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# 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:**
1/8/2018
**Test Site/Location:**
PCTEST Lab, Columbia, MD, USA
**Test Report Serial No.:**
1M1712220333-06.A3L

| | |
|---|---|
| **FCC ID:** | **A3LSMG9650** |
| **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<br>285076 D01 HAC Guidance v05<br>285076 D02 T-Coil testing for CMRS IP v03 |
| **DUT Type:** | Portable Handset |
| **Model:** | SM-G9650 |
| **Test Device Serial No.:** | *Pre-Production Sample* [S/N: A2507] |
| **Class II Permissive Change(s):** | See FCC Change Document |

| | |
|---|---|
| **C63.19-2011 HAC Category:** | **M4 (RF EMISSIONS CATEGORY)** |

This report pertains only to the WIFI modes supported by the device. This wireless portable device has been shown to be Hearing-Aid compatible for WIFI air interfaces, 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

# T A B L E   O F   C O N T E N T S

# 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.

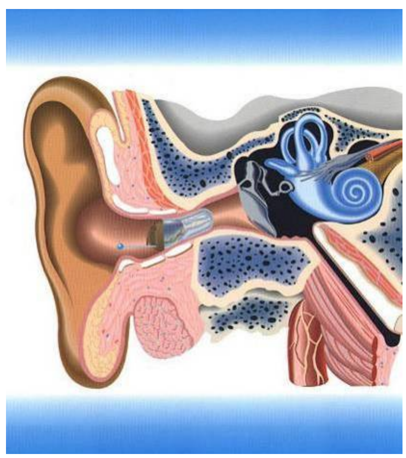


**Figure 1-1 Hearing Aid *in-vitu***

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

# 2. DUT DESCRIPTION

| | |
|---|---|
| FCC ID: | A3LSMG9650 |
| Manufacturer: | Samsung Electronics Co., Ltd.<br>129, Samsung-ro, Maetan dong,<br>Yeongtong-gu, Suwon-si<br>Gyeonggi-do 16677, Korea |
| Model: | SM-G9650 |
| Serial Number: | A2507 |
| Antenna Configurations: | Internal Antenna |
| DUT Type: | Portable Handset |

## I. Power Reduction for WIFI

This device uses an independent fixed level power reduction mechanism for all WIFI operations during voice or VoIP held to ear scenarios. Reduced powers were used to evaluate for low-power exemption in Section 9.II for WIFI. Detailed descriptions of the power reduction mechanism are included in the operational description.

**Table 2-1**
A3LSMG9650 HAC Air Interfaces

| Air-Interface | Band (MHz) | Type Transport | HAC Tested | Simultaneous But Not Tested | Name of Voice Service |
|---|---|---|---|---|---|
| CDMA | 835 | VO | No[1] | Yes: WIFI or BT | CMRS Voice |
| | EvDO | VD | No[1] | Yes: WIFI or BT | Google Duo |
| GSM | 850 | VO | No[1] | Yes: WIFI or BT | CMRS Voice |
| | 1900 | | | | |
| | GPRS/EDGE | VD | No[1] | Yes: WIFI or BT | Google Duo |
| UMTS | 850 | VD | No[1] | Yes: WIFI or BT | CMRS Voice |
| | 1700 | | | | |
| | 1900 | | | | |
| | HSPA | VD | No[1] | Yes: WIFI or BT | Google Duo |
| LTE (FDD) | 700 (B12) | VD | No[1] | Yes: WIFI or BT | Google Duo |
| | 700 (B17) | | | | |
| | 780 (B13) | | | | |
| | 850 (B5) | | | | |
| | 850 (B26) | | | | |
| | 1700 (B4) | | | | |
| | 1700 (B66) | | | | |
| | 1900 (B2) | | | | |
| | 1900 (B25) | | | | |
| LTE (TDD) | 2600 (B41) | VD | No[1] | Yes: WIFI or BT | Google Duo |
| WIFI | 2450 | VD | No[2] | Yes: CDMA, GSM, UMTS, or LTE | 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, or LTE | N/A |

Type Transport
VO = Voice Only
DT = Digital Data - Not intended for CMRS Service
VD = CMRS and IP Voice over Data Transport

Notes:
1. CDMA, GSM, UMTS, and LTE air interfaces are not within the scope of this test report. Please refer to the original certification test report.
2. Evaluated for MIF and low-power exemption.

# 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<br>CW<br>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. SYSTEM SPECIFICATIONS

### ER3DV6 E-Field Probe Description

| | |
|---|---|
| Construction: | One dipole parallel, two dipoles normal to probe axis<br>Built-in shielding against static charges |
| Calibration: | In air from 100 MHz to 3.0 GHz<br>(absolute accuracy ±6.0%, k=2) |
| Frequency: | 100 MHz to > 6 GHz;<br>Linearity: ± 0.2 dB (100 MHz to 3 GHz) |
| Directivity | ± 0.2 dB in air (rotation around probe axis)<br>± 0.4 dB in air (rotation normal to probe axis) |
| Dynamic Range | 2 V/m to > 1000 V/m<br>(M3 or better device readings fall well below diode compression point) |
| Linearity: | ± 0.2 dB |
| Dimensions | Overall length: 330 mm (Tip: 16 mm)<br>Tip diameter: 8 mm (Body: 12 mm)<br>Distance from probe tip to dipole centers: 2.5 mm |

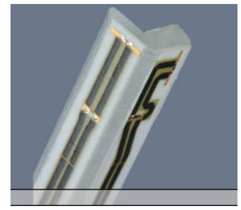
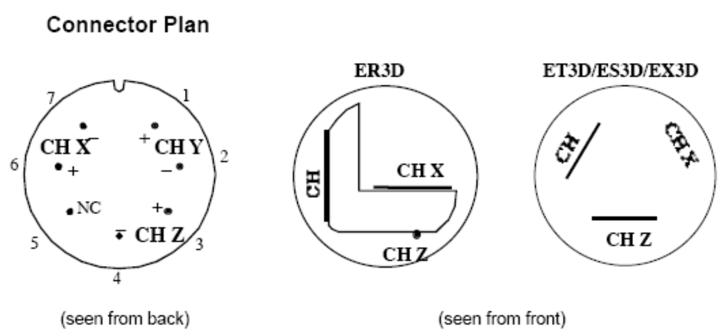


**Figure 4-1**
E-field Free-space Probe

### Probe Tip Description

HAC field measurements take place in the close near field with high gradients. Increasing the measuring distance from the source will generally decrease the measured field values (in case of the validation dipole approx. 10% per mm).

The electric field probes have an irregular internal geometry because it is physically not possible to have the 3 orthogonal sensors situated with the same center. The effect of the different sensor centers is accounted for in the HAC uncertainty budget ("sensor displacement"). Their geometric center is at 2.5mm from the tip, and the element ends are 1.1mm closer to the tip.




The antistatic shielding inside the probe is connected to the probe connector case.

## Instrumentation Chain

### Equation 1

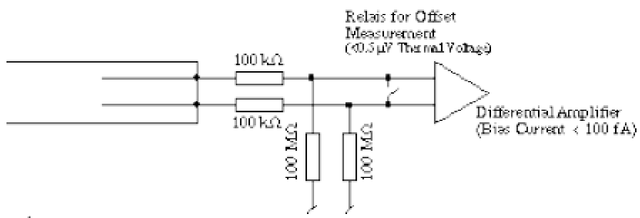
**Conversion of Connector Voltage $u_i$ to E-Field $E_i$**

$$E_i = \sqrt{\frac{u_i + (u_i^2 \cdot CF)/(DCP)}{Norm_i \cdot ConvF}}$$

whereby

| | |
|---|---|
| $E_i$: | electric field in V/m |
| $u_i$: | voltage of channel i at the connector in μV |
| $Norm_i$: | sensitivity of channel i in μV/(V/m)$^2$ |
| $ConvF$: | enhancement factor in liquid (ConvF=1 for Air) |
| $DCP$: | diode compression point in μV |
| $CF$: | signal crest factor (peak power/average power) |

**Conditions of Calibration**




Please note:

- a lower input impedance of the amplifier will result in different sensitivity factors $Norm_i$ and $DCP$
- larger bias currents will cause higher offset

## Probe Response to Frequency

The E-field sensors have inherently a very flat frequency response. They are calibrated with a number of frequencies resulting in a common calibration factor, with the frequency behavior documented in the calibration certificate (See also below).

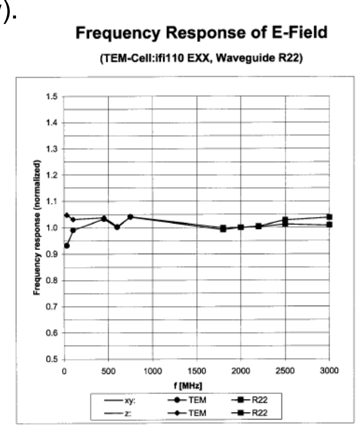



**Figure 4-2** E-Field Probe Frequency Response

## SPEAG Robotic System

E-field measurements are performed using the DASY5 automated dosimetric assessment system. The DASY5 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland and consists of high precision robotics system (Staubli), robot controller, Intel CORE i7 computer, near-field probe, probe alignment sensor, and the HAC phantom. The robot is a six-axis industrial robot performing precise movements to position the probe to the location (points) of maximum electromagnetic field (EMF).


**Figure 4-3**
SPEAG Robotic System

## System Hardware

A cell controller system contains the power supply, robot controller, teach pendant (Joystick), and a remote control used to drive the robot motors. The PC consists of the computer with operating system and RF Measurement Software DASY5 v52.8 (with HAC Extension), A/D interface card, monitor, mouse, and keyboard. The Staubli Robot is connected to the cell controller to allow software manipulation of the robot. A data acquisition electronic (DAE) circuit that performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. is connected to the Electro-optical coupler (EOC). The EOC performs the conversion from the optical into digital electric signal of the DAE and transfers data to the PC plug-in card.

## System Electronics

The DAE consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit.  Transmission to the PC-card is accomplished through an optical downlink for data and status information and an optical uplink for commands and clock lines. The mechanical probe mounting device includes two different sensor systems for frontal and sidewise probe contacts.  They are also used for mechanical surface detection and probe collision detection. The robot uses its own controller with a built in VME-bus computer.

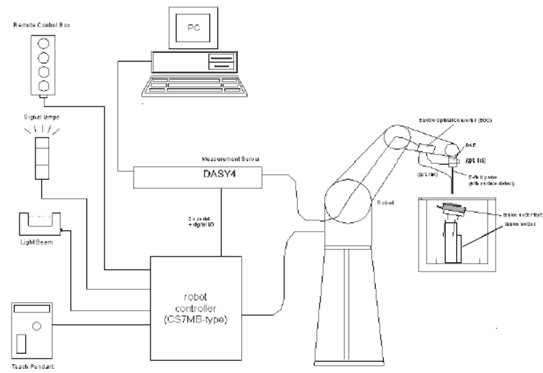



**Figure 4-4**
SPEAG Robotic System Diagram

## DASY5 Instrumentation Chain

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

| | | | |
|---|---|---|---|
| with | $V_i$ | = compensated signal of channel i | (i = x, y, z) |
| | $U_i$ | = input signal of channel i | (i = x, y, z) |
| | $cf$ | = crest factor of exciting field | (DASY parameter) |
| | $dcp_i$ | = diode compression point | (DASY parameter) |

From the compensated input signals the primary field data for each channel can be evaluated:

$$\mathrm{E-fieldprobes:} \qquad E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

| | | | |
|---|---|---|---|
| with | $V_i$ | = compensated signal of channel i | (i = x, y, z) |
| | $Norm_i$ | = sensor sensitivity of channel i | (i = x, y, z) |
| | | $\mu V/(V/m)^2$ for E-field Probes | |
| | $ConvF$ | = sensitivity enhancement in solution | |
| | $E_i$ | = electric field strength of channel i in V/m | |

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

The measurement/integration time per point, as specified by the system manufacturer is >500ms.

The signal response time is evaluated as the time required by the system to reach 90% of the expected final value after an on/off switch of the power source with an integration time of 500ms and a probe response time of <5 ms. In the current implementation, DASY5 waits longer than 100ms after having reached the grid point before starting a measurement, i.e., the response time uncertainty is negligible.

If the device under test does not emit a CW signal, the integration time applied to measure the electric field at a specific point may introduce additional uncertainties due to the discretization. The tolerances for the different systems had the worst-case of 2.6%.

## 5. TEST PROCEDURE

### I. RF EMISSIONS

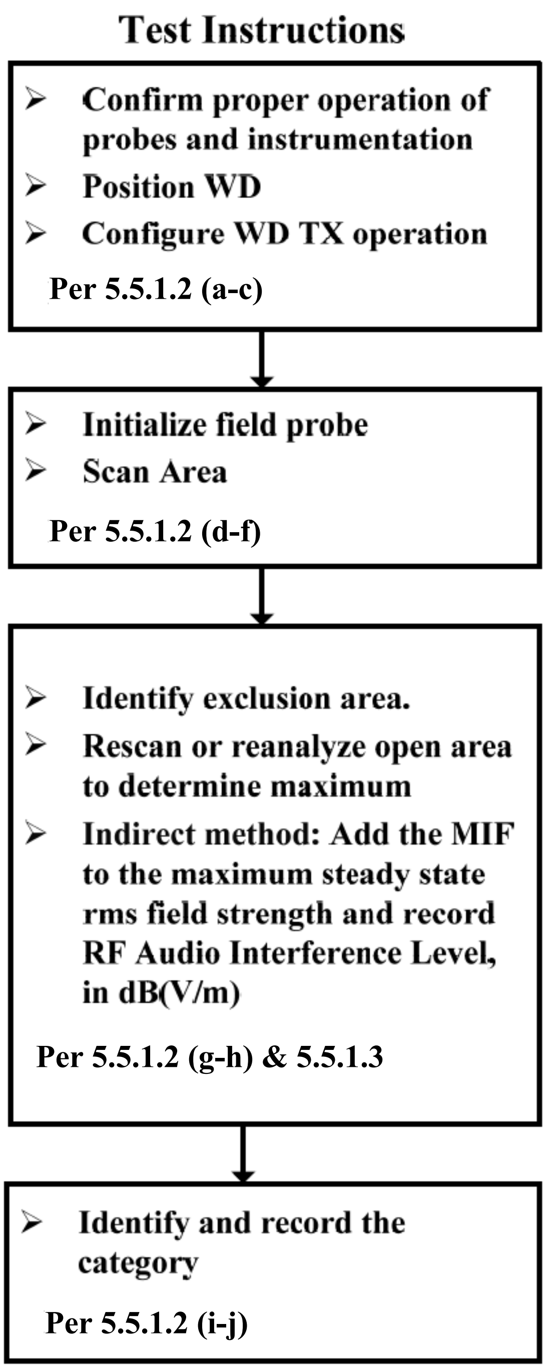



**Figure 5-1 RF Emissions Flow Chart**

## Test Setup

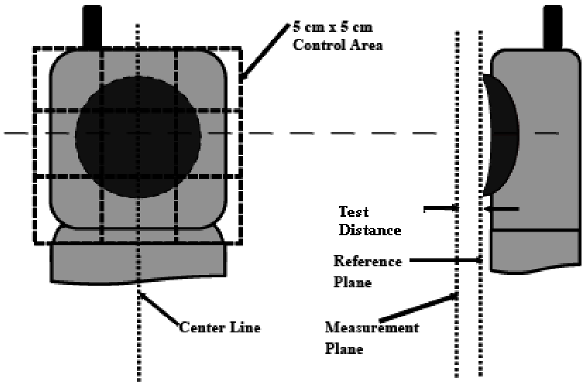



**Figure 5-2**
E-Field Emissions Test Setup Diagram (See Test Photographs for actual WD scan grid overlay)

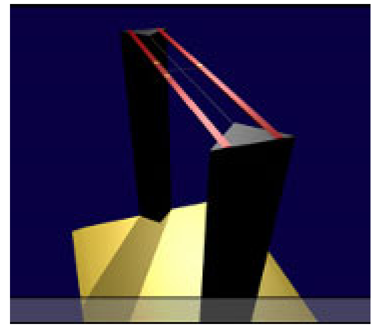


**Figure 5-3**
HAC Phantom

## RF Emissions Test Procedure:

The following illustrate a typical RF emissions test scan over a wireless communications device:

1. Proper operation of the field probe, probe measurement system, other instrumentation, and the positioning system was confirmed.

2. WD is positioned in its intended test position, acoustic output point of the device perpendicular to the field probe.

3. The WD operation for maximum rated RF output power was configured and confirmed with the base station simulator, at the test channel and other normal operating parameters as intended for the test. The battery was ensured to be fully charged before each test.

4. The center sub-grid was centered over the center of the acoustic output (also audio band magnetic output, if applicable). The WD audio output was positioned tangent (as physically possible) to the measurement plane.

5. A surface calibration was performed before each setup change to ensure repeatable spacing and proper maintenance of the measurement plane using the HAC Phantom.

6. The measurement system measured the field strength at the reference location.

7. Measurements at 2mm or 5mm increments in the 5 x 5 cm region were performed at a distance 15 mm from the center point of the probe measurement element to the WD. A 360° rotation about the azimuth axis at the maximum interpolated position was measured. For the worst-case condition, the peak reading from this rotation was used in re-evaluating the HAC category.

8. The system performed a drift evaluation by measuring the field at the reference location. If the power drift deviated by more than 5%, the HAC test and drift measurements were repeated.

# 6. 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

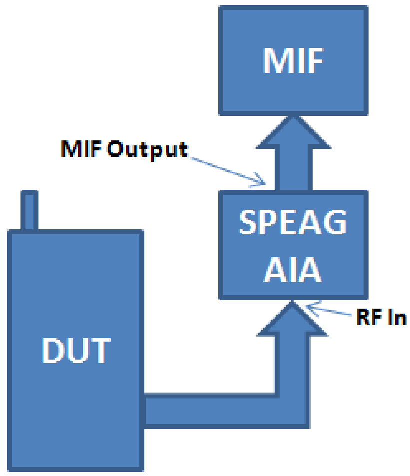



**Figure 6-1**
MIF Measurement Setup
for unlicensed modes

## III. Measured Modulation Interference Factors:

**Table 6-1**
802.11b (2.4GHz, SISO) Modulation Interference Factors[1,2]

| Mode | 802.11b MIF Measurements [dB] | | | |
|---|---|---|---|---|
| | Data Rate [Mbps] | | | |
| | 1 | 2 | 5.5 | 11 |
| 802.11b | -10.31 | -9.59 | -7.33 | -6.36 |

**Table 6-2**
802.11g (2.4GHz, SISO) Modulation Interference Factors[1,2]

| Mode | 802.11g MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 6 | 9 | 12 | 18 | 24 | 36 | 48 | 54 |
| 802.11g | -7.60 | -6.79 | -6.26 | -5.49 | -5.14 | -4.79 | -4.84 | -5.03 |

**Table 6-3**
802.11g (2.4GHz, MIMO) Modulation Interference Factors[1,2]

| Mode | 802.11g MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 12 | 18 | 24 | 36 | 48 | 72 | 96 | 108 |
| 802.11g | -7.53 | -6.75 | -6.23 | -5.46 | -5.11 | -4.76 | -4.82 | -5.01 |

[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: WIFI MIF values were found to be independent of the transmit channel.

**Table 6-4**
802.11n (2.4GHz, SISO) Modulation Interference Factors[1,2]

| Mode | 802.11n (2.4GHz) MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 6.5 | 13 | 19.5 | 26 | 39 | 52 | 58.5 | 65 |
| 802.11n | -7.49 | -6.20 | -5.54 | -5.11 | -4.84 | -4.85 | -4.97 | -5.08 |

**Table 6-5**
802.11n (2.4GHz, MIMO) Modulation Interference Factors[1,2]

| Mode | 802.11n (2.4GHz) MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 13 | 26 | 39 | 52 | 78 | 104 | 117 | 130 |
| 802.11n | -7.44 | -6.15 | -5.51 | -5.07 | -4.80 | -4.81 | -4.93 | -5.05 |

**Table 6-6**
802.11a (5GHz, 20MHz BW, SISO) Modulation Interference Factors[1,2]

| Mode | 802.11a MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 6 | 9 | 12 | 18 | 24 | 36 | 48 | 54 |
| 802.11a | -13.77 | -12.95 | -12.64 | -11.55 | -11.41 | -11.81 | -12.18 | -13.30 |

**Table 6-7**
802.11a (5GHz, 20MHz BW, MIMO) Modulation Interference Factors[1,2]

| Mode | 802.11a MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 12 | 18 | 24 | 36 | 48 | 72 | 92 | 108 |
| 802.11a | -13.47 | -12.85 | -12.06 | -11.43 | -11.80 | -11.75 | -12.39 | -13.17 |

**Table 6-8**
802.11n (5GHz, 20MHz BW, SISO) Modulation Interference Factors[1,2]

| Mode | 20MHz BW 802.11n (5GHz) MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 6.5 | 13 | 19.5 | 26 | 39 | 52 | 58.5 | 65 |
| 802.11n | -13.11 | -11.96 | -11.53 | -11.31 | -11.48 | -11.79 | -12.16 | -12.50 |

**Table 6-9**
802.11n (5GHz, 20MHz BW, MIMO) Modulation Interference Factors[1,2]

| Mode | 20MHz BW 802.11n (5GHz) MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 13 | 26 | 39 | 52 | 78 | 104 | 117 | 130 |
| 802.11n | -13.17 | -12.04 | -11.92 | -11.31 | -11.61 | -12.10 | -12.44 | -12.91 |

[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: WIFI MIF values were found to be independent of the transmit channel.

**Table 6-10**
802.11ac (5GHz, 20MHz BW, SISO) Modulation Interference Factors[1,2]

| Mode | 20MHz BW 802.11ac (5GHz) MIF Measurements [dB] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | | |
| | 6.5 | 13 | 19.5 | 26 | 39 | 52 | 58.5 | 65 | 78 |
| 802.11ac | -13.38 | -12.10 | -11.44 | -11.26 | -11.40 | -11.78 | -12.01 | -12.26 | -13.09 |

**Table 6-11**
802.11ac (5GHz, 20MHz BW, MIMO) Modulation Interference Factors[1,2]

| Mode | 20MHz BW 802.11ac (5GHz) MIF Measurements [dB] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | | |
| | 13 | 26 | 39 | 52 | 78 | 104 | 117 | 130 | 156 |
| 802.11ac | -12.49 | -11.63 | -11.80 | -12.25 | -12.89 | -13.95 | -13.88 | -14.16 | -14.96 |

**Table 6-12**
802.11n (5GHz, 40MHz BW, SISO) Modulation Interference Factors[1,2]

| Mode | 40MHz BW 802.11n (5GHz) MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 13.5 | 27 | 40.5 | 54 | 81 | 108 | 121.5 | 135 |
| 802.11n | -11.69 | -11.06 | -11.48 | -11.97 | -13.32 | -14.16 | -14.63 | -15.12 |

**Table 6-13**
802.11n (5GHz, 40MHz BW, MIMO) Modulation Interference Factors[1,2]

| Mode | 40MHz BW 802.11n (5GHz) MIF Measurements [dB] | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | |
| | 27 | 54 | 81 | 108 | 162 | 216 | 243 | 270 |
| 802.11n | -11.26 | -11.03 | -11.45 | -11.62 | -13.04 | -13.91 | -14.90 | -15.13 |

**Table 6-14**
802.11ac (5GHz, 40MHz BW, SISO) Modulation Interference Factors[1,2]

| Mode | 40MHz BW 802.11ac (5GHz) MIF Measurements [dB] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | | |
| | 13.5 | 27 | 40.5 | 54 | 81 | 108 | 121.5 | 135 | 180 |
| 802.11ac | -11.65 | -10.86 | -11.33 | -11.87 | -13.15 | -14.08 | -14.37 | -14.66 | -15.42 |

**Table 6-15**
802.11ac (5GHz, 40MHz BW, MIMO) Modulation Interference Factors[1,2]

| Mode | 40MHz BW 802.11ac (5GHz) MIF Measurements [dB] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | | |
| | 27 | 54 | 81 | 108 | 162 | 216 | 243 | 270 | 360 |
| 802.11ac | -10.65 | -11.86 | -12.79 | -13.79 | -14.89 | -16.27 | -16.63 | -16.43 | -16.66 |

[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: WIFI MIF values were found to be independent of the transmit channel.

**Table 6-16**
802.11ac (5GHz, 80MHz BW, SISO) Modulation Interference Factors[1,2]

| Mode | 80MHz BW 802.11ac (5GHz) MIF Measurements [dB] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | | | |
| | 29.3 | 58.5 | 87.8 | 117 | 175.5 | 234 | 263.3 | 292.5 | 351 | 390 |
| 802.11ac | -11.32 | -12.46 | -13.53 | -14.31 | -15.44 | -16.63 | -16.62 | -16.59 | -17.01 | -17.24 |

**Table 6-17**
802.11ac (5GHz, 80MHz BW, MIMO) Modulation Interference Factors[1,2]

| Mode | 80MHz BW 802.11ac (5GHz) MIF Measurements [dB] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Data Rate [Mbps] | | | | | | | | | |
| | 58.5 | 117 | 175.5 | 234 | 351 | 468 | 526.5 | 585 | 702 | 780 |
| 802.11ac | -12.30 | -14.13 | -14.91 | -16.20 | -16.63 | -17.37 | -17.32 | -17.91 | -17.93 | -18.47 |

**Table 6-18**
Simultaneous 2.4GHz and 5GHz WIFI Modulation Interference Factors[1,2,3]

| # Tx | 5 GHz WIFI [dBm] | | 2.4 GHz WIFI [dBm] | | Measured MIF (dB) |
|---|---|---|---|---|---|
| | Ant1 | Ant2 | Ant1 | Ant2 | |
| 2 | x | - | - | x | -5.33 |
| 2 | - | x | x | - | -6.32 |
| 2 | x | - | x | - | -6.18 |
| 2 | - | x | - | x | -5.95 |
| 3 | x | x | x | - | -6.77 |
| 3 | x | x | - | x | -6.41 |
| 3 | x | - | x | x | -5.10 |
| 3 | - | x | x | x | -6.05 |
| 4 | x | x | x | x | -6.35 |

[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: WIFI MIF values were found to be independent of the transmit channel.

[3] Note: The configuration for each scenario (e.g. bandwidth, data rate, etc.) was determined using the worst-case configuration from SISO and MIMO MIF measurements.

# 7. RF CONDUCTED POWER MEASUREMENTS

## I. HAC Measurement Conditions

**Output Power Verification**
Maximum output power is verified on the High, Middle and Low channels for all applicable air interfaces. See Table 7-1 for air interface specific settings of transmit power parameters.

**Table 7-1**
**Power Control Parameters and Settings by Air Interface**

| Air Interface: | Parameter Name: | Parameter Set To: |
|---|---|---|
| WIFI | PLS | Mfr Specified |

## II. Setup Used to Measure RF Conducted Powers

Power measurements for unlicensed modes were performed using a power meter and power sensor.

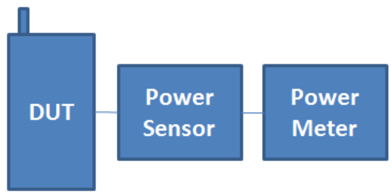



Figure 7-1
Power Measurement Setup for unlicensed modes

## III. WIFI Conducted Powers (SISO/MIMO)

**Table 7-2**
**IEEE 802.11b/g/n (2.4GHz, SISO) Reduced Average RF Power[1]**

| 2.4GHz Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11b | 802.11g | 802.11n |
| 2412 | 1 | 13.08 | 13.26 | 13.14 |
| 2437 | 6 | 13.22 | 13.49 | 13.31 |
| 2462 | 11 | 13.46 | 12.76 | 13.47 |

**Table 7-3**
**IEEE 802.11g/n (2.4GHz, MIMO) Reduced Average RF Power[1]**

| 2.4GHz Conducted Power [dBm] | | | |
|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission mode | |
| | | 802.11g | 802.11n |
| 2412 | 1 | 16.08 | 15.92 |
| 2437 | 6 | 16.47 | 16.30 |
| 2462 | 11 | 15.99 | 16.31 |

[1] Note: This device utilizes independent power reduction mechanisms for the WIFI transmitter in all WIFI modes for held-to-ear scenarios.

## Table 7-4
## IEEE 802.11a/n/ac (5GHz, 20MHz BW, SISO) Reduced Average RF Power[1]

| 5GHz (20MHz) Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11a | 802.11n | 802.11ac |
| 5180 | 36 | 11.36 | 11.43 | 11.38 |
| 5200 | 40 | 11.70 | 11.48 | 11.45 |
| 5220 | 44 | 11.55 | 11.50 | 11.27 |
| 5240 | 48 | 11.49 | 11.38 | 11.43 |
| 5260 | 52 | 11.42 | 11.31 | 11.47 |
| 5280 | 56 | 11.53 | 11.28 | 11.36 |
| 5300 | 60 | 11.52 | 11.55 | 11.30 |
| 5320 | 64 | 11.40 | 11.57 | 11.55 |
| 5500 | 100 | 11.37 | 11.20 | 11.27 |
| 5580 | 116 | 11.45 | 11.48 | 11.24 |
| 5660 | 132 | 11.53 | 11.46 | 12.17 |
| 5700 | 140 | 11.41 | 11.34 | 11.97 |
| 5745 | 149 | 11.23 | 11.28 | 12.19 |
| 5785 | 157 | 11.18 | 11.13 | 12.28 |
| 5825 | 165 | 11.20 | 10.85 | 12.06 |

## Table 7-5
## IEEE 802.11a/n/ac (5GHz, 20MHz BW, MIMO) Reduced Average RF Power[1]

| 5GHz (20MHz) Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11a | 802.11n | 802.11ac |
| 5180 | 36 | 14.62 | 14.72 | 14.57 |
| 5200 | 40 | 14.85 | 14.80 | 14.75 |
| 5220 | 44 | 14.89 | 14.85 | 14.73 |
| 5240 | 48 | 14.88 | 14.83 | 14.89 |
| 5260 | 52 | 14.83 | 14.74 | 14.95 |
| 5280 | 56 | 14.89 | 14.80 | 14.92 |
| 5300 | 60 | 14.97 | 14.91 | 14.95 |
| 5320 | 64 | 14.85 | 14.90 | 15.05 |
| 5500 | 100 | 14.88 | 14.83 | 14.48 |
| 5580 | 116 | 15.01 | 15.02 | 14.47 |
| 5700 | 140 | 14.58 | 14.47 | 14.89 |
| 5745 | 149 | 14.49 | 14.34 | 14.94 |
| 5785 | 157 | 14.44 | 14.21 | 15.01 |
| 5825 | 165 | 14.81 | 14.00 | 14.75 |

## Table 7-6
## IEEE 802.11n/ac (5GHz, 40MHz BW, SISO) Reduced Average RF Power[1]

| 5GHz (40MHz) Conducted Power [dBm] | | | |
|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | |
| | | 802.11n | 802.11ac |
| 5190 | 38 | 11.30 | 11.25 |
| 5230 | 46 | 11.22 | 11.38 |
| 5270 | 54 | 11.38 | 11.34 |
| 5310 | 62 | 11.47 | 11.36 |
| 5510 | 102 | 11.35 | 11.35 |
| 5590 | 118 | 11.48 | 11.36 |
| 5630 | 126 | 11.39 | 11.49 |
| 5710 | 142 | 11.42 | 11.40 |
| 5755 | 151 | 11.49 | 11.32 |
| 5795 | 159 | 11.21 | 11.36 |

[1] Note: This device utilizes independent power reduction mechanisms for the WIFI transmitter in all WIFI modes for held-to-ear scenarios.

## Table 7-7
## IEEE 802.11n/ac (5GHz, 40MHz BW, MIMO) Reduced Average RF Power[1]

| 5GHz (40MHz) Conducted Power [dBm] | | | |
|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | |
| | | 802.11n | 802.11ac |
| 5190 | 38 | 14.25 | 14.19 |
| 5230 | 46 | 14.25 | 14.34 |
| 5270 | 54 | 14.38 | 14.42 |
| 5310 | 62 | 14.43 | 14.41 |
| 5510 | 102 | 14.55 | 14.44 |
| 5590 | 118 | 14.70 | 14.53 |
| 5630 | 126 | 14.60 | 14.65 |
| 5710 | 142 | 14.59 | 14.51 |
| 5755 | 151 | 14.55 | 14.46 |
| 5795 | 159 | 14.33 | 14.44 |

## Table 7-8
## IEEE 802.11ac (5GHz, 80MHz BW, SISO) Reduced Average RF Power[1]

| 5GHz (80MHz) Conducted Power [dBm] | | |
|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode |
| | | 802.11ac |
| 5210 | 42 | 11.61 |
| 5290 | 58 | 11.79 |
| 5530 | 106 | 11.81 |
| 5610 | 122 | 11.71 |
| 5690 | 138 | 12.32 |
| 5775 | 155 | 12.29 |

## Table 7-9
## IEEE 802.11ac (5GHz, 80MHz BW, MIMO) Reduced Average RF Power[1]

| 5GHz (80MHz) Conducted Power [dBm] | | |
|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode |
| | | 802.11ac |
| 5210 | 42 | 15.07 |
| 5290 | 58 | 15.11 |
| 5530 | 106 | 15.01 |
| 5610 | 122 | 14.99 |
| 5690 | 138 | 15.18 |
| 5775 | 155 | 15.40 |

[1] Note: This device utilizes independent power reduction mechanisms for the WIFI transmitter in all WIFI modes for held-to-ear scenarios.

## IV. WIFI Conducted Powers for Operations with Simultaneous 2.4GHz and 5GHz

### Table 7-10
### IEEE 802.11b/g/n (2.4GHz, Ant1) Reduced Average RF Power[1]

| 2.4GHz Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11b | 802.11g | 802.11n |
| 2412 | 1 | 13.08 | 13.26 | 13.14 |
| 2437 | 6 | 13.22 | 13.49 | 13.31 |
| 2462 | 11 | 13.46 | 12.76 | 13.47 |

### Table 7-11
### IEEE 802.11b/g/n (2.4GHz, Ant2) Reduced Average RF Power[1]

| 2.4GHz Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11b | 802.11g | 802.11n |
| 2412 | 1 | 12.76 | 12.87 | 12.66 |
| 2437 | 6 | 13.20 | 13.43 | 13.27 |
| 2462 | 11 | 13.01 | 13.19 | 13.12 |

### Table 7-12
### IEEE 802.11a/n/ac (5GHz, 20MHz BW, Ant1) Reduced Average RF Power[1]

| 5GHz (20MHz) Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11a | 802.11n | 802.11ac |
| 5180 | 36 | 11.36 | 11.43 | 11.38 |
| 5200 | 40 | 11.70 | 11.48 | 11.45 |
| 5220 | 44 | 11.55 | 11.50 | 11.27 |
| 5240 | 48 | 11.49 | 11.38 | 11.43 |
| 5260 | 52 | 11.42 | 11.31 | 11.47 |
| 5280 | 56 | 11.53 | 11.28 | 11.36 |
| 5300 | 60 | 11.52 | 11.55 | 11.30 |
| 5320 | 64 | 11.40 | 11.57 | 11.55 |
| 5500 | 100 | 11.37 | 11.20 | 11.27 |
| 5580 | 116 | 11.45 | 11.48 | 11.24 |
| 5660 | 132 | 11.53 | 11.46 | 12.17 |
| 5700 | 140 | 11.41 | 11.34 | 11.97 |
| 5745 | 149 | 11.23 | 11.28 | 12.19 |
| 5785 | 157 | 11.18 | 11.13 | 12.28 |
| 5825 | 165 | 11.20 | 10.85 | 12.06 |

### Table 7-13
### IEEE 802.11a/n/ac (5GHz, 20MHz BW, Ant2) Reduced Average RF Power[1]

| 5GHz (20MHz) Conducted Power [dBm] | | | | |
|---|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | | |
| | | 802.11a | 802.11n | 802.11ac |
| 5180 | 36 | 11.84 | 11.97 | 11.74 |
| 5200 | 40 | 11.97 | 12.07 | 12.02 |
| 5220 | 44 | 12.19 | 12.16 | 12.12 |
| 5240 | 48 | 12.21 | 12.22 | 12.28 |
| 5260 | 52 | 12.18 | 12.12 | 12.36 |
| 5280 | 56 | 12.21 | 12.25 | 12.39 |
| 5300 | 60 | 12.36 | 12.23 | 12.49 |
| 5320 | 64 | 12.23 | 12.18 | 12.48 |
| 5500 | 100 | 12.32 | 12.37 | 11.66 |
| 5580 | 116 | 12.48 | 12.49 | 11.67 |
| 5660 | 132 | 12.49 | 11.58 | 11.92 |
| 5700 | 140 | 11.72 | 11.57 | 11.79 |
| 5745 | 149 | 11.71 | 11.38 | 11.65 |
| 5785 | 157 | 11.66 | 11.27 | 11.71 |
| 5825 | 165 | 12.33 | 11.13 | 11.40 |

[1] Note: This device utilizes independent power reduction mechanisms for the WIFI transmitter in all WIFI modes for held-to-ear scenarios.

## Table 7-14
## IEEE 802.11n/ac (5GHz, 40MHz BW, Ant1) Reduced Average RF Power[1]

| 5GHz (40MHz) Conducted Power [dBm] | | | |
|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | |
| | | 802.11n | 802.11ac |
| 5190 | 38 | 11.30 | 11.25 |
| 5230 | 46 | 11.22 | 11.38 |
| 5270 | 54 | 11.38 | 11.34 |
| 5310 | 62 | 11.47 | 11.36 |
| 5510 | 102 | 11.35 | 11.35 |
| 5590 | 118 | 11.48 | 11.36 |
| 5630 | 126 | 11.39 | 11.49 |
| 5710 | 142 | 11.42 | 11.40 |
| 5755 | 151 | 11.49 | 11.32 |
| 5795 | 159 | 11.21 | 11.36 |

## Table 7-15
## IEEE 802.11n/ac (5GHz, 40MHz BW, Ant2) Reduced RF Power[1]

| 5GHz (40MHz) Conducted Power [dBm] | | | |
|---|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode | |
| | | 802.11n | 802.11ac |
| 5190 | 38 | 11.18 | 11.11 |
| 5230 | 46 | 11.25 | 11.27 |
| 5270 | 54 | 11.36 | 11.47 |
| 5310 | 62 | 11.37 | 11.43 |
| 5510 | 102 | 11.73 | 11.50 |
| 5590 | 118 | 11.89 | 11.68 |
| 5630 | 126 | 11.79 | 11.79 |
| 5710 | 142 | 11.73 | 11.60 |
| 5755 | 151 | 11.59 | 11.58 |
| 5795 | 159 | 11.42 | 11.50 |

## Table 7-16
## IEEE 802.11ac (5GHz, 80MHz BW, Ant1) Reduced RF Power[1]

| 5GHz (80MHz) Conducted Power [dBm] | | |
|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode |
| | | 802.11ac |
| 5210 | 42 | 11.61 |
| 5290 | 58 | 11.79 |
| 5530 | 106 | 11.81 |
| 5610 | 122 | 11.71 |
| 5690 | 138 | 12.32 |
| 5775 | 155 | 12.29 |

## Table 7-17
## IEEE 802.11ac (5GHz, 80MHz BW, Ant2) Reduced RF Power[1]

| 5GHz (80MHz) Conducted Power [dBm] | | |
|---|---|---|
| Freq [MHz] | Channel | IEEE Transmission Mode |
| | | 802.11ac |
| 5210 | 42 | 12.46 |
| 5290 | 58 | 12.38 |
| 5530 | 106 | 12.18 |
| 5610 | 122 | 12.24 |
| 5690 | 138 | 12.01 |
| 5775 | 155 | 12.49 |

[1] Note: This device utilizes independent power reduction mechanisms for the WIFI transmitter in all WIFI modes for held-to-ear scenarios.

# 8. 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 8-1**
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 |
|---|---|---|---|---|
| 2.4GHz WIFI | 16.47 | -4.76 | 11.71 | No |
| 5GHz WIFI | 15.40 | -10.65 | 4.75 | No |
| Simultaneous 2.4GHz and 5GHz WIFI Operations | 18.99* | -5.10 | 13.89 | No |

* Note: This value is calculated as the linear sum of the worst-case power for each band and antenna combination while in simultaneous 2.4GHz and 5GHz operation. This calculation is conservative and for use in this investigation only.

## III. Low-Power Exemption Conclusions

All WIFI air interfaces are exempt from RF emissions testing and rated M4 under the low power exemption of Clause 4 of ANSI C63.19-2011.

# 9. EQUIPMENT LIST

**Table 9-1**
Equipment List

| Manufacturer | Model | Description | Cal Date | Cal Interval | Cal Due | Serial Number |
|---|---|---|---|---|---|---|
| Anritsu | ML2496A | Power Meter | 4/20/2017 | Annual | 4/20/2018 | 1306009 |
| Anritsu | MA2411B | Pulse Power Sensor | 2/10/2017 | Annual | 2/10/2018 | 1207364 |
| Anritsu | MA2411B | Pulse Power Sensor | 2/10/2017 | Annual | 2/10/2018 | 1339018 |
| 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) | 9/1/2016 | Biennial | 9/1/2018 | 21053 |
| 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.

## 10. MEASUREMENT UNCERTAINTY

**Table 10-1**
Uncertainty Estimation Table

| Uncertainty Component | Data (dB) | Data Type | Prob. Dist. | Divisor | Ci (E) | Unc. (dB) | Notes/Comments |
|---|---|---|---|---|---|---|---|
| **Wireless Communications Device Near-Field Measurement Uncertainty Estimation** | | | | | | | |
| **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.

# 11. CONCLUSION

The measurements indicate that the wireless communications device complies with the HAC limits specified in accordance with the ANSI C63.19 Standard and FCC WT Docket No. 01-309 RM-8658 for the WIFI air interfaces tested. 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.

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