DASY/EASY - Parameters of Probe: EF3DV3 - SN:4060

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu V/(V/m)^2$)	0.79	0.74	1.28	± 10.1 %
DCP (mV)[B]	98.2	95.5	93.6	

Calibration results for Frequency Response (30 MHz – 6 GHz)

Frequency MHz	Target E-Field V/m	Measured E-field (En) V/m	Deviation E-normal in %	Measured E-field (Ep) V/m	Deviation E-normal in %	Unc (k=2) %
30	77.2	77.3	0.2%	77.4	0.3%	± 5.1 %
100	77.3	78.3	1.3%	78.6	1.7%	± 5.1 %
450	77.1	78.1	1.3%	78.2	1.4%	± 5.1 %
600	77.1	77.6	0.7%	77.6	0.7%	± 5.1 %
750	77.2	77.6	0.5%	77.4	0.3%	± 5.1 %
1800	143.1	139.1	-2.8%	139.3	-2.6%	± 5.1 %
2000	135.1	131.5	-2.6%	131.6	-2.6%	± 5.1 %
2200	127.5	123.4	-3.2%	124.8	-2.1%	± 5.1 %
2500	125.5	122.5	-2.3%	123.6	-1.5%	± 5.1 %
3000	79.4	75.9	-4.5%	76.8	-3.3%	± 5.1 %
3500	256.2	247.1	-3.5%	244.6	-4.5%	± 5.1 %
3700	249.5	238.4	-4.4%	237.2	-4.9%	± 5.1 %
5200	50.7	51.2	0.9%	51.5	1.6%	± 5.1 %
5500	49.7	49.4	-0.6%	48.2	-3.0%	± 5.1 %
5800	48.8	48.7	-0.3%	49.6	1.6%	± 5.1 %

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.

DASY/EASY - Parameters of Probe: EF3DV3 - SN:4060

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB√μV	C	D dB	VR mV	Max dev.	Max Unc[E] (k=2)
0	CW	X	0.00	0.00	1.00	0.00	171.1	± 3.5 %	± 4.7 %
		Y	0.00	0.00	1.00		164.2		
		Z	0.00	0.00	1.00		172.8		
10352-AAA	Pulse Waveform (200Hz, 10%)	X	2.72	65.67	9.66	10.00	60.0	± 3.2 %	± 9.6 %
		Y	6.00	74.00	13.00		60.0		
		Z	2.66	66.07	9.64		60.0		
10353-AAA	Pulse Waveform (200Hz, 20%)	X	1.27	62.48	7.17	6.99	80.0	± 1.3 %	± 9.6 %
		Y	1.38	63.43	7.77		80.0		
		Z	1.30	63.08	7.35		80.0		
10354-AAA	Pulse Waveform (200Hz, 40%)	X	0.57	60.93	5.43	3.98	95.0	± 0.9 %	± 9.6 %
		Y	0.70	62.08	6.24		95.0		
		Z	0.61	61.44	5.61		95.0		
10355-AAA	Pulse Waveform (200Hz, 60%)	X	0.31	60.48	4.52	2.22	120.0	± 0.9 %	± 9.6 %
		Y	0.35	60.82	4.90		120.0		
		Z	0.42	61.46	4.70		120.0		
10387-AAA	QPSK Waveform, 1 MHz	X	0.52	60.58	6.63	0.00	150.0	± 2.6 %	± 9.6 %
		Y	0.46	60.00	5.71		150.0		
		Z	0.44	60.00	5.37		150.0		
10388-AAA	QPSK Waveform, 10 MHz	X	2.47	70.93	17.56	0.00	150.0	± 1.0 %	± 9.6 %
		Y	2.22	69.08	16.44		150.0		
		Z	2.44	71.07	17.65		150.0		
10396-AAA	64-QAM Waveform, 100 kHz	X	1.74	65.32	17.52	3.01	150.0	± 3.3 %	± 9.6 %
		Y	1.82	65.53	17.41		150.0		
		Z	2.13	67.57	17.98		150.0		
10399-AAA	64-QAM Waveform, 40 MHz	X	3.57	67.84	16.46	0.00	150.0	± 1.8 %	± 9.6 %
		Y	3.41	67.03	15.92		150.0		
		Z	3.54	67.84	16.52		150.0		
10414-AAA	WLAN CCDF, 64-QAM, 40MHz	X	4.80	66.13	16.05	0.00	150.0	± 3.4 %	± 9.6 %
		Y	4.67	65.67	15.72		150.0		
		Z	4.77	66.19	16.15		150.0		

Note: For details on UID parameters see Appendix

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.

DASY/EASY - Parameters of Probe: EF3DV3 - SN:4060

Sensor Frequency Model Parameters

	Sensor X	Sensor Y	Sensor Z
Frequency Corr. (LF)	0.22	0.21	4.59
Frequency Corr. (HF)	2.82	2.82	2.82

Sensor Model Parameters

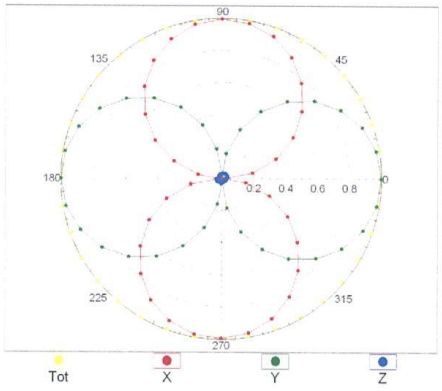
	C1 fF	C2 fF	α V^{-1}	T1 $ms.V^{-2}$	T2 $ms.V^{-1}$	T3 ms	T4 V^{-2}	T5 V^{-1}	T6
X	36.7	244.56	37.42	5.96	0.18	4.95	0.00	0.00	1.01
Y	35.1	235.07	37.62	8.08	0.00	4.99	0.00	0.06	1.01
Z	33.6	228.28	38.82	7.28	0.00	4.99	0.00	0.19	1.00

Other Probe Parameters

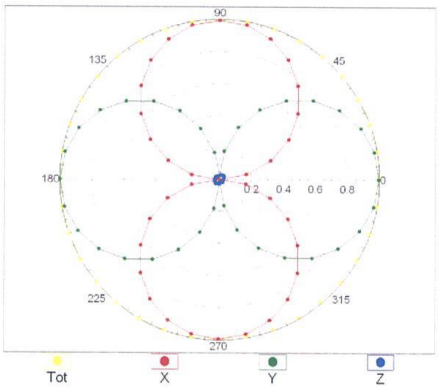
Sensor Arrangement	Rectangular
Connector Angle (°)	-36.4
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	12 mm
Tip Length	25 mm
Tip Diameter	4 mm
Probe Tip to Sensor X Calibration Point	1.5 mm
Probe Tip to Sensor Y Calibration Point	1.5 mm
Probe Tip to Sensor Z Calibration Point	1.5 mm

Receiving Pattern (ϕ), ϑ = 0°

f=600 MHz,TEM,0°

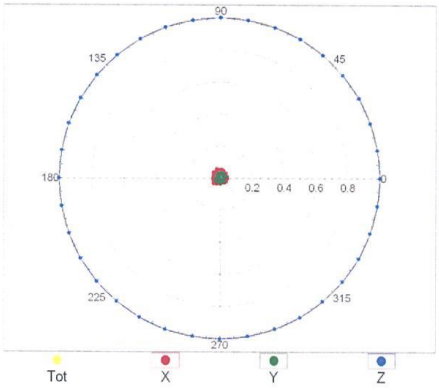


f=1800 MHz,R22,0°

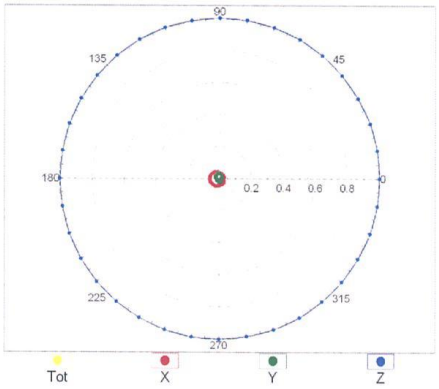


Receiving Pattern (ϕ), ϑ = 90°

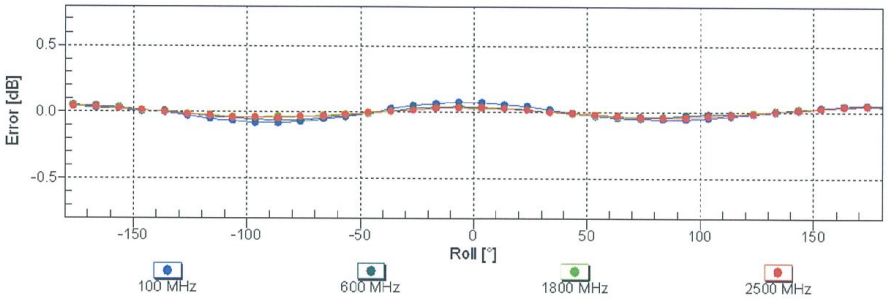
f=600 MHz,TEM,90°



f=1800 MHz,R22,90°

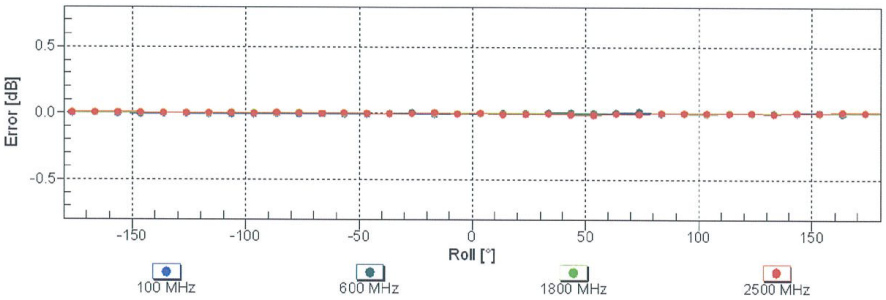


Receiving Pattern (ϕ), ϑ = 0°



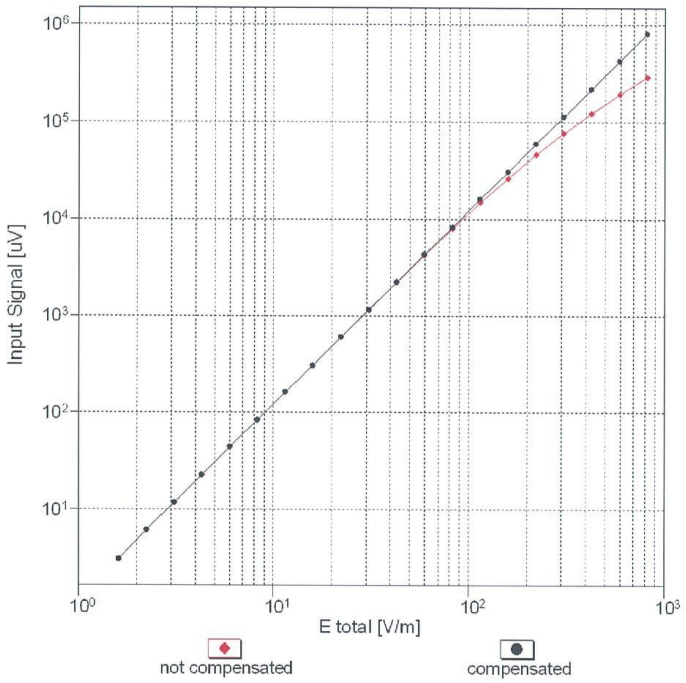
Uncertainty of Axial Isotropy Assessment: ± 0.5% (k=2)

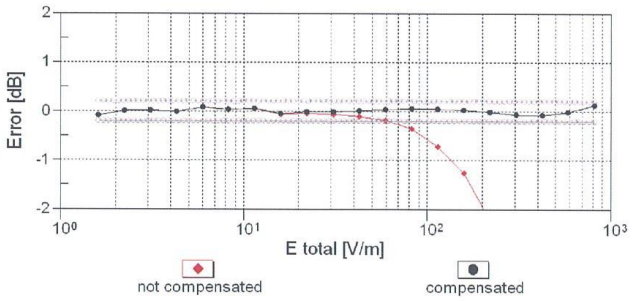
Receiving Pattern (ϕ), ϑ = 90°



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

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

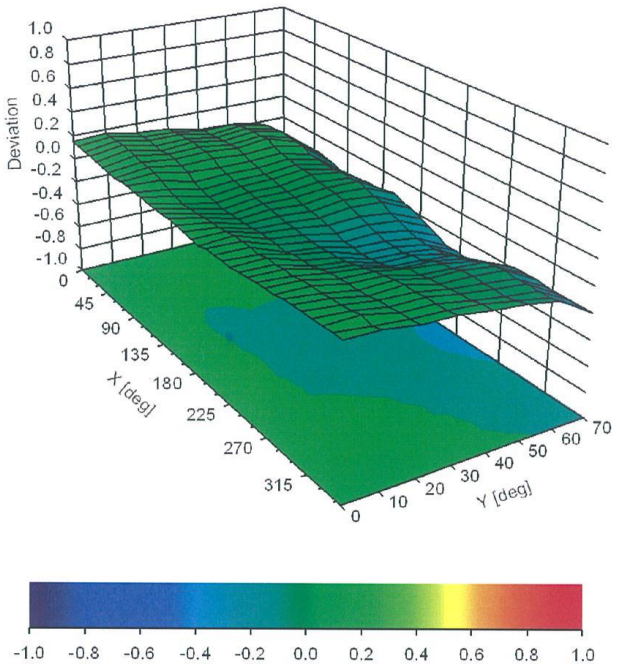




Uncertainty of Linearity Assessment: ± 0.6% (k=2)

Deviation from Isotropy in Air

Error (ϕ, ϑ), f = 900 MHz



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

ANNEX E DIPOLE CALIBRATION CERTIFICATE

Dipole 835 MHz

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: CD835V3-1023_Aug18

CALIBRATION CERTIFICATE

Object: CD835V3 - SN: 1023

Calibration procedure(s): QA CAL-20.v6
Calibration procedure for dipoles in air

Calibration date: August 28, 2018

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	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Probe EF3DV3	SN: 4013	05-Mar-18 (No. EF3-4013_Mar18)	Mar-19
DAE4	SN: 781	17-Jan-18 (No. DAE4-781_Jan18)	Jan-19

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter Agilent 4419B	SN: GB42420191	09-Oct-09 (in house check Oct-17)	In house check: Oct-20
Power sensor HP E4412A	SN: US38485102	05-Jan-10 (in house check Oct-17)	In house check: Oct-20
Power sensor HP 8482A	SN: US37295597	09-Oct-09 (in house check Oct-17)	In house check: Oct-20
RF generator R&S SMT-06	SN: 832283/011	27-Aug-12 (in house check Oct-17)	In house check: Oct-20
Network Analyzer Agilent E8358A	SN: US41080477	31-Mar-14 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: August 28, 2018

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

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

References

[1] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

Methods Applied and Interpretation of Parameters:

- *Coordinate System:* y-axis is in the direction of the dipole arms. z-axis is from the basis of the antenna (mounted on the table) towards its feed point between the two dipole arms. x-axis is normal to the other axes. In coincidence with the standards [1], the measurement planes (probe sensor center) are selected to be at a distance of 15 mm above the top metal edge of the dipole arms.
- *Measurement Conditions:* Further details are available from the hardcopies at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated. The forward power to the dipole connector is set with a calibrated power meter connected and monitored with an auxiliary power meter connected to a directional coupler. While the dipole under test is connected, the forward power is adjusted to the same level.
- *Antenna Positioning:* The dipole is mounted on a HAC Test Arch phantom using the matching dipole positioner with the arms horizontal and the feeding cable coming from the floor. The measurements are performed in a shielded room with absorbers around the setup to reduce the reflections.
  It is verified before the mounting of the dipole under the Test Arch phantom, that its arms are perfectly in a line. It is installed on the HAC dipole positioner with its arms parallel below the dielectric reference wire and able to move elastically in vertical direction without changing its relative position to the top center of the Test Arch phantom. The vertical distance to the probe is adjusted after dipole mounting with a DASY5 Surface Check job. Before the measurement, the distance between phantom surface and probe tip is verified. The proper measurement distance is selected by choosing the matching section of the HAC Test Arch phantom with the proper device reference point (upper surface of the dipole) and the matching grid reference point (tip of the probe) considering the probe sensor offset. The vertical distance to the probe is essential for the accuracy.
- *Feed Point Impedance and Return Loss:* These parameters are measured using a HP 8753E Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminating by applying the averaging function while moving the dipole in the air, at least 70cm away from any obstacles.
- *E-field distribution:* E field is measured in the x-y-plane with an isotropic ER3D-field probe with 100 mW forward power to the antenna feed point. In accordance with [1], the scan area is 20mm wide, its length exceeds the dipole arm length (180 or 90mm). The sensor center is 15 mm (in z) above the metal top of the dipole arms. Two 3D maxima are available near the end of the dipole arms. Assuming the dipole arms are perfectly in one line, the average of these two maxima (in subgrid 2 and subgrid 8) is determined to compensate for any non-parallelity to the measurement plane as well as the sensor displacement. The E-field value stated as calibration value represents the maximum of the interpolated 3D-E-field, in the plane above the dipole surface.

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%.

Measurement Conditions

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

DASY Version	DASY5	V52.10.1
Phantom	HAC Test Arch	
Distance Dipole Top - Probe Center	15 mm	
Scan resolution	dx, dy = 5 mm	
Frequency	835 MHz ± 1 MHz	
Input power drift	< 0.05 dB	

Maximum Field values at 835 MHz

E-field 15 mm above dipole surface	condition	**Interpolated maximum**
Maximum measured above high end	100 mW input power	111.0 V/m = 40.91 dBV/m
Maximum measured above low end	100 mW input power	109.6 V/m = 40.80 dBV/m
Averaged maximum above arm	100 mW input power	**110.3 V/m ± 12.8 % (k=2)**

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

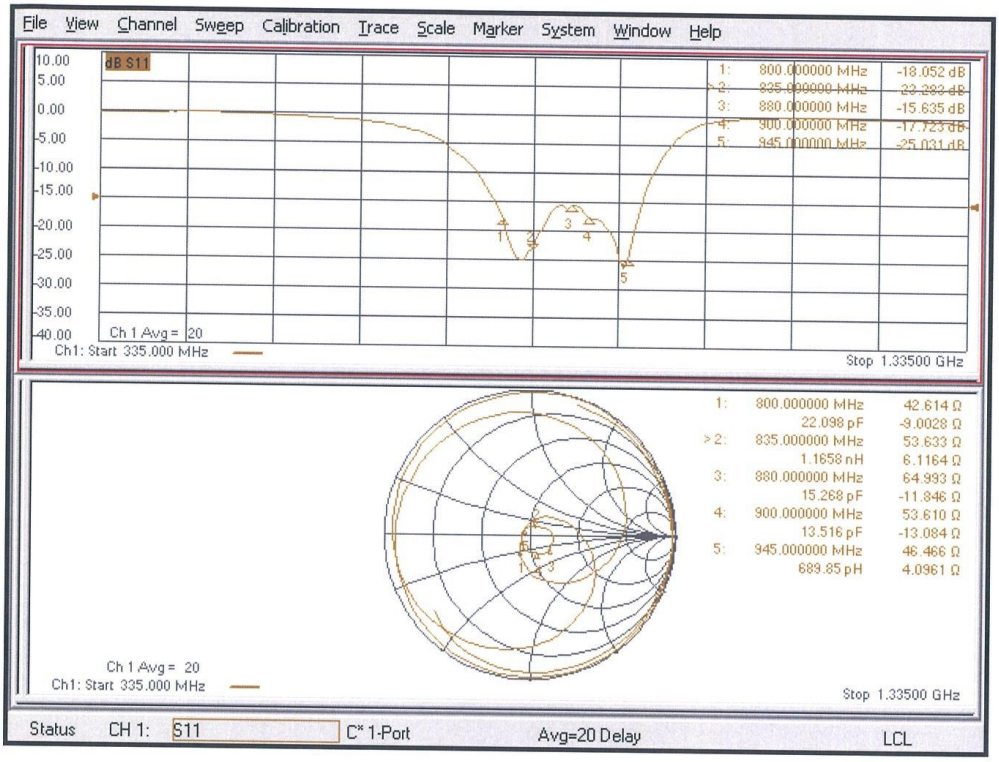
Frequency	**Return Loss**	**Impedance**
800 MHz	18.1 dB	42.6 Ω - 9.0 jΩ
835 MHz	23.3 dB	53.6 Ω + 6.1 jΩ
880 MHz	15.6 dB	65.0 Ω - 11.8 jΩ
900 MHz	17.7 dB	53.6 Ω - 13.1 jΩ
945 MHz	25.0 dB	46.5 Ω + 4.1 jΩ

3.2 Antenna Design and Handling

The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.
Do not apply force to dipole arms, as they are liable to bend. The soldered connections near the feedpoint may be damaged. After excessive mechanical stress or overheating, check the impedance characteristics to ensure that the internal matching network is not affected.

After long term use with 40W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

Impedance Measurement Plot



DASY5 E-field Result

Date: 28.08.2018

Test Laboratory: SPEAG Lab2

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: CD835V3 - SN: 1023

Communication System: UID 0 - CW ; Frequency: 835 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Phantom section: RF Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

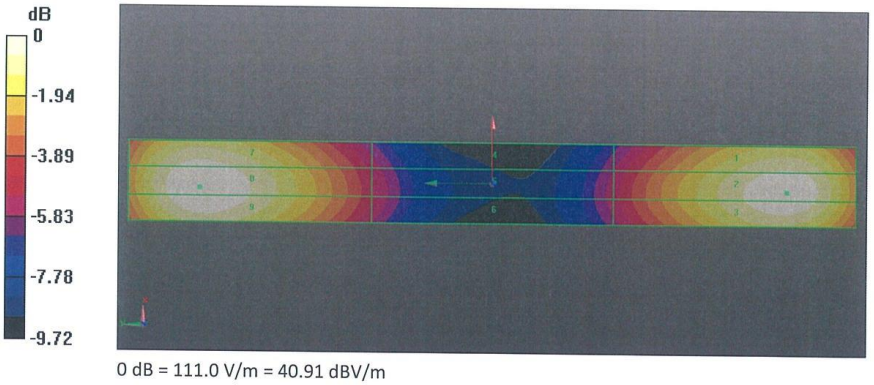
DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1) @ 835 MHz; Calibrated: 05.03.2018
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 17.01.2018
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole E-Field measurement @ 835MHz/E-Scan - 835MHz d=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 = 132.3 V/m; Power Drift = -0.03 dB
Applied MIF = 0.00 dB
RF audio interference level = 40.91 dBV/m
Emission category: M3

MIF scaled E-field

Grid 1 **M3** **40.37 dBV/m**	Grid 2 **M3** **40.8 dBV/m**	Grid 3 **M3** **40.73 dBV/m**
Grid 4 **M4** **35.58 dBV/m**	Grid 5 **M4** **35.93 dBV/m**	Grid 6 **M4** **35.91 dBV/m**
Grid 7 **M3** **40.56 dBV/m**	Grid 8 **M3** **40.91 dBV/m**	Grid 9 **M3** **40.85 dBV/m**



0 dB = 111.0 V/m = 40.91 dBV/m