14 MEASUREMENT UNCERTAINTY

No.	Error source	Type	Uncertainty Value (%)	Prob. Dist.	k	c_i E	Standard Uncertainty (%) u_i' (%) E	Degree of freedom V_{eff} or v_i
Measurement System								
1	Probe Calibration	B	5.	N	1	1	5.1	∞
2	Axial Isotropy	B	4.7	R	$\sqrt{3}$	1	2.7	∞
3	Sensor Displacement	B	16.5	R	$\sqrt{3}$	1	9.5	∞
4	Boundary Effects	B	2.4	R	$\sqrt{3}$	1	1.4	∞
5	Linearity	B	4.7	R	$\sqrt{3}$	1	2.7	∞
6	Scaling to Peak Envelope Power	B	2.0	R	$\sqrt{3}$	1	1.2	∞
7	System Detection Limit	B	1.0	R	$\sqrt{3}$	1	0.6	∞
8	Readout Electronics	B	0.3	N	1	1	0.3	∞
9	Response Time	B	0.8	R	$\sqrt{3}$	1	0.5	∞
10	Integration Time	B	2.6	R	$\sqrt{3}$	1	1.5	∞
11	RF Ambient Conditions	B	3.0	R	$\sqrt{3}$	1	1.7	∞
12	RF Reflections	B	12.0	R	$\sqrt{3}$	1	6.9	∞
13	Probe Positioner	B	1.2	R	$\sqrt{3}$	1	0.7	∞
14	Probe Positioning	A	4.7	R	$\sqrt{3}$	1	2.7	∞
15	Extra. And Interpolation	B	1.0	R	$\sqrt{3}$	1	0.6	∞
Test Sample Related								
16	Device Positioning Vertical	B	4.7	R	$\sqrt{3}$	1	2.7	∞
17	Device Positioning Lateral	B	1.0	R	$\sqrt{3}$	1	0.6	∞
18	Device Holder and Phantom	B	2.4	R	$\sqrt{3}$	1	1.4	∞
19	Power Drift	B	5.0	R	$\sqrt{3}$	1	2.9	∞

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20	AIA measurement	B	12	R	$\sqrt{3}$	1	6.9	∞
Phantom and Setup related								
21	Phantom Thickness	B	2.4	R	$\sqrt{3}$	1	1.4	∞
Combined standard uncertainty(%)							16.2	
Expanded uncertainty (confidence interval of 95 %)		$u_e = 2u_c$		N	k=2		32.4	

15 MAIN TEST INSTRUMENTS

Table 1: List of Main Instruments

No.	Name	Type	Serial Number	Calibration Date	Valid Period
01	Signal Generator	E4438C	MY49071430	February 01, 2016	One Year
02	Power meter	NRVD	102196	March 03, 2016	One year
03	Power sensor	NRV-Z5	100596		
04	Amplifier	60S1G4	0331848	No Calibration Requested	
05	E-Field Probe	ER3DV6	2272	January 19, 2016	One year
06	HAC Dipole	CD835V3	1023	August 20, 2015	One year
07	HAC Dipole	CD1880V3	1018	August 20, 2015	One year
08	BTS	E5515C	MY50263375	January 30, 2016	One year
09	DAE	SPEAG DAE4	777	August 26, 2015	One year
10	AIA	SE UMS 170 CB	1029	No Calibration Requested	

16 CONCLUSION

The HAC measurement indicates that the EUT complies with the HAC limits of the ANSI C63.19-2011. The total M-rating is **M4.**

END OF REPORT BODY

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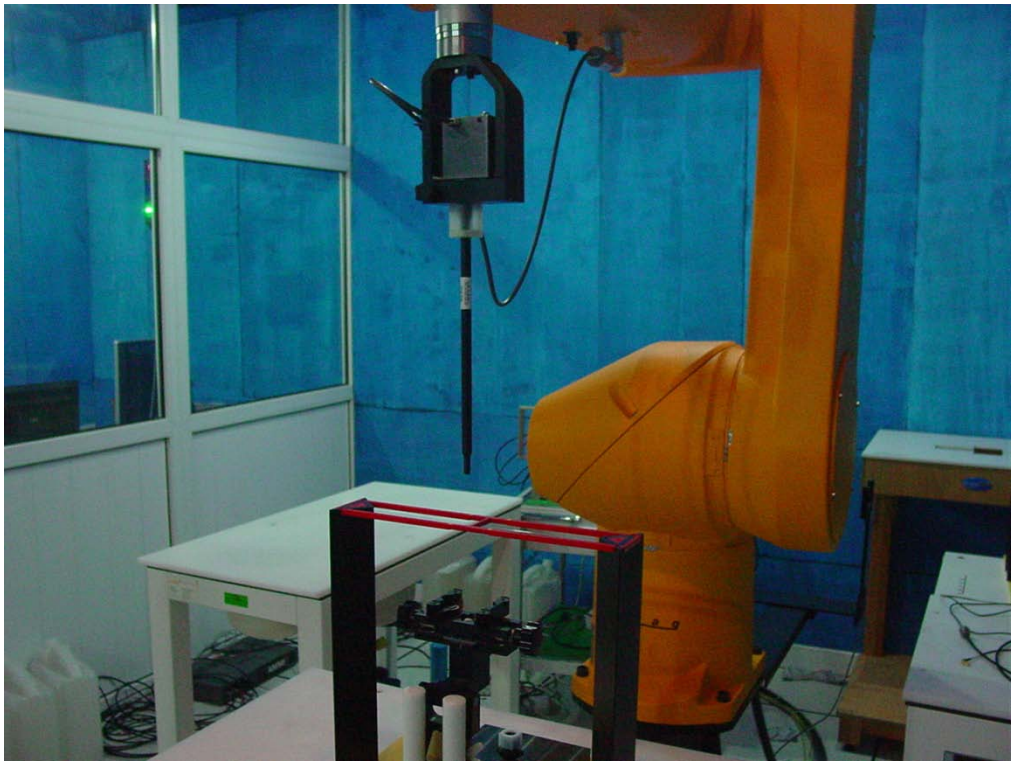
ANNEX A TEST LAYOUT



Picture A1: HAC RF System Layout

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ANNEX B TEST PLOTS

HAC RF E-Field GSM 850 High

Date: 2016-03-10

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3

Ambient Temperature:23.0°C

Communication System: GSM 850; Frequency: 848.8 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 73.74 V/m; Power Drift = -0.06 dB

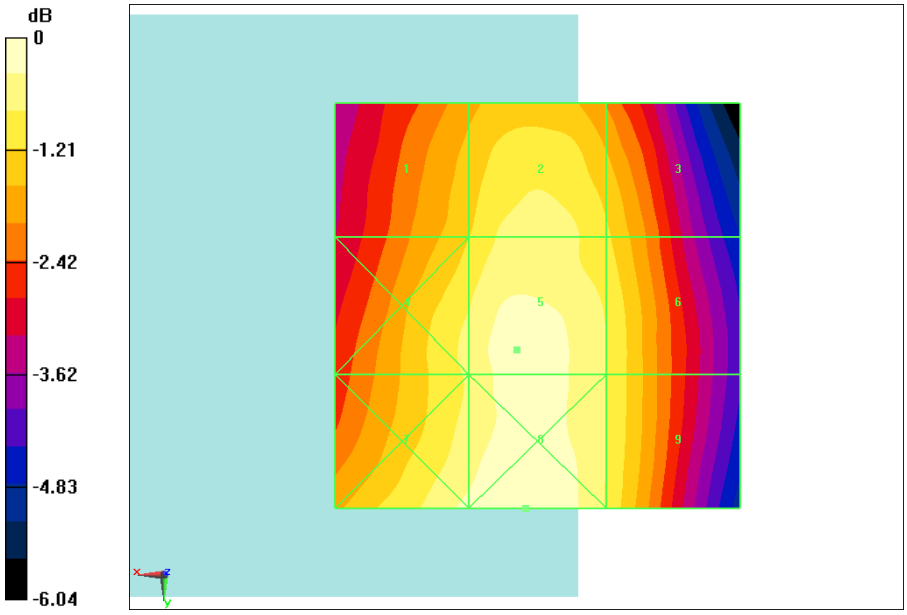
Applied MIF = 3.50 dB

RF audio interference level = 38.73 dBV/m

Emission category: M4

MIF scaled E-field

Grid 1 **M4** **37.76 dBV/m**	Grid 2 **M4** **38.32 dBV/m**	Grid 3 **M4** **37.86 dBV/m**
Grid 4 **M4** **38.32 dBV/m**	Grid 5 **M4** **38.73 dBV/m**	Grid 6 **M4** **38.19 dBV/m**
Grid 7 **M4** **38.7 dBV/m**	Grid 8 **M4** **38.98 dBV/m**	Grid 9 **M4** **38.18 dBV/m**



0 dB = 88.94 V/m = 38.98 dBV/m

Fig B.1 HAC RF E-Field GSM 850 High

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HAC RF E-Field GSM 850 Middle

Date: 2016-03-10

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3

Ambient Temperature:23.0°C

Communication System: GSM 850; Frequency: 836.6 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 2/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 76.22 V/m; Power Drift = 0.03 dB

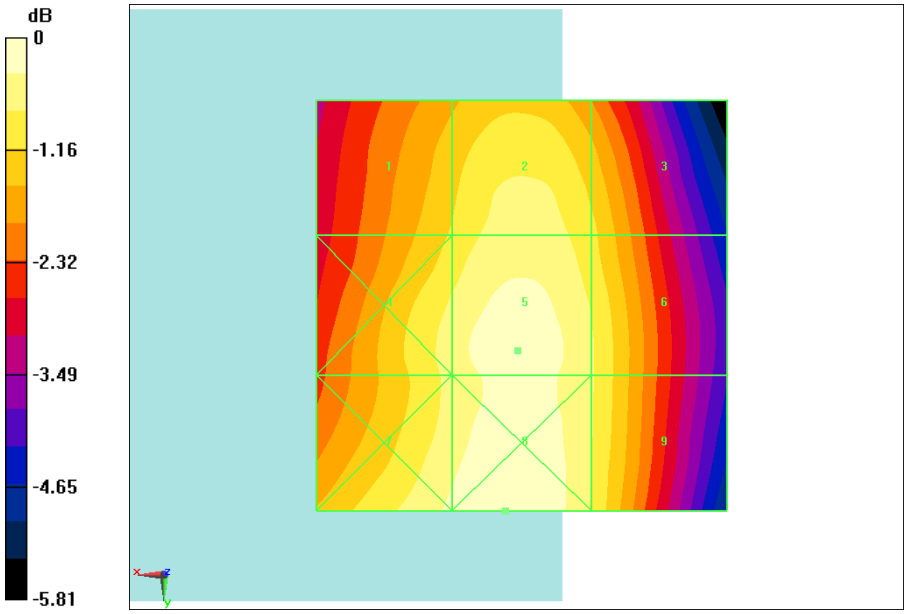
Applied MIF = 3.49 dB

RF audio interference level = 39.09 dBV/m

Emission category: M4

MIF scaled E-field

Grid 1 **M4** **38.16 dBV/m**	Grid 2 **M4** **38.72 dBV/m**	Grid 3 **M4** **38.2 dBV/m**
Grid 4 **M4** **38.67 dBV/m**	Grid 5 **M4** **39.09 dBV/m**	Grid 6 **M4** **38.53 dBV/m**
Grid 7 **M4** **38.96 dBV/m**	Grid 8 **M4** **39.26 dBV/m**	Grid 9 **M4** **38.52 dBV/m**



0 dB = 91.78 V/m = 39.25 dBV/m

Fig B.2 HAC RF E-Field GSM 850 Middle

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HAC RF E-Field GSM 850 Low

Date: 2016-03-10

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3

Ambient Temperature:23.0°C

Communication System: GSM 850; Frequency: 824.2 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 3/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 70.47 V/m; Power Drift = -0.05 dB

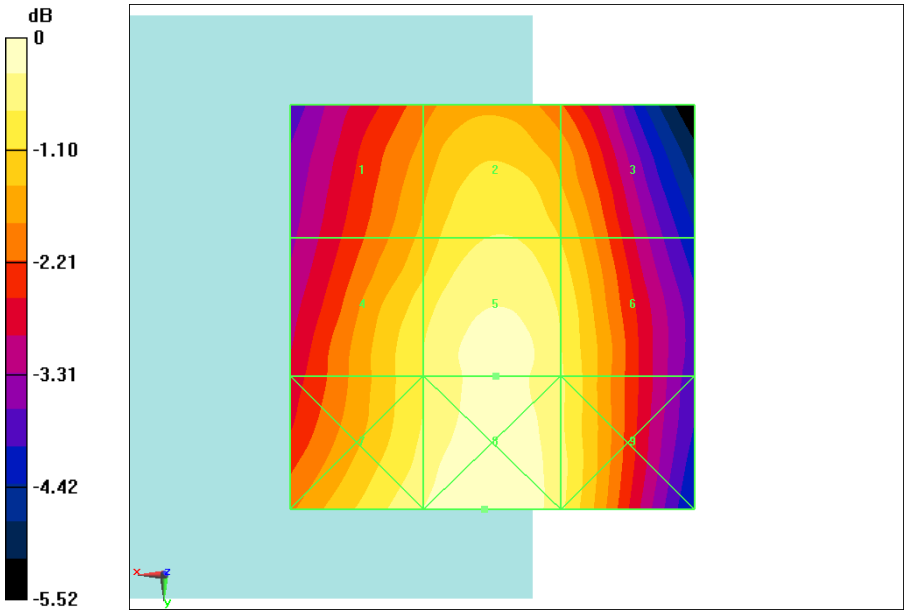
Applied MIF = 3.46 dB

RF audio interference level = 38.33 dBV/m

Emission category: M4

MIF scaled E-field

Grid 1 **M4** **37.25 dBV/m**	Grid 2 **M4** **37.88 dBV/m**	Grid 3 **M4** **37.48 dBV/m**
Grid 4 **M4** **37.87 dBV/m**	Grid 5 **M4** **38.33 dBV/m**	Grid 6 **M4** **37.91 dBV/m**
Grid 7 **M4** **38.24 dBV/m**	Grid 8 **M4** **38.6 dBV/m**	Grid 9 **M4** **37.99 dBV/m**



0 dB = 85.07 V/m = 38.60 dBV/m

Fig B.3 HAC RF E-Field GSM 850 Low

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HAC RF E-Field GSM 1900 High

Date: 2016-03-10

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3

Ambient Temperature:23.0°C

Communication System: DCS 1900; Frequency: 1909.8 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 14.21 V/m; Power Drift = 0.17 dB

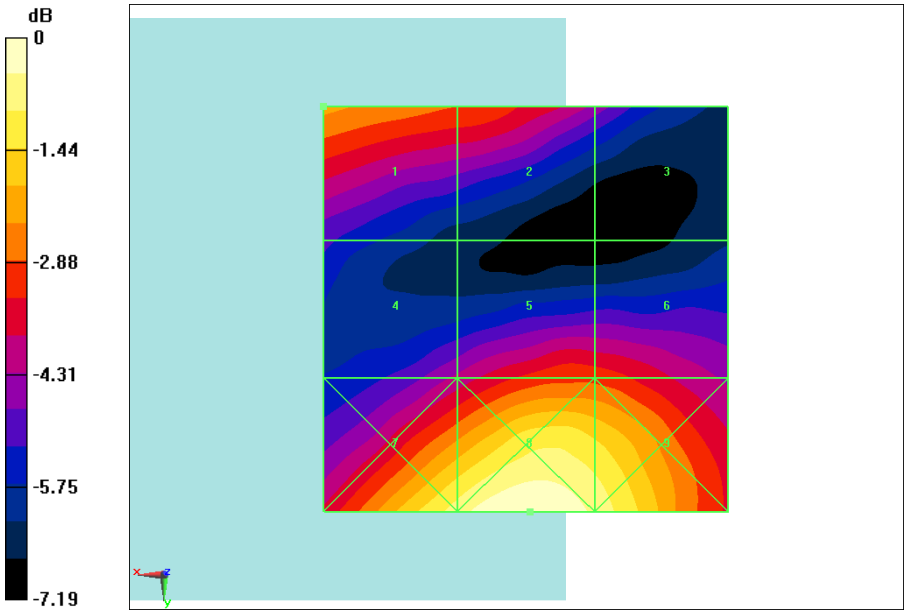
Applied MIF = 3.50 dB

RF audio interference level = 28.61 dBV/m

Emission category: M4

MIF scaled E-field

Grid 1 **M4** **28.61 dBV/m**	Grid 2 **M4** **28 dBV/m**	Grid 3 **M4** **26.39 dBV/m**
Grid 4 **M4** **26.67 dBV/m**	Grid 5 **M4** **27.86 dBV/m**	Grid 6 **M4** **27.82 dBV/m**
Grid 7 **M3** **30.13 dBV/m**	Grid 8 **M3** **30.84 dBV/m**	Grid 9 **M3** **30.24 dBV/m**



0 dB = 34.84 V/m = 30.84 dBV/m

Fig B.4 HAC RF E-Field GSM 1900 High

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HAC RF E-Field GSM 1900 Middle

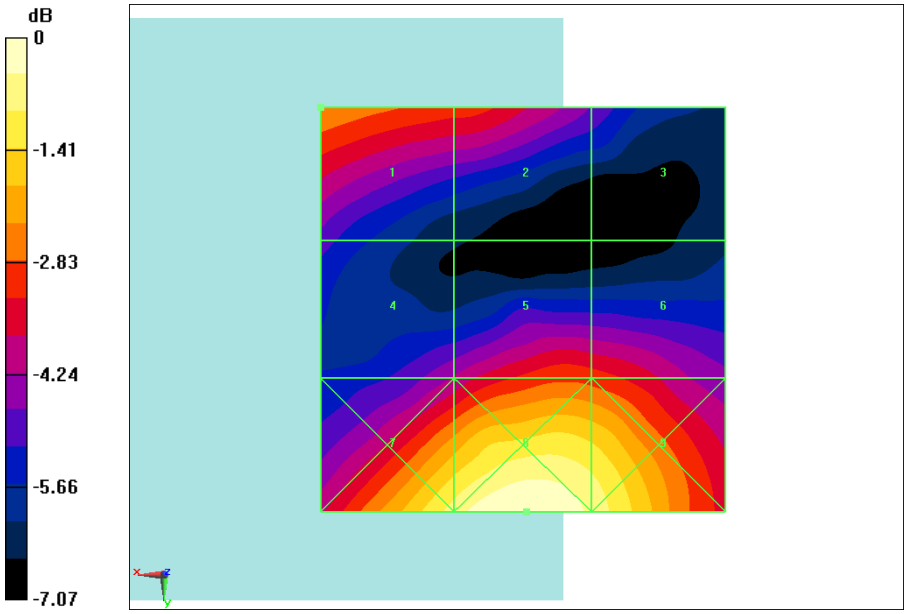
Date: 2016-03-10

Electronics: DAE4 Sn777
Medium: Air
Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Ambient Temperature:23.0°C
Communication System: DCS 1900; Frequency: 1880 MHz; Duty Cycle: 1:8.3
Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 2/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 14.36 V/m; Power Drift = -0.06 dB
Applied MIF = 3.47 dB
RF audio interference level = 28.29 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **28.29 dBV/m**	Grid 2 **M4** **27.55 dBV/m**	Grid 3 **M4** **25.87 dBV/m**
Grid 4 **M4** **26.45 dBV/m**	Grid 5 **M4** **27.68 dBV/m**	Grid 6 **M4** **27.58 dBV/m**
Grid 7 **M4** **29.89 dBV/m**	Grid 8 **M3** **30.59 dBV/m**	Grid 9 **M3** **30 dBV/m**



0 dB = 33.92 V/m = 30.61 dBV/m

Fig B.5 HAC RF E-Field GSM 1900 Middle

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HAC RF E-Field GSM 1900 Low

Date: 2016-03-10

Electronics: DAE4 Sn777

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3

Ambient Temperature:23.0°C

Communication System: DCS 1900; Frequency: 1850.2 MHz; Duty Cycle: 1:8.3

Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)

E Scan - ER3DV6 - 2011: 15 mm from Probe Center to the Device 3/Hearing Aid Compatibility Test (101x101x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm

Device Reference Point: 0, 0, -6.3 mm

Reference Value = 15.06 V/m; Power Drift = 0.12 dB

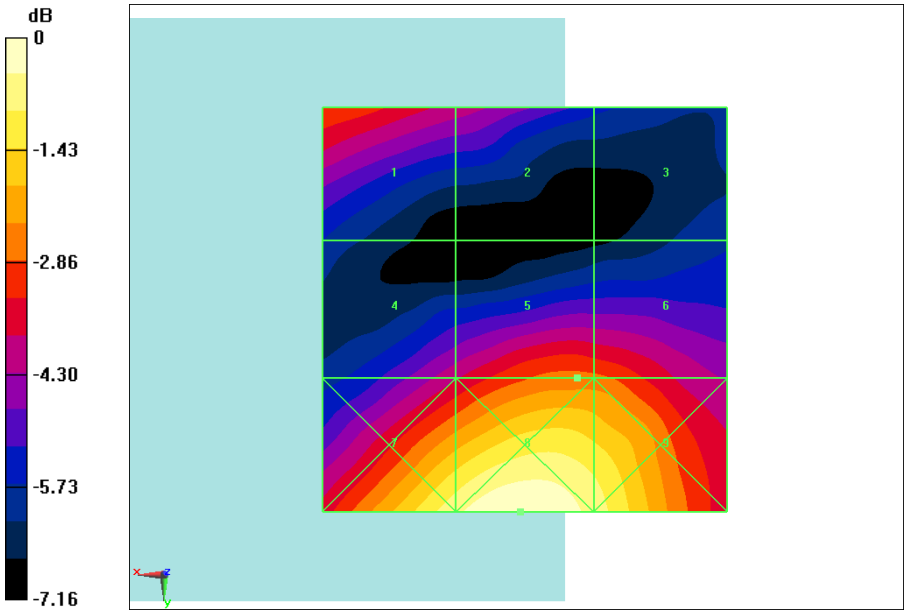
Applied MIF = 3.45 dB

RF audio interference level = 28.15 dBV/m

Emission category: M4

MIF scaled E-field

Grid 1 **M4** **27.85 dBV/m**	Grid 2 **M4** **26.82 dBV/m**	Grid 3 **M4** **25.32 dBV/m**
Grid 4 **M4** **26.96 dBV/m**	Grid 5 **M4** **28.15 dBV/m**	Grid 6 **M4** **28.11 dBV/m**
Grid 7 **M3** **30.22 dBV/m**	Grid 8 **M3** **30.82 dBV/m**	Grid 9 **M3** **30.15 dBV/m**



0 dB = 34.75 V/m = 30.82 dBV/m

Fig B.6 HAC RF E-Field GSM 1900 Low

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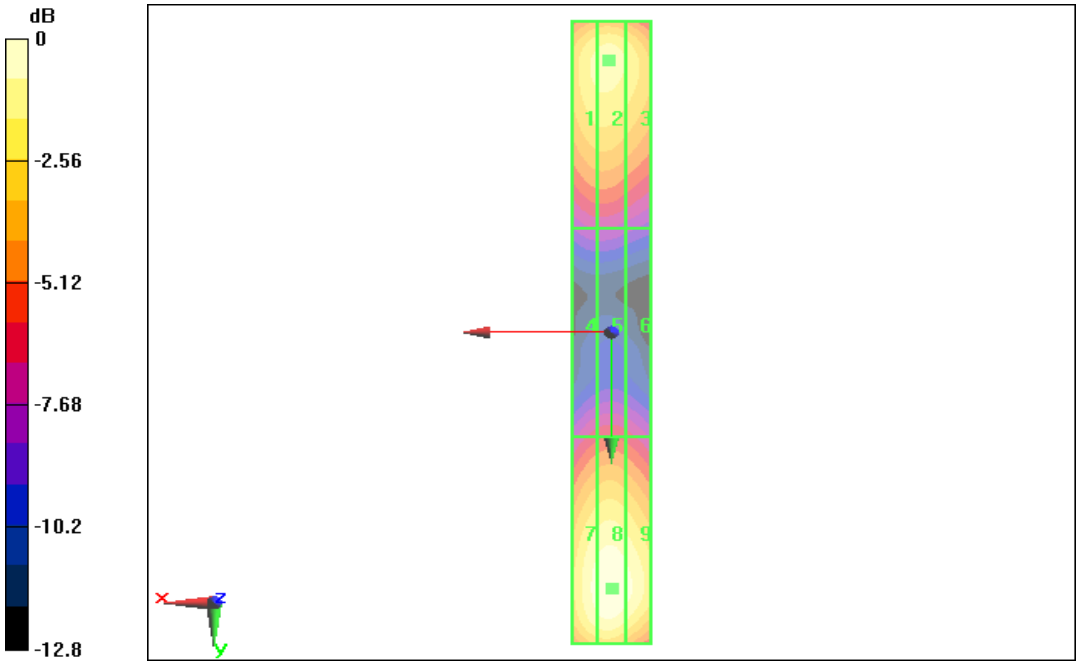
ANNEX C SYSTEM VALIDATION RESULT

E SCAN of Dipole 835 MHz
Date: 2016-3-10
Electronics: DAE4 Sn777
Medium: Air
Medium parameters used: σ = 0 mho/m, εr = 1; ρ = 1000 kg/m3
Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1
Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)
E Scan - measurement distance from the probe sensor center to CD835 Dipole = 15mm/Hearing Aid Compatibility Test (41x361x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 118.6 V/m; Power Drift = 0.08 dB
Applied MIF = 0.00 dB
RF audio interference level = 40.57 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 **M3** **40.38 dBV/m**	Grid 2 **M3** **40.57 dBV/m**	Grid 3 **M3** **40.46 dBV/m**
Grid 4 **M4** **35.59 dBV/m**	Grid 5 **M4** **35.89 dBV/m**	Grid 6 **M4** **35.87 dBV/m**
Grid 7 **M3** **40.02 dBV/m**	Grid 8 **M3** **40.29 dBV/m**	Grid 9 **M3** **40.23 dBV/m**



0 dB = 40.57 dBV/m

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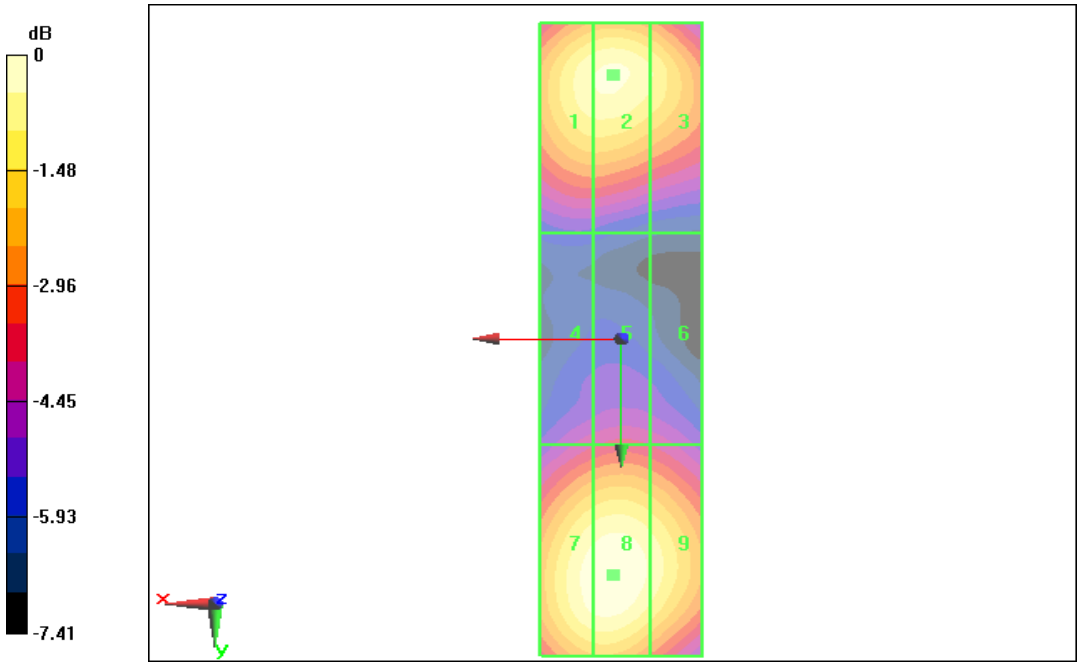
E SCAN of Dipole 1880 MHz
Date: 2016-3-10
Electronics: DAE4 Sn777
Medium: Air
Medium parameters used: $\sigma = 0$ mho/m, $\varepsilon_r = 1$; $\rho = 1000$ kg/m^3
Communication System: CW; Frequency: 1880 MHz; Duty Cycle: 1:1
Probe: ER3DV6 - SN2272;ConvF(1, 1, 1)
E Scan - measurement distance from the probe sensor center to CD1880 Dipole = 15mm/Hearing Aid Compatibility Test (41x181x1): Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 142.9 V/m; Power Drift = -0.03 dB
Applied MIF = 0.00 dB
RF audio interference level = 39.34 dBV/m
Emission category: M2

MIF scaled E-field

Grid 1 **M2** **39.09 dBV/m**	Grid 2 **M2** **39.34 dBV/m**	Grid 3 **M2** **39.19 dBV/m**
Grid 4 **M2** **36.75 dBV/m**	Grid 5 **M2** **36.95 dBV/m**	Grid 6 **M2** **36.89 dBV/m**
Grid 7 **M2** **39.13 dBV/m**	Grid 8 **M2** **39.27 dB V/m**	Grid 9 **M2** **39.16 dBV/m**



0 dB = 39.34 dBV/m

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ANNEX D PROBE CALIBRATION CERTIFICATE

E_Probe ER3DV6

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
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 0108

Client CTTL (Auden) **Certificate No: ER3-2272_Jan16**

CALIBRATION CERTIFICATE

Object: ER3DV6 - SN:2272

Calibration procedure(s): QA CAL-02.v8, QA CAL-25.v6
Calibration procedure for E-field probes optimized for close near field evaluations in air

Calibration date: January 19, 2016

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	01-Apr-15 (No. 217-02128)	Mar-16
Power sensor E4412A	MY41498087	01-Apr-15 (No. 217-02128)	Mar-16
Reference 3 dB Attenuator	SN: S5054 (3c)	01-Apr-15 (No. 217-02129)	Mar-16
Reference 20 dB Attenuator	SN: S5277 (20x)	01-Apr-15 (No. 217-02132)	Mar-16
Reference 30 dB Attenuator	SN: S5129 (30b)	01-Apr-15 (No. 217-02133)	Mar-16
Reference Probe ER3DV6	SN: 2328	12-Oct-15 (No. ER3-2328_Oct15)	Oct-16
DAE4	SN: 789	16-Mar-15 (No. DAE4-789_Mar15)	Mar-16
Secondary Standards	ID	Check Date (in house)	Scheduled Check
RF generator HP 8648C	US3642U01700	4-Aug-99 (in house check Apr-13)	In house check: Apr-16
Network Analyzer HP 8753E	US37390585	18-Oct-01 (in house check Oct-15)	In house check: Oct-16

	Name	Function	Signature
Calibrated by:	Michael Weber	Laboratory Technician	M.Weber
Approved by:	Katja Pokovic	Technical Manager	

Issued: January 20, 2016

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

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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
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 0108

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., 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, Rev 3.0, November 2013

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; 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.
- *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).

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Probe ER3DV6

SN:2272

Manufactured: November 29, 2001
Calibrated: January 19, 2016

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

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DASY/EASY - Parameters of Probe: ER3DV6 - SN:2272

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)	1.66	1.71	1.78	± 10.1 %
DCP (mV)[B]	100.4	99.4	100.7	

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	198.9	±3.8 %
		Y	0.0	0.0	1.0		165.5	
		Z	0.0	0.0	1.0		196.7	

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.

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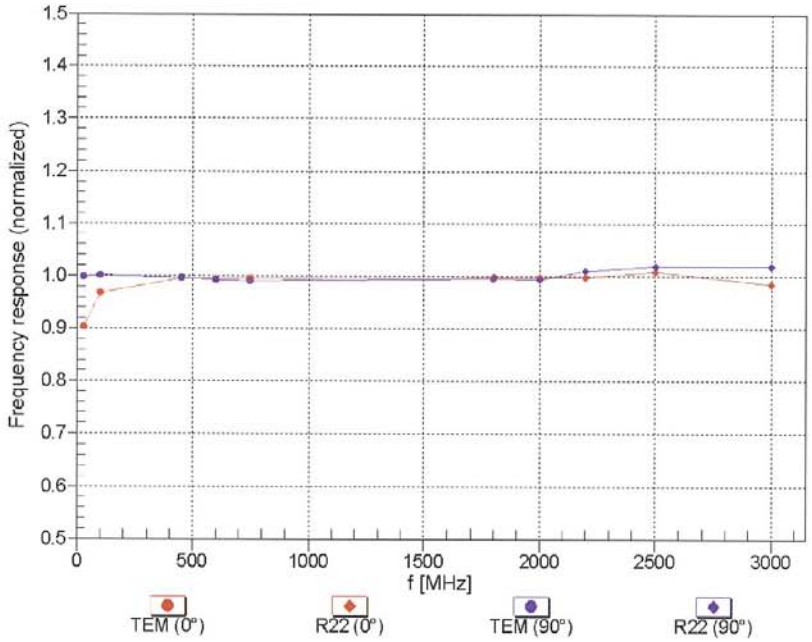
ER3DV6 – SN:2272 January 19, 2016

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



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

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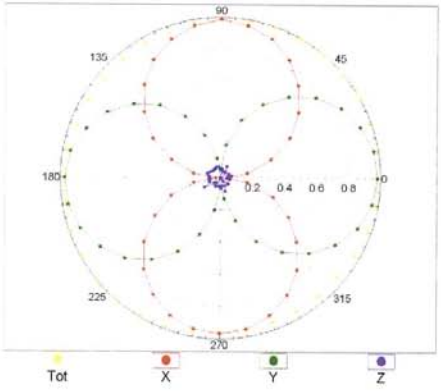
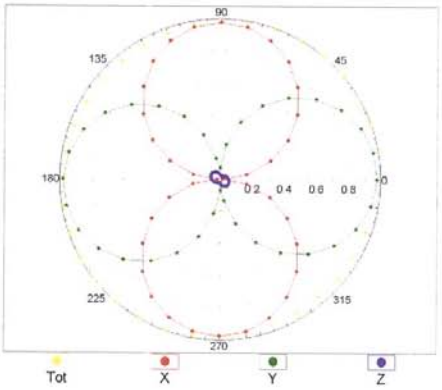
Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0°

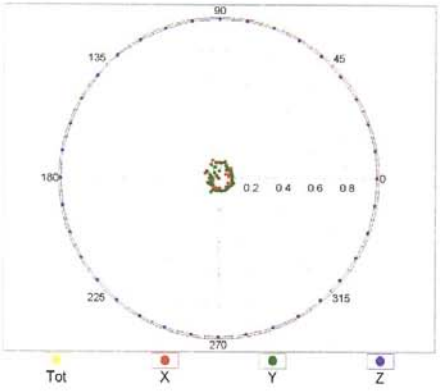


f=2500 MHz,R22,0°

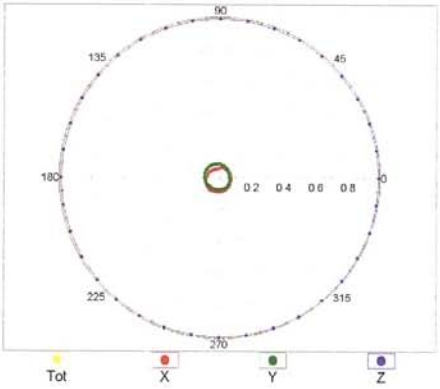


Receiving Pattern (ϕ), ϑ = 90°

f=600 MHz,TEM,90°



f=2500 MHz,R22,90°



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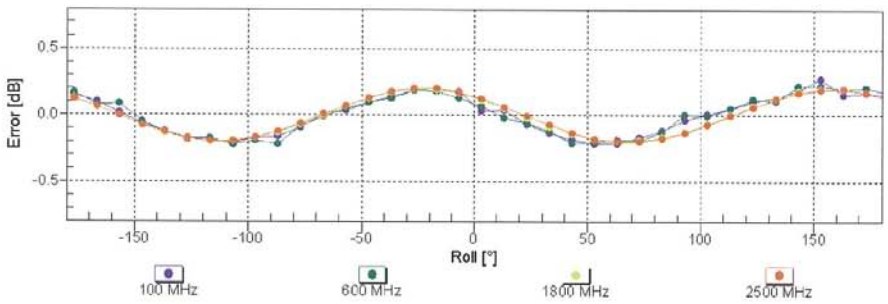
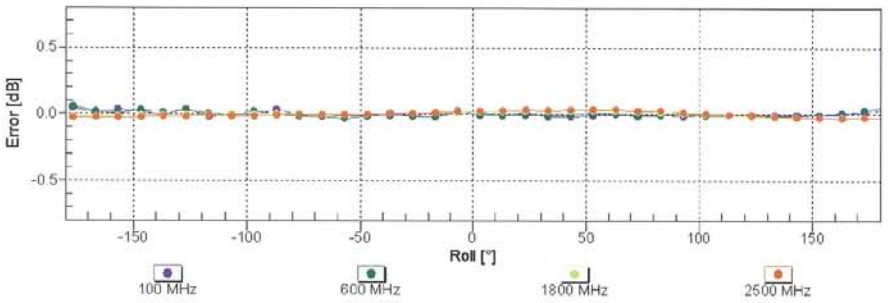
Receiving Pattern (ϕ), ϑ = 0°



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

Receiving Pattern (ϕ), ϑ = 90°



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

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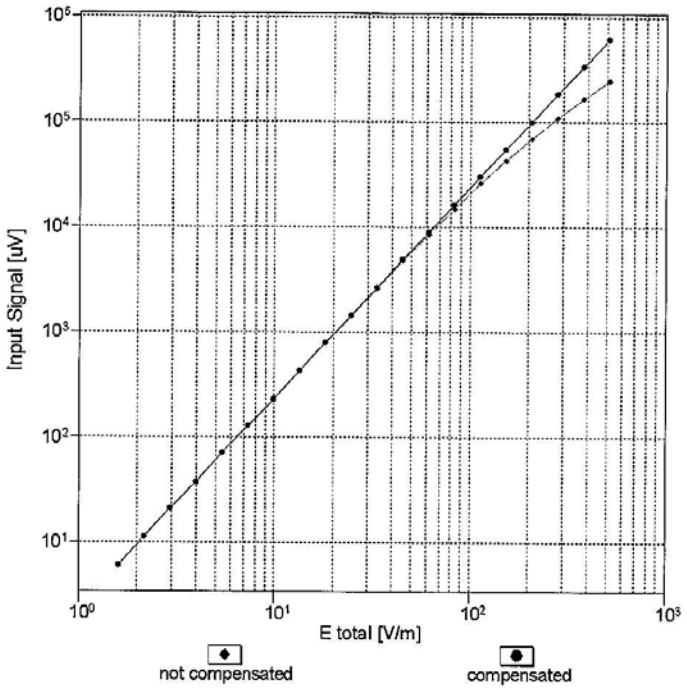
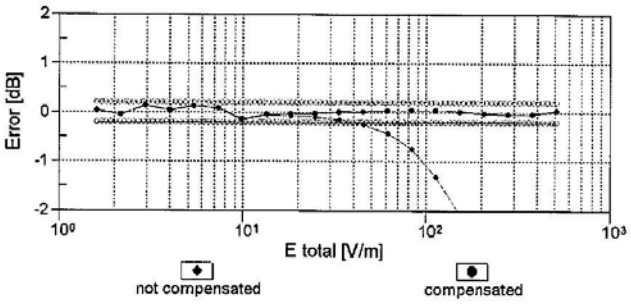
Dynamic Range f(E-field)
(TEM cell , f = 900 MHz)





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

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