



## HAC VOLUME CONTROL TEST REPORT

**FCC 47 CFR § 20.19  
ANSI C63.19-2011**

*For*  
**SMARTPHONE**

**FCC ID: BCG-E8958A  
Model Name: A3523**

**Report Number: 15496245-S3V1  
Issue Date: 7/17/2025**

*Prepared for*  
**APPLE INC.  
1 APPLE PARK WAY  
CUPERTINO, CA 95014-2084**

*Prepared by*  
**UL VERIFICATION SERVICES INC.  
47173 BENICIA STREET  
FREMONT, CA 94538, U.S.A.  
TEL: (510) 319-4000  
FAX: (510) 661-0888**



NVLAP LAB CODE 200065-0

**Revision History**

| Rev. | Date      | Revisions     | Revised By |
|------|-----------|---------------|------------|
| V1   | 7/17/2025 | Initial Issue | --         |
|      |           |               |            |
|      |           |               |            |
|      |           |               |            |

## Table of Contents

|                                                               |           |
|---------------------------------------------------------------|-----------|
| <b>1. Attestation of Test Results .....</b>                   | <b>4</b>  |
| <b>2. Test Methodology .....</b>                              | <b>5</b>  |
| <b>3. Facilities and Accreditation .....</b>                  | <b>5</b>  |
| <b>4. Calibration and Uncertainty .....</b>                   | <b>6</b>  |
| 4.1. Measuring Instrument Calibration.....                    | 6         |
| 4.2. Measurement Uncertainty .....                            | 6         |
| <b>5. Test Considerations per ANSI/TIA-5050-2018, §4.....</b> | <b>7</b>  |
| 5.1. Adjustable Frequency Response.....                       | 7         |
| 5.2. Acoustic Test Interface Equipment.....                   | 7         |
| 5.3. Handset Positioning and Mounting Force .....             | 7         |
| 5.4. Test Signal and Analysis .....                           | 7         |
| 5.5. Narrowband and Wideband Transmission Modes .....         | 7         |
| 5.5.1. Narrowband Mode Testing .....                          | 7         |
| 5.5.2. Wideband Mode Testing .....                            | 8         |
| 5.6. Air Interface .....                                      | 8         |
| 5.7. Precautions.....                                         | 8         |
| 5.8. Test Arrangement.....                                    | 8         |
| <b>6. Test Procedures per ANSI/TIA-5050-2018, §5 .....</b>    | <b>9</b>  |
| 6.1. Receive Volume Control Performance .....                 | 9         |
| 6.1.1. Requirement.....                                       | 9         |
| 6.1.2. Method of Measurement .....                            | 9         |
| 6.2. Receive Distortion and Noise Performance .....           | 9         |
| 6.2.1. Requirement.....                                       | 9         |
| 6.2.2. Measurement Method .....                               | 9         |
| 6.3. Receive Acoustic Frequency Response Performance .....    | 10        |
| 6.3.1. Requirement.....                                       | 10        |
| 6.3.2. Measurement Method .....                               | 12        |
| <b>7. Device Under Test.....</b>                              | <b>13</b> |
| 7.1. Air Interfaces and Operating Mode .....                  | 13        |
| <b>8. HAC (Volume Control) Test Results.....</b>              | <b>15</b> |
| <b>Appendix.....</b>                                          | <b>18</b> |
| Appendix A: T-Coil Setup Photo .....                          | 18        |
| Appendix B: Volume Control Test Plots.....                    | 18        |
| Appendix C: HAC Waiver DA 23-914 .....                        | 18        |

## Table of Tables

|                                                                      |    |
|----------------------------------------------------------------------|----|
| Table 6-1: Stimulus and Stimulus Measurement Bands for PN-SDNR ..... | 10 |
| Table 6-2: Narrowband Receive Frequency Response Limits .....        | 11 |
| Table 6-3: Wideband Receive Frequency Response Limits.....           | 12 |

## Table of Figures

|                                                                |    |
|----------------------------------------------------------------|----|
| Figure 5-1: Test Arrangement.....                              | 8  |
| Figure 6-1: Narrowband Receive Frequency Response Limits ..... | 11 |
| Figure 6-2: Wideband Receive Frequency Response Limits .....   | 12 |

## 1. Attestation of Test Results

|                                     |                                                                                        |      |
|-------------------------------------|----------------------------------------------------------------------------------------|------|
| Applicant Name                      | APPLE INC.                                                                             |      |
| FCC ID                              | BCG-E8958A                                                                             |      |
| Model Name                          | A3523                                                                                  |      |
| Applicable Standards                | FCC 47 CFR § 20.19<br>ANSI C63.19-2019<br>ANSI/TIA 5050-2018<br>Waiver order DA 23-914 |      |
| Conversational Gain Limits (dB)     | 2N                                                                                     | 8N   |
|                                     | $\geq 6$                                                                               |      |
| Worst case Conversational Gain (dB) | 14.85                                                                                  | 17.8 |
| Date Tested                         | 6/11/2025 to 7/4/2025                                                                  |      |
| Test Results                        | Pass                                                                                   |      |

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested can demonstrate compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to ensure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not considered unless noted otherwise.

This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of the U.S. government.

Approved & Released By:



Devin Chang  
Senior Laboratory Engineer  
UL Verification Services Inc.

Prepared By:



Kiara Davis  
Laboratory Engineer  
UL Verification Services Inc.

## 2. Test Methodology

The tests documented in this report were performed in accordance with ANSI C63.19-2019 and ANSI/TIA-5050-2018. Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids and FCC published procedures:

KDB 285076 D04 Volume Control v02  
KDB 285076 D05 CG Interim Waiver DA 23-914 v01  
KDB 388624 D02 Pre-Approval Guidance List v18r07 (WAIVER)

In addition to the above, the following guidance was used:

TCB workshop updates:

- TCB Workshop October 2023; HAC Updates (HAC Waiver Test Guidance for HAC Compliance)
- TCB Workshop April 2024; HAC Updates (Handset Configuration)

## 3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

|                      |
|----------------------|
| 47266 Benicia Street |
| Audio Chamber 1      |

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

The Test Lab Conformity Assessment Body Identifier (CABID)

| Location                                               | CABID  | Company Number |
|--------------------------------------------------------|--------|----------------|
| 47173 Benicia Street, Fremont, CA, 94538 UNITED STATES | US0104 | 2324A          |
| 47266 Benicia Street, Fremont, CA, 94538 UNITED STATES |        |                |

## 4. Calibration and Uncertainty

### 4.1. Measuring Instrument Calibration

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations and is traceable to recognized national standards.

| Name of Equipment                 | Manufacturer | Type/Model | Serial No.  | Cal. Due Date |
|-----------------------------------|--------------|------------|-------------|---------------|
| Head and Torso Simulator          | Brüel & Kjær | 4128C      | 3244297     | 4/30/2026     |
| Signal Conditioner/Amplifier      | Brüel & Kjær | 1708       | 100337      | 4/30/2026     |
| Sound & Vibration Measurement A/S | Brüel & Kjær | 3670       | 3670-000087 | 4/30/2026     |
| Handset Positioner                | Brüel & Kjær | 4606       | 2435148     | N/A           |
| Sound Calibrator                  | Brüel & Kjær | 4231       | 3025131     | 4/30/2026     |
| Radio Communication Tester*       | R & S        | CMW 500    | 125236-eS   | 2/14/2026     |
| Radio Communication Tester*       | R & S        | CMW 500    | 170415-uw   | 2/19/2026     |
| Radio Communication Tester*       | R & S        | CMX 500    | 101639-EE   | 02/14/2026    |

### 4.2. Measurement Uncertainty

Measurement Uncertainty for Audio Band Magnetic Measurement

| Error Description                                     | Uncertainty values (±%) | Probe Dist. | Div. | C <sub>i</sub> ABM1 | C <sub>i</sub> ABM2 | Std. Unc. |           |
|-------------------------------------------------------|-------------------------|-------------|------|---------------------|---------------------|-----------|-----------|
|                                                       |                         |             |      |                     |                     | ABM1 (±%) | ABM2 (±%) |
| <b>Probe Sensitivity</b>                              |                         |             |      |                     |                     |           |           |
| Reference level                                       | 3.0                     | N           | 1    | 1                   | 1                   | 3.0       | 3.0       |
| AMCC geometry                                         | 0.4                     | R           | √3   | 1                   | 1                   | 0.2       | 0.2       |
| AMCC current                                          | 1.0                     | R           | √3   | 1                   | 1                   | 0.6       | 0.6       |
| Probe positioning during calibration                  | 0.1                     | R           | √3   | 1                   | 1                   | 0.1       | 0.1       |
| Noise contribution                                    | 0.7                     | R           | √3   | 0.0143              | 1                   | 0.0       | 0.4       |
| Frequency slope                                       | 5.9                     | R           | √3   | 0.1                 | 1.00                | 0.3       | 3.5       |
| <b>Probe System</b>                                   |                         |             |      |                     |                     |           |           |
| Repeatability / drift                                 | 1.0                     | R           | √3   | 1                   | 1                   | 0.6       | 0.6       |
| Linearity / Dynamic range                             | 0.6                     | R           | √3   | 1                   | 1                   | 0.4       | 0.4       |
| Acoustic noise                                        | 1.0                     | R           | √3   | 0.1                 | 1                   | 0.1       | 0.6       |
| Probe angle                                           | 2.3                     | R           | √3   | 1                   | 1                   | 1.4       | 1.4       |
| Spectral processing                                   | 0.9                     | R           | √3   | 1                   | 1                   | 0.5       | 0.5       |
| Integration time                                      | 0.6                     | N           | 1    | 1                   | 5                   | 0.6       | 3.0       |
| Field disturbance                                     | 0.2                     | R           | √3   | 1                   | 1                   | 0.1       | 0.1       |
| <b>Test Signal</b>                                    |                         |             |      |                     |                     |           |           |
| Reference signal spectral response                    | 0.6                     | R           | √3   | 0                   | 1                   | 0.0       | 0.4       |
| <b>Positioning</b>                                    |                         |             |      |                     |                     |           |           |
| Probe positioning                                     | 1.9                     | R           | √3   | 1                   | 1                   | 1.1       | 1.1       |
| Phantom positioning                                   | 0.9                     | R           | √3   | 1                   | 1                   | 0.5       | 0.5       |
| EUT positioning                                       | 1.9                     | R           | √3   | 1                   | 1                   | 1.1       | 1.1       |
| <b>External Contributions</b>                         |                         |             |      |                     |                     |           |           |
| RF interference                                       | 0.0                     | R           | √3   | 1                   | 0.3                 | 0.0       | 0.0       |
| Test signal variation                                 | 2.0                     | R           | √3   | 1                   | 1                   | 1.2       | 1.2       |
| <b>Combined Std. Uncertainty (ABM field)</b>          |                         |             |      |                     |                     | 4.1       | 6.1       |
| <b>Expanded Std. Uncertainty (%)</b>                  |                         |             |      |                     |                     | 8.1       | 12.3      |
| Notes for table                                       |                         |             |      |                     |                     |           |           |
| 1. N - Nomal                                          |                         |             |      |                     |                     |           |           |
| 2. R - Rectangular                                    |                         |             |      |                     |                     |           |           |
| 3. Div. - Divisor used to obtain standard uncertainty |                         |             |      |                     |                     |           |           |

## 5. Test Considerations per ANSI/TIA-5050-2018, §4

### 5.1. Adjustable Frequency Response

If the terminal provides the ability to adjust the receive frequency response (e.g., via a "tone control" feature), the terminal is considered to be compliant with this Standard if it meets the requirements at one of the available frequency response settings.

### 5.2. Acoustic Test Interface Equipment

An ITU-T P.58 compliant Head and Torso Simulator (HATS) equipped with an ITU-T P.57 type 3.3 ear simulator shall be used for the acoustic transmission measurements specified in this standard. The ear simulator calibration and usage, and the positioning of the handset on the HATS shall be performed according to IEEE Std 269 unless stated otherwise in this document.

### 5.3. Handset Positioning and Mounting Force

The handset shall be placed in either the standard test position as specified in IEEE Std 269 or a recommended test position specified by the manufacturer that complies with the recommended test position requirements in IEEE Std 269.

Requirements in this standard include testing methods with a force of 2 Newtons (2N) and 8N applied when placing the handset receiver against the artificial ear pinna simulator for either the standard test position or recommended test position. The 2N force is used for testing requirements related to use by persons with hearing devices and the 8N force is used for testing requirements related to use by persons without hearing devices.

It is expected that for a person using a hearing device, the hearing device provides the desired amplification. Therefore, the tests using a force of 2N against the artificial ear pinna simulator ensure that when the telephone handset is used with a hearing device operating in the acoustic (microphone) mode, the receiver acoustics will provide the expected acoustic signals.

### 5.4. Test Signal and Analysis

The test signal specified for use in this document is the uncompressed real male speech as published with IEEE Std 269.

The test signal Active Speech Level (ASL) for wireless (mobile) device testing shall be -20 dBm0. The analysis shall be done in 1/12 octave bands averaged over one complete sequence of the four short sentences in the test signal unless otherwise specified.

The acoustic listener reference point shall be the Free Field (FF) or the Diffuse Field (DF) as determined in the method of measurement.

### 5.5. Narrowband and Wideband Transmission Modes

The codecs to be used for testing in the Narrowband and Wideband modes are stated below. If the required codec is not available on the DUT, then the codec closest to the required codec may be used and the codec used shall be reported with the test results.

#### 5.5.1. Narrowband Mode Testing

For testing of a terminal supporting narrowband telephony, the system simulator shall use the AMR speech codec as defined in the 3GPP TS 26 series of specifications, at the source coding bit rate of 12.2 kbit/s.

## 5.5.2. Wideband Mode Testing

For testing of a terminal supporting wideband telephony, the system simulator shall use the AMR-WB speech codec as defined in the 3GPP TS 26 series of specifications, at the source coding bit rate of 12.65 kbit/s.

## 5.6. Air Interface

Wireless handsets typically provide multiple air interface modes such as GSM, CDMA, WCDMA, LTE, etc. When connecting a call between the audio test system and the DUT through the Call Box, any available air interface that supports the codecs described above may be used for testing.

## 5.7. Precautions

Coding, decoding, packetization, and other signal processing may introduce significant delays that must be accounted for by the measurement system. Refer to IEEE Std 269 for additional precautions regarding test signal usage.

## 5.8. Test Arrangement

The general test arrangement is shown in Figure 5-1. The Call Box passes the voice channel stream to the DUT without modification. There is no gain or loss in the voice channel stream due to the Call Box interface. The RETP (receive electrical test point) is the point in the device test arrangement where signals are applied to the DUT in the receive direction.<sup>1</sup>

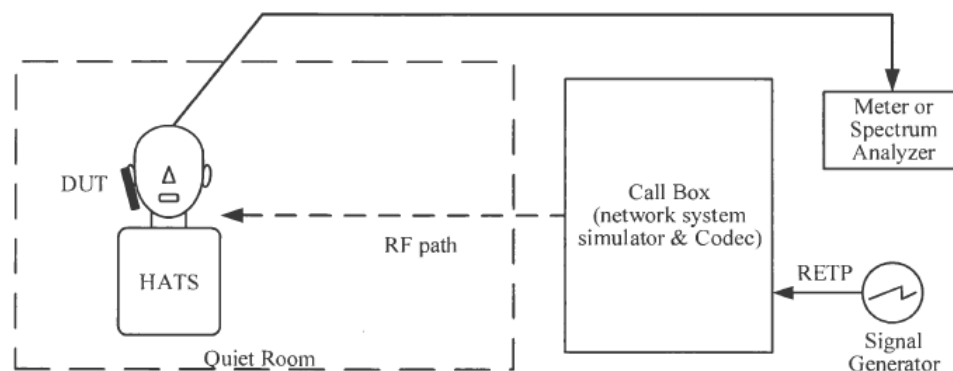


Figure 5-1: Test Arrangement

<sup>1</sup> Additional information related to the air interface for the various RF technologies is specified in several 3GPP documents. A list of these can be found in 3GPP TS 26.132 V14.0.0 §4. Additional information related to the test setup can be found in 3GPP TS 26.132, V14.0.0 §5.1.



## 6. Test Procedures per ANSI/TIA-5050-2018, §5

### 6.1. Receive Volume Control Performance

#### 6.1.1. Requirement

1. With a mounting force of 8N, the DUT shall have at least one volume control setting that will produce a conversational gain of  $\geq 18^2$  dB with the output distortion and the frequency response meeting the requirements in ANSI/TIA-5050-2018 clause 5.2.1 and 5.3.1 respectively.
2. With a mounting force of 2N, the DUT shall have at least one volume control setting that will produce a conversational gain of  $\geq 6$  dB with the output distortion and the frequency response meeting the requirements in ANSI/TIA-5050-2018 clause 5.2.1 and 5.3.1 respectively.

#### 6.1.2. Method of Measurement

1. Configure the DUT with a mounting force of 8N and test equipment as shown in Figure 5-1 in an active call state with the applicable codec for the transmission mode under test.
2. Set the DUT volume control to the maximum setting.
3. If the DUT has an adjustable tone control feature, a tone control setting that meets the frequency response requirements in ANSI/TIA-5050-2018 §5.3.1 shall be used.
4. Apply the real speech test signal at a level of -20 dBm0 at the RETP and measure the acoustic output at the Drum Reference Point (DRP) over one complete sequence of the test signal.
5. Translate the measurement made at the DRP to the Free Field (FF) using the translation data in ANSI/TIA-5050-2018 Annex B.
6. Over the applicable frequency band, determine the ASL in dBSPL for the resulting sound pressure level in accordance with Method B of ITU-T Recommendation P.56:
  - a. Narrowband 100 Hz through 4000 Hz.
  - b. Wideband 100 Hz through 7720 Hz.
7. Calculate the Conversational Gain by subtracting 70 dB from the measured dBSPL.

$$\text{Conversation Gain} = (\text{Measured dBSPL} - 70 \text{ dBSPL}) \text{ dB}$$

8. Measure the output distortion per ANSI/TIA-5050-2018 §5.2. If a distortion failure occurs at the maximum volume control setting, reduce the volume control setting and repeat the measurement to determine if a setting can be found for which the conversational gain requirement is met without a distortion failure.
9. Repeat steps 2-8 with a mounting force of 2N.

### 6.2. Receive Distortion and Noise Performance

#### 6.2.1. Requirement

With a mounting force of 8N and 2N, the ratio of the stimulus signal power to the 100 Hz to 8000 Hz total A-weighted distortion and noise power shall be  $\geq 20$  dB when tested over the range of 1/3 octave band center frequencies:

1. Narrowband transmission mode: Each 1/3 octave band center frequency from 400 Hz to 3150 Hz.
2. Wideband transmission mode: Each 1/3 octave band center frequency from 250 Hz to 5000 Hz.

#### 6.2.2. Measurement Method

1. Configure the DUT with a mounting force of 8N and test equipment as shown in Figure 5-1 in an active call state with the applicable codec for the transmission mode under test with the volume control at the setting determined in ANSI/TIA-5050-2018 §5.1.1.
2. Receive distortion and noise is measured using the PN-SDNR procedure as described in ANSI/TIA-5050-2018 Annex A.

---

<sup>2</sup> <sup>1</sup> Per KDB 285076 D05 CG Interim Waiver DA 23-914 v01, DUT must have at least one volume control setting that will produce a conversational gain of  $\geq 6$  dB for a mounting force of 8N.

3. To ensure DUT activation, apply the real speech test signal at a level of -20 dBm0 followed immediately by the initial 1/3 octave center frequency PN test signal in Table 6-1 based on the narrowband or wideband operating mode. Measure the acoustic output at the DRP over the complete sequence of the PN test signal.
4. Translate the measurement made at the DRP to the FF using the translation data in ANSI/TIA-5050-2018 Annex B.
5. Calculate the acoustic output unweighted total signal power of the stimulus measurement band as described in ANSI/TIA-5050-2018 A.2.
6. Calculate the notched A-weighting distortion and noise components as described in ANSI/TIA-5050-2018 A.3.
7. Calculate the ratio of the signal power to the total A-weighted distortion and noise power using the following equation:

$$PN - SDNR(dB) = 20 * \log \left( \frac{\text{measured stimulus amplitude}}{\text{measured distortion amplitude}} \right)$$

8. Repeat for each of the remaining 1/3 octave center frequencies in Table 6-1 based on the narrowband or wideband operating mode.
9. Repeat steps 2-8 with a mounting force of 2N.

**Table 6-1: Stimulus and Stimulus Measurement Bands for PN-SDNR**

| <i>Stimulus Measurement Lower Band Edge</i> | <i>Stimulus Lower Band Edge</i> | <i>Nominal Center Frequency</i> | <i>Stimulus Upper Band Edge</i> | <i>Stimulus Measurement Upper Band Edge</i> | <i>Handset Operating Mode</i> |
|---------------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------------------|-------------------------------|
| 190                                         | 225                             | 250                             | 280                             | 315                                         | Wideband only                 |
| 245                                         | 280                             | 315                             | 355                             | 390                                         |                               |
| 320                                         | 355                             | 400                             | 445                             | 480                                         |                               |
| 410                                         | 445                             | 500                             | 560                             | 595                                         | Narrowband & Wideband         |
| 525                                         | 560                             | 630                             | 710                             | 745                                         |                               |
| 675                                         | 710                             | 800                             | 890                             | 925                                         |                               |
| 855                                         | 890                             | 1000                            | 1120                            | 1155                                        |                               |
| 1085                                        | 1120                            | 1250                            | 1415                            | 1450                                        |                               |
| 1375                                        | 1410                            | 1600                            | 1780                            | 1815                                        |                               |
| 1745                                        | 1780                            | 2000                            | 2240                            | 2275                                        |                               |
| 2205                                        | 2240                            | 2500                            | 2820                            | 2855                                        |                               |
| 2785                                        | 2820                            | 3150                            | 3550                            | 3585                                        | Wideband only                 |
| 3515                                        | 3550                            | 4000                            | 4465                            | 4500                                        |                               |
| 4430                                        | 4465                            | 5000                            | 5625                            | 5660                                        |                               |

## 6.3. Receive Acoustic Frequency Response Performance

### 6.3.1. Requirement

The receive acoustic frequency response is required to be met when tested with a handset mounting force of 2N and 8N. For a hearing device, a 2N force is used to simulate usage of the handset by a person with a hearing device in the microphone (acoustic) mode.

The receive frequency response is the ratio of the output sound pressure at the listener reference point (LRP) (FF or DF) to the voltage input to the reference codec, or digital bit stream equivalent, as shown in the equation below for each frequency or frequency band ( $f_i$ ):

$$S_{JE} = 20 * \log_{10}(P_E/V_R) \text{ dB re } 1 \text{ Pa/V}$$

Where:

$S_{JE}$  = Receive Sensitivity, Junction to Ear, at  $f_i$   
 $P_E$  = LRP sound pressure measured by ear simulator at DRP and translated to the FF or DF (see ANSI/TIA-5050-2018 Annex B), at  $f_i$ <sup>3</sup>

<sup>3</sup> 3GPP frequency response requirements in TS 26.131 as measured in TS 26.132 only use the DF. This standard allows either the FF or DF to meet the frequency response requirements but requires FF for both the volume control (ANSI/TIA-5050 §5.1) and distortion and noise (ANSI/TIA-5050-2018 §5.2) requirements.

$V_R$  = RMS input voltage to the reference codec, or digital bit stream equivalent, at  $f_i$

For the volume control settings determined in ANSI/TIA-5050-2018 §5.1.1 with a mounting force of 8N and 2N, the receive frequency response shall be measured at the DRP in 1/12 octave bands. After translation to the FF or DF, it shall fall between the applicable upper and lower limits.

The exact limit values at any 1/12 octave band center frequency falling between two consecutive points specified in the table may be calculated using the formula given in the equation below:

$$X_f = X_1 + (X_2 - X_1) * \left( \frac{\log_{10} f - \log_{10} f_1}{\log_{10} f_2 - \log_{10} f_1} \right)$$

Where:

$X_f$  = limit value at frequency  $f$   
 $X_1$  = limit value at frequency  $f_1$  as given in Table 6-2  
 $X_2$  = limit value at frequency  $f_2$  as given in Table 6-2

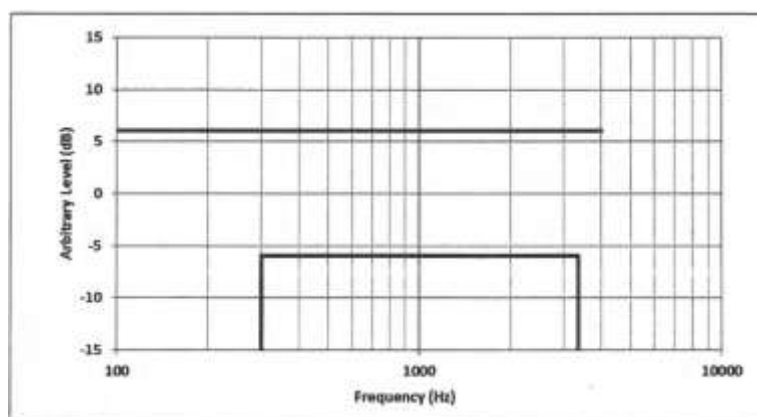
The results for each 1/12 octave band measurement are to be evaluated against the upper and lower limit values only at the center frequency point for that band (i.e., not the entire width of the band). For graphical purposes, the individual 1/12 octave band measurement results are plotted as points on a linear dB scale (y-axis) versus the band's center frequency on a logarithmic frequency scale (x-axis). The frequency response limits are floating or "best fit" (i.e., the maximum and minimum deviations from the upper and lower limits should be equidistant from those limits).

The following narrowband and wideband frequency response limits are referenced from 3GPP TS26.131.<sup>4</sup>

1. Narrowband: The 1/12 octave band frequency response after translation to the FF or DF shall fall between the upper and lower limits given in Table 6-2 and shown in Figure 6-1.

**Table 6-2: 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               |



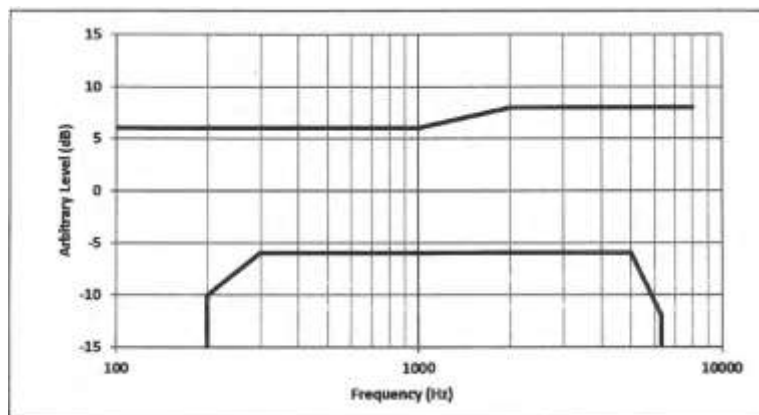
**Figure 6-1: Narrowband Receive Frequency Response Limits**

<sup>4</sup> 3GPP TS 26.132 states the frequency response measurements are referred to the DF.

2. Wideband: The 1112 octave band frequency response after translation to the FF or DF shall fall between the upper and lower limits given in Table 6-3 and shown in Figure 6-2.

**Table 6-3: 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               |
| 6300                       | -12              | 8000                       | +8               |

**Figure 6-2: Wideband Receive Frequency Response Limits**

### 6.3.2. Measurement Method

1. Configure the DUT with a mounting force of 8N and test equipment as shown in Figure 5-1 in an active call state with the applicable codec for the transmission mode under test with the volume control at the setting determined in ANSI/TIA-5050-2018 §5.1.1.
2. If the DUT has an adjustable tone control feature the initial measurement is to be performed with the default tone control setting.
3. Apply the real speech test signal with a level of -20 dBm0 at the RETP.
4. Capture the frequency spectrum at the DRP of the HATS using real-time analysis with 1/12 octave bands over the frequency range from 100 Hz to 4000 Hz for narrowband measurements, or over the frequency range from 100 Hz to 8000 Hz for wideband measurements, averaged over the entire duration of the test signal.
5. Transform the DRP frequency spectrum measurement to the FF or DF (see ANSI/TIA-5050-2018 Annex B).
6. Divide the 1/12 octave measurement data by the 1/12 octave frequency spectrum of the test signal at the RETP and present the measurement in terms of dB (Pa/V).
7. Apply the applicable frequency response limits to determine compliance.
8. If the default tone control setting does not meet the requirement, repeat the above steps for other tone control settings to determine a tone control setting that meets the requirements.
9. Repeat with a mounting force of 2N.

## 7. Device Under Test

|                         |                                 |                    |                            |
|-------------------------|---------------------------------|--------------------|----------------------------|
| Normal operation        | Held to head                    |                    |                            |
| Back Cover              | The Back Cover is not removable |                    |                            |
| Test sample information | <b>S/N</b><br>DQ69GDPGQP        | <b>IMEI</b><br>N/A | <b>Notes</b><br>HAC Sample |

### 7.1. Air Interfaces and Operating Mode

| Air Interface  | Bands (MHz)                         | Type  | C63.19 Tested    | Simultaneous Transmitter                             | Name of Voice Service | Power Mode <sup>4</sup> | Power Reduction | Audio Codecs Evaluated <sup>1,2</sup> |
|----------------|-------------------------------------|-------|------------------|------------------------------------------------------|-----------------------|-------------------------|-----------------|---------------------------------------|
| GSM            | 850                                 | VO    | Yes              | Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB        | CMRS                  | Mode A                  | N/A             | EFR, AMR-NB & AMR-WB                  |
|                | 1900                                |       |                  |                                                      |                       |                         | N/A             |                                       |
|                | GPRS/EDGE                           | DT/VD | No               | Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB        | FaceTime              | Mode A                  | N/A             | ACC-ELD                               |
| W-CDMA (UMTS)  | 850                                 | VO    | Yes              | Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB        | CMRS                  | Mode A                  | N/A             | AMR-NB & AMR-WB                       |
|                | 1700                                |       |                  |                                                      |                       |                         |                 |                                       |
|                | 1900                                | VD    | No               | Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB        | FaceTime              | Mode A                  | N/A             | ACC-ELD                               |
|                | HSPA                                |       |                  |                                                      |                       |                         |                 |                                       |
| LTE - FDD      | 700 (B12/13/17)                     | VD    | Yes              | 5G NR, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB | CMRS FaceTime         | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD        |
|                | 850 (B5/26)                         |       |                  |                                                      |                       |                         |                 |                                       |
|                | 1700 (B4/66)                        |       |                  |                                                      |                       |                         |                 |                                       |
|                | 1900 (B2/25)                        |       |                  |                                                      |                       |                         |                 |                                       |
|                | 2300 (B30)                          |       |                  |                                                      |                       |                         |                 |                                       |
|                | 2500 (B7)                           |       |                  |                                                      |                       |                         |                 |                                       |
| LTE - TDD      | 2500 (B53)                          | VD    | Yes              | 5G NR, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB | CMRS FaceTime         | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD        |
|                | 2600 (B38/41) <sup>5</sup>          |       |                  |                                                      |                       |                         |                 |                                       |
|                | 3600 (B48)                          |       |                  |                                                      |                       |                         |                 |                                       |
| 5G NR(FR1) FDD | 700 (n12)                           | VD    | Yes <sup>3</sup> | LTE, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB   | CMRS FaceTime         | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD        |
|                | 850 (n5/n26)                        |       |                  |                                                      |                       |                         |                 |                                       |
|                | 1700 (n66/n70)                      |       |                  |                                                      |                       |                         |                 |                                       |
|                | 1900 (n2/n25)                       |       |                  |                                                      |                       |                         |                 |                                       |
|                | 2300 (n30)                          |       |                  |                                                      |                       |                         |                 |                                       |
|                | 2500 (n7)                           |       |                  |                                                      |                       |                         |                 |                                       |
| 5G NR(FR1) TDD | 2500 (n53)                          | VD    | Yes <sup>3</sup> | LTE, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB   | CMRS FaceTime         | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD        |
|                | 2600 (n38/n41)                      |       |                  |                                                      |                       |                         |                 |                                       |
|                | 3500 (n77/n78 Block A) <sup>5</sup> |       |                  |                                                      |                       |                         |                 |                                       |
|                | 3600(n77/n78 Block B) <sup>5</sup>  |       |                  |                                                      |                       |                         |                 |                                       |
|                | 3700 (n48)                          |       |                  |                                                      |                       |                         |                 |                                       |
|                | 3900 (n77/78 Block C) <sup>5</sup>  |       |                  |                                                      |                       |                         |                 |                                       |

Type  
VO: Legacy Cellular Voice Service  
DT: Digital Transport only (no voice)  
VD: IP Voice Service over Digital Transport  
CMRS: Commercial Mobile Radio Service

Note(s):

- ASL of -20 dBm0 is required for all codecs.
- ACC-ELD not required for evaluation. Refer to §6.1.1(c).
- VoNR is supported: manufacturer states that VoNR uses the same protocol, Codec(s) and bitrates as VoLTE.
- For all air interfaces, the maximum held-to-head output power was used for Volume Control evaluations. The maximum held-to-head output power is Power State 1 Mode A for WWAN operating modes and Power State 1 Mode A for WLAN operating modes. Refer to §8 for Volume Control evaluations.
- LTE TDD B41 supports Power Class 2 and 3, 5G NR TDD n41, n77 and n78 support Power Class 2 and 3.

**Air Interfaces and Operating Mode (Continued)**

| Air Interface        | Bands (MHz)            | Type | C63.19 Tested   | Simultaneous Transmitter                   | Name of Voice Service | Power Mode <sup>4</sup> | Power Reduction                | Audio Codecs Evaluated <sup>1,2</sup> |
|----------------------|------------------------|------|-----------------|--------------------------------------------|-----------------------|-------------------------|--------------------------------|---------------------------------------|
| Wi-Fi                | 2450                   | VD   | Yes             | WWAN, NB U-NII & 802.15.4ab                | CMRS FaceTime         | Power State 1 Head      | N/A                            | AMR-NB, AMR-WB, EVS, & ACC-ELD        |
|                      | U-NII-1                |      |                 |                                            |                       |                         |                                |                                       |
|                      | U-NII-2A               |      |                 |                                            |                       |                         |                                |                                       |
|                      | U-NII-2C               |      |                 |                                            |                       |                         |                                |                                       |
|                      | U-NII-3                | VD   | No <sup>3</sup> | WWAN, BT, 802.15.4, & 802.15.4ab NB        | CMRS FaceTime         | N/A                     | AMR-NB, AMR-WB, EVS, & ACC-ELD |                                       |
|                      | U-NII-5 (SP, LPI, VLP) |      |                 |                                            |                       |                         |                                |                                       |
|                      | U-NII-6 (LPI, VLP)     |      |                 |                                            |                       |                         |                                |                                       |
|                      | U-NII-7 (SP, LPI, VLP) |      |                 |                                            |                       |                         |                                |                                       |
| U-NII-8 (LPI, VLP)   |                        |      |                 |                                            |                       |                         |                                |                                       |
| NB U-NII             | U-NII-1                | DT   | N/A             | WWAN, Wi-Fi 2.4 GHz                        | N/A                   | N/A                     | N/A                            | N/A                                   |
|                      | U-NII-3                |      |                 |                                            |                       |                         |                                |                                       |
|                      | U-NII-5                |      |                 |                                            |                       |                         |                                |                                       |
| 802.15ab NB          | U-NII-3                | DT   | N/A             | WWAN, BT, 802.15.4 & Wi-Fi <sup>2</sup>    | N/A                   | N/A                     | N/A                            | N/A                                   |
| 802.15.4             | 2450                   | DT   | N/A             | WWAN, 802.15.4ab NB & Wi-Fi 5/6G           | N/A                   | N/A                     | N/A                            | N/A                                   |
| BT                   | 2450                   | DT   | N/A             | WWAN, 802.15.4ab NB & Wi-Fi 5/6G           | N/A                   | N/A                     | N/A                            | N/A                                   |
| MSS                  | 1600                   | DT   | N/A             | N/A                                        | N/A                   | N/A                     | N/A                            | N/A                                   |
| NFC                  | 13                     | DT   | N/A             | WWAN, BT, Wi-Fi 2.4G, Wi-Fi 5/6G, 802.15.4 | N/A                   | N/A                     | N/A                            | N/A                                   |
| UWB (Ultra-Wideband) | 6500                   | DT   | N/A             | N/A                                        | N/A                   | N/A                     | N/A                            | N/A                                   |
|                      | 8000                   |      |                 |                                            |                       |                         |                                |                                       |

Type  
VO: Legacy Cellular Voice Service  
DT: Digital Transport only (no voice)  
VD: IP Voice Service over Digital Transport  
CMRS: Commercial Mobile Radio Service

Note(s):  
1. ASL of -20 dBm0 is required for all codecs.  
2. ACC-ELD not required for evaluation. Refer to §6.1.1(c).  
3. Supported Frequency > 6GHz. ANSI C63,19 2019 only requires HAC evaluations for Technologies/Frequencies < 6GHz.  
4. For all air interfaces, the maximum held-to-head output power was used for Volume Control evaluations. The maximum held-to-head output power is Power State 1 Mode A for WWAN operating modes and Power State 1 Mode A for WLAN operating modes. Refer to §8 for Volume Control evaluations.

## 8. HAC (Volume Control) Test Results

Volume control testing was performed in accordance with KDB 285076 D05 CG Interim Waiver DA 23-914. Test guidance is as follows:

- 1) 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  $\geq 6$  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.
    - i) With a mounting force of 2N, the ratio of the stimulus signal power to the 100 Hz to 8000 Hz total A-weighted distortion and noise power shall be  $\geq 20$  dB when tested over the range of 1/3 octave band center frequencies:
  - 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  $\geq 6$  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 § 5.1.1 of the TIA 5050 Volume Control Standard using one codec bit rate of the applicant's choosing.
    - i) With a mounting force of 8N, the ratio of the stimulus signal power to the 100 Hz to 8000 Hz total A-weighted distortion and noise power shall be  $\geq 20$  dB when tested over the range of 1/3 octave band center frequencies:
- 2) For all other narrowband and wideband codecs not evaluated in 1) 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  $\geq 6$  dB for all voice services, bands of operation and air interfaces over which they operate. The handset volume setting used to comply with 1) shall be used for these other CMRS codec evaluations.
- 3) Any other codec for voice services embedded in the handset, not identified in 1) and 2) above, is not required to comply or demonstrate in the test reports for conversational gain (e.g., Google Meet, non-3GPP VoIP codecs).

For WWAN technologies, the DUT utilizes an Antenna - Port mapping feature. A Port is a collection (cluster) of antennas. Once the Port and Frequency Band has been selected, the transmitting Antenna is auto selected. Below is a description of the Port - Antenna mapping for the DUT.

| Port | Frequency Band | Antenna |
|------|----------------|---------|
| A    | LB             | 3       |
|      | LMB            | 3       |
|      | MBHB           | 3       |
|      | UHB            | 9       |
| B    | LB             | 2       |
|      | LMB            | 2       |
|      | MBHB           | 4       |
|      | UHB            | 8       |
| C    | MBHB           | 2       |
|      | UHB            | 4       |
| D    | MBHB           | 1       |
|      | UHB            | 7       |

LB = Lower Band (617 MHz - 960 MHz)

LMB = Lower - Mid Band (1427 MHz - 1700 MHz)

MBHB = Mid Band - High Band (1710 MHz - 2960 MHz)

UHB = Ultra High Band (3300 MHz - 4200 MHz)

The device supports four (4) WLAN Tx antennas:

| Antenna | Technology      |
|---------|-----------------|
| 1       | Wi-Fi 2.4 GHz   |
| (Lower) | Bluetooth       |
| 2       | Wi-Fi 2.4 GHz   |
| (Upper) | Bluetooth       |
| 5       | Wi-Fi 5 & 6 GHz |
| (Lower) |                 |
| 6       | Wi-Fi 5 & 6 GHz |
| (Upper) |                 |

**Rx Distortion, Rx Frequency Response & Conversational Gain Measured Results**

EVS-NB and EVS-WB codecs were selected for Rx Distortion, Rx Frequency Response & Conversational Gain evaluations.

**LTE**

| RF Air Interface |        | Mode   | Channel | Frequency (MHz) | Channel Bandwidth (MHz) | RB Allocation | RB Offset | Port/ANT  | Power Mode | Codec  | Bitrate (kbps) | Frequency Response |       |       |       | Distortion |         | Conversational Gain (dB) |       | Plot No. |
|------------------|--------|--------|---------|-----------------|-------------------------|---------------|-----------|-----------|------------|--------|----------------|--------------------|-------|-------|-------|------------|---------|--------------------------|-------|----------|
| Technology       | Band   |        |         |                 |                         |               |           |           |            |        |                | 2N DF              | 2N FF | 8N DF | 8N FF | 2N SDNR    | 8N SDNR | 2N                       | 8N    |          |
| LTE              | 25     | QPSK   | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.18                    | 17.90 | 1 - 2    |
| LTE              | 25     | QPSK   | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-WB | 24.4           | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.65                    | 19.52 | 3 - 4    |
| LTE              | 25     | QPSK   | 26365   | 1882.5          | 20                      | 100           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.46                    | 17.98 | 5 - 6    |
| LTE              | 25     | 16QAM  | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.40                    | 18.03 | 7 - 8    |
| LTE              | 25     | 64QAM  | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.29                    | 17.92 | 9 - 10   |
| LTE              | 25     | 256QAM | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.29                    | 18.04 | 11 - 12  |
| LTE              | 25     | QPSK   | 26365   | 1882.5          | 1.4                     | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.41                    | 18.43 | 13 - 14  |
| LTE              | 7      | QPSK   | 21100   | 2535.0          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.12                    | 17.8  | 15 - 16  |
| LTE              | 12     | QPSK   | 23095   | 707.5           | 10                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.18                    | 18.31 | 17 - 18  |
| LTE              | 13     | QPSK   | 23230   | 782.0           | 10                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.32                    | 18.29 | 19 - 20  |
| LTE              | 26     | QPSK   | 26865   | 831.0           | 15                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.16                    | 18.40 | 21 - 22  |
| LTE              | 30     | QPSK   | 27710   | 2310.0          | 10                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.31                    | 18.34 | 23 - 24  |
| LTE              | 41 PC3 | QPSK   | 40620   | 2593.0          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.29                    | 18.35 | 25 - 26  |
| LTE              | 41 PC2 | QPSK   | 40620   | 2593.0          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.57                    | 18.79 | 27 - 28  |
| LTE              | 48 PC3 | QPSK   | 55900   | 3625.0          | 20                      | 1             | 0         | B (ANT 8) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.47                    | 18.29 | 29 - 30  |
| LTE              | 53 PC3 | QPSK   | 60197   | 2489.2          | 10                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.24                    | 18.24 | 31 - 32  |
| LTE              | 66     | QPSK   | 132322  | 1745.0          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.20                    | 17.87 | 33 - 34  |

**5G NR**

| RF Air Interface |              | Mode      | Channel | Frequency (MHz) | Channel Bandwidth (MHz) | SCS (kHz) | RB Allocation | RB Offset | Port/ANT  | Power Mode | Codec  | Bitrate (kbps) | Frequency Response |       |       |       | Distortion |         | Conversational Gain (dB) |       | Plot No. |
|------------------|--------------|-----------|---------|-----------------|-------------------------|-----------|---------------|-----------|-----------|------------|--------|----------------|--------------------|-------|-------|-------|------------|---------|--------------------------|-------|----------|
| Technology       | Band         |           |         |                 |                         |           |               |           |           |            |        |                | 2N DF              | 2N FF | 8N DF | 8N FF | 2N SDNR    | 8N SDNR | 2N                       | 8N    |          |
| 5G NR            | n25          | 11/2 BPSK | 376500  | 1882.5          | 40                      | 15        | 1             | 1         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.9                     | 20.57 | 35 - 36  |
| 5G NR            | n25          | 11/2 BPSK | 376500  | 1882.5          | 40                      | 15        | 1             | 1         | B (ANT 2) | Mode A     | EVS-WB | 24.4           | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 19.33                    | 22.12 | 37 - 38  |
| 5G NR            | n25          | 11/2 BPSK | 376500  | 1882.5          | 40                      | 15        | 216           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.74                    | 20.59 | 39 - 40  |
| 5G NR            | n25          | QPSK      | 376500  | 1882.5          | 40                      | 15        | 216           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.95                    | 20.67 | 41 - 42  |
| 5G NR            | n25          | 16QAM     | 376500  | 1882.5          | 40                      | 15        | 216           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.94                    | 20.9  | 43 - 44  |
| 5G NR            | n25          | 64QAM     | 376500  | 1882.5          | 40                      | 15        | 216           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.98                    | 20.88 | 45 - 46  |
| 5G NR            | n25          | 256QAM    | 376500  | 1882.5          | 40                      | 15        | 216           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.99                    | 21.26 | 47 - 48  |
| 5G NR            | n25          | 11/2 BPSK | 376500  | 1882.5          | 5                       | 15        | 25            | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 18.09                    | 21.1  | 49 - 50  |
| 5G NR            | n7           | 11/2 BPSK | 507000  | 2535.0          | 40                      | 15        | 216           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 18.1                     | 21.25 | 51 - 52  |
| 5G NR            | n12          | 11/2 BPSK | 141500  | 707.5           | 15                      | 15        | 79            | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 18.13                    | 21.33 | 53 - 54  |
| 5G NR            | n30          | 11/2 BPSK | 462000  | 2310.0          | 10                      | 15        | 52            | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 18.08                    | 21.48 | 55 - 56  |
| 5G NR            | n41 PC3      | 11/2 BPSK | 518598  | 2592.99         | 100                     | 30        | 273           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.17                    | 19.37 | 57 - 58  |
| 5G NR            | n41 PC2      | 11/2 BPSK | 518598  | 2592.99         | 100                     | 30        | 273           | 0         | B (ANT 2) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.32                    | 19.63 | 59 - 60  |
| 5G NR            | n77 Bk C PC3 | 11/2 BPSK | 657200  | 3658.0          | 100                     | 30        | 273           | 0         | B (ANT 8) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.48                    | 19.57 | 61 - 62  |
| 5G NR            | n77 Bk C PC2 | 11/2 BPSK | 657200  | 3658.0          | 100                     | 30        | 273           | 0         | B (ANT 8) | Mode A     | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.47                    | 19.55 | 63 - 64  |

**Note(s):**

The DUT supports 5G NR. Per the manufacturer, 5G NR uses the same protocol, Codec(s) and bitrates as LTE. A limited set of 5G NR bands were tested to confirm VoNR Volume Control compliance.

- At least one 5G NR-FDD LB, MB and HB were tested.
- At least one 5G NR-TDD HB and UHB were tested.

**WLAN**

| RF Air Interface |        |          | Modulation | Data Rate (Mbps) | Channel | Frequency (MHz) | Channel Bandwidth (MHz) | Port/ANT | Power Mode         | Codec  | Bitrate (kbps) | Frequency Response |       |       |       | Distortion |         | Conversational Gain (dB) |       | Plot No. |
|------------------|--------|----------|------------|------------------|---------|-----------------|-------------------------|----------|--------------------|--------|----------------|--------------------|-------|-------|-------|------------|---------|--------------------------|-------|----------|
| Technology       | Band   | Mode     |            |                  |         |                 |                         |          |                    |        |                | 2N DF              | 2N FF | 8N DF | 8N FF | 2N SDNR    | 8N SDNR | 2N                       | 8N    |          |
| WLAN             | DTTS   | 802.11b  | DSSS       | 1                | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.32                    | 19.35 | 65 - 66  |
| WLAN             | DTTS   | 802.11b  | DSSS       | 1                | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-WB | 24.4           | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.89                    | 20.98 | 67 - 68  |
| WLAN             | DTTS   | 802.11b  | CKK        | 5.5              | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.16                    | 19.34 | 69 - 70  |
| WLAN             | DTTS   | 802.11b  | CKK        | 11               | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.26                    | 19.34 | 71 - 72  |
| WLAN             | DTTS   | 802.11g  | QPSK       | 12 Mbps          | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.99                    | 19.36 | 73 - 74  |
| WLAN             | DTTS   | 802.11n  | MCS3       | 26 Mbps          | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.25                    | 19.39 | 75 - 76  |
| WLAN             | DTTS   | 802.11ax | MCS5       | 68.8 Mbps        | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.16                    | 22.71 | 77 - 78  |
| WLAN             | UNB-1  | 802.11a  | QPSK       | 18 Mbps          | 36      | 5180.0          | 20                      | ANT 6    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.25                    | 22.56 | 79 - 80  |
| WLAN             | UNB-2A | 802.11n  | MCS3       | 54 Mbps          | 54      | 5270.0          | 40                      | ANT 6    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 15.32                    | 22.56 | 81 - 82  |
| WLAN             | UNB-2C | 802.11ac | MCS5       | 234 Mbps         | 106     | 5530.0          | 80                      | ANT 6    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16                       | 22.61 | 83 - 84  |
| WLAN             | UNB-3  | 802.11ax | MCS6       | 649 Mbps         | 163     | 5815.0          | 160                     | ANT 6    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.92                    | 22.78 | 85 - 86  |
| WLAN             | UNB-5  | 802.11ax | MCS6       | 77 Mbps          | 5       | 5975.0          | 20                      | ANT 6    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 16.35                    | 23.04 | 87 - 88  |
| WLAN             | UNB-5  | 802.11be | MCS6       | 77 Mbps          | 5       | 5975.0          | 20                      | ANT 6    | Power State 1 Head | EVS-NB | 9.6            | PASS               | PASS  | PASS  | PASS  | PASS       | PASS    | 17.78                    | 22.92 | 89 - 90  |



**Conversational Gain Only Measured Results**

The DUT supports EFR-NB, AMR-NB, and AMR-WB codecs. Per KDB 285076 D05 §2(b.), these codecs shall be assessed for conversational gain only.

**GSM**

| RF Air Interface |      | Mode         | Channel | Frequency (MHz) | Port/ANT  | Power Mode | Codec  | Bitrate (kbps) | Conversational Gain (dB) |       |
|------------------|------|--------------|---------|-----------------|-----------|------------|--------|----------------|--------------------------|-------|
| Technology       | Band |              |         |                 |           |            |        |                | 2N                       | 8N    |
| GSM              | 850  | 1 Slot Voice | 190     | 836.6           | B (ANT 2) | Mode A     | EFR-NB | 13.2           | 15.73                    | 19.12 |
| GSM              | 850  | 1 Slot Voice | 190     | 836.6           | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 15.1                     | 18.41 |
| GSM              | 850  | 1 Slot Voice | 190     | 836.6           | B (ANT 2) | Mode A     | AMR-WB | 6.6            | 16.81                    | 19.69 |
| GSM              | 1900 | 1 Slot Voice | 661     | 1880.0          | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 15.33                    | 18.46 |

**W-CDMA**

| RF Air Interface |      | Mode    | Channel | Frequency (MHz) | Port/ANT  | Power Mode | Codec  | Bitrate (kbps) | Conversational Gain (dB) |       |
|------------------|------|---------|---------|-----------------|-----------|------------|--------|----------------|--------------------------|-------|
| Technology       | Band |         |         |                 |           |            |        |                | 2N                       | 8N    |
| W-CDMA           | II   | Rel. 99 | 9400    | 1880.0          | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 15.46                    | 18.61 |
| W-CDMA           | II   | Rel. 99 | 9400    | 1880.0          | B (ANT 2) | Mode A     | AMR-WB | 6.6            | 17.4                     | 20.05 |
| W-CDMA           | IV   | Rel. 99 | 1413    | 1732.6          | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 15.79                    | 18.64 |
| W-CDMA           | V    | Rel. 99 | 4183    | 836.6           | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 15.9                     | 18.8  |

**LTE**

| RF Air Interface |      | Mode | Channel | Frequency (MHz) | Channel Bandwidth (MHz) | RB Allocation | RB Offset | Port/ANT  | Power Mode | Codec  | Bitrate (kbps) | Conversational Gain (dB) |       |
|------------------|------|------|---------|-----------------|-------------------------|---------------|-----------|-----------|------------|--------|----------------|--------------------------|-------|
| Technology       | Band |      |         |                 |                         |               |           |           |            |        |                | 2N                       | 8N    |
| LTE              | 25   | QPSK | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 14.85                    | 17.89 |
| LTE              | 25   | QPSK | 26365   | 1882.5          | 20                      | 1             | 0         | B (ANT 2) | Mode A     | AMR-WB | 6.6            | 16.21                    | 19.16 |

**5G NR**

| RF Air Interface |      | Mode         | Channel | Frequency (MHz) | Channel Bandwidth (MHz) | SCS (kHz) | RB Allocation | RB Offset | Port/ANT  | Power Mode | Codec  | Bitrate (kbps) | Conversational Gain (dB) |       |
|------------------|------|--------------|---------|-----------------|-------------------------|-----------|---------------|-----------|-----------|------------|--------|----------------|--------------------------|-------|
| Technology       | Band |              |         |                 |                         |           |               |           |           |            |        |                | 2N                       | 8N    |
| 5G NR            | n25  | $\pi/2$ BPSK | 376500  | 1882.5          | 40                      | 15        | 1             | 1         | B (ANT 2) | Mode A     | AMR-NB | 4.75           | 17.12                    | 19.88 |
| 5G NR            | n25  | $\pi/2$ BPSK | 376500  | 1882.5          | 40                      | 15        | 1             | 1         | B (ANT 2) | Mode A     | AMR-WB | 6.6            | 18.48                    | 21.21 |

**WLAN**

| RF Air Interface |      |         | Modulation | Data Rate (Mbps) | Channel | Frequency (MHz) | Channel Bandwidth (MHz) | Port/ANT | Power Mode         | Codec  | Bitrate (kbps) | Conversational Gain (dB) |       |
|------------------|------|---------|------------|------------------|---------|-----------------|-------------------------|----------|--------------------|--------|----------------|--------------------------|-------|
| Technology       | Band | Mode    |            |                  |         |                 |                         |          |                    |        |                | 2N                       | 8N    |
| WLAN             | DTS  | 802.11b | DSSS       | 1                | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | AMR-NB | 4.75           | 15.96                    | 19    |
| WLAN             | DTS  | 802.11b | DSSS       | 1                | 6       | 2437.0          | 20                      | ANT 2    | Power State 1 Head | AMR-WB | 6.6            | 17.67                    | 20.74 |

## **Appendix**

**Refer to separate files for the following appendixes**

**Appendix A: T-Coil Setup Photo**

**Appendix B: Volume Control Test Plots**

**Appendix C: HAC Waiver DA 23-914**

**END OF REPORT**