International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.107

Amendment 1

(06/2006)

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

International telephone connections and circuits – General definitions

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

Amendment 1: New Appendix II – Provisional impairment factor framework for wideband speech transmission

ITU-T Recommendation G.107 (2005) – Amendment 1

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ITU-T Recommendation G.107

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

Amendment 1

New Appendix II – Provisional impairment factor framework for wideband speech transmission

Source

Amendment 1 to ITU-T Recommendation G.107 (2005) was agreed on 13 June 2006 by ITU-T Study Group 12 (2005-2008).

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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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, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

ITU-T Recommendation G.107

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

Amendment 1

New Appendix II – Provisional impairment factor framework for wideband speech transmission

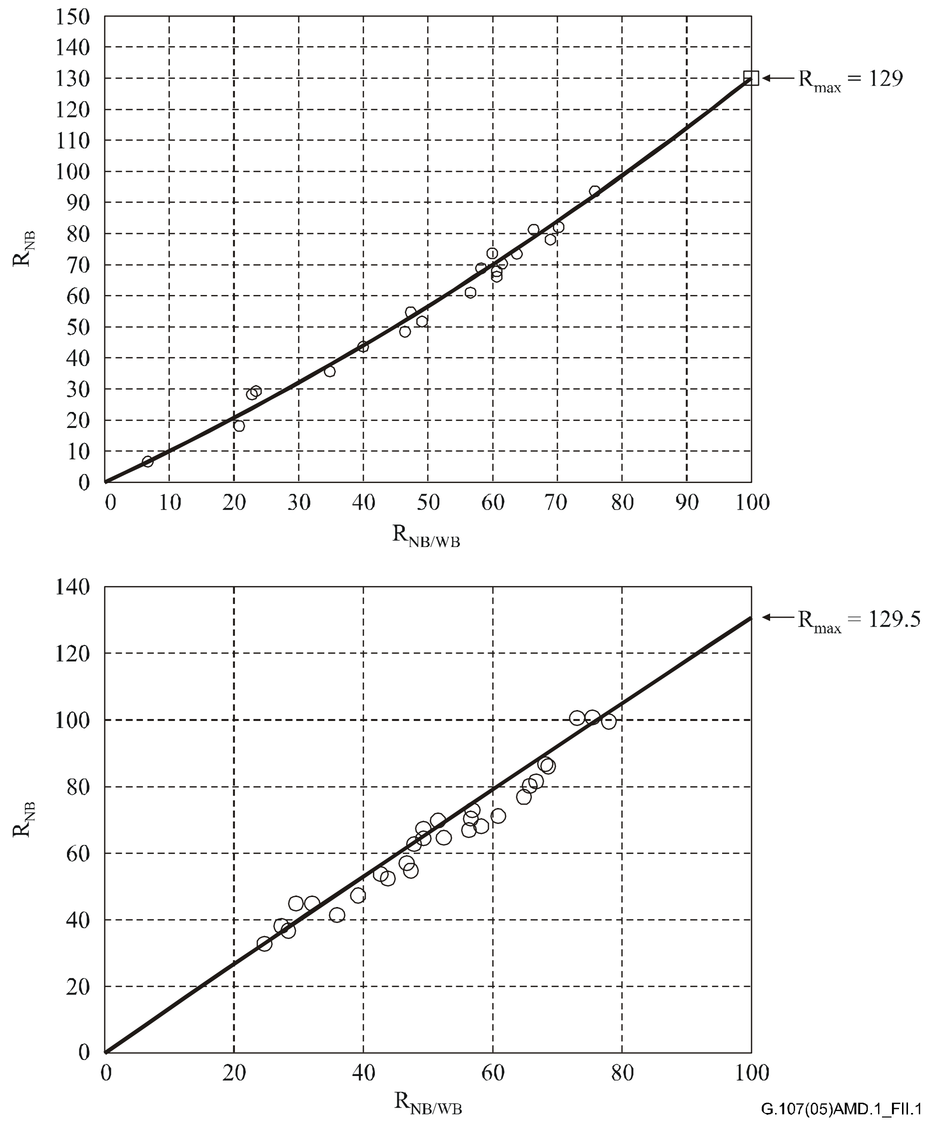
The E-model is based on the "impairment factor principle". According to this principle, it is possible to transform all relevant degradations to a "transmission rating scale" (R-scale) which represents the overall quality in a bidirectional communication situation, taking into account the entire channel mouth-to-ear. For the narrow-band (NB) case, the transmission rating scale ranges from R = 0 (lowest possible quality) to R = 100 (optimum quality). On this scale, a default NB transmission channel including logarithmic PCM coding and a noise floor (default parameter values according to Table 2/G.107) obtains a rating of R = 93.2. For a wideband speech transmission channel, the quality is generally judged better than for a narrow-band channel. Thus, this scale range has to be extended in order to be also applicable for wideband transmission scenarios. In what follows, an extension is defined for a wideband transmission channel of 50-7000 Hz (WB), as it is defined in ITU-T Rec. G.722.

Unfortunately, it is not possible to obtain direct human judgments on the R-scale, as this scale has additivity properties which are not reflected by ordinary rating scales. Instead, for NB conditions the ITU-T recommends collecting judgments on a 5-point absolute category rating scale, see ITU-T Rec. P.800. The mean rating, averaged over all test participants and stimuli reflecting the same circuit condition, is then called a Mean Opinion Score (MOS).

It has been shown that MOS ratings differ between tests where only NB stimuli are presented and tests where both NB/WB or purely WB stimuli are presented, as the use of the scale is largely influenced by the stimulus set. On the other hand, there is also experimental evidence that judgments for WB samples collected in a purely WB context do not differ significantly from those collected in a mixed NB/WB context [1] and [6]. In addition to the stimulus bandwidth, test results are influenced by the test participant group, the language, the participants' native country, etc. [4]. For a NB context, an average S-shaped relationship is defined between the R-scale (range [0;100]) and MOS ratings (range [1;4.5]) collected from "average" test participants in an "average" experimental setting, see Annex B/G.107 and Appendix I/G.107.

For a WB or a mixed NB/WB context, the R-scale has to be extended in a way which leaves the NB use of the scale unaffected, including the position of the reference connection (default parameter settings according to Table 2/G.107). Such an extension can be based on pairs of auditory tests in which the same (NB) test stimuli have been judged once in a purely NB and once in a mixed NB/WB context. The judgments on these common stimuli define a relationship between the use of the MOS-scale in a NB and in a mixed NB/WB context [5].

Two pairs of tests will be considered in the following. Details on the tests can be found in [3] and [2]. The MOS results from these tests have been transformed to the R-scale, using the NB transformation rule given in Annex B/G.107. The resulting R_{NB} values (NB test) and $R_{NB/WB}$ values (mixed NB/WB test) for the conditions which were common in each pair are displayed in Figure II.1.



NOTE – Details on the tests can be found in [3] and [2].

Figure II.1/G.107 – Comparison between *R*-values derived in a NB and in a mixed NB/WB context

Due to the use of the NB relationship between MOS and R for deriving the $R_{NB/WB}$ values, the maximum $R_{NB/WB}$ value corresponding to MOS = 4.5 equals 100. The corresponding R_{NB} value of the panels in Figure II.1 shows the amount by which the R-scale has to be extended in a NB/WB context. This maximum value is around R_{max} = 129. In other words, the NB transmission rating scale of the E-model has to be extended by approximately 29% to reflect the quality improvement when migrating from NB to WB. This extended R-scale is a "universal" R-scale; it is applicable to both NB and WB transmission channels.

Assuming a maximum value of R_{max} = 129 of the extended R-scale, WB equipment impairment factors Ie,wb can be calculated for different WB speech codecs. For this purpose, MOS results from auditory tests have to be transformed to the extended R-scale; the Ie,wb value is then defined as the difference between the R-value corresponding to the respective codec and the R-value corresponding to the "direct" channel:

$$Ie,wb = R(directchannel) - R(\text{codec}) \qquad \text{(II-1)}$$

In the NB case, a "direct" channel is usually associated with a standard ISDN connection, including a channel limitation defined in ITU-T Rec. G.712, a logarithmic PCM codec according to ITU-T Rec. G.711, a passband frequency shape corresponding to an Intermediate Reference System defined in ITU-T Rec. P.48, and all other transmission parameters set to their default values given in Table 2/G.107; this "direct" NB channel results in $R = 93.2$. In the WB case, no similar standard channel is yet defined. Here, it is assumed that the "direct" WB channel has a channel frequency response as defined in ITU-T Rec. G.722, and involves only linear PCM (16-bit quantization, sampling frequency $fs = 16$ kHz). This "direct" WB channel should result in $R = 129$.

On the basis of seven tests which are described in detail in [3] and [2], provisional *Ie,wb* values have been derived for a number of narrow-band and wideband codecs, operating at different bit rates. These values can be found in Appendix IV/G.113.

Appendix II references

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