

## **ATTACHMENT D – PROBE CALIBRATION DATA**

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



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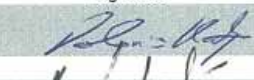
Accreditation No.: **SCS 108**Client **H-CT (Dymstec)**Certificate No: **ER3-2343\_Mar06****CALIBRATION CERTIFICATE**Object **ER3DV6 - SN:2343**Calibration procedure(s) **QA CAL-02.v4  
Calibration procedure for E-field probes optimized for close near field  
evaluations in air**Calibration date: **March 23, 2006**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 ( $22 \pm 3$ )°C and humidity < 70%.

Calibration Equipment used (M&amp;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         | 2-Feb-06 (SPEAG, No. DAE4-654_Feb06)      | Feb-07                 |
| Secondary Standards        | ID #            | Check Date (in house)                     | Scheduled Check        |
| RF generator HP 8648C      | US3642U01700    | 4-Aug-99 (SPEAG, in house check Nov-05)   | In house check: Nov-07 |
| Network Analyzer HP 8753E  | US37390585      | 18-Oct-01 (SPEAG, in house check Nov-05)  | In house check: Nov 06 |

|                |               |                   |                                                                                       |
|----------------|---------------|-------------------|---------------------------------------------------------------------------------------|
|                | Name          | Function          | Signature                                                                             |
| Calibrated by: | Katja Pokovic | Technical Manager |  |
| Approved by:   | Niels Kuster  | Quality Manager   |  |

Issued: March 23, 2006

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Certificate No: ER3-2343\_Mar06

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Accreditation No.: **SCS 108**

**Glossary:**

|                          |                                                                                                                                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| NORM <sub>x,y,z</sub>    | sensitivity in free space                                                                                                                            |
| DCP                      | diode compression point                                                                                                                              |
| Polarization $\phi$      | $\phi$ 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).

ER3DV6 SN:2343

March 23, 2006

# Probe ER3DV6

## SN:2343

|                  |                 |
|------------------|-----------------|
| Manufactured:    | January 1, 2005 |
| Last calibrated: | April 27, 2005  |
| Recalibrated:    | March 23, 2006  |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

ER3DV6 SN:2343

March 23, 2006

**DASY - Parameters of Probe: ER3DV6 SN:2343**Sensitivity in Free Space [ $\mu\text{V}/(\text{V}/\text{m})^2$ ]Diode Compression<sup>A</sup>

|       |                     |
|-------|---------------------|
| NormX | 1.64 ± 10.1 % (k=2) |
| NormY | 1.62 ± 10.1 % (k=2) |
| NormZ | 1.65 ± 10.1 % (k=2) |

|       |       |
|-------|-------|
| DCP X | 93 mV |
| DCP Y | 93 mV |
| DCP Z | 95 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

43 °

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%.

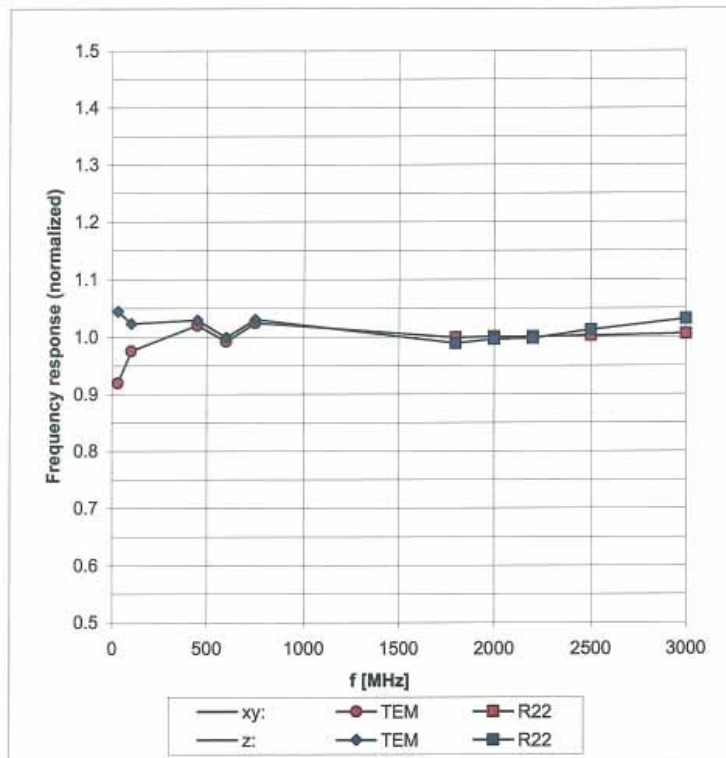
<sup>A</sup> numerical linearization parameter; uncertainty not required

ER3DV6 SN:2343

March 23, 2006

## Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)

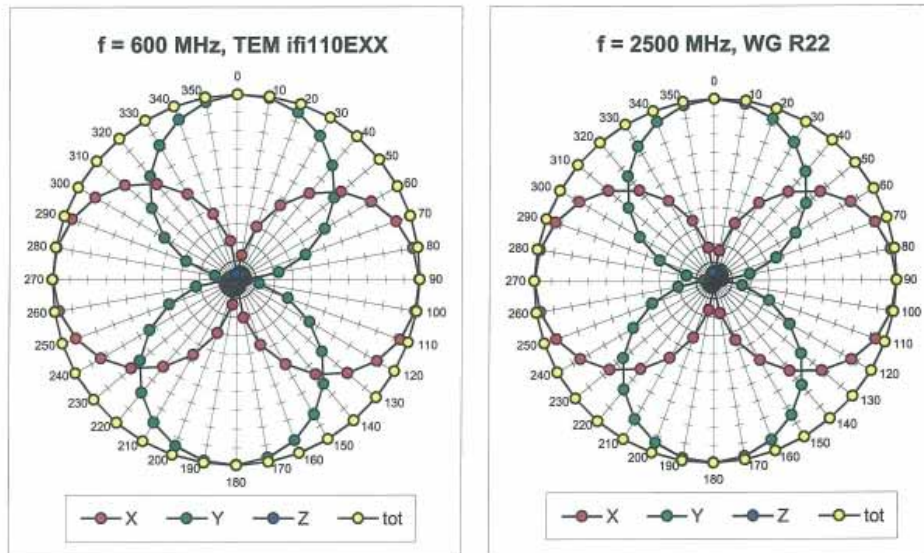


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

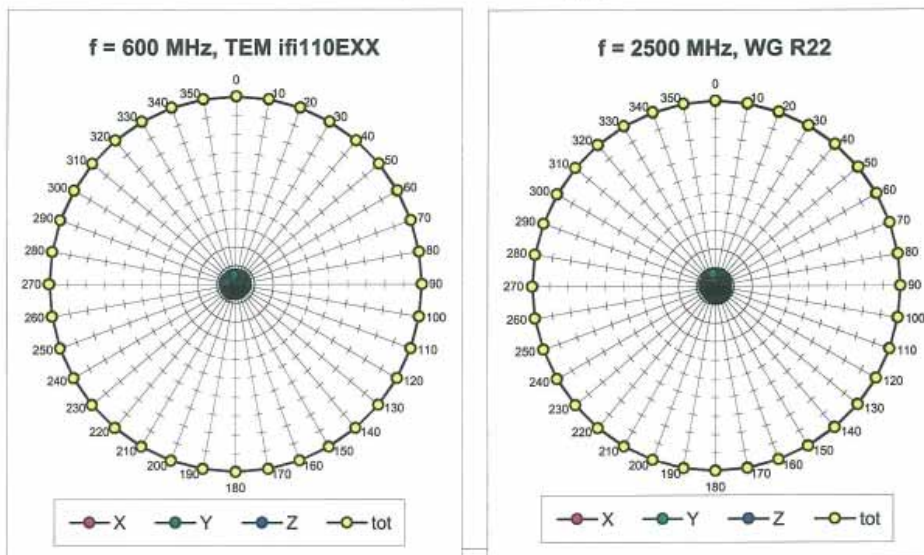
ER3DV6 SN:2343

March 23, 2006

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



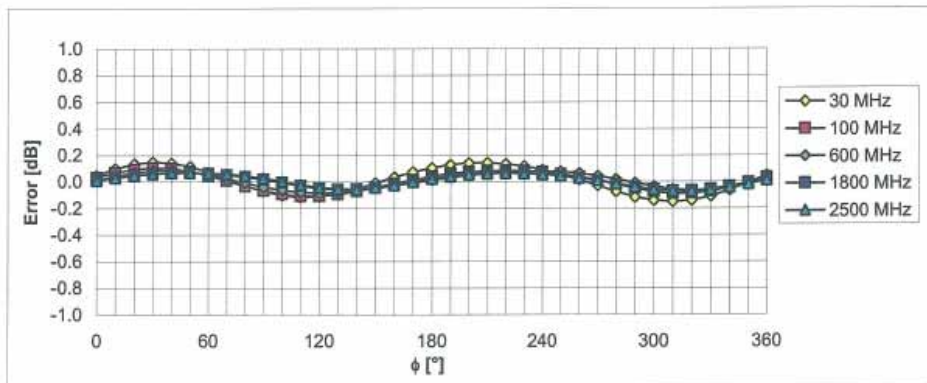
### Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$



ER3DV6 SN:2343

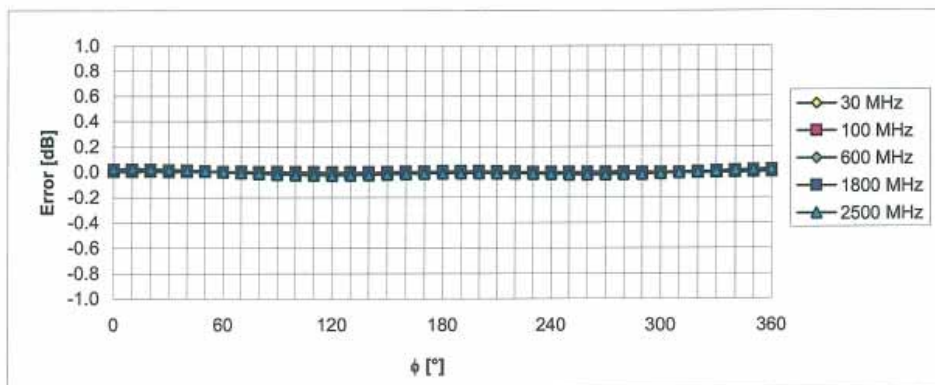
March 23, 2006

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



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

### Receiving Pattern ( $\phi$ ), $\theta = 90^\circ$

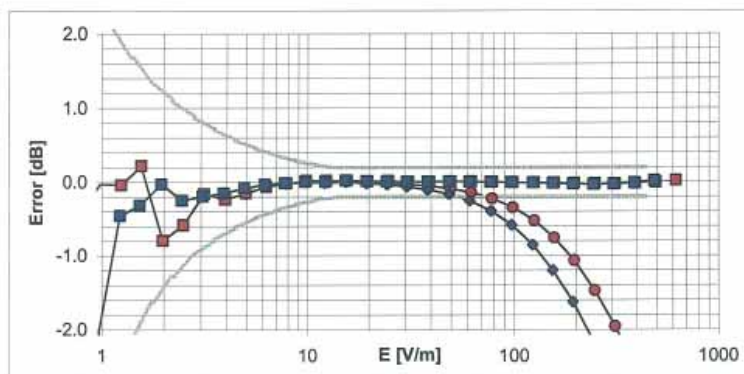
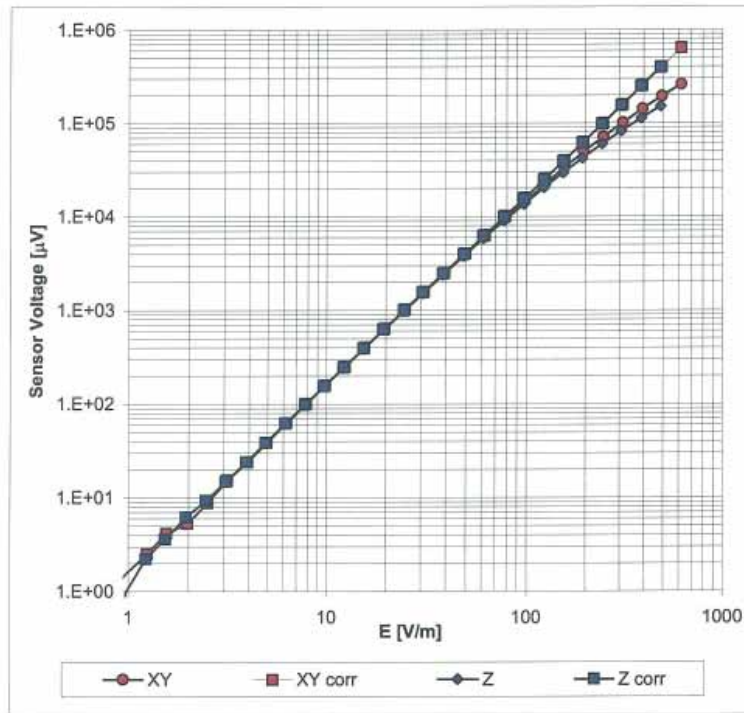


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

ER3DV6 SN:2343

March 23, 2006

### Dynamic Range f(E-field) (Waveguide R22, f = 1800 MHz)

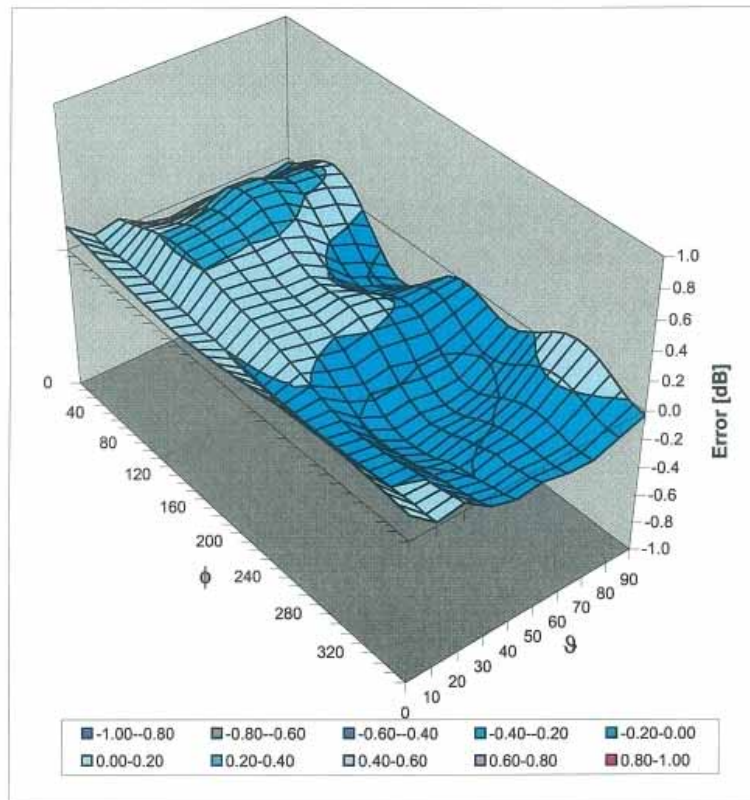


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

ER3DV6 SN:2343

March 23, 2006

**Deviation from Isotropy in Air**  
**Error ( $\phi$ ,  $\theta$ ),  $f = 900$  MHz**



Uncertainty of Spherical Isotropy Assessment:  $\pm 2.6\%$  ( $k=2$ )

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Accreditation No.: **SCS 108**Client **HCT (Dymstec)**Certificate No: **H3-6101\_Jul05****CALIBRATION CERTIFICATE**Object **H3DV6 - SN:6101**Calibration procedure(s) **QA CAL-03.v4  
Calibration procedure for H-field probes optimized for close near field  
evaluations in air**Calibration date: **July 20, 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 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&amp;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                 |
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| Reference 3 dB Attenuator  | SN: S5054 (3c)  | 10-Aug-04 (METAS, No. 251-00403)          | Aug-05                 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 3-May-05 (METAS, No. 251-00467)           | May-06                 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 10-Aug-04 (METAS, No. 251-00404)          | Aug-05                 |
| Reference Probe H3DV6      | SN: 6182        | 6-Oct-04 (SPEAG, No. H3-6182_Oct04)       | Oct-05                 |
| DAE4                       | SN: 907         | 21-Jun-05 (SPEAG, No. DAE4-907_Jun05)     | Jun-06                 |
| 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 |

Calibrated by: **Name** Nico Vetterli **Function** Laboratory Technician

Signature

Approved by: **Name** Katja Pokovic **Function** Technical Manager

Issued: July 20, 2005

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Accreditation No.: **SCS 108**

**Glossary:**

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|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
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| DCP                      | diode compression point                                                                                                                              |
| Polarization $\phi$      | $\phi$ rotation around probe axis                                                                                                                    |
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| 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:**

- $X, Y, Z_{a0a1a2}$ : Assessed for E-field polarization  $\vartheta = 90$  for XY sensors and  $\vartheta = 0$  for Z sensor ( $f \leq 900$  MHz in TEM-cell;  $f > 1800$  MHz: R22 waveguide).
- $X, Y, Z(f)_{a0a1a2} = X, Y, Z_{a0a1a2} * \text{frequency\_response}$  (see Frequency Response Chart).
- $DCP_{x,y,z}$ : 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  $X_{a0a1a2}$  (no uncertainty required).

H3DV6 SN:6101

July 20, 2005

# Probe H3DV6

## SN:6101

|                  |                   |
|------------------|-------------------|
| Manufactured:    | December 10, 2001 |
| Last calibrated: | January 7, 2002   |
| Recalibrated:    | July 20, 2005     |

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

H3DV6 SN:6101

July 20, 2005

**DASY - Parameters of Probe: H3DV6 SN:6101**Sensitivity in Free Space [A/m /  $\sqrt{(\mu V)}$ ]

|   | a0        | a1        | a2                          |
|---|-----------|-----------|-----------------------------|
| X | 2.815E-03 | 4.461E-5  | -2.024E-5 $\pm$ 5.1 % (k=2) |
| Y | 2.855E-03 | -7.592E-5 | -5.205E-5 $\pm$ 5.1 % (k=2) |
| Z | 3.047E-03 | -5.206E-5 | 9.184E-6 $\pm$ 5.1 % (k=2)  |

Diode Compression<sup>1</sup>

|       |       |
|-------|-------|
| DCP X | 87 mV |
| DCP Y | 87 mV |
| DCP Z | 86 mV |

Sensor Offset (Probe Tip to Sensor Center)

|   |        |
|---|--------|
| X | 3.0 mm |
| Y | 3.0 mm |
| Z | 3.0 mm |

Connector Angle 240 °

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%.

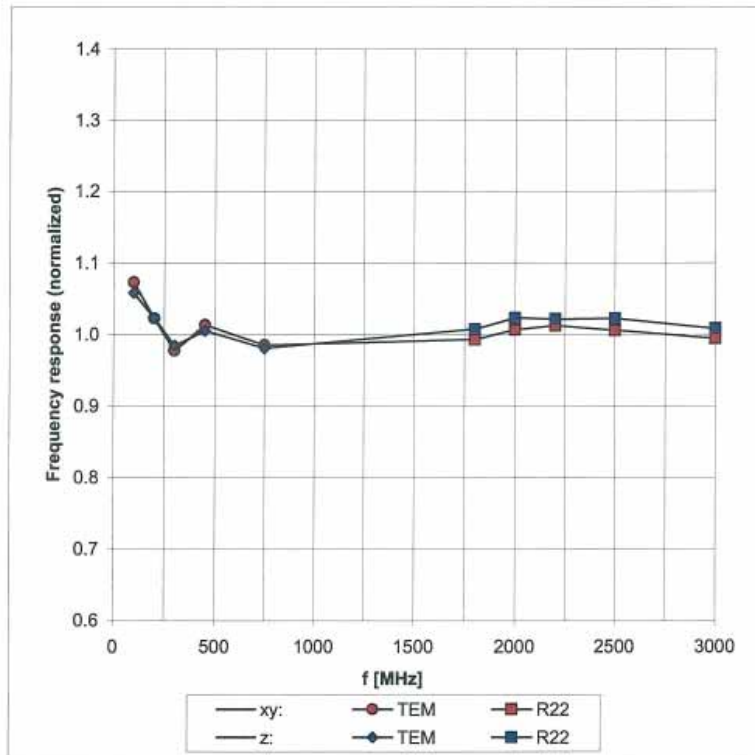
<sup>1</sup> numerical linearization parameter: uncertainty not required

H3DV6 SN:6101

July 20, 2005

## Frequency Response of H-Field

(TEM-Cell:ifi110, Waveguide R22)

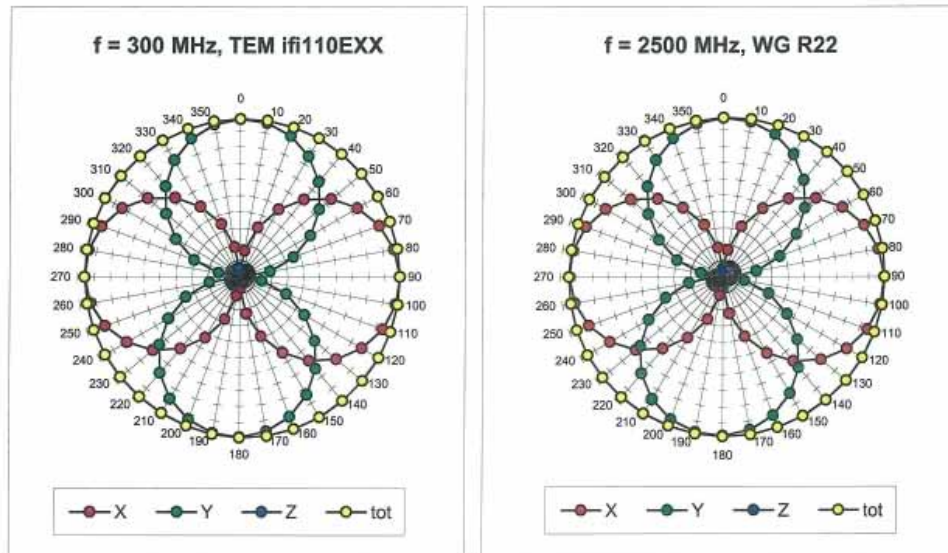


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

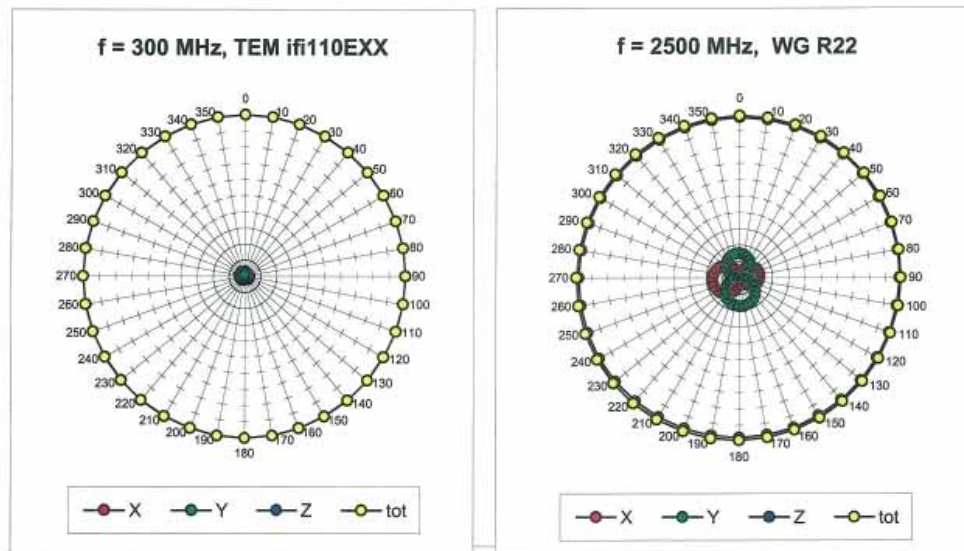
H3DV6 SN:6101

July 20, 2005

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



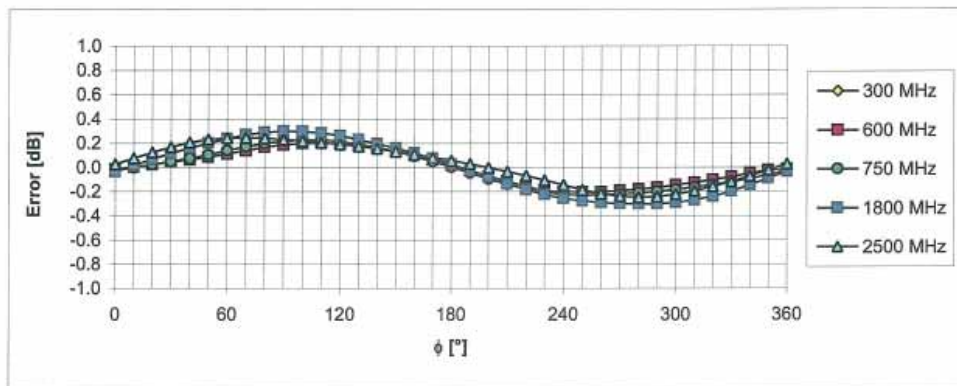
### Receiving Pattern ( $\phi$ ), $\vartheta = 0^\circ$



H3DV6 SN:6101

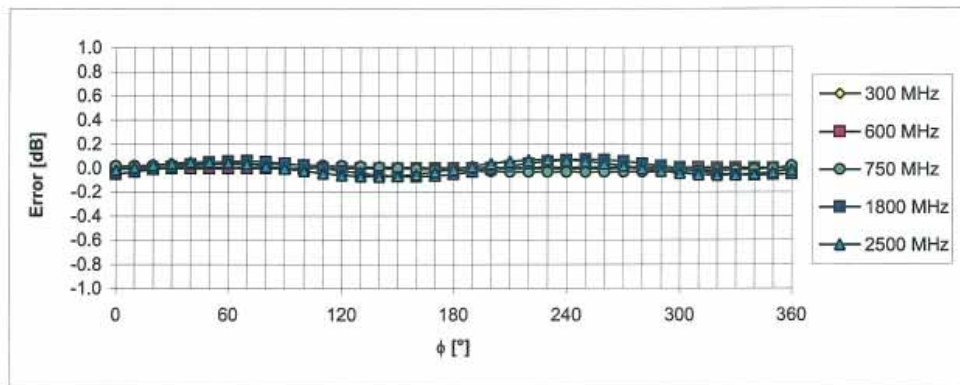
July 20, 2005

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



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

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

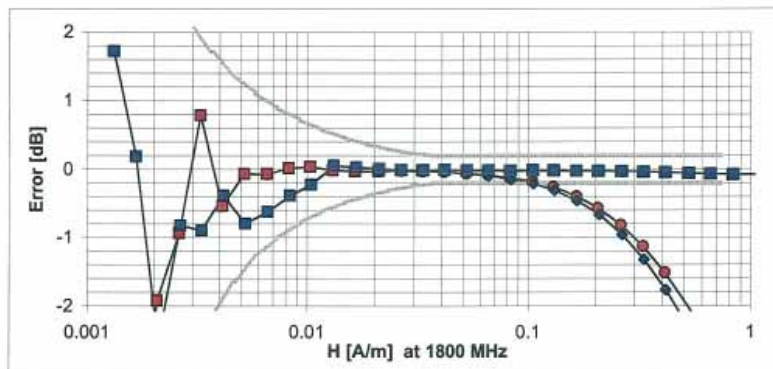
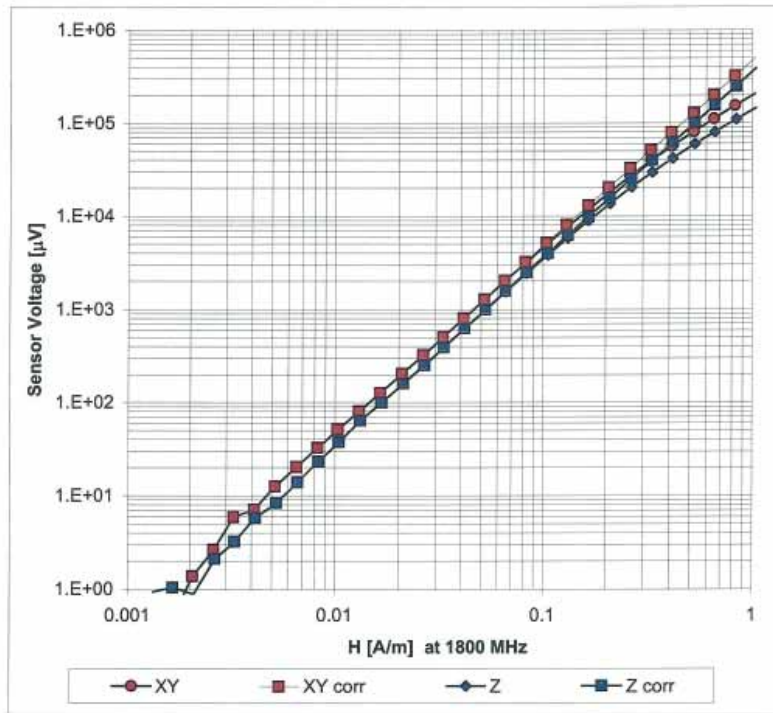


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

H3DV6 SN:6101

July 20, 2005

### Dynamic Range f(H-field) (Waveguide R22, f = 1800 MHz)



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