Hearing Aid Compatibility (HAC)
T-Coil

FCC 47 CFR Part 20.19

C2PC
Test Report

For

Kyocera Corporation
c/o Kyocera Communications, Inc.

Product:	Tri-Band CDMA Mobile Phone
Model:	S2150

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ATTESTATION

The tested device complies with the requirements in respect of all parameters subject to the test.

The test results and statements relate only to the items tested.

The test equipment used was suitable for the tests performed and within manufacturer's published specifications and operating parameters.

The test methods were consistent with the methods described in the relevant standards.

Product:	Tri-Band CDMA Mobile Phone with Bluetooth
Model #:	S2150
FCC ID:	V65S2150
Tested in accordance with:	FCC 47 CFR Part 20.19 ANSI C63.19-2007
Test Requested by:	KYOCERA Corporation C/o KYOCERA Communications, Inc. 8611 Balboa Ave. San Diego, CA 92123 United States
Test performed by:	Comptest Services LLC
Date of Test:	November 15 – November 19, 2012

Responsible Engineer

Benjamin Nguyen

Benjamin Nguyen
Test Engineer

Reviewed and approved by:

Tammy To
Quality Manager

1 SUMMARY OF TESTING

ANSI C63.19 (2007) Section 6 T-coil				
Mode	Test	Test Results	T-Rating	Verdict
CDMA 800-BC0	Min. Axial Field Strength, dB A/m	0.14	--	Pass
	Min. Radial Field Strength, dB A/m	-8.04	--	Pass
	Min. Signal Quality (ABM1/ABM2), dB	49.50	4	Pass
	Frequency Response @ Axial position	--	--	Pass
CDMA 1700-BC15	Min. Axial Field Strength, dB A/m	-0.45	--	Pass
	Min. Radial Field Strength, dB A/m	-8.12	--	Pass
	Min. Signal Quality (ABM1/ABM2), dB	49.50	4	Pass
	Frequency Response @ Axial position	--	--	Pass
CDMA 1900-BC1	Min. Axial Field Strength, dB A/m	-0.56	--	Pass
	Min. Radial Field Strength, dB A/m	-8.58	--	Pass
	Min. Signal Quality (ABM1/ABM2), dB	49.20	4	Pass
	Frequency Response @ Axial position	--	--	Pass
Overall T-Rating:		**T4**		
M-Rating*:		**M4**		
HAC Category Rating:		**M4, T4**		

* M-rating obtained from HAC RF report.

2 EQUIPMENT UNDER TEST INFORMATION

Product:	Tri-Band CDMA Mobile Phone with Bluetooth		
FCC ID:	V65S2150		
Model Number:	S2150		
EUT Serial Number:	268435457816730014		
Type:	[ ] Identical Prototype, [**X**] Pre-Production, [ ] Production		
Device Category:	Portable		
RF Exposure Environment:	General Population / Uncontrolled		
Antenna:	Internal	**Detachable:**	No
External Input:	Audio/Digital Data		
Quantity:	Quantity production is planned		
Mode:	CDMA 1X & EvDo Rev0, A	CDMA 1X & EvDo Rev0, A	CDMA 1x & EvDo Rev0, A
Band:	BC-0	BC-15	BC-1
TX Frequency (MHz):	824.7 -848.3	1711.25 - 1753.75	1851.25 - 1908.75

3 TEST CONDITIONS

3.1 Test Facilities

The test sites and measurement facilities used to collect data are located at 8611 Balboa Avenue, San Diego, CA 92123, USA

3.2 Ambient Conditions

All tests were performed under the following environmental conditions:

Ambient Temperature:	23 ± 2 Degrees C
Relative Humidity (RH):	0% <RH < 80%
Atmospheric Pressure:	101.3kPa + 10 to –5 kPa

3.3 RF characteristics of the test site

All HAC measurements were performed inside a shielded room that provide isolation from external EM fields, with the RF ambient at least 20 dB below the intended measurement limits.

3.4 Ambient Noise of the test site

All HAC measurements were performed inside a shielded room that provide isolation from external EM fields, with the RF ambient at least 20 dB below the intended measurement limits. The test site's ambient magnetic level were determined and found to be at least 10dB below the measurement data ABM2, unless a very low level of AMB2. Measurement of the ambient level was performed for each probe orientation and results are shown in Appendix B.

3.5 Test Signal, Frequencies and Output Power

The device supports CDMA2000 in 1X (Phase I, Protocol revision 6) mode. CDMA2000 1X includes TIA/EIA-95B as a subset and was approved for publishing in July 1999. It provides voice and data capabilities within a standard 1.25 MHz CDMA channel. This RF bandwidth is identical to the legacy IS-95 B system standard.

Maximum average conducted powers were measured to ensure worst case power configuration was tested:

CONFIGURATION (Full Rate)		CONDUCTED POWER (dBm)								
		CDMA 800			CDMA 1700			CDMA 1900		
		Ch 1013	Ch 384	Ch 777	Ch 25	Ch 450	Ch 875	Ch 25	Ch 600	Ch 1175
SO3	RC1	24.68	24.67	24.66	23.83	24.28	24.17	23.81	24.05	24.38
	RC3	24.73	24.67	24.71	23.90	24.29	24.22	23.95	23.96	24.39
SO17	RC2	24.71	24.66	24.70	23.87	24.27	24.22	23.90	24.00	24.40
	RC54	24.74	24.67	24.70	23.91	24.29	24.21	23.95	23.97	24.28

In all operating modes, the phone was set to rate maximum RF power level and the measurements were performed on low, mid and high channels.

The measurement system measures power drift during HAC testing by comparing E/H-field in the same location at the beginning and at the end of measurement. These records were used to monitor stability of power output during tests. Conducted RF power measurements were also performed before and after each HAC measurements to confirm the output power.

During tests, the EUT was put in in-call mode and controlled by a CDMA simulator to generate the required signal and power:

Protocol:	6 (IS-2000)
Radio Configuration:	3
Power Control:	All Up Bits
Service Option:	3
Vocoder:	8K Enhanced (low)
Data Rate:	Full

3.6 EUT Operating Conditions

The EUT was tested with the follow configurations and conditions, if applicable:

Mode	Band (MHz)	Type	Voice Over IP Transport (Data)	Simultaneous Transmissions (Not Tested)	C63.19 (Tested)
CDMA 1x	800, 1700, 1900	Voice	N/A	Yes: BT	Yes
CDMA EVDO Rev0, A					
Bluetooth	2450	Data	N/A	Yes: CDMA	N/A
WiFi					

X	Fully charged standard battery as supplied with the handset
	Closed configurations at ear use position[1]
	Both retracted and extended antenna positions
X	Back-light always ON
X	LCD Contrast High
X	Receiver volume setting at maximum
X	Microphone muted

Note
1: This device has only one configuration for ear usage

4 DESCRIPTION OF TEST EQUIPMENT

4.1 Test Equipment Used

Below is a list of the calibrated equipment used for the measurements.
The calibration certificates of Probe and Helmholtz Coil are attached in Appendix A.

Description	Manufacturer	Model Number	Serial Number	Cal Due Date
Power Meter	Giga-tronics	8541C	1831306	02/24/13
Radio Communication Tester	Rohde & Schwarz	CMU200	101328	05/16/13
Data Acquisition	Speag	DAE4	675	05/23/13
Audio Band Magnetic Probe	Speag	AM1DV2	1045	09/20/13
Audio Band Magnetic Measuring Instrument	Speag	AMMI	1035	N/A
Helmholtz Coil	Speag	AMCC	1001	N/A
Test Arch	Speag	HAC	1015	N/A

4.2 T-Coil Measurement System

The measurements were performed with Dasy4 automated near-field scanning system comprised of high precision robot, robot controller, computer, Magnetic probe, probe alignment sensor, non-conductive phone positioner, Test Arch and software extension. Figure 5.2 show the setup and cabling. The overall expanded uncertainty (K=2) of the measurement system is ±12.3%. The measurement uncertainty budget is given in section 6.

Figure 4.2a T-Coil setup with Helmholtz Coil

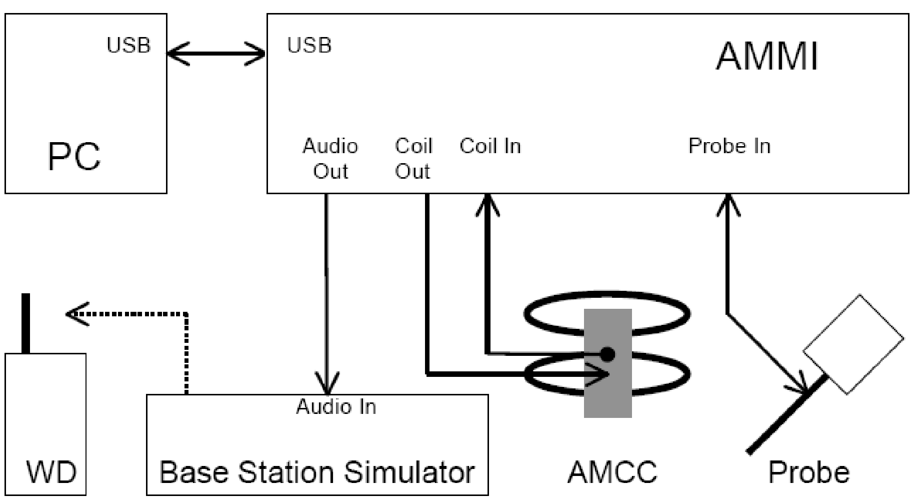


Figure 4.2b Setup Cabling

4.3 Audio Magnetic Probe	
Model:	▪ AM1D
Application:	▪ Active single sensor probe for both axial and radial measurement scans
Construction:	▪ Fully RF shielded ▪ Rounded tip of 6 mm diameter incorporating a pickup coil with its center offset 3mm from the tip and the sides ▪ Compatible with DAE, with adapted probe cup
Frequency Response:	▪ ± 0.5dB of ideal differentiator from 100 Hz to 10 kHz
Linearity:	▪ < 0.1 dB from 5 dB below limitation to 16 dB above noise level
Dynamic Range:	▪ Max 21 dB A/m @ 1 kHz, Noise level typ. –70 dB A/m @ 1kHz, ABM2 typ. –60 dB A/m
Sensitivity:	▪ Typ. -24 dBV / A./m @ 1kHz at probe output
RF Shielding:	▪ Immunity to AM (1 kHz, 80%) modulation RF signal

4.4 Audio Magnetic Measuring Instrument (AMMI)	
Model:	▪ AMMI
Application:	AMMI is a desktop 19-inch unit containing a sampling unit, a waveform generator for test and calibration signals and a USB interface.
Connection:	Front connectors ▪ Audio Out - audio signal to the base station simulator ▪ Coil Out - test and calibration signal to the AMCC ▪ Coil In - monitor signal from the AMCC BNO connector ▪ Probe In - probe signal

4.5 Audio Magnetic Calibration Coil (AMCC)	
Model:	▪ AMCC
Application:	The Audio Magnetic Calibration coil is a Helmholtz Coil designed according to ANSI C63.19-2006 section D.9, for calibration of the AM1D probe. The two horizontal coils generate a homogeneous magnetic field in the z direction. The DC input resistance is adjusted to approximately 50 Ohm by a series resistor, and a shunt resistor of 10 Ohm allows monitoring the current with a scale of 1:10.
Connection:	• Coil In • Coil Monitor

5 SYSTEM VALIDATION & CALIBRATION

At the beginning of the HAC T-coil measurement, a 3-phase calibration was performed per Speag instruction to ensure accurate measurement of the voltages and ABM field. Reference input level was also validated and calibrated per C63.19.

5.1 Input Channel Calibration

Phase 1: The AMMI audio output was switched off, and a 200 mV_pp symmetric rectangular signal of 1 kHz was generated and internally connected directly to both channels of the sampling unit (coil in, probe in).

Phase 2: The AMMI audio output was off, and a 20 mV_pp symmetric 100 Hz signal was internally connected.

The signals during phases 1 and 2 were available at the output on the rear panel of the AMMI. The output must however not be loaded in order not to influence the calibration. After the first two phases, the two input channels were both calibrated for absolute measurements of voltages. The resulting factors were displayed above the multimeter window.

After phases 1 and 2, the input channels were calibrated to measure exact voltages.

5.2 Probe Calibration

Phase 3: a multisine signal covering each third-octave band from 50 Hz to 5 kHz was generated and applied to both audio outputs. The probe was positioned in the center of the AMCC (user point “coil center”) and aligned in the z-direction, the field orientation of the AMCC. The Coil In channel was measuring the voltage over the AMCC internal shunt, which was 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. The ratio of the two voltages – in each third-octave filter – leads to the calibration factor of the probe over the frequency band of interest for the spectral representation.

The Coil signal is scaled in dBV, and the Probe signal is normalized to show dBV at a frequency of 1 kHz. The sensitivity is the ratio at 1 kHz. The frequency response of the probe (subject to an integrator) can be calculated from the difference of the two curves.

The calibration result using a AM1DV2 probe is shown in Appendix B. The internal calibration factors of the coil and probe channel are listed. The graphics represent the values (applying the calibration factors from the previous steps) for the probe and coil channel in dB V for each third-octave filter from 100 Hz to 5 kHz. These values are interconnected with a blue line for the probe and a green line for the coil channel.

The probe sensitivity in V / (A/m) at 1 kHz is calculated from the values in the chart. -20 dBV in the coil channel corresponds approx. to 1 A/m. The lines are typically horizontal. Deviations around 160 Hz typically result from power line interference, and the slight decay at the higher frequency is a result of the channel frequency response.

Calibration Factors	**Measured Value**
Probe Sensitivity, V/(A/m)	0.0655
Probe calibration factor, V	1.1292
Coil calibration factor, V	2.3517

5.3 Reference Input Level

ANSI C63.19 requires the use of reference input level of –18dBm0 that correlate to a normal speech input level for CDMA air interface. In order to create the correct level the CMU200 audio codec and the AMMI output were calibrated.

5.3.1 CMU200 Audio Codec Calibration

To determine the correct input level, the Encoder/Decorder of the CMU200 base station simulator was calibrated for measured full-scale input voltage level. The CMU200 0dBm0 input reference was determined utilizing the build-in functions of "Decoder Cal" and "Encoder Cal".

CMU200 S/N	Modulation	Ref. I/P Level	Target Level
101328	CDMA	-18dBm0	-20.49

Table 5.3a CMU200 Target Level

5.3.2 AMMI Signal Verification

Verification of AMMI output level was performed within 24 hours of the compliance measurement. The measured results are shown in Table 5.3b

Date	Signal	Measured AMMI Output (dBm0)	Target Reference Input (dBm0)	Delta (dB)
11/15/2012	1KHz	-20.48	-20.49	0.01
	48k_voice_1kHz	-20.49	-20.48	-0.01
	48k_voice_300_3000	-20.5	-20.49	-0.01
11/19/2012	1KHz	-20.5	-20.49	-0.01
	48k_voice_1kHz	-20.5	-20.48	-0.02
	48k_voice_300_3000	-20.49	-20.49	0

Table 5.3b Measured Output Level

6 DESCRIPTION OF TEST PROCEDURE

The device was positioned and setup according to ANSI C63.19-2006. Figure 6.0 shows the T-Coil Signal measurement flowchart:

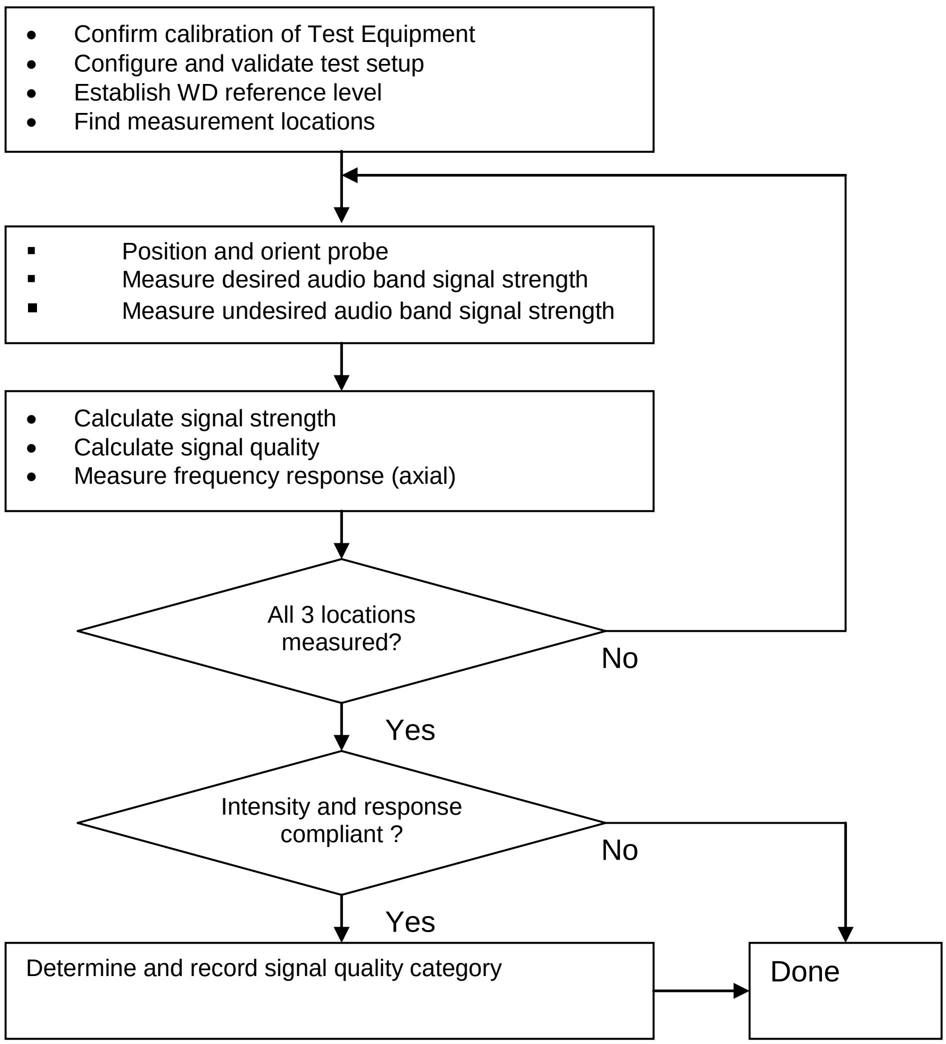


Figure 6.0 T-Coil measurement flowchart

6.1 Test Positions

The device was placed on a non-conductive phone positioner under the Test Arch. The acoustic output of the EUT was aligned with the center point of the area formed by the dielectric wire and the middle bar of the arch's top frame. Please refer to Appendix E for the test setup photos.

6.2 Audio Signals

During tests signal was fed to the EUT via communication Test set. Proper gain setting was used in software to ensure correct signal level fed to communication test set speech input.

The following audio signals were pre-defined by DASY4 and used for calibration and measurements:

48k_voice_1kHz_1 s (duration 1 s): This signal is voice like and has been processed to have a narrow bandwidth mainly within the 1 kHz third-octave band and an even shorter duration of 1 second for faster measurement. This signal passes through a large variety of codecs and permits a direct amplitude and signal quality measurement (S/N) without considerable bandwidth compensation. Its spectrum is shown in a practical measurement in Figure 6.2a.

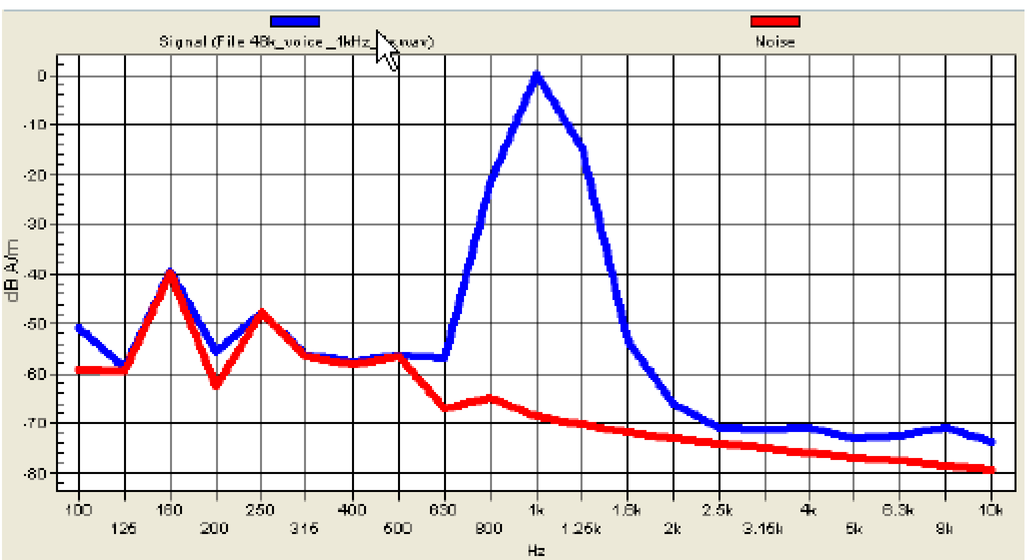


Figure 6.2a 1.0 kHz Voice signal spectrum

Multisine signal 50 Hz – 5 kHz *(duration 10 s):* Signal with carrier centered in each third-octave band, as used during the calibration. Suited for frequency response measurements. Peak to RMS ratio: 11.1 dB.

48k_voice_300-3000 *(duration 2 s):* The signal is voice like and has been processed to have a duration of 2 seconds for fast measurement. At the same time, it has a flat spectrum across all third-octave band filters between 300 Hz to 3 kHz and is vanishing at the beginning and end in order to allow longer measurement sequences without transients. It has bandwidth sufficient for frequency response measurements. The spectrum is shown in a practical measurement in fig. 6.2b. The measurement window length of this signal must be set to a multiple of 2 s in order to integrate over the full voice sample. Peak to RMS ratio: 21.6 dB.

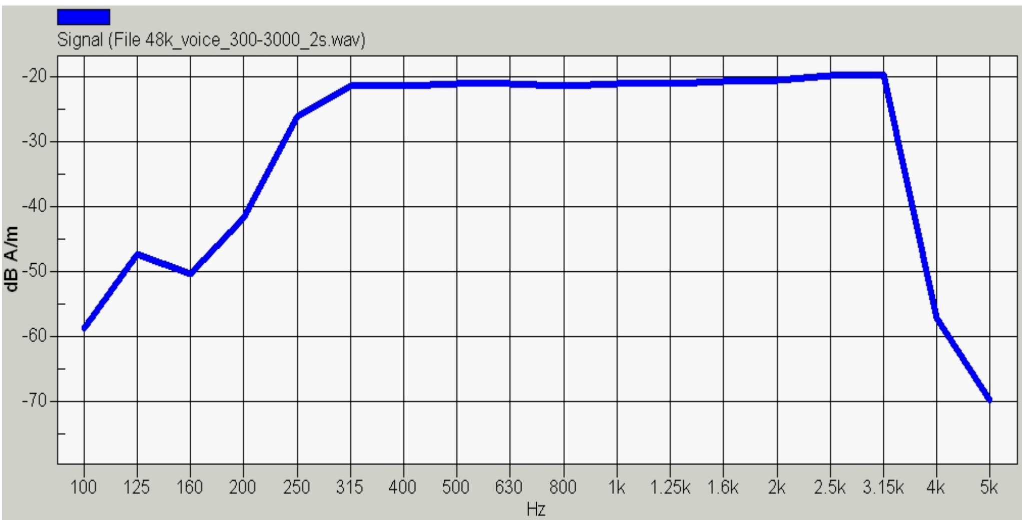


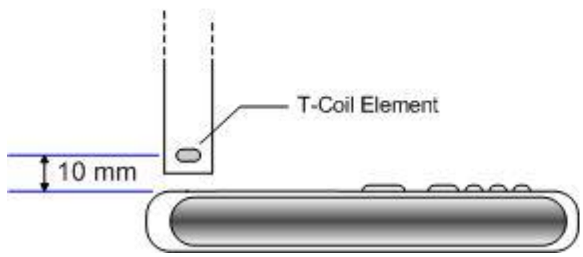
Figure 6.2b Broadband signal spectrum

6.3 Scan Procedures

6.3.1 Signal Strength and SNR

a) A 50mm x 50mm (10mm step) coarse axial scan was performed to search for the “optimal points” and spatial distribution of ABM1.

b) Base on the coarse scan results, a 16mm x 16mm (4mm step) point scan in axial, a 24mmx16mm (4mm step) point scan in radial_L, and a 16mmx24mm (4mm step) point scan in radial-T coil orientation were performed for both ABM1and ABM2.



6.3.2 Frequency Response

Base on the coarse axial scan results, a point axial scan was performed.

7 DESCRIPTION OF TEST PROCEDURE

Table 7.1 shows the uncertainty budget for HAC Audio Band Magnetic Field (AMB) assessment according to ANSI C63.19-2006. The budget is valid for the DASY4 system and represents a worst-case analysis. For specific tests and configurations, the uncertainty could be smaller.

Uncertainty Description	Uncert. Value (± %)	Prob. Dist.	Div.	C_i (ABM1)	C_i (ABM2)	Stand. Uncert (ABM1) (±%)	Stand. Uncert (ABM2) (±%)
PROBE SENSITIVITY							
Reference level	3.0	N	1.0	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	0.4
Frequency slope	5.9	R	1.7	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	1.0	1	5	0.6	3.0
Field distribution	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	0.4
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	1.9	R	1.7	1	1	1.1	1.1
EXTERNAL CONTRIBUTIONS							
RF interference	0	R	1.7	1	1	0	0
Test signal variation	2.0	R	1.7	1	1	1.2	1.2
COMBINED UNCERTAINTY							
Combined Standard Uncertainty (ABM):						**4.1**	**6.1**
Extended Standard Uncertainty (k=2) [%]:						**8.1**	**12.3**

N: Normal
R: Rectangular

Table 7.1 Worst-Case uncertainty budget for HAC ABM assessment

8 T-COIL REQUIREMENTS AND CATEGORY

8.1 RF Emissions

EUT has to fulfill RF emission requirements at the axial measurement location.

8.2 Axial Field Intensity

Table 8.2 shows the minimum limits for ABM1 field intensity:

Component	ABN1 Magnetic Field dB(A/m)	Condition
Axial (z)	≥-18	1 kHz, in 1/3 octave band filter
Radial (x, y)	≥-18	

Table 8.2 ABM1 Intensity Requirements

8.3 Signal Quality

Table 8.3 provides the signal quality requirement for the intended T-Coil signal from a Wireless Device. The worst Signal Quality of the axial and radial components of the magnetic field was used to determine the T-Coil category.

Category	Signal Quality (Signal+Noise to Noise) [dB]
T1	0 to 10
T2	10 to 20
T3	20 to 30
T4	> 30
AWF=0	

Table 8.3 T-coil Signal Quality Categories

8.4 Frequency Response

The frequency response of the axial component must follow the frequency curve specified in ANSI C63.19-2007 section 7.3.2, over the frequency range 300-3000 Hz (Figure 8.4).

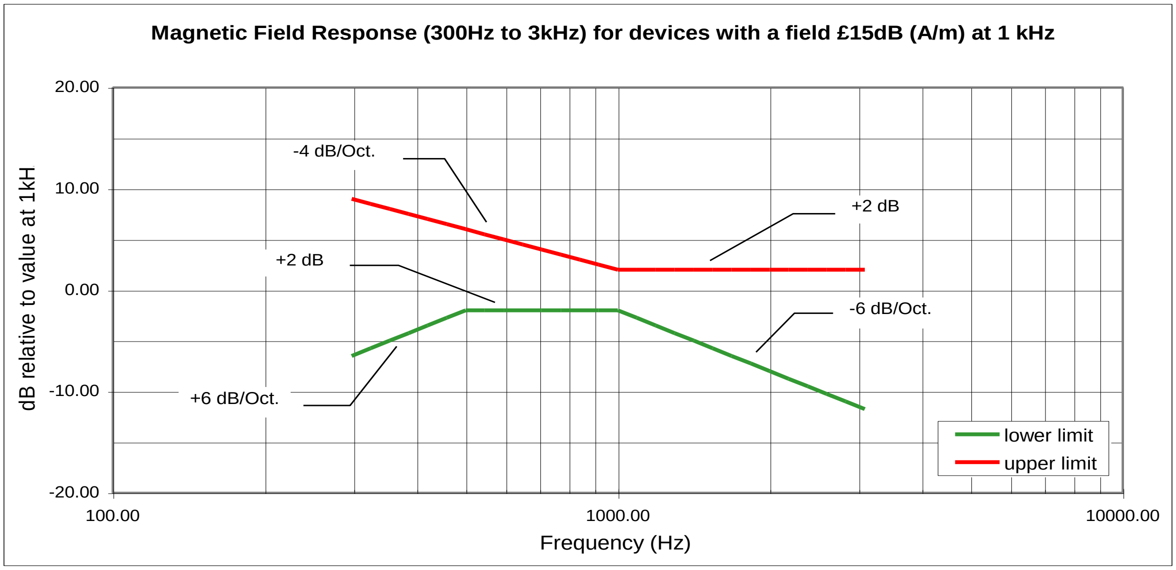


Figure 8.4a Magnetic Field Response (300Hz to 3kHz) for devices with a field ≤15dB (A/m) at 1 kHz

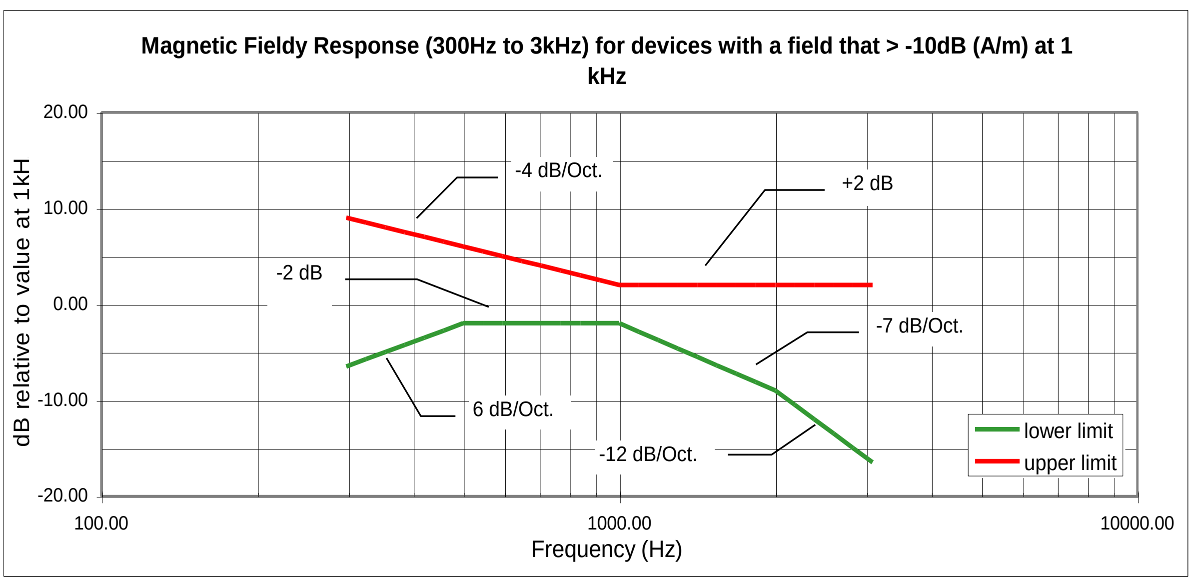


Figure 8.4b Magnetic Field Response (300Hz to 3kHz) for devices with a field that > -15dB (A/m) at 1 kHz

9 T-COIL TEST RESULTS

9.1 Field Strength and Signal Quality

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Slide Close

Band	Ch.	Probe Position	Ambient Noise dB A/m	ABM1 dB A/m	ABM2 dB A/m	ABM1/ABM2 dB	T-Rating
CDMA 800-BC0	1013	Axial (z)	-55.47	0.71	-53.09	53.80	4
		Radial_L (x)	-58.87	-7.94	-58.14	50.20	4
		Radial_T (y)	-58.86	-7.91	-57.61	49.70	4
	384	Axial (z)	-55.47	**0.14**	-53.16	53.30	4
		Radial_L (x)	-58.87	-7.47	-57.87	50.40	4
		Radial_T (y)	-58.86	**-8.04**	-57.74	49.70	4
	777	Axial (z)	-55.47	0.65	-52.85	53.50	4
		Radial_L (x)	-58.87	-7.87	-58.17	50.30	4
		Radial_T (y)	-58.86	-7.93	-57.43	**49.50**	4
CDMA 1700-BC15	25	Axial (z)	-55.47	0.13	-52.57	52.70	4
		Radial_L (x)	-58.87	-7.88	-57.98	50.10	4
		Radial_T (y)	-58.86	**-8.12**	-57.62	49.50	4
	450	Axial (z)	-55.47	**-0.45**	-52.25	51.80	4
		Radial_L (x)	-58.87	-7.70	-57.80	50.10	4
		Radial_T (y)	-58.86	-8.02	-57.52	**49.50**	4
	875	Axial (z)	-55.47	-0.29	-52.59	52.30	4
		Radial_L (x)	-58.87	-7.66	-57.96	50.30	4
		Radial_T (y)	-58.86	-7.78	-57.58	49.80	4
CDMA 1900-BC1	25	Axial (z)	-55.47	-0.46	-52.86	52.40	4
		Radial_L (x)	-58.87	-7.62	-57.92	50.30	4
		Radial_T (y)	-58.86	**-8.58**	-57.88	49.30	4
	600	Axial (z)	-55.47	**-0.56**	-52.86	52.30	4
		Radial_L (x)	-58.87	-7.65	-58.05	50.40	4
		Radial_T (y)	-58.86	-8.32	-57.52	**49.20**	4
	1175	Axial (z)	-55.47	-0.12	-52.72	52.60	4
		Radial_L (x)	-58.87	-7.97	-58.07	50.10	4
		Radial_T (y)	-58.86	-8.10	-57.60	49.50	4

Note:

- Bold Number = worst case at each frequency band
- Data plots are showed in Appendix D

9.2 Frequency Response

ANSI C63.19 (2007) Section 6 T-coil **Frequency Response**			
Mode	**Probe Position**	**Signal Type**	**Result**
CDMA 800	Axial	Voice	Pass
CDMA 1700	Axial	Voice	Pass
CDMA 1900	Axial	Voice	Pass

Figure 9.2 show the worst-case frequency response of the axial component of the magnetic field.

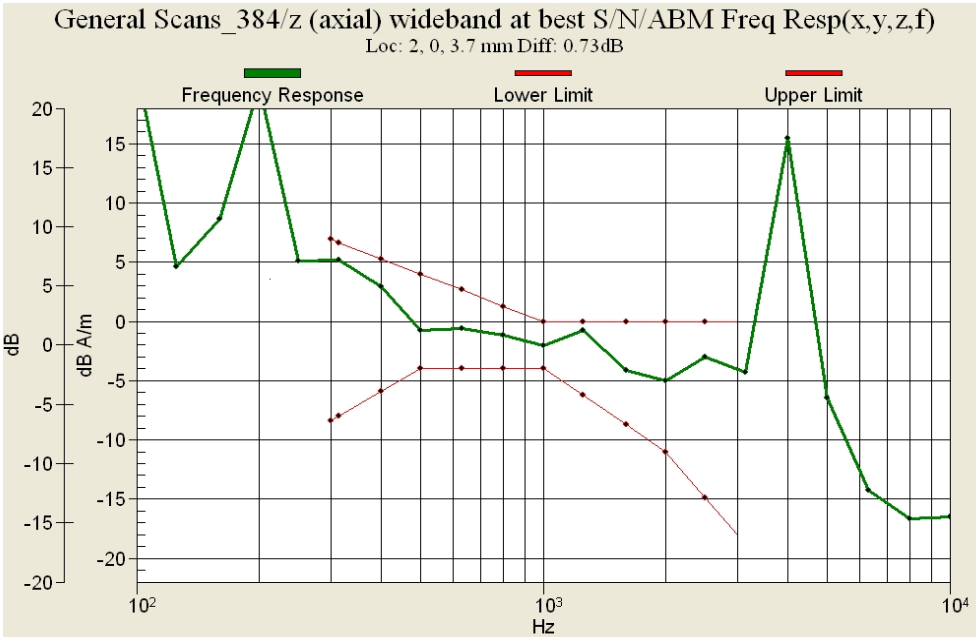


Figure 9.2a CDMA 800 BC-0, Frequency Response

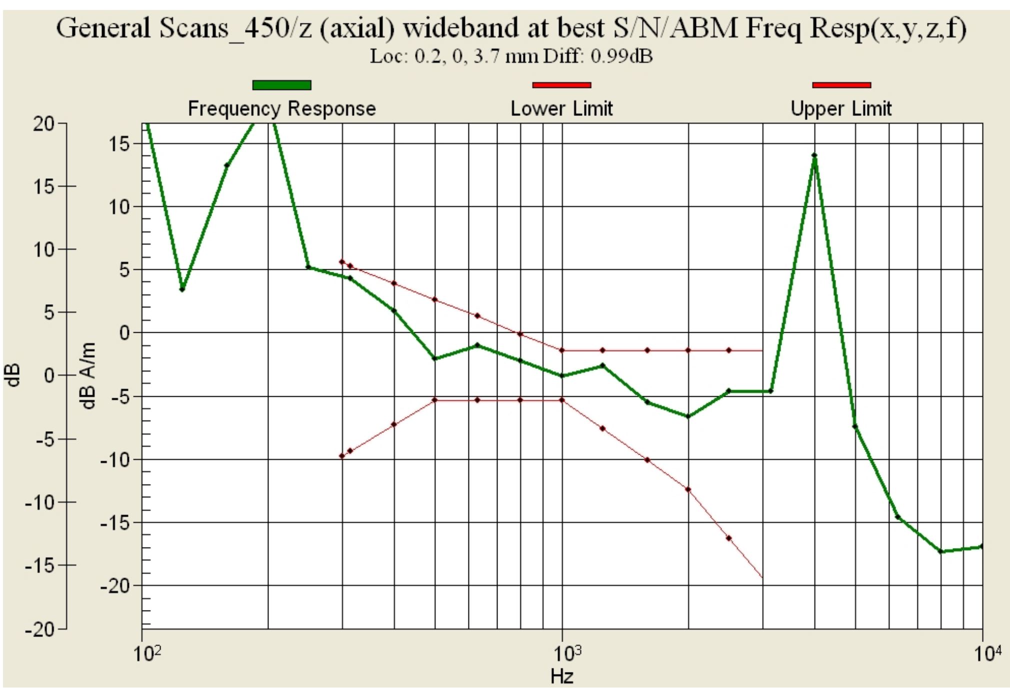


Figure 9.2b CDMA 1700 BC-15, Frequency Response

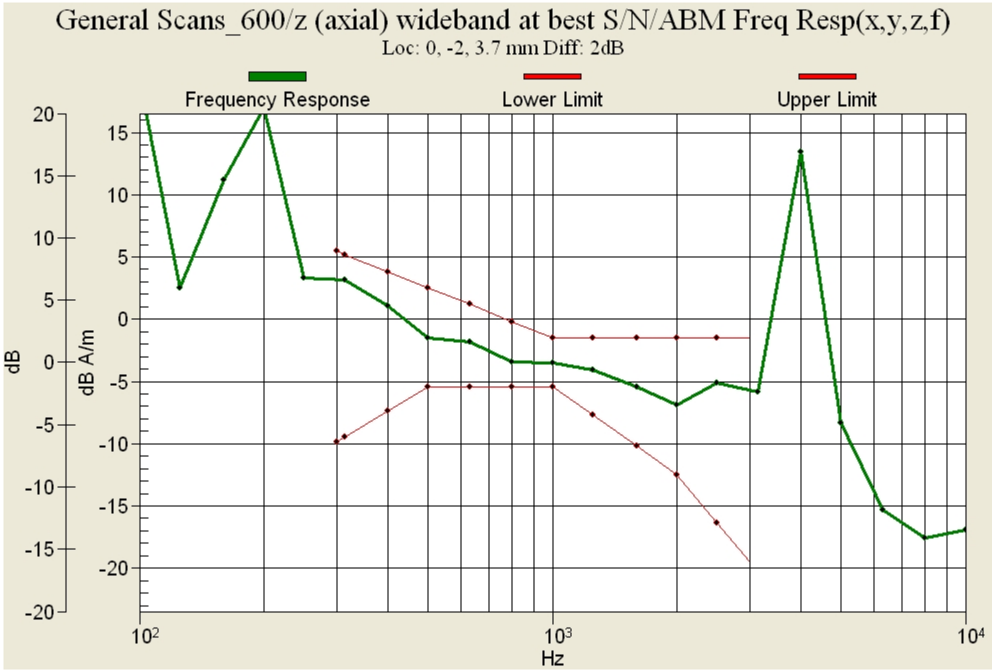
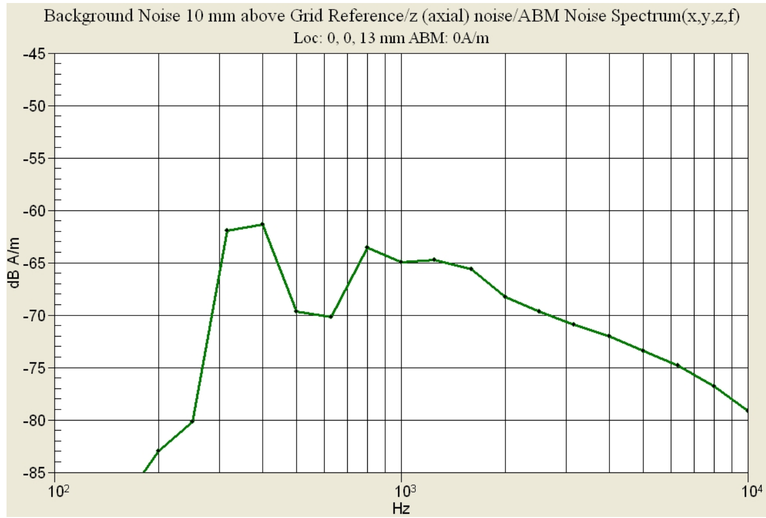


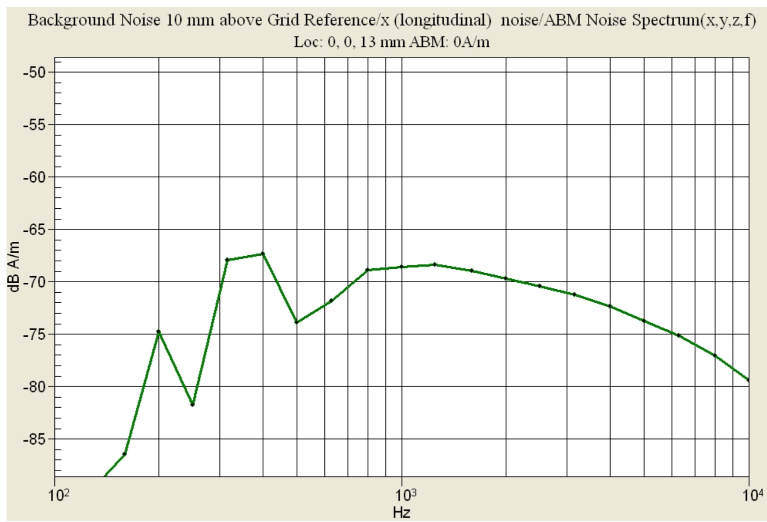
Figure 9.2c CDMA 1900 BC-1, Frequency Response

10 APPENDIX A1: AMBIENT NOISE PLOTS, 800 MHZ

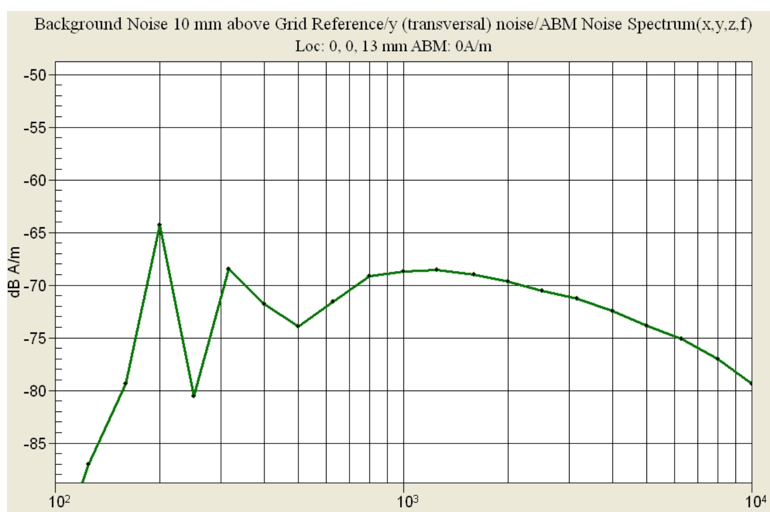
Ambient Noise Spectrum
Plot: Axial (z)



Ambient Noise Spectrum
Plot: Radial Longitudinal (x)

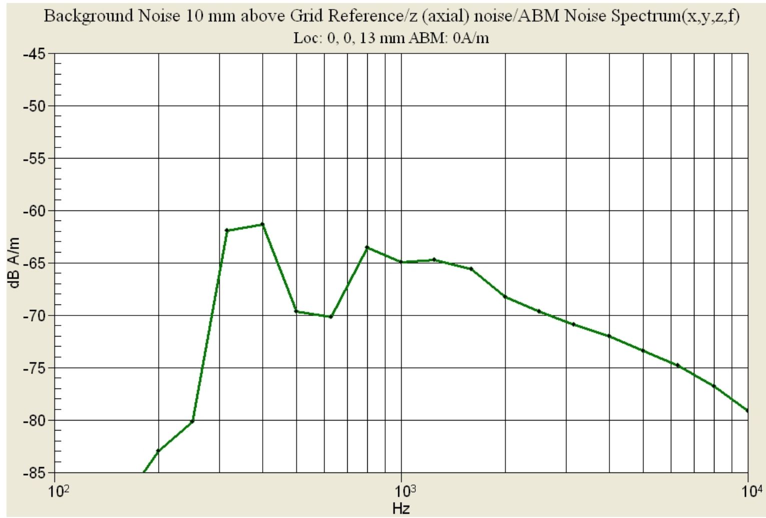


Ambient Noise Spectrum
Plot:
Radial Transversal (y)

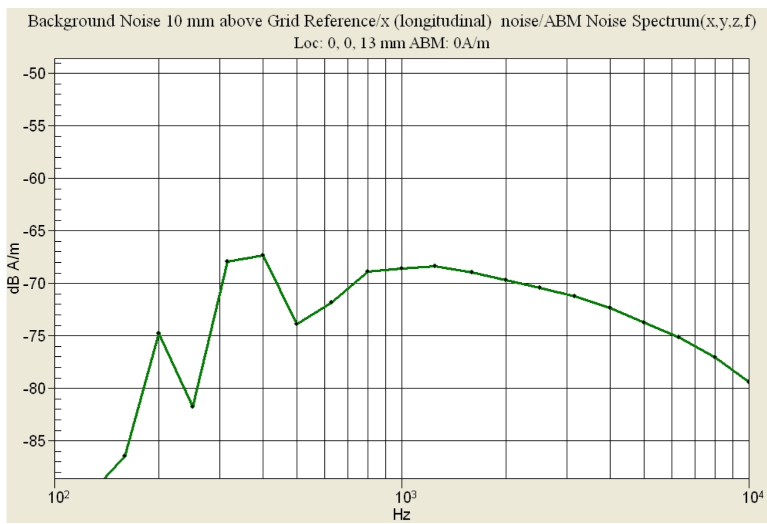


11 APPENDIX A1: AMBIENT NOISE PLOTS, 1700 MHZ

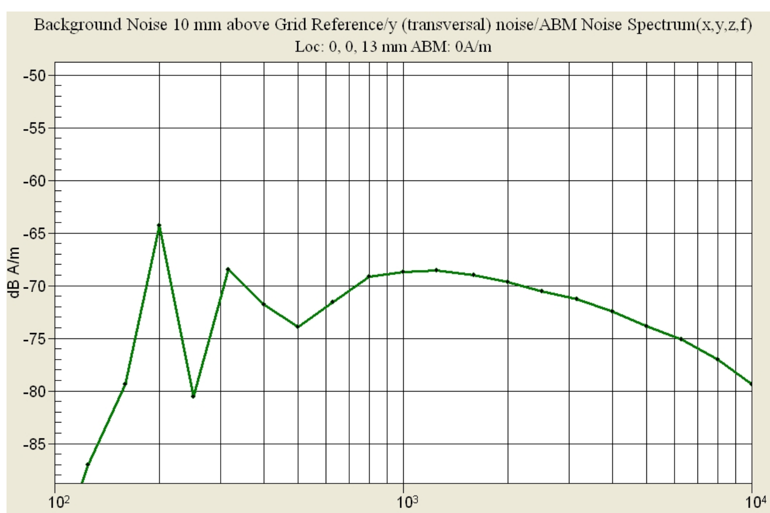
Ambient Noise Spectrum
Plot: Axial (z)



Ambient Noise Spectrum
Plot: Radial Longitudinal (x)

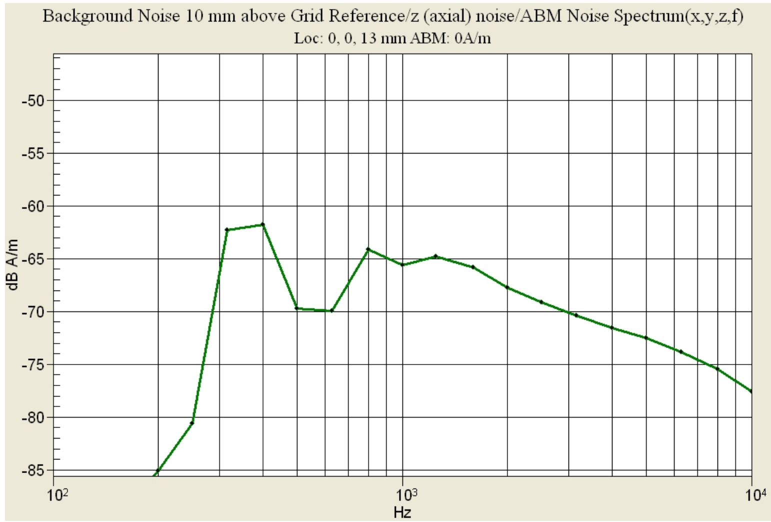


Ambient Noise Spectrum
Plot:
Radial Transversal (y)

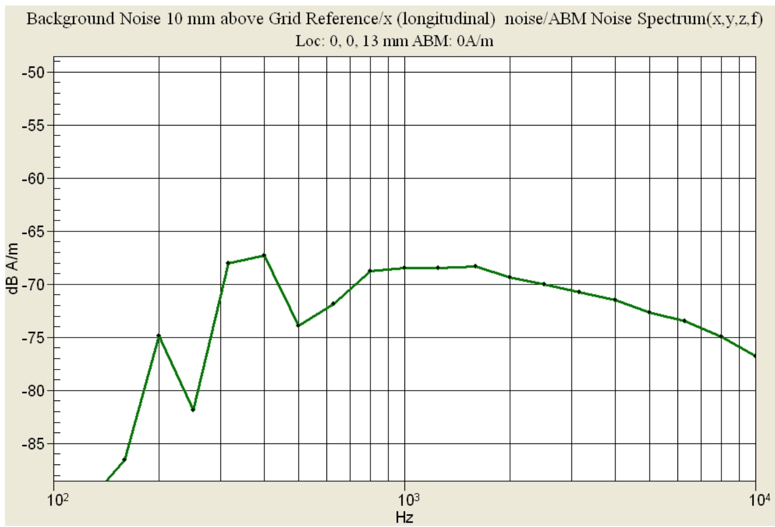


12 APPENDIX A2: AMBIENT NOISE PLOTS, 1900 MHZ

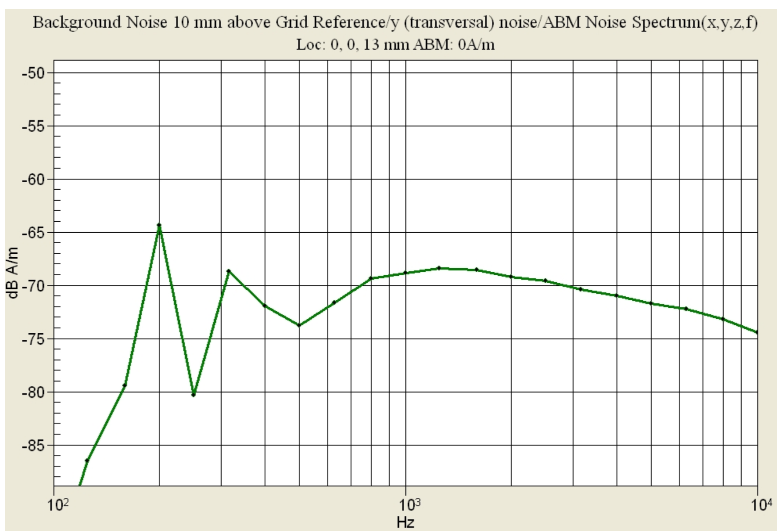
Ambient Noise Spectrum
Plot Axial (z)



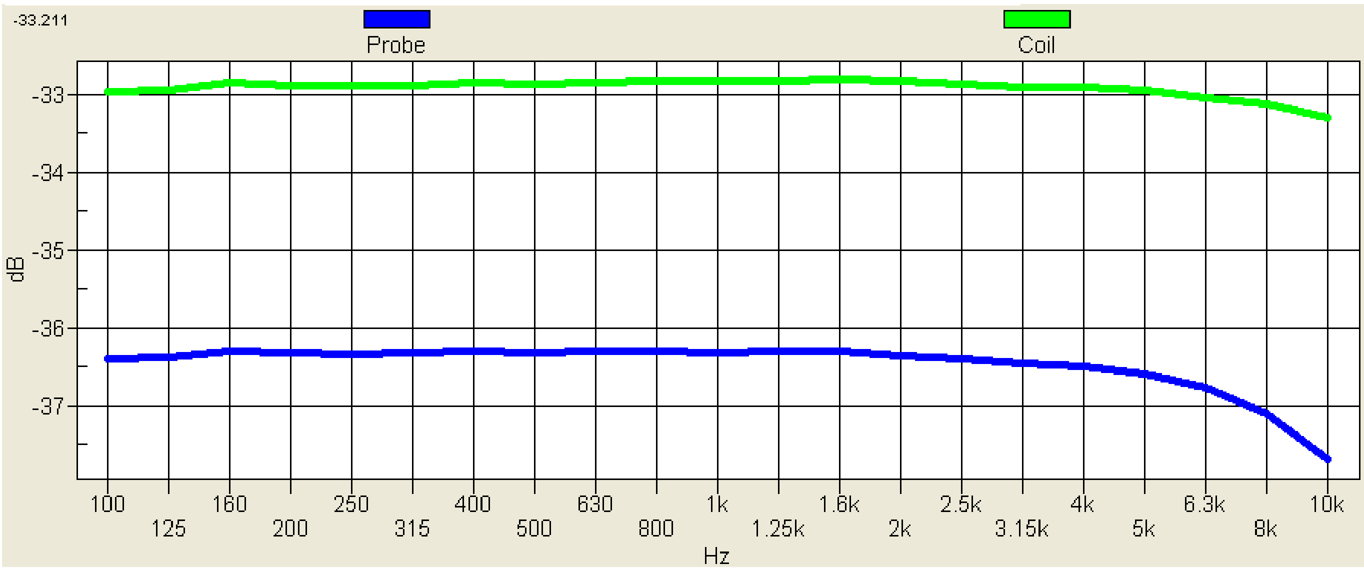
Ambient Noise Spectrum
Plot Radial_Longitudinal (x)



Ambient Noise Spectrum
Plot Radial_Transversal (y)



13 APPENDIX B: SYSTEM CALIBRATION RESULTS



14 APPENDIX C: ABM AND SNR TEST RESULTS/PLOTS

(See attachment)

15 APPENDIX D: PROBE CALIBRATION CERTIFICATE

(See attachment)

16 APPENDIX E: PHOTO TEST SETUP

(See attachment)