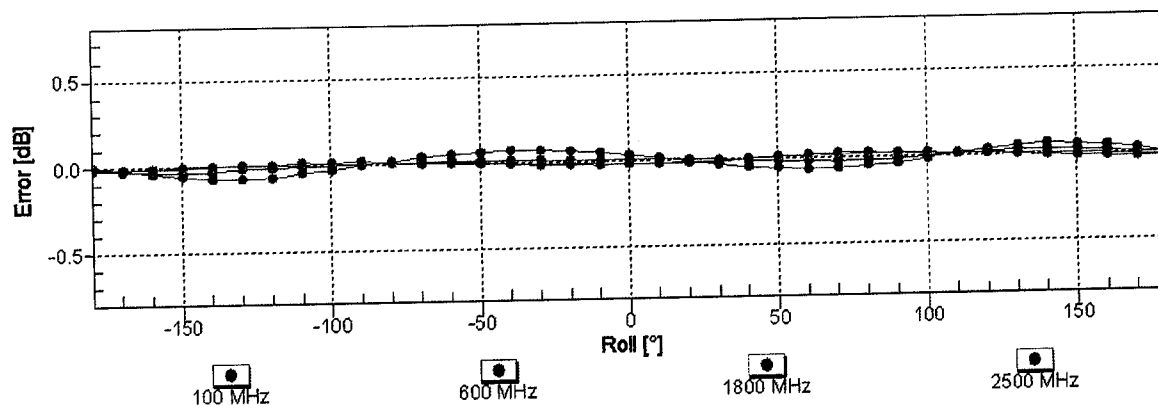
(TEM-Cell:ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

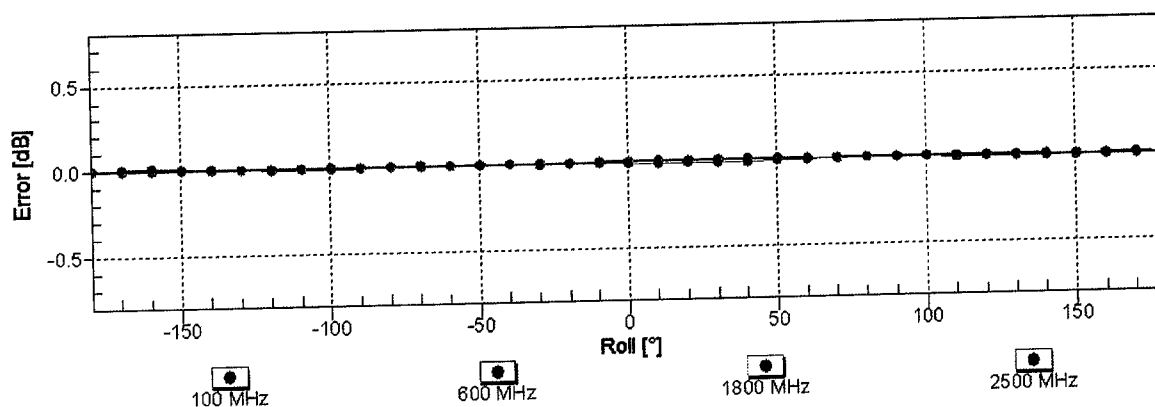
Receiving Pattern (ϕ), $\theta = 0^\circ$ **f=600 MHz,TEM,0°****f=1800 MHz,R22,0°****Receiving Pattern (ϕ), $\theta = 90^\circ$** **f=600 MHz,TEM,90°****f=1800 MHz,R22,90°**

Receiving Pattern (ϕ), $\vartheta = 0^\circ$



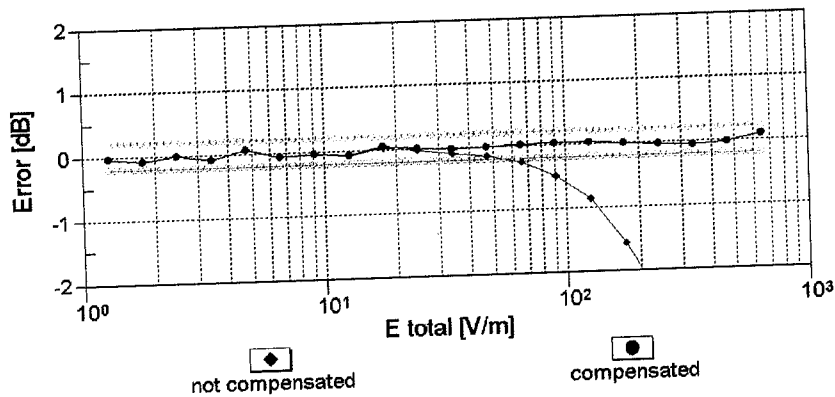
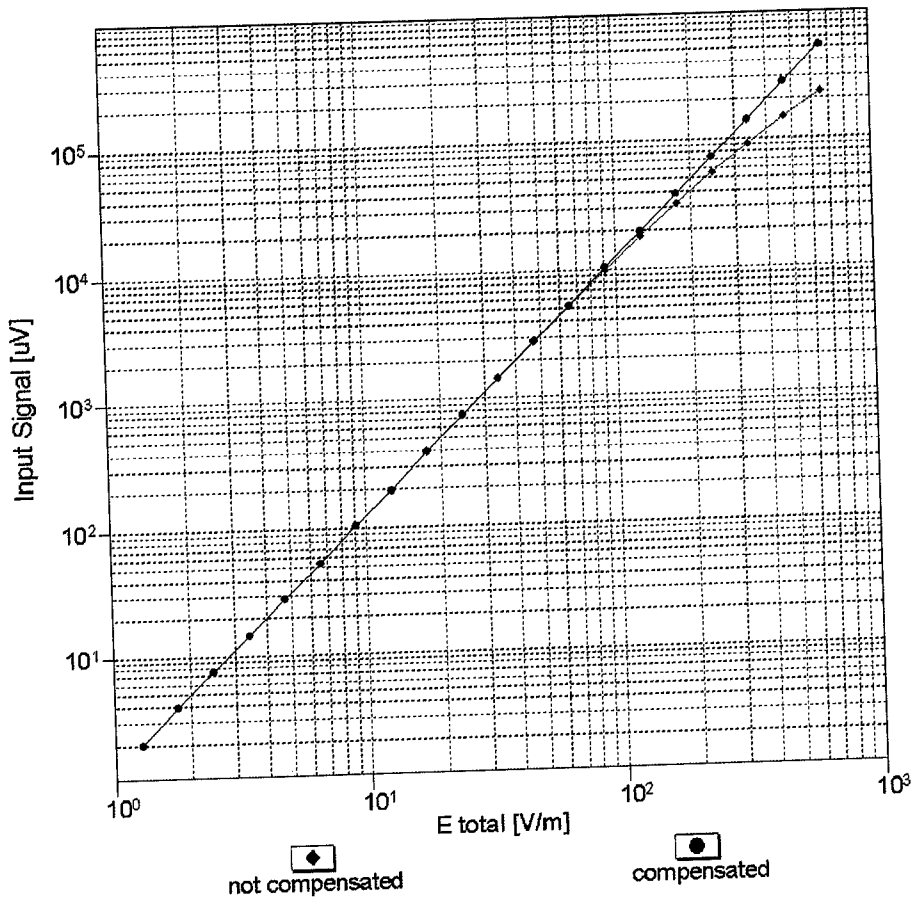
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

Receiving Pattern (ϕ), $\vartheta = 90^\circ$



Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

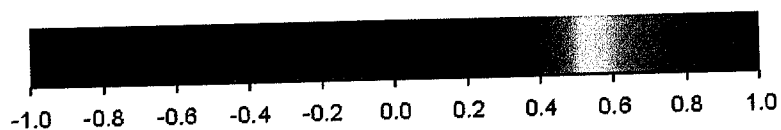
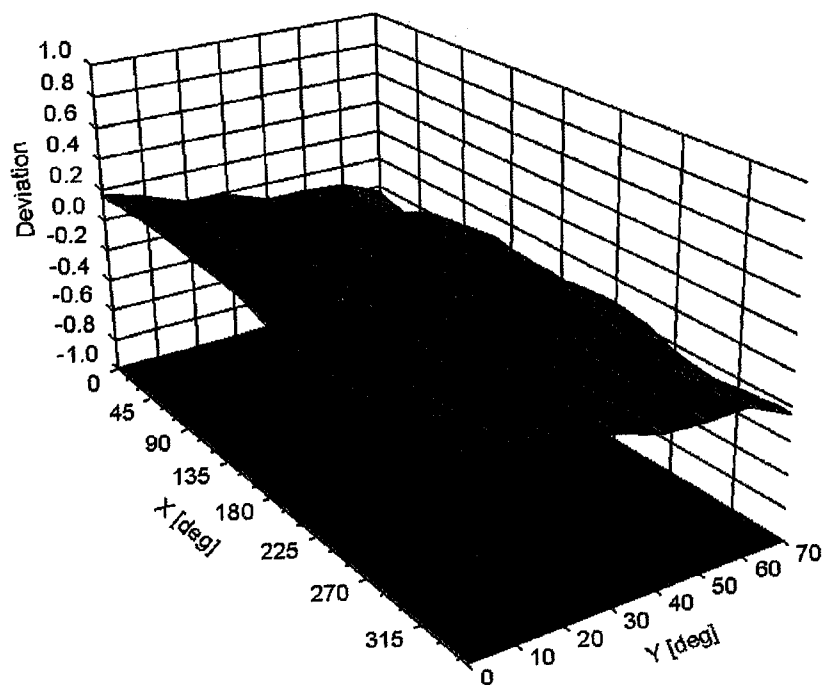
Dynamic Range f(E-field)
(TEM cell , f = 900 MHz)



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

Deviation from Isotropy in Air

Error (ϕ , θ), $f = 900$ MHz



Uncertainty of Spherical Isotropy Assessment: $\pm 2.6\%$ ($k=2$)

DASY/EASY - Parameters of Probe: EF3DV3 - SN:4053

Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	70.2
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	335 mm
Probe Body Diameter	12 mm
Tip Length	25 mm
Tip Diameter	4 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

Appendix (Additional assessments outside the scope of SCS 0108)

Calibration Parameters for 3-4 GHz

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^x	0.77	0.76	1.32	$\pm 10.1 \%$
DCP (mV) ^B	98.7	95.3	97.0	

Calibration Parameters for 5-6 GHz

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^x	0.83	0.82	1.46	$\pm 10.1 \%$
DCP (mV) ^B	98.7	95.3	97.0	

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.

^x Calibration procedure for frequencies above 3 GHz is pending accreditation.