

## PCTEST ENGINEERING LABORATORY, INC.

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## **HEARING AID COMPATIBILITY**

**Applicant Name:** 

LG Electronics MobileComm U.S.A. Inc. 1000 Sylvan Avenue Englewood Cliffs, NJ 07632 United States Date of Testing:

9/6/2017

**Test Site/Location:** 

PCTEST Lab, Columbia, MD, USA

Test Report Serial No.: 1M1709050245-11.ZNF

FCC ID: ZNFX210MA

APPLICANT: LG ELECTRONICS MOBILECOMM U.S.A. INC.

Scope of Test: Audio Band Magnetic Testing (T-Coil)

Application Type: Certification
FCC Rule Part(s): CFR §20.19(b)
HAC Standard: ANSI C63.19-2011

285076 D01 HAC Guidance v04

285076 D02 T-Coil testing for CMRS IP v02

**DUT Type:** Portable Handset **Model:** LM-X210MA

Additional Model(s): LMX210MA,, X210MA, LM-X210TA, LMX210TA, X210TA, LM-X210TAT,

LMX210TAT, X210TAT

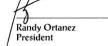
**Test Device Serial No.:** Pre-Production Sample [S/N: 70548]

C63.19-2011 HAC

Category: T3 (SIGNAL TO NOISE CATEGORY)

This wireless portable device has been shown to be hearing-aid compatible 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.







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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-86581 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

<sup>&</sup>lt;sup>1</sup> FCC Rule & Order, WT Docket 01-309 RM-8658

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#### **DUT DESCRIPTION** 2.



FCC ID: ZNFX210MA

LG Electronics MobileComm U.S.A. Inc. Applicant:

1000 Sylvan Avenue

Englewood Cliffs, NJ 07632

**United States** 

Model: LM-X210MA

LMX210MA,, X210MA, LM-X210TA, LMX210TA, X210TA, LM-Additional Model(s):

X210TAT, LMX210TAT, X210TAT

Serial Number: 70548 HW Version: Rev.B

SW Version: X210MA07v Antenna: Internal Antenna

GSM 850, 128, 190, 251, BT Off, WLAN Off, LTE Off **HAC Test Configurations:** 

> GSM 1900, 512, 661, 810, BT Off, WLAN Off, LTE Off UMTS V, 4132, 4183, 4233, BT Off, WLAN Off, LTE Off UMTS IV, 1312, 1412, 1513, BT Off, WLAN Off, LTE Off

UMTS II, 9262, 9400, 9538, BT Off, WLAN Off, LTE Off

DUT Type: Portable Handset

Table 2-1: ZNFX210MA HAC Air Interfaces

Air-Interface	Band (MHz)	Type Transport	HAC Tested	Simultaneous But Not Tested	Voice over Digital Transport OTT Capability	Additional GSM Power Reduction
	850	VO	Yes	Yes: WIFI or BT	N/A	No
GSM	1900	V	res	res. WIFI OF BT	N/A	NO
	GPRS/EDGE	DT	No	Yes: WIFI or BT	Yes	No
	850					
UMTS	1700	VD	Yes	Yes: WIFI or BT	N/A	N/A
UNITS	1900					
	HSPA	DT	No	Yes: WIFI or BT	Yes	N/A
	700 (B12)					
	850 (B5)					
LTE (FDD)	1700 (B66)	VD	No <sup>1</sup>	Yes: WIFI or BT	Yes	N/A
	1700 (B4)					
1900 (	1900 (B2)					
	2450					
	5200			Yes: GSM, UMTS, or LTE	Yes	N/A
WIFI	5300	VD	No <sup>1</sup>			
	5500					
	5800					
BT	2450	DT	No	Yes: GSM, UMTS, or LTE	N/A	N/A

Type Transport Notes:

1. Not tested in accordance with the guidance issued by OET in KDB publication 285076 D02 T-DT = Digital Data - Not intended for CMRS Service | Coil testing for CMRS IP.

VD = CMRS and Data Transport

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## 3. 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  $\geq$  -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.

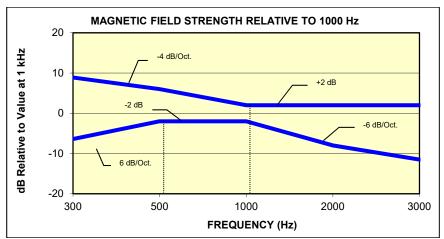


Figure 3-1
Magnetic field frequency response for Wireless Devices with an axial field ≤-15 dB(A/m) at 1 kHz

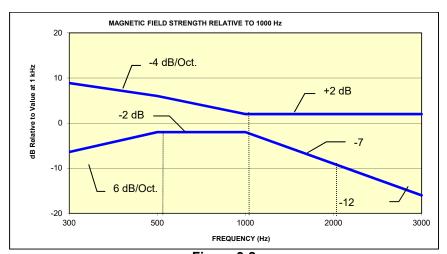


Figure 3-2
Magnetic Field frequency response for wireless devices with an axial field that exceeds
-15 dB(A/m) at 1 kHz

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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			
Category	Wireless Device Signal Quality [(Signal + Noise)-to-noise ratio in dB]			
T1	0 to 10 dB			
T2	10 to 20 dB			
Т3	20 to 30 dB			
T4	> 30 dB			
Table 3-1 Magnetic Coupling Parameters				

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# 4. METHOD OF MEASUREMENT

## I. Test Setup

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

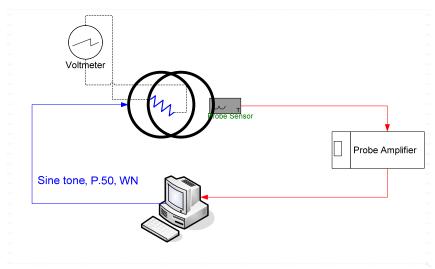
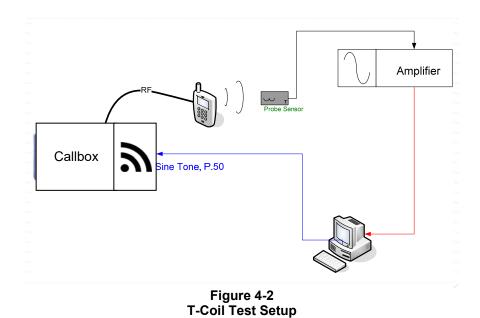


Figure 4-1
Validation Setup with Helmholtz Coil



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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 115 VAC Line Voltage: 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" 36" x 49" x 55" Operating Area:

< -20 dB (in anechoic chamber) Reflections:

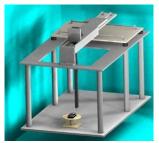


Figure 4-3 RF Near-Field Scanner

#### III. ITU-T P.50 Artificial Voice

Manufacturer: ITU-T

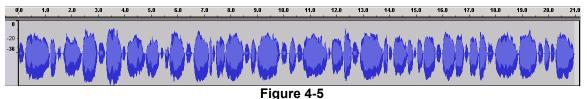
Active Frequency 100 Hz - 8 kHz Range:

Stimulus Type: Male and Female, no spaces

Single Sample 20.96 seconds Duration:

Activity Level: 100%

Figure 4-4 Spectral Characteristic of full P.50



Temporal Characteristic of full P.50

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ABM2 Measurement Block Diagram:



Figure 4-6 Magnetic Measurement Processing Steps

## IV. Test Procedure

- 1. Ambient Noise Check per C63.19 §7.3.1
  - 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 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:

- 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.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=0.08m; R=10.2Ω and using V=18mV:

$$H_c = \frac{20 \cdot (\frac{0.018}{10.2})}{0.08 \cdot \sqrt{1.25^3}} = 0.316A/m \approx -10dB(A/m)$$

Therefore a pure tone of 1kHz was applied into the coils such that 18mV was observed across the 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

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measurement at -10dB(A/m). This was verified to be within  $\pm$  0.5 dB of the -10dB(A/m) value (see Page 21).

## 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:

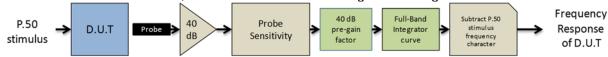


Figure 4-7 Frequency Response Validation

### 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 4-1
ABM2 Frequency Response Validation

	HBI, A -	HBI, A -	
f (Hz)	Measured	Theoretical	dB Var.
	(dB re 1kHz)	(dB re 1kHz)	
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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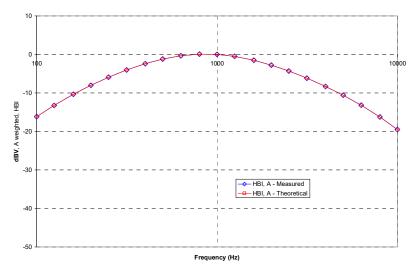
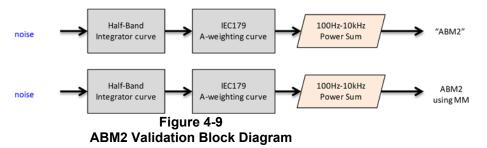


Figure 4-8
ABM2 Frequency Response Validation

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 4-9). Therefore the setup in this step was used to verify the power sum post-processing for ABM2 measurements. See below 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.

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Table 4-2
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

ABM2 Power Sum Validation (LISTEN)

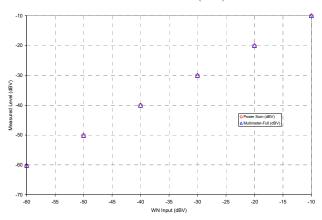


Figure 4-10
ABM2 Power Sum Validation

### 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 (note that in Figure 4-12, the grid is not to scale but merely a graphical representation of the coordinate system in use):

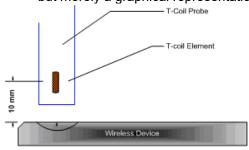


Figure 4-11 Measurement Distance

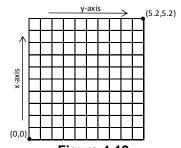


Figure 4-12 Measurement Grid

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- 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 SoundCheck system.
- iii. These steps were repeated for all T-coil orientations (axial and radial) per Figure 4-16 after a T-coil orientation was fully measured with the SoundCheck system.
- b. Speech Signal Setup to Base Station Simulator
  - i. C63.19 Table 7-1 states audio reference input levels for various technologies:

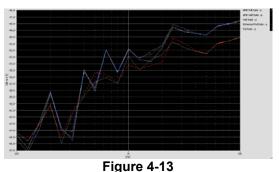
Standard	Technology	Input Level (dBm0)
TIA/EIA/IS-2000	CDMA	-18
J-STD-007	GSM (217)	-16
T1/T1P1/3GPP	UMTS (WCDMA)	-16
iDEN <sup>TM</sup>	TDMA (22 and 11 Hz)	-18

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 4-3
CMU200 Voltage Input Levels for Audio

Olio 200 Voltage Inpat Ecvels for Addic					
dBm0 Ref.	Voltage		Notes		
3.14 dBm0	990.5 mV	-0.08 dBV	From GSM "DECODER CAL". (What is needed through Encoder for FS)		
-16 dBm0	109.4 mV	-19.2 dBV	For Speechcod/Handset Low		
dBm0 Ref.	Volt	age	Notes		
dBm0 Ref. 3.14 dBm0	Volt		Notes From UMTS "DECODER CAL". (What is needed through Encoder for FS)		

- c. Real-Time Analyzer (RTA)
  - The Real-Time Analyzer was configured to analyze measurements using 1/3 Octave band weighted filtering.
- d. WD Radio Configuration Selection
  - i. The device was chosen to be tested in the worst-case ABM2 condition (see below for GSM, see Section 5 for more information regarding worst-case configurations for UMTS.):



Vocoder Analysis for ABM Noise for GSM

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#### 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 3-1 or Figure 3-2 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 4-7. All R10 frequencies were plotted with respect to 0dB at 1kHz value and aligned with respect to the EIA-504 mask.
- 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 off, 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.
- This result was subtracted from the ABM1 result in step a, to obtain the Signal Quality.

### V. Test Setup

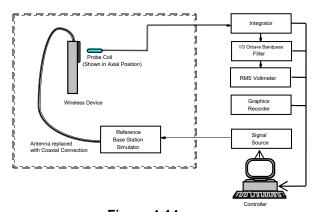


Figure 4-14
Audio Magnetic Field Test Setup

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### VI. Deviation from C63.19 Test Procedure

Non-conducted RF connection due to shielding effects of battery cover.

## VII. Air Interface Technologies Tested

All air interfaces which support voice capabilities over a managed CMRS were tested for T-coil unless otherwise noted. See Table 2-1 for more details regarding which modes were tested.

According to the April 2013 TCB workshop slides, OTT data services are outside the current definition of a managed CMRS service and are currently not required to be evaluated.

VoLTE and VoIP over WIFI CMRS air interfaces were not tested in accordance with the guidance issued by OET in KDB publication 285076 D02 T-Coil testing for CMRS IP.

## VIII. 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.

Table 4-4
Center Channels and Frequencies

Test frequencies & associated channels					
Channel	Frequency (MHz)				
Cellular 850					
190 (GSM)	836.60				
4183 (UMTS)	836.60				
AWS 1750					
1412 (UMTS)	1730.40				
PCS 1900	PCS 1900				
661 (GSM)	1880				
9400 (UMTS)	1880				

## IX. RF Emission Effect on T-coil Measurements

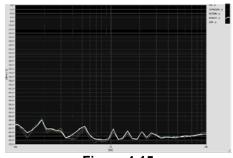


Figure 4-15
High power RF Emissions Effect with HAC Dipole on the T-coil Probe System 10mm between dipole maximum and magnetic probe

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## X. Test Flow

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

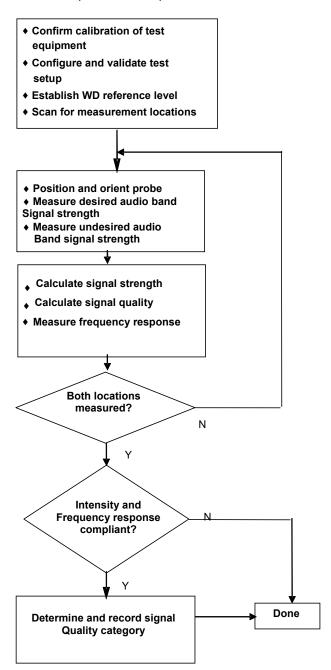


Figure 4-16 C63.19 T-Coil Signal Test Process

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#### FCC 3G MEASUREMENTS 5.

#### I. **UMTS Test Configurations**

AMR at 12.2kbps, 13.6kbps SRB was used for the testing as the worst-case configuration for the handset. See below plot for ABM noise comparison between vocoder rates:

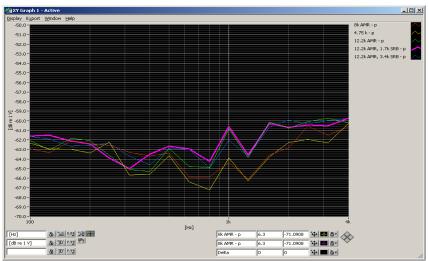
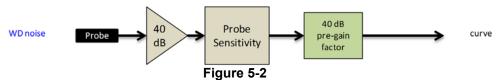


Figure 5-1 **UMTS Audio Band Magnetic Noise** 

Table 5-1 FCC 3G ABM Measurements for ZNFX210MA (UMTS)

Codec Setting:	AMR 12.2kbps	AMR 7.95kbps	AMR 4.75kbps	Orientation	Channel	
ABM1 Pre-test (dBA/m)	-4.10	-4.15	-4.01			
ABM2 Pre-test (dBA/m) (A-weight, Half-Band Int.)	- 38 34	-38.60	-38.87	Radial	9538	
S+N/N (dB)	34.24	34.45	34.86			

- Mute on; Backlight off; Max Volume; Max Contrast
- TPC="All 1s"



**Audio Band Magnetic Curve Measurement Block Diagram** 

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#### TEST SUMMARY 6.

#### I. **T-Coil Test Summary**

Table 6-1 **Table of Results for GSM** 

C63.19 Sec.	Mode	Band	Test Description	Minimum Limit*	Measured	Verdict
				dBA/m	dBA/m	PASS/FAIL
8.3.1			Intensity, Axial	-18	5.3	PASS
8.3.1			Intensity, Radial	-18	-3.8	PASS
8.3.4	GSM	Cellular	Signal-to-Noise/Noise, Axial	20	23.2	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	25.5	PASS
8.3.2			Frequency Response, Axial	0	1.4	PASS
8.3.1			Intensity, Axial	-18	5.3	PASS
8.3.1			Intensity, Radial	-18	-3.8	PASS
8.3.4	GSM	PCS	Signal-to-Noise/Noise, Axial	20	28.3	PASS
8.3.4			Signal-to-Noise/Noise, Radial	20	29.4	PASS
8.3.2			Frequency Response, Axial	0	1.5	PASS

Note: The above summary table represents the worst-case numerical values according to configurations in Table 6-4.

Table 6-2 **Table of Results for UMTS** 

- abit of floodito for only									
C63.19 Sec.	Mode	Band	Test Description	Minimum Limit*	Measured	Verdict			
				dBA/m	dBA/m	PASS/FAIL			
8.3.1			Intensity, Axial	-18	5.1	PASS			
8.3.1			Intensity, Radial	-18	-4.0	PASS			
8.3.4	UMTS	Band 5	Signal-to-Noise/Noise, Axial	20	39.5	PASS			
8.3.4			Signal-to-Noise/Noise, Radial	20	34.8	PASS			
8.3.2			Frequency Response, Axial	0	1.5	PASS			
8.3.1			Intensity, Axial	-18	5.0	PASS			
8.3.1			Intensity, Radial	-18	-4.1	PASS			
8.3.4	UMTS	Band 4	Signal-to-Noise/Noise, Axial	20	39.4	PASS			
8.3.4			Signal-to-Noise/Noise, Radial	20	34.7	PASS			
8.3.2			Frequency Response, Axial	0	1.6	PASS			
8.3.1			Intensity, Axial	-18	5.0	PASS			
8.3.1			Intensity, Radial	-18	-4.1	PASS			
8.3.4	UMTS	Band 2	Signal-to-Noise/Noise, Axial	20	39.3	PASS			
8.3.4			Signal-to-Noise/Noise, Radial	20	34.2	PASS			
8.3.2			Frequency Response, Axial	0	1.6	PASS			

Note: The above summary table represents the worst-case numerical values according to configurations in Table 6-5.

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Table 6-3
Consolidated Tabled Results

	TOTIONIAATOA TADIOA TOTALO									
		Freq. Response Margin		Magnetic Intensity Verdict		FCC SNNR Verdict		FCC Margin (dB)	C63.19-2011 Rating	
		Axial	Radial	Axial	Radial	Axial	Radial			
GSM	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-3.20	Т3	
GSW	PCS	PASS	NA	PASS	PASS	PASS	PASS	-3.20	13	
	Cellular	PASS	NA	PASS	PASS	PASS	PASS			
UMTS	AWS	PASS	NA	PASS	PASS	PASS	PASS	-14.21	T4	
	PCS	PASS	NA	PASS	PASS	PASS	PASS			

Note: Result shown is for T-coil category only.

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#### II. **Raw Handset Data**

Table 6-4 **Raw Data Results for GSM** 

Mode	Orientation	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	FCC Margin (dB)	C63.19-2011 Rating	Test Coordinates	
		128	5.36	-18.11		1.40	23.47	20.00	-3.47	T3		
	Axial	190	5.37	-17.83	-60.65	1.43	23.20	20.00	-3.20	Т3	3.0, 2.6	
GSM850		251	5.32	-18.24		1.39	23.56	20.00	-3.56	Т3		
GSIVIOSU		128	-3.72	-29.21			25.49	20.00	-5.49	T3		
	Radial	190	-3.79	-29.25	-61.09	N/A	25.46	20.00	-5.46	Т3	3.0, 1.6	
		251	-3.75	-29.63				25.88	20.00	-5.88	Т3	
		512	5.32	-23.01		1.46	28.33	20.00	-8.33	Т3		
	Axial	661	5.36	-23.01	-60.65	1.45	28.37	20.00	-8.37	Т3	3.0, 2.6	
GSM1900		810	5.35	-23.02		1.45	28.37	20.00	-8.37	Т3		
GSWITSOU		512	-3.74	-33.16			29.42	20.00	-9.42	Т3		
	Radial	661	-3.74	-33.28	-61.09	N/A	29.54	20.00	-9.54	T3	3.0, 1.6	
		810	-3.78	-33.28			29.50	20.00	-9.50	Т3		

Table 6-5 **Raw Data Results for UMTS** 

Naw Data Nesarts for Chille											
Mode	Orientation	Channel	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	FCC Margin (dB)	C63.19-2011 Rating	Test Coordinates
		4132	5.19	-34.49		1.45	39.68	20.00	-19.68	T4	
	Axial	4183	5.12	-34.54	-60.65	1.49	39.66	20.00	-19.66	T4	3.0, 2.6
UMTS V		4233	5.07	-34.42		1.48	39.49	20.00	-19.49	T4	
UNITSV		4132	-3.99	-38.77			34.78	20.00	-14.78	T4	
	Radial	4183	-4.02	-38.94	-61.09	N/A	34.92	20.00	-14.92	T4	3.0, 1.6
		4233	-4.02	-39.15			35.13	20.00	-15.13	T4	
		1312	5.04	-34.47		1.55	39.51	20.00	-19.51	T4	
	Axial	1412	4.97	-34.58	-60.65	1.59	39.55	20.00	-19.55	T4	3.0, 2.6
UMTS IV		1513	5.00	-34.36		1.61	39.36	20.00	-19.36	T4	
UNITSIV		1312	-4.02	-38.93			34.91	20.00	-14.91	T4	
	Radial	1412	-4.06	-38.79	-61.09	N/A	34.73	20.00	-14.73	T4	3.0, 1.6
		1513	-4.06	-38.73			34.67	20.00	-14.67	T4	
		9262	4.98	-35.03		1.61	40.01	20.00	-20.01	T4	
	Axial	9400	4.97	-34.39	-60.65	1.64	39.36	20.00	-19.36	T4	3.0, 2.6
UMTS II		9538	4.99	-34.35		1.68	39.34	20.00	-19.34	T4	
UNITSII		9262	-4.10	-38.50			34.40	20.00	-14.40	T4	
	Radial	9400	-4.02	-38.77	-61.09	N/A	34.75	20.00	-14.75	T4	3.0, 1.6
		9538	-4.09	-38.30			34.21	20.00	-14.21	T4	

#### III. **Test Notes**

#### A. General

- 1. Phone Condition: Mute on; Backlight off; Max Volume; Max Contrast
- 2. 'Radial' orientation refers to radial transverse.
- 3. Hearing Aid Mode (**Phone→Call Settings→More→Hearing aids**) as well as Noise Suppression Mode (Phone→Call Settings→More→ Noise Suppression) was set to ON as well as for Frequency Response compliance.

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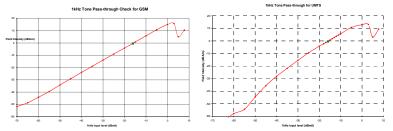
## B. GSM

- 1. Power Configuration: GSM850: PCL=5, GSM1900: PCL=0;
- 2. Vocoder Configuration: EFR (GSM);
- 3. Speech Signal: ITU-T P.50 Artificial Voice

## C. UMTS

- 1. Power Configuration: TPC="All 1s";
- 2. Vocoder Configuration: AMR 12.2 kbps (UMTS);
- 3. Speech Signal: ITU-T P.50 Artificial Voice

#### 1 kHz Vocoder Application Check IV.



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

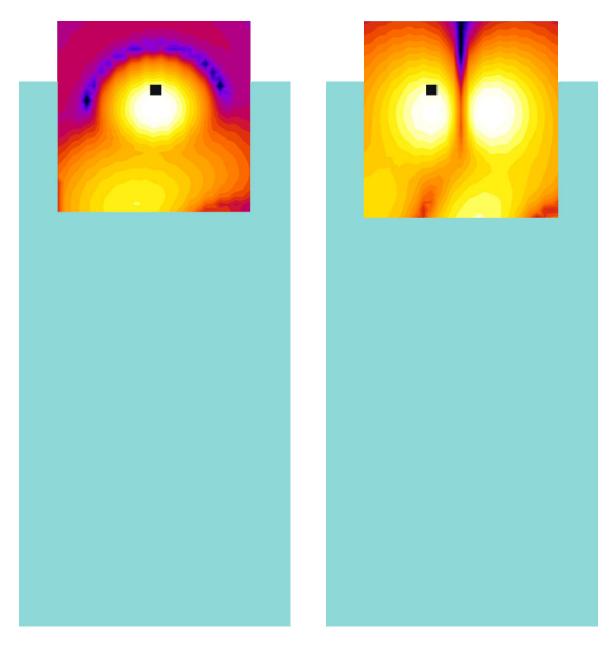
#### ٧. **T-Coil Validation Test Results**

Table 6-6 **Helmholtz Coil Validation Table of Results** 

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	-10 ± 0.5 dB	-10.183	PASS
Environmental Noise	< -58 dBA/m	-60.65	PASS
Frequency Response, from limits	> 0 dB	0.80	PASS
Radial			
Magnetic Intensity, -10 dBA/m	-10 ± 0.5 dB	-10.288	PASS
Environmental Noise	< -58 dBA/m	-61.09	PASS
Frequency Response, from limits	> 0 dB	0.80	PASS

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# VI. ABM1 Magnetic Field Distribution Scan Overlays



Axial Radial (Transverse)

# Figure 6-1 T-Coil Scan Overlay Magnetic Field Distributions

#### Notes:

- 1. Final measurement locations are indicated by a cursor on the contour plots.
- 2. See Test Setup Photographs for actual WD overlay.

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## 7. MEASUREMENT UNCERTAINTY

Table 7-1
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.
- 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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# 8. EQUIPMENT LIST

Table 8-1 Equipment List

		_qa.po				
Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Dell	Latitude E6540	SoundCheck Acoustic Analyzer Laptop	4/11/2017	Annual	4/11/2018	7BFNM32
Listen	SoundConnect	Microphone Power Supply	12/2/2016	Annual	12/2/2017	PS2612
RME	Fireface UC	SoundCheck Acoustic Analyzer External Audio Interface	4/11/2017	Annual	4/11/2018	23528889
Rohde & Schwarz	CMU200	Base Station Simulator	12/12/2016	Annual	12/12/2017	833855/0010
TEM	Radial T-Coil Probe	Radial T-Coil Probe	12/7/2016	Annual	12/7/2017	TEM-1130
TEM	Axial T-Coil Probe	Axial T-Coil Probe	12/7/2016	Annual	12/7/2017	TEM-1124
TEM	Helmholtz Coil	Helmholtz Coil	12/7/2016	Annual	12/7/2017	925
TEM		HAC System Controller with Software	N/A	N/A	N/A	N/A
TEM		HAC Positioner	N/A	N/A	N/A	N/A

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# 9. TEST DATA

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DUT: HH Coil - SN: 925

Type: HH Coil Serial: 925

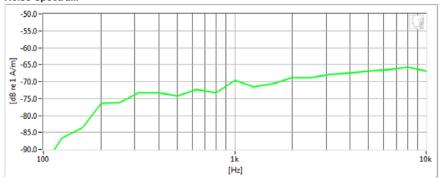
Measurement Standard: ANSI C63.19-2011

#### Equipment:

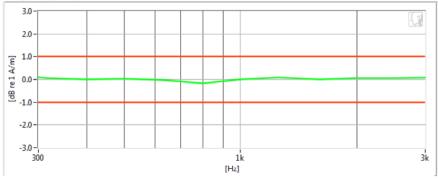
Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 12/07/2016

Helmholtz Coil – SN: 925; Calibrated: 12/07/2016

#### Noise Spectrum



### Frequency Response



### Results

Verification 1kHz Intensity	-10.183 dB	•	Max/Min	-9.5/-10.5
Verification ABM2	-60.65 dB	•	Maximum	-58.0
Frequency Response Margin	800m dB	$\checkmark$	Tolerance curves	Aligned Data

FCC ID: ZNFX210MA	PCTEST*	HAC (T-COIL) TEST REPORT	① LG	Approved by: Quality Manager
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DUT: HH Coil - SN: 925

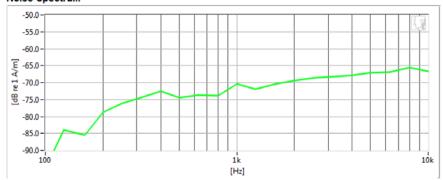
Type: HH Coil Serial: 925

Measurement Standard: ANSI C63.19-2011

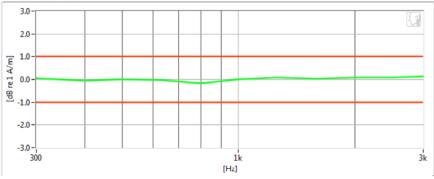
#### Equipment:

- Probe: Radial T-Coil Probe SN: TEM-1130; Calibrated: 12/07/2016
- Helmholtz Coil SN: 925; Calibrated: 12/07/2016

#### Noise Spectrum



### Frequency Response



### Results

Verification 1kHz Intensity	-10.288 dB	$\checkmark$	Max/Min	-9.5/-10.5
Verification ABM2	-61.09 dB	$\checkmark$	Maximum	-58.0
Frequency Response Margin	800m dB	$\checkmark$	Tolerance curves	Aligned Data

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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

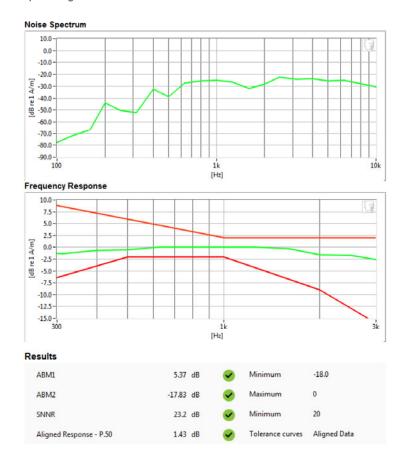
#### Equipment:

Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 12/07/2016

#### **Test Configuration:**

Mode: GSM 850Channel: 190

• Speech Signal: ITU-T P.50 Artificial Voice



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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

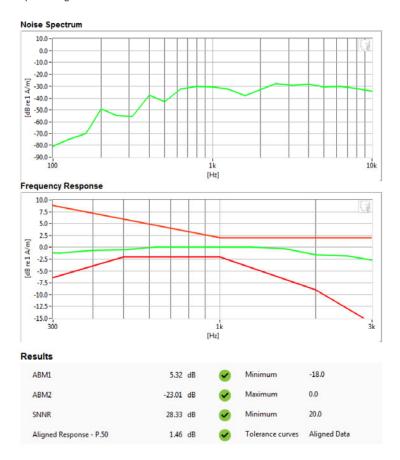
#### Equipment:

Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 12/07/2016

#### **Test Configuration:**

Mode: GSM 1900Channel: 512

• Speech Signal: ITU-T P.50 Artificial Voice



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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

#### Equipment:

Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 12/07/2016

#### **Test Configuration:**

Mode: UMTS Band V

Channel: 4233

Speech Signal: ITU-T P.50 Artificial Voice

#### **Noise Spectrum** 10.0 0.0 -10.0 -20.0 -20.0 -BB -50.0 --60.0 -70.0 -80.0 -90.0 100 [Hz] Frequency Response 10.0 7.5 5.0 2.5 [dB re 1 A/m] 0.0 -2.5 -5.0 -7.5 -10.0 -12.5 -15.0 [Hz] Results ABM1 5.07 dB -18.0 ABM2 -34.42 dB 0 Maximum SNNR 39.49 dB Aligned Response - P.50 1.48 dB Tolerance curves Aligned Data

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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

#### Equipment:

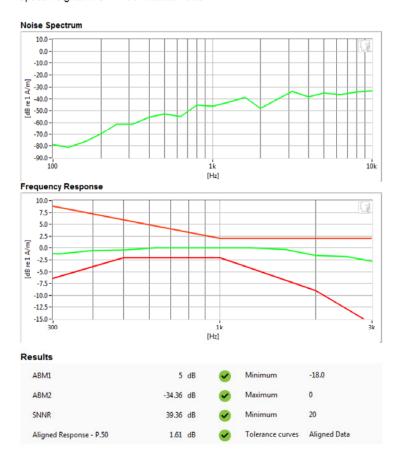
Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 12/07/2016

#### **Test Configuration:**

. Mode: UMTS Band IV

Channel: 1513

Speech Signal: ITU-T P.50 Artificial Voice



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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

#### Equipment:

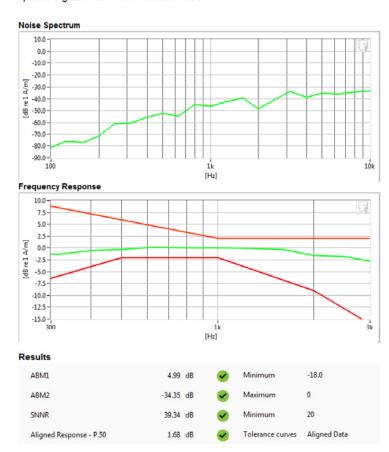
Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 12/07/2016

#### **Test Configuration:**

Mode: UMTS Band II

Channel: 9538

Speech Signal: ITU-T P.50 Artificial Voice



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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

## Equipment:

SNNR

Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 12/07/2016

#### **Test Configuration:**

Mode: GSM 850Channel: 190



25.46 dB

Minimum

20.0

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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

#### Equipment:

SNNR

Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 12/07/2016

### **Test Configuration:**

Mode: GSM 1900Channel: 512



29.42 dB

20.0

Minimum

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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

## Equipment:

Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 12/07/2016

#### **Test Configuration:**

 Mode: UMTS Band V Channel: 4132

#### Noise Spectrum -10.0 --15.0 -20.0 -25.0 --30.0 -35.0 --40.0 --40.0--45.0--50.0--60.0--65.0 --70.0 -75.0 --80.0 -85.0 --90.0 -100

#### Results

ABM1	-3.99 dB	$\checkmark$	Minimum	-18.0
ABM2	-38.78 dB	•	Maximum	0.0
SNNR	34.78 dB	•	Minimum	20.0

1k [Hz]

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Type: Portable Handset Serial: 70548

Measurement Standard: ANSI C63.19-2011

#### Equipment:

ABM2

SNNR

Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 12/07/2016

### **Test Configuration:**

Mode: UMTS Band IVChannel: 1513

#### Noise Spectrum -10.0 --15.0 -20.0 --25.0--30.0--35.0 --40.0 -40.0 --45.0 --50.0 --60.0 --65.0 --70.0 --75.0 --80.0 -85.0 --90.0 -100 [Hz] Results ABM1 Minimum -4.06 dB

-38.73 dB

34.67 dB

Maximum

Minimum

0.0

20.0

FCC ID: ZNFX210MA	PCTEST (NEINLEINE LABORATOR), INC.	HAC (T-COIL) TEST REPORT	① LG	Approved by: Quality Manager
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Type: Portable Handset Serial: 70548

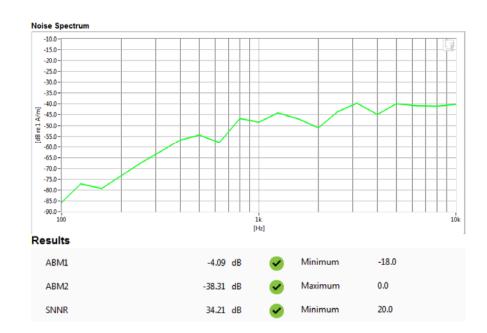
Measurement Standard: ANSI C63.19-2011

#### Equipment:

Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 12/07/2016

### **Test Configuration:**

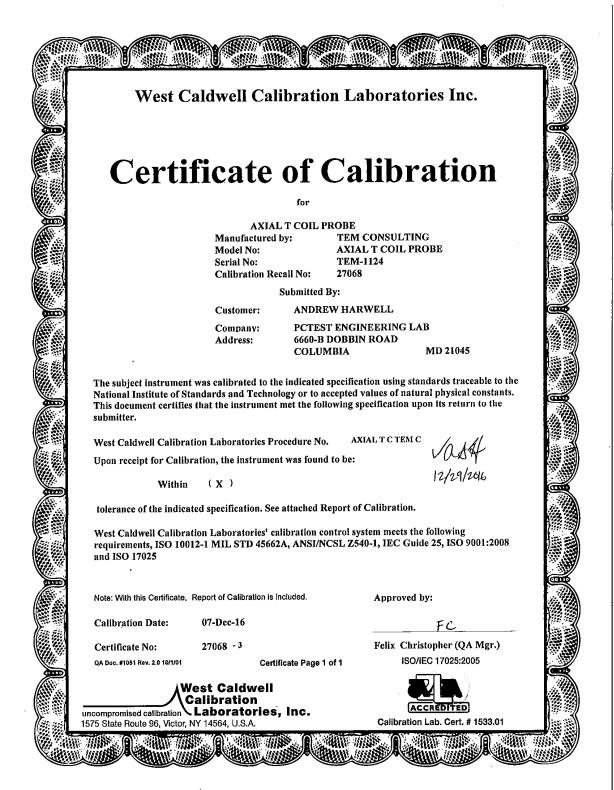
Mode: UMTS Band IIChannel: 9538



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# 10. CALIBRATION CERTIFICATES

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### HCATEMC\_TEM 1124\_Dec-07-2016



ISO/IEC 17025: 2005

1575 State Route 96, Victor NY 14564

Calibration Lab. Cert. # 1533.01

# REPORT OF CALIBRATION

**TEM Consulting LP Axial T Coil Probe** 

Model No.: Axial T Coil Probe

Serial No.: TEM 1124

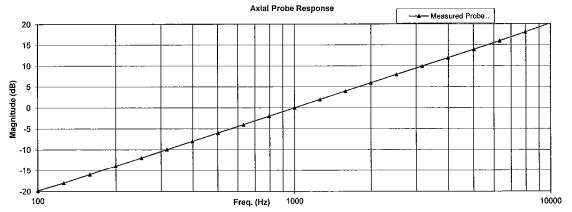
Company: PCTEST Engineering Lab.

I. D. No: 80578

Probe Sensitivity measured wit	h Heimholi	z Coil			
Helmholtz Coil;			Before & after data same:X		
the number of turns on each coil;	10	No.			
the radius of each coil, in meters;	0.204	m	Laboratory Environ	ment:	
the current in the coils, in amperes.;	0.09	Α	Ambient Temperature:	20.2	°C
Helmholtz Coll Constant;	7.09	A/m/V	Ambient Humidity:	31.4	% RH
Helmholtz Coll magnetic field;	5.98	A/m	Ambient Pressure:	99.1	kPa
			Calibration Date:	7-Dec-16	
Probe Sensitivity at	1000	Hz.	Re-calibration Due:	7-Dec-17	
was	-60.23	dBV/A/m	Report Number:	27068	-3
	0.974	mV/A/m	Control Number:	27068	
Probe resistance	904	Ohms			
e above listed instrument meets or			turer's specifications.		
Calibration is traceable through NIST test numbers	<b>s</b> :	683/284413-14	-		

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: 7-Dec-2016

Measurements performed by: ....

Calibrated on WCCL system type 9700 This document shall not be reproduced, except in full, without the written approval from West Caldwell Cal. Labs. Inc. Felix Christopher

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## HCATEMC\_TEM 1124\_Dec-07-2016

## West Caldwell Calibration Laboratories Inc.

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

# Calibration Data Record

TEM Consulting LP Axial T Coil Probe

for Model No.: Axial T Coil Probe

Serial No.: TEM 1124

Company: PCTEST Engineering Lab.

Test	Function	Tolerai	nce	Measured values		
				Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-60.23		
	<del></del>		dB		<del></del>	<u> </u>
2.0	Probe Level Linearity		6	6.03		
	·	Ref. (0 dB)	0	0.00		
			-6	-6.03		Į
			-12	-12.05		
	<del>,</del>	_	Hz			
3.0	Probe Frequency Response		100	-19.8		
			126	-18.0		
			158	-16.0		
			200	-13.9		
			251	-12.0		
			316	-9.9		
			398	-8.0		
			501	-6.0		
			631	-4.0		
			794	-2.0		
		Ref. (0 dB)	1000	0.0		
			1259	2.0		1
			1585	4.0		1
			1995	6.0		1
			2512	7.9		
			3162	9.9		
			3981	11.9		
			5012	13.9		
			6310	15.9		1
			7943	18.0		1
			10000	20.2		

Instruments used for calibration	n:		Date of Cal.	Traceablity No.	Due Date
HP	34401A	S/N 36064102	1-Oct-2016	,287708	1-Oct-2017
HP	34401A	S/N 36102471	1-Oct-2016	287708	1-Oct-2017
HP	33120A	S/N 36043716	1-Oct-2016	287708	1-Oct-2017
в&к	2133	S/N 1583254	1-Oct-2016	683/284413-14	1-Oct-2017

Cal. Date:

7-Dec-2016

Tested by: Felix Christopher

Calibrated on WCCL system type 9700

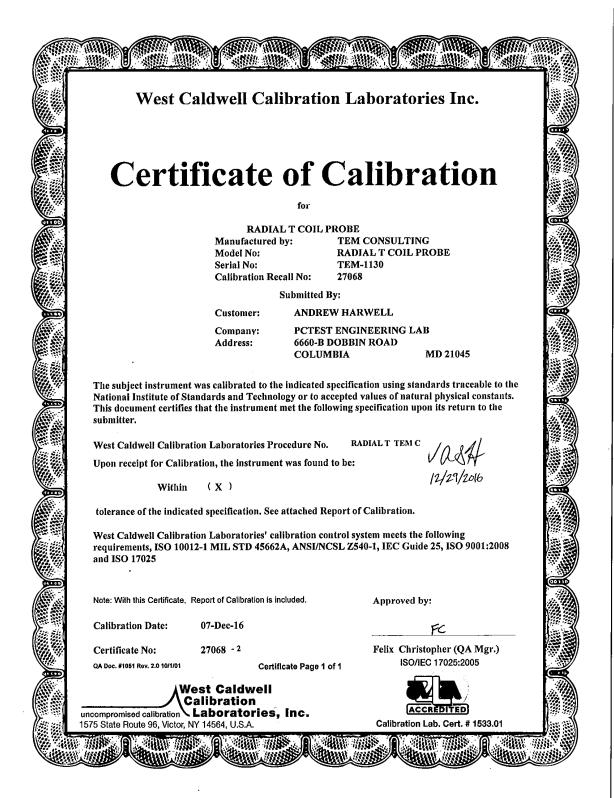
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FCC ID: ZNFX210MA	POTEST*	HAC (T-COIL) TEST REPORT	① LG	Approved by: Quality Manager
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#### HCRTEMC TEM-1130 Dec-07-2016



ACCREDITED

ISO/IEC 17025: 2005

1575 State Route 96, Victor NY 14564

Calibration Lab. Cert. # 1533.01

## REPORT OF CALIBRATION

TEM Consulting LP Radial T Coil Probe

Model No.: Radial T Coil Probe

Serial No.: TEM-1130

Company: PCTEST Engineering Lab.

I. D. No: 80579

Probe Sensitivity measured wit	h Helmholi	z Coil			
Helmholtz Coil;			Before & afte	er data same	:X
the number of turns on each coil;	10	No.			
the radius of each coil, in meters;	0.204	m	Laboratory Enviror	ment:	
the current in the coils, in amperes.;	0.09	Α	Ambient Temperature:	20.2	°C
Helmholtz Coil Constant;	7.09	A/m/V	Ambient Humidity:	31.4	% RH
Helmholtz Coil magnetic field;	5.98	A/m	Ambient Pressure:	99.1	kPa
			Calibration Date:	7-Dec-16	
Probe Sensitivity at	1000	Hz.	Re-calibration Due:	7-Dec-17	
was	-60.27	dBV/A/m	Report Number:	27068	-2
	0.969	mV/A/m	Control Number:	27068	
Probe resistance	902	Ohms			

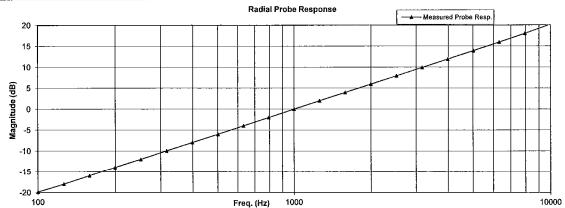
The above listed instrument meets or exceeds the tested manufacturer's specifications.

This Calibration is traceable through NIST test numbers:

683/284413-14

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: 7-Dec-2016

Measurements performed by: .....

Felix Christopher

Calibrated on WCCL system type 9700

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## HCRTEMC\_TEM-1130\_Dec-07-2016

## West Caldwell Calibration Laboratories Inc.

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

# Calibration Data Record

TEM Consulting LP Radial T Coil Probe

for Model No.: Radial T Coil Probe

Serial No.: TEM-1130

Company: PCTEST Engineering Lab.

Test	Function	Tolera	Measured values			
				Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-60.27		:
			dB			
2.0	Probe Level Linearity		6	6.03		
		Ref. (0 dB)	0	0.00		
			-6	-6.03		
			-12	-12.06		
			Hz			
3.0	Probe Frequency Response		100	-19.9		
			126	-18.0		
			158	-16.0		1
			200	-13.9		
			251	-12.0		
			316	-10.0		1
			398	-8.0		1
			501	-6.0		1
			631	-4.0		1
			794	-2.0		
		Ref. (0 dB)	1000	0.0		
			1259	2.0		İ
			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.	Traceability No.	Due Date
HP	34401A	S/N	36064102	1-Oct-2016	,287708	1-Oct-2017
HP	34401A	S/N	36102471	1-Oct-2016	,287708	1-Oct-2017
HP	33120A	S/N	36043716	1-Oct-2016	,287708	1-Oct-2017
B&K	2133	S/N	1583254	1-Oct-2016	683/284413-14	1-Oct-2017

Cal. Date: 7-Dec-2016

Tested by: Felix Christopher

Calibrated on WCCL system type 9700

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## 11. 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(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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FCC ID: ZNFX210MA	PCTEST*	HAC (T-COIL) TEST REPORT	LG	Approved by: Quality Manager	
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