

Hearing Aid Compatibility (HAC) T-Coil Test Report

APPLICANT	: CT Asia
EQUIPMENT	: GSM mobile phone
BRAND NAME	: BLU
MODEL NAME	: spark
FCC ID	: YHLBLUSPARK
STANDARD	: FCC 47 CFR §20.19 ANSI C63.19-2007
T CATEGORY	: T3
OVERALL HAC RATING	: M3/T3

The product sample received on Sep. 17, 2011 and completely tested on Oct. 31, 2011. We, SPORTON INTERNATIONAL (KUNSHAN) INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and shown the compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL (KUNSHAN) INC., the test report shall not be reproduced except in full.

Reviewed by:



Jones Tsai / Manager



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Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
HA191701B	Rev. 01	Initial issue of report	Nov. 03, 2011

1. Statement of Compliance

The Hearing Aid Compliance (HAC) maximum results found during testing for the **CT Asia GSM mobile phone BLU spark** are as follows (with expanded uncertainty $\pm 8.1\%$ for AMB1 and $\pm 12.3\%$ for AMB2):

Reference (63.19)	Description	Verdict	Section
7.3.1.1	Axial Field Intensity	Pass	9.3.1
7.3.1.2	Radial Field Intensity	Pass	9.3.2
7.3.2	Frequency Response	Pass	9.3.3
7.3.3	Signal Quality	T3	9.3.4

Band	(S+N)/N in dB	T Rating
GSM850	25.01	T3
GSM1900	29.06	T3

They are in compliance with HAC limits (HAC Rated category T3) specified in guidelines FCC 47CFR §20.19 and ANSI Standard ANSI C63.19.

Results Summary : T Category = T3 (ANSI C63.19-2007)

2. Administration Data

2.1 Testing Laboratory

Test Site	SPORTON INTERNATIONAL (KUNSHAN) INC.
Test Site Location	No. 3-2, PingXiang Road, Kunshan, Jiangsu Province, P.R.C. TEL: +86-0512-5790-0158 FAX: +86-0512-5790-0958
Test Site No.	Sporton Site No. : SAR01-KS

2.2 Applicant

Company Name	CT Asia
Address	RMA2011, 20/F, GOLDEN CENTRAL TOWER, NO.3037# JINTIAN ROAD, FUTIAN DISTRICT

2.3 Manufacturer

Company Name	TINNO Electronics Technology Co., Ltd.
Address	RM 303, Building 53, Panda Group, Road No. 168 Long Pan Zhong Lu, Nanjing, Jiangsu, P.R.C.

2.4 Application Details

Date of Receipt of Application	Sep. 17, 2011
Date of Start during the Test	Oct. 31, 2011
Date of End during the Test	Oct. 31, 2011

3. General Information

3.1 Description of Device Under Test (DUT)

Product Feature & Specification	
DUT Type	GSM mobile phone
Brand Name	BLU
Model Name	spark
FCC ID	YHLBLUSPARK
Tx Frequency	GSM850 : 824 MHz ~ 849 MHz GSM1900 : 1850 MHz ~ 1910 MHz Bluetooth : 2400 MHz ~ 2483.5 MHz
Rx Frequency	GSM850 : 869 MHz ~ 894 MHz GSM1900 : 1930 MHz ~ 1990 MHz Bluetooth : 2400 MHz ~ 2483.5 MHz
Maximum Output Power to Antenna	GSM850 : 31.30 dBm GSM1900 : 28.33 dBm Bluetooth : 8.22 dBm
Antenna Type	WWAN : Fixed Internal Antenna Bluetooth : Dipole Antenna
HW Version	V0.10
SW Version	E910_MP_F4_BLU_OPEN_01_02
Type of Modulation	GSM / GPRS : GMSK Bluetooth (1Mbps) : GFSK Bluetooth EDR (2Mbps) : $\pi/4$ -DQPSK Bluetooth EDR (3Mbps) : 8-DPSK
DUT Stage	Production Unit

Remark:

1. The above DUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.
2. The Bluetooth is not available for HAC test.

3.2 Product Photos

Refer to Appendix C.

3.3 Applied Standards

The Standard ANSI C63.19:2007 represents performance requirements for acceptable interoperability of hearing aids with wireless communications devices. When these parameters are met, a hearing aid operates acceptably in close proximity to a wireless communications device.

3.4 Test Conditions

3.4.1 Ambient Condition

Ambient Temperature	20-24℃
Humidity	<60%
Acoustic Ambient Noise	>10dB below the measurement level

3.4.2 Test Configuration

The device was controlled by using a base station emulator R&S CMU200. Communication between the device and the emulator was established by coaxial connection. The DUT was set from the emulator to radiate maximum output power during all testing.



4. Hearing Aid Compliance (HAC)

Introduction

In September 2006, the T-Coil requirements of ANSI C63.19 Standard went into effect. The federal communication commission (FCC) adopted ANSI C63.19 as HAC test standard.

5. HAC T-Coil Measurement Setup

5.1 System Configuration



Fig. 5.1 T-Coil setup with HAC Test Arch and AMCC

The DASY system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic (DAE) attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter (ECO) performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows XP
- DASY software
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

Some of the components are described in details in the following sub-sections.

5.2 AM1D Probe

The AM1D probe is an active probe with a single sensor. It is fully RF-shielded and has a rounded tip 6mm in diameter incorporating a pickup coil with its center offset 3mm from the tip and the sides. The symmetric signal preamplifier in the probe is fed via the shielded symmetric output cable from the AMMI with a 48V “phantom” voltage supply. The 7-pin connector on the back in the axis of the probe does not carry any signals. It is mounted to the DAE for the correct orientation of the sensor. If the probe axis is tilted 54.7 degree from the vertical, the sensor is approximately vertical when the signal connector is at the underside of the probe (cable hanging downwards).

Specification:

Frequency Range	0.1 ~ 20 kHz (RF sensitivity <-100dB, fully RF shielded)
Sensitivity	<-50dB A/m @ 1 kHz
Pre-amplifier	40 dB, symmetric
Dimensions	Tip diameter/ length: 6/ 290 mm, sensor according to ANSI-PC63.19

5.2.1 Probe Calibration in AMCC

The probe sensitivity at 1 kHz is 0.00742647 V/(A/m) (-21.29 dBV/(A/m)) was calibrated by AMCC coil for verification of setup performance. The evaluated probe sensitivity was able to be compared to the calibration of the AM1D probe. The frequency response and sensitivity was shown in Fig. 5.3. The probe signal is represented after application of an ideal integrator. The green curve represents the current though the AMCC, the blue curve the integrated probe signal. The DIFFERENCE between the two curves is equivalent to the frequency response of the probe system and shows the characteristics. The probe/system complies with the frequency response and linearity requirements in C63.19 according to the Speag's calibrated report as shown in Annex B (AM1D probe: SPAM100AF)

(1)The frequency response has been tested within +/- 0.5 dB of ideal differentiator from 100 Hz to 10 kHz. (2)The linearity has also been tested within 0.1dB from 5 dB below limitation to 16 dB above noise level. The AMCC coil is qualified according to certificate report, SDHACPO02A as shown in Annex B.

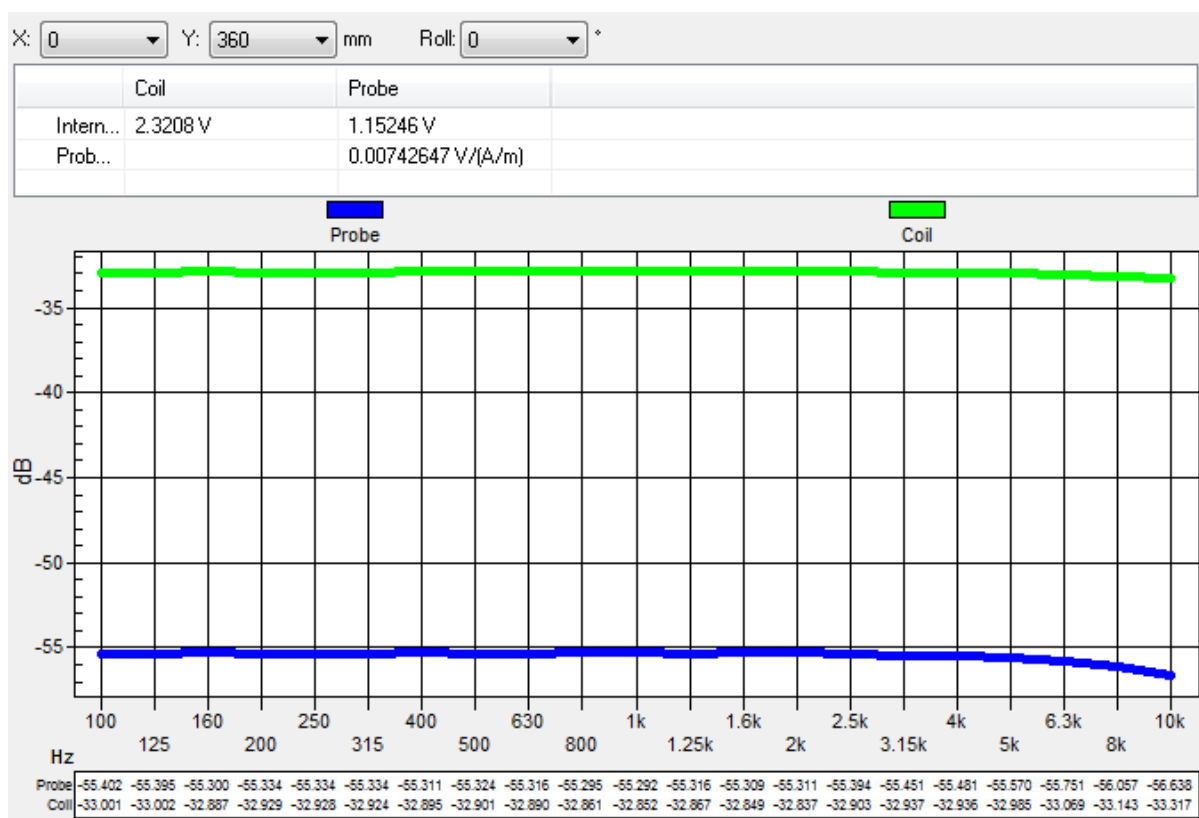


Fig. 5.3 The frequency response and sensitivity of AM1D probe

5.3 AMCC

The Audio Magnetic Calibration coil is a Helmholtz Coil designed for calibration of the AM1D probe. The two horizontal coils generate a homogeneous magnetic field in the z direction. The DC input resistance is adjusted by a series resistor to approximately 50 Ohm, and a shunt resistor of 10 Ohm permits monitoring the current with a scale of 1:10.

Port description:

Signal	Connector	Resistance
Coil In	BNC	typically 50 Ohm
Coil Monitor	BNO	100 Ohm $\pm 1\%$ (100mV corresponding to 1 A/m)

Specification:

Dimensions	370 x 370 x 196 mm, according to ANSI C63.19
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5.4 AMMI



Fig. 5.4 AMMI front panel

The Audio Magnetic Measuring Instrument (AMMI) is a desktop 19-inch unit containing a sampling unit, a waveform generator for test and calibration signals, and a USB interface.

Specification:

Sampling rate	48 kHz/24 bit
Dynamic range	85 dB
Test signal generation	User selectable and predefined (vis PC)
Calibration	Auto-calibration/full system calibration using AMCC with monitor output
Dimensions	482 x 65 x 270 mm

5.5 DATA Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.



Fig. 5.5 Photo of DAE

5.6 Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY5: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)
- 6-axis controller



Fig. 5.7 Photo of DASY5

5.7 Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chipdisk (DASY5: 128 MB), RAM (DASY5: 128 MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.



Fig. 5.9 Photo of Server for DASY5

5.8 Phone Positioner

The phone positioner shown in Fig. 5.10 is used to adjust DUT to the suitable position.



Fig. 5.10 Phone Positioner

5.9 Test Arch Phantom

Construction :	Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.	
Dimensions :	370 x 370 x 370 mm	

Fig. 5.12 Photo of Arch Phantom

5.10 Cabling of System

The principal cabling of the T-Coil setup is shown in Fig. 5.6. All cables provided with the basic setup have a length of approximately 5 m.

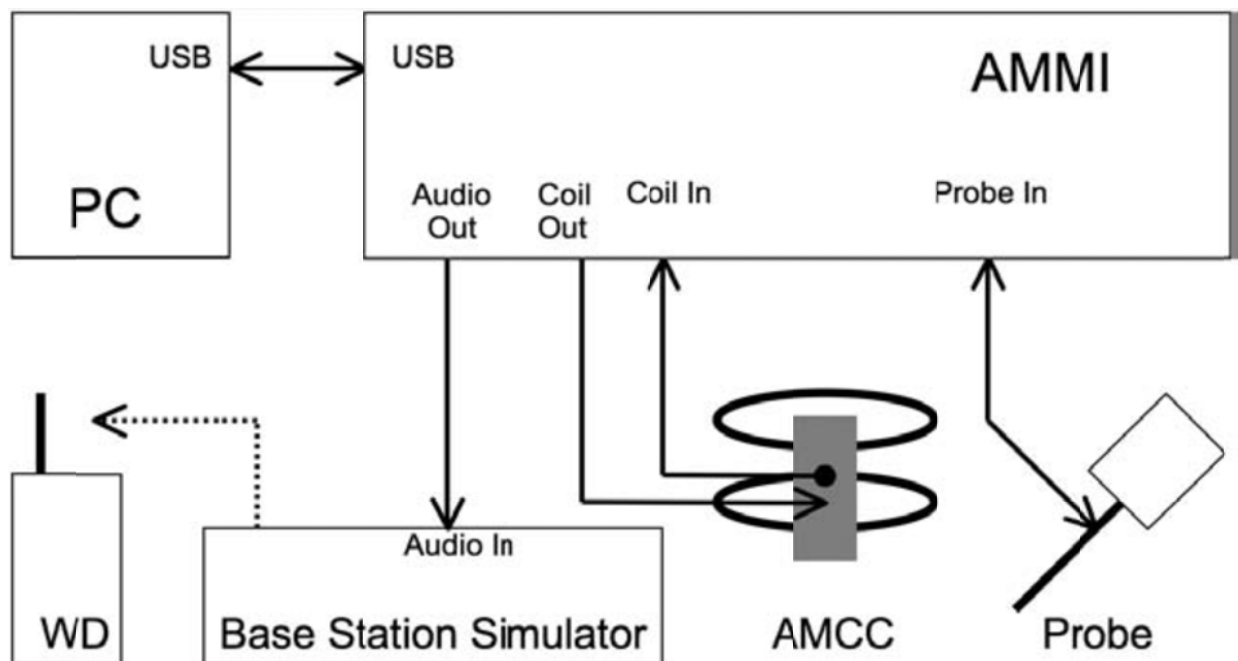


Fig. 5.7 T-Coil setup cabling

5.11 HAC Extension Software

Specification:

Precise teaching	Easy teaching with adaptive distance verification
Measurement area	Flexible selection of measurement area, predefined according to ANSI C63.19
Evaluation	ABM: spectral processing, filtering, weighting and evaluation according to ANSI C63.19
Report	Documentation ready for compliance report

5.12 Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Isotropic E-Field Probe	ER3DV6	2476	Nov. 23, 2010	Nov. 22, 2011
SPEAG	Isotropic H-Field Probe	H3DV6	6300	Nov. 25, 2010	Nov. 24, 2011
SPEAG	835MHz Calibration Dipole	CD835V3	1171	May 02, 2011	May 01, 2012
SPEAG	1880MHz Calibration Dipole	CD1880V3	1155	May 03, 2011	May 02, 2012
SPEAG	Data Acquisition Electronics	DAE4	1210	Nov. 18, 2010	Nov. 17, 2011
SPEAG	HAC Phantom	N/A	1105	NCR	NCR
Agilent	Wireless Communication Test Set	E5515C	GB47050646	Aug. 18, 2011	Aug. 17, 2012
R&S	Universal Radio Communication Tester	CMU200	116456	Sep. 10, 2011	Sep. 09, 2012
AR	Amplifier	551G4	333096	NCR	NCR
R&S	Spectrum Analyzer	FSP30	101400	Jun. 02, 2011	Jun. 01, 2012
R&S	Signal Generator	SMR40	100455	Jan. 01, 2011	Jan. 05, 2012

Table 5.1 Test Equipment List

5.13 Reference Input of Audio Signal Spectrum

With the reference job "use as reference" in the beginning of a procedure, measure the spectrum of the current when applied to the AMCC, i.e. the input magnetic field spectrum, as shown below Fig. 5.8 and Fig. 5.9. For this, the delay of the window shall be set to a multiple of the signal period and at least 2s. From the measurement on the device, using the same signal, the postprocessor deducts the input spectrum, so the result represents the net DUT response.

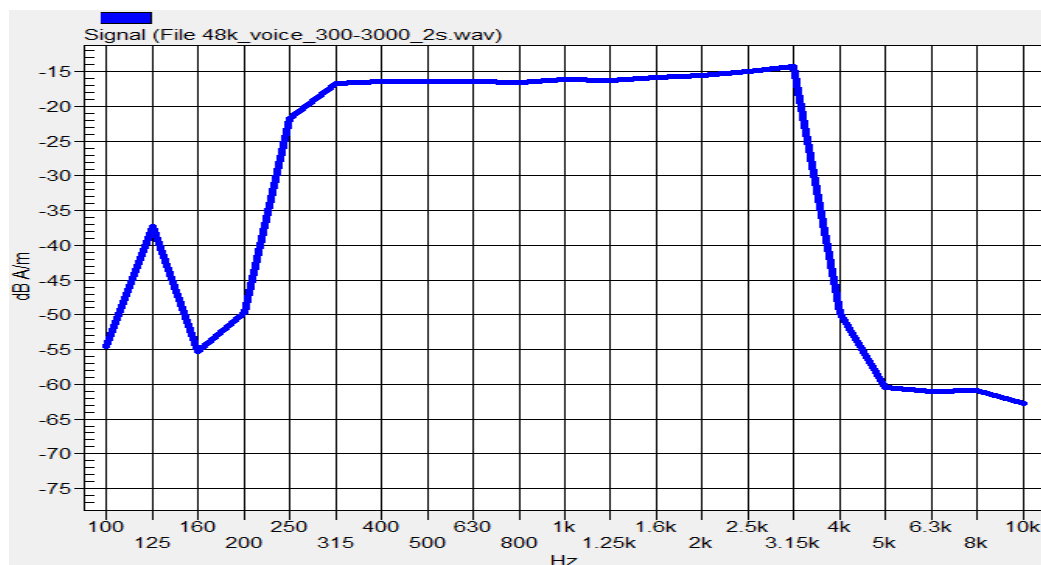


Fig. 5.8 Audio signal spectrum of the broadband signal (48kHz_voice_300Hz~3 kHz)

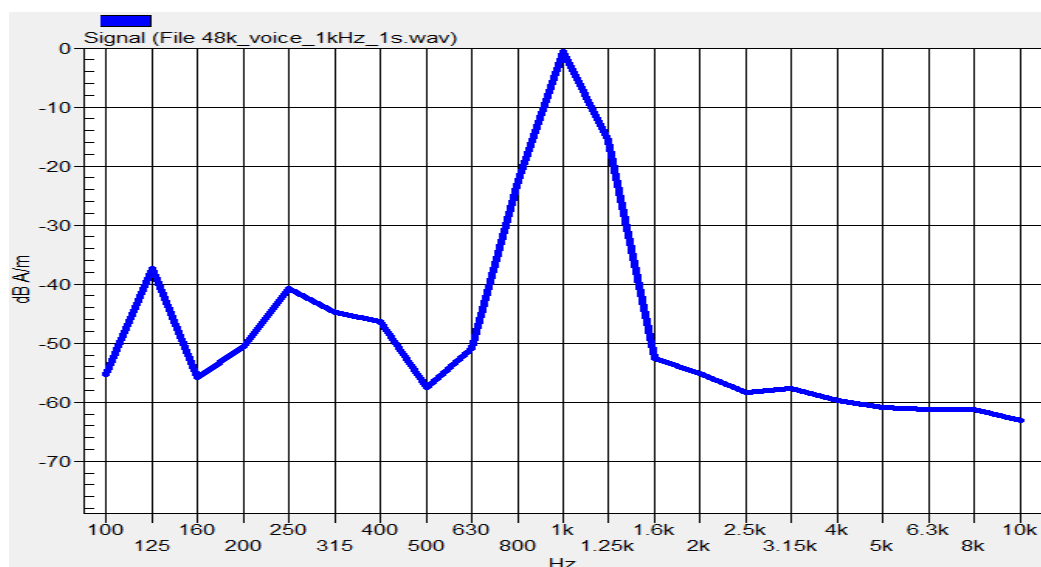


Fig. 5.9 Audio signal spectrum of the narrowband signal (48kHz_voice_1kHz)

5.14 Signal Verification

According to ANSI C63.19:2007 section 6.3.2.1, the normal speech input level for HAC T-coil tests shall be set to -16 dBm0 for GSM and UMTS (WCDMA), and to -18 dBm0 for CDMA. This technical note shows a possibility to evaluate and set the correct level with the HAC T-Coil setup with a Rohde&Schwarz communication tester CMU200 with audio option B52 and B85.

Establish a call from the CMU200 to a wireless device. Select CMU200 Network Bitstream "Decoder Cal" to have a 1 kHz signal with a level of 3.14 dBm0 at the speech output. Run the measurement job and read the voltage level at the multi-meter display "Coil signal". Read the RMS voltage corresponding to 3.14 dBm0 and note it. Calculate the desired signal levels of -16 dBm0:

$$3.14 \text{ dBm0} = -2.57 \text{ dBV}$$

$$-16 \text{ dBm0} = -21.71 \text{ dBV}$$

Determine the 1 kHz input level to generate the desired signal level of -16 dBm0. Select CMU200 Network Bitstream "Codec Cal" to loop the input via the codec to the output. Run the measurement job (AMMI 1 kHz signal with gain 10 inserted) and read the voltage level at the multimeter display "Coil signal". Calculate the required gain setting for the above levels:

$$\text{Gain } 10 = -19.33 \text{ dBV}$$

$$\text{Difference for } -16 \text{ dBm0} = -21.71 - (-19.33) = -2.38 \text{ dB}$$

$$\text{Gain factor} = 10^{((-2.38) / 20)} = 0.760$$

$$\text{Resulting Gain} = 10 \times 0.760 = 7.60$$

The predefined signal types have the following differences / factors compared to the 1 kHz sine signal:

Signal Type	Duration (s)	Peak to RMS (dB)	RMS (dB)	Gain Factor	Gain Setting
1kHz	1	16.2	-12.7	4.33	32.92
300Hz ~ 3kHz	2	21.6	-18.6	8.48	64.48

6. Description for DUT Testing Position

Fig.6.1 illustrate the references and reference plane that shall be used in a typical DUT emissions measurement. The principle of this section is applied to DUT with similar geometry. Please refer to Appendix D for the setup photographs.

- The area is 5 cm by 5 cm.
- The area is centered on the audio frequency output transducer of the DUT.
- The area is in a reference plane, which is defined as the planar area that contains the highest point in the area of the phone that normally rests against the user's ear. It is parallel to the centerline of the receiver area of the phone and is defined by the points of the receiver-end of the DUT handset, which, in normal handset use, rest against the ear.
- The measurement plane is parallel to, and 10 mm in front of, the reference plane.

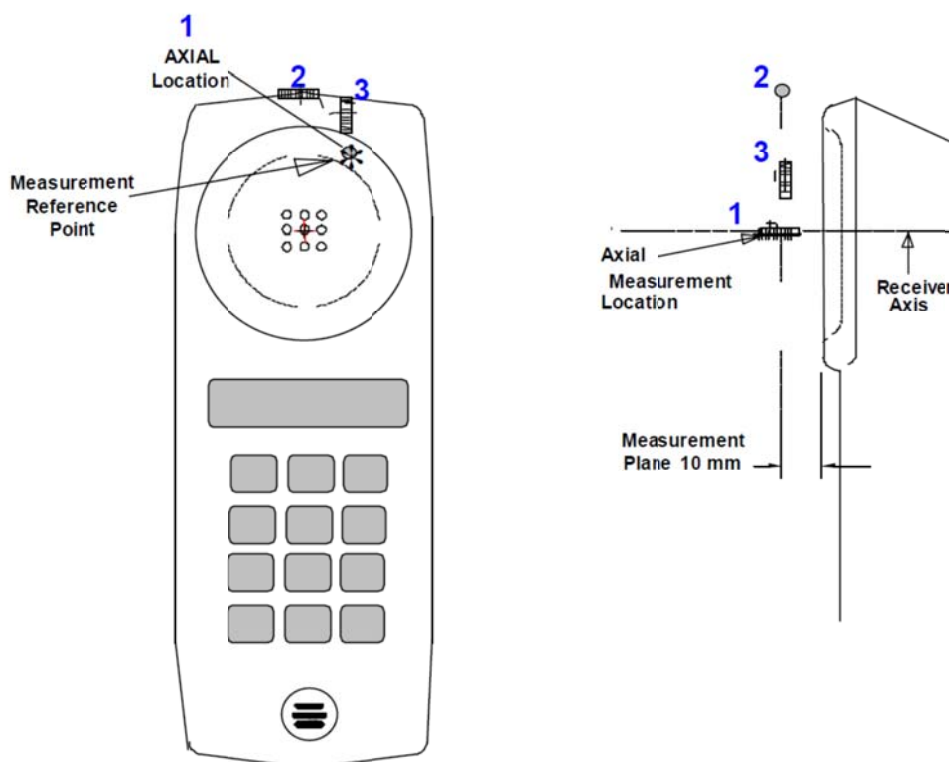


Fig 6.1 A typical DUT reference and plane for T-Coil measurements

7. T-Coil Test Procedure

The following illustrate a typical test scan over a wireless communications device:

1. Geometry and signal check: system probe alignment, proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the test Arch.
2. Set the reference drive level of signal voice defined in C63.19 per 6.3.2.1, as shown in this report of section 5.12.
3. The ambient and test system background noise (dB A/m) was measured as well as ABM2 over the full measurement. The maximum noise level must be at least 10dB below the limit of C63.19 per 7.3.2.
4. The DUT was positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.
5. The DUT operation for maximum rated RF output power was configured and connected by using of coaxial cable connection to the base station simulator at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The DUT audio output was positioned tangent (as physically possible) to the measurement plane.
6. The DUT's RF emission field was eliminated from T-coil results by using a well RF-shielding of the probe, AM1D, and by using of coaxial cable connection to a Base Station Simulator. One test channel was pre-measurement to avoid this possibility.
7. Determined the optimal measurement locations for the DUT by following the three steps, coarse resolution scan, fine resolution scans, and point measurement, as described in C63.19 per 6.3.4.4. At each measurement locations, samples in the measurement window duration were evaluated to get ABM1 and the signal spectrum. The noise measurement was performed after the scan with the signal, the same happened, just with the voice signal switched off. The ABM2 was calculated from this second scan.
 - (1) Coarse resolution scans (1 kHz signal at 50 x 50 mm grid area with 10 mm spacing). Only ABM1 was measured in order to find the location of T-Coil source.
 - (2) Fine resolution scans (1 kHz signal at 10 x 10 mm grid area with 2 mm spacing). The positioned appropriately based on optimal AMB1 of coarse resolution scan. Both ABM1 and ABM2 were measured in order to find the location of the SNR point.
 - (3) Point measurement (1 kHz signal) for ABM1 and ABM2 in axial, radial transverse and radial longitudinal. The positioned appropriately based on optimal SNR of fine resolution scan. The SNR was calculated for axial, radial transverse and radial longitudinal orientation.
 - (4) Point measurement (300Hz to 3 kHz signal) for frequency response in axial. The positioned appropriately based on optimal SNR of fine resolution axial scan.



8. All results resulting from a measurement point in a T-Coil job were calculated from the signal samples during this window interval. ABM values were averaged over the sequence of these samples.
9. At an optimal point measurement, the SNR (ABM1/ABM2) was calculated for axial, radial transverse and radial longitudinal orientation, and the frequency response was measured in axial axis.
10. Corrected for the frequency response after the DUT measurement since the DASY system had known the spectrum of the input signal by using a reference job, as shown in this report of section 5.12.
11. In SEMCAD post-processing, the spectral points are in addition scaled with the high-pass (half-band) and the A-weighting, bandwidth compensated factor (BWC) and those results are final as shown in this report.
12. Classified the signal quality based on the table 8.1: T-Coil Signal Quality Categories.

8. T-Coil Signal Quality Categories

This section provides the signal quality requirement for the intended T-Coil signal from a WD. Only the RF immunity of the hearing aid is measured in T-Coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. A device is assessed beginning by determining the category of the RF environment in the area of the T-Coil source.

The RF measurements made for the T-Coil evaluation are used to assign the category T1 through T4. The limitation is given in Table 8.1. This establishes the RF environment presented by the WD to a hearing aid.

Category	Telephone parameters WD signal quality ((signal + noise) to noise ratio in dB)
Category T1	0 to 10 dB
Category T2	10 to 20 dB
Category T3	20 to 30 dB
Category T4	> 30 dB

Table 8.1 T-Coil Signal Quality Categories

9. HAC T-Coil Test Results

9.1 Magnitude Result

The Table 9.1 shows testing result in position coordinates which are defined as deviation from earpiece center in millimeters. Axial measurement location was defined by the manufacture of the device. Signal strength measurement scans are presented in appendix A.

Plot No.	Band	Channel	Probe Position	Coordinates (mm)	Ambient Noise (dB A/m)	ABM2 (dB A/m)	ABM1 (dB A/m)	SNR (dB)	T Rating
#01	GSM850	128	Axial (Z)	-4,4	52.78	-24.96	27.72	52.68	T4
			Radial 1 (X)	-15,3	51.90	-16.32	12.21	28.53	T3
			Radial 2 (Y)	-3,-3	57.89	-38.59	27.63	66.22	T4
#02	GSM850	189	Axial (Z)	-4,4	52.77	-25.32	30.95	56.27	T4
			Radial 1 (X)	-18,3	52.01	-17.17	8.73	25.90	T3
			Radial 2 (Y)	-3,0	58.14	-36.48	28.78	65.26	T4
#03	GSM850	251	Axial (Z)	-4,4	52.56	-25.52	30.91	56.43	T4
			Radial 1 (X)	-18,-3	51.98	-17.10	7.91	25.01	T3
			Radial 2 (Y)	-3,0	58.09	-39.12	28.59	67.71	T4
#04	GSM1900	512	Axial (Z)	-4,4	52.69	-28.53	30.73	59.26	T4
			Radial 1 (X)	-18,3	51.53	-21.07	7.99	29.06	T3
			Radial 2 (Y)	-3,0	57.92	-39.19	28.56	67.75	T4
#05	GSM1900	661	Axial (Z)	-4,4	52.63	-28.89	30.63	59.52	T4
			Radial 1 (X)	-18,3	51.94	-21.10	8.07	29.17	T3
			Radial 2 (Y)	-3,0	58.05	-39.06	28.44	67.50	T4
#06	GSM1900	810	Axial (Z)	-4,4	52.77	-29.20	30.69	59.89	T4
			Radial 1 (X)	-18,3	52.04	-21.50	8.03	29.53	T3
			Radial 2 (Y)	-3,0	58.00	-39.69	28.59	68.28	T4

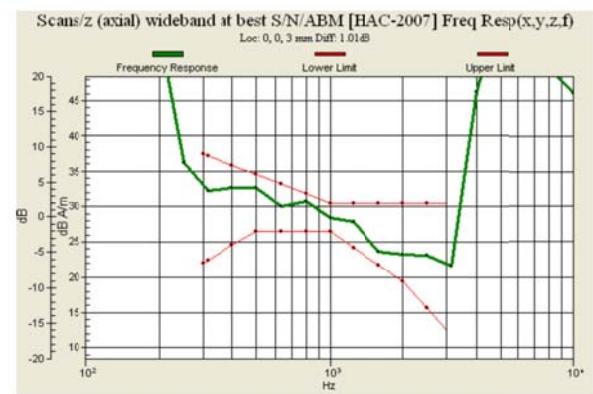
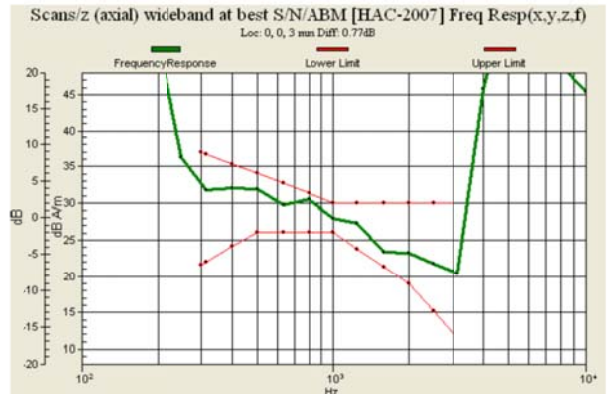
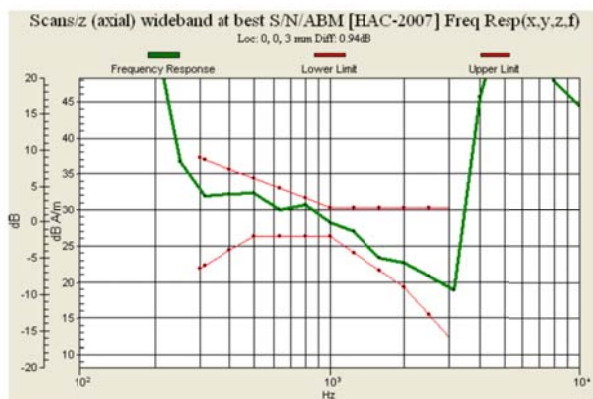
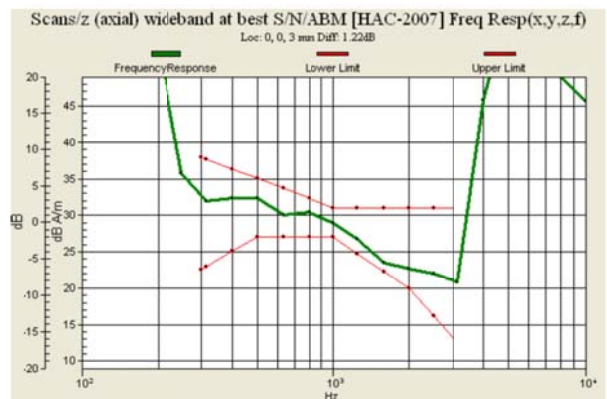
Table 9.1 Test Result for Various Positions

Remark:

1. There is no special HAC mode software on this DUT.
2. The volume was adjusted to maximum level and the backlight turned off during T-Coil testing.
3. Test Engineer : Suhe Yin

9.2 Frequency Response Plots


Fig. 9.1 GSM850 Ch128

Fig. 9.2 GSM850 Ch189

Fig. 9.3 GSM850 Ch251

Fig. 9.4 GSM1900 Ch512

Fig. 9.5 GSM1900 Ch661

Fig. 9.6 GSM1900 Ch810

9.3 T-Coil Coupling Field Intensity

9.3.1 Axial Field Intensity

Cell Phone Mode	Minimum limit (dB A/m)	Result (dB A/m)	Verdict
GSM850	-18	27.72	Pass
GSM1900	-18	30.63	Pass

9.3.2 Radial Field Intensity

Cell Phone Mode	Minimum limit (dB A/m)	Result (dB A/m)	Verdict
GSM850	-18	7.91	Pass
GSM1900	-18	7.99	Pass

9.3.3 Frequency Response at Axial Measurement Point

Cell Phone Mode	Verdict
GSM850	Pass
GSM1900	Pass

9.3.4 Signal Quality

Cell Phone Mode	Minimum limit (dB)				Minimum Result (dB)	Verdict
	T1	T2	T3	T4		
GSM850	0	10	20	>30	25.01	T3
GSM1900	0	10	20	>30	29.06	T3

10. 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.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table 10.1.

Uncertainty Distributions	Normal	Rectangular	Triangular	U-shape
Multiplying factor^(a)	$1/k$ ^(b)	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) k is the coverage factor

Table 10.1 Multiplying Factors for Various Distributions

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. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. 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 10.2.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (ABM1)	Ci (ABM2)	Standard Uncertainty (ABM1)	Standard Uncertainty (ABM2)
Probe Sensitivity							
Reference Level	3.0	Normal	1	1	1	± 3.0 %	± 3.0 %
AMCC Geometry	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %
AMCC Current	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Probe Positioning During Calibrate	0.1	Rectangular	√3	1	1	± 0.1 %	± 0.1 %
Noise Contribution	0.7	Rectangular	√3	0.0143	1	± 0.0 %	± 0.4 %
Frequency Slope	5.9	Rectangular	√3	0.1	1	± 0.3 %	± 3.5 %
Probe System							
Repeatability / Drift	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Linearity / Dynamic Range	0.6	Rectangular	√3	1	1	± 0.4 %	± 0.4 %
Acoustic Noise	1.0	Rectangular	√3	0.1	1	± 0.1 %	± 0.6 %
Probe Angle	2.3	Rectangular	√3	1	1	± 1.4 %	± 1.4 %
Spectral Processing	0.9	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	0.6	Normal	1	1	5	± 0.6 %	± 3.0 %
Field Disturbation	0.2	Rectangular	√3	1	1	± 0.1 %	± 0.1 %
Test Signal							
Reference Signal Spectral Response	0.6	Rectangular	√3	0	1	± 0.0 %	± 0.4 %
Positioning							
Probe Positioning	1.9	Rectangular	√3	1	1	± 1.1 %	± 1.1 %
Phantom Thickness	0.9	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
DUT Positioning	1.9	Rectangular	√3	1	1	± 1.1 %	± 1.1 %
External Contributions							
RF Interference	0.0	Rectangular	√3	1	0.3	± 0.0 %	± 0.0 %
Test Signal Variation	2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %
Combined Standard Uncertainty						± 4.1 %	± 6.1 %
Coverage Factor for 95 %						K = 2	
Expanded Uncertainty						± 8.1 %	± 12.3 %

Table 10.2 Uncertainty Budget of DASY



11. References

- [1] ANSI C63.19 2007, "American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", 8 June 2007
- [2] SPEAG DASY System Handbook



Appendix A. Plots of T-Coil Measurement

The plots are shown as follows.

#01 HAC T-Coil_GSM850_Ch128_Axial(Z)**DUT: 191701**

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

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

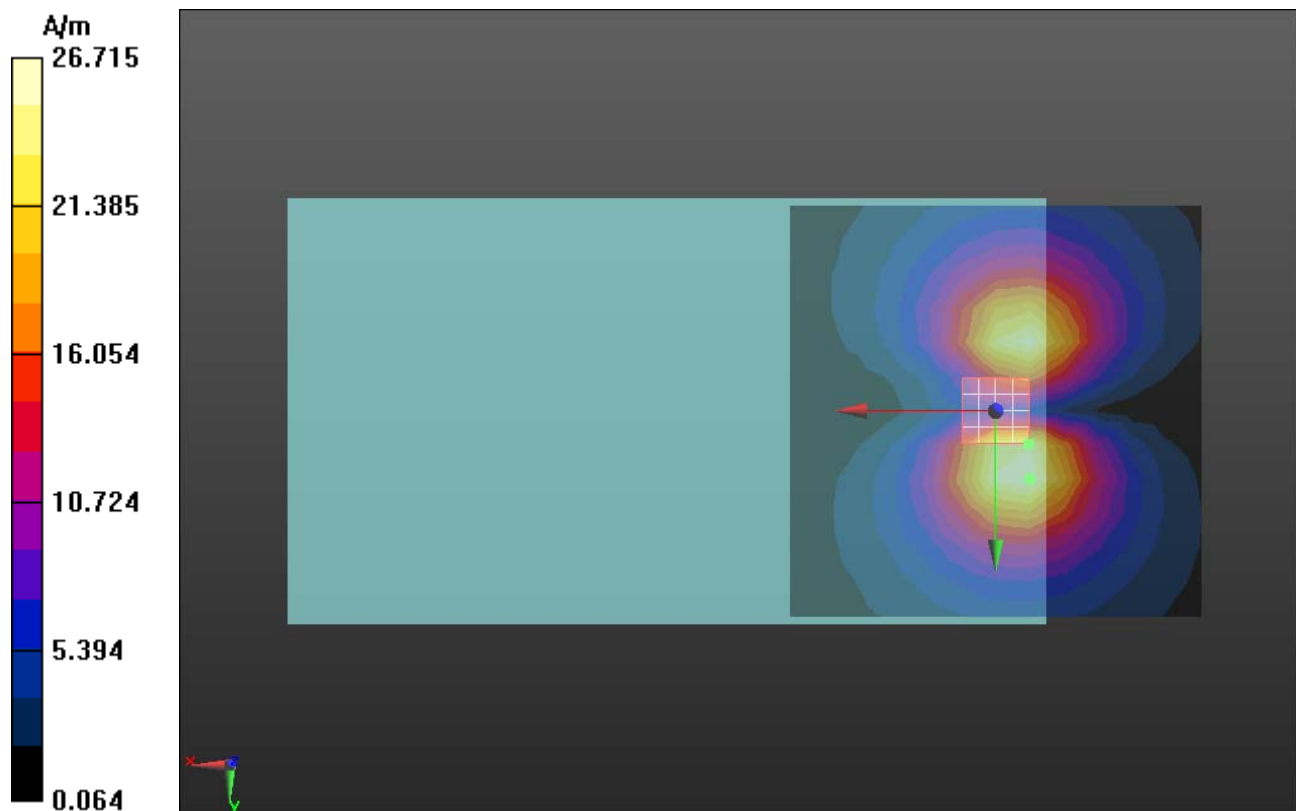
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/z (axial) fine 2mm 8 x 8/ABM [HAC-2007] SNR(x,y,z) (5x5x1):

ABM1/ABM2 = 52.68 dB

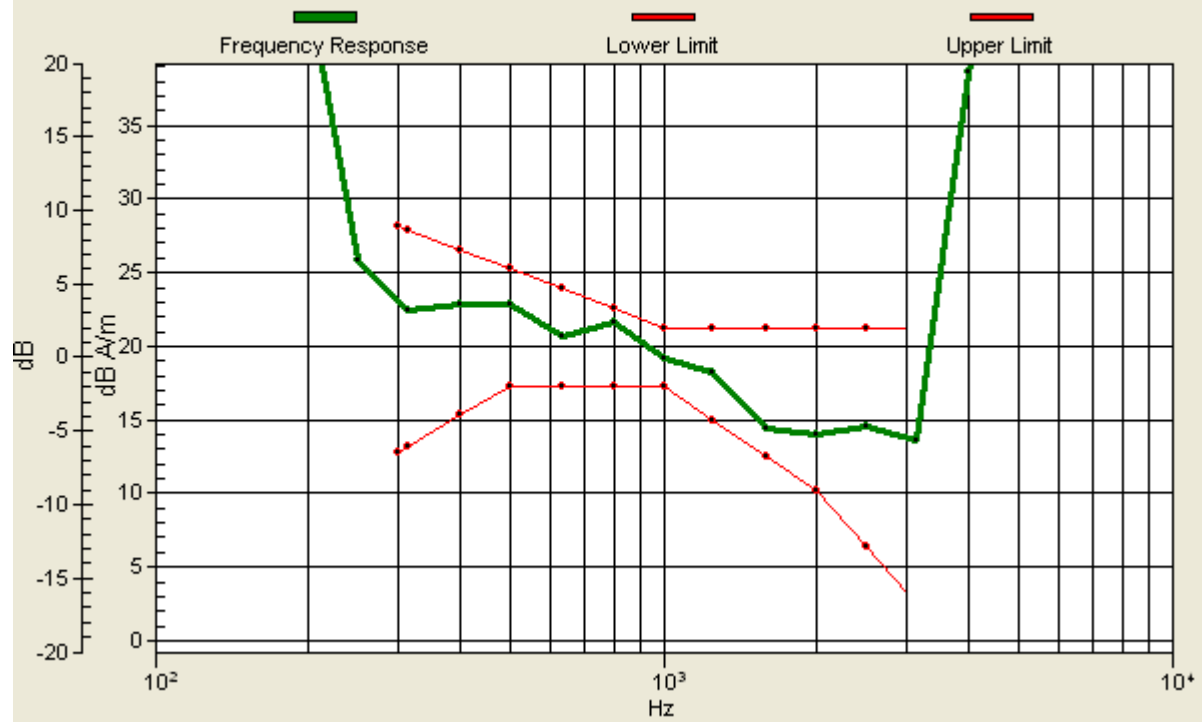
ABM1 comp = 27.72 dB A/m

Location: -4, 4, 3.7 mm



Scans/z (axial) wideband at best S/N/ABM [HAC-2007] Freq Resp(x,y,z,f)

Loc: 0, 0, 3 mm Diff: 0.88dB



#01 HAC T-Coil_GSM850_Ch128_Radial 1(X)**DUT: 191701**

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

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

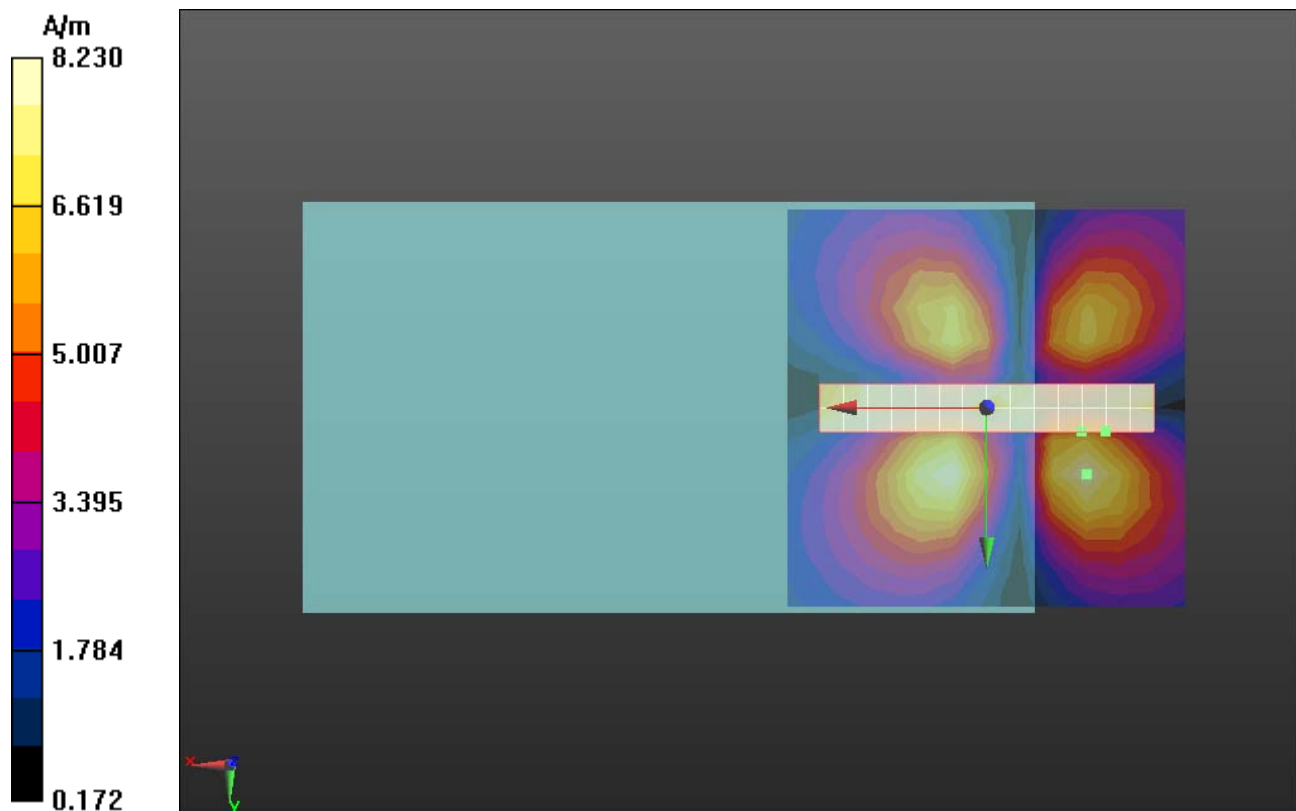
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/x (longitudinal) fine 3mm 42 x 6/ABM [HAC-2007] SNR(x,y,z) (15x3x1):

ABM1/ABM2 = 28.53 dB

ABM1 comp = 12.21 dB A/m

Location: -15, 3, 3.7 mm



#01 HAC T-Coil_GSM850_Ch128_Radial 2(Y)**DUT: 191701**

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

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

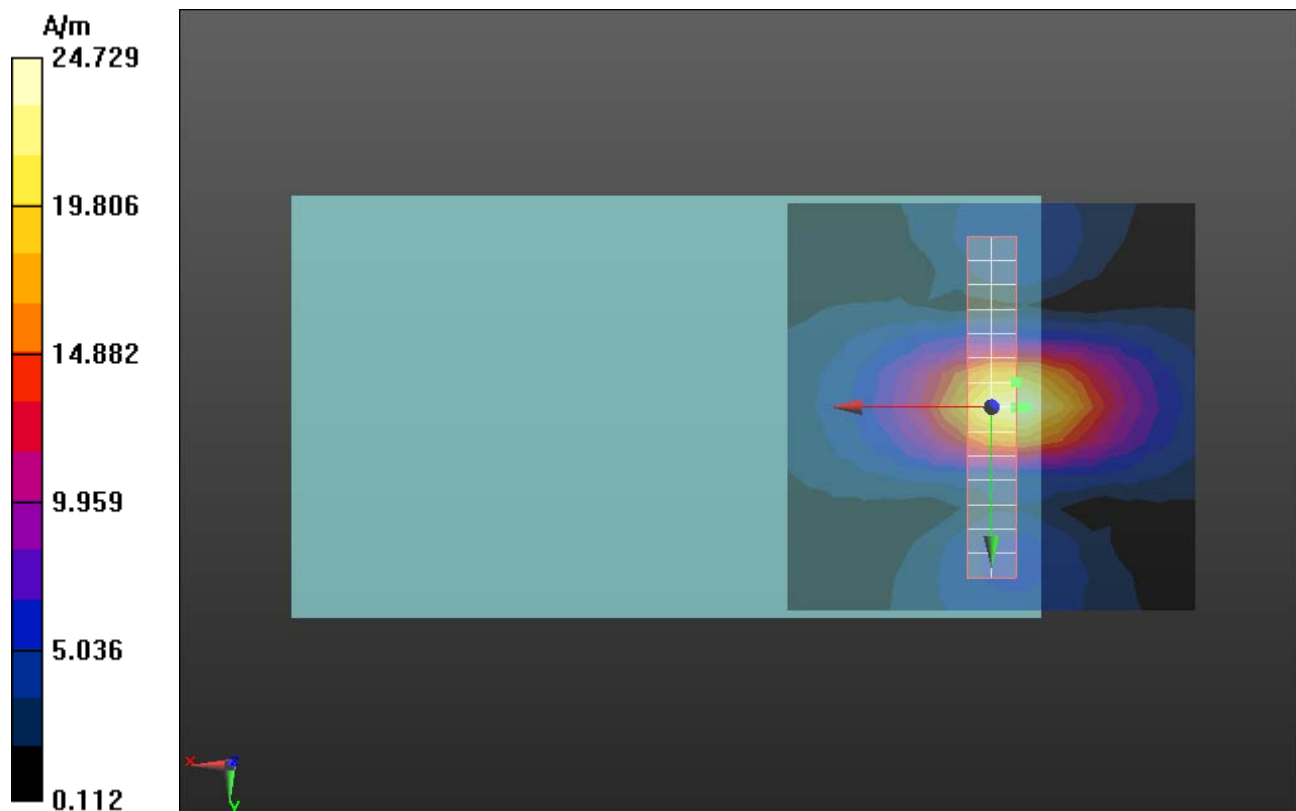
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/y (transversal) fine 3mm 6 x 42/ABM [HAC-2007] SNR(x,y,z) (3x15x1):

ABM1/ABM2 = 66.22 dB

ABM1 comp = 27.63 dB A/m

Location: -3, -3, 3.7 mm



#02 HAC T-Coil_GSM850_Ch189_Axial(Z)**DUT: 191701**

Communication System: Generic GSM; Frequency: 836.4 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

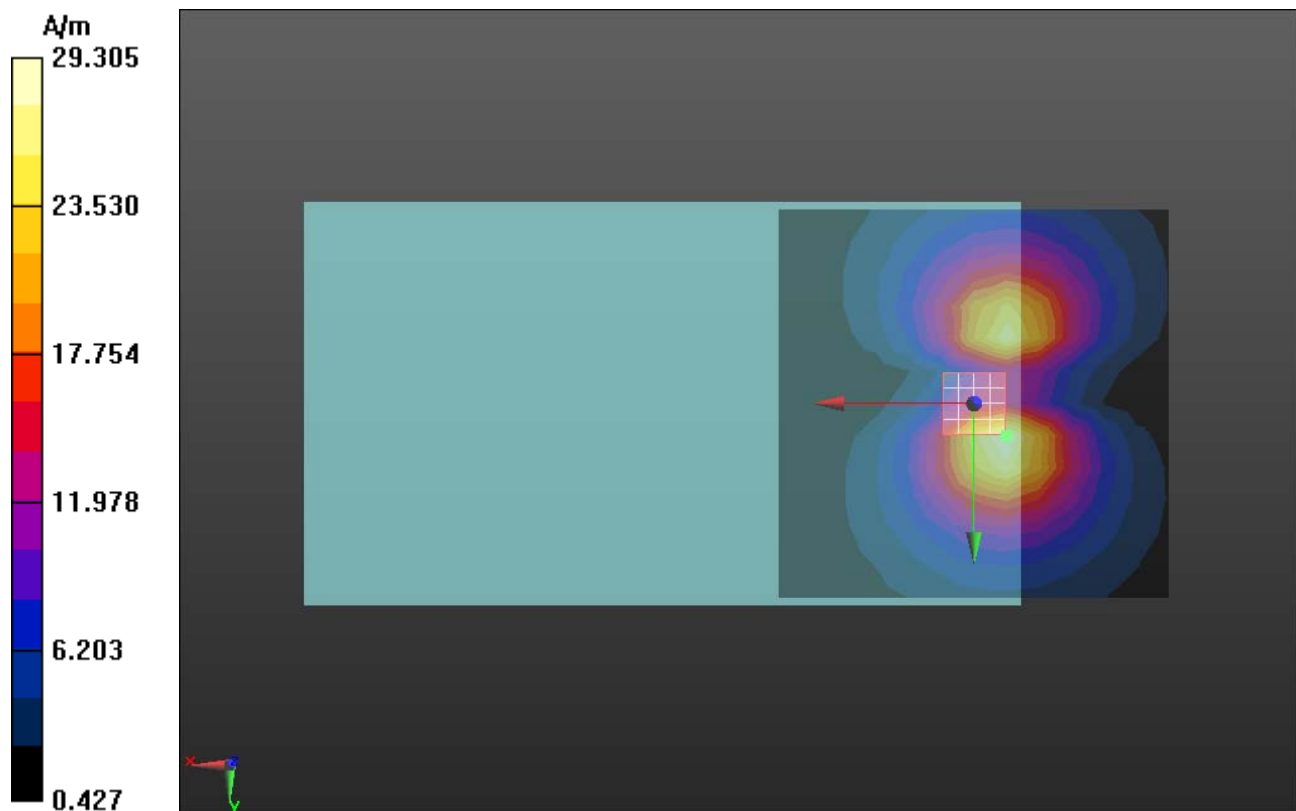
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/z (axial) fine 2mm 8 x 8/ABM [HAC-2007] SNR(x,y,z) (5x5x1):

ABM1/ABM2 = 56.27 dB

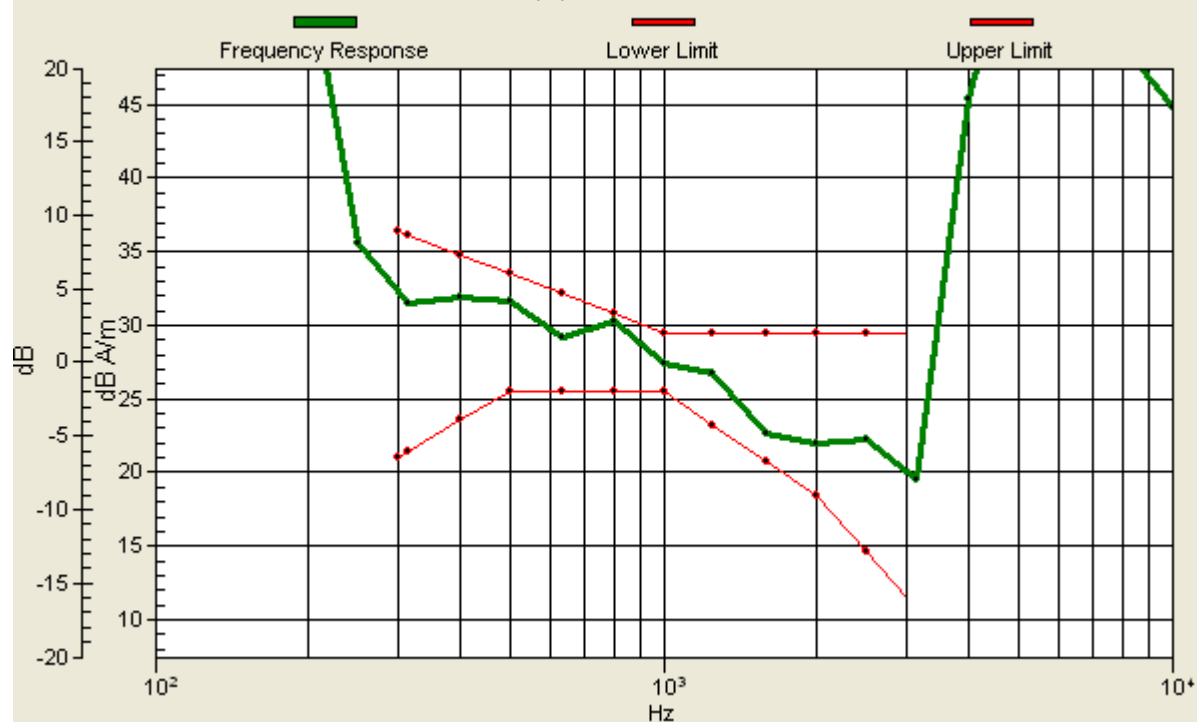
ABM1 comp = 30.95 dB A/m

Location: -4, 4, 3.7 mm



Scans/z (axial) wideband at best S/N/ABM [HAC-2007] Freq Resp(x,y,z,f)

Loc: 0, 0, 3 mm Diff: 0.49dB



#02 HAC T-Coil_GSM850_Ch189_Radial 1(X)**DUT: 191701**

Communication System: Generic GSM; Frequency: 836.4 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

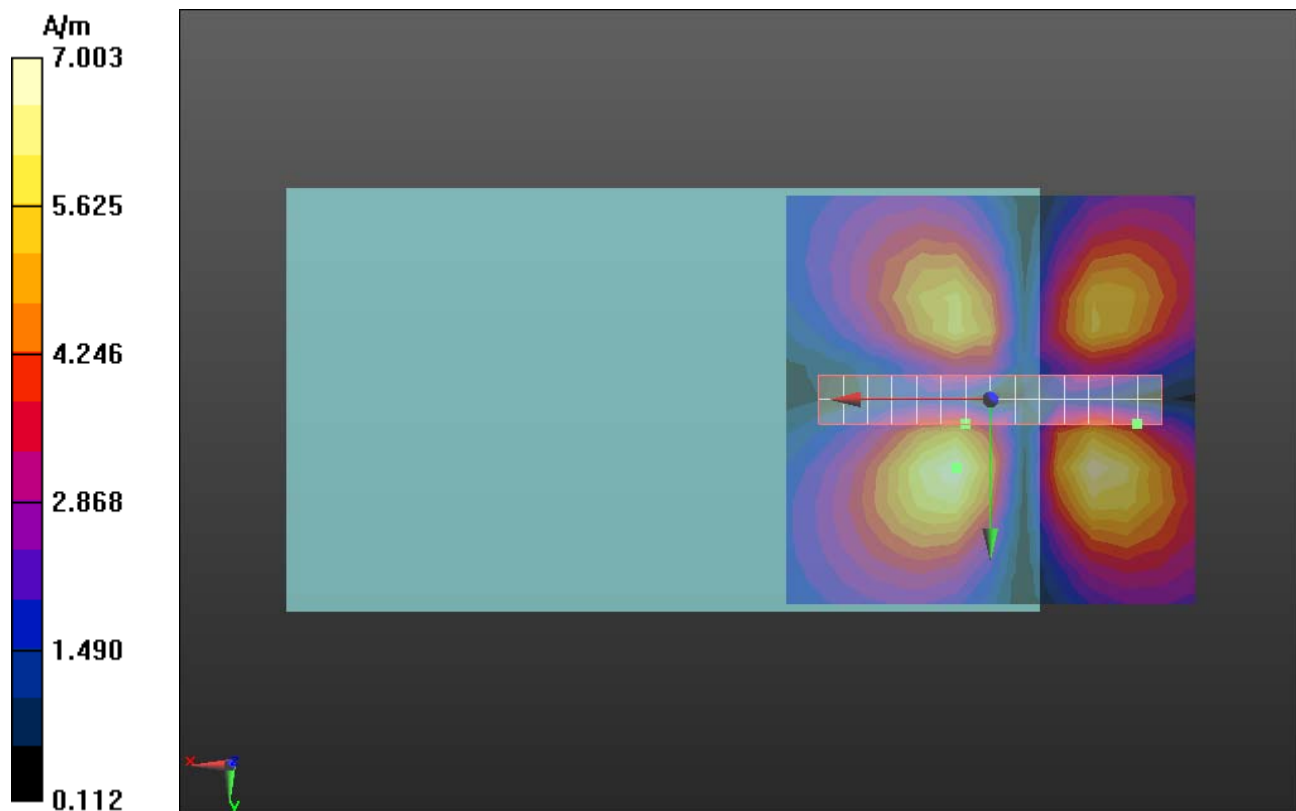
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/x (longitudinal) fine 3mm 42 x 6/ABM [HAC-2007] SNR(x,y,z) (15x3x1):

ABM1/ABM2 = 25.90 dB

ABM1 comp = 8.73 dB A/m

Location: -18, 3, 3.7 mm



#02 HAC T-Coil_GSM850_Ch189_Radial 2(Y)**DUT: 191701**

Communication System: Generic GSM; Frequency: 836.4 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

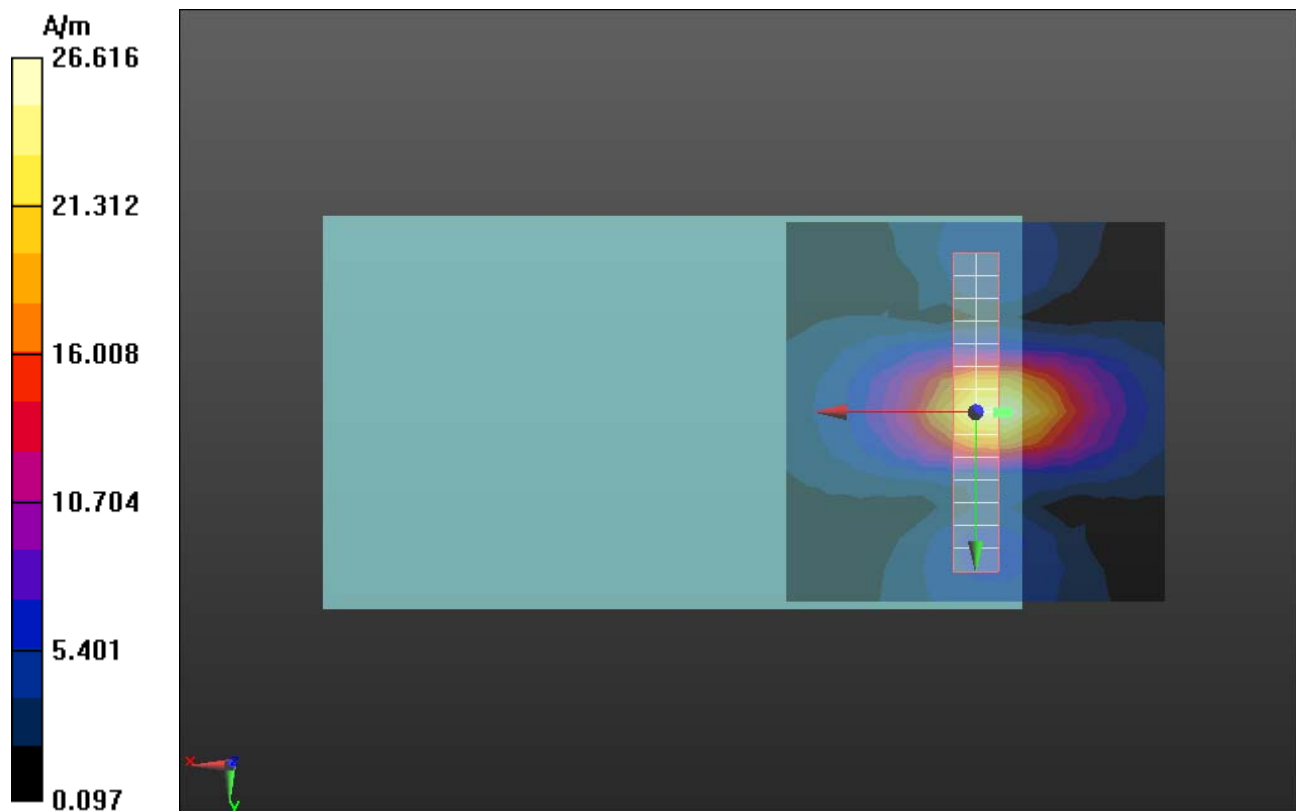
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/y (transversal) fine 3mm 6 x 42/ABM [HAC-2007] SNR(x,y,z) (3x15x1):

ABM1/ABM2 = 65.26 dB

ABM1 comp = 28.78 dB A/m

Location: -3, 0, 3.7 mm



#03 HAC T-Coil_GSM850_Ch251_Axial(Z)

DUT: 191701

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

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

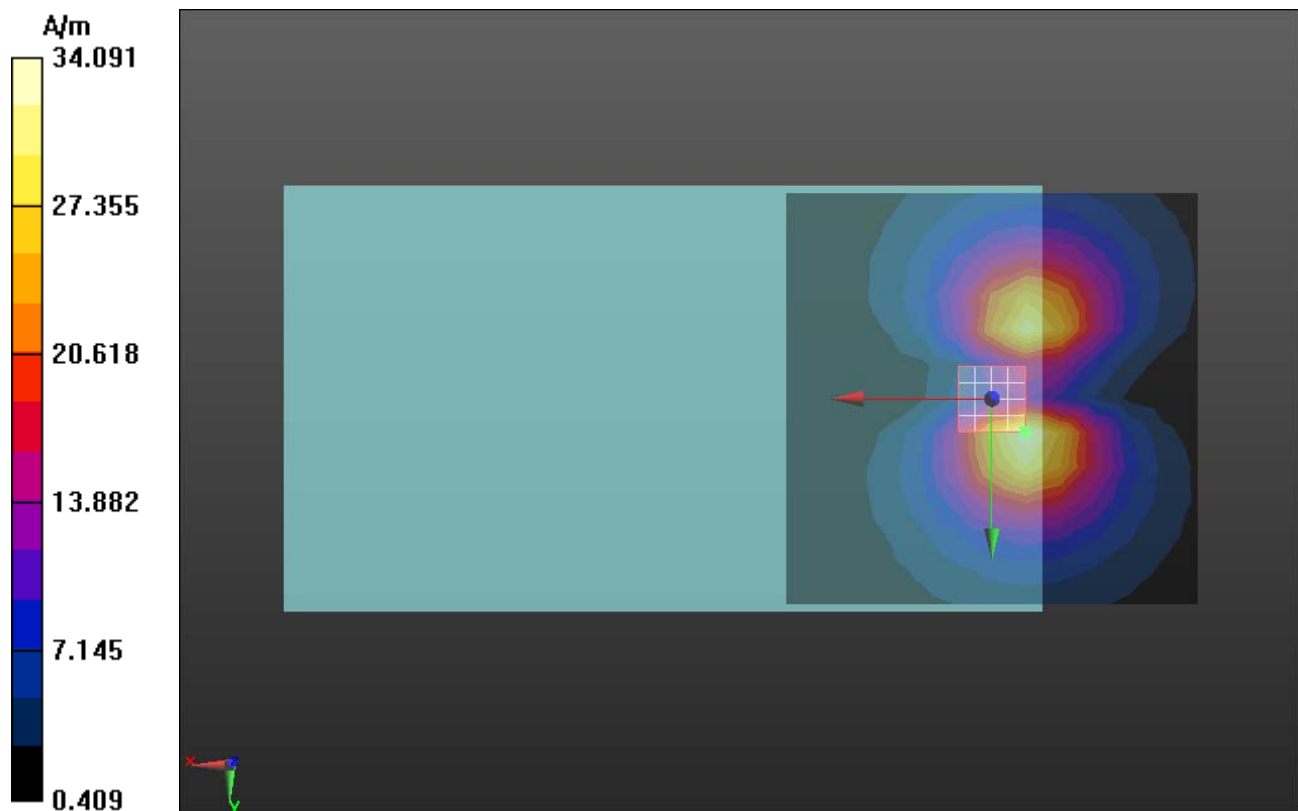
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/z (axial) fine 2mm 8 x 8/ABM [HAC-2007] SNR(x,y,z) (5x5x1):

ABM1/ABM2 = 56.43 dB

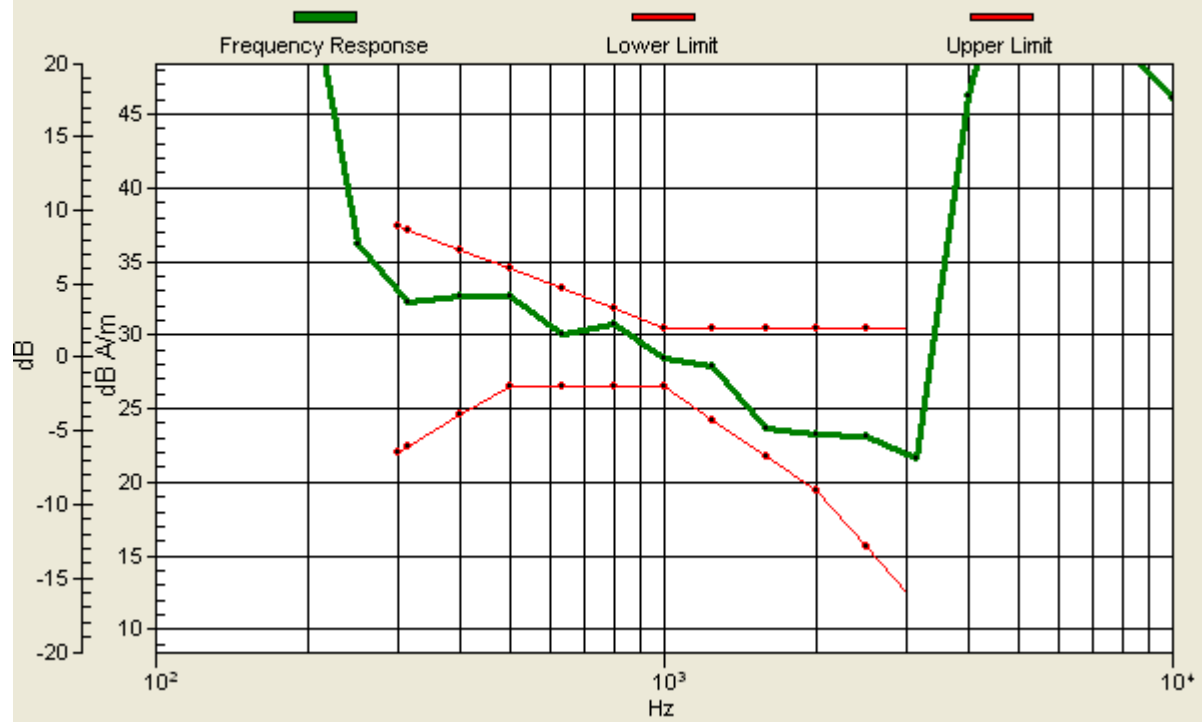
ABM1 comp = 30.91 dB A/m

Location: -4, 4, 3.7 mm



Scans/z (axial) wideband at best S/N/ABM [HAC-2007] Freq Resp(x,y,z,f)

Loc: 0, 0, 3 mm Diff: 1.01dB



#03 HAC T-Coil_GSM850_Ch251_Radial 1(X)**DUT: 191701**

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

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

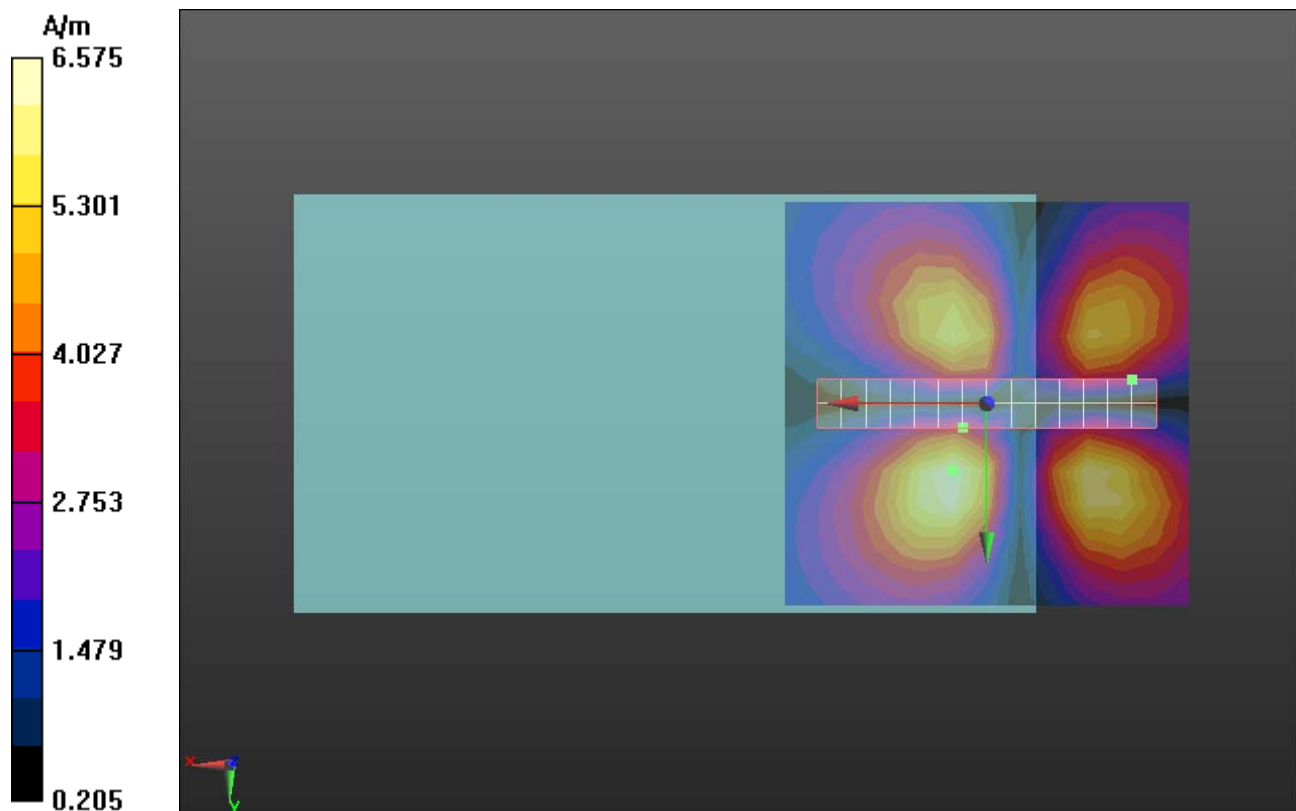
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/x (longitudinal) fine 3mm 42 x 6/ABM [HAC-2007] SNR(x,y,z) (15x3x1):

ABM1/ABM2 = 25.01 dB

ABM1 comp = 7.91 dB A/m

Location: -18, -3, 3.7 mm



#03 HAC T-Coil_GSM850_Ch251_Radial 2(Y)**DUT: 191701**

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

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

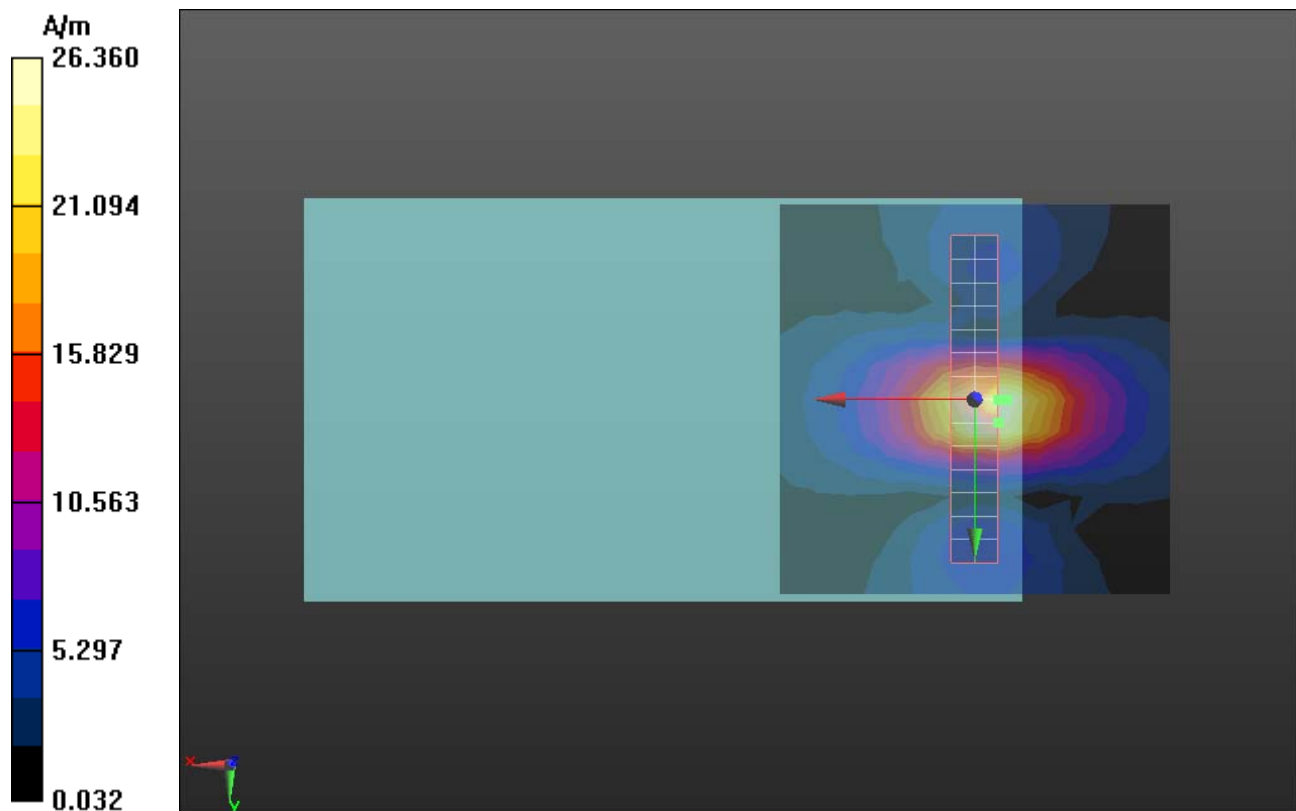
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/y (transversal) fine 3mm 6 x 42/ABM [HAC-2007] SNR(x,y,z) (3x15x1):

ABM1/ABM2 = 67.71 dB

ABM1 comp = 28.59 dB A/m

Location: -3, 0, 3.7 mm



#04 HAC T-Coil_GSM1900_Ch512_Axial(Z)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1850.2 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

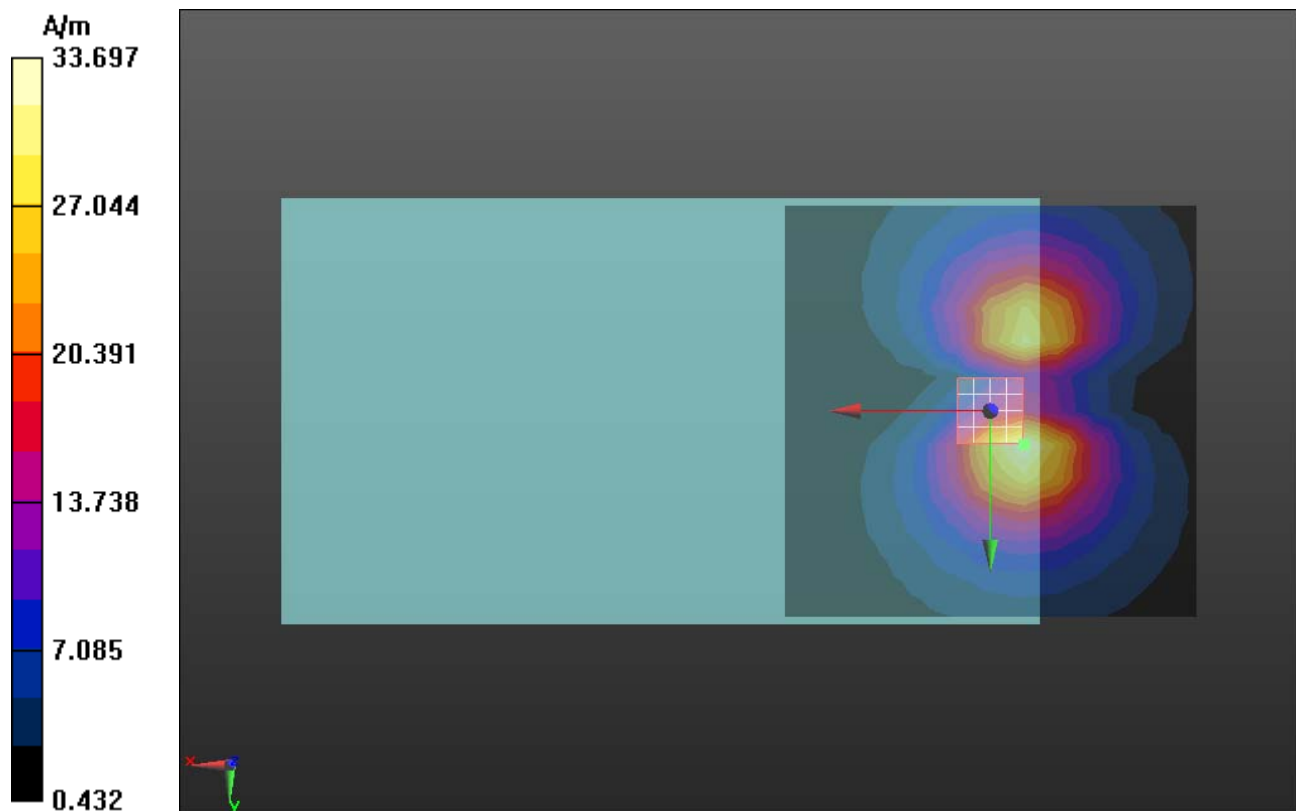
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/z (axial) fine 2mm 8 x 8/ABM [HAC-2007] SNR(x,y,z) (5x5x1):

ABM1/ABM2 = 59.26 dB

ABM1 comp = 30.73 dB A/m

Location: -4, 4, 3.7 mm



Scans/z (axial) wideband at best S/N/ABM [HAC-2007] Freq Resp(x,y,z,f)

Loc: 0, 0, 3 mm Diff: 0.77dB



#04 HAC T-Coil_GSM1900_Ch512_Radial 1(X)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1850.2 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

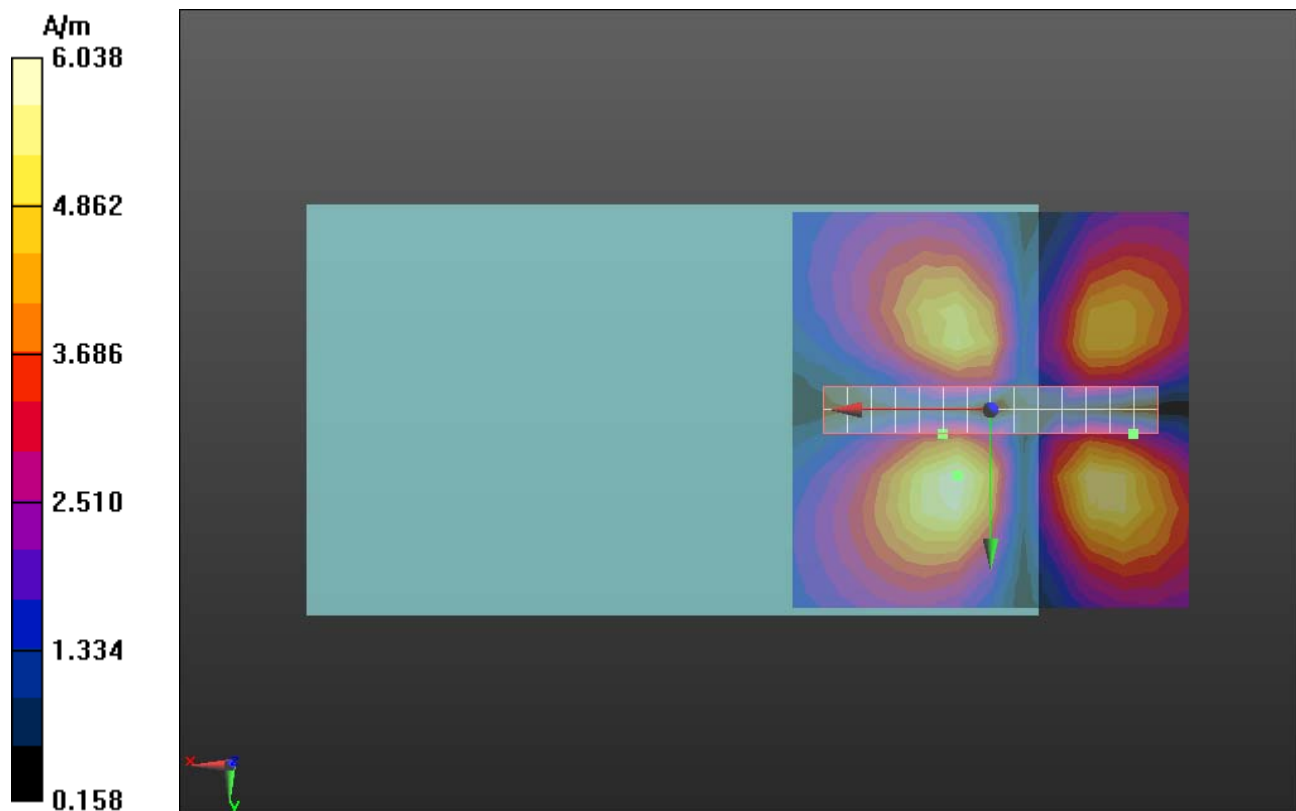
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/x (longitudinal) fine 3mm 42 x 6/ABM [HAC-2007] SNR(x,y,z) (15x3x1):

ABM1/ABM2 = 29.06 dB

ABM1 comp = 7.99 dB A/m

Location: -18, 3, 3.7 mm



#04 HAC T-Coil_GSM1900_Ch512_Radial 2(Y)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1850.2 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

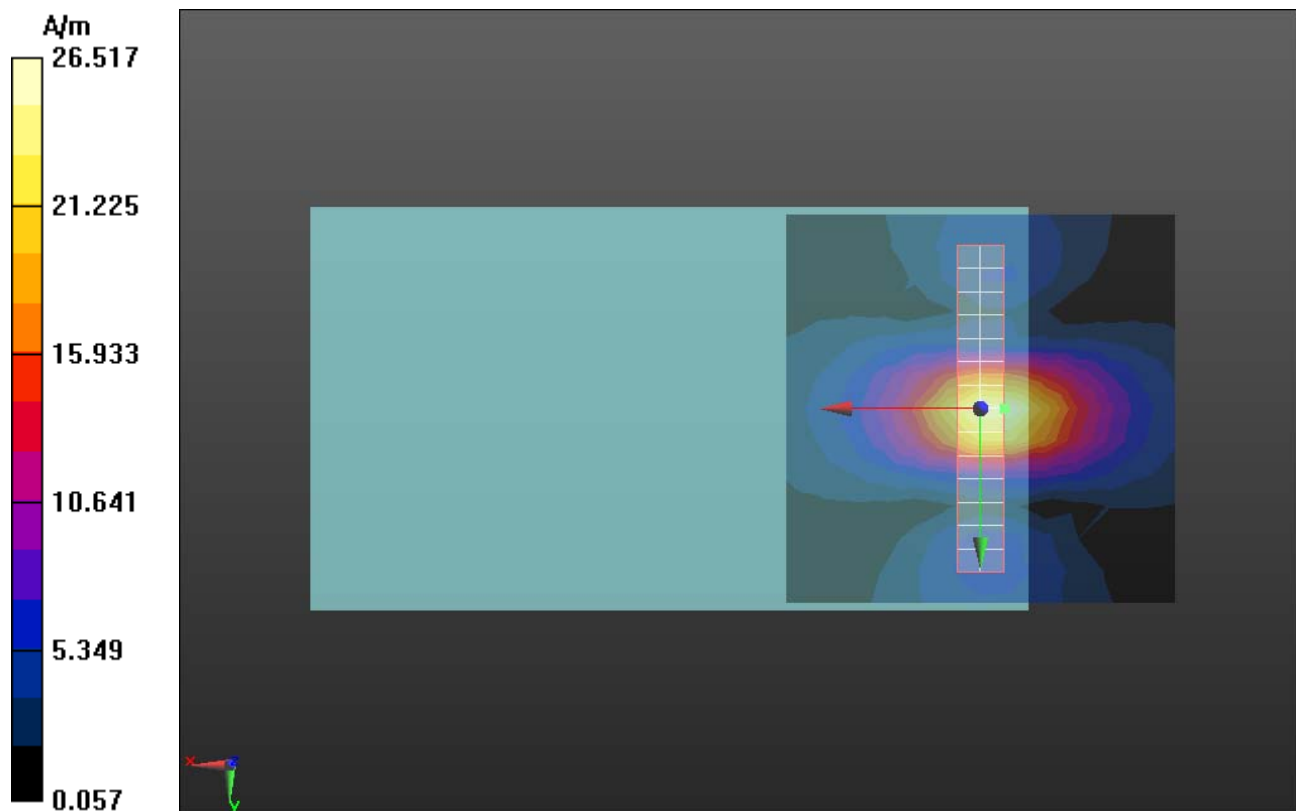
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/y (transversal) fine 3mm 6 x 42/ABM [HAC-2007] SNR(x,y,z) (3x15x1):

ABM1/ABM2 = 67.75 dB

ABM1 comp = 28.56 dB A/m

Location: -3, 0, 3.7 mm



#05 HAC T-Coil_GSM1900_Ch661_Axial(Z)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1880 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

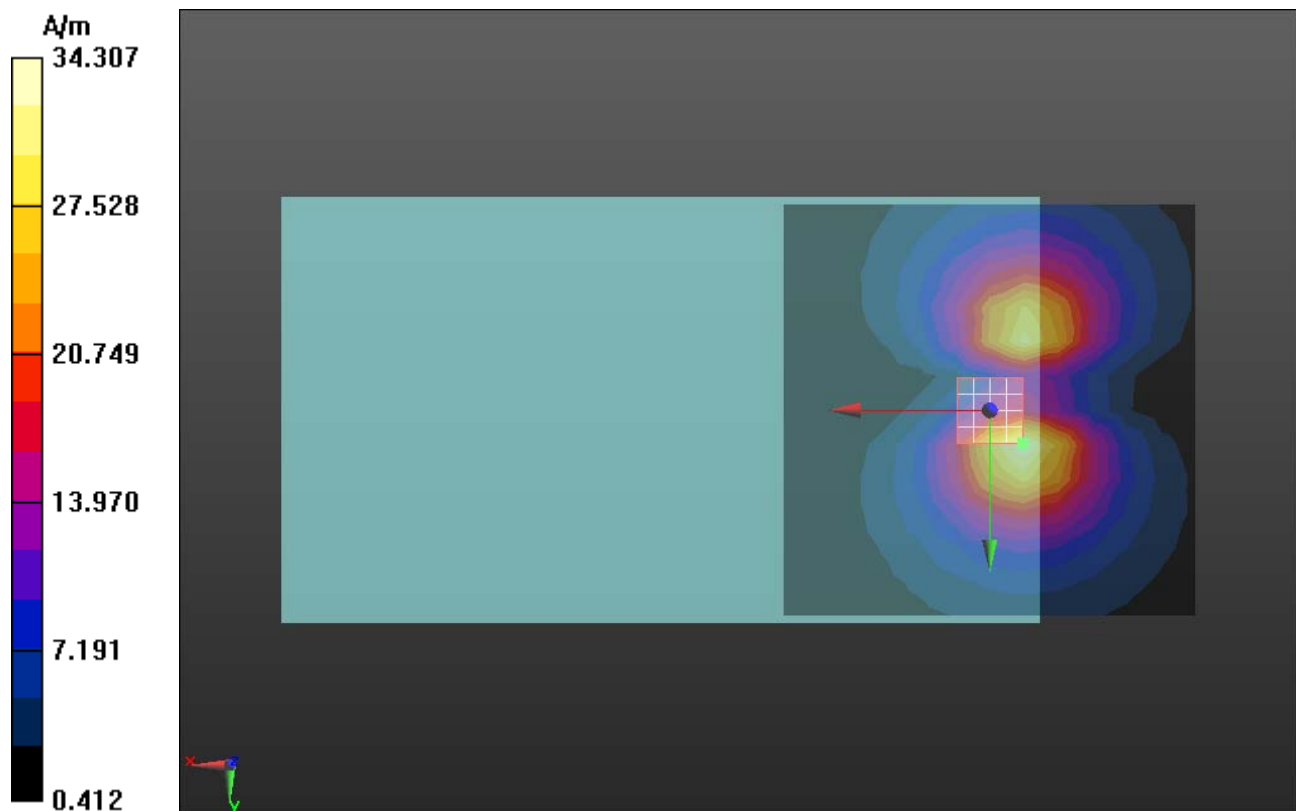
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/z (axial) fine 2mm 8 x 8/ABM [HAC-2007] SNR(x,y,z) (5x5x1):

ABM1/ABM2 = 59.52 dB

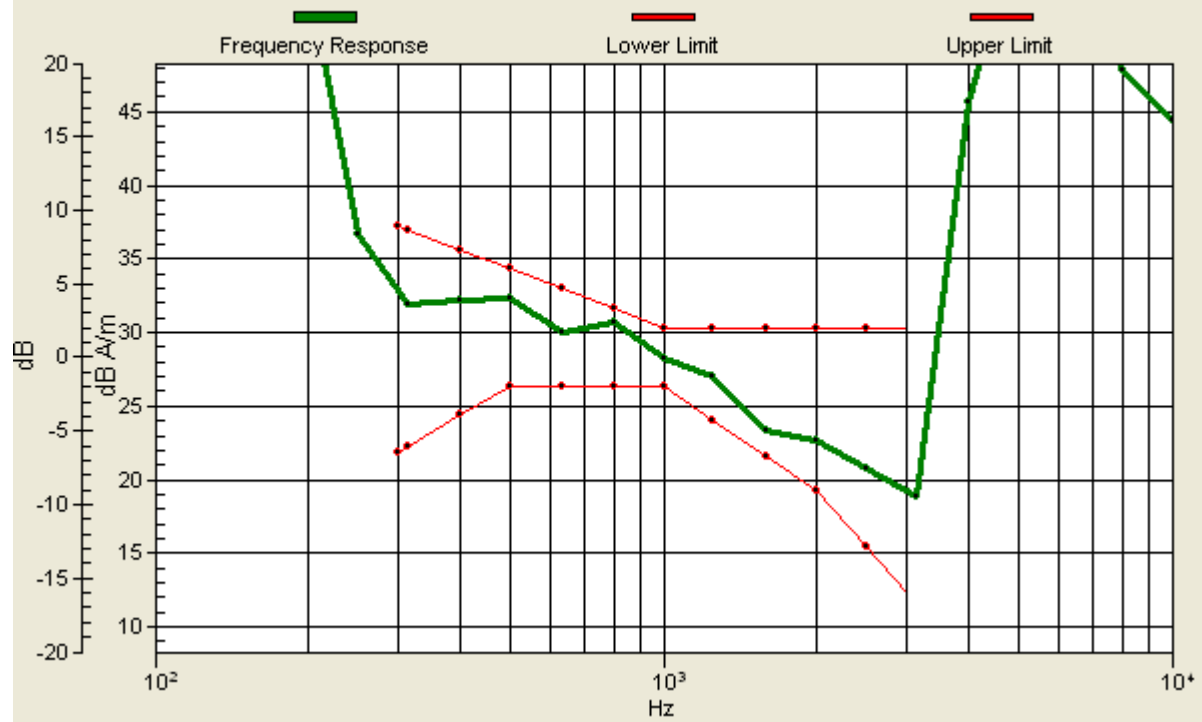
ABM1 comp = 30.63 dB A/m

Location: -4, 4, 3.7 mm



Scans/z (axial) wideband at best S/N/ABM [HAC-2007] Freq Resp(x,y,z,f)

Loc: 0, 0, 3 mm Diff: 0.94dB



#05 HAC T-Coil_GSM1900_Ch661_Radial 1(X)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1880 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

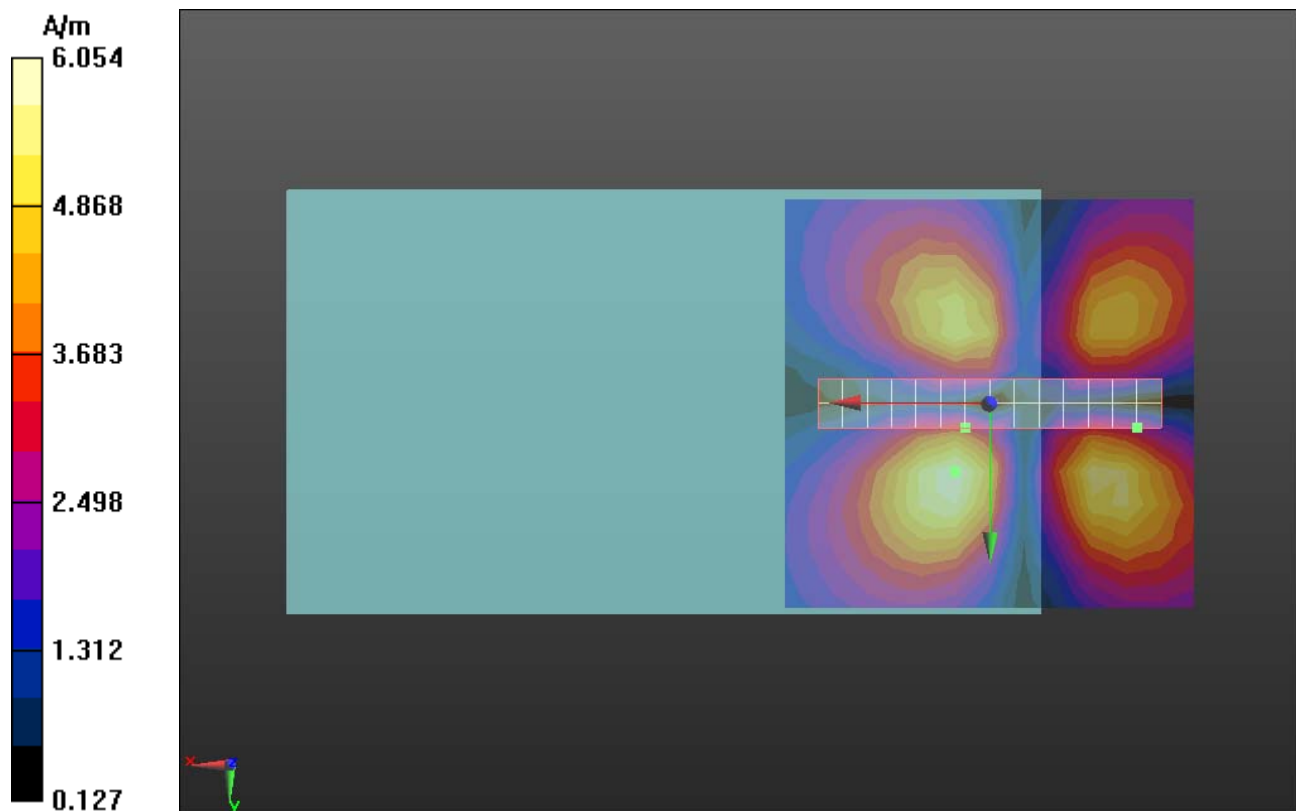
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/x (longitudinal) fine 3mm 42 x 6/ABM [HAC-2007] SNR(x,y,z) (15x3x1):

ABM1/ABM2 = 29.17 dB

ABM1 comp = 8.07 dB A/m

Location: -18, 3, 3.7 mm



#05 HAC T-Coil_GSM1900_Ch661_Radial 2(Y)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1880 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

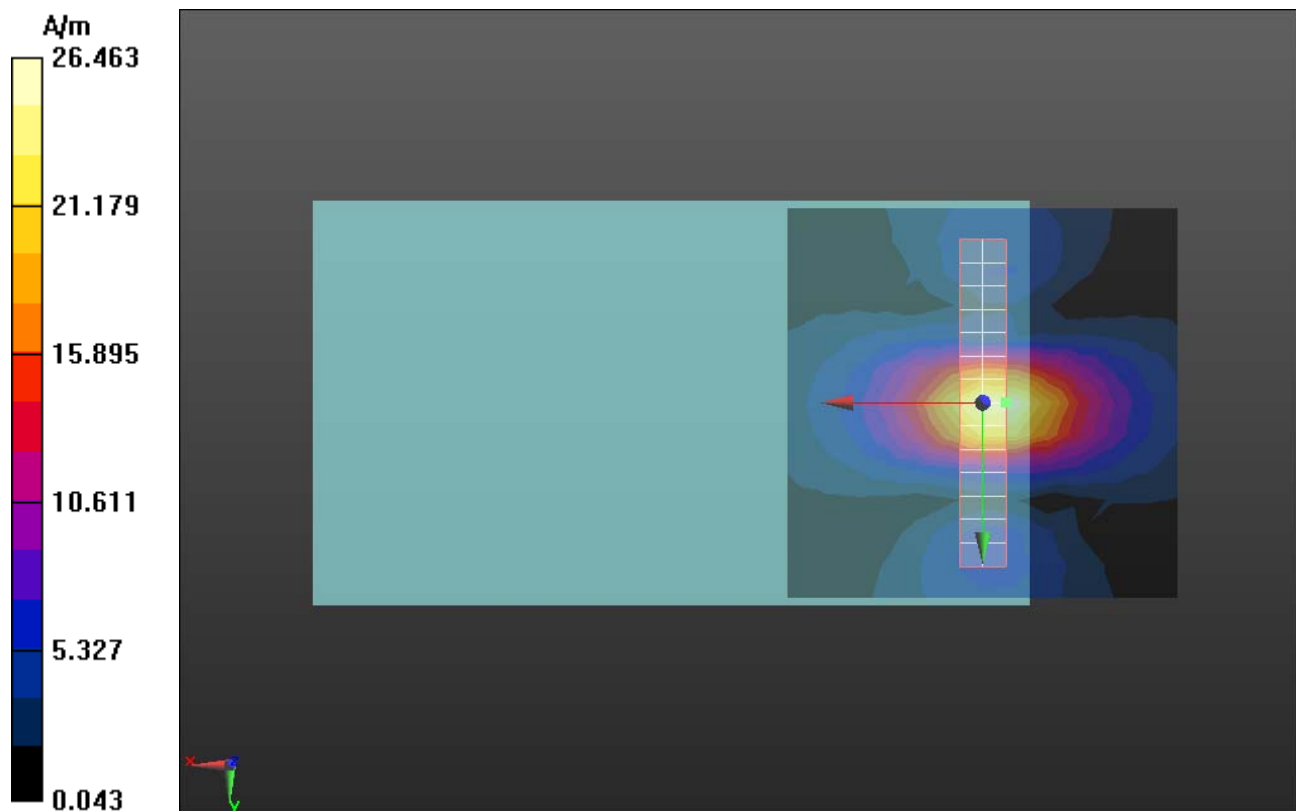
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/y (transversal) fine 3mm 6 x 42/ABM [HAC-2007] SNR(x,y,z) (3x15x1):

ABM1/ABM2 = 67.50 dB

ABM1 comp = 28.44 dB A/m

Location: -3, 0, 3.7 mm



#06 HAC T-Coil_GSM1900_Ch810_Axial(Z)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1909.8 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

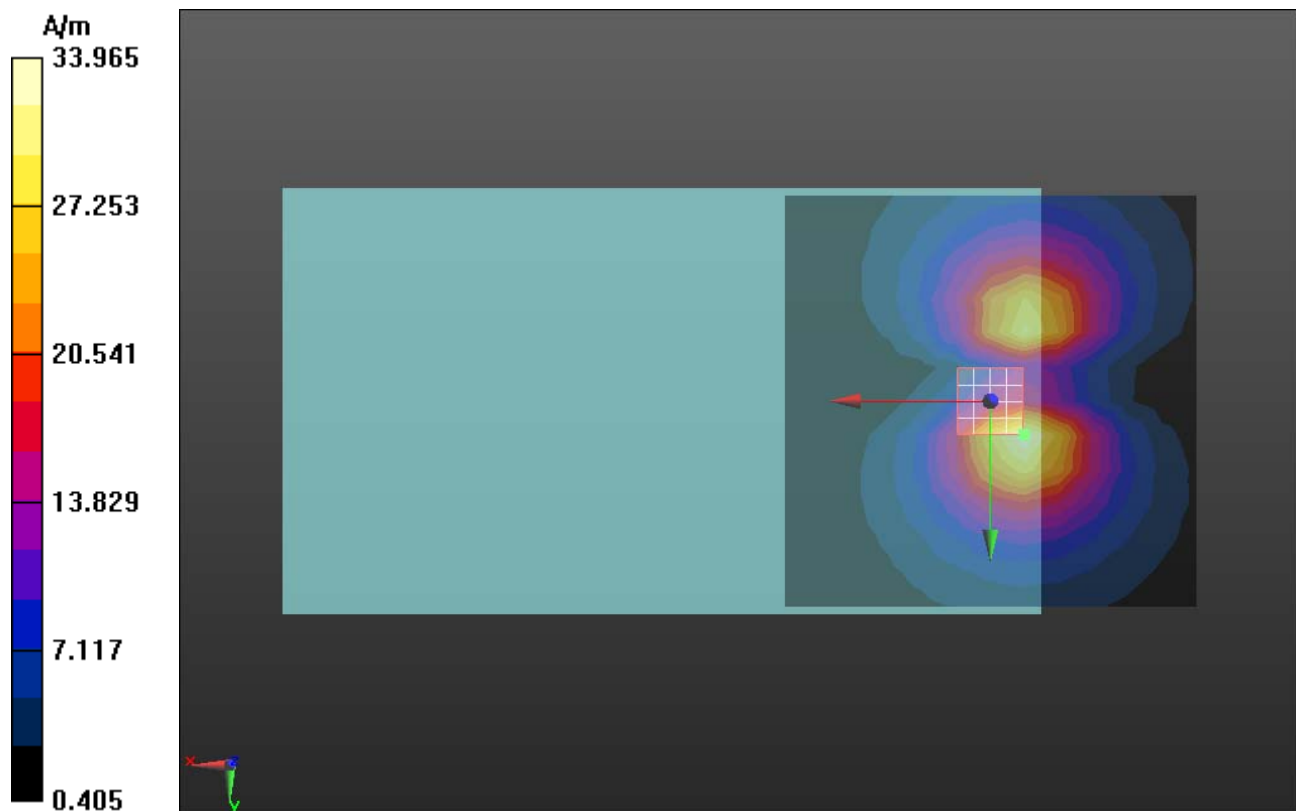
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/z (axial) fine 2mm 8 x 8/ABM [HAC-2007] SNR(x,y,z) (5x5x1):

ABM1/ABM2 = 59.89 dB

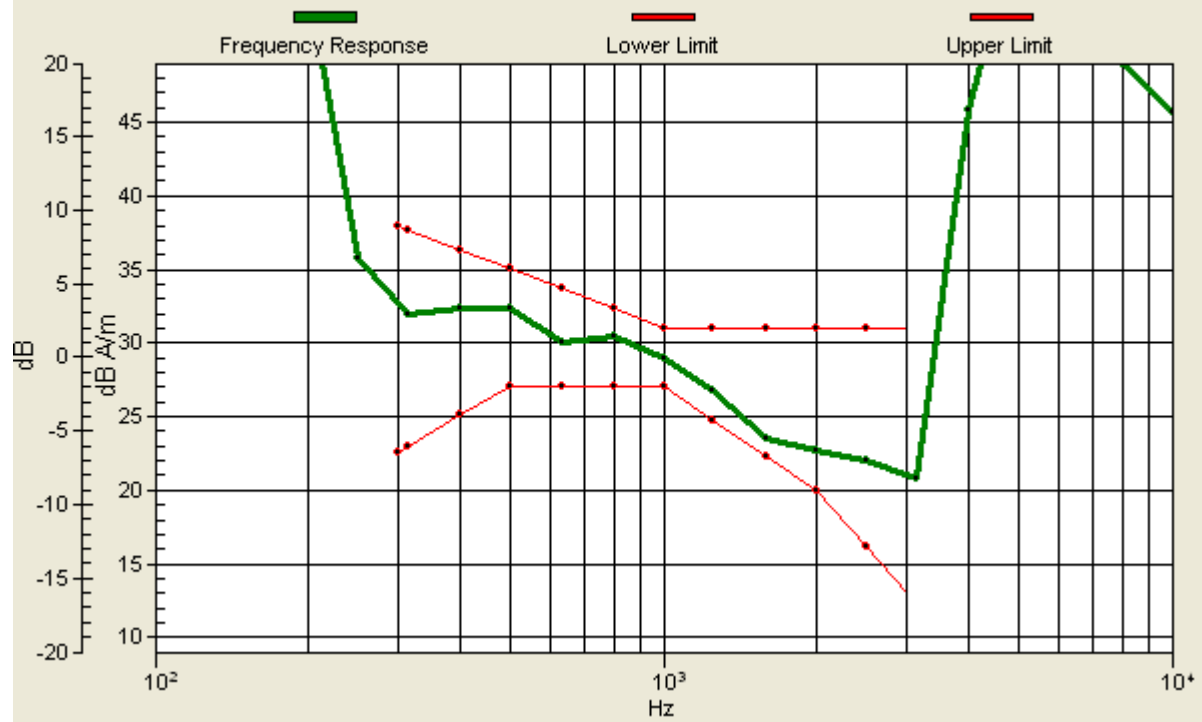
ABM1 comp = 30.69 dB A/m

Location: -4, 4, 3.7 mm



Scans/z (axial) wideband at best S/N/ABM [HAC-2007] Freq Resp(x,y,z,f)

Loc: 0, 0, 3 mm Diff: 1.22dB



#06 HAC T-Coil_GSM1900_Ch810_Radial 1(X)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1909.8 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

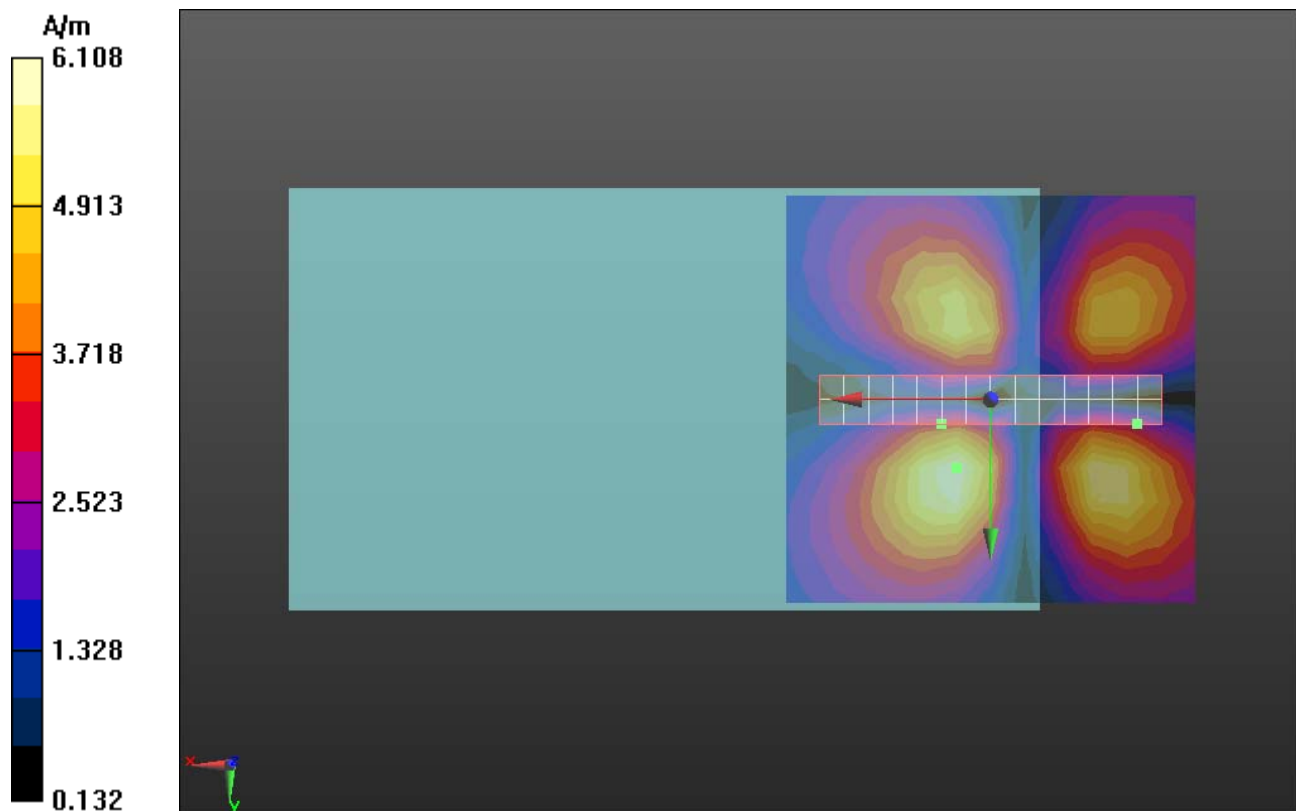
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/x (longitudinal) fine 3mm 42 x 6/ABM [HAC-2007] SNR(x,y,z) (15x3x1):

ABM1/ABM2 = 29.53 dB

ABM1 comp = 8.03 dB A/m

Location: -18, 3, 3.7 mm



#06 HAC T-Coil_GSM1900_Ch810_Radial 2(Y)**DUT: 191701**

Communication System: Generic GSM; Frequency: 1909.8 MHz; Duty Cycle: 1:8.3

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

Ambient Temperature : 22.5 °C

DASY5 Configuration:

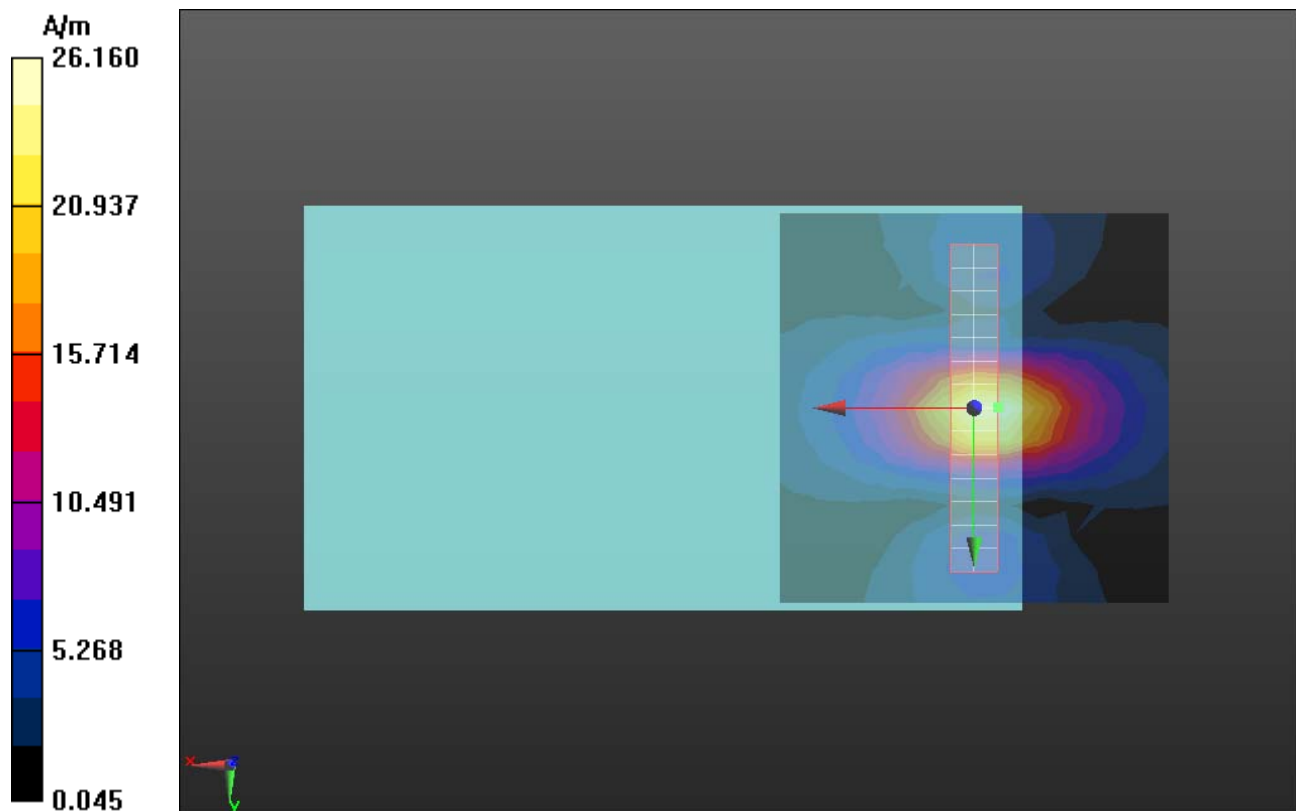
- Probe: AM1DV3 - 3093; ; Calibrated: 2011-4-13
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1210; Calibrated: 2010-11-18
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.6 (2); SEMCAD X Version 14.4.5 (3634)

Scans/y (transversal) fine 3mm 6 x 42/ABM [HAC-2007] SNR(x,y,z) (3x15x1):

ABM1/ABM2 = 68.28 dB

ABM1 comp = 28.59 dB A/m

Location: -3, 0, 3.7 mm





Appendix B. Calibration Data

The DASy calibration certificates are shown as follows.



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 108**

Client **Sporton Kunshan (Auden)**

Certificate No: **CD835V3-1171_May11**

CALIBRATION CERTIFICATE

Object **CD835V3 - SN: 1171**

Calibration procedure(s) **QA CAL-20.v5
 Calibration procedure for dipoles in air**

Calibration date: **May 02, 2011**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
 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 EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Probe ER3DV6	SN: 2336	29-Dec-10 (No. ER3-2336_Dec10)	Dec-11
Probe H3DV6	SN: 6065	29-Dec-10 (No. H3-6065_Dec10)	Dec-11
DAE4	SN: 781	20-Apr-11 (No. DAE4-781_Apr11)	Apr-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-10)	In house check: Oct-11
Power sensor HP 8482H	SN: 3318A09450	09-Oct-09 (in house check Oct-10)	In house check: Oct-11
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-10)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-10)	In house check: Oct-11
RF generator E4433B	MY 41000675	03-Nov-04 (in house check Oct-09)	In house check: Oct-11

	Name	Function	Signature
Calibrated by:	Jeton Kastrati	Laboratory Technician	
Approved by:	Fin Bornholt	R&D Director	

Issued: May 9, 2011

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 108**

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

References

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

Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the top 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 10 mm (in z) above the 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, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

1 Measurement Conditions

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

DASY Version	DASY5	V52.6.2 (424)
DASY PP Version	SEMCAD X	V14.4.4 (2829)
Phantom	HAC Test Arch	SD HAC P01 BA, #1070
Distance Dipole Top - Probe Center	10 mm	
Scan resolution	dx, dy = 5 mm	area = 20 x 180 mm
Frequency	835 MHz $\pm$ 1 MHz	
Forward power at dipole connector	20.0 dBm = 100mW	
Input power drift	< 0.05 dB	

2 Maximum Field values

H-field 10 mm above dipole surface	condition	interpolated maximum
Maximum measured	100 mW forward power	0.474 A/m

Uncertainty for H-field measurement: 8.2% (k=2)

E-field 10 mm above dipole surface	condition	Interpolated maximum
Maximum measured above high end-	100 mW forward power	168.0 V/m
Maximum measured above low end	100 mW forward power	162.5 V/m
Averaged maximum above arm	100 mW forward power	165.3 V/m

Uncertainty for E-field measurement: 12.8% (k=2)

3 Appendix

3.1 Antenna Parameters

Frequency	Return Loss	Impedance
800 MHz	17.2 dB	(43.2 - j11.1) Ohm
835 MHz	24.6 dB	(48.9 + j5.7) Ohm
900 MHz	16.7 dB	(58.2 - j13.7) Ohm
950 MHz	22.9 dB	(46.3 + j5.9) Ohm
960 MHz	17.0 dB	(52.4 + j14.4) Ohm

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.

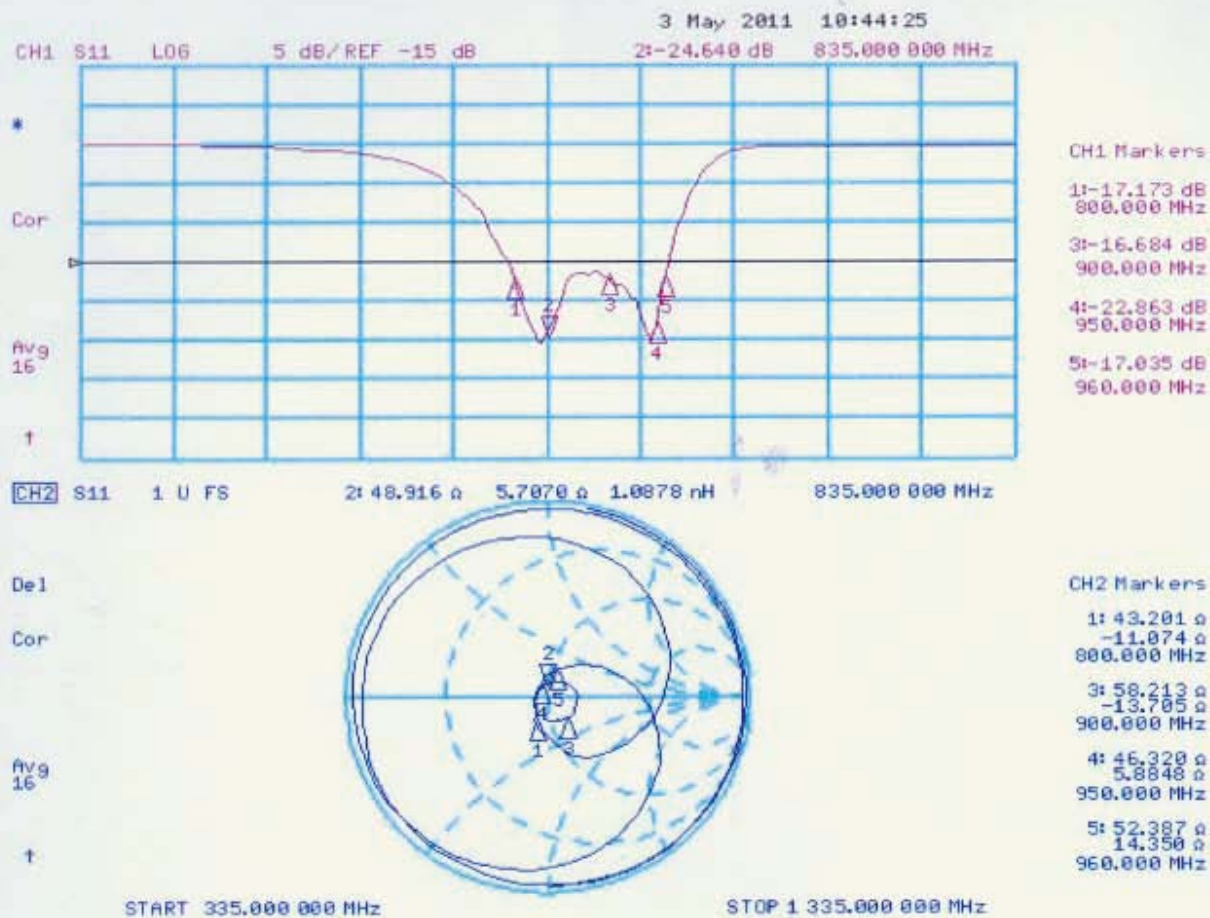
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

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.

3.3 Measurement Sheets

3.3.1 Return Loss and Smith Chart



3.3.2 DASY4 H-field Result

Date/Time: 02.05.2011 14:16:10

Test Laboratory: SPEAG Lab2

HAC RF_CD835_1171_H_110502_CL

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: 1171

Communication System: CW; Frequency: 835 MHz

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

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 29.12.2010
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 20.04.2011
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- Measurement SW: DASY52, V52.6.2 Build (424)
- Postprocessing SW: SEMCAD X, V14.4.4 Build (2829)

Dipole H-Field measurement @ 835MHz/H Scan - measurement distance from the probe sensor center to CD835

Dipole = 10mm/Hearing Aid Compatibility Test (41x361x1): Measurement grid: dx=5mm, dy=5mm

Maximum value of peak Total field = 0.474 A/m

Probe Modulation Factor = 1.000

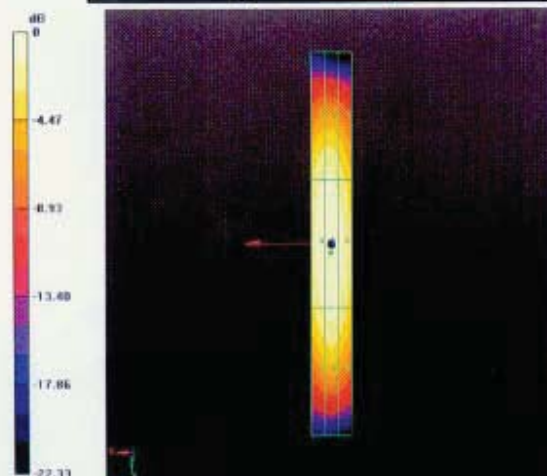
Device Reference Point: 0, 0, -6.3 mm

Reference Value = 0.503 A/m; Power Drift = 0.03 dB

Hearing Aid Near-Field Category: M4 (AWF 0 dB)

Peak H-field in A/m

Grid 1 0.403 M4	Grid 2 0.415 M4	Grid 3 0.383 M4
Grid 4 0.456 M4	Grid 5 0.474 M4	Grid 6 0.442 M4
Grid 7 0.403 M4	Grid 8 0.424 M4	Grid 9 0.397 M4



0 dB = 0.470 A/m

3.3.3 DASY4 E-field Result

Date/Time: 02.05.2011 11:43:42

Test Laboratory: SPEAG Lab2

HAC RF_CD835_1171_E_110502_CL

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: 1171

Communication System: CW; Frequency: 835 MHz

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

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 29.12.2010
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 20.04.2011
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- Measurement SW: DASY52, V52.6.2 Build (424)
- Postprocessing SW: SEMCAD X, V14.4.4 Build (2829)

Dipole E-Field measurement @ 835MHz/E Scan - measurement distance from the probe sensor center to CD835

Dipole = 10mm/Hearing Aid Compatibility Test (41x361x1): Measurement grid: dx=5mm, dy=5mm

Maximum value of peak Total field = 168.0 V/m

Probe Modulation Factor = 1.000

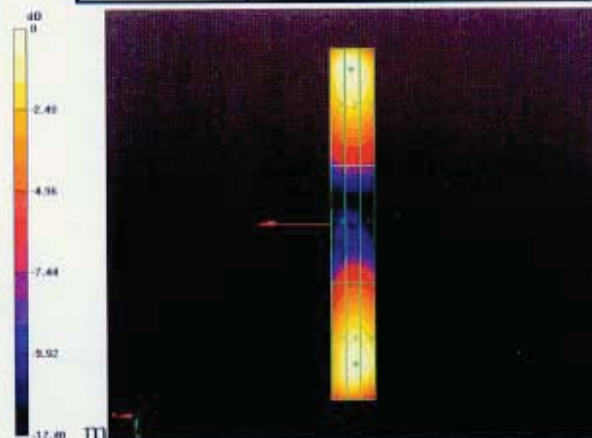
Device Reference Point: 0, 0, -6.3 mm

Reference Value = 125.4 V/m; Power Drift = -0.02 dB

Hearing Aid Near-Field Category: M4 (AWF 0 dB)

Peak E-field in V/m

Grid 1 164.0 M4	Grid 2 168.0 M4	Grid 3 162.2 M4
Grid 4 86.716 M4	Grid 5 91.288 M4	Grid 6 89.980 M4
Grid 7 153.2 M4	Grid 8 162.5 M4	Grid 9 159.9 M4



0 dB = 168.0V/m



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton Kunshan (Auden)**

Certificate No: **CD1880V3-1155_May11**

CALIBRATION CERTIFICATE

Object **CD1880V3 - SN: 1155**

Calibration procedure(s) **QA CAL-20.v5
Calibration procedure for dipoles in air**

Calibration date: **May 03, 2011**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
 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 EPM-442A	GB37480704	06-Oct-10 (No. 217-01266)	Oct-11
Power sensor HP 8481A	US37292783	06-Oct-10 (No. 217-01266)	Oct-11
Probe ER3DV6	SN: 2336	29-Dec-10 (No. ER3-2336_Dec10)	Dec-11
Probe H3DV6	SN: 6065	29-Dec-10 (No. H3-6065_Dec10)	Dec-11
DAE4	SN: 781	20-Apr-11 (No. DAE4-781_Apr11)	Apr-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-10)	In house check: Oct-11
Power sensor HP 8482H	SN: 3318A09450	09-Oct-09 (in house check Oct-10)	In house check: Oct-11
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-10)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-10)	In house check: Oct-11
RF generator E4433B	MY 41000675	03-Nov-04 (in house check Oct-09)	In house check: Oct-11

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

Issued: May 10, 2011

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 108**

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

References

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

Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the top 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 10 mm (in z) above the 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, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

1. Measurement Conditions

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

DASY Version	DASY5	V52.6.2 (424)
DASY PP Version	SEMCAD X	V14.4.4 (2829)
Phantom	HAC Test Arch	SD HAC P01 BA, #1070
Distance Dipole Top - Probe Center	10 mm	
Scan resolution	dx, dy = 5 mm	area = 20 x 90 mm
Frequency	1880 MHz $\pm$ 1 MHz	
Forward power at dipole connector	20.0 dBm = 100mW	
Input power drift	< 0.05 dB	

2. Maximum Field values

H-field 10 mm above dipole surface	condition	Interpolated maximum
Maximum measured	100 mW forward power	0.464 A/m

Uncertainty for H-field measurement: 8.2% (k=2)

E-field 10 mm above dipole surface	condition	Interpolated maximum
Maximum measured above high end	100 mW forward power	145.7 V/m
Maximum measured above low end	100 mW forward power	138.3 V/m
Averaged maximum above arm	100 mW forward power	142.0 V/m

Uncertainty for E-field measurement: 12.8% (k=2)

3. Appendix

3.1 Antenna Parameters

Frequency	Return Loss	Impedance
1730 MHz	34.6 dB	(51.5 - j1.2) Ohm
1880 MHz	18.9 dB	(43.4 + j8.3) Ohm
1900 MHz	19.0 dB	(45.5 + j9.7) Ohm
1950 MHz	23.7 dB	(49.6 + j6.5) Ohm
2000 MHz	19.4 dB	(43.1 + j7.3) Ohm

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.

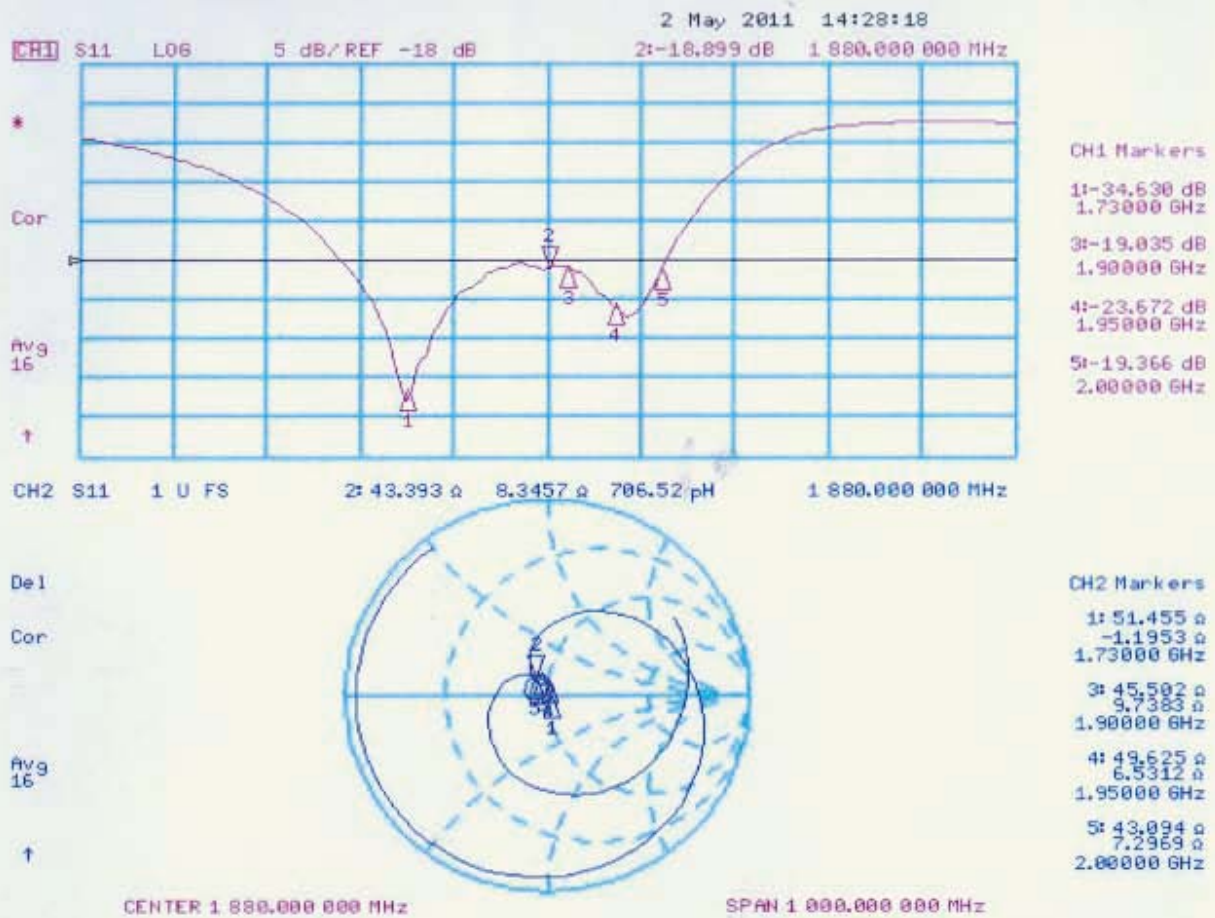
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

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.

3.3 Measurement Sheets

3.3.1 Return Loss and Smith Chart



3.3.2 DASY4 H-Field Result

Date/Time: 03.05.2011 11:59:33

Test Laboratory: SPEAG Lab2

HAC_RF_CD1880_1155_H_110503_JK

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1155

Communication System: CW; Frequency: 1880 MHz

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

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 29.12.2010
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 20.04.2011
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- Measurement SW: DASY52, V52.6.2 Build (424)
- Postprocessing SW: SEMCAD X, V14.4.4 Build (2829)

Dipole H-Field measurement @ 1880MHz/H Scan - measurement distance from the probe sensor center to CD1880

Dipole = 10mm/Hearing Aid Compatibility Test (41x181x1):

Measurement grid: dx=5mm, dy=5mm

Maximum value of peak Total field = 0.464 A/m

Probe Modulation Factor = 1.000

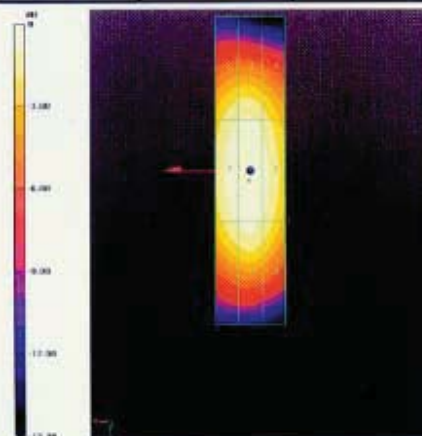
Device Reference Point: 0, 0, -6.3 mm

Reference Value = 0.492 A/m; Power Drift = -0.01 dB

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

Peak H-field in A/m

Grid 1 0.408 M2	Grid 2 0.419 M2	Grid 3 0.391 M2
Grid 4 0.449 M2	Grid 5 0.464 M2	Grid 6 0.435 M2
Grid 7 0.416 M2	Grid 8 0.433 M2	Grid 9 0.406 M2



0 dB = 0.460A/m

3.3.3 DASY4 E-Field Result

Date/Time: 03.05.2011 10:35:18

Test Laboratory: SPEAG Lab2

HAC_RF_CD1880_1155_E_110503_JK

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1155

Communication System: CW; Frequency: 1880 MHz

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

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY5 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 29.12.2010
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 20.04.2011
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- Measurement SW: DASY52, V52.6.2 Build (424)
- Postprocessing SW: SEMCAD X, V14.4.4 Build (2829)

Dipole H-Field measurement @ 1880MHz/H Scan - measurement distance from the probe sensor center to CD1880

Dipole = 10mm @ /Hearing Aid Compatibility Test (41x181x1):

Measurement grid: dx=5mm, dy=5mm

Maximum value of peak Total field = 145.7 V/m

Probe Modulation Factor = 1.000

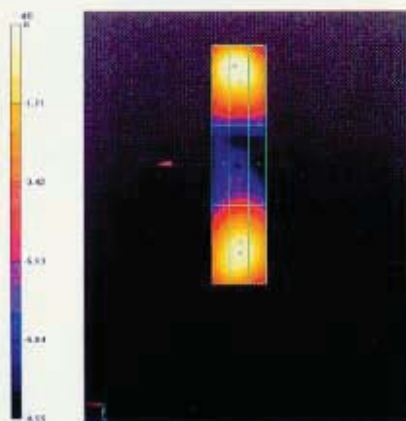
Device Reference Point: 0, 0, -6.3 mm

Reference Value = 143.3 V/m; Power Drift = -0.02 dB

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

Peak E-field in V/m

Grid 1 143.6 M2	Grid 2 145.7 M2	Grid 3 137.7 M2
Grid 4 83.236 M3	Grid 5 87.574 M3	Grid 6 85.990 M3
Grid 7 133.2 M2	Grid 8 138.3 M2	Grid 9 134.9 M2



0 dB = 145.7V/m



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



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

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

Accreditation No.: SCS 108

Client Sporton (Auden)

Certificate No: DAE4-1210_Nov10

CALIBRATION CERTIFICATE

Object DAE4 - SD 000 D04 BJ - SN: 1210

Calibration procedure(s) QA CAL-06.V22
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: November 18, 2010

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	28-Sep-10 (No: 10376)	Sep-11
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V1.1	SE UMS 006 AB 1004	07-Jun-10 (in house check)	In house check: Jan-11

Calibrated by:	Name Andrea Guntli	Function Technician	Signature
Approved by:	Fin Bornholt	R&D Director	

Issued: November 18, 2010

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



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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 108

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	404.092 $\pm$ 0.1% (k=2)	404.921 $\pm$ 0.1% (k=2)	405.027 $\pm$ 0.1% (k=2)
Low Range	3.99932 $\pm$ 0.7% (k=2)	3.98397 $\pm$ 0.7% (k=2)	3.99953 $\pm$ 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	68.0 $^{\circ}$ $\pm$ 1 $^{\circ}$
---	------------------------------------

Appendix

1. DC Voltage Linearity

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	200001.5	-1.32	0.00
Channel X + Input	20000.95	0.95	0.00
Channel X - Input	-19998.31	1.39	-0.01
Channel Y + Input	200000.7	-1.08	-0.00
Channel Y + Input	20000.03	0.23	0.00
Channel Y - Input	-19999.95	-0.35	0.00
Channel Z + Input	200010.3	-0.33	-0.00
Channel Z + Input	19997.81	-2.89	-0.01
Channel Z - Input	-20001.02	-1.32	0.01

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	1999.6	-0.26	-0.01
Channel X + Input	199.98	-0.02	-0.01
Channel X - Input	-200.01	-0.01	0.00
Channel Y + Input	2000.6	0.54	0.03
Channel Y + Input	199.17	-1.03	-0.51
Channel Y - Input	-200.54	-0.84	0.42
Channel Z + Input	1999.9	-0.05	-0.00
Channel Z + Input	199.17	-0.93	-0.47
Channel Z - Input	-201.25	-1.15	0.58

2. Common mode sensitivity

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

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	-6.04	-7.77
	-200	8.97	7.28
Channel Y	200	-8.99	-8.75
	-200	7.60	7.00
Channel Z	200	12.34	11.86
	-200	-14.01	-14.18

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	-	3.24	0.60
Channel Y	200	1.78	-	3.29
Channel Z	200	1.92	-0.13	-

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	15945	17239
Channel Y	15959	16297
Channel Z	15874	17186

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	0.14	-1.10	1.73	0.40
Channel Y	-0.64	-1.49	0.23	0.33
Channel Z	-1.30	-2.71	0.16	0.44

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 108**

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

Client **Sporton CN (Auden)**

Certificate No: **ER-2476_Nov10**

CALIBRATION CERTIFICATE

Object **ER3DV6 - SN:2476**

Calibration procedure(s) **QA CAL-02.v5, QA CAL-25.v2**
Calibration procedure for E-field probes optimized for close near field
evaluations in air

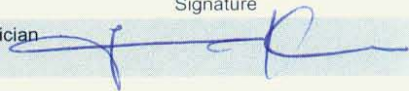
Calibration date: **November 23, 2010**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	01-Apr-10 (No. 217-01136)	Apr-11
Power sensor E4412A	MY41495277	01-Apr-10 (No. 217-01136)	Apr-11
Power sensor E4412A	MY41498087	01-Apr-10 (No. 217-01136)	Apr-11
Reference 3 dB Attenuator	SN: S5054 (3c)	30-Mar-10 (No. 217-01159)	Mar-11
Reference 20 dB Attenuator	SN: S5086 (20b)	30-Mar-10 (No. 217-01161)	Mar-11
Reference 30 dB Attenuator	SN: S5129 (30b)	30-Mar-10 (No. 217-01160)	Mar-11
Reference Probe ER3DV6	SN: 2328	4-Oct-10 (No. ER3-2328_Oct10)	Oct-11
DAE4	SN: 789	31-Aug-10 (No. DAE4-789_Aug10)	Aug-11
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

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

Issued: November 25, 2010

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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 108**

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	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:

- a) IEEE Std 1309-2005, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005.

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.
- Ax,y,z; Bx,y,z; Cx,y,z, VR_{x,y,z}: A, B, C 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:2476

Manufactured: March 31, 2009
Calibrated: November 23, 2010

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

DASY/EASY - Parameters of Probe: ER3DV6 - SN:2476

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$)	1.97	1.74	2.28	$\pm 10.1 \%$
DCP (mV) ^B	98.2	97.0	98.0	

Modulation Calibration Parameters

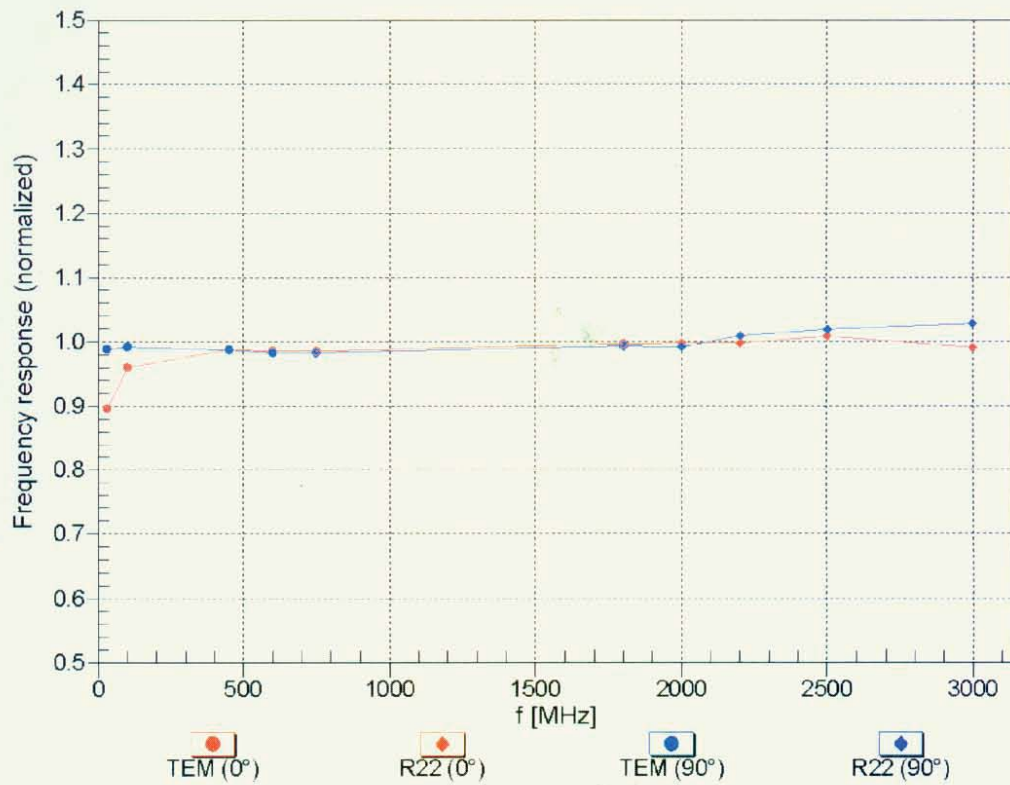
UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc ^E (k=2)
10000	CW	0.00	X	0.00	0.00	1.00	184.4	$\pm 4.06 \%$
			Y	0.00	0.00	1.00	156.8	
			Z	0.00	0.00	1.00	170.9	

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%.

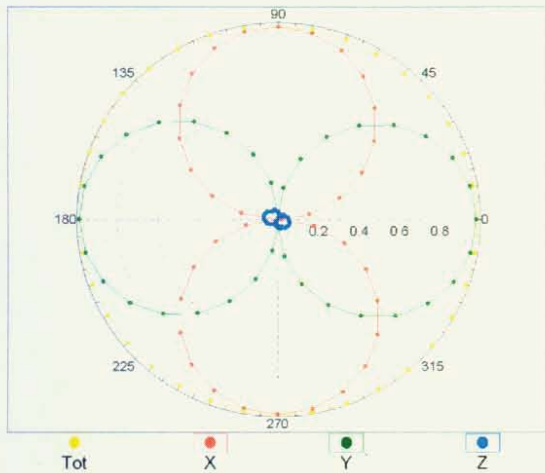
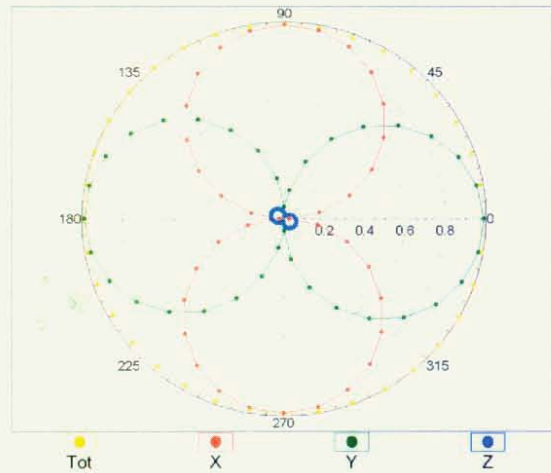
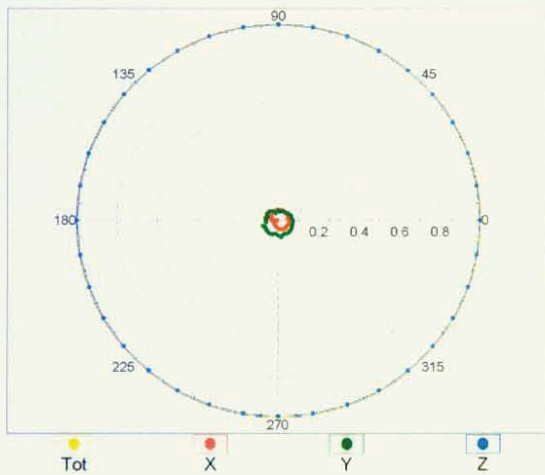
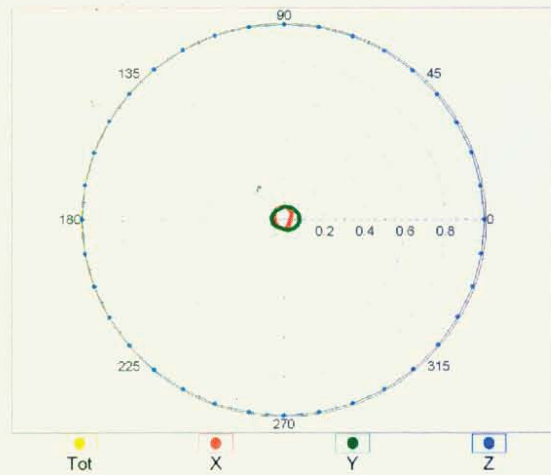
^B Numerical linearization parameter: uncertainty not required.

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

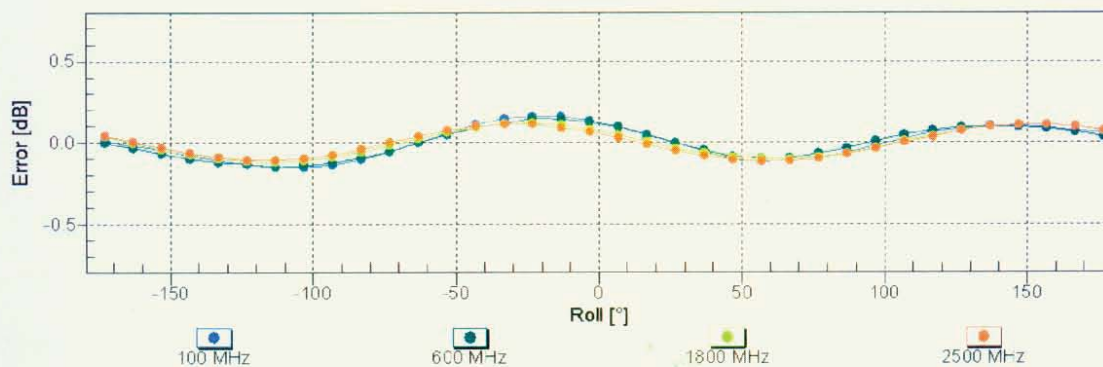
Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



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

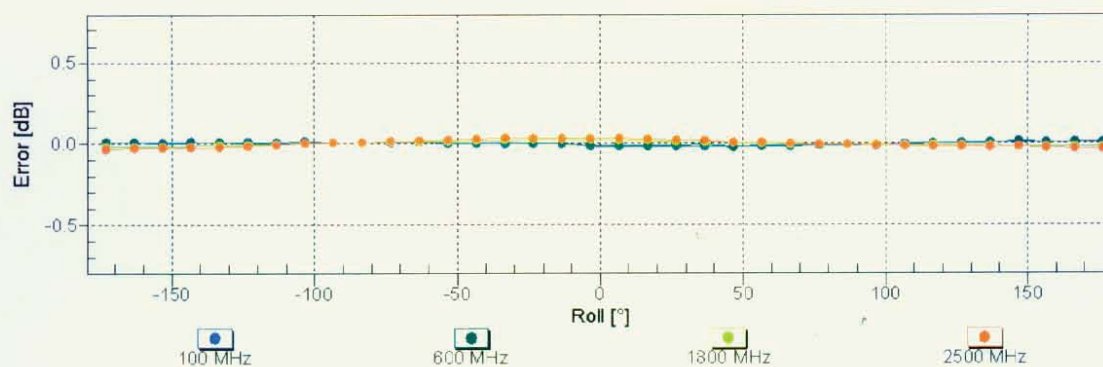
Receiving Pattern (ϕ), $\vartheta = 0^\circ$ **f=600 MHz, TEM, 0°** **f=2500 MHz, R22, 0°** **Receiving Pattern (ϕ), $\vartheta = 90^\circ$** **f=600 MHz, TEM, 90°** **f=2500 MHz, R22, 90°** 

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



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

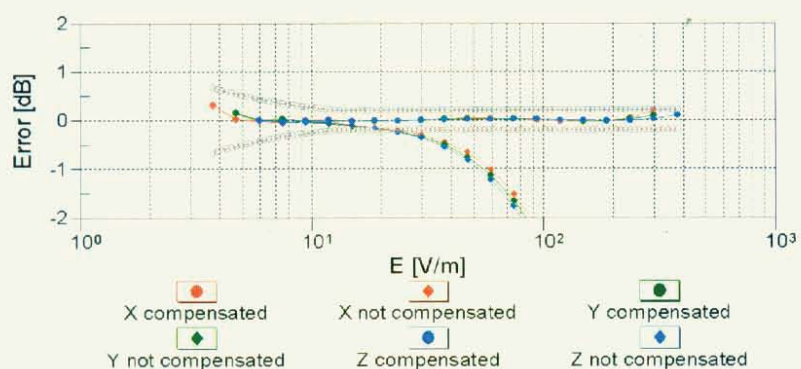
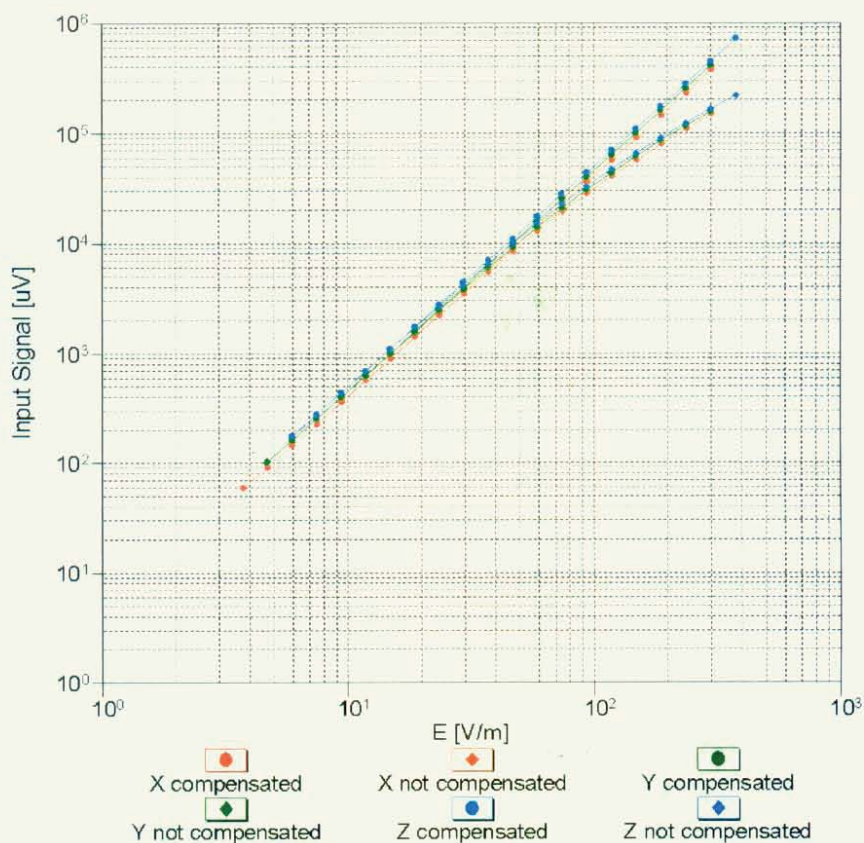
Receiving Pattern (ϕ), $\vartheta = 90^\circ$



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

Dynamic Range f(E-field)

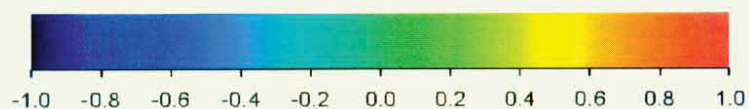
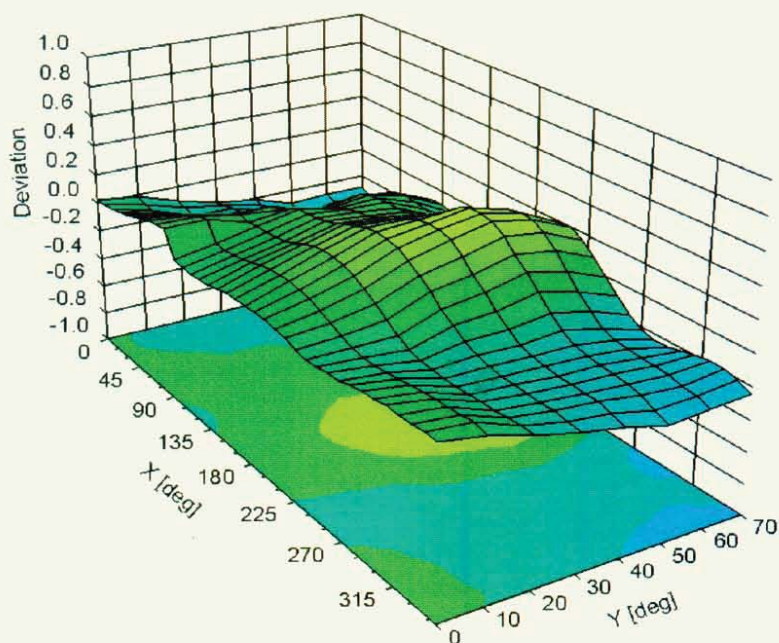
(TEM cell , f = 900 MHz)



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

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: ER3DV6 - SN:2476**Other Probe Parameters**

Sensor Arrangement	Rectangular
Connector Angle (°)	-163.3
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	8 mm
Probe Tip to Sensor X Calibration Point	2.5 mm
Probe Tip to Sensor Y Calibration Point	2.5 mm
Probe Tip to Sensor Z Calibration Point	2.5 mm



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Accreditation No.: **SCS 108**

Client: **Sporton CN (Auden)**

Certificate No: **H3-6300_Nov10**

CALIBRATION CERTIFICATE

Object: **H3DV6 - SN:6300**

Calibration procedure(s): **QA CAL-03.v5, QA CAL-25.v2**
Calibration procedure for H-field probes optimized for close near field
evaluations in air

Calibration date: **November 25, 2010**

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

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

Calibration Equipment used (M&TE critical for calibration):

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	01-Apr-10 (No. 217-01136)	Apr-11
Power sensor E4412A	MY41495277	01-Apr-10 (No. 217-01136)	Apr-11
Power sensor E4412A	MY41498087	01-Apr-10 (No. 217-01136)	Apr-11
Reference 3 dB Attenuator	SN: S5054 (3c)	30-Mar-10 (No. 217-01159)	Mar-11
Reference 20 dB Attenuator	SN: S5086 (20b)	30-Mar-10 (No. 217-01161)	Mar-11
Reference 30 dB Attenuator	SN: S5129 (30b)	30-Mar-10 (No. 217-01160)	Mar-11
Reference Probe H3DV6	SN: 6182	4-Oct-10 (No. H3-6182_Oct10)	Oct-11
DAB4	SN: 789	31-Aug-10 (No. DAE4-789_Aug10)	Aug-11
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Oct-09)	In house check: Oct-11
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-10)	In house check: Oct-11

Calibrated by:	Name Claudio Leubler	Function Laboratory Technician	Signature
Approved by:	Katja Pokovic	Technical Manager	

Issued: November 25, 2010

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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	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., $\theta = 0$ 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.

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ for XY sensors and $\theta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- X, Y, Z(f)_a0a1a2** = X, Y, Z_a0a1a2 * frequency_response (see Frequency Response Chart).
- DCPx, y, z**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- Ax, y, z; Bx, y, z; Cx, y, z; VRx, y, z; A, B, C** 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 X_a0a1a2 (no uncertainty required).



H3DV6 - SN 6300

November 25, 2010

Probe H3DV6

SN:6300

Manufactured: December 16, 2008
Calibrated: November 25, 2010

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

Certificate No: H3-6300_Nov10

Page 3 of 10



H3DV6- SN:6300

November 25, 2010

DASY/EASY - Parameters of Probe: H3DV6 - SN:6300**Basic Calibration Parameters**

		Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (A/m / $\sqrt{(mV)}$)	a0	2.50E-003	2.47E-003	3.18E-003	$\pm 5.1 \%$
Norm (A/m / $\sqrt{(mV)}$)	a1	-6.06E-005	2.44E-006	1.26E-005	$\pm 5.1 \%$
Norm (A/m / $\sqrt{(mV)}$)	a2	-1.56E-005	2.59E-006	2.61E-005	$\pm 5.1 \%$
DCP (mV) ^B		91.3	91.3	91.0	

Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc ^L (k=2)
10000	CW	0.00	X	0.00	0.00	1.00	194.2	$\pm 5.16 \%$
			Y	0.00	0.00	1.00	191.9	
			Z	0.00	0.00	1.00	208.0	

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

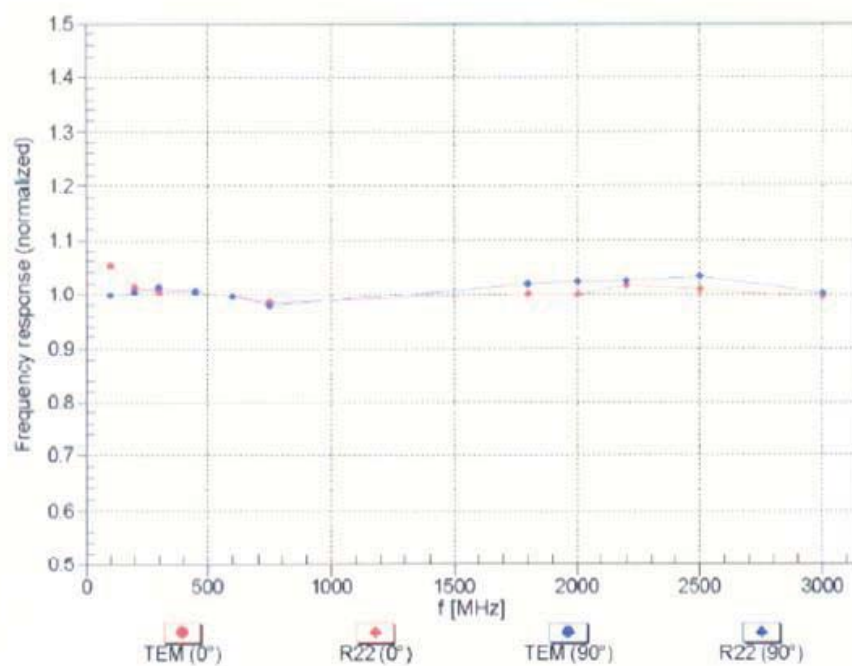
^L Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



H3DVG- SN.6300

November 25, 2010

Frequency Response of H-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



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

H3DV6-SN:6300

November 25, 2010

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

$f=600$ MHz, TEM, 0°

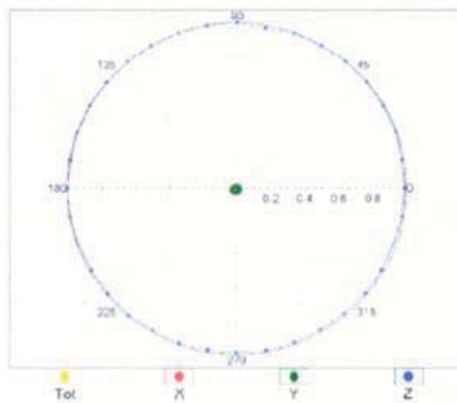


$f=2500$ MHz, R22, 0°

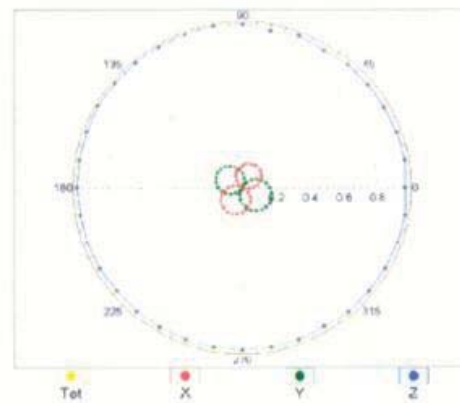


Receiving Pattern (ϕ), $\vartheta = 90^\circ$

$f=600$ MHz, TEM, 90°



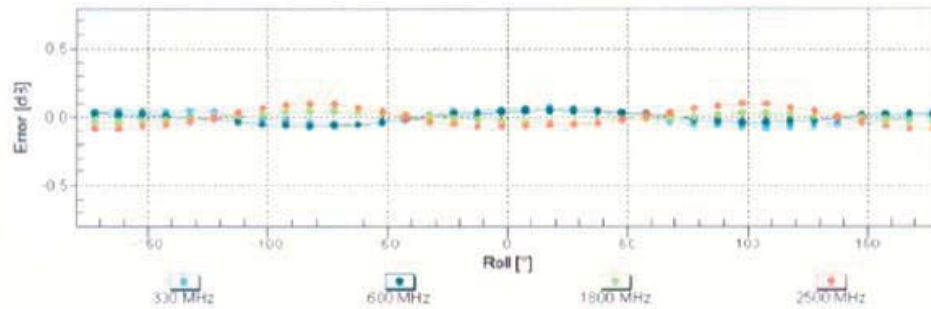
$f=2500$ MHz, R22, 90°



H3DV6—SN:8300

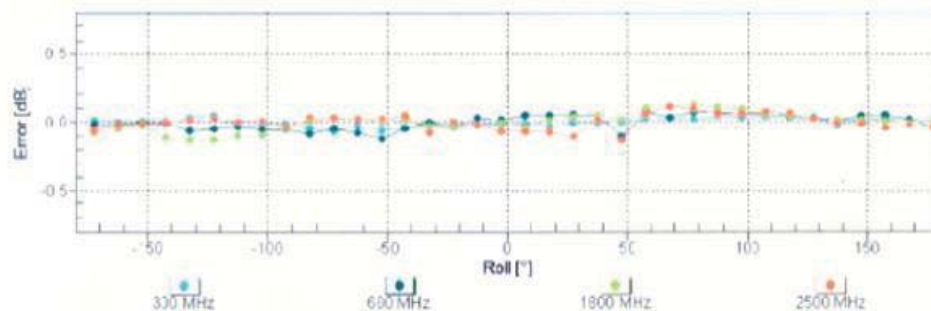
November 25, 2010

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



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

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



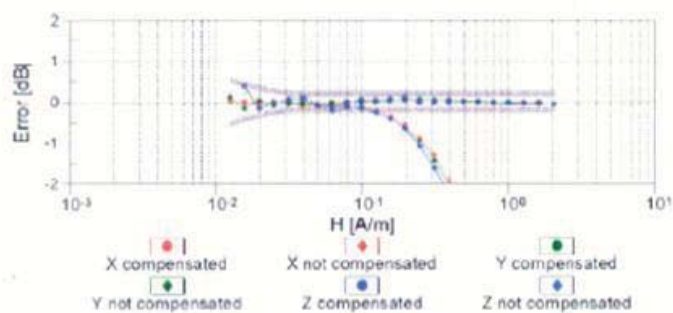
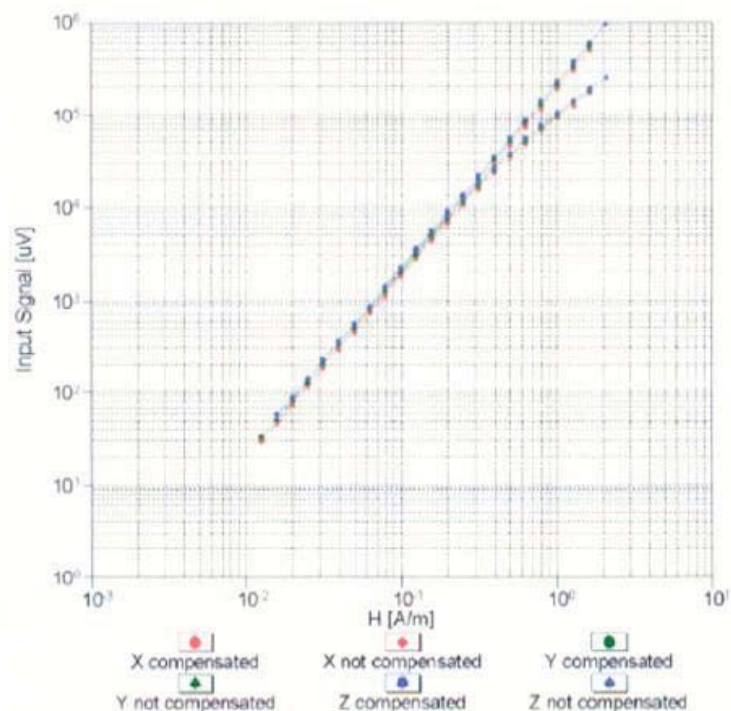
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)



H3DV6 - SN 6300

November 25, 2010

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



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

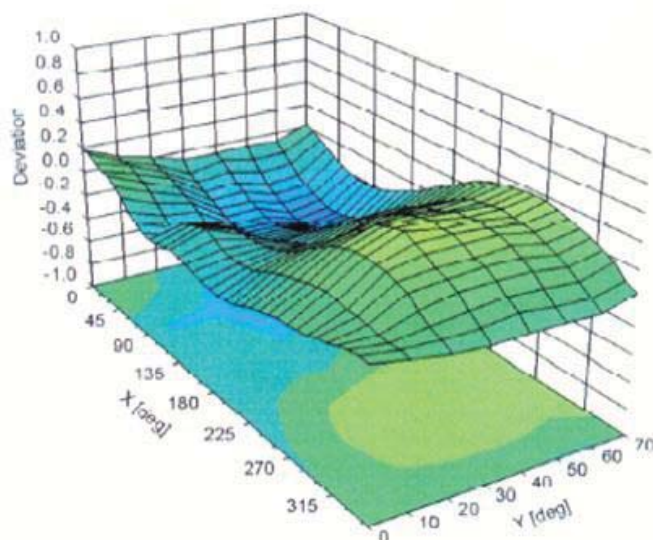


H3DV6-SN-6300

November 25, 2010

Deviation from Isotropy in Air

Error (ϕ , θ), $f = 900$ MHz



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



H3DV6 - SN:6300

November 25, 2010

DASY/EASY - Parameters of Probe: H3DV6 - SN:6300

Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	-32.5
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	20 mm
Tip Diameter	6 mm
Probe Tip to Sensor X Calibration Point	3 mm
Probe Tip to Sensor Y Calibration Point	3 mm
Probe Tip to Sensor Z Calibration Point	3 mm