

Client **ATL (Auden Test Lab)**

Certificate No: **CD2450V3-1037\_Sep05**

## CALIBRATION CERTIFICATE

Object **CD2450V3 - SN: 1037**

Calibration procedure(s) **QA CAL-20.v3**  
**Calibration procedure for dipoles in air**

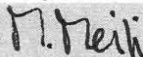
Calibration date: **September 8, 2005**

Condition of the calibrated item **In Tolerance**

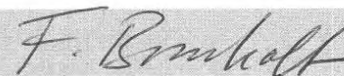
This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).  
All calibrations have been conducted in the closed laboratory facility: environment temperature ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards         | ID #             | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration  |
|---------------------------|------------------|-------------------------------------------|------------------------|
| Power meter EPM-442A      | GB37480704       | 12-Oct-04 (METAS, No. 251-00412)          | Oct-05                 |
| Power sensor HP 8481A     | US37292783       | 12-Oct-04 (METAS, No. 251-00412)          | Oct-05                 |
| 20 dB Attenuator          | SN: 5086 (20g)   | 11-Aug-05 (METAS, No 251-00498)           | Aug-06                 |
| 10 dB Attenuator          | SN: 5047.2 (10r) | 11-Aug-05 (METAS, No 251-00498)           | Aug-06                 |
| Secondary Standards       | ID #             | Check Date (in house)                     | Scheduled Check        |
| Power meter EPM-4419B     | GB43310788       | 10-Aug-03 (SPEAG, in house check Jan-04)  | In house check: Oct-05 |
| Power sensor HP 8481A     | MY41093312       | 10-Aug-03 (SPEAG, in house check Jan-04)  | In house check: Oct-05 |
| Power sensor HP 8481A     | MY41093315       | 10-Aug-03 (SPEAG, in house check Jan-04)  | In house check: Oct-05 |
| Network Analyzer HP 8753E | US37390585       | 18-Oct-01 (SPEAG, in house check Nov-04)  | In house check: Nov-05 |
| RF generator R&S SMT06    | 1039.2000.06     | 26-Jul-04 (SPEAG, in house check Jul-04)  | In house check: Jan-06 |
| DAE4                      | SN: 660          | 16-Dec-04 (SPEAG, No. DAE4-660_Dec04)     | Calibration, Dec-05    |
| Probe ER3DV6              | SN: 2336         | 20-Jan-05 (SPEAG, No. ER3-2336_Jan05)     | Calibration, Jan-06    |
| Probe H3DV6               | SN: 6065         | 10-Dec-04 (SPEAG, No. H3-6065-Dec04)      | Calibration, Dec-05    |

|                |            |                       |                                                                                       |
|----------------|------------|-----------------------|---------------------------------------------------------------------------------------|
|                | Name       | Function              | Signature                                                                             |
| Calibrated by: | Mike Meili | Laboratory Technician |  |

|              |             |                    |
|--------------|-------------|--------------------|
| Approved by: | Fin Bomholt | Technical Director |
|--------------|-------------|--------------------|



Issued: September 20, 2005

This calibration certificate is issued as an intermediate solution until the specific calibration procedure is submitted and accepted in the frame of the accreditation of the Calibration Laboratory of Schmid & Partner Engineering AG (based on ISO/IEC 17025 International Standard)

## References

- [1] ANSI-PC63.19-2001 (Draft 3.x, 2005)  
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

## Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with standard [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the top edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections. It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY4 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminated by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E- field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 10 mm (in z) above the top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

## 1 Measurement Conditions

DASY system configuration, as far as not given on page 1.

|                                    |                                        |                      |
|------------------------------------|----------------------------------------|----------------------|
| DASY Version                       | DASY4                                  | V4.6 B13             |
| DASY PP Version                    | SEMCAD                                 | V1.8 B156            |
| Phantom                            | HAC Test Arch                          | SD HAC P01 BA, #1002 |
| Distance Dipole Top - Probe Center | 10 mm                                  |                      |
| Scan resolution                    | dx, dy = 5 mm                          | area = 20 x 90 mm    |
| Frequency                          | <b>2450 MHz <math>\pm</math> 1 MHz</b> |                      |
| Forward power at dipole connector  | 20.0 dBm = 100mW                       |                      |
| Input power drift                  | < 0.05 dB                              |                      |

## 2 Maximum Field values

| H-field 10 mm above dipole surface | condition            | Interpolated maximum |
|------------------------------------|----------------------|----------------------|
| Maximum measured                   | 100 mW forward power | <b>0.479 A/m</b>     |

Uncertainty for H-field measurement: 8.2% (k=2)

| E-field 10 mm above dipole surface | condition            | Interpolated maximum |
|------------------------------------|----------------------|----------------------|
| Maximum measured above high end    | 100 mW forward power | 132.6 V/m            |
| Maximum measured above low end     | 100 mW forward power | 132.0 V/m            |
| Averaged maximum above arm         | 100 mW forward power | <b>132.3 V/m</b>     |

Uncertainty for E-field measurement: 12.8% (k=2)

## 3 Appendix

### 3.1 Antenna Parameters

| Frequency       | Return Loss    | Impedance                  |
|-----------------|----------------|----------------------------|
| 2250 MHz        | 15.8 dB        | ( 69.4 + j0.8 ) Ohm        |
| 2350 MHz        | 25.8 dB        | ( 52.5 – j4.6 ) Ohm        |
| <b>2450 MHz</b> | <b>31.6 dB</b> | <b>( 52.0 – j1.8 ) Ohm</b> |
| 2550 MHz        | 39.7 dB        | ( 50.9 + j0.6 ) Ohm        |
| 2650 MHz        | 16.7 dB        | ( 63.0 – j10.2 ) Ohm       |

### 3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

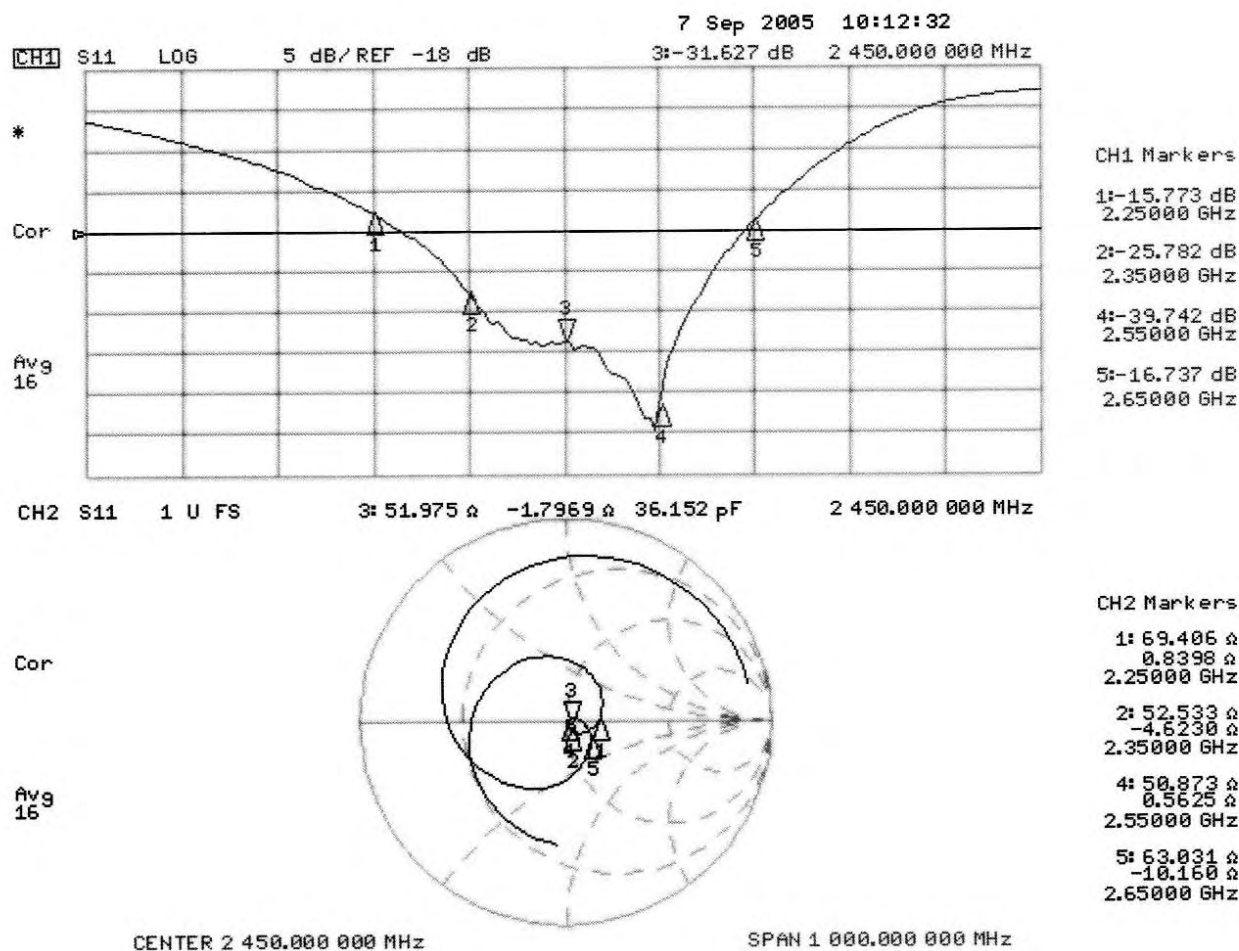
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

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

### 3.3 Measurement Sheets

#### 3.3.1 Return Loss and Smith Chart



3.3.2 DASY4 H-field result

Date/Time: 9/8/2005 3:56:30 PM

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC Dipole 2450 MHz; Type: CD2450V3; Serial: 1037

Communication System: CW; Frequency: 2450 MHz;Duty Cycle: 1:1

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1$  kg/m<sup>3</sup>

Phantom section: H Dipole Section

DASY4 Configuration:

- Probe: H3DV6 - SN6065; Calibrated: 12/10/2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn660; Calibrated: 12/16/2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.6 Build 13; Postprocessing SW: SEMCAD, V1.8 Build 156

H Scan 10mm above CD 2450 MHz/Hearing Aid Compatibility Test (41x181x1): Measurement grid: dx=5mm, dy=5mm

Maximum value of peak Total field = 0.479 A/m

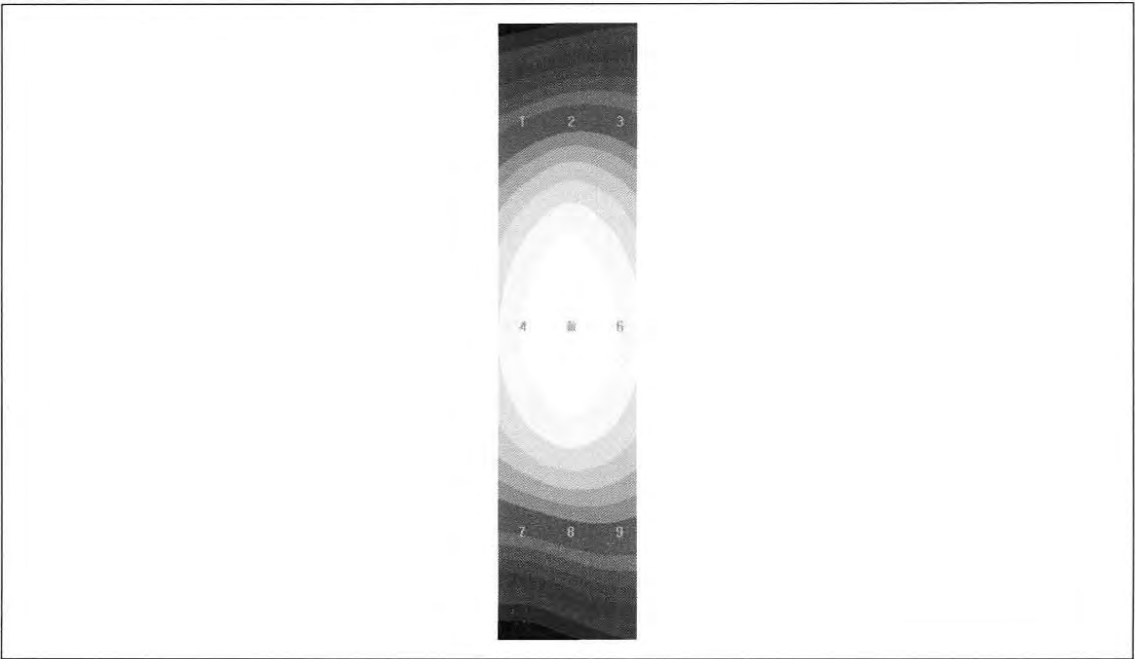
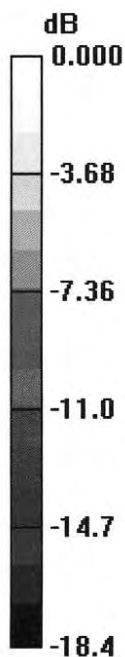
Probe Modulation Factor = 1.00

Reference Value = 0.501 A/m; Power Drift = 0.014 dB

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

Peak H-field in A/m

|        |        |        |
|--------|--------|--------|
| Grid 1 | Grid 2 | Grid 3 |
| 0.369  | 0.399  | 0.384  |
| Grid 4 | Grid 5 | Grid 6 |
| 0.448  | 0.479  | 0.460  |
| Grid 7 | Grid 8 | Grid 9 |
| 0.364  | 0.389  | 0.376  |



0 dB = 0.479A/m

### 3.3.3 DASY4 E-Field result

Date/Time: 9/8/2005 12:58:18 PM

Test Laboratory: SPEAG, Zurich, Switzerland

**DUT: HAC Dipole 2450 MHz; Type: CD2450V3; Serial: 1037**

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: Air

Medium parameters used:  $\sigma = 0$  mho/m,  $\epsilon_r = 1$ ;  $\rho = 1000$  kg/m<sup>3</sup>

Phantom section: E Dipole Section

DASY4 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 1/20/2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn660; Calibrated: 12/16/2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.6 Build 13; Postprocessing SW: SEMCAD, V1.8 Build 156

**E Scan 10mm above CD 2450 MHz/Hearing Aid Compatibility Test (41x181x1):** Measurement grid: dx=5mm, dy=5mm

Maximum value of peak Total field = 132.6 V/m

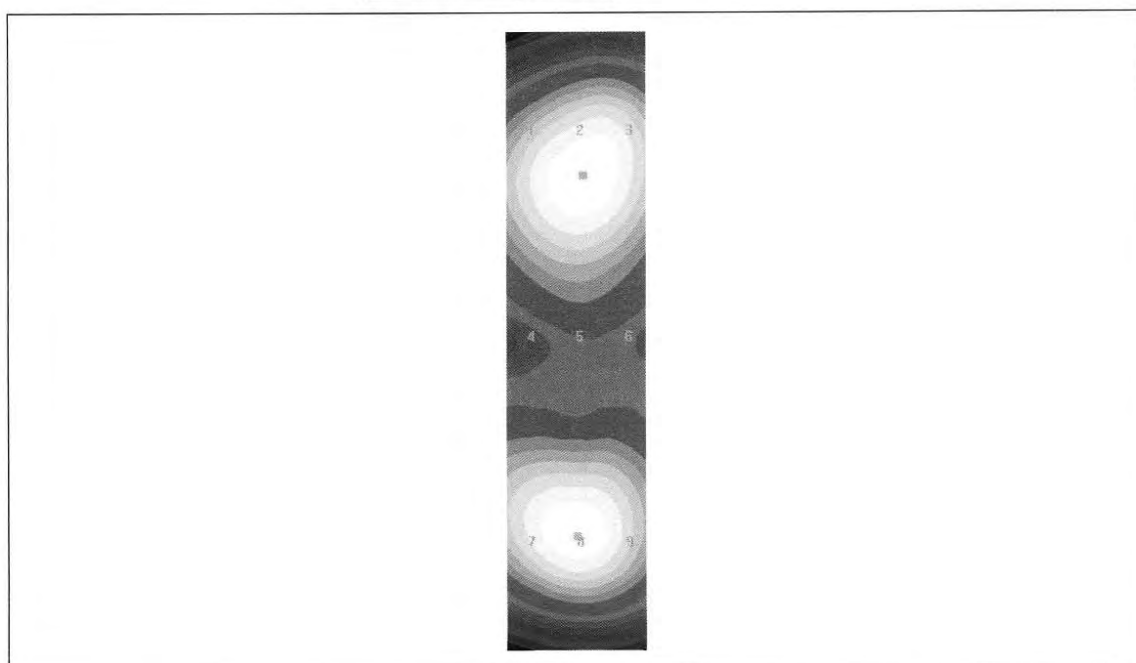
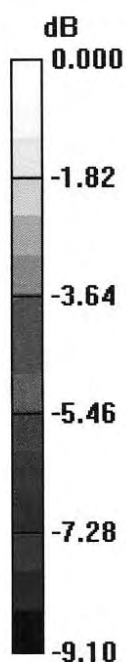
Probe Modulation Factor = 1.00

Reference Value = 80.3 V/m; Power Drift = -0.011 dB

**Hearing Aid Near-Field Category: M2 (AWF 0 dB)**

Peak E-field in V/m

|        |        |        |
|--------|--------|--------|
| Grid 1 | Grid 2 | Grid 3 |
| 124.7  | 132.0  | 130.7  |
| Grid 4 | Grid 5 | Grid 6 |
| 108.6  | 113.8  | 110.2  |
| Grid 7 | Grid 8 | Grid 9 |
| 126.5  | 132.6  | 127.1  |



0 dB = 132.5V/m



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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 **ATL (Auden)**

Certificate No: **ER3-2256\_Oct05**

## CALIBRATION CERTIFICATE

Object **ER3DV6 - SN:2256**

Calibration procedure(s) **QA CAL-02.v4**  
Calibration procedure for E-field probes optimized for close near field  
evaluations in air

Calibration date: **October 21, 2005**

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  $(22 \pm 3)^\circ\text{C}$  and humidity  $< 70\%$ .

Calibration Equipment used (M&TE critical for calibration)

| Primary Standards          | ID #            | Cal Date (Calibrated by, Certificate No.) | Scheduled Calibration |
|----------------------------|-----------------|-------------------------------------------|-----------------------|
| Power meter E4419B         | GB41293874      | 3-May-05 (METAS, No. 251-00466)           | May-06                |
| Power sensor E4412A        | MY41495277      | 3-May-05 (METAS, No. 251-00466)           | May-06                |
| Power sensor E4412A        | MY41498087      | 3-May-05 (METAS, No. 251-00466)           | May-06                |
| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 11-Aug-05 (METAS, No. 251-00499)          | Aug-06                |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-05 (METAS, No. 251-00467)           | May-06                |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 11-Aug-05 (METAS, No. 251-00500)          | Aug-06                |
| Reference Probe ER3DV6     | SN: 2328        | 3-Oct-05 (SPEAG, No. ER3-2328_Oct05)      | Oct-06                |
| DAE4                       | SN: 654         | 29-Nov-04 (SPEAG, No. DAE4-654_Nov04)     | Nov-05                |

| Secondary Standards       | ID #         | Check Date (in house)                    | Scheduled Check        |
|---------------------------|--------------|------------------------------------------|------------------------|
| RF generator HP 8648C     | US3642U01700 | 4-Aug-99 (SPEAG, in house check Dec-03)  | In house check: Dec-05 |
| Network Analyzer HP 8753E | US37390585   | 18-Oct-01 (SPEAG, in house check Nov-04) | In house check: Nov 05 |

|                |               |                       |           |
|----------------|---------------|-----------------------|-----------|
|                | Name          | Function              | Signature |
| Calibrated by: | Nico Vetterli | Laboratory Technician |           |

|              |               |                   |           |
|--------------|---------------|-------------------|-----------|
|              | Name          | Function          | Signature |
| Approved by: | Katja Pokovic | Technical Manager |           |

Issued: October 24, 2005

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



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The Swiss Accreditation Service is one of the signatories to the EA  
Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 108**

**Glossary:**

|                          |                                                                                                                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| NORM <sub>x,y,z</sub>    | sensitivity in free space                                                                                                                            |
| DCP                      | diode compression point                                                                                                                              |
| Polarization $\varphi$   | $\varphi$ rotation around probe axis                                                                                                                 |
| Polarization $\vartheta$ | $\vartheta$ 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 |
| Connector Angle          | information used in DASY system to align probe sensor X to the robot coordinate system                                                               |

**Calibration is Performed According to the Following Standards:**

- a) IEEE Std 1309-1996, "IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", 1996.

**Methods Applied and Interpretation of Parameters:**

- **NORM<sub>x,y,z</sub>**: Assessed for E-field polarization  $\vartheta = 0$  for XY sensors and  $\vartheta = 90$  for Z sensor ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide).
- **NORM(f)<sub>x,y,z</sub>** = NORM<sub>x,y,z</sub> \* frequency\_response (see Frequency Response Chart).
- **DCP<sub>x,y,z</sub>**: DCP are numerical linearization parameters assessed based on the data of power sweep (no uncertainty required). DCP does not depend on frequency.
- **Spherical isotropy (3D deviation from isotropy)**: in a locally homogeneous field realized using an open waveguide setup.
- **Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- **Connector Angle**: The angle is assessed using the information gained by determining the NORM<sub>x</sub> (no uncertainty required).

# Probe ER3DV6

## SN:2256

|                  |                  |
|------------------|------------------|
| Manufactured:    | March 15, 2001   |
| Last calibrated: | May 15, 2003     |
| Recalibrated:    | October 21, 2005 |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

**DASY - Parameters of Probe: ER3DV6 SN:2256**Sensitivity in Free Space [ $\mu\text{V}/(\text{V}/\text{m})^2$ ]Diode Compression<sup>A</sup>NormX      **2.17  $\pm$  10.1 % (k=2)**DCP X      **98 mV**NormY      **1.58  $\pm$  10.1 % (k=2)**DCP Y      **98 mV**NormZ      **1.66  $\pm$  10.1 % (k=2)**DCP Z      **98 mV**

Frequency Correction

X      **0.0**Y      **0.0**Z      **0.0**

Sensor Offset

(Probe Tip to Sensor Center)

X      **2.5 mm**Y      **2.5 mm**Z      **2.5 mm**

Connector Angle

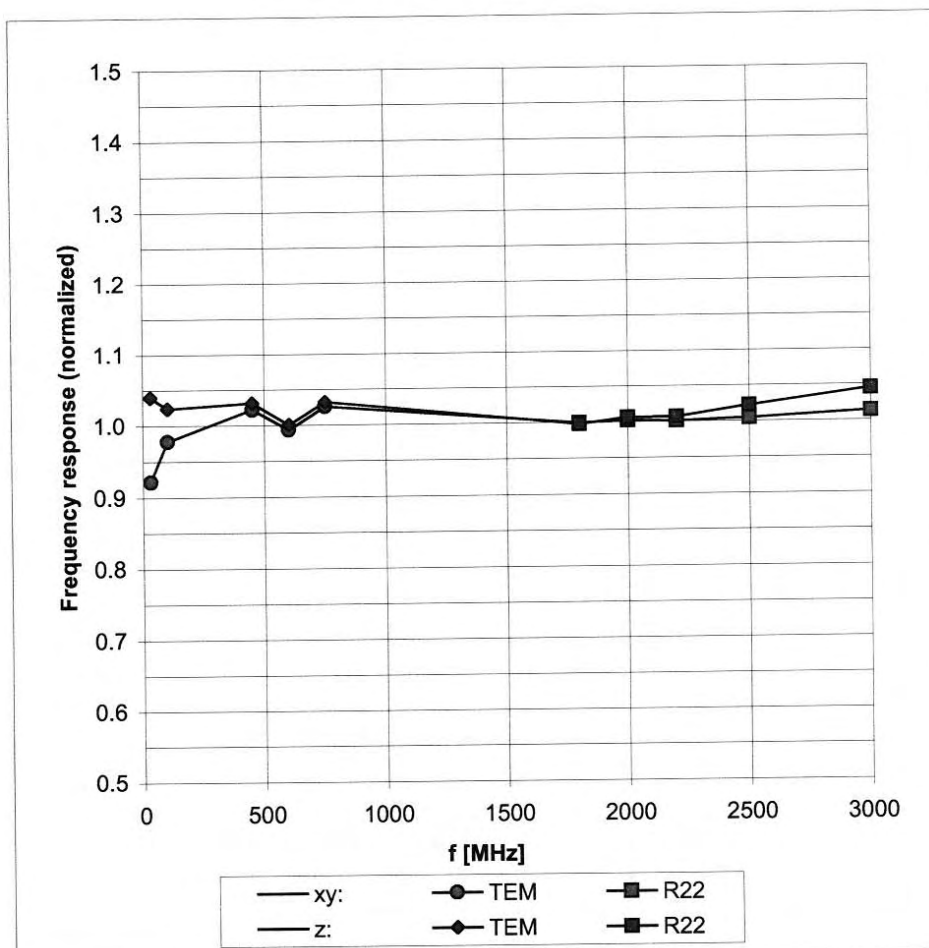
**303 °**

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%.

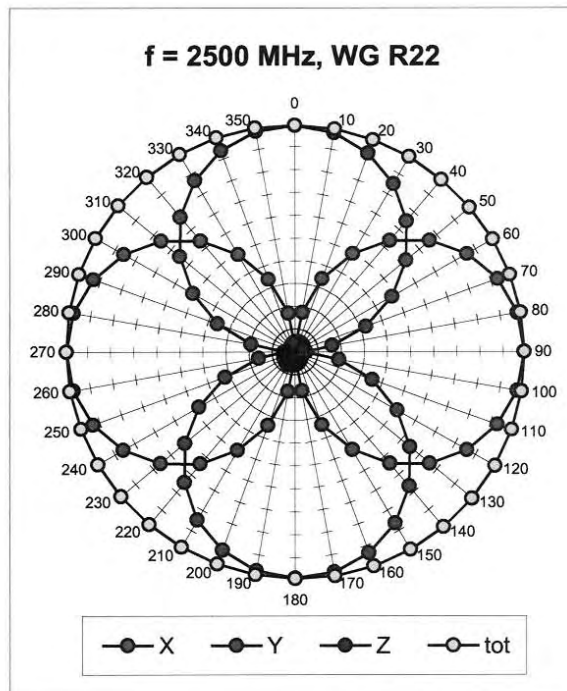
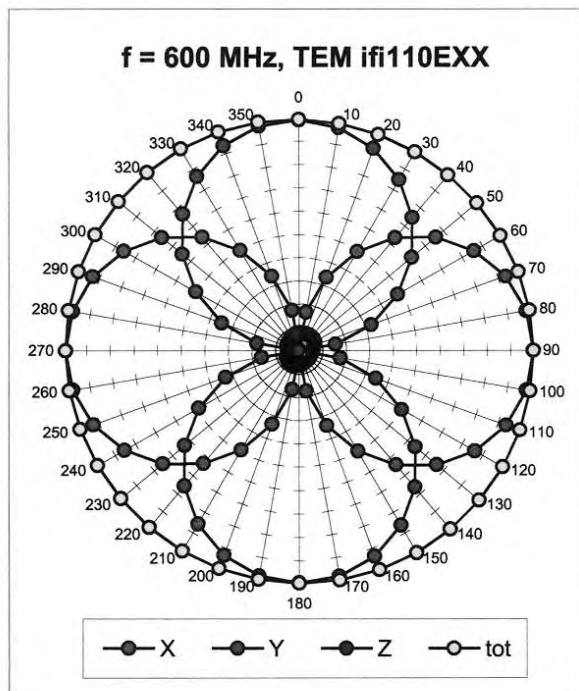
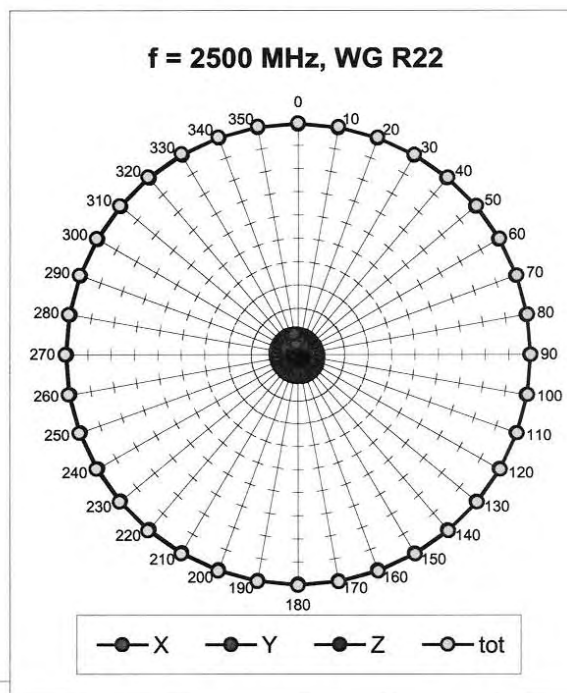
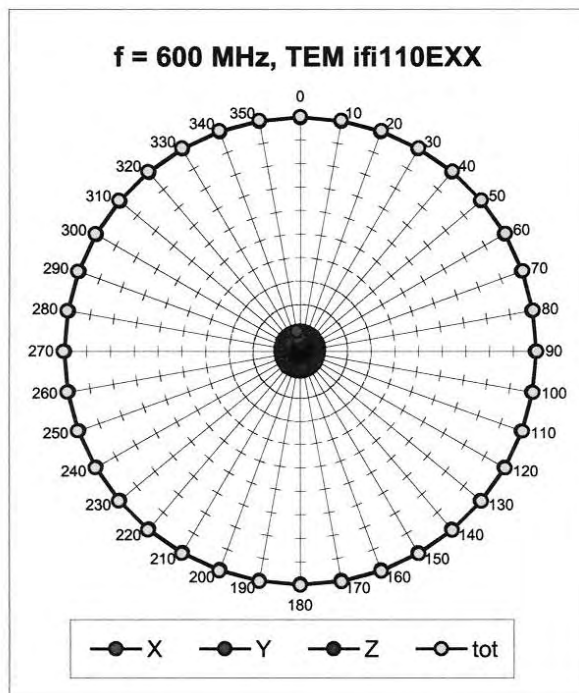
<sup>A</sup> numerical linearization parameter: uncertainty not required

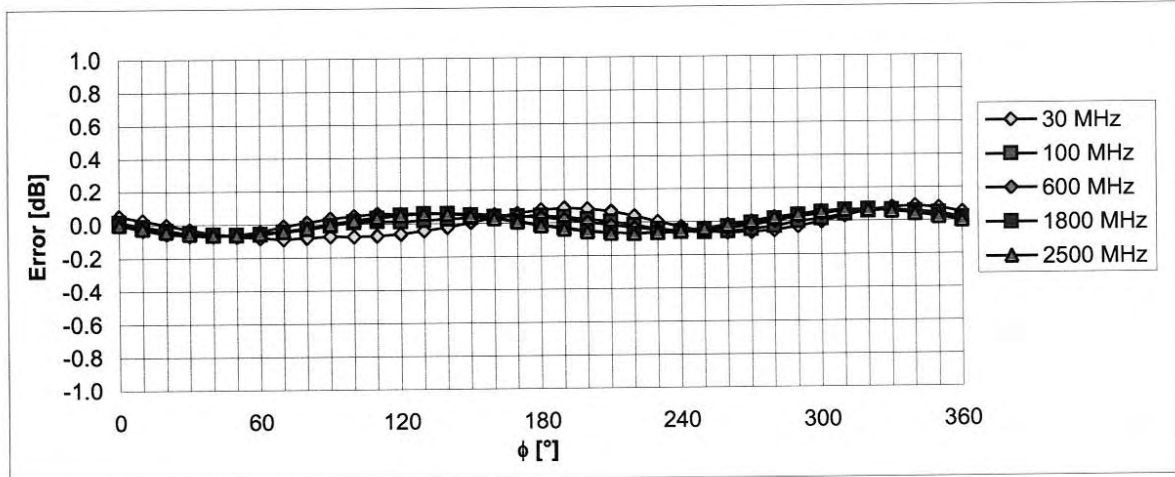
## Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)

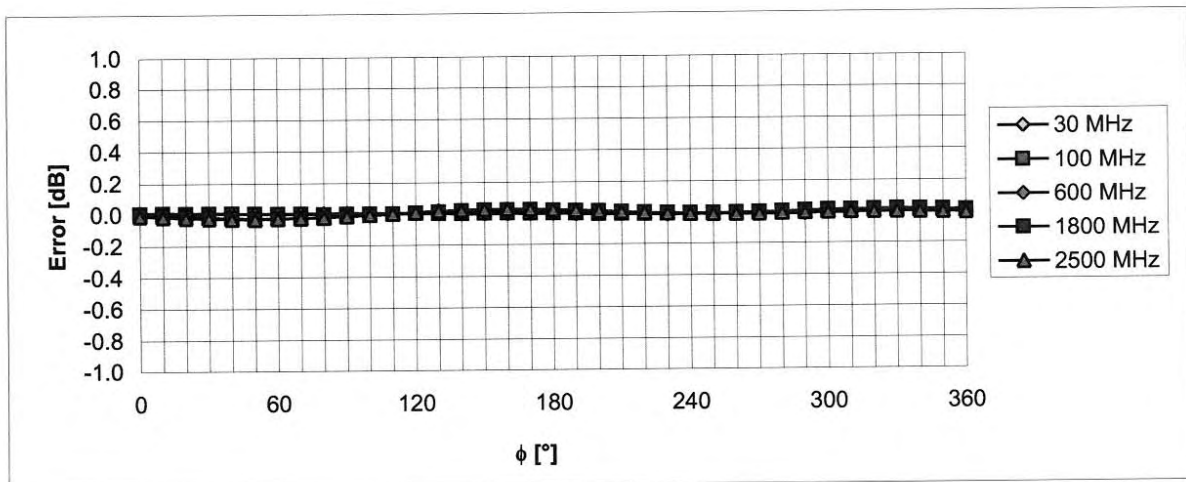


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

**Receiving Pattern ( $\phi$ ),  $\vartheta = 0^\circ$** **Receiving Pattern ( $\phi$ ),  $\vartheta = 90^\circ$** 

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

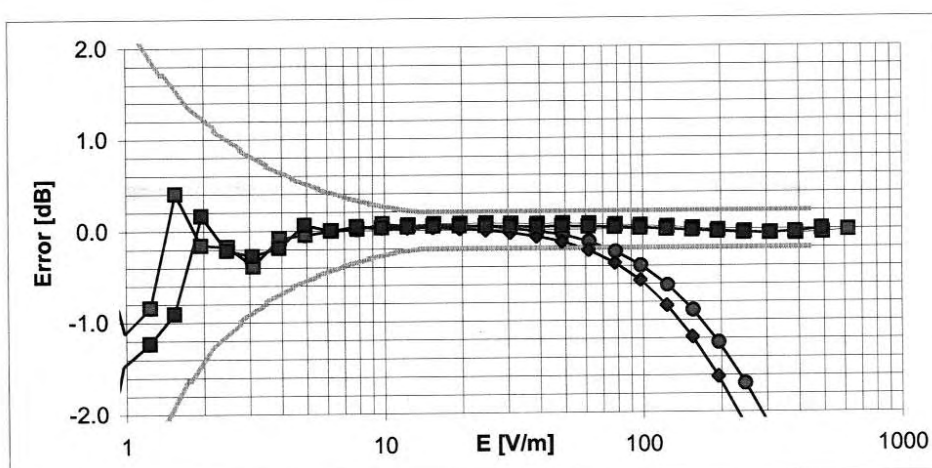
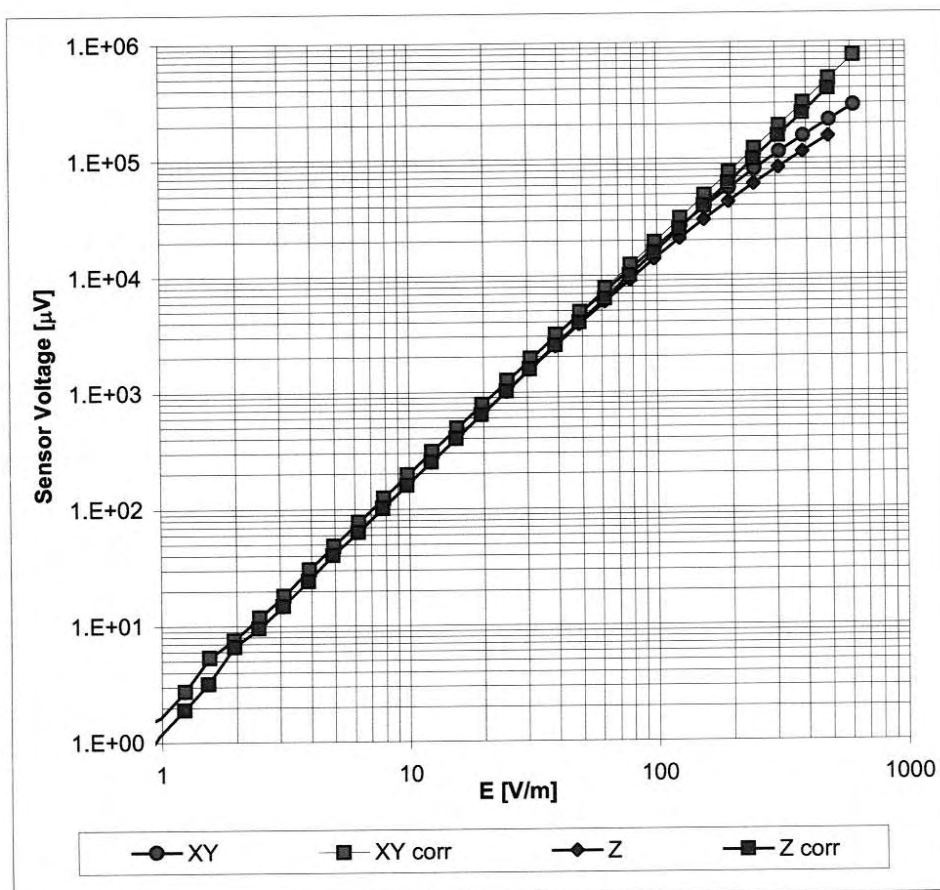
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

**Receiving Pattern ( $\phi$ ),  $\vartheta = 90^\circ$** 

Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

## Dynamic Range f(E-field)

(Waveguide R22,  $f = 1800$  MHz)



Uncertainty of Linearity Assessment:  $\pm 0.6\%$  ( $k=2$ )