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STANDARDIZATION SECTOR
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TELEPHONE TRANSMISSION QUALITY

MEASUREMENTS RELATED TO SPEECH LOUDNESS

DETERMINATION OF LOUDNESS RATINGS; FUNDAMENTAL PRINCIPLES

ITU-T Recommendation P.76

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation P.76 was published in Volume V of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

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

Recommendation P.76

DETERMINATION OF LOUDNESS RATINGS; FUNDAMENTAL PRINCIPLES

(Geneva, 1976; amended at Geneva, 1980
Malaga-Torremolinos, 1984, Melbourne, 1988)

Preface

This Recommendation is one of a set of closely related Recommendations concerned with determination of loudness ratings. The present one deals with the fundamental principles and the others, as follows, deal with certain additional matters[1)].

Recommendation P.48	Specification for an intermediate reference system
Recommendation P.78	Subjective testing method for determination of loudness ratings in accordance with Recommendation P.76
Recommendation P.64	Determination of sensitivity/frequency characteristics of local telephone systems to permit calculation of their loudness ratings
Recommendation P.79	Calculation of loudness ratings
Recommendation P.65	Objective instrumentation for the determination of loudness ratings

1 Introduction

A speech path is, broadly, a transmission path that exists between a talker's mouth and the ear of a listener or, in the case of sidetone, between the mouth and ear of a talker. In typical face-to-face conversation, the speech is transmitted by means of the air path connecting the mouth and ear. Depending on environmental conditions, transmission may be:

a) more or less direct, as in the case of two persons conversing in an open, unobstructed location, such as a golf course;

b) largely indirect, as in the case of two persons conversing in a small, hard surfaced room where a large proportion of the energy reaching the ear may be due to reflections from the walls, ceilings and floor; or

c) something between the two extremes of *a)* and *b)*.

In the case of telephony, the air path is replaced by a system comprising:

a) an air path from the mouth to the telephone microphone;

b) an air path between the telephone earphone and the ear; and

c) a telephone connection consisting of the microphone, earphone and interconnecting circuitry together with a similar system for the reverse direction of transmission. The two situations - face-to-face and using the telephone - differ appreciably in detail but, for speech transmission purposes, they are alike insofar as their function is to provide a means of both-way speech communication.

Telephone engineering is concerned with providing telephone connections which, while not identical to the face-to-face situation, are comparable in effectiveness for providing a means of exchanging information by speech; such telephone connections should also optimize customer satisfaction within technical and economic constraints.

Various tools are used by transmission engineers in planning, design and assessment of the performance of telephone networks. Reference equivalent, based on the criterion of loudness of speech emitted by the talker and perceived by the listener, has been one of the most important of these tools; it provides a measure of the transmission loss, from mouth to ear, of a speech path.

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1) The present Recommendation together with Recommendations P.48, P.78 and P.79 provide complete definitions of overall, sending, receiving and junction loudness ratings, and Administrations are invited to use them to further their studies of Question 19/XII [1].

The *reference equivalent method* is defined in Recommendations P.42 and P.72 *Red Book* and its fundamental principles are briefly explained in [2]. The method for determining *loudness ratings* of local telephone circuits is based upon rather similar fundamental principles but comprises modifications which render it much more flexible and should greatly simplify transmission planning.

A desire to depart from use of reference equivalents as defined by Recommendation P.72 *Red Book* arises from the following reasons:

1) reference equivalents cannot be added algebraically; discrepancies of at least ± 3 dB are found;

2) replication accuracy of reference equivalents is not good; changes in crew can cause changes of as much as 5 dB;

3) increments of real (distortionless) transmission loss are not reflected by equal increments of reference equivalent; 10 dB increase in loss results in an increase in reference equivalent of only about 8 dB.

Use of loudness ratings defined in accordance with the principles given below should largely obviate these difficulties.

In addition to these advantages, the same values of loudness ratings should be obtained whether the determination is by subjective tests, by calculation based on sensitivity/frequency characteristics or by objective instrumentation. The fundamental principles of the method are described below and these differ from those applicable to reference equivalents by the least possible extent to achieve the desirable flexibility.

The loudness rating (which has the dimensions and sign of “loss”) is, in principle, like the reference equivalent, defined by the amount of loss inserted in a reference system to secure equality of perceived loudness to that obtained over the speech path being measured. Practical telephone connections are composed of several parts connected together. To enable the transmission engineer to deal with these parts in different combinations, loudness ratings must be defined in a suitable manner so that “overall”, “sending”, “receiving” and “junction” ratings can be used.

“Sidetone” loudness ratings can also be determined in an analogous manner. Sidetone reference equivalent is defined in Recommendation P.73 *Red Book* and sidetone loudness ratings are defined in § 3 below.

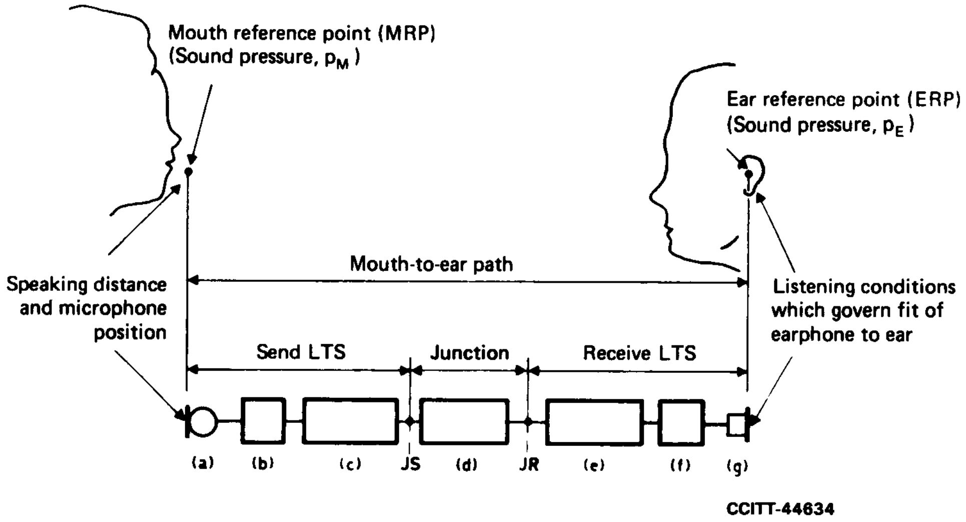
2 Definitions of loudness ratings for principal speech paths

2.1 *General*

§ 2 deals with principal speech paths, namely from a talker at one end of a connection to a listener at the other. Sidetone paths are treated in § 3 below.

In general, loudness ratings are not expressed directly in terms of actual perceived loudness but are expressed in terms of the amounts of transmission loss, independent of frequency, that must be introduced into an *intermediate* reference speech path and the *unknown* speech path to secure the same loudness of received speech as that defined by a fixed setting of NOSFER. This implies that some interface exists or could, by some arrangement, be found in the unknown speech path into which the transmission loss can be introduced. In practice the unknown speech path is composed of a sending local telephone circuit coupled to a receiving local telephone circuit through a chain of circuits interconnecting the two local systems[2)]. Figure 1/P.76 shows this subdivision of one principal speech path of a telephone connection. The interfaces JS and JR separate the three parts of the connection to which loudness ratings are assigned, namely: *sending loudness rating*, from the mouth reference point to JS; *receiving loudness rating* from JR to the ear reference point; and *junction loudness rating* from JS to JR. The *overall loudness rating* is assigned to the whole speech path from mouth reference point to ear reference point.

2) See Annex B for explanation of certain terms.



Note – (a) represents the microphone of the sending local telephone system;

(b) represents the electrical circuit of the telephone set of the sending local telephone system;

(c) represents the subscriber's line and feeding/transmission bridge of the sending local telephone system;

(d) represents the chain of circuits interconnecting the two local systems;

(e) represents the subscriber's line and feeding/transmission bridge of the receiving local telephone system;

(f) represents the electrical circuit of the telephone set of the receiving local telephone system;

(g) represents the earphone of the receiving local telephone system.

FIGURE 1/P.76

Subdivision of a telephone connection

Note that in practical telephone connections:

a) the transmission loss of the junction may be frequency dependent;

b) the image impedances of the "junction" may not be constant with frequency and may not be resistive;

c) the impendances of the local telephone systems presented to the junction at JS and JR may not be constant with frequency and may not be resistive;

d) impedance mismatches may be present at JS or JR or both.

Overall loudness ratings (OLRs), sending loudness ratings (SLRs), receiving loudness ratings (RLRs) and junction loudness ratings (JLRs) are defined so that the following equality is achieved with sufficient accuracy for practical telephone connections.

$$OLR = SLR + RLR + JLR$$

2.2 *Definitions of overall, sending, receiving and junction loudness ratings*

Figure 2/P.76 shows the principles used to define the overall, sending, receiving ad junction loudness ratings.

2.2.1 *Overall loudness rating*

Path 1 in Figure 2/P.76 shows the complete unknown speech path subdivided into local telephone systems and junction. In this example the junction comprises a chain of circuits represented by trunk junctions (JS-NS and NR-JR) and trunk circuits (NS-IS, IS-IR and IR-NR). A suitable arrangement for inserting transmission loss independent of frequency must be provided at some point such as in IS-IR.

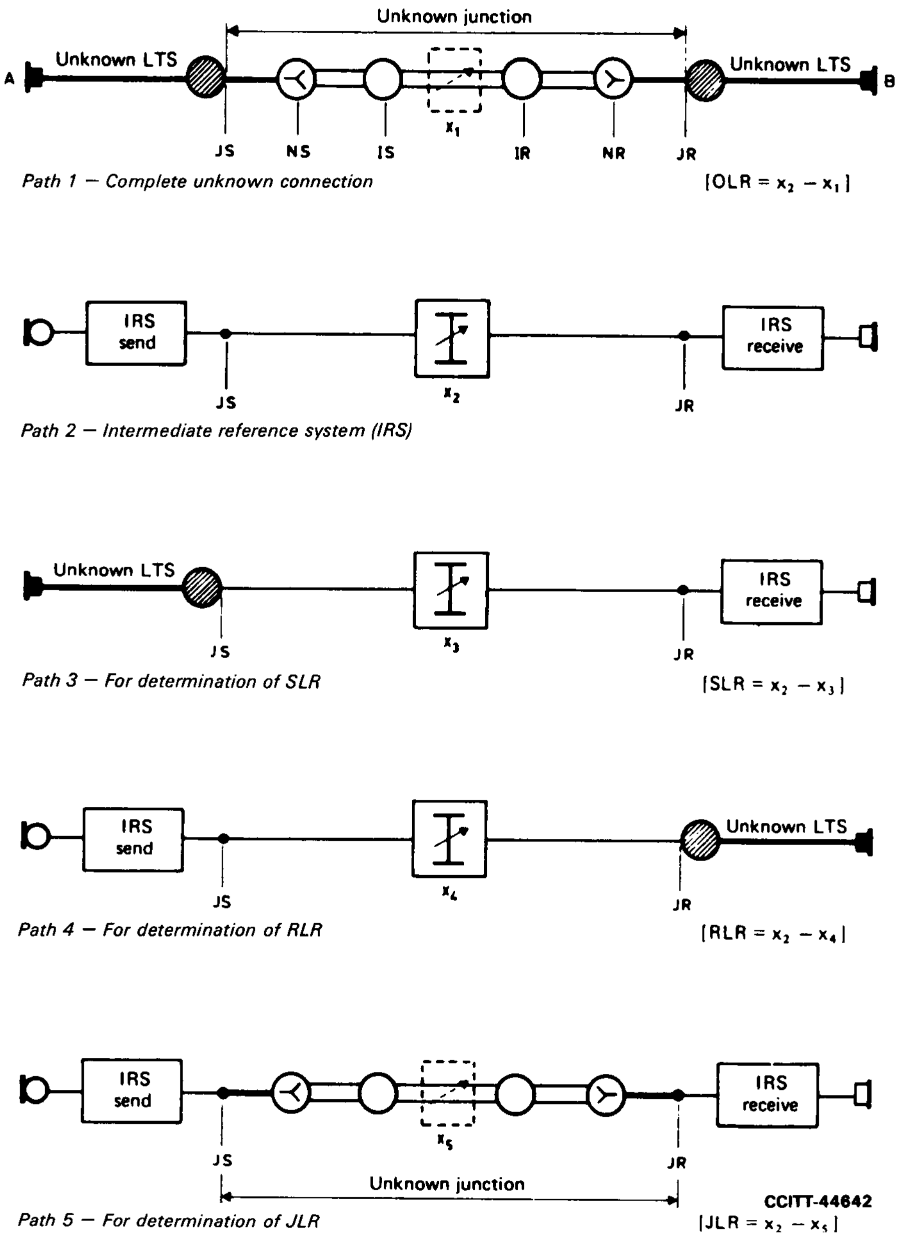


FIGURE 2/P.76

Principles used for defining OLR, SLR, RLR and JLR

Path 2 shows the complete intermediate reference system (IRS) with its adjustable, non-reactive, 600 ohms junction between JS and JR.

The level of received speech sounds to which the additional loss x_1 in Path 1 and the junction attenuator setting x_2 of Path 2 are both adjusted is defined by using the fundamental reference system NOSFER with its attenuator set at 25 dB. When these adjustements have been made, the overall loudness rating (OLR) of the complete unknown connection is given by ($x_2 - x_1$) dB.

2.2.2 *Sending loudness rating*

Path 3 in Figure 2/P.76 shows the IRS with its sending part replaced by the local telephone system of the unknown. The junction is adjusted to produce, via Path 3, the same loudness of received speech sounds as the NOSFER with its attenuator set at 25 dB. If x_3 is the required setting in Path 3, the sending loudness rating (SLR) is given by ($x_2 - x_3$) dB.

2.2.3 *Receiving loudness rating*

Path 4 in Figure 2/P.76 shows the IRS with its receiving part replaced by the local telephone system of the unknown.

The junction is adjusted to produce via Path 4 the same loudness of received speech sounds as the NOSFER with its attenuator set at 25 dB. If x_4 is the required setting in Path 4, the receiving loudness rating (RLR) is given by (x_2- x_4) dB.

2.2.4 *Junction loudness rating*

Path 5 in Figure 2/P.76 shows the IRS with its junction replaced by the unknown chain of circuits as located in Path 1 of Figure 2/P.76 between JS and JR. The arrangement for introducing transmission loss, independent of frequency, must be provided as was required in Path 1. The additional loss is adjusted to produce, via Path 5, the same loudness of received speech as the NOSFER with its attenuator set at 25 dB. If x_5 is the required additional loss in Path 5, the junction loudness rating is given by ($x_2 - x_5$) dB.

2.3 *Conditions under which loudness ratings are determined*

2.3.1 *General*

The loudness of received speech sounds depends upon certain factors that are not well defined under practical conditions of use, but must be defined as precisely as possible to obtain accurately reproducible loudness ratings. Clearly, as shown in Figure 1/P.76, the loudness rating is largely governed by the characteristics of the mouth-to-ear path. This path can be made precise by defining a *mouth reference point* at which the sound pressure p_M of speech emitted by the talker is measured or referred, and an ear reference point at which to measure or to which to refer the sound pressure p_E of speech reproduced by the earphone. These points can be chosen in a fairly arbitrary manner and this becomes important when loudness ratings are to be determined objectively; suitable definitions for such purposes are given in Recommendation P.64 which deals with measurement of sending and receiving sensitivity/frequency characteristics.

It is essential, however, to define vocal level, speaking distance, microphone position and listening conditions which govern the fit of the earphone to the ear. These are indicated in Figure 1/P.76. The essential features that define the conditions under which loudness ratings are determined are indicated in Table 1/P.76.

Some remarks on the items listed in Table 1/P.76 are given below.

2.3.2 *Intermediate reference system*

The intermediate reference system is defined in Recommendation P.48. It has been chosen with the following in mind:

a) It shall correspond approximately, as far as the shapes of sending and receiving frequency characteristics are concerned, with those of national sending and receiving systems in use at present and likely to be used in the near future. For this reason the frequency bandwidths for sending and receiving parts are confined to the nominal range 300-3400 Hz[3)].

b) The absolute sensitivity has been chosen to reduce as much as possible changes in values from reference equivalents to loudness ratings.

c) In external form its handsets are similar to conventional handsets used in actual telephone connections.

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3) The IRS is specified for the range 100-5000 Hz (see Recommendation P.48). The nominal range 300-3400 Hz specified is intended to be consistent with the nominal 4 kHz spacing of FDM systems, and should not be interpreted as restricting improvements in transmission quality which might be obtained by extending the transmitted frequency bandwidth.

TABLE 1/P.76

Conditions under which loudness ratings are determined

No.	Item specified	Specification
1	Intermediate reference system	Recommendation P.48
2	Vocal level of speaker	As Recommendation P.72 (Red Book)
3	Level of received speech sounds at which loudness is judged constant	NOSFER set at 25 dB
4	Handset position relative to talker’s mouth	See Annex A
5	Direction of speech	Head erect
6	Handset arrangement for listening	See § 2.3.7
7	Conditioning of carbon microphones	Recommendation P.75

2.3.3 *Vocal level of speaker*

The vocal level at which speech is emitted from the speaker's mouth conforms to that in use for determining reference equivalents and is defined in Recommendation P.72 *Red Book*. This approximates the level actually used by customers under good transmission conditions. It is defined in terms of the speech level at the output of the NOSFER sending system.

2.3.4 *Listening level*

The level of received speech sounds at which loudness is judged constant is defined by the vocal level (see § 2.3.3 above) and the setting (25 dB) of NOSFER against which all the speech paths shown in Figure 2/P.76 are adjusted. This corresponds to a fairly comfortable listening level of the same order as that commonly experienced by telephone users.

2.3.5 *Handset position*

The position of the telephone handset relative to the talker's mouth is defined in Annex A to this Recommendation. It is intended to approximate fairly well the position used by customers under real telephone connections. The definition covers not only the distance between lips and mouthpiece but also the attitude of the microphone relative to the horizontal axis through the centre of the lips. It is defined in such a way that the lips-to-mouthpiece distance becomes greater as the length of a handset is increased.

2.3.6 *Direction of speech*

The speaker shall hold his head erect and it will be assumed that speech is emitted horizontally from his mouth.

2.3.7 *Handset arrangement for listening*

The listener shall hold the handset in his hand with the earphone placed comfortably against his ear.

2.3.8 *Conditioning of carbon microphones*

Telephone handsets with carbon microphones usually require to be conditioned. This shall be done in accordance with Recommendation P.75.

3 Sidetone loudness ratings

It is necessary to examine the effects of telephone sidetone on the subscriber when considered both as a talker and as a listener. In each case, studies have shown that control of the higher frequencies (>1000 Hz) in the telephone sidetone path is important to preserve good conversational conditions in high-level room noise and/or on long-line connections. Sidetone loudness rating methods that place more weight on these higher frequencies are therefore required; suitable methods are described below.

3.1 *Talker Sidetone*

3.1.1 *Definition of sidetone masking rating (STMR)*

When a telephone subscriber speaks, his own voice reaches his ear by several paths (see Figure 3/P.76):

a) through the telephone set circuit from microphone to earphone due to mismatch of the hybrid balance impedance within the set and the line impedance;

b) through the mechanical path within the human head;

c) through the acoustic path to the ear and involving leakage at the earcap and human ear interface;

d) through the mechanical path along a handset handle [although this may be measured in fact as a contribution to a) above].

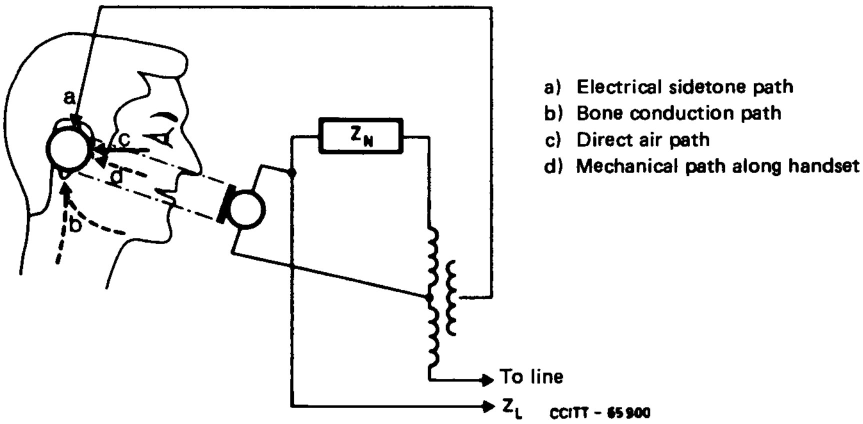


FIGURE 3/P.76

Sidetone paths through which a telephone subscriber may hear his own voice

Determination of these sidetone paths will usually resolve into two main measurements, a) + d) and b) + c). Each is referred to the speech signal at the mouth reference point (MRP) and the measurement made at the ear reference point (ERP).

Thus L_{MEST} is the loss from the mouth to ear (MRP to ERP) of the telephone sidetone path, and L_{MEHS} is the loss from mouth to ear (MRP to ERP) of the human sidetone path.

Note - Recommendation P.64, § 8 describes a method for the measurement of S_{meST}, the sidetone sensitivity/frequency characteristic of a telephone set using the artificial mouth and ear, from which an estimate of S_{MEST} using the human mouth and ear may be obtained by adding correction L_M and L_E as explained in the text.

Thus:

$$L_{MEST} = -S_{MEST} \text{ in dB}$$

L_{MEST} and L_{MEHS} are each usually measured at a number of frequencies in the ISO range of 1/3rd octave frequencies, typically at least 200 to 4000 Hz. Where complex signals are used (for example, during the measurement of L_{MEHS} the subjects' speech signals were used), spectrum density measurements must be made.

Studies completed so far have indicated that for talker sidetone at least, the rating method which correlates best with subjective effects of sidetone is one which takes into account the human sidetone signal as a masking threshold, i.e. sidetone masking rating (SMTR).

3.2 *Listener sidetone*

3.2.1 *Definition of listener sidetone rating (LSTR)*

When the subscriber is listening, any room noise may reach the ERP through paths a) and c) of Figure 3/P.76. It is the high frequencies of local room noise which are most likely to mask the low-level consonants of a received signal. The STMR method described in § 3.1 has the effect of controlling L_{meST} more effectively at frequencies higher than 1000 Hz. Control of these frequencies is also important for room noise sidetone. This is because the low frequencies of a received signal at the earphone will be masked by low frequency room noise (leaking past the earcap) in much the same way as the talker's speech signal heard via the telephone sidetone path (L_{meST}) is masked by that heard via the human sidetone path (L_{MEHS}).

Studies have shown that if the room noise sidetone path (L_{RNST}) is determined as described in Recommendation P.64, and used in the STMR rating method, the resulting ratings correlate well with the subjective effects of room noise heard over the telephone sidetone path. The explanation of this is that the composite room noise signal arriving at the listener's ear and which performs a masking function on the received speech signals is believed to have a characteristic very similar to that of L_{MEHS}.

Thus LSTR is defined as that attenuation that must be inserted into the IRS (Recommendation P.48) to give an equivalent loudness to L_{RNST} when similarly taking L_{MEHS} into account as a masking threshold (Recommendation P.79).

3.2.2 *Determination of LSTR*

To calculate LSTR it is necessary to determine the sensitivity S_{RNST} (where $S_{RNST} = -L_{RNST}$) using a method such as that described in Recommendation P.64, or in the *Handbook on Telephonometry*, Section 3, and making use of the calculation procedure given in Recommendation P.79.

S_{RNST}, room noise sidetone sensitivity, will, in general, not have the same value as S_{meST}, talker sidetone sensitivity, since the sensitivity of the handset microphone may not be the same for random incidence signals as for a point source close to the diaphragm (less that 5 cm). Usually room noise arrives at the microphone at lower levels than speech and this can result in different sensitivity values, particularly where carbon microphones are present.

The difference between S_{RNST} and S_{meST} for a given telephone will usually be constant for different line conditions provided that it is operating in a linear part of its characteristic, and/or the room noise level is constant. This difference is Δ_{Sm}, (or DELSm), and is explained further in Recommendations P.10 and P.64, § 9. The use of Δ_{Sm} can be convenient where values of S_{meST} are known, to determine S_{RNST} for the purpose of calculating LSTR. Thus:

$$S_{RNST} = S_{meST} + \Delta_{Sm}$$

Normally Δ_{Sm} is negative, thus telephones that have a more negative value for Δ_{Sm} will have a lower value of S_{RNST} and perform better in noisy room conditions from the point of view of sidetone.

For telephone sets with linear microphones, Δ_{Sm} can vary over several decibels, typical values ranging from −1.5 to −4 dB. For carbon microphones, measurement values have been reported as low as − 15 dB at some frequencies, but typical average values probably lie in the region of −8 dB for a room noise of 60 dBA. For some sets with linear microphones, the gain is intentionally not constant over their input/output characteristics in order to improve performance in noisy conditions. (See also Recommendation G.111, Annex A on the subject of Δ_{Sm}).

Note - Supplement No. 11 provides information on some of the effects of sidetone on transmission performance quantified over a number of study periods.

ANNEX A

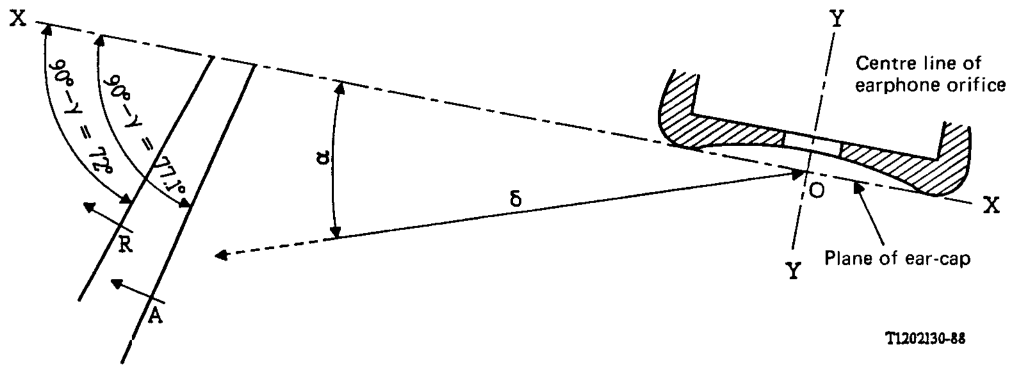
(to Recommendation P.76)

Definition of the speaking position for measuring loudness ratings of handset telephones

This annex describes the speaking position which should be used to measure the sensitivities of commercial telephone sets (by the method described in Recommendation P.64) for the determination of loudness ratings.

A.1 The definition of a speaking position falls into two parts: description of the relative positions of mouth opening and ear-canal opening on an *average* human head; and description of the angles that define the attitude in space of telephone handsets held to such a head. For any given telephone handset, these descriptions together describe the relative special disposition of the microphone opening and the talker's lips, and hence the direction in which speech sound waves arrive at the mouthpiece and the distance they have travelled from a *virtual point source*.

The relative positions of the centre of the lips and that of the ear canal can be described in terms of a distance δ and an angle α as shown in Figure A-1/P.76. Point R in that figure represents the centre of a guard ring located at the reference equivalent speaking position in accordance with Recommendation P.72, *Red Book*. Position A is that used to determine ratings by the articulation method defined in Recommendation P.45, *Orange Book*. Averages of lip positions of 4012 subjects in the People's Republic of China cluster round the point A (see Recommendation P.35).



Note 1 – Points R and A are located as follows:

A) δ = 136 mm, α = 22°, γ = 12.9°
R) δ = 140 mm, α = 15.5°, γ = 18°.

Note 2 – Solid lines through A and R show plane of lips.

FIGURE A-1/P.76

Location of lip position relative to opening of ear canal

A second angle is required to define the direction in which speech is emitted from the mouth into the mouthpiece of the microphone. In former Recommendations P.45 and P.72 reference is made to an angle ß, but this does not lie in the plane of symmetry of the handset, so it is more convenient to use an angle γ, which describes the vertical projection of the direction of speech on this plane.

A.2 The position of the centre of the lips as defined by A in Figure A-1/P.76 is used also to define the new speaking position, but two additional angles must also be defined, namely: the earphone rotational angle Φ and the handset rotational angle Θ. Earphone rotation is considered about an axis through the centre of the ear-cap (YY in Figure A-1/P.76); handset rotation is taken about a longitudinal axis of the handset (XX in Figure A-1/P.76); both angles are zero when the plane of symmetry of the handset is horizontal. Naturally, the earphone rotational angle is positive when the handle is pointed downwards away from the earphone and the handset rotational angle is positive in the sense that the upper part of the earphone is moved farther from the medial plane of the head.

The new speaking position is described by the following values for the distance and angles defined above:

$$\alpha = 22°, \gamma = 12.9°, \delta = 136 \text{ mm}, \Phi = 39° \text{ and } \Theta = 13°$$

The angle γ cannot be determined very precisely and is not convenient for use when setting up a handset for test in front of an artificial mouth. The semi-interaural distance ε may be used in its place, and for the new speaking position ε = 77.8 mm.

For any test jig, the manufacture tolerance should be within ± 0.5° for the angles defined above.

A.3 The foregoing description of the speaking position has shown the complexities of expressing the relative location of the ear reference point and the guard-ring centre, and the relative orientation of the earphone axis and the guard-ring axis. It is often more convenient, particularly in terms of constructing and setting up handset jigs, to express the position of the ear reference point[4)] and the direction of the earphone axis with respect to the lip-ring. This is easier since the axis of the guard-ring is horizontal as would be the axis of an associated artificial mouth.

A.4 Use has been made of a vector analysis method to determine the orthogonal coordinates of the handset ear-cap relative to the lip position when the handset is mounted in the LR guard ring position. It is necessary to define a set of cartesian axes with origin at the centre of the lips (or equivalent lip position of an artificial voice) as follows:

x-axis: horizontal axis of the mouth, with positive direction into the mouth;

y-axis: horizontal, perpendicular to the x-axis, with positive direction towards the side of the mouth on which the handset is held;

z-axis: vertical, with positive direction upwards.

The ear reference point is defined by the vector:

(86.5, 77.8, 70.5) mm.

The handset is mounted so that the ear reference point lies at the intersection of the axis of the ear-cap with a plane in space on which the ear-cap can be considered to be resting. With some shapes of handset, this definition is not adequate; in such cases the position of the ear reference point relative to the handset should be clearly stated.

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:

Unit vector normal to plane of the ear-cap:

± (0.1441, –0.974, 0.1748)

Unit vector normal to plane of symmetry of the handset:

± (0.6519, –0.0394, –0.7572).

When using an artificial voice, the equivalent lip position must be used as the datum; this is not normally the same as the plane of the orifice of the artificial mouth.

Alternatively, it can be convenient to define the speaking position in terms of axes with the origin at the ear reference point. These are defined as follows:

x-axis: axis of ear-cap with positive direction away from earphone;

y-axis: line of intersection of the plane of symmetry of the handset with the ear-cap plane, with positive direction towards the microphone;

z-axis: normal to the plane of symmetry of the handset with positive direction obliquely upwards.

The lip-ring centre is defined by the vector:

(50.95, 126.10, 0) mm.

The orientation of the lip-ring is defined by a unit vector along its axis:

± (0.1441, –0.7444, –0.6250)

and the orientation of the handset is defined by specifying the vertical by the unit vector:

± (0.1748, –0.6293, +0.7572).

4) See Recommendation P.64 for definition of ear reference point.

Note – The speaking position defined above differs from the special guard-ring position in the values of Φ (= 37°) and Θ (= 19°). It has been found that alterning the handset position from the special guard-ring position to the loudness rating guard-ring position described above affects sensitivity measurements to a negligible extent.

ANNEX B

(to Recommendation P.76)

Explanations of certain terminology

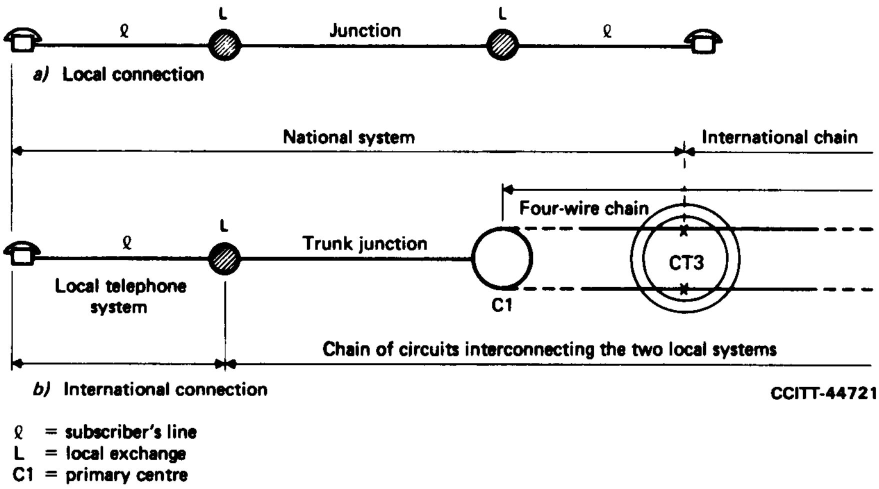


FIGURE B-1/P.76

The terminology of Figure B-1/P.76 applies to parts of a telephone connection according to Recommendations G.101 [3], G.111 [4], G.121 [5] and CCITT manuals.

Note – In the present Recommendation the word "junction" is used in a special sense to denote "chain of circuits interconnecting the two local systems" and the "junction attenuator" used in laboratory tests for determination of loudness ratings.

References

[1] CCITT – Question 19/XII, Contribution COM XII-No. 1, Study Period 1985-1988, Geneva, 1985.

[2] CCITT Manual *Transmission planning of switched telephone networks*, Chapter I, Annex 1, ITU, Geneva, 1976.

[3] CCITT Recommendation *The transmission plan*, Vol. III, Rec. G.101.

[4] CCITT Recommendation *Loudness ratings (LRs) in an international connection*, Vol. III, Rec. G.111.

[5] CCITT Recommendation *Loudness ratings (LRs) of national systems*, Vol. III, Rec. G.121.