HEARING AID COMPATIBILITY
Volume Control Evaluation Report

FCC ID	:	**UZ7EM45A1**
Equipment	:	**Enterprise Mobile**
Brand Name	:	**Zebra**
Model Name	:	**EM45A1**
Receive Volume Control Results	:	**PASS**
Applicant	:	**Zebra Technologies Corporation 3 Overlook Point, Lincolnshire, IL 60069 USA**
Manufacturer	:	**Zebra Technologies Corporation 3 Overlook Point, Lincolnshire, IL 60069 USA**
Standard	:	**FCC 47 CFR §20.19 ANSI C63.19-2019**

The product was received on Oct. 04, 2024 and testing was started from Oct. 28, 2024 and completed on Oct. 28, 2024. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample provide by manufacturer and the test data has been evaluated in accordance with the test procedures given in ANSI 63.19-2019 / 47 CFR Part 20.19 and has been pass the FCC requirement.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC. Laboratory, the test report shall not be reproduced except in full.

Approved by: Cona Huang / Deputy Manager

Sporton International Inc. EMC & Wireless Communications Laboratory
No.52, Huaya 1st Rd., Guishan Dist., Taoyuan City 333, Taiwan

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History of this test report

Report No.	Version	Description	Issued Date
HA460408-02B	Rev. 01	Initial issue of report	Dec. 16, 2024
HA460408-02B	Rev. 02	Update section 10	Feb. 06, 2025

1. General Information

Product Feature & Specification	
Applicant Name	Zebra Technologies Corporation
Equipment Name	Enterprise Mobile
Brand Name	Zebra
Model Name	EM45A1
SN	242605247D0238
FCC ID	UZ7EM45A1
2N lowest conversational gain	15.7 dB
8N lowest conversational gain	16.8 dB
HW Version	DV
SW Version	14-24-09.00-UG-U00-PRD-ATH-04
MFD	05SEP24
EUT Stage	Identical Prototype
Frequency Band	WCDMA Band II: 1850 MHz ~ 1910 MHz WCDMA Band IV: 1710 MHz ~ 1755 MHz WCDMA Band V: 824 MHz ~ 849 MHz LTE Band 2: 1850 MHz ~ 1910 MHz LTE Band 4: 1710 MHz ~ 1755 MHz LTE Band 5: 824 MHz ~ 849 MHz LTE Band 7: 2500 MHz ~ 2570 MHz LTE Band 12: 699 MHz ~ 716 MHz LTE Band 13: 777 MHz ~ 787 MHz LTE Band 14: 788 MHz ~ 798 MHz LTE Band 17: 704 MHz ~ 716 MHz LTE Band 25: 1850 MHz ~ 1915 MHz LTE Band 26: 814 MHz ~ 849 MHz LTE Band 30: 2305 MHz ~ 2315 MHz LTE Band 38: 2570 MHz ~ 2620 MHz LTE Band 41: 2496 MHz ~ 2690 MHz LTE Band 48: 3550 MHz ~ 3700 MHz LTE Band 66: 1710 MHz ~ 1780 MHz LTE Band 71: 663 MHz ~ 698 MHz 5G NR n2 : 1850 MHz ~ 1910 MHz 5G NR n5 : 824 MHz ~ 849 MHz 5G NR n7 : 2500 MHz ~ 2570 MHz 5G NR n12 : 699 MHz ~ 716 MHz 5G NR n13 : 777 MHz ~ 787 MHz 5G NR n14 : 788 MHz ~ 798 MHz 5G NR n25 : 1850 MHz ~ 1915 MHz 5G NR n26 : 814 MHz ~ 849 MHz 5G NR n30 : 2305 MHz ~ 2315 MHz 5G NR n38 : 2570 MHz ~ 2620 MHz 5G NR n41 : 2496 MHz ~ 2690 MHz 5G NR n48 : 3550 MHz ~ 3700 MHz 5G NR n66 : 1710 MHz ~ 1780 MHz 5G NR n71 : 663 MHz ~ 698 MHz 5G NR n77: 3450 MHz ~ 3980 MHz 5G NR n78: 3450 MHz ~ 3800 MHz WLAN 2.4GHz Band: 2412 MHz ~ 2462 MHz WLAN 5.2GHz Band: 5180 MHz ~ 5240 MHz WLAN 5.3GHz Band: 5260 MHz ~ 5320 MHz WLAN 5.5GHz Band: 5500 MHz ~ 5720 MHz WLAN 5.8GHz Band: 5745 MHz ~ 5825 MHz WLAN 6GHz U-NII 5: 5925 MHz ~ 6425 MHz WLAN 6GHz U-NII 6: 6425 MHz ~ 6525 MHz WLAN 6GHz U-NII 7: 6525 MHz ~ 6875 MHz WLAN 6GHz U-NII 8: 6875 MHz ~ 7125 MHz Bluetooth: 2402 MHz ~ 2480 MHz NFC : 13.56 MHz

Mode	RMC/AMR 12.2Kbps HSDPA HSUPA DC-HSDPA HSPA+ (16QAM uplink is supported) LTE: QPSK, 16QAM, 64QAM, 256QAM 5G NR: DFT-s-OFDM/CP-OFDM, Pi/2 BPSK/QPSK/16QAM/64QAM/256QAM WLAN 2.4GHz 802.11b/g/n HT20 WLAN 2.4GHz 802.11ac VHT20 WLAN 2.4GHz 802.11ax HE20 WLAN 5GHz 802.11a/n HT20/HT40 WLAN 5GHz 802.11ac VHT20/VHT40/VHT80/VHT160 WLAN 5GHz 802.11ax HE20/HE40/HE80/HE160 WLAN 6GHz 802.11a/ax HE20/HE40/HE80/HE160 Bluetooth BR/EDR/LE NFC: ASK

Accessories Information				
AC Adapter 1 (Type C Wall Charger 1)	Brand Name	Zebra	Model	SAWA-102-22520A
			Part Number	PWR-WUA5V45W1US
AC Adapter 2 (Type A Wall Charger 2)	Brand Name	Zebra	Model	SAWA-65-20005A
			Part Number	PWR-WUA5V12W0US
Battery 1	Brand Name	Zebra	Model	BT-000501
			Part Number	BT-000501-2000
Earphone 1 (Wired headset USB-C)	Brand Name	Zebra	Part Number	HDST-USBC-PTT1-01
Earphone 2 (Rugged Bluetooth Headset)	Brand Name	Zebra	Part Number	HS3100-OTH
Earphone 3 (3.5mm PTT Headset)	Brand Name	Zebra	Part Number	HDST-35MM-PTT1-02
Earphone 4 (Rugged Headset)	Brand Name	Zebra	Part Number	HS2100-OTH
3.5mm to 3.5mm audio connector	Brand Name	Zebra	Part Number	CBL-HS2100-3MS1-01
Type C-Audio Cable (Type C to 3.5mm)	Brand Name	Zebra	Part Number	ADP-USBC-35MM1-01
USB Cable 1 (USB-C to C Cable)	Brand Name	Zebra	Part Number	CBL-EC5X-USBC3A-01
USB Cable 2 (USB-A to C Cable)	Brand Name	Zebra	Part Number	CBL-TC5X-USBC2A-01
EM45 Protective Case	Brand Name	Zebra	Part Number	SG-EM45EXO2-01

Reviewed by: Jason Wang
Report Producer: Carlie Tsai

2. Testing Location

Sporton Lab is accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 1190) and the FCC designation No. TW1190 under the FCC 2.948(e) by Mutual Recognition Agreement (MRA) in FCC test.

Testing Laboratory	
Test Site	SPORTON INTERNATIONAL INC.
Test Site Location	No.52, Huaya 1st Rd., Guishan Dist., Taoyuan City 333, Taiwan TEL: +886-3-327-3456 FAX: +886-3-328-4978
Test Site No.	Sporton Site No.: **AC01-HY**

3. Applied Standards

- FCC CFR47 Part 20.19
- 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 Operating Mode

Air Interface	Band MHz	Type	C63.19 Volume Control Tested	Simultaneous Transmitter	Name of Voice Service	Power State Compliance
UMTS	Band 2	VO	Yes	WLAN, BT	CMRS Voice	Pmax
	Band 4			WLAN, BT		
	Band 5			WLAN, BT		
	HSPA	VD	No	WLAN, BT	Google Meet(1) WFC(1,4)	
LTE (FDD)	Band 2	VD	Yes	5G NR, WLAN, BT	VoLTE / Google Meet(1) WFC(1,4)	Pmax
	Band 4			5G NR, WLAN, BT		
	Band 5			5G NR, WLAN, BT		
	Band 7			5G NR, WLAN, BT		
	Band 12			5G NR, WLAN, BT		
	Band 13			5G NR, WLAN, BT		
	Band 14			5G NR, WLAN, BT		
	Band 17			5G NR, WLAN, BT		
	Band 25			5G NR, WLAN, BT		
	Band 26			5G NR, WLAN, BT		
	Band 30			5G NR, WLAN, BT		
	Band 66			5G NR, WLAN, BT		
	Band 71			5G NR, WLAN, BT		
LTE (TDD)	Band 38	VD	Yes	5G NR, WLAN, BT	VoLTE / Google Meet(1) WFC(1,4)	
	Band 41			5G NR, WLAN, BT		
	Band 48			5G NR, WLAN, BT		
5G NR	n2	VD	Yes	LTE, WLAN, BT	VoNR / Google Meet(1) WFC(1,4)	Pmax
	n5			LTE, WLAN, BT		
	n7			LTE, WLAN, BT		
	n12			LTE, WLAN, BT		
	n13			LTE, WLAN, BT		
	n14			LTE, WLAN, BT		
	n25			LTE, WLAN, BT		
	n26			LTE, WLAN, BT		
	n30			LTE, WLAN, BT		
	n66			LTE, WLAN, BT		
	n71			LTE, WLAN, BT		
	n77			LTE, WLAN, BT		
	n78			LTE, WLAN, BT		
Wi-Fi	2450	VD	Yes	WCDMA, LTE, 5G NR, 5GHz/6GHz WLAN, BT	VoWiFi / Google Meet(1) WFC(1,4)	Full
	5200			WCDMA, LTE, 5G NR, 2.4GHz WLAN, BT		
	5300			WCDMA, LTE, 5G NR, 2.4GHz WLAN, BT		
	5500			WCDMA, LTE, 5G NR, 2.4GHz WLAN, BT		
	5800			WCDMA, LTE, 5G NR, 2.4GHz WLAN, BT		
Wi-Fi	U-NII 5	VD	Yes(3)	GSM, WCDMA, LTE, 5G NR, 2.4G WLAN, BT	VoWiFi / Google Meet(1) WFC(1,4)	Full
	U-NII 6		No(2)			
	U-NII 7					
	U-NII 8					
BT	2450	DT	No	WCDMA, LTE, 5G NR, 2.4GHz/5GHz/6GHz WLAN	NA	NA

Type Transport:
VO= Voice only
DT= Digital Transport only (no voice)
VD= CMRS and IP Voice Service over Digital Transport

Remark
1. 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.
2. WLAN6GHz U-NII 6/7/8 were above 6GHz and were not evaluated due to outside of the current scope of ANSI C63.19 and FCC HAC regulations.
3. The WLAN6GHz U-NII-5 was evaluated for operations which are entirely below 6 GHz, above 6 GHz were not evaluated due outside of the current scope of ANSI C63.19 and FCC HAC regulations.
4. The Workforce Connect (WFC) is an over-the-top (OTT) – voice services operating over IP, and this voice application was development and pre-installed on a wireless handset by the Zebra Technologies Corporation.
5. The product only 3G/4G/5G support time-average SAR feature, therefore UMTS/LTE/5GFR1 HAC were tested at Pmax level(the maximum power). However, due the GSM and WIFI operation doesn't support Time average SAR feature, therefore, WIFI operation were assessment at head power level / the maximum power to meet HAC Volume Control compliance.

5. Volume Control Requirements

<Conversational Gain>

a. Per KDB 285076 D05, With a mounting force of 8N, the DUT shall have at least one volume control setting that will 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 will produce a conversational gain of ≥ 6 dB.
c. Calculate the Conversational Gain by subtracting 70 dB from the measured dBSPL.
[Conversational Gain = (Measured dBSPL Level – 70 dBSPL) dB]

<Receive Distortion And Noise Performance>

With a mounting force of 8N and 2N, the ratio of the stimulus signal power to the 100 Hz to 8000 Hz total A-weighted distortion and noise power shall be ≥ 20 dB when tested over the range of 1/3 octave band center frequencies:
a. Narrowband transmission mode: Each 1/3 octave band center frequency from 400 Hz to 3150 Hz
b. Wideband transmission mode: Each 1/3 octave band center frequency from 250 Hz to 5000 Hz
c. Per KDB 285076 D05, choose one narrowband and one wideband for all voice services, bands of operation and air interfaces over which it operates using one codec bit rate of the applicant's choosing to meet Receive Distortion And Noise Performance requirement.

<Receive Acoustic 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 or DF, 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 or DF shall fall between the upper and lower limits given in Table 1
For Wideband: The 1/12 octave band frequency response after translation to the FF or DF shall fall between the upper and lower limits given in 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

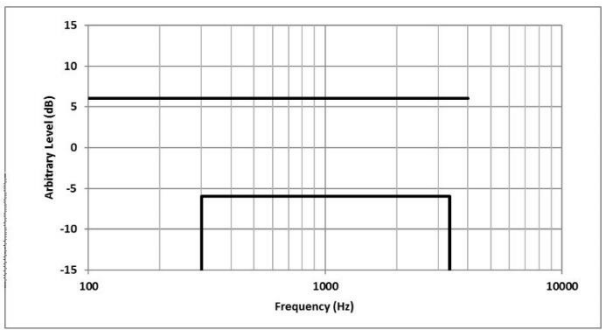
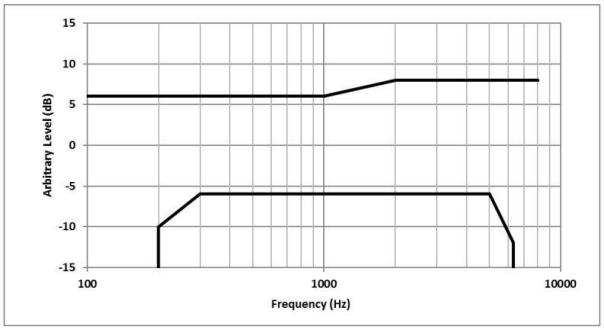
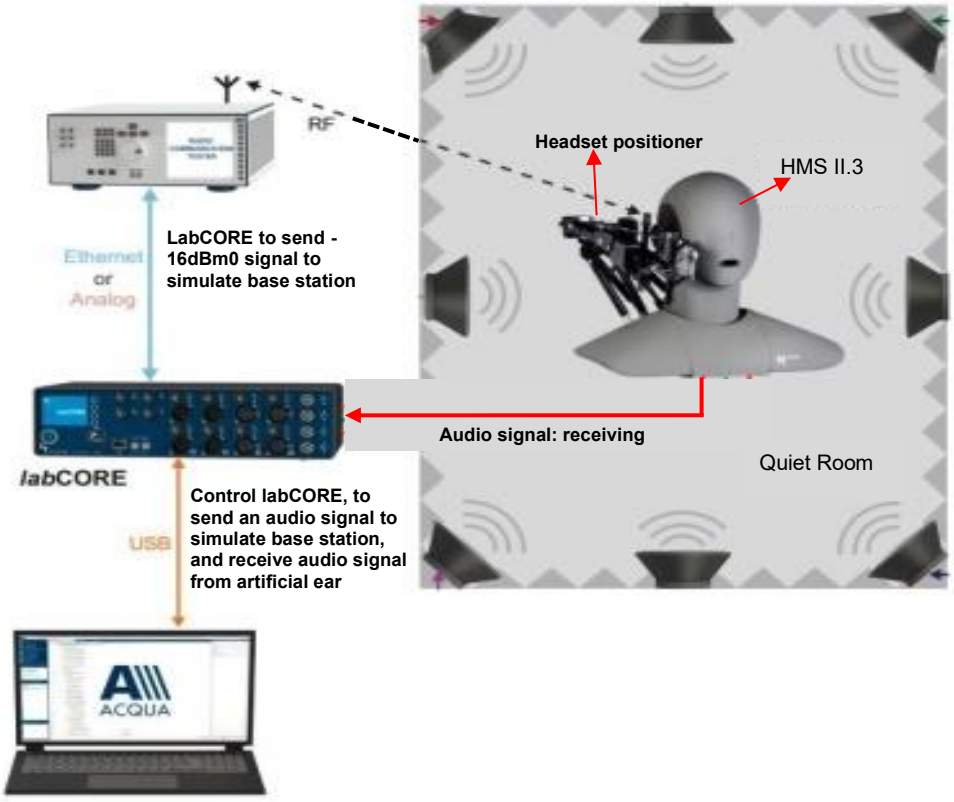


Table 2 – Wideband Receive Frequency Response Limits

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



6. System Description

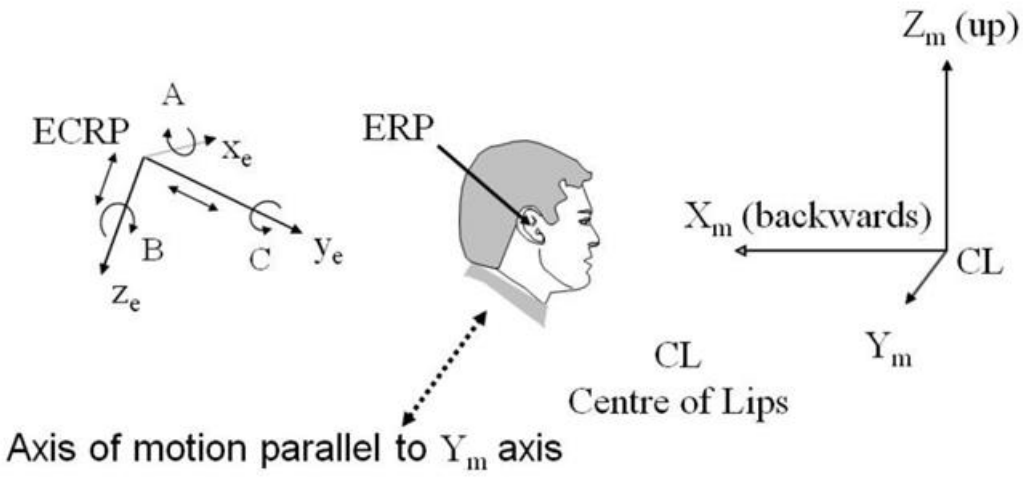


System Components:

Name of Equipment	Equipment Description
	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 Audio Analyzer	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.
HMS II.3, artificial head	HMS II.3 supports measurements 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 requirements 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 version5.1.200 can be evaluated TIA-5050 section5.1, 5.2, 5.3
R&S base station simulator	RF connect with the mobile phone

7. Device positioning

The two primary handset positions are the MECRP and the STP. If an MECRP is defined by the manufacturer, it shall be used. Otherwise, the STP shall be used. Once positioned, all measurements shall be performed in the same primary position. Positioning devices can hold the receiver by position relative to the ERP or by force on the pinna. However, the relationship between applied force and position may be nonlinear. Therefore, the recommended procedure is to begin by placing the receiver in the positioning device without contacting the pinna, then gradually moving the receiver inward so as to increase the force, and stopping at the target force or position.
Following figure shows the device positioning



8. Volume Control Test Procedure

<Conversational Gain>

1. Configure the DUT with a mounting force of 8N and test equipment as shown in section5 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 5.3.1 shall be used.
4. The ACQUA system is apply the real speech test signal at a level of -16 dBm0 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 the DRP to the FF or DF 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:
   a. Narrowband 100 Hz through 4000 Hz.
   b. Wideband 100 Hz through 7720 Hz.
   Calculate the Conversational Gain by subtracting 70 dB from the measured dBSPL.
   [Conversational Gain = (Measured dBSPL Level – 70 dBSPL) dB]
7. Measure the 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 distortion 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 as described in ANSI/TIA-5050 Annex A
3. To ensure DUT activation, the ACQUA system is apply the real speech test signal at a level of -16 dBm0 followed immediately by the initial 1/3 octave center frequency PN test signal in ANSI/TIA-5050 Table A.1 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 the DRP to the FF or DF using the translation data in ANSI/TIA-5050 Annex B
5. Calculate the acoustic output unweighted total signal power of the stimulus measurement band as described in ANSI/TIA-5050 A.2.
6. Calculate the notched A-weighting distortion and noise components as described in ANSI/TIA-5050 A.3.
7. Calculate the ratio of the signal power to the total A-weighted distortion and noise power using ANSI/TIA-5050 Eq A-1.
8. Repeat for each of the remaining 1/3 octave center frequencies in Table A.1 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 calculates or converts to define whether it meets the requirements of ANSI/TIS-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. The ACQUA system is apply the real speech test signal with a level of -16 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 or DF (include ANSI/TIA-5050 Annex B).
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

9. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
HEAD acoustic GmbH	Audio Analyzer	labCORE	7700342	Jul. 08, 2024	Jul. 07, 2025
R&S	Wideband Radio Communication Tester	CMW500	115793	Nov. 20, 2023	Nov. 19, 2024
R&S	Wideband Radio Communication Tester	CMX500	101931	Sep. 23, 2024	Sep. 22, 2025
Testo	Hygro meter	608-H1	45196600	Nov. 02, 2023	Nov. 01, 2024
HEAD acoustic GmbH	Fullband artificial head	HMS II.3	12306610	NCR	NCR

Remark:
1. NCR: no calibration required

10. 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 section11
3. Per KDB 285076 D05, Waiver DA 23-914 only requires conversational gain compliance for CMRS narrowband and CMRS wideband voice codecs. 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

WCDMA Codec/bitrate		
Codec	AMR NB	AMR WB
Bitrate	4.75kbps	6.60kbps
	5.15kbps	8.85kbps
	5.9kbps	12.65kbps
	6.7kbps	
	7.4kbps	
	7.95kbps	
	10.2kbps	
	12.2kbps	

VoLTE/VoNR/VoWIFI Codec/bitrate					
Codec	AMR NB	AMR WB	EVS NB	EVS WB	EVS SWB
Bitrate	4.75kbps	6.60kbps	5.9kbps	5.9kbps	9.6kbps
	5.15kbps	8.85kbps	7.2kbps	7.2kbps	13.2kbps
	5.9kbps	12.65kbps	8kbps	8kbps	16.4kbps
	6.7kbps	14.25kbps	9.6kbps	9.6kbps	24.4kbps
	7.4kbps	15.85kbps	13.2kbps	13.2kbps	
	7.95kbps	18.25kbps	16.4kbps	16.4kbps	
	10.2kbps	19.85kbps	24.4kbps	24.4kbps	
	12.2kbps	23.05kbps			
		23.85kbps			

Google meet Codec/bitrate investigation	
Codec	Opus (Full Band)
Bitrate	6Kbps~75Kbps

WFC Codec/bitrate investigation				
G.711 a-Law 8KHz	G.711 u-Law 8KHz	G.729 8KHz	G.722 16KHz	GSM 8KHz

11. Volume Control Evaluation Results

General Note:

1. All the test result was done at quiet room and ambient noise is 31.36 less than 40dBa.
2. Per KDB 285076 D05, 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:
   a. 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
   b. 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
3. For all other narrowband and wideband codecs not evaluated in item1. 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 item2. shall be used for these other CMRS codec evaluations.
4. Any other codec for voice services embedded in the handset, not identified in item 2. and item3. above, is not required to comply or demonstrate in the test reports for conversational gain.
5. Conversational Gain = (measured dBSPL Level – 70 dB) dB
6. In this report only assessment WiFi 6E operation, other transmitters assessment were include in Report No.:HA460505-02C and worst conversational gain as following

<Evaluation results for KDB 285076 D05 2.a>

<WLAN>

Plot No.	Air Interface	Radio Configuration	Channel	Codec & Bitrate	Mounting Force (N)	Conversational Gain				Receive Volume Control Performance			Receive Acoustic Frequency Response Performance
						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)
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS NB 24.4kbps	2N	86.75	16.75	≥6	10.75	24.98	≥20	4.98	Pass
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS NB 24.4kbps	8N	93.17	23.17	≥6	17.17	22.65	≥20	2.65	Pass
1	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS WB 24.4kbps	2N	86.56	16.56	≥6	10.56	21.77	≥20	1.77	Pass
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS WB 24.4kbps	8N	93.02	23.02	≥6	17.02	22.67	≥20	2.67	Pass

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

<WLAN>

Plot No.	Air Interface	Radio Configuration	Channel	Codec & Bitrate	Mounting Force (N)	Receive Volume Control Performance			
						Measured dBSPL Level	Conversational Gain	Limit (dB)	Margin to Limit (dB)
2	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR NB 4.75kbps	2N	85.7	15.7	≥6	9.7
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR NB 4.75kbps	8N	92.6	22.6	≥6	16.6
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR NB 12.2kbps	2N	86.85	16.85	≥6	10.85
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR NB 12.2kbps	8N	93.49	23.49	≥6	17.49
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR WB 6.60kbps	2N	86.08	16.08	≥6	10.08
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR WB 6.60kbps	8N	92.74	22.74	≥6	16.74
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR WB 23.85kbps	2N	86.92	16.92	≥6	10.92
	WLAN6GHz	802.11ax-HE20 MCS0	1	AMR WB 23.85kbps	8N	93.34	23.34	≥6	17.34
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS NB 5.9kbps	2N	86.12	16.12	≥6	10.12
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS NB 5.9kbps	8N	92.58	22.58	≥6	16.58
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS WB 5.9kbps	2N	85.91	15.91	≥6	9.91
	WLAN6GHz	802.11ax-HE20 MCS0	1	EVS WB 5.9kbps	8N	92.46	22.46	≥6	16.46

Test Engineer：Tommy Chen

12. Uncertainty Assessment

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type A evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.
The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual “root-sum-squares” (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances. Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %.
The judgment of conformity in the report is based on the measurement results excluding the measurement uncertainty.

Component	Standard uncertainty (dB)	U^2 ($\%^2$)
Generator Accuracy To enable harmonic distortion measurements to 0.1%, the generator distortion must be <0.05%. This is equivalent to a standard uncertainty of 0.043 dB.	0.043	0.25
Ear Simulator Pressure Sensitivity (incl. Measurement Mic.) The uncertainty of the ear simulator as per the standards and quoted on its calibration certificate is 0.3 dB with a coverage factor of k = 2. This is equivalent to a standard uncertainty of 0.3/2 = 0.15 dB.	0.15	3.03
Microphone Preamplifier The manufacturer quotes the preamp to be within ± 0.02 dB with a 95% probability or 2σ. This is equivalent to a standard uncertainty of 0.02/2 = 0.01 dB.	0.01	0.01
Analysis System / RMS Detector Typical measurement system detector accuracy is 0.1 dB with a coverage factor of k = 2. This is equivalent to a standard uncertainty of 0.1/2 = 0.05 dB.	0.05	0.33
Effect of Positioning on Mid-Band Sensitivity For a handset, with the HATS positioning jig, the typical standard deviation estimated from a statistically significant number of measurements is ±0.5 dB. This is equivalent to a standard uncertainty of 0.5 dB.	0.5	35.11
Time Varying Effects of the Mouth Simulator for Send & Sidetone For a receive measurement on a handset, the mouth simulator is not used (its uncertainty is zero), The standard uncertainty of 0 dB	0	0.00
Total Standard Uncertainty (%)	6.22	
UMAX (k = 2) (%)	12.45	
UMAX (k = 2) (dB)	1.02	

Uncertainty Budget of Volume Control assessment

13. 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