



Appendix C – Calibration Data

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8904 Zurich, Switzerland



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Accreditation No.: SCS 108

Client Sporton (Auden)

Certificate No: ER3-2358_Feb07

CALIBRATION CERTIFICATE

Object: ER3DV6 - SN:2358

Calibration procedure(s): QA CAL-02.v4
Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date: February 21, 2007

Condition of the calibrated item: In Tolerance

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&C critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter E4419B	CD41203074	5-Apr-06 (METAS, No. 251-00557)	Apr-07
Power sensor E4412A	MY41495277	5-Apr-06 (METAS, No. 251-00557)	Apr-07
Power sensor E4412A	MY41495087	5-Apr-06 (METAS, No. 251-00557)	Apr-07
Reference 3 nH Attenuator	SN: 55054 (30)	10-Aug-06 (METAS, No. 217-00532)	Aug-07
Reference 20 dB Attenuator	SN: 55050 (20s)	4-Apr-06 (METAS, No. 251-00558)	Apr-07
Reference 30 dB Attenuator	SN: 55129 (30s)	10-Aug-06 (METAS, No. 217-00533)	Aug-07
Reference Probe ER3DV6	SN: 2328	2-Oct-06 (SPEAG, No. ER3-2328_Oct06)	Oct-07
DSE4	SN: 654	21-Jun-05 (SPEAG, No. DAC4-654_Jun05)	Jun-07

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642UC1700	4-Aug-99 (SPEAG, in house check Nov-05)	In house check: Nov-07
Network Analyzer HP 8703E	US373J065b	18-Oct-01 (SPEAG, in house check Oct-06)	In house check: Oct-07

Calibrated by: Name: Katja Polkovnikova, Function: Technical Manager, Signature: [Signature]

Approved by: Name: F. Brankhoff, Function: R&D Director, Signature: [Signature]

Issued: February 21, 2007

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Certificate No: ER3-2358_Feb07

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Glossary:

NORM _{x,y,z}	sensitivity in free space
DCP	diode compression point
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 1309-1996, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", 1996.

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).
- NORM(f)_{x,y,z}** = NORM_{x,y,z} * frequency_response (see Frequency Response Chart).
- DCPx,y,z**: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency.
- 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).



ER3DV6 SN:2358

February 21, 2007

Probe ER3DV6

SN:2358

Manufactured:	July 7, 2005
Last calibrated:	September 19, 2005
Recalibrated:	February 21, 2007

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)



ER3DV6 SN:2358

February 21, 2007

DASY - Parameters of Probe: ER3DV6 SN:2358

Sensitivity in Free Space [$\mu\text{V}/(\text{V}/\text{m})^2$]

NormX	$1.69 \pm 10.1 \% (k=2)$
NormY	$1.54 \pm 10.1 \% (k=2)$
NormZ	$1.61 \pm 10.1 \% (k=2)$

Diode Compression^A

DCP X	92 mV
DCP Y	92 mV
DCP Z	96 mV

Frequency Correction

X	0.0
Y	0.0
Z	0.0

Sensor Offset (Probe Tip to Sensor Center)

X	2.5 mm
Y	2.5 mm
Z	2.5 mm

Connector Angle -65 °

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%.

* numerical linearization parameter; uncertainty not required

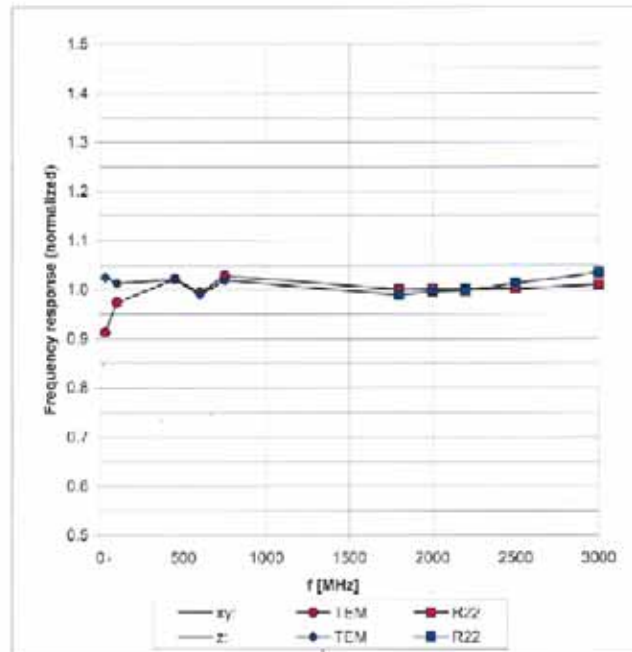


ER3DV6 SN:2358

February 21, 2007

Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)



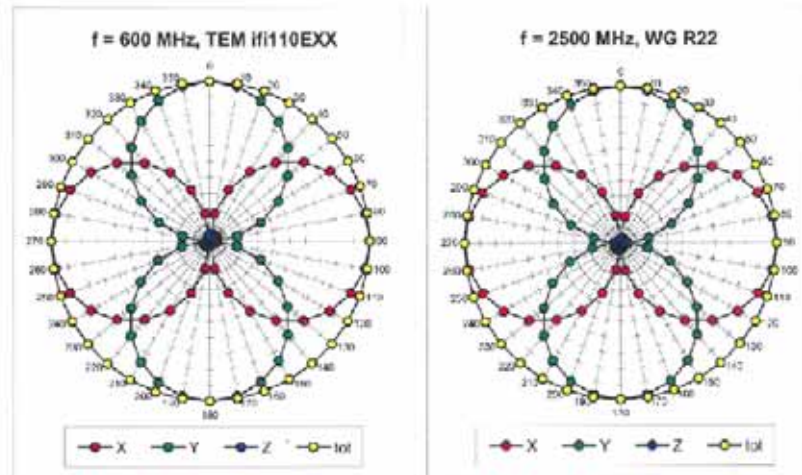
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)



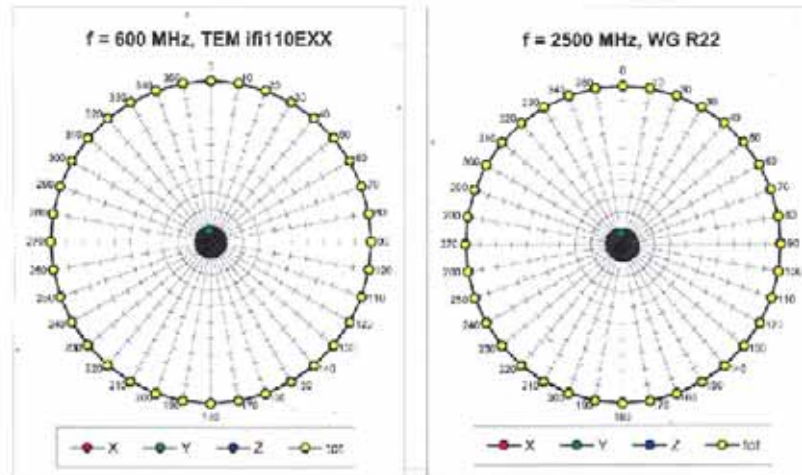
ER3DV6 SN:2358

February 21, 2007

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



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

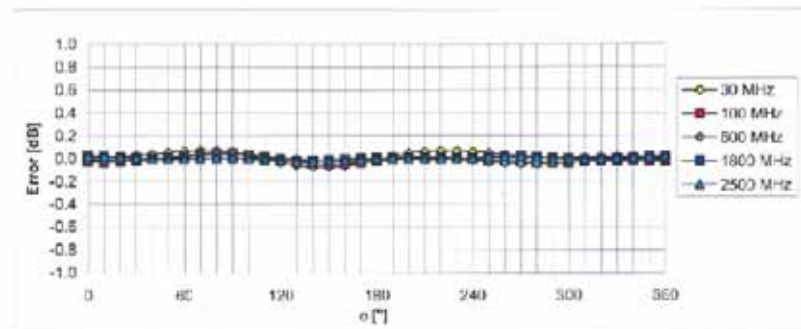




ER3DV6 SN:2358

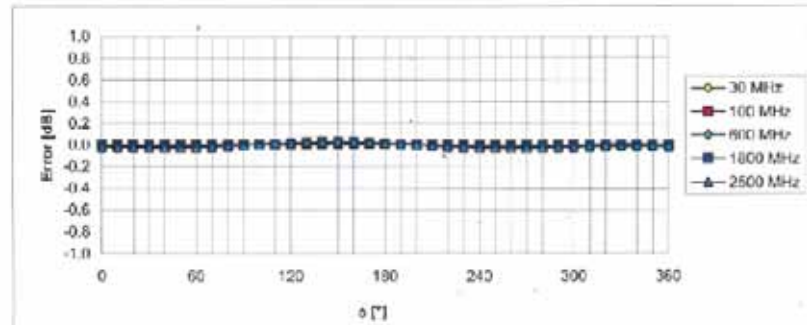
February 21, 2007

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



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

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



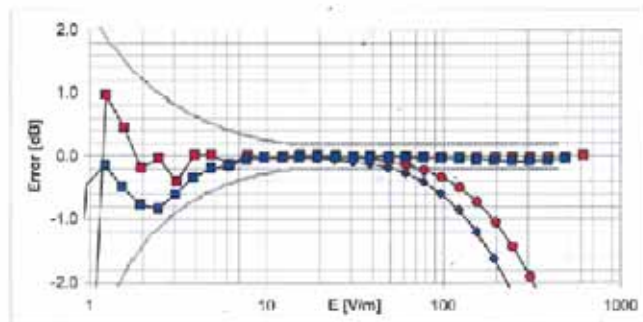
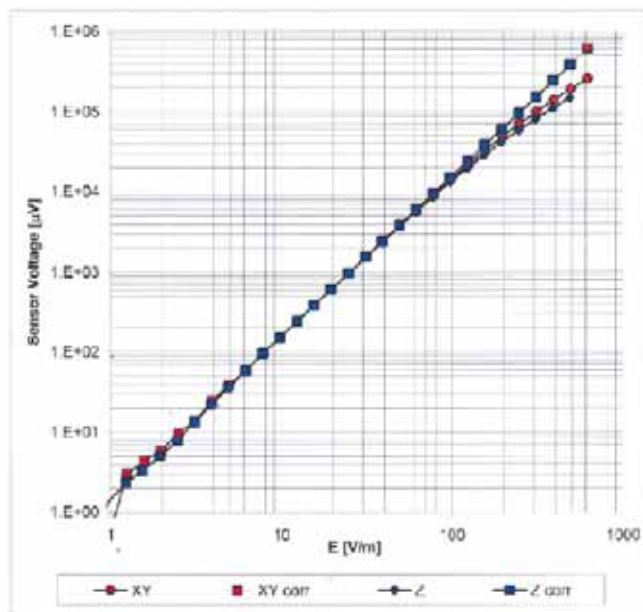
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)



ER3DV6 SN:2358

February 21, 2007

Dynamic Range f(E-field)
(Waveguide R22, $f = 1800$ MHz)



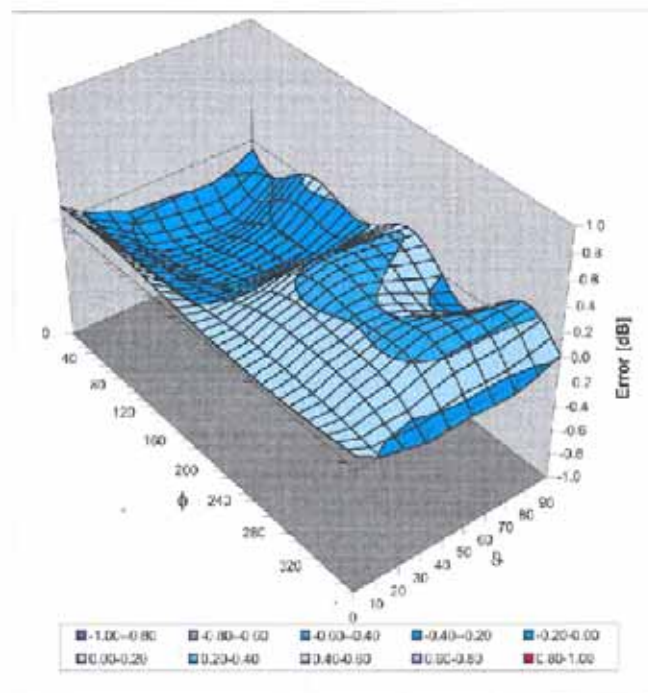
Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)



ER3DV6 SN:2358

February 21, 2007

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



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



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Accreditation No.: SCS 108

Client Sporton (Auden)

Certificate No: H3-6184_Feb07

CALIBRATION CERTIFICATE

Object: H3DV6 - SN:6184

Calibration procedure(s): QA CAL-03.v4
Calibration procedure for H-field probes optimized for close near field evaluations in air

Calibration date: February 21, 2007

Condition of the calibrated item: In Tolerance

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 this 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 (MATEX certified for calibration):

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter E4119B	GB412933/4	5-Apr-06 (METAS, No. 251-05537)	Apr-07
Power sensor E4412A	MY41495277	5-Apr-06 (METAS, No. 251-05537)	Apr-07
Power sensor E4412A	MY41495387	5-Apr-06 (METAS, No. 251-05537)	Apr-07
Reference 3 dB Attenuator	S/N: 55054 (30)	10-Aug-06 (METAS, No. 217-05592)	Aug-07
Reference 20 dB Attenuator	S/N: 55069 (30b)	1-Apr-06 (METAS, No. 251-05533)	Apr-07
Reference 30 dB Attenuator	S/N: 55129 (30b)	16-Aug-06 (METAS, No. 217-05593)	Aug-07
Reference Probe H3DV6	S/N: 6182	2-Oct-06 (SPEAG, No. H3-6182_Oct06)	Oct-07
DAE4	S/N: 664	21-Jun-06 (SPEAG, No. DAE4-664_Jun06)	Jun-07

Secondary Standards	ID #	Check Date (In house)	Scheduled Check
RF generator HP 8445C	US3642101700	4-Aug-99 (SPFAG, in house check Nov-05)	In house check: Nov-07
Network Analyzer HP 8753E	US37390565	18-Oct-01 (SPEAG, in house check Oct-06)	In house check: Oct-07

	Name	Function	Signature
Calibrated by:	Katja Pokovic	Technical Manager	
Approved by:	F. Benschel	R&D Director	

Issued: February 21, 2007

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Glossary:

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DCP	diode compression point
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 1309-1996, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", 1996.

Methods Applied and Interpretation of Parameters:

- X, Y, Z_{a0a1a2} : Assessed for E-field polarization $\theta = 90$ for XY sensors and $\theta = 0$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- $X, Y, Z(f)_{a0a1a2} = X, Y, Z_{a0a1a2} \cdot \text{frequency_response}$ (see Frequency Response Chart).
- DCP_{x,y,z}: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency.
- 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:6184

February 21, 2007

Probe H3DV6

SN:6184

Manufactured:	June 8, 2004
Last calibrated:	September 19, 2005
Recalibrated:	February 21, 2007

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)



H3DV6 SN:6184

February 21, 2007

DASY - Parameters of Probe: H3DV6 SN:6184Sensitivity in Free Space [A/m / $\sqrt{(\mu V)}$]

	a0	a1	a2
X	2.461E-03	1.004E-5	1.195E-6 \pm 5.1 % (k=2)
Y	2.498E-03	-3.536E-5	-1.454E-5 \pm 5.1 % (k=2)
Z	2.915E-03	-2.323E-5	3.844E-5 \pm 5.1 % (k=2)

Diode Compression¹

DCP X 84 mV

DCP Y 84 mV

DCP Z 85 mV

Sensor Offset

(Probe Tip to Sensor Center)

X	3.0 mm
Y	3.0 mm
Z	3.0 mm

Connector Angle

-63 °

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%.

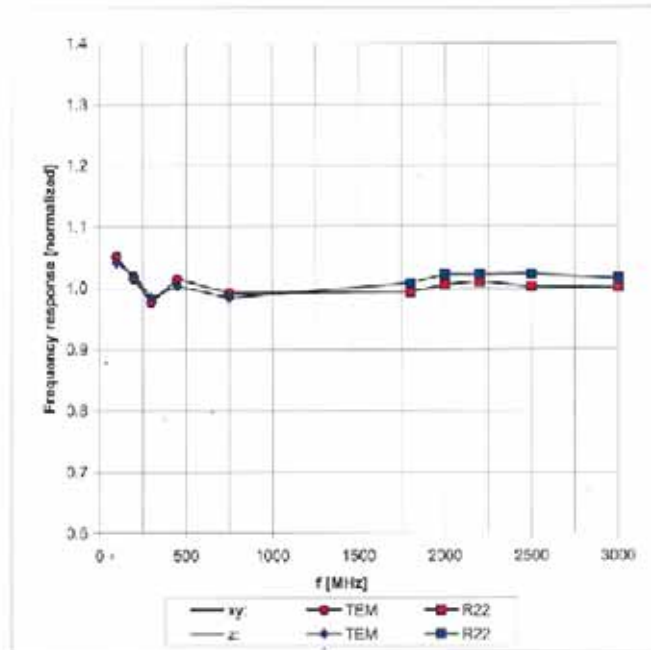
¹ numerical linearizer parameter, uncertainty not required



H3DV6 SN:6184

February 21, 2007

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



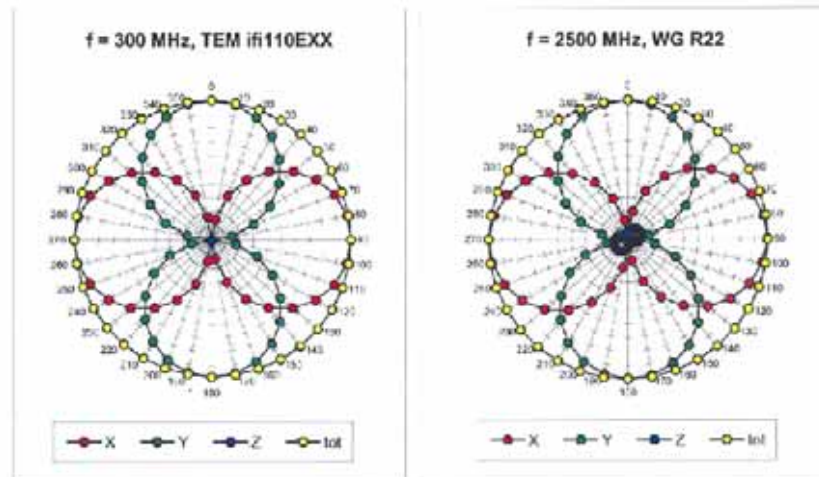
Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)



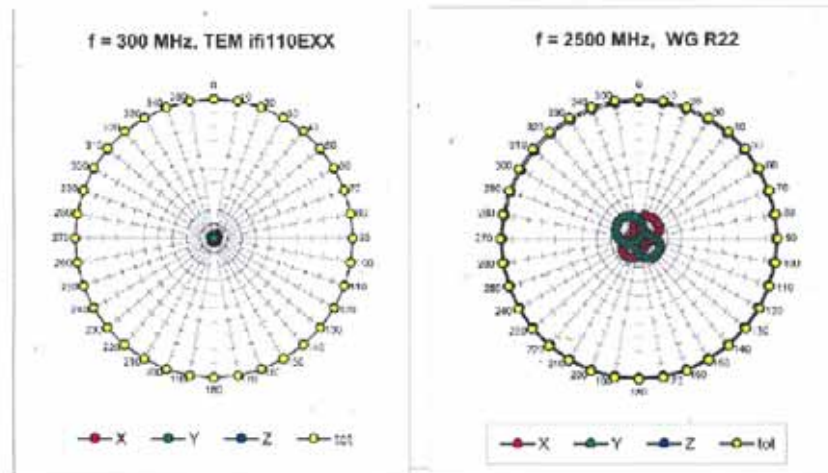
H3DV6 SN:6184

February 21, 2007

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



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

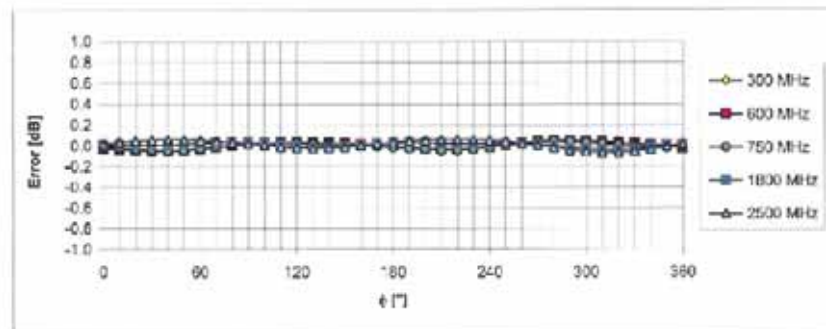




H3DV6 SN:6184

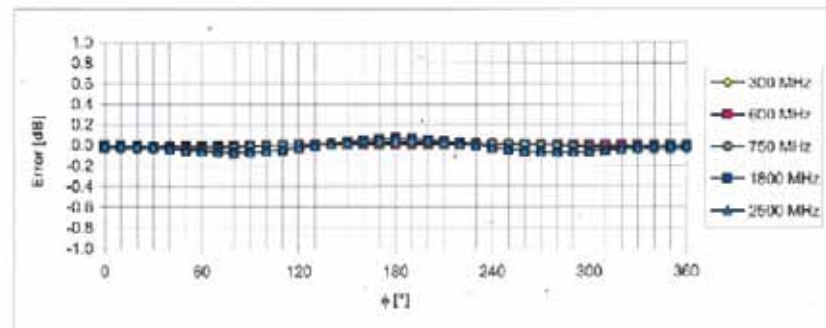
February 21, 2007

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



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

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

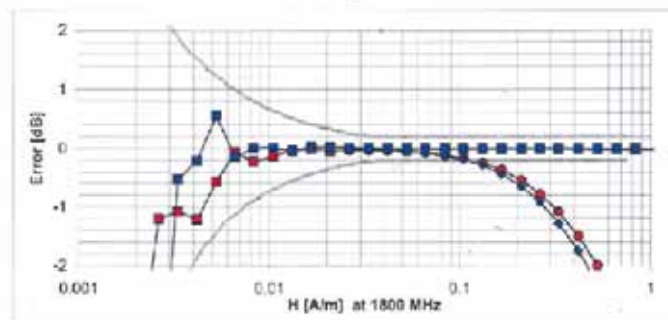
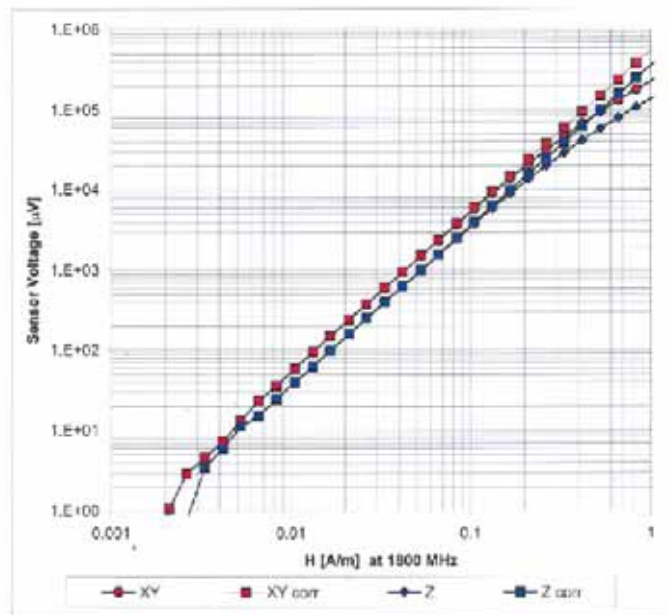


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

H3DV6 SN:6184

February 21, 2007

Dynamic Range f(H-field)
(Waveguide R22, $f = 1800$ MHz)



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



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Accreditation No.: SCS 108

Client **ATL (Auden)**

Certificate No: CD835V3-1017_Jul07

CALIBRATION CERTIFICATEObject **CD835V3 - SN: 1017**Calibration procedure(s) **QA CAL-20.v4
Calibration procedure for dipoles in air**Calibration date: **July 12, 2007**Condition of the calibrated item **In Tolerance**

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 $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&E critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
DAE4	SN: 903	31-Aug-06 (SPEAG, No. DAE4-903_Aug06)	Calibration, Aug-07
Probe ER3DV6	SN: 2336	27-Dec-06 (SPEAG, No. ER3-2336_Dec06)	Calibration, Dec-07
Probe H3DV6	SN: 6065	27-Dec-06 (SPEAG, No. H3-6065-Dec06)	Calibration, Dec-07
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-4419B	GB43310788	12-Aug-03 (SPEAG, in house check Oct-06)	In house check: Oct-07
Power sensor HP 8481A	MY41093312	10-Aug-03 (SPEAG, in house check Oct-06)	In house check: Oct-08
Power sensor HP 8481A	MY41093315	10-Aug-03 (SPEAG, in house check Oct-06)	In house check: Oct-08
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Oct-06)	In house check: Oct-07
RF generator R&S SMT06	SN: 100005	26-Jul-04 (SPEAG, in house check Nov-05)	In house check: Nov-07

Calibrated by:	Name	Function	Signature
	Claudio Leubler	Laboratory Technician	
Approved by:	Name	Technical Director	Signature
	Fin Bornholt		

Issued: July 17, 2007

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Certificate No: CD835V3-1017_Jul07

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Accreditation No.: SCS 108

References

- [1] ANSI-C63.19-2006
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 standard [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 DASY4 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 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	DASY4	V4.7 B53
DASY PP Version	SEMCAD	V1.8 B172
Phantom	HAC Test Arch	SD HAC P01 BA, #1002
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 \approx 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	0.446 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	173.2 V/m
Maximum measured above low end	100 mW forward power	151.9 V/m
Averaged maximum above arm	100 mW forward power	162.6 V/m

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

3 Appendix
3.1 Antenna Parameters

Frequency	Return Loss	Impedance
800 MHz	15.8 dB	(42.5 - j13.2) Ohm
835 MHz	30.2 dB	(50.2 + j3.1) Ohm
900 MHz	18.2 dB	(56.1 - j11.6) Ohm
950 MHz	19.2 dB	(45.2 + j9.4) Ohm
960 MHz	14.4 dB	(51.9 + j19.6) Ohm

3.2 Antenna Design and Handling

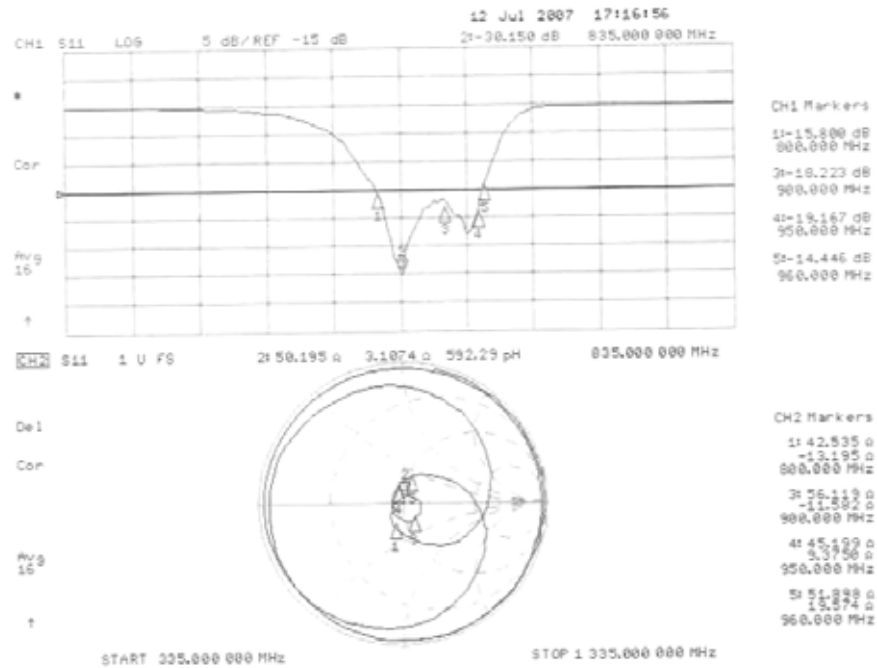
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole 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: 09.07.2007 14:27:10

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: 1017

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

Medium: Air;

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

Phantom section: H Dipole Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 27.12.2006
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn903; Calibrated: 31.08.2006
- Phantom: HAC Test Arch 4.6; Type: SD HAC P01 BA; ;
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 171

H Scan - Sensor Center 10mm above CD835 Dipole/Hearing Aid Compatibility Test (41x361x1):

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

Maximum value of peak Total field = 0.446 A/m

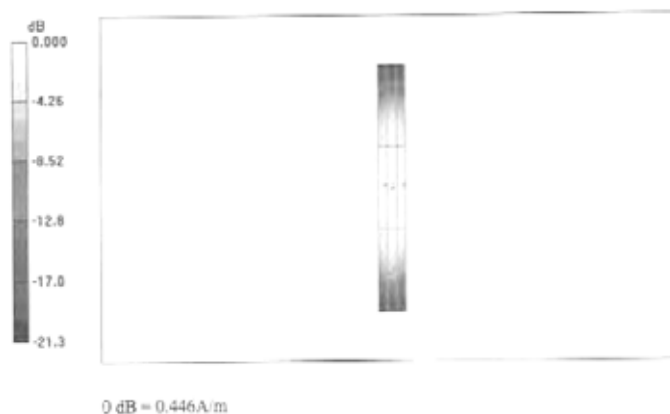
Probe Modulation Factor = 1.00

Reference Value = 0.475 A/m; Power Drift = 0.001 dB

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

Peak H-field in A/m

Grid 1	Grid 2	Grid 3
0.365	0.388	0.376
Grid 4	Grid 5	Grid 6
0.420	0.446	0.427
Grid 7	Grid 8	Grid 9
0.372	0.394	0.374





3.3.3 DASY4 E-Field result

Date/Time: 12.07.2007 18:17:22

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC-Dipole 835 MHz; Type: D835V3; Serial: 1017

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

Medium: Air;

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

Phantom section: E Dipole Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1); Calibrated: 27.12.2006
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn905; Calibrated: 31.08.2006
- Phantom: HAC Test Arch 4.6; Type: SD HAC P01 BA; :
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 171

E Scan - Sensor Center 10mm above CD835 Dipole/Hearing Aid Compatibility Test (41x361x1):

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

Maximum value of peak Total field = 173.2 V/m

Probe Modulation Factor = 1.00

Reference Value = 113.2 V/m; Power Drift = -0.008 dB

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

Peak E-field in V/m

Grid 1	Grid 2	Grid 3
150.5	151.9	141.3
Grid 4	Grid 5	Grid 6
81.7	82.3	76.1
Grid 7	Grid 8	Grid 9
171.9	173.2	155.0





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Client **ATL (Auden)**

Certificate No: **CD1880V3-1036_Jul07**

CALIBRATION CERTIFICATE

Object **CD1880V3 - SN: 1036**

Calibration procedure(s) **QA CAL-20.v4
Calibration procedure for dipoles in air**

Calibration date: **July 12, 2007**

Condition of the calibrated item **In Tolerance**

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 (Calibrated by, Certificate No.)	Scheduled Calibration
DAE4	SN: 903	31-Aug-06 (SPEAG, No. DAE4-903_Aug06)	Calibration, Aug-07
Probe ER3DV6	SN: 2336	27-Dec-06 (SPEAG, No. ER3-2336_Dec06)	Calibration, Dec-07
Probe H3DV6	SN: 6065	27-Dec-06 (SPEAG, No. H3-6065-Dec06)	Calibration, Dec-07
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-4419B	GB43310788	12-Aug-03 (SPEAG, in house check Oct-06)	In house check: Oct-07
Power sensor HP 8481A	MY41093312	10-Aug-03 (SPEAG, in house check Oct-06)	In house check: Oct-08
Power sensor HP 8481A	MY41093315	10-Aug-03 (SPEAG, in house check Oct-06)	In house check: Oct-08
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Oct-06)	In house check: Oct-07
RF generator R&S SMT06	SN: 100005	26-Jul-04 (SPEAG, in house check Nov-05)	In house check: Nov-07

Calibrated by:	Name Claudio Leubler	Function Laboratory Technician	Signature
Approved by:	Name Fin Bornholt	Function Technical Director	Signature

Issued: July 17, 2007

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Certificate No: CD1880V3-1036_Jul07

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Accreditation No.: SCS 108

References

- [1] ANSI-C63.19-2006
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 standard [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 DASY4 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	DASY4	V4.7 B53
DASY PP Version	SEMCAD	V1.8 B172
Phantom	HAC Test Arch	SD HAC P01 BA, #1002
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	0.442 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	133.7 V/m
Maximum measured above low end	100 mW forward power	131.8 V/m
Averaged maximum above arm	100 mW forward power	132.8 V/m

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

3 Appendix**3.1 Antenna Parameters**

Frequency	Return Loss	Impedance
1710 MHz	19.3 dB	(50.3 + j10.9) Ohm
1880 MHz	21.8 dB	(52.2 + j8.1) Ohm
1900 MHz	22.2 dB	(54.2 + j6.9) Ohm
1950 MHz	30.5 dB	(52.7 - j1.4) Ohm
2000 MHz	19.8 dB	(40.9 + j2.1) 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.

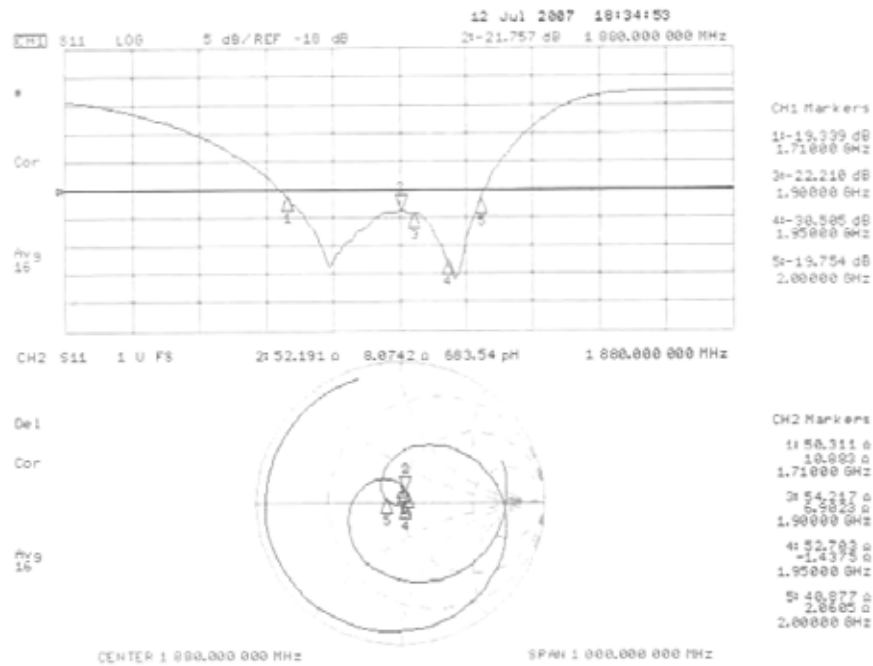
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

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: 09.07.2007 18:09:48

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1036

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

Medium: Air

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

Phantom section: H Dipole Section

DASY4 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 27.12.2006
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn903; Calibrated: 31.08.2006
- Phantom: HAC Test Arch 4.6; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

H Scan - Sensor Center 10mm above CD1880V3 Dipole/Hearing Aid Compatibility Test (41x181x1):

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

Maximum value of peak Total field = 0.442 A/m

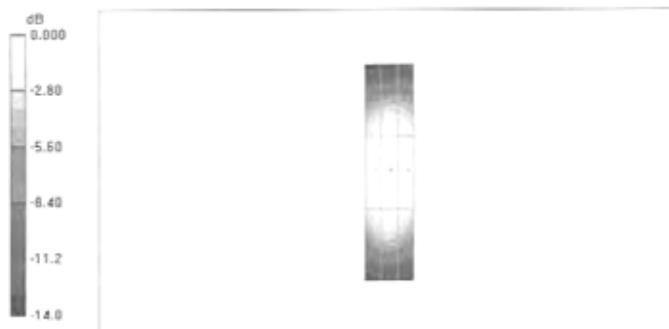
Probe Modulation Factor = 1.00

Reference Value = 0.467 A/m; Power Drift = 0.019 dB

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

Peak H-field in A/m

Grid 1	Grid 2	Grid 3
0.386	0.410	0.399
Grid 4	Grid 5	Grid 6
0.419	0.442	0.427
Grid 7	Grid 8	Grid 9
0.386	0.406	0.385



0 dB = 0.442A/m

3.3.3 DASY4 E-Field Result

Date/Time: 12.07.2007 21:37:22

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1036

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

Medium: Air

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

Phantom section: E Dipole Section

DASY4 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 27.12.2006
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn903; Calibrated: 31.08.2006
- Phantom: HAC Test Arch 4.6; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.7 Build 53; Postprocessing SW: SEMCAD, V1.8 Build 172

E Scan - Sensor Center 10mm above CD1880V3 Dipole/Hearing Aid Compatibility Test (41x181x1):

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

Maximum value of peak Total field = 133.7 V/m

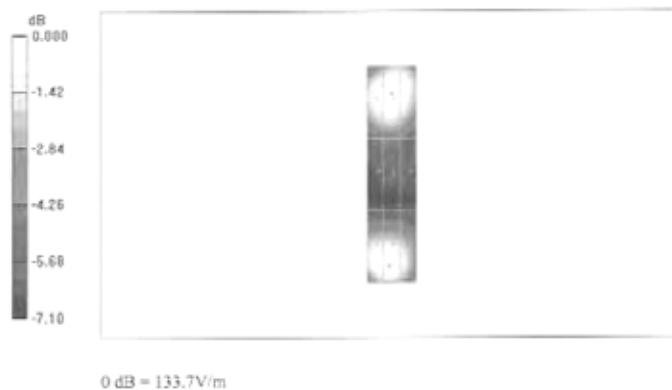
Probe Modulation Factor = 1.00

Reference Value = 146.5 V/m; Power Drift = -0.028 dB

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

Peak E-field in V/m

Grid 1	Grid 2	Grid 3
130.0	133.7	129.7
Grid 4	Grid 5	Grid 6
86.7	88.1	83.9
Grid 7	Grid 8	Grid 9
130.1	131.8	121.8





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Accreditation No.: **SCS 108**Client **Sporton (Auden)**Certificate No: **DAE3-577_Nov06****CALIBRATION CERTIFICATE**Object **DAE3 - SD 000 D03 AA - SN: 577**Calibration procedure(s) **QA CAL-06.v12
Calibration procedure for the data acquisition electronics (DAE)**Calibration date: **November 21, 2006**Condition of the calibrated item **In Tolerance**

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 (Calibrated by, Certificate No.)	Scheduled Calibration
Fluke Process Calibrator Type 702	SN: 6295803	13-Oct-06 (Elcal AG, No: 5492)	Oct-07
Keithley Multimeter Type 2001	SN: 0810278	03-Oct-06 (Elcal AG, No: 5478)	Oct-07
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V1.1	SE UMS 006 AB 1002	15-Jun-06 (SPEAG, in house check)	In house check Jun-07

	Name	Function	Signature
Calibrated by:	Eric Hainfeld	Technician	
Approved by:	Fin Bornholt	R&D Director	

Issued: November 21, 2006

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Certificate No: DAE3-577_Nov06

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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 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:** 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 = 61nV, full range = -1.....+3mV

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

Calibration Factors	X	Y	Z
High Range	404.355 \pm 0.1% (k=2)	403.806 \pm 0.1% (k=2)	404.276 \pm 0.1% (k=2)
Low Range	3.92854 \pm 0.7% (k=2)	3.93862 \pm 0.7% (k=2)	3.93591 \pm 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	268 ° \pm 1 °
---	-----------------

Appendix
1. DC Voltage Linearity

High Range	Input (μV)	Reading (μV)	Error (%)
Channel X + Input	200000	199999.5	0.00
Channel X + Input	20000	20005.87	0.03
Channel X - Input	20000	-19998.71	-0.01
Channel Y + Input	200000	200000	0.00
Channel Y + Input	20000	20004.22	0.02
Channel Y - Input	20000	-20003.23	0.02
Channel Z + Input	200000	200000.6	0.00
Channel Z + Input	20000	20005.24	0.03
Channel Z - Input	20000	-20001.80	0.01

Low Range	Input (μV)	Reading (μV)	Error (%)
Channel X + Input	2000	1999.9	0.00
Channel X + Input	200	200.27	0.13
Channel X - Input	200	-200.73	0.36
Channel Y + Input	2000	2000.1	0.00
Channel Y + Input	200	199.22	-0.39
Channel Y - Input	200	-200.86	0.43
Channel Z + Input	2000	1999.9	0.00
Channel Z + Input	200	199.28	-0.36
Channel Z - Input	200	-200.94	0.47

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	14.24	12.49
	- 200	-12.13	-12.92
Channel Y	200	-6.51	-7.06
	- 200	6.05	5.81
Channel Z	200	1.09	0.86
	- 200	-2.86	-2.63

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	-	2.51	0.09
Channel Y	200	0.43	-	3.37
Channel Z	200	-0.55	0.96	-

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	15970	16306
Channel Y	15851	16305
Channel Z	16208	17068

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	-0.51	-1.55	0.47	0.50
Channel Y	-2.06	-4.32	-0.65	0.60
Channel Z	-1.63	-2.58	-0.15	0.35

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance

	Zeroing (MOhm)	Measuring (MOhm)
Channel X	0.2000	199.8
Channel Y	0.2000	200.7
Channel Z	0.2000	199.8

8. Low Battery Alarm Voltage (verified during pre test)

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

9. Power Consumption (verified during pre test)

Typical values	Switched off (mA)	Stand by (mA)	Transmitting (mA)
Supply (+ Vcc)	+0.0	+6	+14
Supply (- Vcc)	-0.01	-8	-9



Appendix D - CDMA2000 1xRTT Test Modes for HAC

The phone was tested in all normal configurations for the ear usage. These test configurations are tested at the high, middle and low frequency channels of each applicable operating mode, if applicable, each configuration is tested with the antenna in its fully stowed and deployed positions. The signal was setup by linking an over the air connection between the EUT and an Agilent 8960 (E5515C Wireless Communications Tester). The CDMA radio is available on IS-95 (Radio Configuration 1) and CDMA 2000 1XRTT (Radio Configuration 3). The EUT supports IS95 2G networks, CDMA 2000 1X RTT for Cellular band and PCS band. The maximum peak field is chosen for HAC testing for worst case scenario. A full HAC measurement in this report is done in CDMA2000 1XRTT mode SO2 + RC1 for Cellular 850 band and PCS 1900 band.

Peak Field list:

Bands	RC	SO	Type	Data Rate	Channel	Peak Field (V/m)
CDMA2000 PCS 1900	1	2	Loop	Full	600	60.9
				Eighth	600	57.9
	1	55	Loop	Full	600	58.2
				Eighth	600	57.7
	3	2	Loop	Full	600	57.3
	3	3	Voice	-	600	58.3
	3	55	Loop	Full	600	57.3

Power list:

Bands	Test Mode	Test Status	Channel	Frequency (MHz)	Conducted Power (dBm)	Conducted Power (Watts)
CDMA2000 Cellular 850	CDMA 1xRTT	RC1/SO2	1013	824.70 (Low)	24.61	0.29
			384	836.52 (Mid)	24.41	0.28
			777	848.31 (High)	23.06	0.25
		RC3/SO2	1013	824.70 (Low)	24.59	0.29
			384	836.52 (Mid)	24.43	0.28
			777	848.31 (High)	24.09	0.26
		RC3/SO55	1013	824.70 (Low)	24.62	0.29
			384	836.52 (Mid)	24.42	0.28
			777	848.31 (High)	23.08	0.26
CDMA2000 PCS 1900	CDMA 1xRTT	RC1/SO2	25	1851.25 (Low)	23.38	0.22
			600	1880.00 (Mid)	23.57	0.23
			1175	1908.75 (High)	23.45	0.22
		RC3/SO2	25	1851.25 (Low)	23.36	0.22
			600	1880.00 (Mid)	23.52	0.22
			1175	1908.75 (High)	23.44	0.22
		RC3/SO55	25	1851.25 (Low)	23.38	0.22
			600	1880.00 (Mid)	23.58	0.23
			1175	1908.75 (High)	23.48	0.22

Reference:

- [1.] SAR Measurement Procedures for 3G Devices CDMA 2000/Ev-Do/WCDMA/HSDPA, June 2006 Laboratory Division Office of Engineering and Technology Federal Communications Commission
- [2.] 3.1.2.3.4 Maximum RF Output Power 3GPP2 C.S0033-0 Version 2.0, Date: 12 December 2003 Recommended Minimum Performance Standards for cdma2000 High Rate Packet Data Access Terminal
- [3.] May 9, 2006 Preliminary Guidance for Reviewing Applications for Certification of 3G Devices.
- [4.] Publication Number: 766989 Rule Parts: 90S Publication Date: 04/09/2007