

I n t e r n a t i o n a l T e l e c o m m u n i c a t i o n U n i o n

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

P.834

(06/2015)

SERIES P: TERMINALS AND SUBJECTIVE AND OBJECTIVE ASSESSMENT METHODS

Methods for objective and subjective assessment of
speech quality

Methodology for the derivation of equipment impairment factors from instrumental models

Recommendation ITU-T P.834

ITU-T P-SERIES RECOMMENDATIONS

TERMINALS AND SUBJECTIVE AND OBJECTIVE ASSESSMENT METHODS

Vocabulary and effects of transmission parameters on customer opinion of transmission quality	Series	P.10
Voice terminal characteristics	Series	P.30
		P.300
Reference systems	Series	P.40
Objective measuring apparatus	Series	P.50
		P.500
Objective electro-acoustical measurements	Series	P.60
Measurements related to speech loudness	Series	P.70
Methods for objective and subjective assessment of speech quality	Series	P.80
		P.800
Audiovisual quality in multimedia services	Series	P.900
Transmission performance and QoS aspects of IP end-points	Series	P.1000
Communications involving vehicles	Series	P.1100
Models and tools for quality assessment of streamed media	Series	P.1200
Telemeeting assessment	Series	P.1300
Statistical analysis, evaluation and reporting guidelines of quality measurements	Series	P.1400
Methods for objective and subjective assessment of quality of services other than voice services	Series	P.1500

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T P.834

Methodology for the derivation of equipment impairment factors from instrumental models

Summary

Recommendation ITU-T P.834 gives a methodology for deriving equipment impairment factors (*I_e*) for digital signal processing devices, namely low bit-rate codecs. The *I_e* values are intended to be used as an input to the E-model (see Recommendation ITU-T G.107).

The methodology specified in this Recommendation makes use of instrumental models (so-called "objective methods"), e.g., of the model defined in Recommendation ITU-T P.862. It is to be considered as supplementary to the methodology based on auditory listening-only tests, described in Recommendation ITU-T P.833. It will provide valid *I_e* values only for those codecs for which the used instrumental model produces meaningful estimations.

This Recommendation includes an electronic attachment containing speech material.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T P.834	2002-07-14	12	11.1002/1000/6084
1.1	ITU-T P.834 (2002) Cor. 1	2005-01-27	12	11.1002/1000/7828
2.0	ITU-T P.834	2015-06-29	12	11.1002/1000/12516

Keywords

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

* To access the Recommendation, type the URL <http://handle.itu.int/> in the address field of your web browser, followed by the Recommendation's unique ID. For example, <http://handle.itu.int/11.1002/1000/11830-en>.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). 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.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

© ITU 2015

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

Table of Contents

		Page
1	Scope.....	1
2	References.....	1
3	Introduction.....	2
4	Experimental set-up and data processing	3
4.1	Input speech material.....	4
4.2	Reference conditions	4
4.3	Processing of speech material	6
4.4	Calculation of MOS estimations using the instrumental model.....	7
5	Derivation of equipment impairment factors.....	7
6	Interpretation of instrumentally derived equipment impairment factor values	9
	Annex A – Speech material	10
	Appendix I – Calculation of equipment impairment factors from scores provided by the instrumental model described in ITU-T P.862	16
	Bibliography.....	17

Electronic attachment: Freely-available speech material described within the Recommendation.

Recommendation ITU-T P.834

Methodology for the derivation of equipment impairment factors from instrumental models

1 Scope

This Recommendation¹ describes the methodology for deriving equipment impairment factors (*I_{es}*) using instrumental models. The equipment impairment factors derived by this methodology are intended to be used in the E-model (see [ITU-T G.107]). The methodology is to be considered as supplementary to the one based on auditory listening-only tests described in [ITU-T P.833]. It will provide valid *I_e* values only for those codecs for which the instrumental model used produces meaningful estimations.

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. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- | | |
|---------------|--|
| [ITU-T G.107] | Recommendation ITU-T G.107 (2015), <i>The E-model: a computational model for use in transmission planning</i> . |
| [ITU-T G.113] | Recommendation ITU-T G.113 (2007), <i>Transmission impairments due to speech processing</i> . |
| [ITU-T G.711] | Recommendation ITU-T G.711 (1988), <i>Pulse code modulation (PCM) of voice frequencies</i> . |
| [ITU-T G.712] | Recommendation ITU-T G.712 (2001), <i>Transmission performance characteristics of pulse code modulation channels</i> . |
| [ITU-T G.726] | Recommendation ITU-T G.726 (1990), <i>40, 32, 24, 16 kbit/s Adaptive Differential Pulse Code Modulation (ADPCM)</i> . |
| [ITU-T G.727] | Recommendation ITU-T G.727 (1990), <i>5-, 4-, 3- and 2-bit/sample embedded adaptive differential pulse code modulation (ADPCM)</i> . |
| [ITU-T G.728] | Recommendation ITU-T G.728 (2012), <i>Coding of speech at 16 kbit/s using low-delay code excited linear prediction</i> . |
| [ITU-T G.729] | Recommendation ITU-T G.729 (2012), <i>Coding of speech at 8 kbit/s using conjugate-structure algebraic-code-excited linear prediction (CS-ACELP)</i> . |
| [ITU-T P.800] | Recommendation ITU-T P.800 (1996), <i>Methods for subjective determination of transmission quality</i> . |
| [ITU-T P.810] | Recommendation ITU-T P.810 (1996), <i>Modulated noise reference unit (MNRU)</i> . |

¹ This Recommendation includes an electronic attachment containing speech material.

[ITU-T P.830]	Recommendation ITU-T P.830 (1996), <i>Subjective performance assessment of telephone-band and wideband digital codecs</i> .
[ITU-T P.833]	Recommendation ITU-T P.833 (2001), <i>Methodology for derivation of equipment impairment factors from subjective listening-only tests</i> .
[ITU-T P.862]	Recommendation ITU-T P.862 (2001), <i>Perceptual evaluation of speech quality (PESQ): An objective method for end-to-end speech quality assessment of narrowband telephone networks and speech codecs</i> .
[ITU-T P.Sup23]	ITU-T P-series Recommendations – Supplement 23 (1998), <i>ITU-T coded-speech database</i> .

3 Introduction

The equipment impairment factor method of [ITU-T G.113] is now the only one recommended by ITU-T for describing the subjective effects of digital processes other than pure pulse code modulation (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 of [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, and absolute delay, 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 provide evidence that this simple additivity is not satisfied for all the potential combinations of codecs [b-ITU-T COM12-69] and [b-Möller]. In some cases, order effects exist, i.e., the tandem of codec A followed by codec B results in a different degradation to codec B followed by codec A. These deviations from the pure additivity property still have to 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; Appendix I of [ITU-T G.113]. Its derivation is based on numerous 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