

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.107

(06/2015)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA,
DIGITAL SYSTEMS AND NETWORKS

International telephone connections and circuits –
Transmission planning and the E-model

The E-model: a computational model for use in transmission planning

Recommendation ITU-T G.107

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

Recommendation ITU-T G.107

The E-model: a computational model for use in transmission planning

Summary

Recommendation ITU-T G.107 gives the algorithm for the so-called E-model as the common ITU-T transmission rating model. This computational model can be useful to transmission planners, to help ensure that users will be satisfied with end-to-end transmission performance. The primary output of the model is a scalar rating of transmission quality. A major feature of this model is the use of transmission impairment factors that reflect the effects of modern signal processing devices.

In the 2000 version of this Recommendation, an enhanced version of the E-model was provided in order to better take into account the effects of room noise at the send side and quantizing distortion. With the 2002 version, the impairment due to random packet loss was included in a parametric way for different codecs. Since the 2003 version, an enhanced modelling of quality in the case of low talker sidetone levels is provided. The 2005 version enabled more accurate quality predictions for codecs under (short-term) dependent packet loss. The 2009 version included an Appendix II describing a provisional impairment factor framework for wideband speech transmission. In 2011, this appendix was updated in favour of a new Recommendation ITU-T G.107.1. In the current version, the model has been extended to provide an assessment of delay impairments that is also better tailored to less delay-sensitive use cases. Carrier-grade or enterprise-grade telephony systems must be assessed with the default delay sensitivity parameters, while communication systems with low or very low interactivity requirements can be assessed with different parameters. A reference implementation is given in Appendix III.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T G.107	1998-12-03	12	11.1002/1000/4541
2.0	ITU-T G.107	2000-05-18	12	11.1002/1000/5074
3.0	ITU-T G.107	2002-07-14	12	11.1002/1000/6080
4.0	ITU-T G.107	2003-03-16	12	11.1002/1000/6253
5.0	ITU-T G.107	2005-03-01	12	11.1002/1000/7822
5.1	ITU-T G.107 (2005) Amd. 1	2006-06-13	12	11.1002/1000/8864
6.0	ITU-T G.107	2008-08-29	12	11.1002/1000/9538
7.0	ITU-T G.107	2009-04-29	12	11.1002/1000/9730
8.0	ITU-T G.107	2011-12-14	12	11.1002/1000/11460
8.1	ITU-T G.107 (2011) Amd. 1	2012-06-07	12	11.1002/1000/11707
9.0	ITU-T G.107	2014-02-13	12	11.1002/1000/12120
10.0	ITU-T G.107	2015-06-29	12	11.1002/1000/12505

* 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

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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.

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As of the date of approval of this Recommendation, ITU had 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/>.

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Recommendation ITU-T G.107

The E-model: a computational model for use in transmission planning

1 Scope

This Recommendation describes a computational model, known as the E-model, that has proven useful as a transmission planning tool for assessing the combined effects of variations in several transmission parameters that affect the conversational¹ quality of 3.1 kHz handset telephony. This computational model can be used, for example, by transmission planners to help ensure that users will be satisfied with end-to-end transmission performance whilst avoiding over-engineering of networks. It must be emphasized that the primary output from the model is the "rating factor" *R* but this can be transformed to give estimates of customer opinion. Such estimates are only made for transmission planning purposes and not for actual customer opinion prediction (for which there is no agreed-upon model recommended by the ITU-T).

The E-model can be used with confidence for many combinations of high importance to transmission planners, but for some parameter combinations of high importance, E-model predictions have been questioned and are currently under study. Annex A provides further information in this regard.

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.107.1] Recommendation ITU-T G.107.1 (2015), *Wideband E-model*.
<<http://www.itu.int/rec/T-REC-G.107.1>>
- [ITU-T G.108] Recommendation ITU-T G.108 (1999), *Application of the E-model: A planning guide*.
<<http://www.itu.int/rec/T-REC-G.108>>
- [ITU-T G.109] Recommendation ITU-T G.109 (1999), *Definition of categories of speech transmission quality*.
<<http://www.itu.int/rec/T-REC-G.109>>
- [ITU-T G.113] Recommendation ITU-T G.113 (2007), *Transmission impairments due to speech processing*.
<<http://www.itu.int/rec/T-REC-G.113>>
- [ITU-T P.833] Recommendation ITU-T P.833 (2001), *Methodology for derivation of equipment impairment factors from subjective listening-only tests*.
<<http://www.itu.int/rec/T-REC-P.833>>

¹ Conversational quality in this context refers to transmission characteristics, e.g., long transmission times, effects of talker echoes, etc. However, the E-model, as described in this Recommendation, is not intended to model transmission impairments during double talk situations.

- [ITU-T P.834] Recommendation ITU-T P.834 (2015), *Methodology for the derivation of equipment impairment factors from instrumental models*.
<<http://www.itu.int/rec/T-REC-P.834>>
- [ITU-T P.863] Recommendation ITU-T P.863 (2014), *Perceptual objective listening quality assessment*.
<<http://www.itu.int/rec/T-REC-P.863>>

3 Definitions

3.1 Terms defined elsewhere

None.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

BurstR	Burst Ratio
GoB	Good or Better
LSTR	Listener Sidetone Rating
MOS	Mean Opinion Score
MNRU	Modulated Noise Reference Unit
OLR	Overall Loudness Rating
OPINE	Overall Performance Index model for Network Evaluation
PLC	Packet Loss Concealment
PoW	Poor or Worse
qdu	quantization distortion unit
RLR	Receive Loudness Rating
SLR	Send Loudness Rating
STMR	Sidetone Masking Rating
TELR	Talker Echo Loudness Rating
WEPL	Weighted Echo Path Loss

5 Conventions

None.

6 The E-model, a computational model for use in transmission planning

6.1 Introduction

The complexity of modern networks requires not only that, for transmission planning, each of the many transmission parameters be considered individually but also that their combined effects be taken into account. This can be done by "expert, informed guessing", but a more systematic approach is desirable, such as by using a computational model. The output from the model described here is a

scalar quality rating value, R , which varies directly with the overall conversational quality. [ITU-T G.113] gives guidance about specific impairments, including combined effects based upon a simplification of the model. However, the output can also give nominal estimates of the user reactions, for instance in the form of percentages finding the modelled connection good or better (GoB) or poor or worse (PoW), as described in Annex B. Furthermore, detailed guidance on the proper application of the E-model, as described in this Recommendation, is provided in [ITU-T G.108]. In addition, the definition of categories of speech transmission quality can be found in [ITU-T G.109].

7 Structure and basic algorithms of the E-model

The E-model is based on the equipment impairment factor method, following previous transmission rating models. It was developed by an ETSI ad hoc group called "Voice Transmission Quality from Mouth to Ear".

The reference connection, as shown in Figure 1, is split into a send side and a receive side. The model estimates the conversational quality from mouth to ear as perceived by the user at the receive side, both as listener and talker.

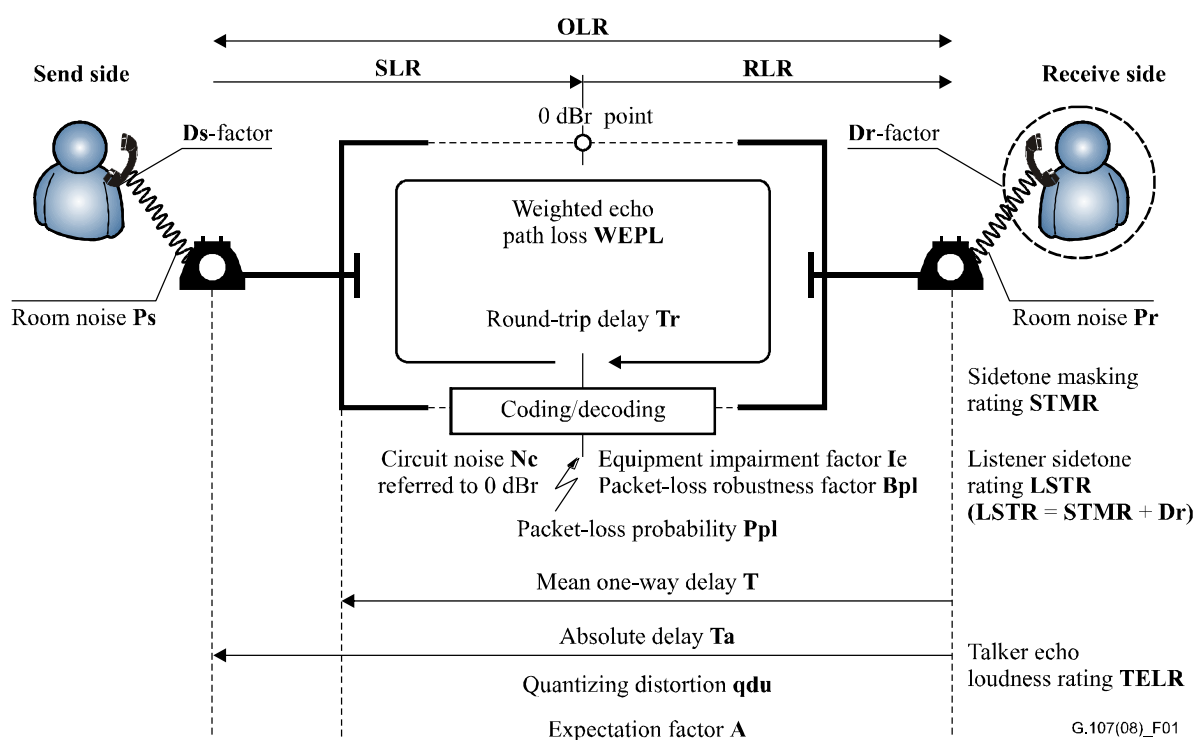


Figure 1 – Reference connection of the E-model

The transmission parameters used as an input to the computation model are shown in Figure 1. Values for room noise and for the D -factors are handled separately in the algorithm for the send side and receive side and may be of different amounts. The parameters send loudness rating (SLR), receive loudness rating (RLR) and circuit noise N_c are referred to a defined 0 dBr point. All other input parameters are either considered as values for the overall connection, such as overall loudness rating (OLR), i.e., the sum of SLR and RLR, number of q_{du} , equipment impairment factors I_e and advantage factor A , or referred to only for the receive side, such as sidetone masking rating (STMR), listener sidetone rating (LSTR), weighted echo path loss (WEPL) used for the calculation of listener echo and talker echo loudness rating (TELR).

There are three different parameters associated with transmission time. The absolute delay T_a represents the total one-way delay between the send side and receive side and is used to estimate the