INTERNATIONAL TELECOMMUNICATION UNION

Addition to Section 3 of the Handbook on Telephonometry

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CONTENTS

ADDITION TO SECTION 3
OF THE HANDBOOK ON TELEPHONOMETRY

Addition to Chapter 3.2.4: Type 3.4 Ear simulator

1 Introduction

The type 3.4 pinna simulator was first presented in ITU-T Study Group 12 in 1993 [1], followed by a more detailed scientific background [2]. Numerous measurement results, including exhaustive repeatability tests were published in 1994-1995 [3], [4], [5].

Useful handset positions were first described in 1995 [6] and the final text for Annex D/P.64 was discussed in 1997 and was finalized in 1998.

Compatibility tests to P.57 type 1 and type 3.2 pinna simulator were performed and published in 1995 and 1997 [5], [8]. Possible applications, especially measurements of cordless and mobile telephones were presented in 1997 [9].

The description of the device can be found in ITU-T P.57 [13] and the positioning of handsets in ITU-T P.64 [15].

2 Comparison to human ears

Comparison measurements were presented in 1993 [1]. Figure 2-1 shows receiving sensitivity frequency response of four different telephones applied to the artificial ear, consisting of the type 3.4 pinna simulator and an IEC 711 ear simulator connected by an ear canal simulator (ECS), in comparison to averaged transfer functions of the same telephones applied to the ears of six male test persons.

For measurements of human ears, a small electret microphone was inserted into the ear canal at a depth of 4mm. The influence of the microphone position was corrected properly [1]. The force applied to the handset was adjusted to 13, 4 and 1N. Since the human ear does not behave like a spring, forces below 8N do not result in well-defined positions. Thus, for low forces the position was defined by the geometrical distance to the position corresponding to a force of 8N.

Figure 2-1 shows the good correspondence between the frequency responses measured by the artificial ear and the averaged frequency responses measured by human ears[1]. The resonances at about 3 kHz and 5 kHz show a large interindividual variance, so they are more attenuated to the human ear due to the averaging process, while the artificial ear shows a typical resonance.

3 Results of the ITU-T round robin test conducted in 1994-1995

In 1994-1995 an exhaustive round robin procedure was organized. The main goal was to test the repeatability of the type 3.4 simulator and to compare the results to those of type 3.2 and type 1 simulators. A detailed description of the test procedure and the results can be found in [5].

The tests which were performed in 1994-1995 in 10 laboratories proved the good repeatability of measurements performed with the type 3.4 pinna simulator.

For a pressure force of 13N, the RLR values are comparable to those measured by the type 3.2 simulator (low leakage option).

[1] See [1] for more details.

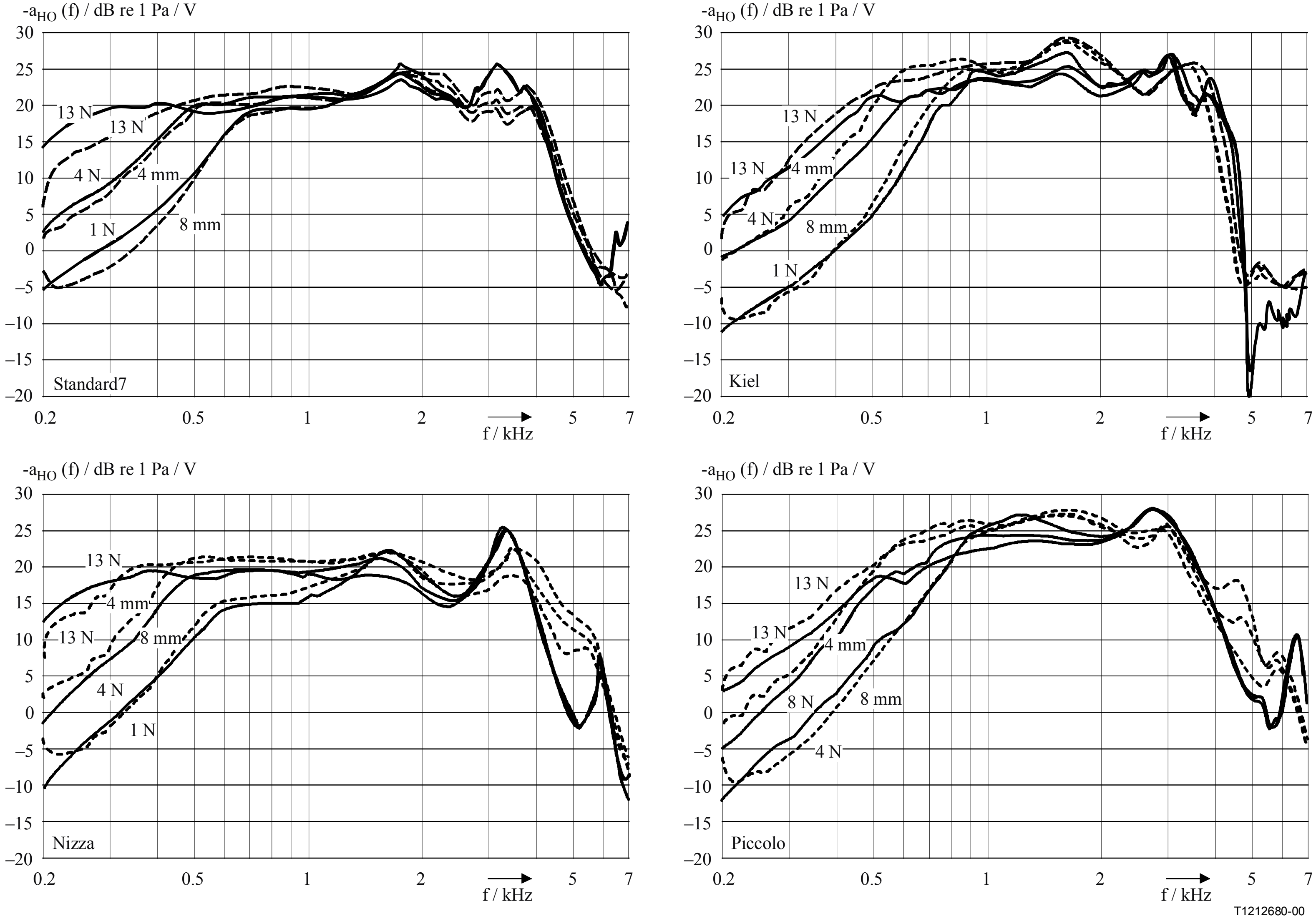

Figure 2-1 – Receiving sensitivity frequency responses: Upper left German standard handset "No. 7", upper right "Kiel", lower left "Nizza", lower right "Piccolo". Curve parameter: force resp. distance, referred to the "8N-position", from top to bottom: 13N, 4 and 8 mm (- -) resp. 13N, 4N (Piccolo: 8N) and 1N (Piccolo: 4N) (–)

The standard deviations of the receive loudness ratings (RLR) in dB achieved in 19-24 trials are listed in the following Table 3-1 (from [5]).

Table 3-1 – Standard deviations of the receive loudness ratings (RLR) in dB

Set	P. 57 type 3.4					P. 57	
No.	2N	4N	6N	8N	13N	type 1	type 3.2
1	0.31	0.36	0.39	0.33	0.20	0.25	0.12
2	0.33	0.36	0.38	0.41	0.26	0.18	0.28
3	0.34	0.37	0.38	0.33	0.22	0.16	0.31
4	0.28	0.31	0.36	0.37	0.35	0.22	0.10
5	0.28	0.31	0.27	0.31	0.31	0.39	0.27
6	0.31	0.38	0.41	0.41	0.26	0.25	0.36
7	0.33	0.40	0.46	0.47	0.58	0.28	0.42
8	0.26	0.26	0.49	0.69	0.29	0.22	0.13
9	0.35	0.26	0.24	0.22	0.17	0.19	0.16
Avg.	**0.31**	**0.33**	**0.38**	**0.39**	**0.29**	**0.24**	**0.24**

4 Influence of the handset orientation on the transfer characteristics

Figure 4-1 shows a typical positioning system indicating all angles and vectors which may be useful for the definition of the position and orientation of the handset in relation to the HATS. A similar system was used in the round robin test mentioned above [4], [5]. The receiving sensitivity frequency response is mainly determined by the pressure force and the angle α (typical 10,2°). The angles β (typical 24°) and γ (typical 0,5°) have a minor impact on the receiving direction, as shown for γ in the following clause. For the sending direction, however, β and α are the most important parameters.

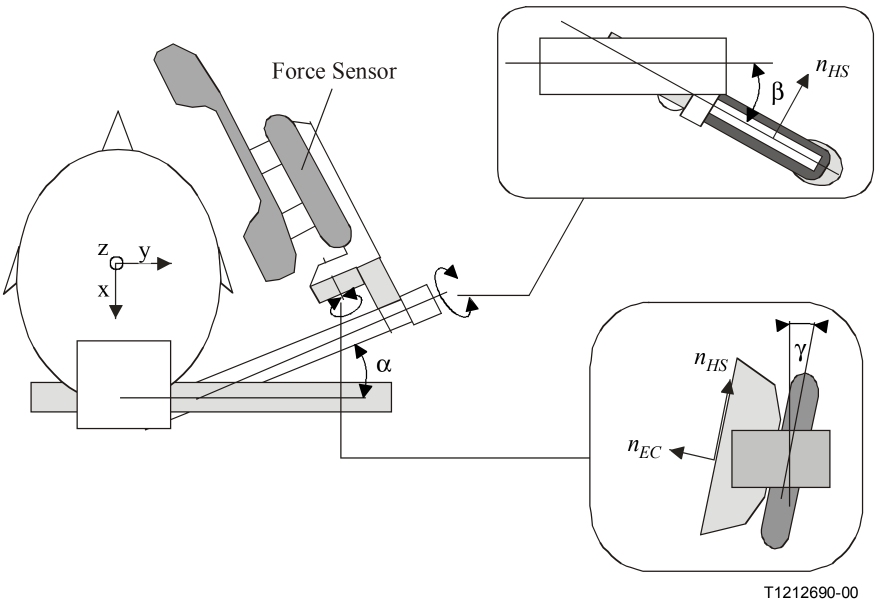

Figure 4-1 – Schematic diagram of a typical positioning system for the definition of angles and vectors

4.1 Influence of angle γ

The influence of the angle γ has been investigated for a group of 8 subjects by the following setup [1]: Using a microphone positioned within the ear canal [2] the receiving sensitivity frequency responses were measured for two different positioning instructions:

1) The subject is told to press the handset against the pinna to ensure that it is optimally sealed. In that position, the frequency response $H_{sealed}(f)$ is measured. Afterwards, the acoustical leakage between handset and ear is increased by increasing γ and keeping the upper edge of the handset close to the ear until a difference of 12 dB, as compared to the sealed position, is obtained for a frequency of 1 kHz. The frequency response $H_{tilt}(f)$ is measured in that position.

2) The subject is told to press the handset against the pinna to ensure that it is optimally sealed. In this position the frequency response $H_{sealed}(f)$ is measured. Afterwards the acoustical leakage between handset and ear is increased by parallel movement, keeping γ, until a difference of 12 dB to the sealed position is obtained for a frequency of 1 kHz. The frequency response $H_{parallel}(f)$ is measured in that position.

Figure 4-2 shows the average difference $H_{tilt}(f) - H_{parallel}(f)$ for 5 different handsets (average of 8 subjects). Up to 5 kHz no significant differences occur.

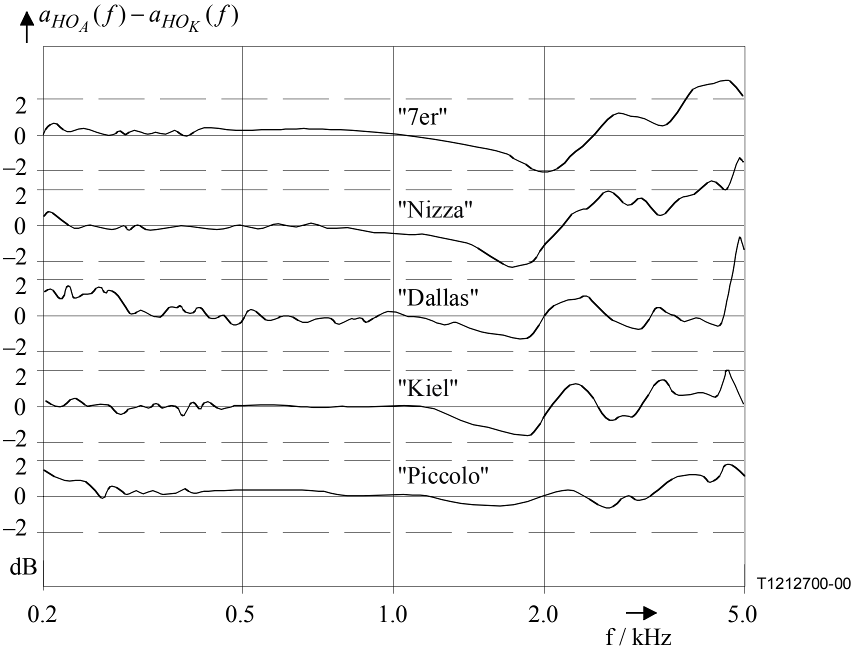

Figure 4-2 – Difference $H_{tilt}(f) - H_{parallel}(f)$ for five handsets (average of 8 subjects) according to [1]

In conclusion, it can be stated that no significant influence of γ exists. Only the leakage dimensions determine the receiving sensitivity frequency response.

5 Definition of handset positions

During the Round Robin Tests, a handset position was used which was adapted as much as possible to LRGP. The problem with that position is that the handset, relative to the mouth, is tilted downwards too much. The angle β, which is 24° for the HATS, is set to 39° in LRGP-position. The reason for this difference is that HATS is always oriented in the "Frankfurter horizontal plane" whereas, for LRGP, a tilting of the head of about 15° is assumed. Using the same angle for HATS would result in a much lower sending sensitivity for the handsets due to the distance between mouth and handset microphone. Therefore, a different position, the **HATS-position**, was defined in order to get:

– the typical leakage effect which is shown in the results of the Round Robin experiment [5];

– a sending sensitivity comparable to the LRGP-position [10].

This new position is defined as follows (see ITU-T P.64 [15]).

5.1 Standard position

The handset position has been defined according to the procedure described in Annex C/P.64 [10]. The orientation of the handset is defined by vectors normal to the plane of the ear cap and the plane of symmetry of the handset.

1) Unit vector normal to the plane of the ear cap:

$\boldsymbol{n}_{EC} = \pm (+0.1771, -0.9842, +0.0086)$

2) Unit vector normal to plane of the symmetry of the handset:

$\boldsymbol{n}_{HS} = \pm (+0.4083, +0.0655, -0.9105)$

The relative position between EEP and plane of lips is defined in ITU-T P.58. The center of the earcap is shifted from the EEP by +11.5 mm in x-direction and +8.0 mm in z-direction.

5.2 Alternative position

For very flat handsets, especially for mobile phones, this position may be impossible since the handset gets in touch with the "cheeck" of HATS (as well as with the cheeck of subjects) outside the pinna area (see also [9]). This can be avoided by decreasing α by 5°. The vectors for that alternative position are:

1) Unit vector normal to the plane of the ear cap:

$\boldsymbol{n}_{EC} = \pm (+0.09066, -0.99587, +0.00869)$

2) Unit vector normal to plane of the symmetry of the handset:

$\boldsymbol{n}_{HS} = \pm (+0.41214, +0.02957, -0.91067)$

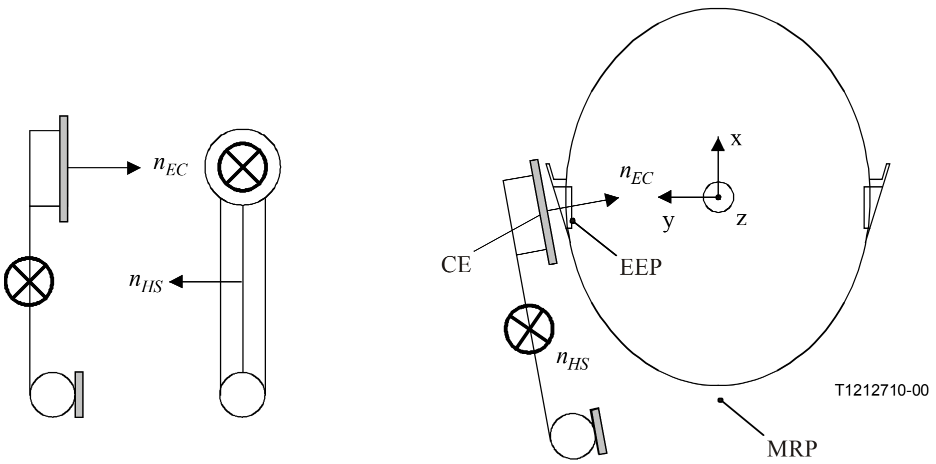

Figure 5-1 – Definition of unit vectors n_{EC} and n_{HS} relative to handset (left) and in connection to HATS (right). In addition, the ear canal entrance point (EEP), the centre of the ear cap (CE) and the mouth reference point (MRP) are indicated

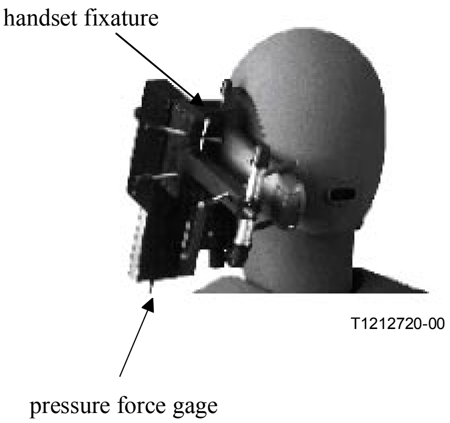

Figure 5-2 – Handset positioner for standardized HATS position with ITU-T P.57 ear simulator Type 3.4 according to Annex D/P.64
(for more information see [16])

6 Measurement examples

6.1 Acoustical measurement setup

The handset is positioned typically on a HATS (according to ITU-T P.58 [14]) as described in ITU-T P.64 using a proper positioning device and applying the desired pressure force. For the following examples the standard position was used.

6.2 Sending loudness ratings (SLR)

Table 6-1 shows SLR values calculated according to ITU-T P.79. Five conventionally shaped handsets already used in the Round Robin procedure (see clause 4) have been measured in LRGP position as well as in the standard HATS position described above, applying a pressure force of 13N. As Table 6-1 indicates, SLR values are comparable with LRGP and HATS position.

Table 6-1 – Comparison of SLR

Handset	SLR, P.79, LRGP-Position	SLR, P.79, HATS-Position	Δ
1	4.3 dB	4.1 dB	–0.2 dB
5	4.7 dB	3.8 dB	–0.9 dB
6	0.7 dB	–0.1 dB	–0.8 dB
7	1.9 dB	2.4 dB	0.5 dB
8	2.3 dB	2.1 dB	–0.2 dB

6.3 Frequency responses in sending direction

Figures 6-1 to 6-5 show sending sensitivity frequency responses for the HATS position compared to LRGP-position.

In general, it can be seen that the frequency responses for the different handsets are, in principle, quite similar to the HATS position in comparison to the LRGP position. However, there are some remarkable differences, due to reflections between head and handset, which are not present when using only the artificial mouth according to ITU-T P.51. In particular, for the handset 7 (see Figure 6-4) it can be seen that, in a frequency range of 3 kHz, the measured frequency response is no longer flat. Obviously a reflection between the very flat handset shape and the HATS leads to this narrow-band attenuation.

6.4 Frequency responses in receiving direction

The receiving sensitivity frequency responses for the HATS position, in comparison to the results of the round robin test [5] and the type 3.2 ear, are shown in Figures 6-8 to 6-14.

The sensitivity frequency responses are shown for 2N and 13N pressure force. In general, it can be seen that the results obtained in the round robin test are very similar to those measured in the standard HATS position according to Annex D/P.64. However, there is a tendency to a closer sealing of the handset in comparison to the round robin test. Nevertheless, it can be seen that both results are very similar to the Type 3.2 ear for 13N pressure force (except handset 7, which cannot be pressed to the HATS in such a way that the handset is seriously sealed: the handset touches the "cheeck" of the HATS with 4N pressure force).

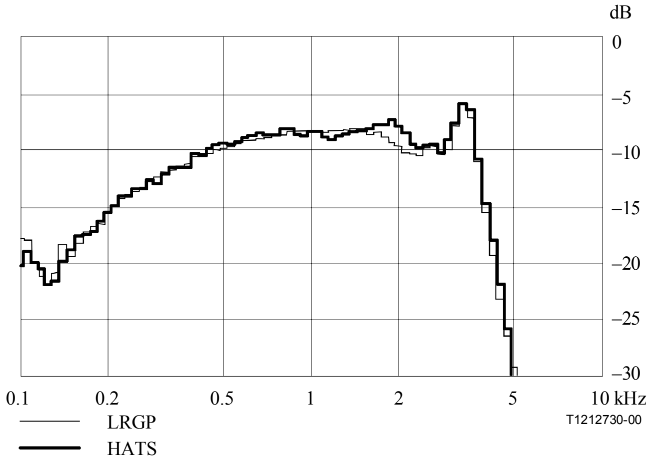

Figure 6-1 – Measurement results (sending) for HATS position (standard position) in comparison with results measured in LRGP position. Handset 1

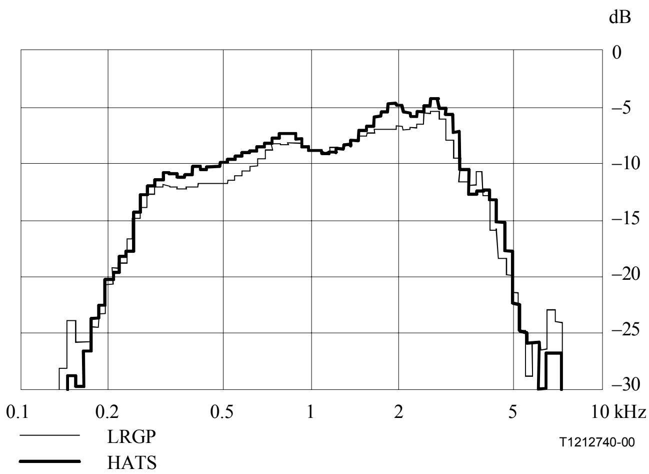

Figure 6-2 – Measurement results (sending) for HATS position (standard position) in comparison with results measured in LRGP position. Handset 5

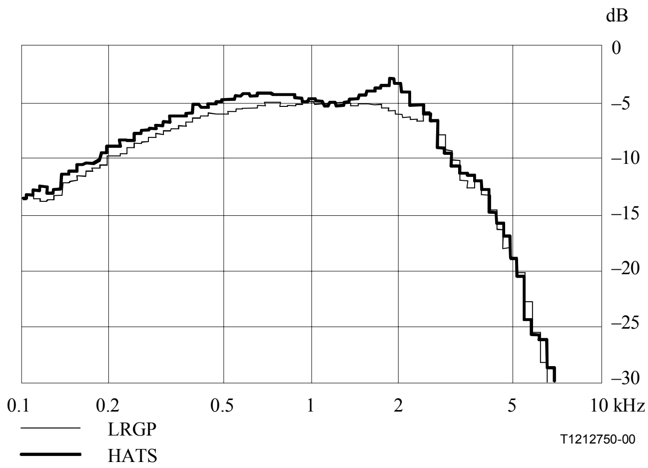

Figure 6-3 – Measurement results (sending) for HATS position (standard position) in comparison with results measured in LRGP position. Handset 6

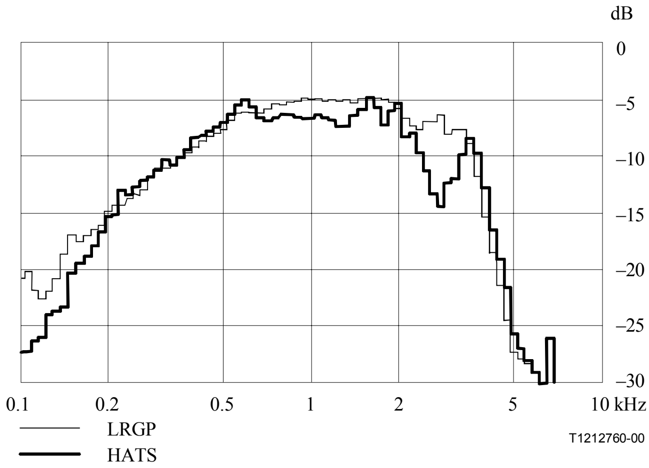

Figure 6-4 – Measurement results (sending) for HATS position (standard position) in comparison with results measured in LRGP position. Handset 7

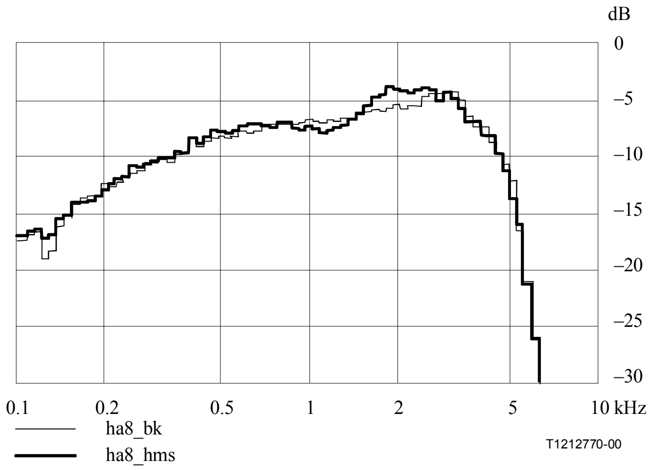

Figure 6-5 – Measurement results (sending) for HATS position (standard position) in comparison with results measured in LRGP position. Handset 8

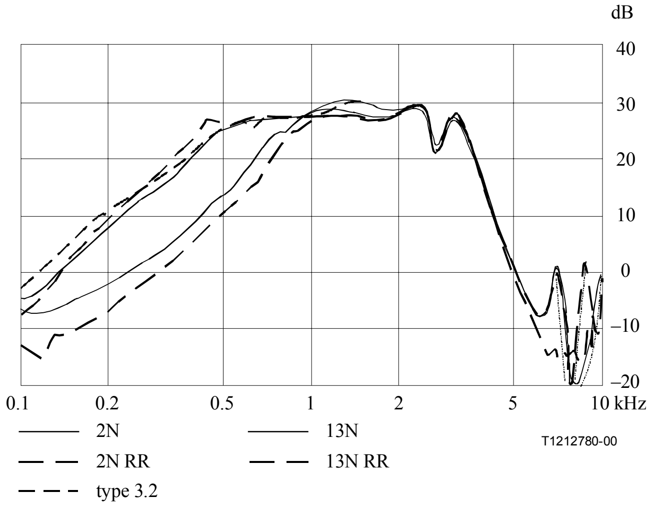

Figure 6-6 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5](— —), using presure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 1

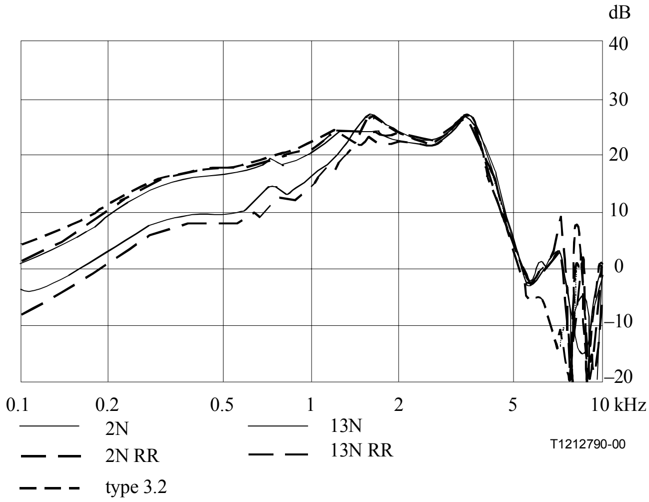

Figure 6-7 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5](— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 2

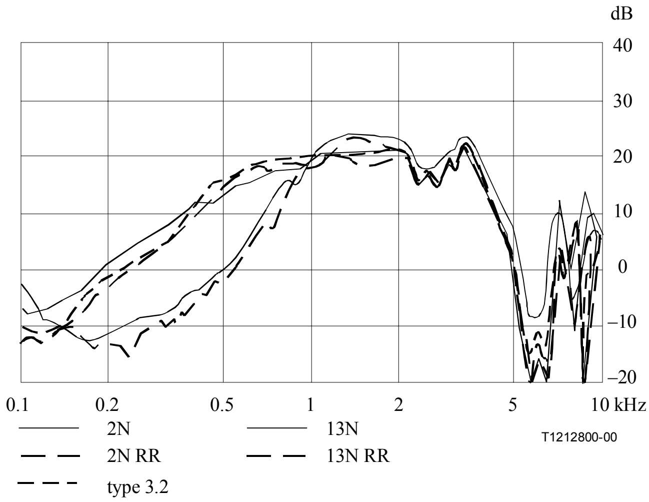

Figure 6-8 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 3

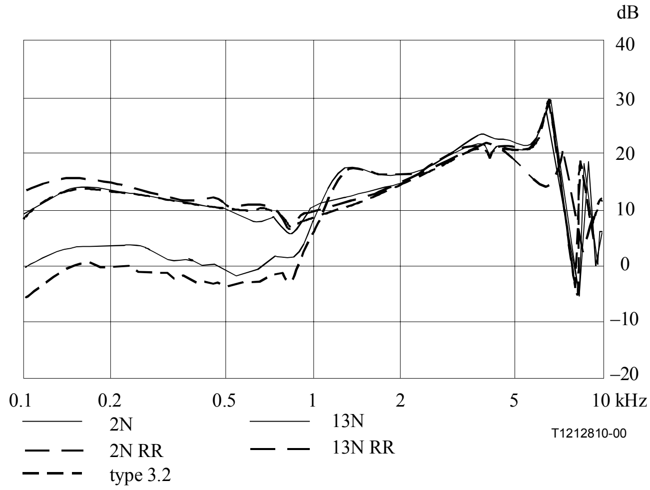

Figure 6-9 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 4

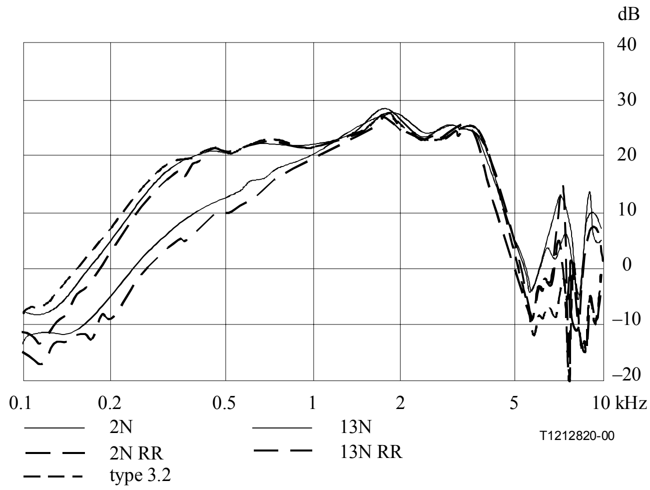

Figure 6-10 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 5

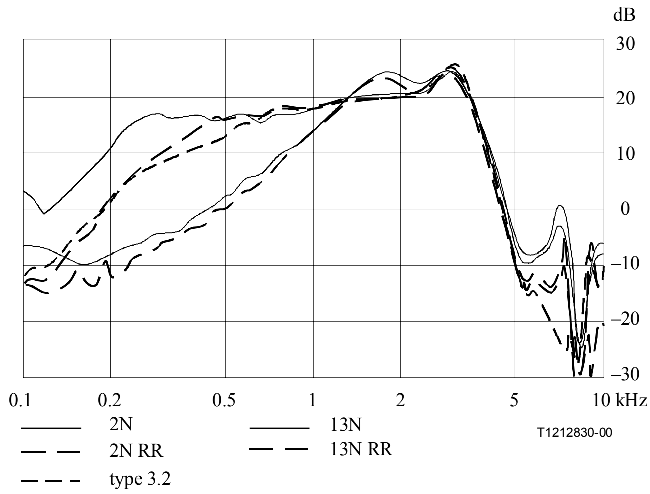

Figure 6-11 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 6

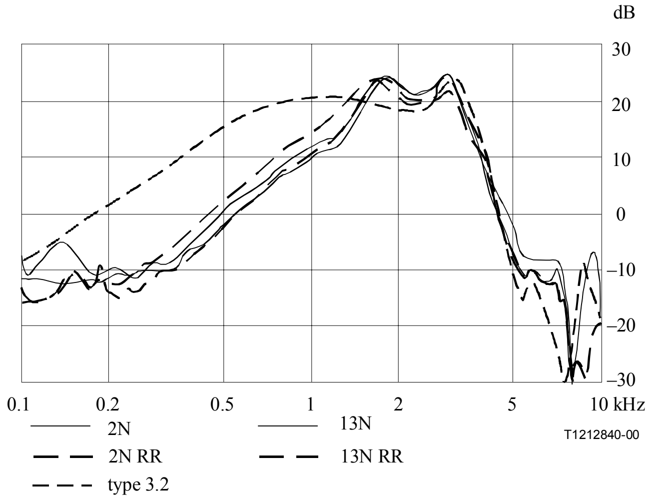

Figure 6-12 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 7

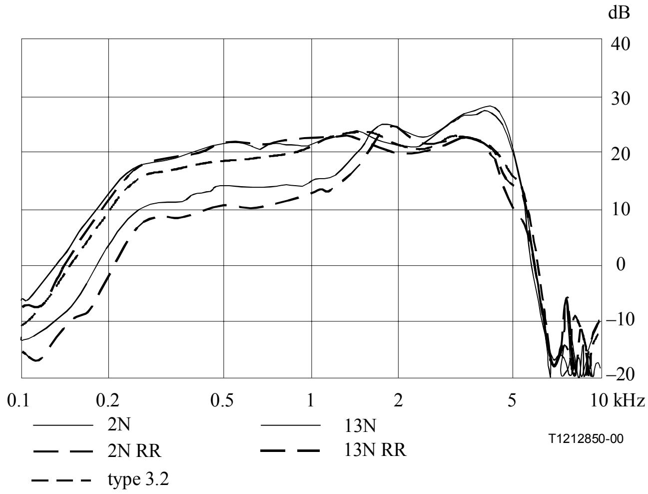

Figure 6-13 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 8

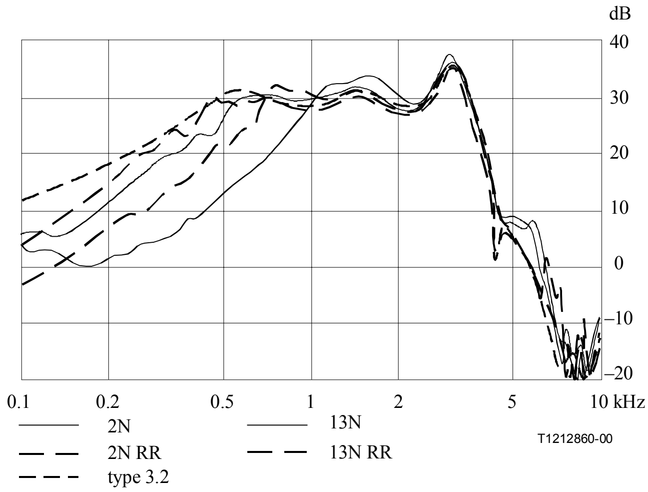

Figure 6-14 – Comparison of measurement results (receiving) for HATS position, standard position (——), for the setup used in the round robin test [5] (— —), using pressure forces 2N and 13N, and for the type 3.2 ear simulator (– – – –). Handset 9

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Addition to clause 3.3: Handset positioning on HATS for ITU-T P.57 ear simulators Type 3.2 and Type 3.3 for measuring loudness ratings and frequency responses

1 Introduction

Traditionally measurements of loudness ratings and frequency responses are performed using a classic telephone testhead. Today, a handset positioning device makes it possible to obtain such accurate and repeatable measurements using HATS. In the following clauses, an overview of the vector description defining this position on HATS is given and a practical setup realising the position is presented.

2 Vector description of HATS position for ITU-T P.57 ear simulators Type 3.2 and 3.3

A Cartesian coordinate system is used to describe the standardized position by means of vectors. Using ITU-T P.64 terminology: the coordinate system originates at CL and consists of three axes called x_m, y_m and z_m. The x_m-axis has positive direction into the mouth and coincides thereby with the mouth reference axis. The y_m-axis is horizontal, perpendicular to the x_m-axis with positive direction towards the right side of the head and the z_m-axis is perpendicular to the x_m-axis and y_m-axis with positive direction upwards. This head-fixed coordinate system corresponds to the HATS reference plane (see Figure 1).

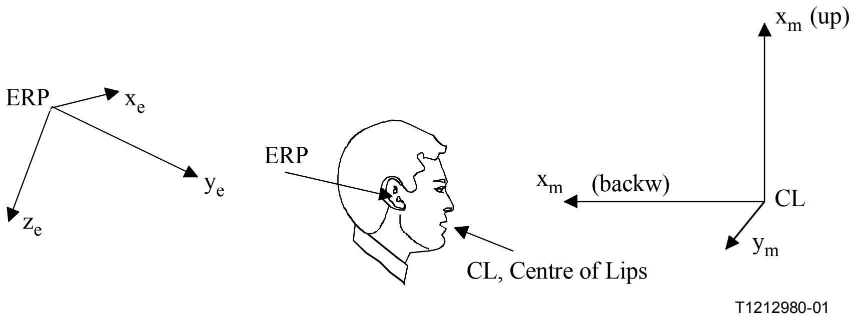

Figure 1 – Diagram of vector directions for head fixed coordinate system

Similar to the head-fixed coordinate system, a Cartesian coordinate system must be defined for the telephone handset. This coordinate system originates from the handset ERP and defines three axes: x_e-axis is normal to the ear-cap plane with positive direction away from the earphone. The y_e-axis is the line of intersection of the handset symmetry plane with positive direction towards the microphone. The z_e-axis is normal to the other two axes and is for handsets applied to the right ear. The z_e-axis points obliquely downwards.

With these two coordinate systems, the HATS-position for ITU-T P.57 Type 3.2 and 3.3 ear simulators can be defined by the following handset vectors expressed in the head-fixed coordinate system:

$\mathbf{x_e}$ unit vector:

$$\begin{bmatrix} x_m \\ y_m \\ z_m \end{bmatrix} = \begin{bmatrix} 0.1932 \\ -0.9740 \\ 0.1184 \end{bmatrix}$$

$\mathbf{y_e}$ unit vector:

$$\begin{bmatrix} x_m \\ y_m \\ z_m \end{bmatrix} = \begin{bmatrix} -0.9088 \\ -0.2231 \\ -0.3527 \end{bmatrix}$$

$\mathbf{z_e}$ unit vector:

$$\begin{bmatrix} x_m \\ y_m \\ z_m \end{bmatrix} = \begin{bmatrix} 0.3699 \\ -0.0394 \\ -0.9282 \end{bmatrix}$$

CL-ERP vector (right side) is defined by:

$$\begin{bmatrix} x_m \\ y_m \\ z_m \end{bmatrix} = \begin{bmatrix} 110.0 \\ 77.9 \\ 40.3 \end{bmatrix}$$

Refer to [1] and Annex E of ITU-T P.64 for a detailed description of the vector calculations.

3 Practical setup for handset positioning on HATS using ITU-T P.57 ear simulators Type 3.2 and 3.3

The Head and Torso Simulator with ear simulator Type 3.2 or 3.3 can be set up to the standardized HATS position (Annex E/P.64) using the Handset Positioner, shown in Figure 2. The HATS position is clearly marked on the Handset Positioner by an "H" at the scales for angle A, B and C and by "ERP" at the ERP-axis on the Handset Positioner barrel. The nominal angle values for the HATS position are: ∠A = 21.2°, ∠B = 12.9° and ∠C = 2.3° (these angles are derived from the x_e, y_e and z_e unit vectors).

While this standardized position is clearly marked on the Handset Positioner, it is possible to investigate the influence of varying the angles and/or the earcap to ERP distance relative to the nominal values.

With the P.57 Type 3.2 ear simulator, having a well defined contact ring, the handset is applied towards the nominal ERP position.

With the P.57 Type 3.3 anatomically shaped pinna simulator, the default position is the nominal ERP position. This position corresponds to a loosely held handset (high leak). Application forces in the range of 10 to 20N may be applied to decrease the acoustic leak.

For a detailed description of the Handset Positioner device refer to [2].

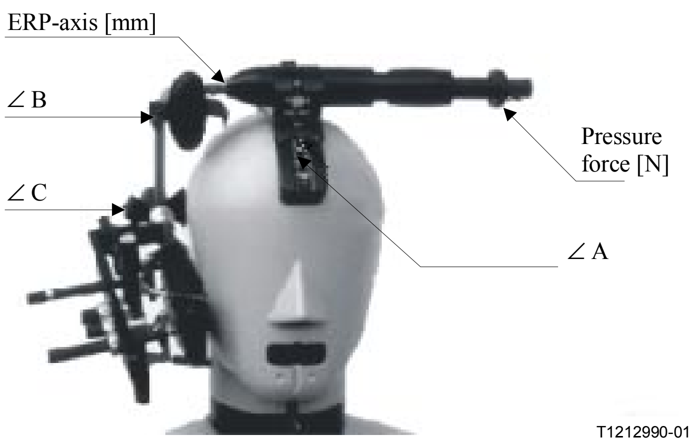

Figure 2 – Handset Positioner for the standardised HATS position with P.57 ear simulators Type 3.2 or Type 3.3 in according to Annex E/P.64.

4 HATS position on the classic Telephone Test Head

The HATS position can also be implemented on a classical Telephone Test Head as described in [3]. When this telephone test head is fitted with a special HATS-referred positioning jig, the geometry of the position corresponds exactly to the standardised HATS position.

References

[1] COM 12-68-E: *On the hierarchy of test heads/simulators – where do we stand and where do we go?* September 1998.

[2] BRÜEL & KJÆR: Technical Documentation: *Head and Torso Simulator (HATS) Type 4128C & Handset Positioner for HATS Type 4606*, English BE1617-11.

[3] BRÜEL & KJÆR: *User Manual for Telephone Test Head Type 4602B*, English BE1273.