

Appendix E – Calibration data

**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 0108**

Client **AT4 Wireless**

Certificate No: **DAE4-669_Jul15**

CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 669**

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

Calibration date: **July 13, 2015**

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	03-Oct-14 (No:15573)	Oct-15
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Auto DAE Calibration Unit	SE UWS 053 AA 1001	06-Jan-15 (In house check)	In house check: Jan-16
Calibrator Box V2.1	SE UMS 006 AA 1002	06-Jan-15 (In house check)	In house check: Jan-16

Calibrated by:	Name Eric Hainfeld	Function Technician	Signature
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: July 13, 2015

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Certificate No: DAE4-669_Jul15

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Glossary

DAE data acquisition electronics
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- **DC Voltage Measurement:** Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- **Connector angle:** The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
 - **DC Voltage Measurement Linearity:** Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
 - **Common mode sensitivity:** Influence of a positive or negative common mode voltage on the differential measurement.
 - **Channel separation:** Influence of a voltage on the neighbor channels not subject to an input voltage.
 - **AD Converter Values with inputs shorted:** Values on the internal AD converter corresponding to zero input voltage
 - **Input Offset Measurement:** Output voltage and statistical results over a large number of zero voltage measurements.
 - **Input Offset Current:** Typical value for information; Maximum channel input offset current, not considering the input resistance.
 - **Input resistance:** Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
 - **Low Battery Alarm Voltage:** Typical value for information. Below this voltage, a battery alarm signal is generated.
 - **Power consumption:** Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

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

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

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

Calibration Factors	X	Y	Z
High Range	403.316 \pm 0.02% (k=2)	403.856 \pm 0.02% (k=2)	404.236 \pm 0.02% (k=2)
Low Range	3.95586 \pm 1.50% (k=2)	3.97459 \pm 1.50% (k=2)	3.97433 \pm 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	192.5 ° \pm 1 °
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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	200039.20	0.36	0.00
Channel X + Input	20009.81	5.49	0.03
Channel X - Input	-20001.49	3.94	-0.02
Channel Y + Input	200034.48	-4.78	-0.00
Channel Y + Input	20009.04	4.84	0.02
Channel Y - Input	-20002.50	3.09	-0.02
Channel Z + Input	200039.88	4.95	0.00
Channel Z + Input	20008.37	4.22	0.02
Channel Z - Input	-20004.02	1.52	-0.01

Low Range	Reading (μV)	Difference (μV)	Error (%)
Channel X + Input	2000.99	0.18	0.01
Channel X + Input	201.17	0.42	0.21
Channel X - Input	-198.81	0.15	-0.08
Channel Y + Input	2000.78	-0.00	-0.00
Channel Y + Input	200.28	-0.43	-0.22
Channel Y - Input	-199.96	-0.88	0.44
Channel Z + Input	2000.74	0.05	0.00
Channel Z + Input	199.41	-1.31	-0.65
Channel Z - Input	-200.05	-0.90	0.45

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	2.14	0.76
	- 200	-0.53	-1.17
Channel Y	200	11.12	11.00
	- 200	-12.56	-12.76
Channel Z	200	-9.30	-9.86
	- 200	7.61	7.45

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	-	-1.77	-3.34
Channel Y	200	9.21	-	-1.30
Channel Z	200	4.15	6.67	-

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	16075	15845
Channel Y	15795	15291
Channel Z	15997	15303

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	0.38	-1.20	1.34	0.45
Channel Y	0.48	-0.62	1.36	0.40
Channel Z	0.10	-1.36	1.40	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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Accreditation No.: **SCS 0108**

Client **AT4 Wireless**

Certificate No: **ES3-3052_Jul15**

CALIBRATION CERTIFICATE

Object **ES3DV3 - SN:3052**

Calibration procedure(s) **QA CAL-01.v9, QA CAL-12.v9, QA CAL-23.v5, QA CAL-25.v6
Calibration procedure for dosimetric E-field probes**

Calibration date: **July 20, 2015**

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

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

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5277 (20x)	01-Apr-15 (No. 217-02132)	Mar-16
Reference 30 dB Attenuator	SN: S5129 (30b)	01-Apr-15 (No. 217-02133)	Mar-16
Reference Probe ES3DV2	SN: 3013	30-Dec-14 (No. ES3-3013_Dec14)	Dec-15
DAE4	SN: 660	14-Jan-15 (No. DAE4-660_Jan15)	Jan-16
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-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

Calibrated by:	Name Israe Elnaouq	Function Laboratory Technician	Signature
Approved by:	Name Katja Pokovic	Function Technical Manager	Signature
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Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,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., $\theta = 0$ 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 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- 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
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z}** = NORM_{x,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.
- DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}**: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ 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 NORM_{x,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.
- Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

ES3DV3 – SN:3052

July 20, 2015

Probe ES3DV3

SN:3052

Manufactured: September 30, 2003
Calibrated: July 20, 2015

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

ES3DV3- SN:3052

July 20, 2015

DASY/EASY - Parameters of Probe: ES3DV3 - SN:3052

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm $(\mu V/(V/m)^2)^A$	1.13	0.42	1.10	$\pm 10.1 \%$
DCP (mV) ^B	105.6	103.0	104.7	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB $\sqrt{\mu V}$	C	D dB	VR mV	Unc ^E (k=2)
0	CW	X	0.0	0.0	1.0	0.00	196.8	$\pm 3.5 \%$
		Y	0.0	0.0	1.0		195.5	
		Z	0.0	0.0	1.0		190.9	
10011- CAB	UMTS-FDD (WCDMA)	X	3.28	67.5	19.0	2.91	134.3	$\pm 0.5 \%$
		Y	3.02	65.2	17.2		132.7	
		Z	3.21	66.9	18.4		131.4	
10012- CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)	X	3.20	71.2	20.2	1.87	135.6	$\pm 0.7 \%$
		Y	2.41	65.5	16.8		132.2	
		Z	2.69	67.7	18.2		133.4	
10013- CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps)	X	10.80	70.2	23.2	9.46	129.4	$\pm 3.0 \%$
		Y	10.48	68.4	21.5		127.3	
		Z	10.64	69.8	22.9		126.0	
10021- DAB	GSM-FDD (TDMA, GMSK)	X	8.94	85.5	23.0	9.39	128.9	$\pm 2.2 \%$
		Y	1.93	64.2	13.0		81.7	
		Z	8.27	84.0	22.0		147.6	
10023- DAB	GPRS-FDD (TDMA, GMSK, TN 0)	X	11.80	90.3	24.8	9.57	145.8	$\pm 2.2 \%$
		Y	1.85	63.9	13.3		77.7	
		Z	8.69	85.2	22.7		141.4	
10024- DAB	GPRS-FDD (TDMA, GMSK, TN 0-1)	X	30.54	99.9	24.9	6.56	134.0	$\pm 1.9 \%$
		Y	2.66	70.1	14.2		131.9	
		Z	8.78	82.5	19.3		131.5	
10025- DAB	EDGE-FDD (TDMA, 8PSK, TN 0)	X	13.11	100.0	39.2	12.62	137.2	$\pm 3.0 \%$
		Y	4.64	68.8	23.6		54.0	
		Z	12.46	98.9	38.8		133.8	
10026- DAB	EDGE-FDD (TDMA, 8PSK, TN 0-1)	X	11.91	94.5	33.8	9.55	133.4	$\pm 2.2 \%$
		Y	4.88	72.4	23.4		112.2	
		Z	9.35	88.0	30.9		130.6	
10027- DAB	GPRS-FDD (TDMA, GMSK, TN 0-1-2)	X	36.19	99.9	23.5	4.80	125.9	$\pm 2.2 \%$
		Y	7.11	80.8	16.5		138.0	
		Z	44.98	99.6	22.5		126.0	
10028- DAB	GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)	X	47.58	100.0	22.2	3.55	138.3	$\pm 2.5 \%$
		Y	1.96	68.0	11.0		130.2	
		Z	68.44	99.7	20.9		136.7	
10029- DAB	EDGE-FDD (TDMA, 8PSK, TN 0-1-2)	X	9.15	87.4	29.4	7.78	128.1	$\pm 1.9 \%$
		Y	4.67	72.7	22.5		135.1	
		Z	10.25	90.6	30.6		126.8	

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10032-CAA	IEEE 802.15.1 Bluetooth (GFSK, DH5)	X	12.49	99.0	22.5	1.16	132.4	±1.9 %
		Y	0.19	57.1	3.6		128.4	
		Z	99.74	91.8	15.1		132.7	
10035-CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH5)	X	4.62	73.2	21.7	3.83	145.0	±0.7 %
		Y	3.53	67.5	18.5		140.4	
		Z	4.35	71.9	20.9		145.0	
10038-CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH5)	X	4.62	72.1	21.5	4.10	145.3	±0.9 %
		Y	3.67	67.0	18.5		142.5	
		Z	4.37	70.9	20.7		145.0	
10048-CAA	DECT (TDD, TDMA/FDM, GFSK, Full Slot, 24)	X	6.02	80.0	24.4	13.80	81.1	±1.4 %
		Y	1.92	61.0	14.1		30.0	
		Z	5.26	77.4	23.1		79.5	
10049-CAA	DECT (TDD, TDMA/FDM, GFSK, Double Slot, 12)	X	12.05	90.8	25.8	10.79	127.7	±1.7 %
		Y	2.25	65.9	14.9		60.7	
		Z	12.63	91.6	25.7		148.9	
10058-DAB	EDGE-FDD (TDMA, 8PSK, TN 0-1-2-3)	X	7.97	84.6	27.5	6.52	135.1	±1.9 %
		Y	4.16	71.4	21.3		128.6	
		Z	7.97	84.8	27.3		135.0	
10097-CAB	UMTS-FDD (HSDPA)	X	4.59	67.1	19.0	3.98	139.7	±0.7 %
		Y	4.40	65.5	17.6		141.5	
		Z	4.49	66.6	18.5		140.0	
10098-CAB	UMTS-FDD (HSUPA, Subtest 2)	X	4.59	67.0	18.9	3.98	140.4	±0.7 %
		Y	4.44	65.7	17.7		142.1	
		Z	4.51	66.6	18.5		140.7	
10100-CAB	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	X	6.53	68.2	20.3	5.67	148.2	±1.4 %
		Y	6.32	66.8	19.0		147.7	
		Z	6.43	67.8	19.9		148.2	
10102-CAB	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM)	X	7.58	67.7	20.2	6.60	134.6	±1.4 %
		Y	7.48	66.7	19.2		135.0	
		Z	7.51	67.5	20.0		135.0	
10101-CAB	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	X	7.58	67.7	20.2	6.42	134.6	±12.2 %
		Y	7.48	66.7	19.2		135.0	
		Z	7.51	67.5	20.0		135.0	
10108-CAC	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	X	6.38	67.8	20.2	5.80	146.1	±1.7 %
		Y	6.21	66.3	18.6		145.5	
		Z	6.28	67.4	19.8		145.6	
10110-CAC	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, QPSK)	X	6.01	67.1	19.8	5.75	141.5	±1.2 %
		Y	5.86	65.7	18.6		141.5	
		Z	5.95	66.8	19.6		141.4	
10154-CAC	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, QPSK)	X	6.01	67.1	19.8	5.75	141.5	±12.2 %
		Y	5.86	65.7	18.6		141.5	
		Z	5.95	66.8	19.6		141.4	
10112-CAC	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM)	X	7.27	67.3	20.1	6.59	130.6	±1.4 %
		Y	7.21	66.4	19.1		130.3	
		Z	7.19	67.0	19.8		130.8	

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July 20, 2015

10109-CAC	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM)	X	7.27	67.3	20.1	6.43	130.6	±12.2 %
		Y	7.21	66.4	19.1		130.3	
		Z	7.19	67.0	19.8		130.8	
10150-CAB	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 64-QAM)	X	7.27	67.3	20.1	6.60	130.6	±12.2 %
		Y	7.21	66.4	19.1		130.3	
		Z	7.19	67.0	19.8		130.8	
10149-CAB	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM)	X	7.27	67.3	20.1	6.42	130.6	±12.2 %
		Y	7.21	66.4	19.1		130.3	
		Z	7.19	67.0	19.8		130.8	
10117-CAB	IEEE 802.11n (HT Mixed, 13.5 Mbps, BPSK)	X	10.22	69.2	21.6	8.07	136.5	±2.2 %
		Y	10.07	68.1	20.5		135.4	
		Z	10.17	69.1	21.5		136.3	
10140-CAB	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM)	X	7.51	67.7	20.2	6.49	135.6	±1.4 %
		Y	7.45	66.8	19.3		136.7	
		Z	7.43	67.4	20.0		135.7	
10141-CAB	LTE-FDD (SC-FDMA, 100% RB, 15 MHz, 64-QAM)	X	7.51	67.7	20.2	6.53	135.6	±12.2 %
		Y	7.45	66.8	19.3		136.7	
		Z	7.43	67.4	20.0		135.7	
10158-CAC	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 64-QAM)	X	7.03	67.1	20.1	6.62	127.5	±1.4 %
		Y	6.93	66.1	19.1		127.0	
		Z	6.98	67.0	19.9		127.3	
10111-CAC	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM)	X	7.03	67.1	20.1	6.44	127.5	±12.2 %
		Y	6.93	66.1	19.1		127.0	
		Z	6.98	67.0	19.9		127.3	
10113-CAC	LTE-FDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM)	X	7.03	67.1	20.1	6.62	127.5	±12.2 %
		Y	6.93	66.1	19.1		127.0	
		Z	6.98	67.0	19.9		127.3	
10155-CAC	LTE-FDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM)	X	7.03	67.1	20.1	6.43	127.5	±12.2 %
		Y	6.93	66.1	19.1		127.0	
		Z	6.98	67.0	19.9		127.3	
10161-CAB	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 16-QAM)	X	7.03	67.1	20.1	6.43	127.5	±12.2 %
		Y	6.93	66.1	19.1		127.0	
		Z	6.98	67.0	19.9		127.3	
10162-CAB	LTE-FDD (SC-FDMA, 50% RB, 15 MHz, 64-QAM)	X	7.03	67.1	20.1	6.58	127.5	±12.2 %
		Y	6.93	66.1	19.1		127.0	
		Z	6.98	67.0	19.9		127.3	
10173-CAB	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	8.13	78.1	28.1	9.48	136.8	±2.5 %
		Y	8.23	70.5	23.4		146.9	
		Z	7.81	77.0	27.5		135.6	
10226-CAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM)	X	8.13	78.1	28.1	9.49	136.8	±12.2 %
		Y	8.23	70.5	23.4		146.9	
		Z	7.81	77.0	27.5		135.6	
10235-CAB	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	8.13	78.1	28.1	9.48	136.8	±12.2 %
		Y	8.23	70.5	23.4		146.9	
		Z	7.81	77.0	27.5		135.6	

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10229-CAB	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM)	X	8.13	78.1	28.1	9.48	136.8	±12.2 %
		Y	6.23	70.5	23.4		146.9	
		Z	7.81	77.0	27.5		135.6	
10232-CAB	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	8.13	78.1	28.1	9.48	136.8	±12.2 %
		Y	6.23	70.5	23.4		146.9	
		Z	7.81	77.0	27.5		135.6	
10238-CAB	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM)	X	8.13	78.1	28.1	9.48	136.8	±12.2 %
		Y	6.23	70.5	23.4		146.9	
		Z	7.81	77.0	27.5		135.6	
10179-CAC	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 64-QAM)	X	5.69	68.4	21.0	6.50	143.1	±1.7 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10170-CAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM)	X	5.69	68.4	21.0	6.52	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10176-CAC	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM)	X	5.69	68.4	21.0	6.52	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10188-CAC	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM)	X	5.69	68.4	21.0	6.52	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10180-CAC	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 64-QAM)	X	5.69	68.4	21.0	6.50	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10178-CAC	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM)	X	5.69	68.4	21.0	6.52	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10182-CAB	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM)	X	5.69	68.4	21.0	6.52	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10185-CAC	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM)	X	5.69	68.4	21.0	6.51	143.1	±12.2 %
		Y	5.23	66.3	19.4		138.0	
		Z	5.63	68.2	20.8		143.0	
10187-CAC	LTE-FDD (SC-FDMA, 1 RB, 1.4 MHz, QPSK)	X	5.01	67.6	20.3	5.73	144.7	±1.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	
10166-CAC	LTE-FDD (SC-FDMA, 50% RB, 1.4 MHz, QPSK)	X	5.01	67.6	20.3	5.46	144.7	±12.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	
10181-CAB	LTE-FDD (SC-FDMA, 1 RB, 15 MHz, QPSK)	X	5.01	67.6	20.3	5.72	144.7	±12.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	
10169-CAB	LTE-FDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	5.01	67.6	20.3	5.73	144.7	±12.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	

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10175-CAC	LTE-FDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	X	5.01	67.6	20.3	5.72	144.7	±12.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	
10177-CAE	LTE-FDD (SC-FDMA, 1 RB, 5 MHz, QPSK)	X	5.01	67.6	20.3	5.73	144.7	±12.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	
10184-CAC	LTE-FDD (SC-FDMA, 1 RB, 3 MHz, QPSK)	X	5.01	67.6	20.3	5.73	144.7	±12.2 %
		Y	4.57	65.2	18.5		137.4	
		Z	4.93	67.1	19.9		144.3	
10196-CAB	IEEE 802.11n (HT Mixed, 6.5 Mbps, BPSK)	X	9.79	68.8	21.5	8.10	129.9	±2.5 %
		Y	9.69	67.7	20.3		128.7	
		Z	9.73	68.7	21.3		128.8	
10225-CAB	UMTS-FDD (HSPA+)	X	6.84	66.9	19.5	5.97	132.7	±1.2 %
		Y	6.84	66.2	18.7		132.9	
		Z	6.81	66.8	19.4		132.4	
10228-CAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, QPSK)	X	7.79	77.2	27.7	9.22	140.4	±2.2 %
		Y	6.01	69.8	23.0		149.6	
		Z	7.63	76.7	27.4		138.3	
10237-CAB	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK)	X	7.79	77.2	27.7	9.21	140.4	±12.2 %
		Y	6.01	69.8	23.0		149.6	
		Z	7.63	76.7	27.4		138.3	
10172-CAB	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK)	X	7.79	77.2	27.7	9.21	140.4	±12.2 %
		Y	6.01	69.8	23.0		149.6	
		Z	7.63	76.7	27.4		138.3	
10231-CAB	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, QPSK)	X	7.79	77.2	27.7	9.19	140.4	±12.2 %
		Y	6.01	69.8	23.0		149.6	
		Z	7.63	76.7	27.4		138.3	
10234-CAB	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, QPSK)	X	7.79	77.2	27.7	9.21	140.4	±12.2 %
		Y	6.01	69.8	23.0		149.6	
		Z	7.63	76.7	27.4		138.3	
10240-CAB	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, QPSK)	X	7.79	77.2	27.7	9.21	140.4	±12.2 %
		Y	6.01	69.8	23.0		149.6	
		Z	7.63	76.7	27.4		138.3	
10246-CAB	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, QPSK)	X	8.17	74.0	26.0	9.30	133.6	±2.2 %
		Y	6.81	68.0	22.0		146.0	
		Z	7.98	73.4	25.6		132.0	
10249-CAB	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, QPSK)	X	8.17	74.0	26.0	9.29	133.6	±12.2 %
		Y	6.81	68.0	22.0		146.0	
		Z	7.98	73.4	25.6		132.0	
10258-CAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK)	X	8.17	74.0	26.0	9.34	133.6	±12.2 %
		Y	6.81	68.0	22.0		146.0	
		Z	7.98	73.4	25.6		132.0	
10256-CAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM)	X	8.92	74.4	26.6	9.96	136.3	±3.0 %
		Y	7.58	68.8	22.7		149.4	
		Z	8.78	74.1	26.3		135.0	

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10247-CAB	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM)	X	8.92	74.4	26.6	9.91	136.3	±12.2 %
		Y	7.58	68.8	22.7		149.4	
		Z	8.78	74.1	26.3		135.0	
10244-CAB	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, 16-QAM)	X	8.92	74.4	26.6	10.06	136.3	±12.2 %
		Y	7.58	68.8	22.7		149.4	
		Z	8.78	74.1	26.3		135.0	
10262-CAB	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM)	X	9.03	72.4	25.3	9.83	126.8	±2.7 %
		Y	8.01	67.9	22.0		140.4	
		Z	8.89	72.0	25.0		125.3	
10250-CAB	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM)	X	9.03	72.4	25.3	9.81	126.8	±12.2 %
		Y	8.01	67.9	22.0		140.4	
		Z	8.89	72.0	25.0		125.3	
10259-CAB	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM)	X	9.03	72.4	25.3	9.98	126.8	±12.2 %
		Y	8.01	67.9	22.0		140.4	
		Z	8.89	72.0	25.0		125.3	
10264-CAB	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, QPSK)	X	8.92	75.0	26.5	9.23	144.6	±3.0 %
		Y	7.07	67.4	21.5		134.5	
		Z	8.67	74.3	26.0		142.4	
10252-CAB	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK)	X	8.92	75.0	26.5	9.24	144.6	±12.2 %
		Y	7.07	67.4	21.5		134.5	
		Z	8.67	74.3	26.0		142.4	
10261-CAB	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, QPSK)	X	8.92	75.0	26.5	9.24	144.6	±12.2 %
		Y	7.07	67.4	21.5		134.5	
		Z	8.67	74.3	26.0		142.4	
10265-CAB	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM)	X	9.70	73.1	25.7	9.92	134.7	±3.5 %
		Y	8.48	68.1	22.1		148.2	
		Z	9.57	72.8	25.5		133.2	
10152-CAB	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM)	X	9.70	73.1	25.7	9.92	134.7	±12.2 %
		Y	8.48	68.1	22.1		148.2	
		Z	9.57	72.8	25.5		133.2	
10267-CAB	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	X	8.79	73.2	25.3	9.30	125.7	±2.7 %
		Y	7.51	67.9	21.6		140.6	
		Z	8.63	72.7	24.9		124.7	
10151-CAB	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK)	X	8.79	73.2	25.3	9.28	125.7	±12.2 %
		Y	7.51	67.9	21.6		140.6	
		Z	8.63	72.7	24.9		124.7	
10297-AAA	LTE-FDD (SC-FDMA, 50% RB, 20 MHz, QPSK)	X	6.41	67.8	20.2	5.81	147.2	±1.4 %
		Y	6.21	66.3	18.8		145.7	
		Z	6.29	67.4	19.8		146.1	

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 Norm X,Y,Z do not affect the E^2 -field uncertainty inside TSL (see Pages 10 and 11).

^B Numerical linearization parameter: uncertainty not required.

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

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DASY/EASY - Parameters of Probe: ES3DV3 - SN:3052

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 ^G	Depth ^G (mm)	Unc (k=2)
450	43.5	0.87	6.91	6.91	6.91	0.20	2.33	± 13.3 %
750	41.9	0.89	6.47	6.47	6.47	0.28	2.08	± 12.0 %
835	41.5	0.90	6.34	6.34	6.34	0.33	1.87	± 12.0 %
900	41.5	0.97	6.23	6.23	6.23	0.45	1.53	± 12.0 %
1750	40.1	1.37	5.17	5.17	5.17	0.52	1.37	± 12.0 %
1900	40.0	1.40	4.97	4.97	4.97	0.68	1.27	± 12.0 %
2000	40.0	1.40	4.95	4.95	4.95	0.80	1.16	± 12.0 %
2450	39.2	1.80	4.40	4.40	4.40	0.77	1.25	± 12.0 %
2600	39.0	1.96	4.23	4.23	4.23	0.80	1.22	± 12.0 %

^C Frequency validity above 300 MHz 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. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^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.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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DASY/EASY - Parameters of Probe: ES3DV3 - SN:3052

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 ^g	Depth ^g (mm)	Unc (k=2)
450	56.7	0.94	7.11	7.11	7.11	0.15	1.78	± 13.3 %
750	55.5	0.96	6.15	6.15	6.15	0.53	1.43	± 12.0 %
835	55.2	0.97	6.06	6.06	6.06	0.53	1.41	± 12.0 %
900	55.0	1.05	6.03	6.03	6.03	0.33	1.64	± 12.0 %
1750	53.4	1.49	4.85	4.85	4.85	0.60	1.34	± 12.0 %
1900	53.3	1.52	4.67	4.67	4.67	0.55	1.49	± 12.0 %
2000	53.3	1.52	4.77	4.77	4.77	0.62	1.46	± 12.0 %
2450	52.7	1.95	4.31	4.31	4.31	0.80	1.20	± 12.0 %
2600	52.5	2.16	4.11	4.11	4.11	0.80	1.24	± 12.0 %

^c Frequency validity above 300 MHz 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. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Above 5 GHz frequency validity can be extended to ± 110 MHz.

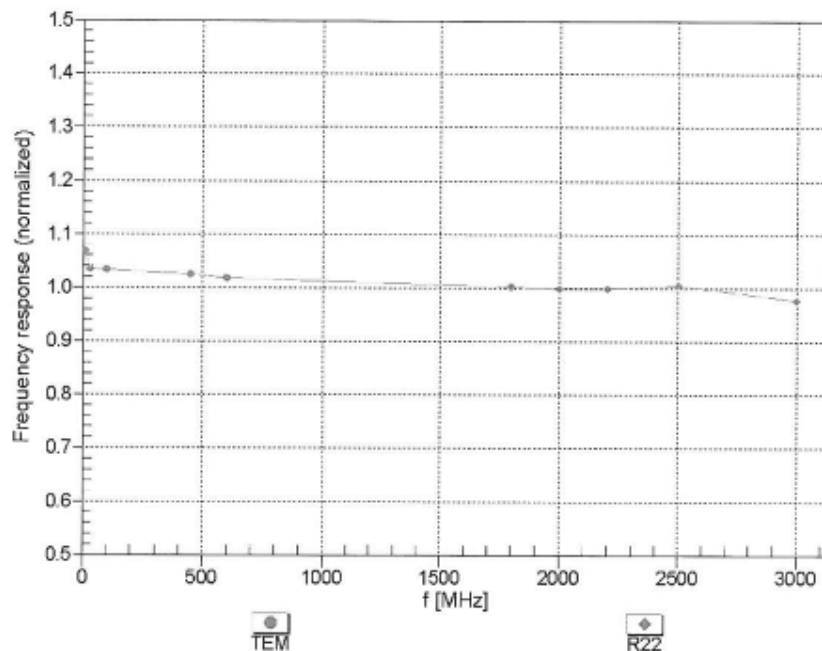
^f At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^g Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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

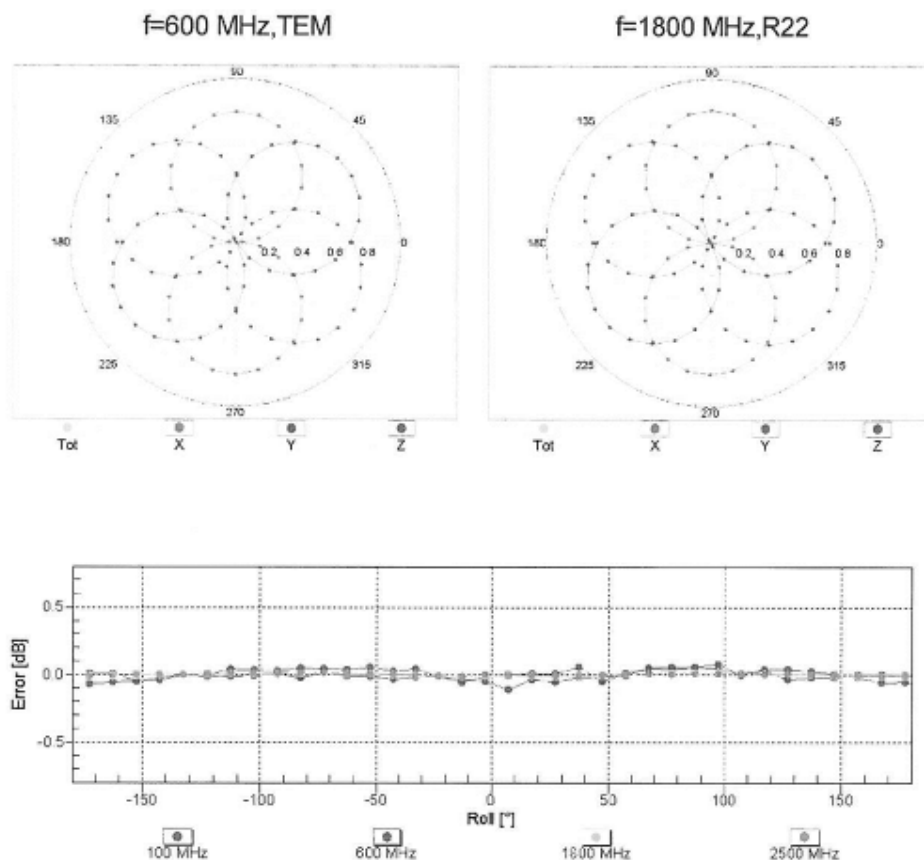


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

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

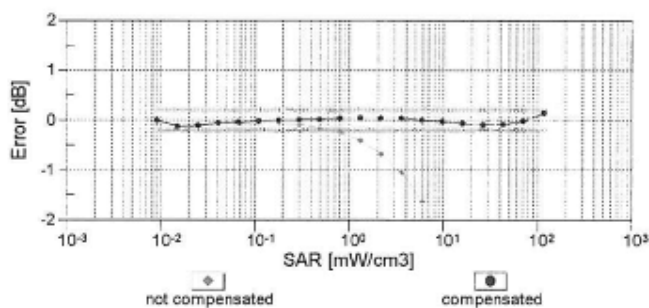
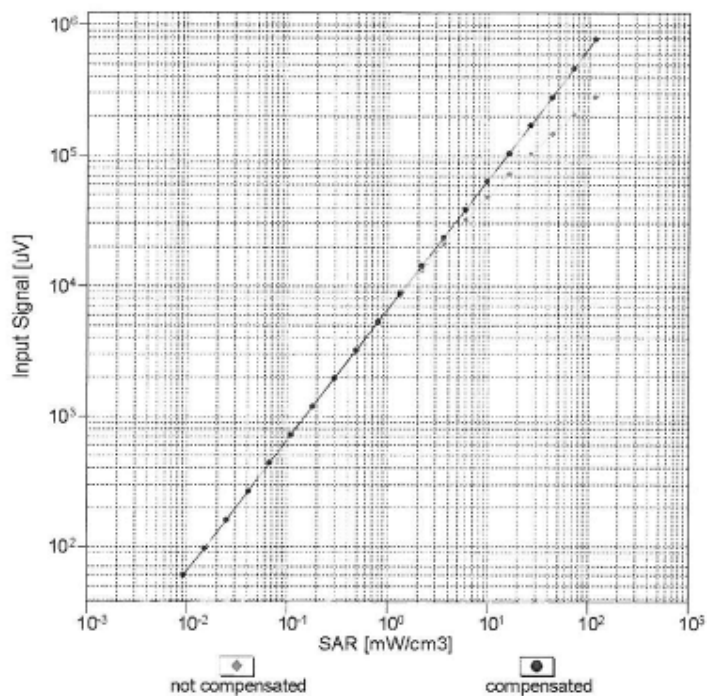


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

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Dynamic Range f(SAR_{head}) (TEM cell , f_{eval}= 1900 MHz)

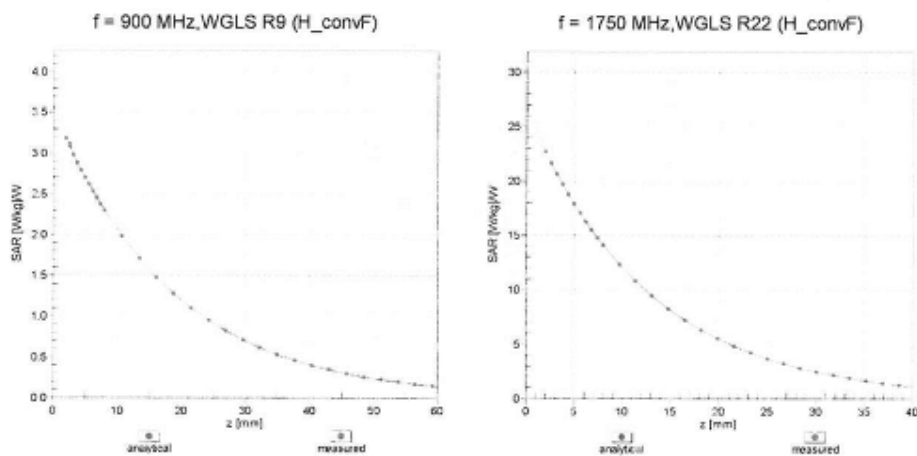


Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

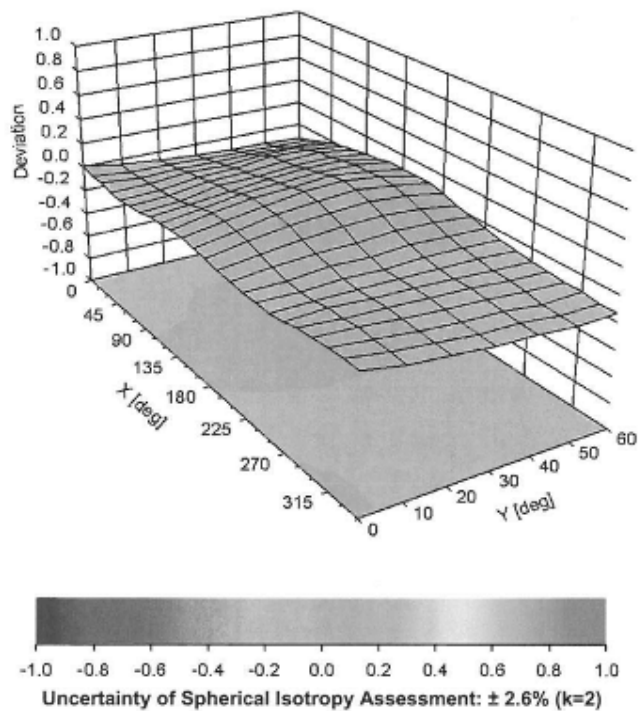
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Conversion Factor Assessment



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



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DASY/EASY - Parameters of Probe: ES3DV3 - SN:3052

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	127.3
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	10 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	2 mm
Probe Tip to Sensor Y Calibration Point	2 mm
Probe Tip to Sensor Z Calibration Point	2 mm
Recommended Measurement Distance from Surface	3 mm

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



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

Accreditation No.: **SCS 0108**

Client **AT4 Wireless**

Certificate No: **D450V3-1092_Jul15**

CALIBRATION CERTIFICATE

Object **D450V3 - SN:1092**

Calibration procedure(s) **QA CAL-15.v8**
 Calibration procedure for dipole validation kits below 700 MHz

Calibration date: **July 07, 2015**

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

All calibrations have been conducted in the closed laboratory facility: environment temperature $(22 \pm 3)^{\circ}\text{C}$ and humidity $< 70\%$.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5058 (20k)	01-Apr-15 (No. 217-02131)	Mar-16
Type-N mismatch combination	SN: 5047.2 / 06327	01-Apr-15 (No. 217-02134)	Mar-16
Reference Probe ET3DV6	SN: 1507	30-Dec-14 (No. ET3-1507_Dec14)	Dec-15
DAE4	SN: 789	16-Mar-15 (No. DAE4-789_Mar15)	Mar-16
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	04-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585 S4206	18-Oct-01 (in house check Oct-14)	In house check: Oct-15

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

Issued: July 9, 2015

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

Certificate No: D450V3-1092_Jul15

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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
S Swiss Calibration Service

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

Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- 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
- IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- Measurement Conditions:** Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- Antenna Parameters with TSL:** The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- Feed Point Impedance and Return Loss:** These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- Electrical Delay:** One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- SAR measured:** SAR measured at the stated antenna input power.
- SAR normalized:** SAR as measured, normalized to an input power of 1 W at the antenna connector.
- SAR for nominal TSL parameters:** The measured TSL parameters are used to calculate the nominal SAR result.

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

Measurement Conditions

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

DASY Version	DASY5	V52.8.8
Extrapolation	Advanced Extrapolation	
Phantom	ELI4 Flat Phantom	Shell thickness: 2 ± 0.2 mm
Distance Dipole Center - TSL	15 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	450 MHz \pm 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	43.5	0.87 mho/m
Measured Head TSL parameters	(22.0 \pm 0.2) °C	42.7 \pm 6 %	0.87 mho/m \pm 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	1.12 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	4.46 W/kg \pm 18.1 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	0.746 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	2.98 W/kg \pm 17.6 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	56.7	0.94 mho/m
Measured Body TSL parameters	(22.0 \pm 0.2) °C	55.0 \pm 6 %	0.95 mho/m \pm 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	1.13 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	4.45 W/kg \pm 18.1 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	0.740 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	2.92 W/kg \pm 17.6 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	58.0 Ω - 1.6 j Ω
Return Loss	- 22.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	53.8 Ω - 6.9 j Ω
Return Loss	- 22.4 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.352 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	February 25, 2013

DASY5 Validation Report for Head TSL

Date: 06.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:1092

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.87$ S/m; $\epsilon_r = 42.7$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ET3DV6 - SN1507; ConvF(6.58, 6.58, 6.58); Calibrated: 30.12.2014;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn789; Calibrated: 16.03.2015
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Head Tissue/d=15mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:

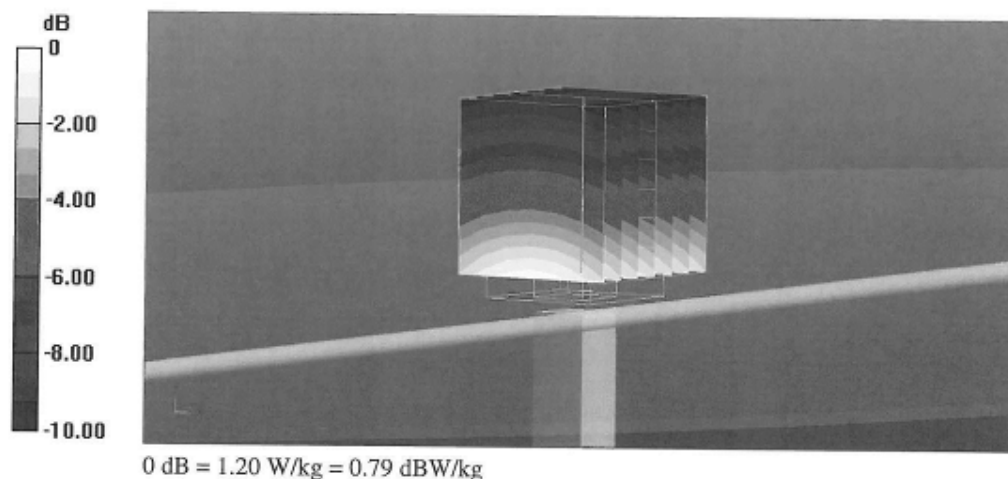
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 39.29 V/m; Power Drift = -0.02 dB

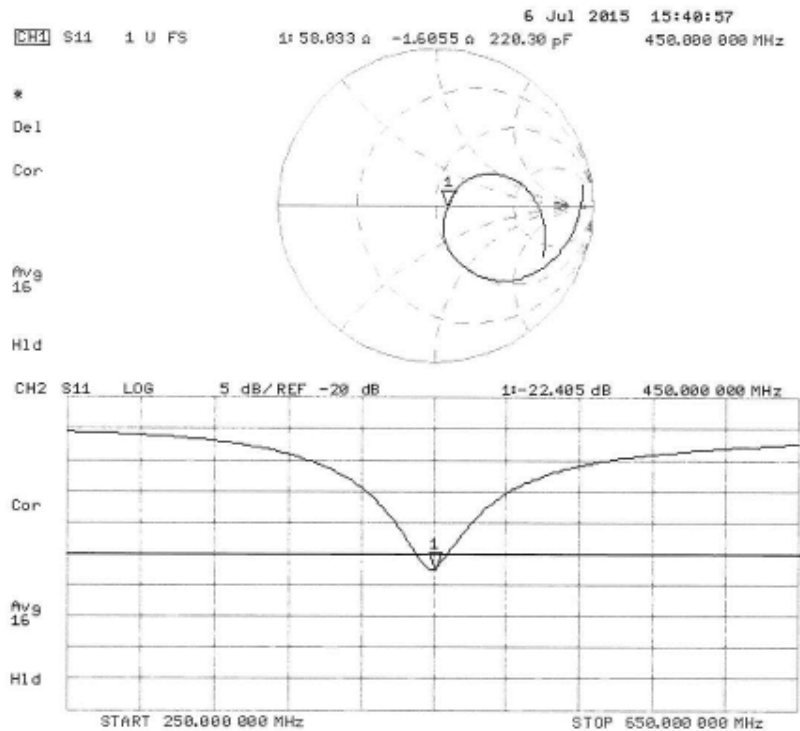
Peak SAR (extrapolated) = 1.61 W/kg

SAR(1 g) = 1.12 W/kg; SAR(10 g) = 0.746 W/kg

Maximum value of SAR (measured) = 1.20 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 07.07.2015

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 450 MHz; Type: D450V3; Serial: D450V3 - SN:1092

Communication System: UID 0 - CW; Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.95$ S/m; $\epsilon_r = 55$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

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

DASY52 Configuration:

- Probe: ET3DV6 - SN1507; ConvF(7.05, 7.05, 7.05); Calibrated: 30.12.2014;
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn789; Calibrated: 16.03.2015
- Phantom: ELI v4.0; Type: QDOVA001BB; Serial: TP:1003
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

Dipole Calibration for Body Tissue/d=15mm, Pin=250mW/Zoom Scan (7x7x7)/Cube 0:

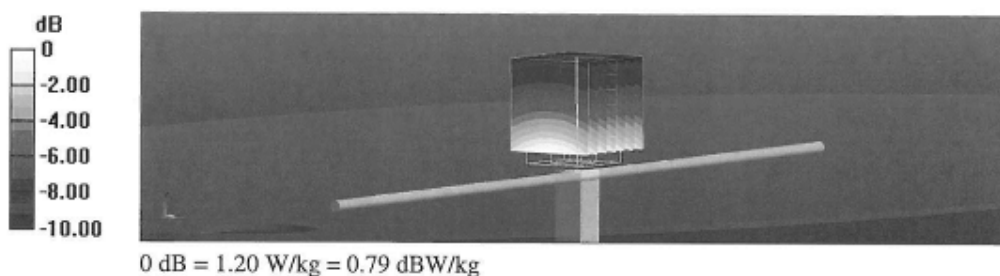
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 36.57 V/m; Power Drift = -0.03 dB

Peak SAR (extrapolated) = 1.83 W/kg

SAR(1 g) = 1.13 W/kg; SAR(10 g) = 0.740 W/kg

Maximum value of SAR (measured) = 1.20 W/kg



Impedance Measurement Plot for Body TSL

