International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.107

Amendment 1

(06/2012)

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

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

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

Amendment 1: New Appendix IV – Use of the E-model in conjunction with noise reduction or echo canceller systems in the network or the terminal equipment

Recommendation ITU-T G.107 (2011) – Amendment 1

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Recommendation ITU-T G.107

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

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New Appendix IV – Use of the E-model in conjunction with noise reduction or echo canceller systems in the network or the terminal equipment

History

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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.

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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/.

Recommendation ITU-T G.107

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

Amendment 1

New Appendix IV – Use of the E-model in conjunction with noise reduction or echo canceller systems in the network or the terminal equipment

Modern networks or terminals frequently contain devices for echo cancellation and/or noise reduction. Echo cancellers are expected to significantly reduce the echo, and the amount of residual echo may be considered in the way the standard E-model does, i.e., via the residual talker echo loudness rating *TELR* and the mean one-way delay *T* of the residual echo path. However, the echo attenuation may also vary over time (so-called "echo pumping"), and the cancellation process may lead to degradations of the transmitted speech signal. Degradations of the transmitted speech signal may also result from imperfect noise reduction, e.g., when parts of the speech spectrum are subtracted by the noise reduction algorithm. Such a degradation due to imperfect noise reduction is also not covered by the current version of the E-model.

In order to assess these effects in a more elaborated way, it is proposed to go through all the steps of the following provisional procedure which apply to the given scenario (i.e., noise reduction, echo cancellation, or both), see also [b-Möller]:

1) The residual noise resulting from imperfect background noise reduction may occur either during speech intervals or during pauses; parameters describing these two situations are defined in [b-ITU-T G.160], namely *SNRI* (the SNR improvement during speech in dB) and *TNLR* (the total noise level reduction in dB). It is proposed to use a weighting of half and half (corresponding to roughly 50% speech activity) for the speech and silence parts and change Equation 7-4 as follows:

$$\begin{aligned} Nos \;=\; & Ps - SLR - Ds - 0.5(SNRI + TNLR) - 100 \\ & + 0.004(Ps - OLR - Ds - 14)^2 \end{aligned} \qquad \text{(IV-1)}$$

   This amendment is meant to capture the effect of residual noise of the noise reduction mechanism.

   In the case that a non-white background noise is assumed, the factor *Ds* of Equation IV-1 might depend on the noise type used for its measurement; see the ITU-T Handbook on Telephonometry [b-ITU-T HB Teleph]. In that case, it is suggested to use noise of the same type as it is assumed to occur in the background.

2) The effects of speech degradation from imperfect noise reduction can be captured by estimating via an additional equipment impairment factor *Ie,nr* reflecting the noise reduction equipment. Such an additional equipment impairment factor should ideally be derived with the help of auditory listening-only tests carried out in accordance with [b-ITU-T P.835]. As an alternative, the S-MOS scores might also be estimated with the objective model of [b-ETSI EG 202]. Provided that such S-MOS scores are available for (1) the connection of the noise-reduced case and (2) for a noise-free connection without the noise-reduction system applied, *Ie,nr* can be calculated as:

$$Ie,nr = \min\left(R(\text{S-MOS2}) - R(\text{S-MOS1}), 0\right) \qquad \text{(IV-2)}$$

In this equation, the transformation from S-MOS to *R* is performed using the relationship between MOS and *R* given in the E-model. The resulting *Ie,nr* scores are preferably normalized following the procedure of [ITU-T P.834].

3) The effects of residual echo are taken into account in the standard way of the E-model, i.e., via the talker-echo impairment factor *Idte*; the frequency-dependent attenuation of the residual echo path has to be used for the calculation of *TELR* at this stage.

4) The effects of speech degradation from imperfect echo cancellation can be estimated via an additional equipment impairment factor *Ie,ec* which is calculated with the help of the procedure of [ITU-T P.834], using the instrumental model of [ITU-T P.863]. The calculation is performed as in step 2, and it is also preferable to normalize the obtained raw *Ie,ec* score with the help of the procedure of [ITU-T P.834].

   Please note that [ITU-T P.863] is not intended to be used with talker echo as a test factor, so applying it to derive impairment factors for echo cancellers should be exercised with care.

5) Both *Ie,nr* and *Ie,ec* are added to the effective equipment impairment factor *Ie,eff* before calculating the overall transmission rating *R*.

6) The effects of delay are captured in the usual way via *Idd*.

The proposed methodology is only provisional, as it has not been thoroughly validated. However, it is assumed that it results in better estimations than by not considering the mentioned effects of noise reduction and echo canceller equipment. The following effects are not yet covered by the methodology and are thus for further study in ITU-T:

– The effect of time-varying echo paths.

– The effects of variable background noise transmission due to the echo canceller.

– The reduction of the double-talk capability due to the echo canceller.

– The degradation resulting from the acoustic characteristics of the terminal in which noise reduction and/or echo cancellers might be integrated into.

Bibliography

[b-ITU-T G.160] Recommendation ITU-T G.160 (2008), *Voice enhancement devices*.

[b-ITU-T P.835] Recommendation ITU-T P.835 (2003), *Subjective test methodology for evaluating speech communication systems that include noise suppression algorithm*.

[b-ITU-T HB Teleph] ITU-T Handbook on Telephonometry (1992).

[b-ETSI EG 202] ETSI EG 202 396-3 (2007), *Speech Quality Performance in the Presence of Background Noise – Part 3: Background Noise Transmission – Objective Test Methods*, European Telecommunications Standards Institute, Sophia Antipolis.

[b-Möller] Möller, S., Kettler, F., Gierlich, H.-W., Poschen, S., Côté, N., Raake, A., Wältermann, M. (2011), *Extending the E-Model For Capturing Noise Reduction and Echo Canceller Impairments*, Journal of the Audio Engineering Society.

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