HEARING AID COMPATIBILITY T-COIL TEST REPORT

FCC ID	:	IHDT56AP9
Equipment	:	Mobile Cellular Phone
Brand Name	:	Motorola
Model Name	:	XT2451-1, XT2451-2
Test Results	:	PASS
Applicant	:	Motorola Mobility LLC 222 W,Merchandise Mart Plaza, Chicago IL 60654 USA
Manufacturer	:	Motorola Mobility LLC 222 W,Merchandise Mart Plaza, Chicago IL 60654 USA
Standard	:	FCC 47 CFR §20.19 ANSI C63.19-2019
Date Tested	:	Mar. 02, 2024 ~ Mar. 15, 2024

We, Sporton International Inc. (Shenzhen), would like to declare that the tested sample provide by manufacturer and the test data has been evaluated in accordance with the test procedures given in ANSI C63.19-2019 / 47 CFR Part 20.19 and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval of Sporton International Inc. (Shenzhen), the test report shall not be reproduced except in full.

Si Zhang

Approved by: Si Zhang

ilac-MRA ACCREDITED Cert #5145.01

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History of this test report

Report No.	Version	Description	Issued Date
HA420703B	Rev. 01	Initial issue of report	Apr. 15, 2024

1. General Information

Product Feature & Specification	
Applicant Name	Motorola Mobility LLC
Equipment Name	Mobile Cellular Phone
Brand Name	Motorola
Model Name	XT2451-1, XT2451-2
IMEI Code	IMEI 1: 350431590016575 IMEI 2: 350431590016583
FCC ID	IHDT56AP9
HW	DVT2
SW	U3UX34.16
EUT Stage	Identical Prototype
Frequency Band	GSM850: 824 MHz ~ 849 MHz GSM1900: 1850 MHz ~ 1910 MHz WCDMA Band II: 1850 MHz ~ 1910 MHz WCDMA Band IV: 1710 MHz ~ 1755 MHz WCDMA Band V: 824 MHz ~ 849 MHz LTE Band 2: 1850 MHz ~ 1910 MHz LTE Band 4: 1710 MHz ~ 1755 MHz LTE Band 5: 824 MHz ~ 849 MHz LTE Band 7: 2500 MHz ~ 2570 MHz LTE Band 12: 699 MHz ~ 716 MHz LTE Band 13: 777 MHz ~ 787 MHz LTE Band 14: 788 MHz ~ 798 MHz LTE Band 17: 704 MHz ~ 716 MHz LTE Band 25: 1850 MHz ~ 1915 MHz LTE Band 26: 814 MHz ~ 849 MHz LTE Band 30: 2305 MHz ~ 2315 MHz LTE Band 38: 2570 MHz ~ 2620 MHz LTE Band 41: 2496 MHz ~ 2690 MHz LTE Band 48: 3550 MHz ~ 3700 MHz LTE Band 66: 1710 MHz ~ 1780 MHz LTE Band 71: 663 MHz ~ 698 MHz 5G NR n2 : 1850 MHz ~ 1910 MHz 5G NR n5 : 824 MHz ~ 849 MHz 5G NR n7 : 2500 MHz ~ 2570 MHz 5G NR n12 : 699 MHz ~ 716 MHz 5G NR n14 : 788 MHz ~ 798 MHz 5G NR n25 : 1850 MHz ~ 1915 MHz 5G NR n26 : 814 MHz ~ 849 MHz 5G NR n30 : 2305 MHz ~ 2315 MHz 5G NR n38 : 2570 MHz ~ 2620 MHz 5G NR n41 : 2496 MHz ~ 2690 MHz 5G NR n48 : 3550 MHz ~ 3700 MHz 5G NR n66 : 1710 MHz ~ 1780 MHz 5G NR n70 : 1695 MHz ~ 1710 MHz 5G NR n71 : 663 MHz ~ 698 MHz 5G NR n77: 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3980 MHz 5G NR n78: 3450 MHz ~ 3550 MHz, 3700 MHz ~ 3800 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5720 MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz WLAN 6GHz U-NII-5: 5925 MHz ~ 6425 MHz WLAN 6GHz U-NII-6: 6425 MHz ~ 6525 MHz WLAN 6GHz U-NII-7: 6525 MHz ~ 6875 MHz WLAN 6GHz U-NII-8: 6875 MHz ~ 7125 MHz Bluetooth: 2402 MHz ~ 2480 MHz NFC: 13.56 MHz WPT: 115 kHz ~ 145 kHz
Mode	GSM/GPRS/EGPRS RMC/AMR 12.2Kbps HSDPA HSUPA DC-HSDPA HSPA+ (16QAM uplink is not supported)

	LTE: QPSK, 16QAM, 64QAM, 256QAM 5G NR: DFT-s-OFDM/CP-OFDM, Pi/2 BPSK/QPSK/16QAM/64QAM/256QAM WLAN 2.4GHz 802.11b/g/n HT20/HT40 WLAN 2.4GHz 802.11ac VHT20/VHT40 WLAN 2.4GHz 802.11ax HE20/HE40 WLAN 2.4GHz 802.11be EHT20/ EHT40 WLAN 5GHz 802.11a/n HT20/HT40 WLAN 5GHz 802.11ac VHT20/VHT40/VHT80/VHT160 WLAN 5GHz 802.11ax HE20/HE40/HE80/HE160 WLAN 5GHz 802.11be EHT20/EHT40/EHT80/EHT160 WLAN 6GHz 802.11a/ax HE20/HE40/HE80/HE160 WLAN 6GHz 802.11be EHT20/EHT40/EHT80/EHT160/EHT320 Bluetooth BR/EDR/LE NFC: ASK WPT: ASK
Remark: 1. The model names XT2451-1, XT2451-2 are only for different market purpose, and all the others are the same.	

2. Testing Location

Sporton International Inc. (Shenzhen) is accredited to ISO/IEC 17025:2017 by American Association for Laboratory Accreditation with Certificate Number 5145.01.

Testing Laboratory			
Test Firm	Sporton International Inc. (Shenzhen)		
Test Site Location	1/F, 2/F, Bldg 5, Shiling Industrial Zone, Xinwei Village, Xili, Nanshan, Shenzhen, 518055 People's Republic of China TEL: +86-755-86379589 FAX: +86-755-86379595		
Test Site No.	**Sporton Site No.**	**FCC Designation No.**	**FCC Test Firm Registration No.**
	SAR05-SZ	CN1256	421272

3. Applied Standards

- FCC CFR47 Part 20.19
- ANSI C63.19-2019
- FCC KDB 285076 D01 HAC Guidance v06r04
- FCC KDB 285076 D02 T Coil testing v04
- FCC KDB 285076 D03 HAC FAQ v01r06

4. 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	Google Meet[1] google Fi	No
	EDGE1900					
UMTS	Band 2	VO	Yes	WLAN, BT	CMRS Voice	No
	Band 4			WLAN, BT		No
	Band 5			WLAN, BT		No
	HSPA	VD	Yes	WLAN, BT	Google Meet[1] google Fi	No
LTE (FDD)	Band 2	VD	Yes	5G NR, WLAN, BT	VoLTE / Google Meet[1] google Fi	No
	Band 4			5G NR, WLAN, BT		No
	Band 5			5G NR, WLAN, BT		No
	Band 7			5G NR, WLAN, BT		No
	Band 12			5G NR, WLAN, BT		No
	Band 13			5G NR, WLAN, BT		No
	Band 14			5G NR, WLAN, BT		No
	Band 17			5G NR, WLAN, BT		No
	Band 25			5G NR, WLAN, BT		No
	Band 26			5G NR, WLAN, BT		No
	Band 30			5G NR, WLAN, BT		No
	Band 66			5G NR, WLAN, BT		No
	Band 71			5G NR, WLAN, BT		No
LTE (TDD)	Band 38	VD	Yes	5G NR, WLAN, BT	VoLTE / Google Meet[1] google Fi	No
	Band 41			5G NR, WLAN, BT		No
	Band 48			5G NR, WLAN, BT		No
5G NR	n2	VD	Yes	LTE, WLAN, BT	VoNR / Google Meet[1] google Fi	No
	n5			LTE, WLAN, BT		No
	n7			LTE, WLAN, BT		No
	n12			LTE, WLAN, BT		No
	n14			LTE, WLAN, BT		No
	n25			LTE, WLAN, BT		No
	n26			LTE, WLAN, BT		No
	n30			LTE, WLAN, BT		No
	n38			LTE, WLAN, BT		No
	n41			LTE, WLAN, BT		No
	n48			LTE, WLAN, BT		No
	n66			LTE, WLAN, BT		No
	n70			LTE, WLAN, BT		No
	n71			LTE, WLAN, BT		No
	n77			LTE, WLAN, BT		No
	n78			LTE, WLAN, BT		No
Wi-Fi	2450	VD	Yes	GSM, WCDMA, LTE, 5G NR, 5G/6G WLAN, BT	VoWiFi / Google Meet[1] google Fi	No
	5200			GSM, WCDMA, LTE, 5G NR, 2.4G WLAN, BT		No
	5300			GSM, WCDMA, LTE, 5G NR, 2.4G WLAN, BT		No
	5500			GSM, WCDMA, LTE, 5G NR, 2.4G WLAN, BT		No
	5800			GSM, WCDMA, LTE, 5G NR, 2.4G WLAN, BT		No
Wi-Fi	U-NII 5	VD	Yes[3]	GSM, WCDMA, LTE, 5G NR, 2.4G WLAN, BT	VoWiFi / Google Meet[1]	No
	U-NII 6		No[2]			
	U-NII 7					
	U-NII 8					
BT	2450	DT	No	GSM, WCDMA, LTE, 5G NR, 5G/6G WLAN	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 6.1 of ANSI C63.19:2019, the average speech level of −20 dBm0 should be used.
2. The WLAN6GHz U-NII 6/7/8 were above 6GHz and were not evaluated due to outside of the current scope of ANSI C63.19 and FCC HAC regulations.
3. The WLAN6GHz U-NII-5 was evaluated for operations which are entirely below 6 GHz, above 6 GHz were not evaluated due outside of the current scope of ANSI C63.19 and FCC HAC regulations.
4. Because features of Google Meet allow the option of voice-only communications, Meet has been tested for HAC/T-Coil compatibility to ensure the best user experience.
5. The device have similar frequency in some LTE and NR bands: LTE B2/B25, B4/B66, B5/B26, B12/B17, B38/41, 5G NR n25/2, 5G NR n26/5, 5G NR n41/38, since the supported frequency spans for the smaller LTE and NR bands are completely cover by the larger LTE and NR bands, therefore, only larger LTE and NR bands were required to be tested for hearing-aid compliance.
6. The Google Meet and google Fi the audio path, parameter and audio codec are all the same, therefore, the Google Meet is evaluation for this device to show compliance.
7. The device has two work states, flip open and flip close, and that support held-to-the-ear mode in open-side positions of a foldable handset only, so flip open mode was performed HAC/T-Coil testing.

8. This is partial report for CMRS voice T-Coil testing. VOIP test report will be separately submitted.

5. T-Coil coupling mode requirements

5.1 T-Coil coupling qualifying field strengths

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, ≥−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 ≤−38 dB(A/m).

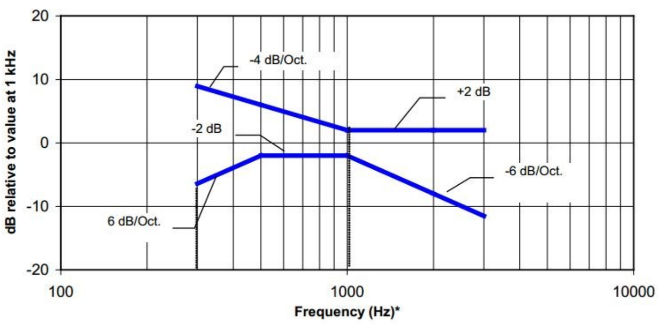
Secondary group: A qualifying measurement point shall have its weighted magnetic noise, undesired ABM field ≤−38 dB(A/m). This group inherently includes all the members of the primary group.

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) 39 at either 1.0 kHz or 1.6 kHz. The hearing aid operational measurements are performed per ANSI S3.22-2014

5.2 Frequency Response

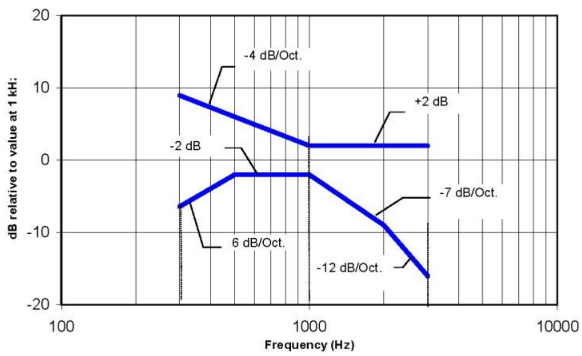
The frequency response of the magnetic field, measured in 1/3 octave bands, shall follow the response curve specified in this subclause, over the frequency range 300 Hz to 3 kHz.

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 ≤−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

5.3 Desired ABM signal, undesired ABM field qualification requirements

<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 requirements of ANSI C63.19-2019 section 6.6.2; 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.

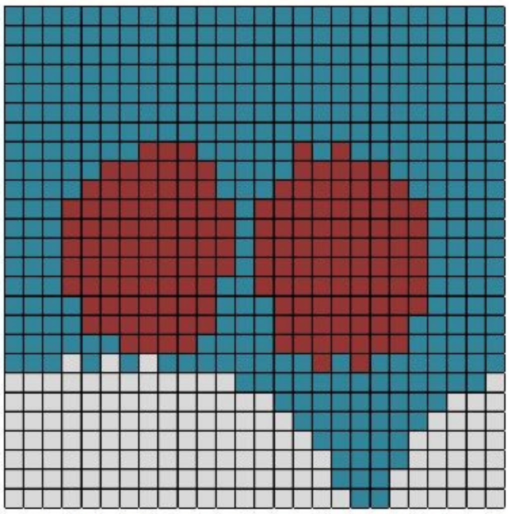
Figure 6.6 is an example of a qualifying scan. The total number of primary group qualifying measurement points is 161 , which is ≥75. The total number of secondary group qualifying points is 536, which is ≥300

The secondary group has a longitudinal column of 26, which is ≥10, and a transverse row also of 26 contiguous points, which is ≥15

<2G GSM operating modes>

If the 2G GSM operating mode(s) are selected for qualification, the qualifying measurement points shall fulfil the requirements of ANSI C63.19-2019 section 6.6.2; both the primary and secondary group requirements shall be met:

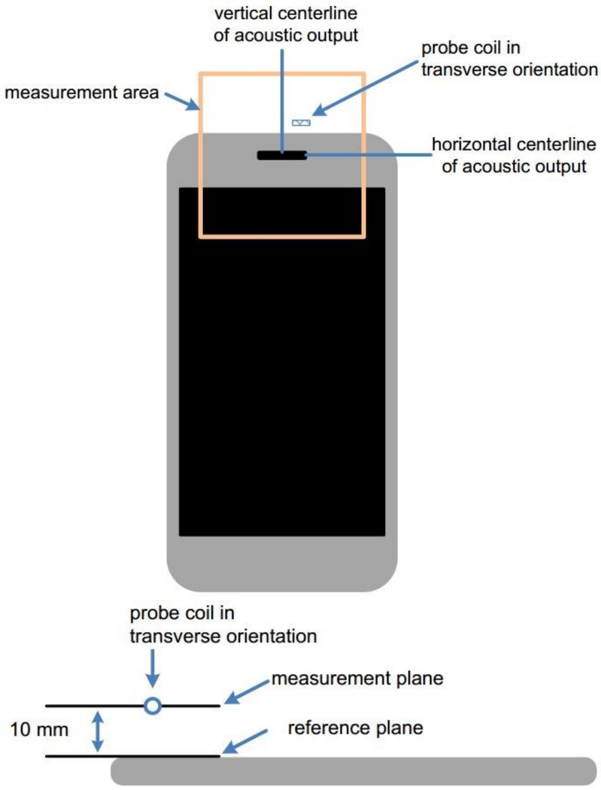
- The primary group shall include at least 25 measurement points
- The secondary group shall include at least 125 contiguous measurement points



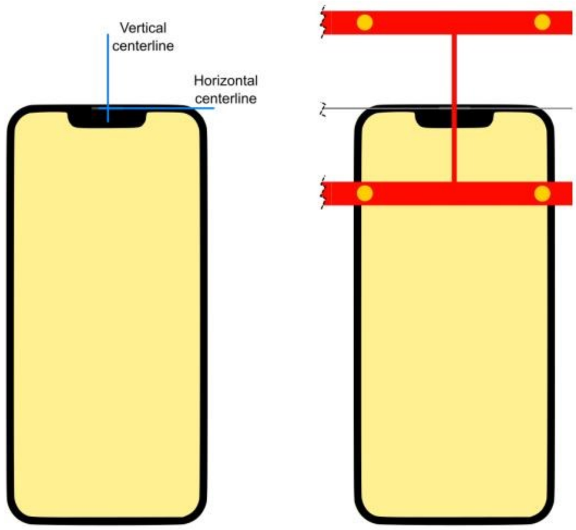
Red (primary group): AB desired ABM signal M1 ≥−18 dB(A/m) and undesired ABM field ≤−38 dB(A/m)
Blue and red (secondary group): undesired ABM field ≤−38 dB(A/m)

Figure 6.6—An example of a qualifying desired ABM signal, undesired ABM field scan:

5.4 T-Coil measurement and reference plane



Measurement and reference planes probe orientation for WD audio frequency magnetic field measurements



Device Under Test Positioning under the Test Arch

The T-Coil measurement plane, reference plane and other measurement parameters shall be:

a. The reference plane is 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 WD handset, which, in normal handset use, rest against the ear.
b. The measurement plane is parallel to, and 1 0 mm in front of, the reference plane.
c. The reference axis is normal to the reference plane and passes through the center of the acoustic output (or the center of the hole array); or may be centered on or near a secondary inductive source. The actual location of the reference axis and resultant measurement area shall be noted in the test report.
d. The measurement area shall be 50 mm by 50 mm. The measurement area for both desired ABM signal and undesired ABM field may be located where the transverse magnetic measurements are optimum with regard to the requirements. However, the measurement area should be in the vicinity of the acoustic output of the WD and shall be located in the same half of the phone as the WD receiver. In a WD handset with a centered receiver and a circularly symmetrical magnetic field, the measurement axis and the reference axis would coincide.
e. Measurements of desired ABM signal strength and undesired ABM field are made at 2.0 mm ± 0.5 mm or 4 mm intervals in an X-Y measurement area pattern over the entire measurement area (676 measurement points total); either all measured, or measured plus interpolated, per ANSI C63.19-2019 section 6.4
f. Desired ABM signal frequency response is measured at a single location at or near the maximum
g. desired ABM signal strength location.
h. The actual locations of the measurement points shall be noted in the test report.

6. Test procedure for T-Coil signal

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 ANSI C63.19-2019 A.3. The measurement area shall be scanned with a uniform measurement point spacing of 2.0 mm ± 0.5 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 ANSI C63.19-2019 D.4 through D.6

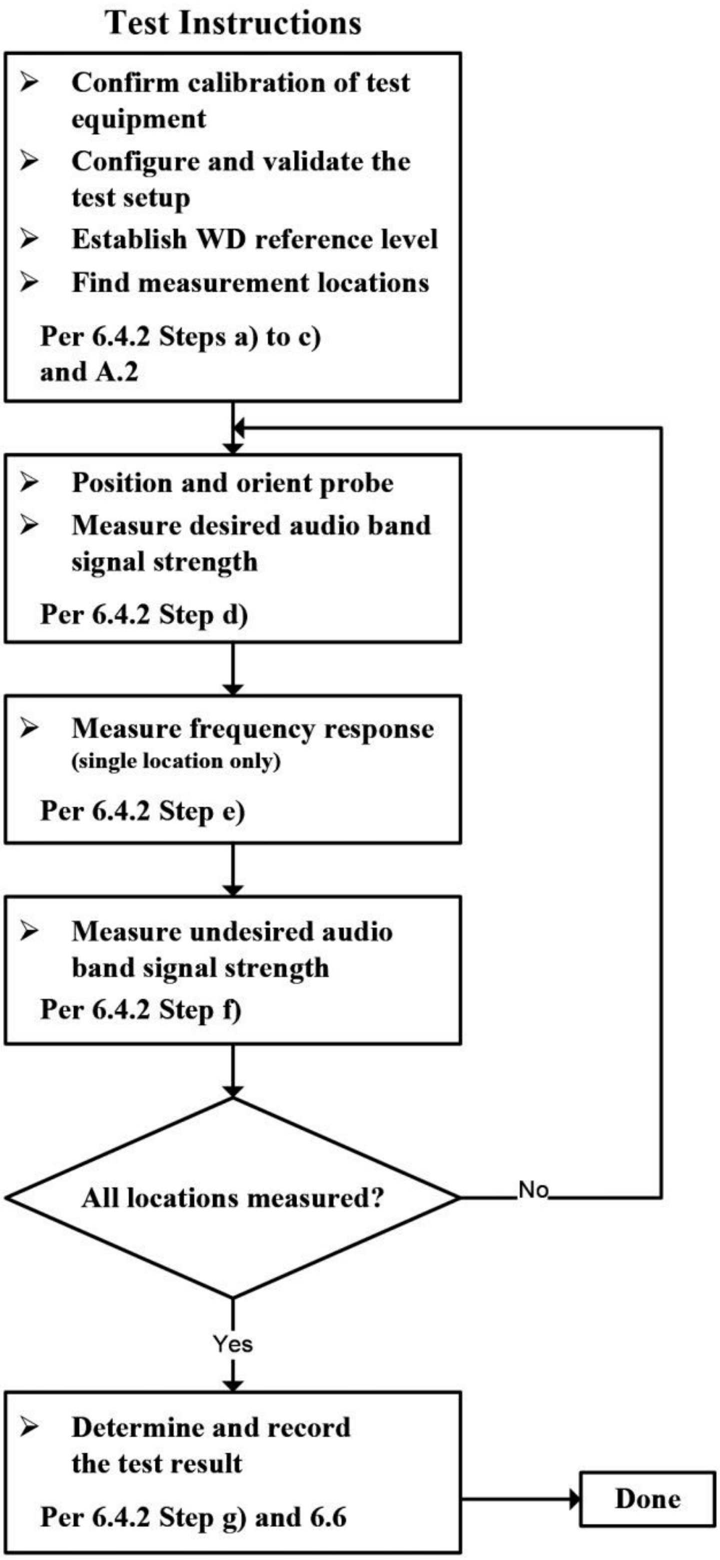
In order to assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal shall be made at the same locations. Measurements shall not include undesired influence from the WD's RF field; therefore, use of a coaxial connection to 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 ANSI C63.19-2019 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 ANSI C63.19-2019 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 ANSI C63.19-2019 Figure 6.3 illustrates this three-stage process.

To minimize the need to test every WD operating mode to the telecoil requirements of ANSI C63.19-2019 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 ANSI C63.19-2019 section 6.4. 34 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 ANSI C63.19-2019 section 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

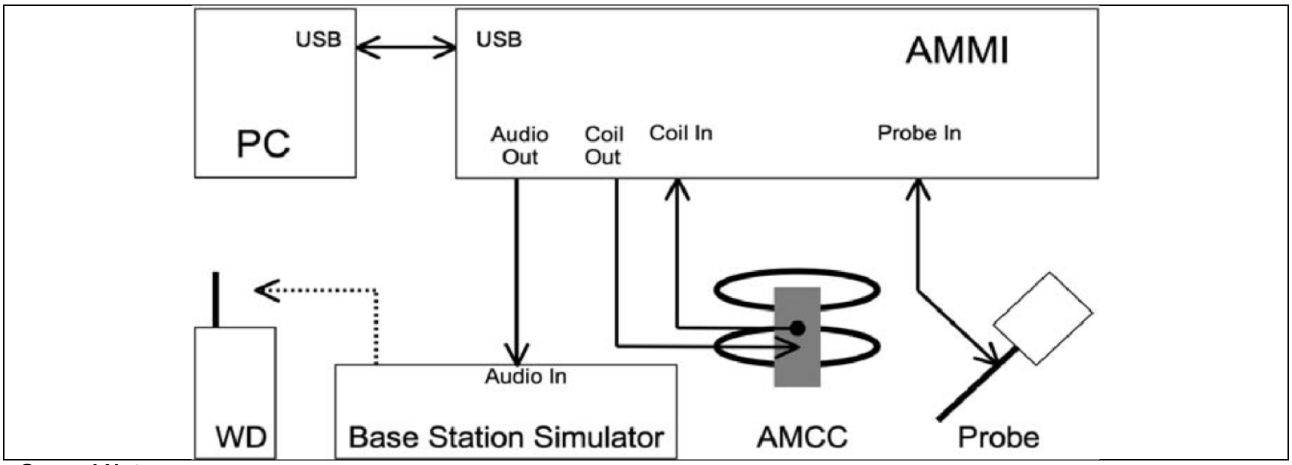
Test flow for T-Coil signal test



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 ABM signal level. An alternative procedure, yielding equivalent results, using a broadband excitation is described in ANSI C63.19-2019 section 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 ANSI C63.19-2019 section 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 section 6.1 or section 6.2.
d. The drive level to the WD is set such that the reference input level specified in ANSI C63.19-2019 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. 35 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 fi) as described in ANSI C63.19-2019 section 6.4.5.2 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 Step c), and the reading taken for that band. 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 ANSI C63.19-2019 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 ANSI C63.19-2019 section 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 ANSI C63.19-2019 section 6.6.2. Compare this to the requirements in ANSI C63.19-2019 section 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 ANSI C63.19-2019 section 6.6.4.

Test Setup Diagram for GSM /UMTS/VoLTE/VoWiFi/VoNR



General Note:

1. Define the all applicable input audio level as below according to ANSI C63.19-2019 table 6.1:
   - GSM input level: -16dBm0
   - UMTS input level: -16dBm0
   - VoLTE input level: -16dBm0
   - VoNR input level: -16dBm0
   - VoWiFi input level: -16dBm0
2. The test setup used for GSM /UMTS is via the callbox of CMW500 for T-coil measurement. The CMW500 input is calibrated and the relation between the analog input voltage and the internal level in dBm0 can be determined. The CMW500 can be manually configured to control the speech input level and ensure that the result is -16dBm0 for GSM/UMTS CMRS Voice connection.
3. 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.
4. The test setup used for VoLTE and VoWiFI over IMS is via the callbox of CMW500 for T-coil measurement. The data application unit of the CMW500 is used to simulate the IP multimedia subsystem server. The CMW500 can be manually configured to control the speech input level and ensure that the result is -16dBm0 for VoLTE, and VoWiFi during the IMS connection.
5. The test setup used for VoNR over IMS is via the callbox of CMX500 for T-coil measurement, The data application unit of the CMX500 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 VoNR when the device during the IMS connection.
6. According to KDB 285076 D02, T-Coil testing for VoLTE, VoNR and VoWiFi requires test instrumentation that can (1) for the system to be able to establish an IP call from/to the handset under test, (2) through an IMS (IP Multimedia Subsystem) and SIP/IP server, (3) to an analog audio adapter containing the permissible set of codecs used by the device under test, and (4) inject the necessary C63.19 test tones at the average speech level for the measurement The test setup is illustrated above Figure. The R&S CMW500 and CMX500 was used as system simulator for VoLTE, VoNR and VoWiFi T-Coil testing. The DAU (Data Application Unit) in CMW500, CMX500 integrates IMS and SIP/IP server that can establish VoLTE, VoNR and Wi-Fi calling, and transport the test tones from AMMI (Audio Magnetic Measuring Instrument) to EUT.

<Example define the input level for GSM /UMTS/VoLTE/VoNR/VoWiFi>

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. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	Audio Magnetic 1D Field Probe	AM1DV3	3106	2023/12/13	2024/12/12
SPEAG	Data Acquisition Electronics	DAE4	1664	2023/6/6	2024/6/5
SPEAG	Audio Magnetic Calibration Coil	AMCC	1128	NCR	NCR
SPEAG	Audio Measuring Instrument	AMMI	1137	NCR	NCR
Anymetre	Thermo-Hygrometer	JR593	2020062101	2023/7/8	2024/7/7
R&S	Wideband Radio Communication Tester	CMW500	157651	2023/12/28	2024/12/27
R&S	Wideband Radio Communication Tester	CMX500	101931	2023/9/12	2024/9/11
SPEAG	Test Arch Phantom	N/A	N/A	NCR	NCR
SPEAG	Phone Positioner	N/A	N/A	NCR	NCR

Note:

1. NCR: “No-Calibration Required”

8. 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 (Primary Group, Secondary Group, longitudinal contiguous points, transverse row contiguous points, 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. Through Internal radio configuration investigation (e.g. bandwidth, modulation data rate, subcarrier spacings, and resource blocks) that the worst radio configuration was document as below table.
   b. Use the worst-case codec test and document a limited set of bands/channel/bandwidths.
   c. According to the ANSI C63.19-2019 section 6.3.3, using a frequency near the center of the frequency band perform T-coil evaluation.

8.1 GSM Evaluation Results

<Codec Investigation>

GSM Codec							
Codec	AMR NB Full Rate	AMR NB Full Rate	AMR WB Full Rate	AMR WB Full Rate	EFR NB (FR V2)	Orientation	Band / Channel
Bit rate	4.75 Kbps	12.2 Kbps	6.6 Kbps	12.65 Kbps	12.2Kbps		
Primary Group Contiguous Point Count	94	96	99	92	97	Transversal (Y)	GSM850 / 189
Secondary Group Contiguous Point Count	338	335	342	331	335		
Secondary Group Max Longitudinal	15	16	17	16	16		
Secondary Group Max Transverse	26	26	26	26	26		
Frequency Response	0.8	1.01	2	2	0.98		

Remark: According to codec investigation, the worst codec is AMR WB Full Rate12.65 Kbps.

<Air Interface Investigation>

Plot No.	Air Interface	Modulation / Mode	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response Margin [dB]	Ambient Noise dB (A/m)
1	GSM850	Voice	189	Transversal (Y)	92	331	16	26	2	-48.77
2	GSM1900	Voice	661	Transversal (Y)	147	363	18	26	2	-48.64

8.2 UMTS Evaluation Results

<Codec Investigation>

UMTS AMR Codec						
Codec	NB AMR 4.75Kbps	WB AMR 6.60Kbps	NB AMR 12.2Kbps	WB AMR 23.85Kbps	Orientation	Band / BW / Channel
Primary Group Contiguous Point Count	244	230	319	287	Transversal (Y)	B2 / 9400
Secondary Group Contiguous Point Count	469	461	541	511		
Secondary Group Max Longitudinal	21	21	23	24		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	1.54	2	1.87	2		

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

<Air Interface Investigation>

Plot No.	Air Interface	Modulation / Mode	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response Margin [dB]	Ambient Noise dB (A/m)
3	WCDMA II	Voice	9400	Transversal (Y)	230	461	21	26	2	-48.73
4	WCDMA IV	Voice	1413	Transversal (Y)	292	528	25	26	2	-49.55
5	WCDMA V	Voice	4182	Transversal (Y)	168	374	20	26	2	-49.22

8.3 VoLTE Evaluation Results

<Codec Investigation>

LTE FDD

VoLTE AMR Codec						
Codec	**NB AMR 4.75Kbps**	**WB AMR 6.60Kbps**	**NB AMR 12.2Kbps**	**WB AMR 23.85Kbps**	**Orientation**	**Band / BW / Channel**
Primary Group Contiguous Point Count	123	133	126	168	Transversal (Y)	B25 / 20M / 26340
Secondary Group Contiguous Point Count	372	388	375	431		
Secondary Group Max Longitudinal	18	18	18	21		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	0.78	1.22	1.05	2		

VoLTE EVS Codec								
Codec	**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**
Primary Group Contiguous Point Count	148	135	122	125	140	133	Transversal (Y)	B25 / 20M / 26340
Secondary Group Contiguous Point Count	389	365	368	371	422	385		
Secondary Group Max Longitudinal	18	18	18	18	19	19		
Secondary Group Max Transverse	26	26	26	26	26	26		
Frequency Response	0.97	2	2	1.8	1.73	1.58		

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

LTE TDD

VoLTE AMR Codec						
Codec	NB AMR 4.75Kbps	WB AMR 6.60Kbps	NB AMR 12.2Kbps	WB AMR 23.85Kbps	Orientation	Band / BW / Channel
Primary Group Contiguous Point Count	154	151	149	147	Transversal (Y)	B41 / 20M / 40620
Secondary Group Contiguous Point Count	366	364	363	362		
Secondary Group Max Longitudinal	18	17	18	17		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	1.41	1.93	1.81	1.71		

VoLTE EVS Codec								
Codec	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
Primary Group Contiguous Point Count	149	154	148	156	131	145	Transversal (Y)	B41 / 20M / 40620
Secondary Group Contiguous Point Count	359	365	356	363	336	358		
Secondary Group Max Longitudinal	18	18	17	17	16	17		
Secondary Group Max Transverse	26	26	26	26	26	26		
Frequency Response	1.47	1.39	1.17	1.51	1.96	1.84		

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

<Air Interface Investigation>

Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	UL-DL Configuration	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response
LTE B41_PC3	20	QPSK	1	0	40620	0	Transversal (Y)	131	336	16	26	Pass
LTE B41_PC3	20	QPSK	100	0	40620	0	Transversal (Y)	141	312	17	26	Pass
LTE B41_PC3	20	16QAM	1	0	40620	0	Transversal (Y)	138	341	17	26	Pass
LTE B41_PC3	20	64QAM	1	0	40620	0	Transversal (Y)	148	332	17	26	Pass
LTE B41_PC3	20	256QAM	1	0	40620	0	Transversal (Y)	156	351	18	26	Pass
LTE B41_PC3	5	QPSK	1	0	40620	0	Transversal (Y)	135	345	17	26	Pass
UL CA B41_PC3	20	QPSK	1	0	40620	0	Transversal (Y)	139	358	17	26	Pass
LTE B41_PC2	20	QPSK	1	0	40620	1	Transversal (Y)	139	341	17	26	Pass
LTE B25	1.4	QPSK	1	0	26340	1	Transversal (Y)	154	365	18	26	Pass

Plot No.	Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response Margin [dB]	Ambient Noise dB (A/m)
6	LTE Band 7	20M	QPSK	1	0	21100	Transversal (Y)	152	362	18	26	1.76	-48.93
7	LTE Band 12	10M	QPSK	1	0	23095	Transversal (Y)	184	394	19	26	1.32	-49.26
8	LTE Band 13	10M	QPSK	1	0	23230	Transversal (Y)	135	342	18	26	1.26	-48.02
9	LTE Band 14	10M	QPSK	1	0	23330	Transversal (Y)	194	408	20	26	1.77	-48.99
10	LTE Band 25	20M	QPSK	1	0	26340	Transversal (Y)	122	368	18	26	2	-48.77
11	LTE Band 26	15M	QPSK	1	0	26865	Transversal (Y)	137	370	18	26	0.8	-48.36
12	LTE Band 30	10M	QPSK	1	0	27710	Transversal (Y)	142	351	18	26	1.73	-48.18
13	LTE Band 66	20M	QPSK	1	0	132322	Transversal (Y)	156	367	18	26	1.31	-48.51
14	LTE Band 71	20M	QPSK	1	0	133297	Transversal (Y)	122	359	18	26	0.23	-48.39
15	LTE Band 41	20M	QPSK	1	0	40620	Transversal (Y)	131	336	16	26	1.96	-48.59
16	LTE Band 48	20M	QPSK	1	0	55830	Transversal (Y)	117	311	17	26	1.38	-48.79

8.4 VoNR Evaluation Results

<Codec Investigation>

5G NR FDD

VoNR AMR Codec						
Codec	**NB AMR 4.75Kbps**	**WB AMR 6.60Kbps**	**NB AMR 12.2Kbps**	**WB AMR 23.85Kbps**	**Orientation**	**Band / BW / Channel**
Primary Group Contiguous Point Count	163	168	166	170	Transversal (Y)	n25 / 40M / 376500
Secondary Group Contiguous Point Count	391	401	389	395		
Secondary Group Max Longitudinal	18	19	18	20		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	1.64	2	2	2		

VoNR EVS Codec								
Codec	**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**
Primary Group Contiguous Point Count	138	135	100	128	103	135	Transversal (Y)	n25 / 40M / 376500
Secondary Group Contiguous Point Count	390	401	349	330	348	338		
Secondary Group Max Longitudinal	19	18	18	17	17	18		
Secondary Group Max Transverse	26	26	26	26	26	26		
Frequency Response	1.92	1.89	1.63	2	2	1.43		

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

5G NR TDD

VoNR AMR Codec						
Codec	**NB AMR 4.75Kbps**	**WB AMR 6.60Kbps**	**NB AMR 12.2Kbps**	**WB AMR 23.85Kbps**	**Orientation**	**Band / BW / Channel**
Primary Group Contiguous Point Count	113	118	106	124	Transversal (Y)	n41 / 100M / 518598
Secondary Group Contiguous Point Count	329	340	316	340		
Secondary Group Max Longitudinal	14	14	14	14		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	0.96	2	2	2		

VoNR EVS Codec								
Codec	**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**
Primary Group Contiguous Point Count	114	106	89	121	83	155	Transversal (Y)	n41 / 100M / 518598
Secondary Group Contiguous Point Count	361	343	356	332	364	362		
Secondary Group Max Longitudinal	18	15	17	14	18	18		
Secondary Group Max Transverse	26	26	26	26	26	26		
Frequency Response	1.38	1.18	2	2	1	1.46		

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

<Air Interface Investigation>

Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response
5G NR B41 PC3	100	DFT-PI/2 BPSK	1	1	518598	Transversal (Y)	86	360	19	26	Pass
5G NR B41 PC3	100	DFT-PI/2 BPSK	270	0	518598	Transversal (Y)	102	385	19	26	Pass
5G NR B41 PC3	100	DFT-QPSK	1	1	518598	Transversal (Y)	83	383	18	26	Pass
5G NR B41 PC3	100	DFT-16QAM	1	1	518598	Transversal (Y)	96	383	18	26	Pass
5G NR B41 PC3	100	DFT-64QAM	1	1	518598	Transversal (Y)	92	383	18	26	Pass
5G NR B41 PC3	100	DFT-256QAM	1	1	518598	Transversal (Y)	90	384	19	26	Pass
5G NR B41 PC3	100	CP-QPSK	1	1	518598	Transversal (Y)	93	379	18	26	Pass
5G NR B41 PC3	10	DFT-QPSK	1	1	518598	Transversal (Y)	139	429	20	26	Pass
5G NR B41 PC2	100	DFT-QPSK	1	1	518598	Transversal (Y)	87	378	18	26	Pass
5G NR B41 PC1.5 UL-MIMO	100	DFT-QPSK	1	1	518598	Transversal (Y)	89	377	18	26	Pass
5G NR B7	40	DFT-QPSK	1	1	507000	Transversal (Y)	118	393	19	26	Pass
5G NR B7	5	DFT-QPSK	1	1	507000	Transversal (Y)	133	402	20	26	Pass

Plot No.	Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response Margin [dB]	Ambient Noise dB (A/m)
17	FR1 n7	40M	QPSK	1	1	507000	Transversal (Y)	110	346	18	26	1.64	-49.05
18	FR1 n12	15M	QPSK	1	1	141500	Transversal (Y)	133	368	18	26	1.8	-49.24
19	FR1 n14	10M	QPSK	1	1	158600	Transversal (Y)	125	365	20	26	2	-48.03
20	FR1 n25	40M	QPSK	1	1	376500	Transversal (Y)	100	349	18	26	1.63	-48.64
21	FR1 n26	20M	QPSK	1	1	166300	Transversal (Y)	131	376	21	26	1.93	-48.73
22	FR1 n30	10M	QPSK	1	1	462000	Transversal (Y)	108	351	19	26	1.53	-49.35
23	FR1 n66	40M	QPSK	1	1	349000	Transversal (Y)	100	338	18	26	1.14	-48.7
24	FR1 n70	15M	QPSK	1	1	340500	Transversal (Y)	113	355	20	26	1.67	-48.13
25	FR1 n71	20M	QPSK	1	1	136100	Transversal (Y)	100	343	17	26	1.3	-49.04
26	FR1 n41	100M	QPSK	1	1	518598	Transversal (Y)	83	364	18	26	0.48	-48.11
27	FR1 n48	40M	QPSK	1	1	641666	Transversal (Y)	112	376	19	26	0.4	-48.88
28	FR1 n77	100M	QPSK	1	1	656000	Transversal (Y)	81	340	17	26	1.02	-49.81
29	FR1 n78	100M	QPSK	1	1	636666	Transversal (Y)	95	352	18	26	1.47	-49.4

8.5 VoWiFi Evaluation Results

<Codec Investigation>

VoWIFI AMR Codec						
Codec	**NB AMR 4.75Kbps**	**WB AMR 6.60Kbps**	**NB AMR 12.2Kbps**	**WB AMR 23.85Kbps**	**Orientation**	**Band / BW / Channel**
Primary Group Contiguous Point Count	173	154	174	173	Transversal (Y)	2.4GHz WLAN / 6
Secondary Group Contiguous Point Count	372	360	368	371		
Secondary Group Max Longitudinal	19	19	19	18		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	1.29	1.79	1.93	2		

VoWIFI EVS Codec								
Codec	**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**
Primary Group Contiguous Point Count	167	175	142	196	141	178	Transversal (Y)	2.4GHz WLAN / 6
Secondary Group Contiguous Point Count	352	373	384	377	384	359		
Secondary Group Max Longitudinal	19	19	19	19	20	19		
Secondary Group Max Transverse	26	26	26	26	26	26		
Frequency Response	1.41	2	1.2	2	0.29	1.55		

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

<Air Interface Investigation>

Air Interface	BW (MHz)	Modulation / Mode	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response
802.11b	20	1M	6	Transversal (Y)	141	384	20	26	Pass
802.11g	20	6M	6	Transversal (Y)	169	412	21	26	Pass
802.11n-HT20	20	MCS0	6	Transversal (Y)	179	423	22	26	Pass
802.11n-HT40	40	MCS0	6	Transversal (Y)	163	402	21	26	Pass
802.11ac-VHT20	20	MCS0	6	Transversal (Y)	169	409	21	26	Pass
802.11ac-VHT40	40	MCS0	6	Transversal (Y)	178	420	22	26	Pass
802.11ax-HE20	20	MCS0	6	Transversal (Y)	168	417	22	26	Pass
802.11ax-HE40	40	MCS0	6	Transversal (Y)	186	414	22	26	Pass
802.11be-EHT20	20	MCS0	6	Transversal (Y)	203	464	23	26	Pass
802.11be-EHT40	40	MCS0	6	Transversal (Y)	210	464	24	26	Pass
802.11b	20	11M	6	Transversal (Y)	147	380	19	26	Pass
802.11a	20	6M	40	Transversal (Y)	165	392	20	26	Pass
802.11n-HT20	20	MCS0	40	Transversal (Y)	159	406	21	26	Pass
802.11n-HT40	40	MCS0	38	Transversal (Y)	148	410	22	26	Pass
802.11ac-VHT20	20	MCS0	40	Transversal (Y)	146	397	21	26	Pass
802.11ac-VHT40	40	MCS0	38	Transversal (Y)	143	395	20	26	Pass
802.11ac-VHT80	80	MCS0	42	Transversal (Y)	138	397	21	26	Pass
802.11ac-VHT160	160	MCS0	50	Transversal (Y)	167	406	21	26	Pass
802.11ax-HE20	20	MCS0	40	Transversal (Y)	180	414	22	26	Pass
802.11ax-HE40	40	MCS0	38	Transversal (Y)	177	428	22	26	Pass
802.11ax-HE80	80	MCS0	42	Transversal (Y)	164	388	20	26	Pass
802.11ax-HE160	160	MCS0	50	Transversal (Y)	180	428	21	26	Pass
802.11be-EHT20	20	MCS0	40	Transversal (Y)	225	489	24	26	Pass
802.11be-EHT40	40	MCS0	38	Transversal (Y)	212	469	23	26	Pass
802.11be-EHT80	80	MCS0	42	Transversal (Y)	214	474	24	26	Pass
802.11be-EHT160	160	MCS0	50	Transversal (Y)	217	483	24	26	Pass
802.11ac-VHT80	80	MCS9	42	Transversal (Y)	177	412	22	26	Pass

Plot No.	Air Interface	BW (MHz)	Modulation / Mode	Channel	Probe Position	Primary Group Contiguous Point Count	Secondary Group Contiguous Point Count	Secondary Group Max Longitudinal	Secondary Group Max Transverse	Frequency Response Margin [dB]	Ambient Noise dB (A/m)
30	WLAN2.4GHz	20M	802.11b 1Mbps	6	Transversal (Y)	141	384	20	26	0.29	-49.56
31	WLAN5GHz	80M	802.11ac-VHT80 MCS0	42	Transversal (Y)	138	397	21	26	0.85	-48.82
32	WLAN5GHz	80M	802.11ac-VHT80 MCS0	58	Transversal (Y)	155	371	18	26	0.67	-48.35
33	WLAN5GHz	80M	802.11ac-VHT80 MCS0	122	Transversal (Y)	171	413	22	26	0.63	-49.1
34	WLAN5GHz	80M	802.11ac-VHT80 MCS0	155	Transversal (Y)	174	406	21	26	0.76	-49.02
35	WLAN6GHz	20M	802.11a 6Mbps	1	Transversal (Y)	179	414	21	26	1.29	-49.12

Remark:

1. Phone Condition: Mute on; Backlight off; Max Volume
2. Hearing Aid mode (Phone -> Setting ->Accessibility->Hearing aids) was set to on for improving the audio signal performance for HAC T-Coil compliance.

Test Engineer : Hank Huang, Kevin Xu, David Dai, Bin He

9. 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 (ABMd)	Ci (ABMu)	Standard Uncertainty (ABMd) (±%)	Standard Uncertainty (ABMu) (±%)
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	3.4
Probe System							
Repeatability / Drift	1.0	Rectangular	√3	1	1	0.6	0.6
Linearity / Dynamic Range	0.6	Rectangular	√3	1	1	0.3	0.3
Acoustic Noise	1.0	Rectangular	√3	0.1	1	0.1	0.6
Probe Angle	1.0	Rectangular	√3	1	1	0.6	0.6
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	0.0	0.3	0.0	0.3
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						3.9%	6.0%
Coverage Factor for 95 %						K = 2	
Expanded Uncertainty						7.7 %	11.9 %
Declaration of Conformity: The test results with all measurement uncertainty excluded are presented in accordance with the regulation limits or requirements declared by manufacturers.							
Comments and Explanations: The declared of product specification for EUT presented in the report are provided by the manufacturer, and the manufacturer takes all the responsibilities for the accuracy of product specification.							

Uncertainty Budget of audio band magnetic measurement

10. References

[1] ANSI C63.19-2019, "American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", Aug. 2019.
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[3] FCC KDB 285076 D02v04, "Guidance for performing T-Coil tests for air interfaces supporting voice over IP (e.g., LTE and WiFi) to support CMRS based telephone services", Feb 2022
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[5] SPEAG DASY System Handbook