Element
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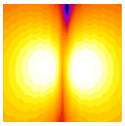

# HEARING AID COMPATIBILITY

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

**Date of Testing:**
10/16/2023 – 11/7/2023
**Test Site/Location:**
Element Washington DC LLC,
Columbia, MD, USA
**Test Report Serial No.:**
1M2309070100-19-R2.A3L
**Date of Issue:**
11/10/2023

| | |
|---|---|
| **FCC ID:** | **A3LSMA156U** |
| **APPLICANT:** | **SAMSUNG ELECTRONICS CO., LTD.** |

| | |
|---|---|
| **Scope of Test:** | Audio Band Magnetic Testing (T-Coil) |
| **Application Type:** | Certification |
| **FCC Rule Part(s):** | CFR §20.19(b) |
| **HAC Standard:** | ANSI C63.19-2019<br>285076 D01 HAC Guidance v06r02<br>285076 D02 T-Coil testing for CMRS IP v04 |
| **DUT Type:** | Portable Handset |
| **Model:** | SM-A156U |
| **Additional Model(s):** | SM-A156U1/DS, SM-S156V |
| **Test Device Serial No.:** | *Pre-Production Sample* [S/N: 2065M] |

**C63.19-2019 HAC Verdict: PASS**

Note: This revised Test Report (S/N: 1M2309070100-19-R2.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 wireless portable device has been shown to be hearing-aid compatible as specified in ANSI/IEEE Std. C63.19-2019 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.

RJ Ortanez
Executive Vice President

ilac-MRA A2LA ACCREDITED 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
- T-coil mode, acoustic-signal conversational gain in the audio band
- T-coil mode, acoustic-signal frequency response through the audio band
- T-coil mode, acoustic-signal distortion through audio band
- Volume Control, receive volume control performance
- Volume Control, receive distortion and noise performance
- Volume Control, receive acoustic frequency response performance

The hearing aid may 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.

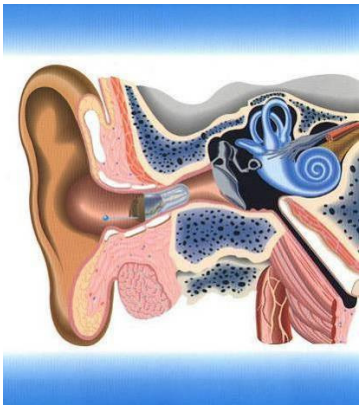


**Figure 1-1 Hearing Aid *in-vitu***

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

# 2. DUT DESCRIPTION

| | |
|---|---|
| FCC ID: | A3LSMA156U |
| Applicant: | Samsung Electronics Co., Ltd.<br>129, Samsung-ro, Maetan dong,<br>Yeongtong-gu, Suwon-si<br>Gyeonggi-do 16677, Korea |
| Model: | SM-A156U |
| Additional Model(s): | SM-A156U1/DS, SM-S156V |
| Serial Number: | 2065M |
| HW Version: | REV1.0 |
| SW Version: | A156U.001 |
| Antenna: | Internal Antenna |
| DUT Type: | Portable Handset |

## I. LTE Band Selection

This device supports LTE capabilities with overlapping transmission frequency ranges. When the supported frequency range of an LTE band falls completely within an LTE band with a larger transmission frequency range, both LTE bands have the same target power (or the band with the larger transmission frequency range has a higher target power), and both LTE bands share the same transmission path and signal characteristics, hearing-aid compatibility compliance was only assessed for the band with the larger transmission frequency range. However, overlapped LTE bands which are anchor bands for dual connectivity (EN-DC) scenarios between LTE and NR were evaluated as independent LTE bands.

## II. NR Band Selection

This device supports NR capabilities with overlapping transmission frequency ranges. When the supported frequency range of an NR band falls completely within an NR band with a larger transmission frequency range, both NR bands have the same target power (or the band with the larger transmission frequency range has a higher target power), and both NR bands share the same transmission path and signal characteristics, hearing-aid compatibility compliance was only assessed for the band with the larger transmission frequency range.

## Table 2-1
## A3LSMA156U HAC Air Interfaces

| Air-Interface | Band (MHz) | Type Transport | HAC Tested | Simultaneous But Not Tested | Name of Voice Service | Audio Codec Evaluated |
|---|---|---|---|---|---|---|
| GSM | 850 | VO | Yes | Yes: WIFI or BT | CMRS Voice[1] | EFR |
| | 1900 | | | | | |
| | GPRS/EDGE | VD | Yes | Yes: WIFI or BT | Google Meet[1] | OPUS |
| UMTS | 850 | VD | Yes | Yes: WIFI or BT | CMRS Voice[1] | NB AMR, WB AMR |
| | 1700 | | | | | |
| | 1900 | | | | | |
| | HSPA | VD | Yes | Yes: WIFI or BT | Google Meet[1] | OPUS |
| LTE (FDD) | 680 (B71) | VD | Yes | Yes: NR, WIFI or BT | VoLTE[1], Google Meet[1] | VoLTE: NB AMR, WB AMR, EVS<br>Google Meet: OPUS |
| | 700 (B12) | | | | | |
| | 780 (B13) | | | | | |
| | 790 (B14) | | | | | |
| | 850 (B5) | | | | | |
| | 850 (B26) | | | | | |
| | 1700 (B4) | | | | | |
| | 1700 (B66) | | | | | |
| | 1900 (B2) | | | | | |
| | 1900 (B25) | | | | | |
| | 2300 (B30) | | | | | |
| | 2500 (B7) | | | | | |
| LTE (TDD) | 2600 (B41) | VD | Yes | Yes: NR, WIFI or BT | VoLTE[1], Google Meet[1] | VoLTE: NB AMR, WB AMR, EVS<br>Google Meet: OPUS |
| | 2600 (B38) | | | | | |
| | 3600 (B48) | | | | | |
| NR (FDD) | 680 (n71) | VD | Yes | Yes: LTE, WIFI or BT | VoNR[1], Google Meet[1] | VoNR: NB AMR, WB AMR, EVS<br>Google Meet: OPUS |
| | 850 (n5) | | | | | |
| | 1700 (n70) | | | | | |
| | 1700 (n66) | | | | | |
| | 1900 (n2) | | | | | |
| | 1900 (n25) | | | | | |
| NR (TDD) | 2600 (n41) | VD | Yes | Yes: LTE, WIFI or BT | VoNR[1], Google Meet[1] | VoNR: NB AMR, WB AMR, EVS<br>Google Meet: OPUS |
| | 2600 (n38) | | | | | |
| | 3500 (n77, DoD) | | | | | |
| | 3500 (n78, DoD) | | | | | |
| | 3600 (n48) | | | | | |
| | 3750 (n78) | | | | | |
| | 3800 (n77) | | | | | |
| WIFI | 2450 | VD | Yes | Yes: GSM, UMTS, LTE, or NR | VoWIFI[1], Google Meet[1] | VoWIFI: NB AMR, WB AMR, EVS<br>Google Meet: OPUS |
| | 5200 (U-NII 1) | | | | | |
| | 5300 (U-NII 2A) | | | | | |
| | 5500 (U-NII 2C) | | | | | |
| | 5800 (U-NII 3) | | | | | |
| BT | 2450 | DT | No | Yes: 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 6.4.3.2 of ANSI C63.19-2019

# 3. ANSI C63.19-2019 COMPLIANCE REQUIREMENTS

The ANSI Standard provides guidance on measuring the baseband (audio frequency) magnetic T-Coil signal from a wireless device (WD) when coupled with a hearing aid's telecoil. This report will cover the measurement and evaluation of the field strength of the desired signal at the center of the audio band (desired ABM signal), the frequency response of the desired signal measured across the audio band and the field strength of the undesired audio band magnetic field.

## I. MAGNETIC COUPLING

### Qualifying Field Strengths

Per C63.19-2019 §6.6.2, there are two groups of qualifying measurement points:

Primary group: A qualifying measurement point shall have magnetic field strength (desired ABM signal, ≥ -18 dB(A/m) at 1 kHz, in a 1/3 octave band filter. Additionally, the qualifying measurement point shall have weighted magnetic noise, undesired ABM field, ≤ -38 dB(A/m)).

Secondary group: A qualifying measurement point shall have weighted magnetic noise ≤ -38 dB(A/m). This group inherently includes all the members of the primary group.

### Desired ABM Signal, undesired ABM field Qualification Requirements

The below requirements ensure an adequate area where desired ABM signal is sufficiently strong to be heard and a larger area where undesired ABM field is sufficiently low as to avoid undue annoyance.

#### Non-2G GSM Operating Modes

Both the primary and secondary group requirements shall be met:

- The primary group shall include at least 75 measurement points.
- The secondary group shall include at least 300 contiguous measurement points.

Additionally, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

#### 2G GSM Operating Modes Requirements

Both the primary and secondary group requirements shall be met:

- The primary group shall include at least 25 measurement points.
- The secondary group shall include at least 125 contiguous measurement points.

## Frequency Response

The frequency response of the magnetic field shall follow the response curve specified in EIA RS-504-1983, over the frequency range 300 Hz – 3000 Hz per §6.6.3.

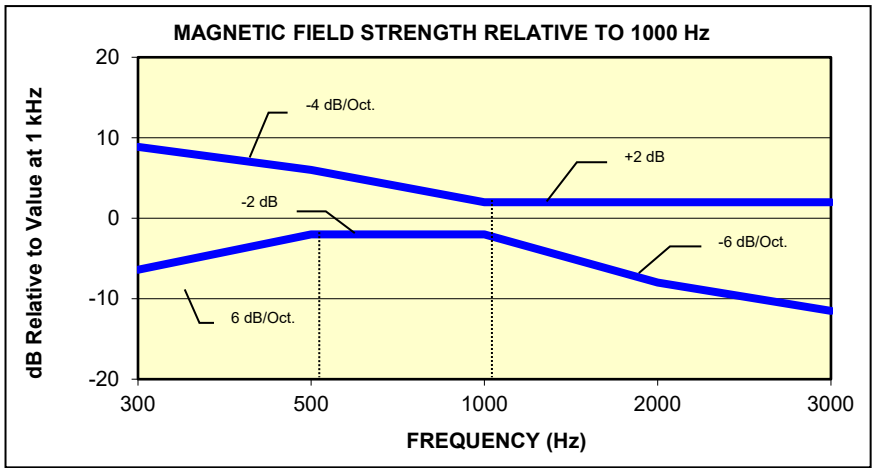



**Figure 3-1**
**Magnetic field frequency response for Wireless Devices with a maximum field strength ≤-15 dB(A/m) at 1 kHz**

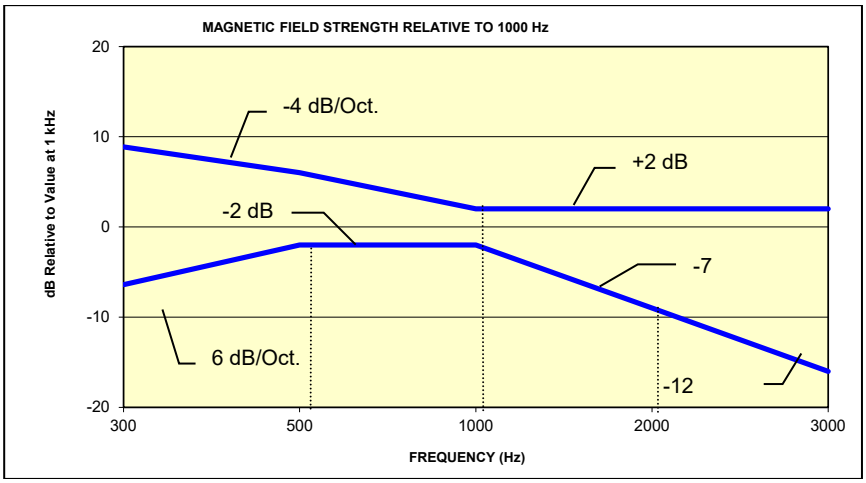



**Figure 3-2**
**Magnetic Field frequency response for wireless devices with a maximum field strength that exceeds-15 dB(A/m) at 1 kHz**

# 4. METHOD OF MEASUREMENT

## I. Test Setup

The equipment was connected as shown in an RF-shielded chamber:

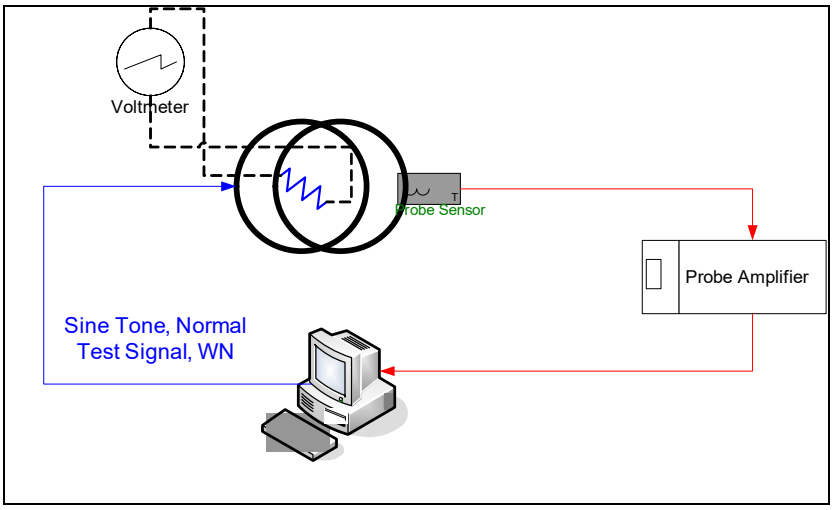



**Figure 4-1**
**Validation Setup with Helmholtz Coil**

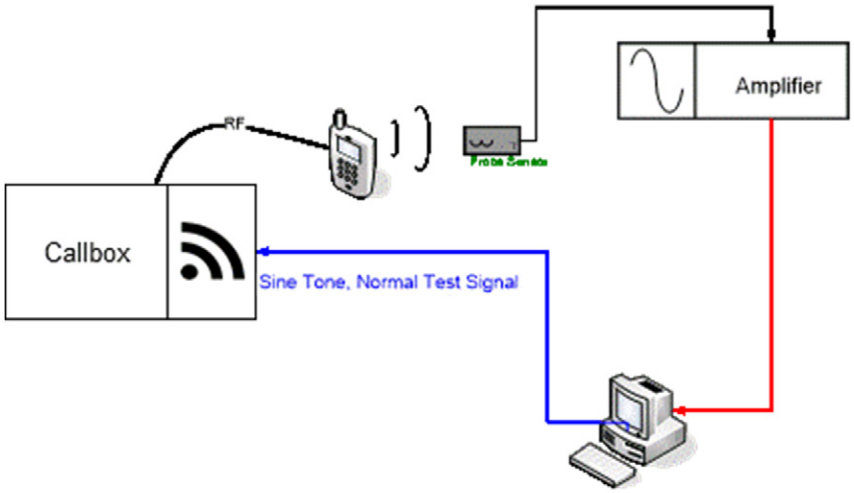



**Figure 4-2**
**T-Coil Test Setup**

## 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) |

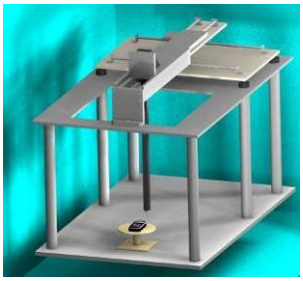


**Figure 4-3**
RF Near-Field Scanner

## 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% |

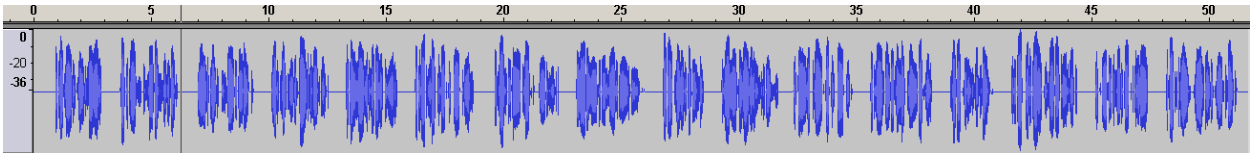



**Figure 4-4**
**Temporal Characteristic of Normal Test Signal**

## IV. Test Procedure

1. Ambient Noise Check per C63.19-2019 §6.3.2
    a. Ambient interference was monitored using a Real-Time Analyzer between 100-10,000 Hz with 1/3 octave filtering.
    b. Spectral/temporal weighting per C63.19-2019 Annex D.4 to D.6 was applied.
    c. Since this measurement was measured using the same method as undesired ABM field measurements, this level was verified to be more than 10 dB below the lowest measurement signal (which is the highest undesired ABM field measurement for a compliant WD). Therefore the maximum noise level for a compliant WD is:
    -38 - 10= -48 dB (A/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. Desired ABM Signal Validation
    The magnetic field at the center of the Helmholtz coil is given by the equation (per C63.19-2019 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
    Therefore, a pure tone of 1kHz was applied into the coils such that 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 42).

    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:

    d. Undesired ABM Field Strength Measurement Validation
    WD noise measurements are filtered with spectral/temporal weighting over a frequency range of 100Hz – 10kHz to process undesired ABM field strength measurements.

3. Point 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 4-6, the grid is not to scale but merely a graphical representation of the coordinate system in use):

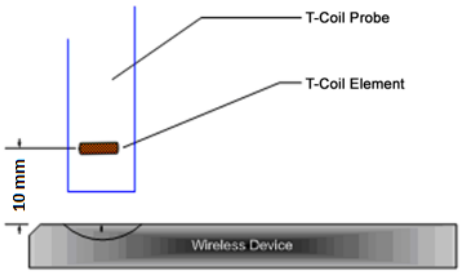



**Figure 4-5**
**Measurement Distance**

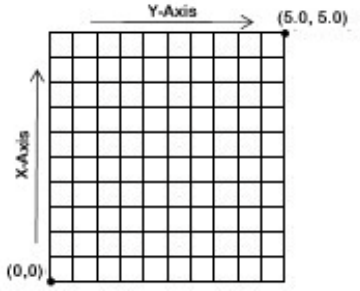



**Figure 4-6**
**Measurement Grid**

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.

b. Speech Signal Setup to Base Station Simulator

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

| Standard | Technology | Input Level (dBm0) |
|---|---|---|
| J-STD-007 | GSM (217) | -16 |
| T1/T1P1/3GPP | UMTS (WCDMA) | -16 |
| iDEN™ | TDMA (22 and 11 Hz) | -18 |
| VoIP | Voice over Internet Protocol | -16 |

i. See Section 5 and 7 for more information regarding CMW500 audio level settings for Voice Over LTE (VoLTE) and Voice Over WIFI (VoWIFI) testing.

ii. See Section 6 for more information regarding CMW500 and CMX500 audio level settings for Voice Over NR (VoNR) testing.

iii. See Section 8 for more information regarding audio level settings for Over-The-Top (OTT) Voice Over IP (VoIP) Testing.

b. Real-Time Analyzer (RTA)

i. The Real-Time Analyzer was configured to analyze measurements using 1/3 Octave band weighted filtering.

c. WD Radio Configuration Selection

i. The device was chosen to be tested in the condition resulting in the worst-case undesired ABM field (See Section 8 and 9 for more information regarding worst-case configurations for GSM and UMTS. LTE configuration information can be found in Section 5 and 8. NR configuration information can be found in Section 6 and 8. WIFI configuration information can be found in Section 7 and 8.)

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 desired ABM signal measurements were evaluated at 1kHz with 1/3 octave band filtering over an averaged period of 10 seconds.

b. Frequency Response

ii. 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.

iii. The appropriate post-processing was applied according to the system processing chain described in C63.19-2019. All R10 frequencies were plotted with respect to 0dB at 1kHz value and aligned with respect to the EIA-504 mask.

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 undesired ABM field measurement (5 second time period is used in noise measurements under standards such as IEEE 269, etc.).

ii. Measure the broadband undesired T-Coil noise at the locations where desired ABM signal strength was just measured. The measurement shall be made using the specified spectral and temporal weighted filter, applied to the half-band integrated probe coil signal (T-Coil response), as described in C63.19-2019 Annex D.9.2. Any additional bandwidth-limiting filtering that might be applied shall not affect frequencies within the range of at least 100 Hz to 10 kHz. Set the measurement system averaging interval duration to be long enough so as to enable an accurate steady state reading. The resulting reading represents the “1 kHz equivalent” value of the broadband weighted T-Coil response magnetic noise (undesired ABM field) for each measurement position. All results should be reported in dB(A/m).

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

5. Signal Compliance Analysis

a. Fine scan above the WD (TEM)

i. The worst-case signal quality index configuration for each wireless communication technology was used to evaluate the respective qualifying measurement points over a 50 mm square measurement area. The measurement step size was in 4 mm increments at 10 mm from the surface of the wireless device.

ii. At each step, a multitone signal was applied to the handset such that the phone acoustic output was stable within 1 dB over the probe settling time and with the acoustic output level at the C63.19 specified level. The desired ABM signal was measured, and the multitone signal was subsequently disabled before measuring the weighted magnitude of the undesired ABM field.

iii. The above steps were repeated for all supported wireless communication technologies.

## V. Test Setup

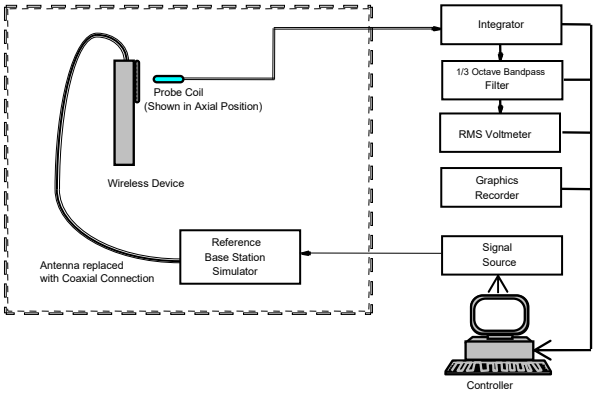



**Figure 4-7**
**Audio Magnetic Field Test Setup**

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. 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 4-1**
**Center Channels and Frequencies**

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

## 2. 4G (LTE) Modes

The middle channel for every band and maximum bandwidth combination was tested at the planar field maximum point. The middle channels and supported bandwidths from the worst-case band according to Tables 8-6 and 8-7 were additionally evaluated with OTT VoIP. See Tables 10-6 to 10-17 as well as 10-36 for LTE bandwidths and channels. The scan result is available in Tables 10-18 and 10-43.

## 3. 5G (NR) Modes

The middle channel for every band and maximum bandwidth combination was tested at the planar field maximum point. The middle channel and supported bandwidths from the worst-case NR band according to Tables 8-9 and 8-10 was evaluated with OTT VoIP. See Tables 10-19 to 10-28 as well as Table 10-37 for NR bandwidths and channels. The scan results are available in Table 10-29.

## 4. WIFI

The middle channel for each IEEE 802.11 standard was tested at the planar field maximum point. 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 10-30 to 10-33 as well as 10-39 to 10-42 for WIFI standards and channels. The scan result is available in Table 10-34.

## IX. Test Flow

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

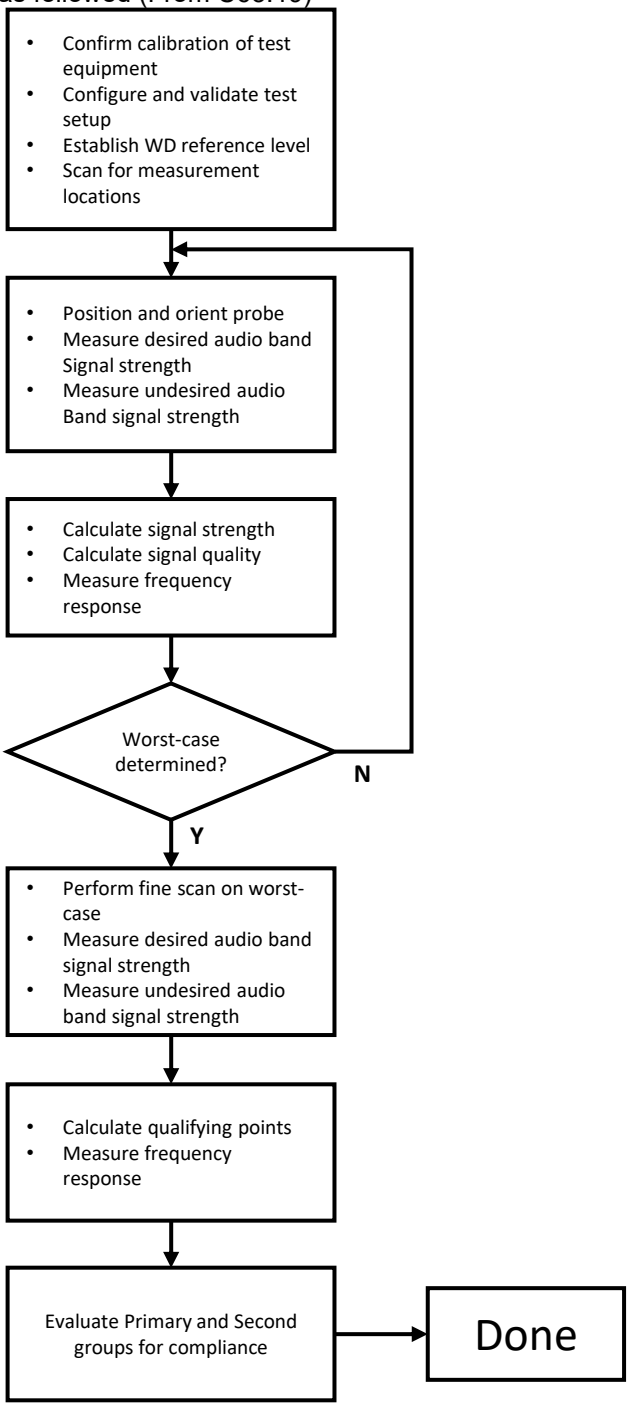



**Figure 4-8**
**C63.19 T-Coil Signal Test Process**

# 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.

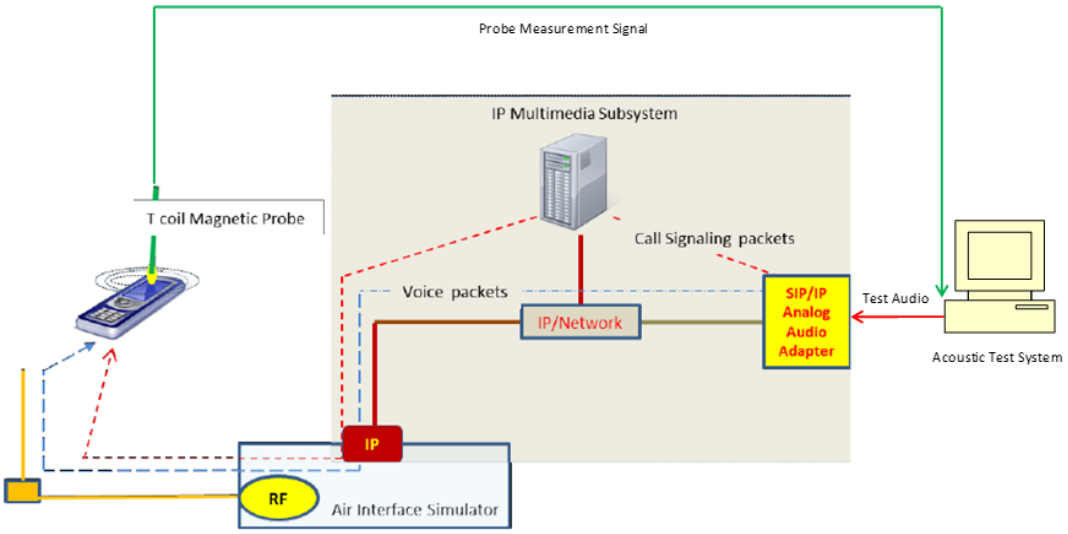



**Figure 5-1**
**Test Setup for VoLTE over IMS T-Coil Measurements**

2. Audio Level Settings

Per C63.19 Table 6-1, -16dBm0 shall be used as the normal speech input level for VoLTE over IMS T-coil testing. 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.

# 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 | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|
| 66 | 1745.0 | 132322 | 20 | QPSK | 1 | 0 | -0.59 | -52.94 | 52.35 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 1 | 0 | -0.84 | -45.18 | **44.34** |
| 66 | 1745.0 | 132322 | 20 | 64QAM | 1 | 0 | -0.37 | -46.10 | 45.73 |
| 66 | 1745.0 | 132322 | 20 | 256QAM | 1 | 0 | -0.35 | -48.77 | 48.42 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 1 | 50 | -0.35 | -45.53 | 45.18 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 1 | 99 | -0.77 | -45.51 | 44.74 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 50 | 0 | -0.50 | -54.47 | 53.97 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 50 | 25 | -0.47 | -50.78 | 50.31 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 50 | 50 | -0.23 | -50.72 | 50.49 |
| 66 | 1745.0 | 132322 | 20 | 16QAM | 100 | 0 | -0.23 | -51.12 | 50.89 |

## 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 |
|---|---|---|---|---|---|---|---|
| Desired (dBA/m) | 0.37 | -0.55 | 0.50 | 0.20 | Radial | Band 66 20MHz | 132322 |
| Undesired (dBA/m) | -45.23 | -45.20 | -45.12 | -45.21 | | | |
| Frequency Response | Pass | Pass | Pass | Pass | | | |
| S+N/N (dB) | 45.60 | **44.65** | 45.62 | 45.41 | | | |

**Table 5-3**
**EVS Codec Investigation - VoLTE over IMS**

| Codec Setting: | EVS Primary SWB 24.4kbps | EVS Primary SWB 9.6kbps | EVS Primary WB 24.4kbps | EVS Primary WB 5.9kbps | EVS Primary NB 24.4kbps | EVS Primary NB 5.9kbps | Orientation | Band / BW | Channel |
|---|---|---|---|---|---|---|---|---|---|
| Desired (dBA/m) | 1.44 | 1.25 | -0.18 | 0.33 | 0.58 | -0.49 | Radial | Band 66 20MHz | 132322 |
| Undesired (dBA/m) | -45.25 | -45.30 | -45.48 | -45.28 | -45.17 | -45.75 | | | |
| Frequency Response | Pass | Pass | Pass | Pass | Pass | Pass | | | |
| S+N/N (dB) | 46.69 | 46.55 | 45.30 | 45.61 | 45.75 | 45.26 | | | |

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

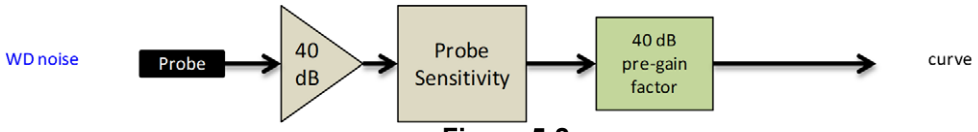



**Figure 5-2**
**Audio Band Magnetic Curve Measurement Block Diagram**

## 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% |

### 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 2 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 | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 0 | -0.34 | -33.16 | 32.82 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 1 | -0.40 | -33.41 | 33.01 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 2 | -0.48 | -33.15 | **32.67** |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 3 | -0.27 | -36.63 | 36.36 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 4 | -0.43 | -36.41 | 35.98 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 5 | -0.74 | -36.01 | 35.27 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 6 | -0.70 | -33.44 | 32.74 |

### 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 2 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 5-6**
**Power Class 2 VoLTE over IMS SNNR by UL-DL Configuration**

| Frequency [MHz] | Channel | Bandwidth [MHz] | Modulation | RB Size | RB Offset | UL-DL Configuration | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 1 | -0.44 | -32.70 | 32.26 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 2 | -0.34 | -32.45 | **32.11** |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 3 | -0.24 | -35.98 | 35.74 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 4 | -0.59 | -35.78 | 35.19 |
| 2593.0 | 40620 | 20 | 16QAM | 1 | 0 | 5 | -0.77 | -35.40 | 34.63 |

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 2 was used to evaluate Power Class 3 and Power Class 2 VoLTE over IMS.

# 6. VONR TEST SYSTEM SETUP AND DUT CONFIGURATION

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

1. Equipment Setup

The general test setup used for VoNR over IMS is shown below. The callboxes used when performing VoNR over IMS T-coil measurements are CMW500 and CMX500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server. The CMX500 provided the baseband signal to perform NR signaling. An external USB audio interface is used to perform the A/D conversion and ensure proper speech input level to the DUT.

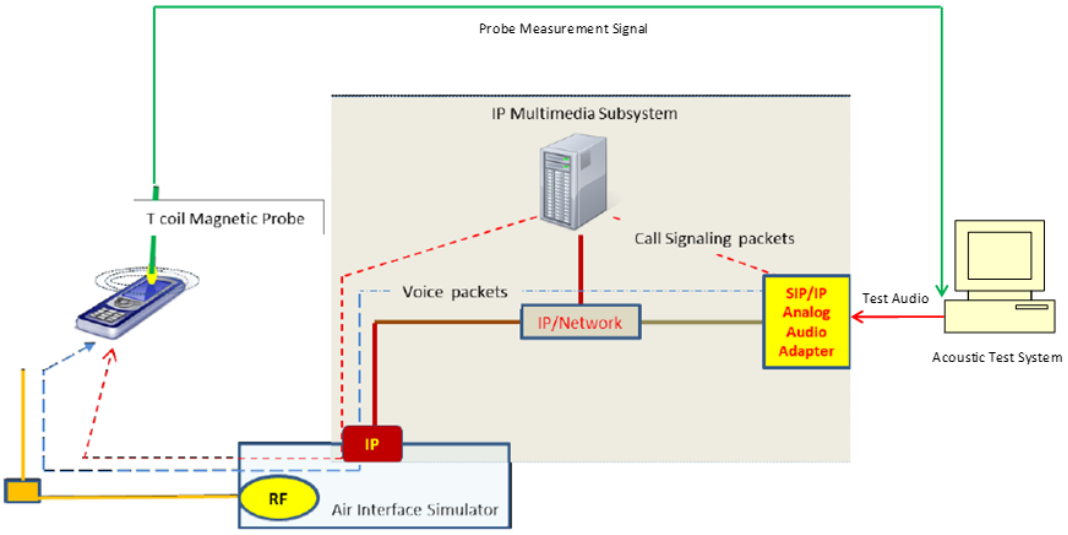



**Figure 6-1**
**Test Setup for VoNR over IMS T-Coil Measurements**

2. Audio Level Settings

Per C63.19 Table 6-1, -16dBm0 was used as the normal speech input level for VoNR over IMS T-coil testing. The acoustic test system 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 VoNR over IMS connection.

# II. DUT Configuration for VoNR over IMS T-coil Testing

## 1. Radio Configuration

An investigation was performed to determine the waveform, modulation, and RB configuration to be used for testing. The effects of waveform, modulation, and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. DFT-s-OFDM, 16QAM, 1RB, 1RB 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 6-1**
**VoNR over IMS SNNR by Radio Configuration (CP-OFDM)**

| Band | Frequency [MHz] | Channel | Bandwidth [MHz] | Waveform | Modulation | RB Size | RB Offset | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| n66 | 1745.0 | 349000 | 40 | CP-OFDM | QPSK | 1 | 1 | 0.18 | -49.53 | 49.71 |
| n66 | 1745.0 | 349000 | 40 | CP-OFDM | 16QAM | 1 | 1 | 0.30 | -49.11 | 49.41 |
| n66 | 1745.0 | 349000 | 40 | CP-OFDM | 64QAM | 1 | 1 | 0.33 | -49.58 | 49.91 |
| n66 | 1745.0 | 349000 | 40 | CP-OFDM | 256QAM | 1 | 1 | 0.27 | -50.58 | 50.85 |

**Table 6-2**
**VoNR over IMS SNNR by Radio Configuration (DFT-s-OFDM)**

| Band | Frequency [MHz] | Channel | Bandwidth [MHz] | Waveform | Modulation | RB Size | RB Offset | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | π/2-BPSK | 1 | 1 | 0.32 | -51.54 | 51.86 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | QPSK | 1 | 1 | 0.28 | -51.58 | 51.86 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 1 | 1 | 0.28 | -46.94 | **47.22** |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 1 | 108 | 0.26 | -49.57 | 49.83 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 1 | 214 | 0.10 | -47.86 | 47.96 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 108 | 0 | 0.23 | -52.39 | 52.62 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 108 | 54 | 0.29 | -51.98 | 52.27 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 108 | 108 | 0.20 | -47.38 | 47.58 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 216 | 0 | 0.27 | -52.62 | 52.89 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 64QAM | 1 | 1 | 0.20 | -48.41 | 48.61 |
| n66 | 1745.0 | 349000 | 40 | DFT-s-OFDM | 256QAM | 1 | 1 | 0.30 | -50.52 | 50.82 |

## 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 CMX500/CMW500 for VoNR over IMS T-coil testing. See below table for comparisons between different codecs and codec data rates:

**Table 6-3**
**AMR Codec Investigation – VoNR over IMS**

| Codec Setting: | WB AMR 23.85kbps | WB AMR 6.60kbps | NB AMR 12.2kbps | NB AMR 4.75kbps | Orientation | Band / BW | Channel |
|---|---|---|---|---|---|---|---|
| Desired (dBA/m) | 1.36 | -0.12 | 0.53 | 1.04 | Radial | NR n66 40MHz | 349000 |
| Undesired (dBA/m) | -46.92 | -47.05 | -47.06 | -47.94 | | | |
| Frequency Response | Pass | Pass | Pass | Pass | | | |
| S+N/N (dB) | 48.28 | **46.93** | 47.59 | 48.98 | | | |

**Table 6-4**
**EVS Codec Investigation - VoNR over IMS**

| Codec Setting: | EVS Primary SWB 24.4kbps | EVS Primary SWB 9.6kbps | EVS Primary WB 24.4kbps | EVS Primary WB 5.9kbps | EVS Primary NB 24.4kbps | EVS Primary NB 5.9kbps | Orientation | Band / BW | Channel |
|---|---|---|---|---|---|---|---|---|---|
| Desired (dBA/m) | 1.16 | 0.44 | 0.12 | 0.21 | 1.08 | 0.35 | Radial | NR n66 40MHz | 349000 |
| Undesired (dBA/m) | -47.99 | -48.17 | -47.72 | -47.60 | -47.63 | -47.85 | | | |
| Frequency Response | Pass | Pass | Pass | Pass | Pass | Pass | | | |
| S+N/N (dB) | 49.15 | 48.61 | 47.84 | 47.81 | 48.71 | 48.20 | | | |

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

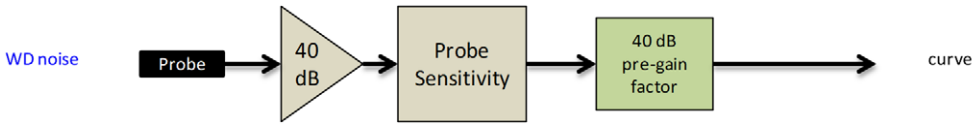



**Figure 6-2**
**Audio Band Magnetic Curve Measurement Block Diagram**

# 7. 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.

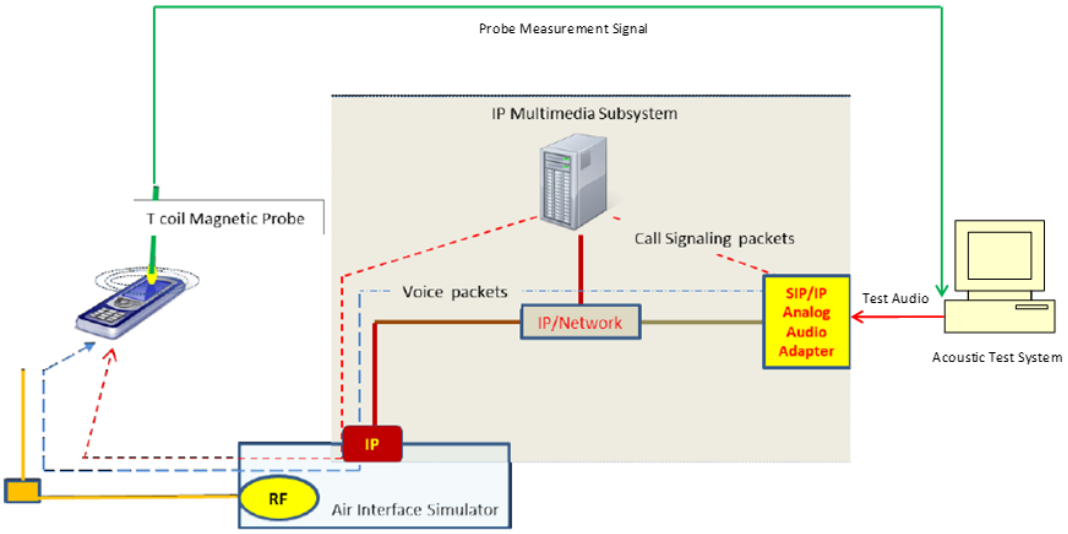



**Figure 7-1**
**Test Setup for VoWIFI over IMS T-Coil Measurements**

2. Audio Level Settings

Per C63.19 Table 6-1, -16dBm0 shall be used as the normal speech input level for VoWIFI over IMS T-coil testing. 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.

# 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 7-1**
**IEEE 802.11b SNNR by Radio Configuration**

| Mode | Channel | Modulation | Data Rate [Mbps] | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|
| IEEE 802.11b | 6 | DSSS | 1 | -0.95 | -40.47 | **39.52** |
| IEEE 802.11b | 6 | CCK | 11 | -1.05 | -41.19 | 40.14 |

**Table 7-2**
**IEEE 802.11g/a SNNR by Radio Configuration**

| Mode | Channel | Modulation | Data Rate [Mbps] | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|
| IEEE 802.11g | 6 | BPSK | 6 | -1.09 | -39.91 | **38.82** |
| IEEE 802.11g | 6 | 64QAM | 54 | -0.76 | -41.13 | 40.37 |

**Table 7-3**
**IEEE 802.11n/ac 20MHz BW SNNR by Radio Configuration**

| Mode | Bandwidth [MHz] | Channel | Modulation | MCS Index | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|
| IEEE 802.11n | 20 | 40 | BPSK | 0 | -1.20 | -40.57 | 39.37 |
| IEEE 802.11n | 20 | 40 | 64QAM | 7 | -1.13 | -40.36 | **39.23** |
| IEEE 802.11ac | 20 | 40 | 256QAM | 8 | -0.86 | -42.20 | 41.34 |

**Table 7-4**
**IEEE 802.11n/ac 40MHz BW SNNR by Radio Configuration**

| Mode | Bandwidth [MHz] | Channel | Modulation | MCS Index | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|
| IEEE 802.11n | 40 | 38 | BPSK | 0 | -1.07 | -39.56 | **38.49** |
| IEEE 802.11n | 40 | 38 | 64QAM | 7 | -0.83 | -43.49 | 42.66 |
| IEEE 802.11ac | 40 | 38 | 256QAM | 9 | -0.79 | -44.05 | 43.26 |

## 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 7-5**
**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 |
|---|---|---|---|---|---|---|---|---|
| Desired (dBA/m) | -0.11 | -1.05 | -0.25 | -0.57 | Radial | 2.4GHz | IEEE 802.11b | 6 |
| Undesired (dBA/m) | -40.61 | -40.81 | -40.90 | -40.96 | | | | |
| Frequency Response | Pass | Pass | Pass | Pass | | | | |
| S+N/N (dB) | 40.50 | **39.76** | 40.65 | 40.39 | | | | |

**Table 7-6**
**EVS Codec Investigation – VoWIFI over IMS**

| Codec Setting: | EVS Primary SWB 24.4kbps | EVS Primary SWB 9.6kbps | EVS Primary WB 24.4kbps | EVS Primary WB 5.9kbps | EVS Primary NB 24.4kbps | EVS Primary NB 5.9kbps | Orientation | Band | Standard | Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Desired (dBA/m) | -0.40 | -0.27 | -0.77 | -0.36 | -0.58 | -0.97 | Radial | 2.4GHz | IEEE 802.11b | 6 |
| Undesired (dBA/m) | -41.56 | -40.80 | -41.11 | -41.07 | -41.38 | -41.45 | | | | |
| Frequency Response | Pass | Pass | Pass | Pass | Pass | Pass | | | | |
| S+N/N (dB) | 41.16 | 40.53 | 40.34 | 40.71 | 40.80 | 40.48 | | | | |

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

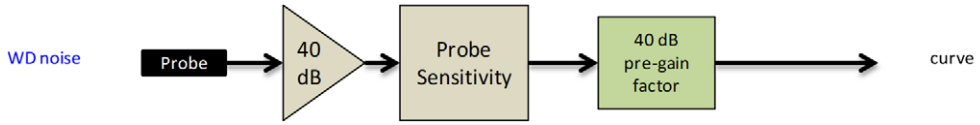



**Figure 7-2**
**Audio Band Magnetic Curve Measurement Block Diagram**

# 8. OTT VOIP TEST SYSTEM AND DUT CONFIGURATION

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

1. OTT VoIP Application

Google Meet is a pre-installed application on the DUT which allows for VoIP calls in a held-to-ear scenario. Meet 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 Meet.

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

Per C63.19 Table 6-1, an average speech level of -16dBm0 shall be used for VoIP testing. 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 -16dBm0 speech input level to the DUT for the OTT VoIP call.

## 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 8-1**
**Codec Investigation – OTT VoIP (EDGE)**

| Codec Setting: | 75kbps | 6kbps | Orientation | Channel |
|---|---|---|---|---|
| Desired ABM (dBA/m) | 0.59 | -0.20 | Radial | 661 |
| Undesired ABM (dBA/m) | -46.20 | -44.77 | | |
| Frequency Response | Pass | Pass | | |
| S+N/N (dB) | 46.79 | **44.57** | | |

**Table 8-2**
**Codec Investigation – OTT VoIP (HSPA)**

| Codec Setting: | 75kbps | 6kbps | Orientation | Channel |
|---|---|---|---|---|
| Desired (dBA/m) | 0.79 | 0.23 | Radial | 9400 |
| Undesired (dBA/m) | -53.16 | -53.20 | | |
| Frequency Response | Pass | Pass | | |
| S+N/N (dB) | 53.95 | **53.43** | | |

**Table 8-3**
**Codec Investigation – OTT VoIP (LTE)**

| Codec Setting: | 75kbps | 6kbps | Orientation | Band / BW | Channel |
|---|---|---|---|---|---|
| Desired ABM (dBA/m) | 0.51 | -0.41 | Radial | Band 66 20MHz | 132322 |
| Undesired ABM (dBA/m) | -45.04 | -45.02 | | | |
| Frequency Response | Pass | Pass | | | |
| S+N/N (dB) | 45.55 | **44.61** | | | |

**Table 8-4**
**Codec Investigation – OTT VoIP (NR)**

| Codec Setting: | 75kbps | 6kbps | Orientation | Band / BW | Channel |
|---|---|---|---|---|---|
| Desired ABM (dBA/m) | 0.09 | -0.62 | Radial | NR n66 40MHz | 349000 |
| Undesired ABM (dBA/m) | -45.02 | -45.20 | | | |
| Frequency Response | Pass | Pass | | | |
| S+N/N (dB) | 45.11 | **44.58** | | | |

**Table 8-5**
**Codec Investigation – OTT VoIP (WIFI)**

| Codec Setting: | 75kbps | 6kbps | Orientation | Band | Standard | Channel |
|---|---|---|---|---|---|---|
| Desired ABM (dBA/m) | 0.72 | -1.00 | Radial | 2.4GHz | IEEE 802.11b | 6 |
| Undesired ABM (dBA/m) | -40.24 | -40.80 | | | | |
| Frequency Response | Pass | Pass | | | | |
| S+N/N (dB) | 40.96 | **39.80** | | | | |

- Mute on; Backlight off; Max Volume; Max Contrast
- Radio Configurations can be found in Section 10.II.G

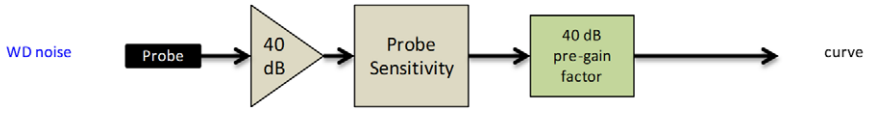



**Figure 8-1**
**Audio Band Magnetic Curve Measurement Block Diagram**

## 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 TDD Band 48 was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different LTE bands:

**Table 8-6**
**OTT VoIP (LTE FDD) SNNR by LTE Band**

| Band | Frequency [MHz] | Channel | Bandwidth [MHz] | Modulation | RB Size | RB Offset | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|
| 71 | 680.5 | 133297 | 20 | 16QAM | 1 | 0 | -0.32 | -51.11 | 50.79 |
| 12 | 707.5 | 23095 | 10 | 16QAM | 1 | 0 | 0.16 | -50.67 | 50.83 |
| 13 | 782.0 | 23230 | 10 | 16QAM | 1 | 0 | -0.27 | -50.56 | 50.29 |
| 14 | 793.0 | 23330 | 10 | 16QAM | 1 | 0 | -0.07 | -50.24 | 50.17 |
| 26 | 831.5 | 26865 | 15 | 16QAM | 1 | 0 | -0.07 | -50.73 | 50.66 |
| 66 (Ant B) | 1745.0 | 132322 | 20 | 16QAM | 1 | 0 | -0.46 | -45.00 | 44.54 |
| 66 (Ant C) | 1745.0 | 132322 | 20 | 16QAM | 1 | 0 | -0.03 | -43.57 | 43.54 |
| 25 (Ant B) | 1882.5 | 26365 | 20 | 16QAM | 1 | 0 | -0.19 | -44.71 | 44.52 |
| 25 (Ant C) | 1882.5 | 26365 | 20 | 16QAM | 1 | 0 | -0.58 | -44.50 | 43.92 |
| 30 | 2310.0 | 27710 | 10 | 16QAM | 1 | 0 | -0.48 | -45.92 | 45.44 |
| 7 | 2535.0 | 21100 | 20 | 16QAM | 1 | 0 | -0.45 | -46.16 | 45.71 |

**Table 8-7**
**OTT VoIP (LTE TDD) SNNR by LTE Band**

| Band | Frequency [MHz] | Channel | Bandwidth [MHz] | Modulation | RB Size | RB Offset | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|
| 41 (PC3) | 2593.0 | 40620 | 20 | 16QAM | 1 | 50 | -0.11 | -33.60 | 33.49 |
| 41 (PC2) | 2593.0 | 40620 | 20 | 16QAM | 1 | 50 | -0.47 | -32.53 | 32.06 |
| 48 | 3625.0 | 55990 | 20 | 16QAM | 1 | 50 | -0.16 | -31.12 | **30.96** |

## 3. LTE TDD Uplink Carrier Aggregation for OTT VoIP

LTE TDD ULCA was evaluated to ensure FCC compliance. The configurations in Table 8-8 were determined from Table 8-7 and satisfy the configuration requirements as defined in 3GPP 36.101.

**Table 8-8**
**LTE TDD SNNR for OTT VoIP Uplink Carrier Aggregation**

| Combination | PCC | | | | | | | SCC | | | | | | | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PCC Band | PCC Bandwidth [MHz] | PCC (UL/DL) Channel | PCC (UL/DL) Frequency [MHz] | Modulation | PCC UL# RB | PCC UL RB Offset | SCC Band | SCC Bandwidth [MHz] | SCC (UL/DL) Channel | SCC (UL/DL) Frequency [MHz] | Modulation | SCC UL# RB | SCC UL RB Offset | | | |
| CA_41C (PC3) | LTE B41 | 20 | 40620 | 2593.0 | 16QAM | 1 | 0 | LTE B41 | 20 | 40422 | 2573.2 | 16QAM | 1 | 99 | -0.62 | -34.32 | 33.70 |
| CA_41C (PC2) | LTE B41 | 20 | 40620 | 2593.0 | 16QAM | 1 | 0 | LTE B41 | 20 | 40422 | 2573.2 | 16QAM | 1 | 99 | -0.57 | -33.02 | 32.45 |
| CA_48C | LTE B48 | 20 | 55990 | 3625.0 | 16QAM | 1 | 0 | LTE B48 | 20 | 55792 | 3605.2 | 16QAM | 1 | 99 | -0.49 | -31.60 | 31.11 |

## 5. Radio Configuration for OTT VoIP (NR)

An investigation was performed to determine the worst-case NR band to be used for OTT VoIP testing. NR TDD n41 (PC2) was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different NR bands:

**Table 8-9**
**OTT VoIP (NR FDD) SNNR by NR Band**

| Band | Frequency [MHz] | Channel | Bandwidth [MHz] | Waveform | Modulation | RB Size | RB Offset | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| n71 | 680.5 | 136100 | 20 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.77 | -50.56 | 49.79 |
| n5 | 836.5 | 167300 | 20 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.63 | -51.19 | 50.56 |
| n70 | 1702.5 | 340500 | 15 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.68 | -42.85 | 42.17 |
| n66 ( ANT B) | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.56 | -45.96 | 45.40 |
| n66 ( ANT C) | 1745.0 | 349000 | 40 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.73 | -44.94 | 44.21 |
| n25 (ANT B) | 1882.5 | 376500 | 40 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.60 | -45.36 | 44.76 |
| n2 (ANT C) | 1880.0 | 376000 | 40 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.80 | -45.76 | 44.96 |

**Table 8-10**
**OTT VoIP (NR TDD) SNNR by NR Band**

| Band | Frequency [MHz] | Channel | Bandwidth [MHz] | Waveform | Modulation | RB Size | RB Offset | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | SNNR [dB] |
|---|---|---|---|---|---|---|---|---|---|---|
| n41 (PC2) | 2592.99 | 518598 | 100 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.67 | -38.01 | **37.34** |
| n77 (DoD, PC2) | 3500.0 | 633334 | 100 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.40 | -38.84 | 38.44 |
| n48 | 3625.0 | 641666 | 100 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.65 | -39.23 | 38.58 |
| n77 (PC2) | 3840.00 | 656000 | 100 | DFT-s-OFDM | 16QAM | 1 | 1 | -0.92 | -39.01 | 38.09 |

# 9. FCC 3G MEASUREMENTS

## I. GSM Test Configurations

FR V2 Was used for the testing as the worst-case configuration for the handset.

**Table 9-1**
**Codec Investigation - GSM**

| Configuration: | FR V1 | FR V2 | HR V1 | Orientation | Channel |
|---|---|---|---|---|---|
| Desired (dBA/m) | 0.25 | 0.18 | 0.24 | Radial | 190 |
| Undesired (dBA/m) | -36.57 | -36.53 | -39.24 | | |
| Frequency Response | Pass | Pass | Pass | | |
| S+N/N (dB) | 36.82 | **36.71** | 39.48 | | |

- Mute on; Backlight off; Max Volume; Max Contrast
- GSM850: PCL=0,

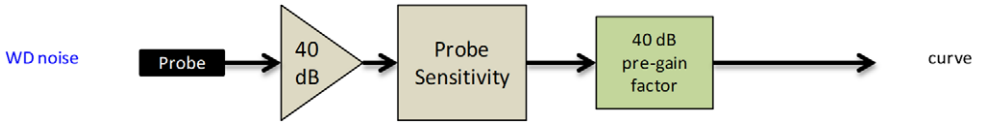



**Figure 9-1**
**Audio Band Magnetic Curve Measurement Block Diagram**

## II. UMTS Test Configurations

WB AMR 6.60kbps, 13.6kbps SRB was used for the testing as the worst-case configuration for the handset.

**Table 9-2**
**Codec Investigation - UMTS**

| Codec Setting: | WB AMR 23.85kbps | WB AMR 6.60kbps | NB AMR 12.2kbps | NB AMR 4.75kbps | Orientation | Channel |
|---|---|---|---|---|---|---|
| Desired (dBA/m) | 0.22 | -0.58 | -0.34 | 0.24 | Radial | 9400 |
| Undesired (dBA/m) | -56.92 | -56.67 | -56.95 | -56.29 | | |
| Frequency Response | Pass | Pass | Pass | Pass | | |
| S+N/N (dB) | 57.14 | **56.09** | 56.61 | 56.53 | | |

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

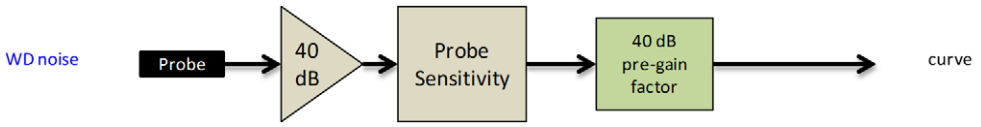



**Figure 9-2**
**Audio Band Magnetic Curve Measurement Block Diagram**

# 10. T-COIL TEST SUMMARY

**Table 10-1**
**Consolidated Tabled Results**

| | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Freq. Response Margin | C63.19 Verdict |
|---|---|---|---|---|---|---|
| GSM | PASS | PASS | PASS | PASS | PASS | Compliant |
| UMTS | PASS | PASS | PASS | PASS | PASS | Compliant |
| LTE | PASS | PASS | PASS | PASS | PASS | Compliant |
| NR | PASS | PASS | PASS | PASS | PASS | Compliant |
| WLAN | PASS | PASS | PASS | PASS | PASS | Compliant |
| OTT VoIP | PASS | PASS | PASS | PASS | PASS | Compliant |

## I. Raw Handset Data

**Table 10-2**
**Raw Data Results for GSM**

| Mode | Orientation | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|
| GSM850 | Radial | 128 | 0.09 | -35.73 | -61.59 | 2.00 | 35.82 | 2.2, 2.4 |
| | | 190 | 0.24 | -36.93 | | 2.00 | 37.17 | |
| | | 251 | 0.19 | -36.70 | | 2.00 | 36.89 | |
| | | | | | | | | |
| GSM1900 | Radial | 512 | 0.15 | -46.14 | -61.59 | 2.00 | 46.29 | 2.2, 2.4 |
| | | 661 | 0.43 | -45.91 | | 2.00 | 46.34 | |
| | | 810 | 0.26 | -45.41 | | 2.00 | 45.67 | |

**Table 10-3**
**Worst-Case Scan Results for GSM**

| Mode | Orientation | Channel | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Frequency Response Margin (dB) | Verdict | Frequency Response Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| C63.19-2019 T-Coil Scan | | | | | | | | | |
| GSM850 | Radial | 128 | 52 | 156 | 13 | 26 | 2.00 | PASS | 2.2, 2.4 |

## Table 10-4
## Raw Data Results for UMTS

| Mode | Orientation | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|
| UMTS V | Radial | 4132 | -0.74 | -55.62 | -61.59 | 2.00 | 54.88 | 2.2, 2.4 |
| | | 4183 | -0.59 | -57.14 | | 2.00 | 56.55 | |
| | | 4233 | -0.73 | -56.69 | | 2.00 | 55.96 | |
| | | | | | | | | |
| UMTS IV | Radial | 1312 | -0.49 | -56.19 | -61.59 | 2.00 | 55.70 | 2.2, 2.4 |
| | | 1412 | -0.73 | -56.18 | | 2.00 | 55.45 | |
| | | 1513 | -0.76 | -56.24 | | 2.00 | 55.48 | |
| | | | | | | | | |
| UMTS II | Radial | 9262 | -0.39 | -56.79 | -61.59 | 2.00 | 56.40 | 2.2, 2.4 |
| | | 9400 | -0.58 | -56.35 | | 2.00 | 55.77 | |
| | | 9538 | -0.61 | -56.40 | | 2.00 | 55.79 | |

## Table 10-5
## Worst-Case Scan Results for UMTS

| Mode | Orientation | Channel | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Frequency Response Margin (dB) | Verdict | Frequency Response Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| C63.19-2019 T-Coil Scan | | | | | | | | | |
| UMTS V | Radial | 4132 | 424 | 671 | 26 | 26 | 2.00 | PASS | 2.2, 2.4 |

## Table 10-6
## Raw Data Results for LTE B71

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 71 | Radial | 20MHz | 133297 | -0.55 | -54.09 | -63.53 | 2.00 | 53.54 | 2.2, 2.4 |

## Table 10-7
## Raw Data Results for LTE B12

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 12 | Radial | 10MHz | 23095 | -0.47 | -54.68 | -63.53 | 2.00 | 54.21 | 2.2, 2.4 |

## Table 10-8
## Raw Data Results for LTE B13

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 13 | Radial | 10MHz | 23230 | -0.32 | -53.21 | -63.53 | 2.00 | 52.89 | 2.2, 2.4 |

## Table 10-9
## Raw Data Results for LTE B14

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 14 | Radial | 10MHz | 23330 | -0.49 | -54.17 | -63.53 | 2.00 | 53.68 | 2.2, 2.4 |

## Table 10-10
## Raw Data Results for LTE B26

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 26 | Radial | 15MHz | 26865 | -0.61 | -54.49 | -63.53 | 2.00 | 53.88 | 2.2, 2.4 |

## Table 10-11
## Raw Data Results for LTE B66

| Mode | Orientation | Bandwidth | Channel | ANT Config. | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 66 | Radial | 20MHz | 132322 | B | -0.78 | -45.31 | -63.53 | 2.00 | 44.53 | 2.2, 2.4 |
| | | 20MHz | 132322 | C | -0.59 | -43.71 | | 2.00 | 43.12 | |

## Table 10-12
## Raw Data Results for LTE B25

| Mode | Orientation | Bandwidth | Channel | ANT Config. | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| LTE Band 25 | Radial | 20MHz | 26365 | B | -0.52 | -43.67 | -63.53 | 2.00 | 43.15 | 2.2, 2.4 |
| | | 20MHz | 26365 | C | -0.51 | -45.11 | | 2.00 | 44.60 | |

## Table 10-13
## Raw Data Results for LTE B30

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 30 | Radial | 10MHz | 27710 | -0.51 | -48.03 | -63.53 | 2.00 | 47.52 | 2.2, 2.4 |

## Table 10-14
## Raw Data Results for LTE B7

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 7 | Radial | 20MHz | 21100 | -0.81 | -47.03 | -63.53 | 2.00 | 46.22 | 2.2, 2.4 |

## Table 10-15
## Raw Data Results for LTE B41 Power Class 3

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 41 (PC3) | Radial | 20MHz | 40620 | -0.41 | -33.12 | -63.53 | 2.00 | 32.71 | 2.2, 2.4 |

## Table 10-16
## Raw Data Results for LTE B41 Power Class 2

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 41 (PC2) | Radial | 20MHz | 40620 | -0.31 | -32.59 | -63.53 | 2.00 | 32.28 | 2.2, 2.4 |

## Table 10-17
## Raw Data Results for LTE B48

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 48 | Radial | 20MHz | 55990 | -0.20 | -30.80 | -63.53 | 2.00 | 30.60 | 2.2, 2.4 |
| | | 15MHz | 56665 | -0.49 | -31.26 | | 2.00 | 30.77 | |
| | | 15MHz | 55990 | -0.52 | -30.76 | | 2.00 | 30.24 | |
| | | 15MHz | 55315 | -0.22 | -31.11 | | 2.00 | 30.89 | |
| | | 10MHz | 55990 | -0.39 | -31.11 | | 2.00 | 30.72 | |
| | | 5MHz | 55990 | -0.51 | -30.79 | | 2.00 | 30.28 | |

## Table 10-18
## Worst-Case Scan Results for LTE

| Mode | Orientation | Bandwidth | Channel | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Frequency Response Margin (dB) | Verdict | Frequency Response Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| C63.19-2019 T-Coil Scan | | | | | | | | | | |
| LTE Band 48 | Radial | 15MHz | 55990 | 136 | 314 | 16 | 26 | 2.00 | PASS | 2.2, 2.4 |

## Table 10-19
## Raw Data Results for NR n71

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n71 | Radial | 20MHz | 136100 | 0.39 | -46.91 | -61.80 | 2.00 | 47.30 | 2.2, 2.4 |

## Table 10-20
## Raw Data Results for NR n5

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n5 | Radial | 20MHz | 167300 | 0.22 | -51.35 | -61.80 | 2.00 | 51.57 | 2.2, 2.4 |

## Table 10-21
## Raw Data Results for NR n70

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n70 | Radial | 15MHz | 340500 | 0.28 | -44.63 | -61.80 | 2.00 | 44.91 | 2.2,2.4 |

## Table 10-22
## Raw Data Results for NR n66

| Mode | Orientation | Bandwidth | Channel | ANT Config. | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| NR n66 | Radial | 40MHz | 349000 | B | 0.18 | -47.48 | -61.80 | 2.00 | 47.66 | 2.2, 2.4 |
| | | 40MHz | 349000 | C | 0.34 | -43.65 | | 2.00 | 43.99 | |

## Table 10-23
## Raw Data Results for NR n25

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n25 | Radial | 40MHz | 376500 | 0.13 | -45.98 | -61.80 | 2.00 | 46.11 | 2.2, 2.4 |

## Table 10-24
## Raw Data Results for NR n2

| Mode | Orientation | Bandwidth | Channel | ANT Config. | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| NR n2 | Radial | 40MHz | 376000 | M2 | 0.33 | -44.78 | -61.80 | 2.00 | 45.11 | 2.2,2.4 |

## Table 10-25
## Raw Data Results for NR n41 (PC2)

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n41 (PC2) | Radial | 100MHz | 528000 | 0.20 | -36.04 | -61.80 | 2.00 | 36.24 | 2.2, 2.4 |
| | | 100MHz | 523302 | 0.12 | -36.10 | | 2.00 | 36.22 | |
| | | 100MHz | 518598 | -0.16 | -35.76 | | 2.00 | 35.60 | |
| | | 100MHz | 513900 | 0.21 | -36.00 | | 2.00 | 36.21 | |
| | | 100MHz | 509202 | 0.22 | -35.95 | | 2.00 | 36.17 | |
| | | 90MHz | 518598 | 0.21 | -36.08 | | 2.00 | 36.29 | |
| | | 80MHz | 518598 | 0.16 | -36.03 | | 2.00 | 36.19 | |
| | | 70MHz | 518598 | 0.23 | -36.10 | | 2.00 | 36.33 | |
| | | 60MHz | 518598 | 0.22 | -36.07 | | 2.00 | 36.29 | |
| | | 50MHz | 518598 | 0.19 | -35.96 | | 2.00 | 36.15 | |
| | | 40MHz | 518598 | 0.10 | -36.07 | | 2.00 | 36.17 | |
| | | 30MHz | 518598 | 0.21 | -36.01 | | 2.00 | 36.22 | |
| | | 20MHz | 518598 | 0.21 | -36.08 | | 2.00 | 36.29 | |
| | | 15MHz | 518598 | 0.25 | -36.06 | | 2.00 | 36.31 | |
| | | 10MHz | 518598 | 0.23 | -35.99 | | 2.00 | 36.22 | |

## Table 10-26
## Raw Data Results for NR n77 (DoD, PC2)

| Mode | Orientation | Bandwidth | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n77 (DoD, PC2) | Radial | 100MHz | 633334 | 0.33 | -35.88 | -61.59 | 2.00 | 36.21 | 2.2, 2.4 |

## Table 10-27
## Raw Data Results for NR n48

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n48 | Radial | 100MHz | 641666 | 0.14 | -35.97 | -61.80 | 2.00 | 36.11 | 2.2, 2.4 |

## Table 10-28
## Raw Data Results for NR n77 (PC2)

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n77 (PC2) | Radial | 100MHz | 656000 | 0.10 | -35.99 | -61.80 | 2.00 | 36.09 | 2.2, 2.4 |

## Table 10-29
## Worst-Case Scan Results for NR TDD

| Mode | Orientation | Bandwidth | Channel | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Frequency Response Margin (dB) | Verdict | Frequency Response Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| C63.19-2019 T-Coil Scan | | | | | | | | | | |
| NR n41 (PC2) | Radial | 100MHz | 518598 | 163 | 323 | 16 | 26 | 2.00 | PASS | 2.2, 2.4 |

## Table 10-30
## Raw Data Results for 2.4GHz WIFI

| Mode | Orientation | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|
| IEEE 802.11b | Radial | 6 | -0.95 | -40.63 | -61.59 | 2.00 | 39.68 | 2.2, 2.4 |
| | | | | | | | | |
| IEEE 802.11g | Radial | 1 | -1.07 | -39.35 | -61.59 | 2.00 | 38.28 | 2.2, 2.4 |
| | | 6 | -0.95 | -40.23 | | 2.00 | 39.28 | |
| | | 11 | -1.10 | -39.52 | | 2.00 | 38.42 | |
| | | | | | | | | |
| IEEE 802.11n | Radial | 6 | -0.85 | -40.67 | -61.59 | 2.00 | 39.82 | 2.2, 2.4 |

## Table 10-31
## Raw Data Results for 5GHz WIFI IEEE 802.11a

| Mode | Orientation | Bandwidth | U-NII | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| IEEE 802.11a | Radial | 20MHz | 1 | 40 | -1.13 | -40.27 | -61.59 | 2.00 | 39.14 | 2.2, 2.4 |

## Table 10-32
## Raw Data Results for 5GHz WIFI IEEE 802.11n

| Mode | Orientation | Bandwidth | U-NII | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| IEEE 802.11n | Radial | 40MHz | 1 | 38 | -1.00 | -39.63 | -61.59 | 2.00 | 38.63 | 2.2, 2.4 |
| | | 20MHz | 1 | 40 | -1.13 | -39.87 | | 2.00 | 38.74 | |
| | | 40MHz | 2A | 54 | -1.12 | -38.82 | | 2.00 | 37.70 | |
| | | 40MHz | 2A | 62 | -1.09 | -39.69 | | 2.00 | 38.60 | |
| | | 20MHz | 2A | 56 | -1.33 | -42.16 | | 2.00 | 40.83 | |
| | | 40MHz | 2C | 118 | -1.32 | -41.13 | | 2.00 | 39.81 | |
| | | 20MHz | 2C | 120 | -1.25 | -41.76 | | 2.00 | 40.51 | |
| | | 40MHz | 3 | 151 | -1.12 | -39.60 | | 2.00 | 38.48 | |
| | | 20MHz | 3 | 157 | -1.12 | -40.80 | | 2.00 | 39.68 | |

## Table 10-33
## Raw Data Results for 5GHz WIFI IEEE 802.11ac

| Mode | Orientation | Bandwidth | U-NII | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| IEEE 802.11ac | Radial | 40MHz | 1 | 38 | -0.97 | -42.13 | -61.59 | 2.00 | 41.16 | 2.2, 2.4 |
| | | 20MHz | 1 | 40 | -1.28 | -42.22 | | 2.00 | 40.94 | |

## Table 10-34
## Worst-Case Scan Results for WIFI

| Mode | Orientation | Bandwidth | U-NII | Channel | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Frequency Response Margin (dB) | Verdict | Frequency Response Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C63.19-2019 T-Coil Scan | | | | | | | | | | | |
| IEEE 802.11n | Radial | 40MHz | 2A | 54 | 206 | 374 | 20 | 26 | 2.00 | PASS | 2.2, 2.4 |

## Table 10-35
## Raw Data Results for EDGE (OTT VoIP)

| Mode | Orientation | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|
| EDGE850 | Radial | 190 | -0.28 | -39.41 | -61.28 | 1.81 | 39.13 | 2.2, 2.4 |
| | | | | | | | | |
| EDGE1900 | Radial | 661 | -0.11 | -44.28 | -61.28 | 2.00 | 44.17 | 2.2, 2.4 |

## Table 10-36
## Raw Data Results for HSPA (OTT VoIP)

| Mode | Orientation | Channel | Desired [dB(A/m)] | Undesired [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|
| HSPA V | Radial | 4183 | 0.17 | -54.10 | -61.28 | 1.84 | 54.27 | 2.2, 2.4 |
| | | | | | | | | |
| HSPA IV | Radial | 1412 | 0.28 | -53.01 | -61.28 | 1.82 | 53.29 | 2.2, 2.4 |
| | | | | | | | | |
| HSPA II | Radial | 9400 | 0.18 | -53.08 | -61.28 | 1.96 | 53.26 | 2.2, 2.4 |

## Table 10-37
## Raw Data Results for LTE TDD B48 (OTT VoIP)

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| LTE Band 48 | Radial | 20MHz | 55990 | -0.06 | -31.20 | -62.95 | 1.72 | 31.14 | 2.2, 2.4 |
| | | 15MHz | 56665 | -0.03 | -31.46 | | 2.00 | 31.43 | |
| | | 15MHz | 55990 | -0.38 | -31.23 | | 1.91 | 30.85 | |
| | | 15MHz | 55315 | 0.01 | -32.06 | | 1.82 | 32.07 | |
| | | 10MHz | 55990 | 0.00 | -31.35 | | 1.63 | 31.35 | |
| | | 5MHz | 55990 | -0.07 | -31.26 | | 1.87 | 31.19 | |

## Table 10-38
## Raw Data Results for NR TDD n41 (PC2) (OTT VoIP)

| Mode | Orientation | Bandwidth | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|
| NR n41 (PC2) | Radial | 100MHz | 528000 | -0.50 | -39.03 | -62.95 | 2.00 | 38.53 | 2.2, 2.4 |
| | | 100MHz | 523302 | -0.20 | -38.02 | | 1.97 | 37.82 | |
| | | 100MHz | 518598 | -0.57 | -38.45 | | 1.93 | 37.88 | |
| | | 100MHz | 513900 | -0.67 | -39.20 | | 1.81 | 38.53 | |
| | | 100MHz | 509202 | -0.55 | -38.78 | | 2.00 | 38.23 | |
| | | 90MHz | 518598 | -0.42 | -38.52 | | 1.71 | 38.10 | |
| | | 80MHz | 518598 | -0.50 | -39.13 | | 1.97 | 38.63 | |
| | | 70MHz | 518598 | -0.69 | -39.04 | | 1.73 | 38.35 | |
| | | 60MHz | 518598 | -0.42 | -38.87 | | 1.95 | 38.45 | |
| | | 50MHz | 518598 | -0.55 | -39.55 | | 1.91 | 39.00 | |
| | | 40MHz | 518598 | -0.37 | -38.71 | | 1.90 | 38.34 | |
| | | 30MHz | 518598 | -0.52 | -39.09 | | 1.85 | 38.57 | |
| | | 20MHz | 518598 | -0.73 | -38.65 | | 2.00 | 37.92 | |
| | | 15MHz | 518598 | -0.77 | -39.29 | | 1.95 | 38.52 | |
| | | 10MHz | 518598 | -0.50 | -38.46 | | 1.93 | 37.96 | |

## Table 10-39
## Raw Data Results for 2.4GHz WIFI (OTT VoIP)

| Mode | Orientation | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|
| IEEE 802.11b | Radial | 1 | -0.89 | -38.58 | -61.59 | 1.70 | 37.69 | 2.2, 2.4 |
| | | 6 | -1.05 | -40.51 | | 1.70 | 39.46 | |
| | | 11 | -0.83 | -38.73 | | 1.66 | 37.90 | |
| IEEE 802.11g | Radial | 6 | -1.13 | -42.54 | -61.59 | 1.80 | 41.41 | 2.2, 2.4 |
| IEEE 802.11n | Radial | 6 | -1.21 | -43.99 | -61.59 | 1.86 | 42.78 | 2.2, 2.4 |

## Table 10-40
## Raw Data Results for 5GHz WIFI IEEE 802.11a (OTT VoIP)

| Mode | Orientation | Bandwidth | U-NII | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| IEEE 802.11a | Radial | 20MHz | 1 | 40 | -0.73 | -38.80 | -61.59 | 1.69 | 38.07 | 2.2, 2.4 |
| | | 20MHz | 2A | 56 | -0.84 | -37.82 | | 1.86 | 36.98 | |
| | | 20MHz | 2C | 100 | -0.89 | -39.54 | | 1.51 | 38.65 | |
| | | 20MHz | 2C | 120 | -0.99 | -37.76 | | 1.53 | 36.77 | |
| | | 20MHz | 2C | 144 | -0.97 | -38.00 | | 1.61 | 37.03 | |
| | | 20MHz | 3 | 157 | -0.82 | -38.06 | | 1.78 | 37.24 | |

## Table 10-41
## Raw Data Results for 5GHz WIFI IEEE 802.11n (OTT VoIP)

| Mode | Orientation | Bandwidth | U-NII | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| IEEE 802.11n | Radial | 40MHz | 1 | 38 | -0.97 | -41.13 | -61.59 | 1.64 | 40.16 | 2.2, 2.4 |
| | | 20MHz | 1 | 40 | -0.90 | -39.56 | | 1.65 | 38.66 | |

## Table 10-42
## Raw Data Results for 5GHz WIFI IEEE 802.11ac (OTT VoIP)

| Mode | Orientation | Bandwidth | U-NII | Channel | Desired ABM [dB(A/m)] | Undesired ABM [dB(A/m)] | Ambient Noise [dB(A/m)] | Frequency Response Margin (dB) | S+N/N (dB) | Test Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| IEEE 802.11ac | Radial | 40MHz | 1 | 38 | -1.09 | -41.21 | -61.59 | 1.83 | 40.12 | 2.2, 2.4 |
| | | 20MHz | 1 | 40 | -0.87 | -39.55 | | 1.91 | 38.68 | |

## Table 10-43
## Worst-Case Scan Results for OTT VoIP

| Mode | Orientation | Bandwidth | Channel | Primary Pts | Secondary Pts | Contiguous Longitudinal | Contiguous Transverse | Frequency Response Margin (dB) | Verdict | Frequency Response Coordinates |
|---|---|---|---|---|---|---|---|---|---|---|
| C63.19-2019 T-Coil Scan | | | | | | | | | | |
| LTE Band 48 | Radial | 15MHz | 55990 | 128 | 313 | 15 | 26 | 1.91 | PASS | 2.2, 2.4 |

## 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 → Other call settings → Hearing aid compatibility) was set to ON for HAC compliance
4. Speech Signal: 3GPP2 Normal Test Signal
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 number of passing points and frequency response value shown in the scan result table satisfy the limit for compliance.

B. GSM

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

C. UMTS

1. Power Configuration: TPC= ”All 1s”;
2. Vocoder Configuration: WB AMR 6.60kbps (UMTS);

D. LTE

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: 16QAM, 1RB, 0RB offset
3. Power Class 3 Uplink-Downlink configuration: 2
4. Power Class 2 Uplink-Downlink configuration: 2
5. Vocoder Configuration: WB AMR 6.60kbps
   LTE Band 48 at 15MHz is the worst-case LTE configuration.

E. NR

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: DFT-s-OFDM, 16QAM, 1RB, 1RB offset
3. Vocoder Configuration: WB AMR 6.60kbps
4. NR n41 (Power Class 2) at 100MHz is the worst-case NR configuration.

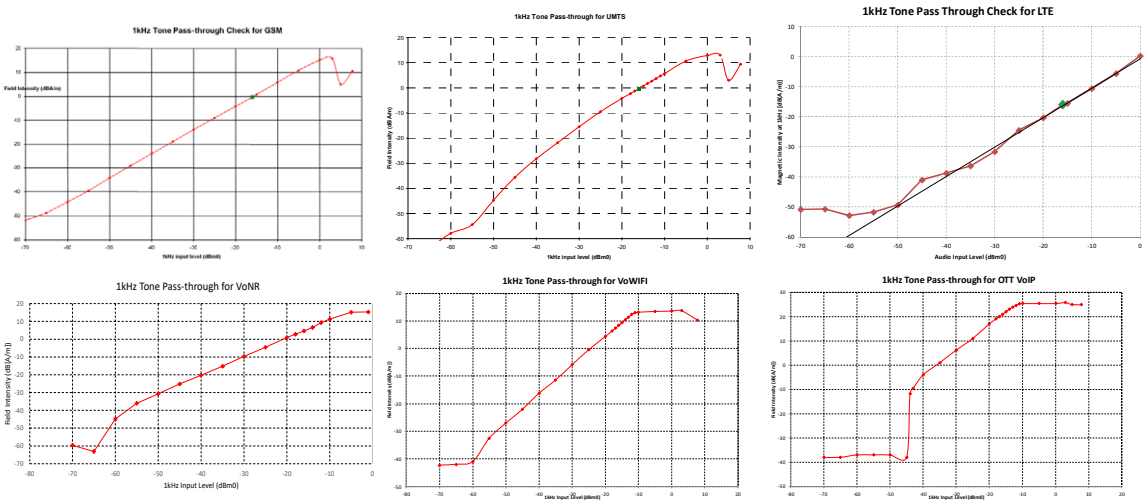
F. WIFI

1. Radio Configuration
   a. IEEE 802.11b: DSSS, 1Mbps
   b. IEEE 802.11g/a: BPSK, 6Mbps
   c. IEEE 802.11n/ac 20MHz: 64QAM, MCS 7
   d. IEEE 802.11n/ac 40MHz: BPSK, MCS 0
2. Vocoder Configuration: WB AMR 6.60kbps
3. The worst-case standard for 2.4GHz WIFI is additionally tested on the low and high channels. IEEE 802.11g is the worst-case 2.4GHz WIFI standard.
4. 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 802.11n (U-NII 2A) 40MHz is the worst-case 5GHz WIFI standard.

G. OTT VoIP

1. Vocoder Configuration: 6kbps
2. EDGE Configuration
    a. MCS Index: 7
    b. Number of TX slots: 2
3. HSPA Configuration:
    a. Release: 6
    b. 3GPP 34.121 Subtest 1
4. LTE Configuration:
    a. Power Configuration: TPC = “Max Power”
    b. Radio Configuration: 16QAM, 1RB, 0RB offset
    c. Power Class 3 Uplink-Downlink configuration: 2
    d. LTE Band 48 was the worst-case band from Table 8-7.
    e. The worst-case band and bandwidth combination is additionally investigated on the low, and high channels. LTE Band 48 at 15MHz is the worst-case LTE configuration.
5. NR TDD Configuration
    a. Power Configuration: TxAGC is set such that the DUT operates at max power.
    b. Radio Configuration: DFT-s-OFDM, 16QAM, 1RB, 1RB offset
    c. NR n41 (PC2) was the worst-case band from Table 8-11.
    d. The worst-case band and bandwidth combination is additionally investigated on the low and high channels for those combinations. NR n41 (PC2) at 100MHz is the worst-case NR configuration.
6. WIFI Configuration:
    a. Radio Configuration
        i. IEEE 802.11b: DSSS, 1Mbps
        ii. IEEE 802.11g/a: BPSK, 6Mbps
        iii. IEEE 802.11n/ac 20MHz: 64QAM, MCS 7
        iv. IEEE 802.11n/ac 40MHz: BPSK, MCS 0
    b. The worst-case standard for 2.4GHz WIFI is additionally investigated on the low and high channels. IEEE 802.11b is the worst-case 2.4GHz WIFI standard.
    c. The worst-case standard for 5GHz WIFI is additionally investigated on higher U-NII bands as well as applicable low and high channels. IEEE 802.11a (U-NII 2C) is the worst-case 5GHz WIFI standard.

## III. 1 kHz Vocoder Application Check



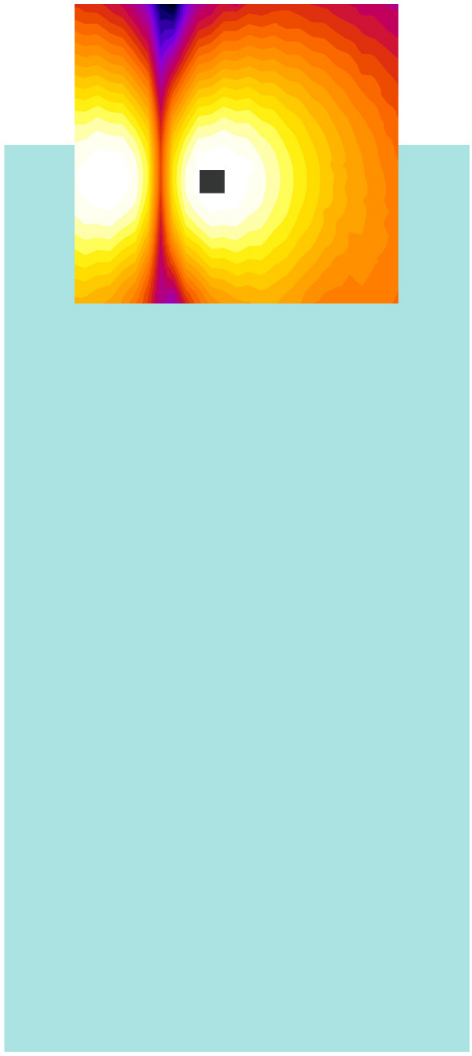

This model was verified to be within the linear region for Desired ABM measurements at -16 dBm0 for GSM, UMTS, VoLTE over IMS, and VoNR over IMS. This model was verified to be within the linear region for Desired ABM measurements at -16 dBm0 for VoWIFI over IMS, and OTT VoIP. This measurement was taken in the Radial configuration above the maximum location.

# IV. T-Coil Validation Test Results

**Table 10-44**
**Helmholtz Coil Verification Table of Results**

| Date | Orientation | Item | Target | Result | Verdict |
|---|---|---|---|---|---|
| 10/16/23 | Radial | Magnetic Intensity, -10 dBA/m | *-10 ± 0.5 dB* | -10.250 | **PASS** |
| | | Environmental Noise | < -48 dBA/m | -61.59 | **PASS** |
| | | Frequency Response, from limits | *> 0 dB* | 0.60 | **PASS** |
| | | | | | |
| 10/23/23 | Radial | Magnetic Intensity, -10 dBA/m | *-10 ± 0.5 dB* | -10.441 | **PASS** |
| | | Environmental Noise | < -48 dBA/m | -61.80 | **PASS** |
| | | Frequency Response, from limits | *> 0 dB* | 0.60 | **PASS** |
| | | | | | |
| 11/06/23 | Radial | Magnetic Intensity, -10 dBA/m | *-10 ± 0.5 dB* | -9.958 | **PASS** |
| | | Environmental Noise | < -48 dBA/m | -62.95 | **PASS** |
| | | Frequency Response, from limits | *> 0 dB* | 0.70 | **PASS** |

## V. Desired ABM Magnetic Field Distribution Scan Overlays



Radial (Transverse)

**Figure 10-1**
**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.

# 11. MEASUREMENT UNCERTAINTY

**Table 11-1**
**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.

# 12. EQUIPMENT LIST

**Table 12-1**
**Equipment List**

| Manufacturer | Model | Description | Cal Date | Cal Interval | Cal Due | Serial Number |
|---|---|---|---|---|---|---|
| Listen | SoundConnect | Microphone Power Supply | 8/10/2022 | Biennial | 8/10/2024 | PS2612 |
| RME | Fireface UC | Soundcheck Acoustic Analyzer External Audio Interface | 8/23/2022 | Biennial | 8/23/2024 | 23528889 |
| Rohde & Schwarz | CMW500 | Wideband Radio Communication Tester | 8/9/2023 | Annual | 8/9/2024 | 162125 |
| Rohde & Schwarz | CMW500 | Radio Communication Tester | 8/10/2023 | Annual | 8/10/2024 | 140144 |
| Rohde & Schwarz | CMX500 | Radio Communication Tester | N/A | | N/A | 100298 |
| Seekonk | NC-100 | Torque Wrench (8" lb) | 11/28/2022 | Biennial | 11/28/2024 | 80790 |
| TEM | Radial T-Coil Probe | Radial T-Coil Probe | 8/10/2022 | Biennial | 8/10/2024 | TEM-1128 |
| TEM | | HAC Positioner | N/A | | N/A | N/A |
| TEM | | HAC System Controller with Software | N/A | | N/A | N/A |
| TEM | Helmholtz Coil | Helmholtz Coil | 9/15/2022 | Biennial | 9/15/2024 | SBI 1052 |
| YellowTec | YT4211 | USB Audio Interface | N/A | | N/A | 20000365 |
| Netgear | XS708E | Ethernet Switch | N/A | | N/A | 4FU3875C001A8 |

# 13. TEST DATA (SINGLE POINT MEASUREMENT)

10/16/2023

## Element Hearing-Aid Compatibility Facility

# DUT: HH Coil – SN: SBI 1052

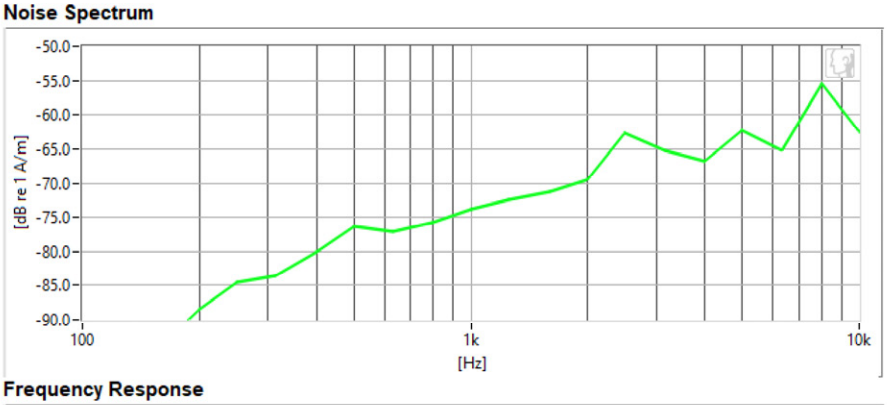
Type: HH Coil
Serial: SBI 1052

**Measurement Standard:** ANSI C63.19

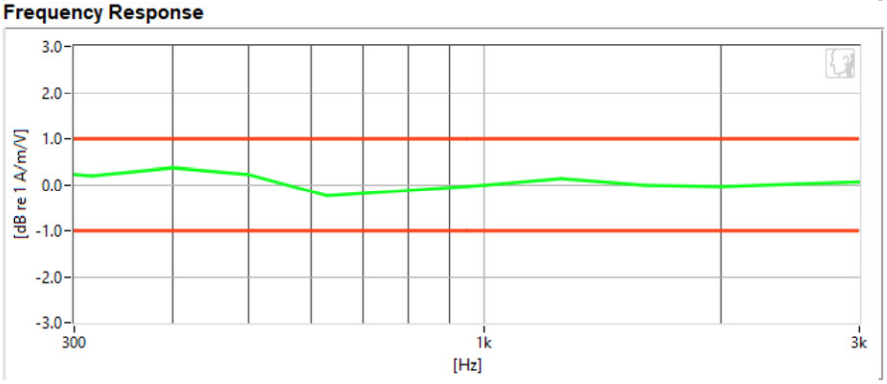
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022
- Helmholtz Coil – SN: SBI 1052; Calibrated: 9/15/2022

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Verification 1kHz Intensity | -10.25 dB | ✓ | Max/Min | -9.5/-10.5 |
| Verification **Undesired ABM** | -61.59 dB | ✓ | Maximum | -58.0 |
| Frequency Response Margin | 600m dB | ✓ | Tolerance curves | Aligned Data |

10/23/2023

## Element Hearing-Aid Compatibility Facility

# DUT: HH Coil – SN: SBI 1052

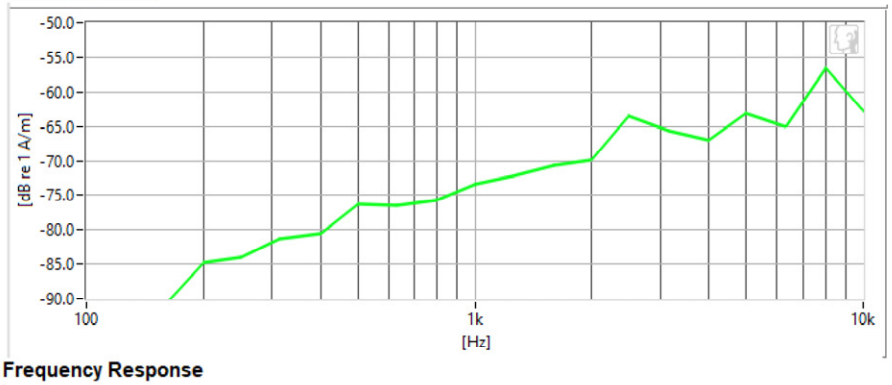
Type: HH Coil
Serial: SBI 1052

**Measurement Standard:** ANSI C63.19

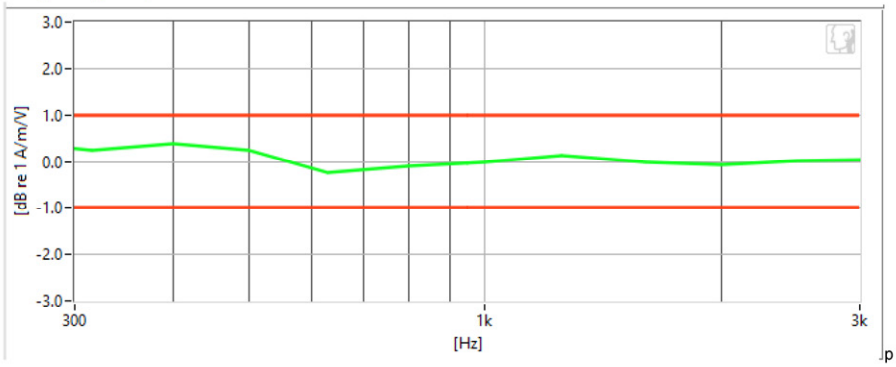
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022
- Helmholtz Coil – SN: SBI 1052; Calibrated: 9/15/2022

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Verification 1kHz Intensity | -10.441 dB | ✓ | Max/Min | -9.5/-10.5 |
| Verification **Undesired ABM** | -61.8 dB | ✓ | Maximum | -58.0 |
| Frequency Response Margin | 600m dB | ✓ | Tolerance curves | Aligned Data |

11/6/2023

## Element Hearing-Aid Compatibility Facility

# DUT: HH Coil – SN: SBI 1052

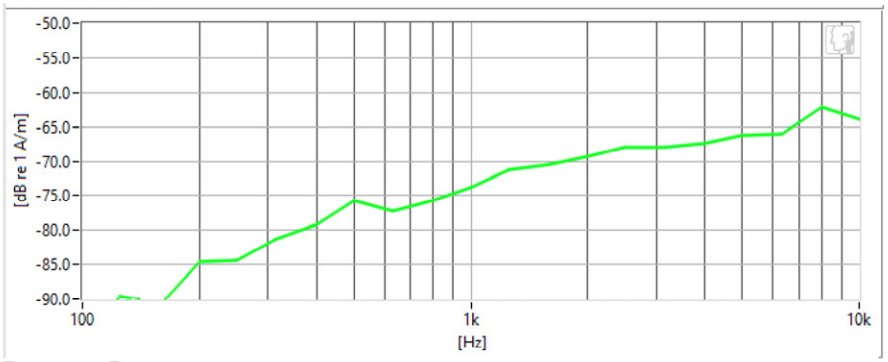
Type: HH Coil
Serial: SBI 1052

**Measurement Standard:** ANSI C63.19

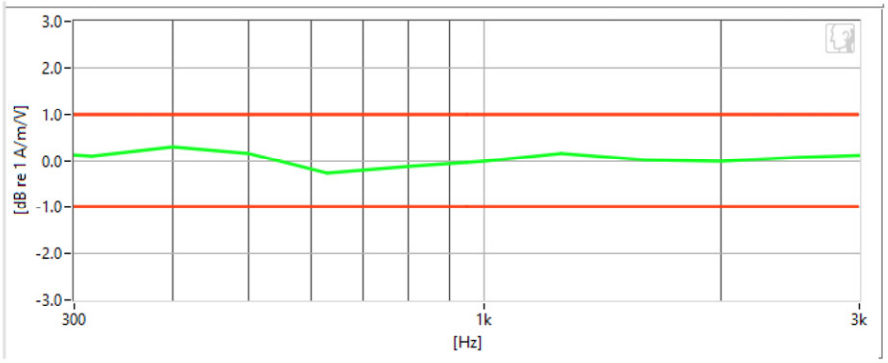
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022
- Helmholtz Coil – SN: SBI 1052; Calibrated: 9/15/2022

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Verification 1kHz Intensity | -9.958 dB | ✓ | Max/Min | -9.5/-10.5 |
| Verification **Undesired ABM** | -62.95 dB | ✓ | Maximum | -58.0 |
| Frequency Response Margin | 700m dB | ✓ | Tolerance curves | Aligned Data |

## Element Hearing-Aid Compatibility Facility

# DUT: A3LSMA156U

Type: Portable Handset
Serial: 2065M

**Measurement Standard:** ANSI C63.19

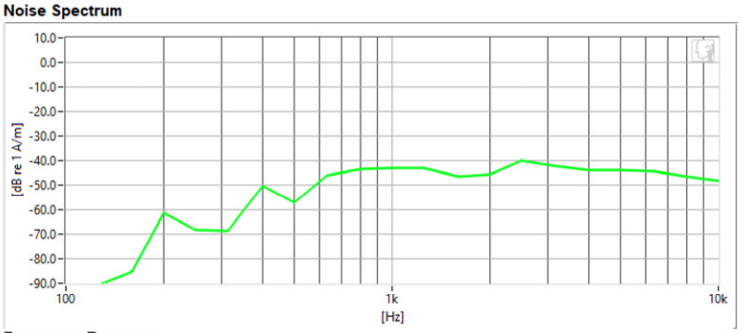
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022

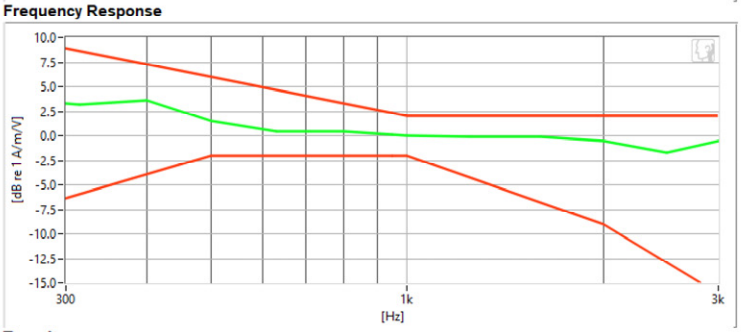
**Test Configuration:**

- Mode: GSM850
- Channel: 128
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Desired ABM | 90m dB | ✓ | Minimum | -18.0 |
| Undesired ABM | -35.73 dB | ✓ | Maximum | 0.0 |
| SNNR | 35.82 dB | ✓ | Minimum | 20.0 |
| Aligned Response - Normal | 2 dB | ✓ | Tolerance curves | Aligned Data |

## Element Hearing-Aid Compatibility Facility

# DUT: A3LSMA156U

Type: Portable Handset
Serial: 2065M

**Measurement Standard:** ANSI C63.19

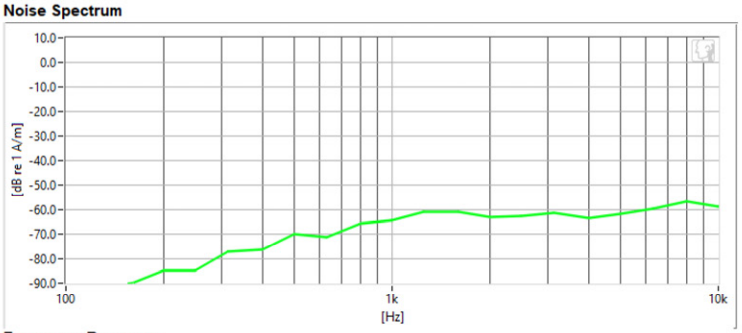
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022

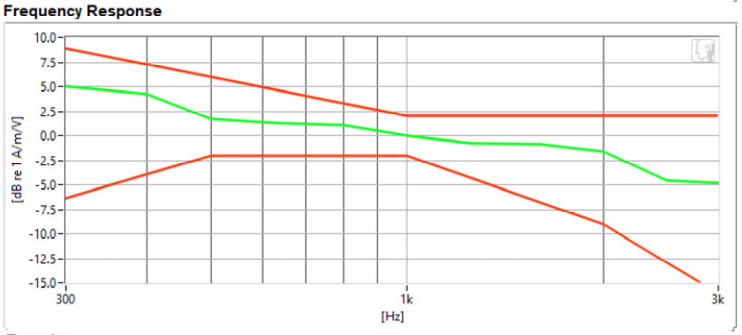
**Test Configuration:**

- Mode: UMTS V
- Channel: 4132
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Desired ABM | -740m dB | ✓ | Minimum | -18.0 |
| Undesired ABM | -55.62 dB | ✓ | Maximum | 0.0 |
| SNNR | 54.88 dB | ✓ | Minimum | 20.0 |
| Aligned Response - Normal | 2 dB | ✓ | Tolerance curves | Aligned Data |

## Element Hearing-Aid Compatibility Facility

# DUT: A3LSMA156U

Type: Portable Handset
Serial: 2065M

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

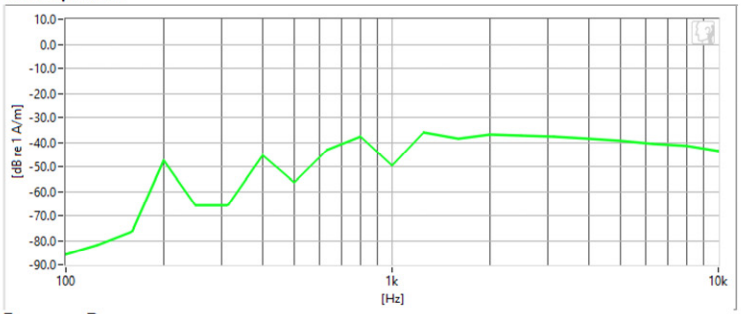
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022

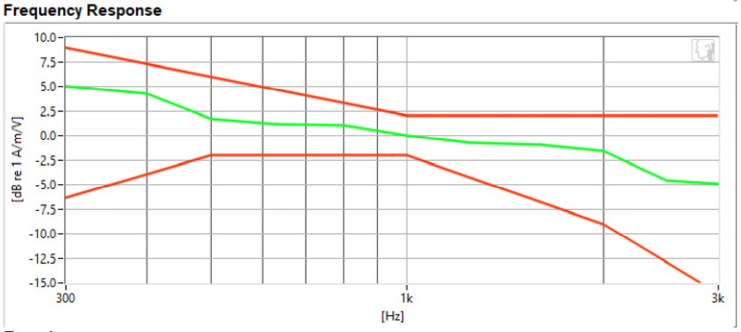
**Test Configuration:**

- Mode: LTE TDD Band 48
- Bandwidth: 15MHz
- Channel: 55990
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Desired ABM | -520m dB | ✓ | Minimum | -18.0 |
| Undesired ABM | -30.76 dB | ✓ | Maximum | 0.0 |
| SNNR | 30.24 dB | ✓ | Minimum | 20.0 |
| Aligned Response - Normal | 2 dB | ✓ | Tolerance curves | Aligned Data |

## Element Hearing-Aid Compatibility Facility

# DUT: A3LSMA156U

Type: Portable Handset
Serial: 2065M

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

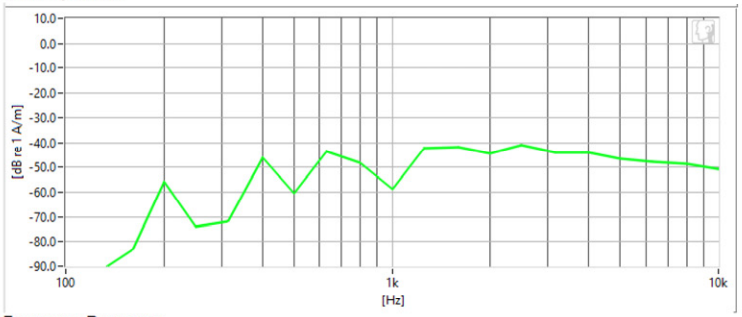
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022

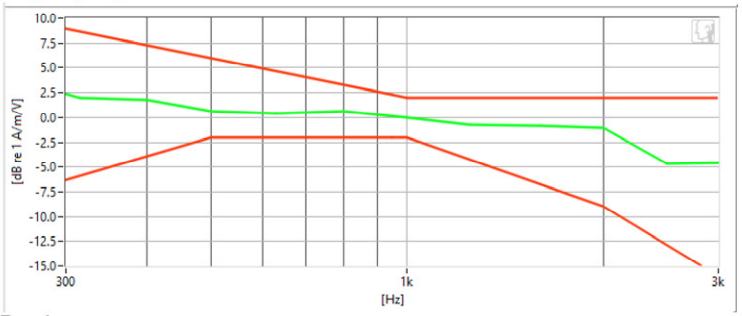
**Test Configuration:**

- Mode: NR TDD Band 41 (PC2)
- Bandwidth: 100MHz
- Channel: 518598
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Desired ABM | -160m dB | ✓ | Minimum | -18.0 |
| Undesired ABM | -35.76 dB | ✓ | Maximum | 0.0 |
| SNNR | 35.6 dB | ✓ | Minimum | 20.0 |
| Aligned Response - Normal | 2 dB | ✓ | Tolerance curves | Aligned Data |

10/18/2023

## Element Hearing-Aid Compatibility Facility

# DUT: A3LSMA156U

Type: Portable Handset
Serial: 2065M

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

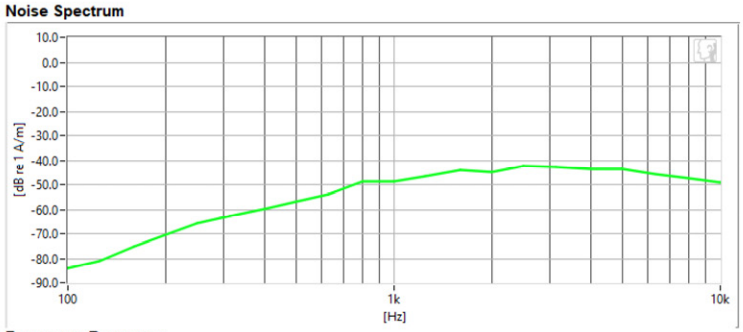
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022

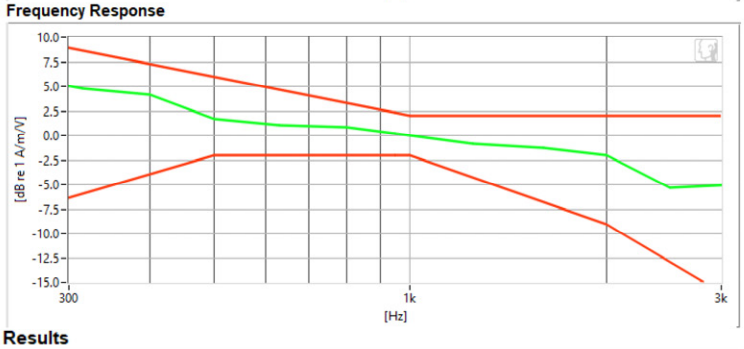
**Test Configuration:**

- Mode: 5GHz WLAN
- Standard: IEEE 802.11n
- Bandwidth: 40MHz
- Channel: 54
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Desired ABM | -1.12 dB | ✓ | Minimum | -18.0 |
| Undesired ABM | -38.82 dB | ✓ | Maximum | 0.0 |
| SNNR | 37.7 dB | ✓ | Minimum | 20.0 |
| Aligned Response - Normal | 2 dB | ✓ | Tolerance curves | Aligned Data |

## Element Hearing-Aid Compatibility Facility

# DUT: A3LSMA156U

Type: Portable Handset
Serial: 2065M

**Measurement Standard:** ANSI C63.19

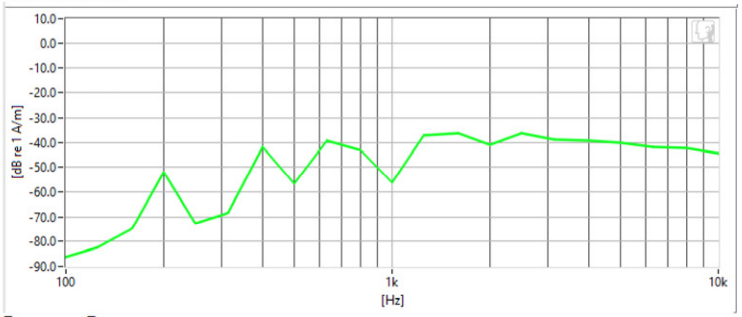
**Equipment:**

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 8/10/2022

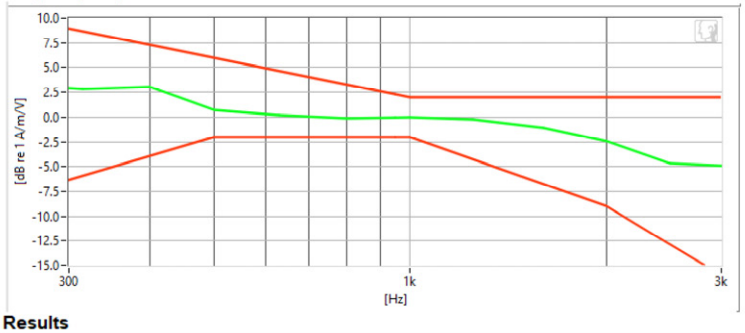
**Test Configuration:**

- VoIP Application: Google Meet
- Mode: LTE TDD Band 48
- Bandwidth: 15MHz
- Channel: 55990
- Speech Signal: 3GPP2 Normal Test Signal

**Noise Spectrum**




**Frequency Response**




**Results**

| | | | | |
|---|---|---|---|---|
| Desired ABM | -380m dB | ✓ | Minimum | -18.0 |
| Undesired ABM | -31.23 dB | ✓ | Maximum | 0.0 |
| SNNR | 30.85 dB | ✓ | Minimum | 20.0 |
| Aligned Response - Normal | 1.91 dB | ✓ | Tolerance curves | Aligned Data |

# 14. TEST DATA (SCAN MEASUREMENT)

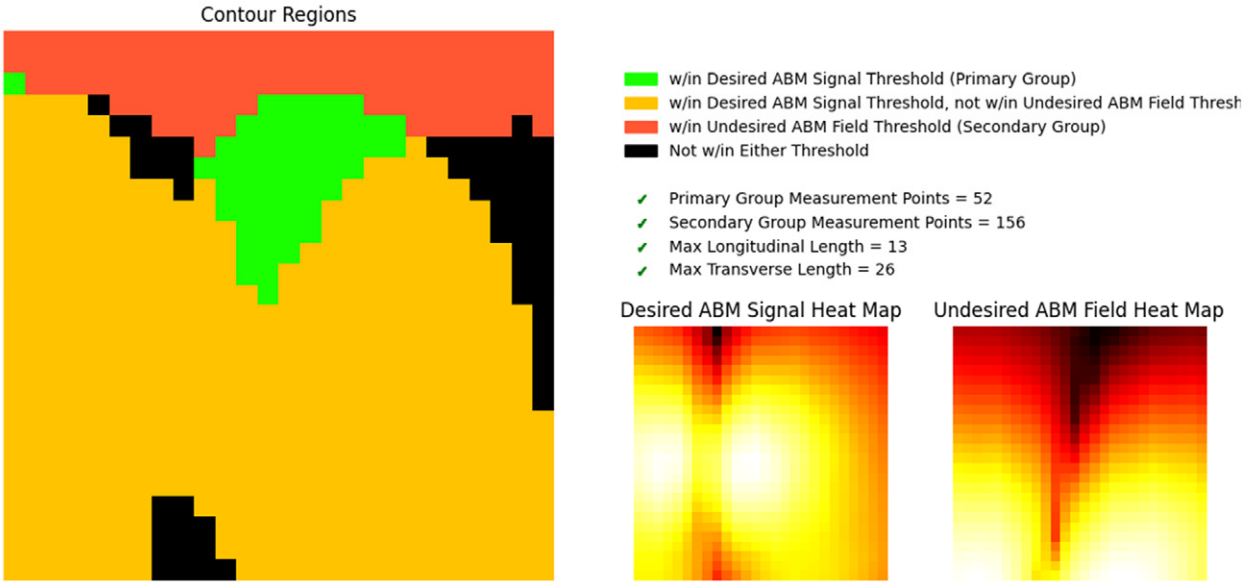



**Table 14-1**
**Worst-Case Scan Results for GSM**
**GSM 850 CH.128, EFR: FR V1**

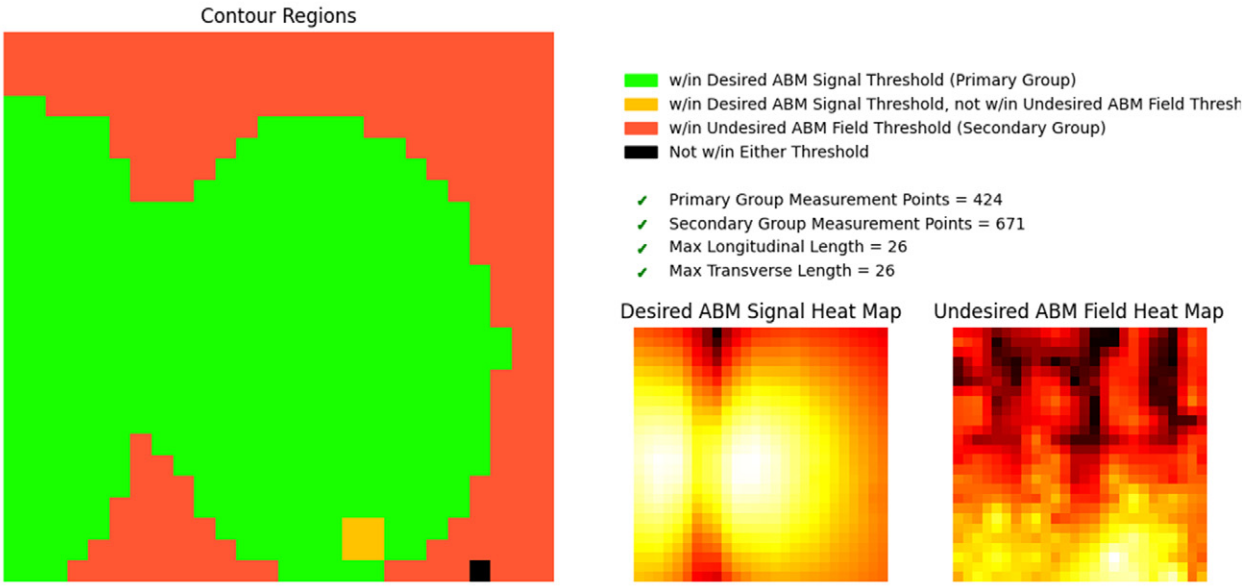



**Table 14-2**
**Worst-Case Scan Results for UMTS**
**UMTS Band 5 CH.4132, WB AMR 6.60KBPS**

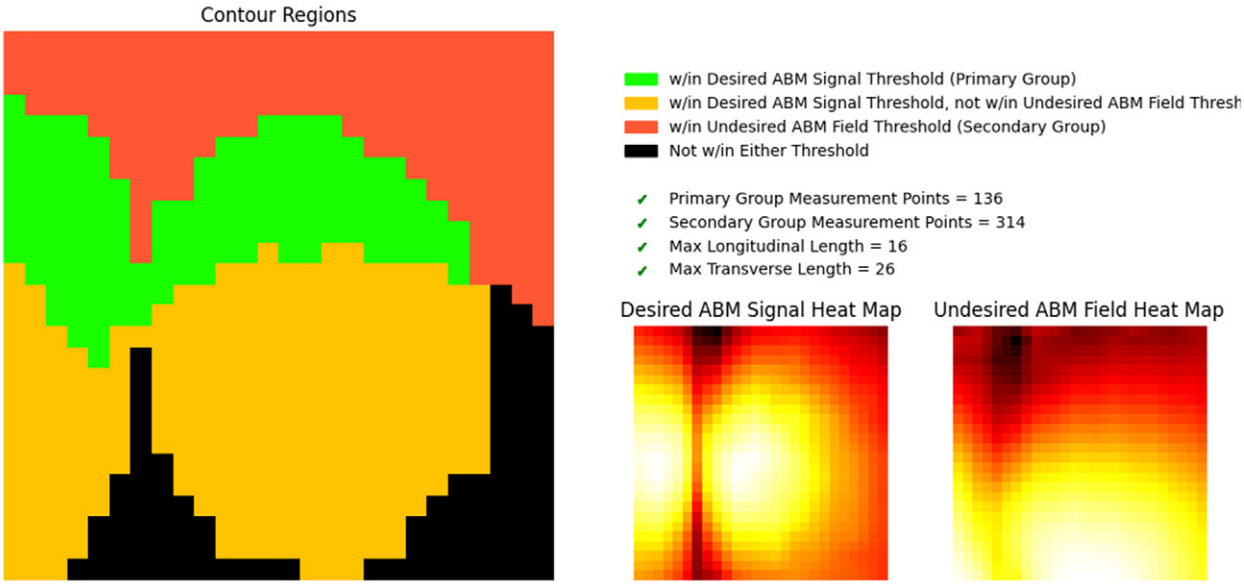



**Table 14-3**
**Worst-Case Scan Results for LTE**
**LTE TDD Band 48 15MHz CH.55990, WB AMR 6.60KBPS**

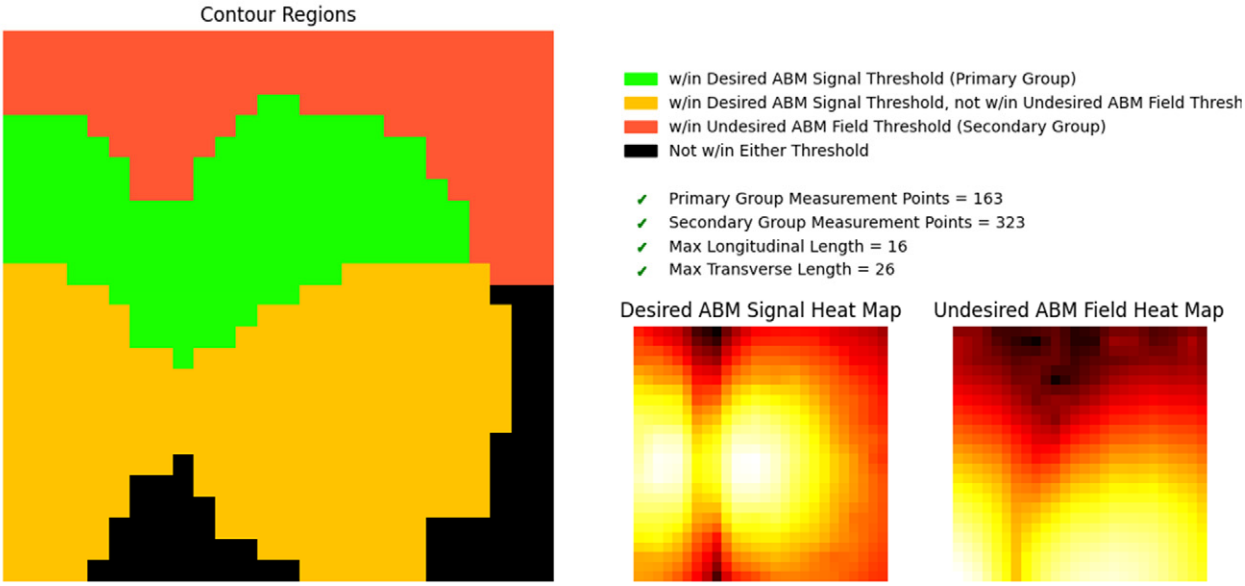



**Table 14-4**
**Worst-Case Scan Results for NR**
**NR TDD n41 (PC2) 100MHz CH.518598, WB AMR 6.60KBPS**

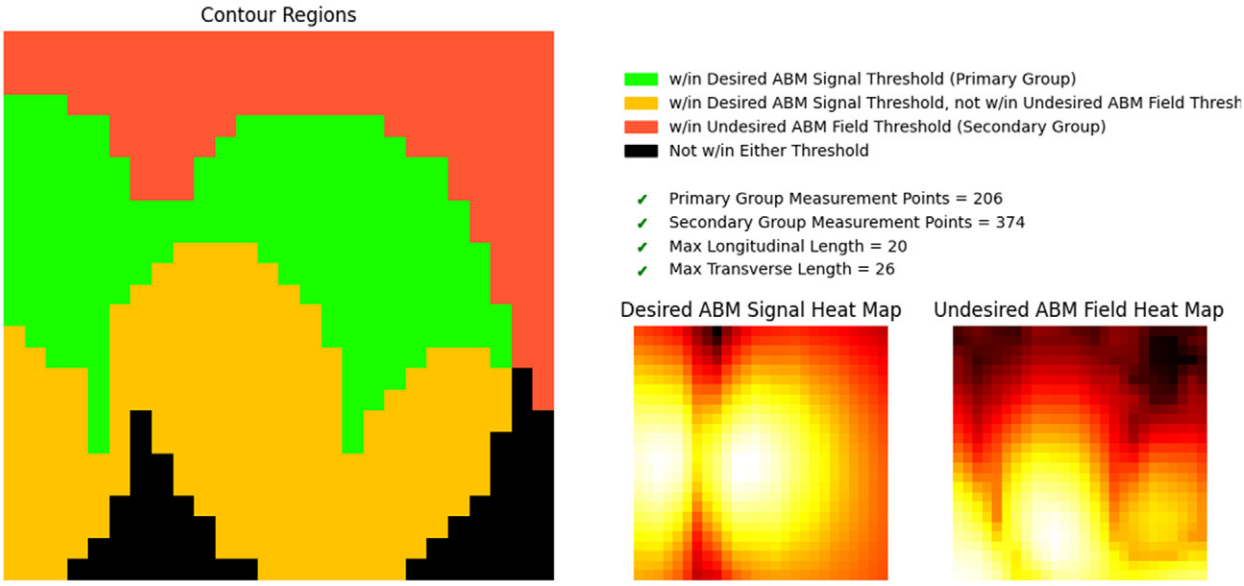



**Table 14-5**
**Worst-Case Scan Results for WIFI**
**5GHz WIFI IEEE 802.11n 40MHz CH.54, WB AMR 6.60KBPS**

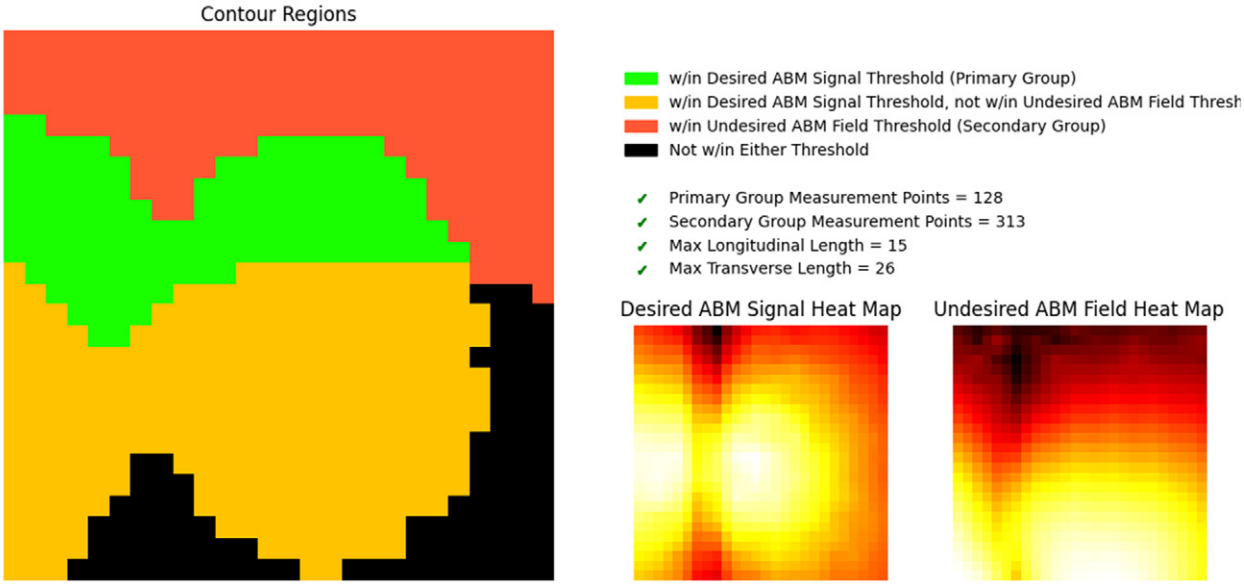



**Table 14-6**
**Worst-Case Scan Results for NR (OTT VoIP)**
**LTE TDD Band 48 15MHz CH.55990, OPUS 6KBPS**

# 15. CALIBRATION CERTIFICATES

## West Caldwell Calibration Laboratories Inc.

# Certificate of Calibration

for

Radial T Coil Probe

| | |
|---|---|
| Manufactured by: | LISTEN INC. |
| Model No: | RADIAL T COIL PROBE |
| Serial No: | TEM-1128 |
| Calibration Recall No: | 33271 |

Submitted By:

| | |
|---|---|
| Customer: | Tae Kim |
| Company: | Element Materials Technology Washington DC LLC |
| Address: | 7185 Oakland Mills Road |
| | Columbia MD 21046 |

The subject instrument was calibrated to the indicated specification using standards traceable to the SI through 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 LISTE

√TK
9/2/2022

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 certifies that the item listed above meets acceptance criteria under the decision rule: A=(L-(U95)), where A is the acceptance criteria, L is manufacturer specifications, and U95 is confidence level of 95% at k=2. The decision rule has been communicated and approved by customer during contract review. Measurements marked with (*) are not covered by the scope of current A2LA accreditation.

West Caldwell Calibration Laboratories' calibration control system meets the following requirements: ANSI/NCSL Z540-1, ISO 9001, and ISO 17025.

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

Approved by:

James Zhu
Quality Manager

| | |
|---|---|
| Calibration Date: | 10-Aug-22 |
| Certificate Issue Date: | 01-Sep-22 Rev 2.0 |
| Certificate No: | 33271 - 2 |

QA Doc. #1051 Rev. 3.0 5/29/20

Certificate Page 1 of 1

ISO/IEC 17025

ACCREDITED

Calibration Lab. Cert. # 1533.01

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

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

ISO/IEC 17025
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-1128**
**Company: Element Materials Technology Washington D.C. LLC.** **I. D. No.: XXXX**

Calibration results:

**Probe Sensitivity measured with Helmholtz Coil**

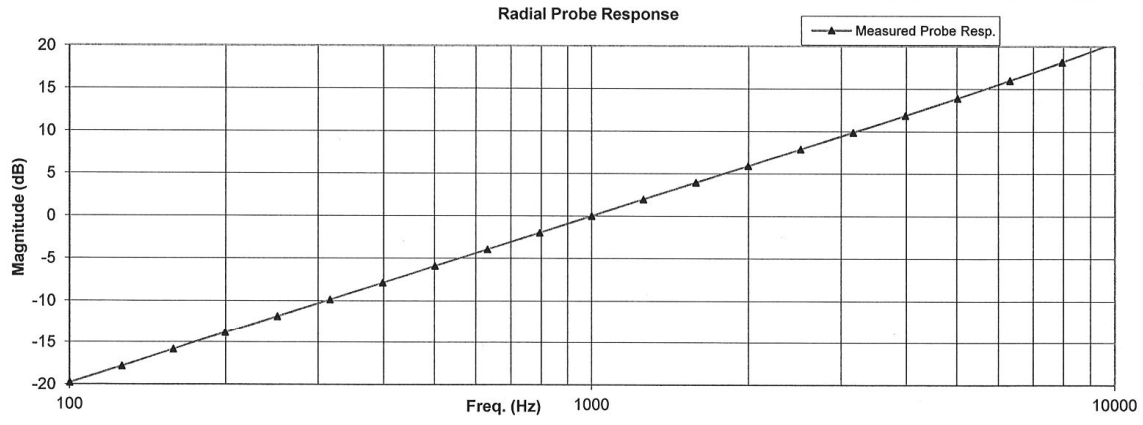
| | | | | | |
|---|---|---|---|---|---|
| ***Helmholtz Coil;*** | | | Before & after data same: | ...X... | |
| the number of turns on each coil; | 10 | No. | | | |
| the radius of each coil, in meters; | 0.204 | m | Laboratory Environment: | | |
| the current in the coils, in amperes.; | 0.09 | A | Ambient Temperature: | 20.5 | °C |
| ***Helmholtz Coil Constant;*** | 7.09 | A/m/V | Ambient Humidity: | 43.5 | % RH |
| ***Helmholtz Coil magnetic field;*** | 5.96 | A/m | Ambient Pressure: | 99.709 | kPa |
| | | | Calibration Date: | 10-Aug-2022 | |
| **Probe Sensitivity at** | 1000 | Hz. | Re-calibration Due: | | |
| **was** | -60.02 | dBV/A/m | Report Number: | 33271 -2 | |
| | 0.997 | mV/A/m | Control Number: | 33271 | |
| **Probe resistance** | 902 | Ohms | | | |

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

This Calibration is traceable through NIST test numbers: ,682636

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 ANSI/NCSL Z540-1, ISO 9001, and ISO 17025.

**Cal. Date: 10-Aug-2022**

**Calibrated on WCCL system type 9700**

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



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

*HCRTEMC_TEM-1128_Aug-10-2022*

**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-1128
Company: Element Materials Technology Washington D.C. LLC.

| Test | Function | Tolerance | | Measured values | | |
|---|---|---|---|---|---|---|
| | | | | Before | Out | Remarks |
| 1.0 | Probe Sensitivity at | 1000 Hz. | dBV/A/m | -60.02 | | |
| 2.0 | Probe Level Linearity | | dB | | | |
| | | Ref. (0 dB) | 6 | 6.03 | | |
| | | | 0 | 0.00 | | |
| | | | -6 | -6.03 | | |
| | | | -12 | -12.05 | | |
| 3.0 | Probe Frequency Response | | Hz | | | |
| | | | 100 | -19.8 | | |
| | | | 126 | -17.8 | | |
| | | | 158 | -15.8 | | |
| | | | 200 | -13.8 | | |
| | | | 251 | -11.9 | | |
| | | | 316 | -9.9 | | |
| | | | 398 | -7.9 | | |
| | | | 501 | -5.9 | | |
| | | | 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 | 16.0 | | |
| | | | 7943 | 18.2 | | |
| | | | 10000 | 20.5 | | |

| Instruments used for calibration: | | | Date of Cal. | Traceability No. | Due Date |
|---|---|---|---|---|---|
| HP | 34401A | S/N US360641 | 24-Jun-2022 | ,682636 | 24-Jun-2023 |
| HP | 34401A | S/N US361024 | 24-Jun-2022 | ,682636 | 24-Jun-2023 |
| HP | 33120A | S/N US360437 | 24-Jun-2022 | ,682636 | 24-Jun-2023 |
| B&K | 2133 | S/N 1583254 | 5-Jul-2022 | ,682636 | 5-Jul-2023 |

Cal. Date: 10-Aug-2022
Calibrated on WCCL system type 9700

Tested by: James Zhu



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

***Page 2 of 2***

# 16. 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.

# 17. REFERENCES


1. ANSI C63.19-2019, American National Standard for Methods of Measurement of Compatibility between Wireless communication devices and Hearing Aids.", New York, NY, IEEE, August 2019

2. FCC Office of Engineering and Technology KDB, "285076 D01 HAC Guidance v06r02," September 19, 2022

3. FCC Office of Engineering and Technology KDB, "285076 D02 T-Coil Testing for CMRS IP v04," February 23, 2022

4. FCC Public Notice DA 06-1215, *Wireless Telecommunications Bureau and Office of Engineering and Technology Clarify Use of Revised Wireless Phone Hearing Aid Compatibility Standard*, June 6, 2006

5. FCC 3G Review Guidance, Laboratory Division OET FCC, May/June 2006

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