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# HEARING AID COMPATIBILITY

**Applicant Name:**
Samsung Electronics Co., Ltd.
129, Samsung-ro, Maetan dong,
Yeongtong-gu, Suwon-si
Gyeonggi-do 16677, Korea

**Date of Testing:**
10/21/2019 - 10/22/2019
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Test Report Serial No.:**
1M1910220167-01-R1.A3L
**Date of Issue:**
10/29/2019

| | |
|---|---|
| **FCC ID:** | **A3LSMJ737P** |
| **APPLICANT:** | **SAMSUNG ELECTRONICS CO., LTD.** |

| | |
|---|---|
| **Scope of Test:** | Audio Band Magnetic Testing (T-Coil) |
| **Application Type:** | Class II Permissive Change |
| **FCC Rule Part(s):** | CFR §20.19(b) |
| **HAC Standard:** | ANSI C63.19-2011<br>285076 D01 HAC Guidance v05<br>285076 D02 T-Coil testing for CMRS IP v03 |
| **DUT Type:** | Portable Handset |
| **Model:** | SM-J737P |
| **Test Device Serial No.:** | *Pre-Production Sample* [S/N: 34952] |
| **Original Grant Date:** | 05/07/2018 |
| **Class II Permissive Change(s):** | See FCC Change Document |

| | |
|---|---|
| **C63.19-2011 HAC Category:** | **T3 (SIGNAL TO NOISE CATEGORY)** |

Note: This revised Test Report (S/N: 1M1910220167-01-R1.A3L) 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 report and category pertain only to the Voice over LTE services supported by this wireless portable device. Please refer to the original certification technical report (S/N: 1M1802160028-12-R1.A3L) for data on other modes supported by this device. This wireless portable device has been shown to be hearing-aid compatible for Voice over LTE services, under the above rated category, specified in ANSI/IEEE Std. C63.19-2011 and has been tested in accordance with the specified measurement procedures. Hearing-Aid Compatibility is based on the assumption that all production units will be designed electrically identical to the device tested in this report. Test results reported herein relate only to the item(s) tested. North America 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

ilac-MRA
ACCREDITED
TESTING CERT#2041.01

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# 1. INTRODUCTION

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

**Compatibility Tests Involved:**

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

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

The hearing aid must be measured for:

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

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

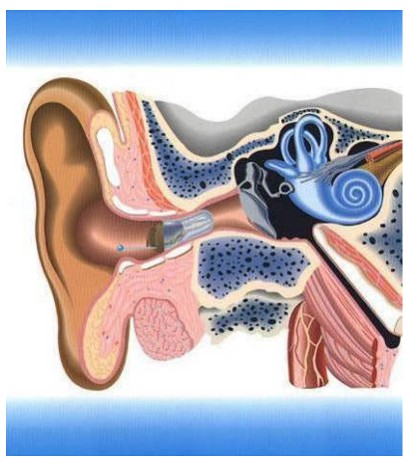


**Figure 1-1 Hearing Aid *in-vitu***

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

## 2. DUT DESCRIPTION

| | |
|---|---|
| FCC ID: | A3LSMJ737P |
| Applicant: | Samsung Electronics Co., Ltd.<br>129, Samsung-ro, Maetan dong,<br>Yeongtong-gu, Suwon-si<br>Gyeonggi-do 16677, Korea |
| Model: | SM-J737P |
| Serial Number: | 34952 |
| HW Version: | J737P.02 |
| SW Version: | J737PVPU0_0406_PROTOCOL_NV |
| Antenna: | Internal Antenna |
| DUT Type: | Portable Handset |

### I. LTE Band Selection

This device supports the following pair of LTE bands with similar frequencies: LTE B5 & B26. 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 B26) was evaluated for hearing-aid compliance.

**Table 2-1**
A3LSMJ737P 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 | No[3] | Yes: WIFI or BT | CMRS Voice[1] | EVRC |
| | 1900 | | | | | |
| | EvDO | VD | No[3] | Yes: WIFI or BT | Google Duo[2] | OPUS |
| GSM | 850 | VO | No[3] | Yes: WIFI or BT | CMRS Voice[1] | EFR |
| | 1900 | | | | | |
| | GPRS/EDGE | VD | No[3] | Yes: WIFI or BT | Google Duo[2] | OPUS |
| UMTS | 850 | VD | No[3] | Yes: WIFI or BT | CMRS Voice[1] | NB AMR |
| | 1700 | | | | | |
| | 1900 | | | | | |
| | HSPA | VD | No[3] | Yes: WIFI or BT | Google Duo[2] | OPUS |
| LTE (FDD) | 700 (B12) | VD | Yes[3] | Yes: WIFI or BT | VoLTE[1], Google Duo[2] | VoLTE: NB AMR, WB AMR<br>Google Duo: OPUS |
| | 850 (B5) | | | | | |
| | 850 (B26) | | | | | |
| | 1700 (B4) | | | | | |
| | 1900 (B2) | | | | | |
| | 1900 (B25) | | | | | |
| LTE (TDD) | 2600 (B41) | VD | Yes[3] | Yes: WIFI or BT | VoLTE[1], Google Duo[2] | VoLTE: NB AMR, WB AMR<br>Google Duo: OPUS |
| WIFI | 2450 | VD | No[3] | Yes: CDMA, GSM, UMTS, or LTE | VoWIFI[2], Google Duo[2] | VoWIFI: NB AMR, WB AMR<br>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, or LTE | 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. This report only pertains to Voice Over LTE services. Please refer to the original certification technical report (S/N: 1M1802160028-12-R1.A3L) for data on other modes supported by this device.

## 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.

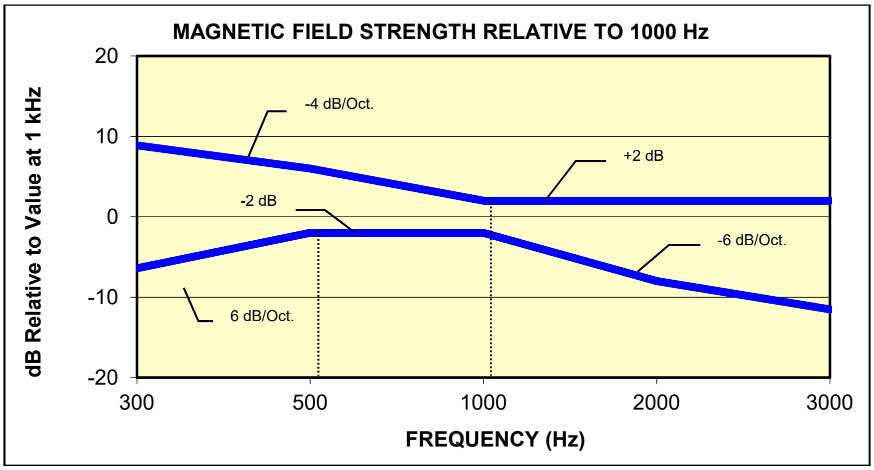



**Figure 3-1**
**Magnetic field frequency response for Wireless Devices with an axial field ≤-15 dB(A/m) at 1 kHz**

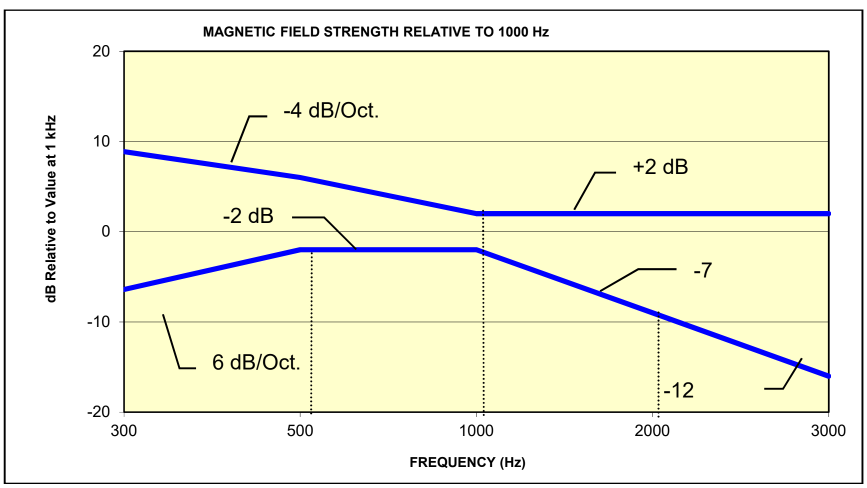



**Figure 3-2**
**Magnetic Field frequency response for wireless devices with an axial field that exceeds -15 dB(A/m) at 1 kHz**

### 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.

# 4. METHOD OF MEASUREMENT

## I. Test Setup

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

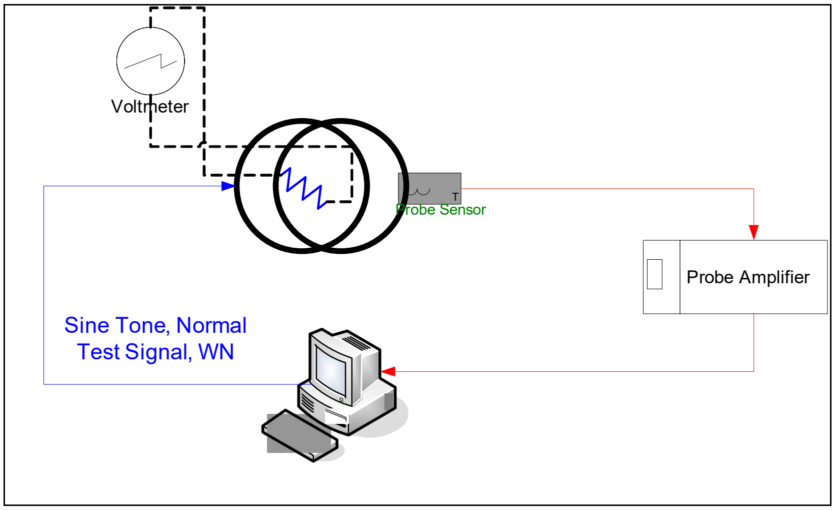



**Figure 4-1**
**Validation Setup with Helmholtz Coil**

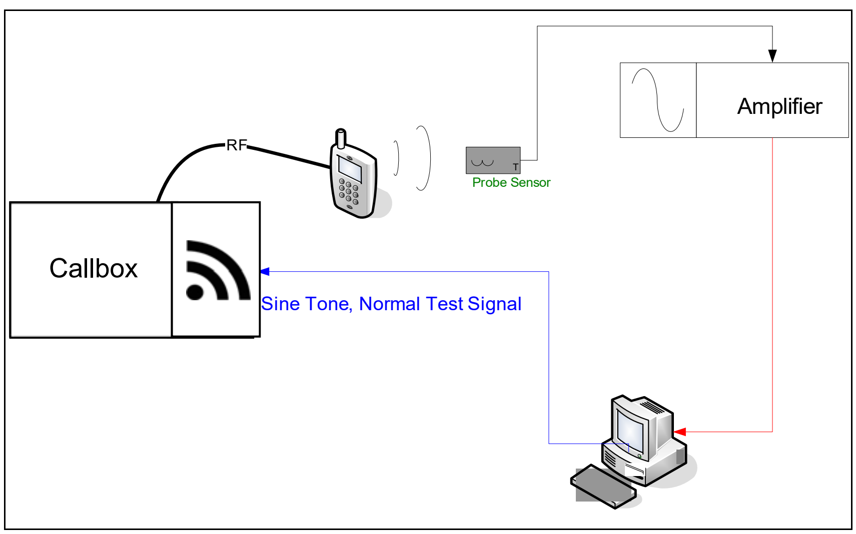



**Figure 4-2**
**T-Coil Test Setup**

## 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) |

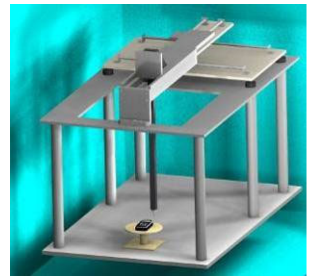


**Figure 4-3**
RF Near-Field Scanner

## III. 3GPP2 Normal Test Signal (Speech)

| | |
|---|---|
| Manufacturer: | 3GPP2 (TIA 1042 §3.3.1) |
| Stimulus Type: | Modified-IRS weighted, multi-talker speech signal, 4 Male and 4 Female speakers (alternating) |
| Single Sample Duration: | 51.62 seconds |
| Activity Level: | 77.4% |

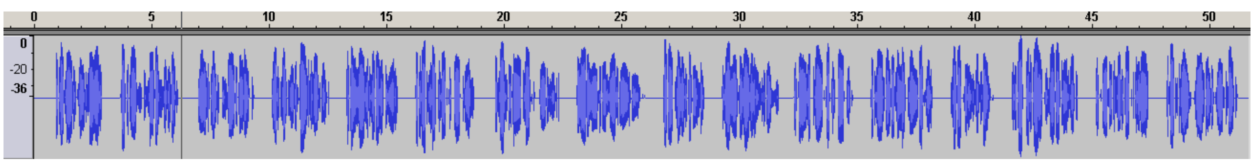



**Figure 4-4**
**Temporal Characteristic of Normal Test Signal**

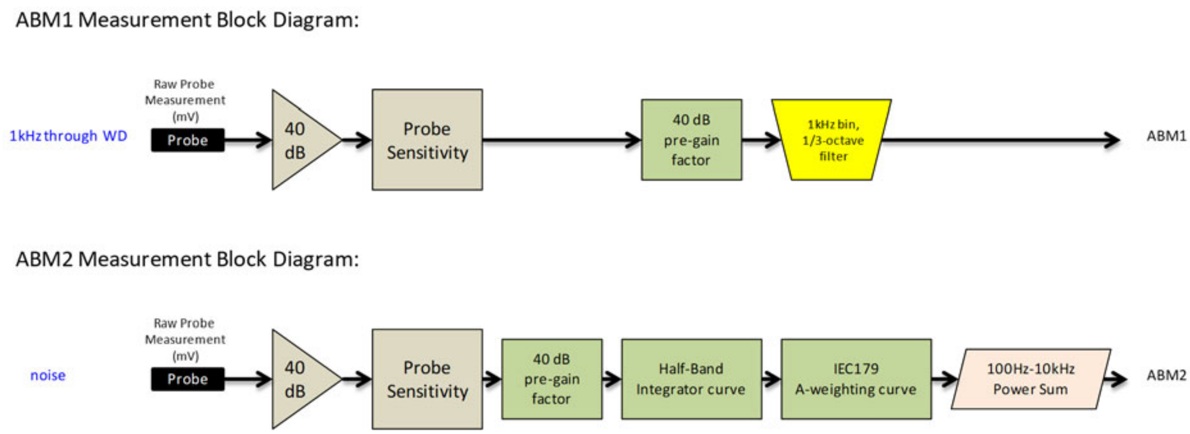



**Figure 4-5 Magnetic Measurement Processing Steps**

## 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, N=20; r=0.13m; R=10.193Ω and using V=29mV:

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

   Therefore a pure tone of 1kHz was applied into the coils such that 29mV was observed across the resistor. The voltmeter used for measurement was verified to be capable of measurements in the audio band range. This theoretically generates an expected field of -10 dB(A/m) in the center of the Helmholtz coil which was used to validate the probe measurement at -10dB(A/m). This was verified to be within ± 0.5 dB of the -10dB(A/m) value (see Page 23).

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 Normal signal as shown below:

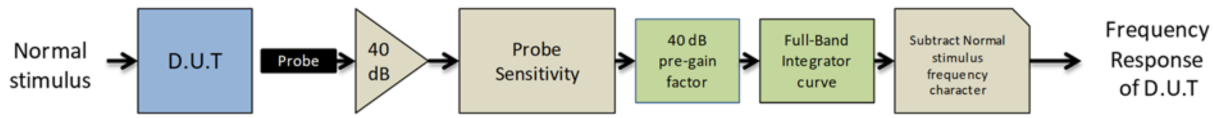



**Figure 4-6 Frequency Response Validation**

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 |

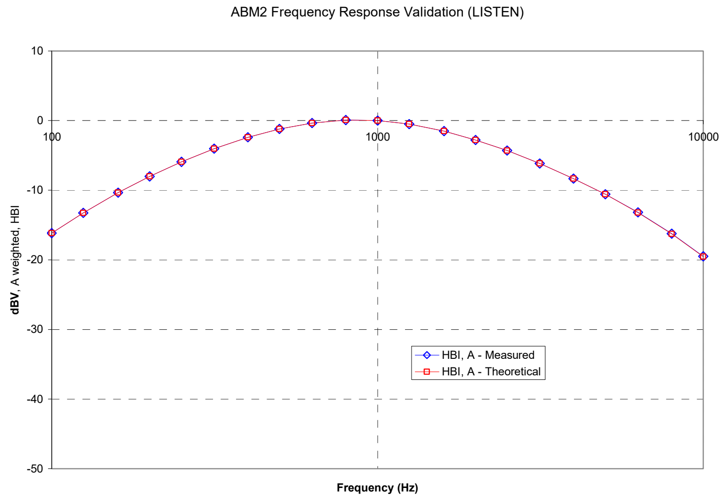



**Figure 4-7**
**ABM2 Frequency Response Validation**

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 4-8). Therefore the setup in this step was used to verify the power sum post-processing for ABM2 measurements. See below block diagram:

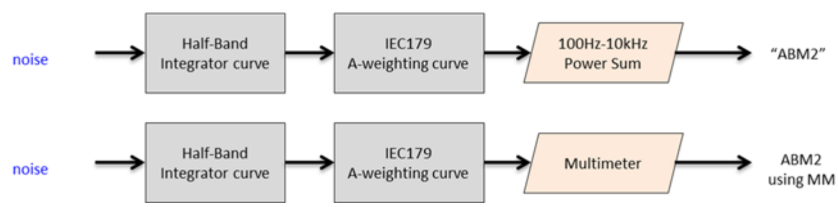



**Figure 4-8**
**ABM2 Validation Block Diagram**

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 |

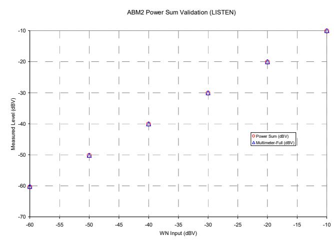



**Figure 4-9**
**ABM2 Power Sum Validation**

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 4-11, the grid is not to scale but merely a graphical representation of the coordinate system in use):

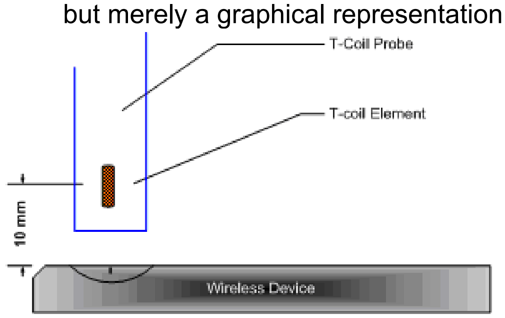



**Figure 4-10**
**Measurement Distance**

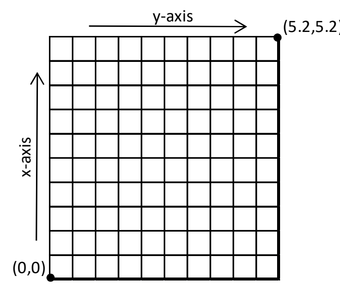



**Figure 4-11**
**Measurement Grid**

        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 4-13 after a T-coil orientation was fully measured with the SoundCheck system.
    b. Speech Signal Setup to Base Station Simulator
        i. See Section 5 for more information regarding CMW500 audio level settings for Voice Over LTE (VoLTE).
    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 (LTE configuration information can be found in Section 5.)
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 4-6. 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.

## V. Test Setup

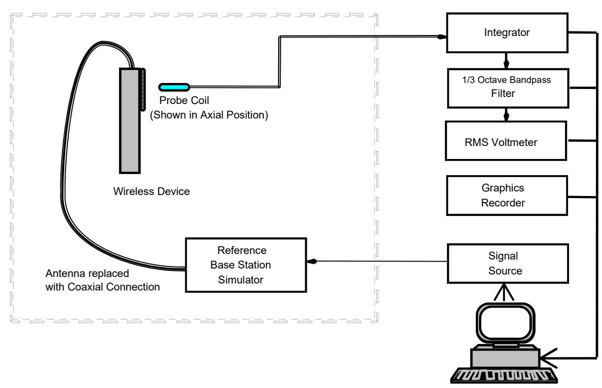



**Figure 4-12**
**Audio Magnetic Field Test Setup**

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.

## VIII. Wireless Device Channels and Frequencies

### 1. 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. See Tables 6-2 to 6-8 for LTE bandwidths and channels.

## IX. Test Flow

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

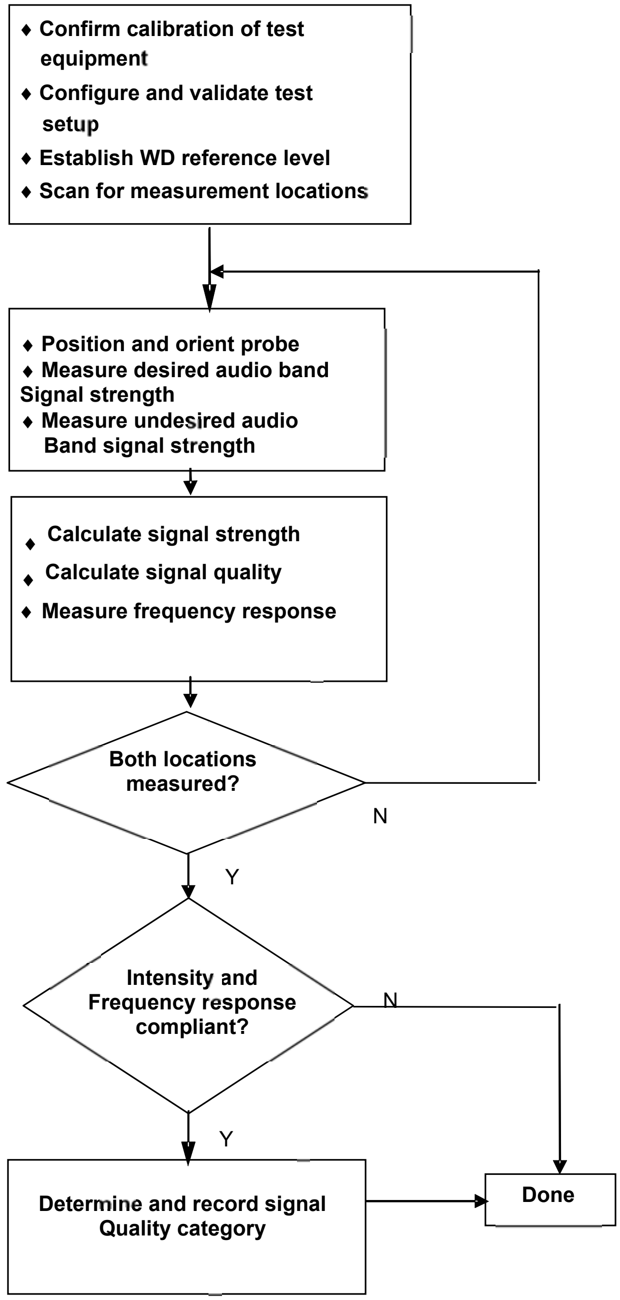



**Figure 4-13**
**C63.19 T-Coil Signal Test Process**

# 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.

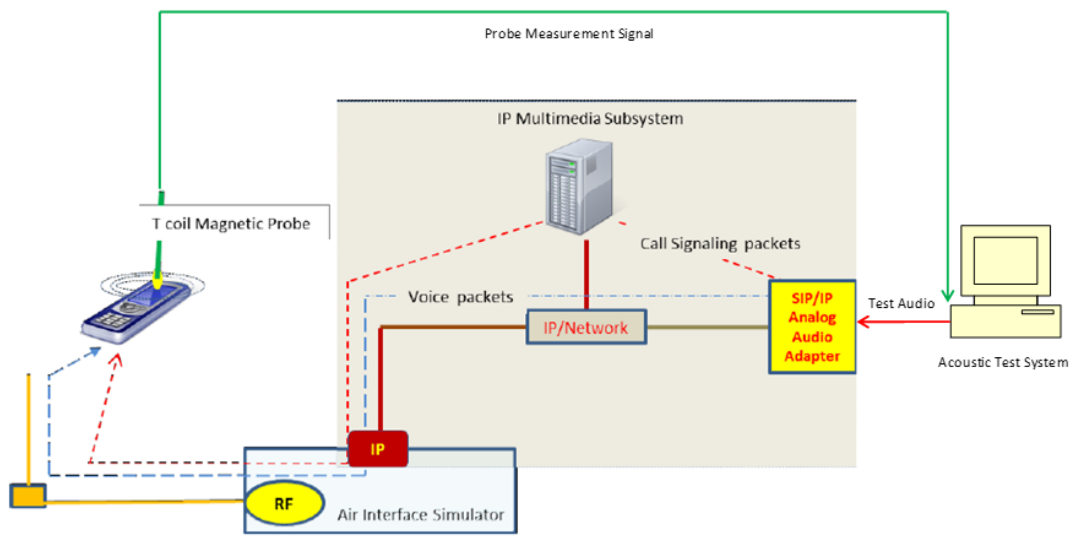



**Figure 5-1**
**Test Setup for VoLTE over IMS T-Coil Measurements**

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

## 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] |
|---|---|---|---|---|---|---|---|---|---|
| 25 | 1882.5 | 26365 | 20 | QPSK | 1 | 0 | 6.69 | -41.71 | 48.40 |
| 25 | 1882.5 | 26365 | 20 | QPSK | 1 | 50 | 6.60 | -41.57 | 48.17 |
| 25 | 1882.5 | 26365 | 20 | QPSK | 1 | 99 | 6.73 | -41.35 | 48.08 |
| 25 | 1882.5 | 26365 | 20 | QPSK | 50 | 0 | 6.42 | -41.70 | 48.12 |
| 25 | 1882.5 | 26365 | 20 | QPSK | 50 | 25 | 6.68 | -41.61 | 48.29 |
| 25 | 1882.5 | 26365 | 20 | QPSK | 50 | 50 | 6.61 | -41.60 | 48.21 |
| 25 | 1882.5 | 26365 | 20 | QPSK | 100 | 0 | 6.58 | -41.64 | 48.22 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 1 | 0 | 6.59 | -41.36 | 47.95 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 1 | 50 | 6.63 | -41.46 | 48.09 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 1 | 99 | 6.38 | -41.64 | 48.02 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 50 | 0 | 6.56 | -41.69 | 48.25 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 50 | 25 | 6.63 | -41.68 | 48.31 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 50 | 50 | 6.62 | -41.78 | 48.40 |
| 25 | 1882.5 | 26365 | 20 | 16QAM | 100 | 0 | 6.62 | -41.70 | 48.32 |

### 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 band and bandwidth; therefore, only one band and bandwidth were 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) | 6.72 | 6.43 | 10.30 | 9.98 | Axial | Band 25 20MHz | 26365 |
| ABM2 (dBA/m) | -41.39 | -41.31 | -41.35 | -41.38 | | | |
| Frequency Response | Pass | Pass | Pass | Pass | | | |
| S+N/N (dB) | 48.11 | 47.74 | 51.65 | 51.36 | | | |

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

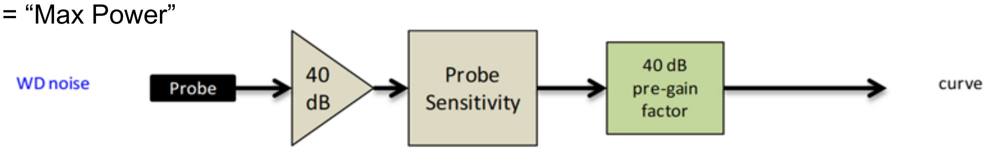



**Figure 5-2**
**Audio Band Magnetic Curve Measurement Block Diagram**

### 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 5-3**
**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% |

#### 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 1 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 5-4**
**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 | 6.95 | -41.15 | 48.10 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 1 | 6.59 | -41.26 | **47.85** |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 2 | 6.77 | -41.31 | 48.08 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 3 | 6.72 | -41.40 | 48.12 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 4 | 6.79 | -41.45 | 48.24 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 5 | 6.73 | -41.31 | 48.04 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 6 | 7.05 | -41.11 | 48.16 |

### b. Power Class 2 Uplink-Downlink Configuration Investigation

Power Class 2 was evaluated with the following radio configuration: channel 40620, 20MHz BW, 16QAM, 1RB, 0RB Offset. For Power Class 2, configurations 1-5 are supported. The configuration which resulted in the worst SNNR was used for full testing. Uplink-Downlink configuration 1 was used as the worst-case configuration for Power Class 2 VoLTE over IMS T-Coil testing. See table below for the SNNR comparison between each Uplink-Downlink configuration:

**Table 5-5**
**Power Class 2 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 | 1 | 6.58 | -40.44 | **47.02** |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 2 | 6.99 | -40.68 | 47.67 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 3 | 6.93 | -40.56 | 47.49 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 4 | 6.54 | -40.86 | 47.40 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 5 | 6.52 | -41.05 | 47.57 |

Note: LTE TDD B41 Power Class 2 only supports UL-DL configurations 1-5, not 0 or 6.

### c. Conclusion

Per the investigations above, UL-DL Configuration 1 was used to evaluate both Power Class 3 & Power Class 2 VoLTE over IMS.

# 6. T-COIL TEST SUMMARY

**Table 6-1**
**Consolidated Tabled Results**

| | | Freq. Response Margin | | Magnetic Intensity Verdict | | FCC SNNR Verdict | | Margin from FCC Limit (dB) | C63.19-2011 Rating |
|---|---|---|---|---|---|---|---|---|---|
| C63.19 Section | | 8.3.2 | | 8.3.1 | | 8.3.4 | | | |
| | | Axial | Radial | Axial | Radial | Axial | Radial | | |
| **LTE FDD** | B12 | PASS | NA | PASS | PASS | PASS | PASS | **-16.10** | **T4** |
| | B26 | PASS | NA | PASS | PASS | PASS | PASS | | |
| | B4 | PASS | NA | PASS | PASS | PASS | PASS | | |
| | B2 | PASS | NA | PASS | PASS | PASS | PASS | | |
| | B25 | PASS | NA | PASS | PASS | PASS | PASS | | |
| **LTE TDD** | B41 (PC3) | PASS | NA | PASS | PASS | PASS | PASS | **-5.62** | **T3** |
| | B41 (PC2) | PASS | NA | PASS | PASS | PASS | PASS | | |

## I. Raw Handset Data

**Table 6-2**
**Raw Data Results for LTE B12**

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 12 | Axial | 10MHz | 23095 | 6.22 | -41.26 | -58.57 | 1.15 | 47.48 | 20.00 | -27.48 | T4 | 2.6, 2.6 |
| | | 5MHz | 23095 | 6.84 | -40.88 | | 1.12 | 47.72 | 20.00 | -27.72 | T4 | |
| | | 3MHz | 23095 | 6.04 | -41.17 | | 1.32 | 47.21 | 20.00 | -27.21 | T4 | |
| | | 1.4MHz | 23173 | 6.45 | -41.35 | | 1.16 | 47.80 | 20.00 | -27.80 | T4 | |
| | | 1.4MHz | 23095 | 6.14 | -40.97 | | 1.20 | 47.11 | 20.00 | -27.11 | T4 | |
| | | 1.4MHz | 23017 | 6.35 | -41.16 | | 1.26 | 47.51 | 20.00 | -27.51 | T4 | |
| | Radial | 10MHz | 23095 | -3.20 | -40.86 | -60.56 | N/A | 37.66 | 20.00 | -17.66 | T4 | 2.6, 1.8 |
| | | 5MHz | 23095 | -3.26 | -40.08 | | | 36.82 | 20.00 | -16.82 | T4 | |
| | | 3MHz | 23095 | -3.20 | -40.10 | | | 36.90 | 20.00 | -16.90 | T4 | |
| | | 1.4MHz | 23173 | -3.37 | -41.65 | | | 38.28 | 20.00 | -18.28 | T4 | |
| | | 1.4MHz | 23095 | -3.28 | -39.82 | | | 36.54 | 20.00 | -16.54 | T4 | |
| | | 1.4MHz | 23017 | -3.29 | -39.39 | | | 36.10 | 20.00 | -16.10 | T4 | |

**Table 6-3**
**Raw Data Results for LTE B26**

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 26 | Axial | 15MHz | 26865 | 6.78 | -41.01 | -58.57 | 1.25 | 47.79 | 20.00 | -27.79 | T4 | 2.6, 2.6 |
| | | 10MHz | 26865 | 6.45 | -41.28 | | 1.19 | 47.73 | 20.00 | -27.73 | T4 | |
| | | 5MHz | 26865 | 6.49 | -41.40 | | 1.14 | 47.89 | 20.00 | -27.89 | T4 | |
| | | 3MHz | 26865 | 6.25 | -41.41 | | 1.25 | 47.66 | 20.00 | -27.66 | T4 | |
| | | 1.4MHz | 26865 | 6.08 | -41.40 | | 1.24 | 47.48 | 20.00 | -27.48 | T4 | |
| | Radial | 15MHz | 26865 | -3.13 | -40.58 | -60.56 | N/A | 37.45 | 20.00 | -17.45 | T4 | 2.6 1.8 |
| | | 10MHz | 26865 | -3.39 | -40.63 | | | 37.24 | 20.00 | -17.24 | T4 | |
| | | 5MHz | 26865 | -3.25 | -40.92 | | | 37.67 | 20.00 | -17.67 | T4 | |
| | | 3MHz | 26865 | -3.31 | -41.74 | | | 38.43 | 20.00 | -18.43 | T4 | |
| | | 1.4MHz | 26865 | -3.15 | -42.24 | | | 39.09 | 20.00 | -19.09 | T4 | |

## Table 6-4
## Raw Data Results for LTE B4

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 4 | Axial | 20MHz | 20175 | 6.45 | -41.37 | -58.57 | 1.24 | 47.82 | 20.00 | -27.82 | T4 | 2.6, 2.6 |
| | | 15MHz | 20175 | 6.49 | -41.43 | | 1.27 | 47.92 | 20.00 | -27.92 | T4 | |
| | | 10MHz | 20175 | 6.65 | -41.35 | | 1.18 | 48.00 | 20.00 | -28.00 | T4 | |
| | | 5MHz | 20175 | 6.38 | -41.23 | | 1.21 | 47.61 | 20.00 | -27.61 | T4 | |
| | | 3MHz | 20175 | 6.25 | -41.26 | | 1.21 | 47.51 | 20.00 | -27.51 | T4 | |
| | | 1.4MHz | 20175 | 6.46 | -41.26 | | 1.21 | 47.72 | 20.00 | -27.72 | T4 | |
| | Radial | 20MHz | 20175 | -3.17 | -42.49 | -60.56 | N/A | 39.32 | 20.00 | -19.32 | T4 | 2.6 1.8 |
| | | 15MHz | 20175 | -3.42 | -42.67 | | | 39.25 | 20.00 | -19.25 | T4 | |
| | | 10MHz | 20175 | -3.27 | -41.79 | | | 38.52 | 20.00 | -18.52 | T4 | |
| | | 5MHz | 20175 | -3.14 | -40.89 | | | 37.75 | 20.00 | -17.75 | T4 | |
| | | 3MHz | 20175 | -3.19 | -40.64 | | | 37.45 | 20.00 | -17.45 | T4 | |
| | | 1.4MHz | 20175 | -3.18 | -40.18 | | | 37.00 | 20.00 | -17.00 | T4 | |

## Table 6-5
## Raw Data Results for LTE B25

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 25 | Axial | 20MHz | 26365 | 6.68 | -41.11 | -58.57 | 1.16 | 47.79 | 20.00 | -27.79 | T4 | 2.6, 2.6 |
| | | 15MHz | 26365 | 6.69 | -41.26 | | 1.31 | 47.95 | 20.00 | -27.95 | T4 | |
| | | 10MHz | 26365 | 6.38 | -41.31 | | 1.24 | 47.69 | 20.00 | -27.69 | T4 | |
| | | 5MHz | 26365 | 6.43 | -41.28 | | 1.30 | 47.71 | 20.00 | -27.71 | T4 | |
| | | 3MHz | 26365 | 6.54 | -41.23 | | 1.19 | 47.77 | 20.00 | -27.77 | T4 | |
| | | 1.4MHz | 26365 | 6.67 | -41.31 | | 1.20 | 47.98 | 20.00 | -27.98 | T4 | |
| | Radial | 20MHz | 26365 | -3.19 | -40.36 | -60.56 | N/A | 37.17 | 20.00 | -17.17 | T4 | 2.6 1.8 |
| | | 15MHz | 26365 | -3.55 | -40.68 | | | 37.13 | 20.00 | -17.13 | T4 | |
| | | 10MHz | 26365 | -3.13 | -41.50 | | | 38.37 | 20.00 | -18.37 | T4 | |
| | | 5MHz | 26365 | -3.13 | -41.32 | | | 38.19 | 20.00 | -18.19 | T4 | |
| | | 3MHz | 26365 | -3.10 | -41.31 | | | 38.21 | 20.00 | -18.21 | T4 | |
| | | 1.4MHz | 26365 | -3.05 | -41.00 | | | 37.95 | 20.00 | -17.95 | T4 | |

## Table 6-6
## Raw Data Results for LTE B2

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 2 | Axial | 20MHz | 18900 | 6.64 | -41.25 | -58.57 | 1.25 | 47.89 | 20.00 | -27.89 | T4 | 2.6, 2.6 |
| | | 15MHz | 18900 | 6.61 | -41.23 | | 1.25 | 47.84 | 20.00 | -27.84 | T4 | |
| | | 10MHz | 18900 | 6.75 | -41.19 | | 1.29 | 47.94 | 20.00 | -27.94 | T4 | |
| | | 5MHz | 18900 | 6.18 | -41.26 | | 1.23 | 47.44 | 20.00 | -27.44 | T4 | |
| | | 3MHz | 18900 | 6.41 | -41.16 | | 1.23 | 47.57 | 20.00 | -27.57 | T4 | |
| | | 1.4MHz | 18900 | 6.66 | -41.21 | | 1.23 | 47.87 | 20.00 | -27.87 | T4 | |
| | Radial | 20MHz | 18900 | -3.18 | -40.60 | -60.56 | N/A | 37.42 | 20.00 | -17.42 | T4 | 2.6 1.8 |
| | | 15MHz | 18900 | -3.00 | -39.92 | | | 36.92 | 20.00 | -16.92 | T4 | |
| | | 10MHz | 18900 | -3.19 | -40.43 | | | 37.24 | 20.00 | -17.24 | T4 | |
| | | 5MHz | 18900 | -3.29 | -40.18 | | | 36.89 | 20.00 | -16.89 | T4 | |
| | | 3MHz | 18900 | -3.49 | -40.11 | | | 36.62 | 20.00 | -16.62 | T4 | |
| | | 1.4MHz | 18900 | -3.31 | -40.50 | | | 37.19 | 20.00 | -17.19 | T4 | |

## Table 6-7
## Raw Data Results for LTE B41 Power Class 3

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 41 | Axial | 20MHz | 40620 | 6.80 | -41.27 | -58.57 | 1.18 | 48.07 | 20.00 | -28.07 | T4 | 2.6, 2.6 |
| | | 15MHz | 40620 | 6.68 | -41.23 | | 1.20 | 47.91 | 20.00 | -27.91 | T4 | |
| | | 10MHz | 40620 | 6.91 | -41.24 | | 1.14 | 48.15 | 20.00 | -28.15 | T4 | |
| | | 5MHz | 40620 | 6.96 | -41.29 | | 1.21 | 48.25 | 20.00 | -28.25 | T4 | |
| | Radial | 20MHz | 40620 | -3.32 | -35.28 | -60.56 | N/A | 31.96 | 20.00 | -11.96 | T4 | 2.6, 1.8 |
| | | 15MHz | 40620 | -3.18 | -35.11 | | | 31.93 | 20.00 | -11.93 | T4 | |
| | | 10MHz | 40620 | -3.44 | -35.27 | | | 31.83 | 20.00 | -11.83 | T4 | |
| | | 5MHz | 40620 | -3.15 | -34.96 | | | 31.81 | 20.00 | -11.81 | T4 | |

## Table 6-8
## Raw Data Results for LTE B41 Power Class 2

| Mode | Orientation | Bandwidth | Channel | ABM1 [dB(A/m)] | ABM2 [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | FCC Limit (dB) | Margin from FCC Limit (dB) | C63.19-2011 Rating | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 41 | Axial | 20MHz | 40620 | 6.86 | -40.42 | -58.57 | 1.17 | 47.28 | 20.00 | -27.28 | T4 | 2.6, 2.6 |
| | | 15MHz | 40620 | 6.64 | -40.33 | | 1.18 | 46.97 | 20.00 | -26.97 | T4 | |
| | | 10MHz | 41490 | 6.67 | -40.02 | | 1.26 | 46.69 | 20.00 | -26.69 | T4 | |
| | | 10MHz | 41055 | 6.93 | -40.47 | | 1.30 | 47.40 | 20.00 | -27.40 | T4 | |
| | | 10MHz | 40620 | 6.72 | -40.24 | | 1.21 | 46.96 | 20.00 | -26.96 | T4 | |
| | | 10MHz | 40185 | 6.65 | -40.30 | | 1.20 | 46.95 | 20.00 | -26.95 | T4 | |
| | | 10MHz | 39750 | 6.95 | -40.21 | | 1.36 | 47.16 | 20.00 | -27.16 | T4 | |
| | | 5MHz | 40620 | 6.63 | -40.48 | | 1.15 | 47.11 | 20.00 | -27.11 | T4 | |
| | Radial | 20MHz | 40620 | -3.19 | -29.88 | -60.56 | N/A | 26.69 | 20.00 | -6.69 | T3 | 2.6, 1.8 |
| | | 15MHz | 40620 | -3.42 | -30.33 | | | 26.91 | 20.00 | -6.91 | T3 | |
| | | 10MHz | 41490 | -3.25 | -28.87 | | | 25.62 | 20.00 | -5.62 | T3 | |
| | | 10MHz | 41055 | -3.12 | -29.52 | | | 26.40 | 20.00 | -6.40 | T3 | |
| | | 10MHz | 40620 | -3.21 | -29.58 | | | 26.37 | 20.00 | -6.37 | T3 | |
| | | 10MHz | 40185 | -3.11 | -30.76 | | | 27.65 | 20.00 | -7.65 | T3 | |
| | | 10MHz | 39750 | -3.40 | -29.21 | | | 25.81 | 20.00 | -5.81 | T3 | |
| | | 5MHz | 40620 | -3.39 | -30.87 | | | 27.48 | 20.00 | -7.48 | T3 | |

# 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→More Settings→Hearing aids**) was set to ON for Frequency Response compliance
4. Speech Signal: 3GPP2 Normal Test Signal
5. Bluetooth and WIFI were disabled while testing 4G modes.
6. The Margin from FCC limit column indicates a margin from the FCC limit for compliance (T3).

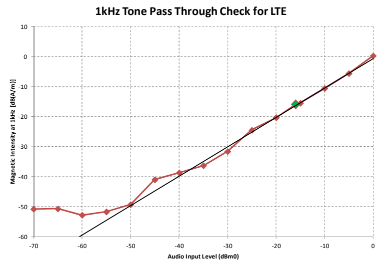
B. LTE FDD

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 12 at 1.4MHz is the worst-case for both the Axial and Radial probe orientations.

C. LTE TDD

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: 16QAM, 1RB, 0RB offset
3. Power Class 3 Uplink-Downlink configuration: 1
4. Power Class 2 Uplink-Downlink configuration: 1
5. Vocoder Configuration: WB AMR 6.60kbps
6. 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 (Powers Class 2) at 10MHz is the worst-case for both the Axial and Radial probe orientations.

## III. 1 kHz Vocoder Application Check



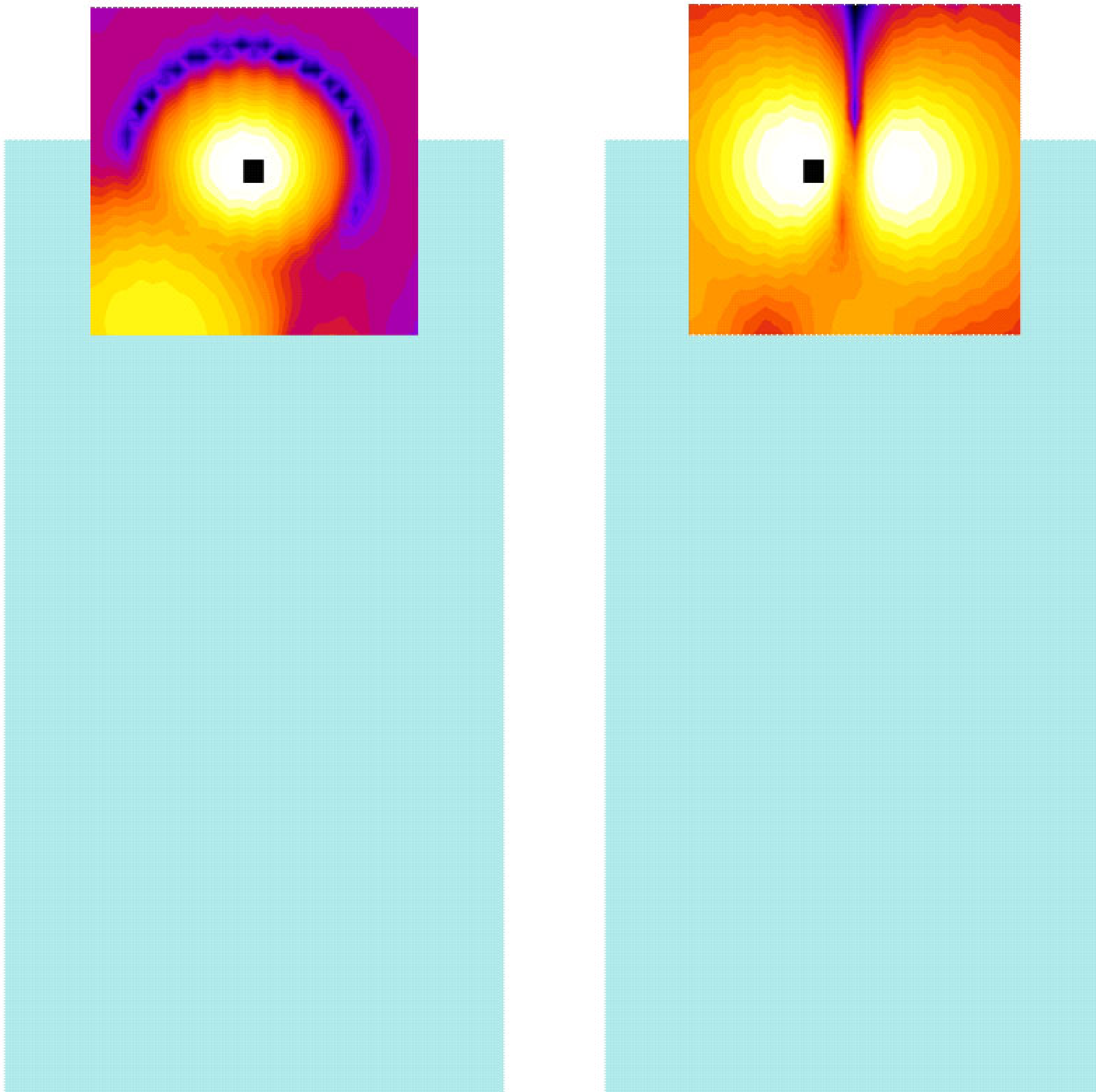

This model was verified to be within the linear region for ABM1 measurements at -16 dBm0 for VoLTE over IMS. This measurement was taken in the axial configuration above the maximum location.

## IV. T-Coil Validation Test Results

**Table 6-9**
**Helmholtz Coil Validation Table of Results**

| Item | Target | Result | Verdict |
|---|---|---|---|
| Axial | | | |
| Magnetic Intensity, -10 dBA/m | *-10 ± 0.5 dB* | -9.895 | **PASS** |
| Environmental Noise | < -58 dBA/m | -58.57 | **PASS** |
| Frequency Response, from limits | *> 0 dB* | 0.50 | **PASS** |
| Radial | | | |
| Magnetic Intensity, -10 dBA/m | *-10 ± 0.5 dB* | -10.177 | **PASS** |
| Environmental Noise | < -58 dBA/m | -60.56 | **PASS** |
| Frequency Response, from limits | *> 0 dB* | 0.70 | **PASS** |

## V. ABM1 Magnetic Field Distribution Scan Overlays



Axial Radial (Transverse)

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

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

# 7. MEASUREMENT UNCERTAINTY

**Table 7-1**
**Uncertainty Estimation Table**

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

Notes:
1. Test equipments are calibrated according to techniques outlined in NIS81, NIS3003 and NIST Tech Note 1297.
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.

# 8. EQUIPMENT LIST

**Table 8-1**
**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 |
| Listen | SoundConnect | Microphone Power Supply | 9/6/2018 | Biennial | 9/6/2020 | 0899-PS150 |
| RME | Fireface UC | Soundcheck Acoustic Analyzer External Audio Interface | 9/6/2018 | Biennial | 9/6/2020 | 23792992 |
| Rohde & Schwarz | CMW500 | Wideband Radio Communication Tester | 1/30/2019 | Annual | 1/30/2020 | 162125 |
| 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 | Radial T-Coil Probe | Radial T-Coil Probe | 9/19/2018 | Biennial | 9/19/2020 | TEM-1129 |
| TEM | Helmholtz Coil | Helmholtz Coil | 10/10/2018 | Biennial | 10/10/2020 | SBI 1052 |
| TEM | | HAC System Controller with Software | N/A | | N/A | N/A |
| TEM | | HAC Positioner | N/A | | N/A | N/A |

# 9. TEST DATA

# PCTEST Hearing-Aid Compatibility Facility

## DUT: HH Coil – SN: SBI 1052

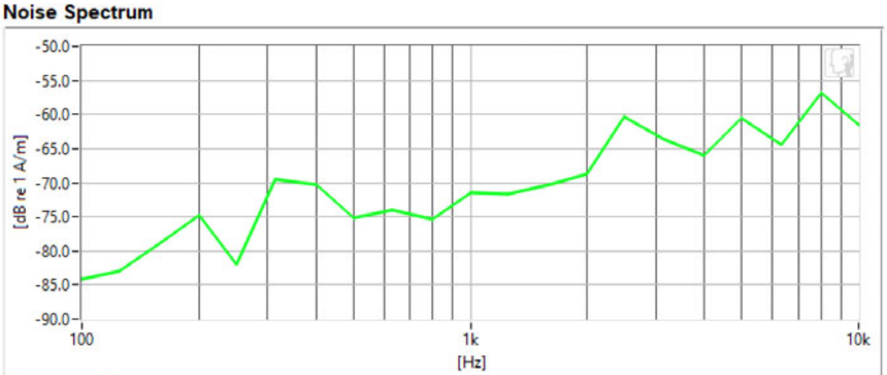
Type: HH Coil
Serial: SBI 1052

**Measurement Standard:** ANSI C63.19-2011

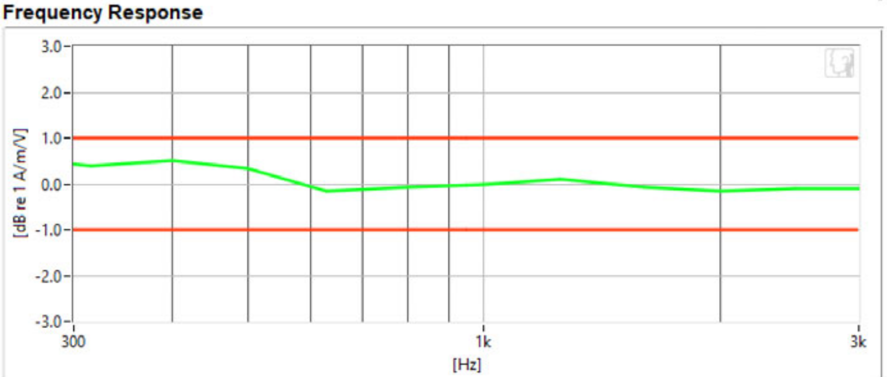
**Equipment:**

- 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 | -9.895 dB | ✓ | Max/Min | -9.5/-10.5 |
| Verification ABM2 | -58.57 dB | ✓ | Maximum | -58.0 |
| Frequency Response Margin | 500m dB | ✓ | Tolerance curves | Aligned Data |

PCTEST 2019

**PCTEST Hearing-Aid Compatibility Facility**

## DUT: HH Coil – SN: SBI 1052

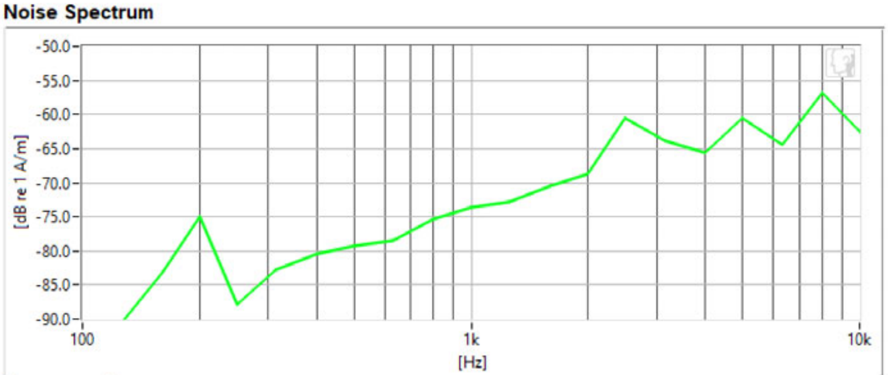
Type: HH Coil
Serial: SBI 1052

**Measurement Standard:** ANSI C63.19-2011

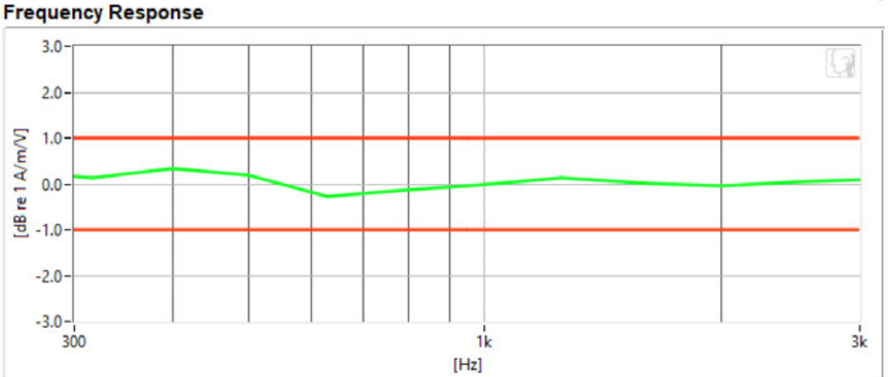
**Equipment:**

- 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 | -10.177 dB | ✔ | Max/Min | -9.5/-10.5 |
| Verification ABM2 | -60.56 dB | ✔ | Maximum | -58.0 |
| Frequency Response Margin | 700m dB | ✔ | Tolerance curves | Aligned Data |

PCTEST 2019

# PCTEST Hearing-Aid Compatibility Facility

## DUT: A3LSMJ737P

Type: Portable Handset
Serial: 34952

**Measurement Standard:** ANSI C63.19-2011

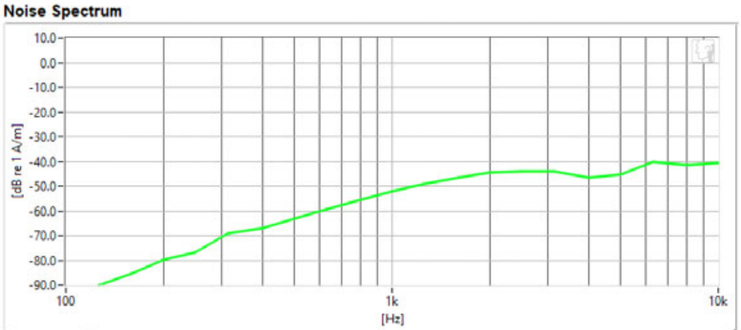
**Equipment:**

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

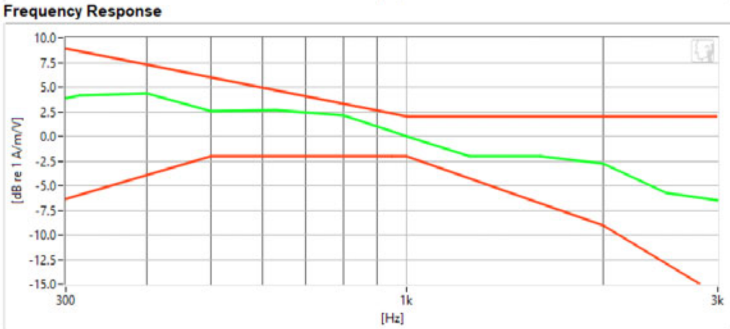
**Test Configuration:**

- Mode: LTE FDD Band 12
- Bandwidth: 1.4MHz
- Channel: 23095
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| ABM1 | 6.14 dB | ✔ | Minimum | -18.0 |
| ABM2 | -40.97 dB | ✔ | Maximum | 0.0 |
| SNNR | 47.11 dB | ✔ | Minimum | 20.0 |
| Aligned Response - Normal | 1.2 dB | ✔ | Tolerance curves | Aligned Data |

PCTEST 2019

10/22/2019

PCTEST Hearing-Aid Compatibility Facility

## DUT: A3LSMJ737P

Type: Portable Handset
Serial: 34952

**Measurement Standard:** ANSI C63.19-2011

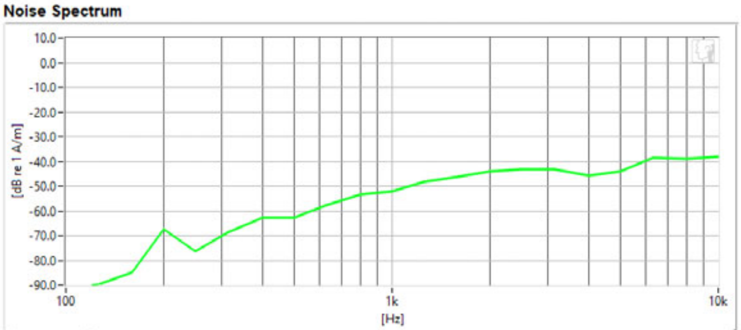
**Equipment:**

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

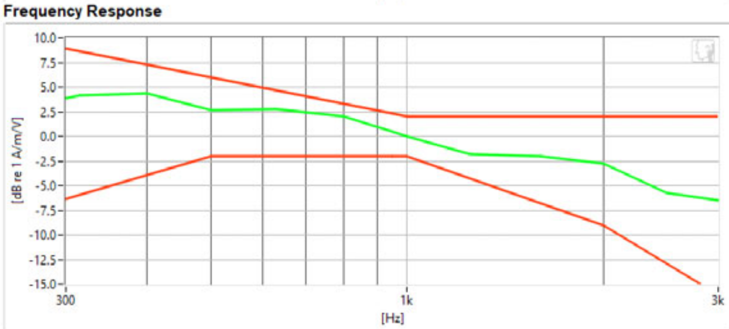
**Test Configuration:**

- Mode: LTE TDD Band 41 (PC2)
- Bandwidth: 10MHz
- Channel: 41490
- Speech Signal: 3GPP2 Normal Test Signal

Noise Spectrum




Frequency Response




**Results**

| | | | | |
|---|---|---|---|---|
| ABM1 | 6.67 dB | ✔ | Minimum | -18.0 |
| ABM2 | -40.02 dB | ✔ | Maximum | 0.0 |
| SNNR | 46.69 dB | ✔ | Minimum | 20.0 |
| Aligned Response - Normal | 1.26 dB | ✔ | Tolerance curves | Aligned Data |

PCTEST 2019

10/22/2019

**PCTEST Hearing-Aid Compatibility Facility**

## DUT: A3LSMJ737P

Type: Portable Handset
Serial: 34952

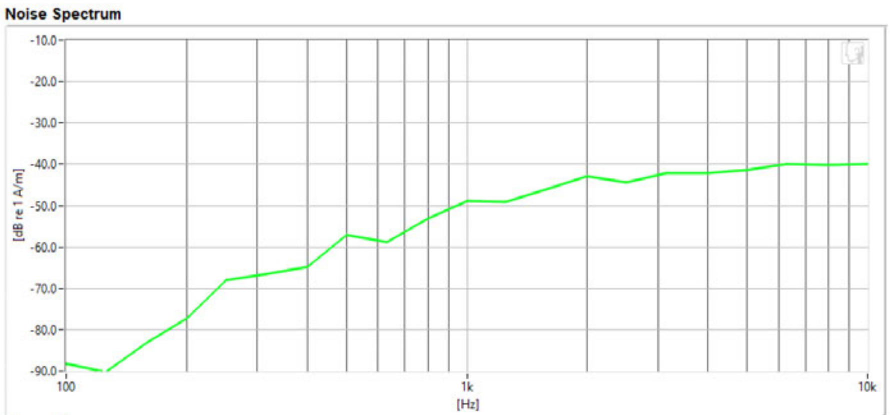
**Measurement Standard:** ANSI C63.19-2011

**Equipment:**

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

**Test Configuration:**

- Mode: LTE FDD Band 12
- Bandwidth: 1.4MHz
- Channel: 23017




### Results

| | | | | | |
|---|---|---|---|---|---|
| ABM1 | -3.29 | dB | ✔ | Minimum | -18.0 |
| ABM2 | -39.39 | dB | ✔ | Maximum | 0.0 |
| SNNR | 36.1 | dB | ✔ | Minimum | 20.0 |

PCTEST 2019

10/22/2019

PCTEST Hearing-Aid Compatibility Facility

## DUT: A3LSMJ737P

Type: Portable Handset
Serial: 34952

**Measurement Standard:** ANSI C63.19-2011

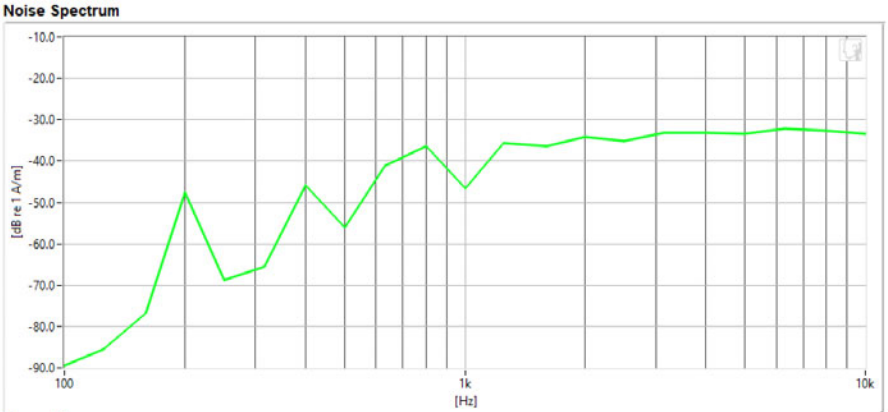
**Equipment:**

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

**Test Configuration:**

- Mode: LTE TDD Band 41 (PC2)
- Bandwidth: 10MHz
- Channel: 41490

Noise Spectrum




**Results**

| | | | | |
|---|---|---|---|---|
| ABM1 | -3.25 dB | ✔ | Minimum | -18.0 |
| ABM2 | -28.87 dB | ✔ | Maximum | 0.0 |
| SNNR | 25.62 dB | ✔ | Minimum | 20.0 |

PCTEST 2019

# 10. CALIBRATION CERTIFICATES

# 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:

VAH 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

Calibration Date: 19-Sep-18

Felix Christopher (QA Mgr.)

Certificate No: 29156 -2

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

Certificate Page 1 of 1

ISO/IEC 17025:2005

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

A2LA ACCREDITED
Calibration Lab. Cert. # 1533.01

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**
**Company: PCTest Enginering Lab**

**Model No.: Axial T Coil Probe**

**Serial No.: TEM-1123**
**I. D. No.: XXXX**

Calibration results:

**Probe Sensitivity measured with Helmholtz Coil**

*Helmholtz Coil;*

| | | |
|---|---|---|
| the number of turns on each coil; | 10 | No. |
| the radius of each coil, in meters; | 0.204 | m |
| the current in the coils, in amperes.; | 0.08 | A |
| *Helmholtz Coil Constant;* | 7.09 | A/m/V |
| *Helmholtz Coil magnetic field;* | 5.95 | A/m |
| **Probe Sensitivity at** | 1000 | Hz. |
| **was** | -59.89 | dBV/A/m |
| | 1.013 | mV/A/m |
| **Probe resistance** | 903 | Ohms |

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

Laboratory Environment:

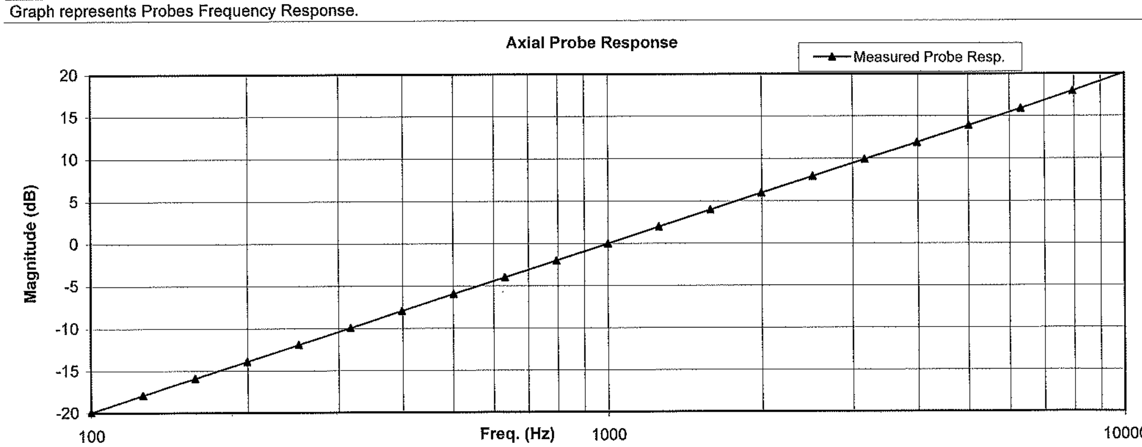
| | | |
|---|---|---|
| Ambient Temperature: | 22.7 | °C |
| Ambient Humidity: | 52.1 | % RH |
| Ambient Pressure: | 99.326 | kPa |
| Calibration Date: | 19-Sep-2018 | |
| Calibration Due: | | |
| Report Number: | 29156 -2 | |
| Control Number: | 29156 | |

**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**

Measurements performed by: ............................
**James Zhu**

**Calibrated on WCCL system type 9700**



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

**Page 1 of 2**

## 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



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

*Page 2 of 2*

## 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:

VAH 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

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.

A2LA ACCREDITED
Calibration Lab. Cert. # 1533.01

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

ISO/IEC 17025: 2005
A2LA 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**

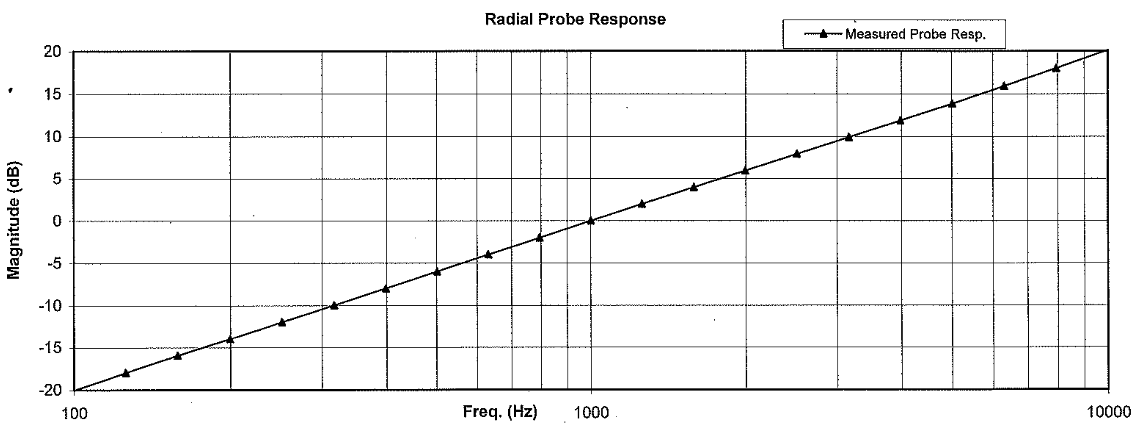
Calibration results:

**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** | **ºC** |
| ***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** Measurements performed by: ..........................

**Calibrated on WCCL system type 9700** **James Zhu**

 **Rev. 7.0 Jan. 24, 2014 Doc. # 1038 HCRTEMC**

***Page 1 of 2***

## 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



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

# 11. CONCLUSION

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

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

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