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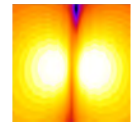

HEARING AID COMPATIBILITY

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

Date of Testing:
12/14/2023 - 12/29/2023
Test Site/Location:
Element Washington DC LLC,
Columbia, MD, USA
Test Report Serial No.:
1M2311010111-20.A3L
Date of Issue:
1/2/2023

FCC ID:	**A3LSMA356U**
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 285076 D01 HAC Guidance v06r02 285076 D02 T-Coil testing for CMRS IP v04
DUT Type:	Portable Handset
Model:	SM-A356U
Additional Model(s):	SM-A356U1, SM-S356V
Test Device Serial No.:	*Pre-Production Sample* [S/N: 2231M, 2280M]

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

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

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 must be measured for:

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

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

Figure 1-1 Hearing Aid *in-vitu*

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

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2. DUT DESCRIPTION

FCC ID:	A3LSMA356U
Applicant:	Samsung Electronics Co., Ltd. 129, Samsung-ro, Maetan dong, Yeongtong-gu, Suwon-si Gyeonggi-do 16677, Korea
Model:	SM-A356U
Additional Model(s):	SM-A356U1, SM-S356V
Serial Number:	2231M, 2280M
HW Version:	REV1.0
SW Version:	A356U.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.

III. Device Serial Numbers

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

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Table 2-1
A3LSMA356U 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 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 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 Google Meet: OPUS
	850 (n5)					
	1700 (n70)					
	1700 (n66)					
	1900 (n2)					
	1900 (n25)					
	2300 (n30)					
NR (TDD)	2600 (n41)	VD	Yes	Yes: LTE, WIFI or BT	VoNR[1], Google Meet[1]	VoNR: NB AMR, WB AMR, EVS Google Meet: OPUS
	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 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

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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.

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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.

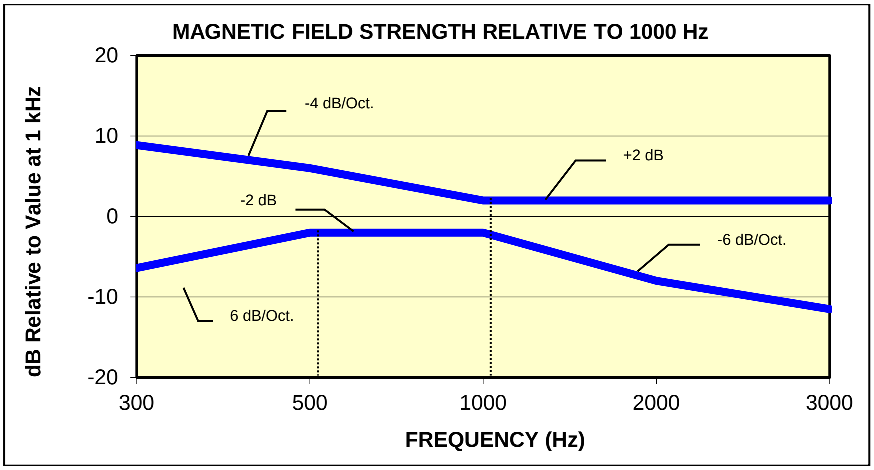

Figure 3-1
Magnetic field frequency response for Wireless Devices with a maximum field strength ≤-15 dB(A/m) at 1 kHz

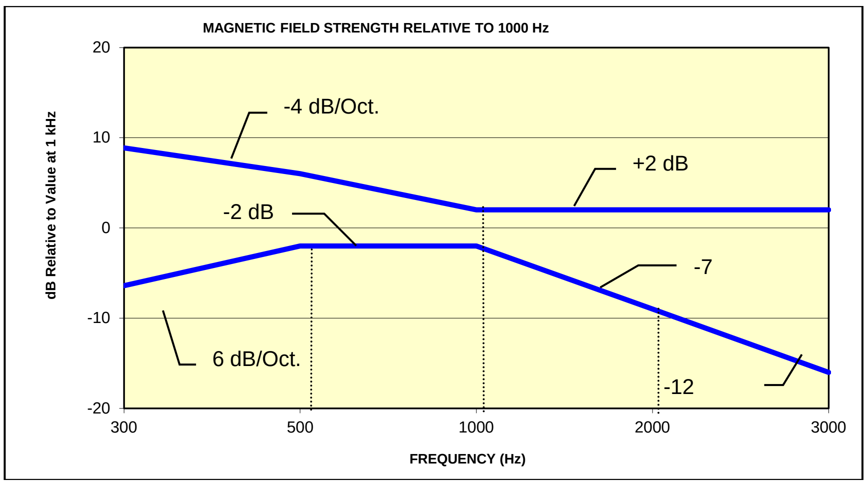

Figure 3-2
Magnetic Field frequency response for wireless devices with a maximum field strength that exceeds-15 dB(A/m) at 1 kHz

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4. METHOD OF MEASUREMENT

I. Test Setup

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

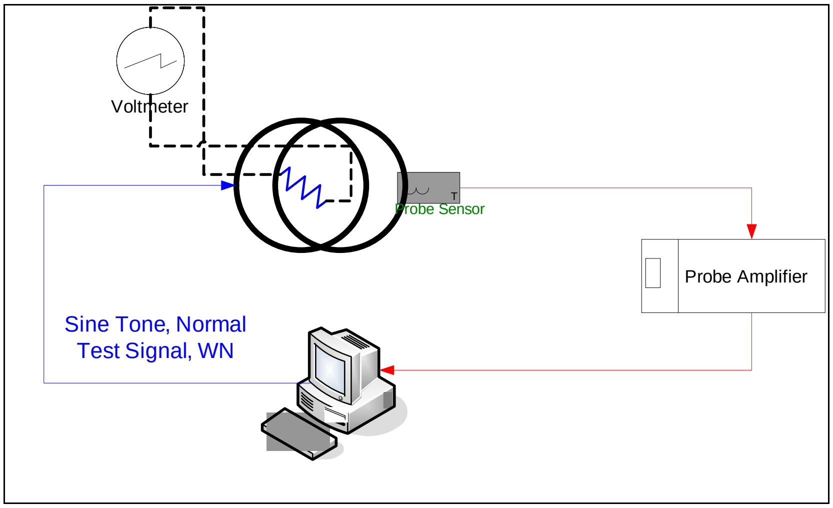

Figure 4-1
Validation Setup with Helmholtz Coil

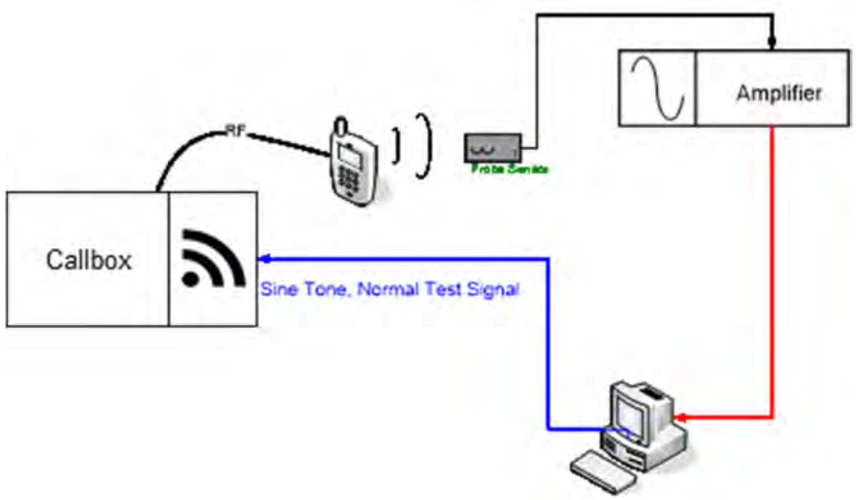

Figure 4-2
T-Coil Test Setup

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II. 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%

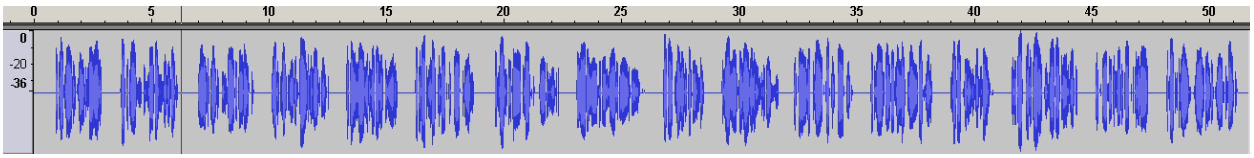

Figure 4-3
Temporal Characteristic of Normal Test Signal

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III. 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
        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 4-5, the grid is not to scale but merely a graphical representation of the coordinate system in use):

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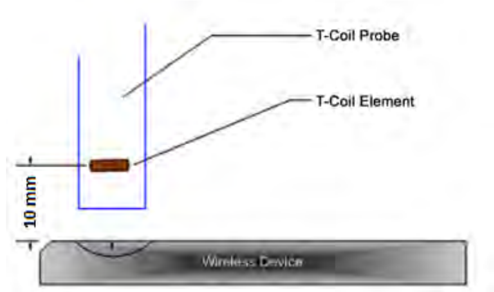

Figure 4-4
Measurement Distance

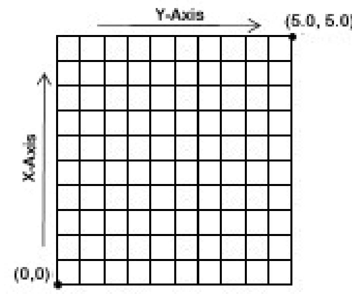

Figure 4-5
Measurement Grid

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.

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    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

    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.

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IV. Test Setup

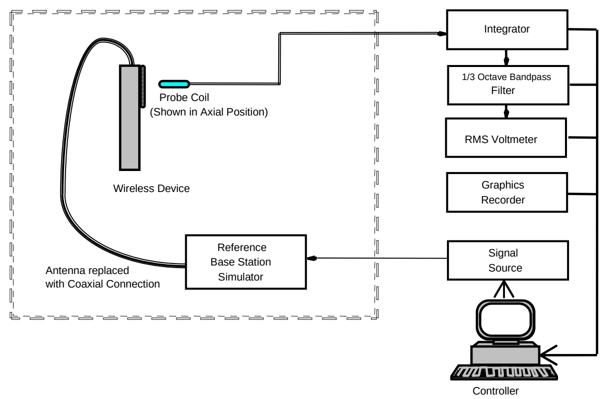

Figure 4-6
Audio Magnetic Field Test Setup

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.

V. Deviation from C63.19 Test Procedure

Non-conducted RF connection due to inaccessible RF ports.

VI. Air Interface Technologies Tested

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

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VII. 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 Table 8-6 was additionally evaluated with OTT VoIP. See Tables 10-6 to 10-16 as well as 10-37 for LTE bandwidths and channels. The scan result is available in Tables 10-17 and 10-44.

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 8-8 was evaluated with OTT VoIP. See Tables 10-18 to 10-27 as well as Table 10-38 for NR bandwidths and channels. The scan results are available in Table 10-28.

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 10-29 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.

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VIII. Test Flow

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

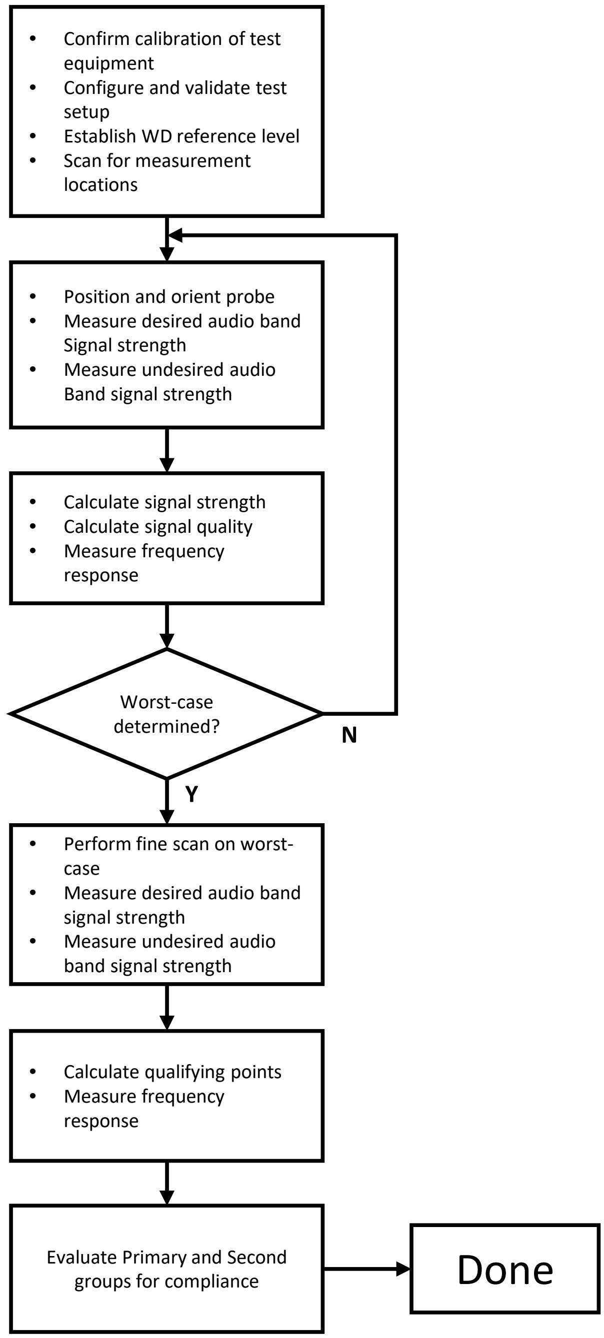

Figure 4-7
C63.19 T-Coil Signal Test Process

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5. VOLTE TEST SYSTEM SETUP AND DUT CONFIGURATION

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

1. Equipment Setup

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

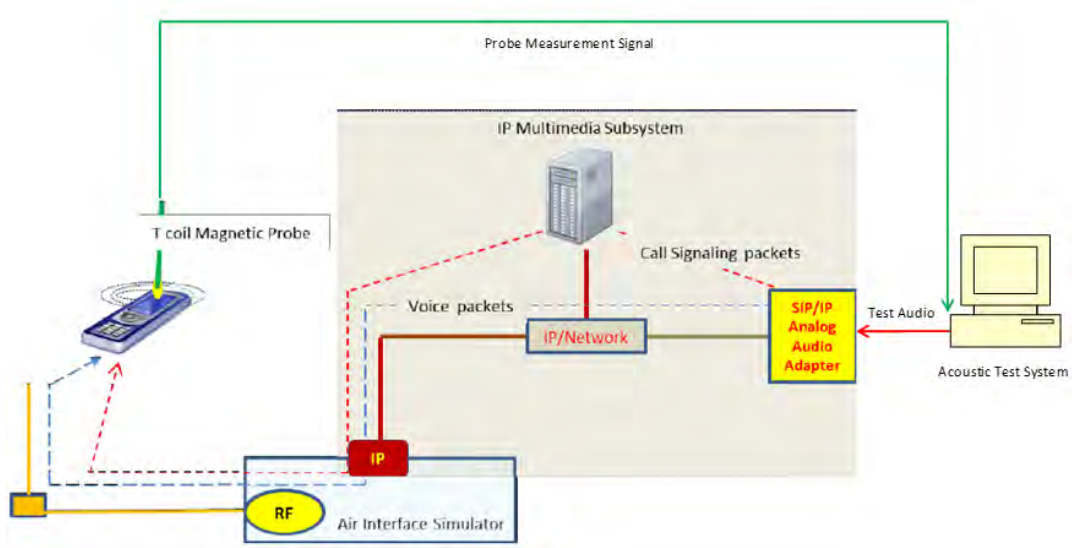

Figure 5-1
Test Setup for VoLTE over IMS T-Coil Measurements

2. Audio Level Settings

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.

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

1. Radio Configuration

An investigation was performed to determine the modulation and RB configuration to be used for testing. The effects of modulation and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. QPSK 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 [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
66	1745.0	132322	20	QPSK	1	0	2.65	-36.72	**39.37**
66	1745.0	132322	20	QPSK	1	50	2.68	-36.79	39.47
66	1745.0	132322	20	QPSK	1	99	2.88	-36.88	39.76
66	1745.0	132322	20	QPSK	50	0	2.47	-36.93	39.40
66	1745.0	132322	20	QPSK	50	25	2.64	-37.20	39.84
66	1745.0	132322	20	QPSK	50	50	2.66	-36.42	39.08
66	1745.0	132322	20	QPSK	100	0	2.35	-37.90	40.25
66	1745.0	132322	20	16QAM	1	0	2.56	-37.78	40.34
66	1745.0	132322	20	64QAM	1	0	2.58	-38.26	40.84
66	1745.0	132322	20	256QAM	1	0	2.49	-38.71	41.20

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)	3.72	2.50	2.84	2.58	Radial	B66 20MHz	132322
Undesired (dBA/m)	-37.41	-36.47	-37.08	-37.40			
Frequency Response	Pass	Pass	Pass	Pass			
S+N/N (dB)	41.13	**38.97**	39.92	39.98			

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Table 5-3
EVS Codec Investigation - VoLTE over IMS

Codec Setting:	EVS Primary SWB 32.0kbps	EVS Primary SWB 9.6kbps	EVS Primary WB 32.0kbps	EVS Primary WB 5.9kbps	EVS Primary NB 24.4kbps	EVS Primary NB 5.9kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	7.30	7.05	3.41	4.21	2.55	5.54	Radial	B66 20MHz	132322
Undesired (dBA/m)	-37.05	-37.56	-36.91	-37.43	-37.24	-36.30			
Frequency Response	Pass	Pass	Pass	Pass	Pass	Pass			
S+N/N (dB)	44.35	44.61	40.32	41.64	39.79	41.84			

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

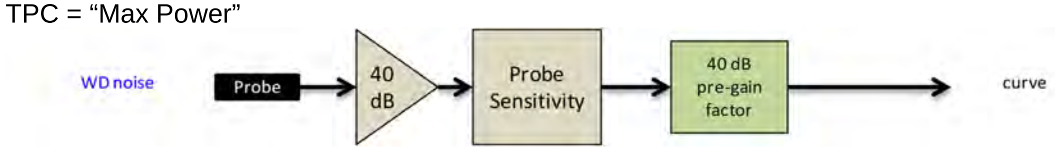

Figure 5-2
Audio Band Magnetic Curve Measurement Block Diagram

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 $2192 \cdot Ts$ which occurs in the normal cyclic prefix and special subframe configuration 4.

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

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

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

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a. Power Class 3 Uplink-Downlink Configuration Investigation

Power Class 3 was evaluated with the following radio configuration: channel 40620, 20MHz BW, QPSK 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 [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
3625.0	55990	20	QPSK	1	0	0	3.01	-38.08	41.09
3625.0	55990	20	QPSK	1	0	1	2.46	-37.43	39.89
3625.0	55990	20	QPSK	1	0	2	2.37	-37.16	**39.53**
3625.0	55990	20	QPSK	1	0	3	2.18	-38.16	40.34
3625.0	55990	20	QPSK	1	0	4	2.91	-39.50	42.41
3625.0	55990	20	QPSK	1	0	5	2.48	-39.51	41.99
3625.0	55990	20	QPSK	1	0	6	2.46	-37.36	39.82

b. Power Class 2 Uplink-Downlink Configuration Investigation

Power Class 2 was evaluated with the following radio configuration: channel 40620, 20MHz BW, QPSK 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 [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
2593.0	40620	20	QPSK	1	0	1	2.57	-35.51	38.08
2593.0	40620	20	QPSK	1	0	2	2.35	-34.84	**37.19**
2593.0	40620	20	QPSK	1	0	3	2.55	-36.76	39.31
2593.0	40620	20	QPSK	1	0	4	2.31	-37.54	39.85
2593.0	40620	20	QPSK	1	0	5	2.35	-36.71	39.06

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.

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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.

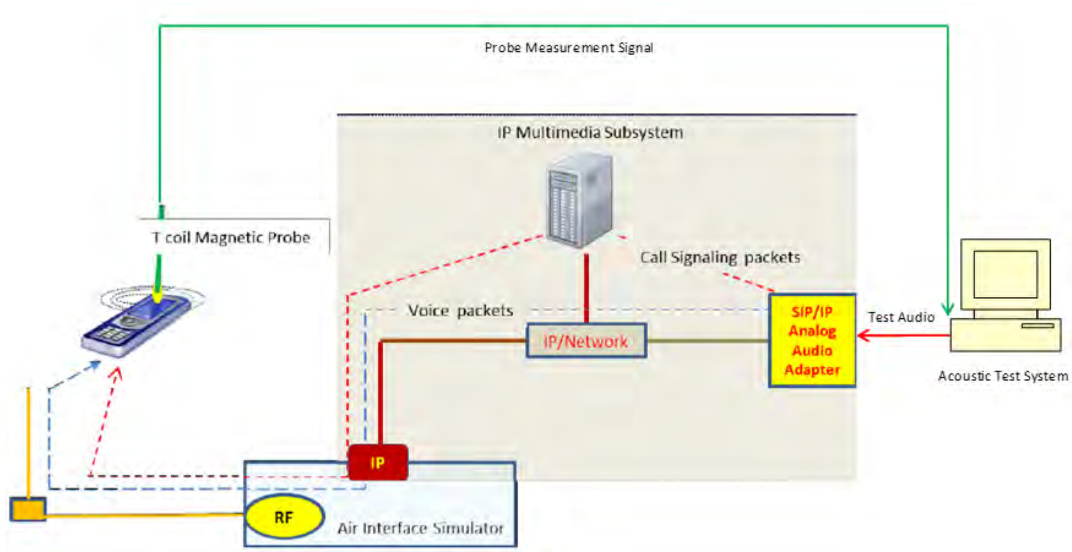

Figure 6-1
Test Setup for VoNR over IMS T-Coil Measurements

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.

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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, QPSK, 100%RB, 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 6-1
VoNR over IMS SNNR by Radio Configuration (CP-OFDM)

Band	Ant Config.	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
66	B	1745.0	349000	40	CP-OFDM	QPSK	1	1	1.55	-36.45	38.00
66	B	1745.0	349000	40	CP-OFDM	16QAM	1	1	1.89	-36.26	38.15
66	B	1745.0	349000	40	CP-OFDM	64QAM	1	1	1.53	-36.52	38.05
66	B	1745.0	349000	40	CP-OFDM	256QAM	1	1	1.86	-36.37	38.23

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

Band	Ant Config.	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
66	B	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	1	1	1.76	-38.02	39.78
66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	1	1	1.94	-36.01	37.95
66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	1	108	2.02	-36.33	38.35
66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	1	214	1.55	-36.06	37.61
66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	108	0	1.74	-35.11	36.85
66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	108	108	1.82	-34.49	36.31
66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	216	0	1.85	-34.06	**35.91**
66	B	1745.0	349000	40	DFT-s-OFDM	16QAM	1	1	1.94	-37.86	39.80
66	B	1745.0	349000	40	DFT-s-OFDM	64QAM	1	1	1.99	-36.42	38.41
66	B	1745.0	349000	40	DFT-s-OFDM	256QAM	1	1	1.82	-37.39	39.21

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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)	2.63	1.84	1.95	1.83	Radial	n66 40MHz	132322
Undesired (dBA/m)	-34.78	-34.80	-34.94	-35.62			
Frequency Response	Pass	Pass	Pass	Pass			
S+N/N (dB)	37.41	36.64	36.89	37.45			

Table 6-4
EVS Codec Investigation - VoNR over IMS

Codec Setting:	EVS Primary SWB 32.0kbps	EVS Primary SWB 9.6kbps	EVS Primary WB 32.0kbps	EVS Primary WB 5.9kbps	EVS Primary NB 24.4kbps	EVS Primary NB 5.9kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	7.78	7.18	3.21	2.66	1.83	4.83	Radial	n66 40MHz	132322
Undesired (dBA/m)	-35.02	-34.57	-34.32	-35.00	-35.61	-34.70			
Frequency Response	Pass	Pass	Pass	Pass	Pass	Pass			
S+N/N (dB)	42.80	41.75	37.53	37.66	37.44	39.53			

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

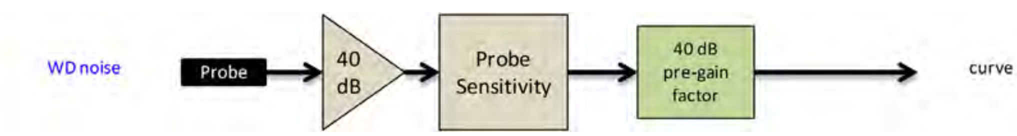

Figure 6-2
Audio Band Magnetic Curve Measurement Block Diagram

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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.

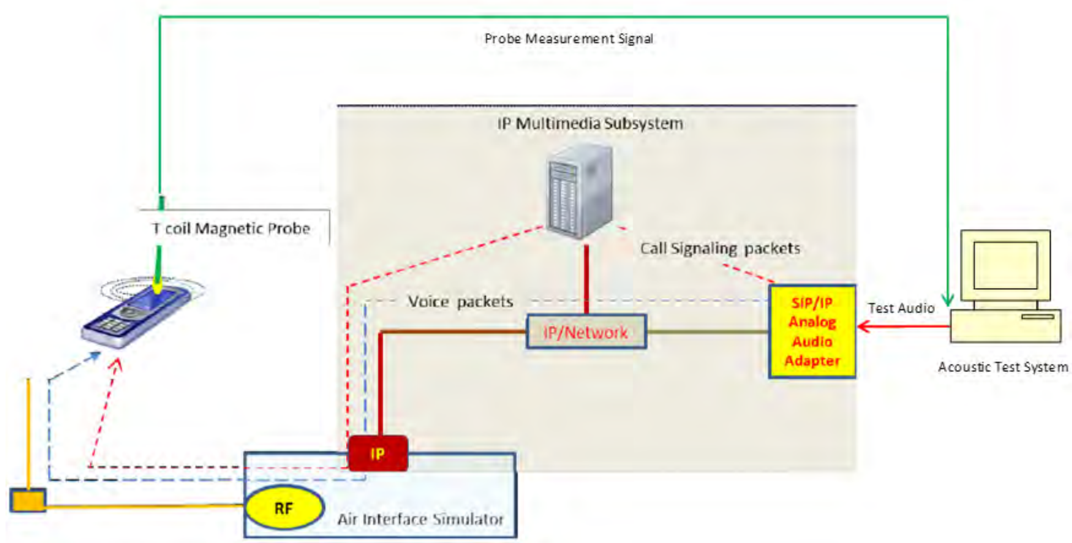

Figure 7-1
Test Setup for VoWIFI over IMS T-Coil Measurements

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.

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

1. Radio Configuration

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

Table 7-1
IEEE 802.11b SNNR by Radio Configuration

Mode	Channel	Modulation	Data Rate [Mbps]	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11b	6	DSSS	1	2.84	-30.88	33.72
IEEE 802.11b	6	CCK	11	2.66	-30.26	**32.92**

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

Mode	Channel	Modulation	Data Rate [Mbps]	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11g	6	BPSK	6	2.47	-34.46	**36.93**
IEEE 802.11g	6	64QAM	54	2.77	-35.37	38.14

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

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11n	20	40	BPSK	0	2.55	-31.69	34.24
IEEE 802.11n	20	40	64QAM	7	2.75	-30.80	**33.55**
IEEE 802.11ac	20	40	256QAM	8	2.89	-31.59	34.48

Table 7-4
IEEE 802.11ax SU 20MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11ax SU	20	40	BPSK	0	2.62	-30.24	**32.86**
IEEE 802.11ax SU	20	40	1024QAM	11	3.04	-32.41	35.45

Table 7-5
IEEE 802.11ax RU 20MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	RU Index	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11ax RU	20	40	BPSK	0	0	2.62	-30.53	**33.15**
IEEE 802.11ax RU	20	40	BPSK	0	61	2.45	-31.39	33.84

Table 7-6
IEEE 802.11n/ac 40MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11n	40	38	BPSK	0	3.00	-33.23	36.23
IEEE 802.11n	40	38	64QAM	7	3.19	-31.90	35.09
IEEE 802.11ac	40	38	256QAM	8	2.79	-31.25	**34.04**
IEEE 802.11ac	40	38	256QAM	9	3.01	-31.34	34.35

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

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11ax SU	40	38	BPSK	0	2.42	-33.23	**35.65**
IEEE 802.11ax SU	40	38	1024QAM	11	2.43	-33.56	35.99

Table 7-8
IEEE 802.11ax RU 40MHz BW SNNR by Radio Configuration

Mode	Bandwidth [MHz]	Channel	Modulation	MCS Index	RU Index	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11ax RU	40	38	BPSK	0	0	2.85	-30.91	**33.76**
IEEE 802.11ax RU	40	38	BPSK	0	65	2.31	-32.08	34.39

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 7-9
AMR Codec Investigation – VoWIFI over IMS

Codec Setting:	WB AMR 23.85kbps	WB AMR 6.60kbps	NB AMR 12.2kbps	NB AMR 4.75kbps	Orientation	Band	Standard	Channel
Desired (dBA/m)	3.78	2.92	3.11	3.15	Radial	2.4GHz	IEEE 802.11 b	6
Undesired (dBA/m)	-30.52	-30.34	-30.23	-30.68				
Frequency Response	Pass	Pass	Pass	Pass				
S+N/N (dB)	34.30	**33.26**	33.34	33.83				

Table 7-10
EVS Codec Investigation – VoWIFI over IMS

Codec Setting:	EVS Primary SWB 32.0kbps	EVS Primary SWB 9.6kbps	EVS Primary WB 32.0kbps	EVS Primary WB 5.9kbps	EVS Primary NB 24.4kbps	EVS Primary NB 5.9kbps	Orientation	Band	Standard	Channel
Desired (dBA/m)	8.81	8.25	3.92	4.45	3.63	5.10	Radial	2.4GHz	IEEE 802.11 b	6
Undesired (dBA/m)	-29.80	-30.58	-30.79	-30.37	-31.10	-30.97				
Frequency Response	Pass	Pass	Pass	Pass	Pass	Pass				
S+N/N (dB)	38.61	38.83	34.71	34.82	34.73	36.07				

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

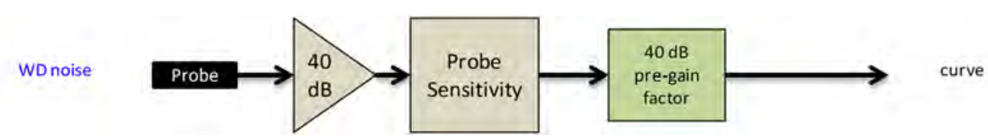

Figure 7-2
Audio Band Magnetic Curve Measurement Block Diagram

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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 (dBA/m)	7.48	7.02	Radial	190
Undesired (dBA/m)	-34.40	-34.30		
Frequency Response	Pass	Pass		
S+N/N (dB)	41.88	**41.32**		

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

Codec Setting:	75kbps	6kbps	Orientation	Channel
Desired (dBA/m)	7.40	7.62	Radial	9400
Undesired (dBA/m)	-41.58	-40.91		
Frequency Response	Pass	Pass		
S+N/N (dB)	48.98	**48.53**		

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

Codec Setting:	75kbps	6kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	7.63	7.38	Radial	B66 20MHz	132322
Undesired (dBA/m)	-37.84	-37.54			
Frequency Response	Pass	Pass			
S+N/N (dB)	45.47	**44.92**			

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

Codec Setting:	75kbps	6kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	7.62	7.23	Radial	n66 40MHz	132322
Undesired (dBA/m)	-35.24	-34.95			
Frequency Response	Pass	Pass			
S+N/N (dB)	42.86	**42.18**			

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

Codec Setting:	75kbps	6kbps	Orientation	Band	Standard	Channel
Desired (dBA/m)	7.35	7.39	Radial	2.4GHz	IEEE 802.11 b	6
Undesired (dBA/m)	-30.36	-29.93				
Frequency Response	Pass	Pass				
S+N/N (dB)	37.71	**37.32**				

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

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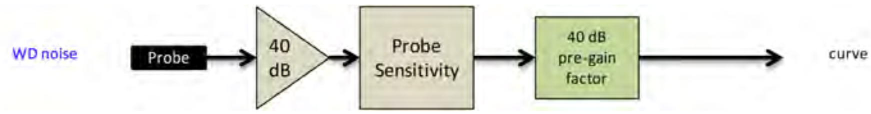

Figure 8-1
Audio Band Magnetic Curve Measurement Block Diagram

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 41 Ant F 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) SNNR by LTE Band

Band	Ant Config.	Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
71	A	680.5	133297	20	QPSK	1	0	7.21	-37.75	44.96
12	A	707.5	23095	10	QPSK	1	0	7.28	-40.10	47.38
13	A	782.0	23230	10	QPSK	1	0	7.44	-39.19	46.63
14	A	793.0	23330	10	QPSK	1	0	7.40	-39.75	47.15
26	A	831.5	26865	15	QPSK	1	0	7.24	-40.21	47.45
66	B	1745.0	132322	20	QPSK	1	0	7.37	-37.65	45.02
66	F	1745.0	132322	20	QPSK	1	0	7.85	-38.96	46.81
25	B	1882.5	26365	20	QPSK	1	0	7.43	-37.09	44.52
25	F	1882.5	26365	20	QPSK	1	0	7.72	-38.85	46.57
30	B	2310.0	27710	10	QPSK	1	0	7.21	-37.67	44.88
30	F	2310.0	27710	10	QPSK	1	0	7.09	-38.32	45.41
7	B	2535.0	21100	20	QPSK	1	0	7.62	-37.45	45.07
7	F	2535.0	21100	20	QPSK	1	0	7.18	-38.25	45.43
41 (PC2)	B	2593.0	40620	20	QPSK	1	0	7.48	-35.68	43.16
41 (PC2)	F	2593.0	40620	20	QPSK	1	0	7.27	-30.07	**37.34**
48	G	3625.0	55990	20	QPSK	1	0	7.64	-38.81	46.45

3. LTE TDD Uplink Carrier Aggregation for OTT VoIP

LTE TDD ULCA was evaluated to ensure FCC compliance. The configurations in Table 8-7 were determined from Table 5-1 and satisfy the configuration requirements as defined in 3GPP 36.101.

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

Combination	PCC								SCC								Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
	PCC Band	Ant Config.	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 (PC2)	LTE B41	B	20	40620	2593.0	QSPK	1	0	LTE B41	20	40422	2573.2	QPSK	1	99		7.61	-33.95	41.56
CA_41C (PC2)	LTE B41	F	20	40620	2593.0	QSPK	1	0	LTE B41	20	40422	2573.2	QPSK	1	99		7.54	-28.87	36.41
CA_48C	LTE B48	G	20	55990	3625.0	QPSK	1	0	LTE B48	20	55792	3605.2	QPSK	1	99		7.61	-37.42	45.03

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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) Ant F was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different NR bands:

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

Band	Ant Config.	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
n71	A	680.5	136100	20	DFT-s-OFDM	QPSK	100	0	7.66	-35.66	43.32
n5	A	836.5	167300	20	DFT-s-OFDM	QPSK	100	0	7.29	-36.20	43.49
n70	A	1702.5	340500	15	DFT-s-OFDM	QPSK	75	0	7.28	-37.20	44.48
n66	B	1745.0	349000	40	DFT-s-OFDM	QPSK	216	0	7.30	-34.57	41.87
n66	F	1745.0	349000	40	DFT-s-OFDM	QPSK	216	0	8.09	-33.47	41.56
n25	B	1880.0	376000	20	DFT-s-OFDM	QPSK	100	0	7.51	-37.58	45.09
n25	F	1882.5	376500	40	DFT-s-OFDM	QPSK	216	0	7.91	-33.71	41.62
n30	B	2310.0	462000	10	DFT-s-OFDM	QPSK	50	0	7.81	-37.64	45.45
n30	F	2310.0	462000	10	DFT-s-OFDM	QPSK	50	0	7.64	-35.37	43.01
n41 (PC2)	B	2592.99	518598	100	DFT-s-OFDM	QPSK	270	0	7.68	-34.73	42.41
n41 (PC2)	F	2592.99	518598	100	DFT-s-OFDM	QPSK	270	0	7.55	-29.88	**37.43**
n77 (DoD, PC2)	G	3500.0	633334	100	DFT-s-OFDM	QPSK	270	0	8.08	-31.21	39.29
n48	G	3625.0	641666	100	DFT-s-OFDM	QPSK	270	0	7.73	-32.17	39.90
n77 (PC2)	G	3840.00	656000	100	DFT-s-OFDM	QPSK	270	0	7.97	-29.82	37.79

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9. FCC 3G MEASUREMENTS

I. GSM Test Configurations

FR V1 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)	3.68	4.44	3.58	Radial	190
Undesired (dBA/m)	-29.68	-30.43	-32.22		
Frequency Response	Pass	Pass	Pass		
S+N/N (dB)	**33.36**	34.87	35.80		

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

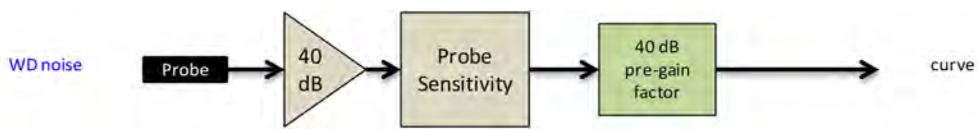

Figure 9-1
Audio Band Magnetic Curve Measurement Block Diagram

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)	4.33	2.40	3.05	3.05	Radial	9400
Undesired (dBA/m)	-37.81	-37.23	-38.09	-38.47		
Frequency Response	Pass	Pass	Pass	Pass		
S+N/N (dB)	42.14	**39.63**	41.14	41.52		

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

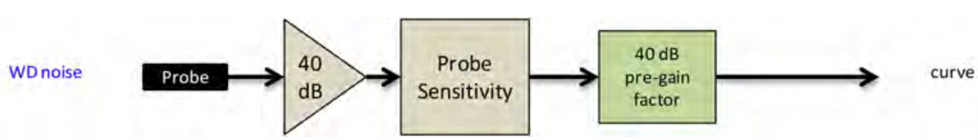

Figure 9-2
Audio Band Magnetic Curve Measurement Block Diagram

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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	Device SN	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	2231M	3.62	-30.28	-61.51	1.99	33.90	0.6, 3.2
		190	2231M	3.59	-29.60		1.89	33.19	
		251	2231M	3.65	-30.13		1.98	33.78	
GSM1900	Radial	512	2231M	3.93	-30.14	-61.51	1.93	34.07	0.6, 3.2
		661	2231M	3.66	-29.71		2.00	33.37	
		810	2231M	3.55	-29.69		1.99	33.24	

Table 10-3
Worst-Case Scan Results for GSM

Mode	Orientation	Channel	Device SN	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Verdict	Frequency Response Coordinates
C63.19-2019 T-Coil Scan										
GSM850	Radial	190	2231M	191	478	24	26	1.89	PASS	0.6, 3.2

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Table 10-4
Raw Data Results for UMTS

Mode	Orientation	Channel	Device SN	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	2231M	2.96	-37.15	-64.51	2.00	40.11	0.6, 3.2
		4183	2231M	2.66	-37.70		1.96	40.36	
		4233	2231M	2.71	-37.42		2.00	40.13	
UMTS IV	Radial	1312	2231M	2.84	-37.10	-64.51	2.00	39.94	0.6, 3.2
		1412	2231M	2.64	-38.06		2.00	40.70	
		1513	2231M	2.83	-37.25		2.00	40.08	
UMTS II	Radial	9262	2231M	2.80	-37.94	-64.51	2.00	40.74	0.6, 3.2
		9400	2231M	2.83	-37.44		2.00	40.27	
		9538	2231M	2.58	-37.76		2.00	40.34	

Table 10-5
Worst-Case Scan Results for UMTS

Mode	Orientation	Channel	Device SN	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Verdict	Frequency Response Coordinates
C63.19-2019 T-Coil Scan										
UMTS IV	Radial	1312	2231M	376	676	26	26	2.00	PASS	0.6, 3.2

Table 10-6
Raw Data Results for LTE B71

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	2.81	-35.71	-64.51	2.00	38.52	0.6, 3.2

Table 10-7
Raw Data Results for LTE B12

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	2.41	-38.56	-64.51	2.00	40.97	0.6, 3.2

Table 10-8
Raw Data Results for LTE B13

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	2.45	-37.70	-64.51	2.00	40.15	0.6, 3.2

Table 10-9
Raw Data Results for LTE B14

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	2.91	-34.58	-64.51	2.00	37.49	0.6, 3.2

Table 10-10
Raw Data Results for LTE B26

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	2.67	-38.75	-64.51	2.00	41.42	0.6, 3.2

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Table 10-11
Raw Data Results for LTE B66

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	B	2.48	-36.53	-64.51	2.00	39.01	0.6, 3.2
		20MHz	132322	2231M	F	2.77	-37.72		2.00	40.49	

Table 10-12
Raw Data Results for LTE B25

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	B	2.63	-36.47	-64.51	2.00	39.10	0.6, 3.2
		20MHz	26365	2231M	F	2.58	-37.40		2.00	39.98	

Table 10-13
Raw Data Results for LTE B30

Mode	Orientation	Bandwidth	Channel	Device SN	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 30	Radial	10MHz	27710	2231M	B	2.48	-30.75	-64.51	2.00	33.23	0.6, 3.2
		5MHz	27710	2231M	F	2.56	-39.00		2.00	41.56	

Table 10-14
Raw Data Results for LTE B7

Mode	Orientation	Bandwidth	Channel	Device SN	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 7	Radial	20MHz	21100	2231M	B	2.22	-36.31	-64.51	2.00	38.53	0.6, 3.2
		20MHz	21100	2231M	F	2.25	-39.10		2.00	41.35	

Table 10-15
Raw Data Results for LTE B41 Power Class 2

Mode	Orientation	Bandwidth	Channel	Device SN	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 41 (PC2)	Radial	20MHz	40620	2231M	B	2.45	-34.88	-64.51	1.81	37.33	0.6, 3.2
		20MHz	41490	2231M	F	2.30	-29.54		2.00	31.84	
		20MHz	41055	2231M	F	2.49	-28.03		1.94	30.52	
		20MHz	40620	2231M	F	2.48	-28.59		2.00	31.07	
		20MHz	40185	2231M	F	2.39	-30.83		2.00	33.22	
		20MHz	39750	2231M	F	2.38	-30.60		2.00	32.98	
		15MHz	40620	2231M	F	2.48	-28.89		2.00	31.37	
		10MHz	40620	2231M	F	2.55	-28.85		2.00	31.40	
		5MHz	40620	2231M	F	2.49	-29.16		2.00	31.65	

Table 10-16
Raw Data Results for LTE B48

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	2.31	-37.05	-64.51	2.00	39.36	0.6, 3.2

Table 10-17
Worst-Case Scan Results for VoLTE

Mode	Orientation	Bandwidth	Channel	Device SN	Ant Config.	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Verdict	Frequency Response Coordinates
C63.19-2019 T-Coil Scan												
LTE Band 41 (PC2)	Radial	20MHz	41055	2231M	F	109	379	22	26	1.94	PASS	0.6, 3.2

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Table 10-18
Raw Data Results for NR n71

Mode	Orientation	Bandwidth	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
NR n71	Radial	20MHz	136100	2231M	1.67	-35.64	-64.51	1.35	37.31	0.6, 3.2

Table 10-19
Raw Data Results for NR n5

Mode	Orientation	Bandwidth	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
NR n5	Radial	20MHz	167300	2231M	1.80	-36.53	-64.51	1.45	38.33	0.6, 3.2

Table 10-20
Raw Data Results for NR n70

Mode	Orientation	Bandwidth	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
NR n70	Radial	15MHz	340500	2231M	1.56	-38.51	-64.51	1.55	40.07	0.6, 3.2

Table 10-21
Raw Data Results for NR n66

Mode	Orientation	Bandwidth	Channel	Device SN	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
NR n66	Radial	40MHz	349000	2231M	B	1.40	-34.63	-64.51	1.33	36.03	0.6, 3.2
		40MHz	349000	2231M	F	1.67	-34.53		1.30	36.20	

Table 10-22
Raw Data Results for NR n25

Mode	Orientation	Bandwidth	Channel	Device SN	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
NR n25	Radial	40MHz	376500	2231M	B	1.33	-37.70	-64.51	1.43	39.03	0.6, 3.2
		40MHz	376500	2231M	F	1.41	-33.84		1.30	35.25	

Table 10-23
Raw Data Results for NR n30

Mode	Orientation	Bandwidth	Channel	Device SN	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
NR n30	Radial	10MHz	462000	2231M	B	1.62	-38.17	-64.51	1.48	39.79	0.6, 3.2
		10MHz	462000	2231M	F	1.28	-36.76		1.74	38.04	

Table 10-24
Raw Data Results for NR n41 (PC2)

Mode	Orientation	Bandwidth	Channel	Device SN	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
NR n41 (PC2)	Radial	100MHz	518598	2231M	B	1.95	-33.39	-64.51	1.56	35.34	0.6, 3.2
		100MHz	528000	2231M	F	1.87	-29.91		1.24	31.78	
		100MHz	523302	2231M	F	1.87	-28.66		1.22	30.53	
		100MHz	518598	2231M	F	1.83	-28.19		1.18	30.02	
		100MHz	513900	2231M	F	1.50	-29.20		1.27	30.70	
		100MHz	509202	2231M	F	1.81	-29.13		1.29	30.94	
		90MHz	518598	2231M	F	1.88	-28.42		1.21	30.30	
		80MHz	518598	2231M	F	1.61	-28.56		1.26	30.17	
		70MHz	518598	2231M	F	1.82	-29.18		1.24	31.00	
		60MHz	518598	2231M	F	1.65	-29.22		1.28	30.87	
		50MHz	518598	2231M	F	1.92	-29.17		1.29	31.09	
		40MHz	518598	2231M	F	1.85	-28.99		1.25	30.84	
		30MHz	518598	2231M	F	1.92	-29.47		1.23	31.39	
		20MHz	518598	2231M	F	1.80	-29.53		1.25	31.33	

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Table 10-25
Raw Data Results for NR n77 (DoD, PC2)

Mode	Orientation	Bandwidth	Channel	Device SN	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	2231M	1.47	-30.52	-64.51	1.30	31.99	0.6, 3.2

Table 10-26
Raw Data Results for NR n48

Mode	Orientation	Bandwidth	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
NR n48	Radial	40MHz	641666	2231M	1.73	-33.47	-64.51	1.66	35.20	0.6, 3.2

Table 10-27
Raw Data Results for NR n77 (PC2)

Mode	Orientation	Bandwidth	Channel	Device SN	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 (PC2)	Radial	100MHz	656000	2231M	2.15	-29.42	-64.51	1.37	31.57	0.6, 3.2

Table 10-28
Worst-Case Scan Results for VoNR

Mode	Orientation	Bandwidth	Channel	Device SN	ANT Config.	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	2231M	F	136	382	21	26	1.18	PASS	0.6, 3.2

Table 10-29
Raw Data Results for 2.4GHz WIFI

Mode	Orientation	Channel	Device SN	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	1	2231M	2.85	-30.09	-64.51	2.00	32.94	0.6, 3.2
		6	2231M	2.78	-30.25		2.00	33.03	
		11	2231M	2.47	-31.70		2.00	34.17	
IEEE 802.11g	Radial	6	2231M	2.56	-34.08	-64.51	2.00	36.64	0.6, 3.2
IEEE 802.11n	Radial	6	2231M	2.70	-31.71	-64.51	2.00	34.41	0.6, 3.2
IEEE 802.11ax SU	Radial	6	2231M	2.85	-32.48	-64.51	2.00	35.33	0.6, 3.2
IEEE 802.11ax RU	Radial	6	2231M	2.67	-31.50	-64.51	2.00	34.17	0.6, 3.2

Table 10-30
Raw Data Results for 5GHz WIFI IEEE 802.11a

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	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	2231M	2.93	-32.49	-64.51	2.00	35.42	0.6, 3.2

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

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	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	2231M	2.88	-30.31	-64.51	1.82	33.19	0.6, 3.2
		20MHz	1	40	2231M	2.64	-30.71		2.00	33.35	

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

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	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	2231M	3.05	-31.03	-64.51	2.00	34.08	0.6, 3.2
		20MHz	1	40	2231M	2.60	-30.91		2.00	33.51	

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

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
IEEE 802.11ax SU	Radial	40MHz	1	38	2231M	2.64	-31.93	-64.51	2.00	34.57	0.6, 3.2
		20MHz	1	40	2231M	2.63	-30.42		2.00	33.05	
		40MHz	2A	54	2231M	2.62	-31.67		2.00	34.29	
		20MHz	2A	56	2231M	2.63	-32.34		2.00	34.97	
		40MHz	2C	118	2231M	3.00	-31.14		2.00	34.14	
		20MHz	2C	120	2231M	2.77	-30.75		2.00	33.52	
		40MHz	3	151	2231M	3.08	-31.41		2.00	34.49	
		20MHz	3	149	2231M	2.66	-30.12		2.00	32.78	
		20MHz	3	157	2231M	2.60	-29.01		2.00	31.61	
		20MHz	3	165	2231M	2.85	-29.80		2.00	32.65	
IEEE 802.11ax RU	Radial	40MHz	1	38	2231M	2.50	-31.07	-64.51	1.81	33.57	0.6, 3.2
		20MHz	1	40	2231M	2.82	-31.68		1.99	34.50	

Table 10-34
Worst-Case Scan Results for VoWIFI

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Verdict	Frequency Response Coordinates
C63.19-2019 T-Coil Scan												
IEEE 802.11ax SU	Radial	20MHz	3	157	2231M	131	381	26	26	2.00	PASS	0.6, 3.2

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

Mode	Orientation	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
EDGE850	Radial	190	2280M	7.38	-34.13	-64.51	1.29	41.51	0.6, 3.2
EDGE1900	Radial	661	2280M	7.39	-34.30	-64.51	1.27	41.69	0.6, 3.2

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

Mode	Orientation	Channel	Device SN	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	2280M	7.51	-40.46	-64.51	1.35	47.97	0.6, 3.2
HSPA IV	Radial	1412	2280M	7.14	-41.99	-64.51	1.25	49.13	0.6, 3.2
HSPA II	Radial	9400	2280M	7.25	-41.01	-64.51	1.41	48.26	0.6, 3.2

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Table 10-37
Raw Data Results for LTE TDD B41 (PC2) (OTT VoIP)

Mode	Orientation	Bandwidth	Channel	Device SN	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 41 (PC2)	Radial	20MHz	41490	2280M	F	7.44	-30.96	-64.51	1.08	38.40	0.6, 3.2
		20MHz	41055	2280M	F	7.60	-28.47		1.05	36.07	
		20MHz	40620	2280M	F	7.47	-30.05		1.08	37.52	
		20MHz	40185	2280M	F	7.50	-32.20		1.10	39.70	
		20MHz	39750	2280M	F	7.08	-32.09		1.01	39.17	
		15MHz	40620	2280M	F	7.54	-30.42		1.20	37.96	
		10MHz	40620	2280M	F	7.48	-30.51		1.10	37.99	
		5MHz	40620	2280M	F	7.37	-30.83		1.00	38.20	

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

Mode	Orientation	Bandwidth	Channel	Device SN	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
NR n41 (PC2)	Radial	100MHz	528000	2280M	F	7.41	-30.41	-64.51	1.41	37.82	0.6, 3.2
		100MHz	523302	2280M	F	7.30	-30.26		1.21	37.56	
		100MHz	518598	2280M	F	7.68	-29.86		1.10	37.54	
		100MHz	513900	2280M	F	7.45	-31.06		1.35	38.51	
		100MHz	509202	2280M	F	7.23	-31.17		1.56	38.40	
		90MHz	518598	2280M	F	7.57	-30.01		1.58	37.58	
		80MHz	518598	2280M	F	7.45	-30.21		1.25	37.66	
		70MHz	518598	2280M	F	7.54	-30.41		1.02	37.95	
		60MHz	518598	2280M	F	7.39	-30.73		1.02	38.12	
		50MHz	518598	2280M	F	7.41	-30.80		1.00	38.21	
		40MHz	518598	2280M	F	7.29	-30.99		1.02	38.28	
		30MHz	518598	2280M	F	7.46	-31.17		1.35	38.63	
		20MHz	518598	2280M	F	7.45	-30.87		1.39	38.32	

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

Mode	Orientation	Channel	Device SN	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	1	2280M	7.54	-28.77	-64.51	1.15	36.31	0.6, 3.2
		6	2280M	7.67	-28.87		1.08	36.54	
		11	2280M	7.04	-30.72		1.13	37.76	
IEEE 802.11g	Radial	6	2280M	7.24	-35.20	-64.51	1.35	42.44	0.6, 3.2
IEEE 802.11n	Radial	6	2280M	7.42	-30.24	-64.51	1.15	37.66	0.6, 3.2
IEEE 802.11ax SU	Radial	6	2280M	7.69	-31.39	-64.51	1.41	39.08	0.6, 3.2
IEEE 802.11ax RU	Radial	6	2280M	7.38	-31.93	-64.51	1.26	39.31	0.6, 3.2

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

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	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	2280M	7.05	-33.56	-64.51	1.13	40.61	0.6, 3.2

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

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	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	2280M	7.16	-31.78	-64.51	1.50	38.94	0.6, 3.2
		20MHz	1	40	2280M	7.86	-32.28		1.13	40.14	

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

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	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	2280M	7.40	-29.94	-64.51	1.13	37.34	0.6, 3.2
		20MHz	1	40	2280M	7.45	-29.38		1.35	36.83	

Table 10-43
Raw Data Results for 5GHz WIFI IEEE 802.11ax (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	Device SN	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	Frequency Response Margin (dB)	S+N/N (dB)	Test Coordinates
IEEE 802.11ax SU	Radial	40MHz	1	38	2280M	7.98	-29.27	-64.51	1.13	37.25	0.6, 3.2
		20MHz	1	36	2280M	7.28	-29.62		1.50	36.90	
		20MHz	1	40	2280M	7.60	-28.63		1.45	36.23	
		20MHz	1	48	2280M	7.63	-28.97		1.15	36.60	
		40MHz	2A	54	2280M	7.86	-30.62		1.55	38.48	
		20MHz	2A	56	2280M	7.63	-28.92		1.21	36.55	
		40MHz	2C	118	2280M	7.33	-31.67		1.27	39.00	
		20MHz	2C	120	2280M	7.95	-29.85		1.58	37.80	
		40MHz	3	151	2280M	7.53	-32.08		1.20	39.61	
		20MHz	3	157	2280M	7.60	-30.06		1.30	37.66	
IEEE 802.11ax RU	Radial	40MHz	1	38	2280M	7.65	-29.92	-64.51	1.15	37.57	0.6, 3.2
		20MHz	1	40	2280M	7.11	-30.73		1.39	37.84	

Table 10-44
Worst-Case Scan Results for OTT VoIP

Mode	Orientation	Bandwidth	Channel	Device SN	Ant Config.	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Verdict	Frequency Response Coordinates
C63.19-2019 T-Coil Scan												
LTE Band 41 (PC2)	Radial	20MHz	41055	2280M	F	195	449	25	26	1.05	PASS	0.6, 3.2

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 aids) was set to ON for Frequency Response 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.

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B. GSM

1. Power Configuration: GSM850: PCL=5, 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: QPSK, 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
6. LTE Band 41 (Power Class 2) Ant F at 20MHz is the worst-case LTE configuration.

E. NR

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: DFT-s-OFDM, QPSK, 100% RB, 0RB offset
3. Vocoder Configuration: WB AMR 6.60kbps
4. NR n41 (Power Class 2) Ant F at 100MHz is the worst-case NR configuration.

F. WIFI

1. Radio Configuration
    a. IEEE 802.11b: CCK, 11Mbps
    b. IEEE 802.11g/a: BPSK, 6Mbps
    c. IEEE 802.11n/ac 20MHz: 64QAM, MCS 7
    d. IEEE 802.11ax SU 20MHz: BPSK, MCS 0
    e. IEEE 802.11n 40MHz: 64QAM, MCS 7
    f. IEEE 802.11ac 40MHz: 256QAM, MCS 8
    g. IEEE 802.11ax SU 40MHz: BPSK, MCS 0
2. RU Index
    a. IEEE 802.11ax RU 20MHz: RU Index 0
    b. IEEE 802.11ax RU 40MHz: RU Index 0
3. Vocoder Configuration: EVS Primary NB 24.4kbps
4. The worst-case standard for 2.4GHz WIFI is additionally tested on the low and high channels. IEEE 802.11b is the worst-case 2.4GHz WIFI standard.
5. The worst-case standard for 5GHz WIFI in each probe orientation is additionally tested on higher U-NII bands as well as applicable low and high channels. IEEE 802.11ax SU (U-NII 3) 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

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3. HSPA Configuration:
    a. Release: 6
    b. 3GPP 34.121 Subtest 1
4. LTE Configuration:
    a. Power Configuration: TPC = “Max Power”
    b. Radio Configuration: QPSK 1RB 0RB OFFSET
    c. Power Class 3 Uplink-Downlink configuration: 2
    d. Power Class 2 Uplink-Downlink configuration: 2
    e. LTE Band 41 (Power Class 2) Ant F was the worst-case band from Table 8-6.
    f. The worst-case band and bandwidth combination is additionally investigated on the low, low-mid, high-mid, and high channels for those combinations. LTE Band 41 (Power Class 2) Ant F at 20MHz is the worst-case LTE TDD configuration.
5. NR Configuration
    a. Power Configuration: TxAGC is set such that the DUT operates at max power.
    b. Radio Configuration: DFT-s-OFDM, QPSK, 100%RB, 0RB offset
    c. NR n41 (Power Class 2) Ant F was the worst-case band from Table 8-8.
    d. The worst-case band and bandwidth combination is additionally investigated on the low and high channels for those combinations. NR n41 (Power Class 2) Ant F at 100MHz is the worst-case NR TDD configuration.
6. WIFI Configuration:
    a. Radio Configuration
        i. IEEE 802.11b: CCK, 11Mbps
        ii. IEEE 802.11g/a: BPSK, 6Mbps
        iii. IEEE 802.11n/ac 20MHz: 64QAM, MCS 7
        iv. IEEE 802.11ax SU 20MHz: BPSK, MCS 0
        v. IEEE 802.11n 40MHz: 64QAM, MCS 7
        vi. IEEE 802.11ac 40MHz: 256QAM, MCS 8
        vii. IEEE 802.11ax SU 40MHz: BPSK, MCS 0
    b. RU Index
        i. IEEE 802.11ax RU 20MHz: RU Index 0
        ii. IEEE 802.11ax RU 40MHz: RU Index 0
    c. 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.
    d. The worst-case standard for 5GHz WIFI is additionally investigated on higher U-NII bands as well as applicable low and high channels. IEEE 802.11ax SU (U-NII 1) is the worst-case 5GHz WIFI standard.

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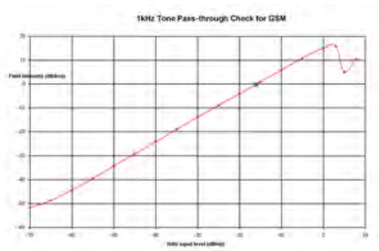
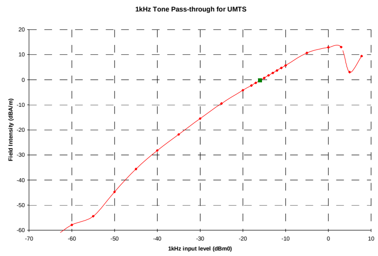
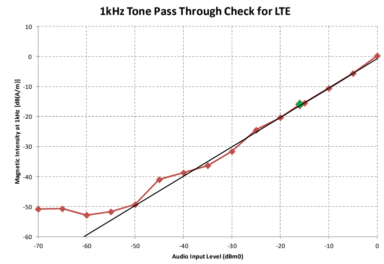
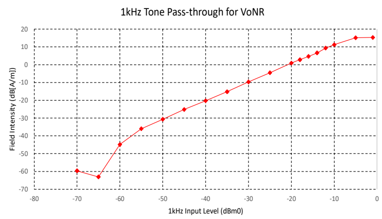
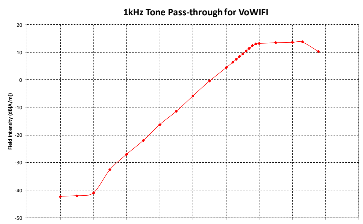
III. 1 kHz Vocoder Application Check

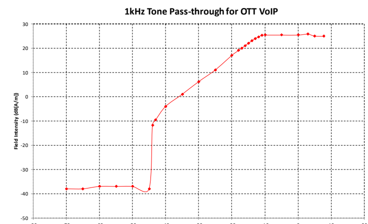












This model was verified to be within the linear region for Desired ABM measurements at -16 dBm0 for GSM, UMTS, VoLTE over IMS, and VoNR over IMS. This model was verified to be within the linear region for Desired ABM measurements at -16 dBm0 for VoWIFI over IMS, and OTT VoIP. This measurement was taken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

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IV. T-Coil Validation Test Results

Table 10-45
Helmholtz Coil Verification Table of Results

Date	Orientation	Item	Target	Result	Verdict
12/14/23	Radial	Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.288	**PASS**
		Environmental Noise	< -48 dBA/m	-61.51	**PASS**
		Frequency Response, from limits	*> 0 dB*	0.70	**PASS**
12/26/23	Radial	Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.369	**PASS**
		Environmental Noise	< -48 dBA/m	-64.51	**PASS**
		Frequency Response, from limits	*> 0 dB*	0.70	**PASS**

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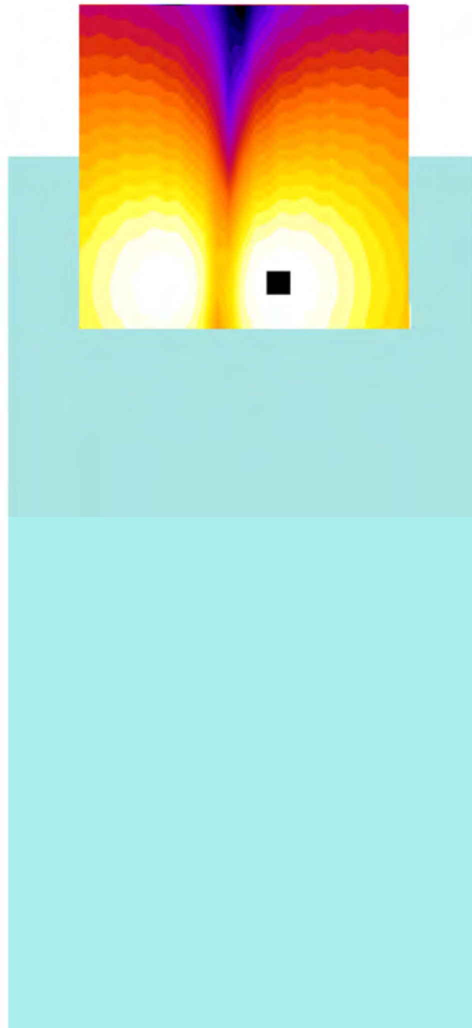
V. ABM1 Magnetic Field Distribution Scan Overlays



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.

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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	5.3%	0.22	Specification	Rectangular	1.73	3.1%	
Combined standard uncertainty, uc (k=1)						17.9%	0.72
Expanded uncertainty (k=2), 95% confidence level						35.8%	1.33

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 measurements results with that of the instrumentation chain using the technique contained in NIS 81 and NIS 3003, the overall measurement uncertainty was estimated.

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12. EQUIPMENT LIST

Table 12-1
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
SPEAG	DAE4	Dasy Data Acquisition Electronics	8/9/2023	Annual	8/9/2024	1680
SPEAG	AM1DV3	Audio Magnetic Field Probe	5/9/2023	Biennial	5/9/2025	3057
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

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13. TEST DATA (SINGLE POINT MEASUREMENT)

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12/14/2023

Element Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

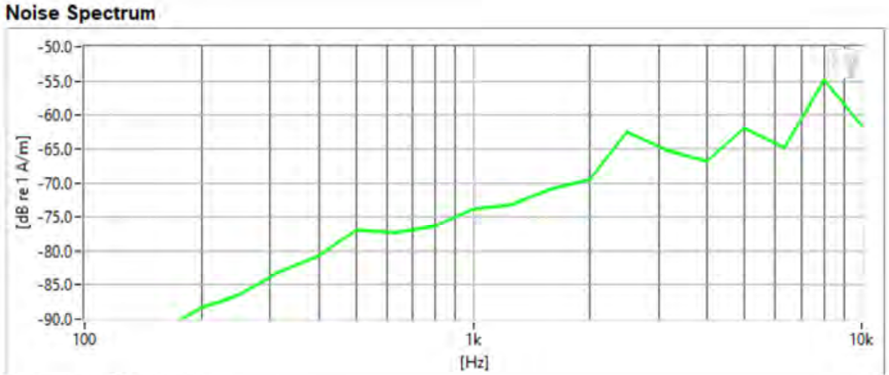
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

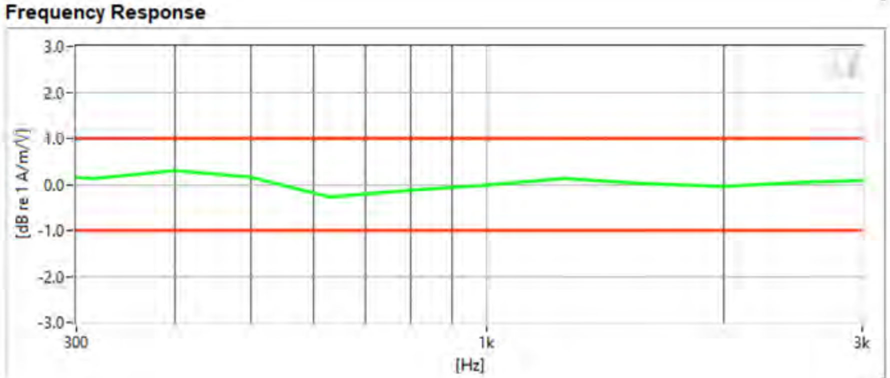
Equipment:

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

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.288	dB	✔	Max/Min	-9.5/-10.5
Verification Environmental Noise	-61.51	dB	✔	Maximum	-58.0
Frequency Response Margin	700m	dB	✔	Tolerance curves	Aligned Data

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Element Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

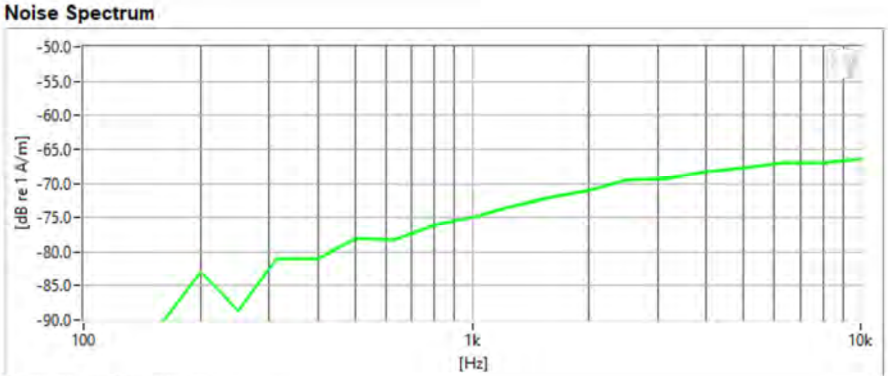
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19-2011

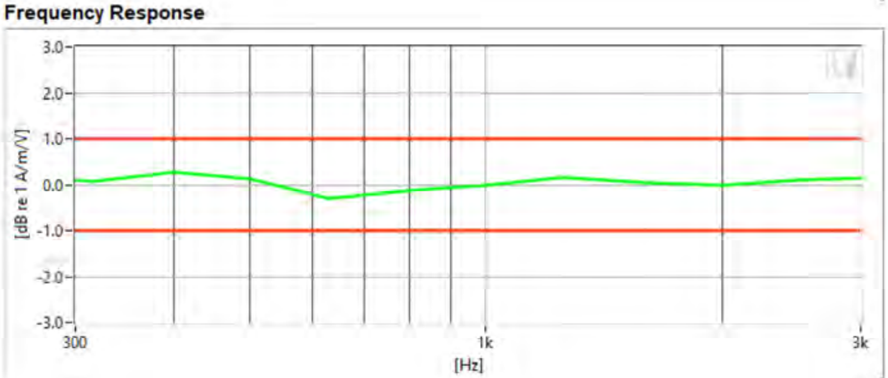
Equipment:

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

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.369 dB	✔	Max/Min	-9.5/-10.5
Verification Environmental Noise	-64.51 dB	✔	Maximum	-58.0
Frequency Response Margin	700m dB	✔	Tolerance curves	Aligned Data

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12/14/2023

Element Hearing-Aid Compatibility Facility

DUT: A3LSMA356U

Type: Portable Handset
Serial: 2231M

Measurement Standard: ANSI C63.19

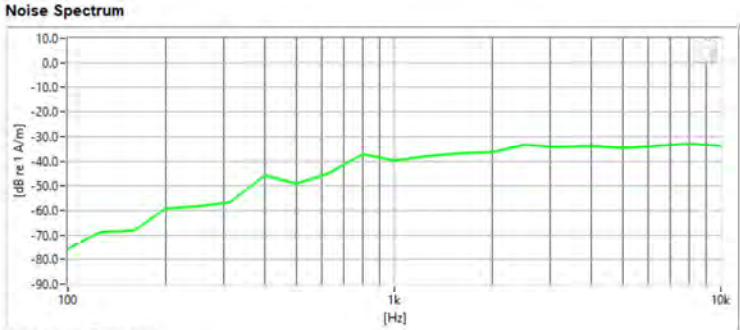
Equipment:

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

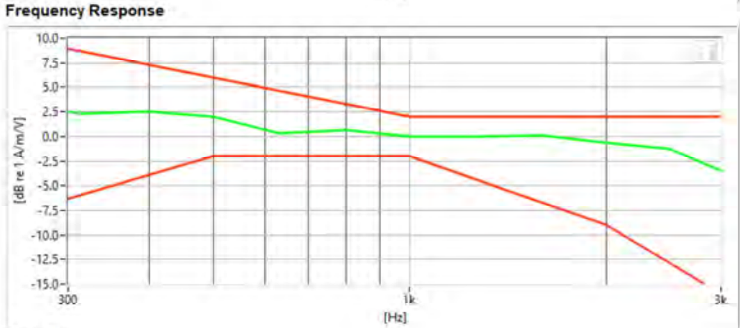
Test Configuration:

- Mode: GSM850
- Channel: 190
- Speech Signal: 3GPP2 Normal Test Signal

Noise Spectrum



Frequency Response



Results

Desired ABM	3.59 dB	✔	Minimum	-18.0
Undesired ABM	-29.6 dB	✔	Maximum	0.0
SNNR	33.19 dB	✔	Minimum	20.0
Aligned Response - Normal	1.89 dB	✔	Tolerance curves	Aligned Data

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Element Hearing-Aid Compatibility Facility

DUT: A3LSMA356U

Type: Portable Handset
Serial: 2231M

Measurement Standard: ANSI C63.19

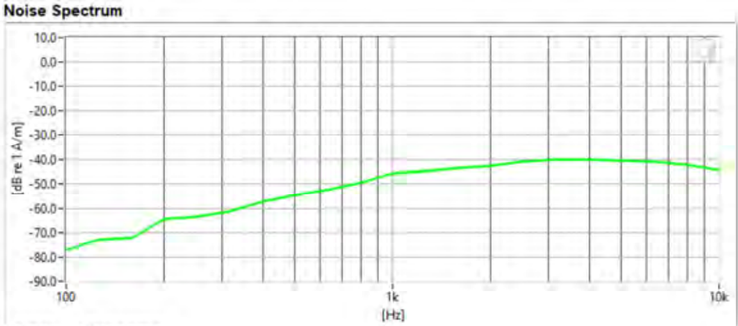
Equipment:

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

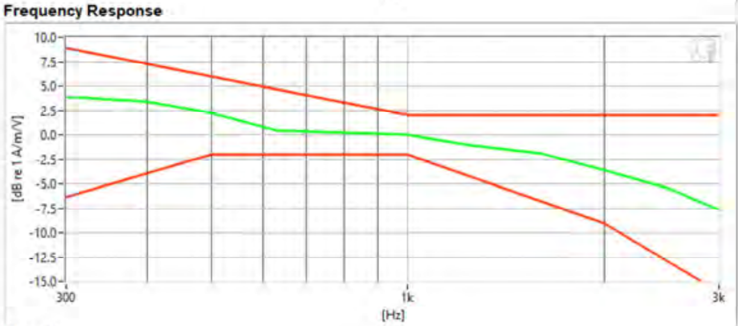
Test Configuration:

- Mode: UMTS IV
- Channel: 1312
- Speech Signal: 3GPP2 Normal Test Signal

Noise Spectrum



Frequency Response



Results

Desired ABM	2.84 dB	✔	Minimum	-18.0
Undesired ABM	-37.1 dB	✔	Maximum	0.0
SNNR	39.94 dB	✔	Minimum	20.0
Aligned Response - Normal	2 dB	✔	Tolerance curves	Aligned Data

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Element Hearing-Aid Compatibility Facility

DUT: A3LSMA356U

Type: Portable Handset
Serial: 2231M

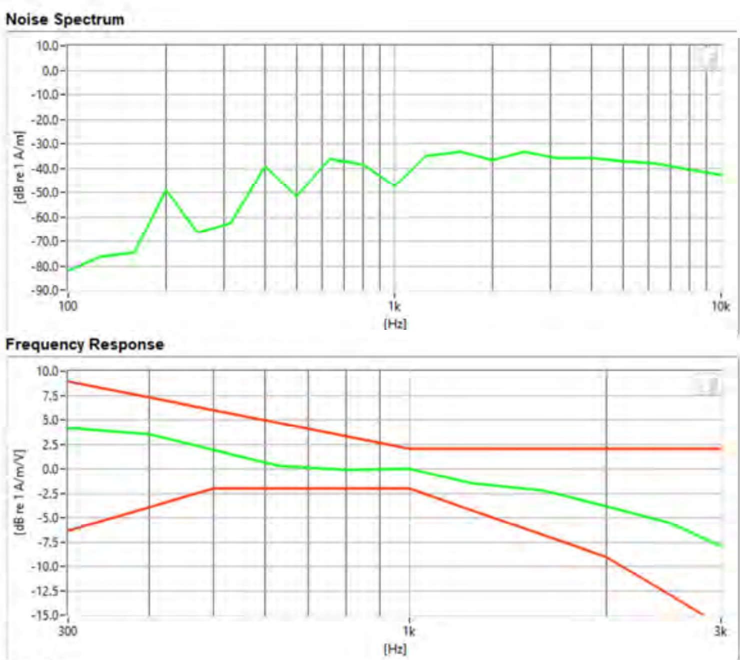
Measurement Standard: ANSI C63.19

Equipment:

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

Test Configuration:

- Mode: LTE TDD Band 41 (PC2)
- Bandwidth: 20MHz
- Channel: 41055
- Antenna Configuration: ANT F
- Speech Signal: 3GPP2 Normal Test Signal



Results

Desired ABM	2.49 dB	✔	Minimum	-18.0
Undesired ABM	-28.03 dB	✔	Maximum	0.0
SNNR	30.52 dB	✔	Minimum	20.0
Aligned Response - Normal	1.94 dB	✔	Tolerance curves	Aligned Data

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Element Hearing-Aid Compatibility Facility

DUT: A3LSMA356U

Type: Portable Handset
Serial: 2231M

Measurement Standard: ANSI C63.19

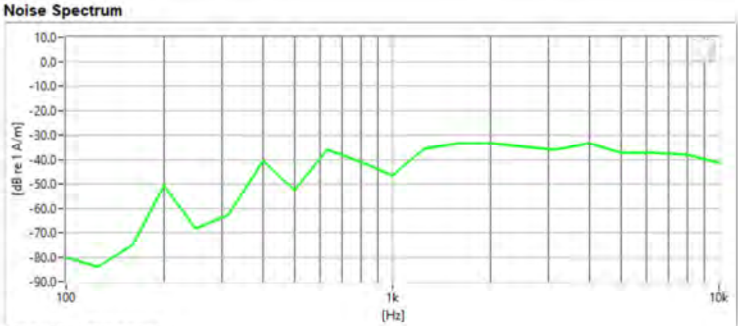
Equipment:

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

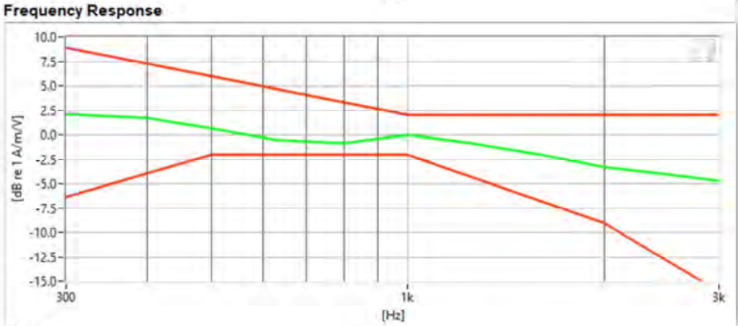
Test Configuration:

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

Noise Spectrum



Frequency Response



Results

Desired ABM	1.83 dB	✔	Minimum	-18.0
Undesired ABM	-28.2 dB	✔	Maximum	0.0
SNNR	30.02 dB	✔	Minimum	20.0
Aligned Response - Normal	1.18 dB	✔	Tolerance curves	Aligned Data

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Element Hearing-Aid Compatibility Facility

DUT: A3LSMA356U

Type: Portable Handset
Serial: 2231M

Measurement Standard: ANSI C63.19

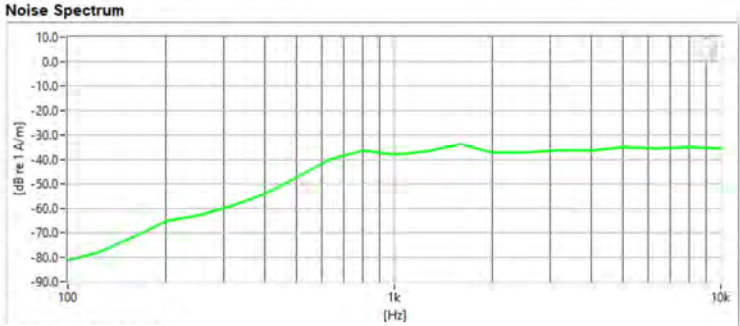
Equipment:

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

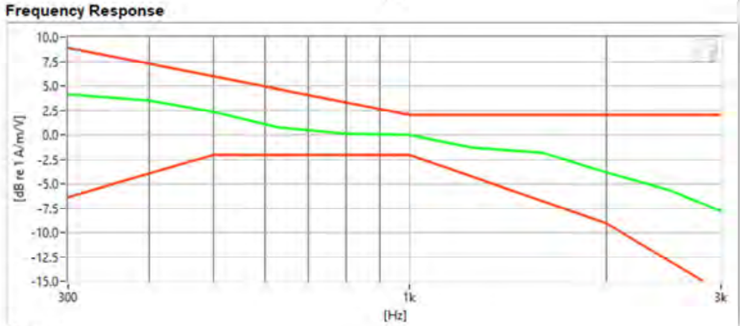
Test Configuration:

- Mode: 5GHz WLAN
- Standard: IEEE 802.11ax (SU)
- Bandwidth: 20MHz
- Channel: 157
- Speech Signal: 3GPP2 Normal Test Signal

Noise Spectrum



Frequency Response



Results

Desired ABM	2.6 dB	✔	Minimum	-18.0
Undesired ABM	-29.01 dB	✔	Maximum	0.0
SNNR	31.61 dB	✔	Minimum	20.0
Aligned Response - Normal	2 dB	✔	Tolerance curves	Aligned Data

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12/28/2023

Element Hearing-Aid Compatibility Facility

DUT: A3LSMA356U

Type: Portable Handset
Serial: 2280M

Measurement Standard: ANSI C63.19

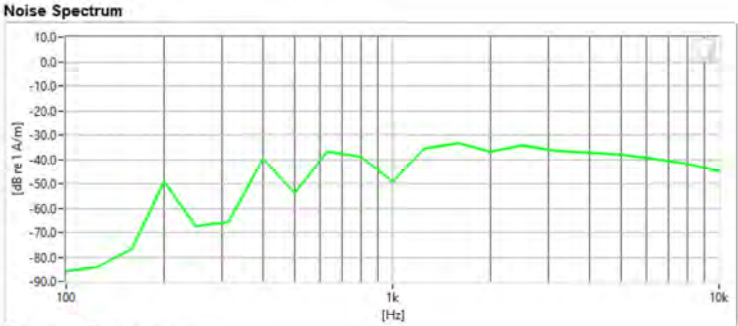
Equipment:

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

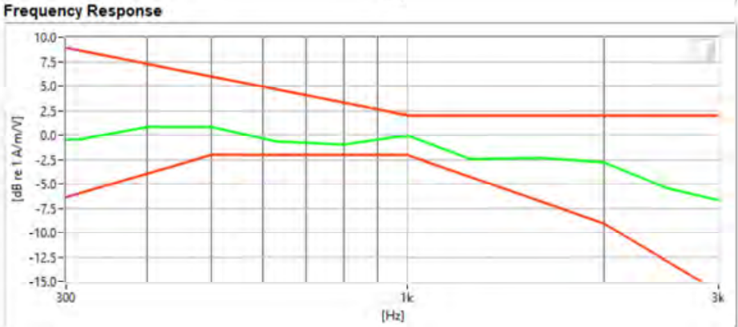
Test Configuration:

- VoIP Application: Google Meet
- Mode: LTE TDD Band 41 (PC2)
- Bandwidth: 20MHz
- Channel: 41055
- Antenna Configuration: ANT F
- Speech Signal: 3GPP2 Normal Test Signal

Noise Spectrum



Frequency Response



Results

Desired ABM	7.6 dB	✔	Minimum	-18.0
Undesired ABM	-28.47 dB	✔	Maximum	0.0
SNNR	36.07 dB	✔	Minimum	20.0
Aligned Response - Normal	1.05 dB	✔	Tolerance curves	Aligned Data

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14. TEST DATA (SCAN MEASUREMENT)

Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
191	478	24	26

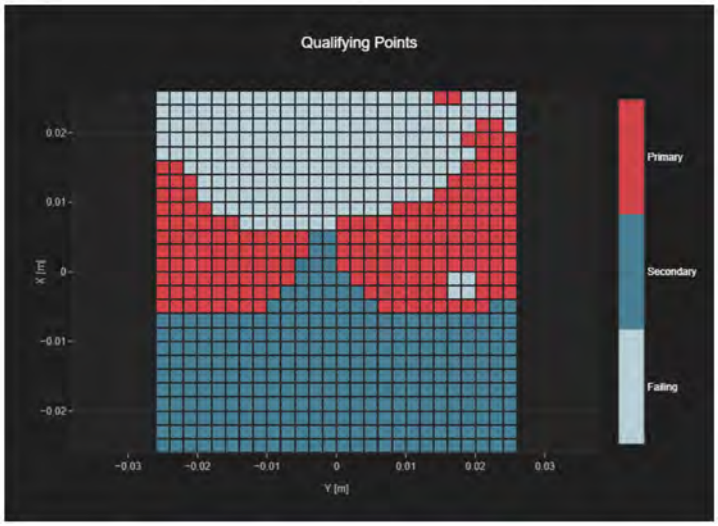

Table 14-1
Worst-Case Scan Results for GSM
GSM 850 CH.128, EFR: FR V1

Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
376	676	28	28

Table 14-2
Worst-Case Scan Results for UMTS
UMTS Band 4 CH.1312, WB AMR 6.60KBPS

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Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
109	379	22	26

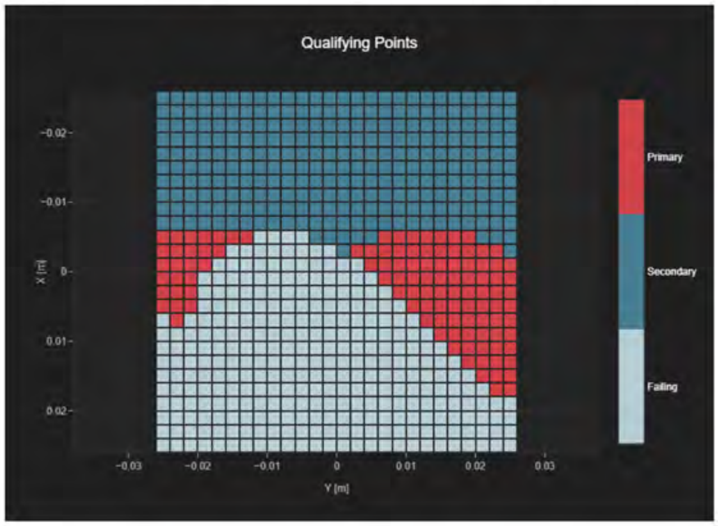

Table 14-3
Worst-Case Scan Results for LTE
LTE TDD Band 41 (Power Class 2) Ant F, 20MHz CH.41055, WB AMR 6.60KBPS

Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
136	392	21	26

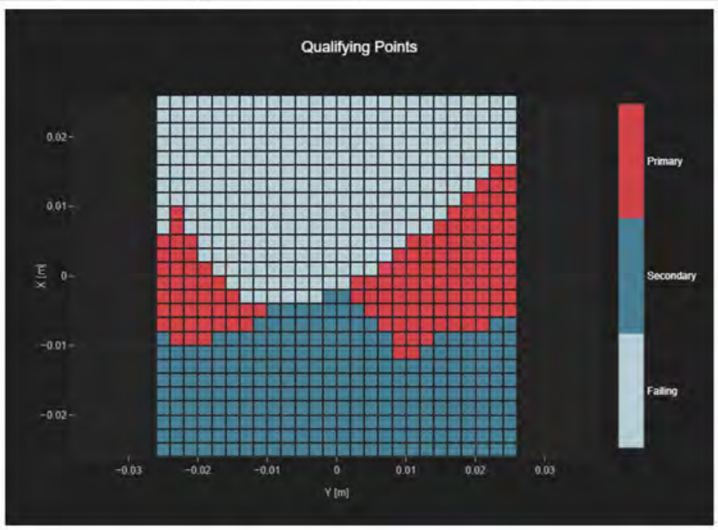

Table 14-4
Worst-Case Scan Results for NR
NR TDD n41 (Power Class 2) Ant F, 100MHz CH.518598, WB AMR 6.60KBPS

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Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
131	351	26	26

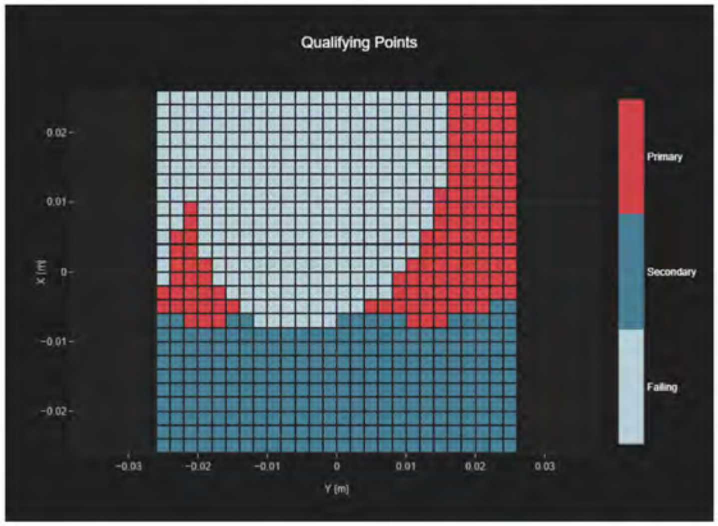

Table 14-5
Worst-Case Scan Results for WIFI
5GHz WIFI IEEE 802.11ax SU 20MHz U-NII 3 CH.157, WB AMR 6.60KBPS

Results

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
195	449	25	26

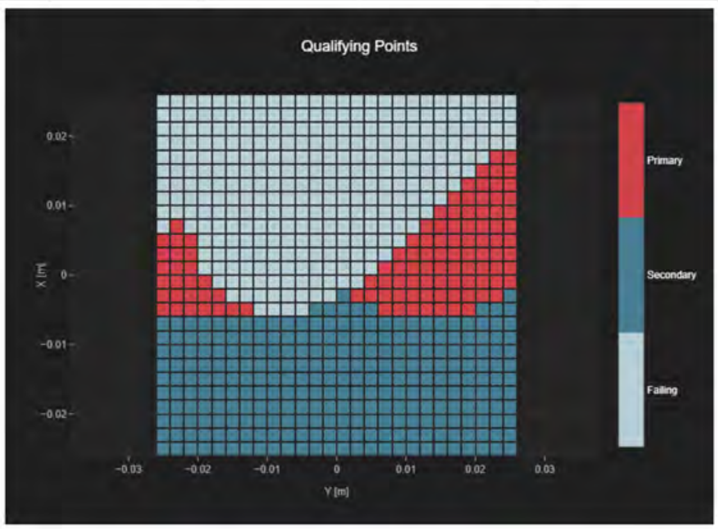

Table 14-6
Worst-Case Scan Results for LTE (OTT VoIP)
LTE TDD Band 41 (Power Class 2) Ant F, 20MHz CH.55990, OPUS 6KBPS

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15. CALIBRATION CERTIFICATES

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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

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

Calibration Lab. Cert. # 1533.01

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

ISO/IEC 17025
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

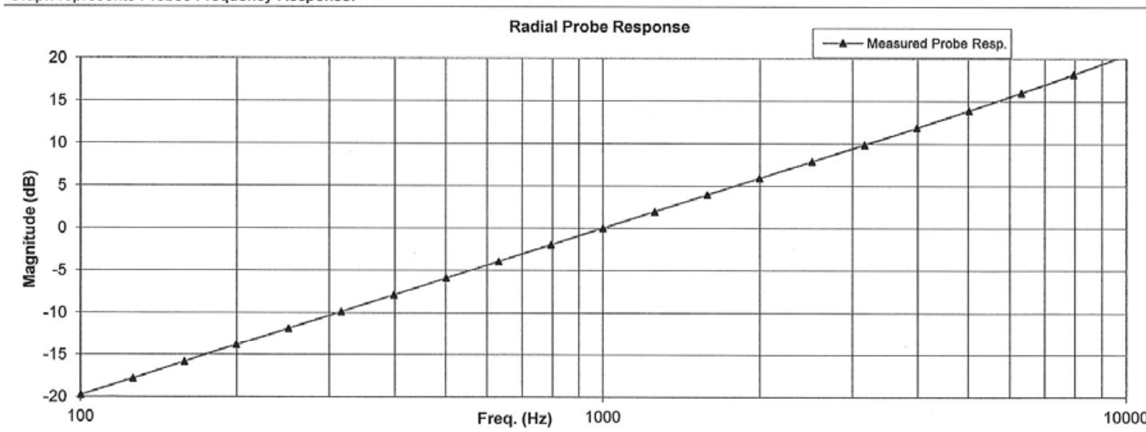
Calibration results:

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

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

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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			
			6	6.03		
		Ref. (0 dB)	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   Tested by: James Zhu

Calibrated on WCCL system type 9700

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

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Calibration Laboratory of
Schmid & Partner
Engineering AG
Zeughausstrasse 43, 8004 Zurich, Switzerland

S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: SCS 0108

Client **Element**
Columbia, USA

Certificate No. AM1DV3-3057_May23

CALIBRATION CERTIFICATE

Object	AM1DV3 - SN: 3057
Calibration procedure(s)	QA CAL-24.v4 Calibration procedure for AM1D magnetic field probes and TMFS in the audio range
Calibration date:	May 09, 2023

TK 10/9/23 ✓

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Keithley Multimeter Type 2001	SN: 0810278	29-Aug-22 (No. 34389)	Aug-23
Reference Probe AM1DV2	SN: 1008	20-Dec-22 (No. AM1DV2-1008_Dec22)	Dec-23
DAE4	SN: 781	03-Jan-23 (No. DAE4-781_Jan23)	Jan-24

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	SN: 1050	01-Oct-13 (in house check Oct-20)	Oct-23
AMMI Audio Measuring Instrument	SN: 1062	26-Sep-12 (in house check Oct-20)	Oct-23

	Name	Function	Signature
Calibrated by:	Aidonia Georgiadou	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: May 10, 2023

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References

[1] ANSI-C63.19-2007
American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[2] ANSI-C63.19-2019 (ANSI-C63.19-2011)
American National Standard, Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids.

[3] DASY System Handbook

Description of the AM1D probe

The AM1D Audio Magnetic Field Probe is a fully shielded magnetic field probe for the frequency range from 100 Hz to 20 kHz. The pickup coil is compliant with the dimensional requirements of [1+2]. The probe includes a symmetric low noise amplifier for the signal available at the shielded 3 pin connector at the side. Power is supplied via the same connector (phantom power supply) and monitored via the LED near the connector. The 7 pin connector at the end of the probe does not carry any signals, but determines the angle of the sensor when mounted on the DAE. The probe supports mechanical detection of the surface.
The single sensor in the probe is arranged in a tilt angle allowing measurement of 3 orthogonal field components when rotating the probe by 120° around its axis. It is aligned with the perpendicular component of the field, if the probe axis is tilted nominally 35.3° above the measurement plane, using the connector rotation and sensor angle stated below.
The probe is fully RF shielded when operated with the matching signal cable (shielded) and allows measurement of audio magnetic fields in the close vicinity of RF emitting wireless devices according to [1+2] without additional shielding.

Handling of the item

The probe is manufactured from stainless steel. In order to maintain the performance and calibration of the probe, it must not be opened. The probe is designed for operation in air and shall not be exposed to humidity or liquids. For proper operation of the surface detection and emergency stop functions in a DASY system, the probe must be operated with the special probe cup provided (larger diameter).

Methods Applied and Interpretation of Parameters

- *Coordinate System:* The AM1D probe is mounted in the DASY system for operation with a HAC Test Arch phantom with AMCC Helmholtz calibration coil according to [3], with the tip pointing to "southwest" orientation.
- *Functional Test:* The functional test preceding calibration includes test of Noise level
RF immunity (1kHz AM modulated signal). The shield of the probe cable must be well connected.
Frequency response verification from 100 Hz to 10 kHz.
- *Connector Rotation:* The connector at the end of the probe does not carry any signals and is used for fixation to the DAE only. The probe is operated in the center of the AMCC Helmholtz coil using a 1 kHz magnetic field signal. Its angle is determined from the two minima at nominally +120° and –120° rotation, so the sensor in the tip of the probe is aligned to the vertical plane in z-direction, corresponding to the field maximum in the AMCC Helmholtz calibration coil.
- *Sensor Angle:* The sensor tilting in the vertical plane from the ideal vertical direction is determined from the two minima at nominally +120° and –120°. DASY system uses this angle to align the sensor for radial measurements to the x and y axis in the horizontal plane.
- *Sensitivity:* With the probe sensor aligned to the z-field in the AMCC, the output of the probe is compared to the magnetic field in the AMCC at 1 kHz. The field in the AMCC Helmholtz coil is given by the geometry and the current through the coil, which is monitored on the precision shunt resistor of the coil.

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AM1D probe identification and configuration data

Item	**AM1DV3** Audio Magnetic 1D Field Probe
Type No	SP AM1 001 BA
Serial No	**3057**

Overall length	296 mm
Tip diameter	6.0 mm (at the tip)
Sensor offset	3.0 mm (centre of sensor from tip)
Internal Amplifier	20 dB

Manufacturer / Origin	Schmid & Partner Engineering AG, Zurich, Switzerland

Calibration data

Connector rotation angle	(in DASY system)	**38.2 °**	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**0.48 °**	+/- 0.5 ° (k=2)
Sensitivity at 1 kHz	(in DASY system)	**0.00740 V/(A/m)**	+/- 2.2 % (k=2)

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

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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.

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17. REFERENCES

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

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