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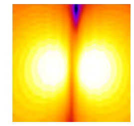

HEARING AID COMPATIBILITY

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

Date of Testing:
02/3/2025 - 02/13/2025
Test Site/Location:
Element Washington DC LLC,
Columbia, MD, USA
Test Report Serial No.:
1M2501020001-29.A3L
Date of Issue:
03/06/2025

FCC ID:	**A3LSMG766U**
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-G766U
Additional Model(s):	SM-G766U1
Test Device Serial No.:	*Pre-Production Sample* [S/N: 4470M]

HAC Compliance:	**PASS**

This wireless portable device has been shown to be hearing-aid compatible as specified in ANSI/IEEE Std. C63.19-2019 and has been tested in accordance with the specified measurement procedures. Test results reported herein relate only to the item(s) tested. Hearing-Aid Compatibility is based on the assumption that all production units will be designed electrically identical to the device tested in this report. North American Bands only.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

RJ Ortanez
Executive Vice President

ilac-MRA
A2LA ACCREDITED
CERT #2041.01

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1. INTRODUCTION

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

Ambient Conditions

- Ambient temperature: 23 °C ± 5 °C
- Relative humidity (RH): 0% < RH < 80%
- Baseband magnetic ambient noise: >10 dB below the measurement level, where applicable

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
- 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

2. DUT DESCRIPTION

FCC ID:	A3LSMG766U
Applicant:	Samsung Electronics Co., Ltd. 129, Samsung-ro, Maetan dong, Yeongtong-gu, Suwon-si Gyeonggi-do 16677, Korea
Model:	SM-G766U
Additional Model(s):	SM-G766U1
Serial Number:	4470M
HW Version:	REV1.0
SW Version:	G766U.001
Antenna:	Internal Antenna
DUT Type:	Portable Handset

I. Band Selection

This device supports LTE/NR capabilities with overlapping transmission frequency ranges. When the supported frequency range of a band falls completely within a band with a larger transmission frequency range, both bands have the same target power (or the band with the larger transmission frequency range has a higher target power), and both 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.

Table 2-1
A3LSMG766U 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)					
	700 (B17)					
	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
	700 (n12)					
	850 (n5)					
	1700 (n70)					
	1700 (n66)					
	1900 (n2)					
	1900 (n25)					
	2300 (n30)					
	2500 (n7)					
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 (n78)					
	3600 (n48)					
	3700 (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)					
	5900 (U-NII 4)					
	6175 (U-NII 5)		Yes[2]			
	6475 (U-NII 6)		No[3]			
	6700 (U-NII 7)					
	7000 (U-NII 8)					
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
2. WIFI U-NII band 5 was evaluated for operations which are entirely below 6 GHz. Operations partially or entierly above 6 GHz were not evaluated due to equipment limitations and being outside the scope of ANSI C63.19 and FCC HAC regulations.
3. WIFI U-NII bands 6 through 8 were not evaluated due to equipment limitations and being outside the scope of ANSI C63.19 and FCC HAC regulations.

3. ANSI C63.19-2019 COMPLIANCE REQUIREMENTS

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

I. MAGNETIC COUPLING

Qualifying Field Strengths

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

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

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

Desired ABM Signal, undesired ABM field Qualification Requirements

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

Non-2G GSM Operating Modes

Both the primary and secondary group requirements shall be met:

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

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

2G GSM Operating Modes Requirements

Both the primary and secondary group requirements shall be met:

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

Frequency Response

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

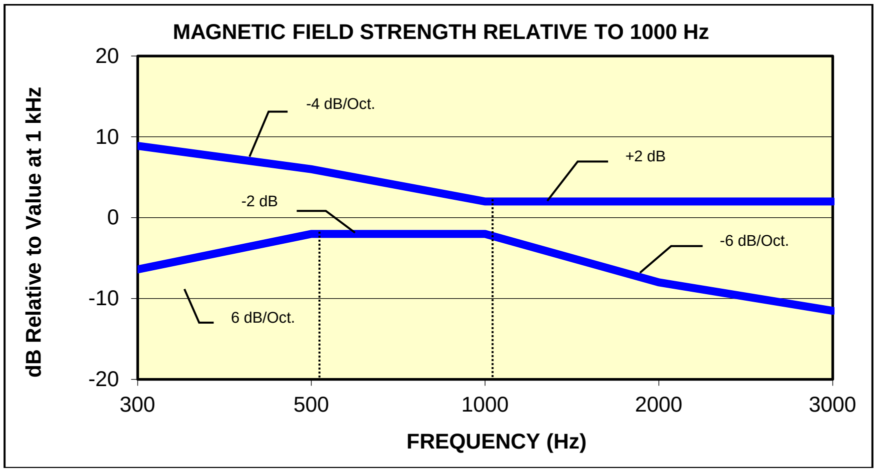


Figure 3-1
Magnetic field frequency response for Wireless Devices with a maximum field strength ≤-15 dB(A/m) at 1 kHz

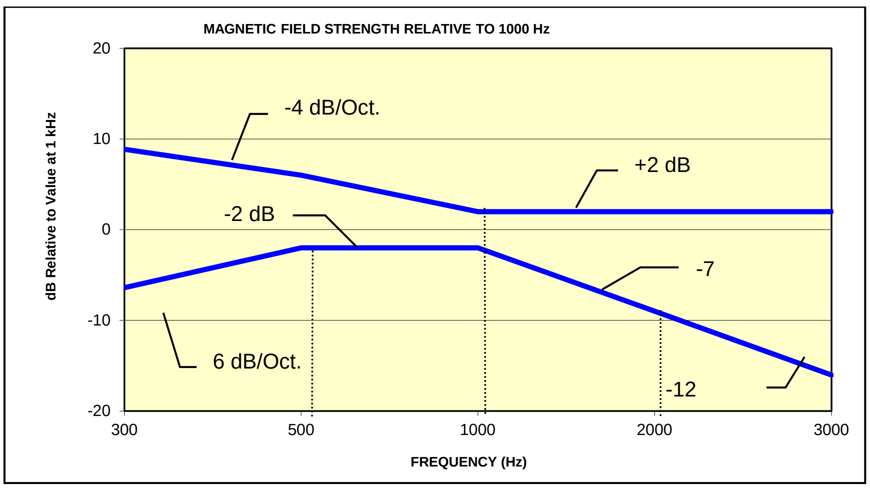


Figure 3-2
Magnetic Field frequency response for wireless devices with a maximum field strength that exceeds-15 dB(A/m) at 1 kHz

4. METHOD OF MEASUREMENT

I. Test Setup

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

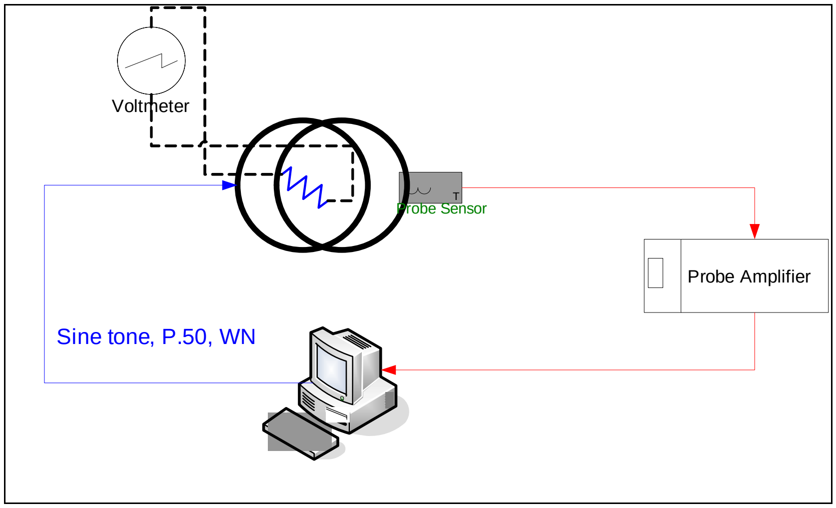


Figure 4-1
Validation Setup with Helmholtz Coil

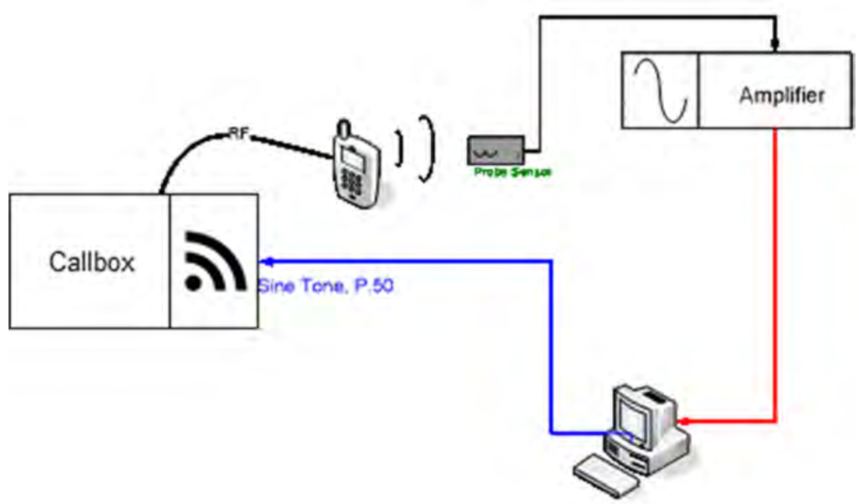


Figure 4-2
T-Coil Test Setup

II. ITU-T P.50 Artificial Voice

Manufacturer:	ITU-T
Active Frequency Range:	100 Hz – 8 kHz
Stimulus Type:	Male and Female, no spaces
Single Sample Duration:	20.96 seconds
Activity Level:	100%

Figure 4-3
Spectral Characteristic of full P.50

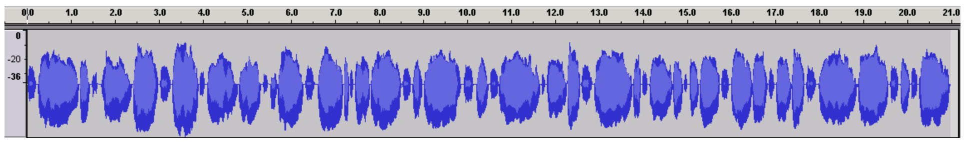


Figure 4-4
Temporal Characteristic of full P.50

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 52).

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

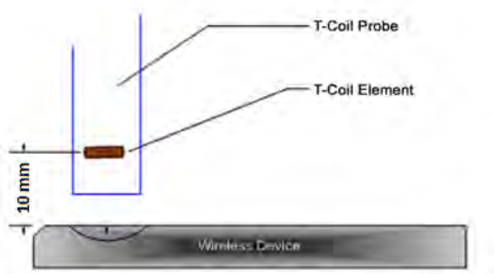


Figure 4-5
Measurement Distance

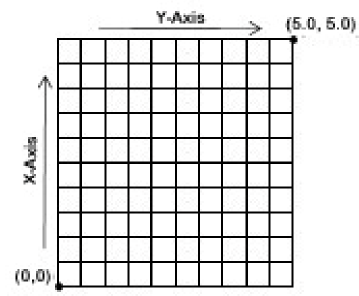


Figure 4-6
Measurement Grid

      ii. After scanning, the planar field maximum point was determined. The position of the probe was moved to this location to setup the test using the SoundCheck system.
   b. Speech Signal Setup to Base Station Simulator
      i. C63.19 Table 6-1 states audio reference input levels for various technologies:

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

      i. See Section 5 and 7 for more information regarding CMW500 audio level settings for Voice Over LTE (VoLTE) and Voice Over WIFI (VoWIFI) testing.
      ii. See Section 6 for more information regarding CMW500 and CMX500 audio level settings for Voice Over NR (VoNR) testing.
      iii. See Section 8 for more information regarding audio level settings for Over-The-Top (OTT) Voice Over IP (VoIP) Testing.
   b. Real-Time Analyzer (RTA)
      i. The Real-Time Analyzer was configured to analyze measurements using 1/3 Octave band weighted filtering.
   c. WD Radio Configuration Selection
      i. The device was chosen to be tested in the condition resulting in the worst-case undesired ABM field (See Section 8 and 9 for more information regarding worst-case configurations for GSM and UMTS. LTE configuration information can be found in Section 5 and 8. NR configuration information can be found in Section 6 and 8. WIFI configuration information can be found in Section 7 and 8.)

4. Signal Quality Data Analysis
    a. Narrow-band Magnetic Intensity
        i. The standard specifies a 1kHz 1/3 octave band minimum field intensity for a sine tone. The desired ABM signal measurements were evaluated at 1kHz with 1/3 octave band filtering over an averaged period of 10 seconds.
    b. Frequency Response
        ii. The appropriate frequency response curve was measured to curves in **Figure 3-1** or **Figure 3-2** between 300 – 3000 Hz using digital linear averaging (limit lines chosen according to measurement found in step 4a). A linear average over 3x the length of the artificial voice signal (3x sampling) was performed. A 10 second delay was configured in the measurement process of the stimulus to ensure handset vocoder latency effects and echo cancellation devices (if any) were appropriately stabilized during measurements.
        iii. The appropriate post-processing was applied according to the system processing chain described in C63.19-2019. All R10 frequencies were plotted with respect to 0dB at 1kHz value and aligned with respect to the EIA-504 mask.
    c. Signal Quality Index
        i. Ensuring the WD was at maximum RF power, maximum volume, backlight off, display on, maximum contrast setting, keypad lights on (when possible) with no audio signal through the vocoder, the WD was measured over at least 100 Hz – 10,000 Hz, maximized over 5 seconds with a 50ms sample time for the undesired ABM field measurement (5 second time period is used in noise measurements under standards such as IEEE 269, etc.).
        ii. Measure the broadband undesired T-Coil noise at the locations where desired ABM signal strength was just measured. The measurement shall be made using the specified spectral and temporal weighted filter, applied to the half-band integrated probe coil signal (T-Coil response), as described in C63.19-2019 Annex D.9.2. Any additional bandwidth-limiting filtering that might be applied shall not affect frequencies within the range of at least 100 Hz to 10 kHz. Set the measurement system averaging interval duration to be long enough so as to enable an accurate steady state reading. The resulting reading represents the "1 kHz equivalent" value of the broadband weighted T-Coil response magnetic noise (undesired ABM field) for each measurement position. All results should be reported in dB(A/m).
        iii. This result was subtracted from the desired ABM signal result in step a, to obtain the Signal Quality.
5. Signal Compliance Analysis
    a. Fine scan above the WD
        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.

IV. Test Setup

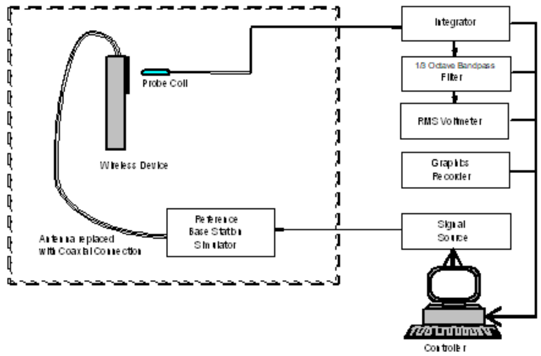


Figure 4-7
Audio Magnetic Field Test Setup

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

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.

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

1. 4G (LTE) Modes

The middle channel for every band and maximum bandwidth combination was tested at the planar field maximum point. The middle channels and supported bandwidths from the worst-case band according to Tables 8-6 and 8-7 was additionally evaluated with OTT VoIP. See Tables 10-6 to 10-16 as well as 10-39 for LTE bandwidths and channels. The scan result is available in Table 10-17.

2. 5G (NR) Modes

The middle channel for every band and maximum bandwidth combination was tested at the planar field maximum point. The middle channel and supported bandwidths from the worst-case NR band according to Tables 8-9 and 8-10 were evaluated with OTT VoIP. See Tables 10-18 to 10-28 as well as Tables 10-40 for NR bandwidths and channels. The scan results are available in Table 10-29.

3. WIFI

The middle channel for each IEEE 802.11 standard was tested at the planar field maximum point. 2.4GHz IEEE 802.11 standard from each probe orientation resulting in the worst-case SNNR was additionally tested using low and high channels. The 5GHz IEEE 802.11 standard from each probe orientation resulting in the worst-case SNNR was additionally tested on higher U-NII bands as well as applicable low and high channels. See Tables 10-30 to 10-35 as well as 10-41 to 10-46 for WIFI standards and channels. The scan result is available in Tables 10-36 and 10-48.

VIII. Test Flow

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

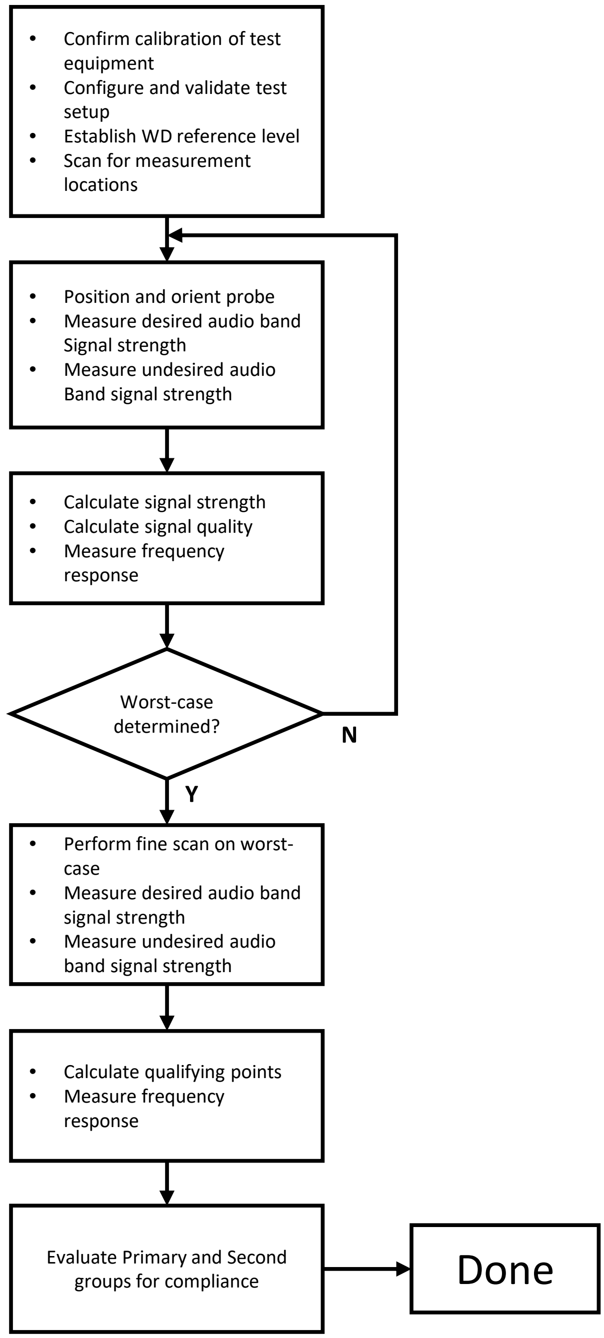


Figure 4-8
C63.19 T-Coil Signal Test Process

5. VOLTE TEST SYSTEM SETUP AND DUT CONFIGURATION

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

1. Equipment Setup

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

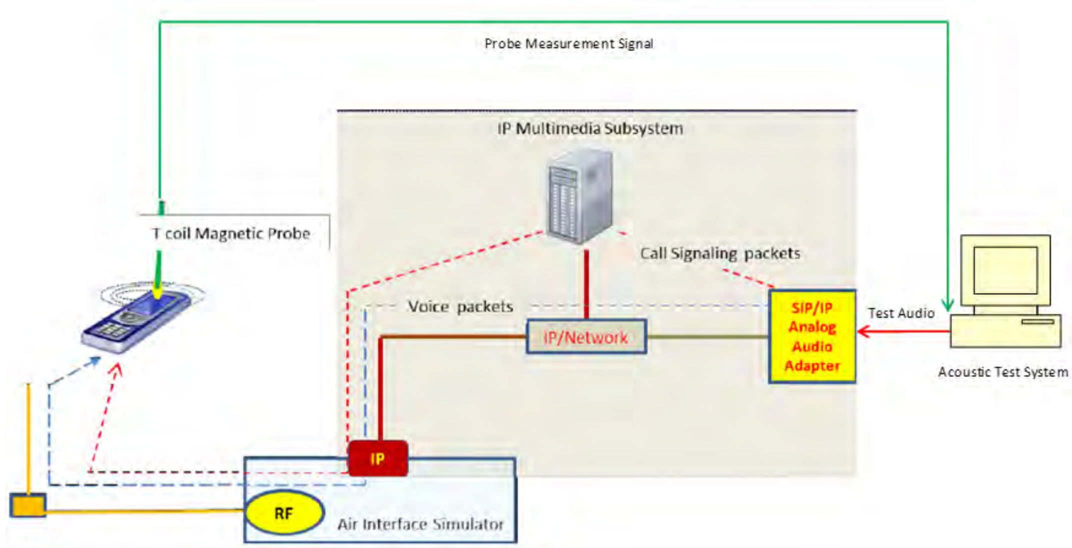


Figure 5-1
Test Setup for VoLTE over IMS T-Coil Measurements

2. Audio Level Settings

Per C63.19 Table 6-1, -16dBm0 shall be used as the normal speech input level for VoLTE over IMS T-coil testing. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -16dBm0 speech input level to the DUT for the VoLTE over IMS connection.

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

1. Radio Configuration

An investigation was performed to determine the modulation and RB configuration to be used for testing. The effects of modulation and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. 64QAM, 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	20.0	132322	20	QPSK	1	0	7.72	-42.36	50.08
66	20.0	132322	20	QPSK	1	50	7.93	-42.42	50.35
66	20.0	132322	20	QPSK	1	99	8.03	-42.01	50.04
66	20.0	132322	20	QPSK	50	0	8.16	-43.09	51.25
66	20.0	132322	20	QPSK	50	25	8.06	-43.58	51.64
66	20.0	132322	20	QPSK	50	50	7.83	-44.13	51.96
66	20.0	132322	20	QPSK	100	0	7.83	-44.05	51.88
66	20.0	132322	20	16QAM	1	0	7.95	-38.50	46.45
66	20.0	132322	20	16QAM	1	50	7.99	-39.75	47.74
66	20.0	132322	20	16QAM	1	99	8.11	-38.88	46.99
66	20.0	132322	20	16QAM	50	0	8.03	-43.17	51.20
66	20.0	132322	20	16QAM	50	25	8.14	-42.98	51.12
66	20.0	132322	20	16QAM	50	50	8.04	-42.76	50.80
66	20.0	132322	20	16QAM	100	0	8.11	-43.20	51.31
66	20.0	132322	20	64QAM	1	0	8.24	-35.03	**43.27**
66	20.0	132322	20	64QAM	1	50	8.32	-35.75	44.07
66	20.0	132322	20	64QAM	1	99	8.08	-35.40	43.48
66	20.0	132322	20	64QAM	50	0	8.09	-36.03	44.12
66	20.0	132322	20	64QAM	50	25	8.01	-35.39	43.40
66	20.0	132322	20	64QAM	50	50	8.12	-35.18	43.30
66	20.0	132322	20	64QAM	100	0	8.11	-35.36	43.47
66	20.0	132322	20	256QAM	1	0	7.90	-40.13	48.03
66	20.0	132322	20	256QAM	1	50	7.58	-40.17	47.75
66	20.0	132322	20	256QAM	1	99	8.08	-40.62	48.70
66	20.0	132322	20	256QAM	50	0	8.12	-42.31	50.43
66	20.0	132322	20	256QAM	50	25	8.15	-42.84	50.99
66	20.0	132322	20	256QAM	50	50	8.07	-43.12	51.19
66	20.0	132322	20	256QAM	100	0	7.99	-42.96	50.95

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)	9.09	8.27	8.95	8.75	Radial	B66 20MHz	132322
Undesired (dBA/m)	-39.48	-39.56	-39.53	-39.71			
Frequency Response	Pass	Pass	Pass	Pass			
S+N/N (dB)	48.57	**47.83**	48.48	48.46			

Table 5-3
EVS Codec Investigation - VoLTE over IMS

Codec Setting:	EVS Primary SWB 24.4kbps	EVS Primary SWB 9.6kbps	EVS Primary WB 24.4kbps	EVS Primary WB 5.9kbps	EVS Primary NB 24.4kbps	EVS Primary NB 5.9kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	13.23	13.33	8.43	8.85	8.63	8.75	Radial	B66 20MHz	132322
Undesired (dBA/m)	-39.15	-39.59	-39.52	-39.51	-39.66	-39.65			
Frequency Response	Pass	Pass	Pass	Pass	Pass	Pass			
S+N/N (dB)	52.38	52.92	47.95	48.36	48.29	48.40			

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

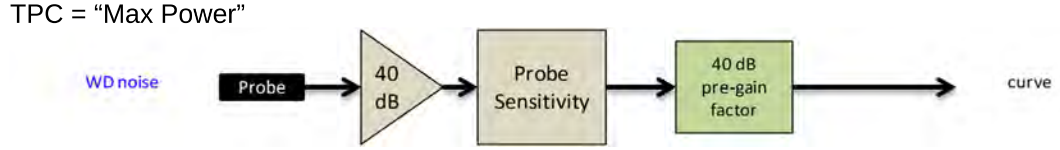


Figure 5-2
Audio Band Magnetic Curve Measurement Block Diagram

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

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

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

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

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

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

a. Power Class 3 Uplink-Downlink Configuration Investigation

Power Class 3 was evaluated with the following radio configuration: channel 40620, 20MHz BW, 64QAM, 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 0 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]
2593.0	40620	20	64QAM	1	0	0	7.63	-32.04	39.67
2593.0	40620	20	64QAM	1	0	1	8.08	-31.97	40.05
2593.0	40620	20	64QAM	1	0	2	7.75	-32.03	39.78
2593.0	40620	20	64QAM	1	0	3	7.89	-31.95	39.84
2593.0	40620	20	64QAM	1	0	4	7.92	-31.96	39.88
2593.0	40620	20	64QAM	1	0	5	7.57	-32.12	39.69
2593.0	40620	20	64QAM	1	0	6	7.91	-32.04	39.95

b. Conclusion

Per the investigations above, UL-DL Configuration 0 was used to evaluate Power Class 3 VoLTE over IMS.

6. VONR TEST SYSTEM SETUP AND DUT CONFIGURATION

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

1. Equipment Setup

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

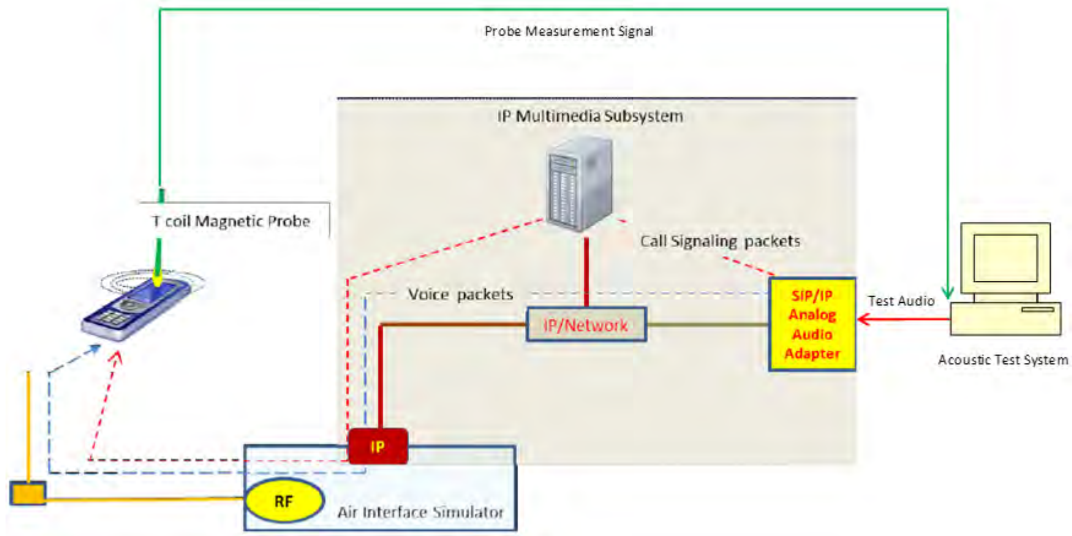


Figure 6-1
Test Setup for VoNR over IMS T-Coil Measurements

2. Audio Level Settings

Per C63.19 Table 6-1, -16dBm0 was used as the normal speech input level for VoNR over IMS T-coil testing. The acoustic test system was manually configured to ensure that the settings for speech input and full scale levels resulted in the -16dBm0 speech input level to the DUT for the VoNR over IMS connection.

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

1. Radio Configuration

An investigation was performed to determine the waveform, modulation, and RB configuration to be used for testing. The effects of waveform, modulation, and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. DFT-s-OFDM, 16QAM, 1RB, 99%RB offset was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different radio configurations:

Table 6-1
VoNR over IMS SNNR by Radio Configuration (CP-OFDM)

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
66	1745.0	349000	40	CP-OFDM	QPSK	1	1	7.72	-39.82	47.54
66	1745.0	349000	40	CP-OFDM	QPSK	1	108	7.65	-40.09	47.74
66	1745.0	349000	40	CP-OFDM	QPSK	1	214	7.82	-38.66	46.48
66	1745.0	349000	40	CP-OFDM	QPSK	108	0	7.71	-40.25	47.96
66	1745.0	349000	40	CP-OFDM	QPSK	108	54	7.70	-41.08	48.78
66	1745.0	349000	40	CP-OFDM	QPSK	108	108	7.77	-40.78	48.55
66	1745.0	349000	40	CP-OFDM	QPSK	216	0	7.81	-40.17	47.98
66	1745.0	349000	40	CP-OFDM	16QAM	1	1	7.90	-37.45	45.35
66	1745.0	349000	40	CP-OFDM	16QAM	1	108	7.97	-38.36	46.33
66	1745.0	349000	40	CP-OFDM	16QAM	1	214	7.88	-36.90	44.78
66	1745.0	349000	40	CP-OFDM	16QAM	108	0	7.87	-39.15	47.02
66	1745.0	349000	40	CP-OFDM	16QAM	108	54	7.96	-40.82	48.78
66	1745.0	349000	40	CP-OFDM	16QAM	108	108	7.83	-40.92	48.75
66	1745.0	349000	40	CP-OFDM	16QAM	216	0	7.86	-40.65	48.51
66	1745.0	349000	40	CP-OFDM	64QAM	1	1	7.92	-38.35	46.27
66	1745.0	349000	40	CP-OFDM	64QAM	1	108	7.91	-39.30	47.21
66	1745.0	349000	40	CP-OFDM	64QAM	1	214	7.96	-38.05	46.01
66	1745.0	349000	40	CP-OFDM	64QAM	108	0	7.81	-39.94	47.75
66	1745.0	349000	40	CP-OFDM	64QAM	108	54	7.81	-40.34	48.15
66	1745.0	349000	40	CP-OFDM	64QAM	108	108	7.78	-39.93	47.71
66	1745.0	349000	40	CP-OFDM	64QAM	216	0	7.88	-40.89	48.77
66	1745.0	349000	40	CP-OFDM	256QAM	1	1	7.89	-38.27	46.16
66	1745.0	349000	40	CP-OFDM	256QAM	1	108	7.94	-39.10	47.04
66	1745.0	349000	40	CP-OFDM	256QAM	1	214	7.78	-38.39	46.17
66	1745.0	349000	40	CP-OFDM	256QAM	108	0	7.89	-40.18	48.07
66	1745.0	349000	40	CP-OFDM	256QAM	108	54	7.96	-39.92	47.88
66	1745.0	349000	40	CP-OFDM	256QAM	108	108	7.91	-40.23	48.14
66	1745.0	349000	40	CP-OFDM	256QAM	216	0	7.79	-39.70	47.49

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

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	1	1	7.91	-39.72	47.63
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	1	108	7.82	-38.37	46.19
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	1	214	7.99	-40.15	48.14
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	108	0	7.86	-41.38	49.24
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	108	54	7.91	-40.67	48.58
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	108	108	7.91	-40.72	48.63
66	1745.0	349000	40	DFT-s-OFDM	π/2-BPSK	216	0	7.91	-40.60	48.51
66	1745.0	349000	40	DFT-s-OFDM	QPSK	1	1	7.76	-40.49	48.25
66	1745.0	349000	40	DFT-s-OFDM	QPSK	1	108	8.01	-40.35	48.36
66	1745.0	349000	40	DFT-s-OFDM	QPSK	1	214	7.86	-40.19	48.05
66	1745.0	349000	40	DFT-s-OFDM	QPSK	108	0	7.90	-40.66	48.56
66	1745.0	349000	40	DFT-s-OFDM	QPSK	108	54	7.94	-40.78	48.72
66	1745.0	349000	40	DFT-s-OFDM	QPSK	108	108	7.94	-40.56	48.50
66	1745.0	349000	40	DFT-s-OFDM	QPSK	216	0	7.96	-40.55	48.51
66	1745.0	349000	40	DFT-s-OFDM	16QAM	1	1	7.99	-37.13	45.12
66	1745.0	349000	40	DFT-s-OFDM	16QAM	1	108	7.88	-38.28	46.16
66	1745.0	349000	40	DFT-s-OFDM	16QAM	1	214	7.92	-36.75	**44.67**
66	1745.0	349000	40	DFT-s-OFDM	16QAM	108	0	7.96	-40.65	48.61
66	1745.0	349000	40	DFT-s-OFDM	16QAM	108	54	7.98	-40.53	48.51
66	1745.0	349000	40	DFT-s-OFDM	16QAM	108	108	7.87	-40.71	48.58
66	1745.0	349000	40	DFT-s-OFDM	16QAM	216	0	7.77	-40.86	48.63
66	1745.0	349000	40	DFT-s-OFDM	64QAM	1	1	7.92	-37.79	45.71
66	1745.0	349000	40	DFT-s-OFDM	64QAM	1	108	7.99	-38.15	46.14
66	1745.0	349000	40	DFT-s-OFDM	64QAM	1	214	7.98	-37.00	44.98
66	1745.0	349000	40	DFT-s-OFDM	64QAM	108	0	7.91	-40.86	48.77
66	1745.0	349000	40	DFT-s-OFDM	64QAM	108	54	7.84	-40.31	48.15
66	1745.0	349000	40	DFT-s-OFDM	64QAM	108	108	7.99	-40.83	48.82
66	1745.0	349000	40	DFT-s-OFDM	64QAM	216	0	7.80	-40.92	48.72
66	1745.0	349000	40	DFT-s-OFDM	256QAM	1	1	7.97	-39.14	47.11
66	1745.0	349000	40	DFT-s-OFDM	256QAM	1	108	7.98	-39.55	47.53
66	1745.0	349000	40	DFT-s-OFDM	256QAM	1	214	7.93	-38.84	46.77
66	1745.0	349000	40	DFT-s-OFDM	256QAM	108	0	7.89	-40.69	48.58
66	1745.0	349000	40	DFT-s-OFDM	256QAM	108	54	7.81	-40.78	48.59
66	1745.0	349000	40	DFT-s-OFDM	256QAM	108	108	7.92	-40.92	48.84
66	1745.0	349000	40	DFT-s-OFDM	256QAM	216	0	7.93	-41.12	49.05

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 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)	9.07	7.84	9.12	8.78	Radial	n66 40MHz	349000
Undesired (dBA/m)	-40.94	-40.24	-40.75	-40.79			
Frequency Response	Pass	Pass	Pass	Pass			
S+N/N (dB)	50.01	**48.08**	49.87	49.57			

Table 6-4
EVS Codec Investigation - VoNR over IMS

Codec Setting:	EVS Primary SWB 24.4kbps	EVS Primary SWB 9.6kbps	EVS Primary WB 24.4kbps	EVS Primary WB 5.9kbps	EVS Primary NB 24.4kbps	EVS Primary NB 5.9kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	13.25	13.34	8.45	8.87	8.99	8.86	Radial	n66 40MHz	349000
Undesired (dBA/m)	-40.16	-40.11	-40.08	-40.47	-40.36	-40.62			
Frequency Response	Pass	Pass	Pass	Pass	Pass	Pass			
S+N/N (dB)	53.41	53.45	48.53	49.34	49.35	49.48			

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

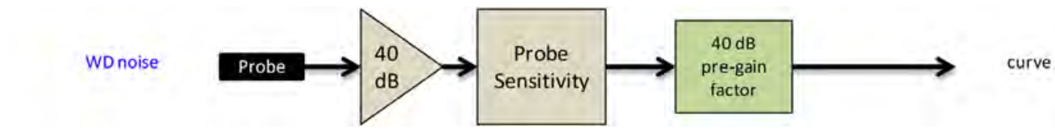


Figure 6-2
Audio Band Magnetic Curve Measurement Block Diagram

7. VOWIFI TEST SYSTEM SETUP AND DUT CONFIGURATION

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

1. Equipment Setup

The general test setup used for VoWIFI over IMS, or CMRS WIFI Calling, is shown below. The callbox used when performing VoWIFI over IMS T-coil measurements is a CMX500. The Data Application Unit (DAU) of the CMX500 was used to simulate the IP Multimedia Subsystem (IMS) server.

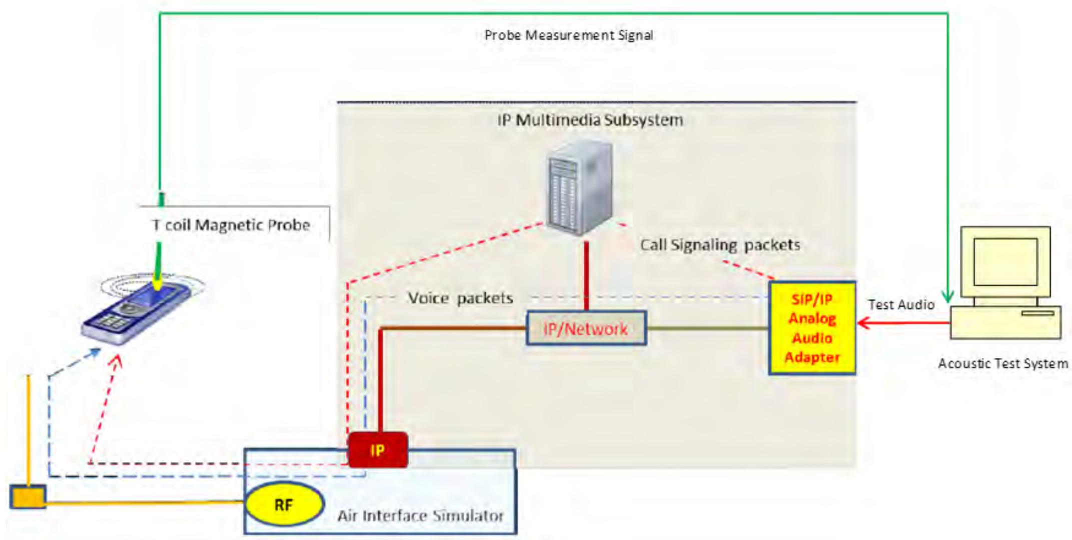


Figure 7-1
Test Setup for VoWIFI over IMS T-Coil Measurements

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 -16dBm0 speech input level to the DUT for the VoWIFI over IMS connection.

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

1. Radio Configuration

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

Table 7-1
IEEE 802.11b SNNR by Radio Configuration

Mode	Channel	Modulation	Data Rate [Mbps]	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
IEEE 802.11b	6	DSSS	1	7.65	-32.93	40.58
IEEE 802.11b	6	CCK	11	7.81	-33.87	41.68

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	7.77	-35.56	43.33
IEEE 802.11g	6	64QAM	54	7.74	-33.18	40.92

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	7.74	-39.15	46.89
IEEE 802.11n	20	40	64QAM	7	7.88	-38.87	46.75
IEEE 802.11ac	20	40	256QAM	8	7.91	-40.47	48.38

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	8.01	-37.07	45.08
IEEE 802.11ax SU	20	40	1024QAM	11	7.78	-39.61	47.39

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	7.98	-37.90	45.88
IEEE 802.11ax RU	20	40	BPSK	0	61	7.79	-40.26	48.05

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	7.71	-38.65	46.36
IEEE 802.11n	40	38	64QAM	7	7.95	-38.01	45.96
IEEE 802.11ac	40	38	256QAM	8	7.91	-38.62	46.53
IEEE 802.11ac	40	38	256QAM	9	7.79	-38.43	46.22

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	7.90	-37.23	**45.13**
IEEE 802.11ax SU	40	38	1024QAM	11	7.92	-40.66	48.58

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	7.85	-39.68	47.53
IEEE 802.11ax RU	40	38	BPSK	0	65	7.89	-38.07	**45.96**

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)	9.32	8.25	9.25	8.85	Radial	2.4GHz	IEEE 802.11b	6
Undesired (dBA/m)	-33.99	-33.42	-33.81	-33.75				
Frequency Response	Pass	Pass	Pass	Pass				
S+N/N (dB)	43.31	**41.67**	43.06	42.60				

Table 7-10
EVS Codec Investigation – VoWIFI over IMS

Codec Setting:	EVS Primary SWB 24.4kbps	EVS Primary SWB 9.6kbps	EVS Primary WB 24.4kbps	EVS Primary WB 5.9kbps	EVS Primary NB 24.4kbps	EVS Primary NB 5.9kbps	Orientation	Band	Standard	Channel
Desired (dBA/m)	13.24	13.36	8.41	8.99	9.03	9.20	Radial	2.4GHz	IEEE 802.11b	6
Undesired (dBA/m)	-33.05	-33.47	-33.59	-33.91	-33.69	-33.11				
Frequency Response	Pass	Pass	Pass	Pass	Pass	Pass				
S+N/N (dB)	46.29	46.83	42.00	42.90	42.72	42.31				

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

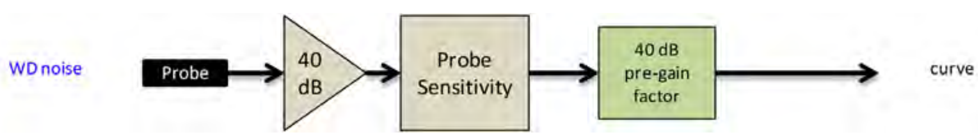


Figure 7-2
Audio Band Magnetic Curve Measurement Block Diagram

8. OTT VOIP TEST SYSTEM AND DUT CONFIGURATION

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

1. OTT VoIP Application

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

2. Equipment Setup

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

3. Audio Level Settings

Per C63.19 Table 6-1, an average speech level of -16dBm0 shall be used for VoIP testing. The auxiliary VoIP unit allowed for monitoring the signal input level to ensure that the settings for speech input and full scale levels resulted in the -16dBm0 speech input level to the DUT for the OTT VoIP call.

II. DUT Configuration for OTT VoIP T-Coil Testing

1. Codec Configuration

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

Table 8-1
Codec Investigation – OTT VoIP (EDGE)

Codec Setting:	75kbps	6kbps	Orientation	Channel
Desired (dBA/m)	14.30	13.55	Radial	661
Undesired (dBA/m)	-36.50	-36.32		
Frequency Response	Pass	Pass		
S+N/N (dB)	50.80	49.87		

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

Codec Setting:	75kbps	6kbps	Orientation	Channel
Desired (dBA/m)	14.22	13.80	Radial	9400
Undesired (dBA/m)	-45.19	-45.37		
Frequency Response	Pass	Pass		
S+N/N (dB)	59.41	59.17		

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

Codec Setting:	75kbps	6kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	14.47	13.94	Radial	B66 20MHz	132322
Undesired (dBA/m)	-37.65	-38.06			
Frequency Response	Pass	Pass			
S+N/N (dB)	52.12	52.00			

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

Codec Setting:	75kbps	6kbps	Orientation	Band / BW	Channel
Desired (dBA/m)	14.26	13.60	Radial	n66 40MHz	349000
Undesired (dBA/m)	-38.70	-38.56			
Frequency Response	Pass	Pass			
S+N/N (dB)	52.96	52.16			

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

Codec Setting:	75kbps	6kbps	Orientation	Band	Standard	Channel
Desired (dBA/m)	14.82	14.19	Radial	2.4GHz	IEEE 802.11b	6
Undesired (dBA/m)	-32.29	-31.26				
Frequency Response	Pass	Pass				
S+N/N (dB)	47.11	45.45				

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

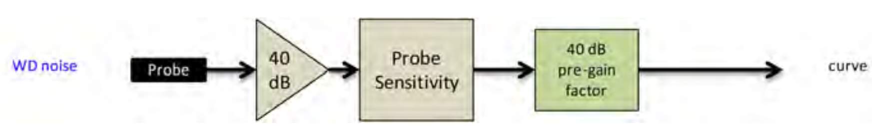


Figure 8-1
Audio Band Magnetic Curve Measurement Block Diagram

2. Radio Configuration for OTT VoIP (LTE)

An investigation was performed to determine the worst-case LTE band to be used for OTT VoIP testing. LTE TDD Band 41 (PC3, ANT 4) was used for the testing as the worst-case configuration for the handset. See below table for SNNR comparison between different LTE TDD bands:

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

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
71	680.5	133297	20	64QAM	1	0	14.01	-40.91	54.92
12	707.5	23095	10	64QAM	1	0	13.75	-41.78	55.53
13	782.0	23230	10	64QAM	1	0	13.57	-43.89	57.46
14	793.0	23330	10	64QAM	1	0	13.80	-41.96	55.76
26	831.5	26865	15	64QAM	1	0	13.63	-43.61	57.24
66 ANT 2	1745.0	132322	20	64QAM	1	0	13.91	-38.38	52.29
66 ANT 4	1745.0	132322	20	64QAM	1	0	13.91	-37.57	51.48
25 ANT 2	1882.5	26365	20	64QAM	1	0	13.61	-39.03	52.64
25 ANT 4	1882.5	26365	20	64QAM	1	0	13.86	-38.09	51.95
30 ANT 2	2310.0	27710	10	64QAM	1	0	13.64	-36.13	49.77
30 ANT 4	2310.0	27710	10	64QAM	1	0	13.85	-36.86	50.71
7 ANT 2	2535.0	21100	20	64QAM	1	0	13.95	-38.69	52.64
7 ANT 4	2535.0	21100	20	64QAM	1	0	13.52	-38.98	52.50

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

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
41 (PC3, ANT 2)	2593.0	40620	20	64QAM	1	0	13.77	-30.81	44.58
41 (PC3, ANT 4)	2593.0	40620	20	64QAM	1	0	13.89	-29.68	**43.57**
48	3625.0	55990	20	64QAM	1	0	13.62	-38.57	52.19

3. LTE TDD Uplink Carrier Aggregation for OTT VoIP

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

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

Combination	PCC							SCC							Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
	PCC Band	PCC Bandwidth [MHz]	PCC (UL/DL) Channel	PCC (UL/DL) Frequency [MHz]	Modulation	PCC UL# RB	PCC UL RB Offset	SCC Band	SCC Bandwidth [MHz]	SCC (UL/DL) Channel	SCC (UL/DL) Frequency [MHz]	Modulation	SCC UL# RB	SCC UL RB Offset			
CA_48C	LTE B48	20	55990	3625.0	64QAM	1	0	LTE B48	20	55792	3605.2	64QAM	1	99	13.81	-40.03	53.84

4. Radio Configuration for OTT VoIP (NR) Radio Configuration for OTT VoIP (NR)

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

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

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
n71	680.5	136100	20	DFT-s-OFDM	16QAM	1	104	13.78	-39.10	52.88
n14	793.0	158600	15	DFT-s-OFDM	16QAM	1	77	13.84	-41.22	55.06
n5	836.5	167300	20	DFT-s-OFDM	16QAM	1	104	13.54	-40.64	54.18
n70	1702.5	340500	20	DFT-s-OFDM	16QAM	1	104	14.04	-37.74	51.78
n66 ANT 2	1745.0	349000	40	DFT-s-OFDM	16QAM	1	214	13.79	-38.20	51.99
n66 ANT 4	1745.0	349000	40	DFT-s-OFDM	16QAM	1	214	13.65	-38.96	52.61
n25 ANT 2	1882.5	376500	40	DFT-s-OFDM	16QAM	1	214	13.78	-38.01	51.79
n25 ANT 4	1882.5	376500	40	DFT-s-OFDM	16QAM	1	214	13.61	-36.79	50.40
n30 ANT 2	2310.0	462000	10	DFT-s-OFDM	16QAM	1	50	13.56	-38.05	51.61
n30 ANT 4	2310.0	462000	10	DFT-s-OFDM	16QAM	1	50	13.77	-36.11	49.88

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

Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	Desired [dB(A/m)]	Undesired [dB(A/m)]	SNNR [dB]
n41 (PC2)	2592.99	518598	100	DFT-s-OFDM	16QAM	1	271	13.78	-28.28	**42.06**
n77 (DoD, PC2)	3500.0	633334	100	DFT-s-OFDM	16QAM	1	271	13.70	-32.39	46.09
n48	3625.0	641666	100	DFT-s-OFDM	16QAM	1	271	13.72	-34.25	47.97
n77 (PC2)	3840.00	656000	100	DFT-s-OFDM	16QAM	1	271	13.91	-32.74	46.65

9. FCC 3G MEASUREMENTS

I. GSM Test Configurations

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

Table 8-9
Codec Investigation - GSM

Configuration:	FRV1	FRV2	HRV1	Orientation	Channel
Desired (dBA/m)	9.14	9.07	9.20	Radial	190
Undesired (dBA/m)	-41.83	-41.62	-42.15		
Frequency Response	Pass	Pass	Pass		
S+N/N (dB)	50.97	**50.69**	51.35		

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

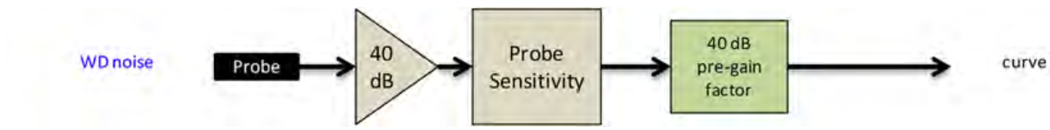


Figure 8-2
Audio Band Magnetic Curve Measurement Block Diagram

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 8-10
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)	8.78	7.71	8.97	9.06	Radial	9400
Undesired (dBA/m)	-49.55	-49.38	-49.70	-49.48		
Frequency Response	Pass	Pass	Pass	Pass		
S+N/N (dB)	58.33	**57.09**	58.67	58.54		

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

Figure 8-3
Audio Band Magnetic Curve Measurement Block Diagram

10. T-COIL TEST SUMMARY

Table 10-1
Consolidated Tabled Results

	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Freq. Response Margin	C63.19 Compliance
GSM	PASS	PASS	PASS	PASS	PASS	PASS
UMTS	PASS	PASS	PASS	PASS	PASS	PASS
LTE FDD	PASS	PASS	PASS	PASS	PASS	PASS
LTE TDD	PASS	PASS	PASS	PASS	PASS	PASS
NR FDD	PASS	PASS	PASS	PASS	PASS	PASS
NR TDD	PASS	PASS	PASS	PASS	PASS	PASS
WLAN	PASS	PASS	PASS	PASS	PASS	PASS
U-NII	PASS	PASS	PASS	PASS	PASS	PASS
OTT VoIP	PASS	PASS	PASS	PASS	PASS	PASS

I. Raw Handset Data

Table 10-2
Raw Data Results for GSM

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
GSM850	Radial	128	9.58	-41.55	-64.97	51.13	1.0,2.2
		190	9.22	-41.41		50.63	
		251	9.59	-41.04		50.63	
GSM1900	Radial	512	9.53	-21.72	-64.97	31.25	1.0,2.2
		661	9.53	-21.60		31.13	
		810	9.50	-21.81		31.31	

Table 10-3
Worst-Case Scan Results for GSM

Mode	Orientation	Channel	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan									
GSM1900	Radial	661	178	373	20	26	2.00	PASS	1.0,2.2

Table 10-4
Raw Data Results for UMTS

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
UMTS V	Radial	4132	8.09	-50.16	-64.97	58.25	1.0,2.2
		4183	8.19	-49.90		58.09	
		4233	8.19	-50.15		58.34	
UMTS IV	Radial	1312	8.22	-50.09	-64.97	58.31	1.0,2.2
		1412	8.15	-49.75		57.90	
		1513	8.14	-50.42		58.56	
UMTS II	Radial	9262	8.24	-50.07	-64.97	58.31	1.0,2.2
		9400	7.83	-49.81		57.64	
		9538	8.18	-50.25		58.43	

Table 10-5
Worst-Case Scan Results for UMTS

Mode	Orientation	Channel	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan									
UMTS II	Radial	9400	481	676	26	26	2.00	PASS	1.0, 2.2

Table 10-6
Raw Data Results for LTE B71

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 71	Radial	20MHz	133297	7.83	-47.93	-64.92	55.76	1.0,2.2

Table 10-7
Raw Data Results for LTE B12

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 12	Radial	10MHz	23095	7.72	-47.60	-64.92	55.32	1.0,2.2

Table 10-8
Raw Data Results for LTE B13

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 13	Radial	10MHz	23230	7.83	-47.81	-64.92	55.64	1.0,2.2

Table 10-9
Raw Data Results for LTE B14

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 14	Radial	10MHz	23330	7.83	-47.77	-64.92	55.60	1.0,2.2

Table 10-10
Raw Data Results for LTE B26

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 26	Radial	15MHz	26865	7.82	-45.44	-64.92	53.26	1.0,2.2

Table 10-11
Raw Data Results for LTE B66

Mode	Orientation	Bandwidth	Channel	Ant Config.	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 66	Radial	20MHz	132322	2	7.85	-45.82	-64.92	53.67	1.0,2.2
		20MHz	132322	4	7.87	-39.59		47.46	

Table 10-12
Raw Data Results for LTE B25

Mode	Orientation	Bandwidth	Channel	Ant Config.	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 25	Radial	20MHz	26365	2	7.83	-45.90	-64.92	53.73	1.0,2.2
		20MHz	26365	4	7.85	-38.92		46.77	

Table 10-13
Raw Data Results for LTE B30

Mode	Orientation	Bandwidth	Channel	Ant Config.	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 30	Radial	10MHz	27710	2	8.09	-36.34	-64.92	44.43	1.0, 2.2
		10MHz	27710	4	7.79	-38.45		46.24	
		5MHz	27735	2	8.01	-38.17		46.18	
		5MHz	27710	2	7.93	-33.66		41.59	
		5MHz	27685	2	7.85	-35.66		43.51	

Table 10-14
Raw Data Results for LTE B7

Mode	Orientation	Bandwidth	Channel	Ant Config.	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 7	Radial	20MHz	21100	2	7.84	-45.86	-64.92	53.70	1.0,2.2
		20MHz	21100	4	7.73	-39.71		47.44	

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

Mode	Orientation	Bandwidth	Channel	Ant Config.	Desired [dB(A/m)]	ABM2 [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 41 (PC3)	Radial	20MHz	41490	4	7.91	-31.95	-64.92	39.86	1.0,2.2
		20MHz	41055	4	7.87	-31.68		39.55	
		20MHz	40620	4	7.67	-29.60		37.27	
		20MHz	40620	2	7.87	-32.51		40.38	
		20MHz	40185	4	7.88	-30.83		38.71	
		20MHz	39750	4	7.94	-31.41		39.35	
		15MHz	40620	4	7.64	-30.50		38.14	
		10MHz	40620	4	7.81	-30.30		38.11	
		5MHz	40620	4	7.85	-30.56		38.41	

Table 10-16
Raw Data Results for LTE B48

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 48	Radial	20MHz	55990	7.80	-32.36	-64.92	40.16	1.0,2.2

Table 10-17
Worst-Case Scan Results for LTE

Mode	Orientation	Bandwidth	Channel	Ant Config.	Primary Pts	Secondary Pts	Contiguous Longitudinal	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan										
LTE Band 41 (PC3)	Radial	20MHz	40620	4	198	393	25	2.00	PASS	1.0, 2.2

Table 10-18
Raw Data Results for NR n71

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n71	Radial	20MHz	136100	7.87	-43.33	-64.92	51.20	1.0, 2.2

Table 10-19
Raw Data Results for NR n14

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n14	Radial	10MHz	158600	7.94	-45.00	-64.92	52.94	1.0, 2.2

Table 10-20
Raw Data Results for NR n5

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n5	Radial	20MHz	167300	7.75	-44.11	-64.92	51.86	1.0, 2.2

Table 10-21
Raw Data Results for NR n70

Mode	Orientation	Bandwidth	Channel	Ant Config.	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
n70	Radial	15MHz	340500	2	7.94	-40.02	-64.92	47.96	1.0, 2.2
		15MHz	340500	4	7.81	-37.47		45.28	

Table 10-22
Raw Data Results for NR n66

Mode	Orientation	Bandwidth	Channel	Ant Config	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n66	Radial	40MHz	349000	2	7.88	-37.57	-64.92	45.45	1.0, 2.2
		40MHz	349000	4	7.79	-38.32		46.11	

Table 10-23
Raw Data Results for NR n25

Mode	Orientation	Bandwidth	Channel	Ant Config	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n25	Radial	40MHz	376500	2	7.70	-37.89	-64.92	45.59	1.0, 2.2
		40MHz	376500	4	7.88	-37.38		45.26	
		35MHz	376500	4	7.86	-37.35		45.21	
		30MHz	376500	4	7.85	-38.76		46.61	
		25MHz	376500	4	7.87	-38.58		46.45	
		20MHz	376500	4	7.87	-38.21		46.08	
		15MHz	376500	4	7.84	-37.84		45.68	
		10MHz	376500	4	7.76	-37.99		45.75	
		5MHz	376500	4	7.82	-39.74		47.56	

Table 10-24
Raw Data Results for NR n30

Mode	Orientation	Bandwidth	Channel	Ant Config	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n30	Radial	10MHz	462000	2	7.86	-38.20	-64.92	46.06	1.0, 2.2
		10MHz	462000	4	7.74	-39.77		47.51	

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

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n41 (PC2)	Radial	100MHz	518598	7.96	-27.70	-64.92	35.66	1.0, 2.2
		90MHz	528996	7.93	-27.06		34.99	
		90MHz	523800	7.96	-28.06		36.02	
		90MHz	518598	7.96	-27.16		35.12	
		90MHz	513402	7.98	-27.98		35.96	
		90MHz	508200	7.94	-27.60		35.54	
		80MHz	518598	7.89	-27.42		35.31	
		70MHz	518598	7.93	-27.50		35.43	
		60MHz	518598	7.85	-27.77		35.62	
		50MHz	518598	7.97	-27.70		35.67	
		40MHz	518598	7.94	-28.20		36.14	
		30MHz	518598	7.97	-28.65		36.62	
		20MHz	518598	8.00	-29.06		37.06	
		15MHz	518598	8.00	-29.12		37.12	
		10MHz	518598	8.02	-29.10		37.12	

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

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n77 (DoD, PC2)	Radial	100MHz	633334	7.96	-31.96	-64.92	39.92	1.0, 2.2

Table 10-27
Raw Data Results for NR n48

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n48	Radial	40MHz	641666	8.05	-34.37	-64.92	42.42	1.0, 2.2

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

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n77 (PC2)	Radial	100MHz	656000	7.88	-32.79	-64.92	40.67	1.0, 2.2

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

Mode	Orientation	Bandwidth	Channel	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan										
NR n41 (PC2)	Radial	90MHz	528996	246	444	18	26	2.00	PASS	1.0, 2.2

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

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11b	Radial	1	7.82	-32.29	-64.92	40.11	1.0, 2.2
		6	7.94	-32.77		40.71	
		11	7.78	-31.13		38.91	
IEEE 802.11g	Radial	6	7.98	-33.16	-64.92	41.14	1.0, 2.2
IEEE 802.11n	Radial	6	7.97	-37.17	-64.92	45.14	1.0, 2.2
IEEE 802.11ac	Radial	6	7.99	-37.21	-64.92	45.20	1.0, 2.2
IEEE 802.11ax SU	Radial	6	8.02	-35.08	-64.92	43.10	1.0, 2.2
IEEE 802.11ax RU	Radial	6	7.86	-35.23	-64.92	43.09	1.0, 2.2

Table 10-31
Raw Data Results for 2.4GHz WIFI - MIMO

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11b	Radial	1	8.15	-32.35	-64.92	40.50	1.0, 2.2
		6	7.90	-33.34		41.24	
		11	8.14	-31.82		39.96	
IEEE 802.11g	Radial	6	8.02	-33.64	-64.92	41.66	1.0, 2.2
IEEE 802.11n	Radial	6	8.04	-37.46	-64.92	45.50	1.0, 2.2
IEEE 802.11ac	Radial	6	8.04	-38.43	-64.92	46.47	1.0, 2.2
IEEE 802.11ax SU	Radial	6	7.98	-34.72	-64.92	42.70	1.0, 2.2
IEEE 802.11ax RU	Radial	6	8.12	-33.96	-64.92	42.08	1.0, 2.2

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

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11a	Radial	20MHz	1	40	7.95	-41.64	-64.92	49.59	1.0, 2.2

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

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11n	Radial	40MHz	1	38	8.01	-38.51	-64.92	46.52	1.0, 2.2
		20MHz	1	40	7.76	-38.66		46.42	

Table 10-34
Raw Data Results for 5GHz WIFI IEEE 802.11ac

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11ac	Radial	40MHz	1	38	8.08	-38.33	-64.92	46.41	1.0, 2.2
		20MHz	1	40	7.91	-38.72		46.63	

Table 10-35
Raw Data Results for 5GHz WIFI IEEE 802.11ax

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11ax SU	Radial	40MHz	1	38	7.96	-37.32	-64.92	45.28	1.0, 2.2
		20MHz	1	40	7.84	-37.92		45.76	
IEEE 802.11ax RU	Radial	40MHz	1	38	7.98	-37.97	-64.92	45.95	1.0, 2.2
		20MHz	1	40	8.09	-37.27		45.36	

Table 10-36
Worst-Case Scan Results for WIFI

Mode	Orientation	Channel	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan									
IEEE 802.11b	Radial	11	308	503	24	26	1.99	PASS	1.0, 2.2

Table 10-37
Raw Data Results for EDGE (OTT VoIP)

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
EDGE850	Radial	190	13.44	-35.02	-64.92	48.46	1.0, 2.2
EDGE1900	Radial	661	13.66	-25.62	-64.92	39.28	1.0, 2.2

Table 10-38
Raw Data Results for HSPA (OTT VoIP)

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
HSPA V	Radial	4183	13.53	-44.71	-64.92	58.24	1.0, 2.2
HSPA IV	Radial	1412	13.58	-44.38	-64.92	57.96	1.0, 2.2
HSPA II	Radial	9400	13.61	-45.45	-64.92	59.06	1.0, 2.2

Table 10-39
Raw Data Results for LTE TDD B41 (PC3, ANT 4) (OTT VoIP)

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
LTE Band 41 (PC3, ANT 4)	Radial	20MHz	40620	14.25	-30.30	-64.92	44.55	1.0, 2.2
		15MHz	40620	14.22	-30.31		44.53	
		10MHz	40620	14.27	-30.03		44.30	
		5MHz	41490	14.23	-29.46		43.69	
		5MHz	41055	14.21	-31.37		45.58	
		5MHz	40620	14.27	-29.66		43.93	
		5MHz	40185	14.20	14.20		44.95	
		5MHz	39750	13.89	13.89		44.76	

Table 10-40
Raw Data Results for NR TDD n41 (PC2) (OTT VoIP)

Mode	Orientation	Bandwidth	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
NR n41 (PC2)	Radial	100MHz	518598	13.88	-28.51	-64.92	42.39	1.0, 2.2
		90MHz	528996	13.89	-28.16		42.05	
		90MHz	523800	13.58	-29.03		42.61	
		90MHz	518598	13.64	-28.46		42.10	
		90MHz	513402	13.86	-29.10		42.96	
		90MHz	508200	13.98	-28.67		42.65	
		80MHz	518598	13.60	-28.60		42.20	
		70MHz	518598	13.75	-28.48		42.23	
		60MHz	518598	13.82	-29.01		42.83	
		50MHz	518598	13.88	-29.30		43.18	
		40MHz	518598	13.92	-29.52		43.44	
		30MHz	518598	13.86	-29.66		43.52	
		20MHz	518598	13.71	-29.58		43.29	
		15MHz	518598	13.64	-29.58		43.22	
		10MHz	518598	13.82	-29.70		43.52	

Table 10-41
Raw Data Results for 2.4GHz WIFI (OTT VoIP) - SISO

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11b	Radial	1	14.19	-28.69	-64.92	42.88	1.0, 2.2
		6	14.20	-30.88		45.08	
		11	14.28	-27.57		41.85	
IEEE 802.11g	Radial	6	14.27	-30.93	-64.92	45.20	1.0, 2.2
IEEE 802.11n	Radial	6	14.31	-34.12	-64.92	48.43	1.0, 2.2
IEEE 802.11ac	Radial	6	14.32	-33.31	-64.92	47.63	1.0, 2.2
IEEE 802.11ax SU	Radial	6	14.26	-33.72	-64.92	47.98	1.0, 2.2
IEEE 802.11ax RU	Radial	6	14.27	-31.97	-64.92	46.24	1.0, 2.2

Table 10-42
Raw Data Results for 2.4GHz WIFI (OTT VoIP) - MIMO

Mode	Orientation	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11b	Radial	1	13.61	-30.20	-64.92	43.81	1.0, 2.2
		6	14.24	-29.46		43.70	
		11	14.27	-29.92		44.19	
IEEE 802.11g	Radial	6	14.16	-31.74	-64.92	45.90	1.0, 2.2
IEEE 802.11n	Radial	6	14.20	-33.89	-64.92	48.09	1.0, 2.2
IEEE 802.11ac	Radial	6	14.18	-35.39	-64.92	49.57	1.0, 2.2
IEEE 802.11ax SU	Radial	6	14.29	-32.40	-64.92	46.69	1.0, 2.2
IEEE 802.11ax RU	Radial	6	14.30	-32.31	-64.92	46.61	1.0, 2.2

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

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11a	Radial	20MHz	1	40	14.16	-30.66	-64.92	44.82	1.0, 2.2

Table 10-44
Raw Data Results for 5GHz WIFI IEEE 802.11n (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11n	Radial	40MHz	1	38	14.20	-37.13	-64.92	51.33	1.0, 2.2
		20MHz	1	40	14.23	-37.62		51.85	

Table 10-45
Raw Data Results for 5GHz WIFI IEEE 802.11ac (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11ac	Radial	40MHz	1	38	14.23	-38.52	-64.92	52.75	1.0, 2.2
		20MHz	1	40	14.06	-37.24		51.30	

Table 10-46
Raw Data Results for 5GHz WIFI IEEE 802.11ax (OTT VoIP)

Mode	Orientation	Bandwidth	U-NII	Channel	Desired [dB(A/m)]	Undesired [dB(A/m)]	Ambient Noise [dB(A/m)]	S+N/N (dB)	Test Coordinates
IEEE 802.11ax SU	Radial	40MHz	1	38	14.24	-39.18	-64.92	53.42	1.0, 2.2
		20MHz	1	40	14.21	-38.48		52.69	
IEEE 802.11ax RU	Radial	40MHz	1	38	14.31	-38.83	-64.92	53.14	1.0, 2.2
		20MHz	1	40	14.26	-38.09		52.35	

Table 10-47
Worst-Case Scan Results for OTT VoIP – EDGE 1900

Mode	Orientation	Channel	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan									
EDGE1900	Radial	661	469	621	26	26	1.07	PASS	1.0, 2.2

Table 10-48
Worst-Case Scan Results for OTT VoIP - 2.4GHz WIFI

Mode	Orientation	Channel	Primary Pts	Secondary Pts	Contiguous Longitudinal	Contiguous Transverse	Frequency Response Margin (dB)	Compliance	Frequency Response Coordinates
C63.19-2019 T-Coil Scan									
IEEE 802.11b	Radial	11	327	479	22	26	1.66	PASS	1.0, 2.2

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 aid compatibility) was set to ON for Frequency Response compliance
4. Speech Signal: ITU-T P.50 Artificial Voice
5. Bluetooth and WIFI were disabled while testing 2G/3G/4G/5G modes.
6. Licensed data modes and Bluetooth were disabled while testing WIFI modes.
7. The number of passing points and frequency response value shown in the scan result table satisfies the limit for compliance.

B. GSM

1. Power Configuration: GSM850: PCL=5, GSM1900: PCL=0;
2. Vocoder Configuration: EFR (GSM); FR V2

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: 64QAM, 1RB, 0RB offset
3. Power Class 3 Uplink-Downlink configuration: 0
4. Vocoder Configuration: WB AMR 6.60kbps
5. LTE Band 41 (Power Class 3) Ant 4 at 20MHz is the worst-case LTE configuration.

E. NR

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: DFT-s-OFDM, 16QAM, 1RB, 99%RB offset
3. Vocoder Configuration: WB AMR 6.60kbps
4. NR n41 (Power Class 2) at 90MHz is the worst-case NR configuration.

F. WIFI

1. Radio Configuration
    a. IEEE 802.11b: DSSS, 1Mbps
    b. IEEE 802.11g/a: 64QAM, 54Mbps
    c. IEEE 802.11n/ac 20MHz: 64QAM, MCS 7
    d. IEEE 802.11ax SU 20MHz: BPSK, MCS 0
    e. IEEE 802.11n/ac 40MHz: 64QAM, MCS 7
    f. 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 65
3. Vocoder Configuration: WB AMR 6.60kbps
4. The worst-case standard for WIFI mode is additionally tested on the applicable low and high channels and higher U-NII bands. IEEE 802.11b is the worst-case WIFI configuration.

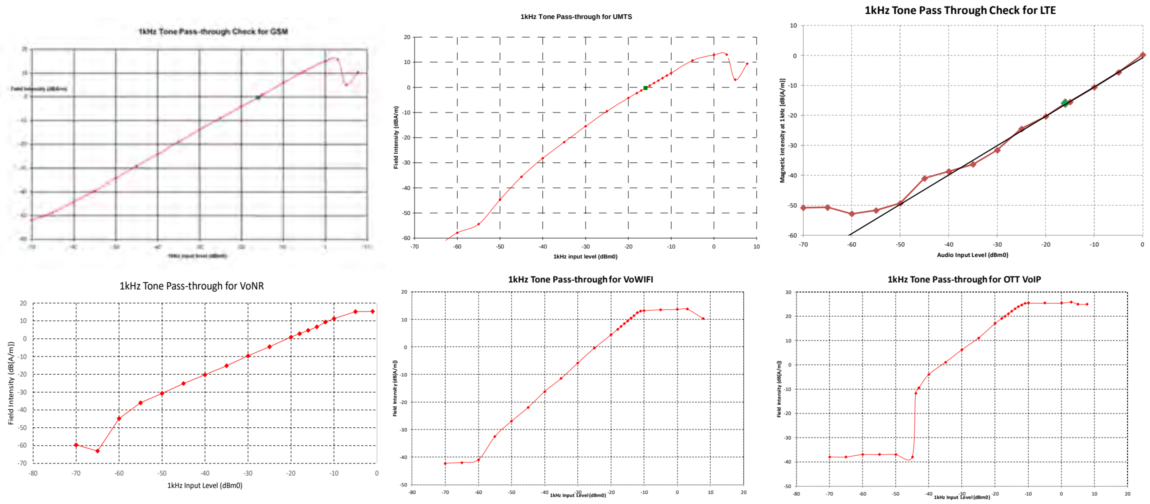
G. OTT VoIP

1. Vocoder Configuration: 6kbps
2. EDGE Configuration
    a. MCS Index: 7
    b. Number of TX slots: 2
3. HSPA Configuration:
    a. Release: 6
    b. 3GPP 34.121 Subtest 1
4. LTE Configuration:
    a. Power Configuration: TPC = “Max Power”
    b. Radio Configuration: 64QAM, 1RB, 0RB offset
    c. LTE Band 41 (PC3, ANT 4) was the worst-case band from Table 8-7.
    d. 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 3) at 5MHz is the worst-case LTE configuration.
5. NR Configuration
    a. Power Configuration: TxAGC is set such that the DUT operates at max power.
    b. Radio Configuration: DFT-s-OFDM, 16QAM, 1RB, 99%RB offset
    c. NR n41 (PC2) was the worst-case band from Table 8-9

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) at 90MHz is the worst-case NR TDD configuration.

6. WIFI Configuration:
    a. Radio Configuration
        i. IEEE 802.11b: DSSS, 1Mbps
        ii. IEEE 802.11g/a: 64QAM, 54Mbps
        iii. IEEE 802.11n/ac 20MHz: 64QAM, MCS 7
        iv. IEEE 802.11ax SU 20MHz: BPSK, MCS 0
        v. IEEE 802.11n/ac 40MHz: 64QAM, MCS 7
        vi. IEEE 802.11ax SU 40MHz: BPSK, MCS 0
    b. RU Index
        vii. IEEE 802.11ax RU 20MHz: RU Index 0
        viii. IEEE 802.11ax RU 40MHz: RU Index 65
    c. The worst-case standard for WIFI mode is additionally investigated on the low and high channels. IEEE 802.11b is the worst-case WIFI configuration.

III. 1 kHz Vocoder Application Check



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

IV. T-Coil Validation Test Results

Table 10-49
Helmholtz Coil Verification Table of Results - TEM

Date	Orientation	Item	Target	Result	Compliance
02/03/25	Radial	Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.204	**PASS**
		Environmental Noise	< -48 dBA/m	-64.97	**PASS**
		Frequency Response, from limits	*> 0 dB*	0.80	**PASS**
02/10/25	Radial	Magnetic Intensity, -10 dBA/m	*-10 ± 0.5 dB*	-10.193	**PASS**
		Environmental Noise	< -48 dBA/m	-64.92	**PASS**
		Frequency Response, from limits	*> 0 dB*	0.80	**PASS**

Table 10-50
Helmholtz Coil Verification Table of Results - SPEAG

Date	AMD Probe	Coil Channel [V]	Probe Channel [V]	Probe Sensitivity [mV/(A/m)]	Calibrated angle [deg]
2/3/2025	3079	2.38	1.34	7.49	-42.95
2/10/2025	3079	2.38	1.34	7.49	-42.95

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.

11. MEASUREMENT UNCERTAINTY

Table 11-1
Uncertainty Estimation Table

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

Notes:
1. Test equipments are calibrated according to techniques outlined in NIS81, NIS3003 and NIST Tech Note 1297.
2. All equipments have traceability according to NIST. Measurement Uncertainties are defined in further detail in NIS 81 and NIST Tech Note 1297 and UKAS M3003.

Measurement uncertainty reflects the quality and accuracy of a measured result as compared to the true value. Such statements are generally required when stating results of measurements so that it is clear to the intended audience that the results may differ when reproduced by different facilities. Measurement results vary due to the measurement uncertainty of the instrumentation, measurement technique, and test engineer. Most uncertainties are calculated using the tolerances of the instrumentation used in the measurement, the measurement setup variability, and the technique used in performing the test. While not generally included, the variability of the equipment under test also figures into the overall measurement uncertainty. Another component of the overall uncertainty is based on the variability of repeated measurements (so-called Type A uncertainty). This may mean that the Hearing Aid compatibility tests may have to be repeated by taking down the test setup and resetting it up so that there are a statistically significant number of repeat measurements to identify the measurement uncertainty. By combining the repeat measurement results with that of the instrumentation chain using the technique contained in NIS 81 and NIS 3003, the overall measurement uncertainty was estimated.

12. EQUIPMENT LIST

Table 12-1
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
SPEAG	DAE4	Dasy Data Acquisition Electronics	12/10/2024	Annual	12/10/2025	1450
SPEAG	AM1DV3	Audio Magnetic Field Probe	1/10/2025	Annual	1/10/2026	3079
Listen	SoundConnect	Microphone Power Supply	8/6/2024	Biennial	8/6/2026	PS2612
RME	Fireface UC	Soundcheck Acoustic Analyzer External Audio Interface	8/8/2024	Biennial	8/8/2026	23528889
Rohde & Schwarz	CMW500	Radio Communication Tester	N/A		N/A	140144
Rohde & Schwarz	CMW500	Radio Communication Tester	N/A		N/A	162125
Rohde & Schwarz	CMX500	Radio Communication Tester	N/A		N/A	100298
Rosenberger	32W 006-016	Torque Wrench	4/2/2024	Biennial	4/2/2026	NA
TEM	Radial T-Coil Probe	Radial T-Coil Probe	8/6/2024	Biennial	8/6/2026	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	8/6/2024	Biennial	8/6/2026	SBI 1052
YellowTec	YT4211	USB Audio Interface	N/A		N/A	20000365

13. TEST DATA (SINGLE POINT MEASUREMENT)

2/3/2025

Element Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

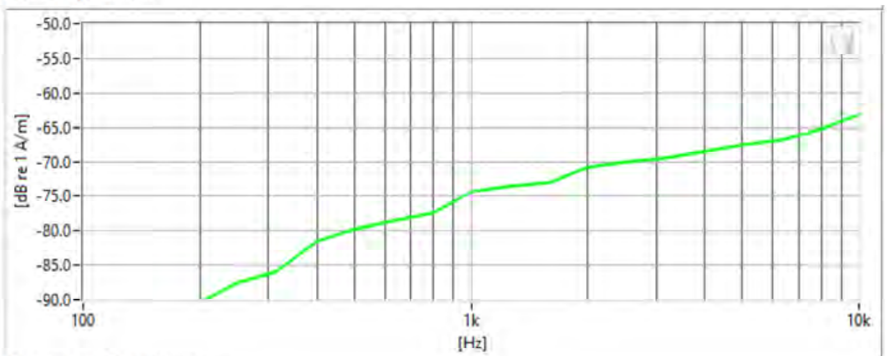
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19

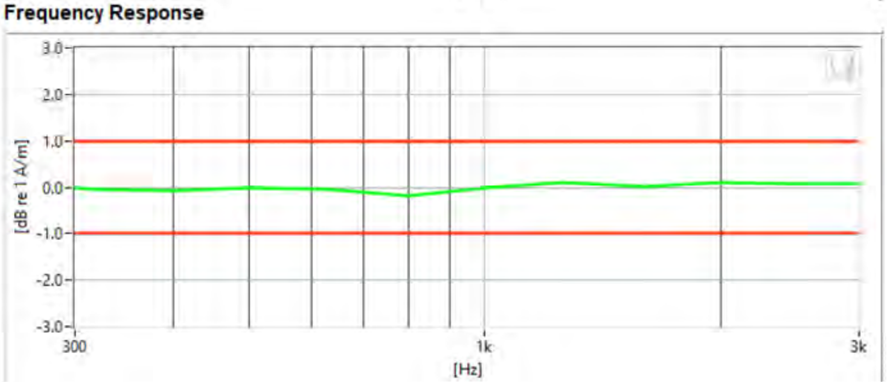
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024
- Helmholtz Coil – SN: SBI 1052; Calibrated: 08/06/2024

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.204 dB	✔	Max/Min	-9.5/-10.5
Verification ABM2	-64.97 dB	✔	Maximum	-58.0
Frequency Response Margin	800m dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

DUT: HH Coil – SN: SBI 1052

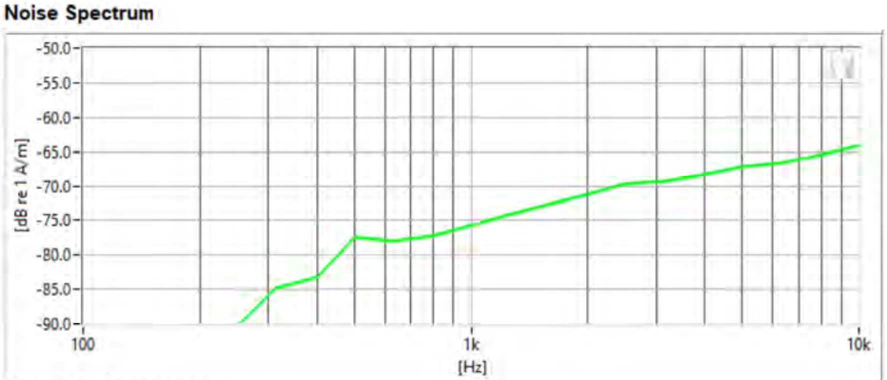
Type: HH Coil
Serial: SBI 1052

Measurement Standard: ANSI C63.19

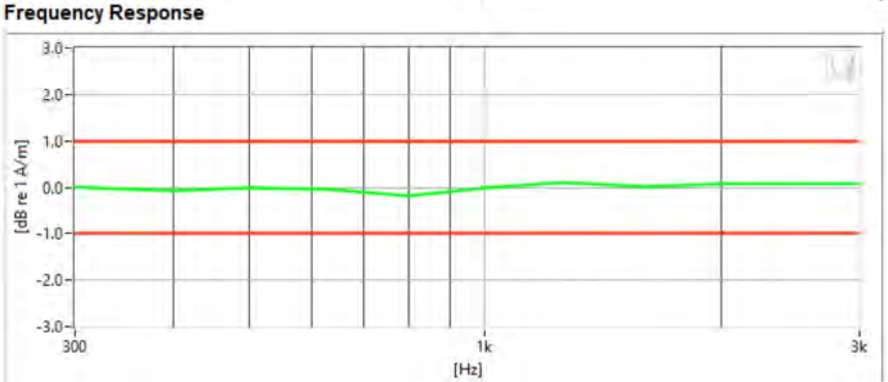
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024
- Helmholtz Coil – SN: SBI 1052; Calibrated: 08/06/2024

Noise Spectrum



Frequency Response



Results

Verification 1kHz Intensity	-10.202 dB	✔	Max/Min	-9.5/-10.5
Verification ABM2	-64.92 dB	✔	Maximum	-58.0
Frequency Response Margin	800m dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

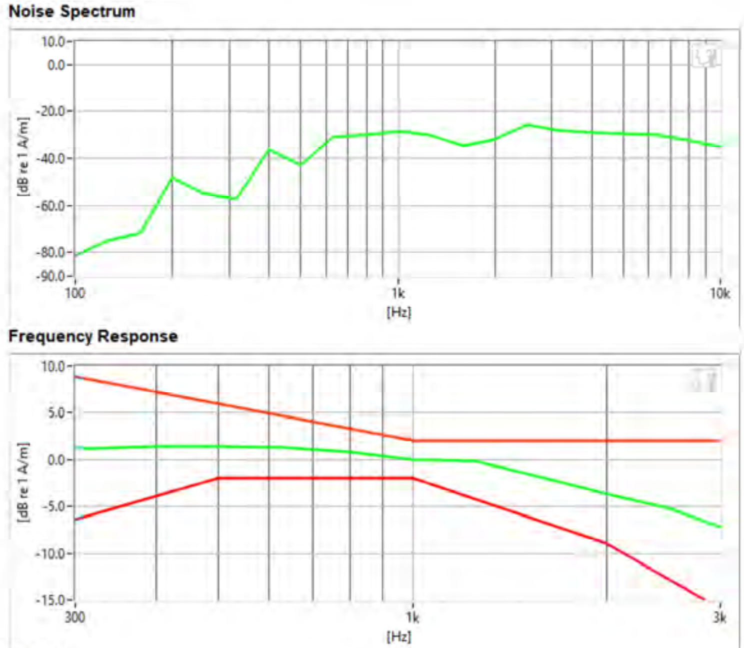
DUT: A3LSMG766U

Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

Equipment:
- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

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



Results

Desired ABM	9.53 dB	✔	Minimum	-18.0
Undesired ABM	-21.61 dB	✔	Maximum	0.0
SNNR	31.13 dB	✔	Minimum	20.0
Aligned Response - P.50	2 dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

DUT: A3LSMG766U

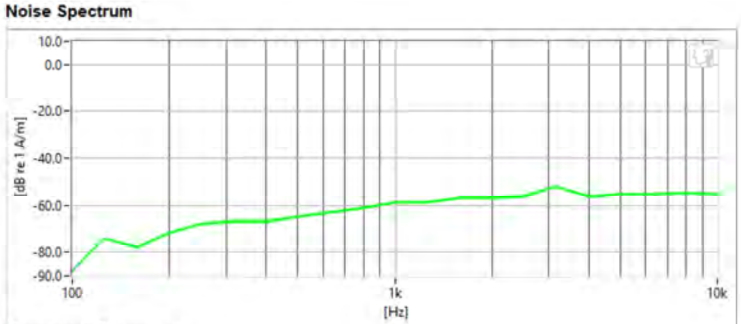
Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

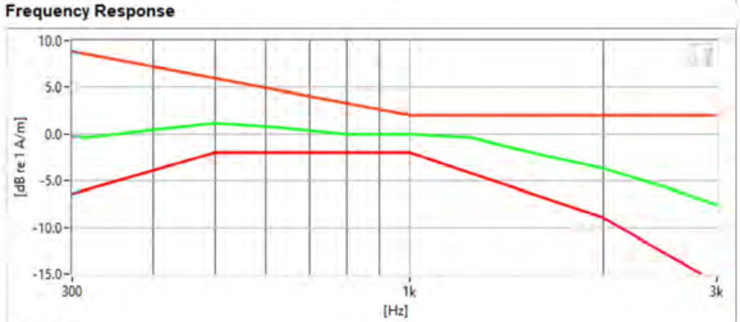
Equipment:
- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

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

Noise Spectrum



Frequency Response



Results

Desired ABM	7.83	dB	✔	Minimum	-18.0
Undesired ABM	-49.81	dB	✔	Maximum	0.0
SNNR	57.64	dB	✔	Minimum	20.0
Aligned Response - P.50	2	dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

DUT: A3LSMG766U

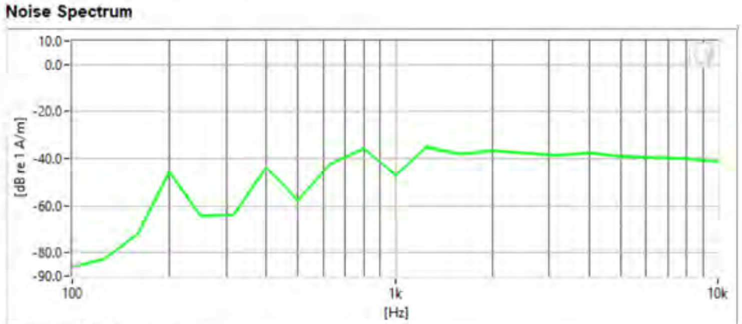
Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

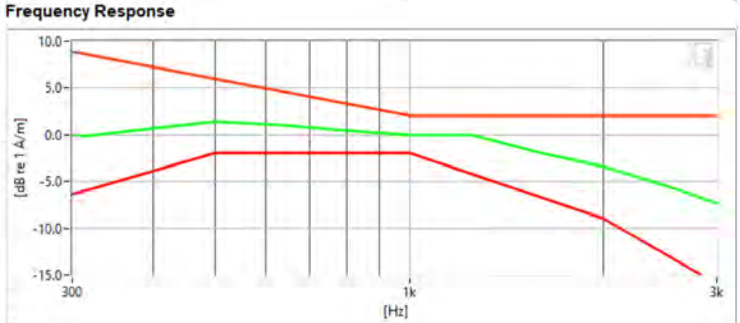
Equipment:
- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

Test Configuration:
- Mode: LTE Band 41
- Bandwidth: 20MHz
- Channel: 40620
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

Desired ABM	7.67 dB	✔	Minimum	-18.0
Undesired ABM	-29.6 dB	✔	Maximum	0.0
SNNR	37.27 dB	✔	Minimum	20.0
Aligned Response - P.50	2 dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

DUT: A3LSMG766U

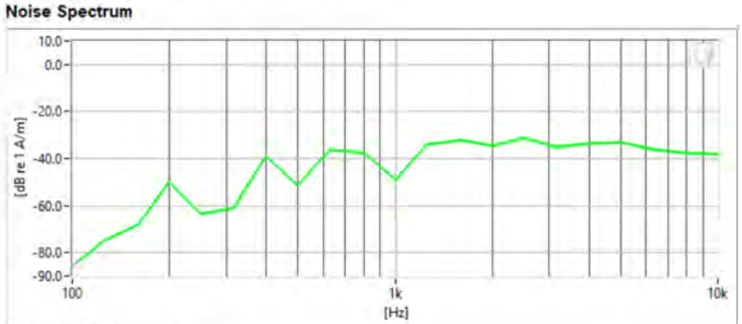
Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

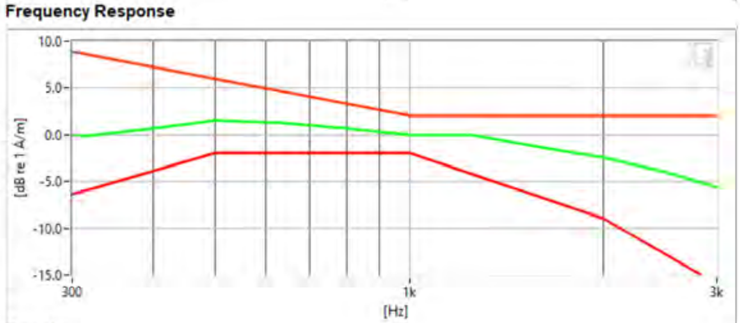
Equipment:
- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

Test Configuration:
- Mode: NR Band n41
- Bandwidth: 90MHz
- Channel: 528996
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

Desired ABM	7.93 dB	✔	Minimum	-18.0
Undesired ABM	-27.06 dB	✔	Maximum	0.0
SNNR	34.99 dB	✔	Minimum	20.0
Aligned Response - P.50	2 dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

DUT: A3LSMG766U

Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

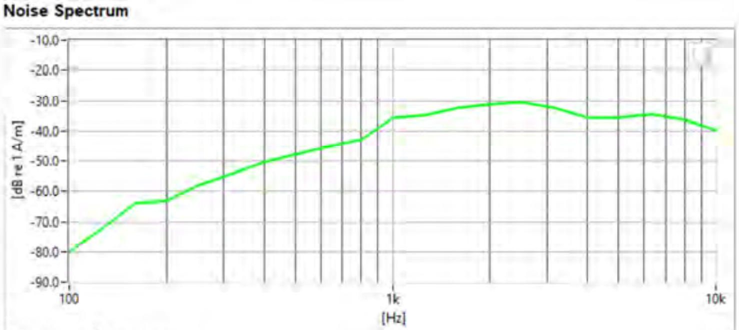
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

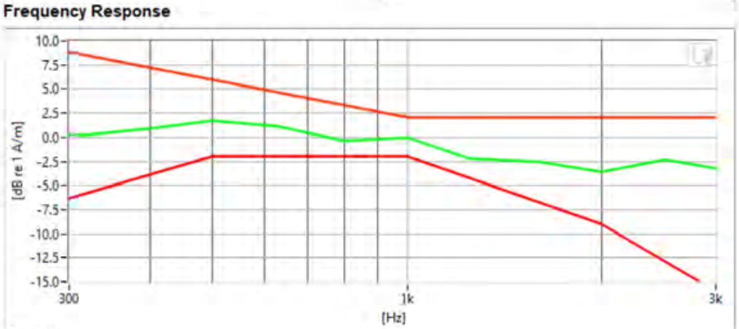
Test Configuration:

- VoIP Application: Google Meet
- Mode: 2.4GHz WIFI
- Standard: IEEE802.11b
- Channel: 11
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

Desired ABM	14.28	dB	✔	Minimum	-18.0
Undesire ABM	-27.57	dB	✔	Maximum	0.0
SNNR	41.85	dB	✔	Minimum	20.0
Aligned Response - P.50	1.66	dB	✔	Tolerance curves	Aligned Data

Element Hearing-Aid Compatibility Facility

DUT: A3LSMG766U

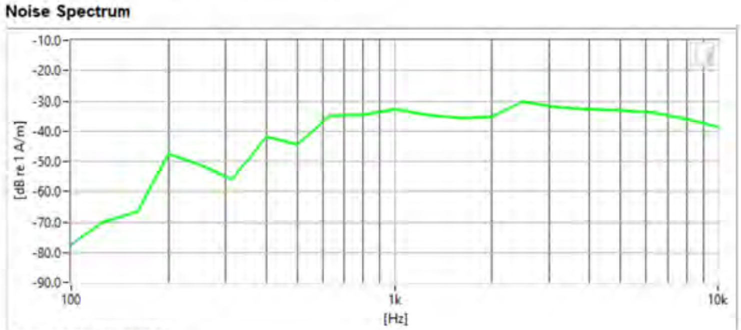
Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

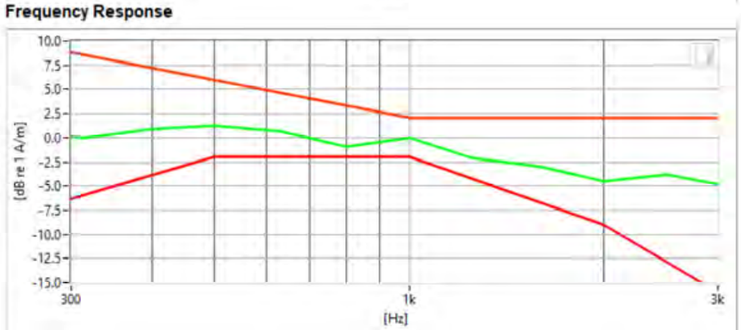
Equipment:
- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

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

Noise Spectrum



Frequency Response



Results

Desired ABM	13.66 dB	✔	Minimum	-18.0
Undesire ABM	-25.62 dB	✔	Maximum	0.0
SNNR	39.28 dB	✔	Minimum	20.0
Aligned Response - P.50	1.07 dB	✔	Tolerance curves	Aligned Data

2/13/2025

Element Hearing-Aid Compatibility Facility

DUT: A3LSMG766U

Type: Portable Handset
Serial: 4470M

Measurement Standard: ANSI C63.19

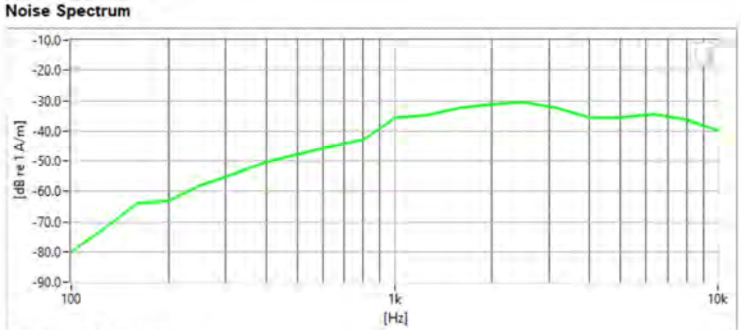
Equipment:

- Probe: Radial T-Coil Probe – SN: TEM-1128; Calibrated: 08/06/2024

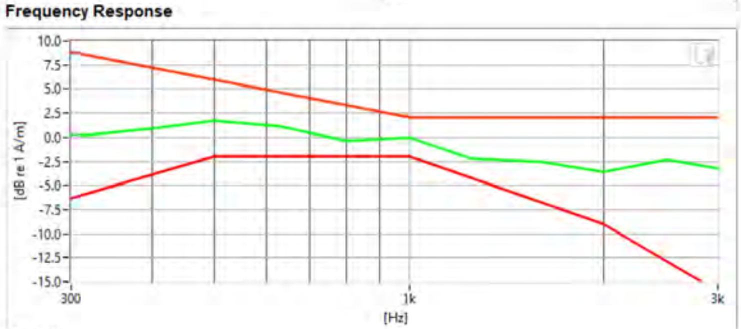
Test Configuration:

- VoIP Application: Google Meet
- Mode: 2.4GHz WIFI
- Standard: IEEE802.11b
- Channel: 11
- Speech Signal: ITU-T P.50 Artificial Voice

Noise Spectrum



Frequency Response



Results

Desired ABM	14.28 dB	✔	Minimum	-18.0
Undesire ABM	-27.57 dB	✔	Maximum	0.0
SNNR	41.85 dB	✔	Minimum	20.0
Aligned Response - P.50	1.66 dB	✔	Tolerance curves	Aligned Data

14. TEST DATA (SCAN MEASUREMENT)

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
178	373	20	26

Table 14-1
Worst-Case Scan Results for GSM
GSM 1900, CH.661, EFR: FR V2

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
481	676	26	26

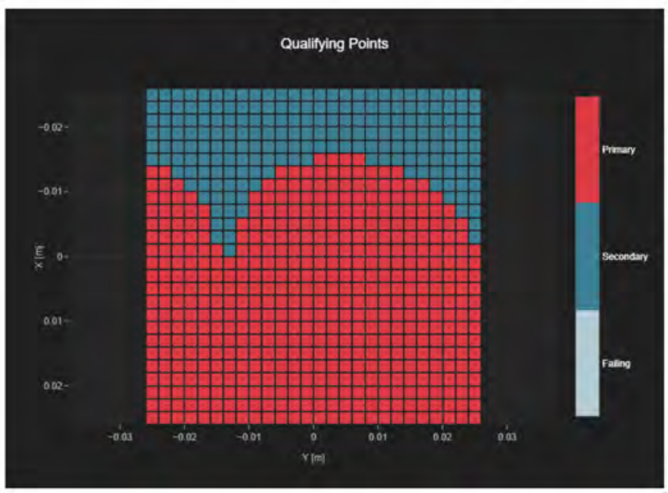


Table 14-2
Worst-Case Scan Results for UMTS
UMTS Band 2, CH.9400, AMR WB 6.60KBPS

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
196	393	25	26

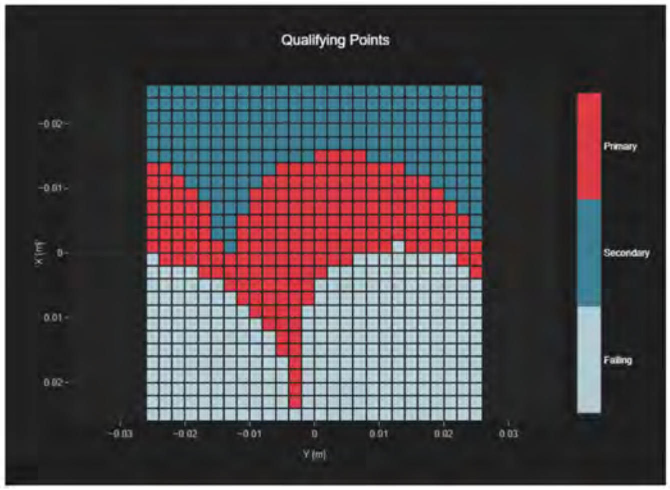


Table 14-3
Worst-Case Scan Results for LTE
VoLTE TDD Band 41 (PC3), ANT 4, CH.40620, AMR WB 6.60KBPS

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
246	444	18	26

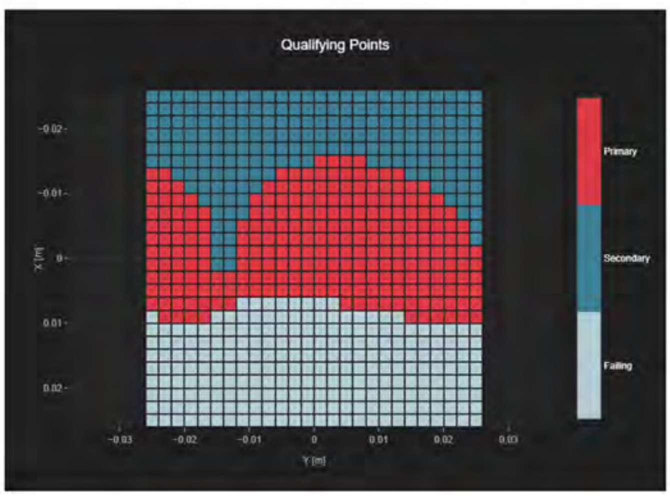


Table 14-4
Worst-Case Scan Results for NR
VoNR TDD Band n41 (PC2), CH.528996, AMR WB 6.60KBPS

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
308	503	24	26

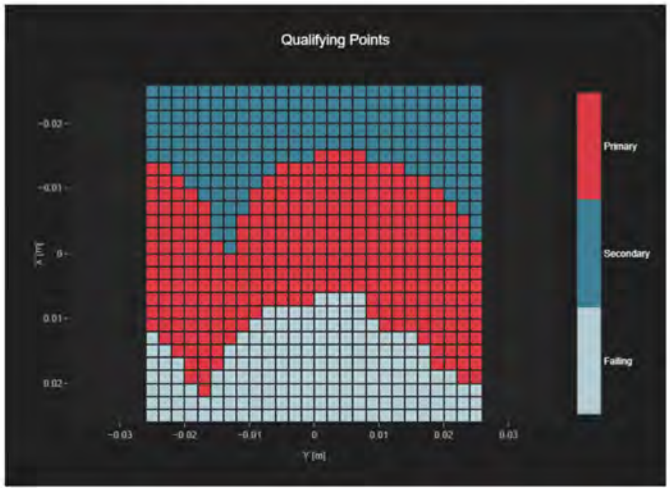


Table 14-6
Worst-Case Scan Results for WIFI
VoWIFI 2.4GHz, SISO, IEEE 802.11b, 20MHz, CH.11, AMR WB 6.60KBPS

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
469	621	26	26

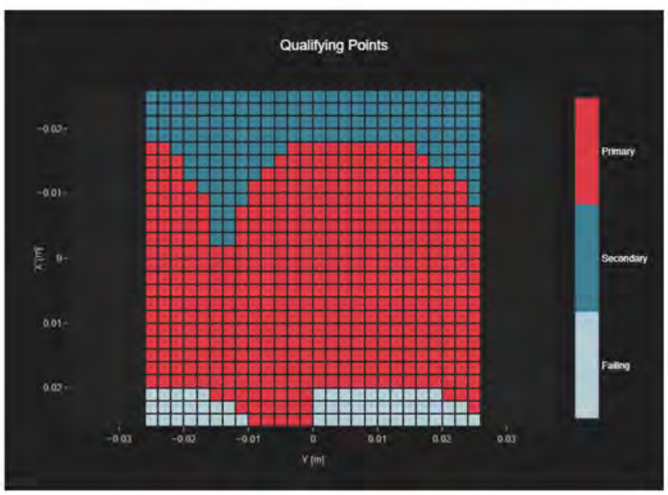


Table 14-8
Worst-Case Scan Results for OTT VoIP
EDGE1900, CH.661, OPUS 6KBPS

Primary Group Contiguous Point Count	Secondary Group Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse
327	479	22	26

Table 14-9
Worst-Case Scan Results for OTT VoIP
WIFI 2.4GHz, SISO, IEEE 802.11b, 20MHz, CH.11, OPUS 6KBPS

15. CALIBRATION CERTIFICATES

West Caldwell Calibration Laboratories Inc.

Certificate of Conformance

for

Radial T Coil Probe

Manufactured by: TEM CONSULTING
Model No: RADIAL T COIL PROBE
Serial No: TEM-1128
Calibration Recall No: 35292

Submitted By:

Customer: TAE WOO KIM
Company: Element Materials Technology Washington DC, LLC
Address: 7185 OAKLAND MILLS ROAD
COLUBIA MD 21046

√ TK 8/20/2024

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 COIL PROBE TEM CONSULTING

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 limit, L is the tolerance limit, and U95 is the expanded uncertainty. This minimizes the probability of false accept about less than 2.5%.
Measurements marked with (*) are not covered by the scope of accreditation.

The expanded uncertainty is based of the standard uncertainty multiplied by a coverage factor k=2 providing a level of confidence of approximately 95%. West Caldwell Calibration Laboratories' calibration control systems meets the requirements of 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: 06-Aug-24
Certificate Issue Date: 08-Aug-24
Certificate No: 35292 -4

QA Doc. #1051 Rev. 4.0 02/02/24

Certificate Page 1 of 1

ISO/IEC 17025

ACCREDITED
Calibration Lab. Cert. # 1533.01

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

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

ISO/IEC 17025
ACCREDITED
Calibration Lab. Cert. # 1533.01

REPORT OF CALIBRATION

for

TEM Consulting LP Radial T Coil Probe   Model No.: Radial T Coil Probe   Serial No.: TEM-1128
Company: Element Materials Technology Washington D.C., LLC.   I. D. No.: XXXX

Calibration results:

Probe Sensitivity measured with Helmholtz Coil

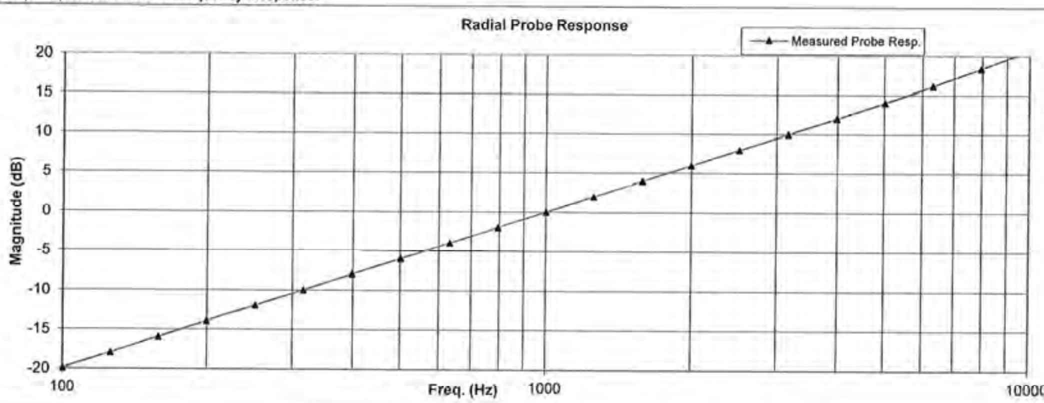
Helmholtz Coil;		
the number of turns on each coil;	10	No.
the radius of each coil, in meters;	0.204	m
the current in the coils, in amperes.;	0.08	A
Helmholtz Coil Constant;	6.57	A/m/V
Helmholtz Coil magnetic field;	5.27	A/m
Probe Sensitivity at	1000	Hz.
was	-59.67	dBV/A/m
	1.038	mV/A/m
Probe resistance	905	Ohms

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

Laboratory Environment:		
Ambient Temperature:	21.3	°C
Ambient Humidity:	49.2	% RH
Ambient Pressure:	99.350	kPa
Calibration Date:	6-Aug-2024	
Re-calibration Due:		
Report Number:	35292 -4	
Control Number:	35292	

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. 8.0 Feb. 08, 2024 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: 6-Aug-2024
Calibrated on WCCL system type 9700

Measurements performed by: ....
James Zhu

Rev. 8.0 Feb. 08, 2024 Doc. # 1038 HCRTEMC

Page 1 of 2

West Caldwell Calibration Laboratories Inc.
1575 State Route 96, Victor NY 14564
Tel. (585) 586-3900 FAX (585) 586-4327

Calibration Data Record

for

TEM Consulting LP Radial T Coil Probe Model No.: Radial T Coil Probe Serial No.: TEM-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	-59.67		
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	-19.9		
				126	-18.0		
				158	-16.0		
				200	-14.0		
				251	-12.0		
				316	-10.0		
				398	-8.0		
				501	-6.0		
				631	-4.0		
				794	-2.0		
			Ref. (0 dB)	1000	0.0		
				1259	2.0		
				1585	4.0		
				1995	6.0		
				2512	8.0		
				3162	10.0		
				3981	12.0		
				5012	14.0		
				6310	16.1		
				7943	18.3		
				10000	20.7		

Instruments used for calibration:			Date of Cal.	Traceability No.	Due Date
HP	34401A	S/N US360641	24-Jun-2024	,682636	31-Jul-2025
HP	34401A	S/N US361024	24-Jun-2024	,682636	31-Jul-2025
HP	33120A	S/N US360437	24-Jun-2024	,682636	31-Jul-2025
B&K	2133	S/N 1583254	25-Jun-2024	,682636	31-Jul-2025

Cal. Date: 6-Aug-2024 Tested by: James Zhu

Calibrated on WCCL system type 9700

 Rev. 8.0 Feb. 08, 2024 Doc. # 1038 HCRTEMC

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. AM1DV3-3079_Jan25

CALIBRATION CERTIFICATE

Object: AM1DV3 - SN: 3079

Calibration procedure(s): QA CAL-24.v4
Calibration procedure for AM1D magnetic field probes and TMFS in the audio range

Calibration date: January 10, 2025

TKV
2/22/25

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	27-Aug-24 (No. 40547)	Aug-25
Reference Probe AM1DV3	SN: 3000	25-Sep-24 (No. AM1DV3-3000_Sep24)	Sep-25
DAE4	SN: 781	16-Feb-24 (No. DAE4-781_Feb24)	Feb-25

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
AMCC	SN: 1050	01-Oct-13 (in house check Sep-24)	Sep-25
AMMI Audio Measuring Instrument	SN: 1062	26-Sep-12 (in house check Sep-24)	Sep-25

	Name	Function	Signature
Calibrated by:	Leif Klysner	Laboratory Technician	
Approved by:	Sven Kühn	Technical Manager	

Issued: January 10, 2025

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

[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.

AM1D probe identification and configuration data

Item	**AM1DV3** Audio Magnetic 1D Field Probe
Type No	SP AM1 001 BA
Serial No	**3079**

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)	**141.9°**	+/- 3.6 ° (k=2)
Sensor angle	(in DASY system)	**0.65°**	+/- 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%.

16. CONCLUSION

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

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

17. REFERENCES

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

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

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

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

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

6. Berger, H. S., "Compatibility Between Hearing Aids and Wireless Devices," Electronic Industries Forum, Boston, MA, May, 1997

7. Berger, H. S., "Hearing Aid and Cellular Phone Compatibility: Working Toward Solutions," Wireless Telephones and Hearing Aids: New Challenges for Audiology, Gallaudet University, Washington, D.C., May, 1997 (To be reprinted in the American Journal of Audiology).

8. Berger, H. S., "Hearing Aid Compatibility with Wireless Communications Devices, " IEEE International Symposium on Electromagnetic Compatibility, Austin, TX, August, 1997.

9. Bronaugh, E. L., "Simplifying EMI Immunity (Susceptibility) Tests in TEM Cells," in the 1990 IEEE International Symposium on Electromagnetic Compatibility Symposium Record, Washington, D.C., August 1990, pp. 488-491

10. Byme, D. and Dillon, H., The National Acoustics Laboratory (NAL) New Procedure for Selecting the Gain and Frequency Response of a Hearing Aid, Ear and Hearing 7:257-265, 1986.

11. Crawford, M. L., "Measurement of Electromagnetic Radiation from Electronic Equipment using TEM Transmission Cells, " U.S. Department of Commerce, National Bureau of Standards, NBSIR 73-306, Feb. 1973.

12. Crawford, M. L., and Workman, J. L., "Using a TEM Cell for EMC Measurements of Electronic Equipment," U.S. Department of Commerce, National Bureau of Standards. Technical Note 1013, July 1981.

13. EHIMA GSM Project, Development phase, Project Report (1st part) Revision A. Technical-Audiological Laboratory and Telecom Denmark, October 1993.

14. EHIMA GSM Project, Development phase, Part II Project Report. Technical-Audiological Laboratory and Telecom Denmark, June 1994.

15. EHIMA GSM Project Final Report, Hearing Aids and GSM Mobile Telephones: Interference Problems, Methods of Measurement and Levels of Immunity. Technical-Audiological Laboratory and Telecom Denmark, 1995.

16. HAMPIS Report, Comparison of Mobile phone electromagnetic near field with an upscaled electromagnetic far field, using hearing aid as reference, 21 October 1999.

17. Hearing Aids/GSM, Report from OTWIDAM, Technical-Audiological Laboratory and Telecom Denmark, April 1993.

18. IEEE 100, The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition.

19. Joyner, K. H, et. al., Interference to Hearing Aids by the New Digital Mobile Telephone System, Global System for Mobile (GSM) Communication Standard, National Acoustic Laboratory, Australian Hearing Series, Sydney 1993.

20. Joyner, K. H., et. al., Interference to Hearing Aids by the Digital Mobile Telephone System, Global System for Mobile Communications (GSM), NAL Report #131, National Acoustic Laboratory, Australian Hearing Series, Sydney, 1995.

21. Kecker, W. T., Crawford, M. L., and Wilson, W. A., "Contruction of a Transverse Electromagnetic Cell", U.S. Department of Commerce, National Bureau of Standards, Technical Note 1011, Nov. 1978.

22. Konigstein, D., and Hansen, D., "A New Family of TEM Cells with enlarged bandwidth and Optimized working Volume," in the Proceedings of the 7th International Symposium on EMC, Zurich, Switzerland, March 1987; 50:9, pp. 127-132.

23. Kuk, F., and Hjorstgaard, N. K., "Factors affecting interference from digital cellular telephones," Hearing Journal, 1997; 50:9, pp 32-34.

24. Ma, M. A., and Kanda, M., "Electromagnetic Compatibility and Interference Metrology," U.S. Department of Commerce, National Bureau of Standards, Technical Note 1099, July 1986, pp. 17-43.

25. Ma, M. A., Sreenivashiah, I. , and Chang, D. C., "A Method of Determining the Emission and Susceptibility Levels of Electrically Small Objects Using a TEM Cell," U.S. Department of Commerce, National Bureau of Standards, Technial Note 1040, July 1981.

26. McCandless, G. A., and Lyregaard, P. E., Prescription of Gain/Output (POGO) for Hearing Aids, Hearing Instruments 1:16-21, 1983

27. Skopec, M., "Hearing Aid Electromagnetic Interference from Digital Wireless Telephones, "IEEE Transactions on Rehabilitation Engineering, vol. 6, no. 2, pp. 235-239, June 1998.

28. Technical Report, GSM 05.90, GSM EMC Considerations, European Telecommunications Standards Institute, January 1993.

29. Victorian, T. A., "Digital Cellular Telephone Interference and Hearing Aid Compatibility—an Update," Hearing Journal 1998; 51:10, pp. 53-60

30. Wong, G. S. K., and Embleton, T. F. W., eds., AIP Handbook of Condenser Microphones: Theory, Calibration and Measurements, AIP Press.