

APPENDIX D (PROBE CALIBRATION DATA)

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8604 Zurich, Switzerland



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

Accredited by the Swiss Accreditation Service (SAS)
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: **LG (Dymstec)**

Certificate No: **ER3-2347_Sep09**

CALIBRATION CERTIFICATE

Object: **ER3DV6 - SN:2347**

Calibration procedure(s): **QA CAL-02.v5 and QA CAL-25.v2**
Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date: **September 18, 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 ($22 \pm 3^\circ\text{C}$) 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
Power sensor E4412A	MY41495277	1-Apr-09 (No. 217-01030)	Apr-10
Power sensor E4412A	MY41493987	1-Apr-09 (No. 217-01030)	Apr-10
Reference 3 dB Attenuator	SN: 55054 (Oct)	31-Mar-09 (No. 217-01026)	Mar-10
Reference 20 dB Attenuator	SN: 55086 (20b)	31-Mar-09 (No. 217-01026)	Mar-10
Reference 30 dB Attenuator	SN: 65129 (30b)	31-Mar-09 (No. 217-01027)	Mar-10
Reference Probe ER3DV6	SN: 2326	1-Oct-08 (No. ER3-2326_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	US3842U01703	4-Aug-09 (in house check Oct-07)	In house check: Oct-09
Network Analyzer HP 8753E	US37350585	18-Oct-01 (in house check Oct-00)	In house check: Oct-09

Calibrated by:	Name	Function	Signature
	Marcel Fehr	Laboratory Technician	
Approved by:	Name	Function	Signature
	Katja Pokovic	Technical Manager	

Issued: September 22, 2009

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

Certificate No: ER3-2347_Sep09

Page 1 of 9

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8604 Zurich, Switzerland



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

Accredited by the Swiss Accreditation Service (SAS)
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_{x,y,z}	sensitivity in free space
DCP	diode compression point
Polarization ϕ	ϕ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ 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 1309-2005, "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_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ for XY sensors and $\theta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- **NORM(f)_{x,y,z}** = NORM_{x,y,z} * 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 NORM_x (no uncertainty required).

ER3DV6 SN:2347

September 18, 2009

Probe ER3DV6

SN:2347

Manufactured:	December 14, 2004
Last calibrated:	September 25, 2007
Recalibrated:	September 18, 2009

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

ER3DV6 SN:2347

September 18, 2009

DASY - Parameters of Probe: ER3DV6 SN:2347

Sensitivity in Free Space [$\mu\text{V}/(\text{V}/\text{m})^2$]

Diode Compression^A

NormX	1.60 $\pm$ 10.1 % (k=2)
NormY	1.59 $\pm$ 10.1 % (k=2)
NormZ	1.81 $\pm$ 10.1 % (k=2)

DCP X	97 mV
DCP Y	95 mV
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

-195 °

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%.

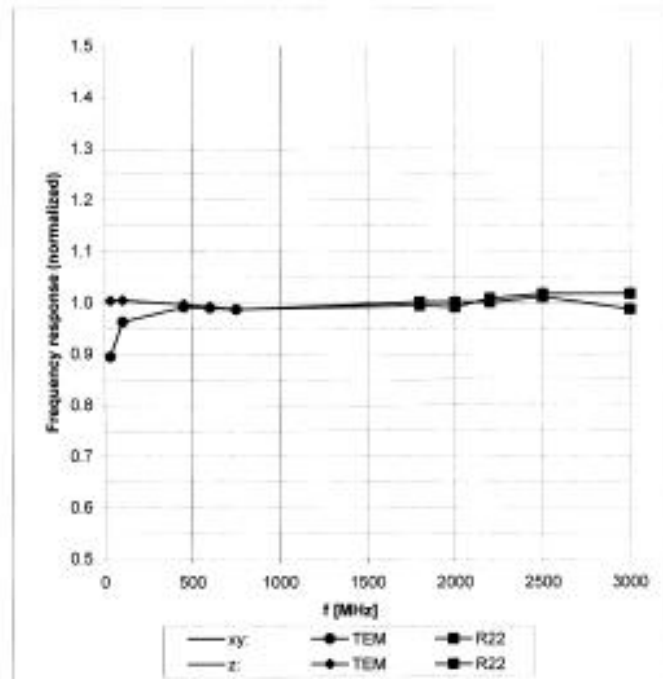
^A numerical linearization parameter: uncertainty not required

ER3DV6 SN:2347

September 18, 2009

Frequency Response of E-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)

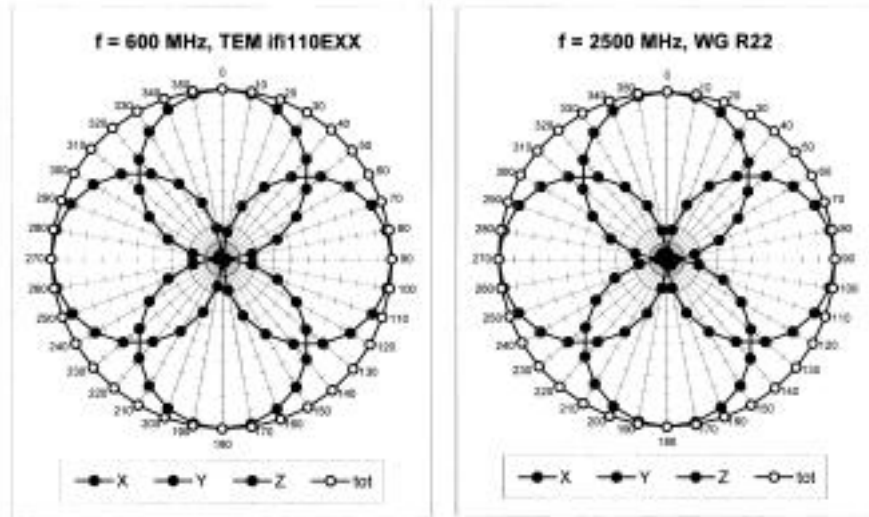


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

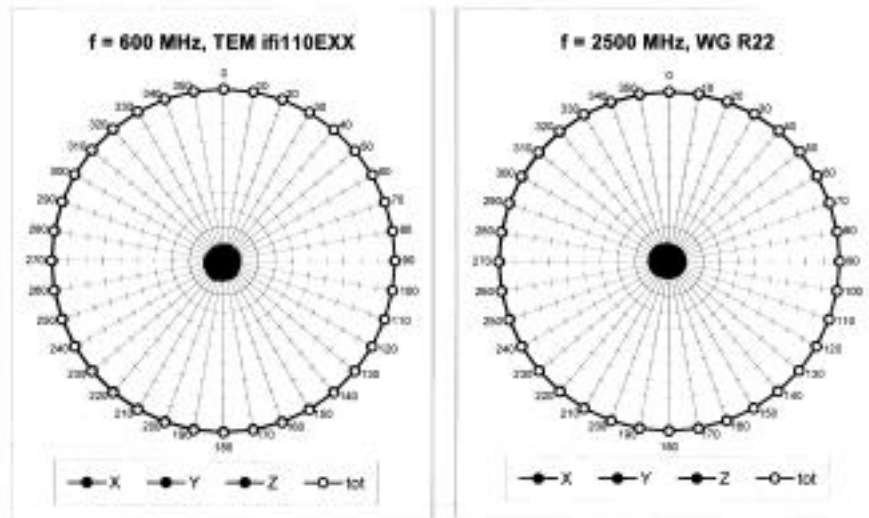
ER3DV6 SN:2347

September 18, 2009

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



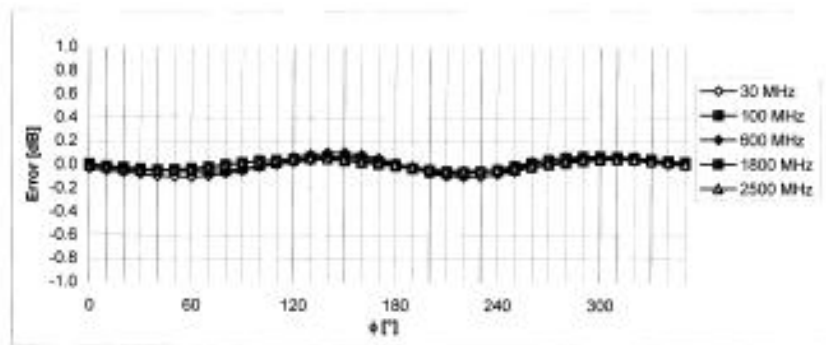
Receiving Pattern (ϕ), $\theta = 90^\circ$



ER3DV6 SN:2347

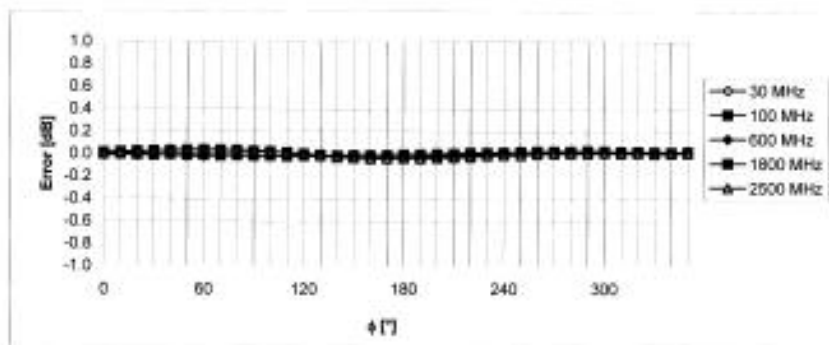
September 18, 2009

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



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

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

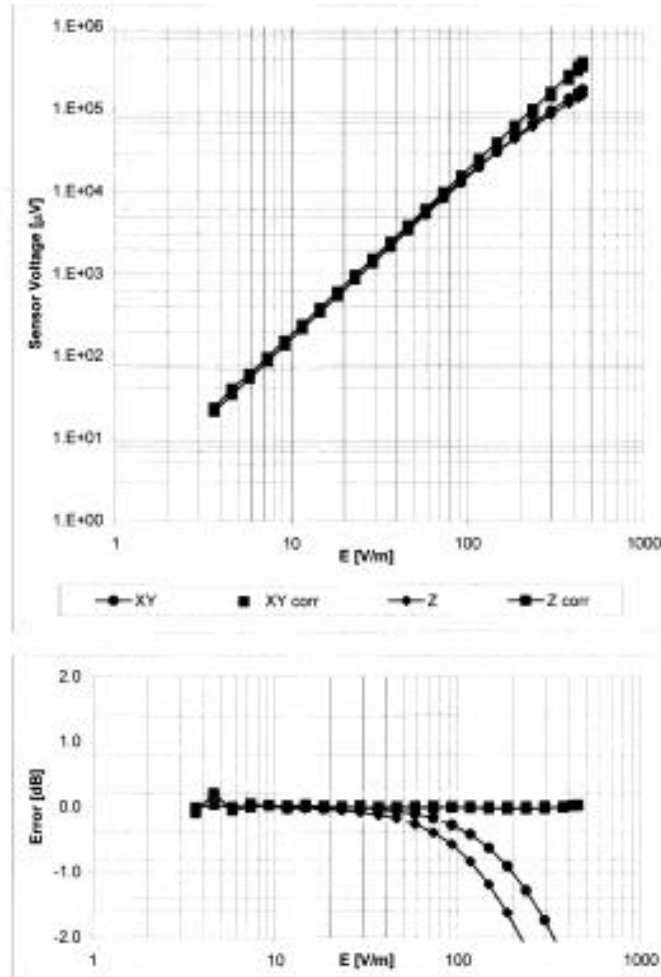


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ ($k=2$)

ER3DV6 SN:2347

September 18, 2009

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

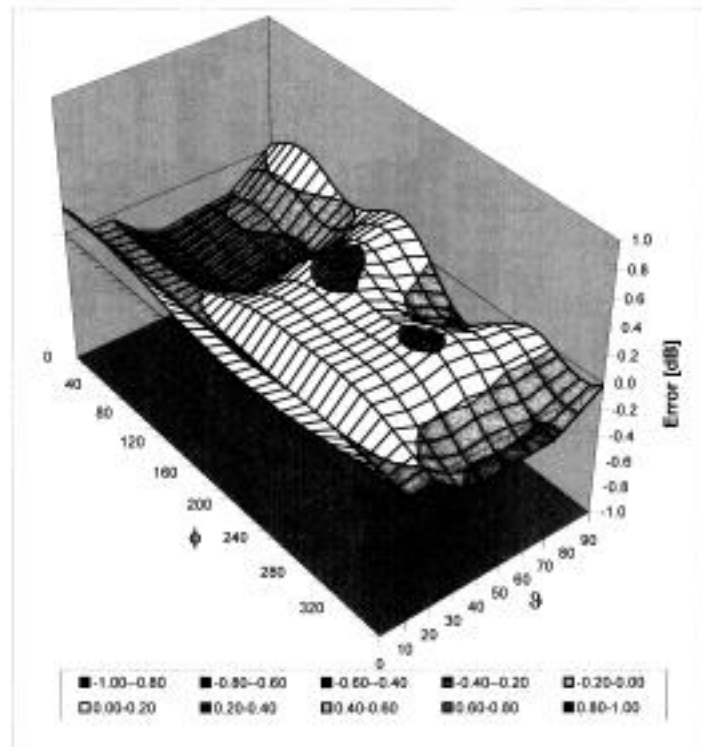


Uncertainty of Linearity Assessment: $\pm 0.6\%$ ($k=2$)

ER3DV6 SN:2347

September 18, 2009

Deviation from Isotropy in Air
Error (ϕ, θ), $f = 900$ MHz



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

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8064 Zurich, Switzerland



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

Accredited by the Swiss Accreditation Service (SAS)
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 **LG (Dymstec)**

Certificate No: **H3-6164_Sep09**

CALIBRATION CERTIFICATE

Object **H3DV6 - SN:6164**

Calibration procedure(s) **QA CAL-03.v5 and QA CAL-25.v2
Calibration procedure for H-field probes optimized for close near field
evaluations in air**

Calibration date: **September 21, 2009**

Condition of the calibrated item **Partly in Tolerance (increased isotropy error)**

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 (MATE critical for calibration)

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	MY41496097	1-Apr-09 (No. 217-01030)	Apr-10
Reference 3 dB Attenuator	SN: S5054 (3c)	31-Mar-09 (No. 217-01025)	Mar-10
Reference 20 dB Attenuator	SN: S5086 (20b)	31-Mar-09 (No. 217-01026)	Mar-10
Reference 30 dB Attenuator	SN: S5129 (30b)	31-Mar-09 (No. 217-01027)	Mar-10
Reference Probe H3DV6	SN: 6162	1-Oct-09 (No. H3-6162_Oct09)	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 8448C	US3642U01700	4-Aug-09 (in house check Oct-07)	In house check: Oct-09
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-03)	In house check: Oct-09

Calibrated by: **Claudio Leubler** **Laboratory Technician**

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

Issued: September 22, 2009

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

Certificate No: H3-6164_Sep09

Page 1 of 9

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

Accredited by the Swiss Accreditation Service (SAS)
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_{x,y,z} sensitivity in free space
DCP diode compression point
Polarization ϕ ϕ rotation around probe axis
Polarization θ θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ 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 1309-2005, "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 $\theta = 90$ for XY sensors and $\theta = 0$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide).
- $X, Y, Z(f)_{a0a1a2} = X, Y, Z_{a0a1a2} \cdot \text{frequency_response}$ (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:6164

September 21, 2009

Probe H3DV6

SN:6164

Manufactured:	July 4, 2004
Last calibrated:	September 27, 2007
Recalibrated:	September 21, 2009

Calibrated for DASY Systems

(Note: non-compatible with DASY2 system!)

H3DV6 SN:6164

September 21, 2009

DASY - Parameters of Probe: H3DV6 SN:6164

Sensitivity in Free Space [A/m / $\sqrt{(\mu V)}$]

	a0	a1	a2
X	2.540E-03	2.387E-5	6.860E-5 $\pm$ 5.1 % (k=2)
Y	2.662E-03	6.405E-6	6.654E-5 $\pm$ 5.1 % (k=2)
Z	3.052E-03	-1.214E-4	1.056E-4 $\pm$ 5.1 % (k=2)

Diode Compression¹

DCP X	86 mV
DCP Y	92 mV
DCP Z	85 mV

Sensor Offset (Probe Tip to Sensor Center)

X	3.0 mm
Y	3.0 mm
Z	3.0 mm

Connector Angle -153 °

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%.

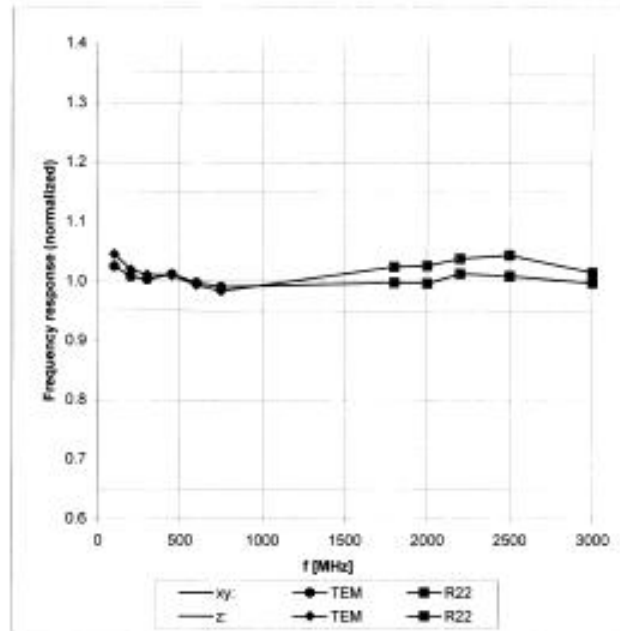
¹ numerical linearization parameter: uncertainty not required

H3DV6 SN:6164

September 21, 2009

Frequency Response of H-Field

(TEM-Cell:ifi110 EXX, Waveguide R22)

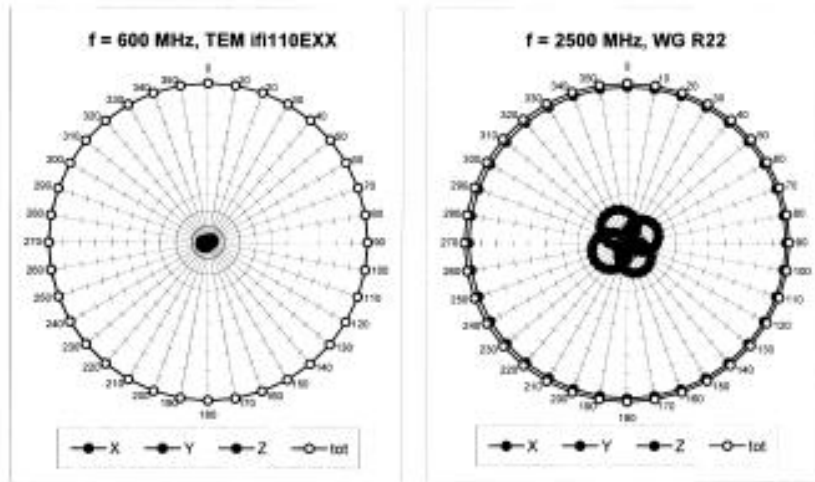


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ ($k=2$)

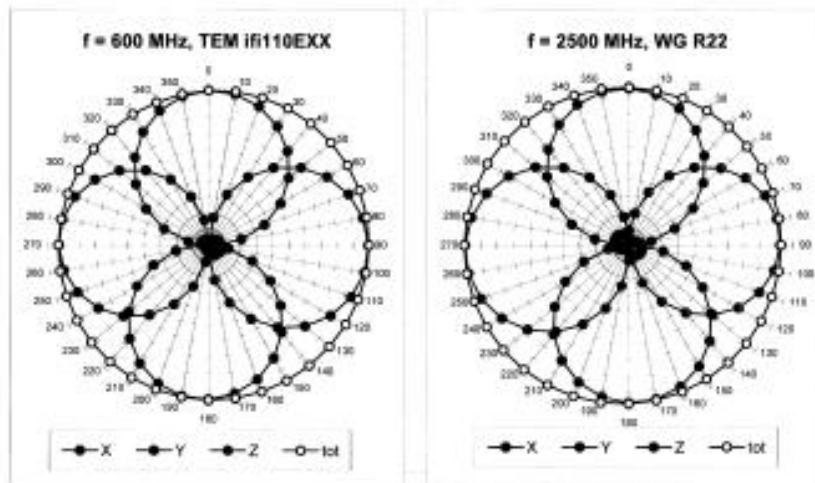
H3DV6 SN:6164

September 21, 2009

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



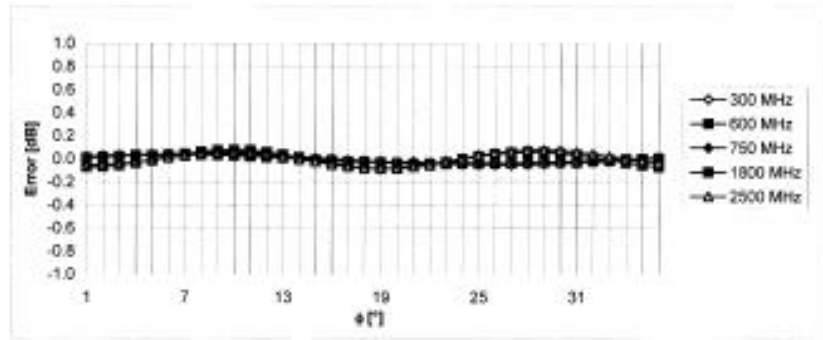
Receiving Pattern (ϕ), $\theta = 0^\circ$



H3DV6 SN:6164

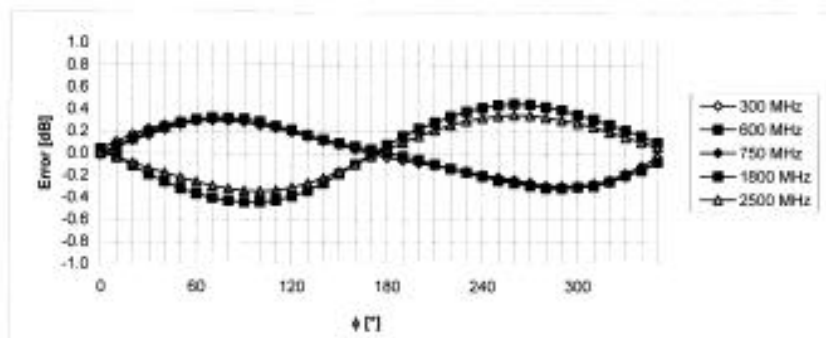
September 21, 2009

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



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

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

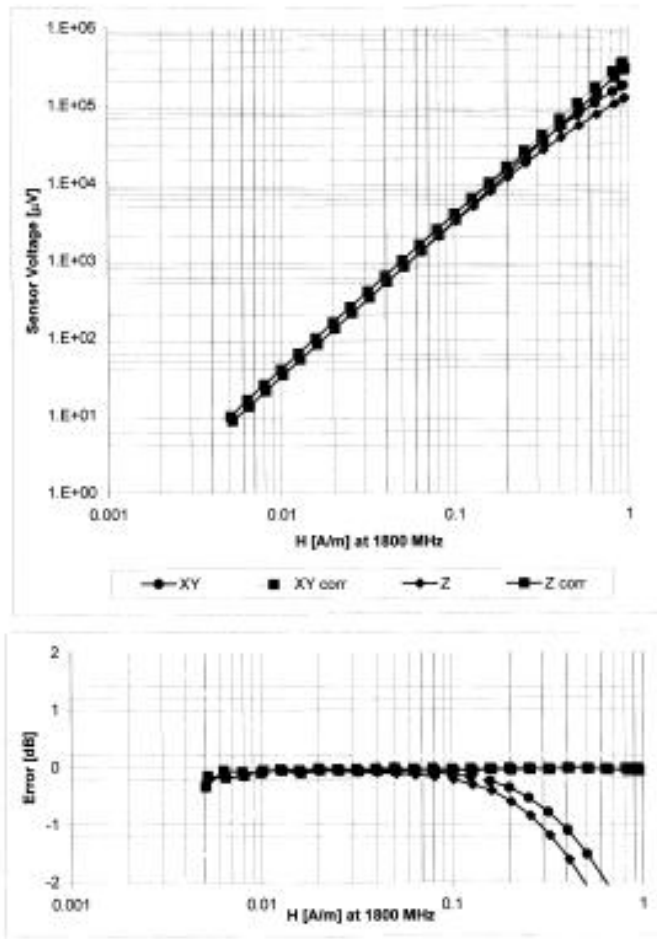


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

H3DV6 SN:6164

September 21, 2009

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

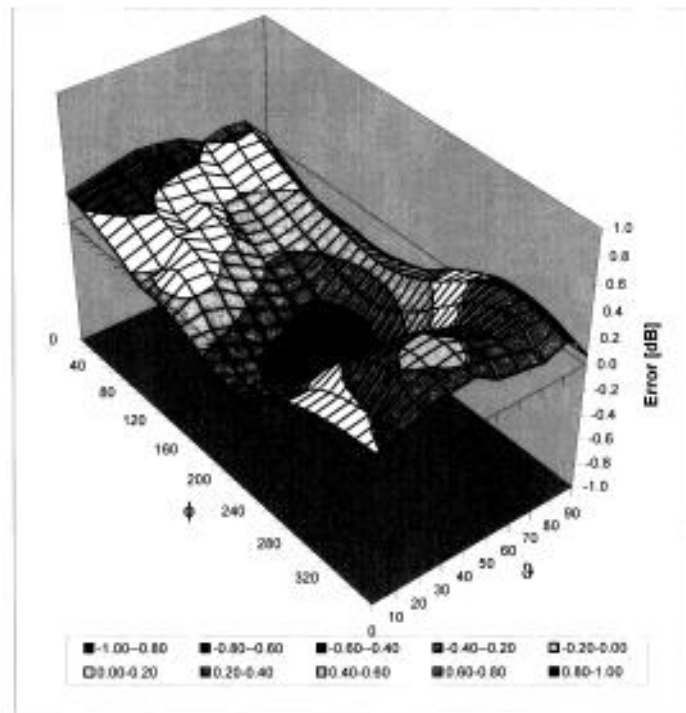


Uncertainty of Linearity Assessment: $\pm 0.6\%$ (k=2)

H3DV6 SN:6164

September 21, 2009

Deviation from Isotropy in Air
Error (ϕ , θ), $f = 900$ MHz



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