

APPENDIX D: CALIBRATION CERTIFICATES

Schmid & Partner Engineering AG

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

Calibration Certificate

Dosimetric E-Field Probe

Type:

ET3DV6

Serial Number:

1504

Place of Calibration:

Zurich

Date of Calibration:

July 26, 2002

Calibration Interval:

12 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:

U. Vella

Approved by:

Philip Kutz

Probe ET3DV6

SN:1504

Manufactured:	October 24, 1999
Last calibration:	January 10, 2002
Recalibrated:	July 26, 2002

Calibrated for System DASY3

DASY3 - Parameters of Probe: ET3DV6 SN:1504

Sensitivity in Free Space

NormX	2.02 $\mu\text{V}/(\text{V}/\text{m})^2$
NormY	1.78 $\mu\text{V}/(\text{V}/\text{m})^2$
NormZ	1.73 $\mu\text{V}/(\text{V}/\text{m})^2$

Diode Compression

DCP X	95	mV
DCP Y	95	mV
DCP Z	95	mV

Sensitivity in Tissue Simulating Liquid

Head	835 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.90 \pm 5\% \text{ mho/m}$
Head	900 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.97 \pm 5\% \text{ mho/m}$
ConvF X	6.5 $\pm 9.5\%$ (k=2)	Boundary effect:	
ConvF Y	6.5 $\pm 9.5\%$ (k=2)	Alpha	0.39
ConvF Z	6.5 $\pm 9.5\%$ (k=2)	Depth	2.42
Head	1880 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
Head	1800 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
ConvF X	5.4 $\pm 9.5\%$ (k=2)	Boundary effect:	
ConvF Y	5.4 $\pm 9.5\%$ (k=2)	Alpha	0.53
ConvF Z	5.4 $\pm 9.5\%$ (k=2)	Depth	2.44

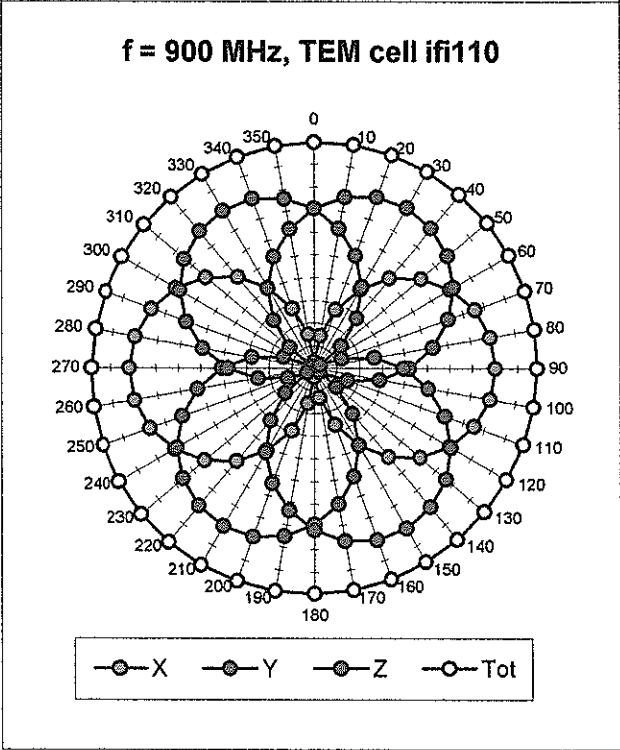
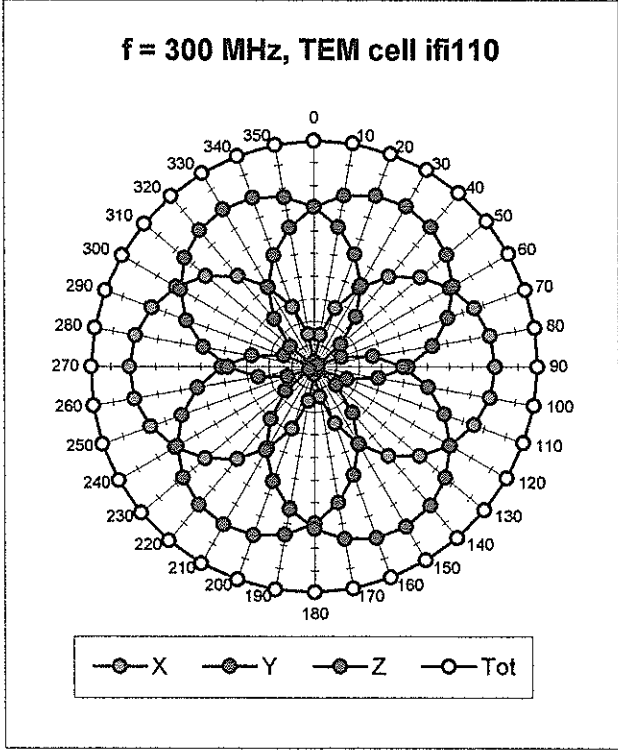
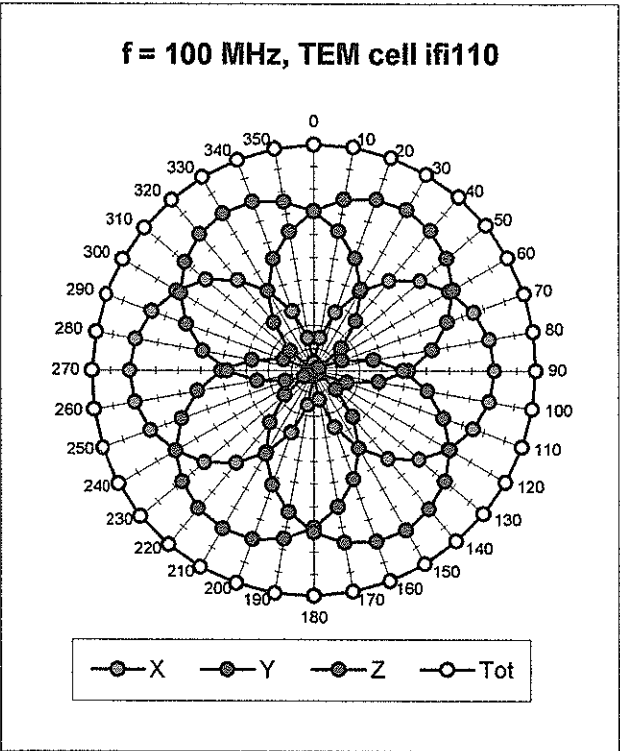
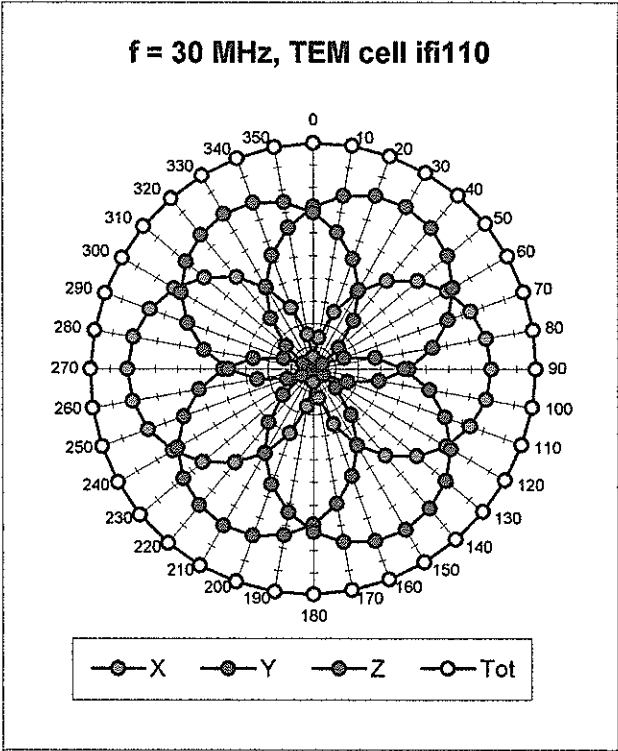
Boundary Effect

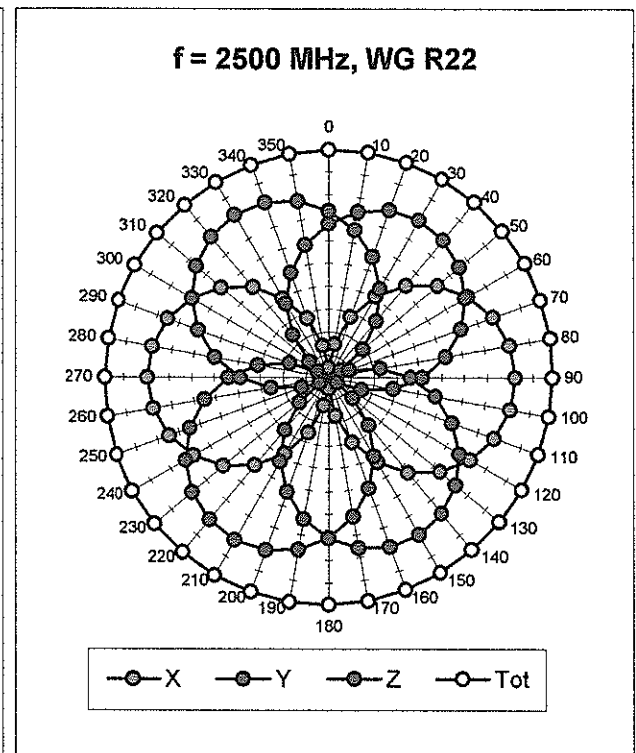
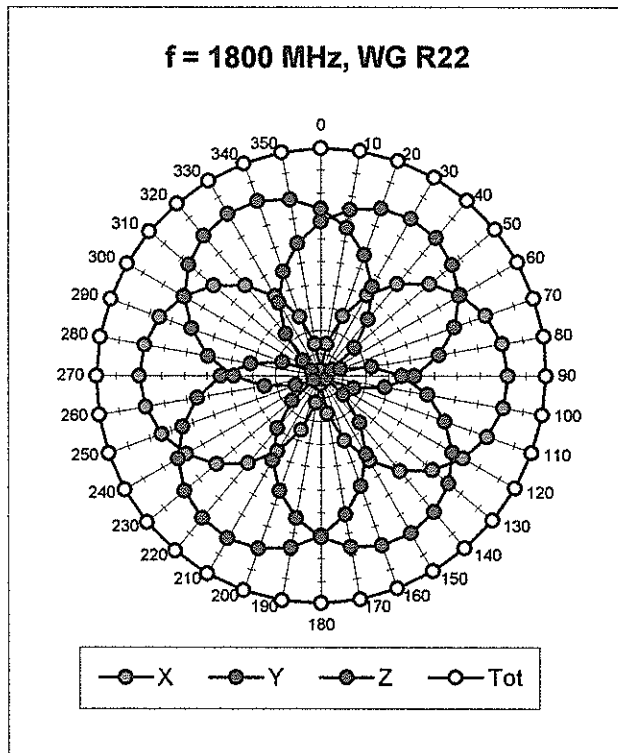
Head	835 MHz	Typical SAR gradient: 5 % per mm	
Probe Tip to Boundary		1 mm	2 mm
SAR _{be} [%]	Without Correction Algorithm	9.6	5.3
SAR _{be} [%]	With Correction Algorithm	0.3	0.5
Head	1880 MHz	Typical SAR gradient: 10 % per mm	
Probe Tip to Boundary		1 mm	2 mm
SAR _{be} [%]	Without Correction Algorithm	13.0	8.5
SAR _{be} [%]	With Correction Algorithm	0.2	0.2

Sensor Offset

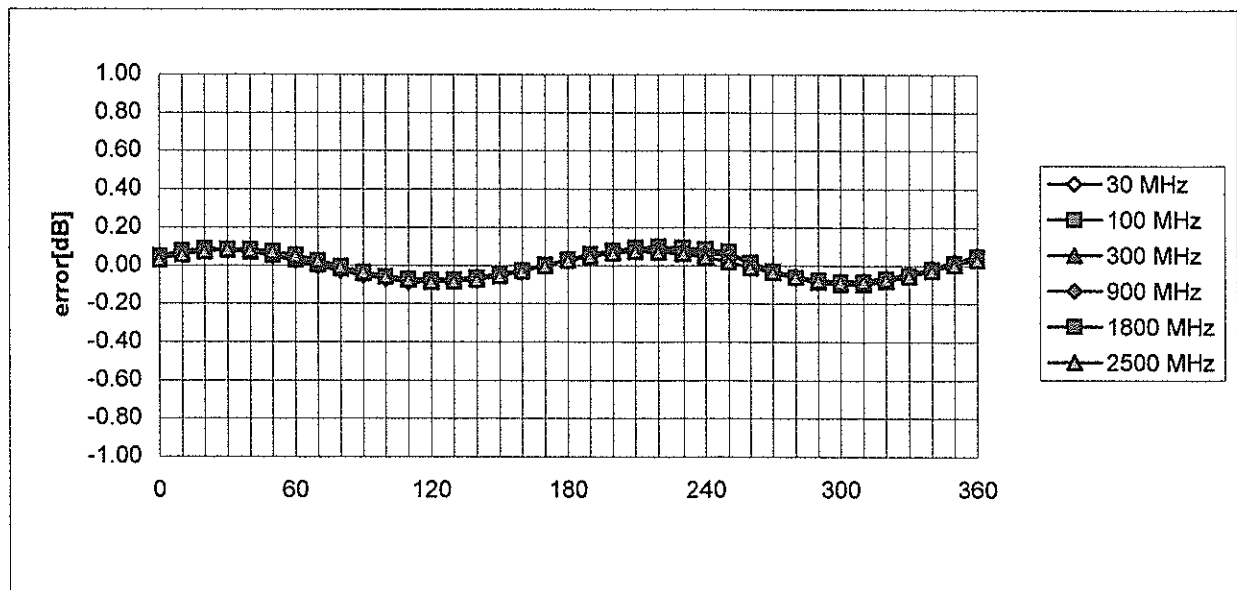
Probe Tip to Sensor Center	2.7	mm
Optical Surface Detection	1.4 $\pm$ 0.2	mm

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



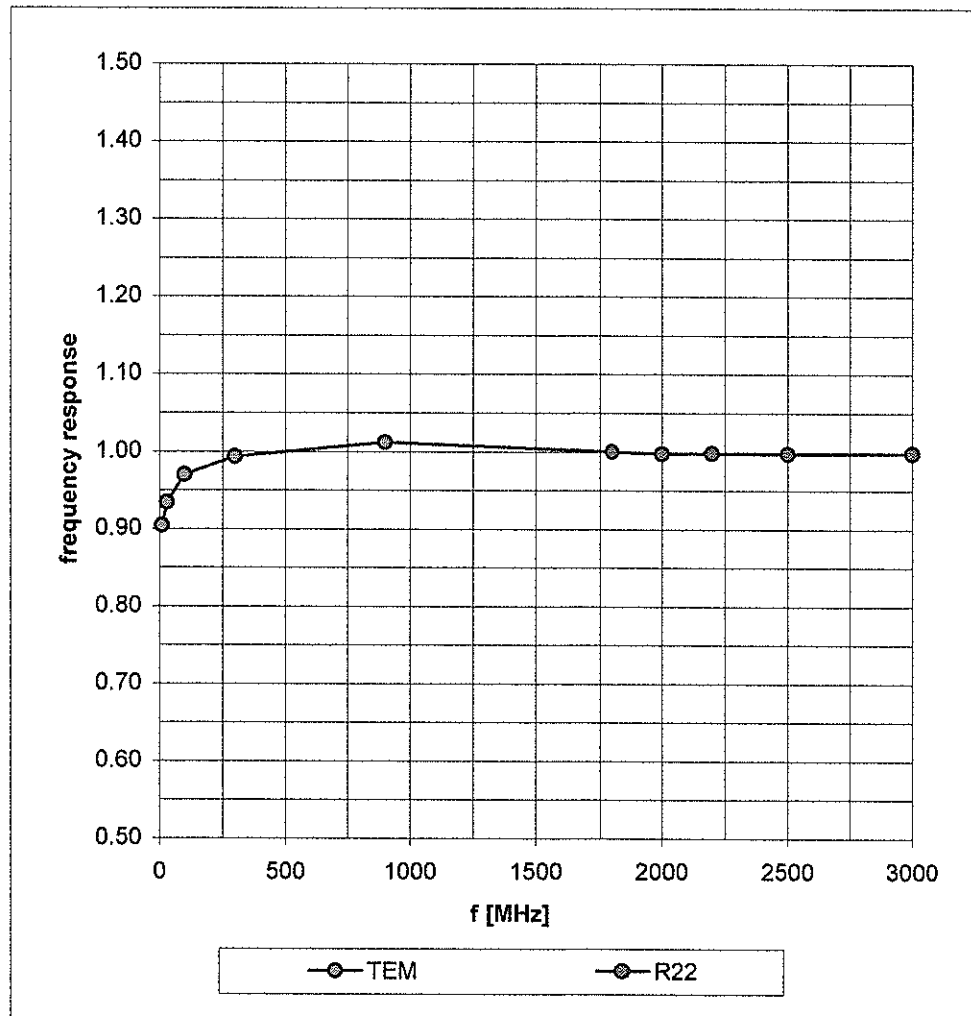


Isotropy Error (ϕ), $\theta = 0^\circ$

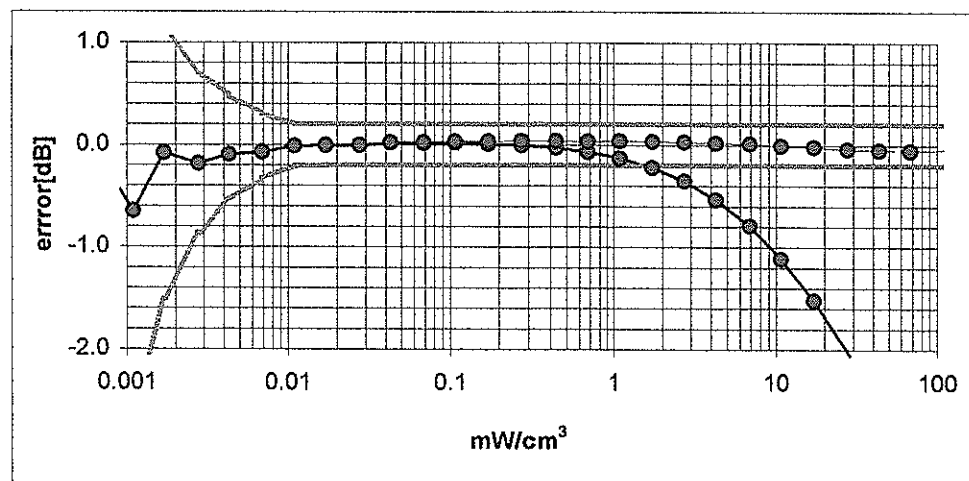
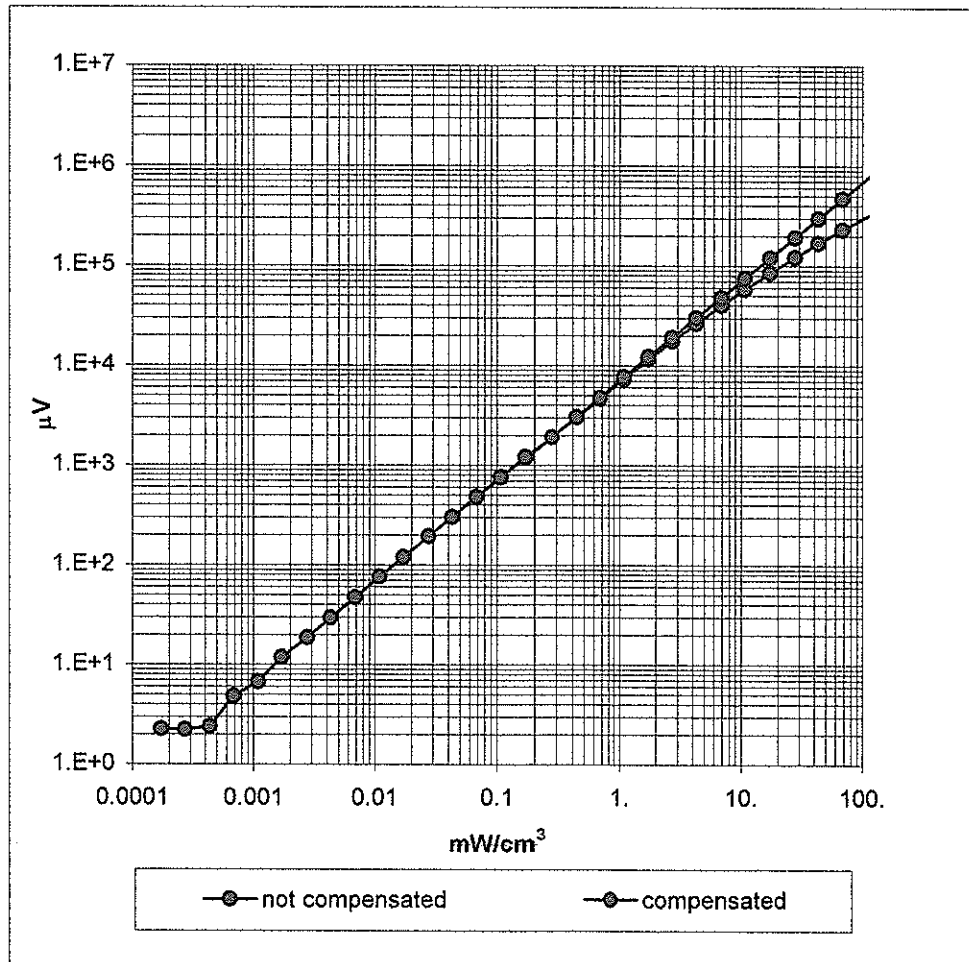


Frequency Response of E-Field

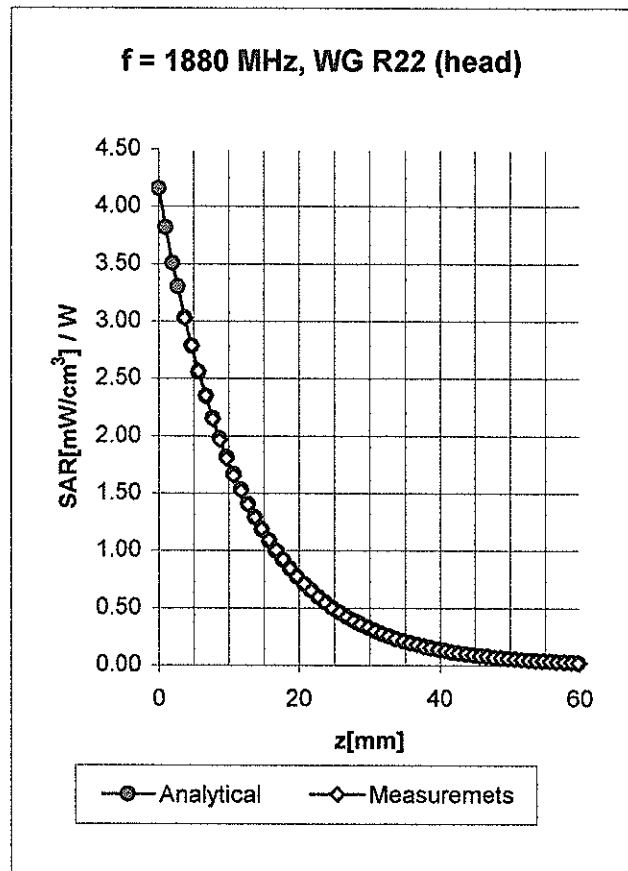
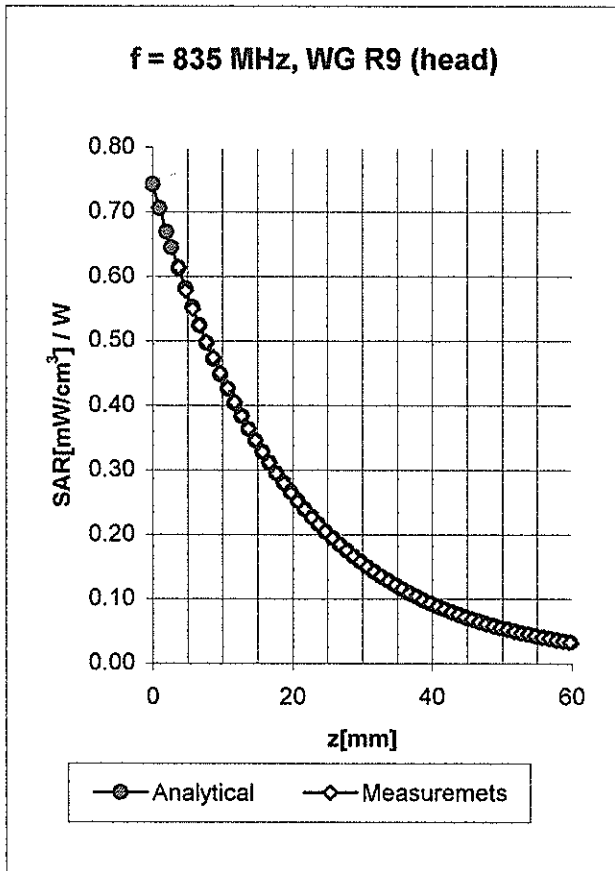
(TEM-Cell:ifi110, Waveguide R22)



Dynamic Range $f(\text{SAR}_{\text{brain}})$ (Waveguide R22)

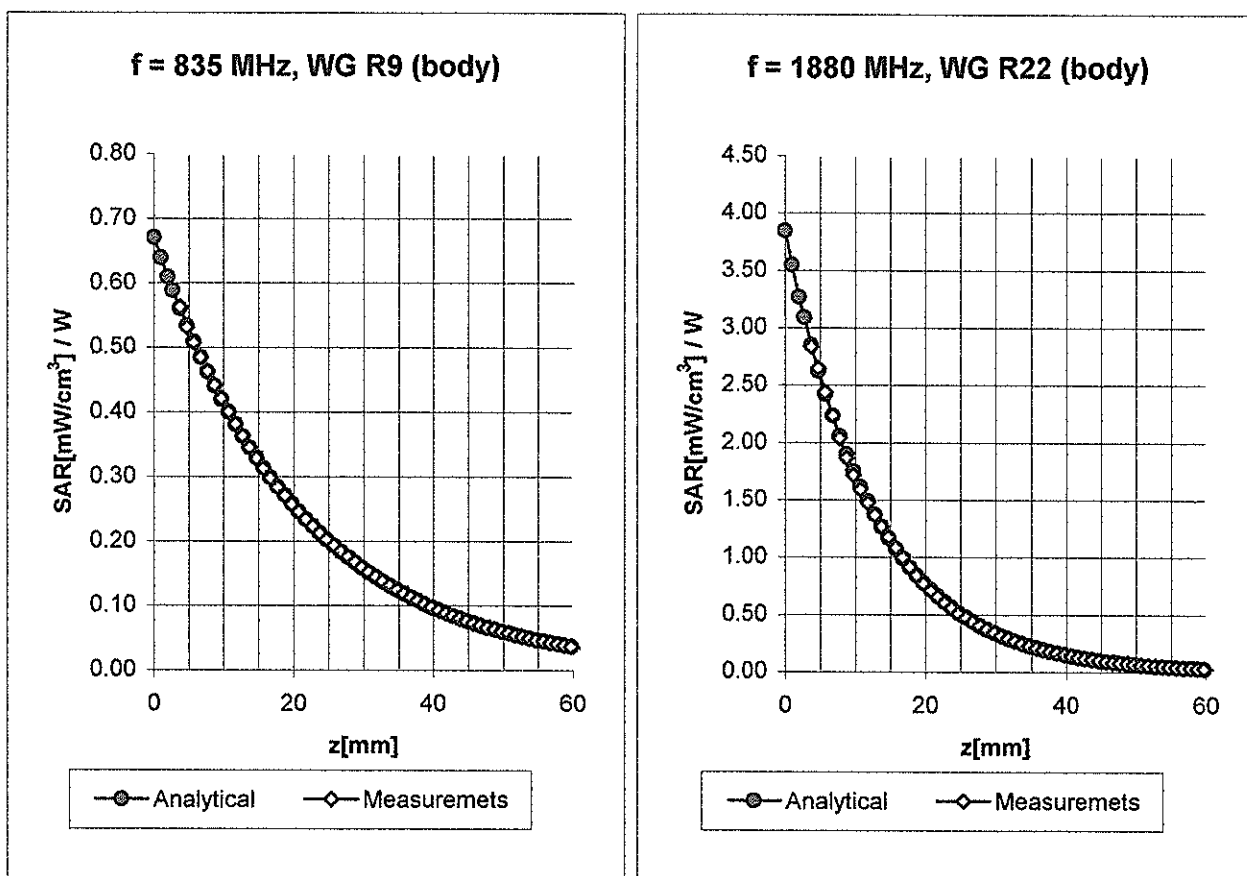


Conversion Factor Assessment



Head	835 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.90 \pm 5\% \text{ mho/m}$
Head	900 MHz	$\epsilon_r = 41.5 \pm 5\%$	$\sigma = 0.97 \pm 5\% \text{ mho/m}$
	ConvF X	$6.5 \pm 9.5\% (k=2)$	Boundary effect:
	ConvF Y	$6.5 \pm 9.5\% (k=2)$	Alpha 0.39
	ConvF Z	$6.5 \pm 9.5\% (k=2)$	Depth 2.42
Head	1880 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
Head	1800 MHz	$\epsilon_r = 40.0 \pm 5\%$	$\sigma = 1.40 \pm 5\% \text{ mho/m}$
	ConvF X	$5.4 \pm 9.5\% (k=2)$	Boundary effect:
	ConvF Y	$5.4 \pm 9.5\% (k=2)$	Alpha 0.53
	ConvF Z	$5.4 \pm 9.5\% (k=2)$	Depth 2.44

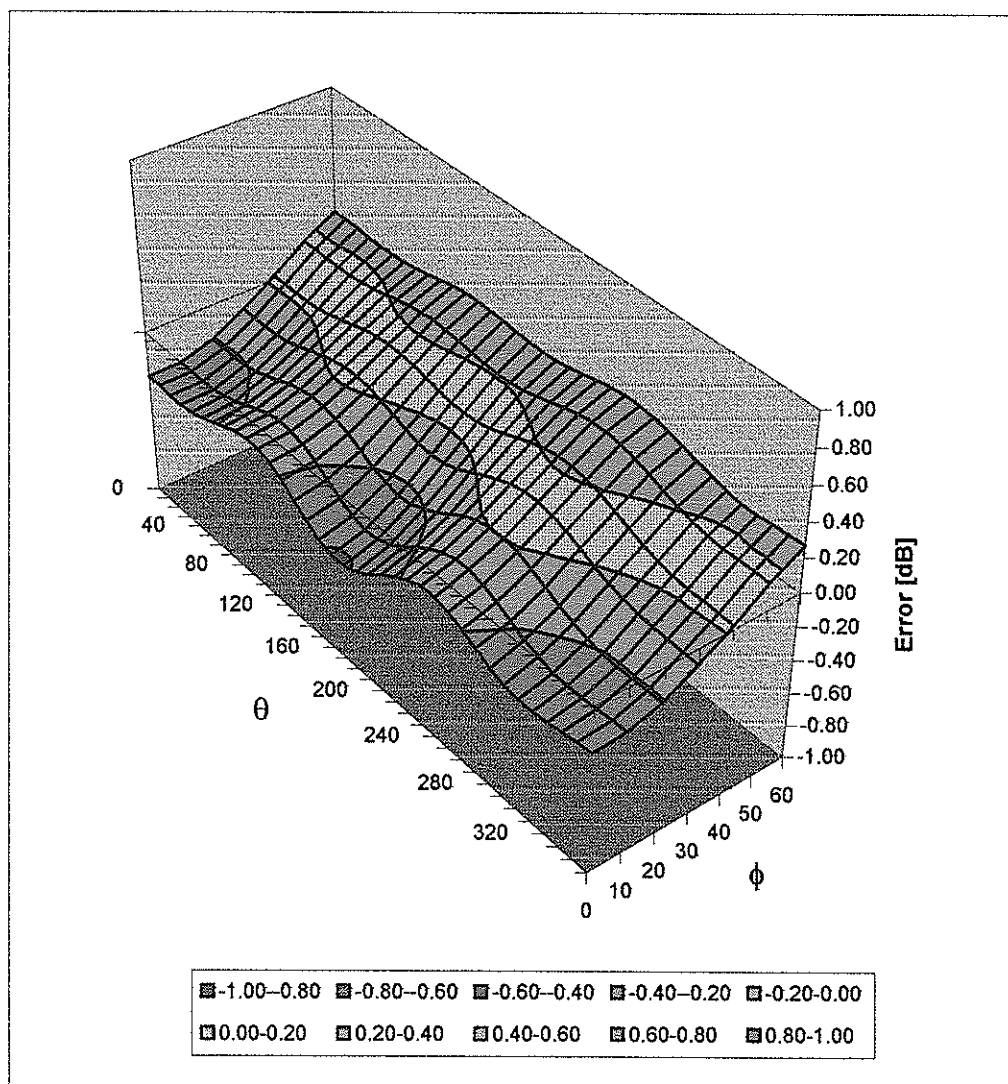
Conversion Factor Assessment



Body	835 MHz	$\epsilon_r = 55.2 \pm 5\%$	$\sigma = 0.97 \pm 5\%$ mho/m
Body	900 MHz	$\epsilon_r = 55.0 \pm 5\%$	$\sigma = 1.05 \pm 5\%$ mho/m
	ConvF X	6.5 $\pm 9.5\%$ (k=2)	Boundary effect:
	ConvF Y	6.5 $\pm 9.5\%$ (k=2)	Alpha 0.42
	ConvF Z	6.5 $\pm 9.5\%$ (k=2)	Depth 2.38
Body	1880 MHz	$\epsilon_r = 53.3 \pm 5\%$	$\sigma = 1.52 \pm 5\%$ mho/m
Body	1800 MHz	$\epsilon_r = 53.3 \pm 5\%$	$\sigma = 1.52 \pm 5\%$ mho/m
	ConvF X	5.0 $\pm 9.5\%$ (k=2)	Boundary effect:
	ConvF Y	5.0 $\pm 9.5\%$ (k=2)	Alpha 0.74
	ConvF Z	5.0 $\pm 9.5\%$ (k=2)	Depth 2.06

Deviation from Isotropy in HSL

Error (θ, ϕ), $f = 900$ MHz



Calibration Certificate

835 MHz System Validation Dipole

Type:

D835V2

Serial Number:

415

Place of Calibration:

Zurich

Date of Calibration:

May 14, 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. Vetterli

Approved by:

Philippe Kety

DASY

Dipole Validation Kit

Type: D835V2

Serial: 415

Manufactured: October 20, 1999

Calibrated: May 14, 2002

1. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with head simulating solution of the following electrical parameters at 835 MHz:

Relative Dielectricity	41.7	$\pm 5\%$
Conductivity	0.89 mho/m	$\pm 5\%$

The DASY3 System (Software version 3.1d) with a dosimetric E-field probe ET3DV6 (SN:1507, Conversion factor 6.6) was used for the measurements.

The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 15mm 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 $250\text{mW} \pm 3\%$. The results are normalized to 1W input power.

2. SAR Measurement

Standard SAR-measurements were performed with the phantom according to the measurement conditions described in section 1. The results have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm^3 (1 g) of tissue:	10.1 mW/g
averaged over 10 cm^3 (10 g) of tissue:	6.4 mW/g

Note: If the liquid parameters for validation are slightly different from the ones used for initial calibration, the SAR-values will be different as well.

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:	1.431 ns	(one direction)
Transmission factor:	0.991	(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 835 MHz:	$\text{Re}\{Z\} = $ 50.5 Ω
---------------------------------	---

	$\text{Im}\{Z\} = $ -1.2 Ω
--	---

Return Loss at 835 MHz	-37.5 dB
------------------------	-----------------

4. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with body simulating solution of the following electrical parameters at 835 MHz:

Relative Dielectricity	55.4	$\pm 5\%$
Conductivity	0.97 mho/m	$\pm 5\%$

The DASY3 System (Software version 3.1d) with a dosimetric E-field probe ET3DV6 (SN:1507, Conversion factor 6.2) was used for the measurements.

The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 15mm 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. SAR Measurement

Standard SAR-measurements were performed with the phantom according to the measurement conditions described in section 4. The results have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm³ (1 g) of tissue: **10.4 mW/g**

averaged over 10 cm³ (10 g) of tissue: **6.7 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 835 MHz: **Re{Z} = 45.8 Ω**

Im {Z} = -4.1 Ω

Return Loss at 835 MHz **-24.3 dB**

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

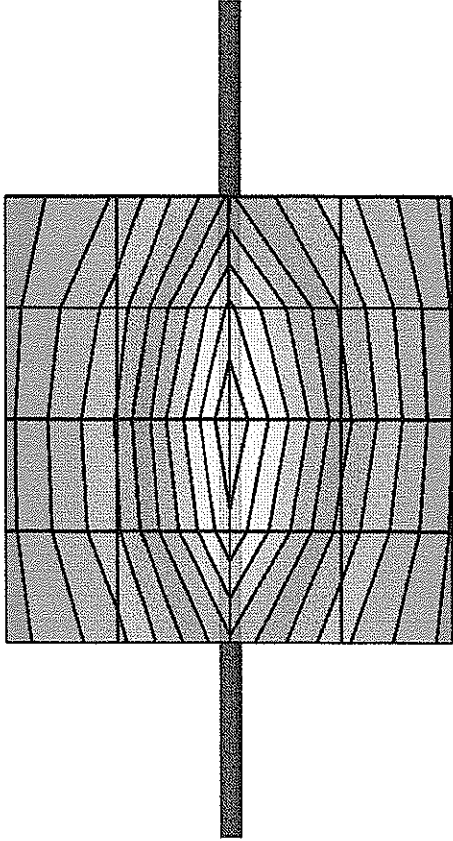
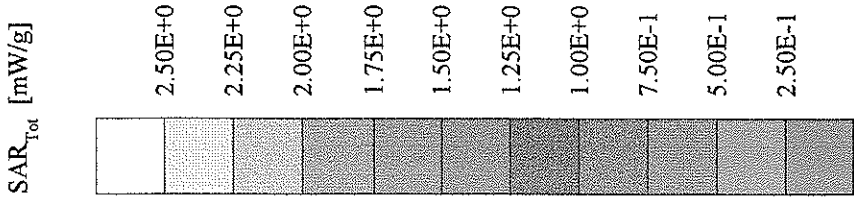
The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.

9. Power Test

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

Validation Dipole D835V2 SN415, d = 15 mm

Frequency: 835 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(6.60,6.60,6.60) at 835 MHz; IEEE1528 835 MHz: $\sigma = 0.89$ mho/m $\epsilon_r = 41.7$ $\rho = 1.00$ g/cm³
Cubes (2): Peak: 4.02 mW/g $\pm$ 0.00 dB, SAR (1g): 2.52 mW/g $\pm$ 0.01 dB, SAR (10g): 1.61 mW/g $\pm$ 0.01 dB, (Worst-case extrapolation)
Penetration depth: 12.0 (10.7, 13.7) [mm]
Powerdrift: 0.01 dB



14 May 2002 10:13:41

CH1 S11 1 U FS

1: 50.547 Ω -1.2363 Ω 154.17 pF

835.000 000 MHz

γ

Del

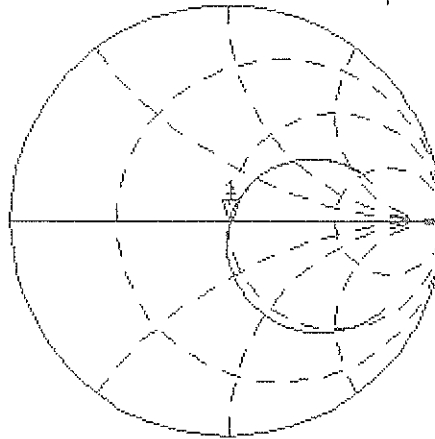
PRM

Cor

Avg

16

$\uparrow$



CH2 S11 LOG

5 dB/REF 0 dB

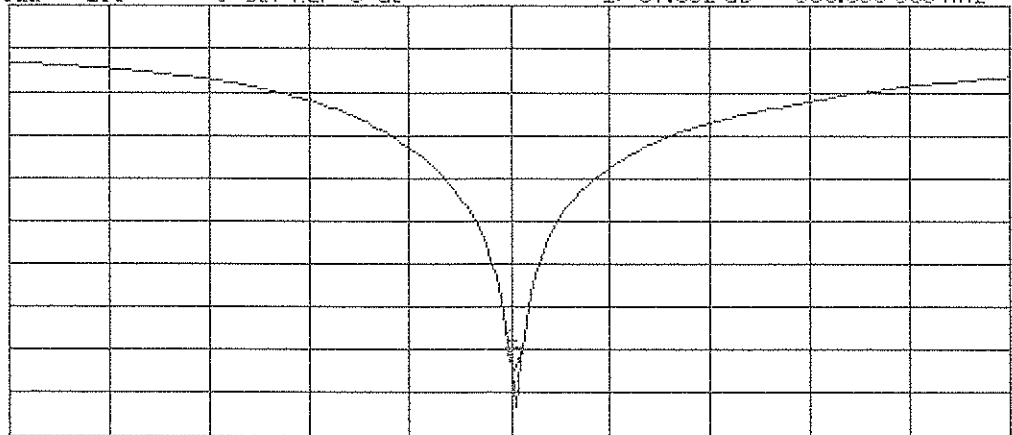
1: -37.502 dB

835.000 000 MHz

PRM

Cor

$\uparrow$

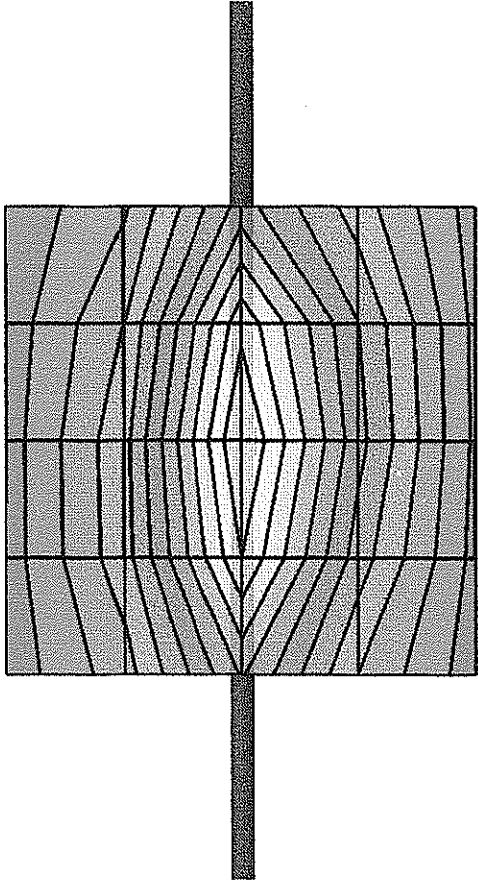
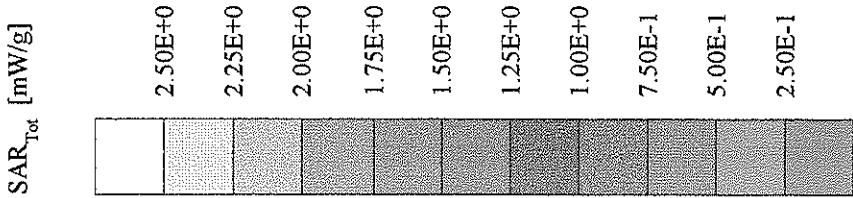


START 835.000 000 MHz

STOP 1 835.000 000 MHz

Validation Dipole D835V2 SN415, d = 15 mm

Frequency: 835 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(6.20,6.20,6.20) at 835 MHz; IEEE1528 835 MHz: $\sigma = 0.97$ mho/m $\epsilon_r = 55.4$ $\rho = 1.00$ g/cm³
Cubes (2): Peak: 4.15 mW/g ± 0.03 dB, SAR (1g): 2.61 mW/g ± 0.01 dB, SAR (10g): 1.68 mW/g ± 0.01 dB, (Worst-case extrapolation)
Penetration depth: 12.4 (11.0, 14.3) [mm]
Powerdrift: -0.01 dB



14 May 2002 17:58:30

[CH1] S11 1 U F8

1: 45.834 Ω -4.1191 Ω 46.273 pF

835.000 000 MHz

↑

Del

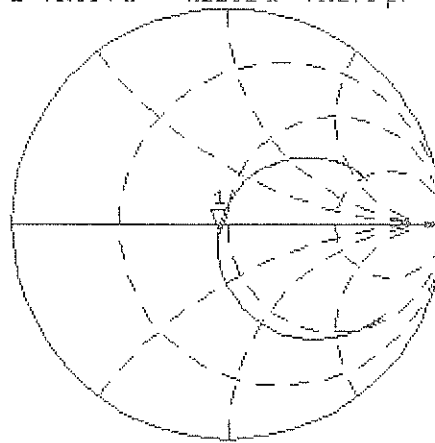
PRm

Cor

Avg

16

↑



CH2 S11 LOG 5 dB/REF 0 dB

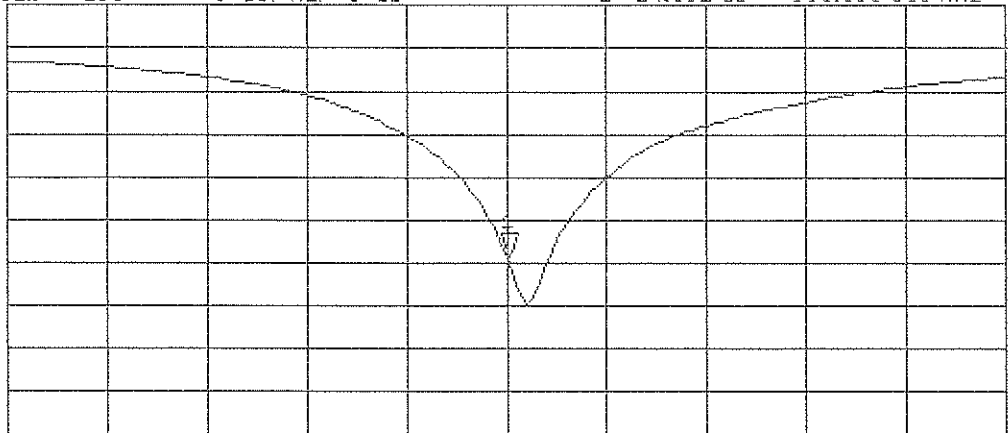
1: -24.301 dB

835.000 000 MHz

PRm

Cor

↑



START 835.000 000 MHz

STOP 1 835.000 000 MHz

Calibration Certificate

1900 MHz System Validation Dipole

Type:

D1900V2

Serial Number:

504

Place of Calibration:

Zurich

Date of Calibration:

May 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:

Volker Katze

DASY

Dipole Validation Kit

Type: D1900V2

Serial: 504

Manufactured: August 25, 1999

Calibrated: May 15, 2002

1. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with head simulating solution of the following electrical parameters at 1900 MHz:

Relative Dielectricity	38.5	$\pm 5\%$
Conductivity	1.44 mho/m	$\pm 5\%$

The DASY3 System (Software version 3.1d) with a dosimetric E-field probe ET3DV6 (SN:1507, Conversion factor 5.2) was used for the measurements.

The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the center marking of the flat phantom section and the dipole was 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. SAR Measurement

Standard SAR-measurements were performed with the phantom according to the measurement conditions described in section 1. The results have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm ³ (1 g) of tissue:	42.8 mW/g
averaged over 10 cm ³ (10 g) of tissue:	22.1 mW/g

Note: If the liquid parameters for validation are slightly different from the ones used for initial calibration, the SAR-values will be different as well.

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:	1.180 ns	(one direction)
Transmission factor:	0.990	(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 1900 MHz:	$\text{Re}\{Z\} = $ 47.5 Ω
----------------------------------	---

	$\text{Im}\{Z\} = $ -1.6 Ω
--	---

Return Loss at 1900 MHz	-30.5 dB
-------------------------	-----------------

4. Measurement Conditions

The measurements were performed in the flat section of the SAM twin phantom filled with body simulating solution of the following electrical parameters at 1900 MHz:

Relative Dielectricity	51.9	$\pm 5\%$
Conductivity	1.58 mho/m	$\pm 5\%$

The DASY3 System (Software version 3.1d) with a dosimetric E-field probe ET3DV6 (SN:1507, Conversion factor 4.9) was used for the measurements.

The dipole was mounted on the small tripod so that the dipole feedpoint was positioned below the center marking of the flat phantom section and the dipole was 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. SAR Measurement

Standard SAR-measurements were performed with the phantom according to the measurement conditions described in section 4. The results have been normalized to a dipole input power of 1W (forward power). The resulting averaged SAR-values are:

averaged over 1 cm³ (1 g) of tissue: **43.6 mW/g**

averaged over 10 cm³ (10 g) of tissue: **22.5 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 1900 MHz: $\text{Re}\{Z\} = 43.2 \Omega$

$\text{Im}\{Z\} = -1.8 \Omega$

Return Loss at 1900 MHz **-22.4 dB**

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

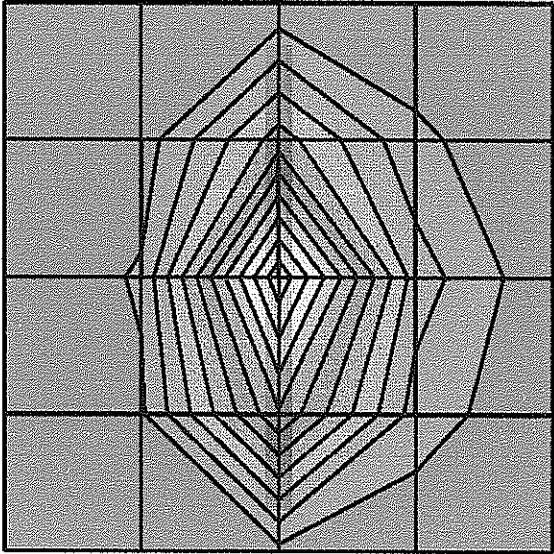
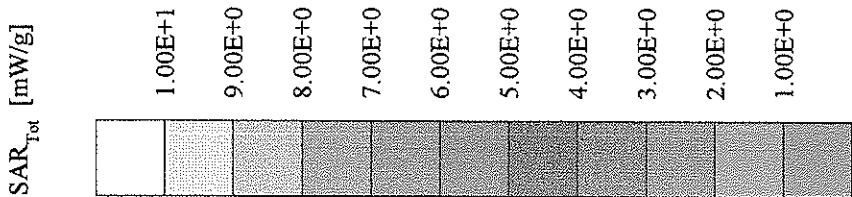
The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals.

9. Power Test

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

Validation Dipole D1900V2 SN504, d = 10 mm

Frequency: 1900 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(5.20,5.20) at 1900 MHz; IEEE1528 1900 MHz: $\sigma = 1.44 \text{ mho/m}$ $\epsilon_r = 38.5$ $\rho = 1.00 \text{ g/cm}^3$
Cubes (2): Peak: 20.0 mW/g $\pm 0.04 \text{ dB}$, SAR (1g): 10.7 mW/g $\pm 0.03 \text{ dB}$, SAR (10g): 5.53 mW/g $\pm 0.01 \text{ dB}$, (Worst-case extrapolation)
Penetration depth: 8.0 (7.7, 8.7) [mm]
Powerdrift: -0.01 dB



15 May 2002 10:09:29

[CH1] S11 1 U FS

1: 47.484 Ω -1.5684 Ω 53.410 pF 1 900.000 000 MHz

↑

De1

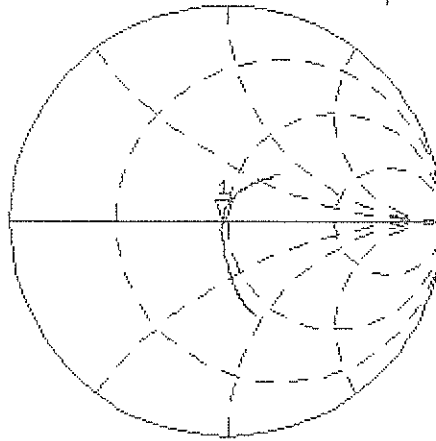
PRm

Cor

Avg

16

↑

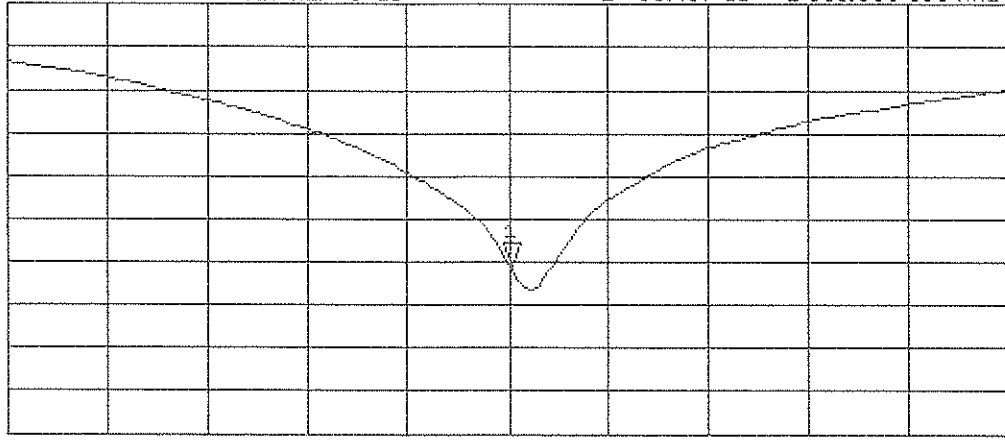


CH2 S11 LOG 5 dB/REF 0 dB 1:-30.467 dB 1 900.000 000 MHz

PRm

Cor

↑

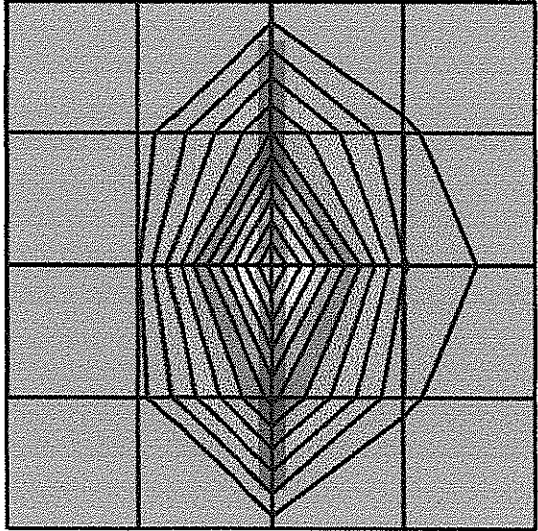


START 1 700.000 000 MHz

STOP 2 100.000 000 MHz

Validation Dipole D1900V2 SN504, d = 10 mm

Frequency: 1900 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(4.90,4.90,4.90) at 1900 MHz; IEEE1528 1900 MHz: $\sigma = 1.58 \text{ mho/m}$ $\epsilon_r = 51.9$ $\rho = 1.00 \text{ g/cm}^3$
Cubes (2): Peak: 20.2 mW/g $\pm 0.00 \text{ dB}$, SAR (1g): 10.9 mW/g $\pm 0.01 \text{ dB}$, SAR (10g): 5.63 mW/g $\pm 0.02 \text{ dB}$, (Worst-case extrapolation)
Penetration depth: 8.5 (8.0, 9.5) [mm]
Powerdrift: 0.02 dB



15 May 2002 15:59:48

[CH1] S11 1 U FS

1: 43.168 Ω -1.8027 Ω 46.466 pF 1 900.000 000 MHz

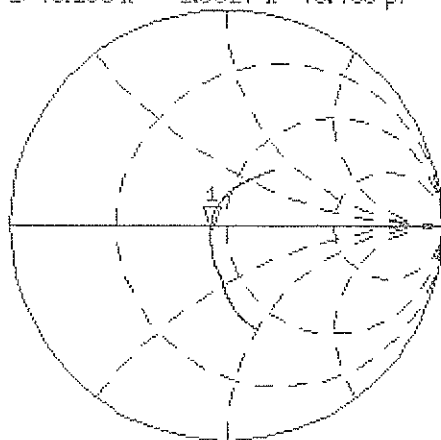
W

De 1

PRm

Cor
Avg
16

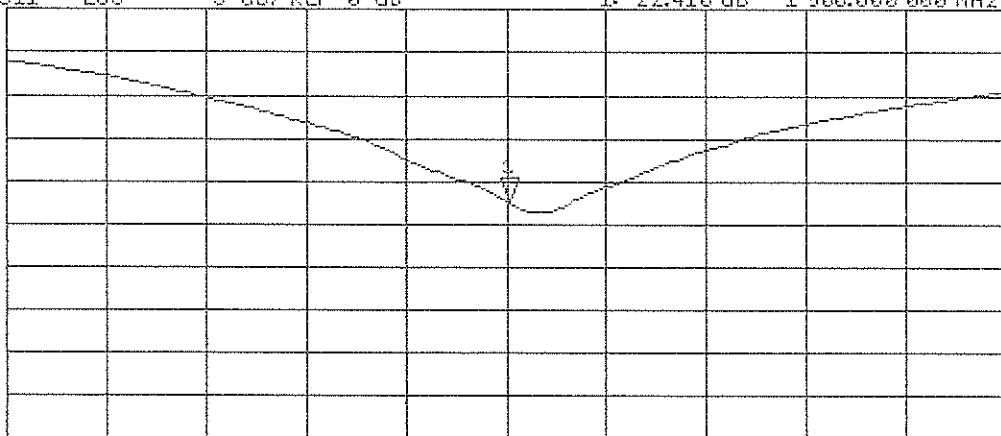
↑



CH2 S11 LOG 5 dB/REF 0 dB 1:-22.410 dB 1 900.000 000 MHz

PRm
Cor

↑



START 1 700.000 000 MHz

STOP 2 100.000 000 MHz