Calibration Laboratory of
Schmid & Partner
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Accreditation No.: SCS 0108

Client Intel France

Certificate No: EUmmWV2-9354_Feb17/2

CALIBRATION CERTIFICATE (Replacement of No: EUmmWV2-9354_Feb17)

Object	EUmmWV2 - SN:9354
Calibration procedure(s)	QA CAL-02.v8, QA CAL-25.v6, QA CAL-42.v2 Calibration procedure for E-field probes optimized for close near field evaluations in air
Calibration date:	February 23, 2017

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 NRP	SN: 104778	06-Apr-16 (No. 217-02288/02289)	Apr-17
Power sensor NRP-Z91	SN: 103244	06-Apr-16 (No. 217-02288)	Apr-17
Power sensor NRP-Z91	SN: 103245	06-Apr-16 (No. 217-02289)	Apr-17
Reference 20 dB Attenuator	SN: S5277 (20x)	05-Apr-16 (No. 217-02293)	Apr-17
Reference Probe ER3DV6	SN: 2328	14-Oct-16 (No. ER3-2328_Oct16)	Oct-17
DAE4	SN: 789	11-Nov-16 (No. DAE4-789_Nov16)	Nov-17
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-16)	In house check: Jun-18
RF generator HP 8648C	SN: US3642U01700	04-Aug-99 (in house check Jun-16)	In house check: Jun-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-16)	In house check: Oct-17

	Name	Function	Signature
Calibrated by:	Fin Bomholt	Deputy Manager	
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 8, 2017

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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, D	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., $\vartheta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system
Sensor Angles	sensor deviation from the probe axis, used to calculate the field orientation and polarization
$\hat{k}$	is the wave propagation direction

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 $\vartheta = 0$ for XY sensors and $\vartheta = 90$ for Z sensor ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). For frequencies > 3 GHz, the far field in front of waveguide horn antennas is measured for a set of frequencies in various waveguide bands up to 90 GHz. The frequency dependency is fitted using a sensor model involving resistors R, R_p, inductance L and capacitors C, C_p.
- *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; Dx,y,z; VRx,y,z*: *A, B, C, D* 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.
- *Sensor Offset*: The sensor offset corresponds to the mechanical 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).
- *Equivalent Sensor Angle*: The two probe sensors are mounted in the same plane at different angles. The angles are assessed using the information gained by determining the *NORMx* (no uncertainty required).
- *Spherical isotropy (3D deviation from isotropy)*: in a locally homogeneous field realized using an open waveguide / horn setup.

Probe EUmmWV2

SN:9354

Manufactured: December 8, 2016
Calibrated: February 23, 2017

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

DASY - Parameters of Probe: EUmmWV2 - SN:9354

Basic Calibration Parameters (300 MHz – 3 GHz)

	Sensor X	Sensor Y	Unc (k=2)
Norm ($\mu V/(V/m)^2$)	0.02530	0.02833	± 10.1 %
DCP (mV)[B]	105.0	105.0	
Equivalent Sensor Angle	-59.6	31.3	

Modulation Calibration Parameters

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Unc[E] (k=2)
0	CW	X	0.0	0.0	1.0	0.00	131.7	±3.3 %
		Y	0.0	0.0	1.0		96.8	

Note: For details on UID parameters see Appendix.

Sensor Model Parameters

Other Probe Parameters (300 MHz – 3 GHz)

Sensor Arrangement	Rectangular
Connector Angle (°)	77.0
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	320 mm
Probe Body Diameter	10 mm
Tip Length	23 mm
Tip Diameter	8.0 mm
Probe Tip to Sensor X Calibration Point	1.5 mm
Probe Tip to Sensor Y Calibration Point	1.5 mm

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.

Appendix (Additional assessments outside the scope of SCS 0108)

DASY - Parameters of Probe: EUmmWV2 - SN:9354

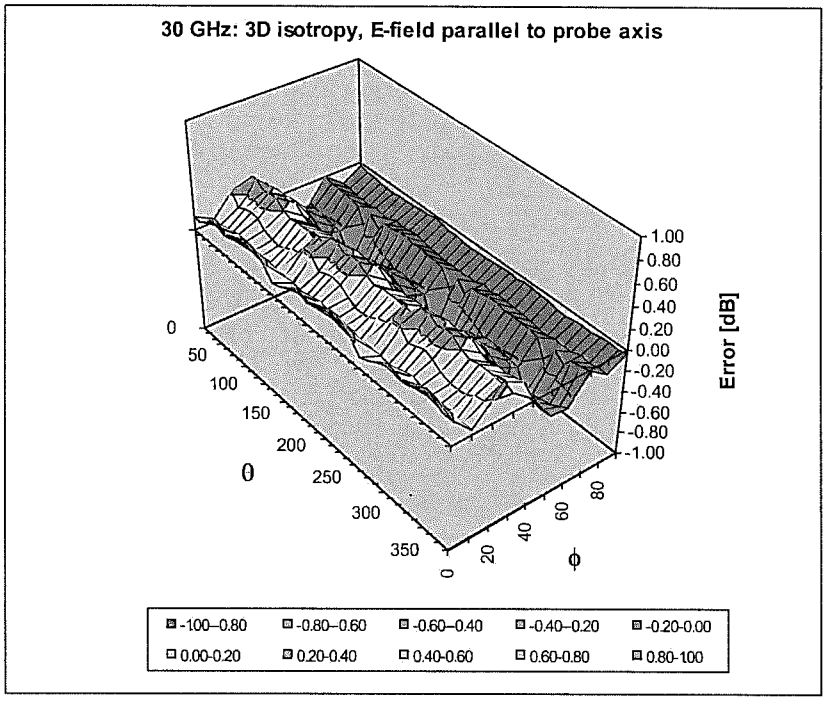
Sensor Frequency Model Parameters for f > 3 GHz [Z]

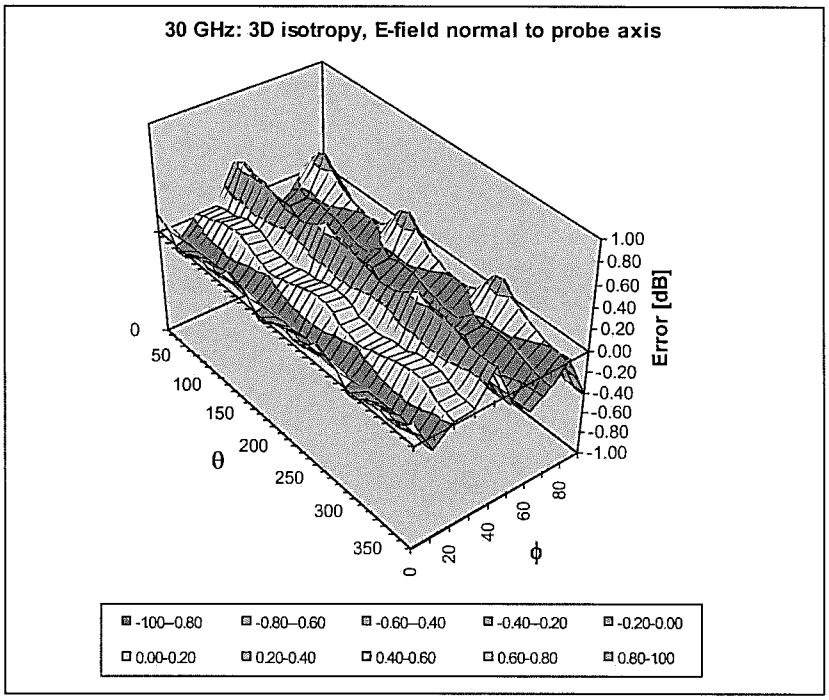
	Sensor X	Sensor Y
R (Ω)	49.96	58.32
R_p (Ω)	112.42	111.97
L (nH)	0.03627	0.03649
C (pF)	0.2106	0.276
C_p (pF)	0.1304	0.1133

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%.

[Z] Uncertainty is the probe model uncertainty including *Norm*, expressed as normal distribution, which is < 1 dB.

Deviation from Isotropy in Air
f = 30 GHz





Probe isotropy for E_{tot}: probe rotated φ = 0° to 360°, tilted from field propagation direction $\vec{k}$
Parallel to the field propagation (ψ =0° - 90°): deviation within ± 0.38 dB
Normal to field orientation (ϑ =0° - 90°): deviation within ± 0.47 dB

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Client **Intel France** **Certificate No:** **Horn_WR15-0590_May17**

CALIBRATION CERTIFICATE

Object	Horn WR15-0590, type: PE9881-24, SN: 37/216
Calibration procedure(s)	QA CAL-44.v1 Calibration procedure for free space horns
Calibration date:	May 8, 2017

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 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power sensor NRP33T	100967	17-Oct-16 (No. 0186)	Oct-18
Power sensor NRP33T	100968	17-Oct-16 (No. 0185)	Oct-18
Attenuator 10 dB	10A (84231)	18-Apr-17 (No. 217-02536)	Apr-19
Mismatch combination	10B (84224), SS001	18-Apr-17 (No. 217-02537)	Apr-19
Probe EUmmWV2	SN: 9350	24-Mar-17 (No. EUmmWV2-9350_Mar17)	Mar-18
DAE4	SN: 908	10-Mar-17 (No. DAE4-781_Mar17)	Mar-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power sensor NRP-Z58	SN: 101016	24-Oct-15 (in house check Nov-16)	In house check: Nov-17
RF generator E8251A	US41140111	04-Aug-03 (in house check Mar-17)	In house check: Mar-19
Frequency Extender 50 – 75 GHz	SN: 13071-01	14-Apr-17 (in house check Apr-17)	In house check: Apr-19
Network Analyzer Agilent E8361A	US43140798	28-Oct-13 (in house check Jan-16)	In house check: Jan-18

	Name	Function	Signature
Calibrated by:	Fin Bomholt	Deputy Manager	
Approved by:	Katja Pokovic	Technical Manager	

Issued: May 9, 2017

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References

[1] IEC106 WG10 draft report, February 2017

Methods Applied and Interpretation of Parameters:

- *Coordinate System:* z-axis in the waveguide horn boresight, x-axis is in the direction of the E-field, y-axis normal to the others in the field scanning plane parallel to the horn flare and horn flange.
- *Measurement Conditions:* The forward power to the horn antenna is measured prior and after the measurement with a power sensor. During the measurements, the horn is directly mounted to the waveguide source. Absorbers are used around the horn, in the boresight axis and at the back connector.
- *Horn Positioning:* The waveguide horn is mounted vertically on the flange of the waveguide source to allow vertical positioning of the EUmmW probe during the scan. The plane is parallel to the phantom surface. Probe distance is verified using mechanical gauges positioned on the flare of the horn.
- *E- field distribution:* E field is measured in the x-y-plane with a vectorial E-field probe with the source power of typ. 20 dBm at < 50 GHz and 10 dBm at > 50 GHz. The probe sensor center is 10 mm (in z) above the flare frame of the waveguide horn in the near field. The E-field value stated as calibration value represents the E-field-maxima 10mm in front of the horn.
- *E-field polarization:* Above the open horn, linear polarization of the field is expected. This is verified graphically in the field representation.

1. Measurement Conditions

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

DASY Version	DASY	V52.10.0.1428
DASY PP Version	SEMCAD X	V14.6.10
Phantom	Free Space	N/A
Distance WG horn front - Probe Center	10 mm	
Scan resolution	dx, dy = 1 mm	30 x 16 mm (longitudinal in E-field polarization)
Reference frequency	**60 GHz** ± 10 MHz	
Measured input power	7.13 dBm	after adapter
Input power at WG horn flange	7.53 dBm	at flange

2. Maximum Field values at 60 GHz, normalized to 10 mW forward power

E-field 10 mm above horn front	condition	**Maximum**
Maximum measured above high end	7.53 dBm source power	67.91 V/m
Maximum measured above low end	7.53 dBm source power	67.86 V/m
Averaged maximum, scaled to 10 dBm	**10 dBm** source power	**90.3 V/m**

3. Appendix

3.1 DASY E-Field Results

Date: 08.05.2017

Test Laboratory: SPEAG mmW

DUT: WG-15 Horn; Type: PE9881-24; Serial: 37/216

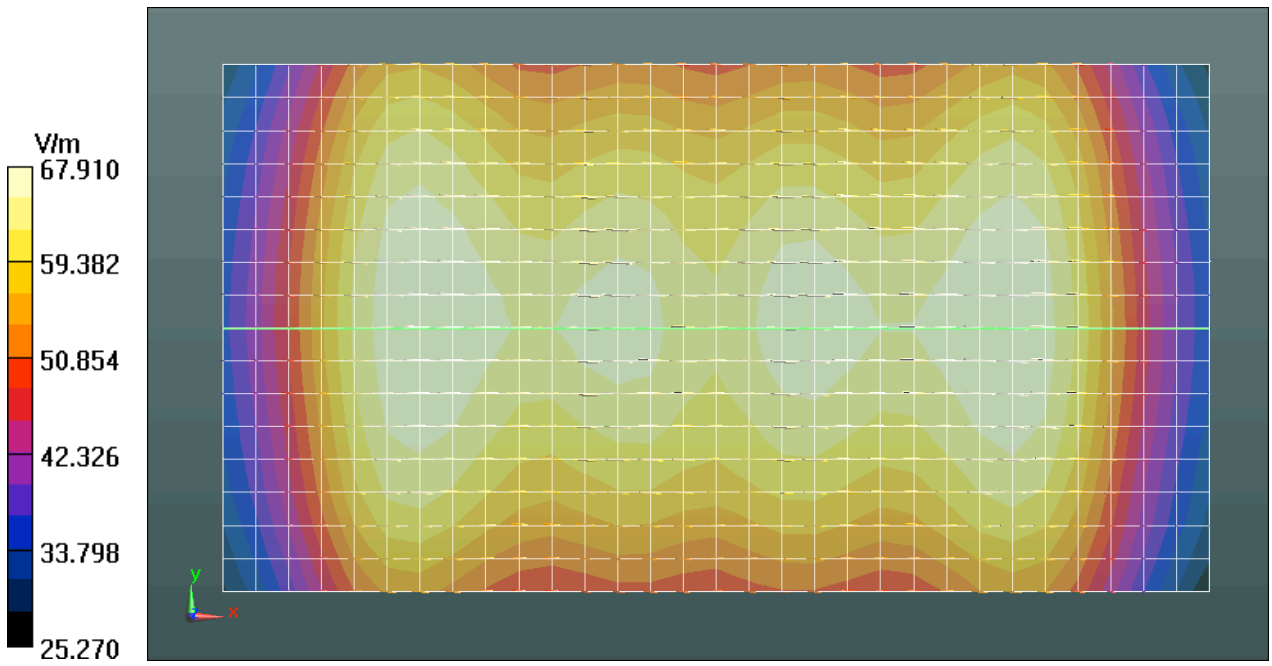
Communication System: UID 0, CW (0); Frequency: 60000 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

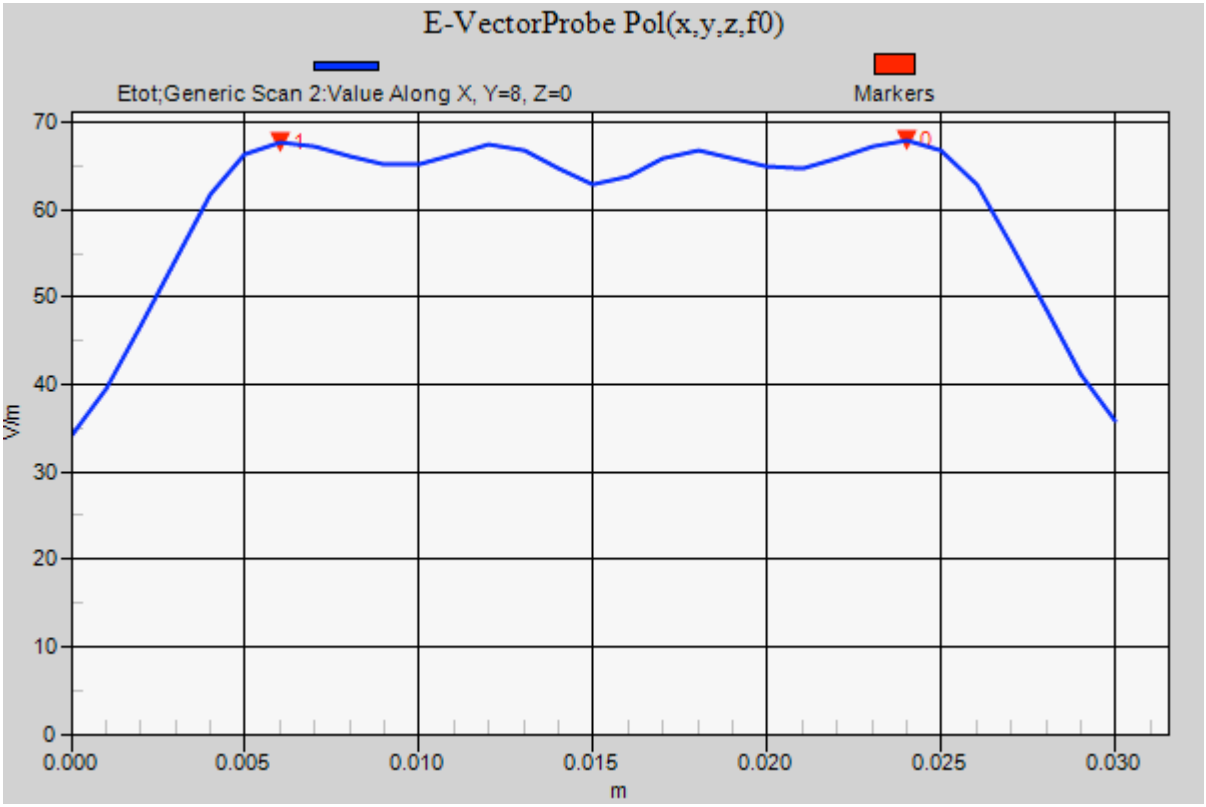
DASY Configuration:

- Probe: EUmmWV2 - SN9350 (as EummW) 60 GHz 170508; ConvF(1, 1, 1); Calibrated: 24.03.2017;
- Sensor-Surface: 0mm (Fix Surface), z = 1.0
- Electronics: DAE4 Sn908; Calibrated: 10.03.2017
- Phantom: Horn Cal Setup Conn_front; Type: Slot4
- DASY52 52.10.0(1428); SEMCAD X 14.6.10(7373)

170508_908_9350_IntelHorn24dB_SAGEsource_7.13dBm/Fine Scans 10mm/Generic Scan 2 (31x17x1):

Measurement grid: dx=1mm, dy=1mm, dz=20mm
Maximum value of Etot (measured) = 67.91 V/m




E-VectorProbe Pol(x,y,z,f0)
Etot;Generic Scan 2:Value Along X, Y=8, Z=0
Markers
70
60
50
40
30
20
10
0
V/m
0.000
0.005
0.010
0.015
0.020
0.025
0.030
m

Author **Fin Bomholt**
Change
Date of origin **2017-06-15**
Date of change

References

[1] Certificate No. Horn_WR15-0590_May17

Overview

The rectangular waveguide Horn WR15-0590 was calibrated at 60 GHz at a distance of 10 mm for the maximum E_{tot}-field according to [1]. The scan area was 30 mm x 16 mm with a resolution of 1.0 mm at a sensor distance of 10.0 mm from the front of the horn. The maxima at this distance are observed along the line of the E-field polarization (short dimension of the horn flare).
Additional plots were required to see the Field variation within the plot; they are scaled to the overall maximum.

Field variation along the E-field polarization

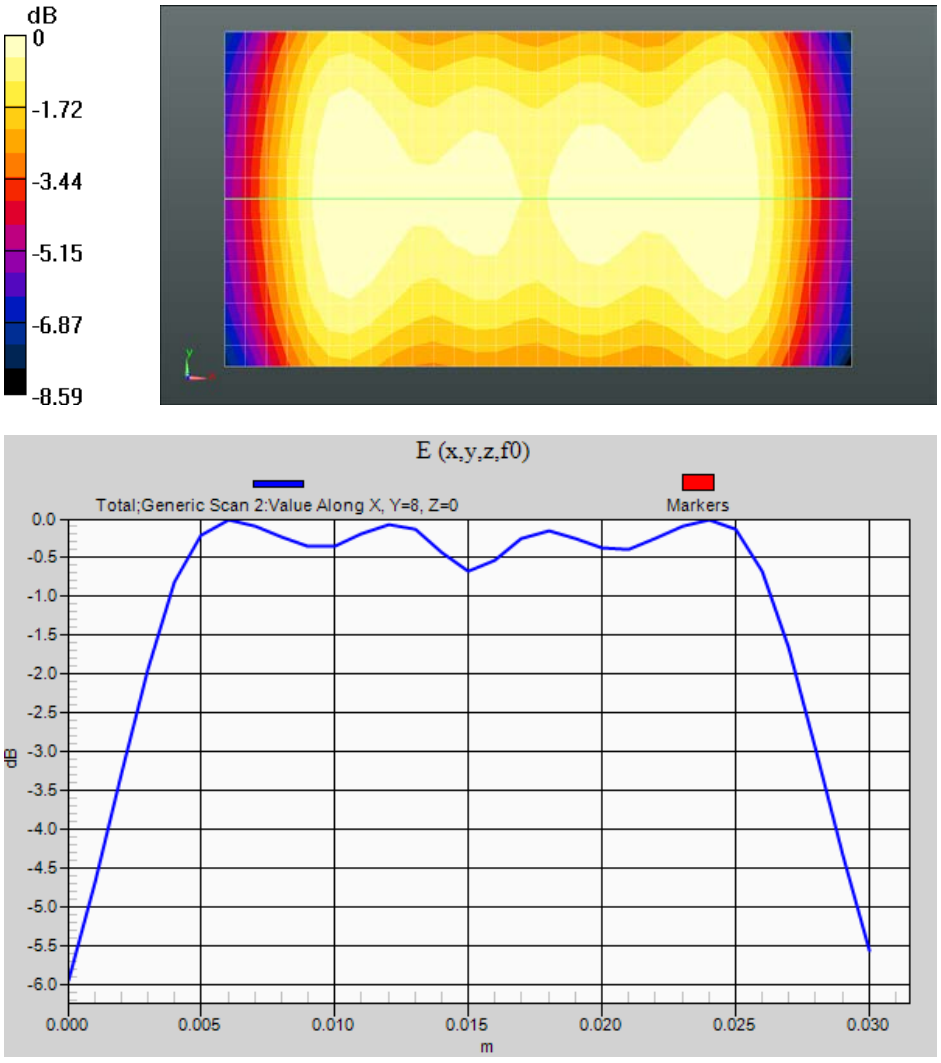


Fig. 1: Field variation through the maximum along the E-field polarization

Field variation across the E-field polarization

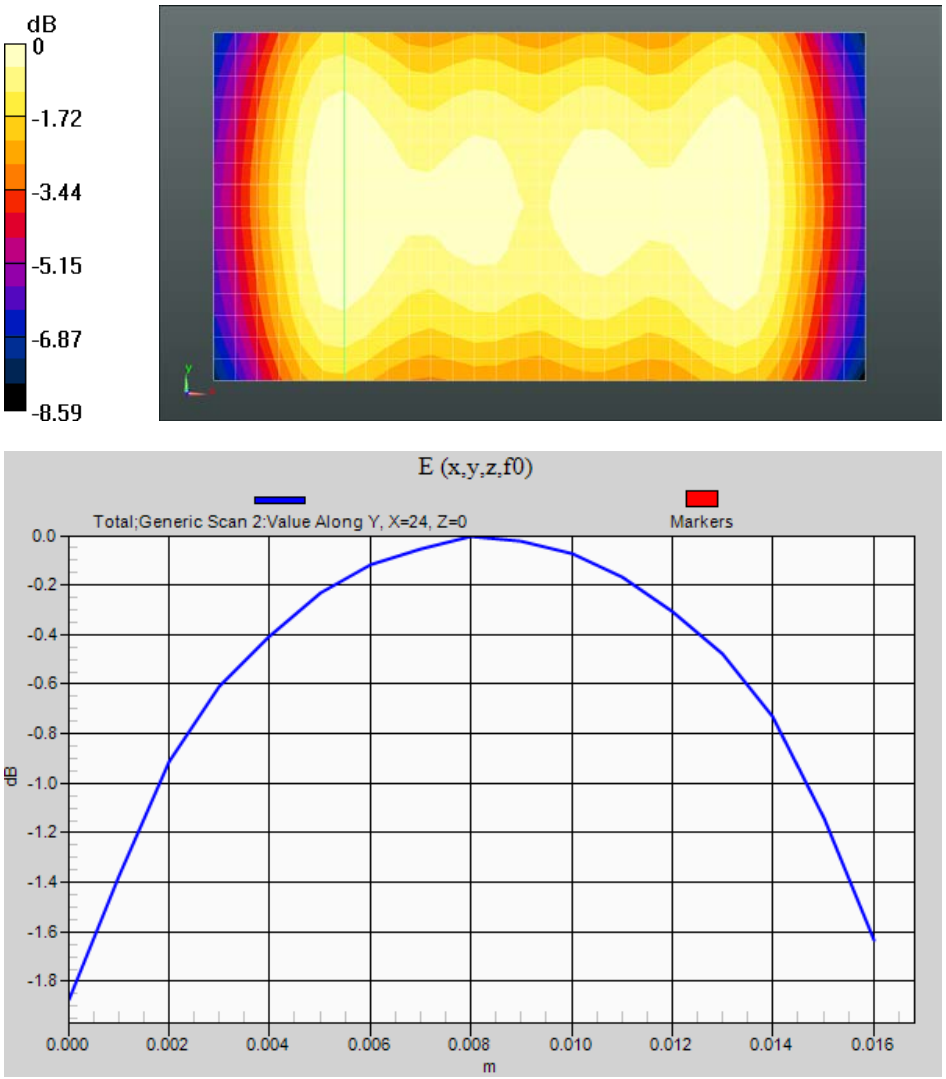


Fig. 2: Field variation through the maximum across (normal to) the E-field polarization

