VARIANT HEARING AID COMPATIBILITY Volume Control Evaluation Report

Report No.	:	**PSU-NQN2402040109AC01**
FCC ID	:	**2AJOTTA-1590**
Equipment	:	**GSM/UMTS/LTE Mobile phone**
Brand Name	:	**HMD**
Model Name	:	**TA-1590**
Applicant	:	**HMD Global Oy**
Address	:	**Bertel Jungin aukio 9 Espoo 02600 Finland**
Manufacturer	:	**HMD Global Oy**
Address	:	**Bertel Jungin aukio 9 Espoo 02600 Finland**
Receive Volume Control Results Lowest	:	**PASS**
Conversational Gain	:	**2N:10.04dB** **8N:14.74dB**
Standards	:	**ANSI C63.19-2019** **ANSI/TIA-5050-2018**
Date of Testing	:	**Jan.18,2024~Mar.07,2024**

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 HAC 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 any government agencies.

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Peibo Sun /Manager

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Release Control Record

Report No.	Reason for Change	Date Issued
PSU-NQN2311090109AC01	Initial release	Feb. 02, 2024
PSU-NQN2311090109AC01	Added WIFI 5.3G/WIFI 5.5G/WIFI5.8G tests and updated test datas of pages 17 and 20, updated Appendix A. Added an overview of the worst-case conversational gain for each band 2N/8N on page 4, added the highlight of the smallest conversational gain for 2N/8N from page 18 to page 20.	Mar. 07, 2024
PSU-NQN2402040109AC01	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-NQN2311090109AC01(model: N159V, FCC ID: 2AJOTTA-1590).	Mar. 07, 2024

1. Summary of Minimum Conv.Gain Value

Mode	Band	Mounting Force (N)	Conv.Gain(dB)	Result
GSM CMRS Voice	GSM850	2N	10.24	PASS
		8N	14.93	
	GSM1900	2N	10.33	PASS
		8N	14.74	
UMTS CMRS Voice	Band II	2N	10.04	PASS
		8N	14.84	
	Band V	2N	10.55	PASS
		8N	15.24	
VoLTE	Band 2	2N	11.37	PASS
		8N	17.10	
	Band 5	2N	11.71	PASS
		8N	17.29	
	Band 12	2N	11.51	PASS
		8N	17.15	
	Band 13	2N	11.41	PASS
		8N	17.23	
	Band 66	2N	11.36	PASS
		8N	17.16	
VoWiFi	2.4G	2N	11.15	PASS
		8N	17.24	
	5.2G	2N	11.39	PASS
		8N	17.12	
	5.3G	2N	12.42	PASS
		8N	15.45	
	5.5G	2N	12.28	PASS
		8N	15.17	
	5.8G	2N	12.41	PASS
		8N	15.80	

2. Description of Equipemnt Under Test

Product Feature &Specification	
Applicant Name	HMD Global Oy
Brand Name	HMD
Model Name	TA-1590
Sample1 IMEI Code	353407230005357
Sample2 IMEI Code	353407230017899
FCC ID	2AJOTTA-1590
HW Version	V1.0
SW Version	02US_0_101
Tx Frequency Bands (Unit: MHz)	GSM 850:824.2~848.8 GSM 1900:1850.2~1909.8 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
EUT Stage	Identical Prototype
Mode	GSM :GMSK,8PSK WCDMA:QPSK LTE:QPSK,16QAM,64QAM 802.11b:DSSS 802.11a/g/n/ac:OFDM Bluetooth : GFSK, π/4-DQPSK, 8-DPSK

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.

3. Applied Standards

- FCC CFR47 PRT20.19
- ANSI C63.19-2019
- FCC KDB 285076 D01 HAC Guidance v06r04
- FCC KDB 285076 D04 Volume Control v02
- FCC KDB 285076 D05 CG Interim Waiver DA 23-914 v01
- ANSI/TIA-5050-2018

4. 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					No
	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. Per KDB 285076 D05 ,Wavier DA 23-914 only requires conversational gain compliance for CMRS narrowband and CMRS wideband voice codecs as started below.All other codecs either part of 3GPP set such as full-band and super-wideband codecs or OTT codecs are to be documented in the test report but not required to comply with the TIA 5050 Volume Control Standard
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.

5. Volume Control Requirement

<Conversational Gain>

a. Per KDB 285076 D05,with a mounting force of 8N,the DUT shall have at least one volume control setting thatwil produce a conversational gain of ≥ 6 dB
b. Per KDB 285076 D05,with a mounting force of 2N,the DUT shall have at least one volume control setting that wil produce a conversational gain of ≥ 6 dB
c. Calculate the Conversational Gain by subtracting 70dB from the measures dBSPL. [Conversational Gain=(Measured dBSPL Level-70dsSPL)dB]

<Receive Distortion And Noise Performance>

With a mounting force of 8N and 2N,the ratio of the stimulus signal power to the 100Hz to 8000Hz total A-weighted distortion and noise power shall ≥20dB when tested over the range of 1/3 octave band center frequencies:

a. Narrowband transmission mode:Each 1/3 octave band center frequency from 400Hz to 3150Hz
b. Wideband transmission mode:Each 1/3 octave band center frequency from 250Hz to 5000Hz
c. Per KDB 285076 D05,choose one narrowband and one wideband for all voice services,bands of operation andair interfaces over which it operates using one codec bit rate of the applicant's choosing to meet Receive Distortion And Noise Performance requirement.

<Receive Acoustics Frequency Response Performance>

For the volume control settings determined in ANSI/TIA-5050-2018 section 5.1.1 with a mounting force of 8N and 2N,the receive frequency response shall be measured at the DRP in 1/12 octave bands.After translation to the FF,it shall fall between the applicable upper and lower limits.The exact limit values at any 1/12 octave band center frequency falling between two consecutive points specified in the table may be calculated using the formula given in Eq 2 below

$$X_f = X_1 + (X_2 - X_1) * \left(\frac{\log_{10} f - \log_{10} f_1}{\log_{10} f_2 - \log_{10} f_1}\right) \qquad \text{Eq 2}$$

Where

X_f = limit value at frequency f

X_1 = limit value at frequency f_1 as given in table

X_2 = limit value at frequency f_2 as given in table

For Narrowband:The 1/12 octave band frequency response after translation to the FF shall fallbetween the upper and lower limits given the Table 1

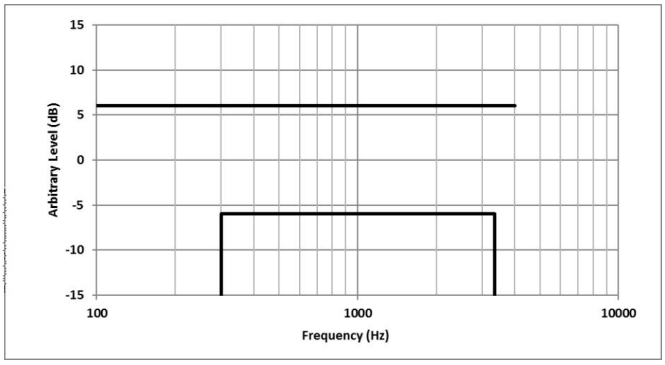
For wideband :The 1/12 octave band frequency response after translation to the FF shall fall between the upper and lower limits given the Table 2

Table 1 – Narrowband Receive Frequency Response Limits

Lower Limit Frequency (Hz)	Lower Limit (dB)	Upper Limit Frequency (Hz)	Upper Limit (dB)
300	-6	100	+6
3400	-6	4000	+6

Table 2 – Wideband Receive Frequency Response Limits

Lower Limit Frequency (Hz)	Lower Limit (dB)	Upper Limit Frequency (Hz)	Upper Limit (dB)
200	-10	100	+6
300	-6	1000	+6
5000	-6	2000	+8
6300	-12	8000	+8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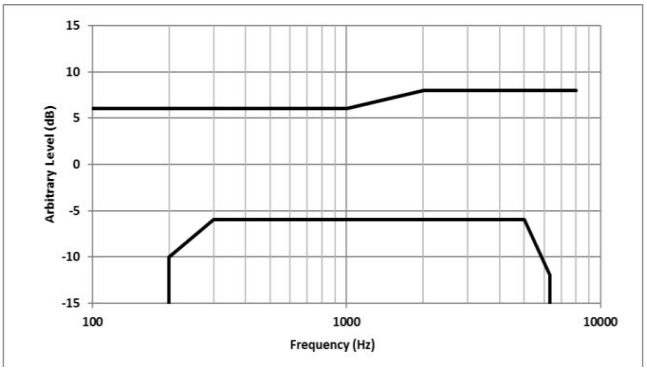
10
5
0
-5
-10
-15
Arbitrary Level (dB)
100
1000
10000
Frequency (Hz)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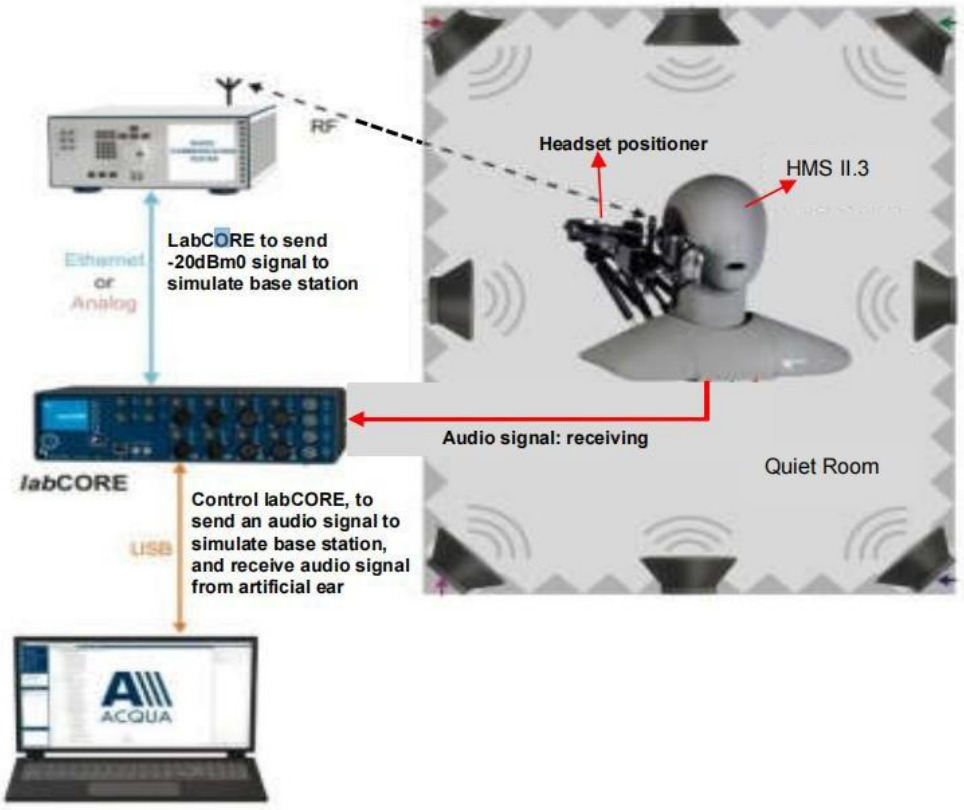
5
0
-5
-10
-15
Arbitrary Level (dB)
100
1000
10000
Frequency (Hz)

6. System Description



System Components:

Name of Equipment	Equipment Description
LabCORE Audio Analyzer	labCORE is a high-precision measurement hardware platform. It provides multiple channels, a wide variety of analog and digital inputs and outputs, high processing power and high-performance interfaces. labCORE is an all-in-one solution for measuring the voice and audio quality of a wide range of devices. labCore is used in conjunction with the communication quality analysis system ACQUA. Connected to a computer via USB (Plug & Play), it is configured and controlled by ACQUA. Combinations with other HEAD acoustics hardware platforms and software applications are possible. labCORE settings are controlled via the intuitive ACQUA settings. They can be stored and assigned to selectable measurement sequences.
HMSII.3 artificial HEAD	HMS II.3 supports measurement in sending and receiving direction.For this purpose,the artificial head is equipped with an impedance simulator in the right ear and a two-way mouth loudspeaker-both meeting the requirement in the recommendations ITU-T P.57 and P.58
Handset Positioner	Control the Newton's force(2N/8N) of the mobile phone on the artificial head
ACQUA,TIA 5050 Test Software	The SW version 5.1.200 can be evaluated TIA-5050 section5.1,5.2,5.3
R&S Base Station Simulator	RF connect with the mobile phone

7. Volume Control Test Procedure

<Conversational Gain>

According to ANSI /TIA-5050, the test procedure for wireless communications device is as below.

1. Configure the DUT with a mounting force of 8N and test equipment as shown in section 4 in an active call state with the applicable codec for the transmission mode under test.
2. Set the DUT volume control to the maximum setting.
3. If the DUT has an adjustable tone control feature,a tone control setting that meets the frequency response requirements in ANSI/TIA-5050 section 5.3.1shall be used.
4. The ACQUA system is apply the real speech test signal at a level of -20dBm0 at the RETP and measure the acoustic output at the Drum Reference Point(DRP) over one complete sequence of the test signal.
5. Translate the measurement made at DRP to Free Filed(FF) using the translation data in ANSI/TIA-5050 Annex B.
6. Over the applicable frequency band,determine the ASL in dBSPL for the resulting sound pressure level in accordance with Method B of ITU-T Recommendation P.56
   - Narrowband 100Hz through 4000 Hz
   - Wideband 100Hz through 7720 Hz

   Calculate the Conversational Gain by subtracting 70dB from the measured dBSPL.
   [Conversational Gain=(Measured dBSPL Level-70dBSPL)dB]
7. Measure output distortion per ANSI/TIA-5050 clause 5.2 .If a distortion failure occurs at the maximum volume control setting.reduce the volume control setting and repeat the measurement to determine if a setting can be found for which the conversational gain requirement is met without a distorton failure.
8. Repeat steps 2-8 with a mounting force of 2N.

<Receive Distortion and Noise Performance>

1. Configure the DUT with a mounting force of 8N and test equipment as shown in section in an active call state with the applicable codec for the transmission mode under test.
2. Receive distortion and noise is measured using the PN-SDNR procedure.
3. To ensure DUT activation, apply the real speech test signal at a level of -20 dBm0 followed immediately by the initial 1/3 octave center frequency PN test signal based on the narrowband or wideband operating mode. Measure the acoustic output at the DRP over the complete sequence of the PN test signal.
4. Translate the measurement made at DRP to the FF.
5. Calculate the acoustic out unweighted test signal power of the stimulus measurement band.
6. Calculate the notched A-weighting distortion and noise components .
7. Calculate the ratio of signal power to the total A-weighted distortion and noise power ad follow:

$$\text{PN-SDNR (dB)} = 20 * Log\left[\frac{measured\ stimulus\ amplitude}{measured\ distortion\ amplitude}\right]$$

8. Repeat for each of the remaining 1/3 octave center frequencies based on the narrowband or wideband operating mode.
9. Repeat steps 2-8 with a mounting force of 2N.

10. The measured value that the system equipment will automatically calculate or converts to define whether it meets the requirements of ANSI/TIA-5050 annex A and annex B.

<Receive Acoustic Frequency Response Performance>

1. Configure the DUT with a mounting force of 8N and test equipment as shown in Figure 1 in an active call state with the applicable codec for the transmission mode under test .
2. If the DUT has an adjustable tone control feature the initial measurement is to be performed with the default tone control setting.
3. Apply the real speech test signal with a level of -20 dBm0 at the RETP.
4. Capture the frequency spectrum at the DRP of the HATS using real-time analysis with 1/12 octave bands over the frequency range from 100 Hz to 4000 Hz for narrowband measurements, or over the frequency range from 100 Hz to 8000 Hz for wideband measurements, averaged over the entire duration of the test signal.
5. Transform the DRP frequency spectrum measurement to the FF .
6. Divide the 1/12 octave measurement data by the 1/12 octave frequency spectrum of the test signal at the RETP and present the measurement in terms of dB(Pa/V).
7. Apply the applicable frequency response limits to determine compliance.
8. If the default tone control setting does not meet the requirement, repeat the above steps for other tone control settings to determine a tone control setting that meets the requirements.
9. Repeat with a mounting force of 2N.
10. The receive acoustic frequency response performance was perform at max tone control setting.

8. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
R&S	Base Station	CMW500	169199	2022/6/27	2024/06/27
HEAD acoustic GmbH	Audio Analyzer	labCORE	77000207	2022/12/25	2024/12/25
HEAD acoustic GmbH	Artificial head	HMSII.3	1236613	2022/4/24	2024/04/24
HEAD acoustic GmbH	Handset Positioner	HHP IV	14060074	N/A	N/A
Deli	Hygrometer	8813	YP2020008	2022/9/6	2024/09/06

9. Device Support Codec

General Note:

1. Per KDB 285076 D04, it is expected to investigate and document only the worst-case test conditions and results. Each submitted test report shall document the codec type (i.e., NB, WB, EVS, etc.), every air interface (i.e., LTE, 5G NR, WI-FI) and band supported for the worst-case codec bit rate, band channel, bandwidth, air interface bit rate, subcarrier spacings, and resource blocks
2. Through Internal codec and air interface configuration investigation (e.g. (i.e., NB, WB, EVS codec, bandwidth, modulation data rate, subcarrier spacing, and resource blocks) that the worst investigate results of codec, air interface configuration etc. were include in section 9
3. Per KDB 285076 D05, Waiver DA 23-914 only requires conversational gain compliance for CMRS narrowband and CMRS wideband voice codecs as stated below. All other codecs either part of 3GPP set such as full-band and super-wideband codecs or OTT codecs are to be documented in the test report but not required to comply with the TIA 5050 Volume Control Standard
4. If a handset does not have a wideband codec or the handset only has an AMR wideband codec, then the test report must document this fact and the passing requirement under these circumstances for the wideband codec test is waived. The passing results for the distortion/noise and frequency response tests must be reported in the handset's test report .

GSM Codec/bitrate		
Codec	AMR NB	AMR WB
Birate	4.75kbps	6.60kbps
	5.15kbps	8.85kbps
	5.90kbps	12.65kbps
	6.70kbps	
	7.40kbps	
	7.95kbps	
	10.20kbps	
	12.20kbps	

WCDMA Codec/bitrate		
Codec	AMR NB	AMR WB
Birate	4.75kbps	6.60kbps
	5.15kbps	8.85kbps
	5.90kbps	12.65kbps
	6.70kbps	14.25kbps
	7.40kbps	15.85kbps
	7.95kbps	18.25kbps
	10.20kbps	19.85kbps
	12.20kbps	23.05kbps

		23.85kbps

VOLTE/VoWIFI Codec/birate				
Codec	AMR NB	AMR WB	EVS NB	EVS WB
Birate	4.75kbps	6.60kbps	5.9kbps	5.9kbps
	5.15kbps	8.85kbps	7.2kbps	7.2kbps
	5.90kbps	12.65kbps	8kbps	8kbps
	6.70kbps	14.25kbps	9.6kbps	9.6kbps
	7.40kbps	15.85kbps	13.2kbps	13.2kbps
	7.95kbps	18.25kbps	16.4kbps	16.4kbps
	10.20kbps	19.85kbps	24.4kbps	24.4kbps
	12.20kbps	23.05kbps		32kbps
		23.85kbps		48kbps
				64kbps
				96kbps
				128kbps

10. Volume Control Evaluation Results

General Note:

1. All the test result was done at quiet room and ambient noise is less than 40dBA.
2. Per KDB 285076 D05, in section2 addresses the technical testing requirements for the conversational gain, distortion, and frequency response tests that amends KDB 285076 D04 Volume Control under the conditions of the limited-term waiver DA 23-914, as follows:
   a. Under the waiver, only CMRS narrowband and CMRS wideband voice codecs are required to comply with the volume control requirements of the TIA 5050-2018 Volume Control Standard as amended as follows:
      1. For the 2N mounting force test, one narrowband and one wideband voice codec embedded with the handset must pass with at least one volume control setting with a conversational gain of ≥ 6 dB for all voice services, bands of operation and air interfaces over which it operates using one codec bit rate of the applicant's choosing .
      2. For the 8N mounting force test, one narrowband and one wideband voice codec embedded with the handset must pass with at least one volume control setting with a conversational gain of ≥ 6 dB 8 for all voice services, bands of operation and air interfaces over which they operate but is not required to meet or exceed the full 18 dB of conversational gain specified in section 5.1.1 of the TIA 5050 Volume Control Standard using one codec bit rate of the applicant's choosing
   b. For all other narrowband and wideband codecs not evaluated in 2.a. above, TIA 5050-2018 Receive Distortion and Noise Performance and Receive Acoustic Frequency Response Performance evaluations are not required; however, these codecs shall be assessed for conversational gain and documented in the test report at the 2N and 8N levels with a gain of ≥ 6 dB for all voice services, bands of operation and air interfaces over which they operate. The handset volume setting used to comply with 2.a. shall be used for these other CMRS codec evaluations.
   c. Any other codec for voice services embedded in the handset, not identified in 2.a. and 2.b. above, is not required to comply or demonstrate in the test reports for conversational gain.
3. All the test results were set the DUT volume control to the maximum setting.
4. Conversational Gain = (measured dBSPL Level – 70 dBSPL) dB

5. Through Internal radio configuration investigation (e.g. bandwidth, modulation data rate, subcarrier spacing, and resource blocks) that the worst radio configuration was document as below table.
6. Per DA 23-914 item 30, for the distortion/noise and frequency response tests at the 2N and 8N force levels, manufacturers must choose codecs that are within the scope of the TIA 5050 Standard, which include narrowband and wideband codecs, but these codecs do not necessarily have to be AMR codecs. That is, we are not limiting the codecs that manufacturers can choose for testing to just AMR narrowband and AMR wideband codecs as defined in sections 4.5.1 and 4.5.2 of the TIA 5050 Standard. While manufacturers may choose to test AMR narrowband and AMR wideband codecs, they can also choose EVS narrowband and EVS wideband codecs or any other narrowband or wideband codecs that are within the scope of the TIA 5050 Standard.
7. The device have similar frequency in some LTE bands: LTE B5/26, 4/66, 2/25, 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.

The 2N mounting force lowest conversational gain is 10.04dB with a hearing aid.
The 8N mounting force lowest conversational gain is 14.74 dB without a hearing aid.

<Evaluation results for KDB 285076 D05 2.a>

<LTE>

HAC(Volume control)Test Record						Conversational Gain				Receive Distortion And Noise Performance			Acoustic Frequency Response Performance
Plot No.	Air Interface	Modulation/Mode	Channel	Codec	Mounting Force(N)	Measured-dBSPL Level	Conv.Gain(dB)	Limit(dB)	Margin to limit(dB)	Minimum PN-SDNR(dB)	Limit(dB)	Margin to Limit(dB)	Free Field(FF)
1	LTE Band 2	20_QPSK_100_0	18900	EVS NB 24.4kbps	2N	82.72	12.72	≥6	6.72	22.71	≥20	2.71	Pass
2	LTE Band 2	20_QPSK_100_0	18900	EVS NB 24.4kbps	8N	87.84	17.84	≥6	11.84	29.09	≥20	9.09	Pass
3	LTE Band 2	20_QPSK_100_0	18900	EVS WB 128kbps	2N	81.62	11.62	≥6	5.62	27.44	≥20	7.44	Pass
4	LTE Band 2	20_QPSK_100_0	18900	EVS WB 128kbps	8N	87.16	17.16	≥6	11.16	28.31	≥20	8.31	Pass
5	LTE Band 5	10_QPSK_50_0	20525	EVS NB 24.4kbps	2N	82.97	12.97	≥6	6.97	30.34	≥20	10.34	Pass
6	LTE Band 5	10_QPSK_50_0	20525	EVS NB 24.4kbps	8N	88.01	18.01	≥6	12.01	25.68	≥20	5.68	Pass
7	LTE Band 5	10_QPSK_50_0	20525	EVS WB 128kbps	2N	82.90	12.90	≥6	6.90	22.74	≥20	2.74	Pass
8	LTE Band 5	10_QPSK_50_0	20525	EVS WB 128kbps	8N	87.42	17.42	≥6	11.42	22.63	≥20	2.63	Pass
9	LTE Band 12	10_QPSK_50_0	23095	EVS NB 24.4kbps	2N	81.51	11.51	≥6	5.51	21.74	≥20	1.74	Pass
10	LTE Band 12	10_QPSK_50_0	23095	EVS NB 24.4kbps	8N	87.27	17.27	≥6	11.27	29.97	≥20	9.97	Pass
11	LTE Band 12	10_QPSK_50_0	23095	EVS WB 128kbps	2N	81.80	11.80	≥6	5.80	28.84	≥20	8.84	Pass
12	LTE Band 12	10_QPSK_50_0	23095	EVS WB 128kbps	8N	87.39	17.39	≥6	11.39	31.77	≥20	11.77	Pass
13	LTE Band 13	10_QPSK_50_0	23230	EVS NB 24.4kbps	2N	81.51	11.51	≥6	5.51	28.87	≥20	8.87	Pass
14	LTE Band 13	10_QPSK_50_0	23230	EVS NB 24.4kbps	8N	87.44	17.44	≥6	11.44	32.43	≥20	12.43	Pass
15	LTE Band 13	10_QPSK_50_0	23230	EVS WB 128kbps	2N	81.47	11.47	≥6	5.47	25.05	≥20	5.05	Pass
16	LTE Band 13	10_QPSK_50_0	23230	EVS WB 128kbps	8N	87.45	17.45	≥6	11.45	26.44	≥20	6.44	Pass
17	LTE Band 66	20_QPSK_100_0	132322	EVS NB 24.4kbps	2N	81.50	11.50	≥6	5.50	24.07	≥20	4.07	Pass
18	LTE Band 66	20_QPSK_100_0	132322	EVS NB 24.4kbps	8N	87.36	17.36	≥6	11.36	22.4	≥20	2.40	Pass
19	LTE Band 66	20_QPSK_100_0	132322	EVS WB 128kbps	2N	81.41	11.41	≥6	5.41	26.5	≥20	6.50	Pass
20	LTE Band 66	20_QPSK_100_0	132322	EVS WB 128kbps	8N	87.32	17.32	≥6	11.32	28.44	≥20	8.44	Pass

<WLAN>

HAC(Volume control)Test Record						Conversational Gain				Receive Distortion And Noise Performance			Acoustic Frequency Response Performance
Plot No.	Air Interface	Modulation/Mode	Channel	Codec	Mounting Force(N)	Measured-dBSPL Level	Conv. Gain(dB)	Limit (dB)	Margin to limit(dB)	Minimum PN-SDNR(dB)	Limit(dB)	Margin to Limit(dB)	Free Field(FF)
21	WIFI2.4GHz	802.11b 1Mbps	6	EVS NB 24.4kbps	2N	81.34	11.34	≥6	5.34	20.42	≥20	0.42	Pass
22	WIFI2.4GHz	802.11b 1Mbps	6	EVS NB 24.4kbps	8N	87.37	17.37	≥6	11.37	21.42	≥20	1.42	Pass
23	WIFI2.4GHz	802.11b 1Mbps	6	EVS WB 128kbps	2N	81.16	11.16	≥6	5.16	22.80	≥20	2.80	Pass
24	WIFI2.4GHz	802.11b 1Mbps	6	EVS WB 128kbps	8N	87.24	17.24	≥6	11.24	21.96	≥20	1.96	Pass
25	WIFI2.4GHz	802.11g 6M	6	EVS NB 24.4kbps	2N	81.07	11.07	≥6	5.07	28.44	≥20	8.44	Pass
26	WIFI2.4GHz	802.11g 6M	6	EVS NB 24.4kbps	8N	87.60	17.60	≥6	11.60	25.93	≥20	5.93	Pass
27	WIFI2.4GHz	802.11g 6M	6	EVS WB 128kbps	2N	81.13	11.13	≥6	5.13	25.50	≥20	5.50	Pass
28	WIFI2.4GHz	802.11g 6M	6	EVS WB 128kbps	8N	87.70	17.70	≥6	11.70	30.92	≥20	10.92	Pass
29	WIFI2.4GHz	802.11n-HT40 MCS0	6	EVS NB 24.4kbps	2N	81.10	11.10	≥6	5.10	29.35	≥20	9.35	Pass
30	WIFI2.4GHz	802.11n-HT40 MCS0	6	EVS NB 24.4kbps	8N	87.11	17.11	≥6	11.11	25.63	≥20	5.63	Pass
31	WIFI2.4GHz	802.11n-HT40 MCS0	6	EVS WB 128kbps	2N	81.23	11.23	≥6	5.23	25.08	≥20	5.08	Pass
32	WIFI2.4GHz	802.11n-HT40 MCS0	6	EVS WB 128kbps	8N	87.44	17.44	≥6	11.44	22.56	≥20	2.56	Pass
45	WIFI 5.2GHz	802.11a 6M	40	EVS NB 24.4kbps	2N	81.59	11.59	≥6	5.59	20.88	≥20	0.88	Pass
46	WIFI 5.2GHz	802.11a 6M	40	EVS NB 24.4kbps	8N	87.25	17.25	≥6	11.25	23.68	≥20	3.68	Pass
47	WIFI 5.2GHz	802.11a 6M	40	EVS WB 128kbps	2N	81.39	11.39	≥6	5.39	21.83	≥20	1.83	Pass
48	WIFI 5.2GHz	802.11a 6M	40	EVS WB 128kbps	8N	87.24	17.24	≥6	11.24	23.85	≥20	3.85	Pass
49	WIFI 5.3GHz	802.11a 6M	60	EVS NB 24.4kbps	2N	82.70	12.70	≥6	6.70	22.19	≥20	2.19	Pass
50	WIFI 5.3GHz	802.11a 6M	60	EVS NB 24.4kbps	8N	86.74	16.74	≥6	10.74	21.90	≥20	1.90	Pass
51	WIFI 5.3GHz	802.11a 6M	60	EVS WB 128kbps	2N	82.66	12.66	≥6	6.66	21.76	≥20	1.76	Pass
52	WIFI 5.3GHz	802.11a 6M	60	EVS WB 128kbps	8N	86.69	16.69	≥6	10.69	22.31	≥20	2.31	Pass
53	WIFI 5.5GHz	802.11a 6M	132	EVS NB 24.4kbps	2N	82.28	12.28	≥6	6.28	21.96	≥20	1.96	Pass
54	WIFI 5.5GHz	802.11a 6M	132	EVS NB 24.4kbps	8N	85.23	15.23	≥6	9.23	22.52	≥20	2.52	Pass
55	WIFI 5.5GHz	802.11a 6M	132	EVS WB 128kbps	2N	82.50	12.50	≥6	6.50	21.67	≥20	1.67	Pass
56	WIFI 5.5GHz	802.11a 6M	132	EVS WB 128kbps	8N	85.34	15.34	≥6	9.34	22.83	≥20	2.83	Pass
57	WIFI 5.8Hz	802.11a 6M	157	EVS NB 24.4kbps	2N	82.41	12.41	≥6	6.41	22.32	≥20	2.32	Pass
58	WIFI 5.8Hz	802.11a 6M	157	EVS NB 24.4kbps	8N	86.07	16.07	≥6	10.07	22.23	≥20	2.23	Pass
59	WIFI 5.8Hz	802.11a 6M	157	EVS WB 128kbps	2N	82.49	12.49	≥6	6.49	22.55	≥20	2.55	Pass
60	WIFI 5.8Hz	802.11a 6M	157	EVS WB 128kbps	8N	85.80	15.80	≥6	9.80	23.00	≥20	3.00	Pass

<Codec Investigation and Evaluation results for KDB 285076 D05 2.b>

<GSM>

HAC(Volume control)Test Record						Conversational Gain			
Plot No.	Air Interface	Modulation/Mode	Channel	Codec	Mounting Force(N)	Measured-dBSPL Level	Conv.Gain(dB)	Limit(dB)	Margin to limit(dB)
	GSM 850	Voice	162	AMR NB 12.2kbps	2N	84.28	14.28	≥6	8.28
45	GSM 850	Voice	162	AMR WB 12.65kbps	2N	80.24	10.24	≥6	4.24
	GSM 850	Voice	162	AMR NB 12.2kbps	8N	88.69	18.69	≥6	12.69
	GSM 850	Voice	162	AMR WB 12.65kbps	8N	84.93	14.93	≥6	8.93
	GSM 1900	Voice	600	AMR NB 12.2kbps	2N	84.26	14.26	≥6	8.26
	GSM 1900	Voice	600	AMR WB 12.65kbps	2N	80.33	10.33	≥6	4.33
	GSM 1900	Voice	600	AMR NB 12.2kbps	8N	89.03	19.03	≥6	13.03
	GSM 1900	Voice	600	AMR WB 12.65kbps	8N	84.74	14.74	≥6	8.74

<UMTS>

HAC(Volume control)Test Record						Conversational Gain			
Plot No.	Air Interface	Modulation/Mode	Channel	Codec	Mounting Force(N)	Measured-dBSPL Level	Conv.Gain(dB)	Limit(dB)	Margin to limit(dB)
	WCDMA II	Voice	9262	AMR NB 12.2kbps	2N	84.41	14.41	≥6	8.41
46	WCDMA II	Voice	9262	AMR WB 23.85kbps	2N	80.23	10.04	≥6	4.23
	WCDMA II	Voice	9262	AMR NB 12.2kbps	8N	88.94	18.94	≥6	12.94
	WCDMA II	Voice	9262	AMR WB 23.85kbps	8N	85.19	14.84	≥6	9.19
	WCDMA V	Voice	4132	AMR NB 12.2kbps	2N	84.27	14.27	≥6	8.27
	WCDMA V	Voice	4132	AMR WB 23.85kbps	2N	80.55	10.55	≥6	4.55
	WCDMA V	Voice	4132	AMR NB 12.2kbps	8N	88.91	18.91	≥6	12.91
	WCDMA V	Voice	4132	AMR WB 23.85kbps	8N	85.24	15.24	≥6	9.24

<LTE>

HAC(Volume control)Test Record						Conversational Gain			
Plot No.	Air Interface	Modulation/Mode	Channel	Codec	Mounting Force(N)	Measured-dBSPL Level	Conv.Gain(dB)	Limit(dB)	Margin to limit(dB)
	LTE Band 2	20_QPSK_100_0	18900	AMR NB 12.2kbps	2N	81.71	11.71	≥6	5.71
	LTE Band 2	20_QPSK_100_0	18900	AMR WB 23.85kbps	2N	81.37	11.37	≥6	5.37
	LTE Band 2	20_QPSK_100_0	18900	EVS NB 24.4kbps	2N	82.72	12.72	≥6	6.72
	LTE Band 2	20_QPSK_100_0	18900	EVS WB 128kbps	2N	81.62	11.62	≥6	5.62
	LTE Band 2	20_QPSK_100_0	18900	AMR NB 12.2kbps	8N	87.10	17.10	≥6	11.10
	LTE Band 2	20_QPSK_100_0	18900	AMR WB 23.85kbps	8N	87.20	17.20	≥6	11.20
	LTE Band 2	20_QPSK_100_0	18900	EVS NB 24.4kbps	8N	87.84	17.84	≥6	11.84
	LTE Band 2	20_QPSK_100_0	18900	EVS WB 128kbps	8N	87.16	17.16	≥6	11.16

	LTE Band 5	10_QPSK_50_0	20525	AMR NB 12.2kbps	2N	81.71	11.71	≥6	5.71
	LTE Band 5	10_QPSK_50_0	20525	AMR WB 23.85kbps	2N	81.88	11.88	≥6	5.88
	LTE Band 5	10_QPSK_50_0	20525	EVS NB 24.4kbps	2N	82.97	12.97	≥6	6.97
	LTE Band 5	10_QPSK_50_0	20525	EVS WB 128kbps	2N	82.90	12.90	≥6	6.90
	LTE Band 5	10_QPSK_50_0	20525	AMR NB 12.2kbps	8N	87.29	17.29	≥6	11.29
	LTE Band 5	10_QPSK_50_0	20525	AMR WB 23.85kbps	8N	87.30	17.30	≥6	11.30
	LTE Band 5	10_QPSK_50_0	20525	EVS NB 24.4kbps	8N	88.01	18.01	≥6	12.01
	LTE Band 5	10_QPSK_50_0	20525	EVS WB 128kbps	8N	87.42	17.42	≥6	11.42
	LTE Band 12	10_QPSK_50_0	23095	AMR NB 12.2kbps	2N	81.56	11.56	≥6	5.56
	LTE Band 12	10_QPSK_50_0	23095	AMR WB 23.85kbps	2N	81.75	11.75	≥6	5.75
	LTE Band 12	10_QPSK_50_0	23095	EVS NB 24.4kbps	2N	81.51	11.51	≥6	5.51
	LTE Band 12	10_QPSK_50_0	23095	EVS WB 128kbps	2N	81.80	11.80	≥6	5.80
	LTE Band 12	10_QPSK_50_0	23095	AMR NB 12.2kbps	8N	87.15	17.15	≥6	11.15
	LTE Band 12	10_QPSK_50_0	23095	AMR WB 23.85kbps	8N	87.64	17.64	≥6	11.64
	LTE Band 12	10_QPSK_50_0	23095	EVS NB 24.4kbps	8N	87.27	17.27	≥6	11.27
	LTE Band 12	10_QPSK_50_0	23095	EVS WB 128kbps	8N	87.39	17.39	≥6	11.39
	LTE Band 13	10_QPSK_50_0	23230	AMR NB 12.2kbps	2N	81.41	11.41	≥6	5.41
	LTE Band 13	10_QPSK_50_0	23230	AMR WB 23.85kbps	2N	81.43	11.43	≥6	5.43
	LTE Band 13	10_QPSK_50_0	23230	EVS NB 24.4kbps	2N	81.51	11.51	≥6	5.51
	LTE Band 13	10_QPSK_50_0	23230	EVS WB 128kbps	2N	81.47	11.47	≥6	5.47
	LTE Band 13	10_QPSK_50_0	23230	AMR NB 12.2kbps	8N	87.44	17.44	≥6	11.44
	LTE Band 13	10_QPSK_50_0	23230	AMR WB 23.85kbps	8N	87.23	17.23	≥6	11.23
	LTE Band 13	10_QPSK_50_0	23230	EVS NB 24.4kbps	8N	87.44	17.44	≥6	11.44
	LTE Band 13	10_QPSK_50_0	23230	EVS WB 128kbps	8N	87.45	17.45	≥6	11.45
47	LTE Band 66(4)	20_QPSK_100_0	132322	AMR NB 12.2kbps	2N	81.36	11.36	≥6	5.36
	LTE Band 66(4)	20_QPSK_100_0	132322	AMR WB 23.85kbps	2N	81.40	11.40	≥6	5.40
	LTE Band 66(4)	20_QPSK_100_0	132322	EVS NB 24.4kbps	2N	81.50	11.50	≥6	5.50
	LTE Band 66(4)	20_QPSK_100_0	132322	EVS WB 128kbps	2N	81.41	11.41	≥6	5.41
	LTE Band 66(4)	20_QPSK_100_0	132322	AMR NB 12.2kbps	8N	87.29	17.29	≥6	11.29
	LTE Band 66(4)	20_QPSK_100_0	132322	AMR WB 23.85kbps	8N	87.16	17.16	≥6	11.16
	LTE Band 66(4)	20_QPSK_100_0	132322	EVS NB 24.4kbps	8N	87.36	17.36	≥6	11.36
	LTE Band 66(4)	20_QPSK_100_0	132322	EVS WB 128kbps	8N	87.32	17.32	≥6	11.32

<WLAN>

HAC(Volume control)Test Record						Conversational Gain			
Plot No.	Air Interface	Modulation/Mode	Channel	Codec	Mounting Force(N)	Measured-dBSPL Level	Conv.Gain(dB)	Limit(dB)	Margin to limit(dB)
	WIFI2.4GHz	802.11b 1Mbps	6	AMR NB 12.2kbps	2N	81.22	11.22	≥6	5.22
48	WIFI2.4GHz	802.11b 1Mbps	6	AMR WB 23.85kbps	2N	81.15	11.15	≥6	5.15
	WIFI2.4GHz	802.11b 1Mbps	6	EVS NB 24.4kbps	2N	81.34	11.34	≥6	5.34
	WIFI2.4GHz	802.11b 1Mbps	6	EVS WB 128kbps	2N	81.16	11.16	≥6	5.16
	WIFI2.4GHz	802.11b 1Mbps	6	AMR NB 12.2kbps	8N	87.36	17.36	≥6	11.36
	WIFI2.4GHz	802.11b 1Mbps	6	AMR WB 23.85kbps	8N	87.46	17.46	≥6	11.46

	WIFI2.4GHz	802.11b 1Mbps	6	EVS NB 24.4kbps	8N	87.37	17.37	≥6	11.37
	WIFI2.4GHz	802.11b 1Mbps	6	EVS WB 128kbps	8N	87.24	17.24	≥6	11.24
	WIFI5.2GHz	802.11a 6M	40	AMR NB 12.2kbps	2N	81.41	11.41	≥6	5.41
	WIFI5.2GHz	802.11a 6M	40	AMR WB 23.85kbps	2N	81.48	11.48	≥6	5.48
	WIFI5.2GHz	802.11a 6M	40	EVS NB 24.4kbps	2N	81.59	11.59	≥6	5.59
	WIFI5.2GHz	802.11a 6M	40	EVS WB 128kbps	2N	81.39	11.39	≥6	5.39
	WIFI5.2GHz	802.11a 6M	40	AMR NB 12.2kbps	8N	87.55	17.55	≥6	11.55
	WIFI5.2GHz	802.11a 6M	40	AMR WB 23.85kbps	8N	87.12	17.12	≥6	11.12
	WIFI5.2GHz	802.11a 6M	40	EVS NB 24.4kbps	8N	87.25	17.25	≥6	11.25
	WIFI5.2GHz	802.11a 6M	40	EVS WB 128kbps	8N	87.34	17.34	≥6	11.34
	WIFI 5.3GHz	802.11a 6M	60	AMR NB 12.2kbps	2N	82.46	12.46	≥6	6.46
	WIFI 5.3GHz	802.11a 6M	60	AMR WB 23.85kbps	2N	82.42	12.42	≥6	6.42
	WIFI 5.3GHz	802.11a 6M	60	EVS NB 24.4kbps	2N	82.70	12.70	≥6	6.70
	WIFI 5.3GHz	802.11a 6M	60	EVS WB 128kbps	2N	82.66	12.66	≥6	6.66
	WIFI 5.3GHz	802.11a 6M	60	AMR NB 12.2kbps	8N	85.45	15.45	≥6	9.45
	WIFI 5.3GHz	802.11a 6M	60	AMR WB 23.85kbps	8N	85.58	15.58	≥6	9.58
	WIFI 5.3GHz	802.11a 6M	60	EVS NB 24.4kbps	8N	86.74	16.74	≥6	10.74
	WIFI 5.3GHz	802.11a 6M	60	EVS WB 128kbps	8N	86.69	16.69	≥6	10.69
	WIFI 5.5GHz	802.11a 6M	132	AMR NB 12.2kbps	2N	82.45	12.45	≥6	6.45
	WIFI 5.5GHz	802.11a 6M	132	AMR WB 23.85kbps	2N	82.43	12.43	≥6	6.43
	WIFI 5.5GHz	802.11a 6M	132	EVS NB 24.4kbps	2N	82.28	12.28	≥6	6.28
	WIFI 5.5GHz	802.11a 6M	132	EVS WB 128kbps	2N	82.50	12.50	≥6	6.50
	WIFI 5.5GHz	802.11a 6M	132	AMR NB 12.2kbps	8N	85.17	15.17	≥6	9.17
	WIFI 5.5GHz	802.11a 6M	132	AMR WB 23.85kbps	8N	85.33	15.33	≥6	9.33
	WIFI 5.5GHz	802.11a 6M	132	EVS NB 24.4kbps	8N	85.23	15.23	≥6	9.23
	WIFI 5.5GHz	802.11a 6M	132	EVS WB 128kbps	8N	85.34	15.34	≥6	9.34
	WIFI 5.8GHz	802.11a 6M	157	AMR NB 12.2kbps	2N	82.60	12.60	≥6	6.60
	WIFI 5.8GHz	802.11a 6M	157	AMR WB 23.85kbps	2N	82.52	12.52	≥6	6.52
	WIFI 5.8GHz	802.11a 6M	157	EVS NB 24.4kbps	2N	82.41	12.41	≥6	6.41
	WIFI 5.8GHz	802.11a 6M	157	EVS WB 128kbps	2N	82.49	12.49	≥6	6.49
	WIFI 5.8GHz	802.11a 6M	157	AMR NB 12.2kbps	8N	85.08	15.08	≥6	9.08
	WIFI 5.8GHz	802.11a 6M	157	AMR WB 23.85kbps	8N	85.38	15.38	≥6	9.38
	WIFI 5.8GHz	802.11a 6M	157	EVS NB 24.4kbps	8N	86.07	16.07	≥6	10.07
	WIFI 5.8GHz	802.11a 6M	157	EVS WB 128kbps	8N	85.80	15.80	≥6	9.80

Test Engineer：Gao Guannan and Wang Yuyan

11. Uncertainy Assessment

For ANSI/TIA5050 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 testing. Also EUT was set to backlight off during testing.

Item	Accuracy
Electrical signal power of labCORE analog inputs	±0.1dB at 1kHz for levels>-50dBm
	±0.2dB at 1kHz for levels>-100dBm
	±0.05dB spectral flatness for 20Hz to 20 kHz
Sound pressure	±0.2dB[1]
Time	±2.25 ppm[2]
Frequency	±2.25 ppm[2]
Clock	±2.25 ppm

Note:1.Depends on the microphone calibration.The value is valid if calibration is carried out with recommended pistonphone/calibrator in the HMS II.3 manual.

2.Time and frequency accuracies of labCORE determined by the internal clock accuracy.The time and frequency resolution and accuracy may change due to analysis of the digital signals in ACQUA or if an external clock is applied.

12. References

[1] ANSI C63.19:2019, " American National Standard for Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids", Aug. 2019.

[2] FCC KDB 285076 D01v06r04, "Equipment Authorization Guidance for Hearing Aid Compatibility", Sep. 2023.

[3] FCC KDB 285076 D04 Volume Control v02, "GUIDANCE FOR PERFORMING VOLUME CONTROL MEASUREMENTS ON MOBILE HANDSETS", Sep. 2023

[4] FCC KDB 285076 D05 HAC Waiver DA 23-914 v01, "HAC COMPLIANCE UNDER WAIVER DA 23-914", Sep. 2023

[5] ANSI/TIA-5050-2018, "Receive Volume Control Requirements for Wireless (Mobile) Devices", Jan. 2018

[6] Head Acoustic System Handbook

13. 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:

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The road map of all our labs can be found in our web site also
Web: http://www.7Layers.com

Appendix A. Volume Control Evaluation Results

Appendix B. Calibration Certificate

Appendix C. Photographs of EUT and Setup

Please refer to the report PSU-NQN2311090109AC01(model:N159V, FCC ID: 2AJOTTA-1590).

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