

## **APPENDIX D (PROBE CALIBRATION DATA)**

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



**S** Schweizerischer Kalibrierdienst  
**C** Service suisse d'étalonnage  
**S** Servizio svizzero di taratura  
**S** Swiss Calibration Service

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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 **HCT (Dymstec)**

Certificate No: **ER3-2343\_May09**

CALIBRATION CERTIFICATE																																																			
Object	ER3DV6 - SN:2343																																																		
Calibration procedure(s)	QA CAL-02.v5 Calibration procedure for E-field probes optimized for close near field evaluations in air																																																		
Calibration date:	May 22, 2009																																																		
Condition of the calibrated item	In Tolerance																																																		
<p>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.</p> <p>All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity &lt; 70%.</p> <p>Calibration Equipment used (M&amp;TE critical for calibration)</p> <table border="1"> <thead> <tr> <th>Primary Standards</th> <th>ID #</th> <th>Cal Date (Certificate No.)</th> <th>Scheduled Calibration</th> </tr> </thead> <tbody> <tr> <td>Power meter E4419B</td> <td>GB41293874</td> <td>1-Apr-09 (No. 217-01030)</td> <td>Apr-10</td> </tr> <tr> <td>Power sensor E4412A</td> <td>MY41495277</td> <td>1-Apr-09 (No. 217-01030)</td> <td>Apr-10</td> </tr> <tr> <td>Power sensor E4412A</td> <td>MY41498087</td> <td>1-Apr-09 (No. 217-01030)</td> <td>Apr-10</td> </tr> <tr> <td>Reference 3 dB Attenuator</td> <td>SN: S5054 (3c)</td> <td>31-Mar-09 (No. 217-01026)</td> <td>Mar-10</td> </tr> <tr> <td>Reference 20 dB Attenuator</td> <td>SN: S5086 (20b)</td> <td>31-Mar-09 (No. 217-01028)</td> <td>Mar-10</td> </tr> <tr> <td>Reference 30 dB Attenuator</td> <td>SN: S5129 (30b)</td> <td>31-Mar-09 (No. 217-01027)</td> <td>Mar-10</td> </tr> <tr> <td>Reference Probe ER3DV6</td> <td>SN: 2328</td> <td>1-Oct-08 (No. ER3-2328_Oct08)</td> <td>Oct-09</td> </tr> <tr> <td>DAE4</td> <td>SN: 789</td> <td>19-Dec-08 (No. DAE4-789_Dec08)</td> <td>Dec-09</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th>Secondary Standards</th> <th>ID #</th> <th>Check Date (in house)</th> <th>Scheduled Check</th> </tr> </thead> <tbody> <tr> <td>RF generator HP 8648C</td> <td>US3642U01700</td> <td>4-Aug-99 (in house check Oct-07)</td> <td>In house check: Oct-09</td> </tr> <tr> <td>Network Analyzer HP 8753E</td> <td>US37390585</td> <td>18-Oct-01 (in house check Oct-08)</td> <td>In house check: Oct-09</td> </tr> </tbody> </table>				Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration	Power meter E4419B	GB41293874	1-Apr-09 (No. 217-01030)	Apr-10	Power sensor E4412A	MY41495277	1-Apr-09 (No. 217-01030)	Apr-10	Power sensor E4412A	MY41498087	1-Apr-09 (No. 217-01030)	Apr-10	Reference 3 dB Attenuator	SN: S5054 (3c)	31-Mar-09 (No. 217-01026)	Mar-10	Reference 20 dB Attenuator	SN: S5086 (20b)	31-Mar-09 (No. 217-01028)	Mar-10	Reference 30 dB Attenuator	SN: S5129 (30b)	31-Mar-09 (No. 217-01027)	Mar-10	Reference Probe ER3DV6	SN: 2328	1-Oct-08 (No. ER3-2328_Oct08)	Oct-09	DAE4	SN: 789	19-Dec-08 (No. DAE4-789_Dec08)	Dec-09	Secondary Standards	ID #	Check Date (in house)	Scheduled Check	RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Oct-07)	In house check: Oct-09	Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-08)	In house check: Oct-09
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Approved by:	Name Katja Pokovic	Technical Manager																																																	
			Issued: May 25, 2009																																																
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**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:**

- IEEE Std 1309-2005, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005.

**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

May 22, 2009

# Probe ER3DV6

## SN:2343

Manufactured:	December 14, 2004
Last calibrated:	May 19, 2008
Recalibrated:	May 22, 2009

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

ER3DV6 SN:2343

May 22, 2009

**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 1.68 ± 10.1 % (k=2)

DCP X 92 mV

NormY 1.63 ± 10.1 % (k=2)

DCP Y 94 mV

NormZ 1.63 ± 10.1 % (k=2)

DCP Z 97 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

63 °

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%.

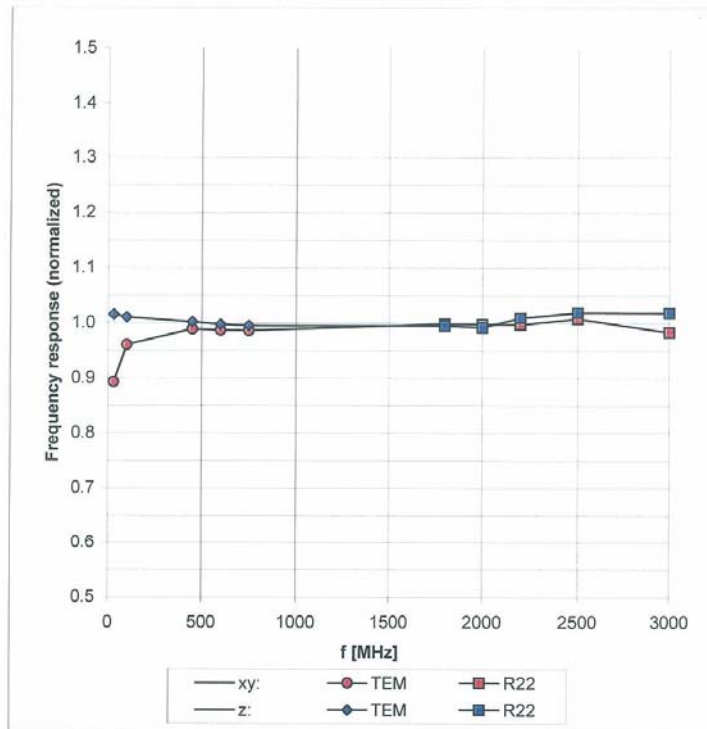
<sup>A</sup> numerical linearization parameter: uncertainty not required

ER3DV6 SN:2343

May 22, 2009

### Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)

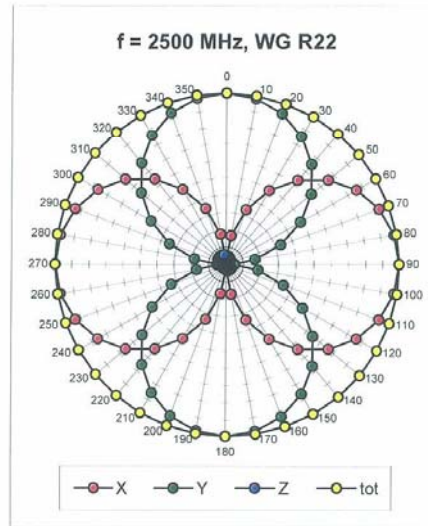
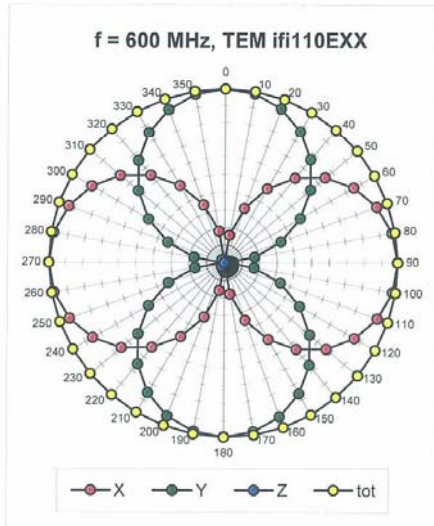


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  ( $k=2$ )

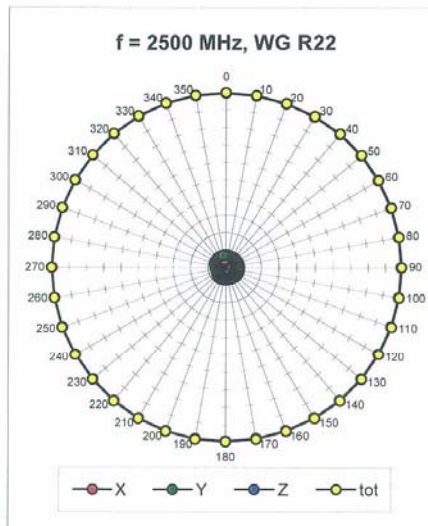
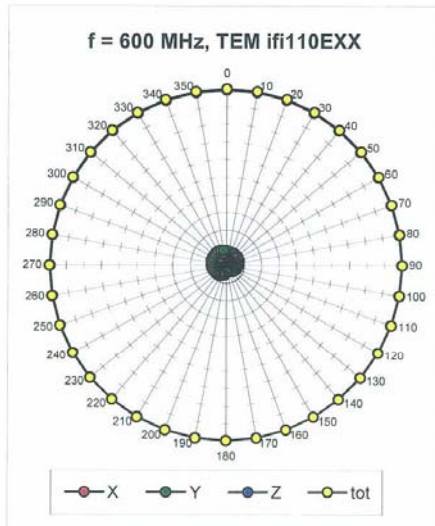
ER3DV6 SN:2343

May 22, 2009

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



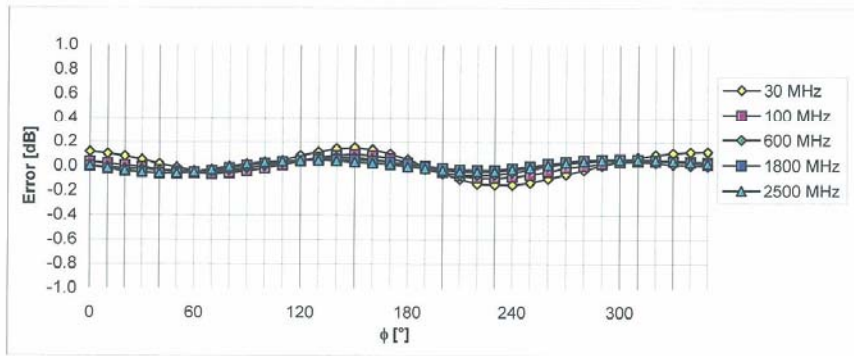
**Receiving Pattern ( $\phi$ ),  $\vartheta = 90^\circ$**



ER3DV6 SN:2343

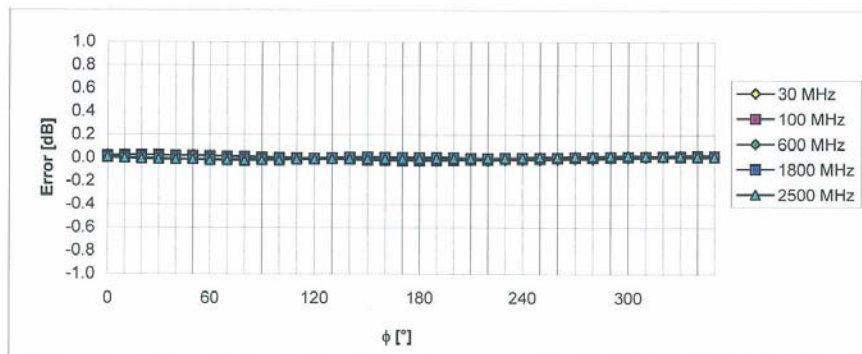
May 22, 2009

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



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

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



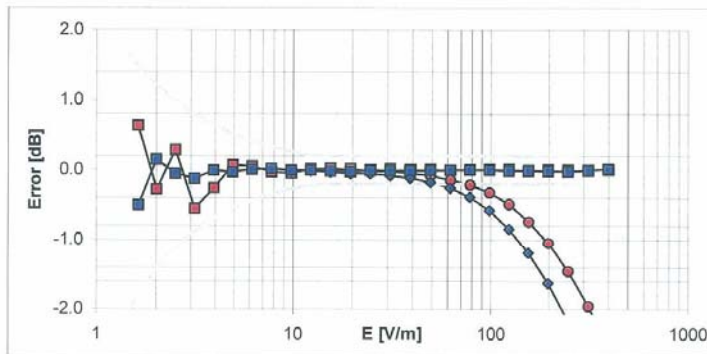
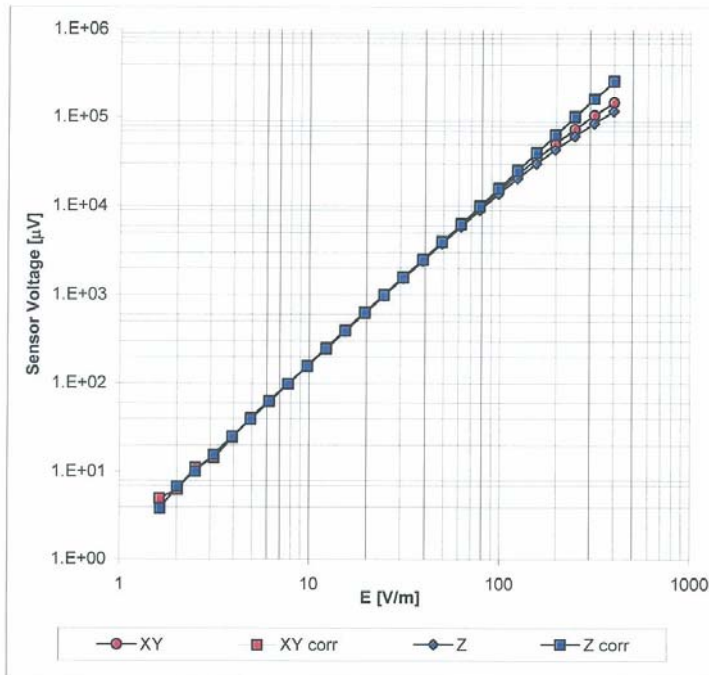
Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  (k=2)



ER3DV6 SN:2343

May 22, 2009

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

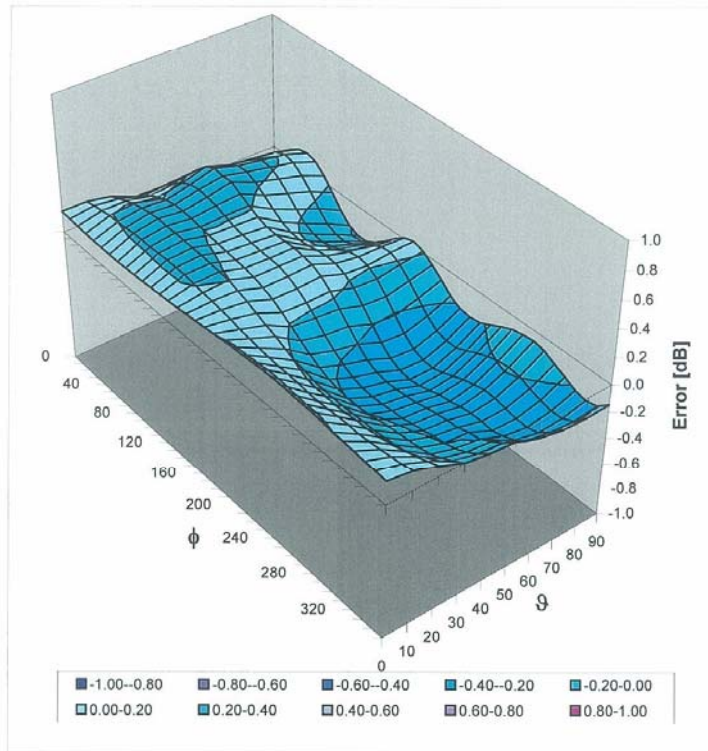


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

ER3DV6 SN:2343

May 22, 2009

### 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\_May09**

CALIBRATION CERTIFICATE			
Object	H3DV6 - SN:6101		
Calibration procedure(s)	QA CAL-03.v5 Calibration procedure for H-field probes optimized for close near field evaluations in air		
Calibration date:	May 22, 2009		
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&TE critical for calibration)			
Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter E4419B	GB41293874	1-Apr-09 (No. 217-01030)	Apr-10
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Reference 20 dB Attenuator	SN: S5086 (20b)	31-Mar-09 (No. 217-01028)	Mar-10
Reference 30 dB Attenuator	SN: S5129 (30b)	31-Mar-09 (No. 217-01027)	Mar-10
Reference Probe H3DV6	SN: 6182	1-Oct-08 (No. H3-6182_Oct08)	Oct-09
DAE4	SN: 789	19-Dec-08 (No. DAE4-789_Dec08)	Dec-09
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Oct-07)	In house check: Oct-09
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-08)	In house check: Oct-09
Calibrated by:	Name Jeton Kastrati	Function Laboratory Technician	Signature 
Approved by:	Name Katja Pokovic	Function Technical Manager	Signature 
			Issued: May 25, 2009
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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

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- a) IEEE Std 1309-2005, " IEEE Standard for calibration of electromagnetic field sensors and probes, excluding antennas, from 9 kHz to 40 GHz", December 2005.

**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

May 22, 2009

# Probe H3DV6

## SN:6101

Manufactured:	December 10, 2001
Last calibrated:	May 19, 2008
Recalibrated:	May 22, 2009

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

H3DV6 SN:6101

May 22, 2009

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

	a0	a1	a2
X	2.945E-03	-9.310E-5	-8.342E-6 $\pm$ 5.1 % (k=2)
Y	2.924E-03	-1.510E-4	-3.093E-5 $\pm$ 5.1 % (k=2)
Z	3.293E-03	-5.896E-5	1.890E-5 $\pm$ 5.1 % (k=2)

Diode Compression<sup>1</sup>

DCP X	82 mV
DCP Y	93 mV
DCP Z	84 mV

Sensor Offset (Probe Tip to Sensor Center)

X	3.0 mm
Y	3.0 mm
Z	3.0 mm

Connector Angle -63 °

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%.

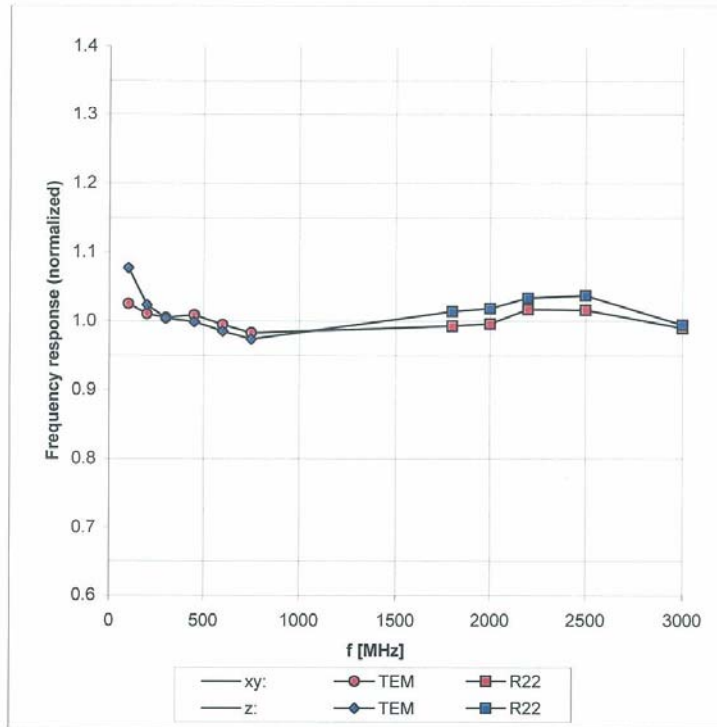
<sup>1</sup> numerical linearization parameter: uncertainty not required

H3DV6 SN:6101

May 22, 2009

### Frequency Response of H-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)

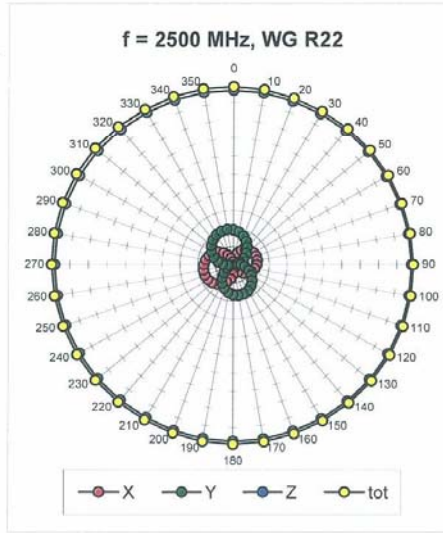
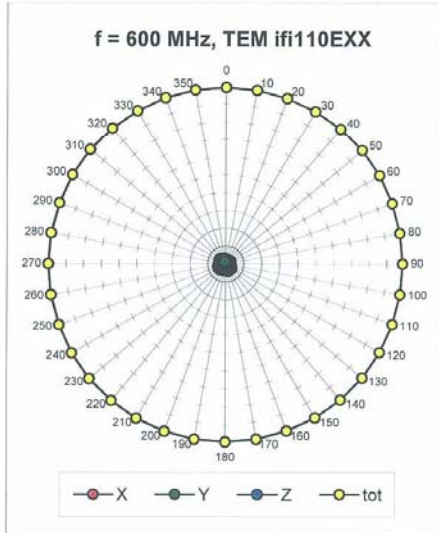


Uncertainty of Frequency Response of E-field:  $\pm 6.3\%$  (k=2)

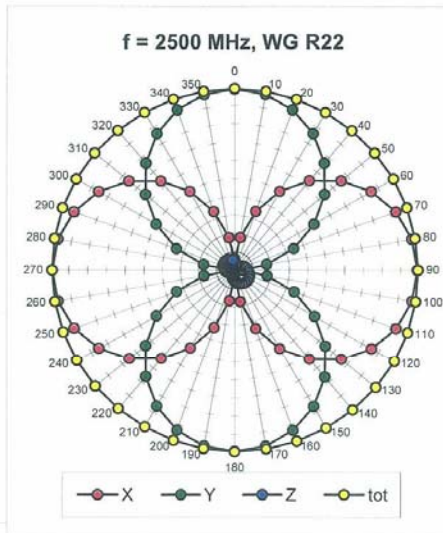
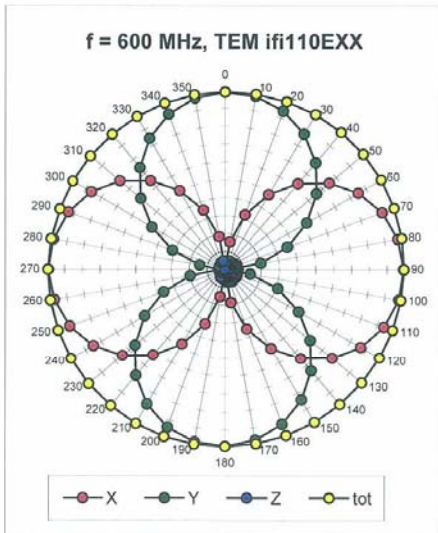
H3DV6 SN:6101

May 22, 2009

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



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

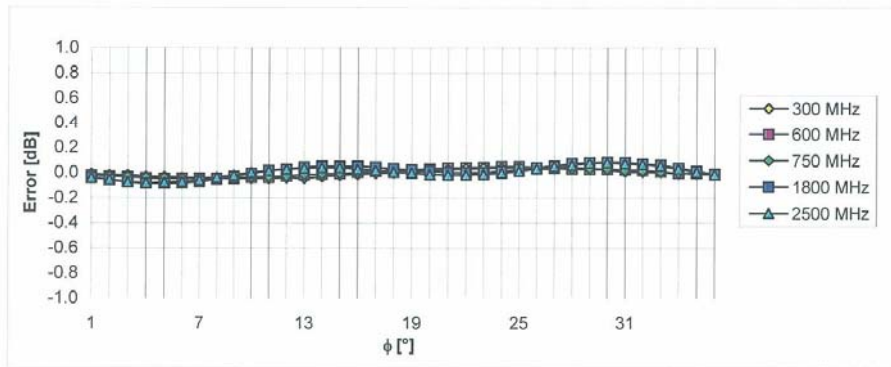




H3DV6 SN:6101

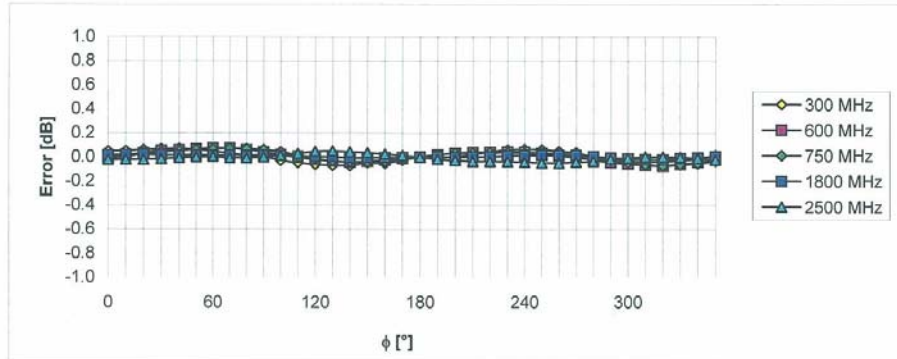
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### Receiving Pattern ( $\phi$ ), $\vartheta = 90^\circ$



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

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

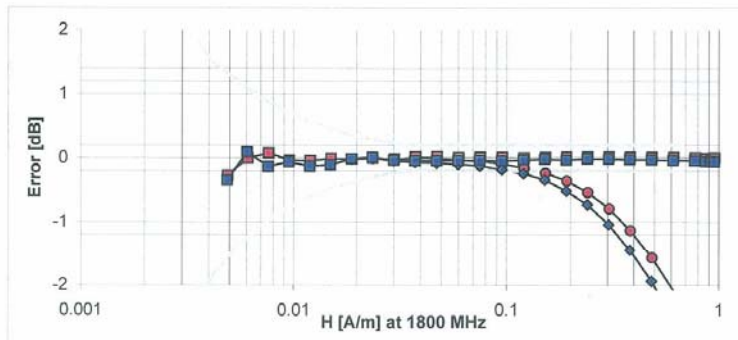
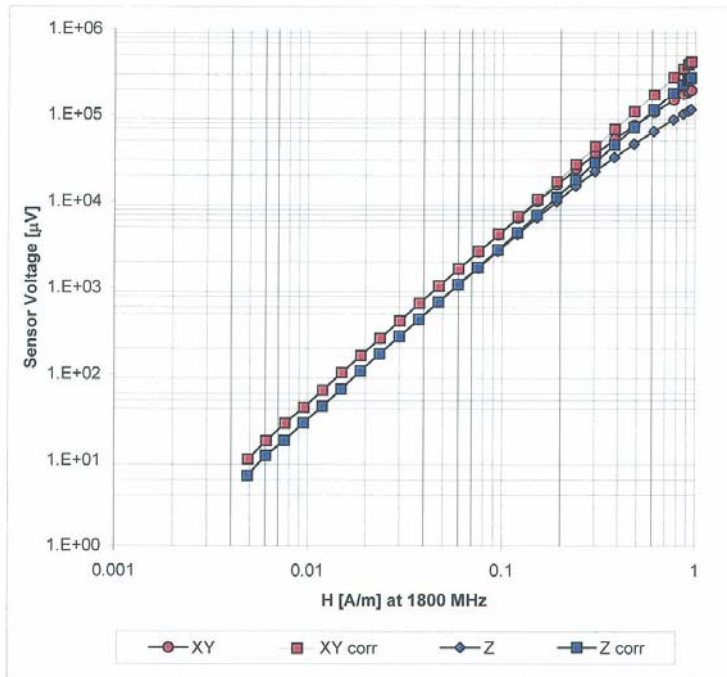


Uncertainty of Axial Isotropy Assessment:  $\pm 0.5\%$  ( $k=2$ )

H3DV6 SN:6101

May 22, 2009

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

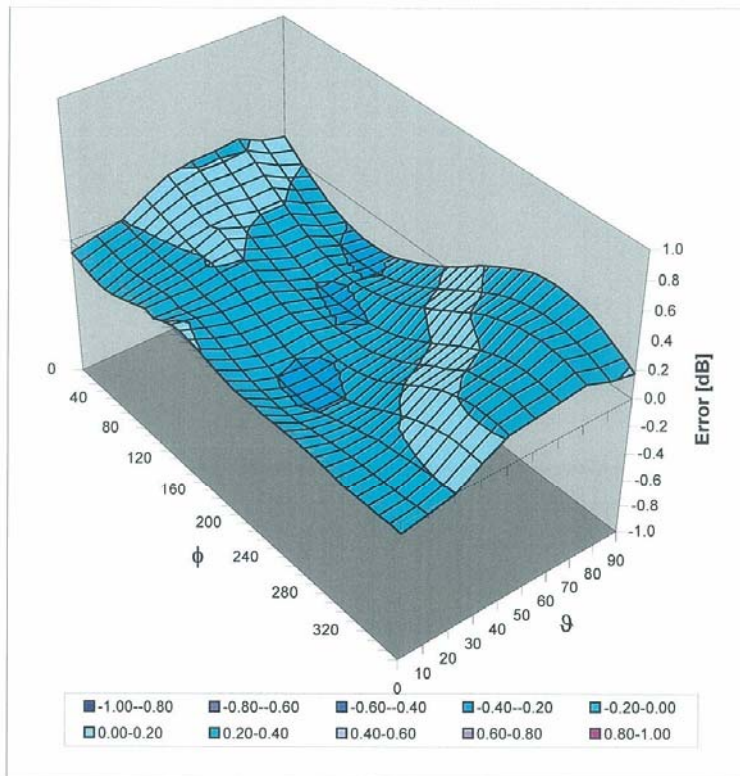


Uncertainty of Linearity Assessment:  $\pm 0.6\%$  (k=2)

H3DV6 SN:6101

May 22, 2009

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



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