APPENDIX D: PROBE & DIPOLE CALIBRATION DATA

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

**Client** RIM

## CALIBRATION CERTIFICATE

| | |
|---|---|
| Object(s) | ET3DV6 - SN:1643 |
| Calibration procedure(s) | QA CAL-01.v2<br>Calibration procedure for dosimetric E-field probes |
| Calibration date: | October 9, 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 |
|---|---|---|---|
| Power meter EPM E4419B | GB41293874 | 2-Apr-03 (METAS, No 252-0250) | Apr-04 |
| Power sensor E4412A | MY41495277 | 2-Apr-03 (METAS, No 252-0250) | Apr-04 |
| Reference 20 dB Attenuator | SN: 5086 (20b) | 3-Apr-03 (METAS No. 251-0340 | Apr-04 |
| Fluke Process Calibrator Type 702 | SN: 6295803 | 8-Sep-03 (Sintrel SCS No. E-030020) | Sep-04 |
| Power sensor HP 8481A | MY41092180 | 18-Sep-02 (Agilent, No. 20020918) | In house check: Oct 03 |
| RF generator HP 8684C | US3642U01700 | 4-Aug-99 (SPEAG, in house check Aug-02) | In house check: Aug-05 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (Agilent, No. 24BR1033101) | In house check: Oct 03 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Nico Vetterli | Technician | |
| Approved by: | Katja Pokovic | Laboratory Director | |

Date issued: October 9, 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.

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# Probe ET3DV6

# SN:1643

Manufactured: November 7, 2001
Last calibration: September 24, 2002
Recalibrated: October 9, 2003

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

ET3DV6 SN:1643 October 9, 2003

# DASY - Parameters of Probe: ET3DV6 SN:1643

## Sensitivity in Free Space

| | | | | |
|---|---|---|---|---|
| NormX | **1.73** | $\mu V/(V/m)^2$ | DCP X | **96** mV |
| NormY | **1.88** | $\mu V/(V/m)^2$ | DCP Y | **96** mV |
| NormZ | **1.81** | $\mu V/(V/m)^2$ | DCP Z | **96** mV |

## Sensitivity in Tissue Simulating Liquid

Head 900 MHz $\varepsilon_r$ = 41.5 ± 5% $\sigma$ = 0.97 ± 5% mho/m

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

| | | | |
|---|---|---|---|
| ConvF X | **6.5** ± 9.5% (k=2) | Boundary effect: | |
| ConvF Y | **6.5** ± 9.5% (k=2) | Alpha | **0.37** |
| ConvF Z | **6.5** ± 9.5% (k=2) | Depth | **2.72** |

Head 1800 MHz $\varepsilon_r$ = 40.0 ± 5% $\sigma$ = 1.40 ± 5% mho/m

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

| | | | |
|---|---|---|---|
| ConvF X | **5.2** ± 9.5% (k=2) | Boundary effect: | |
| ConvF Y | **5.2** ± 9.5% (k=2) | Alpha | **0.47** |
| ConvF Z | **5.2** ± 9.5% (k=2) | Depth | **2.87** |

## Boundary Effect

Head 900 MHz **Typical SAR gradient: 5 % per mm**

| Probe Tip to Boundary | | 1 mm | 2 mm |
|---|---|---|---|
| $SAR_{be}$ [%] | Without Correction Algorithm | 10.8 | 6.3 |
| $SAR_{be}$ [%] | With Correction Algorithm | 0.4 | 0.6 |

Head 1800 MHz **Typical SAR gradient: 10 % per mm**

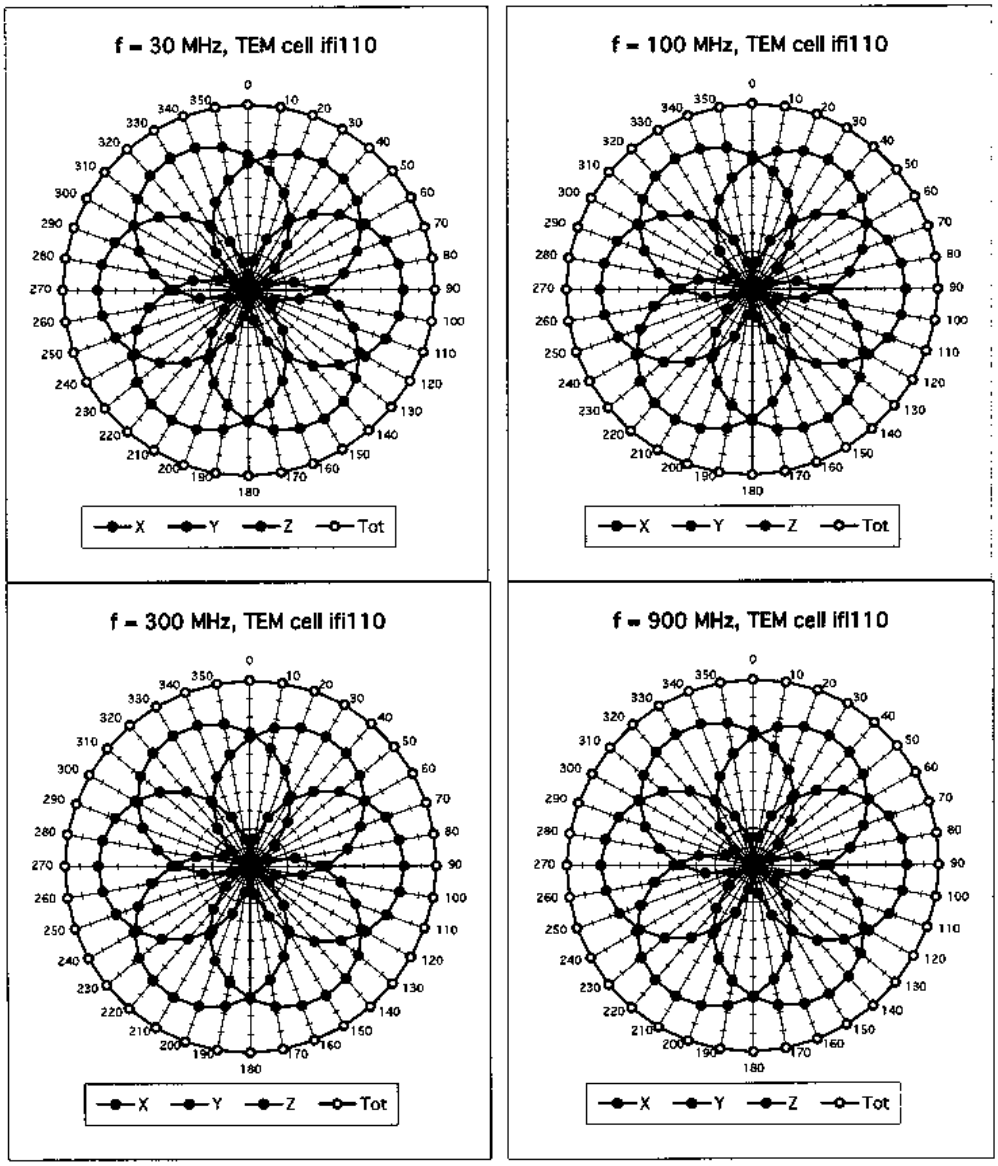
| Probe Tip to Boundary | | 1 mm | 2 mm |
|---|---|---|---|
| $SAR_{be}$ [%] | Without Correction Algorithm | 14.5 | 10.1 |
| $SAR_{be}$ [%] | With Correction Algorithm | 0.2 | 0.1 |

## Sensor Offset

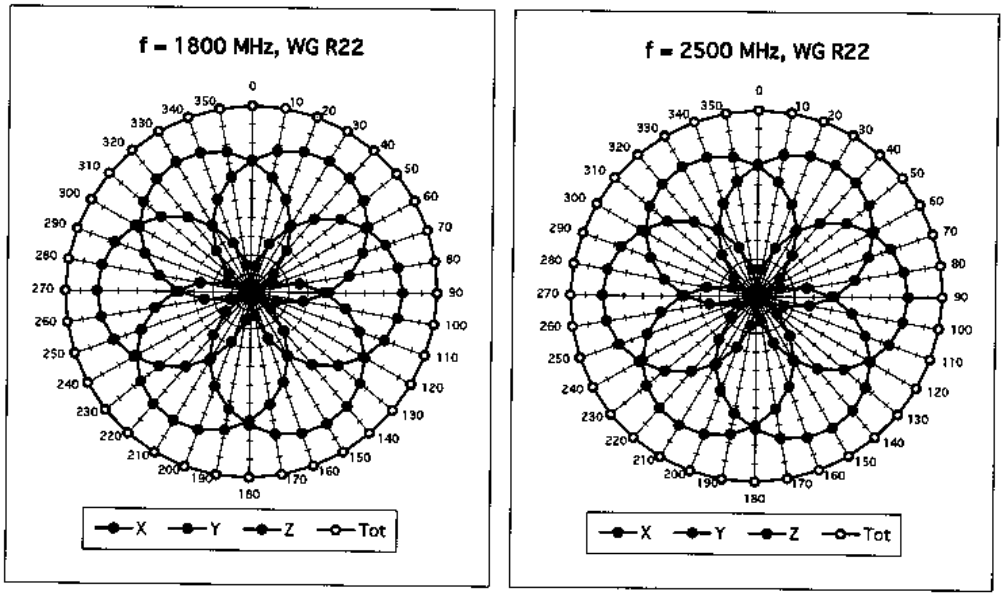
| | | |
|---|---|---|
| Probe Tip to Sensor Center | **2.7** | mm |
| Optical Surface Detection | **1.4 ± 0.2** | mm |

**ET3DV6 SN:1643** **October 9, 2003**

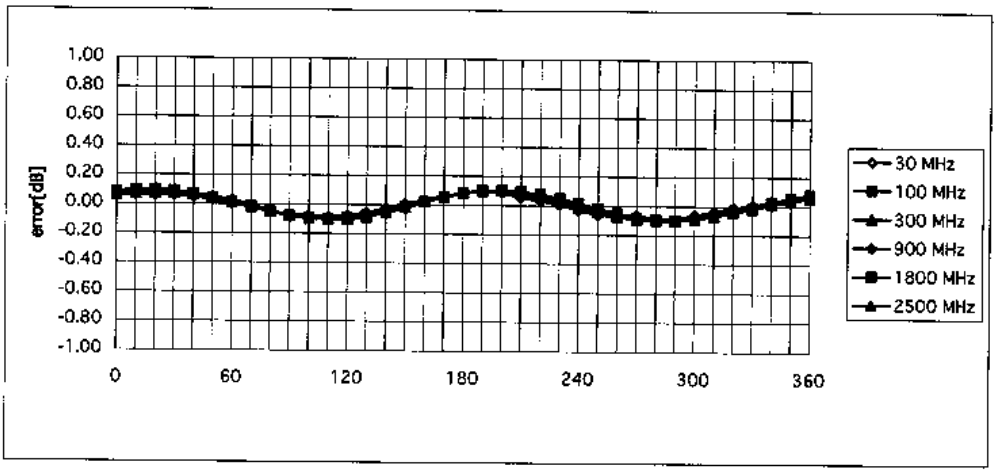
## Receiving Pattern (ϕ), θ = 0°



**ET3DV6 SN:1643** **October 9, 2003**



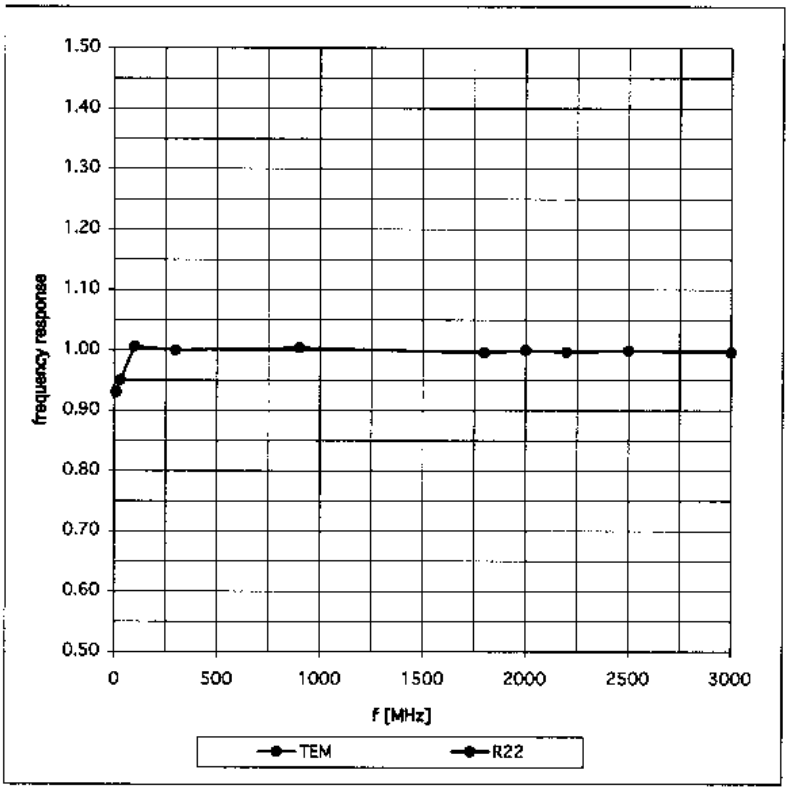

## Isotropy Error (ϕ), θ = 0°



**ET3DV6 SN:1643** **October 9, 2003**

## Frequency Response of E-Field

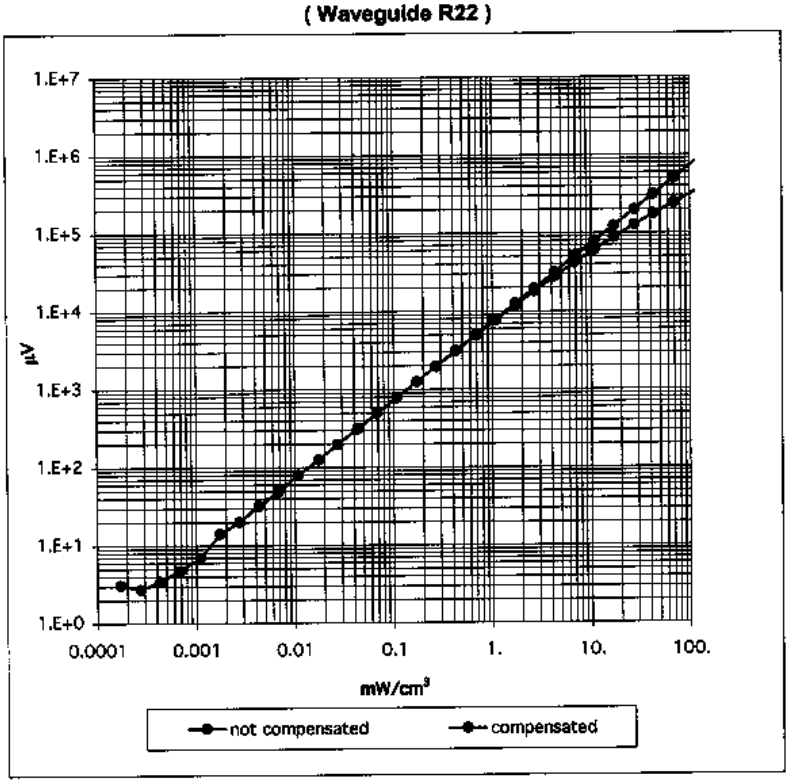
**( TEM-Cell:ifi110, Waveguide R22)**

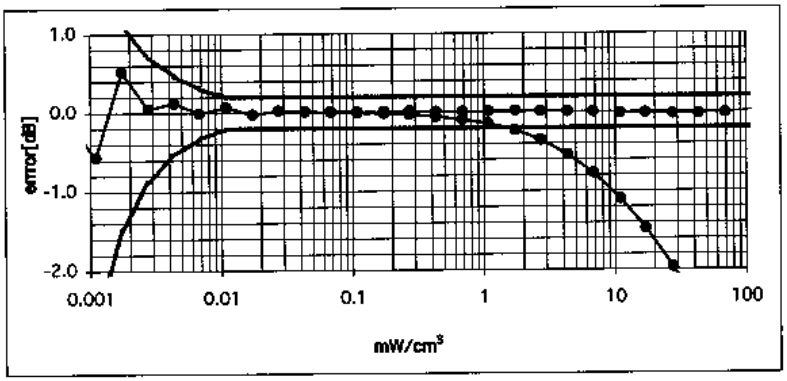


**ET3DV6 SN:1643** **October 9, 2003**

## Dynamic Range f(SARhead)

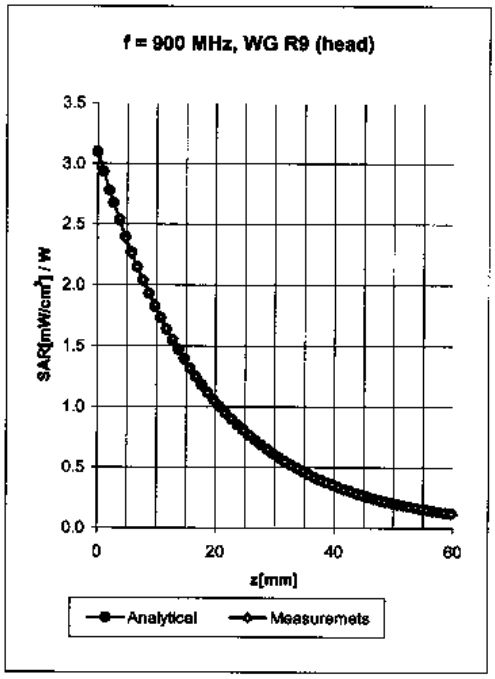
**( Waveguide R22 )**

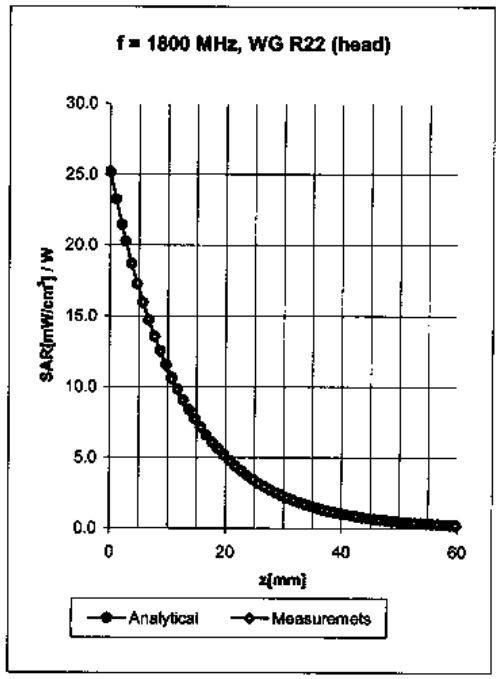


**ET3DV6 SN:1643** **October 9, 2003**

# Conversion Factor Assessment




**Head** 900 MHz $\varepsilon_r$ = 41.5 ± 5% $\sigma$ = 0.97 ± 5% mho/m

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

| | | | |
|---|---|---|---|
| ConvF X | 6.5 ± 9.5% (k=2) | Boundary effect: | |
| ConvF Y | 6.5 ± 9.5% (k=2) | Alpha | 0.37 |
| ConvF Z | 6.5 ± 9.5% (k=2) | Depth | 2.72 |

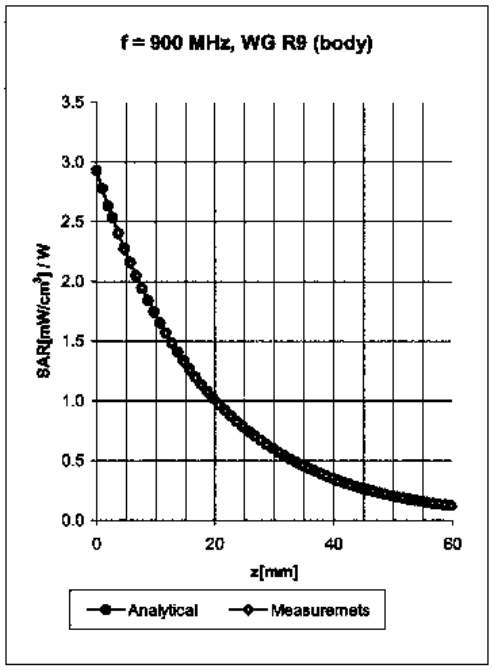
**Head** 1800 MHz $\varepsilon_r$ = 40.0 ± 5% $\sigma$ = 1.40 ± 5% mho/m

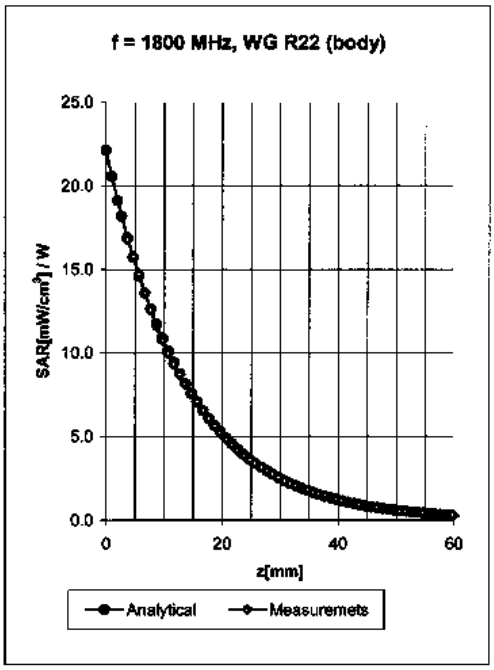
Valid for f=1710-1910 MHz with Head Tissue Simulating Liquid according to EN 50361, P1528-200X

| | | | |
|---|---|---|---|
| ConvF X | 5.2 ± 9.5% (k=2) | Boundary effect: | |
| ConvF Y | 5.2 ± 9.5% (k=2) | Alpha | 0.47 |
| ConvF Z | 5.2 ± 9.5% (k=2) | Depth | 2.87 |

**ET3DV6 SN:1643** **October 9, 2003**

# Conversion Factor Assessment




**Body** **900 MHz** $\varepsilon_r$ = 55.0 ± 5% $\sigma$ = 1.05 ± 5% mho/m

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

| | | | |
|---|---|---|---|
| ConvF X | 6.3 ± 9.5% (k=2) | Boundary effect: | |
| ConvF Y | 6.3 ± 9.5% (k=2) | Alpha | 0.43 |
| ConvF Z | 6.3 ± 9.5% (k=2) | Depth | 2.49 |

**Body** **1800 MHz** $\varepsilon_r$ = 53.3 ± 5% $\sigma$ = 1.52 ± 5% mho/m

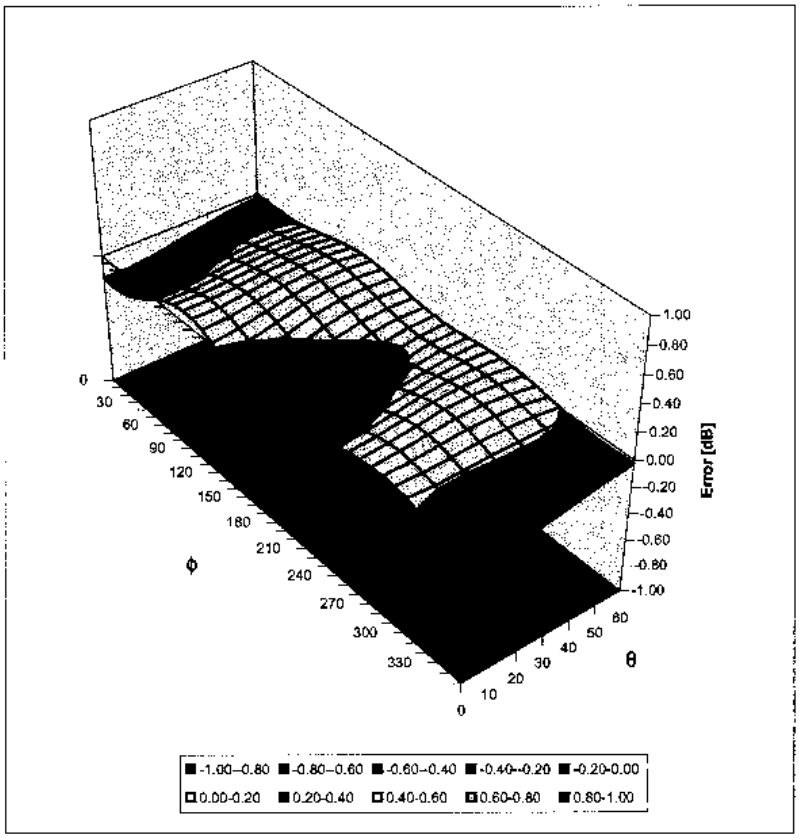
Valid for f=1710-1910 MHz with Body Tissue Simulating Liquid according to OET 65 Suppl. C

| | | | |
|---|---|---|---|
| ConvF X | 4.8 ± 9.5% (k=2) | Boundary effect: | |
| ConvF Y | 4.8 ± 9.5% (k=2) | Alpha | 0.57 |
| ConvF Z | 4.8 ± 9.5% (k=2) | Depth | 2.74 |

**ET3DV6 SN:1643** **October 9, 2003**

## Deviation from Isotropy in HSL

**Error (θ,ϕ), f = 900 MHz**



**Calibration Laboratory of**
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**Zeughausstrasse 43, 8004 Zurich, Switzerland**

**Client** **RIM**

## CALIBRATION CERTIFICATE

| | |
|---|---|
| Object(s) | D835V2 - SN 446 |
| Calibration procedure(s) | QA CAL-05.v2<br>Calibration procedure for dipole validation kits |
| Calibration date: | August 21, 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 R&S SML-03 | 100698 | 27-Mar-2002 (R&S, No. 20-92389) | In house check: Mar-05 |
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (Agilent, No. 20021018) | Oct-04 |
| Power sensor HP 8481A | US37292783 | 30-Oct-02 (METAS, No. 252-0236) | Oct-03 |
| Power meter EPM E442 | GB37480704 | 30-Oct-02 (METAS, No. 252-0236) | Oct-03 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (Agilent, No. 24BR1033101) | In house check: Oct 03 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Judith Mueller | Technician | |
| Approved by: | Katja Pokovic | Laboratory Director | |

Date issued: August 22, 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

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Schmid & Partner Engineering AG

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# DASY

## Dipole Validation Kit

## Type: D835V2

## Serial: 446

Manufactured: October 24, 2001
Calibrated: August 21, 2003

## 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 | **43.3** | ± 5% |
| Conductivity | **0.91 mho/m** | ± 5% |

The DASY4 System with a dosimetric E-field probe ET3DV6 (SN:1507, Conversion factor 6.7 at 835 MHz) 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 spacer was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 15mm was aligned with the dipole. The 7x7x7 fine cube was chosen for cube integration.
The dipole input power (forward power) was 250 mW ± 3 %. The results are normalized to 1W input power.

## 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 $cm^3$ (1 g) of tissue: | **9.60 mW/g** ± 16.8 % (k=2)[1] |
| averaged over 10 $cm^3$ (10 g) of tissue: | **6.24 mW/g** ± 16.2 % (k=2)[1] |

[1] validation uncertainty

## 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: | **1.395 ns** | (one direction) |
| Transmission factor: | **0.983** | (voltage transmission, one direction) |

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

| | |
|---|---|
| Feedpoint impedance at 835 MHz: | Re{Z} = **48.9 Ω** |
| | Im {Z} = **-5.5 Ω** |
| Return Loss at 835 MHz | **-24.9 dB** |

## 4. 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.

## 5. 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.

## 6. Power Test

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

Date/Time: 08/21/03 10:03:51

Test Laboratory: SPEAG, Zurich, Switzerland
File Name: SN446_SN1507_HSL835_210803.da4

**DUT: Dipole 835 MHz; Type: D835V2; Serial: D835V2 - SN446**
**Program: Dipole Calibration**

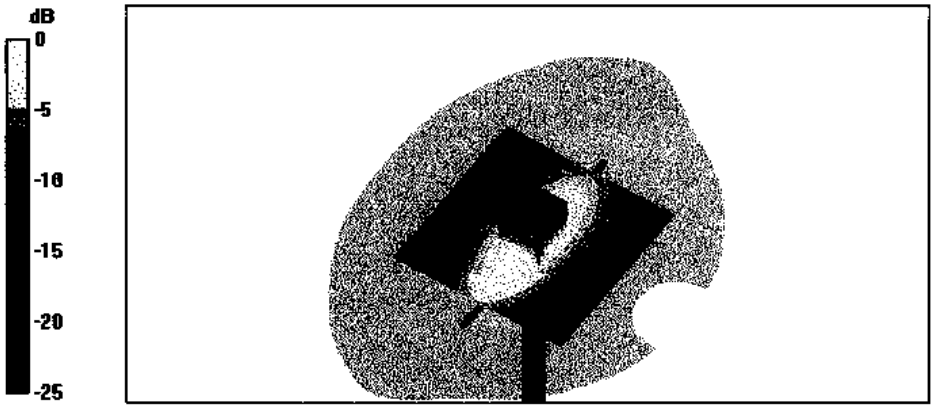
Communication System: CW-835; Frequency: 835 MHz;Duty Cycle: 1:1
Medium: HSL 835 MHz ($\sigma$ = 0.91 mho/m, $\varepsilon_r$ = 43.28, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ET3DV6 - SN1507; ConvF(6.7, 6.7, 6.7); Calibrated: 1/18/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 - SN411; Calibrated: 1/16/2003
- Phantom: SAM with CRP - TP1006; Type: SAM 4.0; Serial: TP:1006
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

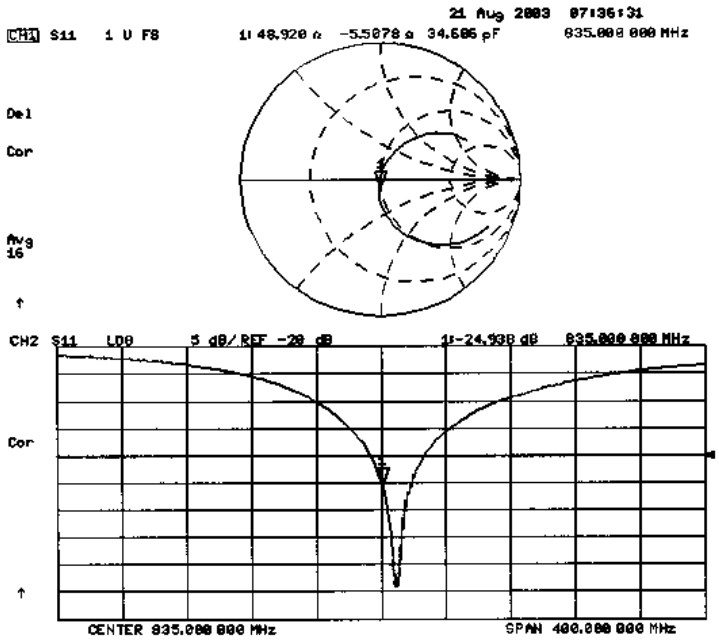
***Pin = 250 mW; d = 15 mm/Area Scan (81x81x1):*** *Measurement grid: dx=15mm, dy=15mm*
Reference Value = 55.3 V/m
Power Drift = -0.02 dB
Maximum value of SAR = 2.55 mW/g

**Pin = 250 mW; d = 15 mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Peak SAR (extrapolated) = 3.52 W/kg
SAR(1 g) = 2.4 mW/g; SAR(10 g) = 1.56 mW/g
Reference Value = 55.3 V/m
Power Drift = -0.02 dB
Maximum value of SAR = 2.56 mW/g



0 dB = 2.56mW/g

446



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

**Client** **RIM**

## CALIBRATION CERTIFICATE

| | |
|---|---|
| Object(s) | D1900V2 - SN:545 |
| Calibration procedure(s) | QA CAL-05.v2<br>Calibration procedure for dipole validation kits |
| Calibration date: | August 22, 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 R&S SML-03 | 100698 | 27-Mar-2002 (R&S, No. 20-92389) | In house check: Mar-05 |
| Power sensor HP 8481A | MY41092317 | 18-Oct-02 (Agilent, No. 20021018) | Oct-04 |
| Power sensor HP 8481A | US37292783 | 30-Oct-02 (METAS, No. 252-0236) | Oct-03 |
| Power meter EPM E442 | GB37480704 | 30-Oct-02 (METAS, No. 252-0236) | Oct-03 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (Agilent, No. 24BR1033101) | In house check: Oct 03 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Judith Mueller | Technician | |
| Approved by: | Katja Pokovic | Laboratory Director | |

Date issued: August 24, 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.

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# DASY

## Dipole Validation Kit

## Type: D1900V2

## Serial: 545

Manufactured: November 15, 2001
Calibrated: August 22, 2003

## 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 | **40.2** | ± 5% |
| Conductivity | **1.46 mho/m** | ± 5% |

The DASY4 System with a dosimetric E-field probe ET3DV6 (SN:1507, Conversion factor 5.2 at 1900 MHz) 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 spacer was used during measurements for accurate distance positioning.

The coarse grid with a grid spacing of 15mm was aligned with the dipole. The 7x7x7 fine cube was chosen for cube integration.
The dipole input power (forward power) was 250 mW ± 3 %. The results are normalized to 1W input power.

## 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 $cm^3$ (1 g) of tissue: | **41.2 mW/g ± 16.8 % (k=2)**[1] |
| averaged over 10 $cm^3$ (10 g) of tissue: | **21.3 mW/g ± 16.2 % (k=2)**[1] |

[1] validation uncertainty

## 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: | **1.198 ns** | (one direction) |
| Transmission factor: | **0.984** | (voltage transmission, one direction) |

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

| | |
|---|---|
| Feedpoint impedance at 1900 MHz: | Re{Z} = **49.7 Ω** |
| | Im {Z} = **0.96 Ω** |
| Return Loss at 1900 MHz | **-39.9 dB** |

## 4. 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.

## 5. 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.

## 6. Power Test

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

**Date/Time: 08/22/03 15:40:53**

Test Laboratory: SPEAG, Zurich, Switzerland
File Name: SN545_SN1507_HSL1900_220803.da4

**DUT: Dipole 1900 MHz; Type: D1900V2; Serial: D1900V2 - SN545**
**Program: Dipole Calibration**

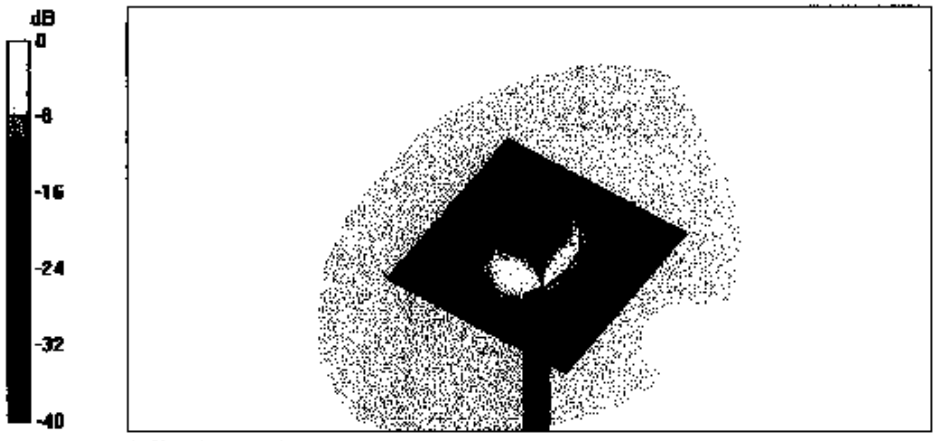
Communication System: CW-1900; Frequency: 1900 MHz;Duty Cycle: 1:1
Medium: HSL 1900 MHz ($\sigma$ = 1.46 mho/m, $\epsilon_r$ = 40.17, $\rho$ = 1000 kg/m$^3$)
Phantom section: Flat Section
Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ET3DV6 - SN1507; ConvF(5.2, 5.2, 5.2); Calibrated: 1/18/2003
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE3 - SN411; Calibrated: 1/16/2003
- Phantom: SAM with CRP - TP1006; Type: SAM 4.0; Serial: TP:1006
- Measurement SW: DASY4, V4.1 Build 47; Postprocessing SW: SEMCAD, V1.6 Build 115

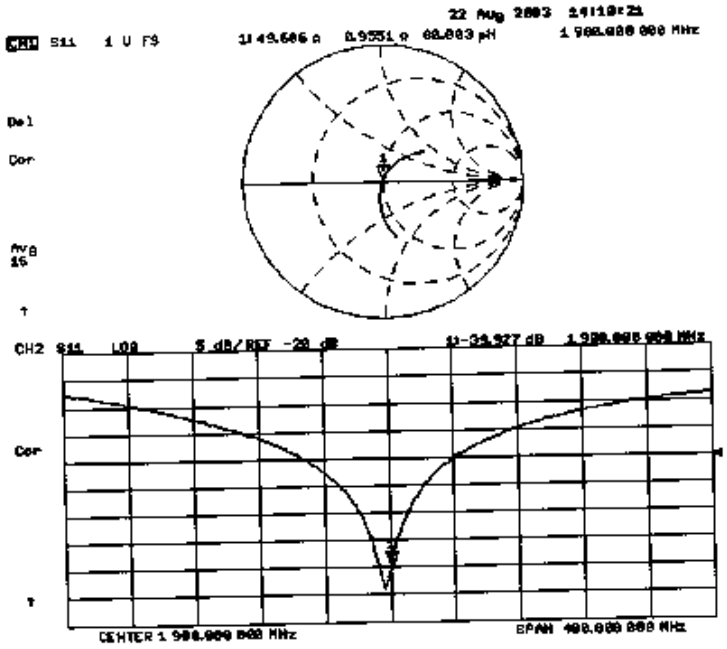
**Pin = 250 mW; d = 10 mm/Area Scan (81x81x1):** Measurement grid: dx=15mm, dy=15mm
Reference Value = 93.6 V/m
Power Drift = 0.05 dB
Maximum value of SAR = 11.5 mW/g

**Pin = 250 mW; d = 10 mm/Zoom Scan (7x7x7)/Cube 0:** Measurement grid: dx=5mm, dy=5mm, dz=5mm
Peak SAR (extrapolated) = 17.7 W/kg
SAR(1 g) = 10.3 mW/g; SAR(10 g) = 5.32 mW/g
Reference Value = 93.6 V/m
Power Drift = 0.05 dB
Maximum value of SAR = 11.5 mW/g




0 dB = 11.5mW/g

545



# APPENDIX E: SAR SET UP PHOTOS

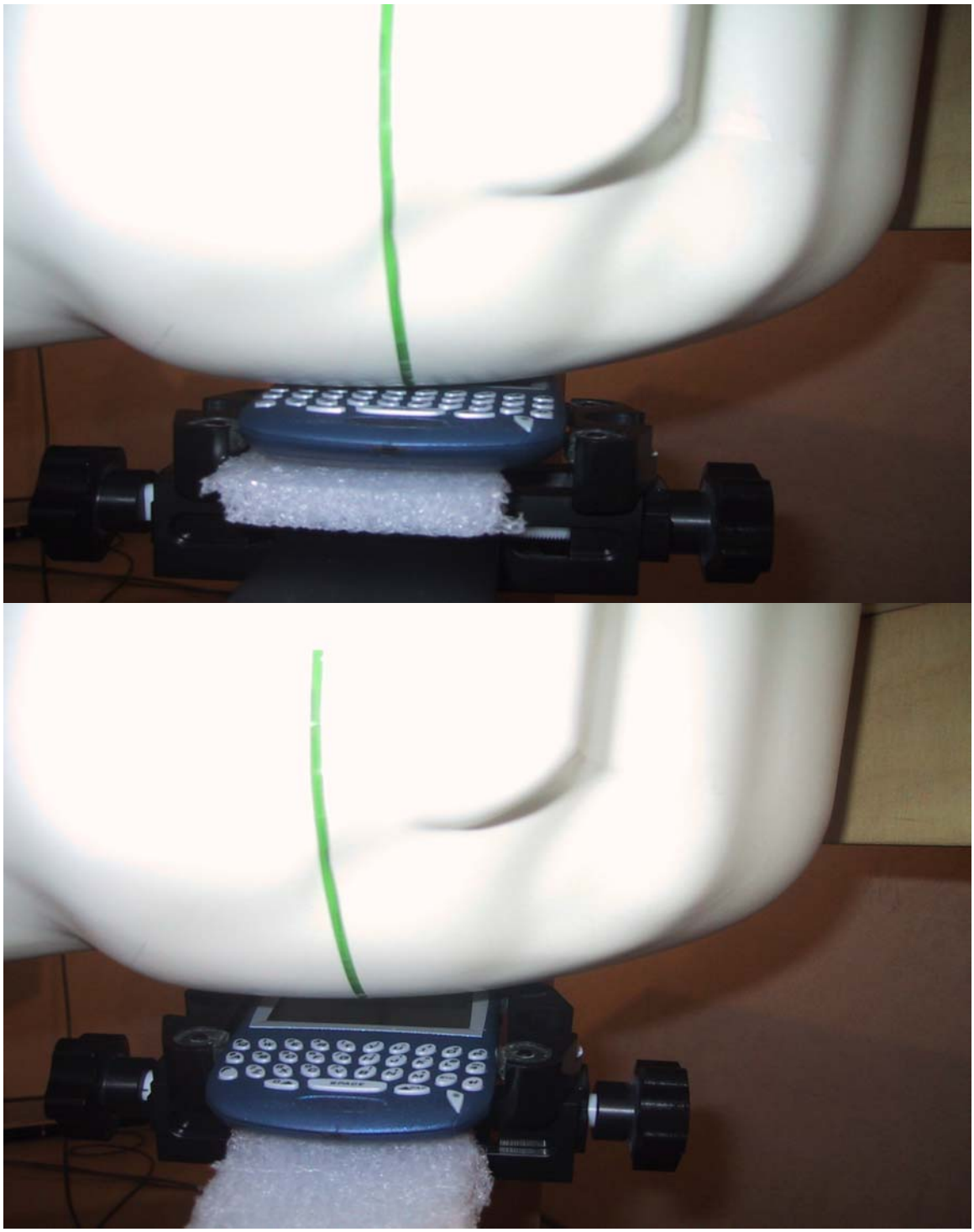


**Figure E1. Left ear configuration**

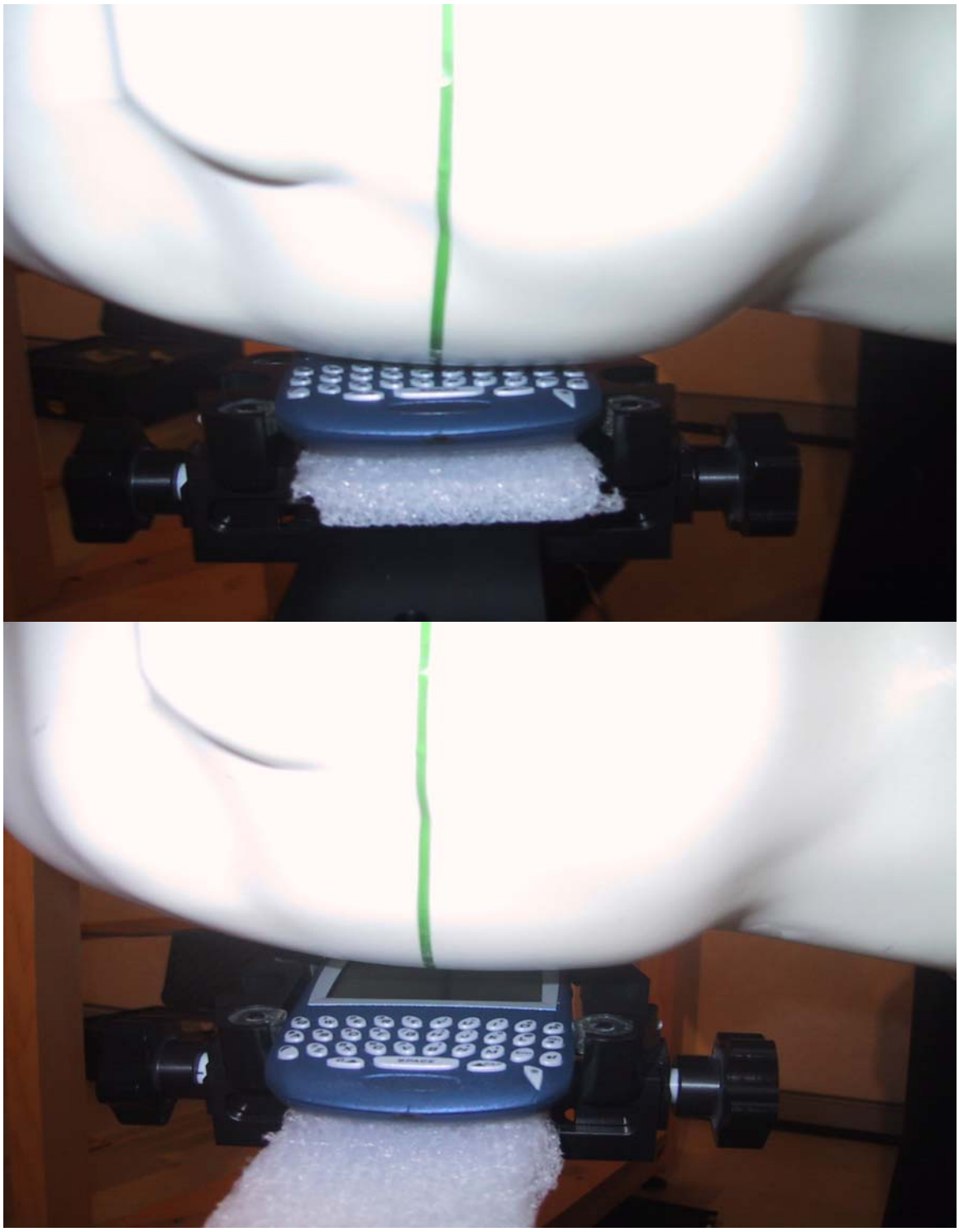


**Figure E2. Right ear configuration**

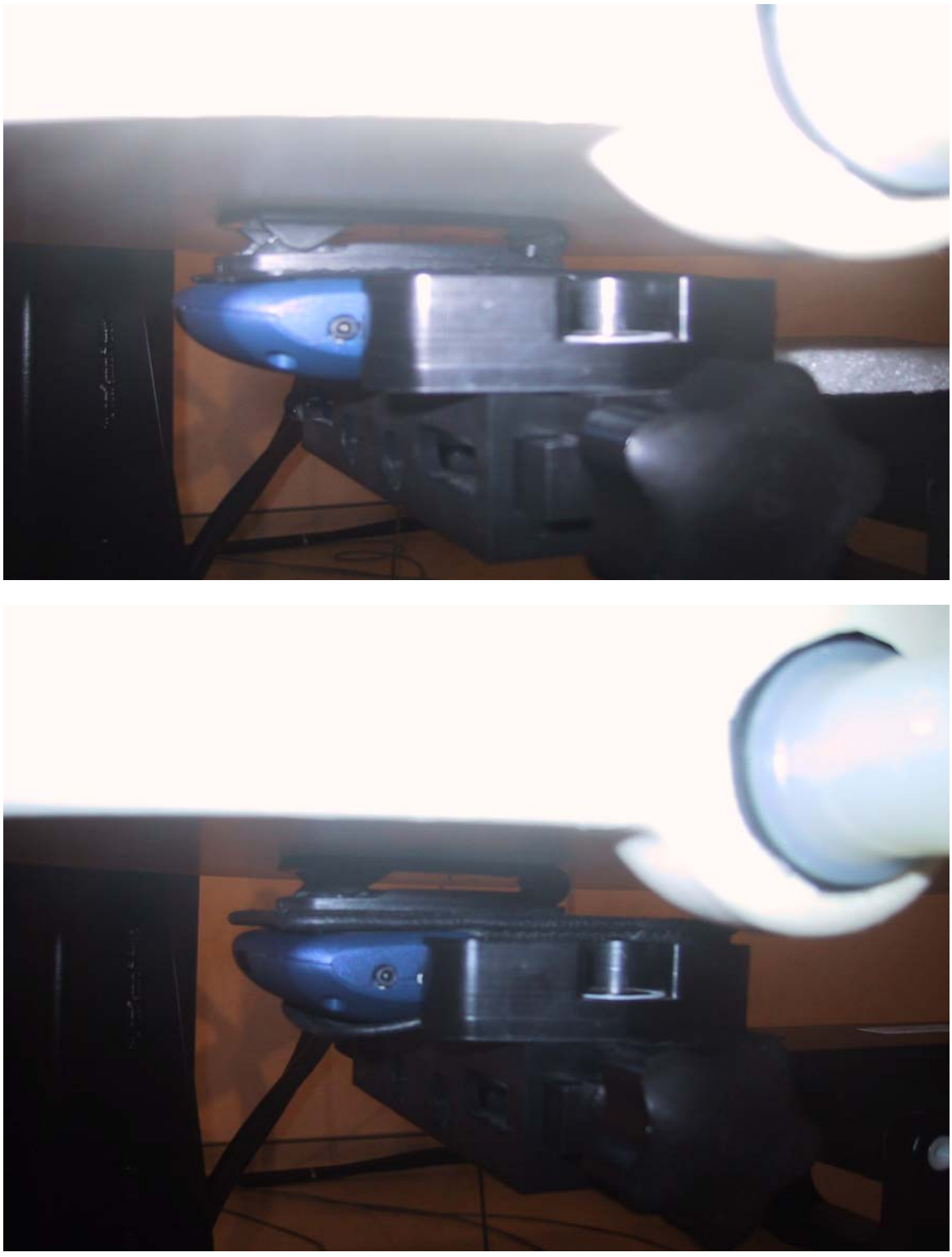


**Figure E3. Body worn configuration with Plastic Holster and Leather Swivel Holster**

**Figure E4. Body worn configuration with Leather Swivel Holster & Headset**

**Figure E5. Body worn configuration with Vertical Foam Holster**

**Figure E6. Body worn configuration with Horizontal Foam Holster**