C.4.4 Device Holder for Phantom

The SAR in the phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source at 5mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ±20%. Accurate device positioning is therefore crucial for accurate and repeatable measurements. The positions in which the devices must be measured are defined by the standards.

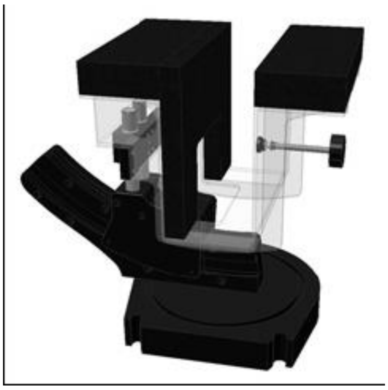
The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales are the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.

The DASY device holder is constructed of low-loss POM material having the following dielectric parameters: relative permittivity ε =3 and loss tangent δ =0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

<Laptop Extension Kit>

The extension is lightweight and made of POM, acrylic glass and foam. It fits easily on the upper part of the Mounting Device in place of the phone positioner. The extension is fully compatible with the Twin-SAM and ELI phantoms.

Picture C7-1: Device Holder



Picture C.7-2: Laptop Extension Kit

C.4.5 Phantom

The SAM Twin Phantom V4.0 is constructed of a fiberglass shell integrated in a table. The shape of the shell is based on data from an anatomical study designed to

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)

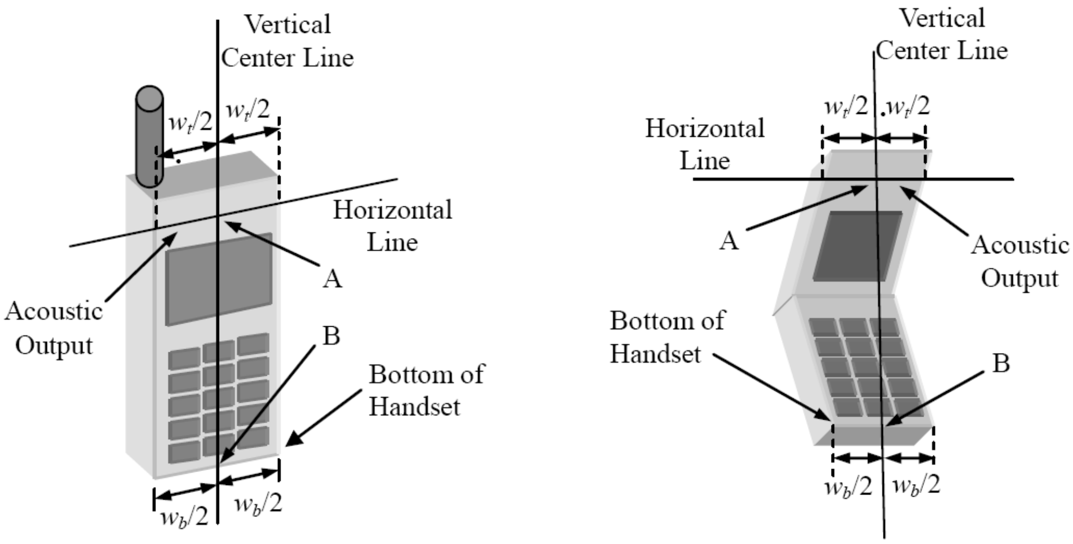
Available: Special

Picture C.8: SAM Twin Phantom

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

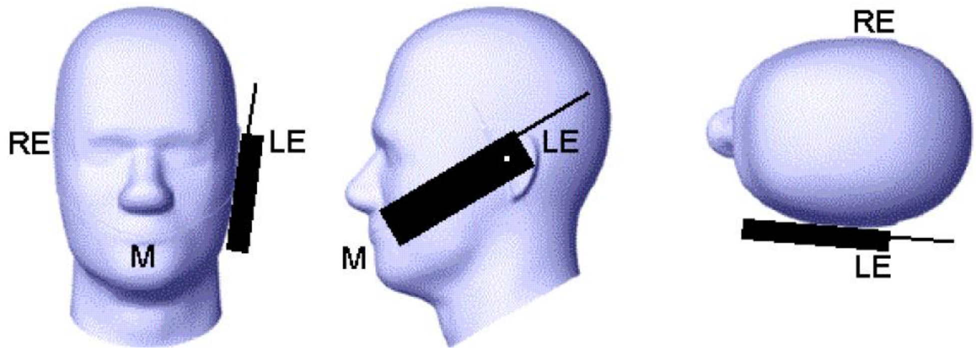
D.1 General considerations

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

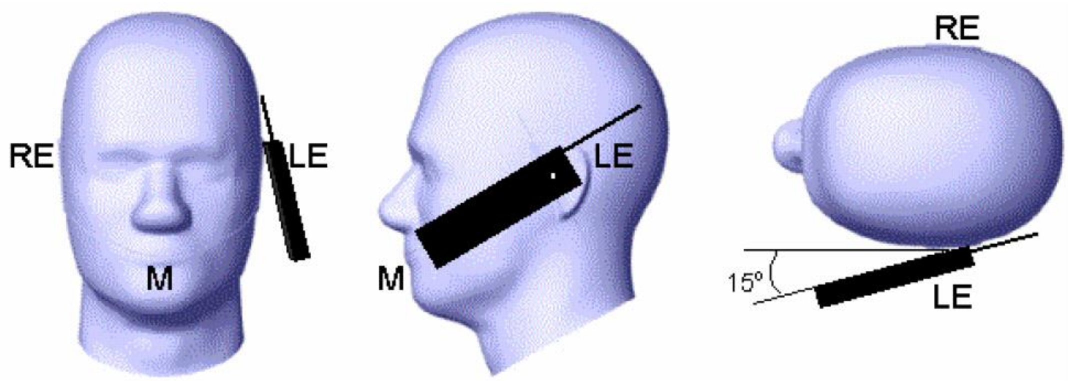


W_t	Width of the handset at the level of the acoustic
W_b	Width of the bottom of the handset
A	Midpoint of the width W_t of the handset at the level of the acoustic output
B	Midpoint of the width W_b of the bottom of the handset

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



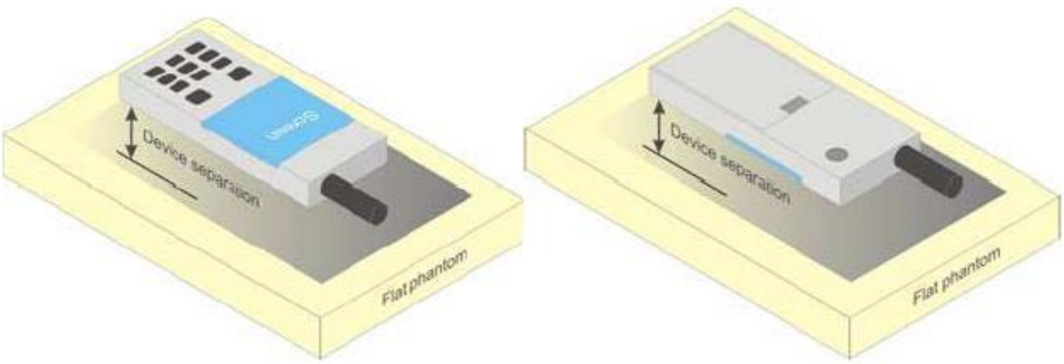
Picture D.2 Cheek position of the wireless device on the left side of SAM



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.

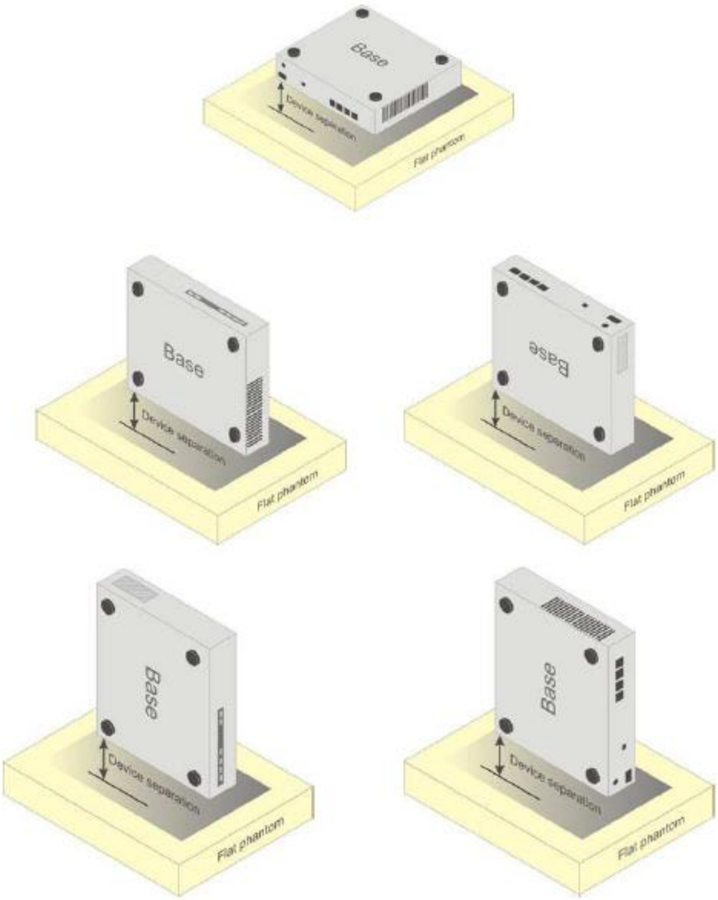


Picture D.4Test positions for body-worn devices

D.3 Desktop device

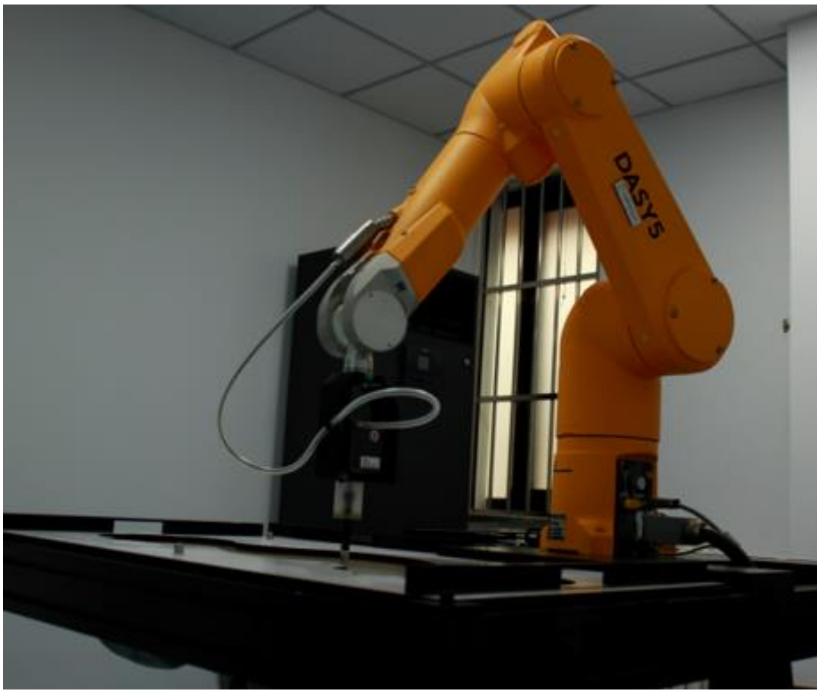
A typical example of a desktop device is a wireless enabled desktop computer placed on a table or desk when used.

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. Picture8.5 show positions for desktop device SAR tests. If the intended use is not specified, the device shall be tested directly against the flat phantom.



Picture D.5 Test positions for desktop devices

D.4 DUT Setup Photos



Picture D.6

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.

TableE.1: Composition of the Tissue Equivalent Matter

Frequency (MHz)	835Head	835Body	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.

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 7464

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
7464	Head 13MHz	February 26,2024	13MHz	OK
7464	Head 64MHz	February 26,2024	64MHz	OK
7464	Head 150MHz	February 26,2024	150MHz	OK
7464	Head 300MHz	February 26,2024	300MHz	OK
7464	Head 450MHz	February 26,2024	450MHz	OK
7464	Head 750MHz	February 26,2024	750MHz	OK
7464	Head 835MHz	February 26,2024	835MHz	OK
7464	Head 900MHz	February 26,2024	900MHz	OK
7464	Head 1450MHz	February 26,2024	1450MHz	OK
7464	Head 1640MHz	February 26,2024	1640MHz	OK
7464	Head 1750MHz	February 26,2024	1750MHz	OK
7464	Head 1810MHz	February 26,2024	1810MHz	OK
7464	Head 1900MHz	February 26,2024	1900MHz	OK
7464	Head 2000MHz	February 27,2024	2000MHz	OK
7464	Head 2100MHz	February 27,2024	2100MHz	OK
7464	Head 2300MHz	February 27,2024	2300MHz	OK
7464	Head 2450MHz	February 27,2024	2450MHz	OK
7464	Head 2600MHz	February 27,2024	2600MHz	OK
7464	Head 3300MHz	February 28,2024	3300MHz	OK
7464	Head 3500MHz	February 28,2024	3500MHz	OK
7464	Head 3700MHz	February 28,2024	3700MHz	OK
7464	Head 3900MHz	February 28,2024	3900MHz	OK
7464	Head 4100MHz	February 28,2024	4100MHz	OK
7464	Head 4200MHz	February 28,2024	4200MHz	OK
7464	Head 4400MHz	February 28,2024	4400MHz	OK
7464	Head 4600MHz	February 28,2024	4600MHz	OK
7464	Head 4800MHz	February 28,2024	4800MHz	OK
7464	Head 4950MHz	February 28,2024	4950MHz	OK
7464	Head 5200MHz	February 29,2024	5200MHz	OK
7464	Head 5250MHz	February 29,2024	5250MHz	OK
7464	Head 5300MHz	February 29,2024	5300MHz	OK
7464	Head 5500MHz	February 29,2024	5500MHz	OK
7464	Head 5600MHz	February 29,2024	5600MHz	OK
7464	Head 5750MHz	February 29,2024	5750MHz	OK
7464	Head 5800MHz	February 29,2024	5800MHz	OK
7464	Head 6500MHz	March 01,2024	6500MHz	OK
7464	Head 7000MHz	March 01,2024	7000MHz	OK

Table F.1: System Validation for 3846

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
3846	Head 750MHz	July 20,2024	750MHz	OK
3846	Head 900MHz	July 20,2024	900MHz	OK
3846	Head 1450MHz	July 20,2024	1450MHz	OK
3846	Head 1750MHz	July 20,2024	1750MHz	OK
3846	Head 1900MHz	July 20,2024	1900MHz	OK
3846	Head 2100MHz	July 21,2024	2100MHz	OK
3846	Head 2300MHz	July 21,2024	2300MHz	OK
3846	Head 2450MHz	July 21,2024	2450MHz	OK
3846	Head 2600MHz	July 21,2024	2600MHz	OK
3846	Head 3300MHz	July 22,2024	3300MHz	OK
3846	Head 3500MHz	July 22,2024	3500MHz	OK
3846	Head 3700MHz	July 22,2024	3700MHz	OK
3846	Head 3900MHz	July 22,2024	3900MHz	OK
3846	Head 4100MHz	July 22,2024	4100MHz	OK
3846	Head 4200MHz	July 22,2024	4200MHz	OK
3846	Head 4400MHz	July 22,2024	4400MHz	OK
3846	Head 4600MHz	July 22,2024	4600MHz	OK
3846	Head 4800MHz	July 22,2024	4800MHz	OK
3846	Head 4950MHz	July 22,2024	4950MHz	OK
3846	Head 5250MHz	July 23,2024	5250MHz	OK
3846	Head 5600MHz	July 23,2024	5600MHz	OK
3846	Head 5750MHz	July 23,2024	5750MHz	OK

Table F.1: System Validation for 7673

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
7673	Head 750MHz	July.30,2024	750 MHz	OK
7673	Head 900MHz	July.30,2024	900 MHz	OK
7673	Head 1750MHz	July.30,2024	1750 MHz	OK
7673	Head 1900MHz	July.30,2024	1900 MHz	OK
7673	Head 2000MHz	July.30,2024	2000 MHz	OK
7673	Head 2300MHz	July.30,2024	2300 MHz	OK
7673	Head 2450MHz	July.30,2024	2450 MHz	OK
7673	Head 2600MHz	July.30,2024	2600 MHz	OK
7673	Head 3500MHz	July.30,2024	3500 MHz	OK
7673	Head 3700MHz	July.30,2024	3700 MHz	OK
7673	Head 5250MHz	July.30,2024	5250 MHz	OK
7673	Head 5600MHz	July.30,2024	5600 MHz	OK
7673	Head 5750MHz	July.30,2024	5750 MHz	OK

Table F.3: System Validation for 7517

Probe SN.	Liquid name	Validation date	Frequency point	Status (OK or Not)
7517	Head 750MHz	March 09,2024	750 MHz	OK
7517	Head 900MHz	March 09,2024	900 MHz	OK
7517	Head 1450MHz	March 09,2024	1450 MHz	OK
7517	Head 1750MHz	March 09,2024	1750 MHz	OK
7517	Head 1900MHz	March 09,2024	1900 MHz	OK
7517	Head 2100MHz	March 09,2024	2100 MHz	OK
7517	Head 2300MHz	March 09,2024	2300 MHz	OK
7517	Head 2450MHz	March 09,2024	2450 MHz	OK
7517	Head 2600MHz	March 09,2024	2600 MHz	OK
7517	Head 3300MHz	March 10,2024	3300 MHz	OK
7517	Head 3500MHz	March 10,2024	3500 MHz	OK
7517	Head 3700MHz	March 10,2024	3700 MHz	OK
7517	Head 3900MHz	March 10,2024	3900 MHz	OK
7517	Head 4100MHz	March 10,2024	4100 MHz	OK
7517	Head 4200MHz	March 10,2024	4200 MHz	OK
7517	Head 4400MHz	March 10,2024	4400 MHz	OK
7517	Head 4600MHz	March 11,2024	4600 MHz	OK
7517	Head 4800MHz	March 11,2024	4800 MHz	OK
7517	Head 4950MHz	March 11,2024	4950 MHz	OK
7517	Head 5250MHz	March 11,2024	5250 MHz	OK
7517	Head 5600MHz	March 11,2024	5600 MHz	OK
7517	Head 5750MHz	March 11,2024	5750 MHz	OK

ANNEX G PROBE CALIBRATION CERTIFICATE

Probe 3846 Calibration Certificate

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Client **CTTL** **Certificate No: 24J02Z000266**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN : 3846
Calibration Procedure(s)	FF-Z11-004-02 Calibration Procedures for Dosimetric E-field Probes
Calibration date:	June 19, 2024

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)℃ and humidity<70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
Power Meter NRP2	106277	19-Oct-23(CTTL, No.J23X11026)	Oct-24
Power sensor NRP8S	104291	19-Oct-23(CTTL, No.J23X11026)	Oct-24
Power sensor NRP8S	104292	19-Oct-23(CTTL, No.J23X11026)	Oct-24
Reference 10dBAttenuator	18N50W-10dB	19-Jan-23(CTTL, No.J23X00212)	Jan-25
Reference 20dBAttenuator	18N50W-20dB	19-Jan-23(CTTL, No.J23X00211)	Jan-25
Reference Probe EX3DV4	SN 7464	22-Jan-24(SPEAG, No.EX-7464_Jan24)	Jan-25
DAE4	SN 1555	24-Aug-23(SPEAG, No.DAE4-1555_Aug23)	Aug-24
Secondary Standards	**ID #**	**Cal Date(Calibrated by, Certificate No.)**	**Scheduled Calibration**
SignalGenerator MG3700A	6201052605	12-Jun-24(CTTL, No.24J02X005419)	Jun-25
SignalGenerator APSIN26G	181-33A6D0700-1959	26-Mar-24(CTTL, No.24J02X002468)	Mar-25
Network Analyzer E5071C	MY46110673	25-Dec-23(CTTL, No.J23X13425)	Dec-24
Reference 10dBAttenuator	BT0520	11-May-23(CTTL, No.J23X04061)	May-25
Reference 20dBAttenuator	BT0267	11-May-23(CTTL, No.J23X04062)	May-25
OCP DAK-12	SN 1174	25-Oct-23(SPEAG, No.OCP-DAK12-1174_Oct23)	Oct-24

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Lin Jun	SAR Test Engineer	
Approved by:	Qi Dianyuan	SAR Project Leader	

Issued: June 30, 2024

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

Certificate No: 24J02Z000266 Page 1 of 9

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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 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, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016

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≤900MHz in TEM-cell; f>1800MHz: waveguide). NORMx,y,z are only intermediate values, i.e., the uncertainties of NORMx,y,z does not effect 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 (no uncertainty required). DCP does not depend on frequency nor media.
- PAR: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics.
- *Ax,y,z; Bx,y,z; Cx,y,z;VRx,y,z:*A,B,C are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- *ConvF and Boundary Effect Parameters:* Assessed in flat phantom using E-field (or Temperature Transfer Standard for f≤800MHz) and inside waveguide using analytical field distributions based on power measurements for f >800MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty valued 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±50MHz to±100MHz.
- *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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DASY/EASY – Parameters of Probe: EX3DV4 – SN:3846

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(μV/(V/m)^2)[A]	0.39	0.47	0.48	±10.0%
DCP(mV)[B]	100.4	101.0	102.4	

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	153.1	±2.0%
		Y	0.0	0.0	1.0		174.2	
		Z	0.0	0.0	1.0		173.4	

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 Page 4).
[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainly 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:3846

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)	Unct. (*k*=2)
750	41.9	0.89	9.89	9.89	9.89	0.20	1.25	±12.7%
900	41.5	0.97	9.38	9.38	9.38	0.15	1.49	±12.7%
1450	40.5	1.20	8.62	8.62	8.62	0.17	1.16	±12.7%
1750	40.1	1.37	8.25	8.25	8.25	0.29	0.99	±12.7%
1900	40.0	1.40	7.95	7.95	7.95	0.28	1.10	±12.7%
2100	39.8	1.49	7.80	7.80	7.80	0.25	1.09	±12.7%
2300	39.5	1.67	7.69	7.69	7.69	0.66	0.69	±12.7%
2450	39.2	1.80	7.43	7.43	7.43	0.66	0.70	±12.7%
2600	39.0	1.96	7.28	7.28	7.28	0.66	0.70	±12.7%
3300	38.2	2.71	6.96	6.96	6.96	0.54	0.88	±13.9%
3500	37.9	2.91	6.81	6.81	6.81	0.44	1.05	±13.9%
3700	37.7	3.12	6.71	6.71	6.71	0.46	1.05	±13.9%
3900	37.5	3.32	6.65	6.65	6.65	0.40	1.25	±13.9%
4100	37.2	3.53	6.57	6.57	6.57	0.35	1.30	±13.9%
4200	37.1	3.63	6.45	6.45	6.45	0.35	1.35	±13.9%
4400	36.9	3.84	6.37	6.37	6.37	0.40	1.25	±13.9%
4600	36.7	4.04	6.33	6.33	6.33	0.45	1.27	±13.9%
4800	36.4	4.25	6.26	6.26	6.26	0.45	1.25	±13.9%
4950	36.3	4.40	6.05	6.05	6.05	0.50	1.19	±13.9%
5250	35.9	4.71	5.45	5.45	5.45	0.45	1.40	±13.9%
5600	35.5	5.07	4.75	4.75	4.75	0.55	1.20	±13.9%
5750	35.4	5.22	4.90	4.90	4.90	0.50	1.30	±13.9%

[C] Frequency validity above 300 MHz of ±100MHz only applies for DASY v4.4 and higher (Page 2), else it is restricted to ±50MHz. The uncertainty is the RSS of 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 frequency up to 6 GHz, the validity of tissue parameters (ε and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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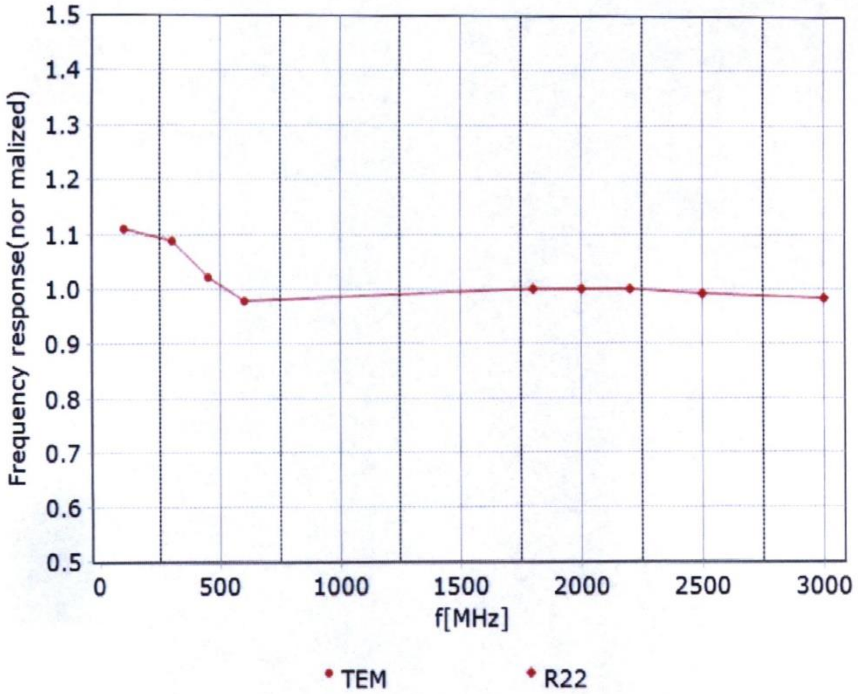
Frequency Response of E-Field
(TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: ±7.4% (*k*=2)

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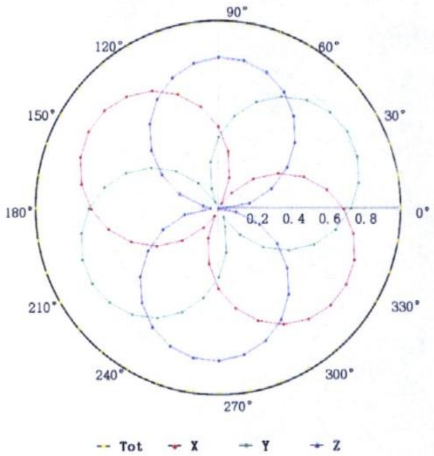
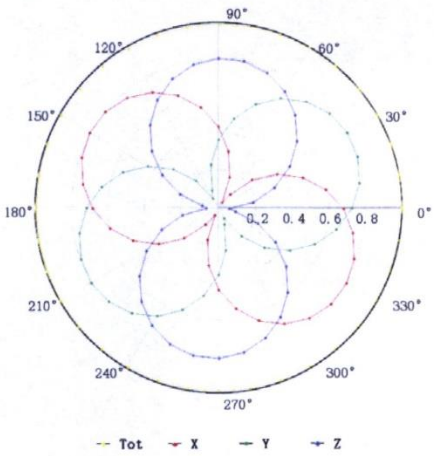
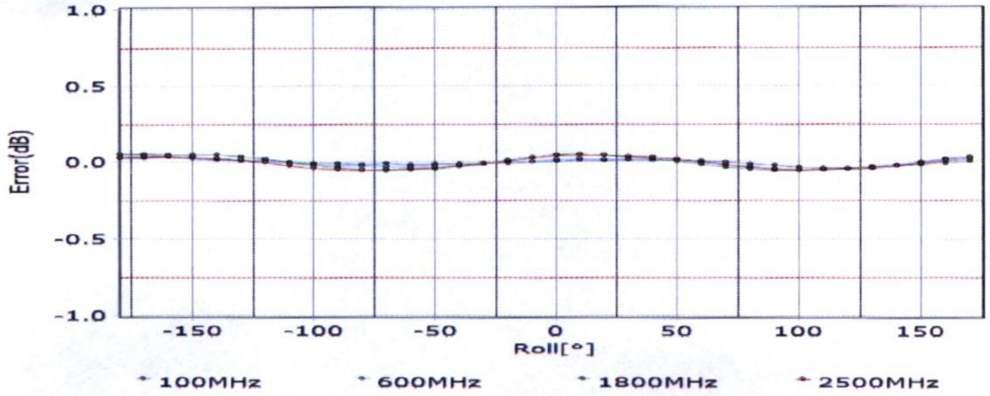
Receiving Pattern (Φ), θ=0°

f=600 MHz, TEM



f=1800 MHz, R22

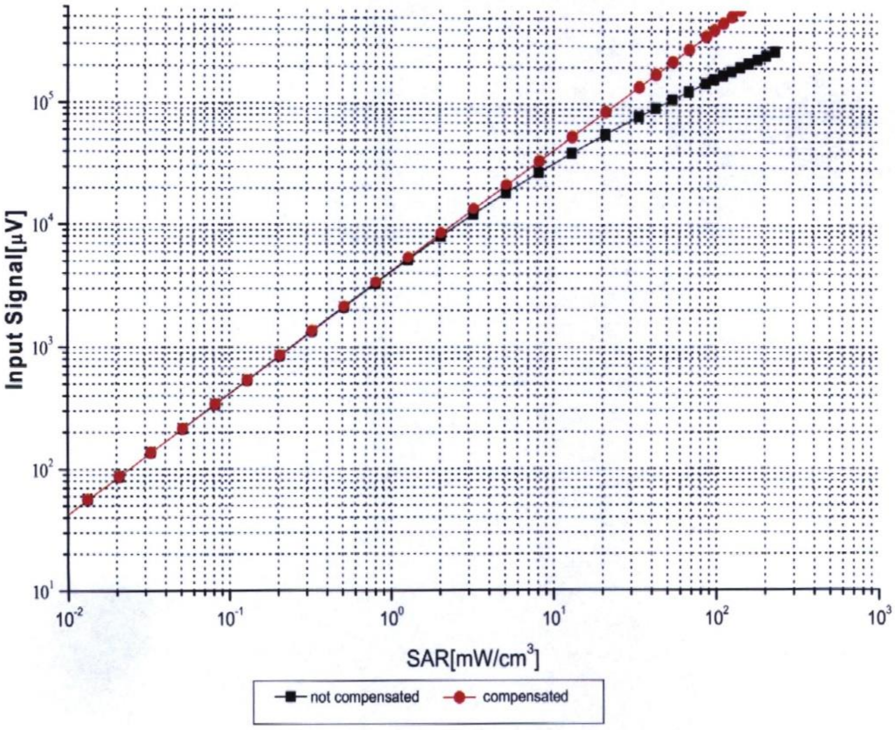


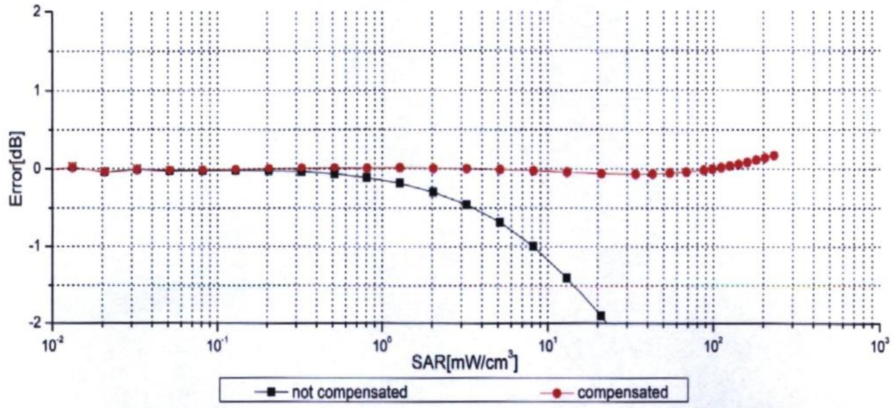


Uncertainty of Axial Isotropy Assessment: ±1.2% (k=2)

Add: No.52 HuaYuanBei Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2117
E-mail: emf@caict.ac.cn http://www.caict.ac.cn

Dynamic Range f(SAR$_{head}$)
(TEM cell, f = 900 MHz)





Uncertainty of Linearity Assessment: ±0.9% (*k*=2)

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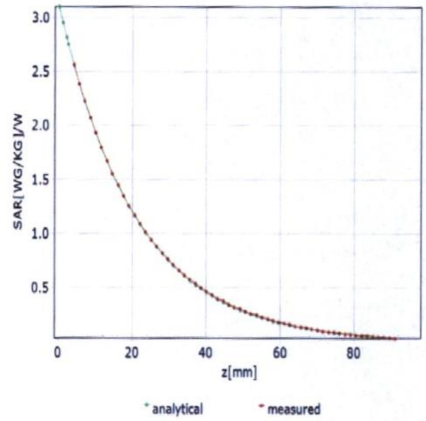
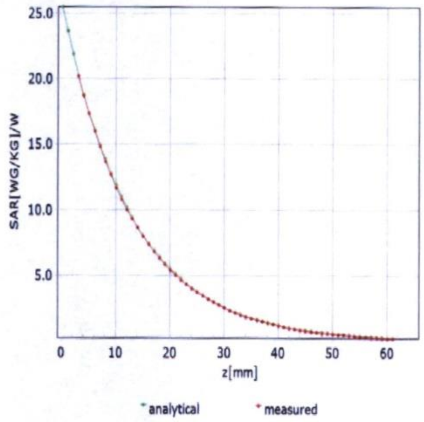
Tel: +86-10-62304633-2117
E-mail: emf@caict.ac.cn http://www.caict.ac.cn

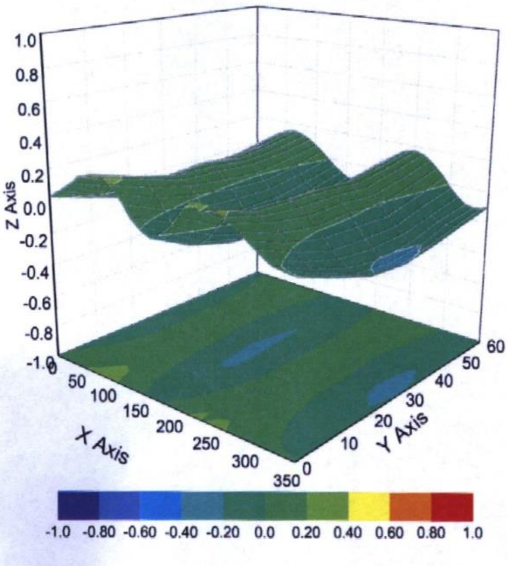
Conversion Factor Assessment

f=750 MHz,WGLS R9(H_convF) **f=1750 MHz,WGLS R22(H_convF)**





Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±3.2% (*k*=2)

Add: No.52 HuaYuanBei Road, Haidian District, Beijing, 100191, China
Tel: +86-10-62304633-2117
E-mail: emf@caict.ac.cn http://www.caict.ac.cn

DASY/EASY – Parameters of Probe: EX3DV4 – SN:3846

Other Probe Parameters

Sensor Arrangement	**Triangular**
Connector Angle (°)	**16.2**
Mechanical Surface Detection Mode	**enabled**
Optical Surface Detection Mode	**disable**
Probe Overall Length	**337mm**
Probe Body Diameter	**10mm**
Tip Length	**9mm**
Tip Diameter	**2.5mm**
Probe Tip to Sensor X Calibration Point	**1mm**
Probe Tip to Sensor Y Calibration Point	**1mm**
Probe Tip to Sensor Z Calibration Point	**1mm**
Recommended Measurement Distance from Surface	**1.4mm**

Probe 7464 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**
Beijing

Certificate No. **EX-7464_Jan24**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:7464
Calibration procedure(s)	QA CAL-01.v10, QA CAL-12.v10, QA CAL-14.v7, QA CAL-23.v6, QA CAL-25.v8 Calibration procedure for dosimetric E-field probes
Calibration date	January 22, 2024

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 NRP2	SN: 104778	30-Mar-23 (No. 217-03804/03805)	Mar-24
Power sensor NRP-Z91	SN: 103244	30-Mar-23 (No. 217-03804)	Mar-24
OCP DAK-3.5 (weighted)	SN: 1249	05-Oct-23 (OCP-DAK3.5-1249_Oct23)	Oct-24
OCP DAK-12	SN: 1016	05-Oct-23 (OCP-DAK12-1016_Oct23)	Oct-24
Reference 20 dB Attenuator	SN: CC2552 (20x)	30-Mar-23 (No. 217-03809)	Mar-24
DAE4	SN: 660	16-Mar-23 (No. DAE4-660_Mar23)	Mar-24
Reference Probe EX3DV4	SN: 7349	03-Nov-23 (No. EX3-7349_Nov23)	Nov-24

Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-22)	In house check: Jun-24
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-22)	In house check: Jun-24
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-22)	In house check: Oct-24

	Name	Function	Signature
Calibrated by	Joanna Lleshaj	Laboratory Technician	[signature]
Approved by	Sven Kühn	Technical Manager	[signature]

Issued: January 24, 2024

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., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

a) IEC/IEEE 62209-1528, "Measurement Procedure For The Assessment Of Specific Absorption Rate Of Human Exposure To Radio Frequency Fields From Hand-Held And Body-Worn Wireless Communication Devices – Part 1528: Human Models, Instrumentation And Procedures (Frequency Range of 4 MHz to 10 GHz)", October 2020.
b) 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 $\vartheta = 0$ ($f \leq 900$ 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. 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 $f \leq 800$ 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 *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).

Parameters of Probe: EX3DV4 - SN:7464

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k = 2)
Norm (μV/(V/m)^2) [A]	0.47	0.45	0.46	±10.1%
DCP (mV) [B]	99.7	100.5	100.4	±4.7%

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB$\sqrt{\mu V}$	C	D dB	VR mV	Max dev.	Max Unc[E] k = 2
0	CW	X	0.00	0.00	1.00	0.00	119.1	±2.0%	±4.7%
		Y	0.00	0.00	1.00		137.6		
		Z	0.00	0.00	1.00		116.5		
10352	Pulse Waveform (200Hz, 10%)	X	18.57	89.69	20.49	10.00	60.0	±2.7%	±9.6%
		Y	20.00	93.91	22.75		60.0		
		Z	20.00	92.74	22.54		60.0		
10353	Pulse Waveform (200Hz, 20%)	X	20.00	90.77	19.55	6.99	80.0	±1.4%	±9.6%
		Y	20.00	98.49	24.17		80.0		
		Z	20.00	92.95	21.35		80.0		
10354	Pulse Waveform (200Hz, 40%)	X	20.00	93.60	19.50	3.98	95.0	±1.6%	±9.6%
		Y	20.00	110.50	28.77		95.0		
		Z	20.00	95.00	20.85		95.0		
10355	Pulse Waveform (200Hz, 60%)	X	20.00	96.22	19.51	2.22	120.0	±1.6%	±9.6%
		Y	20.00	133.23	37.93		120.0		
		Z	20.00	99.33	21.57		120.0		
10387	QPSK Waveform, 1 MHz	X	1.90	66.53	15.71	1.00	150.0	±1.6%	±9.6%
		Y	2.23	69.84	17.98		150.0		
		Z	1.96	66.48	15.85		150.0		
10388	QPSK Waveform, 10 MHz	X	2.56	69.56	16.46	0.00	150.0	±0.9%	±9.6%
		Y	3.31	74.50	19.22		150.0		
		Z	2.65	69.90	16.61		150.0		
10396	64-QAM Waveform, 100 kHz	X	3.42	71.74	19.12	3.01	150.0	±0.7%	±9.6%
		Y	4.98	79.46	22.89		150.0		
		Z	4.16	74.48	20.31		150.0		
10399	64-QAM Waveform, 40 MHz	X	3.59	67.28	15.89	0.00	150.0	±1.0%	±9.6%
		Y	3.96	69.24	17.20		150.0		
		Z	3.64	67.41	15.98		150.0		
10414	WLAN CCDF, 64-QAM, 40 MHz	X	5.01	65.58	15.52	0.00	150.0	±1.9%	±9.6%
		Y	5.19	66.39	16.16		150.0		
		Z	5.06	65.58	15.53		150.0		

Note: For details on UID parameters see Appendix

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 to 7).
[B] Linearization parameter uncertainty for maximum specified field strength.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

Parameters of Probe: EX3DV4 - SN:7464

Sensor Model Parameters

	C1 fF	C2 fF	α V^{-1}	T1 $ms V^{-2}$	T2 $ms V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
x	63.3	469.89	35.22	13.36	0.57	5.02	1.43	0.37	1.01
y	64.3	474.26	35.19	20.37	0.17	5.10	1.70	0.31	1.01
z	72.2	537.29	35.39	17.48	0.83	5.05	1.31	0.47	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle	33.9°
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

Note: Measurement distance from surface can be increased to 3–4 mm for an *Area Scan* job.

Parameters of Probe: EX3DV4 - SN:7464

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc (k = 2)
13	55.0	0.75	17.62	17.62	17.62	0.00	1.25	±13.3%
64	54.2	0.75	13.32	13.32	13.32	0.00	1.25	±13.3%
150	52.3	0.76	11.73	11.73	11.73	0.00	1.25	±13.3%
300	45.3	0.87	11.39	11.39	11.39	0.09	1.00	±13.3%
450	43.5	0.87	10.79	10.79	10.79	0.16	1.30	±13.3%
750	41.9	0.89	9.09	9.18	9.51	0.37	1.27	±12.0%
835	41.5	0.90	8.69	9.48	9.34	0.36	1.27	±12.0%
900	41.5	0.97	8.73	9.09	9.30	0.37	1.27	±12.0%
1450	40.5	1.20	8.01	8.19	8.34	0.49	1.27	±12.0%
1640	40.2	1.31	7.66	7.69	7.93	0.45	1.27	±12.0%
1750	40.1	1.37	7.99	8.13	8.29	0.26	1.27	±12.0%
1810	40.0	1.40	8.04	8.18	8.37	0.29	1.27	±12.0%
1900	40.0	1.40	7.64	7.81	7.99	0.28	1.27	±12.0%
2000	40.0	1.40	7.57	7.71	7.88	0.29	1.27	±12.0%
2100	39.8	1.49	7.39	7.51	7.70	0.29	1.27	±12.0%
2300	39.5	1.67	7.46	7.60	7.77	0.30	1.27	±12.0%
2450	39.2	1.80	7.63	7.75	7.92	0.30	1.27	±12.0%
2600	39.0	1.96	7.34	7.45	7.58	0.29	1.27	±12.0%
3300	38.2	2.71	6.74	6.84	6.97	0.34	1.27	±14.0%
3500	37.9	2.91	6.73	6.82	6.94	0.34	1.27	±14.0%
3700	37.7	3.12	6.48	6.59	6.69	0.35	1.27	±14.0%
3900	37.5	3.32	6.74	6.84	6.96	0.36	1.27	±14.0%
4100	37.2	3.53	6.72	6.83	6.93	0.36	1.27	±14.0%
4200	37.1	3.63	6.65	6.76	6.87	0.36	1.27	±14.0%
4400	36.9	3.84	6.54	6.64	6.73	0.36	1.27	±14.0%
4600	36.7	4.04	6.46	6.56	6.66	0.36	1.27	±14.0%
4800	36.4	4.25	6.60	6.72	6.81	0.36	1.27	±14.0%
4950	36.3	4.40	6.05	6.11	6.28	0.48	1.36	±14.0%

[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. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10%. If TSL with deviations from the target of less than ±5% are used, the calibration uncertainties are 11.1% for 0.7 - 3 GHz and 13.1% for 3 - 6 GHz.

[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.

Parameters of Probe: EX3DV4 - SN:7464

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
5200	36.0	4.66	5.41	5.50	5.64	0.38	1.64	±14.0%
5250	35.9	4.71	5.38	5.48	5.64	0.37	1.62	±14.0%
5300	35.9	4.76	5.31	5.35	5.51	0.37	1.65	±14.0%
5500	35.6	4.96	4.81	4.83	5.01	0.42	1.61	±14.0%
5600	35.5	5.07	4.68	4.70	4.88	0.40	1.66	±14.0%
5750	35.4	5.22	4.76	4.79	4.95	0.41	1.75	±14.0%
5800	35.3	5.27	4.72	4.77	4.92	0.39	1.86	±14.0%

[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. Validity of ConvF assessed at 6 MHz is 4–9 MHz, and ConvF assessed at 13 MHz is 9–19 MHz. Above 5 GHz frequency validity can be extended to ±110 MHz.

[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±5% from the target values (typically better than ±3%) and are valid for TSL with deviations of up to ±10%. If TSL with deviations from the target of less than ±5% are used, the calibration uncertainties are 11.1% for 0.7 - 3 GHz and 13.1% for 3 - 6 GHz.

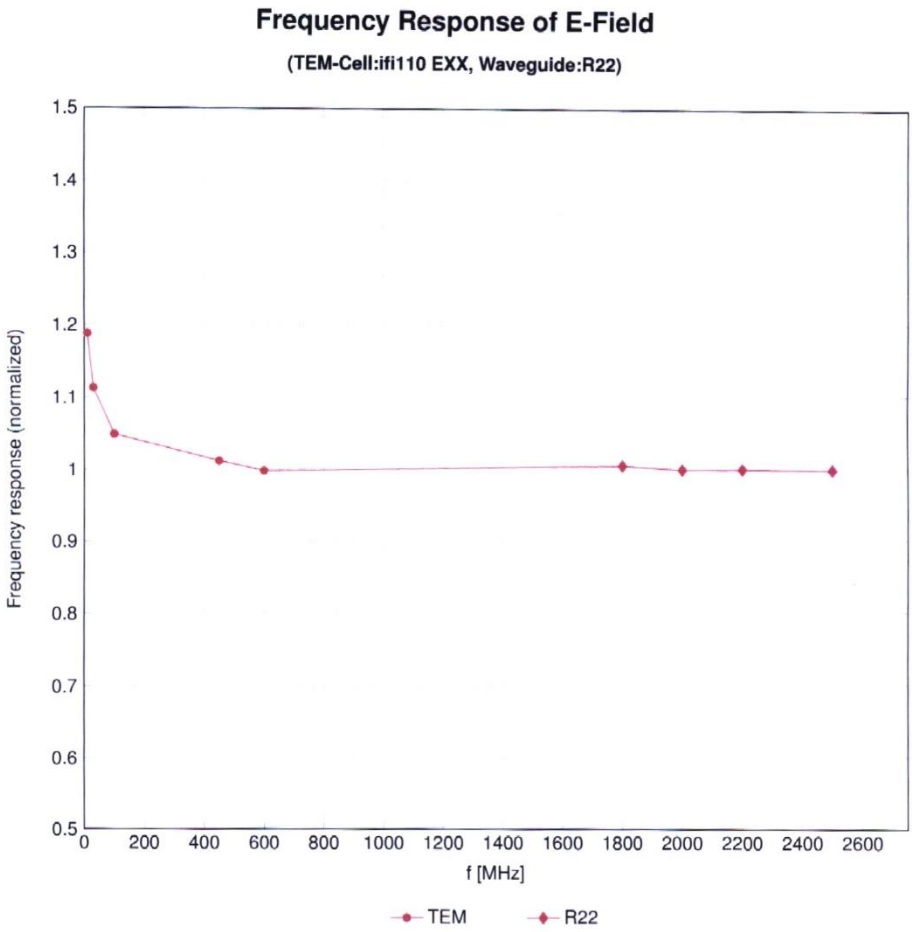
[G] Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ±1% for frequencies below 3 GHz and below ±2% for frequencies between 3–6 GHz at any distance larger than half the probe tip diameter from the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

Parameters of Probe: EX3DV4 - SN:7464

Calibration Parameter Determined in Head Tissue Simulating Media

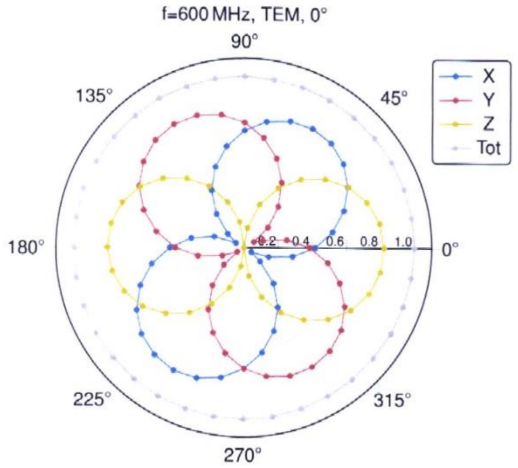
f (MHz)[C]	Relative Permittivity[F]	Conductivity[F] (S/m)	ConvF X	ConvF Y	ConvF Z	Alpha[G]	Depth[G] (mm)	Unc ($k = 2$)
6500	34.5	6.07	5.18	5.25	5.28	0.20	2.50	±18.6%
7000	33.9	6.65	5.50	5.55	5.59	0.20	2.00	±18.6%

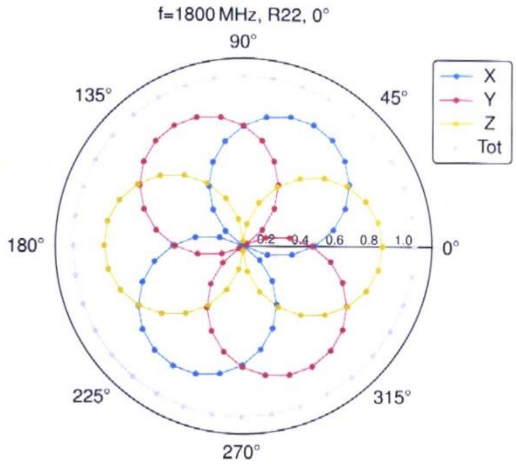
[C] Frequency validity at 6.5 GHz is −600/+700 MHz, and ±700 MHz at or above 7 GHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.
[F] The probes are calibrated using tissue simulating liquids (TSL) that deviate for ε and σ by less than ±10% from the target values (typically better than ±6%) and are valid for TSL with deviations of up to ±10%.
[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; below ±2% for frequencies between 3–6 GHz; and below ±4% for frequencies between 6–10 GHz at any distance larger than half the probe tip diameter from the boundary.

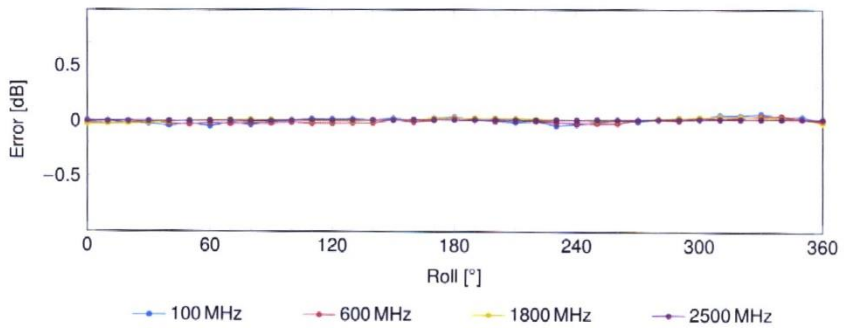


Uncertainty of Frequency Response of E-field: ±6.3% (k=2)

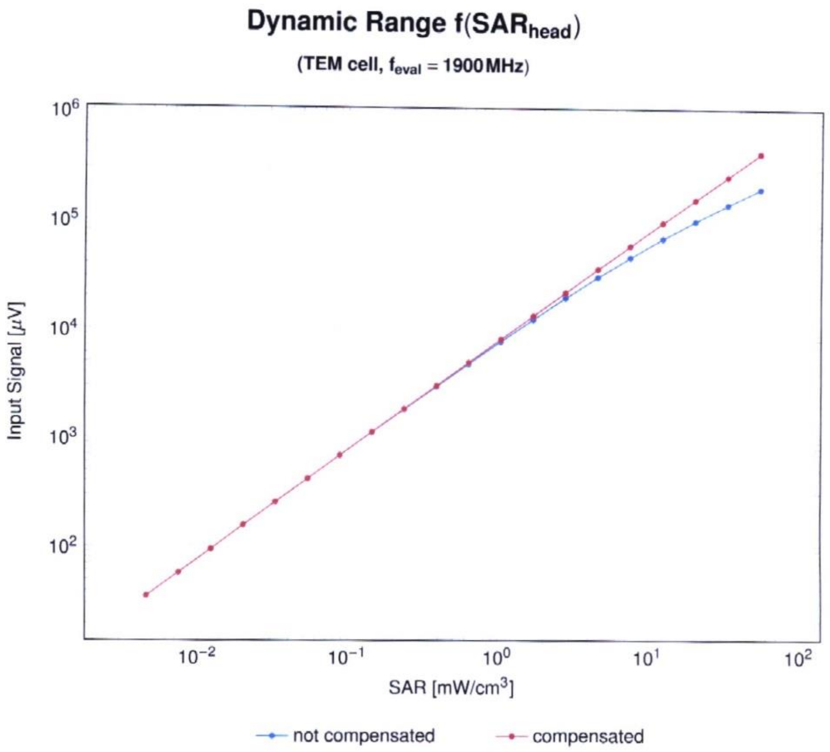
Receiving Pattern (ϕ), $\vartheta = 0°$

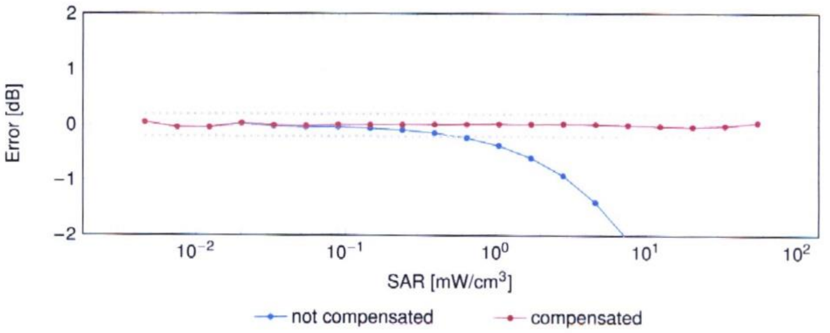






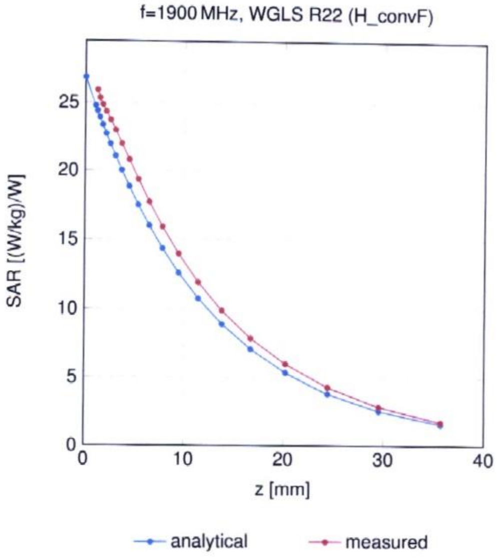
Uncertainty of Axial Isotropy Assessment: ±0.5% (k=2)



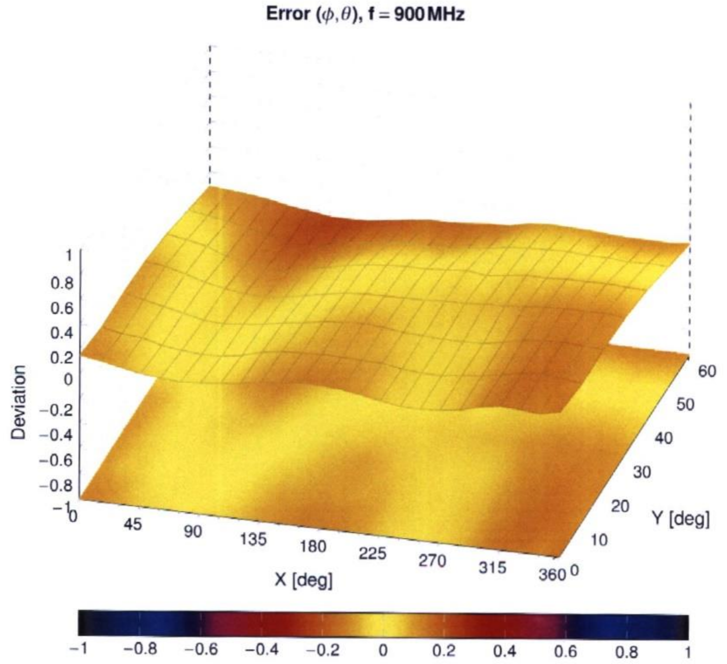


Uncertainty of Linearity Assessment: ±0.6% (k=2)

Conversion Factor Assessment



Deviation from Isotropy in Liquid



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