HAC (T-Coil) Test Report

Report No:	ZR/2020/70008
Applicant:	OnePlus Technology （shenzhen） Co., Ltd.
Manufacturer:	OnePlus Technology （shenzhen） Co., Ltd.
Product Name:	Smart Phone
Model No.(EUT):	BE2011, BE2012, BE2015
Trade Mark:	ONEPLUS
FCC ID:	2ABZ2-EF164
Standards:	ANSI C63.19-2011 CFR 47 FCC Part 20
Date of Receipt:	2020-08-16
Date of Test:	2020-08-31 to 2020-09-17
Date of Issue:	2020-09-18
Test conclusion:	**PASS ***

* In the configuration tested, the EUT detailed in this report complied with the standards specified above.

Authorized Signature:

Derek Yang

Derek Yang
Wireless Laboratory Manager

The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS International Electrical Approvals or testing done by SGS International Electrical Approvals in connection with, distribution or use of the product described in this report must be approved by SGS International Electrical Approvals in writing.

REVISION HISTORY

Revision Record				
Version	Chapter	Date	Modifier	Remark
01		2020-09-18		Original

TEST SUMMARY

Frequency Band	T-rating
GSM850	T4
GSM1900	T4
WCDMA Band II	T4
WCDMA Band IV	T4
WCDMA Band V	T4
CDMA BC0	T4
CDMA BC1	T4
CDMA BC10	T4
LTE Band 2/25	T4
LTE Band 4/66	T4
LTE Band 5/26	T4
LTE Band 7	T3
LTE Band 12/17	T4
LTE Band 13	T4
LTE Band 71	T4
LTE Band 38/41	T3
WiFi2.4G	T3
WiFi5G	T3
HAC Rate Category: T3	

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CONTENTS

1 General Information

1.1 Introduction

The purpose of this standard is to establish categories for hearing aids and for WD (wireless communications devices) that can indicate to health care practitioners and hearing aid users which hearing aids are compatible with which WD, and to provide tests that can be used to assess the electromagnetic characteristics of hearing aids and WD and assign them to these categories. The various parameters required, in order to demonstrate compatibility and accessibility are measured. The design of the standard is such that when a hearing aid and WD achieve one of the categories specified, as measured by the methodology of this standard, the indicated performance is realized.

In order to provide for the usability of a hearing aid with a WD, several factors must be coordinated:

a) Radio frequency (RF) measurements of the near-field electric and magnetic fields emitted by a WD to categorize these emissions for correlation with the RF immunity of a hearing aid.

b) Magnetic field measurements of a WD emitted via the audio transducer associated with the T-coil mode of the hearing aid, for assessment of hearing aid performance.

c) Measurements with the hearing aid and a simulation of the categorized WD T-coil emissions to assess the hearing aid RF immunity in the T-coil mode.

The WD radio frequency (RF) and audio band emissions are measured.

Hence, the following are measurements made for the WD:

a) RF E-Field emissions
b) T-coil mode, magnetic signal strength in the audio band
c) T-coil mode, magnetic signal and noise articulation index
d) T-coil mode, magnetic signal frequency response through the audio band

Corresponding to the WD measurements, the hearing aid is measured for:

a) RF immunity in microphone mode
b) RF immunity in T-coil mode

1.2 Details of Client

Applicant:	OnePlus Technology （shenzhen） Co., Ltd.
Address:	18C02, 18C03, 18C04 and 18C05, Shum Yip Terra Building, Binhe Avenue North, Futian District, Shenzhen,China.
Manufacturer:	OnePlus Technology （shenzhen） Co., Ltd.
Address:	18C02, 18C03, 18C04 and 18C05, Shum Yip Terra Building, Binhe Avenue North, Futian District, Shenzhen,China.

1.3 Test Location

Company:	SGS-CSTC Standards Technical Services Co., Ltd. Xi'an Branch
Address:	Single floor D, building 1, Kanghong orange square science and technology park, No.137 keyuan 3rd road, fengdong new town, Xi 'an city, shaanxi China
Post code:	710086
Telephone:	+86 (0) 29 6282 7885
Fax:	+86 (0) 29 6282 7885
E-mail:	ee.xian@sgs.com

1.4 Test Facility

The test facility is recognized, certified, or accredited by the following organizations:

- **A2LA (Certificate No. 4854.01)**

SGS-CSTC Standards Technical Services Co., Ltd., Xi'an Branch is accredited by the American Association for Laboratory Accreditation(A2LA). Certificate No. 4854.01.

- **FCC –Designation Number: CN1271**

SGS-CSTC Standards Technical Services Co., Ltd., Xi'an Branch has been recognized as an accredited testing laboratory.
Designation Number: CN1271. Test Firm Registration Number: 637380.

- **Innovation, Science and Economic Development Canada**

SGS-CSTC Standards Technical Services Co., Ltd., Xi'an Branch has been recognized by ISED as an accredited testing laboratory.
CAB identifier: CN0095
ISED#: 25613.

1.5 General Description of EUT

Product Name:	Smart Phone		
Model No.(EUT):	BE2011, BE2012, BE2015		
Trade Mark:	ONEPLUS		
Device Type :	portable device		
Exposure Category:	uncontrolled environment / general population		
Product Phase:	production unit		
FCC ID:	2ABZ2-EF164		
SN:	ddcb956d/e34a434a		
Hardware Version:	44		
Software Version:	10.5.5.BE82CB		
Antenna Type:	Inner Antenna		
Device Operating Configurations :			
Modulation Mode:	**GSM:** GMSK, 8PSK; **CDMA:** QPSK; **WCDMA:** QPSK; **LTE:** QPSK,16QAM, 64QAM; **WIFI:** DSSS, OFDM **BT:** GFSK, π/4DQPSK,8DPSK		
Device Class:	B		
GPRS Multi-slots Class:	12	EGPRS Multi-slots Class:	12
HSDPA UE Category:	14	HSUPA UE Category	6
DC-HSDPA UE Category:	24		
Power Class	4,tested with power level 5(GSM850)		
	1,tested with power level 0(GSM1900)		
	3, tested with power control "all up"(CDMA BC0/BC1/BC10)		
	3, tested with power control "all 1"(WCDMA Band II/IV/V)		
	3, tested with power control Max Power(LTE Band 2/4/5/7/12/13/17/25/26/66/71/38/41)		
Frequency Bands:	Band	Tx (MHz)	Rx (MHz)
	GSM850	824~849	869~894
	GSM1900	1850~1910	1930~1990
	WCDMA Band II	1850~1910	1930~1990
	WCDMA Band IV	1710~1755	2110~2155
	WCDMA Band V	824~849	869~894
	CDMA BC0	824~849	869~894
	CDMA BC1	1850~1910	1930~1990
	CDMA BC10	806~824	851~869
	LTE Band 2	1850~1910	1930~1990
	LTE Band 4	1710~1755	2110~2155
	LTE Band 5	824~849	869~894
	LTE Band 7	2500~2570	2620~2690
	LTE Band 12	699~716	729~746
	LTE Band 13	777~787	746~756
	LTE Band 17	704~716	734~746
	LTE Band 25	1850~1915	1930~1995
	LTE Band 26	814~849	859~894
	LTE Band 66	1710~1780	2110~2180
	LTE Band 71	663~698	617~652
	LTE Band 38	2570~2620	2570~2620
	LTE Band 41	2535~2655	2535~2655
	WIFI 2.4G	2412~2462	2412~2462
	WIFI 5G	5150~5250	5150~5250
		5250~5350	5250~5350
		5470~5725	5470~5725

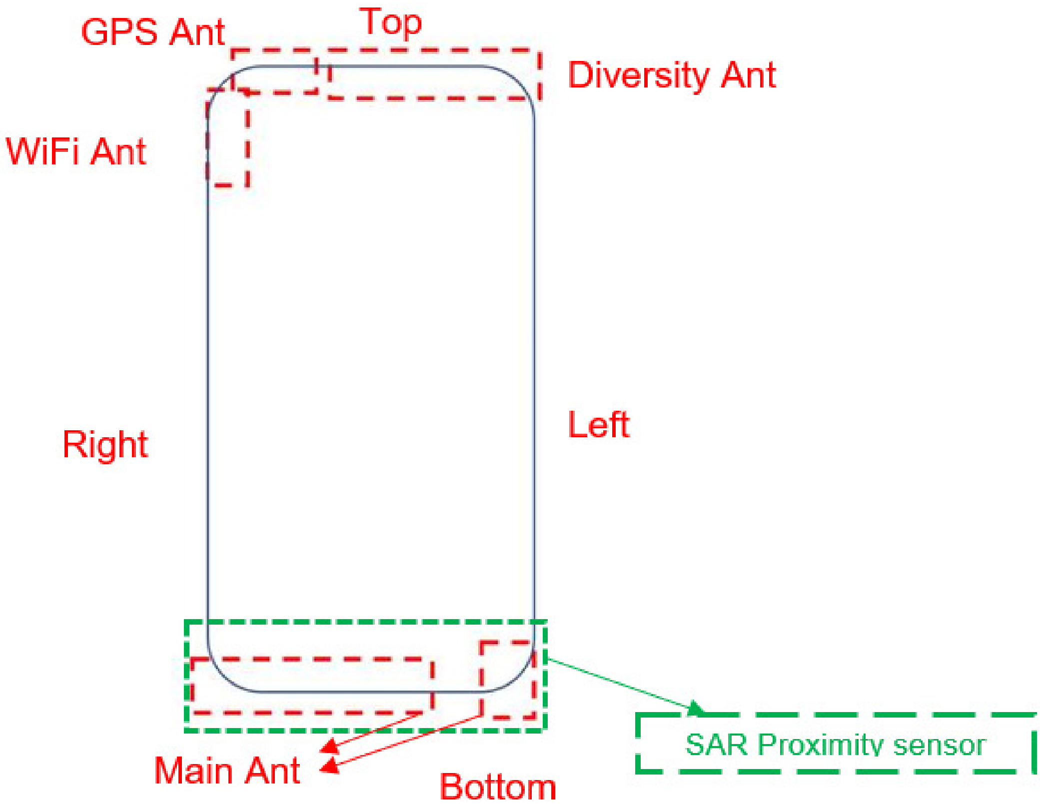
		5725~5850	5725~5850
	BT	2402~2480	2402~2480
Battery Information:	Model:	BLP813	
	Normal Voltage:	+3.87V	
	Rated capacity:	4890mAh	
	Manufacturer:	Huizhou Desay Battery Co., Ltd.	

Remark:
The mobile phone BE2012 and BE2015 and BE2011 are GSM/CDMA/WCDMA/LTE mobile phone. The differences between BE2012 and BE2015 and BE2011 are showed in the following table. They only have different model name, other parts of the mobile phone are the same, including Chipsets, the appearance, Bluetooth mode, Wifi mode, Adapter, Battery, and so on.

Model name	BE2012	BE2011	BE2015
Type	Object of reference	New model	New model
GSM bands	/	The same	The same
WCDMA bands	/	The same	The same
LTE bands	/	The same	The same
SIM card	/	The same	The same
External camera	/	The same	The same
Internal camera	/	The same	The same
FLASH	/	The same	The same
Mainboard	/	The same	The same
PCB layout	/	The same	The same
Appearance	/	The same	The same
Bluetooth mode	/	The same	The same
WLAN mode	/	The same	The same
BT/ WLAN antenna	/	The same	The same
GSM/ WCDMA /LTE antenna	/	The same	The same
Adapter	/	The same	The same
Battery	/	The same	The same
Chipset	/	The same	The same
Memory	/	The same	The same
RF Parameter	/	The same	The same
Dimension	/	The same	The same

Note:
Model No.: BE2012, BE2011, BE2015.
According to the declaration from the applicant, only the Model BE2012 was tested, the Model BE2011 and the Model BE2015 test data please refer to the Model BE2012.

1.5.1 DUT Antenna Locations(Back view)



Note:
1) SAR Proximity sensor location is same as main Ant.
2) The diversity Antenna does not support transmitter function.

1.5.2 List of air interfaces/frequency bands

Air Interface	Band (MHz)	Type	ANSI C63.19 Tested	Simultaneous Transmitter	Name of Voice Service	Power Reduction
GSM	850	VO	Yes	BT, Wi-Fi	CMRS Voice	NA
	1900					
	EDGE	VD	Yes		Google Duo*	
WCDMA	Band II	VO	Yes	BT, Wi-Fi	CMRS Voice	NA
	Band IV					
	Band V					
	HSPA	VD	Yes		Google Duo*	
CDMA	BC0	VO	Yes	BT, Wi-Fi	CMRS Voice	NA
	BC1					
	BC10					
	EVDO	VD	Yes		Google Duo*	
LTE (FDD)	Band 2	VD	Yes	BT, Wi-Fi	VoLTE Google Duo*	NA
	Band 4					
	Band 5					
	Band 7					
	Band 12					
	Band 13					
	Band 17					
	Band 25					
	Band 26					
	Band 66					
	Band 71					
LTE (TDD)	Band 38	VD	Yes	BT, Wi-Fi	VoLTE Google Duo*	NA
	Band 41					
Wi-Fi	2450	VD	Yes	WWAN	Wi-Fi calling* Google Duo*	NA
	5200					
	5300					
	5500					
	5800					
BT	2450	DT	NA	WWAN	NA	NA

VO: Legacy Cellular Voice Service from Table 7.1 in 7.4.2.1 of ANSI C63.19-2011
DT: Digital Transport (no voice)
VD: IP Voice Service over Digital Transport
* For protocols not listed in Table 7.1 of ANSI C63.19-2011 or the ANSI C63.19-2011 VoLTE interpretation, the average speech level of −20 dBm0 should be used.
Note: The device has similar frequency in some LTE bands: LTE 2/25, 4/66, B5/26, B12/17, B38/41, since the supported frequency spans for the smaller LTE bands are completely cover by the larger LTE bands, therefore, only larger LTE bands were required to be tested for hearing-aid compliance.

1.6 Test Specification

Identity	Document Title
CFR 47 FCC Part 20	§20.19 Hearing aid-compatible mobile handsets.
ANSI C63.19-2011	American National Standard for Methods of Measurement of Compatibility between Wireless Communication Devices
KDB 285076 D01	HAC Guidance v05r01
KDB 285076 D02	T-Coil testing v03
KDB 285076 D03	HAC FAQ v01r02

2 Calibration certificate

Temperature	Min. = 18°C, Max. = 25 °C
Relative humidity	Min. = 30%, Max. = 70%

Table 1： The Ambient Conditions

3 HAC (T-Coil) Measurement System

3.1 Measurement System Diagram for SPEAG Robotic

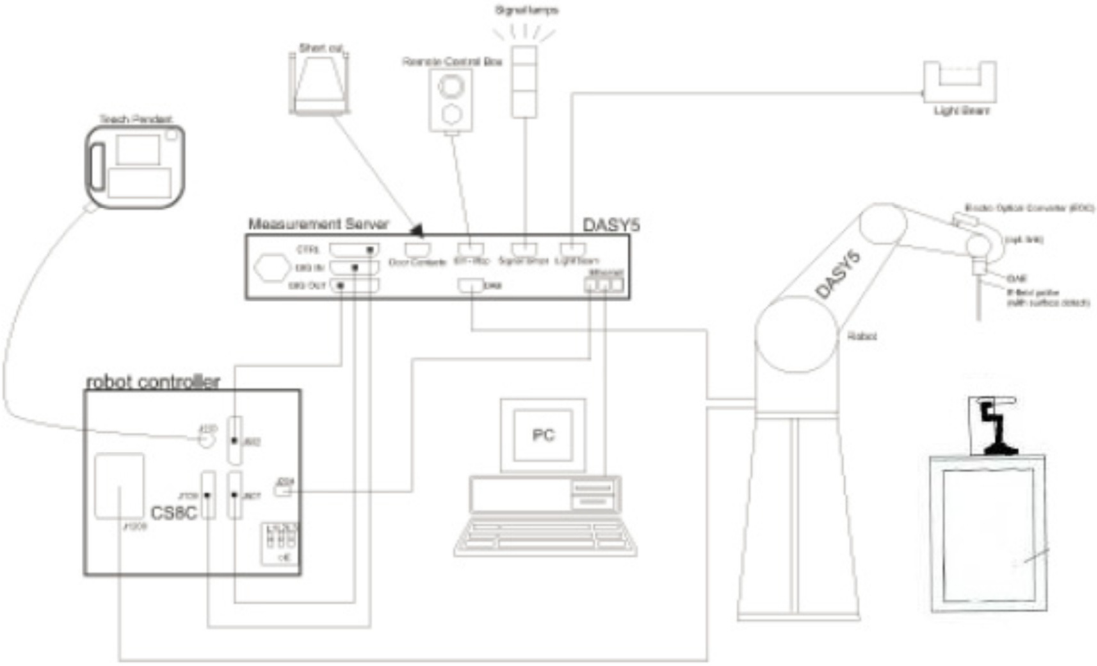


Fig. 1. The SPEAG Robotic Diagram

The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stabile RX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
- An Audio Magnetic probe.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7.
- DASY5 software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The Test Arch SAM phantom
- The device holder for handheld mobile phones.
- Validation dipole kits allowing to validate the proper functioning of the system.

3.2 T-Coil Measurement Set-up

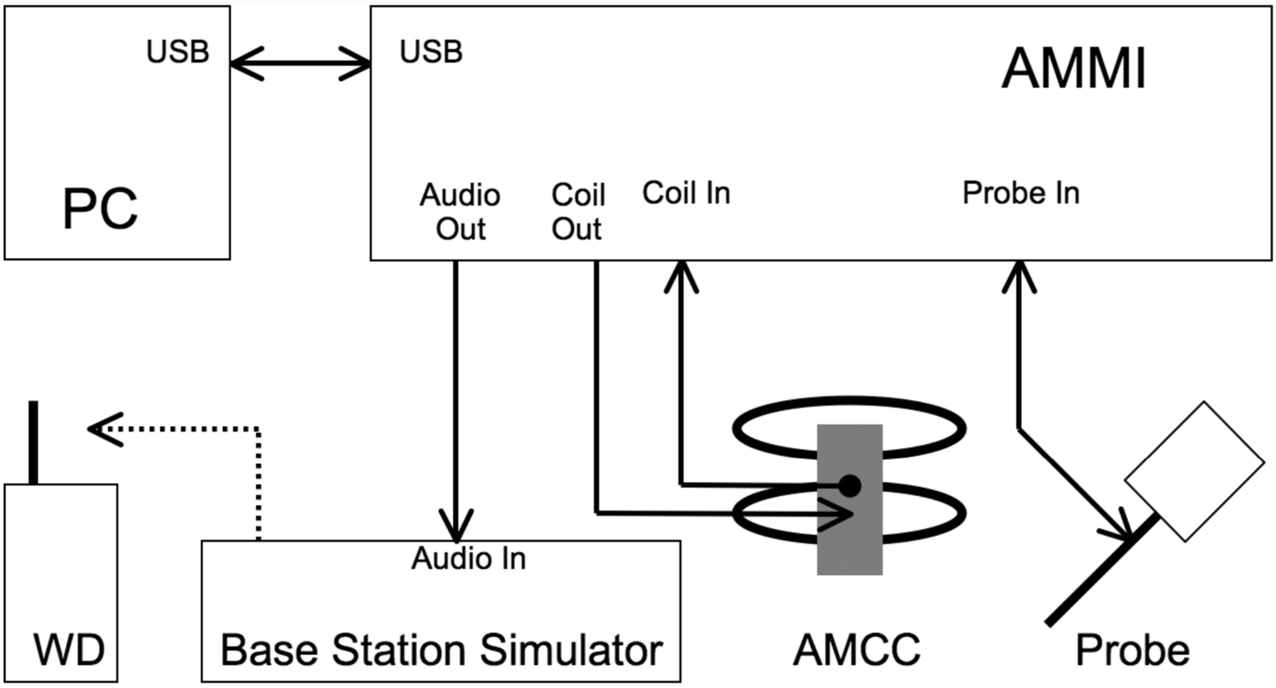


Fig. 2. T-coil signal measurement test setup

The sequence of the measurement is T-Coil testing procedure over a wireless communication device:

1. Confirm Geometry & signal check. Probe phantom alignment and check of accuracy.
2. Background noise measurement in the area of the WD.
3. Perform 50x50mm area scan with narrow band signal to determine ABM1, ABM2 and SNR for axial and radial orientation positions.
4. For Axial position, perform optimal SNR point measurement with a broadband signal – determine Frequency Response
5. Define the all applicable input audio level according to ANSI C63.19-2011 and KDB 285076 D02v03.

Note.

#. The EUT do not use the special HAC SW.
#. Setting the maximum volume for EUT during the measurement.
#. For the measurement, it don't use the "post-test measurement processing of results".
#. Per KDB 285076 D01v05, handsets that that have the ability to support concurrent connections using simultaneous transmissions shall be independently tested for each air interface/band given in ANSI C63.19-2011. At the present time ANSI C63.19 does not provide simultaneous transmission test procedures.

3.3 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 mVpp 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 mVpp 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 mVRMS during the first phase and 10 mVRMS 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.

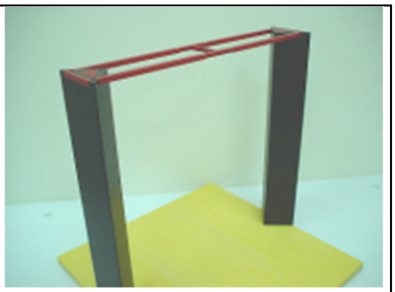
In phase 3, a multi-sine signal covering each third-octave band from 50 Hz to 10 kHz is generated and applied to both audio outputs. The probe should be positioned in the center of the AMCC and aligned in the z-direction, the field orientation of the AMCC. The “Coil In” channel is measuring the voltage 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.

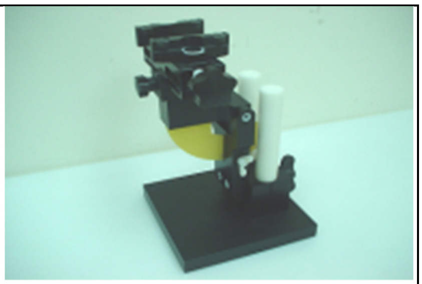
3.4 Audio Magnetic Probe AM1DV3

Description	Active single sensor probe for both axial and radial measurement scans- Fully RF shielded, compatible with DAE, with adapted probe cup	 AM1DV3 Audio Probe
Dynamic Range	0.1 KHz to 20 KHz	
Sensitivity	<-50dB A/m @ 1KHz	
Internal Amp	20dB	
Dimensions	300X18mm	

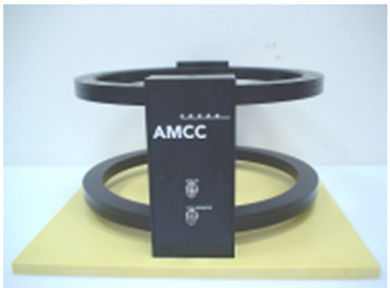
3.5 Test Arch

Description	Enables easy and well defined positioning of the phone and validation dipoles as well as simple teaching of the robot.	 Test Arch
Dimensions	length: 370 mm width: 370 mm height: 370 mm	

3.6 Phone Holder

Description	Supports accurate and reliable positioning of any phone Effect on near field <+/- 0.5 dB	 Phone Holder

3.7 AMCC- Audio Magnetic Calibration Coil

Description	Allows calibration of the complete measurement setup, the two horizontal coils create a homogeneous magnetic field in the z direction. Refer to Appendix 5 for more detail on AMCC coil	 AMCC

3.8 AMMI - Audio Magnetic Measurement Instrument

Description	-USB interface to PC - Probe signal digitization and power supply- Test signal generation for wireless device (via base station simulator)- Auto-calibration and interfaces to AMCC for complete setup-calibration	 AMMI
Data Rate	48 KHz / 24bit	
Dynamic Range	85 dB	
Dimensions:	19" X 65 X 270mm	

4 Measurement uncertainty evaluation

Error Description	Uncertainty Value (%)	Probability Dist.	Divisor	ci ABM1	ci ABM2	Standard Uncertainty ABM1 (%)	Standard Uncertainty ABM2 (%)
Related to probe sensitivity							
Reference level	±3.0	R	$\sqrt{3}$	1	1	±3.0	±3.0
AMCC geometry	±0.4	R	$\sqrt{3}$	1	1	±0.2	±0.2
AMCC current	±0.6	R	$\sqrt{3}$	1	1	±0.4	±0.4
Probe positioning during calibration	±0.2	R	$\sqrt{3}$	1	1	±0.1	±0.1
Noise distribution	±0.7	R	$\sqrt{3}$	0.0143	1	±0.0	±0.4
Frequency slope	±5.9	R	$\sqrt{3}$	0.1	1	±0.3	±3.5
Related to probe system							
Repeatability / drift	±1.0	R	$\sqrt{3}$	1	1	±0.6	±0.6
Linearity / dynamic range	±0.6	N	1	1	1	±0.4	±0.4
Audio noise	±1.0	R	$\sqrt{3}$	0.1	1	±0.1	±0.6
Probe angle	±2.3	R	$\sqrt{3}$	1	1	±1.4	±1.4
Spectral Processing	±0.9	R	$\sqrt{3}$	1	1	±0.5	±0.5
Integration time	±0.6	N	1	1	5	±0.6	±3.0
Field distribution	±0.2	R	$\sqrt{3}$	1	1	±0.1	±0.1
Test signal							
Reference signal spectrum response	±0.6	R	$\sqrt{3}$	0	1	±0.0	±0.4
Positioning							
Probe positioning	±1.9	R	$\sqrt{3}$	1	1	±1.1	±1.1
Phantom Thickness	±0.9	R	$\sqrt{3}$	1	1	±0.5	±0.5
DUT positioning	±1.9	R	$\sqrt{3}$	1	1	±1.1	±1.1
External Contributions							
RF interference	±0.0	R	$\sqrt{3}$	1	0.3	±0.0	±0.0
Test Signal Variation	±2.0	R	$\sqrt{3}$	1	1	±1.2	±1.2
Combined Std. Uncertainty (ABM Field)	$u_c^{'} = \sqrt{\sum_{i=1}^{20} c_i^2 u_i^2}$					±4.1	±6.2
Expanded Std. Uncertainty (K=2)						±8.2	±12.4

Table 2： Measurement uncertainties for T-Coil

5 HAC (T-Coil) Measurement

5.1 T-Coil Performance Requirements

In order to be rated for T-Coil use, a WD shall meet the requirements for signal level and signal quality contained in this part.

1) T-Coil coupling field intensity
When measured as specified in ANSI C63.19, the T-Coil signal shall be ≥ –18 dB (A/m) at 1 kHz, in a 1/3 octave band filter for all orientations.

2) Frequency response
The frequency response of the axial component of the magnetic field, measured in 1/3 octave bands, shall follow the response curve specified in this sub-clause, over the frequency range 300 Hz to 3000 Hz. Figure 1 and Figure 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.

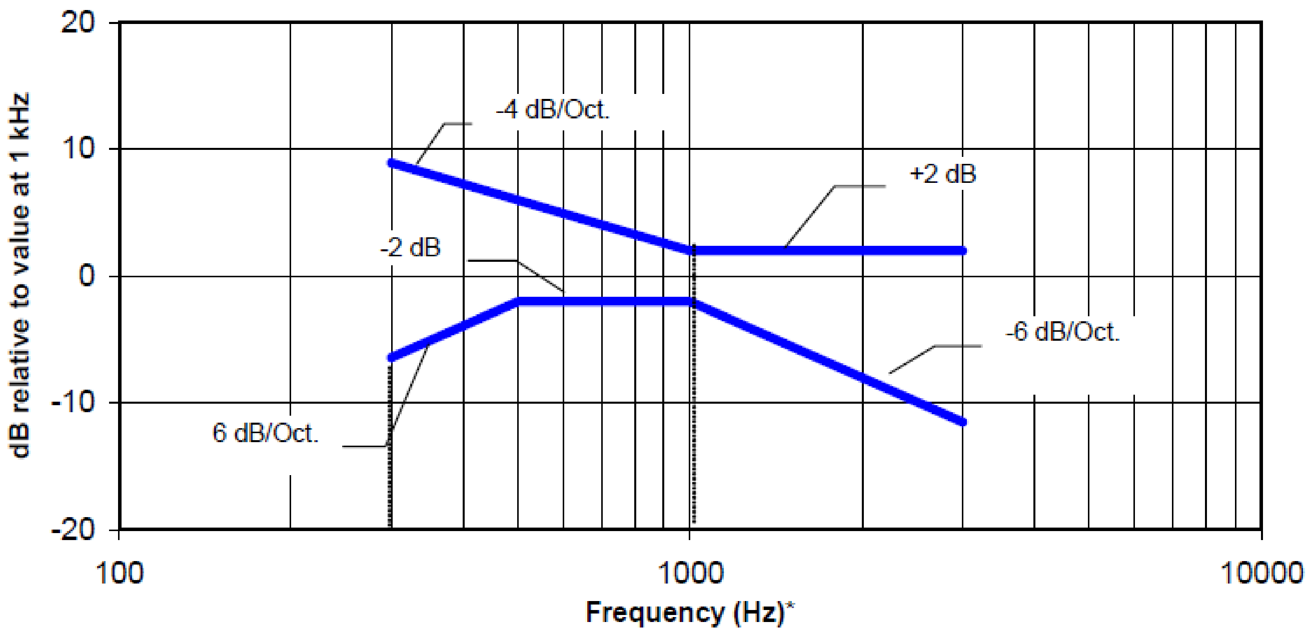


Figure 1—Magnetic field frequency response for WDs with a field ≤ –15 dB (A/m) at 1 kHz

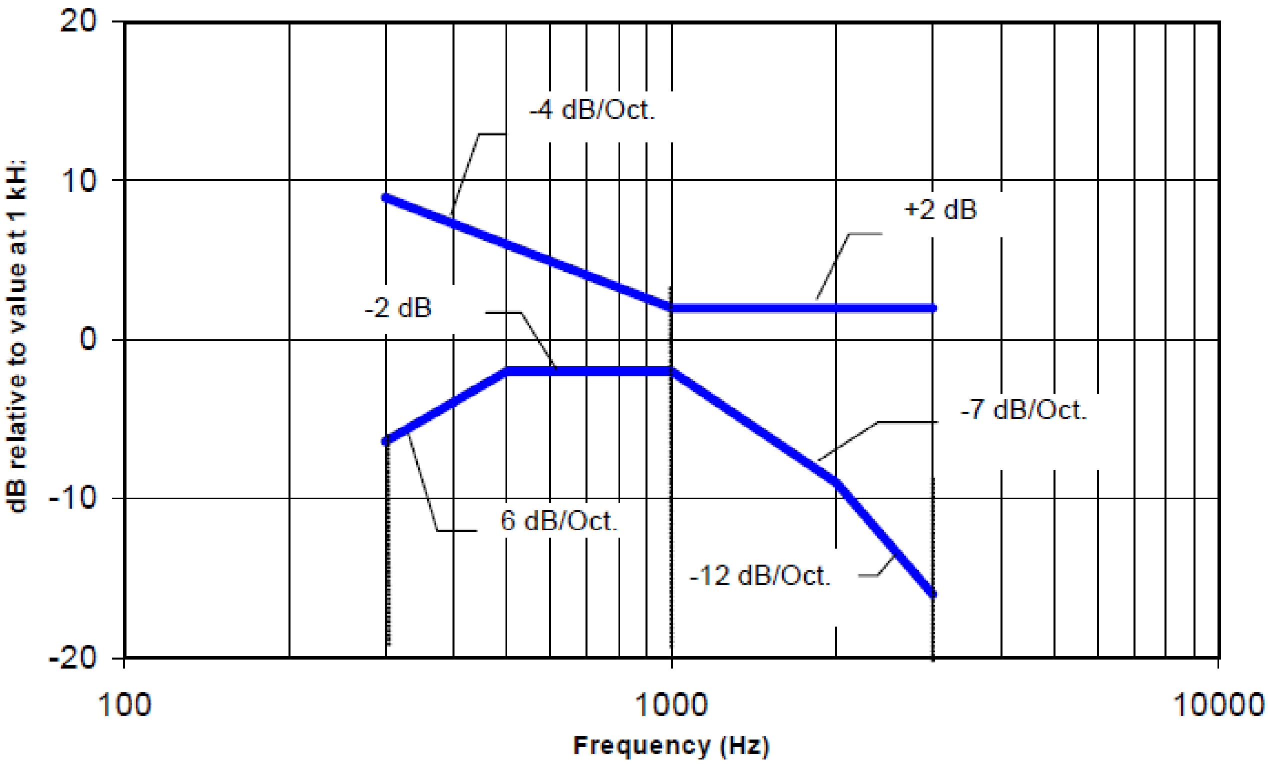


Figure 2 —Magnetic field frequency response for WDs with a field that exceeds –15dB(A/m) at 1 kHz

3) Signal quality

This part provides the signal quality requirement for the intended T-Coil signal from a WD. Only the RF immunity of the hearing aid is measured in T-Coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. So, the only criteria that can be measured is the RF immunity in T-Coil mode. This is measured using the same procedure as for the audio coupling mode and at the same levels.

The worst signal quality of the three T-Coil signal measurements shall be used to determine the T-Coil mode category per Table 3

Category	Telephone parameters WD signal quality [(signal + noise) – to – noise ratio in decibels]
Category T1	0 dB to 10 dB
Category T2	10 dB to 20 dB
Category T3	20 dB to 30 dB
Category T4	> 30 dB

Table 3： T-Coil signal quality categories

5.2 T-Coil measurement points and reference plane

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

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

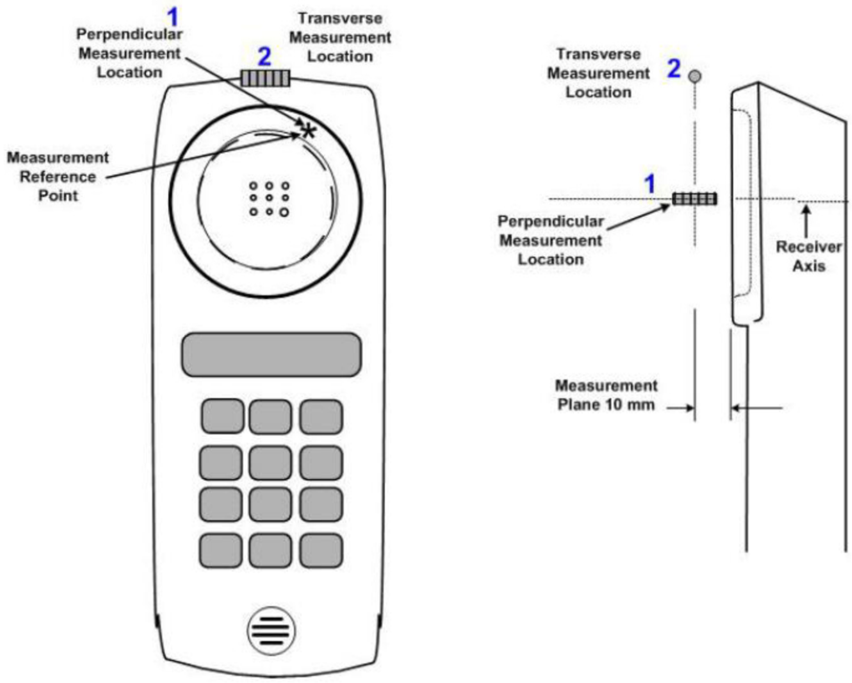


Figure 3 Axis and planes for WD audio frequency magnetic field measurements

5.3 T-Coil Measurement Procedure

According to ANSI C63.19-2011, section 7.4:
This section describes the procedures used to measure the ABM (T-Coil) performance of the WD. In addition to measuring the absolute signal levels, the A-weighted magnitude of the unintended signal shall also be determined. To assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal must be made at the same location for each measurement position. In addition, the RF field strength at each measurement location must be at or below that required for the assigned category.
Measurements shall not include undesired properties from the WD's RF field; therefore, use of a coaxial connection to a base station simulator or nonradiating load might be necessary. However, even with a coaxial connection to a base station simulator or nonradiating load, there might still be RF leakage from the WD, which can interfere with the desired measurement. Premeasurement checks should be made to avoid this possibility. All measurements shall be performed with the WD operating on battery power with an appropriate normal speech audio signal input level given in ANSI C63.19-2011 Table 7.1. If the device display can be turned off during a phone call, then that may be done during the measurement as well.
Measurements shall be performed at two locations specified in ANSI C63.19-2011 A.3, with the correct probe orientation for aparticular location, in a multistage sequence by first measuring the field intensity of the desired T-Coil signal (ABM1) that is useful to a hearing aid T-Coil. The undesired magnetic components (ABM2) shall be examined for each probe orientation to determine the possible effects from the WD display and battery current paths that might disrupt the desired T-Coil signal. The undesired magnetic signal (ABM2) must be measured at the same location as the desired ABM or T-Coil signal (ABM1), and the ratio of desired to undesired ABM signals must be calculated. For the perpendicular field location, only the ABM1 frequency response shall be determined in a third measurement stage.
The following steps summarize the basic test flow for determining ABM1 and ABM2. These steps assume that a sine-wave or narrowband 1/3 octave signal can be used for the measurement of ABM1.
a) A validation of the test setup and instrumentation may be performed using a TMFS or Helmholtz coil. Measure the emissions and confirm that they are within the specified tolerance.
b) Position the WD in the test setup and connect the WD RF connector to a base station simulator or a nonradiating load as shown in ANSI C63.19-2011 Figure 7.1 or Figure 7.2. Confirm that the equipment that requires calibration has been calibrated and that the noise level meets the requirements of ANSI C63.19-2011 clause 7.3.1.
c) The drive level to the WD is set such that the reference input level specified in ANSI C63.19-2011Table 7.1 is input to the base station simulator (or manufacturer's test mode equivalent) in the 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (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 C63.19-2011 clause 7.4.2, shall be used for the reference audio signal. If interference is found at 1025 Hz, an alternative nearby reference audio signal frequency may be used.47 The same drive level shall be used for the ABM1 frequency response measurements at each 1/3 octave band center frequency.The WD volume control may be set at any level up to maximum, provided that a signal at any frequency at maximum modulation would not result in clipping or signal overload.
d) Determine the magnetic measurement locations for the WD device (A.3), if not already specified by the manufacturer, as described in C63.19-2011 clause 7.4.4.1.1 and 7.4.4.2.
e) At each measurement location, measure and record the desired T-Coil magnetic signals (ABM1 at fi) as specified in C63.19-2011 clause 7.4.4.2 in each ISO 266-1975 R10 standard 1/3 octave band. The desired audio band input frequency (fi) shall be centered in each 1/3 octave band maintaining the same drive level as determined in item c) and the reading taken for that band.
f) Equivalent methods of determining the frequency response may also be employed, such as fast Fourier transform (FFT) analysis using noise excitation or input–output comparison using simulated speech. The full-band integrated or half-band integrated probe output, as specified in D.9, may be used, as long as the appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB A/m.)
g) All measurements of the desired signal shall be shown to be of the desired signal and not of an undesired signal. This may be shown by turning the desired signal ON and OFF with the probe measuring the same location. If the scanning method is used, the scans shall show that all measurement points selected for the ABM1 measurement meet the ambient and test system noise criteria in C63.19-2011 clause 7.3.1.
h) At the measurement location for each orientation, measure and record the undesired broadband audio magnetic signal (ABM2) as specified in C63.19-2011 clause 7.4.4.4 with no audio signal applied (or digital zero applied, if appropriate) using A-weighting49 and the half-band integrator. Calculate the ratio of the desired to undesired signal strength (i.e., signal quality).
g) Determine the category that properly classifies the signal quality, based on C63.19-2011 Table 8.5.

6 T-Coil testing for CMRS Voice

6.1 General Description

1. Codec Investigation:

For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following worst investigation codec would be remarked to be used for the testing for the handset.

2. Air Interface Investigation:

a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface.

b. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

6.2 GSM Tests Results

Codec Investigation:

Band	Test Mode	Codec Setting	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
GSM850	GSM Voice	FR V1	190/836.6	Axial (Z)	17.43	-21.93	**39.36**	T4	1.27	PASS
	GSM Voice	HR V1	190/836.6	Axial (Z)	17.73	-23.39	41.12	T4	1.85	PASS

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

Air Interface Investigation:

Band	Test Mode	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
GSM850	GSM Voice	190/836.6	Axial (Z)	17.43	-21.93	39.36	T4	1.27	PASS
			Transversal (Y)	7.90	-36.54	44.44	T4	N/A	/
GSM1900	GSM Voice	661/1880	Axial (Z)	16.78	-26.61	43.39	T4	1.56	PASS
			Transversal (Y)	7.67	-36.91	44.58	T4	N/A	/

Remark:

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

6.3 UMTS Tests Results

Codec Investigation:

Band	Test Mode	Codec Setting	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WCDMA Band V	AMR Voice	4.75kbps	4182/836.4	Axial (Z)	16.63	-31.21	47.84	T4	1.40	PASS
	AMR Voice	7.95kbps	4182/836.4	Axial (Z)	16.87	-31.48	48.35	T4	1.91	PASS
	AMR Voice	12.2kbps	4182/836.4	Axial (Z)	16.37	-31.02	**47.39**	T4	1.61	PASS

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

Air Interface Investigation:

Band	Test Mode	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WCDMA Band II	AMR Voice	9400/1900	Axial (Z)	16.97	-33.35	50.32	T4	1.66	PASS
			Transversal (Y)	7.65	-39.29	46.94	T4	N/A	/
WCDMA Band IV	AMR Voice	1412/1732.4	Axial (Z)	16.48	-33.00	49.48	T4	1.37	PASS
			Transversal (Y)	7.92	-39.86	47.78	T4	N/A	/
WCDMA Band V	AMR Voice	4182/836.4	Axial (Z)	16.37	-31.02	47.39	T4	1.61	PASS
			Transversal (Y)	7.94	-38.46	46.40	T4	N/A	/

Remark:
1. Phone Condition: Mute on; Backlight off; Max Volume
2. The detail frequency response results please refer to appendix A.

6.4 CDMA Tests Results

Codec Investigation:

Band	Test Mode	Codec Setting	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
CDMA BC0	1/8th Rate	RC1 SO68	384/836.52	Axial (Z)	15.19	-30.69	45.88	T4	1.06	PASS
	1/8th Rate	RC3 SO68	384/836.52	Axial (Z)	15.10	-30.15	**45.25**	T4	1.34	PASS
	1/8th Rate	RC4 SO68	384/836.52	Axial (Z)	16.20	-31.81	48.01	T4	1.91	PASS

Remark: According to codec investigation, the worst codec is **RC3 SO68**.

Air Interface Investigation:

Band	Test Mode	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
CDMA BC0	1xRTT, RC3 SO68, 1/8th Rate	384/836.52	Axial (Z)	15.10	-30.15	45.25	T4	1.34	PASS
			Transversal (Y)	6.67	-38.98	45.65	T4	N/A	/
CDMA BC1	1xRTT, RC3 SO68, 1/8th Rate	600/1880	Axial (Z)	14.80	-31.62	46.42	T4	0.64	PASS
			Transversal (Y)	6.48	-38.16	44.64	T4	N/A	/
CDMA BC10	1xRTT, RC3 SO68, 1/8th Rate	580/820.5	Axial (Z)	14.04	-31.30	45.34	T4	1.35	PASS
			Transversal (Y)	6.28	-38.87	45.15	T4	N/A	/

Remark:
1. Phone Condition: Mute on; Backlight off; Max Volume
2. The detail frequency response results please refer to appendix A.

7 T-Coil testing for CMRS IP Voice

7.1 VoLTE Tests Results

1. Codec Investigation:

For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel / band, the following worst investigation codec would be remarked to be used for the testing for the handset.

2. Air Interface Investigation:

a. Use the worst-case codec test and document a limited set of bands / channel / bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface and the following worst configure would be remarked to be used for the testing for the handset.

b. Select LTE FDD/TDD one frequency band to do measurement at the worst SNR position was additionally performed with varying the BWs/Modulations/RB size to verify the variation to find out worst configuration, the observed variation is very little to be within 1.5 dB which is much less than the margin from the rating threshold.

c. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

Codec Investigation:

LTE FDD

Band	Test Mode	Codec Setting	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
LTE Band 25	20M QPSK 1RB_0	WB AMR 6.60kbps	26365/1882.5	Axial (Z)	14.36	-31.65	46.01	T4	1.56	PASS
	20M QPSK 1RB_0	WB AMR 23.85kbps	26365/1882.5	Axial (Z)	14.55	-30.81	45.36	T4	1.01	PASS
	20M QPSK 1RB_0	NB AMR 4.75kbps	26365/1882.5	Axial (Z)	14.34	-31.05	45.39	T4	1.95	PASS
	20M QPSK 1RB_0	NB AMR 12.2kbps	26365/1882.5	Axial (Z)	14.09	-30.48	**44.57**	T4	2.00	PASS
LTE Band 25	20M QPSK 1RB_0	SWB EVS 9.60kbps	26365/1882.5	Axial (Z)	16.80	-30.15	46.95	T4	0.38	PASS
	20M QPSK 1RB_0	SWB EVS 13.2kbps	26365/1882.5	Axial (Z)	16.92	-31.51	48.43	T4	1.39	PASS
	20M QPSK 1RB_0	WB EVS 5.90kbps	26365/1882.5	Axial (Z)	14.47	-30.76	45.23	T4	1.28	PASS
	20M QPSK 1RB_0	WB EVS 13.2kbps	26365/1882.5	Axial (Z)	17.10	-29.50	46.60	T4	1.80	PASS
	20M QPSK 1RB_0	NB EVS 5.90kbps	26365/1882.5	Axial (Z)	14.99	-30.48	45.47	T4	1.24	PASS
	20M QPSK 1RB_0	NB EVS 13.2kbps	26365/1882.5	Axial (Z)	14.80	-30.42	45.22	T4	0.87	PASS

Remark: According to codec investigation, the worst codec is **NB AMR 12.2kbps**.

LTE TDD

Band	Test Mode	Codec Setting	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
LTE Band 41	20M QPSK 1RB_0	WB AMR 6.60kbps	40620/2593	Axial (Z)	16.98	-27.45	44.43	T4	0.47	PASS
	20M QPSK 1RB_0	WB AMR 23.85kbps	40620/2593	Axial (Z)	18.19	-27.01	45.20	T4	1.32	PASS
	20M QPSK 1RB_0	NB AMR 4.75kbps	40620/2593	Axial (Z)	17.05	-27.43	44.48	T4	0.77	PASS
	20M QPSK 1RB_0	NB AMR 12.2kbps	40620/2593	Axial (Z)	17.04	-27.49	44.53	T4	1.91	PASS
LTE Band 41	20M QPSK 1RB_0	SWB EVS 9.60kbps	40620/2593	Axial (Z)	17.02	-27.54	44.56	T4	1.05	PASS
	20M QPSK 1RB_0	SWB EVS 13.2kbps	40620/2593	Axial (Z)	16.91	-27.86	44.77	T4	1.38	PASS
	20M QPSK 1RB_0	WB EVS 5.90kbps	40620/2593	Axial (Z)	14.37	-27.22	41.59	T4	1.27	PASS
	20M QPSK 1RB_0	WB EVS 13.2kbps	40620/2593	Axial (Z)	17.56	-27.64	45.20	T4	1.93	PASS
	20M QPSK 1RB_0	NB EVS 5.90kbps	40620/2593	Axial (Z)	10.57	-26.50	**37.07**	T4	1.10	PASS
	20M QPSK 1RB_0	NB EVS 13.2kbps	40620/2593	Axial (Z)	17.22	-27.40	44.62	T4	2.00	PASS

Remark: According to codec investigation, the worst codec is **NB EVS 5.90kbps**.

Air Interface Investigation:

Band	Test Mode	Test Ch./Freq.	UL-DL Configuration	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
LTE Band 25	20M QPSK 1RB_0	26365/1882.5	-	Axial (Z)	14.09	-30.48	**44.57**	T4	2.00	PASS
	20M QPSK 1RB_50	26365/1882.5	-	Axial (Z)	16.90	-28.81	45.71	T4	1.44	PASS
	20M QPSK 1RB_99	26365/1882.5	-	Axial (Z)	16.37	-28.34	44.71	T4	1.67	PASS
	20M QPSK 50RB_0	26365/1882.5	-	Axial (Z)	16.60	-30.37	46.97	T4	1.55	PASS
	20M QPSK 50RB_25	26365/1882.5	-	Axial (Z)	16.35	-31.43	47.78	T4	1.53	PASS
	20M QPSK 50RB_50	26365/1882.5	-	Axial (Z)	16.21	-31.33	47.54	T4	1.24	PASS
	20M QPSK 100RB_0	26365/1882.5	-	Axial (Z)	17.12	-29.44	46.56	T4	1.02	PASS
	20M 16QAM 1RB_0	26365/1882.5	-	Axial (Z)	16.31	-30.46	46.77	T4	1.67	PASS
	20M 64QAM 1RB_0	26365/1882.5	-	Axial (Z)	15.83	-30.54	46.37	T4	1.28	PASS
	15M QPSK 1RB_0	26365/1882.5	-	Axial (Z)	15.30	-30.77	46.07	T4	1.18	PASS
	10M QPSK 1RB_0	26365/1882.5	-	Axial (Z)	15.72	-30.36	46.08	T4	1.19	PASS
	5M QPSK 1RB_0	26365/1882.5	-	Axial (Z)	15.45	-30.66	46.11	T4	0.93	PASS
	3M QPSK 1RB_0	26365/1882.5	-	Axial (Z)	15.92	-30.37	46.29	T4	1.16	PASS
	1.4M QPSK 1RB_0	26365/1882.5	-	Axial (Z)	16.01	-30.29	46.30	T4	1.14	PASS
LTE Band 41 (PC3)	20M QPSK 1RB_0	40620/2593	0	Axial (Z)	10.57	-26.50	**37.07**	T4	1.10	PASS
	20M QPSK 1RB_50	40620/2593	0	Axial (Z)	12.42	-27.14	39.56	T4	1.20	PASS
	20M QPSK 1RB_99	40620/2593	0	Axial (Z)	13.60	-27.65	41.25	T4	1.32	PASS
	20M QPSK 50RB_0	40620/2593	0	Axial (Z)	12.73	-27.76	40.49	T4	1.13	PASS
	20M QPSK 50RB_25	40620/2593	0	Axial (Z)	12.76	-27.82	40.58	T4	1.61	PASS
	20M QPSK 50RB_50	40620/2593	0	Axial (Z)	11.32	-27.52	38.84	T4	1.68	PASS
	20M QPSK 100RB_0	40620/2593	0	Axial (Z)	12.43	-27.67	40.10	T4	2.00	PASS
	20M 16QAM 1RB_99	40620/2593	0	Axial (Z)	10.66	-26.97	37.63	T4	1.97	PASS
	20M 64QAM 1RB_0	40620/2593	0	Axial (Z)	10.76	-27.74	38.50	T4	0.27	PASS
	15M QPSK 1RB_0	40620/2593	0	Axial (Z)	13.76	-27.31	41.07	T4	0.65	PASS
	10M QPSK 1RB_0	40620/2593	0	Axial (Z)	13.91	-27.29	41.20	T4	0.65	PASS
	5M QPSK 1RB_0	40620/2593	0	Axial (Z)	14.08	-27.21	41.29	T4	0.96	PASS
	20M QPSK 1RB_0	40620/2593	1	Axial (Z)	12.58	-28.54	41.12	T4	1.84	PASS
	20M QPSK 1RB_0	40620/2593	2	Axial (Z)	14.38	-28.14	42.52	T4	1.18	PASS
	20M QPSK 1RB_0	40620/2593	3	Axial (Z)	13.09	-28.91	42.00	T4	0.40	PASS
	20M QPSK 1RB_0	40620/2593	4	Axial (Z)	12.27	-29.28	41.55	T4	1.27	PASS
	20M QPSK 1RB_0	40620/2593	5	Axial (Z)	12.03	-29.50	41.53	T4	1.05	PASS
	20M QPSK 1RB_0	40620/2593	6	Axial (Z)	14.12	-27.86	41.98	T4	1.98	PASS
LTE Band 41 (PC2)	20M QPSK 1RB_0	40620/2593	1	Axial (Z)	12.52	-26.04	38.56	T4	1.56	PASS
	20M QPSK 1RB_0	40620/2593	2	Axial (Z)	11.14	-26.80	37.94	T4	1.36	PASS
	20M QPSK 1RB_0	40620/2593	3	Axial (Z)	12.66	-27.64	40.30	T4	1.44	PASS
	20M QPSK 1RB_0	40620/2593	4	Axial (Z)	11.46	-28.41	39.87	T4	0.93	PASS
	20M QPSK 1RB_0	40620/2593	5	Axial (Z)	12.86	-27.70	40.56	T4	1.20	PASS

Air interface:

Band	Test Mode	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
LTE Band 7	20M QPSK 1RB_0	21100/2535	Axial (Z)	15.97	-29.28	45.25	T4	1.75	PASS
			Transversal (Y)	6.78	-37.41	44.19	T4	N/A	/
LTE Band 12	10M QPSK 1RB_0	23095/707.5	Axial (Z)	16.29	-31.11	47.40	T4	1.52	PASS
			Transversal (Y)	7.05	-37.92	44.97	T4	N/A	/
LTE Band 13	10M QPSK 1RB_0	23230/782	Axial (Z)	16.27	-31.53	47.80	T4	1.01	PASS
			Transversal (Y)	7.99	-37.51	45.50	T4	N/A	/
LTE Band 25	20M QPSK 1RB_0	26365/1882.5	Axial (Z)	14.09	-30.48	44.57	T4	2.00	PASS
			Transversal (Y)	7.50	-37.48	44.98	T4	N/A	/
LTE Band 26	15M QPSK 1RB_0	26865/831.5	Axial (Z)	16.39	-29.87	46.26	T4	1.85	PASS
			Transversal (Y)	6.90	-37.56	44.46	T4	N/A	/
LTE Band 66	20M QPSK 1RB_0	132322/1745	Axial (Z)	16.65	-30.81	47.46	T4	1.17	PASS
			Transversal (Y)	7.04	-37.21	44.25	T4	N/A	/
LTE Band 71	20M QPSK 1RB_0	133297/680.5	Axial (Z)	16.01	-29.80	45.81	T4	1.37	PASS
			Transversal (Y)	6.82	-37.85	44.67	T4	N/A	/
LTE Band 41	20M QPSK 1RB_0	40620/2593	Axial (Z)	10.57	-26.50	37.07	T4	1.10	PASS
			Transversal (Y)	6.37	-31.26	37.63	T4	N/A	/

Remark:

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

7.2 VoWiFi Tests Results

1. Codec Investigation:

For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following worst investigation codec would be remarked to be used for the testing for the handset.

2. Air Interface Investigation:

a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface and the following worst configure would be remarked to be used for the testing for the handset.

b. Select WLAN 2.4GHz one frequency band to do measurement at the worst SNR position was additionally performed with varying the BWs/Modulations/data rate to verify the variation to find out worst configuration, the observed variation is very little to be within 1 dB which is much less than the margin from the rating threshold.

c. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.

Codec Investigation:

Band	Test Mode	Codec Setting	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WiFi 2.4G	802.11b	WB AMR 6.60kbps	6/2437	Axial (Z)	13.83	-30.36	44.19	T4	1.72	13.83
	802.11b	WB AMR 23.85kbps	6/2437	Axial (Z)	15.03	-30.08	45.11	T4	1.10	15.03
	802.11b	NB AMR 4.75kbps	6/2437	Axial (Z)	14.03	-30.68	44.71	T4	1.70	14.03
	802.11b	NB AMR 12.2kbps	6/2437	Axial (Z)	14.24	-30.18	44.42	T4	1.83	14.24
	802.11b	SWB EVS 9.60kbps	6/2437	Axial (Z)	16.07	-31.66	47.73	T4	1.76	16.07
	802.11b	SWB EVS 13.2kbps	6/2437	Axial (Z)	15.64	-31.60	47.24	T4	1.57	15.64
	802.11b	WB EVS 5.90kbps	6/2437	Axial (Z)	9.67	-31.18	40.85	T4	1.42	9.67
	802.11b	WB EVS 13.2kbps	6/2437	Axial (Z)	15.17	-31.54	46.71	T4	1.66	15.17
	802.11b	NB EVS 5.90kbps	6/2437	Axial (Z)	6.51	-31.66	**38.17**	T4	1.93	6.51
	802.11b	NB EVS 13.2kbps	6/2437	Axial (Z)	14.45	-31.32	45.77	T4	1.35	14.45

Remark: According to codec investigation, the worst codec is **NB EVS 5.90kbps.**

Air Interface Investigation:

Band	Test Mode	Data Rate	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WiFi 2.4G	802.11b	1Mbps	6/2437	Axial (Z)	**6.51**	-31.66	**38.17**	T4	1.93	PASS
WiFi 2.4G	802.11b	11Mbps	6/2437	Axial (Z)	9.80	-31.83	41.63	T4	1.32	PASS
WiFi 2.4G	802.11g	6Mbps	6/2437	Axial (Z)	20.98	-31.32	52.30	T4	1.52	PASS
WiFi 2.4G	802.11g	54Mbps	6/2437	Axial (Z)	20.94	-32.20	53.14	T4	1.12	PASS
WiFi 2.4G	802.11n-HT20	MCS0	6/2437	Axial (Z)	20.88	-32.34	53.22	T4	0.68	PASS
WiFi 2.4G	802.11n-HT20	MCS7	6/2437	Axial (Z)	20.99	-31.17	52.16	T4	0.29	PASS
WiFi 2.4G	802.11n-HT40	MCS0	6/2437	Axial (Z)	21.04	-32.42	53.46	T4	0.96	PASS
WiFi 2.4G	802.11n-HT40	MCS7	6/2437	Axial (Z)	20.92	-32.97	53.89	T4	1.45	PASS
WiFi 5G	802.11a	6Mbps	40/5200	Axial (Z)	7.62	-31.35	**38.97**	T4	1.09	PASS
WiFi 5G	802.11a	54Mbps	40/5200	Axial (Z)	6.38	-33.17	39.55	T4	1.62	PASS
WiFi 5G	802.11n-HT20	6Mbps	40/5200	Axial (Z)	8.32	-31.87	40.19	T4	1.76	PASS
WiFi 5G	802.11n-HT20	54Mbps	40/5200	Axial (Z)	9.71	-32.35	42.06	T4	1.33	PASS
WiFi 5G	802.11n-HT40	MCS0	38/5190	Axial (Z)	8.28	-33.11	41.39	T4	1.16	PASS
WiFi 5G	802.11n-HT40	MCS7	38/5190	Axial (Z)	9.01	-32.50	41.51	T4	1.72	PASS
WiFi 5G	802.11ac-VHT20	MCS0	40/5200	Axial (Z)	20.07	-31.60	51.67	T4	1.11	PASS
WiFi 5G	802.11ac-VHT20	MCS8	40/5200	Axial (Z)	20.46	-31.76	52.22	T4	1.30	PASS
WiFi 5G	802.11ac-VHT40	MCS0	38/5190	Axial (Z)	20.84	-31.47	52.31	T4	1.78	PASS
WiFi 5G	802.11ac-VHT40	MCS8	38/5190	Axial (Z)	20.82	-31.47	52.29	T4	1.42	PASS
WiFi 5G	802.11ac-VHT80	MCS0	50/5250	Axial (Z)	20.63	-31.89	52.52	T4	1.67	PASS
WiFi 5G	802.11ac-VHT80	MCS8	50/5250	Axial (Z)	20.93	-31.62	52.55	T4	1.65	PASS

Remark: According to codec investigation, WiFi 2.4G the worst codec is **802.11b 1Mbps**, WiFi 5G the worst codec is **802.11a 6Mbps.**

Air interface:

Band	Test Mode	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WiFi 2.4G	802.11b	6/2437	Axial (Z)	6.51	-31.66	38.17	T4	1.93	PASS
			Transversal (Y)	4.13	-35.90	40.03	T4	N/A	/
WiFi 5G	802.11a	40/5200	Axial (Z)	7.62	-31.35	38.97	T4	1.09	PASS
			Transversal (Y)	1.98	-38.77	40.75	T4	N/A	/
WiFi 5G	802.11a	60/5300	Axial (Z)	8.95	-32.85	41.80	T4	1.16	PASS
			Transversal (Y)	-0.53	-38.50	37.97	T4	N/A	/
WiFi 5G	802.11a	116/5580	Axial (Z)	7.08	-31.76	38.84	T4	1.83	PASS
			Transversal (Y)	-1.51	-37.76	36.25	T4	N/A	/
WiFi 5G	802.11a	157/5785	Axial (Z)	9.48	-32.01	41.49	T4	1.40	PASS
			Transversal (Y)	1.49	-38.55	40.04	T4	N/A	/

Remark:
1. Phone Condition: Mute on; Backlight off; Max Volume
2. The detail frequency response results please refer to appendix A.

7.3 T-Coil testing for OTT VoIP Application

1. According to the ANSI C63.19 2011 section 7.3.2, test middle channel of each frequency band for HAC testing for each orientation to determine worst HAC T-Coil rating.
2. The google Duo VoIP application are pre-installed on this device. According to KDB 285076 D02, all air interfaces via a data connection with VoIP application need to be considered HAC testing.
3. The Google Duo only support OPUS audio codec and support 6kbps to 75kbps bitrate.
4. The test setup used for OTT VoIP call is the DUT connect to the CMW500 and via the data application unit on CMW500 connection to the Internet, the Auxiliary EUT is connected to the WiFi access point, the channel/Modulation/Frequency bands/data rate is configured on the CMW500 for the DUT unit. For the Auxiliary VoIP unit which is used to configure the audio codec rate and determine the audio input level of -20dBm0 based on the KDB 285076 D02v03 requirement.
5. Codec Investigation: For a voice service/air interface, investigate the variations of codec configurations (WB, NB bit rate) and document the parameters (ABM1, ABM2, S+N/N, frequency response) for that voice service. It is only necessary to document this for one channel/band, the following tests results which the worst case codec would be remarked to be used for the testing for the handset.
6. Air Interface Investigation:
a. Use the worst-case codec test and document a limited set of bands/channel/bandwidths. Observe the effect of changing the band and bandwidth to ensure that there are no unexpected variations. Using the knowledge of the observed variations, it is necessary to report only a set band/channel/bandwidth for each orientation for a voice service/air interface.
b. Due to OTT service and CMRS IP service are all be established over the internet protocol for the voice service, and on both services use the identical RF air interface for the WIFI and LTE, therefore according to VoLTE and VoWiFi test results of air interface investigation, the worst configuration and frequency band of air interface was used for OTT T-Coil testing.
-LTE FDD worst configuration and band: LTE Band 7/20MHz/QPSK/1RB Size
-LTE TDD worst configuration and band: LTE Band 41/20MHz/QPSK/1RB Size
-WLAN2.4GHz worst configuration: 802.11b /1Mbps
-WLAN5GHz worst configuration: WLAN 5.3GHz/802.11a /6Mbps

Codec Investigation:
EDGE:

Band	Test Mode	Codec Setting	Test Ch./ Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
GSM850	EGPRS 4TS	OPUS 6kbps	190/836.6	Axial (Z)	10.90	-22.75	**33.65**	T4	1.44	PASS
	EGPRS 4TS	OPUS 40kbps	190/836.6	Axial (Z)	11.53	-22.35	33.88	T4	1.90	PASS
	EGPRS 4TS	OPUS 75kbps	190/836.6	Axial (Z)	10.96	-24.51	35.47	T4	1.51	PASS

Remark: According to codec investigation, the worst codec bitrate is **OPUS 6kbps**.

HSPA:

Band	Test Mode	Codec Setting	Test Ch./ Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WCDMA Band V	HPSA	OPUS 6kbps	4182/836.4	Axial (Z)	11.92	-31.78	43.70	T4	0.22	PASS
	HPSA	OPUS 40kbps	4182/836.4	Axial (Z)	11.23	-30.30	**41.53**	T4	1.96	PASS
	HPSA	OPUS 75kbps	4182/836.4	Axial (Z)	12.13	-31.92	44.05	T4	1.93	PASS

Remark: According to codec investigation, the worst codec bitrate is **OPUS 40kbps**.

1XEVDO Rev A:

Band	Test Mode	Codec Setting	Test Ch./ Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
CDMA BC0	1xEVDO RTAP 153.6kbps	OPUS 6kbps	384/836.52	Axial (Z)	11.92	-31.78	43.70	T4	0.22	11.92
	1xEVDO RTAP 153.6kbps	OPUS 40kbps	4182/836.4	Axial (Z)	11.23	-30.30	**41.53**	T4	1.96	11.23
	1xEVDO RTAP 153.6kbps	OPUS 75kbps	384/836.52	Axial (Z)	12.13	-31.92	44.05	T4	1.93	12.13

Remark: According to codec investigation, the worst codec bitrate is **OPUS 40kbps**.

LTE FDD:

Band	Test Mode	Codec Setting	Test Ch./ Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
LTE Band 7	20M QPSK 1RB_0	OPUS 6kbps	21100/2535	Axial (Z)	4.87	-30.57	35.44	T4	0.87	PASS
	20M QPSK 1RB_0	OPUS 40kbps	21100/2535	Axial (Z)	1.22	-30.65	**31.87**	T4	2.00	PASS
	20M QPSK 1RB_0	OPUS 75kbps	21100/2535	Axial (Z)	1.33	-30.71	32.04	T4	1.86	PASS

Remark: According to codec investigation, the worst codec bitrate is **OPUS 40kbps**.

LTE TDD:

Band	Test Mode	Codec Setting	Test Ch./ Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
LTE Band 41	20M QPSK 1RB_0	OPUS 6kbps	20175/1732.5	Axial (Z)	0.33	-27.30	27.63	T3	1.81	PASS
	20M QPSK 1RB_0	OPUS 40kbps	20175/1732.5	Axial (Z)	0.58	-27.38	27.96	T3	2.00	PASS
	20M QPSK 1RB_0	OPUS 75kbps	20175/1732.5	Axial (Z)	0.30	-27.31	**27.61**	T3	1.37	PASS

Remark: According to codec investigation, the worst codec bitrate is **OPUS 75kbps**.

WLAN:

Band	Test Mode	Codec Setting	Test Ch./ Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
WiFi 2.4G	802.11b	OPUS 6kbps	6/2437	Axial (Z)	0.78	-31.12	**31.90**	T4	1.53	PASS
	802.11b	OPUS 40kbps	6/2437	Axial (Z)	1.38	-31.54	32.92	T4	1.62	PASS
	802.11b	OPUS 75kbps	6/2437	Axial (Z)	1.50	-31.13	32.63	T4	1.75	PASS

Remark: According to codec investigation, the worst codec bitrate is **OPUS 6kbps**.

Air interface:

Band	Test Mode	Test Ch./Freq.	Probe Position	ABM1 (dBA/m)	ABM2 (dBA/m)	Signal Quality (dB)	T Rating	Freq. Response Variation (dB)	Frequency Response
GSM850	EGPRS 4TS	190/836.6	Axial (Z)	10.90	-22.75	33.65	T4	1.44	PASS
			Transversal (Y)	2.25	-35.82	38.07	T4	N/A	/
GSM1900	EGPRS 4TS	661/1880	Axial (Z)	11.18	-28.04	39.22	T4	1.51	PASS
			Transversal (Y)	1.54	-39.05	40.59	T4	N/A	/
WCDMA Band II	HSPA	9400/1900	Axial (Z)	3.10	-28.49	31.59	T4	1.19	PASS
			Transversal (Y)	-6.59	-36.98	30.39	T4	N/A	/
WCDMA Band IV	HSPA	1412/1732.4	Axial (Z)	3.53	-29.21	32.74	T4	1.43	PASS
			Transversal (Y)	-5.23	-35.68	30.45	T4	N/A	/
WCDMA Band V	HSPA	4182/836.4	Axial (Z)	11.23	-30.30	41.53	T4	1.96	PASS
			Transversal (Y)	2.47	-37.40	39.87	T4	N/A	/
CDMA BC0	1xEVDO RTAP 153.6kbps	384/836.52	Axial (Z)	12.55	-29.92	42.47	T4	1.56	PASS
			Transversal (Y)	2.54	-36.10	38.64	T4	N/A	/
CDMA BC1	1xEVDO RTAP 153.6kbps	600/1880	Axial (Z)	12.21	-31.68	43.89	T4	1.01	PASS
			Transversal (Y)	2.42	-36.00	38.42	T4	N/A	/
CDMA BC10	1xEVDO RTAP 153.6kbps	580/820.5	Axial (Z)	12.88	-30.90	43.78	T4	0.73	PASS
			Transversal (Y)	2.13	-35.51	37.64	T4	N/A	/
LTE Band 7	20M QPSK 1RB_0	21100/2535	Axial (Z)	1.22	-30.65	31.87	T4	2.00	PASS
			Transversal (Y)	-8.67	-38.12	29.45	T3	N/A	/
LTE Band 41	20M QPSK 1RB_0	40620/2593	Axial (Z)	0.30	-27.31	27.61	T3	1.37	PASS
			Transversal (Y)	-7.77	-33.40	25.63	T3	N/A	/
WiFi 2.4G	802.11b	6/2437	Axial (Z)	0.78	-31.12	31.90	T4	1.53	PASS
			Transversal (Y)	-8.49	-34.05	25.56	T3	N/A	/
WiFi 5G	802.11a	116/5580	Axial (Z)	0.72	-32.55	33.27	T4	0.72	PASS
			Transversal (Y)	-7.46	-37.21	29.75	T3	N/A	/

Remark:

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

8 Equipment list

	Equipment	Manufacturer	Model	Serial Number	Calibration Date	Due date of calibration
☒	Software	SPEAG	DASY52 52.8.8	NA	NCR	NCR
☒	DAE	SPEAG	DAE4	1428	2020-03-03	2021-03-02
☒	Audio Magnetic 1D Field Probe	SPEAG	AM1DV3	3115	2020-05-26	2021-05-25
☒	Test Arch SD HAC	SPEAG	NA	NA	NCR	NCR
☒	Audio Magnetic Measuring Instrument	SPEAG	AMMI	1028	NCR	NCR
☒	Audio Magnetic	SPEAG	AMCC	1143	N/A	N/A
☒	Universal Radio Communication Tester	R&S	CMU200	123090	2020-06-11	2021-06-10
☒	Universal Radio Communication Tester	R&S	CMW500	111637	2020-04-16	2021-04-15
☒	Humidity and Temperature Indicator	KIMTOKA	KIMTOKA	NA	2020-04-15	2021-04-14

Note:
1. All the equipments are within the valid period when the tests are performed.
2. NCR: "No-Calibration Required".

9 Calibration certificate

Please see the Appendix B

10 Photographs

Please see the Appendix C

Appendix A: Detailed Test Results

Appendix B: Calibration certificate

Appendix C: Photographs

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