# Annex B: Probe and dipole description and calibration certificates

## B.1 Probe, measurement chain description, specification and calibration certificate

DASY Dosimetric Assessment System by Schmid & Partner Engineering AG


Applications

Support & Downloads

Products
- DASY4 Packages
- EASY4
- Probes
  - ET3DV6 - Isotropic Dos-Probe
  - ES3DV3 - Isotropic Dos-Probe
  - EX3DV4 - Isotropic Dos-Probe
  - ET1DV3 - D-Probe
  - EUV3 - Universal Vector E-Probe
  - H3DV6 - Isotropic H-Probe
  - HUV4 - Universal Vector H-Probe
  - T1V3 - Temp-Probe
  - DP1 - Dummy-Probe
- Data Acquisition System
- Software
- Phantoms
- Robots
- Validation Kits & Calibration Dipoles
- Hearing Aid Compatibility (HAC) Ext
- Tissue Simulating Liquids

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**ER3DV6 ISOTROPIC E-FIELD PROBE FOR GENERAL NEAR-FIELD MEASUREMENTS**

Download Product Flyer (PDF, 192kB)

| | |
|---|---|
| **Construction** | One dipole parallel, two dipoles normal to probe axis<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., glycolether) |
| **Calibration** | In air from 100 MHz to 3.0 GHz (absolute accuracy ±6.0%, k=2) |
| **Frequency** | 100 MHz to > 6 GHz; Linearity: ± 0.2 dB (100 MHz to 3 GHz) |
| **Directivity** | ± 0.2 dB in air (rotation around probe axis)<br>± 0.4 dB in air (rotation normal to probe axis) |
| **Dynamic Range** | 2 V/m to > 1000 V/m; Linearity: ± 0.2 dB |
| **Dimensions** | Overall length: 330 mm (Tip: 16 mm)<br>Tip diameter: 8 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 2.5 mm |
| **Application** | General near-field measurements up to 6 GHz<br>Field component measurements<br>Fast automatic scanning in phantoms |

http://www.dasy4.com/er3.htm

DASY Dosimetric Assessment System by Schmid & Partner Engineering AG


Applications

Support & Downloads

Products

- DASY4 Packages
- EASY4
- Probes
  - ET3DV6 - Isotropic Dos-Probe
  - ES3DV3 - Isotropic Dos-Probe
  - EX3DV4 - Isotropic Dos-Probe
  - ET1DV3 - D-Probe
  - ER3DV6 - Isotropic E-Probe
  - EUV3 - Universal Vector E-Probe
  - HUV4 - Universal Vector H-Probe
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## H3DV6 3-DIMENSIONAL H-FIELD PROBE FOR SMALL BAND APPLICATIONS

Download Product Flyer (PDF, 192kB)

| | |
|---|---|
| **Construction** | Three concentric loop sensors with 3.8 mm loop diameters<br>Resistively loaded detector diodes for linear response<br>Built-in shielding against static charges<br>PEEK enclosure material (resistant to organic solvents, e.g., glycolether) |
| **Frequency** | 200 MHz to 3 GHz (absolute accuracy ± 6.0%, k=2);<br>Output linearized |
| **Directivity** | ± 0.25 dB (spherical isotropy error) |
| **Dynamic Range** | 10 mA/m to 2 A/m at 1 GHz |
| **E-Field Interference** | < 10% at 3 GHz (for plane wave) |
| **Dimensions** | Overall length: 330 mm (Tip: 40 mm)<br>Tip diameter: 6 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 3 mm |
| **Application** | General magnetic near-field measurements up to 3 GHz<br>Field component measurements<br>Surface current measurements<br>Measurements in air or liquids<br>Low interaction with the measured field |

http://www.dasy4.com/h3d.htm

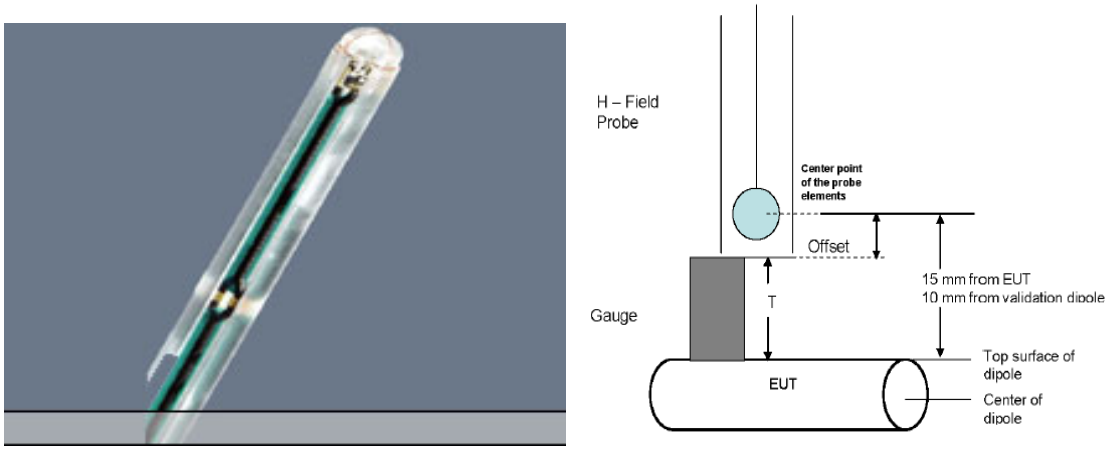
All measurements were performed to the nearest element point as per the C63.19 standard. Offset distances were entered in the DASY5 software so that the measurement was to the nearest element.

Figures 1 and 2, provided by the manufacturer, illustrate detail of the probe tip and its dimensions.

**ER3DV6** E-Field probe: The distances from the probe tip to the closest points on the dipole sensors are 1.45mm for X and Y and 1.25mm for Z. From the probe tip to the center of the sensors is 2.5mm.

**H3DV6** H-Field probe: The distance from the probe tip to the closest point of the X, Y and Z loop sensors is 1.1mm. From the probe tip to the center of the sensor is 3.00mm.


**E-Field Probe (ER3DV6)**




**H-Field Probe (H3DV6)**

The following information is from the system manufacturer user manual describing the process chain:

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i} \tag{20.1}$$

with $V_i$ = compensated signal of channel i (i = x, y, z)
$U_i$ = input signal of channel i (i = x, y, z)
$cf$ = crest factor of exciting field (DASY parameter)
$dcp_i$ = diode compression point (DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

$$\text{E} - \text{fieldprobes}: \quad E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

$$\text{H} - \text{fieldprobes}: \quad H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1} f + a_{i2} f^2}{f}$$

with $V_i$ = compensated signal of channel i (i = x, y, z)
$Norm_i$ = sensor sensitivity of channel i (i = x, y, z)
$\mu V/(V/m)^2$ for E-field Probes
$ConvF$ = sensitivity enhancement in solution
$a_{ij}$ = sensor sensitivity factors for H-field probes
$f$ = carrier frequency [GHz]
$E_i$ = electric field strength of channel i in V/m
$H_i$ = magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2} \tag{20.2}$$

The measurement / integration time per point is > 500 ms, as per the system manufacturer:

The time response of the field probes has been assessed by exposing the probe to a well-controlled field producing signals larger than HAC E- and H-fields of class M4. The signal response time is evaluated as the time required by the system to reach 90% of the expected final value after an on/off switch of the power source with an integration time of 500 ms and a probe response time of <5 ms. In the current implementation, DASY4 waits longer than 100 ms after having reached the grid point before starting a measurement, i.e., the response time uncertainty is negligible.

If the device under test does not emit a CW signal, the integration time applied to measure the electric field at a specific point may introduce additional uncertainties due to the discretization. The tolerances for the different systems had the worst-case of 2.6%.

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**Accreditation No.: SCS 108**

**Client** RTS (RIM Testing Services) **Certificate No: ER3-2286_Jan12**

# CALIBRATION CERTIFICATE

Object: ER3DV6 - SN:2286

Calibration procedure(s): QA CAL-02.v6, QA CAL-25.v4
Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date: January 9, 2012

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 | 31-Mar-11 (No. 217-01372) | Apr-12 |
| Power sensor E4412A | MY41496087 | 31-Mar-11 (No. 217-01372) | Apr-12 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 29-Mar-11 (No. 217-01369) | Apr-12 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 29-Mar-11 (No. 217-01367) | Apr-12 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 29-Mar-11 (No. 217-01370) | Apr-12 |
| Reference Probe ER3DV6 | SN: 2328 | 11-Oct-11 (No. ER3-2328_Oct11) | Oct-12 |
| DAE4 | SN: 789 | 6-Apr-11 (No. DAE4-789_Apr11) | Apr-12 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-11) | In house check: Apr-13 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-11) | In house check: Oct-12 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: January 12, 2012

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

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## Glossary:

| | |
|---|---|
| NORMx,y,z | sensitivity in free space |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C | modulation dependent linearization parameters |
| 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., ϑ = 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:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 for XY sensors and ϑ = 90 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide).
- *NORM(f)x,y,z = NORMx,y,z * frequency_response* (see Frequency Response Chart).
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z, VRx,y,z: A, B, C* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *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 *NORMx* (no uncertainty required).

# Probe ER3DV6

## SN:2286

Manufactured: September 18, 2002
Calibrated: January 9, 2012

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: ER3DV6 - SN:2286

## Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|
| Norm ($\mu V/(V/m)^2$) | 2.19 | 1.48 | 1.51 | ± 10.1 % |
| DCP (mV)[B] | 98.8 | 100.1 | 98.9 | |

## Modulation Calibration Parameters

| UID | Communication System Name | PAR | | A dB | B dB | C dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 10000 | CW | 0.00 | X | 0.00 | 0.00 | 1.00 | 107.7 | ±3.0 % |
| | | | Y | 0.00 | 0.00 | 1.00 | 107.0 | |
| | | | Z | 0.00 | 0.00 | 1.00 | 93.5 | |
| 10011 | UMTS-FDD (WCDMA) | 3.40 | X | 3.54 | 66.3 | 18.9 | 116.1 | ±0.7 % |
| | | | Y | 3.38 | 65.4 | 18.2 | 114.7 | |
| | | | Z | 3.58 | 66.5 | 18.9 | 138.6 | |
| 10021 | GSM-FDD (TDMA, GMSK) | 9.20 | X | 16.11 | 100.0 | 28.4 | 105.3 | ±1.4 % |
| | | | Y | 4.39 | 79.8 | 20.9 | 135.3 | |
| | | | Z | 5.62 | 83.0 | 23.2 | 123.8 | |
| 10039 | CDMA2000 (1xRTT, RC1) | 5.30 | X | 5.37 | 67.3 | 20.2 | 118.3 | ±1.4 % |
| | | | Y | 4.87 | 65.7 | 19.1 | 113.6 | |
| | | | Z | 5.10 | 66.4 | 19.5 | 137.9 | |
| 10081 | CDMA2000 (1xRTT, RC3) | 4.60 | X | 4.41 | 66.3 | 19.5 | 115.0 | ±0.9 % |
| | | | Y | 4.07 | 64.9 | 18.5 | 112.0 | |
| | | | Z | 4.30 | 65.9 | 19.1 | 135.1 | |
| 10151 | LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK) | 7.73 | X | 8.16 | 72.5 | 24.6 | 117.6 | ±4.1 % |
| | | | Y | 6.86 | 68.2 | 21.9 | 111.8 | |
| | | | Z | 7.47 | 69.9 | 22.7 | 138.4 | |

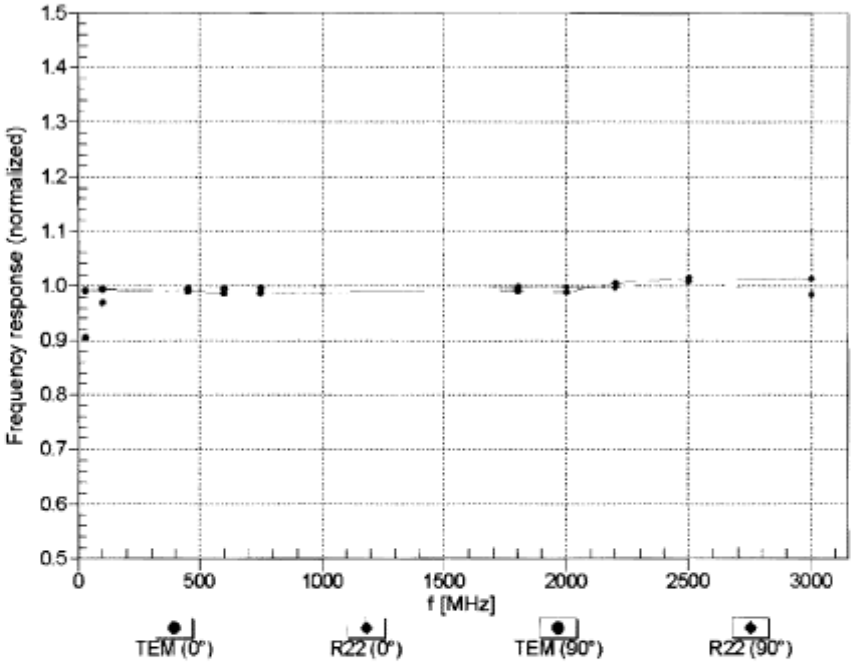
The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

ER3DV6– SN:2286 January 9, 2012

## Frequency Response of E-Field

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

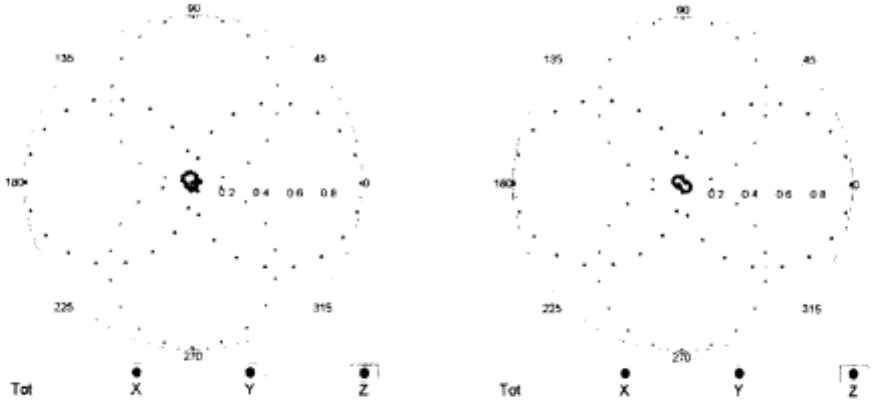



**Uncertainty of Frequency Response of E-field: ± 6.3% (k=2)**

ER3DV6– SN:2286 January 9, 2012

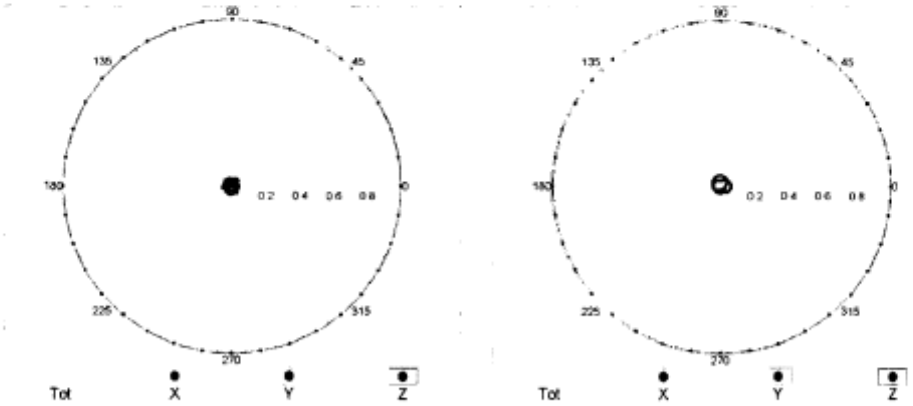
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0° f=2500 MHz,R22,0°



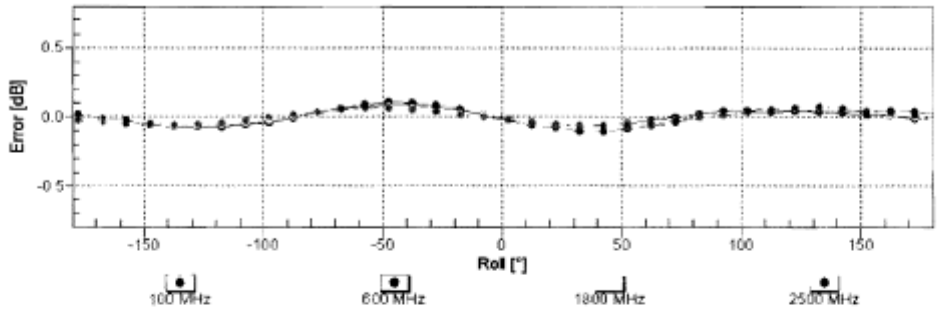

## Receiving Pattern (ϕ), ϑ = 90°

f=600 MHz,TEM,90° f=2500 MHz,R22,90°



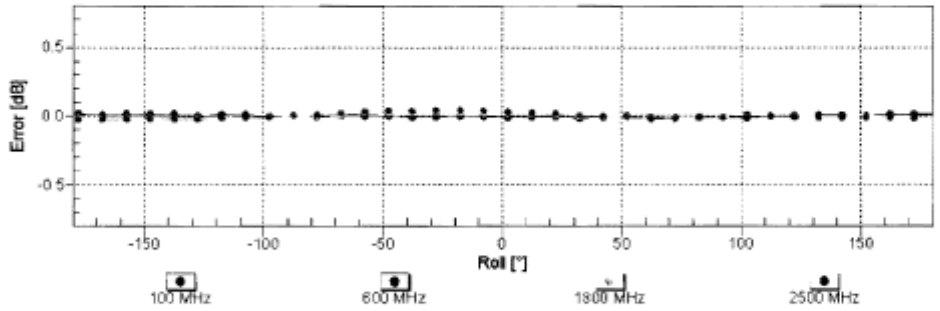
ER3DV6– SN:2286 January 9, 2012

## Receiving Pattern (ϕ), ϑ = 0°



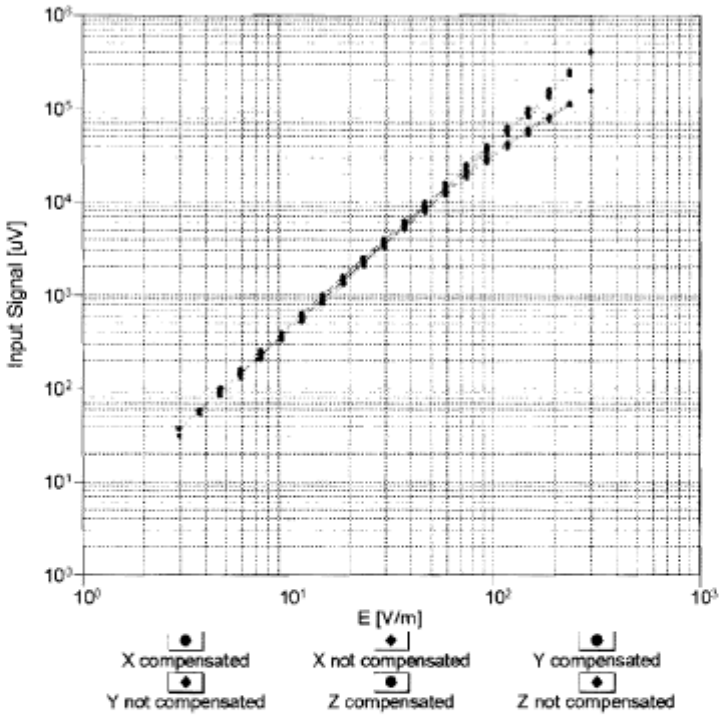

**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

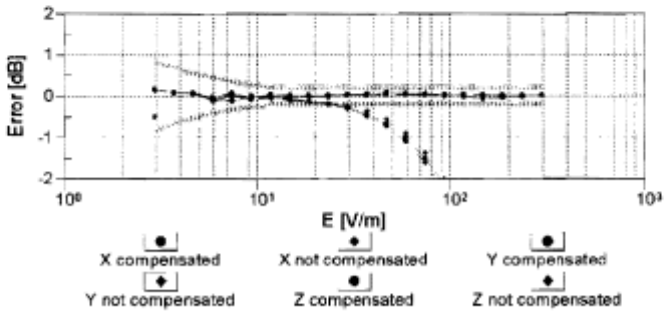
## Receiving Pattern (ϕ), ϑ = 90°




**Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)**

## Dynamic Range f(E-field)
**(TEM cell , f = 900 MHz)**

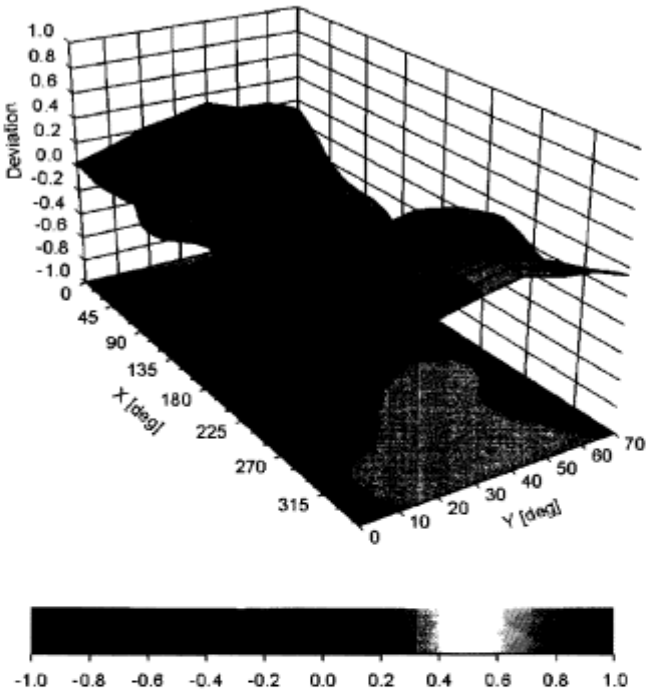



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

## Deviation from Isotropy in Air

**Error (ϕ, ϑ), f = 900 MHz**




**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: ER3DV6 - SN:2286

**Other Probe Parameters**

| | |
|---|---|
| Sensor Arrangement | Rectangular |
| Connector Angle (°) | -7.6 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 10 mm |
| Tip Diameter | 8 mm |
| Probe Tip to Sensor X Calibration Point | 2.5 mm |
| Probe Tip to Sensor Y Calibration Point | 2.5 mm |
| Probe Tip to Sensor Z Calibration Point | 2.5 mm |

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Accreditation No.: SCS 108

Client: RTS (RIM Testing Services)

Certificate No: H3-6105_Nov12

# CALIBRATION CERTIFICATE

Object: H3DV6 - SN:6105

Calibration procedure(s): QA CAL-03.v6, QA CAL-25.v4
Calibration procedure for H-field probes optimized for close near field evaluations in air

Calibration date: November 9, 2012

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 | 29-Mar-12 (No. 217-01508) | Apr-13 |
| Power sensor E4412A | MY41498087 | 29-Mar-12 (No. 217-01508) | Apr-13 |
| Reference 3 dB Attenuator | SN: S5054 (3c) | 27-Mar-12 (No. 217-01531) | Apr-13 |
| Reference 20 dB Attenuator | SN: S5086 (20b) | 27-Mar-12 (No. 217-01529) | Apr-13 |
| Reference 30 dB Attenuator | SN: S5129 (30b) | 27-Mar-12 (No. 217-01532) | Apr-13 |
| Reference Probe H3DV6 | SN: 6182 | 12-Oct-12 (No. H3-6182_Oct12) | Oct-13 |
| DAE4 | SN: 789 | 18-Sep-12 (No. DAE4-789_Sep12) | Sep-13 |
| | | | |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| RF generator HP 8648C | US3642U01700 | 4-Aug-99 (in house check Apr-11) | In house check: Apr-13 |
| Network Analyzer HP 8753E | US37390585 | 18-Oct-01 (in house check Oct-12) | In house check: Oct-13 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: November 13, 2012

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**Accreditation No.: SCS 108**

## Glossary:

| | |
|---|---|
| NORMx,y,z | sensitivity in free space |
| DCP | diode compression point |
| CF | crest factor (1/duty_cycle) of the RF signal |
| A, B, C | modulation dependent linearization parameters |
| 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., ϑ = 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.
b) CTIA Test Plan for Hearing Aid Compatibility, April 2010.

## Methods Applied and Interpretation of Parameters:

- *NORMx,y,z:* Assessed for E-field polarization ϑ = 0 for XY sensors and ϑ = 90 for Z sensor (f ≤ 900 MHz in TEM-cell; f > 1800 MHz: R22 waveguide).
- *X,Y,Z(f)_a0a1a2= X,Y,Z_a0a1a2* frequency_response* (see Frequency Response Chart).
- *DCPx,y,z:* DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- *PAR:* PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- *Ax,y,z; Bx,y,z; Cx,y,z, VRx,y,z*: *A, B, C* are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. *VR* is the maximum calibration range expressed in RMS voltage across the diode.
- *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).

# Probe H3DV6

# SN:6105

Manufactured: January 5, 2002
Calibrated: November 9, 2012

Calibrated for DASY/EASY Systems
(Note: non-compatible with DASY2 system!)

# DASY/EASY - Parameters of Probe: H3DV6 - SN:6105

## Basic Calibration Parameters

| | | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|---|---|---|---|---|---|
| Norm (A/m / √(mV)) | a0 | 2.92E-003 | 2.69E-003 | 2.98E-003 | ± 5.1 % |
| Norm (A/m / √(mV)) | a1 | 4.61E-005 | 4.09E-005 | -6.60E-005 | ± 5.1 % |
| Norm (A/m / √(mV)) | a2 | -8.67E-006 | 3.24E-006 | 4.02E-006 | ± 5.1 % |
| DCP (mV)[B] | | 93.7 | 97.1 | 88.7 | |

## Modulation Calibration Parameters

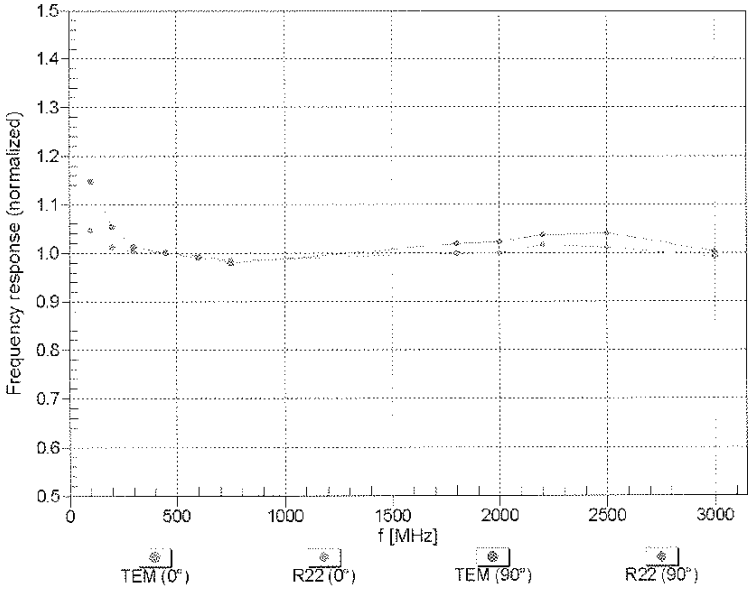
| UID | Communication System Name | PAR | | A dB | B dB | C dB | VR mV | Unc[E] (k=2) |
|---|---|---|---|---|---|---|---|---|
| 0 | CW | 0.00 | X | 0.0 | 0.0 | 1.0 | 118.6 | ±3.3 % |
| | | | Y | 0.0 | 0.0 | 1.0 | 130.1 | |
| | | | Z | 0.0 | 0.0 | 1.0 | 135.8 | |

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%.

[B] Numerical linearization parameter: uncertainty not required.
[E] Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.

H3DV6- SN:6105 November 9, 2012

## Frequency Response of H-Field
(TEM-Cell:ifi110 EXX, Waveguide: R22)




Uncertainty of Frequency Response of H-field: ± 6.3% (k=2)

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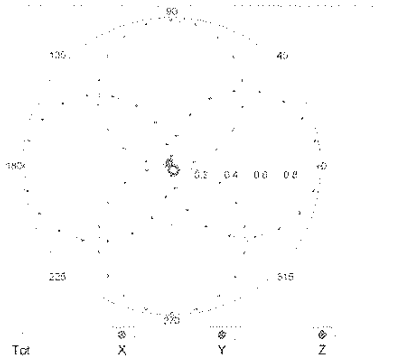
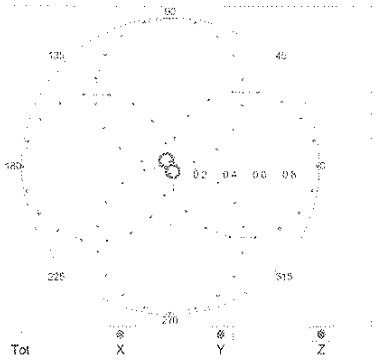
## Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0°

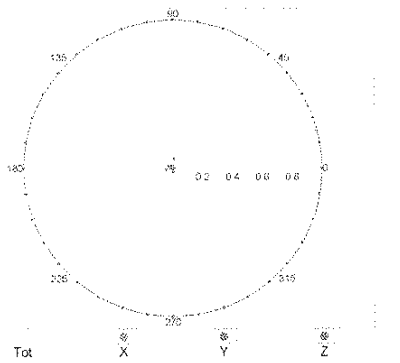



f=2500 MHz,R22,0°

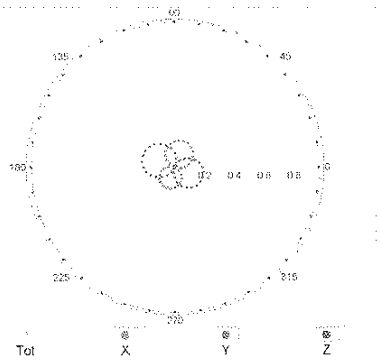



## Receiving Pattern (ϕ), ϑ = 90°

f=600 MHz,TEM,90°




f=2500 MHz,R22,90°



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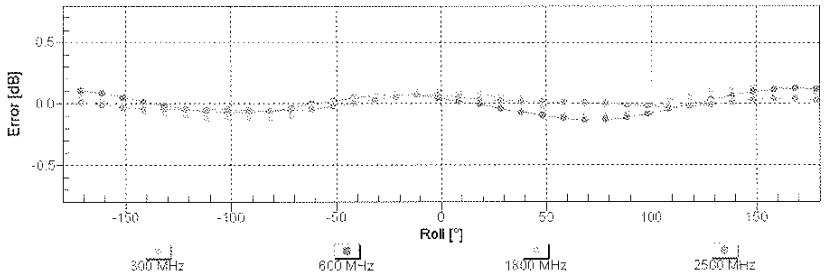
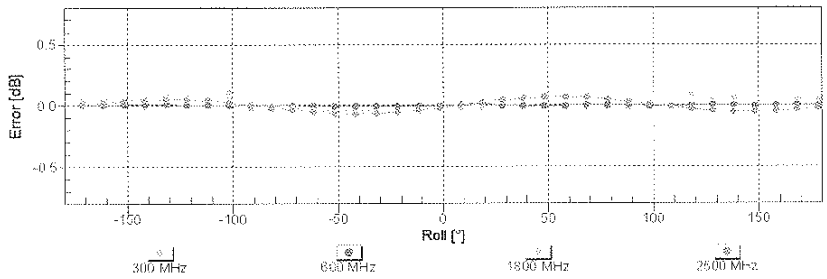
## Receiving Pattern (ϕ), ϑ = 0°




Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

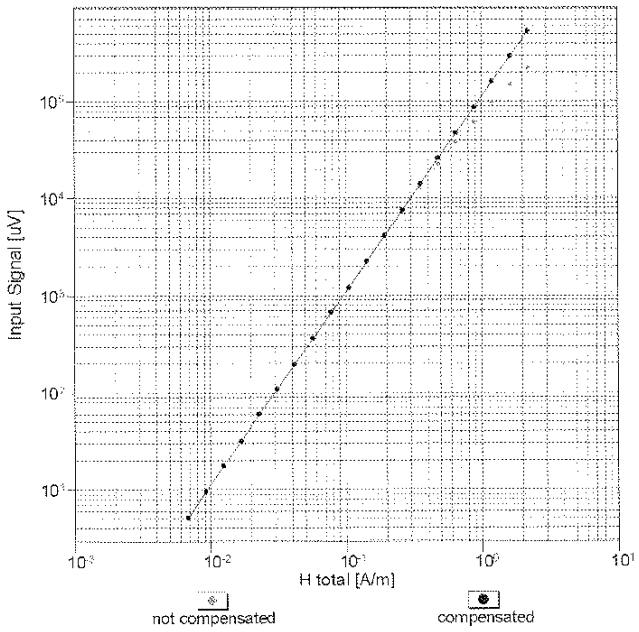
## Receiving Pattern (ϕ), ϑ = 90°

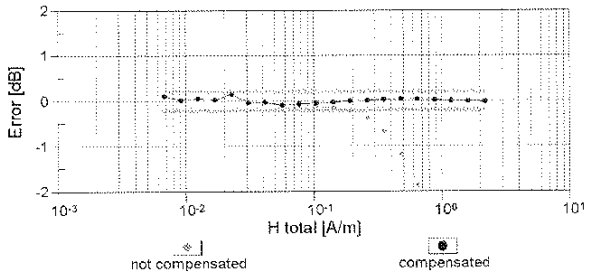



Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

## Dynamic Range f(H-field)

(TEM cell, f = 900 MHz)

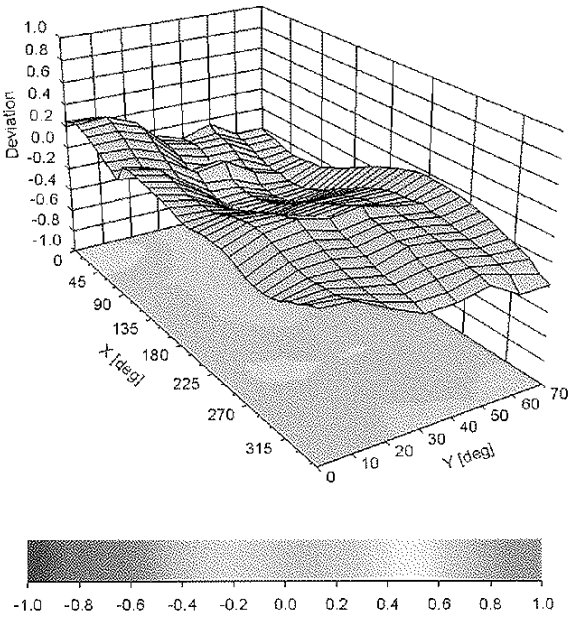



**Uncertainty of Linearity Assessment: ± 0.6% (k=2)**

## Deviation from Isotropy in Air

Error (ϕ, ϑ), f = 900 MHz







**Uncertainty of Spherical Isotropy Assessment: ± 2.6% (k=2)**

# DASY/EASY - Parameters of Probe: H3DV6 - SN:6105

**Other Probe Parameters**

| | |
|---|---|
| Sensor Arrangement | Rectangular |
| Connector Angle (°) | -61.6 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 10 mm |
| Tip Length | 20 mm |
| Tip Diameter | 6 mm |
| Probe Tip to Sensor X Calibration Point | 3 mm |
| Probe Tip to Sensor Y Calibration Point | 3 mm |
| Probe Tip to Sensor Z Calibration Point | 3 mm |