Represent the 90th percentile of the population. The phantom enables the dissymmetric evaluation of SAR for both left and right handed handset usage, as well as body-worn usage using the flat phantom region. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot. The shell phantom has a 2mm shell thickness (except the ear region where shell thickness increases to 6 mm).

Shell Thickness: 2 ± 0. 2 mm
Filling Volume: Approx. 25 liters
Dimensions: 810 x l000 x 500 mm (H x L x W)
Available: Special

Picture C.10: SAM Twin Phantom

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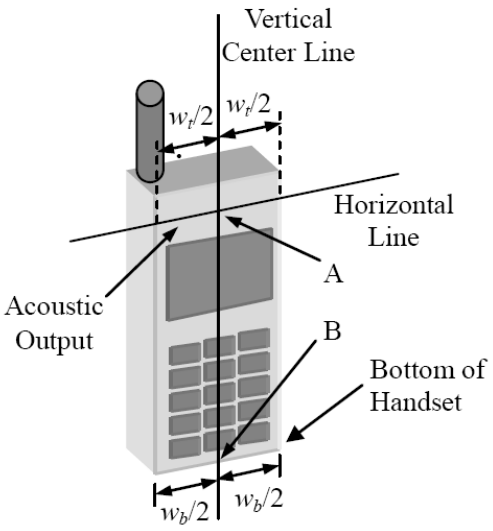
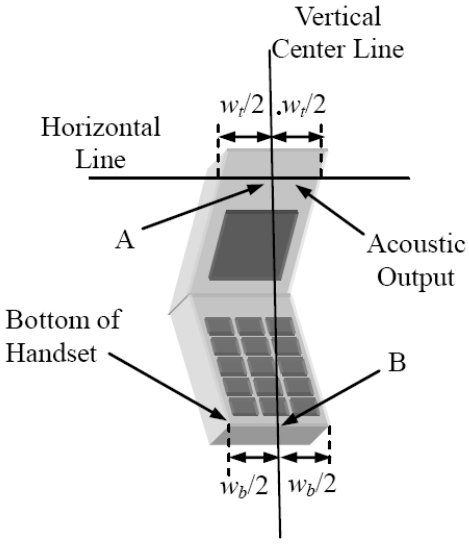
ANNEX D Position of the wireless device in relation to the phantom

D.1 General considerations

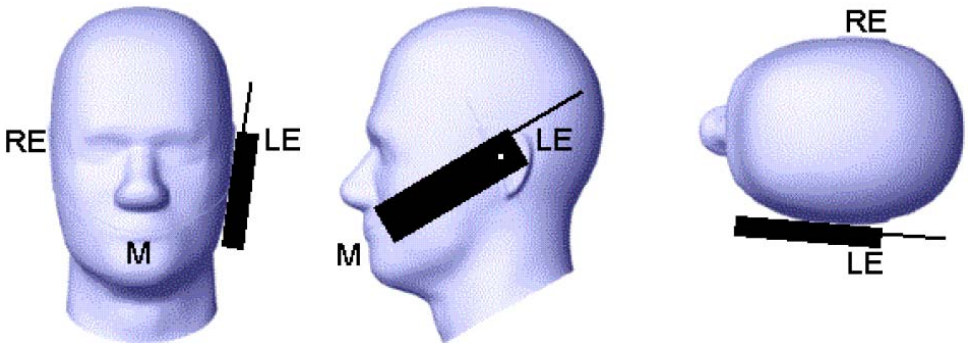
This standard specifies two handset test positions against the head phantom – the “cheek” position and the “tilt” position.





w_t	Width of the handset at the level of the acoustic
w_b	Width of the bottom of the handset
A	Midpoint of the width w_t of the handset at the level of the acoustic output
B	Midpoint of the width w_b of the bottom of the handset

Picture D.1-a Typical “fixed” case handset **Picture D.1-b Typical “clam-shell” case handset**



Picture D.2 Cheek position of the wireless device on the left side of SAM

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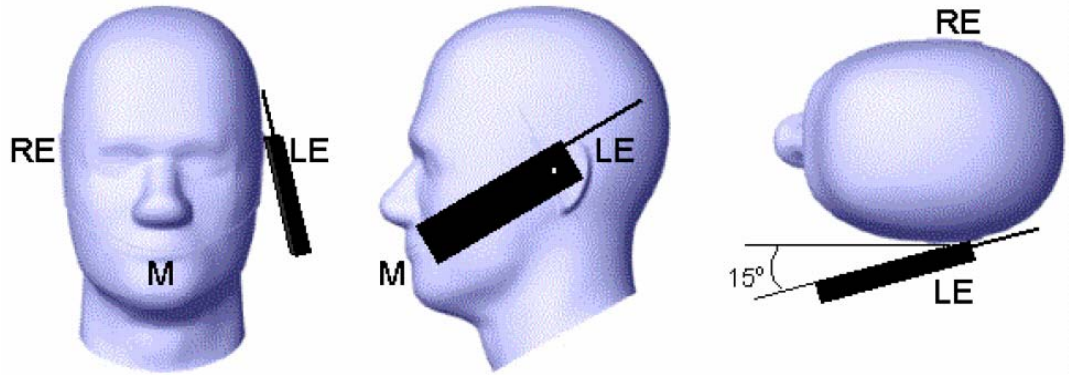
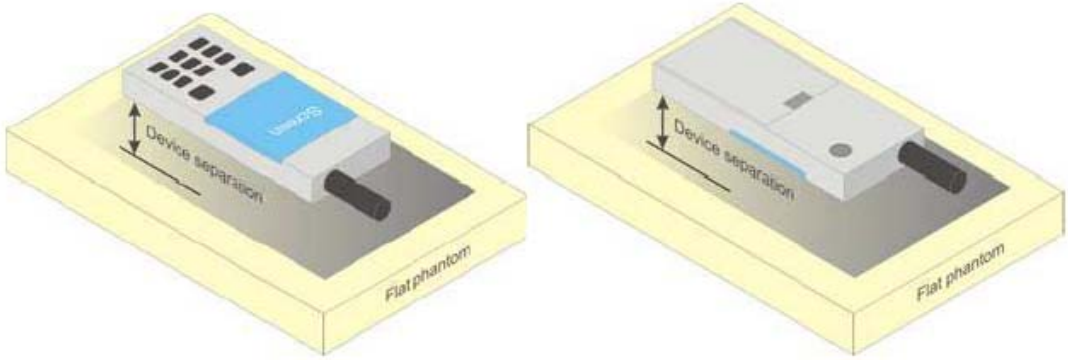


Picture D.3 Tilt position of the wireless device on the left side of SAM

D.2 Body-worn device

A typical example of a body-worn device is a mobile phone, wireless enabled PDA or other battery operated wireless device with the ability to transmit while mounted on a person's body using a carry accessory approved by the wireless device manufacturer.



Picture D.4 Test positions for body-worn devices

D.3 Desktop device

A typical example of a desktop device is a wireless enabled desktop computer placed on a table or desk when used.

The DUT shall be positioned at the distance and in the orientation to the phantom that corresponds to the intended use as specified by the manufacturer in the user instructions. For devices that employ an external antenna with variable positions, tests shall be performed for all antenna positions specified. Picture 8.5 show positions for desktop device SAR tests. If the intended use is not specified, the device shall be tested directly against the flat phantom.

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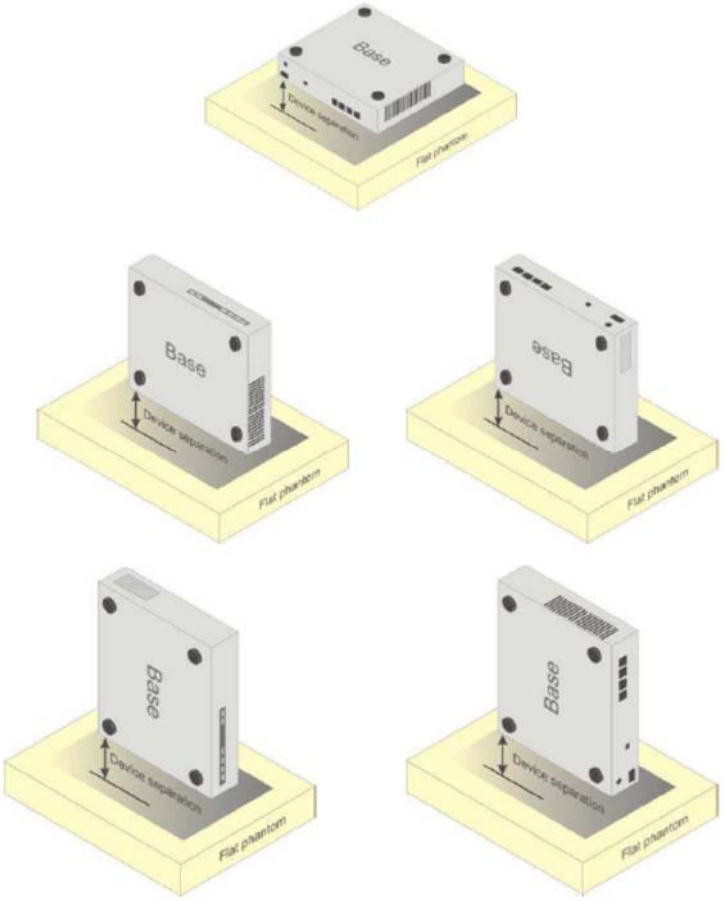

Picture D.5 Test positions for desktop devices

D.4 DUT Setup Photos

Picture D.6

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ANNEX E Equivalent Media Recipes

The liquid used for the frequency range of 800-3000 MHz consisted of water, sugar, salt, preventol, glycol monobutyl and Cellulose. The liquid has been previously proven to be suited for worst-case. The Table E.1 shows the detail solution. It's satisfying the latest tissue dielectric parameters requirements proposed by the IEEE 1528 and IEC 62209.

Table E.1: Composition of the Tissue Equivalent Matter

Frequency (MHz)	835 Head	835 Body	1900 Head	1900 Body	2450 Head	2450 Body	5800 Head	5800 Body
Ingredients (% by weight)								
Water	41.45	52.5	55.242	69.91	58.79	72.60	65.53	65.53
Sugar	56.0	45.0	\	\	\	\	\	\
Salt	1.45	1.4	0.306	0.13	0.06	0.18	\	\
Preventol	0.1	0.1	\	\	\	\	\	\
Cellulose	1.0	1.0	\	\	\	\	\	\
Glycol Monobutyl	\	\	44.452	29.96	41.15	27.22	\	\
Diethylenglycol monohexylether	\	\	\	\	\	\	17.24	17.24
Triton X-100	\	\	\	\	\	\	17.24	17.24
Dielectric Parameters Target Value	ε=41.5 σ=0.90	ε=55.2 σ=0.97	ε=40.0 σ=1.40	ε=53.3 σ=1.52	ε=39.2 σ=1.80	ε=52.7 σ=1.95	ε=35.3 σ=5.27	ε=48.2 σ=6.00

Note: There are a little adjustment respectively for 750, 1750, 2600, 5200, 5300 and 5600 based on the recipe of closest frequency in table E.1.

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ANNEX F System Validation

The SAR system must be validated against its performance specifications before it is deployed. When SAR probes, system components or software are changed, upgraded or recalibrated, these must be validated with the SAR system(s) that operates with such components.

Table F.1: System Validation for 3617

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
3617	Head 750MHz	Sep. 5, 2015	750 MHz	OK
3617	Head 850MHz	Sep. 5, 2015	850 MHz	OK
3617	Head 900MHz	Sep. 6, 2015	900 MHz	OK
3617	Head 1450MHz	Sep. 6, 2015	1450 MHz	OK
3617	Head 1640MHz	Sep. 7, 2015	1640 MHz	OK
3617	Head 1750MHz	Sep. 7, 2015	1750 MHz	OK
3617	Head 1810MHz	Sep. 8, 2015	1810 MHz	OK
3617	Head 1900MHz	Sep. 8, 2015	1900 MHz	OK
3617	Head 2000MHz	Sep. 9, 2015	2000 MHz	OK
3617	Head 2100MHz	Sep. 9, 2015	2100 MHz	OK
3617	Head 2300MHz	Sep. 10, 2015	2300 MHz	OK
3617	Head 2450MHz	Sep. 10, 2015	2450 MHz	OK
3617	Head 2600MHz	Sep. 11, 2015	2600 MHz	OK
3617	Head 3500MHz	Sep. 11, 2015	3500 MHz	OK
3617	Head 3700MHz	Sep. 12, 2015	3700 MHz	OK
3617	Head 5200MHz	Sep. 12, 2015	5200 MHz	OK
3617	Head 5300MHz	Sep. 13, 2015	5300 MHz	OK
3617	Head 5500MHz	Sep. 13, 2015	5500 MHz	OK
3617	Head 5600MHz	Sep. 14, 2015	5600 MHz	OK
3617	Head 5800MHz	Sep. 14, 2015	5800 MHz	OK
3617	Body 750MHz	Sep. 5, 2015	750 MHz	OK
3617	Body 850MHz	Sep. 5, 2015	850 MHz	OK
3617	Body 900MHz	Sep. 6, 2015	900 MHz	OK
3617	Body 1450MHz	Sep. 6, 2015	1450 MHz	OK
3617	Body 1640MHz	Sep. 7, 2015	1640 MHz	OK
3617	Body 1750MHz	Sep. 7, 2015	1750 MHz	OK
3617	Body 1810MHz	Sep. 8, 2015	1810 MHz	OK
3617	Body 1900MHz	Sep. 8, 2015	1900 MHz	OK
3617	Body 2000MHz	Sep. 9, 2015	2000 MHz	OK
3617	Body 2100MHz	Sep. 9, 2015	2100 MHz	OK
3617	Body 2300MHz	Sep. 10, 2015	2300 MHz	OK
3617	Body 2450MHz	Sep. 10, 2015	2450 MHz	OK
3617	Body 2600MHz	Sep. 11, 2015	2600 MHz	OK
3617	Body 3500MHz	Sep. 11, 2015	3500 MHz	OK
3617	Body 3700MHz	Sep. 12, 2015	3700 MHz	OK
3617	Body 5200MHz	Sep. 12, 2015	5200 MHz	OK
3617	Body 5300MHz	Sep. 13, 2015	5300 MHz	OK
3617	Body 5500MHz	Sep. 13, 2015	5500 MHz	OK
3617	Body 5600MHz	Sep. 14, 2015	5600 MHz	OK
3617	Body 5800MHz	Sep. 14, 2015	5800 MHz	OK

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Table F.2: System Validation for 7307

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
7307	Head 750MHz	Mar. 15, 2016	750 MHz	OK
7307	Head 850MHz	Mar. 15, 2016	850 MHz	OK
7307	Head 900MHz	Mar. 16, 2016	900 MHz	OK
7307	Head 1450MHz	Mar. 16, 2016	1450 MHz	OK
7307	Head 1640MHz	Mar. 17, 2016	1640 MHz	OK
7307	Head 1750MHz	Mar. 17, 2016	1750 MHz	OK
7307	Head 1810MHz	Mar. 18, 2016	1810 MHz	OK
7307	Head 1900MHz	Mar. 18, 2016	1900 MHz	OK
7307	Head 2000MHz	Mar. 19, 2016	2000 MHz	OK
7307	Head 2100MHz	Mar. 19, 2016	2100 MHz	OK
7307	Head 2300MHz	Mar. 20, 2016	2300 MHz	OK
7307	Head 2450MHz	Mar. 20, 2016	2450 MHz	OK
7307	Head 2600MHz	Mar. 21, 2016	2600 MHz	OK
7307	Head 3500MHz	Mar. 21, 2016	3500 MHz	OK
7307	Head 3700MHz	Mar. 22, 2016	3700 MHz	OK
7307	Head 5200MHz	Mar. 22, 2016	5200 MHz	OK
7307	Head 5300MHz	Mar. 23, 2016	5300 MHz	OK
7307	Head 5500MHz	Mar. 23, 2016	5500 MHz	OK
7307	Head 5600MHz	Mar. 24, 2016	5600 MHz	OK
7307	Head 5800MHz	Mar. 24, 2016	5800 MHz	OK
7307	Body 750MHz	Mar. 15, 2016	750 MHz	OK
7307	Body 850MHz	Mar. 15, 2016	850 MHz	OK
7307	Body 900MHz	Mar. 16, 2016	900 MHz	OK
7307	Body 1450MHz	Mar. 16, 2016	1450 MHz	OK
7307	Body 1640MHz	Mar. 17, 2016	1640 MHz	OK
7307	Body 1750MHz	Mar. 17, 2016	1750 MHz	OK
7307	Body 1810MHz	Mar. 18, 2016	1810 MHz	OK
7307	Body 1900MHz	Mar. 18, 2016	1900 MHz	OK
7307	Body 2000MHz	Mar. 19, 2016	2000 MHz	OK
7307	Body 2100MHz	Mar. 19, 2016	2100 MHz	OK
7307	Body 2300MHz	Mar. 20, 2016	2300 MHz	OK
7307	Body 2450MHz	Mar. 20, 2016	2450 MHz	OK
7307	Body 2600MHz	Mar. 21, 2016	2600 MHz	OK
7307	Body 3500MHz	Mar. 21, 2016	3500 MHz	OK
7307	Body 3700MHz	Mar. 22, 2016	3700 MHz	OK
7307	Body 5200MHz	Mar. 22, 2016	5200 MHz	OK

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ANNEX G Probe Calibration Certificate

Probe 3617 Calibration Certificate

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 0108

Client CTTL (Auden)

Certificate No: EX3-3617_Aug15

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3617
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:	August 26, 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

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

Issued: August 27, 2015

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

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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 0108

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
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 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
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
c) 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
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

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.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

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Probe EX3DV4

SN:3617

Manufactured: May 3, 2007
Calibrated: August 26, 2015

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

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3617

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.35	0.22	0.32	± 10.1 %
DCP (mV)[B]	103.7	99.6	98.7	

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	181.1	±2.5 %
		Y	0.0	0.0	1.0		172.2	
		Z	0.0	0.0	1.0		179.1	

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 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.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3617

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)
750	41.9	0.89	9.98	9.98	9.98	0.41	0.88	± 12.0 %
835	41.5	0.90	9.56	9.56	9.56	0.50	0.80	± 12.0 %
900	41.5	0.97	9.41	9.41	9.41	0.45	0.85	± 12.0 %
1450	40.5	1.20	8.76	8.76	8.76	0.27	1.02	± 12.0 %
1640	40.3	1.29	8.62	8.62	8.62	0.30	0.80	± 12.0 %
1750	40.1	1.37	8.34	8.34	8.34	0.26	0.94	± 12.0 %
1810	40.0	1.40	8.13	8.13	8.13	0.28	0.89	± 12.0 %
1900	40.0	1.40	8.07	8.07	8.07	0.34	0.80	± 12.0 %
2000	40.0	1.40	8.04	8.04	8.04	0.32	0.89	± 12.0 %
2100	39.8	1.49	8.11	8.11	8.11	0.31	0.89	± 12.0 %
2300	39.5	1.67	7.74	7.74	7.74	0.27	0.97	± 12.0 %
2450	39.2	1.80	7.24	7.24	7.24	0.28	0.96	± 12.0 %
2600	39.0	1.96	7.21	7.21	7.21	0.43	0.80	± 12.0 %
3500	37.9	2.91	7.28	7.28	7.28	0.30	1.20	± 13.1 %
3700	37.7	3.12	6.79	6.79	6.79	0.28	1.20	± 13.1 %
5200	36.0	4.66	5.46	5.46	5.46	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.28	5.28	5.28	0.35	1.80	± 13.1 %
5500	35.6	4.96	5.05	5.05	5.05	0.35	1.80	± 13.1 %
5600	35.5	5.07	4.75	4.75	4.75	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.85	4.85	4.85	0.40	1.80	± 13.1 %

[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: EX3DV4 - SN:3617

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)
750	55.5	0.96	9.76	9.76	9.76	0.58	0.79	± 12.0 %
835	55.2	0.97	9.71	9.71	9.71	0.50	0.80	± 12.0 %
900	55.0	1.05	9.47	9.47	9.47	0.50	0.80	± 12.0 %
1450	54.0	1.30	8.27	8.27	8.27	0.21	1.33	± 12.0 %
1640	53.8	1.40	8.31	8.31	8.31	0.39	0.91	± 12.0 %
1750	53.4	1.49	7.96	7.96	7.96	0.43	0.80	± 12.0 %
1810	53.3	1.52	7.88	7.88	7.88	0.44	0.80	± 12.0 %
1900	53.3	1.52	7.74	7.74	7.74	0.37	0.83	± 12.0 %
2000	53.3	1.52	7.97	7.97	7.97	0.24	1.05	± 12.0 %
2100	53.2	1.62	8.08	8.08	8.08	0.27	1.00	± 12.0 %
2300	52.9	1.81	7.68	7.68	7.68	0.32	0.94	± 12.0 %
2450	52.7	1.95	7.35	7.35	7.35	0.32	0.80	± 12.0 %
2600	52.5	2.16	7.20	7.20	7.20	0.25	0.80	± 12.0 %
3500	51.3	3.31	6.60	6.60	6.60	0.30	1.20	± 13.1 %
3700	51.0	3.55	6.72	6.72	6.72	0.32	1.25	± 13.1 %
5200	49.0	5.30	4.88	4.88	4.88	0.40	1.90	± 13.1 %
5300	48.9	5.42	4.69	4.69	4.69	0.40	1.90	± 13.1 %
5500	48.6	5.65	4.41	4.41	4.41	0.40	1.90	± 13.1 %
5600	48.5	5.77	4.27	4.27	4.27	0.45	1.90	± 13.1 %
5800	48.2	6.00	4.41	4.41	4.41	0.45	1.90	± 13.1 %

[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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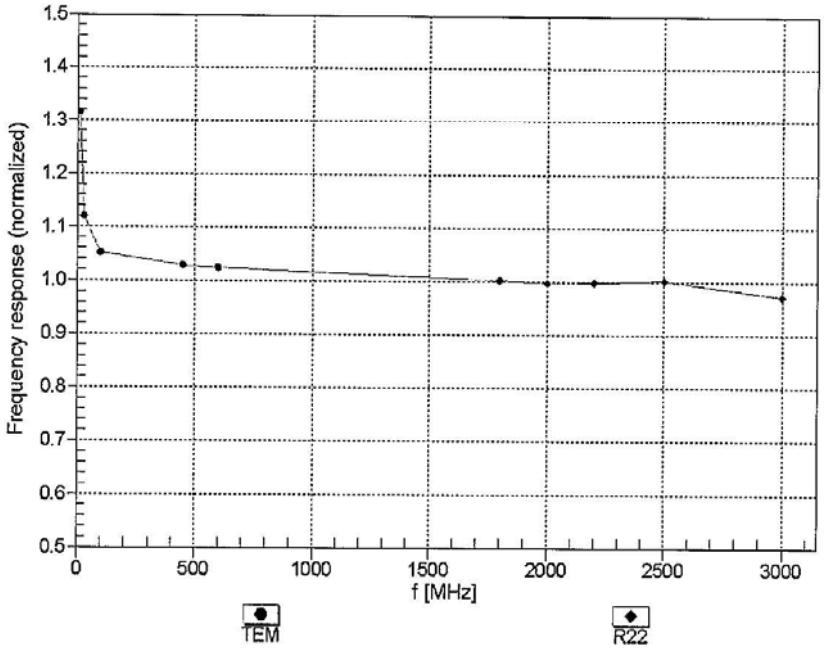
EX3DV4– SN:3617

August 26, 2015

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



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

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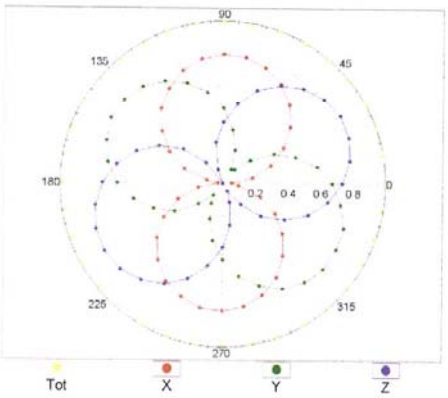
EX3DV4– SN:3617

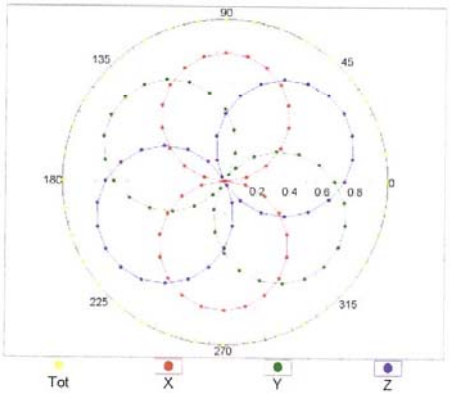
August 26, 2015

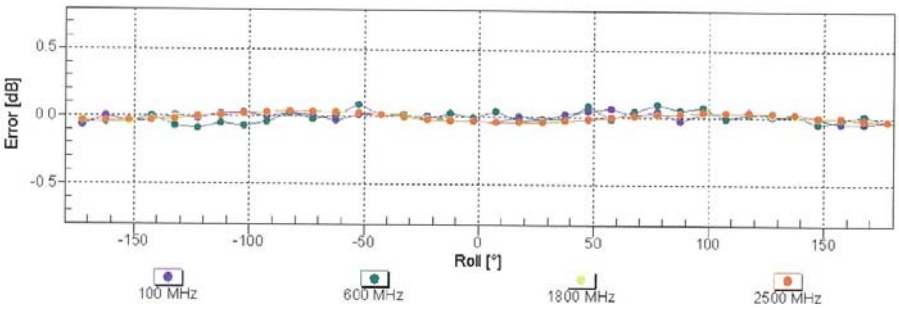
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



f=1800 MHz,R22





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

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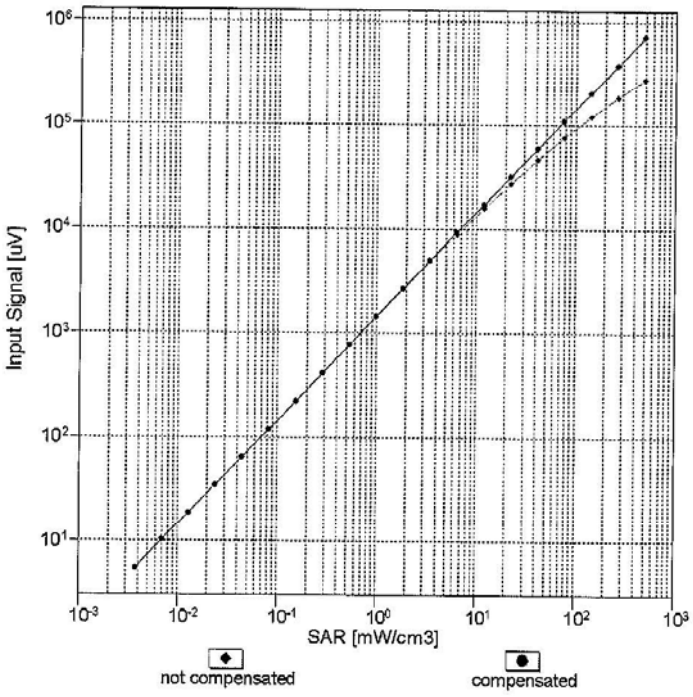
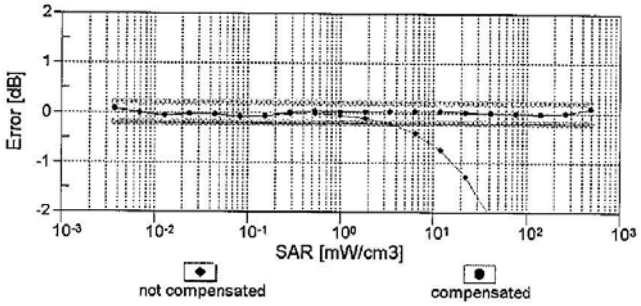
EX3DV4– SN:3617

August 26, 2015

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





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

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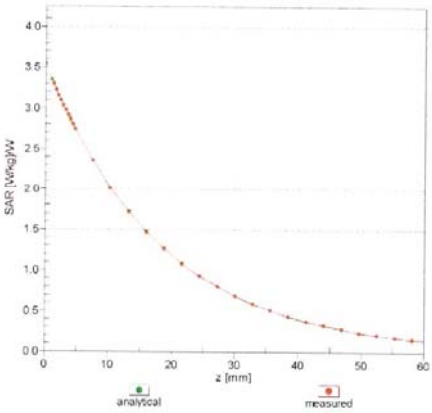
EX3DV4– SN:3617

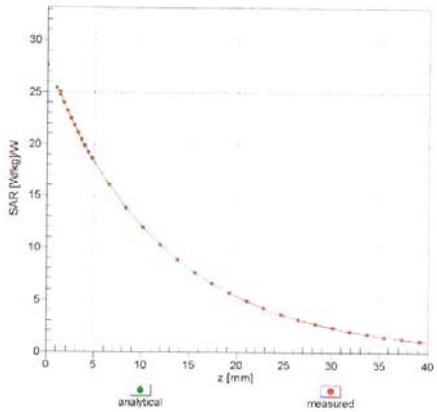
August 26, 2015

Conversion Factor Assessment

f = 900 MHz,WGLS R9 (H_convF)

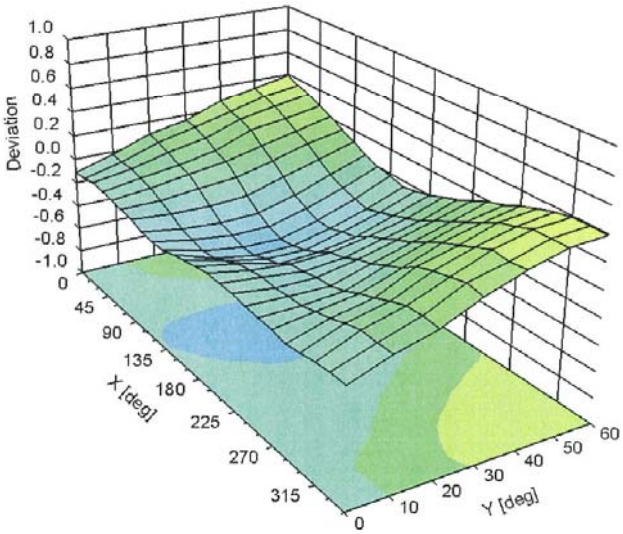


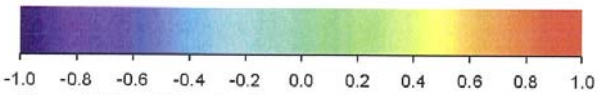
f = 1810 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz





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

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:3617

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	67.5
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	1.4 mm

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Probe 7307 Calibration Certificate

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 0108

Client CTTL (Auden)

Certificate No: EX3-7307_Feb16

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7307
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:	February 19, 2016

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	31-Dec-15 (No. ES3-3013_Dec15)	Dec-16
DAE4	SN: 660	23-Dec-15 (No. DAE4-660_Dec15)	Dec-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-15)	In house check: Oct-16

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

Issued: February 20, 2016

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

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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 0108

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
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 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
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
c) 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
d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

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.
- *Connector Angle*: The angle is assessed using the information gained by determining the *NORMx* (no uncertainty required).

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Probe EX3DV4

SN:7307

Manufactured: March 11, 2014
Calibrated: February 19, 2016

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

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7307

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)[A]	0.40	0.62	0.65	± 10.1 %
DCP (mV)[B]	101.6	97.3	97.6	

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	146.6	±3.3 %
		Y	0.0	0.0	1.0		133.9	
		Z	0.0	0.0	1.0		135.8	

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 Norm X,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.

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7307

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)
750	41.9	0.89	10.47	10.47	10.47	0.50	0.80	± 12.0 %
835	41.5	0.90	10.01	10.01	10.01	0.49	0.83	± 12.0 %
900	41.5	0.97	9.82	9.82	9.82	0.43	0.85	± 12.0 %
1450	40.5	1.20	8.72	8.72	8.72	0.43	0.80	± 12.0 %
1640	40.3	1.29	8.46	8.46	8.46	0.31	0.85	± 12.0 %
1750	40.1	1.37	8.37	8.37	8.37	0.39	0.80	± 12.0 %
1810	40.0	1.40	8.14	8.14	8.14	0.36	0.83	± 12.0 %
1900	40.0	1.40	8.10	8.10	8.10	0.34	0.85	± 12.0 %
2000	40.0	1.40	8.02	8.02	8.02	0.39	0.84	± 12.0 %
2100	39.8	1.49	8.22	8.22	8.22	0.31	0.85	± 12.0 %
2300	39.5	1.67	7.65	7.65	7.65	0.41	0.80	± 12.0 %
2450	39.2	1.80	7.36	7.36	7.36	0.44	0.80	± 12.0 %
2600	39.0	1.96	7.21	7.21	7.21	0.50	0.80	± 12.0 %
3500	37.9	2.91	7.11	7.11	7.11	0.45	0.89	± 13.1 %
3700	37.7	3.12	6.65	6.65	6.65	0.31	1.23	± 13.1 %
5200	36.0	4.66	5.32	5.32	5.32	0.35	1.80	± 13.1 %
5300	35.9	4.76	5.02	5.02	5.02	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.85	4.85	4.85	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.52	4.52	4.52	0.45	1.80	± 13.1 %
5800	35.3	5.27	4.45	4.45	4.45	0.50	1.80	± 13.1 %

[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: EX3DV4 - SN:7307

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)
750	55.5	0.96	9.93	9.93	9.93	0.48	0.83	± 12.0 %
835	55.2	0.97	9.83	9.83	9.83	0.36	0.94	± 12.0 %
900	55.0	1.05	9.90	9.90	9.90	0.45	0.84	± 12.0 %
1450	54.0	1.30	8.72	8.72	8.72	0.40	0.80	± 12.0 %
1640	53.8	1.40	8.69	8.69	8.69	0.39	0.84	± 12.0 %
1750	53.4	1.49	8.18	8.18	8.18	0.41	0.82	± 12.0 %
1810	53.3	1.52	7.82	7.82	7.82	0.46	0.81	± 12.0 %
1900	53.3	1.52	7.67	7.67	7.67	0.44	0.81	± 12.0 %
2000	53.3	1.52	7.83	7.83	7.83	0.40	0.80	± 12.0 %
2100	53.2	1.62	8.08	8.08	8.08	0.40	0.80	± 12.0 %
2300	52.9	1.81	7.41	7.41	7.41	0.39	0.80	± 12.0 %
2450	52.7	1.95	7.22	7.22	7.22	0.37	0.85	± 12.0 %
2600	52.5	2.16	7.03	7.03	7.03	0.40	0.80	± 12.0 %
3500	51.3	3.31	6.58	6.58	6.58	0.38	1.08	± 13.1 %
3700	51.0	3.55	6.47	6.47	6.47	0.33	1.28	± 13.1 %
5200	49.0	5.30	4.48	4.48	4.48	0.50	1.90	± 13.1 %
5300	48.9	5.42	4.29	4.29	4.29	0.50	1.90	± 13.1 %
5500	48.6	5.65	3.97	3.97	3.97	0.55	1.90	± 13.1 %
5600	48.5	5.77	3.72	3.72	3.72	0.60	1.90	± 13.1 %
5800	48.2	6.00	3.91	3.91	3.91	0.60	1.90	± 13.1 %

[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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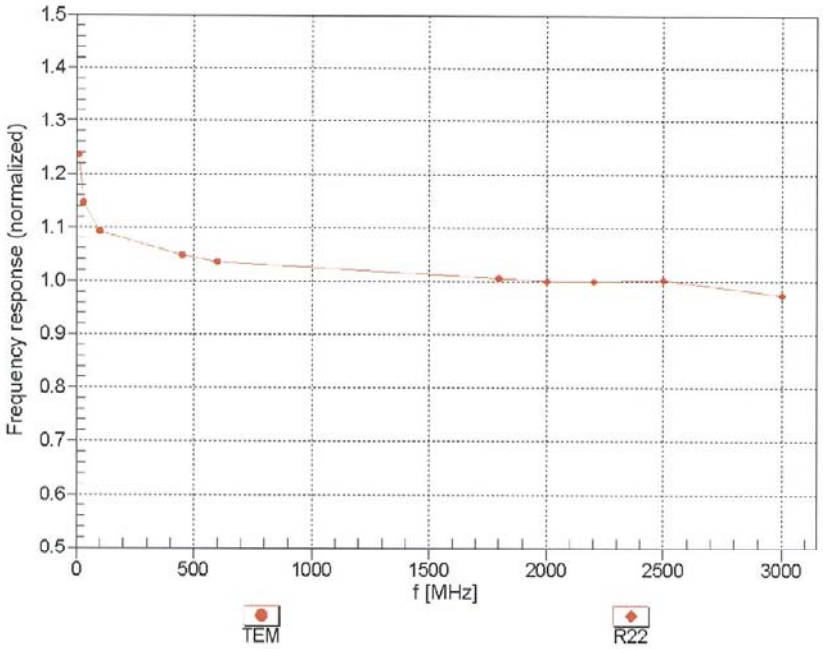
EX3DV4– SN:7307

February 19, 2016

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



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

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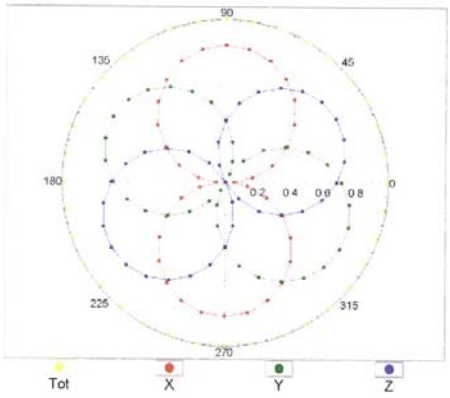
EX3DV4– SN:7307

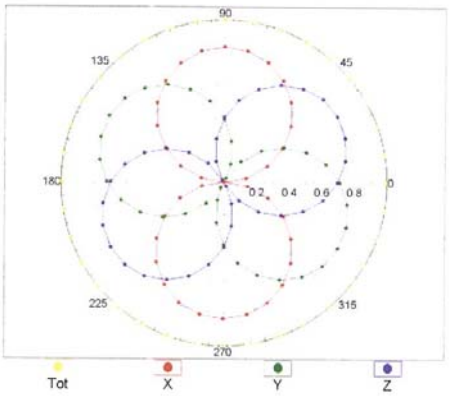
February 19, 2016

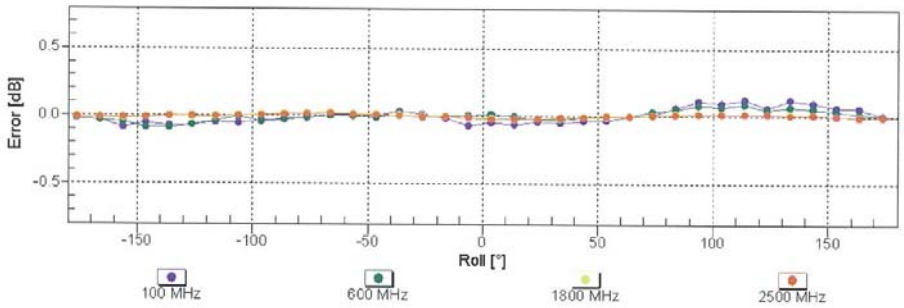
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM



f=1800 MHz,R22





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

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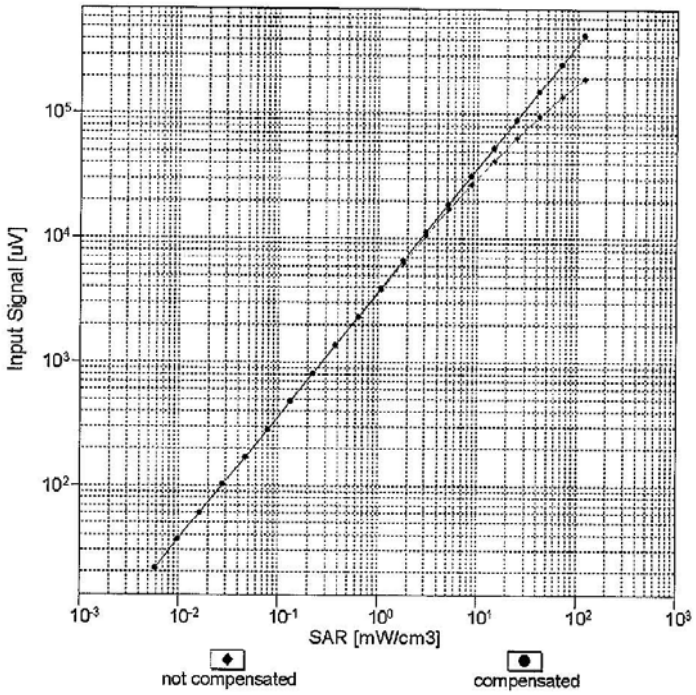
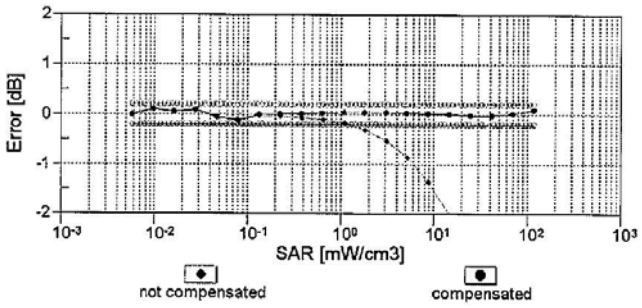
EX3DV4– SN:7307

February 19, 2016

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





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

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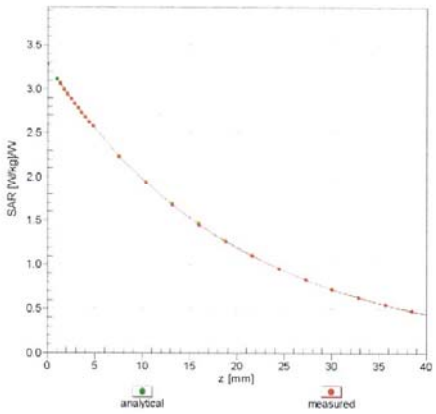
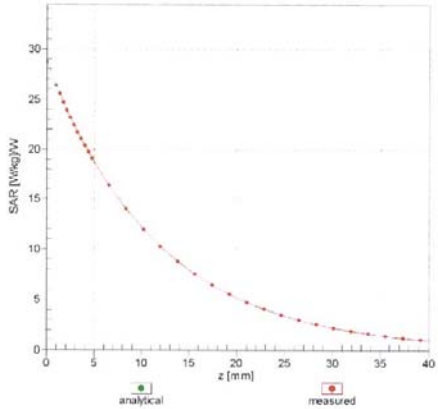
EX3DV4– SN:7307 February 19, 2016

Conversion Factor Assessment

f = 835 MHz,WGLS R9 (M_convF)

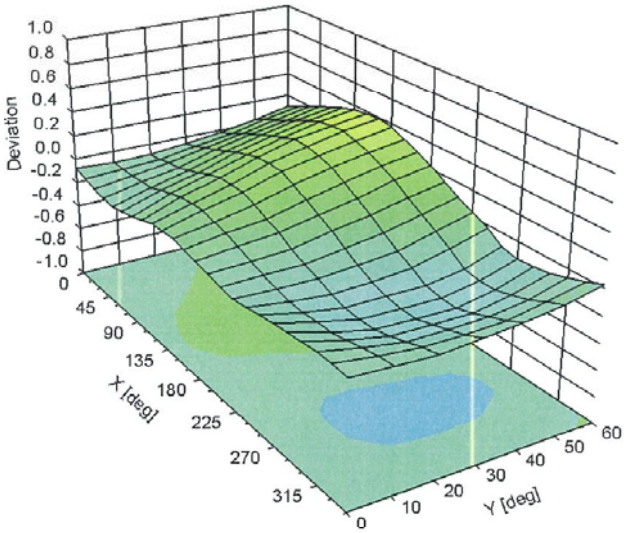


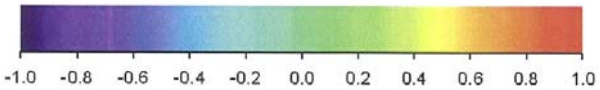
f = 1900 MHz,WGLS R22 (H_convF)



Deviation from Isotropy in Liquid

Error (ϕ, ϑ), f = 900 MHz





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

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DASY/EASY - Parameters of Probe: EX3DV4 - SN:7307

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	43.6
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	1.4 mm

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ANNEX H Dipole Calibration Certificate

750 MHz Dipole Calibration Certificate

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
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

Client **CTTL (Auden)**

Certificate No: D750V3-1017_Jul15

CALIBRATION CERTIFICATE

Object	D750V3 - SN: 1017
Calibration procedure(s)	QA CAL-05.v9 Calibration procedure for dipole validation kits above 700 MHz
Calibration date:	July 23, 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 EPM-442A	GB37480704	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	US37292783	07-Oct-14 (No. 217-02020)	Oct-15
Power sensor HP 8481A	MY41092317	07-Oct-14 (No. 217-02021)	Oct-15
Reference 20 dB Attenuator	SN: 5058 (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 ES3DV3	SN: 3205	30-Dec-14 (No. ES3-3205_Dec14)	Dec-15
DAE4	SN: 601	18-Aug-14 (No. DAE4-601_Aug14)	Aug-15

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator R&S SMT-06	100005	04-Aug-99 (in house check Oct-13)	In house check: Oct-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:	Michael Weber	Laboratory Technician	M. Weber
Approved by:	Katja Pokovic	Technical Manager	

Issued: July 23, 2015

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

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