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

FCC Federal Communications Commission

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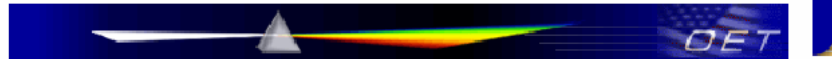
Office of Engineering and Technology

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.

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

Applicant:	Kanematsu USA Inc.	FCC ID:	IV9BSH16UH	Model(s):	BSH16UH	KANEMATSU USA INC.
DUT Type:	4 Watt Portable FM UHF PTT Radio Transceiver			Frequency Range:	470 - 520 MHz	

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450 MHz Dipole Calibration

Type:

450 MHz Validation Dipole

Asset Number:

00024

Serial Number:

136

Place of Calibration:

Celltech Labs Inc.

Date(s) of Calibration:

Jan. 19 & Feb. 09, 2009

Celltech Labs Inc. certifies that the 450 MHz Dipole Calibration was performed on the date(s) indicated above.
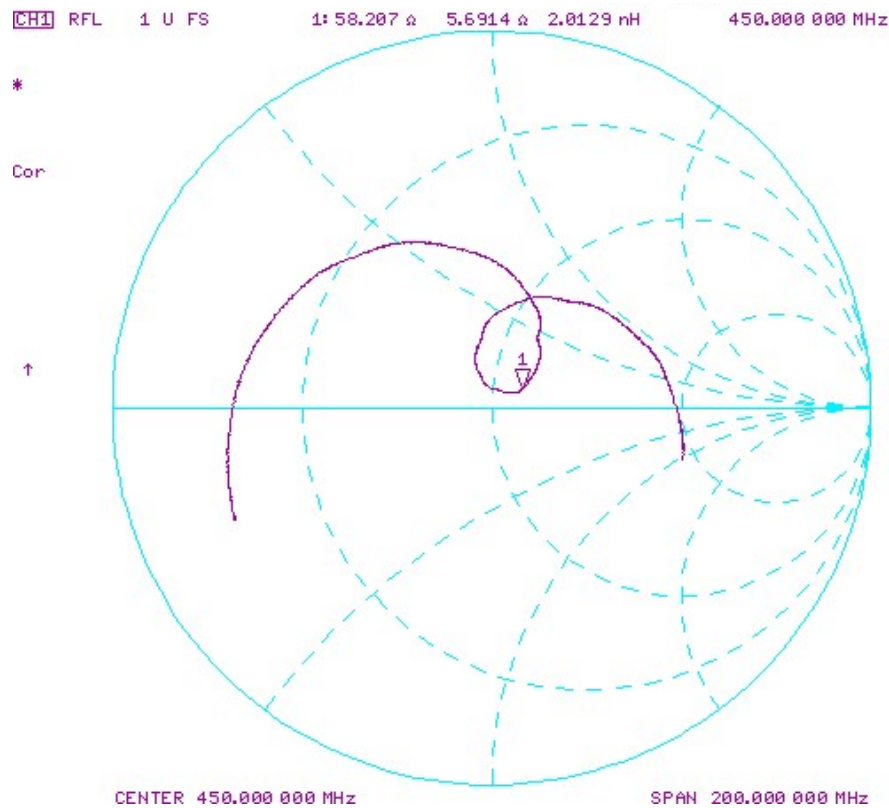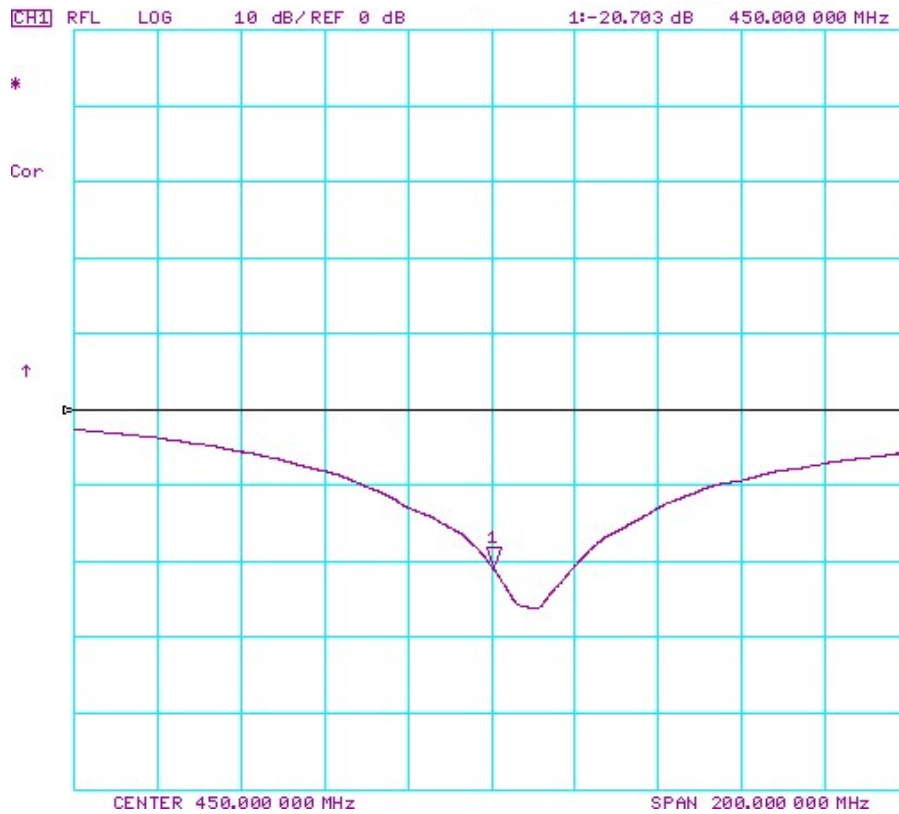
Calibrated by:

Sean Johnston

Signature:

1. Dipole Construction & Electrical Characteristics

The validation dipole was constructed with RG401/U semi-rigid coax 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 15.1 mm from the simulating fluid using a loss-less dielectric spacer. The measured input impedance is:

Feed point impedance at 450 MHz $Re\{Z\} = 58.207 \ \Omega$

$Im\{Z\} = 5.6914 \ \Omega$

Return Loss at 450 MHz   -20.703 dB

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)	**270.0**	**272.7**	**+2.7**	**+1%**
h (mm)	**166.7**	**167.0**	**+0.3**	**+0.2%**
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 was used for the simulation.

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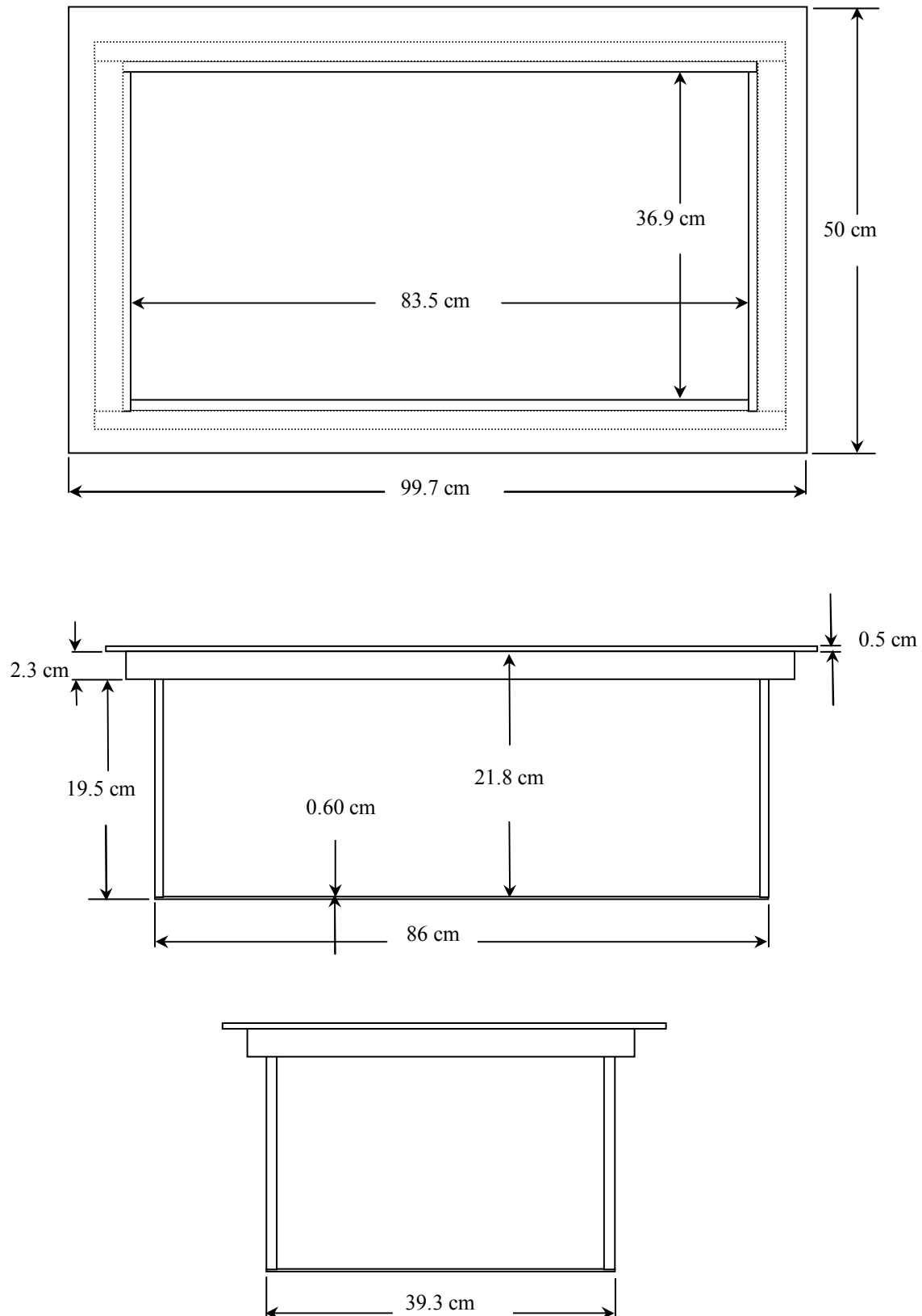
s = 3.175mm(d/2) + 6.0mm(phantom) + 6.0mm(spacer) = 15.175mm

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 5S1G4 Power Amplifier	00106	26235	CNR	CNR
CNR = Calibration Not Required				

6. Dimensions of Plexiglas Planar Validation Phantom

7. Plexiglas Planar Validation Phantom

8. 450 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	450	6	2.7	1	0	700, 600, 170	43.5	0.87	1	15.175	6	270	166.7	6.35	1	4	4.893	3.263	6.845	3.101

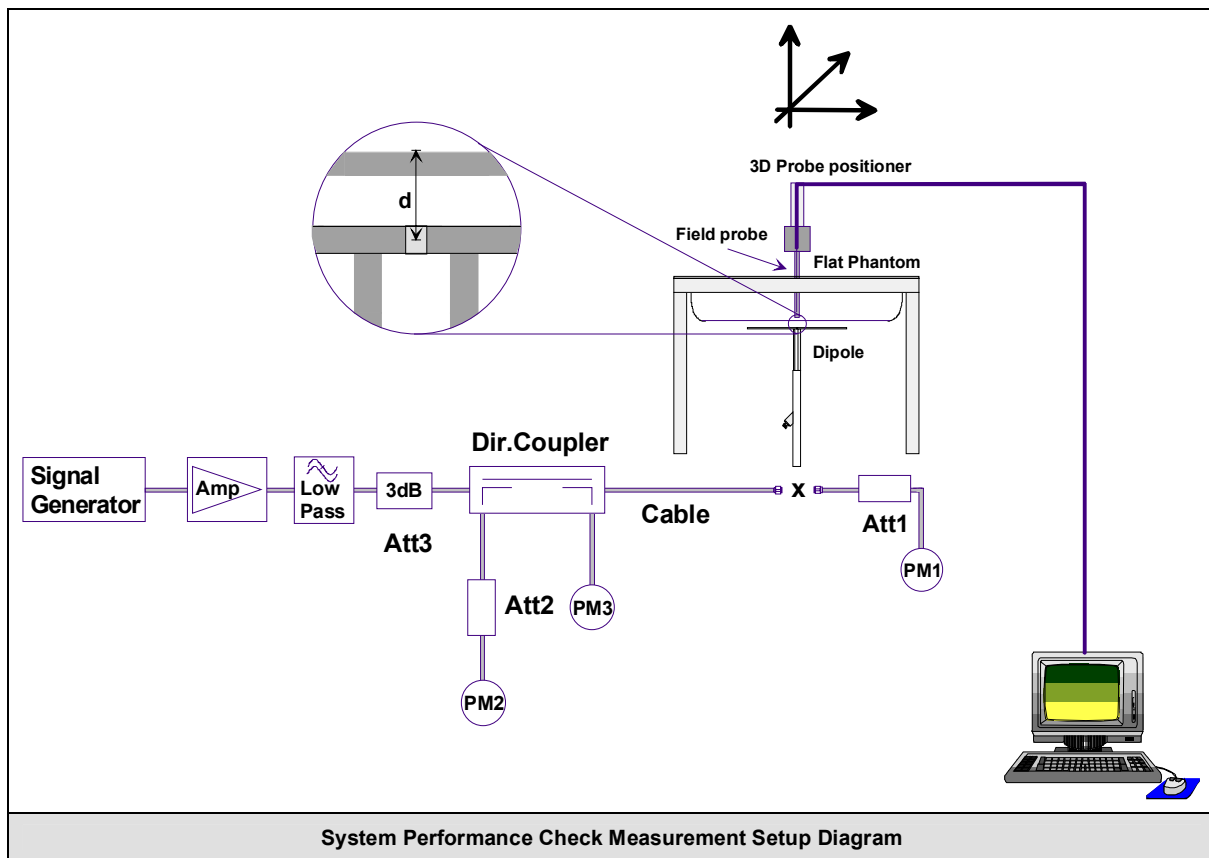| CELLTECH TARGET		
1.223 W/kg	**1g**	**0.25 W**
0.816 W/kg	**10g**	**0.25 W**

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 7.66). 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 450 MHz Head tissue simulant.

Relative Permittivity: 43.8 (+0.7% deviation from target)
Conductivity: 0.86 mho/m (-1.1% deviation from target)
Fluid Temperature: 22.1°C (Start of Test) / 22.3°C (End of Test)
Fluid Depth: $\geq$ 15.0 cm

Environmental Conditions:
Ambient Temperature: 23.1°C
Barometric Pressure: 101.1 kPa
Humidity: 35%

The 450 MHz Head tissue simulant consisted of the following ingredients:

Ingredient	Percentage by weight	
Water	38.56%	
Sugar	56.32%	
Salt	3.95%	
HEC	0.98%	
Dowicil 75	0.19%	
IEEE/IEC Target Dielectric Parameters (450 MHz):	ε_r = 43.5 (+/- 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 (450)		Measured	Deviation	Validation Target (450)		Measured	Deviation
1.223	+/- 10%	1.216	-0.57%	4.892	+/- 10%	4.864	-0.57%
SAR @ 0.25W Input averaged over 10g (W/kg)				SAR @ 1W Input averaged over 10g (W/kg)			
Validation Target (450)		Measured	Deviation	Validation Target (450)		Measured	Deviation
0.816	+/- 10%	0.799	-2.08%	3.264	+/- 10%	3.196	-2.08%

450 MHz System Performance Check @ 250mW (1g)					
	SAR 1g (mW/g)	Deviation From 450 MHz Numerical Simulation (1.223 mW/g)	STDEV	Mean	Coefficient of Variation
Test 1	1.21	-1.06%	0.008	1.216	**0.007**
Test 2	1.22	-0.25%			
Test 3	1.22	-0.25%			
Test 4	1.21	-1.06%			
Test 5	1.22	-0.25%			
Test 6	1.20	-1.88%			
Test 7	1.22	-0.25%			
Test 8	1.22	-0.25%			
Test 9	1.23	0.57%			
Test 10	1.21	-1.06%			
	1.216	-0.57%			

450 MHz System Performance Check @ 250mW (10g)					
	SAR 10g (mW/g)	Deviation From 450 MHz Numerical Simulation (0.816 mW/g)	STDEV	Mean	Coefficient of Variation
Test 1	0.799	-2.08%	0.006	0.799	**0.007**
Test 2	0.800	-1.96%			
Test 3	0.803	-1.59%			
Test 4	0.796	-2.45%			
Test 5	0.801	-1.84%			
Test 6	0.793	-2.82%			
Test 7	0.802	-1.72%			
Test 8	0.802	-1.72%			
Test 9	0.807	-1.10%			
Test 10	0.787	-3.55%			
	0.799	-2.08%			

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 point of zoom scan located at x=10, y=10.
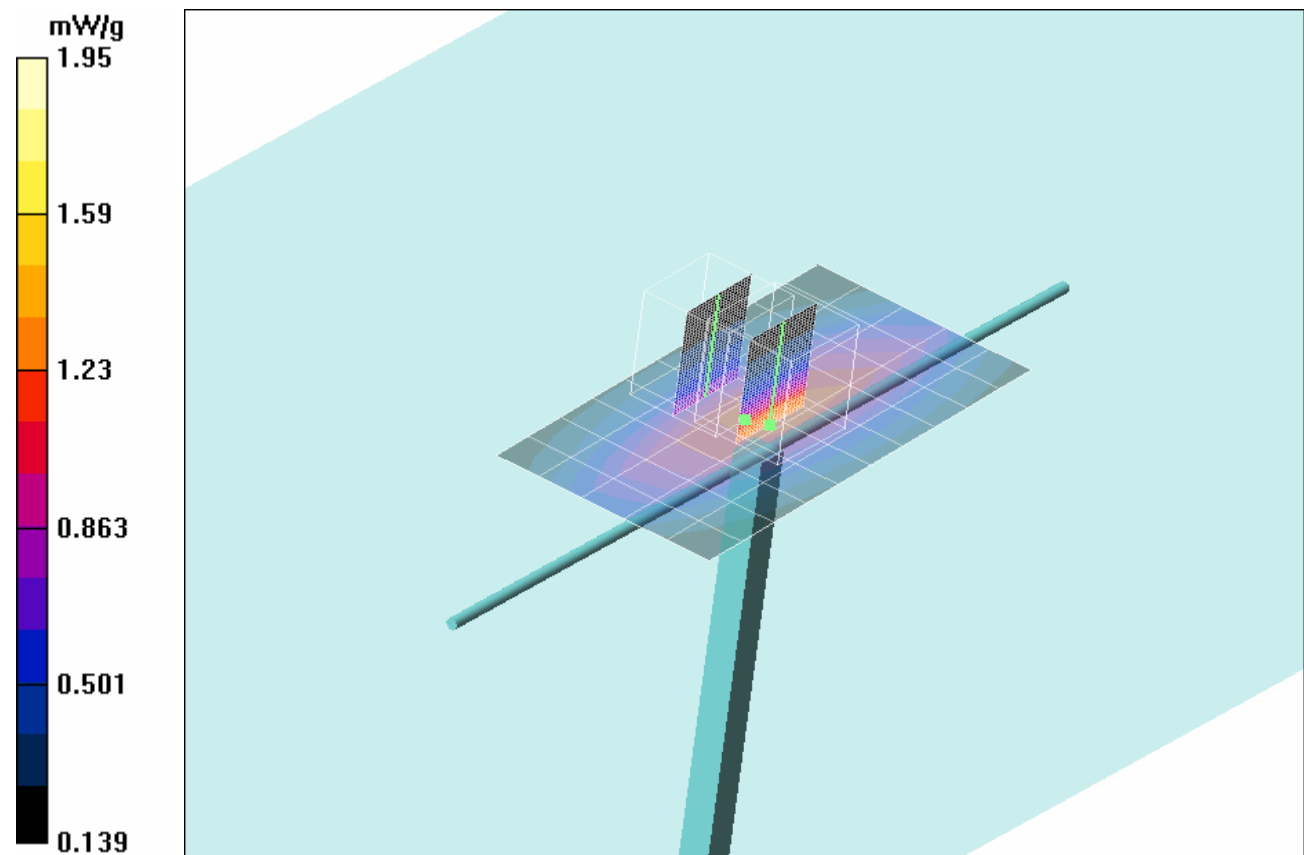
Measurement Location	Measured SAR mW/g	SAR 1W Normalized	Peak Target mW/g	Deviation	System Performance Check Expanded Uncertainty +-%
Feed Point	1.93*	7.72	6.85	12.7%	17.86
2 cm Offset	0.79	3.16	3.10	1.9%	17.86

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

Interpolated SAR(x,y,z,f0)
SAR; Zoom Scan above feed point :Value Along Z, X=10, Y=10

Interpolated SAR(x,y,z,f0)
SAR; Zoom Scan 2 20mm offset from feedpoint:Value Along Z, X=10, Y=10

System Performance Check - 450 MHz Dipole - HSL
DUT: Dipole 450 MHz; Asset: 00024; Serial: 136

Ambient Temp: 23.1°C; Fluid Temp: 22.1°C; Barometric Pressure: 101.1 kPa; Humidity: 35%
Communication System: CW
Frequency: 450 MHz; Duty Cycle: 1:1
Medium: HSL450 Medium parameters used: f = 450 MHz; σ = 0.86 mho/m; ε_r = 43.8; ρ = 1000 kg/m^3
- Probe: ET3DV6 - SN1590; ConvF(7.66, 7.66, 7.66); Calibrated: 21/07/2008
- Sensor-Surface: 4mm (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
450 MHz Area Scan (6x11x1): Measurement grid: dx=15mm, dy=15mm
Maximum value of SAR (measured) = 1.20 mW/g
450 MHz Zoom Scan 1 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.6 V/m; Power Drift = -0.035 dB
Peak SAR (extrapolated) = 1.92 W/kg
SAR(1 g) = 1.21 mW/g; SAR(10 g) = 0.799 mW/g
Maximum value of SAR (measured) = 1.30 mW/g
450 MHz Zoom Scan 2 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.5 V/m; Power Drift = -0.022 dB
Peak SAR (extrapolated) = 1.93 W/kg
SAR(1 g) = 1.22 mW/g; SAR(10 g) = 0.800 mW/g
Maximum value of SAR (measured) = 1.30 mW/g
450 MHz Zoom Scan 3 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.4 V/m; Power Drift = 0.010 dB
Peak SAR (extrapolated) = 1.92 W/kg
SAR(1 g) = 1.22 mW/g; SAR(10 g) = 0.803 mW/g
Maximum value of SAR (measured) = 1.30 mW/g
450 MHz Zoom Scan 4 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.3 V/m; Power Drift = 0.001 dB
Peak SAR (extrapolated) = 1.92 W/kg
SAR(1 g) = 1.21 mW/g; SAR(10 g) = 0.796 mW/g
Maximum value of SAR (measured) = 1.29 mW/g
450 MHz Zoom Scan 5 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.5 V/m; Power Drift = 0.006 dB
Peak SAR (extrapolated) = 1.94 W/kg
SAR(1 g) = 1.22 mW/g; SAR(10 g) = 0.801 mW/g
Maximum value of SAR (measured) = 1.32 mW/g
450 MHz Zoom Scan 6 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.3 V/m; Power Drift = -0.017 dB
Peak SAR (extrapolated) = 1.90 W/kg
SAR(1 g) = 1.20 mW/g; SAR(10 g) = 0.793 mW/g
Maximum value of SAR (measured) = 1.29 mW/g
450 MHz Zoom Scan 7 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.4 V/m; Power Drift = 0.006 dB
Peak SAR (extrapolated) = 1.94 W/kg
SAR(1 g) = 1.22 mW/g; SAR(10 g) = 0.802 mW/g
Maximum value of SAR (measured) = 1.31 mW/g
450 MHz Zoom Scan 8 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.7 V/m; Power Drift = 0.010 dB
Peak SAR (extrapolated) = 1.93 W/kg
SAR(1 g) = 1.22 mW/g; SAR(10 g) = 0.802 mW/g
Maximum value of SAR (measured) = 1.30 mW/g
450 MHz Zoom Scan 9 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
Reference Value = 39.6 V/m; Power Drift = -0.009 dB
Peak SAR (extrapolated) = 1.95 W/kg
SAR(1 g) = 1.23 mW/g; SAR(10 g) = 0.807 mW/g
Maximum value of SAR (measured) = 1.32 mW/g
450 MHz Zoom Scan 10 (5x5x7)/Cube 0: Measurement grid: dx=7.5mm, dy=7.5mm, dz=5mm
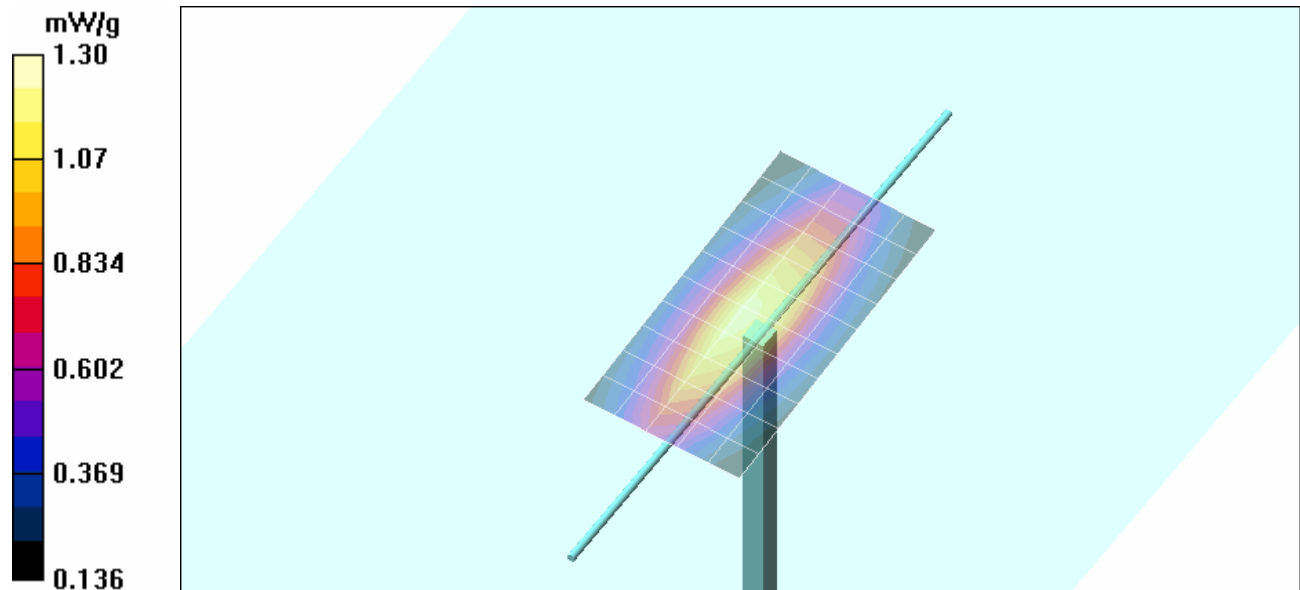Reference Value = 39.3 V/m; Power Drift = 0.007 dB
Peak SAR (extrapolated) = 1.92 W/kg
SAR(1 g) = 1.21 mW/g; SAR(10 g) = 0.787 mW/g
Maximum value of SAR (measured) = 1.29 mW/g

13. Measured Fluid Dielectric Parameters

450 MHz (Head)

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************************************************************
Celltech Labs Inc.
Test Result for UIM Dielectric Parameter
19/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
0.3500	44.70	0.87	44.61	0.78
0.3600	44.58	0.87	46.57	0.79
0.3700	44.46	0.87	45.58	0.79
0.3800	44.34	0.87	44.52	0.80
0.3900	44.22	0.87	44.68	0.82
0.4000	44.10	0.87	44.30	0.83
0.4100	43.98	0.87	43.79	0.84
0.4200	43.86	0.87	44.67	0.85
0.4300	43.74	0.87	43.93	0.86
0.4400	43.62	0.87	43.86	0.86
0.4500	43.50	0.87	43.79	0.86
0.4600	43.45	0.87	43.00	0.86
0.4700	43.40	0.87	42.82	0.88
0.4800	43.34	0.87	42.69	0.89
0.4900	43.29	0.87	42.38	0.91
0.5000	43.24	0.87	42.02	0.90
0.5100	43.19	0.87	42.04	0.92
0.5200	43.14	0.88	42.26	0.95
0.5300	43.08	0.88	41.66	0.94
0.5400	43.03	0.88	41.84	0.95
0.5500	42.98	0.88	41.33	0.96

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 (450 MHz)	E.2.1	6.65	Normal	1	1	1	6.65	6.65	∞
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	1	Rectangular	1.732050808	1	1	0.6	0.6	∞
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	0.5	Normal	1.732050808	1	1	0.3	0.3	∞
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	1.1	Normal	1	0.64	0.43	0.7	0.5	∞
Liquid Permittivity (target)	E.3.2	5	Rectangular	1.732050808	0.6	0.49	1.7	1.4	∞
Liquid Permittivity (measured)	E.3.3	0.7	Normal	1	0.6	0.49	0.4	0.3	∞
Combined Standard Uncertainty		**RSS**					**8.93**	**8.75**	
Expanded Uncertainty (95% Confidence Interval)		**k=2**					**17.86**	**17.50**	
Measurement Uncertainty Table in accordance with IEEE Standard 1528-2003 and IEC International Standard 62209-1:2005									

15. Dipole Calibration History
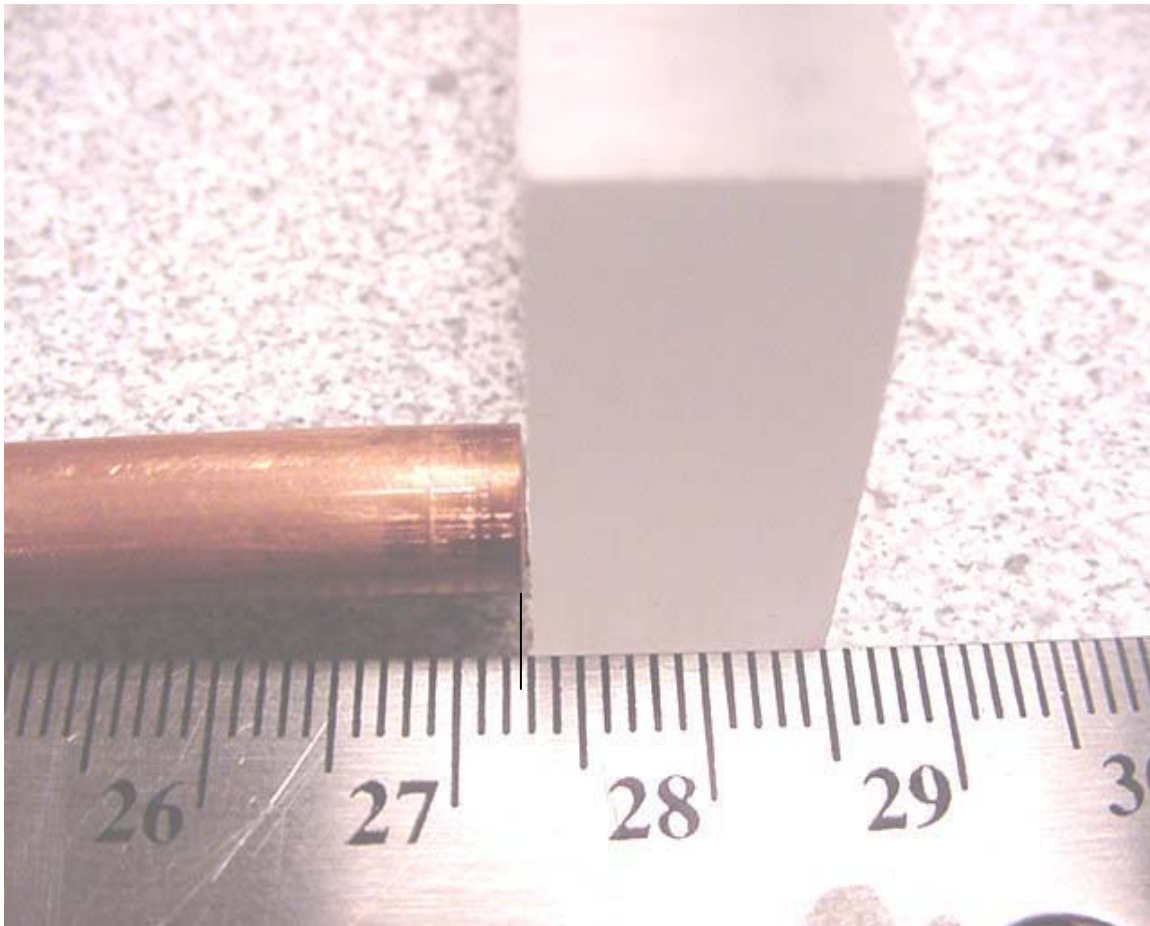
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<th colspan="3">SAR Probe Information</th>
<th colspan="5">Celltech Measured Data</th>
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<th rowspan="2">Serial Number</th>
<th rowspan="2">Calibration Factor</th>
<th rowspan="2">Calibration Procedure</th>
<th rowspan="2">SAR (W/kg) Measured at 250 mW</th>
<th rowspan="2">% Deviation from IEEE 1528 Target (4.9 W/kg @ 1 W)</th>
<th rowspan="2">% Deviation from Target validated by Celltech (4.893 W/kg @ 1 W)</th>
<th colspan="2">Dielectric Parameters</th>
<th rowspan="2">RL (dB)</th>
<th rowspan="2">Impedance</th>
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<th>σ</th>
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<tr>
<td>2004</td><td>1387</td><td>7.50</td><td>Numerical</td><td>1.23</td><td>0.41</td><td></td><td>42.90</td><td>0.85</td><td>-23.74</td><td>54.04</td>
</tr>
<tr>
<td>2005</td><td>1387</td><td>7.50</td><td>Numerical</td><td>1.24</td><td>1.22</td><td></td><td>43.20</td><td>0.84</td><td>-20.40</td><td>58.50</td>
</tr>
<tr>
<td>2006</td><td>1387</td><td>7.40</td><td>Numerical</td><td>1.27</td><td>3.67</td><td></td><td>44.70</td><td>0.90</td><td>-21.60</td><td>56.17</td>
</tr>
<tr>
<td>2007</td><td>1387</td><td>7.00</td><td>Numerical</td><td>1.29</td><td>5.31</td><td></td><td>43.10</td><td>0.85</td><td>-22.20</td><td>55.20</td>
</tr>
<tr>
<td>2008</td><td>1387</td><td>7.32</td><td>Measured</td><td>1.19</td><td></td><td>-2.72</td><td>43.60</td><td>0.86</td><td>-23.10</td><td>55.60</td>
</tr>
<tr>
<td>2008</td><td>1590</td><td>7.66</td><td>Measured</td><td>1.18</td><td></td><td>-3.53</td><td>43.44</td><td>0.89</td><td>-20.70</td><td>58.20</td>
</tr>
<tr>
<td>2008</td><td>1590</td><td>7.66</td><td>Measured</td><td>1.22</td><td></td><td>-0.26</td><td>43.80</td><td>0.86</td><td>-20.70</td><td>58.20</td>
</tr>
<tr>
<td colspan="9">Target Dielectric Parameters: $\varepsilon_r = 43.5$, $\sigma = 0.87$ s/m</td>
</tr>
</table>

APPENDIX A - PHOTOGRAPHS

Dipole Dimension L = 272.7mm

Dipole Dimension h = 167mm

Dipole Dimension d = 6.36mm

Dipole Spacer Dimension = 6.0mm

APPENDIX B - SEMCAD SIMULATION LOG FILE

```
iSolve X, Version 13.4, Build 34, 64Bit Windows, Single Precision
Simulation name 'Dielec Const = 2.7, Low Conduct'
Maxwell Solver started the 2009-Feb-09 10:40:20.
Initializing FDTD (x1 CFL) Harmonic Simulation at 450 MHz

Overall discretization:
Smallest number of cells per wavelength = 20.202, largest = 422.988, average = 113.419
Simulation time-step = 9.781e-013 s
Simulation time-step / minimum of CFL criteria = 0.999938
Maximum of CFL criteria / minimum of CFL criteria = 64.6059
Average of CFL criteria / minimum of CFL criteria = 9.92029

Discretization by solids:
Background: epsr = 1, mur = 1, sigma = 0, sigma* = 0 - smallest number of cells per wavelength =
133.241, largest = 422.988, average = 145.219
Phantom/Shell: epsr = 2.7, mur = 1, sigma = 0, sigma* = 0 - smallest number of cells per wavelength =
81.0879, largest = 237.738, average = 120.104
Phantom/Liquid: epsr = 43.5, mur = 1, sigma = 0.87, sigma* = 0 - smallest number of cells per
wavelength = 20.202, largest = 55.4378, average = 23.1303

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=285x233x175, number of voxels=11464512

Excitations:
Initializing (Voltage) edge source Quelle
Overall duration : 3.33333e-008 s or 34080 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: 17.8 seconds.

Hardware acceleration not used, please contact SPEAG for more information.
Yee (explicit) iterations starting using U-PML Boundary Condition.
0% - iterations: 8 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:34:02
0% - iterations: 16 / 34079 - [7.64 MCells/s] - Estimated time to completion: 14:11:34
0% - iterations: 24 / 34079 - [8.34 MCells/s] - Estimated time to completion: 13:00:25
0% - iterations: 32 / 34079 - [7.64 MCells/s] - Estimated time to completion: 14:11:10
0% - iterations: 43 / 34079 - [11.5 MCells/s] - Estimated time to completion: 09:27:16
0% - iterations: 53 / 34079 - [10.4 MCells/s] - Estimated time to completion: 10:23:48
0% - iterations: 62 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:32:56
```

```
0% - iterations: 70 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:59:22
0% - iterations: 77 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:50:31
0% - iterations: 84 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:11:17
0% - iterations: 91 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:50:09
0% - iterations: 100 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:32:09
0% - iterations: 110 / 34079 - [10.4 MCells/s] - Estimated time to completion: 10:22:45
0% - iterations: 118 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:58:16
0% - iterations: 126 / 34079 - [7.64 MCells/s] - Estimated time to completion: 14:08:49
0% - iterations: 133 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:49:03
0% - iterations: 140 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:48:52
0% - iterations: 147 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:48:41
0% - iterations: 154 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:48:30
0% - iterations: 161 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:48:19
0% - iterations: 170 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:30:44
1% - iterations: 179 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:30:33
1% - iterations: 186 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:47:40
1% - iterations: 191 / 34079 - [5.21 MCells/s] - Estimated time to completion: 20:42:33
1% - iterations: 198 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:08:01
1% - iterations: 203 / 34079 - [4.78 MCells/s] - Estimated time to completion: 22:35:02
1% - iterations: 208 / 34079 - [4.78 MCells/s] - Estimated time to completion: 22:34:50
1% - iterations: 214 / 34079 - [6.25 MCells/s] - Estimated time to completion: 17:14:45
1% - iterations: 221 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:07:22
1% - iterations: 228 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:46:34
1% - iterations: 235 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:06:58
1% - iterations: 243 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:55:24
1% - iterations: 252 / 34079 - [7.94 MCells/s] - Estimated time to completion: 13:34:21
1% - iterations: 257 / 34079 - [5.21 MCells/s] - Estimated time to completion: 20:40:08
1% - iterations: 262 / 34079 - [5.21 MCells/s] - Estimated time to completion: 20:39:57
1% - iterations: 269 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:45:30
1% - iterations: 277 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:54:37
1% - iterations: 286 / 34079 - [8.6 MCells/s] - Estimated time to completion: 12:30:57
1% - iterations: 290 / 34079 - [3.82 MCells/s] - Estimated time to completion: 28:09:27
1% - iterations: 295 / 34079 - [4.78 MCells/s] - Estimated time to completion: 22:31:21
1% - iterations: 300 / 34079 - [4.78 MCells/s] - Estimated time to completion: 22:31:09
1% - iterations: 305 / 34079 - [5.21 MCells/s] - Estimated time to completion: 20:38:22
1% - iterations: 313 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:53:48
1% - iterations: 320 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:44:09
1% - iterations: 327 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:43:58
1% - iterations: 339 / 34079 - [12.5 MCells/s] - Estimated time to completion: 08:35:28
1% - iterations: 347 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:53:01
1% - iterations: 355 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:52:50
1% - iterations: 362 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:03:20
1% - iterations: 369 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:42:52
1% - iterations: 376 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:02:56
1% - iterations: 383 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:42:30
1% - iterations: 391 / 34079 - [7.64 MCells/s] - Estimated time to completion: 14:02:12
1% - iterations: 400 / 34079 - [8.6 MCells/s] - Estimated time to completion: 12:28:25
1% - iterations: 407 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:41:53
1% - iterations: 415 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:51:28
1% - iterations: 424 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:25:33
1% - iterations: 433 / 34079 - [8.6 MCells/s] - Estimated time to completion: 12:27:41
1% - iterations: 442 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:25:11
1% - iterations: 449 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:40:47
1% - iterations: 456 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:00:39
1% - iterations: 461 / 34079 - [5.21 MCells/s] - Estimated time to completion: 20:32:39
1% - iterations: 468 / 34079 - [6.69 MCells/s] - Estimated time to completion: 16:00:18
1% - iterations: 475 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:40:06
1% - iterations: 481 / 34079 - [6.25 MCells/s] - Estimated time to completion: 17:06:36
1% - iterations: 486 / 34079 - [4.78 MCells/s] - Estimated time to completion: 22:23:43
1% - iterations: 491 / 34079 - [5.21 MCells/s] - Estimated time to completion: 20:31:33
1% - iterations: 498 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:39:30
1% - iterations: 504 / 34079 - [5.73 MCells/s] - Estimated time to completion: 18:39:10
1% - iterations: 510 / 34079 - [5.29 MCells/s] - Estimated time to completion: 20:12:12
2% - iterations: 516 / 34079 - [5.73 MCells/s] - Estimated time to completion: 18:38:46
2% - iterations: 523 / 34079 - [7.3 MCells/s] - Estimated time to completion: 14:38:50
2% - iterations: 531 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:48:48
2% - iterations: 539 / 34079 - [8.34 MCells/s] - Estimated time to completion: 12:48:37
2% - iterations: 548 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:23:02
2% - iterations: 557 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:22:51
2% - iterations: 566 / 34079 - [8.6 MCells/s] - Estimated time to completion: 12:24:44
2% - iterations: 575 / 34079 - [9.38 MCells/s] - Estimated time to completion: 11:22:29
```

```
62% - iterations: 21213 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:22:05
62% - iterations: 21221 / 34079 - [7.64 MCells/s] - Estimated time to completion: 05:21:27
62% - iterations: 21229 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:54:28
62% - iterations: 21238 / 34079 - [8.6 MCells/s] - Estimated time to completion: 04:45:21
62% - iterations: 21246 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:54:05
62% - iterations: 21254 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:53:54
62% - iterations: 21263 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:21:03
62% - iterations: 21271 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:53:31
62% - iterations: 21280 / 34079 - [8.6 MCells/s] - Estimated time to completion: 04:44:25
62% - iterations: 21289 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:20:32
62% - iterations: 21298 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:20:21
63% - iterations: 21307 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:20:10
63% - iterations: 21316 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:19:59
63% - iterations: 21329 / 34079 - [13.5 MCells/s] - Estimated time to completion: 02:59:48
63% - iterations: 21340 / 34079 - [10.5 MCells/s] - Estimated time to completion: 03:51:37
63% - iterations: 21349 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:19:18
63% - iterations: 21358 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:19:07
63% - iterations: 21367 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:18:56
63% - iterations: 21376 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:18:45
63% - iterations: 21383 / 34079 - [7.3 MCells/s] - Estimated time to completion: 05:32:30
63% - iterations: 21390 / 34079 - [6.69 MCells/s] - Estimated time to completion: 06:02:32
63% - iterations: 21397 / 34079 - [6.69 MCells/s] - Estimated time to completion: 06:02:20
63% - iterations: 21404 / 34079 - [6.69 MCells/s] - Estimated time to completion: 06:02:08
63% - iterations: 21411 / 34079 - [7.3 MCells/s] - Estimated time to completion: 05:31:46
63% - iterations: 21418 / 34079 - [7.3 MCells/s] - Estimated time to completion: 05:31:35
63% - iterations: 21425 / 34079 - [7.3 MCells/s] - Estimated time to completion: 05:31:24
63% - iterations: 21433 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:49:48
63% - iterations: 21442 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:17:25
63% - iterations: 21451 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:17:14
63% - iterations: 21457 / 34079 - [6.25 MCells/s] - Estimated time to completion: 06:25:40
63% - iterations: 21462 / 34079 - [5.21 MCells/s] - Estimated time to completion: 07:42:37
63% - iterations: 21467 / 34079 - [5.21 MCells/s] - Estimated time to completion: 07:42:26
63% - iterations: 21473 / 34079 - [5.29 MCells/s] - Estimated time to completion: 07:35:13
63% - iterations: 21482 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:16:36
63% - iterations: 21491 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:16:25
63% - iterations: 21499 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:48:17
63% - iterations: 21508 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:16:04
63% - iterations: 21516 / 34079 - [8.34 MCells/s] - Estimated time to completion: 04:47:54
63% - iterations: 21525 / 34079 - [8.6 MCells/s] - Estimated time to completion: 04:38:58
63% - iterations: 21534 / 34079 - [9.38 MCells/s] - Estimated time to completion: 04:15:32
63% - iterations: 21546 / 34079 - [12.5 MCells/s] - Estimated time to completion: 03:11:28
63% - iterations: 21557 / 34079 - [11.5 MCells/s] - Estimated time to completion: 03:28:42
63% - iterations: 21569 / 34079 - [12.5 MCells/s] - Estimated time to completion: 03:11:07
63% - iterations: 21581 / 34079 - [12.5 MCells/s] - Estimated time to completion: 03:10:56
Steady state detected at iteration: 21585 - 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: 21585 / 22153 - [0.0356 MCells/s] - Estimated time to completion: 50:45:54
97% - iterations: 21592 / 22153 - [6.69 MCells/s] - Estimated time to completion: 00:16:01
98% - iterations: 21600 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:12:40
98% - iterations: 21609 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:11:04
98% - iterations: 21618 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:10:53
98% - iterations: 21627 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:10:42
98% - iterations: 21636 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:10:31
98% - iterations: 21644 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:11:39
98% - iterations: 21653 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:10:11
98% - iterations: 21662 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:10:00
98% - iterations: 21671 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:10:42
98% - iterations: 21680 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:09:38
98% - iterations: 21689 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:09:27
98% - iterations: 21698 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:09:16
98% - iterations: 21706 / 22153 - [7.64 MCells/s] - Estimated time to completion: 00:11:10
98% - iterations: 21713 / 22153 - [7.3 MCells/s] - Estimated time to completion: 00:11:31
98% - iterations: 21720 / 22153 - [7.3 MCells/s] - Estimated time to completion: 00:11:20
98% - iterations: 21727 / 22153 - [6.69 MCells/s] - Estimated time to completion: 00:12:10
```

```
98% - iterations: 21735 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:09:34
98% - iterations: 21743 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:09:23
98% - iterations: 21751 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:09:12
98% - iterations: 21760 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:08:44
98% - iterations: 21769 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:08:32
98% - iterations: 21778 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:08:20
98% - iterations: 21786 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:08:24
98% - iterations: 21794 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:08:13
98% - iterations: 21802 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:08:02
98% - iterations: 21810 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:07:51
98% - iterations: 21818 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:07:40
99% - iterations: 21826 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:07:29
99% - iterations: 21834 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:07:18
99% - iterations: 21841 / 22153 - [7.3 MCells/s] - Estimated time to completion: 00:08:10
99% - iterations: 21849 / 22153 - [7.64 MCells/s] - Estimated time to completion: 00:07:36
99% - iterations: 21857 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:06:47
99% - iterations: 21865 / 22153 - [7.64 MCells/s] - Estimated time to completion: 00:07:12
99% - iterations: 21873 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:06:25
99% - iterations: 21881 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:06:14
99% - iterations: 21889 / 22153 - [7.64 MCells/s] - Estimated time to completion: 00:06:36
99% - iterations: 21897 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:05:52
99% - iterations: 21905 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:05:41
99% - iterations: 21913 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:05:30
99% - iterations: 21921 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:05:19
99% - iterations: 21929 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:05:08
99% - iterations: 21938 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:04:46
99% - iterations: 21947 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:04:11
99% - iterations: 21956 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:04:22
99% - iterations: 21965 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:03:49
99% - iterations: 21972 / 22153 - [7.3 MCells/s] - Estimated time to completion: 00:04:44
99% - iterations: 21981 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:03:30
99% - iterations: 21990 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:03:19
99% - iterations: 22001 / 22153 - [11.5 MCells/s] - Estimated time to completion: 00:02:32
99% - iterations: 22012 / 22153 - [11.5 MCells/s] - Estimated time to completion: 00:02:21
99% - iterations: 22021 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:02:41
99% - iterations: 22030 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:02:44
99% - iterations: 22039 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:02:19
100% - iterations: 22048 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:02:08
100% - iterations: 22056 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:02:13
100% - iterations: 22065 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:01:47
100% - iterations: 22072 / 22153 - [7.3 MCells/s] - Estimated time to completion: 00:02:07
100% - iterations: 22078 / 22153 - [6.25 MCells/s] - Estimated time to completion: 00:02:17
100% - iterations: 22084 / 22153 - [6.25 MCells/s] - Estimated time to completion: 00:02:06
100% - iterations: 22092 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:01:23
100% - iterations: 22101 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:01:03
100% - iterations: 22109 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:01:00
100% - iterations: 22118 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:00:42
100% - iterations: 22126 / 22153 - [8.34 MCells/s] - Estimated time to completion: 00:00:37
100% - iterations: 22135 / 22153 - [9.38 MCells/s] - Estimated time to completion: 00:00:22
100% - iterations: 22144 / 22153 - [8.6 MCells/s] - Estimated time to completion: 00:00:12
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: 22153 / 22153 - [0.0834 MCells/s] - Estimated time to completion: 00:00:00

Convert time-domain data to frequency-domain data.

Maxwell Solver run ended the 2009-Feb-09 21:12:38. Total simulation time was 10:32:18 (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.

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

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Accreditation No.: **SCS 108**

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 ≤ 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 ≤ 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

|		3.7 mm	4.7 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).

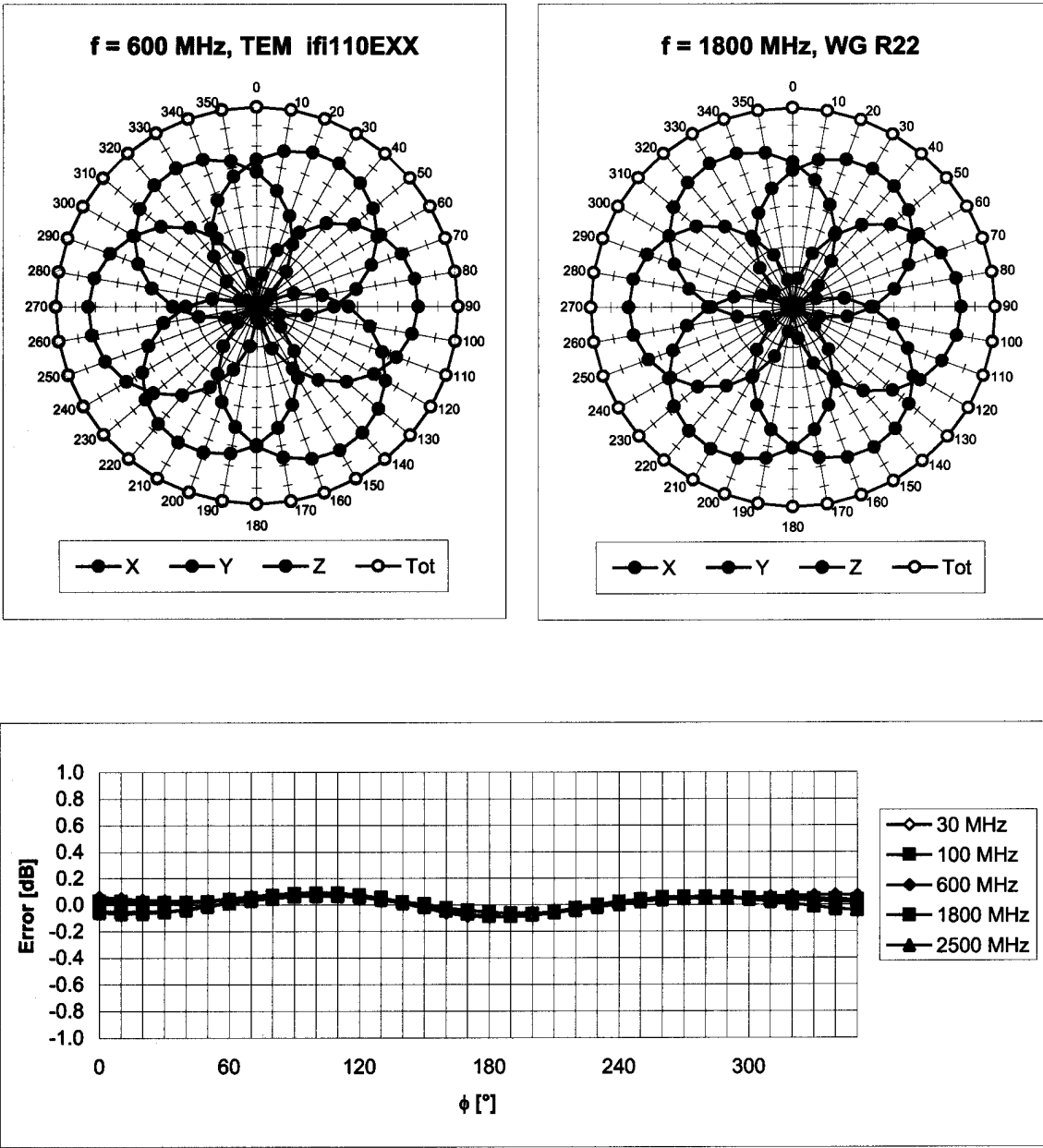[B] Numerical linearization parameter: uncertainty not required.

Frequency Response of E-Field
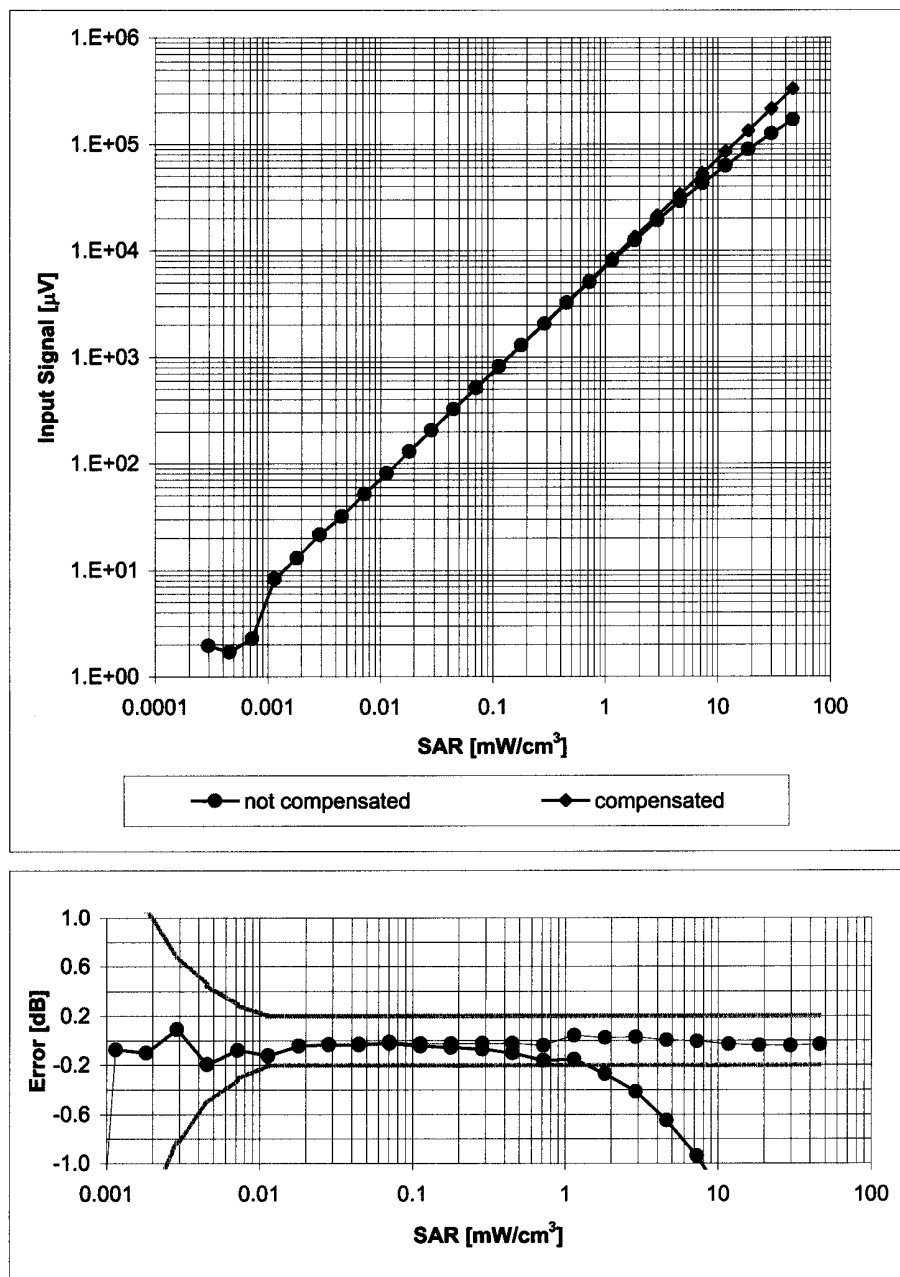
(TEM-Cell:ifi110 EXX, Waveguide: R22)
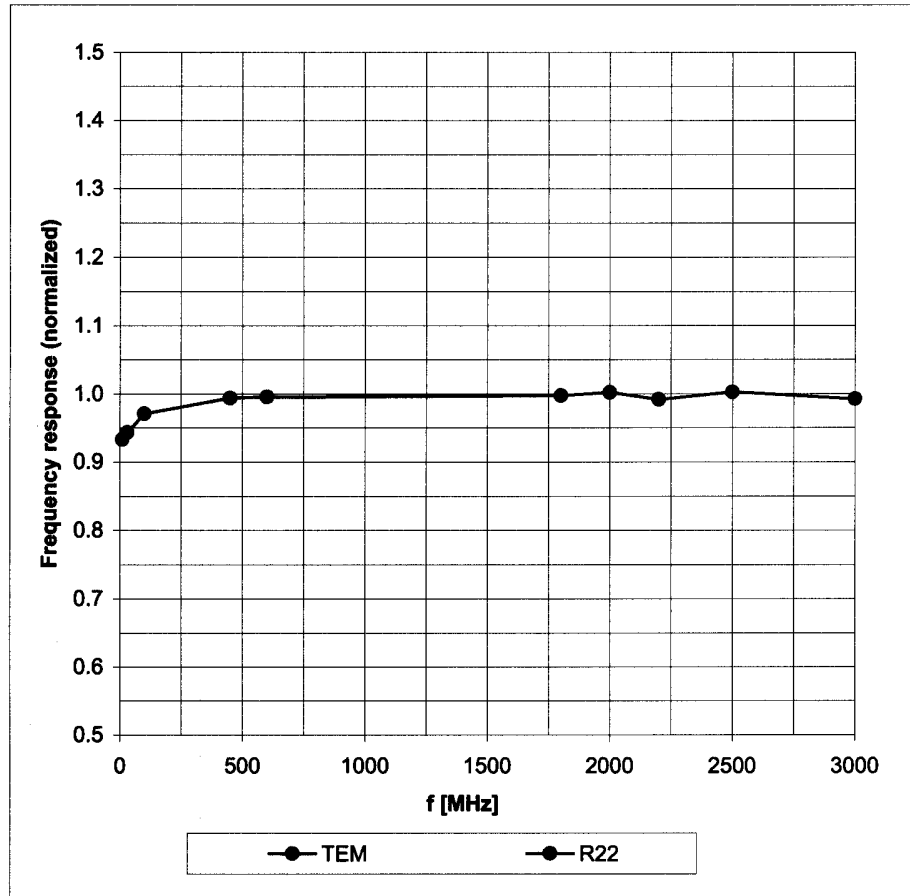
Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)
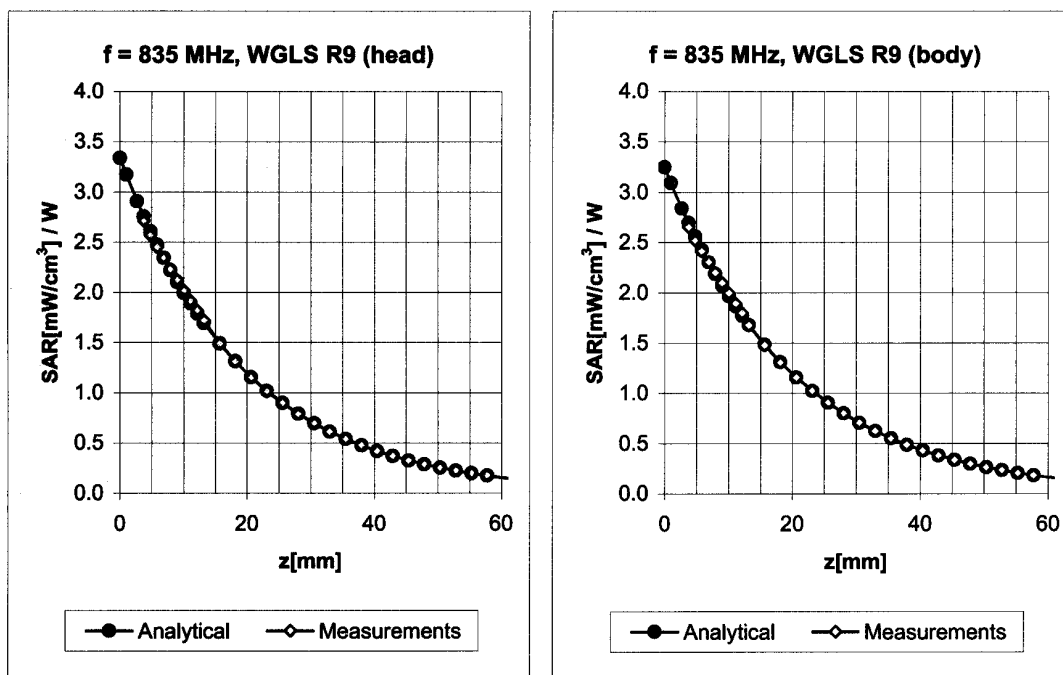
Receiving Pattern (ϕ), $\vartheta = 0°$

f = 600 MHz, TEM ifi110EXX

f = 1800 MHz, WG R22

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 = 835 MHz, WGLS R9 (head)

f = 835 MHz, WGLS R9 (body)

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

Legend:
■ -1.00--0.80 ▨ -0.80--0.60 ▨ -0.60--0.40 ▨ -0.40--0.20 ▨ -0.20-0.00
□ 0.00-0.20 ▨ 0.20-0.40 □ 0.40-0.60 ▨ 0.60-0.80 ■ 0.80-1.00
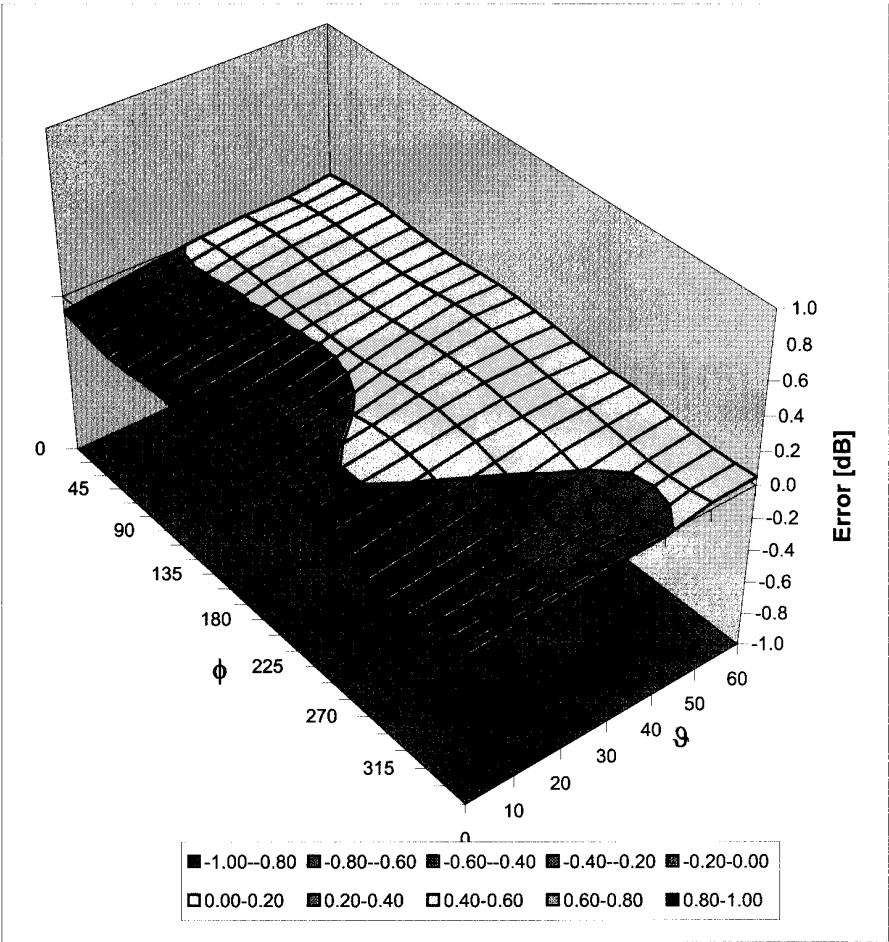
Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)