INTERNATIONAL TELECOMMUNICATION UNION

Addition to Section 2.3 of the Handbook on Telephonometry

ITU-T

TELECOMMUNICATION STANDARDIZATION SECTOR OF ITU

2000

CONTENTS

ADDITION TO SECTION 2.3 OF THE HANDBOOK ON TELEPHONOMETRY

Calculation of wideband (100-8000 Hz) loudness ratings

1 Introduction

Annex G to Recommendation P.79 gives a set of W-Weights that is suitable for the calculation of sending and receiving loudness ratings of wideband (100-8000 Hz) terminals. This addition describes the background and considerations in the derivation of the wideband algorithm, and provides guidance on the use of this algorithm in the calculation of sending and receiving loudness ratings for the wideband terminals.

2 Derivation of the wideband algorithm

2.1 Algorithm

ISO Standard 532 is a general applicable algorithm for the calculation of loudness. However, in ITU-T Recommendation P.79, a relatively simple algorithm is chosen. This is based on the following considerations:

a) From the definition of Loudness Rating, two systems, a reference system and an unknown system, were used for "equal loudness" comparison. The sound sources are the same – speech from a given talker, and the spectra of the resulting signals (after the transmission of the two systems) for loudness comparison usually have the same nature, and do not differ dremendously from each other;

b) Usually there is no strong peak or valley in the spectra of the resulting signals, so that the effect of inter-band masking should not be considered;

c) The subjective tests were made under "R25" conditions, i.e. a "constant listening level" condition. Under this condition, the G-Function used in this simple algorithm was then derived from the filter loudness test carried out by the previous CCITT Laboratory test crew.

There is no reason that this simple algorithm should be limited to use within the bandwidth of 200-4000 Hz. In fact, many years ago, the previous CCITT laboratory successfully used this simple algorithm for the calibration of NOSFER. The bandwidth used was from 100 to 8000 Hz. It was then decided that the same algorithm as in Recommendation P.79 should be chosen for wideband loudness rating calculation.

2.2 Reference system

For the wideband loudness comparison, it is preferable that the frequency response of the reference system should also be wideband. Also, according to the definition of loudness rating, when the Intermediate Reference System (IRS, see Recommendation P.48) is used as "unknown system", the calculated sending and receiving loudness ratings should be both 0 dB.

It is reasonable to use the frequency response of the "one meter air-path" as the frequency response of the reference system. For practical reasons, this response has to be divided into sending and receiving parts. Since the ARAEN system was the simulation of the "one meter air-path", its frequency response has been divided into sending and receiving parts. This is the reason that these parts were used as the frequency response of the wideband reference system.

After two sets of temporary W-Weights (for sending and receiving) are derived, we may correct each by a constant value so that when the sending part and receiving part of IRS are used as "unknown" systems, the calculated sending and receiving loudness ratings are both 0 dB.

In other words, the sending and receiving parts of the wideband reference system have the same frequency responses as those of the ARAEN system. However, the absolute sensitivities of the sending and receiving parts are different from those of ARAEN. In this way, the calculated loudness rating of the "unknown" wideband system will have the same loudness as an "unknown" narrow band system if their loudness rating values are equal.

2.3 G-Function and slope parameter m

According to Recommendation P.78, in subjective tests of loudness ratings, the listening level is fixed to that corresponding to "R25" which is much quieter than normal use. For narrow band applications, if loudness balance is made under slightly louder conditions, the resulting loudness rating could not differ significantly from that under specified listening level. However, for wideband applications, the higher, and especially lower frequency components, will contribute to loudness to a much greater extent if the listening level is higher. This phenomenon can be easily understood from the classical *Fletcher-Munson equal loudness curves*.

It is quite clear that if the listening level corresponding to R25 is used for subjective wideband loudness rating determination, the result might not be representative. It is then considered that the listening level corresponding to normal use will be adopted as the "reference condition". In this way, if "simple algorithm" as defined in Recommendation P.79 is used, we have to find another set of G-Functions suitable for the derivation of W-Weights.

On the other hand, it has been found that, for many years, the G-Function used in Recommendation P.79 (which was derived from the filter test result of the previous CCITT laboratory subjective test crew) inordinately estimates the contribution to loudness by the higher, and especially lower frequency components. Perhaps it would be more suitable for the wideband application! Further work has proven this to be true [1]. In this case, the consistent G-Function, as in Recommendation P.79, is chosen for the wideband calculations. The slope parameter, m, is also the same, i.e. 0.175.

3 Guidance on the use of the wideband algorithm

The method for using the wideband algorithm is the same as using the narrow band algorithm, except in the calculation, the range of the centre frequencies of 1/3 octave bands is from 100 to 8000 Hz. However, attention should be paid to the correct use of the data of sensitivity/frequency characteristics, especially the receiving sensitivity/frequency characteristics.

Type 1 artificial ear is not suitable for wideband use. In Recommendation P.57, Type 3.2 artificial ear is recommended for wideband applications. If the shape of the earcap is special and does not fit the circular rim of Type 3.2 artificial ear, then Type 3.3 or 3.4 artificial ears can also be used. In all these cases, coupling losses are included in the artificial ears, so the values of L_E should be set to zero during calculation. In other words, the values of L_E given in Table 2 of Recommendation P.79 should not be used.

For Types 3.2, 3.3 and 3.4 artificial ears, the sound pressure level is physically measured with a microphone placed in a position corresponding to the eardrum. For Type 3.2 artificial ear, the individually provided calibration data allows the transferred voltage to be directly referred to the pressure level at the ERP, which is the suitable reference point for the calculation of loudness ratings. For Types 3.3 and 3.4 artificial ears, the sound pressure level measured at the DRP shall be converted to the corresponding level at the ERP by using the ERP to DRP transfer function (S_{DF}), provided in Recommendation P.57, before calculating the loudness rating.

For Types 3.3 and 3.4 artificial ears, suitable force should be applied during measurement. Since the measured result depends upon the applied force, it is advisable to indicate the applied force on the report. The type of artificial ear used in the measurement should also be indicated in the test report, even if the same force is applied, because the measured sensitivity/frequency characteristics, and the calculated loudness rating, may be different.

Type 3.2 artificial ear has two options: high-leakage and low-leakage. Which ever leakage is used should be reported as well.

4 Sidetone

In Recommendation P.79, the bandwidth used for STMR and LSTR calculations is from 100 to 8000 Hz, which is really "wideband". That is to say, the recommended procedure can be used directly for wideband applications.

Reference

[1] COM 12-15-E, MPT China, *WIDEBAND LOUDNESS RATING ALGORITHM*, July 1998.