International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.113

Amendment 2

(01/2007)

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

International telephone connections and circuits – General Recommendations on the transmission quality for an entire international telephone connection

---

Transmission impairments due to speech processing

Amendment 2: Revised Appendix I – Provisional planning values for the equipment impairment factor *Ie* and packet-loss robustness factor *Bpl*

ITU-T Recommendation G.113 (2001) – Amendment 2

ITU-T G-SERIES RECOMMENDATIONS

TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

INTERNATIONAL TELEPHONE CONNECTIONS AND CIRCUITS	G.100–G.199
General definitions	G.100–G.109
General Recommendations on the transmission quality for an entire international telephone connection	**G.110–G.119**
General characteristics of national systems forming part of international connections	G.120–G.129
General characteristics of the 4-wire chain formed by the international circuits and national extension circuits	G.130–G.139
General characteristics of the 4-wire chain of international circuits; international transit	G.140–G.149
General characteristics of international telephone circuits and national extension circuits	G.150–G.159
Apparatus associated with long-distance telephone circuits	G.160–G.169
Transmission plan aspects of special circuits and connections using the international telephone connection network	G.170–G.179
Protection and restoration of transmission systems	G.180–G.189
Software tools for transmission systems	G.190–G.199
GENERAL CHARACTERISTICS COMMON TO ALL ANALOGUE CARRIER-TRANSMISSION SYSTEMS	G.200–G.299
INDIVIDUAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON METALLIC LINES	G.300–G.399
GENERAL CHARACTERISTICS OF INTERNATIONAL CARRIER TELEPHONE SYSTEMS ON RADIO-RELAY OR SATELLITE LINKS AND INTERCONNECTION WITH METALLIC LINES	G.400–G.449
COORDINATION OF RADIOTELEPHONY AND LINE TELEPHONY	G.450–G.499
TRANSMISSION MEDIA CHARACTERISTICS	G.600–G.699
DIGITAL TERMINAL EQUIPMENTS	G.700–G.799
DIGITAL NETWORKS	G.800–G.899
DIGITAL SECTIONS AND DIGITAL LINE SYSTEM	G.900–G.999
QUALITY OF SERVICE AND PERFORMANCE – GENERIC AND USER-RELATED ASPECTS	G.1000–G.1999
TRANSMISSION MEDIA CHARACTERISTICS	G.6000–G.6999
DATA OVER TRANSPORT – GENERIC ASPECTS	G.7000–G.7999
PACKET OVER TRANSPORT ASPECTS	G.8000–G.8999
ACCESS NETWORKS	G.9000–G.9999

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

ITU-T Recommendation G.113

Transmission impairments due to speech processing

Amendment 2

Revised Appendix I – Provisional planning values for the equipment impairment factor *Ie* and packet-loss robustness factor *Bpl*

Summary

This appendix provides up-to-date information on available values of the Equipment Impairment Factor, *Ie* and Packet-loss Robustness Factor, *Bpl* for codecs or codec families. It is intended to be updated regularly.

Source

Amendment 2 to ITU-T Recommendation G.113 (2001) was agreed on 25 January 2007 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.

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 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 2007

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

ITU-T Recommendation G.113

Transmission impairments due to speech processing

Amendment 2

Revised Appendix I – Provisional planning values for the equipment impairment factor *Ie* and packet-loss robustness factor *Bpl*

(This appendix does not form an integral part of this Recommendation)

This appendix provides up-to-date information on available values of the Equipment Impairment Factor, *Ie* and Packet-loss Robustness Factor, *Bpl* for codecs or codec families. It is intended to be updated regularly.

Table I.1 provides provisional planning values for the equipment impairment factor *Ie*. These *Ie* values refer to non-error conditions without propagation errors, frame-erasures or packet loss. Subsequent tables deal with error and various loss conditions.

Table I.1 – Provisional planning values for the equipment impairment factor *Ie*

Codec type	Reference	Operating rate kbit/s	*Ie* value
PCM (see Note)	G.711	64	0
ADPCM	G.726, G.727	40	2
	G.721 (1988), G.726, G.727	32	7
	G.726, G.727	24	25
	G.726, G.727	16	50
LD-CELP	G.728	16	7
		12.8	20
CS-ACELP	G.729	8	10
	G.729-A + VAD	8	11
VSELP	IS-54	8	20
ACELP	IS-641	7.4	10
QCELP	IS-96a	8	21
RCELP	IS-127	8	6
VSELP	Japanese PDC	6.7	24
RPE-LTP	GSM 06.10, Full-rate	13	20
VSELP	GSM 06.20, Half-rate	5.6	23
ACELP	GSM 06.60, Enhanced Full Rate	12.2	5
ACELP	G.723.1	5.3	19
MP-MLQ	G.723.1	6.3	15
NOTE – For every PCM process the number of Quantization Distortion Units, qdu (which should be determined according to Table 1) needs to be considered as a separate input parameter to the E-model.			

Table I.2 provides provisional planning values for the equipment impairment factor *Ie* under propagation error conditions for GSM codecs.

Table I.2 – Provisional planning values for the equipment impairment factor *Ie* under propagation error conditions, GSM codecs

Codec type	Error pattern	*Ie* Range
GSM-HR	EP1	25...32
	EP2	31...42
GSM-FR	EP1	32...39
	EP2	40...45
GSM-EFR	EP1	15...22
	EP2	26...35
NOTE 1 – The range given results from the difficulties in deriving exact impairment factor values for these conditions. NOTE 2 – EP1 is equivalent to 10 dB C/I, EP2 is equivalent to 7 dB C/I. C/I is the carrier-to-interference ratio.		

Table I.3 provides provisional planning values for the equipment impairment factor *Ie* and for Packet-loss Robustness Factor *Bpl* as specified in 3.5 of [ITU-T G.107].

Table I.3 – Provisional planning values for the equipment impairment factor *Ie* and for packet-loss robustness factor *Bpl*

Codec	Packet size	PLC type	*Ie*	*Bpl*
G.723.1+VAD	30 ms	Native	15	16.1
G.729A+VAD	20 ms (2 frames)	Native	11	19.0
GSM-EFR	20 ms (?)	Native (?)	5	10.0
G.711	10 ms	None	0	4.3
G.711	10 ms	Appendix I of [ITU-T G.711]	0	25.1

The method to take account of packet loss is derived from conditions with random packet loss. This is the case where the probability of loss of a packet is independent of the probability of loss of any other packet. In systems with a jitter buffer (such as most VoIP applications), the applicable packet loss is measured at the output of the jitter buffer. [ITU-T G.1020] proposes a de-jitter buffer emulation that may be used to estimate the packet discard to be expected at the output of a de-jitter buffer in case of network jitter. In general, users should be aware that:

- the assumption of packet loss independence is unsatisfactory for many real networks, for example VoIP and mobile networks;
- jitter buffer implementations vary considerably, both between manufacturers and even between software revisions for a given device;
- proprietary codec implementations may have different robustness to packet loss from the values tabulated in [ITU-T G.113].

However, for some coders, the subjective impairment due to burst packet loss can be reflected using the so-called Burst ratio, *BurstR*, which partly captures the "burstiness" of a specific loss distribution (see Formula 3-29 of [ITU-T G.107]).

$$BurstR = \frac{\text{Average length of observed bursts in an arrival sequence}}{\text{Average length of bursts expected for the network under } \textit{random} \text{ loss}}$$

when packet loss is random $BurstR = 1$ and

when packet loss is bursty $BurstR > 1$.

Until further validation is provided, it is recommended that for bursty packet loss the BurstR-approach of the E-model (Formula 3-29 of [ITU-T G.107]) should be employed only for codecs with an efficient codec-state based PLC (i.e., with a packet loss robustness factor $Bpl \geq 16$).

Two additional burst-loss cases with $Bpl < 16$ can currently be handled by using the provisional planning values of Table I.4, when loss ratios are low, i.e., for packet loss percentages $Ppl \leq 2\%$. The provided *Bpl* values are to be used with the packet loss model as specified in [ITU-T G.107], artificially setting $BurstR = 1$ in Formula 3-29 of [ITU-T G.107] as in case of random packet loss.

Table I.4 – Provisional planning values for codecs under burst packet loss (to be applied for Ppl ≤ 2% with the random packet loss model, see [ITU-T G.107])

Codec	Packet size	PLC type	*BurstR*	*Ie*	*Bpl*
G.729E	20 ms	Native	4 (Note)	4	8.1
G.711	20 ms	Repeat 1/Silence	4 (Note)	0	4.8
NOTE – Set *BurstR* = 1 in Formula 3-29 of [ITU-T G.107].					

It has to be noted that the above *Ie* and *Bpl* values have been derived for a very specific sample of burst packet loss, and may not reflect the impairment due to burst packet loss in general.

Table I.5 provides examples for bursty packet loss conditions where all packets are lost in one burst. In this special loss-case, the values for the effective equipment impairment factor *Ie-eff* listed in Table I.5 should directly be used with Formula 3-1 of [ITU-T G.107].

Table I.5 – Examples for burst packet loss (all packets lost in one burst)

Codec	n (lost packets)	Packet size	PLC type	*Ppl*	*BurstR*	*Ie-eff* (Note)
G.729E	6	20 ms	Native	1.5	5.91	9
G.729E	8	20 ms	Native	2	7.84	11
G.711	6	20 ms	Repeat 1/Silence	1.5	5.91	7
G.711	8	20 ms	Repeat 1/Silence	2	7.84	10
NOTE – To be used directly in Formula 3-1 of [ITU-T G.107].						

Table I.6 provides additional descriptive information on various low bit-rate codecs.

Table I.6 – Brief description of the low bit-rate codecs

IS-54	First generation digital TDMA cellular system in North America utilizing Vector Sum Excited Linear Prediction (**VSELP**) coding at a net bit rate of 7.95 kbit/s (plus 5.05 kbit/s FEC).
IS-96a	First generation digital CDMA cellular system in North America utilizing Qualcomm Code-Excited Linear Prediction (**QCELP**) coding at a variable net bit rate of 8, 4, and 2 kbit/s.
IS-127	Second generation digital CDMA cellular system in North America utilizing Residual Code-Excited Linear Prediction (**RCELP**) coding at a variable net bit rate of 8, 4, and 2 kbit/s.
IS-641	Second generation digital TDMA cellular system in North America utilizing Algebraic Code-Excited Linear Prediction (**ACELP**) coding at a net bit rate of 7.4 kbit/s (plus 5.6 kbit/s FEC).
GSM-FR	First generation digital European Global System for Mobile communications (**GSM**) cellular system utilizing Regular Pulse Excitation Long Term Prediction (**RPE-LTP**) coding at a net bit rate of 13 kbit/s (plus 9.8 kbit/s FEC). Defined in [ETSI GSM 06.10].
GSM-HR	Half-rate version of the voice codec for the GSM system utilizing Vector Sum Excited Linear Prediction (**VSELP**) coding at a net bit rate of 5.6 kbit/s. Defined in [ETSI GSM 06.20].
GSM-EFR	Second generation speech codec of the digital European Global System for Mobile communications (GSM) cellular system utilizing Algebraic Code-Excited Linear Prediction (**ACELP**) coding at a net bit rate of 12.2 kbit/s (plus 10.6 kbit/s FEC). Defined in [ETSI GSM 06.60].
PDC	First generation digital Japanese Personal Digital Communication (PDC) system utilizing a Japanese version of Vector Sum Excited Linear Prediction (**JVSELP**) coding at a net bit rate of 6.7 kbit/s (plus 4.5 kbit/s FEC).
G.723.1	ITU-T Recommendation for speech coding in PSTN videophones utilizing Algebraic Code-Excited Linear Prediction (**ACELP**) coding at 5.3 kbit/s and Multipulse Maximum Likelihood Quantization (**MP-MLQ**) at 6.3 kbit/s.
G.726	ITU-T Recommendation for speech coding at 40, 32, 24, and 16 kbit/s utilizing Adaptive Differential Pulse Code Modulation (**ADPCM**).
G.728	ITU-T Recommendation for speech coding at 16 kbit/s utilizing Low-Delay Code-Excited Linear Prediction (**LD-CELP**) Coding. This algorithm also has 12.8 and 9.6 kbit/s bit-rate extensions.
G.729	ITU-T Recommendation for speech coding at 8 kbit/s utilizing Conjugate Structure Algebraic Code-Excited Linear Prediction (**CS-ACELP**) Coding.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	Global information infrastructure, Internet protocol aspects and next-generation networks
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2007