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OBJECTIVE ELECTRO-ACOUSTICAL MEASUREMENTS

OBJECTIVE INSTRUMENTATION FOR THE DETERMINATION OF LOUDNESS RATINGS

ITU-T Recommendation P.65

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. The 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, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation P.65 was revised by the ITU-T Study Group XII (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

2 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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OBJECTIVE INSTRUMENTATION FOR THE DETERMINATION OF LOUDNESS RATINGS

(Malaga-Torremolinos, 1984, amended at Melbourne, 1988 and at Helsinki, 1993)

1 Introduction

This Recommendation describes the essential features of objective instrumentation suitable for the determination of loudness ratings. These features are drawn from current Recommendations relating to loudness ratings, the principles of which are defined in Recommendation P.76.

It is possible to realize objective instrumentation for loudness rating purposes in a number of ways, for example by the assembly of a number of separate instruments, each having its own defined function, and possibly under some central control, or by means of a dedicated piece of apparatus specially designed for the purpose. However, in order to ensure that loudness rating measurements made in different laboratories have an acceptable level of agreement, say ± 1 dB, it is essential that the Recommendations relating to the measurement of the electro-acoustic performance of telephone systems should be followed.

The relevant Recommendations are:

P.48 Specification for an intermediate reference system

P.51 Artificial mouth

P.57 Artificial ears

P.64 Determination of sensitivity/frequency characteristics of local telephone systems

P.75 Standard conditioning method for handsets with carbon microphones

P.76 Determination of loudness ratings; fundamental principles

P.79 Calculation of loudness ratings for telephone sets.

2 Instrumentation

The four electro-acoustic sections that are required to be included in equipment intended for use in determining loudness ratings are described below. In each case appropriate calibration is required as a function of frequency, and calibration values recorded in the fifth section where the particular sensitivity/frequency characteristic is derived and the loudness rating calculated. If the instrumentation is to include the measurement of listener sidetone rating (LSTR), a sixth section must be provided, namely a diffuse room noise source together with appropriate facilities for calibration, measurement and analysis in one-third octave bands.

It is necessary to provide certain auxiliary apparatus, such as feeding circuits, artificial subscriber cable and exchange terminations, as required by the particular Recommendation(s) being followed for any given measurement.

2.1 Artificial ear

See *a)* of Figure 1.

The artificial ear in the system should be in accordance with Recommendation P.51 and contain within it a measuring amplifier so that the pressure p_e occurring at the artificial ear cavity can be measured as a function of frequency, or in frequency bands within the recording and measurement system, *e)* of Figure 1. Means must also be available to calibrate the standard microphone used in the artificial ear employing, for example, an acoustic calibrator or piston-phone.

2.2 Artificial voice

See *b)* of Figure 1.

An artificial mouth complying with Recommendation P.51 must be part of the system and be able to produce a prescribed sound field at the MRP 25 mm in front of the lip plane. A signal source will be part of the artificial voice and this source may be sine waves (swept or discrete frequencies) or a wideband signal (e.g. the artificial voice defined in Recommendation P.50, or shaped Gaussian noise (see 3.6.3 of the *Handbook on Telephonometry*).

Equalization and gain control should be part of the drive system to the artificial mouth such that the sound pressure at the MRP can be controlled in accordance with the requirements of 3.6.3 of the *Handbook on Telephonometry* or as appropriate.

Calibration of the sound pressure and/or spectrum at the MRP may be carried out using the standard microphone used in the artificial ear of 2.1 above, making use of the recording and measurement system of 2.5 below to determine p_m as a function of frequency, or in frequency bands.

Mechanical means must be provided to hold the test handset in the LRGP (loudness rating guard-ring position), in accordance with the requirements of Annex C/P.64. If handsets having carbon microphone are being tested, conditioning in accordance with Recommendation P.75 must be provided.

2.3 Electrical termination

See *c)* of Figure 1.

The system should contain a 600 ohm balanced terminating impedance with means for measuring the terminating voltage, V_J (see 6/P.64 and 9/P.64), as a function of frequency, or in frequency bands, using the recording and measurement system of 2.5 below. Calibration of this section may be carried out using a calibrated voltage source.

Administrations who wish to use complex impedance termination are referred to Annex B/P.64.

2.4 Electrical signal source

See *d)* of Figure 1.

An electrical signal source must be provided having a 600 ohm balanced impedance. The electrical source need not be the same as that used for the artificial voice but should either be sine waves or a wideband signal. There should be means for calibrating and adjusting the generator voltage, E_J, to the requirements of 7/P.64 and 9/P.64 over the frequency range 100-8000 Hz. This may be carried out using calibration of the electrical termination of 2.3 above.

2.5 Recording and measurement system

See *e)* of Figure 1.

In order to determine the sound pressure p_e at the artificial ear or the voltage V_J at the electrical termination it will be necessary to provide a recording and measurement system. This measurement system may, using hardware or software, contain filters in order to improve signal-to-noise ratio or for analysing the output of the telephone set in 1/3rd octave frequency bands. Where a bank of 1/3rd octave filters is used these should be centred on the preferred frequencies in accordance with ISO 266 and have the characteristics in accordance with IEC Publication 225.

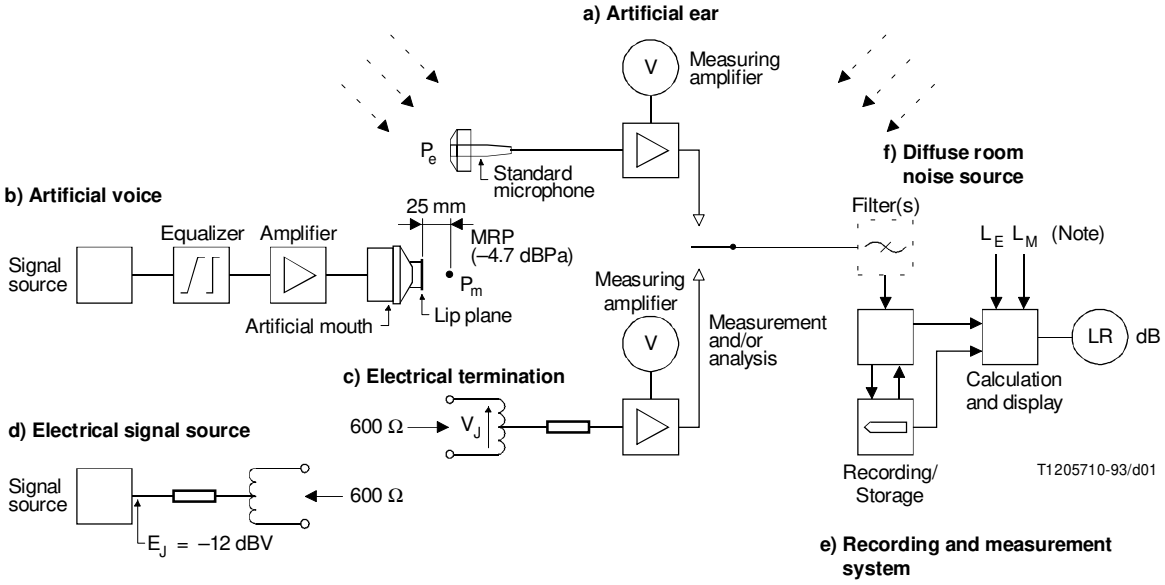
Within this part of the system there should be recording or storage facilities so that calibration and measurement data may be used to derive the necessary sensitivity/frequency characteristics in accordance with Recommendation P.64. The various loudness ratings are then computed in accordance with Recommendation P.79 from the sensitivity/frequency characteristics, taking into account any recognized adjustments, for example L_E or L_M. Values for L_E and L_M may be fed into the calculation using default values (e.g. those listed for L_E in Table 4/P.79) or from other more appropriate data sources when available.

2.6 Diffuse room noise source

See *f)* of Figure 1.

If LSTR is to be measured, a diffuse room noise source must be available, calibrated to provide a prescribed sound field at the position to be occupied by the MRP in the absence of the test head and all other obstacles, and as described in 9/P.64. Calibration of the diffuse sound pressure p_{RN} may be carried out using the standard microphone used in the artificial ear of 2.1, making use of the recording and measurement system of 2.5 to determine p_{RN} as a function of frequency in the frequency bands.

Because of the nature of room noise sidetone, it will normally be appropriate to use a diffuse sound pressure p_{RN} that is much lower than the value of –4.7 dBPa used for p_m in determining STMR and SLR. Typical values for p_{RN} would lie in the range 40-65 dB SPL (–54 to –29 dBPa, A weighted), and it should have a frequency spectrum appropriate for the application, for example as given in Recommendation P.80. The actual level and type of noise should always be stated in quoting test results.



NOTE – The artificial real mouth corrections L_M has been assumed to be zero but is currently under study.

FIGURE 1/P.65

Essential features of instrumentation for the determination of loudness ratings

3 Measurements

Facilities should be provided to enable the various sections of the instrumentation to be connected allowing the measurement of the necessary sensitivity/frequency characteristics and calculation of the loudness ratings.

A summary of these interconnections, together with the sensitivity/frequency characteristics (SFC) measured for particular loudness rating determinations, are given below.

3.1 Send loudness rating (SLR)

Source: *b)* of Figure 1.

Load: *c)* of Figure 1.

Send SFC given by:

$$S_{mJ} = 20 \log_{10} \frac{V_J}{p_m} \quad \text{dB}$$

3.2 Receive loudness rating (RLR)

Source: *d)* of Figure 1.

Load: *a)* of Figure 1.

Receive SFC given by:

$$S_{Je} = 20 \log_{10} \frac{p_e}{½ E_J} \quad \text{dB}$$

3.3 Sidetone masking rating (STMR) (Talker Sidetone)

Source: *b)* of Figure 1.

Load: *a)* of Figure 1.

Sidetone SFC is given by:

$$S_{meST} = 20 \log_{10} \frac{p_e}{p_m} \quad \text{dB}$$

NOTE – The quantity L_{meST} used in the calculation of STMR is given by:

$$L_{meST} = - S_{meST} \quad \text{dB}$$

3.4 Listener sidetone rating (LSTR)

Source: *f)* of Figure 1.

Load: *a)* of Figure 1.

Room noise sidetone SFC is given by:

$$S_{RNST} = 20 \log_{10} \frac{p_e}{p_{RN}} \quad \text{dB}$$

3.5 Overall loudness rating (OLR) [Overall Send + Receive (OSR)]

Source: *b)* of Figure 1.

Load: *a)* of Figure 1.

Overall SFC given by:

$$S_{me} = 20 \log_{10} \frac{p_e}{p_m} \quad \text{dB}$$

3.6 JLR Junction loudness rating

Source: *d)* of Figure 1.

Load: *c)* of Figure 1.

Junction loss/frequency characteristics given by:

$$X_{JJ} = 20 \log_{10} \frac{½ E_J}{V_J} \quad \text{dB}$$

NOTE – Impedance terminations of 600 ohms are assumed.