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HEARING AID COMPATIBILITY

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

Date of Testing:
10/09/2023 - 10/22/2023
Test Site/Location:
Element Washington DC LLC,
Columbia, MD, USA
Test Report Serial No.:
1M2308210092-28-R1.A3L
Date of Issue:
11/1/2023

FCC ID:	**A3LSMS928U**
APPLICANT:	**SAMSUNG ELECTRONICS CO., LTD.**

Scope of Test:	Volume Control Testing
Application Type:	Certification
FCC Rule Part(s):	CFR §20.19(b)
HAC Standard/ Guidance:	ANSI C63.19-2019 ANSI/TIA-5050-2018 285076 D01 HAC Guidance v06 285076 D04 Volume Control v02 285076 D05 CG Interim Waiver DA 23-914 v01
DUT Type:	Portable Handset
Model:	SM-S928U
Additional Model(s):	SM-S928U1
Test Device Serial No.:	*Sample* [S/N: 0879M]

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

Note: This revised Test Report (S/N: 1M2308210092-28-R1.A3L) supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

This wireless portable device has been shown to be hearing-aid compatible, specified in ANSI/IEEE Std. C63.19-2019 and ANSI/TIA-5050-2018 and has been tested in accordance with the specified measurement procedures. Test results reported herein relate only to the item(s) tested. Hearing-Aid Compatibility is based on the assumption that all production units will be designed electrically identical to the device tested in this report. North American Bands only.

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

RJ Ortanez
Executive Vice President

ACCREDITED
CERT #2041.01

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1. INTRODUCTION

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

Compatibility Tests Involved:

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

- RF Electric-field emissions
- T-coil mode, magnetic-signal strength in the audio band
- T-coil mode, magnetic-signal frequency response through the audio band
- T-coil mode, magnetic-signal and noise articulation index
- T-coil mode, acoustic-signal conversational gain in the audio band
- T-coil mode, acoustic-signal frequency response through the audio band
- T-coil mode, acoustic-signal distortion through audio band
- Volume Control, receive volume control performance
- Volume Control, receive distortion and noise performance
- Volume Control, receive acoustic frequency response performance

The hearing aid may be measured for:

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

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

Figure 1-1 Hearing Aid *in-vitu*

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

2. DUT DESCRIPTION

FCC ID:	A3LSMS928U
Applicant:	Samsung Electronics Co., Ltd. 129, Samsung-ro, Maetan dong, Yeongtong-gu, Suwon-si Gyeonggi-do 16677, Korea
Model:	SM-S928U
Additional Model(s):	SM-S928U1
Serial Number:	0879M
HW Version:	REV1.0
SW Version:	S928U.001
Antenna:	Internal Antenna
DUT Type:	Portable Handset

I. LTE Band Selection

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

II. NR Band Selection

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

Table 2-1
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[1]	Yes: WIFI or BT	CMRS Voice	EFR
	1900					
UMTS	850	VD	Yes[1]	Yes: WIFI or BT	CMRS Voice	NB AMR, WB AMR
	1700					
	1900					
LTE (FDD)	680 (B71)	VD	Yes[1, 2]	Yes: NR, WIFI or BT	VoLTE	VoLTE: NB AMR, WB AMR, EVS
	700 (B12)					
	780 (B13)					
	790 (B14)					
	850 (B5)					
	850 (B26)					
	1700 (B4)					
	1700 (B66)					
	1900 (B2)					
	1900 (B25)					
	2300 (B30)					
	2500 (B7)					
LTE (TDD)	2600 (B41)	VD	Yes[1, 2]	Yes: NR, WIFI or BT	VoLTE	VoLTE: NB AMR, WB AMR, EVS
	2600 (B38)					
	3600 (B48)					
NR (FDD)	680 (n71)	VD	Yes[1, 2]	Yes: LTE, WIFI or BT	VoNR	VoNR: NB AMR, WB AMR, EVS
	700 (n12)					
	850 (n5)					
	850 (n26)					
	1700 (n70)					
	1700 (n66)					
	1900 (n2)					
	1900 (n25)					
	2300 (n30)					
	2500 (n7)					
NR (TDD)	2600 (n41)	VD	Yes[1, 2]	Yes: LTE, WIFI or BT	VoNR	VoNR: NB AMR, WB AMR, EVS
	2600 (n38)					
	3500 (n77, DoD)					
	3500 (n78, DoD)					
	3600 (n48)					
	3750 (n78)					
	3800 (n77)					
	24500 (n258)		No[3]			
	28000 (n261)					
	39000 (n260)					
WIFI	2450	VD	Yes[1, 2]	Yes: GSM, UMTS, LTE, or NR	VoWIFI	VoWIFI: NB AMR, WB AMR, EVS
	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[1, 2, 4]			
	6475 (U-NII 6)		No[5]			
	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. According to FCC guidance and waiver DA 23-914, all CMRS codecs supported by the model are tested for Conversational Gain.
2. According to FCC guidance and waiver DA 23-914, manufactur has chosen NB EVS 24.4KBPS and WB EVS 128KBPS audio codecs and bitrate supported on this device for Frequency Response and Distortion evaluation.
3. n258, n260, and n261 are currently outside the scope of ANSI C63.19 and FCC HAC regulations therefore they were not evaluated.
4. WIFI U-NII band 5 was evaluated for operations which are entirely below 6 GHz. Operations partially or entirely above 6 GHz were not evaluated due to equipment limitations and being outside of the current scope of ANSI C63.19 and FCC HAC regulations.
5. 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 PERFORMANCE CATEGORIES

I. Acoustic Coupling Requirements

According to ANSI C63.19-2019 §7, devices shall comply with ANSI/TIA-5050-2018 in order to comply with C63.19-2019. No additional requirements are imposed and no special allowances are made regarding testing to and compliance with ANSI/TIA-5050-2018.

II. ANSI/TIA-5050-2018 Volume Control

All Volume Control requirements (i.e., Volume Control, Distortion and Noise, and Frequency Response) shall be met for at least one volume control setting for narrowband as well as wideband (as applicable) per §5. All testing shall be performed with both a 2N mounting force and an 8N mounting force. The passing volume control setting may be different between narrowband and wideband tests as well as between 2N and 8N tests, but the setting may not change within a test in order to pass the separate performance criteria.

Note: The test data margins indicate a margin from the limit for compliance.

1. Receive Volume Control Performance

With a mounting force of 8N, the EUT shall have a Conversational Gain of ≥18dB per §5.1.1, and with a mounting force of 2N, the EUT shall have a Conversational Gain of ≥6dB per ANSI/TIA-5050-2018 §5.1.1.

2. Receive Distortion and Noise Performance

With a mounting force of 8N and 2N, the Pulsed Noise Signal-to-Distortion Ratio (PN-SDNR) of the stimulus signal to the 100Hz to 8kHz total distortion and noise shall be ≥20dB when tested over the applicable 1/3 octave band center frequencies per ANSI/TIA-5050-2018 §5.2.1. For narrowband, the applicable 1/3 octave band center frequencies are those from 400Hz to 3.15kHz; for wideband, the applicable 1/3 octave band center frequencies are those from 250Hz to 5kHz.

3. Receive Acoustic Frequency Response Performance

With a mounting force of 8N and 2N, the receive frequency response, as measured at the DRP in 1/12 octave bands and after translation to the diffuse field or free field, shall fall between the applicable upper and lower limits per ANSI/TIA-5050-2018 §5.3.1. See below for narrowband limits (Table 3-1 and Figure 3-1) and wideband limits (Table 3-2 and Figure 3-2).

Table 3-1
Narrowband Receive Frequency Response Limits

Lower Limit Frequency (Hz)	Lower Limit (dB)	Upper Limit Frequency (Hz)	Upper Limit (dB)
300	-6	100	+6
3400	-6	4000	+6

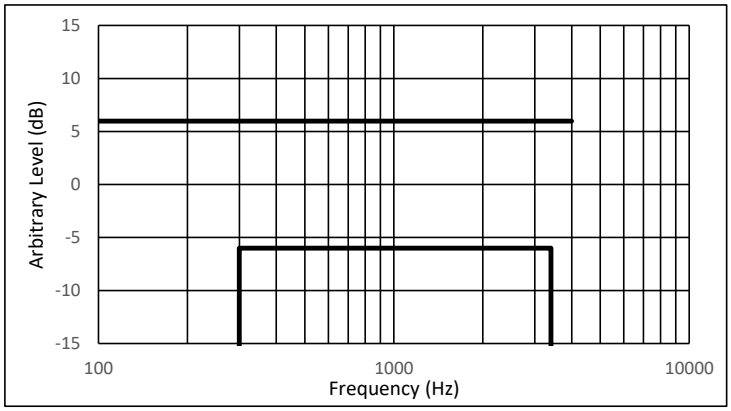


Figure 3-1
Narrowband Receive Frequency Response Limits

Table 3-2
Wideband Receive Frequency Response Limits

Lower Limit Frequency (Hz)	Lower Limit (dB)	Upper Limit Frequency (Hz)	Upper Limit (dB)
200	-10	100	+6
300	-6	1000	+6
5000	-6	2000	+8
6000	-12	8000	+8

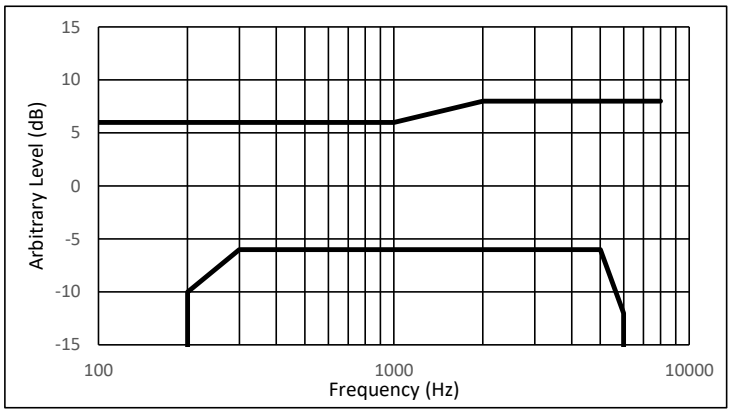


Figure 3-2
Wideband Receive Frequency Response Limits

4. METHOD OF MEASUREMENT

I. Test Setup

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

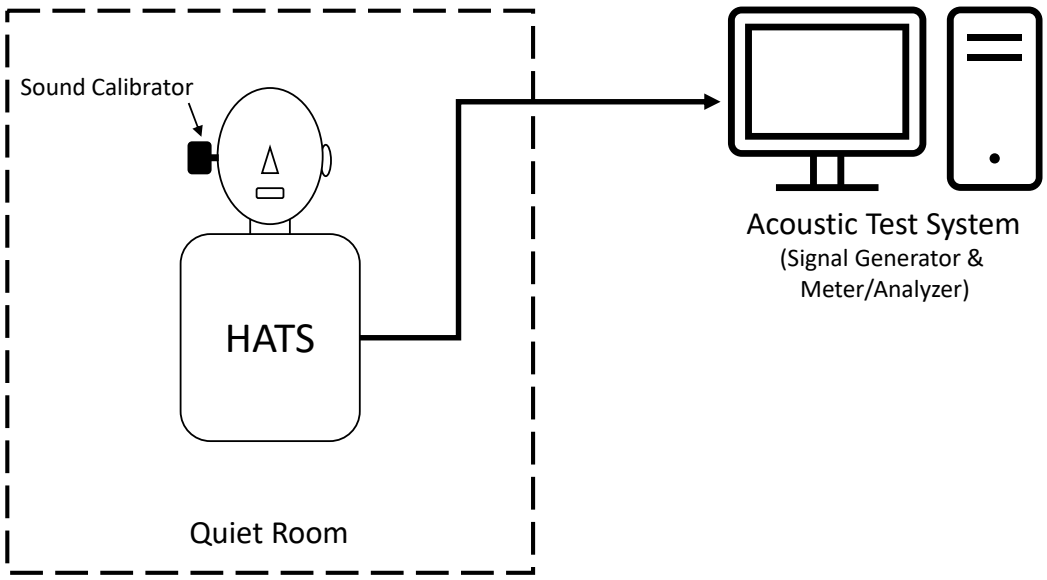


Figure 4-1
Verification Setup with Sound Calibrator

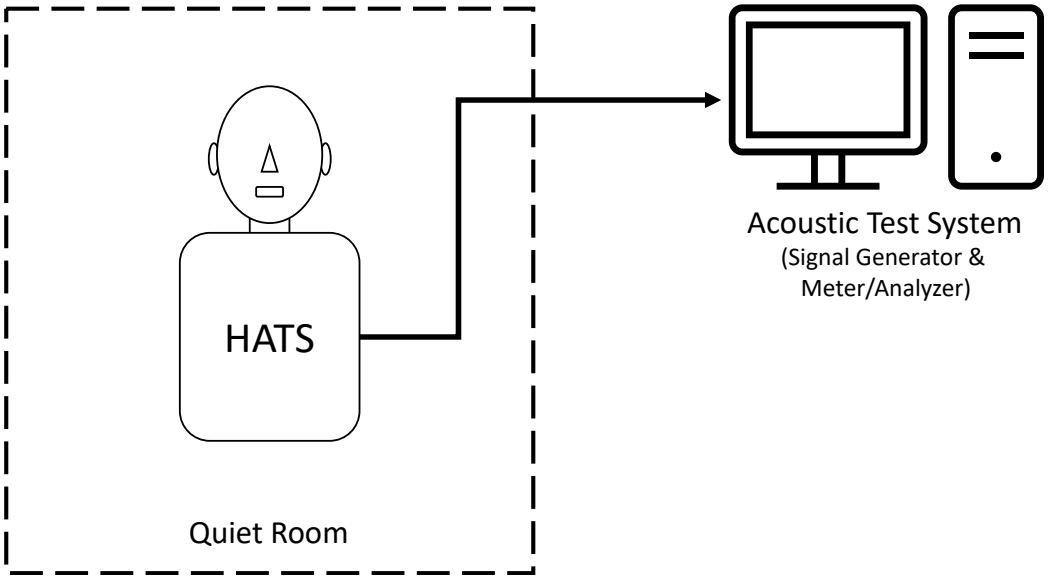


Figure 4-2
Ambient Noise Verification Setup

II. Head and Torso Simulator

Manufacturer:	Brüel & Kjær
Model:	Type 4128-D
Frequency Response:	Conforms to ITU-T Rec. P.58 up to 16 kHz
Ear Simulator:	ITU-T Rec. P.57 Type 3.3-based calibrated ear simulator complying with ITU-T Rec. P.57
Ear Simulator Output:	7-core, 3 m cable terminated with a Lemo® (1B) plug
Pressure-field Response:	±1 dB from 5 Hz to 7 kHz ±3 dB from 3.15 Hz to 20 kHz
Typical Noise Level	19 dBA at DRP
Pinna Simulator:	Compliant with ITU-T Rec. P.58
Total Head and Torso Height:	695mm
HATS Dimensions:	Main dimensions comply with the dimensional requirements of ITU-T Rec. P.58
Handset Positioner:	Brüel & Kjær Type 4606
Positioner Angles:	Variable positions; ∠A adjustable from +15° to +35°, ∠B adjustable from +30° to –10°, ∠C adjustable from +20° to –20°; 0.5° resolution
Applied Ear Force:	Mounting force can be adjusted from 0 to 18 N

Figure 4-3
Heat and Torso Simulator
(with Handset Positioner)

III. IEEE Std 269 Uncompressed Real Male Speech

Manufacturer:	IEEE
Active Frequency Range:	100 Hz – 8 kHz
Stimulus Type:	Multi-talker speech signal, four male speakers
Single Sample Duration:	12 seconds
Activity Level:	84%

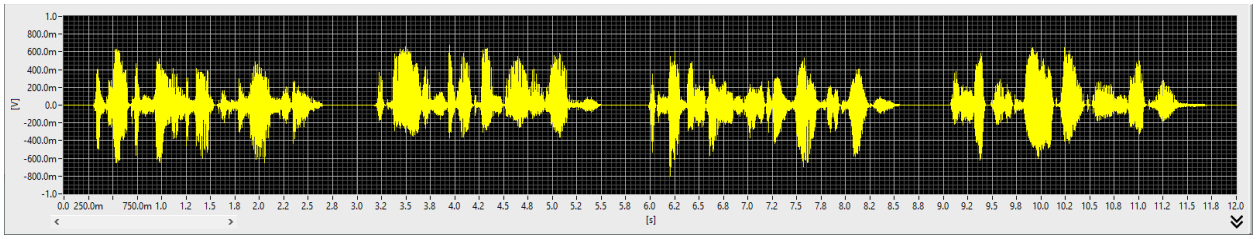


Figure 4-4
Temporal Characteristic of full IEEE 269

Volume Control Measurement Block Diagrams:

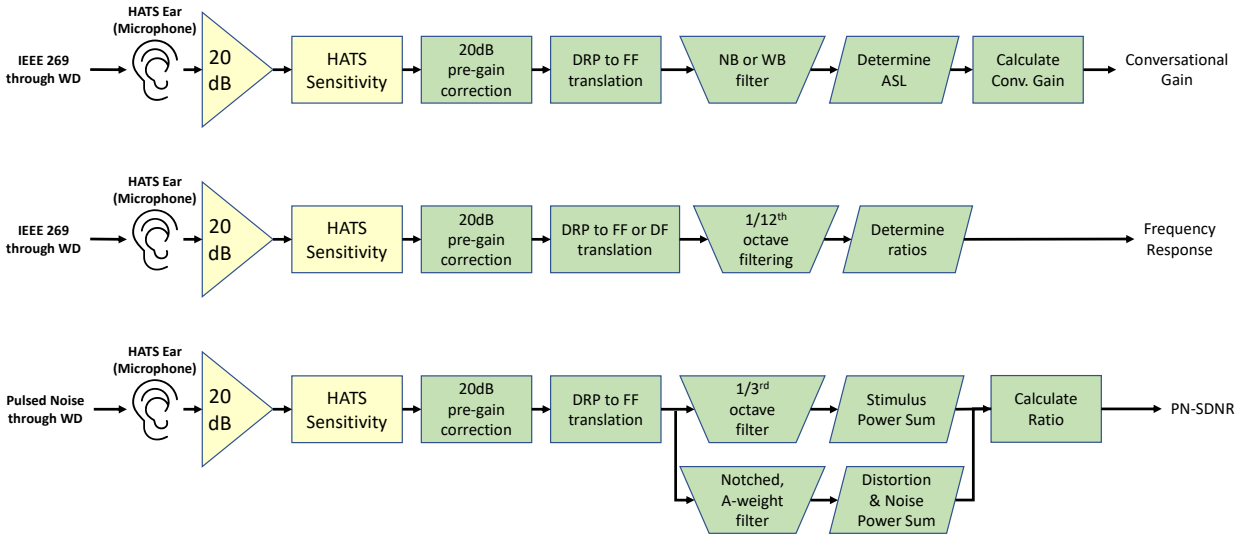


Figure 4-5 Acoustic Measurement Processing Steps

IV. Test Procedure

1. Ambient Noise Check per ANSI/TIA-5050-2018 §3.1 (See Figure 4-2)
   a. Ambient noise was monitored using a Real-Time Analyzer between 100-10,000 Hz with 1/12 octave filtering.
   b. "A-weighting" was applied to the measurements per the definition of a "quiet room" in ANSI/TIA-5050-2018. Below is the verification of the system processing A-weighting between system input to output within 0.5 dB of the theoretical result:

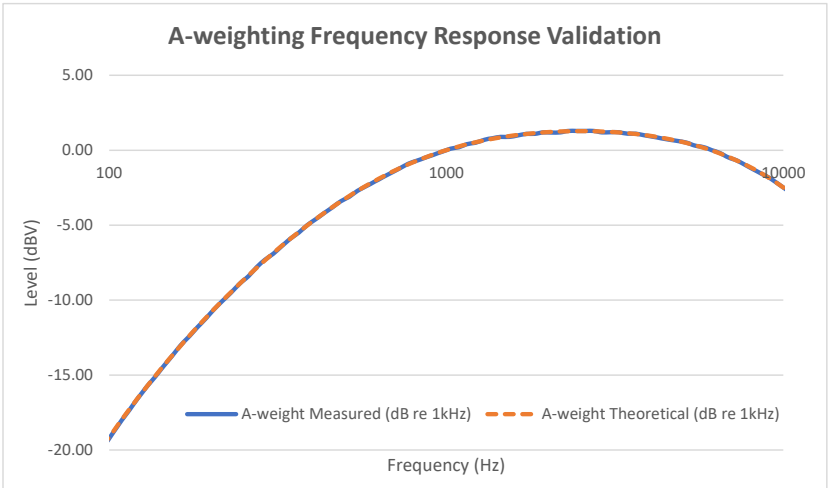


Figure 4-6
A-weighting Frequency Response Validation

Table 4-1
A-weighting Frequency Response Validation

f (Hz)	A-weight Measured (dB re 1kHz)	A-weight Theoretical (dB re 1kHz)	Deviation (dB)	f (Hz)	A-weight Measured (dB re 1kHz)	A-weight Theoretical (dB re 1kHz)	Deviation (dB)
97.2	-19.63	-19.54	-0.09	1030	0.10	0.09	0.01
103	-18.81	-18.74	-0.07	1090	0.20	0.25	-0.05
109	-18.01	-17.97	-0.04	1150	0.40	0.38	0.02
115	-17.31	-17.26	-0.05	1220	0.50	0.52	-0.02
122	-16.51	-16.50	-0.01	1300	0.70	0.66	0.04
130	-15.71	-15.70	-0.01	1370	0.80	0.76	0.04
137	-15.11	-15.06	-0.05	1450	0.89	0.85	0.04
145	-14.41	-14.38	-0.03	1540	0.89	0.94	-0.05
154	-13.71	-13.68	-0.03	1630	0.99	1.02	-0.03
163	-13.01	-13.04	0.03	1730	1.09	1.08	0.01
173	-12.40	-12.38	-0.02	1830	1.09	1.14	-0.05
183	-11.80	-11.77	-0.03	1940	1.19	1.18	0.01
194	-11.20	-11.16	-0.04	2050	1.18	1.22	-0.04
205	-10.60	-10.60	0.00	2180	1.19	1.24	-0.05
218	-10.00	-9.98	-0.02	2300	1.29	1.26	0.03
230	-9.50	-9.46	-0.04	2440	1.29	1.27	0.02
244	-8.90	-8.90	0.00	2590	1.29	1.27	0.02
259	-8.40	-8.35	-0.05	2740	1.29	1.26	0.03
274	-7.80	-7.84	0.04	2900	1.19	1.24	-0.05
290	-7.30	-7.35	0.05	3070	1.20	1.22	-0.02
307	-6.90	-6.86	-0.04	3250	1.20	1.18	0.02
325	-6.40	-6.39	-0.01	3450	1.10	1.13	-0.03
345	-5.90	-5.90	0.00	3650	1.10	1.08	0.02
365	-5.50	-5.46	-0.04	3870	1.00	1.01	-0.01
387	-5.00	-5.02	0.02	4100	0.90	0.93	-0.03
410	-4.60	-4.59	-0.01	4340	0.80	0.84	-0.04
434	-4.20	-4.19	-0.01	4600	0.70	0.73	-0.03
460	-3.80	-3.79	-0.01	4870	0.61	0.61	0.00
487	-3.40	-3.42	0.02	5160	0.51	0.48	0.03
516	-3.10	-3.05	-0.05	5460	0.31	0.33	-0.02
546	-2.70	-2.71	0.01	5790	0.21	0.16	0.05
579	-2.40	-2.37	-0.03	6130	0.01	-0.02	0.03
613	-2.10	-2.05	-0.05	6490	-0.19	-0.22	0.03
649	-1.80	-1.75	-0.05	6880	-0.49	-0.45	-0.04
688	-1.50	-1.47	-0.03	7290	-0.69	-0.70	0.01
729	-1.20	-1.20	0.00	7720	-0.99	-0.97	-0.02
772	-0.90	-0.94	0.04	8180	-1.30	-1.26	-0.04
818	-0.70	-0.71	0.01	8660	-1.59	-1.58	-0.01
866	-0.50	-0.49	-0.01	9170	-1.89	-1.92	0.03
917	-0.30	-0.28	-0.02	9720	-2.29	-2.30	0.01
972	-0.10	-0.09	-0.01	10300	-2.69	-2.70	0.01

c. The ambient room noise is a power sum of the A-weighted spectrum from 100-10,000 Hz. To verify the power sum measurement, a power sum over the full band was measured and verified to track with the source level. Therefore, the setup in this step was used to verify the power sum post-processing for measurements. See below block diagram:

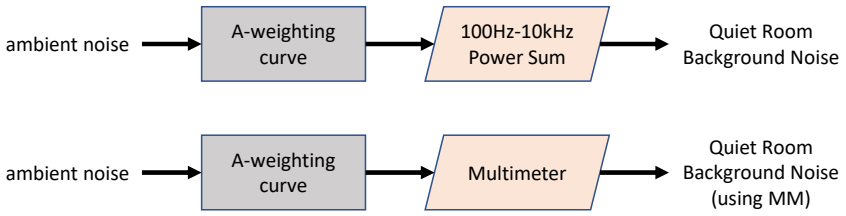


Figure 4-7
Power Sum Validation Block Diagram

The power summed output results for a known input were compared to the multi-meter results to verify any deviation in the post-processing implemented with the power-sum.

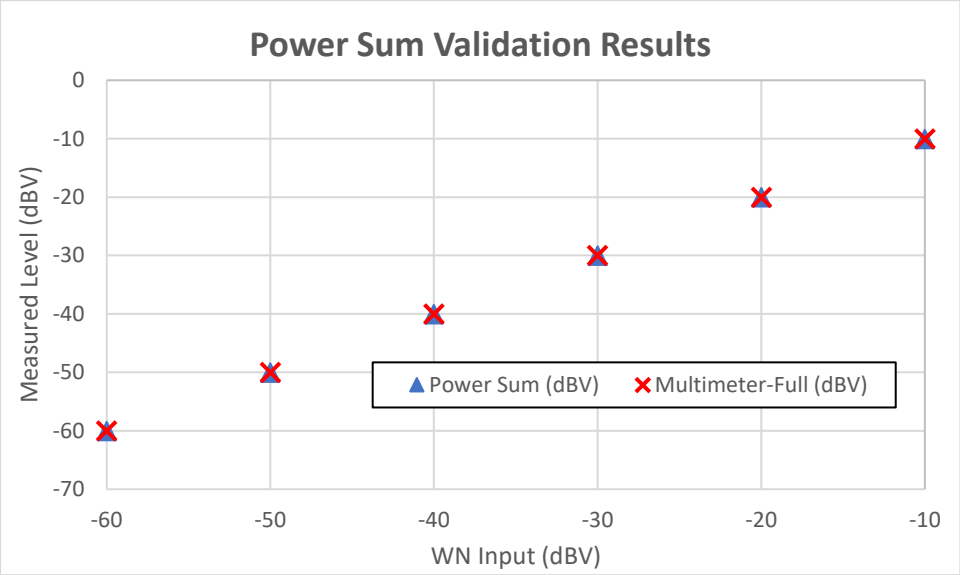


Figure 4-8
Power Sum Validation Results

Table 4-2
Power Sum Validation Results

WN Input (dBV)	Power Sum (dBV)	Multimeter-Full (dBV)	Dev (dB)
-60	-60.05	-60.03	0.02
-50	-50.04	-50.03	0.01
-40	-40.04	-40.02	0.02
-30	-30.04	-30.02	0.02
-20	-20.05	-20.03	0.02
-10	-10.05	-10.03	0.02

d. The maximum room noise inside the quiet room was recorded and verified to be less than or equal to 40dBA.

2. Measurement System Validation (See Figure 4-1)
   a. The measurement system including the HATS, pre-amplifier and acquisition system were validated as an entire system to ensure the reliability of test measurements.
   b. HATS Sensitivity Verification
   A pure tone of 1kHz was applied into the HATS ear (microphone) using a calibrated sound calibrator. The sound calibrator generates an expected sound pressure level of 97.1dBSPL at the HATS ear which was used to verify the measured signal from the HATS. This measured value was verified to be within ±0.2dB of the 97.1dBSPL expected value (see Page 29).

3. Measurement Test Setup
   a. Positioning DUT in HATS

i. According to ANSI/TIA-5050-2018 §4.2, a HATS which is ITU-T P.58 compliant and an ear simulator which is ITU-T P.57 type 3.3 compliant are used for Volume Control testing.
ii. Per ANSI/TIA-5050-2018 §4.3, the DUT is positioned on the HATS in the standard test position according to IEEE Std 269 or, alternatively, a recommended test position specified by the manufacturer. Manufacturer recommended positions must comply with the recommended test position requirements in IEEE Std 269 and, if used, are noted in this report.
iii. The DUT is mounted such that a certain force, in Newtons, is applied when the DUT is placed against the artificial pinna. ANSI/TIA-5050-2018 specifies a mounting force of either 2N or 8N, depending on the test. Mounting force is indicated for each test in this report.

b. Speech Signal Setup and Analysis
i. For testing in this report, the test signal is the uncompressed real male speech as published with IEEE Std 269 unless otherwise specified.
ii. The test signal is used with an Active Speech Level (ASL) of -20dBm0, and analysis is performed with 1/12 octave bands averaged over one complete sequence of the test signal unless otherwise specified.
iii. The acoustic listener reference point for testing is the Free Field (FF) for Conversational Gain and PN-SDNR measurements. For Frequency Response (FR) measurements, the acoustic listener reference point is either the Free Field (FF) or the Diffuse Field (DF); the chosen acoustic listener reference point for FR measurements in this report is indicated for each test.
iv. Per the Spring 2021 TCB Workshop, all supported audio voice codecs are tested for the DUT. For each codec, narrowband and wideband modes are tested if supported. For narrowband modes, a source coding bit-rate of 12.2 kbps, or the closest available setting, is used. For wideband modes, a source coding bit-rate of 12.65 kbps, or the closest available setting, is used.

c. DUT Radio Configuration
i. Each supported codec may be tested with any air interface which supports the codec being tested. Air interfaces used for testing in this report are noted with each test.

4. Measurement Data Analysis
a. Conversational Gain
i. With the DUT at its maximum volume control setting and tone control set such that the DUT meets the FR requirements, the test signal is applied to the DUT, and the resulting acoustic output is measured at the Drum Reference Point (DRP). A lower volume setting may be used if needed to meet the PN-SDNR requirements.
ii. The appropriate post processing is applied according to the system processing chain shown in Figure 4-5, and the Conversational Gain is determined.
iii. Conversational Gain is tested with both 8N and 2N mounting force.

b. PN-SDNR
i. The DUT is tested for distortion using PN-SDNR which is the ratio of the signal power to the full, A-weighted distortion and noise power of the DUR output (in dB).
ii. The pulsed noise stimulus signal is a combination of the real speech test signal followed by a series of pink noise pulses from a 1/3 octave band. A stimulus signal is generated for each 1/3 octave band centered within the applicable frequency range for either narrowband or wideband.
iii. Each stimulus signal is applied to the DUT, and the resulting acoustic output is measured at the DRP.

iv. The appropriate post processing is applied according to the system processing chain shown in Figure 4-5, and the PN-SDNR is determined by subtracting the full, A-weighted distortion and noise power, from the signal power, in This process is repeated to determine ethe PN-SDNR for all applicable 1/3 octave band center frequencies.
v. PN-SDNR is tested with both 8N and 2N mounting force and may be repeated at volume levels below maximum if needed to get passing results. Note that Conversational Gain must still receive passing results while at the lower volume level if such a lower level is used for PN-SDNR compliance.

c. Frequency Response
   i. Frequency response is measured with respect to the appropriate curves from either Figure 3-1, for narrowband modes, or Figure 3-2, for wideband modes. The measurement is taken over one full sequence of the test signal, although a delay was configured in the measurement process of the stimulus to ensure handset vocoder latency effects and echo cancellation devices (if any) were appropriately stabilized during measurements.
   ii. The appropriate post processing is applied according to the system processing chain shown in Figure 4-5, and the FR is determined. All 1/12 octave band center frequencies were plotted and aligned with respect to the applicable mask in a floating, or best fit, fashion.
   iii. FR is tested with both 8N and 2N mounting force and may be repeated with tone control settings other than default if needed to get passing results. Note that Conversational Gain must still receive passing results while using the non-default tone control settings if such non-default settings are used for FR compliance.

d. Speech Signal Setup to Base Station Simulator
   i. See Section 6 and 8 for more information regarding CMW500 audio level settings for Voice Over LTE (VoLTE) and Voice Over WIFI (VoWIFI) testing.
   ii. See Section 7 for more information regarding CMX500 audio level settings for Voice Over NR (VoNR).

e. WD Radio Configuration Selection
   i. The device was chosen to be tested in the default test configuration (See Section 5 for more information regarding worst-case configurations for GSM and UMTS. LTE configuration information can be found in Section 6. NR configuration information can be found in Section 7. WIFI configuration information can be found in Section 8.)

V. Test Setup

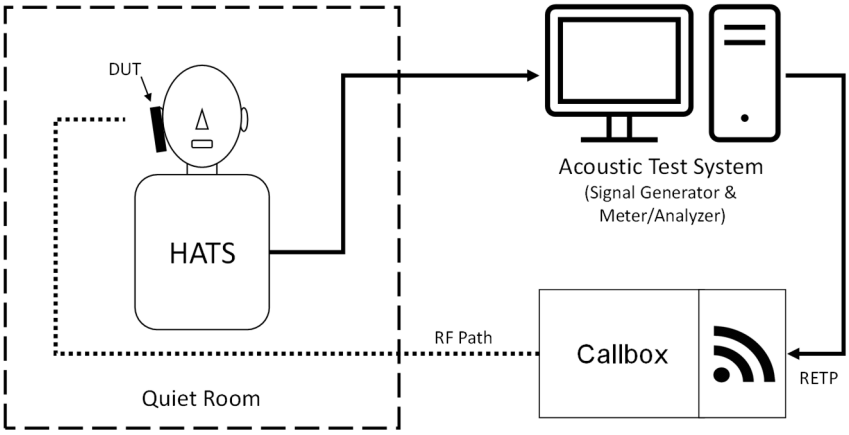


Figure 4-9
Volume Control Test Setup

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

VI. Deviation from ANSI/TIA-5050-2018 Test Procedure

Deviation from ANSI/TIA-5050-2018 Test Procedure to indicate guidance in FCC HAC waiver was followed.

VII. Air Interface Technologies Tested

According to ANSI/TIA-5050-2018, any air interface which support voice capabilities over a managed CMRS or pre-installed OTT VoIP applications may be chosen for Volume Control testing. According to the Spring 2021 TCB Workshop, all voice codecs supported by the DUT must be tested for Volume Control. The air interfaces used during testing were chosen such that all voice codecs supported by the DUT were able to be tested. See Table 2-1 for more details regarding which modes were tested.

VIII. Wireless Device Channels and Frequencies

1. 2G/3G Modes

The frequencies listed in the table below are those that lie in the center of the bands used for cellular telephony. The middle channel for each supported band was tested to confirm that results between bands are substantially similar. More information on default test configuration chosen for testing can be found in Section 5.

Table 4-3
Center Channels and Frequencies

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

2. 4G (LTE) Modes

The middle channel for every band was tested for conversational gain to confirm that the band configuration for VoLTE over IMS does not substantially affect the results. The default band was additionally tested for Frequency Response and Distortion. More information on default LTE test configuration chosen for testing can be found in Section 6. See Table 10-4 for full volume control evaluation.

3. 5G (NR) Modes

The middle channel for every band was tested for conversational gain to confirm that the band configuration for VoNR over IMS does not substantially affect the results. The default band was additionally tested for Frequency Response and Distortion. More information on default NR test configuration chosen for testing can be found in Section 7. See Table 10-5 for full volume control evaluation.

4. WIFI

The middle channel for each IEEE 802.11 standard was tested for conversational gain to confirm that the standard and data rate configuration for VoWIFI over IMS does not substantially affect the results. The 2.4GHz IEEE802.11b was additionally tested for Frequency Response and Distortion. More information on default WIFI test configuration chosen for testing can be found in Section 8. See Table 10-6 for full volume control evaluation.

IX. Test Flow

The flow diagram below was followed:

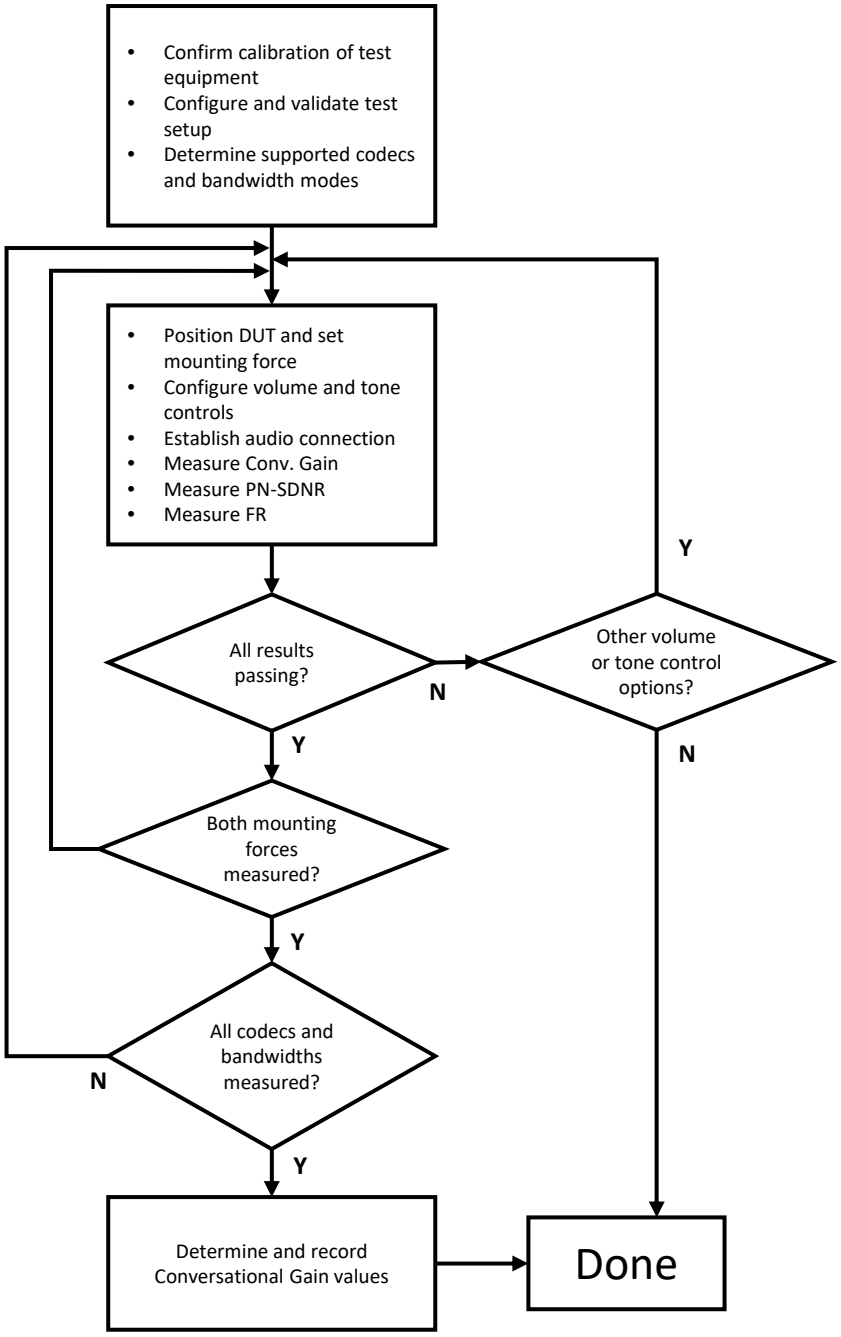


Figure 4-10
C63.19 Volume Control Test Process

5. FCC 2G & 3G MEASUREMENTS

I. GSM Test Configurations

1. Band Configuration

An investigation was performed to ensure the GSM band used for testing does not substantially affect the measurement results. GSM EFR FR V1 codec was used for this evaluation. The effects of band configuration were found to be independent of radio configuration; therefore, only one radio configuration was used for this investigation. See below table for comparisons between different bands:

Table 5-1
GSM Results by Band

Mode	Channel	HAC Mode	Mounting Force (N)	Traffic Mode	Codec Bandwidth	Volume Level	Ambient Noise (dBA)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
GSM850	190	On	2	FR V1	NB	MAX -1	33.08	18.53	6.00	12.53	Pass
GSM1900	661	On	2	FR V1	NB	MAX -1	33.08	18.57	6.00	12.57	Pass

- Mute off; Backlight off; Max Volume-1; Max Contrast
- Power Control Bits = GSM850: PCL=0, GSM1900: PCL=0;

II. UMTS Test Configurations

1. Radio Configuration

An investigation was performed to ensure that UMTS band used for testing does not substantially affect the measurement results. NB AMR 4.75KBPS, 13.6kbps SRB was used for this evaluation. The effects of band configuration were found to be independent of radio configuration; therefore, only one radio configuration was used for this investigation. See below table for comparisons between different bands:

Table 5-2
UMTS Results by Radio Configuration

Mode	Channel	HAC Mode	Mounting Force (N)	Codec Bandwidth	Codec Bitrate (kbps)	Volume Level	Ambient Noise (dBA)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
UMTS V	4183	On	2	NB	4.75	MAX -1	33.08	20.24	6.00	14.24	Pass
UMTS IV	1412	On	2	NB	4.75	MAX -1	33.08	20.28	6.00	14.28	Pass
UMTS II	9400	On	2	NB	4.75	MAX -1	33.08	19.45	6.00	13.45	Pass

- Mute off; Backlight off; Max Volume-1; Max Contrast
- Power Control Bits = "All Up"

6. 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 Volume Control measurements is a CMW500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server.

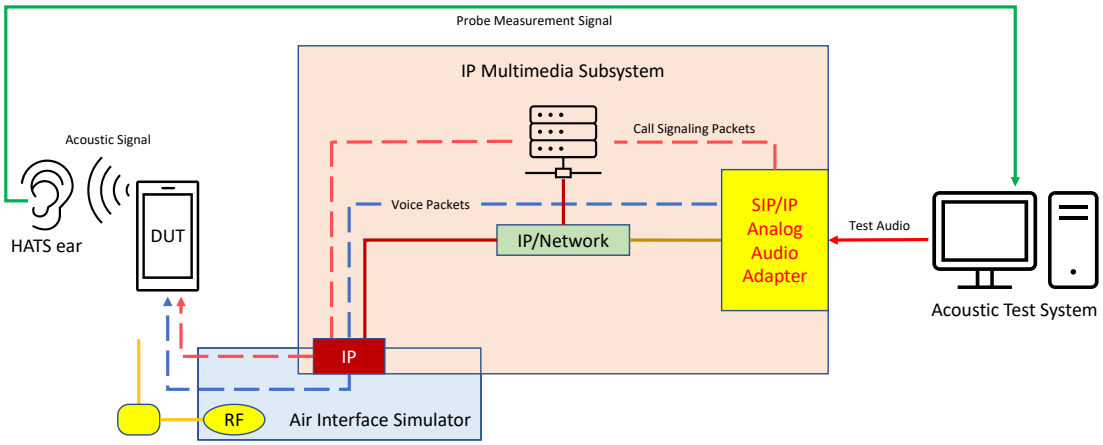


Figure 6-1
Test Setup for VoLTE over IMS Volume Control Measurements

2. Audio Level Settings

According to ANSI/TIA-5050-2018, the appropriate audio level to be used for VoLTE over IMS Volume Control testing is -20dBm0 (ASL) and shall be used for the normal speech input level. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -20dBm0 (ASL) speech input level to the DUT for the VoLTE over IMS connection.

II. DUT Configuration for VoLTE over IMS Volume Control Testing

1. Radio Configuration

An investigation was performed to ensure the modulation and RB configuration used for testing do not substantially affect the measurement results. The effects of modulation and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. 16QAM, 1RB, 0RB offset was used as the default testing configuration for the handset given the results of this investigation. See below table for comparison between different radio configurations:

Table 6-1
VoLTE over IMS Results by Radio Configuration

Mode	RF Bandwidth (MHz)	Radio Configuration	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Value (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	Distortion Margin (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
LTE Band 66	20	QPSK/1RB/0RB offset	132322	On	2	EVS	WB	128	MAX -1	DF	31.23	38.31	2.82	16.87	18.31	6.00	10.87	Pass
		16QAM/1RB/0RB offset								DF	31.23	38.12	2.89	16.70	18.12	6.00	10.70	Pass
		64QAM/1RB/0RB offset								DF	31.23	38.16	2.90	16.76	18.16	6.00	10.76	Pass
		256QAM/1RB/0RB offset								DF	31.23	38.25	2.83	16.77	18.25	6.00	10.77	Pass
		16QAM/50RB/0RB offset								DF	31.23	37.87	2.91	16.74	17.87	6.00	10.74	Pass
		16QAM/100RB/0RB offset								DF	31.23	38.18	2.89	16.72	18.18	6.00	10.72	Pass

2. Band Configuration

An investigation was performed to ensure the LTE band used for testing does not substantially affect the measurement results. The effects of band configuration were found to be independent of radio configuration; therefore, only one radio configuration was used for this investigation. LTE B66 was used as the default test band for VoLTE over IMS Volume Control testing given the results of this investigation. See below table for comparisons between different bands:

Table 6-2
VoLTE over IMS Results by Band

Mode	Antenna Config	RF Bandwidth (MHz)	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Ambient Noise (dBA)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
LTE Band 71	A	20	133297	On	2	EVS	WB	128	31.23	16.77	6.00	10.77	Pass
	E				2				31.23	16.73	6.00	10.73	Pass
LTE Band 12	A	10	23095		2				31.23	16.80	6.00	10.80	Pass
	E				2				31.23	16.71	6.00	10.71	Pass
LTE Band 13	A	10	23230		2				31.23	16.87	6.00	10.87	Pass
	E				2				31.23	16.70	6.00	10.70	Pass
LTE Band 14	A	10	23330		2				31.23	16.91	6.00	10.91	Pass
	E				2				31.23	16.88	6.00	10.88	Pass
LTE Band 26	A	15	26865		2				31.23	16.83	6.00	10.83	Pass
	E				2				31.23	16.83	6.00	10.83	Pass
												0.00	
LTE Band 66	A	20	132322	On	2	EVS	WB	128	31.23	16.68	6.00	10.68	Pass
	E				2				31.23	16.74	6.00	10.74	Pass
												0.00	
LTE Band 25	A	20	26365	On	2	EVS	WB	128	31.23	16.92	6.00	10.92	Pass
	E				2				31.23	16.85	6.00	10.85	Pass
												0.00	
LTE Band 30	A	10	27710	On	2	EVS	WB	128	31.23	16.77	6.00	10.77	Pass
	F				2				31.23	16.75	6.00	10.75	Pass
LTE Band 7	B	20	21100		2				31.23	16.80	6.00	10.80	Pass
	F				2				31.23	16.72	6.00	10.72	Pass
LTE Band 41 (PC3)	B	20	40620		2				31.23	16.87	6.00	10.87	Pass
	F				2				31.23	16.88	6.00	10.88	Pass
LTE Band 41 (PC2)	B	20	40620		2				31.23	16.83	6.00	10.83	Pass
	F				2				31.23	16.82	6.00	10.82	Pass
LTE Band 48	F	20	55990		2				31.23	16.90	6.00	10.90	Pass

7. VONR TEST SYSTEM SETUP AND DUT CONFIGURATION

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

1. Equipment Setup

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

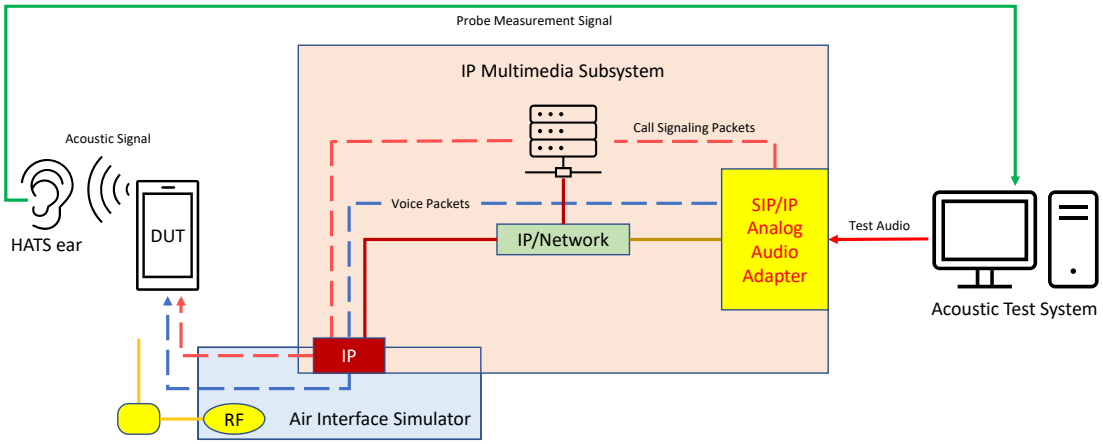


Figure 7-1
Test Setup for VoNR over IMS Volume Control Measurements

2. Audio Level Settings

According to ANSI/TIA-5050-2018, the appropriate audio level to be used for VoNR over IMS Volume Control testing is -20dBm0 (ASL) and shall be used for the normal speech input level. The acoustic test system was manually configured to ensure that the settings for speech input and full scale levels resulted in the -20dBm0 (ASL) speech input level to the DUT for the VoNR over IMS connection.

II. DUT Configuration for VoNR over IMS Volume Control Testing

1. Radio Configuration

An investigation was performed to ensure the waveform, modulation, and RB configuration used for testing do not substantially affect the measurement results. The effects of waveform, modulation, and RB configuration were found to be independent of band and bandwidth; therefore, only one band and bandwidth were used for this investigation. DFT-s-OFDM, 16QAM, 1RB, 1RB offset was used as the default testing configuration for the handset given the results of this investigation. See below table for comparison between different radio configurations:

Table 7-1
VoNR over IMS Results by Radio Configuration – CP-OFDM

Mode	RF Bandwidth (MHz)	Waveform	Radio Configuration	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Value (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	Distortion Margin (dB)	FCC CG Limit (dB)	FCC Margin from Limit (dB)	Verdict
NR n66	40	CP-OFDM	QPSK/1RB/1RB offset	349000	On	2	EVS	WB	128	MAX -1	DF	31.23	37.35	2.83	14.58	17.35	6.00	8.58	PASS
			16QAM/1RB/0RB 1ffset								DF	31.23	37.51	2.97	14.55	17.51	6.00	8.55	PASS
			64QAM/1RB/1RB offset								DF	31.23	35.74	2.86	14.56	15.74	6.00	8.56	PASS
			256QAM/1RB/1RB offset								DF	31.23	40.08	2.91	14.53	20.08	6.00	8.53	PASS
			16QAM/50RB/0RB offset								DF	31.23	35.46	2.88	14.53	15.46	6.00	8.53	PASS
			16QAM/100RB/0RB offset								DF	31.23	37.12	2.92	14.50	17.12	6.00	8.50	PASS

Table 7-2
VoNR over IMS Results by Radio Configuration – DFT-s-OFDM

Mode	RF Bandwidth (MHz)	Waveform	Radio Configuration	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Value (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	Distortion Margin (dB)	FCC CG Limit (dB)	FCC Margin from Limit (dB)	Verdict
NR n66	40	DFT-s-OFDM	PI/2 BPSK /1RB/0RB offset	349000	On	2	EVS	WB	128	MAX -1	DF	31.23	37.88	2.89	14.54	17.88	6.00	8.54	PASS
			QPSK/1RB/0RB offset								DF	31.23	37.71	2.91	14.38	17.71	6.00	8.38	PASS
			16QAM/1RB/0RB offset								DF	31.23	37.14	2.87	14.40	17.14	6.00	8.40	PASS
			64QAM/1RB/0RB offset								DF	31.23	37.81	2.84	14.48	17.81	6.00	8.48	PASS
			256QAM/1RB/0RB offset								DF	31.23	40.19	2.88	14.52	20.19	6.00	8.52	PASS
			16QAM/50RB/0RB offset								DF	31.23	38.83	2.90	14.56	18.83	6.00	8.56	PASS
			16QAM/100RB/0RB offset								DF	31.23	37.99	2.80	14.47	17.99	6.00	8.47	PASS

2. Band Configuration

An investigation was performed to ensure the NR band used for testing does not substantially affect the measurement results. The effects of band configuration were found to be independent of radio configuration; therefore, only one radio configuration was used for this investigation. NR n66 was

used as the default test band for VoNR over IMS Volume Control testing given the results of this investigation. See below table for comparisons between different bands:

Table 7-3
VoNR over IMS Results by Band

Mode	Antenna Config	RF Bandwidth (MHz)	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Ambient Noise (dBA)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	FCC Margin from Limit (dB)	Verdict
NR n71	A	20	N/A	On	2	EVS	WB	128	31.23	14.44	6.00	8.44	PASS
	E				2				31.23	14.51	6.00	8.51	PASS
NR n12	A	15	N/A		2				31.23	14.45	6.00	8.45	PASS
	E				2				31.23	14.41	6.00	8.41	PASS
NR n26	A	20	N/A		2				31.23	14.50	6.00	8.50	PASS
	E				2				31.23	14.49	6.00	8.49	PASS
NR n70	A	15	N/A	On	2	EVS	WB	128	31.23	14.48	6.00	8.48	PASS
	E				2				31.23	14.46	6.00	8.46	PASS
NR n66	A	40	N/A		2				31.23	14.47	6.00	8.47	PASS
	E				2				31.23	14.53	6.00	8.53	PASS
NR n25	A	40	N/A	On	2	EVS	WB	128	31.23	14.55	6.00	8.55	PASS
	E				2				31.23	14.53	6.00	8.53	PASS
NR n30	A	10	N/A	On	2	EVS	WB	128	31.23	14.46	6.00	8.46	PASS
	F				2				31.23	14.51	6.00	8.51	PASS
NR n7	B	40	N/A		2				31.23	14.41	6.00	8.41	PASS
	F				2				31.23	14.50	6.00	8.50	PASS
NR n41 (PC2)	B	100	N/A		2				31.23	14.48	6.00	8.48	PASS
	F				2				31.23	14.46	6.00	8.46	PASS
NR n77 DoD (PC2)	F	100	N/A		2				31.23	14.46	6.00	8.46	PASS
NR n77 C (PC2)	F	100	N/A		2				31.23	14.44	6.00	8.44	PASS
NR n48	F	40	55990		2				31.23	14.54	6.00	8.54	PASS

8. 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 VoLTE over IMS Volume Control measurements is a CMW500. The Data Application Unit (DAU) of the CMW500 was used to simulate the IP Multimedia Subsystem (IMS) server.

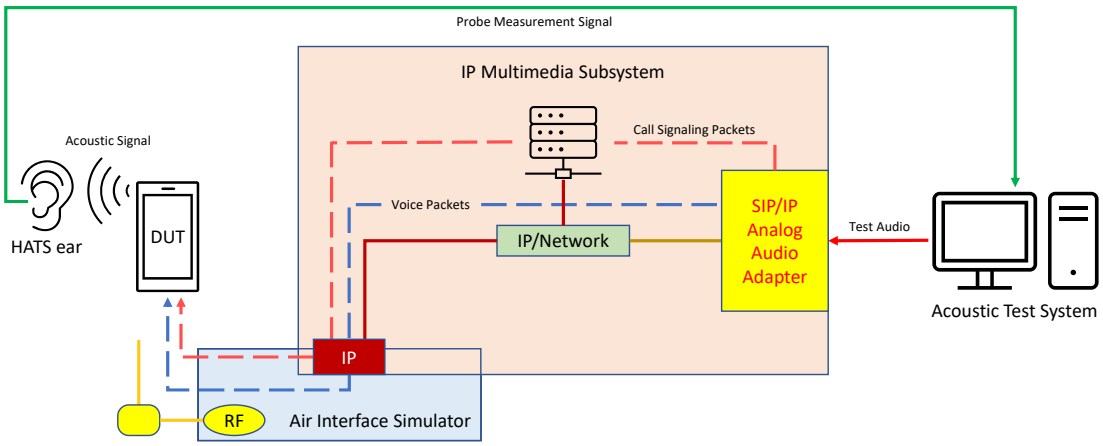


Figure 8-1
Test Setup for VoLTE over IMS Volume Control Measurements

2. Audio Level Settings

According to ANSI/TIA-5050-2018, the appropriate audio level to be used for VoWIFI over IMS Volume Control testing is -20dBm0 (ASL) and shall be used for the normal speech input level. The CMW500 base station simulator was manually configured to ensure that the settings for speech input and full scale levels resulted in the -20dBm0 (ASL) speech input level to the DUT for the VoWIFI over IMS connection.

II. DUT Configuration for VoWIFI over IMS Volume Control Testing

1. IEEE Standard Configuration

An investigation was performed to ensure the IEEE standard used for testing does not substantially affect the measurement results. The effects of IEEE standard were found to be independent of WIFI data rate; therefore, only one data rate was used for each IEEE standard in this investigation. IEEE 802.11b was used as the default testing configuration for the handset given the results of this investigation. See below table for comparison between different radio configurations:

Table 8-1
VoWIFI over IMS Results by IEEE Standard

Mode	RF Bandwidth (MHz)	U-NII Band	Channel	HAC Mode	Mounting Force (N)	Codec Bandwidth	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Margin (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	Distortion Margin (dB)	CG Margin (dB)	Verdict
IEEE 802.11b	20	1	6	On	2	WB	MAX -1	DF	31.23	36.82	2.79	16.82	6.00	16.82	10.82	PASS
IEEE 802.11g	20	1	6	On	2	WB	MAX -1	DF	31.23	37.88	2.85	16.84	6.00	17.88	10.84	PASS
IEEE 802.11n	20	1	6	On	2	WB	MAX -1	DF	31.23	33.21	2.87	16.84	6.00	13.21	10.84	PASS
IEEE 802.11ac	20	1	6	On	2	WB	MAX -1	DF	31.23	37.66	2.81	16.84	6.00	17.66	10.84	PASS
IEEE 802.11ax (SU)	20	1	6	On	2	WB	MAX -1	DF	31.23	34.59	2.76	16.90	6.00	14.59	10.90	PASS
IEEE 802.11ax (RU)	20	1	6	On	2	WB	MAX -1	DF	31.23	34.68	2.74	16.84	6.00	14.68	10.84	PASS
IEEE 802.11a	20	1	40	On	2	WB	MAX -1	DF	31.23	38.05	2.87	16.83	6.00	18.05	10.83	PASS
IEEE 802.11n	20	1	40	On	2	WB	MAX -1	DF	31.23	38.13	2.87	16.83	6.00	18.13	10.83	PASS
IEEE 802.11n	40	1	38	On	2	WB	MAX -1	DF	31.23	37.86	2.91	16.75	6.00	17.86	10.75	PASS
IEEE 802.11ac	20	1	40	On	2	WB	MAX -1	DF	31.23	37.97	2.79	16.87	6.00	17.97	10.87	PASS
IEEE 802.11ac	40	1	38	On	2	WB	MAX -1	DF	31.23	37.97	2.88	16.81	6.00	17.97	10.81	PASS
IEEE 802.11ax (SU)	20	1	40	On	2	WB	MAX -1	DF	31.23	38.06	2.92	16.83	6.00	18.06	10.83	PASS
IEEE 802.11ax (SU)	40	1	38	On	2	WB	MAX -1	DF	31.23	37.95	2.95	16.86	6.00	17.95	10.86	PASS
IEEE 802.11ax (RU)	20	1	40	On	2	WB	MAX -1	DF	31.23	37.19	2.91	16.90	6.00	17.19	10.90	PASS
IEEE 802.11ax (RU)	40	1	38	On	2	WB	MAX -1	DF	31.23	37.91	2.90	16.87	6.00	17.91	10.87	PASS

2. Data Rate Configuration

An investigation was performed to ensure the WIFI data rate used for testing does not substantially affect the measurement results. The effects of data rate configuration were found to be independent of IEEE standard; therefore, only one IEEE standard was used for this investigation. 1Mbps was used as the default WIFI data rate for VoWIFI over IMS Volume Control testing given the results of this investigation. See below table for comparisons between different bands:

Table 8-2
VoWIFI over IMS Results by Data Rate

Data Rate (Mbps)	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Value (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	Distortion Margin (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
1	6	On	2	EVS	WB	128	MAX -1	DF	31.23	37.79	2.89	17.04	17.79	6.00	11.04	PASS
11		On	2	EVS	WB	128	MAX -1	NA	31.23	38.07	2.92	17.03	18.07	6.00	11.03	PASS

9. INTERIM WAIVER DA 23-914

I. Under the waiver, only CMRS narrowband and CMRS wideband voice codecs are required to comply with the volume control requirements of the TIA 5050-2018 Volume Control Standard as amended as follows:

   a. For the 2N mounting force test, one narrowband and one wideband voice codec embedded with the handset must pass with at least one volume control setting with a conversational gain of ≥ 6 dB for all voice services, bands of operation and air interfaces over which it operates using one codec bit rate of the applicant's choosing.
   b. For the 8N mounting force test, one narrowband and one wideband voice codec embedded with the handset must pass with at least one volume control setting with a conversational gain of ≥ 6 dB for all voice services, bands of operation and air interfaces over which they operate but is not required to meet or exceed the full 18 dB of conversational gain specified in section 5.1.1 of the TIA 5050 Volume Control Standard using one codec bit rate of the applicant's choosing.

II. For all other narrowband and wideband codecs not evaluated in I.a. above, TIA 5050-2018 Receive Distortion and Noise Performance and Receive Acoustic Frequency Response Performance evaluations are not required; however, these codecs shall be assessed for conversational gain and documented in the test report at the 2N and 8N levels with a gain of ≥ 6 dB for all voice services, bands of operation and air interfaces over which they operate. The handset volume setting used to comply with I.a. shall be used for these other CMRS codec evaluations.

III. Any other codec for voice services embedded in the handset, not identified in sections I and II above are not required to comply or demonstrate in the test reports for conversational gain.

IV. Under the waiver, the manufacturer has chosen NB EVS 24.4kbps and WB EVS 128kbps audio codec bitrates for full evaluation.

10. VOLUME CONTROL TEST SUMMARY

Table 10-1
Consolidated Tabled Results

	Conversational Gain (CG) (dB)		FR Margin (dB)	Distortion Value (dB)	C63.19 Verdict
	2N	8N			
GSM	18.57	21.86	-	-	Compliant
UMTS	19.45	20.17	-	-	Compliant
LTE	16.06	18.81	2.37	26.05	Compliant
NR	14.08	17.09	2.56	26.63	Compliant
WLAN	16.61	18.87	2.29	27.62	Compliant

I. Raw Handset Data

Table 10-2
Raw Data Results for GSM

Mode	Channel	HAC Mode	Mounting Force (N)	Traffic Mode	Codec Bandwidth	Volume Level	Ambient Noise (dBA)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
GSM1900	661	On	2	FR V1	NB	MAX -1	33.08	18.57	6.00	12.57	Pass
	661	On	2	FR V2	NB	MAX -1	33.08	19.17	6.00	13.17	Pass
	661	On	2	HR V1	NB	MAX -1	33.08	19.14	6.00	13.14	Pass
	661	On	8	FR V1	NB	MAX -1	33.08	21.86	6.00	15.86	Pass
	661	On	8	FR V2	NB	MAX -1	33.08	22.01	6.00	16.01	Pass
	661	On	8	HR V1	NB	MAX -1	33.08	22.12	6.00	16.12	Pass

Table 10-3
Raw Data Results for UMTS

Mode	Channel	HAC Mode	Mounting Force (N)	Codec Bandwidth	Codec Bitrate (kbps)	Volume Level	Ambient Noise (dBA)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
UMTS II	9400	On	2	NB	4.75	MAX -1	33.08	19.45	6.00	13.45	Pass
	9400	On	2	NB	12.20	MAX -1	33.08	20.68	6.00	14.68	Pass
	9400	On	2	WB	6.60	MAX -1	33.08	19.87	6.00	13.87	Pass
	9400	On	2	WB	12.65	MAX -1	33.08	20.17	6.00	14.17	Pass
	9400	On	2	WB	23.85	MAX -1	33.08	20.19	6.00	14.19	Pass
	9400	On	8	NB	4.75	MAX -1	33.08	22.79	6.00	16.79	Pass
	9400	On	8	NB	12.20	MAX -1	33.08	23.41	6.00	17.41	Pass
	9400	On	8	WB	6.60	MAX -1	33.08	22.55	6.00	16.55	Pass
	9400	On	8	WB	12.65	MAX -1	33.08	22.88	6.00	16.88	Pass
	9400	On	8	WB	23.85	MAX -1	33.08	23.03	6.00	17.03	Pass

Table 10-4
Raw Data Results for VoLTE

Mode	RF Bandwidth (MHz)	Radio Configuration	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Value (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	Distortion Margin (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
LTE Band 66	20	16QAM/1RB /0RB offset	132322	On	2	EVS	NB	5.9	MAX -1	NA	31.23	-	-	18.42	-	6.00	12.42	Pass
				On	2	EVS	NB	13.2	MAX -1	NA	31.23	-	-	18.42	-	6.00	12.42	Pass
				On	2	EVS	NB	24.4	MAX -1	DF	31.23	26.05	2.55	18.44	6.05	6.00	12.44	Pass
				On	8	EVS	NB	5.9	MAX -1	NA	31.23	-	-	21.40	-	6.00	15.40	Pass
				On	8	EVS	NB	13.2	MAX -1	NA	31.23	-	-	21.29	-	6.00	15.29	Pass
				On	8	EVS	NB	24.4	MAX -1	DF	31.23	27.41	2.42	21.29	7.41	6.00	15.29	Pass
				On	2	EVS	WB	5.9	MAX -1	NA	31.23	-	-	16.16	-	6.00	10.16	Pass
				On	2	EVS	WB	13.2	MAX -1	NA	31.23	-	-	16.47	-	6.00	10.47	Pass
				On	2	EVS	WB	128	MAX -1	DF	31.23	38.13	2.98	17.05	18.13	6.00	11.05	Pass
				On	8	EVS	WB	5.9	MAX -1	NA	31.23	-	-	19.27	-	6.00	13.27	Pass
				On	8	EVS	WB	13.2	MAX -1	NA	31.23	-	-	19.20	-	6.00	13.20	Pass
				On	8	EVS	WB	128	MAX -1	DF	31.23	38.10	2.37	19.87	18.10	6.00	13.87	Pass
				On	2	AMR	NB	4.75	MAX -1	NA	31.23	-	-	18.25	-	6.00	12.25	Pass
				On	2	AMR	NB	12.2	MAX -1	NA	31.23	-	-	18.80	-	6.00	12.80	Pass
				On	8	AMR	NB	4.75	MAX -1	NA	31.23	-	-	20.97	-	6.00	14.97	Pass
				On	8	AMR	NB	12.2	MAX -1	NA	31.23	-	-	21.51	-	6.00	15.51	Pass
				On	2	AMR	WB	6.6	MAX -1	NA	31.23	-	-	16.06	-	6.00	10.06	Pass
				On	2	AMR	WB	12.65	MAX -1	NA	31.23	-	-	16.44	-	6.00	10.44	Pass
				On	2	AMR	WB	23.85	MAX -1	NA	31.23	-	-	16.53	-	6.00	10.53	Pass
				On	8	AMR	WB	6.6	MAX -1	NA	31.23	-	-	18.81	-	6.00	12.81	Pass
				On	8	AMR	WB	12.65	MAX -1	NA	31.23	-	-	19.15	-	6.00	13.15	Pass
				On	8	AMR	WB	23.85	MAX -1	NA	31.23	-	-	19.20	-	6.00	13.20	Pass

Table 10-5
Raw Data Results for VoNR

Mode	RF Bandwidth (MHz)	Waveform	Radio Configuration	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Values (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	FCC CG Limit (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
NR n66	40	DFT-S-OFDM	16QAM /1RB / 1RB offset	349000	On	2	EVS	NB	5.9	MAX -1	NA	31.23	-	-	16.47	-	6.00	10.47	PASS
					On	2	EVS	NB	13.2	MAX -1	NA	31.23	-	-	16.30	-	6.00	10.30	PASS
					On	2	EVS	NB	24.4	MAX -1	FF	31.23	26.63	2.56	16.69	6.63	6.00	10.69	PASS
					On	8	EVS	NB	5.9	MAX -1	NA	31.23	-	-	19.39	-	6.00	13.39	PASS
					On	8	EVS	NB	13.2	MAX -1	NA	31.23	-	-	19.49	-	6.00	13.49	PASS
					On	8	EVS	NB	24.4	MAX -1	FF	31.23	29.00	2.74	19.75	9.00	6.00	13.75	PASS
					On	2	EVS	WB	5.9	MAX -1	NA	31.23	-	-	14.08	-	6.00	8.08	PASS
					On	2	EVS	WB	13.2	MAX -1	NA	31.23	-	-	14.19	-	6.00	8.19	PASS
					On	2	EVS	WB	128	MAX -1	DF	31.23	37.92	2.87	14.59	17.92	6.00	8.59	PASS
					On	8	EVS	WB	5.9	MAX -1	NA	31.23	-	-	17.14	-	6.00	11.14	PASS
					On	8	EVS	WB	13.2	MAX -1	NA	31.23	-	-	17.29	-	6.00	11.29	PASS
					On	8	EVS	WB	128	MAX -1	DF	31.23	38.00	2.97	17.76	18.00	6.00	11.76	PASS
					On	2	AMR	NB	4.75	MAX -1	NA	31.23	-	-	16.40	-	6.00	10.40	PASS
					On	2	AMR	NB	12.2	MAX -1	NA	31.23	-	-	16.77	-	6.00	10.77	PASS
					On	8	AMR	NB	4.75	MAX -1	NA	31.23	-	-	19.18	-	6.00	13.18	PASS
					On	8	AMR	NB	12.2	MAX -1	NA	31.23	-	-	19.83	-	6.00	13.83	PASS
					On	2	AMR	WB	6.6	MAX -1	NA	31.23	-	-	14.24	-	6.00	8.24	PASS
					On	2	AMR	WB	12.65	MAX -1	NA	31.23	-	-	14.35	-	6.00	8.35	PASS
					On	2	AMR	WB	23.85	MAX -1	NA	31.23	-	-	14.44	-	6.00	8.44	PASS
					On	8	AMR	WB	6.6	MAX -1	NA	31.23	-	-	17.09	-	6.00	11.09	PASS
					On	8	AMR	WB	12.65	MAX -1	NA	31.23	-	-	17.38	-	6.00	11.38	PASS
					On	8	AMR	WB	23.85	MAX -1	NA	31.23	-	-	17.43	-	6.00	11.43	PASS

Table 10-6
Raw Data Results for VoWIFI

Mode	Band	Bandwidth	Data Rate (Mbps)	Channel	HAC Mode	Mounting Force (N)	Codec Type	Codec Bandwidth	Codec Bitrate	Volume Level	DRP Translation	Ambient Noise (dBA)	Distortion Value (dB)	FR Margin (dB)	Conversational Gain (CG) (dB)	Distortion Margin (dB)	FCC CG Limit (dB)	CG Margin (dB)	Verdict
IEEE 802.11b	2.4GHz	20	1	6	On	2	EVS	NB	5.9	MAX -1	NA	31.23	-	-	18.45	-	6.00	12.45	PASS
					On	2	EVS	NB	13.2	MAX -1	NA	31.23	-	-	19.58	-	6.00	13.58	PASS
					On	2	EVS	NB	24.4	MAX -1	DF	31.23	27.14	2.41	18.51	7.14	6.00	12.51	PASS
					On	8	EVS	NB	5.9	MAX -1	NA	31.23	-	-	21.25	-	6.00	15.25	PASS
					On	8	EVS	NB	13.2	MAX -1	NA	31.23	-	-	21.47	-	6.00	15.47	PASS
					On	8	EVS	NB	24.4	MAX -1	DF	31.23	27.62	2.29	21.67	7.62	6.00	15.67	PASS
					On	2	EVS	WB	5.9	MAX -1	NA	31.23	-	-	16.88	-	6.00	10.28	PASS
					On	2	EVS	WB	13.2	MAX -1	NA	31.23	-	-	17.20	-	6.00	11.20	PASS
					On	2	EVS	WB	128	MAX -1	DF	31.23	38.15	2.96	16.82	18.15	6.00	11.18	PASS
					On	8	EVS	WB	5.9	MAX -1	NA	31.23	-	-	19.82	-	6.00	13.05	PASS
					On	8	EVS	WB	13.2	MAX -1	NA	31.23	-	-	19.81	-	6.00	13.08	PASS
					On	8	EVS	WB	128	MAX -1	DF	31.23	38.21	2.70	19.83	18.21	6.00	13.42	PASS
					On	2	AMR	NB	4.75	MAX -1	NA	31.23	-	-	19.21	-	6.00	13.21	PASS
					On	2	AMR	NB	12.2	MAX -1	NA	31.23	-	-	19.73	-	6.00	13.73	PASS
					On	8	AMR	NB	4.75	MAX -1	NA	31.23	-	-	20.95	-	6.00	14.95	PASS
					On	8	AMR	NB	12.2	MAX -1	NA	31.23	-	-	21.56	-	6.00	15.56	PASS
					On	2	AMR	WB	6.6	MAX -1	NA	31.23	-	-	16.61	-	6.00	10.61	PASS
					On	2	AMR	WB	12.65	MAX -1	NA	31.23	-	-	16.94	-	6.00	10.94	PASS
					On	2	AMR	WB	23.85	MAX -1	NA	31.23	-	-	17.02	-	6.00	11.02	PASS
					On	8	AMR	WB	6.6	MAX -1	NA	31.23	-	-	18.87	-	6.00	12.87	PASS
					On	8	AMR	WB	12.65	MAX -1	NA	31.23	-	-	19.32	-	6.00	13.32	PASS
					On	8	AMR	WB	23.85	MAX -1	NA	31.23	-	-	19.42	-	6.00	13.42	PASS

II. Test Notes

A. General

1. Phone Condition: Phone Condition: Mute off; Backlight off; Max Volume -1; Max Contrast
2. Test Signal: IEEE Std 269 uncompressed real male speech
3. Hearing Aid Mode was set according to the following menu path: (**Phone→Call Settings→Other call Settings→Hearing aids**) was set to ON for HAC compliance.
4. Bluetooth and WIFI were disabled while testing 2G/3G/4G/5G modes.
5. WD was evaluated with one volume notch down from MAX volume setting for HAC compliance.
6. The FCC Margin from Limit column indicates a margin from the FCC limit for compliance.

B. GSM

1. Power Configuration: GSM850: PCL=0;
2. Vocoder Configuration: EFR (GSM): FR V1, FR V2, HR V1

C. UMTS

1. Power Configuration: TPC = “All 1’s”
2. Vocoder Configuration:
    a. AMR-NB: 4.75kbps, 12.2kbps
    b. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps

D. Voice over LTE

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: 16QAM, 1RB, 0RB offset
3. Vocoder Configuration:
    a. AMR-NB: 4.75kbps, 12.2kbps
    b. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps
    c. EVS-NB: 5.9kbps,13.2kbps, 24.4kbps
    d. EVS-WB: 5.9kbps,13.2kbps, 128kbps
    e. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps

E. Voice over NR

1. Power Configuration: TPC = “Max Power”
2. Radio Configuration: DFT-s-OFDM, 16QAM, 1RB, 1RB offset
3. Vocoder Configuration:
    a. AMR-NB: 4.75kbps, 12.2kbps
    b. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps
    c. EVS-NB: 5.9kbps,13.2kbps, 24.4kbps
    d. EVS-WB: 5.9kbps,13.2kbps, 128kbps
    e. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps

F. Voice over WIFI

1. Radio Configuration: IEEE 802.11b: DSSS, 1Mbps
2. Vocoder Configuration:
    a. AMR-NB: 4.75kbps, 12.2kbps
    b. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps
    c. EVS-NB: 5.9kbps,13.2kbps, 24.4kbps
    d. EVS-WB: 5.9kbps,13.2kbps, 128kbps
    e. AMR-WB: 6.60kbps,12.65kbps, 23.85kbps

III. Volume Control Verification Test Results

Table 10-7
Verification Results Table

Date of Testing	Test Location	Air Interface Equipment	Acoustical Calibrator	HATS Sens. [dB]	Ambient Noise (dBA)
10/09/2023	Whisper1	CMW500	2343018	97.16	31.52
10/16/2023	Whisper1	CMW500	2343018	97.22	31.23
10/23/2023	Whisper1	CMW500	2343018	97.24	33.08

11. MEASUREMENT UNCERTAINTY

Table 11-1
Uncertainty Estimation Table

Receive Volume Control Requirement	Expanded uncertainty (k=2), 95% confidence level (dB)
Conversational Gain	0.33
Frequency Response (FF)	0.23
Frequency Response (DF)	0.19
Distortion	0.81

Notes:

1. Test equipment is calibrated according to techniques outlined in NIS81, NIS3003 and NIST Tech Note 1297.
2. All equipment has 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. The above uncertainties were estimated experimentally using the techniques contained in NIS 81 and NIS 3003.

12. EQUIPMENT LIST

Table 12-1
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Listen	SoundConnect	Microphone Power Supply	9/15/2022	Biennial	9/15/2024	0899-PS150
RME	Fireface UC	Soundcheck Acoustic Analyzer External Audio Interface	9/19/2022	Biennial	9/19/2024	23792992
Rohde & Schwarz	CMW500	Wideband Radio Communication Tester	8/9/2023	Annual	8/9/2024	162125
Rohde & Schwarz	CMW500	Radio Communication Tester	8/10/2023	Annual	8/10/2024	140144
Rohde & Schwarz	CMX500	Radio Communication Tester	N/A		N/A	100298
Seekonk	NC-100	Torque Wrench (8" lb)	11/28/2022	Biennial	11/28/2024	80790
YellowTec	YT4211	USB Audio Interface	N/A		N/A	20000365
Netgear	XS708E	Ethernet Switch	N/A		N/A	4FU3875C001A8
Bruel & Kjaer (HBK)	4128	Head and Torso Simulator	4/5/2022	Biennial	4/5/2024	1947220
Bruel & Kjaer (HBK)	4231	Acoustical Calibrator Type 4231 with UA1546	4/6/2022	Biennial	4/6/2024	2343018
Bruel & Kjaer (HBK)	DZ-9769	Artificial Ear	9/15/2022	Triennial	9/15/2025	SBM553623

13. TEST DATA

10/9/2023

element

Element Hearing-Aid Compatibility Facility

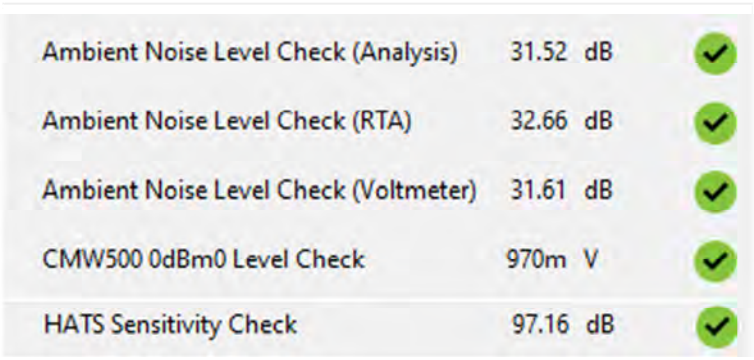
Whisper Room 1 / HATS

Type: HATS 4128
Serial: 1947220

Measurement Standard: ANSI C63.19

Equipment:

- Head and Torso Simulator Type 4128: SN: 1947220; Calibrated: 4/5/2022
- Acoustical Calibrator Type 4231 W/ UA1546: SN 2343018; Calibrated: 4/6/2022



element

Element Hearing-Aid Compatibility Facility

Whisper Room 1 / HATS

Type: HATS 4128
Serial: 1947220

Measurement Standard: ANSI C63.19

Equipment:

- Head and Torso Simulator Type 4128: SN: 1947220 ; Calibrated: 4/5/2024
- Acoustical Calibrator Type 4231 W/ UA1546: SN 2343018; Calibrated: 4/6/2023

Ambient Noise Level Check (Analysis)	31.23 dB	✓
Ambient Noise Level Check (RTA)	32.25 dB	✓
Ambient Noise Level Check (Voltmeter)	31.1 dB	✓
CMW500 0dBm0 Level Check	969m V	✓
HATS Sensitivity Check	97.22 dB	✓

10/23/2023

Element Hearing-Aid Compatibility Facility

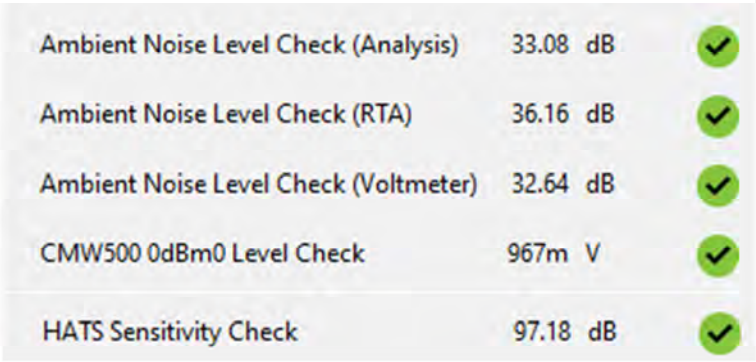
Whisper Room 1 / HATS

Type: HATS 4128
Serial: 1947220

Measurement Standard: ANSI C63.19

Equipment:

- Head and Torso Simulator Type 4128: SN: 1947220; Calibrated: 4/5/2024
- Acoustical Calibrator Type 4231 W/ UA1546: SN 2343018; Calibrated: 4/6/2023



element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

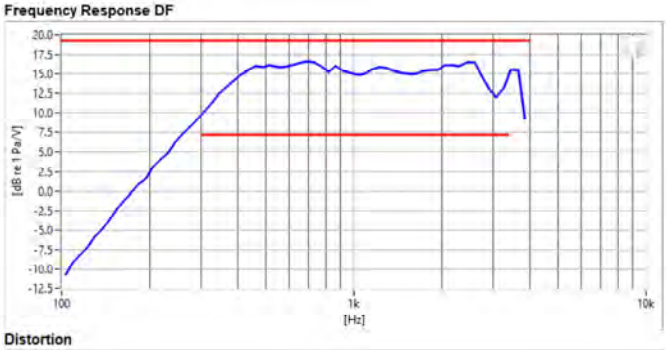
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

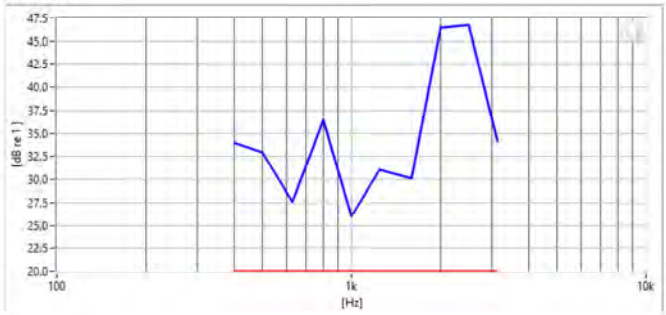
Test Configuration:

- Mode: LTE Band 66
- Bandwidth: 20MHz
- Channel: 132322
- Codec Bandwidth: Narrowband
- Mounting Force: 2N

Frequency Response DF



Distortion



Results DF

Conversational Gain (2N)	18.44 dB	✓	Minimum	6.0
Distortion Value (NB)	26.05 dB	✓	Minimum	20.0
Distortion Margin (NB)	6.05 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, NB)	2.55 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

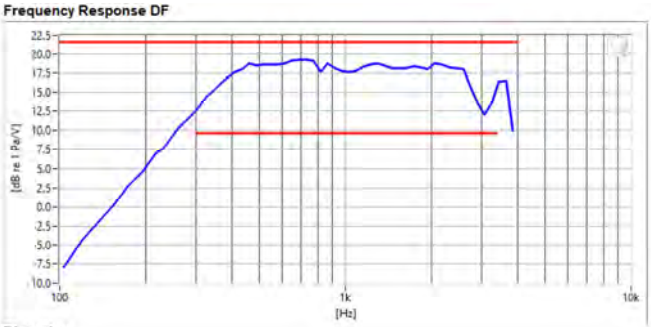
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

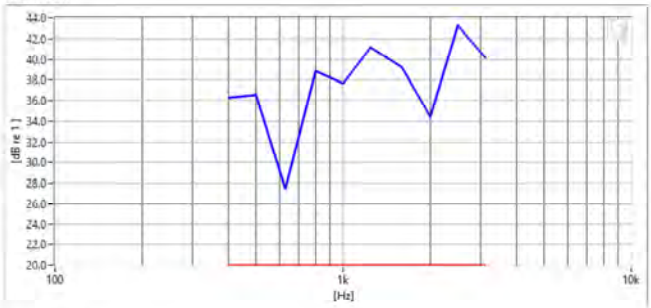
Test Configuration:

- Mode: LTE Band 66
- Bandwidth: 20MHz
- Channel: 132322
- Codec Bandwidth: Narrowband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	21.29 dB	✓	Minimum	18
Distortion Value (NB)	27.41 dB	✓	Minimum	20
Distortion Margin (NB)	7.41 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, NB)	2.42 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

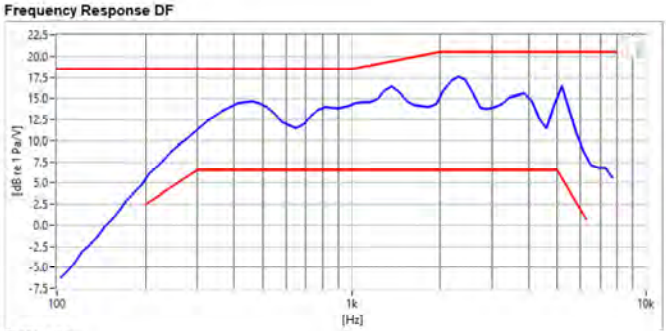
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

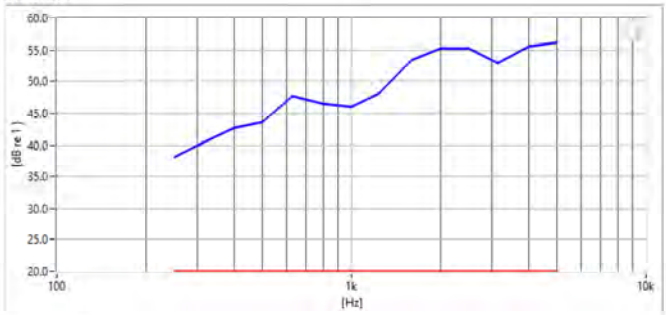
Test Configuration:

- Mode: LTE Band 66
- Bandwidth: 20MHz
- Channel: 132322
- Codec Bandwidth: Wideband
- Mounting Force: 2N

Frequency Response DF



Distortion



Results DF

Conversational Gain (2N)	17.05 dB	✓	Minimum	6.0
Distortion Value (WB)	38.13 dB	✓	Minimum	20.0
Distortion Margin (WB)	18.13 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.98 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

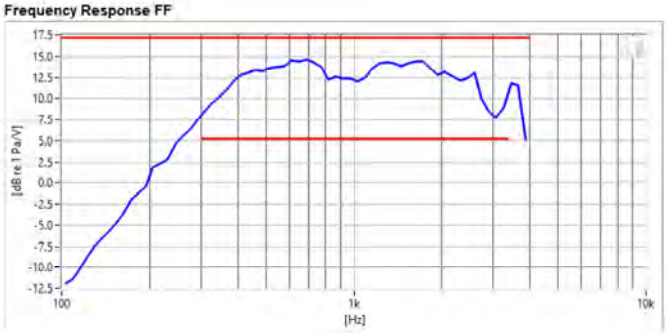
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

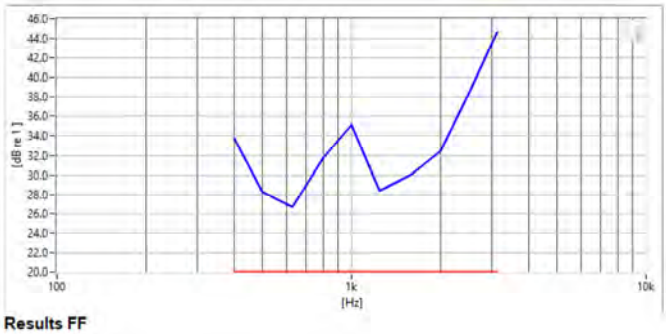
Test Configuration:

- Mode: NR n66
- Bandwidth: 40MHz
- Channel: 349000
- Codec Bandwidth: Narrowband
- Mounting Force: 2N

Frequency Response FF



Distortion



Results FF

Conversational Gain (2N)	16.69 dB	✓	Minimum	6.0
Distortion Value (NB)	26.63 dB	✓	Minimum	20.0
Distortion Margin (NB)	6.63 dB	✓	Tolerance curves	Absolute Limits
FR Margin (FF, NB)	2.56 dB	✓	Tolerance curves	Floating Limits

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

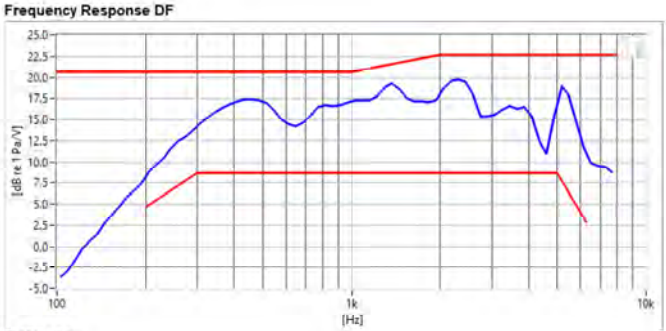
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

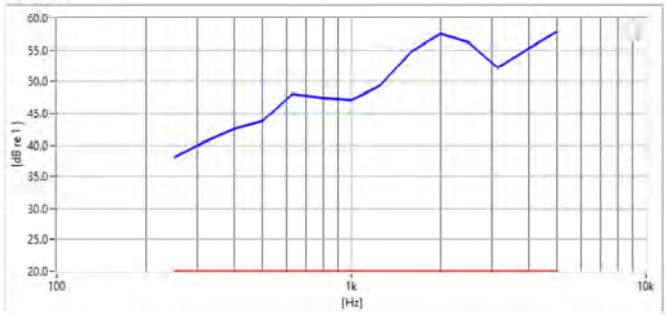
Test Configuration:

- Mode: LTE Band 66
- Bandwidth: 20MHz
- Channel: 132322
- Codec Bandwidth: Wideband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	19.87 dB	✓	Minimum	18.0
Distortion Value (WB)	38.1 dB	✓	Minimum	20.0
Distortion Margin (WB)	18.1 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.37 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

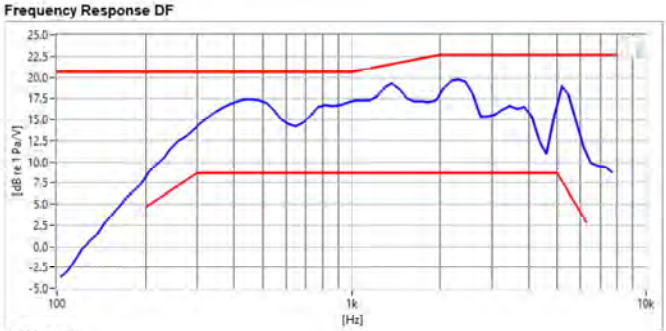
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

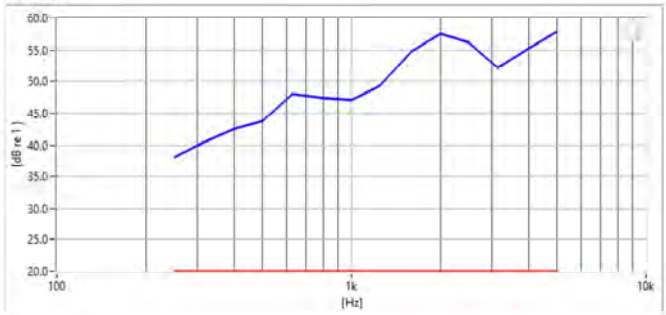
Test Configuration:

- Mode: LTE Band 66
- Bandwidth: 20MHz
- Channel: 132322
- Codec Bandwidth: Wideband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	19.87 dB	✓	Minimum	18.0
Distortion Value (WB)	38.1 dB	✓	Minimum	20.0
Distortion Margin (WB)	18.1 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.37 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

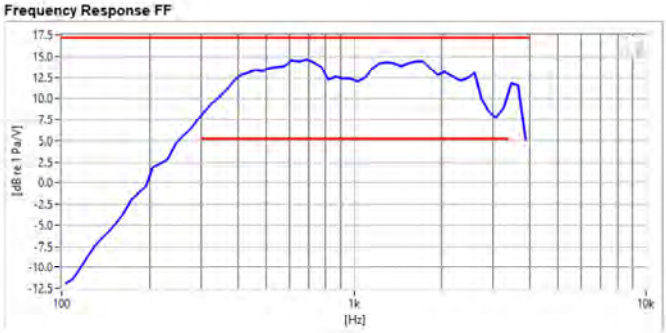
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

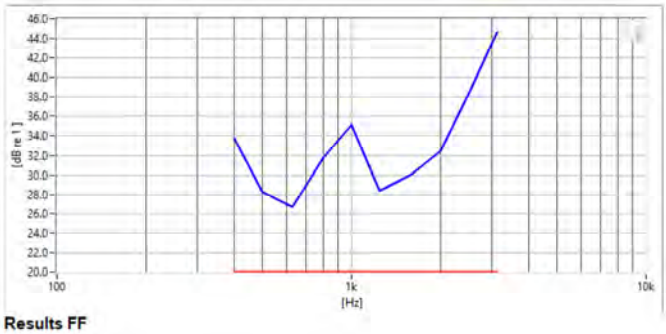
Test Configuration:

- Mode: NR n66
- Bandwidth: 40MHz
- Channel: 349000
- Codec Bandwidth: Narrowband
- Mounting Force: 2N

Frequency Response FF



Distortion



Results FF

Conversational Gain (2N)	16.69 dB	✓	Minimum	6.0
Distortion Value (NB)	26.63 dB	✓	Minimum	20.0
Distortion Margin (NB)	6.63 dB	✓	Tolerance curves	Absolute Limits
FR Margin (FF, NB)	2.56 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

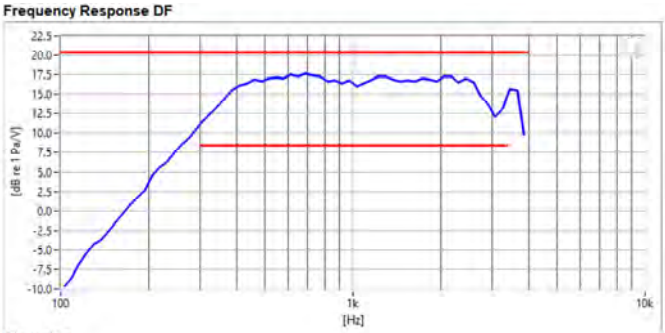
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

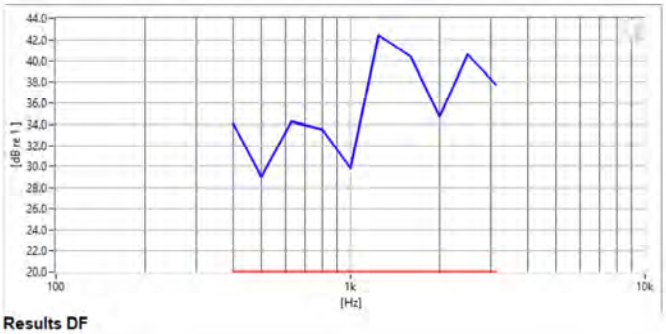
Test Configuration:

- Mode: NR n66
- Bandwidth: 40MHz
- Channel: 349000
- Codec Bandwidth: Narrowband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	19.75 dB	✓	Minimum	6
Distortion Value (NB)	29 dB	✓	Minimum	20
Distortion Margin (NB)	9 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, NB)	2.74 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

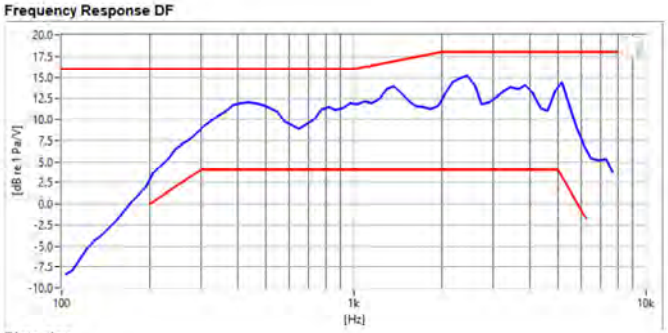
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

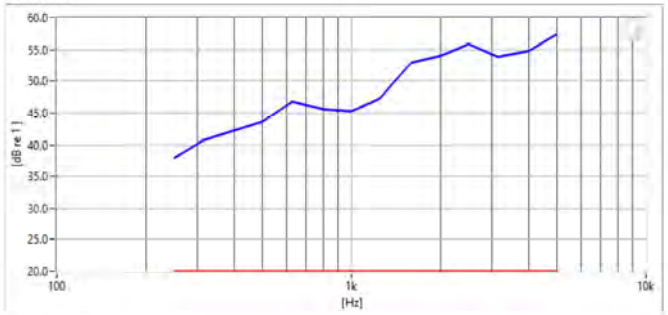
Test Configuration:

- Mode: NR n66
- Bandwidth: 40MHz
- Channel: 349000
- Codec Bandwidth: Wideband
- Mounting Force: 2N

Frequency Response DF



Distortion



Results DF

Conversational Gain (2N)	14.59 dB	✓	Minimum	6.0
Distortion Value (WB)	37.92 dB	✓	Minimum	20.0
Distortion Margin (WB)	17.92 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.87 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

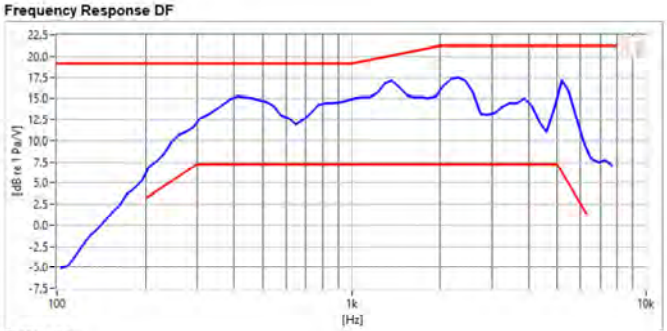
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

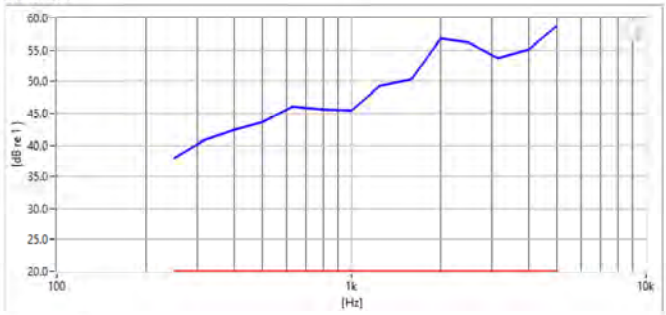
Test Configuration:

- Mode: NR n66
- Bandwidth: 40MHz
- Channel: 349000
- Codec Bandwidth: Wideband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	17.76 dB	✓	Minimum	6.0
Distortion Value (WB)	38 dB	✓	Minimum	20.0
Distortion Margin (WB)	18 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.97 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

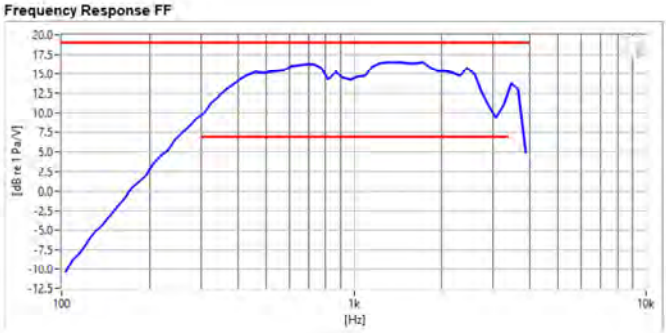
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

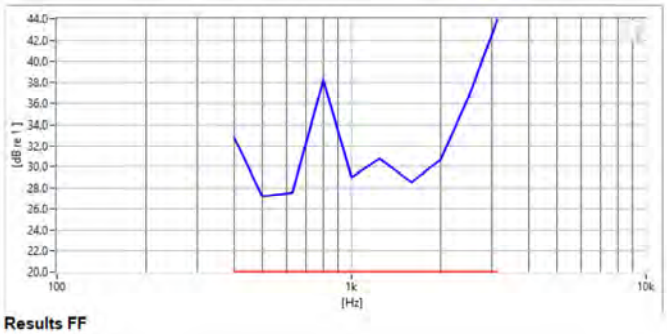
Test Configuration:

- Mode: 2.4GHz WIFI
- Standard: IEEE 802.11b
- Channel: 6
- Codec Bandwidth: Narrowband
- Mounting Force: 2N

Frequency Response FF



Distortion



Results FF

Conversational Gain (2N)	18.51 dB	✓	Minimum	6.0
Distortion Value (NB)	27.14 dB	✓	Minimum	20.0
Distortion Margin (NB)	7.14 dB	✓	Tolerance curves	Absolute Limits
FR Margin (FF, NB)	2.41 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

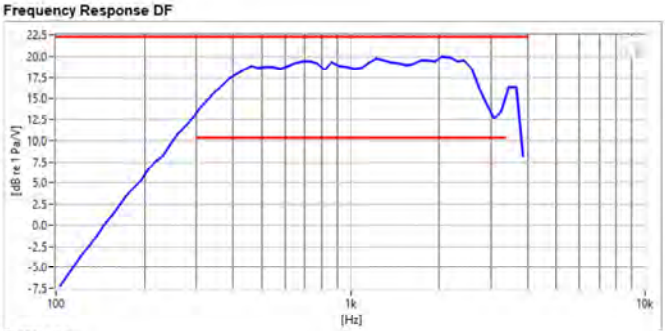
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

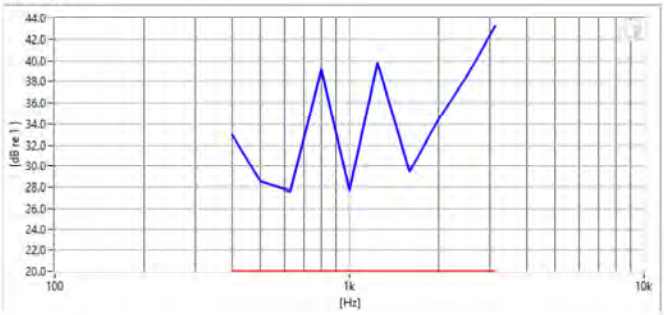
Test Configuration:

- Mode: 2.4GHz WIFI
- Standard: IEEE 802.11b
- Channel: 6
- Codec Bandwidth: Narrowband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	21.67 dB	✓	Minimum	18.0
Distortion Value (NB)	27.62 dB	✓	Minimum	20.0
Distortion Margin (NB)	7.62 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, NB)	2.29 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

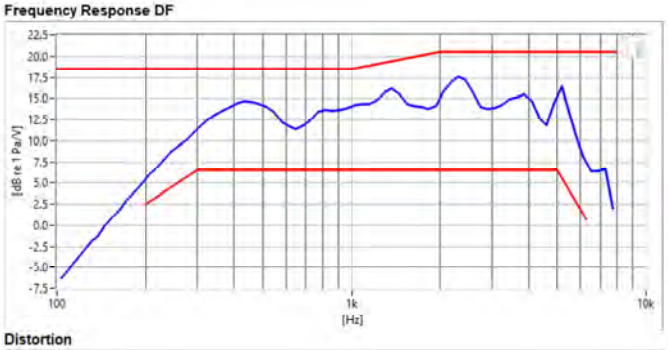
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

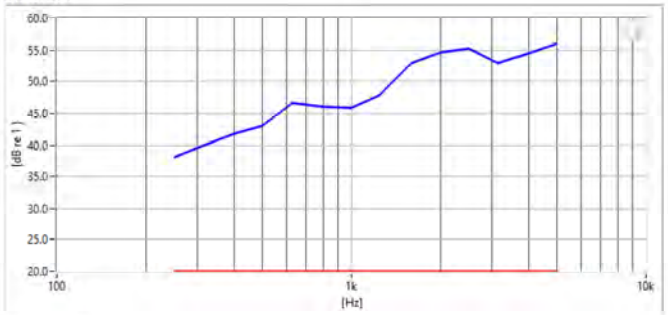
Test Configuration:

- Mode: 2.4GHz WIFI
- Standard: IEEE 802.11b
- Channel: 6
- Codec Bandwidth: Wideband
- Mounting Force: 2N

Frequency Response DF



Distortion



Results DF

Conversational Gain (2N)	16.82 dB	✓	Minimum	6.0
Distortion Value (WB)	38.15 dB	✓	Minimum	20.0
Distortion Margin (WB)	18.15 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.96 dB	✓	Tolerance curves	Floating Limits

element

Element Hearing-Aid Compatibility Facility

DUT: A3LSMS928U

Type: Portable Handset
Serial: 0879M

Measurement Standard: ANSI C63.19; ANSI/TIA-5050-2018

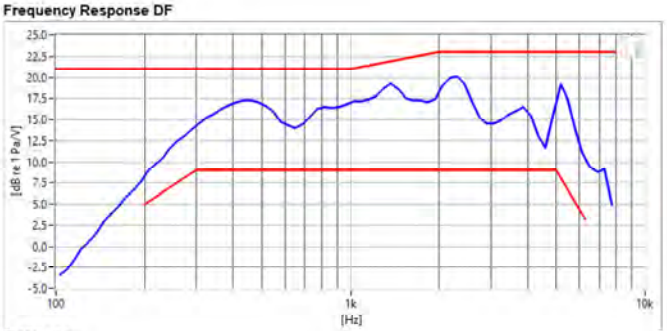
Equipment:

- Head and Torso Simulator: Bruel & Kjaer Model 4128 – SN: 1947220; Calibrated: 4/5/2022
- Ear Simulator: Bruel & Kjaer Model 4158 – SN: 18862222; Calibrated: 4/6/2022

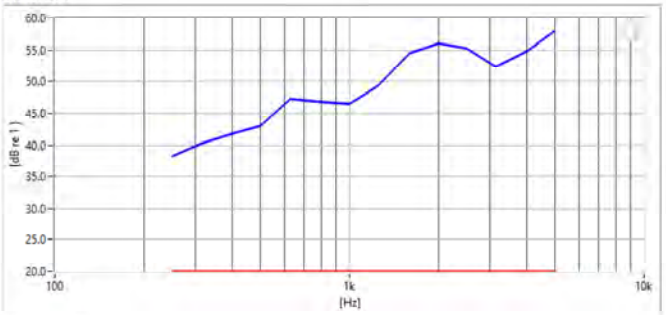
Test Configuration:

- Mode: 2.4GHz WIFI
- Standard: IEEE 802.11b
- Channel: 6
- Codec Bandwidth: Wideband
- Mounting Force: 8N

Frequency Response DF



Distortion



Results DF

Conversational Gain (8N)	19.83 dB	✓	Minimum	6.0
Distortion Value (WB)	38.21 dB	✓	Minimum	20.0
Distortion Margin (WB)	18.21 dB	✓	Tolerance curves	Absolute Limits
FR Margin (DF, WB)	2.7 dB	✓	Tolerance curves	Floating Limits

14. CALIBRATION CERTIFICATES

The Hottinger Brüel & Kjær Inc. Calibration Laboratory
3079 Premiere Parkway
Duluth, GA 30097
Telephone: 770-209-6907
Fax: 770-447-4033
Web site address: http//www.hbkworld.com

The Hottinger Brüel and Kjær Inc.
Service Center is Certified to ISO 9001:2015

CERTIFICATE OF CALIBRATION

No.: CAS-565027-G1J7F1-101

Calibration Of:

Model Number : 4128-C-001 Serial Number: 1947220

Customer:

PCTEST Engineering Laboratory Inc
7185 Oakland Mills Road
Columbia, MD 21046

√ TK
5/6/2022

CALIBRATION CONDITIONS:

Environment conditions	Air temperature :	23	°C
	Air pressure:	97.3	kPa
	Relative Humidity:	32	% RH

SPECIFICATIONS:

This document certifies that the instrument as listed under "Model Number" has been calibrated and unless otherwise indicated under "Final Data", meets acceptance criteria as prescribed by the referenced Procedure. Statements of compliance, where applicable, are based on calibration results falling within specified criteria with no reduction by the uncertainty of the measurements. The calibration of the listed instrumentation was accomplished using a test system which conforms with the requirements of ISO/IEC 17025, ANSI/NCSL Z540-1, and guidelines of ISO 10012-1. For "as received" and "final" data, see the attached page(s). This Certificate and attached data pages shall not be reproduced, except in full, without written approval of the Hottinger Bruel and Kjaer Inc. Calibration Laboratory-Duluth, GA. Results relate only to the items tested. The Instrumentation has been calibrated using Measurement Standards with values traceable to the National Institute of Standards and Technology, National Measurement Institutes or derived from natural physical constants.

PROCEDURE:

The calibration was performed according to procedure number: 4128 DP Rev. 7.21

RESULTS:

"As Received" Physical Condition: Acceptable for Calibration

"As Received" Data: "As Received" = "Final Data" "Final Data": Within Acceptance Criteria

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k=2$ providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from standards, calibration method, effect of environmental conditions and any short term contribution from the device under calibration.

Date of Calibration: 05-Apr-2022 Certificate issued: 05-Apr-2022

John Avitabile — Calibration Technician

Meshaun Hobbs — Quality Representative

Hottinger Brüel & Kjær Inc. Calibration Laboratory

RESULTS:

Rev 7.21

I. Bruel & Kjaer Torso Model 4128, Serial Number: 1947220.

As Received Data		Final Data		As Received = Final Data	X

	Acceptance Criteria	Actual
A. Speaker and Speaker Assembly Mechanical Check.	Pass/Fail	Pass
B. Protection Circuit	Acceptance Criteria	Actual
1. 6.4 VRMS 750 Hertz Input	Signal remains for more than 30 Seconds	Pass
2. 7.5 VRMS 750 Hertz Input	Signal disappears in 12 Seconds Pass/Fail	Pass
C. Ear Simulator		
1. See enclosed Calibration Results for 4158, serial number: 1886222.	Calibration Results Included Yes/No/NA	Yes
2. See enclosed Calibration Results for 4159, serial number: .	Calibration Results Included Yes/No/NA	N/A

Reference Standards:

Model	Serial Number	Trace Number	Cal Due	Interval (mo)
HP 3458A	2823A03931	472263	30Sep22	12
HP 5315A	2536A15836	468431	30Jun22	12

HBK HOTTINGER BRÜEL & KJÆR
The Hottinger Brüel & Kjær Inc. Calibration Laboratory
3079 Premiere Parkway Suite 120
Duluth, GA 30097
Telephone: 770-209-6907
Fax: 770-447-4033
Web site address: http://www.hbkworld.com

A2LA ACCREDITED
Calibration Certificate # 1568.01

CERTIFICATE OF CALIBRATION

No.: CAS-565027-G1J7F1-401

CALIBRATION OF:

Microphone:	Brüel & Kjær	Type	4158/2669/UA1345	Serial No.	1886222/2025786

CUSTOMER:

PCTEST Engineering Laboratory Inc
7185 Oakland Mills Road
Columbia, MD 21046

✓ TK
5/6/2022

CALIBRATION CONDITIONS:

Environment conditions:	Air temperature:	23.2	°C
	Air pressure:	98.229	kPa
	Relative Humidity:	30	%RH
Applied polarization voltage:	200 Vdc		

SPECIFICATIONS:

This document certifies that the instrument as listed under "Type" has been calibrated and unless otherwise indicated under "Final Data", meets acceptance criteria as prescribed by the referenced Procedure. Statements of compliance, where applicable, are based on calibration results falling within specified criteria with no reduction by the uncertainty of the measurements. The calibration of the listed transducer was accomplished using a test system which conforms to the requirements of ISO/IEC 17025, ANSI/NCSL Z540-1, and guidelines of ISO 10012-1. For "as received" and "final" data, see the attached page(s). Items marked with one asterisk (*) are not covered by the scope of the current A2LA accreditation. This Certificate and attached data pages shall not be reproduced, except in full, without written approval of the Hottinger Brüel & Kjær Inc. Calibration Laboratory-Duluth, GA. Results relate only to the items tested. The transducer has been calibrated using Measurement Standards with values traceable to the National Institute of Standards and Technology, National Measurement Institutes or derived from natural physical constants.

PROCEDURE:

The measurements have been performed with the assistance of the Hottinger Brüel & Kjær Inc. Microphone Calibration System B&K 9721 with application software WT9649 and WT9650 version 5.3.0.10 using calibration procedure: 4158-2669-UA1345-S251

RESULTS:

- [X] "As Received" Data: Within Acceptance Criteria
- [ ] "As Received" Data: Outside Acceptance Criteria
- [X] "Final" Data : Within Acceptance Criteria
- [ ] "Final" Data : Outside Acceptance Criteria

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor k =2 providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from standards, calibration method, effect of environmental conditions and any short term contribution from the device under calibration.

Date of Calibration: April 11, 2022

Certificate issued: April 11, 2022

Meshaun Hobbs
Calibration Technician

Kyle Chancey
Quality Representative

Sensitivity

Nominal sensitivity:	-38 dB re. 1V/Pa	+/-	2	dB
Sensitivity at calibration conditions:	-38.26 dB re. 1V/Pa	or	12.22	mV/Pa
Sensitivity at reference conditions:	-38.28 dB re. 1V/Pa	or	12.19	mV/Pa
Uncertainty:	+/- 0.08 dB			
Correction factor K at reference conditions:	12.28 dB			
Calibration Frequency:	251.19 Hz			

Reference Conditions:
Pressure: 101.3 kPa
Temperature: 23 °C
Relative Humidity: 50%

Traceable references

Type	Serial no	Cal. date	Due date	Calibrated by	Trace number
4180	2602426	2020-06-09	2022-06-30	DPLA	M2.10-1392-2.1

Condition "As Received":
Good

Comments:
This Preamplifier predates the availability of TEDS

Acoustic Pressure Response Results *

The results in this table are not covered by the current A2LA Scope of Accreditation *

Frequency in Hertz	Sound Pressure Level in dB	IEC 711 Tolerance in dB	Actual Result in dB
100	-0.3	± 0.5	-0.59
125	-0.2	± 0.5	-0.36
160	-0.2	± 0.5	-0.47
200	-0.1	± 0.4	-0.41
250	-0.1	± 0.4	0.09
315	-0.1	± 0.4	-0.36
400	0	± 0.4	-0.34
500	Ref	Ref	0.00
630	0.1	± 0.4	-0.25
800	0.2	± 0.4	0.16
1,000	1.6	± 0.5	1.61
1,250	3.3	± 0.5	3.06
1,600	4.5	± 0.5	4.89
2,000	5.2	± 0.6	4.99
2,500	6	± 0.6	5.49
3,150	6.9	± 0.7	6.59
4,000	8	± 0.8	8.08
5,000	9.3	± 1.0	9.27
6,300	11.4	± 1.0	10.57
8,000	13.7	± 1.5	12.95
10,000	18	± 2.0	17.57

HBK HOTTINGER BRÜEL & KJÆR
The Hottinger Brüel & Kjær Inc. Calibration Laboratory
3079 Premiere Parkway Suite 120
Duluth, GA 30097
Telephone: 770-209-6907
Fax: 770-447-4033
Web site address: http://www.hbkworld.com

ACCREDITED

Calibration Certificate # 1568.01

CERTIFICATE OF CALIBRATION

No.: CAS-565027-G1J7F1-501

CALIBRATION OF:

Calibrator:	Brüel & Kjær	Type	4231	Serial No.:	2343018
Identification:		IEC Class:	1		

CUSTOMER:

PCTEST Engineering Laboratory Inc
7185 Oakland Mills Road
Columbia, MD 21046

V TK
5/6/2022

CALIBRATION CONDITIONS:

Environment conditions:	Air temperature:	23	°C
	Air pressure:	96.93	kPa
	Relative Humidity:	40	%RH

SPECIFICATIONS:

This document certifies that the acoustic calibrator as listed under "Type" has been calibrated and unless otherwise indicated under "Final Data", meets acceptance criteria as prescribed by the referenced Procedure. Statements of compliance, where applicable, are based on calibration results falling within specified criteria with no reduction by the uncertainty of the measurements. The calibration of the listed transducer was accomplished using a test system which conforms to the requirements of ISO/IEC 17025, ANSI/NCSL Z540-1, and guidelines of ISO 10012-1. For "as received" and "final" data, see the attached page(s). Items marked with one asterisk (*) are not covered by the scope of the current A2LA accreditation. This Certificate and attached data pages shall not be reproduced, except in full, without written approval of the Hottinger Brüel & Kjær Inc. Calibration Laboratory-Duluth, GA. Results relate only to the items tested. The transducer has been calibrated using Measurement Standards with values traceable to the National Institute of Standards and Technology, National Measurement Institutes or derived from natural physical constants. The acoustic calibrator has been calibrated in accordance with the requirements as specified in IEC60942.

PROCEDURE:

The measurements have been performed with the assistance of Hottinger Brüel & Kjær Inc. acoustic calibrator calibration application
Software version 2.3.4 Type 7794 using calibration procedure 4231 Complete

RESULTS:

- [X] "As Received" Data: Within Acceptance Criteria
- [ ] "As Received" Data: Outside Acceptance Criteria
- [X] "Final" Data : Within Acceptance Criteria
- [ ] "Final" Data : Outside Acceptance Criteria

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with EA-4/02from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the calibrator under calibration.

Date of Calibration: 06 April 2022

Certificate issued: 06 April 2022

Jimmy Smith
Calibration Technician

Meshaun Hobbs
Quality Representative

Sound Pressure Levels

All stated values are valid at environmental reference conditions

Nominal Level [dB]	Accept Limit Lower [dB]	Accept Limit Upper [dB]	Measured Level [dB]	Measurement Uncertainty [dB]
94	93.80	94.20	93.99	0.12
114	113.80	114.20	114.03	0.12

Frequency

Nominal Frequency [Hz]	Accept Limit Lower [Hz]	Accept Limit Upper [Hz]	Measured Frequency [Hz]	Measurement Uncertainty [Hz]
1000	999.00	1001.00	999.98	0.10

Total Distortion*

Distortion mode: [X] TD* [ ] THD*

Calibration Level [dB]*	Accept Limit [%]*	Measured Distortion [%]*	Measurement Uncertainty [%]*
94	1.00	0.53	0.13
114	1.00	0.17	0.13

Environmental Reference Conditions:

Pressure: 101.3 kPa, Temperature: 23 °C, Relative Humidity: 50%

Instrument List

Type	Description	Serial no	Cal. date	Due date	Calibrated by	Trace number
3560	PULSE Analyzer	2723320	2021-10-18	2022-10-18	JCA	CAS-541708-J2Z8Q8-301
9545	Transfer Microphone	3	2021-10-28	2022-10-31	MH	CAS-541708-J2Z8Q8-403
4228	Reference Sound Source	1618502	2021-04-30	2023-04-30	M. Hobbs	CAS-512601-T0X4B1-402

During the calibration the calibrator has been loaded by the load volume of the Transfer Microphone. The load volumes for a number of different types of Transfer Microphones are listed in the table below.
For Brüel & Kjær Pistonphones types 4220 and 4228 the result of the SPL calibration has been corrected to be valid for a load volume of 1333 mm^3 . For all other types the result is valid with the actual load volume.

Transfer Microphone Type	Fulfils standard IEC 61094-1 LS	Fulfils standard IEC 61094-4 WS	Load Volume 1" (1/2" mic including DP-0776)	Load Volume 1/2"
4180	yes	yes	1126 mm^3	43 mm^3
4192	-	yes	1273 mm^3	190 mm^3
9545	-	-	1333 mm^3	-

Condition "As Received":

Good

Comments

15. 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.

16. REFERENCES

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