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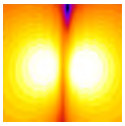

HEARING AID COMPATIBILITY

Applicant Name:
LG Electronics U.S.A, Inc.
1000 Sylvan Avenue
Englewood Cliffs, NJ 07632
United States

Date of Testing:
12/09/2019 - 1/14/2020
Test Site/Location:
PCTEST, Columbia, MD, USA
Test Report Serial No.:
1M1911250199-16-R2.ZNF
Date of Issue:
1/29/2020

FCC ID:	**ZNFV600VM**
APPLICANT:	**LG ELECTRONICS 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 v05 285076 D02 T-Coil testing for CMRS IP v03
DUT Type:	Portable Handset
Model:	LM-V600VM
Additional Model(s):	LMV600VM, V600VM, LM-V600QM5, LMV600QM5, V600QM5, LM-V600QM6, LMV600QM6, V600QM6
Test Device Serial No.:	*Pre-Production Sample* [S/N: 00288, 00387]

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

Note: This revised Test Report (S/N: 1M1911250199-16-R2.ZNF) supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

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.

Randy Ortanez
President

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01/16/2020

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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-situ*

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

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2. DUT DESCRIPTION

FCC ID:	ZNFV600VM
Applicant:	LG Electronics U.S.A, Inc. 1000 Sylvan Avenue Englewood Cliffs, NJ 07632 United States
Model:	LM-V600VM
Additional Model(s):	LMV600VM, V600VM, LM-V600QM5, LMV600QM5, V600QM5, LM-V600QM6, LMV600QM6, V600QM6
Serial Number:	00288, 00387
HW Version:	Rev.B
SW Version:	V600VM06h_1203
Antenna:	Internal Antenna
DUT Type:	Portable Handset

I. LTE Band Selection

This device supports the following pair of LTE bands with similar frequencies: LTE B4 & B66. This pair of LTE bands has the same target power and shares the same transmission path. Since the supported frequency span for the smaller LTE band is completely covered by the larger LTE band, only the larger LTE band (LTE B66) was evaluated for hearing-aid compliance.

II. Device Serial Numbers

Several samples with identical hardware were used to support HAC testing. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical, and thermal characteristics are within operational tolerances expected for production units. The serial numbers used for each test are indicated alongside the results in Section 9.

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Table 2-1
ZNFV600VM HAC Air Interfaces

Air-Interface	Band (MHz)	Type Transport	HAC Tested	Simultaneous But Not Tested	Name of Voice Service	Audio Codec Evaluated
CDMA	835	VO	Yes	Yes: WIFI or BT	CMRS Voice[1]	EVRC
	1900					
	EvDO	VD	Yes	Yes: WIFI or BT	Google Duo[2]	OPUS
GSM	850	VO	Yes	Yes: WIFI or BT	CMRS Voice[1]	EFR
	1900					
	GPRS/EDGE	VD	Yes	Yes: WIFI or BT	Google Duo[2]	OPUS
UMTS	850	VD	Yes	Yes: WIFI or BT	CMRS Voice[1]	NB AMR
	1700					
	1900					
	HSPA	VD	Yes	Yes: WIFI or BT	Google Duo[2]	OPUS
LTE (FDD)	700 (B12)	VD	Yes	Yes: WIFI or BT	VoLTE[1], Google Duo[2]	VoLTE: NB AMR, WB AMR, EVS Google Duo: OPUS
	780 (B13)					
	790 (B14)					
	850 (B5)					
	1700 (B4)					
	1700 (B66)					
	1900 (B2)					
	2300 (B30)					
LTE (TDD)	2600 (B41)	VD	Yes	Yes: WIFI or BT	VoLTE[1], Google Duo[2]	VoLTE: NB AMR, WB AMR, EVS Google Duo: OPUS
	3600 (B48)					
NR (FDD)	850 (n5)	VD	Yes	Yes: WIFI or BT	Google Duo[2]	OPUS
	1700 (n66)					
	1900 (n2)					
NR (TDD)	28000 (n261)	VD	No[3]	Yes: WIFI or BT	Google Duo	OPUS
	39000 (n260)					
WIFI	2450	VD	Yes	Yes: CDMA, GSM, UMTS, LTE, or NR	VoWIFI[2], Google Duo[2]	VoWIFI: NB AMR, WB AMR, EVS Google Duo: OPUS
	5200 (U-NII 1)					
	5300 (U-NII 2A)					
	5500 (U-NII 2C)					
	5800 (U-NII 3)					
BT	2450	DT	No	Yes: CDMA, GSM, UMTS, LTE, or NR	N/A	N/A

Type Transport
VO = Voice Only
DT = Digital Data - Not intended for Voice Services
VD = CMRS and/or IP Voice over Data Transport

Notes:
1. Reference level in accordance with 7.4.2.1 of ANSI C63.19-2011 and July 2012 C63 VoLTE Interpretation.
2. Reference level is -20dBm0 in accordance with FCC KDB 285076 D02
3. n260 and n261 are currently outside the scope of ANSI C63.19 and FCC HAC regulations therefore they were not evaluated.

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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 ≥ -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.

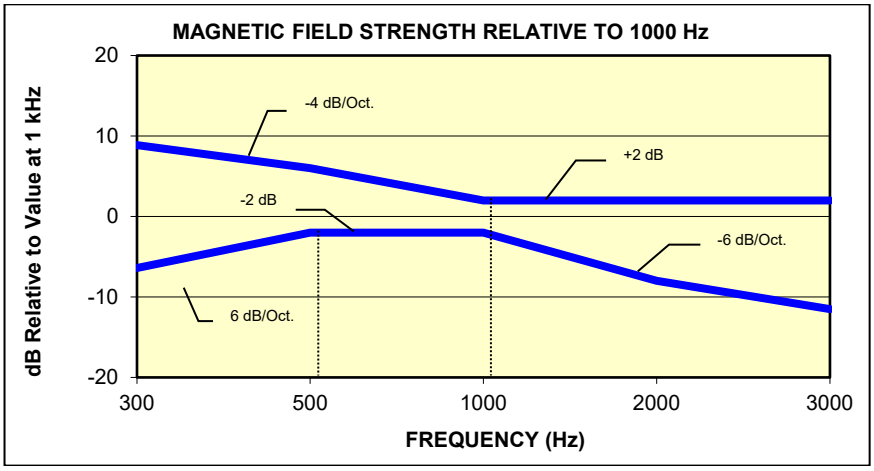

Figure 3-1
Magnetic field frequency response for Wireless Devices with an axial field ≤-15 dB(A/m) at 1 kHz

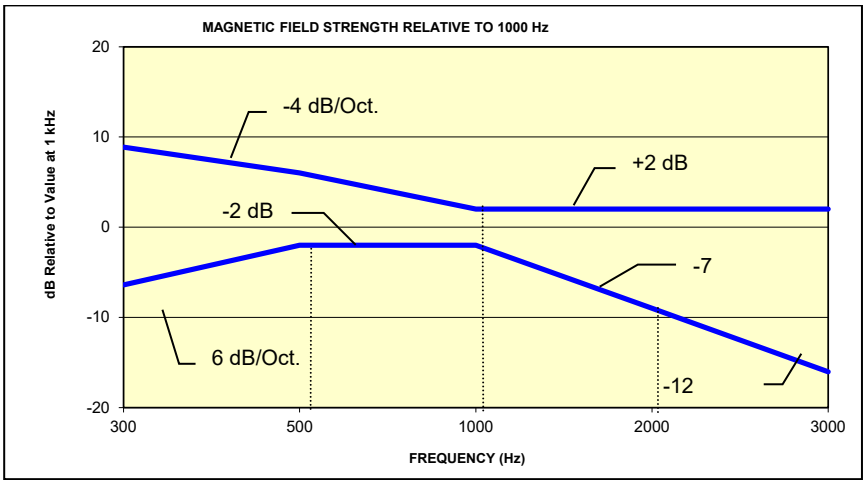

Figure 3-2
Magnetic Field frequency response for wireless devices with an axial field that exceeds -15 dB(A/m) at 1 kHz

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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
	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 3-1
Magnetic Coupling Parameters

Note: The FCC limit for SNNR is 20dB and the test data margins will indicate a margin from the FCC limit for compliance.

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4. METHOD OF MEASUREMENT

I. Test Setup

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

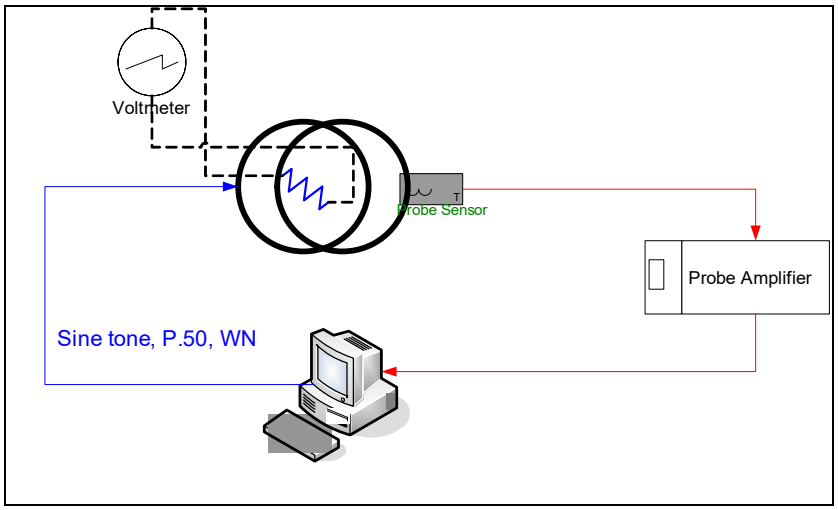

Figure 4-1
Validation Setup with Helmholtz Coil

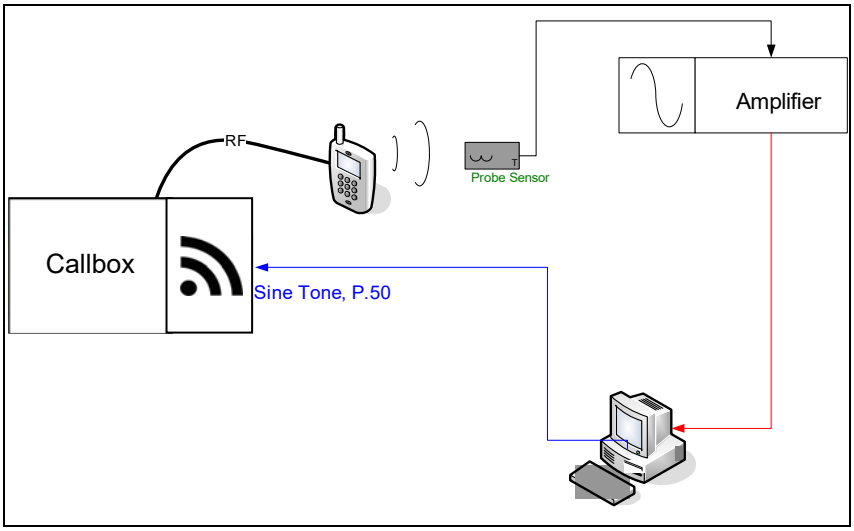

Figure 4-2
T-Coil Test Setup

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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)

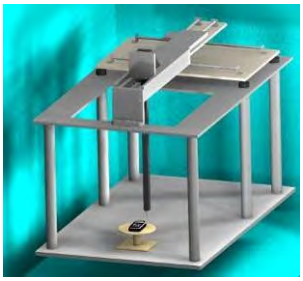

Figure 4-3
RF Near-Field Scanner

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%

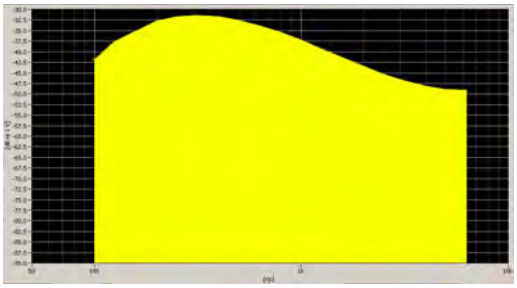

Figure 4-4
Spectral Characteristic of full P.50

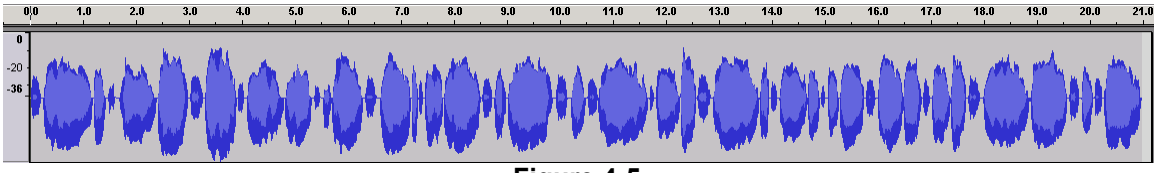

Figure 4-5
Temporal Characteristic of full P.50

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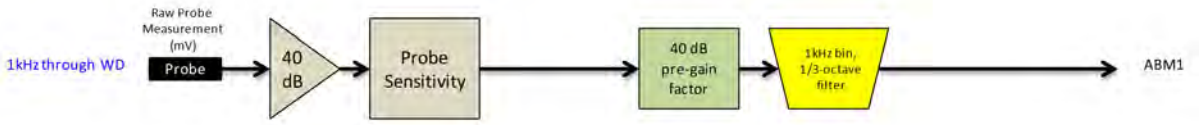
ABM1 Measurement Block Diagram:



ABM2 Measurement Block Diagram:

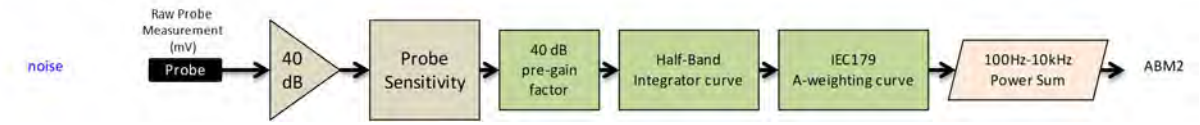


Figure 4-6 Magnetic Measurement Processing Steps

IV. Test Procedure

1. Ambient Noise Check per C63.19 §7.3.1
   a. Ambient interference was monitored using a Real-Time Analyzer 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:

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

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 (SN: 925), N=20; r=0.08m; R=10.2Ω and using V=18mV:

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

For the Helmholtz Coil (SN: SBI 1052), N=20; r=0.13m; R=10.193Ω and using V=29mV:

$$H_c = \frac{20\cdot(\frac{0.029}{10.193})}{0.13\cdot\sqrt{1.25^3}} = 0.316A/m \approx -10dB(A/m)$$

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Therefore a pure tone of 1kHz was applied into the coils such that 18mV was observed across the resistor for Helmholtz Coil (SN: 925) and 29mV for Helmholtz Coil (SN: SBI 1052). 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 Pages 46 to 48).

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:

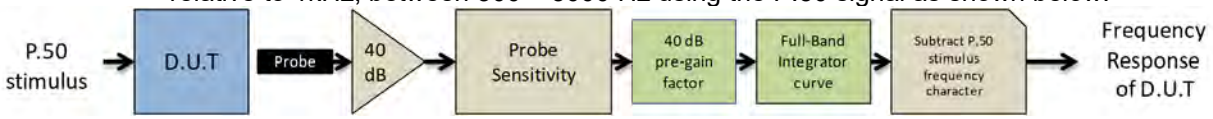

Figure 4-7 Frequency Response Validation

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

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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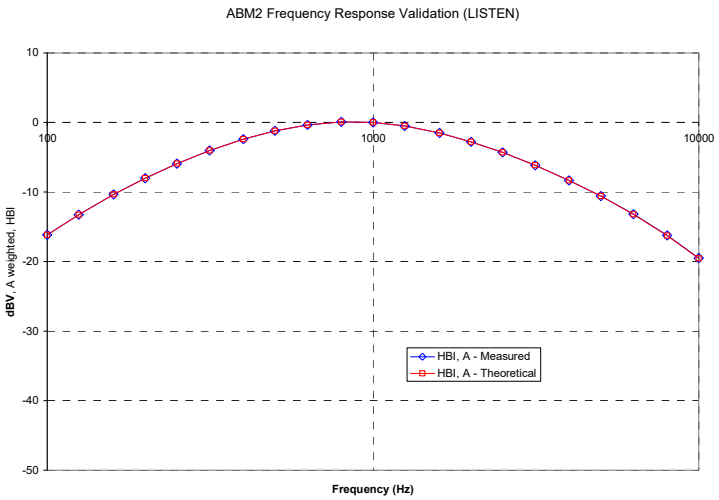

Figure 4-8
ABM2 Frequency Response Validation

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:

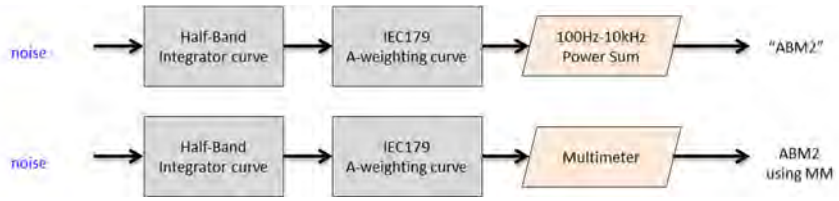

Figure 4-9
ABM2 Validation Block Diagram

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 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

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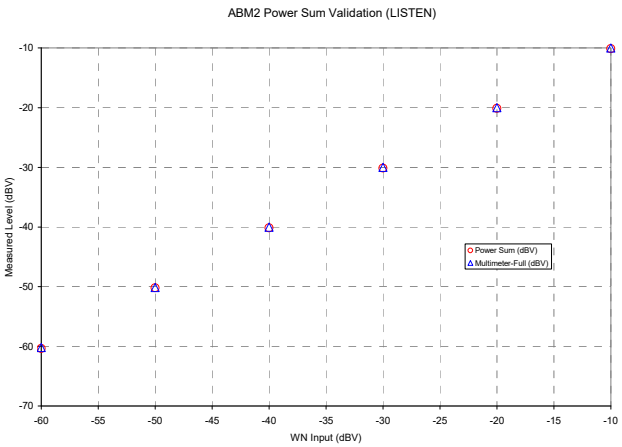

Figure 4-10
ABM2 Power Sum Validation

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):

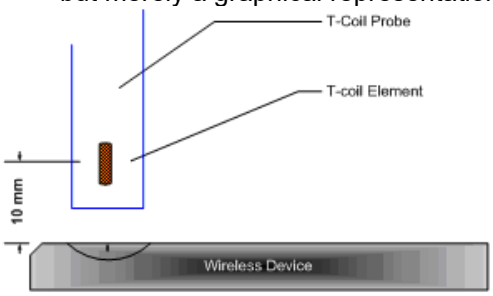

Figure 4-11
Measurement Distance

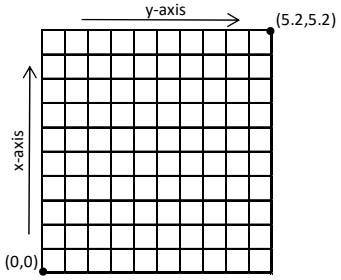

Figure 4-12
Measurement Grid

        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 4-14 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™	TDMA (22 and 11 Hz)	-18

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ii. See Section 5 and 6 for more information regarding CMW500 audio level settings for Voice Over LTE (VoLTE), and Voice Over WIFI (VoWIFI) testing.
iii. See Section 7 for more information regarding audio level settings for Over-The-Top (OTT) Voice Over IP (VoIP) Testing.

c. Real-Time Analyzer (RTA)
   i. 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 Section 8 for more information regarding worst-case configurations for CDMA and UMTS. LTE configuration information can be found in Section 5 and 7. NR configuration information can be found in Section 7. WIFI configuration information can be found in Section 6 and 7.)
   ii. Supported GSM vocoders were investigated for the worst-case ABM2 condition. GSM-EFR was deemed the worst-case condition for the GSM air interface.

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.
      iii. This result was subtracted from the ABM1 result in step a, to obtain the Signal Quality.

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V. Test Setup

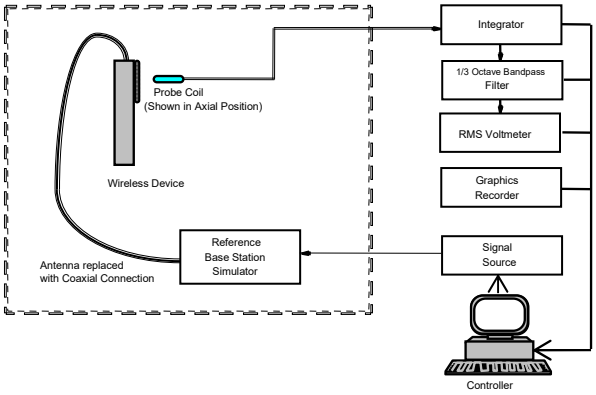

Figure 4-13
Audio Magnetic Field Test Setup

Environmental conditions such as temperature and relative humidity are monitored to ensure there are no impacts on system specifications. Proper voltage and power line frequency conditions are maintained with three phase power sources. Environmental noise and reflections are monitored through system checks.

VI. Deviation from C63.19 Test Procedure

Non-conducted RF connection due to inaccessible RF ports.

VII. Air Interface Technologies Tested

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

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VIII. Wireless Device Channels and Frequencies

1. 2G/3G Modes

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. Only middle channels were evaluated for data modes.

Table 4-3
Center Channels and Frequencies

Test frequencies & associated channels	
Channel	**Frequency (MHz)**
Cellular 850	
384 (CDMA)	836.52
190 (GSM)	836.60
4183 (UMTS)	836.60
AWS 1750	
1412 (UMTS)	1730.40
PCS 1900	
600 (CDMA)	1880
661 (GSM)	1880
9400 (UMTS)	1880

2. 4G (LTE) Modes

The middle channel for every band and bandwidth combination was tested for each probe orientation. The band and bandwidth combination from each probe orientation resulting in the worst-case SNNR was additionally tested using low and high channels for that band and bandwidth combination. Low-mid and mid-high channels are additionally tested for LTE TDD. The middle channel and supported bandwidths from the worst-case band according to Tables 7-6 as well as 7-7 were additionally evaluated with OTT VoIP for each probe orientation. See Tables 9-5 to 9-13 and Tables 9-22 and 9-23 for LTE bandwidths and channels.

3. 5G (NR) Modes

The middle channel and supported bandwidths from the worst-case band according to Table 7-11 was evaluated with OTT VoIP for each probe orientation. The band and bandwidth combination from each probe orientation resulting in the worst-case SNNR was additionally tested using low and high channels for that band and bandwidth combination. See Table 9-24 for NR bandwidths and channels.

4. WIFI

The middle channel for each IEEE 802.11 standard was tested for each probe orientation. The 2.4GHz IEEE 802.11 standard from each probe orientation resulting in the worst-case SNNR was additionally tested using low and high channels. The 5GHz IEEE 802.11 standard from each probe orientation resulting in the worst-case SNNR was additionally tested on higher U-NII bands as well as applicable low and high channels. See Tables 9-14 to 9-18 and Tables 9-25 to 9-29 for WIFI standards and channels.

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IX. Test Flow

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

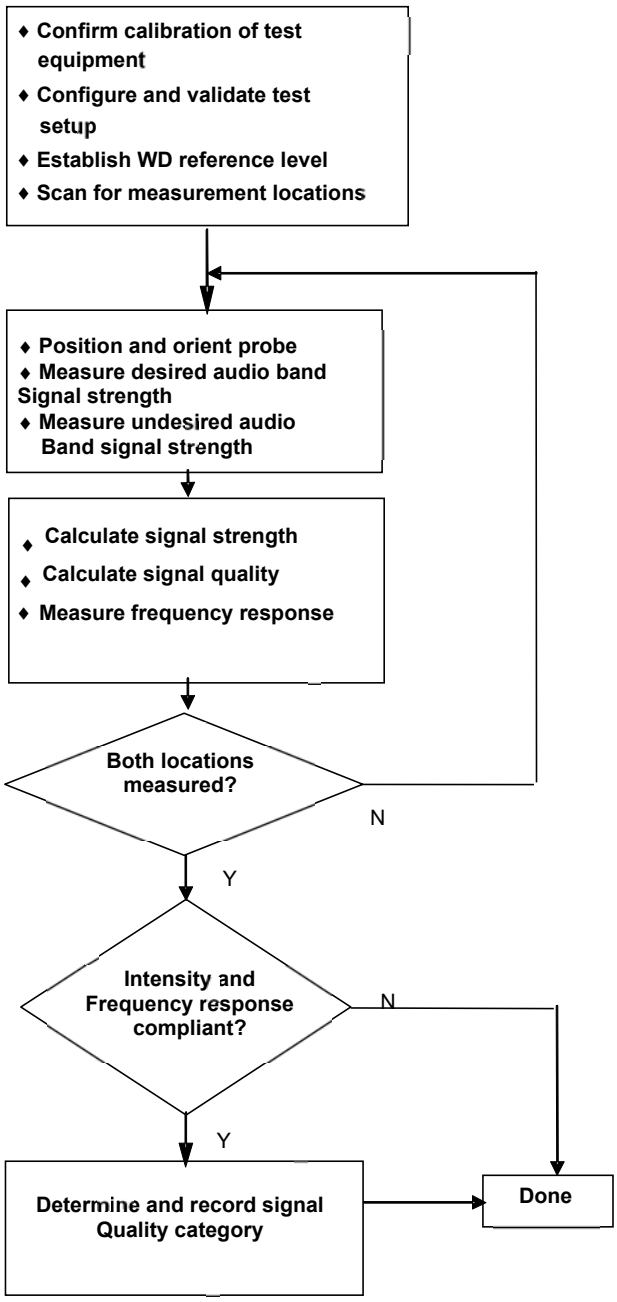

Figure 4-14
C63.19 T-Coil Signal Test Process

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5. VOLTE TEST SYSTEM SETUP AND DUT CONFIGURATION

I. Test System Setup for VoLTE over IMS T-coil Testing

1. Equipment Setup

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

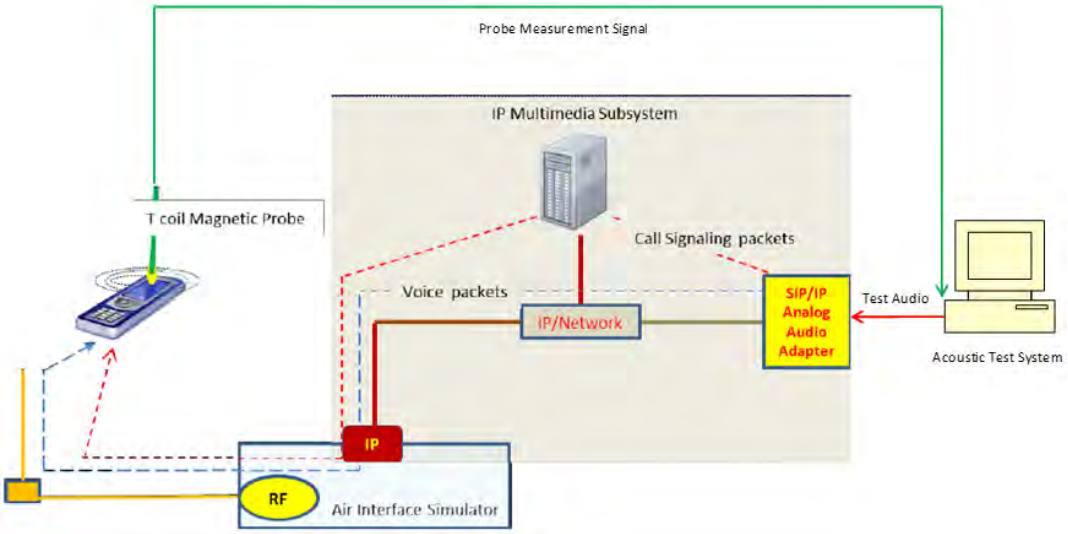

Figure 5-1
Test Setup for VoLTE over IMS T-Coil Measurements

2. Audio Level Settings

According to the July 2012 interpretations by the C63 Committee regarding the appropriate audio levels to be used for VoLTE over IMS 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 over IMS connection.

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

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II. DUT Configuration for VoLTE over IMS T-coil Testing

1. Radio Configuration

An investigation was performed to determine the modulation and RB configuration to be used for testing. The effects of modulation and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. 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:

Table 5-1
VoLTE over IMS SNNR by Radio Configuration

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
12	707.5	23095	10	QPSK	1	0	11.60	-54.10	65.70
12	707.5	23095	10	QPSK	1	25	11.78	-57.52	69.30
12	707.5	23095	10	QPSK	1	49	11.68	-55.08	66.76
12	707.5	23095	10	QPSK	25	0	11.70	-58.43	70.13
12	707.5	23095	10	QPSK	25	12	11.55	-53.37	64.92
12	707.5	23095	10	QPSK	25	25	11.91	-57.86	69.77
12	707.5	23095	10	QPSK	50	0	11.94	-58.03	69.97
12	707.5	23095	10	16QAM	1	0	11.71	-51.09	**62.80**
12	707.5	23095	10	16QAM	1	25	11.72	-52.45	64.17
12	707.5	23095	10	16QAM	1	49	11.76	-51.47	63.23
12	707.5	23095	10	16QAM	25	0	11.72	-57.12	68.84
12	707.5	23095	10	16QAM	25	12	12.05	-57.84	69.89
12	707.5	23095	10	16QAM	25	25	11.92	-57.83	69.75
12	707.5	23095	10	16QAM	50	0	11.84	-57.86	69.70
12	707.5	23095	10	64QAM	1	0	11.74	-51.49	63.23
12	707.5	23095	10	64QAM	1	25	11.82	-52.10	63.92
12	707.5	23095	10	64QAM	1	49	11.88	-51.38	63.26
12	707.5	23095	10	64QAM	25	0	11.79	-57.76	69.55
12	707.5	23095	10	64QAM	25	12	11.66	-57.41	69.07
12	707.5	23095	10	64QAM	25	25	12.02	-57.14	69.16
12	707.5	23095	10	64QAM	50	0	11.92	-57.33	69.25
12	707.5	23095	10	256QAM	1	0	11.48	-57.87	69.35
12	707.5	23095	10	256QAM	1	25	11.58	-57.79	69.37
12	707.5	23095	10	256QAM	1	49	11.78	-57.66	69.44
12	707.5	23095	10	256QAM	25	0	12.07	-57.68	69.75
12	707.5	23095	10	256QAM	25	12	11.53	-57.70	69.23
12	707.5	23095	10	256QAM	25	25	11.96	-58.02	69.98
12	707.5	23095	10	256QAM	50	0	11.82	-57.84	69.66

2. Codec Configuration

An investigation was performed to determine the audio codec configuration to be used for testing. The effects of codec configuration were found to be independent of radio configuration; therefore, only one radio configuration was used for this investigation. The WB AMR 6.60kbps setting was used for the audio codec on the CMW500 for VoLTE over IMS T-coil testing. See below table for comparisons between different codecs and codec data rates:

Table 5-2
AMR Codec Investigation – VoLTE over IMS

Codec Setting:	WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Band / BW	Channel
ABM1 (dBA/m)	12.38	11.56	13.05	12.71	Axial	Band 12 10MHz	23095
ABM2 (dBA/m)	-51.29	-51.35	-51.55	-51.03			
Frequency Response	Pass	Pass	Pass	Pass			
S+N/N (dB)	63.67	**62.91**	64.60	63.74			

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Table 5-3
EVS Codec Investigation - VoLTE over IMS

Codec Setting:	EVS Primary SWB 13.2kbps	Orientation	Band / BW	Channel
ABM1 (dBA/m)	14.77	Axial	Band 12 10MHz	23095
ABM2 (dBA/m)	-51.61			
Frequency Response	Pass			
S+N/N (dB)	66.38			

- Mute on; Backlight off; Max Volume; Max Contrast
- TPC = "Max Power"

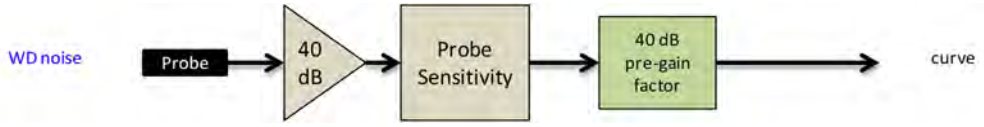

Figure 5-2
Audio Band Magnetic Curve Measurement Block Diagram

3. LTE TDD Uplink-Downlink Configuration Investigation for VoLTE over IMS

An investigation was performed to determine the worst-case Uplink-Downlink configuration for VoLTE over IMS T-Coil testing.

Per 3GPP TS 36.211, the total frame length for each TDD radio frame of length $T_f = 307200 \cdot T_s$ = 10 ms, where T_s is a number of time units equal to 1/(15000 x 2048) seconds. Additionally, each radio frame consists of 10 subframes, each of length $30720 \cdot T_s$ = 1 ms, and subframes can be designated as uplink (U), downlink (D), or special subframe (S), depending on the Uplink-Downlink configuration as indicated in Table 4.2-2 of 3GPP TS 36.211. In the transmission duty factor calculation, the special subframe configuration with the shortest UpPTS duration within the special subframe is used and will be applied for measurement. From 3GPP TS 36.211 Table 4.2-1, the shortest UpPTS is 2192 · Ts which occurs in the normal cyclic prefix and special subframe configuration 4.

See table below outlining the calculated transmission duty cycles for each Uplink-Downlink configuration:

Table 5-4
Uplink-Downlink Configurations for Type 2 Frame Structures

Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number										Calculated Transmission Duty Cycle (%)
		0	1	2	3	4	5	6	7	8	9	
0	5 ms	D	S	U	U	U	D	S	U	U	U	61.4%
1	5 ms	D	S	U	U	D	D	S	U	U	D	41.4%
2	5 ms	D	S	U	D	D	D	S	U	D	D	21.4%
3	10 ms	D	S	U	U	U	D	D	D	D	D	30.7%
4	10 ms	D	S	U	U	D	D	D	D	D	D	20.7%
5	10 ms	D	S	U	D	D	D	D	D	D	D	10.7%
6	5 ms	D	S	U	U	U	D	S	U	U	D	51.4%

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a. Power Class 3 Uplink-Downlink Configuration Investigation

Power class 3 was evaluated with the following radio configuration: channel 40620, 20MHz BW, 16QAM, 1RB, 0RB Offset. For Power Class 3, all configurations (0-6) are supported. The configuration which resulted in the worst SNNR was used for full testing. Uplink-Downlink configuration 6 was used as the worst-case configuration for Power Class 3 VoLTE over IMS T-Coil testing. See table below for the SNNR comparison between each Uplink-Downlink configuration:

Table 5-5
Power Class 3 VoLTE over IMS SNNR by UL-DL Configuration

Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	UL-DL Configuration	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
2593.0	40620	20	16QAM	1	0	0	11.54	-43.45	54.99
2593.0	40620	20	16QAM	1	0	1	11.68	-43.39	55.07
2593.0	40620	20	16QAM	1	0	2	11.92	-43.17	55.09
2593.0	40620	20	16QAM	1	0	3	11.59	-46.24	57.83
2593.0	40620	20	16QAM	1	0	4	11.80	-46.38	58.18
2593.0	40620	20	16QAM	1	0	5	11.48	-45.77	57.25
2593.0	40620	20	16QAM	1	0	6	11.53	-43.12	**54.65**

b. Conclusion

Per the investigations above, UL-DL Configuration 6 was used to evaluate Power Class 3 VoLTE over IMS.

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6. VOWIFI TEST SYSTEM SETUP AND DUT CONFIGURATION

I. Test System Setup for VoWIFI over IMS T-coil Testing

1. Equipment Setup

The general test setup used for VoWIFI over IMS, or CMRS WIFI Calling, is shown below. The callbox used when performing VoWIFI over IMS T-coil measurements is a CMW500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server.

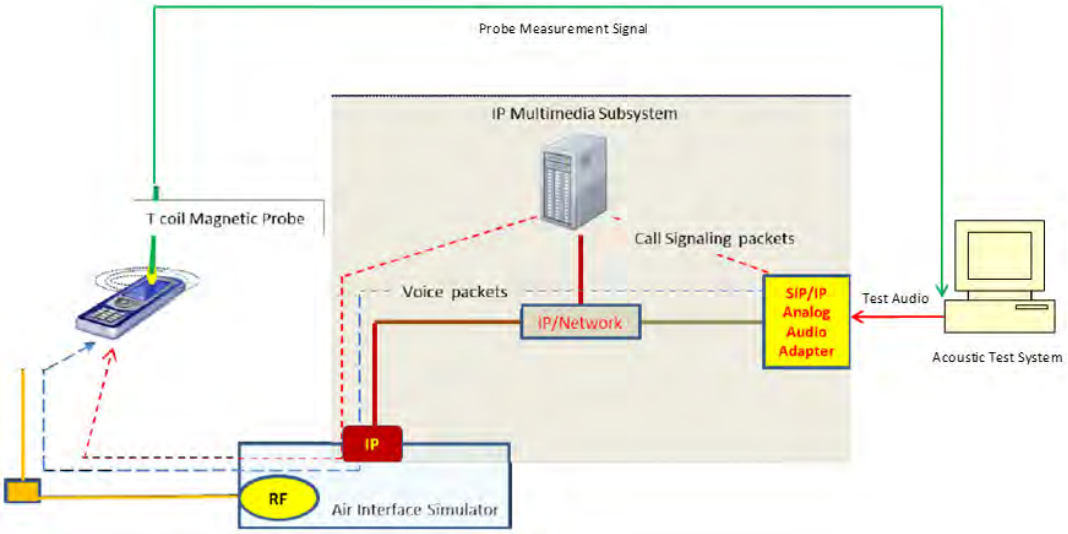

Figure 6-1
Test Setup for VoWIFI over IMS T-Coil Measurements

2. Audio Level Settings

According to KDB 285076 D02 released by the FCC OET regarding the appropriate audio levels to be used for VoWIFI over IMS T-Coil testing, -20dBm0 shall be used for the normal speech input level[2]. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -20dBm0 speech input level to the DUT for the VoWIFI over IMS connection.

[2] FCC Office of Engineering and Technology KDB, "285076 D02 T-Coil Testing for CMRS IP v03," September 13, 2017

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II. DUT Configuration for VoWIFI over IMS T-coil Testing

1. Radio Configuration

An investigation was performed on all applicable data rates and modulations to determine the radio configuration to be used for testing. See tables below for SNNR comparison between radio configurations in each IEEE 802.11 standard:

Table 6-1
IEEE 802.11b SNNR by Radio Configuration

Mode	Channel	Modulation	Data Rate [Mbps]	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11b	6	DSSS	1	7.96	-48.77	56.73
IEEE 802.11b	6	DSSS	2	8.06	-48.27	56.33
IEEE 802.11b	6	CCK	5.5	7.58	-47.68	**55.26**
IEEE 802.11b	6	CCK	11	7.67	-47.82	55.49

Table 6-2
IEEE 802.11g/a SNNR by Radio Configuration

Mode	Channel	Modulation	Data Rate [Mbps]	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11g	6	BPSK	6	7.73	-47.78	**55.51**
IEEE 802.11g	6	BPSK	9	7.95	-47.70	55.65
IEEE 802.11g	6	QPSK	12	7.76	-48.81	56.57
IEEE 802.11g	6	QPSK	18	7.66	-48.89	56.55
IEEE 802.11g	6	16-QAM	24	7.59	-49.36	56.95
IEEE 802.11g	6	16-QAM	36	7.54	-50.44	57.98
IEEE 802.11g	6	64-QAM	48	8.07	-50.70	58.77
IEEE 802.11g	6	64-QAM	54	7.88	-50.11	57.99

Table 6-3
IEEE 802.11n/ac 20MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11n	20	40	BPSK	0	8.03	-48.57	56.60
IEEE 802.11n	20	40	QPSK	1	7.47	-48.99	**56.46**
IEEE 802.11n	20	40	QPSK	2	7.70	-49.47	57.17
IEEE 802.11n	20	40	16-QAM	3	7.99	-48.53	56.52
IEEE 802.11n	20	40	16-QAM	4	7.93	-50.27	58.20
IEEE 802.11n	20	40	64-QAM	5	8.07	-49.31	57.38
IEEE 802.11n	20	40	64-QAM	6	7.62	-50.23	57.85
IEEE 802.11n	20	40	64-QAM	7	7.61	-49.40	57.01
IEEE 802.11ac	20	40	256-QAM	8	8.04	-50.56	58.60

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Table 6-4
IEEE 802.11ax SU 20MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11ax SU	20	40	BPSK	0	8.17	-44.46	52.63
IEEE 802.11ax SU	20	40	QPSK	1	8.26	-44.86	53.12
IEEE 802.11ax SU	20	40	QPSK	2	7.81	-44.66	52.47
IEEE 802.11ax SU	20	40	16-QAM	3	7.65	-44.77	**52.42**
IEEE 802.11ax SU	20	40	16-QAM	4	7.69	-44.99	52.68
IEEE 802.11ax SU	20	40	64-QAM	5	8.10	-45.17	53.27
IEEE 802.11ax SU	20	40	64-QAM	6	7.73	-45.02	52.75
IEEE 802.11ax SU	20	40	64-QAM	7	8.13	-45.02	53.15
IEEE 802.11ax SU	20	40	256-QAM	8	7.75	-45.38	53.13
IEEE 802.11ax SU	20	40	256-QAM	9	7.76	-45.79	53.55
IEEE 802.11ax SU	20	40	1024-QAM	10	8.16	-45.75	53.91
IEEE 802.11ax SU	20	40	1024-QAM	11	7.89	-45.88	53.77

Table 6-5
IEEE 802.11ax RU 20MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	RU Index	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11ax RU	20	40	16-QAM	3	0	7.79	-38.36	46.15
IEEE 802.11ax RU	20	40	16-QAM	3	8	7.46	-38.64	46.10
IEEE 802.11ax RU	20	40	16-QAM	3	37	7.75	-38.53	46.28
IEEE 802.11ax RU	20	40	16-QAM	3	40	7.87	-38.41	46.28
IEEE 802.11ax RU	20	40	16-QAM	3	53	7.90	-38.41	46.31
IEEE 802.11ax RU	20	40	16-QAM	3	54	7.83	-38.22	**46.05**
IEEE 802.11ax RU	20	40	16-QAM	3	61	7.75	-38.49	46.24

Table 6-6
IEEE 802.11n/ac 40MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11n	40	38	BPSK	0	7.71	-49.13	**56.84**
IEEE 802.11n	40	38	QPSK	1	8.01	-49.18	57.19
IEEE 802.11n	40	38	QPSK	2	7.92	-49.38	57.30
IEEE 802.11n	40	38	16-QAM	3	7.72	-50.47	58.19
IEEE 802.11n	40	38	16-QAM	4	7.80	-50.38	58.18
IEEE 802.11n	40	38	64-QAM	5	7.72	-49.88	57.60
IEEE 802.11n	40	38	64-QAM	6	7.84	-49.28	57.12
IEEE 802.11n	40	38	64-QAM	7	7.61	-51.18	58.79
IEEE 802.11ac	40	38	256-QAM	8	7.44	-52.34	59.78
IEEE 802.11ac	40	38	256-QAM	9	7.75	-51.84	59.59

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Table 6-7
IEEE 802.11ax SU 40MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
IEEE 802.11ax SU	40	38	BPSK	0	8.04	-44.85	52.89
IEEE 802.11ax SU	40	38	QPSK	1	7.89	-44.91	**52.80**
IEEE 802.11ax SU	40	38	QPSK	2	8.29	-45.26	53.55
IEEE 802.11ax SU	40	38	16-QAM	3	7.78	-45.17	52.95
IEEE 802.11ax SU	40	38	16-QAM	4	8.31	-45.15	53.46
IEEE 802.11ax SU	40	38	64-QAM	5	7.84	-45.13	52.97
IEEE 802.11ax SU	40	38	64-QAM	6	7.82	-44.99	52.81
IEEE 802.11ax SU	40	38	64-QAM	7	7.79	-45.33	53.12
IEEE 802.11ax SU	40	38	256-QAM	8	8.14	-45.62	53.76
IEEE 802.11ax SU	40	38	256-QAM	9	7.83	-45.61	53.44
IEEE 802.11ax SU	40	38	1024-QAM	10	7.71	-45.46	53.17
IEEE 802.11ax SU	40	38	1024-QAM	11	7.83	-45.21	53.04

Table 6-8
IEEE 802.11ax RU 40MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	RU Index	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
802.11ax RU	40	38	QPSK	1	0	8.21	-45.01	53.22
802.11ax RU	40	38	QPSK	1	17	7.73	-44.91	52.64
802.11ax RU	40	38	QPSK	1	37	7.78	-44.82	**52.60**
802.11ax RU	40	38	QPSK	1	44	7.62	-45.30	52.92
802.11ax RU	40	38	QPSK	1	53	8.16	-45.24	53.40
802.11ax RU	40	38	QPSK	1	56	7.82	-45.13	52.95
802.11ax RU	40	38	QPSK	1	61	8.07	-45.41	53.48
802.11ax RU	40	38	QPSK	1	62	7.60	-45.16	52.76
802.11ax RU	40	38	QPSK	1	65	7.43	-45.31	52.74

2. Codec Configuration

An investigation was performed to determine the audio codec configuration to be used for testing. The effects of codec configuration were found to be independent of radio configuration; therefore, only one radio configuration was used for this investigation. The WB AMR 6.60kbps setting was used for the audio codec on the CMW500 for VoWIFI over IMS T-coil testing. See below table for comparisons between different codecs and codec data rates:

Table 6-9
AMR Codec Investigation – VoWIFI over IMS

Codec Setting:	WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Band	Standard	Channel
ABM1 (dBA/m)	8.73	7.84	9.44	9.20	Axial	2.4GHz	IEEE 802.11b	6
ABM2 (dBA/m)	-49.98	-49.46	-49.93	-49.45				
Frequency Response	Pass	Pass	Pass	Pass				
S+N/N (dB)	58.71	**57.30**	59.37	58.65				

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Table 6-10
EVS Codec Investigation – VoWIFI over IMS

Codec Setting:	EVS Primary SWB 13.2kbps	Orientation	Band	Standard	Channel
ABM1 (dBA/m)	11.11	Axial	2.4GHz	IEEE 802.11b	6
ABM2 (dBA/m)	-48.21				
Frequency Response	Pass				
S+N/N (dB)	59.32				

- Mute on; Backlight off; Max Volume; Max Contrast

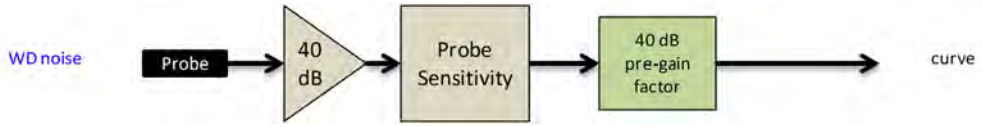

Figure 6-2
Audio Band Magnetic Curve Measurement Block Diagram

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7. OTT VOIP TEST SYSTEM AND DUT CONFIGURATION

I. Test System Setup for OTT VoIP T-Coil Testing

1. OTT VoIP Application

Google Duo is a pre-installed application on the DUT which allows for VoIP calls in a held-to-ear scenario. Duo uses the OPUS audio codec and supports a bitrate range of 6kb/s to 75kb/s. All air interfaces capable of a data connection were evaluated with Google Duo.

2. Equipment Setup

A CMW500 callbox was used to perform OTT VoIP T-coil measurements. The Data Application Unit (DAU) of the CMW500 was connected to the internet and allowed for an IP data connection on the DUT. An auxiliary VoIP unit was used to initiate an OTT VoIP call to the DUT. The auxiliary VoIP unit allowed for the configuration and monitoring of the OTT VoIP codec bitrate during a call. Both high and low bitrate settings were evaluated in to determine the worst-case configuration.

3. Audio Level Settings

According to KDB 285076 D02, the average speech level of -20dBm0 shall be used for protocols not specifically listed in Table 7.1 of ANSI C63.19-2011 or the ANSI C63.19-2011 VoLTE interpretation[3]. The auxiliary VoIP unit allowed for monitoring the signal input level to ensure that the settings for speech input and full scale levels resulted in the -20dBm0 speech input level to the DUT for the OTT VoIP call.

Note: The green highlighted text is approved by FCC under the TCB PAG Re-Use Policy 388624 D01 IV. D. for T-Coil Testing for WI-FI calling and Google Duo.

II. DUT Configuration for OTT VoIP T-Coil Testing

1. Codec Configuration

An investigation was performed for each applicable data mode to determine the audio codec configuration to be used for testing. The effects of codec configuration were found to be independent of radio configuration; therefore, only one radio configuration for each applicable data mode was used for these investigations. The 6kbps codec setting was used for the audio codec on the auxiliary VoIP unit for OTT VoIP T-Coil testing. See below tables for comparisons between codec data rates on all applicable data modes:

Table 7-1
Codec Investigation – OTT VoIP (EvDO)

Codec Setting:	75kbps	6kbps	Orientation	Channel
ABM1 (dBA/m)	22.89	22.91	Axial	600
ABM2 (dBA/m)	-57.17	-55.49		
Frequency Response	Pass	Pass		
S+N/N (dB)	80.06	**78.40**		

[3] FCC Office of Engineering and Technology KDB, "285076 D02 T-Coil Testing for CMRS IP v03," September 13, 2017

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Table 7-2
Codec Investigation – OTT VoIP (EDGE)

Codec Setting:	75kbps	6kbps	Orientation	Channel
ABM1 (dBA/m)	22.97	22.83	Axial	661
ABM2 (dBA/m)	-28.63	-27.50		
Frequency Response	Pass	Pass		
S+N/N (dB)	51.60	**50.33**		

Table 7-3
Codec Investigation – OTT VoIP (HSPA)

Codec Setting:	75kbps	6kbps	Orientation	Channel
ABM1 (dBA/m)	22.99	22.79	Axial	9400
ABM2 (dBA/m)	-54.76	-54.43		
Frequency Response	Pass	Pass		
S+N/N (dB)	77.75	**77.22**		

Table 7-4
Codec Investigation – OTT VoIP (LTE)

Codec Setting:	75kbps	6kbps	Orientation	Band / BW	Channel
ABM1 (dBA/m)	23.23	22.92	Axial	Band 5 10MHz	20525
ABM2 (dBA/m)	-50.49	-50.32			
Frequency Response	Pass	Pass			
S+N/N (dB)	73.72	**73.24**			

Table 7-5
Codec Investigation – OTT VoIP (WIFI)

Codec Setting:	75kbps	6kbps	Orientation	Band	Standard	Channel
ABM1 (dBA/m)	22.84	22.81	Axial	2.4GHz	IEEE 802.11b	6
ABM2 (dBA/m)	-45.68	-44.24				
Frequency Response	Pass	Pass				
S+N/N (dB)	68.52	**67.05**				

- Mute on; Backlight off; Max Volume; Max Contrast
- Radio Configurations can be found in Section 9.II.H

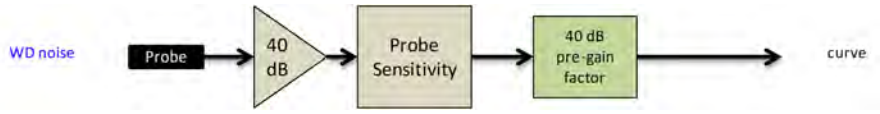

Figure 7-1
Audio Band Magnetic Curve Measurement Block Diagram

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2. Radio Configuration for OTT VoIP (LTE)

An investigation was performed to determine the worst-case LTE band to be used for OTT VoIP testing. LTE FDD Band 13 was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different LTE bands:

Table 7-6
OTT VoIP (LTE FDD) SNNR by LTE Band

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
12	707.5	23095	10	16QAM	1	0	22.70	-50.29	72.99
13	782.0	23230	10	16QAM	1	0	22.91	-47.52	**70.43**
14	793.0	23330	10	16QAM	1	0	22.73	-49.58	72.31
5	836.5	20525	10	16QAM	1	0	22.84	-50.44	73.28
66	1745.0	132322	20	16QAM	1	0	23.19	-50.41	73.60
2	1880.0	18900	20	16QAM	1	0	22.72	-48.21	70.93
30	2310.0	27710	10	16QAM	1	0	22.68	-50.19	72.87

An investigation was performed to determine the worst-case LTE TDD band to be used for OTT VoIP testing. LTE TDD Band 41 Power Class 3 was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different LTE TDD bands:

Table 7-7
OTT VoIP (LTE TDD) SNNR by LTE Band

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
41 (PC3)	2593.0	40620	20	16QAM	1	0	23.03	-42.23	**65.26**
48	3625.0	55990	20	16QAM	1	0	22.80	-44.66	67.46

3. LTE FDD Uplink Carrier Aggregation for OTT VoIP

LTE FDD ULCA was evaluated to ensure LTE FDD standalone was the worst-case scenario. The configuration in Table 7-8 was determined from Table 7-6 and satisfy the configuration requirements as defined in 3GPP 36.101.

Table 7-8
LTE FDD SNNR for OTT VoIP Uplink Carrier Aggregation

Combination	PCC							SCC							ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
	PCC Band	PCC Bandwidth [MHz]	PCC (UL) Channel	PCC (UL) Frequency [MHz]	Modulation	PCC UL# RB	PCC UL RB Offset	SCC Band	SCC Bandwidth [MHz]	SCC (UL) Channel	SCC (UL) Frequency [MHz]	Modulation	SCC UL# RB	SCC UL RB Offset			
CA_5B	LTE B5	10	20525	836.5	16QAM	1	0	LTE B5	5	20453	829.3	16QAM	1	24	22.50	-51.16	73.66

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4. Radio Configuration for OTT VoIP (NR)

An investigation was performed to determine the waveform, modulation, and RB configuration to be used for testing. Due to equipment limitations, the overall worst-case ABM1 from LTE OTT VoIP testing was used with the ABM2 measured for each NR radio configuration. DFT-s-OFDM 16QAM, 1RB, 0 RB offset was determined to be the worst-case configuration for the handset and will be used for full testing in Section 9.

Table 7-9
NR OTT VoIP SNNR by Radio Configuration (CP-OFDM)

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
n5	836.5	167300	20	CP-OFDM	QPSK	1	1	22.47	-48.39	70.86
n5	836.5	167300	20	CP-OFDM	QPSK	1	53	22.47	-48.09	70.56
n5	836.5	167300	20	CP-OFDM	QPSK	1	105	22.47	-48.46	70.93
n5	836.5	167300	20	CP-OFDM	QPSK	53	0	22.47	-49.28	71.75
n5	836.5	167300	20	CP-OFDM	QPSK	53	25	22.47	-48.90	71.37
n5	836.5	167300	20	CP-OFDM	QPSK	53	53	22.47	-49.20	71.67
n5	836.5	167300	20	CP-OFDM	QPSK	106	0	22.47	-49.89	72.36
n5	836.5	167300	20	CP-OFDM	16QAM	1	0	22.47	-47.77	70.24
n5	836.5	167300	20	CP-OFDM	16QAM	1	53	22.47	-47.71	70.18
n5	836.5	167300	20	CP-OFDM	16QAM	1	105	22.47	-47.97	70.44
n5	836.5	167300	20	CP-OFDM	16QAM	53	0	22.47	-48.63	71.10
n5	836.5	167300	20	CP-OFDM	16QAM	53	25	22.47	-49.32	71.79
n5	836.5	167300	20	CP-OFDM	16QAM	53	53	22.47	-49.59	72.06
n5	836.5	167300	20	CP-OFDM	16QAM	106	0	22.47	-49.51	71.98
n5	836.5	167300	20	CP-OFDM	64QAM	1	0	22.47	-47.36	69.83
n5	836.5	167300	20	CP-OFDM	64QAM	1	53	22.47	-47.76	70.23
n5	836.5	167300	20	CP-OFDM	64QAM	1	105	22.47	-47.78	70.25
n5	836.5	167300	20	CP-OFDM	64QAM	53	0	22.47	-49.76	72.23
n5	836.5	167300	20	CP-OFDM	64QAM	53	25	22.47	-49.78	72.25
n5	836.5	167300	20	CP-OFDM	64QAM	53	53	22.47	-49.67	72.14
n5	836.5	167300	20	CP-OFDM	64QAM	106	0	22.47	-49.91	72.38
n5	836.5	167300	20	CP-OFDM	256QAM	1	0	22.47	-48.54	71.01
n5	836.5	167300	20	CP-OFDM	256QAM	1	53	22.47	-49.01	71.48
n5	836.5	167300	20	CP-OFDM	256QAM	1	105	22.47	-48.89	71.36
n5	836.5	167300	20	CP-OFDM	256QAM	53	0	22.47	-49.62	72.09
n5	836.5	167300	20	CP-OFDM	256QAM	53	25	22.47	-49.72	72.19
n5	836.5	167300	20	CP-OFDM	256QAM	53	53	22.47	-49.67	72.14
n5	836.5	167300	20	CP-OFDM	256QAM	106	0	22.47	-49.73	72.20

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Table 7-10
NR OTT VoIP SNNR by Radio Configuration (DFT-s-OFDM)

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	1	0	22.47	-48.70	71.17
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	1	53	22.47	-48.73	71.20
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	1	105	22.47	-48.95	71.42
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	50	0	22.47	-49.89	72.36
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	50	25	22.47	-49.84	72.31
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	50	53	22.47	-49.67	72.14
n5	836.5	167300	20	DFT-s-OFDM	π/2 BPSK	100	0	22.47	-49.75	72.22
n5	836.5	167300	20	DFT-s-OFDM	QPSK	1	1	22.47	-49.29	71.76
n5	836.5	167300	20	DFT-s-OFDM	QPSK	1	53	22.47	-49.42	71.89
n5	836.5	167300	20	DFT-s-OFDM	QPSK	1	105	22.47	-49.44	71.91
n5	836.5	167300	20	DFT-s-OFDM	QPSK	50	0	22.47	-49.78	72.25
n5	836.5	167300	20	DFT-s-OFDM	QPSK	50	25	22.47	-49.82	72.29
n5	836.5	167300	20	DFT-s-OFDM	QPSK	50	53	22.47	-49.80	72.27
n5	836.5	167300	20	DFT-s-OFDM	QPSK	100	0	22.47	-49.54	72.01
n5	836.5	167300	20	DFT-s-OFDM	16QAM	1	0	22.47	-46.44	**68.91**
n5	836.5	167300	20	DFT-s-OFDM	16QAM	1	53	22.47	-46.76	69.23
n5	836.5	167300	20	DFT-s-OFDM	16QAM	1	105	22.47	-46.61	69.08
n5	836.5	167300	20	DFT-s-OFDM	16QAM	50	0	22.47	-49.42	71.89
n5	836.5	167300	20	DFT-s-OFDM	16QAM	50	25	22.47	-49.59	72.06
n5	836.5	167300	20	DFT-s-OFDM	16QAM	50	53	22.47	-49.21	71.68
n5	836.5	167300	20	DFT-s-OFDM	16QAM	100	0	22.47	-49.43	71.90
n5	836.5	167300	20	DFT-s-OFDM	64QAM	1	0	22.47	-46.98	69.45
n5	836.5	167300	20	DFT-s-OFDM	64QAM	1	53	22.47	-47.09	69.56
n5	836.5	167300	20	DFT-s-OFDM	64QAM	1	105	22.47	-47.29	69.76
n5	836.5	167300	20	DFT-s-OFDM	64QAM	50	0	22.47	-48.25	70.72
n5	836.5	167300	20	DFT-s-OFDM	64QAM	50	25	22.47	-49.69	72.16
n5	836.5	167300	20	DFT-s-OFDM	64QAM	50	53	22.47	-49.75	72.22
n5	836.5	167300	20	DFT-s-OFDM	64QAM	100	0	22.47	-49.86	72.33
n5	836.5	167300	20	DFT-s-OFDM	256QAM	1	0	22.47	-47.69	70.16
n5	836.5	167300	20	DFT-s-OFDM	256QAM	1	53	22.47	-48.13	70.60
n5	836.5	167300	20	DFT-s-OFDM	256QAM	1	105	22.47	-48.17	70.64
n5	836.5	167300	20	DFT-s-OFDM	256QAM	50	0	22.47	-49.62	72.09
n5	836.5	167300	20	DFT-s-OFDM	256QAM	50	25	22.47	-49.64	72.11
n5	836.5	167300	20	DFT-s-OFDM	256QAM	50	53	22.47	-49.46	71.93
n5	836.5	167300	20	DFT-s-OFDM	256QAM	100	0	22.47	-49.70	72.17

An investigation was performed to determine the worst-case NR band to be used for OTT VoIP testing. NR n5 was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different NR bands:

Table 7-11
OTT VoIP (NR) SNNR by Band

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	SNNR [dB]
n5	836.5	167300	20	DFT-s-OFDM	16QAM	1	0	22.47	-46.63	**69.10**
n66	1745.0	349000	20	DFT-s-OFDM	16QAM	1	0	22.47	-48.54	71.01
n2	1880.0	376000	20	DFT-s-OFDM	16QAM	1	0	22.47	-47.68	70.15

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8. FCC 3G MEASUREMENTS

I. CDMA Test Configurations

Radio Configuration 1, Service Option 3 (thick, green data curve) was used for the testing as the worst-case configuration for the handset due to vocoder gating from the EVRC logic. See below plot for ABM noise comparison between operational field service options and radio configurations for a CDMA2000 handset:

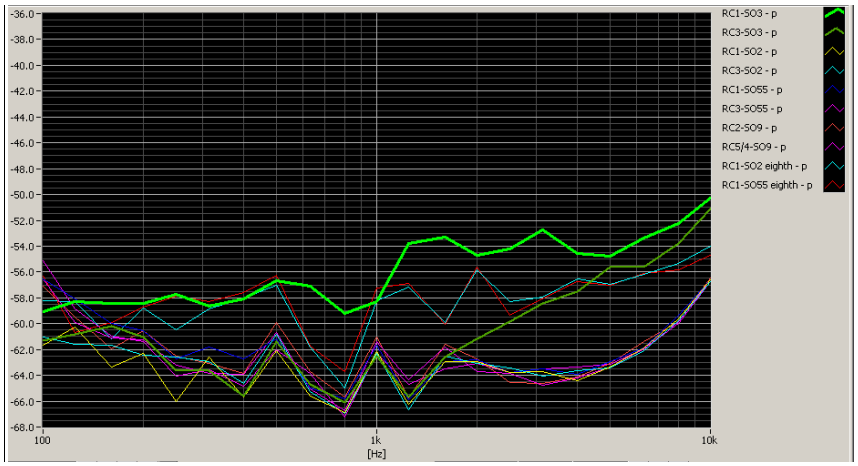

Figure 8-1
CDMA Audio Band Magnetic Noise

Table 8-1
FCC 3G ABM Measurements for ZNFV600VM (CDMA)

Configuration:	RC1/SO3	RC3/SO3	RC4/SO3	Orientation	Channel
ABM1 (dBA/m)	17.11	16.71	16.89	Axial	384
ABM2 (dBA/m)	-46.52	-59.78	-60.11		
Frequency Response	Pass	Pass	Pass		
S+N/N (dB)	63.63	76.49	77.00		

- Mute on; Backlight off; Max Volume; Max Contrast
- Power Control Bits = "All Up"

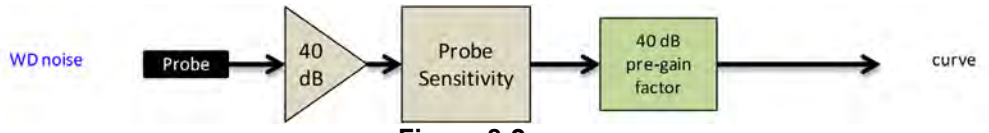

Figure 8-2
Audio Band Magnetic Curve Measurement Block Diagram

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II. UMTS Test Configurations

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

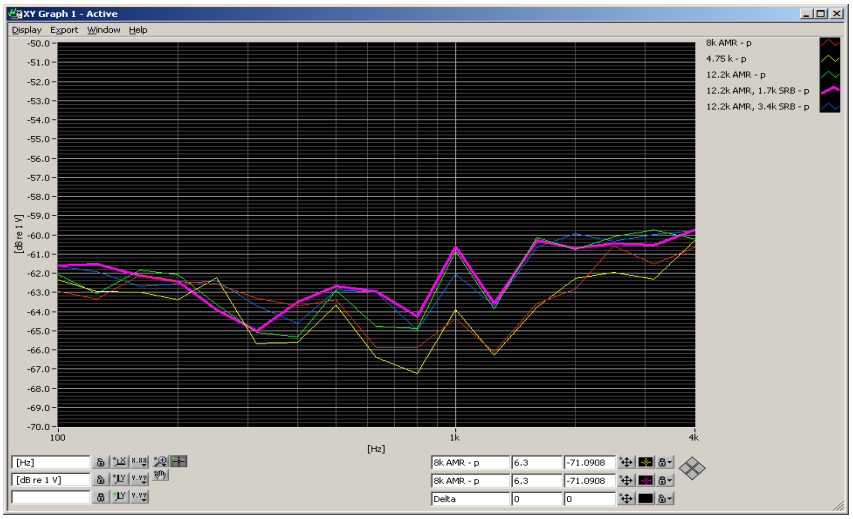

Figure 8-3
UMTS Audio Band Magnetic Noise

Table 8-2
Codec Investigation - UMTS

Codec Setting:	AMR 12.2kbps	AMR 7.95kbps	AMR 4.75kbps	Orientation	Channel
ABM1 (dBA/m)	13.62	13.84	13.86	Axial	9400
ABM2 (dBA/m)	-59.27	-59.11	-59.53		
Frequency Response	Pass	Pass	Pass		
S+N/N (dB)	72.89	72.95	73.39		

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

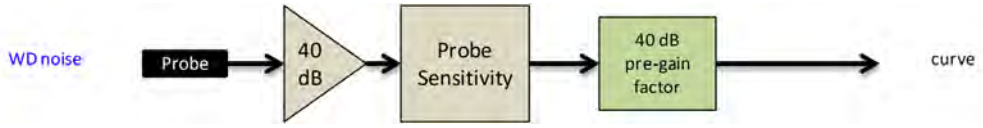

Figure 8-4
Audio Band Magnetic Curve Measurement Block Diagram

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9. T-COIL TEST SUMMARY

Table 9-1
Consolidated Tabled Results

C63.19 Section		Freq. Response Margin		Magnetic Intensity Verdict		FCC SNNR Verdict		Margin from FCC Limit (dB)	C63.19-2011 Rating
		8.3.2		8.3.1		8.3.4			
		Axial	Radial	Axial	Radial	Axial	Radial		
CDMA	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-34.00	T4
	PCS	PASS	NA	PASS	PASS	PASS	PASS		
EvDO (OTT VoIP)	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-51.56	T4
	PCS	PASS	NA	PASS	PASS	PASS	PASS		
GSM	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-24.90	T4
	PCS	PASS	NA	PASS	PASS	PASS	PASS		
EDGE (OTT VoIP)	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-26.18	T4
	PCS	PASS	NA	PASS	PASS	PASS	PASS		
UMTS	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-54.70	T4
	AWS	PASS	NA	PASS	PASS	PASS	PASS		
	PCS	PASS	NA	PASS	PASS	PASS	PASS		
HSPA (OTT VoIP)	Cellular	PASS	NA	PASS	PASS	PASS	PASS	-52.51	T4
	AWS	PASS	NA	PASS	PASS	PASS	PASS		
	PCS	PASS	NA	PASS	PASS	PASS	PASS		
LTE FDD	B12	PASS	NA	PASS	PASS	PASS	PASS	-31.40	T4
	B13	PASS	NA	PASS	PASS	PASS	PASS		
	B14	PASS	NA	PASS	PASS	PASS	PASS		
	B5	PASS	NA	PASS	PASS	PASS	PASS		
	B66	PASS	NA	PASS	PASS	PASS	PASS		
	B2	PASS	NA	PASS	PASS	PASS	PASS		
	B30	PASS	NA	PASS	PASS	PASS	PASS		
LTE FDD (OTT VoIP)	B13	PASS	NA	PASS	PASS	PASS	PASS	-43.76	T4
LTE TDD	B41 (PC3)	PASS	NA	PASS	PASS	PASS	PASS	-27.67	T4
	B48	PASS	NA	PASS	PASS	PASS	PASS		
LTE TDD (OTT VoIP)	B41 (PC3)	PASS	NA	PASS	PASS	PASS	PASS	-37.99	T4
NR FDD (OTT VoIP)	n5	NA	NA	PASS	PASS	PASS	PASS	-40.52	T4
WLAN	IEEE 802.11b	PASS	NA	PASS	PASS	PASS	PASS	-18.78	T4
	IEEE 802.11g	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11n	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ac	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax SU	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax RU	PASS	NA	PASS	PASS	PASS	PASS		
WLAN (OTT VoIP)	IEEE 802.11b	PASS	NA	PASS	PASS	PASS	PASS	-30.56	T4
	IEEE 802.11g	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11n	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ac	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax SU	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax RU	PASS	NA	PASS	PASS	PASS	PASS		
U-NII	IEEE 802.11a	PASS	NA	PASS	PASS	PASS	PASS	-22.34	T4
	IEEE 802.11n	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ac	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax SU	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax RU	PASS	NA	PASS	PASS	PASS	PASS		
U-NII (OTT VoIP)	IEEE 802.11a	PASS	NA	PASS	PASS	PASS	PASS	-28.87	T4
	IEEE 802.11n	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ac	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax SU	PASS	NA	PASS	PASS	PASS	PASS		
	IEEE 802.11ax RU	PASS	NA	PASS	PASS	PASS	PASS		

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I. Raw Handset Data

Table 9-2
Raw Data Results for CDMA

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
Cellular	Axial	1013	00288	16.93	-46.50	-64.41	2.00	63.43	20.00	-43.43	T4	1.8, 4.2
		384	00288	16.82	-47.01		2.00	63.83	20.00	-43.83	T4	
		777	00288	16.86	-45.24		2.00	62.10	20.00	-42.10	T4	
	Radial	1013	00288	9.90	-44.10	-62.97	N/A	54.00	20.00	-34.00	T4	1.8, 3.2
		384	00288	10.13	-44.68			54.81	20.00	-34.81	T4	
		777	00288	10.22	-44.75			54.97	20.00	-34.97	T4	
PCS	Axial	25	00288	16.80	-45.44	-64.41	2.00	62.24	20.00	-42.24	T4	1.8, 4.2
		600	00288	17.01	-46.05		2.00	63.06	20.00	-43.06	T4	
		1175	00288	17.01	-47.19		2.00	64.20	20.00	-44.20	T4	
	Radial	25	00288	10.03	-49.50	-62.97	N/A	59.53	20.00	-39.53	T4	1.8, 3.2
		600	00288	9.99	-50.44			60.43	20.00	-40.43	T4	
		1175	00288	10.30	-51.40			61.70	20.00	-41.70	T4	

Table 9-3
Raw Data Results for GSM

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
GSM850	Axial	128	00288	21.17	-23.73	-61.48	2.00	44.90	20.00	-24.90	T4	1.8, 4.2
		190	00288	20.63	-24.75		2.00	45.38	20.00	-25.38	T4	
		251	00288	21.11	-25.13		2.00	46.24	20.00	-26.24	T4	
	Radial	128	00288	14.84	-34.26	-62.41	N/A	49.10	20.00	-29.10	T4	1.8, 3.2
		190	00288	14.83	-35.06			49.89	20.00	-29.89	T4	
		251	00288	14.93	-35.44			50.37	20.00	-30.37	T4	
GSM1900	Axial	512	00288	21.17	-24.66	-61.48	2.00	45.83	20.00	-25.83	T4	1.8, 4.2
		661	00288	21.32	-24.03		2.00	45.35	20.00	-25.35	T4	
		810	00288	21.19	-25.74		2.00	46.93	20.00	-26.93	T4	
	Radial	512	00288	14.92	-34.97	-62.41	N/A	49.89	20.00	-29.89	T4	1.8, 3.2
		661	00288	14.83	-34.36			49.19	20.00	-29.19	T4	
		810	00288	14.46	-36.00			50.46	20.00	-30.46	T4	

Table 9-4
Raw Data Results for UMTS

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
UMTS V	Axial	4132	00288	19.49	-59.56	-61.48	2.00	79.05	20.00	-59.05	T4	1.8, 4.2
		4183	00288	19.99	-59.38		2.00	79.37	20.00	-59.37	T4	
		4233	00288	19.97	-59.64		2.00	79.61	20.00	-59.61	T4	
	Radial	4132	00288	13.47	-61.51	-62.41	N/A	74.98	20.00	-54.98	T4	1.8, 3.2
		4183	00288	13.48	-61.44			74.92	20.00	-54.92	T4	
		4233	00288	13.49	-61.21			74.70	20.00	-54.70	T4	
UMTS IV	Axial	1312	00288	19.31	-59.00	-61.48	2.00	78.31	20.00	-58.31	T4	1.8, 4.2
		1412	00288	20.01	-58.91		2.00	78.92	20.00	-58.92	T4	
		1513	00288	20.02	-59.76		2.00	79.78	20.00	-59.78	T4	
	Radial	1312	00288	13.48	-61.54	-62.41	N/A	75.02	20.00	-55.02	T4	1.8, 3.2
		1412	00288	13.48	-61.86			75.34	20.00	-55.34	T4	
		1513	00288	13.48	-61.64			75.12	20.00	-55.12	T4	
UMTS II	Axial	9262	00288	20.03	-59.26	-61.48	2.00	79.29	20.00	-59.29	T4	1.8, 4.2
		9400	00288	20.00	-59.19		2.00	79.19	20.00	-59.19	T4	
		9538	00288	20.02	-59.25		2.00	79.27	20.00	-59.27	T4	
	Radial	9262	00288	13.51	-61.32	-62.41	N/A	74.83	20.00	-54.83	T4	1.8, 3.2
		9400	00288	13.52	-61.28			74.80	20.00	-54.80	T4	
		9538	00288	13.51	-61.55			75.06	20.00	-55.06	T4	

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Table 9-5
Raw Data Results for LTE B12

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 12	Axial	10MHz	23095	00288	11.75	-51.49	-59.32	1.21	63.24	20.00	-43.24	T4	1.8, 4.2
		5MHz	23095	00288	11.95	-51.84		1.39	63.79	20.00	-43.79	T4	
		3MHz	23095	00288	11.81	-52.28		1.22	64.09	20.00	-44.09	T4	
		1.4MHz	23095	00288	11.79	-52.51		1.13	64.30	20.00	-44.30	T4	
	Radial	10MHz	23095	00288	4.89	-49.29	-62.97	N/A	54.18	20.00	-34.18	T4	1.8, 3.2
		5MHz	23095	00288	5.22	-49.59			54.81	20.00	-34.81	T4	
		3MHz	23095	00288	5.21	-50.84			56.05	20.00	-36.05	T4	
		1.4MHz	23095	00288	5.25	-49.34			54.59	20.00	-34.59	T4	

Table 9-6
Raw Data Results for LTE B13

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 13	Axial	10MHz	23230	00288	11.67	-48.94	-59.32	1.38	60.61	20.00	-40.61	T4	1.8, 4.2
		5MHz	23255	00288	11.66	-51.65		1.35	63.31	20.00	-43.31	T4	
		5MHz	23230	00288	11.72	-47.83		1.29	59.55	20.00	-39.55	T4	
		5MHz	23205	00288	11.68	-47.96		1.35	59.64	20.00	-39.64	T4	
	Radial	10MHz	23230	00288	5.15	-46.25	-62.97	N/A	51.40	20.00	-31.40	T4	1.8, 3.2
		5MHz	23230	00288	5.28	-48.07			53.35	20.00	-33.35	T4	

Table 9-7
Raw Data Results for LTE B14

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 14	Axial	10MHz	23330	00288	11.65	-49.83	-59.32	1.34	61.48	20.00	-41.48	T4	1.8, 4.2
		5MHz	23330	00288	11.65	-51.13		1.28	62.78	20.00	-42.78	T4	
	Radial	10MHz	23330	00288	5.14	-47.73	-62.97	N/A	52.87	20.00	-32.87	T4	1.8, 3.2
		5MHz	23330	00288	5.11	-50.66			55.77	20.00	-35.77	T4	

Table 9-8
Raw Data Results for LTE B5

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 5	Axial	10MHz	20525	00288	11.69	-53.20	-59.32	1.71	64.89	20.00	-44.89	T4	1.8, 4.2
		5MHz	20525	00288	11.84	-52.12		1.15	63.96	20.00	-43.96	T4	
		3MHz	20525	00288	11.60	-52.30		1.20	63.90	20.00	-43.90	T4	
		1.4MHz	20525	00288	11.58	-51.39		1.13	62.97	20.00	-42.97	T4	
	Radial	10MHz	20525	00288	4.88	-50.44	-62.97	N/A	55.32	20.00	-35.32	T4	1.8, 3.2
		5MHz	20525	00288	5.17	-50.30			55.47	20.00	-35.47	T4	
		3MHz	20525	00288	5.09	-50.36			55.45	20.00	-35.45	T4	
		1.4MHz	20525	00288	5.14	-49.36			54.50	20.00	-34.50	T4	

Table 9-9
Raw Data Results for LTE B66

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 66	Axial	20MHz	132322	00288	11.60	-51.93	-59.32	1.37	63.53	20.00	-43.53	T4	1.8, 4.2
		15MHz	132322	00288	11.64	-52.20		1.34	63.84	20.00	-43.84	T4	
		10MHz	132322	00288	11.76	-52.44		1.24	64.20	20.00	-44.20	T4	
		5MHz	132322	00288	11.44	-51.65		1.21	63.09	20.00	-43.09	T4	
		3MHz	132322	00288	11.66	-52.04		1.23	63.70	20.00	-43.70	T4	
		1.4MHz	132322	00288	11.80	-50.76		1.21	62.56	20.00	-42.56	T4	
	Radial	20MHz	132322	00288	5.00	-52.45	-62.97	N/A	57.45	20.00	-37.45	T4	1.8, 3.2
		15MHz	132322	00288	5.00	-52.50			57.50	20.00	-37.50	T4	
		10MHz	132322	00288	5.26	-52.31			57.57	20.00	-37.57	T4	
		5MHz	132322	00288	4.89	-50.36			55.25	20.00	-35.25	T4	
		3MHz	132322	00288	4.98	-51.87			56.85	20.00	-36.85	T4	
		1.4MHz	132322	00288	5.28	-52.58			57.86	20.00	-37.86	T4	

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Table 9-10
Raw Data Results for LTE B2

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 2	Axial	20MHz	18900	00288	11.73	-48.49	-59.32	1.22	60.22	20.00	-40.22	T4	1.8, 4.2
		15MHz	18900	00288	11.97	-49.86		1.38	61.83	20.00	-41.83	T4	
		10MHz	18900	00288	11.53	-50.98		1.12	62.51	20.00	-42.51	T4	
		5MHz	18900	00288	11.55	-51.50		1.24	63.05	20.00	-43.05	T4	
		3MHz	18900	00288	11.62	-52.41		1.17	64.03	20.00	-44.03	T4	
		1.4MHz	18900	00288	11.82	-52.85		1.20	64.67	20.00	-44.67	T4	
	Radial	20MHz	18900	00288	5.30	-49.24	-62.97	N/A	54.54	20.00	-34.54	T4	1.8, 3.2
		15MHz	18900	00288	4.95	-49.58			54.53	20.00	-34.53	T4	
		10MHz	18900	00288	4.92	-50.68			55.60	20.00	-35.60	T4	
		5MHz	18900	00288	4.98	-51.62			56.60	20.00	-36.60	T4	
		3MHz	18900	00288	4.99	-52.29			57.28	20.00	-37.28	T4	
		1.4MHz	18900	00288	5.25	-52.87			58.12	20.00	-38.12	T4	

Table 9-11
Raw Data Results for LTE B30

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 30	Axial	10MHz	27710	00288	11.59	-50.96	-59.32	1.28	62.55	20.00	-42.55	T4	1.8, 4.2
		5MHz	27710	00288	11.68	-49.31		1.28	60.99	20.00	-40.99	T4	
	Radial	10MHz	27710	00288	5.00	-50.95	-62.97	N/A	55.95	20.00	-35.95	T4	1.8, 3.2
		5MHz	27710	00288	5.05	-48.97			54.02	20.00	-34.02	T4	

Table 9-12
Raw Data Results for LTE B41 – Power Class 3

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 41	Axial	20MHz	40620	00288	11.60	-43.19	-59.32	1.33	54.79	20.00	-34.79	T4	1.8, 4.2
		15MHz	41490	00288	11.82	-43.43		1.16	55.25	20.00	-35.25	T4	
		15MHz	41055	00288	11.63	-43.76		1.46	55.39	20.00	-35.39	T4	
		15MHz	40620	00288	11.66	-42.93		1.29	54.59	20.00	-34.59	T4	
		15MHz	40185	00288	11.66	-42.93		1.21	54.59	20.00	-34.59	T4	
		15MHz	39750	00288	11.83	-41.82		1.26	53.65	20.00	-33.65	T4	
		10MHz	40620	00288	11.56	-44.19		1.18	55.75	20.00	-35.75	T4	
		5MHz	40620	00288	11.67	-43.74		0.96	55.41	20.00	-35.41	T4	
	Radial	20MHz	41490	00288	5.08	-44.13	-62.97	N/A	49.21	20.00	-29.21	T4	1.8, 3.2
		20MHz	41055	00288	5.03	-45.54			50.57	20.00	-30.57	T4	
		20MHz	40620	00288	5.14	-44.48			49.62	20.00	-29.62	T4	
		20MHz	40185	00288	5.13	-44.05			49.18	20.00	-29.18	T4	
		20MHz	39750	00288	5.04	-42.63			47.67	20.00	-27.67	T4	
		15MHz	40620	00288	5.16	-45.23			50.39	20.00	-30.39	T4	
		10MHz	40620	00288	5.20	-45.83			51.03	20.00	-31.03	T4	
		5MHz	40620	00288	5.29	-45.80			51.09	20.00	-31.09	T4	

Table 9-13
Raw Data Results for LTE B48

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 48	Axial	20MHz	55990	00288	11.85	-44.27	-59.32	1.28	56.12	20.00	-36.12	T4	1.8, 4.2
		15MHz	55990	00288	11.56	-45.56		1.27	57.12	20.00	-37.12	T4	
		10MHz	55990	00288	11.66	-45.40		1.34	57.06	20.00	-37.06	T4	
		5MHz	55990	00288	11.60	-45.38		1.09	56.98	20.00	-36.98	T4	
	Radial	20MHz	55990	00288	5.11	-44.53	-62.97	N/A	49.64	20.00	-29.64	T4	1.8, 3.2
		15MHz	55990	00288	5.39	-44.38			49.77	20.00	-29.77	T4	
		10MHz	55990	00288	5.40	-44.55			49.95	20.00	-29.95	T4	
		5MHz	55990	00288	5.10	-44.84			49.94	20.00	-29.94	T4	

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Table 9-14
Raw Data Results for 2.4GHz WIFI

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11b	Axial	6	00288	7.29	-48.14	-60.06	1.26	55.43	20.00	-35.43	T4	1.8, 4.2
	Radial	6	00288	0.43	-43.87	-62.97	N/A	44.30	20.00	-24.30	T4	1.8, 3.2
IEEE 802.11g	Axial	6	00288	8.12	-46.59	-60.06	1.27	54.71	20.00	-34.71	T4	1.8, 4.2
	Radial	6	00288	0.55	-41.62	-62.97	N/A	42.17	20.00	-22.17	T4	1.8, 3.2
IEEE 802.11n	Axial	6	00288	7.95	-49.56	-60.06	1.00	57.51	20.00	-37.51	T4	1.8, 4.2
	Radial	6	00288	0.18	-49.51	-62.97	N/A	49.69	20.00	-29.69	T4	1.8, 3.2
IEEE 802.11ac	Axial	6	00288	7.63	-49.72	-60.06	1.22	57.35	20.00	-37.35	T4	1.8, 4.2
	Radial	6	00288	0.75	-49.49	-62.97	N/A	50.24	20.00	-30.24	T4	1.8, 3.2
IEEE 802.11ax SU	Axial	6	00288	7.63	-48.27	-60.59	1.36	55.90	20.00	-35.90	T4	1.8, 4.2
	Radial	6	00288	0.20	-44.84	-61.11	N/A	45.04	20.00	-25.04	T4	1.8, 3.2
IEEE 802.11ax RU	Axial	1	00288	8.33	-41.59	-60.59	1.36	49.92	20.00	-29.92	T4	1.8, 4.2
		6	00288	7.70	-41.93		1.27	49.63	20.00	-29.63	T4	
		11	00288	8.04	-41.85		1.35	49.89	20.00	-29.89	T4	
	Radial	1	00288	0.48	-38.30	-61.11	N/A	38.78	20.00	-18.78	T4	1.8, 3.2
		6	00288	0.49	-38.78			39.27	20.00	-19.27	T4	
		11	00288	0.55	-38.32			38.87	20.00	-18.87	T4	

Table 9-15
Raw Data Results for 5GHz WIFI IEEE 802.11a

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11a	Axial	20MHz	1	40	00288	7.97	-49.78	-60.06	1.22	57.75	20.00	-37.75	T4	1.8, 4.2
	Radial	20MHz	1	40	00288	0.50	-44.48	-61.11	N/A	44.98	20.00	-24.98	T4	1.8, 3.2

Table 9-16
Raw Data Results for 5GHz WIFI IEEE 802.11n

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11n	Axial	40MHz	1	38	00288	7.96	-48.27	-60.06	1.24	56.23	20.00	-36.23	T4	1.8, 4.2
		20MHz	1	40	00288	7.64	-48.61		1.27	56.25	20.00	-36.25	T4	
	Radial	40MHz	1	38	00288	0.89	-44.53	-61.11	N/A	45.42	20.00	-25.42	T4	1.8, 3.2
		20MHz	1	40	00288	0.39	-45.22			45.61	20.00	-25.61	T4	

Table 9-17
Raw Data Results for 5GHz WIFI IEEE 802.11ac

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11ac	Axial	40MHz	1	38	00288	7.46	-51.12	-60.06	1.24	58.58	20.00	-38.58	T4	1.8, 4.2
		20MHz	1	40	00288	7.80	-50.56		1.25	58.36	20.00	-38.36	T4	
	Radial	40MHz	1	38	00288	0.41	-46.06	-61.11	N/A	46.47	20.00	-26.47	T4	1.8, 3.2
		20MHz	1	40	00288	0.56	-45.82			46.38	20.00	-26.38	T4	

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Table 9-18
Raw Data Results for 5GHz WIFI IEEE 802.11ax

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11ax SU	Axial	40MHz	1	38	00288	7.67	-44.93	-60.59	1.22	52.60	20.00	-32.60	T4	1.8, 4.2
		20MHz	1	40	00288	7.76	-44.59		1.37	52.35	20.00	-32.35	T4	
	Radial	40MHz	1	38	00288	0.58	-41.76	-61.11	N/A	42.34	20.00	-22.34	T4	1.8, 3.2
		20MHz	1	40	00288	-0.04	-42.95			42.91	20.00	-22.91	T4	
IEEE 802.11ax RU	Axial	40MHz	1	38	00288	7.64	-44.25	-60.59	1.30	51.89	20.00	-31.89	T4	1.8, 4.2
		20MHz	1	36	00288	8.22	-38.82		1.37	47.04	20.00	-27.04	T4	
		20MHz	1	40	00288	7.74	-39.36		1.35	47.10	20.00	-27.10	T4	
		20MHz	1	48	00288	8.22	-38.91		1.36	47.13	20.00	-27.13	T4	
		40MHz	2A	54	00288	7.59	-45.21		1.38	52.80	20.00	-32.80	T4	
		20MHz	2A	56	00288	7.16	-44.16		1.25	51.32	20.00	-31.32	T4	
		40MHz	2C	118	00288	8.26	-43.51		1.43	51.77	20.00	-31.77	T4	
		20MHz	2C	120	00288	7.93	-45.35		1.39	53.28	20.00	-33.28	T4	
		40MHz	3	151	00288	7.88	-46.98		1.36	54.86	20.00	-34.86	T4	
		20MHz	3	157	00288	7.87	-48.18		1.42	56.05	20.00	-36.05	T4	
	Radial	40MHz	1	38	00288	0.57	-36.50	-61.11	N/A	37.07	20.00	-17.07	T4	1.8, 3.2
		20MHz	1	40	00288	0.57	-36.57			37.14	20.00	-17.14	T4	
		40MHz	2A	54	00288	0.37	-37.32			37.69	20.00	-17.69	T4	
		20MHz	2A	52	00288	0.62	-37.04			37.66	20.00	-17.66	T4	
		20MHz	2A	56	00288	0.02	-36.79			36.81	20.00	-16.81	T4	
		20MHz	2A	64	00288	0.66	-37.15			37.81	20.00	-17.81	T4	
		40MHz	2C	118	00288	-0.02	-36.92			36.90	20.00	-16.90	T4	
		20MHz	2C	120	00288	0.72	-36.52			37.24	20.00	-17.24	T4	
		40MHz	3	151	00288	0.55	-39.09			39.64	20.00	-19.64	T4	
		20MHz	3	157	00288	0.79	-38.13			38.92	20.00	-18.92	T4	

Table 9-19
Raw Data Results for EvDO (OTT VoIP)

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
Cellular EvDO	Axial	384	00288	22.43	-57.24	-60.12	1.10	79.67	20.00	-59.67	T4	1.8, 4.2
	Radial	384	00288	14.57	-57.91	-62.97	N/A	72.48	20.00	-52.48	T4	1.8, 3.2
PCS EvDO	Axial	600	00288	22.73	-55.96	-60.12	1.14	78.69	20.00	-58.69	T4	1.8, 4.2
	Radial	600	00288	14.56	-57.00	-62.97	N/A	71.56	20.00	-51.56	T4	1.8, 3.2

Table 9-20
Raw Data Results for EDGE (OTT VoIP)

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
EDGE850	Axial	190	00288	22.56	-28.08	-60.12	1.20	50.64	20.00	-30.64	T4	1.8, 4.2
	Radial	190	00288	14.52	-31.66	-62.97	N/A	46.18	20.00	-26.18	T4	1.8, 3.2
EDGE1900	Axial	661	00288	23.00	-27.36	-60.12	1.10	50.36	20.00	-30.36	T4	1.8, 4.2
	Radial	661	00288	14.39	-34.46	-62.97	N/A	48.85	20.00	-28.85	T4	1.8, 3.2

Table 9-21
Raw Data Results for HSPA (OTT VoIP)

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
HSPA V	Axial	4183	00288	22.98	-56.13	-60.12	1.35	79.11	20.00	-59.11	T4	1.8, 4.2
	Radial	4183	00288	14.64	-58.08	-62.97	N/A	72.72	20.00	-52.72	T4	1.8, 3.2
HSPA IV	Axial	1412	00288	22.94	-55.91	-60.12	1.24	78.85	20.00	-58.85	T4	1.8, 4.2
	Radial	1412	00288	14.45	-58.06	-62.97	N/A	72.51	20.00	-52.51	T4	1.8, 3.2
HSPA II	Axial	9400	00288	22.53	-54.54	-60.12	1.19	77.07	20.00	-57.07	T4	1.8, 4.2
	Radial	9400	00288	14.60	-58.56	-62.97	N/A	73.16	20.00	-53.16	T4	1.8, 3.2

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Table 9-22
Raw Data Results for LTE B13 (OTT VoIP)

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 13	Axial	10MHz	23230	00288	22.98	-47.18	-60.12	1.21	70.16	20.00	-50.16	T4	1.8, 4.2
		5MHz	23230	00288	22.65	-48.46		1.27	71.11	20.00	-51.11	T4	
	Radial	10MHz	23230	00288	14.72	-49.04	-62.97	N/A	63.76	20.00	-43.76	T4	1.8, 3.2
		5MHz	23230	00288	14.76	-51.02			65.78	20.00	-45.78	T4	

Table 9-23
Raw Data Results for LTE B41 - Power Class 3 (OTT VoIP)

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
LTE Band 41	Axial	20MHz	41490	00288	22.59	-41.28	-60.12	1.32	63.87	20.00	-43.87	T4	1.8, 4.2
		20MHz	41055	00288	22.50	-43.56		1.28	66.06	20.00	-46.06	T4	
		20MHz	40620	00288	22.52	-41.93		0.95	64.45	20.00	-44.45	T4	
		20MHz	40185	00288	22.75	-42.44		1.31	65.19	20.00	-45.19	T4	
		20MHz	39750	00288	22.47	-40.46		1.29	62.93	20.00	-42.93	T4	
		15MHz	40620	00288	22.65	-42.06		1.29	64.71	20.00	-44.71	T4	
		10MHz	40620	00288	22.86	-42.52		1.42	65.38	20.00	-45.38	T4	
		5MHz	40620	00288	22.64	-42.38		1.32	65.02	20.00	-45.02	T4	
	Radial	20MHz	40620	00288	14.76	-44.60	-62.97	N/A	59.36	20.00	-39.36	T4	1.8, 3.2
		15MHz	41490	00288	14.67	-44.09			58.76	20.00	-38.76	T4	
		15MHz	41055	00288	14.46	-43.53			57.99	20.00	-37.99	T4	
		15MHz	40620	00288	14.67	-44.47			59.14	20.00	-39.14	T4	
		15MHz	40185	00288	14.45	-43.64			58.09	20.00	-38.09	T4	
		15MHz	39750	00288	14.44	-44.03			58.47	20.00	-38.47	T4	
		10MHz	40620	00288	14.79	-45.27			60.06	20.00	-40.06	T4	
		5MHz	40620	00288	14.71	-45.48			60.19	20.00	-40.19	T4	

Table 9-24
Raw Data Results for NR n5 (OTT VoIP)

Mode	Orientation	Bandwidth	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
NR n5	Axial	20MHz	167800	00387	22.47	-46.49	-60.59	N/A	68.96	20.00	-48.96	T4	1.8, 4.2
		20MHz	167300	00387	22.47	-46.08			68.55	20.00	-48.55	T4	
		20MHz	166800	00387	22.47	-46.20			68.67	20.00	-48.67	T4	
		15MHz	167300	00387	22.47	-47.08			69.55	20.00	-49.55	T4	
		10MHz	167300	00387	22.47	-46.93			69.40	20.00	-49.40	T4	
		5MHz	167300	00387	22.47	-47.85			70.32	20.00	-50.32	T4	
	Radial	20MHz	167800	00387	14.44	-46.52	-61.11	N/A	60.96	20.00	-40.96	T4	1.8, 3.2
		20MHz	167300	00387	14.44	-46.46			60.90	20.00	-40.90	T4	
		20MHz	166800	00387	14.44	-46.08			60.52	20.00	-40.52	T4	
		15MHz	167300	00387	14.44	-47.34			61.78	20.00	-41.78	T4	
		10MHz	167300	00387	14.44	-47.45			61.89	20.00	-41.89	T4	
		5MHz	167300	00387	14.44	-47.92			62.36	20.00	-42.36	T4	

Table 9-25
Raw Data Results for 2.4GHz WIFI (OTT VoIP)

Mode	Orientation	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11b	Axial	6	00288	22.59	-44.73	-60.06	1.23	67.32	20.00	-47.32	T4	1.8, 4.2
	Radial	6	00288	13.96	-44.97	-61.11	N/A	58.93	20.00	-38.93	T4	1.8, 3.2
IEEE 802.11g	Axial	6	00288	22.73	-45.92	-60.06	1.17	68.65	20.00	-48.65	T4	1.8, 4.2
	Radial	6	00288	12.67	-39.24	-61.11	N/A	51.91	20.00	-31.91	T4	1.8, 3.2
IEEE 802.11n	Axial	6	00288	22.69	-42.34	-60.06	1.43	65.03	20.00	-45.03	T4	1.8, 4.2
	Radial	6	00288	12.71	-40.59	-61.11	N/A	53.30	20.00	-33.30	T4	1.8, 3.2
IEEE 802.11ac	Axial	6	00288	22.63	-45.29	-60.06	1.15	67.92	20.00	-47.92	T4	1.8, 4.2
	Radial	6	00288	14.37	-46.60	-61.11	N/A	60.97	20.00	-40.97	T4	1.8, 3.2
IEEE 802.11ax SU	Axial	6	00288	21.49	-45.65	-60.59	1.24	67.14	20.00	-47.14	T4	1.8, 4.2
	Radial	6	00288	14.16	-42.50	-61.11	N/A	56.66	20.00	-36.66	T4	1.8, 3.2
IEEE 802.11ax RU	Axial	1	00288	19.04	-41.18	-60.59	1.21	60.22	20.00	-40.22	T4	1.8, 4.2
		6	00288	21.88	-42.09		1.19	63.97	20.00	-43.97	T4	
		11	00288	19.09	-40.45		1.32	59.54	20.00	-39.54	T4	
	Radial	1	00288	13.39	-37.17	-61.11	N/A	50.56	20.00	-30.56	T4	1.8, 3.2
		6	00288	13.49	-37.25			50.74	20.00	-30.74	T4	
		11	00288	13.36	-37.24			50.60	20.00	-30.60	T4	

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Table 9-26
Raw Data Results for 5GHz WIFI IEEE 802.11a (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11a	Axial	20MHz	1	40	00288	22.92	-43.80	-60.06	1.52	66.72	20.00	-46.72	T4	1.8, 4.2
	Radial	20MHz	1	40	00288	12.64	-37.08	-61.11	N/A	49.72	20.00	-29.72	T4	1.8, 3.2

Table 9-27
Raw Data Results for 5GHz WIFI IEEE 802.11n (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11n	Axial	40MHz	1	38	00288	23.22	-45.21	-60.06	1.23	68.43	20.00	-48.43	T4	1.8, 4.2
		20MHz	1	40	00288	23.22	-45.15		1.30	68.37	20.00	-48.37	T4	
	Radial	40MHz	1	38	00288	12.62	-37.55	-61.11	N/A	50.17	20.00	-30.17	T4	1.8, 3.2
		20MHz	1	40	00288	13.44	-35.43			48.87	20.00	-28.87	T4	

Table 9-28
Raw Data Results for 5GHz WIFI IEEE 802.11ac (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11ac	Axial	40MHz	1	38	00288	22.73	-44.81	-60.06	1.23	67.54	20.00	-47.54	T4	1.8, 4.2
		20MHz	1	40	00288	22.82	-44.80		1.22	67.62	20.00	-47.62	T4	
	Radial	40MHz	1	38	00288	12.94	-38.78	-61.11	N/A	51.72	20.00	-31.72	T4	1.8, 3.2
		20MHz	1	40	00288	13.44	-37.49			50.93	20.00	-30.93	T4	

Table 9-29
Raw Data Results for 5GHz WIFI IEEE 802.11ax (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	DUT S/N	ABM1 [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	FCC Limit (dB)	Margin from FCC Limit (dB)	C63.19-2011 Rating	Test Coordinates
IEEE 802.11ax SU	Axial	40MHz	1	38	00288	20.69	-45.52	-60.59	1.28	66.21	20.00	-46.21	T4	1.8, 4.2
		20MHz	1	40	00288	20.51	-43.18		1.40	63.69	20.00	-43.69	T4	
	Radial	40MHz	1	38	00288	12.79	-38.02	-61.11	N/A	50.81	20.00	-30.81	T4	1.8, 3.2
		20MHz	1	40	00288	14.56	-39.18			53.74	20.00	-33.74	T4	
IEEE 802.11ax RU	Axial	40MHz	1	38	00288	20.78	-43.95	-60.59	1.41	64.73	20.00	-44.73	T4	1.8, 4.2
		20MHz	1	40	00288	22.18	-39.62		1.29	61.80	20.00	-41.80	T4	
		40MHz	2A	54	00288	21.34	-41.57		1.08	62.91	20.00	-42.91	T4	
		20MHz	2A	52	00288	22.07	-41.81		1.26	63.88	20.00	-43.88	T4	
		20MHz	2A	56	00288	21.51	-39.65		1.38	61.16	20.00	-41.16	T4	
		20MHz	2A	64	00288	21.40	-41.92		1.25	63.32	20.00	-43.32	T4	
		40MHz	2C	118	00288	21.01	-41.22		1.16	62.23	20.00	-42.23	T4	
		20MHz	2C	120	00288	21.36	-44.29		1.35	65.65	20.00	-45.65	T4	
		40MHz	3	151	00288	20.52	-42.49		1.21	63.01	20.00	-43.01	T4	
		20MHz	3	157	00288	21.13	-41.68		1.40	62.81	20.00	-42.81	T4	
	Radial	40MHz	1	38	00288	12.84	-34.79	-61.11	N/A	47.63	20.00	-27.63	T4	1.8, 3.2
		20MHz	1	36	00288	13.54	-33.97			47.51	20.00	-27.51	T4	
		20MHz	1	40	00288	12.88	-34.00			46.88	20.00	-26.88	T4	
		20MHz	1	48	00288	12.94	-33.92			46.86	20.00	-26.86	T4	
		40MHz	2A	54	00288	13.32	-34.91			48.23	20.00	-28.23	T4	
		20MHz	2A	56	00288	13.46	-35.04			48.50	20.00	-28.50	T4	
		40MHz	2C	118	00288	13.98	-34.85			48.83	20.00	-28.83	T4	
		20MHz	2C	120	00288	13.70	-35.59			49.29	20.00	-29.29	T4	
		40MHz	3	151	00288	12.74	-36.46			49.20	20.00	-29.20	T4	
		20MHz	3	157	00288	13.06	-35.83			48.89	20.00	-28.89	T4	

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II. 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→Additional Settings→Hearing aids**) was set to ON for Frequency Response compliance
4. Speech Signal: ITU-T P.50 Artificial Voice
5. Bluetooth and WIFI were disabled while testing 2G/3G/4G/5G modes.
6. Licensed data modes and Bluetooth were disabled while testing WIFI modes.
7. The Margin from FCC limit column indicates a margin from the FCC limit for compliance (T4).

B. CDMA

1. Power Configuration: Power Control Bits = "All Up"
2. Vocoder Configuration: RC1/SO3 (CDMA – EVRC)

C. GSM

1. Power Configuration: GSM850: PCL=5, GSM1900: PCL=0;
2. Vocoder Configuration: EFR (GSM);

D. UMTS

1. Power Configuration: TPC= ”All 1s”;
2. Vocoder Configuration: AMR 12.2 kbps (UMTS);

E. LTE FDD

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: 16QAM, 1RB, 0RB offset
3. Vocoder Configuration: WB AMR 6.60kbps
4. The worst-case band and bandwidth combination for each probe orientation is additionally tested on the low and high channels for those combinations. LTE Band 13 at 5MHz is the worst-case for the Axial probe orientation. LTE Band 13 at 10MHz bandwidth is the worst-case for the Radial probe orientation, however, LTE Band 13 at 10MHz only supports one channel therefore low and high channels were not evaluated.

F. LTE TDD

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: 16QAM, 1RB, 0RB offset
3. Power Class 3 Uplink-Downlink configuration: 6
4. Vocoder Configuration: WB AMR 6.60kbps
5. The worst-case band and bandwidth combination for each probe orientation is additionally tested on the low, low-mid, high-mid, and high channels for those combinations. LTE Band 41 (Power Class 3) at 15MHz is the worst-case for the Axial probe orientation. LTE Band 41 (Power Class 3) at 20MHz is the worst-case for the Radial probe orientation.

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G. WIFI

1. Radio Configuration
    a. IEEE 802.11b: CCK, 5.5Mbps
    b. IEEE 802.11g/a: BPSK, 6Mbps
    c. IEEE 802.11n/ac 20MHz: QPSK, MCS 1
    d. IEEE 802.11ax SU 20MHz: 16QAM, MCS 3
    e. IEEE 802.11n/ac 40MHz: BPSK, MCS 0
    f. IEEE 802.11ax SU 40MHz: QPSK, MCS 1
2. RU Index
    a. IEEE 802.11ax RU 20MHz: 54
    b. IEEE 802.11ax RU 40MHz: 37
3. Vocoder Configuration: WB AMR 6.60kbps
4. The worst-case standard for 2.4GHz WIFI in each probe orientation is additionally tested on the low and high channels. IEEE 802.11ax RU is the worst-case for both the Axial and Radial probe orientations.
5. The worst-case standard for 5GHz WIFI in each probe orientation is additionally tested on higher U-NII bands as well as applicable low and high channels. IEEE 802.11ax RU 20MHz (U-NII 1) is the worst-case for the Axial probe orientation. IEEE 802.11ax RU 20MHz (U-NII 2A) is the worst-case for the Radial probe orientation.

H. OTT VoIP

1. Vocoder Configuration: 6kbps
2. EvDO Configuration
    a. Revision: A
3. EDGE Configuration
    a. MCS Index: 7
    b. Number of TX slots: 2
4. HSPA Configuration:
    a. Release: 6
    b. 3GPP 34.121 Subtest 1
5. LTE FDD Configuration:
    a. Power Configuration: TPC = “Max Power”
    b. Radio Configuration: 16QAM, 1RB, 0RB offset
    c. LTE Band 13 was the worst-case band from Table 7-6 and was used to test both Axial and Radial probe orientations.
    d. The worst-case band and bandwidth combination for each probe orientation is additionally tested on the low and high channels for those combinations. LTE Band 13 at 10MHz is the worst-case for both the Axial and Radial probe orientations, however, LTE Band 13 at 10MHz only supports one channel therefore low and high channels were not evaluated.
6. LTE TDD Configuration:
    a. Power Configuration: TPC = “Max Power”
    b. Radio Configuration: 16QAM, 1RB, 0RB offset
    c. Power Class 3 Uplink-Downlink configuration: 6
    d. LTE Band 41 was the worst-case band from Table 7-7 and was used to test both Axial and Radial probe orientations.
    e. The worst-case band and bandwidth combination for each probe orientation is additionally tested on the low, low-mid, high-mid, and high channels for those combinations. LTE Band 41 (Power Class 3) at 20MHz is the worst-case for the Axial probe orientation. LTE Band 41 (Power Class 3) at 15MHz is the worst-case for the Radial probe orientation.

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7. NR Configuration
    a. Power Configuration: TxAGC is set such that the DUT operates at max power.
    b. Radio Configuration: DFT-s-OFDM, 16QAM, 1RB, 0 RB Offset
    c. Due to equipment limitations, ABM1 measurements were not possible. Therefore, the overall worst-case ABM1 from LTE OTT VoIP was combined with NR ABM2 measurements to obtain SNNR values. Additionally, Frequency Response measurements were not possible due to equipment limitations.
    d. NR n5 was the worst-case band from Table 7-11 was used to test both Axial and Radial probe orientations.
    e. The worst-case band and bandwidth combination for each probe orientation is additionally tested on the low and high channels for those combinations. NR n5 at 20MHz is the worst-case for both the Axial and Radial probe orientations.
8. WIFI Configuration:
    a. Radio Configuration
        i. IEEE 802.11b: CCK, 5.5Mbps
        ii. IEEE 802.11g/a: BPSK, 6Mbps
        iii. IEEE 802.11n/ac 20MHz: QPSK, MCS1
        iv. IEEE 802.11ax SU 20MHz: 16QAM, MCS 3
        v. IEEE 802.11n/ac 40MHz: BPSK, MCS 0
        vi. IEEE 802.11ax SU 40MHz: QPSK, MCS 1
    b. RU Index
        i. IEEE 802.11ax RU 20MHz: 54
        ii. IEEE 802.11ax RU 40MHz: 37
    c. The worst-case standard for 2.4GHz WIFI in each probe orientation is additionally tested on the low and high channels. IEEE 802.11ax RU is the worst-case for both the Axial and Radial probe orientations.
    d. The worst-case standard for 5GHz WIFI in each probe orientation is additionally tested on higher U-NII bands as well as applicable low and high channels. IEEE 802.11ax RU 20MHz (U-NII 2A) is the worst-case for the Axial probe orientation. IEEE 802.11ax RU 20MHz (U-NII 1) is the worst-case for the Radial probe orientation.

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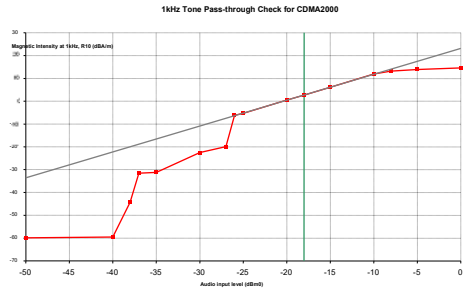
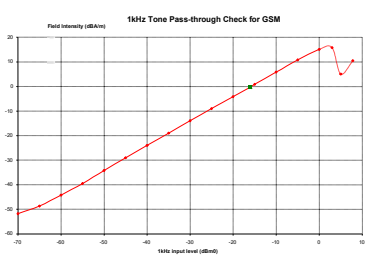
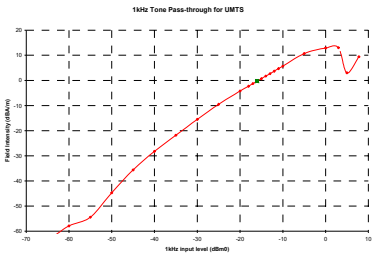
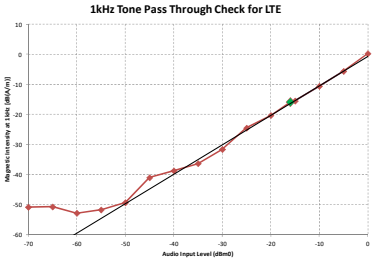
III. 1 kHz Vocoder Application Check



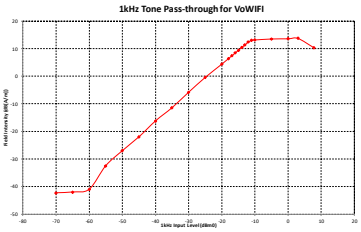
This model was verified to be within the linear region for ABM1 measurements at -18 dBm0 for CDMA. This measurement was taken in the axial configuration above the maximum location.

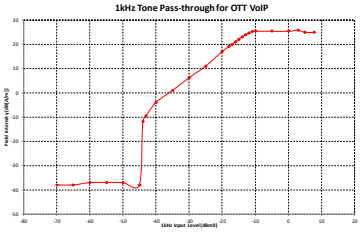






This model was verified to be within the linear region for ABM1 measurements at -16 dBm0 for GSM, UMTS, and VoLTE over IMS. This measurement was taken in the axial configuration above the maximum location.





This model was verified to be within the linear region for ABM1 measurements at -20 dBm0 for VoWIFI over IMS and OTT VoIP. This measurement was taken in the axial configuration above the maximum location.

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IV. T-Coil Validation Test Results

Table 9-30
Helmholtz Coil (SN: 925) Validation Table of Results – 12/9/2019

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.242	**PASS**
Environmental Noise	< -58 dBA/m	-61.48	**PASS**
Frequency Response, from limits	*> 0 dB*	0.80	**PASS**
Radial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.386	**PASS**
Environmental Noise	< -58 dBA/m	-62.41	**PASS**
Frequency Response, from limits	*> 0 dB*	0.80	**PASS**

Table 9-31
Helmholtz Coil (SN: SBI 1052) Validation Table of Results – 12/16/2019

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-9.891	**PASS**
Environmental Noise	< -58 dBA/m	-59.32	**PASS**
Frequency Response, from limits	*> 0 dB*	0.60	**PASS**

Table 9-32
Helmholtz Coil (SN: SBI 1052) Validation Table of Results – 12/23/2019

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-9.790	**PASS**
Environmental Noise	< -58 dBA/m	-60.12	**PASS**
Frequency Response, from limits	*> 0 dB*	0.50	**PASS**

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Table 9-33
Helmholtz Coil (SN: 925) Validation Table of Results – 12/23/2019

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.301	**PASS**
Environmental Noise	< -58 dBA/m	-64.41	**PASS**
Frequency Response, from limits	*> 0 dB*	0.80	**PASS**

Table 9-34
Helmholtz Coil (SN: 925) Validation Table of Results - 12/30/2019

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.305	**PASS**
Environmental Noise	< -58 dBA/m	-62.02	**PASS**
Frequency Response, from limits	*> 0 dB*	0.80	**PASS**
Radial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.359	**PASS**
Environmental Noise	< -58 dBA/m	-62.97	**PASS**
Frequency Response, from limits	*> 0 dB*	0.80	**PASS**

Table 9-35
Helmholtz Coil (SN: SBI 1052) Validation Table of Results - 12/30/2019

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-9.819	**PASS**
Environmental Noise	< -58 dBA/m	-60.06	**PASS**
Frequency Response, from limits	*> 0 dB*	0.50	**PASS**
Radial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.060	**PASS**
Environmental Noise	< -58 dBA/m	-61.41	**PASS**
Frequency Response, from limits	*> 0 dB*	0.70	**PASS**

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Table 9-36
Helmholtz Coil (SN: SBI 1052) Validation Table of Results – 1/13/2020

Item	Target	Result	Verdict
Axial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-9.885	**PASS**
Environmental Noise	< -58 dBA/m	-60.59	**PASS**
Frequency Response, from limits	*> 0 dB*	0.70	**PASS**
Radial			
Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.085	**PASS**
Environmental Noise	< -58 dBA/m	-61.11	**PASS**
Frequency Response, from limits	*> 0 dB*	0.80	**PASS**

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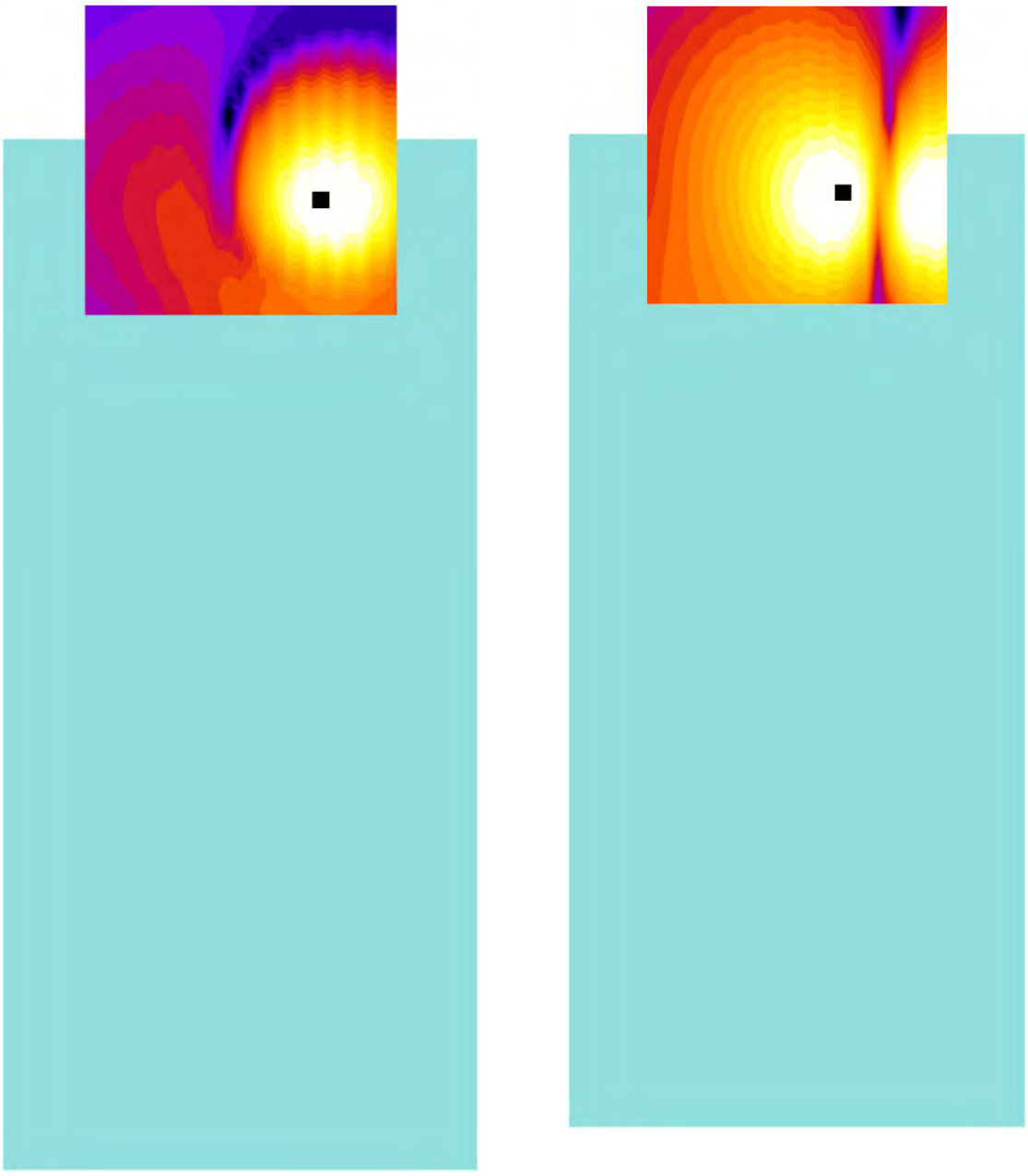
V. ABM1 Magnetic Field Distribution Scan Overlays



Axial Radial (Transverse)

Figure 9-1
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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10. MEASUREMENT UNCERTAINTY

Table 10-1
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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11. EQUIPMENT LIST

Table 11-1
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Temperature / Humidity Monitor	2/28/2018	Biennial	2/28/2020	150761911
Dell	Latitude E6540	SoundCheck Acoustic Analyzer Laptop	9/6/2018	Biennial	9/6/2020	2655082910
Dell	Latitude E6540	SoundCheck Acoustic Analyzer Laptop	4/24/2019	Biennial	4/24/2021	7BFNM32
Listen	SoundConnect	Microphone Power Supply	9/6/2018	Biennial	9/6/2020	0899-PS150
Listen	SoundConnect	Microphone Power Supply	4/22/2019	Biennial	4/22/2021	PS2612
RME	Fireface UC	Soundcheck Acoustic Analyzer External Audio Interface	9/6/2018	Biennial	9/6/2020	23792992
RME	Fireface UC	Soundcheck Acoustic Analyzer External Audio Interface	4/24/2019	Biennial	4/24/2021	23528889
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	1/30/2019	Annual	1/30/2020	162125
Rohde & Schwarz	CMW500	Radio Communication tester	5/17/2019	Annual	5/17/2020	128635
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	6/6/2019	Annual	6/6/2020	161662
Rohde & Schwarz	CMW500	Radio Communication tester	8/14/2019	Annual	8/14/2020	140144
Seekonk	NC-100	Torque Wrench (8" lb)	5/10/2018	Biennial	5/10/2020	21053
TEM	Axial T-Coil Probe	Axial T-Coil Probe	9/19/2018	Biennial	9/19/2020	TEM-1123
TEM	Axial T-Coil Probe	Axial T-Coil Probe	5/17/2019	Biennial	5/17/2021	TEM-1124
TEM	Radial T-Coil Probe	Radial T-Coil Probe	9/19/2018	Biennial	9/19/2020	TEM-1129
TEM	Radial T-Coil Probe	Radial T-Coil Probe	5/17/2019	Biennial	5/17/2021	TEM-1130
TEM	Helmholtz Coil	Helmholtz Coil	10/10/2018	Biennial	10/10/2020	SBI 1052
TEM	C63.19	Helmholtz Coil	5/20/2019	Biennial	5/20/2021	925
TEM		HAC System Controller with Software	N/A		N/A	N/A
TEM		HAC Positioner	N/A		N/A	N/A

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12. TEST DATA

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN:925

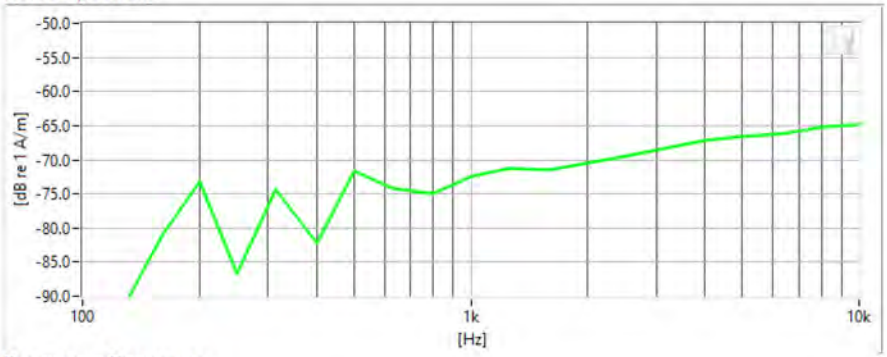
Type: HH Coil
Serial: 925

Measurement Standard: ANSI C63.19-2011

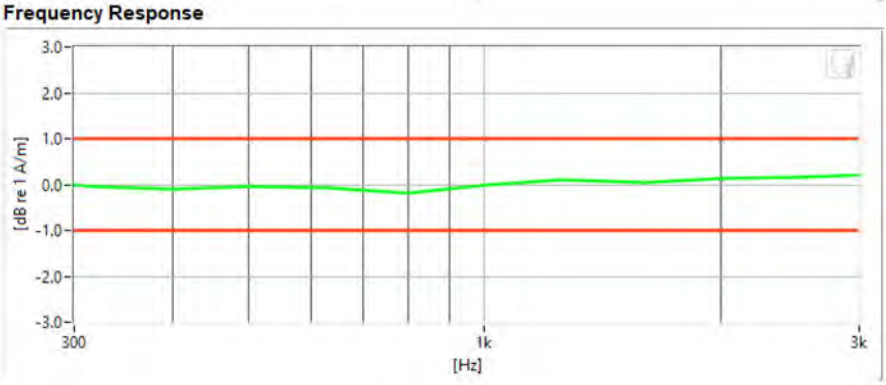
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019
- Helmholtz Coil – SN: 925; Calibrated: 05/20/2019

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.242 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-61.48 dB	✓	Maximum	-58.0
Frequency Response Margin	800m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

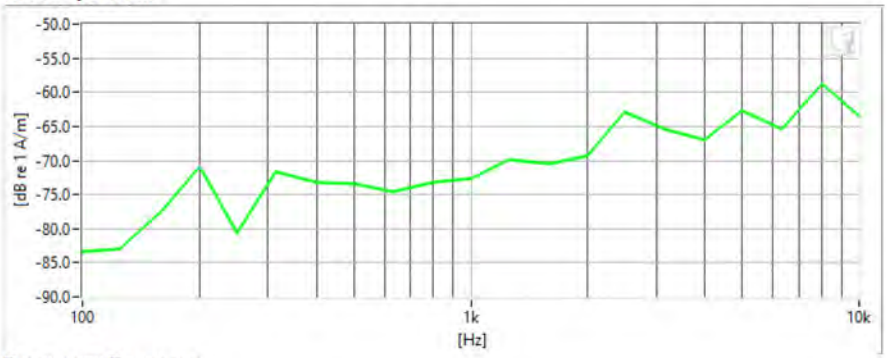
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

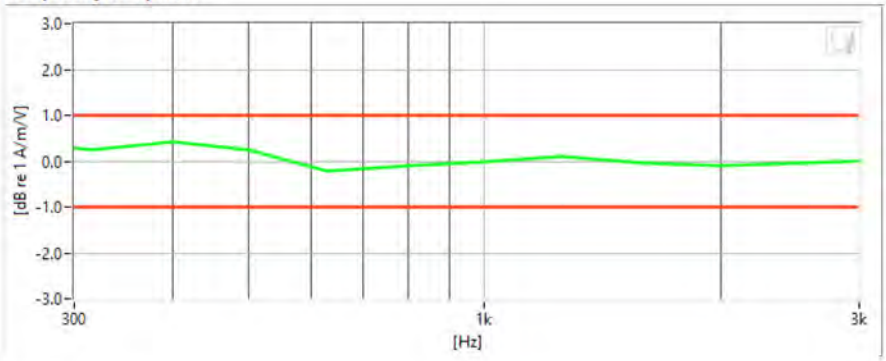
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018
- Helmholtz Coil – SN: SBI 1052; Calibrated: 10/10/2018

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-9.891 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-59.32 dB	✓	Maximum	-58.0
Frequency Response Margin	600m dB	✓	Tolerance curves	Aligned Data

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

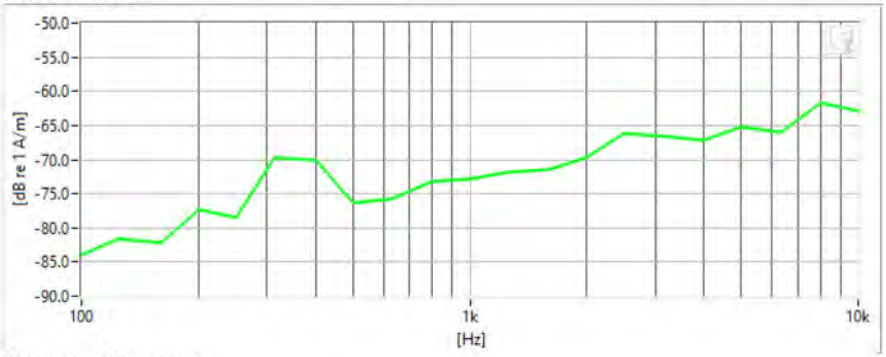
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

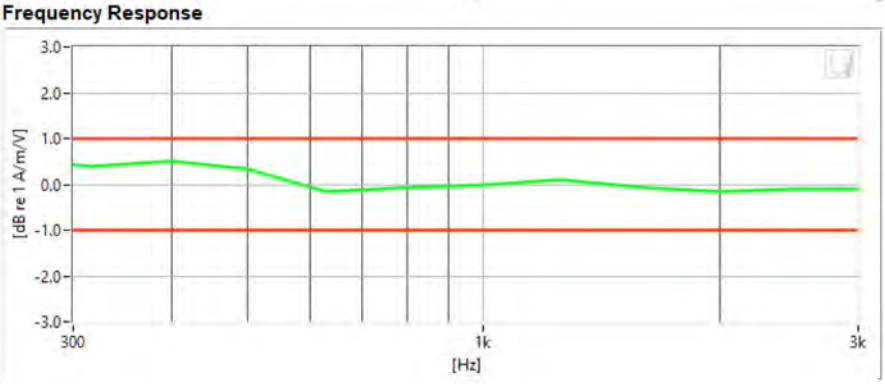
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018
- Helmholtz Coil – SN: SBI 1052; Calibrated: 10/10/2018

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-9.79 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-60.12 dB	✓	Maximum	-58.0
Frequency Response Margin	500m dB	✓	Tolerance curves	Aligned Data

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN:925

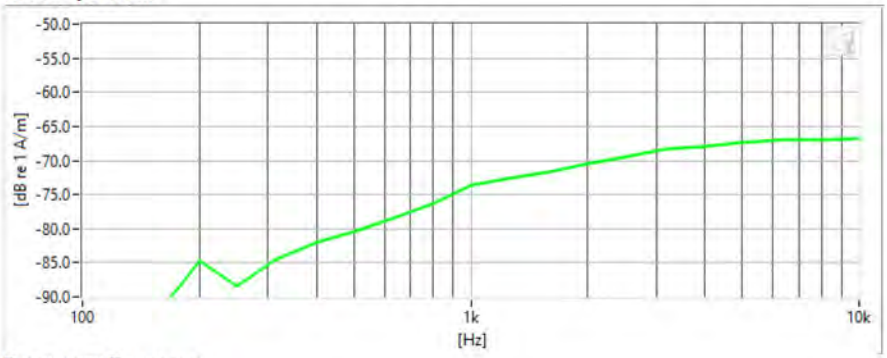
Type: HH Coil
Serial: 925

Measurement Standard: ANSI C63.19-2011

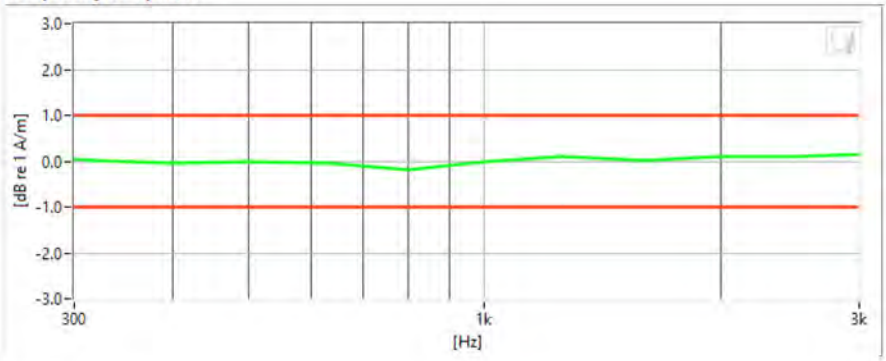
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019
- Helmholtz Coil – SN: 925; Calibrated: 05/20/2019

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.301 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-64.41 dB	✓	Maximum	-58.0
Frequency Response Margin	800m dB	✓	Tolerance curves	Aligned Data

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN:925

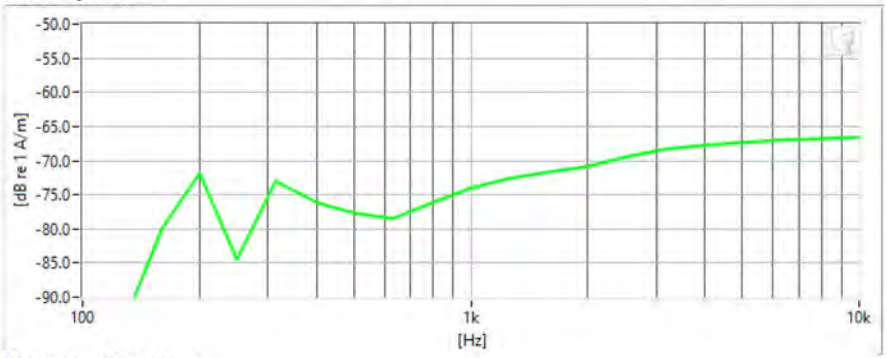
Type: HH Coil
Serial: 925

Measurement Standard: ANSI C63.19-2011

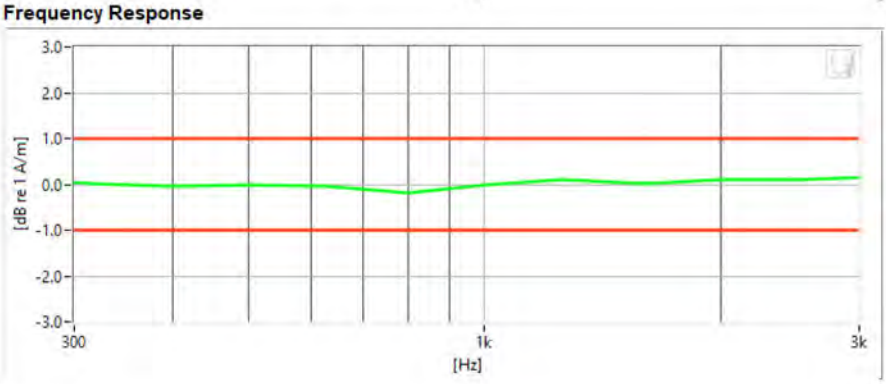
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019
- Helmholtz Coil – SN: 925; Calibrated: 05/20/2019

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.305 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-62.02 dB	✓	Maximum	-58.0
Frequency Response Margin	800m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

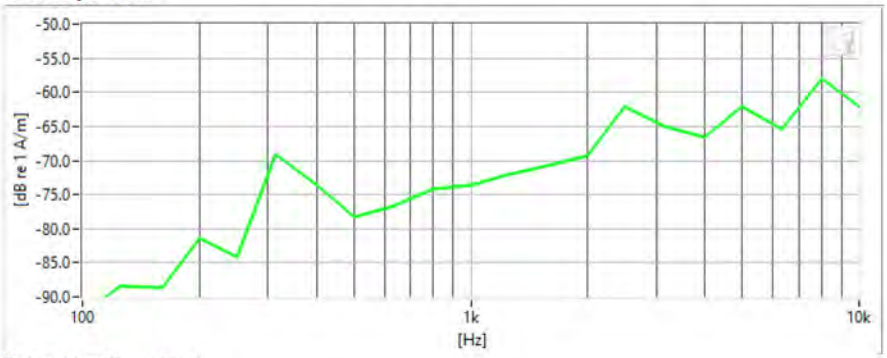
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

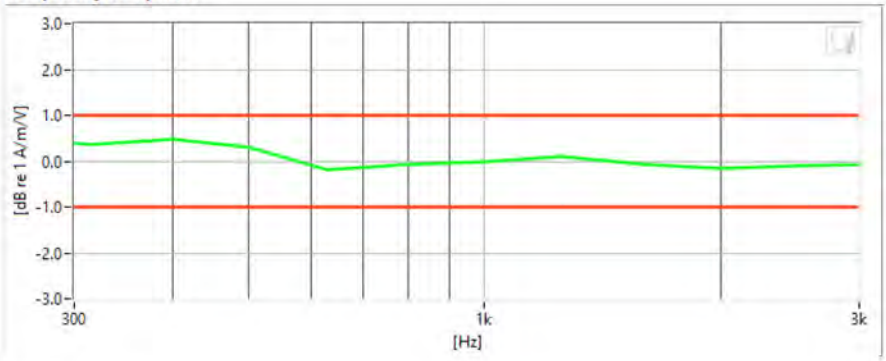
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018
- Helmholtz Coil – SN: SBI 1052; Calibrated: 10/10/2018

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-9.819 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-60.06 dB	✓	Maximum	-58.0
Frequency Response Margin	500m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

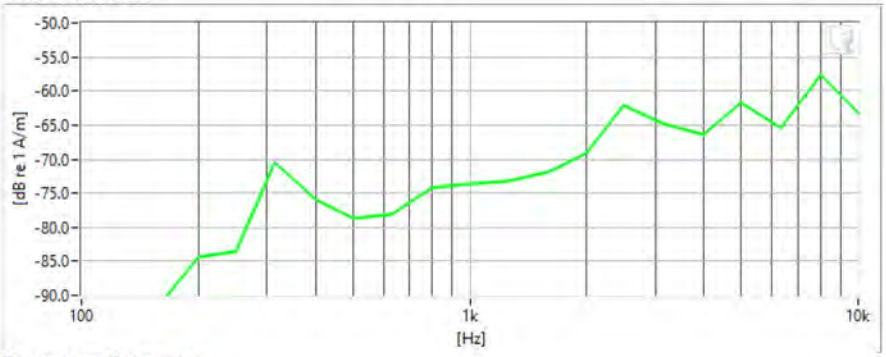
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

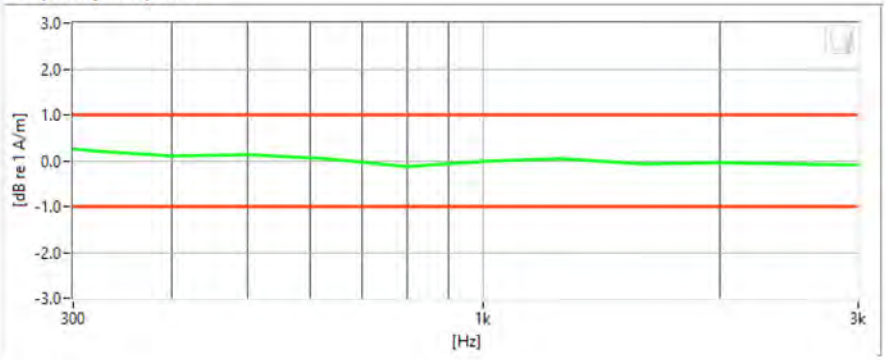
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018
- Helmholtz Coil – SN: SBI 1052; Calibrated: 10/10/2018

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-9.885 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-60.59 dB	✓	Maximum	-58.0
Frequency Response Margin	700m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN:925

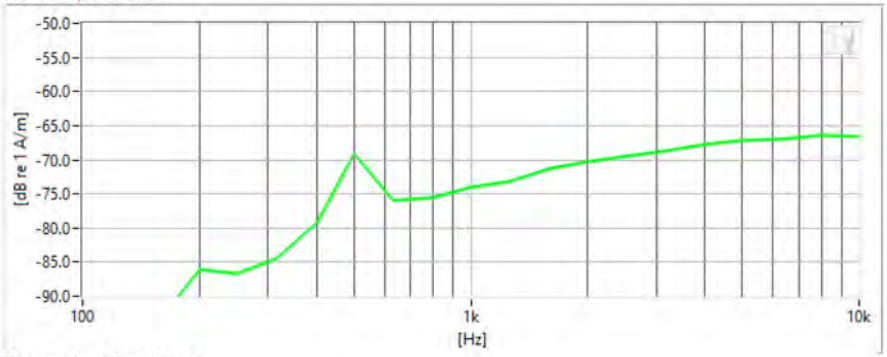
Type: HH Coil
Serial: 925

Measurement Standard: ANSI C63.19-2011

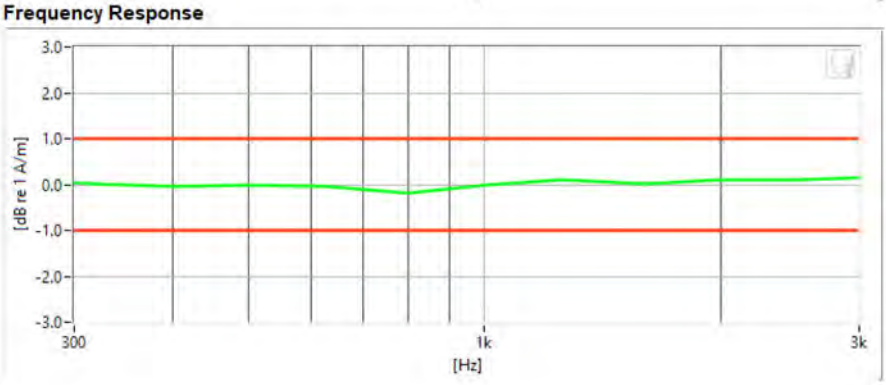
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019
- Helmholtz Coil – SN: 925; Calibrated: 05/20/2019

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.386 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-62.41 dB	✓	Maximum	-58.0
Frequency Response Margin	800m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN:925

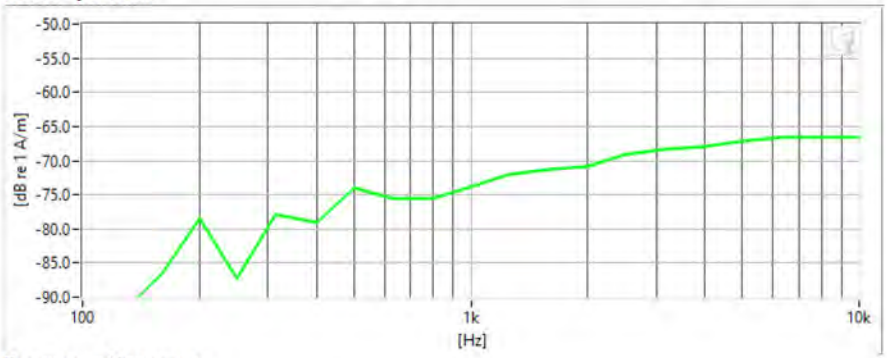
Type: HH Coil
Serial: 925

Measurement Standard: ANSI C63.19-2011

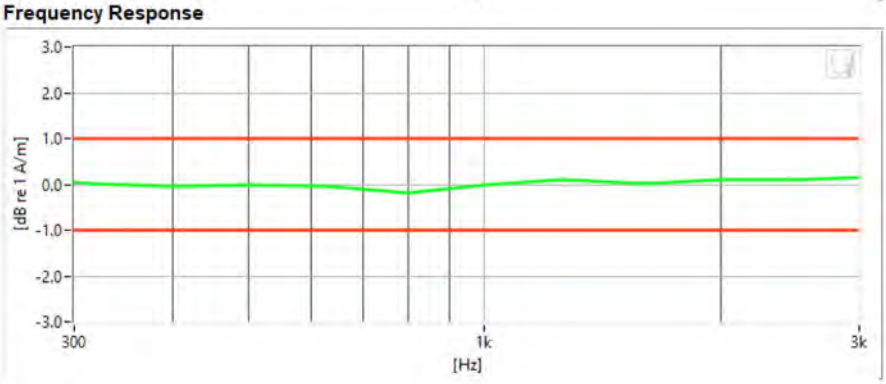
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019
- Helmholtz Coil – SN: 925; Calibrated: 05/20/2019

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.359 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-62.97 dB	✓	Maximum	-58.0
Frequency Response Margin	800m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

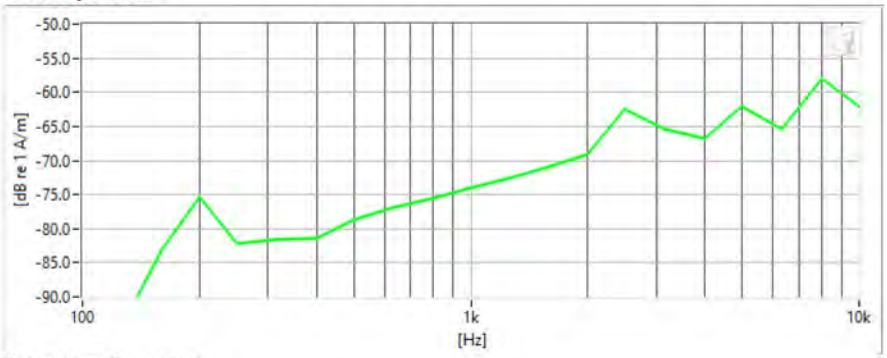
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

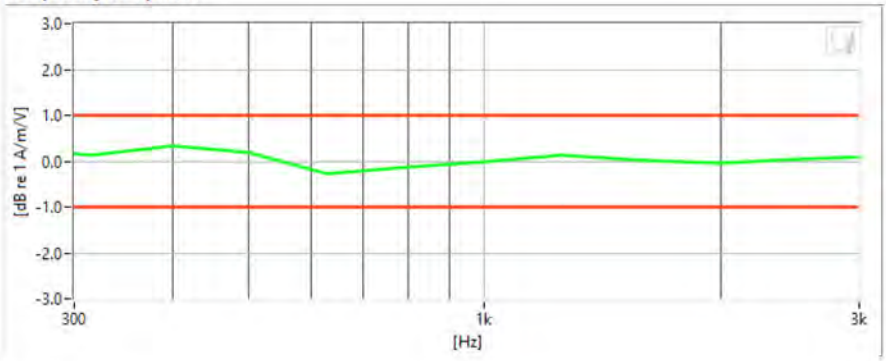
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1129; Calibrated: 09/19/2018
- Helmholtz Coil – SN: SBI 1052; Calibrated: 10/10/2018

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.06 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-61.41 dB	✓	Maximum	-58.0
Frequency Response Margin	700m dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

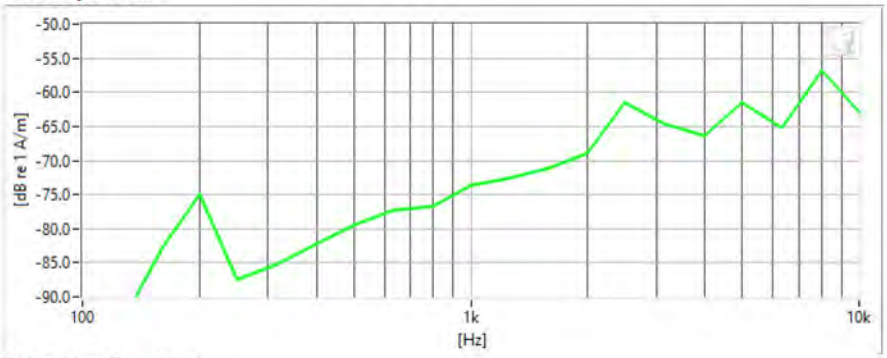
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

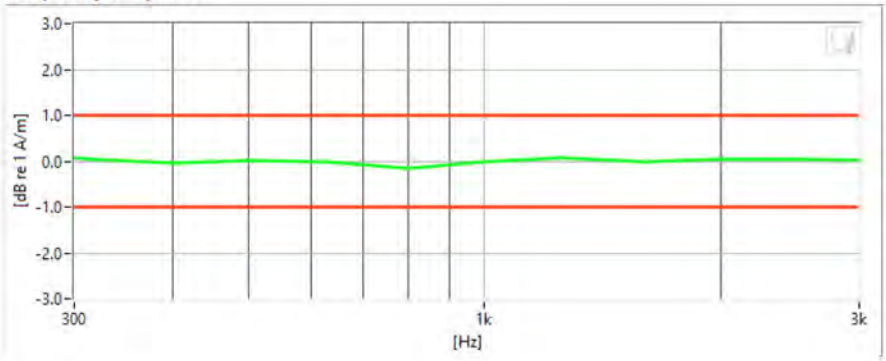
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1129; Calibrated: 09/19/2018
- Helmholtz Coil – SN: SBI 1052; Calibrated: 10/10/2018

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.085 dB	✓	Max/Min	-9.5/-10.5
Verification ABM2	-61.11 dB	✓	Maximum	-58.0
Frequency Response Margin	800m dB	✓	Tolerance curves	Aligned Data

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

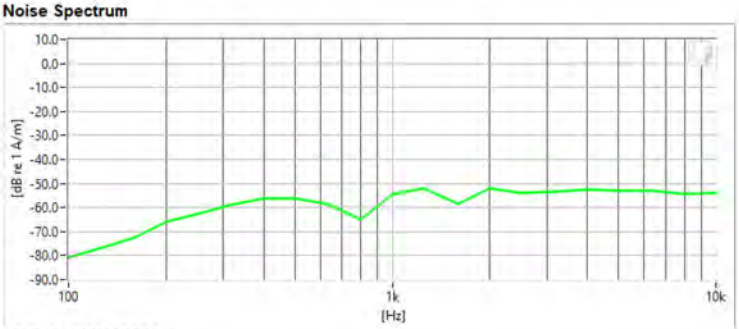
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

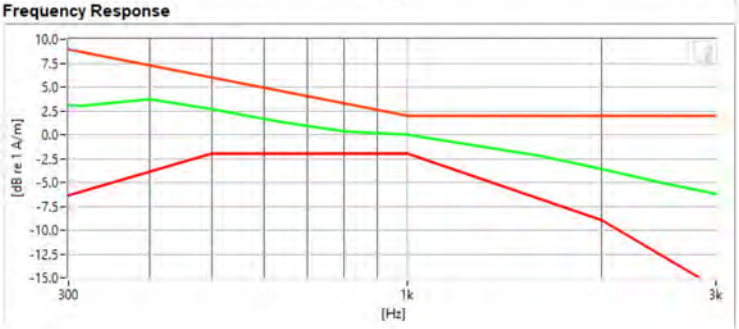
Test Configuration:

- Mode: CDMA Cellular
- Channel: 777
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	16.86 dB	✓	Minimum	-18.0
ABM2	-45.24 dB	✓	Maximum	0
SNNR	62.1 dB	✓	Minimum	20
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

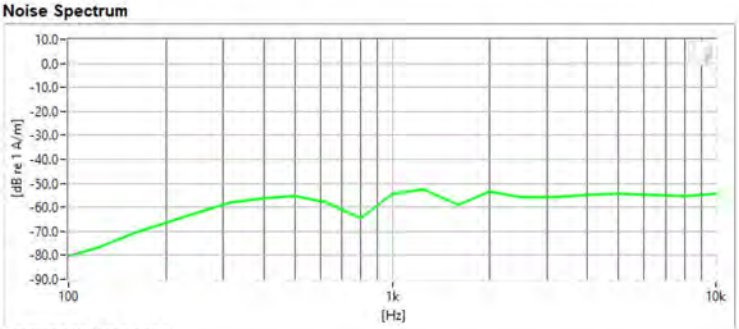
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

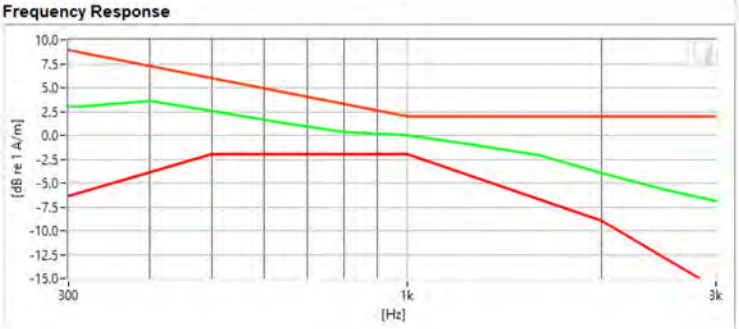
Test Configuration:

- Mode: CDMA PCS
- Channel: 25
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	16.8 dB	✓	Minimum	-18.0
ABM2	-45.44 dB	✓	Maximum	0.0
SNNR	62.24 dB	✓	Minimum	20.0
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

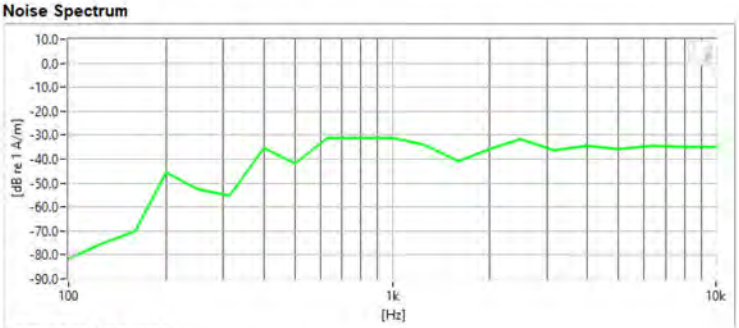
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

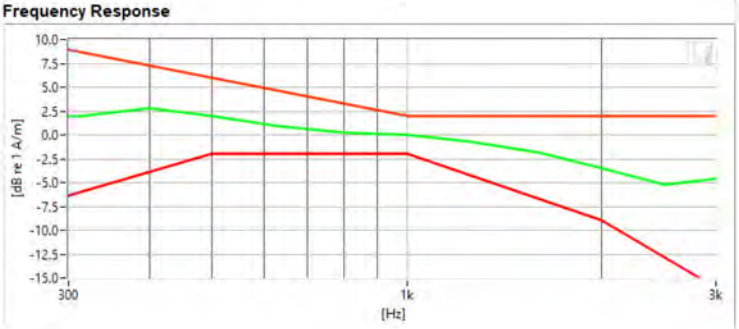
Test Configuration:

- Mode: GSM 850
- Channel: 128
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	21.17 dB	✓	Minimum	-18.0
ABM2	-23.74 dB	✓	Maximum	0.0
SNNR	44.9 dB	✓	Minimum	20.0
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

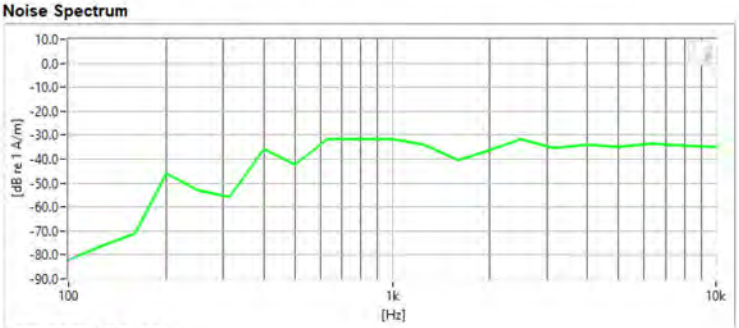
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

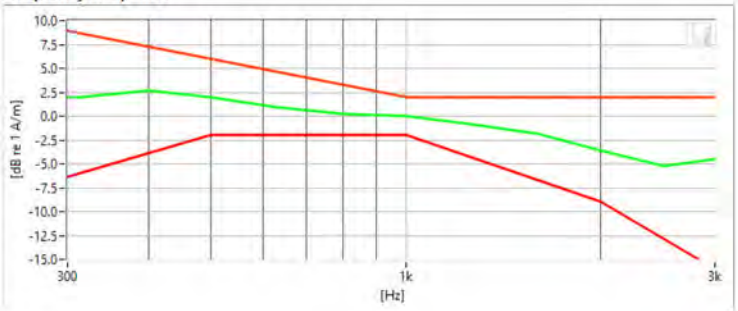
Test Configuration:

- Mode: GSM 1900
- Channel: 661
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	21.32 dB	✓	Minimum	-18.0
ABM2	-24.03 dB	✓	Maximum	0.0
SNNR	45.35 dB	✓	Minimum	20.0
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

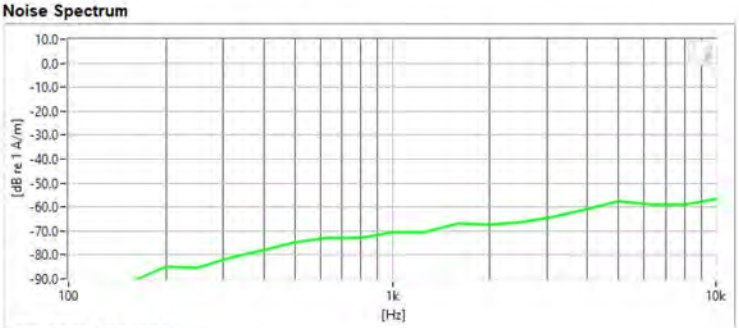
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

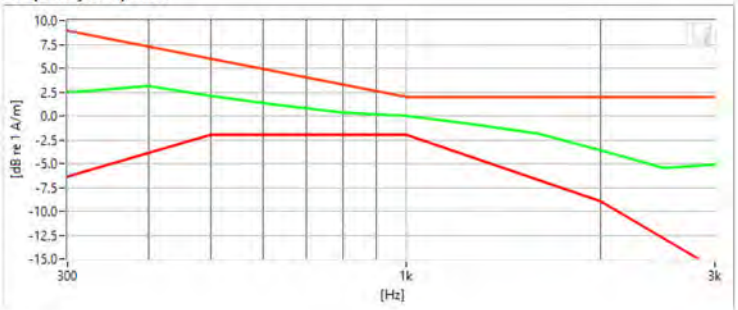
Test Configuration:

- Mode: UMTS Band V
- Channel: 4132
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	19.49 dB	✓	Minimum	-18.0
ABM2	-59.56 dB	✓	Maximum	0.0
SNNR	79.05 dB	✓	Minimum	20.0
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

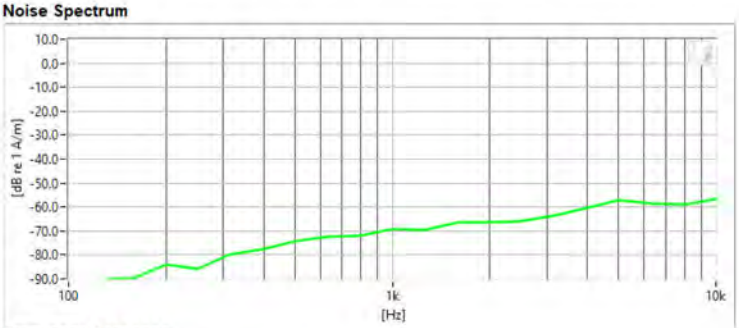
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

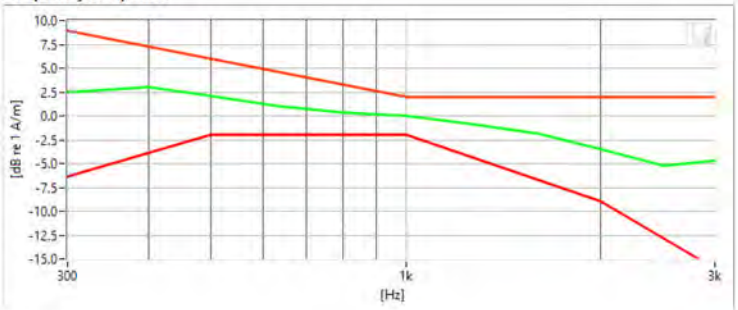
Test Configuration:

- Mode: UMTS Band IV
- Channel: 1312
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	19.31 dB	✓	Minimum	-18.0
ABM2	-58.99 dB	✓	Maximum	0
SNNR	78.31 dB	✓	Minimum	20
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

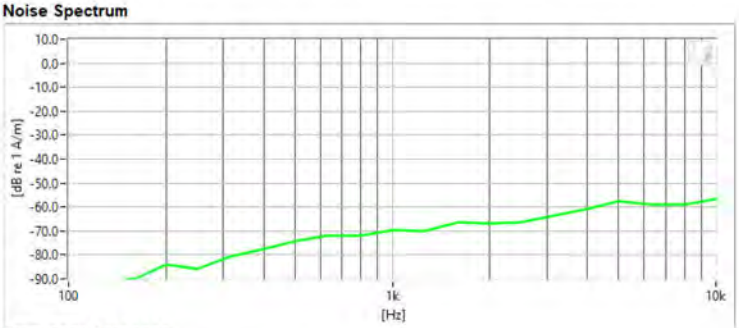
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1124; Calibrated: 05/17/2019

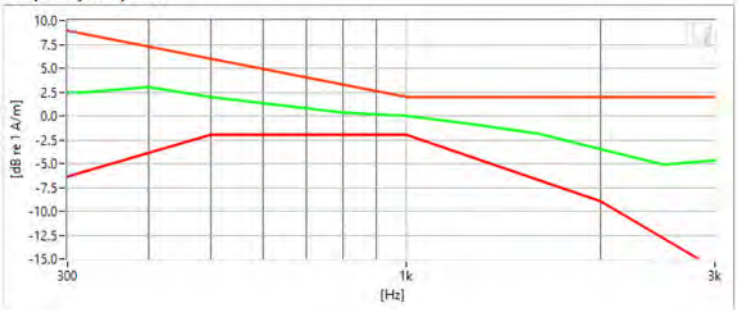
Test Configuration:

- Mode: UMTS Band II
- Channel: 9400
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	20 dB	✓	Minimum	-18.0
ABM2	-59.18 dB	✓	Maximum	0.0
SNNR	79.19 dB	✓	Minimum	20.0
Aligned Response - P.50	2 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

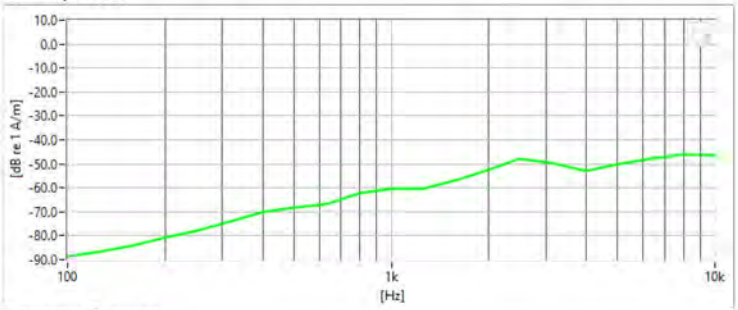
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018

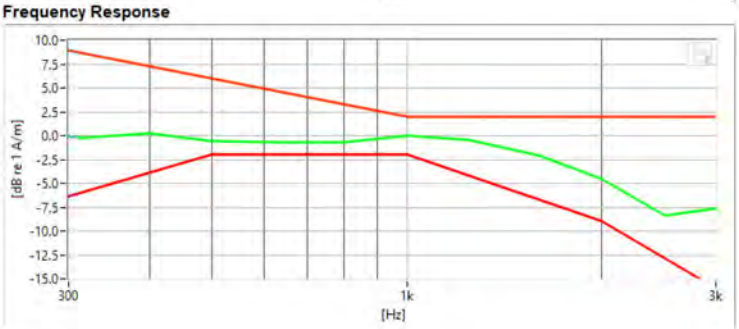
Test Configuration:

- Mode: LTE FDD Band 13
- Bandwidth: 5MHz
- Channel: 23230
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	11.72 dB	✓	Minimum	-18.0
ABM2	-47.83 dB	✓	Maximum	0
SNNR	59.55 dB	✓	Minimum	20
Aligned Response - P.50	1.29 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

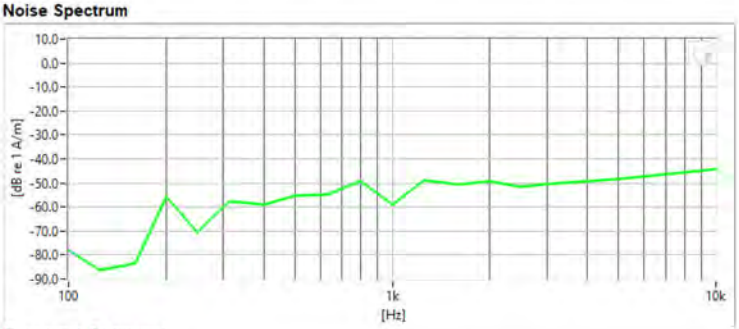
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018

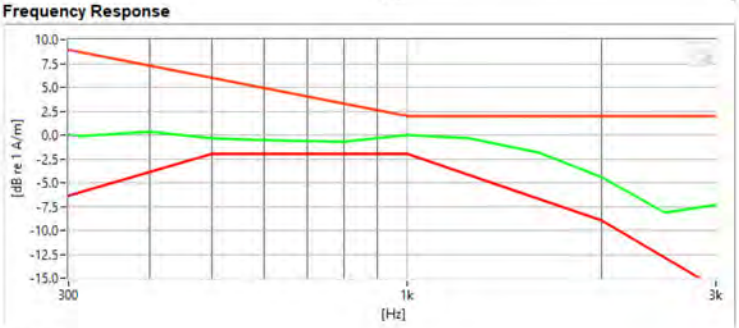
Test Configuration:

- Mode: LTE TDD Band 41 (Power Class 3)
- Bandwidth: 15MHz
- Channel: 39750
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	11.83 dB	✓	Minimum	-18.0
ABM2	-41.83 dB	✓	Maximum	0.0
SNNR	53.65 dB	✓	Minimum	20.0
Aligned Response - P.50	1.26 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

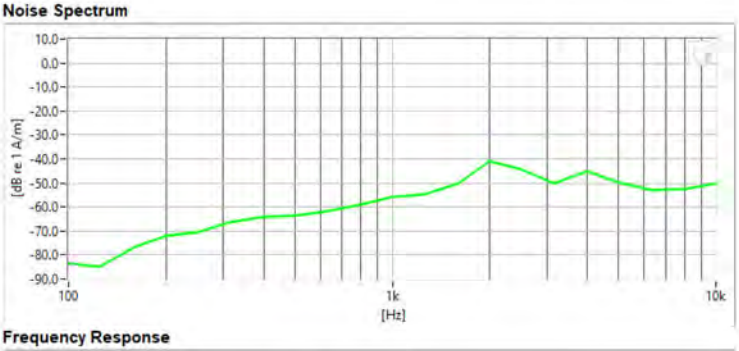
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018

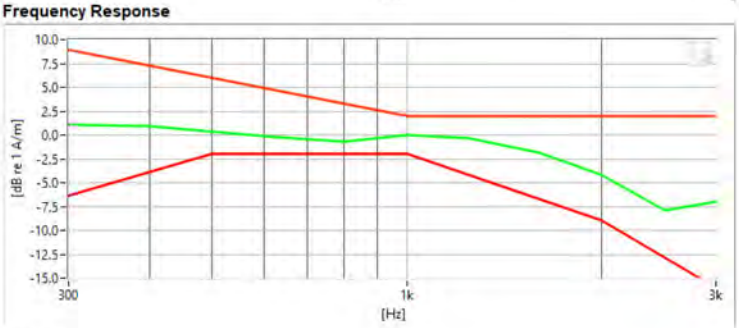
Test Configuration:

- Mode: 2.4GHz WIFI
- Standard: IEEE 802.11ax RU
- Channel: 6
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	7.7 dB	✓	Minimum	-18.0
ABM2	-41.94 dB	✓	Maximum	0.0
SNNR	49.63 dB	✓	Minimum	20.0
Aligned Response - P.50	1.27 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

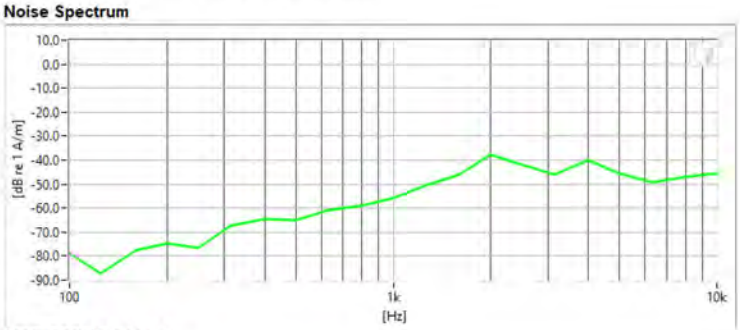
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018

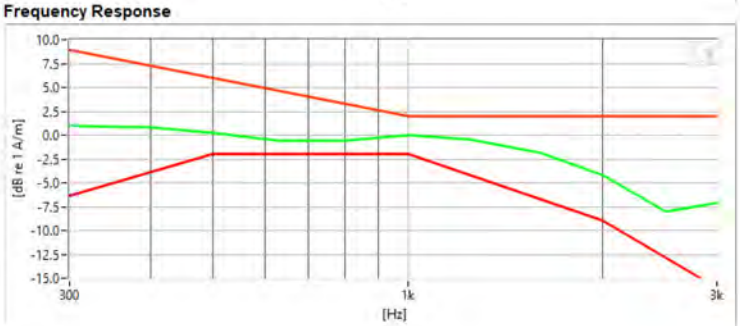
Test Configuration:

- Mode: 5GHz WIFI
- Standard: IEEE 802.11ax RU (U-NII 1)
- Bandwidth: 20MHz
- Channel: 36
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	8.22 dB	✓	Minimum	-18.0
ABM2	-38.82 dB	✓	Maximum	0.0
SNNR	47.04 dB	✓	Minimum	20.0
Aligned Response - P.50	1.37 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

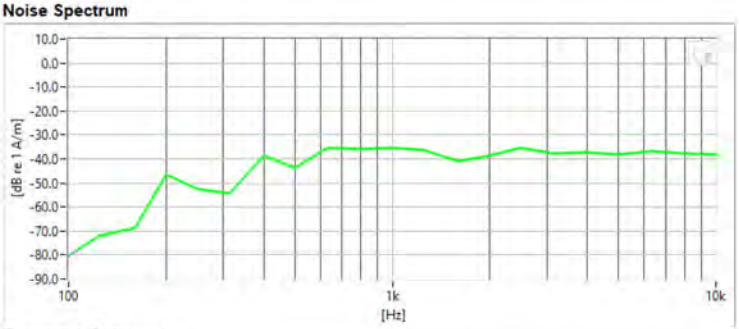
Equipment:

- Probe: Axial T-Coil Probe – SN: TEM-1123; Calibrated: 09/19/2018

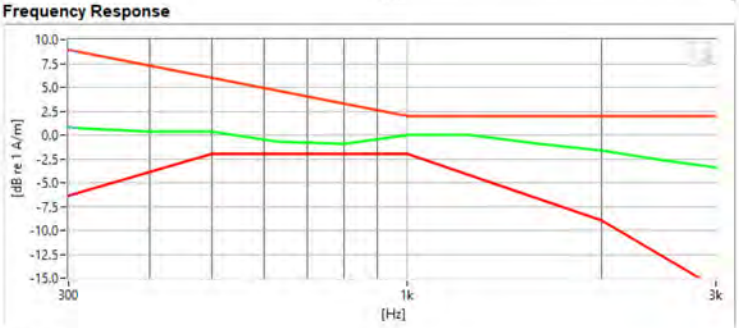
Test Configuration:

- VoIP Application: Google Duo
- Mode: EDGE 1900
- Channel: 661
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

ABM1	23 dB	✓	Minimum	-18.0
ABM2	-27.36 dB	✓	Maximum	0
SNNR	50.36 dB	✓	Minimum	20
Aligned Response - P.50	1.1 dB	✓	Tolerance curves	Aligned Data

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

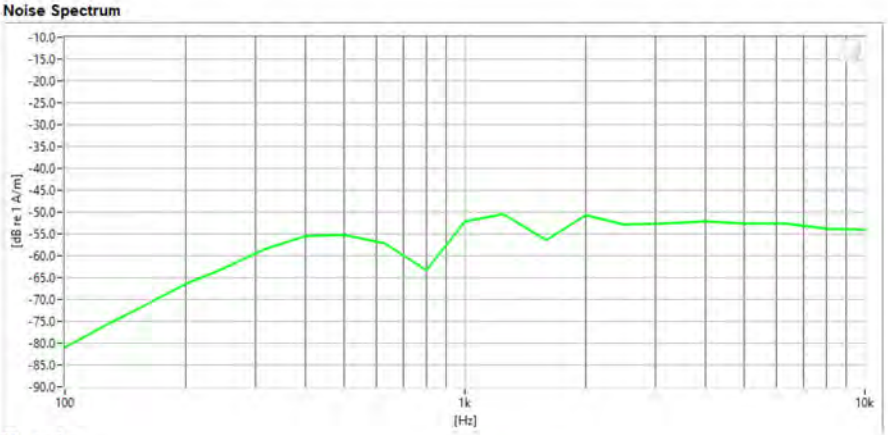
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: CDMA Cellular
- Channel: 1013

Noise Spectrum



Results

ABM1	9.9 dB	✓	Minimum	-18.0
ABM2	-44.1 dB	✓	Maximum	0.0
SNNR	54 dB	✓	Minimum	20.0

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

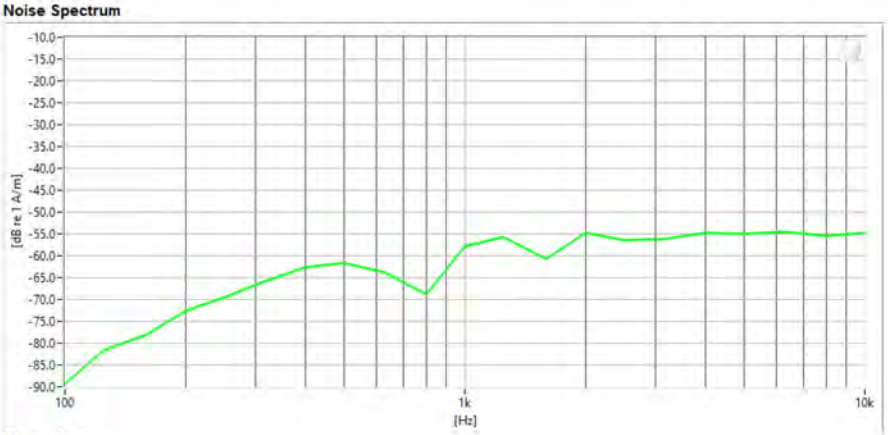
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: CDMA PCS
- Channel: 25

Noise Spectrum



Results

ABM1	10.03 dB	✓	Minimum	-18.0
ABM2	-49.5 dB	✓	Maximum	0.0
SNNR	59.53 dB	✓	Minimum	20.0

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PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

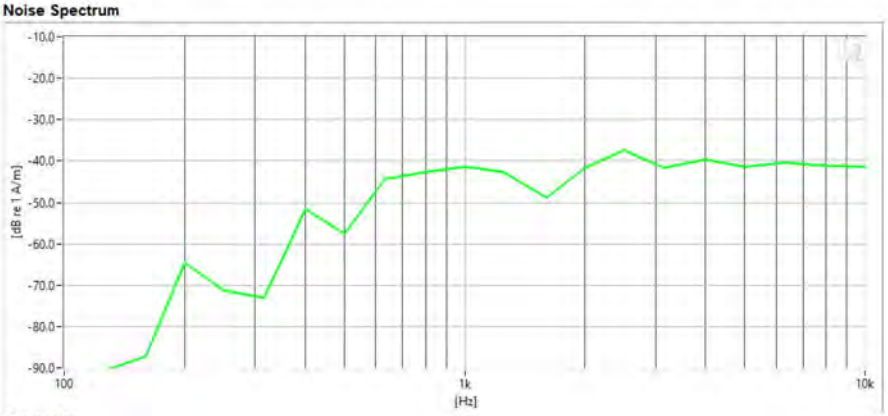
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: GSM 850
- Channel: 128

Noise Spectrum



Results

ABM1	14.84 dB	✓	Minimum	-18.0
ABM2	-34.26 dB	✓	Maximum	0.0
SNNR	49.1 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

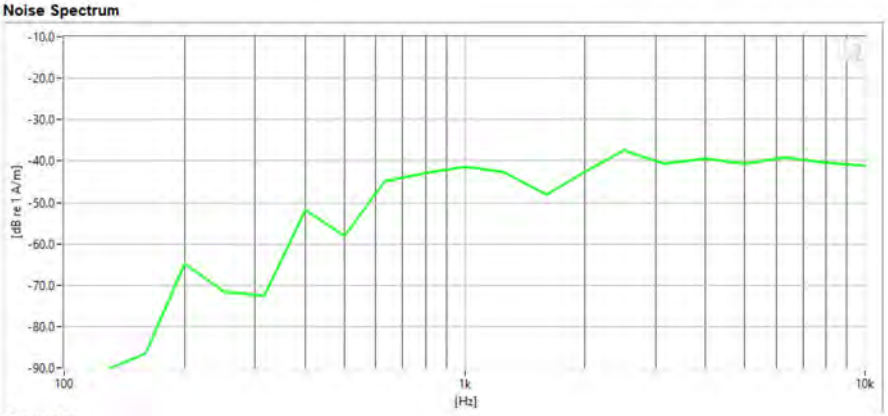
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: GSM 1900
- Channel: 661

Noise Spectrum



Results

ABM1	14.83 dB	✓	Minimum	-18.0
ABM2	-34.36 dB	✓	Maximum	0.0
SNNR	49.19 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

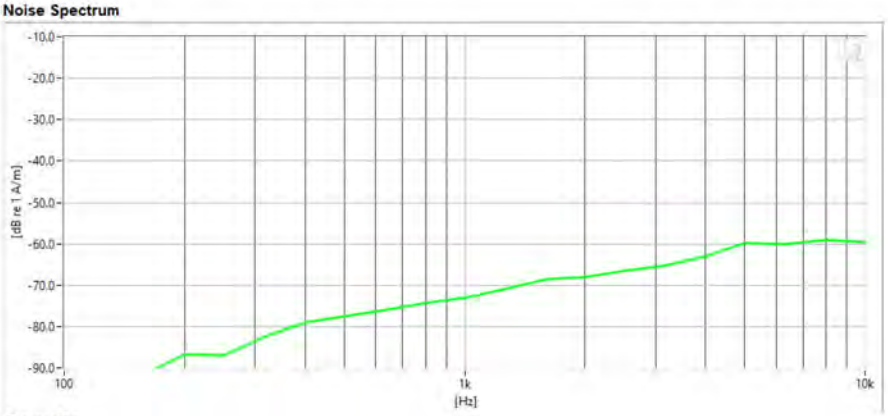
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: UMTS Band V
- Channel: 4233

Noise Spectrum



Results

ABM1	13.49 dB	✓	Minimum	-18.0
ABM2	-61.22 dB	✓	Maximum	0.0
SNNR	74.7 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

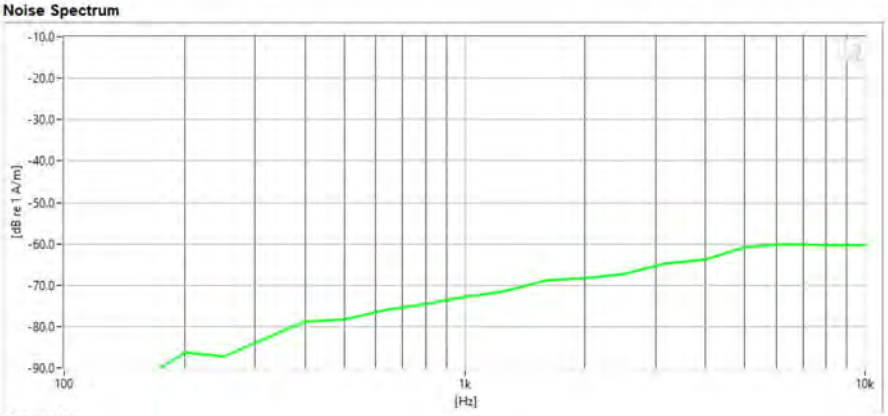
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: UMTS Band IV
- Channel: 1312

Noise Spectrum



Results

ABM1	13.48 dB	✓	Minimum	-18.0
ABM2	-61.54 dB	✓	Maximum	0.0
SNNR	75.02 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

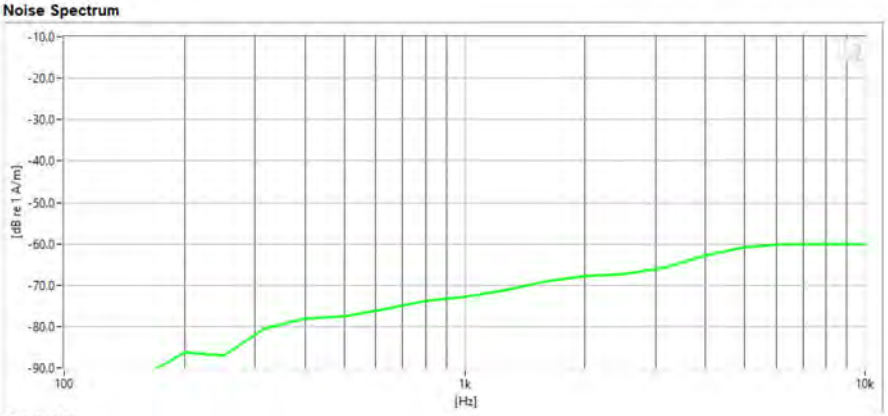
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: UMTS Band II
- Channel: 9400

Noise Spectrum



Results

ABM1	13.52 dB	✓	Minimum	-18.0
ABM2	-61.28 dB	✓	Maximum	0.0
SNNR	74.8 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

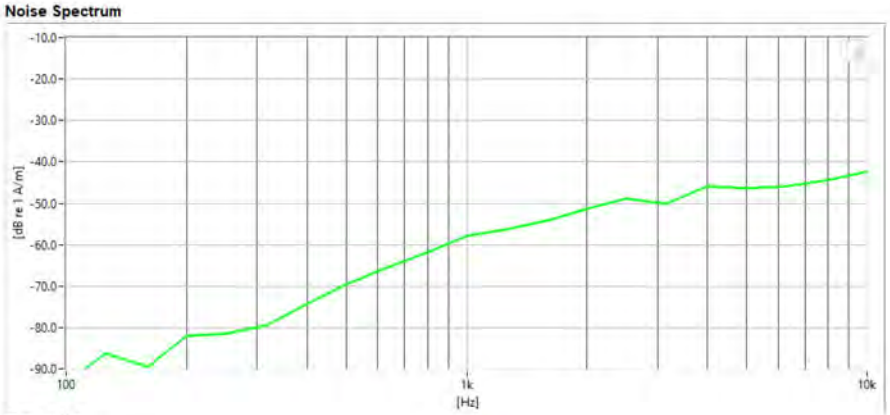
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: LTE FDD Band 13
- Bandwidth: 10MHz
- Channel: 23230

Noise Spectrum



Results

ABM1	5.15 dB	✓	Minimum	-18.0
ABM2	-46.25 dB	✓	Maximum	0.0
SNNR	51.4 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

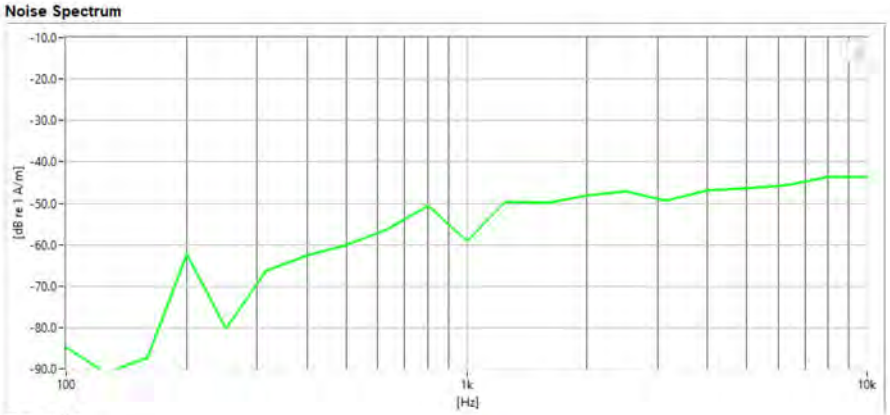
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: LTE TDD Band 41 (Power Class 3)
- Bandwidth: 20MHz
- Channel: 39750

Noise Spectrum



Results

ABM1	5.04 dB	✓	Minimum	-18.0
ABM2	-42.63 dB	✓	Maximum	0.0
SNNR	47.67 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

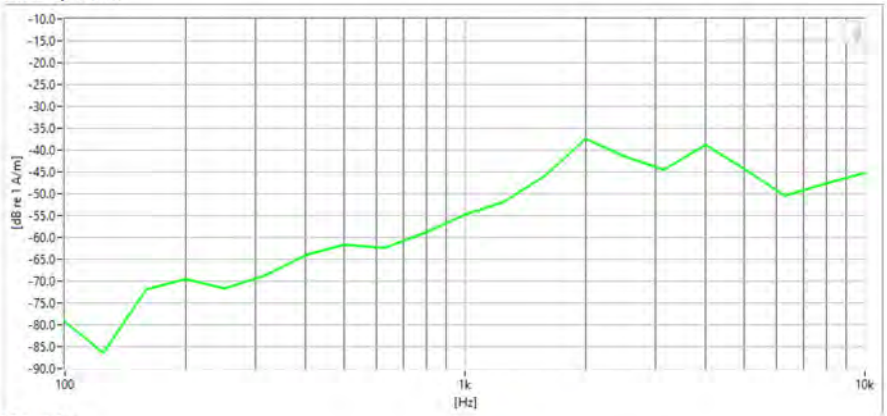
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- Mode: 2.4GHz WIFI
- Standard: IEEE 802.11ax RU
- Channel: 1

Noise Spectrum



Results

ABM1	480m dB	✓	Minimum	-18.0
ABM2	-38.3 dB	✓	Maximum	0.0
SNNR	38.78 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

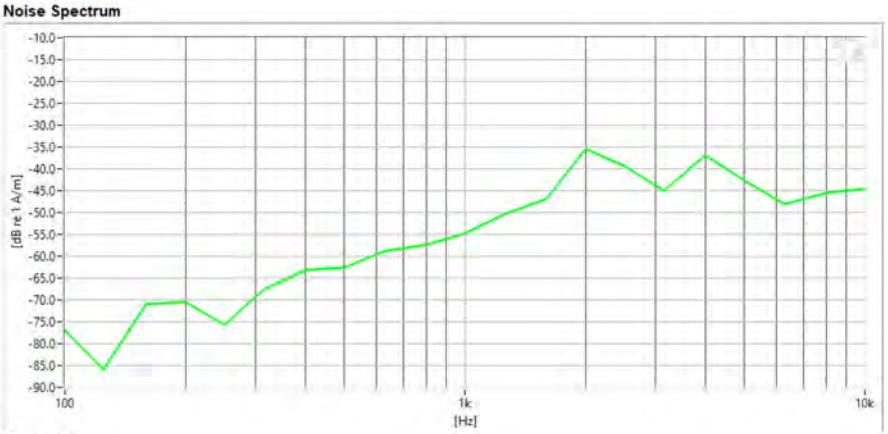
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1129; Calibrated: 09/19/2018

Test Configuration:

- Mode: 5GHz WIFI
- Standard: IEEE 802.11ax RU (U-NII 2A)
- Bandwidth: 20MHz
- Channel: 56

Noise Spectrum



Results

ABM1	20m dB	✓	Minimum	-18.0
ABM2	-36.79 dB	✓	Maximum	0.0
SNNR	36.81 dB	✓	Minimum	20.0

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PCTEST

PCTEST Hearing-Aid Compatibility Facility

DUT: ZNFV600VM

Type: Portable Handset
Serial: 00288

Measurement Standard: ANSI C63.19-2011

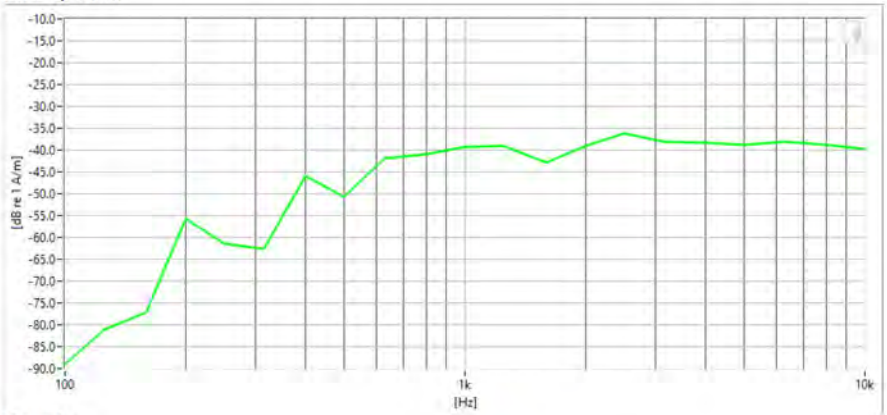
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1130; Calibrated: 05/17/2019

Test Configuration:

- VoIP Application: Google Duo
- Mode: EDGE 850
- Channel: 190

Noise Spectrum



Results

ABM1	14.52 dB	✓	Minimum	-18.0
ABM2	-31.65 dB	✓	Maximum	0.0
SNNR	46.18 dB	✓	Minimum	20.0

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13. CALIBRATION CERTIFICATES

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West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

AXIAL T COIL PROBE

Manufactured by:	TEM CONSULTING LP
Model No:	AXIAL T COIL PROBE
Serial No:	TEM-1123
Calibration Recall No:	29156

Submitted By:

Customer:	Andrew Harwell
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 C TEM C

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

√ OA
12/4/2019

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.
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.

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

Approved by: Fc

Felix Christopher (QA Mgr.)

Calibration Date: 19-Sep-18

Certificate No: 29156 -2

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 Enginering Lab **I. D. No.: XXXX**

Calibration results:

Probe Sensitivity measured with Helmholtz Coil

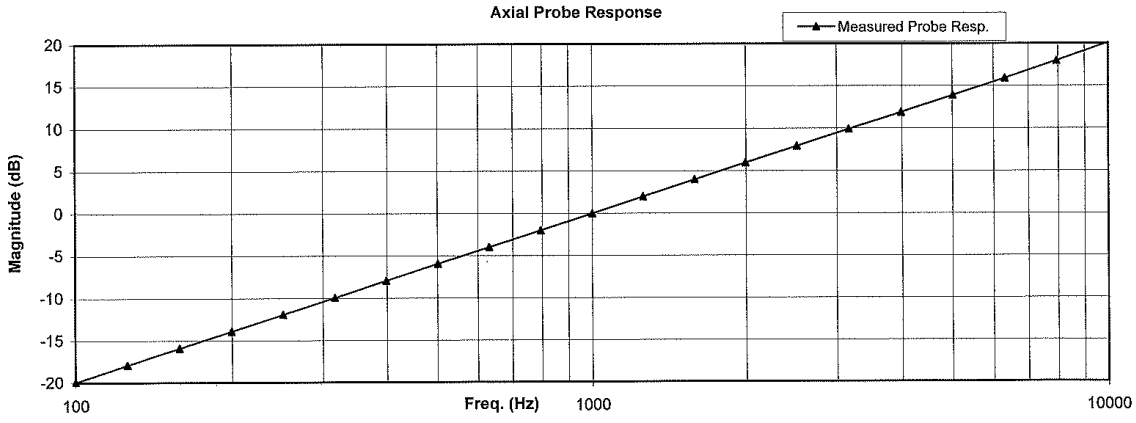
Helmholtz Coil;			**Before & after data same:**	...**X**.:.	
the number of turns on each coil;	**10**	**No.**			
the radius of each coil, in meters;	**0.204**	**m**	Laboratory Environment:		
the current in the coils, in amperes.;	**0.08**	**A**	Ambient Temperature:	**22.7**	°C
Helmholtz Coil Constant;	**7.09**	**A/m/V**	Ambient Humidity:	**52.1**	% RH
Helmholtz Coil magnetic field;	**5.95**	**A/m**	Ambient Pressure:	**99.326**	kPa
			Calibration Date:	**19-Sep-2018**	
Probe Sensitivity at	**1000**	**Hz.**	Calibration Due:		
was	**-59.89**	**dBV/A/m**	Report Number:	**29156 -2**	
	1.013	**mV/A/m**	Control Number:	**29156**	
Probe resistance	**903**	**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 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: 19-Sep-2018

Calibrated on WCCL system type 9700

Measurements performed by: .....
James Zhu

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Rev. 7.0 Jan. 24, 2014 Doc. # 1038 HCATEMC

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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 Axial T Coil Probe | Model No.: Axial T Coil Probe | Serial No.: TEM-1123
Company: PCTest Enginering Lab

Test	Function	Tolerance		Measured values		
				Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-59.89		
			dB			
2.0	Probe Level Linearity		6	6.03		
		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	-11.9		
			316	-9.9		
			398	-7.9		
			501	-6.0		
			631	-4.0		
			794	-2.0		
		Ref. (0 dB)	1000	0.0		
			1259	2.0		
			1585	4.0		
			1995	5.9		
			2512	7.9		
			3162	9.9		
			3981	11.9		
			5012	13.9		
			6310	15.9		
			7943	18.0		
			10000	20.1		

Instruments used for calibration:			Date of Cal.	Traceablity No.	Due Date
HP	34401A	S/N US360641	25-Jul-2018	,287708	25-Jul-2019
HP	34401A	S/N US361024	25-Jul-2018	,287708	25-Jul-2019
HP	33120A	S/N US360437	25-Jul-2018	,287708	25-Jul-2019
B&K	2133	S/N 1583254	25-Jul-2018	683/284413-14	25-Jul-2019

Cal. Date: 19-Sep-2018 — Tested by: James Zhu

Calibrated on WCCL system type 9700

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Rev. 7.0 Jan. 24, 2014 Doc. # 1038 HCATEMC

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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-1124
Calibration Recall No:	29973

Submitted By:

Customer:	ANDREW HARWELL
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 C TEM C

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

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.
West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2015 and ISO 17025.

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

Approved by: James Zhu

Quality Manager
ISO/IEC 17025:2005

Calibration Date: 17-May-19

Certificate No: 29973 -1

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-1124**
Company: PCTest Engineering Labs | **I. D. No.: XXXX**

Calibration results:

Probe Sensitivity measured with Helmholtz Coil

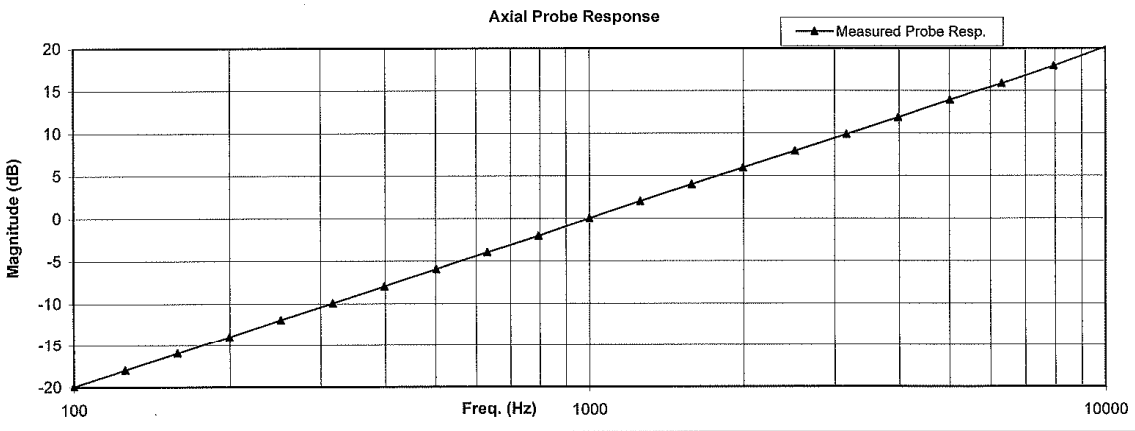
Helmholtz Coil;			**Before & after data same:**	...X...	
the number of turns on each coil;	10	No.			
the radius of each coil, in meters;	0.204	m	Laboratory Environment:		
the current in the coils, in amperes.;	0.09	A	Ambient Temperature:	20.7	°C
Helmholtz Coil Constant;	7.09	A/m/V	Ambient Humidity:	42.7	% RH
Helmholtz Coil magnetic field;	5.96	A/m	Ambient Pressure:	98.256	kPa
			Calibration Date:	17-May-2019	
Probe Sensitivity at	1000	Hz.	Calibration Due:	17-May-2020	
was	-60.41	dBV/A/m	Report Number:	29973 -1	
	0.954	mV/A/m	Control Number:	29973	
Probe resistance	903	Ohms			

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

This Calibration is traceable through NIST test numbers: 683/290345-18

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 17025

Cal. Date: 17-May-2019

Calibrated on WCCL system type 9700

Measurements performed by: .....
James Zhu

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HCATEMC_TEM-1124_May-17-2019

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-1124**

Company: PCTest Engineering Labs

Test	Function	Tolerance		Measured values		
				Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-60.41		
2.0	Probe Level Linearity		dB			
			6	6.10		
		Ref. (0 dB)	0	0.00		
			-6	-6.00		
			-12	-12.00		
3.0	Probe Frequency Response		Hz			
			100	-19.9		
			126	-17.9		
			158	-16.0		
			200	-14.0		
			251	-12.0		
			316	-10.0		
			398	-8.0		
			501	-6.0		
			631	-3.9		
			794	-2.0		
		Ref. (0 dB)	1000	0.0		
			1259	2.0		
			1585	4.0		
			1995	5.9		
			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 US360641	25-Jul-2018	,1010733	26-Jul-2019
HP	34401A	S/N US361024	25-Jul-2018	,1010733	26-Jul-2019
HP	33120A	S/N US360437	25-Jul-2018	,1010733	26-Jul-2019
B&K	2133	S/N 1583254	25-Jul-2018	683/290345-18	26-Jul-2019

Cal. Date: 17-May-2019 **Tested by: James Zhu**

Calibrated on WCCL system type 9700

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Rev. 7.0 Jan. 24, 2014 Doc. # 1038 HCATEMC

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West Caldwell Calibration Laboratories Inc.

Certificate of Calibration

for

RADIAL T COIL PROBE

Manufactured by:	TEM CONSULTING LP
Model No:	RADIAL T COIL PROBE
Serial No:	TEM-1129
Calibration Recall No:	29156

Submitted By:

Customer:	Andrew Harwell
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 TEM C

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

12/4/2018

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.
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.

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

Approved by: FC

Felix Christopher (QA Mgr.)

Calibration Date: 19-Sep-18

Certificate No: 29156 -1

ISO/IEC 17025:2005

ACCREDITED

Calibration Lab. Cert. # 1533.01

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.

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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.: XXXX**

Calibration results:

Probe Sensitivity measured with Helmholtz Coil

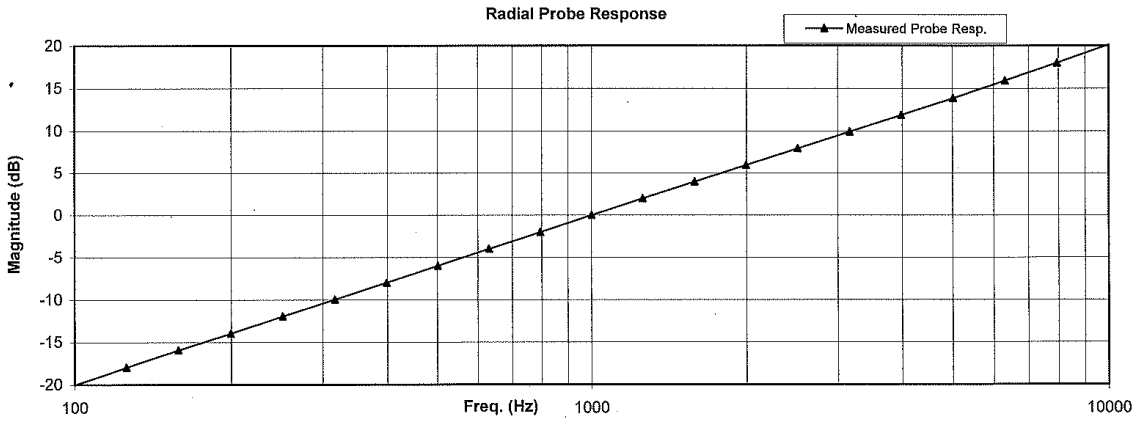
Helmholtz Coil;			**Before & after data same: ...X...**		
the number of turns on each coil;	**10**	**No.**			
the radius of each coil, in meters;	**0.204**	**m**	Laboratory Environment:		
the current in the coils, in amperes.;	**0.08**	**A**	Ambient Temperature:	**22.7**	**°C**
Helmholtz Coil Constant;	**7.09**	**A/m/V**	Ambient Humidity:	**52.1**	**% RH**
Helmholtz Coil magnetic field;	**5.95**	**A/m**	Ambient Pressure:	**99.326**	**kPa**
			Calibration Date:	**19-Sep-2018**	
Probe Sensitivity at	**1000**	**Hz.**	Re-calibration Due:		
was	**-60.37**	**dBV/A/m**	Report Number:	**29156**	**-1**
	0.958	**mV/A/m**	Control Number:	**29156**	
Probe resistance	**886**	**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: 19-Sep-2018

Calibrated on WCCL system type 9700

Measurements performed by: .....
James Zhu

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HCRTEMC_TEM-1129_Sep-19-2018

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	-60.37		
			dB			
2.0	Probe Level Linearity		6	6.03		
		Ref. (0 dB)	0	0.00		
			-6	-6.03		
			-12	-12.05		
			Hz			
3.0	Probe Frequency Response		100	-20.0		
			126	-17.9		
			158	-15.9		
			200	-14.0		
			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	20.1		

Instruments used for calibration:			Date of Cal.	Traceability No.	Due Date
HP	34401A	S/N US360641	25-Jul-2018	,287708	25-Jul-2019
HP	34401A	S/N US361024	25-Jul-2018	,287708	25-Jul-2019
HP	33120A	S/N US360437	25-Jul-2018	,287708	25-Jul-2019
B&K	2133	S/N 1583254	25-Jul-2018	683/284413-14	25-Jul-2019

Cal. Date: 19-Sep-2018 Tested by: James Zhu

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-1130
Calibration Recall No:	29973

Submitted By:

Customer:	ANDREW HARWELL
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 TEM C

6/4/2019

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

Within (X)

tolerance of the indicated specification. See attached Report of Calibration.
The information supplied relates to the calibrated item listed above.
West Caldwell Calibration Laboratories' calibration control system meets the requirements, ISO 10012-1 MIL-STD-45662A, ANSI/NCSL Z540-1, IEC Guide 25, ISO 9001:2015 and ISO 17025.

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

Approved by:

James Zhu

Quality Manager
ISO/IEC 17025:2005

Calibration Date: 17-May-19

Certificate No: 29973 -2

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-1130**
Company: PCTest Engineering Labs **I. D. No.: XXXX**

Calibration results:

Probe Sensitivity measured with Helmholtz Coil

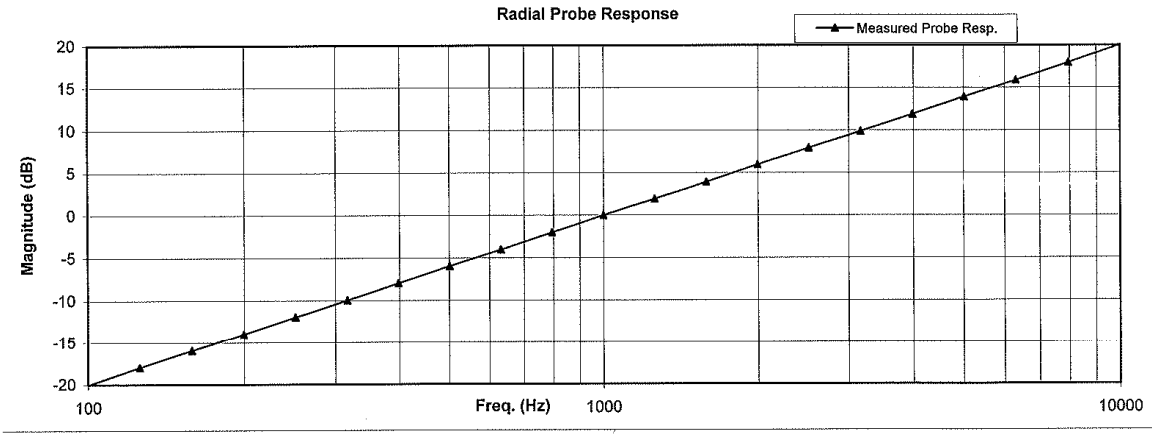
Helmholtz Coil;			**Before & after data same:**	...X...	
the number of turns on each coil;	10	No.			
the radius of each coil, in meters;	0.204	m	Laboratory Environment:		
the current in the coils, in amperes.;	0.08	A	Ambient Temperature:	20.7	°C
Helmholtz Coil Constant;	7.09	A/m/V	Ambient Humidity:	42.7	% RH
Helmholtz Coil magnetic field;	5.94	A/m	Ambient Pressure:	98.256	kPa
			Calibration Date:	17-May-2019	
Probe Sensitivity at	1000	Hz.	Calibration Due:	17-May-2020	
was	-60.37	dBV/A/m	Report Number:	29973 -2	
	0.958	mV/A/m	Control Number:	29973	
Probe resistance	895	Ohms			

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

This Calibration is traceable through NIST test numbers: 683/290345-18

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 17025

Cal. Date: 17-May-2019

Calibrated on WCCL system type 9700

Measurements performed by: .....
James Zhu

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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-1130**
Company: PCTest Engineering Labs

Test	Function	Tolerance		Measured values		
				Before	Out	Remarks
1.0	Probe Sensitivity at	1000 Hz.	dBV/A/m	-60.37		
			dB			
2.0	Probe Level Linearity		6	6.00		
		Ref. (0 dB)	0	0.00		
			-6	-6.10		
			-12	-12.10		
			Hz			
3.0	Probe Frequency Response		100	-20.0		
			126	-17.9		
			158	-16.0		
			200	-14.0		
			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	1.9		
			1585	3.9		
			1995	5.9		
			2512	7.9		
			3162	9.9		
			3981	11.9		
			5012	13.9		
			6310	15.9		
			7943	18.0		
			10000	20.1		

Instruments used for calibration:			Date of Cal.	Traceability No.	Due Date
HP	34401A	S/N US360641	25-Jul-2018	,1010733	26-Jul-2019
HP	34401A	S/N US361024	25-Jul-2018	,1010733	26-Jul-2019
HP	33120A	S/N US360437	25-Jul-2018	,1010733	26-Jul-2019
B&K	2133	S/N 1583254	25-Jul-2018	683/290345-18	26-Jul-2019

Cal. Date: 17-May-2019 Tested by: James Zhu

Calibrated on WCCL system type 9700

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14. 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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