INTERNATIONAL TELECOMMUNICATION UNION

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.729

Annex D
(09/98)

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ITU-T Recommendation G.729 – Annex D

(Previously CCITT Recommendation)

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ITU-T RECOMMENDATION G.729

CODING OF SPEECH AT 8 kbit/s USING CONJUGATE-STRUCTURE ALGEBRAIC-CODE-EXCITED LINEAR-PREDICTION (CS-ACELP)

ANNEX D

6.4 kbit/s CS-ACELP speech coding algorithm

Summary

This Annex provides the lower bit-rate extension designed to achieve a quality somewhat below the one achieved with Recommendation G.729.

Source

Annex D to ITU-T Recommendation G.729 was prepared by ITU-T Study Group 16 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on the 25th of September 1998.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The 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 Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 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, the 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.

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6.4 kbit/s CS-ACELP speech coding algorithm

(Geneva, 1998)

D.1 Scope

This Annex is intended as a lower rate extension to the algorithm in Recommendation G.729, and is specified to increase the flexibility of the algorithm in Recommendation G.729, e.g. to handle overload conditions. It does not provide the same level of quality as does the algorithm in the main body of Recommendation G.729, but for most conditions it provides significantly higher quality than Recommendation G.726 at 24 kbit/s. However, for high levels of car noise, the algorithm could have some performance limitations. The differences to the main body of Recommendation G.729 are described in this Annex.

D.2 Normative references

The following ITU-T Recommendation 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; all 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.

[1] ITU-T Recommendation G.729 (1996), *Coding of speech at 8 kbit/s using conjugate-structure algebraic-code-excited linear-prediction (CS-ACELP).*

D.3 General coder description for the 6.4 kbit/s extension

The coder is similar to that of Recommendation G.729 [1] with a few exceptions. The modifications are summarized below, and described in more detail in the following sections.

1) The ACELP codebook of G.729 has been changed to a new ACELP codebook which is using two signed pulses in two overlapping tracks of different lengths (16 and 32 positions respectively).

2) The conjugate-structured codebook for the gains has been replaced with a new conjugate-structured codebook with 6 bits.

3) A modified coding of the pitch delay in the second subframe is used. The number of bits are reduced to 4 bits. The delta lag range is maintained, using an uneven distribution of fractional delta values.

4) An additional postfiltering technique is applied to reduce the effects of the sparser algebraic codebook.

5) The pitch-delay parity bit has been removed.

The new coder uses 6.4 kbit/s or 64 bits per frame instead of the 8.0 kbit/s or 80 bits per frame used in Recommendation G.729.

D.4 Bit allocation

Table D.1/G.729 – Bit allocation for 6.4 kbit/s of G.729

Parameter	Number of bits per frame (10 ms)
LP parameters	18
Adaptive codebook	8 + **4**
Fixed codebook	2 * **11**
Gain quantizer	2 * **6**
Total	64
NOTE – Bold figures represent changes compared to those in Recommendation G.729	

D.5 Functional description of the encoder

D.5.1 Pre-processing

Same as that in Recommendation G.729.

D.5.2 Linear prediction analysis and quantization

Same as that in Recommendation G.729.

D.5.3 Perceptual weighting

Same as that in Recommendation G.729.

D.5.4 Open-loop pitch analysis

Same as that in Recommendation G.729.

D.5.5 Computation of the impulse response

Same as that in Recommendation G.729.

D.5.6 Computation of the target signal

Same as that in Recommendation G.729.

D.5.7 Adaptive codebook search

The LTP coding for the absolute coded subframes (first subframe) are the same as that in the main body of Recommendation G.729. The number of LTP lags in the second subframe has been reduced from 32 to 16. Integer delta lag values are used for the ranges *int*(T1) – 5 to *int*(T1) – 2 and *int*(T1) + 1 to *int*(T1) + 4, where T1 is the LTP lag of the previous subframe. Fractional lags with a resolution of 1/3 are used in the range *int*(T1) – 1 2/3 to *int*(T1) + 2/3.

D.5.8 Fixed codebook structure and search

The original four-pulse codebook is exchanged for an ACELP codebook with 2 signed pulses in two overlapping tracks. The track table is given in Table D.2. The signs of the pulses are preset as in the main body of Recommendation G.729. The search of pulse positions is an exhaustive yet computationally efficient search over all 512 vectors.

Table D.2/G.729 – ACELP track table

Pulse	Sign	Positions
i_0	+1/–1	1, 3, 6, 8, 11, 13, 16, 18, 21, 23, 26, 28, 31, 33, 36, 38
i_1	+1/–1	0, 1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 14, 15, 16, 17, 19, 20, 21, 22, 24, 25, 26, 27, 29, 30, 31, 32, 34, 35, 36, 37, 39

D.5.9 Quantization of the gains

The conjugate-structured gain codebook is re-designed. Six bits per subframe are allocated to the gain codebook. The codebook is trained with the condition of 0.1% bit error rate with a random distribution. This codebook requires 32 words of memory.

D.5.10 Memory update

Same as that in Recommendation G.729.

D.6 Functional description of decoder

D.6.1 Parameter decoding procedure

Similar to that in Recommendation G.729. The number of parameters is smaller. Less fixed excitation codebook parameters are used.

D.6.2 Fixed codebook post-processing

An additional post-processing filter is applied in the decoder in order to reduce the perceptually adverse effects of the sparse excitation. The filter alters the innovation signal such that a new innovation is created which has the energy more spread over the subframe. The filter alters mainly the phase of the innovation through a "semi-random" impulse response. The filtering is performed by circular convolution, using one of the three stored impulse responses. The filter selection is controlled by a voicing decision, based on the filtered received LTP gain. The three impulse responses correspond to different amounts of spreading. Maximum spreading is applied in noise like segments, when the filtered LTP gain is low. Medium spreading is applied for intermediate LTP gains, and no spreading is applied in voiced speech, when the filtered LTP gain is high. Additionally, strong increase in codebook gain is detected, to avoid spreading of onsets.

D.6.3 Post filtering and post processing

Same as that in Recommendation G.729.

D.6.4 Concealment of frame-erasures

Same as that in Recommendation G.729.

D.7 ANSI C code

ANSI C code specifying the G.729 lower bitrate extension is available as an attachment to this Annex. The current version of this ANSI C code is Version 1.2 of May 1998. The ANSI C code represents the normative specification of this Annex. The algorithmic description given by the C code shall take precedence over the texts contained in the main body of Recommendation G.729 and in Annex D.

Tables D.3 to D.6 contain lists of the ANSI C code files grouped by function.

Table D.3/G.729 – List of software files specific to G.729 lower bit-rate extension encoder

File name	Description	Size (Bytes)
acelpcod.c	Search fixed codebook	41 657
codld8kd.c	Encoder routine	27 883
coderd.c	Encoder	5 467
pitchd.c	Pitch search	23 000
qua_g6k.c	Gain quantizer	19 506

Table D.4/G.729 – List of software files specific to G.729 lower bit-rate extension decoder

File name	Description	Size (Bytes)
declag3d.c	Decode adaptive-codebook index	3 416
decld8kd.c	Decoder routine	10 930
decoderd.c	Decoder	6 971
deacelpd.c	Decode algebraic codebook	1 331
dec_g6k.c	Decode gain	4 443

Table D.5/G.729 – List of software files specific to G.729 lower bit-rate extension routines common to encoder and decoder

File name	Description	Size (Bytes)
bitsd.c	Bit manipulation routines	4 952
filterd.c	Filter functions	8 540
ld8kd.h	Switching variables	7 136
tabld8kd.c	Tables	3 545
tabld8kd.h		710

Table D.6/G.729 – List of software files specific to G.729 lower bit-rate extension routines common to G.729 and G.729 Annex D

File name	Description
basic_op.h	*Common to G.729 main body*
ld8k.h	
oper_32b.h	
tab_ld8k.h	
typedef.h	
basic_op.c	
de_acelp.c	
dec_gain.c	
dspfunc.c	
gainpred.c	
lpc.c	
lpcfunc.c	
lspdec.c	
lspgetq.c	
oper_32b.c	
p_parity.c	
post_pro.c	
pre_proc.c	
pred_lt3.c	
pst.c	
pwf.c	
qua_gain.c	
qua_lsp.c	
tab_ld8k.c	
util.c	

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