

**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**

Client **Sporton-TW (Auden)**

Certificate No: **ER3-2358\_Jun12**

## CALIBRATION CERTIFICATE

Object **ER3DV6 - SN:2358**

Calibration procedure(s) **QA CAL-02.v6, QA CAL-25.v4**  
 Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date: **June 21, 2012**

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 ( $22 \pm 3$ )°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	29-Mar-12 (No. 217-01508)	Apr-13
Power sensor E4412A	MY41498087	29-Mar-12 (No. 217-01508)	Apr-13
Reference 3 dB Attenuator	SN: S5054 (3c)	27-Mar-12 (No. 217-01531)	Apr-13
Reference 20 dB Attenuator	SN: S5086 (20b)	27-Mar-12 (No. 217-01529)	Apr-13
Reference 30 dB Attenuator	SN: S5129 (30b)	27-Mar-12 (No. 217-01532)	Apr-13
Reference Probe ER3DV6	SN: 2328	11-Oct-11 (No. ER3-2328_Oct11)	Oct-12
DAE4	SN: 789	30-Jan-12 (No. DAE4-789_Jan12)	Jan-13
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-11)	In house check: Oct-12

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

Issued: June 21, 2012

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### Glossary:

NORM <sub>x,y,z</sub>	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 $\varphi$	$\varphi$ rotation around probe axis
Polarization $\vartheta$	$\vartheta$ 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
- b) CTIA Test Plan for Hearing Aid Compatibility, April 2010.

### Methods Applied and Interpretation of Parameters:

- NORM<sub>x,y,z</sub>: 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).
- $NORM(f)x,y,z = NORMx,y,z * frequency\_response$  (see Frequency Response Chart).
- DCP<sub>x,y,z</sub>: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- Ax,y,z; Bx,y,z; Cx,y,z, 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 NORM<sub>x</sub> (no uncertainty required).

# Probe ER3DV6

## SN:2358

Manufactured: July 7, 2005  
Calibrated: June 21, 2012

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

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

### Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ( $\mu\text{V}/(\text{V}/\text{m})^2$ )	1.70	1.55	1.57	$\pm 10.1 \%$
DCP (mV) <sup>B</sup>	98.8	99.0	102.3	

### Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc <sup>E</sup> (k=2)
0	CW	0.00	X	0.00	0.00	1.00	204.2	$\pm 3.8 \%$
			Y	0.00	0.00	1.00	201.7	
			Z	0.00	0.00	1.00	188.3	
10011	UMTS-FDD (WCDMA)	3.40	X	3.49	65.8	18.4	120.1	$\pm 0.5 \%$
			Y	3.47	65.8	18.4	120.4	
			Z	3.31	65.1	17.9	110.1	
10021	GSM-FDD (TDMA, GMSK)	9.40	X	19.88	99.9	28.7	121.6	$\pm 1.9 \%$
			Y	20.54	100.0	28.7	125.4	
			Z	17.30	94.8	26.8	121.8	
10039	CDMA2000 (1xRTT, RC1)	4.57	X	4.72	66.3	19.1	119.0	$\pm 0.9 \%$
			Y	4.69	66.2	18.9	120.7	
			Z	4.75	67.2	19.4	147.6	
10042	IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Halfrate)	7.78	X	28.22	95.6	24.2	102.8	$\pm 2.5 \%$
			Y	11.67	82.8	20.0	104.6	
			Z	13.01	83.3	20.2	98.4	
10056	UMTS-TDD (TD-SCDMA, 1.28 Mcps)	11.01	X	13.97	98.8	37.5	141.8	$\pm 3.5 \%$
			Y	14.17	98.9	37.4	144.4	
			Z	15.22	98.9	36.6	135.8	
10081	CDMA2000 (1xRTT, RC3)	3.96	X	3.83	65.3	18.4	118.3	$\pm 0.7 \%$
			Y	3.82	65.5	18.4	119.4	
			Z	3.99	67.0	19.2	147.7	
10082	IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Fullrate)	4.77	X	45.52	99.5	22.7	117.8	$\pm 2.7 \%$
			Y	56.03	99.6	22.2	119.8	
			Z	50.02	99.8	22.6	109.6	
10100	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	5.66	X	6.65	68.5	20.6	134.6	$\pm 2.2 \%$
			Y	6.62	68.5	20.6	136.4	
			Z	6.25	67.1	19.7	119.9	
10101	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	6.41	X	7.82	69.0	21.2	146.1	$\pm 3.0 \%$
			Y	7.78	69.0	21.2	147.3	
			Z	7.37	67.6	20.2	129.8	
10108	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	5.79	X	6.49	67.9	20.4	133.5	$\pm 2.2 \%$
			Y	6.51	68.1	20.5	134.9	
			Z	6.07	66.6	19.5	119.0	
10109	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM)	6.42	X	7.56	68.7	21.1	142.7	$\pm 2.7 \%$
			Y	7.53	68.6	21.0	143.0	
			Z	7.10	67.3	20.1	126.7	

10110	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)	5.75	X	6.20	67.5	20.3	131.4	$\pm 1.9\%$
			Y	6.13	67.2	20.1	131.1	
			Z	5.77	66.1	19.3	116.7	
10111	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM)	6.44	X	7.26	68.2	20.9	138.5	$\pm 2.7\%$
			Y	7.24	68.2	20.9	139.0	
			Z	6.83	67.1	20.0	123.0	
10139	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, QPSK)	6.14	X	7.30	69.0	21.1	140.1	$\pm 2.7\%$
			Y	7.27	68.9	21.1	140.4	
			Z	6.81	67.3	20.0	124.7	
10140	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM)	6.49	X	8.03	69.2	21.4	148.3	$\pm 3.3\%$
			Y	7.99	69.1	21.3	148.7	
			Z	7.56	67.8	20.4	132.2	
10142	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, QPSK)	5.73	X	6.00	67.1	20.0	128.3	$\pm 1.7\%$
			Y	5.99	67.1	20.1	129.3	
			Z	5.58	65.8	19.2	114.2	
10143	LTE-FDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM)	6.35	X	7.02	68.1	20.8	135.3	$\pm 2.7\%$
			Y	7.00	68.0	20.8	136.5	
			Z	6.56	66.9	19.9	119.4	
10145	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK)	5.76	X	5.74	66.7	19.9	124.5	$\pm 1.7\%$
			Y	5.70	66.6	19.8	126.2	
			Z	5.38	65.8	19.2	110.7	
10146	LTE-FDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM)	6.42	X	6.76	68.0	20.8	129.3	$\pm 2.5\%$
			Y	6.72	67.9	20.7	131.3	
			Z	6.31	66.9	20.0	113.6	
10148	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)	5.83	X	6.59	68.1	20.6	133.8	$\pm 2.2\%$
			Y	6.61	68.2	20.6	135.5	
			Z	6.15	66.6	19.6	119.0	
10149	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM)	6.42	X	7.58	68.8	21.2	141.8	$\pm 3.0\%$
			Y	7.49	68.5	21.0	143.7	
			Z	7.09	67.3	20.1	125.4	
10154	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)	5.76	X	6.20	67.4	20.3	130.1	$\pm 1.9\%$
			Y	6.19	67.4	20.2	131.5	
			Z	5.75	66.0	19.3	115.4	
10155	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM)	6.43	X	7.28	68.3	21.0	138.5	$\pm 2.7\%$
			Y	7.25	68.2	20.9	139.0	
			Z	6.79	66.9	20.0	122.1	
10156	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, QPSK)	5.79	X	5.98	67.1	20.2	127.4	$\pm 1.9\%$
			Y	5.94	66.9	20.0	127.7	
			Z	5.56	65.8	19.3	112.8	
10157	LTE-FDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM)	6.49	X	7.06	68.2	21.0	134.2	$\pm 2.7\%$
			Y	7.01	68.1	20.9	133.4	
			Z	6.54	66.8	19.9	117.2	
10160	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, QPSK)	5.81	X	6.64	68.0	20.4	135.9	$\pm 2.2\%$
			Y	6.61	67.9	20.4	135.1	
			Z	6.20	66.6	19.5	121.1	

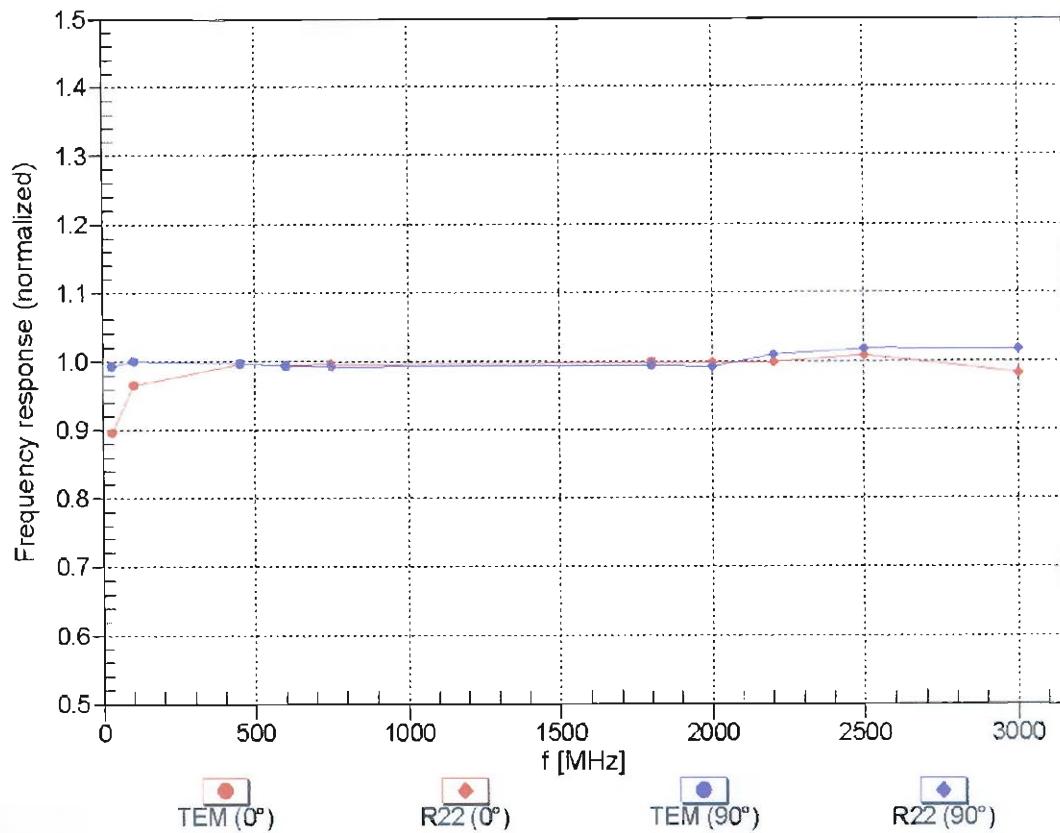
10161	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 16-QAM)	6.42	X	7.61	68.7	21.1	143.4	$\pm 3.0\%$
			Y	7.57	68.6	21.0	141.9	
			Z	7.14	67.4	20.1	127.4	
10163	LTE-FDD (SC-FDMA, 50% RB, 3 MHz, QPSK)	5.68	X	5.81	67.0	20.0	125.7	$\pm 1.7\%$
			Y	5.74	66.7	19.8	125.4	
			Z	5.41	65.8	19.2	112.7	
10164	LTE-FDD (SC-FDMA, 50% RB, 3 MHz, 16-QAM)	6.44	X	6.90	68.1	20.9	130.8	$\pm 2.5\%$
			Y	6.87	68.0	20.8	130.7	
			Z	6.41	66.9	20.0	115.8	
10166	LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, QPSK)	5.45	X	5.08	66.0	19.4	118.9	$\pm 1.4\%$
			Y	5.10	66.2	19.5	119.3	
			Z	5.23	67.3	20.1	149.7	
10167	LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, 16-QAM)	6.21	X	6.19	67.8	20.7	121.9	$\pm 2.2\%$
			Y	6.13	67.6	20.5	123.4	
			Z	5.77	66.6	19.7	109.5	

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%.

<sup>b</sup> Numerical linearization parameter: uncertainty not required.

<sup>c</sup> Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

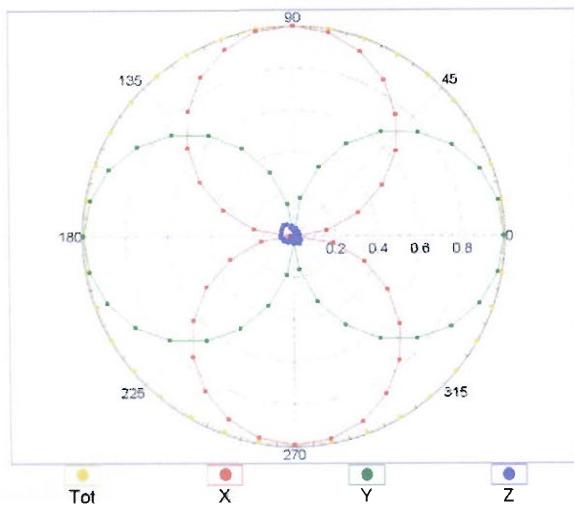
## Frequency Response of E-Field (TEM-Cell:ifi110 EXX, Waveguide: R22)



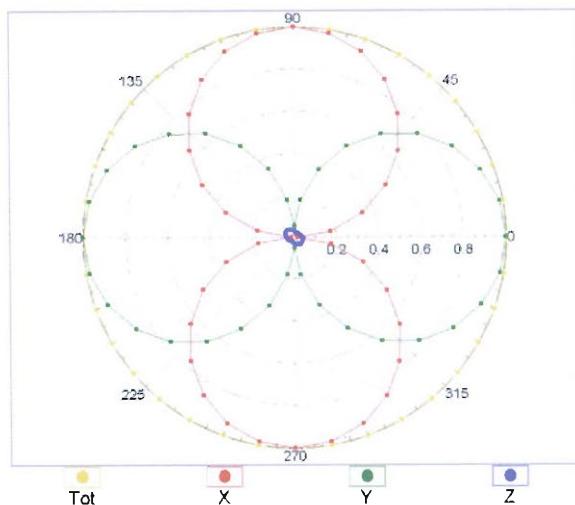
Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM,0°

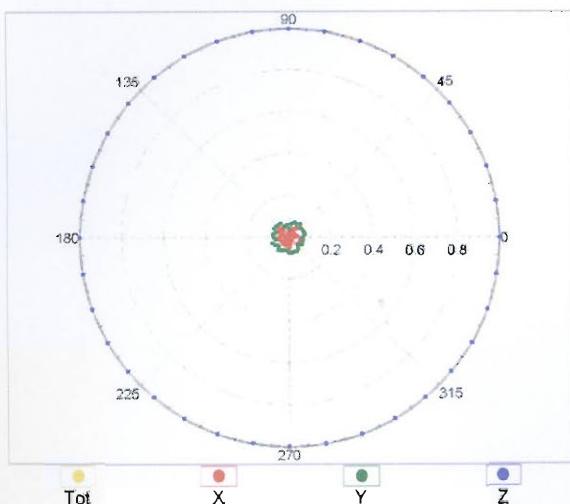


f=2500 MHz,R22,0°

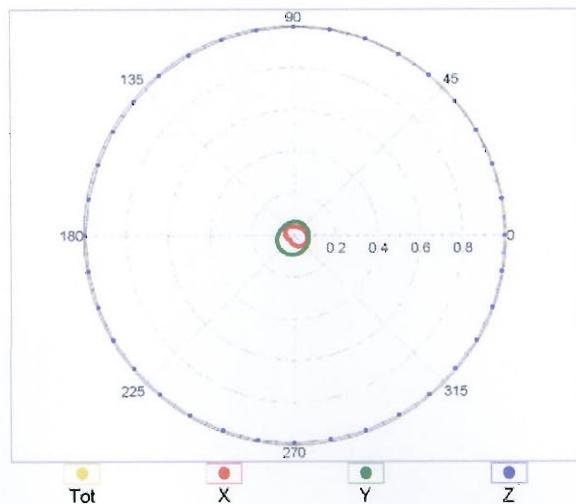


### Receiving Pattern ( $\phi$ ), $\theta = 90^\circ$

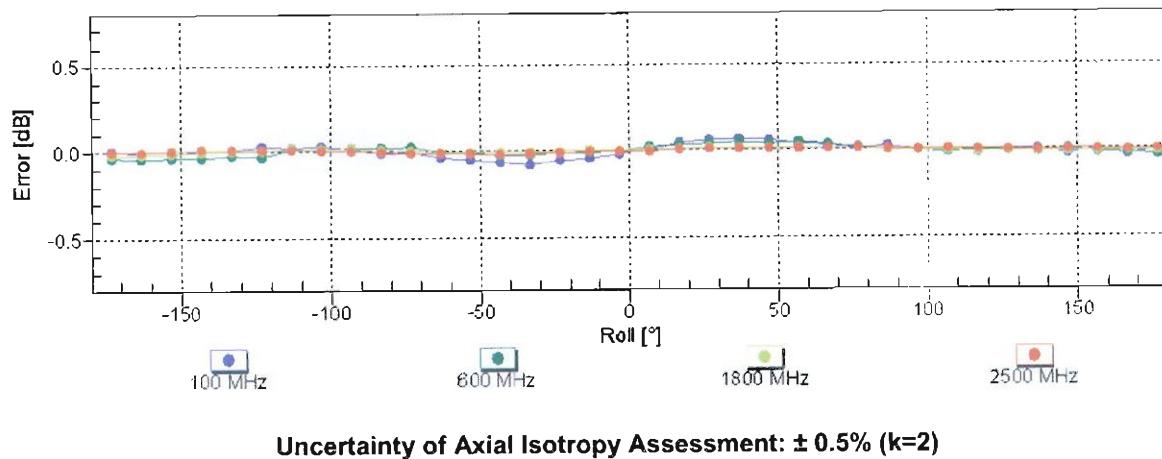
f=600 MHz,TEM,90°



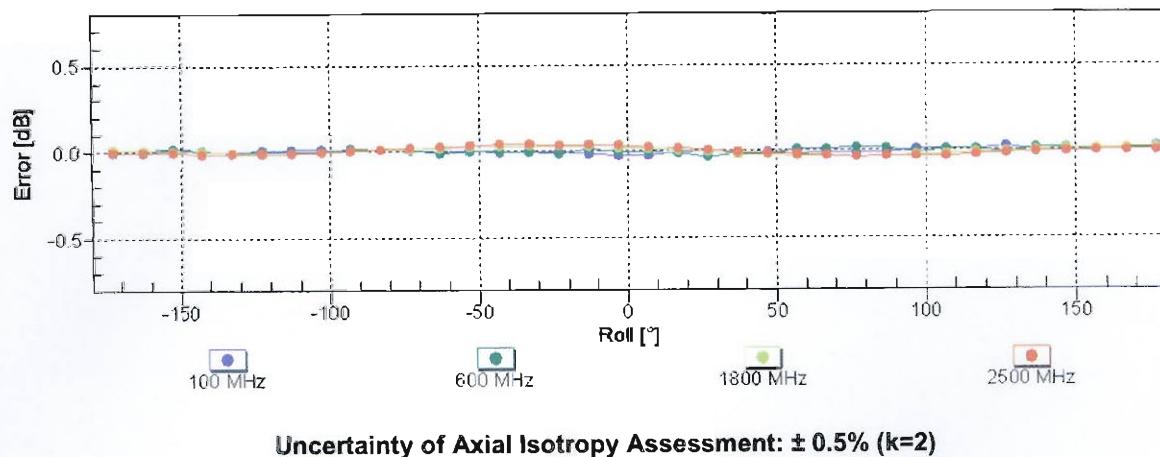
f=2500 MHz,R22,90°



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

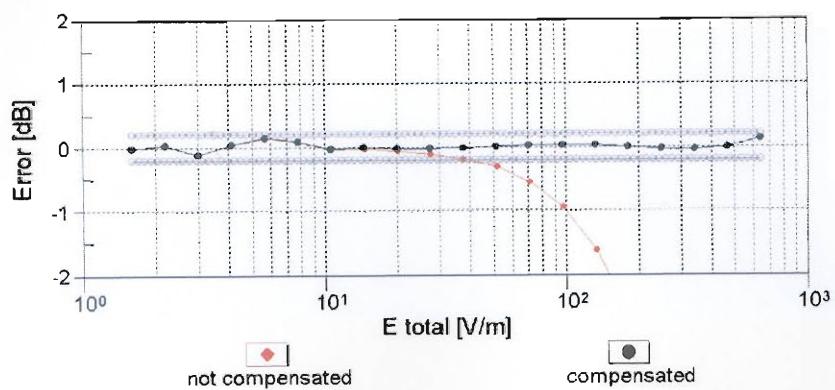
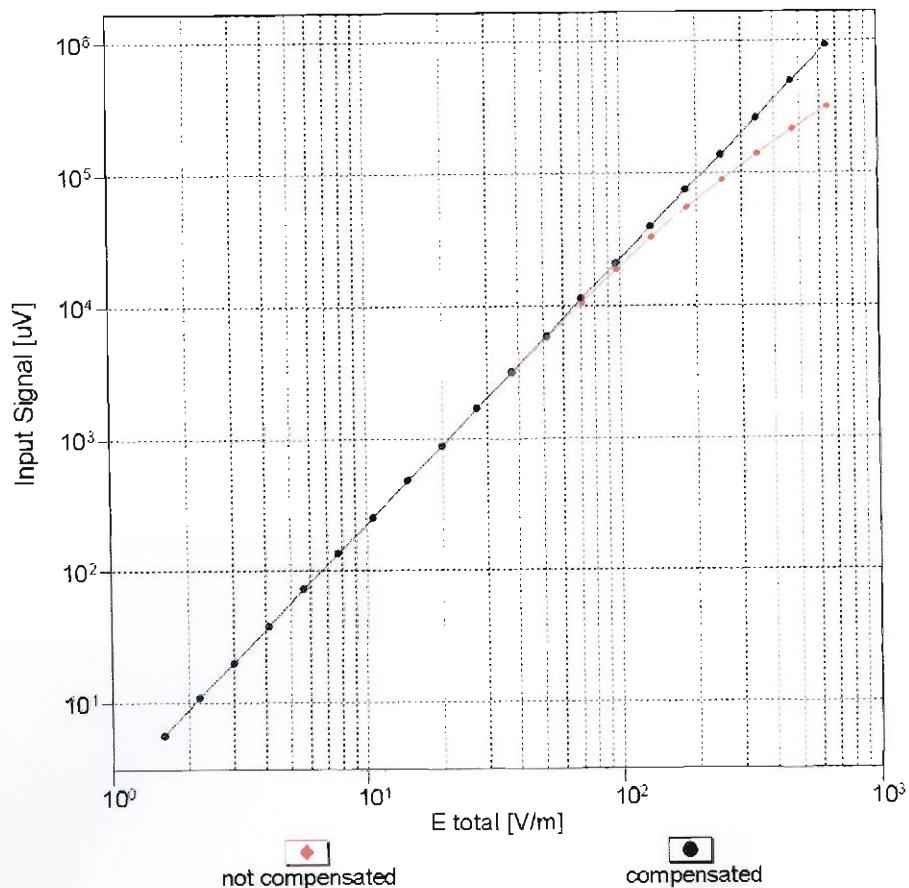


## Receiving Pattern ( $\phi$ ), $\theta = 90^\circ$



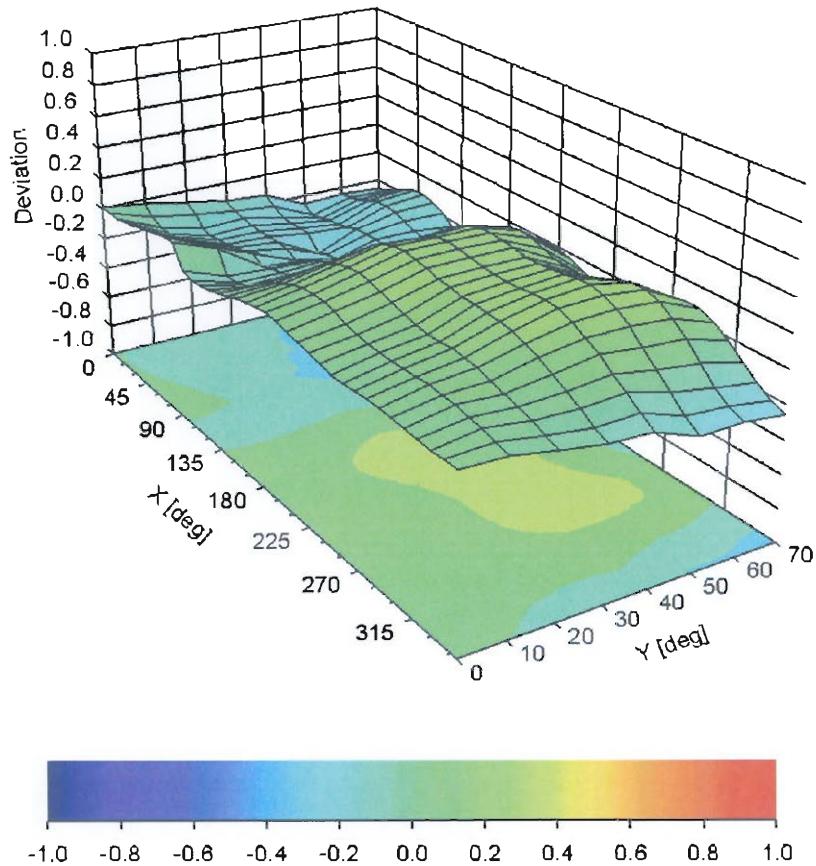
## Dynamic Range f(E-field)

(TEM cell , f = 900 MHz)



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

## Deviation from Isotropy in Air Error ( $\phi, \theta$ ), f = 900 MHz



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

### Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	-63.2
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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**Zeughausstrasse 43, 8004 Zurich, Switzerland**



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

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Accreditation No.: SCS 108

Client Sporton (Auden)

Certificate No: H3-6184\_Jan12

## CALIBRATION CERTIFICATE

Object H3DV6 - SN:6184

Calibration procedure(s) QA CAL-03.v6, QA CAL-25.v4  
 Calibration procedure for H-field probes optimized for close near field evaluations in air

Calibration date: January 26, 2012

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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

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Reference 3 dB Attenuator	SN: S5054 (3c)	29-Mar-11 (No. 217-01369)	Apr-12
Reference 20 dB Attenuator	SN: S5086 (20b)	29-Mar-11 (No. 217-01367)	Apr-12
Reference 30 dB Attenuator	SN: S5129 (30b)	29-Mar-11 (No. 217-01370)	Apr-12
Reference Probe H3DV6	SN: 6182	11-Oct-11 (No. H3-6182_Oct11)	Oct-12
DAE4	SN: 789	6-Apr-11 (No. DAE4-789_Apr11)	Apr-12
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-11)	In house check: Apr-13
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-11)	In house check: Oct-12

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

Issued: January 27, 2012

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Accreditation No.: **SCS 108**

### 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 $\varphi$	$\varphi$ rotation around probe axis
Polarization $\theta$	$\theta$ 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:

- 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  $\theta = 0$  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).
- DCP $x,y,z$ : DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- $Ax,y,z; Bx,y,z; Cx,y,z; VRx,y,z$ : 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).

# Probe H3DV6

**SN:6184**

Manufactured: June 8, 2004  
Calibrated: January 26, 2012

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

## DASY/EASY - Parameters of Probe: H3DV6 - SN:6184

### Basic Calibration Parameters

		Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm (A/m / $\sqrt{\text{mV}}$ )	a0	2.49E-003	2.55E-003	2.96E-003	$\pm 5.1\%$
Norm (A/m / $\sqrt{\text{mV}}$ )	a1	8.55E-006	-6.85E-005	-7.97E-005	$\pm 5.1\%$
Norm (A/m / $\sqrt{\text{mV}}$ )	a2	1.06E-005	3.23E-007	6.05E-005	$\pm 5.1\%$
DCP (mV) <sup>b</sup>		90.9	91.8	90.9	

### Modulation Calibration Parameters

UID	Communication System Name	PAR		A dB	B dB	C dB	VR mV	Unc <sup>c</sup> (k=2)
10000	CW	0.00	X	0.00	0.00	1.00	103.1	$\pm 1.9\%$
			Y	0.00	0.00	1.00	103.9	
			Z	0.00	0.00	1.00	96.8	

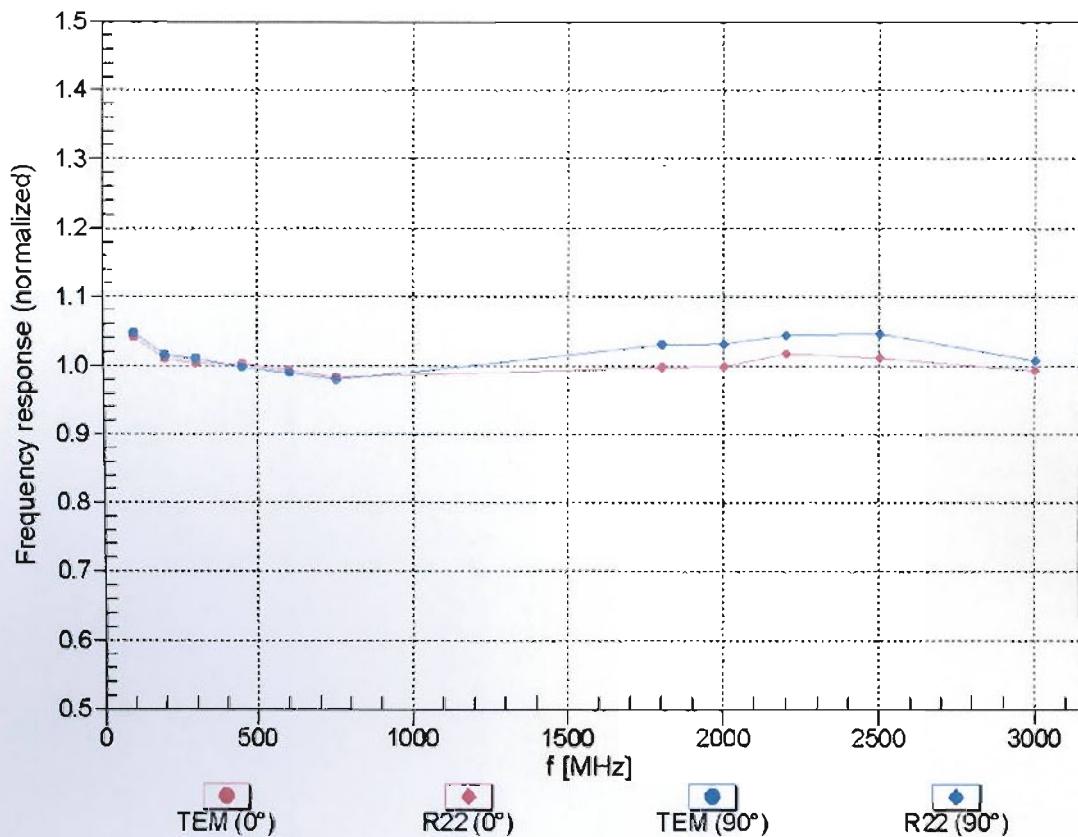
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

<sup>b</sup> Numerical linearization parameter: uncertainty not required.

<sup>c</sup> 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 H-Field

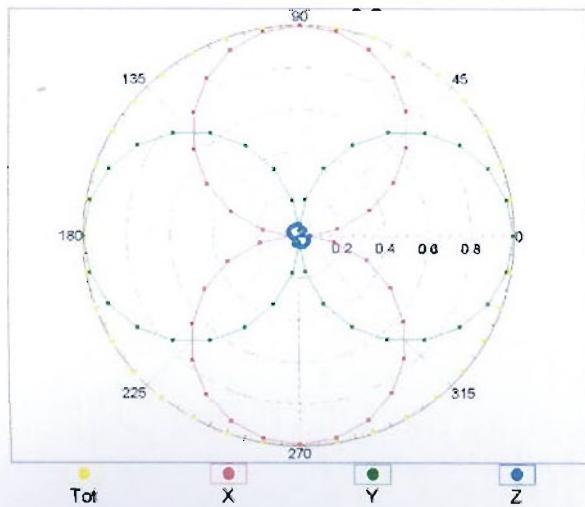
(TEM-Cell:ifi110 EXX, Waveguide: R22)



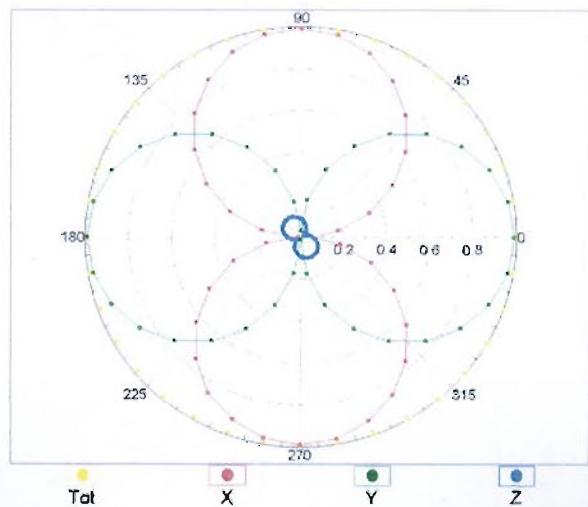
Uncertainty of Frequency Response of H-field:  $\pm 6.3\%$  ( $k=2$ )

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

f=600 MHz,TEM,0°

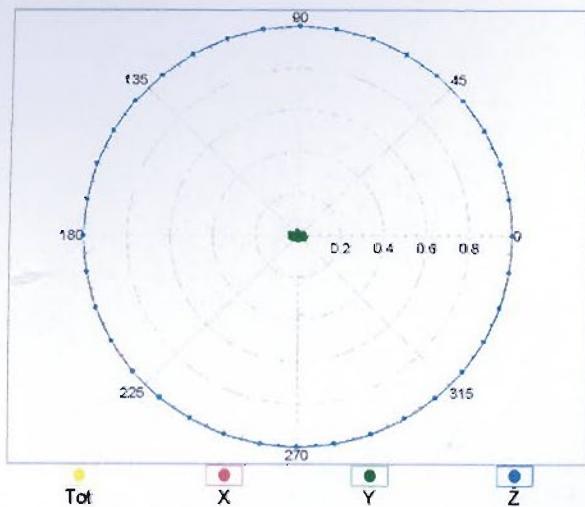


f=2500 MHz,R22,0°

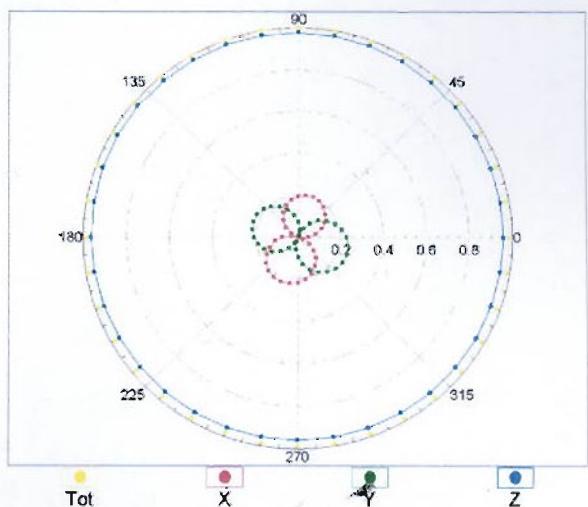


## Receiving Pattern ( $\phi$ ), $\theta = 90^\circ$

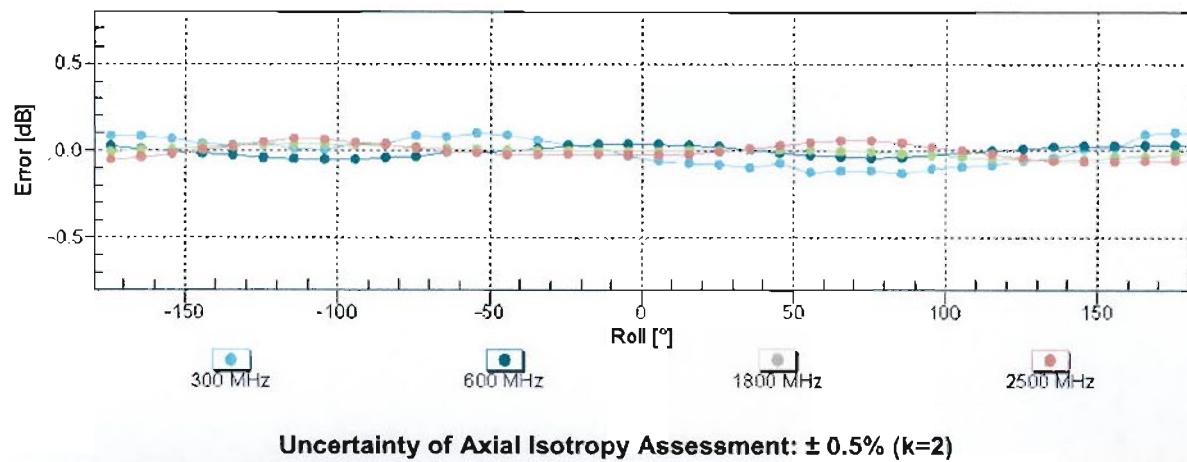
f=600 MHz,TEM,90°



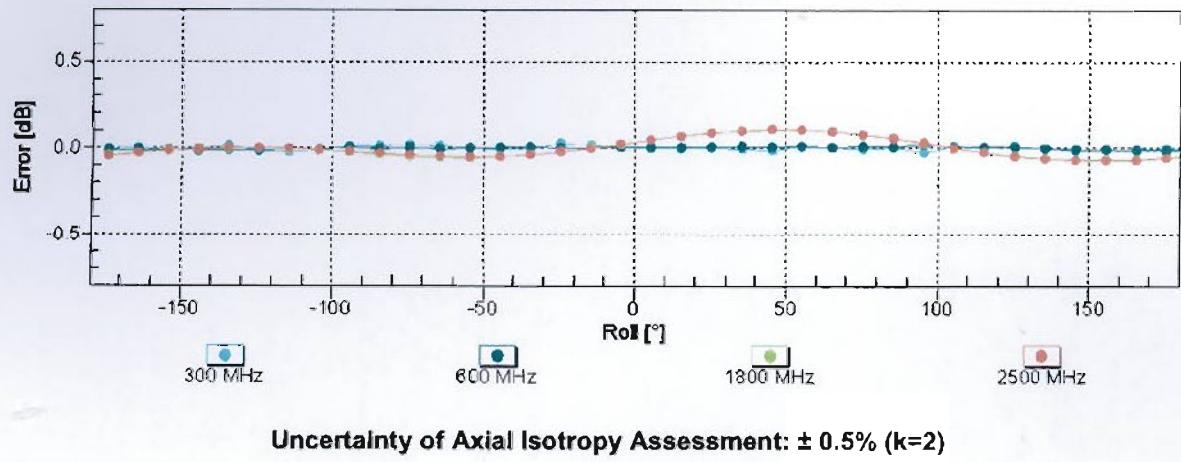
f=2500 MHz,R22,90°



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

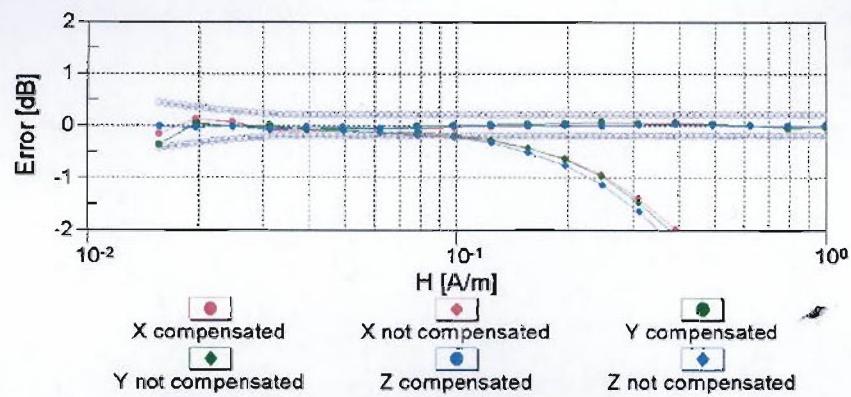
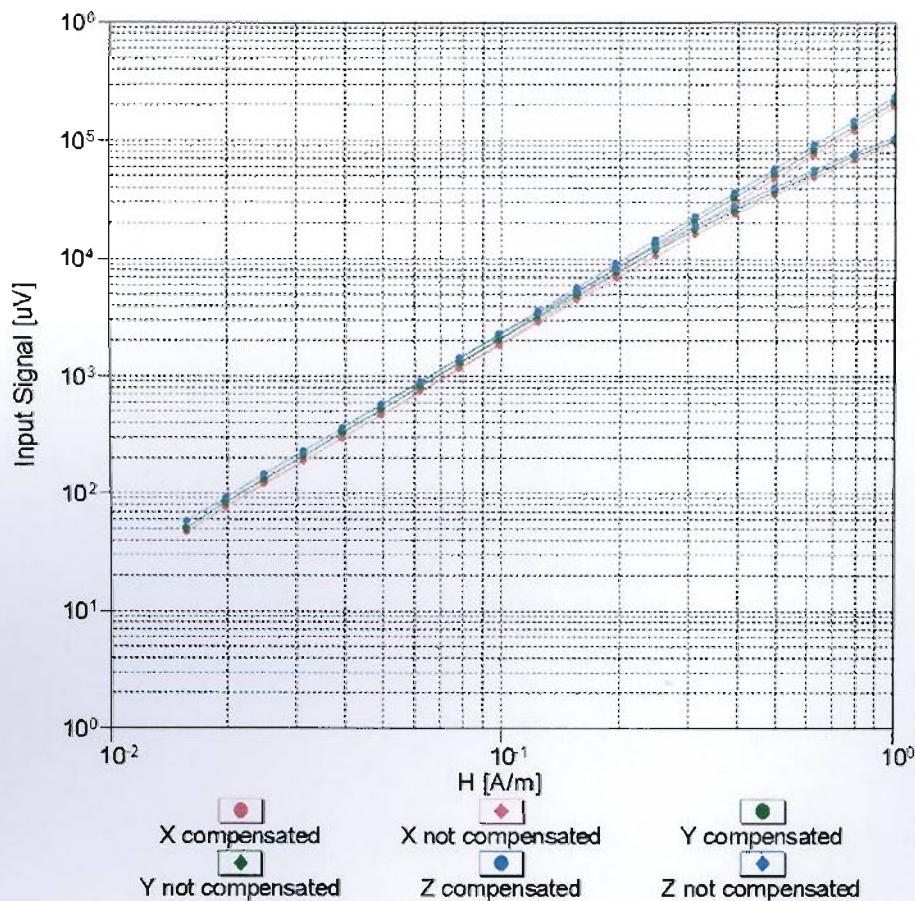


## Receiving Pattern ( $\phi$ ), $\theta = 90^\circ$



## Dynamic Range f(H-field)

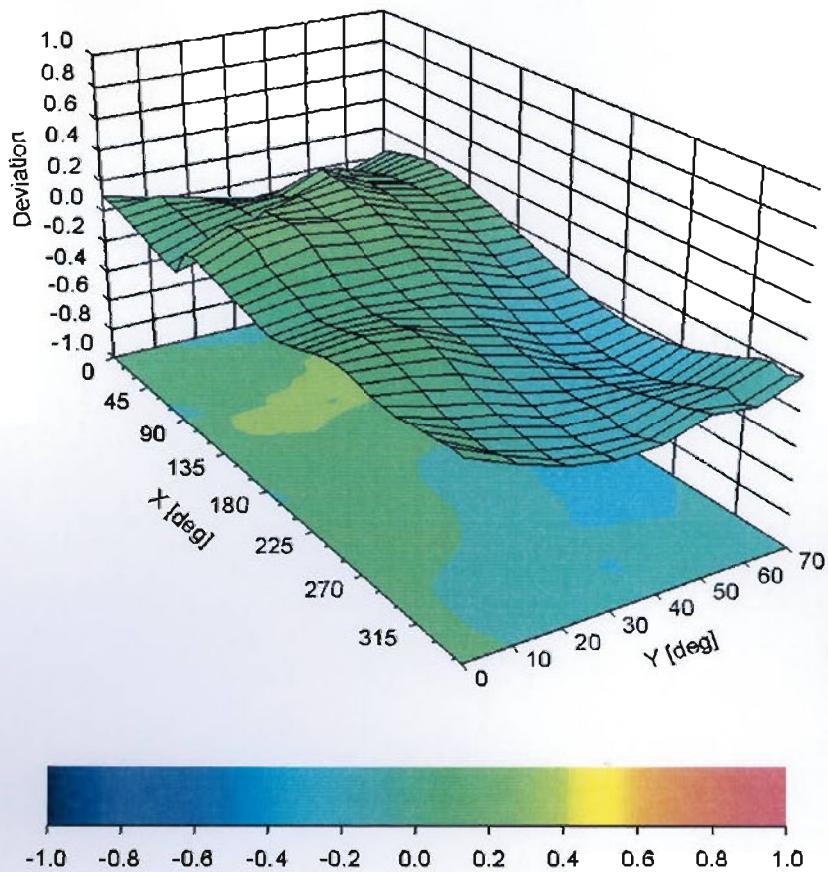
(TEM cell,  $f = 900$  MHz)



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

## Deviation from Isotropy in Air

Error ( $\phi, \theta$ ), f = 900 MHz



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

## DASY/EASY - Parameters of Probe: H3DV6 - SN:6184

### Other Probe Parameters

Sensor Arrangement	Rectangular
Connector Angle (°)	-64.5
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

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



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

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Client Sporton-TW (Auden)

Accreditation No.: **SCS 108**

Certificate No: **CD1880V3-1038\_Jun12**

## CALIBRATION CERTIFICATE

Object **CD1880V3 - SN: 1038**

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

Calibration date: **June 14, 2012**

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 ( $22 \pm 3$ )°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	05-Oct-11 (No. 217-01451)	Oct-12
Power sensor HP 8481A	US37292783	05-Oct-11 (No. 217-01451)	Oct-12
Probe ER3DV6	SN: 2336	29-Dec-11 (No. ER3-2336_Dec11)	Dec-12
Probe H3DV6	SN: 6065	29-Dec-11 (No. H3-6065_Dec11)	Dec-12
DAE4	SN: 781	29-May-12 (No. DAE4-781_May12)	May-13

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-11)	In house check: Oct-12
Power sensor HP 8482H	SN: 3318A09450	09-Oct-09 (in house check Oct-11)	In house check: Oct-12
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-11)	In house check: Oct-12
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-11)	In house check: Oct-12
RF generator E4433B	MY 41000675	03-Nov-04 (in house check Oct-11)	In house check: Oct-13

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

Issued: June 18, 2012

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Accreditation No.: **SCS 108**

## References

- [1] ANSI-C63.19-2007 American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
- [2] ANSI-C63.19-2011 American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

## Methods Applied and Interpretation of Parameters:

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

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

## Measurement Conditions

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

<b>DASY Version</b>	DASY5	V52.8.1
<b>Extrapolation</b>	Advanced Extrapolation	
<b>Phantom</b>	HAC Test Arch	
<b>Distance Dipole Top - Probe Center</b>	10mm 15mm	
<b>Scan resolution</b>	dx, dy = 5 mm	
<b>Frequency</b>	1880 MHz ± 1 MHz	
<b>Input power drift</b>	< 0.05 dB	

## Maximum Field values at 1880 MHz

<b>H-field 10 mm above dipole surface</b>	condition	<b>interpolated maximum</b>
Maximum measured	100 mW input power	<b>0.463 A / m ± 8.2 % (k=2)</b>

<b>E-field 10 mm above dipole surface</b>	condition	<b>Interpolated maximum</b>
Maximum measured above high end	100 mW input power	139.9 V / m
Maximum measured above low end	100 mW input power	138.1 V / m
Averaged maximum above arm	100 mW input power	<b>139.0 V / m ± 12.8 % (k=2)</b>

<b>E-field 15 mm above dipole surface</b>	condition	<b>Interpolated maximum</b>
Maximum measured above high end	100 mW input power	90.4 V / m
Maximum measured above low end	100 mW input power	88.0 V / m
Averaged maximum above arm	100 mW input power	<b>89.2 V / m ± 12.8 % (k=2)</b>

## Appendix

### Antenna Parameters

Frequency	Return Loss	Impedance
1730 MHz	21.5 dB	$50.7 \Omega + 8.4 j\Omega$
1880 MHz	22.5 dB	$53.3 \Omega + 7.0 j\Omega$
1900 MHz	22.2 dB	$55.4 \Omega + 6.2 j\Omega$
1950 MHz	25.2 dB	$53.9 \Omega - 4.1 j\Omega$
2000 MHz	20.0 dB	$40.9 \Omega + 0.1 j\Omega$

### 3.2 Antenna Design and Handling

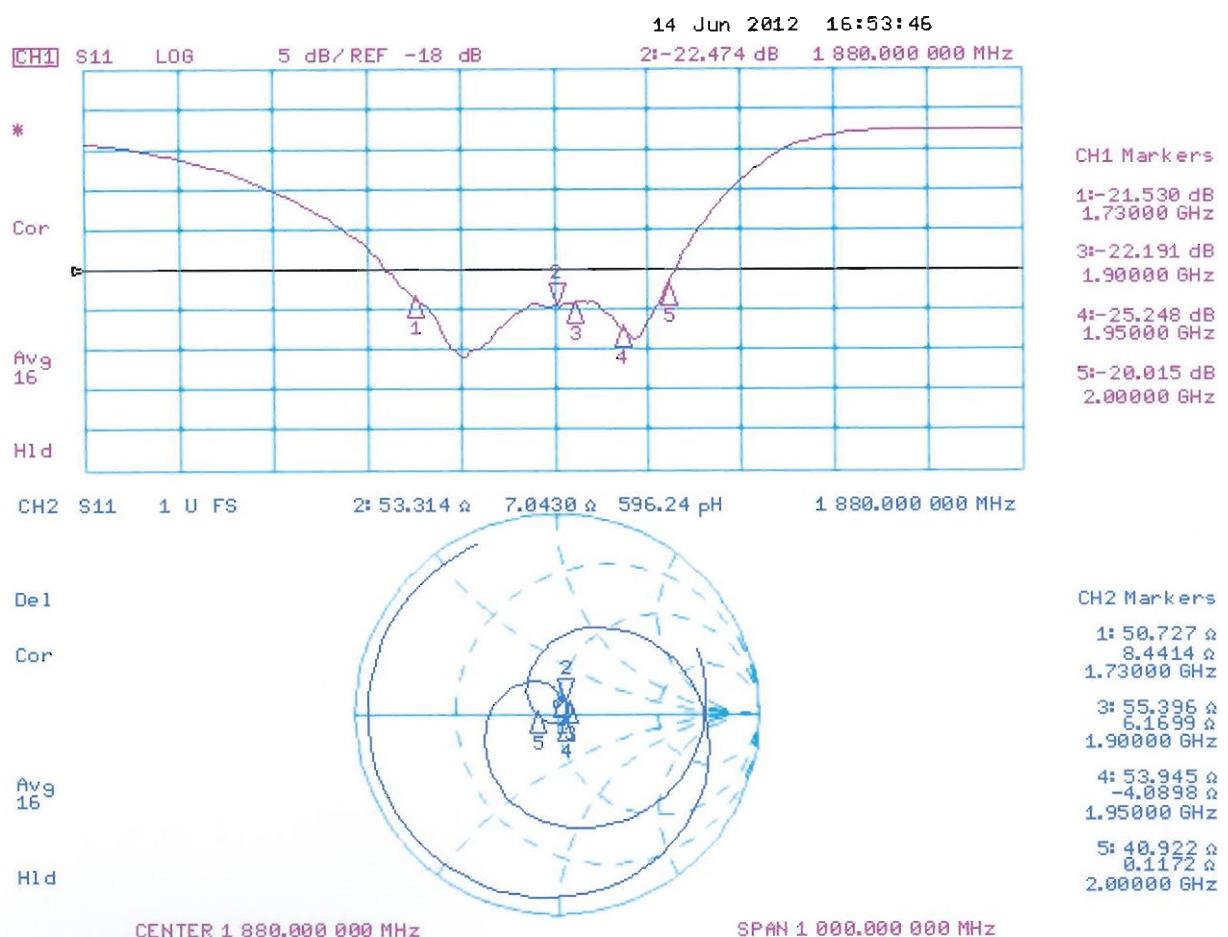
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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

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

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

## Impedance Measurement Plot



## DASY4 H-field Result

Date: 14.06.2012

Test Laboratory: SPEAG Lab2

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

Communication System: CW; Frequency: 1880 MHz  
Medium parameters used:  $\sigma = 0 \text{ mho/m}$ ,  $\epsilon_r = 1$ ;  $\rho = 1 \text{ kg/m}^3$   
Phantom section: RF Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 29.12.2011
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 29.05.2012
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.8.1(838); SEMCAD X 14.6.5(6469)

### Dipole H-Field measurement @ 1880MHz/H-Scan - 1880MHz d=10mm/Hearing Aid Compatibility Test (41x181x1):

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

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 0.4900 A/m; Power Drift = 0.01 dB

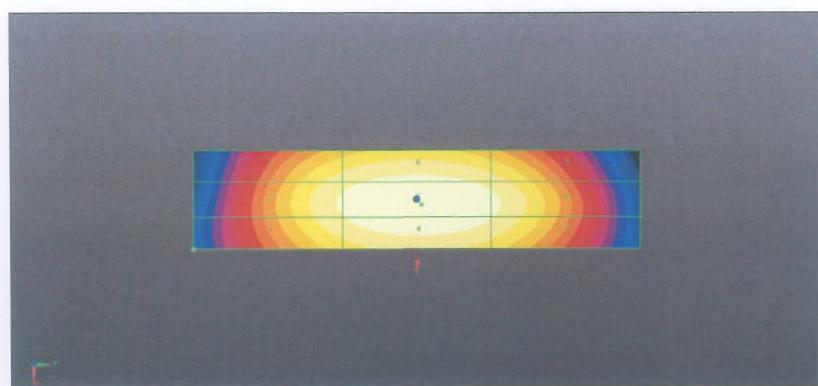
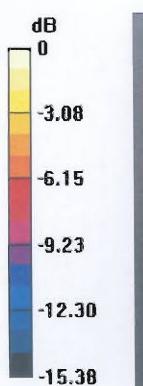
PMR not calibrated. PMF = 1.000 is applied.

H-field emissions = 0.4633 A/m

**Near-field category: M2 (AWF 0 dB)**

PMF scaled H-field

Grid 1 <b>M2</b>	Grid 2 <b>M2</b>	Grid 3 <b>M2</b>
0.409 A/m	0.420 A/m	0.394 A/m
Grid 4 <b>M2</b>	Grid 5 <b>M2</b>	Grid 6 <b>M2</b>
0.451 A/m	0.463 A/m	0.432 A/m
Grid 7 <b>M2</b>	Grid 8 <b>M2</b>	Grid 9 <b>M2</b>
<b>0.415 A/m</b>	0.427 A/m	0.393 A/m



0 dB = 0.4633 A/m = -6.68 dB A/m

## DASY4 E-field Result

Date: 14.06.2012

Test Laboratory: SPEAG Lab2

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

Communication System: CW; Frequency: 1880 MHz  
Medium parameters used:  $\sigma = 0 \text{ mho/m}$ ,  $\epsilon_r = 1$ ;  $\rho = 1000 \text{ kg/m}^3$   
Phantom section: RF Section  
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2007)

DASY52 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 29.12.2011
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 29.05.2012
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.8.1(838); SEMCAD X 14.6.5(6469)

### Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=10mm/Hearing Aid Compatibility Test (41x181x1):

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

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 157.8 V/m; Power Drift = -0.00 dB

PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 139.9 V/m

**Near-field category: M2 (AWF 0 dB)**

PMF scaled E-field

Grid 1 M2	Grid 2 M2	Grid 3 M2
134.4 V/m	138.1 V/m	133.2 V/m
Grid 4 M3	Grid 5 M3	Grid 6 M3
89.96 V/m	91.35 V/m	86.69 V/m
Grid 7 M2	Grid 8 M2	Grid 9 M2
136.5 V/m	139.9 V/m	132.2 V/m

**Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=15mm/Hearing Aid Compatibility Test (41x181x1):**

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

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 157.7 V/m; Power Drift = 0.02 dB

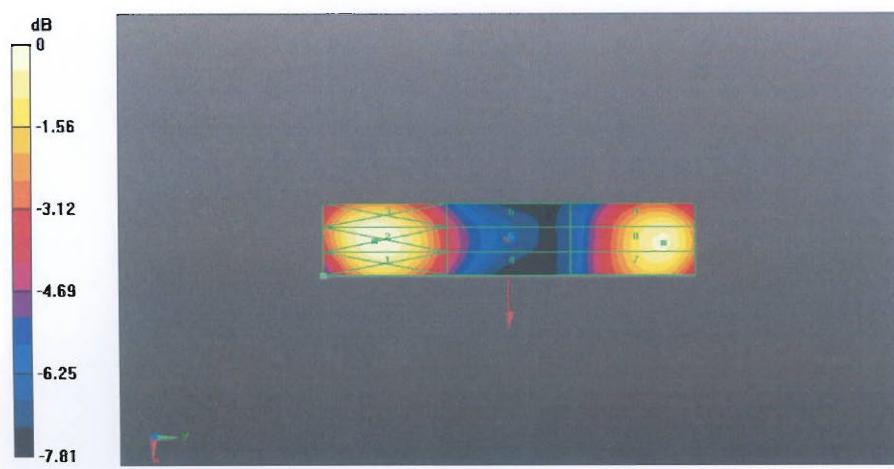
PMR not calibrated. PMF = 1.000 is applied.

E-field emissions = 87.97 V/m

**Near-field category: M3 (AWF 0 dB)**

PMF scaled E-field

Grid 1 M3	Grid 2 M3	Grid 3 M3
89.00 V/m	90.38 V/m	88.77 V/m
Grid 4 M3	Grid 5 M3	Grid 6 M3
69.82 V/m	70.24 V/m	68.73 V/m
Grid 7 M3	Grid 8 M3	Grid 9 M3
87.06 V/m	87.97 V/m	85.67 V/m





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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton**

Certificate No: **DAE3-577\_Jun12**

## CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AA - SN: 577**

Calibration procedure(s) **QA CAL-06.v24**  
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **June 06, 2012**

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 ( $22 \pm 3$ )°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-11 (No:11450)	Sep-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V2.1	SE UWS 053 AA 1001	05-Jan-12 (in house check)	In house check: Jan-13

Calibrated by: Name **Dominique Steffen** Function **Technician** Signature

Approved by: Name **Fin Bomholt** Function **R&D Director** Signature

Issued: June 6, 2012

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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

## Glossary

<b>DAE</b>	data acquisition electronics
<b>Connector angle</b>	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 =  $6.1\mu V$ , 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	$404.058 \pm 0.1\% (k=2)$	$403.945 \pm 0.1\% (k=2)$	$404.061 \pm 0.1\% (k=2)$
Low Range	$3.93352 \pm 0.7\% (k=2)$	$3.95384 \pm 0.7\% (k=2)$	$3.95036 \pm 0.7\% (k=2)$

## Connector Angle

Connector Angle to be used in DASY system	$111.5^\circ \pm 1^\circ$
---	---------------------------

## Appendix

### 1. DC Voltage Linearity

High Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	199995.54	-0.89	-0.00
Channel X	+ Input	20002.00	1.99	0.01
Channel X	- Input	-19998.81	2.31	-0.01
Channel Y	+ Input	199996.22	-0.29	-0.00
Channel Y	+ Input	19999.47	-0.49	-0.00
Channel Y	- Input	-20001.10	0.06	-0.00
Channel Z	+ Input	199994.90	-1.65	-0.00
Channel Z	+ Input	20001.77	1.80	0.01
Channel Z	- Input	-19999.69	1.56	-0.01

Low Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	2000.56	0.24	0.01
Channel X	+ Input	200.49	-0.28	-0.14
Channel X	- Input	-198.35	0.69	-0.35
Channel Y	+ Input	2000.53	0.31	0.02
Channel Y	+ Input	200.35	-0.44	-0.22
Channel Y	- Input	-199.12	0.17	-0.08
Channel Z	+ Input	1999.73	-0.51	-0.03
Channel Z	+ Input	199.96	-0.76	-0.38
Channel Z	- Input	-200.14	-0.91	0.46

### 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 ( $\mu$ V)	Low Range Average Reading ( $\mu$ V)
Channel X	200	-8.13	-11.22
	-200	12.49	10.42
Channel Y	200	10.28	10.45
	-200	-12.29	-11.56
Channel Z	200	7.71	8.46
	-200	-10.39	-10.87

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu$ V)	Channel Y ( $\mu$ V)	Channel Z ( $\mu$ V)
Channel X	200	-	-0.16	-3.68
Channel Y	200	6.63	-	0.62
Channel Z	200	5.48	4.85	-

#### 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	16237	16308
Channel Y	16451	16683
Channel Z	15995	16468

#### 5. Input Offset Measurement

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

Input 10MΩ

	Average (µV)	min. Offset (µV)	max. Offset (µV)	Std. Deviation (µV)
Channel X	-0.65	-2.12	0.66	0.54
Channel Y	0.02	-1.35	1.15	0.59
Channel Z	-2.84	-3.96	-1.77	0.47

#### 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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**Engineering AG**  
**Zeughausstrasse 43, 8004 Zurich, Switzerland**



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

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Client Sporton-TW (Auden)

Accreditation No.: **SCS 108**

Certificate No: **DAE4-778\_Aug12**

## CALIBRATION CERTIFICATE

Object DAE4 - SD 000 D04 BJ - SN: 778

Calibration procedure(s) QA CAL-06.v25  
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: August 27, 2012

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 ( $22 \pm 3$ )°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-11 (No:11450)	Sep-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V2.1	SE UWS 053 AA 1001	05-Jan-12 (in house check)	In house check: Jan-13

Calibrated by:	Name	Function	Signature
	Dominique Steffen	Technician	
Approved by:	Fin Bomholt	R&D Director	

Issued: August 27, 2012

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



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

Accredited by the Swiss Accreditation Service (SAS)

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

Accreditation No.: **SCS 108**

## Glossary

<b>DAE</b>	data acquisition electronics
<b>Connector angle</b>	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 =  $6.1\mu V$ , 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	$404.663 \pm 0.1\% (k=2)$	$403.465 \pm 0.1\% (k=2)$	$405.010 \pm 0.1\% (k=2)$
Low Range	$3.98578 \pm 0.7\% (k=2)$	$3.96516 \pm 0.7\% (k=2)$	$3.99894 \pm 0.7\% (k=2)$

## Connector Angle

Connector Angle to be used in DASY system	$283^\circ \pm 1^\circ$
---	-------------------------

## Appendix

### 1. DC Voltage Linearity

High Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	200000.39	2.63	0.00
Channel X	+ Input	20001.58	1.36	0.01
Channel X	- Input	-19998.48	2.54	-0.01
Channel Y	+ Input	200000.90	3.34	0.00
Channel Y	+ Input	20000.55	0.30	0.00
Channel Y	- Input	-19999.91	1.23	-0.01
Channel Z	+ Input	199999.59	1.90	0.00
Channel Z	+ Input	19998.55	-1.57	-0.01
Channel Z	- Input	-20004.33	-3.11	0.02

Low Range		Reading ( $\mu\text{V}$ )	Difference ( $\mu\text{V}$ )	Error (%)
Channel X	+ Input	2000.71	0.06	0.00
Channel X	+ Input	201.15	0.23	0.11
Channel X	- Input	-198.08	0.92	-0.46
Channel Y	+ Input	2000.36	-0.13	-0.01
Channel Y	+ Input	199.81	-0.98	-0.49
Channel Y	- Input	-200.22	-1.21	0.61
Channel Z	+ Input	2000.89	0.54	0.03
Channel Z	+ Input	200.06	-0.72	-0.36
Channel Z	- Input	-199.79	-0.68	0.34

### 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 ( $\mu\text{V}$ )	Low Range Average Reading ( $\mu\text{V}$ )
Channel X	200	-4.83	-5.89
	-200	7.67	5.93
Channel Y	200	-1.95	-2.63
	-200	-0.79	-0.35
Channel Z	200	-8.43	-9.27
	-200	8.42	8.08

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu\text{V}$ )	Channel Y ( $\mu\text{V}$ )	Channel Z ( $\mu\text{V}$ )
Channel X	200	-	-1.46	-2.45
Channel Y	200	9.44	-	0.28
Channel Z	200	4.92	6.59	-

#### **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	16053	16715
Channel Y	16161	14601
Channel Z	16434	15429

#### **5. Input Offset Measurement**

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

Input  $10M\Omega$

	Average ( $\mu V$ )	min. Offset ( $\mu V$ )	max. Offset ( $\mu V$ )	Std. Deviation ( $\mu V$ )
Channel X	1.04	0.34	1.84	0.34
Channel Y	-1.10	-2.50	0.04	0.56
Channel Z	-0.63	-1.70	1.29	0.47

#### **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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 Multilateral Agreement for the recognition of calibration certificates

Client **Amphenol (Auden)**

Accreditation No.: **SCS 108**

Certificate No: **DAE3-495\_Apr12**

## CALIBRATION CERTIFICATE

Object **DAE3 - SD 000 D03 AD - SN: 495**

Calibration procedure(s) **QA CAL-06.v24**  
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **April 23, 2012**

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 ( $22 \pm 3$ )°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-11 (No:11450)	Sep-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V2.1	SE UWS 053 AA 1001	05-Jan-12 (in house check)	In house check: Jan-13

Calibrated by:	Name	Function	Signature
	Eric Hainfeld	Technician	

Approved by:	Name	Function	Signature
	Fin Bomholt	R&D Director	

Issued: April 23, 2012

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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 =  $6.1\mu V$ , 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	$404.352 \pm 0.1\% (k=2)$	$405.327 \pm 0.1\% (k=2)$	$405.654 \pm 0.1\% (k=2)$
Low Range	$3.95463 \pm 0.7\% (k=2)$	$3.99214 \pm 0.7\% (k=2)$	$3.96716 \pm 0.7\% (k=2)$

## Connector Angle

Connector Angle to be used in DASY system	$147.5^\circ \pm 1^\circ$
---	---------------------------

## Appendix

### 1. DC Voltage Linearity

High Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	199997.08	-0.41	-0.00
Channel X	+ Input	20003.46	2.34	0.01
Channel X	- Input	-19997.49	2.47	-0.01
Channel Y	+ Input	199999.33	2.06	0.00
Channel Y	+ Input	20001.56	0.65	0.00
Channel Y	- Input	-19999.50	0.75	-0.00
Channel Z	+ Input	199996.88	-0.61	-0.00
Channel Z	+ Input	20002.89	1.96	0.01
Channel Z	- Input	-19998.27	1.91	-0.01

Low Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	2003.09	1.65	0.08
Channel X	+ Input	202.47	0.71	0.35
Channel X	- Input	-197.92	0.18	-0.09
Channel Y	+ Input	2001.21	0.06	0.00
Channel Y	+ Input	201.12	-0.45	-0.22
Channel Y	- Input	-199.11	-0.70	0.35
Channel Z	+ Input	2002.44	1.11	0.06
Channel Z	+ Input	200.50	-1.13	-0.56
Channel Z	- Input	-198.21	-0.02	0.01

### 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 ( $\mu$ V)	Low Range Average Reading ( $\mu$ V)
Channel X	200	3.65	2.03
	-200	-1.07	-2.24
Channel Y	200	-0.86	-1.37
	-200	0.62	0.64
Channel Z	200	1.94	1.92
	-200	-2.48	-2.59

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu$ V)	Channel Y ( $\mu$ V)	Channel Z ( $\mu$ V)
Channel X	200	-	-2.83	-1.94
Channel Y	200	4.87	-	-5.00
Channel Z	200	14.63	-0.87	-

#### 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	15807	16448
Channel Y	15754	16462
Channel Z	15889	15649

#### 5. Input Offset Measurement

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

Input  $10M\Omega$

	Average ( $\mu V$ )	min. Offset ( $\mu V$ )	max. Offset ( $\mu V$ )	Std. Deviation ( $\mu V$ )
Channel X	-0.14	-1.77	1.06	0.51
Channel Y	0.58	-1.02	2.16	0.57
Channel Z	-0.65	-2.31	1.22	0.68

#### 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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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton (Auden)**

Certificate No: **DAE4-1279\_May12**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BJ - SN: 1279**

Calibration procedure(s) **QA CAL-06.v24**  
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **May 03, 2012**

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 ( $22 \pm 3$ )°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-11 (No:11450)	Sep-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V2.1	SE UWS 053 AA 1001	05-Jan-12 (in house check)	In house check: Jan-13

Calibrated by:	Name	Function	Signature
	Dominique Steffen	Technician	
Approved by:	Fin Bomholt	R&D Director	

Issued: May 3, 2012

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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 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 =  $6.1\mu V$ , 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
<b>High Range</b>	$405.179 \pm 0.1\% (k=2)$	$404.974 \pm 0.1\% (k=2)$	$404.316 \pm 0.1\% (k=2)$
<b>Low Range</b>	$3.98658 \pm 0.7\% (k=2)$	$3.98731 \pm 0.7\% (k=2)$	$3.99734 \pm 0.7\% (k=2)$

## Connector Angle

Connector Angle to be used in DASY system	$117.0^\circ \pm 1^\circ$
---	---------------------------

## Appendix

### 1. DC Voltage Linearity

High Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	199991.33	-3.98	-0.00
Channel X	+ Input	20000.42	1.05	0.01
Channel X	- Input	-20000.99	0.62	-0.00
Channel Y	+ Input	199992.57	-2.48	-0.00
Channel Y	+ Input	20000.37	1.13	0.01
Channel Y	- Input	-20001.77	-0.06	0.00
Channel Z	+ Input	199995.61	0.39	0.00
Channel Z	+ Input	19999.27	0.00	0.00
Channel Z	- Input	-20002.85	-1.22	0.01

Low Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	1999.48	-0.32	-0.02
Channel X	+ Input	200.41	0.23	0.11
Channel X	- Input	-199.28	0.50	-0.25
Channel Y	+ Input	2000.24	0.55	0.03
Channel Y	+ Input	200.58	0.44	0.22
Channel Y	- Input	-199.75	-0.01	0.00
Channel Z	+ Input	1998.83	-0.82	-0.04
Channel Z	+ Input	198.55	-1.51	-0.75
Channel Z	- Input	-201.15	-1.30	0.65

### 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 ( $\mu$ V)	Low Range Average Reading ( $\mu$ V)
Channel X	200	17.08	15.93
	-200	-15.69	-16.88
Channel Y	200	8.48	8.38
	-200	-9.22	-9.58
Channel Z	200	-0.67	-0.84
	-200	-0.62	-0.65

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu$ V)	Channel Y ( $\mu$ V)	Channel Z ( $\mu$ V)
Channel X	200	-	3.17	-3.15
Channel Y	200	7.76	-	3.57
Channel Z	200	8.98	6.44	-

#### 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	15658	14778
Channel Y	16426	15731
Channel Z	15918	15544

#### 5. Input Offset Measurement

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

Input 10MΩ

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	0.78	-0.61	2.27	0.58
Channel Y	0.16	-1.45	2.45	0.76
Channel Z	-0.63	-2.21	0.54	0.54

#### 6. Input Offset Current

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

#### 7. Input Resistance (Typical values for information)

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

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

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

#### 9. Power Consumption (Typical values for information)

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



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 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

Client **Sporton – TW (Auden)**

Certificate No: **DAE4-1338\_Jun12**

## CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BJ - SN: 1338**

Calibration procedure(s) **QA CAL-06.v24**  
 Calibration procedure for the data acquisition electronics (DAE)

Calibration date: **June 12, 2012**

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 ( $22 \pm 3$ )°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-11 (No:11450)	Sep-12
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Calibrator Box V2.1	SE UWS 053 AA 1001	05-Jan-12 (in house check)	In house check: Jan-13

Calibrated by:	Name	Function	Signature
	Eric Hainfeld	Technician	

Approved by:	Name	Function	Signature
	Fin Bomholt	R&D Director	

Issued: June 12, 2012

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Accreditation No.: **SCS 108**

## Glossary

<b>DAE</b>	data acquisition electronics
<b>Connector angle</b>	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 =  $6.1\mu V$ , 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	$404.366 \pm 0.1\% (k=2)$	$404.310 \pm 0.1\% (k=2)$	$404.168 \pm 0.1\% (k=2)$
Low Range	$3.99870 \pm 0.7\% (k=2)$	$3.95735 \pm 0.7\% (k=2)$	$3.96903 \pm 0.7\% (k=2)$

## Connector Angle

Connector Angle to be used in DASY system	$293^\circ \pm 1^\circ$
---	-------------------------

## Appendix

### 1. DC Voltage Linearity

High Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	200001.31	3.63	0.00
Channel X	+ Input	20003.03	1.95	0.01
Channel X	- Input	-19999.40	0.63	-0.00
Channel Y	+ Input	200001.67	3.96	0.00
Channel Y	+ Input	19999.92	-0.95	-0.00
Channel Y	- Input	-20002.00	-1.71	0.01
Channel Z	+ Input	199999.59	2.13	0.00
Channel Z	+ Input	19998.38	-2.33	-0.01
Channel Z	- Input	-20000.67	-0.23	0.00

Low Range		Reading ( $\mu$ V)	Difference ( $\mu$ V)	Error (%)
Channel X	+ Input	2002.42	1.05	0.05
Channel X	+ Input	201.78	-0.10	-0.05
Channel X	- Input	-198.09	-0.02	0.01
Channel Y	+ Input	2002.29	1.07	0.05
Channel Y	+ Input	201.72	-0.00	-0.00
Channel Y	- Input	-198.35	-0.09	0.05
Channel Z	+ Input	2002.89	1.58	0.08
Channel Z	+ Input	200.81	-0.86	-0.43
Channel Z	- Input	-199.74	-1.50	0.76

### 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 ( $\mu$ V)	Low Range Average Reading ( $\mu$ V)
Channel X	200	-3.02	-4.63
	-200	5.76	3.48
Channel Y	200	-14.73	-14.79
	-200	13.33	13.35
Channel Z	200	22.85	22.46
	-200	-26.37	-25.59

### 3. Channel separation

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

	Input Voltage (mV)	Channel X ( $\mu$ V)	Channel Y ( $\mu$ V)	Channel Z ( $\mu$ V)
Channel X	200	-	3.62	-2.93
Channel Y	200	8.50	-	4.83
Channel Z	200	9.97	5.98	-

#### 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	16034	14839
Channel Y	15828	15515
Channel Z	15288	15751

#### 5. Input Offset Measurement

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

Input 10MΩ

	Average ( $\mu$ V)	min. Offset ( $\mu$ V)	max. Offset ( $\mu$ V)	Std. Deviation ( $\mu$ V)
Channel X	0.33	-0.86	1.85	0.54
Channel Y	-0.48	-2.47	1.00	0.54
Channel Z	-1.66	-3.08	-0.24	0.50

#### 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