

## HEARING AID COMPATIBILITY

**Applicant Name:**  
 Samsung Electronics Co., Ltd.  
 129, Samsung-ro, Maetan dong,  
 Yeongtong-gu, Suwon-si  
 Gyeonggi-do 16677, Korea

**Date of Testing:**  
 4/2/2020  
**Test Site/Location:**  
 PCTEST, Columbia, MD, USA  
**Test Report Serial No.:**  
 1M2003230050-03.A3L  
**Date of Issue:**  
 4/21/2020


**FCC ID:** **A3LSMN976U**  
**APPLICANT:** **SAMSUNG ELECTRONICS CO., LTD.**

**Scope of Test:** RF Emissions Testing  
**Application Type:** Class II Permissive Change  
**FCC Rule Part(s):** CFR §20.19(b)  
**HAC Standard:** ANSI C63.19-2011  
 285076 D01 HAC Guidance v05  
 285076 D02 T-Coil testing for CMRS IP v03  
**DUT Type:** Portable Handset  
**Model:** SM-N976U  
**Test Device Serial No.:** Pre-Production Sample [S/N: 0466M]  
**Class II Permissive Change(s):** See FCC Change Document  
**Original Grant Date:** 11/15/2019



**C63.19-2011 HAC Category:** **M4 (RF EMISSIONS CATEGORY, NR Only)**

This report and category pertain only to NR modes supported by this wireless portable device. The overall category rating of the device is determined by the lowest rating obtained over all air interfaces supported by the device. This wireless portable device has been shown to be hearing-aid compatible for NR modes, under the above rated category, specified in ANSI/IEEE Std. C63.19-2011 and has been tested in accordance with the specified measurement procedures. Hearing-Aid Compatibility is based on the assumption that all production units will be designed electrically identical to the device tested in this report. Test results reported herein relate only to the item(s) tested. North America bands only.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them.

  
 Randy Ortanez  
 President





<b>FCC ID:</b> A3LSMN976U		<b>HAC (RF EMISSIONS) TEST REPORT</b>		<b>Approved by:</b> Quality Manager
<b>Filename:</b> 1M2003230050-03.A3L	<b>Test Dates:</b> 4/2/2020	<b>DUT Type:</b> Portable Handset	Page 1 of 16	

# TABLE OF CONTENTS

---

1.	INTRODUCTION .....	3
2.	DUT DESCRIPTION.....	4
3.	ANSI/IEEE C63.19 PERFORMANCE CATEGORIES .....	6
4.	MODULATION INTERFERENCE FACTOR.....	7
5.	RF CONDUCTED POWER MEASUREMENTS.....	9
6.	JUSTIFICATION OF HELD TO EAR MODES TESTED .....	11
7.	EQUIPMENT LIST .....	12
8.	MEASUREMENT UNCERTAINTY .....	13
9.	CONCLUSION.....	14
10.	REFERENCES .....	15

<b>FCC ID:</b> A3LSMN976U	 <small>Proud to be part of</small>	<b>HAC (RF EMISSIONS) TEST REPORT</b>		<b>Approved by:</b> Quality Manager
<b>Filename:</b> 1M2003230050-03.A3L	<b>Test Dates:</b> 4/2/2020	<b>DUT Type:</b> Portable Handset	Page 2 of 16	

# 1. INTRODUCTION

On July 10, 2003, the Federal Communications Commission (FCC) adopted new rules requiring wireless manufacturers and service providers to provide digital wireless phones that are compatible with hearing aids. The FCC has modified the exemption for wireless phones under the Hearing Aid Compatibility Act of 1998 (HAC Act) in WT Docket 01-309 RM-8658<sup>1</sup> to extend the benefits of wireless telecommunications to individuals with hearing disabilities. These benefits encompass business, social and emergency communications, which increase the value of the wireless network for everyone. An estimated more than 10% of the population in the United States show signs of hearing impairment and of that fraction, almost 80% use hearing aids. Approximately 500 million people worldwide suffer from hearing loss.

## Compatibility Tests Involved:

The standard calls for wireless communications devices to be measured for:

- RF Electric-field emissions
- T-coil mode, magnetic-signal strength in the audio band
- T-coil mode, magnetic-signal frequency response through the audio band
- T-coil mode, magnetic-signal and noise articulation index

The hearing aid must be measured for:




- RF immunity in microphone mode
- RF immunity in T-coil mode

In the following tests and results, this report includes the evaluation for a wireless communications device.



Figure 1-1 Hearing Aid *in-vitu*

<sup>1</sup> FCC Rule & Order, WT Docket 01-309 RM-8658

FCC ID: A3LSMN976U	 PCTEST Proud to be part of  Samsung	HAC (RF EMISSIONS) TEST REPORT	 Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 3 of 16



## 2. DUT DESCRIPTION



FCC ID: A3LSMN976U  
Manufacturer: Samsung Electronics Co., Ltd.  
129, Samsung-ro, Maetan dong,  
Yeongtong-gu, Suwon-si  
Gyeonggi-do 16677, Korea  
Model: SM-N976U  
Serial Number: 0466M  
Antenna Configurations: Internal Antenna  
DUT Type: Portable Handset




### I. Power Reduction for Licensed Modes

This device uses an independent fixed level power reduction mechanism for NR n41 during voice or VoIP held to ear scenarios. Reduced powers were used to evaluate for low-power exemption in Section 6.II for these modes. Detailed descriptions of the power reduction mechanism are included in the operational description.

FCC ID: A3LSMN976U	 <b>PCTEST</b> Proud to be part of Samsung	HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 4 of 16	

**Table 2-1**  
**A3LSMG976U HAC Air Interfaces**

Air-Interface	Band (MHz)	Type Transport	HAC Tested	Simultaneous But Not Tested	Name of Voice Service
GSM	850	VO	No <sup>3</sup>	Yes: WIFI or BT	CMRS Voice
	1900				
	GPRS/EDGE	VD	No <sup>3</sup>	Yes: WIFI or BT	Google Duo
UMTS	850	VD	No <sup>3</sup>	Yes: WIFI or BT	CMRS Voice
	1700				
	1900	VD	No <sup>3</sup>	Yes: WIFI or BT	Google Duo
	HSPA				
LTE (FDD)	680 (B71)	VD	No <sup>3</sup>	Yes: WIFI or BT	VoLTE, Google Duo
	700 (B12)				
	780 (B13)				
	790 (B14)				
	850 (B5)				
	850 (B26)				
	1700 (B4)				
	1700 (B66)				
	1900 (B2)				
	1900 (B25)				
	2300 (B30)				
	2500 (B7)				
LTE (TDD)	2600 (B38)	VD	No <sup>3</sup>	Yes: WIFI or BT	VoLTE, Google Duo
	2600 (B41)				
	3600 (B48)				
NR (FDD)	680 (n71)	VD	No <sup>1,2,3</sup>	Yes: WIFI or BT	Google Duo
	850 (n5)		No <sup>1,3</sup>		
NR (TDD)	2600 (n41)	VD	No <sup>1,4</sup>	Yes: WIFI or BT	Google Duo
WIFI	2450	VD	No <sup>3</sup>	Yes: GSM, UMTS, LTE, or NR	VoWIFI, Google Duo
	5200 (U-NII 1)				
	5300 (U-NII 2A)				
	5500 (U-NII 2C)				
	5800 (U-NII 3)				
BT	2450	DT	No	Yes: GSM, UMTS, LTE, or NR	N/A
Type Transport VO = Voice Only DT = Digital Data - Not intended for Voice Services VD = CMRS and/or IP Voice over Data Transport			Notes: 1. Evaluated for MIF and low-power exemption. 2. NR n71, while outside the scope of ANSI C63.19 and FCC HAC regulations, was additionally tested according to the existing HAC procedures with currently available test equipment. 3. This report only pertains to NR modes. For full data, please refer to the Original Certification Test Report (Report S/N: 1M1909040147-18-R1.A3L). 4. This report only pertains to NR modes. For full data on NR n41, please refer to the Class II Permissive Change Certification Test Report (Report S/N: 1M1911080182-03.A3L).		




FCC ID: A3LSMN976U	 <b>PCTEST</b> <small>Proud to be part of</small> 	<b>HAC (RF EMISSIONS) TEST REPORT</b>		<b>Approved by:</b> Quality Manager
<b>Filename:</b> 1M2003230050-03.A3L	<b>Test Dates:</b> 4/2/2020	<b>DUT Type:</b> Portable Handset	Page 5 of 16	

### 3. ANSI/IEEE C63.19 PERFORMANCE CATEGORIES

#### I. RF EMISSIONS

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

Category	Telephone RF Parameters
<b>Near field Category</b>	<b>E-field emissions CW dB(V/m)</b>
<b>f &lt; 960 MHz</b>	
<b>M1</b>	50 to 55
<b>M2</b>	45 to 50
<b>M3</b>	40 to 45
<b>M4</b>	< 40
<b>f &gt; 960 MHz</b>	
<b>M1</b>	40 to 45
<b>M2</b>	35 to 40
<b>M3</b>	30 to 35
<b>M4</b>	< 30
<b>Table 3-1 WD near-field categories as defined in ANSI C63.19-2011</b>	

FCC ID: A3LSMN976U	 <b>PCTEST</b> Proud to be part of 	HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 6 of 16	

## 4. MODULATION INTERFERENCE FACTOR

### I. Measuring Modulation Interference Factors

For any specific fixed and repeatable modulated signal, a modulation interference factor (MIF, expressed in dB) may be determined that relates its interference potential to its steady-state RMS signal level or average power level. This factor is a function only of the audio-frequency amplitude modulation characteristics of the signal and is the same for field-strength and conducted power measurements. The MIF is valid only for a specific repeatable audio-frequency amplitude modulation characteristic; any change in modulation characteristic requires determination and application of a new MIF.

The MIF may be determined using a radiated RF field or a conducted RF signal:

- a. Using RF illumination or conducted coupling, apply the specific modulated signal in question to the measurement system at a level within its confirmed operating dynamic range.
- b. Measure the steady-state RMS level at the output of the fast probe or sensor.
- c. Measure the steady-state average level at the weighting output.
- d. Without changing the square-law detector or weighting system, and using RF illumination or conducted coupling, substitute for the specific modulated signal a 1 kHz, 80% amplitude modulated carrier at the same frequency and adjust its strength until the level at the weighting output equals the step c) measurement.
- e. Without changing the carrier level from step d), remove the 1 kHz modulation and again measure the steady-state RMS level indicated at the output of the fast probe or sensor.
- f. The MIF for the specific modulation characteristic is provided by the ratio of the step e) measurement to the step b) measurement, expressed in dB ( $20 \times \log[(\text{step e})/(\text{step b})]$ ).



The following procedure was used to measure the MIF using the SPEAG Audio Interference Analyzer (AIA), Type No: SE UMS 170 CB, Serial No.: 1010:

1. The device was placed into a simulated call using a base station simulator or set to transmit using test software for a given mode.
2. The device was then set to continuously transmit at maximum power.
3. Using a coupler if needed, the device output signal was connected to the RF In port of the AIA, which was connected to a desktop computer. Alternatively, a radiated RF signal may be used with the AIA's built-in antenna.
4. The MIF measurement procedure in the DASY software was run, and the resulting MIF value was recorded.
5. Steps 1-4 were repeated for all CMRS air interfaces, frequency bands, and modulations.

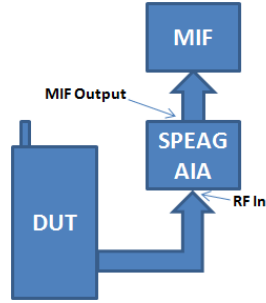
The modulation interference factors obtained were applied to readings taken of the actual wireless device in order to obtain an accurate audio interference level reading using the formula:

$$\text{Audio Interference Level [dB(V/m)]} = 20 * \log[\text{Raw Field Value (V/m)}] + \text{MIF (dB)}$$

Because the MIF value is output power independent, MIF values for a given mode should be constant across all devices; however, per C63.19-2011 §D.7, MIF values should be measured for each device being evaluated. The voice modes for this device have been investigated in this section of the report.

FCC ID: A3LSMN976U	 PCTEST Proud to be part of	HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset		Page 7 of 16

## II. MIF Measurement Block Diagrams



**Figure 4-1**  
MIF Measurement Setup

## III. Measured Modulation Interference Factors:

**Table 4-1**  
NR FDD Modulation Interference Factors<sup>1 2</sup>

NR Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	MIF [dB]
71	680.5	136100	20	DFT-s-OFDM	$\pi/2$ -BPSK	1	1	-14.40
5	836.5	167300	20	DFT-s-OFDM	$\pi/2$ -BPSK	1	1	-15.27
71	680.5	136100	20	DFT-s-OFDM	$\pi/2$ -BPSK	1	53	-15.01
71	680.5	136100	20	DFT-s-OFDM	$\pi/2$ -BPSK	1	104	-15.28
71	680.5	136100	20	DFT-s-OFDM	$\pi/2$ -BPSK	50	0	-18.10
71	680.5	136100	20	DFT-s-OFDM	$\pi/2$ -BPSK	100	0	-17.97
71	680.5	136100	15	DFT-s-OFDM	$\pi/2$ -BPSK	1	1	-15.31
71	680.5	136100	10	DFT-s-OFDM	$\pi/2$ -BPSK	1	1	-14.96
71	680.5	136100	5	DFT-s-OFDM	$\pi/2$ -BPSK	1	1	-16.25



**Table 4-2**  
NR TDD Modulation Interference Factors<sup>1 3</sup>

NR Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	MIF [dB]
n41	2593.0	518598	100	DFT-s-OFDM	$\pi/2$ -BPSK	1	1	1.35
n41	2593.0	518598	100	DFT-s-OFDM	$\pi/2$ -BPSK	1	137	1.46
n41	2593.0	518598	100	DFT-s-OFDM	$\pi/2$ -BPSK	1	271	1.33
n41	2593.0	518598	100	DFT-s-OFDM	$\pi/2$ -BPSK	135	0	1.33
n41	2593.0	518598	100	DFT-s-OFDM	$\pi/2$ -BPSK	270	0	1.33
n41	2593.0	518598	90	DFT-s-OFDM	$\pi/2$ -BPSK	1	123	1.45
n41	2593.0	518598	80	DFT-s-OFDM	$\pi/2$ -BPSK	1	109	1.42
n41	2593.0	518598	60	DFT-s-OFDM	$\pi/2$ -BPSK	1	81	1.41
n41	2593.0	518598	50	DFT-s-OFDM	$\pi/2$ -BPSK	1	67	1.34
n41	2593.0	518598	40	DFT-s-OFDM	$\pi/2$ -BPSK	1	53	1.35
n41	2593.0	518598	20	DFT-s-OFDM	$\pi/2$ -BPSK	1	26	1.42

<sup>1</sup> Note: Measured MIF values may be lower than sample MIF values provided in ANSI C63.19-2011 Annex D.7 Table D.5 due to manufacturing variations for each device, however per Annex D.7, the sample MIF values of Table D.5 are not intended to substitute for measurements of actual devices under test and their respective operating modes.

<sup>2</sup> Note: Since n71 at 20MHz bandwidth is the overall worst-case NR FDD MIF and does not support 3 non overlapping channels, MIF measurements were made only on the middle channel.

<sup>3</sup> Note: Since n41 at 100MHz bandwidth is the overall worst-case NR TDD MIF and does not support 3 non overlapping channels, MIF measurements were made only on the middle channel.

FCC ID: A3LSMN976U	 PCTEST Proud to be part of	HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset		Page 8 of 16

## 5. RF CONDUCTED POWER MEASUREMENTS

### I. Procedures Used to Establish RF Signal for HAC Testing

The handset was configured to transmit the required air interface in a shielded chamber. Measurements were taken with a fully charged battery.

### II. HAC Measurement Conditions

#### Output Power Verification

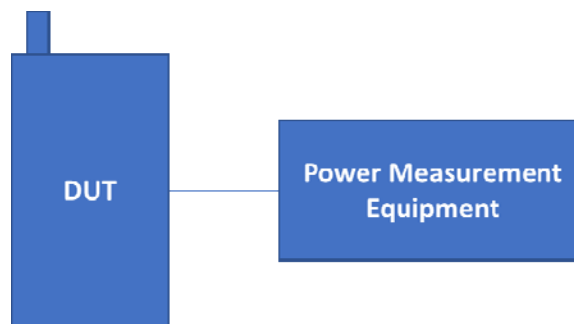
Maximum output power is verified on the High, Middle and Low channels for all applicable air interfaces for which full testing scans are required. Modes which are exempted from full testing according to Section 6 of this report have only their conducted power targets listed below, not measured values. See Table 5-1 for air interface specific settings of transmit power parameters. See Table 6-1 for more information regarding which modes required full testing and had conducted power measurements taken.

**Table 5-1  
Power Control Parameters and Settings by Air Interface**




Air Interface:	Parameter Name:	Parameter Set To:
NR	PLS	Mfr Specified

### III. Setup Used to Measure RF Conducted Powers

The general setup for conducted power is shown in Figure 5-1 below. The power measurement equipment could be a base station simulator, signal analyzer, or power meter depending on the applicable air interface.



**Figure 5-1  
Power Measurement Setup**

FCC ID: A3LSMN976U	 PCTEST Proud to be part of  Samsung	HAC (RF EMISSIONS) TEST REPORT	 Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 9 of 16

#### IV. NR FDD Target Powers

**Table 5-2  
NR FDD Conducted Power Targets**



Mode / Band		Modulated Average (dBm)
NR Band n71	Maximum	<b>25.8</b>
	Nominal	<b>24.8</b>
NR Band n5	Maximum	<b>25.8</b>
	Nominal	<b>24.8</b>

#### V. NR TDD Target Powers

**Table 5-3  
NR TDD Reduced Conducted Power Targets<sup>1</sup>**

Mode / Band		Modulated Average (dBm)
NR Band n41	Maximum	<b>21.0</b>
	Nominal	<b>20.0</b>

<sup>1</sup>Note: This device utilizes independent power reduction mechanisms for the LTE TDD n41 transmitter in all LTE TDD n41 bandwidths for held-to-ear scenarios.

FCC ID: A3LSMN976U	 <b>PCTEST</b> <small>Proud to be part of</small>	HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 10 of 16	

## 6. JUSTIFICATION OF HELD TO EAR MODES TESTED

### I. Analysis of RF Air Interface Technologies

An analysis was performed, following the guidance of §4.3 and §4.4 of the ANSI standard, of the RF air interface technologies being evaluated. The factors that will affect the RF interference potential were evaluated, and the worst-case operating modes were identified and used in the evaluation. A WD's interference potential is a function both of the WD's average near-field field strength and of the signal's audio-frequency amplitude modulation characteristics. Per §4.4, RF air interface technologies that have low power have been found to produce sufficiently low RF interference potential, so it is possible to exempt them from the product testing specified in Clause 5 of the ANSI standard. An RF air interface technology of a device is exempt from testing when its average antenna input power plus its MIF is  $\leq 17$ dBm for all of its operating modes. RF air interface technologies exempted from testing in this manner are automatically assigned an M4 rating to be used in determining the overall rating for the WD.

The worst-case MIF plus the worst-case average antenna input power for all modes are investigated below to determine the testing requirements for this device.

### II. Individual Mode Evaluations




**Table 6-1**  
Max Power + MIF calculations for Low Power Exemptions

Air Interface	Maximum Average Power (dBm)	Worst Case MIF (dB)	Total (Power + MIF, dB)	C63.19 Testing Required
NR FDD	25.80	-14.40	11.40	No
NR TDD	14.98*	1.46	16.44	No

\* Note: ANSI C63.19-2011 Sec. 4.4 Footnote 20 indicates the use of a long averaging time for measuring the antenna input power when using this method of exclusion. Therefore, the frame averaged power was calculated for these modes in this investigation. For final implementation, TDD NR slot configuration is synchronized using maximum duty cycle of 25%. Therefore, a duty cycle of 25% was used for the frame averaged power calculations.

### III. Low-Power Exemption Conclusions

Per ANSI C63.19-2011, NR modes are exempt from RF emissions testing and rated M4 under the low power exemption of Clause 4 from ANSI C63.19-2011.

FCC ID: A3LSMN976U	 PCTEST Proud to be part of 	HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 11 of 16	



## 7. EQUIPMENT LIST

**Table 7-1**  
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Temperature / Humidity Monitor	10/9/2018	Biennial	10/9/2020	181647812
Mini-Circuits	BW-N20W5	Power Attenuator	N/A	CBT*	N/A	1226
Pasternack	PE2237-20	Bidirectional Coupler	N/A	CBT*	N/A	N/A
Seekonk	NC-100	Torque Wrench (8" lb)	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	AIA	Audio Interference Analyzer	N/A	CBT*	N/A	1010

Calibration traceable to the National Institute of Standards and Technology (NIST).

**\*Note: CBT (Calibrated Before Testing).** Prior to testing, the measurement paths containing a cable, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.

FCC ID: A3LSMN976U	 <b>PCTEST</b> Proud to be part of 	HAC (RF EMISSIONS) TEST REPORT	Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 12 of 16

## 8. MEASUREMENT UNCERTAINTY



**Table 8-1**  
Uncertainty Estimation Table

Wireless Communications Device Near-Field Measurement Uncertainty Estimation							
Uncertainty Component	Data (dB)	Data Type	Prob. Dist.	Divisor	Ci (E)	Unc. (dB)	Notes/Comments
<b>Measurement System</b>							
RF System Reflections	0.50	Tolerance	N	1.00	1	0.50	* Refl. < -20 dB
Field Probe Calibration	0.21	Tolerance	N	1.00	1	0.21	
Field Probe Isotropy	0.01	Tolerance	N	1.00	1	0.01	
Field Probe Frequency Response	0.135	Tolerance	N	1.00	1	0.14	
Field Probe Linearity	0.013	Tolerance	N	1.00	1	0.01	
Modulation Interference Factor	0.20	Tolerance	R	1.73	1	0.12	Applicable for M-rating testing
Boundary Effects	0.105	Accuracy	R	1.73	1	0.06	*
Probe Positioning Accuracy	0.20	Accuracy	R	1.73	1	0.12	*
Probe Positioner	0.050	Accuracy	R	1.73	1	0.03	*
Extrapolation/Interpolation	0.045	Tolerance	R	1.73	1	0.03	*
Resolution to 2mm error	0.21	Tolerance	N	1.00	1	0.21	
System Detection Limit	0.05	Tolerance	R	1.73	1	0.03	*
Readout Electronics	0.015	Tolerance	N	1.00	1	0.02	*
Integration Time	0.11	Tolerance	R	1.73	1	0.06	*
Response Time	0.033	Tolerance	R	1.73	1	0.02	*
Phantom Thickness	0.10	Tolerance	R	1.73	1	0.06	*
System Repeatability (Field x 2=power)	0.17	Tolerance	N	1.00	1	0.17	*
<b>Test Sample Related</b>							
Device Positioning Vertical	0.2	Tolerance	R	1.73	1	0.12	*
Device Positioning Lateral	0.045	Tolerance	R	1.73	1	0.03	*
Device Holder and Phantom	0.1	Tolerance	R	1.73	1	0.06	*
Power Drift	0.21	Tolerance	R	1.73	1	0.12	
<i>Combined Standard Uncertainty (k=1)</i>						0.66	16.3%
<i>Expanded Uncertainty [95% confidence]</i>						1.31	32.6%
<i>Expanded Uncertainty [95% confidence] on Field</i>						0.66	16.3%

Notes:

1. Test equipments are calibrated according to techniques outlined in NIS81, NIS3003 and NIST Tech Note 1297. All equipments have traceability according to NIST. Measurement Uncertainties are defined in further detail in NIS 81 and NIST Tech Note 1297 and UKAS M3003.
2. \* Uncertainty specifications from Schmidt & Partner Engineering AG (not site specific)




Measurement uncertainty reflects the quality and accuracy of a measured result as compared to the true value. Such statements are generally required when stating results of measurements so that it is clear to the intended audience that the results may differ when reproduced by different facilities. Measurement results vary due to the measurement uncertainty of the instrumentation, measurement technique, and test engineer. Most uncertainties are calculated using the tolerances of the instrumentation used in the measurement, the measurement setup variability, and the technique used in performing the test. While not generally included, the variability of the equipment under test also figures into the overall measurement uncertainty. Another component of the overall uncertainty is based on the variability of repeated measurements (so-called Type A uncertainty). This may mean that the Hearing Aid immunity tests may have to be repeated by taking down the test setup and resetting it up so that there are a statistically significant number of repeat measurements to identify the measurement uncertainty. By combining the repeat measurement results with that of the instrumentation chain using the technique contained in NIS 81 and NIS 3003, the overall measurement uncertainty was estimated.

FCC ID: A3LSMN976U		HAC (RF EMISSIONS) TEST REPORT		Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 13 of 16	

## 9. CONCLUSION



The measurements indicate that NR modes of the wireless communications device comply with the HAC limits specified in accordance with the ANSI C63.19 Standard and FCC WT Docket No. 01-309 RM-8658. Precise laboratory measures were taken to assure repeatability of the tests. The tested device complies with the requirements in respect to all parameters specific to the test. The test results and statements relate only to the item(s) tested.

Please note that the M-rating for this equipment only represents the field interference possible against a hypothetical and typical hearing aid. The measurement system and techniques presented in this evaluation are proposed in the ANSI standard as a means of best approximating wireless device compatibility with a hearing-aid. The literature is under continual re-construction.



<b>FCC ID:</b> A3LSMN976U	 <b>PCTEST</b> Proud to be part of 	<b>HAC (RF EMISSIONS) TEST REPORT</b>		<b>Approved by:</b> Quality Manager
<b>Filename:</b> 1M2003230050-03.A3L	<b>Test Dates:</b> 4/2/2020	<b>DUT Type:</b> Portable Handset	Page 14 of 16	

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FCC ID: A3LSMN976U	 PCTEST Proud to be part of 	HAC (RF EMISSIONS) TEST REPORT	Approved by: Quality Manager
Filename: 1M2003230050-03.A3L	Test Dates: 4/2/2020	DUT Type: Portable Handset	Page 15 of 16

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<b>FCC ID:</b> A3LSMN976U	 <b>PCTEST</b> <small>Proud to be part of</small> 	<b>HAC (RF EMISSIONS) TEST REPORT</b>	<b>Approved by:</b> Quality Manager
<b>Filename:</b> 1M2003230050-03.A3L	<b>Test Dates:</b> 4/2/2020	<b>DUT Type:</b> Portable Handset	Page 16 of 16