



## HAC T-COIL SIGNAL TEST REPORT

FCC 47 CFR § 20.19  
ANSI C63.19-2019

*For*  
**SMARTPHONE**

**FCC ID: BCG-E8685A**  
**Model Name: A3295**

**Report Number: 14982480-S2V1**  
**Issue Date: 8/21/2024**

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Revision History

| Rev. | Date      | Revisions     | Revised By |
|------|-----------|---------------|------------|
| V1   | 8/21/2024 | Initial Issue | --         |
|      |           |               |            |
|      |           |               |            |
|      |           |               |            |

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## 1. Attestation of Test Results

|                      |                                        |
|----------------------|----------------------------------------|
| Applicant Name       | APPLE, INC.                            |
| FCC ID               | BCG-E8685A                             |
| Model Name           | A3295                                  |
| Applicable Standards | FCC 47 CFR § 20.19<br>ANSI C63.19-2019 |
| Date Tested          | 6/20/2024 to 8/20/2024                 |
| Test Results         | Pass                                   |

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

This report contains data provided by the customer which can impact the validity of results. UL Verification Services Inc. is only responsible for the validity of results after the integration of the data provided by the customer.

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 assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples assessed 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 conducted 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 A2LA, NIST, or any agency of the U.S. Government, or any agency of the U.S. government.

|                                                                                                                    |                                                                                                          |
|--------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| Approved & Released By:<br><br> | Prepared By:<br><br> |
| Devin Chang<br>Senior Laboratory Engineer<br>UL Verification Services Inc.                                         | Coltyce Sanders<br>Staff Laboratory Engineer<br>UL Verification Services Inc.                            |

## 2. Test Methodology

The tests documented in this report were performed in accordance with ANSI C63.19-2019 Methods of Measurement of Compatibility Between Wireless Communications Devices and Hearing Aids and FCC published procedure:

KDB 285076 D01 HAC Guidance v06r04

KDB 285076 D02 T-Coil testing for CMRS IP v04

KDB 285076 D03 HAC FAQ v01r06

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

TCB workshop updates:

- TCB Workshop October 2022; Publication Update & Administrative Notes (Publication Update: 285076 D01 & D04)
- TCB Workshop October 2022; Federal Communications Commission Hearing Aid Compatibility Updates
- TCB Workshop April 2023; Publication Update & Administrative Notes (Publications Since Oct Workshop: 285076 HAC Update)
- TCB Workshop October 2023; Publication Update & Administrative Notes (Publication Update: 285076 09/29/2023: HAC Guidance blanket)
- 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 |
| SAR Lab 11           |

UL Verification Services Inc. is accredited by A2LA, Certificate Number 0751.05

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. Test Equipment and Uncertainty

### 4.1. Test Equipment

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.

#### Lab Equipment

| Name of Equipment            | Manufacturer  | Type/Model    | Serial No.   | Cal. Due Date |
|------------------------------|---------------|---------------|--------------|---------------|
| Magnetic Field Probe         | SPEAG         | AM1DV3        | 3083         | 1/8/2025      |
| Data Acquisition Electronics | SPEAG         | DAE4          | 1352         | 11/15/2024    |
| AMMI                         | SPEAG         | SE UMS 010 BB | 1113         | N/A           |
| DAC                          | Sound Devices | USBPre 2      | HB1420133009 | N/A           |
| DAC                          | Yellow tech   | YT4211        | 22000115     | N/A           |
| Amplifier                    | KROHN-HITE    | 7500          | 926          | N/A           |
| Switch                       | TP-Link       | TL-SG1024D    | 13688100415  | N/A           |
| Support Device               | APPLE         | iMAC          | PT867513     | N/A           |
| Support Device               | APPLE         | MacBook Pro   | HRP119301    | N/A           |
| Thermometer                  | TRACEABLE     | 6530CC        | 181073773    | 1/31/2025     |
| Radio Communication Tester   | R&S           | CMW 500       | 125236-eS    | 2/19/2025     |
| Radio Communication Tester   | R&S           | CMX 500       | 101156-bz    | 3/18/2025     |
| Up/Down Converter            | R&S           | CMW-Z800A     | 100198-XW    | 02/28/2025    |

#### 4.1.1. Base Station Simulator Software and Firmware

The following software/firmware was used to simulate the VoLTE, VoNR (5G NR) and VoWiFi server for CMRS testing using R&S CMW500 and CMX500 base station simulators.

| Technology            | Firmware              | License Key           | Software Name            |
|-----------------------|-----------------------|-----------------------|--------------------------|
| VoLTE                 | V3.8.10 for LTE       | KS500                 | LTE FDD R8 SIG BASIC     |
|                       |                       | KS550                 | LTE TDD R8 SIG BASIC     |
|                       | V3.8.10 for Audio     | KA100                 | IP APPL ENABLING IPv4    |
|                       |                       | KA150                 | IP APPL ENABLING IPv6    |
|                       |                       | KAA20                 | IP APPL IMS BASIC        |
|                       |                       | KM050                 | DATA APPL MEAS           |
|                       |                       | KS104                 | EVS SPEECH CODEC         |
| VoNR -<br>5G NR (FR1) | V7.70.0.116 for 5G NR | CMX-KS600B            | NR SIG BASIC FSET1       |
|                       |                       | CMX-KS600M            | NR SIG MEDIUM FSET1      |
|                       |                       | CMX-KS600X            | NR SIG XPERT FSET1       |
|                       |                       | CMX-KS601B            | NR SIG BASIC FSET2       |
|                       |                       | CMX-KS601M            | NR SIG MEDIUM FSET2      |
|                       |                       | CMX-KS601X            | NR SIG XPERT FSET2       |
|                       |                       | CMX-KS610B            | NR SIG BASIC FSET3       |
|                       |                       | CMX-KS610M            | NR SIG MEDIUM FSET3      |
|                       |                       | CMX-KS610X            | NR SIG XPERT FSET3       |
|                       |                       | CMX-KS611B            | NR SIG BASIC FSET4       |
|                       |                       | CMX-KS611M            | NR SIG MEDIUM FSET4      |
|                       |                       | CMX-KS611X            | NR SIG XPERT FSET4       |
|                       |                       | CMX-KS612B-CMX-KS612B | NR SIG EXT. BASIC FSET5  |
|                       |                       | CMX-KS612M-CMX-KS612M | NR SIG EXT. MEDIUM FSET5 |
|                       |                       | CMX-KS612X-CMX-KS612X | NR SIG EXT. EXPERT FSET5 |
|                       |                       | CMX-KS617B-CMX-KS617B | NR SIG EXT. BASIC FSET6  |
|                       |                       | CMX-KS617M-CMX-KS617M | NR SIG EXT. MEDIUM FSET6 |
|                       |                       | CMX-KS617X-CMX-KS617X | NR SIG EXT. EXPERT FSET6 |
| VoWiFi                | V3.8.20 for WLAN      | KS650                 | WLAN A/B/G SIG BASIC     |
|                       |                       | KS651                 | WLAN N SIG BASIC         |
|                       |                       | KS656                 | WLAN IEEE 802.11ac       |
|                       |                       | KS657                 | WLAN IEEE 802.11ax       |
|                       | V3.8.10 for Audio     | KA100                 | IP APPL ENABLING IPv4    |
|                       |                       | KA150                 | IP APPL ENABLING IPv6    |
|                       |                       | KAA20                 | IP APPL IMS BASIC        |
|                       |                       | KM050                 | DATA APPL MEAS           |
|                       |                       | KS104                 | EVS SPEECH CODEC         |

## 4.2. Measurement Uncertainty

| Uncertainty of Audio Band Magnetic Measurements       |                         |             |      |                           |                        |                  |           |
|-------------------------------------------------------|-------------------------|-------------|------|---------------------------|------------------------|------------------|-----------|
| Error Description                                     | Uncertainty Values (±%) | Probe Dist. | Div. | (c <sub>i</sub> )<br>ABMd | c <sub>i</sub><br>ABMu | Std. Uncertainty |           |
|                                                       |                         |             |      |                           |                        | ABMd (±%)        | ABMu (±%) |
| Probe Sensitivity                                     |                         |             |      |                           |                        |                  |           |
| 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                       | 1.0                    | 0.3              | 3.5       |
| Probe System                                          |                         |             |      |                           |                        |                  |           |
| 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                                           | 1.0                     | R           | √3   | 1                         | 1                      | 0.6              | 0.6       |
| 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 Disturbation                                    | 0.2                     | R           | √3   | 1                         | 1                      | 0.1              | 0.1       |
| Test Signal                                           |                         |             |      |                           |                        |                  |           |
| Reference Signal Spectral Response                    | 0.6                     | R           | √3   | 0                         | 1                      | 0.0              | 0.4       |
| Positioning                                           |                         |             |      |                           |                        |                  |           |
| Probe Positioning                                     | 1.9                     | R           | √3   | 1                         | 1                      | 1.1              | 1.1       |
| Phantom Thickness                                     | 0.9                     | R           | √3   | 1                         | 1                      | 0.5              | 0.5       |
| DUT Positioning                                       | 1.9                     | R           | √3   | 1                         | 1                      | 1.1              | 1.1       |
| External Contributions                                |                         |             |      |                           |                        |                  |           |
| 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       |
| Combined Uncertainty                                  |                         |             |      |                           |                        |                  |           |
| Combined Std. Uncertainty (ABM field)                 |                         |             |      |                           |                        | 3.9              | 6.0       |
| Expanded Std. Uncertainty (%)                         |                         |             |      |                           |                        | 7.8              | 11.9      |
| Notes:                                                |                         |             |      |                           |                        |                  |           |
| 1. N - Nomal                                          |                         |             |      |                           |                        |                  |           |
| 2. R - Rectangular                                    |                         |             |      |                           |                        |                  |           |
| 3. Div. - Divisor used to obtain standard uncertainty |                         |             |      |                           |                        |                  |           |
| 4. ABMd - Desired ABM Signal                          |                         |             |      |                           |                        |                  |           |
| 5. ABMu - Undesired ABM Field                         |                         |             |      |                           |                        |                  |           |

## 5. Test Procedures for all Technologies

### 5.1. Test Procedure for T-Coil signal per ANSI C63.19-2019, §6

This subclause describes the procedures used to measure the ABM (T-Coil) performance of the WD. Measurements shall be performed over a measurement area 50 mm square, in the measurement plane, as specified in Annex A.3. The measurement area shall be scanned with a uniform measurement point spacing of  $2.0 \text{ mm} \pm 0.5 \text{ mm}$  in each X-Y axis of the plane, yielding 676 measurement points with approximately even spacing throughout the area.

Optionally, measurement point spacing may be increased to 4 mm, with interpolation employed to yield the required 676 equivalent measurement points distributed uniformly over the 50 mm square measurement area. Interpolated points shall be derived from the average of the linear representations of the field strengths of the nearest two or four equidistant measured points. The area of measurement is increased to a 52 mm square so that edge rows and columns of the required 50 mm square can be either measured or interpolated, with none extrapolated.

In addition to measuring the desired ABM signal levels, the weighted magnitude of the unintended signal shall also be determined. Weighting of the unintended and undesired ABM field shall be by the spectral and temporal weighting described in Annex D.4 through D.6.

In order to assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal shall be made at the same locations. Measurements shall not include undesired influence from the WD's RF field; therefore, use of a coaxial connection to a base station simulator or non-radiating load might be necessary. However, even then with a coaxial connection to a base station simulator or non-radiating load there could still be RF leakage from the WD, which could interfere with the desired measurement. Pre-measurement checks should be made to avoid this possibility. All measurements shall be done with the WD operating on battery power with an appropriate normal speech audio signal input level given in Table 6.1. If the device display can be turned off during a phone call, then that may be done during the measurement as well. If tested with the display in the off state this shall be documented in the test report.

Measurements shall be performed with the probe coil oriented in the transverse direction, as illustrated in Annex A.3, that is, aligned in the plane of the measurement area and perpendicular to the long dimension of the WD. A multi-stage sequence consists of first measuring the field strength of the desired T-Coil signal (desired ABM signal) that is useful to a hearing aid T-Coil at each specified measurement point. The undesired magnetic component (undesired ABM field) is then measured in the same transverse orientation at each of the same measurement points. At a single location only, taken at or near the highest desired ABM signal reading, the desired ABM signal frequency response shall be determined in a third measurement stage. The flowchart in Figure 6.3 illustrates this three-stage process.

To minimize the need to test every WD operating mode to the telecoil requirements of Clause 6, it is permissible to exclude some subset of supported configurations. For a given WD, every mode that supports voice communication shall be considered for telecoil testing. However, if it can be demonstrated that a certain configuration will not be the worst-case telecoil configuration, such configurations may be excluded from the full telecoil scans of 6.4.<sup>1</sup> For example, operating modes may be pre-screened by scanning for both desired ABM signal and undesired ABM field at a lower measurement point density than the final scans, thus saving considerable testing time by eliminating configurations that are excellent performers from more detailed testing for worst-case. In any case, the specific methods and criteria used to determine which configurations are excluded for a WD shall be explicitly stated and justified in the test report. To be considered for exclusion from telecoil testing, operating modes shall also be shown to pass the frequency response requirements of 6.6.3.

Many factors could affect telecoil test results. RF power level and amplitude modulation characteristics as well as the specific current paths within the WD associated with the RF output stage(s), the display, and processing circuitry could affect the undesired ABM field. Audio codec implementation and acoustic receiver characteristics could also affect the desired ABM signal). Therefore, any justifications for exclusions should be thorough documented. If an operating mode is under user control and instructions on how to place the WD in a less interfering condition is in the user instructions, those instructions may be followed in configuring the device for testing.

The following steps summarize the basic test flow for determining desired ABM signal and undesired ABM field. These steps assume that a sine wave or narrowband 1/3 octave signal can be used for the measurement of desired

<sup>1</sup> The allowance to not test all modes does not remove the requirement that all modes meet the requirements of this standard if a claim of compliance is to be made. What is allowed is a reduction of testing, where there is a good basis for believing that testing that is performed demonstrates the compliance of all possible operating modes.

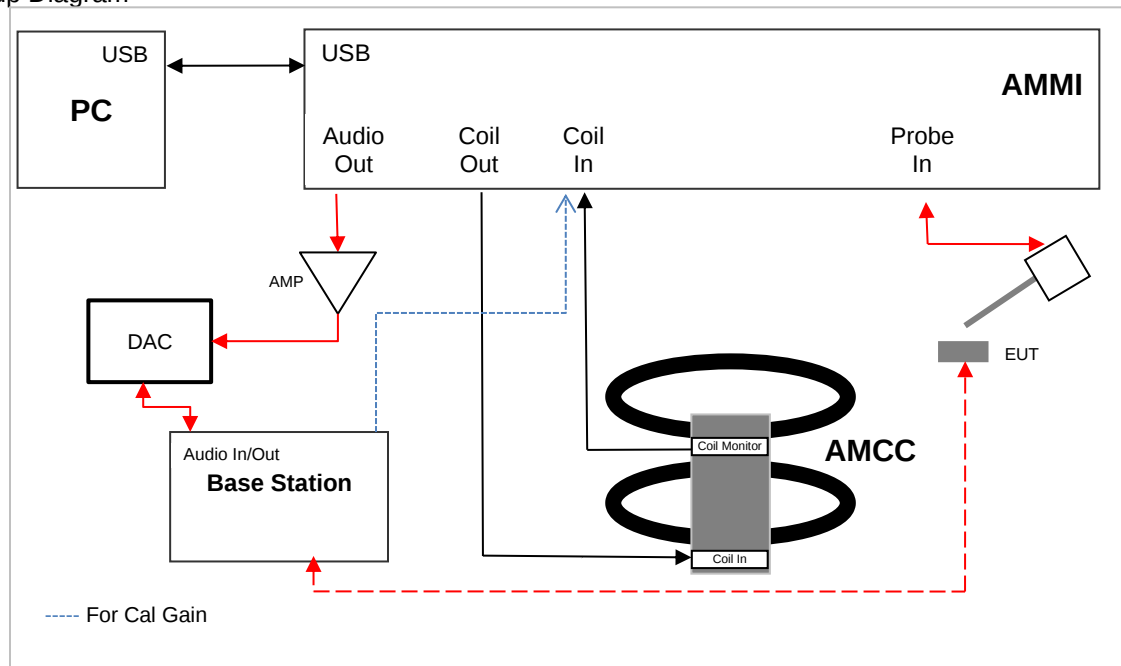
ABM signal level. An alternative procedure, yielding equivalent results, using a broadband excitation is described in 6.5.

- a) A validation of the test setup and instrumentation shall be performed. This may be done using a TMFS or Helmholtz Coil. Measure the emissions and confirm that they are within tolerance of the expected values.
- b) Confirm that equipment that requires calibration has been calibrated, and that the noise level meets the requirements given in 6.3.2.
- c) Position the WD in the test setup and connect the WD RF connector to a base station simulator or a non-radiating load (if necessary to control RF interference in the measurement equipment) as shown in Figure 6.1 or Figure 6.2.
- d) The drive level to the WD is set such that the reference input level specified in Table 6.1 is input to the base station simulator (or manufacturer's test mode equivalent) in the 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (desired ABM signal) at  $f = 1$  kHz. Either a sine wave at 1025 Hz, or a voice-like signal, band-limited to the 1 kHz 1/3 octave, as specified in 6.4.3, shall be used for the reference audio signal. If interference is found at 1025 Hz an alternative nearby reference audio signal frequency may be used.<sup>2</sup> The same drive level will be used for the desired ABM signal frequency response measurements at each 1/3 octave band center frequency. The WD volume control may be set at any level up to maximum, provided that a signal at any frequency at maximum modulation would not result in clipping or signal overload.
- e) At each measurement location over the measurement area and in the transverse orientation, measure and record the desired 1 kHz T-Coil magnetic signal (desired ABM signal) as described in Step c).
- f) At or near a location representing a maximum in the just-measured desired ABM signal, measure and record the desired T-Coil magnetic signals (desired ABM signal at  $f_i$ ) as described in 6.4.5.2 in each individual ISO 266:1975 R10 standard 1/3 octave band. The desired audio band input frequency ( $f_i$ ) shall be centered in each 1/3 octave band maintaining the same drive level as determined in Step c), and the reading taken for that band.<sup>3</sup> Equivalent methods of determining the frequency response may also be employed, such as fast Fourier transform (FFT) analysis using noise excitation or input-output comparison using simulated speech. The full-band integrated or half-band integrated probe output, as described in D.9, may be used, as long as the appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB(A/m).) Compare the frequency response found to the requirements of 6.6.3.
- g) At the same locations measured in Step d), measure and record the undesired broadband audio magnetic signal (undesired ABM field) with no audio signal applied (or digital zero applied, if appropriate) using the specified spectral weighting, the half-band integrator followed by the temporal weighting.
- h) Calculate and record the location and number of the measurement points that satisfy both the minimum desired ABM signal level and the maximum undesired ABM field level specified in 6.6.2. Compare this to the requirements in 6.6.4 and record the result.
- i) Calculate and record the location and number of the measurement points that satisfy the maximum undesired ABM field level and distribution requirements specified in 6.6.4.

<sup>2</sup> The 1025 Hz frequency was selected rather than 1 kHz because a 1 kHz reference frequency could interfere with emission harmonics or test equipment fundamental frequencies.

<sup>3</sup> See 6.4.5.2 and 6.4.5.4 for details.

## Test Setup Diagram

**Note(s):**

For Audio OUT, an amplifier was added to amplify signal to meet DAC specifications.

## 5.2. Reference Input Levels per ANSI C63.19-2019, §6

The following reference input levels (Figure 6.1) that correlate to a normal speech input level shall be used for the standard transmission protocols.<sup>4</sup>

Table 6.1 - Normal speech input levels

| Standard                       | Protocol                     | Input (dBm0) |
|--------------------------------|------------------------------|--------------|
| TIA-2000                       | CDMA                         | -18          |
| TIA/EIA-136                    | TDMA (50 Hz)                 | -18          |
| J-STD-007                      | GSM (217 Hz)                 | -16          |
| T1/T1P1/3GPP<br>(See Note 1)   | UMTS (WCDMA)                 | -16          |
| iDEN <sup>a</sup>              | TDMA (22 Hz and 11 Hz)       | -18          |
| VoIP <sup>a</sup> (See Note 2) | Voice over Internet Protocol | -16          |

NOTE 1 - For UMTS (Universal Mobile Telecommunications System), refer to 3GPP TS26.131 and TS26.132 (<http://www.3gpp.org>).

NOTE 2 - VoIP is used in this table as a general term specifying a group of voice services that use -16 dBm0 as their normal acoustic level. The group includes a variety of voice services, including Voice-over-LTE (VoLTE), Voice-over-IP-multimedia-subsystem (VoIMS), Voice-over-Wi-Fi (VoWiFi) and similar services. For 3G, LTE, and WLAN terminals used for Commercial Mobile Radio Service (CMRS) based telephony, refer to 3GPP TS26.131 and TS26.132.

<sup>a</sup> The manufacturer shall establish that -16 dBm0 is the normal acoustic level in order to place it in this category.

For protocols not listed in Table 6.1, use the normal speech input level per the relevant specifications for that air interface.

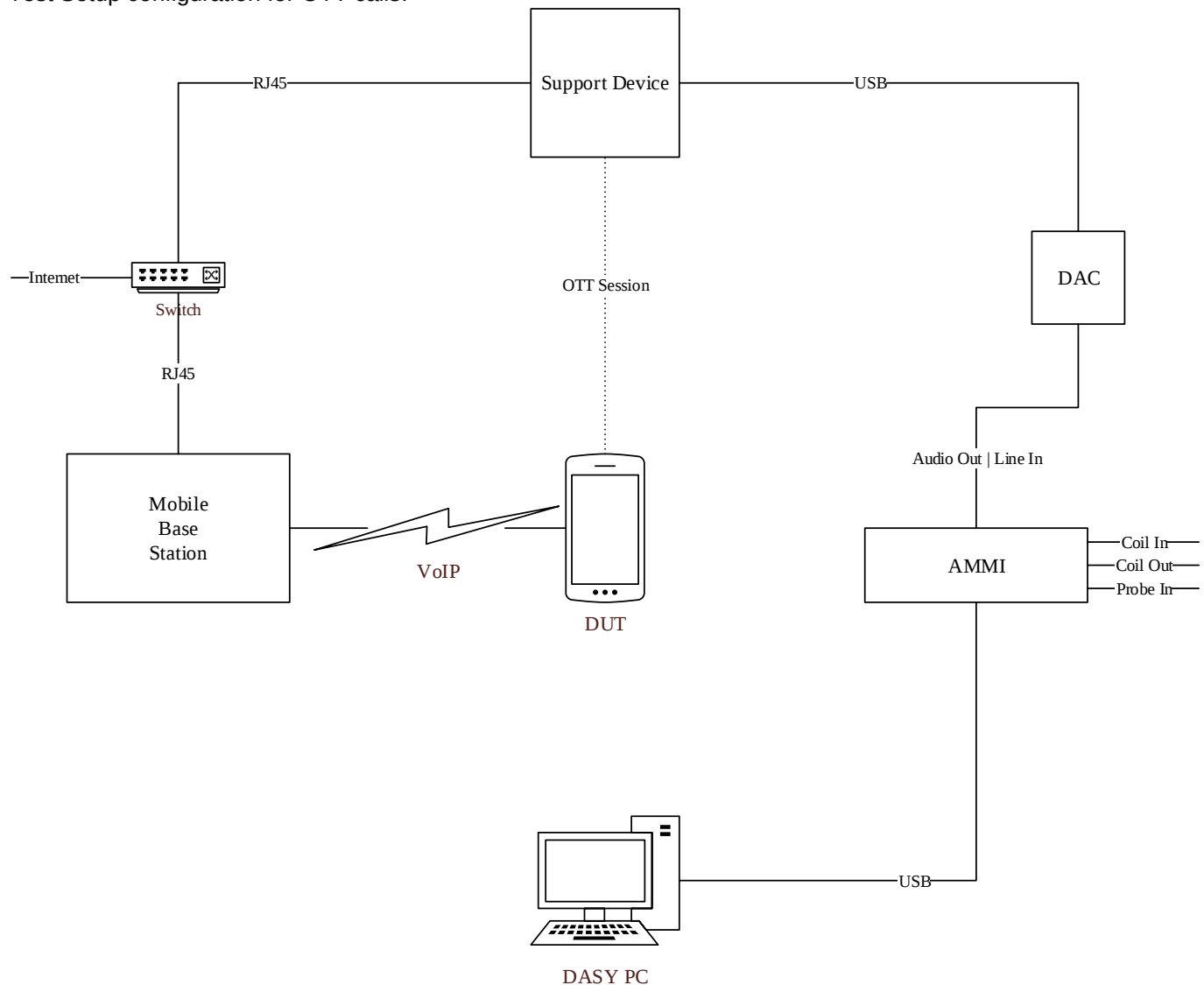
<sup>4</sup> The intent of this subclause is to provide a nominal level speech input independent of air interface and measure the magnetic response in a normal use condition without requiring an acoustic reference. The nominal level speech signals in 6.4.3.2 will result in acoustic speech levels that are mutually consistent and also span a range including 94 dB SPL, as shown in the examples below. This is intended to allow the operator to set WD adjustable volume controls as needed to produce a sufficient desired magnetic level (desired ABM signal) based on intended usage. When measuring with the specified nominal speech input level of -16 dBm0 for GSM, a GSM phone shall not exceed a receive loudness rating (RLR) of -13 dB at maximum volume setting. However, at a nominal volume control setting with the same -16 dBm0 input, a GSM phone shall have an RLR of at least 2 dB  $\pm$  3 dB. An RLR of 2 dB  $\pm$  3 dB corresponds to a sound pressure level of 84 dB  $\pm$  3 dB SPL, assuming an earpiece frequency response that is flat over the frequency bands specified as per ITU-T Recommendation P.79. An RLR of -13 dB corresponds to a sound pressure level of 99 dB SPL, assuming an earpiece frequency response that is flat over the frequency bands specified as per ITU-T Recommendation P.79. When measuring with the specified nominal speech input level of -18 dBm0 for CDMA, a CDMA phone with volume control set to the midpoint should provide an RLR of 2 dB  $\pm$  5 dB. The CTIA (Rev. 3.21, 2003) CDMA test plan (V1.2) does not specifically place an upper limit on RLR. References: ITU-T Recommendation P.79. Calculation of loudness ratings for telephone handsets. Cellular Telecommunications Industry Association Performance Evaluation Standard for 800 MHz AMPS and Cellular/PCS CDMA Dual Mode Wireless Subscriber Stations.

### 5.3. Over the Top (OTT)

This device supports VoIP via a preinstalled application that uses the FaceTime service, using ACC-ELD as its only codec (refer to §8.1 for air interface details and §9.2.2 for codec bit rates). VoIP capabilities require HAC assessment when voice calls are supported over the cellular data connection via pre-installed VoIP applications.

The equipment is set up as shown below with a support device used to originate the call using the IP transport. The support device<sup>5</sup> connects to the cloud-based FaceTime service via a Wi-Fi access point and router, or an RJ45 Ethernet connection. The DUT connects to the VoIP service via a cellular/unlicensed air interface to the call box and an Ethernet connection from call box to Internet. The various codec bit rate and air interface configurations are evaluated to determine the worst-case configuration (refer to §9.2).

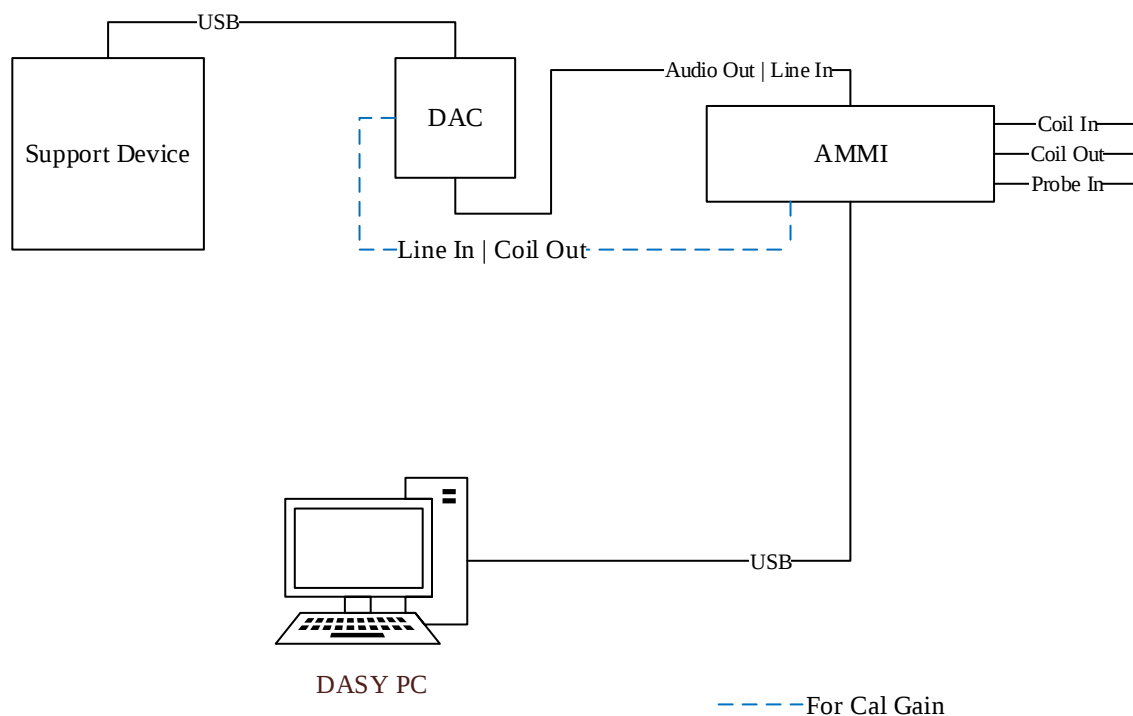
Test Setup configuration for OTT calls:



For the OTT call, the calibrated audio card within the CMW500 cannot be used so the AMMI is connected to an external Digital-Analog Converter (DAC) and the DAC is connected to the Support Device via USB. The test signal is sent from the DASY PC to the AMMI, from the AMMI to the DAC, from the DAC to the Support Device, and, via the VoIP call, to the DUT.

<sup>5</sup> The support device is a Google Mobile Phone.

As this test set up uses an external DAC between the AMMI's audio output and support device, the appropriate gain factor for the OTT call needs to be determined. This is done by connecting the DAC between the AMMI Audio output and Coil input as shown below.



Once the proper cable connections are established, the procedures outlined in §6 are followed to calculate the appropriate Gain and codec / system delays for OTT measurements. Please refer to §6.5 for computed OTT gain settings and the test data tables in §9 & 10 for all Codec / system delay measurements performed during OTT testing.

## 6. Calibrations & Gain Measurements

Calibrations and Gain measurements are performed using guidance from SPEAG's *DASY6/8 Module HAC System Handbook §7.3*.

### 6.1. Calibration of AM1DVx Probe

For correct measurement of the audio-band magnetic field, the AM1DVx probe must first be calibrated. The calibration is performed in the Helmholtz Audio Magnetic Calibration Coil (AMCC).

#### 6.1.1. Calibration Setup

During the calibration procedure, the system is set as described below:

- the AMMI is powered on and connected to the DASY6/8 PC via USB.
- the AMMI COIL OUT port is connected to the AMCC COIL IN.
- the AMMI COIL IN port is connected to the AMCC COIL MONITOR.
- the AM1DVx probe is mounted on the robot.

#### 6.1.2. Sensor Angle Alignment

The sensor angle relative to the robot arm depends on several factors: probe connector angle, Data Acquisition Electronics (DAE) connector angle, use of a Quick Adaptor Change System (QACS). In DASY6/8, the sensor angle is assessed automatically during the alignment phase.

The alignment procedure consists of rotating the probe in the AMCC for an angle within the  $[0^\circ - 360^\circ]$  in  $10^\circ$  steps. The sensor angle is defined as the angle giving the maximum H-field response for the sensor. The angle corresponds to the sensor in the axial direction (same orientation as the AMCC field).

**Note:** The calibration must be repeated after any change in the measurement instrumentation, especially when the probe / DAE has been remounted on the robot.

#### 6.1.3. System Response Calibration

The sensitivity and frequency response of the AM1DVx probe is calibrated over the  $[50\text{Hz} - 10\text{kHz}]$  frequency range using a multi-sine signal. The sines are at the center frequency of each 1/3 octave band.

The measurement is performed in the AMCC with the probe sensor in axial orientation. The Coil In channel of the Audio Magnetic Measurement Instrument (AMMI) measures the voltage over the AMCC internal shunt, which is proportional to the magnetic field in the AMMI. In parallel, the Probe In channel measures the amplified signal picked up by the probe coil. The sensitivity of the probe in  $\text{V}/(\text{A}/\text{m})$  is defined as the voltage ratio at 1 kHz. The frequency response in dB is defined as the ratio between the voltages in each 1/3 octave band normalized to the 1 kHz ratio.

The obtained sensitivity is compared to the one from the probe configuration file for verification purposes. A warning is issued if the deviation exceeds 2 %.

### 6.2. AMMI Audio Output Calibration

The audio output calibration of the AMMI is performed as described below:

- Connect Audio Out to Coil In on the AMMI and click on Calibrate.
- Click on the Calibrate button.
- Once calibration is complete, re-establish the cabling illustrated in Test Setup Diagram §5.1.

### 6.3. Codec / System Delay Measurements

Codec / system delay measurements are calculated using the guidance from SPEAG's *DASY6/8 Module HAC System Handbook §7.3.2.4*:

- A time delay might occur in the audio signal path (latency of the codec, Windows settings ...). For accurate measurements, the system must consider this delay, and shift in time the probe readings accordingly.
- Module HAC features automated measurement of the delay. The assessed delay will then be used for the subsequent desired ABM signal level and undesired ABM field level measurements.
- The delay is measured by pressing the Assess Delay button under the Scan Control section of the Measurement tab. The system must be ready to measure, and the DUT must be transmitting in the desired test mode.
- A scan with reduced resolution will be performed and the delay will be assessed at the measured maximum.
- This measurement must be repeated after every change in the hardware setup, or when a different DUT / Codec is used.

### 6.4. Compute Gain Settings

Gain settings are computed using the following procedure:

- Define the Scan Type as Signal in the Scan Type section.
- Specify the Input Level and Codec Delay in the Base Station Simulator Settings.
  - Input level refers to full scale input level equivalent to 3.14 dBm0.
    - Input level of 1V is used for R&S CMW500 Base Station Simulator.
    - Input level of 1V is used for R&S CMX500
  - The codec delay can be measured automatically using the procedure described above in §6.3 above.
- Enter the desired speech level in dBm0. Refer to §5.2 for applicable Reference Input Levels.
- Specify the audio file and the measurement duration to be used for the area and frequency response scans.
  - Use Audio file 48k\_voice\_1kHz\_1s.wav for ABMd and ABMu measurements.
  - Use Audio file 48k\_voice\_300-3000\_2s.wav for Frequency Response measurements.
- Click on Compute Gain Settings. The properties of the audio file, such as the bandwidth compensation factor (BWC), peak value, etc. will be automatically computed. In addition, the audio file scaling (also called gain) will be calculated. A popup is displayed in case the resulting gain exceeds the AMMI dynamic range.

Computed Gain settings for each supported technology for CMRS evaluations is illustrated in the table below:

#### SAR 11

| Computed Gain Settings |                |                     |                         |                        |          |                     |
|------------------------|----------------|---------------------|-------------------------|------------------------|----------|---------------------|
| Technology             | Signal Type    | Speech Level (dBm0) | Peak to Full Scale (dB) | Peak to RMS Scale (dB) | BWC (dB) | Scaling (Gain) (dB) |
| GSM                    | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.47              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.64               |
| W-CDMA                 | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.5               |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.67               |
| VoLTE                  | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.48              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.65               |
| VoNR                   | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.47              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.63               |
| VoWiFi                 | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -11.02              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -5.19               |

## 6.5. Over the Top (OTT)

For GSM, W-CDMA, LTE, 5G NR and Wi-Fi, the procedures outlined in §6.4 above were followed to compute the appropriate Gain settings for OTT measurements.

Computed Gain settings for each supported technology for OTT evaluations is illustrated in the table below:

### SAR 11

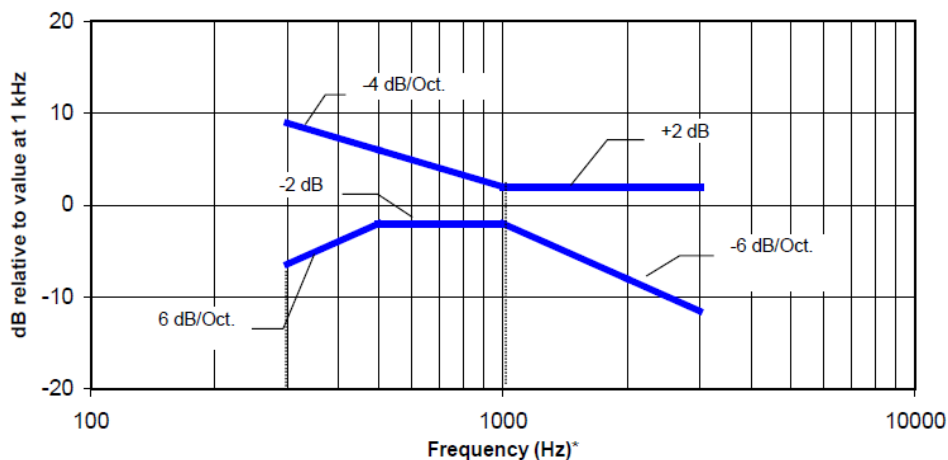
| Computed Gain Settings |                |                     |                         |                        |          |                     |
|------------------------|----------------|---------------------|-------------------------|------------------------|----------|---------------------|
| Technology             | Signal Type    | Speech Level (dBm0) | Peak to Full Scale (dB) | Peak to RMS Scale (dB) | BWC (dB) | Scaling (Gain) (dB) |
| GSM                    | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.13              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.3                |
| W-CDMA                 | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.12              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.29               |
| LTE                    | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.12              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.29               |
| 5G NR                  | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.14              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.31               |
| WLAN                   | Voice 1 kHz    | -16.0               | -0.37                   | 15.74                  | 0.07     | -12.13              |
|                        | Voice 300-3kHz | -16.0               | 0                       | 21.57                  | 10.81    | -6.3                |

## 7. T-coil Measurement Criteria

### 7.1. Frequency Response

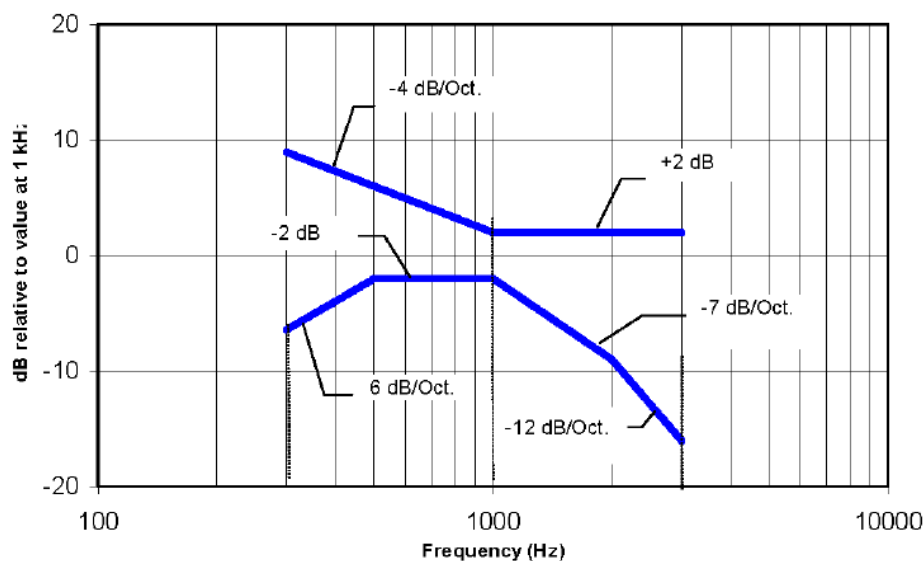
The frequency response of the magnetic field, measured in 1/3 octave bands, shall follow the response curve specified in this subclause, over the frequency range 300 Hz to 3 kHz.

Figure 6.4 and Figure 6.5 provide the boundaries for the specified frequency. These response curves are for true field strength measurements of the T-Coil signal. Thus the 6 dB/octave probe response has been corrected from the raw readings.



NOTE—Frequency response is between 300 Hz and 3 kHz.

**Figure 6.4—Magnetic field frequency response for WDs with a maximum field  $\leq -15$  dB(A/m) at 1 kHz**



NOTE—Frequency response is between 300 Hz and 3000 Hz.

**Figure 6.5—Magnetic field frequency response for WDs with a maximum field that exceeds  $-15$  dB(A/m) at 1 kHz**

## 7.2. Coupling Mode Requirements

In order to comply with the requirements for T-Coil use, a WD's tested operating modes shall simultaneously meet the requirements for minimum desired ABM signal level and maximum undesired ABM field contained in this subclause at the minimum specified number of scanned locations.

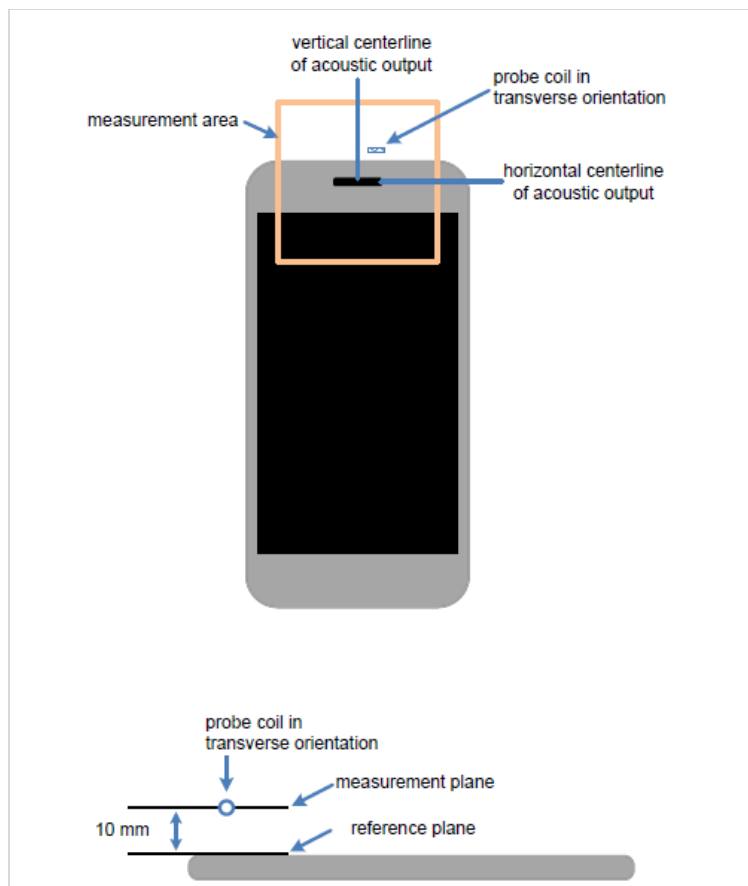
When measured as specified in this standard, there are two groups of qualifying measurement points:

*Primary group:* A qualifying measurement point shall have its T-Coil signal, desired ABM signal,  $\geq -18$  dB(A/m) at 1 kHz, in a 1/3 octave band filter. These measurements shall be made with the WD operating at a reference input level as specified in Table 6.1. Simultaneously, the qualifying measurement point shall have its weighted magnetic noise, undesired ABM field  $\leq -38$  dB(A/m).

*Secondary group:* A qualifying measurement point shall have its weighted magnetic noise, undesired ABM field  $\leq -38$  dB(A/m). This group inherently includes all the members of the primary group.

These levels are designed to be compatible with hearing aids that produce the same acoustic output level for either an acoustic input level of 65 dB SPL or a magnetic input level of  $-25$  dB(A/m) (56.2 mA/m)<sup>6</sup> at either 1.0 kHz or 1.6 kHz. The hearing aid operational measurements are performed per ANSI S3.22-2014.

Measurement locations and reference plane to be used for the T-coil measurements.



<sup>6</sup> IEC 60118-1 refers to hearing aid output being the same for an acoustic input of 70 dB SPL and a magnetic input of 100 mA/m. Thus 31.6 mA/m is equivalent to an acoustic input of 60 dB SPL, and an acoustic input of 65 dB SPL is equivalent to 56.2 mA/m.

### 7.3. Desired ABM Signal and Undesired ABM Field Requirements

For a WD that is expected to operate primarily in radio access technologies that include 2G GSM for legacy support, the WD shall be qualified for telecoil compatibility one of two ways:

- The DUT shall be rated for telecoil use for all other voice operating modes, exclusive of 2G GSM, according to the criteria of §6.6.4.2 of ANSI C63.19 2019.
- If the DUT is to be rated for telecoil use in its 2G GSM operating modes, these modes shall be qualified according to the criteria of §6.6.4.3 of ANSI C63.19 2019.

#### 7.3.1. Non-2G GSM Operating modes

The goal of this requirement is to ensure an adequate area where desired ABM signal is sufficiently strong to be heard clearly and a larger area where undesired ABM field is sufficiently low as to avoid undue annoyance. Qualifying measurement points shall fulfill the coupling mode requirements; both the primary and secondary group requirements shall be met:

- The primary group shall include at least 75 measurement points.
  - The secondary group shall include at least 300 contiguous measurement points.
- Additionally, to avoid an oddly shaped area of low noise, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

#### 7.3.2. 2G GSM Operating modes

For 2G GSM operating mode(s), the qualifying measurement points shall fulfil the coupling mode requirements; both the primary and secondary group requirements shall be met:

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

Additionally, to avoid an oddly shaped area of low noise, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

## 8. Device Under Test

|                         |                                 |                    |                            |
|-------------------------|---------------------------------|--------------------|----------------------------|
| Normal operation        | Held to head                    |                    |                            |
| Back Cover              | The Back Cover is not removable |                    |                            |
| Test sample information | <b>S/N</b><br>L277QQK1F6        | <b>IMEI</b><br>N/A | <b>Notes</b><br>HAC Sample |

### 8.1. Air Interfaces and Operating Mode

All air interfaces which support voice capabilities over a managed CMRS, or pre-installed OTT VoIP applications were evaluated.

| Air Interface                                                                                                                                                              | Bands (MHz)        | Type  | C63.19 Tested    | Simultaneous Transmitter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Name of Voice Service | Power Mode <sup>3</sup> | Power Reduction | Audio Codecs Evaluated <sup>1</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 | Yes              | 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    | Yes              | Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | FaceTime              | Mode A                  | N/A             | ACC-ELD                             |
|                                                                                                                                                                            | HSPA               |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
| LTE - FDD                                                                                                                                                                  | 600 (B71)          | VD    | Yes              | 5G NR, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | CMRS<br>FaceTime      | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD      |
|                                                                                                                                                                            | 700 (B12/13/14/17) |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 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<br>FaceTime      | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD      |
|                                                                                                                                                                            | 2600 (B41)         |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 3600 (B48)         |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
| 5G NR(FR1) FDD                                                                                                                                                             | 600 (n71)          | VD    | Yes <sup>2</sup> | LTE, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CMRS<br>FaceTime      | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD      |
|                                                                                                                                                                            | 700 (n12/n14)      |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 850 (n5/n26)       |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 1700 (n66/n70)     |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 1900 (n2/n25)      |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 2300 (n30)         |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 2500 (n7)          |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
| 5G NR(FR1) TDD                                                                                                                                                             | 2500 (n53)         | VD    | Yes <sup>2</sup> | LTE, Wi-Fi, BT, NB U-NII, 802.15.4 & 802.15.4ab NB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | CMRS<br>FaceTime      | Mode A                  | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD      |
|                                                                                                                                                                            | 2600 (n41)         |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 3500 (n77 Block A) |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 3700 (n48)         |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
|                                                                                                                                                                            | 3900 (n77 Block C) |       |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                         |                 |                                     |
| Type<br>VO: Legacy Cellular Voice Service<br>DT: Digital Transport only (no voice)<br>VD: IP Voice Service over Digital Transport<br>CMRS: Commercial Mobile Radio Service |                    |       |                  | Note(s):<br>1. For protocols not listed in Table 6.1 of ANSI C63.19-2019, the average speech level of -20 dBm0 was used. Refer to §5.2 for reference input levels.<br>2. 5G NR (VoNR) is supported: manufacturer states that 5G NR (VoNR) uses the same protocol, Codec(s) and bitrates as LTE (VoLTE).<br>3. For all air interfaces, the maximum held-to-head output power was used for T-Coil evaluations. The maximum held-to-head output power is Mode A for WWAN operating modes and Power State 1 Mode A for WLAN operating modes. Refer to §9 & §10 for T-Coil evaluations. |                       |                         |                 |                                     |

**Air Interfaces and Operating Modes**

| Air Interface                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Bands (MHz)            | Type | C63.19 Tested   | Simultaneous Transmitter                   | Name of Voice Service | Power Mode <sup>3</sup> | Power Reduction | Audio Codecs Evaluated <sup>1</sup> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------|-----------------|--------------------------------------------|-----------------------|-------------------------|-----------------|-------------------------------------|
| Wi-Fi                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2450                   | VD   | Yes             | WWAN, NB U-NII & 802.15.4ab                | CMRS FaceTime         | Power State 1 Mode A    | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-1                |      |                 |                                            |                       |                         |                 |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-2A               |      |                 |                                            |                       |                         |                 |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-2C               |      |                 |                                            |                       |                         |                 |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-3                | VD   | No <sup>2</sup> | WWAN, BT, 802.15.4, & 802.15.4ab NB        | CMRS FaceTime         | N/A                     | N/A             | AMR-NB, AMR-WB, EVS, & ACC-ELD      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-5 (VLP, SP, LPI) |      |                 |                                            |                       |                         |                 |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-6 (LPI)          |      |                 |                                            |                       |                         |                 |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-7 (VLP, SP, LPI) |      |                 |                                            |                       |                         |                 |                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | U-NII-8 (LPI)          |      |                 |                                            |                       |                         |                 |                                     |
| NB U-NII                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 5200 (U-NII-1)         | DT   | N/A             | WWAN, Wi-Fi 2.4 GHz                        | N/A                   | N/A                     | N/A             | N/A                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 5800 (U-NII-3)         |      |                 |                                            |                       |                         |                 |                                     |
| 802.15ab NB                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 5800 (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                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2.4GHz                 | 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                   |      |                 |                                            |                       |                         |                 |                                     |
| <div>Note(s):<div><div>Type<br/>VO: Legacy Cellular Voice Service<br/>DT: Digital Transport only (no voice)<br/>VD: IP Voice Service over Digital Transport<br/>CMRS: Commercial Mobile Radio Service</div><div><div>1.</div><div>For protocols not listed in Table 6.1 of ANSI C63.19-2019, the average speech level of -20 dBm0 was used. Refer to §5.2 for reference input levels.</div></div><div><div>2.</div><div>Supported Frequency &gt; 6GHz. ANSI C63.19 2019 only requires HAC evaluations for Technologies/Frequencies &lt; 6GHz.</div></div><div><div>3.</div><div>For all air interfaces, the maximum held-to-head output power was used for T-Coil evaluations. The maximum held-to-head output power is Mode A for WWAN operating modes and Power State 1 Mode A for WLAN operating modes. Refer to §9 &amp; §10 for T-Coil evaluations.</div></div></div></div> |                        |      |                 |                                            |                       |                         |                 |                                     |

## 9. Investigations (Antenna, Codec, & Air Interface)

In order to comply with the requirements for T-Coil use, a WD's tested operating modes shall simultaneously meet the requirements for minimum desired ABM signal level and maximum undesired ABM field contained in this subclause at the minimum specified number of scanned locations.

When measured as specified in this standard, there are two groups of qualifying measurement points:

Primary group: A qualifying measurement point shall have its T-Coil signal, desired ABM signal,  $\geq -18$  dB(A/m) at 1 kHz, in a 1/3 octave band filter. These measurements shall be made with the WD operating at a reference input level as specified in Table 6.1. Simultaneously, the qualifying measurement point shall have its weighted magnetic noise, undesired ABM field  $\leq -38$  dB(A/m).

Secondary group: A qualifying measurement point shall have its weighted magnetic noise, undesired ABM field  $\leq -38$  dB(A/m). This group inherently includes all the members of the primary group.

### **2G GSM Operating modes**

For 2G GSM operating mode(s), the qualifying measurement points shall fulfil the coupling mode requirements; both the primary and secondary group requirements shall be met:

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

Additionally, to avoid an oddly shaped area of low noise, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

### **Non-2G GSM Operating modes**

Qualifying measurement points shall fulfill the coupling mode requirements; both the primary and secondary group requirements shall be met:

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

Additionally, to avoid an oddly shaped area of low noise, the secondary group shall include at least one longitudinal column of at least 10 contiguous qualifying points and at least one transverse row containing at least 15 contiguous qualifying points.

### **5G NR Operating modes**

The DUT supports 5G NR, Voice over New Radio (VoNR). Per the manufacturer, 5G NR (VoNR) uses the same protocol, Codec(s) and bitrates as LTE (VoLTE). Investigations were performed on LTE (VoLTE) and the worst-case Port/Antenna/Codec/Air Interface configurations from LTE (VoLTE) was used for 5G NR (VoNR) evaluations. Refer to §10 for 5G NR (VoNR) evaluations.

### **All Operating modes**

For all air interfaces, the maximum held-to-head output power was used for T-Coil evaluations. The maximum held-to-head output power is Mode A for WWAN operating modes and Power State 1 Mode A for WLAN operating modes. Refer to §9 & §10 for T-Coil evaluations.

The worst-case configuration is determined by the lowest margin of Primary Group Contiguous Points. The margin Primary Group Contiguous Points is calculated by subtracting the Primary Group points coupling mode requirement (25 for GSM modes and 75 for non-GSM modes) from the measured Primary Group Contiguous Points. The lowest margin of Primary Group Contiguous Points will be highlighted in each table.

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             | 1       |
|      | LMB            | 1       |
|      | MBHB           | 1       |
|      | UHB            | 7       |
| B    | LB             | 2       |
|      | LMB            | 2       |
|      | MBHB           | 2       |
|      | UHB            | 8       |
| C    | MBHB           | 3       |
|      | UHB            | 9       |
| D    | MBHB           | 4       |
|      | UHB            | 4       |

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)

An investigation was performed to determine the worst-case Port for each Licensed technology. All subsequent measurements were determined by this investigation.

The device supports four (4) WLAN Tx antennas:

| Antenna   | Technology   |
|-----------|--------------|
| 3 (Lower) | Wi-Fi 2.4GHz |
|           | Bluetooth    |
| 4 (Upper) | Wi-Fi 2.4GHz |
|           | Bluetooth    |
| 5 (Lower) | Wi-Fi 5GHz   |
|           | Bluetooth    |
| 6 (Upper) | Wi-Fi 5GHz   |
|           | Bluetooth    |

An investigation was performed to determine the worst-case WLAN Antenna. All subsequent measurements were determined by this investigation.

## 9.1. CMRS

### 9.1.1. Antenna Investigation

| Mode:                                              | Channel and Frequency | Bandwidth (Data Rate)       | Power Mode              | Port/Antenna | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin |
|----------------------------------------------------|-----------------------|-----------------------------|-------------------------|--------------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|
| GSM 1900<br>Voice Coder<br>Speechcodec Low         | 661<br>1880 MHz       | N/A                         | Mode A                  | A (ANT 1)    | Transverse  | Pass               | -56.37                | 270                          | 632                            | 26                               | 26                             | 245                                 | 507                                   |
|                                                    |                       |                             |                         | B (ANT 2)    | Transverse  | Pass               | -56.37                | 259                          | 620                            | 26                               | 26                             | 234                                 | 495                                   |
|                                                    |                       |                             |                         | C (ANT 3)    | Transverse  | Pass               | -56.37                | 262                          | 621                            | 26                               | 26                             | 237                                 | 496                                   |
|                                                    |                       |                             |                         | D (ANT 4)    | Transverse  | Pass               | -56.37                | 242                          | 603                            | 26                               | 26                             | 217                                 | 478                                   |
| W-CDMA BII<br>Rel. 99<br>AMR-NB: 4.75 kbps         | 9400<br>1880 MHz      | N/A                         | Mode A                  | A (ANT 1)    | Transverse  | Pass               | -56.37                | 363                          | 675                            | 26                               | 26                             | 288                                 | 375                                   |
|                                                    |                       |                             |                         | B (ANT 2)    | Transverse  | Pass               | -56.37                | 343                          | 655                            | 26                               | 26                             | 268                                 | 355                                   |
|                                                    |                       |                             |                         | C (ANT 3)    | Transverse  | Pass               | -56.37                | 358                          | 670                            | 26                               | 26                             | 283                                 | 370                                   |
|                                                    |                       |                             |                         | D (ANT 4)    | Transverse  | Pass               | -56.37                | 343                          | 654                            | 26                               | 26                             | 268                                 | 354                                   |
| LTE Band 25<br>QPSK<br>RB 1/0<br>AMR-NB: 4.75 kbps | 26365<br>1882.5 MHz   | 20 MHz                      | Mode A                  | A (ANT 1)    | Transverse  | Pass               | -56.45                | 360                          | 675                            | 26                               | 26                             | 285                                 | 375                                   |
|                                                    |                       |                             |                         | B (ANT 2)    | Transverse  | Pass               | -56.45                | 358                          | 675                            | 26                               | 26                             | 283                                 | 375                                   |
|                                                    |                       |                             |                         | C (ANT 3)    | Transverse  | Pass               | -56.45                | 358                          | 675                            | 26                               | 26                             | 283                                 | 375                                   |
|                                                    |                       |                             |                         | D (ANT 4)    | Transverse  | Pass               | -56.45                | 358                          | 675                            | 26                               | 26                             | 283                                 | 375                                   |
| LTE Band 41<br>QPSK<br>RB 1/0<br>AMR-NB: 4.75 kbps | 40620<br>2593 MHz     | 20 MHz                      | Mode A                  | A (ANT 1)    | Transverse  | Pass               | -56.45                | 356                          | 666                            | 26                               | 26                             | 281                                 | 366                                   |
|                                                    |                       |                             |                         | B (ANT 2)    | Transverse  | Pass               | -56.45                | 305                          | 607                            | 26                               | 26                             | 230                                 | 307                                   |
|                                                    |                       |                             |                         | C (ANT 3)    | Transverse  | Pass               | -56.45                | 295                          | 595                            | 26                               | 26                             | 220                                 | 295                                   |
|                                                    |                       |                             |                         | D (ANT 4)    | Transverse  | Pass               | -56.45                | 213                          | 506                            | 26                               | 26                             | 138                                 | 206                                   |
| 802.11b<br>AMR-NB: 4.75 kbps                       | 6<br>2437 MHz         | DSSS<br>1 Mbps<br>20 MHz BW | Power State 1<br>Mode A | ANT 3        | Transverse  | Pass               | -56.18                | 345                          | 672                            | 26                               | 26                             | 270                                 | 372                                   |
|                                                    |                       |                             |                         | ANT 4        | Transverse  | Pass               | -56.18                | 347                          | 673                            | 26                               | 26                             | 272                                 | 373                                   |
| 802.11a<br>AMR-NB: 4.75 kbps                       | 36<br>5180 MHz        | BPSK<br>6 Mbps<br>20 MHz BW | Power State 1<br>Mode A | ANT 5        | Transverse  | Pass               | -56.18                | 351                          | 675                            | 26                               | 26                             | 276                                 | 375                                   |
|                                                    |                       |                             |                         | ANT 6        | Transverse  | Pass               | -56.18                | 349                          | 675                            | 26                               | 26                             | 274                                 | 375                                   |

#### Note(s):

- PORT D (ANT 4) has been determined to be the worst-case antenna for GSM.
- PORT D (ANT 4) has been determined to be the worst-case antenna for W-CDMA.
- PORT D (ANT 4) has been determined to be the worst-case antenna for LTE-FDD.
- PORT D (ANT 4) has been determined to be the worst-case antenna for LTE-TDD.
- ANT 3 has been determined to be the worst-case antenna for Wi-Fi 2.4 GHz.
- ANT 6 has been determined to be the worst-case antenna for Wi-Fi 5 GHz.

### 9.1.2. Codec Investigation

An investigation between the various codec configurations (Low/Mid/High bit rates for Narrowband, Wideband and EVS) was performed to determine the worst-case bit rates for each voice service type. The table below compares the varying codec configurations. A codec investigation was performed on one band of each W-CDMA, LTE FDD, LTE TDD, Wi-Fi 2.4GHz and Wi-Fi 5GHz.

#### W-CDMA Codec Investigation

| W-CDMA Codec Investigation                    |            |              |             |        |                   |                       |                             |                                    |                                      |                                     |                                   |                                           |                                             |
|-----------------------------------------------|------------|--------------|-------------|--------|-------------------|-----------------------|-----------------------------|------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|
| Band/Channel/<br>Bandwidth                    | Power Mode | Port/Antenna | Orientation | Codec  | Bitrate<br>(kbps) | Frequency<br>Response | Ambient<br>Noise<br>dB(A/m) | Primary Group<br>Contiguous<br>Pts | Secondary Group<br>Contiguous<br>Pts | Secondary Group<br>Max Longitudinal | Secondary Group<br>Max Transverse | Primary Group<br>Contiguous<br>Pts Margin | Secondary Group<br>Contiguous<br>Pts Margin |
| W-CDMA BII<br>Rel. 99<br>Ch. 9400<br>1880 MHz | Mode A     | D (ANT 4)    | Transverse  | AMR-NB | 4.75              | Pass                  | -56.37                      | 400                                | 666                                  | 26                                  | 26                                | 325                                       | 366                                         |
|                                               |            |              |             |        | 7.4               | Pass                  | -56.37                      | 402                                | 668                                  | 26                                  | 26                                | 327                                       | 368                                         |
|                                               |            |              |             |        | 12.2              | Pass                  | -56.37                      | 402                                | 667                                  | 26                                  | 26                                | 327                                       | 367                                         |
|                                               |            |              |             | AMR-WB | 6.6               | Pass                  | -56.39                      | 288                                | 668                                  | 26                                  | 26                                | 213                                       | 368                                         |
|                                               |            |              |             |        | 15.85             | Pass                  | -56.39                      | 296                                | 666                                  | 26                                  | 26                                | 221                                       | 366                                         |
|                                               |            |              |             |        | 23.85             | Pass                  | -56.39                      | 298                                | 668                                  | 26                                  | 26                                | 223                                       | 368                                         |

#### Note(s):

- For W-CDMA, it is observed that 6.60 kbps is the worst-case bit rate.

#### VoLTE Codec Investigation

| VoLTE Codec Investigation                               |            |              |             |        |                   |                       |                             |                                    |                                      |                                     |                                   |                                           |                                             |
|---------------------------------------------------------|------------|--------------|-------------|--------|-------------------|-----------------------|-----------------------------|------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|
| Band/Channel/<br>Bandwidth                              | Power Mode | Port/Antenna | Orientation | Codec  | Bitrate<br>(kbps) | Frequency<br>Response | Ambient<br>Noise<br>dB(A/m) | Primary Group<br>Contiguous<br>Pts | Secondary Group<br>Contiguous<br>Pts | Secondary Group<br>Max Longitudinal | Secondary Group<br>Max Transverse | Primary Group<br>Contiguous<br>Pts Margin | Secondary Group<br>Contiguous<br>Pts Margin |
| LTE Band 25<br>CH. 26365<br>QPSK<br>RB 1/0<br>20 MHz BW | Mode A     | D (ANT 4)    | Transverse  | AMR-NB | 4.75              | Pass                  | -56.45                      | 358                                | 675                                  | 26                                  | 26                                | 283                                       | 375                                         |
|                                                         |            |              |             |        | 7.4               | Pass                  | -56.45                      | 361                                | 675                                  | 26                                  | 26                                | 286                                       | 375                                         |
|                                                         |            |              |             |        | 12.2              | Pass                  | -56.45                      | 364                                | 671                                  | 26                                  | 26                                | 289                                       | 371                                         |
|                                                         |            |              |             | AMR-WB | 6.6               | Pass                  | -54.06                      | 279                                | 665                                  | 26                                  | 26                                | 204                                       | 365                                         |
|                                                         |            |              |             |        | 15.85             | Pass                  | -54.06                      | 289                                | 666                                  | 26                                  | 26                                | 214                                       | 366                                         |
|                                                         |            |              |             |        | 23.85             | Pass                  | -54.06                      | 291                                | 668                                  | 26                                  | 26                                | 216                                       | 368                                         |
|                                                         |            |              |             | EVS    | 5.9               | Pass                  | -54.06                      | 282                                | 651                                  | 26                                  | 26                                | 207                                       | 351                                         |
|                                                         |            |              |             |        | 9.6               | Pass                  | -56.45                      | 381                                | 676                                  | 26                                  | 26                                | 306                                       | 376                                         |
|                                                         |            |              |             |        | 24.4              | Pass                  | -56.45                      | 382                                | 676                                  | 26                                  | 26                                | 307                                       | 376                                         |
| LTE Band 41<br>CH. 40620<br>QPSK<br>RB 1/0<br>20 MHz BW | Mode A     | D (ANT 4)    | Transverse  | AMR-NB | 4.75              | Pass                  | -56.45                      | 213                                | 506                                  | 26                                  | 26                                | 138                                       | 206                                         |
|                                                         |            |              |             |        | 7.4               | Pass                  | -56.45                      | 215                                | 502                                  | 26                                  | 26                                | 140                                       | 202                                         |
|                                                         |            |              |             |        | 12.2              | Pass                  | -56.45                      | 216                                | 503                                  | 26                                  | 26                                | 141                                       | 203                                         |
|                                                         |            |              |             | AMR-WB | 6.6               | Pass                  | -54.80                      | 200                                | 543                                  | 26                                  | 26                                | 125                                       | 243                                         |
|                                                         |            |              |             |        | 15.85             | Pass                  | -54.80                      | 198                                | 533                                  | 24                                  | 26                                | 123                                       | 233                                         |
|                                                         |            |              |             |        | 23.85             | Pass                  | -54.80                      | 201                                | 534                                  | 25                                  | 26                                | 126                                       | 234                                         |
|                                                         |            |              |             | EVS    | 5.9               | Pass                  | -56.45                      | 224                                | 571                                  | 26                                  | 26                                | 149                                       | 271                                         |
|                                                         |            |              |             |        | 9.6               | Pass                  | -56.45                      | 369                                | 665                                  | 26                                  | 26                                | 294                                       | 365                                         |
|                                                         |            |              |             |        | 24.4              | Pass                  | -56.45                      | 368                                | 664                                  | 26                                  | 26                                | 293                                       | 364                                         |

#### Note(s):

- For LTE-FDD, it is observed that 6.60 kbps is the worst-case bit rate.
- For LTE-TDD, it is observed that 15.85 kbps is the worst-case bit rate.

**VoWiFi Codec Investigation**

| VoWiFi Codec Investigation           |            |         |             |        |                   |                       |                             |                                    |                                      |                                     |                                   |                                           |                                             |
|--------------------------------------|------------|---------|-------------|--------|-------------------|-----------------------|-----------------------------|------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|
| Band/Channel/<br>Bandwidth           | Power Mode | Antenna | Orientation | Codec  | Bitrate<br>(kbps) | Frequency<br>Response | Ambient<br>Noise<br>dB(A/m) | Primary Group<br>Contiguous<br>Pts | Secondary Group<br>Contiguous<br>Pts | Secondary Group<br>Max Longitudinal | Secondary Group<br>Max Transverse | Primary Group<br>Contiguous<br>Pts Margin | Secondary Group<br>Contiguous<br>Pts Margin |
| DSSS<br>1 Mbps<br>Ch. 6<br>20 MHz BW | Mode A     | ANT 3   | Transverse  | AMR-NB | 4.75              | Pass                  | -56.18                      | 345                                | 672                                  | 26                                  | 26                                | 270                                       | 372                                         |
|                                      |            |         |             |        | 7.4               | Pass                  | -56.18                      | 353                                | 676                                  | 26                                  | 26                                | 278                                       | 376                                         |
|                                      |            |         |             |        | 12.2              | Pass                  | -56.18                      | 359                                | 676                                  | 26                                  | 26                                | 284                                       | 376                                         |
|                                      |            |         |             | AMR-WB | 6.6               | Pass                  | -56.38                      | 290                                | 670                                  | 26                                  | 26                                | 215                                       | 370                                         |
|                                      |            |         |             |        | 15.85             | Pass                  | -56.38                      | 294                                | 668                                  | 26                                  | 26                                | 219                                       | 368                                         |
|                                      |            |         |             |        | 23.85             | Pass                  | -56.38                      | 299                                | 673                                  | 26                                  | 26                                | 224                                       | 373                                         |
|                                      |            |         |             | EVS    | 5.9               | Pass                  | -56.38                      | 295                                | 672                                  | 26                                  | 26                                | 220                                       | 372                                         |
|                                      |            |         |             |        | 9.6               | Pass                  | -56.18                      | 368                                | 676                                  | 26                                  | 26                                | 293                                       | 376                                         |
|                                      |            |         |             |        | 24.4              | Pass                  | -56.18                      | 365                                | 676                                  | 26                                  | 26                                | 290                                       | 376                                         |
| BPSK<br>902.11a<br>Ch. 36<br>6 Mbps  | Mode A     | ANT 6   | Transverse  | AMR-NB | 4.75              | Pass                  | -56.18                      | 349                                | 675                                  | 26                                  | 26                                | 274                                       | 375                                         |
|                                      |            |         |             |        | 7.4               | Pass                  | -56.18                      | 349                                | 675                                  | 26                                  | 26                                | 274                                       | 375                                         |
|                                      |            |         |             |        | 12.2              | Pass                  | -56.18                      | 359                                | 675                                  | 26                                  | 26                                | 284                                       | 375                                         |
|                                      |            |         |             | AMR-WB | 6.6               | Pass                  | -56.38                      | 292                                | 676                                  | 26                                  | 26                                | 217                                       | 376                                         |
|                                      |            |         |             |        | 15.85             | Pass                  | -56.38                      | 302                                | 676                                  | 26                                  | 26                                | 227                                       | 376                                         |
|                                      |            |         |             |        | 23.85             | Pass                  | -56.38                      | 287                                | 661                                  | 26                                  | 26                                | 212                                       | 361                                         |
|                                      |            |         |             | EVS    | 5.9               | Pass                  | -56.38                      | 309                                | 676                                  | 26                                  | 26                                | 234                                       | 376                                         |
|                                      |            |         |             |        | 9.6               | Pass                  | -56.18                      | 370                                | 675                                  | 26                                  | 26                                | 295                                       | 375                                         |
|                                      |            |         |             |        | 24.4              | Pass                  | -56.18                      | 365                                | 675                                  | 26                                  | 26                                | 290                                       | 375                                         |

**Note(s):**

- For Wi-Fi 2.4 GHz, it is observed that 6.60 kbps is the worst-case bit rate.
- For Wi-Fi 5 GHz, it is observed that 23.85 kbps is the worst-case bit rate.

### 9.1.3. Air Interface Investigation

A limited set of bands/channels/bandwidths were evaluated to confirm that there is no effect to the ABM levels when changing the band/channel/bandwidth.

#### W-CDMA Air Interface Investigation

| W-CDMA Air Interface Investigation            |            |              |                       |             |                    |                       |                              |                                |                                  |                                |                                     |                                       |
|-----------------------------------------------|------------|--------------|-----------------------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|
| Mode:                                         | Power Mode | Port/Antenna | Channel and Frequency | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin |
| W-CDMA Band II<br>Rel. 99<br>AMR-WB: 6.6 kbps | Mode A     | D (ANT 4)    | 9262<br>1852.4 MHz    | Transverse  | Pass               | -56.37                | 289                          | 668                            | 26                               | 26                             | 214                                 | 368                                   |
|                                               |            |              | 9400<br>1880.0 MHz    | Transverse  | Pass               | -56.39                | 288                          | 668                            | 26                               | 26                             | 213                                 | 368                                   |
|                                               |            |              | 9538<br>1907.6 MHz    | Transverse  | Pass               | -56.39                | 286                          | 665                            | 26                               | 26                             | 211                                 | 365                                   |

#### Note(s):

- For all subsequent tests for W-CDMA, high channel was used in conjunction with the worst-case bit rate found in §9.1.2.

#### VoLTE Air Interface Investigation

| VoLTE Air Interface Investigation           |           |            |              |                       |               |   |             |                    |                       |                              |                                |                                  |                                |                                     |                                       |
|---------------------------------------------|-----------|------------|--------------|-----------------------|---------------|---|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|
| Mode:                                       | Bandwidth | Power Mode | Port/Antenna | Channel and Frequency | RB Allocation |   | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin |
| LTE Band 25<br>QPSK<br>AMR-WB: 6.6 kbps     | 20 MHz    | Mode A     | D (ANT 4)    | 26365<br>1882.5 MHz   | 1             | 0 | Transverse  | Pass               | -54.06                | 279                          | 665                            | 26                               | 26                             | 204                                 | 365                                   |
|                                             |           |            |              |                       | 100           | 0 | Transverse  | Pass               | -54.06                | 282                          | 668                            | 26                               | 26                             | 207                                 | 368                                   |
| LTE Band 25<br>16QAM<br>AMR-WB: 6.6 kbps    | 20 MHz    | Mode A     | D (ANT 4)    | 26365<br>1882.5 MHz   | 1             | 0 | Transverse  | Pass               | -54.06                | 284                          | 672                            | 26                               | 26                             | 209                                 | 372                                   |
| LTE Band 25<br>64QAM<br>AMR-WB: 6.6 kbps    | 20 MHz    | Mode A     | D (ANT 4)    | 26365<br>1882.5 MHz   | 1             | 0 | Transverse  | Pass               | -54.06                | 280                          | 668                            | 26                               | 26                             | 205                                 | 368                                   |
| LTE Band 25<br>256QAM<br>AMR-WB: 6.6 kbps   | 20 MHz    | Mode A     | D (ANT 4)    | 26365<br>1882.5 MHz   | 1             | 0 | Transverse  | Pass               | -54.06                | 289                          | 674                            | 26                               | 26                             | 214                                 | 374                                   |
| LTE Band 25<br>QPSK<br>AMR-WB: 6.6 kbps     | 1.4 MHz   | Mode A     | D (ANT 4)    | 26365<br>1882.5 MHz   | 1             | 0 | Transverse  | Pass               | -54.06                | 281                          | 671                            | 26                               | 26                             | 206                                 | 371                                   |
| LTE Band 41<br>QPSK<br>AMR-WB: 15.85 kbps   | 20 MHz    | Mode A     | D (ANT 4)    | 40620<br>2593 MHz     | 1             | 0 | Transverse  | Pass               | -54.80                | 198                          | 533                            | 24                               | 26                             | 123                                 | 233                                   |
|                                             |           |            |              |                       | 100           | 0 | Transverse  | Pass               | -56.47                | 248                          | 661                            | 26                               | 26                             | 173                                 | 361                                   |
| LTE Band 41<br>16QAM<br>AMR-WB: 15.85 kbps  | 20 MHz    | Mode A     | D (ANT 4)    | 40620<br>2593 MHz     | 1             | 0 | Transverse  | Pass               | -56.47                | 251                          | 663                            | 26                               | 26                             | 176                                 | 363                                   |
| LTE Band 41<br>64QAM<br>AMR-WB: 15.85 kbps  | 20 MHz    | Mode A     | D (ANT 4)    | 40620<br>2593 MHz     | 1             | 0 | Transverse  | Pass               | -56.47                | 247                          | 662                            | 26                               | 26                             | 172                                 | 362                                   |
| LTE Band 41<br>256QAM<br>AMR-WB: 15.85 kbps | 20 MHz    | Mode A     | D (ANT 4)    | 40620<br>2593 MHz     | 1             | 0 | Transverse  | Pass               | -56.47                | 256                          | 671                            | 26                               | 26                             | 181                                 | 371                                   |
| LTE Band 41<br>QPSK<br>AMR-WB: 15.85 kbps   | 5 MHz     | Mode A     | D (ANT 4)    | 40620<br>2593 MHz     | 1             | 0 | Transverse  | Pass               | -56.47                | 247                          | 662                            | 26                               | 26                             | 172                                 | 362                                   |

#### Note(s):

- For all subsequent tests for LTE-FDD, middle channel, QPSK modulation, and 1% RB size and low RB allocation was used in conjunction with the worst-case bit rate found in §9.1.2.
- For all subsequent tests for LTE-TDD, middle channel, QPSK modulation, and 1% RB size and low RB allocation was used in conjunction with the worst-case bit rate found in §9.1.2.

## VoWiFi Air Interface Investigation

| VoWiFi Air Interface Investigation     |                       |                         |         |                  |           |             |                    |                       |                              |                                |                                  |                                |                                     |                                       |
|----------------------------------------|-----------------------|-------------------------|---------|------------------|-----------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|
| Mode:                                  | Channel and Frequency | Power Mode              | Antenna | Modulation/Index | Data Rate | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin |
| 802.11b<br>AMR-WB: 6.6 kbps            | 6<br>2437 MHz         | Power State 1<br>Mode A | ANT 3   | DSSS             | 1 Mbps    | Transverse  | Pass               | -56.38                | 290                          | 670                            | 26                               | 26                             | 215                                 | 370                                   |
|                                        |                       |                         |         | CCK              | 5.5 Mbps  | Transverse  | Pass               | -56.38                | 291                          | 673                            | 26                               | 26                             | 216                                 | 373                                   |
|                                        |                       |                         |         |                  | 11 Mbps   | Transverse  | Pass               | -56.38                | 291                          | 675                            | 26                               | 26                             | 216                                 | 375                                   |
| 802.11g<br>AMR-WB: 6.6 kbps            | 6<br>2437 MHz         | Power State 1<br>Mode A | ANT 3   | DSSS             | 1 Mbps    | Transverse  | Pass               | -56.38                | 294                          | 676                            | 26                               | 26                             | 219                                 | 376                                   |
| 802.11n<br>AMR-WB: 6.6 kbps            | 6<br>2437 MHz         | Power State 1<br>Mode A | ANT 3   | MCS0             | 6.5 Mbps  | Transverse  | Pass               | -56.38                | 293                          | 676                            | 26                               | 26                             | 218                                 | 376                                   |
| 802.11ax<br>AMR-WB: 6.6 kbps           | 6<br>2437 MHz         | Power State 1<br>Mode A | ANT 3   | MCS0             | 7.3 Mbps  | Transverse  | Pass               | -56.38                | 294                          | 676                            | 26                               | 26                             | 219                                 | 376                                   |
| 802.11a<br>AMR-WB: 23.85 kbps          | 36<br>5180 MHz        | Power State 1<br>Mode A | ANT 6   | BPSK             | 6 Mbps    | Transverse  | Pass               | -56.38                | 287                          | 661                            | 26                               | 26                             | 212                                 | 361                                   |
|                                        |                       |                         |         | QPSK             | 18 Mbps   | Transverse  | Pass               | -56.38                | 302                          | 676                            | 26                               | 26                             | 227                                 | 376                                   |
|                                        |                       |                         |         | 64QAM            | 54 Mbps   | Transverse  | Pass               | -56.38                | 302                          | 676                            | 26                               | 26                             | 227                                 | 376                                   |
| 802.11n 20 MHz<br>AMR-WB: 23.85 kbps   | 36<br>5180 MHz        | Power State 1<br>Mode A | ANT 6   | MCS3             | 26 Mbps   | Transverse  | Pass               | -56.38                | 301                          | 676                            | 26                               | 26                             | 226                                 | 376                                   |
| 802.11n 40 MHz<br>AMR-WB: 23.85 kbps   | 38<br>5190 MHz        | Power State 1<br>Mode A | ANT 6   | MCS3             | 54 Mbps   | Transverse  | Pass               | -56.38                | 301                          | 676                            | 26                               | 26                             | 226                                 | 376                                   |
| 802.11ac 20 MHz<br>AMR-WB: 23.85 kbps  | 36<br>5180 MHz        | Power State 1<br>Mode A | ANT 6   | MCS4             | 39 Mbps   | Transverse  | Pass               | -56.38                | 302                          | 676                            | 26                               | 26                             | 227                                 | 376                                   |
| 802.11ac 40 MHz<br>AMR-WB: 23.85 kbps  | 38<br>5190 MHz        | Power State 1<br>Mode A | ANT 6   | MCS5             | 108 Mbps  | Transverse  | Pass               | -56.38                | 302                          | 676                            | 26                               | 26                             | 227                                 | 376                                   |
| 802.11ac 80 MHz<br>AMR-WB: 23.85 kbps  | 42<br>5210 MHz        | Power State 1<br>Mode A | ANT 6   | MCS5             | 234 Mbps  | Transverse  | Pass               | -56.38                | 302                          | 676                            | 26                               | 26                             | 227                                 | 376                                   |
| 802.11ac 160 MHz<br>AMR-WB: 23.85 kbps | 50<br>5250 MHz        | Power State 1<br>Mode A | ANT 6   | MCS5             | 468 Mbps  | Transverse  | Pass               | -56.18                | 289                          | 673                            | 26                               | 26                             | 214                                 | 373                                   |
| 802.11ax 20 MHz<br>AMR-WB: 23.85 kbps  | 36<br>5180 MHz        | Power State 1<br>Mode A | ANT 6   | MCS6             | 77 Mbps   | Transverse  | Pass               | -56.18                | 291                          | 675                            | 26                               | 26                             | 216                                 | 375                                   |
| 802.11ax 40 MHz<br>AMR-WB: 23.85 kbps  | 38<br>5190 MHz        | Power State 1<br>Mode A | ANT 6   | MCS6             | 155 Mbps  | Transverse  | Pass               | -56.18                | 293                          | 675                            | 26                               | 26                             | 218                                 | 375                                   |
| 802.11ax 80 MHz<br>AMR-WB: 23.85 kbps  | 42<br>5210 MHz        | Power State 1<br>Mode A | ANT 6   | MCS6             | 324 Mbps  | Transverse  | Pass               | -56.18                | 293                          | 676                            | 26                               | 26                             | 218                                 | 376                                   |
| 802.11ax 160 MHz<br>AMR-WB: 23.85 kbps | 50<br>5250 MHz        | Power State 1<br>Mode A | ANT 6   | MCS6             | 649 Mbps  | Transverse  | Pass               | -56.18                | 294                          | 676                            | 26                               | 26                             | 219                                 | 376                                   |

## Note(s):

- For all subsequent tests for Wi-Fi 2.4 GHz, 802.11b DSSS 1 Mbps was used in conjunction with the worst-case bit rate found in §9.1.2.
  - 802.11be has the same max output power, supports the same channel BWs (20MHz) and multiplexing as 802.11ax. Therefore, 802.11ax test results are representative of 802.11be.
- For all subsequent tests for Wi-Fi 5 GHz, 802.11a BPSK 6 Mbps was used in conjunction with the worst-case bit rate found in §9.1.2.
  - 802.11be has the same max output power, supports the same channel BWs (20/40/80/160MHz) and multiplexing as 802.11ax. Therefore, 802.11ax test results are representative of 802.11be.

## 9.2. OTT Application

CMRS and OTT voice services support the same technologies, antennas and air interfaces. CMRS and OTT voice services require the same Reference input level of -16 dBm0 per ANSI C63.19 2019 §6.

Antenna, Codec (bit rates) and Air Interface investigations were conducted on CMRS voice services for supported technologies (Codec bit rate was measured separately for OTT voice services). For all subsequent OTT voice service testing, the worst-case CMRS Air interface configurations were used in conjunction with the worst-case bit rate found in §9.2.1 below.

### 9.2.1. Codec Investigation

The OTT Application did not support a means for the test lab to change the codec's (ACC-ELD) bit rates. When a VoIP call was established, the test lab recorded the bit rate used during that session, listed below, for the supported technologies: GSM, W-CDMA, LTE, 5G NR, Wi-Fi 2.4 GHz, and Wi-Fi 5 GHz

#### Codec Bit Rates

| Codec Bit Rate   |                 |         |                 |
|------------------|-----------------|---------|-----------------|
| Technology       | Mode            | Codec   | Bit Rate (kbps) |
| GSM              | EDGE            | ACC-ELD | 24              |
| W-CDMA           | HSPA            | ACC-ELD | 24              |
| LTE              | FDD             | ACC-ELD | 24              |
|                  | TDD             | ACC-ELD | 24              |
| 5G NR            | FDD             | ACC-ELD | 24              |
|                  | TDD             | ACC-ELD | 24              |
| Wi-Fi<br>2.4 GHz | 802.11b         | ACC-ELD | 39              |
|                  | 802.11g         | ACC-ELD | 39              |
|                  | 802.11n         | ACC-ELD | 39              |
|                  | 802.11ax        | ACC-ELD | 39              |
| Wi-Fi<br>5 GHz   | 802.11a         | ACC-ELD | 39              |
|                  | 802.11n HT20    | ACC-ELD | 39              |
|                  | 802.11n HT40    | ACC-ELD | 39              |
|                  | 802.11ac VHT20  | ACC-ELD | 39              |
|                  | 802.11ac VHT40  | ACC-ELD | 39              |
|                  | 802.11ac VHT80  | ACC-ELD | 39              |
|                  | 802.11ac VHT160 | ACC-ELD | 39              |
|                  | 802.11ax HE20   | ACC-ELD | 39              |
|                  | 802.11ax HE40   | ACC-ELD | 39              |
|                  | 802.11ax HE80   | ACC-ELD | 39              |
|                  | 802.11ax HE160  | ACC-ELD | 39              |

For all subsequent OTT testing, the measured bit rates above were used in conjunction with the worst-case air interfaces found in §9.1.3. Refer to §10 for OTT T-Coil Test Results.

## 10. HAC (T-coil) Test Results

Antenna, Codec (bit rates) and Air Interface investigations were conducted on CMRS voice services (Codec bit rate was measured separately for OTT voice services refer to §9.2.1). The worst-case antenna, codec (bit rate) and air interface configurations were used for final T-Coil testing for CMRS and OTT voice services. Please refer to tables below for final T-Coil Test Results.

### GSM/W-CDMA Test Results

#### CMRS

| Mode:                                   | Channel and Frequency | Power Mode | Port/Antenna | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin | Plot Page # |
|-----------------------------------------|-----------------------|------------|--------------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|-------------|
| GSM 850 Voice Coder Speechcodec Low     | 190 836.6 MHz         | Mode A     | B (ANT 2)    | Transverse  | Pass               | -54.06                | 356                          | 632                            | 26                               | 26                             | 331                                 | 507                                   |             |
| GSM 1900 Voice Coder Speechcodec Low    | 661 1880 MHz          | Mode A     | D (ANT 4)    | Transverse  | Pass               | -54.06                | 312                          | 588                            | 26                               | 26                             | 287                                 | 463                                   |             |
| W-CDMA Band II Rel. 99 AMR-WB: 6.6 kbps | 9538 1907.6 MHz       | Mode A     | D (ANT 4)    | Transverse  | Pass               | -56.39                | 286                          | 665                            | 26                               | 26                             | 211                                 | 365                                   |             |
| W-CDMA Band IV Rel. 99 AMR-WB: 6.6 kbps | 1513 1752.6 MHz       | Mode A     | D (ANT 4)    | Transverse  | Pass               | -56.39                | 286                          | 667                            | 26                               | 26                             | 211                                 | 367                                   |             |
| W-CDMA Band V Rel. 99 AMR-WB: 6.6 kbps  | 4233 846.6 MHz        | Mode A     | B (ANT 2)    | Transverse  | Pass               | -56.39                | 285                          | 667                            | 26                               | 26                             | 210                                 | 367                                   |             |

#### OTT

| Mode:                                 | Channel and Frequency | Power Mode | Port/Antenna | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin | Plot Page # |
|---------------------------------------|-----------------------|------------|--------------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|-------------|
| GSM 850 EGDE/EGPRS ACC-ELD: 24 kbps   | 190 836.6 MHz         | Mode A     | B (ANT 2)    | Transverse  | Pass               | -56.38                | 179                          | 671                            | 26                               | 26                             | 154                                 | 546                                   | 1 - 2       |
| GSM 1900 EGDE/EGPRS ACC-ELD: 24 kbps  | 661 1880 MHz          | Mode A     | D (ANT 4)    | Transverse  | Pass               | -56.38                | 180                          | 661                            | 26                               | 26                             | 155                                 | 536                                   | 3 - 4       |
| W-CDMA Band II HSPA+ ACC-ELD: 24 kbps | 9538 1907.6 MHz       | Mode A     | D (ANT 4)    | Transverse  | Pass               | -56.38                | 192                          | 676                            | 26                               | 26                             | 117                                 | 376                                   | 5 - 6       |
| W-CDMA Band IV HSPA+ ACC-ELD: 24 kbps | 1513 1752.6 MHz       | Mode A     | D (ANT 4)    | Transverse  | Pass               | -56.38                | 187                          | 676                            | 26                               | 26                             | 112                                 | 376                                   | 7 - 8       |
| W-CDMA Band V HSPA+ ACC-ELD: 24 kbps  | 4233 846.6 MHz        | Mode A     | B (ANT 2)    | Transverse  | Pass               | -56.38                | 189                          | 673                            | 26                               | 26                             | 114                                 | 373                                   | 9 - 10      |

### LTE (VoLTE) Test Results

#### CMRS

| Mode:                                   | Bandwidth (Data Rate) | Power Mode | Port/Antenna | Channel and Frequency | RB Allocation | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin | Plot Page # |
|-----------------------------------------|-----------------------|------------|--------------|-----------------------|---------------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|-------------|
| LTE Band 7 QPSK AMR-WB: 6.6 kbps        | 20 MHz                | Mode A     | D (ANT 4)    | 21100 2535 MHz        | 1 0           | Transverse  | Pass               | -54.80                | 271                          | 652                            | 26                               | 26                             | 196                                 | 352                                   |             |
| LTE Band 12 QPSK AMR-WB: 6.6 kbps       | 10 MHz                | Mode A     | B (ANT 2)    | 23095 707.5 MHz       | 1 0           | Transverse  | Pass               | -54.80                | 276                          | 659                            | 26                               | 26                             | 201                                 | 359                                   |             |
| LTE Band 13 QPSK AMR-WB: 6.6 kbps       | 10 MHz                | Mode A     | B (ANT 2)    | 23230 782 MHz         | 1 0           | Transverse  | Pass               | -54.80                | 283                          | 665                            | 26                               | 26                             | 208                                 | 365                                   |             |
| LTE Band 14 QPSK AMR-WB: 6.6 kbps       | 10 MHz                | Mode A     | B (ANT 2)    | 23330 793 MHz         | 1 0           | Transverse  | Pass               | -54.80                | 282                          | 665                            | 26                               | 26                             | 207                                 | 365                                   |             |
| LTE Band 25 QPSK AMR-WB: 6.6 kbps       | 20 MHz                | Mode A     | D (ANT 4)    | 26365 1882.5 MHz      | 1 0           | Transverse  | Pass               | -54.06                | 279                          | 665                            | 26                               | 26                             | 204                                 | 365                                   |             |
| LTE Band 26 QPSK AMR-WB: 6.6 kbps       | 15 MHz                | Mode A     | B (ANT 2)    | 26865 831.5 MHz       | 1 0           | Transverse  | Pass               | -54.80                | 286                          | 667                            | 26                               | 26                             | 211                                 | 367                                   |             |
| LTE Band 30 QPSK AMR-WB: 6.6 kbps       | 10 MHz                | Mode A     | D (ANT 4)    | 27710 2310 MHz        | 1 0           | Transverse  | Pass               | -54.80                | 283                          | 667                            | 26                               | 26                             | 208                                 | 367                                   |             |
| LTE Band 41 PC3 QPSK AMR-WB: 15.85 kbps | 20 MHz                | Mode A     | D (ANT 4)    | 40620 2593 MHz        | 1 0           | Transverse  | Pass               | -54.80                | 198                          | 533                            | 24                               | 26                             | 123                                 | 233                                   |             |
| LTE Band 41 PC2 QPSK AMR-WB: 15.85 kbps | 20 MHz                | Mode A     | D (ANT 4)    | 40620 2593 MHz        | 1 0           | Transverse  | Pass               | -54.80                | 191                          | 523                            | 25                               | 26                             | 116                                 | 223                                   |             |
| LTE Band 48 PC3 QPSK AMR-WB: 15.85 kbps | 20 MHz                | Mode A     | D (ANT 4)    | 55990 3625 MHz        | 1 0           | Transverse  | Pass               | -54.80                | 292                          | 663                            | 26                               | 26                             | 217                                 | 363                                   |             |
| LTE Band 53 PC3 QPSK AMR-WB: 15.85 kbps | 10 MHz                | Mode A     | B (ANT 2)    | 60197 2489.2 MHz      | 1 0           | Transverse  | Pass               | -54.80                | 296                          | 667                            | 26                               | 26                             | 221                                 | 367                                   |             |
| LTE Band 66 QPSK AMR-WB: 6.6 kbps       | 20 MHz                | Mode A     | D (ANT 4)    | 132322 1745 MHz       | 1 0           | Transverse  | Pass               | -54.80                | 284                          | 667                            | 26                               | 26                             | 209                                 | 367                                   |             |
| LTE Band 71 QPSK AMR-WB: 6.6 kbps       | 20 MHz                | Mode A     | B (ANT 2)    | 133297 680.5 MHz      | 1 0           | Transverse  | Pass               | -54.80                | 286                          | 667                            | 26                               | 26                             | 211                                 | 367                                   |             |

**OTT**

| Mode:                                       | Bandwidth<br>(Data Rate) | Power Mode | Port/Antenna | Channel and<br>Frequency | RB<br>Allocation | Orientation | Frequency<br>Response | Ambient<br>Noise<br>dB(A/m) | Primary Group<br>Contiguous<br>Pts | Secondary Group<br>Contiguous<br>Pts | Secondary Group<br>Max Longitudinal | Secondary Group<br>Max Transverse | Primary Group<br>Contiguous<br>Pts Margin | Secondary Group<br>Contiguous<br>Pts Margin | Plot<br>Page # |         |
|---------------------------------------------|--------------------------|------------|--------------|--------------------------|------------------|-------------|-----------------------|-----------------------------|------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|----------------|---------|
| LTE Band 7<br>QPSK<br>ACC-ELD: 24 kbps      | 20 MHz                   | Mode A     | D (ANT 4)    | 21100<br>2535 MHz        | 1                | 0           | Transverse            | Pass                        | -56.38                             | 183                                  | 668                                 | 26                                | 26                                        | 108                                         | 368            | 11 - 12 |
| LTE Band 12<br>QPSK<br>ACC-ELD: 24 kbps     | 10 MHz                   | Mode A     | B (ANT 2)    | 23095<br>707.5 MHz       | 1                | 0           | Transverse            | Pass                        | -56.38                             | 189                                  | 674                                 | 26                                | 26                                        | 114                                         | 374            | 13 - 14 |
| LTE Band 13<br>QPSK<br>ACC-ELD: 24 kbps     | 10 MHz                   | Mode A     | B (ANT 2)    | 23230<br>782 MHz         | 1                | 0           | Transverse            | Pass                        | -56.38                             | 189                                  | 674                                 | 26                                | 26                                        | 114                                         | 374            | 15 - 16 |
| LTE Band 14<br>QPSK<br>ACC-ELD: 24 kbps     | 10 MHz                   | Mode A     | B (ANT 2)    | 23330<br>793 MHz         | 1                | 0           | Transverse            | Pass                        | -56.38                             | 189                                  | 674                                 | 26                                | 26                                        | 114                                         | 374            | 17 - 18 |
| LTE Band 25<br>QPSK<br>ACC-ELD: 24 kbps     | 20 MHz                   | Mode A     | D (ANT 4)    | 26365<br>1882.5 MHz      | 1                | 0           | Transverse            | Pass                        | -56.38                             | 176                                  | 656                                 | 26                                | 26                                        | 101                                         | 356            | 19 - 20 |
| LTE Band 26<br>QPSK<br>ACC-ELD: 24 kbps     | 15 MHz                   | Mode A     | B (ANT 2)    | 26865<br>831.5 MHz       | 1                | 0           | Transverse            | Pass                        | -56.38                             | 188                                  | 673                                 | 26                                | 26                                        | 113                                         | 373            | 21 - 22 |
| LTE Band 30<br>QPSK<br>ACC-ELD: 24 kbps     | 10 MHz                   | Mode A     | D (ANT 4)    | 27710<br>2310 MHz        | 1                | 0           | Transverse            | Pass                        | -56.38                             | 189                                  | 674                                 | 26                                | 26                                        | 114                                         | 374            | 23 - 24 |
| LTE Band 41 PC3<br>QPSK<br>ACC-ELD: 24 kbps | 20 MHz                   | Mode A     | D (ANT 4)    | 40620<br>2593 MHz        | 1                | 0           | Transverse            | Pass                        | -56.38                             | 160                                  | 626                                 | 26                                | 26                                        | 85                                          | 326            | 25 - 26 |
| LTE Band 41 PC2<br>QPSK<br>ACC-ELD: 24 kbps | 20 MHz                   | Mode A     | D (ANT 4)    | 40620<br>2593 MHz        | 1                | 0           | Transverse            | Pass                        | -56.38                             | 162                                  | 628                                 | 26                                | 26                                        | 87                                          | 328            | 27 - 28 |
| LTE Band 48 PC3<br>QPSK<br>ACC-ELD: 24 kbps | 20 MHz                   | Mode A     | D (ANT 4)    | 55990<br>3625 MHz        | 1                | 0           | Transverse            | Pass                        | -56.38                             | 159                                  | 608                                 | 26                                | 26                                        | 84                                          | 308            | 29 - 30 |
| LTE Band 53 PC3<br>QPSK<br>ACC-ELD: 24 kbps | 10 MHz                   | Mode A     | B (ANT 2)    | 60197<br>2489.2 MHz      | 1                | 0           | Transverse            | Pass                        | -56.38                             | 192                                  | 676                                 | 26                                | 26                                        | 117                                         | 376            | 31 - 32 |
| LTE Band 66<br>QPSK<br>ACC-ELD: 24 kbps     | 20 MHz                   | Mode A     | D (ANT 4)    | 132322<br>1745 MHz       | 1                | 0           | Transverse            | Pass                        | -56.38                             | 178                                  | 659                                 | 26                                | 26                                        | 103                                         | 359            | 33 - 34 |
| LTE Band 71<br>QPSK<br>ACC-ELD: 24 kbps     | 20 MHz                   | Mode A     | B (ANT 2)    | 133297<br>680.5 MHz      | 1                | 0           | Transverse            | Pass                        | -56.38                             | 189                                  | 673                                 | 26                                | 26                                        | 114                                         | 373            | 35 - 36 |

**5G NR (VoNR) Test Results****CMRS**

| Mode:                                                           | Bandwidth<br>(Data Rate) | SCS<br>(kHz) | Power Mode | Port/Antenna | Channel and<br>Frequency | RB<br>Allocation |   | Orientation | Frequency<br>Response | Ambient<br>Noise<br>dB(A/m) | Primary Group<br>Contiguous<br>Pts | Secondary Group<br>Contiguous<br>Pts | Secondary Group<br>Max Longitudinal | Secondary Group<br>Max Transverse | Primary Group<br>Contiguous<br>Pts Margin | Secondary Group<br>Contiguous<br>Pts Margin | Plot<br>Page # |
|-----------------------------------------------------------------|--------------------------|--------------|------------|--------------|--------------------------|------------------|---|-------------|-----------------------|-----------------------------|------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|----------------|
| NR Band n25<br>DFT-s π/2 BPSK<br>AMR-WB: 6.6 kbps               | 40 MHz                   | 15           | Mode A     | D (ANT 4)    | 376500<br>1882.5 MHz     | 1                | 1 | Transverse  | Pass                  | -55.68                      | 259                                | 666                                  | 26                                  | 26                                | 184                                       | 366                                         |                |
| NR Band n30<br>DFT-s π/2 BPSK<br>AMR-WB: 6.6 kbps               | 10 MHz                   | 15           | Mode A     | D (ANT 4)    | 462000<br>2310 MHz       | 1                | 1 | Transverse  | Pass                  | -55.68                      | 255                                | 662                                  | 26                                  | 26                                | 180                                       | 362                                         |                |
| NR Band n41 PC3<br>DFT-s π/2 BPSK<br>AMR-WB: 15.85 kbps         | 100 MHz                  | 30           | Mode A     | D (ANT 4)    | 518598<br>2592.99 MHz    | 1                | 1 | Transverse  | Pass                  | -55.68                      | 255                                | 662                                  | 26                                  | 26                                | 180                                       | 362                                         |                |
| NR Band n41 PC2<br>DFT-s π/2 BPSK<br>AMR-WB: 15.85 kbps         | 100 MHz                  | 30           | Mode A     | D (ANT 4)    | 518598<br>2592.99 MHz    | 1                | 1 | Transverse  | Pass                  | -55.68                      | 233                                | 638                                  | 26                                  | 26                                | 158                                       | 338                                         |                |
| NR Band n71<br>DFT-s π/2 BPSK<br>AMR-WB: 6.6 kbps               | 20 MHz                   | 15           | Mode A     | B (ANT 2)    | 136100<br>680.5 MHz      | 1                | 1 | Transverse  | Pass                  | -55.68                      | 258                                | 666                                  | 26                                  | 26                                | 183                                       | 366                                         |                |
| NR Band n77 Block C PC2<br>DFT-s π/2 BPSK<br>AMR-WB: 15.85 kbps | 100 MHz                  | 30           | Mode A     | D (ANT 4)    | 657734<br>3866.01 MHz    | 1                | 1 | Transverse  | Pass                  | -55.68                      | 252                                | 659                                  | 26                                  | 26                                | 177                                       | 359                                         |                |

**OTT**

| Mode:                                                         | Bandwidth<br>(MHz) | SCS<br>(kHz) | Power Mode | Port/Antenna | Channel and<br>Frequency | RB<br>Allocation | Orientation | Frequency<br>Response | Ambient<br>Noise<br>dB(A/m) | Primary Group<br>Contiguous<br>Pts | Secondary Group<br>Contiguous<br>Pts | Secondary Group<br>Max Longitudinal | Secondary Group<br>Max Transverse | Primary Group<br>Contiguous<br>Pts Margin | Secondary Group<br>Contiguous<br>Pts Margin | Plot<br>Page # |         |
|---------------------------------------------------------------|--------------------|--------------|------------|--------------|--------------------------|------------------|-------------|-----------------------|-----------------------------|------------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------------|---------------------------------------------|----------------|---------|
| NR Band n25<br>DFT-s π/2 BPSK<br>ACC-ELD: 23 kbps             | 40 MHz             | 15           | Mode A     | D (ANT 4)    | 376500<br>1882.5 MHz     | 1                | 1           | Transverse            | Pass                        | -56.27                             | 190                                  | 673                                 | 26                                | 26                                        | 115                                         | 373            | 37 - 38 |
| NR Band n30<br>DFT-s π/2 BPSK<br>ACC-ELD: 23 kbps             | 10 MHz             | 15           | Mode A     | D (ANT 4)    | 462000<br>2310 MHz       | 1                | 1           | Transverse            | Pass                        | -56.27                             | 188                                  | 673                                 | 26                                | 26                                        | 113                                         | 373            | 39 - 40 |
| NR Band n41 PC3<br>DFT-s π/2 BPSK<br>ACC-ELD: 23 kbps         | 100 MHz            | 30           | Mode A     | D (ANT 4)    | 518598<br>2592.99 MHz    | 1                | 1           | Transverse            | Pass                        | -56.27                             | 184                                  | 668                                 | 26                                | 26                                        | 109                                         | 368            | 41 - 42 |
| NR Band n41 PC2<br>DFT-s π/2 BPSK<br>ACC-ELD: 23 kbps         | 100 MHz            | 30           | Mode A     | D (ANT 4)    | 518598<br>2592.99 MHz    | 1                | 1           | Transverse            | Pass                        | -56.27                             | 160                                  | 619                                 | 26                                | 26                                        | 85                                          | 319            | 43 - 44 |
| NR Band n71<br>DFT-s π/2 BPSK<br>ACC-ELD: 23 kbps             | 20 MHz             | 15           | Mode A     | B (ANT 2)    | 136100<br>680.5 MHz      | 1                | 1           | Transverse            | Pass                        | -56.27                             | 189                                  | 673                                 | 26                                | 26                                        | 114                                         | 373            | 45 - 46 |
| NR Band n77 Block C PC2<br>DFT-s π/2 BPSK<br>ACC-ELD: 23 kbps | 100 MHz            | 30           | Mode A     | D (ANT 4)    | 657734<br>3866.01 MHz    | 1                | 1           | Transverse            | Pass                        | -56.27                             | 180                                  | 647                                 | 26                                | 26                                        | 105                                         | 347            | 47 - 48 |

**Note(s):**

The DUT supports 5G NR, Voice over New Radio (VoNR). Per the manufacturer, 5G NR (VoNR) uses the same protocol, Codec(s) and bitrates as LTE (VoLTE). Investigations were performed on LTE (VoLTE) and the worst-case Port/Antenna/Codec/Air Interface configurations from LTE (VoLTE) was used for 5G NR (VoNR) evaluations. A limited set of 5G NR (VoNR) bands were evaluated to confirm 5G NR (VoNR) compliance.

- At least one 5G NR (VoNR)-FDD LB, MB and HB were evaluated for CMRS and OTT voice services.
- At least one 5G NR (VoNR)-TDD HB and UIHB were evaluated for CMRS and OTT voice services.

**Wi-Fi (VoWiFi) Test Results****CMRS**

| Mode:                         | Channel and Frequency | Data Rate      | Power Mode              | Antenna | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin | Plot Page # |
|-------------------------------|-----------------------|----------------|-------------------------|---------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|-------------|
| 802.11b<br>AMR-WB: 6.6 kbps   | 6<br>2437 MHz         | DSSS<br>1 Mbps | Power State 1<br>Mode A | ANT 3   | Transverse  | Pass               | -56.38                | 290                          | 670                            | 26                               | 26                             | 215                                 | 370                                   |             |
| 802.11a<br>AMR-WB: 23.85 kbps | 36<br>5180 MHz        | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.38                | 287                          | 661                            | 26                               | 26                             | 212                                 | 361                                   |             |
|                               | 52<br>5260 MHz        | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.38                | 303                          | 676                            | 26                               | 26                             | 228                                 | 376                                   |             |
|                               | 100<br>5500 MHz       | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.38                | 300                          | 676                            | 26                               | 26                             | 225                                 | 376                                   |             |
|                               | 149<br>5745 MHz       | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.38                | 300                          | 676                            | 26                               | 26                             | 225                                 | 376                                   |             |
|                               | 1<br>5955 MHz         | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.38                | 253                          | 672                            | 26                               | 26                             | 178                                 | 372                                   |             |

**OTT**

| Mode:                       | Channel and Frequency | Data Rate      | Power Mode              | Antenna | Orientation | Frequency Response | Ambient Noise dB(A/m) | Primary Group Contiguous Pts | Secondary Group Contiguous Pts | Secondary Group Max Longitudinal | Secondary Group Max Transverse | Primary Group Contiguous Pts Margin | Secondary Group Contiguous Pts Margin | Plot Page # |
|-----------------------------|-----------------------|----------------|-------------------------|---------|-------------|--------------------|-----------------------|------------------------------|--------------------------------|----------------------------------|--------------------------------|-------------------------------------|---------------------------------------|-------------|
| 802.11b<br>ACC-ELD: 39 kbps | 6<br>2437 MHz         | DSSS<br>1 Mbps | Power State 1<br>Mode A | ANT 3   | Transverse  | Pass               | -56.27                | 172                          | 655                            | 26                               | 26                             | 97                                  | 355                                   | 49 - 50     |
| 802.11a<br>ACC-ELD: 39 kbps | 36<br>5180 MHz        | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.27                | 194                          | 676                            | 26                               | 26                             | 119                                 | 376                                   | 51 - 52     |
|                             | 52<br>5260 MHz        | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.27                | 194                          | 676                            | 26                               | 26                             | 119                                 | 376                                   | 53 - 54     |
|                             | 100<br>5500 MHz       | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.27                | 194                          | 676                            | 26                               | 26                             | 119                                 | 376                                   | 55 - 56     |
|                             | 149<br>5745 MHz       | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.27                | 187                          | 669                            | 26                               | 26                             | 112                                 | 369                                   | 57 - 58     |
|                             | 1<br>5955 MHz         | BPSK<br>6 Mbps | Power State 1<br>Mode A | ANT 6   | Transverse  | Pass               | -56.27                | 194                          | 676                            | 26                               | 26                             | 119                                 | 376                                   | 59 - 60     |

10.1. Worst Case T-Coil Test Plot(s)

UL Verification Services Inc. SAR Lab 11

Date/Time: August 20, 2024 at 08:55

T-Coil Signal Test Report: LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK, UL  
Subframe=2,3,4,7,8,9)

Device Under Test

| Manufacturer | Model | Dimensions [mm]    | Speaker Position [mm] |
|--------------|-------|--------------------|-----------------------|
|              |       | 146.2 x 71.8 x 7.5 | 144.3                 |

Hardware Setup

| Probe Name    | Probe Calibration Date | DAE Name    | DAE Calibration Date |
|---------------|------------------------|-------------|----------------------|
| AM1DV3 - 3083 | January 08, 2024       | DAE4 Sn1352 | November 15, 2023    |

Communication Systems

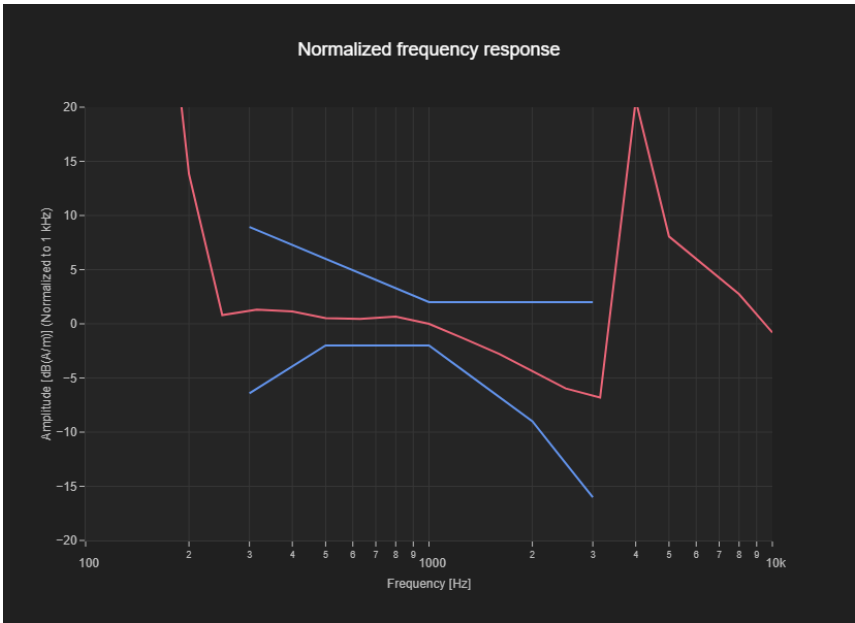
| Band Name               | Communication Systems Name                                     | Channel | Frequency [MHz] |
|-------------------------|----------------------------------------------------------------|---------|-----------------|
| Band 48, E-UTRA/TDD PC3 | LTE-TDD (SC-FDMA, 1 RB, 20 MHz, QPSK, UL Subframe=2,3,4,7,8,9) | 55990   | 3625.0          |

Grid Settings

| Extent X [mm] | Extent Y [mm] | Step X [mm] | Step Y [mm] | Distance [mm] |
|---------------|---------------|-------------|-------------|---------------|
| 52.0          | 52.0          | 4.0         | 4.0         | 10.0          |

Results

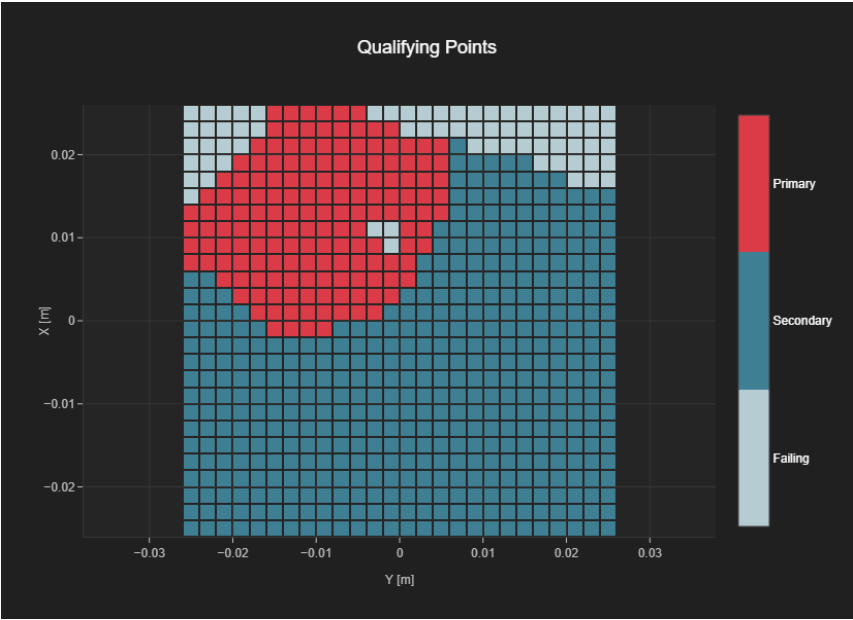
| Audio File                | Measurement Duration [s] | Margin Upper Bound [dB] | Margin Lower Bound [dB] |
|---------------------------|--------------------------|-------------------------|-------------------------|
| 48k_voice_300-3000_2s.wav | 2.0                      | 2.0                     | 2.0                     |



T-Coil Coupling Mode Test Report:

Results

| Primary Group<br>Contiguous<br>Point Count | Secondary<br>Group Point<br>Count | Secondary<br>Group Max<br>Longitudinal | Secondary<br>Group Max<br>Transverse |
|--------------------------------------------|-----------------------------------|----------------------------------------|--------------------------------------|
| 159                                        | 608                               | 26                                     | 26                                   |



## **Appendix**

Refer to separated files for the following appendixes.

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

### **Appendix B: T-Coil Test Plots**

### **Appendix C: T-Coil Probe Certificates**

**END OF REPORT**