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SERIES P: TELEPHONE TRANSMISSION QUALITY, TELEPHONE INSTALLATIONS, LOCAL LINE NETWORKS

Objective measuring apparatus

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

ITU-T Recommendation P.581

(Formerly CCITT Recommendation)

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ITU-T Recommendation P.581

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

Summary

This ITU-T Recommendation specifies the use of Head and Torso Simulator (HATS) for hands-free terminals subjective and objective evaluations (e.g. ITU-T Recommendation 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 ITU-T Recommendation P.832.

Source

ITU-T Recommendation P.581 was prepared by ITU-T Study Group 12 (1997-2000) and approved under the WTSC Resolution 1 procedure on 18 May 2000.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSC Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation P.581

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

1 Scope

This ITU-T Recommendation specifies the use of Head And Torso Simulator (HATS) for hands-free terminal testing, for subjective tests as described in ITU-T Recommendation P.832 [5] or for objective measurements as described in, for example, ITU-T Recommendation P.340 [1]. The test positions, equalizations and calibration are specified. The binaural test conditions are also considered. Test methods for both sending and receiving characteristics testing are specified.

For the applications described in this ITU-T 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 Recommendation P.57 [2] and with a mouth simulator. The HATS is specified physically as well as acoustically, in ITU-T Recommendation P.58 [3].

2 Normative 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; all 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.

[1] ITU-T Recommendation P.340 (2000), *Transmission characteristics of hands-free telephones*.

[2] ITU-T Recommendation P.57 (1996), *Artificial ears*.

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

[4] ITU-T Recommendation P.79 (1999), *Calculation of loudness ratings for telephone sets*.

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

3 Definitions and abbreviations

3.1 Definitions

This ITU-T Recommendation defines the following terms:

3.1.1 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. HATS shall conform to ITU-T Recommendation P.58 [3].

3.1.2 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.

3.1.3 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.

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

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

3.1.6 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.

3.1.7 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 HATS is normally different from the plane of the mouth simulator orifice.

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

3.1.9 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.

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

3.1.11 HATS reference point (HRP): The point bisecting the line joining the Ear canal Entrance Points (EEPs).

3.1.12 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.

3.1.13 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).

3.1.14 free-field plane wave diffraction at 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.

3.1.15 HATS Hands-free Reference Point (HATS HFRP): Corresponds to a reference point "n" from ITU-T Recommendation P.58 [3]: "n" shall be one of the points numbered from 11 to 17 and defined in Table 6a/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/HFT microphone under test.

NOTE – As an example, if the manufacturer indicates that the HFT 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/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 1/3 octave bands centred on 200 Hz;

– 24 dB ±3 dB in the 1/3 octave bands centred on 250 Hz, 315 Hz, 400 Hz, 500 Hz and 2 kHz;

– 24 dB +3/–4 dB in the 1/3 octave bands centred on 1.25 kHz and 1.6 kHz;

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

– 27 dB +3/–4 dB in the 1/3 octave band centred on 800 Hz.

3.2 Abbreviations

This ITU-T Recommendation uses the following abbreviations:

EEP	Ear Canal Entrance Point
ERP	Ear Reference Point
HATS	Head and Torso Simulator
HATS HFRP	HATS Hands-free Reference Point
HFL_E	L_E Factor for Hands-free Terminal RLR Calculation
HFT	Hands-free Terminal
HRP	HATS 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 HATS HFRP position(s).

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 HATS should be indicated in the test report.

4.2 Positioning of the HATS

4.2.1 Desktop hands-free

The test arrangement defined in 5.2/ P.340 [1] applies. The centre of the lip-ring of HATS shall be located as defined in Figure 3/P.340, but the reference axis of the mouth shall be horizontal.

4.2.2 Other types of hands-free terminals

The HATS is positioned according to 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 4.2.1.

The test conditions should be indicated in the test report.

NOTE – This subclause applies to mobile, portable, multimedia, lap-top hands-free terminals, Group Audio Terminals and conference systems.

Example: Mobile hands-free (car-mounted)

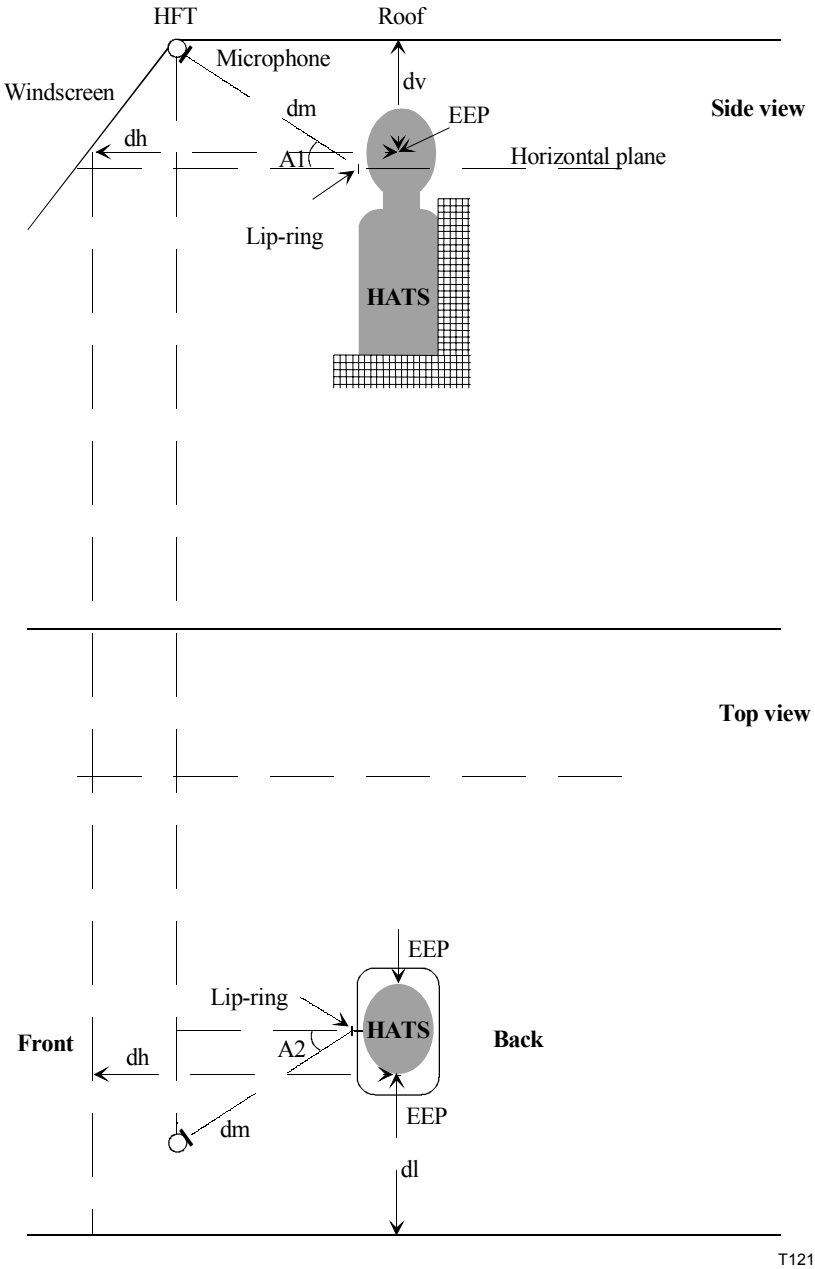
The HATS is placed inside the car (or car simulator) as shown in Figure 1.

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

The manufacturer of the hands-free 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. distance to the roof and distance to the upper edge of the windscreen.

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

The hands-free 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/P.581 – Position of a HATS inside the car

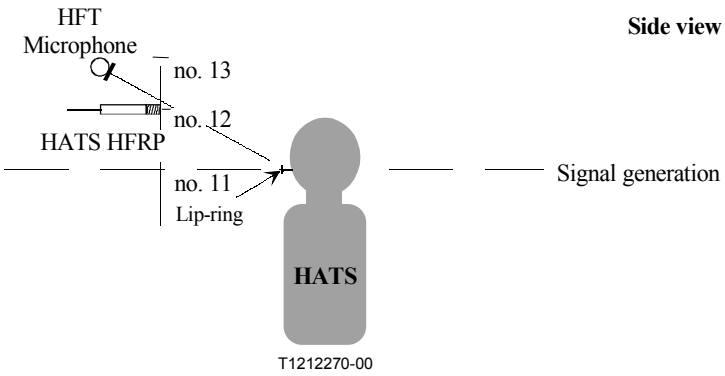


Figure 2/P.581 – Position of HATS HFRP for calibration

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 Recommendation P.57 [2] and shall be equipped with two artificial pinnas.

The pinna shall be positioned on HATS according to ITU-T Recommendation P.58 [3].

5.2 Calibration of the artificial mouth of the HATS

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 sending characteristics.

The test setup shall be in conformance with Figure 2, but, depending on the microphone position, the appropriate HATS HFRP defined in 3.1.15 will be used instead of point No. 11 (see ITU-T Recommendation P.58 [3]).

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

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

where:

V_s is the measured voltage across the appropriate termination (unless stated otherwise, a 600 ohms 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 receiving characteristics

Due to the diffractions and reflections of 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 Recommendation P.58 [3]. 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 Recommendation P.58 [3], is used.

If the HATS used for test is not free-field equalized, the test setup as described in the following 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 free-field equalization of left ear, $H_{EQr}(0°, 0°, f)$ is called free-field equalization of right ear. These free-field equalizations are necessary to determine properly the receiving sensitivity of the hands-free terminal as described in 4.5.1.2/P.340 [1].

The equalization must be correct within ±0.5 dB within the frequency range from 100 Hz to 8 kHz measured in 1/3 octave bands.

NOTE 1 – The free-field equalization of a HATS requires a very careful setup 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.

5.4 Combination of left and right ear receiving sensitivity

The equalized receiving 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 1/3 octave band frequency band; these 1/3 octave band data are considered as the input signal to be used for calculations or measurements.

To compute Receiving Loudness Rating (RLR) for hands-free terminal (see 4.5.2.2/P.340 [1]), 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 Recommendation P.340 [1], subtracted by 6 dB due to the voltage summation of the signals measured at the two ears.

6 Application of HATS for subjective evaluation procedures

The third-party listening test procedure is defined in ITU-T Recommendation P.832 [5]. 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 1/3 octave bands from 100 Hz to 8 kHz according to 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 1/3 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 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 1/3 octave band) produced by each equalized artificial ear of the HATS is within ±1 dB 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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