



TTL-P-G 158



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**Appendix for the Report**

**Dosimetric Assessment of the**

**MSA EVOLUTION 5000 Transmitter**

**According to the FCC Requirements**

**Calibration Data**

November 13, 2003  
**IMST GmbH**  
**Carl-Friedrich-Gauß-Str. 2**  
**D-47475 Kamp-Lintfort**

Customer  
MSA AUER  
Thielemannstraße 1  
12059 Berlin  
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# Schmid & Partner Engineering AG

Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

## Calibration Certificate

### 2450 MHz System Validation Dipole

Type:

D2450V2

Serial Number:

709

Place of Calibration:

Zurich

Date of Calibration:

July 15, 2002

Calibration Interval:

24 months

Schmid & Partner Engineering AG hereby certifies, that this device has been calibrated on the date indicated above. The calibration was performed in accordance with specifications and procedures of Schmid & Partner Engineering AG.

Wherever applicable, the standards used in the calibration process are traceable to international standards. In all other cases the standards of the Laboratory for EMF and Microwave Electronics at the Swiss Federal Institute of Technology (ETH) in Zurich, Switzerland have been applied.

Calibrated by:

D. Vetter

Approved by:

Adrian Katya

**Schmid & Partner  
Engineering AG**

Zeughausstrasse 43, 8004 Zurich, Switzerland, Phone +41 1 245 97 00, Fax +41 1 245 97 79

# DASY3

## Dipole Validation Kit

Type: D2450V2

Serial: 709

Manufactured: July 5, 2002  
Calibrated: July 15, 2002

## 1. Measurement Conditions

The measurements were performed in the flat section of the new SAM twin phantom filled with head simulating solution of the following electrical parameters at 2450 MHz:

Relative permittivity	<b>38.3</b>	$\pm 5\%$
Conductivity	<b>1.90 mho/m</b>	$\pm 10\%$

The DASY3 System (Software version 3.1d) with a dosimetric E-field probe ET3DV6 (SN:1507, conversion factor 5.0 at 2450 MHz) was used for the measurements.

The dipole feedpoint was positioned below the center marking and oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole center to the solution surface. The included distance holder was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 20mm was aligned with the dipole. The 5x5x7 fine cube was chosen for cube integration. Probe isotropy errors were cancelled by measuring the SAR with normal and 90° turned probe orientations and averaging.

The dipole input power (forward power) was 250mW  $\pm 3\%$ . The results are normalized to 1W input power.

### 2.1. SAR Measurement with DASY3 System

Standard SAR-measurements were performed according to the measurement conditions described in section 1. The results (see figure supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured with the dosimetric probe ET3DV6 SN:1507 and applying the worst-case extrapolation are:

averaged over 1 cm <sup>3</sup> (1 g) of tissue:	<b>58.0 mW/g</b>
averaged over 10 cm <sup>3</sup> (10 g) of tissue:	<b>26.7 mW/g</b>

### 2.2 SAR Measurement with DASY4 System

Standard SAR-measurements were performed according to the measurement conditions described in section 1. The results (see figure supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured with the dosimetric probe ET3DV6 SN:1507 and applying the advanced extrapolation are:

averaged over 1 cm <sup>3</sup> (1 g) of tissue:	<b>54.8 mW/g</b>
averaged over 10 cm <sup>3</sup> (10 g) of tissue:	<b>25.5 mW/g</b>

### 3. Dipole impedance and return loss

The impedance was measured at the SMA-connector with a network analyzer and numerically transformed to the dipole feedpoint. The transformation parameters from the SMA-connector to the dipole feedpoint are:

Electrical delay:	<b>1.159 ns</b>	(one direction)
Transmission factor:	<b>0.992</b>	(voltage transmission, one direction)

The dipole was positioned at the flat phantom sections according to section 1 and the distance holder was in place during impedance measurements.

Feedpoint impedance at 2450 MHz:	$\text{Re}\{Z\} = $	<b>51.6 <math>\Omega</math></b>
	$\text{Im}\{Z\} = $	<b>1.7 <math>\Omega</math></b>
Return Loss at 2450 MHz		<b>- 33.0 dB</b>

### 4. Measurement Conditions

The measurements were performed in the flat section of the new SAM twin phantom filled with body simulating solution of the following electrical parameters at 2450 MHz:

Relative permittivity	<b>51.7</b>	$\pm 5\%$
Conductivity	<b>2.01 mho/m</b>	$\pm 10\%$

The DASY3 System (Software version 3.1d) with a dosimetric E-field probe ET3DV6 (SN:1507, conversion factor 4.5 at 2450 MHz) was used for the measurements.

The dipole feedpoint was positioned below the center marking and oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 10mm from dipole center to the solution surface. The included distance holder was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 20mm was aligned with the dipole. The 5x5x7 fine cube was chosen for cube integration. Probe isotropy errors were cancelled by measuring the SAR with normal and 90° turned probe orientations and averaging.

The dipole input power (forward power) was 250mW  $\pm 3\%$ . The results are normalized to 1W input power.

### **5.1. SAR Measurement with DASY3 System**

Standard SAR-measurements were performed according to the measurement conditions described in section 4. The results (see figure supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured with the dosimetric probe ET3DV6 SN:1507 and applying the worst-case extrapolation are:

averaged over 1 cm<sup>3</sup> (1 g) of tissue:       **57.6 mW/g**

averaged over 10 cm<sup>3</sup> (10 g) of tissue:       **26.8 mW/g**

### **5.2 SAR Measurement with DASY4 System**

Standard SAR-measurements were performed according to the measurement conditions described in section 4. The results (see figure supplied) have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values measured with the dosimetric probe ET3DV6 SN:1507 and applying the advanced extrapolation are:

averaged over 1 cm<sup>3</sup> (1 g) of tissue:       **52.0 mW/g**

averaged over 10 cm<sup>3</sup> (10 g) of tissue:       **25.0 mW/g**

### **6. Dipole impedance and return loss**

The dipole was positioned at the flat phantom sections according to section 4 and the distance holder was in place during impedance measurements.

Feedpoint impedance at 2450 MHz:       Re{Z} = **47.6 Ω**

Im {Z} = **2.8 Ω**

Return Loss at 2450 MHz                   **- 28.5**

### **7. Handling**

Do not apply excessive force to the dipole arms, because they might bend. Bending of the dipole arms stresses the soldered connections near the feedpoint leading to a damage of the dipole.

### **8. Design**

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.

Small end caps have been added to the dipole arms in order to improve matching when loaded according to the position as explained in Section 1. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

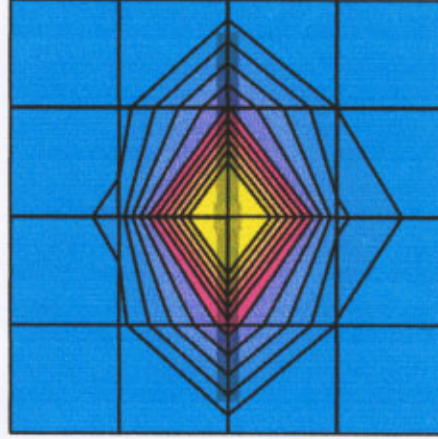
### **9. Power Test**

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

07/10/02

### Validation Dipole D2450V2 SN709, d = 10 mm

Frequency: 2450 MHz; Antenna Input Power: 250 [mW]  
SAM Phantom, Flat Section; Grid Spacing: Dx = 20.0, Dy = 20.0, Dz = 10.0  
Probe: ET3DV6 - SN1507; ConvF(5.00,5.00,5.00) at 2450 MHz; IEEE1528 2450 MHz:  $\sigma = 1.90$  mho/m  $\epsilon_r = 38.3$   $\rho = 1.00$  g/cm<sup>3</sup>  
Cubes (2): Peak: 29.8 mW/g  $\pm$  0.03 dB, SAR (1g): 14.5 mW/g  $\pm$  0.03 dB, SAR (10g): 6.68 mW/g  $\pm$  0.02 dB, (Worst-case extrapolation)  
Penetration depth: 6.5 (6.3, 6.9) [mm]  
Powerdrift: 0.01 dB

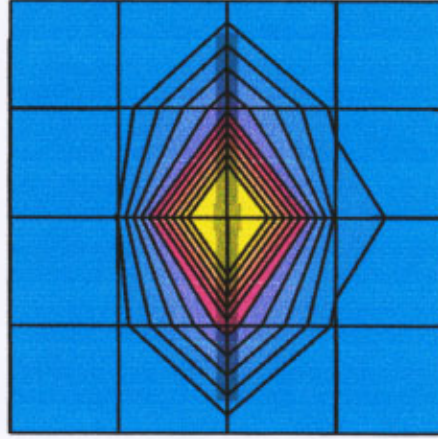




07/15/02

### Validation Dipole D2450V2 SN709, d = 10 mm

Frequency: 2450 MHz, Antenna Input Power: 250 [mW]  
SAM Phantom; Flat Section; Grid Spacing: Dx = 20.0, Dy = 20.0, Dz = 10.0  
Probe: ET3DV6 - SNI507; ConvF(4.50,4.50,4.50) at 2450 MHz; IEEE1528 2450 MHz:  $\sigma = 2.01$  mho/m  $\epsilon_r = 51.7$   $\rho = 1.00$  g/cm<sup>3</sup>  
Cubes (2): Peak: 28.8 mW/g  $\pm$  0.02 dB, SAR (1g): 14.4 mW/g  $\pm$  0.02 dB, SAR (10g): 6.71 mW/g  $\pm$  0.01 dB, (Worst-case extrapolation)  
Penetration depth: 7.2 (6.9, 7.9) [mm]  
Powerdrift: 0.01 dB

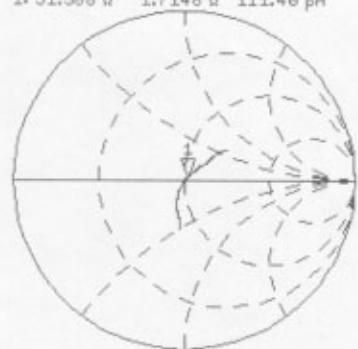


10 Jul 2002 10:01:35  
[CH1] S11 1 U FS 1: 51.500  $\Omega$  1.7148  $\mu$  111.40 pM 2 450.000 000 MHz

De1

PRa  
Cor  
Avg  
15

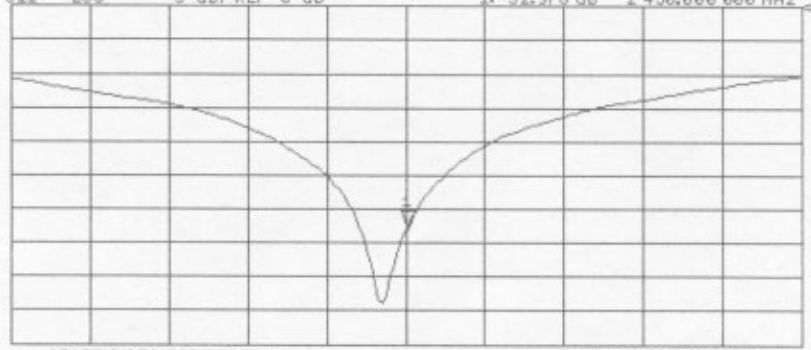
↑



CH2 S11 LOG 5 dB/REF 0 dB 1: -32.978 dB 2 450.000 000 MHz

PRa  
Cor

↑



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz

07/10/02

### Validation Dipole D2450V2 SN709, d = 10 mm

Frequency: 2450 MHz; Antenna Input Power: 250 [mW]

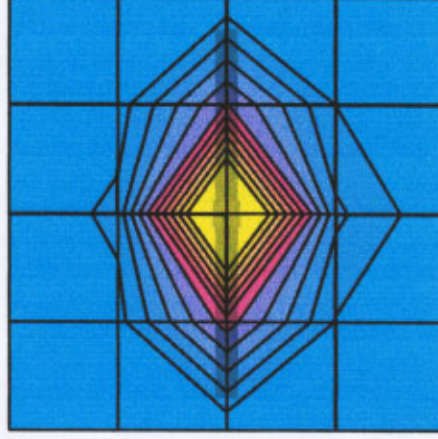
SAM Phantom; Flat Section; Grid Spacing: Dx = 20.0, Dy = 20.0, Dz = 10.0

Probe: ET3DY6 - SN1507; ConvF(5.00,5.00,5.00) at 2450 MHz; IEEE1528 2450 MHz;  $\sigma = 1.90$  mho/m  $\epsilon_r = 38.3$   $\rho = 1.00$  g/cm<sup>3</sup>

Cubes (2): Peak: 27.2 mW/g  $\pm 0.03$  dB, SAR (1g): 13.7 mW/g  $\pm 0.03$  dB, SAR (10g): 6.38 mW/g  $\pm 0.02$  dB, (Advanced extrapolation)

Penetration depth: 6.8 (6.6, 7.0) [mm]

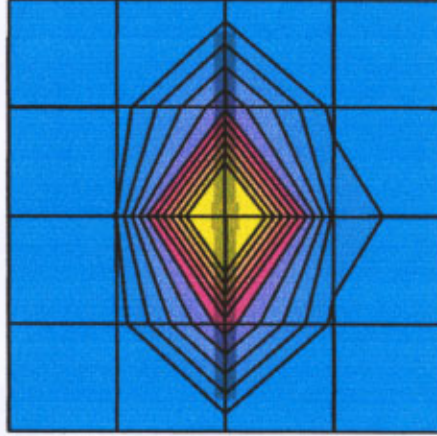
Powerdrift: 0.01 dB



07/15/02

### Validation Dipole D2450V2 SN709, d = 10 mm

Frequency: 2450 MHz; Antenna Input Power: 250 [mW]  
SAM Phantom; Flat Section; Grid Spacing: Dx = 20.0, Dy = 20.0, Dz = 10.0  
Probe: ET3DV6 - SN1507; ConvF(4.50,4.50) at 2450 MHz; IEEE1528 2450 MHz:  $\sigma = 2.01$  mho/m  $\epsilon_r = 51.7$   $\rho = 1.00$  g/cm<sup>3</sup>  
Cubes (2): Peak: 24.7 mW/g  $\pm 0.02$  dB, SAR (1g): 13.0 mW/g  $\pm 0.02$  dB, SAR (10g): 6.24 mW/g  $\pm 0.01$  dB, (Advanced extrapolation)  
Penetration depth: 7.8 (7.7, 8.1) [mm]  
Powerdrift: 0.01 dB



15 Jul 2002 09:44:33  
[CH1] S11 1 U FS 1: 47.592  $\alpha$  2.7949  $\alpha$  181.56 pH 2 450.000 000 MHz

2.450 MHz

Del

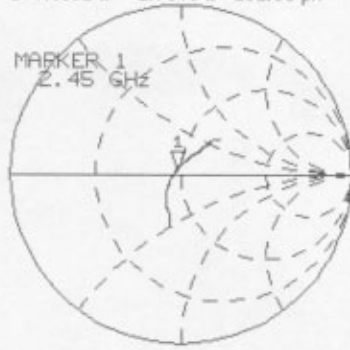
PRm

Cor

Avg

16

↑

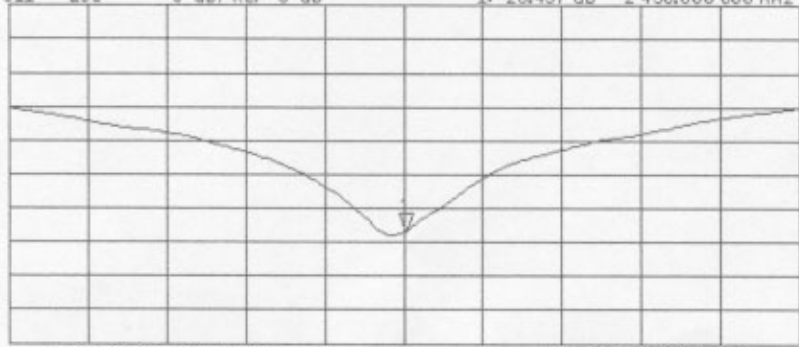


CH2 S11 LOG 5 dB/REF 0 dB 1: -28.457 dB 2 450.000 000 MHz

PRm

Cor

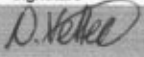
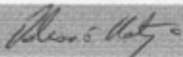
↑



START 2 250.000 000 MHz

STOP 2 650.000 000 MHz

Client **IMST**

CALIBRATION CERTIFICATE			
Object(s)	ET3DV6 - SN:1579		
Calibration procedure(s)	QA CAL-01.v2 Calibration procedure for dosimetric E-field probes		
Calibration date:	May 15, 2003		
Condition of the calibrated item	In Tolerance (according to the specific calibration document)		
This calibration statement documents traceability of M&TE used in the calibration procedures and conformity of the procedures with the ISO/IEC 17025 international standard.			
All calibrations have been conducted in the closed laboratory facility: environment temperature 22 +/- 2 degrees Celsius and humidity < 75%.			
Calibration Equipment used (M&TE critical for calibration)			
Model Type	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
RF generator HP 8684C	US3642U01700	4-Aug-99 (SPEAG, in house check Aug-02)	In house check: Aug-05
Power sensor E4412A	MY41495277	2-Apr-03 (METAS, No 252-0250)	Apr-04
Power sensor HP 8481A	MY41092180	18-Sep-02 (Agilent, No. 20020918)	Sep-03
Power meter EPM E4419B	GB41293874	2-Apr-03 (METAS, No 252-0250)	Apr-04
Network Analyzer HP 8753E	US38432426	3-May-00 (Agilent, No. 8702K064602)	In house check: May 03
Fluke Process Calibrator Type 702	SN: 6295803	3-Sep-01 (ELCAL, No.2360)	Sep-03
Calibrated by:	Name Nico Vetterli	Function Technician	Signature 
Approved by:	Katja Pokovic	Laboratory Director	
Date issued: May 15, 2003			
This calibration certificate is issued as an intermediate solution until the accreditation process (based on ISO/IEC 17025 International Standard) for Calibration Laboratory of Schmid & Partner Engineering AG is completed.			



# Probe ET3DV6

SN:1579

Manufactured:	May 7, 2001
Last calibration:	August 27, 2002
Recalibrated:	May 15, 2003

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

**DASY - Parameters of Probe: ET3DV6 SN:1579****Sensitivity in Free Space**

NormX	<b>1.65</b> $\mu\text{V}/(\text{V}/\text{m})^2$
NormY	<b>1.59</b> $\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	<b>1.58</b> $\mu\text{V}/(\text{V}/\text{m})^2$

**Diode Compression**

DCP X	<b>94</b>	mV
DCP Y	<b>94</b>	mV
DCP Z	<b>94</b>	mV

**Sensitivity in Tissue Simulating Liquid**

Head                      900 MHz                       $\epsilon_r = 41.5 \pm 5\%$                        $\sigma = 0.97 \pm 5\%$  mho/m

Valid for f=800-1000 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	<b>6.7</b> $\pm 9.5\%$ (k=2)	Boundary effect:
ConvF Y	<b>6.7</b> $\pm 9.5\%$ (k=2)	Alpha <b>0.34</b>
ConvF Z	<b>6.7</b> $\pm 9.5\%$ (k=2)	Depth <b>2.58</b>

Head                      1800 MHz                       $\epsilon_r = 40.0 \pm 5\%$                        $\sigma = 1.40 \pm 5\%$  mho/m

Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	<b>5.3</b> $\pm 9.5\%$ (k=2)	Boundary effect:
ConvF Y	<b>5.3</b> $\pm 9.5\%$ (k=2)	Alpha <b>0.45</b>
ConvF Z	<b>5.3</b> $\pm 9.5\%$ (k=2)	Depth <b>2.77</b>

**Boundary Effect**

Head                      900 MHz                      Typical SAR gradient: 5 % per mm

Probe Tip to Boundary		<b>1 mm</b>	<b>2 mm</b>
SAR <sub>be</sub> [%]	Without Correction Algorithm	9.2	5.3
SAR <sub>be</sub> [%]	With Correction Algorithm	0.3	0.5

Head                      1800 MHz                      Typical SAR gradient: 10 % per mm

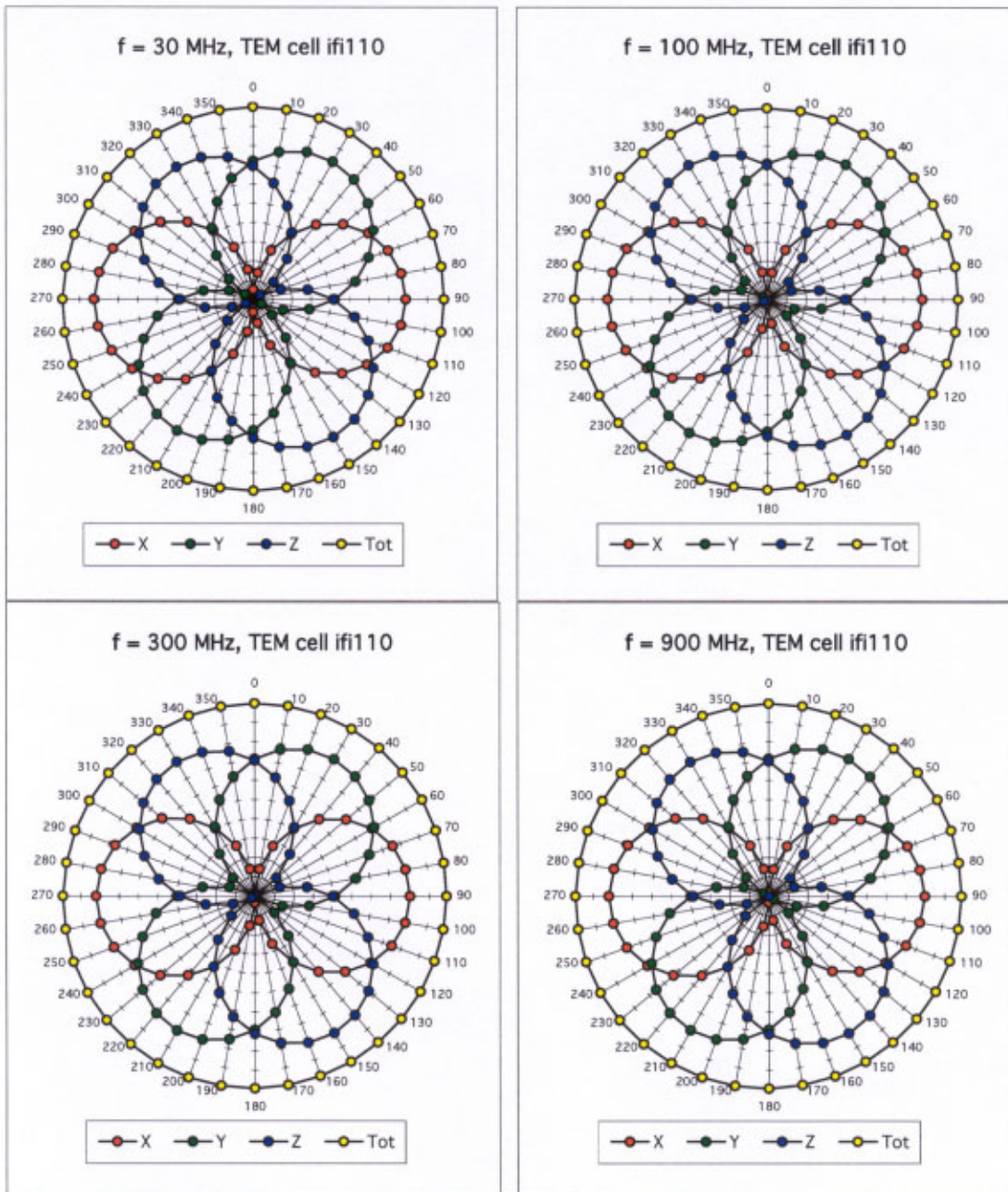
Probe Tip to Boundary		<b>1 mm</b>	<b>2 mm</b>
SAR <sub>be</sub> [%]	Without Correction Algorithm	13.2	9.3
SAR <sub>be</sub> [%]	With Correction Algorithm	0.2	0.2

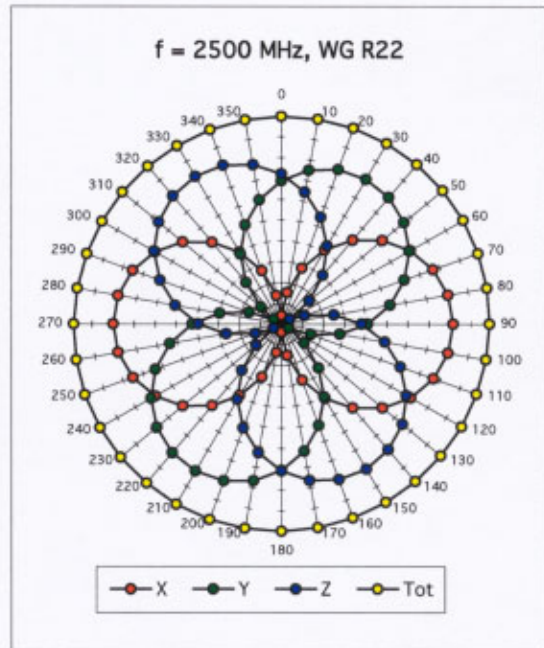
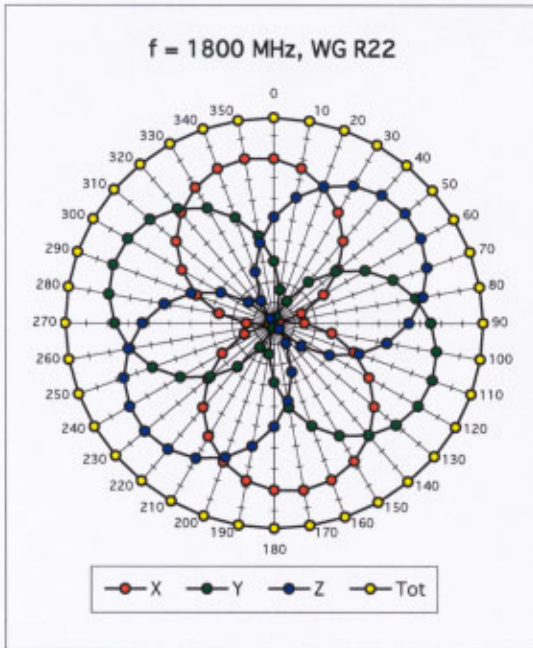
**Sensor Offset**

Probe Tip to Sensor Center	<b>2.7</b>	mm
Optical Surface Detection	<b>1.1 <math>\pm</math> 0.2</b>	mm

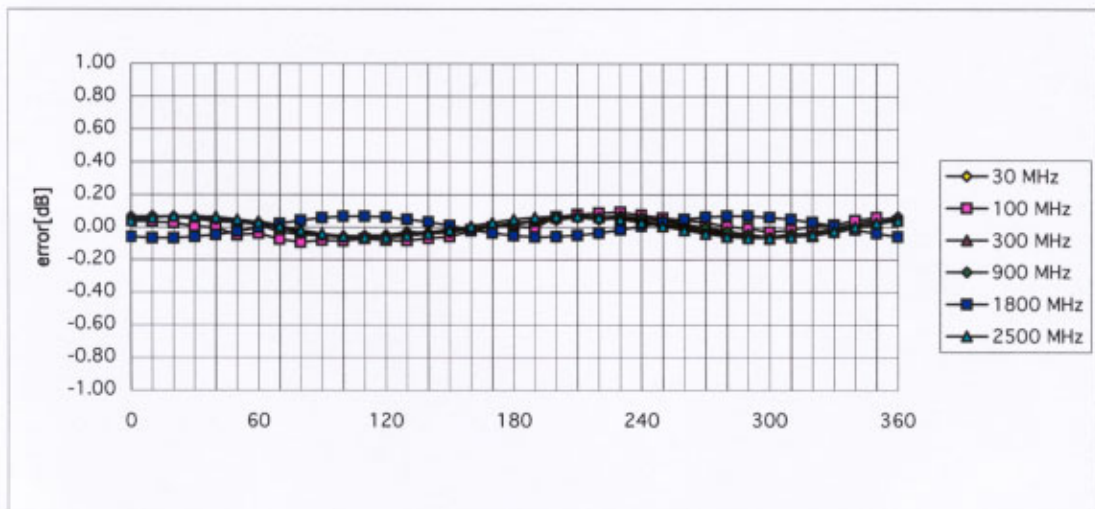


Receiving Pattern ( $\phi$ ),  $\theta = 0^\circ$



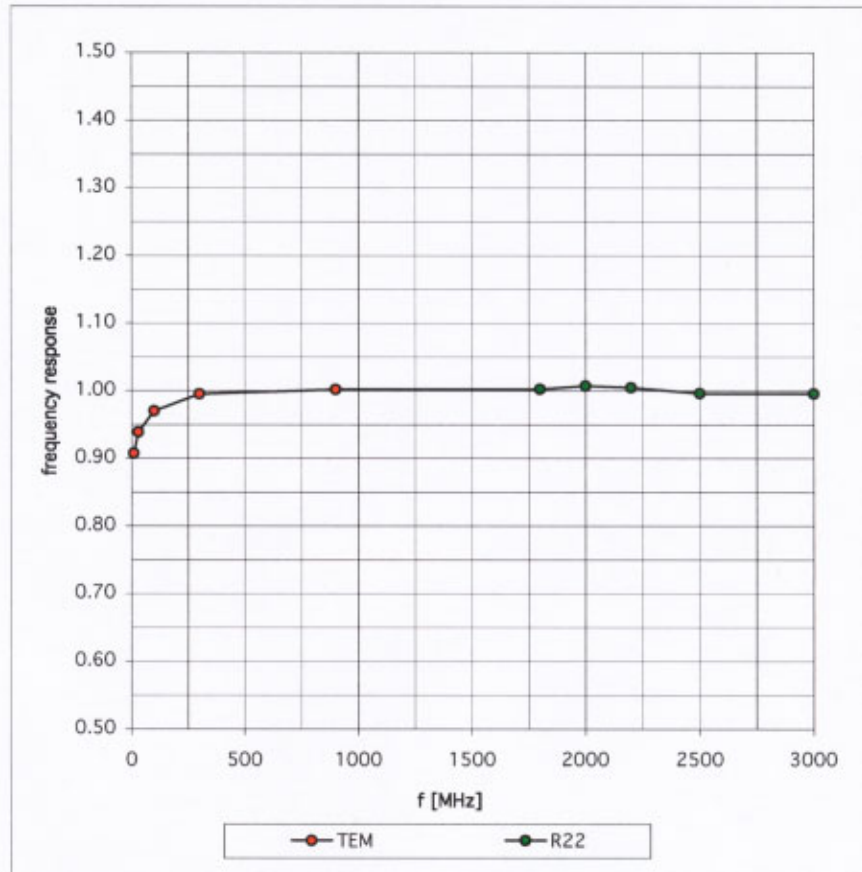


**Isotropy Error ( $\phi$ ),  $\theta = 0^\circ$**



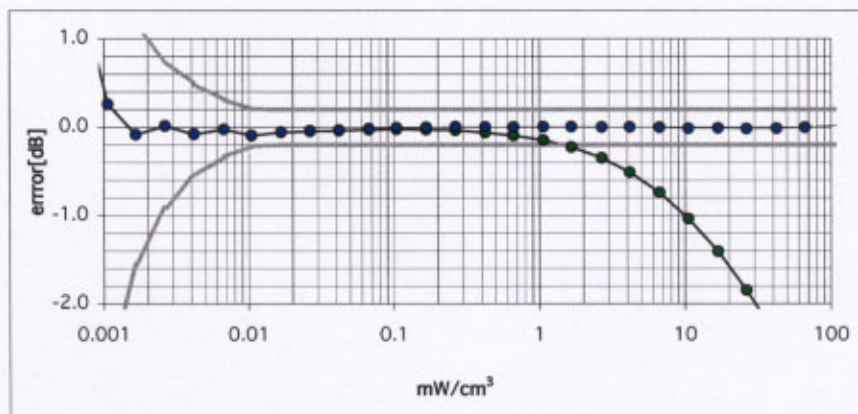
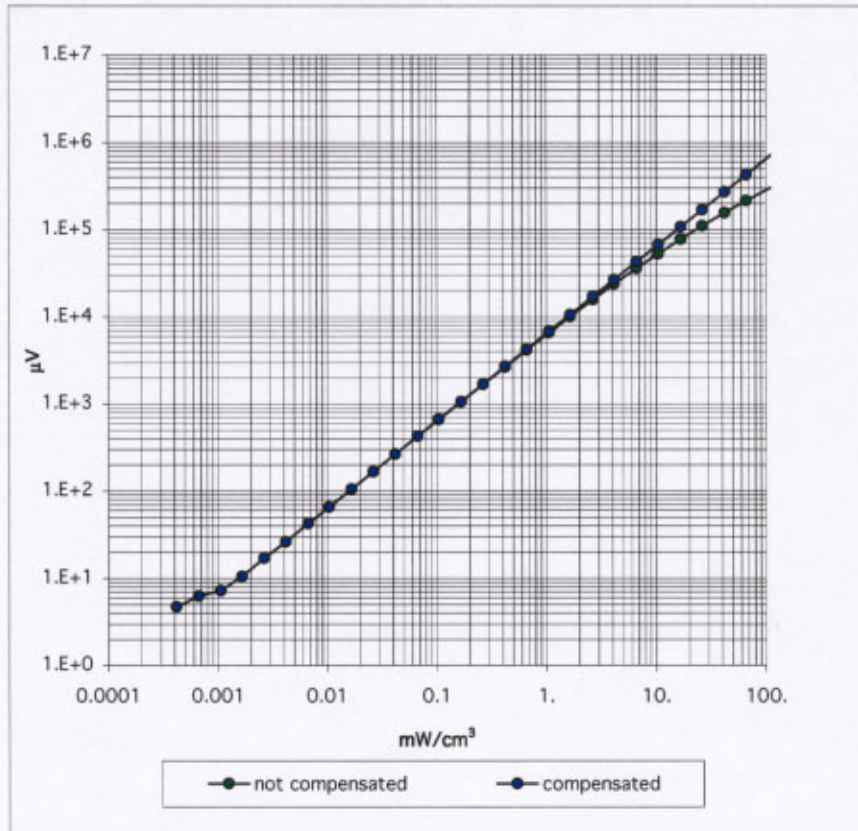
## Frequency Response of E-Field

( TEM-Cell:ifi110, Waveguide R22)



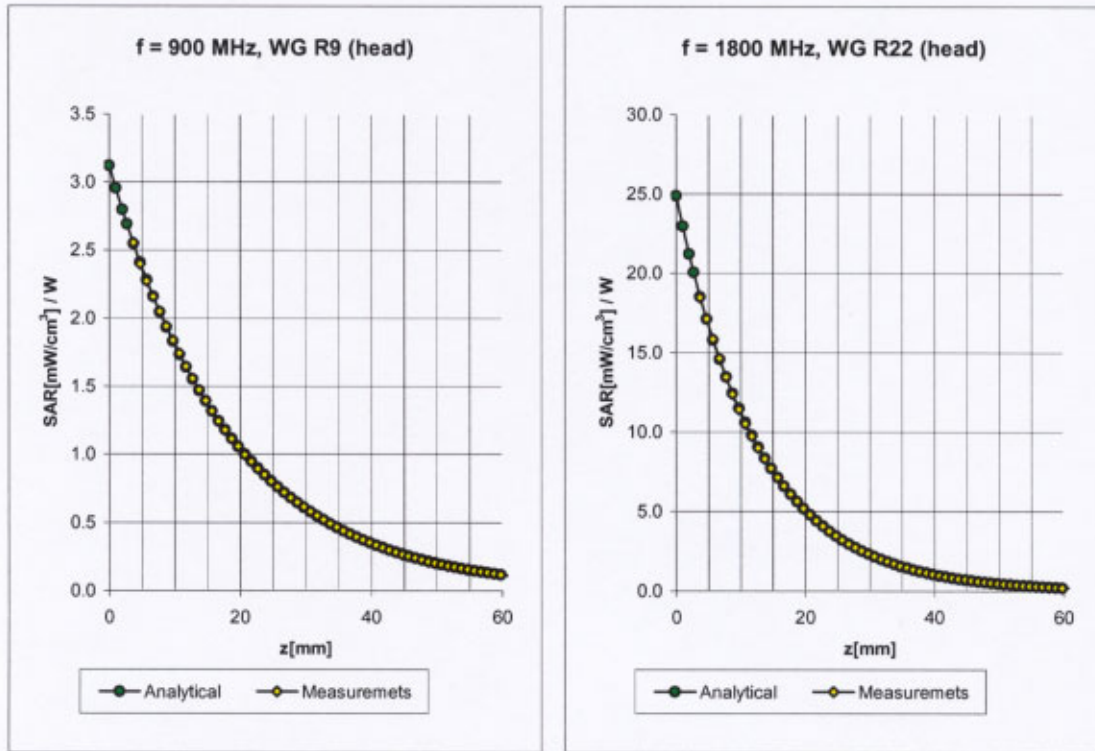
### Dynamic Range f(SAR<sub>brain</sub>)

( Waveguide R22 )





### Conversion Factor Assessment



Head                      900 MHz                       $\epsilon_r = 41.5 \pm 5\%$                        $\sigma = 0.97 \pm 5\%$  mho/m

Valid for f=800-1000 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

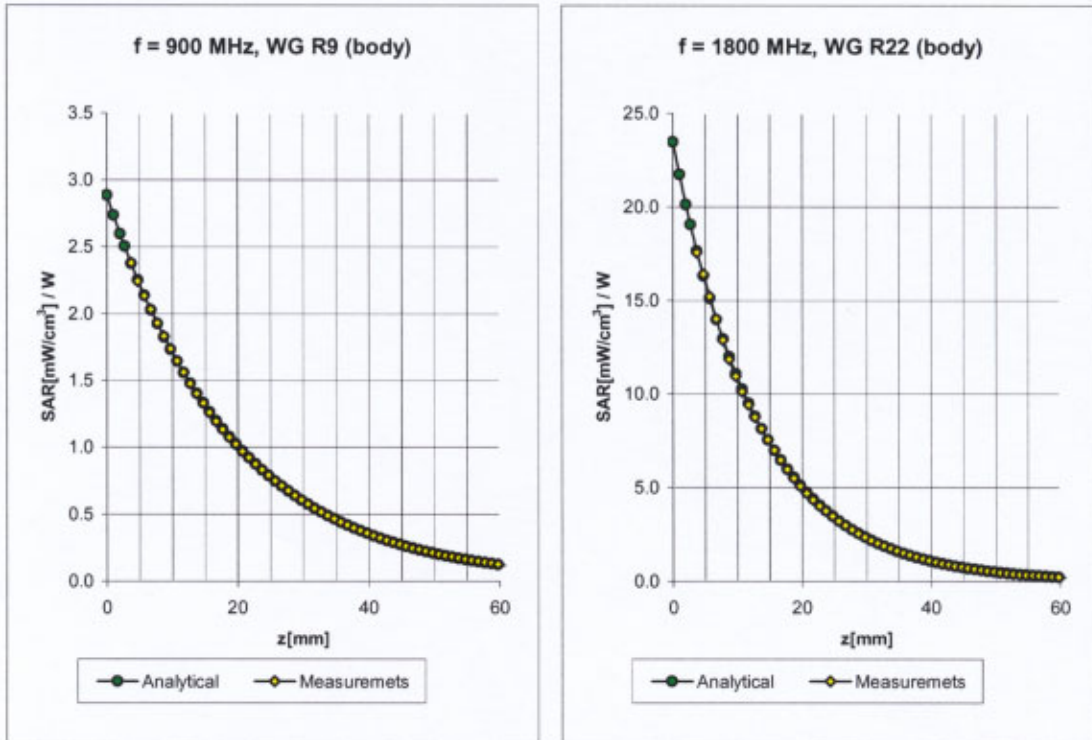
ConvF X	<b>6.7</b> $\pm 9.5\%$ (k=2)	Boundary effect:	
ConvF Y	<b>6.7</b> $\pm 9.5\%$ (k=2)	Alpha	<b>0.34</b>
ConvF Z	<b>6.7</b> $\pm 9.5\%$ (k=2)	Depth	<b>2.58</b>

Head                      1800 MHz                       $\epsilon_r = 40.0 \pm 5\%$                        $\sigma = 1.40 \pm 5\%$  mho/m

Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	<b>5.3</b> $\pm 9.5\%$ (k=2)	Boundary effect:	
ConvF Y	<b>5.3</b> $\pm 9.5\%$ (k=2)	Alpha	<b>0.45</b>
ConvF Z	<b>5.3</b> $\pm 9.5\%$ (k=2)	Depth	<b>2.77</b>

### Conversion Factor Assessment



Body                      900 MHz                       $\epsilon_r = 55.0 \pm 5\%$                        $\sigma = 1.05 \pm 5\%$  mho/m

Valid for f=800-1000 MHz with Body Tissue Simulating Liquid according to OET 65 Suppl. C

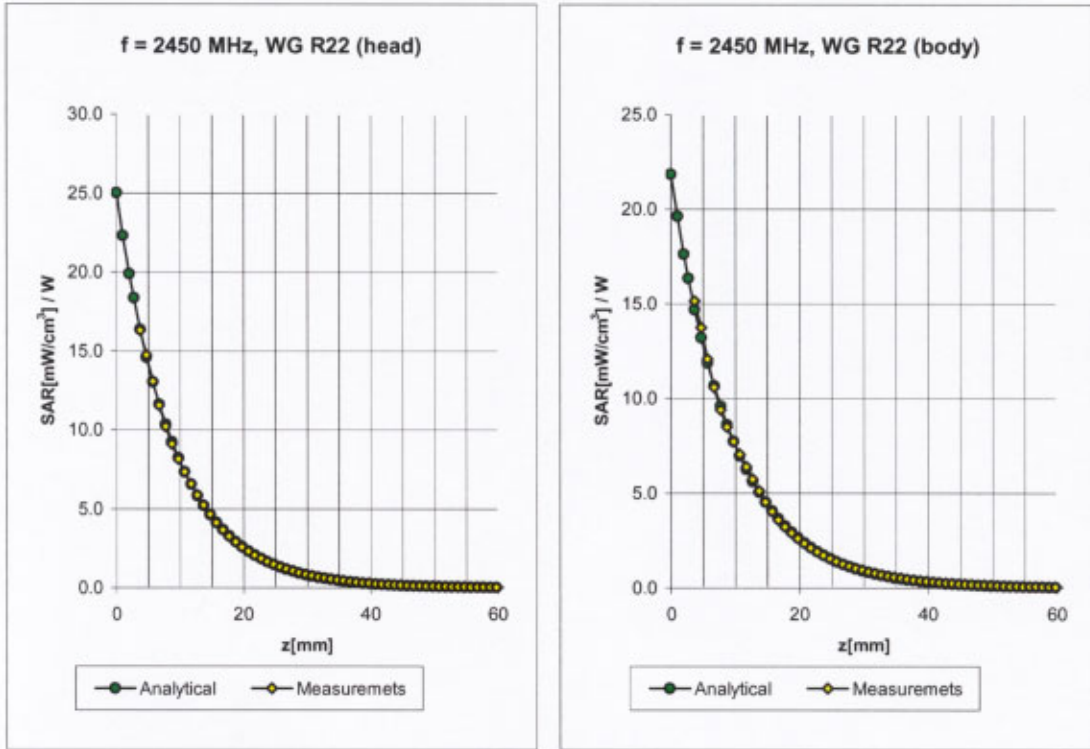
ConvF X	6.5 ± 9.5% (k=2)	Boundary effect:	
ConvF Y	6.5 ± 9.5% (k=2)	Alpha	<b>0.37</b>
ConvF Z	6.5 ± 9.5% (k=2)	Depth	<b>2.52</b>

Body                      1800 MHz                       $\epsilon_r = 53.3 \pm 5\%$                        $\sigma = 1.52 \pm 5\%$  mho/m

Valid for f=1710-1910 MHz with Body Tissue Simulating Liquid according to OET 65 Suppl. C

ConvF X	4.8 ± 9.5% (k=2)	Boundary effect:	
ConvF Y	4.8 ± 9.5% (k=2)	Alpha	<b>0.53</b>
ConvF Z	4.8 ± 9.5% (k=2)	Depth	<b>2.66</b>

### Conversion Factor Assessment



Head      2450      MHz       $\epsilon_r = 39.2 \pm 5\%$        $\sigma = 1.80 \pm 5\%$  mho/m

Valid for f=2400-2500 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

ConvF X	<b>4.8</b> $\pm 8.9\%$ (k=2)	Boundary effect:	
ConvF Y	<b>4.8</b> $\pm 8.9\%$ (k=2)	Alpha	<b>0.93</b>
ConvF Z	<b>4.8</b> $\pm 8.9\%$ (k=2)	Depth	<b>1.95</b>

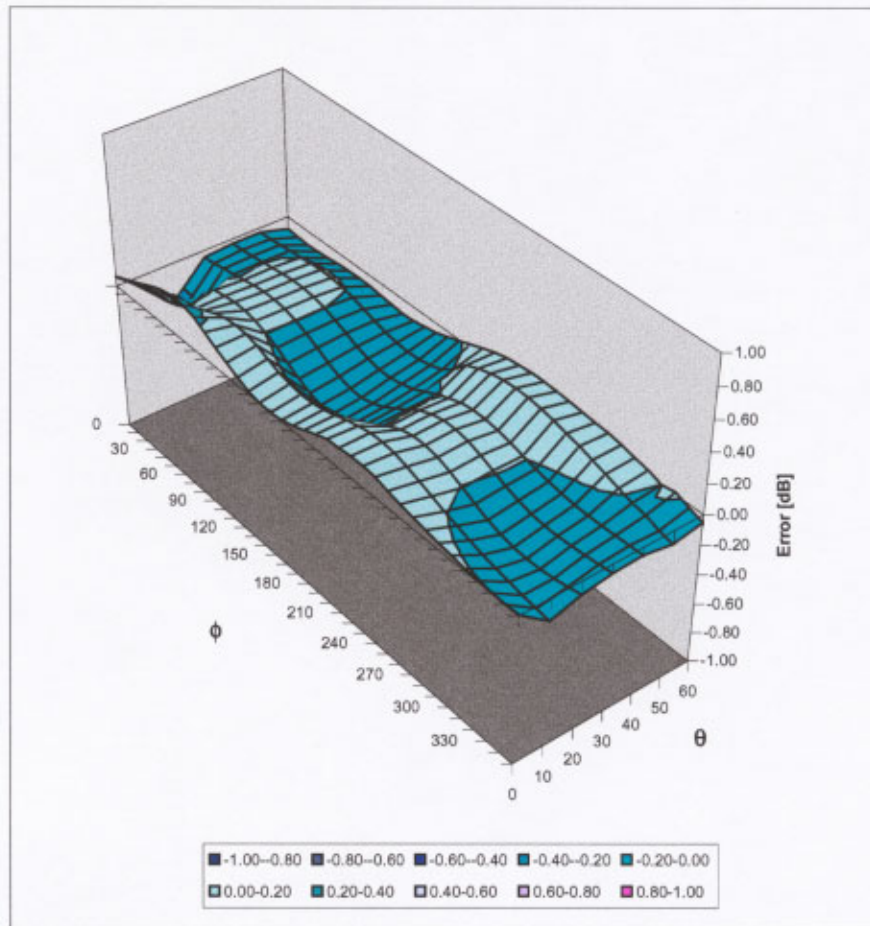
Body      2450      MHz       $\epsilon_r = 52.7 \pm 5\%$        $\sigma = 1.95 \pm 5\%$  mho/m

Valid for f=2400-2500 MHz with Body Tissue Simulating Liquid according to OET 65 Suppl. C

ConvF X	<b>4.4</b> $\pm 8.9\%$ (k=2)	Boundary effect:	
ConvF Y	<b>4.4</b> $\pm 8.9\%$ (k=2)	Alpha	<b>1.35</b>
ConvF Z	<b>4.4</b> $\pm 8.9\%$ (k=2)	Depth	<b>1.50</b>

### Deviation from Isotropy in HSL

Error ( $\theta, \phi$ ),  $f = 900$  MHz





## Additional Conversion Factors for Dosimetric E-Field Probe

Type:

ET3DV6

Serial Number:

1579

Place of Assessment:

Zurich

Date of Assessment:

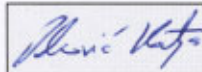
May 19, 2003

Probe Calibration Date:

May 15, 2003

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 900 MHz or at 1800 MHz.

Assessed by:



### Dosimetric E-Field Probe ET3DV6 SN:1579

Conversion factor ( $\pm$  standard deviation)

450 MHz      ConvF       $7.6 \pm 8\%$

$\epsilon_r = 43.5 \pm 5\%$   
 $\sigma = 0.87 \pm 5\%$  mho/m  
(head tissue)

450 MHz      ConvF       $7.7 \pm 8\%$

$\epsilon_r = 56.7 \pm 5\%$   
 $\sigma = 0.94 \pm 5\%$  mho/m  
(body tissue)