

FCC HAC (T-Coil) Test Report

Report No. : W7L-P23120020SA03

Applicant : POINTMOBILE CO.,LTD

Address : 9F Kabul Great Valley, 32, Digital-ro 9-gil, Geumcheon-gu, Seoul, Korea 08512

Manufacturer : POINTMOBILE CO.,LTD

Address : 9F Kabul Great Valley, 32, Digital-ro 9-gil, Geumcheon-gu, Seoul, Korea 08512

Product : Moblie computer

FCC ID : V2X-PM95

Brand : point mobile

Model No. : PM95

Standards : CC 47 CFR PART 20.19 / ANSI C63.19-2019
KDB 285076 D01 v06r04 / KDB 285076 D02 v04 / KDB 285076 D03 v01r06

Sample Received Date : Jan. 12, 2024

Date of Testing : Feb. 20, 2024 ~ May. 19, 2024

FCC Designation No. : CN1325 FCC Site Registration No. : 434559

Issued By : Huarui 7layers High Technology (Suzhou) Co., Ltd.

Address : Tower N, Innovation Center, 88 Zuyi Road, High-tech District, Suzhou City,
Anhui Province China

CERTIFICATION: The above equipment have been tested by **Huarui 7layers High Technology (Suzhou) Co., Ltd.**, and found compliance with the requirement of the above standards. The test record, data evaluation & Equipment Under Test (EUT) configurations represented herein are true and accurate accounts of the measurements of the sample's SAR characteristics under the conditions specified in this report. It should not be reproduced except in full, without the written approval of our laboratory. The client should not use it to claim product certification, approval, or endorsement by A2LA or any government agencies.

Prepared By :

Chang Gao

Chang Gao / Engineer

Approved By :

Sam fei bo

Peibo Sun / Manager

This report is governed by, and incorporates by reference, CPS Conditions of Service as posted at the date of issuance of this report at <http://www.bureauveritas.com/home/about-us/our-business/cps/about-us/terms-conditions/> and is intended for your exclusive use. Any copying or replication of this report to or for any other person or entity, or use of our name or trademark, is permitted only with our prior written permission. This report sets forth our findings solely with respect to the test samples identified herein. The results set forth in this report are not indicative or representative of the quality or characteristics of the lot from which a test sample was taken or any similar or identical product unless specifically and expressly noted. Our report includes all of the tests requested by you and the results thereof based upon the information that you provided to us. Measurement uncertainty is only provided upon request for accredited tests. You have 60 days from date of issuance of this report to notify us of any material error or omission caused by our negligence or if you require measurement uncertainty; provided, however, that such notice shall be in writing and shall specifically address the issue you wish to raise. A failure to raise such issue within the prescribed time shall constitute your unqualified acceptance of the completeness of this report, the tests conducted and the correctness of the report contents.

Table of Contents

Table of Contents	2
Release Control Record	3
1. Summary of Maximum RF Value	4
2. Description of Equipment Under Test.....	5
Air Interface and Operational Mode:	7
2 HAC T-Coil Measurement System	9
2.1 Speag Dasy System	9
3 HAC Measurement Evaluation	22
3.1 Measurement Criteria	22
3.1.1 Field Intensity	22
3.1.2 Frequency Response	22
3.3.1 GSM CMRS Voice Testing Results	23
3.3.2 WCDMA CMRS Voice Testing Results	24
3.3.3 VoLTE Testing Results	25
3.3.4 VoNR Testing Results.....	27
3.3.5 VoWiFi Testing Results	30
3.3.6 T-Coil testing for OTT Voice Calling	32
4 Calibration of Test Equipment.....	36
5 Measurement Uncertainty	37
6 Information of the Testing Laboratories	38

Appendix A. Plots of HAC T-Coil Measurement

Appendix B. Calibration Certificate for Probe

Appendix C. Photographs of EUT and Setup

Release Control Record

Report No.	Reason for Change	Date Issued
W7L-P23120020SA03	Initial release	May. 26, 2024

1. Summary of Maximum RF Value

Mode	Band	Frequency Response	Result
GSM CMRS Voice	GSM850	PASS	PASS
	GSM1900	PASS	PASS
UMTS CMRS Voice	Band II	PASS	PASS
	Band IV	PASS	PASS
	Band V	PASS	PASS
VoLTE	Band 7	PASS	PASS
	Band 12	PASS	PASS
	Band 13	PASS	PASS
	Band 14	PASS	PASS
	Band 25/2	PASS	PASS
	Band 26/5	PASS	PASS
	Band 30	PASS	PASS
	Band 38	PASS	PASS
	Band 41	PASS	PASS
	Band 42	PASS	PASS
	Band 43	PASS	PASS
	Band 48	PASS	PASS
	Band 66/4	PASS	PASS
	Band 71	PASS	PASS
VoNR	NR n7	PASS	PASS
	NR n12	PASS	PASS
	NR n13	PASS	PASS
	NR n14	PASS	PASS
	NR n25/2	PASS	PASS
	NR n26/5	PASS	PASS
	NR n30	PASS	PASS
	NR n38	PASS	PASS
	NR n41	PASS	PASS
	NR n48	PASS	PASS
	NR n66	PASS	PASS
	NR n71	PASS	PASS
	NR n77/78	PASS	PASS
VoWiFi	WLAN 2.4G	PASS	PASS
	WLAN 5.2G	PASS	PASS
	WLAN 5.3G	PASS	PASS
	WLAN 5.5G	PASS	PASS
	WLAN 5.8G	PASS	PASS
	WLAN 6E	PASS	PASS

Note:

1. The HAC T-Coil emission limit is specified in FCC 47 CFR part 20.19 and ANSI C63.19.

2. Description of Equipment Under Test

EUT Type	Mobile computer
FCC ID	V2X-PM95
Brand Name	point mobile
Model Name	PM95
IMEI Code	IMEI1: 355801740001476 IMEI2: 355801740001484
HW Version	MP
SW Version	95.00
Tx Frequency Bands (Unit: MHz)	GSM850 : 824.2 ~ 848.8 GSM1900 : 1850.2 ~ 1909.8 WCDMA Band II : 1850 ~ 1910 WCDMA Band IV : 1710 ~ 1755 WCDMA Band V : 824 ~ 849 LTE Band 2 : 1850 ~ 19010 LTE Band 4 : 1710 ~ 1755 LTE Band 5 : 824 ~ 849 LTE Band 7 : 2500 ~ 2570 LTE Band 12 : 699 ~ 716 LTE Band 13 : 777 ~ 787 LTE Band 14 : 788 ~ 798 LTE Band 17 : 704 ~ 716 LTE Band 25 : 1850 ~ 1915 LTE Band 26 : 814 ~ 849 LTE Band 30 : 2305 ~ 2315 LTE Band 38 : 2570 ~ 2620 LTE Band 41 : 2496 ~ 2690 LTE Band 42 : 3452.5 ~ 3547.5, 3552.5 ~ 3597.5 LTE Band 43 : 3600 ~ 3700 LTE Band 48 : 3550 ~ 3700 LTE Band 66 : 1710 ~ 1780 LTE Band 71 : 663 ~ 698 NR Band n2 : 1850 ~ 1910 NR Band n5 : 824 ~ 849 NR Band n7 : 2500 ~ 2570 NR Band n12 : 699 ~ 716 NR Band n13 : 777 ~ 787 NR Band n14 : 788 ~ 798 NR Band n25 : 1850 ~ 1915 NR Band n26 : 814 ~ 849 NR Band n30 : 2305 ~ 2315 NR Band n38 : 2570 ~ 2620 NR Band n41 : 2496 ~ 2690 NR Band n48 : 3550 ~ 3700 NR Band n66 : 1710 ~ 1780 NR Band n71 : 663 ~ 698 NR Band n77 : 3450 ~ 3550, 3700 ~ 3980 NR Band n78 : 3450 ~ 3550 WLAN : 2412 ~ 2462, 5180 ~ 5240, 5260 ~ 5320, 5500 ~ 5700, 5745 ~ 5825 WLAN 6E: 5925 ~ 6425, 6425 ~ 6525, 6525 ~ 6875, 6875 ~ 7125 Bluetooth : 2402 ~ 2480
Uplink Modulations	GSM & GPRS & EDGE : GMSK, 8PSK WCDMA : QPSK LTE : QPSK, 16QAM, 64QAM, 256QAM NR : Pi/2 BPSK (DFT-s-OFDM), QPSK (DFT-s-OFDM, CP-OFDM), 16QAM (DFT-s-OFDM, CP-OFDM), 64QAM (DFT-s-OFDM, CP-OFDM), 256QAM DFT-s-OFDM, CP-OFDM 802.11b : DSSS 802.11a/g/n/ac : OFDM 802.11ax : OFDMA Bluetooth : GFSK, $\pi/4$ -DQPSK, 8-DPSK, LE
Subcarrier Spacing	15 kHz (FDD) / 30 kHz (TDD)
Uplink Transmission Duty Cycle	For 5G NR bands test, using FTM (Factory Test Mode) with default 100% duty cycle



BUREAU
VERITAS

FCC HAC (T-Coil) Test Report



Certificate #6613.01

	transmission to perform evaluation.
Antenna Type	WWAN: Internal Antenna WLAN / BT: PIFA Antenna
EUT Stage	Identical Prototype

Note:

1. The above EUT information is declared by manufacturer and for more detailed features description please refers to the manufacturer's specifications or User's Manual.

Air Interface and Operational Mode:

Air Interface	Bands	Transport Type	ANSI C63.19	Simultaneous But Not Tested	Name of Voice Service	Power Reduction
GSM	850	VO	Yes	WLAN, BT	CMRS Voice	No
	1900					No
	EGPRS	VD	Yes	WLAN, BT	Google Meet ⁽¹⁾	No
UMTS	Band 2	VO	Yes	WLAN, BT	CMRS Voice	No
	Band 4					No
	Band 5					No
	HSPA	VD	Yes	WLAN, BT	Google Meet ⁽¹⁾	No
LTE (FDD)	Band 2	VD	Yes	NR, WLAN, BT	VoLTE / Google Meet ⁽¹⁾	No
	Band 4					No
	Band 5					No
	Band 7					No
	Band 12					No
	Band 13					No
	Band 14					No
	Band 17					No
	Band 25					No
	Band 26					No
	Band 30					No
	Band 66					No
	Band 71					No
LTE (TDD)	Band 38					No
	Band 41					No
	Band 42					No
	Band 43					No
	Band 48					No
NR (FDD)	NR n2	VD	Yes	LTE, WLAN, BT	VoNR / Google Meet ⁽¹⁾	No
	NR n5					No
	NR n7					No
	NR n12					No
	NR n13					No
	NR n14					No
	NR n25					No
	NR n26					No
	NR n30					No
	NR n66					No
NR (TDD)	NR n71					No
	NR n38					No
	NR n41					No
	NR n48					No
	NR n77					No
WLAN	2.4G	VD	Yes	GSM, WCDMA, LTE, NR	VoWiFi / Google Meet ⁽¹⁾	No
	5.2G					No
	5.3G					No
	5.5G					No
	5.8G					No
WLAN	6E	VD	No	GSM, WCDMA, LTE, NR	VoWiFi / Google Meet ⁽¹⁾	No
Bluetooth	2.4G	DT	No	GSM, WCDMA, LTE, NR	N/A	No

FCC HAC (T-Coil) Test Report

Transport Type:

VO = Legacy Cellular Voice Service

DT = Digital Transport Only (No Voice)

VD = IP Voice Service over Digital Transport

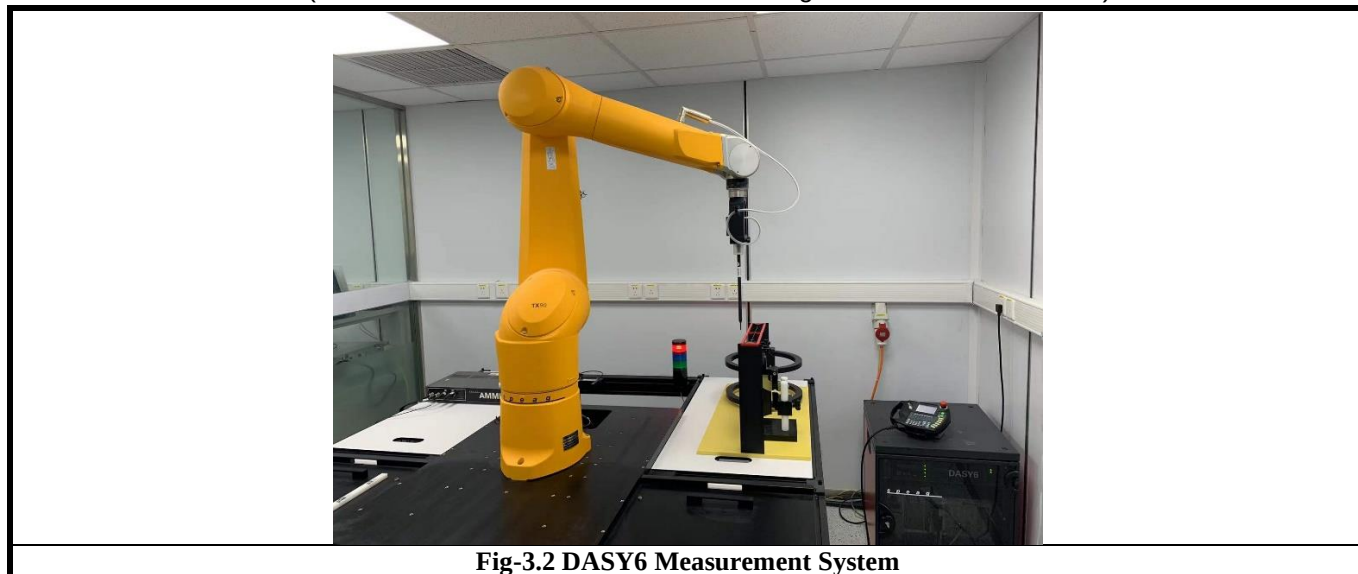
Note:

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. 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.
3. The UNII-5 was evaluated for operations which are entirely below 6GHz, above 6GHz were not evaluated due outside of the current scope of ANSI C63.19 and FCC HAC regulations.
4. The device have similar frequency in some LTE/5G NR FR1 bands: LTE B2/25, 5/26, 4/66, 12/17, 42/48, 43/48, 5G NR n2/25, n5/26, n78/77 since the supported frequency spans for the smaller LTE/5G NR FR1 bands are completely cover by the larger LTE/5G NR FR1 bands, therefore, only larger LTE/5G NR FR1 bands were required to be tested for hearing-aid compliance.
5. 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.

2.1.1 Robot

The DASY6 system uses the high precision robots from Stäubli SA (France). For the 6-axis controller system, the robot controller version (DASY6: CS8c) from Stäubli is used. The Stäubli robot series have many features that are important for our application:

- High precision (repeatability ± 0.035 mm)
- High reliability (industrial design)
- Jerk-free straight movements
- Low ELF interference (the closed metallic construction shields against motor control fields)



2.1.2 AM1D Probe

The AM1D probe is an active probe with a single sensor. It is fully RF-shielded and has a rounded tip 6 mm in diameter incorporating a pickup coil with its center offset 3 mm from the tip and the sides. The symmetric signal preamplifier in the probe is fed via the shielded symmetric output cable from the AMMI with a 48V “phantom” voltage supply. The 7-pin connector on the back in the axis of the probe does not carry any signals. It is mounted to the DAE for the correct orientation of the sensor. If the probe axis is tilted 54.7 degrees from the vertical, the sensor is approximately vertical when the signal connector is at the underside of the probe (cable hanging downwards).

Model	AM1DV3	
Sampling Rate	0.1 kHz to 20 kHz RF sensitivity < -100 dB	
Preamplifier	Symmetric, 40 dB	
Dynamic Range	-60 to 40 dB A/m	
Calibration	at 1kHz	
Dimensions	Tip diameter : 6 mm Length : 290 mm	

2.1.3 Audio Magnetic Calibration Coil (AMCC)

The AMCC is a Helmholtz Coil designed for calibration of the AM1D probe. The two horizontal coils generate a homogeneous magnetic field in the z direction. The DC input resistance is adjusted by a series resistor to approximately 50 Ohm, and a shunt resistor of 10 Ohm permits monitoring the current with a scale of 1:10.

Signal	Connector	Resistance
Coil In	BNC	Typically 50 Ohm
Coil Monitor	BNO	10 Ohm $\pm 1\%$ (100mV corresponding to 1 A/m)
Dimensions	370 x 370 x 196 mm	



2.1.4 Audio Magnetic Measuring Instrument (AMMI)

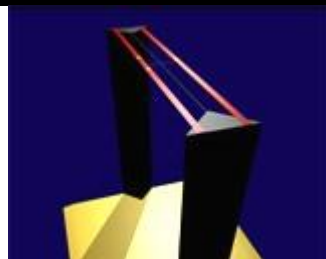
The AMMI is a desktop 19-inch unit containing a sampling unit, a waveform generator for test and calibration signals, and a USB interface.

Sampling Rate	48 kHz / 24 bit	
Dynamic Range	100 dB (with AM1DV3 probe)	
Test Signal Generation	User selectable and predefined (via PC)	
Calibration	Auto-calibration / full system calibration using AMCC with monitor output	
Dimensions	482 x 65 x 270 mm	

2.1.5 Data Acquisition Electronics (DAE)

Model	DAE3, DAE4	
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.	
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4mV, 400mV)	
Input Offset Voltage	< 5 μ V (with auto zero)	
Input Bias Current	< 50 fA	
Dimensions	60 x 60 x 68 mm	

2.1.6 Phantoms

Model	Test Arch	
Construction	Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.	
Dimensions	Length : 370 mm Width : 370 mm Height : 370 mm	

2.1.7 Device Holder

Model	Mounting Device	
Construction	The Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to ANSI C63.19.	
Material	POM	

2.2 System Calibration

For correct and calibrated measurement of the voltages and ABM field, DASY will perform a calibration job as below. In phase 1, the audio output is switched off, and a 200 mV_{pp} symmetric rectangular signal of 1 kHz is generated and internally connected directly to both channels of the sampling unit (Coil in, Probe in).

In phase 2, the audio output is off, and a 20 mV_{pp} symmetric 100 Hz signal is internally connected. The signals during phases 1 and 2 are available at the output on the rear panel of the AMMI. However, the output must not be loaded, in order to avoid influencing the calibration. An RMS voltmeter would indicate 100 mV_{RMS} during the first phase and 10 mV_{RMS} during the second phase. After the first two phases, the two input channels are both calibrated for absolute measurements of voltages. The resulting factors are displayed above the multi-meter window.

After phases 1 and 2, the input channels are calibrated to measure exact voltages. This is required to use the inputs for measuring voltages with their peak and RMS value.

In phase 3, a multi-sine signal covering each third-octave band from 50 Hz to 10 kHz is generated and applied to both audio outputs. The probe should be positioned in the center of the AMCC and aligned in the z-direction, the field orientation of the AMCC. The "Coil In" channel is measuring the voltage over the AMCC internal shunt, which is proportional to the magnetic field in the AMCC. At the same time, the "Probe In" channel samples the amplified signal picked up by the probe coil and provides it to a numerical integrator. The ratio of the two voltages in each third-octave filter leads to the spectral representation over the frequency band of interest. The Coil signal is scaled in dBV, and the Probe signal is first integrated and normalized to show dB A/m. The ratio probe-to-coil at the frequency of 1 kHz is the sensitivity which will be used in the consecutive T-Coil jobs.

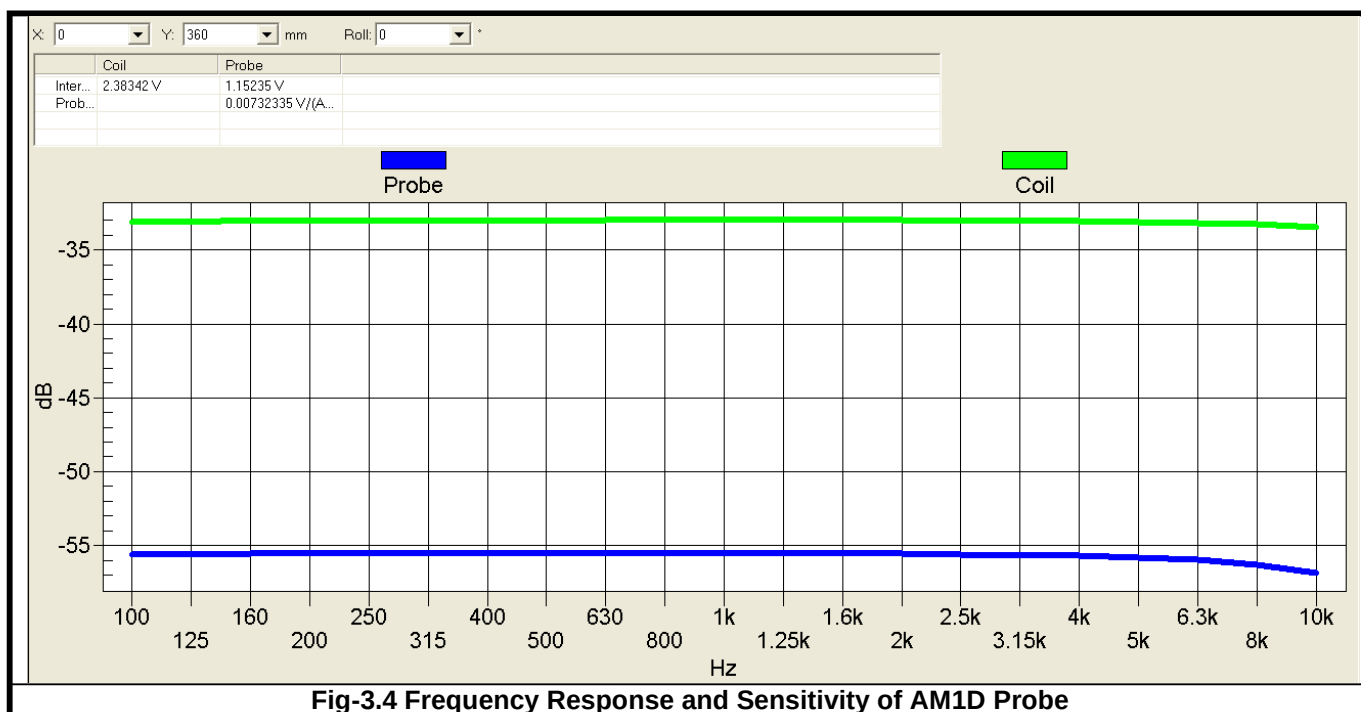


Fig-3.4 Frequency Response and Sensitivity of AM1D Probe

2.3 Eut Measurements Reference And Plane

The EUT is mounted in the device holder. The acoustic output of the EUT will coincide with the center point of the area formed by the dielectric wire and the middle bar of the arch's top frame. Then EUT will be moved vertically upwards until it touches the frame.

Figure 3.5 The T-Coil measurement plane, reference plane and other measurement parameters shall be:

- (1) 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.
- (2) The measurement plane is parallel to, and 10 mm in front of, the reference plane.
- (3) The reference axis is normal to the reference plane and passes through the center of the receiver speaker section or it may be centered on a secondary inductive source.
- (4) 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.
- (5) Measurements of desired ABM signal strength and undesired ABM field are made at $2.0 \text{ mm} \pm 0.5 \text{ mm}$ 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 6.4.
- (6) Desired ABM signal frequency response is measured at a single location at or near the maximum desired ABM signal strength location.

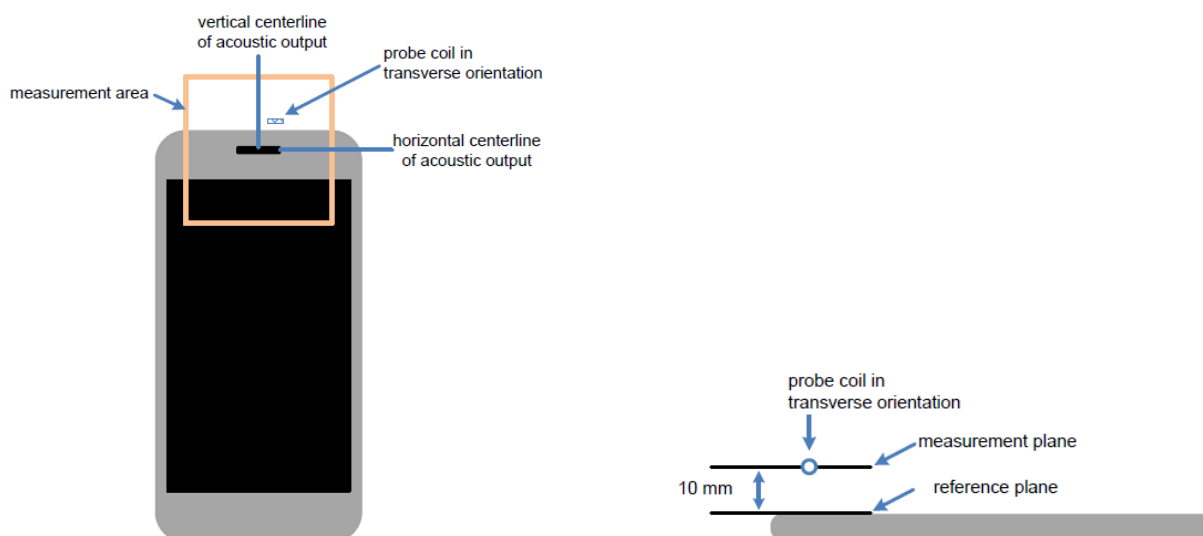


Fig-3.5 Measurement and reference planes probe orientation for WD audio frequency magnetic field measurements

2.4 HAC T-Coil Measurement Procedure

According to ANSI C63.19-2019, the T-Coil test procedure for wireless communications device is as below.

1. Position the EUT in the test setup and connect the EUT RF connector to a base station simulator.
2. The drive level to the EUT is set such that the reference input level specified in Table 6.1 is input to the base station simulator in the 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 7.4.2, shall be used for the reference audio signal. If interference is found at 1025 Hz, an alternate nearby reference audio signal frequency may be used. The same drive level will be used for the ABM1 frequency response measurements at each 1/3 octave band center frequency. The EUT 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.
3. Determine the magnetic measurement locations for the EUT, if not already specified by the manufacturer, as described in 6.4.5.2 and 6.4.5.3.
4. At each measurement location, measure and record the desired T-Coil magnetic signals (ABM1 at f_i) as described in 6.4.2 in each individual ISO 266-1975 R10 standard 1/3 octave band. The desired audio band input frequency (f_i) shall be centered in each 1/3 octave band maintaining the same drive level as determined in Step c) and the reading taken for that band. Equivalent methods of determining the frequency response may also be employed, such as fast Fourier transform (FFT) analysis using noise excitation or input–output comparison using simulated speech. The full-band integrated or half-band integrated probe output, as described in D.9, may be used, as long as the appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB A/m.) 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 ABM signal measurement meet the ambient and test system noise criterion in 6.3.2.

<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 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.

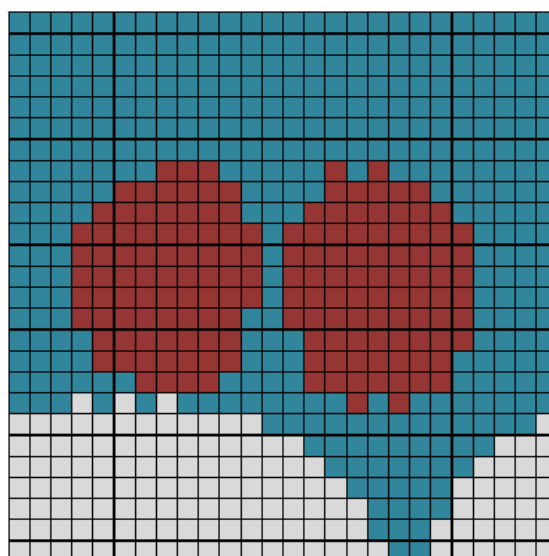
Figure 6.6 is an example of a qualifying scan. The total number of primary group qualifying measurement points is 161, which is ≥ 75 . The total number of secondary group qualifying points is 536, which is ≥ 300 .

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 $M1 \geq 18$ 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:

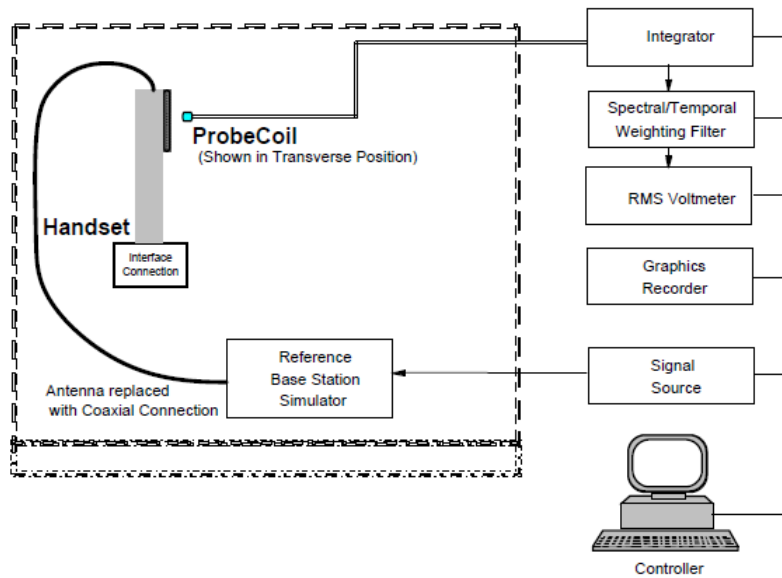


Fig-3.6 T-Coil Measurement Test Setup

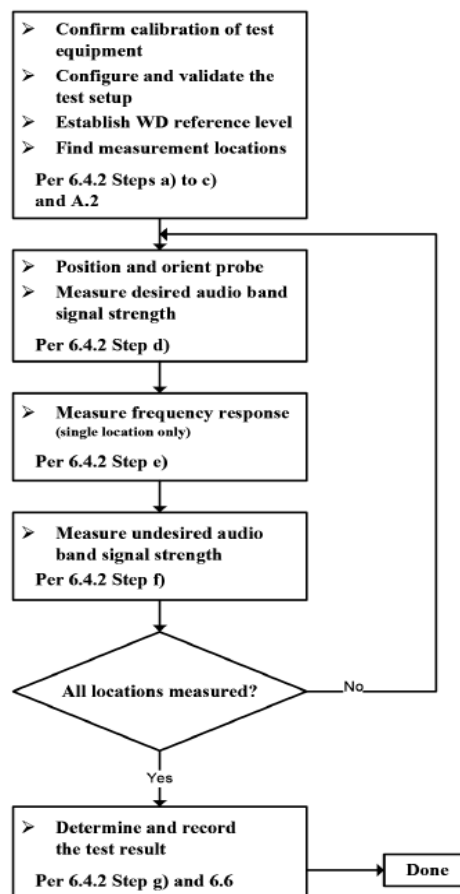


Fig-3.7 T-Coil Signal Test Flowchart

2.5 Test System Setup and Audio Input Level

The test setup shown in below is to extend DASY system with the capability of Audio Band Magnetic (ABM) measurements according to standard ANSI C63.19-2019. Together with the HAC RF extension, it permits complete characterization of the emissions of a wireless device (WD). The signals measured during these tests represent the field picked up by the T-Coil of a hearing aid. Using DASY software, these orthogonal axes can be scanned with a probe incorporating a single sensor coil. The WD is mounted on the Test Arch Phantom. The acoustic center of the WD is mounted in such a way that it is centered, and this represents the reference for the combination of ABM and RF field evaluation. The ABM fields of the WD (frequency range <20 kHz) are scanned with a fully RF-shielded active 1-D probe. The probe axis is oriented in the space diagonal to the three orthogonal axes, and its single sensor can be oriented to the axes by 120 degree rotation. The probe signal is evaluated by an Audio Magnetic Measurement Instrument (AMMI) which is interfaced to the DASY computer via USB. The AMMI also provides test and calibration signals and interfaces to the Helmholtz Audio Magnetic Calibration Coil (AMCC). Through the connector at the AMMI, predefined or user-definable audio signals are available for injection into the WD during the test.

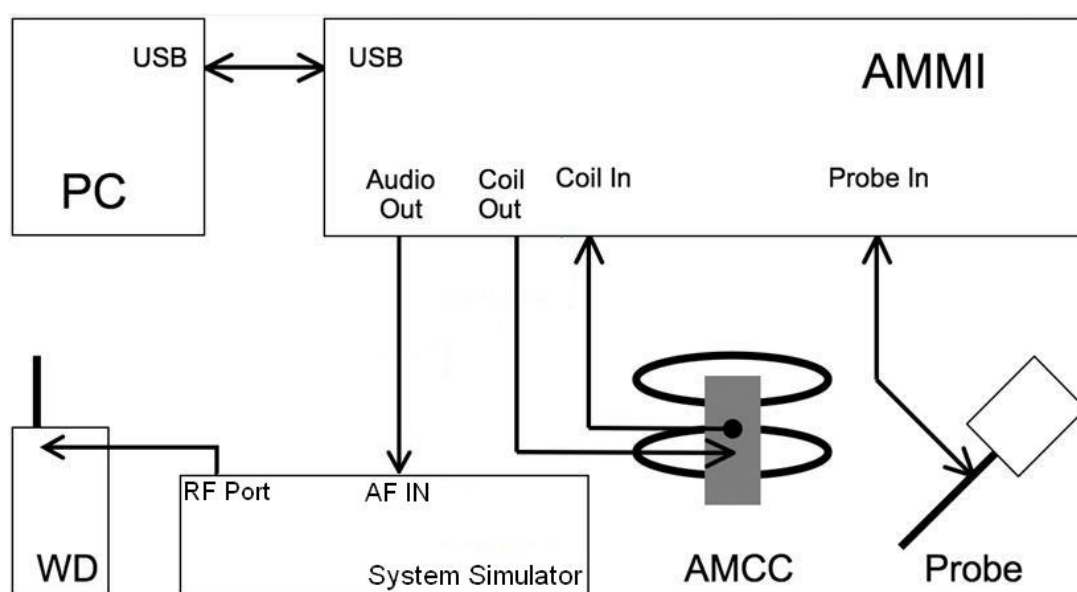


Fig-3.8 System Setup for T-Coil Testing

General Note:

Define the all applicable input audio level as below according to ANSI63.19-2019 table 6.1:

- 16 dBm0 is used for GSM input level
- 16 dBm0 is used for UMTS input level
- 16 dBm0 is used for VoLTE input level
- 16 dBm0 is used for VoNR input level
- 16 dBm0 is used for VoWiFi input level

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 CWM500 can be manually configured to speech input level and ensure that the result is -16dBm0 for GSM/UMTS CMRD Voice connection.

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.

The test setup used for VoLTE and VoWiFi over IMS is via the callbox if 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.

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.

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		-3.01	
100	9.26		40	3.11	3.26
5.46	-16		14.74		
Signal Type	Duration (s)	Peak to RMS (dB)	RMS (dB)	Gain Factor	Gain Setting
1kHz sine	-	3	0	1	5.46
48k_voice_1kHz	1	16.2	-12.7	4.33	23.63
48k_voice_300-3000	2	21.6	-18.6	8.48	46.28

The test setup for OTT VoIP is using the R&S CMW500, CMX500 as base station simulator. The CMW500, CMX500's data application unit was connected to the internet and allowed for an IP data connection on the EUT. An auxiliary VoIP unit installed the same OTT VoIP application was used to initiate an OTT VoIP call to the EUT. The auxiliary VoIP unit can allow for configure and monitor the codec bit rate during the OTT VoIP call.

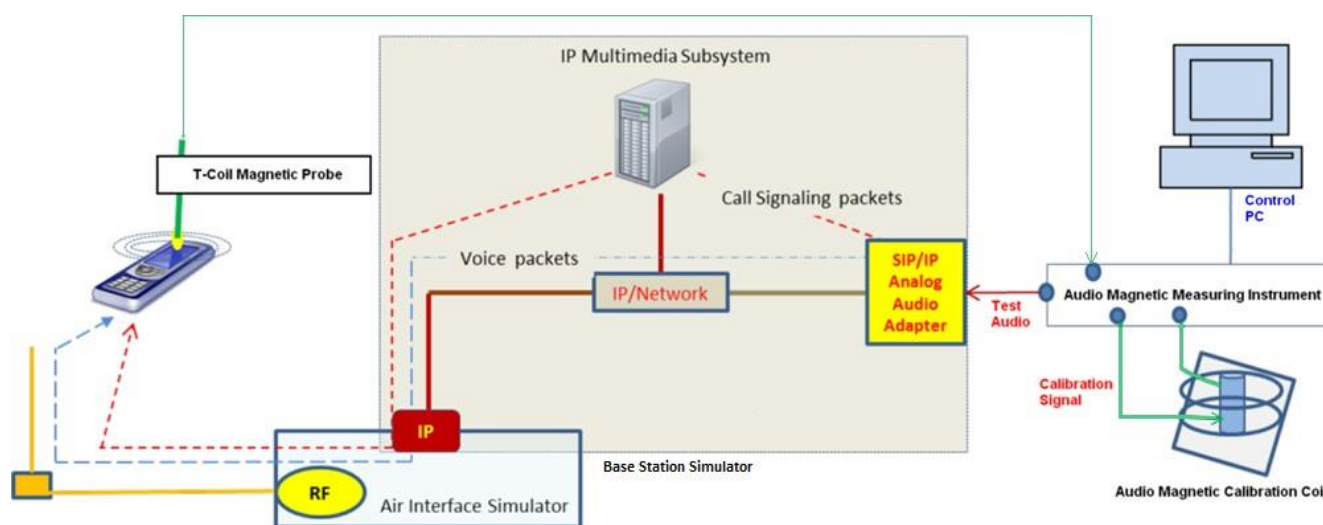


Fig-3.9 Testing Setup for OTT VoIP

1. Define the all applicable input audio level as below according to KDB 285076 D02:
 - OTT Voice calling input Level: -20dBm0
2. OTT voice, such as that enabled when a user opts to communicate in a voice-only mode using the Google Meet application, is a methodology and group of technologies for the delivery of voice communications and multimedia sessions over 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. Google Meet application support code and bitrate are listed in section 3.3.6, and the customized Google Meet software is installed on a mobile phone that is used as the Auxiliary for the test. The software enables the 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 OTT application that supports the voice-only communication option on the Google Meet application and related codec. The test configuration establishes a call between the device under test and an auxiliary handset via Google Meet server.
5. The test setup used for Google Meet OTT voice-only communication is via the data application unit on the simulate base station, connected to the internet via the Google Meet server 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

section 3.3.6. An assessment was made of each of the different codec bit rates to determine the worst case for each different OTT transport (GSM, WCDMA, LTE, NR, WiFi).

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-only communication between auxiliary device and device under test, the audio put 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 0dBmFull Scale (0dBFS) value being equivalent to 3.14dBm0.

The speech levels with the settings at the AF connector of R&S CMW500, CMX500 have been calibrated, and it can be set manually to ensure the specific full-scale speech level during T-Coil testing. For an example, the gain setting for -16 dBm0 has been calculated through below formula.

$$3.14 \text{ dBm0} = X \text{ dBV} = -3.01 \text{ dBV}$$

$$-16 \text{ dBm0} = L_{-16\text{dBm0}} \text{ dBV} = -22.00 \text{ dBV}$$

$$\text{Gain } 100 = G \text{ dBV} = 3.13 \text{ dBV}$$

$$\text{Difference for } -16 \text{ dBm0} = D_{-16\text{dBm0}} = L_{-16\text{dBm0}} - G = -22 - 3.13 = -25.13 \text{ dBV}$$

$$\text{Resulting Gain for } -16 \text{ dBm0} = 10^{(D_{-16\text{dBm0}} / 20)} \times 100 = 5.54$$

$$\text{Gain Setting} = \text{Resulting Gain} \times \text{Required Gain Factor}$$

$$\text{Gain setting for voice 1kHz} = 5.54 \times 4.33 = 23.99$$

$$\text{Gain setting for voice 300-3kHz} = 5.54 \times 8.48 = 46.98$$

The gain setting for other signal types need to be adjusted to achieve the same average level. Those signal types have the following differences/factors compared to the 1 kHz sine signal:

Signal Type	Duration (s)	BWC (dB)	Required Gain Factor
1 kHz sine	-	0.0	1.00
48k_voice_1kHz	1	0.16	4.33
48k_voice_300-3000	2	10.8	8.48

3 HAC Measurement Evaluation

3.1 Measurement Criteria

The HAC Standard ANSI C63.19-2019 represents performance requirements for acceptable interoperability of hearing aids with wireless communications devices. When these parameters are met, a hearing aid operates acceptably in close proximity to a wireless communications device.

3.1.1 Field Intensity

When measured as specified in this standard, the T-Coil signal shall be ≥ -18 dB (A/m) at 1 kHz, in a 1/3 octave band filter for all orientations.

3.1.2 Frequency Response

The frequency response of the axial component of the magnetic field, measured in 1/3 octave bands, shall follow the below response curve, over the frequency range 300 Hz to 3000 Hz. Figure 4.1 and Figure 4.2 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.

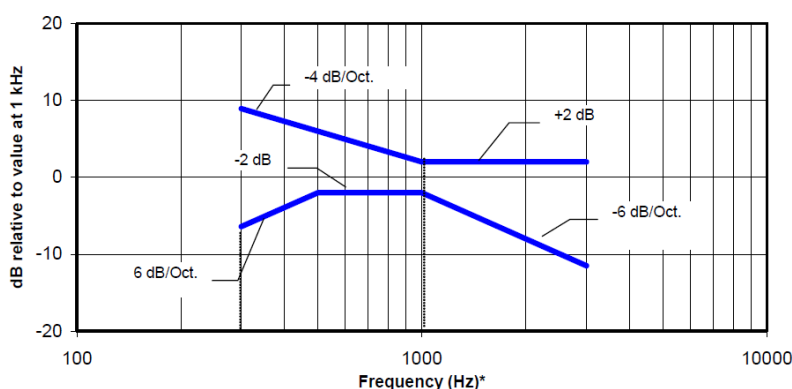


Fig-4.1 Boundaries for EUT with a field ≤ -15 dB (A/m) at 1 kHz

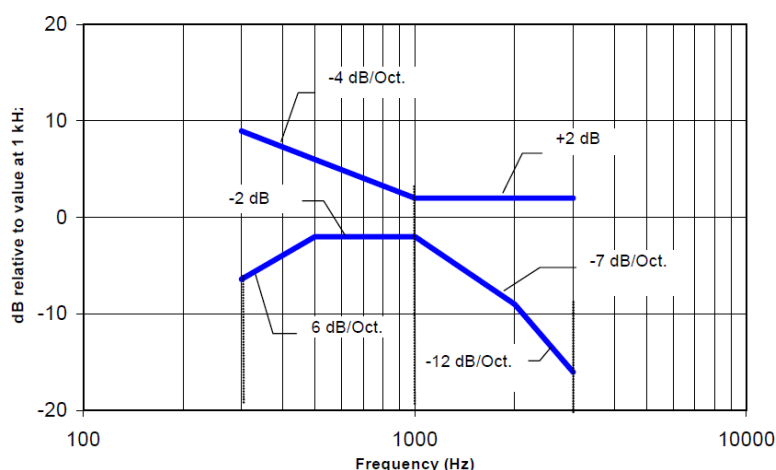


Fig-4.2 Boundaries for EUT with a field > -15 dB (A/m) at 1 kHz

3.2 EUT Configuration and Setting

For HAC T-Coil testing, the EUT was linked and controlled by base station emulator. Communication between the EUT and the emulator was established by coaxial connection. The EUT was set from the emulator to radiate maximum output power during HAC testing. Also EUT was set to mute on, maximum volume, and backlight off during T-Coil testing.

3.3 HAC T-Coil Testing Results

3.3.1 GSM CMRS Voice Testing 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:

- 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.
- Use the worst-case codec test and document a limited set of bands/channel/bandwidths.
- 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.

<Codec Investigation>

GSM Codec						Orientation	Band / Channel
Codec	AMR NB Full Rate	AMR NB Full Rate	AMR WB Full Rate	AMR WB Full Rate	EFR NB (FR V2)		
Bit rate	4.75 Kbps	12.2 Kbps	6.6 Kbps	12.65 Kbps	12.2Kbps		
Primary Group Contiguous Point Count	250	252	230	252	233	Transversal (Y)	GSM850 / 189
Secondary Group Contiguous Point Count	327	328	305	328	310		
Secondary Group Max Longitudinal	20	20	20	20	20		
Secondary Group Max Transverse	26	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is AMR WB 6.6Kbps.

Test Summary

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	Ambient Noise dB (A/m)
P01	GSM850	Voice	189	Transversal (Y)	230	305	20	26	PASS	-58.04
P02	GSM1900	Voice	661	Transversal (Y)	259	356	21	26	PASS	-57.75

3.3.2 WCDMA CMRS Voice Testing Results

<Codec Investigation>

UMTS AMR Codec						
Codec	NB AMR	NB AMR	WB AMR	WB AMR	Orientation	Band / Channel
Bit rate	4.75 Kbps	12.2 Kbps	6.6 Kbps	23.85Kbps		
Primary Group Contiguous Point Count	546	547	547	537	Transversal (Y)	B5 / 4182
Secondary Group Contiguous Point Count	672	676	676	676		
Secondary Group Max Longitudinal	26	26	26	26		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is AMR WB 23.85Kbps.

Test Summary

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	Ambient Noise dB (A/m)
P03	WCDMA II	Voice	9400	Transversal (Y)	532	674	26	26	PASS	-57.96
P04	WCDMA IV	Voice	1413	Transversal (Y)	534	676	26	26	PASS	-57.24
P05	WCDMA V	Voice	4182	Transversal (Y)	530	676	26	26	PASS	-57.38

3.3.3 VoLTE Testing Results

LTE FDD

<Codec Investigation>

VoLTE AMR Codec						
Codec	NB AMR	WB AMR	NB AMR	WB AMR	Orientation	Band / Channel
Bit rate	4.75 Kbps	6.60Kbps	12.2Kbps	23.85Kbps		
Primary Group Contiguous Point Count	492	488	497	484	Transversal (Y)	B25 / 20M / 26340
Secondary Group Contiguous Point Count	587	589	592	596		
Secondary Group Max Longitudinal	26	26	26	26		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

VoLTE EVS Codec						
Codec	EVS WB	EVS WB	EVS NB	EVS NB	Orientation	Band / Channel
Bit rate	5.9Kbps	128Kbps	5.9Kbps	24.4Kbps		
Primary Group Contiguous Point Count	473	509	464	491	Transversal (Y)	B25 / 20M / 26340
Secondary Group Contiguous Point Count	593	589	594	587		
Secondary Group Max Longitudinal	26	26	26	26		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is EVS NB 5.9kbps

LTE TDD

<Codec Investigation>

VoLTE AMR Codec						
Codec	NB AMR	WB AMR	NB AMR	WB AMR	Orientation	Band / Channel
Bit rate	4.75 Kbps	6.60Kbps	12.2Kbps	23.85Kbps		
Primary Group Contiguous Point Count	372	386	363	390	Transversal (Y)	B41 / 20M / 40620
Secondary Group Contiguous Point Count	463	479	456	483		
Secondary Group Max Longitudinal	23	22	21	23		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

VoLTE EVS Codec						
Codec	EVS WB	EVS WB	EVS NB	EVS NB	Orientation	Band / Channel
Bit rate	5.9Kbps	128Kbps	5.9Kbps	24.4Kbps		
Primary Group Contiguous Point Count	385	386	385	443	Transversal (Y)	B41 / 20M / 40620
Secondary Group Contiguous Point Count	483	484	483	537		
Secondary Group Max Longitudinal	23	24	22	26		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is AMR NB 12.2kbps

<Air Interface Investigation>

Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Frequency Response
LTE B25	20	QPSK	1	0	26340	Transversal (Y)	464	PASS
LTE B25	20	QPSK	100	0	26340	Transversal (Y)	498	PASS
LTE B25	20	16QAM	1	0	26340	Transversal (Y)	496	PASS
LTE B25	20	64QAM	1	0	26340	Transversal (Y)	511	PASS
LTE B25	15	QPSK	1	0	26340	Transversal (Y)	509	PASS
LTE B25	10	QPSK	1	0	26340	Transversal (Y)	507	PASS
LTE B25	5	QPSK	1	0	26340	Transversal (Y)	504	PASS
LTE B25	3	QPSK	1	0	26340	Transversal (Y)	504	PASS
LTE B25	1.4	QPSK	1	0	26340	Transversal (Y)	502	PASS
LTE B41_PC3	20	QPSK	1	0	40620	Transversal (Y)	363	PASS
LTE B41_PC2	20	QPSK	1	0	40620	Transversal (Y)	386	PASS

Test Summary

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	Ambient Noise dB (A/m)
P06	LTE B7	20	QPSK	1	0	21100	Transversal (Y)	456	540	25	26	PASS	-56.46
P07	LTE B12	10	QPSK	1	0	23095	Transversal (Y)	538	655	26	26	PASS	-55.78
P08	LTE B13	10	QPSK	1	0	23230	Transversal (Y)	533	640	26	26	PASS	-55.59
P09	LTE B14	10	QPSK	1	0	23330	Transversal (Y)	532	647	26	26	PASS	-56.44
P10	LTE B25	20	QPSK	1	0	26340	Transversal (Y)	464	594	26	26	PASS	-56.72
P11	LTE B26	15	QPSK	1	0	26865	Transversal (Y)	537	659	26	26	PASS	-56.18
P12	LTE B30	10	QPSK	1	0	27710	Transversal (Y)	455	555	26	26	PASS	-55.93
P13	LTE B38	20	QPSK	1	0	38000	Transversal (Y)	346	422	20	26	PASS	-56.09
P14	LTE B41_PC3	20	QPSK	1	0	40620	Transversal (Y)	363	456	21	26	PASS	-55.87
P15	LTE B42 Part27Q	20	QPSK	1	0	42590	Transversal (Y)	306	386	21	26	PASS	-56.39
P16	LTE B48	20	QPSK	1	0	56150	Transversal (Y)	387	472	23	26	PASS	-56.42
P17	LTE B66	20	QPSK	1	0	132322	Transversal (Y)	460	555	25	26	PASS	-55.79

FCC HAC (T-Coil) Test Report

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	Ambient Noise dB (A/m)
P18	LTE B71	20	QPSK	1	0	133322	Transversal (Y)	527	669	26	26	PASS	-56.17

3.3.4 VoNR Testing Results

NR FDD

<Codec Investigation>

VoNR AMR Codec						
Codec	NB AMR	WB AMR	NB AMR	WB AMR	Orientation	Band / Channel
Bit rate	4.75 Kbps	6.60Kbps	12.2Kbps	23.85Kbps		
Primary Group Contiguous Point Count	448	452	440	447	Transversal (Y)	NR Band n25 / 40M / 376500
Secondary Group Contiguous Point Count	552	556	549	552		
Secondary Group Max Longitudinal	26	26	26	26		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

VoNR EVS Codec						
Codec	EVS WB	EVS WB	EVS NB	EVS NB	Orientation	Band / Channel
Bit rate	5.9Kbps	128Kbps	5.9Kbps	24.4Kbps		
Primary Group Contiguous Point Count	431	445	428	446	Transversal (Y)	NR Band n25 / 40M / 376500
Secondary Group Contiguous Point Count	555	550	558	552		
Secondary Group Max Longitudinal	26	26	26	26		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is EVS NB 5.9kbps

NR TDD

<Codec Investigation>

VoNR AMR Codec						
Codec	NB AMR	WB AMR	NB AMR	WB AMR	Orientation	Band / Channel
Bit rate	4.75 Kbps	6.60Kbps	12.2Kbps	23.85Kbps		
Primary Group Contiguous Point Count	240	279	231	275	Transversal (Y)	NR Band n41 / 100M / 518598
Secondary Group Contiguous Point Count	353	385	346	381		
Secondary Group Max Longitudinal	17	18	17	17		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

VoNR EVS Codec						
Codec	EVS WB	EVS WB	EVS NB	EVS NB	Orientation	Band / Channel
Bit rate	5.9Kbps	128Kbps	5.9Kbps	24.4Kbps		
Primary Group Contiguous Point Count	250	262	242	251	Transversal (Y)	NR Band n41 / 100M / 518598
Secondary Group Contiguous Point Count	375	373	370	369		
Secondary Group Max Longitudinal	17	17	17	18		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is AMR NB 12.2kbps

<Air Interface Investigation>

Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Frequency Response
NR n41	100	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	231	PASS
NR n41	100	DFT-s-OFDM QPSK	270	0	518598	Transversal (Y)	266	PASS
NR n41	100	DFT-s-OFDM BPSK	1	1	518598	Transversal (Y)	233	PASS
NR n41	100	DFT-s-OFDM 16QAM	1	1	518598	Transversal (Y)	279	PASS
NR n41	100	DFT-s-OFDM 64QAM	1	1	518598	Transversal (Y)	289	PASS
NR n41	100	DFT-s-OFDM 256QAM	1	1	518598	Transversal (Y)	319	PASS
NR n41	90	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	275	PASS
NR n41	80	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	234	PASS
NR n41	70	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	278	PASS
NR n41	60	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	248	PASS
NR n41	50	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	276	PASS
NR n41	40	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	279	PASS



BUREAU
VERITAS

FCC HAC (T-Coil) Test Report



Certificate #6613.01

Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Frequency Response
NR n41	30	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	278	PASS
NR n41	20	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	286	PASS
NR n41	15	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	288	PASS
NR n41	10	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	277	PASS
NR n41_PC2	100	DFT-s-OFDM QPSK	1	1	518598	Transversal (Y)	269	PASS

Test Summary

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	Ambient Noise dB (A/m)
P19	NR n7	25	QPSK	1	1	507000	Transversal (Y)	418	542	26	26	PASS	-57.21
P20	NR n12	15	QPSK	1	1	141500	Transversal (Y)	498	638	26	26	PASS	-56.77
P21	NR n13	10	QPSK	1	1	156400	Transversal (Y)	476	620	26	26	PASS	-56.13
P22	NR n14	10	QPSK	1	1	158600	Transversal (Y)	486	627	26	26	PASS	-56.59
P23	NR n25	40	QPSK	1	1	376500	Transversal (Y)	428	558	26	26	PASS	-57.12
P24	NR n26	20	QPSK	1	1	166300	Transversal (Y)	496	640	26	26	PASS	-56.98
P25	NR n30	10	QPSK	1	1	462000	Transversal (Y)	412	541	26	26	PASS	-56.12
P26	NR n38	40	QPSK	1	1	519000	Transversal (Y)	323	427	20	26	PASS	-56.07
P27	NR n41	100	QPSK	1	1	518598	Transversal (Y)	231	346	17	26	PASS	-56.11
P28	NR n48	40	QPSK	1	1	641666	Transversal (Y)	364	470	25	26	PASS	-56.57
P29	NR n66	40	QPSK	1	1	349000	Transversal (Y)	418	551	26	26	PASS	-56.42
P30	NR n71	20	QPSK	1	1	136100	Transversal (Y)	514	640	26	26	PASS	-56.78
P31	NR n77_Part27Q	100	QPSK	1	1	633334	Transversal (Y)	270	373	23	26	PASS	-56.83
P32	NR n77_Part27O	100	QPSK	1	1	656000	Transversal (Y)	238	343	22	26	PASS	-56.39

3.3.5 VoWiFi Testing Results

<Codec Investigation>

VoWiFi AMR Codec						
Codec	NB AMR	WB AMR	NB AMR	WB AMR	Orientation	Band / Channel
Bit rate	4.75 Kbps	6.60Kbps	12.2Kbps	23.85Kbps		
Primary Group Contiguous Point Count	373	372	371	376	Transversal (Y)	WLAN2.4GHz / 6
Secondary Group Contiguous Point Count	531	490	527	535		
Secondary Group Max Longitudinal	24	23	26	23		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

VoWiFi EVS Codec						
Codec	EVS WB	EVS WB	EVS NB	EVS NB	Orientation	Band / Channel
Bit rate	5.9Kbps	128Kbps	5.9Kbps	24.4Kbps		
Primary Group Contiguous Point Count	427	428	442	407	Transversal (Y)	WLAN2.4GHz / 6
Secondary Group Contiguous Point Count	555	559	592	544		
Secondary Group Max Longitudinal	25	25	26	24		
Secondary Group Max Transverse	26	26	26	26		
Frequency Response	Pass	Pass	Pass	Pass		

Note: According to codec investigation, the worst codec is NB AMR 12.2kbps

<Air Interface Investigation>

Frequency Bands	Air Interface	BW (MHz)	Modulation / Mode	Channel	Probe Position	Primary Group Contiguous Point Count	Frequency Response
WLAN2.4GHz	802.11b	20	1M	6	Transversal (Y)	371	PASS
	802.11g	20	6M	6	Transversal (Y)	462	PASS
	802.11n-HT20	20	MCS0	6	Transversal (Y)	422	PASS
	802.11n-HT40	40	MCS0	6	Transversal (Y)	456	PASS
	802.11ac-VHT20	20	MCS0	6	Transversal (Y)	447	PASS
	802.11ac-VHT40	40	MCS0	6	Transversal (Y)	471	PASS
	802.11b	20	11M	6	Transversal (Y)	391	PASS
WLAN5GHz	802.11a	20	6M	40	Transversal (Y)	405	PASS
	802.11an-HT20	20	MCS0	40	Transversal (Y)	407	PASS
	802.11an-HT40	40	MCS0	38	Transversal (Y)	409	PASS
	802.11ac-VHT20	20	MCS0	40	Transversal (Y)	412	PASS
	802.11ac-VHT40	40	MCS0	38	Transversal (Y)	426	PASS
	802.11ac-VHT80	80	MCS0	42	Transversal (Y)	418	PASS

Test Summary

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	Ambient Noise dB (A/m)
P33	802.11b	20	1M	6	Transversal (Y)	371	527	26	26	PASS	-56.78
P34	802.11a	20	6M	40	Transversal (Y)	405	535	22	26	PASS	-55.64
P35	802.11a	20	6M	60	Transversal (Y)	425	555	24	26	PASS	-56.07
P36	802.11a	20	6M	132	Transversal (Y)	457	593	25	26	PASS	-55.88
P37	802.11a	20	6M	157	Transversal (Y)	465	624	26	26	PASS	-55.39
P38	802.11ax	20	MSC0	5	Transversal (Y)	545	610	26	26	PASS	-56.12

3.3.6 T-Coil testing for OTT Voice Calling

General Notes:

1. 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.
 2. Phone Condition: Mute on; Backlight off; Max Volume
 3. The device supported a pre-installed application, Google Meet, whose features allow the option of voice-only communications. According to KDB 285076 D02, all air interfaces via a data connection with an application providing voice functionality need to be considered for HAC testing.
 4. Google Meet only support OPUS audio codec and support 6Kbps to 75Kbps bitrate.
 5. The test setup used for OTT Voice call is the DUT connect to the CMW500/CMX500 and via the data application unit on CMW500/CMX500 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/CMX500 for the DUT unit. For the Auxiliary OTT unit which is used to configure the audio codec rate and determine the audio input level of -20dBm0 based on the KDB 285076 D02 requirement.
 6. 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.
 7. Air Interface Investigation:
 - a. Through Internal radio configuration investigation (e.g. bandwidth, modulation data rate, subcarrier spacing, 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. OTT service and CMRS IP service are established over the internet protocol for the voice service, and on both services the identical RF air interface is used for LTE and WIFI. Therefore, according to HA3O1004B VoLTE and VoWiFi test results from the air interface investigation, the worst configuration and frequency band of the air interface is used for OTT T-Coil testing.
- LTE FDD worst configuration and band: LTE Band 30/10MHz/QPSK/1RB Size
 -LTE TDD worst configuration and band: LTE Band 42/20MHz/QPSK/1RB Size
 -NR FDD worst configuration and band: NR Band 30/10MHz/QPSK/1RB Size
 -NR TDD worst configuration and band: NR Band 41/100MHz/QPSK/1RB Size
 -WLAN DTS worst configuration: 802.11b/1Mbps
 -WLAN NII worst configuration and Band: WLAN 5.2GHz/11a/6Mbps

<Codec Investigation>

EDGE

EDGE					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	436	440	441	Transversal (Y)	GSM850 / 189
Secondary Group Contiguous Point Count	476	476	476		
Secondary Group Max Longitudinal	23	23	25		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

HSPA

HSPA					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	439	474	472	Transversal (Y)	B5 / 4182
Secondary Group Contiguous Point Count	496	526	528		
Secondary Group Max Longitudinal	26	26	26		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

LTE FDD

LTE FDD					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	447	441	452	Transversal (Y)	B25 / 20M / 26340
Secondary Group Contiguous Point Count	489	493	490		
Secondary Group Max Longitudinal	26	26	24		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

LTE TDD

LTE TDD					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	389	387	388	Transversal (Y)	B41 / 20M / 40620
Secondary Group Contiguous Point Count	426	425	423		
Secondary Group Max Longitudinal	22	22	21		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

NR FDD

NR FDD					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	427	429	431	Transversal (Y)	NR Band n25 / 40M / 376500
Secondary Group Contiguous Point Count	462	460	460		
Secondary Group Max Longitudinal	24	24	23		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

NR TDD

NR TDD					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	302	307	310	Transversal (Y)	NR Band n41 / 100M / 518598
Secondary Group Contiguous Point Count	338	339	344		
Secondary Group Max Longitudinal	17	17	17		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

WLAN

WLAN					
Codec	Opus	Opus	Opus	Orientation	Band / Channel
Bit rate	6kbps	40kbps	75kbps		
Primary Group Contiguous Point Count	397	400	399	Transversal (Y)	WLAN2.4GHz / 6
Secondary Group Contiguous Point Count	433	434	430		
Secondary Group Max Longitudinal	22	24	23		
Secondary Group Max Transverse	26	26	26		
Frequency Response	Pass	Pass	Pass		

Test Summary

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	Ambient Noise dB (A/m)
P39	GSM850	Voice	189	Transversal (Y)	436	476	23	26	PASS	-55.77
P40	GSM1900	Voice	661	Transversal (Y)	416	449	26	26	PASS	-55.45
P41	WCDMA II	HSPA	9400	Transversal (Y)	471	518	26	26	PASS	-56.28
P42	WCDMA IV	HSPA	1413	Transversal (Y)	478	527	26	26	PASS	-56.42
P43	WCDMA V	HSPA	4182	Transversal (Y)	439	496	26	26	PASS	-55.79
P44	LTE B30	10M_QPSK_1RB_OS0	27710	Transversal (Y)	442	485	26	26	PASS	-56.13
P45	LTE B42 Part27Q	20M_QPSK_1RB_OS0	42590	Transversal (Y)	386	423	22	26	PASS	-55.59
P46	NR n30	10M_QPSK_1RB_OS1	462000	Transversal (Y)	475	505	25	26	PASS	-56.19
P47	NR n41_PC3	100M_QPSK_1RB_OS1	518598	Transversal (Y)	302	338	17	26	PASS	-55.47
P48	WLAN2.4GHz	802.11b 1Mbps	6	Transversal (Y)	397	433	22	26	PASS	-55.21
P49	WLAN5GHz	802.11a 6Mbps	40	Transversal (Y)	436	477	25	26	PASS	-55.93

Test Engineer: Renjie Liu and Zixiao Xia

4 Calibration of Test Equipment

Equipment	Manufacturer	Model	SN	Cal. Date	Cal. Interval
Audio Band Magnetic Probe	SPEAG	AM1DV3	3144	Feb. 14, 2024	1 Year
Audio Band Magnetic Probe	SPEAG	AM1DV3	1021	Oct. 23, 2023	1 Year
Data Acquisition Electronics	SPEAG	DAE	1633	Mar. 06, 2024	1 Year
Data Acquisition Electronics	SPEAG	DAE	1423	Mar. 17, 2023	1 Year
Universal Radio Communication Tester	R&S	CMW500	169210	Jun. 27, 2022	2 Year
Universal Radio Communication Tester	R&S	CMX500	101873	Oct. 08, 2023	2 Year
Audio Measuring Instrument	SPEAG	AMMI	1180	N/A	N/A
Audio Magnetic Calibration Coil	SPEAG	AMCC	1158	N/A	N/A
Test Arch Phantom	SPEAG	Arch	N/A	N/A	N/A

5 Measurement Uncertainty

HAC Uncertainty Budget for T-Coil 2019 version According to ANSI C63.19							
Error Description	Uncertainty Value (±%)	Probability	Divisor	(Ci) ABM1	(Ci) ABM2	Standard Uncertainty (ABM1) (±%)	Standard Uncertainty (ABM2) (±%)
Probe Sensitivity							
Reference Level	3.0	N	1	1	1	3.0	3.0
AMCC Geometry	0.4	R	1.732	1	1	0.2	0.2
AMCC Current	1.0	R	1.732	1	1	0.6	0.6
Probe Positioning during Calibr.	0.1	R	1.732	1	1	0.1	0.1
Noise Contribution	0.7	R	1.732	0.014	1	0.0	0.4
Frequency Slope	5.9	R	1.732	0.1	1	0.3	3.4
Probe System							
Repeatability / Drift	1.0	R	1.732	1	1	0.6	0.6
Linearity / Dynamic Range	0.6	R	1.732	1	1	0.3	0.3
Acoustic Noise	1.0	R	1.732	0.1	1	0.1	0.6
Probe Angle	2.3	R	1.732	1	1	1.3	1.3
Spectral Processing	0.9	R	1.732	1	1	0.5	0.5
Integration Time	0.6	N	1	1	5	0.6	3.0
Field Distribution	0.2	R	1.732	1	1	0.1	0.1
Test Signal							
Ref. Signal Spectral Response	0.6	R	1.732	0	1	0.0	0.3
Positioning							
Probe Positioning	1.9	R	1.732	1	1	1.1	1.1
Phantom Thickness	0.9	R	1.732	1	1	0.5	0.5
DUT Positioning	1.9	R	1.732	1	1	1.1	1.1
External Contributions							
RF Interference	0.0	R	1.732	1	0.3	0.0	0.0
Test Signal Variation	2.0	R	1.732	1	1	1.2	1.2
Combined Std. Uncertainty						4.0%	6.1%
Coverage Factor for 95 %						K=2	
Expanded STD Uncertainty						8.1%	12.2%

Uncertainty Budget for HAC T-Coil

6 Information of the Testing Laboratories

We, Huarui 7layers High Technology (Suzhou) Co., Ltd., were founded in 2020 to provide our best service in EMC, Radio, Telecom and Safety consultation.

If you have any comments, please feel free to contact us at the following:

Add: Tower N, Innovation Center, 88 Zuyi Road, High-tech District, Suzhou City, Anhui Province

Tel: +86 (0557) 368 1008

The road map of all our labs can be found in our web site also

Web: <http://www.7Layers.com>

---END---