# Hearing Aid Compatibility (HAC) TEST REPORT

## <For T-Coil Measurement>

| | |
|---|---|
| Applicant Name | GREAT TALENT TECHNOLOGY LIMITED |
| Address of Applicant | RM602,T3 Software Park,Hi-Tech Park South, Nanshan, Shenzhen, China |
| Model No. | L50 |
| FCC ID | 2ALZM-L50 |
| Date of Receive | May. 20, 2018 |
| Date of Test(s) | May. 23, 2018 ~ May. 24, 2018 |
| Date of Issue | May. 30, 2018 |

Standards:

**ANSI C63.19-2011**

**FCC RULE PART(S): 47 CFR PART 20.19(B)**
**HAC RATE CATEGORY: T3 (T Category)**

In the configuration tested, the EUT complied with the standards specified above.

**Remarks:**

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

This report may only be reproduced and distributed in full. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS Taiwan Electronics & Communication Laboratory or testing done by SGS Taiwan Electronics & Communication Laboratory in connection with distribution or use of the product described in this report must be approved by SGS Taiwan Electronics & Communication Laboratory in writing.

**Signed on behalf of SGS**

**Sr. Engineer**

Matt Kuo

**Matt Kuo**
**Date: May. 30, 2018**

**Asst. Manager**

John Yeh

**John Yeh**
**Date: May. 30, 2018**

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# Revision History

| Report Number | Revision | Description | Issue Date |
|---|---|---|---|
| E5/2018/50018 | Rev.00 | Initial creation of document | May. 30, 2018 |
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# Table of Contents



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# 1. Introduction

The purpose of this standard is to establish categories for hearing aids and for WD (wireless communications devices) that can indicate to health care practitioners and hearing aid users which hearing aids are compatible with which WD, and to provide tests that can be used to assess the electromagnetic characteristics of hearing aids and WD and assign them to these categories. The various parameters required, in order to demonstrate compatibility and accessibility are measured. The design of the standard is such that when a hearing aid and WD achieve one of the categories specified, as measured by the methodology of this standard, the indicated performance is realized.
In order to provide for the usability of a hearing aid with a WD, several factors must be coordinated:

a) Radio frequency (RF) measurements of the near-field electric and magnetic fields emitted by a WD to categorize these emissions for correlation with the RF immunity of a hearing aid.
b) Magnetic field measurements of a WD emitted via the audio transducer associated with the T-coil mode of the hearing aid, for assessment of hearing aid performance.
c) Measurements with the hearing aid and a simulation of the categorized WD T-coil emissions to assess the hearing aid RF immunity in the T-coil mode.

The WD radio frequency (RF) and audio band emissions are measured.
Hence, the following are measurements made for the WD:
a) RF E-Field emissions
b) T-coil mode, magnetic signal strength in the audio band
c) T-coil mode, magnetic signal and noise articulation index
d) T-coil mode, magnetic signal frequency response through the audio band

Corresponding to the WD measurements, the hearing aid is measured for:
a) RF immunity in microphone mode
b) RF immunity in T-coil mode

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## 2. Testing Laboratory

| | |
|---|---|
| Company Name | SGS Taiwan Ltd. Electronics & Communication Laboratory |
| Company address | No.2, Keji 1st Rd., Guishan Township, Taoyuan County 333, Taiwan (R.O.C.) |
| Telephone | +886-2-2299-3279 |
| Fax | +886-2-2298-0488 |
| Website | http://www.tw.sgs.com/ |

## 3. Details of Applicant

| | |
|---|---|
| Applicant Name | GREAT TALENT TECHNOLOGY LIMITED. |
| Applicant Address | RM602,T3 Software Park,Hi-Tech Park South,Nanshan, Shenzhen, China |

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# 4. Description of EUT

| | | | | |
|---|---|---|---|---|
| Model No. | L50 | | | |
| FCC ID | 2ALZM-L50 | | | |
| Mode of Operation | ☒CDMA 1xRTT ☒CDMA EVDO<br>☒LTE FDD ☒ LTE TDD<br>☒WLAN802.11b/g/n/(20M) ☒Bluetooth | | | |
| Duty Cycle | CDMA | 1 | | |
| | LTE FDD | 1 | | |
| | LTE TDD | 0.633 | | |
| | WLAN802.11b/g/n(20M) | 1 | | |
| | Bluetooth | 1 | | |
| TX Frequency Range (MHz) | CDMA BC 0 | 824 | – | 849 |
| | CDMA BC 1 | 1850 | – | 1910 |
| | CDMA BC 10 | 815 | – | 826 |
| | LTE FDD Band 2 | 1850 | – | 1910 |
| | LTE FDD Band 4 | 1710 | – | 1755 |
| | LTE FDD Band 5 | 824 | – | 849 |
| | LTE FDD Band 13 | 777 | – | 787 |
| | LTE FDD Band 25 | 1850 | – | 1915 |
| | LTE FDD Band 26 | 814 | – | 849 |
| | LTE FDD Band 41 | 2496 | – | 2690 |
| | WLAN802.11 b/g/n(20M) | 2412 | – | 2462 |
| | Bluetooth | 2402 | – | 2480 |

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| | | | | |
|---|---|---|---|---|
| Channel Number (ARFCN) | CDMA BC 0 | 1013 | – | 777 |
| | CDMA BC 1 | 25 | – | 1175 |
| | CDMA BC 10 | 476 | – | 684 |
| | LTE FDD Band 2 | 18607 | – | 19193 |
| | LTE FDD Band 4 | 19957 | – | 20393 |
| | LTE FDD Band 5 | 20407 | – | 20643 |
| | LTE FDD Band 13 | 23205 | – | 23255 |
| | LTE FDD Band 25 | 26047 | – | 26683 |
| | LTE FDD Band 26 | 26697 | – | 27033 |
| | LTE TDD Band 41 | 39675 | – | 41565 |
| | WLAN802.11 b/g/n(20M) | 1 | – | 11 |
| | Bluetooth | 0 | – | 78 |

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# 5. Air Interfaces and Bands

| Air-Interface | Band (MHZ) | Type | ANSI C63.19 Tested | Simultaneous Transmitter | Name of Voice Service | Power Reduction |
|---|---|---|---|---|---|---|
| CDMA | BC0 | VO | Yes | BT or Wi-Fi | * | NA |
| | BC1 | | | | | |
| | BC10 | | | | | |
| | EVDO | DT | NA | | NA | |
| LTE FDD | 2 | DT | NA | BT or Wi-Fi | NA | NA |
| | 4 | | | | | |
| | 5 | | | | | |
| | 13 | | | | | |
| | 25 | | | | | |
| | 26 | | | | | |
| LTE TDD | 41 | DT | NA | BT or Wi-Fi | NA | NA |
| Wi-Fi | 2450 | DT | NA | WWAN | NA | NA |
| BT | 2450 | DT | NA | WWAN | NA | NA |

VO: Legacy Cellular Voice Service from Table 7.1 in 7.4.2.1 of ANSI C63.19-2011
DT: Digital Transport (no voice)
VD: IP Voice Service over Digital Transport

Note
1. *: Ref Lev in accordance with 7.4.2.1 of ANSI C63.19-2011 and the July 2012 VoLTE interpretation

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# 6. Test Environment

| | |
|---|---|
| Ambient Temperature | 21.7° C |
| Relative Humidity | <80 % |

# 7. Description of test system

## 7.1 Measurement System Diagram for SPEAG Robotic

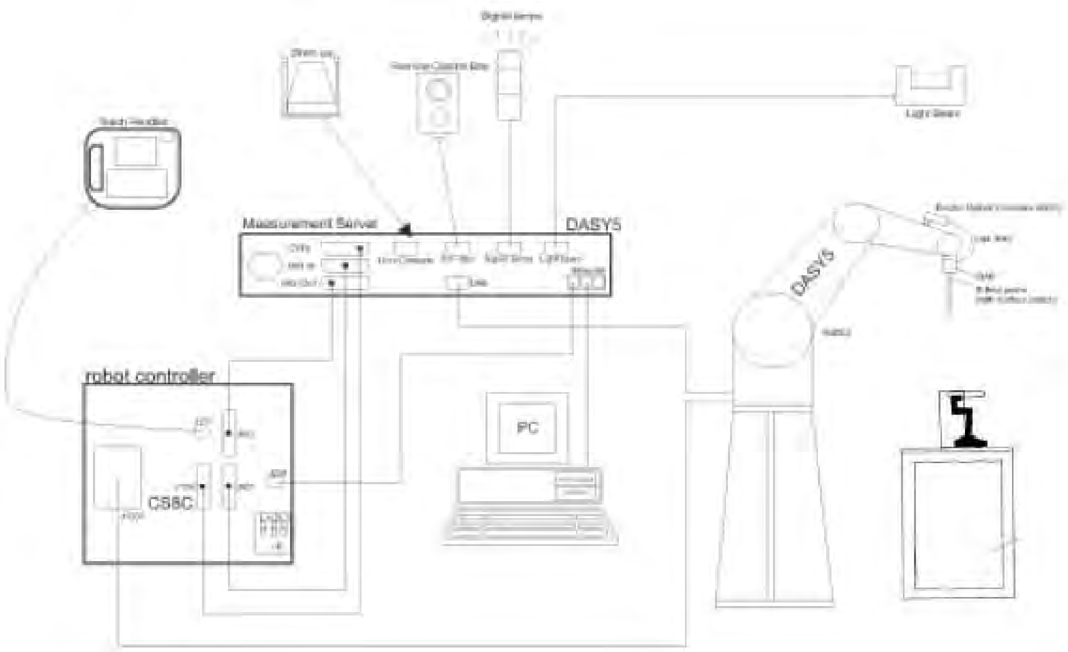


Fig. 1. The SPEAG Robotic Diagram

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The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stabile RX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
- An Audio Magnetic probe.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7.
- DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The Test Arch SAM phantom
- The device holder for handheld mobile phones.
- Validation dipole kits allowing to validate the proper functioning of the system.

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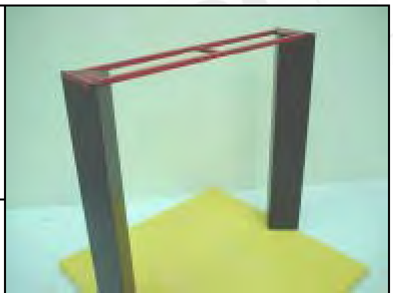
## 7.2 Audio Magnetic Probe AM1DV3

| | | |
|---|---|---|
| Description | - Active single sensor probe for both axial and radial measurement scans- Fully RF shielded, compatible with DAE, with adapted probe cup |  AM1DV3 Audio Probe |
| Dynamic Range | 0.1 KHz to 20 KHz | |
| Sensitivity | <-50dB A/m @ 1KHz | |
| Internal Amp | 20dB | |
| Dimensions | 300X18mm | |

## 7.3 Test Arch

| | | |
|---|---|---|
| Description | Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot. |  Test Arch |
| Dimensions | length: 370 mm<br>width: 370 mm<br>height: 370 mm | |

## 7.4 AMCC- Audio Magnetic Calibration Coil

| | | |
|---|---|---|
| Description | Allows calibration of the complete measurement setup, The two horizontal coils create a homogeneous magnetic field in the z direction. Refer to Appendix 5 for more detail on AMCC coil |  AMCC |

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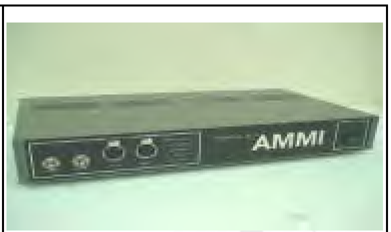
## 7.5 Phone Holder

| | | |
|---|---|---|
| Description | Supports accurate and reliable positioning of any phone Effect on near field <+/- 0.5 dB |  Phone Holder |

## 7.6 AMMI - Audio Magnetic Measurement Instrument

| | | |
|---|---|---|
| Description | -USB interface to PC<br>- Probe signal digitization and power supply- Test signal generation for wireless device (via base station simulator)- Auto-calibration and interfaces to AMCC for complete setup-calibration |  AMMI |
| Data Rate | 48 KHz / 24bit | |
| Dynamic Range | 85 dB | |
| Dimensions: | 19” X 65 X 270mm | |

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# 8. Measurement Procedure

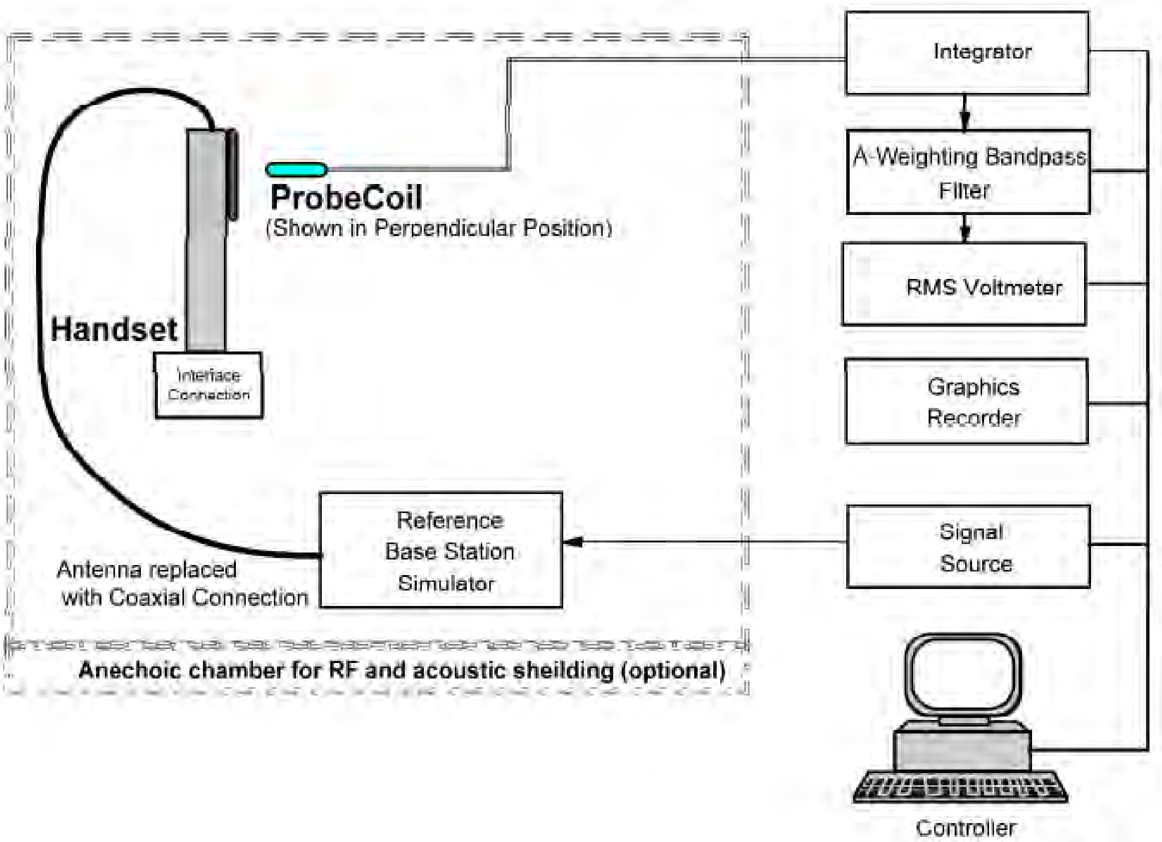


Fig. 2. T-coil signal measurement test setup

The sequence of the measurement is T-Coil testing procedure over a wireless communication device:

1. Confirm Geometry & signal check. Probe phantom alignment and check of accuracy.
2. Background noise measurement in the area of the WD.
3. Perform 50x50mm area scan with narrow band signal to determine ABM1, ABM2 and SNR for axial and radial orientation positions.

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4. For Axial position, perform optimal SNR point measurement with a broadband signal – determine Frequency Response
5. Speech input level is -18dBm0.

**Note.**

**#.** The EUT do not use the special HAC SW.

**#.** Setting the maximum volume for EUT during the measurement.

**#.** For the measurement, it don't use the "post-test measurement processing of results".

**#.** Per KDB 285076 D01v05, handsets that that have the ability to support concurrent connections using simultaneous transmissions shall be independently tested for each air interface/band given in ANSI C63.19-2011. At the present time ANSI C63.19 does not provide simultaneous transmission test procedures.

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# 9. System calibration

For correct and calibrated measurement of the voltages and ABM field, DASY will perform a calibration job as below.

In phase 1, the audio output is switched off, and a 200 mVpp symmetric rectangular signal of 1 kHz is generated and internally connected directly to both channels of the sampling unit (Coil in, Probe in).

In phase 2, the audio output is off, and a 20 mVpp symmetric 100 Hz signal is internally connected. The signals during phases 1 and 2 are available at the output on the rear panel of the AMMI. However, the output must not be loaded, in order to avoid influencing the calibration. An RMS voltmeter would indicate 100 mVRMS during the first phase and 10 mVRMS during the second phase. After the first two phases, the two input channels are both calibrated for absolute measurements of voltages. The resulting factors are displayed above the multi-meter window.

After phases 1 and 2, the input channels are calibrated to measure exact voltages. This is required to use the inputs for measuring voltages with their peak and RMS value.

In phase 3, a multi-sine signal covering each third-octave band from 50 Hz to 10 kHz is generated and applied to both audio outputs. The probe should be positioned in the center of the AMCC and aligned in the z-direction, the field orientation of the AMCC. The “Coil In” channel is measuring the voltage over the AMCC internal shunt, which is proportional to the magnetic field in the AMCC. At the same time, the “Probe In" channel samples the amplified

signal picked up by the probe coil and provides it to a numerical integrator. The ratio of the two voltages in each third-octave filter leads to the spectral representation over the frequency band of interest. The Coil signal is scaled in dBV, and the Probe signal is first integrated and normalized to show dB A/m. The ratio probe-to-coil at the frequency of 1 kHz is the sensitivity which will be used in the consecutive T-Coil jobs.

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# 10. T-coil testing for CDMA

RC1/SO68 was used for the testing as the worst-case configuration

| Codec Investigation | | | | | |
|---|---|---|---|---|---|
| **Codec** | **RC1/SO68** | **RC3/SO68** | **RC4/SO68** | **Orientation** | **Channel** |
| **ABM1 (dB A/m)** | -8.97 | -12.64 | -9.33 | Axial | 777 |
| **ABM2 (dB A/m)** | -35.97 | -45.5 | -41.63 | | |
| **Frequency Response** | Pass | Pass | Pass | | |
| **Signal quality (dB)** | **27** | 32.86 | 32.3 | | |

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# 11. Justification of held to ear modes tested

a. The device doesn't support VoLTE/VoWLAN, so T-coil test for VoLTE/VoWLAN is not required.

b. There is no OTT voice service pre-installed (installed and delivered) by the manufacturer.

c. There is no OTT voice service pre-installed (installed and delivered) by the manufacturer for the operating system manufacturer's software partner.

d. There is no OTT voice service installed and delivered by the manufacturer at the direction of the service provider.

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# 12. Test Standards and Limits

The measurements were performed to ensure compliance to the ANSI C63.19-2011 standard.

The limit values please follow in Table 2

| **Category** | **Telephone parameters WD signal quality** |
|---|---|
| T1 | 0 dB to 10 dB |
| T2 | 10 dB to 20 dB |
| T3 | 20 dB to 30 dB |
| T4 | > 30 dB |

Table 2. Signal Quality Range

Signal strength

Axial field intensity

The axial component of the magnetic field, directed along the measurement axis and located at the measurement plane, shall be ≥ -18 dB (A/m) at 1 kHz, in 1/3 octave band filter.

Radial(Y) field intensity

The radial component of the magnetic field, as measured at the radial, measurement points shall be ≥ -18 dB (A/m) at 1 kHz, in 1/3 octave band filter.

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# 13. Instruments List

| Manufacturer | Device | Type | Serial Number | Date of Last Calibration | Date of Next Calibration |
|---|---|---|---|---|---|
| Schmid & Partner Engineering AG | Data acquisition Electronics | DAE4 | 1336 | Mar.21,2018 | Mar.20,2019 |
| Schmid & Partner Engineering AG | Software | DASY52 52.8.8 | N/A | Calibration not required | Calibration not required |
| Schmid & Partner Engineering AG | Audio Magnetic 1D Field Probe | AM1DV3 | 3115 | Mar.15.2018 | Mar.14.2019 |
| Schmid & Partner Engineering AG | AMMI | 010 AB | 1028 | Calibration not required | Calibration not required |
| Schmid & Partner Engineering AG | AMCC SD HAC | P01 BA | 1026 | N/A | N/A |
| Schmid & Partner Engineering AG | Test Arch SD HAC | P01 | 1047 | N/A | N/A |
| R&S | Radio Communication Test | CMU200 | 113505 | Dec.20.2017 | Dec.19.2018 |

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# 14. Summary of Results

| Mode | Orientation | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | Signal quality (dB) | C63.19-2011 Rating |
|---|---|---|---|---|---|---|---|---|
| CDMA BC0 | Axial | 384 | -9.45 | -37.55 | -55.84 | 0.88 | 28.1 | T3 |
| | | 777 | -9.27 | -36.08 | | 1.96 | 26.81 | T3 |
| | | 1013 | -13.11 | -40.15 | | 1.22 | 27.04 | T3 |
| | Radial | 384 | -17.04 | -41.5 | -53.64 | N/A | 24.46 | T3 |
| | | 777 | -17.6 | -39.47 | | | 21.87 | T3 |
| | | 1013 | -17.91 | -39.49 | | | 21.58 | T3 |

| Mode | Orientation | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | Signal quality (dB) | C63.19-2011 Rating |
|---|---|---|---|---|---|---|---|---|
| CDMA BC1 | Axial | 25 | -13.2 | -41.01 | -56.82 | 0.72 | 27.81 | T4 |
| | | 600 | -12.22 | -43.96 | | 1.69 | 31.74 | T4 |
| | | 1175 | -11.86 | -38.88 | | 1.68 | 27.02 | T4 |
| | Radial | 25 | -17.82 | -43.49 | -53.66 | N/A | 25.67 | T3 |
| | | 600 | -17.54 | -46.36 | | | 28.82 | T3 |
| | | 1175 | -17.21 | -40.8 | | | 23.59 | T3 |

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| Mode | Orientation | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | Signal quality (dB) | C63.19-2011 Rating |
|---|---|---|---|---|---|---|---|---|
| CDMA BC10 | Axial | 476 | -12.24 | -39.68 | -55.84 | 1.03 | 27.44 | T3 |
| | | 560 | -10.35 | -38.96 | | 1.69 | 28.61 | T3 |
| | | 684 | -9.96 | -37.41 | | 0.62 | 27.45 | T3 |
| | Radial | 476 | -17.1 | -40.13 | -53.64 | N/A | 23.03 | T3 |
| | | 560 | -17.52 | -40.71 | | | 23.19 | T3 |
| | | 684 | -17.57 | -39.57 | | | 22.00 | T3 |

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# 15. Measurement Data

Date: 2018/5/23

## HAC-T-Coil-CDMA Cellular(BC0) CH 384_RC1 SO68

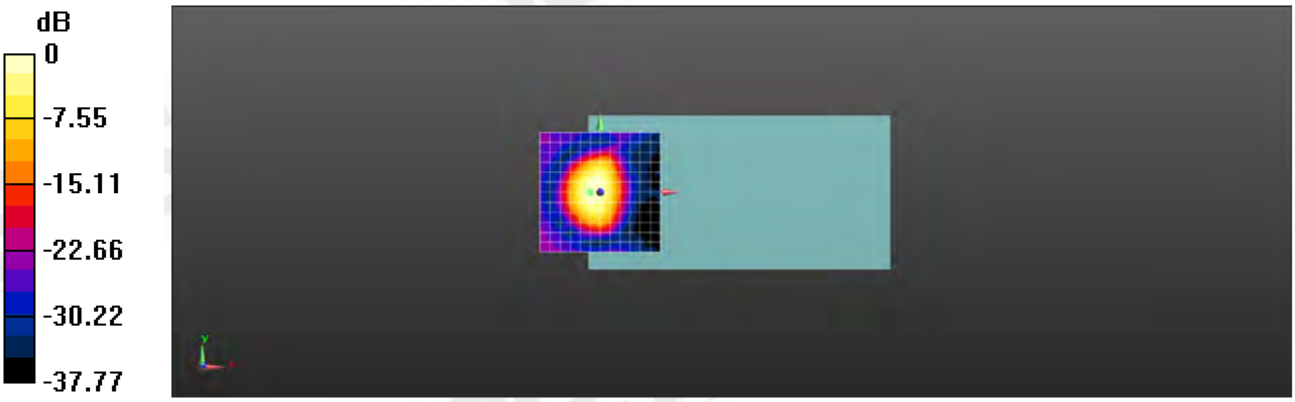
Communication System: CDMA; Frequency: 836.52 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 28.10 dB
ABM1 comp = -9.45 dBA/m
Location: -4.2, 0, 3.7 mm




0 dB = 20.87 = 28.10 dB

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Date: 2018/5/23

# HAC-T-Coil-CDMA Cellular(BC0) CH 384_RC1 SO68

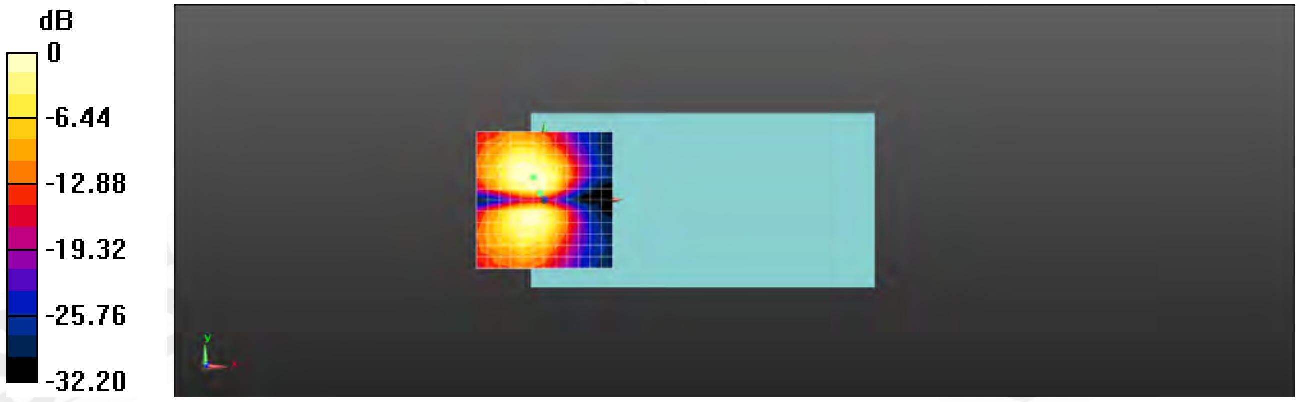
Communication System: CDMA; Frequency: 836.52 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 24.46 dB
ABM1 comp = -17.04 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 11.19 = 24.46 dB

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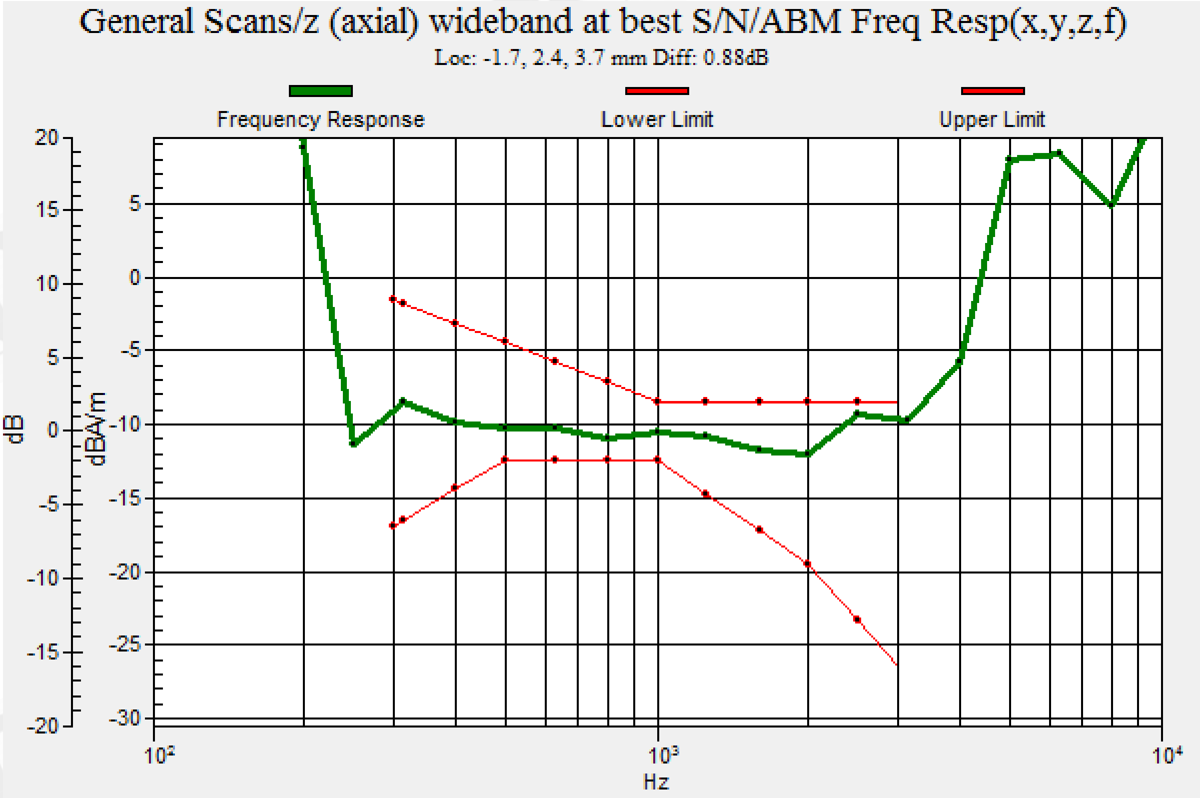


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Date: 2018/5/23

# HAC-T-Coil-CDMA Cellular(BC0) CH 777_RC1 SO68

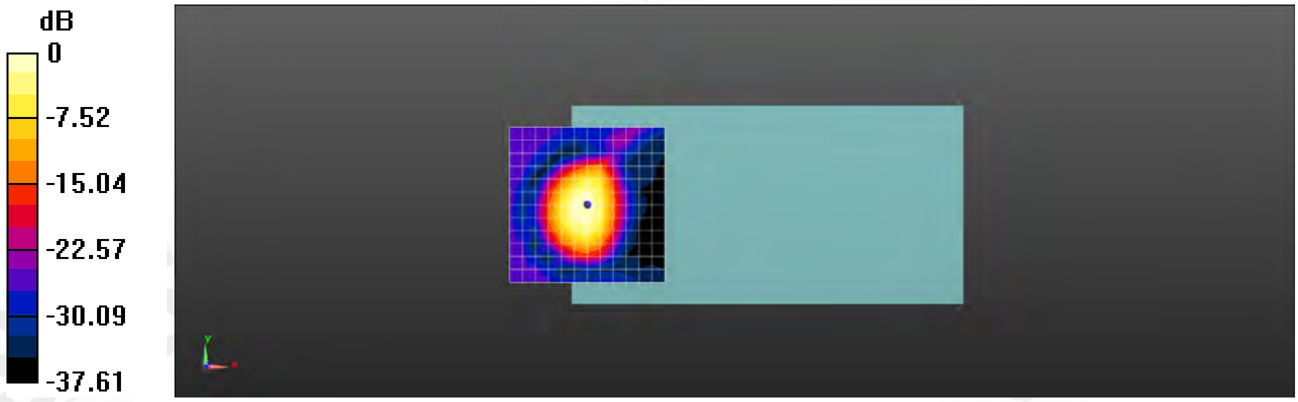
Communication System: CDMA; Frequency: 848.31 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 26.81 dB
ABM1 comp = -9.27 dBA/m
Location: 0, 0, 3.7 mm




0 dB = 21.91 = 26.81 dB

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Date: 2018/5/23

# HAC-T-Coil-CDMA Cellular(BC0) CH 777_RC1 SO68

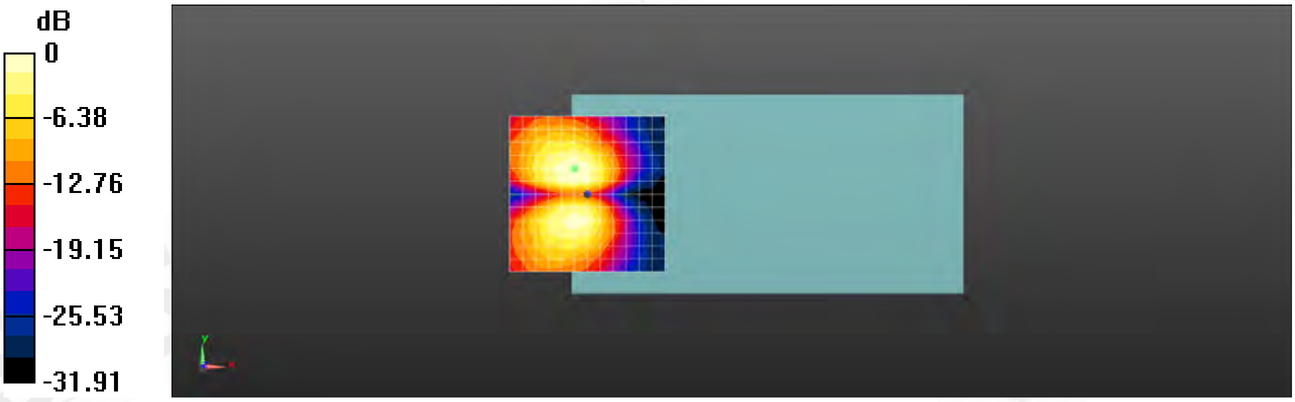
Communication System: CDMA; Frequency: 848.31 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 21.87 dB
ABM1 comp = -17.60 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 12.40 = 21.87 dB

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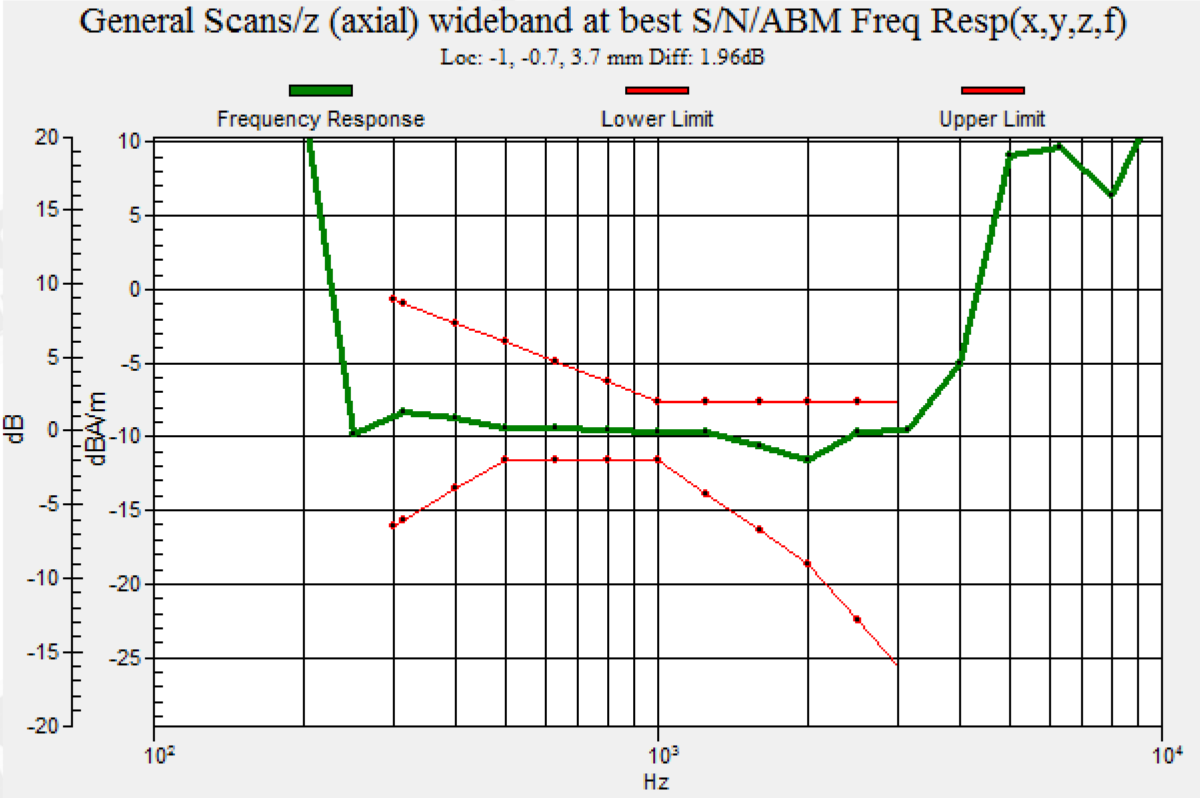


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Date: 2018/5/23

# HAC-T-Coil-CDMA Cellular(BC0) CH 1013_RC1 SO68

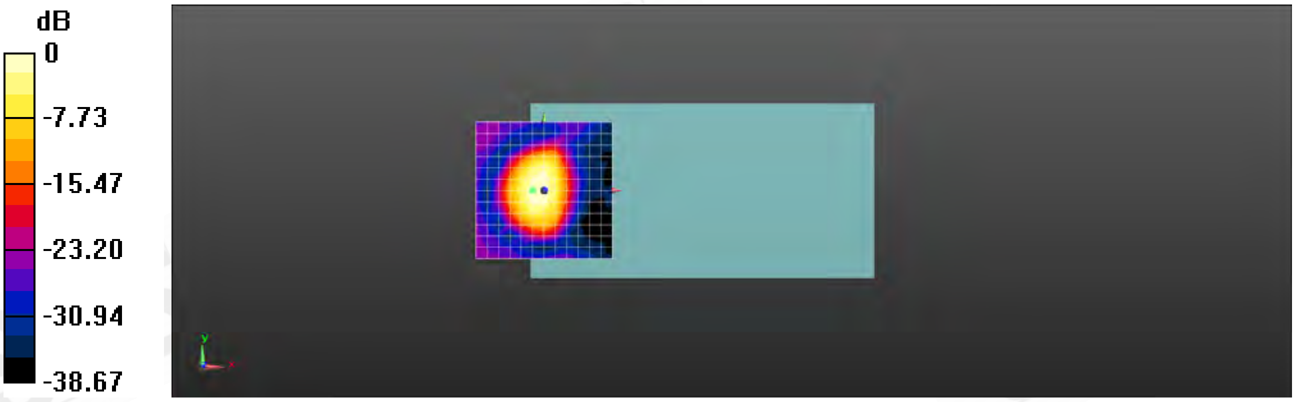
Communication System: CDMA; Frequency: 824.7 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.04 dB
ABM1 comp = -13.11 dBA/m
Location: -4.2, 0, 3.7 mm




0 dB = 22.50 = 27.04 dB

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Date: 2018/5/23

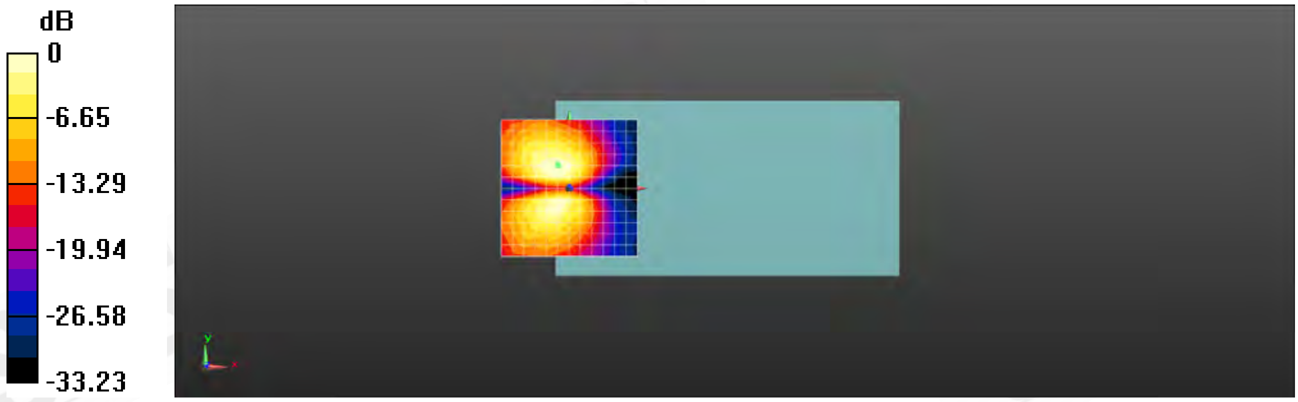
# HAC-T-Coil-CDMA Cellular(BC0) CH 1013_RC1 SO68

Communication System: CDMA; Frequency: 824.7 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 21.58 dB
ABM1 comp = -17.91 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 12.00 = 21.58 dB

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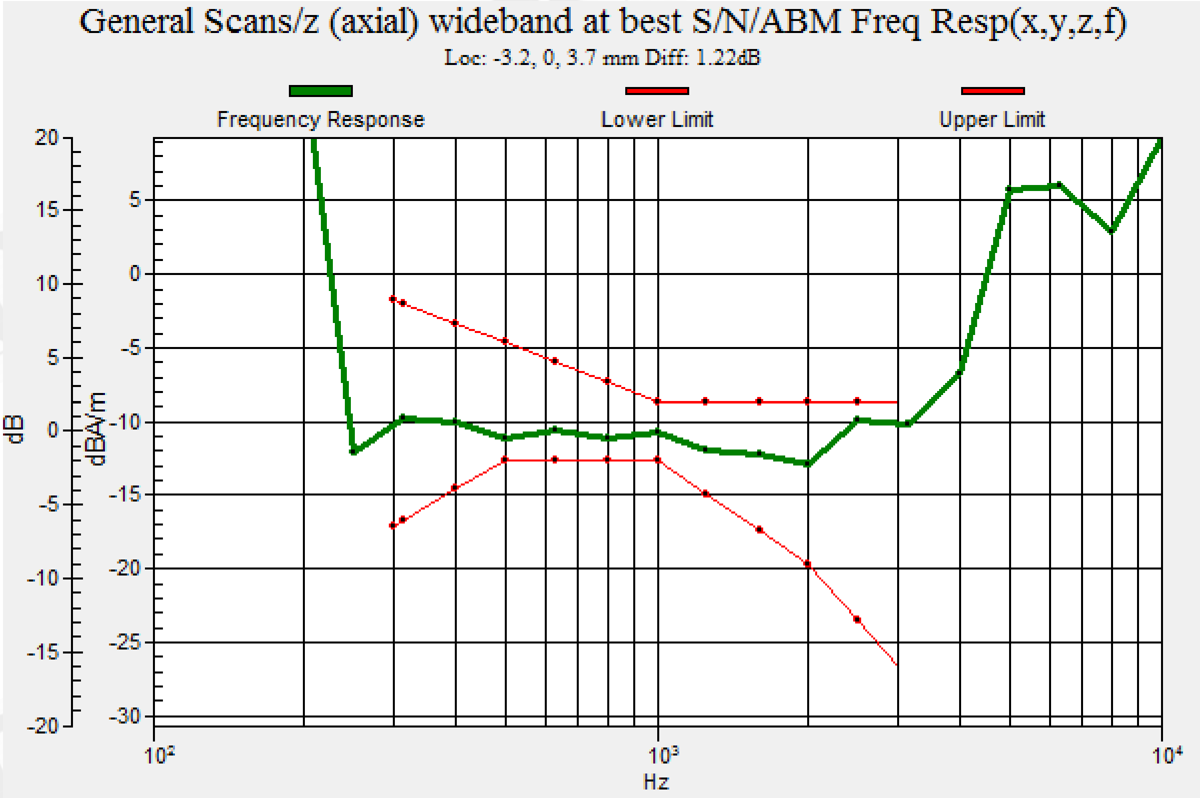


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Date: 2018/5/24

# HAC-T-Coil-CDMA PCS(BC1) CH 25_RC1 SO68

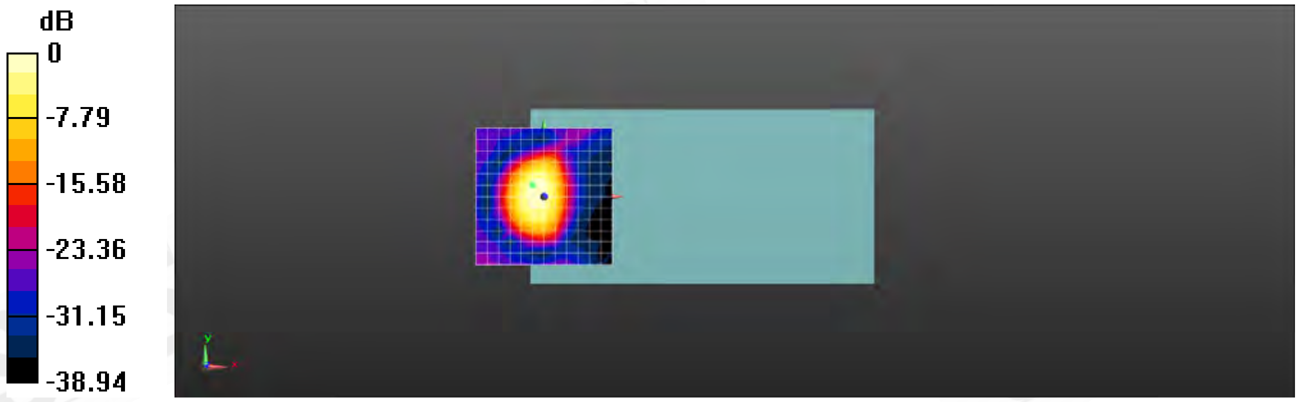
Communication System: CDMA; Frequency: 1851.25 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.81 dB
ABM1 comp = -13.20 dBA/m
Location: -4.2, 4.2, 3.7 mm




0 dB = 24.58 = 27.81 dB

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Date: 2018/5/24

# HAC-T-Coil-CDMA PCS(BC1) CH 25_RC1 SO68

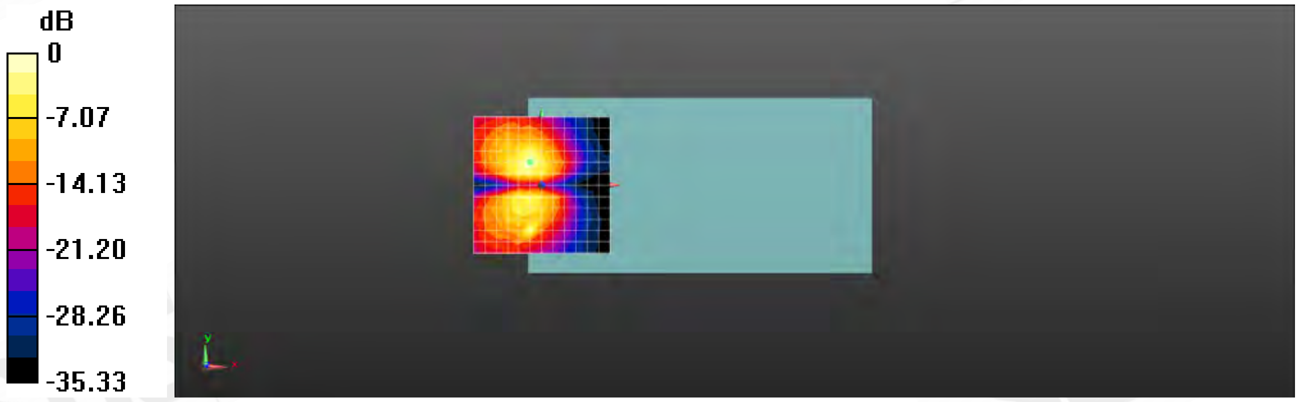
Communication System: CDMA; Frequency: 1851.25 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 25.67 dB
ABM1 comp = -17.82 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 19.20 = 25.67 dB

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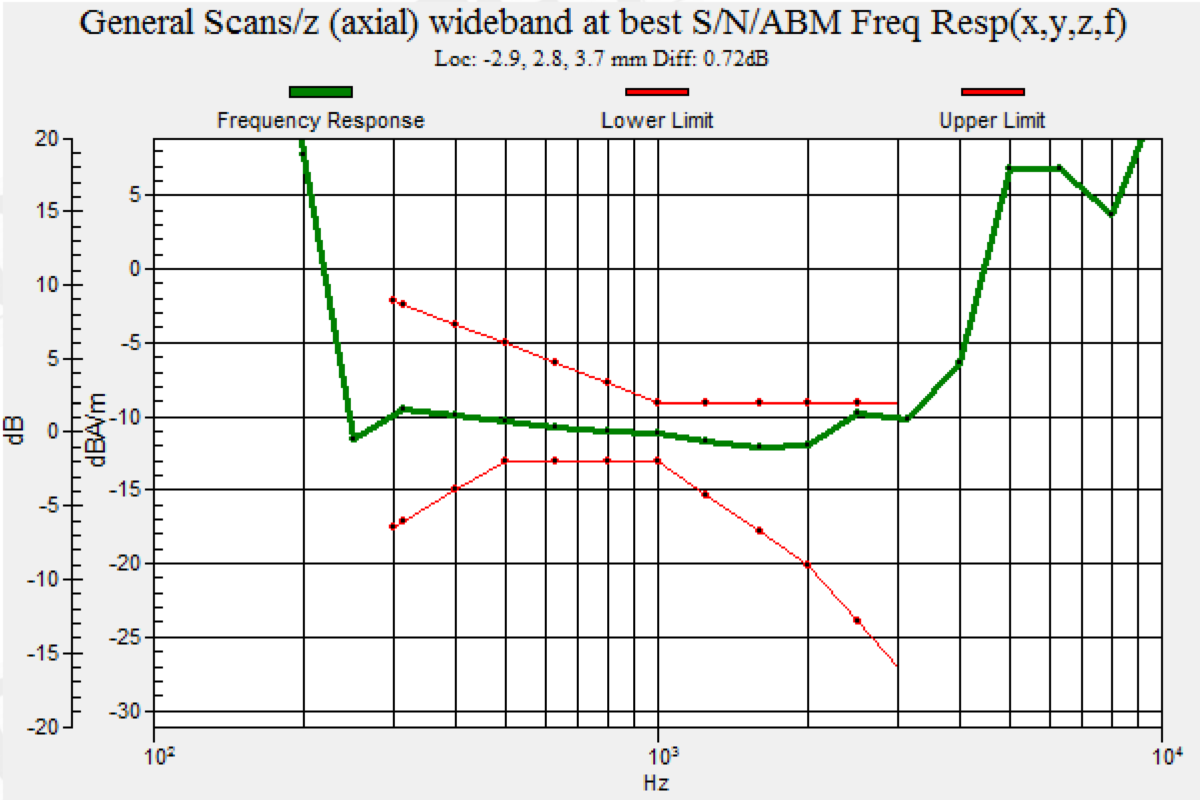


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Date: 2018/5/24

# HAC-T-Coil-CDMA PCS(BC1) CH 600_RC1 SO68

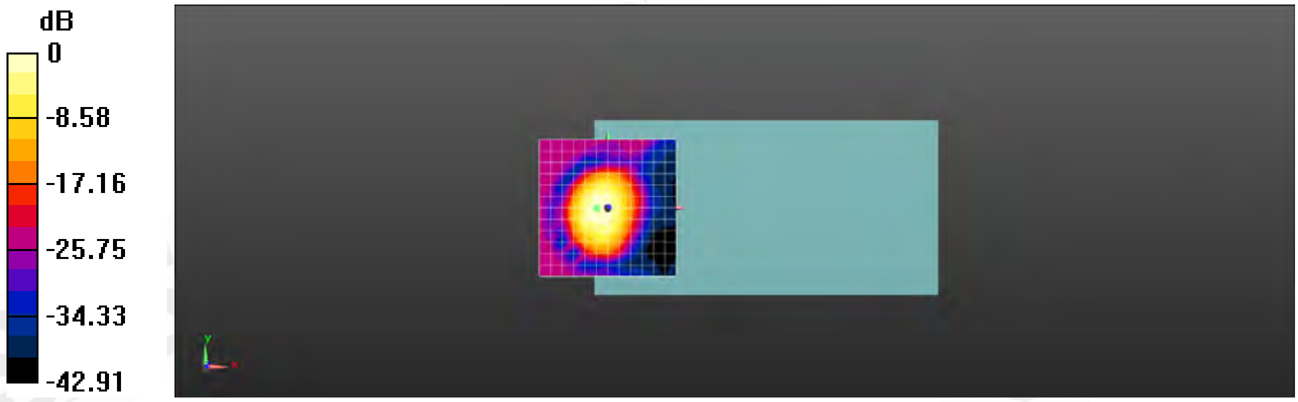
Communication System: CDMA; Frequency: 1880 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 31.74 dB
ABM1 comp = -12.22 dBA/m
Location: -4.2, 0, 3.7 mm




0 dB = 38.64 = 31.74 dB

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Date: 2018/5/24

# HAC-T-Coil-CDMA PCS(BC1) CH 600_RC1 SO68

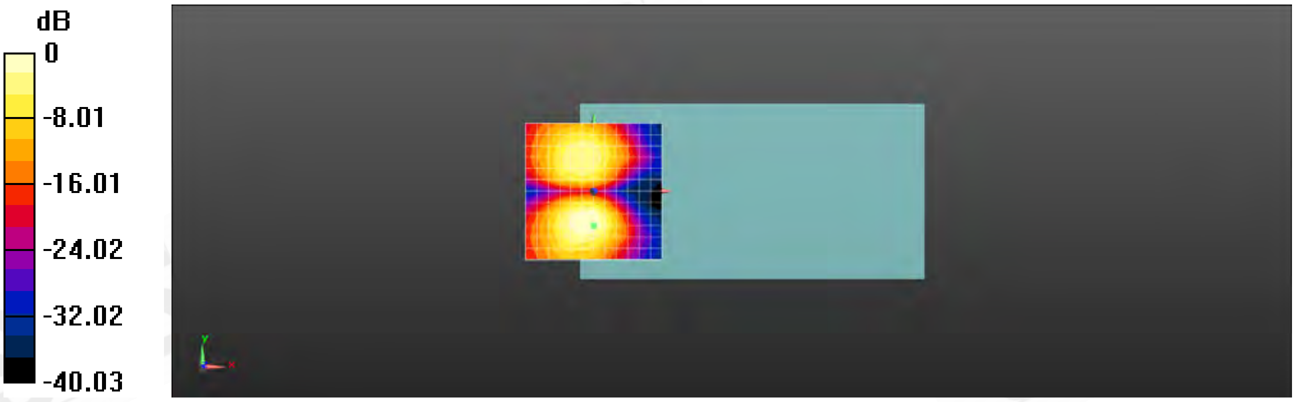
Communication System: CDMA; Frequency: 1880 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 28.82 dB
ABM1 comp = -17.54 dBA/m
Location: 0, -12.5, 3.7 mm




0 dB = 27.61 = 28.82 dB

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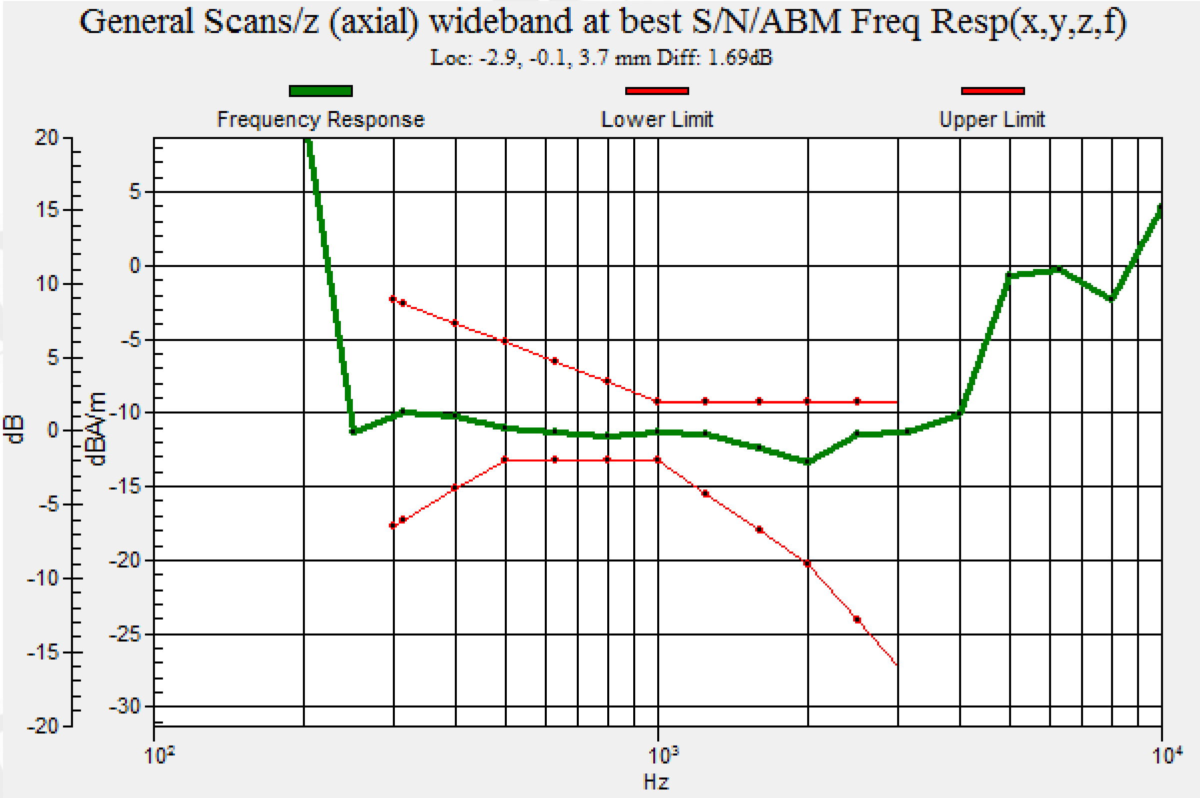


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Date: 2018/5/24

# HAC-T-Coil-CDMA PCS(BC1) CH 1175_RC1 SO68

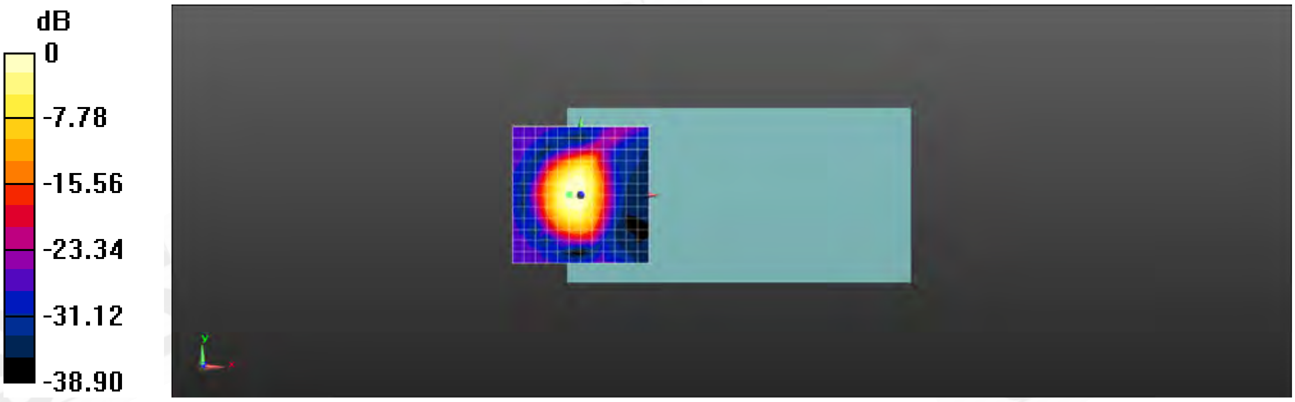
Communication System: CDMA; Frequency: 1908.75 MHz
Medium parameters used: $\sigma$ = 0 S/m, $\varepsilon_r$ = 1; $\rho$ = 1 kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.02 dB
ABM1 comp = -11.86 dBA/m
Location: -4.2, 0, 3.7 mm




0 dB = 22.44 = 27.02 dB

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Date: 2018/5/24

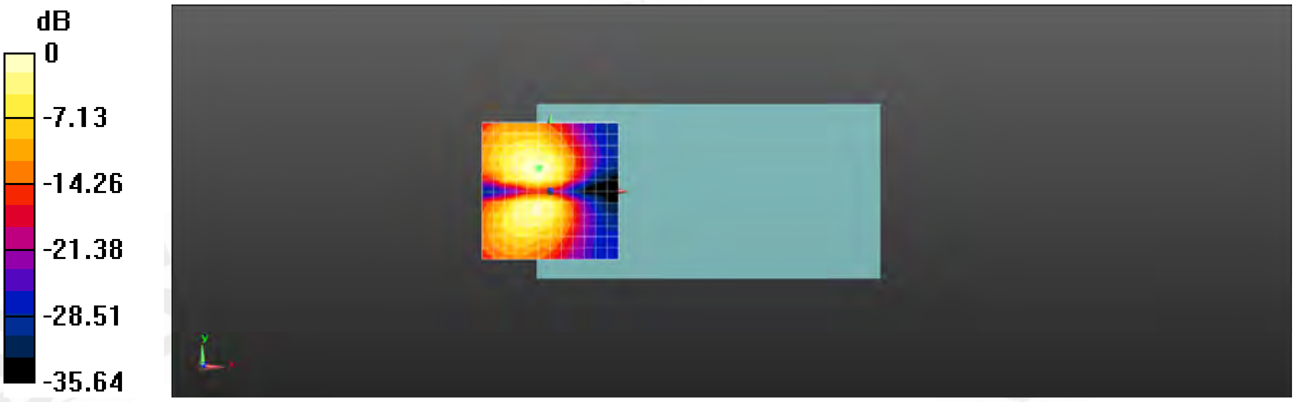
# HAC-T-Coil-CDMA PCS(BC1) CH 1175_RC1 SO68

Communication System: CDMA; Frequency: 1908.75 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 23.59 dB
ABM1 comp = -17.21 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 15.11 = 23.59 dB

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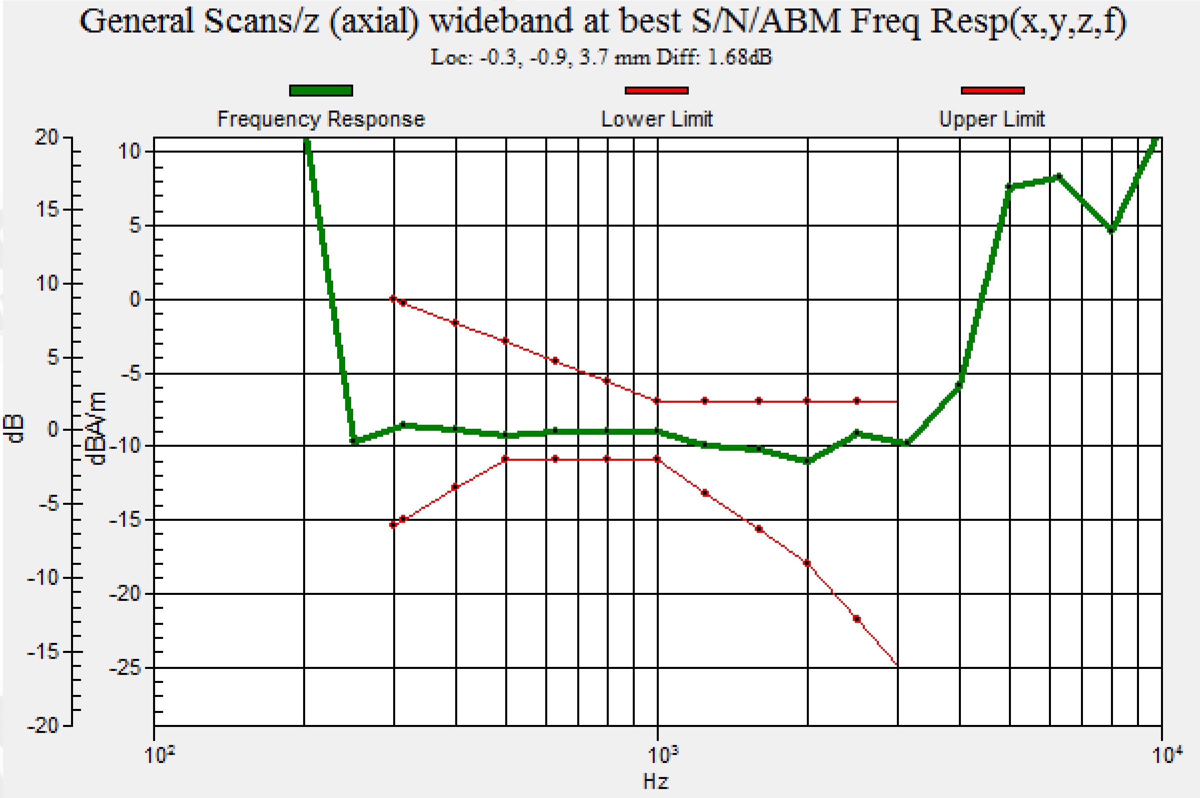


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Date: 2018/5/23

# HAC-T-Coil-CDMA Secondary(BC10) CH 476_RC1 SO68

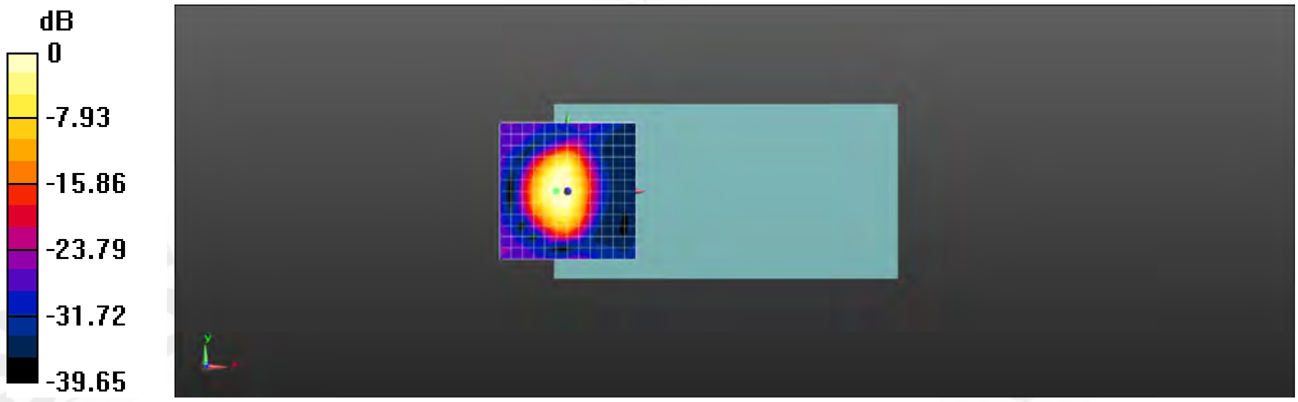
Communication System: CDMA; Frequency: 817.9 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.44 dB
ABM1 comp = -12.24 dBA/m
Location: -4.2, 0, 3.7 mm




0 dB = 23.56 = 27.44 dB

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Date: 2018/5/23

# HAC-T-Coil-CDMA Secondary(BC10) CH 476_RC1 SO68

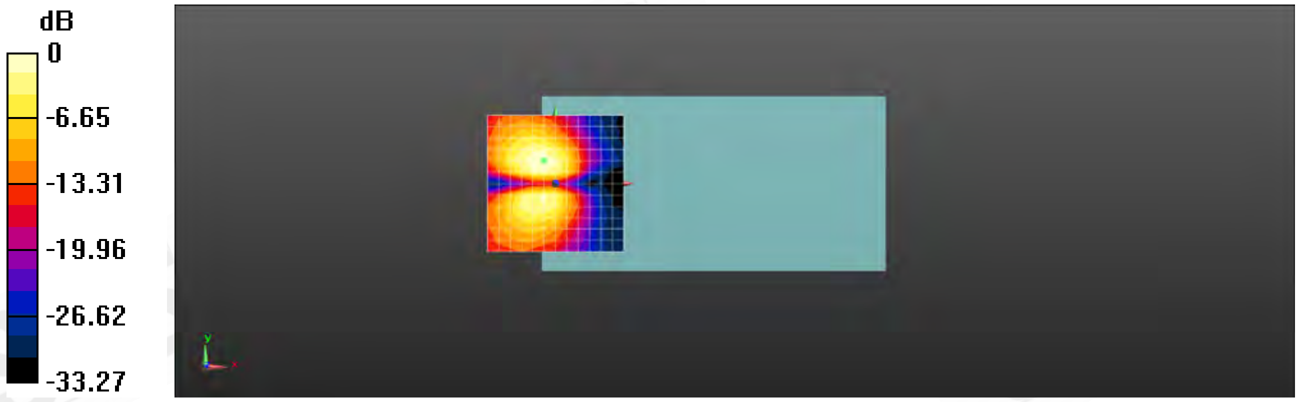
Communication System: CDMA; Frequency: 817.9 MHz
Medium parameters used: $\sigma$ = 0 S/m, $\varepsilon_r$ = 1; $\rho$ = 1 kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 23.03 dB
ABM1 comp = -17.10 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 14.18 = 23.03 dB

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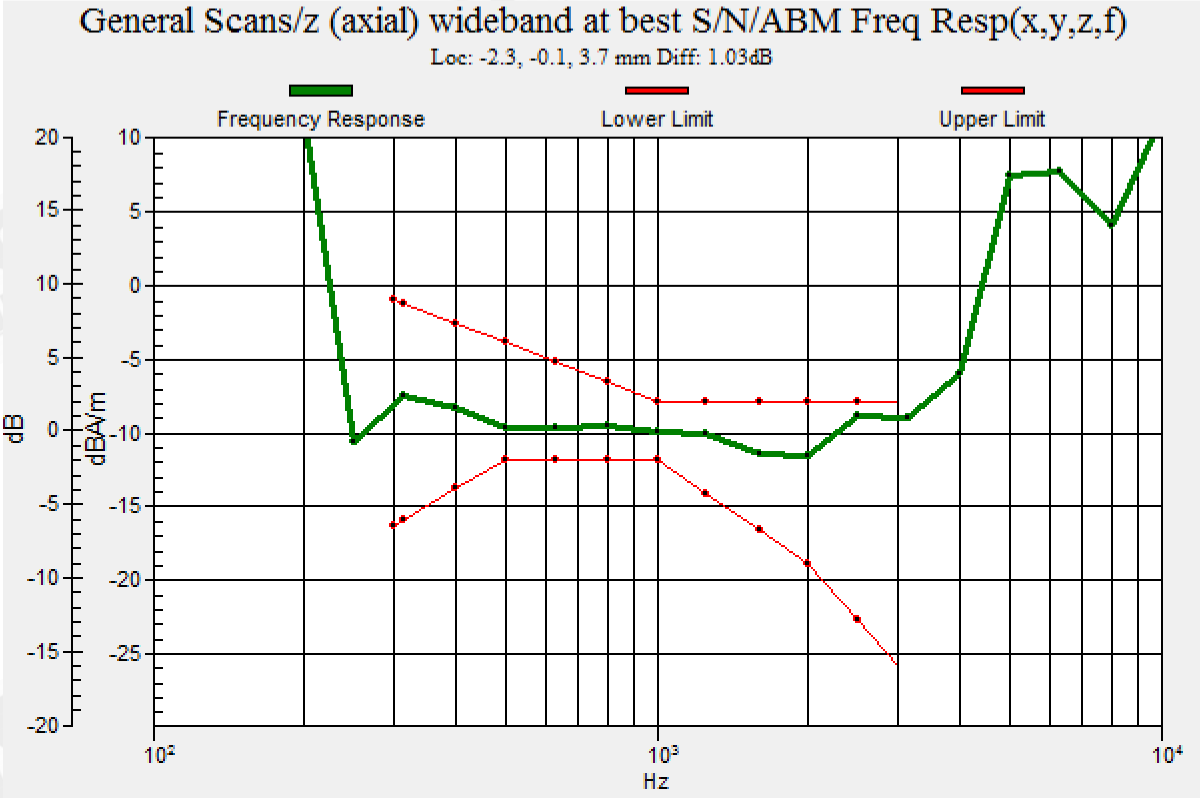


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Date: 2018/5/23

# HAC-T-Coil-CDMA Secondary(BC10) CH 560_RC1 SO68

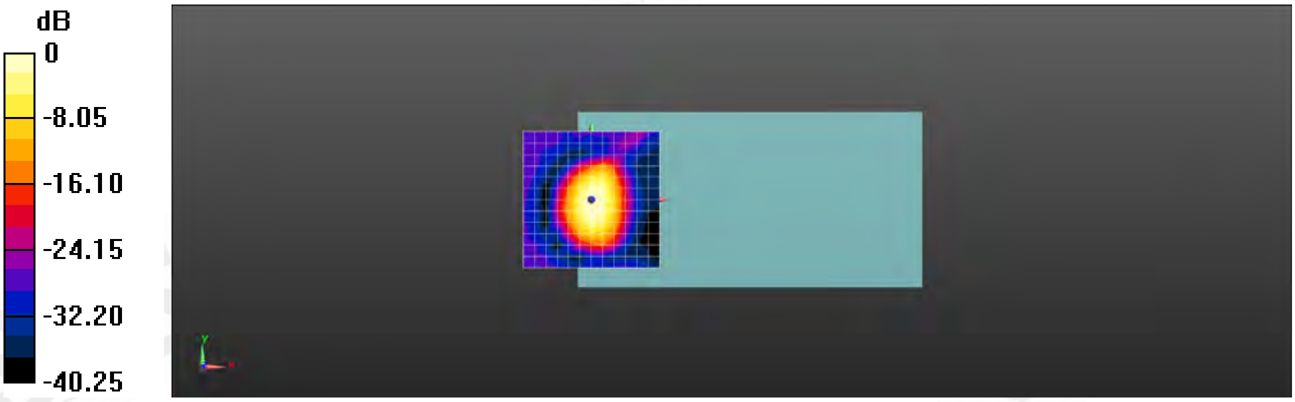
Communication System: CDMA; Frequency: 820 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 28.61 dB
ABM1 comp = -10.35 dBA/m
Location: 0, 0, 3.7 mm




0 dB = 26.96 = 28.61 dB

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Date: 2018/5/23

# HAC-T-Coil-CDMA Secondary(BC10) CH 560_RC1 SO68

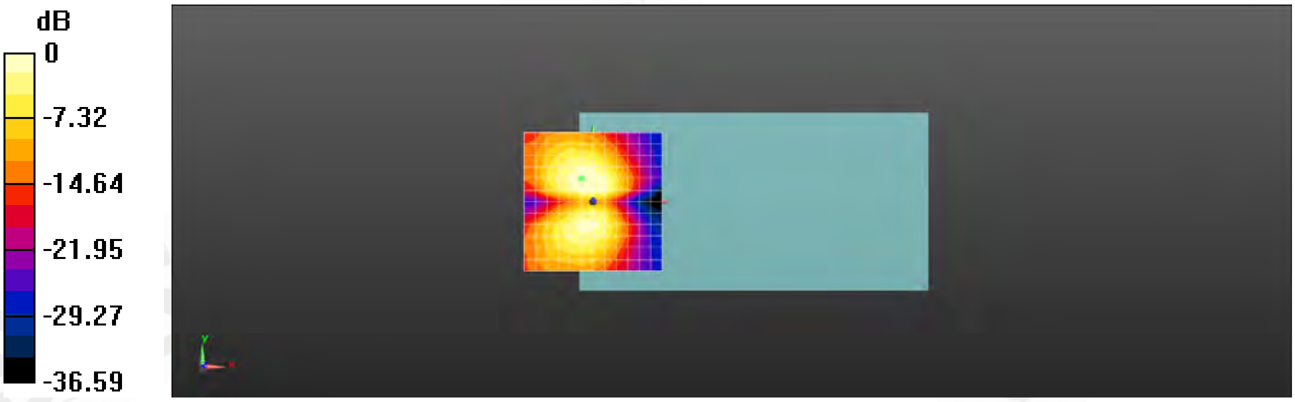
Communication System: CDMA; Frequency: 820 MHz
Medium parameters used: $\sigma = 0$ S/m, $\varepsilon_r = 1$; $\rho = 1$ kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**

Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 23.19 dB
ABM1 comp = -17.5 2 dBA/m
Location: -4.2, 8.3, 3.7 mm




0 dB = 14.44 = 23.19 dB

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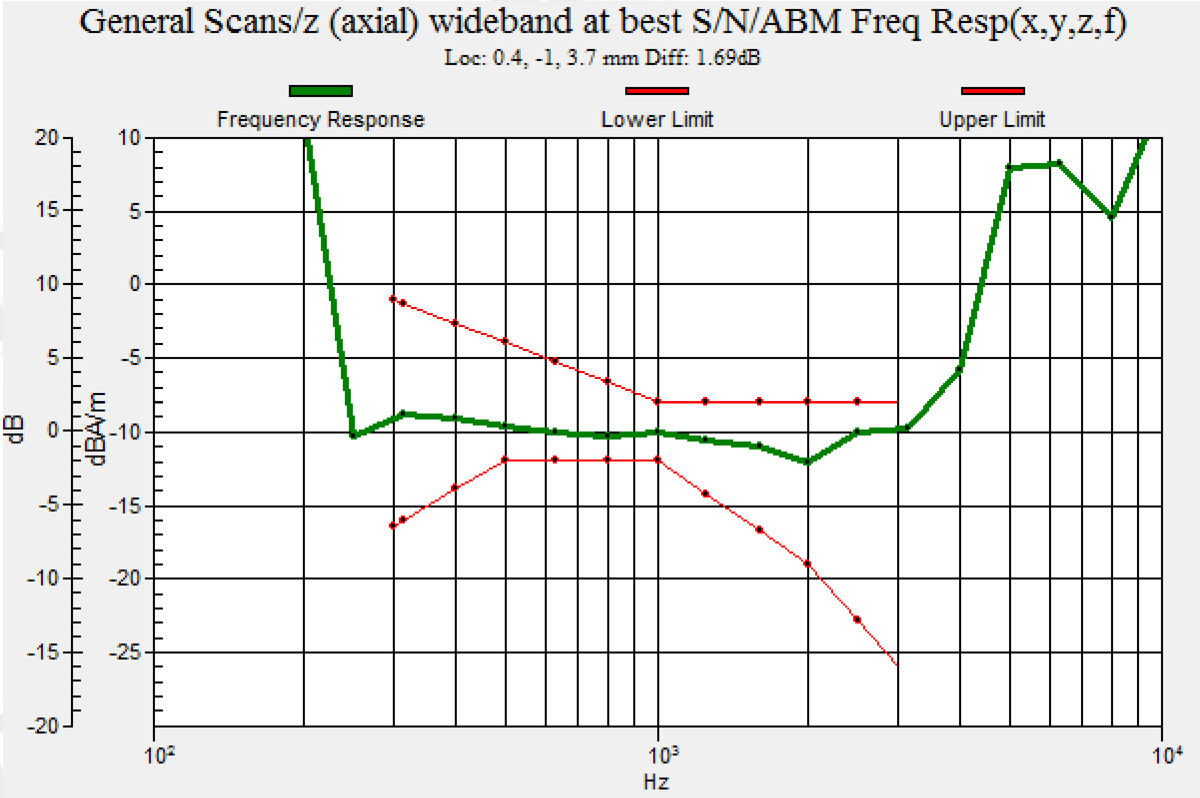


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Date: 2018/5/23

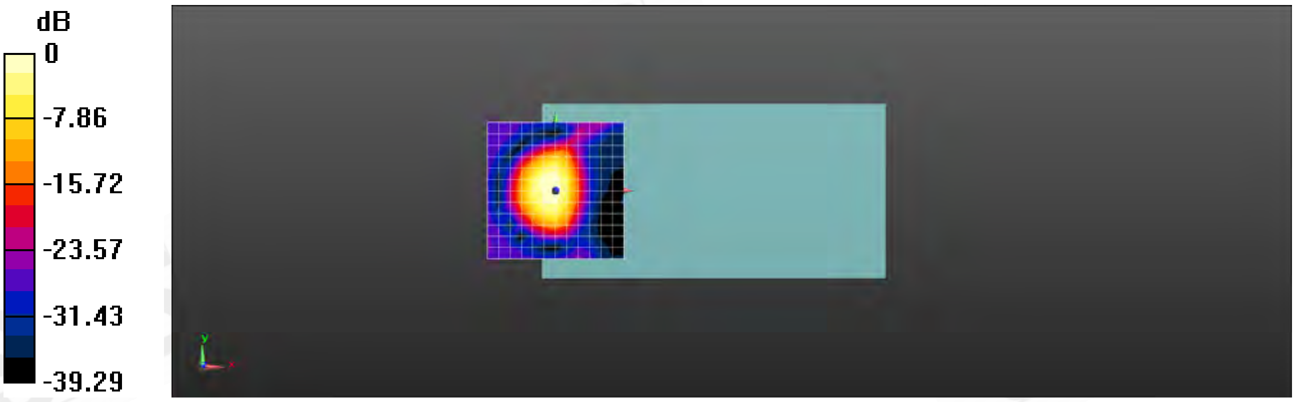
# HAC-T-Coil-CDMA Secondary(BC10) CH 684_RC1 SO68

Communication System: CDMA; Frequency: 823.1 MHz
Medium parameters used: σ = 0 S/m, $\varepsilon_r$ = 1; ρ = 1 kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/z (axial) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 27.45 dB
ABM1 comp = -9.96 dBA/m
Location: 0, 0, 3.7 mm




0 dB = 23.57 = 27.45 dB

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Date: 2018/5/23

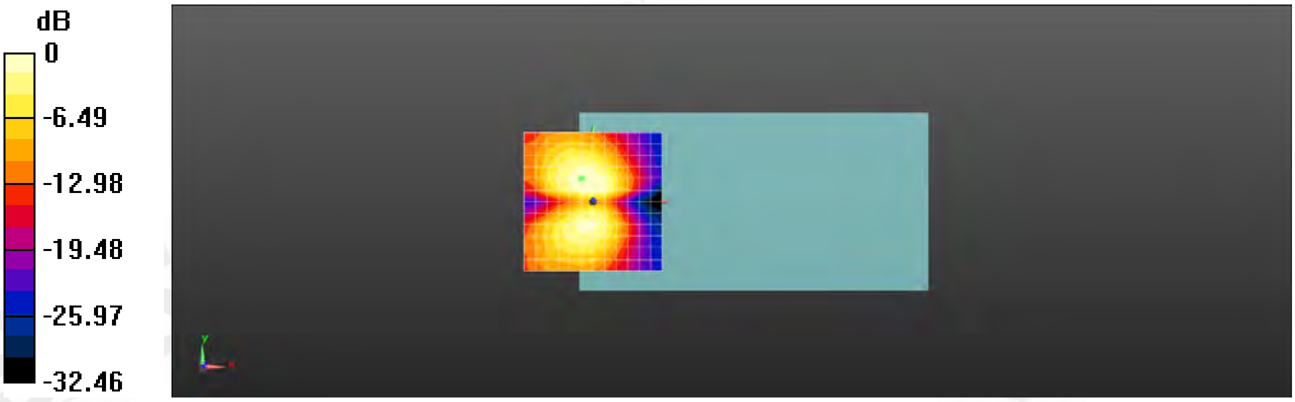
# HAC-T-Coil-CDMA Secondary(BC10) CH 684_RC1 SO68

Communication System: CDMA; Frequency: 823.1 MHz
Medium parameters used: σ = 0 S/m, $\varepsilon_r$ = 1; ρ = 1 kg/m$^3$
Phantom section: TCoil Section

DASY5 Configuration:

- Probe: AM1DV3 - 3115; ; Calibrated: 2018/3/15
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE4 Sn1336; Calibrated: 2018/3/21
- Phantom: HAC Test Arch with AMCC; ;
- DASY52 52.8.8(1258); SEMCAD X 14.6.10(7373)

**General Scans/ y (transversal) 4.2mm 50 x 50/ABM SNR(x,y,z) (13x13x1):**
Measurement grid: dx=10mm, dy=10mm
ABM1/ABM2 = 22.00 dB
ABM1 comp = -17.57 dBA/m
Location: 0, 0, -6.3 mm




0 dB = 12.60 = 22.00 dB

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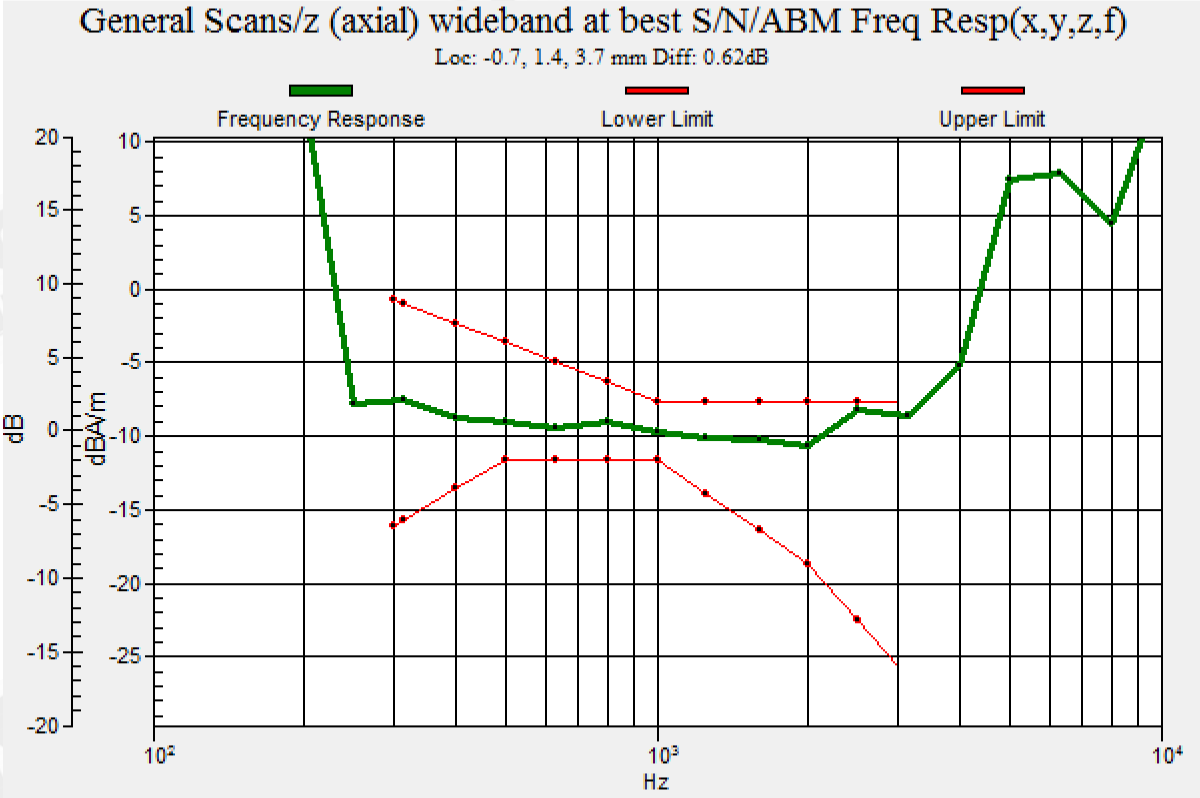


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# 16. DAE & Probe Calibration Certificate

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Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

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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 SGS-TW (Auden)

Certificate No: DAE4-1336_Mar18

## CALIBRATION CERTIFICATE

Object: DAE4 - SD 000 D04 BM - SN: 1336

Calibration procedure(s): QA CAL-06.v29
Calibration procedure for the data acquisition electronics (DAE)

Calibration date: March 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: | Adrian Gehring | Laboratory Technician | A. Geh |
| Approved by: | Sven Kühn | Deputy Manager | i.V. B. Blum |

Issued: March 21, 2018

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

Certificate No: DAE4-1336_Mar18 Page 1 of 5

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Accreditation No.: **SCS 0108**

## Glossary

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

## Methods Applied and Interpretation of Parameters

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



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## 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 | 403.362 ± 0.02% (k=2) | 403.664 ± 0.02% (k=2) | 403.144 ± 0.02% (k=2) |
| Low Range | 3.95108 ± 1.50% (k=2) | 3.98716 ± 1.50% (k=2) | 3.99791 ± 1.50% (k=2) |

## Connector Angle

| | |
|---|---|
| **Connector Angle** to be used in DASY system | 122.0 ° ± 1 ° |



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Appendix (Additional assessments outside the scope of SCS0108)

1. DC Voltage Linearity

| High Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 200032.51 | 0.12 | 0.00 |
| Channel X | + Input | 20006.40 | 1.23 | 0.01 |
| Channel X | - Input | -20003.02 | 1.97 | -0.01 |
| Channel Y | + Input | 200031.85 | -0.59 | -0.00 |
| Channel Y | + Input | 20004.04 | -0.97 | -0.00 |
| Channel Y | - Input | -20005.95 | -0.92 | 0.00 |
| Channel Z | + Input | 200033.31 | 0.61 | 0.00 |
| Channel Z | + Input | 20003.33 | -1.61 | -0.01 |
| Channel Z | - Input | -20007.20 | -2.06 | 0.01 |

| Low Range | | Reading (μV) | Difference (μV) | Error (%) |
|---|---|---|---|---|
| Channel X | + Input | 2001.00 | -0.33 | -0.02 |
| Channel X | + Input | 201.62 | 0.25 | 0.12 |
| Channel X | - Input | -198.41 | 0.24 | -0.12 |
| Channel Y | + Input | 2001.15 | -0.05 | -0.00 |
| Channel Y | + Input | 200.95 | -0.35 | -0.17 |
| Channel Y | - Input | -199.53 | -0.77 | 0.39 |
| Channel Z | + Input | 2001.57 | 0.47 | 0.02 |
| Channel Z | + Input | 199.98 | -1.22 | -0.61 |
| Channel Z | - Input | -200.14 | -1.28 | 0.65 |

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 | 6.48 | 4.38 |
| | - 200 | -3.75 | -4.83 |
| Channel Y | 200 | -4.18 | -3.84 |
| | - 200 | 1.89 | 2.38 |
| Channel Z | 200 | 20.84 | 21.26 |
| | - 200 | -23.99 | -24.35 |

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 | - | 5.48 | -1.63 |
| Channel Y | 200 | 8.85 | - | 6.35 |
| Channel Z | 200 | 8.27 | 6.90 | - |

Certificate No: DAE4-1336_Mar18 Page 4 of 5

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## 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 | 15667 | 16592 |
| Channel Y | 15909 | 15806 |
| Channel Z | 15857 | 15707 |

## 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 | 0.56 | -0.27 | 1.89 | 0.40 |
| Channel Y | -0.08 | -0.95 | 0.75 | 0.36 |
| Channel Z | -1.39 | -2.93 | -0.50 | 0.41 |

## 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 |



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Accreditation No.: **SCS 0108**

Client **SGS-TW (Auden)**

Certificate No: **AM1DV3-3115_Mar18**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | AM1DV3 - SN: 3115 |
| Calibration procedure(s) | QA CAL-24.v4<br>Calibration procedure for AM1D magnetic field probes and TMFS in the audio range |
| Calibration date: | March 15, 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 |
| Reference Probe AM1DV3 | SN: 3000 | 24-Aug-17 (No. AM1DV3-3000_Aug17) | Aug-18 |
| 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: | Jeton Kastrati | Laboratory Technician | |
| Approved by: | Katja Pokovic | Technical Manager | |

Issued: March 20, 2018

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Certificate No: AM1DV3-3115_Mar18 Page 1 of 3

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[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.



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AM1D probe identification and configuration data

| | |
|---|---|
| Item | **AM1DV3** Audio Magnetic 1D Field Probe |
| Type No | SP AM1 001 BB |
| Serial No | **3115** |

| | |
|---|---|
| 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 |
| Manufacturing date | November 15, 2011 |

Calibration data

| | | | |
|---|---|---|---|
| Connector rotation angle | (in DASY system) | **263.0°** | +/- 3.6 ° (k=2) |
| Sensor angle | (in DASY system) | **0.32 °** | +/- 0.5 ° (k=2) |
| Sensitivity at 1 kHz | (in DASY system) | **0.00791 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%.



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# 17. Uncertainty Budget

| Uncertainty of Audio Band Magnetic Measurements | | | | | | | |
|---|---|---|---|---|---|---|---|
| Error Description | Unc. Value | Prob. Dist. | Div. | $(c_i)$ ABM1 | $(c_i)$ ABM2 | Std. Unc. ABM1 | Std. Unc. ABM2 |
| **Probe Sensitivity** | | | | | | | |
| Reference Level | ±3.0% | N | 1 | 1 | 1 | ±3.0% | ±3.0% |
| AMCC Geometry | ±0.4% | R | $\sqrt{3}$ | 1 | 1 | ±0.2% | ±0.2% |
| AMCC Current | ±1.0% | R | $\sqrt{3}$ | 1 | 1 | ±0.6% | ±0.6% |
| Probe Positioning during Calibr. | ±0.1% | R | $\sqrt{3}$ | 1 | 1 | ±0.1,% | ±0.1% |
| Noise Contribution | ±0.7% | R | $\sqrt{3}$ | 0.0143 | 1 | ±0.0% | ±0.4% |
| Frequency Slope | ±5.9% | R | $\sqrt{3}$ | 0.1 | 1.0 | ±0.3% | ±3.5% |
| **Probe System** | | | | | | | |
| Repeatability / Drift | ±1.0% | R | $\sqrt{3}$ | 1 | 1 | ±0.6% | ±0.6% |
| Linearity / Dynamic Range | ±0.6% | R | $\sqrt{3}$ | 1 | 1 | ±0.4% | ±0.4% |
| Acoustic Noise | ±1.0% | R | $\sqrt{3}$ | 0.1 | 1 | ±0.1% | ±0.6% |
| Probe Angle | ±2.3% | R | $\sqrt{3}$ | 1 | 1 | ±1.4% | ±1.4% |
| Spectral Processing | ±0.9% | R | $\sqrt{3}$ | 1 | 1 | ±0.5% | ±0.5% |
| Integration Time | ±0.6% | N | 1 | 1 | 5 | ±0.6% | ±3.0% |
| Field Disturbation | ±0.2% | R | $\sqrt{3}$ | 1 | 1 | ±0.1% | ±0.1% |
| **Test Signal** | | | | | | | |
| Ref. Signal Spectral Response | ±0.6% | R | $\sqrt{3}$ | 0 | 1 | ±0.0% | ±0.4% |
| **Positioning** | | | | | | | |
| Probe Positioning | ±1.9% | R | $\sqrt{3}$ | 1 | 1 | ±1.1% | ±1.1% |
| Phantom Thickness | ±0.9% | R | $\sqrt{3}$ | 1 | 1 | ±0.5% | ±0.5% |
| DUT Positioning | ±1.9% | R | $\sqrt{3}$ | 1 | 1 | ±1.1% | ±1.1% |
| **External Contributions** | | | | | | | |
| RF Interference | ±0.0% | R | $\sqrt{3}$ | 1 | 0.3 | ±0.0% | ±0.0% |
| Test Signal Variation | ±2.0% | R | $\sqrt{3}$ | 1 | 1 | ±1.2% | ±1.2% |
| **Combined Uncertainty** | | | | | | | |
| Combined Std. Uncertainty (ABM Field) | | | | | | ±4.1% | ±6.1% |
| **Expanded Std. Uncertainty** | | | | | | **±8.1%** | **±12.3%** |

## End of report

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