



INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.113

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Transmission impairments due to speech processing

Appendix I

Provisional planning values for the equipment impairment factor *I_e* and packet-loss robustness factor *B_{pl}*

Source

Appendix I to ITU-T Recommendation G.113 was prepared by ITU-T Study Group 12 (2001-2004) and approved under the WTSA Resolution 1 procedure on 31 May 2002.

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 not 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.

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ITU-T Recommendation G.113

Transmission impairments due to speech processing

Appendix I

Provisional planning values for the equipment impairment factor I_e and packet-loss robustness factor B_{pl}

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

Table I.1 provides provisional planning values for the equipment impairment factor I_e . These I_e 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/G.113 – Provisional planning values for the equipment impairment factor I_e

Codec type	Reference	Operating rate kbit/s	I_e 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 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 I_e under propagation error conditions for GSM codecs.

Table I.2/G.113 – Provisional planning values for the equipment impairment factor I_e under propagation error conditions, GSM codecs

Codec type	Error pattern	I_e 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 I_e and for Packet-loss Robustness Factor B_{pl} as specified in 3.5/G.107.

Table I.3/G.113 – Provisional planning values for the equipment impairment factor I_e and for packet-loss robustness factor B_{pl}

Codec	Packet size	PLC type	I_e	B_{pl}
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	App. I/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. 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 Rec. G.113.

However, the subjective impairment due to burst packet loss can be captured using an equivalent random packet loss (equivalent with respect to the impairment). The burst loss can provisionally be modelled with the Formula 29/G.107 for random packet loss (currently under study in SG 12). For this purpose, the so-called Burst ratio $BurstR$ has been defined, which partly captures the "burstiness" of a specific loss distribution.

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

when packet loss is random $BurstR = 1$ and

when packet loss is bursty $BurstR > 1$.

Table I.4 provides provisional planning values for codecs under bursty packet loss conditions and where loss ratios are low, i.e. for Ppl \leq 2% with the random packet loss model as specified in ITU-T Rec. G.107.

Table I.4/G.113 – Provisional planning values for codecs under burst packet loss (to be applied for Ppl \leq 2% with the random packet loss model, cf. Rec. G.107)

Codec	Packet size	PLC type	<i>BurstR</i>	<i>Ie</i>	<i>Bpl</i>
G.729A	20 ms	Native	4	11*	19
G.729E	20 ms	Native	4	4	8.1
G.711	20 ms	Repeat 1/Silence	4	0	4.8
* Iepl fit from G.729A + VAD					

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.

Table I.5/G.113 – Examples for burst packet loss (all packets lost in one burst)

Codec	n(lost packets)	Packet size	PLC type	<i>Bpl</i>	<i>BurstR</i>	<i>Ie,eff</i>
G.729A	2	20 ms	Native	0.5	1.99	13
G.729A	6	20 ms	Native	1.5	5.91	15
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

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

Table I.6/G.113 – 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 Coding (LD-CELP). 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 Coding (CS-ACELP).

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