



Test Plan for Hearing Aid Compatibility

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Section 1 Introduction

1.1 Purpose

The purpose of this Test Plan is to define the CTIA Certification Program test requirements for evaluating Hearing Aid Compatibility (HAC) of wireless devices. Tests are performed using test equipment in a laboratory environment.

1.2 Scope

HAC testing is based on the ANSI C63.19 specification. Wireless devices submitted for HAC testing will be tested according to ANSI C63.19 with the special considerations outlined in this test plan. The air interfaces subject to testing include CDMA and LTE. Testing for CDMA in the AWS band is not covered by this test plan. No other air interfaces are considered within the scope of this document.

This Test Plan does not provide specific test equipment configurations or detailed test procedures by which to execute certification testing. Such documentation and procedures must be presented by the CTIA Authorized Testing Laboratory (CATL) as part of the CATL authorization process and subsequently maintained and employed by the CATL to remain authorized to conduct certification testing.

1.3 Applicable Documents

The following documents are referenced in this Test Plan:

- [1] American National Standard for Methods of Measurement of Compatibility between Wireless Communication Devices and Hearing Aids, ANSI C63.19-2011, American National Standards Institute.
- [2] FCC 47 CFR, Section 20.19, Federal Communications Commission.
- [3] CTIA LTE/CDMA Wireless Device Certification Program Management Document, Latest Revision, CTIA.
- [4] IEEE Standard for Calibration of Electromagnetic Field Sensors and Probes, Excluding Antennas, from 9 kHz to 40 GHz, IEEE Std 1309-2005.
- [5] TIA Standard Electro-Acoustic Recommended Performance Specification for cdma 2000 Mobile Stations, TIA-1042.
- [6] Common test environments for User Equipment conformance testing for LTE, Latest Revision, 3GPP TS 36.508

1.4 Test Overview

To evaluate RF emissions compliance, near-field measurements are made in the vicinity of the WD earpiece using an RF electric or "E" field probe. The "E" field measurements are made while the WD is operating in the frequency bands covered by this test plan. The specific frequency(s) used for this test will depend upon the capabilities of the WD. The E field strength obtained from this measurement is used in combination with a waveform-specific modulation interference factor (MIF) to calculate a hearing aid compliance rating at one of four levels, M1 through M4. This compliance rating, when used in conjunction with the RF immunity rating of the user's hearing aid, helps determine the relative user experience that would be expected when the two devices are used together in the acoustic coupling mode (e.g. using the hearing aid's microphone to acoustically couple to the WD earpiece).

In addition to acoustic coupling between the hearing aid and a WD, some hearing aids support a feature known as a "Tele-Coil" or "T-coil" coupling. The T-coil was originally developed to support hearing aid use with landline telephone handsets that employ a magnetic earpiece transducer (such as those made through the mid 1980's). Later landline phones began to use piezo-electric transducers that did not generate a magnetic field. Consequently, some landline phones and some WDs include a special inductor specifically intended to generate a strong audio-band magnetic field for T-coils. Hearing aids equipped with a T-coil can be configured by the user to disable the microphone and instead reproduce audio that is magnetically coupled to the T-coil.

Because audio-band magnetic (ABM) coupling is the only coupling mode available when the T-coil is enabled, this coupling mode also makes the hearing aid susceptible to any unintentional magnetic emissions from the WD that fall within the audio frequency band. For example, switching a time-domain access WD power amplifier on and off may generate a relatively strong magnetic field along the current-carrying conductors to the PA. This magnetic field will have the potential to generate interference to a T-coil if the pulse repetition rate and its harmonics fall within the audio frequency band. Because of the potential for audio-band interference, ANSI C63.19 also includes a specification to quantify the following aspects of T-coil operation in a WD:

1. Magnetic field intensity of the desired audio-band signal from the WD
2. Frequency response of the desired magnetic audio-band signal from the WD
3. Ratio between the desired audio-band signal and any undesired audio-band signals from the WD
4. RF environment

Once these four attributes of the WD magnetic audio-band signal have been measured, the results are used to determine a "T" rating on a scale from T1-T4. Like the "M" rating, the "T" rating is employed in conjunction with the hearing aid's RF immunity "M" rating to help determine the relative user experience when the two devices are used together in the magnetic coupling mode.

1.5 Test Process

All testing shall be conducted at a CTIA Authorized Testing Laboratory (CATL). A current list of CATLs can be found at <http://www.ctia.org/certification>. Products shall be submitted for testing in accordance with the instructions detailed in the CTIA LTE/CDMA Wireless Device Certification Program Management Document.

1.6 WD - Equipment Under Test (Wireless Device)

Units for test are to be supplied with all required peripherals and accessories. In addition, any auxiliary equipment which is available as part of the product, either for installation or as an option, should be supplied.

1.7 Wireless Device Documentation

All documentation associated with the installation and operation of the wireless device shall be supplied. This should include:

- User guides or manuals
- Programming instructions
- Installation guides or manuals

The device documentation shall also include the location of the T-coil measurement point.

In addition to the documentation, the manufacturer shall provide contact information, including telephone number and e-mail address, of an individual responsible for providing technical and operational assistance.

1.8 Acronyms

ABM	Audio-Band Magnetic
CATL	CTIA Authorized Testing Laboratory
CDMA	Code Division Multiple Access
LTE	Long Term Evolution
HAC	Hearing Aid Compatibility
MIF	Modulation Interference Factor
PA	Power Amplifier
RF	Radio Frequency
TMFS	Telephone Magnetic Field Simulator
VoLTE	Voice Over LTE
WD	Wireless Device

Section 2 RF Emissions Measurements

HAC RF emissions measurements shall be performed according to the requirements of ANSI C63.19¹ with the special considerations detailed in this section. The RF field probes used for the measurements must be calibrated to IEEE 1309-2005. System validation will then be done for the RF probe and reference dipole combination. In addition, the MIF for each waveform-specific case must be determined as described in C63.19 Annex D.7. The indirect measurement method shall be used in measuring the RF audio interference level.

2.1 Measurement Probes

Measurement probes shall be certified to meet the following:

- RF probes must be calibrated for use in an air medium.
- Accuracy: $\leq 6\%$ ($k=2$)
- Axial isotropy: $\leq .25$ dB when rotated about the probe axis
- Dynamic range: E-field 2 to 500 V/m
- Linearity: $\pm .2$ dB
- Frequency response: $\leq .2$ dB over the handset measurement range
- Spatial Resolution: ≤ 5 mm

2.2 RF Probe Positioning Equipment

Careful attention to the positioning of the RF probe is absolutely critical if accurate and precise results are to be obtained. The importance of this facet of the HAC test process must not be underestimated, especially when repeatability across multiple labs is considered. HAC emissions measurements place extraordinary requirements on the ability to accurately position the measurement probe in the following respects:

- WD form factors may limit the options for securing the device under test with respect to the measurement probe
- The RF emissions measurement area surrounding the earpiece on the WD is quite small
- RF emissions measurements are made at very close distance to the WD

For the reasons stated above, computer-controlled data acquisition and positioning equipment shall be used for HAC measurements. Positioning resolution shall be at a maximum of 5 mm.

2.3 RF Power meter

This instrument and its associated matched sensor shall be capable of handset continuous or pulsed transmission power measurements. It generally is equipped with an internal calibration source, and often is used with an external attenuator with adjustable power offset compensation to measure and directly report power levels greater than 20 dBm.

¹ Described in Section 5, which also references other relevant sections of this standard

- Video filter bandwidth: \geq emission occupied bandwidth
- Dynamic range: \geq 50 dB, with power offset compensation
- Triggering: internal trigger at any value in the dynamic range; external
- Input impedance: 50 Ohms nominal with VSWR \leq 1.2:1
- Absolute accuracy: \leq 0.2 dB log, \leq 5% linear

2.4 Base Station Simulator

The base station simulator used must be capable of supporting a circuit-switched call using the appropriate airlink technology for the WD. The simulator must have the following capabilities in addition to the capabilities defined in ANSI C63.19:

- Ability to set the WD output power to the maximum rated power level with fast power control active
- Ability to set all required vocoder operating modes

2.5 Setup Parameters and Test Details

The setup parameters and test details specified herein are required to ensure that all test labs are using similar setup parameters to maximize lab-to-lab reproducibility. These details are also required to ensure that the device is tested in a user configuration that is representative of end use.

- The WD shall be in a normal operating state for the test and shall not be in a test mode.
- The test shall be run in a radiated environment and shall not be a cabled test.
- The test shall be run with all possible antenna configurations.
- The test shall be run with all device configurations that support use where the receiver is placed on the ear.
- The test shall be run with all battery options and wireless charging covers, if applicable.
- The test shall be run with other simultaneous transmitters turned off (e.g. Wi-Fi, Bluetooth, LTE).
- The test shall be repeated while centered over the T-Coil location, if the T-Coil location is \geq 5.0 mm from the center of the acoustic output, per Section 5.5 of ANSI C63.19.

The device RF emissions rating should be determined by the minimum rating that is derived from all device configurations above. Only one rating shall be specified. However in cases where the RF emissions rating can only be achieved in certain device configurations, the configurations shall be reported with the assigned rating in the user documentation, label, or other locations where the rating is communicated to the user. This information shall also be reported in the certification test report.

2.5.1. CDMA Setup Parameters and Test Details

The following setup parameters and test details apply for CDMA.

- The WD shall be tested in the following two test configurations.
 - The WD shall be placed on a Service Option 3 call using Radio Configuration 1. The WD microphone shall be muted such that the RF gating is guaranteed to be 1/8th rate. The MIF shall be determined accordingly.
 - The WD shall be placed on a Service Option 2 or Service Option 55 call using Radio Configuration 1. The data rate shall be set to "Full". The MIF shall be determined accordingly. This configuration may be excluded based on the low power exemption. If this is the case, this shall be noted in the test report.
- Power control bits shall be set to "Always Up."
- The test shall be run in Cell Band and PCS Band at low, mid, and high channels. Cell Band test channels shall be 1013, 384, and 777. PCS Band test channels shall be 25, 600, and 1175.

2.5.2. LTE Setup Parameters and Test Details

The following setup parameters and test details apply for LTE.

- The LTE MIFs for the WD shall be evaluated to determine the overall worst case configuration. There are several transmission parameters to consider when determining the worst case configuration, including the following:
 - Operating Band
 - Bandwidth
 - Modulation
 - Resource Block Characteristics
- This mode may be excluded based on the low power exemption per C63.19-2011. If this is the case, this shall be noted and justified through the appropriate calculations in the test report.
- Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD) LTE bands shall be considered separately for low power exemption per C63.19-2011. When evaluating LTE TDD bands, the lowest duty factor (simulating the highest pulsed interference) based on 3GPP specifications shall be considered and explained.
- The Transmit Power Control shall always be set to 'Max Power'.

Section 3 Audio Band Magnetic Field Measurements

HAC ABM field measurements shall be performed according to the requirements of ANSI C63.19 with the special considerations detailed in this section. The 'in-call' preferred method shall be used for ABM field measurements. The alternate method known as "manufacturer's test mode" shall not be used.

3.1 Measurement Probes

Measurement probes for ABM field measurements shall be certified to fit the requirements outlined in ANSI C63.19 D.8.

T-Coil Probe level calibration shall use the Telephone Magnetic Field Simulator (TMFS) or a Helmholtz Coil. The TMFS or Helmholtz Coil shall provide a method to validate a known audio band signal level and frequency response across the WD measurement band.

3.2 T-Coil Probe Positioning Equipment

The same tolerances used in section 2.2, "RF Probe Positioning Equipment" of this Test Plan Document apply to the positioning of the T-Coil Probe.

3.3 Base Station Simulator

The Base Station Simulator shall be able to perform the following.

- The Base Station Simulator referenced in section 2.4 shall have the ability to inject the audio signal at the levels referenced in C63.19 and as specified herein. Set the base station simulator to provide a low-level RF signal. Adjust the Forward Link Power as needed to establish/maintain the voice/traffic channel such that the transmitter is not gated off during measurements.
- The Base Station Simulator shall also have the ability to establish pack-data voice calls using the IP Multimedia Subsystem (IMS) server.
- The Base Station Simulator shall have the ability to support all applicable vocoder operating modes.

3.4 Setup Parameters and Test Details

The setup parameters and test details specified herein are required to ensure that all test labs are using similar setup parameters to maximize lab-to-lab reproducibility. These details are also required to ensure that the device is tested in a user configuration that is representative of end use.

- The WD shall be in a normal operating state for the test and shall not be in a test mode.
- The test shall be run in a conducted environment unless there are shielding effects from the battery cover. Any deviation shall be noted in the test report.
- The test shall be run with all possible antenna configurations.
- The test shall be run with all device configurations that support use where the receiver is placed on the ear.
- The test shall be run with all battery options and wireless charging covers, if applicable.
- The test shall be run with other simultaneous transmitters turned off (e.g. Wi-Fi, Bluetooth, LTE).

- The test shall be run with the device always muted while in a voice call.
- The device display backlight shall be set to 'Always On'. If this mode is not supported, the device display backlight shall be set to 'On' for the maximum time permitted. If the device display backlight goes out during testing, testing shall be halted until the display backlight is reset to 'On'. Care shall be taken during reset not to disturb the test device position in the test fixture.
- Frequency response shall be evaluated with the use of the Normal Test Signal at -19 dBm0 signal level as specified in TIA 1042 section 3.3.1.
- The equipment used to process the signal received by the T-Coil Probe shall integrate the audio signal over at least two multiples of the audio sample time period, however 3 multiples of the audio sample time period is recommended. That is to say the input and output signals should be ensured to capture accurately the energy of the waveform, taking into account handset vocoder latency effects and ensuring echo cancellation devices (if any) is appropriately stabilized during measurements. Delays may be used to ensure such considerations are minimized.
- In order to increase test repeatability, accuracy and to reduce the amount of time required to locate the WD T-Coil location Manufacturers shall identify the location of the T-Coil measurement point.

3.4.1. CDMA Setup Parameters and Test Details

The following setup parameters and test details will apply for CDMA.

- The WD shall be placed on a Service Option 68 using Radio Configuration 1. If the device does not support RC1/SO68, then RC1/SO3 shall be used.
- Power control bits shall be set to "Always Up."
- An audio signal level of -18dBm0 shall be used for evaluating the signal-to-noise ratio per C63.19-2011.

3.4.2. LTE Setup Parameters and Test Details

The following setup parameters and test details apply for evaluating VoLTE for T-Coil.

- All US-supported LTE bands and all supported bandwidths in each band shall be evaluated.
- All supported audio codecs shall be evaluated. The lowest and highest bit rate of each codec shall be evaluated. The audio codec configuration with the lowest signal-to-noise ratio shall be used for all test cases per C63.19-2011.
- An investigation shall be performed to determine the overall worst case radio configuration. The radio configuration entails the modulation and Resource Block configuration. The radio configuration with the lowest signal-to-noise ratio shall be used during testing to ensure worst case conditions.
- An audio signal level of -16dBm0 shall be used for evaluating the signal-to-noise ratio per C63.19-2011.
- Test channels for LTE bands shall include low, middle and high channels that adhere to 3GPP TS 36.508 Clause 4.3.1.

Section 4 Measurement Uncertainty

Section 9.4 of ANSI C63.19 indicates that the measurement uncertainty is to be stated in the test report. Therefore, for CTIA Certification purposes, the measurement uncertainty shall be stated in the certification test report. The measurement uncertainty shall be calculated in accordance with the approach stated in Section 9.4 of ANSI C63.19.

Appendix A Revision History

Date	Version	Description
August 2006	1.0	<ul style="list-style-type: none"> • First Revision
April 2010	2.0	<ul style="list-style-type: none"> • Updated Applicable Documents section • Updated Wireless Device Documentation section • Changed references to CTIA Certification Program Management Document to CTIA CDMA Certification Program Management Document • Updated Section 2.5 to indicate that the test shall be run with Wi-Fi and Bluetooth off • Added ABM Field Measurements procedures
October 2013	3.0	<ul style="list-style-type: none"> • Updated to harmonize with C63.19-2011 requirements
February 2017	3.1	<ul style="list-style-type: none"> • Added LTE and VoLTE • Changed references from CTIA CDMA Certification Program Management Document to CTIA LTE/CDMA Wireless Device Certification Program Management Document • Updated Audio Band Magnetic Field Measurements section
May 2017	3.1.1	<ul style="list-style-type: none"> • Editorial revisions