# HEARING AID COMPATIBILITY T-COIL TEST REPORT

| | | |
|---|---|---|
| **FCC ID** | : | **2ABZ2-EE103** |
| **Equipment** | : | **Smart Phone** |
| **Brand Name** | : | **ONEPLUS** |
| **Model Name** | : | **IN2017** |
| **T-Rating** | : | **T3** |
| **Applicant** | : | **OnePlus Technology （Shenzhen） Co., Ltd**<br>**18C02, 18C03, 18C04 and 18C05, Shum Yip Terra Building, Binhe Avenue North, Futian District, Shenzhen** |
| **Manufacturer** | : | **OnePlus Technology （Shenzhen） Co., Ltd**<br>**18C02, 18C03, 18C04 and 18C05, Shum Yip Terra Building, Binhe Avenue North, Futian District, Shenzhen** |
| **Standard** | : | **FCC 47 CFR §20.19**<br>**ANSI C63.19-2011** |

**The product was received on Dec. 25, 2019 and testing was started from Dec. 28, 2019 and completed on Jan. 12, 2020. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.**

**The report must not be used by the client to claim product certification, approval, or endorsement by TAF or any agency of government.**

**The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory, the test report shall not be reproduced except in full.**

**Approved by: Cona Huang / Deputy Manager**

***SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory***
*No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)*

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**Appendix A. Plots of T-Coil Measurement**
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# History of this test report

| Report No. | Version | Description | Issued Date |
|---|---|---|---|
| HA9N2021-02B | Rev. 01 | Initial issue of report | Mar. 13, 2020 |
| HA9N2021-02B | Rev. 02 | Update section7 | Apr. 09, 2020 |
| | | | |

# 1. Attestation of Test Results

| Air Interface | Band MHz | T-Rating | Frequency Response | Magnetic Intensity |
|---|---|---|---|---|
| GSM CMRS Voice | GSM850 | T3 | Pass | Pass |
| | GSM1900 | T4 | Pass | Pass |
| OTT over EDGE | EDGE850 | T4 | Pass | Pass |
| | EDGE1900 | T4 | Pass | Pass |
| UMTS CMRS Voice | Band 2 | T4 | Pass | Pass |
| | Band 4 | T4 | Pass | Pass |
| | Band 5 | T4 | Pass | Pass |
| OTT over UMTS | Band 2 | T4 | Pass | Pass |
| | Band 4 | T4 | Pass | Pass |
| | Band 5 | T4 | Pass | Pass |
| CDMA CMRS Voice | BC0 | T4 | Pass | Pass |
| | BC1 | T4 | Pass | Pass |
| | BC10 | T4 | Pass | Pass |
| OTT over CDMA | BC0 | T4 | Pass | Pass |
| | BC1 | T4 | Pass | Pass |
| | BC10 | T4 | Pass | Pass |
| VoLTE | Band 2 | T4 | Pass | Pass |
| | Band 4 | T4 | Pass | Pass |
| | Band 5 | T4 | Pass | Pass |
| | Band 7 | T4 | Pass | Pass |
| | Band 12 | T4 | Pass | Pass |
| | Band 13 | T4 | Pass | Pass |
| | Band 17 | T4 | Pass | Pass |
| | Band 25 | T4 | Pass | Pass |
| | Band 26 | T4 | Pass | Pass |
| | Band 30 | T4 | Pass | Pass |
| | Band 66 | T4 | Pass | Pass |
| | Band 71 | T4 | Pass | Pass |
| | Band 38 | T4 | Pass | Pass |
| | Band 48 | T4 | Pass | Pass |
| | Band 41 | T4 | Pass | Pass |
| OTT over LTE | Band 66 | T4 | Pass | Pass |
| | Band 41 | T4 | Pass | Pass |
| OTT over 5G NR | n2 | T4 | Pass | Pass |
| | n5 | T4 | Pass | Pass |
| | n41 | T4 | Pass | Pass |
| | n66 | T4 | Pass | Pass |
| | n71 | T4 | Pass | Pass |
| VoWiFI | 2450 | T4 | Pass | Pass |
| | 5200 | T4 | Pass | Pass |
| | 5300 | T4 | Pass | Pass |
| | 5500 | T4 | Pass | Pass |
| | 5800 | T4 | Pass | Pass |
| OTT over WiFi | 2450 | T4 | Pass | Pass |
| | 5800 | T4 | Pass | Pass |
| Date Tested | 2019/12/28 ~ 2020/1/12 | | | |

The device is compliance with HAC limits specified in guidelines FCC 47CFR §20.19 and ANSI Standard ANSI C63.19.

**Reviewed by: Jason Wang**
**Report Producer: Wan Liu**

## 2. General Information

| Product Feature & Specification | |
|---|---|
| **Applicant Name** | OnePlus Technology （Shenzhen） Co., Ltd |
| **Equipment Name** | Smart Phone |
| **Brand Name** | ONEPLUS |
| **Model Name** | IN2017 |
| **FCC ID** | 2ABZ2-EE103 |
| **EUT Stage** | Production Unit |
| **Frequency Band** | GSM850: 824.2 MHz ~ 848.8 MHz<br>GSM1900: 1850.2 MHz ~ 1909.8 MHz<br>WCDMA Band II: 1852.4 MHz ~ 1907.6 MHz<br>WCDMA Band IV: 1712.4 MHz ~ 1752.6 MHz<br>WCDMA Band V: 826.4 MHz ~ 846.6 MHz<br>CDMA2000 BC0: 824.7 MHz ~ 848.31 MHz<br>CDMA 2000 BC1: 1851.25 MHz ~ 1908.75 MHz<br>CDMA 2000 BC10: 817.9 MHz ~ 823.1 MHz<br>LTE Band 2: 1850.7 MHz ~ 1909.3 MHz<br>LTE Band 4: 1710.7 MHz ~ 1754.3 MHz<br>LTE Band 5: 824.7 MHz ~ 848.3 MHz<br>LTE Band 7: 2502.5 MHz ~ 2567.5 MHz<br>LTE Band 12: 699.7 MHz ~ 715.3 MHz<br>LTE Band 13: 779.5 MHz ~ 784.5 MHz<br>LTE Band 17: 706.5 MHz ~ 713.5 MHz<br>LTE Band 25: 1850.7 MHz ~ 1914.3 MHz<br>LTE Band 26: 814.7 MHz ~ 848.3 MHz<br>LTE Band 30: 2307.5 MHz ~ 2312.5 MHz<br>LTE Band 38: 2572.5 MHz ~ 2617.5 MHz<br>LTE Band 41: 2498.5 MHz ~ 2687.5 MHz<br>LTE Band 48: 3552.5 MHz ~ 3697.5 MHz<br>LTE Band 66: 1710.7 MHz ~ 1779.3 MHz<br>LTE Band 71: 665.5 MHz ~ 695.5 MHz<br>5G NR n2 : 1852.5 MHz ~ 1907.5 MHz<br>5G NR n5 : 826.5 MHz ~ 846.5 MHz<br>5G NR n41 : 2506.02 MHz ~ 2679.99MHz<br>5G NR n66 : 1712.5 MHz ~ 1777.5 MHz<br>5G NR n71 : 665.5 MHz ~ 695.5 MHz<br>WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz<br>WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz<br>WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz<br>WLAN 5.5GHz Band: 5500 MHz ~ 5720 MHz<br>WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz<br>Bluetooth: 2402 MHz ~ 2480 MHz<br>NFC: 13.56 MHz |
| **Mode** | GSM/GPRS/EGPRS<br>AMR / RMC 12.2Kbps<br>HSDPA<br>HSUPA<br>DC-HSDPA<br>HSPA+ (16QAM uplink)<br>CDMA2000 : 1xRTT/1xEv-Do(Rel.0)/1xEv-Do(Rev.A)<br>LTE: QPSK, 16QAM, 64QAM<br>5G NR : CP-OFDM / DFT-s-OFDM，PI/2 BPSK , QPSK, 16QAM, 64QAM<br>WLAN 2.4GHz : 802.11b/g/n/ax HT20/HE20/HE40<br>WLAN 5GHz : 802.11a/n/ac/ax HT20/HT40/VHT20/VHT40/VHT80/HE20/HE40/HE80<br>Bluetooth BR/EDR/LE<br>NFC:ASK |
| **Remark:**<br>1. This device has WWAN UAT and LAT transmitter antennas which can refer to antenna location chapter.<br>2. The 2.4GHz/5GHz WLAN can transmit in MIMO antenna mode only and it has no SISO antenna mode. | |

## 3. Testing Location

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 1190) and the FCC designation No. TW1190 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC test.

| Testing Laboratory | |
|---|---|
| Test Site | SPORTON INTERNATIONAL INC. |
| Test Site Location | No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City, Taiwan (R.O.C.)<br>TEL: +886-3-327-3456<br>FAX: +886-3-328-4978 |
| Test Site No. | Sporton Site No.:<br>**SAR04-HY** |

## 4. Applied Standards

- FCC CFR47 Part 20.19
- ANSI C63.19 2011-version
- FCC KDB 285076 D01 HAC Guidance v05
- FCC KDB 285076 D02 T Coil testing v03
- FCC KDB 285076 D03 HAC FAQ v01

# 5. Air Interface and Operating Mode

| Air Interface | Band MHz | Type | C63.19 Tested | Simultaneous Transmitter | Name of Voice Service | Power Reduction |
|---|---|---|---|---|---|---|
| GSM | GSM850 | VO | Yes | WLAN, BT | CMRS Voice | No |
| | GSM1900 | | | WLAN, BT | | No |
| | EDGE850 | VD | Yes | WLAN, BT | Android dialing(1,2) / Google Duo(1) | No |
| | EDGE1900 | | | | | |
| UMTS | 850 | VO | Yes | WLAN, BT | CMRS Voice | No |
| | 1750 | | | WLAN, BT | | No |
| | 1900 | | | WLAN, BT | | No |
| | HSPA | VD | Yes | WLAN, BT | Android dialing(1,2) / Google Duo(1) | No |
| CDMA | 850 | VO | Yes | WLAN, BT | CMRS Voice | No |
| | 1900 | | | WLAN, BT | | No |
| | EVDO | VD | Yes | WLAN, BT | Android dialing(1,2) / Google Duo(1) | No |
| LTE (FDD) | Band 2 | VD | Yes | WLAN, BT | VoLTE / Android dialing(1,2) / Google Duo(1) | No |
| | Band 4 | | | WLAN, BT | | No |
| | Band 5 | | | WLAN, BT | | No |
| | Band 7 | | | WLAN, BT | | No |
| | Band 12 | | | WLAN, BT | | No |
| | Band 13 | | | WLAN, BT | | No |
| | Band 17 | | | WLAN, BT | | No |
| | Band 25 | | | WLAN, BT | | No |
| | Band 26 | | | WLAN, BT | | No |
| | Band 30 | | | WLAN, BT | | No |
| | Band 66 | | | WLAN, BT | | No |
| | Band 71 | | | WLAN, BT | | No |
| LTE (TDD) | Band 38 | VD | Yes | WLAN, BT | VoLTE / Android dialing(1,2) / Google Duo(1) | No |
| | Band 41 | | | WLAN, BT | | No |
| | Band 48 | | | WLAN, BT | | No |
| 5G NR (FDD) | n2 | VD | Yes | WLAN, BT | Android dialing(1,2) / Google Duo(1) | No |
| | n5 | | | WLAN, BT | | No |
| | n66 | | | WLAN, BT | | No |
| | n71 | | | WLAN, BT | | No |
| 5G NR (TDD) | n41 | VD | Yes | WLAN, BT | Android dialing(1,2) / Google Duo(1) | No |
| Wi-Fi | 2450 | VD | Yes | GSM,CDMA,WCDMA,LTE or NR | VoWiFi(1) / Android dialing(1,2) / Google Duo(1) | No |
| | 5200 | | | | | No |
| | 5300 | | | | | No |
| | 5500 | | | | | No |
| | 5800 | | | | | No |
| BT | 2450 | DT | No | GSM,CDMA,WCDMA,LTE or NR | NA | No |

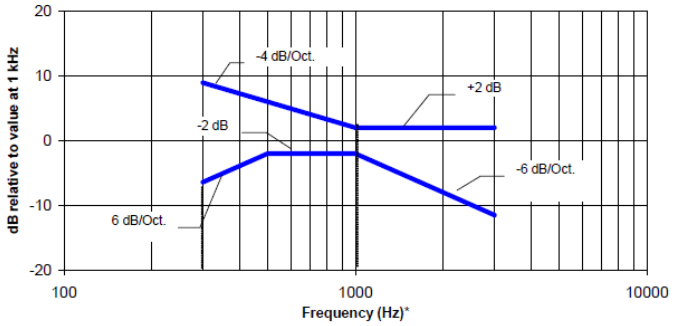
**Type Transport:**
VO= Voice only
DT= Digital Transport only (no voice)
VD= CMRS and IP Voice Service over Digital Transport

**Remark:**
1. For protocols not listed in Table 7.1 of ANSI C63.19-2011 or the ANSI C63.19-2011 VoLTE interpretation, the average speech level of −20 dBm0 should be used.
2. Android SIP calling is an pre-installed feature but does not itself represent a service, to use SIP calling the user has to enter the account/password and the information of the server which actually provides the service. In this report it is demonstrated that both Android SIP calling and Duo are both compliant to FCC HAC technical requirement
3. The device have similar frequency in some LTE bands: LTE B12/17, 5/26, 4/66, 2/25, 38/41, since the supported frequency spans for the smaller LTE bands are completely cover by the larger LTE bands, therefore, only larger LTE bands were required to be tested for hearing-aid compliance.

# 6. Measurement standards for T-Coil

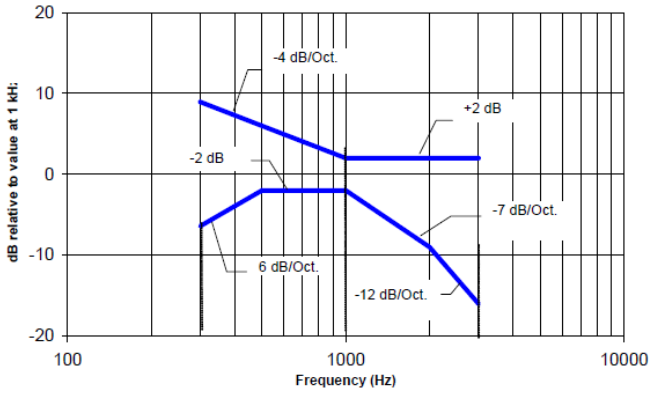
## 6.1 Frequency Response

The frequency response of the perpendicular component of the magnetic field, measured in 1/3 octave bands, shall follow the response curve specified in this sub-clause, over the frequency range 300 Hz to 3000 Hz.
Figure 1.1 and Figure 1.2 provide the boundaries as a function of 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—The frequency response is between 300 Hz and 3000 Hz.

**Fig. 1.1 Magnetic field frequency response for WDs with field strength≤-15dB at 1 KHz**




NOTE—The frequency response is between 300 Hz and 3000 Hz.

**Fig. 1.2 Magnetic field frequency response for WDs with a field that exceeds –15 dB(A/m) at 1 kHz**

## 6.2 T-Coil Signal Quality Categories

This section provides the signal quality requirement for the intended T-Coil signal from a WD. Only the RF immunity of the hearing aid is measured in T-Coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. A device is assessed beginning by determining the category of the RF environment in the area of the T-Coil source.
The RF measurements made for the T-Coil evaluation are used to assign the category T1 through T4. The limitation is given in Table 1. This establishes the RF environment presented by the WD to a hearing aid.

| Category | Telephone parameters WD signal quality ((signal + noise) to noise ratio in dB) |
|---|---|
| Category T1 | 0 to 10 dB |
| Category T2 | 10 to 20 dB |
| Category T3 | 20 to 30 dB |
| Category T4 | > 30 dB |

**Table 1 T-Coil Signal Quality Categories**

# 7. T-Coil Test Procedure

Referenced to ANSI C63.19-2011, Section 7.4,

This section describes the procedures used to measure the ABM (T-Coil) performance of the WD. In addition to measuring the absolute signal levels, the A-weighted magnitude of the unintended signal shall also be determined. To assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal must be made at the same location for each measurement position. In addition, the RF field strength at each measurement location must be at or below that required for the assigned category.

Measurements shall not include undesired properties from the WD's RF field; therefore, use of a coaxial connection to a base station simulator or non-radiating load, there might still be RF leakage from the WD, which can interfere with the desired measurement. Pre-measurement checks should be made to avoid this possibility. All measurements shall be performed with the WD operating on battery power with an appropriate normal speech audio signal input level given in ANSI C63.19-2011 Table 7.1. If the device display can be turned off during a phone call, then that may be done during the measurement as well,

Measurement shall be performed at two locations specified in ANSI C63.19-2011 A.3, with the correct probe orientation for a particular location, in a multistage sequence by first measuring the field intensity of the desired T-Coil signal the same location as the desired ABM or T-Coil signal (ABM1), and the ratio of desired to undesired magnetic components (ABM2) must be measured at the same location as the desired ABM or T-Coil signal (ABM1), and the ratio of desired to undesired ABM signals must be calculated. For the perpendicular field location, only the ABM1 frequency response shall be determined in a third measurement stage.

The following steps summarize the basic test flow for determining ABM1 and ABM2. These steps assume that a sine wave or narrowband 1/3 octave signal can be used for the measurement of ABM1.

a. A validation of the test setup and instrumentation may be performed using a TMFS or Helmholtz coil Measure the emissions and confirm that they are within the specified tolerance.
b. Position the WD in the test setup and connect the WD RF connector to a base station simulator or a non-radiating load. Confirm that equipment that requires calibration has been calibrated, and that the noise level meets the requirements given in ANSI C63.19-2011 clause 7.3.1.
c. The drive level to the WD ise set such that the reference input level specified in ANSI C63.19-2011 Table 7.1 is input to the base station simulator (or manufacturer's test mode equivalent) in 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (ABM1) 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 defined in ANSI C63.19-2011 clause 7.4.2, 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. The same drive level shall be used for the ABM1 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.
d. Determine the magnetic measurement locations for the WD device (A.3), if not already specified by the manufacturer, as described in ANSI C63.19-2011 clause 7.4.4.1.1 and 7.4.4.2.
e. At each measurement location, measure and record the desired T-Coil magnetic signals (ABM1 at fi) as described in ANSI C63.19-2011 clause 7.4.4.2 in each individual ISO 266-1975 R10 standard 1/3 octave band. The desired audio band input frequency (fi) shall be centered in each 1/3 octave band maintaining the same drive level as determined in item c) and the reading taken for that band.
f. 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 probe output, as specified 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.)
g. All Measurements of the desired signal shall be shown to be of the desired signal and not of an undesired signal. This may be shown by turning the desired signal ON and OFF with the probe measuring the same location. If the scanning method is used the scans shall show that all measurement points selected for the ABM1 measurement meet the ambient and test system noise criteria in ANSI C63.19-2011 clause 7.3.1.
h. At the measurement location for each orientation, measure and record the undesired broadband audio magnetic signal (ABM2) as specified in ANSI C63.19-2011 clause 7.4.4.4 with no audio signal applied (or digital zero applied, if appropriate) using A-weighting and the half-band integrator. Calculate the ratio of the desired to undesired signal strength (i,e., signal quality).
i. Obtain the data from the postprocessor, SEMCAD, and determine the category that properly classifies the signal quality based on ANSI C63.19-2011 Table 8.5.

## 7.1 Test Flow Chart

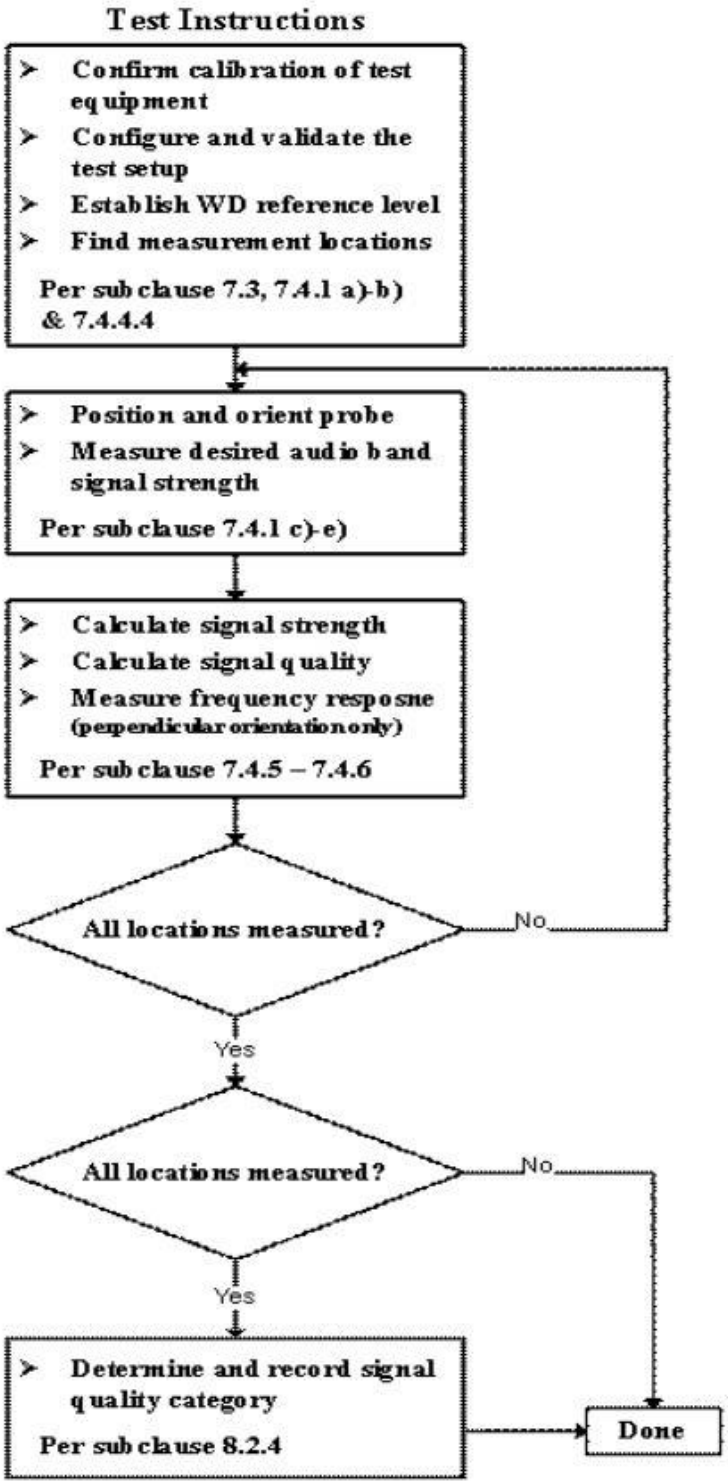
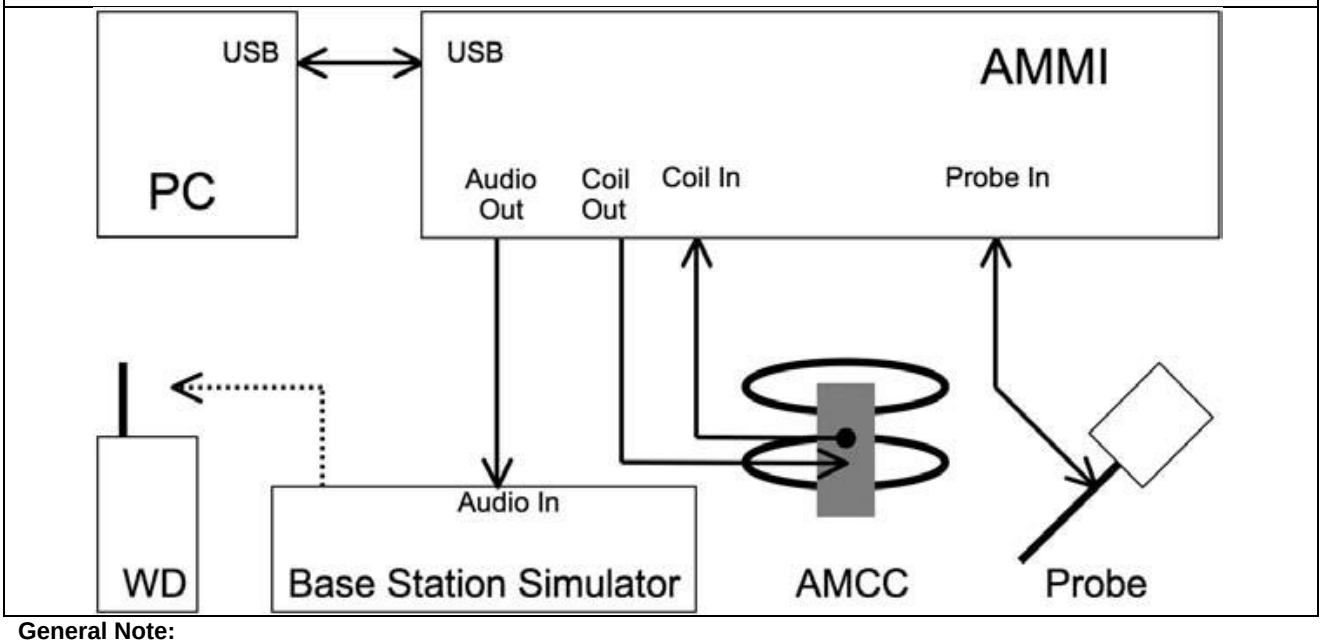



**Fig. 2 T-Coil Signal Test flowchart**

## 7.2 Test Setup Diagram for GSM/UMTS/CDMA/VoLTE

**Test Setup for GSM / CDMA / VoLTE**




**General Note:**

1. Define the all applicable input audio level as below according to C63 and KDB 285076 D02v03:
   - GSM input level: -16dBm0
   - UMTS input level: -16dBm0
   - CDMA input level: -18dBm0
   - VoLTE input level: -16dBm0
2. For GSM / UMTS / CDMA test setup and input level, the correct input level definition is via a communication tester CMU200's "Decoder Cal" and "Codec Cal" with audio option B52 and B85 to set the correct audio input levels.
3. CMU200 is able to output 1kHz audio signal equivalent to 3.14dBm0 at "Decoder Cal." confuguration, the signal reference is used to adjust the AMMI gain setting to reach -16dBm0 for GSM/UMTS and -18dBm0 for CDMA. CMW500 input is calibrated and the relation between the analog input voltage and the internal level in dBm0 can be determined
4. Voice over Long-Term Evolution (VoLTE) is a standard for high-speed wireless communication for mobile phones and data terminals — including IoT devices and wearables. It is based on the IP Multimedia Subsystem (IMS) network, with specific profiles for control and media planes of voice service on LTE defined by GSMA in PRD IR.92. This approach results in the voice service (control and media planes) being delivered as data flows within the LTE data bearer. This means that there is no dependency on the legacy circuit-switched voice network to be maintained
5. The test setup used for VoLTE over IMS is via the callbox of CMW500 for T-coil measurement, The data application unit of the CMW500 was used to simulate the IP multimedia subsystem server. The CMW500 can be manually configured to ensure and control the speech input level result is -16dBm0 for VoLTE when the device during the IMS connection.

**<Define the input level for GSM/UMTS/CDMA>**

1. The Required gain factor for the specific signal shall typically be multiplied by this factor to achieve approx. the same level as for the 1kHz sine signal
2. The below calculation formula is an example and showing how to determine the input level for the device.

The predefined signal types have the following differences / factors compared to the 1kHz sine signal:

| Signal [file name] | Duration [s] | Peak-to-RMS [dB] | RMS [dB] | Required gain factor *) | Gain setting |
|---|---|---|---|---|---|
| 1kHz sine | --- | 3.0 | 0.0 | 1.00 | |
| 48k_1.025kHz_10s.wav | 10 | 3.0 | 0.0 | 1.00 | |
| 48k_1kHz_3.15kHz_10s.wav | 10 | 6.0 | -3.0 | 1.42 | |
| 48k_315Hz_1kHz_10s.wav | 10 | 6.0 | -2.9 | 1.40 | |
| 48k_csek_8k_441_white_10s.wav | 10 | 13.8 | -10.5 | 3.34 | |
| 48k_multisine_50-5000_10s.wav | 10 | 11.1 | -7.9 | 2.49 | |
| 48k_voice_1kHz_1s.wav | 1 | 16.2 | -12.7 | 4.33 | |
| 48k_voice_300-3000_2s.wav | 2 | 21.6 | -18.6 | 8.48 | |

(*) The gain for the specific signal shall typically be multiplied by this factor to acheive approx. the same level as for the 1kHz sine signal.

Insert the gain applicable for your setup in the last column of the table.

**<Example define the input level for GSM/UMTS/CDMA>**

| Gain Value | 20* log(gain) | AMCC Coil In | Level |
|---|---|---|---|
| (linear) | dB | (dBv RMS) | dBm0 |
| | | -2.47 | 3.14 |
| 10 | 20 | -19.85 | -14.24 |
| 8.17 | 18.24 | -21.61 | -16 |

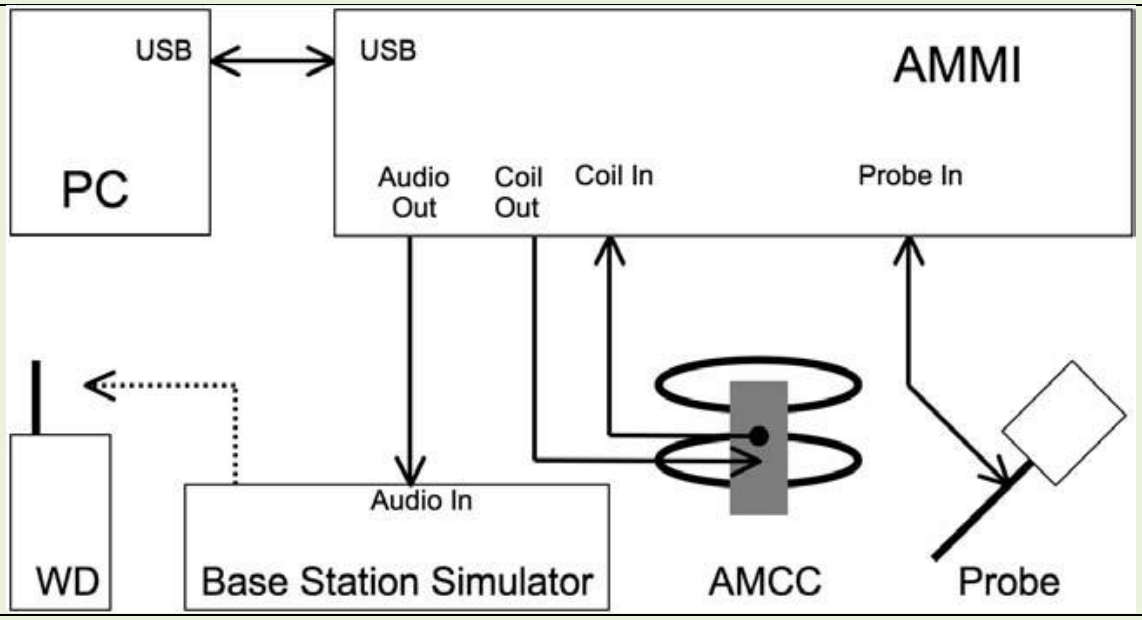
| Signal Type | Duration (s) | Peak to RMS (dB) | RMS (dB) | Required Gain Factor | Calculated Gain Setting |
|---|---|---|---|---|---|
| 1kHz sine | - | 3 | 0 | 1 | 8.17 |
| 48k_voice_1kHz | 1 | 16.2 | -12.7 | 4.33 | 35.36 |
| 48k_voice_300Hz ~ 3kHz | 2 | 21.6 | -18.6 | 8.48 | 69.25 |

**<Example define the input level for VoLTE>**

| Gain Value | dBm0 | Full scal Voltage | dB | AMMI audio out dBv (RMS) | AMCC Coil Out (dBv (RMS) |
|---|---|---|---|---|---|
| | 3.14 | 1.5 | | 0.51 | |
| 100 | 5.61 | | 40 | 2.98 | 3.13 |
| 8.31 | -16 | | 18.39 | | -18.48 |
| **Signal Type** | **Duration (s)** | **Peak to RMS (dB)** | **RMS (dB)** | **Gain Factor** | **Gain Setting** |
| 1kHz sine | - | 3 | 0 | 1 | 8.31 |
| 48k_voice_1kHz | 1 | 16.2 | -12.7 | 4.33 | 35.98 |
| 48k_voice_300-3000 | 2 | 21.6 | -18.6 | 8.48 | 70.46 |

## 7.3 Test Setup Diagram for VoWiFi – PAG reuse

**Test Setup for VoWiFi**




**General Note:**

1. Define the all applicable input audio level as below according to C63 and KDB 285076 D02v03:
   - VoWiFi input level: -20dBm0
2. For Voice over Wi-Fi (VoWiFi) is a term typically employed to describe the delivery of commercial telephony services using Voice over IP (VoIP) technologies from mobile devices connected across Wi-Fi. This is typically counter to alternatives, predominantly Voice over LTE (VoLTE), in which a mobile network operator's (MNO's) licensed spectrum (i.e. 4G LTE) is used to carry packetized voice. Broadly speaking, VoWiFi terminology is assigned to all core IMS services accessed from unlicensed spectrum and across untrusted access infrastructures, such as public Wi-Fi access points
3. The test setup used for VoWiFi over IMS is via the callbox of CMW500 for T-coil measurement, The data application unit of the CMW500 was used to simulate the IP multimedia subsystem server. The CMW500 can be manually configured to ensure and control the speech input level result is -20dBm0 for VoWiFi when the device during the IMS connection.
4. An investigation was perfromed to determine worst case codec, bit rate and air interface configuration refer to section10.2

**<Define the input level for VoWiFi>**

1. The Required gain factor for the specific signal shall typically be multiplied by this factor to achieve approx. the same level as for the 1kHz sine signal
2. The below calculation formula is an example and showing how to determine the input level for the device.

The predefined signal types have the following differences / factors compared to the 1kHz sine signal:

| Signal [file name] | Duration [s] | Peak-to-RMS [dB] | RMS [dB] | Required gain factor *) | Gain setting |
|---|---|---|---|---|---|
| 1kHz sine | --- | 3.0 | 0.0 | 1.00 | |
| 48k_1.025kHz_10s.wav | 10 | 3.0 | 0.0 | 1.00 | |
| 48k_1kHz_3.15kHz_10s.wav | 10 | 6.0 | -3.0 | 1.42 | |
| 48k_315Hz_1kHz_10s.wav | 10 | 6.0 | -2.9 | 1.40 | |
| 48k_csek_8k_441_white_10s.wav | 10 | 13.8 | -10.5 | 3.34 | |
| 48k_multisine_50-5000_10s.wav | 10 | 11.1 | -7.9 | 2.49 | |
| 48k_voice_1kHz_1s.wav | 1 | 16.2 | -12.7 | 4.33 | |
| 48k_voice_300-3000_2s.wav | 2 | 21.6 | -18.6 | 8.48 | |

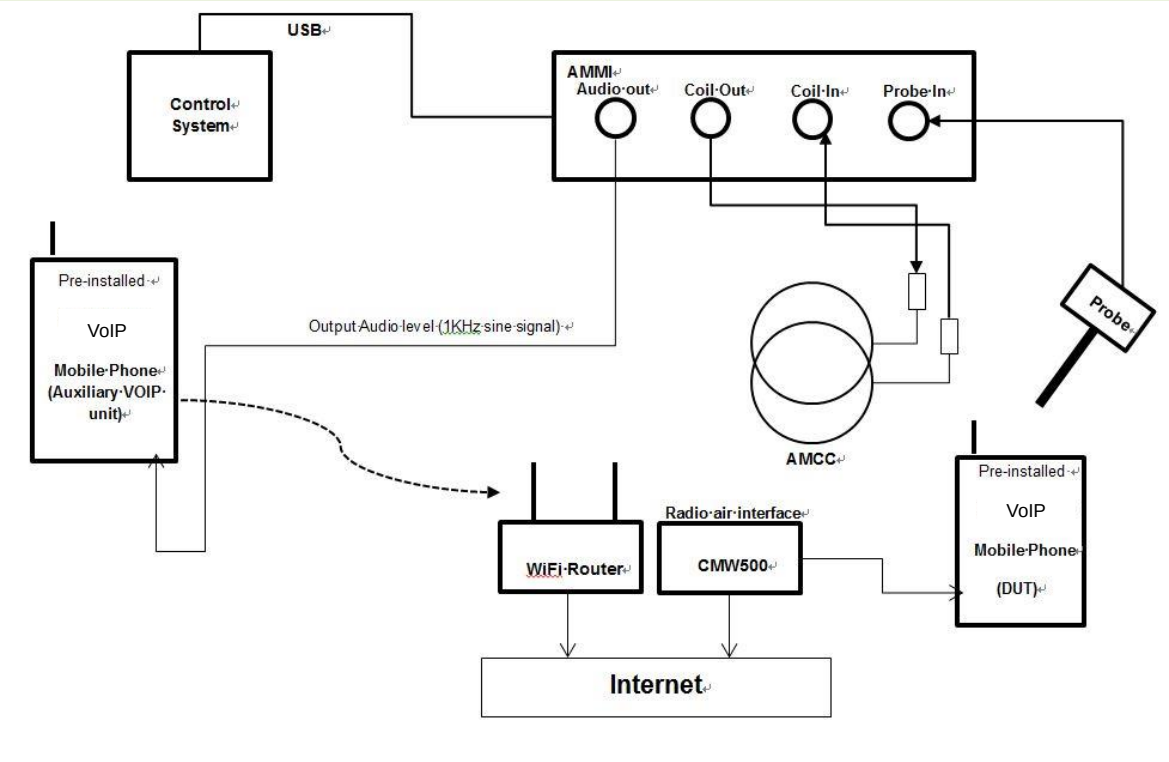
(*) The gain for the specific signal shall typically be multiplied by this factor to acheive approx. the same level as for the 1kHz sine signal.

Insert the gain applicable for your setup in the last column of the table.

| Gain Value | dBm0 | Full scal Voltage | dB | AMMI audio out dBv (RMS) | AMCC Coil Out (dBv (RMS) |
|---|---|---|---|---|---|
| | 3.14 | 1.5 | | 0.51 | |
| 100 | 5.61 | | 40 | 2.98 | 3.13 |
| 5.24 | -20 | | 14.39 | | -22.48 |
| **Signal Type** | **Duration (s)** | **Peak to RMS (dB)** | **RMS (dB)** | **Gain Factor** | **Gain Setting** |
| 1kHz sine | - | 3 | 0 | 1 | 5.24 |
| 48k_voice_1kHz | 1 | 16.2 | -12.7 | 4.33 | 22.70 |
| 48k_voice_300-3000 | 2 | 21.6 | -18.6 | 8.48 | 44.46 |

## 7.4 Test Setup and Diagram for OTT VoIP – PAG reuse

**Test Setup for 3rd party VoIP calling**




**General Note:**

1. Define the all applicable input audio level as below according to C63 and KDB 285076 D02v03:
   - OTT VoIP input Level: -20dBm0
2. Voice over Internet Protocol (VoIP) such as google duo application, also called IP telephony, is a methodology and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. The terms Internet telephony, broadband telephony, and broadband phone service specifically refer to the provisioning of communications services (voice, fax, SMS, voice-messaging) over the public Internet, rather than via the public switched telephone network (PSTN)
3. The Google DUO / android dialing service support code and bitrate are list in section11, the customized Google DUO / android dialing software is installed on a mobile phone which is used as the Auxiliary for the test. The software enables audio coding rate to be changed, and reports the input digital audio level before audio processing which can be used to calibrate the input audio level.
4. This device comes with the preinstalled VoIP application that supports the Google DUO / android dialing service and related codec. The test configuration establishes a call between the device under test and an auxiliary handset via the google DUO / android dialing server
5. The test setup used for Google DUO / android dialing VoIP call is via the data application unit on the CMW, connected to the internet via the google DUO / android dialing serverr to the auxiliary device. The auxiliary device runs special software that allows the codecs and bit rate to be fixed to a specific value. Please refer to section11, an assessment was made of each of the different codec bit rates to determine the worst case for each of the different OTT transport (WiFi, LTE FDD, LTE TDD, GSM, WCDMA)
6. The auxiliary device includes software that displays the audio level in dBFS which allows calibration of the system to establish the -20dBm0 reference level. After establishing the voice call between auxiliary device and device under test the audio output from the AMMI is injected into the auxiliary device. The gain factor to establish a reference level of -20dBm0 for use during the test is determined as detailed in the next page based on the 0dBFull Scale (0dBFS) value being equivalent to 3.14dBm0.

**<Define the input level for OTT VoIP>**

1. The Required gain factor for the specific signal shall typically be multiplied by this factor to achieve approx. the same level as for the 1kHz sine signal
2. The below calculation formula is an example and showing how to determine the input level for the device.
3. Input a gain value to readout the -23dBFS level as reference. (0dBFS = 3.14 dBm0)
4. Adjust gain level until to readout the dBFS level until it changes to -24dBFS.
5. Based on the step 1 and 2, and then calculate the gain value(dB) by interpolation to get the -20dBm0 corresponding gain value.

The predefined signal types have the following differences / factors compared to the 1kHz sine signal:

| Signal [file name] | Duration [s] | Peak-to-RMS [dB] | RMS [dB] | Required gain factor *) | Gain setting |
|---|---|---|---|---|---|
| 1kHz sine | --- | 3.0 | 0.0 | 1.00 | |
| 48k_1.025kHz_10s.wav | 10 | 3.0 | 0.0 | 1.00 | |
| 48k_1kHz_3.15kHz_10s.wav | 10 | 6.0 | -3.0 | 1.42 | |
| 48k_315Hz_1kHz_10s.wav | 10 | 6.0 | -2.9 | 1.40 | |
| 48k_csek_8k_441_white_10s.wav | 10 | 13.8 | -10.5 | 3.34 | |
| 48k_multisine_50-5000_10s.wav | 10 | 11.1 | -7.9 | 2.49 | |
| 48k_voice_1kHz_1s.wav | 1 | 16.2 | -12.7 | 4.33 | |
| 48k_voice_300-3000_2s.wav | 2 | 21.6 | -18.6 | 8.48 | |

(*) The gain for the specific signal shall typically be multiplied by this factor to acheive approx. the same level as for the 1kHz sine signal.

Insert the gain applicable for your setup in the last column of the table.

| Step | Signal type | Audio out | | Target Level | |
|---|---|---|---|---|---|
| | | Gain value | Gain value (dB) | dBFS | dBm0 |
| Step 1 | 1KHz Sine | 7.7 | 17.73 (Ref.) | -23 | |
| Step 2 | 1KHz Sine | 6.8 | 16.65 | -24 | |
| Step 3 | 1KHz Sine | 7.57** | 17.58* | -23.14 | -20 |
| Remark | (*) Based on the step 1 and 2 and then via interpolation to get this value.<br>(**) Gain value=10^Gain value(dB)/20 | | | | |

| Signal type | Duration (s) | Peak to RMS (dB) | RMS (dB) | Gain Factor | Gain value |
|---|---|---|---|---|---|
| 1kHz sine | | 3 | 0 | 1 | 7.57 |
| 48k_voice_1kHz_1s.wav | 1 | 16.2 | -12.7 | 4.33 | 32.77 |
| 48k_voice_300-3000_2s.wav | 2 | 21.6 | -18.6 | 8.48 | 64.79 |

1. According to the gain setting for 1kHz sine wave, determine the gain setting for signals above.
2. The gain for the specific signal is multiplied by this factor to achieve the same level as for the 1kHz sine signal.

## 7.5 Description of EUT Test Position

Fig.3 illustrate the references and reference plane that shall be used in a typical EUT emissions measurement. The principle of this section is applied to EUT with similar geometry. Please refer to Appendix C for the setup photographs.

- The area is 5 cm by 5 cm.
- The area is centered on the audio frequency output transducer of the EUT.
- The area is in a reference plane, which is defined as the planar area that contains the highest point in the area of the phone that normally rests against the user's ear. It is parallel to the centerline of the receiver area of the phone and is defined by the points of the receiver-end of the EUT handset, which, in normal handset use, rest against the ear.
- The measurement plane is parallel to, and 10 mm in front of, the reference plane.

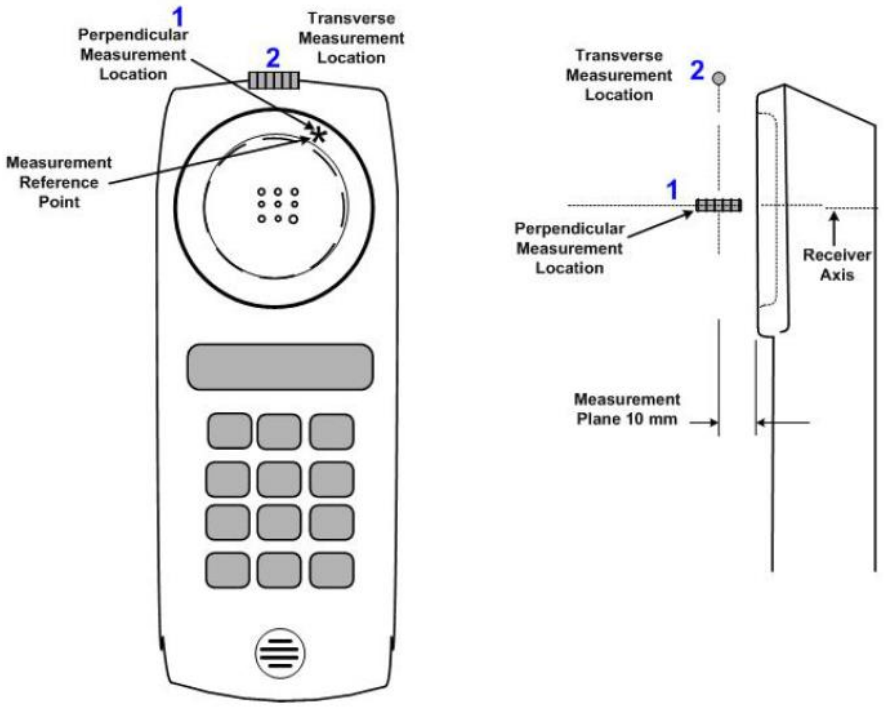



**Fig.3 A typical EUT reference and plane for T-Coil measurements**

# 8. Test Equipment List

| Manufacturer | Name of Equipment | Type/Model | Serial Number | Calibration | |
|---|---|---|---|---|---|
| | | | | Last Cal. | Due Date |
| SPEAG | Audio Magnetic 1D Field Probe | AM1DV3 | 3130 | Nov. 20, 2019 | Nov. 19, 2020 |
| SPEAG | Data Acquisition Electronics | DAE4 | 854 | May. 21, 2019 | May. 20, 2020 |
| SPEAG | Audio Magnetic Calibration Coil | AMCC | 1049 | NCR | NCR |
| SPEAG | Audio Measuring Instrument | AMMI | 1041 | NCR | NCR |
| SPEAG | Test Arch Phantom | N/A | N/A | NCR | NCR |
| SPEAG | Phone Positioner | N/A | N/A | NCR | NCR |
| Testo | Hygro meter | 608-H1 | 45207528 | Nov. 18, 2019 | Nov. 17, 2020 |
| R&S | Base Station | CMW500 | 115793 | Jun. 04, 2019 | Jun. 03, 2020 |
| R&S | Base Station | CMU200 | 117591 | Dec. 09, 2019 | Dec. 08, 2020 |

**Note:**
1. NCR: “No-Calibration Required”

# 9. T-Coil testing for CMRS Voice

**General Note:**

1. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following worst investigation codec would be remarked to be used for the testing for the handset.
2. Air Interface Investigation:
   a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface.
   b. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

## 9.1 GSM Tests Results

### <Codec Investigation>

| GSM Codec | | | | |
|---|---|---|---|---|
| Codec | FR_V1 | HR_V1 | Orientation | Band / Channel |
| ABM 1 (dBA/m) | 7.95 | 9.07 | Axial | GSM850 / 189 |
| ABM 2 (dBA/m) | -22.25 | -24.97 | | |
| Signal Quality (dB) | 30.2 | 34.04 | | |
| Freq. Response | PASS | PASS | | |

Remark: According to codec investigation, the worst codec is FR_V1

### <Air Interface Investigation>

| Plot No. | Air Interface | Mode | Channel | Probe Position | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB | T Rating | Ambient Noise dB (A/m) | Freq. Response Variation dB | Frequency Response |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | GSM850 | Voice | 189 | Axial (Z) | 7.95 | -21.26 | 29.21 | T3 | -50.33 | 1.77 | Pass |
| | | | | Transversal (Y) | -1.12 | -30.68 | 29.56 | T3 | -50.21 | | |
| 2 | GSM1900 | Voice | 661 | Axial (Z) | 8.10 | -27.24 | 35.34 | T4 | -50.34 | 2 | Pass |
| | | | | Transversal (Y) | 0.62 | -36.37 | 36.99 | T4 | -50.25 | | |

## 9.2 UMTS Tests Results

### <Codec Investigation>

| Codec | AMR 4.75Kbps | AMR 7.95Kbps | AMR 12.2Kbps | Orientation | Band / Channel |
|---|---|---|---|---|---|
| ABM 1 (dBA/m) | 8.69 | 8.69 | 11.91 | Axial | Band 5 / 4182 |
| ABM 2 (dBA/m) | -36.24 | -34.2 | -30.15 | | |
| Signal Quality (dB) | 44.93 | 42.89 | 42.06 | | |
| Freq. Response | PASS | PASS | PASS | | |

Remark: According to codec investigation, the worst codec is AMR 12.2Kbps

### <Air Interface Investigation>

| Plot No. | Air Interface | Mode | Channel | Probe Position | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB | T Rating | Ambient Noise dB (A/m) | Freq. Response Variation dB | Frequency Response |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | WCDMA II | Voice | 9400 | Axial (Z) | 7.67 | -34.26 | 41.93 | 7.67 | -34.26 | 2 | Pass |
| | | | | Transversal (Y) | 3.50 | -37.80 | 41.30 | 3.50 | -37.80 | | |
| 4 | WCDMA IV | Voice | 1413 | Axial (Z) | 11.77 | -30.06 | 41.83 | 11.77 | -30.06 | 2 | Pass |
| | | | | Transversal (Y) | 3.80 | -37.88 | 41.68 | 3.80 | -37.88 | | |
| 5 | WCDMA V | Voice | 4182 | Axial (Z) | 11.91 | -30.15 | 42.06 | 11.91 | -30.15 | 2 | Pass |
| | | | | Transversal (Y) | 2.84 | -38.53 | 41.37 | 2.84 | -38.53 | | |

## 9.3 CDMA Tests Results

### <Codec Investigation>

| CDMA Codec | | | | | |
|---|---|---|---|---|---|
| **Codec** | **RC1 SO68** | **RC3 SO68** | **RC4 SO68** | **Orientation** | **Band / Channel** |
| ABM 1 (dBA/m) | 5.35 | 5.97 | 6.55 | Axial | BC0 / 384 |
| ABM 2 (dBA/m) | -39.89 | -39.61 | -38.31 | | |
| Signal Quality (dB) | 45.24 | 45.58 | 44.86 | | |
| Freq. Response | PASS | PASS | PASS | | |

Remark: According to codec investigation, the worst codec is RC4 SO68.

### <Air Interface Investigation>

| Plot No. | Air Interface | Mode | Channel | Probe Position | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB | T Rating | Ambient Noise dB (A/m) | Freq. Response Variation dB | Frequency Response |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | CDMA BC0 | RC3+SO68 Voice codec8K Enhanced low | 384 | Axial (Z) | 6.55 | -38.31 | 44.86 | T4 | -50.35 | 2 | Pass |
| | | | | Transversal (Y) | -2.75 | -44.17 | 41.42 | T4 | -50.22 | | |
| 7 | CDMA BC1 | RC3+SO68 Voice codec8K Enhanced low | 600 | Axial (Z) | 6.35 | -35.98 | 42.33 | T4 | -50.37 | 2 | Pass |
| | | | | Transversal (Y) | -4.94 | -46.70 | 41.76 | T4 | -50.26 | | |
| 8 | CDMA BC10 | RC3+SO68 Voice codec8K Enhanced low | 580 | Axial (Z) | 4.38 | -40.33 | 44.71 | T4 | -5.30 | 1.93 | Pass |
| | | | | Transversal (Y) | -1.57 | -43.44 | 41.87 | T4 | -50.24 | | |

# 10. T-Coil testing for CMRS IP Voice

## 10.1 VoLTE Tests Results

**General Note:**

1. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel / band, the following worst investigation codec would be remarked to be used for the testing for the handset.
2. Air Interface Investigation:
   a. Use the worst-case codec test and document a limited set of bands / channel / bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface and the following worst configure would be remarked to be used for the testing for the handset.
   b. Select LTE FDD / TDD one frequency band to do measurement at the worst SNR position was additionally performed with varying the BWs/Modulations/RB size to verify the variation to find out worst configuration , the observed variation is very little to be within 1.5 dB which is much less than the margin from the rating threshold.
   c. The TDD LTE power class 3 supports uplink-downlink configuration 0 and 6 and power class 2 supports uplink-downlink configuration1 to 5 for this device, an investigation was performed to determine the worst-case uplink-downlink configuration to be used for the testing for the handset.
   d. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

**<Codec Investigation>**

**LTE FDD**

| Codec | NB AMR 4.75Kbps | WB AMR 6.60Kbps | NB AMR 12.2Kbps | WB AMR 23.85Kbps | EVS SWB 9.6Kbps | EVS SWB 128Kbps | EVS WB 5.9Kbps | EVS WB 128Kbps | EVS NB 5.9Kbps | EVS NB 24.4Kbps | Orientation | Band / BW / Channel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABM 1 (dBA/m) | 7.76 | 5.9 | 8.1 | 7.03 | 9.79 | 6.9 | 7.61 | 6.86 | 6.47 | 7.5 | Axial | B25 / 20M / 26340 |
| ABM 2 (dBA/m) | -33.65 | -32.9 | -32.57 | -32.65 | -30.08 | -33.02 | -32.34 | -32.99 | -33.43 | -32.42 | | |
| Signal Quality (dB) | 41.41 | 38.8 | 40.67 | 39.68 | 39.87 | 39.92 | 39.95 | 39.85 | 39.9 | 39.92 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec is WB AMR 6.60Kbps

**LTE TDD**

| Codec | NB AMR 4.75Kbps | WB AMR 6.60Kbps | NB AMR 12.2Kbps | WB AMR 23.85Kbps | EVS SWB 9.6Kbps | EVS SWB 128Kbps | EVS WB 5.9Kbps | EVS WB 128Kbps | EVS NB 5.9Kbps | EVS NB 24.4Kbps | Orientation | Band / BW / Channel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABM 1 (dBA/m) | 6.97 | 5.83 | 8.4 | 8.45 | 8.07 | 7.31 | 7.46 | 6.15 | 6.19 | 8.42 | Axial | B41 / 20M / 40620 |
| ABM 2 (dBA/m) | -33.75 | -32.96 | -32.21 | -31.19 | -31.98 | -32.63 | -32.61 | -33.81 | -33.83 | -31.25 | | |
| Signal Quality (dB) | 40.72 | 38.79 | 40.61 | 39.64 | 40.05 | 39.94 | 40.07 | 39.96 | 40.02 | 39.67 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec is WB AMR 6.60Kbps

## <Air Interface Investigation>

| Air Interface | | BW (MHz) | Modulation | RB Size | RB offset | Channel | UL-DL Configuration | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB |
|---|---|---|---|---|---|---|---|---|---|---|
| FDD | LTE B25 | 20 | QPSK | 1 | 0 | 26340 | - | 5.73 | -32.62 | 38.35 |
| | LTE B25 | 20 | QPSK | 50 | 0 | 26340 | - | 6.21 | -32.77 | 38.98 |
| | LTE B25 | 20 | QPSK | 100 | 0 | 26340 | - | 5.99 | -32.78 | 38.77 |
| | LTE B25 | 20 | 16QAM | 1 | 0 | 26340 | - | 5.81 | -32.76 | 38.57 |
| | LTE B25 | 20 | 64QAM | 1 | 0 | 26340 | - | 6.02 | -32.67 | 38.69 |
| | LTE B25 | 15 | QPSK | 1 | 0 | 26340 | - | 6.19 | -32.70 | 38.89 |
| | LTE B25 | 10 | QPSK | 1 | 0 | 26340 | - | 6.11 | -32.78 | 38.89 |
| | LTE B25 | 5 | QPSK | 1 | 0 | 26340 | - | 5.93 | -32.72 | 38.65 |
| | LTE B25 | 3 | QPSK | 1 | 0 | 26340 | - | 6.43 | -32.81 | 39.24 |
| | LTE B25 | 1.4 | QPSK | 1 | 0 | 26340 | - | 6.19 | -32.89 | 39.08 |
| TDD | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 0 | 5.82 | -31.93 | 37.75 |
| | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 1 | 6.27 | -31.82 | 38.09 |
| | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 2 | 6.26 | -31.77 | 38.03 |
| | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 3 | 6.18 | -32.10 | 38.28 |
| | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 4 | 6.56 | -31.99 | 38.55 |
| | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 5 | 6.37 | -31.80 | 38.17 |
| | LTE B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 6 | 6.20 | -31.84 | 38.04 |
| | UL CA B41_PC3 | 20 | QPSK | 1 | 0 | 40620 | 0 | 6.23 | -31.80 | 38.03 |
| | LTE B41_PC2 | 20 | QPSK | 1 | 0 | 40620 | 1 | 6.24 | -31.69 | 37.93 |
| | LTE B41_PC2 | 20 | QPSK | 1 | 0 | 40620 | 2 | 6.27 | -31.84 | 38.11 |
| | LTE B41_PC2 | 20 | QPSK | 1 | 0 | 40620 | 3 | 6.26 | -32.02 | 38.28 |
| | LTE B41_PC2 | 20 | QPSK | 1 | 0 | 40620 | 4 | 6.31 | -32.01 | 38.32 |
| | LTE B41_PC2 | 20 | QPSK | 1 | 0 | 40620 | 5 | 6.28 | -32.10 | 38.38 |
| | UL CA B41_PC2 | 20 | QPSK | 1 | 0 | 40620 | 1 | 6.44 | -31.85 | 38.29 |

| Plot No. | Air Interface | BW (MHz) | Modulation | RB Size | RB offset | Channel | Probe Position | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB | T Rating | Ambient Noise dB (A/m) | Freq. Response Variation dB | Frequency Response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | LTE Band 7 | 20 | QPSK | 1 | 0 | 21100 | Axial (Z) | 5.85 | -33.30 | 39.15 | T4 | -58.33 | 1.48 | Pass |
| | | | | | | | Transversal (Y) | -1.68 | -40.17 | 38.49 | T4 | -50.26 | | |
| 10 | LTE Band 12 | 10 | QPSK | 1 | 0 | 23095 | Axial (Z) | 5.76 | -33.41 | 39.17 | T4 | -50.31 | 1.79 | Pass |
| | | | | | | | Transversal (Y) | -3.27 | -41.65 | 38.38 | T4 | -50.24 | | |
| 11 | LTE Band 13 | 10 | QPSK | 1 | 0 | 23230 | Axial (Z) | 4.83 | -34.64 | 39.47 | T4 | -50.35 | 1.42 | Pass |
| | | | | | | | Transversal (Y) | -2.48 | -41.10 | 38.62 | T4 | -50.26 | | |
| 12 | LTE Band 25 | 20 | QPSK | 1 | 0 | 26340 | Axial (Z) | 5.90 | -32.90 | 38.80 | T4 | -50.30 | 1.7 | Pass |
| | | | | | | | Transversal (Y) | -0.91 | -45.84 | 44.93 | T4 | -50.21 | | |
| 13 | LTE Band 26 | 15 | QPSK | 1 | 0 | 26865 | Axial (Z) | 5.50 | -33.83 | 39.33 | T4 | -50.32 | 1.96 | Pass |
| | | | | | | | Transversal (Y) | -3.15 | -41.77 | 38.62 | T4 | -50.25 | | |
| 14 | LTE Band 30 | 20 | QPSK | 1 | 0 | 27710 | Axial (Z) | 3.88 | -35.46 | 39.34 | T4 | -50.33 | 1.55 | Pass |
| | | | | | | | Transversal (Y) | -2.56 | -41.13 | 38.57 | T4 | -50.23 | | |
| 15 | LTE Band 66 | 20 | QPSK | 1 | 0 | 132322 | Axial (Z) | 6.15 | -33.21 | 39.36 | T4 | -50.36 | 1.54 | Pass |
| | | | | | | | Transversal (Y) | -1.67 | -40.01 | 38.34 | T4 | -50.21 | | |
| 16 | LTE Band 71 | 20 | QPSK | 1 | 0 | 133322 | Axial (Z) | 4.84 | -34.68 | 39.52 | T4 | -50.34 | 1.87 | Pass |
| | | | | | | | Transversal (Y) | -0.83 | -39.42 | 38.59 | T4 | -50.22 | | |
| 17 | LTE Band 41 | 20 | QPSK | 1 | 0 | 40620 | Axial (Z) | 5.83 | -32.96 | 38.79 | T4 | -50.37 | 1.03 | Pass |
| | | | | | | | Transversal (Y) | -3.32 | -41.69 | 38.37 | T4 | -50.23 | | |
| 18 | LTE Band 48 | 20 | QPSK | 1 | 0 | 55830 | Axial (Z) | 4.16 | -34.14 | 38.30 | T4 | -50.33 | 1.38 | Pass |
| | | | | | | | Transversal (Y) | -2.09 | -39.66 | 37.57 | T4 | -50.26 | | |

## 10.2 VoWiFi Tests Results

**General Note:**

1. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following worst investigation codec would be remarked to be used for the testing for the handset.
2. Air Interface Investigation:
   a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface and the following worst configure would be remarked to be used for the testing for the handset.
   b. Select WLAN 2.4GHz and WLAN 5GHz one frequency band to do measurement at the worst SNR position was additionally performed with varying the BWs/Modulations/data rate to verify the variation to find out worst configuration , the observed variation is very little to be within 1 dB which is much less than the margin from the rating threshold.
   c. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

**<Codec Investigation>**

| Codec | NB AMR 4.75Kbps | WB AMR 6.60Kbps | NB AMR 12.2Kbps | WB AMR 23.85Kbps | EVS SWB 9.6Kbps | EVS SWB 128Kbps | EVS WB 5.9Kbps | EVS WB 128Kbps | EVS NB 5.9Kbps | EVS NB 24.4Kbps | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ABM 1 (dBA/m) | 4.58 | -1.58 | 4.35 | 5 | 1.36 | 1.43 | 1.02 | 1.45 | 3.25 | 2.87 | Axial | 2.4GHz WLAN / 6 |
| ABM 2 (dBA/m) | -34.14 | -38.17 | -33.9 | -32.33 | -36.82 | -36.19 | -32.73 | -36.41 | -34.13 | -38.19 | | |
| Signal Quality (dB) | 38.72 | 36.59 | 38.25 | 37.33 | 38.18 | 37.62 | 33.75 | 37.86 | 37.38 | 41.06 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec is EVS WB 5.9Kbps.9Kbps

## <Air Interface Investigation>

| Frequency Bands | Modulation | Bandwidth | Data Rate | Channel | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB |
|---|---|---|---|---|---|---|---|
| WLAN 2.4GHz | 802.11b | 20 | 1M | 6 | 4.56 | -31.43 | 35.99 |
| | 802.11b | 20 | 11M | 6 | 4.62 | -31.52 | 36.14 |
| | 802.11g | 20 | 6M | 6 | 4.89 | -31.72 | 36.61 |
| | 802.11g | 20 | 54M | 6 | 4.58 | -31.63 | 36.21 |
| | 802.11n-HT20 | 20 | MCS0 | 6 | 4.61 | -31.64 | 36.25 |
| | 802.11n-HT20 | 20 | MCS7 | 6 | 4.71 | -31.55 | 36.26 |
| | 802.11n-HT40 | 40 | MCS0 | 6 | 4.56 | -31.61 | 36.17 |
| | 802.11n-HT40 | 40 | MCS7 | 6 | 4.64 | -31.67 | 36.31 |
| | 802.11ax-HE20 | 20 | MCS0 | 6 | 4.62 | -31.64 | 36.26 |
| | 802.11ax-HE20 | 20 | MCS11 | 6 | 4.54 | -31.63 | 36.17 |
| | 802.11ax-HE40 | 40 | MCS0 | 6 | 4.62 | -31.69 | 36.31 |
| | 802.11ax-HE40 | 40 | MCS11 | 6 | 4.58 | -31.65 | 36.23 |
| WLAN 5GHz | 802.11a | 20 | 6M | 40 | -0.14 | -35.06 | 34.92 |
| | 802.11a | 20 | 54M | 40 | 4.75 | -31.43 | 36.18 |
| | 802.11an-HT20 | 20 | MCS0 | 40 | 4.95 | -31.54 | 36.49 |
| | 802.11an-HT20 | 20 | MCS7 | 40 | 4.58 | -31.37 | 35.95 |
| | 802.11an-HT40 | 40 | MCS0 | 38 | 0.20 | -35.47 | 35.67 |
| | 802.11an-HT40 | 40 | MCS7 | 38 | 0.74 | -34.95 | 35.69 |
| | 802.11ac-VHT20 | 20 | MCS0 | 40 | 3.95 | -35.05 | 39.00 |
| | 802.11ac-VHT20 | 20 | MCS8 | 40 | 4.09 | -35.29 | 39.38 |
| | 802.11ac-VHT40 | 40 | MCS0 | 38 | 0.73 | -35.47 | 36.20 |
| | 802.11ac-VHT40 | 40 | MCS8 | 38 | 0.38 | -35.44 | 35.82 |
| | 802.11ac-VHT80 | 80 | MCS0 | 50 | 4.41 | -31.62 | 36.03 |
| | 802.11ac-VHT80 | 80 | MCS8 | 50 | 3.76 | -35.47 | 39.23 |
| | 802.11ax-HE20 | 20 | MCS0 | 40 | 3.93 | -35.35 | 39.28 |
| | 802.11ax-HE20 | 20 | MCS11 | 40 | 4.13 | -35.32 | 39.45 |
| | 802.11ax-HE40 | 40 | MCS0 | 38 | 0.78 | -35.57 | 36.35 |
| | 802.11ax-HE40 | 40 | MCS11 | 38 | 0.35 | -35.58 | 35.93 |
| | 802.11ax-HE80 | 80 | MCS0 | 50 | 4.46 | -31.46 | 35.92 |
| | 802.11ax-HE80 | 80 | MCS11 | 50 | 3.88 | -35.32 | 39.20 |

| Plot No. | Air Interface | Mode | Channel | Ant Status | Probe Position | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB | T Rating | Ambient Noise dB (A/m) | Freq. Response Variation dB | Frequency Response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | WLAN2.4GHz | 802.11b 1Mbps | 6 | Ant 1+2 | Axial (Z) | 1.85 | -34.74 | 36.59 | T4 | -50.32 | 2 | Pass |
| | | | | | Transversal (Y) | -4.36 | -39.88 | 35.52 | T4 | -50.21 | | |
| 20 | WLAN5GHz | 802.11a 6Mbps | 40 | Ant 1+2 | Axial (Z) | 1.55 | -35.57 | 37.12 | T4 | -50.33 | 1.47 | Pass |
| | | | | | Transversal (Y) | -6.99 | -42.61 | 35.62 | T4 | -50.20 | | |
| 21 | WLAN5GHz | 802.11a 6Mbps | 60 | Ant 1+2 | Axial (Z) | 4.84 | -31.69 | 36.53 | T4 | -50.32 | 1.75 | Pass |
| | | | | | Transversal (Y) | -5.48 | -40.62 | 35.14 | T4 | -50.26 | | |
| 22 | WLAN5GHz | 802.11a 6Mbps | 124 | Ant 1+2 | Axial (Z) | 3.61 | -32.75 | 36.36 | T4 | -50.30 | 1.63 | Pass |
| | | | | | Transversal (Y) | -5.90 | -41.07 | 35.17 | T4 | -50.21 | | |
| 23 | WLAN5GHz | 802.11a 6Mbps | 157 | Ant 1+2 | Axial (Z) | 2.11 | -34.21 | 36.32 | T4 | -50.31 | 1.48 | Pass |
| | | | | | Transversal (Y) | -4.80 | -39.88 | 35.08 | T4 | -50.24 | | |

# 11. T-Coil testing for OTT VoIP Application

**General Notes:**

1. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.
2. The google Duo VoIP application are pre-installed on this device. According to KDB 285076 D02, all air interfaces via a data connection with VoIP application need to be considered HAC testing.
3. The Google Duo only support OPUS audio codec and support 6Kbps to 75Kbps bitrate.
4. The test setup used for OTT VoIP call is the DUT connect to the CMW500 and via the data application unit on CMW500 connection to the Internet, the Auxiliary EUT is connected to the WiFi access point, the channel/Modulation/Frequency bands/data rate is configured on the CMW500 for the DUT unit. For the Auxiliary VoIP unit which is used to configure the audio codec rate and determine the audio input level of -20dBm0 based on the KDB 285076 D02v03 requirement.
5. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following tests results which the worst case codec would be remarked to be used for the testing for the handset.
6. Air Interface Investigation:
   a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface.
   b. Due to OTT service and CMRS IP service are all be established over the internet protocol for the voice service, and on both services use the identical RF air interface for the WIFI and LTE, therefore according to VoLTE and VoWiFi test results of air interface investigation, the worst configuration and frequency band of air interface was used for OTT T-Coil testing.
      -LTE FDD worst configuration and band: LTE Band 66/20MHz/QPSK/1RB Size
      -LTE TDD worst configuration and band: LTE Band 41/20MHz/QPSK/1RB Size
      -WLAN2.4GHz Ant 1+2 worst configuration: 802.11b /1Mbps
      -WLAN5GHz Ant 1+2 worst configuration and Band: WLAN 5.2GHz /11a/6Mbps
7. An investigation was performed to determine the modulation and RB configuration to be used for NR band n2/n5/n66/n71/n41 testing. Due to equipment limitation, the worst-case AMB1 from LTE B66/B41 were used with the AMM2 measured for each NR band n2/n5/n66/n71/n41 modulation and RB configuration.
8. Due to equipment limitation, ABM1 and frequency response measurement were not possible. Therefore, the worst-case ABM1 measurement from LTE FDD/TDD OTT VoIP testing for Axial and Radial were combined with 5G n2/n5/n66/n71/n41 ABM2 measurement to obtain SNNR values.

## <Codec Investigation>

### EDGE

| google Duo | | | | Android dialing | | | | | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Codec | Opus 6kbps | Opus 40kbps | Opus 75kbps | AMR NB 12.2 Kbit/s | GSM 13Kbit/s | GSM_EFR 12.2 Kbit/s | PCMA 64 Kbit/s | PCMU 64 Kbit/s | | |
| ABM 1 (dBA/m) | 5.12 | -3.55 | -3.05 | 6.49 | 5.4 | 6.62 | 5.04 | 5.79 | Axial | GSM850 / 189 |
| ABM 2 (dBA/m) | -34.39 | -37.87 | -36.88 | -27.81 | -28.37 | -27.58 | -28.26 | -28.22 | | |
| Signal Quality (dB) | 39.51 | 34.32 | 33.83 | 34.3 | 33.77 | 34.2 | 33.3 | 34.01 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec bitrate is PCMA 64 Kbit/s.

### HSPA

| google Duo | | | | Android dialing | | | | | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Codec | Opus 6kbps | Opus 40kbps | Opus 75kbps | AMR NB 12.2 Kbit/s | GSM 13Kbit/s | GSM_EFR 12.2 Kbit/s | PCMA 64 Kbit/s | PCMU 64 Kbit/s | | |
| ABM 1 (dBA/m) | 12.4 | 13.11 | 12.72 | 5.35 | 6.27 | 5.16 | 6.39 | 4.79 | Axial | UMTS B5 / 4182 |
| ABM 2 (dBA/m) | -46.89 | -46.44 | -46.28 | -35.19 | -33.56 | -35.8 | -32.84 | -34.67 | | |
| Signal Quality (dB) | 59.29 | 59.55 | 59 | 40.54 | 39.83 | 40.96 | 39.23 | 39.46 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec bitrate is PCMA 64 Kbit/s.

### 1XEVDO Rev A

| google Duo | | | | Android dialing | | | | | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Codec | Opus 6kbps | Opus 40kbps | Opus 75kbps | AMR NB 12.2 Kbit/s | GSM 13Kbit/s | GSM_EFR 12.2 Kbit/s | PCMA 64 Kbit/s | PCMU 64 Kbit/s | | |
| ABM 1 (dBA/m) | 12.33 | 12.06 | 11.96 | 0.21 | 3.34 | 3.73 | 3.12 | 3.12 | Axial | BC0 / 384 |
| ABM 2 (dBA/m) | -45.76 | -46.02 | -45.69 | -40.28 | -34.64 | -35.37 | -34.51 | -34.69 | | |
| Signal Quality (dB) | 58.09 | 58.08 | 57.65 | 40.49 | 37.98 | 39.1 | 37.63 | 37.81 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec bitrate is PCMA 64 Kbit/s.

### LTE FDD

| google Duo | | | | Android dialing | | | | | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Codec | Opus 6kbps | Opus 40kbps | Opus 75kbps | AMR NB 12.2 Kbit/s | GSM 13Kbit/s | GSM_EFR 12.2 Kbit/s | PCMA 64 Kbit/s | PCMU 64 Kbit/s | | |
| ABM 1 (dBA/m) | 7.96 | 7.16 | 8.04 | 3.47 | 2.73 | 3.38 | 3.98 | 4.8 | Axial | B66 / 20M / 132322 |
| ABM 2 (dBA/m) | -47.07 | -47.3 | -45.37 | -34.81 | -34.65 | -34.16 | -31.91 | -32.54 | | |
| Signal Quality (dB) | 55.03 | 54.46 | 53.41 | 38.28 | 37.38 | 37.54 | 35.89 | 37.34 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec bitrate is PCMA 64 Kbit/s.

## LTE TDD

| google Duo | | | | Android dialing | | | | | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Codec | Opus 6kbps | Opus 40kbps | Opus 75kbps | AMR NB 12.2 Kbit/s | GSM 13Kbit/s | GSM_EFR 12.2 Kbit/s | PCMA 64 Kbit/s | PCMU 64 Kbit/s | | |
| ABM 1 (dBA/m) | 7.11 | 6.52 | 11.8 | 3.67 | 3.85 | 3.68 | 4.05 | 3.73 | Axial | B41 / 20M / 40620 |
| ABM 2 (dBA/m) | -46.16 | -46 | -37.63 | -34.62 | -33.59 | -34.61 | -33.12 | -33.5 | | |
| Signal Quality (dB) | 53.27 | 52.52 | 49.43 | 38.29 | 37.44 | 38.29 | 37.17 | 37.23 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec bitrate is PCMA 64 Kbit/s.

## WLAN

| google Duo | | | | Android dialing | | | | | Orientation | Band / Channel |
|---|---|---|---|---|---|---|---|---|---|---|
| Codec | Opus 6kbps | Opus 40kbps | Opus 75kbps | AMR NB 12.2 Kbit/s | GSM 13Kbit/s | GSM_EFR 12.2 Kbit/s | PCMA 64 Kbit/s | PCMU 64 Kbit/s | | |
| ABM 1 (dBA/m) | 11.83 | 12.08 | 11.54 | 3.77 | 3.04 | 4.42 | 3.93 | 5.9 | Axial | WLAN2.4G / 6 |
| ABM 2 (dBA/m) | -44.4 | -43.76 | -44.15 | -35.36 | -34.96 | -34.63 | -33.78 | -32.61 | | |
| Signal Quality (dB) | 56.23 | 55.84 | 55.69 | 39.13 | 38 | 39.05 | 37.71 | 38.51 | | |
| Freq. Response | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | | |

Remark: According to codec investigation, the worst codec bitrate is PCMA 64 Kbit/s.

| Plot No. | Air Interface | Modulation / Mode | Channel | Ant Status | Probe Position | ABM1 dB (A/m) | ABM2 dB (A/m) | Signal Quality dB | T Rating | Ambient Noise dB (A/m) | Freq. Response Variation dB | Frequency Response |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | GSM850 | EDGE 2 Tx slots | 189 | - | Axial (Z) | 5.04 | -28.26 | 33.30 | T4 | -50.34 | 0.68 | Pass |
| | | | | | Transversal (Y) | -1.28 | -36.05 | 34.77 | T4 | -50.21 | | |
| 25 | GSM1900 | EDGE 2 Tx slots | 661 | - | Axial (Z) | 4.67 | -29.60 | 34.27 | T4 | -50.37 | 0.79 | Pass |
| | | | | | Transversal (Y) | -4.97 | -40.01 | 35.04 | T4 | -50.20 | | |
| 26 | WCDMA II | HSPA | 9400 | - | Axial (Z) | 4.86 | -34.51 | 39.37 | T4 | -50.33 | 0.67 | Pass |
| | | | | | Transversal (Y) | -0.57 | -39.20 | 38.63 | T4 | -50.28 | | |
| 27 | WCDMA IV | HSPA | 1413 | - | Axial (Z) | 4.31 | -35.25 | 39.56 | T4 | -50.32 | 0.72 | Pass |
| | | | | | Transversal (Y) | -1.23 | -40.02 | 38.79 | T4 | -50.26 | | |
| 28 | WCDMA V | HSPA | 4182 | - | Axial (Z) | 6.39 | -32.84 | 39.23 | T4 | -50.36 | 0.95 | Pass |
| | | | | | Transversal (Y) | -1.13 | -39.66 | 38.53 | T4 | -50.22 | | |
| 29 | CDMA BC0 | RTAP 153.6Kbps | 384 | - | Axial (Z) | 3.12 | -34.51 | 37.63 | T4 | -50.33 | 0.71 | Pass |
| | | | | | Transversal (Y) | -3.56 | -40.32 | 36.76 | T4 | -50.28 | | |
| 30 | CDMA BC1 | RTAP 153.6Kbps | 600 | - | Axial (Z) | 3.22 | -34.59 | 37.81 | T4 | -50.35 | 0.72 | Pass |
| | | | | | Transversal (Y) | -3.60 | -40.44 | 36.84 | T4 | -50.26 | | |
| 31 | CDMA BC10 | RTAP 153.6Kbps | 580 | - | Axial (Z) | 3.07 | -34.67 | 37.74 | T4 | -50.31 | 0.75 | Pass |
| | | | | | Transversal (Y) | -3.18 | -40.09 | 36.91 | T4 | -50.25 | | |
| 32 | LTE Band 66 | 20M_QPSK_1_0 | 132322 | - | Axial (Z) | 3.98 | -31.91 | 35.89 | T4 | -50.38 | 0.77 | Pass |
| | | | | | Transversal (Y) | -6.36 | -43.16 | 36.80 | T4 | -50.28 | | |
| 33 | LTE Band 41 | 20M_QPSK_1_0 | 40620 | - | Axial (Z) | 4.05 | -33.12 | 37.17 | T4 | -50.35 | 0.73 | Pass |
| | | | | | Transversal (Y) | -4.71 | -40.85 | 36.14 | T4 | -50.24 | | |
| 34 | WLAN2.4GHz | 802.11b 1Mbps | 6 | Ant 1+2 | Axial (Z) | 3.93 | -33.78 | 37.71 | T4 | -50.36 | 0.63 | Pass |
| | | | | | Transversal (Y) | -6.30 | -42.11 | 35.81 | T4 | -50.26 | | |
| 35 | WLAN5GHz | 802.11a 6Mbps | 157 | Ant 1+2 | Axial (Z) | 4.18 | -33.51 | 37.69 | T4 | -50.35 | 0.82 | Pass |
| | | | | | Transversal (Y) | -6.72 | -42.51 | 35.79 | T4 | -50.28 | | |
| | 5G NR n2 | 20M_QPSK_1_1 | 376000 | - | Axial (Z) | 3.98 | -32.90 | 36.88 | T4 | -50.38 | na | na |
| | | | | | Transversal (Y) | -6.36 | -45.84 | 39.48 | T4 | -50.28 | | |
| | 5G NR n5 | 20M _QPSK_1_1 | 1673000 | - | Axial (Z) | 3.98 | -33.83 | 37.81 | T4 | -50.33 | na | na |
| | | | | | Transversal (Y) | -6.36 | -41.77 | 35.41 | T4 | -50.31 | | |
| | 5G NR n66 | 20M _QPSK_1_1 | 349000 | - | Axial (Z) | 3.98 | -33.21 | 37.19 | T4 | -50.52 | na | na |
| | | | | | Transversal (Y) | -6.36 | -40.01 | 33.65 | T4 | -50.18 | | |
| | 5G NR n71 | 20M _QPSK_1_1 | 1361000 | - | Axial (Z) | 3.98 | -34.68 | 38.66 | T4 | -50.28 | na | na |
| | | | | | Transversal (Y) | -6.36 | -39.42 | 33.06 | T4 | -50.19 | | |
| | 5G NR n41 | 100M_QPSK_1_1 | 518598 | - | Axial (Z) | 4.05 | -32.96 | 37.01 | T4 | -50.22 | na | na |
| | | | | | Transversal (Y) | -4.71 | -41.69 | 36.98 | T4 | -50.36 | | |

**Remark:**

1. Phone Condition: Mute on; Backlight off; Max Volume
2. The detail frequency response results please refer to appendix A.
3. Test Engineer：Tom Jiang

## 12. Uncertainty Assessment

The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance. The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual “root-sum-squares” (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances. Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is showed in Table 8.2.
The judgment of conformity in the report is based on the measurement results excluding the measurement uncertainty.

| Error Description | Uncertainty Value (±%) | Probability Distribution | Divisor | Ci (ABM1) | Ci (ABM2) | Standard Uncertainty (ABM1) | Standard Uncertainty (ABM2) |
|---|---|---|---|---|---|---|---|
| Probe Sensitivity | | | | | | | |
| Reference Level | 3.0 | Normal | 1 | 1 | 1 | ± 3.0 % | ± 3.0 % |
| AMCC Geometry | 0.4 | Rectangular | √3 | 1 | 1 | ± 0.2 % | ± 0.2 % |
| AMCC Current | 1.0 | Rectangular | √3 | 1 | 1 | ± 0.6 % | ± 0.6 % |
| Probe Positioning During Calibrate | 0.1 | Rectangular | √3 | 1 | 1 | ± 0.1 % | ± 0.1 % |
| Noise Contribution | 0.7 | Rectangular | √3 | 0.0143 | 1 | ± 0.0 % | ± 0.4 % |
| Frequency Slope | 5.9 | Rectangular | √3 | 0.1 | 1 | ± 0.3 % | ± 3.5 % |
| Probe System | | | | | | | |
| Repeatability / Drift | 1.0 | Rectangular | √3 | 1 | 1 | ± 0.6 % | ± 0.6 % |
| Linearity / Dynamic Range | 0.6 | Rectangular | √3 | 1 | 1 | ± 0.4 % | ± 0.4 % |
| Acoustic Noise | 1.0 | Rectangular | √3 | 0.1 | 1 | ± 0.1 % | ± 0.6 % |
| Probe Angle | 2.3 | Rectangular | √3 | 1 | 1 | ± 1.4 % | ± 1.4 % |
| Spectral Processing | 0.9 | Rectangular | √3 | 1 | 1 | ± 0.5 % | ± 0.5 % |
| Integration Time | 0.6 | Normal | 1 | 1 | 5 | ± 0.6 % | ± 3.0 % |
| Field Disturbation | 0.2 | Rectangular | √3 | 1 | 1 | ± 0.1 % | ± 0.1 % |
| Test Signal | | | | | | | |
| Reference Signal Spectral Response | 0.6 | Rectangular | √3 | 0 | 1 | ± 0.0 % | ± 0.4 % |
| Positioning | | | | | | | |
| Probe Positioning | 1.9 | Rectangular | √3 | 1 | 1 | ± 1.1 % | ± 1.1 % |
| Phantom Thickness | 0.9 | Rectangular | √3 | 1 | 1 | ± 0.5 % | ± 0.5 % |
| EUT Positioning | 1.9 | Rectangular | √3 | 1 | 1 | ± 1.1 % | ± 1.1 % |
| External Contributions | | | | | | | |
| RF Interference | 0.0 | Rectangular | √3 | 1 | 0.3 | ± 0.0 % | ± 0.0 % |
| Test Signal Variation | 2.0 | Rectangular | √3 | 1 | 1 | ± 1.2 % | ± 1.2 % |
| Combined Standard Uncertainty | | | | | | ± 4.1 % | ± 6.1 % |
| Coverage Factor for 95 % | | | | | | K = 2 | |
| Expanded Uncertainty | | | | | | ± 8.1 % | ± 12.3 % |

**Table 8.2 Uncertainty Budget of audio band magnetic measurement**

## 13. References

[1] ANSI C63.19-2011, “American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids”, 27 May 2011.

[2] FCC KDB 285076 D01v05, “Equipment Authorization Guidance for Hearing Aid Compatibility”, Sep 2017

[3] FCC KDB 285076 D02v03, “Guidance for performing T-Coil tests for air interfaces supporting voice over IP (e.g., LTE and WiFi) to support CMRS based telephone services”, Sep 2017

[4] FCC KDB 285076 D03v01, “Hearing aid compatibility frequently asked questions”, Sep 2017

[5] SPEAG DASY System Handbook