APPENDIX E - DIPOLE CALIBRATION (FCC KDB 250418) & PROBE CALIBRATION

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OET

Office of Engineering and Technology

Inquiry:
Uploading 300 MHz and 450 MHz Dipole Calibration Reports

Response:
FCC confirmation attached for Celltech Labs Dipoles with following identifications:

Serial #: 136 / 450 MHz / Head Tissue-Equivalent Medium / Expires 02/28/2010
Serial #: 135 / 300 MHz / Head Tissue-Equivalent Medium / Expires 02/28/2010

A copy of the confirmation and corresponding Dipole Report(s) are required to be included in SAR reports of applicable equipment certification filings. Each filing must have KDB tracking number 250418 included on 731 Form.

OET

The dipoles listed below have prior coordination with the FCC Lab for use in SAR system validation and verification by Celltech Labs through February 2010. The SAR target values, specific operating parameters and identifications are indicated below. SAR measurements using these dipoles must be in accordance with the parameters specified below; for example, phantom shell and tissue dielectric requirements etc. These will be verified during each equipment certification by the FCC or TCB, according to measurement protocols required for testing the specific device and wireless technology, to support the test methodologies and measurement results.

This confirmation and copies of the dipole calibration reports are required to be included in SAR reports for equipment certification containing SAR system verification results involving these dipoles. The information is available and can be verified through the KDB inquiry tracking number provided to Celltech Labs. The same tracking number must also be included on the 731 Form of the corresponding equipment certifications.

Dipole Serial Number	136	135
Calibration Document No.	DC450H-021209-R1.2	DC300H-021209-R1.2
Frequency	450 MHz	300 MHz
Dipole Impedance	58.21 + j 5.69 Ohms	46.39 + j 6.25 Ohms
Dipole Return Loss	-20.7 dB	- 22.6 dB
Tissue-Equivalent Dielectric Type	Head	
Tissue Dielectric Constant	43.5	45.3
Tissue Conductivity	0.87 S/m	0.87 S/m
Phantom Shell Thickness	6.0 mm Plexiglas	
Phantom Shell Dielectric Constant	2.7	
Dipole Axis to Tissue Medium Separation Distance	15.175 mm	
Numerical Simulation:	FDTD	
1-g SAR Target Value	4.893 W/kg @ 1.0 W	3.019 W/kg @ 1.0 W
10-g SAR Target Value	3.263 W/kg @ 1.0 W	2.051 W/kg @ 1.0 W
SAR at Phantom Surface above Dipole Feed-Point	6.845 W/kg @ 1.0 W	4.046 W/kg @ 1.0 W
SAR at Phantom Surface at 2.0 cm offset from Dipole Feed-Point	3.101 W/kg @ 1.0 W	2.049 W/kg @ 1.0 W
Experimental Verification:	SAR Measurements	
1-g SAR Target Value	1.21 ~ 1.23 W/kg @ 0.25 W	0.753 ~ 0.765 W/kg @ 0.25 W
10-g SAR Target Value	0.787 ~ 0.803 W/kg @ 0.25W	0.503 ~ 0.509 W/kg @ 0.25 W
SAR at Phantom Surface above Dipole Feed-Point	1.93 W/kg (average) @ 0.25 W	1.20 W/kg (average) @ 0.25 W
SAR at Phantom Surface at 2.0 cm offset from Dipole Feed-Point	0.79 W/kg @ 0.25 W	0.56 W/kg @ 0.25 W

Expires February 2010 Celltech Labs Inc. February 13, 2009

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300 MHz Dipole Calibration

Type:	**300 MHz Validation Dipole**
Asset Number:	**00023**
Serial Number:	**135**
Place of Calibration:	**Celltech Labs Inc.**
Date of Calibration:	**Jan. 26 & Feb. 09, 2009**

Celltech Labs Inc. certifies that the 300 MHz Dipole Calibration was performed on the date(s) indicated above.

Validated by:	**Sean Johnston**
Signature:	

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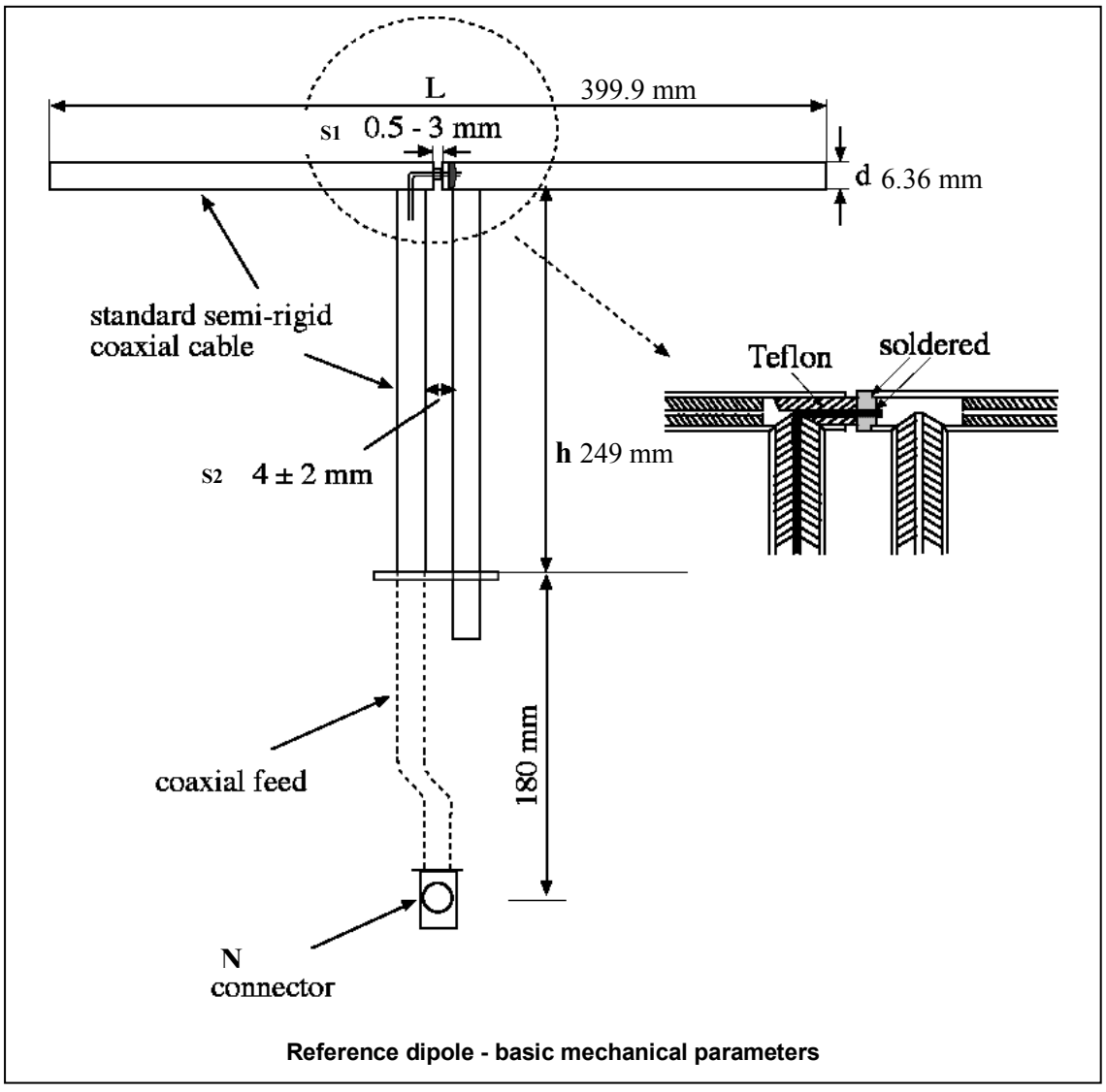
1. Dipole Construction & Electrical Characteristics

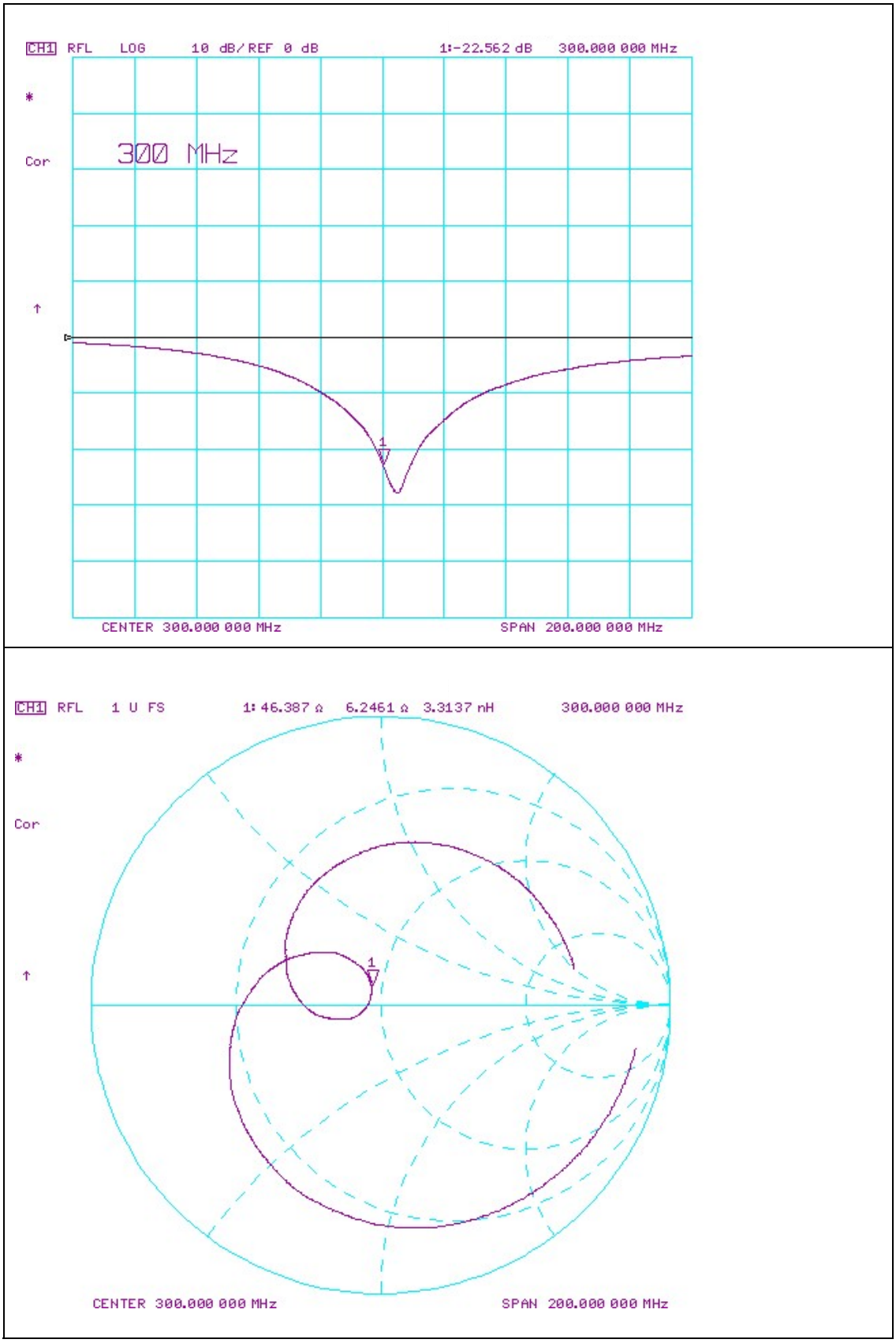
The validation dipole was constructed in accordance with the requirements specified in IEEE Standard 1528-2003 and International Standard IEC 62209-1:2005. The electrical properties were measured using an HP 8753ET Network Analyzer. The network analyzer was calibrated to the validation dipole N-type connector feed point using an HP85032E Type N calibration kit. The dipole was placed parallel to a planar phantom at a separation distance of 15.1mm from the simulating fluid using a loss-less dielectric spacer. The measured input impedance is:

Feed point impedance at 300 MHz	Re{Z} = 46.387Ω
	Im{Z} = 6.2461Ω
Return Loss at 300 MHz	-22.562dB



Reference dipole - basic mechanical parameters

2. Validation Dipole VSWR Data



3. Validation Dipole Dimensions

Dimension	IEEE 1528 (mm)	Measured (mm)	Difference (mm)	Tolerance (1528 1%)
L (mm)	396.0	399.9	+3.9	+0.98%
h (mm)	250.0	249.0	-1.0	-0.4%
d (mm)	6.35	6.36	+0.01	+0.2%

The L, h and d dimensions should be within ±1% tolerance per 1528-2003.

4. Validation Phantom

The validation phantom (planar) was constructed using relatively low-loss tangent Plexiglas material. The dielectric constant used for the numerical analysis was 2.7. The typical range of 2.5 - 3 was selected and the mean of this value used.

The inner dimensions of the validation phantom are as follows:

Length: 83.5 cm
Width: 36.9 cm
Height: 21.8 cm

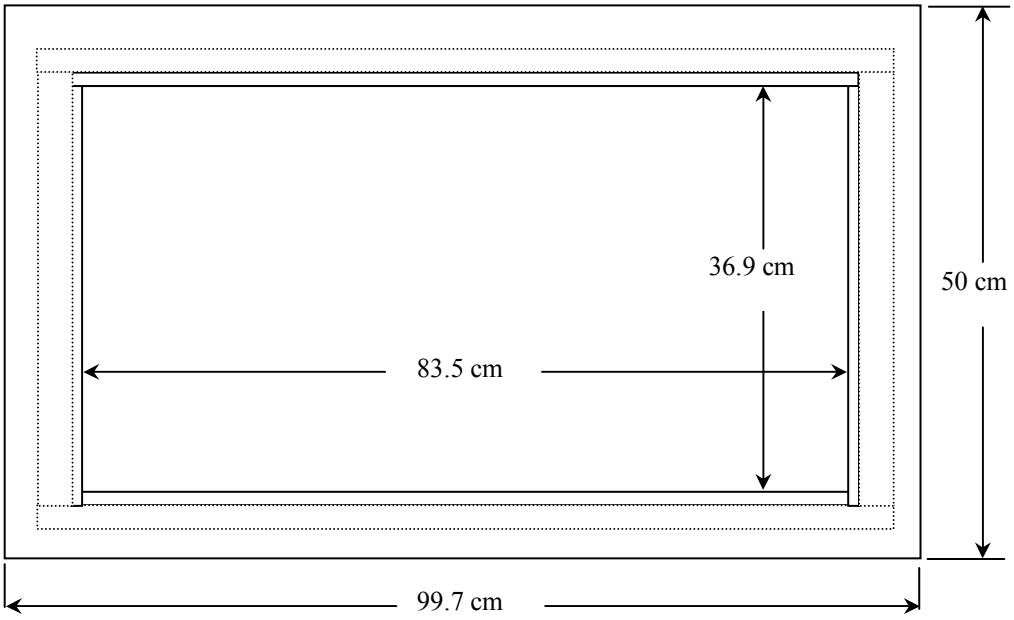
The bottom section of the validation phantom is constructed of 6.0 ± 0.1mm Plexiglas.

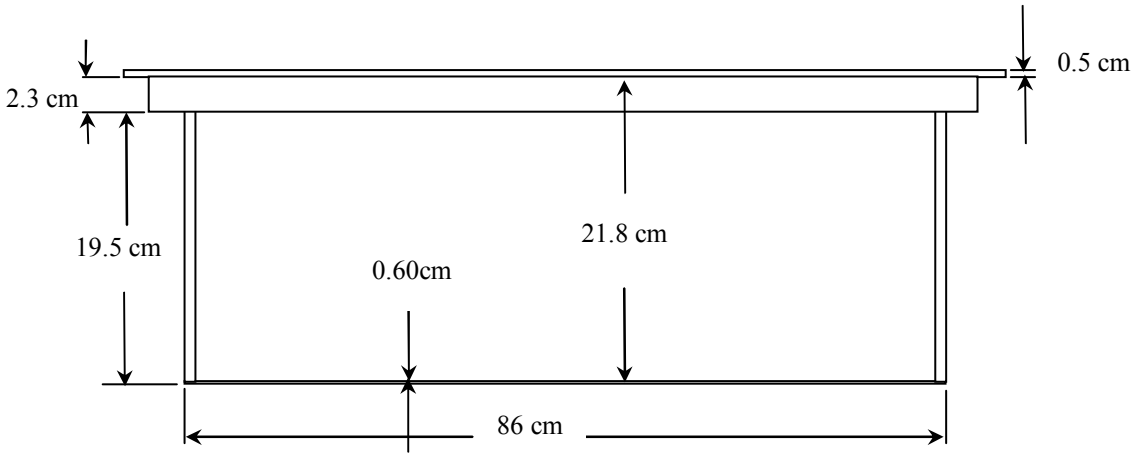
s = 3.175mm(d/2) + 6.0mm(phantom) + 6.0mm(spacer) = 15.175mm

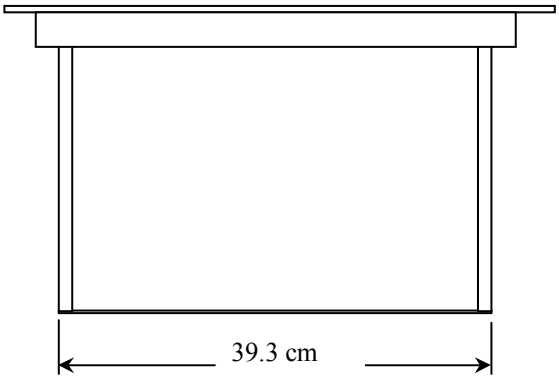
5. Test Equipment List

TEST EQUIPMENT	ASSET NO.	SERIAL NO.	DATE OF CAL.	CAL. DUE DATE
SPEAG DASY4 Measurement Server	00158	1078	CNR	CNR
SPEAG Robot	00046	599396-01	CNR	CNR
SPEAG DAE4	00019	353	22Apr08	22Apr09
SPEAG ET3DV6 E-Field Probe	00017	1590	21Jul08	21Jul09
Plexiglas Validation Planar Phantom	00157	137	CNR	CNR
HP 85070C Dielectric Probe Kit	00033	US39240170	CNR	CNR
Gigatronics 8652A Power Meter	00007	1835272	23Apr08	23Apr09
Gigatronics 80701A Power Sensor	00014	1833699	23Apr08	23Apr09
HP 8753ET Network Analyzer	00134	US39170292	28Apr08	28Apr09
HP 8648D Signal Generator	00005	3847A00611	CNR	CNR
Amplifier Research 10W1000C Power Amplifier	00041	27887	CNR	CNR
CNR = Calibration Not Required				

6. Dimensions of Plexiglas Planar Phantom







7. Plexiglas Planar Validation Phantom

8. 300 MHz Validation Dipole

9. SAR Target Validation

Parameter															Result			
	Frequency (MHz)	Shell thickness (mm)	Shell permittivity	Shell permeability	Shell Conductivity (σ) (S/m)	Phantom dimensions (mm) [x, y, z]	Liquid Relative permittivity	Liquid Conductivity (σ) (S/m)	Liquid permeability	Reference dipole distances from the liquid (mm)	Spacer (mm)	Dipole L (mm)	Dipole h (mm)	Dipole d (mm)	Distance between dipole feedpoint gap S1 (mm)	Distance between dipole balun elements S2 (mm)	1 g SAR (1 Watt)	10 g SAR (1 Watt)	Local SAR at surface (above feed-point)	Local SAR at surface (y = 2 cm offset from feed-point)
SEMCAD Simulation	300	6	2.7	1	0	1000, 800, 170	45.3	0.87	1	15.175	6	396	250	6.35	1	4	3.019	2.051	4.046	2.049

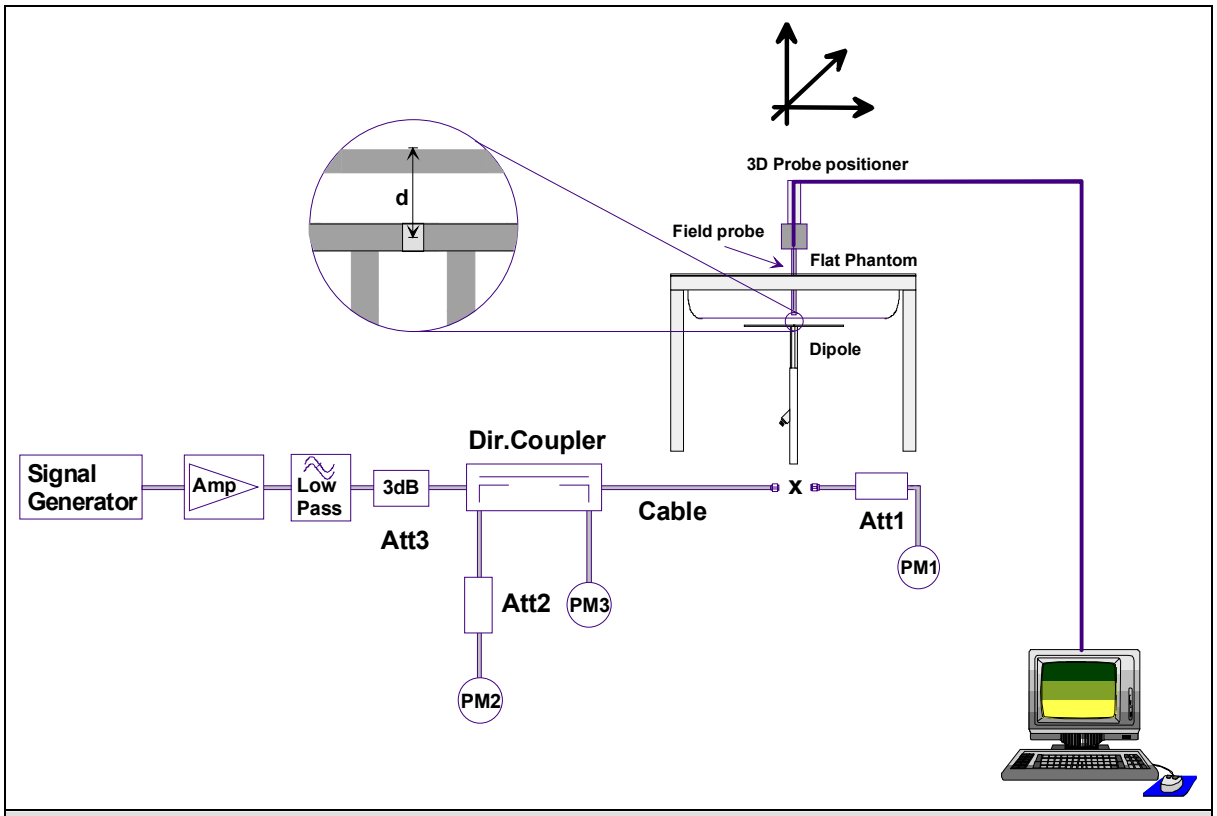
CELLTECH TARGET		
0.755 W/kg	1g	0.25 W
0.513 W/kg	10g	0.25 W

1. Standard dipole dimensions used in simulation per 1528-2003 mechanical dimensions of the reference dipole.
2. Reference distance from liquid is actual measured distance.

10. SAR Measurement

Measurements were made using a dosimetric E-field probe ET3DV6 (S/N: 1590, Conversion Factor 8.0). The SAR measurement was performed with the E-field probe in mechanical detection mode only. The setup and determination of the forward power into the dipole was performed using the procedures described below.

First the power meter PM1 (including attenuator Att1) is connected to the cable to measure the forward power at the location of the dipole connector (X). The signal generator is adjusted for the desired forward power at the dipole connector (taking into account the attenuation of Att1) as read by power meter PM2. After connecting the cable to the dipole, the signal generator is readjusted for the same reading at power meter PM2. If the signal generator does not allow adjustment in 0.01dB steps, the remaining difference at PM2 must be taken into consideration. PM3 records the reflected power from the dipole to ensure that the value is not changed from the previous value. The reflected power should be 20dB below the forward power.



System Performance Check Measurement Setup Diagram

11. Measurement Conditions

The validation phantom was filled with 300 MHz Head tissue simulant.

Relative Permittivity: 44.9 (-1.0% deviation from target)
Conductivity: 0.85 mho/m (-2.3% deviation from target)
Fluid Temperature: 21.8 °C (Start of Test) / 22.0 °C (End of Test)
Fluid Depth: ≥ 15 cm

Environmental Conditions:
Ambient Temperature: 23.0 °C
Barometric Pressure: 100.7 kPa
Humidity: 34%

The 300 MHz Head tissue simulant consisted of the following ingredients:

Ingredient	Percentage by weight	
Water	37.56%	
Sugar	55.32%	
Salt	5.95%	
HEC	0.98%	
Dowicil 75	0.19%	
IEEE/IEC Target Dielectric Parameters (300 MHz):	**ε_r = 45.3 (+/- 5%)**	**σ = 0.87 S/m (+/- 5%)**

12. System Performance Check SAR Results

SAR @ 0.25W Input averaged over 1g (W/kg)				SAR @ 1W Input averaged over 1g (W/kg)			
Validation Target (300)		**Measured**	**Deviation**	**Validation Target (300)**		**Measured**	**Deviation**
0.755	**+/- 10%**	0.760	+0.7%	**3.020**	**+/- 10%**	3.040	+0.7%
SAR @ 0.25W Input averaged over 10g (W/kg)				**SAR @ 1W Input averaged over 10g (W/kg)**			
Validation Target (300)		**Measured**	**Deviation**	**Validation Target (300)**		**Measured**	**Deviation**
0.513	**+/- 10%**	0.506	-1.36%	**2.052**	**+/- 10%**	2.024	-1.36%

300 MHz System Performance Check @ 250mW (1g)					
	SAR (mW/g)	Deviation From 300 MHz Numerical Simulation (0.755 mW/g)	STDEV	Mean	Coefficient of Variation
Test 1	0.763	1.73%	0.004	0.760	**0.005**
Test 2	0.762	1.60%			
Test 3	0.759	1.20%			
Test 4	0.761	1.47%			
Test 5	0.763	1.73%			
Test 6	0.762	1.60%			
Test 7	0.753	0.40%			
Test 8	0.760	1.33%			
Test 9	0.754	0.53%			
Test 10	0.765	2.00%			
	0.760	1.36%			

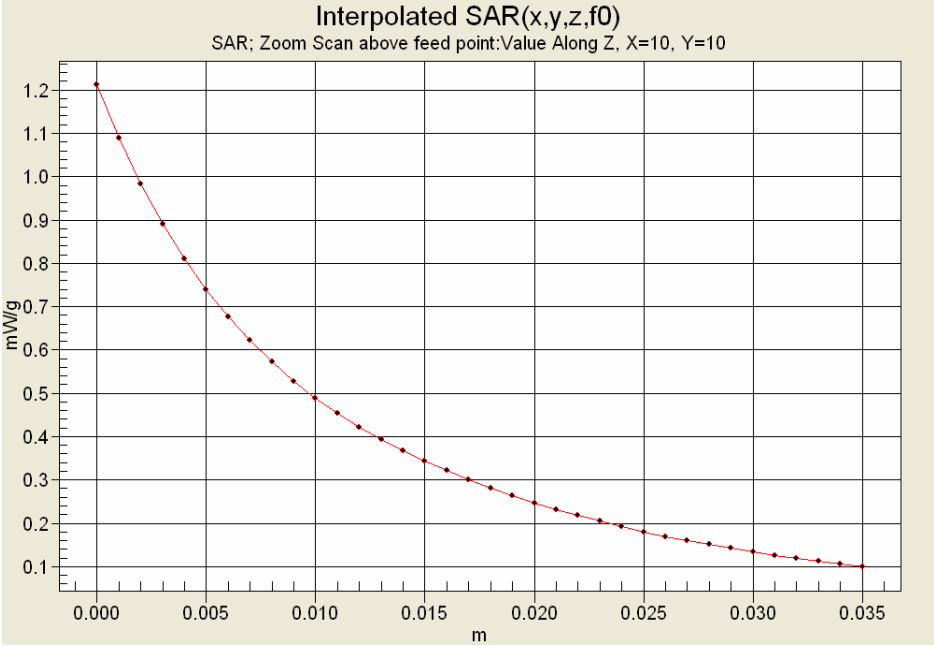
300 MHz System Performance Check @ 250mW (10g)					
	SAR (mW/g)	Deviation From 300 MHz Numerical Simulation (0.513 mW/g)	STDEV	Mean	Coefficient of Variation
Test 1	0.507	-1.17%	0.002	0.506	**0.004**
Test 2	0.507	-1.17%			
Test 3	0.505	-1.56%			
Test 4	0.505	-1.56%			
Test 5	0.507	-1.17%			
Test 6	0.507	-1.17%			
Test 7	0.503	-1.95%			
Test 8	0.508	-0.97%			
Test 9	0.504	-1.75%			
Test 10	0.509	-0.78%			
	0.506	-1.33%			

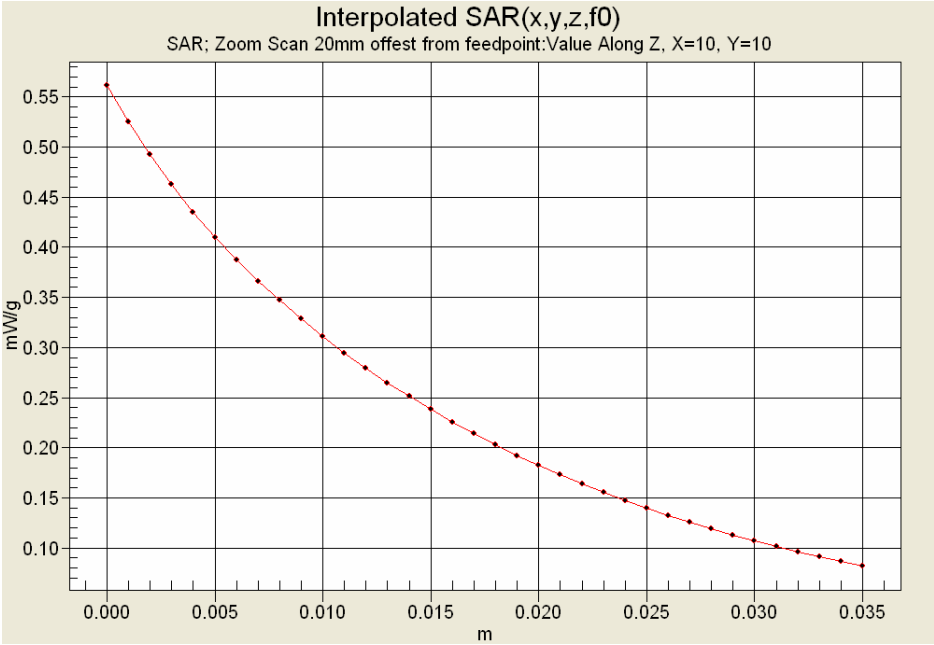
b) Extrapolation Routine:

The zoom scan routine was used to extrapolate the peak SAR above the feed point and offset at 20mm. Two zoom scans were used, the first centered above the feedpoint and the second offset 20mm. The interpolated SAR at these points are shown in the table below. Note: Center of zoom scan located at x=10, y=10.

Measurement Location	Measured SAR mW/g	SAR 1W Normalized	Peak Target mW/g	Deviation	System Performance Check Expanded Uncertainty +-%
Feed Point	1.20*	4.80	4.05	18.5%	21.98
2 cm Offset	0.56	2.24	2.05	9.3%	21.98

*Note: measured SAR level is the average from the 10 evaluations



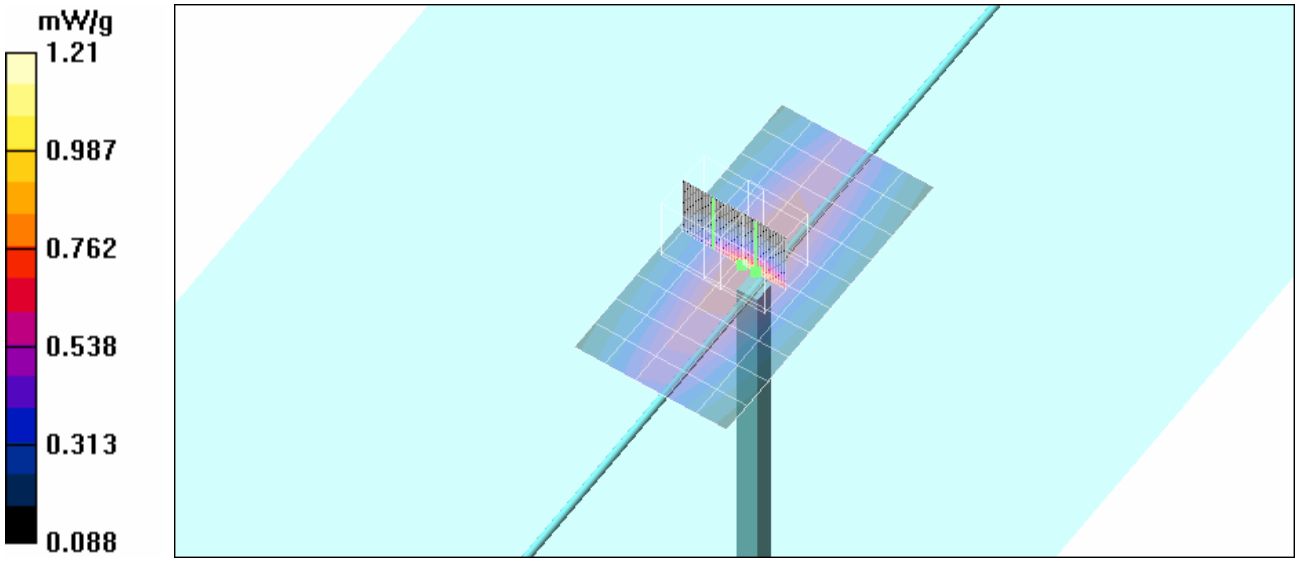


System Performance Check - 300 MHz Dipole - HSL

DUT: Dipole 300 MHz; Asset: 00023; Serial: 135

Ambient Temp: 23.0°C; Fluid Temp: 21.8°C; Barometric Pressure: 100.7 kPa; Humidity: 34%
Communication System: CW
Frequency: 300 MHz; Duty Cycle: 1:1
Medium: 300 HSL Medium parameters used: f = 300 MHz; σ = 0.85 mho/m; ε_r = 44.9; ρ = 1000 kg/m^3
- Probe: ET3DV6 - SN1590; ConvF(8, 8, 8); Calibrated: 21/07/2008
- Sensor-Surface: 5mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn353; Calibrated: 22/04/2008
- Phantom: Validation Planar; Type: Plexiglas; Serial: TE#137
- Measurement SW: DASY4, V4.7 Build 44; Postprocessing SW: SEMCAD, V1.8 Build 171

300 MHz Area Scan (6x11x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 0.699 mW/g
300 MHz Zoom Scan 1 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.4 V/m; Power Drift = -0.012 dB
Peak SAR (extrapolated) = 1.21 W/kg
SAR(1 g) = 0.763 mW/g; SAR(10 g) = 0.507 mW/g
Maximum value of SAR (measured) = 0.743 mW/g
300 MHz Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.3 V/m; Power Drift = 0.000 dB
Peak SAR (extrapolated) = 1.21 W/kg
SAR(1 g) = 0.762 mW/g; SAR(10 g) = 0.507 mW/g
Maximum value of SAR (measured) = 0.740 mW/g
300 MHz Zoom Scan 3 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.3 V/m; Power Drift = 0.002 dB
Peak SAR (extrapolated) = 1.20 W/kg
SAR(1 g) = 0.759 mW/g; SAR(10 g) = 0.505 mW/g
Maximum value of SAR (measured) = 0.736 mW/g
300 MHz Zoom Scan 4 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.3 V/m; Power Drift = -0.015 dB
Peak SAR (extrapolated) = 1.21 W/kg
SAR(1 g) = 0.761 mW/g; SAR(10 g) = 0.505 mW/g
Maximum value of SAR (measured) = 0.741 mW/g
300 MHz Zoom Scan 5 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.4 V/m; Power Drift = -0.040 dB
Peak SAR (extrapolated) = 1.21 W/kg
SAR(1 g) = 0.763 mW/g; SAR(10 g) = 0.507 mW/g
Maximum value of SAR (measured) = 0.742 mW/g
300 MHz Zoom Scan 6 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.4 V/m; Power Drift = -0.062 dB
Peak SAR (extrapolated) = 1.21 W/kg
SAR(1 g) = 0.762 mW/g; SAR(10 g) = 0.507 mW/g
Maximum value of SAR (measured) = 0.741 mW/g
300 MHz Zoom Scan 7 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.4 V/m; Power Drift = -0.064 dB
Peak SAR (extrapolated) = 1.18 W/kg
SAR(1 g) = 0.753 mW/g; SAR(10 g) = 0.503 mW/g
Maximum value of SAR (measured) = 0.715 mW/g
300 MHz Zoom Scan 8 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.3 V/m; Power Drift = -0.027 dB
Peak SAR (extrapolated) = 1.19 W/kg
SAR(1 g) = 0.760 mW/g; SAR(10 g) = 0.508 mW/g
Maximum value of SAR (measured) = 0.723 mW/g
300 MHz Zoom Scan 9 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.4 V/m; Power Drift = -0.056 dB
Peak SAR (extrapolated) = 1.17 W/kg
SAR(1 g) = 0.754 mW/g; SAR(10 g) = 0.504 mW/g
Maximum value of SAR (measured) = 0.707 mW/g
300 MHz Zoom Scan 10 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 29.5 V/m; Power Drift = 0.001 dB
Peak SAR (extrapolated) = 1.20 W/kg
SAR(1 g) = 0.765 mW/g; SAR(10 g) = 0.509 mW/g
Maximum value of SAR (measured) = 0.714 mW/g


mW/g
1.21
0.987
0.762
0.538
0.313
0.088

13. Measured Fluid Dielectric Parameters

300 MHz (Head)

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Celltech Labs Inc.
Test Result for UIM Dielectric Parameter
26/Jan/2009
Frequency (GHz)
IEEE_eH IEEE 1528-2003 Limits for Head Epsilon
IEEE_sH IEEE 1528-2003 Limits for Head Sigma
Test_e Epsilon of UIM
Test_s Sigma of UIM

****

Freq	FCC_eH	FCC_sH	Test_e	Test_s
0.2000	49.97	0.80	50.36	0.75
0.2100	49.50	0.80	48.48	0.78
0.2200	49.03	0.81	48.95	0.77
0.2300	48.57	0.82	47.15	0.79
0.2400	48.10	0.83	46.67	0.79
0.2500	47.63	0.83	47.33	0.80
0.2600	47.17	0.84	47.88	0.81
0.2700	46.70	0.85	47.19	0.81
0.2800	46.23	0.86	46.24	0.83
0.2900	45.77	0.86	44.89	0.83
0.3000	45.30	0.87	44.85	0.85
0.3100	45.18	0.87	44.70	0.85
0.3200	45.06	0.87	45.13	0.88
0.3300	44.94	0.87	44.44	0.87
0.3400	44.82	0.87	43.21	0.87
0.3500	44.70	0.87	43.24	0.89
0.3600	44.58	0.87	43.79	0.91
0.3700	44.46	0.87	43.54	0.91
0.3800	44.34	0.87	42.64	0.91
0.3900	44.22	0.87	42.01	0.92
0.4000	44.10	0.87	41.81	0.94

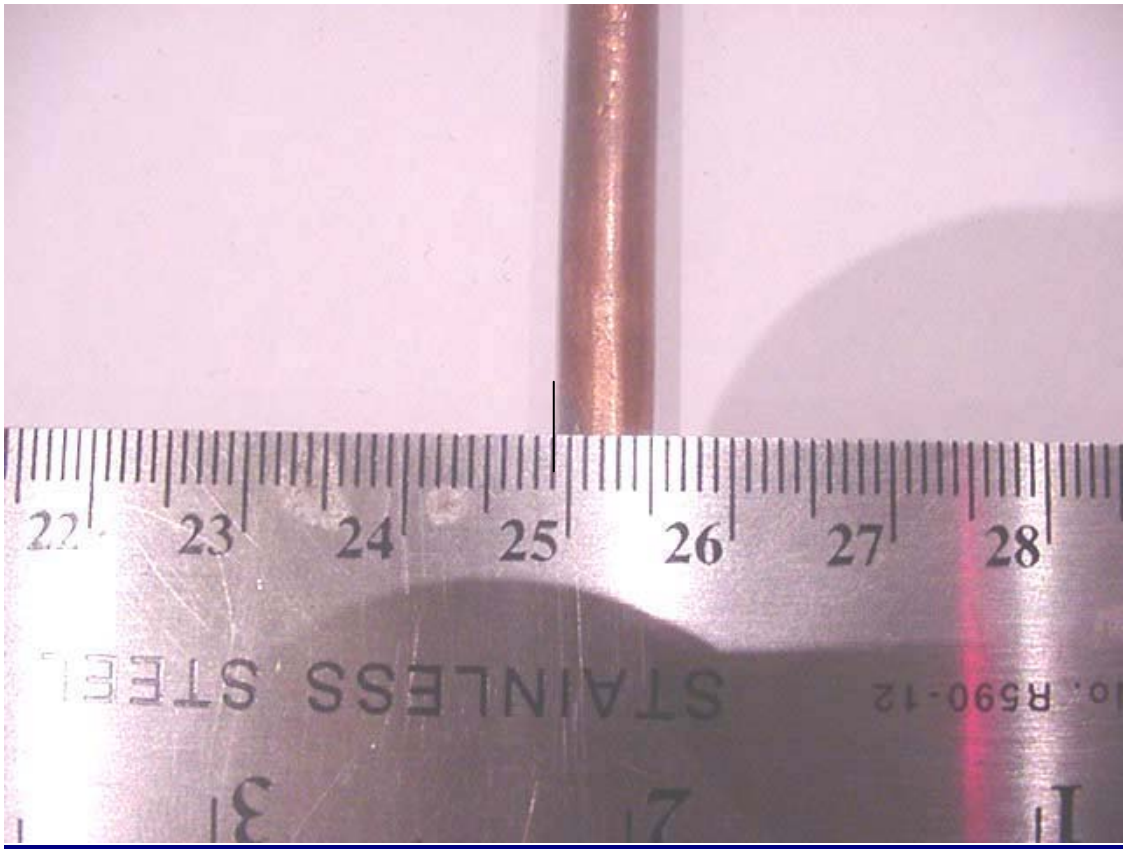
14. Measurement Uncertainties

UNCERTAINTY BUDGET FOR SYSTEM PERFORMANCE CHECK									
Uncertainty Component	**IEEE 1528 Section**	**Uncertainty Value ±%**	**Probability Distribution**	**Divisor**	**ci 1g**	**ci 10g**	**Uncertainty Value ±% (1g)**	**Uncertainty Value ±% (10g)**	**V_i or V_{eff}**
Measurement System									
Probe Calibration (300 MHz)	E.2.1	9	Normal	1	1	1	9	9	∞
Axial Isotropy	E.2.2	4.7	Rectangular	1.732050808	1	1	2.7	2.7	∞
Hemispherical Isotropy	E.2.2	0	Rectangular	1.732050808	1	1	0.0	0.0	∞
Boundary Effect	E.2.3	2.5	Rectangular	1.732050808	1	1	1.4	1.4	∞
Linearity	E.2.4	4.7	Rectangular	1.732050808	1	1	2.7	2.7	∞
System Detection Limits	E.2.5	1	Rectangular	1.732050808	1	1	0.6	0.6	∞
Readout Electronics	E.2.6	0.3	Normal	1	1	1	0.3	0.3	∞
Response Time	E.2.7	0	Rectangular	1.732050808	1	1	0.0	0.0	∞
Integration Time	E.2.8	0	Rectangular	1.732050808	1	1	0.0	0.0	∞
RF Ambient Conditions	E.6.1	3	Rectangular	1.732050808	1	1	1.7	1.7	∞
Probe Positioner Mechanical Tolerance	E.6.2	0.4	Rectangular	1.732050808	1	1	0.2	0.2	∞
Probe Positioning wrt Phantom Shell	E.6.3	2.9	Rectangular	1.732050808	1	1	1.7	1.7	∞
Extrapolation, interpolation & integration algorithms for max. SAR evaluation	E.5	1	Rectangular	1.732050808	1	1	0.6	0.6	∞
Dipole									
Dipole Positioning	E.4.2	2	Normal	1.732050808	1	1	1.2	1.2	∞
SAR Drift Measurement	6.6.2	1.5	Normal	1.732050808	1	1	0.9	0.9	∞
Phantom and Tissue Parameters									
Phantom Uncertainty	E.3.1	4	Rectangular	1.732050808	1	1	2.3	2.3	∞
Liquid Conductivity (target)	E.3.2	5	Rectangular	1.732050808	0.64	0.43	1.8	1.2	∞
Liquid Conductivity (measured)	E.3.3	2.3	Normal	1	0.64	0.43	1.5	1.0	∞
Liquid Permittivity (target)	E.3.2	5	Rectangular	1.732050808	0.6	0.49	1.7	1.4	∞
Liquid Permittivity (measured)	E.3.3	1	Normal	1	0.6	0.49	0.6	0.5	∞
Combined Standard Uncertainty			**RSS**				**10.99**	**10.80**	
Expanded Uncertainty (95% Confidence Interval)			**k=2**				**21.98**	**21.60**	
Measurement Uncertainty Table in accordance with IEEE Standard 1528-2003 and IEC International Standard 62209-1:2005									

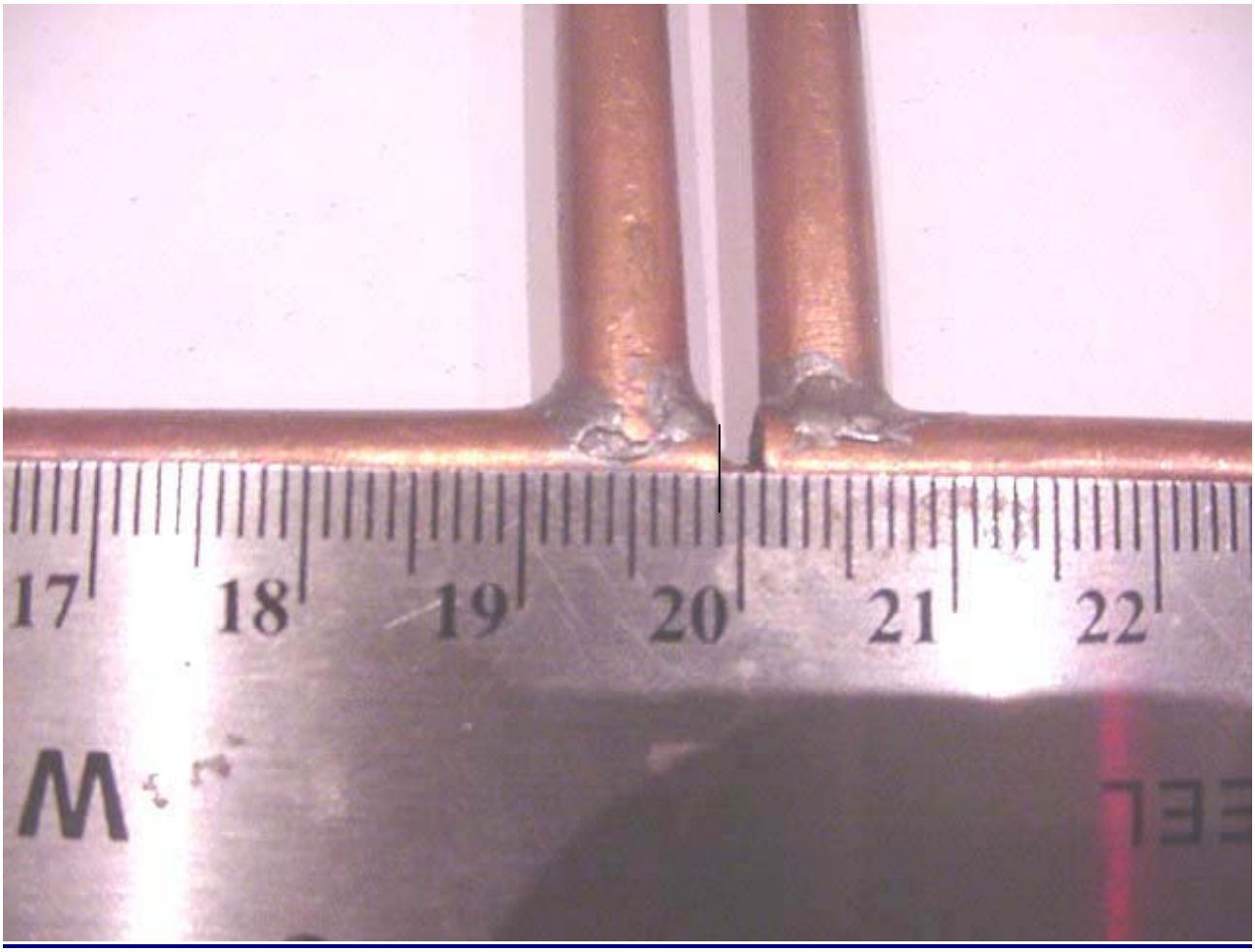
15. Dipole Calibration History

300 MHz Dipole Calibration History										
Dipole Calibration Date	SAR Probe Information			Celltech Measured Data						
	Serial Number	Calibration Factor	Calibration Procedure	SAR (W/kg) Measured at 250 mW	% Deviation from IEEE 1528 Target (0.750 W/kg @ 1W)	% Deviation from Target Validated by Celltech (3.019 W/kg @ 1W)	Dielectric Parameters		RL (dB)	Impedance
							ε_r	σ		
2003	1387	7.9	Numerical	0.782	4.27%		45.7	0.88	-21.70	43.59
2004	1387	7.8	Numerical	0.742	-1.07%		45.9	0.87	-25.00	45.20
2005	1387	7.9	Numerical	0.750	0.00%		44.3	0.84	-24.30	44.40
2006	1387	7.8	Numerical	0.760	1.33%		45.4	0.85	-24.30	44.40
2007	1387	7.3	Numerical	0.768	2.40%		45.2	0.89	-20.30	45.80
2008	1387	7.8	Measured	0.794		5.20%	45.6	0.90	-20.20	46.70
2008	1590	8.0	Measured	0.768		1.76%	43.5	0.89	-22.50	46.70
2008	1590	8.0	Measured	0.777		2.95%	44.9	0.85	-22.50	46.40
Target Dielectric Parameters: ε_r = 45.3, σ = 0.87 s/m										

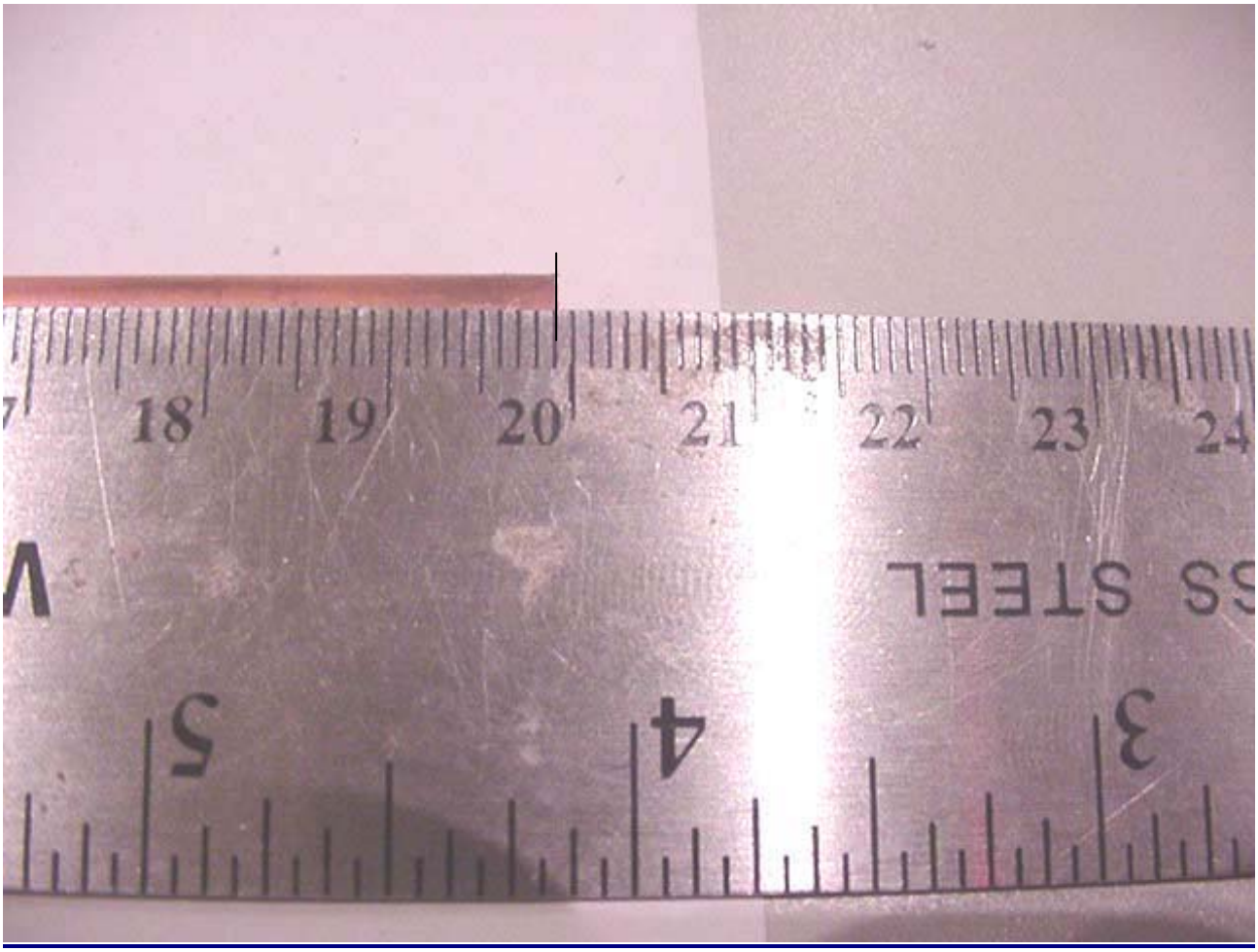
APPENDIX A - PHOTOGRAPHS



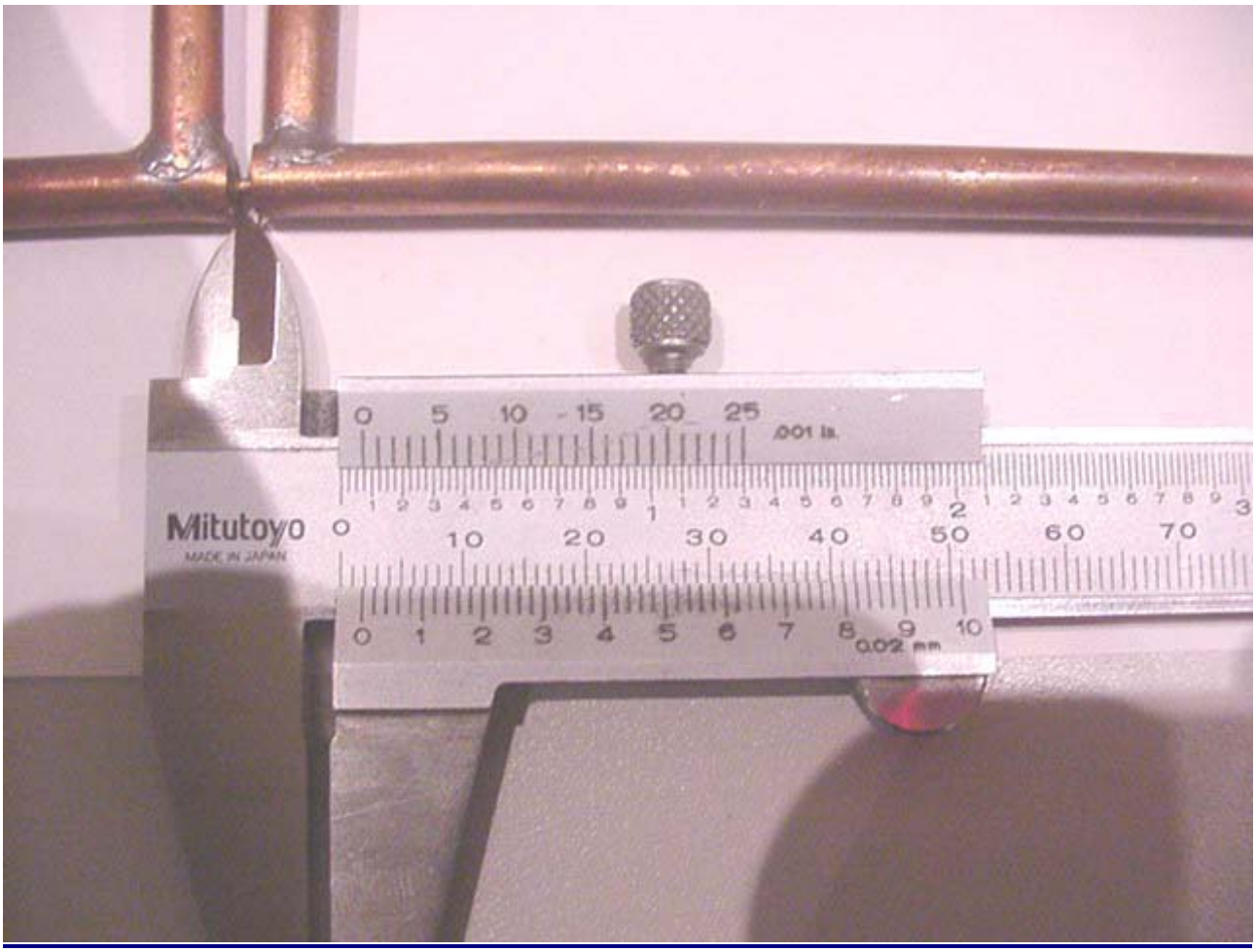
Dipole Dimension h = 249mm



Right Element = 199mm

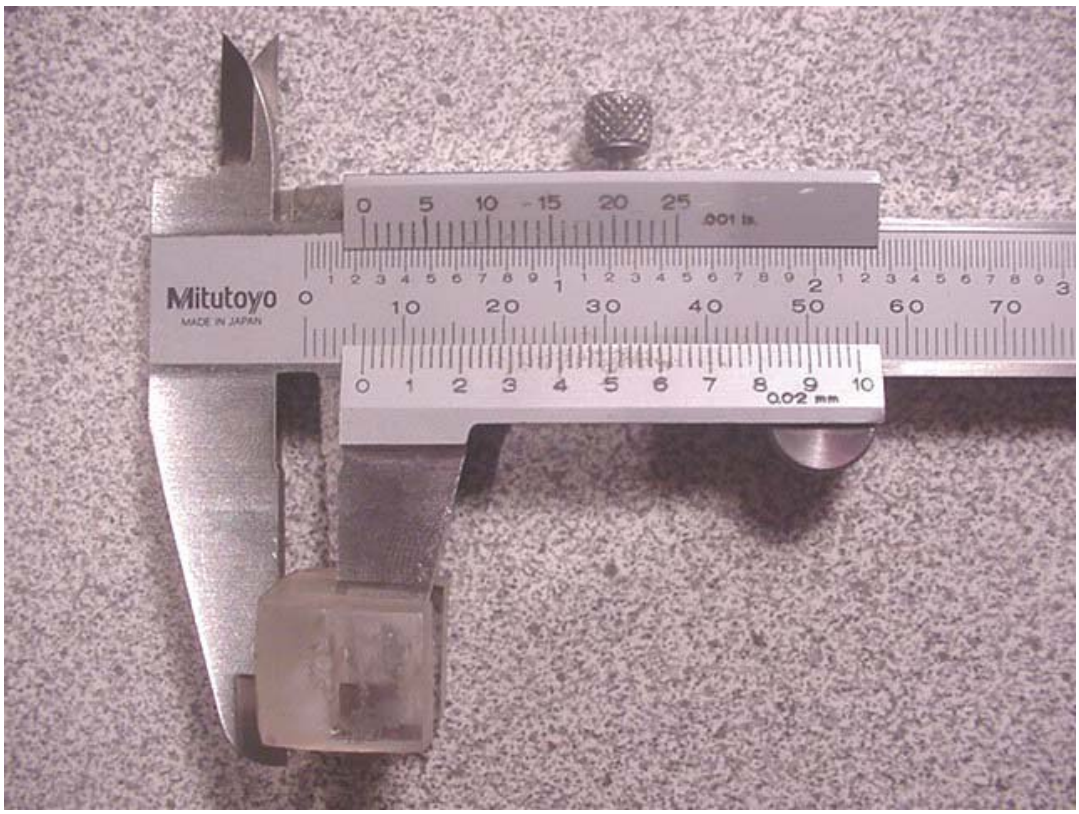


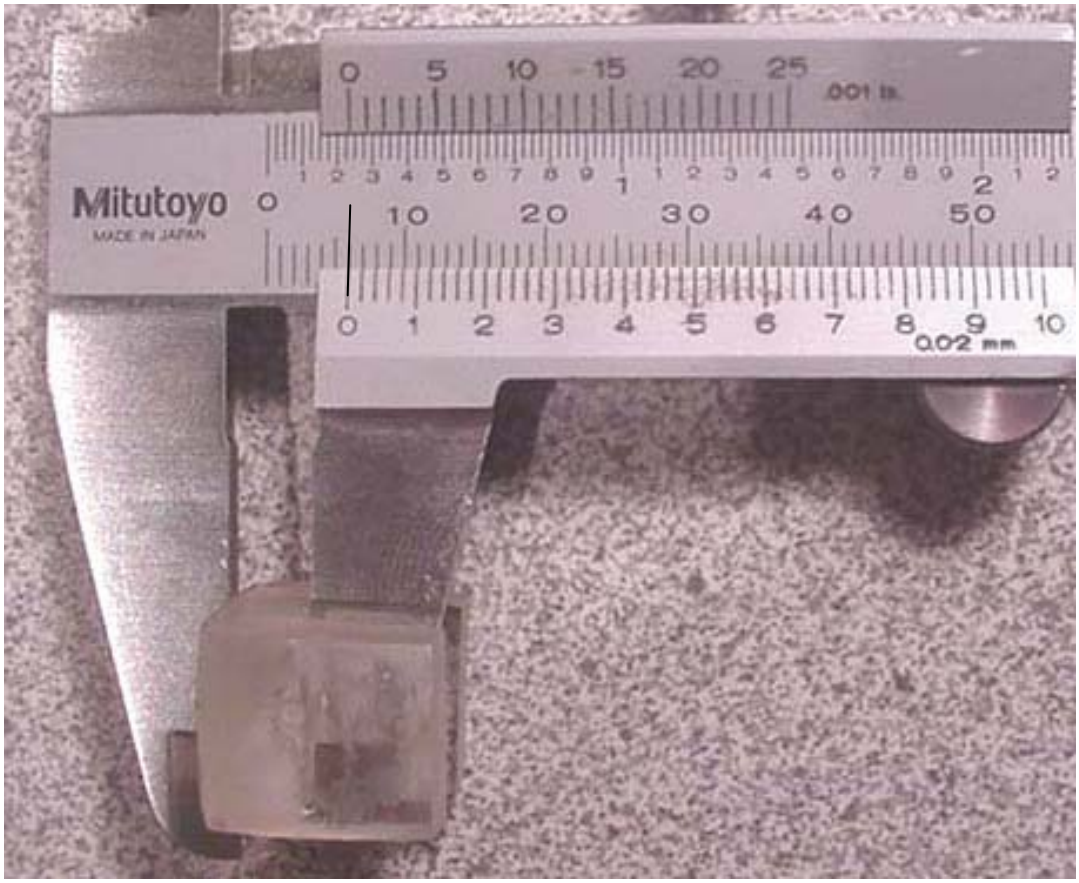
Left Element = 199mm



Dimension Between Elements = 1.88mm

Total Dimension L: 199mm + 199mm + 1.88mm = 399.9mm





Dipole Spacer Dimension = 6.0mm

APPENDIX B - SEMCAD SIMULATION LOG FILE

```
iSolve X, Version 13.4, Build 34, 64Bit Windows, Single Precision
Simulation name 'Dielectric Const = 2.7'
Maxwell Solver started the 2009-Feb-09 10:40:13.
Initializing FDTD (x1 CFL) Harmonic Simulation at 300 MHz

Overall discretization:
Smallest number of cells per wavelength = 29.6948, largest = 395.114, average = 163.379
Simulation time-step = 1.257e-012 s
Simulation time-step / minimum of CFL criteria = 0.998584
Maximum of CFL criteria / minimum of CFL criteria = 51.1583
Average of CFL criteria / minimum of CFL criteria = 9.93237

Discretization by solids:
Background: epsr = 1, mur = 1, sigma = 0, sigma* = 0 - smallest number of cells per wavelength =
199.862, largest = 395.114, average = 205.114
Phantom/Shell: epsr = 2.7, mur = 1, sigma = 0, sigma* = 0 - smallest number of cells per
wavelength = 122.674, largest = 240.458, average = 141.978
Phantom/Liquid: epsr = 45.3, mur = 1, sigma = 0.87, sigma* = 0 - smallest number of cells per
wavelength = 29.6948, largest = 64.3059, average = 31.9627

Boundary conditions:
Side X-: U-PML(8)
Side X+: U-PML(8)
Side Y-: U-PML(8)
Side Y+: U-PML(8)
Side Z-: U-PML(8)
Side Z+: U-PML(8)

Grid:
Number of nodes=323x275x177, number of voxels=15528128

Excitations:
Initializing (Voltage) edge source Quelle
Overall duration : 4.33333e-008 s or 34474 iterations

Probes & Sensors:
Initializing near-field sensor 1g
Initializing near-field sensor 10g
Initializing near to far field transformation
Initializing near-field sensor Overall Field
Initializing near-field sensor Unnamed
Initializing port sensor Sensor of Quelle
Initializing port sensor TDSensor
Initializing port sensor FDSensor
Initializing port sensor ObererSensor

Enable monitoring:
Sensor of Quelle, V(t)
Sensor of Quelle, I(t)
TDSensor, V(t)
TDSensor, I(t)
FDSensor, V(t)
FDSensor, I(t)
ObererSensor, V(t)
ObererSensor, I(t)

Checking out the license feature ISOLVEX_SOLVER_FDTD, expiring the 1-mar-2009, version 10.0, (1).

Calculating update coefficients:
Created thread pool with 2 thread(s).
Calculating update coefficients: completed. Time: 24 seconds.

Hardware acceleration not used, please contact SPEAG for more information.
Yee (explicit) iterations starting using U-PML Boundary Condition.
0% - iterations: 5 / 34473 - [8.47 MCells/s] - Estimated time to completion: 17:33:11
0% - iterations: 11 / 34473 - [7.76 MCells/s] - Estimated time to completion: 19:08:44
0% - iterations: 17 / 34473 - [7.76 MCells/s] - Estimated time to completion: 19:08:32
0% - iterations: 23 / 34473 - [8.47 MCells/s] - Estimated time to completion: 17:32:38
0% - iterations: 32 / 34473 - [11.6 MCells/s] - Estimated time to completion: 12:45:21
0% - iterations: 41 / 34473 - [12.7 MCells/s] - Estimated time to completion: 11:41:23
0% - iterations: 53 / 34473 - [16.9 MCells/s] - Estimated time to completion: 08:45:51
```

```
0% - iterations: 63 / 34473 - [14.1 MCells/s] - Estimated time to completion: 10:30:51
0% - iterations: 73 / 34473 - [14.1 MCells/s] - Estimated time to completion: 10:30:40
0% - iterations: 82 / 34473 - [11.6 MCells/s] - Estimated time to completion: 12:44:14
0% - iterations: 88 / 34473 - [8.47 MCells/s] - Estimated time to completion: 17:30:39
0% - iterations: 95 / 34473 - [9.88 MCells/s] - Estimated time to completion: 15:00:22
0% - iterations: 102 / 34473 - [9.88 MCells/s] - Estimated time to completion: 15:00:11
0% - iterations: 108 / 34473 - [7.17 MCells/s] - Estimated time to completion: 20:40:57
0% - iterations: 114 / 34473 - [7.76 MCells/s] - Estimated time to completion: 19:05:18
0% - iterations: 120 / 34473 - [7.17 MCells/s] - Estimated time to completion: 20:40:31
0% - iterations: 126 / 34473 - [7.76 MCells/s] - Estimated time to completion: 19:04:54
0% - iterations: 131 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:59:12
0% - iterations: 136 / 34473 - [6.47 MCells/s] - Estimated time to completion: 22:53:28
0% - iterations: 140 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:59:42
0% - iterations: 144 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:59:29
0% - iterations: 149 / 34473 - [5.97 MCells/s] - Estimated time to completion: 24:47:22
0% - iterations: 154 / 34473 - [6.47 MCells/s] - Estimated time to completion: 22:52:45
0% - iterations: 160 / 34473 - [8.47 MCells/s] - Estimated time to completion: 17:28:27
0% - iterations: 166 / 34473 - [8.47 MCells/s] - Estimated time to completion: 17:28:16
1% - iterations: 173 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:19:59
1% - iterations: 179 / 34473 - [7.76 MCells/s] - Estimated time to completion: 19:03:08
1% - iterations: 184 / 34473 - [6.47 MCells/s] - Estimated time to completion: 22:51:33
1% - iterations: 189 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:57:04
1% - iterations: 194 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:56:53
1% - iterations: 198 / 34473 - [5.18 MCells/s] - Estimated time to completion: 28:33:45
1% - iterations: 203 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:56:34
1% - iterations: 210 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:18:56
1% - iterations: 217 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:18:44
1% - iterations: 223 / 34473 - [7.17 MCells/s] - Estimated time to completion: 20:36:48
1% - iterations: 227 / 34473 - [5.18 MCells/s] - Estimated time to completion: 28:32:18
1% - iterations: 235 / 34473 - [11.3 MCells/s] - Estimated time to completion: 13:04:37
1% - iterations: 244 / 34473 - [11.6 MCells/s] - Estimated time to completion: 12:40:38
1% - iterations: 248 / 34473 - [5.18 MCells/s] - Estimated time to completion: 28:31:15
1% - iterations: 252 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:53:38
1% - iterations: 256 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:53:25
1% - iterations: 261 / 34473 - [6.47 MCells/s] - Estimated time to completion: 22:48:28
1% - iterations: 266 / 34473 - [6.47 MCells/s] - Estimated time to completion: 22:48:16
1% - iterations: 269 / 34473 - [4.23 MCells/s] - Estimated time to completion: 34:50:14
1% - iterations: 273 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:52:30
1% - iterations: 278 / 34473 - [6.47 MCells/s] - Estimated time to completion: 22:47:48
1% - iterations: 283 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:53:38
1% - iterations: 288 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:53:27
1% - iterations: 293 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:53:16
1% - iterations: 298 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:53:05
1% - iterations: 304 / 34473 - [7.76 MCells/s] - Estimated time to completion: 18:58:58
1% - iterations: 310 / 34473 - [8.47 MCells/s] - Estimated time to completion: 17:23:52
1% - iterations: 315 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:52:27
1% - iterations: 319 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:50:00
1% - iterations: 323 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:49:47
1% - iterations: 327 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:49:34
1% - iterations: 331 / 34473 - [5.65 MCells/s] - Estimated time to completion: 26:04:50
1% - iterations: 336 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:51:41
1% - iterations: 340 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:48:52
1% - iterations: 345 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:51:21
1% - iterations: 350 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:51:10
1% - iterations: 355 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:50:59
1% - iterations: 362 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:14:35
1% - iterations: 369 / 34473 - [9.88 MCells/s] - Estimated time to completion: 14:53:12
1% - iterations: 375 / 34473 - [7.76 MCells/s] - Estimated time to completion: 18:56:36
1% - iterations: 381 / 34473 - [7.76 MCells/s] - Estimated time to completion: 18:56:24
1% - iterations: 388 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:13:51
1% - iterations: 395 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:13:39
1% - iterations: 400 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:49:20
1% - iterations: 405 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:49:09
1% - iterations: 409 / 34473 - [4.44 MCells/s] - Estimated time to completion: 33:07:04
1% - iterations: 413 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:44:55
1% - iterations: 417 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:44:42
1% - iterations: 421 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:44:29
1% - iterations: 425 / 34473 - [4.78 MCells/s] - Estimated time to completion: 30:44:16
1% - iterations: 430 / 34473 - [7.06 MCells/s] - Estimated time to completion: 20:48:14
1% - iterations: 437 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:12:27
1% - iterations: 444 / 34473 - [9.06 MCells/s] - Estimated time to completion: 16:12:15
```

```
72% - iterations: 24653 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:20:02
72% - iterations: 24663 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:59:51
72% - iterations: 24673 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:59:40
72% - iterations: 24683 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:59:29
72% - iterations: 24692 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:19:14
72% - iterations: 24702 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:59:08
72% - iterations: 24712 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:58:57
72% - iterations: 24722 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:58:46
72% - iterations: 24731 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:18:26
72% - iterations: 24741 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:58:25
72% - iterations: 24751 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:58:14
72% - iterations: 24761 / 34473 - [12.9 MCells/s] - Estimated time to completion: 03:14:14
72% - iterations: 24771 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:57:52
72% - iterations: 24781 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:57:41
72% - iterations: 24791 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:57:30
72% - iterations: 24800 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:17:02
72% - iterations: 24810 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:57:09
72% - iterations: 24820 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:56:58
72% - iterations: 24829 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:16:27
72% - iterations: 24839 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:56:37
72% - iterations: 24849 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:56:26
72% - iterations: 24859 / 34473 - [12.9 MCells/s] - Estimated time to completion: 03:12:16
72% - iterations: 24869 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:56:04
72% - iterations: 24879 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:55:53
72% - iterations: 24888 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:15:15
72% - iterations: 24898 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:55:32
72% - iterations: 24908 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:55:21
72% - iterations: 24918 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:55:10
72% - iterations: 24927 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:14:27
72% - iterations: 24937 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:54:49
72% - iterations: 24947 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:54:38
72% - iterations: 24957 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:54:27
72% - iterations: 24966 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:13:39
72% - iterations: 24976 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:54:06
72% - iterations: 24986 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:53:55
73% - iterations: 24995 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:13:04
73% - iterations: 25005 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:53:34
73% - iterations: 25015 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:53:23
73% - iterations: 25025 / 34473 - [12.9 MCells/s] - Estimated time to completion: 03:08:57
73% - iterations: 25035 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:53:01
73% - iterations: 25045 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:52:50
73% - iterations: 25055 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:52:39
73% - iterations: 25064 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:11:39
73% - iterations: 25074 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:52:18
73% - iterations: 25084 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:52:07
73% - iterations: 25094 / 34473 - [12.9 MCells/s] - Estimated time to completion: 03:07:34
73% - iterations: 25104 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:51:45
73% - iterations: 25114 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:51:34
73% - iterations: 25123 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:10:27
73% - iterations: 25133 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:51:14
73% - iterations: 25143 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:51:03
73% - iterations: 25153 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:50:52
73% - iterations: 25162 / 34473 - [12.7 MCells/s] - Estimated time to completion: 03:09:40
73% - iterations: 25172 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:50:31
73% - iterations: 25182 / 34473 - [14.1 MCells/s] - Estimated time to completion: 02:50:20
73% - iterations: 25192 / 34473 - [12.9 MCells/s] - Estimated time to completion: 03:05:37
Steady state detected at iteration: 25195 - the simulation will end shortly.
Please wait ... saving the sensor 'Overall Field' (E-fields) on disk.

Please wait ... saving the sensor 'Overall Field' (H-fields) on disk.

Please wait ... saving the sensor 'Unnamed' (E-fields) on disk.

Please wait ... saving the sensor 'Unnamed' (H-fields) on disk.

97% - iterations: 25195 / 25858 - [0.0214 MCells/s] - Estimated time to completion: 133:42:18
97% - iterations: 25205 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:11:58
98% - iterations: 25215 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:11:47
98% - iterations: 25225 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:12:39
98% - iterations: 25235 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:11:25
98% - iterations: 25245 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:11:14
98% - iterations: 25255 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:11:03
98% - iterations: 25264 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:12:06
98% - iterations: 25274 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:10:42
```

```
98% - iterations: 25284 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:10:31
98% - iterations: 25294 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:11:16
98% - iterations: 25304 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:10:09
98% - iterations: 25314 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:09:58
98% - iterations: 25324 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:09:47
98% - iterations: 25333 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:10:41
98% - iterations: 25343 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:09:26
98% - iterations: 25352 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:10:18
98% - iterations: 25362 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:09:05
98% - iterations: 25372 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:08:54
98% - iterations: 25381 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:09:43
98% - iterations: 25391 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:08:33
98% - iterations: 25401 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:08:22
98% - iterations: 25410 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:09:07
98% - iterations: 25420 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:08:01
98% - iterations: 25428 / 25858 - [10.4 MCells/s] - Estimated time to completion: 00:10:45
98% - iterations: 25437 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:08:34
98% - iterations: 25446 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:08:23
98% - iterations: 25456 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:07:22
98% - iterations: 25466 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:07:11
99% - iterations: 25476 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:07:38
99% - iterations: 25486 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:06:49
99% - iterations: 25496 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:06:38
99% - iterations: 25506 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:06:27
99% - iterations: 25515 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:06:59
99% - iterations: 25525 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:06:06
99% - iterations: 25535 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:05:55
99% - iterations: 25544 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:06:23
99% - iterations: 25554 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:05:34
99% - iterations: 25564 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:05:23
99% - iterations: 25574 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:05:40
99% - iterations: 25584 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:05:01
99% - iterations: 25594 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:04:50
99% - iterations: 25604 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:05:04
99% - iterations: 25614 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:04:28
99% - iterations: 25624 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:04:17
99% - iterations: 25634 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:04:06
99% - iterations: 25643 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:04:22
99% - iterations: 25653 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:03:45
99% - iterations: 25663 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:03:34
99% - iterations: 25673 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:03:42
99% - iterations: 25683 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:03:12
99% - iterations: 25693 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:03:01
99% - iterations: 25703 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:03:06
99% - iterations: 25713 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:02:39
99% - iterations: 25723 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:02:28
100% - iterations: 25733 / 25858 - [12.9 MCells/s] - Estimated time to completion: 00:02:30
100% - iterations: 25743 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:02:06
100% - iterations: 25753 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:01:55
100% - iterations: 25763 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:01:44
100% - iterations: 25771 / 25858 - [11.3 MCells/s] - Estimated time to completion: 00:01:59
100% - iterations: 25779 / 25858 - [10.4 MCells/s] - Estimated time to completion: 00:01:58
100% - iterations: 25787 / 25858 - [10.4 MCells/s] - Estimated time to completion: 00:01:46
100% - iterations: 25795 / 25858 - [11.3 MCells/s] - Estimated time to completion: 00:01:26
100% - iterations: 25805 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:00:58
100% - iterations: 25814 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:00:53
100% - iterations: 25824 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:00:37
100% - iterations: 25834 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:00:26
100% - iterations: 25844 / 25858 - [14.1 MCells/s] - Estimated time to completion: 00:00:15
100% - iterations: 25853 / 25858 - [12.7 MCells/s] - Estimated time to completion: 00:00:06
Please wait ... saving the sensor 'Overall Field' (E-fields) on disk.

Please wait ... saving the sensor 'Overall Field' (H-fields) on disk.

Please wait ... saving the sensor 'Unnamed' (E-fields) on disk.

Please wait ... saving the sensor 'Unnamed' (H-fields) on disk.

100% - iterations: 25858 / 25858 - [0.0357 MCells/s] - Estimated time to completion: 00:00:00

Convert time-domain data to frequency-domain data.

Maxwell Solver run ended the 2009-Feb-10 00:57:28. Total simulation time was 14:17:15 (hh:mm:ss,
wall-clock time).
```

APPENDIX C - PROBE CALIBRATION REPORT

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

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

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

Accreditation No.: SCS 108

Client Celltech

Certificate No: ET3-1590_Jul08

CALIBRATION CERTIFICATE

Object	ET3DV6 - SN:1590
Calibration procedure(s)	QA CAL-01.v6, QA CAL-12.v5 and QA CAL-23.v3 Calibration procedure for dosimetric E-field probes
Calibration date:	July 21, 2008
Condition of the calibrated item	In Tolerance

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	1-Apr-08 (No. 217-00788)	Apr-09
Power sensor E4412A	MY41495277	1-Apr-08 (No. 217-00788)	Apr-09
Power sensor E4412A	MY41498087	1-Apr-08 (No. 217-00788)	Apr-09
Reference 3 dB Attenuator	SN: S5054 (3c)	1-Jul-08 (No. 217-00865)	Jul-09
Reference 20 dB Attenuator	SN: S5086 (20b)	31-Mar-08 (No. 217-00787)	Apr-09
Reference 30 dB Attenuator	SN: S5129 (30b)	1-Jul-08 (No. 217-00866)	Jul-09
Reference Probe ES3DV2	SN: 3013	2-Jan-08 (No. ES3-3013_Jan08)	Jan-09
DAE4	SN: 660	3-Sep-07 (No. DAE4-660_Sep07)	Sep-08

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Oct-07)	In house check: Oct-09
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-07)	In house check: Oct-08

	Name	Function	Signature
Calibrated by:	Katja Pokovic	Technical Manager	
Approved by:	Niels Kuster	Quality Manager	

Issued: July 21, 2008

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

Glossary:

TSL	tissue simulating liquid
NORMx,y,z	sensitivity in free space
ConvF	sensitivity in TSL / NORMx,y,z
DCP	diode compression point
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

Calibration is Performed According to the Following Standards:

a) IEEE Std 1528-2003, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", December 2003
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

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 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.
- *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.

Probe ET3DV6

SN:1590

Manufactured:	March 19, 2001
Last calibrated:	May 20, 2005
Recalibrated:	July 21, 2008

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

DASY - Parameters of Probe: ET3DV6 SN:1590

Sensitivity in Free Space[A] Diode Compression[B]

NormX	**1.81** ± 10.1%	$\mu V/(V/m)^2$	DCP X	**87** mV
NormY	**2.00** ± 10.1%	$\mu V/(V/m)^2$	DCP Y	**92** mV
NormZ	**1.72** ± 10.1%	$\mu V/(V/m)^2$	DCP Z	**85** mV

Sensitivity in Tissue Simulating Liquid (Conversion Factors)

Please see Page 8.

Boundary Effect

TSL **835 MHz** **Typical SAR gradient: 5 % per mm**

Sensor Center to Phantom Surface Distance		**3.7 mm**	**4.7 mm**
SAR_{be} [%]	Without Correction Algorithm	10.7	7.2
SAR_{be} [%]	With Correction Algorithm	0.8	0.5

Sensor Offset

Probe Tip to Sensor Center	**2.7** mm

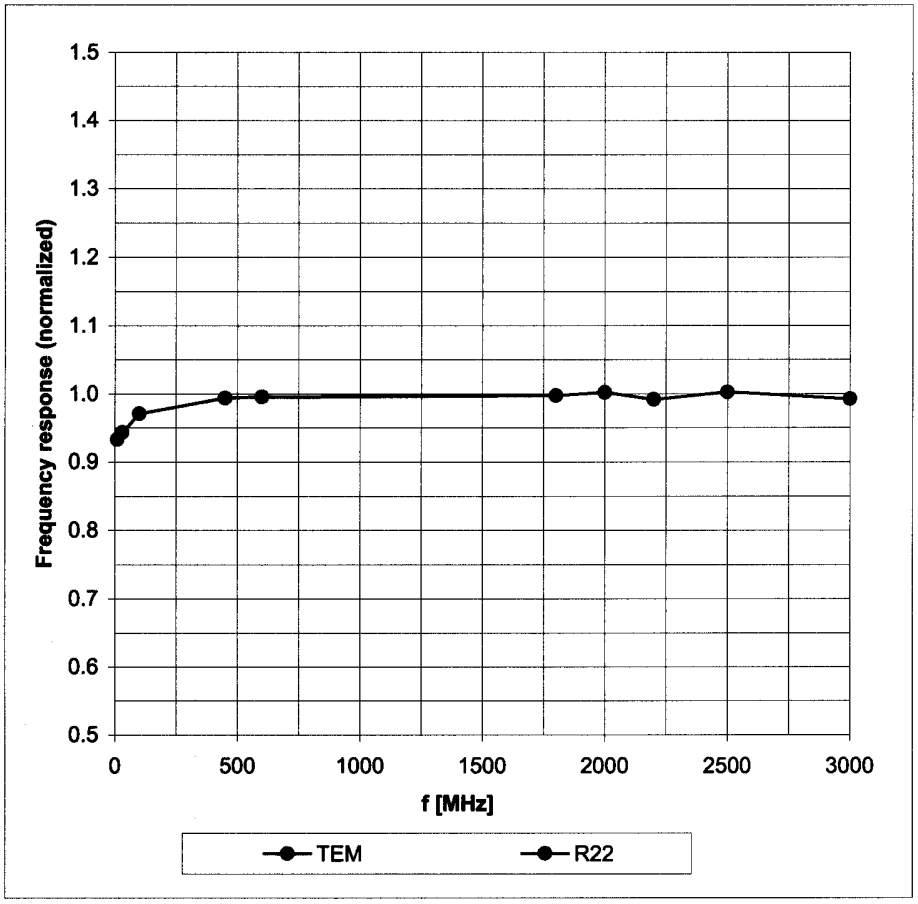
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[A] The uncertainties of NormX,Y,Z do not affect the E^2-field uncertainty inside TSL (see Page 8).

[B] Numerical linearization parameter: uncertainty not required.

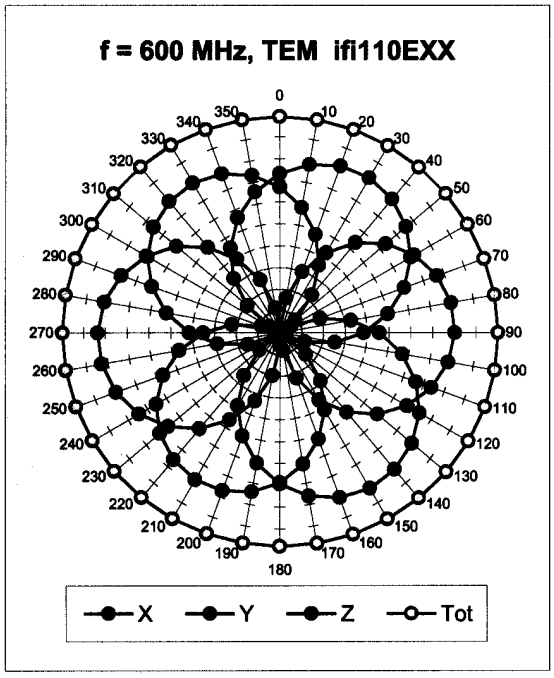
Frequency Response of E-Field

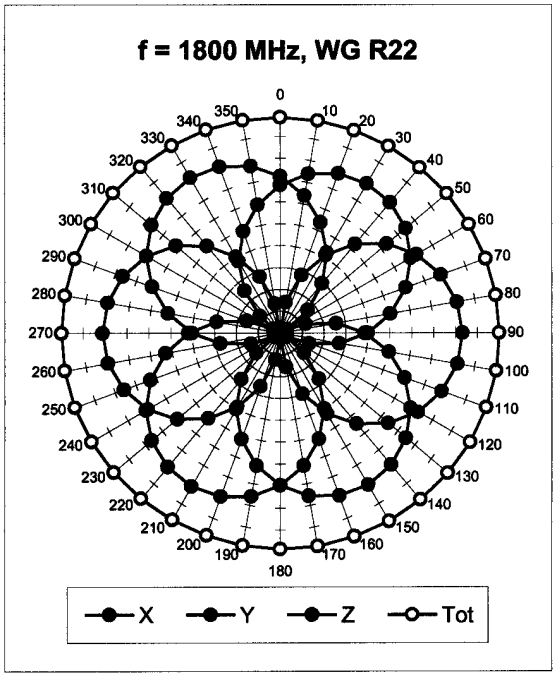
(TEM-Cell:ifi110 EXX, Waveguide: R22)

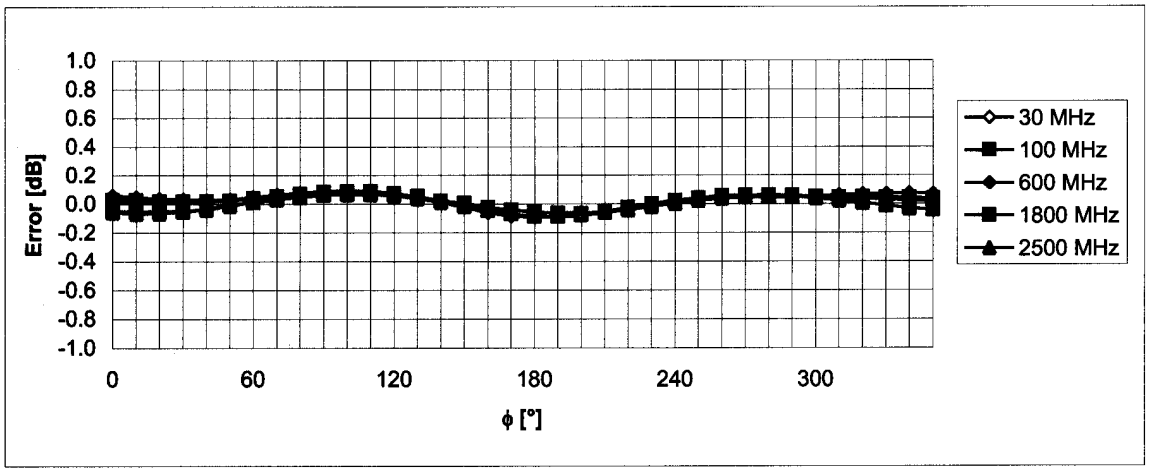


Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)

Receiving Pattern (ϕ), ϑ = 0°



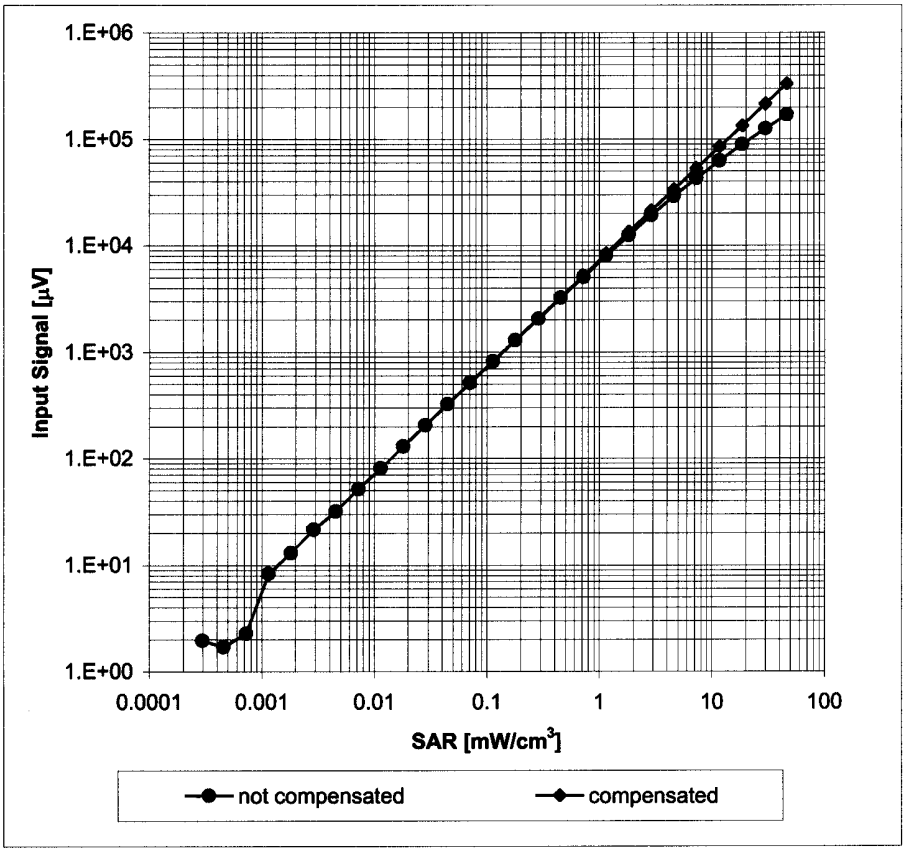


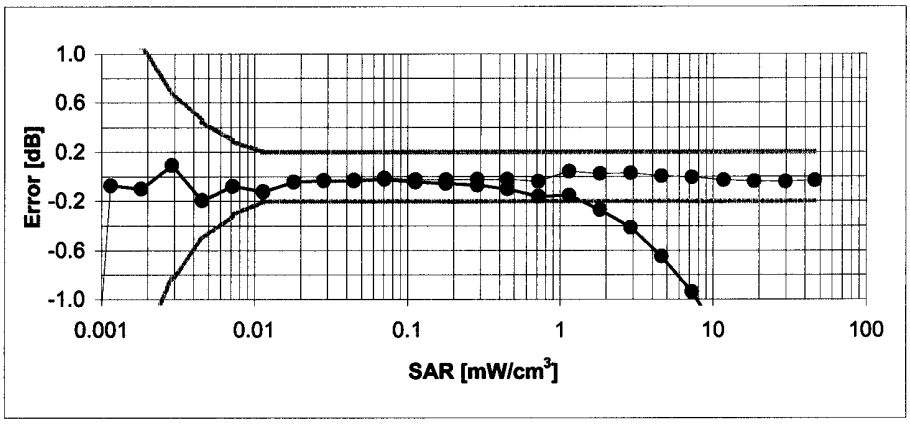


Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

Dynamic Range f(SAR_{head})

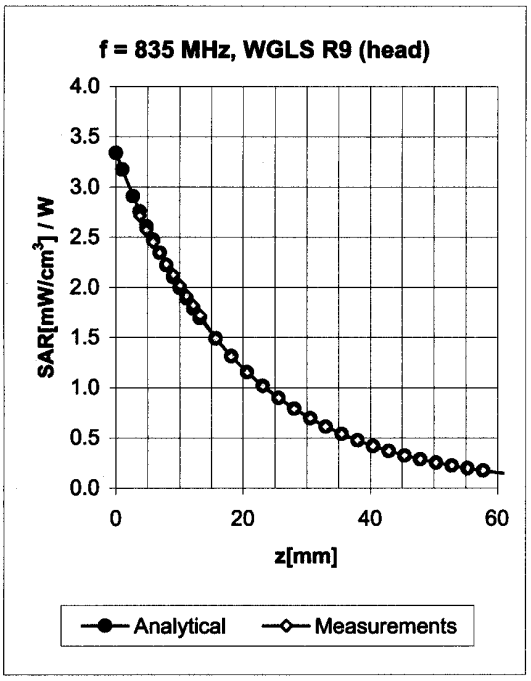
(Waveguide R22, f = 1800 MHz)

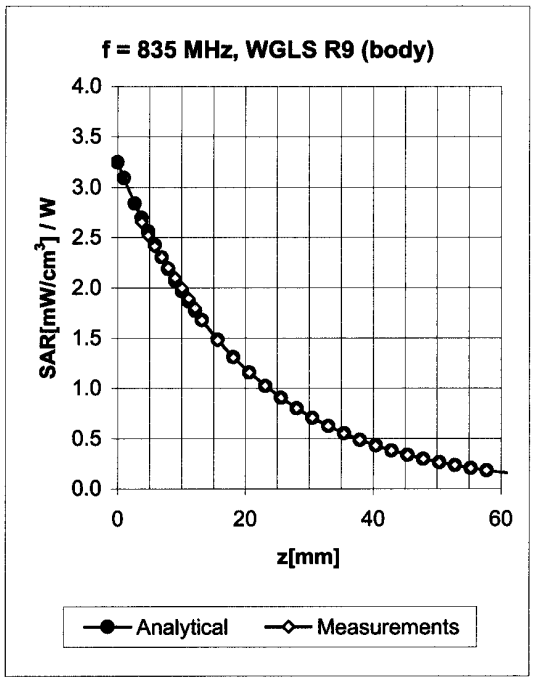




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Conversion Factor Assessment



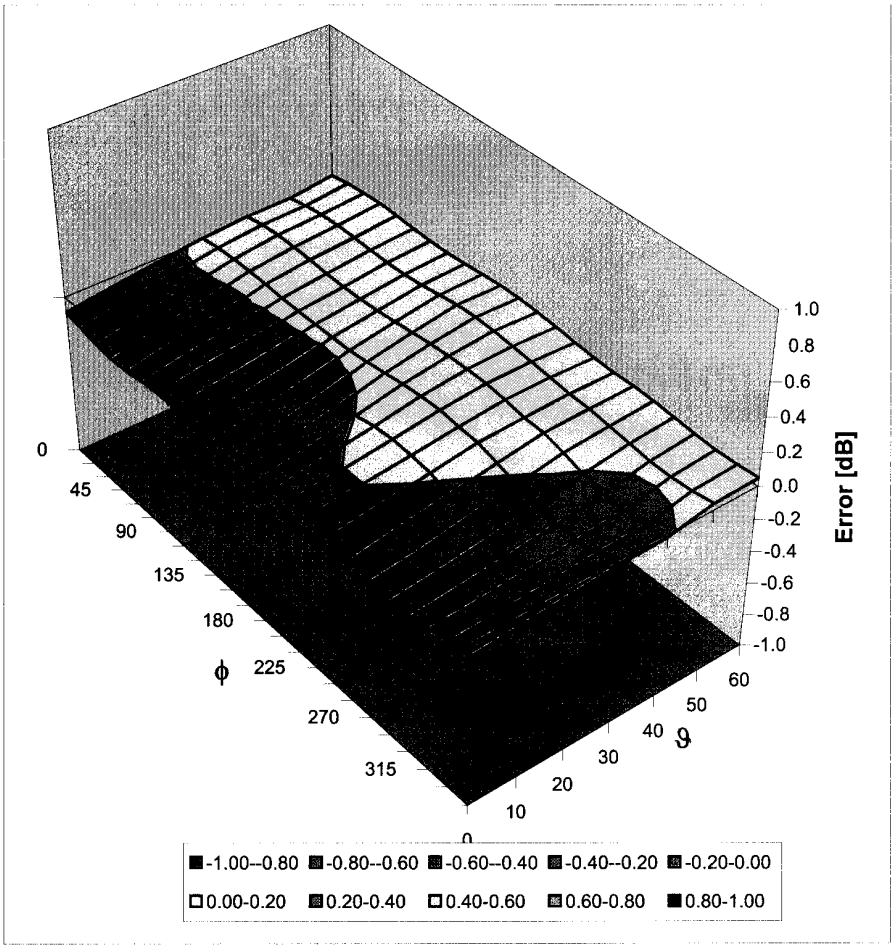


f [MHz]	Validity [MHz][C]	TSL	Permittivity	Conductivity	Alpha	Depth	ConvF Uncertainty	
450	± 50 / ± 100	Head	43.5 ± 5%	0.87 ± 5%	0.34	1.75	7.66	± 13.3% (k=2)
835	± 50 / ± 100	Head	41.5 ± 5%	0.90 ± 5%	0.32	3.52	6.54	± 11.0% (k=2)
450	± 50 / ± 100	Body	56.7 ± 5%	0.94 ± 5%	0.28	1.77	8.27	± 13.3% (k=2)
835	± 50 / ± 100	Body	55.2 ± 5%	0.97 ± 5%	0.36	3.31	6.39	± 11.0% (k=2)

[C] **The validity of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2). The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band.**

Deviation from Isotropy in HSL

Error (ϕ, ϑ), f = 900 MHz



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

Schmid & Partner Engineering AG

s p e a g

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info@speag.com, http://www.speag.com

Additional Conversion Factors

for Dosimetric E-Field Probe

Type:	**ET3DV6**
Serial Number:	**1590**
Place of Assessment:	**Zurich**
Date of Assessment:	**July 23, 2008**
Probe Calibration Date:	**July 21, 2008**

Schmid & Partner Engineering AG hereby certifies that conversion factor(s) of this probe have been evaluated on the date indicated above. The assessment was performed using the FDTD numerical code SEMCAD of Schmid & Partner Engineering AG. Since the evaluation is coupled with measured conversion factors, it has to be recalculated yearly, i.e., following the re-calibration schedule of the probe. The uncertainty of the numerical assessment is based on the extrapolation from measured value at 450 and 835 MHz.

Assessed by:

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 44 245 9700, Fax +41 44 245 9779
info@speag.com, http://www.speag.com

Dosimetric E-Field Probe ET3DV6 SN:1590

Conversion factor (± standard deviation)

150 MHz	*ConvF*	**8.9 ± 10%**	**ε_r = 52.3** **σ = 0.76 mho/m** (head tissue)
300 MHz	*ConvF*	**8.0 ± 9%**	**ε_r = 45.3** **σ = 0.87 mho/m** (head tissue)
150 MHz	*ConvF*	**8.5 ± 10%**	**ε_r = 61.9** **σ = 0.80 mho/m** (body tissue)

Important Note:

For numerically assessed probe conversion factors, parameters Alpha and Delta in the DASY software must have the following entries: Alpha = 0 and Delta = 1.

Please see also Section 4.7 of the DASY4 Manual.