VARIANT FCC HAC (T-Coil) Test Report

Report No.	:	**PSU-NQN2402040109SA03**
Applicant	:	**HMD Global Oy**
Address	:	**Bertel Jungin aukio 9 Espoo 02600 Finland**
Manufacturer	:	**HMD Global Oy**
Address	:	**Bertel Jungin aukio 9 Espoo 02600 Finland**
Product	:	**Smartphone**
FCC ID	:	**2AJOTTA-1590**
Brand	:	**HMD**
Model No.	:	**TA-1590**
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. 02, 2024**
Date of Testing	:	**Jan. 04, 2024 ~ Feb. 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 :	Chao Wu Chao Wu / Engineer	**Approved By :**	Sun Peibo Peibo Sun / Manager

Table of Contents

Release Control Record

Report No.	Reason for Change	Date Issued
PSU-NQN2311090109SA03	Initial release	Feb. 02, 2024
PSU-NQN2402040109SA03	For FCC ID 2AJOTTA-1590 that it is involved in two product models N159V and TA-1590, the difference of N159V and TA-1590 is only model name, memory and software customization applications. For HW, the TA-1590 product has only 6+128 memory, the memory of the N159V product is 3+64, hardware is the same except the memory, and there is no change of the hardware version number. For SW, on the basis of N159V, some customized applications of TA-1590 on the software are removed, and the software version number is changed. So this report data is copied from the report PSU-NQN2311090109SA03(model:N159V, FCC ID: 2AJOTTA-1590).	Feb. 19, 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 V	PASS	PASS
VoLTE	Band 2	PASS	PASS
	Band 4	PASS	PASS
	Band 5	PASS	PASS
	Band 12	PASS	PASS
	Band 13	PASS	PASS
	Band 66	PASS	PASS
VoWiFi	2.4G	PASS	PASS
	5.2G	PASS	PASS
	5.3G	PASS	PASS
	5.5G	PASS	PASS
	5.8G	PASS	PASS

Note:

1. The HAC T-Coil emission limit is specified in FCC 47 CFR part 20.19 and ANSI C63.19.
2. The device T-Coil emission rating is determined by the minimum rating.

Certificate #6613.01

2. Description of Equipment Under Test

EUT Type	Smartphone
FCC ID	2AJOTTA-1590
Brand Name	HMD
Model Name	TA-1590
Sample 1 IMEI Code	IMEI1: 353407230018145
Sample 2 IMEI Code	IMEI1: 353407230025314
HW Version	V 1.0
SW Version	00US_0_100
Tx Frequency Bands (Unit: MHz)	GSM850 : 824.2 ~ 848.8 GSM1900 : 1850.2 ~ 1909.8 WCDMA Band II : 1852.4 ~ 1907.6 WCDMA Band V : 826.4 ~ 846.6 LTE Band 2 : 1850.7 ~ 1909.3 LTE Band 4 : 1710.7 ~ 1754.3 LTE Band 5 : 824.7 ~ 848.3 LTE Band 12 : 699.7 ~ 715.3 LTE Band 13 : 779.5 ~ 784.5 LTE Band 66 : 1710.7 ~ 1779.3 WLAN : 2412 ~ 2462, 5180 ~ 5240, 5260 ~ 5320, 5500 ~ 5700, 5745 ~ 5825 Bluetooth : 2402 ~ 2480
Uplink Modulations	GSM & GPRS & EDGE : GMSK, 8PSK WCDMA : QPSK LTE : QPSK, 16QAM, 64QAM 802.11b : DSSS 802.11a/g/n/ac : OFDM Bluetooth : GFSK, π/4-DQPSK, 8-DPSK
Antenna Type	WWAN ANT1: PIFA Antenna WWAN ANT4 PIFA Antenna WLAN ANT5: PIFA Antenna WLAN ANT6: 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.
2. According to the document <Difference of change> provided by the manufacturer, these changes do not affect the RF parameters, so sample 1 is fully tested, and sample 2 verifies the worst case.
3. For FCC ID 2AJOTTA-1590 that it is involved in two product models N159V and TA-1590, the difference of N159V and TA-1590 is only model name, memory and software customization applications. For HW, the TA-1590 product has only 6+128 memory, the memory of the N159V product is 3+64, hardware is the same except the memory, and there is no change of the hardware version number. For SW, on the basis of N159V, some customized applications of TA-1590 on the software are removed, and the software version number is changed. So this report data is copied from the report PSU-NQN2311090109SA03(model:N159V, FCC ID: 2AJOTTA-1590).

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[1]	No
	1900					No
	EGPRS	DT	No	WLAN, BT	Google Meet[1]	No
UMTS	II	VO	Yes	WLAN, BT	CMRS Voice[1]	No
	V					No
	HSPA	DT	Yes	WLAN, BT	Google Meet[1]	No
LTE (FDD)	2	VD	Yes	WLAN, BT	VoLTE[1] / Google Meet[1]	No
	4					No
	5					No
	12					No
	13					No
	66					No
WLAN	2.4G	VD	Yes	GSM, WCDMA, LTE	VoWiFi[1] / Google Meet[1]	No
	5.2G					No
	5.3G					No
	5.5G					
	5.8G					No
Bluetooth	2.4G	DT	No	GSM, WCDMA, LTE	N/A	No

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 device have similar frequency in some LTE bands: LTE B4/66, since the supported frequency spans for the smaller LTE bands are completely cover by the larger LTE bands, therefore, only larger LTE bands were required to be tested for hearing-aid compliance.
4. This is partial report for CMRS voice T-Coil testing. VOIP test report will be separately submitted.

2 HAC T-Coil Measurement System

2.1 Speag Dasy System

DASY system consists of high precision robot, probe alignment sensor, phantom, robot controller, controlled measurement server and near-field probe. The robot includes six axes that can move to the precision position of the DASY5 software defined. The DASY software can define the area that is detected by the probe. The robot is connected to controlled box. Controlled measurement server is connected to the controlled robot box. The DAE includes amplifier, signal multiplexing, AD converter, offset measurement and surface detection. It is connected to the Electro-optical coupler (ECO). The ECO performs the conversion form the optical into digital electric signal of the DAE and transfers data to the PC.

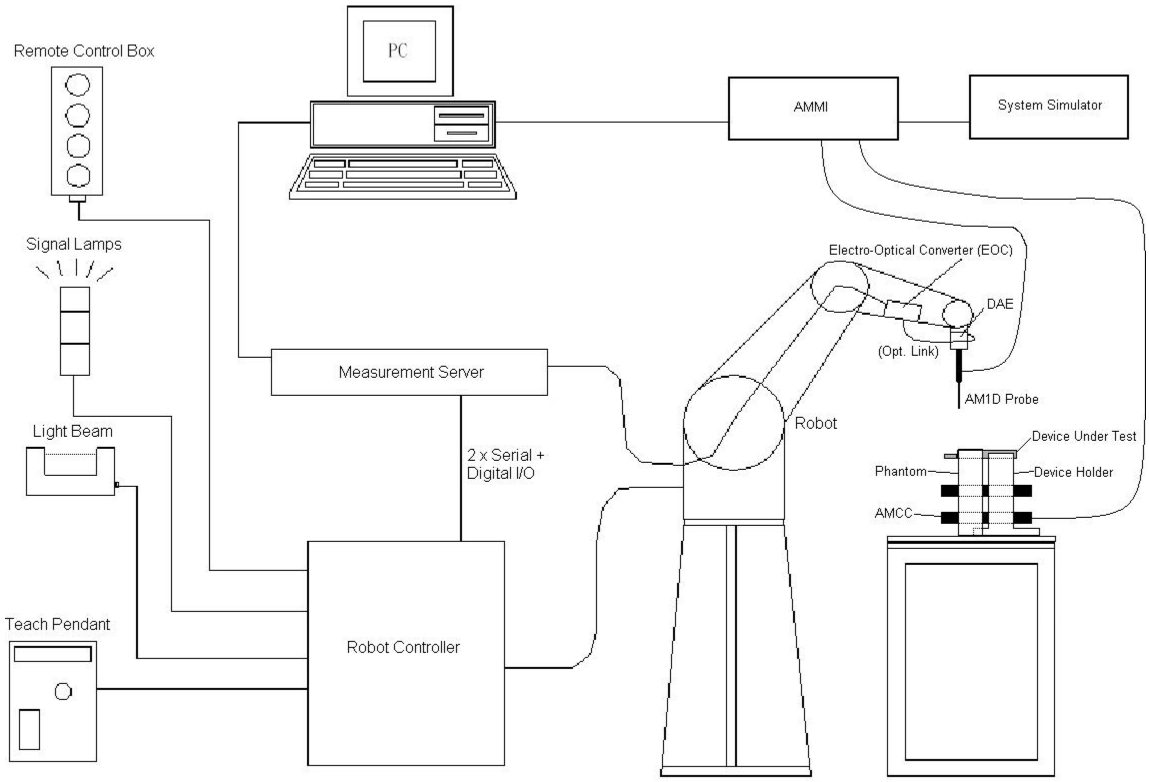


Fig-3.1 DASY System Setup

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)

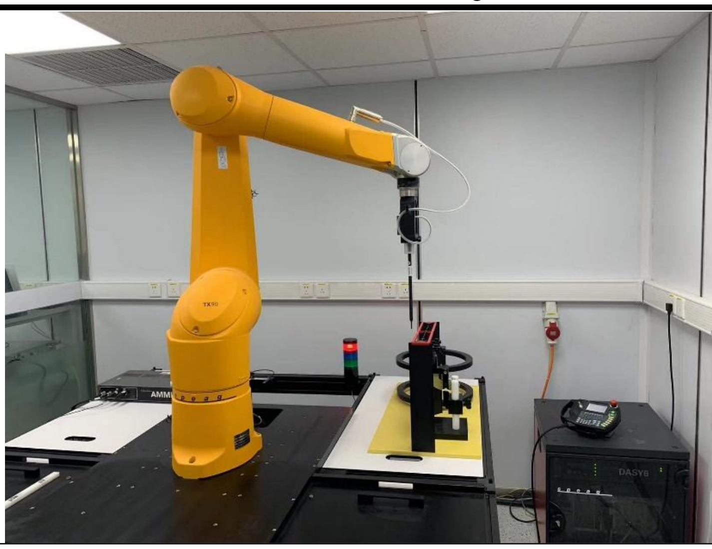
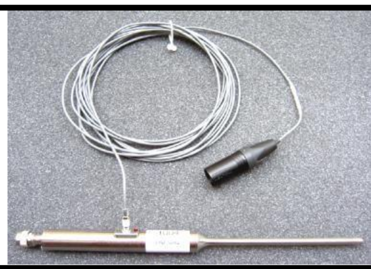


Fig-3.2 DASY6 Measurement System

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 ±1% (100mV corresponding to 1 A/m)
Dimensions	370 x 370 x 196 mm	

2.1.4 Audio Magnetic Measuring Instrument (AMMI)

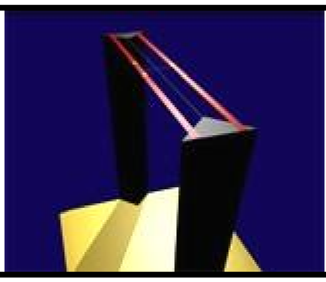
The AMMI is a desktop 19-inch unit containing a sampling unit, a waveform generator for test and calibration signals, and a USB interface.

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	< 5µV (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.

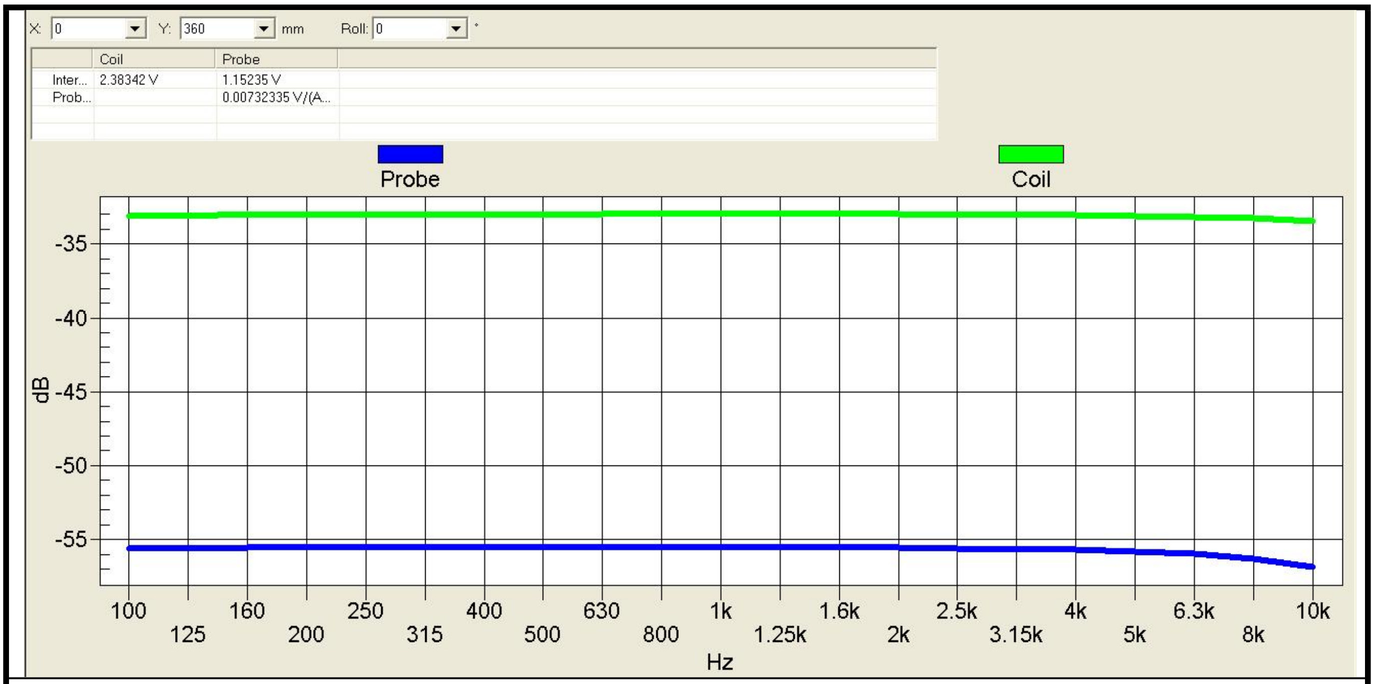


Fig-3.4 Frequency Response and Sensitivity of AM1D Probe

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.

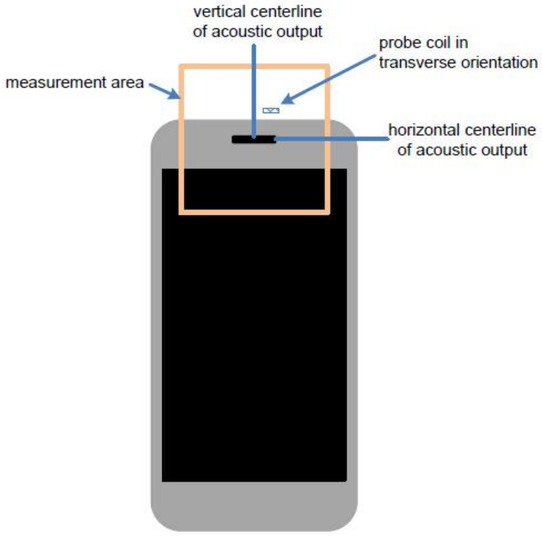
(2) The measurement plane is parallel to, and 10 mm in front of, the reference plane.

(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 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 6.4.

(6) Desired ABM signal frequency response is measured at a single location at or near the maximum desired ABM signal strength location.



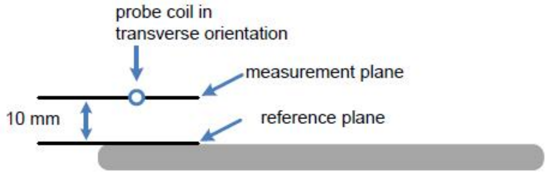


Fig-3.5 Measurement and reference planes probe orientation for WD audio frequency magnetic field measurements

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.

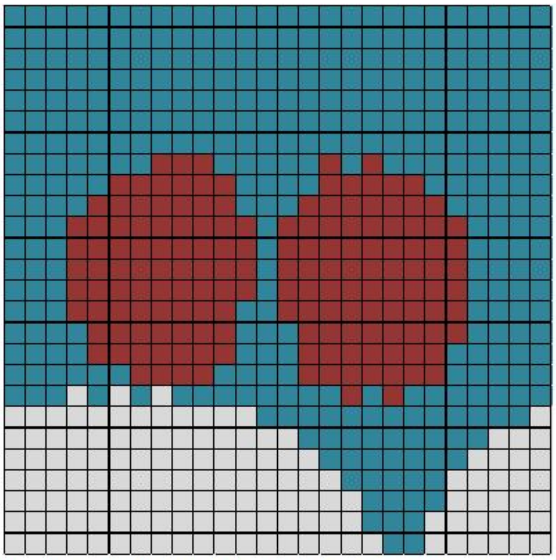
The secondary group has a longitudinal column of 26, which is ≥10, and a transverse row also of 26 contiguous points, which is ≥15

<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 ≥−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:

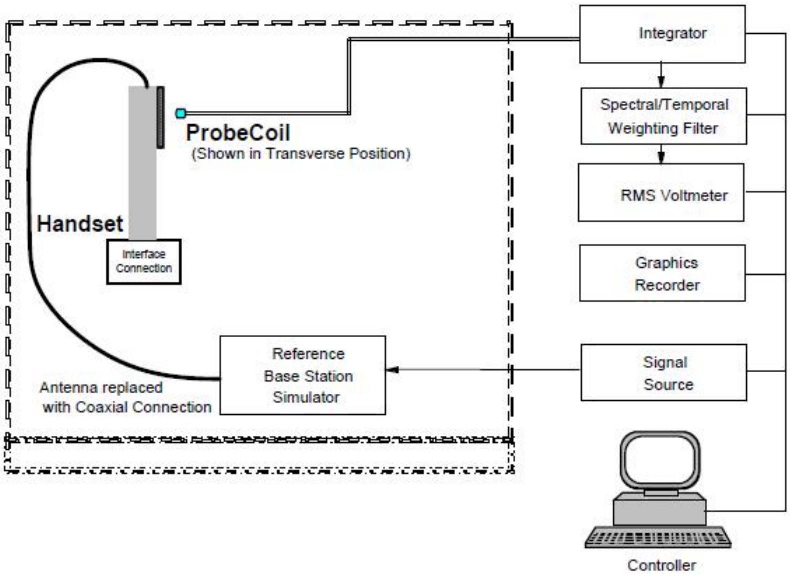


Fig-3.6 T-Coil Measurement Test Setup

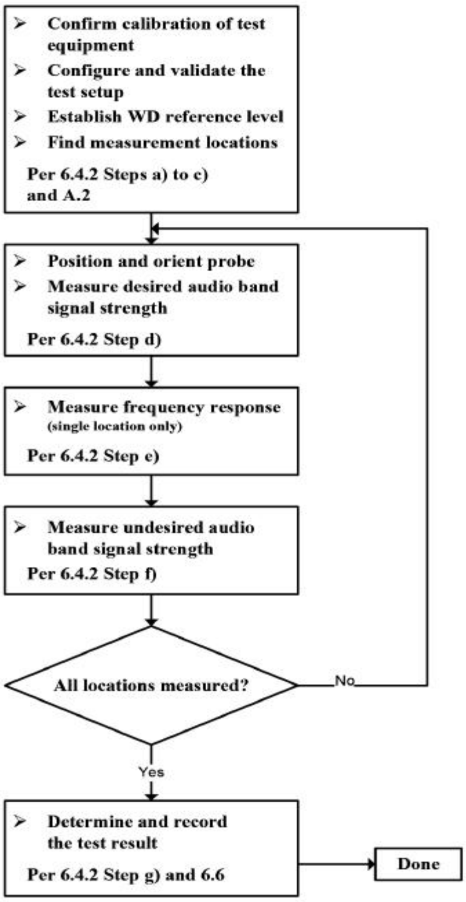


Fig-3.7 T-Coil Signal Test Flowchart

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.

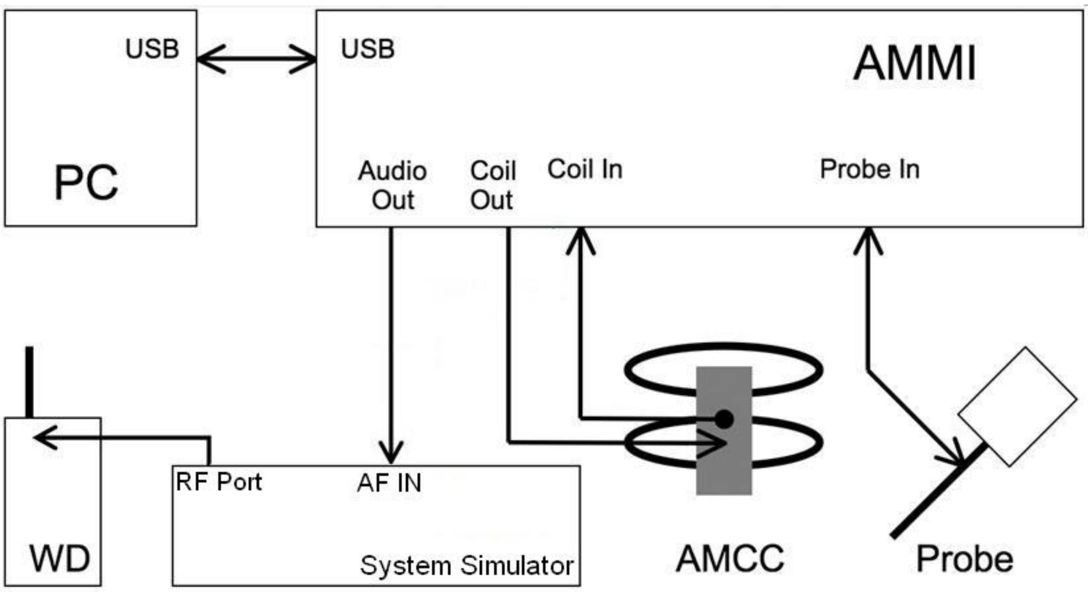


Fig-3.8 System Setup for T-Coil Testing

According to KDB 285076 D02, T-Coil testing for VoLTE 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 in Figure 3.8. The R&S CMW500 was used as system simulator for VoLTE and VoWiFi T-Coil testing. The DAU (Data Application Unit) in CMW500 integrates IMS and SIP/IP server that can establish VoLTE and Wi-Fi calling, and transport the test tones from AMMI (Audio Magnetic Measuring Instrument) to EUT.

According to KDB 285076 D02 and ANSI C63.19-2019, the applied reference input level applied at the calibrated reference point for legacy protocols fixed to specific air-interfaces are defined in 6.4.3.2 Table 6.1 of ANSI C63.19-2019 or the ANSI C63.19-2019 VoLTE interpretation with −16 dBm0. The normal speech input level for HAC T-coil tests shall be set to -16 dBm0 for GSM, WCDMA and VoLTE. According to KDB 285076 D03 Q&A 9 , for 5G Sub 6 calls that use the same protocol, Codec(s) and reference level as VoLTE over LTE (i.e. -16 dBm0). The technical description below shows a possibility to evaluate and set the correct level with the HAC T-Coil setup with an R&S communication tester with codec.

For protocols not listed in Table 6.1 of ANSI C63.19-2019 or the ANSI C63.19-2019 VoLTE interpretation, the average speech level of −20 dBm0 should be used. For VoWiFi, the average speech level of -20 dBm0 was used for testing.

Reference Audio Input Level:
-16 dBm0 is used for GSM, WCDMA, and VoLTE
-20 dBm0 is used for VoWiFi

The speech levels with the settings at the AF connector of R&S CMW500 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 dBm0 = ***X*** dBV = -3.01 dBV
-16 dBm0 = $\boldsymbol{L_{-16dBm0}}$ dBV = -22.00 dBV
Gain 100 = ***G*** dBV = 3.13 dBV
Difference for -16 dBm0 = $\boldsymbol{D_{-16dBm0}} = \boldsymbol{L_{-16dBm0}} - \boldsymbol{G}$ = -22 – 3.13 = -25.13 dBV
Resulting Gain for -16 dBm0 = 10 ^ ($\boldsymbol{D_{-16dBm0}}$ / 20) x 100 = 5.54
Gain Setting = Resulting Gain x Required Gain Factor
Gain setting for voice 1kHz = 5.54 x 4.33 = 23.99
Gain setting for voice 300-3kHz = 5.54 x 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:

<Example define the input level for -16dBm0>

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

<Example define the input level for -20dBm0>

Signal Type	Duration (s)	Peak to RMS (dB)	RMS (dB)	Gain Factor	Gain Setting
1kHz sine	-	3	0	1	3.44
48k_voice_1kHz	1	16.2	-12.7	4.33	14.91
48k_voice_300-3000	2	21.6	-18.6	8.48	29.20

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.

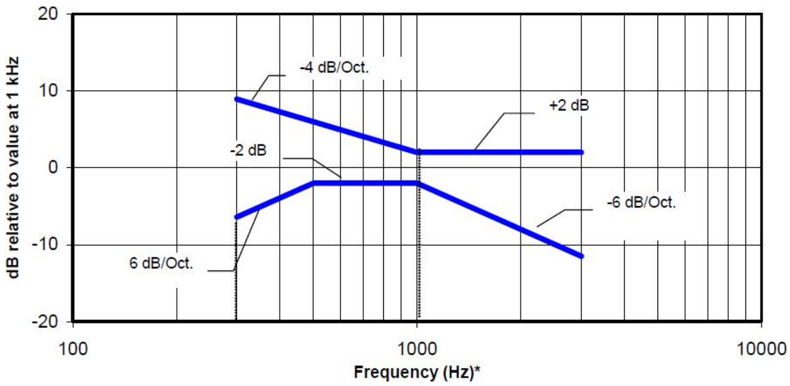


Fig-4.1 Boundaries for EUT with a field ≤ -15 dB (A/m) at 1 kHz

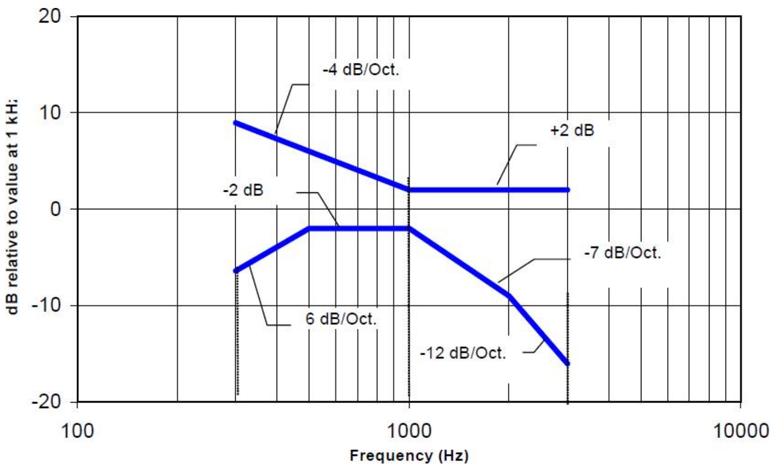


Fig-4.2 Boundaries for EUT with a field > -15 dB (A/m) at 1 kHz

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:
    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.

<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	208	212	**197**	207	199	Transversal (Y)	GSM850 / 189
Secondary Group Contiguous Point Count	618	626	662	636	622		
Secondary Group Max Longitudinal	26	26	26	26	26		
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 Full Rate.

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)	197	662	26	26	PASS	-57.34
P02	GSM1900	Voice	661	Transversal (Y)	192	616	26	26	PASS	-57.41

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	202	196	190	**173**	Transversal (Y)	B5 / 4182
Secondary Group Contiguous Point Count	612	636	608	628		
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 Full Rate.

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)	190	656	26	26	PASS	-57.53
P04	WCDMA V	Voice	4182	Transversal (Y)	173	628	26	26	PASS	-55.27

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	153	**149**	162	157	Transversal (Y)	B2 / 18900
Secondary Group Contiguous Point Count	596	588	582	594		
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	166	168	158	163	Transversal (Y)	B2 / 18900
Secondary Group Contiguous Point Count	566	561	576	582		
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 WB AMR 6.60kbps

<Air Interface Investigation>

Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Probe Position	Primary Group Contiguous Point Count	Frequency Response
LTE B2	20	QPSK	1	0	18900	Transversal (Y)	149	PASS
LTE B2	20	QPSK	100	0	18900	Transversal (Y)	155	PASS
LTE B2	20	16QAM	1	0	18900	Transversal (Y)	151	PASS
LTE B2	20	64QAM	1	0	18900	Transversal (Y)	153	PASS
LTE B2	15	QPSK	1	0	18900	Transversal (Y)	152	PASS
LTE B2	10	QPSK	1	0	18900	Transversal (Y)	155	PASS
LTE B2	5	QPSK	1	0	18900	Transversal (Y)	150	PASS
LTE B2	3	QPSK	1	0	18900	Transversal (Y)	151	PASS
LTE B2	1.4	QPSK	1	0	18900	Transversal (Y)	163	PASS
LTE B2	20	QPSK	1	0	18900	Transversal (Y)	149	PASS

Test Summary

Plot No.	Air Interface	BW (MHz)	Modulation / Mode	RB Size	RB offset	Channel	Sample	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
P05	LTE B2	20	QPSK	1	0	18900	1	Transversal (Y)	149	588	26	26	PASS	-54.26
P06	LTE B5	10	QPSK	1	0	20525	1	Transversal (Y)	172	607	26	26	PASS	-53.12
P07	LTE B12	10	QPSK	1	0	23095	1	Transversal (Y)	127	623	26	26	PASS	-55.09
P08	LTE B13	10	QPSK	1	0	23230	1	Transversal (Y)	151	556	25	26	PASS	-56.07
P09	LTE B66	20	QPSK	1	0	132322	1	Transversal (Y)	134	493	26	26	PASS	-55.19
	LTE B12	10	QPSK	1	0	23095	2	Transversal (Y)	147	562	25	26	PASS	-54.92

3.3.4 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	166	**154**	162	166	Transversal (Y)	WLAN2.4GHz / 6
Secondary Group Contiguous Point Count	546	556	562	558		
Secondary Group Max Longitudinal	25	25	25	26		
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	181	178	196	188	Transversal (Y)	WLAN2.4GHz / 6
Secondary Group Contiguous Point Count	588	582	576	566		
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 WB AMR 6.60kbps

<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)	**154**	PASS
	802.11b	20	11M	6	Transversal (Y)	166	PASS
	802.11g	20	6M	6	Transversal (Y)	163	PASS
	802.11g	20	54M	6	Transversal (Y)	161	PASS
	802.11n-HT20	20	MCS0	6	Transversal (Y)	161	PASS
	802.11n-HT20	20	MCS7	6	Transversal (Y)	165	PASS
	802.11n-HT40	40	MCS0	6	Transversal (Y)	172	PASS
	802.11n-HT40	40	MCS7	6	Transversal (Y)	166	PASS
WLAN5GHz	802.11a	20	6M	40	Transversal (Y)	**158**	PASS
	802.11a	20	54M	40	Transversal (Y)	160	PASS
	802.11an-HT20	20	MCS0	40	Transversal (Y)	245	PASS
	802.11an-HT20	20	MCS7	40	Transversal (Y)	239	PASS
	802.11an-HT40	40	MCS0	38	Transversal (Y)	251	PASS
	802.11an-HT40	40	MCS7	38	Transversal (Y)	255	PASS
	802.11ac-VHT20	20	MCS0	40	Transversal (Y)	164	PASS
	802.11ac-VHT20	20	MCS8	40	Transversal (Y)	162	PASS
	802.11ac-VHT40	40	MCS0	38	Transversal (Y)	163	PASS
	802.11ac-VHT40	40	MCS8	38	Transversal (Y)	169	PASS
	802.11ac-VHT80	80	MCS0	42	Transversal (Y)	172	PASS
	802.11ac-VHT80	80	MCS8	42	Transversal (Y)	175	PASS

Test Summary

Plot No.	Air Interface	BW (MHz)	Modulation / Mode	Channel	Sample	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
P10	802.11b	20	1M	6	1	Transversal (Y)	154	556	25	26	PASS	-52.19
P11	802.11a	20	6M	40	1	Transversal (Y)	150	542	24	26	PASS	-53.02
P12	802.11a	20	6M	60	1	Transversal (Y)	141	547	23	26	PASS	-54.18
P13	802.11a	20	6M	132	1	Transversal (Y)	145	553	24	26	PASS	-53.11
P14	802.11a	20	6M	157	1	Transversal (Y)	155	559	24	26	PASS	-54.09
	802.11a	20	6M	60	2	Transversal (Y)	179	546	24	26	PASS	-54.63

Test Engineer： Chang Gao and Zixiao Xia

4 Calibration of Test Equipment

Equipment	Manufacturer	Model	SN	Cal. Date	Cal. Interval
Audio Band Magnetic Probe	SPEAG	AM1DV3	3144	Feb.16,2023	1 Year
Audio Band Magnetic Probe	SPEAG	AM1DV3	3144	Feb.16,2024	1 Year
Data Acquisition Electronics	SPEAG	DAE	1633	Feb.08,2023	1 Year
Data Acquisition Electronics	SPEAG	DAE	1633	Feb.08,2024	1 Year
Universal Radio Communication Tester	R&S	CMW500	169210	Jun.27,2022	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

4 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

5 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---

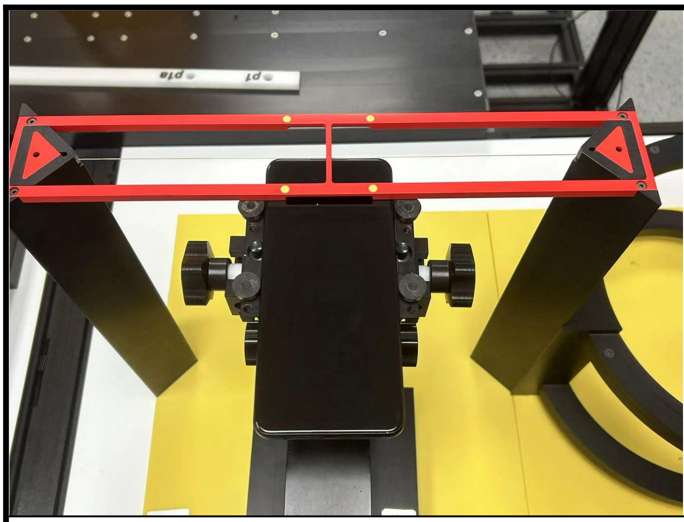
Appendix A. Plots of HAC T-Coil Measurement

The plots for HAC measurement are shown as follows.

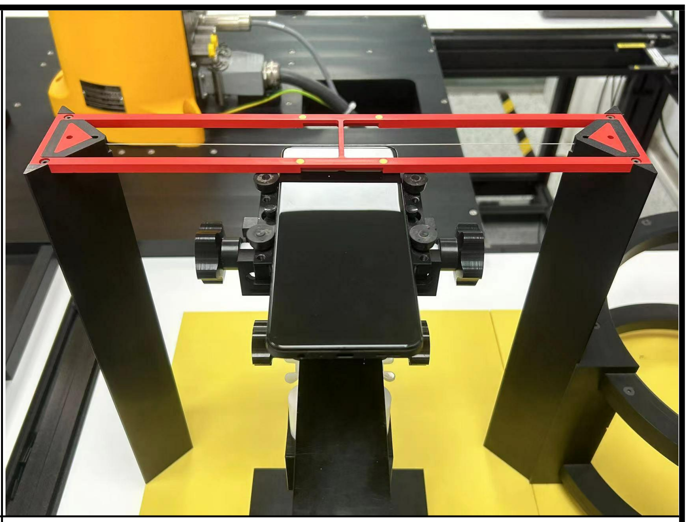
Appendix B. Calibration Certificate for Probe

The SPEAG calibration certificates are shown as follows.

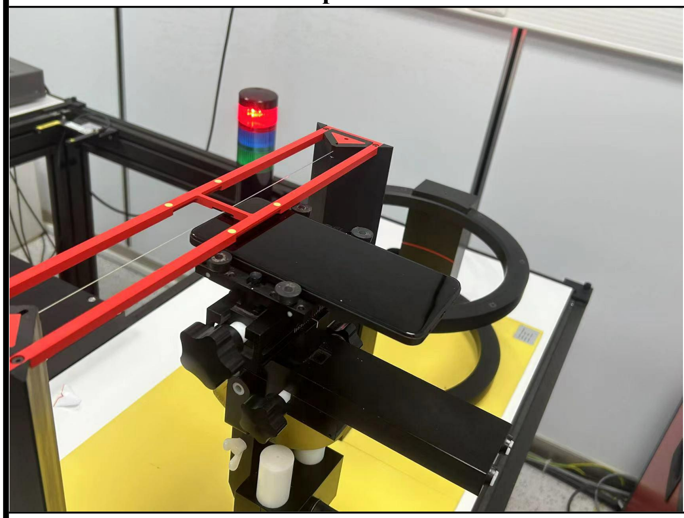
Appendix C. Photographs of EUT and Setup



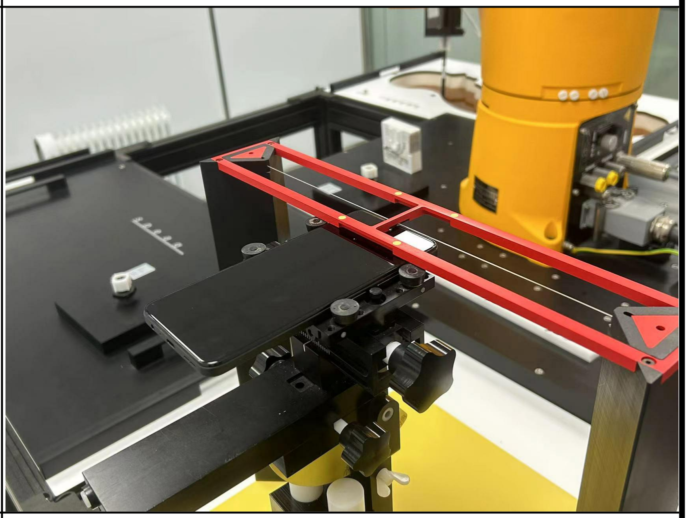
Top View



Bottom View



Left Side View



Right Side View