# HAC Test Report for Telecoil

| | |
|---|---|
| **Tests Requested By:** | Motorola Mobility, LLC<br>600 N. US Highway 45<br>Libertyville, IL 60048 |
| **Date of Tests:**<br>**Date of Report:** | January 9, 2014<br>January 24, 2014 |
| **Test Laboratory:** | Motorola Mobility, LLC - ADR Test Services Laboratory<br>600 N. US Highway 45<br>Libertyville, Illinois 60048 |
| **Report Author:** | Thomas Knipple<br>Senior Staff Test Engineer |
| **Statement of Compliance:** | Motorola declares under its sole responsibility that portable cellular telephone FCC IHDT56PG1 to which this declaration relates, complies with recommendations and guidelines per FCC 47 CFR §20.19. The measurements were performed to ensure compliance to ANSI C63.19-2011. It also declares that the product was tested in accordance with the appropriate measurement standards, guidelines and recommended practices. Any deviations from these standards, guidelines and recommended practices are noted below:<br><br>(none) |
| **Results Summary:** | T Category = **T3** |



Motorola encourages all feedback, both positive and negative, on this test report.

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## Revision History

| Revision Version | Date | Notes |
|---|---|---|
| Rev. 0 | Jan-24-2014 | Initial report release |

# 1. Introduction

The Motorola Mobility ADR Test Services Laboratory has performed Hearing Aid Compatibility (HAC) measurements for the portable cellular phone (FCC ID IHDT56PG1). The portable cellular phone was tested in accordance with ANSI C63.19-2011 standard. The test results presented herein clearly demonstrate compliance FCC 47 CFR § 20.19. This report demonstrates compliance for Telecoil performance only and not for near-field emissions.

# 2. Description of the Device Under Test

**Table 1: Information for the Device Under Test**

| | |
|---|---|
| **Serial Number(s)** | LDGB2D0017 |
| **Production Unit or Identical Prototype (47 CFR §2..908)** | Identical Prototype |
| **Device Category** | Portable |

| Air Interface | Frequency Bands | Transport Type | Maximum Output Power Setting (dBm) | CMRS Voice Support on Interface? | Evaluated for HAC? | Concurrent Simultaneous Operation with: | Other Concurrent Operation with: | Voice Support via OTT Capability |
|---|---|---|---|---|---|---|---|---|
| LTE | B2, B4, B5, B17 | DATA | 24.0 | NO | **NO** | Wi-Fi, Bluetooth | NONE | YES |
| GSM | 850 | VOICE | 33.5 | YES | **YES** | Wi-Fi, Bluetooth | NONE | NO |
| GSM | 1900 | VOICE | 30.5 | YES | **YES** | Wi-Fi, Bluetooth | NONE | NO |
| GPRS | 850 | DATA | 33.5 | NO | **NO** | Wi-Fi, Bluetooth | NONE | YES |
| GPRS | 1900 | DATA | 30.5 | NO | **NO** | Wi-Fi, Bluetooth | NONE | YES |
| EGPRS | 850 | DATA | 28.0 | NO | **NO** | Wi-Fi, Bluetooth | NONE | YES |
| EGPRS | 1900 | DATA | 27.0 | NO | **NO** | Wi-Fi, Bluetooth | NONE | YES |
| WCDMA | B5, B4, B2 | VOICE/DATA | 24.0 | YES | **YES** | Wi-Fi, Bluetooth | NONE | YES |
| HSPA | B5, B4, B2 | DATA | 24.0 | NO | **NO** | Wi-Fi, Bluetooth | NONE | YES |
| Wi-Fi 802.11b/g/n | 2.44 GHz | DATA | 18.26 | NO | **NO** | GSM, WCDMA | NONE | YES |
| Bluetooth | 2.44 GHz | DATA | 10.6 | NO | **NO** | GSM, WCDMA | NONE | NO |

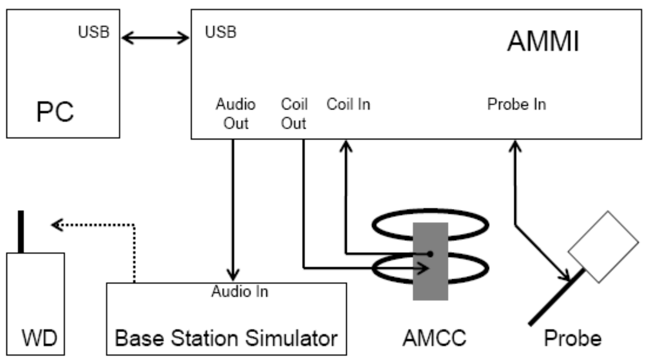
## 3. Test Equipment Used

The Motorola Mobility Inc. ADR Test Services Laboratory utilizes a Dosimetric Assessment System (DASY4™ v4.7) manufactured by Schmid & Partner Engineering AG (SPEAG™) of Zurich, Switzerland. All Telecoil measurements are taken within a shielded enclosure. The measurement uncertainty budget is given in Appendix 5. The list of calibrated equipment used for the measurements is shown in Table 2.

**Table 2: Test Equipment**

| | Description | Serial Number | Cal Date | Cal Due Date |
|---|---|---|---|---|
| **Dosimetric System Equipment** | DAE4 | 437 | Sep-10-2013 | Sep-10-2014 |
| | Audio Magnetic 1D Field Probe AM1DV3 | 3080 | | |
| | AMMI SE UMS 010 AA | 1005 | | |
| | AMCC SD HAC P02 AB | 1005 | | |
| | Test Arch SD HAC D01 BA | 1073 | | |
| **Additional Test Equipment** | Rohde & Schwarz CMU 200 | 106338 | Sep-23-2013 | Sep-23-2014 |

**Figure 1: Telecoil setup and cabling (pictures from DASY manual)**




<u>AMMI</u> (Audio Magnetic Measurement Instrument) is a desktop unit containing a sampling unit, a waveform generator for test, calibration signals and a USB interface. Front connectors include: Audio Out - predefined or user definable audio signals for injection into the WD; Probe In - the probe signal is evaluated by AMMI; Coil Out - test and calibration signal to the AMCC; Coil In - monitor signal from the AMCC.

<u>Audio Magnetic Probe</u> (AM1DV2) is an active probe with a single sensor. The same probe coil is used to measure two orthogonal field components (perpendicular and transverse). The probe is rotated to properly orient the coil for each field component. The probe's frequency response, linearity and other characteristics are given in the certificate in
Appendix 6.

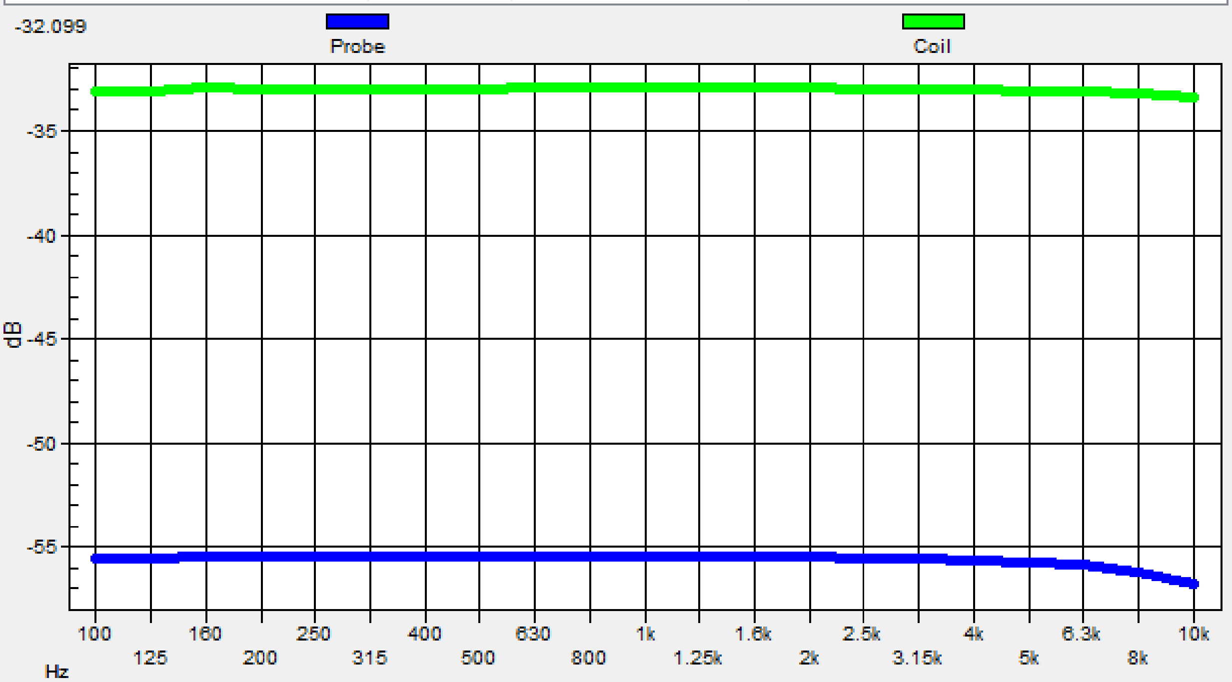
<u>AMCC</u> (Audio Magnetic Calibration Coil) is a Helmoltz coil for calibration of the AM1D probe. The two horizontal coils create a homogeneous magnetic field in the z direction. Refer to Appendix 7 for more details on AMCC coil.

The probe is calibrated in the AMCC coil. The frequency response and sensitivity are measured and stored. Sensitivity includes both probe sensitivity and pre-amplifier sensitivity.

**Graph 1: Frequency Response measured in AMCC**

X: 0 Y: 360 mm Roll: 0 °

| | Coil | Probe | |
|---|---|---|---|
| Internal calibration factor | 2.3565 V | 1.1403 V | |
| Probe sensitivity at 1 kHz | | 0.007391 V/(A/m) | |




| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Probe | -55.509 | -55.499 | -55.398 | -55.435 | -55.447 | -55.436 | -55.412 | -55.420 | -55.416 | -55.398 | -55.414 | -55.417 | -55.414 | -55.452 | -55.503 | -55.561 | -55.597 | -55.683 | -55.871 | -56.187 | -56.772 |
| Coil | -33.068 | -33.062 | -32.953 | -32.993 | -33.004 | -32.988 | -32.961 | -32.962 | -32.950 | -32.925 | -32.932 | -32.927 | -32.911 | -32.934 | -32.967 | -33.001 | -33.005 | -33.051 | -33.141 | -33.226 | -33.407 |

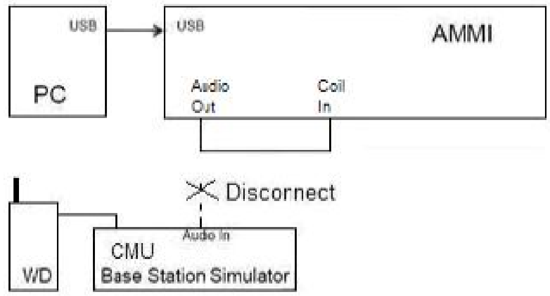
Sensitivity measured in AMCC: 0.007391 $^{V}/_{(A/m)}$

The sensitivity is for a 1 kHz sine signal. The sensitivity includes both probe sensitivity and pre-amplifier sensitivity. It is the total calibration, and there are no additional probe calibration factors. The voltage into the Helmholtz coil is across the shunt resistor.

## 4. Signal Verification

An Input Level is measured to verify that it is within ±0.2 dB from the Reference Input Level in section 7.4.2.1 of ANSI C63.19-2011.

**Figure 2: Signal Verification Setup**




In Figure 2 setup, "Audio Out" of the AMMI is connected to the "Coil In" of the AMMI. The "Audio Out" of the AMMI is measured using 1V as the reference.

Section 7.4.2.1 of ANSI C63.19-2011 specifies the reference input level to be -16 for GSM/WCDMA and -18 for CDMA. Each CMU has a slightly different "0dBm0 Input Reference" value that must be measured. When the CMU box is replaced or externally re-calibrated, an internal calibration procedure must be completed in each transmission mode. On the CMU 200 (SN 106338), the 0dBm0 Input Reference value is 0.73 V for GSM/WCDMA and 0.73 V for CDMA. For more information on "0dBm0 Input Reference" measurements, refer to Appendix 3-5.

The Target Level for "Audio Out" of the AMMI is shown in Table 3. This target level takes into account the difference between AMMI's and CMU's reference levels.

**Table 3: Measured Input Level**

| Modulation | Reference Input Level from ANSI C63.19 (dBm0) | CMU's 0dBm0 Input Reference Value (dB) | Target Level for "Audio Out" of AMMI (dBm0) |
|---|---|---|---|
| GSM/WCDMA | -16 | -2.73 | -18.73 |
| CDMA | -18 | -2.73 | -20.73 |

The signal level for "Audio Out" of the AMMI is measured. Signal Verification has been conducted on the same days as DUT measurements. If it is not within +/-0.2 dB, the gain settings in the DASY template are adjusted. The obtained results are displayed in Table 4.

**Table 4: Measured Input Level**

| Modulation | Measured date | Signal | Measured Level for "Audio Out" of AMMI (dBm0) | Target Level for "Audio Out" of AMMI (dBm0) |
|---|---|---|---|---|
| GSM/WCDMA | January 9, 2014 | Narrowband | -18.77 | -18.73 |
| | | Broadband | -18.72 | |

# 5. Test Results

## 5.1 Telecoil SNR Results

The phone was tested in normal configurations for against-the-ear use. The DASY4 v4.7 measurement system specified in section 3.1 was utilized within the intended operations as set by the SPEAG™ setup. The Test Arch provided by SPEAG is used to position the DUT. All tests are done via conducted setup with CMU 200. The volume on the phone is adjusted to maximum. Backlight was off during testing, and HAC compliance will be explained in the manual.

The tests are performed with a telecoil software function enabled. To enable the telecoil function, select:
Phone Dialer >> Vertical Ellipsis Button >> Settings >> Hearing aids [CHECK BOX]

The proper test distance is established by positioning the device beneath the test arch phantom so that it is touching the frame. The location and thickness of the arch, and the location/orientation of the coil within the probe housing, are precisely known values in the DASY software. The height of the measurement plane is further fine-tuned by performing a Surface Detection job at the beginning of each test. The end result is that the probe sensor is very precisely located 10 mm above the device reference plane.

ABM2 investigation has been carried out to determine the worst-case channel / frequency of each applicable frequency band. At the location of the Telecoil source, ABM2 is measured in the perpendicular probe position for each frequency (Table 5). For each band, the channel with the highest ABM2 measurement is highlighted in **bold**.

**Table 5: ABM2 measurements across the frequency band for the portable cellular telephone at highest possible output power.**

| ABM2 Measurements (dB A/m) | | |
|---|---|---|
| GSM 850 | Ch 128 | -23.1224 |
| | Ch 190 | **-22.7327** |
| | Ch 251 | -22.9663 |
| GSM 1900 | Ch 512 | -27.3859 |
| | Ch 661 | **-27.1347** |
| | Ch 810 | -27.4612 |
| WCDMA 850 | Ch 4132 | -45.0971 |
| | Ch 4180 | **-44.9674** |
| | Ch 4233 | -45.0888 |
| WCDMA 1700 | Ch 1312 | **-44.7441** |
| | Ch 1413 | -46.1994 |
| | Ch 1513 | -45.4212 |
| WCDMA 1900 | Ch 9262 | **-44.5363** |
| | Ch 9400 | -44.7117 |
| | Ch 9538 | -45.1940 |

For the channels highlighted in bold in Table 5, Telecoil SNR measurements are shown in Table 6. The sequence of the Telecoil SNR measurement is listed in the steps below.

a) Geometry & signal check
b) Background noise measurement. The background noise is measured at the center of the listening area.
c) Coarse resolution perpendicular scan (narrowband signal, 1 s measurement times, 50 x 50 mm grid with 5.55 mm spacing). Only ABM1 is measured in order to find the location of the Telecoil source.
d) Fine resolution perpendicular and transverse scans, positioned appropriately based on optimal ABM1 of coarse resolution perpendicular scan (narrowband signal, 1 s measurement times, variable grid size with 2 mm spacing). Both ABM1 and ABM2 are measured in order to find the location of the SNR point.
e) ABM1 & ABM2 point measurements in perpendicular and transverse coil orientations, positioned appropriately based on optimal signal quality of fine resolution scans (narrowband signal, 2 s measurement times). SNR is calculated for each coil orientation.
f) Frequency Response point measurement in perpendicular coil orientation, positioned appropriately based on optimal signal quality of fine resolution perpendicular scan (broadband signal, 12 s measurement time)

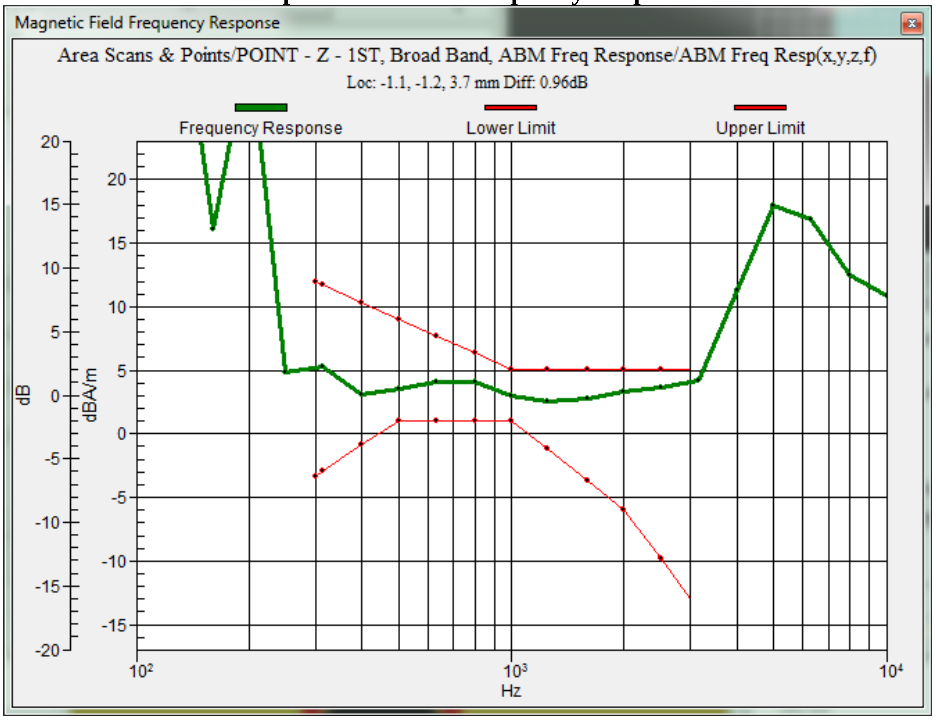
The ABM1, SNR and Telecoil Rating results are shown in Table 6. Also shown are the measured conducted output power, location of the measured point, noise and ABM2. The delta between Ambient Noise measurement and ABM2 measurement should be greater than 10 dB. However, in cases where ABM2 is very low, it is suitable for the delta to be less than 10 dB. For the two probe positions, contour plots for the lowest SNR, indicated in **bold numbers**, are given in Appendix 1. For the two probe positions, noise spectrum plots for the highest ambient noise, indicated with **bold numbers**, are given in Appendix 2. These noise spectrum plots are half band integrated with an A-weighting filter applied.

| Telecoil SNR Limits | | |
|---|---|---|
| ABM 1 | Greater or equal to -18 dB A/m | |
| SNR | T3 | Greater than 20 dB |
| | T4 | Greater than 30 dB |

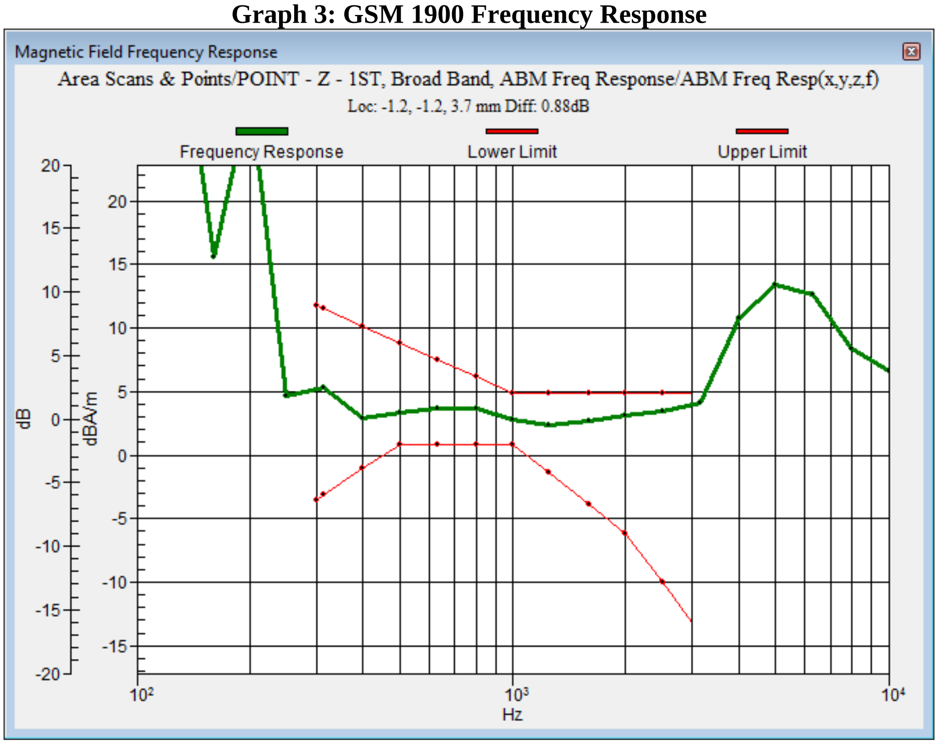
**Table 6: Telecoil SNR measurement results for the portable cellular telephone at highest possible output power.**

| Probe Position | Frequency Band (MHz) | Channel | Conducted Output Power (dBm) | Measured Point Location (x mm, y mm) | Ambient Noise (dB A/m) | ABM2 (dB A/m) | ABM2 – Ambient Noise (dB) | ABM1 (dB A/m) | SNR (dB) | Telecoil SNR Rating |
|---|---|---|---|---|---|---|---|---|---|---|
| Perpendicular | GSM 850 | 190 | 33.30 | -1.1, -1.2 | -53.6359 | -23.3278 | 30.3081 | 3.0432 | **26.37** | T3 |
| | GSM 1900 | 661 | 30.70 | -1.2, -1.2 | -53.7517 | -27.7375 | 26.0142 | 2.8354 | 30.57 | T4 |
| | WCDMA 850 | 4180 | 23.63 | -2.7, 3.6 | -53.7211 | -49.7210 | 4.0001 | -0.5000 | 49.22 | T4 |
| | WCDMA 1700 | 1312 | 23.39 | -2.7, 3.6 | **-53.2057** | -49.7974 | 3.4083 | -1.3163 | 48.48 | T4 |
| | WCDMA 1900 | 9262 | 23.03 | -2.8, 2.0 | -53.2610 | -48.5000 | 4.7610 | -0.0800 | 48.42 | T4 |
| Transverse | GSM 850 | 190 | 33.30 | -3.5, 6.8 | -55.4865 | -33.7288 | 21.7577 | -6.9480 | **26.78** | T3 |
| | GSM 1900 | 661 | 30.70 | -3.2, 6.8 | **-55.3131** | -37.9385 | 17.3746 | -7.0434 | 30.90 | T4 |
| | WCDMA 850 | 4180 | 23.63 | -3.1, -5.6 | -55.6674 | -53.5681 | 2.0993 | -8.0652 | 45.50 | T4 |
| | WCDMA 1700 | 1312 | 23.39 | -3.2, -5.2 | -55.6485 | -53.8342 | 1.8143 | -8.9098 | 44.92 | T4 |
| | WCDMA 1900 | 9262 | 23.03 | -3.2, -5.6 | -55.7136 | -53.8952 | 1.8184 | -8.9409 | 44.95 | T4 |

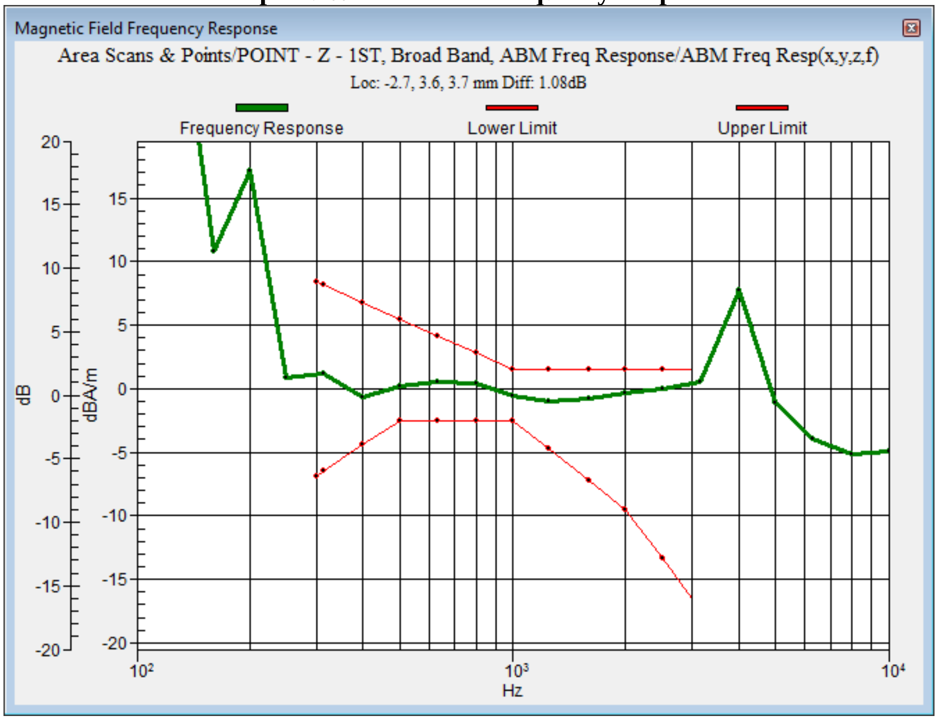
**Graph 2: GSM 850 Frequency Response**



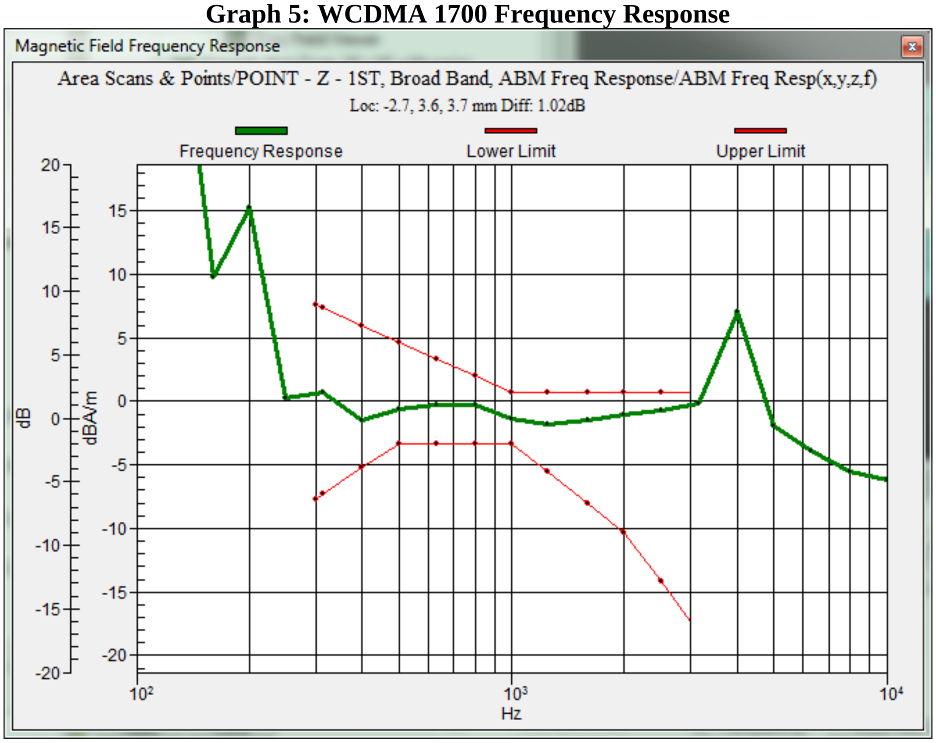

**Graph 3: GSM 1900 Frequency Response**



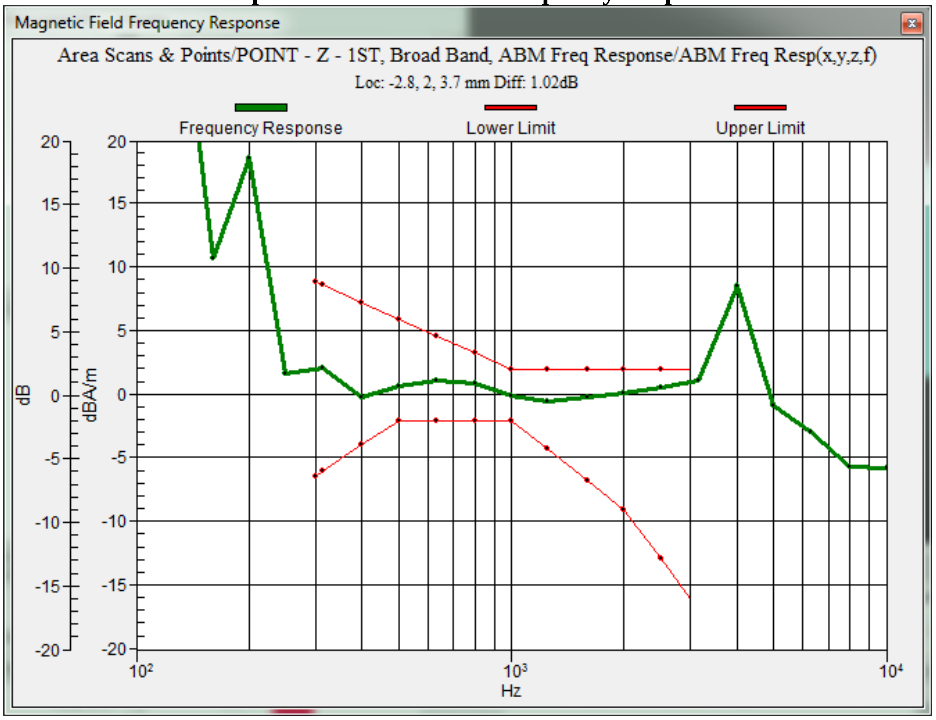
**Graph 4: WCDMA 850 Frequency Response**




**Graph 5: WCDMA 1700 Frequency Response**



**Graph 6: WCDMA 1900 Frequency Response**



# 6. Device Conducted Power Measurements

For GSM devices, 1-slot circuit-switch voice mode is considered. The conducted power measurements for this mode are shown in the table below.

**Table 7: Conducted Power (dBm) for GSM modes evaluated for HAC**

| Band | Mode | Channel | Measured Value (dBm) |
|---|---|---|---|
| GSM 850 | Circuit-Switched Voice (1 Uplink Timeslot) | 128 | 33.35 |
| | | 190 | 33.30 |
| | | 251 | 33.48 |
| GSM 1900 | Circuit-Switched Voice (1 Uplink Timeslot) | 512 | 30.50 |
| | | 661 | 30.70 |
| | | 810 | 30.32 |

For WCDMA devices, 12.2 kbps AMR modes is considered. The conducted power measurements for each mode are shown in the table below.

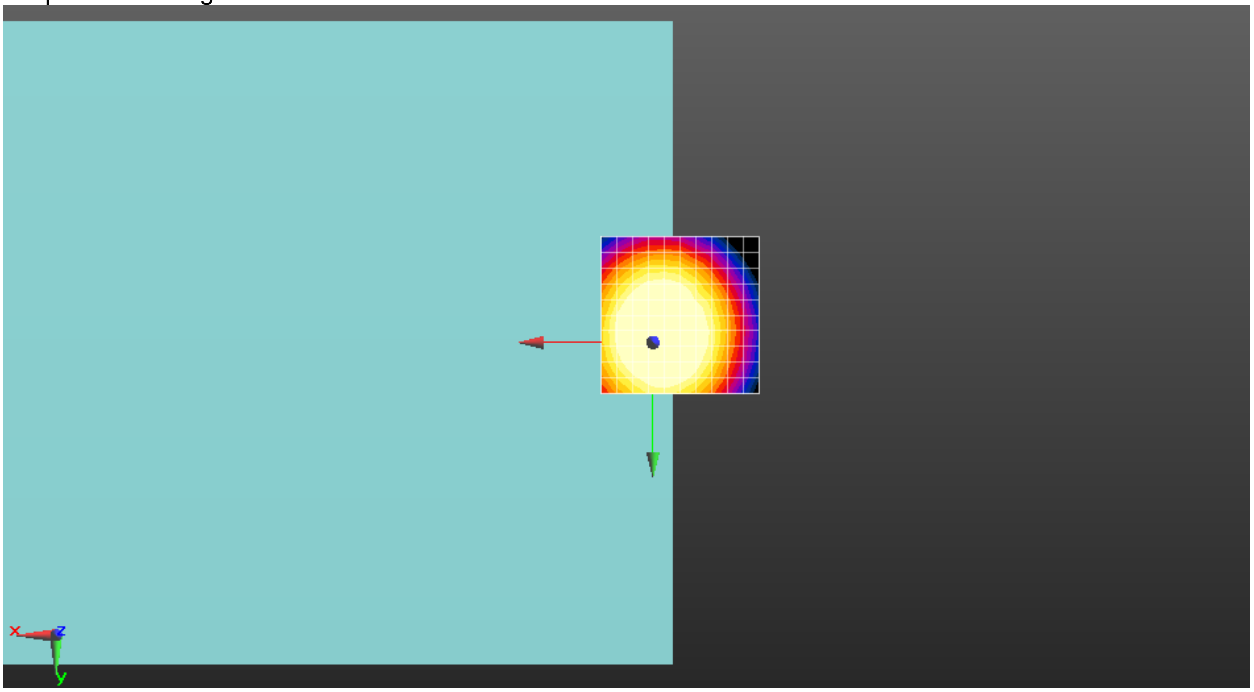
**Table 8: Conducted Power (dBm) for WCDMA modes evaluated for HAC**

| Band | Mode | Channel | Measured Value (dBm) |
|---|---|---|---|
| WCDMA 850 | 12.2 kbps AMR | 4132 | 23.61 |
| | | 4180 | 23.63 |
| | | 4233 | 23.60 |
| WCDMA 1700 | 12.2 kbps AMR | 1312 | 23.36 |
| | | 1413 | 23.39 |
| | | 1513 | 23.29 |
| WCDMA 1900 | 12.2 kbps AMR | 9262 | 23.03 |
| | | 9400 | 22.80 |
| | | 9538 | 22.74 |

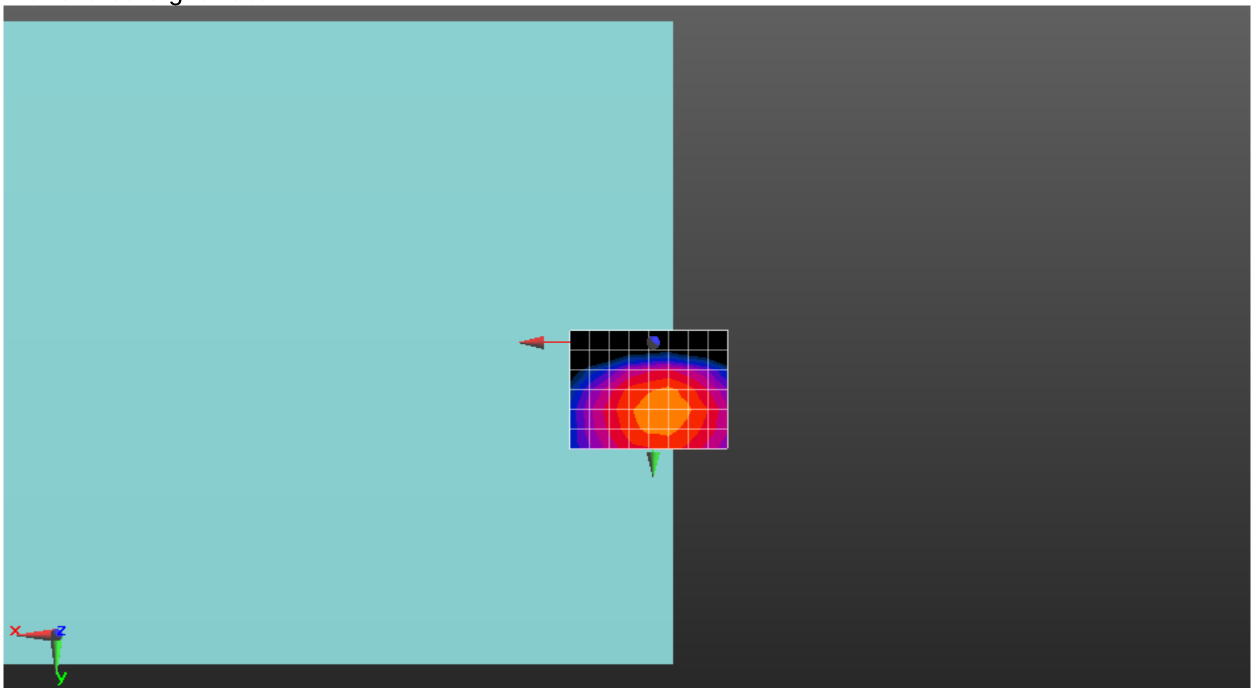
# Appendix 1

## Contour Plots

Perpendicular Signal Scan

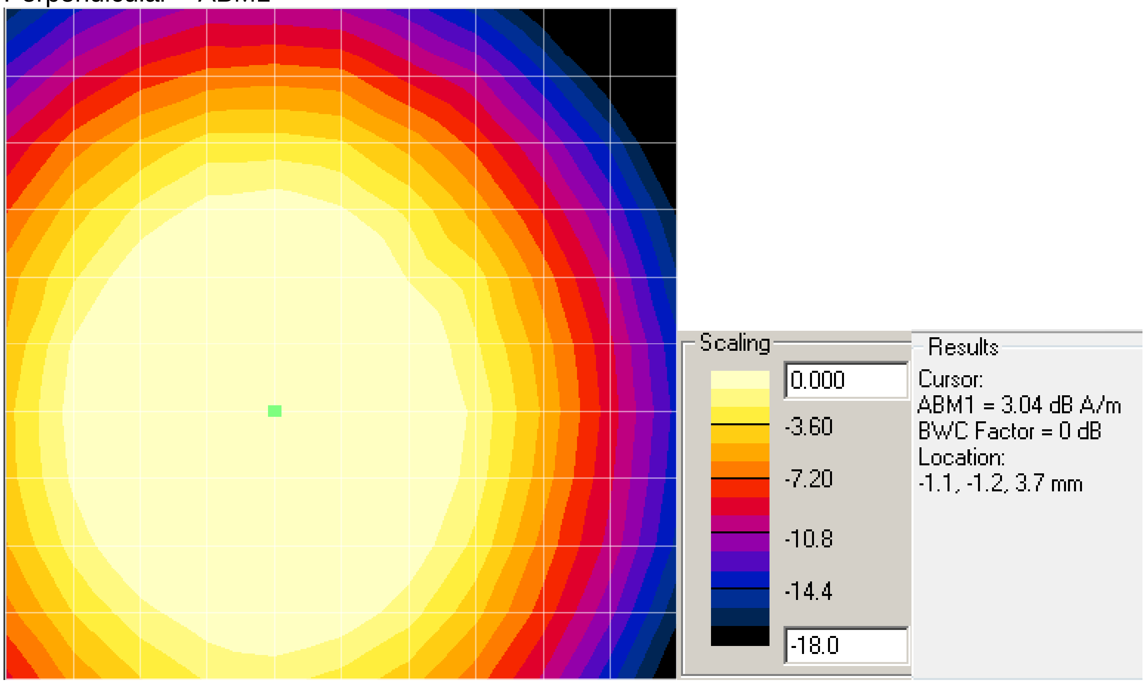



Transverse Signal Scan

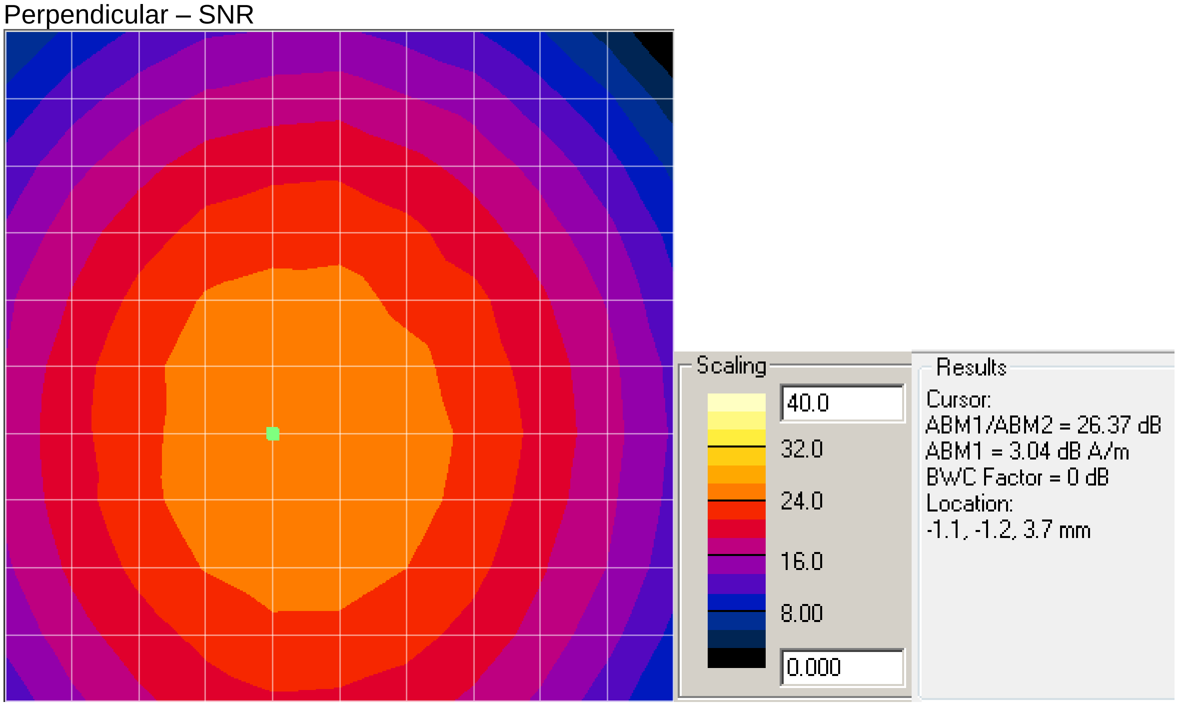



Note: The blue dot designates the device reference point.

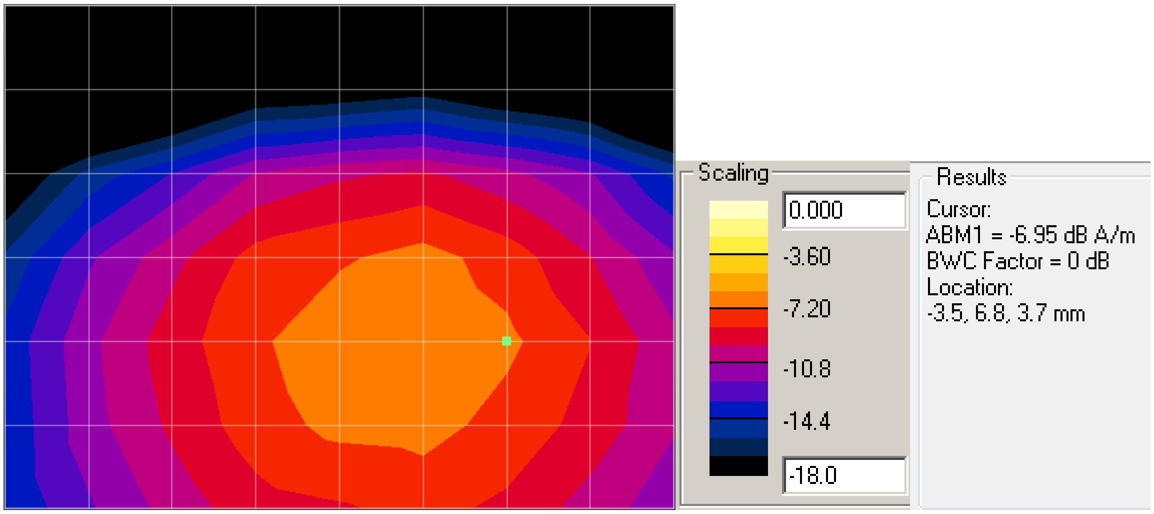
Perpendicular – ABM1



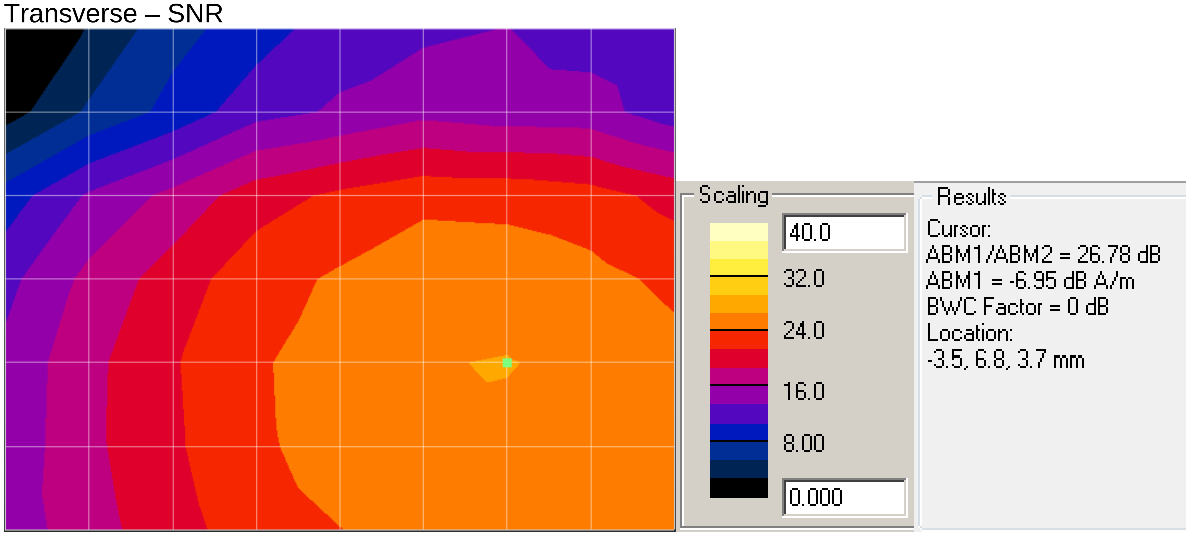

Perpendicular – SNR



Transverse – ABM1



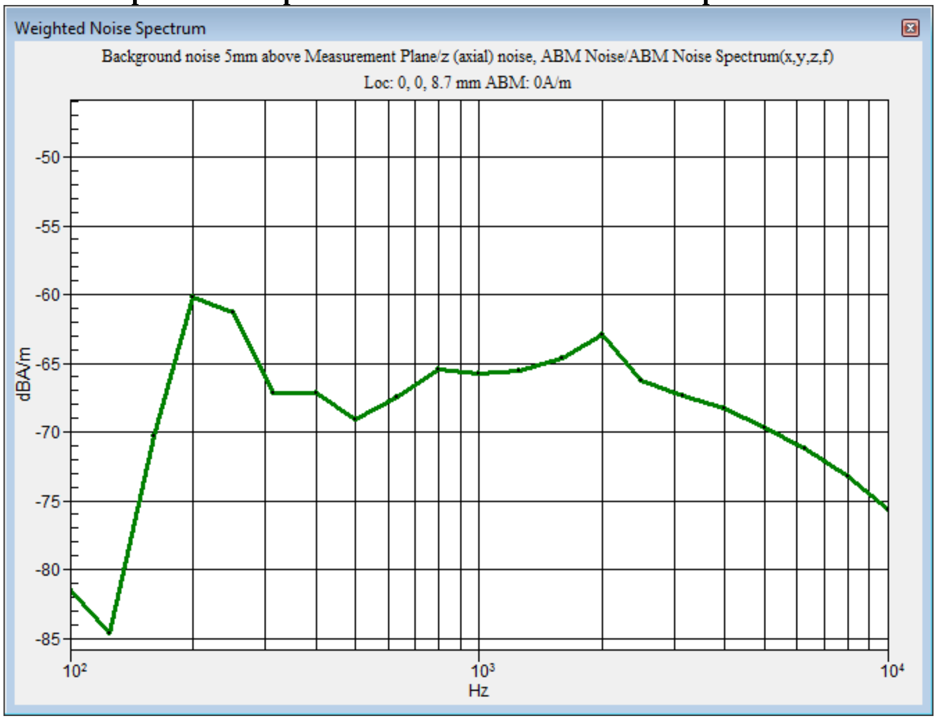

Transverse – SNR



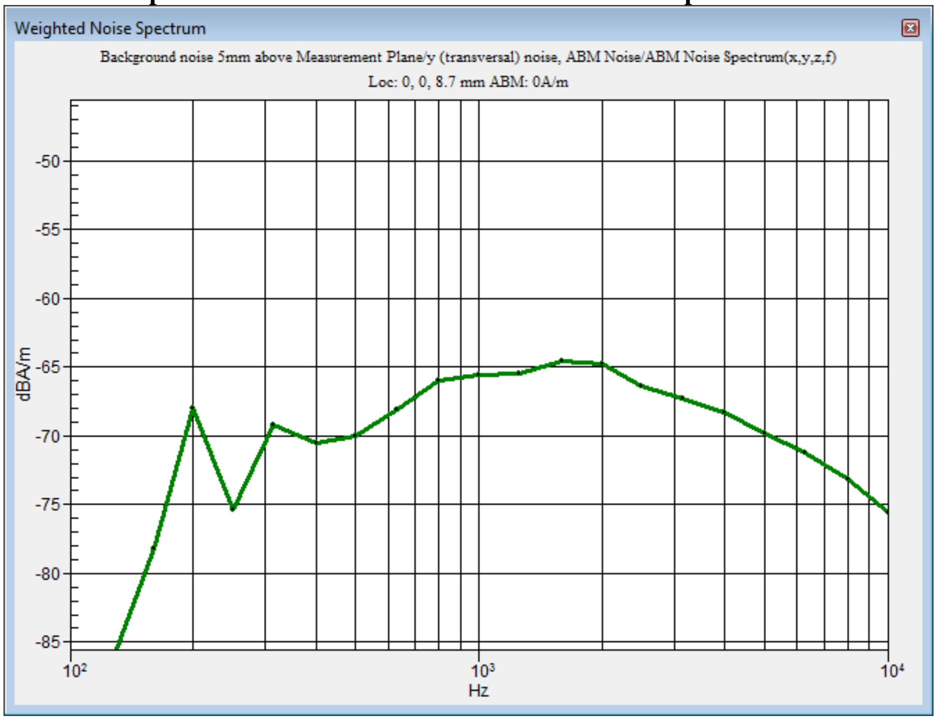
# Appendix 2

## Ambient Noise Spectrum Plots

**Graph A2-1. Perpendicular Position Ambient Noise Spectrum Plot**




**Graph A2-2. Transverse Position Ambient Noise Spectrum Plot**



# Appendix 3

## Details on the Measurement Systems

## 3-1) Details on ABM2 measurements by the system

**(Description provided by Schmid & Partner Engineering, AG)**:

The processing applies a convolution in the time-domain. This filtering is composed of integrator (straight-forward), Half-Band filter (first-order filter) and A-weighting. The convolved data stream is then integrated over the desired period and represented and stored numerically in DASY4 as the ABM Noise (= ABM2).

During the validation process of our system, the functionality of this process has been verified by debugging the filters step-by-step progressive and comparing the results also with a Rohde & Schwarz UPL Analyzer. The intermediate steps are not accessible in the final software code operated by the end user. In addition, the following verification has been made, using a single frequency (sine) signal: At the reference frequency of 1 kHz, the signal is equivalent to ABM1. ABM1 is visible from the calibration job, inclusive its frequency slope from 100Hz to 5kHz. This function (conversion of the coil voltage to the field) is the same integration function.

The verification of the probe linearity and the linearity of the integrator has been determined and documented in the certificate 880-SP AM1 001 A, inclusive the integrator, over the required frequency range (exceeding 5 kHz). The additional frequency slope of the Half-Band filter and the A-weighting have also been tested by changing the applied frequency over the full range. The attenuation was verified for each third-octave-band and up to > 10 kHz. In addition, the correct processing of multiple sine-wave signals was verified.

The convolutions work over the full frequency range available in the analog path, only limited by AC-coupling at the low end and anti-aliasing filter at the high frequency end. White noise signal without band limitation has not been used for filter measurements. Pink noise, decreasing with frequency, resulting in a frequency independent response of the third-octave filter bank was used to optically verify the correct filtering function. Precision measurements were however made with pure sine signals.

Frequency components beyond the visible range of 5 kHz are contained in the ABM2 figure.

**(Measurements made by Motorola)**:

Comparison of 1kHz narrowband signal driven extenally into TMFS coil

| ABM1 @ 1kHz | ABM2 @ 1kHz | difference |
|---|---|---|
| -25.122 | -25.124 | 0.002 dB |

Frequency dependent ABM1 - ABM2 with broadband noise and narrowband tones driven externally into TMFS coil

| Frequency | dB difference ABM1-ABM2 broadband signal | dB difference ABM1-ABM2 single frequency signals | ideal value for ABM1-ABM2 | variance from ideal boadband | variance from ideal single frequencies |
|---|---|---|---|---|---|
| 200 | | 22.062 | 22.35 | | 0.288 |
| 250 | | | 17.89 | | |
| 315 | | | 14.03 | | |
| 400 | | 10.371 | 10.39 | | 0.019 |
| 500 | 6.852 | | 7.18 | 0.328 | |
| 630 | 4.228 | | 4.36 | 0.132 | |
| 800 | 1.587 | 1.881 | 1.88 | 0.293 | -0.001 |
| 1000 | 0.013 | 0.013 | 0 | -0.013 | -0.013 |
| 1250 | -1.473 | | -1.46 | 0.013 | |
| 1600 | -2.72 | | -2.58 | 0.14 | |
| 2000 | -3.535 | -3.235 | -3.24 | 0.295 | -0.005 |
| 2500 | -3.738 | | -3.67 | 0.068 | |
| 3150 | -3.837 | | -3.79 | 0.047 | |
| 4000 | -3.733 | -3.744 | -3.75 | -0.017 | -0.006 |
| 5000 | -3.283 | -3.336 | -3.34 | -0.057 | -0.004 |
| | **maximum variation from ideal:** | | | 0.328 dB | |

## 3-2) Details on the compliancy of the frequency and linearity response

**(Description provided by Schmid & Partner Engineering, AG)**:
See also probe certificate of conformity in Appendix 6, titled 880-SP AM1 001 A-A
See also coil certificate of conformity in Appendix 7, titled 880-SD HAC P02A-A

Frequency response has been tested to be within +/- 0.5 dB of ideal differentiator from 100 Hz to 10 kHz. The test was made with the real integrator and deducting the ideal integrator values. Reference signal was the Helmholtz calibration coil current which is equivalent to the field. The coil is qualified according to certificate 880-SD HAC P02 A-A.

The test data up to 5 kHz are visible directly in the calibration job result (coil current / shunt voltage, and probe voltage). Separate measurements were made for a very wide frequency range, including higher frequencies. For the third-octave bands up to 5 kHz do not exceed 0.05 dB and decay by < 0.2 dB to 5 kHz and by < 0.5 dB to 10 kHz, as required.

Linearity has also been tested and is stated in the certificate. Deviation was not measurable from 5 dB below limitation to 26 dB above noise level. For lower levels, the deviation increased to 0.1 dB at 16 dB above noise level, which corresponds to the theoretical value of 0.11 dB expected at that noise suppression level.

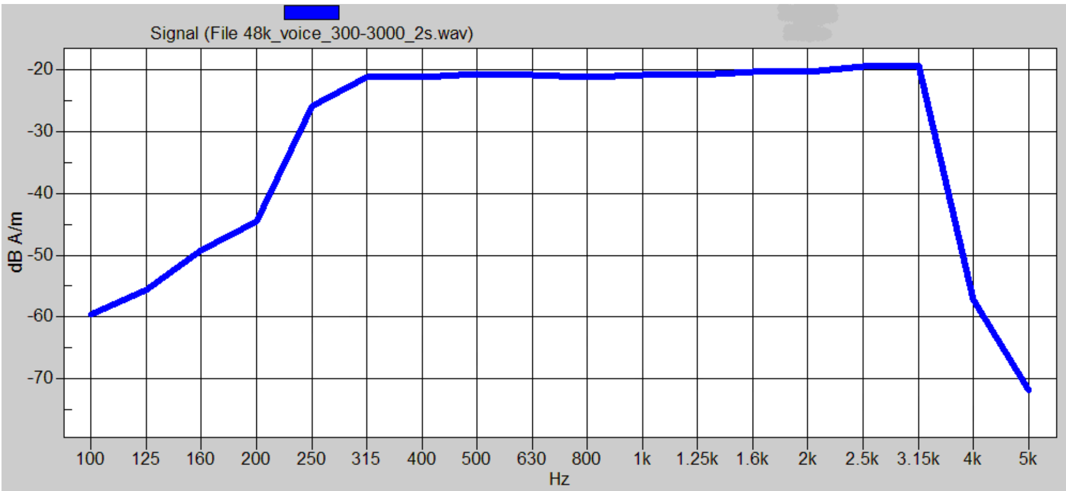
Significant noise contribution beyond 10 kHz will be attenuated by the convoluting A-filter as explained in answer #2. Such interferences contribute also to ABM2 represented as numerical value from the integration.

## 3-3) Details on Measurements by the systems

Details regarding timing and averaging of the reported final measured points are as follows:

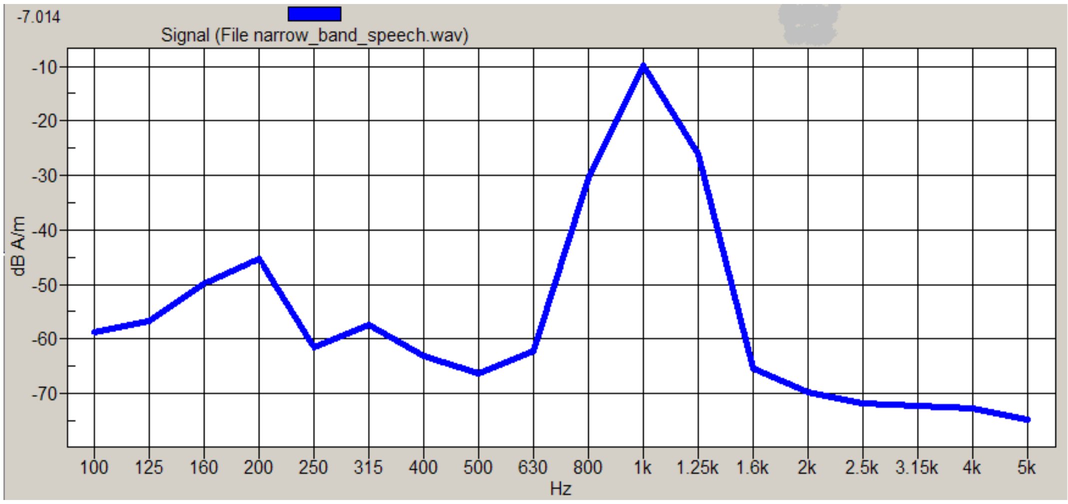
| | Narrowband Signal | Broadband Signal |
|---|---|---|
| Signal Length (sec): | 1 | 2 |
| Total Data Acquisition Time per Location (sec): | 2 | 12 |
| | Averaging is over 2 signal repetitions | Averaging is over 6 signal repetitions |

The broadband signal utilized is shown in the following plot:



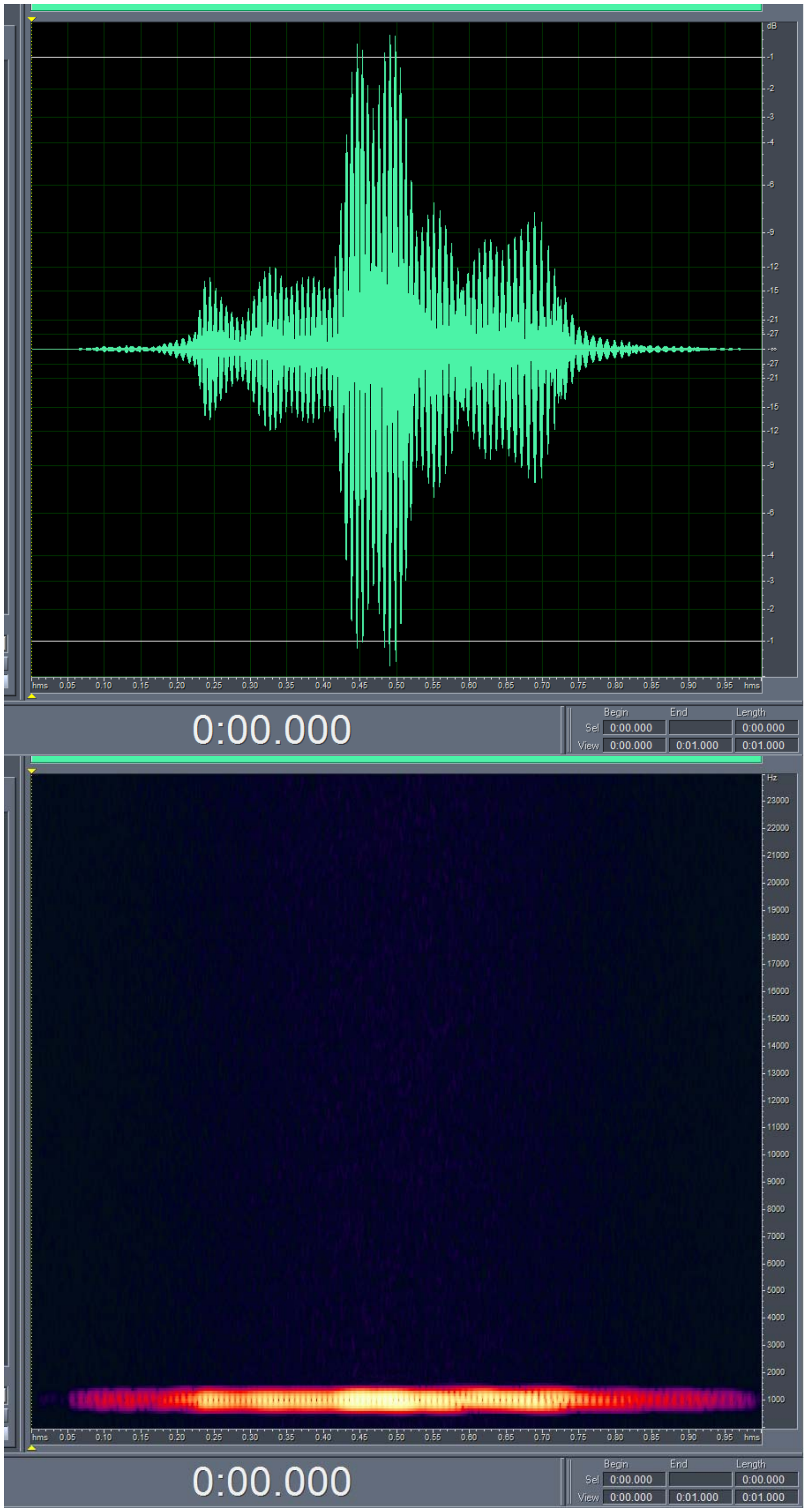

Mathematical processing is not required because the preferred method (as described in ANSI C63.19-2011 section 7.4) is utilized. The broadband audio signal is used only for assessment of frequency response. The DASY4 system corrects for the spectral response after measurement since it knows the spectrum of the input signal. However, please note that for the signal that we use, the spectrum is flat when measured in 1/3 octave bands, covering the range up to 3 kHz.

The narrowband signal utilized is shown in the following plot:

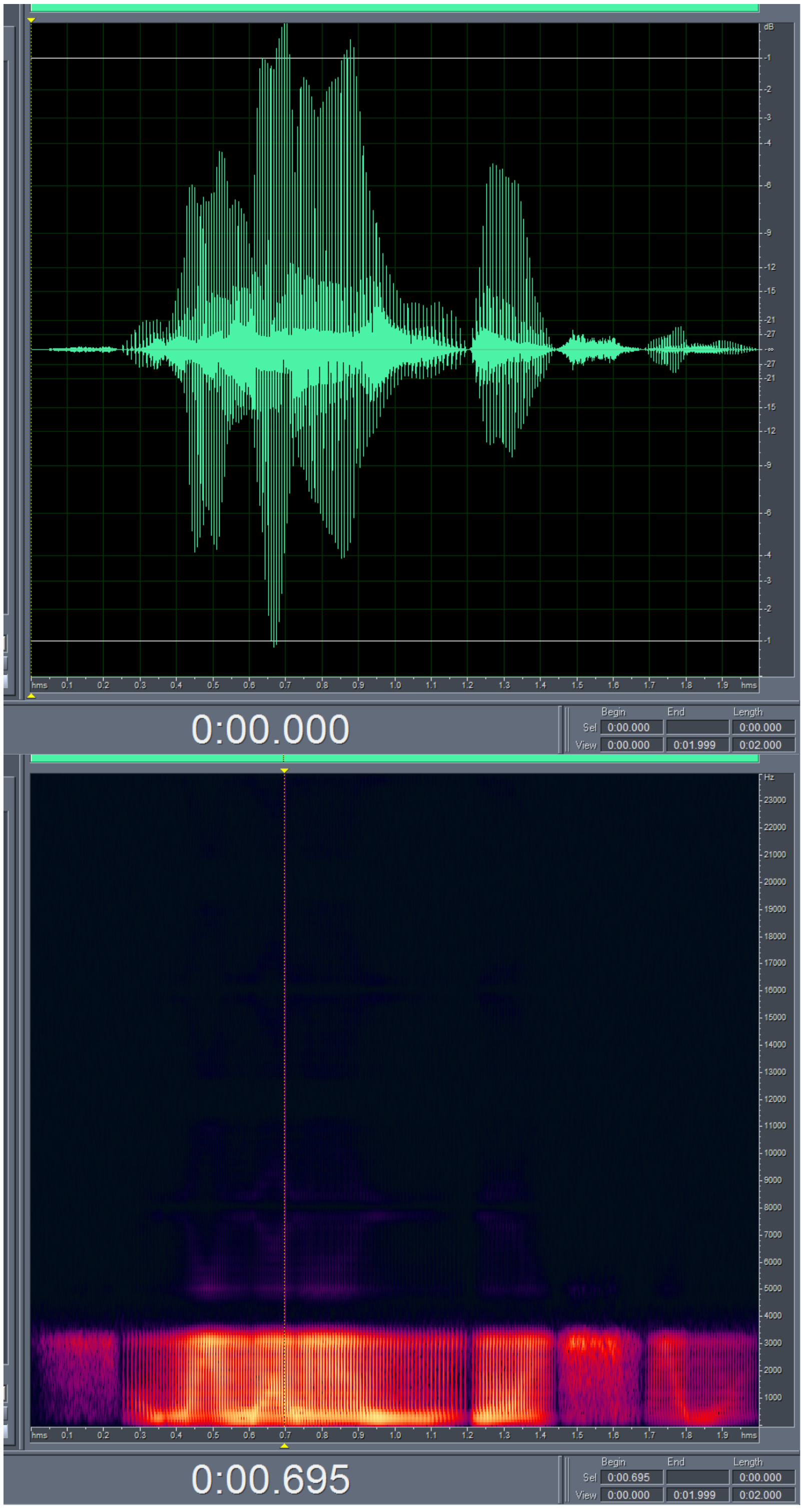


## 3-4) Details of the source audio signals for all aspects of the test

Here is the temporal response of the narrow band signal. The signal is one second of the standard P.50 speech band limited to the ANSI 1kHz 1/3 octave band. The signal is Hann windowed to ensure continuity of the signal.



Here is the temporal response of the 300 Hz - 3 kHz broadband signal. The signal is a 2 second segment of the standard P.50 speech that is equalized flat (for ANSI 1/3 octaves) over the 300 Hz to 3 kHz range. The signal is Hann windowed to ensure continuity of the signal.



## 3-5) Details of the CMU-200 “0dBm0 Input Reference value”

**Measure “Ref Input Level”**

a) Generate a 1 kHz Sine Signal using AMMI.
b) Capture a signal level using AMMI.
c) Record the value as the "Ref Input Level"

**Measure Value “X”**

d) Connect CMU to AMMI.
e) Connect a phone which operates in the desired modulation to the CMU. Establish a call to the CMU. Select Decoder Cal on CMU.
f) Capture a signal level from CMU using AMMI.
g) Record the value as the "Value X".

**Measure Value “M”**

h) Make another connection from AMMI to CMU. Change to Encoder Cal on CMU.
i) Generate a 1 kHz Sine Signal using AMMI
j) Capture a signal from CMU using AMMI.
k) Record the value as the "Value M".

Calculate the resulting Input Correction Factor & the 0dBm0 Input Reference

**Relevant Equations:**

Measured values from above: Ref Input Level, X, M

Input Correction Factor = Ref Input Level + X – M
0dBm0 Input Reference = 10^(Input Corr Factor/20) * CMU-200 manual ref value

# Appendix 4

## Pictures of Test Setup

See Exhibit 7B

# Appendix 5

## Motorola Uncertainty Budget

**Table A5-1: Telecoil Uncertainty Budget, provided by SPEAG**

| Error Description | Uncertainty value (%) | Prob. Dist. | Div. | c ABM1 | c ABM2 | St.Unc ABM1 (%) | St.Unc ABM2 (%) |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| **PROBE SENSITIVITY** | | | | | | | |
| Reference level | 3.0 | N | 1 | 1 | 1 | 3.0 | 3.0 |
| AMCC geometry | 0.4 | R | 1.7 | 1 | 1 | 0.2 | 0.2 |
| AMCC current | 0.6 | R | 1.7 | 1 | 1 | 0.4 | 0.4 |
| Probe positioning during calibration | 0.1 | R | 1.7 | 1 | 1 | 0.1 | 0.1 |
| Noise contribution | 0.7 | R | 1.7 | 0.0143 | 1 | 0.0 | 0.4 |
| Frequency slope | 5.9 | R | 1.7 | 0.1 | 1 | 0.3 | 3.5 |
| | | | | | | | |
| **PROBE SYSTEM** | | | | | | | |
| Repeatability / Drift | 1.0 | R | 1.7 | 1 | 1 | 0.6 | 0.6 |
| Linearity / Dynamic range | 0.6 | R | 1.7 | 1 | 1 | 0.4 | 0.4 |
| Acoustic noise | 1.0 | R | 1.7 | 0.1 | 1 | 0.1 | 0.6 |
| Probe angle | 2.3 | R | 1.7 | 1 | 1 | 1.4 | 1.4 |
| Spectral processing | 0.9 | R | 1.7 | 1 | 1 | 0.5 | 0.5 |
| Integration time | 0.6 | N | 1 | 1 | 5 | 0.6 | 3.0 |
| Field disturbation | 0.2 | R | 1.7 | 1 | 1 | 0.1 | 0.1 |
| | | | | | | | |
| **TEST SIGNAL** | | | | | | | |
| Reference signal spectral response | 0.6 | R | 1.7 | 0 | 1 | 0.0 | 0.4 |
| | | | | | | | |
| **POSITIONING** | | | | | | | |
| Probe positioning | 1.9 | R | 1.7 | 1 | 1 | 1.1 | 1.1 |
| Phantom thickness | 0.9 | R | 1.7 | 1 | 1 | 0.5 | 0.5 |
| DUT positioning ** | 4.0 | R | 1.7 | 1 | 1 | 2.4 | 2.4 |
| | | | | | | | |
| **EXTERNAL CONTRIBUTIONS** | | | | | | | |
| RF interference | 0.0 | R | 1.7 | 1 | 1 | 0.0 | 0.0 |
| Test signal variation | 2.0 | R | 1.7 | 1 | 1 | 1.2 | 1.2 |
| | | | | | | | |
| **COMBINED UNCERTAINTY** | | | | | | | |
| **Combined Std.Uncert. (ABM field)** | | | | | | 4.6 | 6.5 |
| **Expanded Std. Uncertainty, k=2 (%)** | | | | | | 9.1 | 12.9 |

** based on repeat measurements of reference unit

# Appendix 6

## Audio Magnetic Probe Certificate

**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** **Motorola MDb**

**Certificate No: AM1DV3-3080_Nov10**

# CALIBRATION CERTIFICATE

| | |
|---|---|
| Object | AM1DV3 - SN: 3080 |
| Calibration procedure(s) | QA CAL-24.v2<br>Calibration procedure for AM1D magnetic field probes and TMFS in the audio range |
| Calibration date: | November 29, 2010 |

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 | 28-Sep-10 (No:10376) | Sep-11 |
| Reference Probe AM1DV3 | SN: 3000 | 6-Sep-10 (No. AM1D-3000_Sep10) | Sep-11 |
| DAE4 | SN: 781 | 22-Jan-10 (No. DAE4-781_Jan10) | Jan-11 |

| Secondary Standards | ID # | Check Date (in house) | Scheduled Check |
|---|---|---|---|
| AMCC | 1050 | 15-Oct-09 (in house check Oct-09) | Oct-11 |

| | Name | Function | Signature |
|---|---|---|---|
| Calibrated by: | Mike Meili | Laboratory Technician | M. Meili |
| Approved by: | Fin Bomholt | R&D Director | F. Bomholt |

Issued: November 29, 2010

## References

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

[2] DASY4 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 BA |
| Serial No | **3080** |

| | |
|---|---|
| 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 | May-2010 |
| Last calibration date | n/a |

## Calibration data

| | | | |
|---|---|---|---|
| Connector rotation angle | (in DASY system) | **157.7 °** | +/- 3.6 ° (k=2) |
| Sensor angle | (in DASY system) | **0.69 °** | +/- 0.5 ° (k=2) |
| Sensitivity at 1 kHz | (in DASY system) | **0.00739 V / (A/m)** | +/- 2.2 % (k=2) |

# Appendix 7

## AMCC Certificate (Helmholtz Coil)

Zeughausstrasse 43, 8004 Zurich, Switzerland
Phone +41 1 245 9700, Fax +41 1 245 9779
info@speag.com, http://www.speag.com

## Certificate of conformity

| | |
|---|---|
| Item | Audio Magnetic Calibration Coil<br>AMCC |
| Type No | **SD HAC P02 A** |
| Series No | 1001 ff. |
| Manufacturer / Origin | Schmid & Partner Engineering AG<br>Zurich, Switzerland |

**Description of the item**
The Audio Magnetic Calibration coil (AMCC) is a Helmholtz Coil designed according to standard [1], section D.9 for calibration of the AM1D probe. Two horizontal coils are positioned above a non-metallic base plate and generate a homogeneous magnetic field in the z direction (normal to it).

**Configuration**
The AMCC consists of two parallel coils of 20 turns with radius 143 mm connected in parallel in a distance of 143 mm. With this design, a current of 10 mA produces a field of 1 A/m.
The DC input resistance at the input BNC socket is adjusted by a series resistor to a DC resistance of approximately 50 Ohm. The voltage required to produce a field of 1 A/m is consequently approx. 500 mV.
To current through the coil is monitored via a shunt resistor of 10 Ohm +/- 1%. The voltage is available on a BNO socket with 100 mV corresponding to 1 A/m.

**Handling of the item**
The coil shall be positioned in a non-metallic environment to avoid distortion of the magnetic field.

**Tests**

| Test | Requirement | Details | Units tested |
|---|---|---|---|
| Number of turns | N = 20 per coil | Resistance measurment | all |
| Orientation of coils | parallel coils with same direction of windings | Magnetic field variation in the AMCC axis | all |
| Coil radius | r = 143 mm | mechanical dimension | First article |
| Coil distance | d = 143 mm<br>distance between coil centers | mechanical dimension | First article |
| Input resistance | 51.7 +/- 2 Ohm | DC resistance at BNC input connector | all |
| Shunt resistance | R = 10.0 Ohm +/- 1 % | DC resistance at BNO output connector | all |
| Shunt sensitivity | Hc = 1 A/m per 100 mV according to formula<br>Hc = (U / R) * N / r / (1.25^1.5) | Field measurement compared with Narda ELT400 + BN2300/90.10 | First article |

**Standards**
[1] ANSI PC63.19-2006 Draft 3.12

**Conformity**
Based on the tests above, we certify that this item is in compliance with the requirements of [1].

**Date** 22.5.2006

**Stamp / Signature**

s p e a g
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# END OF REPORT