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Regulatory Compliance Group
IT R&D Center

416, Maetan-3dong,
Yeongtong-gu, Suwon-si,
Gyeonggi-do, Korea 443-742

TEST REPORT ON HAC

Model Tested:	**SPH-i350**
FCC ID (Requested):	**A3LSPHI350**
Job No:	**AG-080**
Report No:	**AG-080-T1**
Date issued:	**August 12, 2009**
Result Summary:	**T3 – 2007 (Signal To Noise Category)**

- Abstract –
This document reports on HAC Tests carried out in accordance with ANSI C63.19(2007) §6.3, §7.3, FCC Rule Part(s) FCC 47 CFR §20.19

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1. GENERAL INFORMATION

Test Sample :	Dual-Band CDMA/GSM Phone with WLAN & Bluetooth
Model Number :	SPH-i350
Serial Number :	Identical prototype (S/N : # AG-080-A)
Manufacturer :	SAMSUNG ELECTRONICS Co., Ltd.
Address :	416 Maetan3-Dong, Yeongtong-gu, Suwon City Gyeonggi-Do, Korea 443-742
Test Standard :	ANSI C63.19 (2007) §6.3, §7.3, FCC 47 CFR § 20.19
FCC Classification :	Licensed Portable Transmitter Held to Ear (PCE)
Test Dates :	July. 29, 2009 ~ July. 31, 2009
Tested for :	FCC/TCB Certification

2. DESCRIPTION OF DEVICE

Tx Freq. Range :	824.70 ~ 848.31 MHz(CDMA) 1851.25 ~ 1908.76 MHz(PCS) 824.2 ~ 848.8 MHz(GSM850) 1850.2 ~ 1909.8 MHz(GSM1900)
Rx Freq. Range :	869.70 ~ 893.31 MHz(CDMA) 1931.25 ~ 1988.76 MHz(PCS) 869.2 ~ 893.8 MHz(GSM850) 1930.2 ~ 1989.8 MHz(GSM1900)
Antenna Manufacturer :	Partron
Model No.:	DISPHI350PA
Antenna Dimensions :	44.14mm * 7.48mm * 9.05mm

3. Performance

3.1 RF EMISSIONS

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

Category	Telephone RF Parameters	
Near field Category	**E-field emissions CW dB(V/m)**	**H-field emissions CW dB(A/m)**
f < 960 MHz		
M1	56 to 61 + 0.5 x AWF	5.6 to 10.6 +0.5 x AWF
M2	51 to 56 + 0.5 x AWF	0.6 to 5.6 +0.5 x AWF
M3	46 to 51 + 0.5 x AWF	–4.4 to 0.6 +0.5 x AWF
M4	< 46 + 0.5 x AWF	< –4.4 + 0.5 x AWF
f > 960 MHz		
M1	46 to 51 + 0.5 x AWF	–4.4 to 0.6 +0.5 x AWF
M2	41 to 46 + 0.5 x AWF	–9.4 to –4.4 +0.5 x AWF
M3	36 to 41 + 0.5 x AWF	–14.4 to –9.4 +0.5 x AWF
M4	< 36 + 0.5 x AWF	< –14.4 + 0.5 x AWF

Table 4-1
Hearing aid and WD near-field categories as defined in ANSI C63.19-2007 [2]

3.2 ARTICULATION WEIGHTING FACTOR (AWF)

Standard	Technology	Articulation Weighing Factor (AWF)
T1/T1P1/3GPP	**UMTS (WCDMA)**	0
TIA/EIA/IS-2000	**CDMA**	0
iDEN™	**TDMA (22 and 11 Hz)**	0
J-STD-007	**GSM (217 Hz)**	-5

Table 4-2
Articulation Weighting Factors

3.3 MAGNETIC COUPLING

Axial and Radial Field Intensity

All orientations of the magnetic field, in the axial, horizontal and vertical position along the measurement plane shall be ≥ -18 dB(A/m) at 1 kHz in a 1/3 octave band filter per 7.3.1.

Frequency Response

The frequency response of the axial component of the magnetic field shall follow the response curve specified in EIA RS-504-1983, over the frequency range 300 Hz – 3000 Hz per 7.3.2.

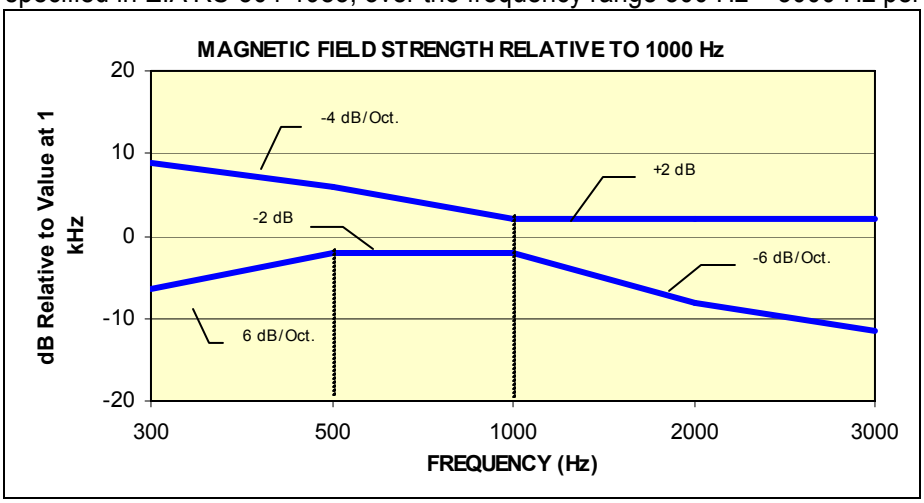

Figure 4-1

Magnetic field frequency response for Wireless Devices with an axial field below ≤ -15 dB (A/m) at 1 kHz

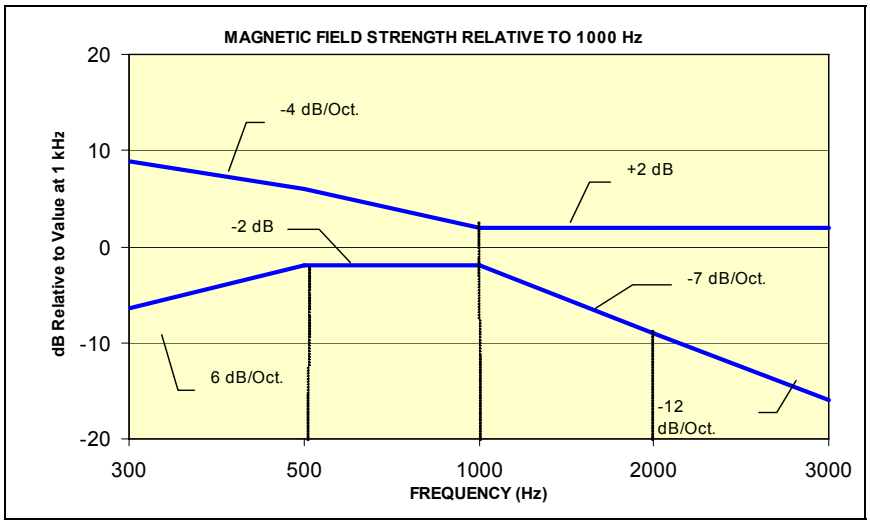

Figure 4-2

Magnetic Field frequency response for wireless devices with an axial field that exceeds –15 dB(A/m) at 1 kHz

Signal Quality

The table below provides the signal quality requirement for the intended audio magnetic signal from a wireless device. Only the RF immunity of the hearing aid is measured in T-coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. The only criterion that can be measured is the RF immunity in T-coil mode. This is measured using the same procedure as the audio coupling mode at the same levels.

The signal quality of the axial and radial components of the magnetic field was used to determine the T-coil mode category.

Category	Telephone RF Parameters
	Wireless Device Signal Quality (Signal + Noise-to-noise ratio in dB)
T1	0 to 10 dB
T2	10 to 20 dB
T3	20 to 30 dB
T4	> 30 dB

Table 4-3
Magnetic Coupling Parameters

4. DESCRIPTION OF TEST EQUIPMENT

4.1 HAC Measurement Setup

The equipment was connected as shown in an acoustic/RF hemi-anechoic chamber:

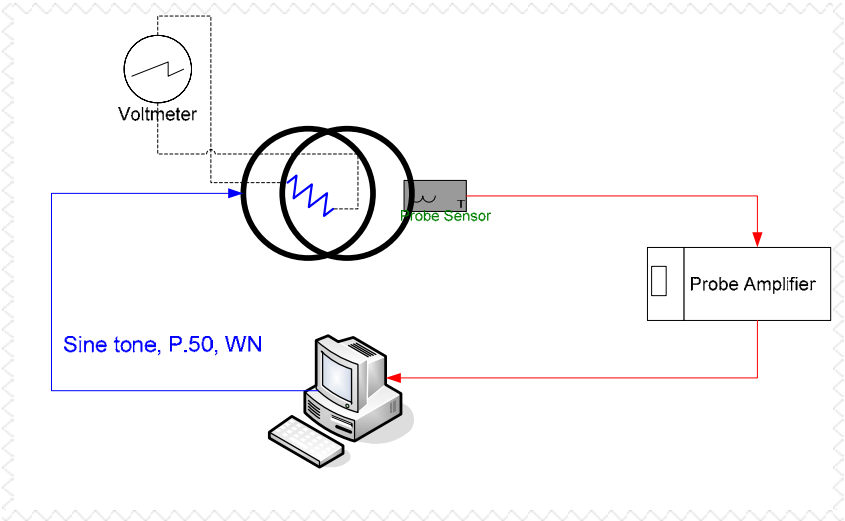

Figure 4-1 Validation Setup with Helmholtz Coil

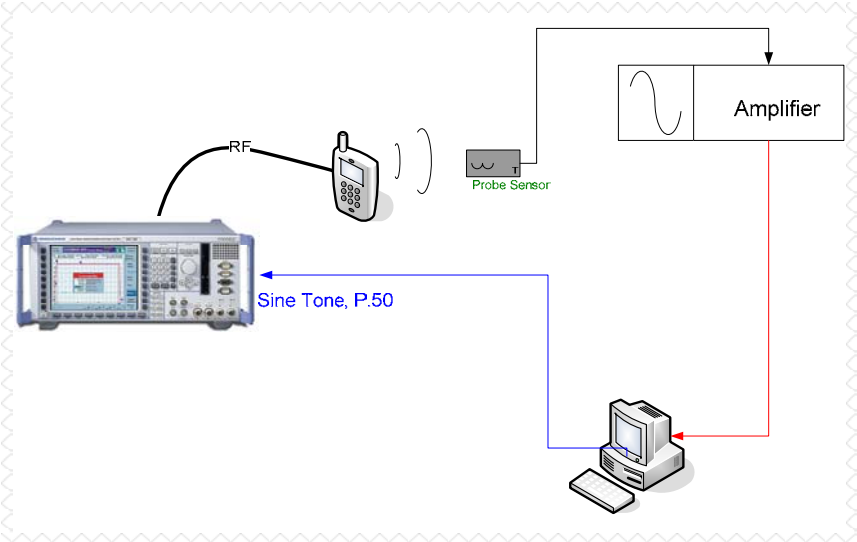

Figure 4-2 T-Coil Test Setup

4.2 Scanning Mechanism

Manufacturer:	TEM
Accuracy:	± 0.83 cm/meter
Minimum Step Size:	0.1 mm
Maximum speed	6.1 cm/sec
Line Voltage:	115 VAC
Line Frequency:	60 Hz
Material Composite:	Delrin (Acetal)
Data Control:	Parallel Port
Dynamic Range (X-Y-Z):	45 x 31.75 x 47 cm
Dimensions:	36” x 25” x 38”
Operating Area:	36” x 49” x 55”
Reflections:	< -20 dB (in anechoic chamber)

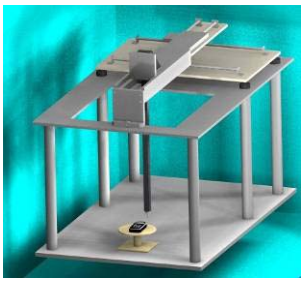

Figure 4-3
RF Near-Field Scanner

4.3 ITU-T P.50 Artificial Voice

Manufacturer:	ITU-T
Active Frequency Range:	100 Hz – 8 kHz
Stimulus Type:	Male and Female, no spaces
Single Sample Duration:	20.96 seconds
Activity Level:	100%

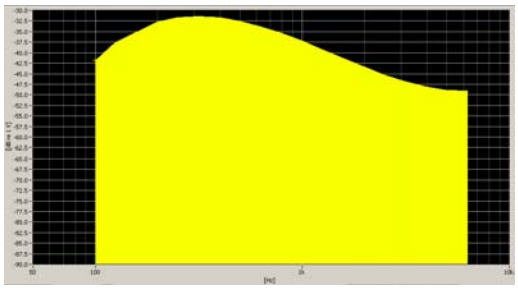

Figure 4-4
Spectral Characteristic of full P.50

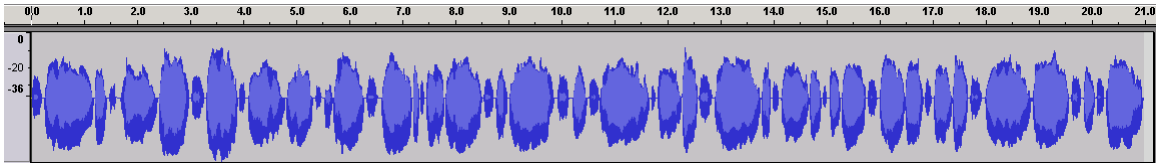

Figure 4-5
Temporal Characteristic of full P.50

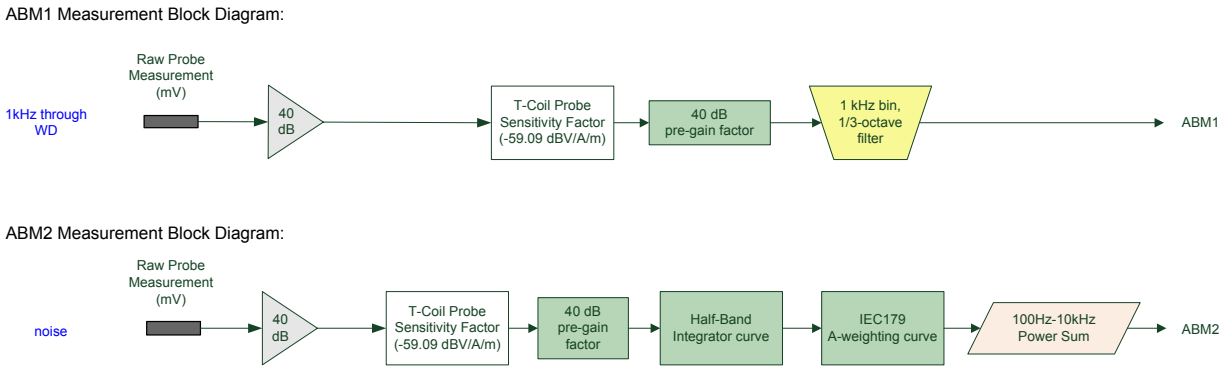

Figure 4-6 Magnetic Measurement Processing Steps

4.4 Equipment Calibration

Table 3.2 Test Equipment Calibration

Model	Description	Cal. Due Date	Serial No.
CMU200	Base Station Simulator	6/2/2010	114300
4474	Data Acquisition Card	N/A	N/A
Positioner	HAC Positioner	N/A	N/A
HAC System	HAC System controller with S/W	N/A	N/A
Axial T-coil Probe	Axial T-coil Probe	10/28/2009	TEM-1111
Radial T-coil Probe	Radial T-coil Probe	10/28/2009	TEM-1110
E4440A	PSA Spectrum analyzer	2/13/2010	MY46186167
E4419B	EPM Power Meter	5/8/2010	MY45101764
E9300B	Power Sensor	5/8/2010	MY41495894
Fluke87	RMS Multimeter	1/6/2010	65030199
E3640A	Power supply	3/5/2010	MY40006140
AMCC	H/H coil(Speag)	N/A	N/A

5. HAC MEASUREMENT PROCEDURE

The flow diagram below was followed (From C63.19):

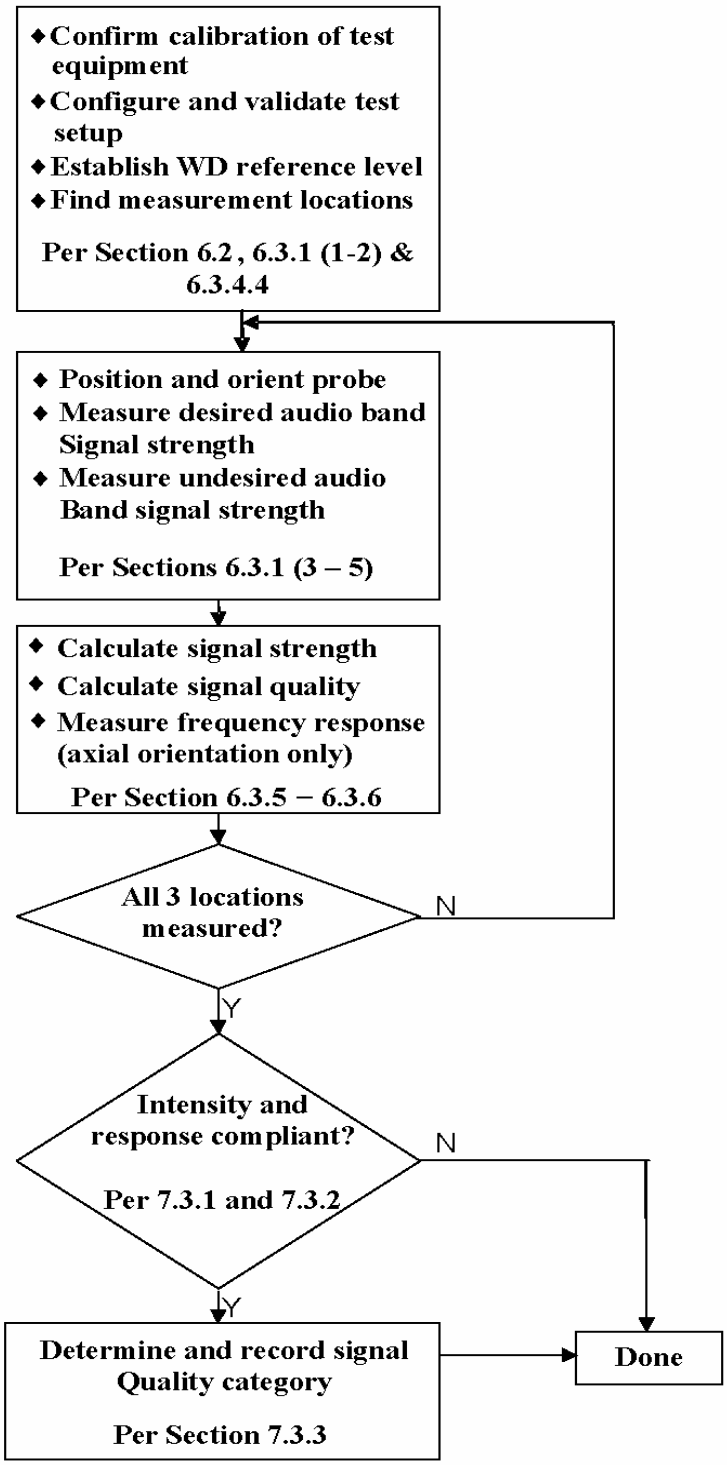

Figure 5-1 Test Procedure for T-coil Measurement

5.1 Ambient Noise Check per C63.19 §6.2.1

a. Ambient interference was monitored using a Real-Time Analyzer between 100-10,000 Hz with 1/3 octave filtering.
b. "A-weighting" and Half-Band Integration was applied to the measurements.
c. Since this measurement was measured in the same method as ABM2 measurements, this level was verified to be less than 10 dB below the lowest measurement signal (which is the highest ABM2 measurement for a T4 WD). Therefore the maximum noise level for a T4 WD with an ABM1 = -18 dBA/m is:

-18 - 30 - 10 = -58 dBA/m

5.2 Measurement System Validation (See Figure 4-1)

a. The measurement system including the probe, pre-amplifier and acquisition system were validated as an entire system to ensure the reliability of test measurements.

b. ABM1 Validation

The magnetic field at the center of the Helmholtz coil is given by the equation (per C63.19 Annex D.9.1):

$$H_c = \frac{NI}{r\sqrt{1.25^3}} = \frac{N(\frac{V}{R})}{r\sqrt{1.25^3}}$$

Where H_c = magnetic field strength in amperes per meter
N = number of turns per coil

For a Helmholtz Coil, N=20; r=0.143m; R=10.2Ω and using V=102mV:

$$H_c = \frac{20 \cdot (\frac{0.102}{10.2})}{0.143 \cdot \sqrt{1.25^3}} = 1.0007 A/m$$

Therefore a pure tone of 1kHz was applied into the coils such that 102 mV was observed across the 10.2 Ω resistor. The voltmeter used for measurement was verified to be capable of measurements in the audio band range. This theoretically generates an expected field of 1 A/m in the center of the Helmholtz coil which was used to validate the probe measurement at 1 A/m. This was verified to be within ± 0.5 dB of the 1 A/m value.

c. Frequency Response Validation

The frequency response through the Helmholtz Coil was verified to be within 0.5 dB relative to 1 kHz, between 300 – 3000 Hz using the ITU-P.50 artificial speech signal as shown below:

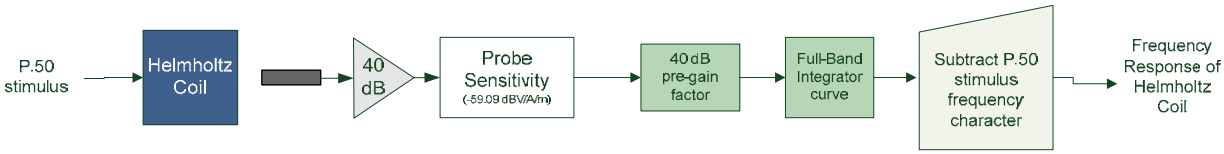

Figure 5-2 Frequency Response Validation

d. ABM2 Measurement Validation

WD noise measurements are filtered with A-weighting and Half-Band Integration over a frequency range of 100Hz – 10kHz to process ABM2 measurements. Below is the verification of the system processing A-weighting and Half-Band integration between system input to output within 0.5 dB of the theoretical result:

Table 5-1
ABM2 Frequency Response Validation

f (Hz)	HBI, A - Measured (dB re 1kHz)	HBI, A - Theoretical (dB re 1kHz)	dB Var.
100	-16.180	-16.170	-0.010
125	-13.257	-13.250	-0.007
160	-10.347	-10.340	-0.007
200	-8.017	-8.010	-0.007
250	-5.925	-5.920	-0.005
315	-4.045	-4.040	-0.005
400	-2.405	-2.400	-0.005
500	-1.212	-1.210	-0.002
630	-0.349	-0.350	0.001
800	0.071	0.070	0.001
1000	0.000	0.000	0.000
1250	-0.503	-0.500	-0.003
1600	-1.513	-1.510	-0.003
2000	-2.778	-2.780	0.002
2500	-4.316	-4.320	0.004
3150	-6.166	-6.170	0.004
4000	-8.322	-8.330	0.008
5000	-10.573	-10.590	0.017
6300	-13.178	-13.200	0.022
8000	-16.241	-16.270	0.029
10000	-19.495	-19.520	0.025

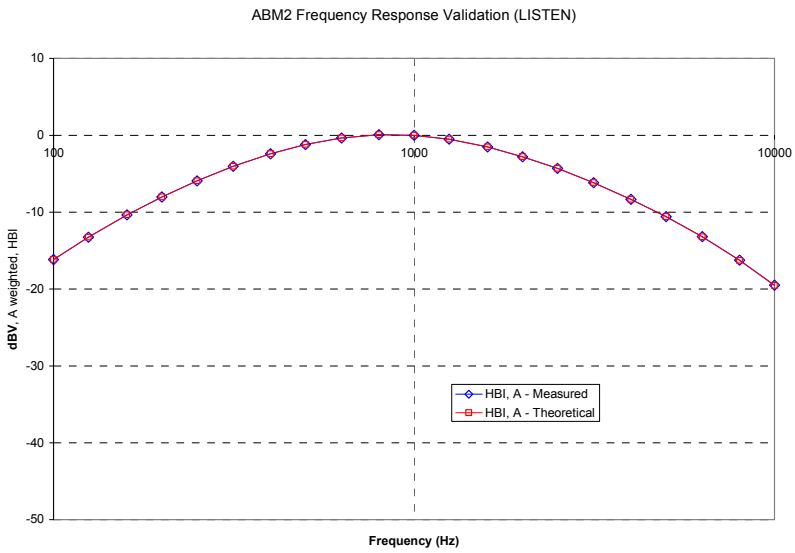

Figure 5-3
ABM2 Frequency Response Validation

The ABM2 result is a power sum from 100 Hz to 10 kHz with half-band integration and A-weighting. To verify the power sum measurement, a power sum over the full band was measured and verified to track with the source level (See Figure 5-9). Therefore the setup in this step was used to verify the power sum post-processing for ABM2 measurements. See below block diagram:

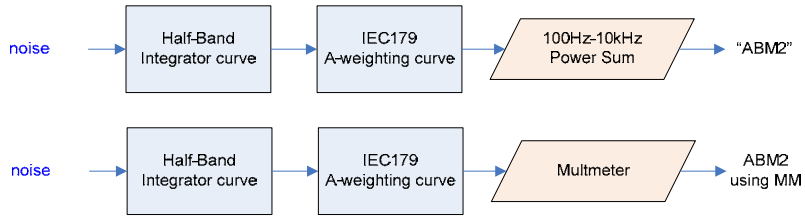

Figure 5-4 ABM2 Validation Block Diagram

The power summed output results for a known input were compared to the multi-meter results to verify any deviation in the post-processing implemented with the power-sum.

Table 5-2 ABM2 Power Sum Validation

WN Input (dBV)	Power Sum (dBV)	Multimeter-Full (dBV)	Dev (dB)
-60	-60.36	-60.2	0.16
-50	-50.19	-50.13	0.06
-40	-40.14	-40.03	0.11
-30	-30.13	-30.01	0.12
-20	-20.12	-20	0.12
-10	-10.14	-10	0.14

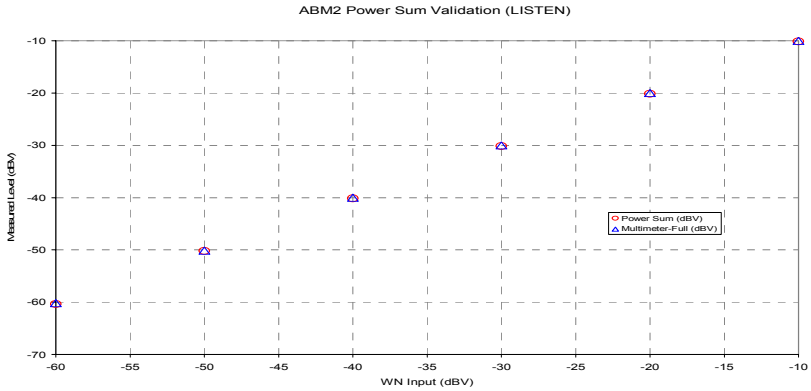

Figure 5-5 ABM2 Power Sum Validation

5.3 Measurement Test Setup

5.3.1 Fine scan above the WD (TEM)

a. A multi-tone signal was applied to the handset such that the phone acoustic output was stable within 1dB over the probe settling time and with the acoustic output level at the C63.19 specified levels (below). The measurement step size was in 2 mm increments at a distance of 10 mm between the surface of the wireless device as shown below:

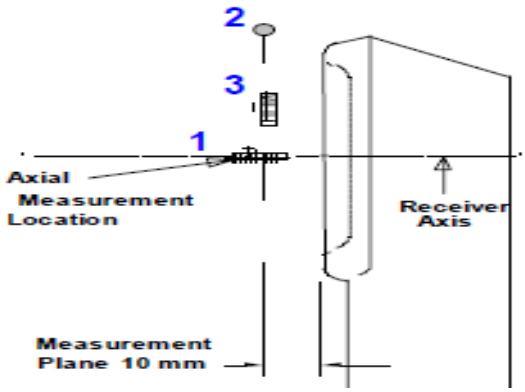

Figure 5-6
Measurement Distance

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b. After scanning, the planar field maximum point was determined. The position of the probe was moved to this location to setup the test using the sound check system.

c. These steps were repeated for the other T-coil orientations (of axial, radial transverse, or radial longitudinal) per Figure 5-16 after a T-coil orientation was fully measured with the sound check system.

5.3.2 Speech Signal Setup to Base Station Simulator

a. C63.19 Table 6-1 states audio reference input levels for various technologies:

Standard	Technology	Input Level (dBm0)
TIA/EIA/IS-2000	CDMA	-18
J-STD-007	GSM (217)	-16
T1/T1P1/3GPP	UMTS (WCDMA)	-16
iDEN™	TDMA (22 and 11 Hz)	-18

The CMU200 audio levels were determined using base station simulator manufacturer calibration procedures resulting in the below corresponding voltages relative to handset test point level (in dBm0):

Table 5-3
CMU200 Voltage Input Levels for Audio

	GSM		
	Encoder Cal.		Sensitivity (DUT R)
	Peak 1(mV)	Peak 1(dBV)	
3.14dBm0	1069	0.58	1.037
-16dBm0	118.25	-18.54	
	CDMA		
	Encoder Cal.		Sensitivity (DUT R)
	Peak 1(mV)	Peak 1(dBV)	
3.14dBm0	1069	0.58	1.051
-18dBm0	94.09	-20.53	

*** Encoder cal. value adjusts to Decoder cal. value.**

b. Real-Time Analyzer (RTA)
   i. The Real-Time Analyzer was configured to analyze measurements using 1/3 Octave band weighted filtering.
c. WD Radio Configuration Selection
   i. The device was chosen to be tested in the worst-case ABM2 condition under Full Rate 2 for GSM(see below):

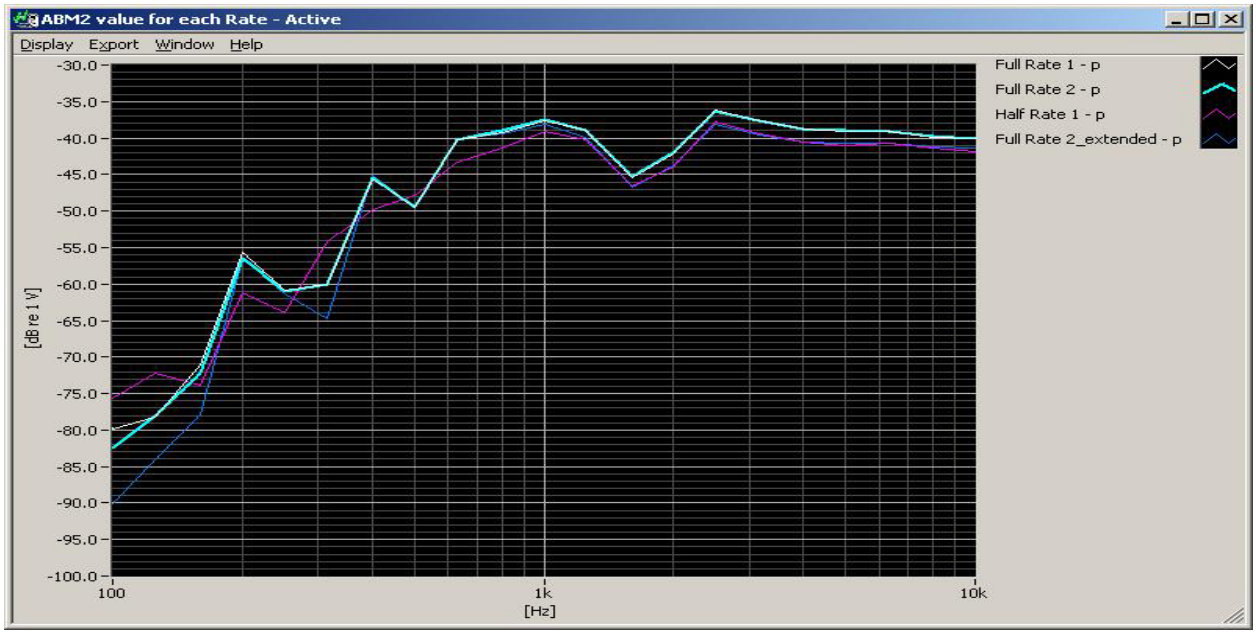


Figure 5-7
Vocoder Analysis for ABM Noise(GSM)

   ii. The device was chosen to be tested in the worst-case ABM2 condition under RC1/SO3 for CDMA(see below):

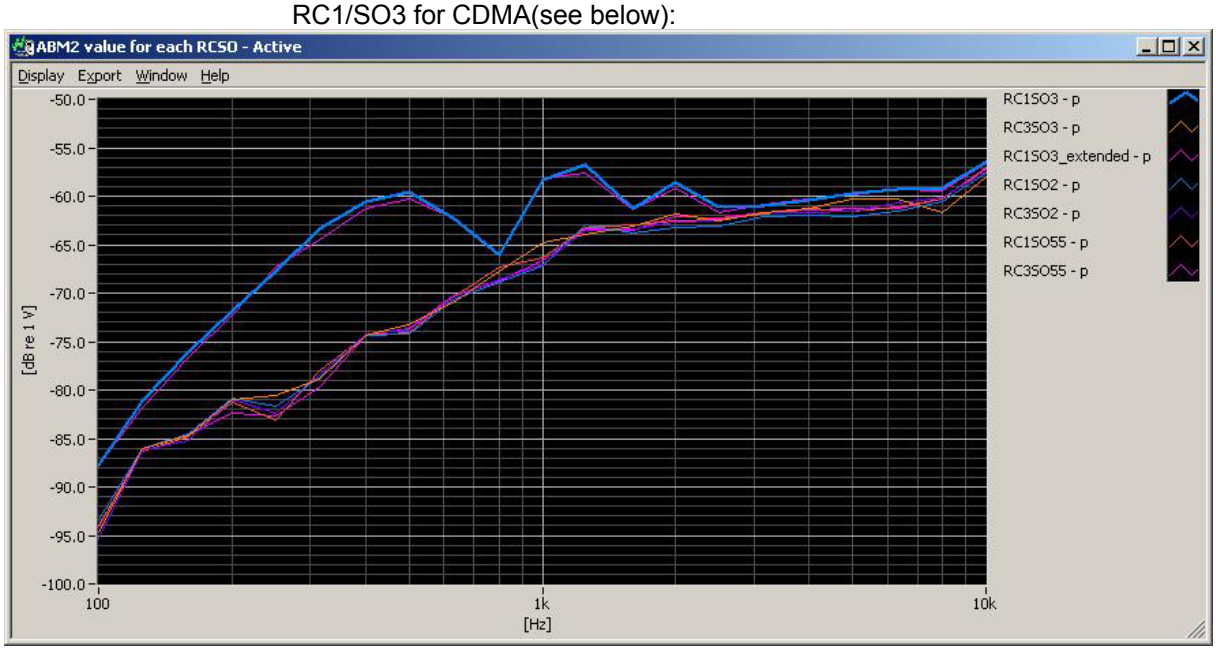


Figure 5-8
Vocoder Analysis for ABM Noise(CDMA)

5.3.3 Signal Quality Data Analysis

a. Narrow-band Magnetic Intensity
   i. The standard specifies a 1 kHz 1/3 octave band minimum field intensity for a sine tone. The ABM1 measurements were evaluated at 1kHz with 1/3 octave band filtering over an averaged period of 10 seconds.

b. Frequency Response
   i. The appropriate frequency response curve was measured to curves in Figure 4-1 or Figure 4-2 between 300 – 3000 Hz using digital linear averaging (limit lines chosen according to measurement found in step 4a.) A linear average over 3x the length of the artificial voice signal (3x sampling) was performed. A 10 second delay was configured in the measurement process of the stimulus to ensure handset vocoder latency effects and echo cancellation devices (if any) were appropriately stabilized during measurements.
   ii. The appropriate post-processing was applied according to the system processing chain illustrated in Figure 5-13. All R10 frequencies were plotted with respect to 0dB at 1 kHz value and aligned with respect to the EIA-504 mask.

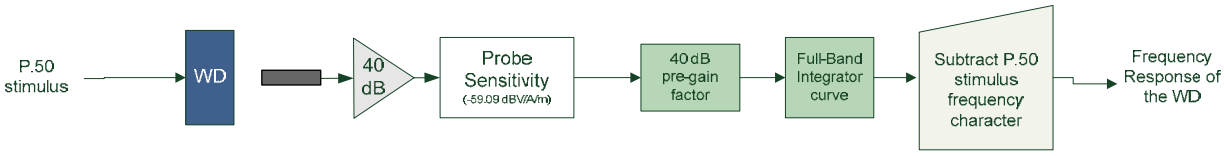


Figure 5-8 Frequency Response Block Diagram

   iii. The margin is represented by the closest measured data point on the curve to the EIA-504 limit lines, in dB.

c. Signal Quality Index
   i. Ensuring the WD was at maximum RF power, maximum volume, backlight on, display on, maximum contrast setting, keypad lights on (when possible) with no audio signal through the vocoder, the WD was measured over at least 100 Hz – 10,000 Hz, maximized over 5 seconds with a 50ms sample time for the ABM2 measurement (5 second time period is used in noise measurements under standards such as IEEE 269, etc.)
   ii. After applying half-band integration and A-weighting to the result, a power sum was applied over each 1/3 octave bandwidth frequency for an ABM2 value
   iii. This result was subtracted from the ABM1 result in step a, to obtain the Signal Quality.

iv.

5.3.4 Wireless Device Channels and Frequencies

The frequencies listed in the table below are those that lie in the center of the bands used for cellular telephony. Low, middle and high channels were tested in each band for FCC compliance evaluation to ensure the maximum emission is captured across the entire band.

To facilitate setting of a base station simulator for ABM measurements, specific band plan channel numbers are listed that may be used in lieu of the band center frequencies.

Table 5-4
Center Channels and Frequencies

Test frequencies & associated channels	
Channel	**Frequency (MHz)**
Cellular 850	
384 (CDMA)	**836.52**
UARFCN 4183(UMTS)	**836.60**
190 (GSM)	**836.60**
PCS 1900	
661 (GSM)	**1880**
600 (CDMA)	**1880**
UARFCN 9400 (UMTS)	**1880**

5.3.5 RF Emission Effect on T-coil Measurements

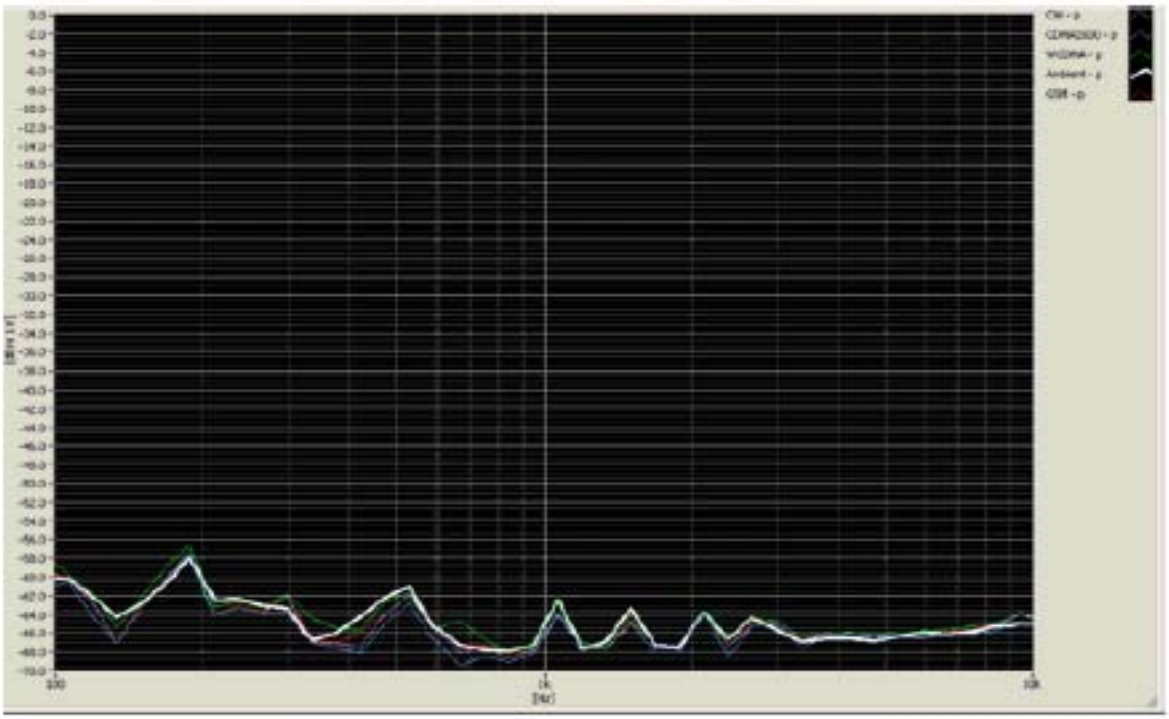


Figure 5-9
High Power RF Emissions Effect with HAC Dipole on the T-coil Probe System 10mm between dipole maximum and magnetic probe

6. MEASUREMENT UNCERTAINTY

Source of Uncertainty	Value %	Probability distribution	Divisor	c_i	$u_i(y)$	$(u_i(y))^2$	v_i or v_{eff}	$ui(y)^4/v_{eff}$
Measurement system								
ABM Noise	0.16	normal	1.000	1	0.16	0.024	4	0.0001469
RF Reflection	4.70	rectangular	1.732	1	2.71	7.363	∞	0
Reference Signal Level	12.20	rectangular	1.732	1	7.04	49.613	∞	0
Probe Coil Sensitivity	12.20	rectangular	1.732	1	7.04	49.613	∞	0
Probe Linearity	2.40	rectangular	1.732	1	1.39	1.920	∞	0
Cable Loss	2.80	rectangular	1.732	1	1.62	2.613	∞	0
Frequency Analyzer	5.00	rectangular	1.732	1	2.89	8.333	∞	0
System Repeatibility	2.04	normal	1.000	1	2.04	4.176	4	4.360
Positioner Accuracy	1.00	rectangular	1.732	1	0.58	0.333	∞	0
Test sample related								
WD Repeatibility	10.40	normal	1.000	1	10.40	108.137	4	2923.396
Phantom and set-up								
Positioning Accuracy	9.75	normal	1.000	1	9.75	95.045	4	2258.375
Combined Standard Uncertainty		normal			18.09	327.172	21	5186.131
Expanded Uncertainty		**normal k=**	**1.96**		35.45		21	

Notes:

1. Test equipments are calibrated according to techniques outlined in NIS81, NIS3003 and NIST Tech Note 1297.
2. All equipments have traceability according to NIST. Measurement Uncertainties are defined in further detail in NIS 81 and NIST Tech Note 1297 and UKAS M3003.

Measurement uncertainty reflects the quality and accuracy of a measured result as compared to the true value. Such statements are generally required when stating results of measurements so that it is clear to the intended audience that the results may differ when reproduced by different facilities. Measurement results vary due to the measurement uncertainty of the instrumentation, measurement technique, and test engineer. Most uncertainties are calculated using the tolerances of the instrumentation used in the measurement, the measurement setup variability, and the technique used in performing the test. While not generally included, the variability of the equipment under test also figures into the overall measurement uncertainty. Another component of the overall uncertainty is based on the variability of repeated measurements (so-called Type A uncertainty). This may mean that the Hearing Aid compatibility tests may have to be repeated by taking down the test setup and resetting it up so that there are a statistically significant number of repeat measurements to identify the measurement uncertainty. By combining the repeat measurement results with that of the instrumentation chain using the technique contained in NIS 81 and NIS 3003, the overall measurement uncertainty was estimated.

7. Test Results

7.1 Test Summary

7.1.1 GSM

Table 7-1
Table of Results for GSM

Mode	Band	Orientation	Measurement Item	Limit	Measured	Verdict	Result
GSM	GSM 850	Axial	Intensity	-18	5.24	PASS	T4
			Frequency Response	0	2	PASS	
			SNNR	20	32.24	PASS	
		Radial Transverse	Intensity	-18	-0.85	PASS	
			Frequency Response	0	2	PASS	
			SNNR	20	49.18	PASS	
		Radial Longitudinal	Intensity	-18	1.13	PASS	
			Frequency Response	0	2	PASS	
			SNNR	20	30.11	PASS	
	GSM 1900	Axial	Intensity	-18	5.13	PASS	T4
			Frequency Response	0	2	PASS	
			SNNR	20	35.61	PASS	
		Radial Transverse	Intensity	-18	-0.83	PASS	
			Frequency Response	0	2	PASS	
			SNNR	20	49.52	PASS	
		Radial Longitudinal	Intensity	-18	1.16	PASS	
			Frequency Response	0	2	PASS	
			SNNR	20	33.65	PASS	

*Note : The above results are tested in the worst case of ABM2 configuration.
(GSM Full Rate Version2)

The measured T-coil category is T4 for GSM mode and all raw data is in Section 7.2.

7.1.2 CDMA

Table 7-2
Table of Results for CDMA

Mode	Band	Orientation	Measurement Item	Limit	Measured	Verdict	Result
CDMA	Cellular	Axial	Intensity	-18	-5.5	PASS	T3
			Frequency Response	0	1.31	PASS	
			SNNR	20	47.38	PASS	
		Radial Transverse	Intensity	-18	-11.42	PASS	
			Frequency Response	0	1.39	PASS	
			SNNR	20	38.8	PASS	
		Radial Longitudinal	Intensity	-18	-12.24	PASS	
			Frequency Response	0	1.22	PASS	
			SNNR	20	26.36	PASS	
	PCS	Axial	Intensity	-18	-6.19	PASS	T3
			Frequency Response	0	1.51	PASS	
			SNNR	20	42.25	PASS	
		Radial Transverse	Intensity	-18	-11.74	PASS	
			Frequency Response	0	1.5	PASS	
			SNNR	20	28.79	PASS	
		Radial Longitudinal	Intensity	-18	-12.73	PASS	
			Frequency Response	0	1.43	PASS	
			SNNR	20	26.43	PASS	

*Note : The above results are tested in the worst case of ABM2 configuration.
(CDMA RC1SO3 configuration)

The measured T-coil category is T3 for CDMA mode and all raw data is in Section 7.2.

7.2 Raw Data for T-coil Measurement

7.2.1 GSM

Table 7-3
Raw data for GSM

	GSM850								
	Axial			Radial Transverse			Radial Longitudinal		
	Ch.128	Ch.190	Ch.251	Ch.128	Ch.190	Ch.251	Ch.128	Ch.190	Ch.251
ABM1 (dBA/m)	5.24	5.41	5.24	-0.72	-0.7	-0.85	1.13	1.24	1.23
ABM2(dBA/m)	-27	-27.25	-27.62	-49.89	-49.91	-50.06	-28.97	-29.31	-29.58
Frequency Response(dB)	2	2	2	2	2	2	2	2	2
SNNR(dB)	32.24	32.67	32.86	49.18	49.21	49.21	30.11	30.54	30.82
Ambient Noise(dBA/m)	-60.66			-60.95			-60.67		
Minimum of SNNR	32.24			49.18			30.11		

	GSM1900								
	Axial			Radial Transverse			Radial Longitudinal		
	Ch.512	Ch.661	Ch.810	Ch.512	Ch.661	Ch.810	Ch.512	Ch.661	Ch.810
ABM1 (dBA/m)	5.22	5.13	5.23	-0.62	-0.49	-0.83	1.22	1.16	1.25
ABM2(dBA/m)	-30.78	-30.78	-30.37	-50.12	-50.47	-50.45	-32.73	-32.54	-32.4
Frequency Response(dB)	2	2	2	2	2	2	2	2	2
SNNR(dB)	36.01	35.91	35.61	49.52	49.97	49.62	33.95	33.7	33.65
Ambient Noise(dBA/m)	-60.66			-60.95			-60.67		
Minimum of SNNR	35.61			49.52			33.65		

WD Configuration :
1. Power configuration : PCL=5 (GSM850), PCL=0 (GSM1900)
2. Phone condition : Mute On, Backlight On, Max Volume, Max Contrast
3. Voice Configuration : Full Rate Version2

7.2.2 CDMA

Table 7-4
Raw data for CDMA

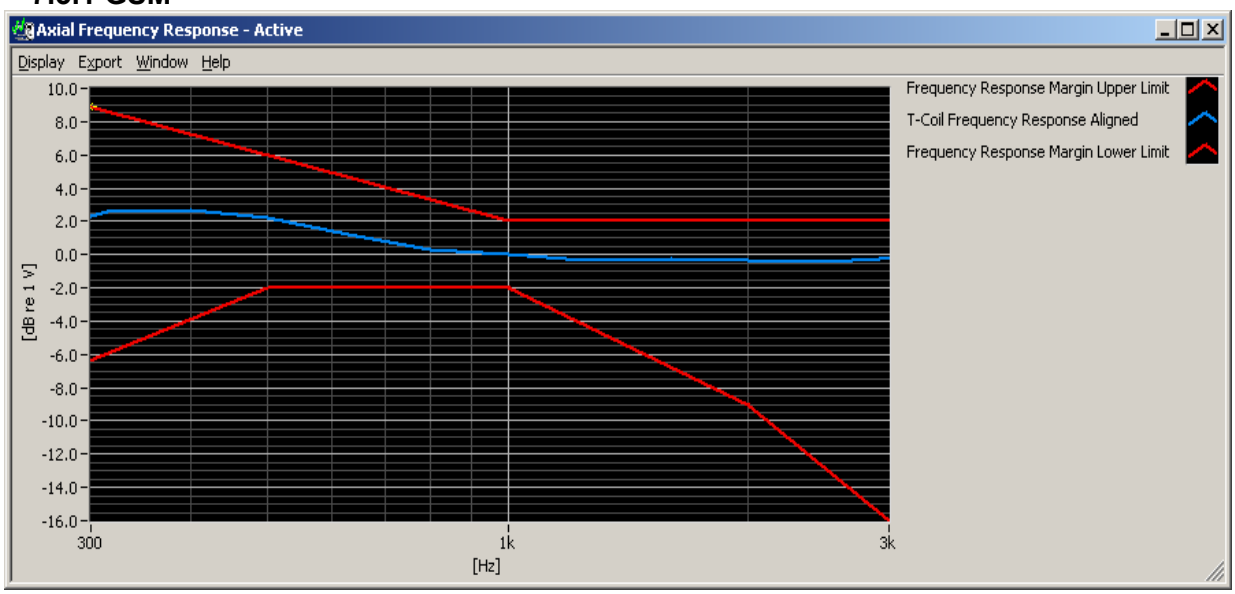
	CDMA								
	Axial			Radial Transverse			Radial Longitudinal		
	Ch.1013	Ch.384	Ch.777	Ch.1013	Ch.384	Ch.777	Ch.1013	Ch.384	Ch.777
ABM1 (dBA/m)	-5.27	-5.5	-4.83	-11.42	-11.34	-11.22	-11.83	-11.92	-12.24
ABM2(dBA/m)	-52.83	-52.88	-52.52	-50.21	-50.25	-50.18	-40.1	-39.92	-38.6
Frequency Response(dB)	1.52	1.31	1.49	1.5	1.49	1.39	1.33	1.22	1.26
SNNR(dB)	47.56	47.38	47.69	38.8	38.91	38.96	28.27	28	26.36
Ambient Noise(dBA/m)	-60.66			-60.95			-60.67		
Minimum of SNNR	47.38			38.8			26.36		

	PCS								
	Axial			Radial Transverse			Radial Longitudinal		
	Ch.25	Ch.600	Ch.1175	Ch.25	Ch.600	Ch.1175	Ch.25	Ch.600	Ch.1175
ABM1 (dBA/m)	-4.86	-6.19	-5.25	-10.56	-10.94	-11.74	-11.83	-12.17	-12.73
ABM2(dBA/m)	-47.38	-49.8	-47.5	-40.01	-42.34	-40.53	-40.57	-43.32	-39.16
Frequency Response(dB)	1.51	1.69	1.64	1.5	1.67	1.64	1.46	1.67	1.43
SNNR(dB)	42.52	43.61	42.25	29.45	31.4	28.79	28.74	31.16	26.43
Ambient Noise(dBA/m)	-60.66			-60.95			-60.67		
Minimum of SNNR	42.25			28.79			26.43		

WD Configuration :
1. Power configuration : Power Control Bits = “All up”
2. Phone condition : Mute On, Backlight On, Max Volume, Max Contrast
3. Radio Configuration : RC1/SO3

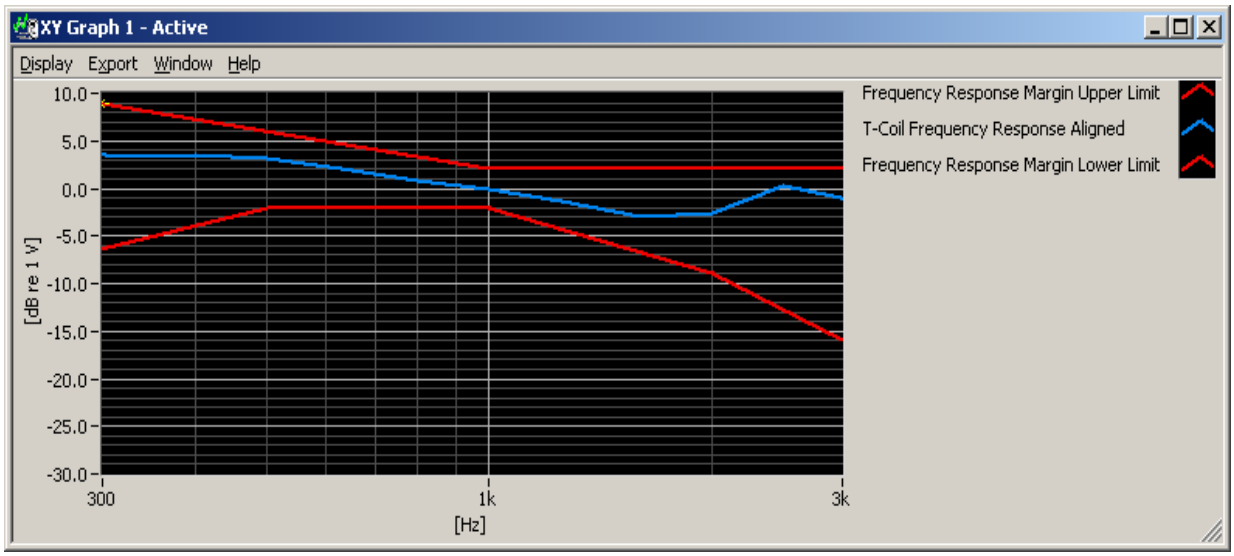
7.3 Frequency Response Graph

7.3.1 GSM



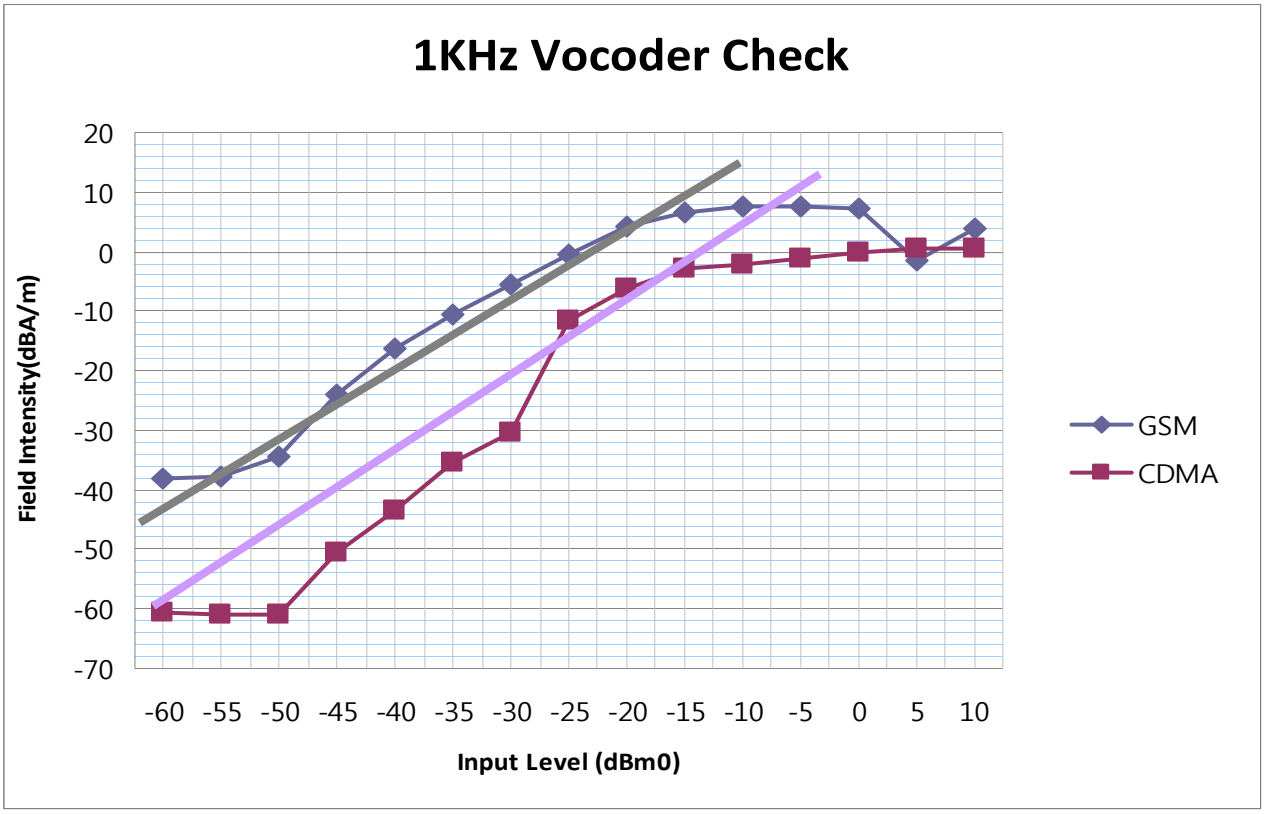
Note : This frequency response represents the worst-case ABM2 test configuration according to Table 7-3 for GSM

7.3.2 CDMA



Note : This frequency response represents the worst-case ABM2 test configuration according to Table 7-4 for CDMA

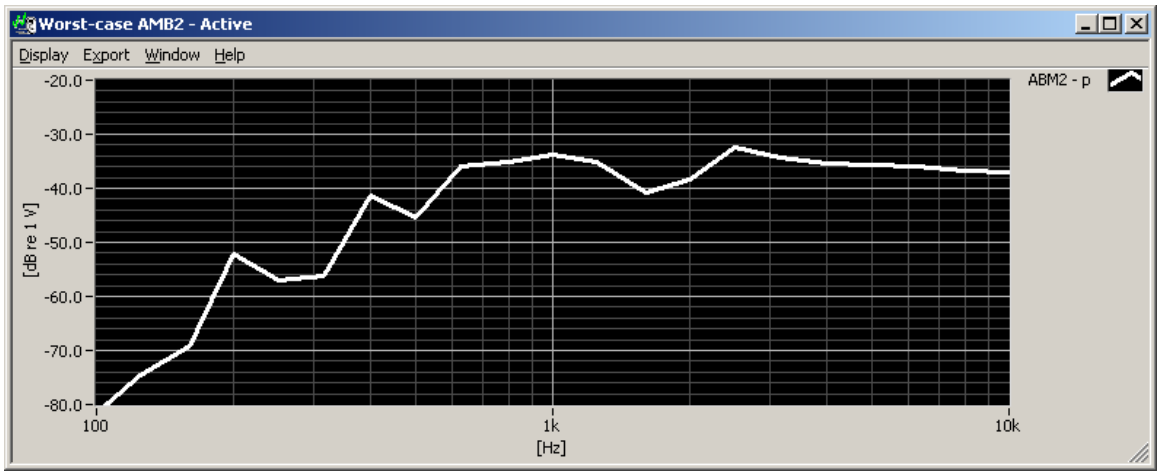
7.4 1KHz Vocoder Application Check



This model was verified to be within the linear region for ABM1 measurements. Two type of modes were tested in the axial configuration above the ABM1 maximum location/configuration derived from Table 7-3 & Table 7-4.

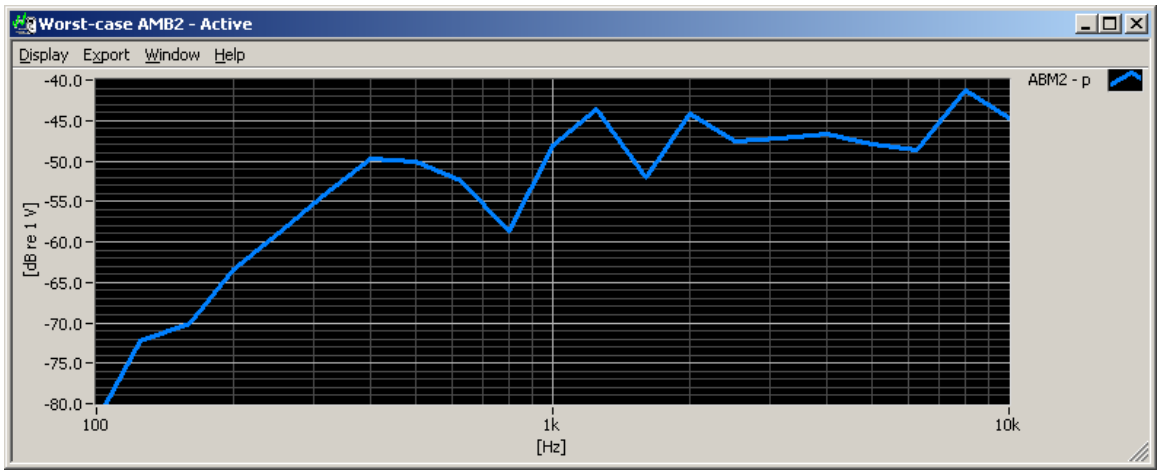
7.5 Undesirable Audio Magnetic Band Plot (ABM2)

7.5.1 ABM2 for GSM



Note : This plot represents the data from the location/configuration resulting in the highest ABM2 result regarding Table 7-3 for GSM

7.5.2. ABM2 for CDMA



Note : This plot represents the data from the location/configuration resulting in the highest ABM2 result regarding Table 7-4 for CDMA

7.6 T-coil Validation Test Results

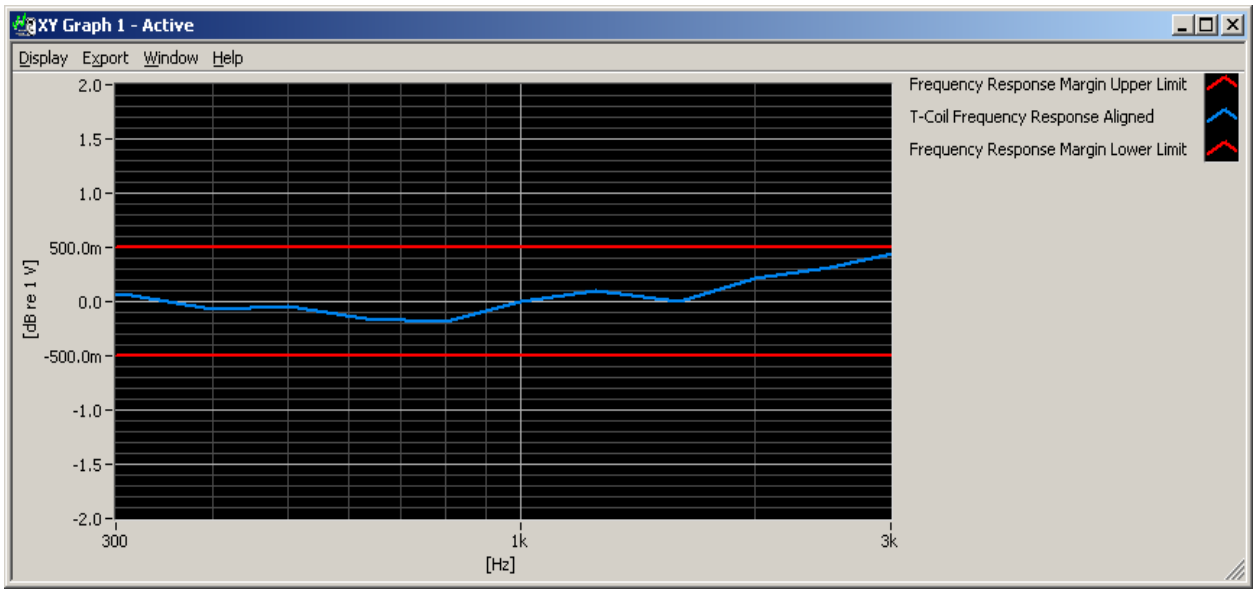


Figure 7-1
Helmholtz coil Validation for Frequency Response

Table 7-5
Table of Results for Helmholtz coil and Noise Validation

Orientation	Item	Target	Measured dB	Verdict
Helmholtz coil validation				
Axial	Frequency Response	0 ±0.5dB	**0.11**	**PASS**
	Magnetic Intensity, 0 dBA/m	0 ±0.5dB	**0.44**	**PASS**
Radial	Frequency Response	0 ±0.5dB	**-0.01**	**PASS**
	Magnetic Intensity, 0 dBA/m	0 ±0.5dB	**0.43**	**PASS**
Noise Validation				
Axial		< -58dBA/m	**-60.66**	**PASS**
Radial Transverse		< -58dBA/m	**-60.95**	**PASS**
Radial Longitudinal		< -58dBA/m	**-60.67**	**PASS**

8. Conclusion

The measurements indicate that the wireless communications device complies with the HAC limits specified in accordance with the ANSI C63.19 standard and FCC WT Docket No. 01-309 RM-8658. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters specific to the test. The test results and statements relate only to the item tested.

The measurement system and techniques presented in this evaluation are proposed in the ANSI standard as a means of best approximating wireless device compatibility with a hearing-aid. The literature is under continual re-construction.

9. Reference

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APPENDIX A

Probe Calibration

CERTIFICATION OF CALIBRATION CONFORMANCE

LIBERTY LABS, INC. 1346 Yellowwood Road Kimballton, IA 51543
EMAIL: mhoward@liberty-labs.com TEL: (712) 773-2199 FAX: (712)773-2299

This antenna has been individually calibrated using one or more of the following methods. NIST Procedures, Mil-Std-461E, IEEE Std. 291-1991 Section 2.2 for loop antennas, and SAE ARP 958. All results of this calibration relate only to the items that were calibrated.

ACCREDITATION NOTES:
A complete copy of the scope of our A2LA accreditation is available upon request.

Instrumentation Environment: TEMP: 20°C RH: 37%
Calibration Environment: TEMP: 20°C RH: 37%
Barometric Pressure (inches): 30.52
CERTIFICATE NO.: 2008082801
CLIENT: TEM Consulting, LP, 140 River Road, Georgetown, TX, 78628, USA
MANUFACTURER: TEM Consulting
MODEL NUMBER: T-Coil Probe Set
SERIAL NUMBER: 1110
ASSET NUMBER:
DATE OF CALIBRATION: Tuesday, October 28, 2008
NAME OF CALIBRATING ORGANIZATION: Liberty Labs, Inc.
CALIBRATED BY: MWH MWH
RE-CALIBRATION DATE: Re-calibration interval is at customer discretion.

RECEIVED STATUS
Received in tolerance: ☑

RETURNED STATUS
Returned in tolerance: ☑
Returned limited cal.: ☐

NOTES: In Tolerance Conditions based on Theoretical Curve provided by TEM Corp.

LL, Inc.

This report is not to be reproduced, except in full, without written approval of Liberty Labs, Inc.

Michael W. Howard

ENGINEER IN CHARGE
MICHAEL W. HOWARD
NARTE CERTIFIED EMC ENGINEER, NO. EM C-000102-NE

ACCREDITED
Certificate Number: 2123.01

CERTIFICATE NO: 2008082801

IN TOLERANCE/OUT OF TOLERANCE EXPLANATION:

The In Tolerance/Out of Tolerance criteria are based on one of the following conditions, of judgement of this laboratory:

1. If the manufacturer has a specified tolerance for the antenna or item under test, then the calibration results, with our uncertainty value added, are compared to this tolerance, and the combined value must fall within the manufacturer's tolerance. The tolerance may be obtained from the manufacturer's web site, catalogs specification sheets, manuals, etc.
2. In the case where the manufacturer does not have any specified tolerances, the calibration results, with our uncertainty value added, are compared to typical curves provided by the manufacturer or historical in-house data with a +/- 3 dB tolerance.
3. Where results are compared to published specifications from a standard, the calibration results, with our uncertainty value added, are compared to this tolerance, and the combined value must fall within the standard's tolerance.
4. In the situation that this laboratory's uncertainty of measurement is larger than the manufacturer's specified tolerance, the comparison criteria will be based on historical in-house data as defined above. This judgement will only be made using accredited calibration methods.

INTERPRETATION TO THE GUIDANCE AND USE OF CALIBRATION DATA:

The calibration values supplied with this certificate apply to measurements made under the physical (geometric) arrangements with respect to the ground plane and distances to reference points on the antenna. Use of these antennas under other conditions will result in additional sources of error of which is the responsibility of the user.

CALIBRATION TRACEABILITY:

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request. Measurement procedure per Military Handbook 52A as guidance for Military Standard (MIL-STD) 45662A, ANSI/NCSL Z540-1-1994, ISO/IEC 17025, and Liberty Labs, Inc. procedure CP-1.

LL, Inc.

CERTIFICATE NO: 2008082801

CALIBRATION EQUIPMENT USED:

Manufacturer	Model Number	Serial Number	Trace Number	Cal Due Date
HP	54845A	US36250219	21278	4/21/2009
Liberty Labs	S1	021	2003122212	
QSC Audio	RMX 2450	060527894		
Solar	7334-1	965309	SC00014307	9/9/2010

FILENAME(S) OF CALIBRATION DATA CONTAINED ON DISKETTE AND/OR WEBSITE:

A printed copy of the contents of the file names with a * are attached to this certificate.

Hearing aid data10.xls* T Coil Factors from 100 Hz to 10 kHz

LL, Inc.

CERTIFICATE NO: 2008082801

Calibration Uncertainty:

☐ **Actual uncertainty (Expanded)**

☑ **Typical uncertainties are shown below and checked for those that apply to this calibration. Best uncertainty equals our typical Muc in most cases. Best uncertainty is based on type A evaluations of at least 10 data sets or more.**

Parameter/Equipment:	Range:	Best Uncertainty*** (+/-):	Comments:
Loop Antennas***** - ACF valid to 10m per NIST methods.	20 Hz to 100 kHz	0.34 dB	Using series resistor to measure loop current

LL, Inc.

* This laboratory offers commercial calibration service

** Best Uncertainties represents an expanded uncertainty corresponding to a 95.45 % level of confidence using a coverage factor k. Values of k other than 2 were approximated by a t distribution with the effective degrees of freedom, veT, obtained from the Welch-Satterthwaite formula.

*** "Best Uncertainty" is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of k = 2. The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer's device, to the environment (if the calibration is performed in the field) and to influences from the circumstances of the specific calibration.

**** In the statement of best uncertainty, M is the Mismatch error due to connections of device to other devices in actual use.

***** On-site calibration service is available for this calibration. The uncertainties achievable on a customer's site can normally be expected to be larger than the Best Measurement Capabilities (BMC) that the accredited laboratory has been assigned as Best Uncertainty on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the calibration uncertainty being larger than the BMC.

CERTIFICATION OF CALIBRATION CONFORMANCE

LIBERTY LABS, INC. 1346 Yellowwood Road Kimballton, IA 51543
EMAIL: mhoward@liberty-labs.com TEL: (712) 773-2199 FAX: (712)773-2299

This antenna has been individually calibrated using one or more of the following methods. NIST Procedures, Mil-Std-461E, IEEE Std. 291-1991 Section 2.2 for loop antennas, and SAE ARP 958. All results of this calibration relate only to the items that were calibrated.

ACCREDITATION NOTES:
A complete copy of the scope of our A2LA accreditation is available upon request.

Instrumentation Environment: TEMP: 20°C RH: 37%
Calibration Environment: TEMP: 20°C RH: 37%
Barometric Pressure (inches): 30.52
CERTIFICATE NO.: 2008082802
CLIENT: TEM Consulting, LP, 140 River Road, Georgetown, TX, 78628, USA
MANUFACTURER: TEM Consulting
MODEL NUMBER: T-Coil Probe Set
SERIAL NUMBER: 1111
ASSET NUMBER:
DATE OF CALIBRATION: Tuesday, October 28, 2008
NAME OF CALIBRATING ORGANIZATION: Liberty Labs, Inc.
CALIBRATED BY: MWH
RE-CALIBRATION DATE: Re-calibration interval is at customer discretion.

RECEIVED STATUS
Received in tolerance: ✔

RETURNED STATUS
Returned in tolerance: ✔
Returned limited cal.: ☐

NOTES: In Tolerance Conditions based on Theoretical Curve provided by TEM Corp.

LL, Inc.

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Michael W. Howard

ENGINEER IN CHARGE
MICHAEL W. HOWARD
NARTE CERTIFIED EMC ENGINEER, NO. EM C-000102-NE

ACCREDITED
Certificate Number: 2123.01

CERTIFICATE NO: 2008082802

IN TOLERANCE/OUT OF TOLERANCE EXPLANATION:

The In Tolerance/Out of Tolerance criteria are based on one of the following conditions, of judgement of this laboratory:

1. If the manufacturer has a specified tolerance for the antenna or item under test, then the calibration results, with our uncertainty value added, are compared to this tolerance, and the combined value must fall within the manufacturer's tolerance. The tolerance may be obtained from the manufacturer's web site, catalogs specification sheets, manuals, etc.
2. In the case where the manufacturer does not have any specified tolerances, the calibration results, with our uncertainty value added, are compared to typical curves provided by the manufacturer or historical in-house data with a +/- 3 dB tolerance.
3. Where results are compared to published specifications from a standard, the calibration results, with our uncertainty value added, are compared to this tolerance, and the combined value must fall within the standard's tolerance.
4. In the situation that this laboratory's uncertainty of measurement is larger than the manufacturer's specified tolerance, the comparison criteria will be based on historical in-house data as defined above. This judgement will only be made using accredited calibration methods.

INTERPRETATION TO THE GUIDANCE AND USE OF CALIBRATION DATA:

The calibration values supplied with this certificate apply to measurements made under the physical (geometric) arrangements with respect to the ground plane and distances to reference points on the antenna. Use of these antennas under other conditions will result in additional sources of error of which is the responsibility of the user.

CALIBRATION TRACEABILITY:

All measurement instrumentation is traceable to the National Institute of Standards and Technology (NIST). Supporting documentation relative to traceability is on file and is available for examination upon request. Measurement procedure per Military Handbook 52A as guidance for Military Standard (MIL-STD) 45662A, ANSI/NCSL Z540-1-1994, ISO/IEC 17025, and Liberty Labs, Inc. procedure CP-1.

LL, Inc.

CERTIFICATE NO: 2008082802

CALIBRATION EQUIPMENT USED:

Manufacturer	Model Number	Serial Number	Trace Number	Cal Due Date
HP	54845A	US36250219	21278	4/21/2009
Liberty Labs	S1	021	2003122212	
QSC Audio	RMX 2450	060527894		
Solar	7334-1	965309	S000014307	9/9/2010

FILENAME(S) OF CALIBRATION DATA CONTAINED ON DISKETTE AND/OR WEBSITE:

A printed copy of the contents of the file names with a * are attached to this certificate.

Hearing aid data11.xls* T Coil Factors from 100 Hz to 10kHz

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Calibration Uncertainty:

☐ Actual uncertainty (Expanded)

☑ Typical uncertainties are shown below and checked for those that apply to this calibration. Best uncertainty equals our typical Muc in most cases. Best uncertainty is based on type A evaluations of at least 10 data sets or more.

Parameter/Equipment:	Range:	Best Uncertainty*** (+/-):	Comments:
Loop Antennas***** - ACF valid to 10m per NIST methods.	20 Hz to 100 kHz	0.34 dB	Using series resistor to measure loop current

LL, Inc.

* This laboratory offers commercial calibration service.

** Best Uncertainties represents an expanded uncertainty corresponding to a 95.45 % level of confidence using a coverage factor, k. Values of k other than 2 were approximated by a t-distribution with the effective degrees of freedom, veff, obtained from the Welch-Satterthwaite formula.

*** "Best Uncertainty" is the smallest uncertainty of measurement that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards of nearly ideal measuring equipment. Best uncertainties represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of k = 2. The best uncertainty of a specific calibration performed by the laboratory may be greater than the best uncertainty due to the behavior of the customer's device, to the environment (if the calibration is performed in the field) and to influences from the circumstances of the specific calibration.

**** In the statement of best uncertainty, M is the Mismatch error due to connections of device to other devices in actual use.

***** On-site calibration service is available for this calibration. The uncertainties achievable on a customer's site can normally be expected to be larger than the Best Measurement Capabilities (BMC) that the accredited laboratory has been assigned as Best Uncertainty on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the calibration uncertainty being larger than the BMC.

S/N TEM 1111
Date 6-Dec-06

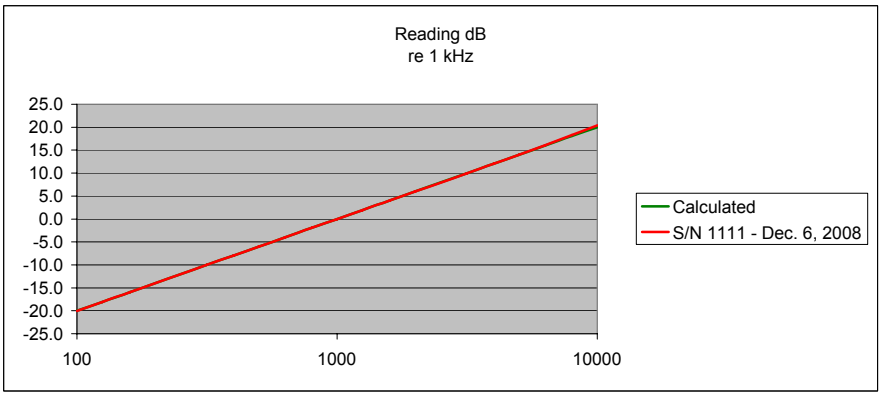
Probe Axial

Sensor Factor 0.5
Factor to convert dB mV to dB A/m

Dynamic Range

Helmholtz Coil Constant for Formula *17.89*

Freq	Field Strength		Coil Input mV	Meter Output	Probe Output Sensor Factor	Sensor Linearity
Hz	dB (A/m)	A/m	Across 10 Ohm	mV	dB mV --> dB A/m	Delta to Calculated in dB
1000	25	17.783	994.15	18.86	0.5	0.0
1000	20	10.000	559.05	10.59	0.5	0.0
1000	15	5.623	314.38	5.95	0.5	0.0



Frequency Response - Voltage into a Fluke 8860A Multimeter

Freq	Sig Gen	mV	H	H	Raw Reading	Reading dB mV	Reading Normalized for drive level	Reading	Delta
Hz	V	Across 10.1 Ohm resister into Coil	A/m	dB (A/m)	mV	dB		dB re 1 kHz	to Calculated
100	10.0	1115.16	26.84	28.58	2.11	6.49		-20.0	0.0
125	10.0	1115.19	26.84	28.58	2.64	8.43		-18.1	0.0
160	10.0	1115.22	26.84	28.58	3.38	10.58		-15.9	0.0
200	10.0	1115.20	26.84	28.58	4.23	12.52		-14.0	0.0
250	10.0	1115.21	26.84	28.58	5.29	14.47		-12.0	0.0
315	10.0	1115.20	26.84	28.58	6.67	16.48		-10.0	0.0
400	10.0	1115.15	26.84	28.58	8.47	18.55		-8.0	0.0
500	10.0	1115.07	26.84	28.58	10.59	20.49		-6.0	0.0
630	10.0	1114.95	26.84	28.57	13.34	22.50		-4.0	0.0
800	10.0	1114.72	26.83	28.57	16.93	24.57		-1.9	0.0
1000	10.0	1114.38	26.82	28.57	21.15	26.51		0.0	0.0
1250	10.0	1113.83	26.81	28.57	26.41	28.44		1.9	0.0
1600	10.0	1112.88	26.79	28.56	33.76	30.58		4.1	0.0
2000	10.0	1111.48	26.75	28.55	42.12	32.51		6.0	0.0
2500	10.0	1109.33	26.70	28.53	52.54	34.45		7.9	0.0
3150	10.0	1105.83	26.62	28.50	66.01	36.46		10.0	0.0
4000	10.0	1100.11	26.48	28.46	83.53	38.55		12.0	0.0
5000	10.0	1091.84	26.28	28.39	104.01	40.52		14.0	0.0
6300	10.0	1078.72	25.96	28.29	130.46	42.59		16.1	0.1
8000	10.0	1058.05	25.47	28.12	164.88	44.79		18.3	0.2
10000	10.0	1029.56	24.78	27.88	205.15	46.93		20.4	0.4

S/N TEM1110
Date 6-Oct-06

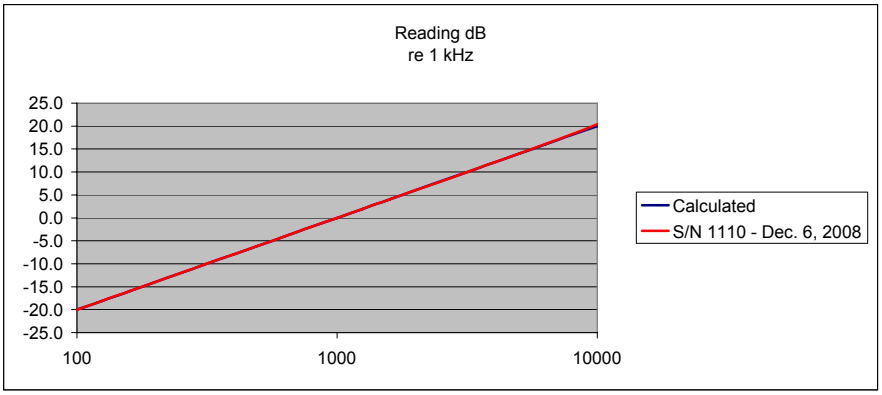
Probe Radial

Sensor Factor -2.1
Factor to convert dB mV to dB A/m

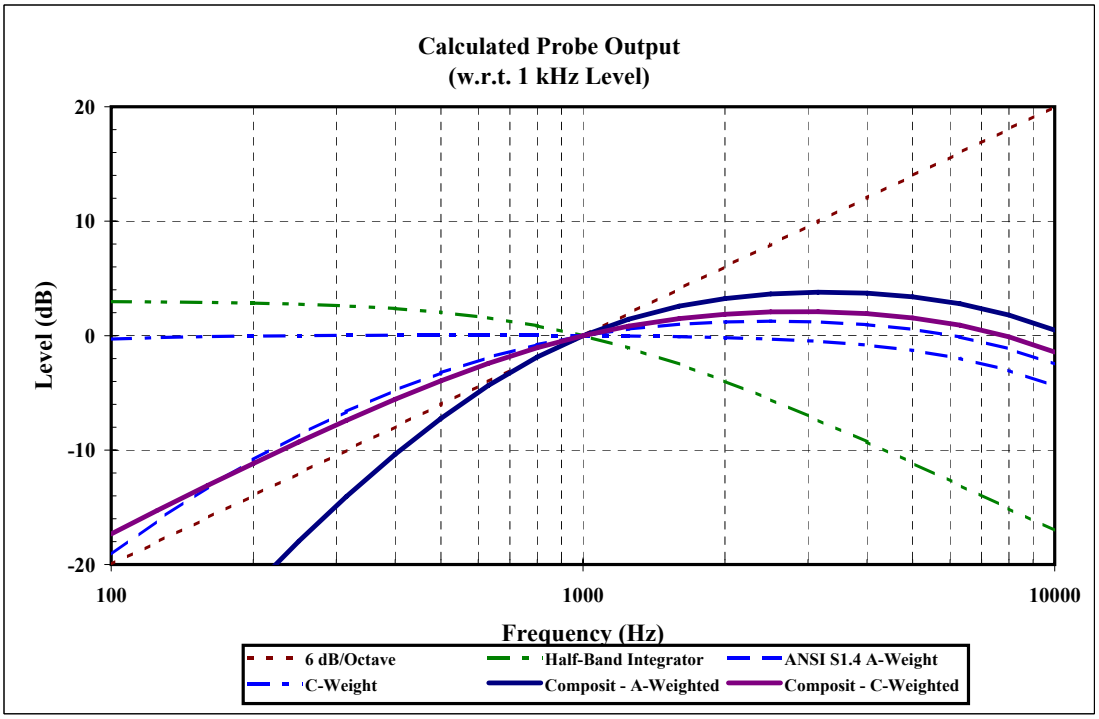
Dynamic Range

Helmholtz Coil Constant for Formula *17.89*

Freq	Field Strength		Coil Input mV	Meter Output	Probe Output Sensor Factor	Sensor Linearity
Hz	dB (A/m)	A/m	Across 10 Ohm	mV	dB dB mV --> dB A/m	Delta to Calculated in dB
1000	28.0	25.119	1404.27	19.76	-2.1	0.0
1000	23.0	14.125	789.68	11.10	-2.1	0.0
1000	18.0	7.943	444.07	6.23	-2.1	0.0
1000	0.0	1.000	55.90	0.77	-2.2	-0.1



Frequency Response - Voltage into a Fluke 8860A Multimeter

Freq	Sig Gen	mV	H	H	Raw Reading	Reading dB mV	Reading	Delta
Hz	V	Across 10.1 Ohm resister into Coil	A/m	dB (A/m)	mV	dB	dB re 1 kHz	to Calculated
100	10.0	1113.48	26.80	28.56	2.10	6.41	-20.1	-0.1
125	10.0	1113.52	26.80	28.56	2.62	8.37	-18.1	0.0
160	10.0	1113.15	26.79	28.56	3.36	10.53	-15.9	0.0
200	10.0	1113.18	26.79	28.56	4.21	12.48	-14.0	0.0
250	10.0	1113.22	26.80	28.56	5.27	14.43	-12.0	0.0
315	10.0	1113.21	26.79	28.56	6.64	16.44	-10.0	0.0
400	10.0	1112.77	26.78	28.56	8.44	18.52	-8.0	0.0
500	10.0	1112.72	26.78	28.56	10.55	20.46	-6.0	0.0
630	10.0	1112.61	26.78	28.56	13.30	22.47	-4.0	0.0
800	10.0	1112.57	26.78	28.56	16.88	24.54	-1.9	0.0
1000	10.0	1112.24	26.77	28.55	21.08	26.48	0.0	0.0
1250	10.0	1111.20	26.75	28.55	26.32	28.42	1.9	0.0
1600	10.0	1110.75	26.74	28.54	33.65	30.55	4.1	0.0
2000	10.0	1109.46	26.70	28.53	41.97	32.48	6.0	0.0
2500	10.0	1107.31	26.65	28.51	52.35	34.42	7.9	0.0
3150	10.0	1103.75	26.57	28.49	65.78	36.43	10.0	0.0
4000	10.0	1098.53	26.44	28.45	83.22	38.51	12.0	0.0
5000	10.0	1090.35	26.24	28.38	103.58	40.48	14.0	0.0
6300	10.0	1077.32	25.93	28.28	129.91	42.55	16.1	0.1
8000	10.0	1056.80	25.44	28.11	164.10	44.75	18.3	0.2
10000	10.0	1028.54	24.76	27.87	204.04	46.87	20.4	0.4

Frequency (Hz)	ANSI S1.4-1983 A-Weight	ANSI S1.4-1983 C-Weight	6 dB/octave (dB)	Half-Band Integrator	6 dB/Octave + Half-Band + A-Weighting	6 dB/Octave + Half-Band + C-Weighting
100	-19.1	-0.3	-20.0	2.97	-36.2	-17.3
125	-16.2	-0.2	-18.1	2.94	-31.3	-15.3
160	-13.2	-0.1	-15.9	2.9	-26.3	-13.1
200	-10.8	0.0	-14.0	2.84	-22.0	-11.2
250	-8.7	0.0	-12.0	2.75	-18.0	-9.3
315	-6.6	0.0	-10.0	2.6	-14.1	-7.4
400	-4.8	0.0	-8.0	2.37	-10.4	-5.6
500	-3.2	0.0	-6.0	2.04	-7.2	-3.9
630	-1.9	0.0	-4.0	1.56	-4.4	-2.4
800	-0.8	0.0	-1.9	0.86	-1.9	-1.1
1000	0.0	0.0	0.0	0	0.0	0.0
1250	0.6	0.0	1.9	-1.08	1.4	0.8
1600	1.0	-0.1	4.1	-2.5	2.6	1.5
2000	1.2	-0.2	6.0	-3.98	3.2	1.9
2500	1.3	-0.3	8.0	-5.59	3.6	2.1
3150	1.2	-0.5	10.0	-7.37	3.8	2.1
4000	1.0	-0.8	12.0	-9.29	3.7	1.9
5000	0.6	-1.3	14.0	-11.14	3.4	1.6
6300	-0.1	-2.0	16.0	-13.08	2.8	0.9
8000	-1.1	-3.0	18.1	-15.12	1.8	-0.1
10000	-2.5	-4.4	20.0	-17.03	0.5	-1.4