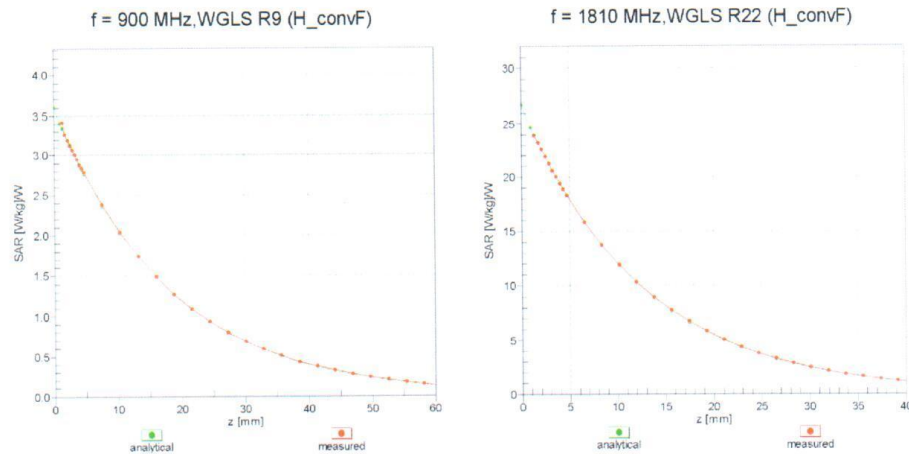


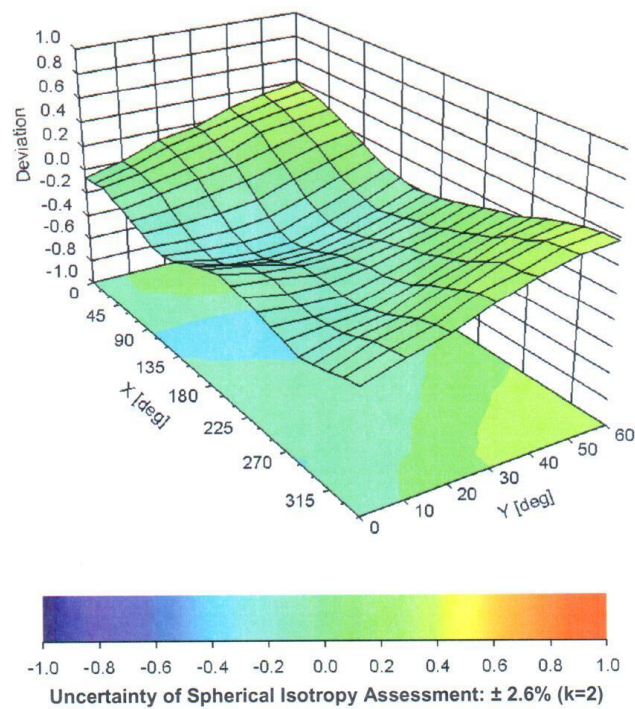
EX3DV4- SN:3617

August 28, 2014

Conversion Factor Assessment



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





EX3DV4- SN:3617

August 28, 2014

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

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-138.3
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

Probe ES3DV3-SN:3151 Calibration Certificate



In Collaboration with



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CALIBRATION
No. L0570

Client **CTTL(South Branch)**
Certificate No: **Z14-97077**

CALIBRATION CERTIFICATE

Object: **ES3DV3 - SN:3151**

Calibration Procedure(s): **TMC-OS-E-02-195
Calibration Procedures for Dosimetric E-field Probes**

Calibration date: **September 01, 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)°C 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-14 (CTTL, No.J14X02146)	Jun-15
Power sensor NRP-Z91	101547	01-Jul-14 (CTTL, No.J14X02146)	Jun-15
Power sensor NRP-Z91	101548	01-Jul-14 (CTTL, No.J14X02146)	Jun-15
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 1331	23-Jan-14 (SPEAG, DAE4-1331_Jan14)	Jan -15

Secondary Standards	ID #	Cal Date(Calibrated by, Certificate No.)	Scheduled Calibration
SignalGeneratorMG3700A	6201052605	01-Jul-14 (CTTL, No.J14X02145)	Jun-15
Network Analyzer E5071C	MY46110673	15-Feb-14 (TMC, No.JZ14-781)	Feb-15

Calibrated by: **Yu Zongying**

Reviewed by: **Qi Dianyuan**

Approved by: **Lu Bingsong**

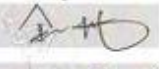
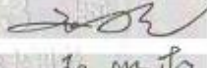
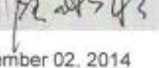
Name: Yu Zongying

Function: SAR Test Engineer

SAR Project Leader

Deputy Director of the laboratory

Signature

Issued: September 02, 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
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A,B,C,D	modulation dependent linearization parameters
Polarization Φ	Φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i $\theta=0$ is normal to probe axis

Connector Angle Information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- IEC 62209-1, "Procedure to measure the Specific Absorption Rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300MHz to 3GHz)", February 2005

Methods Applied and Interpretation of Parameters:

- NORM_{x,y,z}:** Assessed for E-field polarization $\theta=0$ (fs900MHz in TEM-cell; $f>1800$ MHz: waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not effect the E^2 -field uncertainty inside TSL (see below ConvF).
- NORM(f)_{x,y,z} = NORM_{x,y,z}* frequency_response** (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- 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 fs800MHz) 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 valued are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z}* ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- Spherical isotropy (3D deviation from isotropy):** in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- Sensor Offset:** The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- Connector Angle:** The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).



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Probe ES3DV3

SN: 3151

Calibrated: September 01, 2014

Calibrated for DASY/EASY Systems

(Note: non-compatible with DASY2 system!)



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DASY – Parameters of Probe: ES3DV3 - SN: 3151

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	1.11	1.20	1.14	±10.8%
DCP(mV) ^B	103.4	103.3	102.9	

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	264.1	±2.3%
		Y	0.0	0.0	1.0		275.7	
		Z	0.0	0.0	1.0		268.7	

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 E²-field uncertainty inside TSL (see Page 5 and Page 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 – Parameters of Probe: ES3DV3 - SN: 3151

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)
850	41.5	0.92	6.04	6.04	6.04	0.41	1.49	± 12%
900	41.5	0.97	6.17	6.17	6.17	0.38	1.55	± 12%
1810	40.0	1.40	5.44	5.44	5.44	0.57	1.49	± 12%
1900	40.0	1.40	5.16	5.16	5.16	0.74	1.25	± 12%
2000	40.0	1.40	5.23	5.23	5.23	0.50	1.57	± 12%
2100	39.8	1.49	5.25	5.25	5.25	0.74	1.24	± 12%
2300	39.5	1.67	4.91	4.91	4.91	0.73	1.21	± 12%
2450	39.2	1.80	4.71	4.71	4.71	0.82	1.16	± 12%
2600	39.0	1.96	4.57	4.57	4.57	0.89	1.14	± 12%

^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: ES3DV3 - SN: 3151

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)
850	55.2	0.99	6.14	6.14	6.14	0.34	1.78	± 12%
900	55.0	1.05	6.08	6.08	6.08	0.51	1.43	± 12%
1810	53.3	1.52	5.03	5.03	5.03	0.52	1.54	± 12%
1900	53.3	1.52	4.77	4.77	4.77	0.48	1.66	± 12%
2000	53.3	1.52	5.00	5.00	5.00	0.68	1.33	± 12%
2100	53.2	1.62	5.04	5.04	5.04	0.73	1.32	± 12%
2300	52.9	1.81	4.56	4.56	4.56	0.58	1.57	± 12%
2450	52.7	1.95	4.42	4.42	4.42	0.67	1.39	± 12%
2600	52.5	2.16	4.26	4.26	4.26	0.69	1.37	± 12%

^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.

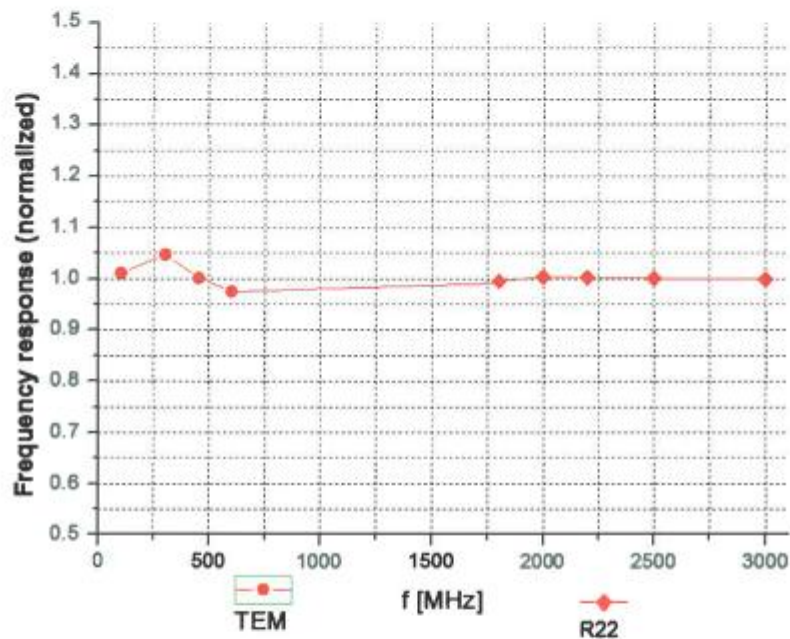
^F At frequency below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ±10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ±5%. The uncertainty is the RSS of the ConvF uncertainty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



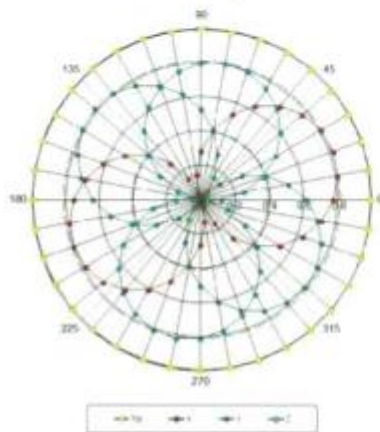
Uncertainty of Frequency Response of E-field: $\pm 7.5\%$ ($k=2$)



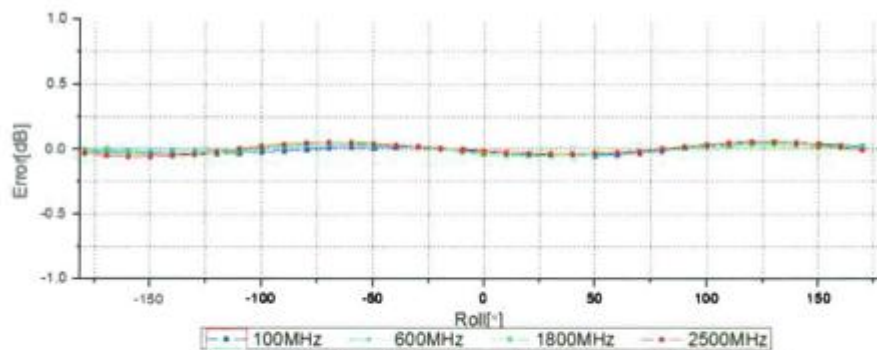
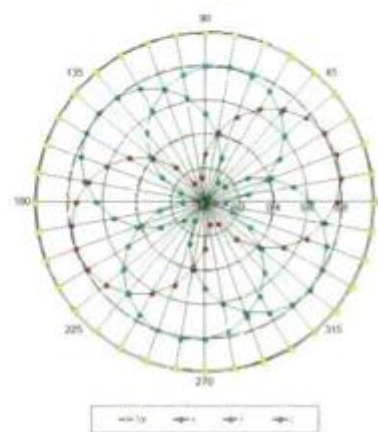
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Receiving Pattern (Φ), $\theta=0^\circ$

f=600 MHz, TEM



f=1800 MHz, R22

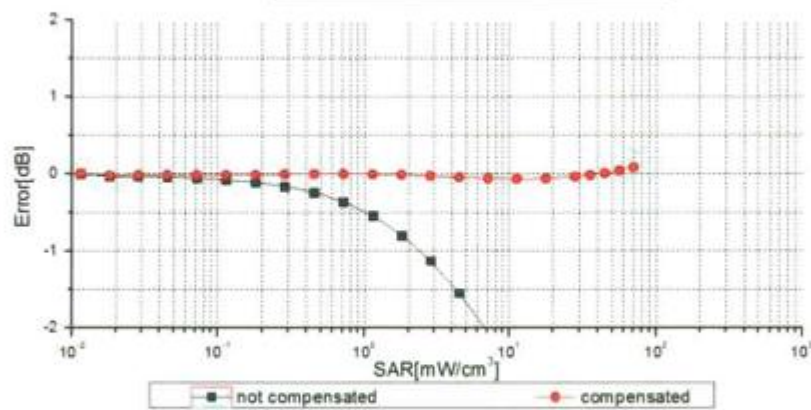
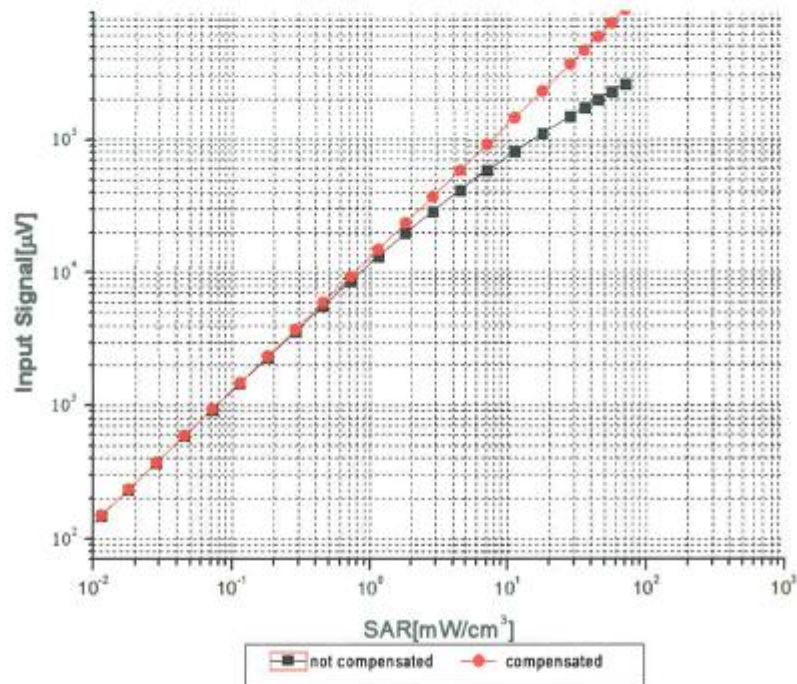


Uncertainty of Axial Isotropy Assessment: $\pm 0.9\%$ (k=2)



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



Uncertainty of Linearity Assessment: $\pm 0.9\%$ ($k=2$)

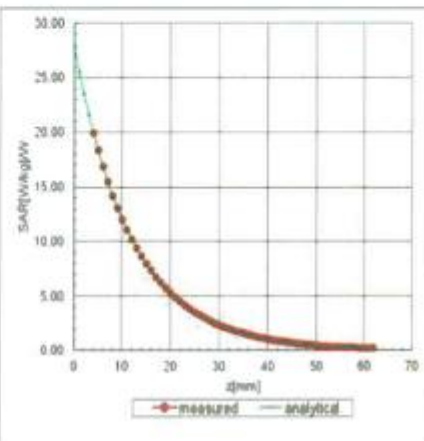
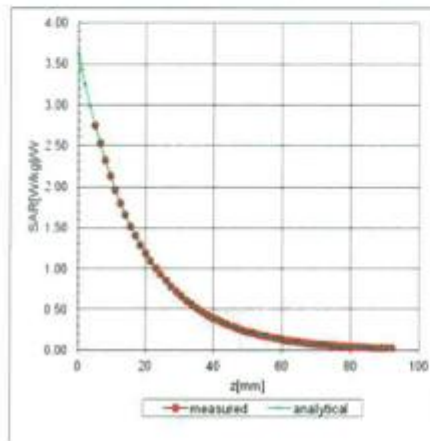


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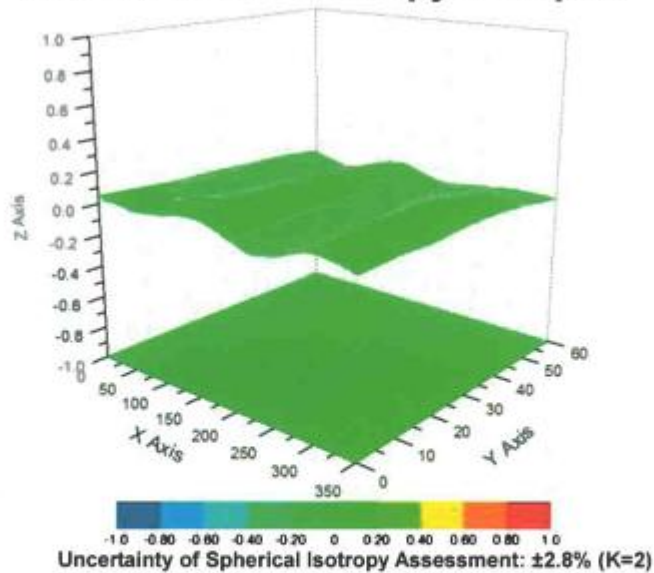
Conversion Factor Assessment

f=900 MHz, WGLS R9(H_convF)

f=1810 MHz, WGLS R22(H_convF)



Deviation from Isotropy in Liquid





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DASY - Parameters of Probe: ES3DV3 - SN: 3151

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	85.2
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disable
Probe Overall Length	337mm
Probe Body Diameter	10mm
Tip Length	10mm
Tip Diameter	4mm
Probe Tip to Sensor X Calibration Point	2mm
Probe Tip to Sensor Y Calibration Point	2mm
Probe Tip to Sensor Z Calibration Point	2mm
Recommended Measurement Distance from Surface	3mm