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:
03/23/2020 - 03/25/2020
Test Site/Location:
PCTEST, Columbia, MD, USA
Test Report Serial No.:
1M2003120045-14.A3L
Date of Issue:
04/15/2020

FCC ID:	**A3LSMG986W**
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-G986W
Test Device Serial No.:	*Pre-Production Sample* [S/N: 1011M]
Class II Permissive Change(s):	*See FCC Change Document*
Original Grant Date:	02/21/2020

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

ilac-MRA
ACCREDITED
TESTING CERT#2041.01

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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[1] 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.

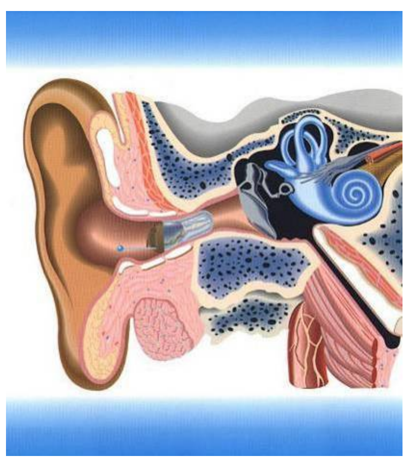

Figure 1-1 Hearing Aid *in-vitu*

[1] FCC Rule & Order, WT Docket 01-309 RM-8658

2. DUT DESCRIPTION

FCC ID:	A3LSMG986W
Manufacturer:	Samsung Electronics Co., Ltd. 129, Samsung-ro, Maetan dong, Yeongtong-gu, Suwon-si Gyeonggi-do 16677, Korea
Model:	SM-G986W
Serial Number:	1011M
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 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.

Table 2-1
A3LSMG986W HAC Air Interfaces

Air-Interface	Band (MHz)	Type Transport	HAC Tested	Simultaneous But Not Tested	Name of Voice Service
CDMA	835	VO	No[3]	Yes: WIFI or BT	CMRS Voice
	EvDO	VD	No[3]	Yes: WIFI or BT	Google Duo
GSM	850	VO	No[3]	Yes: WIFI or BT	CMRS Voice
	1900				
	GPRS/EDGE	VD	No[3]	Yes: WIFI or BT	Google Duo
UMTS	850	VD	No[3]	Yes: WIFI or BT	CMRS Voice
	1700				
	1900				
	HSPA	VD	No[3]	Yes: WIFI or BT	Google Duo
LTE (FDD)	680 (B71)	VD	No[3]	Yes: WIFI or BT	VoLTE, Google Duo
	700 (B12)		No[3]		
	780 (B13)				
	850 (B5)				
	1700 (B4)				
	1700 (B66)				
	1900 (B2)				
	1900 (B25)				
	2300 (B30)				
	2500 (B7)				
LTE (TDD)	2600 (B38)	VD	No[3]	Yes: WIFI or BT	VoLTE, Google Duo
	2600 (B41)				
NR (FDD)	680 (n71)	VD	No[1 2]	Yes: WIFI or BT	Google Duo
	1700 (n66)		No[1]		
NR (TDD)	2600 (n41)	VD	No[1]	Yes: WIFI or BT	Google Duo
WIFI	2450	VD	No[3]	Yes: CDMA, 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: CDMA, 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: 1M1911010179-14-R1.A3L).

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
Near field Category	**E-field emissions CW dB(V/m)**
f < 960 MHz	
M1	50 to 55
M2	45 to 50
M3	40 to 45
M4	< 40
f > 960 MHz	
M1	40 to 45
M2	35 to 40
M3	30 to 35
M4	< 30

Table 3-1
WD near-field categories as defined in ANSI C63.19-2011

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 × log[(step e)/(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:

Audio Interference Level [dB(V/m)] = 20 * log[Raw Field Value (V/m)] + 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.

II. MIF Measurement Block Diagrams

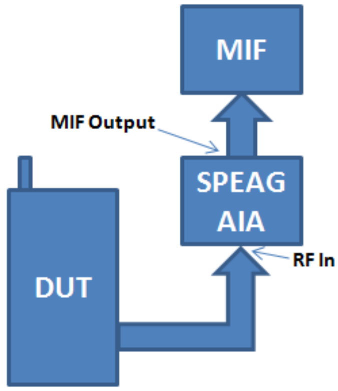

Figure 4-1
MIF Measurement Setup

III. Measured Modulation Interference Factors:

Table 4-1
NR FDD Modulation Interference Factors[1,2]

NR Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	MIF [dB]
n71	680.5	136100	20	DFT-s-OFDM	π/2-BPSK	1	1	-16.90
n66	1745.0	349000	20	DFT-s-OFDM	π/2-BPSK	1	1	-16.88
n66	1745.0	349000	20	DFT-s-OFDM	π/2-BPSK	1	53	-17.17
n66	1745.0	349000	20	DFT-s-OFDM	π/2-BPSK	1	104	-17.21
n66	1745.0	349000	20	DFT-s-OFDM	π/2-BPSK	50	0	-23.27
n66	1745.0	349000	20	DFT-s-OFDM	π/2-BPSK	100	0	-24.66
n66	1754.1	350820	15	DFT-s-OFDM	π/2-BPSK	1	1	-16.92
n66	1755.0	351000	10	DFT-s-OFDM	π/2-BPSK	1	1	-16.88
n66	1755.8	351160	5	DFT-s-OFDM	π/2-BPSK	1	1	-16.46
n66	1712.5	342500	5	DFT-s-OFDM	π/2-BPSK	1	1	-16.51
n66	1777.5	355500	5	DFT-s-OFDM	π/2-BPSK	1	1	-16.40

Table 4-2
NR TDD Modulation Interference Factors[1,3]

NR Band	Frequency [MHz]	Channel	Bandwidth [MHz]	Waveform	Modulation	RB Size	RB Offset	MIF [dB]
n41	2593.0	518598	100	DFT-s-OFDM	π/2-BPSK	1	1	1.34
n41	2593.0	518598	100	DFT-s-OFDM	π/2-BPSK	1	137	1.35
n41	2593.0	518598	100	DFT-s-OFDM	π/2-BPSK	1	271	1.33
n41	2593.0	518598	100	DFT-s-OFDM	π/2-BPSK	135	0	1.36
n41	2593.0	518598	100	DFT-s-OFDM	π/2-BPSK	270	0	1.35
n41	2593.0	518598	90	DFT-s-OFDM	π/2-BPSK	120	0	1.36
n41	2593.0	518598	80	DFT-s-OFDM	π/2-BPSK	108	0	1.35
n41	2593.0	518598	60	DFT-s-OFDM	π/2-BPSK	81	0	1.36
n41	2593.0	518598	50	DFT-s-OFDM	π/2-BPSK	64	0	1.35
n41	2593.0	518598	40	DFT-s-OFDM	π/2-BPSK	50	0	1.33
n41	2593.0	518598	20	DFT-s-OFDM	π/2-BPSK	25	0	1.33

[1] 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.

[2] Note: All FDD NR bands were found to have substantially similar MIF values given similar RB, BW, and modulation configurations.

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

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.

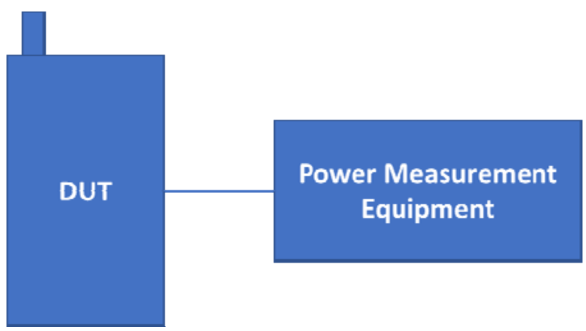

Figure 5-1
Power Measurement Setup

IV. NR FDD Target Powers

Table 5-2
NR FDD Conducted Power Targets

Mode / Band		Modulated Average (dBm)
NR FDD Band n71	Maximum	**25.5**
	Nominal	**24.5**
NR FDD Band n66	Maximum	**25.0**
	Nominal	**24.0**

V. NR TDD Target Powers

Table 5-3
NR TDD Reduced Conducted Power Targets

Mode / Band		Modulated Average (dBm)
NR TDD Band n41[1]	Maximum	**21.0[2]**
	Nominal	**20.0[2]**

[1] Note: This device utilizes independent power reduction mechanisms for the NR TDD n41 transmitter in all NR TDD n41 bandwidths for held-to-ear scenarios.

[2] Note: The maximum and nominal values listed for NR TDD n41 are using the "force peak" setting described in the operational description.

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 ≤17dBm 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	25.50	-16.40	9.10	No
NR TDD	14.98*	1.36	16.34	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.

7. EQUIPMENT LIST

Table 7-1
Equipment List

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Control Company	4040	Therm./ Clock/ Humidity Monitor	2/17/2020	Biennial	2/17/2022	200113274
Mini-Circuits	BW-N20W5	Power Attenuator	N/A	CBT*	N/A	1226
Seekonk	NC-100	Torque Wrench (8" lb)	5/23/2018	Biennial	5/23/2020	N/A
SPEAG	AIA	Audio Interference Analzyer	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.

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
Measurement System							
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	*
Test Sample Related							
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	
Combined Standard Uncertainty (k=1)						0.66	16.3%
Expanded Uncertainty [95% confidence]						1.31	32.6%
Expanded Uncertainty [95% confidence] on Field						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.

9. CONCLUSION

The measurements indicate that the 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.

10. REFERENCES

1. ANSI/IEEE C63.19-2011, “American National Standard for Methods of Measurement of Compatibility between Wireless Communication Devices and Hearing Aids.”, New York, NY, IEEE, May 2011

2. FCC Office of Engineering and Technology KDB, “285076 D01 HAC Guidance v05,” September 13, 2017

3. FCC Office of Engineering and Technology KDB, “285076 D02 T-Coil Testing for CMRS IP v03,” September 13, 2017

4. FCC Public Notice DA 06-1215, *Wireless Telecommunications Bureau and Office of Engineering and Technology Clarify Use of Revised Wireless Phone Hearing Aid Compatibility Standard*, June 6, 2006

5. FCC 3G Review Guidance, Laboratory Division OET FCC, May/June 2006

6. Berger, H. S., “Compatibility Between Hearing Aids and Wireless Devices,” Electronic Industries Forum, Boston, MA, May, 1997

7. Berger, H. S., “Hearing Aid and Cellular Phone Compatibility: Working Toward Solutions,” Wireless Telephones and Hearing Aids: New Challenges for Audiology, Gallaudet University, Washington, D.C., May, 1997 (To be reprinted in the American Journal of Audiology).

8. Berger, H. S., “Hearing Aid Compatibility with Wireless Communications Devices, “ IEEE International Symposium on Electromagnetic Compatibility, Austin, TX, August, 1997.

9. Bronaugh, E. L., “Simplifying EMI Immunity (Susceptibility) Tests in TEM Cells,” in the 1990 IEEE International Symposium on Electromagnetic Compatibility Symposium Record, Washington, D.C., August 1990, pp. 488-491

10. Byme, D. and Dillon, H., The National Acoustics Laboratory (NAL) New Procedure for Selecting the Gain and Frequency Response of a Hearing Aid, Ear and Hearing 7:257-265, 1986.

11. Crawford, M. L., “Measurement of Electromagnetic Radiation from Electronic Equipment using TEM Transmission Cells, “ U.S. Department of Commerce, National Bureau of Standards, NBSIR 73-306, Feb. 1973.

12. Crawford, M. L., and Workman, J. L., “Using a TEM Cell for EMC Measurements of Electronic Equipment,” U.S. Department of Commerce, National Bureau of Standards. Technical Note 1013, July 1981.

13. Decker, W. F., Crawford, M. L., and Wilson, W. A., “Construction of a Large Transverse Electromagnetic Cell”, U.S. Department of Commerce, National Bureau of Standards, Technical Note 1011, Feb. 1979.

14. EHIMA GSM Project, Development phase, Project Report (1st part) Revision A. Technical-Audiological Laboratory and Telecom Denmark, October 1993.

15. EHIMA GSM Project, Development phase, Part II Project Report. Technical-Audiological Laboratory and Telecom Denmark, June 1994.

16. EHIMA GSM Project Final Report, Hearing Aids and GSM Mobile Telephones: Interference Problems, Methods of Measurement and Levels of Immunity. Technical-Audiological Laboratory and Telecom Denmark, 1995.

17. HAMPIS Report, Comparison of Mobile phone electromagnetic near field with an upscaled electromagnetic far field, using hearing aid as reference, 21 October 1999.

18. Hearing Aids/GSM, Report from OTWIDAM, Technical-Audiological Laboratory and Telecom Denmark, April 1993.

19. IEEE 100, The Authoritative Dictionary of IEEE Standards Terms, Seventh Edition.

20. Joyner, K. H, et. al., Interference to Hearing Aids by the New Digital Mobile Telephone System, Global System for Mobile (GSM) Communication Standard, National Acoustic Laboratory, Australian Hearing Series, Sydney 1993.

21. Joyner, K. H., et. al., Interference to Hearing Aids by the Digital Mobile Telephone System, Global System for Mobile Communications (GSM), NAL Report #131, National Acoustic Laboratory, Australian Hearing Series, Sydney, 1995.

22. Konigstein, D., and Hansen, D., “A New Family of TEM Cells with enlarged bandwidth and Optimized working Volume,” in the Proceedings of the 7th International Symposium on EMC, Zurich, Switzerland, March 1987; 50:9, pp. 127-132.

23. Kuk, F., and Hjorstgaard, N. K., “Factors affecting interference from digital cellular telephones,” Hearing Journal, 1997; 50:9, pp 32-34.

24. Ma, M. A., and Kanda, M., ”Electromagnetic Compatibility and Interference Metrology,” U.S. Department of Commerce, National Bureau of Standards, Technical Note 1099, July 1986, pp. 17-43.

25. Ma, M. A., Sreenivashiah, I. , and Chang, D. C., “A Method of Determining the Emission and Susceptibility Levels of Electrically Small Objects Using a TEM Cell,” U.S. Department of Commerce, National Bureau of Standards, Technial Note 1040, July 1981.

26. McCandless, G. A., and Lyregaard, P. E., Prescription of Gain/Output (POGO) for Hearing Aids, Hearing Instruments 1:16-21, 1983

27. Skopec, M., “Hearing Aid Electromagnetic Interference from Digital Wireless Telephones, “IEEE Transactions on Rehabilitation Engineering, vol. 6, no. 2, pp. 235-239, June 1998.

28. Technical Report, GSM 05.90, GSM EMC Considerations, European Telecommunications Standards Institute, January 1993.

29. Victorian, T. A., “Digital Cellular Telephone Interference and Hearing Aid Compatibility—an Update,” Hearing Journal 1998; 51:10, pp. 53-60

30. Wong, G. S. K., and Embleton, T. F. W., eds., AIP Handbook of Condenser Microphones: Theory, Calibration and Measurements, AIP Press.