



INTERNATIONAL TELECOMMUNICATION UNION

# ITU-T

TELECOMMUNICATION  
STANDARDIZATION SECTOR  
OF ITU

# G.729

**Annex H**  
(02/00)

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

Digital transmission systems – Terminal equipments –  
Coding of analogue signals by methods other than PCM

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Coding of speech at 8 kbit/s using Conjugate  
Structure Algebraic Code-Excited Linear Prediction  
(CS-ACELP)

**Annex H: Reference implementation of  
switching procedure between G.729 Annexes D  
and E**

ITU-T Recommendation G.729 – Annex H

(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 H**

##### **Reference implementation of switching procedure between G.729 Annexes D and E**

#### **Summary**

This annex defines the necessary mechanisms for switching operation between 6.4 kbit/s G.729 Annex D and 11.8 kbit/s G.729 Annex E. Previously, only one switching from 8 kbit/s G.729 was specified.

This annex includes an electronic attachment containing version 1.1. of reference C code and test vectors for fixed-point implementation of CS-ACELP at 6.4 kbit/s, 8 kbit/s and 11.8 kbit/s without DTX functionality.

#### **Source**

Annex H 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 17 February 2000.

## FOREWORD

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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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Electronic attachment:

- reference C code implementation
- test vectors



## Recommendation G.729

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

#### ANNEX H

#### Reference implementation of switching procedure between G.729 Annexes D and E<sup>1</sup>

(Geneva, 2000)

### H.1 Scope

This annex provides a description of the integration of G.729 Annexes D and E, hereby defining switching procedure between Annex D and E. It presents a standard way of performing this integration and expansion of the functionality thereby guiding the industry and ensuring a standard speech quality and compatibility worldwide. The integration has been performed with focus on several constraints in order to satisfy the need of the industry:

- 1) Bit-exactness with the main body and individual annexes.
- 2) Minimum additional program code, memory, and complexity usage.
- 3) Stringent quality requirements to new functionality inline with quality and application areas of the according standard annexes.

### H.2 Normative references

The following ITU-T Recommendations 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)*.
- [2] ITU-T Recommendation G.729 Annex D (1998), *6.4 kbit/s CS-ACELP speech coding algorithm*.
- [3] ITU-T Recommendation G.729 Annex E (1998), *11.8 kbit/s CS-ACELP speech coding algorithm*.

### H.3 Overview

Recommendation G.729 main body [1] and Annexes D [2] and E [3] provide a bit-exact, fixed-point specification of a CS-ACELP coder at 8 kbit/s, lower and higher bit-rate extension capability at 6.4 and 11.8 kbit/s. Exact details of these specifications are given in bit-exact, fixed-point C code in an electronic file attached to this annex. This annex describes and defines the integration of the G.729 Annexes D and E.

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<sup>1</sup> This annex includes an electronic attachment containing version 1.1 of reference C code and test vectors for fixed-point implementation of CS-ACELP at 6.4 kbit/s, 8 kbit/s and 11.8 kbit/s without DTX functionality.

## H.4 Algorithm Description

This subclause presents the algorithm description of the necessary additions to the algorithms of the individual annexes in order to facilitate the integration. All remaining modules originate from the main body, Annex D or E.

### H.4.1 Update of state variables specific to Annex D during Annex E frames

The only state variables specific to Annex D are the state variables of the phase dispersion module (see D.6.2 of ITU-T G.729 – Annex D [2]) at the decoder. In case of 11.8 kbit/s frames, the same update procedure as in case of nominal bit rate (8 kbit/s) is followed.

### H.4.2 Update of state variables specific to Annex E during Annex D frames

#### H.4.2.1 Update of encoder state variables specific to Annex E

At the encoder in case of 6.4 kbit/s frames, the update of state variables is identical to the update performed in G.729 Annex E [3] in case of switch to the nominal bit rate 8 kbit/s. The update procedure is the following: the LP mode is set to 0, the global stationarity indicator is decreased and the high stationarity indicator is reset to 0 (see E.3.2.7.2 of ITU-T G.729 – Annex E [3]), the interpolation factor used to smoothly switch from LP forward filter to backward LP filter is reset to its maximum value (see E.3.2.7.1 of ITU-T G.729 – Annex E [3]).

#### H.4.2.2 Update of decoder state variables specific to Annex E during Annex D frames

At the decoder in case of 6.4 kbit/s frames, the update of state variables is identical to the update performed in G.729 Annex E [3] in case of switch to the nominal bit-rate (8 kbit/s) mode.

## H.5 Description of C source code

Annex H of G.729, integrating the G.729 Annexes D and E, is simulated in 16-bit fixed-point ANSI-C code using the same types of fixed-point data and the same set of fixed-point basic operators as in the G.729 software. 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 Annexes D, E and H. The following subclauses summarize the use of this simulation code, and how the software is organized.

### H.5.1 Use of the simulation software

The C code consists of two main programs **coderh.c** and **decoderh.c**, which simulate encoder and decoder, respectively. The encoder is run as follows:

```
coderh inputfile bitstreamfile rate_option
```

The decoder is run as follows:

```
decoderh bitstreamfile outputfile
```

The **inputfile** and **outputfile** are 8 kHz sampled data files containing 16-bit PCM signals. The **bitstreamfile** is a binary file containing the bit stream; the mapping table of the encoded bit stream is contained in the simulation software. The parameter used for the encoder is: **rate\_option** where:

**rate\_option** = 0 to select the lower rate (6.4 kbit/s); = 1 to select the main Recommendation G.729 (8 kbit/s); = 2 is to select the higher rate (11.8 kbit/s) or a **file\_rate\_name**: a binary file of 16-bit word containing either 0, 1, 2 to select the rate on a frame-by-frame basis; the default is 1 (8 kbit/s).

## H.5.2 Organization of the simulation software

The files can be classified into three groups:

- 1) Files identical to software files of G.729 main body [1], Annex D [2] or Annex E [3], listed in Table H.1.
- 2) Files adapted from software files of G.729 Annex D or Annex E, listed in Table H.2, some minor modifications have been introduced to cope with the integration of G.729 Annexes D and E. Most modifications come from the integration of annexes routines prototypes declaration files in one file (ld8cp.h) or to the integration of extern ROM declaration annexes files into one file (tabld8cp.h). Some were introduced to deal with the update of the annexes state variables.
- 3) Files integrating G.729 software files of Annex D or Annex E, listed in Table H.3.

**Table H.1/G.729 – List of software files identical to software files of G.729 main body, Annex D or E**

File name	Description	Identical to
Basic_op.c	Basic operators	Main
Oper_32b.c	Extended basic operators	Main
Dspfunc.c	Mathematical functions	Main
Gainpred.c	Gain predictor	Main
Lpcfunc.c	Miscellaneous routines related to LP filter	Main
Pre_proc.c	Pre-processing (HP filtering and scaling)	Main
P_parity.c	Compute pitch parity	Main
Pwf.c	Computation of perceptual weighting coefficients (8 kbit/s)	Main
Pred_lt3.c	Generation of adaptive codebook	Main
Post_pro.c	Post processing (HP filtering and scaling)	Main
Tab_ld8k.c	ROM tables	Main
Basic_op.h	Basic operators prototypes	Main
Ld8k.h	Function prototypes	Main
Oper_32b.h	Extended basic operators prototypes	Main
Tab_ld8k.h	Extern ROM table declarations	Main
Typedef.h	Data type definition (machine dependent)	Main
Taming.c	Pitch instability control	B
Qua_g8k.c	Gain quantizer	D
Qua_g6k.c	Gain quantizer	D
Tabld8kd.c	ROM tables for G.729 at 6.4 kbit/s	D
Tabld8kd.h	Extern ROM declarations for G.729 at 6.4 kbit/s	D
ld8kd.h	Function prototypes for G.729 Annex D	D
Bwfwfunc.c	Miscellaneous routines related to backward/forward switch selection	E
Filtere.c	Filter functions	E
Lpce.c	LP analysis	E
Lspcdece.c	LSP decoding routines	E
Lspgetqe.c	LSP quantizer	E

**Table H.1/G.729 – List of software files identical to software files of G.729  
main body, Annex D or E (concluded)**

<b>File name</b>	<b>Description</b>	<b>Identical to</b>
Qua_lspe.c	LSP quantizer	E
Pstpe.c	Postfilter routines	E
Track_pi.c	Pitch tracking	E
Tab_ld8e.c	ROM tables for G.729 at 11.8 kbit/s	E
Tab_ld8e.h	Extern ROM declarations for G.729 at 11.8 kbit/s	E
Util.c	Utility functions	E

**Table H.2/G.729 – List of software files adapted from software files of G.729  
main body and Annexes D and E**

<b>File name</b>	<b>Description</b>	<b>Adapted from</b>
Phdisp.c	Phase dispersion	D
Bwfw.h.c	Backward/forward switch selection	E

**Table H.3/G.729 – List of software files integrating software files from G.729  
main body, Annex D or E**

<b>File name</b>	<b>Description</b>	<b>Integrated from</b>
Coderh.c	Main encoder routine	D+E
Cod_ld8h.c	Encoder routine	D+E
Decoderh.c	Main decoder routine	D+E
Dec_ld8h.c	Decoder routine	D+E
Acelp_h.c	search ACELP fixed codebook (6.4, 8, 11.8 kbit/s)	D+E
Deacelp.h.c	Decode algebraic codebook (6.4, 8, 11.8 kbit/s)	D+E
Pitchh.c	Pitch search	D+E
Declagh.c	Decode adaptive-codebook index	D+E
Decgainh.c	Decode gain	D+E
Bitsh.c	Bit manipulation routines	D+E
Ld8h.h	Constant and Function prototypes for G.729 Annex H	D+E