Hearing Aid Compatibility (HAC) T-Coil Test Report

APPLICANT	:	**ZTE Corporation**
EQUIPMENT	:	**Wcdma Digital Mobile Phone**
BRAND NAME	:	**ZTE**
MODEL NAME	:	**Z432**
MARKETING NAME	:	**ZTE Z432**
FCC ID	:	**SRQ-Z432**
STANDARD	:	**FCC 47 CFR §20.19** **ANSI C63.19-2007**
T CATEGORY	:	**T3**

The product sample completely tested on Feb. 13, 2014. We, SPORTON INTERNATIONAL (SHENZHEN) INC., would like to declare that the tested sample has been evaluated in accordance with the procedures and shown the compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL (SHENZHEN) INC., the test report shall not be reproduced except in full.

Eric Huang

Reviewed by: Eric Huang / Deputy Manager

Jones Tsai

Approved by: Jones Tsai / Manager

ilac-MRA

TAF Testing Laboratory 2353

SPORTON INTERNATIONAL (SHENZHEN) INC.
No. 101, Complex Building C, Guanlong Village, Xili Town, Nanshan District, Shenzhen, Guangdong, P.R.C.

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Revision History

REPORT NO.	VERSION	DESCRIPTION	ISSUED DATE
HA410701B	Rev. 01	Initial issue of report	Feb. 17, 2014

1. Statement of Compliance

The Hearing Aid Compliance (HAC) maximum results found during testing for the **ZTE Corporation Wcdma Digital Mobile Phone ZTE Z432 ZTE Z432** are as follows:

Reference (63.19)	Description	Verdict	Section
7.3.1.1	Axial Field Intensity	Pass	9.4.1
7.3.1.2	Radial Field Intensity	Pass	9.4.2
7.3.2	Frequency Response	Pass	9.4.3
7.3.3	Signal Quality	T3	9.4.4

Band	(S+N)/N in dB	T Rating
GSM850	23.04	T3
GSM1900	25.70	T3
WCDMA Band V	46.47	T4
WCDMA Band II	46.01	T4

They are in compliance with HAC limits specified in guidelines FCC 47CFR §20.19 and ANSI Standard ANSI C63.19.

Results Summary : T Category = T3 (ANSI C63.19-2007)

2. Administration Data

2.1 Testing Laboratory

Test Site	SPORTON INTERNATIONAL (SHENZHEN) INC.	
Test Site Location	No. 101, Complex Building C, Guanlong Village, Xili Town, Nanshan District, Shenzhen, Guangdong, P.R.C. TEL:+86-755-8637-9589 FAX: +86-755-8637-9595	
Test Site No.	**Sporton Site No. :**	
	SAR01-SZ	

2.2 Applicant

Company Name	ZTE Corporation
Address	ZTE Plaza, Keji Road South, Hi-Tech, Industrial Park, Nanshan District, Shenzhen, Guangdong, P.R.China

2.3 Manufacturer

Company Name	ZTE Corporation
Address	ZTE Plaza, Keji Road South, Hi-Tech, Industrial Park, Nanshan District, Shenzhen, Guangdong, P.R.China

2.4 Application Details

Date of Start during the Test	Feb. 13, 2014
Date of End during the Test	Feb. 13, 2014

3. General Information

3.1 Description of Equipment Under Test (EUT)

Product Feature & Specification	
EUT Type	Wcdma Digital Mobile Phone
Brand Name	ZTE
Model Name	Z432
Marketing Name	ZTE Z432
IMEI Code	863487020001827
Tx Frequency	GSM850 : 824.2 MHz ~ 848.8 MHz GSM1900 : 1850.2 MHz ~ 1909.8 MHz WCDMA Band V : 826.4 MHz ~ 846.6 MHz WCDMA Band II : 1852.4 MHz ~ 1907.6 MHz Bluetooth: 2402 MHz ~ 2480 MHz
Antenna Type	WWAN: FPC Antenna Bluetooth: FPC Antenna
HW Version	Z432_V1MB_A
SW Version	2.0.0
Type of Modulation	GSM: GMSK GPRS: GMSK EDGE: GMSK / 8PSK WCDMA (Rel 99): QPSK HSDPA (Rel 5): QPSK Bluetooth: GFSK Bluetooth EDR: π/4-DQPSK, 8-DPSK
EUT Stage	Identical Prototype

List of Accessory:

Specification of Accessory		
Battery	**Brand Name**	ZTE
	Model Name	Li3709T42P3h504047

Remark: The above EUT's information was declared by manufacturer. Please refer to the specifications or user's manual for more detailed description.

List of air interfaces / frequency bands

Air Interface	Band (MHz)	Voice/Data	C63.19-2007 Tested	Concurrent connections	Reduced power 20.19 (c)(1)
GSM	850, 1900	Voice	Yes	Bluetooth	No
WCDMA	Band V, Band II	Data(*)	Yes	Bluetooth	No
Bluetooth	2450	Data	No	GSM, WCDMA	No

Note:

1. (*): The voice function maybe be activated via 3rd party software application.
2. Per KDB 285076 D01 v04)10)a), during T-Coil test, concurrent transmission is disabled.

3.2 Product Photos

Refer to Appendix C.

3.3 Applied Standards

The Standard ANSI C63.19:2007 represents performance requirements for acceptable interoperability of hearing aids with wireless communications devices. When these parameters are met, a hearing aid operates acceptably in close proximity to a wireless communications device.

3.4 Test Conditions

3.4.1 Ambient Condition

Ambient Temperature	20-24℃
Humidity	<60%
Acoustic Ambient Noise	>10dB below the measurement level

3.4.2 Test Configuration

The device was controlled by using a base station emulator R&S CMU200. Communication between the device and the emulator was established by coaxial connection. The DUT was set from the emulator to radiate maximum output power during all testing.

4. Hearing Aid Compliance (HAC)

4.1 Introduction

In September 2006, the T-Coil requirements of ANSI C63.19 Standard went into effect. The federal communication commission (FCC) adopted ANSI C63.19 as HAC test standard.

5. HAC T-Coil Measurement Setup

5.1 System Configuration

Fig. 5.1 T-Coil setup with HAC Test Arch and AMCC

The DASY system for performance compliance tests is illustrated above graphically. This system consists of the following items:

- A standard high precision 6-axis robot with controller, a teach pendant and software
- A data acquisition electronic (DAE) attached to the robot arm extension
- A dosimetric probe equipped with an optical surface detector system
- The electro-optical converter (EOC) performs the conversion between optical and electrical signals
- A measurement server performs the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the accuracy of the probe positioning
- A computer operating Windows XP
- DASY software
- Remove control with teach pendant and additional circuitry for robot safety such as warming lamps, etc.
- The SAM twin phantom
- A device holder
- Tissue simulating liquid
- Dipole for evaluating the proper functioning of the system

Some of the components are described in details in the following sub-sections.

5.2 AM1D Probe

The AM1D probe is an active probe with a single sensor. It is fully RF-shielded and has a rounded tip 6mm in diameter incorporating a pickup coil with its center offset 3mm from the tip and the sides. The symmetric signal preamplifier in the probe is fed via the shielded symmetric output cable from the AMMI with a 48V “phantom” voltage supply. The 7-pin connector on the back in the axis of the probe does not carry any signals. It is mounted to the DAE for the correct orientation of the sensor. If the probe axis is tilted 54.7 degree from the vertical, the sensor is approximately vertical when the signal connector is at the underside of the probe (cable hanging downwards).

Specification:

Frequency Range	0.1 ~ 20 kHz (RF sensitivity <-100dB, fully RF shielded)
Sensitivity	<-50dB A/m @ 1 kHz
Pre-amplifier	40 dB, symmetric
Dimensions	Tip diameter/ length: 6/ 290 mm, sensor according to ANSI-PC63.19

5.2.1 Probe Calibration in AMCC

The probe sensitivity at 1 kHz is 0.06556 V/(A/m) (-23.66 dBV/(A/m)) was calibrated by AMCC coil for verification of setup performance. The evaluated probe sensitivity was able to be compared to the calibration of the AM1D probe. The frequency response and sensitivity was shown in Fig. 5.2. The probe signal is represented after application of an ideal integrator. The green curve represents the current though the AMCC, the blue curve the integrated probe signal. The DIFFERENCE between the two curves is equivalent to the frequency response of the probe system and shows the characteristics. The probe/system complies with the frequency response and linearity requirements in C63.19 according to the Speag's calibrated report as shown in Annex B (AM1D probe: SPAM100AF) (1)The frequency response has been tested within +/- 0.5 dB of ideal differentiator from 100 Hz to 10 kHz. (2)The linearity has also been tested within 0.1dB from 5 dB below limitation to 16 dB above noise level. The AMCC coil is qualified according to certificate report, SDHACPO02A as shown in Annex B.

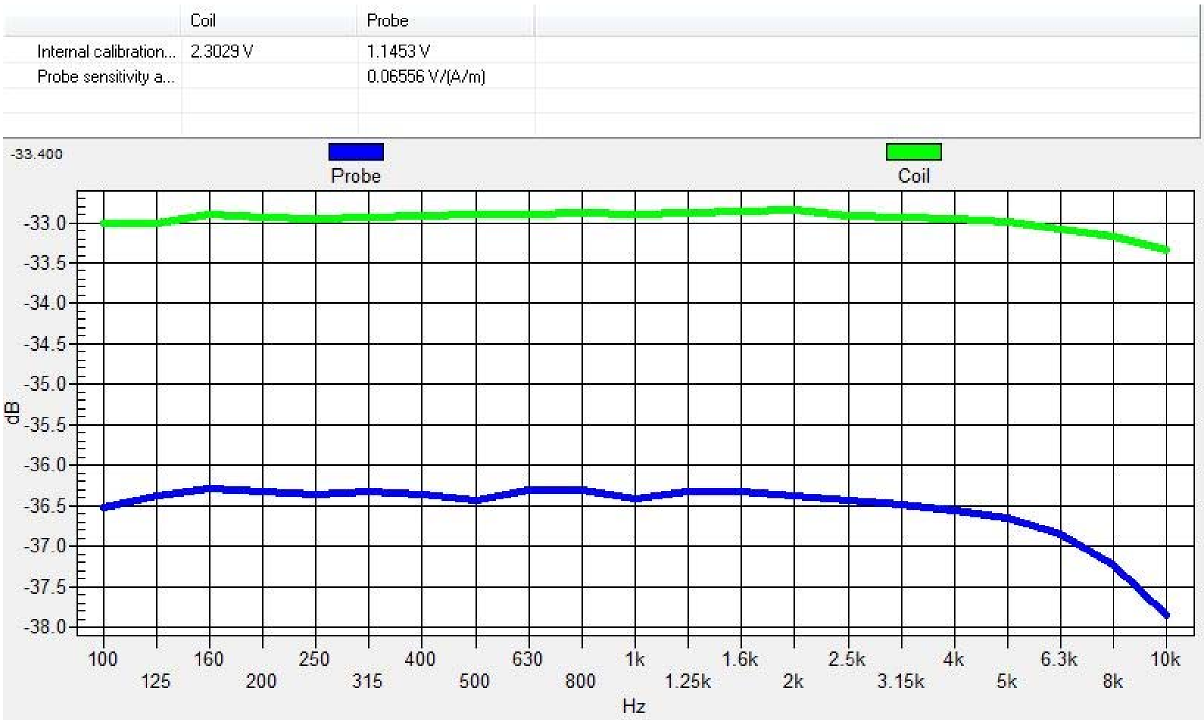


Fig. 5.2 The frequency response and sensitivity of AM1D probe

5.3 AMCC

The Audio Magnetic Calibration coil is a Helmholtz Coil designed for calibration of the AM1D probe. The two horizontal coils generate a homogeneous magnetic field in the z direction. The DC input resistance is adjusted by a series resistor to approximately 50Ohm, and a shunt resistor of 10 Ohm permits monitoring the current with a scale of 1:10.

Port description:

Signal	Connector	Resistance
Coil In	BNC	typically 50 Ohm
Coil Monitor	BNO	10Ohm ±1%(100mV corresponding to 1 A/m)

Specification:

Dimensions	370 x 370 x 196 mm, according to ANSI C63.19

5.4 AMMI

Fig. 5.3 AMMI front panel

The Audio Magnetic Measuring Instrument (AMMI) is a desktop 19-inch unit containing a sampling unit, a waveform generator for test and calibration signals, and a USB interface.

Specification:

Sampling rate	48 kHz/24 bit
Dynamic range	85 dB
Test signal generation	User selectable and predefined (vis PC)
Calibration	Auto-calibration/full system calibration using AMCC with monitor output
Dimensions	482 x 65 x 270 mm

5.5 DATA Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.

The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

Fig. 5.4 Photo of DAE

5.6 Robot

The SPEAG DASY system uses the high precision robots (DASY5: TX90XL) type from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY5: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ±0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)
- 6-axis controller

Fig. 5.5 Photo of DASY5

5.7 Measurement Server

The measurement server is based on a PC/104 CPU board with CPU (DASY5: 400 MHz, Intel Celeron), chipdisk (DASY5: 128 MB), RAM (DASY5: 128 MB). The necessary circuits for communication with the DAE electronic box, as well as the 16 bit AD converter system for optical detection and digital I/O interface are contained on the DASY I/O board, which is directly connected to the PC/104 bus of the CPU board.

The measurement server performs all the real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operations.

Fig. 5.6 Photo of Server for DASY5

5.8 Phone Positioner

The phone positioner shown in Fig. 5.9 is used to adjust DUT to the suitable position.

Fig. 5.7 Phone Positioner

5.9 Test Arch Phantom

Construction :	Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.	
Dimensions :	370 x 370 x 370 mm	**Fig. 5.8 Photo of Arch Phantom**

5.10 Cabling of System

The principal cabling of the T-Coil setup is shown in Fig. 5.11. All cables provided with the basic setup have a length of approximately 5 m.

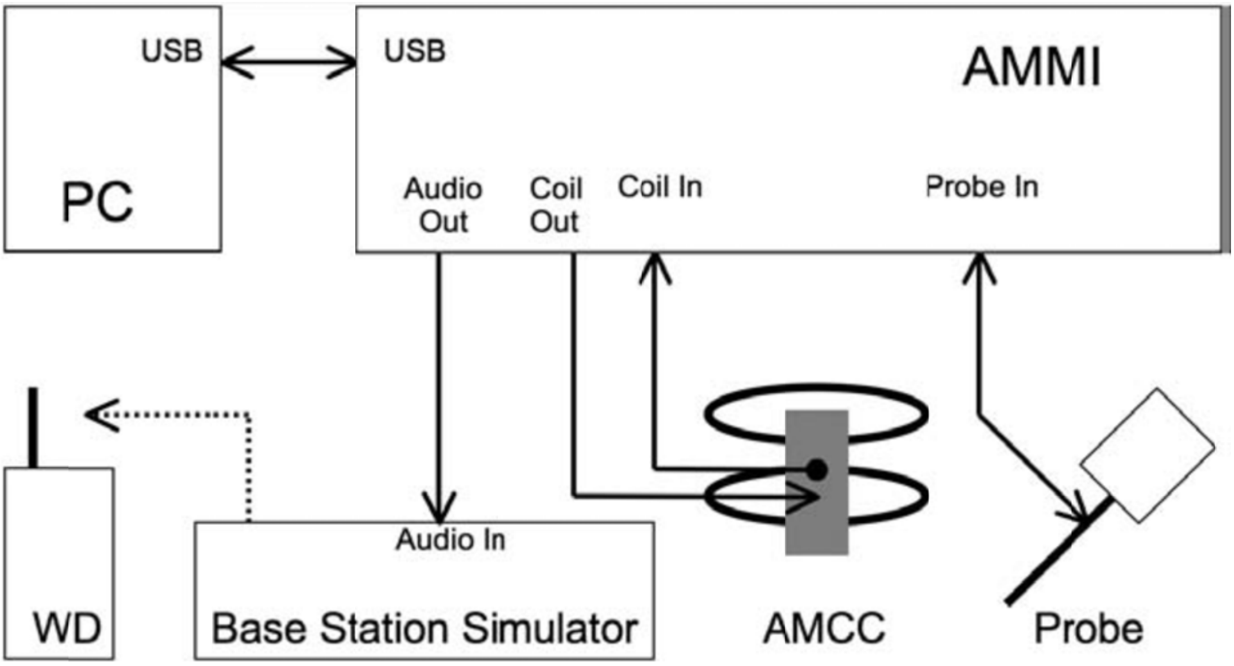


Fig. 5.9 T-Coil setup cabling

5.11 HAC Extension Software

Specification:

Precise teaching	Easy teaching with adaptive distance verification
Measurement area	Flexible selection of measurement area, predefined according to ANSI C63.19
Evaluation	ABM: spectral processing, filtering, weighting and evaluation according to ANSI C63.19
Report	Documentation ready for compliance report

5.12 Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Active Audio Magnetic Field Probe	AM1DV3	3106	Mar. 25, 2013	Mar. 24, 2014
SPEAG	Data Acquisition Electronics	DAE4	1303	Nov. 22, 2013	Nov. 21, 2014
SPEAG	Test Arch Phantom	Par phantom	1105	NCR	NCR
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR
R&S	Universal Radio Communication Tester	CMU200	112352	Nov. 12, 2013	Nov. 11, 2014
SPEAG	Audio Magnetic Measuring Instrument	AMMI	1137	NA	NA
SPEAG	Helmholtz calibration coil	AMCC	NA	NA	NA

Table 5.1 Test Equipment List

5.13 Reference Input of Audio Signal Spectrum

With the reference job "use as reference" in the beginning of a procedure, measure the spectrum of the current when applied to the AMCC, i.e. the input magnetic field spectrum, as shown below Fig. 5.12 and Fig. 5.13. For this, the delay of the window shall be set to a multiple of the signal period and at least 2s. From the measurement on the device, using the same signal, the postprocessor deducts the input spectrum, so the result represents the net DUT response.

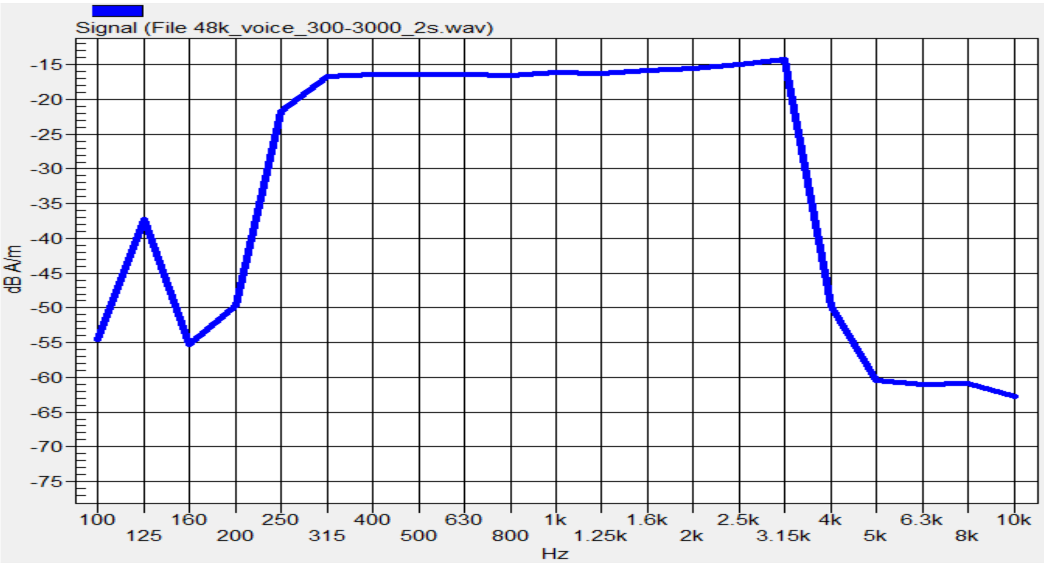


Fig. 5.12 Audio signal spectrum of the broadband signal (48kHz_voice_300Hz~3 kHz)

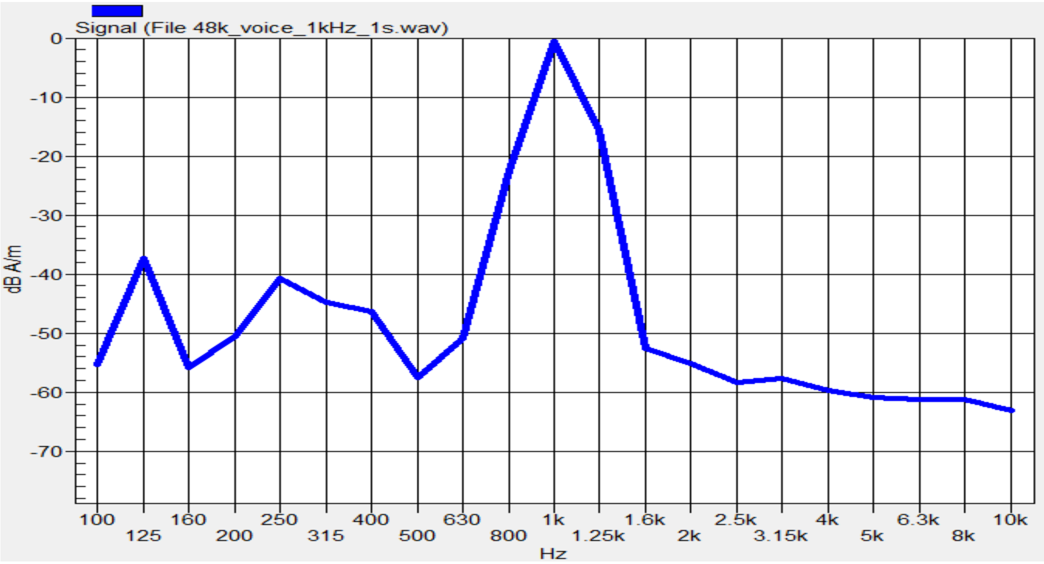


Fig. 5.13 Audio signal spectrum of the narrowband signal (48kHz_voice_1kHz)

5.14 Signal Verification

According to ANSI C63.19:2007 section 6.3.2.1, the normal speech input level for HAC T-coil tests shall be set to -16 dBm0 for GSM and UMTS (WCDMA), and to -18 dBm0 for CDMA. This technical note shows a possibility to evaluate and set the correct level with the HAC T-Coil setup with a Rohde&Schwarz communication tester CMU200 with audio option B52 and B85.

Establish a call from the CMU200 to a wireless device. Select CMU200 Network Bitstream "Decoder Cal" to have a 1 kHz signal with a level of 3.14 dBm0 at the speech output. Run the measurement job and read the voltage level at the multi-meter display "Coil signal". Read the RMS voltage corresponding to 3.14 dBm0 and note it. Calculate the desired signal levels of -16 dBm0:

3.14 dBm0 = -2.45 dBV
-16 dBm0 = -21.59 dBV

Determine the 1 kHz input level to generate the desired signal level of -16 dBm0. Select CMU200 Network Bitstream "Codec Cal" to loop the input via the codec to the output. Run the measurement job (AMMI 1 kHz signal with gain 10 inserted) and read the voltage level at the multimeter display "Coil signal". Calculate the required gain setting for the above levels:

Gain 10 = -20.07 dBV
Difference for -16 dBm0 = -21.59 - (-20.07) = -0.89 dB
Gain factor = 10 ^ ((-0.89) / 20) = -0.903
Resulting Gain = 10 x 0.903 = 9.03

The predefined signal types have the following differences / factors compared to the 1 kHz sine signal:

Signal Type	Duration (s)	Peak to RMS (dB)	RMS (dB)	Gain Factor	Gain Setting
48k_voice_1kHz	1	16.2	-12.7	4.33	39.08
48k_voice_300Hz~3kHz	2	21.6	-18.6	8.48	76.54

6. Description for DUT Testing Position

Fig.6.1 illustrate the references and reference plane that shall be used in a typical DUT emissions measurement. The principle of this section is applied to DUT with similar geometry. Please refer to Appendix D for the setup photographs.

- The area is 5 cm by 5 cm.
- The area is centered on the audio frequency output transducer of the DUT.
- The area is in a reference plane, which is defined as the planar area that contains the highest point in the area of the phone that normally rests against the user's ear. It is parallel to the centerline of the receiver area of the phone and is defined by the points of the receiver-end of the DUT handset, which, in normal handset use, rest against the ear.
- The measurement plane is parallel to, and 10 mm in front of, the reference plane.

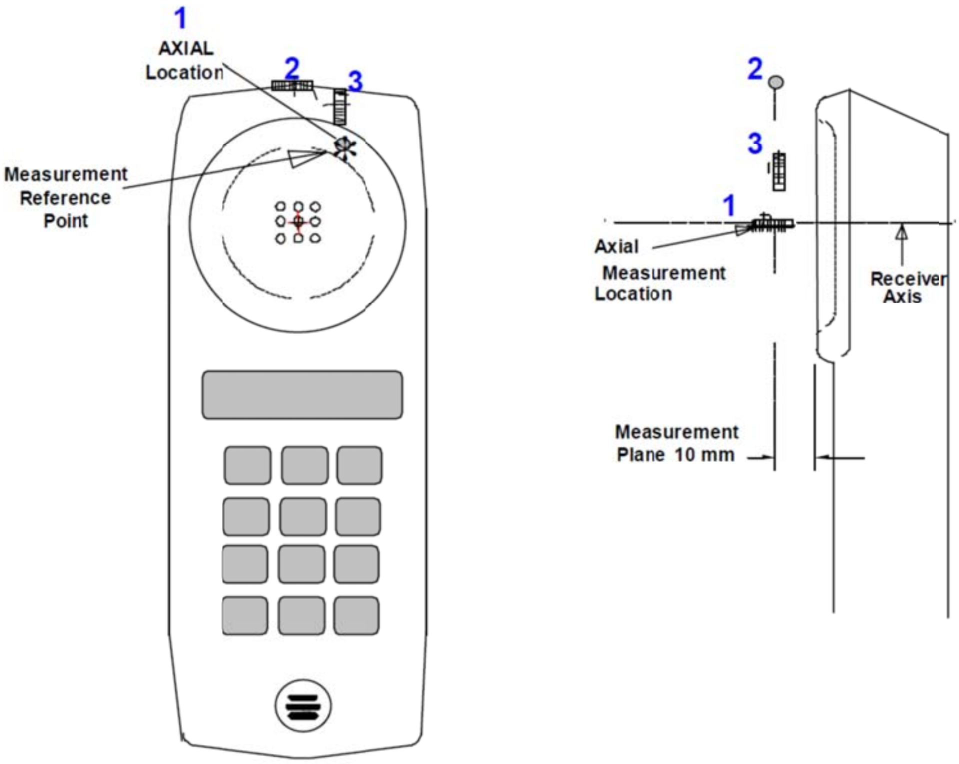


Fig 6.1 A typical DUT reference and plane for T-Coil measurements

7. T-Coil Test Procedure

The following illustrate a typical test scan over a wireless communications device:

1. Geometry and signal check: system probe alignment, proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the test Arch.
2. Set the reference drive level of signal voice defined in C63.19 per 6.3.2.1, as shown in this report of section 5.12.
3. The ambient and test system background noise (dB A/m) was measured as well as ABM2 over the full measurement. The maximum noise level must be at least 10dB below the limit of C63.19 per 7.3.2.
4. The DUT was positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.
5. The DUT operation for maximum rated RF output power was configured and connected by using of coaxial cable connection to the base station simulator at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The DUT audio output was positioned tangent (as physically possible) to the measurement plane.
6. The DUT's RF emission field was eliminated from T-coil results by using a well RF-shielding of the probe, AM1D, and by using of coaxial cable connection to a Base Station Simulator. One test channel was pre-measurement to avoid this possibility.
7. Determined the optimal measurement locations for the DUT by following the three steps, coarse resolution scan, fine resolution scans, and point measurement, as described in C63.19 per 6.3.4.4. At each measurement locations, samples in the measurement window duration were evaluated to get ABM1 and the signal spectrum. The noise measurement was performed after the scan with the signal, the same happened, just with the voice signal switched off. The ABM2 was calculated from this.

a) 5x5 cm scan z (axial) with narrowband voice signal and noise scan(for S/N)
b) Robot movement to point of the best S/N of the previous z (axial) scan, with wide band voice signal (allowing extraction of the frequency response) and noise measurement (to observe the S/N) (allowing later extraction of the frequency response).
c) 5x5 cm scan x (longitudinal) with narrowband voice signal and noise scan.
d) 5x5 cm scan y (lateral) with narrowband voice signal and noise scan.
With the above scans, full characterization according to the standard is possible. Optimum points can be found by interpolation from scans.
Other sequences allowing shorter scanning time are possible if the noise level in the periphery of the scanning area is not higher than at the axial point. Scanning with a short signal, without the noise and maybe in a limited area leads to the signal maximum in the neighborhood of the optimal point. The signal plus noise scans can then be limited to a small area or even points. The frequency response measurement need only be taken at the optimum z point (high S and S/N) with the wide band signal, because it should not depend on the location and be measured without low noise influence. Automatic probe positioning for this purpose is supported with the "Move to measured maximum" or "Move to interpolated maximum" command in order to anchor further T-Coil jobs to the

"current position" found.

8. All results resulting from a measurement point in a T-Coil job were calculated from the signal samples during this window interval. ABM values were averaged over the sequence of these samples.
9. At an optimal point measurement, the SNR (ABM1/ABM2) was calculated for axial, radial transverse and radial longitudinal orientation, and the frequency response was measured in axial axis.
10. Corrected for the frequency response after the DUT measurement since the DASY system had known the spectrum of the input signal by using a reference job, as shown in this report of section 5.12.
11. In SEMCAD post-processing, the spectral points are in addition scaled with the high-pass (half-band) and the A-weighting, bandwidth compensated factor (BWC) and those results are final as shown in this report.
12. Classified the signal quality based on the table 8.1: T-Coil Signal Quality Categories.

8. T-Coil Signal Quality Categories

This section provides the signal quality requirement for the intended T-Coil signal from a WD. Only the RF immunity of the hearing aid is measured in T-Coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. A device is assessed beginning by determining the category of the RF environment in the area of the T-Coil source.

The RF measurements made for the T-Coil evaluation are used to assign the category T1 through T4. The limitation is given in Table 8.1. This establishes the RF environment presented by the WD to a hearing aid.

Category	Telephone parameters WD signal quality ((signal + noise) to noise ratio in dB)
Category T1	0 to 10 dB
Category T2	10 to 20 dB
Category T3	20 to 30 dB
Category T4	> 30 dB

Table 8.1 T-Coil Signal Quality Categories

9. HAC T-Coil Test Results

9.1 Conducted Power (Unit: dBm)

Conducted Power (*Unit: dBm)						
Band	GSM850			GSM1900		
Channel	128	189	251	512	661	810
Frequency	824.2	836.4	848.8	1850.2	1880	1909.8
GSM (GMSK, 1 Tx slot)	**32.54**	32.52	32.42	29.30	29.64	**29.77**
GPRS (GMSK, 1 Tx slot) – CS1	32.46	32.43	32.31	29.29	29.57	29.71
GPRS (GMSK, 2 Tx slots) – CS1	30.94	30.92	30.82	27.74	28.03	28.18
EDGE (8PSK, 1 Tx slot) – MCS5	26.60	26.59	26.50	25.28	25.60	25.76
EDGE (8PSK, 2 Tx slots) – MCS5	25.11	25.09	25.01	23.77	24.08	24.23

Band	WCDMA Band V			WCDMA Band II		
Channel	4132	4182	4233	9262	9400	9538
Frequency	826.4	836.4	846.6	1852.4	1880.0	1907.6
AMR 12.2Kbps	22.75	22.93	22.84	23.07	23.65	23.74
RMC 12.2Kbps	22.76	**22.95**	22.86	23.09	23.68	**23.75**
HSDPA Subtest-1	20.73	21.05	20.84	21.27	21.65	21.74
HSDPA Subtest-2	20.60	20.98	20.88	21.23	21.58	21.73
HSDPA Subtest-3	20.63	21.01	20.92	21.23	21.61	21.75
HSDPA Subtest-4	20.60	20.96	20.78	21.22	21.71	21.77

9.2 Magnitude Result

The Table 9.1 shows testing result in position coordinates which are defined as deviation from earpiece center in millimeters. Axial measurement location was defined by the manufacture of the device. Signal strength measurement scans are presented in appendix A.

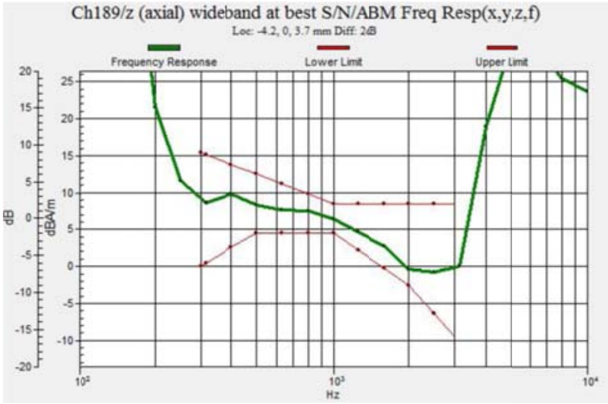
Plot No.	Band	Channel	Probe Position	ABM2 (dB A/m)	ABM1 (dB A/m)	SNR (dB)	T Rating
#01	GSM850	189	Axial (Z)	6.64	-25.29	31.93	T4
			Radial 1 (X)	**1.06**	**-21.98**	**23.04**	**T3**
			Radial 2 (Y)	-1.43	-37.96	36.53	T4
#02	GSM1900	661	Axial (Z)	8.63	-26.35	34.98	T4
			Radial 1 (X)	**1.11**	**-24.59**	**25.70**	**T3**
			Radial 2 (Y)	-0.85	-41.93	41.08	T4
#03	WCDMA Band V	4182	Axial (Z)	8.76	-40.55	49.31	T4
			Radial 1 (X)	**0.83**	**-45.64**	**46.47**	**T4**
			Radial 2 (Y)	-0.47	-48.51	48.04	T4
#04	WCDMA Band II	9400	Axial (Z)	6.39	-41.95	48.34	T4
			Radial 1 (X)	**0.97**	**-45.04**	**46.01**	**T4**
			Radial 2 (Y)	1.29	-47.34	48.63	T4

Table 9.1 Test Result for Various Positions

Remark:

1. There is no special HAC mode software on this DUT.
2. The volume was adjusted to maximum level and the backlight turned off during T-Coil testing.
3. Test Engineer：Luke Lu

9.3 Frequency Response Plots



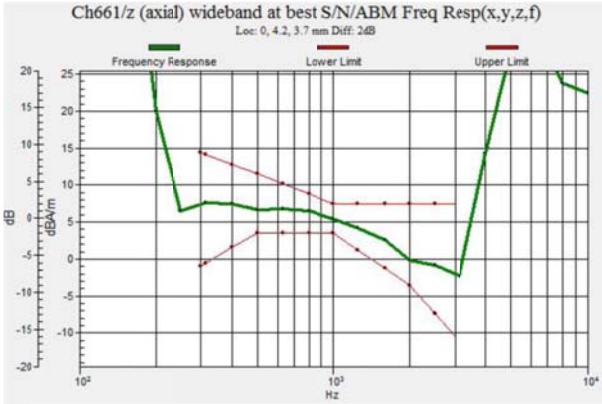
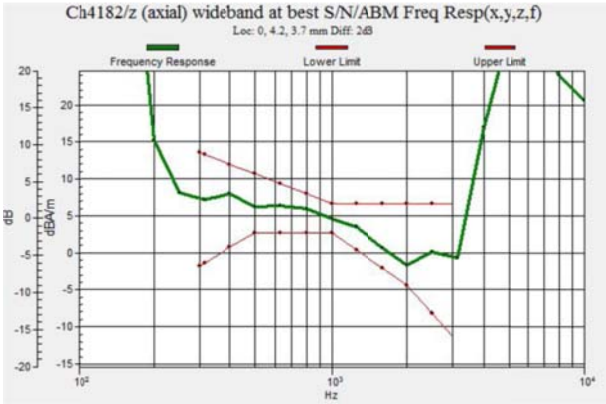


Fig 9.1 GSM850 Ch189

Fig 9.2 GSM1900 Ch661



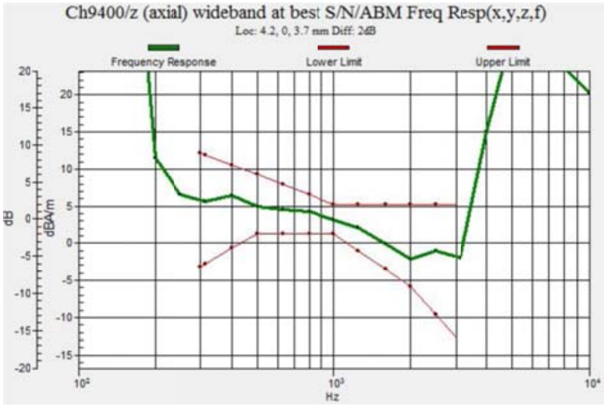


Fig 9.3 WCDMA Band V Ch4182

Fig 9.4 WCDMA Band II Ch9400

9.4 T-Coil Coupling Field Intensity

9.4.1 Axial Field Intensity

Cell Phone Mode	Minimum limit (dB A/m)	Result (dB A/m)	Verdict
GSM850	-18	6.64	Pass
GSM1900	-18	8.63	Pass
WCDMA Band V	-18	8.76	Pass
WCDMA Band II	-18	6.39	Pass

9.4.2 Radial Field Intensity

Cell Phone Mode	Minimum limit (dB A/m)	Result (dB A/m)	Verdict
GSM850	-18	-1.43	Pass
GSM1900	-18	-0.85	Pass
WCDMA Band V	-18	-0.47	Pass
WCDMA Band II	-18	0.97	Pass

9.4.3 Frequency Response at Axial Measurement Point

Cell Phone Mode	Verdict
GSM850	Pass
GSM1900	Pass
WCDMA Band V	Pass
WCDMA Band II	Pass

9.4.4 Signal Quality

Cell Phone Mode	Minimum limit (dB)				Minimum Result (dB)	Verdict
	T1	T2	T3	T4		
GSM850	0	10	20	>30	23.04	T3
GSM1900	0	10	20	>30	25.70	T3
WCDMA Band V	0	10	20	>30	46.47	T4
WCDMA Band II	0	10	20	>30	46.01	T4

10. Uncertainty Assessment

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in Table 10.1.

Uncertainty Distributions	Normal	Rectangular	Triangular	U-shape
Multiplying factor[(a)]	1/k [(b)]	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) κ is the coverage factor

Table 10.1 Multiplying Factions for Various Distributions

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is showed in Table 10.2.

Error Description	Uncertainty Value (±%)	Probability Distribution	Divisor	Ci (ABM1)	Ci (ABM2)	Standard Uncertainty (ABM1)	Standard Uncertainty (ABM2)
Probe Sensitivity							
Reference Level	3.0	Normal	1	1	1	± 3.0 %	± 3.0 %
AMCC Geometry	0.4	Rectangular	√3	1	1	± 0.2 %	± 0.2 %
AMCC Current	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Probe Positioning During Calibrate	0.1	Rectangular	√3	1	1	± 0.1 %	± 0.1 %
Noise Contribution	0.7	Rectangular	√3	0.0143	1	± 0.0 %	± 0.4 %
Frequency Slope	5.9	Rectangular	√3	0.1	1	± 0.3 %	± 3.5 %
Probe System							
Repeatability / Drift	1.0	Rectangular	√3	1	1	± 0.6 %	± 0.6 %
Linearity / Dynamic Range	0.6	Rectangular	√3	1	1	± 0.4 %	± 0.4 %
Acoustic Noise	1.0	Rectangular	√3	0.1	1	± 0.1 %	± 0.6 %
Probe Angle	2.3	Rectangular	√3	1	1	± 1.4 %	± 1.4 %
Spectral Processing	0.9	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
Integration Time	0.6	Normal	1	1	5	± 0.6 %	± 3.0 %
Field Disturbation	0.2	Rectangular	√3	1	1	± 0.1 %	± 0.1 %
Test Signal							
Reference Signal Spectral Response	0.6	Rectangular	√3	0	1	± 0.0 %	± 0.4 %
Positioning							
Probe Positioning	1.9	Rectangular	√3	1	1	± 1.1 %	± 1.1 %
Phantom Thickness	0.9	Rectangular	√3	1	1	± 0.5 %	± 0.5 %
DUT Positioning	1.9	Rectangular	√3	1	1	± 1.1 %	± 1.1 %
External Contributions							
RF Interference	0.0	Rectangular	√3	1	0.3	± 0.0 %	± 0.0 %
Test Signal Variation	2.0	Rectangular	√3	1	1	± 1.2 %	± 1.2 %
Combined Standard Uncertainty						± 4.1 %	± 6.1 %
Coverage Factor for 95 %						K = 2	
Expanded Uncertainty						**± 8.1 %**	**± 12.3 %**

Table 10.2 Uncertainty Budget of DASY

11. References

[1] ANSI C63.19 2007, "American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", 8 June 2007
[2] SPEAG DASY System Handbook

Appendix A. Plots of T-Coil Measurement

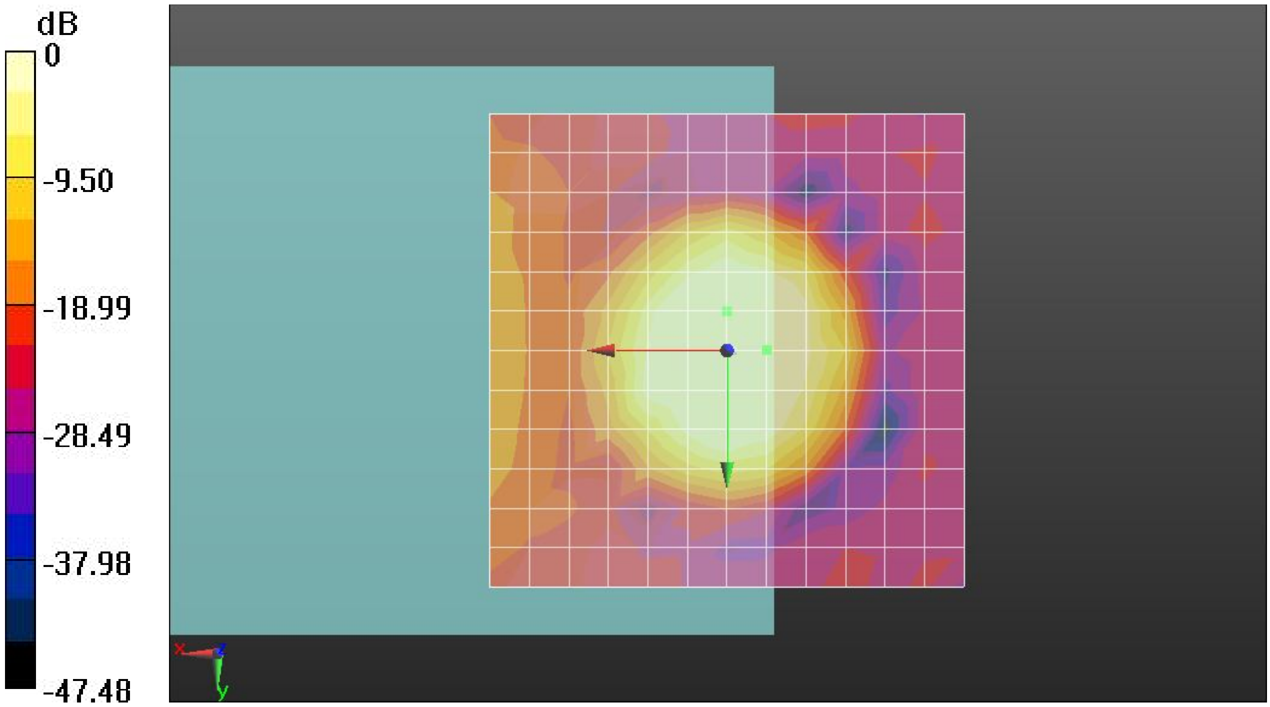
The plots are shown as follows.

#01 HAC T-Coil_GSM850_GSM Voice_Ch189_Z

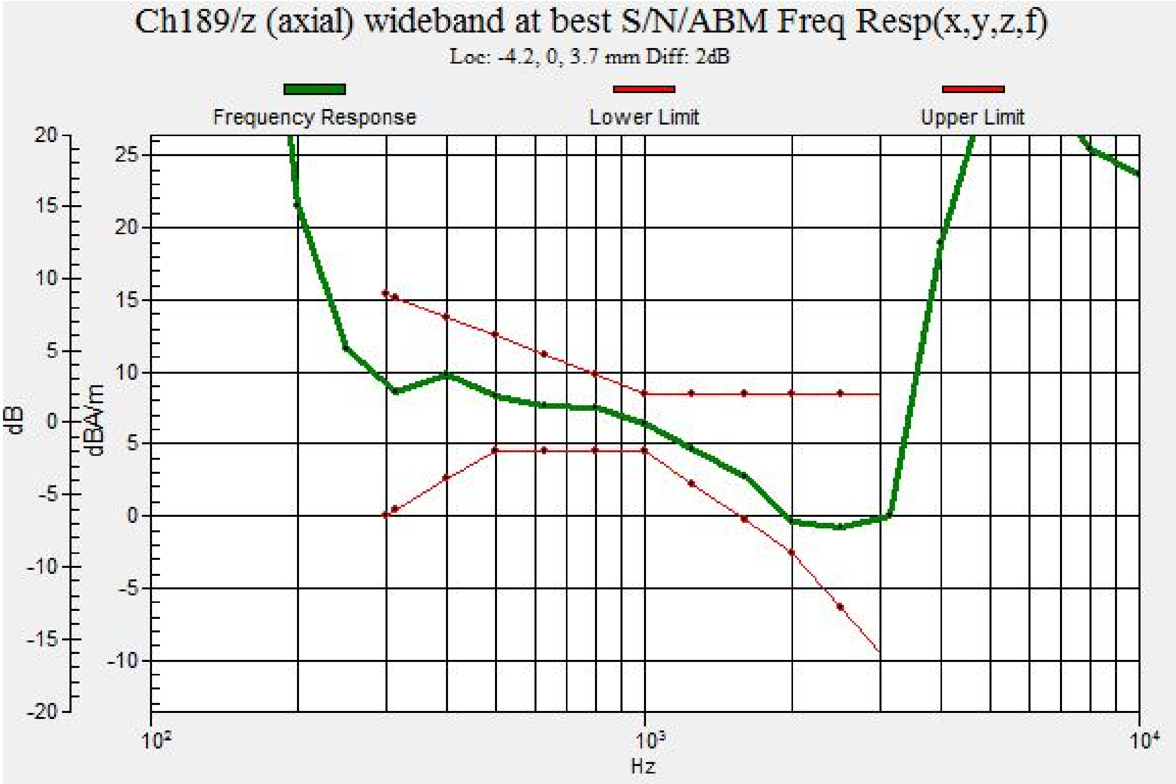
Communication System: UID 0, Generic GSM (0); Frequency: 836.4 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch189/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 31.93 dB
ABM1 comp = 6.64 dBA/m
BWC Factor = 0.16 dB
Location: -4.2, 0, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m



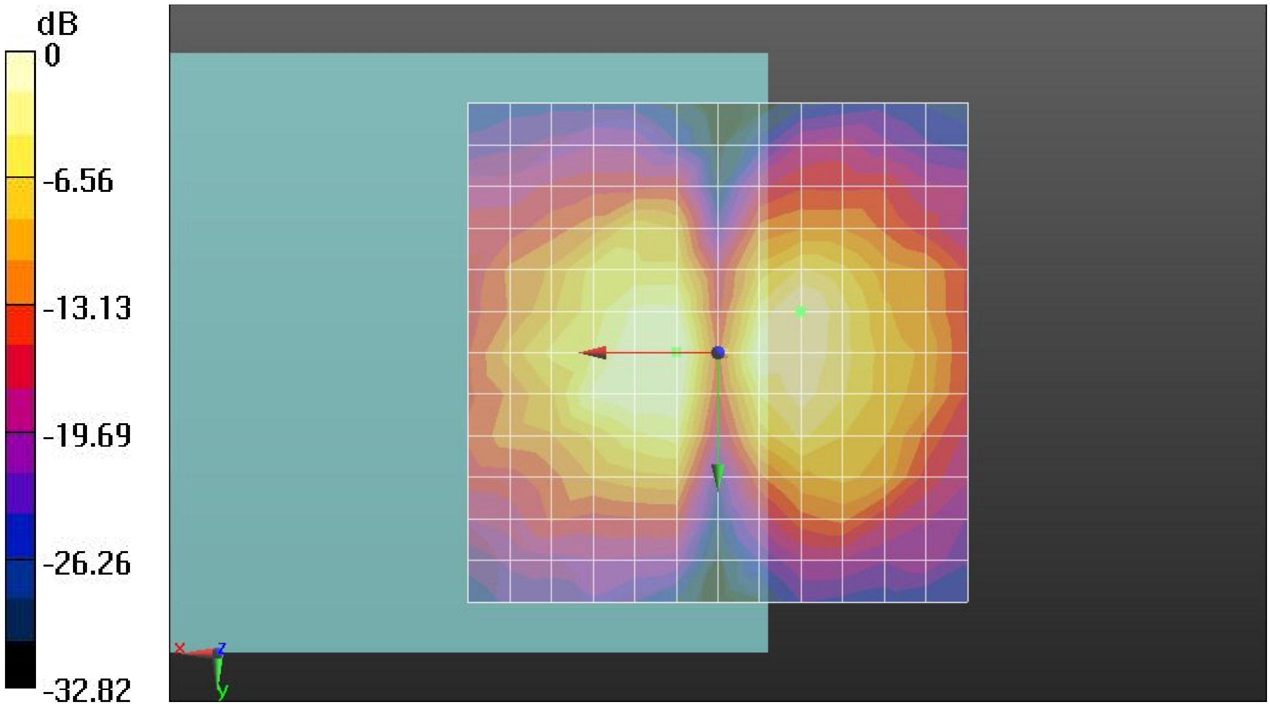
Ch189/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: -4.2, 0, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

#01 HAC T-Coil_GSM850_GSM Voice_Ch189_X

Communication System: UID 0, Generic GSM (0); Frequency: 836.4 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: σ = 0 S/m, ε_r = 1; ρ = 0 kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch189/x (longitudinal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 23.04 dB
ABM1 comp = 1.06 dBA/m
BWC Factor = 0.16 dB
Location: -8.3, -4.2, 3.7 mm



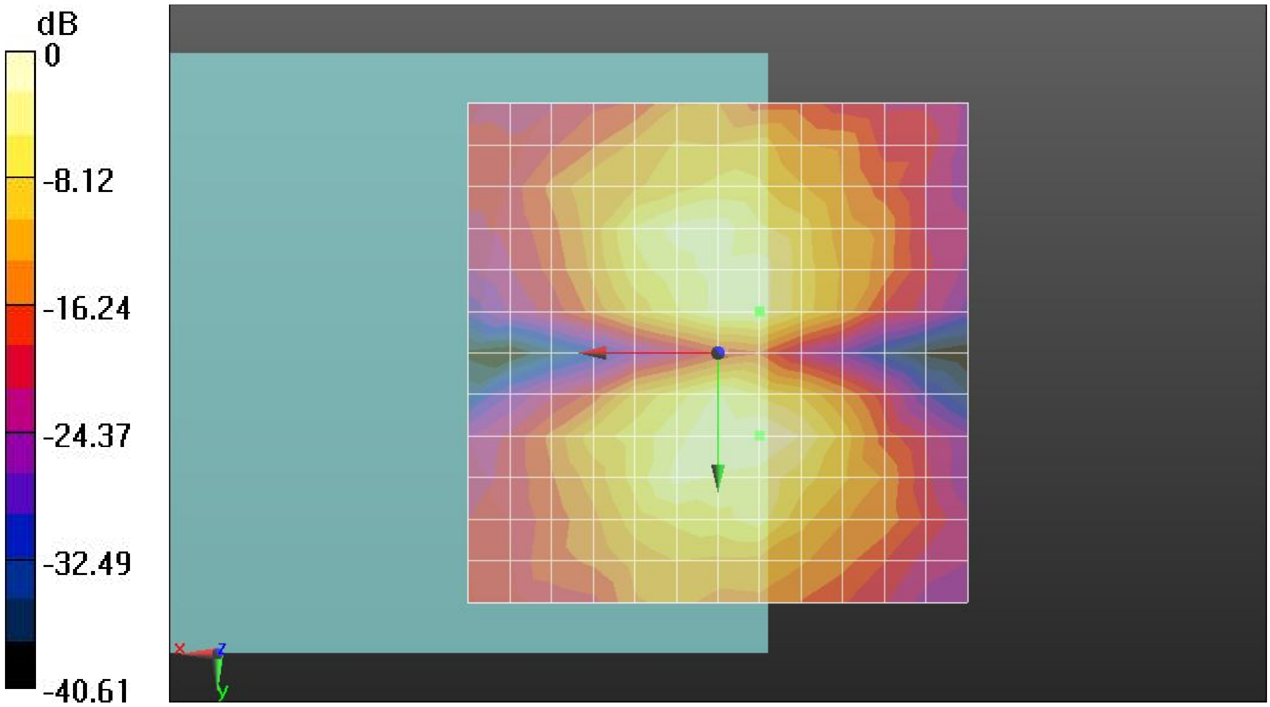
0 dB = 1.000 A/m = 0.00 dBA/m

#01 HAC T-Coil_GSM850_GSM Voice_Ch189_Y

Communication System: UID 0, Generic GSM (0); Frequency: 836.4 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch189/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 36.53 dB
ABM1 comp = -1.43 dBA/m
BWC Factor = 0.16 dB
Location: -4.2, -4.2, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m

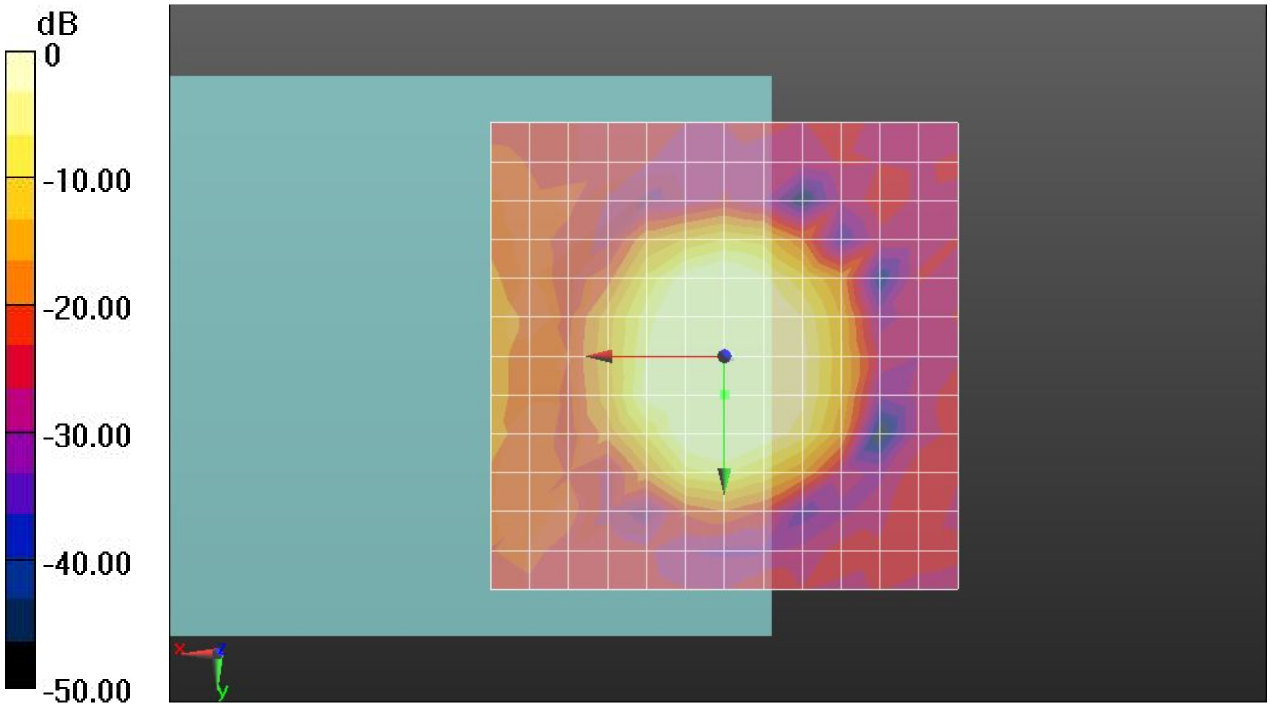
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2014.02.13

#02 HAC T-Coil_GSM1900_GSM Voice_Ch661_Z

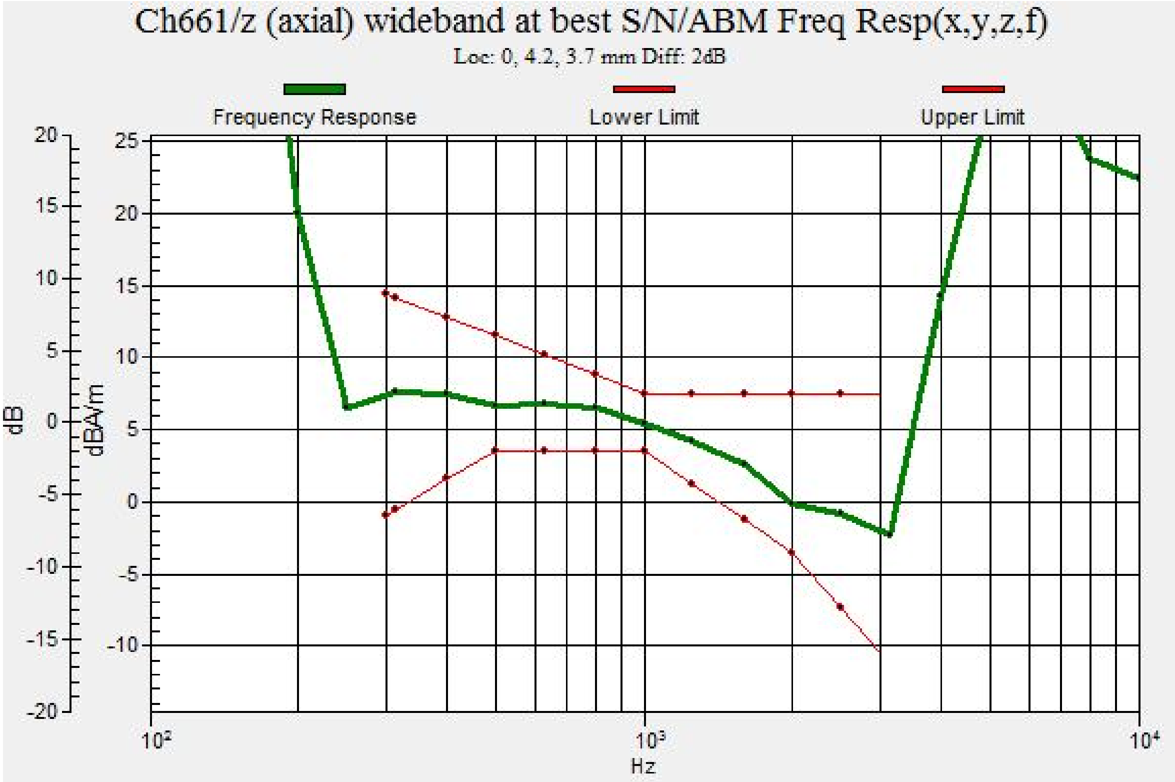
Communication System: UID 0, Generic GSM (0); Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch661/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 34.98 dB
ABM1 comp = 8.63 dBA/m
BWC Factor = 0.16 dB
Location: 0, 4.2, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m



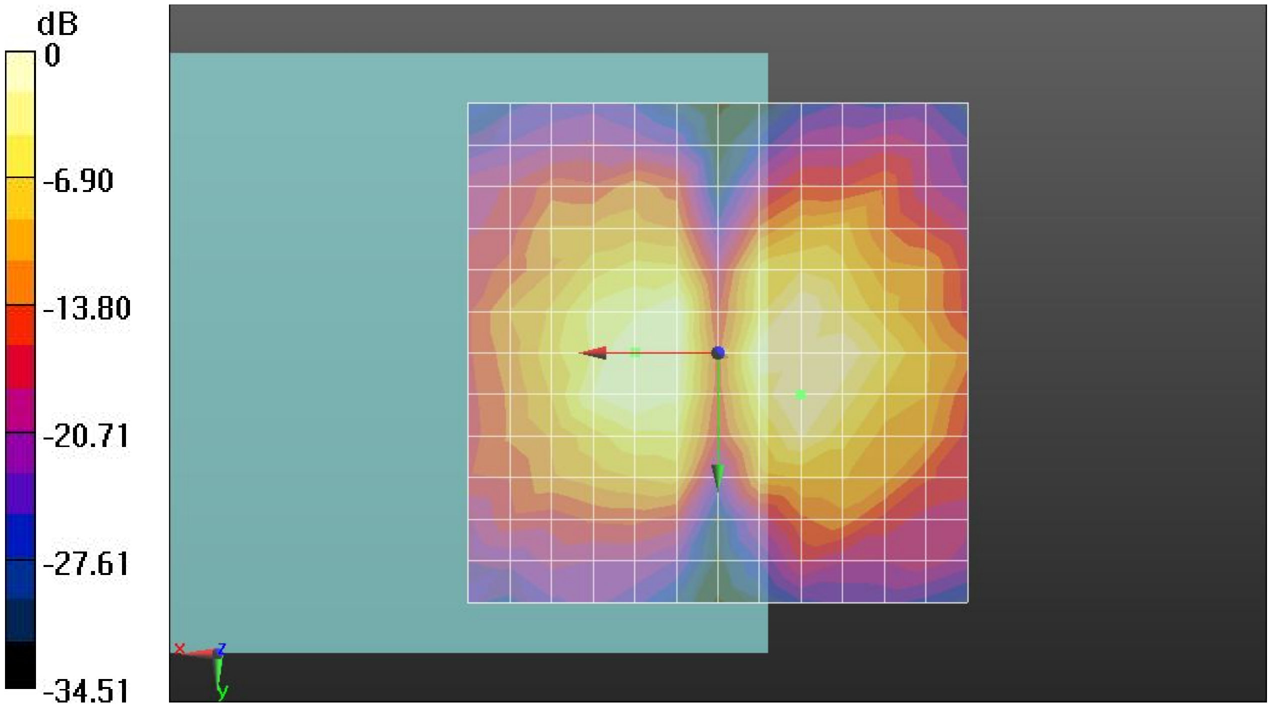
Ch661/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, 4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

#02 HAC T-Coil_GSM1900_GSM Voice_Ch661_X

Communication System: UID 0, Generic GSM (0); Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch661/x (longitudinal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 25.70 dB
ABM1 comp = 1.11 dBA/m
BWC Factor = 0.16 dB
Location: -8.3, 4.2, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m

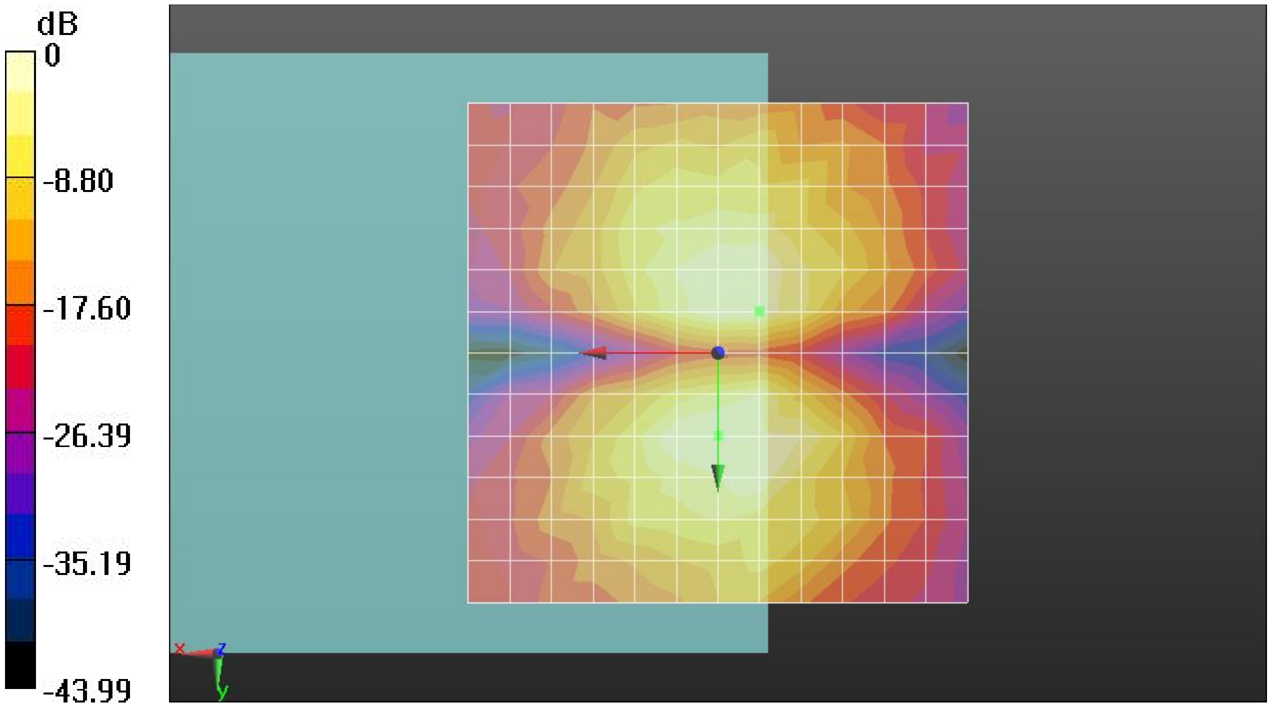
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2014.02.13

#02 HAC T-Coil_GSM1900_GSM Voice_Ch661_Y

Communication System: UID 0, Generic GSM (0); Frequency: 1880 MHz;Duty Cycle: 1:8.3
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch661/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 41.08 dB
ABM1 comp = -0.85 dBA/m
BWC Factor = 0.16 dB
Location: -4.2, -4.2, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m

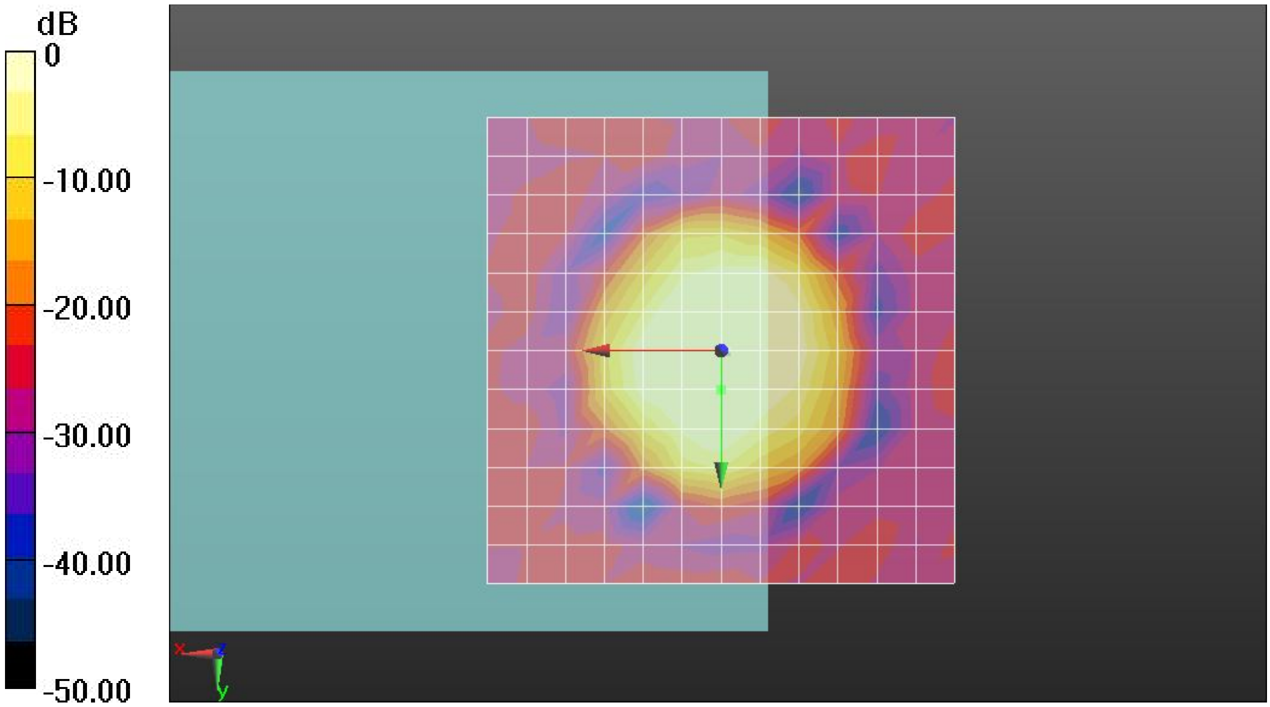
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2014.02.13

#03 HAC T-Coil_WCDMA Band V_Voice_Ch4182_Z

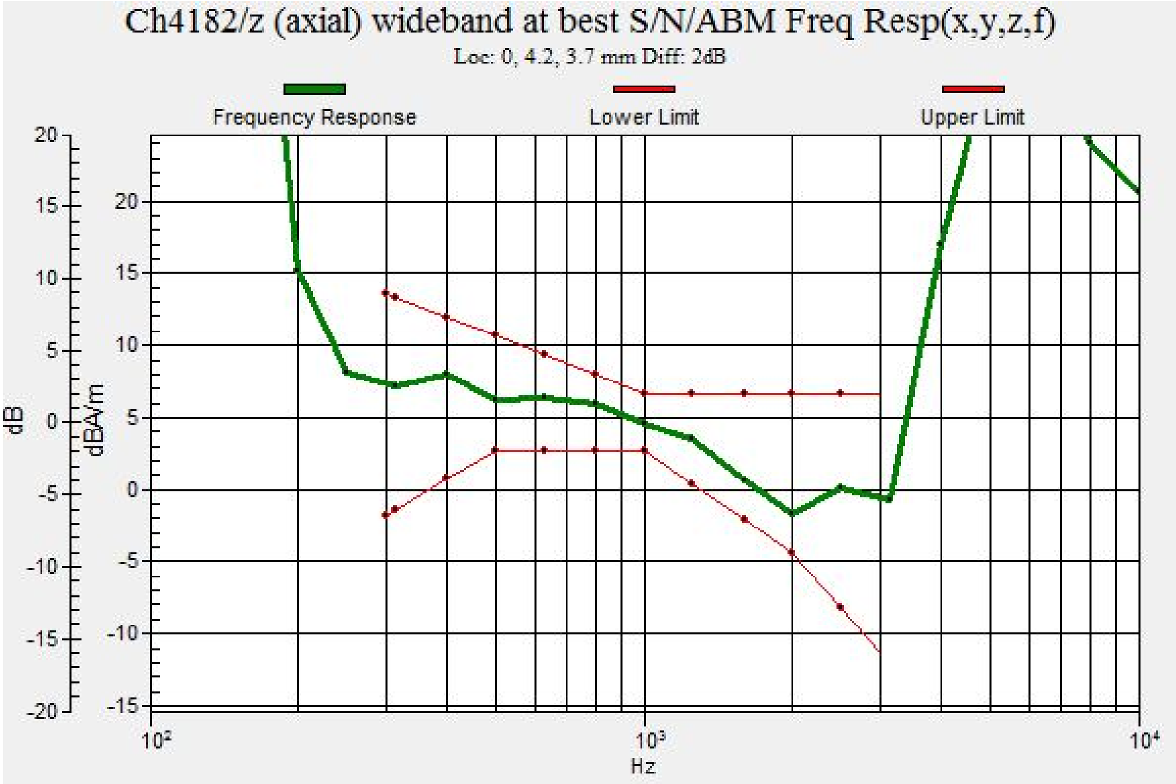
Communication System: UID 0, UMTS (0); Frequency: 836.4 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch4182/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 49.31 dB
ABM1 comp = 8.76 dBA/m
BWC Factor = 0.16 dB
Location: 0, 4.2, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m



Ch4182/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 0, 4.2, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
Hz

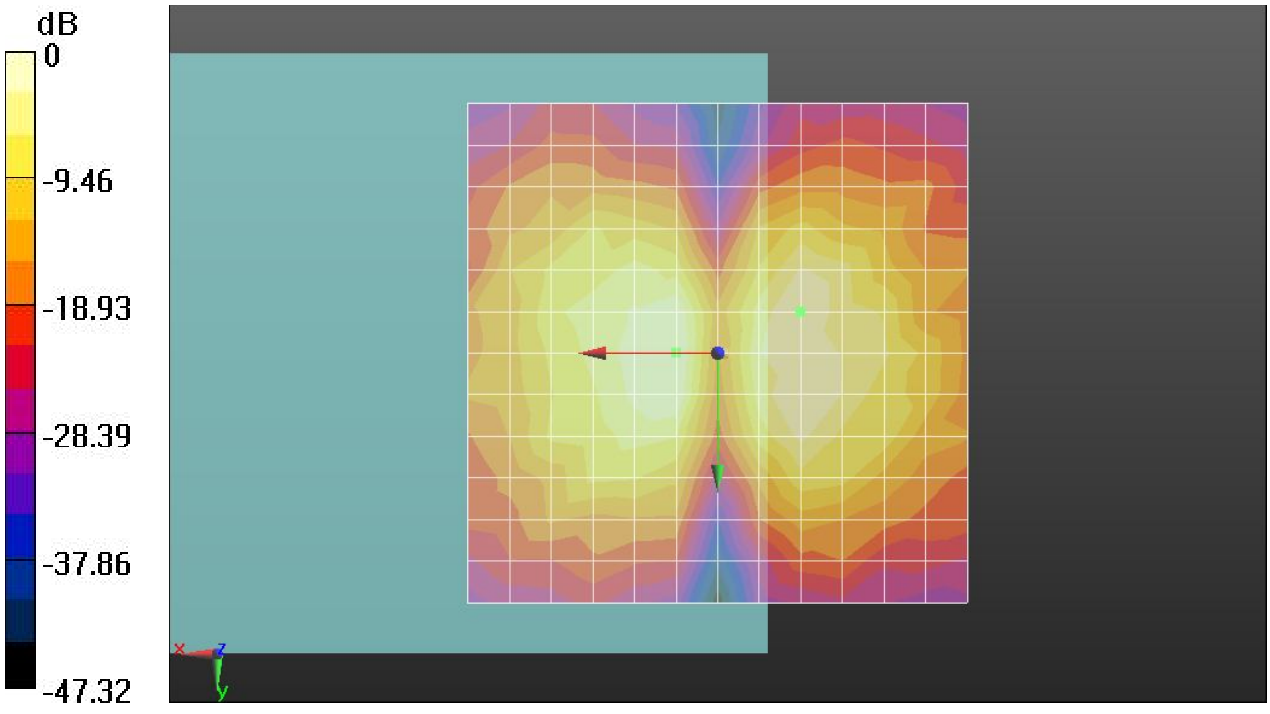
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2014.02.13

#03 HAC T-Coil_WCDMA Band V_Voice_Ch4182_X

Communication System: UID 0, UMTS (0); Frequency: 836.4 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch4182/x (longitudinal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 46.47 dB
ABM1 comp = 0.83 dBA/m
BWC Factor = 0.16 dB
Location: -8.3, -4.2, 3.7 mm



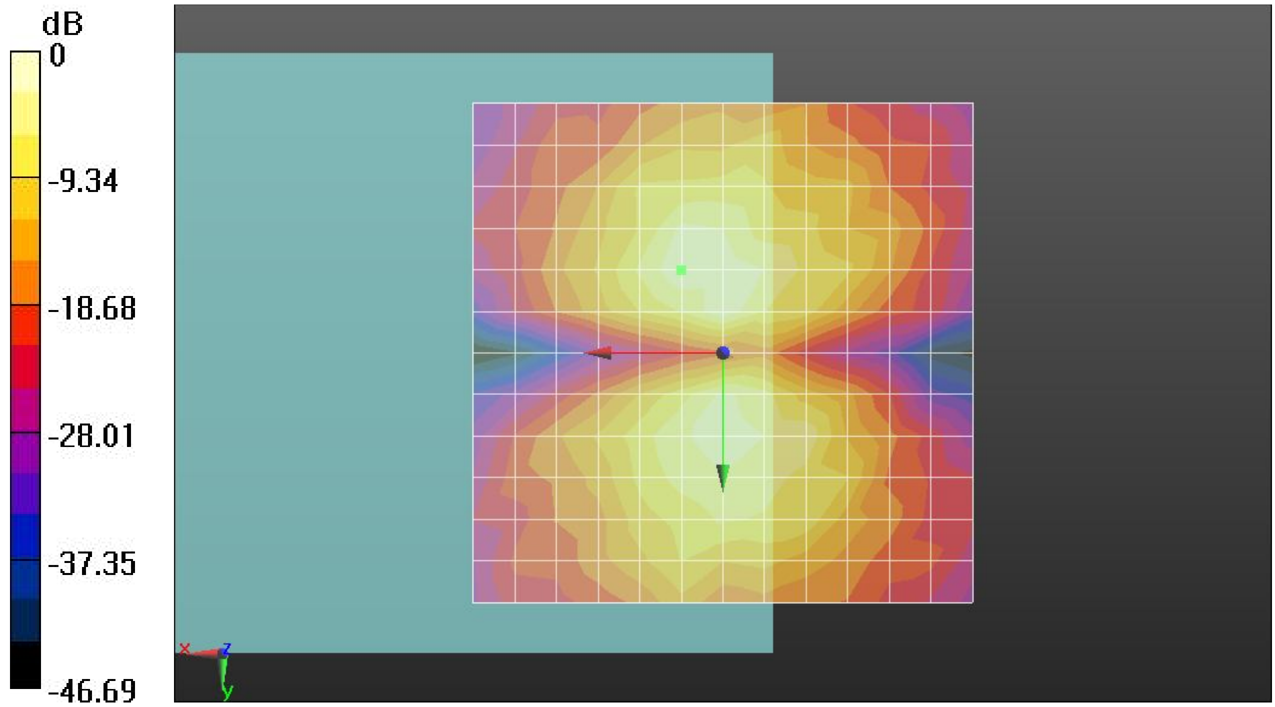
0 dB = 1.000 A/m = 0.00 dBA/m

#03 HAC T-Coil_WCDMA Band V_Voice_Ch4182_Y

Communication System: UID 0, UMTS (0); Frequency: 836.4 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch4182/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 48.04 dB
ABM1 comp = -0.47 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, -8.3, 3.7 mm



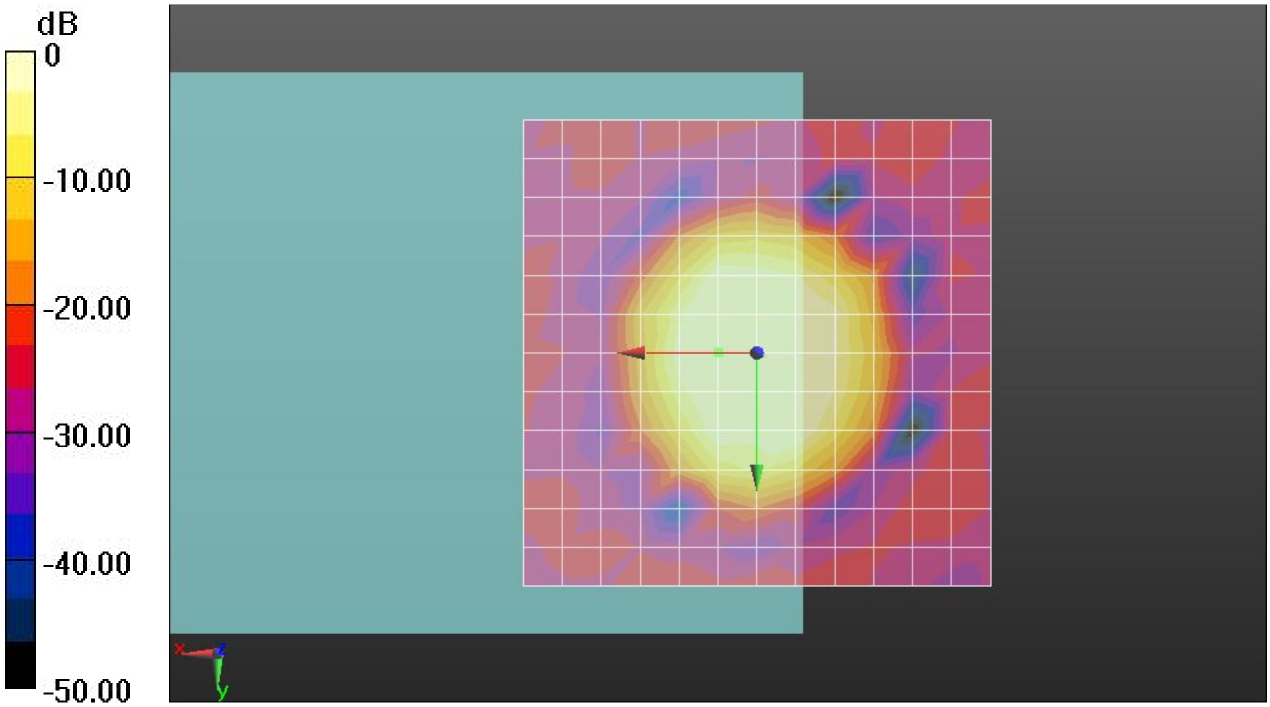
0 dB = 1.000 A/m = 0.00 dBA/m

#04 HAC T-Coil_WCDMA Band II_Voice_Ch9400_Z

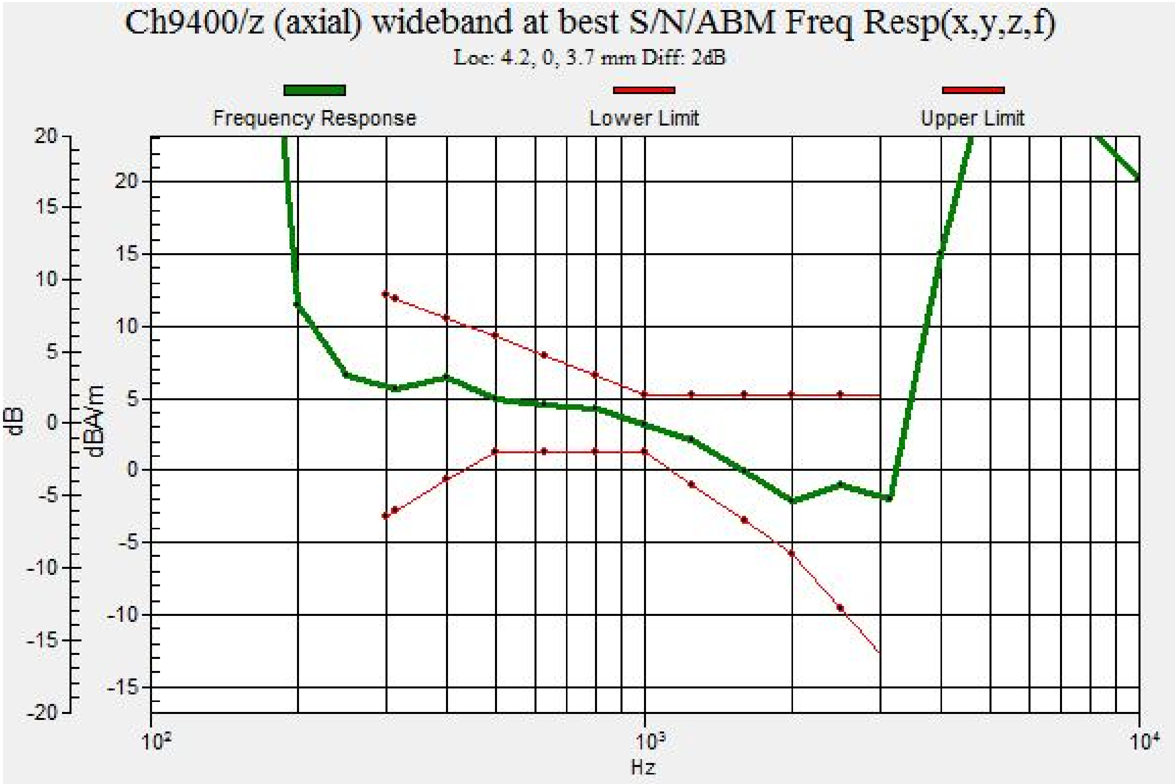
Communication System: UID 0, UMTS (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch9400/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 48.34 dB
ABM1 comp = 6.39 dBA/m
BWC Factor = 0.16 dB
Location: 4.2, 0, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m



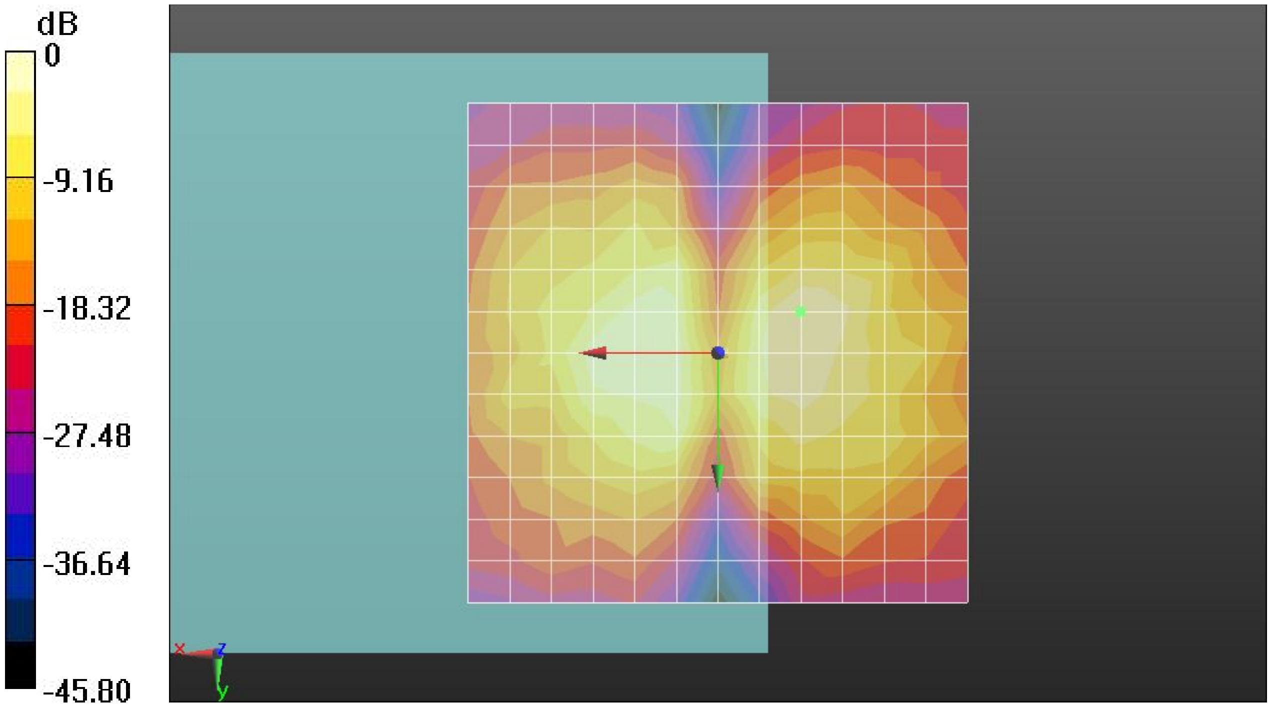
Ch9400/z (axial) wideband at best S/N/ABM Freq Resp(x,y,z,f)
Loc: 4.2, 0, 3.7 mm Diff: 2dB
Frequency Response
Lower Limit
Upper Limit
dB
dBA/m
20
15
10
5
0
-5
-10
-15
-20
Hz
10^2
10^3
10^4

#04 HAC T-Coil_WCDMA Band II_Voice_Ch9400_X

Communication System: UID 0, UMTS (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch9400/x (longitudinal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 46.01 dB
ABM1 comp = 0.97 dBA/m
BWC Factor = 0.16 dB
Location: -8.3, -4.2, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m

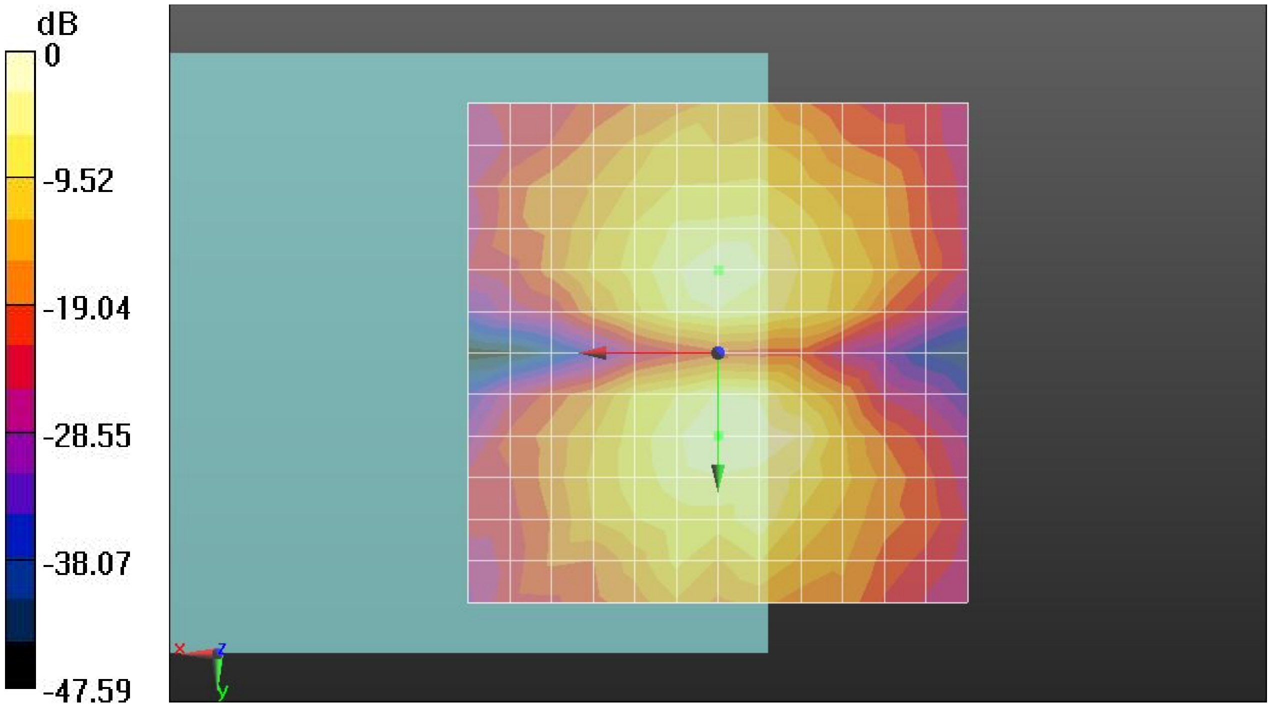
Test Laboratory: Sporton International Inc. SAR/HAC Testing Lab Date: 2014.02.13

#04 HAC T-Coil_WCDMA Band II_Voice_Ch9400_Y

Communication System: UID 0, UMTS (0); Frequency: 1880 MHz;Duty Cycle: 1:1
Medium: Air Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 0$ kg/m^3
Ambient Temperature：23.5 ℃

DASY5 Configuration:
- Probe: AM1DV3 - 3106; ; Calibrated: 2013.03.25
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1303; Calibrated: 2013.11.22
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BA;
- Measurement SW: DASY52, Version 52.8 (7); SEMCAD X Version 14.6.10 (7164)

Ch9400/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1): Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 48.63 dB
ABM1 comp = 1.29 dBA/m
BWC Factor = 0.16 dB
Location: 0, 8.3, 3.7 mm



0 dB = 1.000 A/m = 0.00 dBA/m

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 108**

Client **Sporton-SZ (Auden)**

Certificate No: **AM1DV3-3106_Mar13**

CALIBRATION CERTIFICATE

Object	AM1DV3 - SN: 3106
Calibration procedure(s)	QA CAL-24.v3 Calibration procedure for AM1D magnetic field probes and TMFS in the audio range
Calibration date:	March 25, 2013

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	02-Oct-12 (No:12728)	Oct-13
Reference Probe AM1DV2	SN: 1008	10-Jan-13 (No. AM1D-1008_Jan13)	Jan-14
DAE4	SN: 781	29-May-12 (No. DAE4-781_May12)	May-13

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	1050	12-Oct-11 (in house check Oct-11)	Oct-13
AMMI Audio Measuring Instrument	1062	26-Sep-12 (in house check Sep-12)	Sep-14

	Name	Function	Signature
Calibrated by:	Claudio Leubler	Laboratory Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	F. Bomholt

Issued: March 25, 2013

References

[1] ANSI C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[2] 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]. 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] 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 [2], 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 BB
Serial No	**3106**

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	June 10, 2011
Last calibration date	March 13, 2012

Calibration data

Connector rotation angle	(in DASY system)	**231.3** °	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**- 0.28** °	+/- 0.5 ° (k=2)
Sensitivity at 1 kHz	(in DASY system)	**0.00786 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%.

Schmid & Partner Engineering AG

s p e a g

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IMPORTANT NOTICE

USAGE OF THE DAE 4

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 closed 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 108

Client **Sporton - KS (Auden)**

Certificate No: DAE4-1303_Nov13

CALIBRATION CERTIFICATE

Object: DAE4 - SD 000 D04 BM - SN: 1303

Calibration procedure(s): QA CAL-06.v26
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: November 22, 2013

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	01-Oct-13 (No:13976)	Oct-14
Secondary Standards	**ID #**	**Check Date (in house)**	**Scheduled Check**
Auto DAE Calibration Unit	SE UWS 053 AA 1001	07-Jan-13 (in house check)	In house check: Jan-14
Calibrator Box V2.1	SE UMS 006 AA 1002	07-Jan-13 (in house check)	In house check: Jan-14

	Name	Function	Signature
Calibrated by:	Eric Hainfeld	Technician	
Approved by:	Fin Bomholt	Deputy Technical Manager	

Issued: November 22, 2013

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	405.599 ± 0.02% (k=2)	403.486 ± 0.02% (k=2)	404.930 ± 0.02% (k=2)
Low Range	3.96509 ± 1.50% (k=2)	3.99387 ± 1.50% (k=2)	3.98737 ± 1.50% (k=2)

Connector Angle

Connector Angle to be used in DASY system	96.5 ° ± 1 °

Appendix

1. DC Voltage Linearity

High Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	199995.72	-1.74	-0.00
Channel X	+ Input	20003.85	2.70	0.01
Channel X	- Input	-19998.74	1.79	-0.01
Channel Y	+ Input	199996.92	-0.72	-0.00
Channel Y	+ Input	19998.82	-2.29	-0.01
Channel Y	- Input	-20001.53	-1.03	0.01
Channel Z	+ Input	199997.58	-0.04	-0.00
Channel Z	+ Input	20000.58	-0.54	-0.00
Channel Z	- Input	-20001.75	-1.16	0.01

Low Range		Reading (μV)	Difference (μV)	Error (%)
Channel X	+ Input	2001.54	0.26	0.01
Channel X	+ Input	202.49	0.85	0.42
Channel X	- Input	-197.26	0.85	-0.43
Channel Y	+ Input	2001.47	0.25	0.01
Channel Y	+ Input	200.98	-0.76	-0.38
Channel Y	- Input	-199.10	-0.95	0.48
Channel Z	+ Input	2001.84	0.65	0.03
Channel Z	+ Input	201.81	0.14	0.07
Channel Z	- Input	-199.07	-0.81	0.41

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	8.76	7.24
	- 200	-5.31	-7.17
Channel Y	200	4.82	4.75
	- 200	-7.49	-7.67
Channel Z	200	-3.55	-3.50
	- 200	2.95	3.03

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	-	0.81	-4.10
Channel Y	200	7.90	-	2.59
Channel Z	200	9.41	5.40	-

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	15922	16944
Channel Y	15627	16637
Channel Z	16131	14226

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	1.07	-0.03	2.09	0.36
Channel Y	-0.77	-2.11	0.68	0.52
Channel Z	-0.29	-1.43	1.26	0.52

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