

ATTACHMENT E – DIPOLE CALIBRATION DATA

Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

Client **H-CT (Dymstec)**Certificate No: **CD835V3-1024_Apr05****CALIBRATION CERTIFICATE**Object **CD835V3 - SN: 1024**Calibration procedure(s) **QA CAL-20.v3**
Calibration procedure for dipoles in airCalibration date: **April 27, 2005**Condition of the calibrated item **In Tolerance**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
All calibrations have been conducted at an environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	12-Oct-04 (METAS, No. 251-00412)	Oct-05
Power sensor HP 8481A	US37292783	12-Oct-04 (METAS, No. 251-00412)	Oct-05
20 dB Attenuator	SN: 5086 (20g)	10-Aug-04 (METAS, No 251-00402)	Aug-05
10 dB Attenuator	SN: 5047.2 (10r)	10-Aug-04 (METAS, No 251-00402)	Aug-05
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-4419B	GB43310788	10-Aug-03 (SPEAG, in house check Jan-04)	In house check: Oct-05
Power sensor HP 8481A	MY41092312	10-Aug-03 (SPEAG, in house check Jan-04)	In house check: Oct-05
Power sensor HP 8481A	MY41093315	10-Aug-03 (SPEAG, in house check Jan-04)	In house check: Oct-05
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Nov-04)	In house check: Nov-05
RF generator R&S SMT06	1039.2000.06	26-Jul-04 (SPEAG, in house check Jul-04)	In house check: Jan-06
DAE4	SN: 901	29-Jun-04 (SPEAG, No. DAE4-901_Jun04)	Calibration, Jun-05
Probe ER3DV6	SN: 2336	20-Jan-05 (SPEAG, No. ER3-2336_Jan05)	Calibration, Jan-06
Probe H3DV6	SN: 6065	10-Dec-04 (SPEAG, No. H3-6065-Dec04)	Calibration, Dec-05

	Name	Function	Signature
Calibrated by:	Mike Meili	Laboratory Technician	<i>M. Meili</i>

Approved by:	Fin Bornholt	Technical Director
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Issued: May 30, 2005

This calibration certificate is issued as an intermediate solution until the specific calibration procedure is accepted in the frame of the accreditation of the Calibration Laboratory of Schmid & Partner Engineering AG (based on ISO/IEC 17025 International Standard)

Certificate No: CD835V3-1024_Apr05

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Calibration Laboratory of
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References

- [1] ANSI-PC63.19-2001 (Draft 3.x, 2005)
American National Standard for 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 standard [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the top 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 DASY4 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 10 mm (in z) above the 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, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

1 Measurement Conditions

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

DASY Version	DASY4	V4.5 B19
DASY PP Version	SEMCAD	V1.8 B146
Phantom	HAC Test Arch	SD HAC P01 BA, #1002
Distance Dipole Top - Probe Center	10 mm	
Scan resolution	dx, dy = 5 mm	area = 20 x 180 mm
Frequency	835 MHz $\pm$ 1 MHz	
Forward power at dipole connector	20.0 dBm = 100mW	
Input power drift	< 0.05 dB	

2 Maximum Field values

H-field 10 mm above dipole surface	condition	interpolated maximum
Maximum measured	100 mW forward power	0.453 A/m

Uncertainty for H-field measurement: 8.2% (k=2)

E-field 10 mm above dipole surface	condition	Interpolated maximum
Maximum measured above high end	100 mW forward power	166.8 V/m
Maximum measured above low end	100 mW forward power	159.1 V/m
Averaged maximum above arm	100 mW forward power	163.0 V/m

Uncertainty for E-field measurement: 12.8% (k=2)

3 Appendix

3.1 Antenna Parameters

Frequency	Return Loss	Impedance
800 MHz	17.7 dB	(42.3. - j9.2) Ohm
835 MHz	24.8 dB	(50.1 + j6.3) Ohm
900 MHz	17.5 dB	(51.1 - j13.5) Ohm
950 MHz	18.4 dB	(56.1 + j11.3) Ohm
960 MHz	13.8 dB	(69.6 + j14.8) Ohm

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.

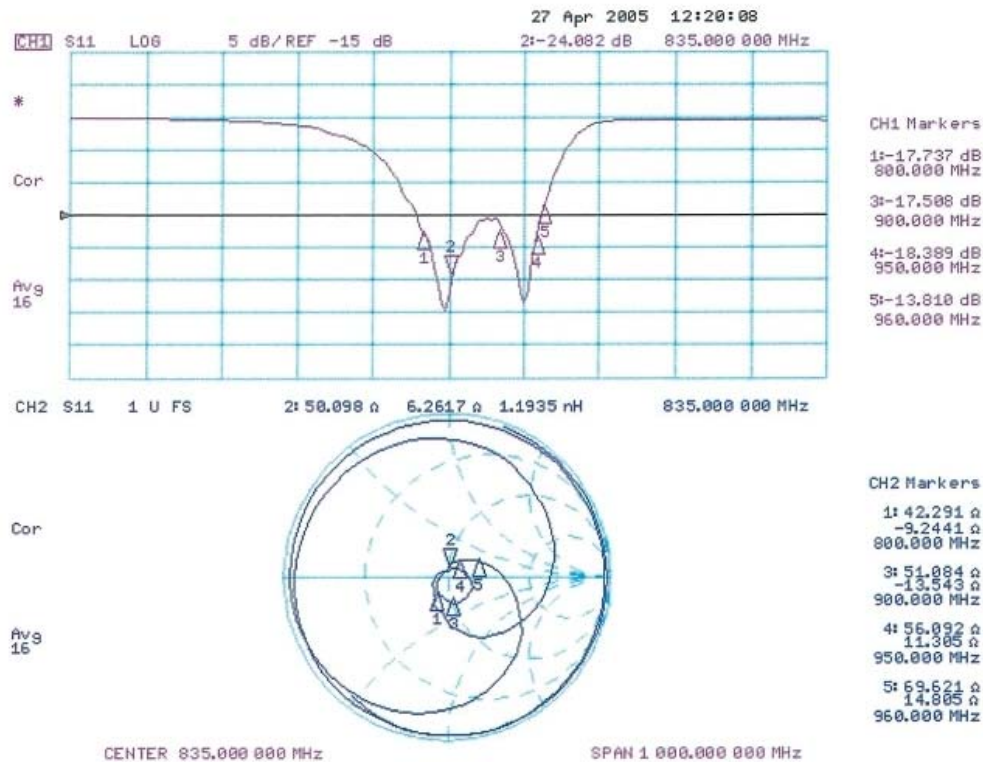
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

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.

3.3 Measurement Sheets

3.3.1 Return Loss and Smith Chart



3.3.2 DASY4 H-field result

Date/Time: 27.4.2005 12:56:18

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC Dipole 835 MHz; Type: D835V3; Serial: 1024

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\epsilon_r = 1$; $\rho = 1$ kg/m³

Phantom section: H Dipole Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: H3DV6 - SN6065; ; Calibrated: 12/10/2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 6/29/2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.5 Build 19; Postprocessing SW: SEMCAD, V1.8 Build 146

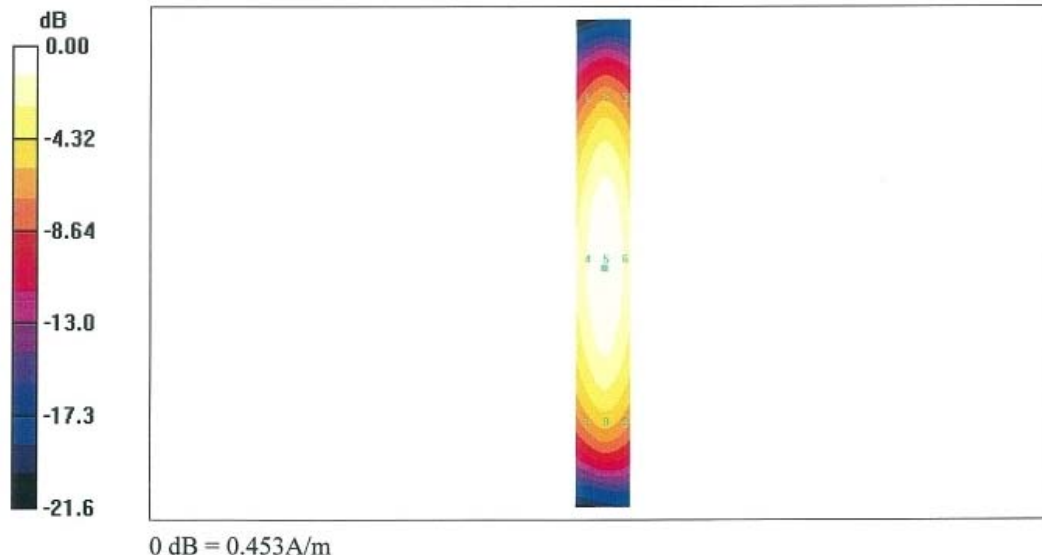
H Scan 10mm above CD 835 MHz/Hearing Aid Compatibility Test (41x361x1):

Measurement grid: dx=5mm, dy=5mm

Maximum value of Total field (slot averaged) = 0.453 A/m

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

H in A/m (Time averaged)			H in A/m (Slot averaged)		
Grid 1	Grid 2	Grid 3	Grid 1	Grid 2	Grid 3
0.361	0.395	0.380	0.361	0.395	0.380
Grid 4	Grid 5	Grid 6	Grid 4	Grid 5	Grid 6
0.417	0.453	0.435	0.417	0.453	0.435
Grid 7	Grid 8	Grid 9	Grid 7	Grid 8	Grid 9
0.369	0.401	0.385	0.369	0.401	0.385



3.3.3 DASY4 E-Field result

Date/Time: 27.4.2005 16:06:42

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC-Dipole 835 MHz; Type: D835V3; Serial: 1024

Communication System: CW; Frequency: 835 MHz; Duty Cycle: 1:1

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\epsilon_r = 1$; $\rho = 1000$ kg/m³

Phantom section: E Dipole Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 1/20/2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 6/29/2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA; Serial: 1002
- Measurement SW: DASY4, V4.5 Build 19; Postprocessing SW: SEMCAD, V1.8 Build 146

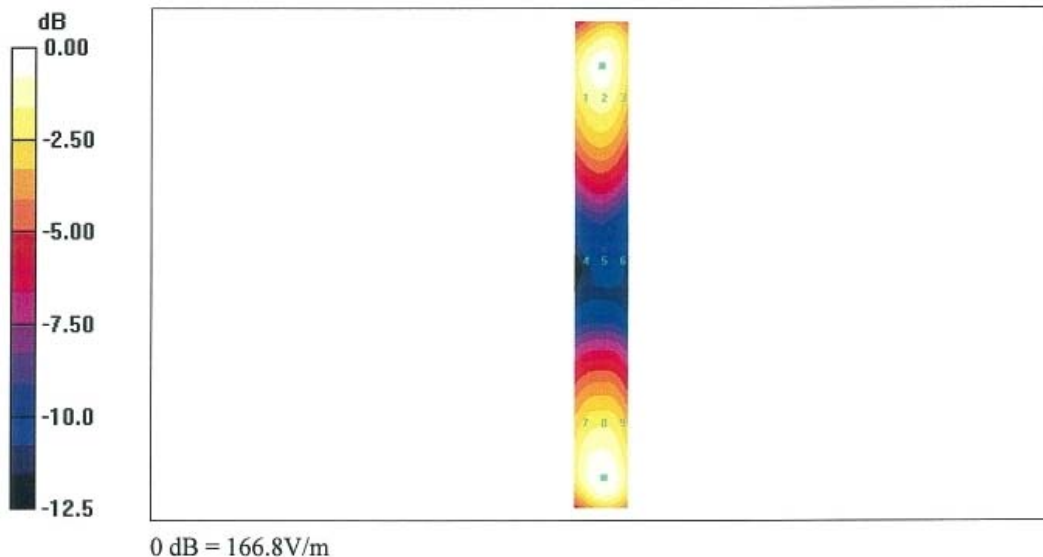
E Scan 10mm above CD 835 MHz/Hearing Aid Compatibility Test (41x361x1):

Measurement grid: dx=5mm, dy=5mm

Maximum value of Total field (slot averaged) = 166.8 V/m

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

E in V/m (Time averaged)			E in V/m (Slot averaged)		
Grid 1	Grid 2	Grid 3	Grid 1	Grid 2	Grid 3
154.4	159.1	154.6	154.4	159.1	154.6
Grid 4	Grid 5	Grid 6	Grid 4	Grid 5	Grid 6
83.3	85.9	83.2	83.3	85.9	83.2
Grid 7	Grid 8	Grid 9	Grid 7	Grid 8	Grid 9
157.5	166.8	164.6	157.5	166.8	164.6



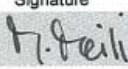
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Client **H-CT (Dymstec)**Certificate No: **CD1880V3-1019_Apr05****CALIBRATION CERTIFICATE**Object **CD1880V3 - SN: 1019**Calibration procedure(s) **QA CAL-20.v3
Calibration procedure for dipoles in air**Calibration date: **April 28, 2005**Condition of the calibrated item **In Tolerance**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
All calibrations have been conducted at an environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Calibrated by, Certificate No.)	Scheduled Calibration
Power meter EPM-442A	GB37480704	12-Oct-04 (METAS, No. 251-00412)	Oct-05
Power sensor HP 8481A	US37292783	12-Oct-04 (METAS, No. 251-00412)	Oct-05
20 dB Attenuator	SN: 5086 (20g)	10-Aug-04 (METAS, No 251-00402)	Aug-05
10 dB Attenuator	SN: 5047.2 (10r)	10-Aug-04 (METAS, No 251-00402)	Aug-05
Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-4419B	GB43310788	10-Aug-03 (SPEAG, in house check Jan-04)	In house check: Oct-05
Power sensor HP 8481A	MY41092312	10-Aug-03 (SPEAG, in house check Jan-04)	In house check: Oct-05
Power sensor HP 8481A	MY41093315	10-Aug-03 (SPEAG, in house check Jan-04)	In house check: Oct-05
Network Analyzer HP 8753E	US37390585	18-Oct-01 (SPEAG, in house check Nov-04)	In house check: Nov-05
RF generator R&S SMT06	1039.2000.06	26-Jul-04 (SPEAG, in house check Jul-04)	In house check: Jan-06
DAE4	SN: 901	29-Jun-04 (SPEAG, No. DAE4-901_Jun04)	Calibration, Jun-05
Probe ER3DV6	SN: 2336	20-Jan-05 (SPEAG, No. ER3-2336_Jan05)	Calibration, Jan-06
Probe H3DV6	SN: 6065	10-Dec-04 (SPEAG, No. H3-6065-Dec04)	Calibration, Dec-05

	Name	Function	Signature
Calibrated by:	Mike Meili	Laboratory Technician	
Approved by:	Fin Bornholt	Technical Director	

Issued: May 30, 2005

This calibration certificate is issued as an intermediate solution until the specific calibration procedure is submitted and accepted in the frame of the accreditation of the Calibration Laboratory of Schmid & Partner Engineering AG (based on ISO/IEC 17025 International Standard)

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References

- [1] ANSI-PC63.19-2001 (Draft 3.x, 2005)
American National Standard for 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 standard [1], the measurement planes (probe sensor center) are selected to be at a distance of 10 mm above the top 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 DASY4 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 10 mm (in z) above the 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, 10mm above the dipole surface.
- *H-field distribution:* H-field is measured with an isotropic H-field probe with 100mW forward power to the antenna feed point, in the x-y-plane. The scan area and sensor distance is equivalent to the E-field scan. The maximum of the field is available at the center (subgrid 5) above the feed point. The H-field value stated as calibration value represents the maximum of the interpolated H-field, 10mm above the dipole surface at the feed point.

1 Measurement Conditions

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

DASY Version	DASY4	V4.5 B19
DASY PP Version	SEMCAD	V1.8 B146
Phantom	HAC Test Arch	SD HAC P01 BA, #1002
Distance Dipole Top - Probe Center	10 mm	
Scan resolution	dx, dy = 5 mm	area = 20 x 90 mm
Frequency	1880 MHz $\pm$ 1 MHz	
Forward power at dipole connector	20.0 dBm = 100mW	
Input power drift	< 0.05 dB	

2 Maximum Field values

H-field 10 mm above dipole surface	condition	interpolated maximum
Maximum measured	100 mW forward power	0.455 A/m

Uncertainty for H-field measurement: 8.2% (k=2)

E-field 10 mm above dipole surface	condition	interpolated maximum
Maximum measured above high end	100 mW forward power	139.6 V/m
Maximum measured above low end	100 mW forward power	136.3 V/m
Averaged maximum above arm	100 mW forward power	138.0 V/m

Uncertainty for E-field measurement: 12.8% (k=2)

3 Appendix

3.1 Antenna Parameters

Frequency	Return Loss	Impedance
1710 MHz	23.1 dB	(55.9 + j4.5) Ohm
1880 MHz	20.0 dB	(56.0 + j8.7) Ohm
1900 MHz	20.6 dB	(57.9 + j6.2) Ohm
1950 MHz	25.1 dB	(55.7 - j1.4) Ohm
2000 MHz	24.1 dB	(49.2 + j6.1) Ohm

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.

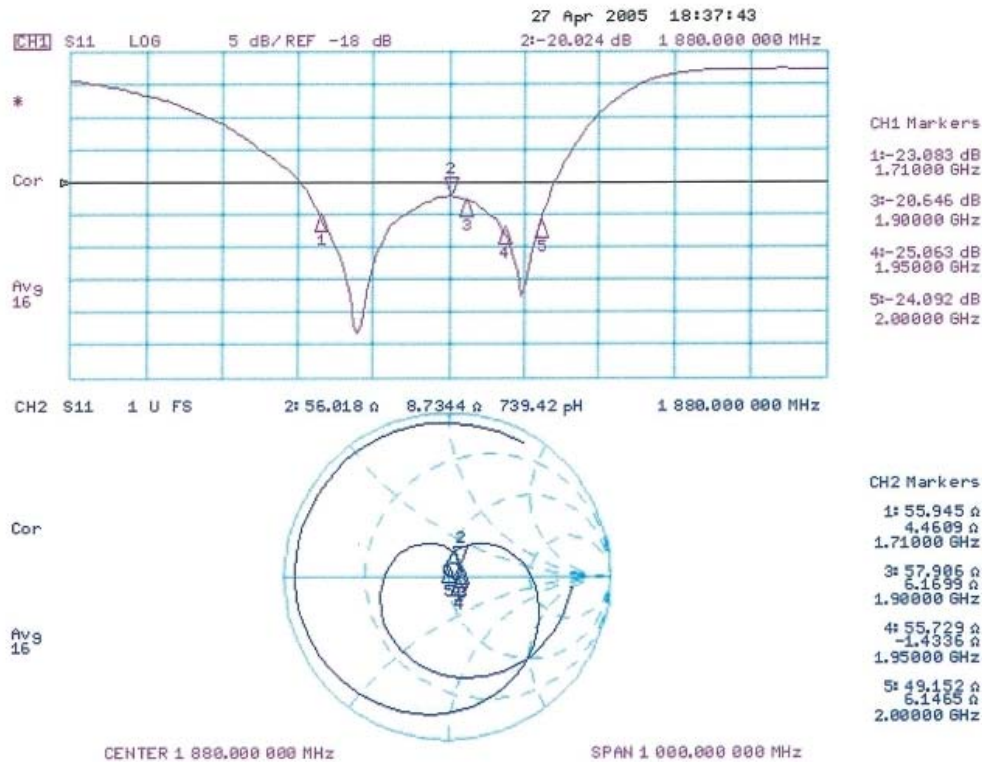
The dipole is built of standard semirigid coaxial cable. The internal matching line is open ended. The antenna is therefore open for DC signals.

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.

3.3 Measurement Sheets

3.3.1 Return Loss and Smith Chart



3.3.2 DASY4 H-field result

Date/Time: 28.4.2005 09:52:17

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1019

Communication System: CW; Frequency: 1880 MHz; Duty Cycle: 1:1

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\epsilon_r = 1$; $\rho = 1$ kg/m³

Phantom section: H Dipole Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: H3DV6 - SN6065; Calibrated: 10.12.2004
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 29.06.2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA
- Measurement SW: DASY4, V4.5 Build 19; Postprocessing SW: SEMCAD, V1.8 Build 146

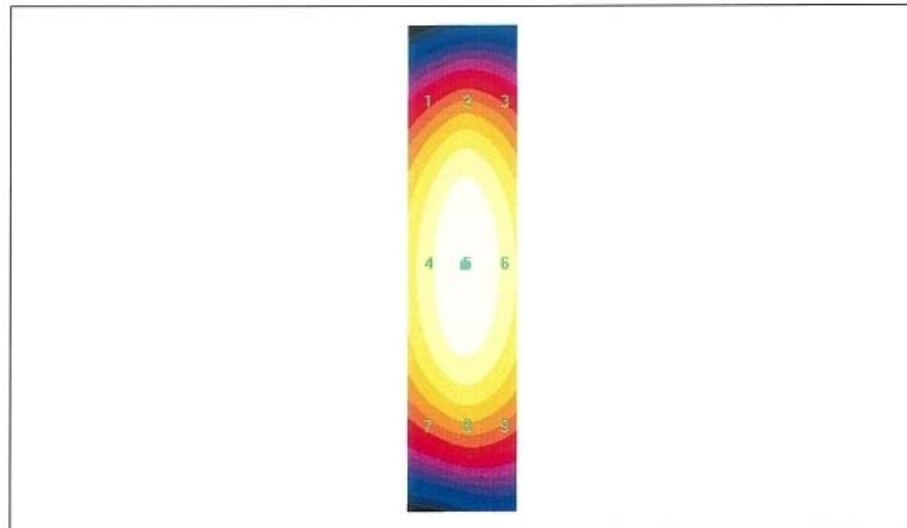
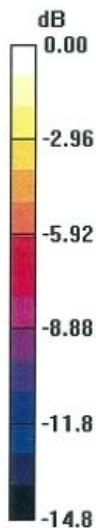
H Scan 10mm above CD 1880 MHz/Hearing Aid Compatibility Test (41x181x1):

Measurement grid: dx=5mm, dy=5mm

Maximum value of Total field (slot averaged) = 0.455 A/m

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

H in A/m (Time averaged)			H in A/m (Slot averaged)		
Grid 1	Grid 2	Grid 3	Grid 1	Grid 2	Grid 3
0.383	0.417	0.402	0.383	0.417	0.402
Grid 4	Grid 5	Grid 6	Grid 4	Grid 5	Grid 6
0.421	0.455	0.441	0.421	0.455	0.441
Grid 7	Grid 8	Grid 9	Grid 7	Grid 8	Grid 9
0.386	0.415	0.402	0.386	0.415	0.402



0 dB = 0.455A/m

3.3.3 DASY4 E-Field result

Date/Time: 28.04.2005 08:27:51

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: 1019

Communication System: CW; Frequency: 1880 MHz; Duty Cycle: 1:1

Medium: Air

Medium parameters used: $\sigma = 0$ mho/m, $\epsilon_r = 1$; $\rho = 1000$ kg/m³

Phantom section: E Dipole Section

Measurement Standard: DASY4 (High Precision Assessment)

DASY4 Configuration:

- Probe: ER3DV6 - SN2336; ConvF(1, 1, 1); Calibrated: 20.01.2005
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn901; Calibrated: 29.06.2004
- Phantom: HAC Phantom; Type: SD HAC P01 BA
- Measurement SW: DASY4, V4.5 Build 19; Postprocessing SW: SEMCAD, V1.8 Build 146

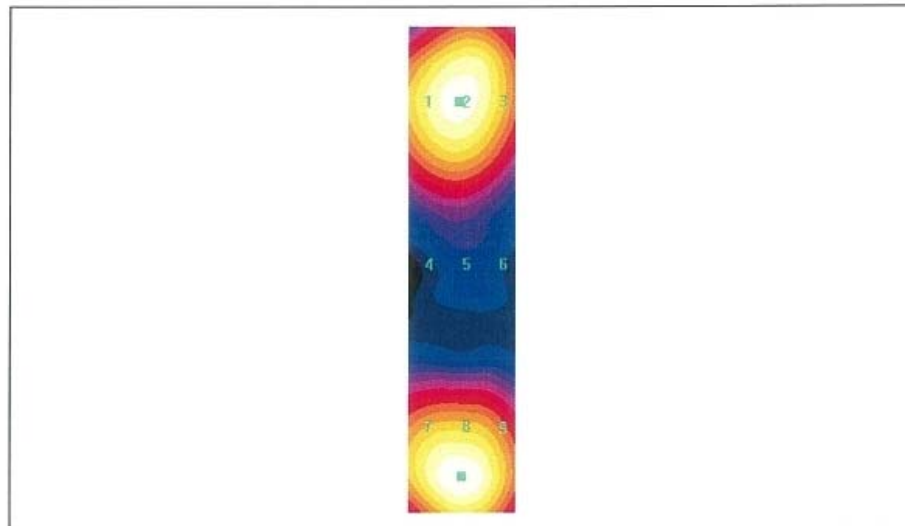
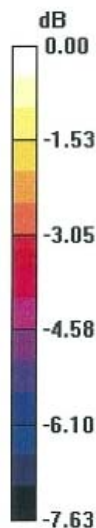
E Scan 10mm above CD 1880 MHz/Hearing Aid Compatibility Test (41x181x1):

Measurement grid: dx=5mm, dy=5mm

Maximum value of Total field (slot averaged) = 139.6 V/m

Hearing Aid Near-Field Category: M2 (AWF 0 dB)

E in V/m (Time averaged)			E in V/m (Slot averaged)		
Grid 1	Grid 2	Grid 3	Grid 1	Grid 2	Grid 3
132.2	136.3	130.9	132.2	136.3	130.9
Grid 4	Grid 5	Grid 6	Grid 4	Grid 5	Grid 6
91.4	93.1	88.0	91.4	93.1	88.0
Grid 7	Grid 8	Grid 9	Grid 7	Grid 8	Grid 9
133.8	139.6	133.5	133.8	139.6	133.5



0 dB = 139.6V/m