INTERNATIONAL TELECOMMUNICATION UNION

CCITT

G.728

(09/92)

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

GENERAL ASPECTS OF DIGITAL TRANSMISSION SYSTEMS;

TERMINAL EQUIPMENTS

CODING OF SPEECH AT 16 kbit/s USING LOW-DELAY CODE EXCITED LINEAR PREDICTION

Recommendation G.728

Geneva, 1992

FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT 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 Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation G.796 was prepared by Study Group XV and was approved under the Resolution No. 2 procedure on the 1st of September 1992.

CCITT NOTES

1) In this Recommendation, the expression “Administration” is used for conciseness to indicate both a telecommunication administration and a recognized private operating agency.

2) A list of abbreviations used in this Recommendation can be found in Annex F.

CODING OF SPEECH AT 16 kbit/s USING LOW-DELAY CODE EXCITED LINEAR PREDICTION

(1992)

1 Introduction

This Recommendation contains the description of an algorithm for the coding of speech signals at 16 kbit/s using low-delay code excited linear prediction (LD-CELP). This Recommendation is organized as follows.

In § 2 a brief outline of the LD-CELP algorithm is given. In §§ 3 and 4, the LD-CELP encoder and LD-CELP decoder principles are discussed, respectively. In § 5, the computational details pertaining to each functional algorithmic block are defined. Annexes A, B, C and D contain tables of constants used by the LD-CELP algorithm. In Annex E the sequencing of variable adaptation and use is given. Finally, in Appendix I information is given on procedures applicable to the implementation verification of the algorithm.

Under further study is the future incorporation of three additional appendices (to be published separately) consisting of LD-CELP network aspects, LD-CELP fixed-point implementation description, and LD-CELP fixed-point verification procedures.

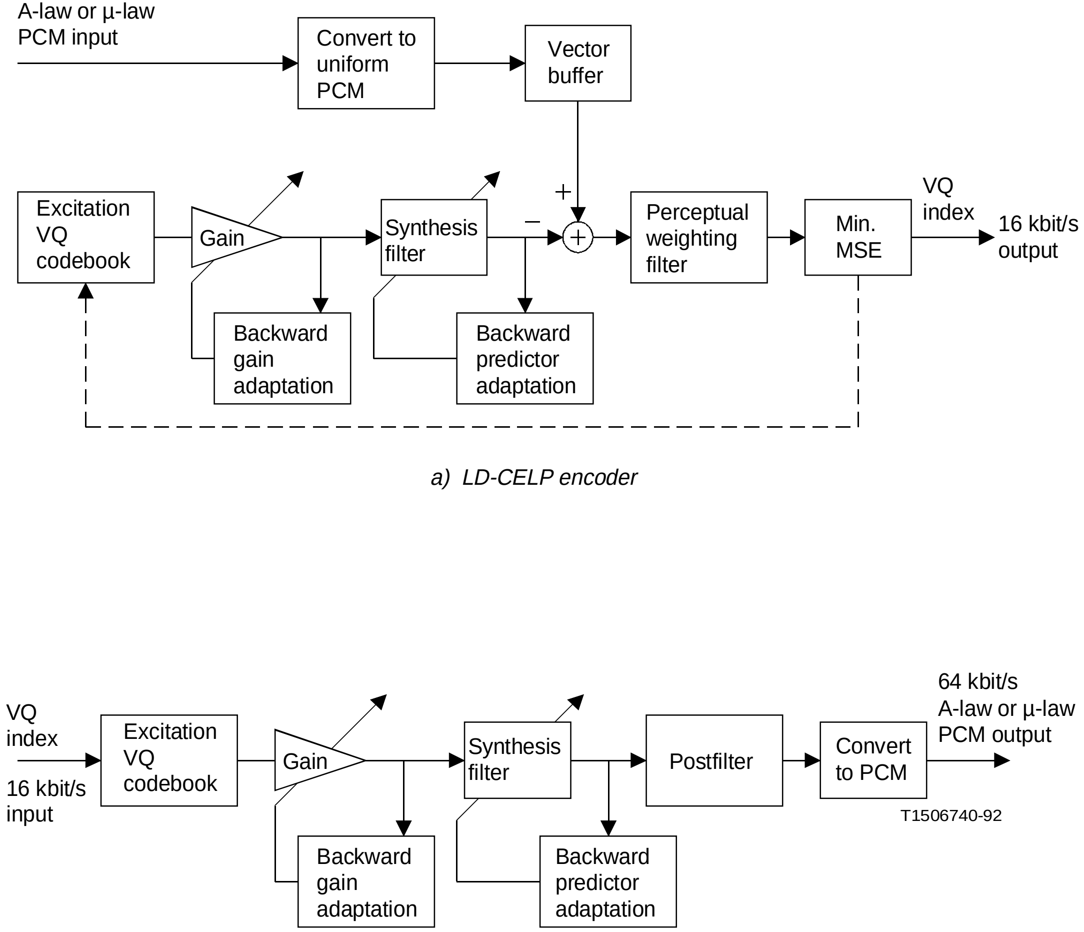
2 Outline of LD-CELP

The LD-CELP algorithm consists of an encoder and a decoder described in §§ 2.1 and 2.2 respectively, and illustrated in Figure 1/G.728.

The essence of CELP techniques, which is an analysis-by-synthesis approach to codebook search, is retained in LD-CELP. The LD-CELP however, uses backward adaptation of predictors and gain to achieve an algorithmic delay of 0.625 ms. Only the index to the excitation codebook is transmitted. The predictor coefficients are updated through LPC analysis of previously quantized speech. The excitation gain is updated by using the gain information embedded in the previously quantized excitation. The block size for the excitation vector and gain adaptation is five samples only. A perceptual weighting filter is updated using LPC analysis of the unquantized speech.

2.1 *LD-CELP encoder*

After the conversion from A-law or μ-law PCM to uniform PCM, the input signal is partitioned into blocks of five-consecutive input signal samples. For each input block, the encoder passes each of 1024 candidate codebook vectors (stored in an excitation codebook) through a gain scaling unit and a synthesis filter. From the resulting 1024 candidate quantized signal vectors, the encoder identifies the one that minimizes a frequency-weighted mean-squared error measure with respect to the input signal vector. The 10-bit codebook index of the corresponding best codebook vector (or "codevector"), which gives rise to that best candidate quantized signal vector, is transmitted to the decoder. The best codevector is then passed through the gain scaling unit and the synthesis filter to establish the correct filter memory in preparation for the encoding of the next signal vector. The synthesis filter coefficients and the gain are updated periodically in a backward adaptive manner based on the previously quantized signal and gain-scaled excitation.



a) LD-CELP encoder

b) LD-CELP decoder

FIGURE 1/G.728

Simplified block diagram of LD-CELP coder

2.2 *LD-CELP decoder*

The decoding operation is also performed on a block-by-block basis. Upon receiving each 10-bit index, the decoder performs a table look-up to extract the corresponding codevector from the excitation codebook. The extracted codevector is then passed through a gain scaling unit and a synthesis filter to produce the current decoded signal vector. The synthesis filter coefficients and the gain are then updated in the same way as in the encoder. The decoded signal vector is then passed through an adaptive postfilter to enhance the perceptual quality. The postfilter coefficients are updated periodically using the information available at the decoder. The five samples of the postfilter signal vector are next converted to five A-law or µ-law PCM output samples.

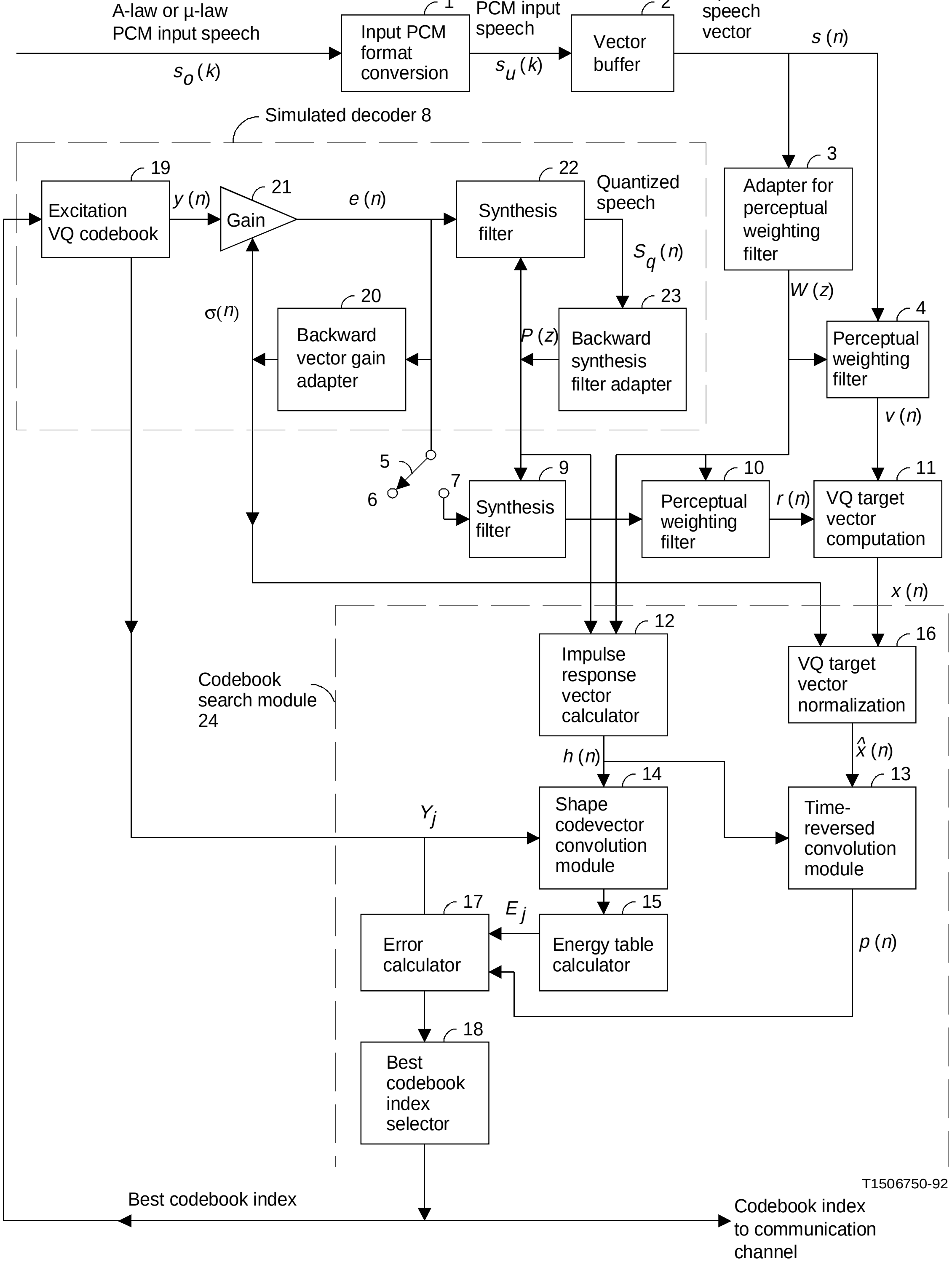


FIGURE 2/G.728

LD-CELP encoder block schematic

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