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Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **CD835V3-1045_Sep21**

CALIBRATION CERTIFICATE

Object **CD835V3 - SN: 1045**

Calibration procedure(s) **QA CAL-20.v7
Calibration Procedure for Validation Sources in air**

Calibration date: **September 27, 2021**

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 | 09-Apr-21 (No. 217-03291/03292) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
| Probe EF3DV3 | SN: 4013 | 28-Dec-20 (No. EF3-4013_Dec20) | Dec-21 |
| DAE4 | SN: 781 | 23-Dec-20 (No. DAE4-781_Dec20) | Dec-21 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter Agilent 4419B | SN: GB42420191 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP E4412A | SN: US38485102 | 05-Jan-10 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP 8482A | SN: US37295597 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| RF generator R&S SMT-06 | SN: 837633/005 | 10-Jan-19 (in house check Oct-20) | In house check: Oct-23 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-21 |

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

Issued: September 27, 2021

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References

- [1] ANSI-C63.19-2019 (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 Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminated 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 E-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 | V52.10.4 |
| Phantom | HAC Test Arch | |
| Distance Dipole Top - Probe Center | 15 mm | |
| Scan resolution | dx, dy = 5 mm | |
| Frequency | 835 MHz \pm 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 | 108.2 V/m = 40.68 dBV/m |
| Maximum measured above low end | 100 mW input power | 105.4 V/m = 40.46 dBV/m |
| Averaged maximum above arm | 100 mW input power | 106.8 V/m \pm 12.8 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

| Frequency | Return Loss | Impedance |
|-----------|-------------|---------------------------------|
| 800 MHz | 15.7 dB | 39.6 Ω - 10.5 j Ω |
| 835 MHz | 31.8 dB | 49.3 Ω + 2.5 j Ω |
| 880 MHz | 19.0 dB | 56.2 Ω - 10.2 j Ω |
| 900 MHz | 18.4 dB | 49.6 Ω - 12.0 j Ω |
| 945 MHz | 20.4 dB | 48.2 Ω + 9.2 j Ω |

3.2 Antenna Design and Handling

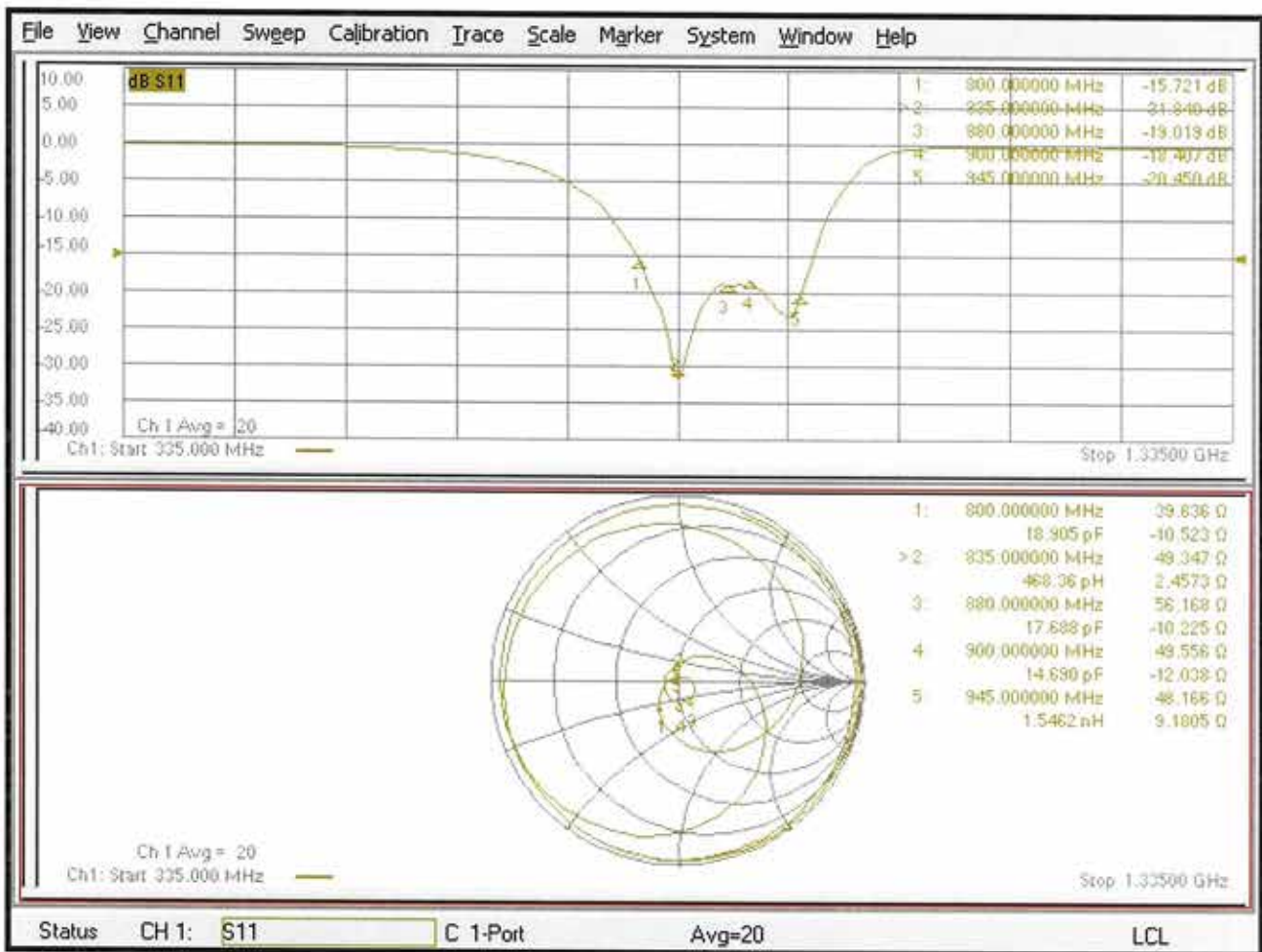
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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: 27.09.2021

Test Laboratory: SPEAG Lab2

DUT: HAC-Dipole 835 MHz; Type: CD835V3; Serial: CD835V3 - SN: 1045

Communication System: UID 0 - CW ; Frequency: 835 MHz

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

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: 28.12.2020
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 23.12.2020
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

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 = 127.6 V/m; Power Drift = 0.01 dB

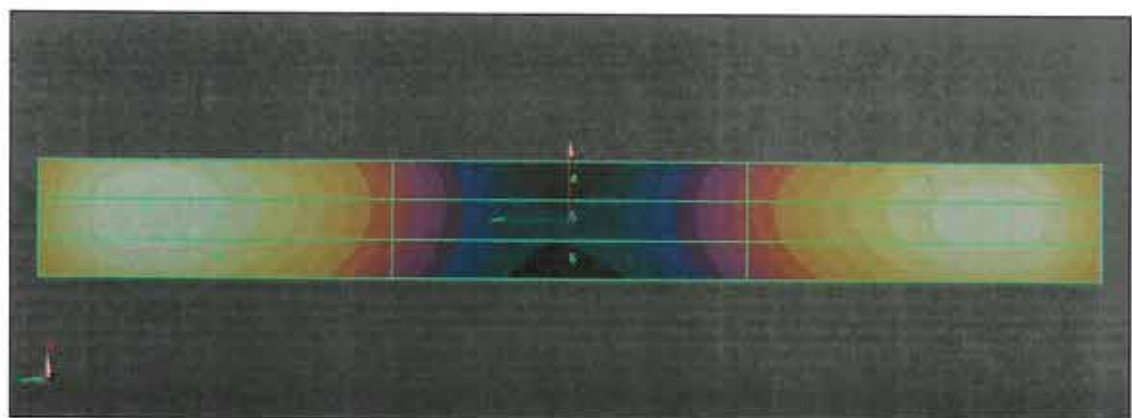
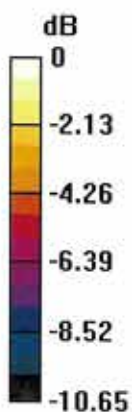
Applied MIF = 0.00 dB

RF audio interference level = 40.69 dBV/m

Emission category: M3

MIF scaled E-field

| | | |
|--------------------------|--------------------------|--------------------------|
| Grid 1 M3 40.39 dBV/m | Grid 2 M3 40.46 dBV/m | Grid 3 M3 40.17 dBV/m |
| Grid 4 M4 35.69 dBV/m | Grid 5 M4 35.69 dBV/m | Grid 6 M4 35.38 dBV/m |
| Grid 7 M3 40.64 dBV/m | Grid 8 M3 40.68 dBV/m | Grid 9 M3 40.31 dBV/m |



0 dB = 108.2 V/m = 40.68 dBV/m



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Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **CD1880V3-1038_Sep21**

CALIBRATION CERTIFICATE

Object **CD1880V3 - SN: 1038**

Calibration procedure(s) **QA CAL-20.v7
Calibration Procedure for Validation Sources in air**

Calibration date: **September 27, 2021**

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 | 09-Apr-21 (No. 217-03291/03292) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
| Probe EF3DV3 | SN: 4013 | 28-Dec-20 (No. EF3-4013_Dec20) | Dec-21 |
| DAE4 | SN: 781 | 23-Dec-20 (No. DAE4-781_Dec20) | Dec-21 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter Agilent 4419B | SN: GB42420191 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP E4412A | SN: US38485102 | 05-Jan-10 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP 8482A | SN: US37295597 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| RF generator R&S SMT-06 | SN: 837633/005 | 10-Jan-19 (in house check Oct-20) | In house check: Oct-23 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-21 |

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

Issued: September 27, 2021

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References

- [1] ANSI-C63.19-2019 (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 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 E-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 | V52.10.4 |
| Phantom | HAC Test Arch | |
| Distance Dipole Top - Probe Center | 15 mm | |
| Scan resolution | dx, dy = 5 mm | |
| Frequency | 1880 MHz \pm 1 MHz | |
| Input power drift | < 0.05 dB | |

Maximum Field values at 1880 MHz

| E-field 15 mm above dipole surface | condition | Interpolated maximum |
|------------------------------------|--------------------|---|
| Maximum measured above high end | 100 mW input power | 86.3 V/m = 38.72 dBV/m |
| Maximum measured above low end | 100 mW input power | 84.7 V/m = 38.56 dBV/m |
| Averaged maximum above arm | 100 mW input power | 85.5 V/m \pm 12.8 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

| Frequency | Return Loss | Impedance |
|-----------|-------------|--------------------------------|
| 1730 MHz | 22.1 dB | 55.9 Ω + 5.9 j Ω |
| 1880 MHz | 22.1 dB | 58.1 Ω + 2.7 j Ω |
| 1900 MHz | 22.1 dB | 58.5 Ω - 0.6 j Ω |
| 1950 MHz | 26.6 dB | 50.3 Ω - 4.7 j Ω |
| 2000 MHz | 20.5 dB | 43.5 Ω + 6.0 j Ω |

3.2 Antenna Design and Handling

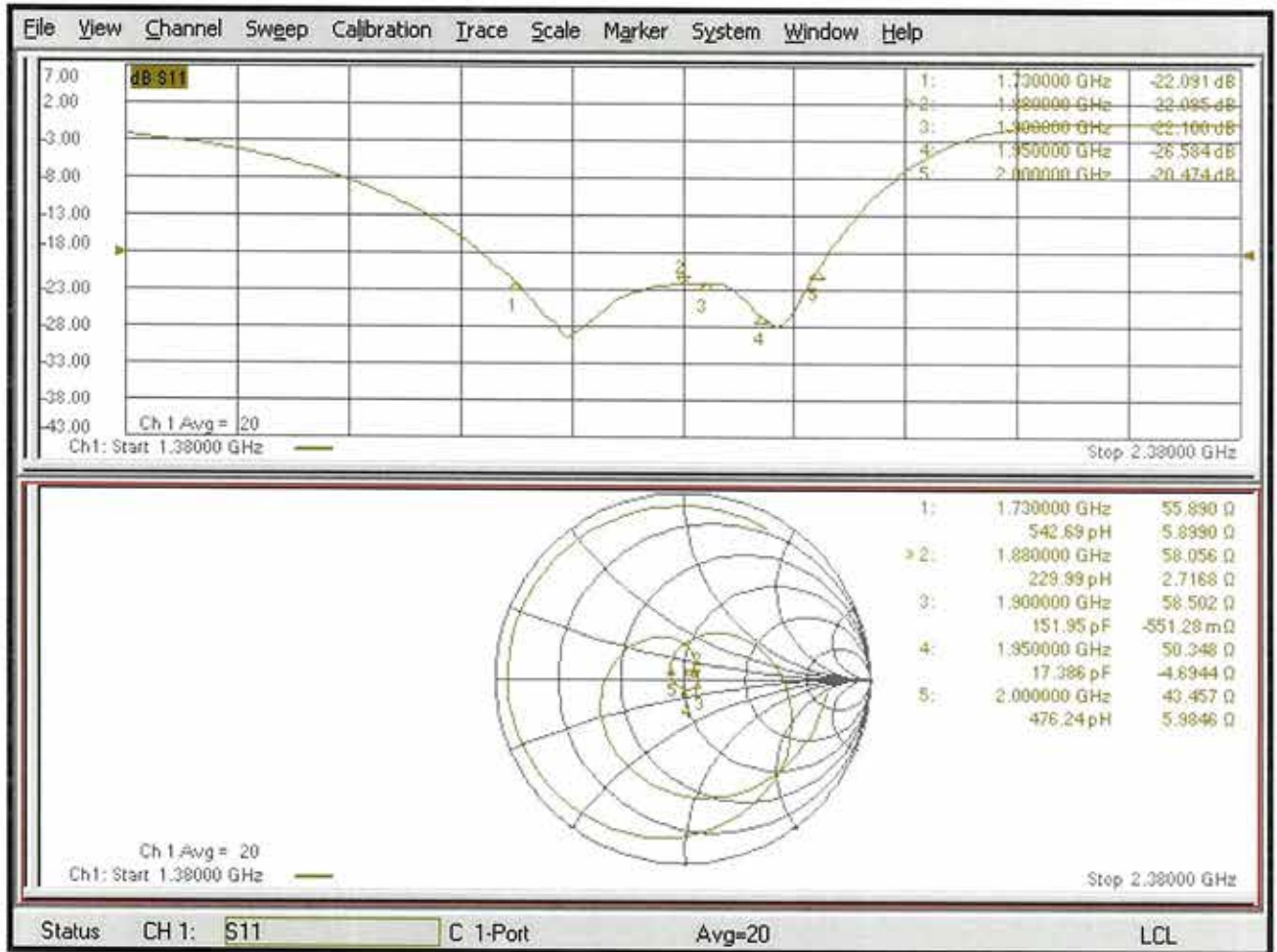
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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: 27.09.2021

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 1880 MHz; Type: CD1880V3; Serial: CD1880V3 - SN: 1038

Communication System: UID 0 - CW ; Frequency: 1880 MHz

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

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1) @ 1880 MHz; Calibrated: 28.12.2020
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 23.12.2020
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole E-Field measurement @ 1880MHz/E-Scan - 1880MHz d=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 = 151.4 V/m; Power Drift = -0.00 dB

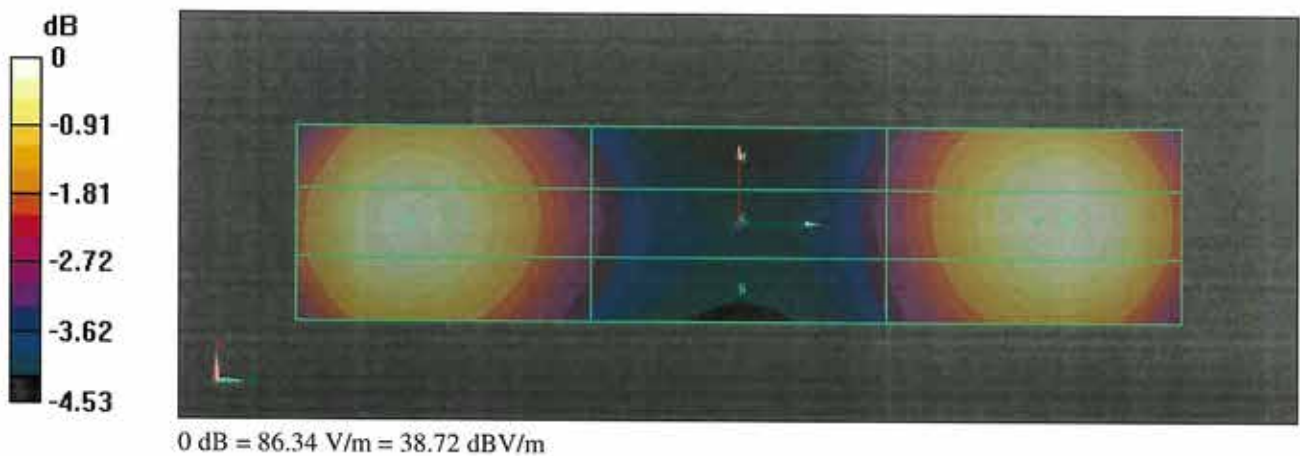
Applied MIF = 0.00 dB

RF audio interference level = 38.72 dBV/m

Emission category: M2

MIF scaled E-field

| | | |
|--------------------------|--------------------------|--------------------------|
| Grid 1 M2 38.39 dBV/m | Grid 2 M2 38.56 dBV/m | Grid 3 M2 38.37 dBV/m |
| Grid 4 M2 35.91 dBV/m | Grid 5 M2 35.93 dBV/m | Grid 6 M2 35.8 dBV/m |
| Grid 7 M2 38.61 dBV/m | Grid 8 M2 38.72 dBV/m | Grid 9 M2 38.45 dBV/m |





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Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **CD2450V3-1186_Jan22**

CALIBRATION CERTIFICATE

Object **CD2450V3 - SN: 1186**

Calibration procedure(s) **QA CAL-20.v7
Calibration Procedure for Validation Sources in air**

Calibration date: **January 25, 2022**

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 |
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| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
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| Power meter Agilent 4419B | SN: GB42420191 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
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| Power sensor HP 8482A | SN: US37295597 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| RF generator R&S SMT-06 | SN: 837633/005 | 10-Jan-19 (in house check Oct-20) | In house check: Oct-23 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-22 |

| | | | |
|----------------|--------------|-----------------------|-----------|
| | Name | Function | Signature |
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Sven Kühn | Deputy Manager | |

Issued: January 25, 2022

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- **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.
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- **E-field distribution:** E field is measured in the x-y-plane with an isotropic E-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.

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Measurement Conditions

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

| | | |
|------------------------------------|----------------------|----------|
| DASY Version | DASY5 | V52.10.4 |
| Phantom | HAC Test Arch | |
| Distance Dipole Top - Probe Center | 15 mm | |
| Scan resolution | dx, dy = 5 mm | |
| Frequency | 2450 MHz \pm 1 MHz | |
| Input power drift | < 0.05 dB | |

Maximum Field values at 2450 MHz

| E-field 15 mm above dipole surface | condition | Interpolated maximum |
|------------------------------------|--------------------|---|
| Maximum measured above high end | 100 mW input power | 85.2 V/m = 38.61 dBV/m |
| Maximum measured above low end | 100 mW input power | 84.3 V/m = 38.51 dBV/m |
| Averaged maximum above arm | 100 mW input power | 84.7 V/m \pm 12.8 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

| Frequency | Return Loss | Impedance |
|-----------|-------------|--------------------------------|
| 2250 MHz | 16.6 dB | 64.8 Ω + 8.3 j Ω |
| 2350 MHz | 26.2 dB | 54.3 Ω - 2.7 j Ω |
| 2450 MHz | 29.5 dB | 53.1 Ω - 1.5 j Ω |
| 2550 MHz | 37.1 dB | 51.4 Ω - 0.1 j Ω |
| 2650 MHz | 17.0 dB | 65.9 Ω - 3.8 j Ω |

3.2 Antenna Design and Handling

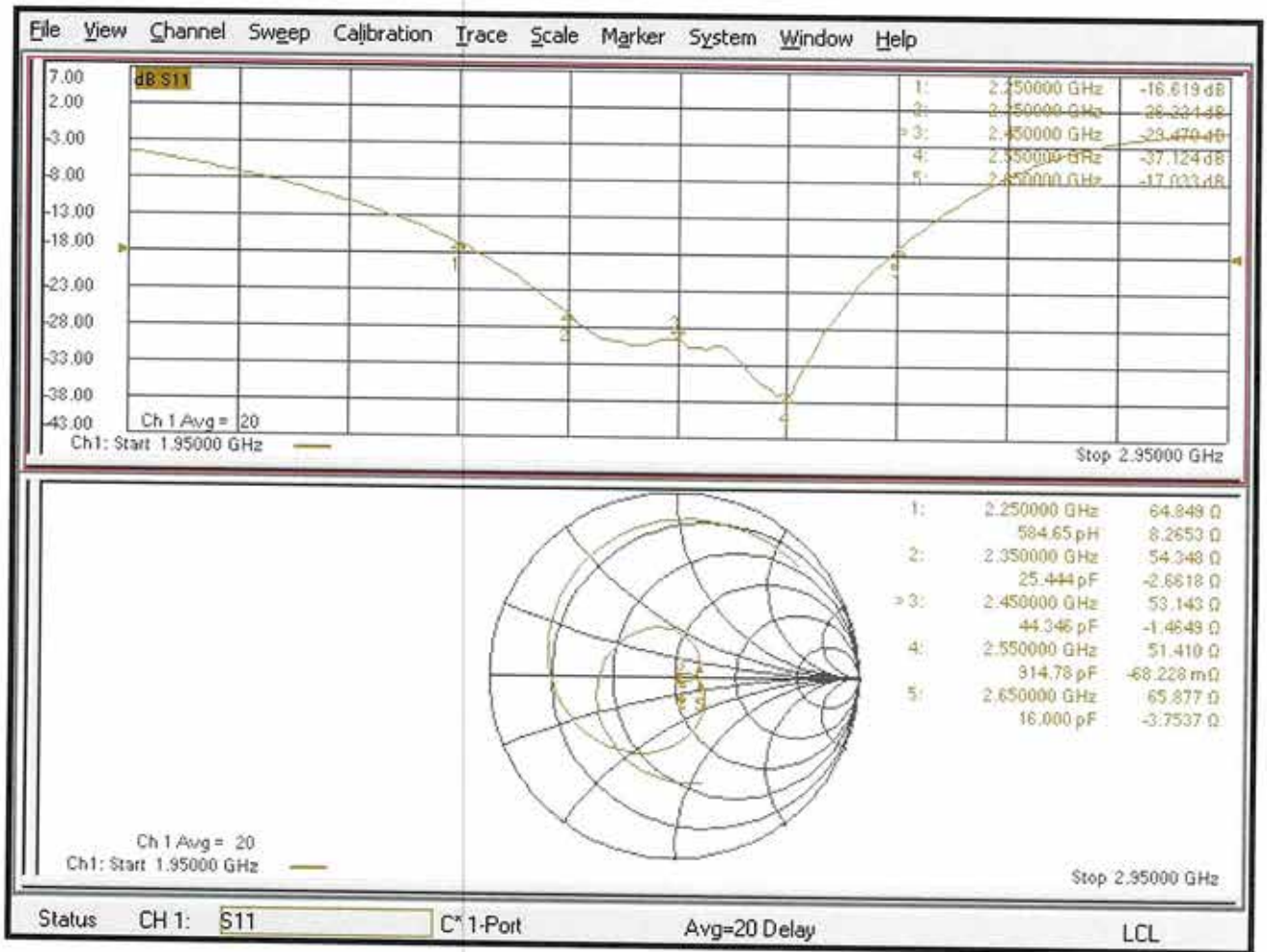
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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: 25.01.2022

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 2450 MHz; Type: CD2450V3; Serial: CD2450V3 - SN: 1186

Communication System: UID 0 - CW ; Frequency: 2450 MHz
Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³
Phantom section: RF Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

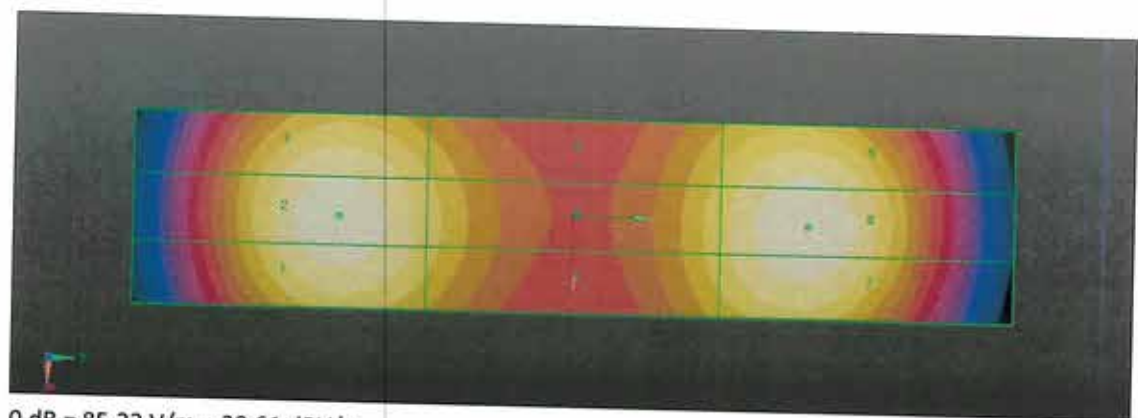
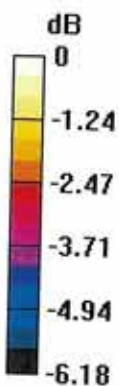
DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1) @ 2450 MHz; Calibrated: 28.12.2021
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 22.12.2021
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole E-Field measurement @ 2450MHz/E-Scan - 2450MHz d=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 = 76.03 V/m; Power Drift = 0.01 dB
Applied MIF = 0.00 dB
RF audio interference level = 38.61 dBV/m
Emission category: M2

MIF scaled E-field

| | | |
|--------------------------|--------------------------|--------------------------|
| Grid 1 M2 38.41 dBV/m | Grid 2 M2 38.51 dBV/m | Grid 3 M2 38.24 dBV/m |
| Grid 4 M2 37.64 dBV/m | Grid 5 M2 37.69 dBV/m | Grid 6 M2 37.53 dBV/m |
| Grid 7 M2 38.5 dBV/m | Grid 8 M2 38.61 dBV/m | Grid 9 M2 38.36 dBV/m |





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Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **CD2600V3-1018_Aug21**

CALIBRATION CERTIFICATE

Object **CD2600V3 - SN: 1018**

Calibration procedure(s) **QA CAL-20.v7
Calibration Procedure for Validation Sources in air**

Calibration date: **August 24, 2021**

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 | 09-Apr-21 (No. 217-03291/03292) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
| Probe EF3DV3 | SN: 4013 | 28-Dec-20 (No. EF3-4013_Dec20) | Dec-21 |
| DAE4 | SN: 781 | 23-Dec-20 (No. DAE4-781_Dec20) | Dec-21 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter Agilent 4419B | SN: GB42420191 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP E4412A | SN: US38485102 | 05-Jan-10 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP 8482A | SN: US37295597 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| RF generator R&S SMT-06 | SN: 837633/005 | 10-Jan-19 (in house check Oct-20) | In house check: Oct-23 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-21 |

Calibrated by: **Leif Klysner** (Name), **Laboratory Technician** (Function), **[Signature]** (Signature)

Approved by: **Katja Pokovic** (Name), **Technical Manager** (Function)

Issued: August 27, 2021

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Accreditation No.: **SCS 0108**

References

- [1] ANSI-C63.19-2019 (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 Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminated 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 E-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 | V52.10.4 |
| Phantom | HAC Test Arch | |
| Distance Dipole Top - Probe Center | 15 mm | |
| Scan resolution | dx, dy = 5 mm | |
| Frequency | 2600 MHz \pm 1 MHz | |
| Input power drift | < 0.05 dB | |

Maximum Field values at 2600 MHz

| E-field 15 mm above dipole surface | condition | Interpolated maximum |
|------------------------------------|--------------------|---|
| Maximum measured above high end | 100 mW input power | 86.7 V/m = 38.76 dBV/m |
| Maximum measured above low end | 100 mW input power | 85.6 V/m = 38.65 dBV/m |
| Averaged maximum above arm | 100 mW input power | 86.1 V/m \pm 12.8 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

| Frequency | Return Loss | Impedance |
|-----------|-------------|--------------------------------|
| 2450 MHz | 19.2 dB | 43.0 Ω - 7.4 j Ω |
| 2550 MHz | 29.2 dB | 47.0 Ω + 1.5 j Ω |
| 2600 MHz | 34.5 dB | 49.9 Ω + 1.9 j Ω |
| 2650 MHz | 34.9 dB | 51.7 Ω + 0.7 j Ω |
| 2750 MHz | 21.3 dB | 50.1 Ω - 8.7 j Ω |

3.2 Antenna Design and Handling

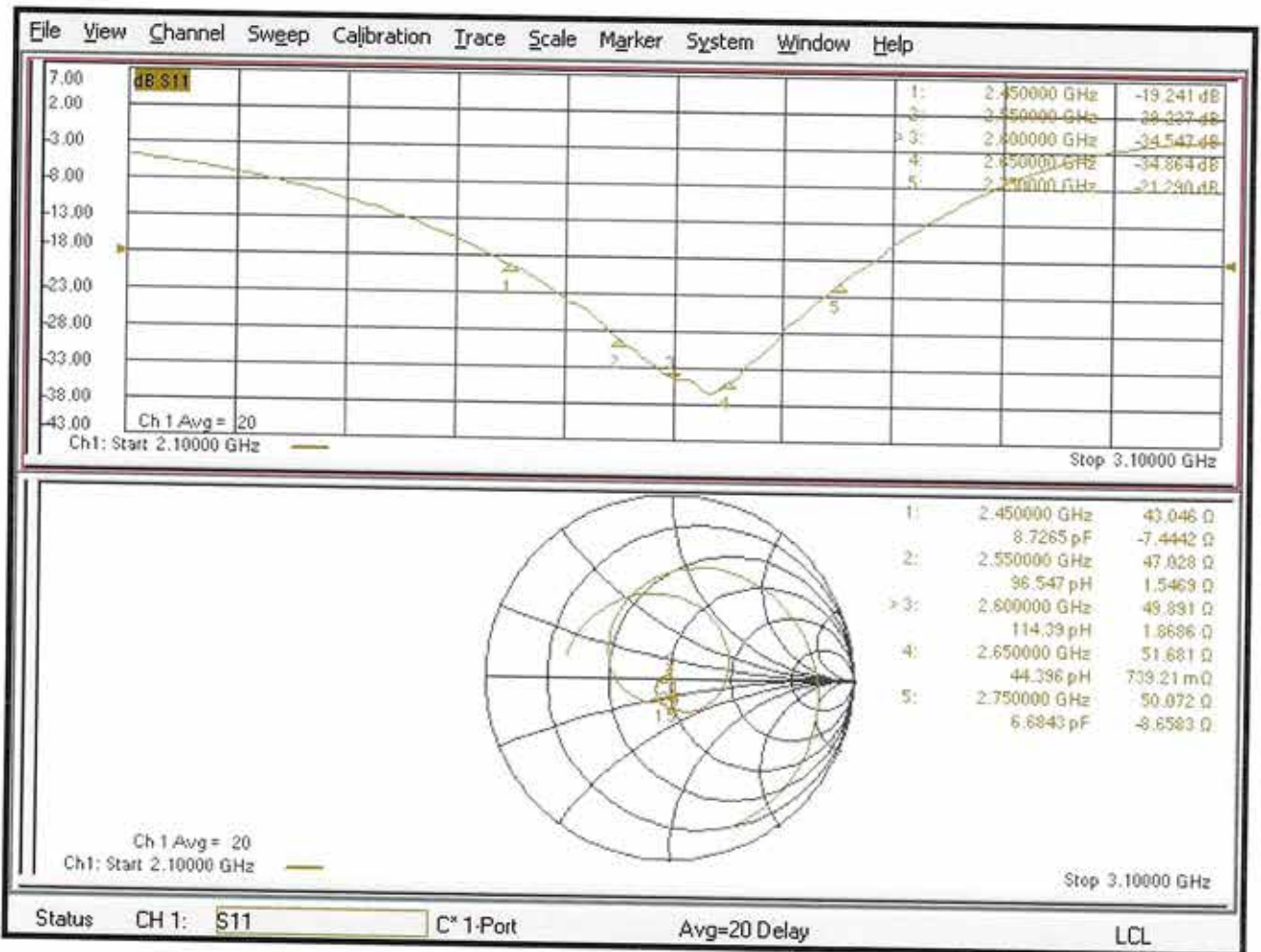
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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: 24.08.2021

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 2600 MHz; Type: CD2600V3; Serial: CD2600V3 - SN: 1018

Communication System: UID 0 - CW ; Frequency: 2600 MHz

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

Phantom section: RF Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1) @ 2600 MHz; Calibrated: 28.12.2020
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 23.12.2020
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole E-Field measurement @ 2600MHz/E-Scan - 2600MHz d=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 = 68.33 V/m; Power Drift = -0.01 dB

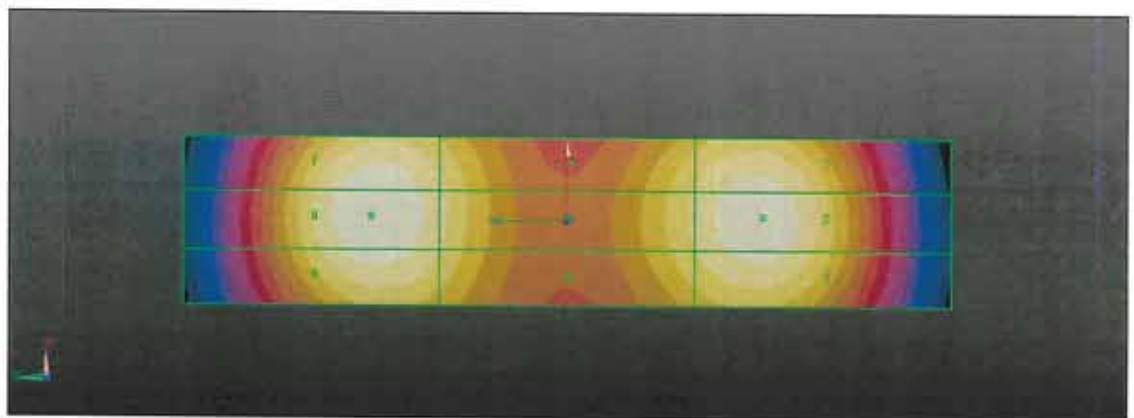
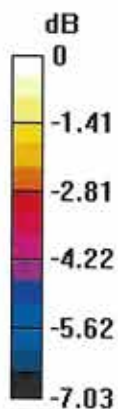
Applied MIF = 0.00 dB

RF audio interference level = 38.76 dBV/m

Emission category: M2

MIF scaled E-field

| | | |
|--------------------------|--------------------------|--------------------------|
| Grid 1 M2 38.51 dBV/m | Grid 2 M2 38.65 dBV/m | Grid 3 M2 38.44 dBV/m |
| Grid 4 M2 37.95 dBV/m | Grid 5 M2 37.99 dBV/m | Grid 6 M2 37.82 dBV/m |
| Grid 7 M2 38.65 dBV/m | Grid 8 M2 38.76 dBV/m | Grid 9 M2 38.51 dBV/m |



0 dB = 86.65 V/m = 38.76 dBV/m



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Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **CD3500V3-1009_Mar22**

CALIBRATION CERTIFICATE

Object **CD3500V3 - SN: 1009**

Calibration procedure(s) **QA CAL-20.v7
Calibration Procedure for Validation Sources in air**

Calibration date: **March 03, 2022**

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 $(22 \pm 3)^\circ\text{C}$ 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 | 09-Apr-21 (No. 217-03291/03292) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: BH9394 (20k) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| Type-N mismatch combination | SN: 310982 / 06327 | 09-Apr-21 (No. 217-03344) | Apr-22 |
| Probe EF3DV3 | SN: 4013 | 28-Dec-21 (No. EF3-4013_Dec21) | Dec-22 |
| DAE4 | SN: 781 | 22-Dec-21 (No. DAE4-781_Dec21) | Dec-22 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---------------------------------|----------------|-----------------------------------|------------------------|
| Power meter Agilent 4419B | SN: GB42420191 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP E4412A | SN: US38485102 | 05-Jan-10 (in house check Oct-20) | In house check: Oct-23 |
| Power sensor HP 8482A | SN: US37295597 | 09-Oct-09 (in house check Oct-20) | In house check: Oct-23 |
| RF generator R&S SMT-06 | SN: 837633/005 | 10-Jan-19 (in house check Oct-20) | In house check: Oct-23 |
| Network Analyzer Agilent E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-22 |

| | Name | Function | Signature |
|----------------|--------------|-----------------------|-----------|
| Calibrated by: | Leif Klysner | Laboratory Technician | |
| Approved by: | Niels Kuster | Quality Manager | |

Issued: March 3, 2022

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Accreditation No.: **SCS 0108**

References

- [1] ANSI-C63.19-2019 (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 Vector Network Analyzer. The impedance is specified at the SMA connector of the dipole. The influence of reflections was eliminated 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 E-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 | V52.10.4 |
| Phantom | HAC Test Arch | |
| Distance Dipole Top - Probe Center | 15 mm | |
| Scan resolution | dx, dy = 5 mm | |
| Frequency | 3500 MHz \pm 1 MHz | |
| Input power drift | < 0.05 dB | |

Maximum Field values at 3500 MHz

| E-field 15 mm above dipole surface | condition | Interpolated maximum |
|------------------------------------|--------------------|---|
| Maximum measured above high end | 100 mW input power | 84.1 V/m = 38.50 dBV/m |
| Maximum measured above low end | 100 mW input power | 82.8 V/m = 38.36 dBV/m |
| Averaged maximum above arm | 100 mW input power | 83.4 V/m \pm 12.8 % (k=2) |

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters

| Frequency | Return Loss | Impedance |
|-----------|-------------|--------------------------------|
| 3300 MHz | 17.6 dB | 65.0 Ω + 2.4 j Ω |
| 3400 MHz | 22.3 dB | 55.7 Ω - 5.8 j Ω |
| 3500 MHz | 23.9 dB | 52.8 Ω - 5.9 j Ω |
| 3600 MHz | 22.0 dB | 47.9 Ω - 7.6 j Ω |
| 3700 MHz | 21.7 dB | 42.8 Ω - 2.5 j Ω |

3.2 Antenna Design and Handling

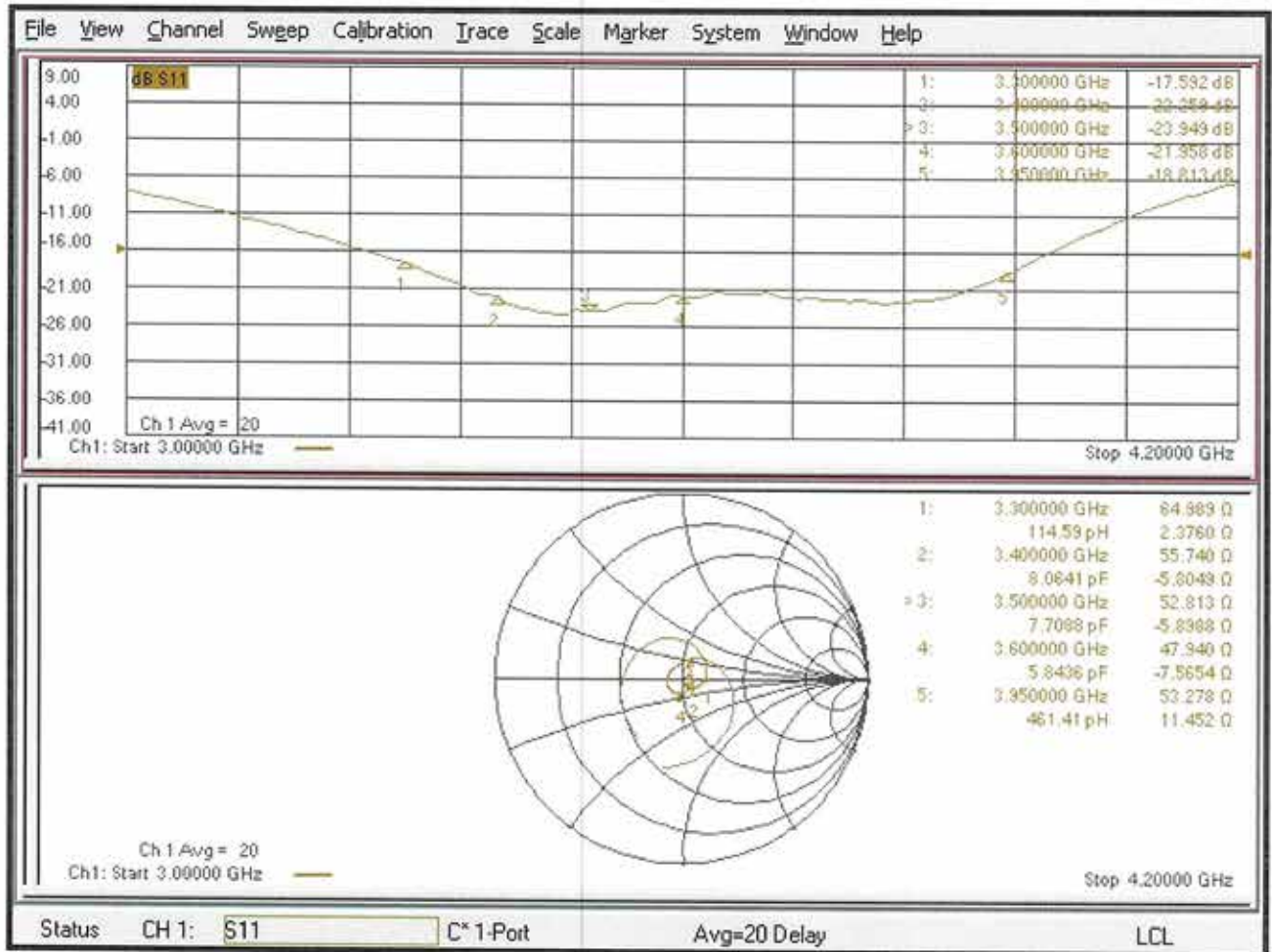
The calibration dipole has a symmetric geometry with a built-in two stub matching network, which leads to the enhanced bandwidth.

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: 03.03.2022

Test Laboratory: SPEAG Lab2

DUT: HAC Dipole 3500 MHz; Type: CD3500V3; Serial: CD3500V3 - SN: 1009

Communication System: UID 0 - CW ; Frequency: 3500 MHz
 Medium parameters used: $\sigma = 0$ S/m, $\epsilon_r = 1$; $\rho = 0$ kg/m³
 Phantom section: RF Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

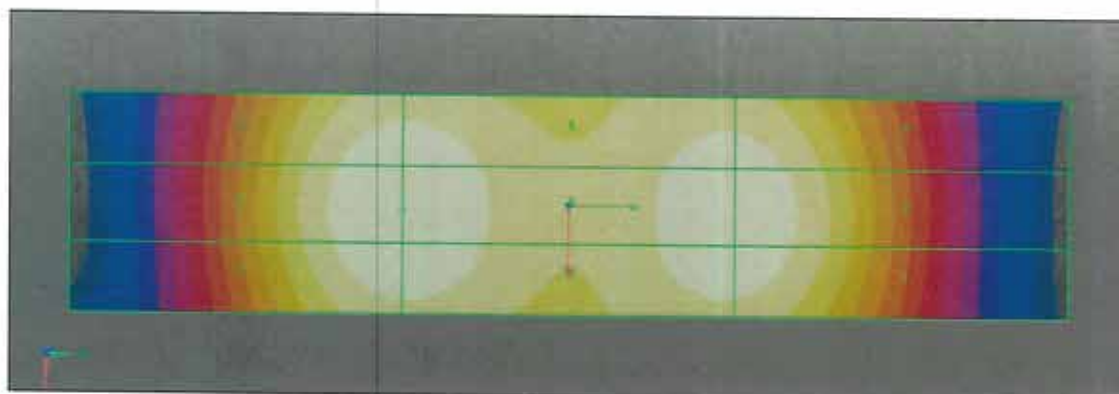
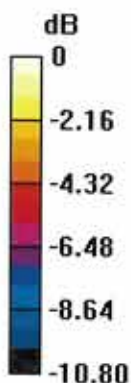
- Probe: EF3DV3 - SN4013; ConvF(1, 1, 1) @ 3500 MHz; Calibrated: 28.12.2021
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn781; Calibrated: 22.12.2021
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA; Serial: 1070
- DASY52 52.10.4(1535); SEMCAD X 14.6.14(7501)

Dipole E-Field measurement @ 3500MHz/E-Scan - 3500MHz d=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 = 35.66 V/m; Power Drift = 0.03 dB
 Applied MIF = 0.00 dB
 RF audio interference level = 38.50 dBV/m
Emission category: M2

MIF scaled E-field

| | | |
|--------------------------|--------------------------|--------------------------|
| Grid 1 M2 38.4 dBV/m | Grid 2 M2 38.5 dBV/m | Grid 3 M2 38.31 dBV/m |
| Grid 4 M2 38.4 dBV/m | Grid 5 M2 38.5 dBV/m | Grid 6 M2 38.31 dBV/m |
| Grid 7 M2 38.28 dBV/m | Grid 8 M2 38.36 dBV/m | Grid 9 M2 38.14 dBV/m |



0 dB = 84.12 V/m = 38.50 dBV/m



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Accreditation No.: **SCS 0108**

Client **Sporton**

Certificate No: **DAE4-1311_Aug21**

CALIBRATION CERTIFICATE

Object **DAE4 - SD 000 D04 BM - SN: 1311**

Calibration procedure(s) **QA CAL-06.v30
Calibration procedure for the data acquisition electronics (DAE)**

Calibration date: **August 20, 2021**

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 |
|-------------------------------|--------------------|----------------------------|------------------------|
| Keithley Multimeter Type 2001 | SN: 0810278 | 07-Sep-20 (No:28647) | Sep-21 |
| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
| Auto DAE Calibration Unit | SE UWS 053 AA 1001 | 07-Jan-21 (in house check) | In house check: Jan-22 |
| Calibrator Box V2.1 | SE UMS 006 AA 1002 | 07-Jan-21 (in house check) | In house check: Jan-22 |

| | | | |
|----------------|----------------------------------|-----------------------------------|---------------|
| Calibrated by: | Name Dominique Steffen | Function Laboratory Technician | Signature |
| Approved by: | Name Sven Kühn | Deputy Manager | |

Issued: August 20, 2021

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Accreditation No.: **SCS 0108**

Glossary

DAE data acquisition electronics
Connector angle information used in DASY system to align probe sensor X to the robot coordinate system.

Methods Applied and Interpretation of Parameters

- *DC Voltage Measurement:* Calibration Factor assessed for use in DASY system by comparison with a calibrated instrument traceable to national standards. The figure given corresponds to the full scale range of the voltmeter in the respective range.
- *Connector angle:* The angle of the connector is assessed measuring the angle mechanically by a tool inserted. Uncertainty is not required.
- The following parameters as documented in the Appendix contain technical information as a result from the performance test and require no uncertainty.
 - *DC Voltage Measurement Linearity:* Verification of the Linearity at +10% and -10% of the nominal calibration voltage. Influence of offset voltage is included in this measurement.
 - *Common mode sensitivity:* Influence of a positive or negative common mode voltage on the differential measurement.
 - *Channel separation:* Influence of a voltage on the neighbor channels not subject to an input voltage.
 - *AD Converter Values with inputs shorted:* Values on the internal AD converter corresponding to zero input voltage
 - *Input Offset Measurement:* Output voltage and statistical results over a large number of zero voltage measurements.
 - *Input Offset Current:* Typical value for information; Maximum channel input offset current, not considering the input resistance.
 - *Input resistance:* Typical value for information: DAE input resistance at the connector, during internal auto-zeroing and during measurement.
 - *Low Battery Alarm Voltage:* Typical value for information. Below this voltage, a battery alarm signal is generated.
 - *Power consumption:* Typical value for information. Supply currents in various operating modes.

DC Voltage Measurement

A/D - Converter Resolution nominal

High Range: 1LSB = 6.1 μ V, full range = -100...+300 mV
Low Range: 1LSB = 61nV, full range = -1.....+3mV

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| Calibration Factors | X | Y | Z |
|---------------------|---------------------------|---------------------------|---------------------------|
| High Range | 405.510 \pm 0.02% (k=2) | 405.047 \pm 0.02% (k=2) | 404.821 \pm 0.02% (k=2) |
| Low Range | 3.96328 \pm 1.50% (k=2) | 3.99400 \pm 1.50% (k=2) | 3.97320 \pm 1.50% (k=2) |

Connector Angle

| | |
|---|-------------------------------------|
| Connector Angle to be used in DASY system | 222.5 $^{\circ}$ \pm 1 $^{\circ}$ |
|---|-------------------------------------|

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|------------|---------|---------------------------|------------------------------|-----------|
| Channel X | + Input | 200031.77 | -5.20 | -0.00 |
| Channel X | + Input | 20006.58 | 0.39 | 0.00 |
| Channel X | - Input | -20002.34 | 3.46 | -0.02 |
| Channel Y | + Input | 200032.86 | -4.26 | -0.00 |
| Channel Y | + Input | 20001.39 | -4.67 | -0.02 |
| Channel Y | - Input | -20005.28 | 0.77 | -0.00 |
| Channel Z | + Input | 200032.31 | -5.12 | -0.00 |
| Channel Z | + Input | 20004.31 | -1.66 | -0.01 |
| Channel Z | - Input | -20004.31 | 1.82 | -0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|-----------|---------|---------------------------|------------------------------|-----------|
| Channel X | + Input | 2001.11 | -0.37 | -0.02 |
| Channel X | + Input | 201.74 | 0.40 | 0.20 |
| Channel X | - Input | -197.72 | 0.81 | -0.41 |
| Channel Y | + Input | 2001.85 | 0.48 | 0.02 |
| Channel Y | + Input | 200.73 | -0.57 | -0.28 |
| Channel Y | - Input | -200.26 | -1.56 | 0.79 |
| Channel Z | + Input | 2001.67 | 0.41 | 0.02 |
| Channel Z | + Input | 201.03 | -0.17 | -0.09 |
| Channel Z | - Input | -199.06 | -0.31 | 0.15 |

2. Common mode sensitivity

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Common mode Input Voltage (mV) | High Range Average Reading (μV) | Low Range Average Reading (μV) |
|-----------|--------------------------------|--|---|
| Channel X | 200 | 13.39 | 11.44 |
| | - 200 | -10.26 | -12.53 |
| Channel Y | 200 | -13.63 | -13.74 |
| | - 200 | 12.59 | 12.05 |
| Channel Z | 200 | -18.60 | -18.48 |
| | - 200 | 17.68 | 17.19 |

3. Channel separation

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | Input Voltage (mV) | Channel X (μV) | Channel Y (μV) | Channel Z (μV) |
|-----------|--------------------|-----------------------------|-----------------------------|-----------------------------|
| Channel X | 200 | - | 3.58 | -2.54 |
| Channel Y | 200 | 8.76 | - | 5.69 |
| Channel Z | 200 | 9.62 | 6.67 | - |

4. AD-Converter Values with inputs shorted

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

| | High Range (LSB) | Low Range (LSB) |
|-----------|------------------|-----------------|
| Channel X | 15446 | 16713 |
| Channel Y | 16320 | 15746 |
| Channel Z | 16580 | 17710 |

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec

Input 10M Ω

| | Average (μ V) | min. Offset (μ V) | max. Offset (μ V) | Std. Deviation (μ V) |
|-----------|--------------------|------------------------|------------------------|---------------------------|
| Channel X | 0.50 | -0.98 | 1.81 | 0.67 |
| Channel Y | -0.01 | -1.13 | 1.26 | 0.57 |
| Channel Z | 0.08 | -1.25 | 1.61 | 0.57 |

6. Input Offset Current

Nominal Input circuitry offset current on all channels: <25fA

7. Input Resistance (Typical values for information)

| | Zeroing (kOhm) | Measuring (MOhm) |
|-----------|----------------|------------------|
| Channel X | 200 | 200 |
| Channel Y | 200 | 200 |
| Channel Z | 200 | 200 |

8. Low Battery Alarm Voltage (Typical values for information)

| Typical values | Alarm Level (VDC) |
|----------------|-------------------|
| Supply (+ Vcc) | +7.9 |
| Supply (- Vcc) | -7.6 |

9. Power Consumption (Typical values for information)

| Typical values | Switched off (mA) | Stand by (mA) | Transmitting (mA) |
|----------------|-------------------|---------------|-------------------|
| Supply (+ Vcc) | +0.01 | +6 | +14 |
| Supply (- Vcc) | -0.01 | -8 | -9 |

IMPORTANT NOTICE

USAGE OF THE DAE4

The DAE unit is a delicate, high precision instrument and requires careful treatment by the user. There are no serviceable parts inside the DAE. Special attention shall be given to the following points:

Battery Exchange: The battery cover of the DAE4 unit is fixed using a screw, over tightening the screw may cause the threads inside the DAE to wear out.

Shipping of the DAE: Before shipping the DAE to SPEAG for calibration, remove the batteries and pack the DAE in an antistatic bag. This antistatic bag shall then be packed into a larger box or container which protects the DAE from impacts during transportation. The package shall be marked to indicate that a fragile instrument is inside.

E-Stop Failures: Touch detection may be malfunctioning due to broken magnets in the E-stop. Rough handling of the E-stop may lead to damage of these magnets. Touch and collision errors are often caused by dust and dirt accumulated in the E-stop. To prevent E-stop failure, the customer shall always mount the probe to the DAE carefully and keep the DAE unit in a non-dusty environment if not used for measurements.

Repair: Minor repairs are performed at no extra cost during the annual calibration. However, SPEAG reserves the right to charge for any repair especially if rough unprofessional handling caused the defect.

DASY Configuration Files: Since the exact values of the DAE input resistances, as measured during the calibration procedure of a DAE unit, are not used by the DASY software, a nominal value of 200 MOhm is given in the corresponding configuration file.

Important Note:

Warranty and calibration is void if the DAE unit is disassembled partly or fully by the Customer.

Important Note:

Never attempt to grease or oil the E-stop assembly. Cleaning and readjusting of the E-stop assembly is allowed by certified SPEAG personnel only and is part of the annual calibration procedure.

Important Note:

To prevent damage of the DAE probe connector pins, use great care when installing the probe to the DAE. Carefully connect the probe with the connector notch oriented in the mating position. Avoid any rotational movement of the probe body versus the DAE while turning the locking nut of the connector. The same care shall be used when disconnecting the probe from the DAE.

**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 **Sporton**

Certificate No: **EF3-4047_Jan22**

CALIBRATION CERTIFICATE

Object **EF3DV3- SN:4047**

Calibration procedure(s) **QA CAL-02.v9, QA CAL-25.v7
Calibration procedure for E-field probes optimized for close near field
evaluations in air**

Calibration date: **January 24, 2022**

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 | 09-Apr-21 (No. 217-03291/03292) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103244 | 09-Apr-21 (No. 217-03291) | Apr-22 |
| Power sensor NRP-Z91 | SN: 103245 | 09-Apr-21 (No. 217-03292) | Apr-22 |
| Reference 20 dB Attenuator | SN: CC2552 (20x) | 09-Apr-21 (No. 217-03343) | Apr-22 |
| DAE4 | SN: 789 | 24-Dec-21 (No. DAE4-789_Dec21) | Dec-22 |
| Reference Probe ER3DV6 | SN: 2328 | 08-Oct-21 (No. ER3-2328_Oct21) | Oct-22 |
| Secondary Standards | ID | Check Date (in house) | Scheduled Check |
| Power meter E4419B | SN: GB41293874 | 06-Apr-16 (in house check Jun-20) | In house check: Jun-22 |
| Power sensor E4412A | SN: MY41498087 | 06-Apr-16 (in house check Jun-20) | In house check: Jun-22 |
| Power sensor E4412A | SN: 000110210 | 06-Apr-16 (in house check Jun-20) | In house check: Jun-22 |
| RF generator HP 8648C | SN: US3642U01700 | 04-Aug-99 (in house check Jun-20) | In house check: Jun-22 |
| Network Analyzer E8358A | SN: US41080477 | 31-Mar-14 (in house check Oct-20) | In house check: Oct-22 |

| | | | |
|----------------|--------------------------------|-----------------------------------|---------------|
| Calibrated by: | Name Jeffrey Katzman | Function Laboratory Technician | Signature |
| Approved by: | Name Sven Kühn | Function Deputy Manager | Signature |

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

Issued: January 26, 2022



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:

| | |
|-----------------------|---|
| NORM _{x,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 |
| En | incident E-field orientation normal to probe axis |
| Ep | incident E-field orientation parallel to probe axis |
| 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 3.1.1, May 2017

Methods Applied and Interpretation of Parameters:

- *NORM_{x,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}* = *NORM_{x,y,z}* * *frequency_response* (see Frequency Response Chart).
- *DCP_{x,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
- *A_{x,y,z}*; *B_{x,y,z}*; *C_{x,y,z}*; *D_{x,y,z}*; *VR_{x,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 *NORM_x* (no uncertainty required).

DASY/EASY - Parameters of Probe: EF3DV3 - SN:4047

Basic Calibration Parameters

| | Sensor X | Sensor Y | Sensor Z | Unc (k=2) |
|--|----------|----------|----------|--------------|
| Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) | 0.84 | 0.68 | 1.19 | $\pm 10.1\%$ |
| DCP (mV) ^B | 98.6 | 99.8 | 98.0 | |

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

| Frequency MHz | Target E-Field V/m | Measured E-field (E _n) V/m | Deviation E-normal in % | Measured E-field (E _p) V/m | Deviation E-normal in % | Unc (k=2) % |
|---------------|--------------------|--|-------------------------|--|-------------------------|-------------|
| 30 | 77.2 | 77.4 | 0.3% | 77.3 | 0.2% | $\pm 5.1\%$ |
| 100 | 77.1 | 77.8 | 0.9% | 77.7 | 0.8% | $\pm 5.1\%$ |
| 450 | 77.1 | 77.9 | 1.0% | 78.1 | 1.2% | $\pm 5.1\%$ |
| 600 | 77.1 | 77.6 | 0.6% | 77.7 | 0.8% | $\pm 5.1\%$ |
| 750 | 77.1 | 77.4 | 0.4% | 77.6 | 0.7% | $\pm 5.1\%$ |
| 1800 | 143.3 | 139.6 | -2.6% | 140.0 | -2.3% | $\pm 5.1\%$ |
| 2000 | 135.1 | 131.6 | -2.6% | 132.0 | -2.3% | $\pm 5.1\%$ |
| 2200 | 127.7 | 123.6 | -3.2% | 124.8 | -2.2% | $\pm 5.1\%$ |
| 2500 | 125.6 | 122.6 | -2.3% | 123.9 | -1.3% | $\pm 5.1\%$ |
| 3000 | 79.5 | 75.9 | -4.5% | 77.0 | -3.1% | $\pm 5.1\%$ |
| 3500 | 256.9 | 248.8 | -3.1% | 245.7 | -4.4% | $\pm 5.1\%$ |
| 3700 | 249.5 | 239.8 | -3.9% | 237.9 | -4.6% | $\pm 5.1\%$ |
| 5200 | 50.7 | 51.3 | 1.1% | 51.6 | 1.7% | $\pm 5.1\%$ |
| 5500 | 49.6 | 49.3 | -0.6% | 48.2 | -2.7% | $\pm 5.1\%$ |
| 5800 | 48.9 | 48.5 | -0.9% | 49.6 | 1.5% | $\pm 5.1\%$ |

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:4047

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 | 175.5 | ± 3.5 % | ± 4.7 % |
| | | Y | 0.00 | 0.00 | 1.00 | | 153.1 | | |
| | | Z | 0.00 | 0.00 | 1.00 | | 169.8 | | |
| 10352-AAA | Pulse Waveform (200Hz, 10%) | X | 5.65 | 73.94 | 15.07 | 10.00 | 60.0 | ± 2.1 % | ± 9.6 % |
| | | Y | 6.48 | 75.80 | 16.15 | | 60.0 | | |
| | | Z | 6.02 | 74.99 | 15.16 | | 60.0 | | |
| 10353-AAA | Pulse Waveform (200Hz, 20%) | X | 5.68 | 75.85 | 14.59 | 6.99 | 80.0 | ± 0.8 % | ± 9.6 % |
| | | Y | 7.40 | 78.90 | 16.01 | | 80.0 | | |
| | | Z | 11.04 | 82.90 | 16.56 | | 80.0 | | |
| 10354-AAA | Pulse Waveform (200Hz, 40%) | X | 20.00 | 88.88 | 17.04 | 3.98 | 95.0 | ± 0.8 % | ± 9.6 % |
| | | Y | 20.00 | 89.65 | 17.66 | | 95.0 | | |
| | | Z | 20.00 | 88.80 | 16.67 | | 95.0 | | |
| 10355-AAA | Pulse Waveform (200Hz, 60%) | X | 20.00 | 89.78 | 16.24 | 2.22 | 120.0 | ± 0.8 % | ± 9.6 % |
| | | Y | 20.00 | 90.26 | 16.67 | | 120.0 | | |
| | | Z | 20.00 | 88.43 | 15.24 | | 120.0 | | |
| 10387-AAA | QPSK Waveform, 1 MHz | X | 2.09 | 68.95 | 17.16 | 1.00 | 150.0 | ± 1.9 % | ± 9.6 % |
| | | Y | 2.00 | 68.34 | 16.60 | | 150.0 | | |
| | | Z | 1.96 | 69.29 | 16.91 | | 150.0 | | |
| 10388-AAA | QPSK Waveform, 10 MHz | X | 2.87 | 71.97 | 17.85 | 0.00 | 150.0 | ± 0.9 % | ± 9.6 % |
| | | Y | 2.65 | 70.70 | 17.12 | | 150.0 | | |
| | | Z | 2.72 | 71.72 | 17.75 | | 150.0 | | |
| 10396-AAA | 64-QAM Waveform, 100 kHz | X | 1.75 | 65.51 | 17.08 | 3.01 | 150.0 | ± 8.6 % | ± 9.6 % |
| | | Y | 3.61 | 73.61 | 20.18 | | 150.0 | | |
| | | Z | 3.14 | 72.64 | 20.00 | | 150.0 | | |
| 10399-AAA | 64-QAM Waveform, 40 MHz | X | 3.73 | 68.12 | 16.54 | 0.00 | 150.0 | ± 1.4 % | ± 9.6 % |
| | | Y | 3.62 | 67.68 | 16.20 | | 150.0 | | |
| | | Z | 3.69 | 68.19 | 16.57 | | 150.0 | | |
| 10414-AAA | WLAN CCDF, 64-QAM, 40MHz | X | 5.03 | 65.79 | 15.82 | 0.00 | 150.0 | ± 2.9 % | ± 9.6 % |
| | | Y | 4.96 | 65.65 | 15.66 | | 150.0 | | |
| | | Z | 5.01 | 66.16 | 16.04 | | 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:4047

Sensor Frequency Model Parameters

| | Sensor X | Sensor Y | Sensor Z |
|----------------------|----------|----------|----------|
| Frequency Corr. (LF) | -0.34 | -0.20 | 5.90 |
| Frequency Corr. (HF) | 2.82 | 2.82 | 2.82 |

Sensor Model Parameters

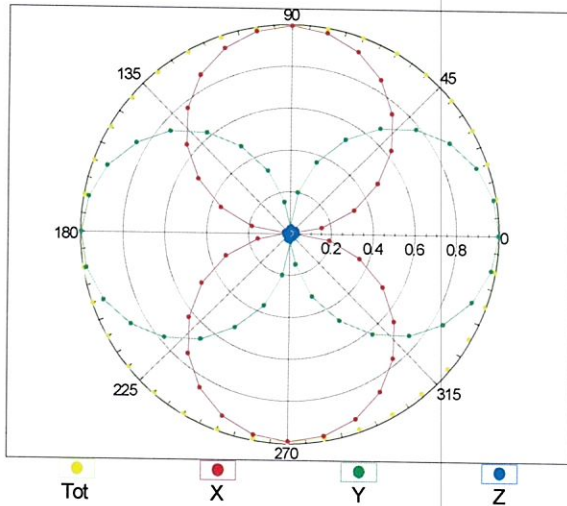
| | C1 fF | C2 fF | α V^{-1} | T1 $ms.V^{-2}$ | T2 $ms.V^{-1}$ | T3 ms | T4 V^{-2} | T5 V^{-1} | T6 |
|---|----------|----------|----------------------|-------------------|-------------------|----------|----------------|----------------|------|
| X | 69.7 | 459.14 | 36.77 | 12.98 | 0.88 | 4.99 | 0.00 | 0.00 | 1.00 |
| Y | 65.8 | 429.68 | 36.14 | 14.23 | 1.01 | 5.00 | 0.55 | 0.45 | 1.01 |
| Z | 54.9 | 365.02 | 37.34 | 10.96 | 0.61 | 5.02 | 0.74 | 0.30 | 1.00 |

Other Probe Parameters

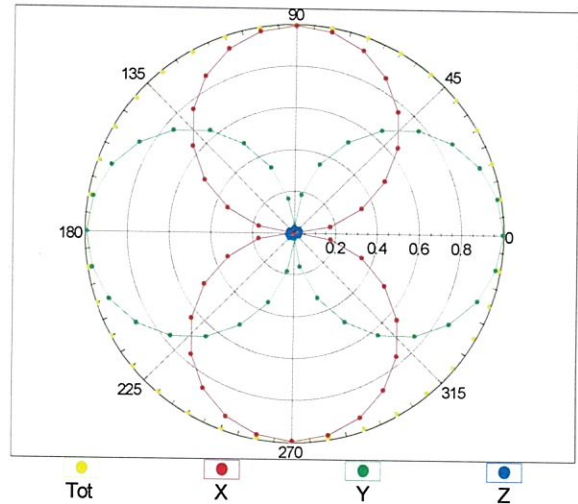
| | |
|---|-------------|
| Sensor Arrangement | Rectangular |
| Connector Angle (°) | 150.8 |
| Mechanical Surface Detection Mode | enabled |
| Optical Surface Detection Mode | disabled |
| Probe Overall Length | 337 mm |
| Probe Body Diameter | 12 mm |
| Tip Length | 25 mm |
| Tip Diameter | 4 mm |
| 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), $\vartheta = 0^\circ$

f=600 MHz, TEM, 0°

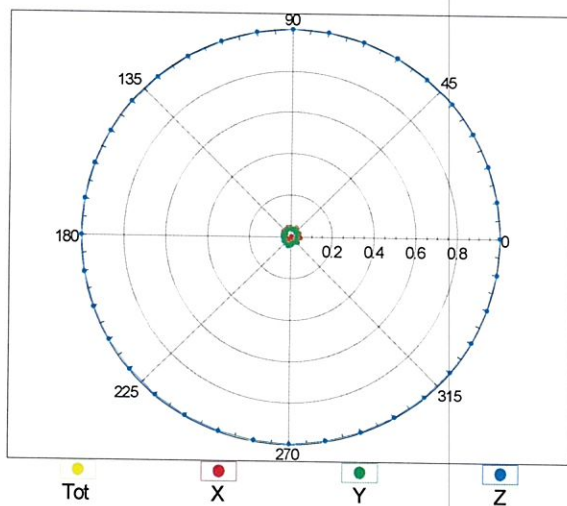


f=1800 MHz, R22, 0°

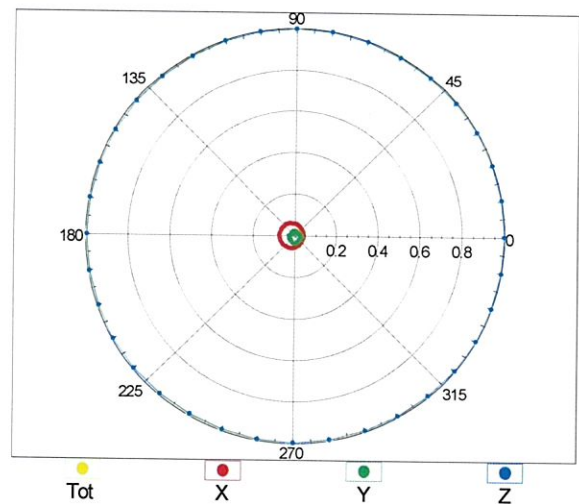


Receiving Pattern (ϕ), $\vartheta = 90^\circ$

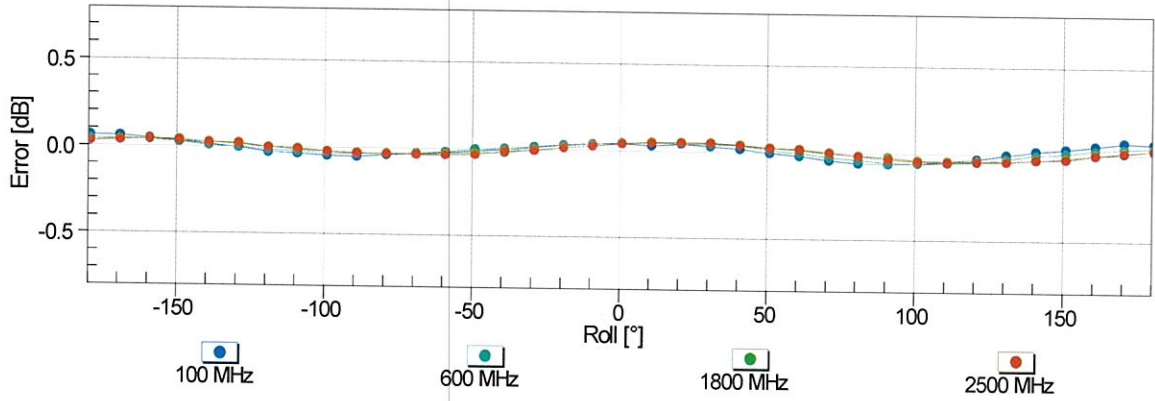
f=600 MHz, TEM, 90°



f=1800 MHz, R22, 90°

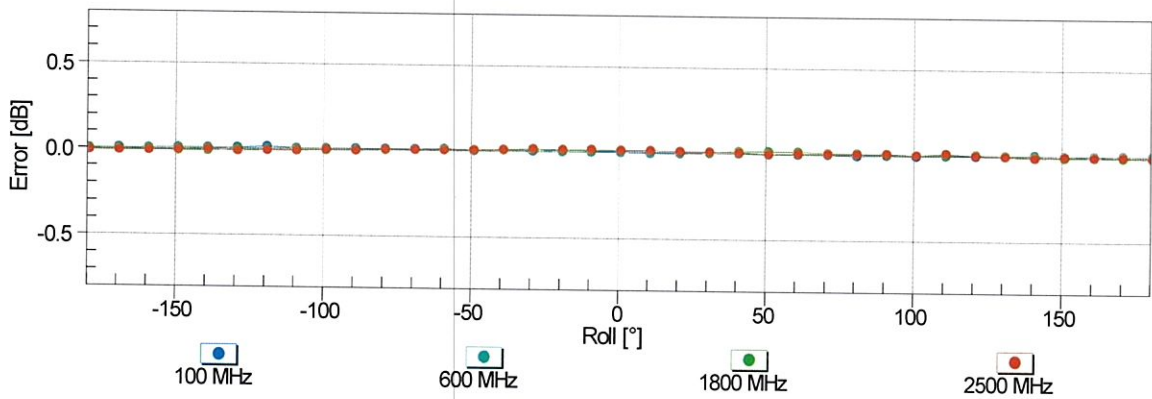


Receiving Pattern (ϕ), $\vartheta = 0^\circ$



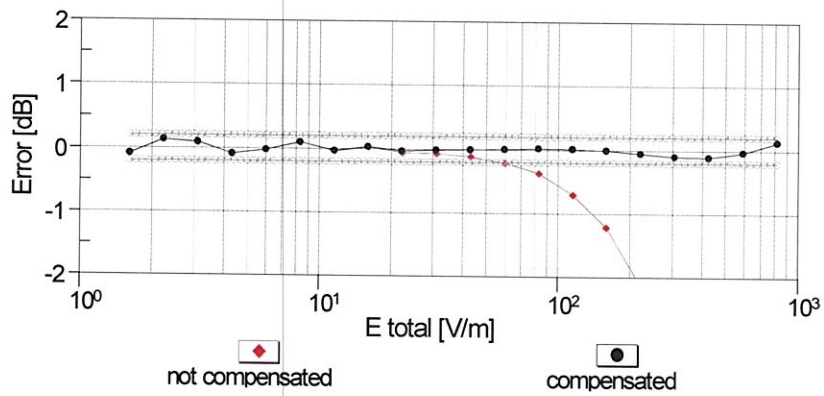
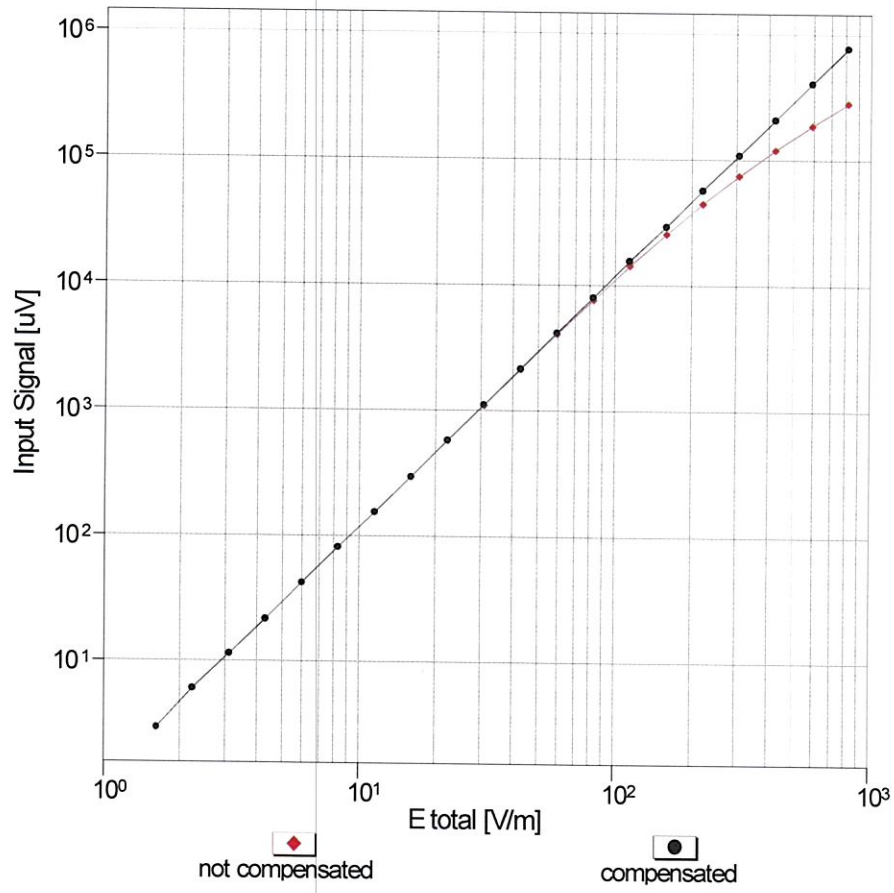
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

Receiving Pattern (ϕ), $\vartheta = 90^\circ$



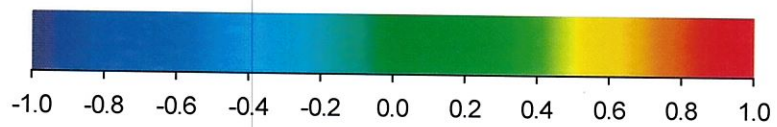
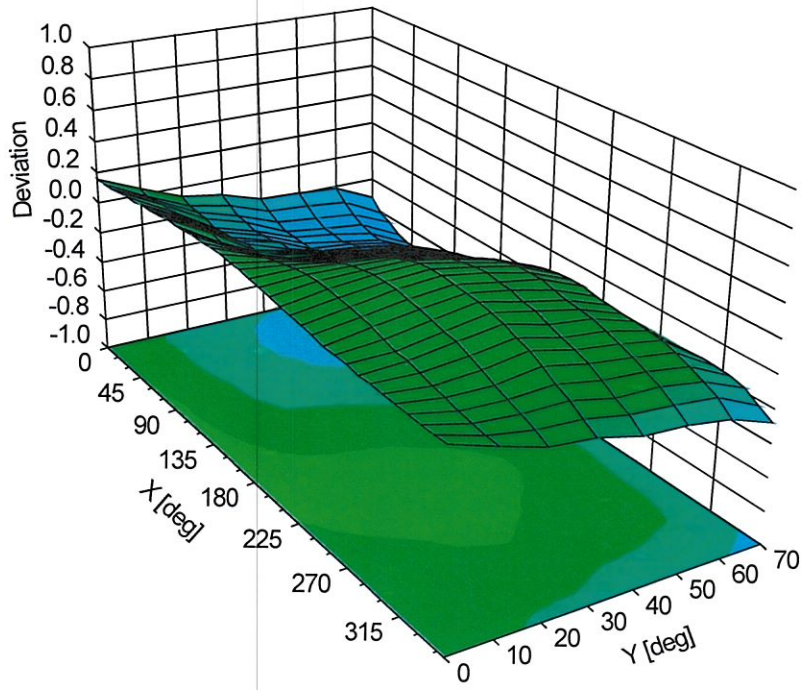
Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

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: $\pm 2.6\%$ ($k=2$)