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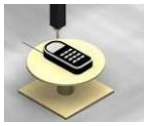

HEARING AID COMPATIBILITY

Applicant Name:
Samsung Electronics Co., Ltd.
129, Samsung-ro, Maetan dong,
Yeongtong-gu, Suwon-si
Gyeonggi-do 443-742, Korea

Date of Testing:
September 9-10, 2014
Test Site/Location:
PCTEST Lab, Columbia, MD, USA
Test Report Serial No.:
0Y1409051816.A3L

FCC ID:	**A3LSMN910A**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD.**

Scope of Test:	Audio Band Magnetic Testing (T-Coil)
Application Type:	Class II Permissive Change
FCC Rule Part(s):	CFR §20.19(b)
HAC Standard:	ANSI C63.19-2011
EUT Type:	Portable Handset
Model(s):	SM-N910A
Test Device Serial No.:	*Pre-Production Sample* [S/N: 01FC3]
Class II Permissive Changes:	*VoLTE Testing*
Original Grant Date:	*09/03/2014*

C63.19-2011 HAC Category:	**T4 (SIGNAL TO NOISE CATEGORY, LTE ONLY)**

This report pertains only to the LTE bands supported by the device. This wireless portable device has been shown to be hearing-aid compatible for the LTE air interface, under the above rated category, specified in ANSI/IEEE Std. C63.19-2011 and has been tested in accordance with the specified measurement procedures. Test results reported herein relate only to the item(s) tested. Hearing-Aid Compatibility is based on the assumption that all production units will be designed electrically identical to the device tested in this report. North American Bands only.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

Randy Ortanez
President

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1. INTRODUCTION

On July 10, 2003, the Federal Communications Commission (FCC) adopted new rules requiring wireless manufacturers and service providers to provide digital wireless phones that are compatible with hearing aids. The FCC has modified the exemption for wireless phones under the Hearing Aid Compatibility Act of 1998 (HAC Act) in WT Docket 01-309 RM-8658[1] to extend the benefits of wireless telecommunications to individuals with hearing disabilities. These benefits encompass business, social and emergency communications, which increase the value of the wireless network for everyone. An estimated more than 10% of the population in the United States show signs of hearing impairment and of that fraction, almost 80% use hearing aids. Approximately 500 million people worldwide and 30 million people in the United States suffer from hearing loss.

Compatibility Tests Involved:

The standard calls for wireless communications devices to be measured for:

- RF Electric-field emissions
- T-coil mode, magnetic-signal strength in the audio band
- T-coil mode, magnetic-signal frequency response through the audio band
- T-coil mode, magnetic-signal and noise articulation index

The hearing aid must be measured for:

- RF immunity in microphone mode
- RF immunity in T-coil mode

In the following tests and results, this report includes the evaluation for a wireless communications device.

Figure 1-1 Hearing Aid *in-vitu*

[1] FCC Rule & Order, WT Docket 01-309 RM-8658

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2. TEST SITE

I. Test Facility / Accreditations:

Measurements were performed at an independent accredited PCTEST Engineering Lab located in Columbia, MD, U.S.A.

- PCTEST Lab is accredited to ISO 17025-2005 by the American Association for Laboratory Accreditation (A2LA) in Specific Absorption Rate (SAR) testing, Hearing-Aid Compatibility (HAC), Long-Term Evolution (LTE), CTIA Test Plans, and wireless testing for FCC and Industry Canada Rules.
- PCTEST Lab is accredited to ISO 17025 by U.S. National Institute of Standards and Technology (NIST) under the National Voluntary Laboratory Accreditation Program (NVLAP Lab code: 100431-0) in EMC, FCC and Telecommunications.
- PCTEST facility is an FCC registered (PCTEST Reg. No. 90864) test facility with the site description report on file and has met all the requirements specified in Section 2.948 of the FCC Rules and Industry Canada (IC-2451).
- PCTEST Lab is a recognized U.S. Conformity Assessment Body (CAB) in EMC and R&TTE (n.b. 0982) under the U.S.-EU Mutual Recognition Agreement (MRA).
- PCTEST TCB is a Telecommunication Certification Body (TCB) accredited to ISO/IEC Guide 65 by the American National Standards Institute (ANSI) in all scopes of FCC Rules and all Industry Canada Standards (RSS).
- PCTEST facility is an IC registered (IC-2451) test laboratory with the site description on file at Industry Canada.

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3. EUT DESCRIPTION

FCC ID:	A3LSMN910A
Applicant:	Samsung Electronics Co., Ltd. 129, Samsung-ro, Maetan dong, Yeongtong-gu, Suwon-si Gyeonggi-do 443-742, Korea
Model(s):	SM-N910A
Serial Number:	01FC3
HW Version:	N910A.10A
SW Version:	N910AUCU0ANHJV
Antenna:	Internal Antenna
HAC Test Configurations:	LTE FDD B2; BW's: 20MHz, 15MHz, 10MHz, 5MHz, 3MHz, 1.4MHz; BT Off, WLAN Off LTE FDD B4; BW's: 20MHz, 15MHz, 10MHz, 5MHz, 3MHz, 1.4MHz; BT Off, WLAN Off LTE FDD B5; BW's: 10MHz, 5MHz, 3MHz, 1.4MHz; BT Off, WLAN Off LTE FDD B12; BW's: 10MHz, 5MHz, 3MHz, 1.4MHz; BT Off, WLAN Off LTE FDD B17; BW's: 10MHz, 5MHz; BT Off, WLAN Off * Note: LTE test channels for different bands and bandwidths can be found in Sect. 7.II
EUT Type:	Portable Handset

Air-Interface	Band (MHz)	Type Transport	HAC Tested	Simultaneous But Not Tested	Voice over Digital Transport OTT Capability	WIFI Low Power	Additional GSM Power Reduction
GSM	850	VO	Yes[2]	Yes: WIFI or BT	N/A	N/A	No
	1900						
	GPRS/EDGE	DT	No	Yes: WIFI or BT	Yes	N/A	No
UMTS	850	VO	Yes[2]	Yes: WIFI or BT	N/A	N/A	N/A
	1900						
	HSPA	DT	No	Yes: WIFI or BT	Yes	N/A	N/A
LTE	700 (B12)	VD[1]	Yes	Yes: WIFI or BT	Yes	N/A	N/A
	700 (B17)						
	850						
	1700						
	1900						
WIFI	2450	DT	No	Yes: GSM, UMTS or LTE	Yes	N/A	N/A
	5200						
	5300						
	5500						
	5800						
BT	2450	DT	No	Yes: GSM, UMTS or LTE	N/A	N/A	N/A

Type Transport
VO = Voice Only
DT = Digital Data - Not intended for CMRS Service
VD = CMRS and Data Transport

Notes:
1. The 3GPP VoLTE CMRS service is defined by GSMA in PRD IR.92 for IP Voice Service and Digital Transport.
2. GSM and UMTS air interfaces are not within the scope of this test report. Please refer to appropriate test reports.

Table 3-1: A3LSMN910A HAC Air Interfaces

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4. ANSI C63.19-2011 PERFORMANCE CATEGORIES

I. MAGNETIC COUPLING

Axial and Radial Field Intensity

All orientations of the magnetic field, in the axial and radial position along the measurement plane shall be ≥ -18 dB(A/m) at 1 kHz in a 1/3 octave band filter per §8.3.1.

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 §8.3.2.

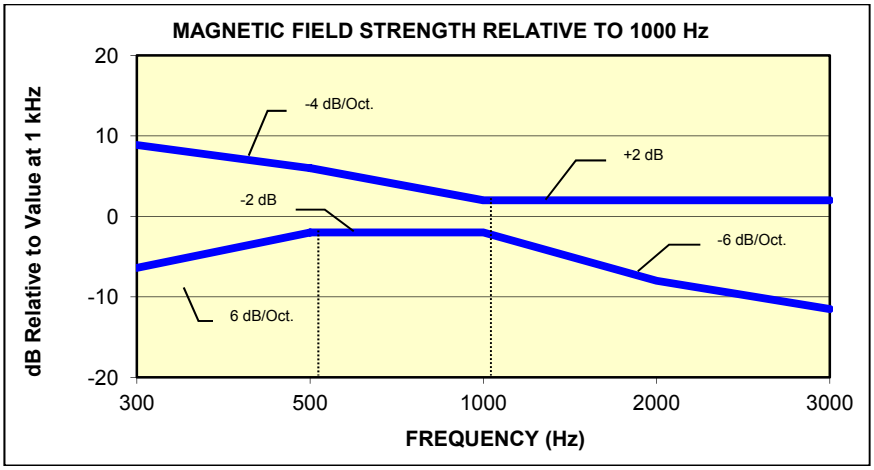

Figure 4-1
Magnetic field frequency response for Wireless Devices with an axial field ≤-15 dB (A/m) at 1 kHz

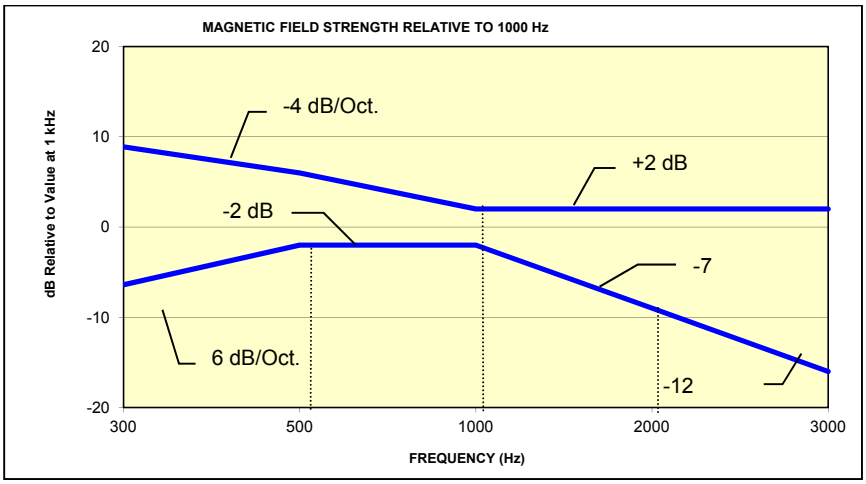

Figure 4-2
Magnetic Field frequency response for wireless devices with an axial field that exceeds -15 dB(A/m) at 1 kHz

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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 4-1
Magnetic Coupling Parameters

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5. METHOD OF MEASUREMENT

I. Test Setup

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

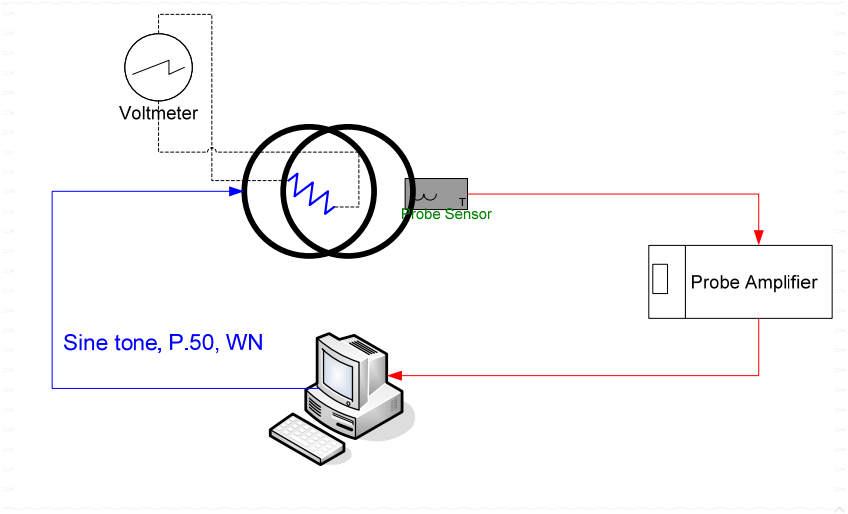

Figure 5-1
Validation Setup with Helmholtz Coil

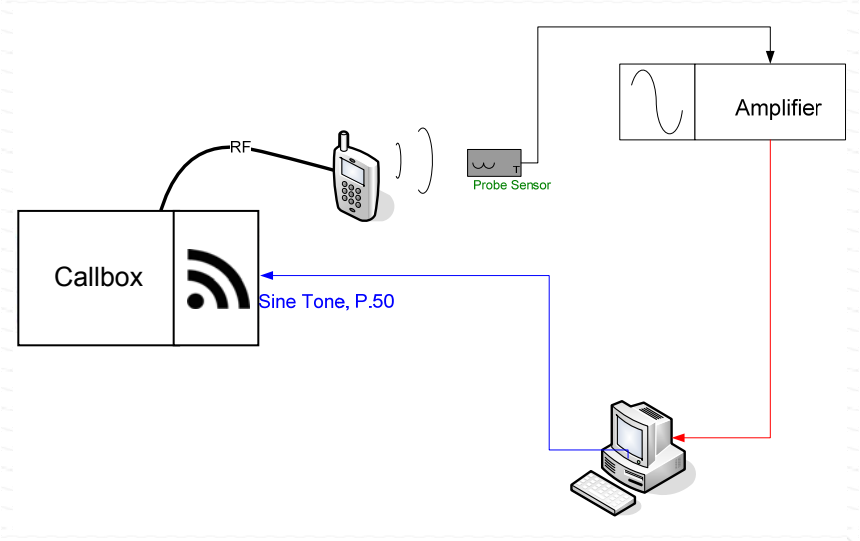

Figure 5-2
General T-Coil Test Setup

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II. 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)

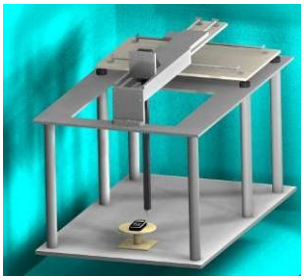

Figure 5-3
RF Near-Field Scanner

III. 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%

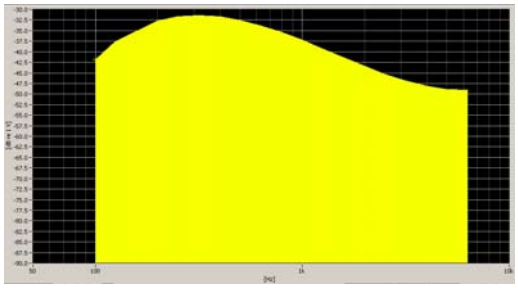

Figure 5-4
Spectral Characteristic of full P.50

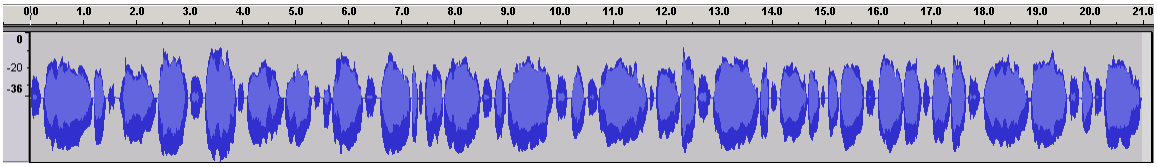

Figure 5-5
Temporal Characteristic of full P.50

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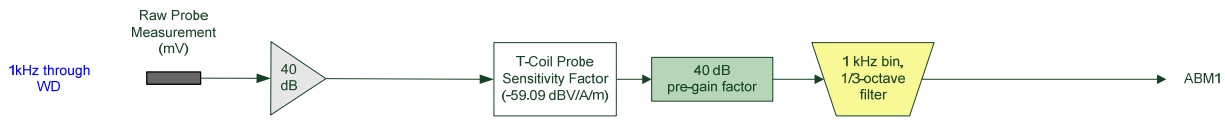
ABM1 Measurement Block Diagram:



ABM2 Measurement Block Diagram:

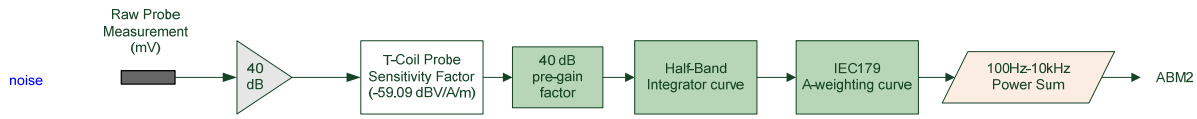


Figure 5-6 Magnetic Measurement Processing Steps

IV. Test Procedure

1. Ambient Noise Check per C63.19 §7.3.1
   a. Ambient interference was monitored using a Real-Time Analyzer between100-10,000 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 more 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

2. Measurement System Validation(See Figure 5-1)
   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.10.1):

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

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

For the Helmholtz Coil, N=20; r=0.13m; R=10.193Ω and using V=29mV:

$$H_c = \frac{20 \cdot (\frac{0.029}{10.193})}{0.13 \cdot \sqrt{1.25^3}} = 0.31623 A/m \approx -10 dB(A/m)$$

Therefore a pure tone of 1kHz was applied into the coils such that 29 mV was observed across the 10 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 -10 dB(A/m) in the center of the Helmholtz coil which was used to validate the probe measurement at -10dB(A/m). This was verified to be within ± 0.5 dB of the -10dB(A/m) value (see Page 35).

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c. Frequency Response Validation

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

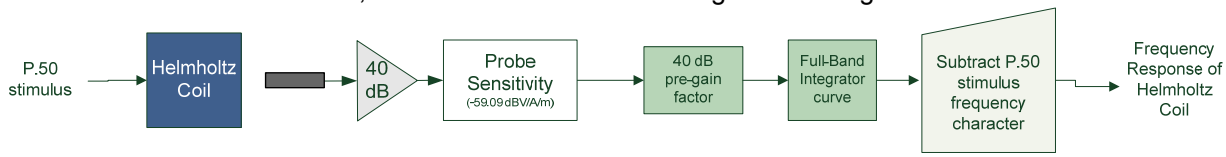

Figure 5-7 Frequency Response Validation

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

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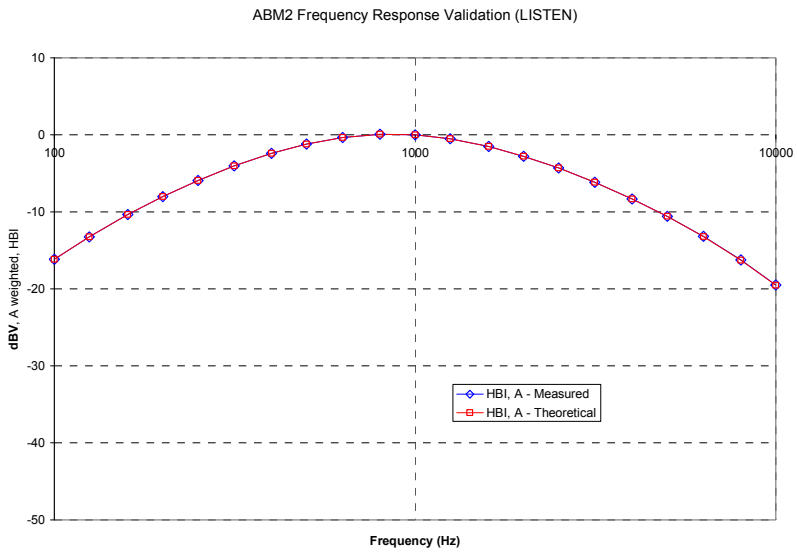

Figure 5-8
ABM2 Frequency Response Validation

The ABM2 result is a power sum from 100Hz to 10kHz 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:

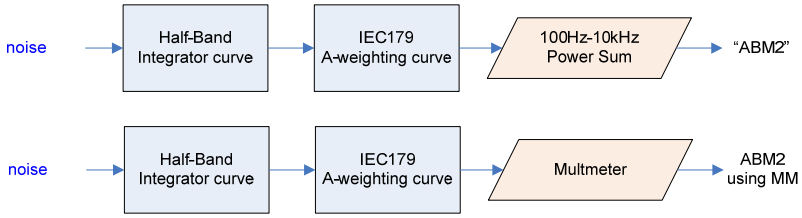

Figure 5-9
ABM2 Validation Block Diagram

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

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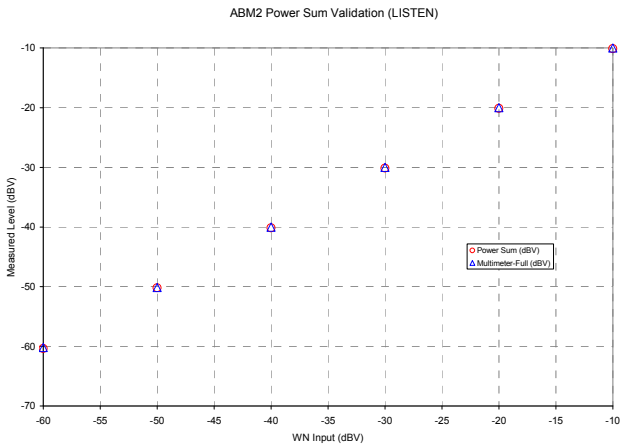

Figure 5-10
ABM2 Power Sum Validation

3. Measurement Test Setup
   a. Fine scan above the WD (TEM)
      i. A multitone 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:

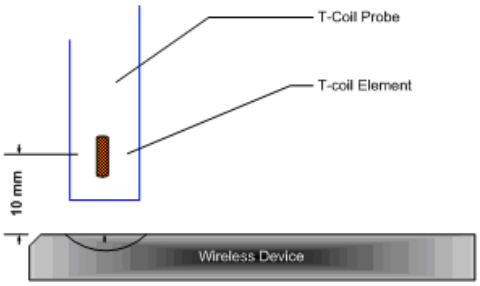

Figure 5-11
Measurement Distance

.

      ii. 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.
      iii. These steps were repeated for all T-coil orientations (axial and radial) per Figure 5-16 after a T-coil orientation was fully measured with the SoundCheck system.

   b. Speech Signal Setup to Base Station Simulator
      i. According to the C63 Committee, a speech input level of -16dBm0 shall be used for LTE T-Coil testing.
      ii. See Section 6 for more information regarding CMW500 audio level settings for Voice Over LTE (VoLTE) testing.
   c. Real-Time Analyzer (RTA)
      i. The Real-Time Analyzer was configured to analyze measurements using 1/3 Octave band weighted filtering.

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d. WD Radio Configuration Selection
    i. LTE configuration information can be found in Section 6

4. Signal Quality Data Analysis
    a. Narrow-band Magnetic Intensity
        i. The standard specifies a 1kHz 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 4-2between 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 1kHz value and aligned with respect to the EIA-504 mask.

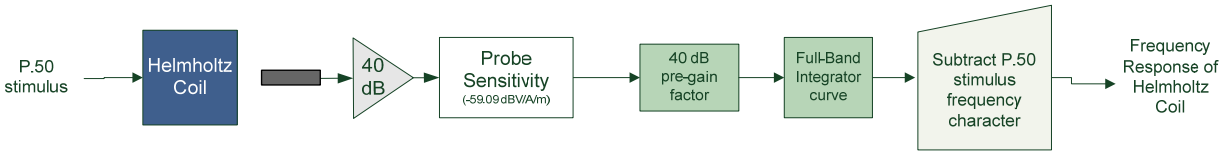

Figure 5-12 Frequency Response Block Diagram

        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.

V. Deviation from C63.19 Test Procedure

Non-conducted RF connection to account for effects of the wireless charging cover versus the standard battery cover.

VI. Air Interface Technologies Tested

This report covers only T-Coil testing for LTE. Other air interfaces supported by the device are not included in the test scope for this report.

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VII. Wireless Device Channels and Frequencies

Please see Tables 7-6 through 7-16 for LTE bandwidths and channels.

VIII. RF Emission Effect on T-coil Measurements

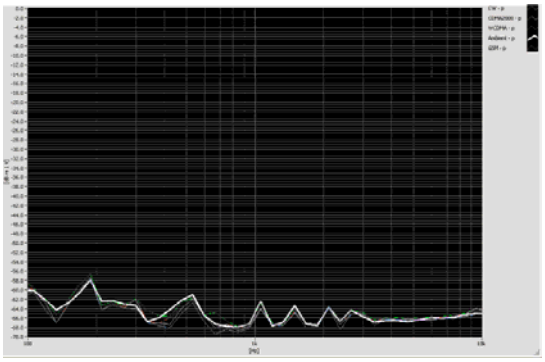

Figure 5-13
High power RF Emissions Effect with HAC Dipole on the T-coil Probe System 10mm between dipole maximum and magnetic probe

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IX. Test Flow

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

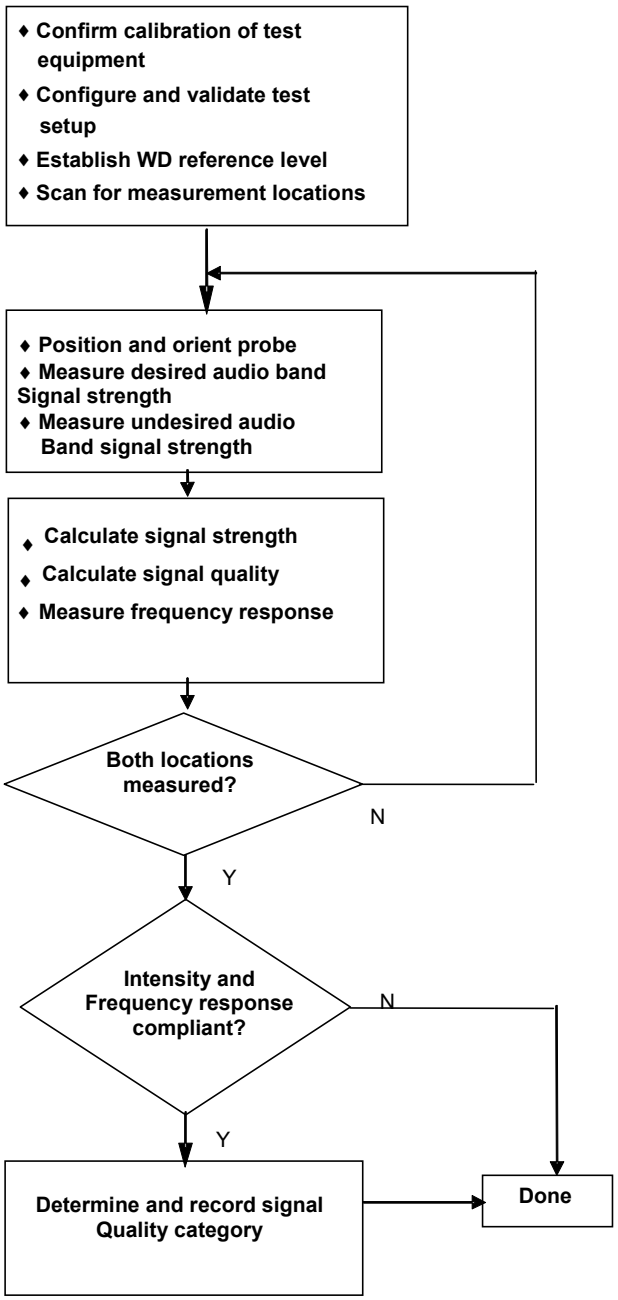

Figure 5-14
C63.19 T-Coil Signal Test Process

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6. VOLTE TEST SYSTEM SETUP AND DUT CONFIGURATION

I. Test System Setup for VoLTE T-coil Testing

1. Equipment Setup

The general test setup used for VoLTE is shown below (adopted from FCC KDB 285076 D02). The callbox used when performing VoLTE T-coil measurements is a CMW500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server.

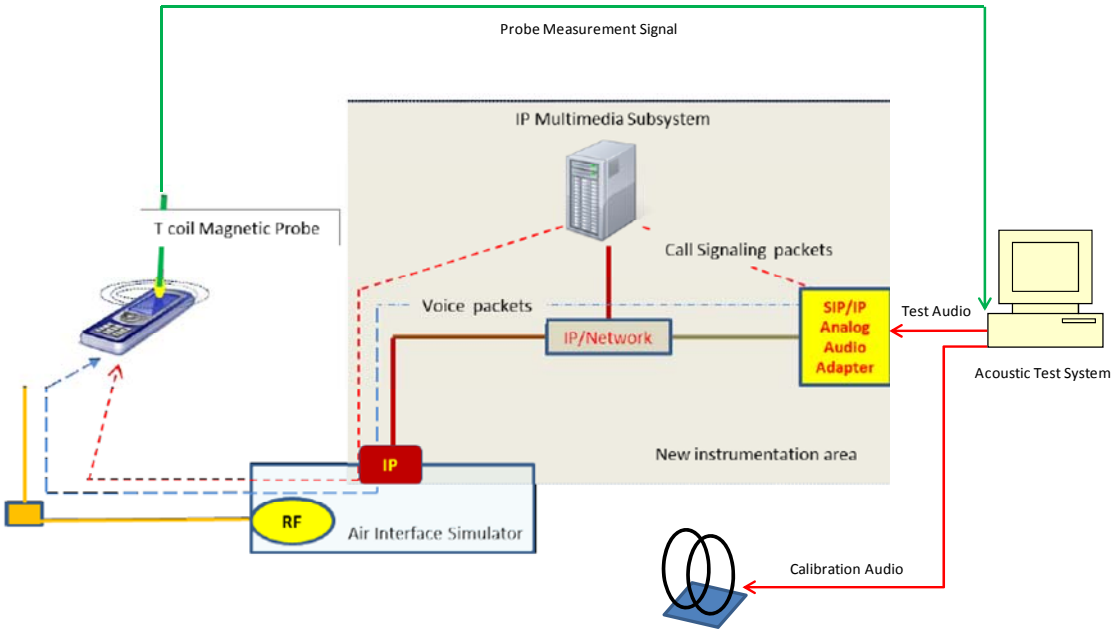

Figure 6-1
Test Setup for VoLTE T-Coil Measurements

2. Audio Level Settings

According to the July 2012 interpretations by the C63 Committee regarding the appropriate audio levels to be used for LTE T-coil testing, -16dBm0 shall be used for the normal speech input level*. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -16dBm0 speech input level to the DUT for the VoLTE connection.

* http://c63.org/documents/misc/posting/new_interpretations.htm

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II. DUT Configuration for VoLTE T-coil Testing

1. Radio Configuration

An investigation was performed on the highest bandwidth of the worst-case LTE Band to determine the modulation and RB configuration to be used for testing. 16QAM, 1RB, 0RB offset was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different radio configurations:

Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	ABM1	ABM2	SNNR
1880.0	18900	20	QPSK	1	0	-10.76	-50.50	39.74
1880.0	18900	20	QPSK	1	50	-10.46	-50.60	40.14
1880.0	18900	20	QPSK	1	99	-10.82	-51.00	40.18
1880.0	18900	20	QPSK	50	0	-10.69	-51.65	40.96
1880.0	18900	20	QPSK	50	25	-10.53	-51.13	40.60
1880.0	18900	20	QPSK	50	50	-10.64	-50.90	40.26
1880.0	18900	20	QPSK	100	0	-10.16	-51.48	41.32
1880.0	18900	20	16QAM	1	0	-10.46	-49.75	**39.29**
1880.0	18900	20	16QAM	1	50	-10.77	-50.29	39.52
1880.0	18900	20	16QAM	1	99	-10.66	-50.75	40.09
1880.0	18900	20	16QAM	50	0	-10.26	-51.24	40.98
1880.0	18900	20	16QAM	50	25	-11.00	-51.27	40.27
1880.0	18900	20	16QAM	50	50	-10.30	-51.03	40.73
1880.0	18900	20	16QAM	100	0	-10.77	-51.32	40.55

Table 6-1
LTE SNNR by Radio Configuration

2. Codec Configuration

An investigation was performed on the highest bandwidth of the worst-case LTE Band to determine the audio codec configuration to be used for testing. The NB AMR 4.75kbps setting was used for the audio codec on the CMW500 for VoLTE T-coil testing. See below table for ABM1 and ABM2 comparisons between different codecs and codec data rates:

ABM1 Pre-Test (dBA/m)

WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Channel
-7.89	-9.01	-9.35	-11.52	Radial	18900 (20MHz)

ABM2 Pre-Test (dBA/m), A, HBI

WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Channel
-50.22	-50.33	-51.17	-50.15	Radial	18900 (20MHz)

Table 6-2
VoLTE Codec Comparison for A3LSMN910A

- Mute on; Backlight on; Max Volume, Max Contrast
- TPC = “Max Power”

Figure 6-2
Audio Band Magnetic Curve Measurement Block Diagram

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7. TEST SUMMARY

I. T-Coil Test Summary

Table 7-1
Table of Results for LTE Band 17

C63.19 Sec.	Mode	Band/ BW	Test Description	Minimum Limit*	Measured	Verdict
				dBA/m	*dBA/m*	*PASS/FAIL*
8.3.1	LTE	Band 17/ 5MHz BW	Intensity, Axial	-18	-1.6	PASS
8.3.1			Intensity, Radial	-18	-8.6	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.6	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	43.3	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 17/ 10MHz BW	Intensity, Axial	-18	-1.5	PASS
8.3.1			Intensity, Radial	-18	-8.7	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.1	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.6	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS

Table 7-2
Table of Results for LTE Band 12

C63.19 Sec.	Mode	Band/ BW	Test Description	Minimum Limit*	Measured	Verdict
				dBA/m	*dBA/m*	*PASS/FAIL*
8.3.1	LTE	Band 12/ 1.4MHz BW	Intensity, Axial	-18	-1.6	PASS
8.3.1			Intensity, Radial	-18	-8.8	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.4	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.0	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 12/ 3MHz BW	Intensity, Axial	-18	-2.7	PASS
8.3.1			Intensity, Radial	-18	-8.9	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.3	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.5	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 12/ 5MHz BW	Intensity, Axial	-18	-2.6	PASS
8.3.1			Intensity, Radial	-18	-8.8	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	41.3	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.0	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 12/ 10MHz BW	Intensity, Axial	-18	-1.9	PASS
8.3.1			Intensity, Radial	-18	-8.4	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.8	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.4	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS

Note: The above summary tables represent the worst-case numerical values according to configurations in Tables 7-6 through 7-16.

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Table 7-3
Table of Results for LTE Band 5

C63.19 Sec.	Mode	Band/ BW	Test Description	Minimum Limit*	Measured	Verdict
				dBA/m	*dBA/m*	*PASS/FAIL*
8.3.1	LTE	Band 5/ 1.4MHz BW	Intensity, Axial	-18	-1.9	PASS
8.3.1			Intensity, Radial	-18	-8.9	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	40.7	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	40.9	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 5/ 3MHz BW	Intensity, Axial	-18	-2.9	PASS
8.3.1			Intensity, Radial	-18	-9.0	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.0	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.8	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 5/ 5MHz BW	Intensity, Axial	-18	-3.0	PASS
8.3.1			Intensity, Radial	-18	-8.8	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.2	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.9	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 5/ 10MHz BW	Intensity, Axial	-18	-3.6	PASS
8.3.1			Intensity, Radial	-18	-8.5	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.9	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.0	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS

Note: The above summary tables represent the worst-case numerical values according to configurations in Tables 7-6 through 7-16.

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Table 7-4
Table of Results for LTE Band 4

C63.19 Sec.	Mode	Band/ BW	Test Description	Minimum Limit*	Measured	Verdict
				dBA/m	*dBA/m*	*PASS/FAIL*
8.3.1	LTE	Band 4/ 1.4MHz BW	Intensity, Axial	-18	-2.1	PASS
8.3.1			Intensity, Radial	-18	-9.6	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	41.7	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	42.1	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 4/ 3MHz BW	Intensity, Axial	-18	-2.1	PASS
8.3.1			Intensity, Radial	-18	-9.6	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	41.7	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.2	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 4/ 5MHz BW	Intensity, Axial	-18	-2.7	PASS
8.3.1			Intensity, Radial	-18	-9.6	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.5	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.5	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 4/ 10MHz BW	Intensity, Axial	-18	-1.7	PASS
8.3.1			Intensity, Radial	-18	-9.6	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.2	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.5	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 4/ 15MHz BW	Intensity, Axial	-18	-2.0	PASS
8.3.1			Intensity, Radial	-18	-9.8	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.0	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.1	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 4/ 20MHz BW	Intensity, Axial	-18	-1.5	PASS
8.3.1			Intensity, Radial	-18	-8.7	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.6	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	41.1	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS

Note: The above summary tables represent the worst-case numerical values according to configurations in Tables 7-6 through 7-16.

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Table 7-5
Table of Results for LTE Band 2

C63.19 Sec.	Mode	Band/ BW	Test Description	Minimum Limit*	Measured	Verdict
				dBA/m	*dBA/m*	*PASS/FAIL*
8.3.1	LTE	Band 2/ 1.4MHz BW	Intensity, Axial	-18	-1.5	PASS
8.3.1			Intensity, Radial	-18	-11.9	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.2	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	39.3	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 2/ 3MHz BW	Intensity, Axial	-18	-1.5	PASS
8.3.1			Intensity, Radial	-18	-11.7	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.7	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	38.4	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS
8.3.1	LTE	Band 2/ 5MHz BW	Intensity, Axial	-18	-1.5	PASS
8.3.1			Intensity, Radial	-18	-10.8	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	44.3	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	39.1	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 2/ 10MHz BW	Intensity, Axial	-18	-1.6	PASS
8.3.1			Intensity, Radial	-18	-10.8	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.8	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	39.3	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 2/ 15MHz BW	Intensity, Axial	-18	-2.2	PASS
8.3.1			Intensity, Radial	-18	-10.7	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	43.5	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	39.4	PASS
8.3.2			Frequency Response, Axial	0	1.2	PASS
8.3.1	LTE	Band 2/ 20MHz BW	Intensity, Axial	-18	-1.3	PASS
8.3.1			Intensity, Radial	-18	-10.7	PASS
8.3.4			Signal-to-Noise/Noise, Axial	20	42.3	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	39.7	PASS
8.3.2			Frequency Response, Axial	0	1.3	PASS

Note: The above summary tables represent the worst-case numerical values according to configurations in Tables 7-6 through 7-16.

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II. Raw Handset Data

Table 7-6
Raw Data Results for LTE Band 17

	Volume	5MHz BW	
		Axial	Radial
		23790	23790
ABM1, dBA/m	Maximum	-1.59	-8.59
ABM2, dBA/m		-45.18	-51.87
Ambient Noise, dBA/m		-62.30	-62.21
Freq. Response Margin (dB)		1.33	N/A
S+N/N (dB)		43.59	43.28
S+N/N per orientation (dB)		43.59	43.28
C63.19-2011 Rating per orientation		**T4**	**T4**
	Volume	10MHz BW	
		Axial	Radial
		23790	23790
ABM1, dBA/m	Maximum	-1.50	-8.74
ABM2, dBA/m		-44.64	-51.33
Ambient Noise, dBA/m		-62.30	-62.21
Freq. Response Margin (dB)		1.30	N/A
S+N/N (dB)		43.14	42.59
S+N/N per orientation (dB)		43.14	42.59
C63.19-2011 Rating per orientation		**T4**	**T4**
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6	2.6, 3.5

Notes:

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice
7. Since LTE Band 17 at 10MHz and 5MHz bandwidth does not support 3 non-overlapping channels, only the middle channel was selected for testing.

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Table 7-7
Raw Data Results for LTE Band 12 (1.4MHz and 3MHz BW's)

	Volume	1.4MHz BW					
		Axial			Radial		
		23017	23095	23173	23017	23095	23173
ABM1, dBA/m	Maximum	1.79	-1.52	-1.62	-8.71	-8.84	-8.51
ABM2, dBA/m		-41.14	-45.58	-44.03	-50.74	-51.87	-50.91
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.30	1.27	1.35	N/A	N/A	N/A
S+N/N (dB)		42.93	44.06	42.41	42.03	43.03	42.40
S+N/N per orientation (dB)		42.41			42.03		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	3MHz BW					
		Axial			Radial		
		23025	23095	23165	23025	23095	23165
ABM1, dBA/m	Maximum	-2.71	-2.12	-2.29	-8.78	-8.89	-8.51
ABM2, dBA/m		-46.38	-45.42	-46.64	-51.26	-51.91	-51.04
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.40	1.24	1.30	N/A	N/A	N/A
S+N/N (dB)		43.67	43.30	44.35	42.48	43.02	42.53
S+N/N per orientation (dB)		43.30			42.48		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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Table 7-8
Raw Data Results for LTE Band 12 (5MHz and 10MHz BW's)

	Volume	5MHz BW					
		Axial			Radial		
		23035	23095	23155	23035	23095	23155
ABM1, dBA/m	Maximum	-2.33	-1.58	-2.58	-8.81	-8.78	-8.52
ABM2, dBA/m		-47.08	-42.92	-47.84	-51.05	-50.79	-51.27
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.24	1.47	1.29	N/A	N/A	N/A
S+N/N (dB)		44.75	41.34	45.26	42.24	42.01	42.75
S+N/N per orientation (dB)		41.34			42.01		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	10MHz BW					
		Axial			Radial		
		23095			23095		
ABM1, dBA/m	Maximum	-1.88			-8.38		
ABM2, dBA/m		-44.70			-50.75		
Ambient Noise, dBA/m		-62.30			-62.21		
Freq. Response Margin (dB)		1.31			N/A		
S+N/N (dB)		42.82			42.37		
S+N/N per orientation (dB)		42.82			42.37		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice
7. Since LTE Band 12 at 10MHz bandwidth does not support 3 non-overlapping channels, only the middle channel was selected for testing.

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Table 7-9
Raw Data Results for LTE Band 5 (1.4MHz and 3MHz BW's)

	Volume	1.4MHz BW					
		Axial			Radial		
		20407	20525	20643	20407	20525	20643
ABM1, dBA/m	Maximum	-1.89	-1.71	-1.80	-8.85	-8.59	-8.76
ABM2, dBA/m		-45.30	-46.10	-42.50	-50.91	-50.97	-49.70
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.28	1.26	1.48	N/A	N/A	N/A
S+N/N (dB)		43.41	44.39	40.70	42.06	42.38	40.94
S+N/N per orientation (dB)		40.70			40.94		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	3MHz BW					
		Axial			Radial		
		20415	20525	20635	20415	20525	20635
ABM1, dBA/m	Maximum	-2.94	-1.73	-2.27	-8.83	-8.59	-8.95
ABM2, dBA/m		-45.93	-44.93	-45.42	-50.65	-51.02	-50.92
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.38	1.28	1.33	N/A	N/A	N/A
S+N/N (dB)		42.99	43.20	43.15	41.82	42.43	41.97
S+N/N per orientation (dB)		42.99			41.82		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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Table 7-10
Raw Data Results for LTE Band 5 (5MHz and 10MHz BW's)

	Volume	5MHz BW					
		Axial			Radial		
		20425	20525	20625	20425	20525	20625
ABM1, dBA/m	Maximum	-2.36	-3.02	-2.83	-8.8	-8.54	-8.8
ABM2, dBA/m		-46.21	-45.25	-47.38	-50.69	-50.67	-51.71
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.34	1.39	1.31	N/A	N/A	N/A
S+N/N (dB)		43.85	42.23	44.55	41.89	42.13	42.91
S+N/N per orientation (dB)		42.23			41.89		
C63.19-2011 Rating per orientation		**T4**			**T4**		

	Volume	10MHz BW	
		Axial	Radial
		20525	20525
ABM1, dBA/m	Maximum	-3.56	-8.5
ABM2, dBA/m		-46.48	-50.50
Ambient Noise, dBA/m		-62.30	-62.21
Freq. Response Margin (dB)		1.33	N/A
S+N/N (dB)		42.92	42.00
S+N/N per orientation (dB)		42.92	42.00
C63.19-2011 Rating per orientation		**T4**	**T4**
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6	2.6, 3.5

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice
7. Since LTE Band 5 at 10MHz bandwidth does not support 3 non-overlapping channels, only the middle channel was selected for testing.

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Table 7-11
Raw Data Results for LTE Band 4 (1.4MHz and 3MHz BW's)

	Volume	1.4MHz BW					
		Axial			Radial		
		19957	20175	20393	19957	20175	20393
ABM1, dBA/m	Maximum	-1.91	-1.91	-2.05	-9.40	-9.59	-9.50
ABM2, dBA/m		-43.64	-45.92	-45.51	-51.54	-51.67	-51.61
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.25	1.30	1.35	N/A	N/A	N/A
S+N/N (dB)		41.73	44.01	43.46	42.14	42.08	42.11
S+N/N per orientation (dB)		41.73			42.08		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	3MHz BW					
		Axial			Radial		
		19965	20175	20385	19965	20175	20385
ABM1, dBA/m	Maximum	-1.73	-1.64	-2.11	-9.36	-9.57	-9.61
ABM2, dBA/m		-45.72	-45.70	-43.77	-51.20	-51.49	-50.82
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.35	1.18	1.22	N/A	N/A	N/A
S+N/N (dB)		43.99	44.06	41.66	41.84	41.92	41.21
S+N/N per orientation (dB)		41.66			41.21		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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Table 7-12
Raw Data Results for LTE Band 4 (5MHz and 10MHz BW's)

	Volume	5MHz BW					
		Axial			Radial		
		19975	20175	20375	19975	20175	20375
ABM1, dBA/m	Maximum	-1.72	-2.71	-1.58	-9.23	-9.59	-9.63
ABM2, dBA/m		-44.18	-45.52	-45.62	-50.74	-51.05	-51.20
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.40	1.29	1.42	N/A	N/A	N/A
S+N/N (dB)		42.46	42.81	44.04	41.51	41.46	41.57
S+N/N per orientation (dB)		42.46			41.46		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	10MHz BW					
		Axial			Radial		
		20000	20175	20350	20000	20175	20350
ABM1, dBA/m	Maximum	-1.40	-1.48	-1.71	-9.63	-9.44	-9.44
ABM2, dBA/m		-45.05	-45.11	-44.89	-51.15	-51.37	-51.13
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.26	1.30	1.18	N/A	N/A	N/A
S+N/N (dB)		43.65	43.63	43.18	41.52	41.93	41.69
S+N/N per orientation (dB)		43.18			41.52		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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Table 7-13
Raw Data Results for LTE Band 4 (15MHz and 20MHz BW's)

	Volume	15MHz BW					
		Axial			Radial		
		20025	20175	20325	20025	20175	20325
ABM1, dBA/m	Maximum	-1.98	-1.47	-1.33	-8.7	-9.78	-8.69
ABM2, dBA/m		-45.37	-44.46	-46.29	-50.22	-50.83	-50.01
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.16	1.21	1.31	N/A	N/A	N/A
S+N/N (dB)		43.39	42.99	44.96	41.52	41.05	41.32
S+N/N per orientation (dB)		42.99			41.05		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	20MHz BW					
		Axial			Radial		
		20175			20175		
ABM1, dBA/m	Maximum	-1.47			-8.69		
ABM2, dBA/m		-45.04			-49.79		
Ambient Noise, dBA/m		-62.30			-62.21		
Freq. Response Margin (dB)		1.23			N/A		
S+N/N (dB)		43.57			41.10		
S+N/N per orientation (dB)		43.57			41.10		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice
7. Since LTE Band 4 at 20MHz bandwidth does not support 3 non-overlapping channels, only the middle channel was selected for testing.

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Table 7-14
Raw Data Results for LTE Band 2 (1.4MHz and 3MHz BW's)

	Volume	1.4MHz BW						
		Axial			Radial			
		18607	18900	19193	18607	18900	19193	
ABM1, dBA/m	Maximum	-1.47	-1.51	-1.52	-11.86	-11.69	-11.41	
ABM2, dBA/m		-46.03	-43.74	-44.92	-51.22	-51.03	-51.10	
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21	
Freq. Response Margin (dB)		1.31	1.32	1.29	N/A	N/A	N/A	
S+N/N (dB)		44.56	42.23	43.40	39.36	39.34	39.69	
S+N/N per orientation (dB)		42.23			39.34			
C63.19-2011 Rating per orientation		**T4**			**T4**			
	Volume	3MHz BW						
		Axial			Radial			
		18615	18900	19185	18615	18900	19185	19185 - WCC
ABM1, dBA/m	Maximum	-1.49	-1.24	-1.50	-11.72	-11.31	-11.38	-11.13
ABM2, dBA/m		-46.08	-46.39	-45.20	-51.10	-51.65	-49.81	-50.60
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.27	1.31	1.34	N/A	N/A	N/A	N/A
S+N/N (dB)		44.59	45.15	43.70	39.38	40.34	38.43	39.47
S+N/N per orientation (dB)		43.70			38.43			
C63.19-2011 Rating per orientation		**T4**			**T4**			
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5			

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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Table 7-15
Raw Data Results for LTE Band 2 (5MHz and 10MHz BW's)

	Volume	5MHz BW					
		Axial			Radial		
		18625	18900	19175	18625	18900	19175
ABM1, dBA/m	Maximum	-1.20	-1.45	-1.20	-10.43	-10.62	-10.84
ABM2, dBA/m		-47.42	-47.41	-45.45	-50.40	-50.37	-49.91
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.22	1.31	1.33	N/A	N/A	N/A
S+N/N (dB)		46.22	45.96	44.25	39.97	39.75	39.07
S+N/N per orientation (dB)		44.25			39.07		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	10MHz BW					
		Axial			Radial		
		18650	18900	19150	18650	18900	19150
ABM1, dBA/m	Maximum	-1.42	-1.59	-1.61	-10.48	-10.78	-10.67
ABM2, dBA/m		-46.33	-46.43	-45.43	-50.24	-50.87	-50.01
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.20	1.25	1.27	N/A	N/A	N/A
S+N/N (dB)		44.91	44.84	43.82	39.76	40.09	39.34
S+N/N per orientation (dB)		43.82			39.34		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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Table 7-16
Raw Data Results for LTE Band 2 (15MHz and 20MHz BW's)

	Volume	15MHz BW					
		Axial			Radial		
		18675	18900	19125	18675	18900	19125
ABM1, dBA/m	Maximum	-2.18	-1.40	-1.10	-10.73	-10.69	-10.44
ABM2, dBA/m		-45.66	-45.41	-44.73	-50.74	-50.05	-49.96
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.22	1.21	1.24	N/A	N/A	N/A
S+N/N (dB)		43.48	44.01	43.63	40.01	39.36	39.52
S+N/N per orientation (dB)		43.48			39.36		
C63.19-2011 Rating per orientation		**T4**			**T4**		
	Volume	20MHz BW					
		Axial			Radial		
		18700	18900	19100	18700	18900	19100
ABM1, dBA/m	Maximum	-1.30	-1.32	-1.27	-10.65	-10.60	-10.66
ABM2, dBA/m		-44.93	-45.22	-43.57	-50.82	-50.28	-50.69
Ambient Noise, dBA/m		-62.30	-62.30	-62.30	-62.21	-62.21	-62.21
Freq. Response Margin (dB)		1.30	1.32	1.25	N/A	N/A	N/A
S+N/N (dB)		43.63	43.90	42.30	40.17	39.68	40.03
S+N/N per orientation (dB)		42.30			39.68		
C63.19-2011 Rating per orientation		**T4**			**T4**		
T-coil Coordinates (cm)	[x,y] from bottom left	2.6, 2.6			2.6, 3.5		

Notes:

1. Power Configuration: TPC = "Max Power"
2. Radio Configuration: 16QAM, 1RB, 0RB Offset
3. Phone Condition: Mute on; Backlight on; Max Volume, Max Contrast
4. Vocoder Configuration: NB AMR 4.75kbps (LTE)
5. 'Radial' orientation refers to radial transverse.
6. Speech Signal: ITU-T P.50 Artificial Voice

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III. Frequency Response Graph

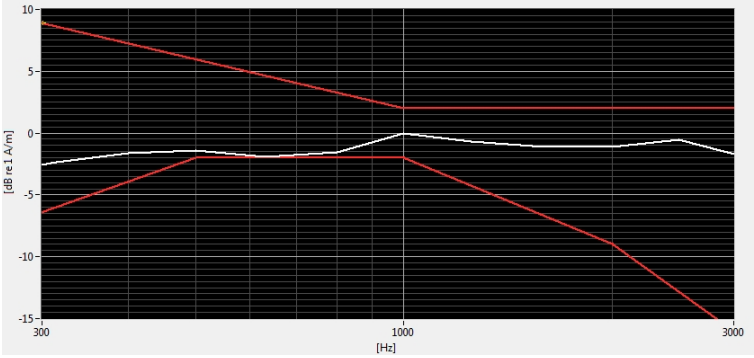
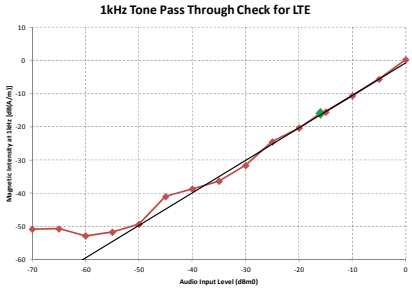


Figure 7-1
Axial Frequency Response

Note: User T-coil Mode (**Settings→Accessibility→Hearing→Hearing aids**) was set to ON for Frequency Response compliance. This frequency response represents the worst-case ABM2 test configuration according to Tables 7-6 through 7-16.

IV. 1 kHz Vocoder Application Check



This model was verified to be within the linear region for ABM1 measurements at -16 dBm0 for VoLTE. This measurement was taken in the axial configuration above the maximum location.

V. Undesirable Audio Magnetic Band Plot (ABM2)

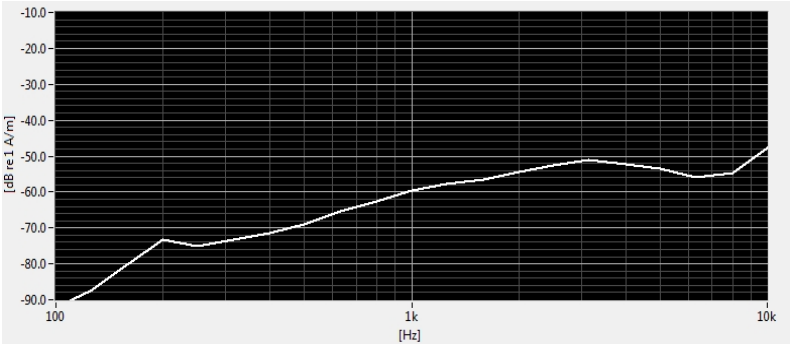


Figure 7-2
Worst-case ABM2 Plot for WD

Note: This plot represents the data from the location/configuration resulting in the highest ABM2 result shown in Tables 7-6 through 7-16 (Axial configuration, LTE Band 12, ch.23017, 1.4MHz BW).

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VI. T-Coil Validation Test Results

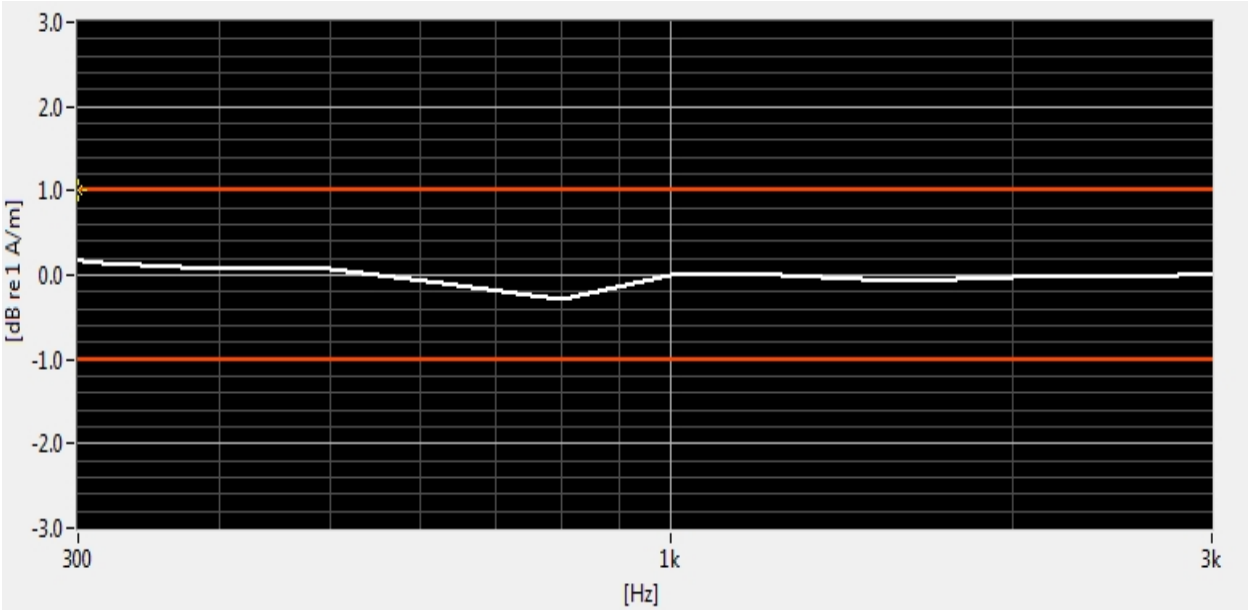

Figure 7-3
Helmholtz Coil Validation for Frequency Response

Table 7-17
Helmholtz Coil Validation Table of Results

Item	Target	Result	Verdict
Signal Validation			
Frequency Response, from limits	*> 0 dB*	0.70	**PASS**
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-9.963	**PASS**
Noise Validation			
Axial Environmental Noise	< - 58 dBA/m	-62.30	**PASS**
Radial Environmental Noise	< - 58 dBA/m	-62.21	**PASS**

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8. MEASUREMENT UNCERTAINTY

Table 8-1
Uncertainty Estimation Table

Contribution	Data +/- %	Data +/- dB	Data Type	Probability distribution	Divisor	Standard uncertainty	Standard Uncertainty (dB)
ABM Noise	7.0%	0.29	Std. Dev.	Normal k=1	1.00	7.0%	
RF Reflections	4.7%	0.20	Specification	Rectangular	1.73	2.7%	
Reference Signal Level	12.2%	0.50	Specification	Rectangular	1.73	7.0%	
Positioning Accuracy	10.0%	0.41	Uncertainty	Rectangular	1.73	5.8%	
Probe Coil Sensitivity	12.2%	0.50	Specification	Rectangular	1.73	7.0%	
Probe Linearity	2.4%	0.10	Std. Dev.	Normal k=1	1.00	2.4%	
Cable Loss	2.8%	0.12	Specification	Rectangular	1.73	1.6%	
Frequency Analyzer	5.0%	0.21	Specification	Rectangular	1.73	2.9%	
System Repeatability	5.0%	0.21	Std. Dev.	Normal k=1	1.00	5.0%	
WD Repeatability	9.0%	0.37	Std. Dev.	Normal k=1	1.00	9.0%	
Positioner Accuracy	1.0%	0.04	Specification	Rectangular	1.73	0.6%	
Combined standard uncertainty, uc (k=1)						17.7%	0.71
Expanded uncertainty (k=2), 95% confidence level						35.3%	1.31

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.

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9. EQUIPMENT LIST

Table 9-1
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	36934-158	Wall-Mounted Thermometer	4/29/2014	Biennial	4/29/2016	122014488
Listen	SoundCheck	Acoustic Analyzer System	10/11/2013	Annual	10/11/2014	04-06-5876-SC2850
Listen	SoundConnect	Microphone Power Supply	2/17/2014	Annual	2/17/2015	0899-PS150
NI	4474	Data Acquisition Card	N/A		N/A	N/A
Rohde & Schwarz	CMW500	Radio Communication Tester	10/4/2013	Biennial	10/4/2015	103962
TEM	Axial T-Coil Probe	Axial T-Coil Probe	2/17/2014	Annual	2/17/2015	TEM-1123
TEM		HAC Positioner	N/A		N/A	N/A
TEM		HAC System Controller with Software	N/A		N/A	N/A
TEM	C63.19	Helmholtz Coil	3/8/2014	Annual	3/8/2015	925
TEM	Radial T-Coil Probe	Radial T-Coil Probe	2/17/2014	Annual	2/17/2015	TEM-1129

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10. CALIBRATION CERTIFICATES

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West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

Axial T Coil Probe

Manufactured by:	TEM CONSULTING
Model No:	Axial T Coil Probe
Serial No:	TEM-1123
Calibration Recall No:	23889

Submitted By:

Customer:	JUSTIN CHAO
Company:	PCTEST ENGINEERING LAB
Address:	6660-B DOBBIN ROAD COLUMBIA MD 21045

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. Axial T Coi TEM

Upon receipt for Calibration, the instrument was found to be:

Within (X) see attached Report of Calibration.

the tolerance of the indicated specification.

West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025.

JC
4/4/14

Note: With this Certificate, Report of Calibration is included.

Approved by:

Calibration Date: 17-Feb-14

FC

Certificate No: 23889 - 1

Felix Christopher (QA Mgr.)
ISO/IEC 17025:2005

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

ACCREDITED
Calibration Lab. Cert. # 1533.01

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West Caldwell Calibration Laboratories, Inc.
uncompromised calibration

1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

TEM Consulting LP Axial T Coil Probe **Model No.: Axial T Coil Probe** **Serial No.: TEM-1123**

Company : PCTEST Engineering Lab. **I. D. No: 80582**

Calibration results: **Before data:** ..... **After data:** .....

Probe Sensitivity measured with Helmholtz Coil

Before & after data same: ...X.....

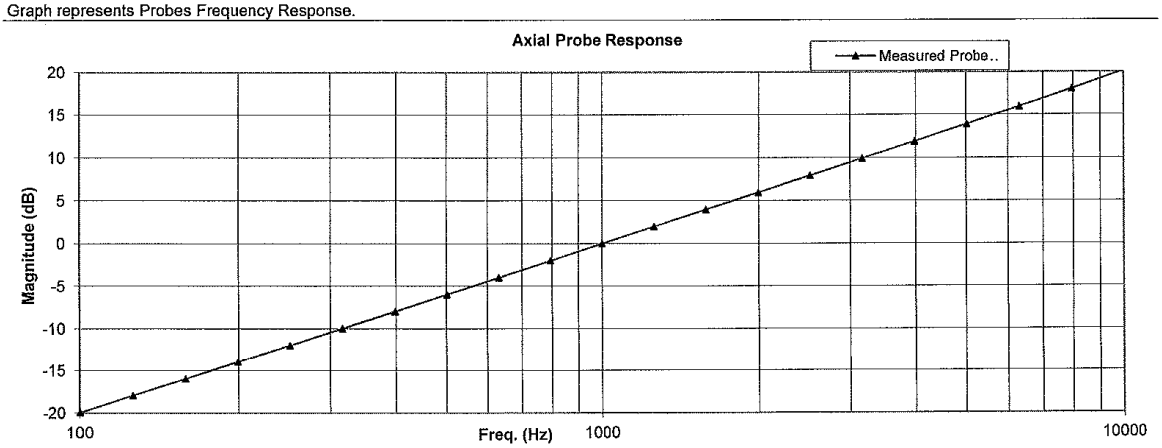
Helmholtz Coil;					
the number of turns on each coil;	10	No.			
the radius of each coil, in meters;	0.204	m	Laboratory Environment:		
the current in the coils, in amperes.;	0.09	A	Ambient Temperature:	21.2	°C
Helmholtz Coil Constant;	7.09	A/m/V	Ambient Humidity:	29.1	% RH
Helmholtz Coil magnetic field;	5.98	A/m	Ambient Pressure:	100.7	kPa
			Calibration Date:	17-Feb-14	
Probe Sensitivity at	1000	Hz.	Re-calibration Due:	17-Feb-15	
was	-60.20	dBV/A/m	Report Number:	23889	-1
	0.977	mV/A/m	Control Number:	23889	
Probe resistance	894	Ohms			

The above listed instrument meets or exceeds the tested manufacturer's specifications.

This Calibration is traceable through NIST test numbers: ,287708

The expanded uncertainty of calibration: 0.30dB at 95% confidence level with a coverage factor of k=2.

Graph represents Probes Frequency Response.



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 HCATEMC**

Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Cal. Date: 17-Feb-2014 Measurements performed by: .....

Calibrated on WCCL system type 9700 **Felix Christopher**

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HCATEMC_TEM-1123_Feb-17-2014

West Caldwell Calibration Laboratories Inc.

1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

TEM Consulting LP Axial T Coil Probe — Model No.: Axial T Coil Probe — Serial No.: TEM-1123

Company : PCTEST Engineering Lab.

Test	Function	Tolerance		Measured values Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-60.20		
			dB			
2.0	Probe Level Linearity		6	6.03		
		Ref. (0 dB)	0	0.00		
			-6	-6.02		
			-12	-12.05		
			Hz			
3.0	Probe Frequency Response		100	-19.9		
			126	-17.9		
			158	-16.0		
			200	-13.9		
			251	-12.0		
			316	-10.0		
			398	-8.0		
			501	-6.0		
			631	-4.0		
			794	-2.0		
		Ref. (0 dB)	1000	0.0		
			1259	2.0		
			1585	4.0		
			1995	6.0		
			2512	7.9		
			3162	9.9		
			3981	11.9		
			5012	13.9		
			6310	15.9		
			7943	18.0		
			10000	20.2		

Instruments used for calibration:			Date of Cal.	Traceablity No.	Due Date
HP	34401A	S/N 36064102	8-Oct-2013	,287708	8-Oct-2014
HP	34401A	S/N 36102471	8-Oct-2013	,287708	8-Oct-2014
HP	33120A	S/N 36043716	8-Oct-2013	,287708	8-Oct-2014
Brüel & Kjær	2133	S/N 1583254	6-Jan-2014	683/284413-14	7-Jan-2015

Cal. Date: 17-Feb-2014 — Tested by: Felix Christopher

Calibrated on WCCL system type 9700

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West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

Radial T Coil Probe

Manufactured by:	TEM CONSULTING
Model No:	Radial T Coil Probe
Serial No:	TEM-1129
Calibration Recall No:	23889

Submitted By:

Customer:	JUSTIN CHAO
Company:	PCTEST ENGINEERING LAB
Address:	6660-B DOBBIN ROAD COLUMBIA MD 21045

The subject instrument was calibrated to the indicated specification using standards traceable to the National Institute of Standards and Technology or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the submitter.

West Caldwell Calibration Laboratories Procedure No. Radial T C TEM

Upon receipt for Calibration, the instrument was found to be:

Within (X) see attached Report of Calibration.

the tolerance of the indicated specification.

West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2008 and ISO 17025.

JSC
4/4/14

Note: With this Certificate, Report of Calibration is included.

Approved by:

Calibration Date: 17-Feb-14

FC

Certificate No: 23889 - 2

Felix Christopher (QA Mgr.)
ISO/IEC 17025:2005

QA Doc. #1051 Rev. 2.0 10/1/01

Certificate Page 1 of 1

West Caldwell Calibration Laboratories, Inc.
uncompromised calibration
1575 State Route 96, Victor, NY 14564, U.S.A.

ACCREDITED
Calibration Lab. Cert. # 1533.01

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West Caldwell Calibration Laboratories, Inc.
uncompromised calibration

1575 State Route 96, Victor NY 14564

ISO/IEC 17025: 2005
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

TEM Consulting LP Radial T Coil Probe **Model No.: Radial T Coil Probe** **Serial No.: TEM-1129**

Company : PCTEST Engineering Lab. **I. D. No: 80583**

Calibration results: **Before data:** ..... **After data:** .....

Probe Sensitivity measured with Helmholtz Coil

Before & after data same: ...X.....

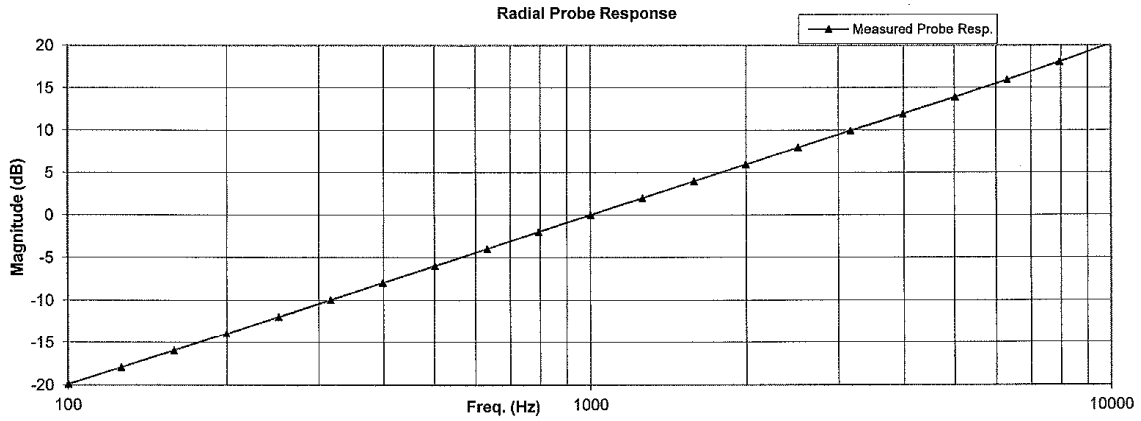
Helmholtz Coil;					
the number of turns on each coil;	10	No.			
the radius of each coil, in meters;	0.204	m	Laboratory Environment:		
the current in the coils, in amperes.;	0.09	A	Ambient Temperature:	21.2	°C
Helmholtz Coil Constant;	7.09	A/m/V	Ambient Humidity:	29.1	% RH
Helmholtz Coil magnetic field;	5.98	A/m	Ambient Pressure:	100.7	kPa
			Calibration Date:	17-Feb-14	
Probe Sensitivity at	1000	Hz.	Re-calibration Due:	17-Feb-15	
was	-60.38	dBV/A/m	Report Number:	23889	-2
	0.957	mV/A/m	Control Number:	23889	
Probe resistance	900	Ohms			

The above listed instrument meets or exceeds the tested manufacturer's specifications.

This Calibration is traceable through NIST test numbers: ,287708

The expanded uncertainty of calibration: 0.30dB at 95% confidence level with a coverage factor of k=2.

Graph represents Probes Frequency Response.



The above listed instrument was checked using calibration procedure documented in West Caldwell Calibration Laboratories Inc. procedure : **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 HCRTEMC**

Calibration was performed by West Caldwell Calibration Laboratories Inc. under Operating Procedures intended to implement the requirements of ISO10012-1, IEC Guide 25, ANSI/NCSL Z540-1, (MIL-STD-45662A) and ISO 9001:2008, ISO 17025

Cal. Date: 17-Feb-2014 Measurements performed by: .....

Calibrated on WCCL system type 9700 **Felix Christopher**

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West Caldwell Calibration Laboratories Inc.
1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

TEM Consulting LP Radial T Coil Probe **Model No.: Radial T Coil Probe** **Serial No.: TEM-1129**

Company : PCTEST Engineering Lab.

Test	Function	Tolerance		Measured values Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-60.38		
			dB			
2.0	Probe Level Linearity		6	6.04		
		Ref. (0 dB)	0	0.00		
			-6	-6.03		
			-12	-12.05		
			Hz			
3.0	Probe Frequency Response		100	-19.9		
			126	-17.9		
			158	-15.9		
			200	-13.9		
			251	-12.0		
			316	-10.0		
			398	-8.0		
			501	-6.0		
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			794	-2.0		
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			1259	2.0		
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Instruments used for calibration:			Date of Cal.	Traceability No.	Due Date
HP	34401A	S/N 36064102	8-Oct-2013	,287708	8-Oct-2014
HP	34401A	S/N 36102471	8-Oct-2013	,287708	8-Oct-2014
HP	33120A	S/N 36043716	8-Oct-2013	,287708	8-Oct-2014
Brüel & Kjær	2133	S/N 1583254	6-Jan-2014	683/284413-14	7-Jan-2015

Cal. Date: 17-Feb-2014 Tested by: Felix Christopher

Calibrated on WCCL system type 9700

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11. CONCLUSION

The measurements indicate that the LTE air interface of this 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(s) 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.

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