Appendix (Additional assessments outside the scope of SCS108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	48.9 Ω - 7.9 jΩ
Return Loss	- 21.9 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	48.8 Ω - 3.3 jΩ
Return Loss	- 28.9 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	50.3 Ω - 4.8 jΩ
Return Loss	- 26.4 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	55.7 Ω - 4.7 jΩ
Return Loss	- 23.1 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	54.1 Ω - 1.7 jΩ
Return Loss	- 27.5 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	48.8 Ω - 6.9 jΩ
Return Loss	- 23.0 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	48.8 Ω - 2.9 jΩ
Return Loss	- 30.0 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	50.6 Ω - 3.7 jΩ
Return Loss	- 28.6 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	55.8 Ω - 3.3 jΩ
Return Loss	- 24.0 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	55.2 Ω - 0.6 jΩ
Return Loss	- 26.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 ns

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	December 30, 2005

DASY5 Validation Report for Head TSL

Date: 20.06.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1040

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 4.47 S/m; ε_r = 34.7; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 4.57 S/m; ε_r = 34.6; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 4.76 S/m; ε_r = 34.3; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 4.86 S/m; ε_r = 34.2; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 5.06 S/m; ε_r = 33.9; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.52, 5.52, 5.52); Calibrated: 30.12.2013, ConvF(5.2, 5.2, 5.2); Calibrated: 30.12.2013, ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.86, 4.86, 4.86); Calibrated: 30.12.2013, ConvF(4.91, 4.91, 4.91); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (front); Type: QD000P50AA; Serial: 1001
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

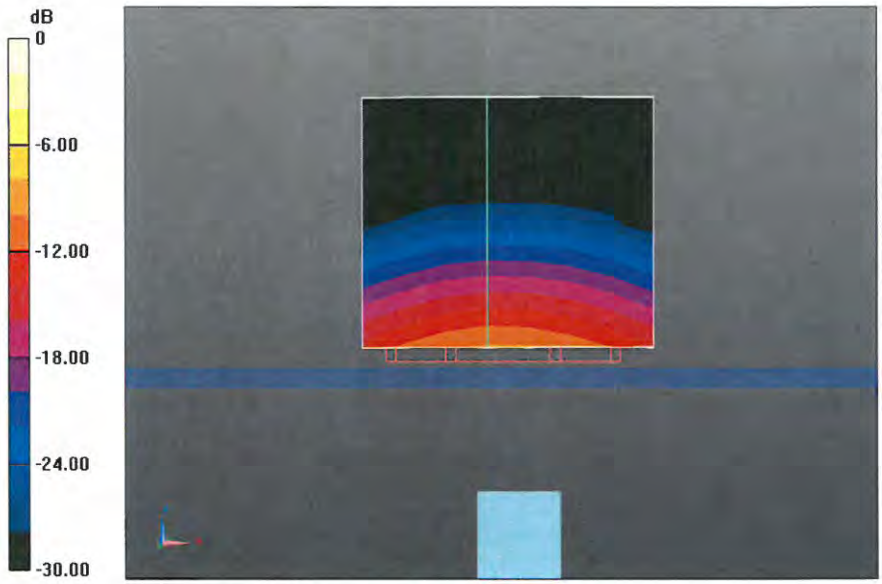
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.23 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 29.7 W/kg
SAR(1 g) = 8.15 W/kg; SAR(10 g) = 2.33 W/kg
Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.39 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 31.8 W/kg
SAR(1 g) = 8.47 W/kg; SAR(10 g) = 2.42 W/kg
Maximum value of SAR (measured) = 19.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.33 V/m; Power Drift = 0.08 dB
Peak SAR (extrapolated) = 34.0 W/kg
SAR(1 g) = 8.63 W/kg; SAR(10 g) = 2.44 W/kg
Maximum value of SAR (measured) = 20.7 W/kg

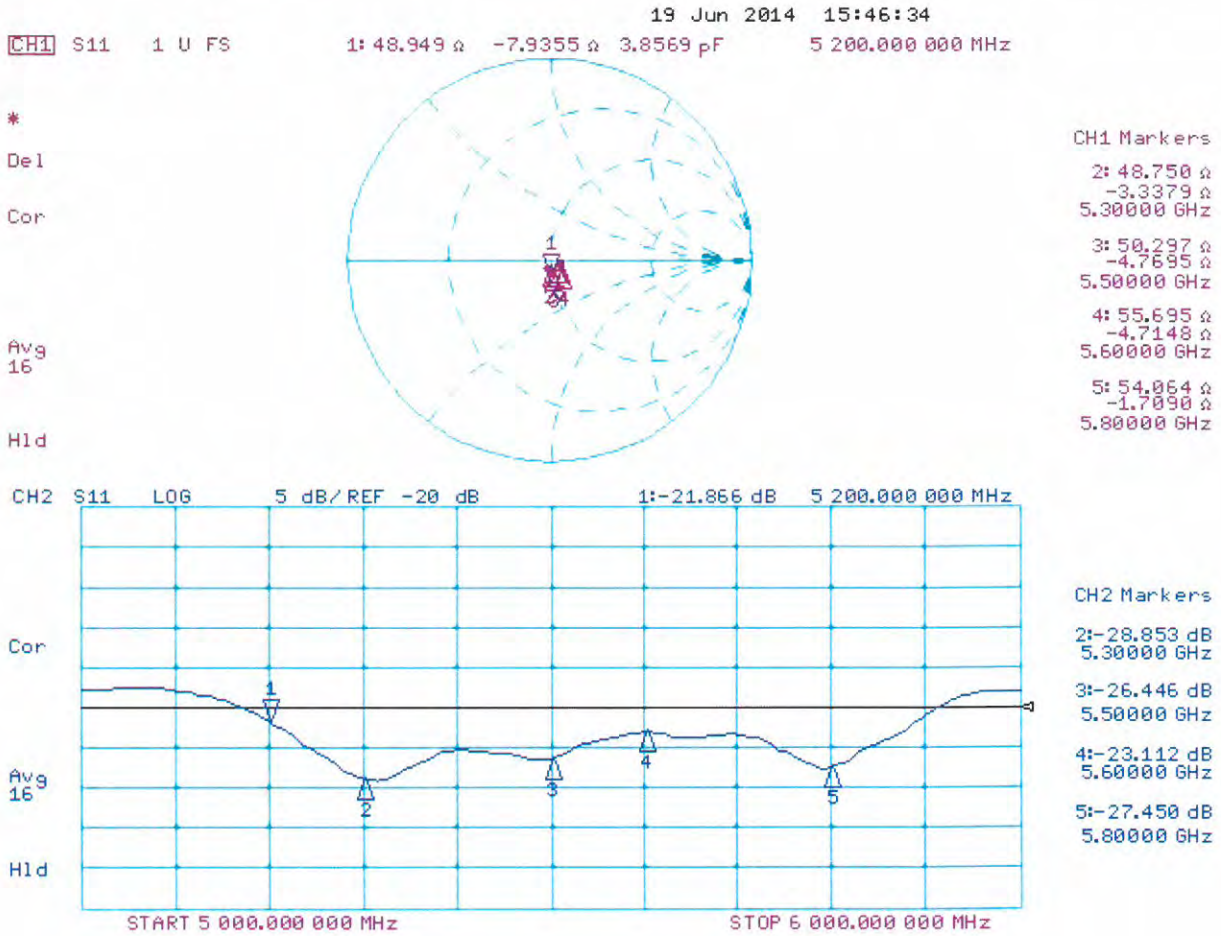
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 65.11 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 33.8 W/kg
SAR(1 g) = 8.52 W/kg; SAR(10 g) = 2.42 W/kg
Maximum value of SAR (measured) = 20.3 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 62.32 V/m; Power Drift = 0.05 dB
Peak SAR (extrapolated) = 33.7 W/kg
SAR(1 g) = 8.12 W/kg; SAR(10 g) = 2.3 W/kg
Maximum value of SAR (measured) = 19.7 W/kg



0 dB = 19.7 W/kg = 12.94 dBW/kg

Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 19.06.2014

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 5GHz; Type: D5GHzV2; Serial: D5GHzV2 - SN: 1040

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz, Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; σ = 5.35 S/m; ε_r = 47.4; ρ = 1000 kg/m^3 , Medium parameters used: f = 5300 MHz; σ = 5.48 S/m; ε_r = 47.2; ρ = 1000 kg/m^3 , Medium parameters used: f = 5500 MHz; σ = 5.72 S/m; ε_r = 46.9; ρ = 1000 kg/m^3 , Medium parameters used: f = 5600 MHz; σ = 5.86 S/m; ε_r = 46.7; ρ = 1000 kg/m^3 , Medium parameters used: f = 5800 MHz; σ = 6.13 S/m; ε_r = 46.4; ρ = 1000 kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.01, 5.01, 5.01); Calibrated: 30.12.2013, ConvF(4.76, 4.76, 4.76); Calibrated: 30.12.2013, ConvF(4.52, 4.52, 4.52); Calibrated: 30.12.2013, ConvF(4.3, 4.3, 4.3); Calibrated: 30.12.2013, ConvF(4.47, 4.47, 4.47); Calibrated: 30.12.2013;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 30.04.2014
- Phantom: Flat Phantom 5.0 (back); Type: QD000P50AA; Serial: 1002
- DASY52 52.8.8(1222); SEMCAD X 14.6.10(7331)

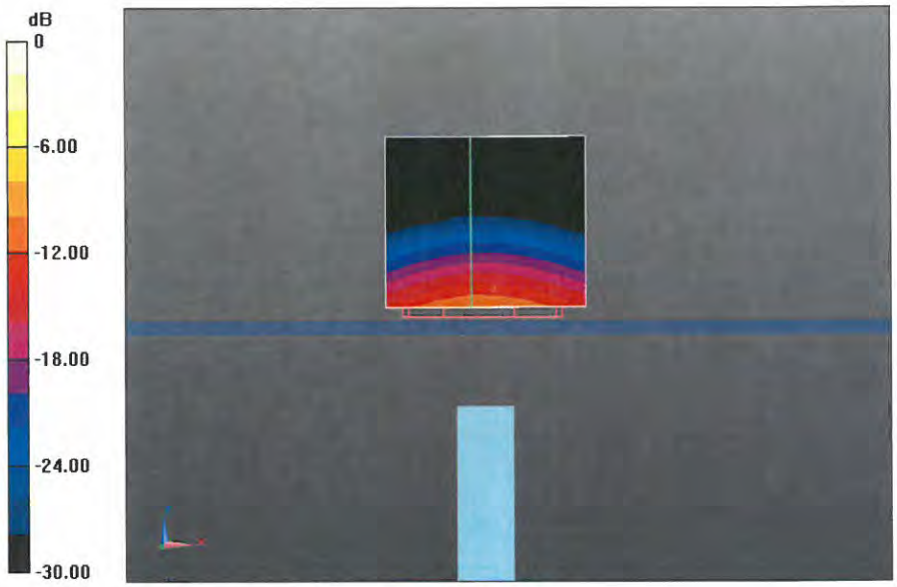
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 60.88 V/m; Power Drift = -0.00 dB
Peak SAR (extrapolated) = 30.6 W/kg
SAR(1 g) = 7.83 W/kg; SAR(10 g) = 2.19 W/kg
Maximum value of SAR (measured) = 18.5 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 60.56 V/m; Power Drift = 0.03 dB
Peak SAR (extrapolated) = 32.0 W/kg
SAR(1 g) = 7.96 W/kg; SAR(10 g) = 2.22 W/kg
Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 61.02 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 35.5 W/kg
SAR(1 g) = 8.31 W/kg; SAR(10 g) = 2.3 W/kg
Maximum value of SAR (measured) = 20.3 W/kg

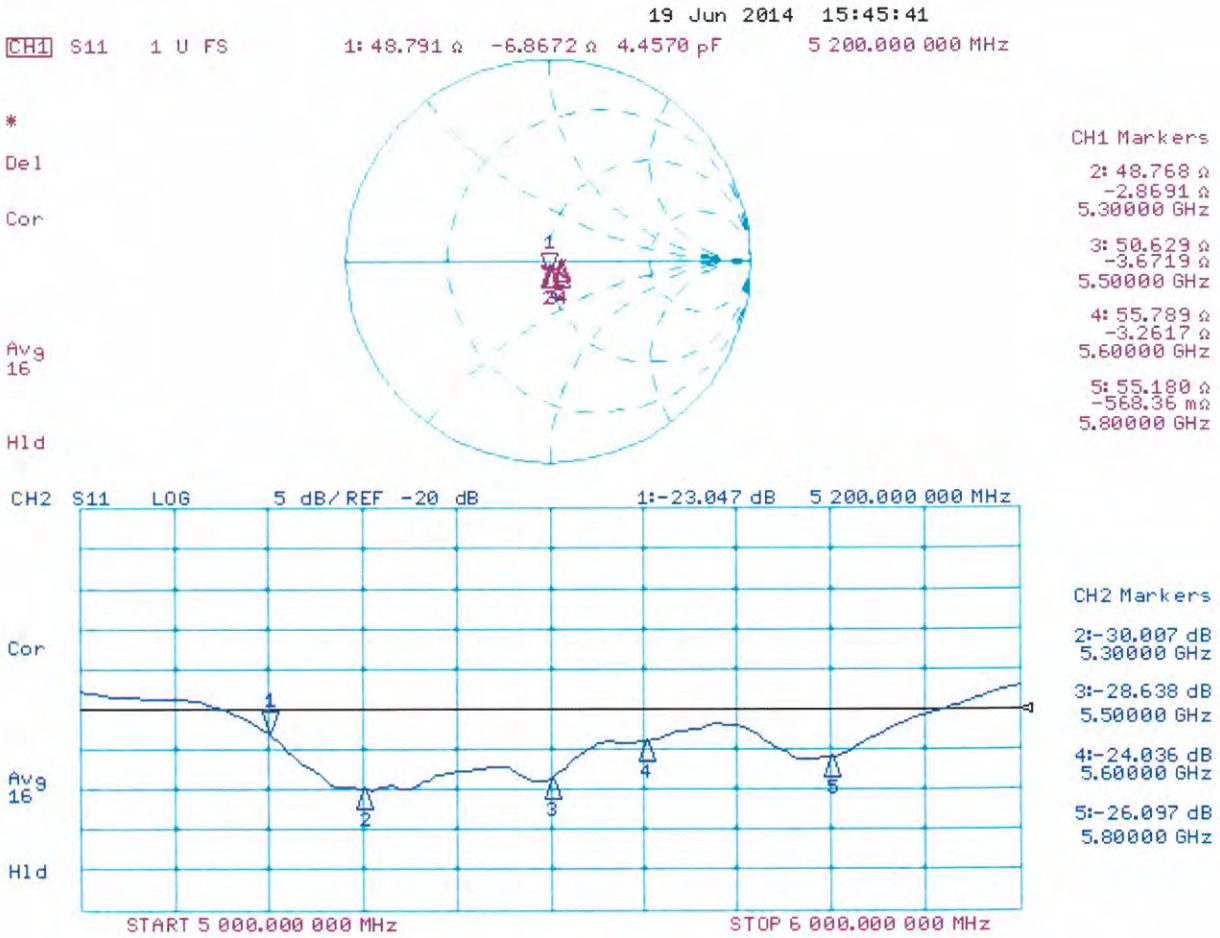
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 60.24 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 36.4 W/kg
SAR(1 g) = 8.33 W/kg; SAR(10 g) = 2.31 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 57.11 V/m; Power Drift = 0.01 dB
Peak SAR (extrapolated) = 36.0 W/kg
SAR(1 g) = 7.78 W/kg; SAR(10 g) = 2.15 W/kg
Maximum value of SAR (measured) = 19.5 W/kg



0 dB = 19.5 W/kg = 12.90 dBW/kg

Impedance Measurement Plot for Body TSL



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校 准
CNAS L0442

Client **Auden** **Certificate No: Z14-97002**

CALIBRATION CERTIFICATE

Object	EX3DV4 - SN:3661
Calibration Procedure(s)	TMC-OS-E-02-195 Calibration Procedures for Dosimetric E-field Probes
Calibration date:	March 10, 2014

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	101919	01-Jul-13 (TMC, No.JW13-044)	Jun-14
Power sensor NRP-Z91	101547	01-Jul-13 (TMC, No.JW13-044)	Jun-14
Power sensor NRP-Z91	101548	01-Jul-13 (TMC, No.JW13-044)	Jun-14
Reference10dBAttenuator	BT0520	12-Dec-12(TMC,No.JZ12-867)	Dec-14
Reference20dBAttenuator	BT0267	12-Dec-12(TMC,No.JZ12-866)	Dec-14
Reference Probe EX3DV4	SN 3846	03-Sep-13(SPEAG,No.EX3-3846_Sep13)	Sep-14
DAE4	SN 777	22-Feb-13 (SPEAG, DAE4-777_Feb13)	Feb -14
DAE4	SN 905	11-Jun-13 (SPEAG, DAE4-905_Jun13)	Jun -14
Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	01-Jul-13 (TMC, No.JW13-045)	Jun-14
Network Analyzer E5071C	MY46110673	15-Feb-14 (TMC, No.JZ14-781)	Feb-15

	Name	Function	Signature
Calibrated by:	Yu Zongying	SAR Test Engineer	
Reviewed by:	Qi Dianyuan	SAR Project Leader	
Approved by:	Lu Bingsong	Deputy Director of the laboratory	

Issued: March 12, 2014

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

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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), 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 300MHz to 3GHz)", February 2005

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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Probe EX3DV4

SN: 3661

Calibrated: March 10, 2014

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)

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DASY – Parameters of Probe: EX3DV4 - SN: 3661

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm(μV/(V/m)^2)[A]	0.45	0.49	0.47	±10.8%
DCP(mV)[B]	102.2	100.3	100.2	

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	198.0	±2.0%
		Y	0.0	0.0	1.0		204.8	
		Z	0.0	0.0	1.0		200.9	

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 5 and Page 6).
[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 – Parameters of Probe: EX3DV4 - SN: 3661

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	10.13	10.13	10.13	2.70	0.45	±12%
850	41.5	0.92	9.50	9.50	9.50	0.08	1.39	±12%
900	41.5	0.97	9.73	9.73	9.73	0.09	1.72	±12%
1750	40.1	1.37	8.29	8.29	8.29	0.18	1.38	±12%
1900	40.0	1.40	8.18	8.18	8.18	0.17	1.50	±12%
2000	40.0	1.40	8.21	8.21	8.21	0.14	1.68	±12%
2450	39.2	1.80	7.59	7.59	7.59	0.60	0.67	±12%
2600	39.0	1.96	7.38	7.38	7.38	0.58	0.67	±12%
5200	36.0	4.66	5.43	5.43	5.43	0.35	1.51	±13%
5300	35.9	4.76	5.27	5.27	5.27	0.37	1.07	±13%
5500	35.6	4.96	4.90	4.90	4.90	0.39	1.27	±13%
5600	35.5	5.07	4.67	4.67	4.67	0.43	1.26	±13%
5800	35.3	5.27	4.81	4.81	4.81	0.47	1.22	±13%

[C] Frequency validity 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.
[F] At frequency 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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DASY – Parameters of Probe: EX3DV4 - SN: 3661

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)	Unct. (k=2)
750	55.5	0.96	9.92	9.92	9.92	0.93	0.64	±12%
850	55.2	0.99	9.45	9.45	9.45	0.20	1.21	±12%
900	55.0	1.05	9.38	9.38	9.38	0.26	1.06	±12%
1750	53.4	1.49	8.06	8.06	8.06	0.13	1.83	±12%
1900	53.3	1.52	7.75	7.75	7.75	0.16	1.86	±12%
2000	53.3	1.52	8.01	8.01	8.01	0.15	2.85	±12%
2450	52.7	1.95	7.47	7.47	7.47	0.45	0.83	±12%
2600	52.5	2.16	7.15	7.15	7.15	0.66	0.66	±12%
5200	49.0	5.30	4.77	4.77	4.77	0.41	1.44	±13%
5300	48.9	5.42	4.52	4.52	4.52	0.43	1.59	±13%
5500	48.6	5.65	4.28	4.28	4.28	0.44	1.57	±13%
5600	48.5	5.77	4.21	4.21	4.21	0.45	1.57	±13%
5800	48.2	6.00	4.30	4.30	4.30	0.47	1.69	±13%

[C] Frequency validity 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.
[F] At frequency 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 the frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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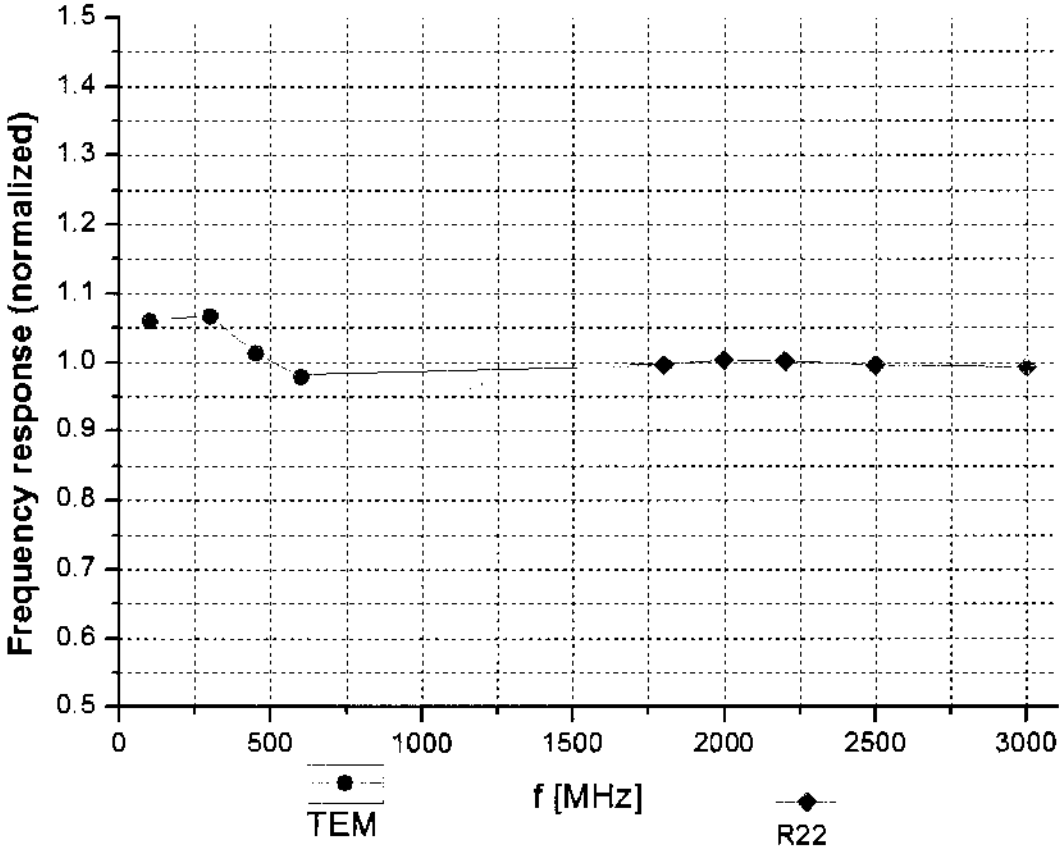
Frequency Response of E-Field
(TEM-Cell: ifi110 EXX, Waveguide: R22)



Uncertainty of Frequency Response of E-field: ±7.5% (k=2)

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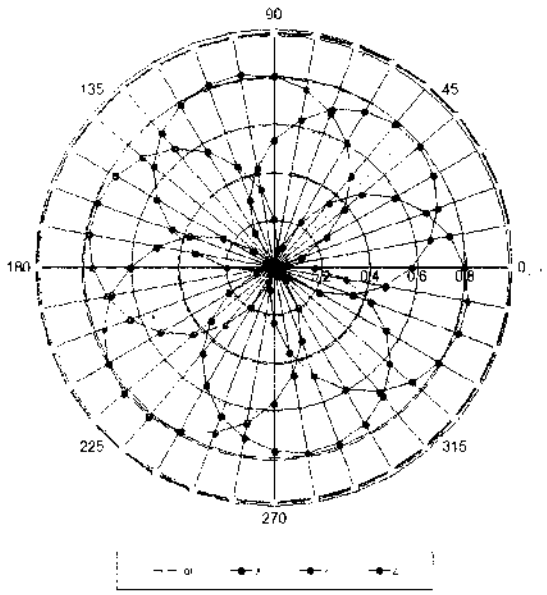
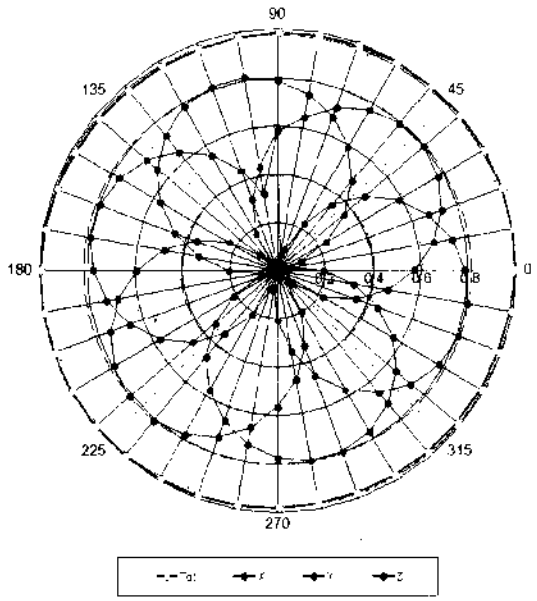
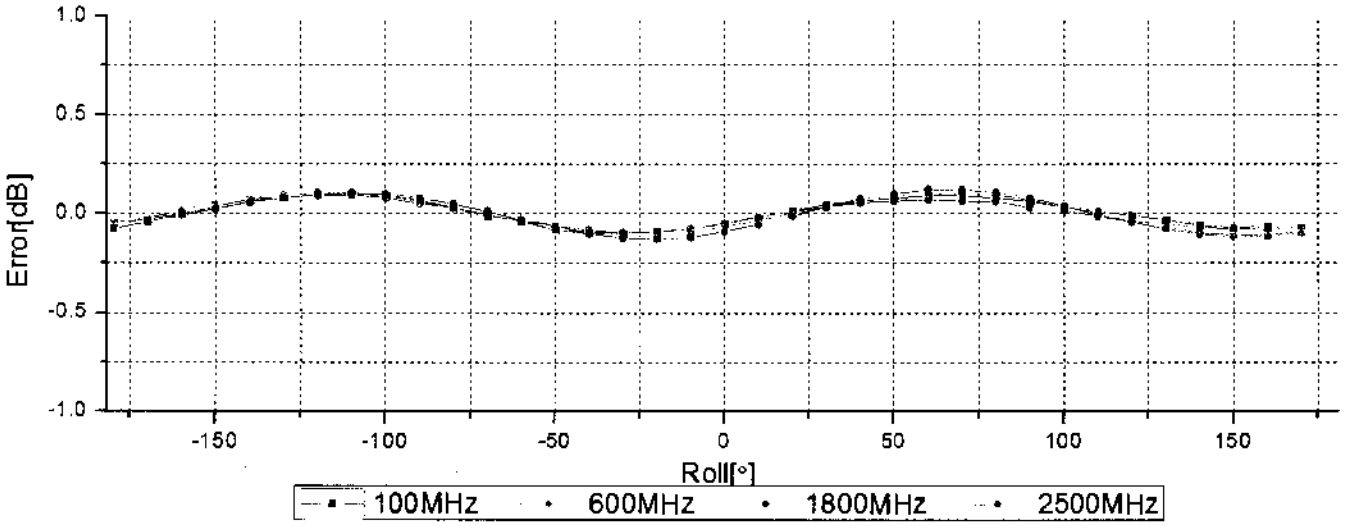
Receiving Pattern (Φ), θ=0°

f=600 MHz, TEM



f=1800 MHz, R22





Uncertainty of Axial Isotropy Assessment: ±0.9% (k=2)

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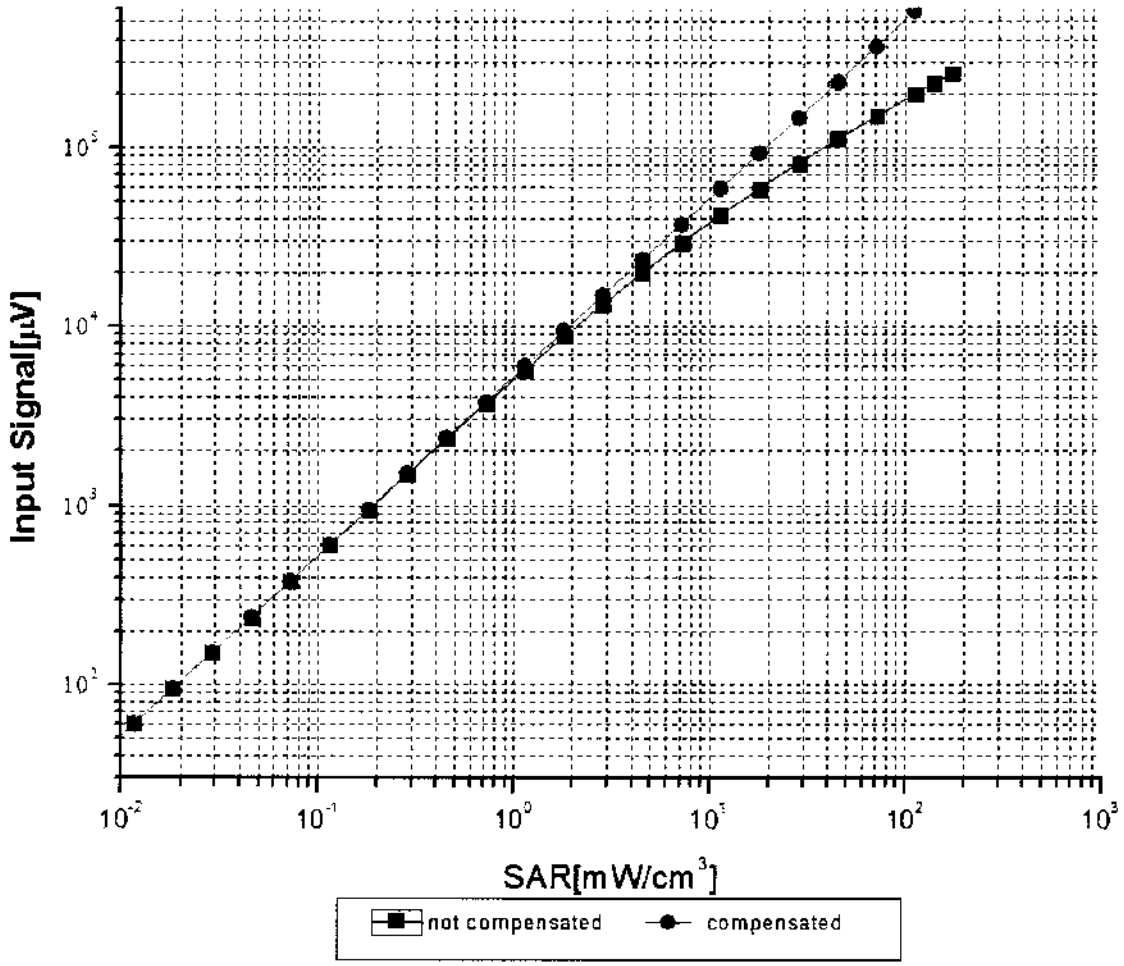
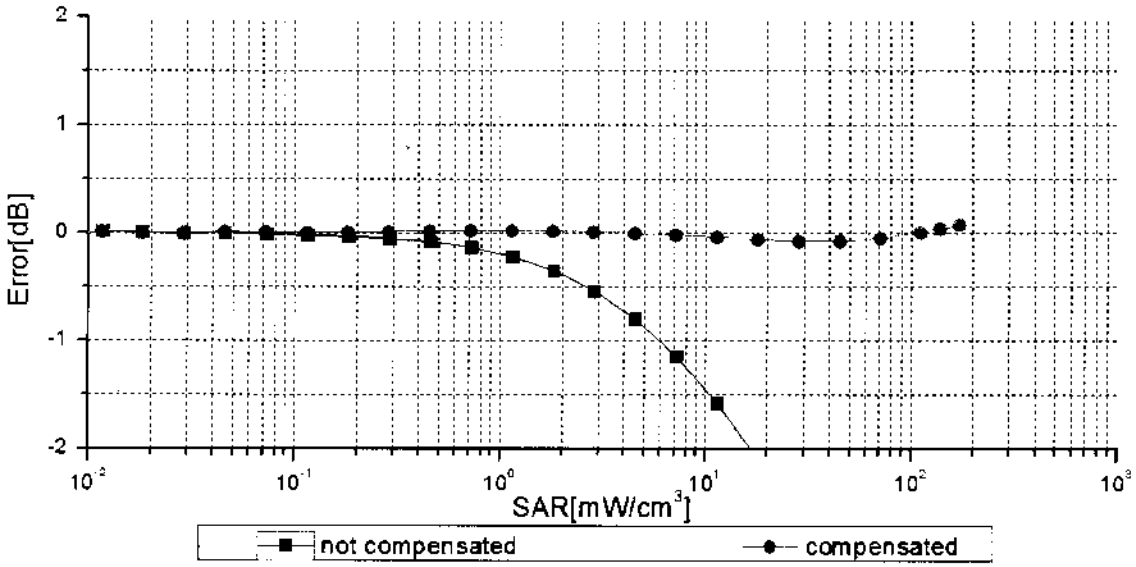
Dynamic Range f(SAR_{head})
(TEM cell, f = 900 MHz)





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

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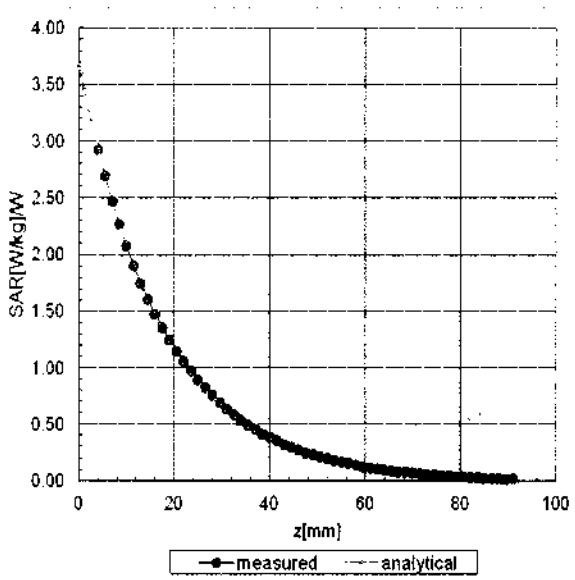
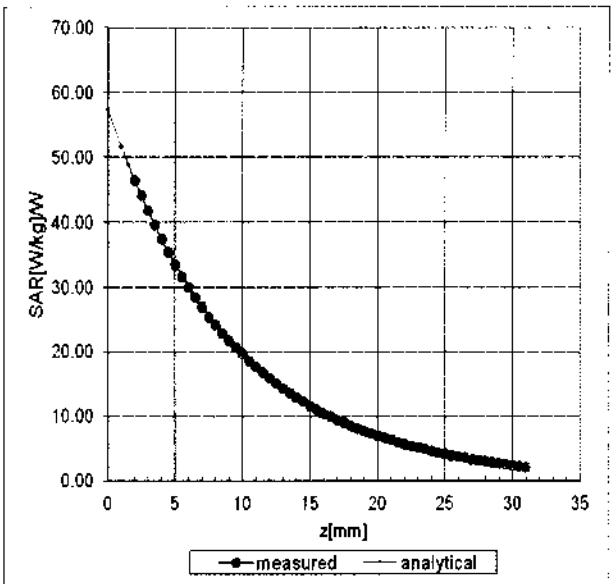
Conversion Factor Assessment

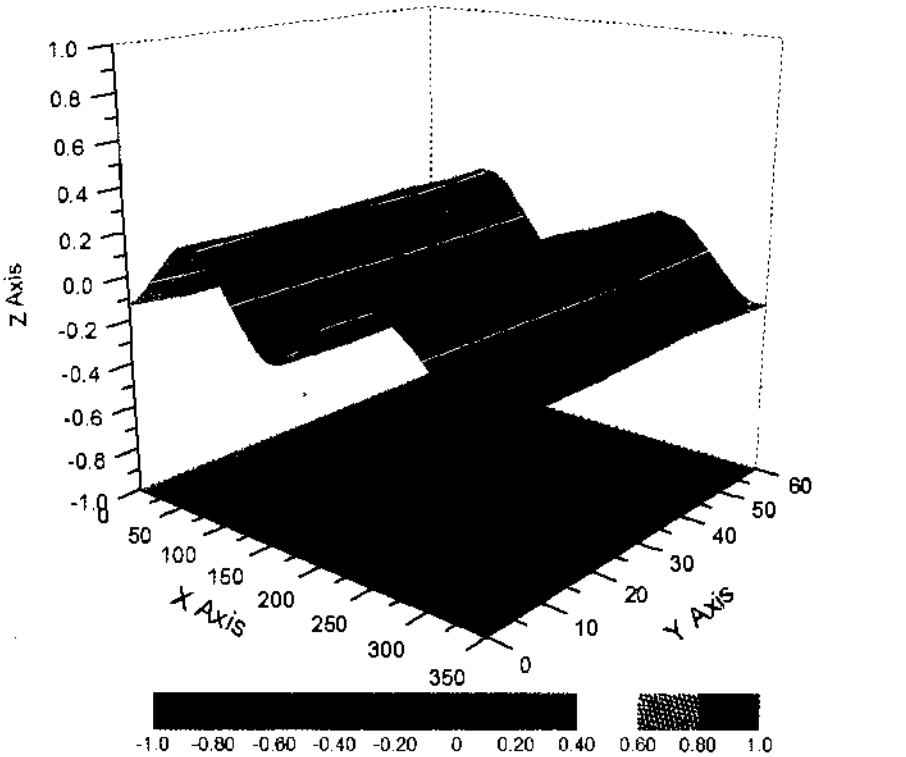
f=900 MHz, WGLS R9(H_convF)



f=2450 MHz, WGLS R26(H_convF)



Deviation from Isotropy in Liquid



Uncertainty of Spherical Isotropy Assessment: ±2.8% (K=2)

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DASY - Parameters of Probe: EX3DV4 - SN: 3661

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	18.4
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	2mm