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S Schweizerischer Kalibrierdienst
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S Swiss Calibration Service

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Accreditation No.: SCS 108

Client Audix-TW (Auden)

Certificate No: EX3-3855_Sep13

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3855
Calibration procedure(s)	QA CAL-01.v9, QA CAL-14.v4, QA CAL-23.v5, QA CAL-25.v6 Calibration procedure for dosimetric E-field probes
Calibration date:	September 26, 2013

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	04-Apr-13 (No. 217-01733)	Apr-14
Power sensor E4412A	MY41498087	04-Apr-13 (No. 217-01733)	Apr-14
Reference 3 dB Attenuator	SN: S5054 (3c)	04-Apr-13 (No. 217-01737)	Apr-14
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-13 (No. 217-01735)	Apr-14
Reference 30 dB Attenuator	SN: S5129 (30b)	04-Apr-13 (No. 217-01738)	Apr-14
Reference Probe ES3DV2	SN: 3013	28-Dec-12 (No. ES3-3013_Dec12)	Dec-13
DAE4	SN: 660	4-Sep-13 (No. DAE4-660_Sep13)	Apr-14
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-15
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-12)	In house check: Oct-13

	Name	Function	Signature
Calibrated by:	Israe El-Naouq	Laboratory Technician	Israe El-Naouq
Approved by:	Katja Pokovic	Technical Manager	

Issued: September 26, 2013

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization ϑ	ϑ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., ϑ = 0 is normal to probe axis

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
b) IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)", February 2005

Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not affect the E^2-field uncertainty inside TSL (see below *ConvF*).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of *ConvF*.
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z; Dx,y,z; VRx,y,z: A, B, C, D* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f ≤ 800 MHz) and inside waveguide using analytical field distributions based on power measurements for f > 800 MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to *NORMx,y,z * ConvF* whereby the uncertainty corresponds to that given for *ConvF*. A frequency dependent *ConvF* is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- *Spherical isotropy (3D deviation from isotropy)*: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- *Sensor Offset*: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.

Probe EX3DV4

SN:3855

Manufactured: January 23, 2012
Calibrated: September 26, 2013

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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3855

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.47	0.17	0.13	± 10.1 %
DCP (mV)[B]	95.4	93.3	94.1	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	153.6	±3.3 %
		Y	0.0	0.0	1.0		197.1	
		Z	0.0	0.0	1.0		162.8	

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%.

[A] The uncertainties of NormX,Y,Z do not affect the E^2-field uncertainty inside TSL (see Pages 5 and 6).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3855

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	41.9	0.89	10.06	10.06	10.06	0.63	0.67	± 12.0 %
835	41.5	0.90	9.66	9.66	9.66	0.53	0.71	± 12.0 %
900	41.5	0.97	9.41	9.41	9.41	0.76	0.63	± 12.0 %
1750	40.1	1.37	8.60	8.60	8.60	0.33	0.91	± 12.0 %
1900	40.0	1.40	8.35	8.35	8.35	0.45	0.70	± 12.0 %
2000	40.0	1.40	8.40	8.40	8.40	0.34	0.75	± 12.0 %
2450	39.2	1.80	7.40	7.40	7.40	0.20	0.94	± 12.0 %
2600	39.0	1.96	7.59	7.59	7.59	0.45	0.66	± 12.0 %
5200	36.0	4.66	5.52	5.52	5.52	0.30	1.80	± 13.1 %
5300	35.9	4.76	5.19	5.19	5.19	0.35	1.80	± 13.1 %
5500	35.6	4.96	5.14	5.14	5.14	0.30	1.80	± 13.1 %
5600	35.5	5.07	4.68	4.68	4.68	0.40	1.80	± 13.1 %
5800	35.3	5.27	5.01	5.01	5.01	0.30	1.80	± 13.1 %

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3855

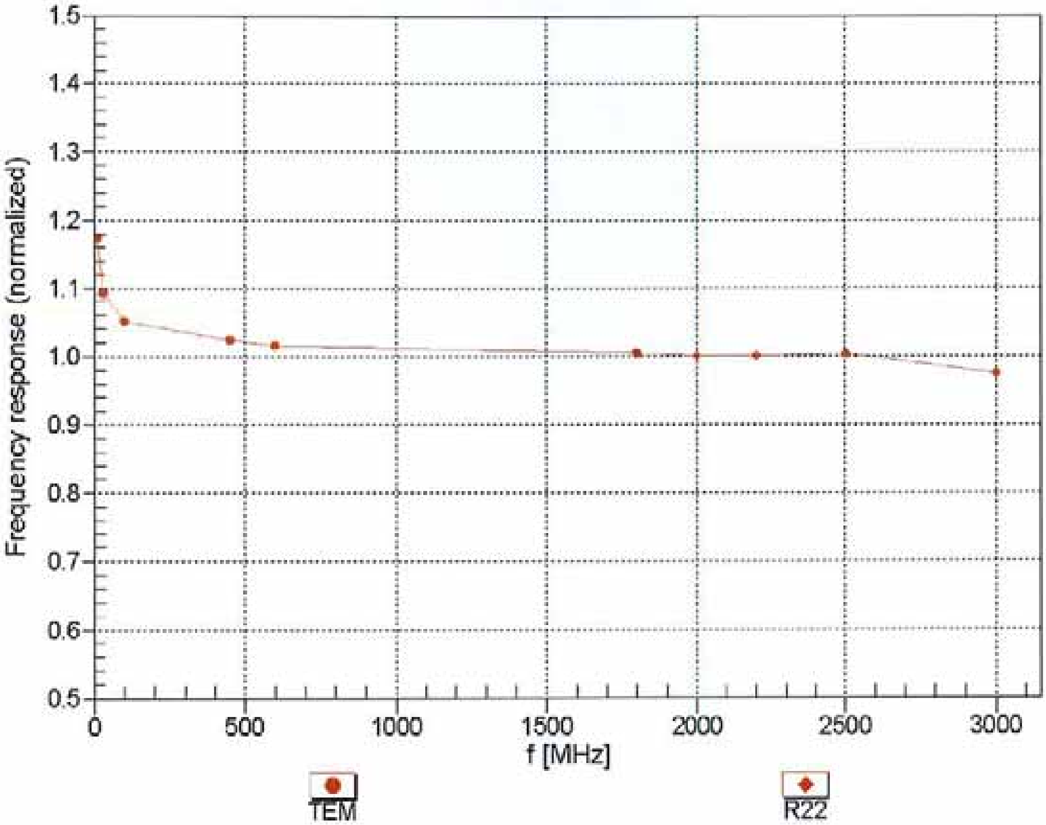
Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) [C]	Relative Permittivity [F]	Conductivity (S/m) [F]	ConvF X	ConvF Y	ConvF Z	Alpha	Depth (mm)	Unct. (k=2)
750	55.5	0.96	9.80	9.80	9.80	0.56	0.70	± 12.0 %
835	55.2	0.97	9.73	9.73	9.73	0.80	0.61	± 12.0 %
900	55.0	1.05	9.53	9.53	9.53	0.61	0.65	± 12.0 %
1750	53.4	1.49	8.32	8.32	8.32	0.60	0.66	± 12.0 %
1900	53.3	1.52	8.02	8.02	8.02	0.32	0.92	± 12.0 %
2000	53.3	1.52	8.14	8.14	8.14	0.47	0.74	± 12.0 %
2450	52.7	1.95	7.69	7.69	7.69	0.79	0.57	± 12.0 %
2600	52.5	2.16	7.57	7.57	7.57	0.80	0.50	± 12.0 %
5200	49.0	5.30	4.76	4.76	4.76	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.36	4.36	4.36	0.50	1.90	± 13.1 %
5500	48.6	5.65	4.29	4.29	4.29	0.40	1.90	± 13.1 %
5600	48.5	5.77	4.12	4.12	4.12	0.40	1.90	± 13.1 %
5800	48.2	6.00	4.25	4.25	4.25	0.50	1.90	± 13.1 %

[C] Frequency validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] At frequencies below 3 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ε and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

Frequency Response of E-Field

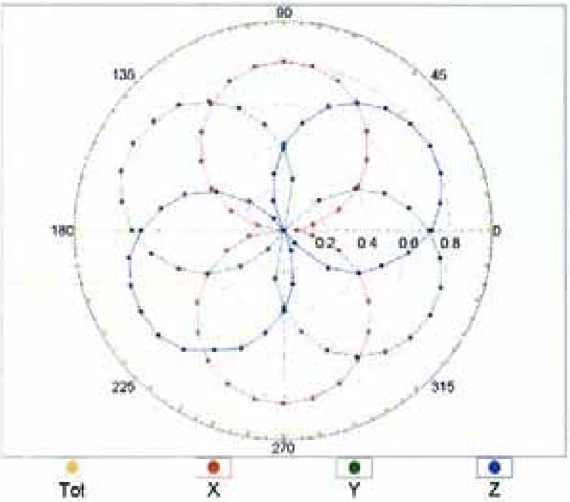
(TEM-Cell:ifi110 EXX, Waveguide: R22)

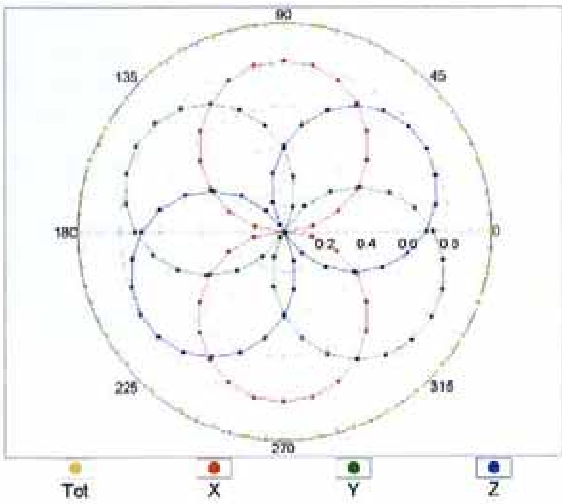


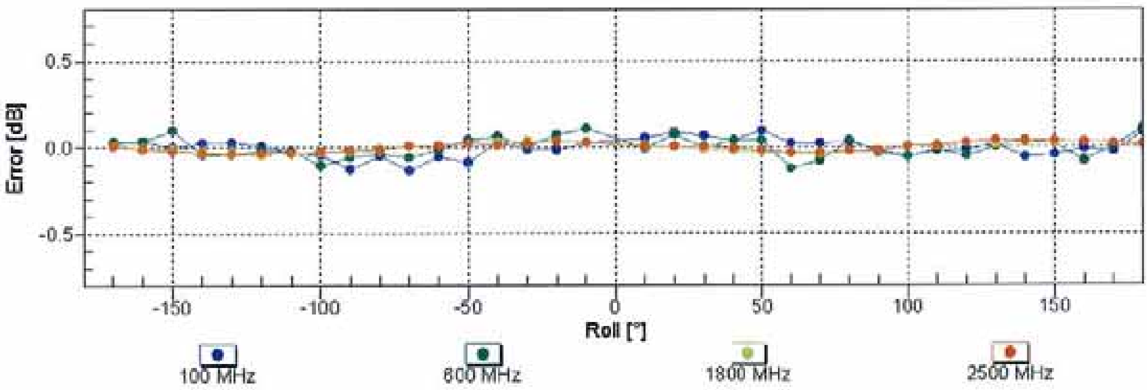
Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

Receiving Pattern (ϕ), $\vartheta = 0°$

f=600 MHz,TEM f=1800 MHz,R22

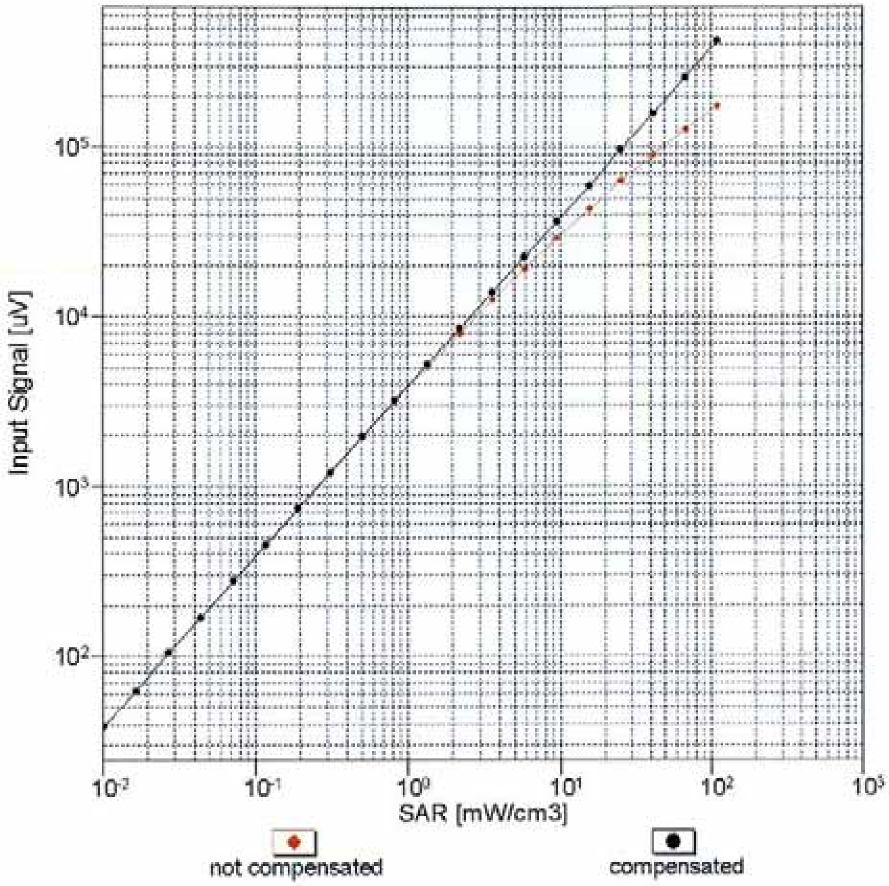


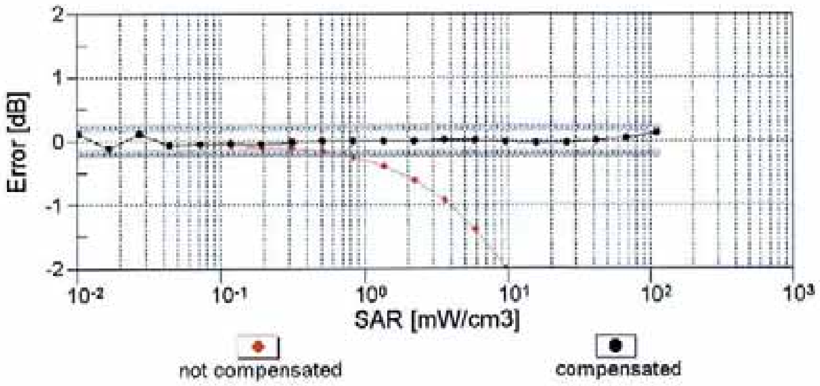




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

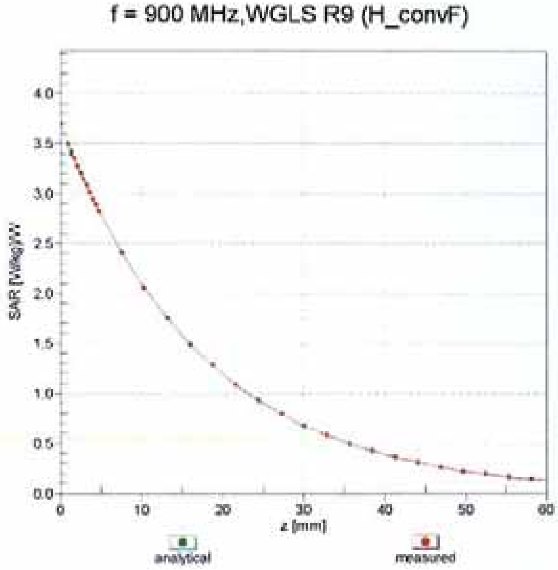
Dynamic Range f(SAR_{head})
(TEM cell , f = 900 MHz)

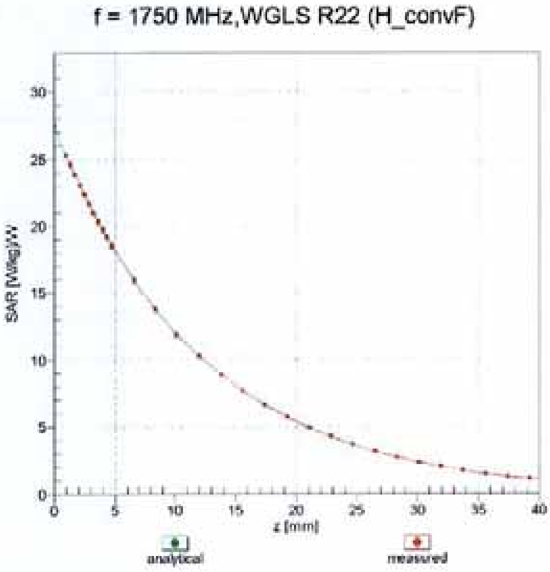




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

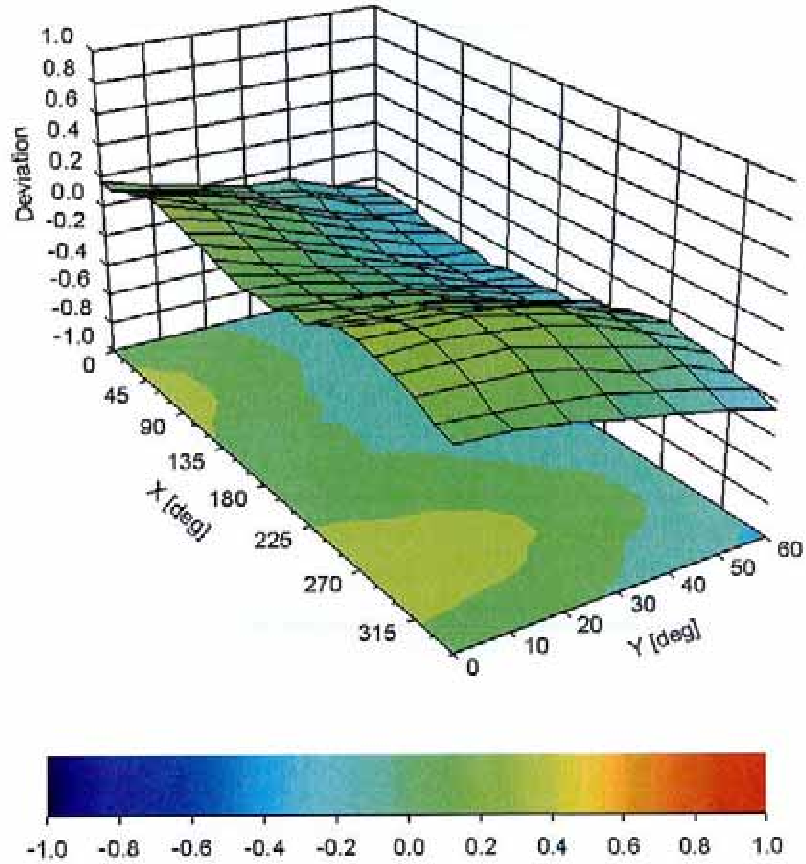
Conversion Factor Assessment





Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz



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

DASY/EASY - Parameters of Probe: EX3DV4 - SN:3855

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	20
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	2 mm

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Statement of Due Date for DAE Calibration

We have defined that the calibration interval of following Data Acquisition Electronics (DAE) which use for SAR system is 1 year.

SPEAG	DAE4	1337

Please note that the Cal Interval may be other than 1 year, e.g. 2 years or 3 years.

Also we have determined that the original calibration result of these instruments are not significantly affected before the first-time use of them, when they are stored in good condition.

According to the above reasons, the DAE calibration Due Date described as below:

Example:

Date tested at SPEAG: May 7, 2012

Example Calibration Interval: 1 Year

First-Time Use of Instrument: September 13, 2012

First-Time Use + Selected Interval = Date for Next Calibration

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September 13, 2012 + 1 Year = September 12, 2013

Leon Liu

Leon Liu / Quality Manager

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Statement of Due Date for Dipole Calibration

We have defined that the calibration interval of following dipole which use for SAR system is 2 years.

SPEAG	D1750V2	1065
SPEAG	D900V2	1d133
SPEAG	D750V3	1056
SPEAG	D835V2	4d136
SPEAG	D1900V2	5d156
SPEAG	D2000V2	1061
SPEAG	D2450V2	888
SPEAG	D2600V2	1048
SPEAG	D5GHzV2	1124
SPEAG	CD2450V3	1161
SPEAG	CD1880V3	1173
SPEAG	CD835V3	1187

Please note that the Cal Interval may be other than 1 year, e.g. 2 years or 3 years.

Also we have determined that the original calibration result of these instruments are not significantly affected before the first-time use of them, when they are stored in good condition.

According to the above reasons, the dipole calibration Due Date described as below:

Example:

Date tested at SPEAG: May 9, 2012

Example Calibration Interval: 2 Years

First-Time Use of Instrument: September 13, 2012

First-Time Use + Selected Interval = Date for Next Calibration

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September 13, 2012 + 2 Years = September 12, 2014

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IMPORTANT NOTICE

USAGE OF THE DAE 4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

Battery Exchange: The battery cover of the DAE4 unit is closed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

Shipping of the DAE: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

E-Stop Failures: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

Repair: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

DASY Configuration Files: Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

Important Note:
Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.

Important Note:
Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.

Important Note:
To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.

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Accreditation No.: SCS 108

Client **Audix-TW (Auden)**

Certificate No: DAE4-1337_May12

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BJ - SN: 1337
Calibration procedure(s)	QA CAL-06.v24 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	May 07, 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 ± 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

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

Issued: May 7, 2012

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 =	6.1μV ,	full range =	-100...+300 mV
Low Range:	1LSB =	61nV ,	full range =	-1.......+3mV

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

Calibration Factors	X	Y	Z
High Range	404.769 ± 0.1% (k=2)	404.739 ± 0.1% (k=2)	404.965 ± 0.1% (k=2)
Low Range	3.98638 ± 0.7% (k=2)	3.99974 ± 0.7% (k=2)	3.96882 ± 0.7% (k=2)

Connector Angle

Connector Angle to be used in DASY system	269.0 ° ± 1 °

Appendix

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	199996.78	0.80	0.00
Channel X	+ Input	20003.07	2.82	0.01
Channel X	- Input	-19998.03	2.66	-0.01
Channel Y	+ Input	199997.92	2.05	0.00
Channel Y	+ Input	19998.26	-2.01	-0.01
Channel Y	- Input	-20001.07	-0.28	0.00
Channel Z	+ Input	199997.89	1.56	0.00
Channel Z	+ Input	19997.95	-2.30	-0.01
Channel Z	- Input	-20001.72	-0.86	0.00

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2002.23	1.53	0.08
Channel X	+ Input	200.33	-0.77	-0.38
Channel X	- Input	-198.96	-0.24	0.12
Channel Y	+ Input	2000.01	-0.54	-0.03
Channel Y	+ Input	200.73	-0.26	-0.13
Channel Y	- Input	-200.12	-1.33	0.67
Channel Z	+ Input	2000.76	0.22	0.01
Channel Z	+ Input	200.33	-0.60	-0.30
Channel Z	- Input	-199.06	-0.31	0.16

2. Common mode sensitivity

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

	Common mode Input Voltage (mV)	High Range Average Reading (μV)	Low Range Average Reading (μV)
Channel X	200	-6.59	-8.94
	- 200	11.43	8.92
Channel Y	200	6.70	6.39
	- 200	-9.50	-9.44
Channel Z	200	-15.62	-15.51
	- 200	13.73	14.06

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	-	0.26	-3.30
Channel Y	200	8.08	-	2.73
Channel Z	200	10.15	3.72	-

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	16198	16057
Channel Y	16237	15845
Channel Z	16346	15485

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	0.95	-0.82	3.97	0.78
Channel Y	-0.84	-2.26	0.94	0.62
Channel Z	-0.42	-2.43	0.98	0.53

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