Appendix A. Plots of T-Coil Measurement

The plots are shown as follows.

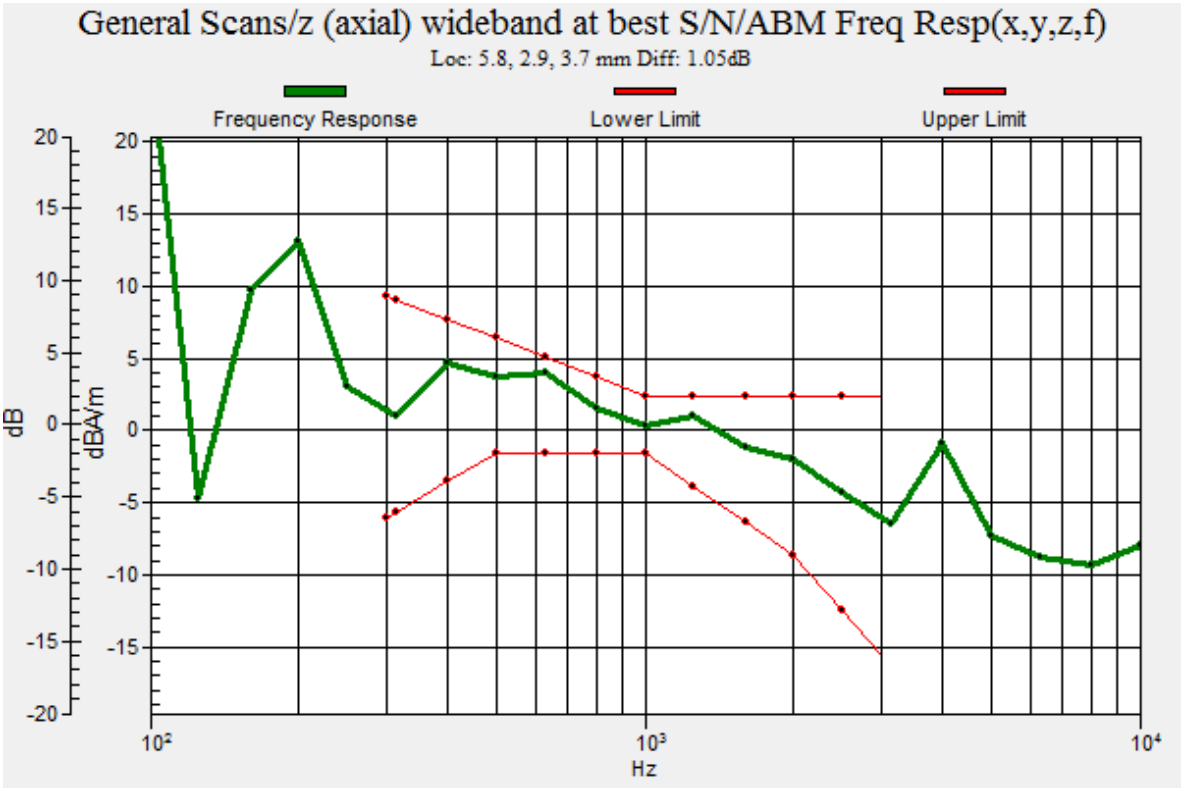
#01_HAC_T-Coil_LTE Band 2_20M_QPSK_1_0_Ch18900_Axial (Z)

Communication System: LTE ; Frequency: 1880 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.71 dB
ABM1 comp = -0.49 dBA/m
Location: 6.1, 3, 3.7 mm

0 dB = 1.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 5.8, 2.9, 3.7 mm Diff: 1.05dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4
Hz

#01_HAC_T-Coil_LTE Band 2_20M_QPSK_1_0_Ch18900_Transversal (Y)

Communication System: LTE ; Frequency: 1880 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 39.82 dB
ABM1 comp = -8.44 dBA/m
Location: 4, -7.5, 3.7 mm

0 dB = 97.94 = 39.82 dB

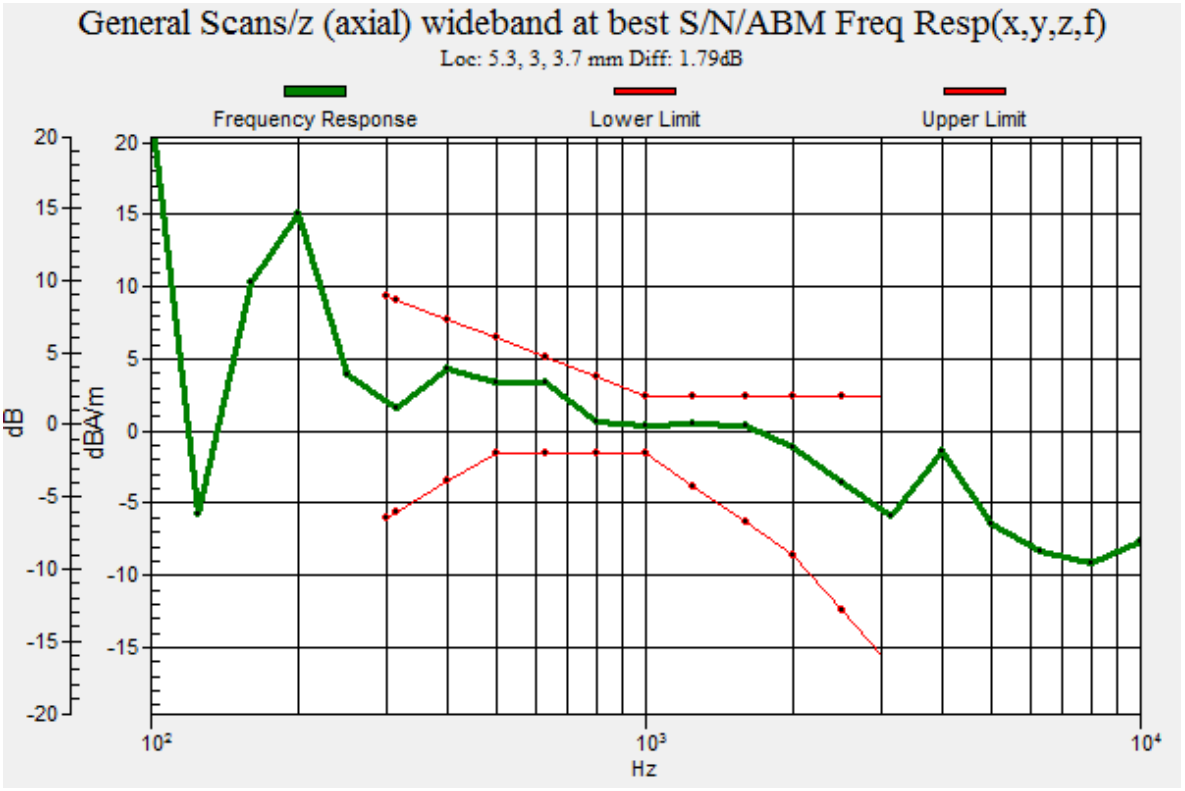
#02_HAC_T-Coil_LTE Band 4_20M_QPSK_1_0_Ch20175_Axial (Z)

Communication System: LTE; Frequency: 1732.5 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.20 dB
ABM1 comp = -0.22 dBA/m
Location: 5.4, 3, 3.7 mm

0 dB = 144.5 = 43.20 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 5.3, 3, 3.7 mm Diff: 1.79dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4
Hz

#02_HAC_T-Coil_LTE Band 4_20M_QPSK_1_0_Ch20175_Transversal (Y)

Communication System: LTE; Frequency: 1732.5 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 40.44 dB
ABM1 comp = -8.02 dBA/m
Location: 4, -7.5, 3.7 mm

0 dB = 105.2 = 40.44 dB

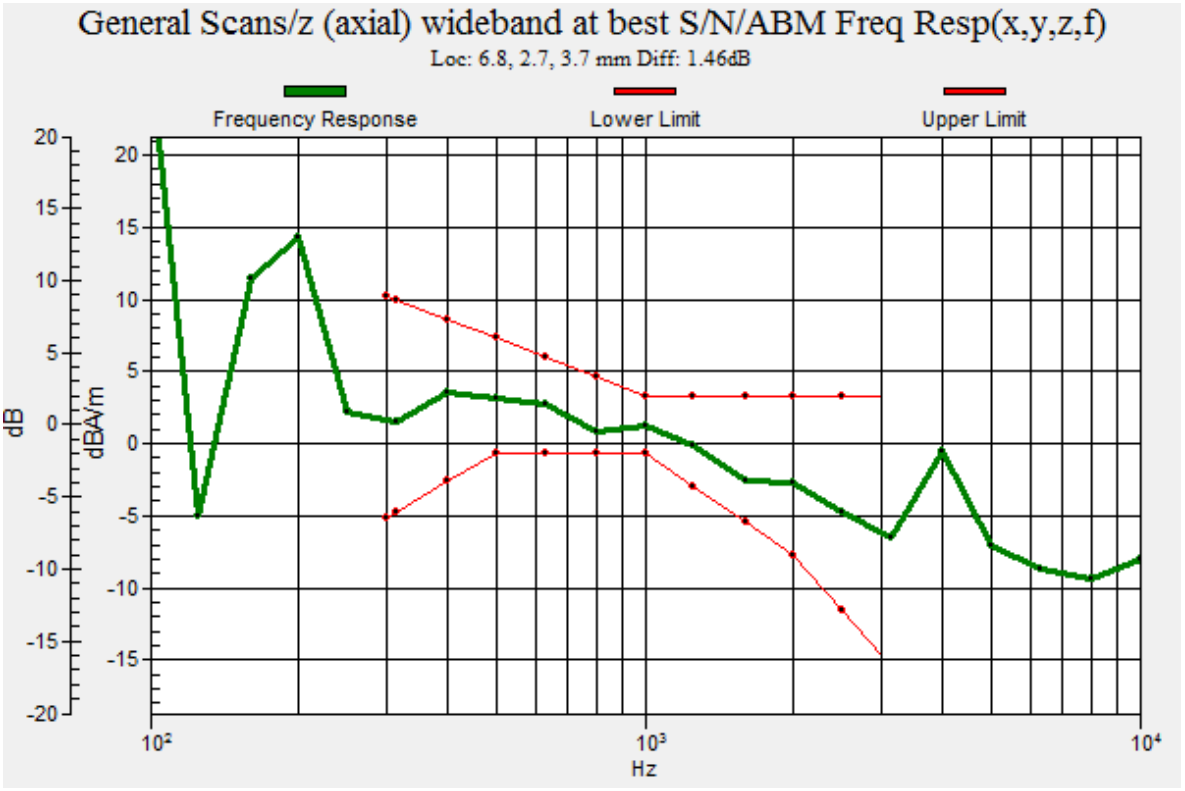
#03_HAC_T-Coil_LTE Band 5_10M_QPSK_1_0_Ch20525_Axial (Z)

Communication System: LTE; Frequency: 836.5 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.61 dB
ABM1 comp = -0.55 dBA/m
Location: 6.8, 2.3, 3.7 mm

0 dB = 151.6 = 43.61 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 6.8, 2.7, 3.7 mm Diff: 1.46dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4
Hz

#03_HAC_T-Coil_LTE Band 5_10M_QPSK_1_0_Ch20525_Transversal (Y)

Communication System: LTE; Frequency: 836.5 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 40.47 dB
ABM1 comp = -7.94 dBA/m
Location: 4.7, 10, 3.7 mm

0 dB = 105.5 = 40.47 dB

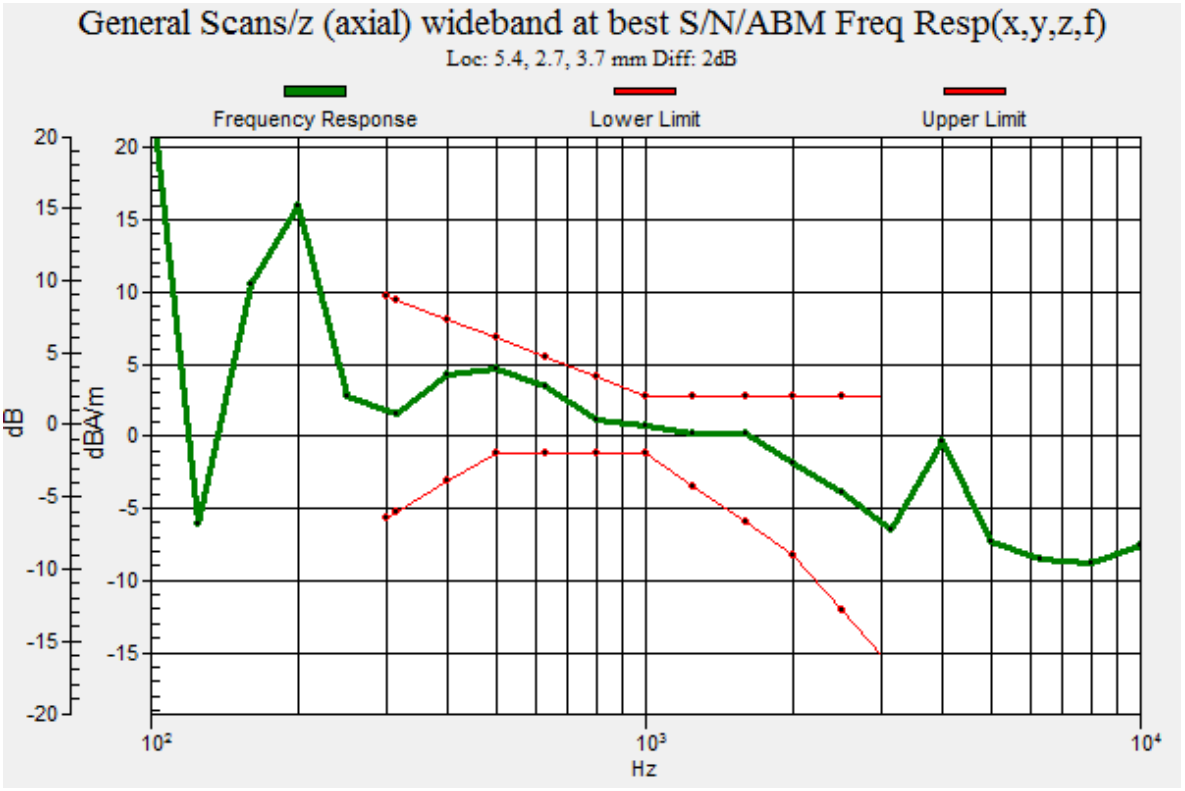
#04_HAC_T-Coil_LTE Band 13_10M_QPSK_1_0_Ch23230_Axial (Z)

Communication System: LTE; Frequency: 782 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.99 dB
ABM1 comp = -0.20 dBA/m
Location: 5.4, 3, 3.7 mm

0 dB = 1.00 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 5.4, 2.7, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4
Hz

#04_HAC_T-Coil_LTE Band 13_10M_QPSK_1_0_Ch23230_Transversal (Y)

Communication System: LTE; Frequency: 782 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 40.30 dB
ABM1 comp = -7.99 dBA/m
Location: 4, 10, 3.7 mm

0 dB = 103.5 = 40.30 dB

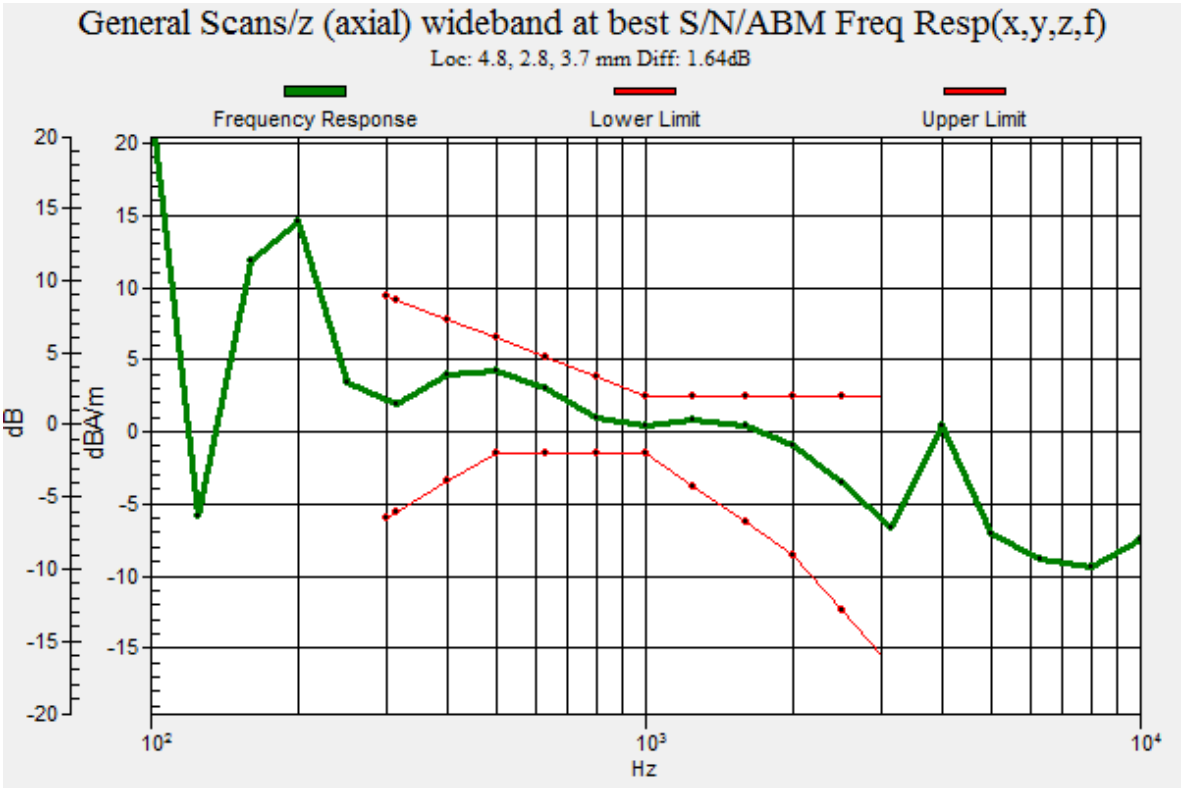
#05_HAC_T-Coil_LTE Band 66_20M_QPSK_1_0_Ch132322_Axial (Z)

Communication System: LTE; Frequency: 1745 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 44.02 dB
ABM1 comp = 0.44 dBA/m
Location: 4.7, 3, 3.7 mm

0 dB = 158.8 = 44.02 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.8, 2.8, 3.7 mm Diff: 1.64dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4
Hz

#05_HAC_T-Coil_LTE Band 66_20M_QPSK_1_0_Ch132322_Transversal (Y)

Communication System: LTE; Frequency: 1745 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 40.52 dB
ABM1 comp = -8.14 dBA/m
Location: 4.7, -7.5, 3.7 mm

0 dB = 106.1 = 40.51 dB

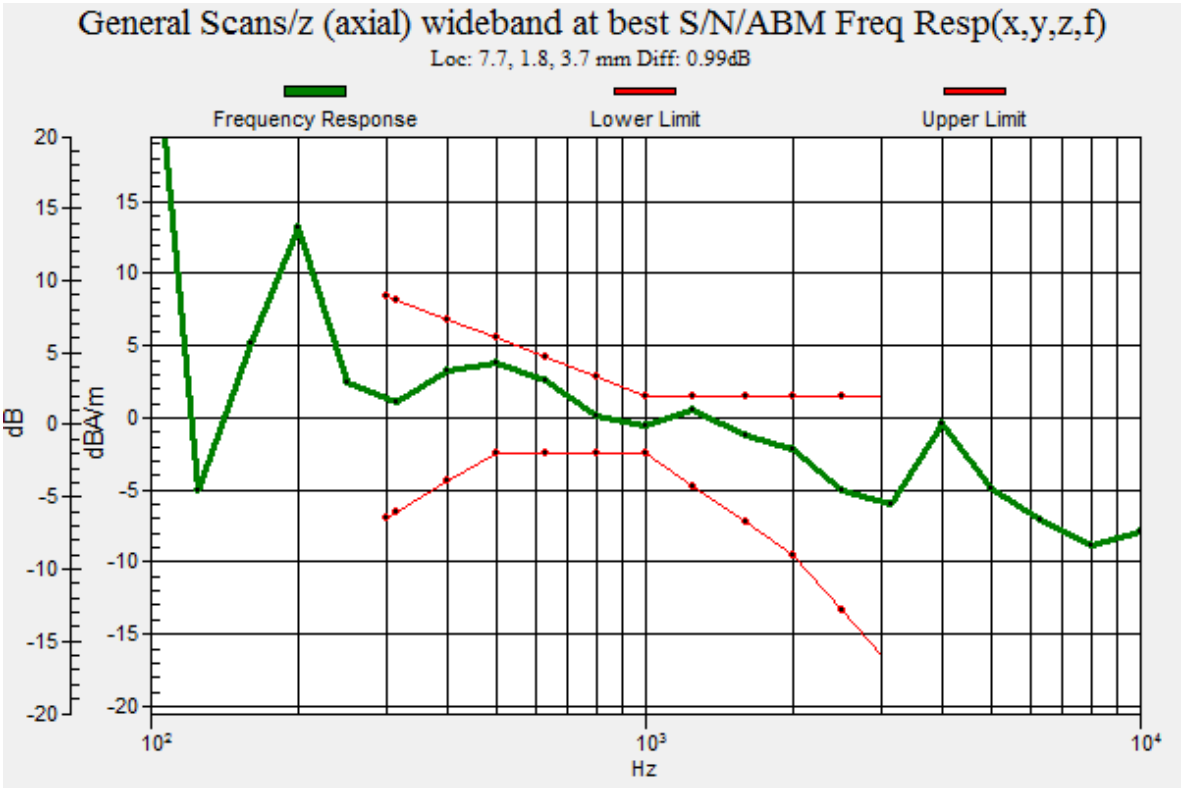
#06_HAC_T-Coil_LTE Band 48_20M_QPSK_1_0_Ch55830_Axial (Z)

Communication System: LTE TDD; Frequency: 3609 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 43.97 dB
ABM1 comp = -1.04 dBA/m
Location: 7.5, 1.6, 3.7 mm

0 dB = 157.9 = 43.97 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 7.7, 1.8, 3.7 mm Diff: 0.99dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz
20
15
10
5
0
-5
-10
-15
-20
10²
10³
10⁴

#06_HAC_T-Coil_LTE Band 48_20M_QPSK_1_0_Ch55830_Transversal (Y)

Communication System: LTE TDD; Frequency: 3609 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.4 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2018/11/20
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn854; Calibrated: 2018/6/14
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 41.30 dB
ABM1 comp = -7.42 dBA/m
Location: 4.7, 9.3, 3.7 mm

0 dB = 116.1 = 41.30 dB

#07_HAC_T-Coil_GSM850_Voice(speech codec handset low)_Ch189_Axial (Z)

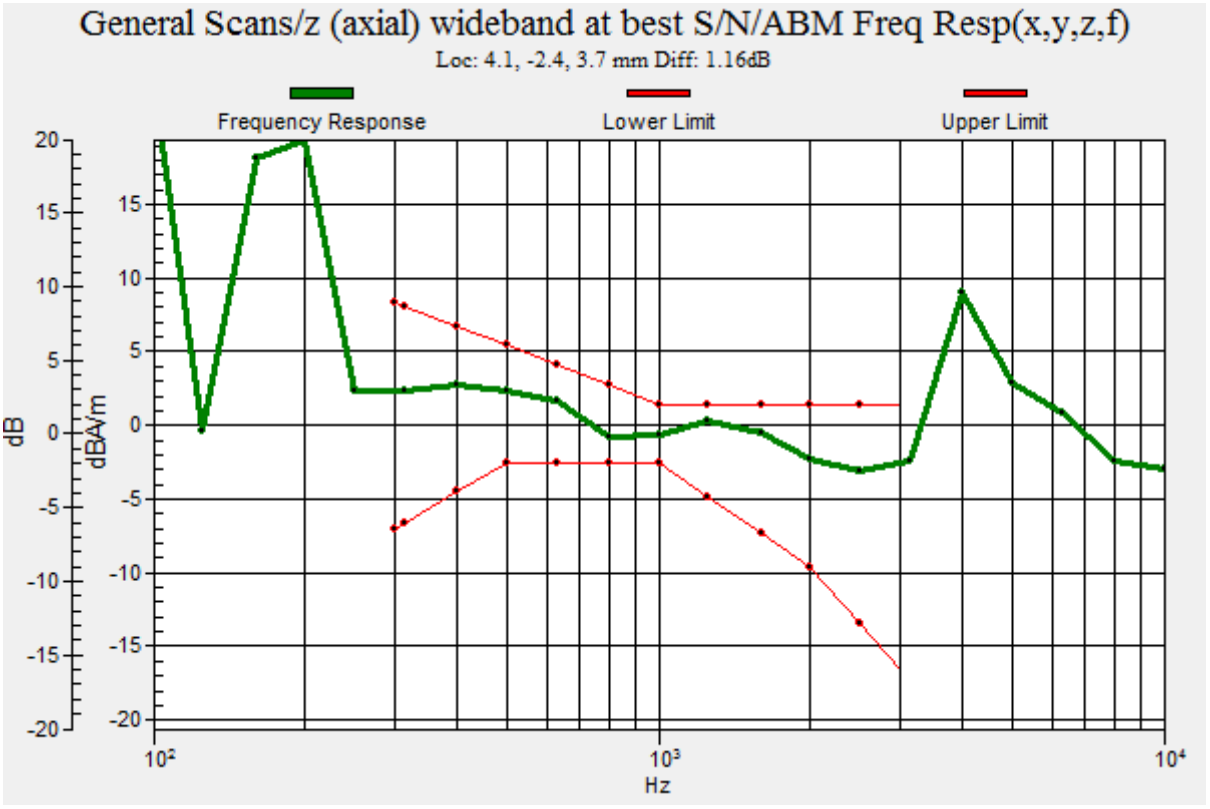
Communication System: GSM850 ; Frequency: 836.4 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.8 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/z (axial) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 30.10 dB
ABM1 comp = -1.82 dBA/m
Location: 4, -2.6, 3.7 mm

0 dB = 32.00 = 30.10 dB


General Scans/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.1, -2.4, 3.7 mm Diff: 1.16dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
10^2
10^3
10^4
Hz

#07_HAC_T-Coil_GSM850_Voice(speech codec handset low)_Ch189_Transversal (Y)

Communication System: GSM850 ; Frequency: 836.4 MHz
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.8 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3130; ; Calibrated: 2017/11/21
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn910; Calibrated: 2018/6/21
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.10 (0);SEMCAD X Version 14.6.10 (7417)

General Scans/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1):

Interpolated grid: dx=1.000 mm, dy=1.000 mm
ABM1/ABM2 = 33.72 dB
ABM1 comp = -11.13 dBA/m
Location: 1.2, -11, 3.7 mm

0 dB = 48.54 = 33.72 dB

Appendix B. Calibration Data

The DASY calibration certificates are shown as follows.

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 (Auden)

Certificate No: AM1DV3-3130_Nov17

CALIBRATION CERTIFICATE

Object	AM1DV3 - SN: 3130
Calibration procedure(s)	QA CAL-24.v4 Calibration procedure for AM1D magnetic field probes and TMFS in the audio range
Calibration date:	November 21, 2017

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	31-Aug-17 (No. 21092)	Aug-18
Reference Probe AM1DV2	SN: 1008	30-Dec-16 (No. AM1D-1008_Dec16)	Dec-17
DAE4	SN: 781	13-Jul-17 (No. DAE4-781_Jul17)	Jul-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	SN: 1050	01-Oct-13 (in house check Oct-17)	Oct-19
AMMI Audio Measuring Instrument	SN: 1062	26-Sep-12 (in house check Oct-17)	Oct-19

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

Issued: November 21, 2017

[References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
[2] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
[3] DASY5 manual, Chapter: Hearing Aid Compatibility (HAC) T-Coil Extension

Description of the AM1D probe

The AM1D Audio Magnetic Field Probe is a fully shielded magnetic field probe for the frequency range from 100 Hz to 20 kHz. The pickup coil is compliant with the dimensional requirements of [1+2]. The probe includes a symmetric low noise amplifier for the signal available at the shielded 3 pin connector at the side. Power is supplied via the same connector (phantom power supply) and monitored via the LED near the connector. The 7 pin connector at the end of the probe does not carry any signals, but determines the angle of the sensor when mounted on the DAE. The probe supports mechanical detection of the surface.
The single sensor in the probe is arranged in a tilt angle allowing measurement of 3 orthogonal field components when rotating the probe by 120° around its axis. It is aligned with the perpendicular component of the field, if the probe axis is tilted nominally 35.3° above the measurement plane, using the connector rotation and sensor angle stated below.
The probe is fully RF shielded when operated with the matching signal cable (shielded) and allows measurement of audio magnetic fields in the close vicinity of RF emitting wireless devices according to [1+2] without additional shielding.

Handling of the item

The probe is manufactured from stainless steel. In order to maintain the performance and calibration of the probe, it must not be opened. The probe is designed for operation in air and shall not be exposed to humidity or liquids. For proper operation of the surface detection and emergency stop functions in a DASY system, the probe must be operated with the special probe cup provided (larger diameter).

Methods Applied and Interpretation of Parameters

- *Coordinate System:* The AM1D probe is mounted in the DASY system for operation with a HAC Test Arch phantom with AMCC Helmholtz calibration coil according to [3], with the tip pointing to "southwest" orientation.
- *Functional Test:* The functional test preceding calibration includes test of
  Noise level
  RF immunity (1kHz AM modulated signal). The shield of the probe cable must be well connected.
  Frequency response verification from 100 Hz to 10 kHz.
- *Connector Rotation:* The connector at the end of the probe does not carry any signals and is used for fixation to the DAE only. The probe is operated in the center of the AMCC Helmholtz coil using a 1 kHz magnetic field signal. Its angle is determined from the two minima at nominally +120° and –120° rotation, so the sensor in the tip of the probe is aligned to the vertical plane in z-direction, corresponding to the field maximum in the AMCC Helmholtz calibration coil.
- *Sensor Angle:* The sensor tilting in the vertical plane from the ideal vertical direction is determined from the two minima at nominally +120° and –120°. DASY system uses this angle to align the sensor for radial measurements to the x and y axis in the horizontal plane.

Sensitivity: With the probe sensor aligned to the z-field in the AMCC, the output of the probe is compared to the magnetic field in the AMCC at 1 kHz. The field in the AMCC Helmholtz coil is given by the geometry and the current through the coil, which is monitored on the precision shunt resistor of the coil.

AM1D probe identification and configuration data

Item	**AM1DV3** Audio Magnetic 1D Field Probe
Type No	SP AM1 001 BA
Serial No	**3130**

Overall length	296 mm
Tip diameter	6.0 mm (at the tip)
Sensor offset	3.0 mm (centre of sensor from tip)
Internal Amplifier	20 dB

Manufacturer / Origin	Schmid & Partner Engineering AG, Zürich, Switzerland
Manufacturing date	July 09, 2012
Last calibration date	November 16, 2016

Calibration data

Connector rotation angle	(in DASY system)	**81.2 °**	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**1.03 °**	+/- 0.5 ° (k=2)
Sensitivity at 1 kHz	(in DASY system)	**0.00743 V / (A/m)**	+/- 2.2 % (k=2)

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%.

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
S 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: AM1DV3-3130_Nov18

CALIBRATION CERTIFICATE

Object	AM1DV3 - SN: 3130
Calibration procedure(s)	QA CAL-24.v4 Calibration procedure for AM1D magnetic field probes and TMFS in the audio range
Calibration date:	November 20, 2018

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	03-Sep-18 (No. 23488)	Sep-19
Reference Probe AM1DV2	SN: 1008	03-Jan-18 (No. AM1DV2-1008_Jan18)	Jan-19
DAE4	SN: 781	17-Jan-18 (No. DAE4-781_Jan18)	Jan-19

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	SN: 1050	01-Oct-13 (in house check Oct-17)	Oct-19
AMMI Audio Measuring Instrument	SN: 1062	26-Sep-12 (in house check Oct-17)	Oct-19

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

Issued: November 20, 2018

[References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
[2] ANSI-C63.19-2011
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.
[3] DASY5 manual, Chapter: Hearing Aid Compatibility (HAC) T-Coil Extension

Description of the AM1D probe

The AM1D Audio Magnetic Field Probe is a fully shielded magnetic field probe for the frequency range from 100 Hz to 20 kHz. The pickup coil is compliant with the dimensional requirements of [1+2]. The probe includes a symmetric low noise amplifier for the signal available at the shielded 3 pin connector at the side. Power is supplied via the same connector (phantom power supply) and monitored via the LED near the connector. The 7 pin connector at the end of the probe does not carry any signals, but determines the angle of the sensor when mounted on the DAE. The probe supports mechanical detection of the surface.
The single sensor in the probe is arranged in a tilt angle allowing measurement of 3 orthogonal field components when rotating the probe by 120° around its axis. It is aligned with the perpendicular component of the field, if the probe axis is tilted nominally 35.3° above the measurement plane, using the connector rotation and sensor angle stated below.
The probe is fully RF shielded when operated with the matching signal cable (shielded) and allows measurement of audio magnetic fields in the close vicinity of RF emitting wireless devices according to [1+2] without additional shielding.

Handling of the item

The probe is manufactured from stainless steel. In order to maintain the performance and calibration of the probe, it must not be opened. The probe is designed for operation in air and shall not be exposed to humidity or liquids. For proper operation of the surface detection and emergency stop functions in a DASY system, the probe must be operated with the special probe cup provided (larger diameter).

Methods Applied and Interpretation of Parameters

- *Coordinate System:* The AM1D probe is mounted in the DASY system for operation with a HAC Test Arch phantom with AMCC Helmholtz calibration coil according to [3], with the tip pointing to "southwest" orientation.
- *Functional Test:* The functional test preceding calibration includes test of
  Noise level
  RF immunity (1kHz AM modulated signal). The shield of the probe cable must be well connected.
  Frequency response verification from 100 Hz to 10 kHz.
- *Connector Rotation:* The connector at the end of the probe does not carry any signals and is used for fixation to the DAE only. The probe is operated in the center of the AMCC Helmholtz coil using a 1 kHz magnetic field signal. Its angle is determined from the two minima at nominally +120° and –120° rotation, so the sensor in the tip of the probe is aligned to the vertical plane in z-direction, corresponding to the field maximum in the AMCC Helmholtz calibration coil.
- *Sensor Angle:* The sensor tilting in the vertical plane from the ideal vertical direction is determined from the two minima at nominally +120° and –120°. DASY system uses this angle to align the sensor for radial measurements to the x and y axis in the horizontal plane.

Sensitivity: With the probe sensor aligned to the z-field in the AMCC, the output of the probe is compared to the magnetic field in the AMCC at 1 kHz. The field in the AMCC Helmholtz coil is given by the geometry and the current through the coil, which is monitored on the precision shunt resistor of the coil.

AM1D probe identification and configuration data

Item	**AM1DV3** Audio Magnetic 1D Field Probe
Type No	SP AM1 001 BA
Serial No	**3130**

Overall length	296 mm
Tip diameter	6.0 mm (at the tip)
Sensor offset	3.0 mm (centre of sensor from tip)
Internal Amplifier	20 dB

Manufacturer / Origin	Schmid & Partner Engineering AG, Zurich, Switzerland

Calibration data

Connector rotation angle	(in DASY system)	**80.9°**	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**1.06 °**	+/- 0.5 ° (k=2)
Sensitivity at 1 kHz	(in DASY system)	**0.00743 V / (A/m)**	+/- 2.2 % (k=2)

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%.

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 **Auden**

Certificate No: DAE4-910_Jun18

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BK - SN: 910
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	June 21, 2018

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	31-Aug-17 (No:21092)	Aug-18
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	04-Jan-18 (in house check)	In house check: Jan-19
Calibrator Box V2.1	SE UMS 006 AA 1002	04-Jan-18 (in house check)	In house check: Jan-19

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

Issued: June 21, 2018

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 =	6.1μV ,	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	403.316 ± 0.02% (k=2)	402.740 ± 0.02% (k=2)	403.223 ± 0.02% (k=2)
Low Range	3.98189 ± 1.50% (k=2)	3.94034 ± 1.50% (k=2)	3.94948 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	270.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200036.85	-0.57	-0.00
Channel X	+ Input	20007.13	1.21	0.01
Channel X	- Input	-20003.15	2.23	-0.01
Channel Y	+ Input	200035.57	-4.86	-0.00
Channel Y	+ Input	20005.66	-0.36	-0.00
Channel Y	- Input	-20005.78	-0.47	0.00
Channel Z	+ Input	200031.43	-6.16	-0.00
Channel Z	+ Input	20004.85	-0.87	-0.00
Channel Z	- Input	-20006.04	-0.58	0.00

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.67	0.16	0.01
Channel X	+ Input	201.92	0.42	0.21
Channel X	- Input	-198.17	0.31	-0.16
Channel Y	+ Input	2001.38	-0.14	-0.01
Channel Y	+ Input	201.49	-0.03	-0.01
Channel Y	- Input	-198.91	-0.42	0.21
Channel Z	+ Input	2002.08	0.66	0.03
Channel Z	+ Input	199.86	-1.52	-0.75
Channel Z	- Input	-200.22	-1.73	0.87

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	-12.45	-14.44
	- 200	16.44	14.50
Channel Y	200	6.37	5.97
	- 200	-7.85	-7.73
Channel Z	200	-11.52	-12.01
	- 200	10.51	10.13

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	-	4.62	-2.89
Channel Y	200	9.63	-	4.93
Channel Z	200	10.63	7.69	-

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	16196	17184
Channel Y	15388	15032
Channel Z	16713	16294

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	1.84	0.59	3.46	0.62
Channel Y	1.42	0.15	2.77	0.52
Channel Z	-0.96	-2.82	0.61	0.60

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

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: DAE4-854_Jun18

CALIBRATION CERTIFICATE

Object	DAE4 - SD 000 D04 BM - SN: 854
Calibration procedure(s)	QA CAL-06.v29 Calibration procedure for the data acquisition electronics (DAE)
Calibration date:	June 14, 2018

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	31-Aug-17 (No:21092)	Aug-18
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	04-Jan-18 (in house check)	In house check: Jan-19
Calibrator Box V2.1	SE UMS 006 AA 1002	04-Jan-18 (in house check)	In house check: Jan-19

	Name	Function	Signature
Calibrated by:	Eric Hainfeld	Laboratory Technician	
Approved by:	Sven Kühn	Deputy Manager	

Issued: June 14, 2018

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 =	6.1μV ,	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	404.937 ± 0.02% (k=2)	404.730 ± 0.02% (k=2)	405.829 ± 0.02% (k=2)
Low Range	3.97284 ± 1.50% (k=2)	3.94535 ± 1.50% (k=2)	3.99553 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	325.0 ° ± 1 °

Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	200033.40	-4.54	-0.00
Channel X	+ Input	20004.28	-1.77	-0.01
Channel X	- Input	-20002.65	2.58	-0.01
Channel Y	+ Input	200036.32	-2.03	-0.00
Channel Y	+ Input	20002.05	-3.86	-0.02
Channel Y	- Input	-20005.10	0.28	-0.00
Channel Z	+ Input	200036.91	-1.46	-0.00
Channel Z	+ Input	20003.85	-2.05	-0.01
Channel Z	- Input	-20005.17	0.36	-0.00

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2002.16	0.22	0.01
Channel X	+ Input	202.15	0.38	0.19
Channel X	- Input	-198.29	-0.31	0.16
Channel Y	+ Input	2001.95	0.27	0.01
Channel Y	+ Input	201.01	-0.63	-0.31
Channel Y	- Input	-198.91	-0.79	0.40
Channel Z	+ Input	2001.73	-0.08	-0.00
Channel Z	+ Input	200.57	-1.12	-0.56
Channel Z	- Input	-199.68	-1.47	0.74

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	-11.94	-13.63
	- 200	15.47	13.71
Channel Y	200	-8.45	-8.32
	- 200	7.64	7.27
Channel Z	200	16.23	16.03
	- 200	-18.86	-19.07

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	-	1.45	-3.45
Channel Y	200	7.54	-	3.39
Channel Z	200	9.04	5.14	-

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	16138	16479
Channel Y	16030	14603
Channel Z	15846	16180

5. Input Offset Measurement

DASY measurement parameters: Auto Zero Time: 3 sec; Measuring time: 3 sec
Input 10MΩ

	Average (μV)	min. Offset (μV)	max. Offset (μV)	Std. Deviation (μV)
Channel X	0.51	-0.22	1.41	0.30
Channel Y	1.02	-0.44	1.87	0.35
Channel Z	0.62	-0.69	1.46	0.38

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