



MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Introdução ao DPCM para compressão de imagens da câmera PAN do CBERS-3&4

Desenvolvido por CAST, CRESDA

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Requisitos do compressor:

- ★ **Processamento** rápido;

- Bom **desempenho** de compressão;

- Boa **qualidade** da imagem recuperada;

- ★ **Baixa complexidade** computacional;

- ★ **Fácil implementação** em FPGA.

Métodos de Compressão



Sem perda

Permite recuperar a
imagem original

Com perda

Permite maior compressão



Métodos de Compressão



Domínio espacial

Métodos Preditivos



Domínio da frequência

Métodos baseados em Transformadas

DPCM

DPCM

1950 ...

JPEG

Lossless JPEG

1992

1993

...

JPEG-LS

1999

2000

...

CCSDS

2005

2006

...

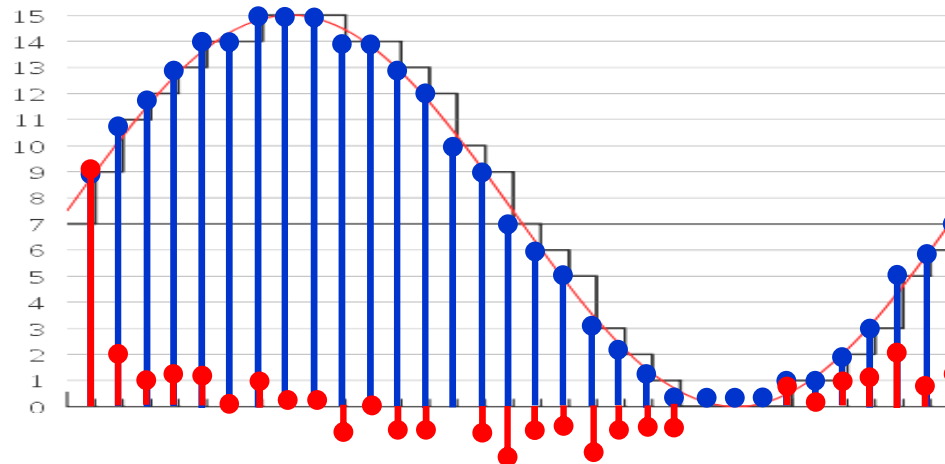
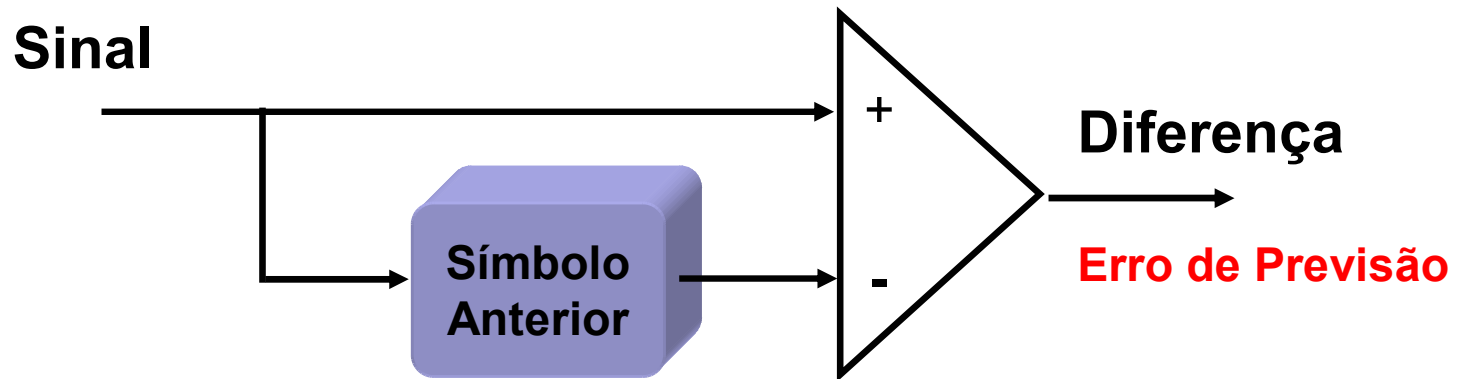
JPEG-XR

2009

LOCO-I

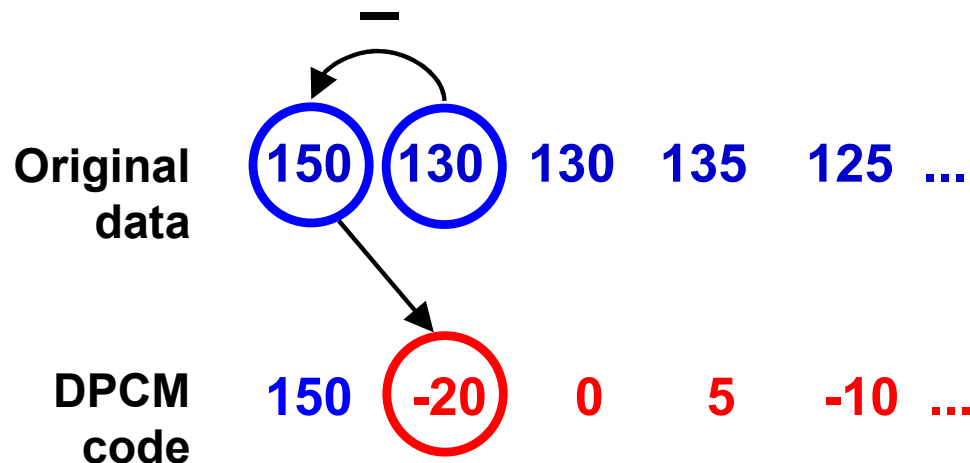
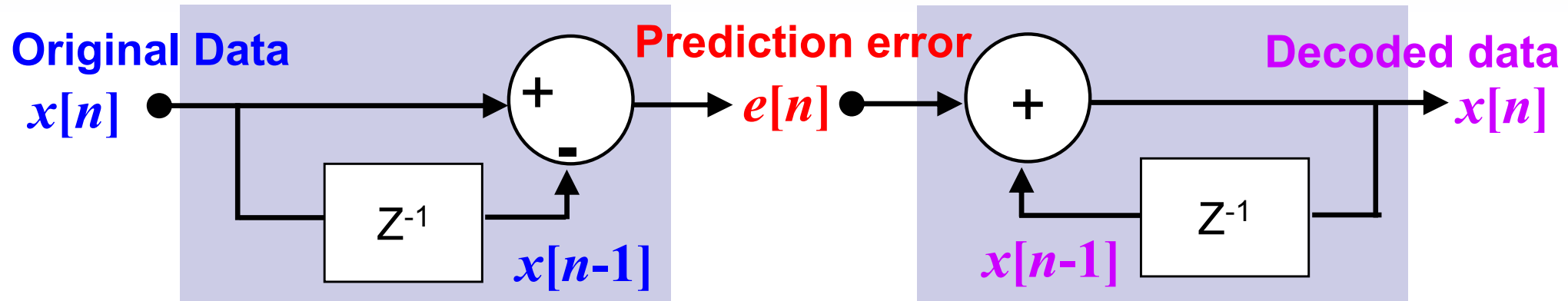
DPCM

Modulação por Codificação de Pulso Diferencial



Sinal	9	11	12	13	14	14	15	15	15	14	...
DPCM	9	2	1	1	1	0	1	0	0	-1	...

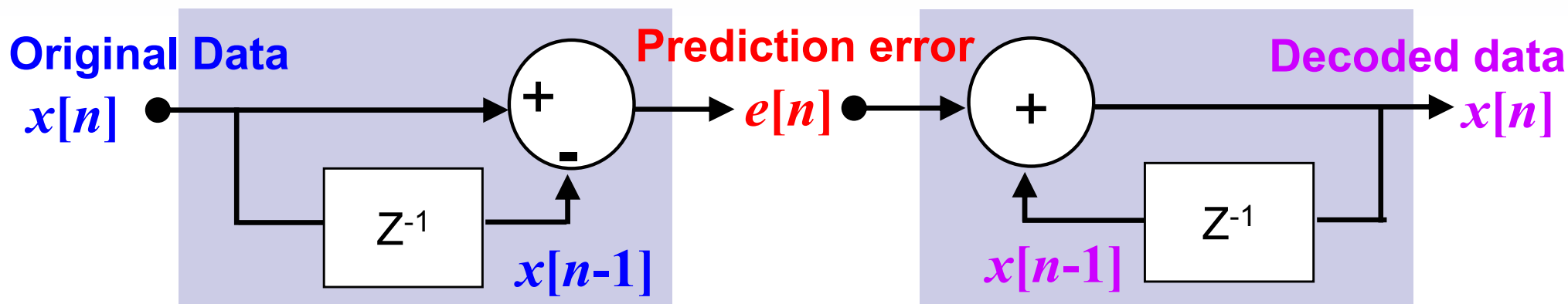
Compressor preditivo sem perda



$$e[n] = x[n] - x[n-1]$$

Decoded
data

Compressor preditivo sem perda



Original data 150 130 130 135 125 ...

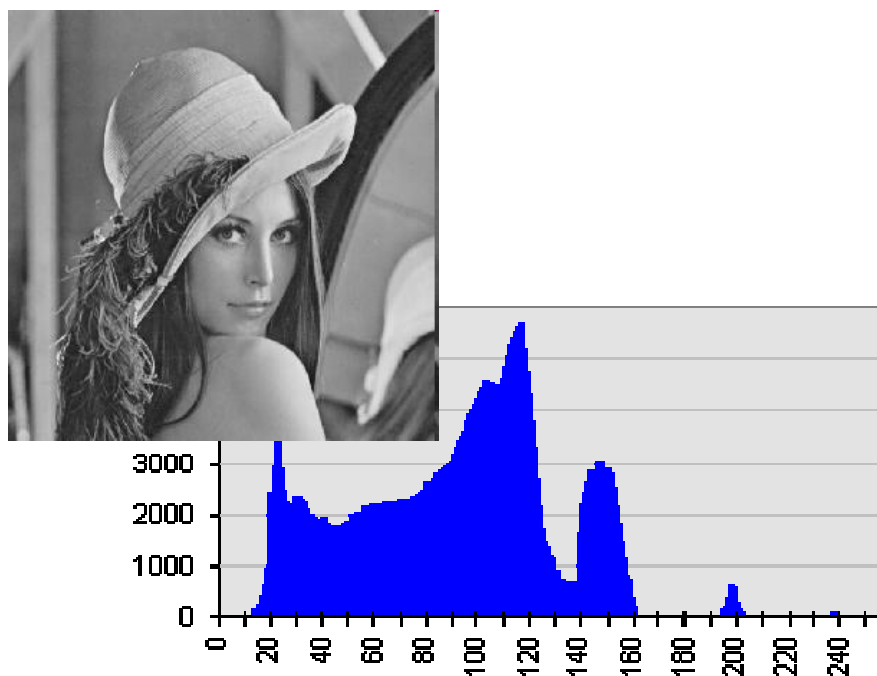
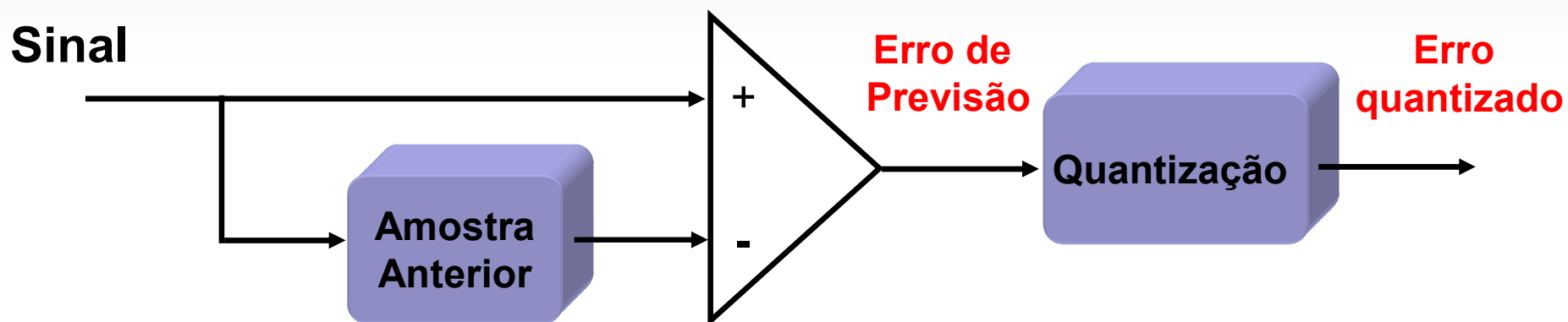
DPCM code 150 **-20** 0 5 -10 ...

Decoded data 150 130 130 135 125 ...

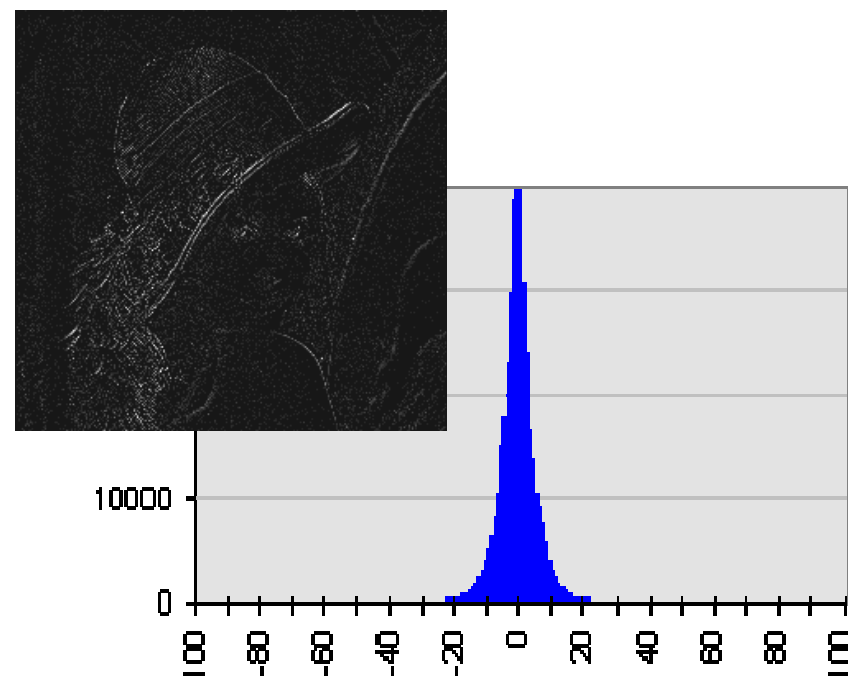
$$e[n] = x[n] - x[n-1]$$

$$x[n] = x[n-1] + e[n]$$

Compressor preditivo sem perda



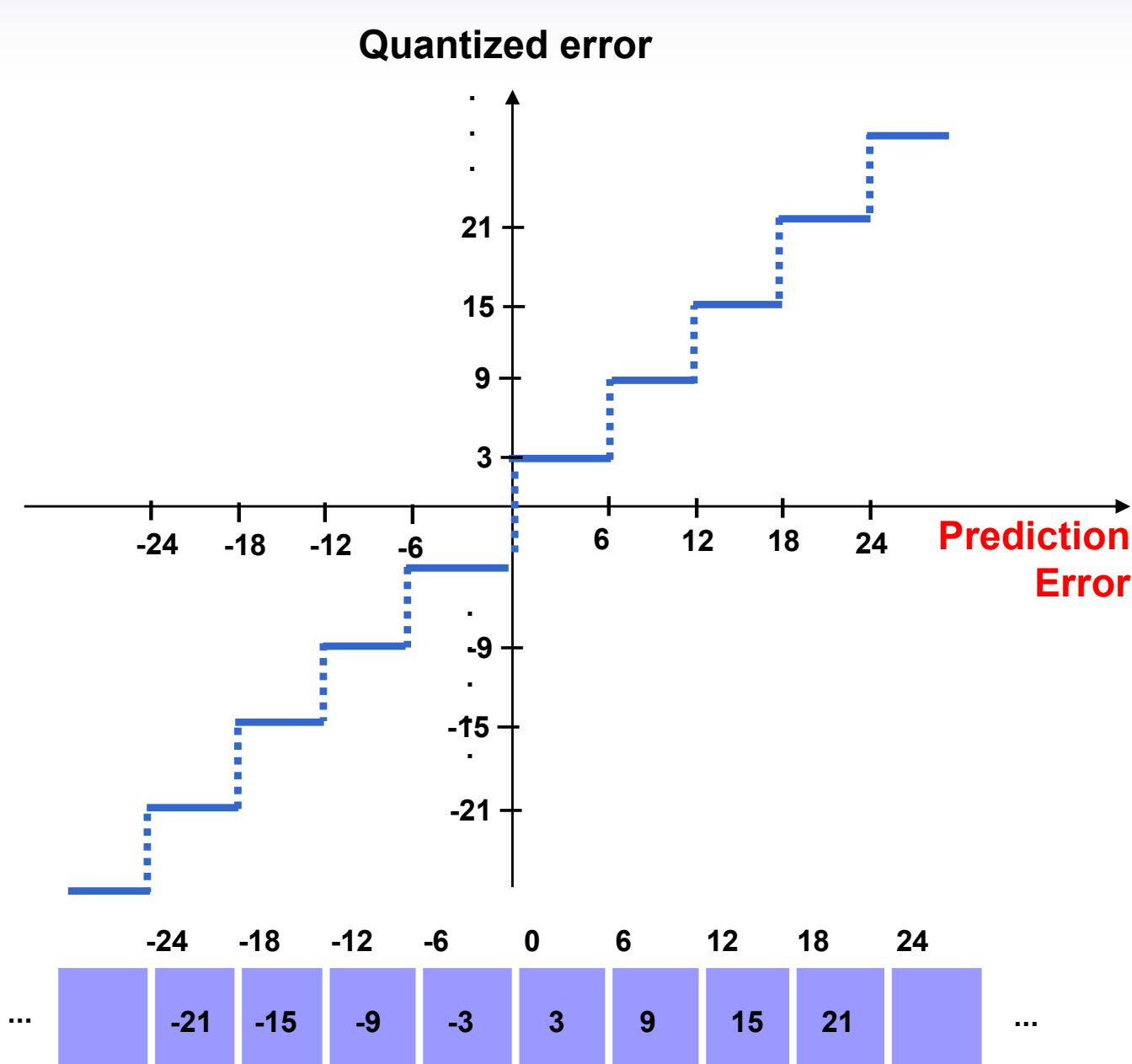
Original [0, 255] (8 bits)



Diferença [-255, 255] (> 8 bits)

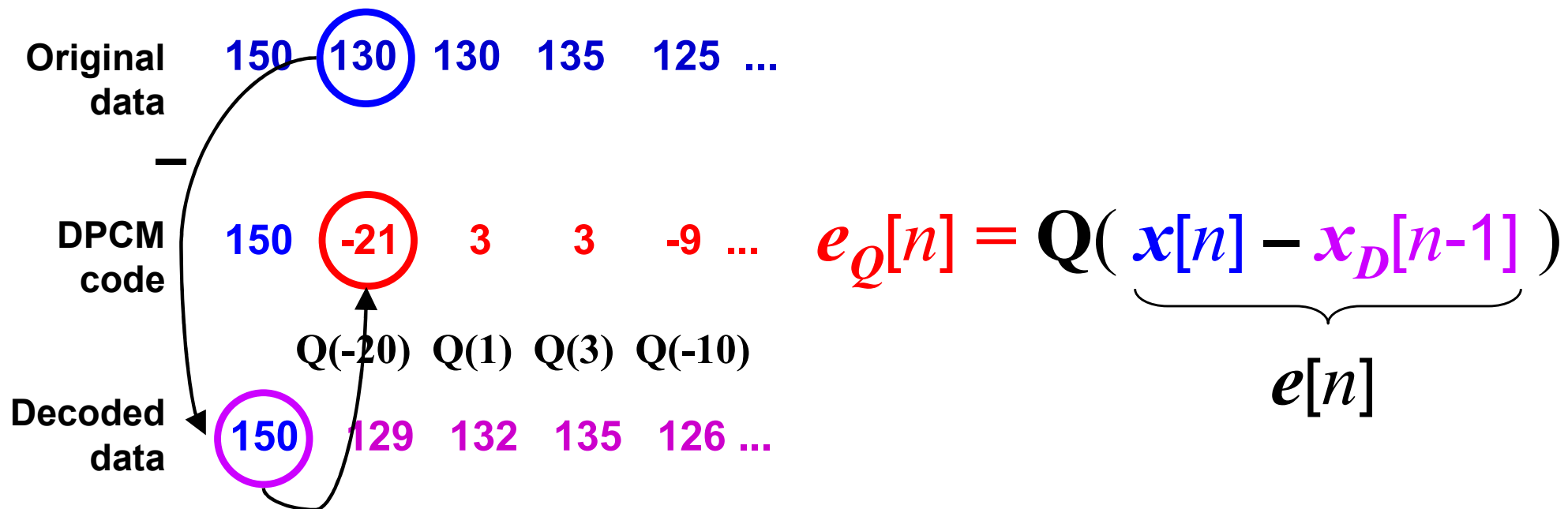
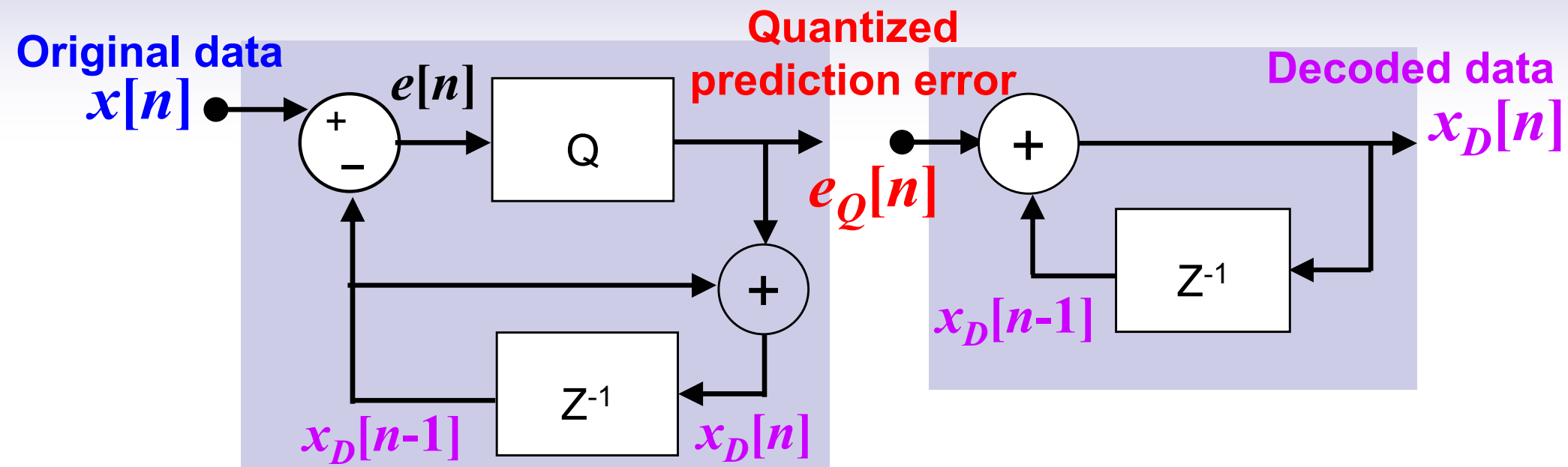
Sem compressão

Quantização do erro de predição

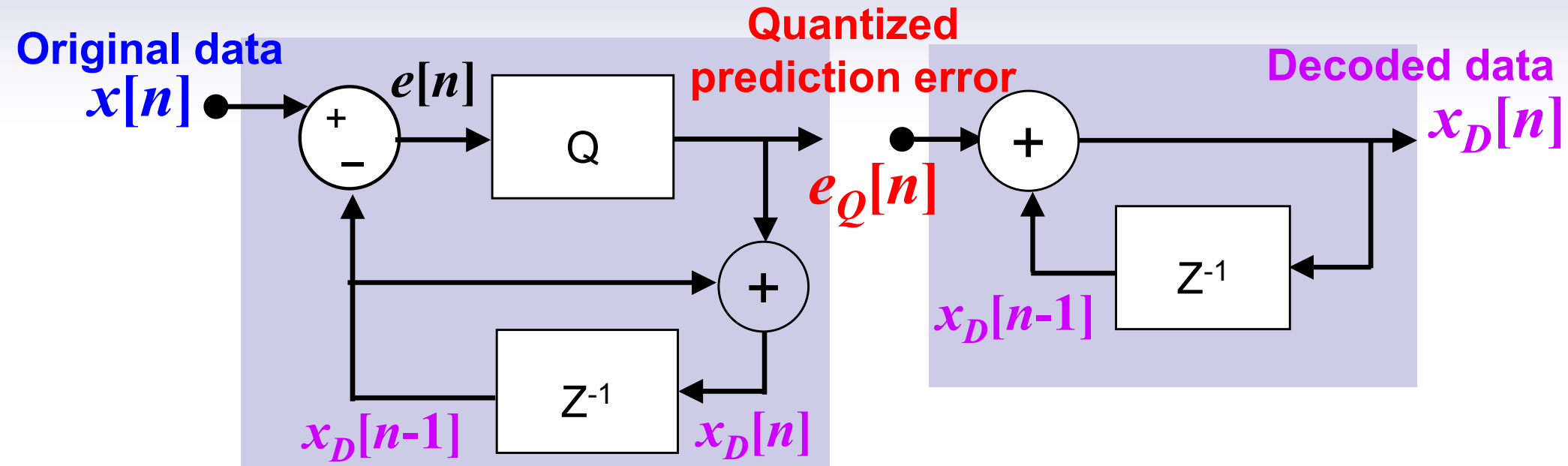


Prediction error	Quantized error
.	.
.	.
.	.
[18, 23]	21
[12, 17]	15
[6, 11]	9
[0, 5]	3
[-6, -1]	-3
[-12, -7]	-9
[-18, -13]	-15
[-24, -19]	-21
.	.
.	.
.	.

DPCM

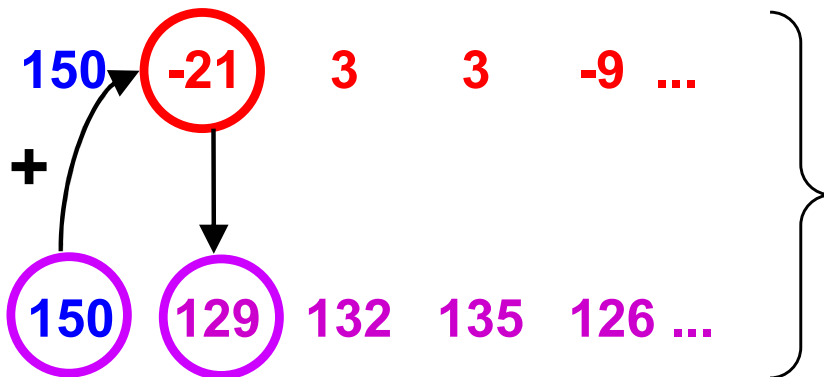


DPCM



Original data 150 130 130 135 125 ...

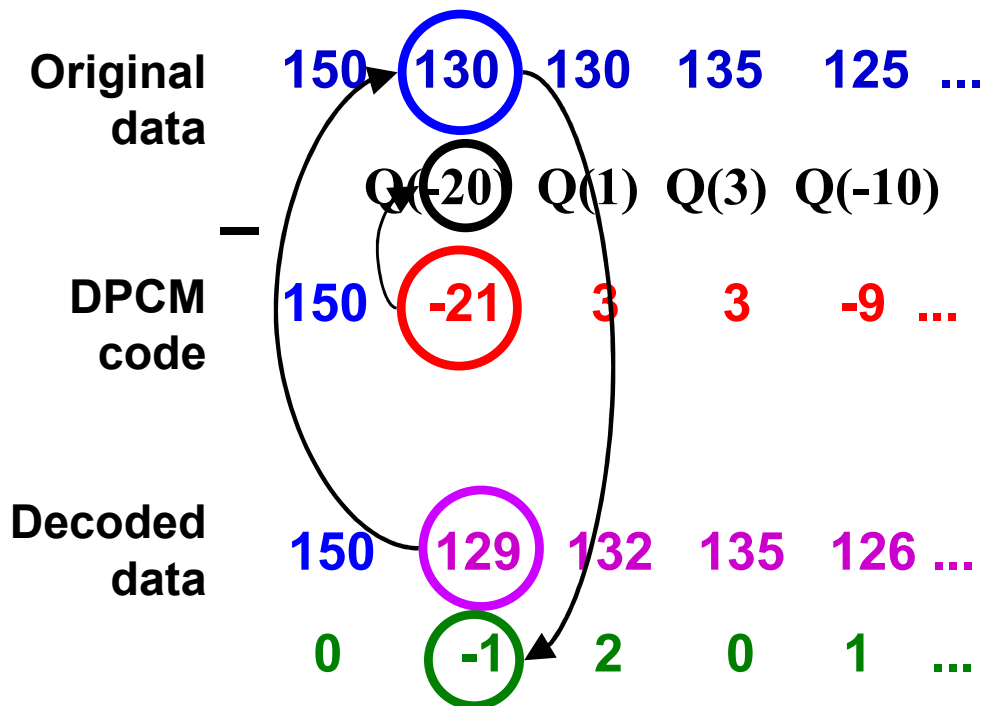
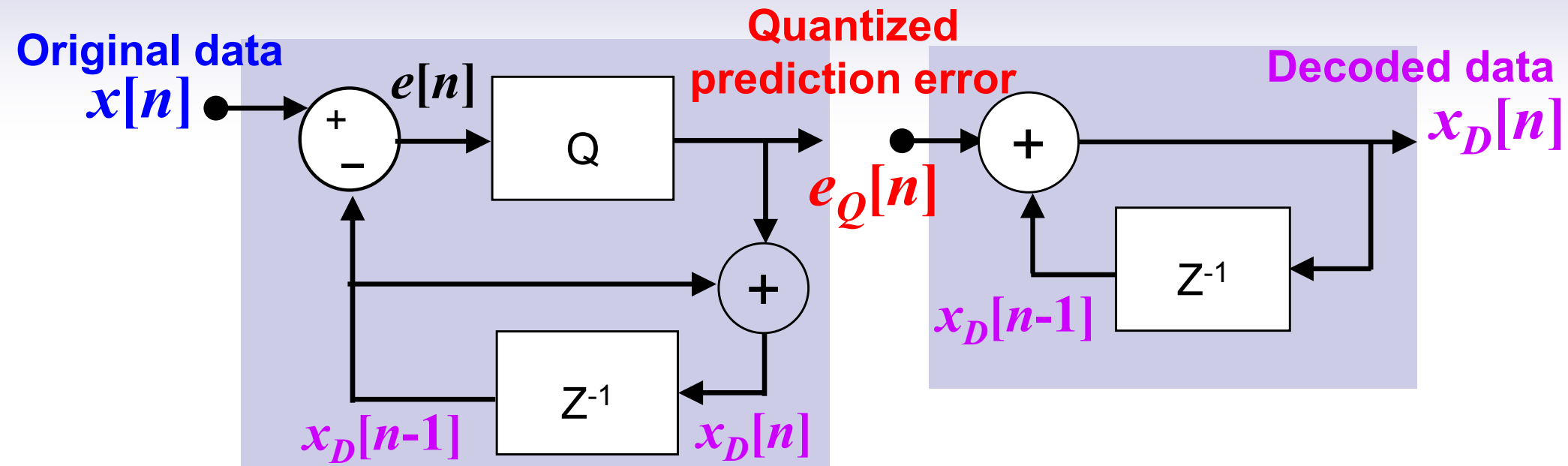
DPCM code



Decodificação dentro da codificação

$$x_D[n] = x_D[n-1] + e_Q[n]$$

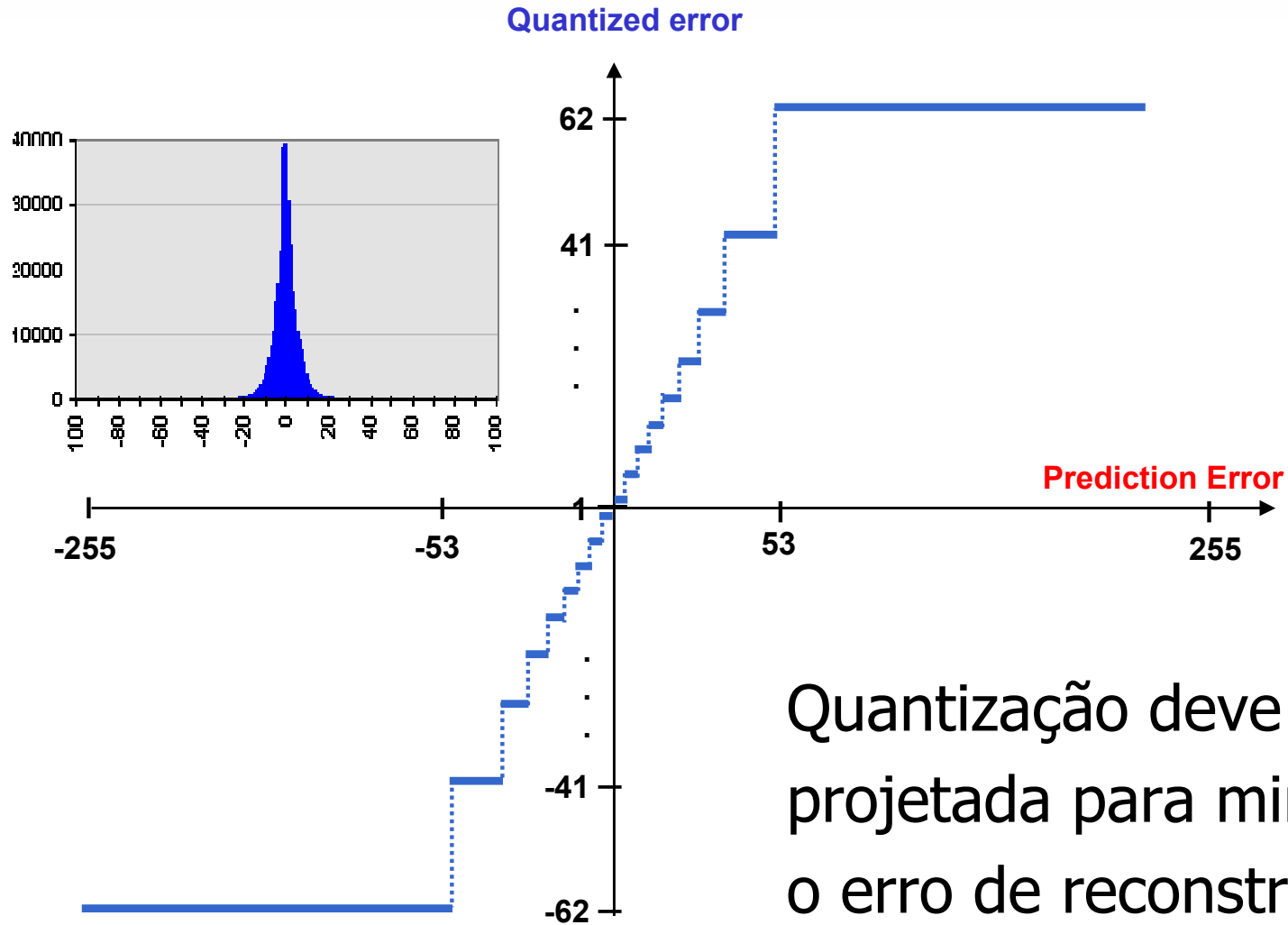
DPCM



$$x_D[n] - x[n] = e_Q[n] - e[n]$$

Erro de reconstrução =
Erro de quantização

Quantização do erro de predição



DPCM

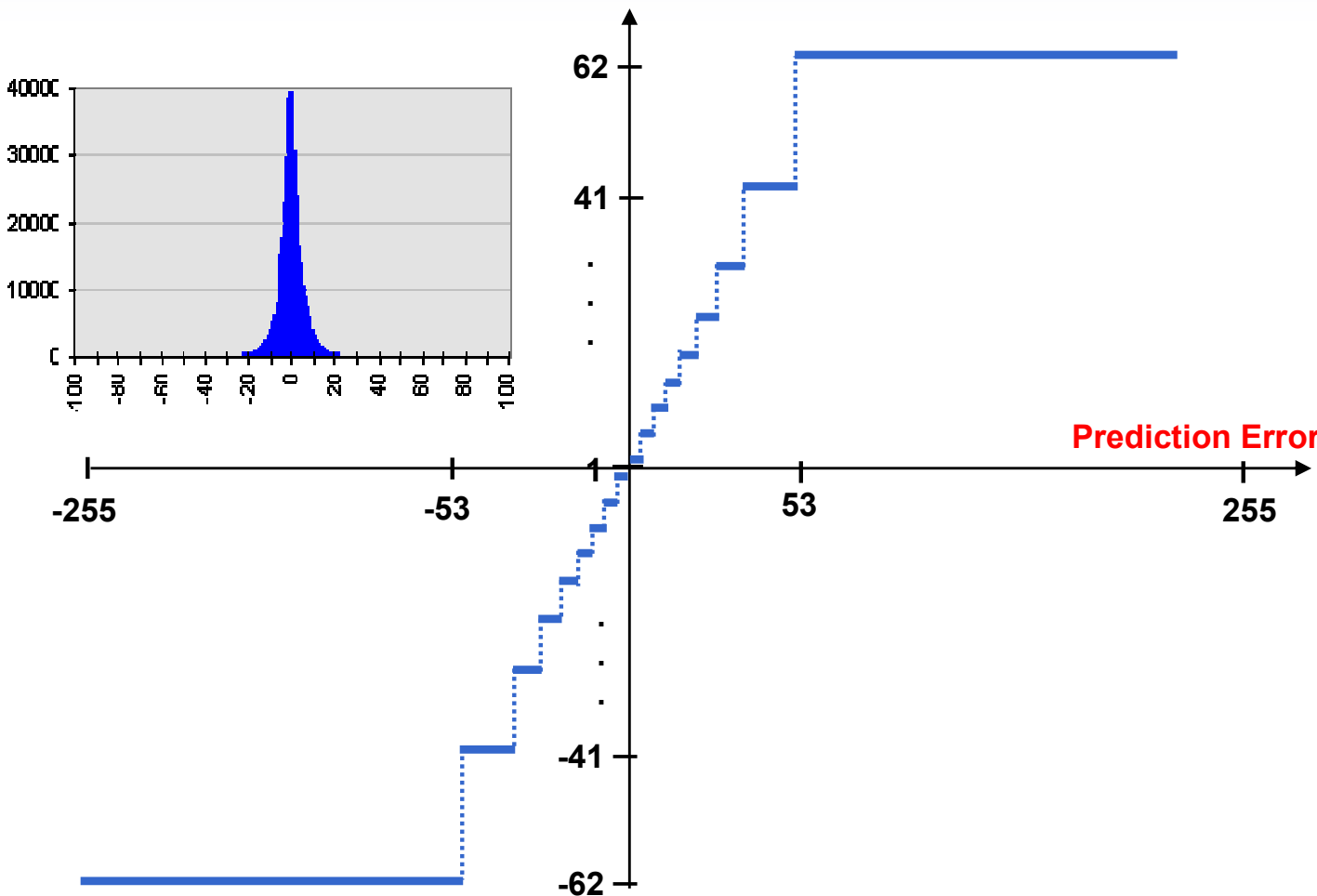
*Sub-System of PANMUX_IRMSS
Onboard CBERS 3 & 4 Satellites*



Source: Introduction to DPCM Encoding Algorithm in Data Transmission: Sub-system of PANMUX_IRMSS Onboard CBERS 3&4 Satellites, CAST, CRESDA, August 3, 2010.

Quantização do erro de predição

Quantized error



Prediction error	Quantized error	Code
[53, 255]	62	0111
[36, 52]	41	0110
[26, 35]	29	0101
[19, 25]	21	0100
[13, 18]	15	0011
[8, 12]	9	0010
[4, 7]	5	0001
[0, 3]	1	0000
[-3, -1]	-1	1000
[-7, -4]	-5	1001
[-12, -8]	-9	1010
[-18, -13]	-15	1011
[-25, -19]	-21	1100
[-35, -26]	-29	1101
[-52, -36]	-41	1110
[-255, -53]	-62	1111

4 bits

-62 (1111)

17

10

7

6

4

3

4

4

5

6

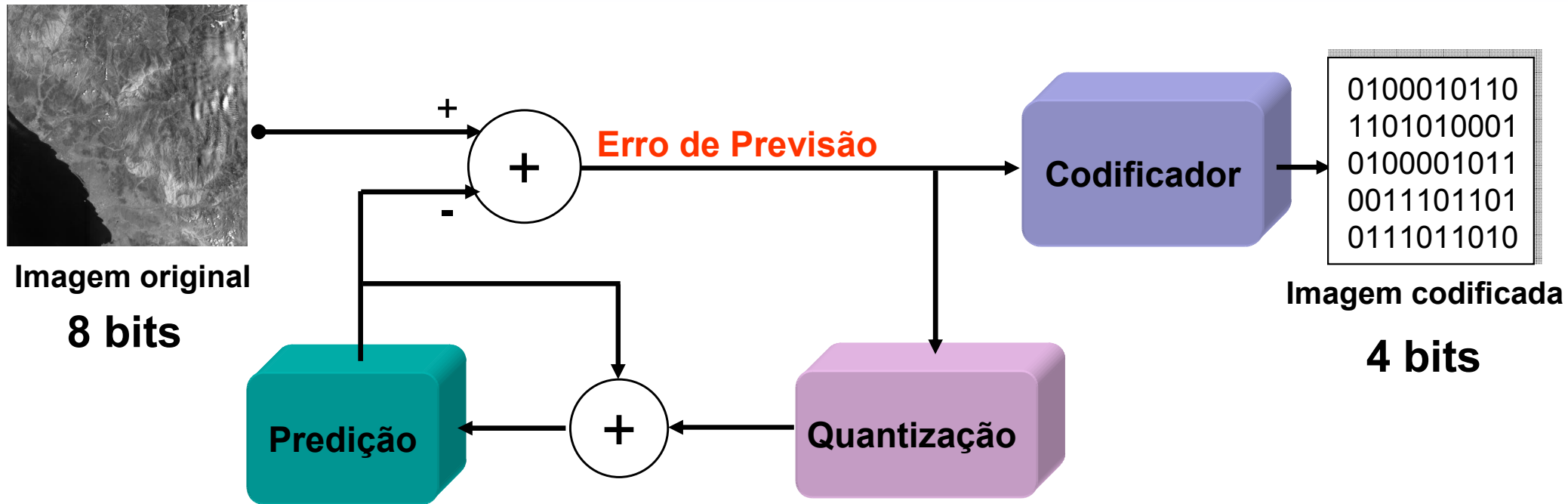
7

10

17

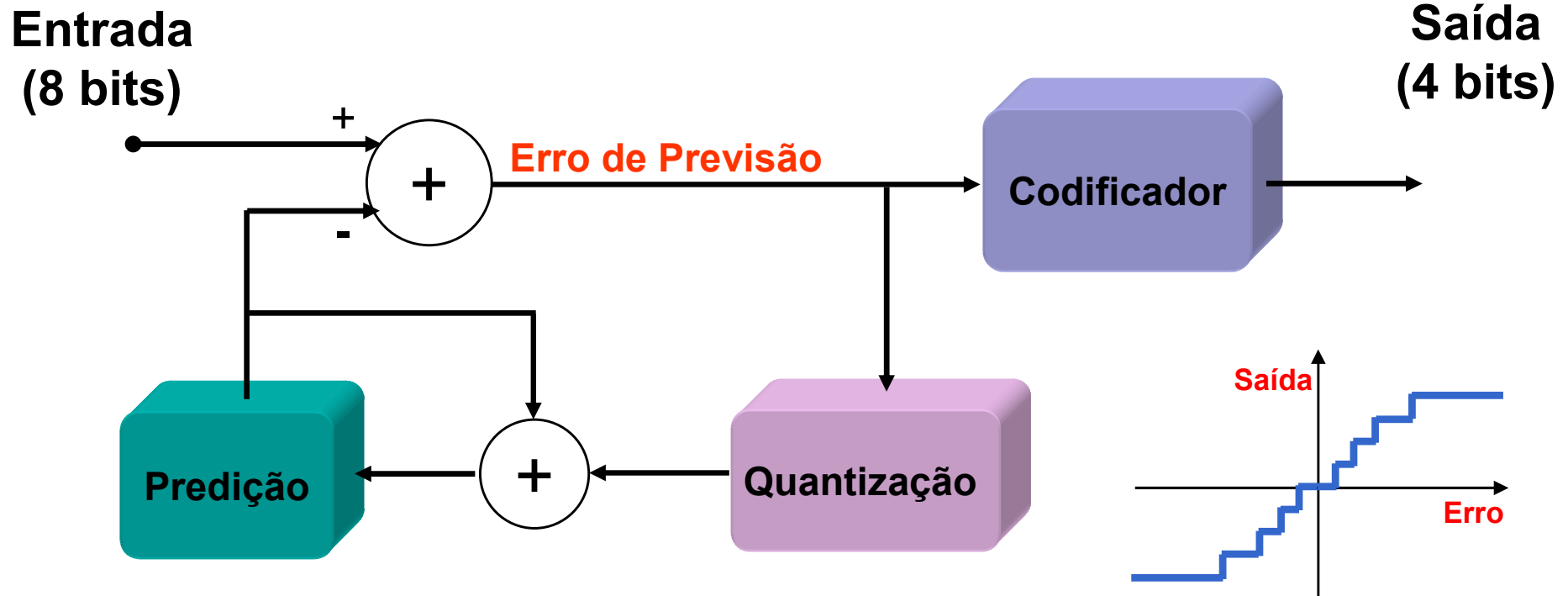
62 (0111)

Codificador DPCM



Taxa de Compressão
2:1

Codificador DPCM



-233	-52	-35	-25	-18	-12	-7	-3	0	4	8	13	19	26	36	53	255
1111	1110	1101	1100	1011	1010	1001	1000	0000	0001	0010	0011	0100	0101	0110	0111	

Tabela de codificação do erro quantizado

Codificador DPCM

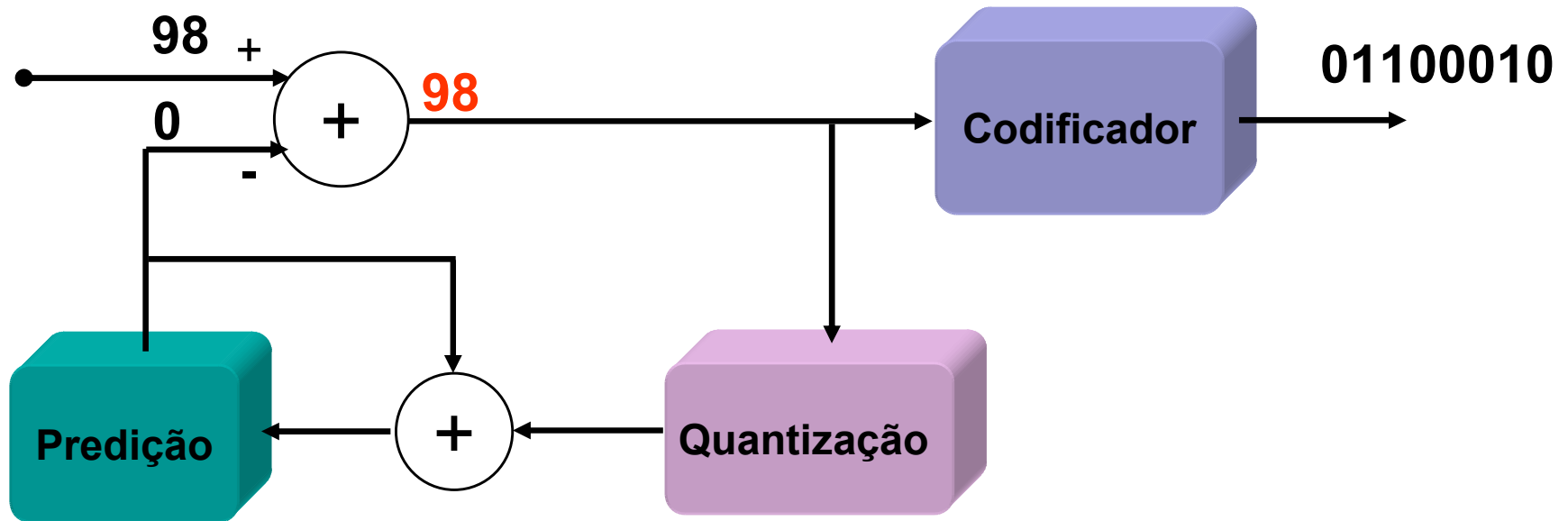
98

95

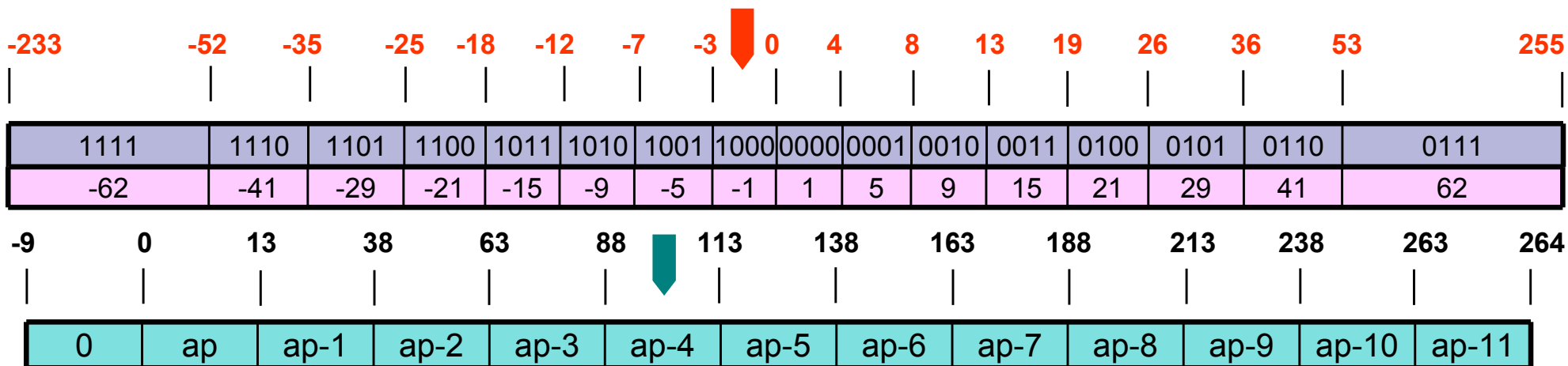
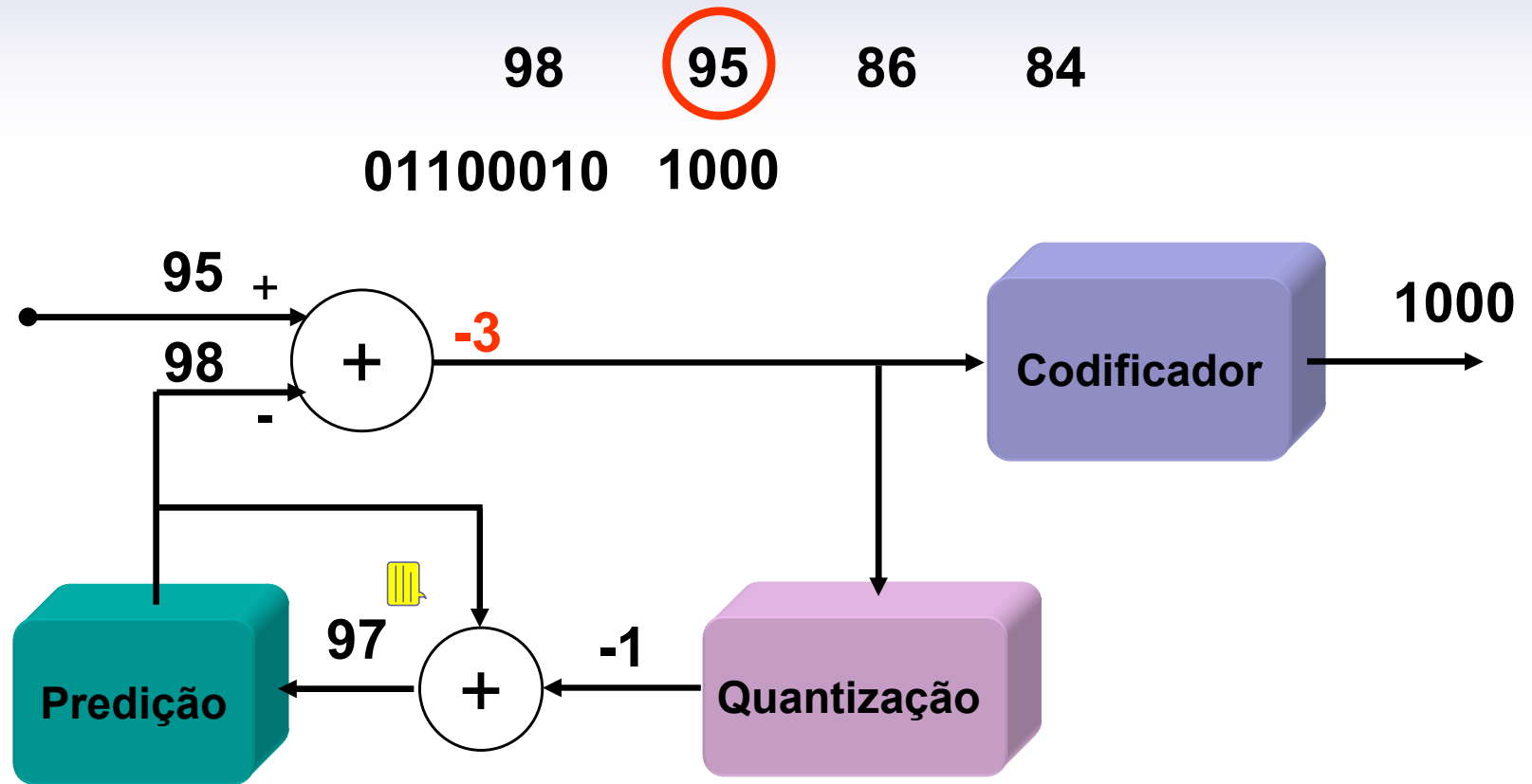
86

84

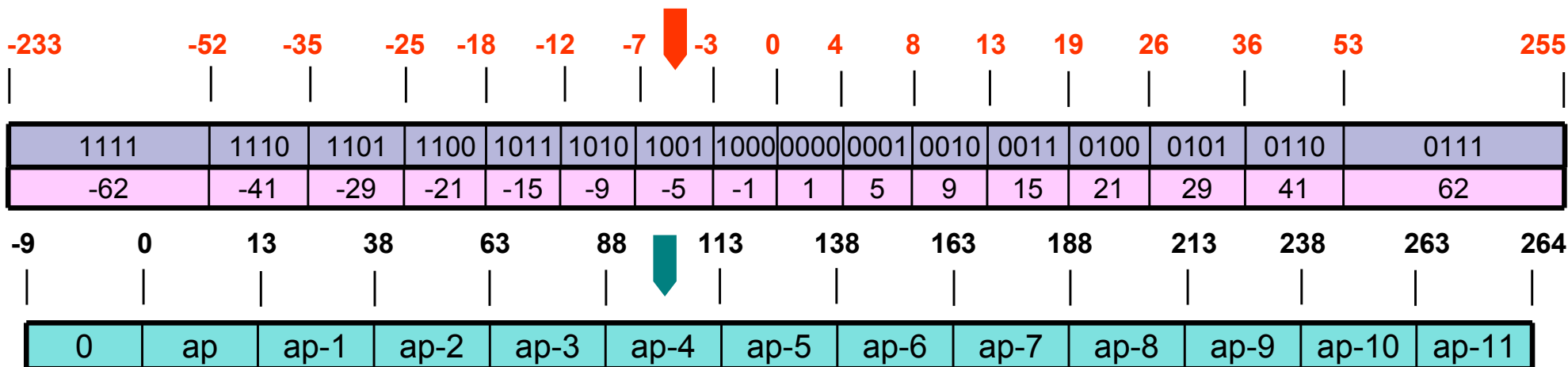
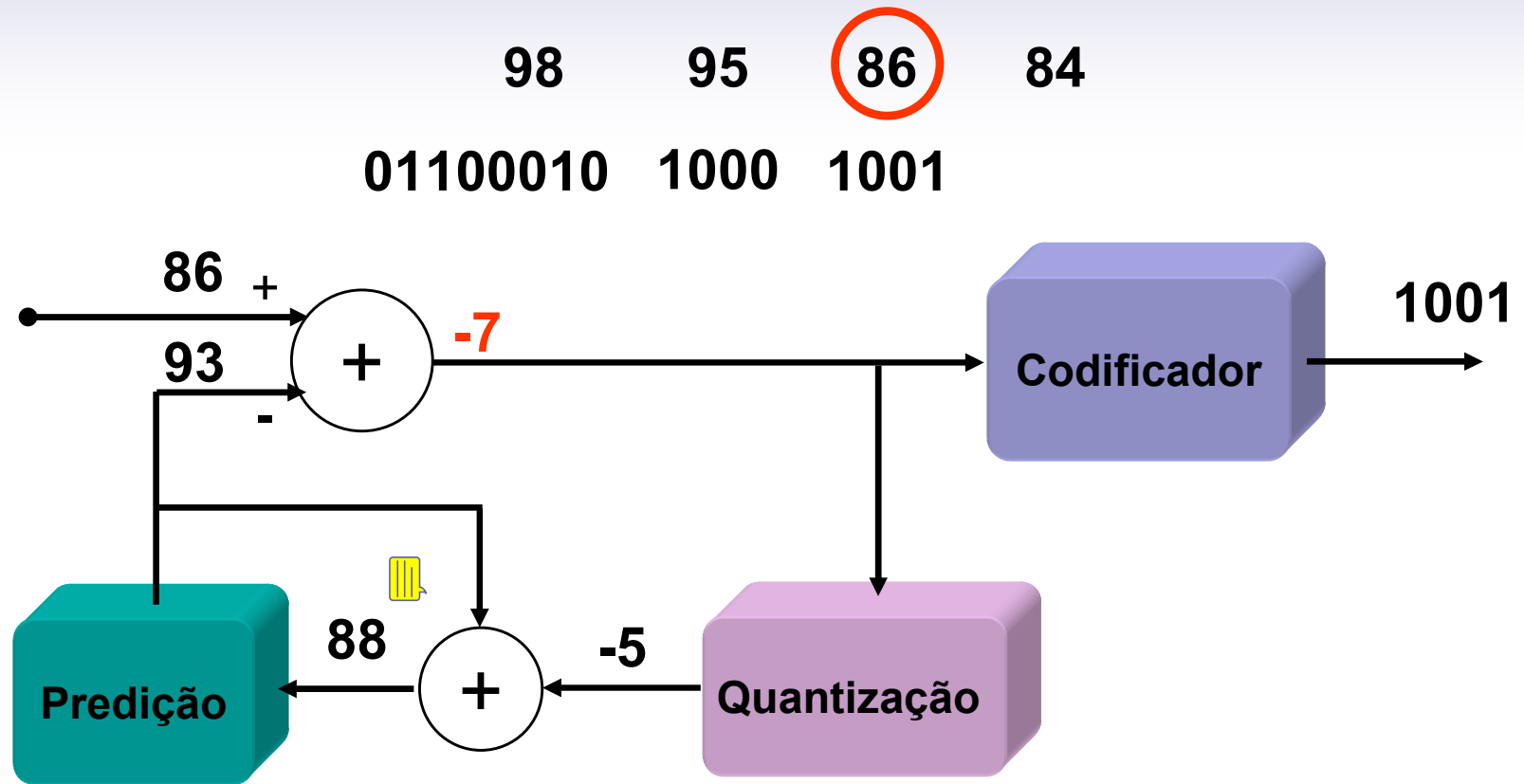
01100010



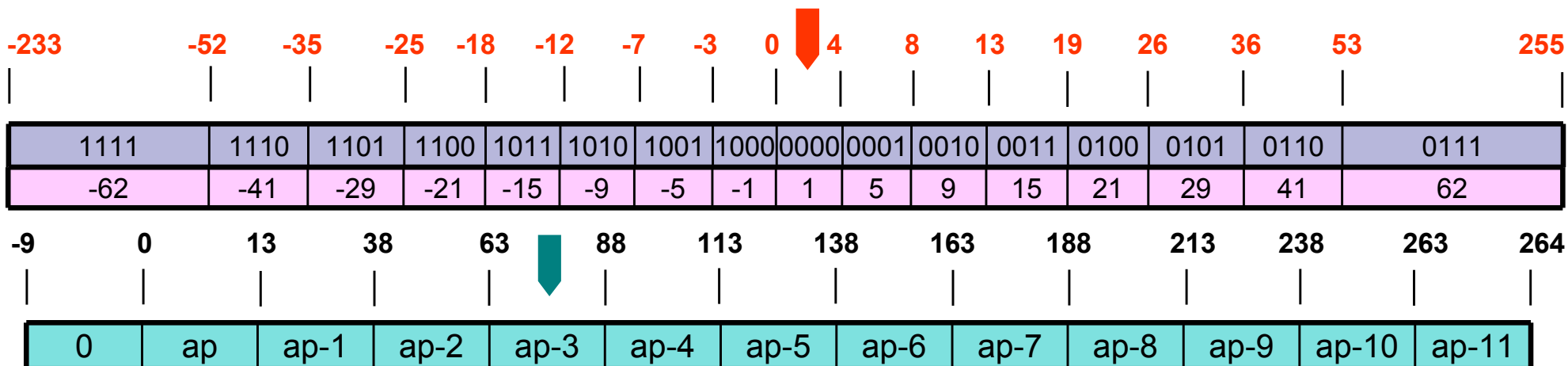
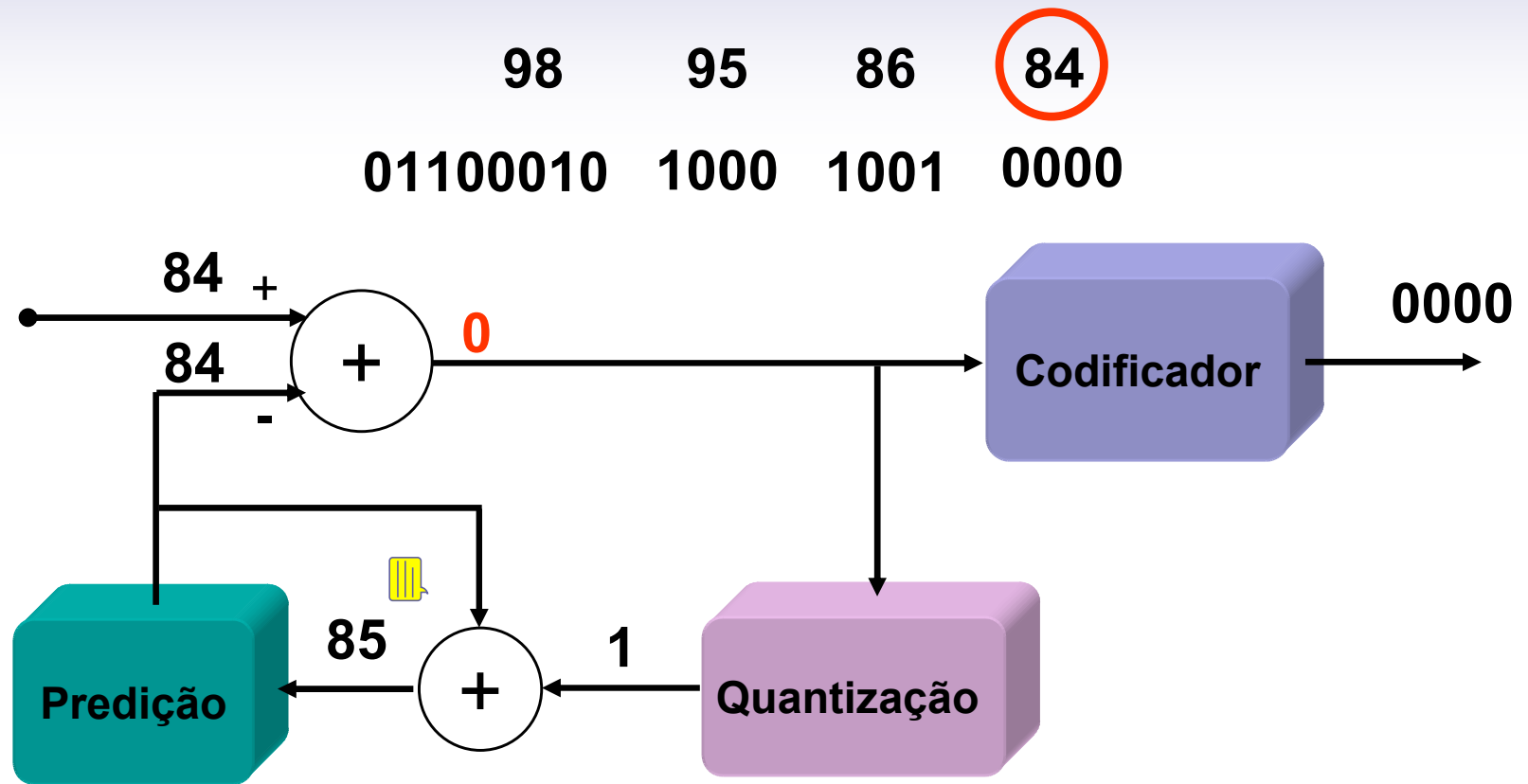
Codificador DPCM



Codificador DPCM



Codificador DPCM



Codificador DPCM

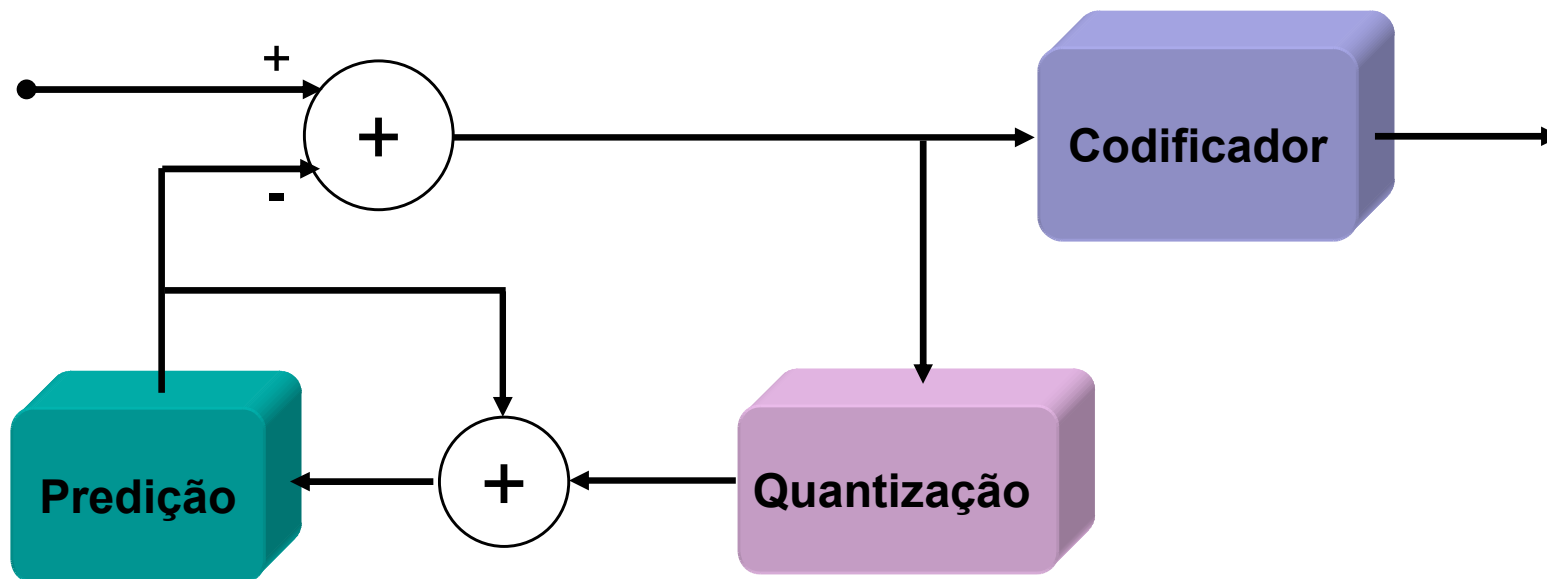
98

95

86

84

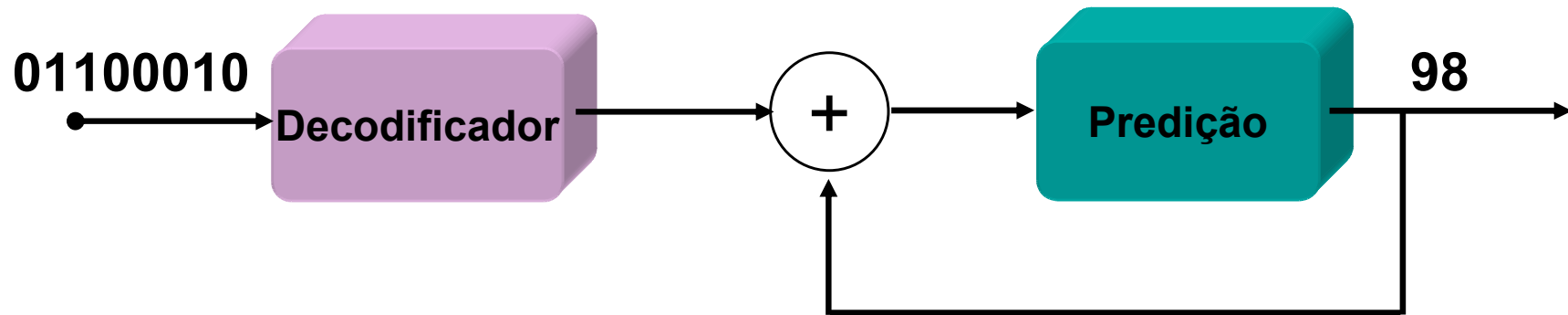
01100010 1000 1001 0000 ...



Fim da Codificação

Decodificador DPCM

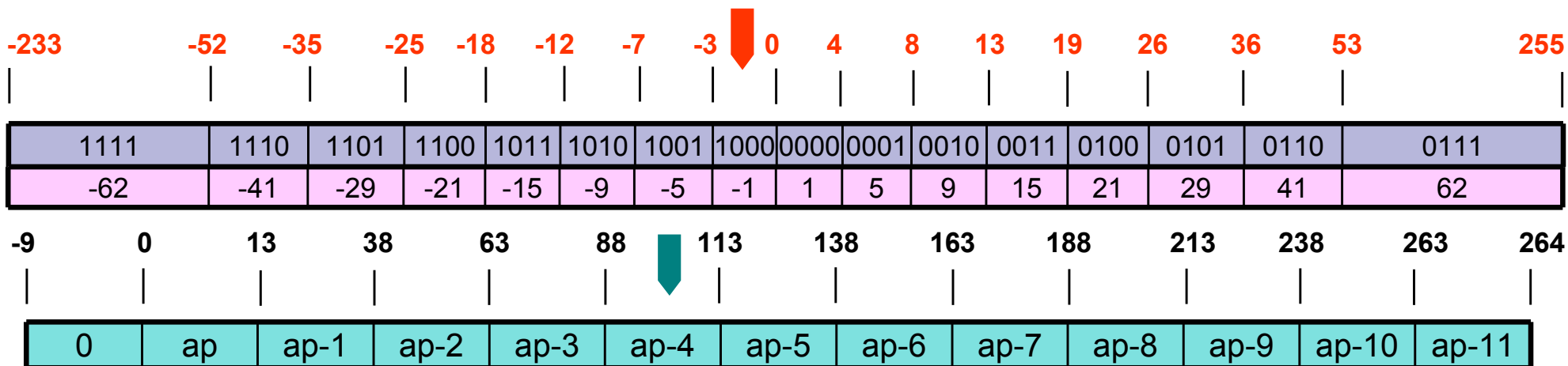
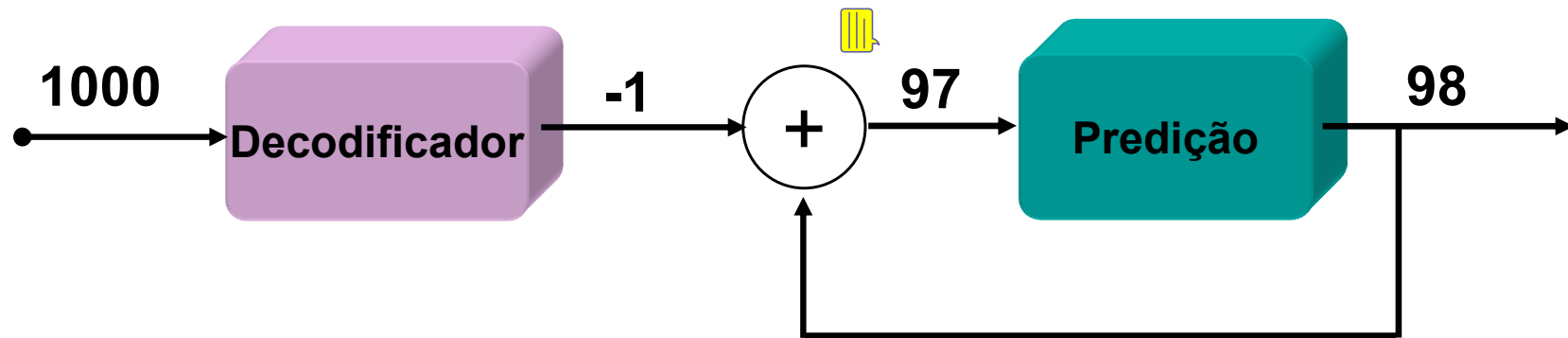
01100010 1000 1001 0000
98



Decodificador DPCM

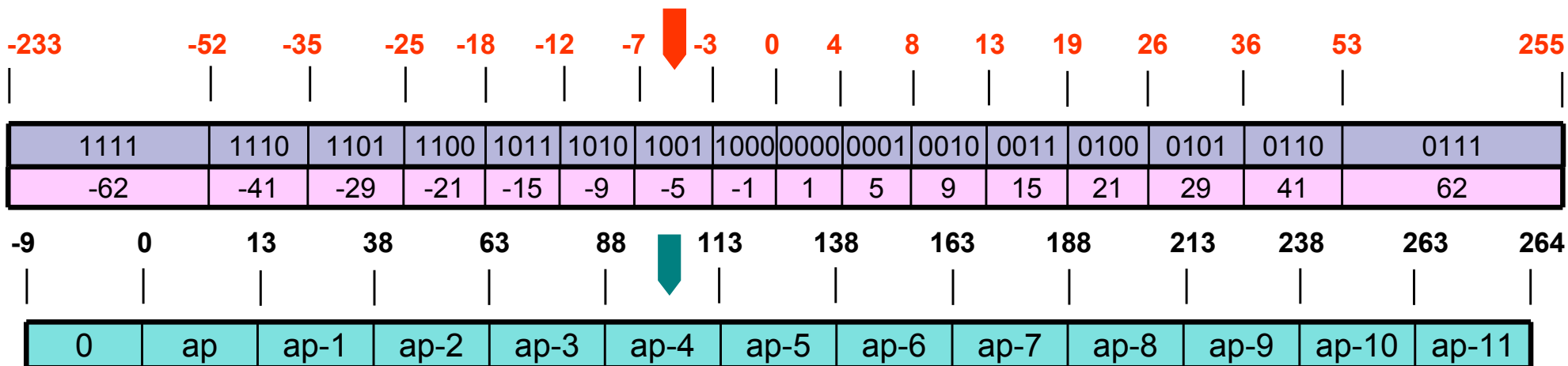
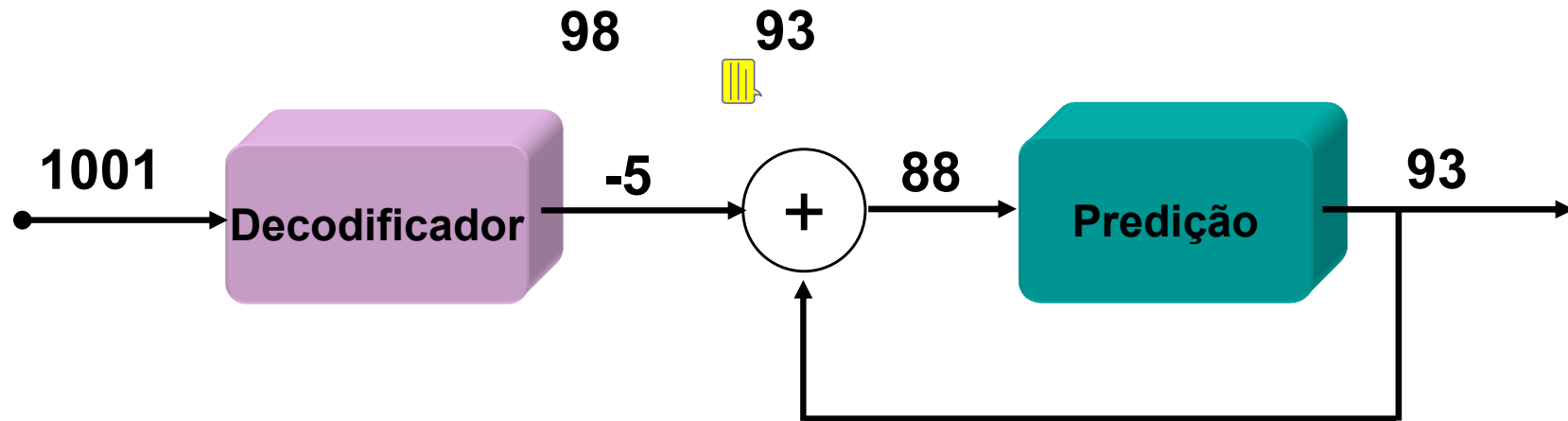
01100010 **1000** 1001 0000

98



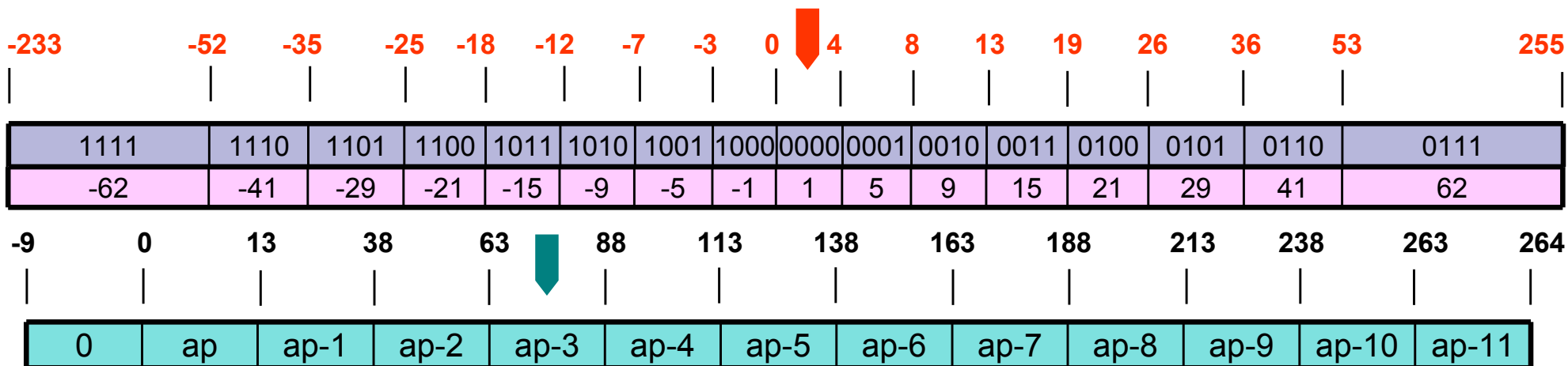
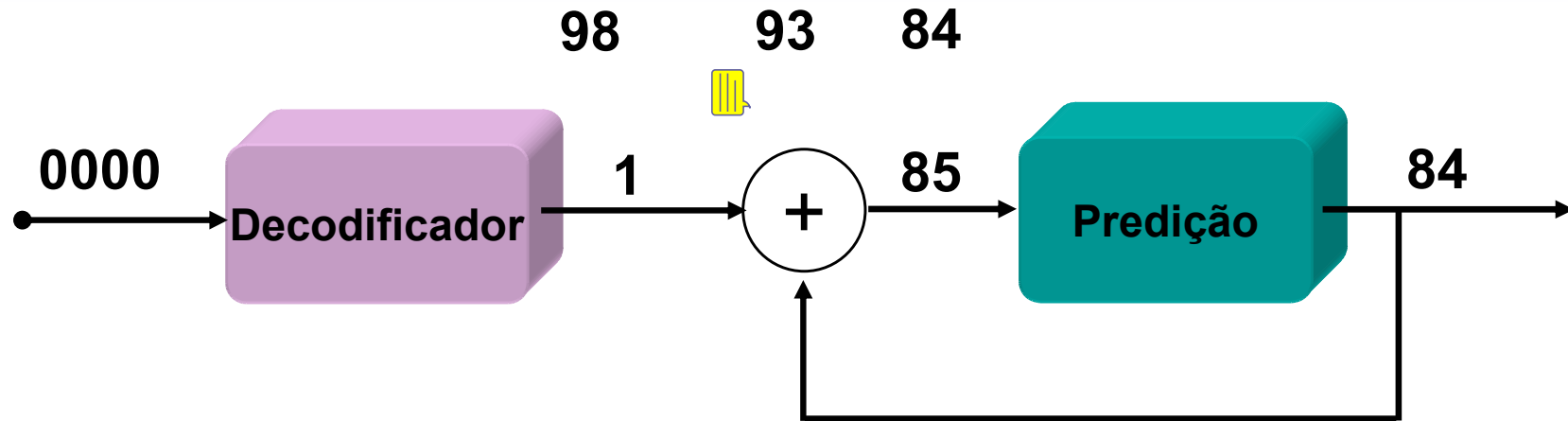
Decodificador DPCM

01100010 1000 **1001** 0000



Decodificador DPCM

01100010 1000 1001 0000



Decodificador DPCM

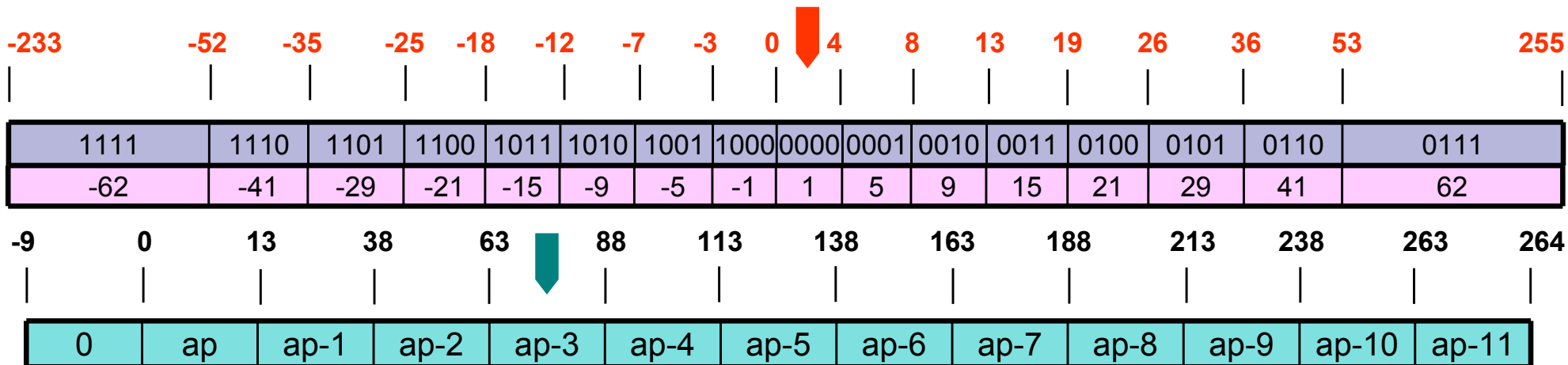
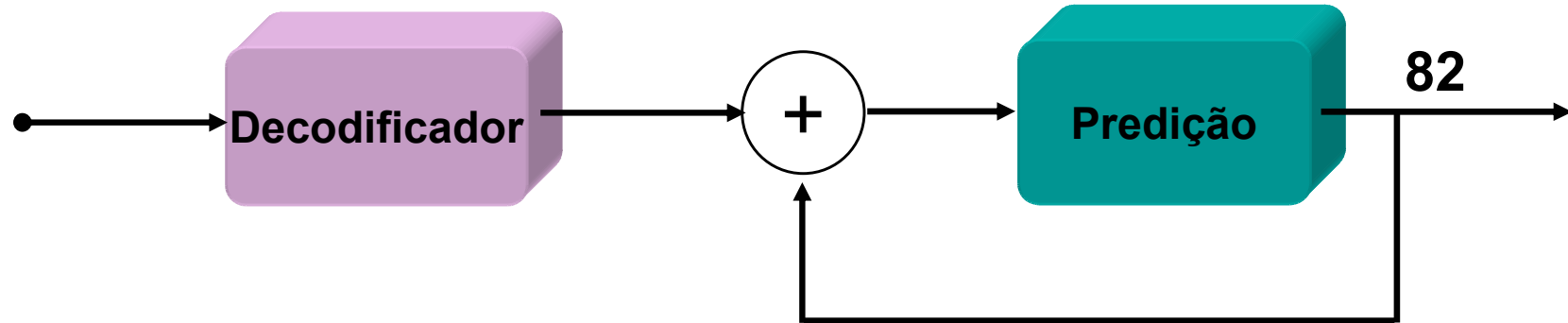
01100010 1000 1001 0000

98

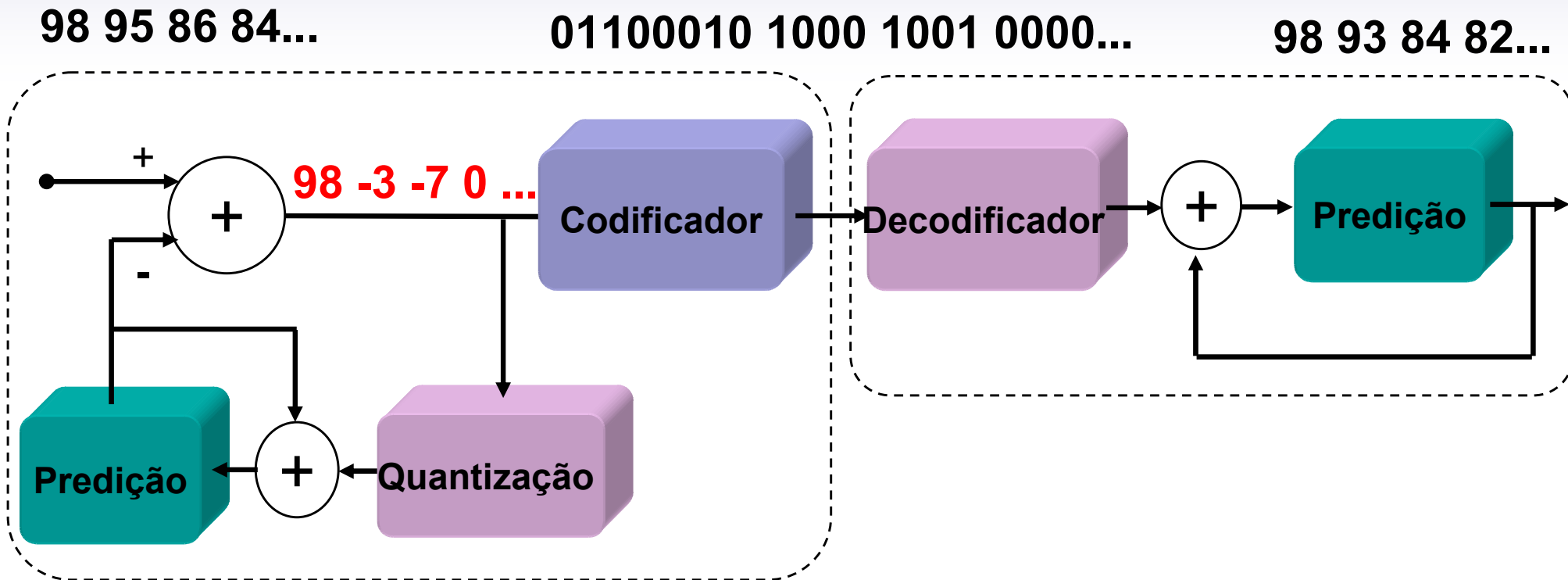
93

84

82



Sistema de Compressão DPCM



Baixa complexidade

Compressão com Perda

Taxa de Compressão 2:1

Análise Visual de Qualidade

HRC/CBERS-2B

Brasília, DF

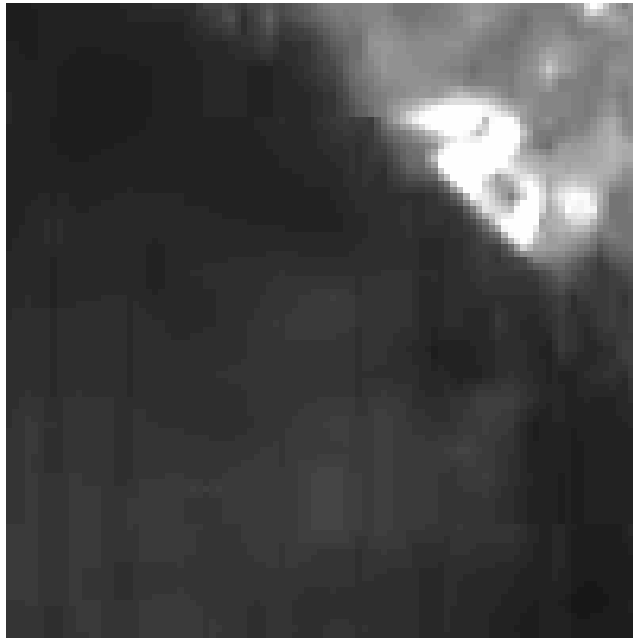
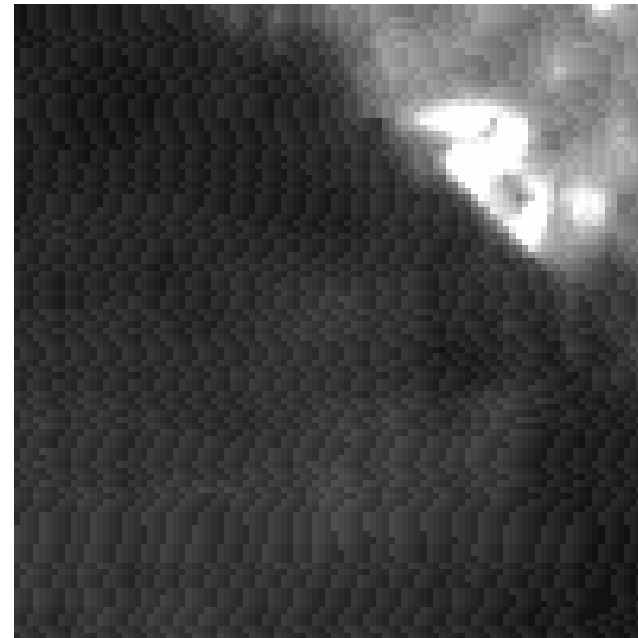


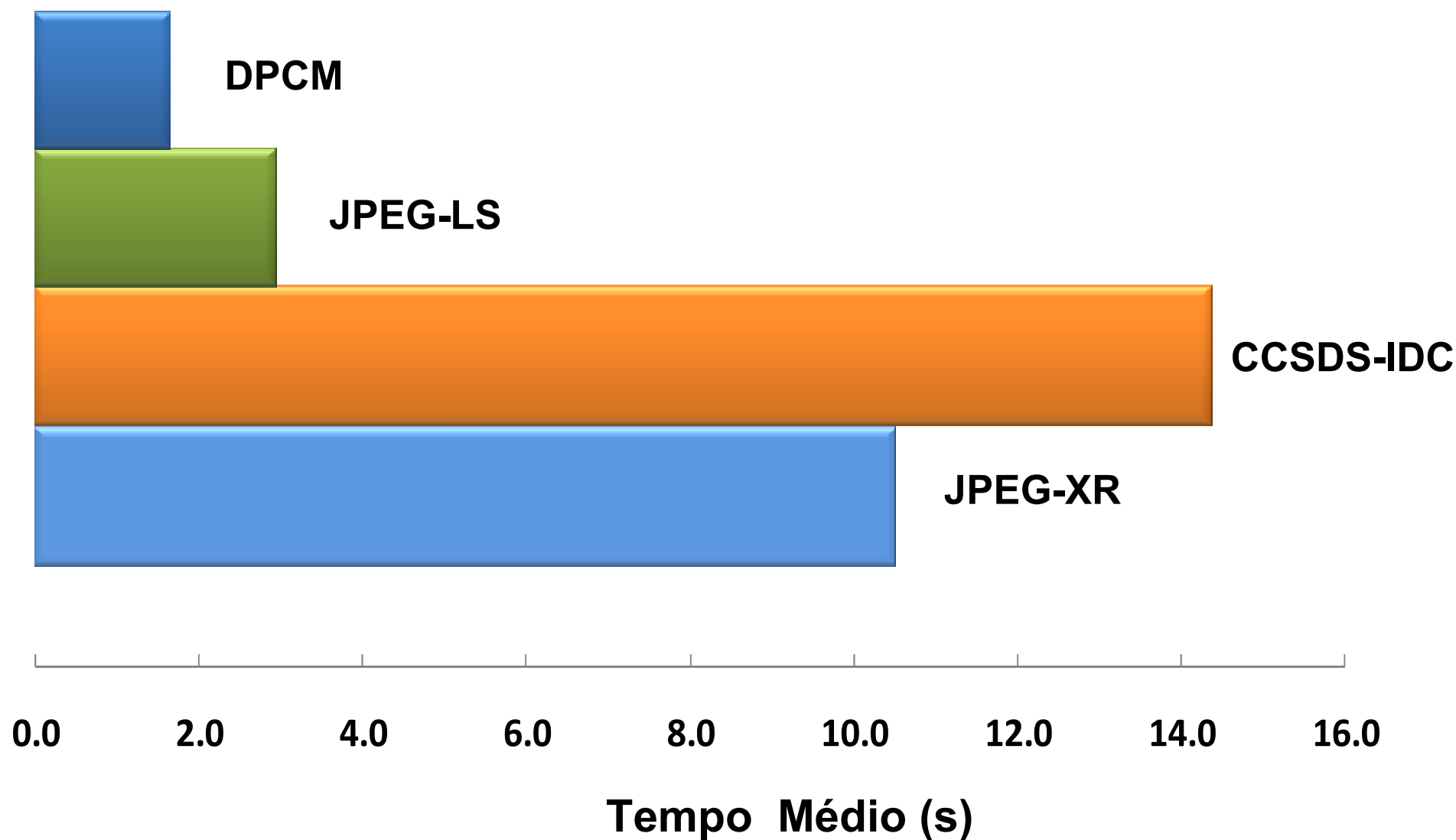
Imagem original



DPCM 2:1 (CAST)

**Ruído granular em
áreas planas**

Tempo de Processamento



Principais referências

China Academy of Space Technology, “**Introduction to DCPM encoding algorithm in data transmission sub-system of PANMUX IRMSS onboard CBERS 3&4 satellites,**” *[S.I.]: CAST, (Wx CBERS03/04DPS.SM01), 2010.

Lilian N. Faria, Leila M. G. Fonseca, and Max H. M. Costa, “**Performance Evaluation of Data Compression Systems Applied to Satellite Imagery,**” *Journal of Electrical and Computer Engineering*, vol. 2012, Article ID 471857, 15 pages, 2012.
doi:10.1155/2012/471857
<http://www.hindawi.com/journals/jece/2012/471857/>



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Obrigada!

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