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SERIES P: TERMINALS AND SUBJECTIVE AND OBJECTIVE ASSESSMENT METHODS

Objective measuring apparatus

Use of head and torso simulator (HATS) for hands-free and handset terminal testing

Recommendation ITU-T P.581

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Recommendation ITU-T P.581

Use of head and torso simulator (HATS) for hands-free and handset terminal testing

Summary

This revised version of Recommendation ITU-T P.581 covers hands-free (including speakerphone, loudspeaking and headset) and handset terminals and includes clauses for the calibration and use of the head and torso simulator (HATS) for handset and headset terminals. This Recommendation specifies the use of the HATS for speakerphone terminal subjective and objective evaluations (e.g., Recommendation ITU-T P.340). It defines the test arrangements, the mouth calibration, the binaural equalization and loudness summation, as well as the method for headphone calibration to be applied for subjective third-party listening tests as described in Recommendation ITU-T P.832.

Source

Recommendation ITU-T P.581 was approved on 14 December 2009 by ITU-T Study Group 12 (2009-2012) under Recommendation ITU-T A.8 procedures.

FOREWORD

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Recommendation ITU-T P.581

Use of head and torso simulator (HATS) for hands-free and handset terminal testing

1 Scope

This Recommendation specifies the use of the head and torso simulator (HATS) for hands-free (including speakerphone, loudspeaking and headset functions) and handset terminal testing. It applies for subjective tests, e.g., as described in [ITU-T P.832] or for objective measurements as described in, for example, [ITU-T P.340]. The test positions, equalizations and calibration are specified. The binaural test conditions are also considered. Test methods for both send and receive characteristics testing are specified.

For the applications described in this Recommendation, the HATS consists of a head mounted on a torso that extends to the waist. The head is equipped with two artificial ears according to [ITU-T P.57] and with a mouth simulator. The HATS is specified physically as well as acoustically, in [ITU-T P.58].

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T P.57] Recommendation ITU-T P.57 (2009), *Artificial ears*.

[ITU-T P.58] Recommendation ITU-T P.58 (1996), *Head and torso simulator for telephonometry*.

[ITU-T P.79] Recommendation ITU-T P.79 (2007), *Calculation of loudness ratings for telephone sets*.

[ITU-T P.340] Recommendation ITU-T P.340 (2000), *Transmission characteristics and speech quality parameters of hands-free terminals*.

[ITU-T P.832] Recommendation ITU-T P.832 (2000), *Subjective performance evaluation of hands-free terminals*.

[ITU-T P.1100] Recommendation ITU-T P.1100 (2008), *Narrow-band hands-free communication in motor vehicles*.

3 Definitions and abbreviations

3.1 Definitions

This Recommendation defines the following terms:

3.1.1 artificial ear: A device for the calibration of earphones incorporating an acoustic coupler and a calibrated microphone for the measurement of the sound pressure and having an overall acoustic impedance similar to that of the median adult human ear over a given frequency band.

3.1.2 diffuse field equalization: Equalization of the HATS sound pick-up, equalization of the difference, in dB, between the spectrum level of the acoustic pressure at the ear-drum reference point (DRP) and the spectrum level of the acoustic pressure at the HATS reference point (HRP) in a diffuse sound field with the HATS absent using the reverse nominal curve given in Table 3 of [ITU-T P.58].

3.1.3 ear canal entrance point (EEP): A point located at the centre of the ear canal opening.

3.1.4 ear-drum reference point (DRP): Point located at the end of the ear canal, corresponding to the ear-drum position.

3.1.5 ear reference point (ERP): A virtual point for geometric reference located at the entrance to the listener's ear, traditionally used for calculating telephonometric loudness ratings.

3.1.6 free-field frequency response of HATS (sound pick-up): Difference, in dB, between the third-octave spectrum level of the acoustic pressure at the ear-drum reference point (DRP) and the third-octave spectrum level of the acoustic pressure at the HATS reference point (HRP) in a free sound field with the HATS absent (test point).

3.1.7 free-field plane wave diffraction at mouth reference point (MRP): Difference, in dB, between the third-octave spectrum level of the acoustic pressure at the mouth reference point (MRP) and the third-octave spectrum level of the acoustic pressure at the same point in a free sound field with the HATS absent.

The characteristic is measured for a frontal sound incidence, with a propagation direction parallel to the reference axis.

3.1.8 free-field reference point: Point located in the free sound field, at least 1.5 m from a sound source radiating in free air (in case of a head and torso simulator (HATS) in the centre of the artificial head with no artificial head present).

3.1.9 hands-free terminal: A telephone set that does not require the use of hands during the communications session; examples are headset, speakerphone and group-audio terminal.

3.1.10 HATS hands-free reference point (HATS HFRP): Corresponds to a reference point "n" from [ITU-T P.58]: "n" shall be one of the points numbered from 11 to 17 and defined in Table 6a of [ITU-T P.58] (coordinates of far-field front point). The HATS HFRP depends on the location(s) of the microphones of the terminal under test: the appropriate axis lip-ring/HATS HFRP shall be as close as possible to the axis lip-ring/speakerphone microphone under test.

NOTE – As an example, if the manufacturer indicates that the speakerphone microphone should be located in front of the HATS, but with an elevation angle of 40° from the horizontal plane, the HATS HFRP, for this test configuration, shall be chosen as point 13 (Table 6a of [ITU-T P.58]).

In such a case, the transfer function between the HATS HFRP and MRP amounts to:

– 25.0 dB +3/–4 dB in the third-octave bands centred on 200 Hz;

– 24 dB ±3 dB in the third-octave bands centred on 250 Hz, 315 Hz, 400 Hz, 500 Hz and 2 kHz;

– 24 dB +3/–4 dB in the third-octave bands centred on 1.25 kHz and 1.6 kHz;

– 25.5 dB +3/–4 dB in the third-octave bands centred on 630 Hz and 1 kHz; and

– 27 dB +3/–4 dB in the third-octave band centred on 800 Hz.

3.1.11 HATS reference point (HRP): The point bisecting the line joining the ear canal entrance points (EEPs).

3.1.12 head and torso simulator (HATS) for telephonometry: Manikin extending downward from the top of the head to the waist, designed to simulate the sound pick-up characteristics and the acoustic diffraction produced by a median human adult and to reproduce the acoustic field generated by the human mouth. The HATS shall conform to [ITU-T P.58].

3.1.13 horizontal plane of HATS: The plane containing the reference axis, perpendicular to the vertical plane. It is horizontally oriented when the HATS is in the reference position.

3.1.14 lip plane: Outer plane of the lip-ring. When the HATS is in the reference position, the lip plane is vertically oriented. The lip plane of the HATS is normally different from the plane of the mouth simulator orifice.

3.1.15 lip-ring: Circular ring of thin rigid rod, having a diameter of 25 mm and less than 2 mm thick. It shall be constructed of non-magnetic material and be solidly fixable to the HATS. The lip-ring defines both the reference axis of the mouth and the mouth reference point.

3.1.16 loudspeaking function: The handset is used in the normal position. The incoming signal is simultaneously presented to the user(s) from loudspeaker(s).

3.1.17 mouth reference point (MRP): The point on the reference axis, 25 mm in front of the lip plane.

3.1.18 pinna simulator: A device which has the approximate shape and dimensions of a median adult human pinna.

3.1.19 reference axis: The line perpendicular to the lip plane containing the centre of the lip-ring.

3.1.20 reference position of HATS: The reference position of the HATS in the test space is intended to simulate a person in the upright position. The HATS is in the reference position when the following conditions are met:

– the reference point coincides with the test point;

– the HATS reference plane is horizontal.

3.1.21 speakerphone set: A telephone set using a loudspeaker as a telephone receiver with or without an embedded microphone as a telephone transmitter; it may be used without the handset.

3.2 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

DRP	ear-Drum Reference Point
EEP	Ear canal Entrance Point
ERP	Ear Reference Point
HATS	Head And Torso Simulator
HATS HFRP	Head And Torso Simulator Hands-Free Reference Point
HFL_E	L_E factor for hands-free terminal receiving loudness rating calculation
HFT	Hands-Free Terminal
HRP	Head And Torso Simulator Reference Point
L_E	Earphone Coupling Loss
MRP	Mouth Reference Point
RLR	Receiving Loudness Rating

4 Test arrangement

4.1 General

Unless stated otherwise, the calibration of the artificial mouth refers to:

– the MRP for handset and headset;

– the HATS HFRP position(s) for loudspeaking hands-free terminals.

It shall be checked that the test conditions guarantee an accurate and repeatable positioning of the HATS in the reference position.

The horizontal positioning of the HATS reference plane shall be guaranteed within ±2°.

The use of the HATS should be indicated in the test report.

4.2 Positioning of the HATS

4.2.1 Desktop speakerphone

The general test arrangement defined in clause 5.2 of [ITU-T P.340] applies. The centre of the lip-ring of the HATS shall be located as defined in Figure 3 of [ITU-T P.340], but the reference axis of the mouth shall be horizontal.

4.2.2 Other types of speakerphone terminals

The HATS is positioned according to clause 4.2.1.

The test arrangement will be recommended unambiguously by the manufacturer.

If this information is missing, the test laboratory should apply test positions based on the principles described in clause 4.2.1.

The test conditions should be indicated in the test report.

NOTE – This subclause applies to mobile, portable, multimedia, lap-top speakerphone terminals, group audio terminals and conference systems.

Example: Mobile speakerphone (car-mounted)

For more detailed arrangements, see [ITU-T P.1100].

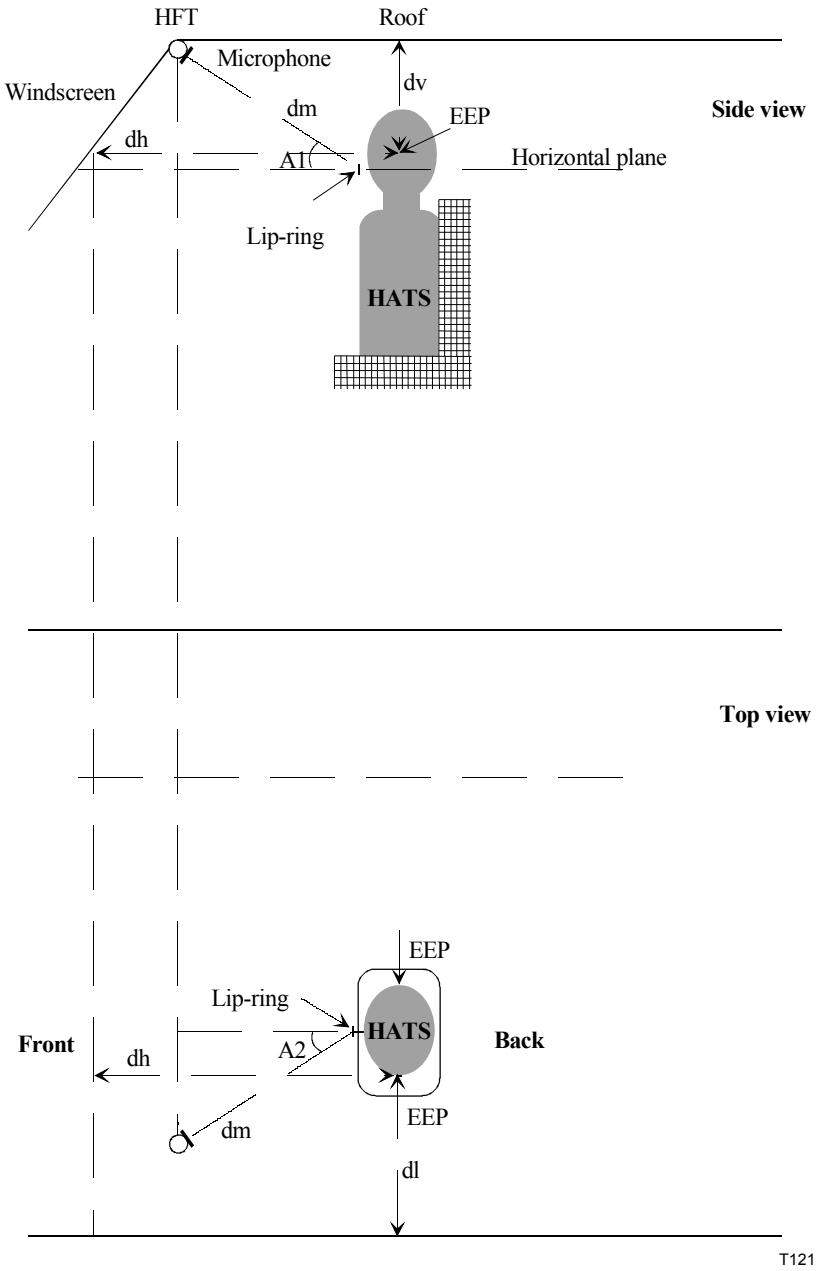
The HATS is placed inside the car (or car simulator) as shown in Figure 1.

The lip-ring of the HATS is adjusted as described in Figure 1.

The manufacturer of the speakerphone terminal needs to define unambiguously the exact position of the left and/or right ear canal entrance point (EEP) relative to fixed positions inside the car, e.g., the distance to the roof and the distance to the upper edge of the windscreen.

Unless specified otherwise by the manufacturer, the distance between the speakerphone microphone under test and the lip-ring should be as specified in Figure 1.

The speakerphone terminal is positioned in the car as recommended by the manufacturer.



A1 Angle between horizontal plane and the line through lip-ring and HFT Microphone.
dh Distance between EEP and Windscreen (horizontal plane).
dv Distance between EEP and car roof (vertical plane).
dm Distance between centre of the lip-ring and the microphone.
A2 Angle between the reference axis of the HATS and the line through lip-ring and HFT Microphone (in a vertical plane).
d1 Distance between EEP and the lateral side of the car (simulator).
A1, A2 and dm permit to define the appropriate HATS HFRP.

Figure 1 – Position of a HATS inside the car

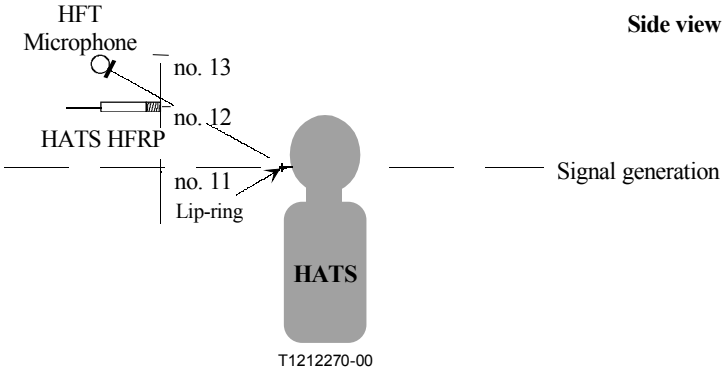


Figure 2 – Position of HATS HFRP for calibration

5 Acoustic characteristics

5.1 Sound pick-up

The HATS shall be equipped with two type 3.3 or 3.4 artificial ears, as specified in [ITU-T P.57] and shall be equipped with two artificial pinnas.

The pinna shall be positioned on the HATS according to [ITU-T P.58].

5.2 Calibration of the artificial mouth of the HATS

5.2.1 Handset and headset terminals

The input signal from the artificial mouth is calibrated under free-field conditions at the MRP. The overall signal level is set to –4.7 dBPa.

More details may be used in [ITU-T P.58].

5.2.2 Loudspeaking and speakerphone terminals

The following procedure shall be used to perform the calibration of the artificial mouth of the HATS:

– The input signal from the artificial mouth is first calibrated under free-field conditions at the MRP. The total level on the frequency range is set to –4.7 dBPa.

– The spectrum at MRP is recorded.

– Then the level is adjusted to –28.7 dBPa at the HATS HFRP.

– The actual level at MRP (measured in third-octave bands) is used as the reference for send characteristics.

The test set-up shall be in conformance with Figure 2, but, depending on the microphone position, the appropriate HATS HFRP defined in clause 3.1 will be used instead of point No. 11 (see [ITU-T P.58]).

NOTE – When using this calibration method, send sensitivity must be calculated as follows:

$$S_{mJ} = 20\log V_s - 20\log P_{MRP} + \mathrm{Corr} - 24$$

where:

V_s is the measured voltage across the appropriate termination (unless stated otherwise, a 600-ohm termination).

P_{MRP} is the applied sound pressure at the MRP.

Corr is 20 log (P_{MRP}/P_{HFRP}) of the used artificial mouth.

The value of Corr is the value given in the calibration chart of the artificial mouth (24.0 dB is the ideal value).

5.3 Equalization of HATS for test of receive characteristics

5.3.1 Loudspeaking and hands-free terminals

Due to the diffraction and reflection of the torso, shoulder and pinna, the HATS behaves differently from an ordinary measurement microphone. The transfer functions are directional and not flat. The typical head transfer function for different directions can be found in [ITU-T P.58]. Since the characteristics of the artificial head are directional, a reference position must be found which gives comparable results to those obtained with an ordinary measurement microphone. For this reference position, the HATS is equalized in such a way that the measured frequency response is flat (like a standard measurement microphone). A suitable reference position is 0 degrees in front of the HATS, in anechoic conditions. The equalization for this reference condition is defined as "free-field equalization".

For the measurement, a HATS complying with the free-field and diffuse-field reception characteristics, as described in [ITU-T P.58], is used.

If the HATS used for the test is not free-field equalized, the test set-up as described below needs to be used:

The equalization is made for this reference position in an anechoic room. The reference source is placed on the reference axis of the HATS, at a minimum distance of 1.5 m from the HATS lip-ring.

The measured free-field response of the HATS is:

$$H_{ff}(0°,0°,f)$$

From this, the free-field equalization is calculated:

$$H_{EQ}(0°,0°,f) = 1/H_{ff}(0°,0°,f)$$

$H_{EQl}(0°, 0°, f)$ is called the free-field equalization of the left ear, $H_{EQr}(0°, 0°, f)$ is called the free-field equalization of the right ear. These free-field equalizations are necessary to determine properly the receive sensitivity of the speakerphone terminal as described in clause 4.5.1.2 of [ITU-T P.340].

The equalization must be correct within ±0.5 dB of the frequency range from 100 Hz to 8 kHz measured in third-octave bands.

NOTE 1 – The free-field equalization of a HATS requires a very careful set-up of the measurement. Due to the directivity of the HATS, small deviations from the reference position (0°, 0°) may cause wrong equalized transfer functions.

NOTE 2 – The procedure defined in this subclause applies for free-field equalization, when HATS is used in an anechoic environment.

For the use of HATS in a diffuse-field environment, the diffuse-field equalization should be used (measurements are done according to ISO 4869).

Another equalization procedure, called "independent of the direction" equalization, could be used as an alternative to the diffuse field equalization.

5.3.2 Handset and headset terminals

The diffuse-field frequency response of HATS (sound pick-up) as defined in [ITU-T P.58] is the difference, in dB, between the third-octave spectrum level of the acoustic pressure at the ear-drum reference point (DRP) and the third-octave spectrum level of the acoustic pressure at the HATS reference point (HRP) in a diffuse sound field with the HATS absent.

For most of the parameter testing (except loudness rating) HATS is diffuse-field equalized. The equalized output signal is power-averaged on the total time of analysis.

The sensitivity is expressed in terms of dBPa/V.

For RLR measurement, HATS is not diffuse-field equalized. The DRP-ERP correction, as defined in [ITU-T P.57], is applied. No leakage correction shall be applied for the measurement.

5.4 Combination of left and right ear receive sensitivity

The equalized receive sensitivity of the left and right artificial ears of the HATS are combined on the following principle:

– The equalized output signal of each artificial ear is power-averaged on the total time of analysis; the "right" and "left" signals are voltage-summed for each third-octave band frequency band; these third-octave band data are considered as the input signal to be used for calculations or measurements.

5.4.1 Loudspeaking and speakerphone terminals

To compute receiving loudness rating (RLR) for loudspeaking and speakerphone terminal (see clause 4.5.2.2 of [ITU-T P.340]), when using the combination of left and right ear signals from HATS, the correction factor has to be 8 dB, instead of 14 dB.

NOTE – The 8 dB correction results from the 14 dB correction, as specified in [ITU-T P.340], subtracting 6 dB due to the voltage summation of the signals measured at the two ears.

5.4.2 Handset and headset terminals

Receiving loudness rating (RLR) for a binaural headset terminal is computed as defined in [ITU-T P.79], using the combination of left and right ear signals from HATS expressed in terms of dBPa/V for S_{Je} (F_i).

6 Application of HATS for calibration of headphones used for subjective evaluation procedures

For third-party listening test procedures, as defined in [ITU-T P.832], the speech materials for this subjective test have to be recorded by means of an equalized HATS and reproduced by a stereo equalized headphone.

The principle described for headphone equalization is applicable for free-field equalization.

NOTE 1 – The headphone should be circumaural and have a sufficiently low acoustical impedance.

Phase 1

The HATS (equipped with type 3.3 or 3.4 artificial ears) is first equalized, in the frequency range covering the third-octave bands from 100 Hz to 8 kHz according to clause 5.3 (the equalization is made in an anechoic room); the reference source – a loudspeaker fed with a broadband signal – is placed on the reference axis of the HATS, at a minimum distance of 1.5 m from the HATS lip-ring.

The equalized signals from the left and right ears of the HATS are:

– analysed in third-octave bands. The spectrum and the level of the two signals are kept as references for the equalization of the headphones;

– recorded in stereo.

Phase 2

The headphone is placed on the HATS (equipped with type 3.3 or 3.4 artificial ears).

The stereo signal recorded during phase 1 (from each equalized artificial ear) is fed to the playback system including the headphone and the associated stereo equalization system.

The new signal produced by each equalized artificial ear of the HATS is analysed in the third-octave band, and compared to the corresponding signal analysed during phase 1.

The correct equalization of the headphone is achieved when the signal levels (and the spectrum in each third-octave band) produced by each equalized artificial ear of the HATS is within ±1 dB of being equal to the reference signal of the corresponding ear analysed during phase 1, for each third-octave band in the frequency range from 100 Hz to 8 kHz.

NOTE 2 – It shall be checked that the equalization is not significantly modified if the headphone is removed and replaced on the HATS.

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