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

**Methods for objective and subjective assessment of
quality**

**Methodology for derivation of equipment
impairment factors from subjective
listening-only tests**

ITU-T Recommendation P.833

(Formerly CCITT Recommendation)

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**Methodology for derivation of equipment impairment factors
from subjective listening-only tests**

Summary

This Recommendation gives a methodology for deriving equipment impairment factors (*I_{es}*) for digital signal processing devices, namely low bit-rate codecs with or without transmission errors.

The *I_e* values are derived from the results of subjective listening-only tests. They are intended to be used as an input to the E-model (see ITU-T G.107).

Source

ITU-T Recommendation P.833 was prepared by ITU-T Study Group 12 (2001-2004) and approved under the WTSA Resolution 1 procedure on 23 February 2001.

Keywords

E-model, equipment impairment factor, impairment factor method, low bit-rate codecs.

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 Assembly (WTSA), 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 WTSA 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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ITU-T Recommendation P.833

Methodology for derivation of equipment impairment factors from subjective listening-only tests

1 Scope

This Recommendation describes the methodology for deriving equipment impairment factors (*I_{es}*) from subjective listening-only tests. It is intended that it primarily be applied to determining *I_{es}* for digital signal processing devices used in the network that have not otherwise been covered by the E-model. The equipment impairment factors derived by this methodology are intended to be used in the E-model (see ITU-T G.107). They will reflect the auditory impairments of the corresponding equipment in a listening-only mode.

2 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; 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.

- ITU-T G.107 (2000), *The E-Model, a computational model for use in transmission planning*.
- ITU-T G.108.1 (2000), *Guidance for assessing conversational speech transmission quality effects not covered by the E-model*.
- ITU-T G.113 (2001), *Transmission impairments due to speech processing*.
- ITU-T G.711 (1988), *Pulse code modulation (PCM) of voice frequencies*.
- ITU-T G.726 (1990), *40, 32, 24, 16 kbit/s adaptive differential pulse code modulation (ADPCM)*.
- ITU-T G.727 (1990), *5-, 4-, 3- and 2-bit/sample embedded adaptive differential pulse code modulation (ADPCM)*.
- ITU-T G.728 (1992), *Coding of speech at 16 kbit/s using low-delay code excited linear prediction*.
- ITU-T G.729 (1996), *Coding of speech at 8 kbit/s using conjugate-structure algebraic-code-excited linear-prediction (CS-ACELP)*.
- ITU-T P.800 (1996), *Methods for subjective determination of transmission quality*.
- ITU-T P.810 (1996), *Modulated noise reference unit (MNRU)*.
- ITU-T P.830 (1996), *Subjective performance assessment of telephone-band and wideband digital codecs*.
- ITU-T P.831 (1998), *Subjective performance evaluation of network echo cancellers*.
- ITU-T Handbook, *Handbook on Telephony*, 1992.

3 Introduction

The equipment impairment factor method (ITU-T G.113) is now the only one recommended by ITU-T for describing the subjective effects of digital processes other than pure PCM on the integral quality for transmission planning purposes. It is based on the principle that individual transmission impairments can be transformed into "psychological factors", and that these psychological factors are additive on a "psychological scale". It is assumed that the transmission rating scale underlying the E-model (ITU-T G.107) has the properties of such a "psychological scale".

In transmission planning of modern telecommunication networks, it is important to consider the combined effects of different types of impairments occurring simultaneously in a connection. This is performed by computational models like the E-model. Individual sources of degradations, such as a non-optimum overall loudness rating or sidetone path attenuation, talker echo attenuation and delay, quantizing distortion, absolute delay, etc., are transformed into so-called impairment factors. Degradations due to low bit-rate codecs are taken into account by means of an equipment impairment factor. Whereas interrelationships exist between the other impairment factors due to the underlying instrumentally measurable quantities of the connection (e.g. loudness ratings), the equipment impairment factor is by its very definition independent of all the other impairment factors. It is only dependent on the digital process whose perceptual characteristics it aims to model. The final transmission rating for the entire connection is calculated from all the individual impairment factors, by subtracting them from a basic signal-to-noise ratio.

For asynchronous tandems of multiple codecs of the same type, or of multiple codecs of different types, it is assumed that individual equipment impairment factors are additive. The overall equipment impairment factor for the chain of codecs is then calculated as a simple sum of all the individual *I*es. Experimental test data collected provide evidence that this simple additivity is not satisfied for all the potential combinations of codecs [5]. In some cases order effects exist, i.e. the tandem of codec A followed by codec B results in a different degradation than codec B followed by codec A. These deviations from the pure additivity property will be examined in more detail.

Equipment impairment factors have been introduced as a simplified measure of the perceptual effects of non-waveform codecs on the integral transmission quality from mouth to ear, for narrow-band (300-3400 Hz) handset telephony. They are in no way an exact description of the effects related to each individual codec or codec tandem, which may be very diverse in their perceptual nature. Instead, they represent the relative degradation in comparison to other impairments occurring in a connection. In order to provide guidance on the quantitative amount of impairment introduced by such codecs, a framework of equipment impairment factors for the most common non-waveform codecs has been derived by ITU-T, see Appendix I/G.113. Derivation is based on many subjective listening-only tests carried out in different test laboratories, so as to guarantee stable values for all the codecs under investigation so far, as well as their relations to each other. If new equipment impairment factor values for different codecs have to be derived, then the overall consistency with the established framework is of primary importance if results are to be obtained that are valid for network planning. The methodology described in this Recommendation was designed to fulfil this requirement.

As long as no instrumental methods can be defined, equipment impairment factors have to be derived from subjective test data. Such tests are generally carried out in a listening-only mode, which allows several, different connections to be tested within one test session. As a result, equipment impairment factors derived in this way will only reflect the influence on the one-way speech transmission quality, and will disregard degradations in the conversational quality. It has not yet been proven that the quantitative degradation in the listening-only and in the conversational modes are similar, but for reasons of simplicity a strong interrelation is assumed. Users of transmission rating models, however, should be aware that differences may exist, and that most of the data derived only reflects the listening-only situation.