Part V: Requirements and Test Methods for Magnetic Output From Handset Telephones for Hearing Aid Coupling and for Receive Volume Control
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1. **Introduction**

Part V provides the technical requirements for handset telephones to be hearing aid compatible (HAC). A telephone set is defined as HAC if it complies with the technical requirements prescribed in this Part to couple magnetically with hearing aids and to provide volume control.

2. **General requirements**

These requirements apply to all analogue and digital handset telephones. Handset telephones must meet all applicable technical requirements of CS-03, *Compliance Specification for Terminal Equipment, Terminal Systems, Network Protection Devices, Connection Arrangements and Hearing Aids Compatibility*, including the technical requirements of this Part.

3. **Exemptions**

Cellular telephones and secure telephone units are exempt from the requirements of this Part.

4. **Definitions**

**Artificial Ear:** a device for calibrating earphones that incorporate an acoustic coupler and a calibration microphone for measuring sound pressure. These devices have an overall acoustic impedance similar to that of the average human ear over a given frequency band.

**Conversational Gain:** the level of an acoustic output from a telephone relative to the acoustic level that would be present in a face-to-face conversation at a distance of one (1) meter. This reference acoustic level for a face-to-face conversation is 64 dBSPL for binaural listening. However, for monaural listening (such as when using a handset), the reference acoustic level is 70 dBSPL.

**Note:** When only one ear is used for listening, a talker is perceived to be about 6 dB quieter than when both ears are used. Therefore, to be perceived at an equivalent loudness, the level at a single ear should be about 6 dB louder.

\[
\text{Conversational Gain} = (\text{Measured dBSPL Level} - 70 \text{ dBSPL}) \text{ dB}
\]

**Handset:** the part of a telephone set that is held to the ear and mouth. It contains the speaker (receiver) and the microphone (transmitter).

**Measurement Axis:** the axis parallel to the reference axis which may be displaced from the axis by a maximum of 16 mm. Within this constraint, the measurement axis may be located where the radial and axial field intensity measurements are optimum with regard to the requirements. For a handset with a centred receiver and a circular symmetric magnetic field, the reference axis and the measurement axis coincide.
Measurement Plane: the planar area parallel to and 10 mm in front of the reference plane.

Reference Axis: the axis which is normal to the reference plane and which passes through the centre of the receiver cap (or the centre of the hole array for handset types that do not have receiver caps).

Reference Plane: the planar area containing points of the receiver-end of the handset that, in normal handset use, rests against the ear.

5. Reference documents

This regulatory standard refers to the following publications, and where such reference is made, it shall be to the edition listed below. Should there be discrepancies between the requirements stated in CS-03, Part V and the relevant text of the publications referenced in this section, CS-03, Part V shall take precedence.

- ANSI/TIA-4965, Telecommunications Telephone Terminal Equipment Receive Volume Control Requirements for Digital and Analog Wireline Handset Terminals (latest published edition)

ANSI – American National Standards Institute
TIA – Telecommunications Industry Association
TSB – Telecommunications Systems Bulletin

6. Magnetic output

6.1 Requirements

The parameters below, which describe the magnetic field at points in the measurement plane, shall be used to ascertain adequacy for magnetic coupling. The three parameters are:

- Axial field intensity;
- Radial field intensity; and
- Magnetic field intensity frequency response associated with the resulting field vector.
6.1.1 **Axial field intensity**

When measured in accordance with the requirements specified in Section 6.2 of this Part, the axial component of the magnetic field directed along the measurement axis and located at the measurement plane shall be greater than -22 dB relative to 1 A/m, for an input of -10 dBV at 1000 Hz (see Figure 1 and Figure 2).

**Note:** If the magnitude of the axial component exceeds -19 dB relative to 1 A/m, relaxation in the frequency response is permitted (see Figure 3).

6.1.2 **Radial field intensity**

When measured in accordance with the requirements specified in Section 6.2, radial components of the magnetic field shall be greater than -27 dB relative to 1 ampere per metre (A/m), for an input of -10 dBV at 1000 Hz (see Figure 1 and Figure 2) when measured at four points (90 degrees apart) and at a distance greater than or equal to 16 mm from the measurement axis (as selected in the axial field intensity measurement).

6.1.3 **Magnetic field intensity frequency response**

The frequency response of the magnetic field intensity as measured in Section 6.2 shall fall within the acceptable region of Figure 3 and Figure 4, over a frequency range of 300 Hz to 3300 Hz.

(a) For receivers with an axial field intensity that is greater than -19 dB relative to 1 A/m, when measured in accordance with the requirements specified in Section 6.2, the frequency response shall fall within the acceptable region specified in Figure 1.

(b) For receivers with an axial field intensity that is less than -19 dB but greater than -22 dB relative to 1 A/m, when measured as specified in Section 6.2, the frequency response shall fall within the acceptable region specified in Figure 4.

**Note:** The coil will need to be recalibrated in order to establish absolute field intensity at 1 kHz and relative response across the frequency band of interest. The procedures for calibrating the probe coil are provided in the Institute of Electrical and Electronics Engineers (IEEE) Standards Association (SA) Specification 1027-1996, *IEEE Standard Method for Measurement of the Magnetic Field in the Vicinity of a Telephone Receiver*. 
Figure 1: Reference and measurement planes and axis

Figure 2: Typical probe coil (magnetic material core) parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC resistance</td>
<td>900 Ohm</td>
</tr>
<tr>
<td>Inductance</td>
<td>150 mH</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>-60 dBV/(A/m)</td>
</tr>
</tbody>
</table>

For calibration see IEEE Standard 1027, Section 5.0.
Figure 3: Magnetic field intensity frequency response for receivers with an axial field that exceeds -19 dB relative to 1 A/m.
6.2 Method of measurement

Listed below are the methods of measurement for analogue and digital telephones.

6.2.1 Analogue telephones

The following methods of measurement are applicable to analogue telephones:

(a) Arrange the DC feed circuit so that the total resistance between its tip and ring terminals is 1650 ohms (Ω) and the battery voltage is 48 volts DC.

(b) Connect the terminal equipment (TE) to the test circuit as shown in Figure 5.

(c) With the TE off-hook, set the signal source frequency to 1 kHz and adjust its level to -10 dBV. Average the selective level meter to pass 1 kHz.

(d) With reference to the definitions contained in Section 4 of this Part, locate the reference axis, position the probe in an axial orientation on the receiver of the handset and move the probe across the surface of the receiver to find the measurement axis. Record the voltage measured.
Notes:

- The measured voltage must be converted into magnetic field strength. This conversion requires knowledge of the probe’s sensitivity as established through calibration.

- For the purpose of repeating these measurements, it is useful to note the measurement axis location. The measurement axis is normally considered as that location within the prescribed distance from the reference axis where the maximum field intensity is observed. However, the measurement axis may be selected as a location within the prescribed distance from the reference axis that is to the optimum advantage in order to satisfy the axial and radial requirements. Once a measurement axis is established, it is used as a basis for all measurements.

(e) With the probe in an axial orientation and located at the measurement axis, set the signal source to sweep the band of frequencies from 300 Hz to 3300 Hz. Arrange the selective voltmeter to track the signal source frequency. Record the measurement results, taking into account the variation in sensitivity that occurs with changing frequency. Plot the frequency response relative to 1 kHz.

(f) Set the signal source as in step (c). Position the probe in a radial orientation at 16 mm from the measurement axis. Move the probe in a radial direction, away from measurement axis. Record the maximum voltage observed.

(g) Repeat step (f) to obtain a total of four measurements, each separated by 90 degrees around the circumference of the receiver.

6.2.2 Digital telephones

The following methods of measurement are applicable to digital telephones:

(a) For digital telephones, an appropriate input test level that produces an equivalent acoustic level to analogue sets (nominal +0 dBPa) must first be determined, with the receive volume control set to its nominal gain level. The acoustic output of the handset is measured instead of the magnetic output to determine the input test level.

(b) Place the telephone receiver in the Type 3.3 artificial ear, using the high leak condition specified in ANSI/TIA-920.110-B, *Telecommunications Communications Products Transmission Requirements for Digital Interface Communications Devices with Handsets*, and connect the telephone set to the circuit interface as shown in Figure 6. Alternatively, the Type 1 artificial ear may be used if a seal can be achieved between the handset and the artificial ear without the use of sealing putty or similar materials.

(c) Apply a 1000 Hz input signal from a sinewave generator and measure the microphone output signal using an AC voltmeter. Determine the sound pressure produced in the artificial ear, taking into account the microphone sensitivity (in dBV/Pa), the gain (if any) of the microphone amplifier, the gain or loss of the bandpass filter, and the reading of the AC voltmeter (in dBV). Adjust the input level to produce +0 dBPa at 1000 Hz. Record the
input level required to produce +0 dBPa at 1000 Hz, as this is the input level determined for the magnetic field measurement.

(d) Connect the TE to the test circuit, as shown in Figure 6.

(e) With the TE off hook, set the signal source frequency to 1 kHz and adjust its level to the input level determined in step (c). Average the selective level meter to pass 1 kHz.

(f) With reference to the definitions contained in Section 4 of this Part, locate the reference axis, position the probe in an axial orientation on the receiver of the handset and move the probe across the surface of the receiver to find the measurement axis. Record the voltage measured.

Notes:

• The measured voltage must be converted into magnetic field strength. This conversion requires knowledge of the probe’s sensitivity as established through calibration.

• For the purpose of repeating these measurements, it is useful to note the measurement axis location.

• The measurement axis is normally considered as that location within the prescribed distance from the reference axis where the maximum field intensity is observed. However, the measurement axis may be selected as a location within the prescribed distance from the reference axis that is to the optimum advantage to satisfy the axial and radial requirements. Once a measurement axis is established, it is used as a basis for all measurements.

(g) With the probe in an axial orientation and located at the measurement axis, set the signal source to sweep the band of frequencies from 300 Hz to 3300 Hz. Arrange the selective voltmeter to track the signal source frequency. Record the measurement results, taking into account the variation in sensitivity that occurs with changing frequency. Plot the frequency response relative to 1 kHz.

(h) Set the signal source as in step (e). Position the probe in a radial orientation at 16 mm from the measurement axis. Move the probe in a radial direction away from measurement axis. Record the maximum voltage observed.

(i) Repeat step (h) to obtain a total of four measurements, each separated by 90 degrees around the circumference of the receiver.

7. Telephone receive volume control

For receive volume control requirements for digital and analogue wireline handset terminal, compliance with CS-03, Part V can be demonstrated by observing the receive volume requirements contained in Section 7.1 of this Part or by complying with the receive volume requirements contained in the standard
7.1 Requirements

An analogue, digital or IP-based telephone set shall be equipped with a receive volume control that provides, 12 dB of gain (minimum) and up to 18 dB of gain (maximum) through the receiver in the handset of the telephone. The 18 dB of receive gain may be exceeded provided that:

(a) In order to minimize the likelihood of damage to individuals with normal hearing, the amplified receive capacity automatically resets to the measured (nominal) level when the telephone is caused to pass through a proper on-hook transition; or

(b) The maximum gain of 18 dB in the handset of the telephone may be exceeded, without automatic volume reset, using an override switch located on the equipment such that is will not be susceptible to accidental engagement. Clear labelling near the override switch and a caution note printed in the user manual shall be required to observe safe operating practices. This switch shall also enable a bright indicator light, prominently displayed on the front of the telephone, with an accompanied printed notification of high amplification present at the handset receiver. A printed warning message in braille shall be supplied for visually impaired persons. The message shall be capable of securely attaching to the back of the handset to indicate that a high-volume setting may be engaged.

The unamplified receiver level shall comply within the defined limits and be evaluated using a Receiver Objective Loudness Rating (ROLR), as required by ANSI/TIA-470.110-C, *Telecommunications Telephone Terminal Equipment – Transmission Requirements for Analog Telephones With Handsets*, for analogue telephones, or Receiver Loudness Rating (RLR) ANSI /TIA-920.110-B for digital and IP-based telephone sets. No variation in loop conditions is required for digital and IP-based telephones since the receive level of these telephones is independent of loop length.

Loop conditions for analogue telephones are defined as follows:

(a) Zero loop of 26 AWG non-loaded cables or equivalent (52.5 Vdc, 400 Ω), with a nominal ROLR value of +46 dB, within a permissible range of +41 dB to +51 dB.

(b) Medium loop, 2.7 km, of 26 AWG non-loaded cables or equivalent (52.5 Vdc, 1200 Ω), with a nominal ROLR value of +48 dB, within a permissible range of +43 dB to +53 dB.

(c) Maximum loop, 4.6 km, of 26 AWG non-loaded cables or equivalent (42.5 Vdc, 1740 Ω), with a nominal ROLR value of +50 dB, within a permissible range of +45 dB to +55 dB.

For digital telephone sets, the nominal ROLR value is +53 dB, within a permissible range of +49.5 dB to +56.5 dB.

For digital telephone sets, the RLR values measured with the receiver at the high leak position shall have a nominal RLR value of 2 dB, with a tolerance of ±4 dB at the normal unamplified level or the manufacturer’s defined nominal volume control setting.
Gain at the receiver is evaluated by comparing additional loudness rating measurement(s) for any given volume control setting(s), provided that no clipping of the signal has occurred.

Notes:

- Although the receive volume control requirement is described in terms of ROLR in IEEE 661-1979 R2008, IEEE Standard Method for Determining Objective Loudness Ratings of Telephone Connections current industry standards ANSI/TIA-470.110-C and ANSI/TIA-920.110-B have shifted to measuring receive loudness in terms of Receive Loudness Rating (RLR) as defined by ITU-T Recommendation P.79, Calculation of Loudness Ratings for Telephone Sets. Annex G of ANSI/TIA-470.110-C provides the following relationship between these two loudness rating measures:

\[
\text{ROLR (IEEE 661-1979 (R2008))} = \text{RLR (ITU-T P.79)} + 51 \text{ dB}
\]

- The receive gain measurements apply to telephone sets that are fully operational. They do not apply during AC power failure if a telephone set is designed to operate with AC-adapter powering.

### 7.2 Method of measurement

Compliance with receive volume control requirements for digital and analogue wireline handset terminal can be alternatively demonstrated by employing the method of measurement contained in this Part or by employing the conversational gain method of measurements as specified in TIA-TSB-31-D standard.

The Department proposes the adoption of ANSI/TIA-4965 Standard in CS-03, Part V, by reference, as an alternative to RORL requirements. A two-year transition period is permitted following the publication of this Amendment during which compliance with either the old or new requirements will be acceptable. At the end of that transition period, the testing guidance provided in Section 7.2 of this Part will become obsolete and only the guidance provided in TIA-TSB-31-D standard will apply.

#### 7.2.1 Analogue telephones

The following methods of measurement are applicable to analogue telephones:

(a) With the volume control in the unamplified or off setting, place the telephone receiver in the Type 3.3 artificial ear using the high leak condition specified in ANSI/TIA-470.110-C and connect the telephone set to the circuit interface, as shown in Figure 6. Alternatively, the Type 1 artificial ear may be used if a seal can be achieved between the handset and the artificial ear without the use of sealing putty or similar materials.

(b) Configure the artificial line and battery for zero loop conditions.

(c) Using a signal source, sweep the frequency range logarithmically from 200 Hz to 4000 Hz. The sweep rate is to be such that one complete transverse of the 200 Hz to 4000 Hz band requires approximately 8 to 10 seconds. The generator output is to be adjusted to an open
circuit voltage of 0.316 volts (i.e. -10 dB relative to 1 volt) from a 900 Ω source. The electric source and the measurement circuit should have the capability of operating linearly up to a level of approximately 1 volt.

(d) The ROLR of the telephone under test is to be determined by first measuring the receive frequency response, in accordance with IEEE 269-2010, *IEEE Standard Method for Measuring Transmission Performance of Analog and Digital Telephone Sets, Handsets, and Headsets*. The ROLR is then calculated from the measured frequency response, as specified in IEEE 661-1979 (R2008). Perform an ROLR measurement and record the unamplified receive level. Verify that the measured ROLR is within the permissible range at zero loop.

(e) Place the volume control to its maximum setting. Perform an ROLR measurement and record the maximum receive level.

(f) Calculate the gain by subtracting the maximum ROLR value from the unamplified ROLR value.

(g) If the calculated gain is greater than 18 dB, place the telephone in the on-hook mode, go off-hook and verify that the volume resets to the unamplified measured (nominal) level, or check for an override switch with the appropriate visual indicator and printed messages, accompanied by a warning message in braille.

(h) Repeat steps (c) to (g) for 2.7 km and 4.6 km loop lengths.

### 7.2.2 Digital telephones

The following methods of measurement are applicable to digital telephones:

(a) With the volume control in the unamplified or off setting, place the telephone receiver in the Type 3.3 artificial ear using the high leak condition specified in ANSI/TIA-920.110-B, and connect the telephone set to the circuit interface, as shown in Figure 6. Alternatively, the Type 1 artificial ear may be used if a seal can be achieved between the handset and the artificial ear without the use of sealing putty or similar materials.

(b) Configure the encoder/decoder to be capable of encoding or decoding signals with zero loss.

(c) Using a signal source, sweep the frequency range logarithmically from 200 Hz to 4000 Hz. The sweep rate is to be such that one complete transverse of the 200 Hz to 4000 Hz band requires approximately 8 to 10 seconds. The signal source is to be adjusted to produce an equivalent acoustic level to analogue sets (nominal +0 dBPa) with the receive volume control set to its nominal gain. The electric source and the measurement circuit should have the capability of operating linearly up to a level of approximately 1 volt. When testing digital telephones (e.g. Voice over Internet Protocol (VoIP) telephones), because of the packet delay (generally ranging from 100 ms to 300 ms) in the digital network, the test signal from the signal source should be long enough for the measuring amplifier and the level recorder to capture the maximum readings at each of the measuring frequencies.
(d) The RLR of the telephone under test is to be determined by first measuring the receive frequency response according to IEEE 269-2010. The RLR is then calculated from the measured frequency response as specified in IEEE 661-1979 (R2008).

(e) Place the volume control to its maximum setting. Perform an RLR measurement and record the maximum receive level.

(f) Calculate the gain by subtracting the maximum RLR value from the unamplified RLR value.

(g) If the calculated gain is greater than 18 dB, place the telephone in the on-hook mode, go off-hook and verify that the volume resets to the unamplified measured (nominal) level, or check for an override switch with the appropriate visual indicator and printed messages, accompanied by a warning message in braille.
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CS-03, Part V

Figure 5: Measurement block diagram

Signal Source → Communications Interface for TE

→ TE

→ HAC Probe

Signal Level Meter

Figure 6: Receive volume control measurement (ROLR)

Signal Source → Communications Interface for TE

→ TE

→ Ear Simulator

→ Audio Signal Analyzer

→ PreAmp