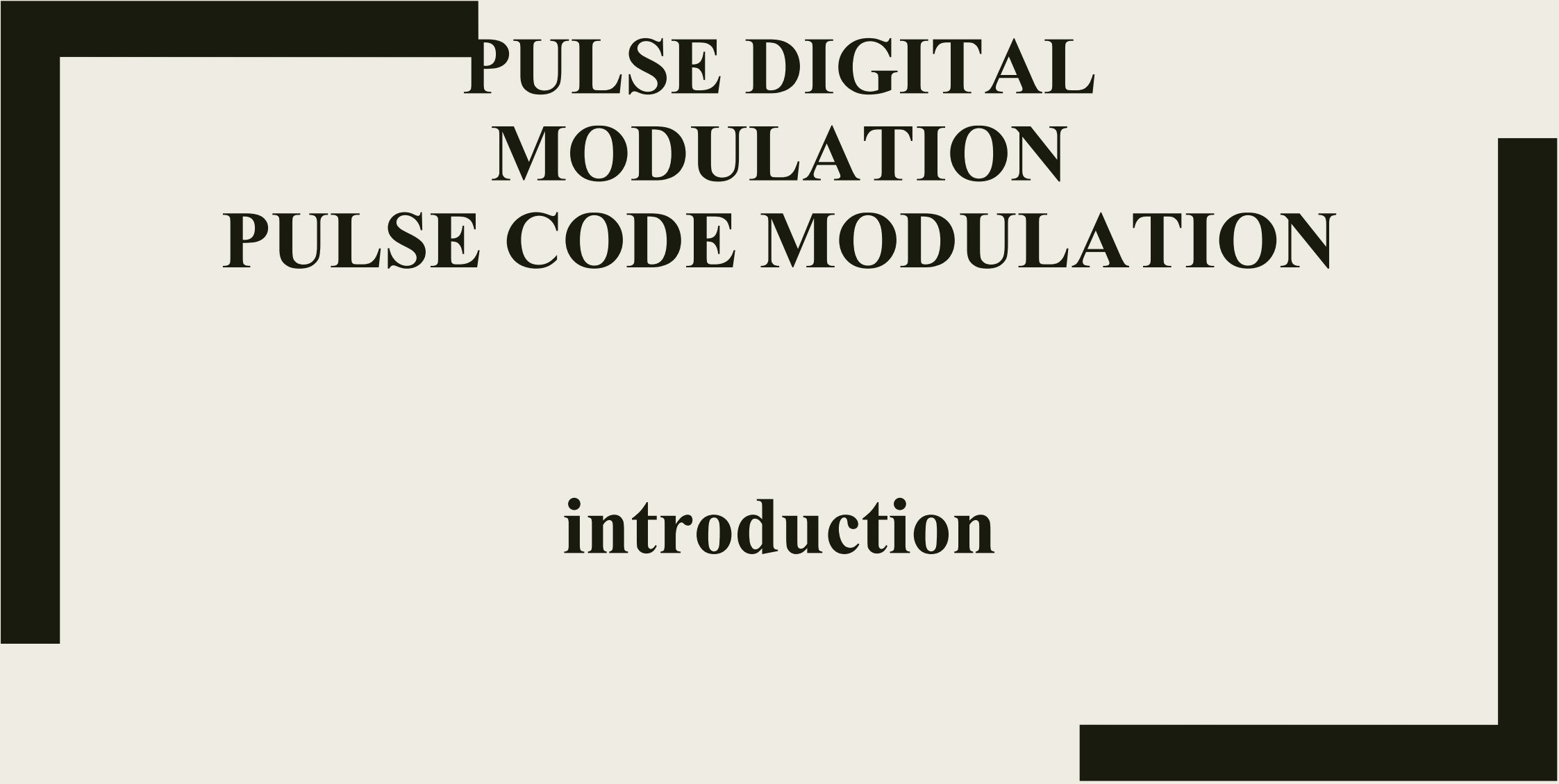


A thick black L-shaped frame is positioned on the left and bottom edges of the slide, framing the text.

PULSE DIGITAL MODULATION PULSE CODE MODULATION

introduction

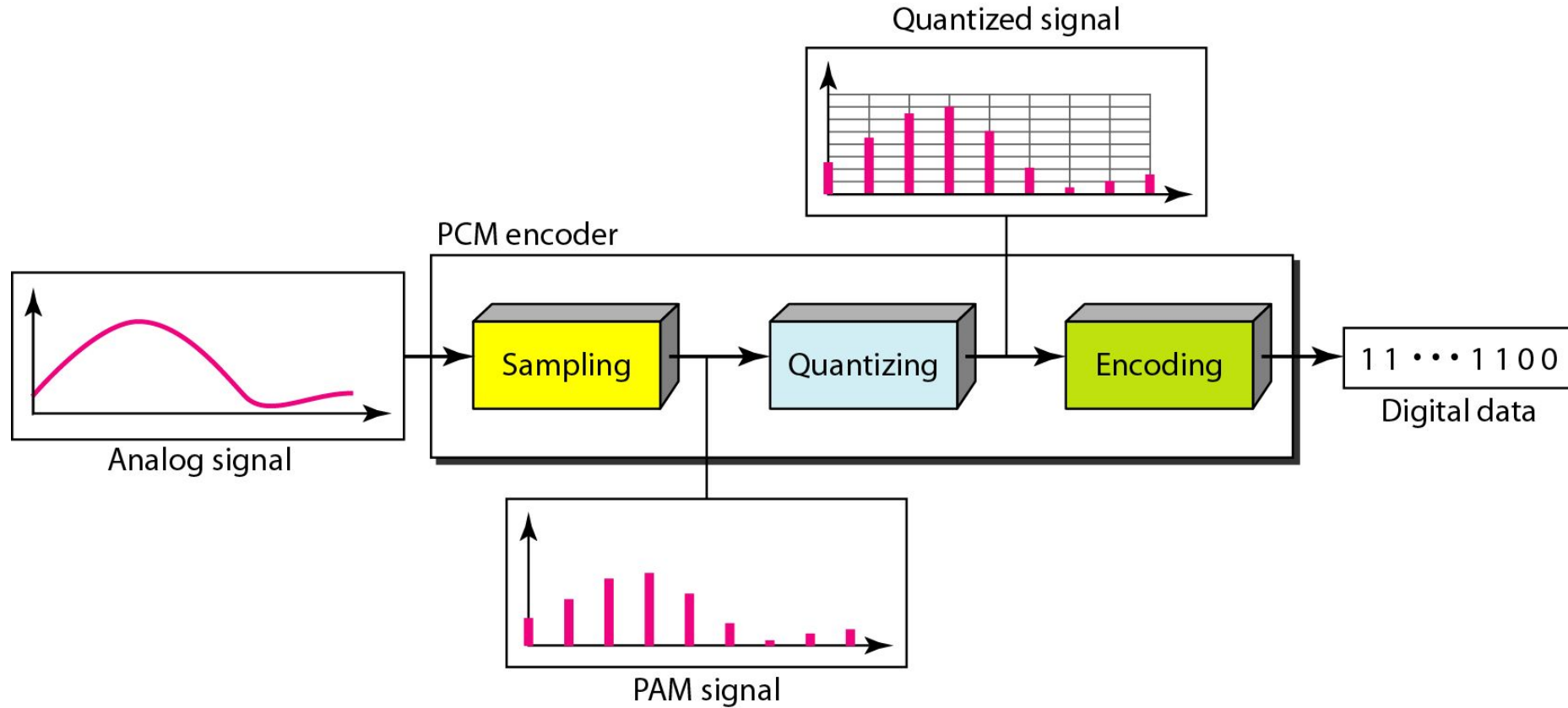
Introduction

- ❑ To transport an information signal from one point to another over a communication channel, we can use digital or analog techniques.
- ❑ The use of digital communication offers several advantages as compared with to analog communication. such as:
 - ruggedness to channel noise
 - flexible operation of the system
 - common format for all information source
 - security of information during the transmission.
- ❑ To transmit analog signal by digital communication system , the signal has to undergo an analog to digital conversion.
- ❑ In PAM the analog signal is converted from analog form(analog in amplitude and time) to signal discrete in time and analog in amplitude.
- ❑ To completely conversion of analog signal to digital one, addition process called waveform coding technique is required.

Pulse Code Modulation **PCM**

- The process of coding sampled signal (conversion to digital form) can be done by Pulse Code Modulation (**PCM**)
- In, PCM the message signal pass through three process:
 - a. **sampling** – conversion of analog signal (in both amplitude and time) to a signal discrete in time analog in amplitude
 - b. **Quantization**- conversion of signal analog amplitude to discrete by rounding off the analog amplitude to nearest one of a finite set of allowable values known as quantization levels.
 - c. **Encoding**- conversion of discrete amplitudes(quantized) to digital form (0,1)

Figure 4.21 *Components of PCM encoder*



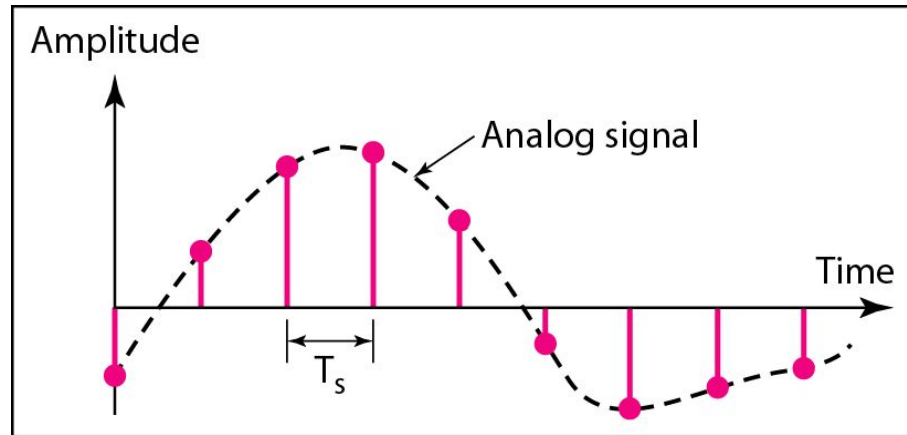
a. Sampling

- The samples are taken according to sampling theorem, i.e.
 $F_s \geq 2 F_m$
- That means the samples are taken at discrete time points,
 $T_s, 2 T_s, 3T_s, \dots, NT_s$
with $T_s = 1/F_s$
- At these intervals the amplitude of samples are depend on
signal amplitude at instant of sampling.
- That means the signal now is discret in time analog in
amplitude

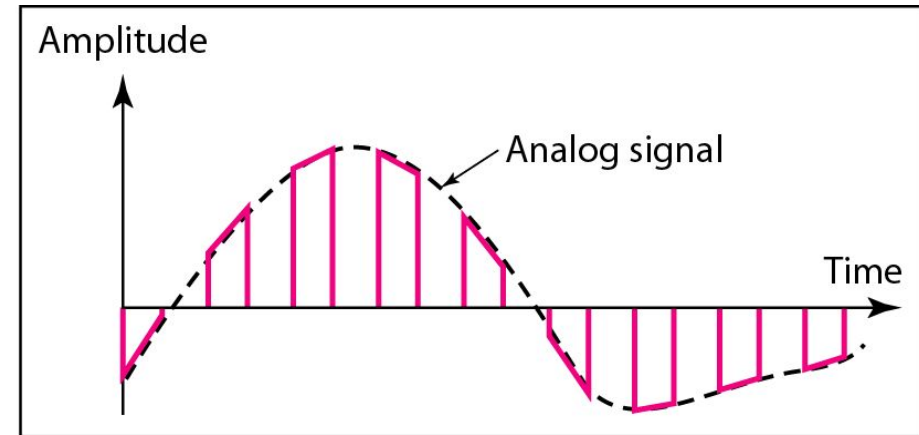
Sampling

- Analog signal is sampled every T_s secs.
- T_s is referred to as the sampling interval.
- $f_s = 1/T_s$ is called the sampling rate or sampling frequency.
- There are 3 sampling methods:
 - Ideal - an impulse at each sampling instant
 - Natural - a pulse of short width with varying amplitude
 - Flat top - sample and hold, like natural but with single amplitude value
- The process is referred to as pulse amplitude modulation PAM and the outcome is a signal with analog (non integer) values

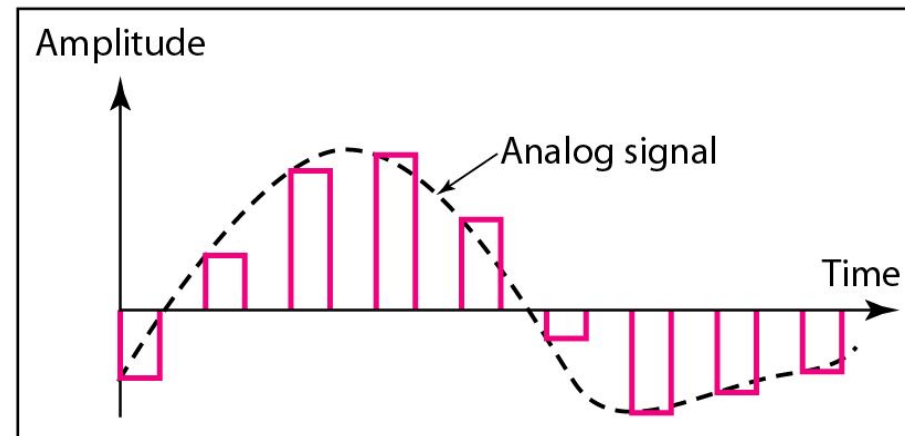
Figure 4.22 *Three different sampling methods for PCM*



a. Ideal sampling



b. Natural sampling



c. Flat-top sampling

b- Quantization

- ❑ The amplitude of each sample can take any value in a continuous range, the signal after sampling is still analog in amplitude. ■
- ❑ The difficulty is resolved by a process known as quantization.
- ❑ In this process, the total amplitude range which the signal may occupy is divided into a number of slandered levels.

- ❑ If the signal $x(t)$ has a peak value, X_p , that means the signal lie in the range $(-X_p, X_p)$

and if it is partitional into q intervals, then each of magnitude $\delta = \frac{2x_p}{q}$

- ❑ Now, each sample amplitude is approximated or rounded off to the nearest quantized level (which is defined level), the signal become discrete in time and discrete in amplitude.

Quantization

- Sampling results in a series of pulses of varying amplitude values ranging between two limits: a min and a max.
- The amplitude values are infinite between the two limits.
- We need to map the *infinite* amplitude values onto a finite set of known values.
- This is achieved by dividing the distance between min and max into **L zones**, each of **height Δ** .

$$\Delta = (\max - \min)/L$$

Quantization Levels

- The midpoint of each zone is assigned a value from 0 to $L-1$ (resulting in L values)
- Each sample falling in a zone is then approximated to the value of the midpoint.

Example Quantization Zones

- Assume we have a voltage signal with amplitudes $V_{\min} = -20V$ and $V_{\max} = +20V$.
- We want to use $L=8$ quantization levels.
- Zone width $\Delta = (20 - -20)/8 = 5$
- The 8 zones are: -20 to -15, -15 to -10, -10 to -5, -5 to 0, 0 to +5, +5 to +10, +10 to +15, +15 to +20
- The midpoints are: -17.5, -12.5, -7.5, -2.5, 2.5, 7.5, 12.5, 17.5

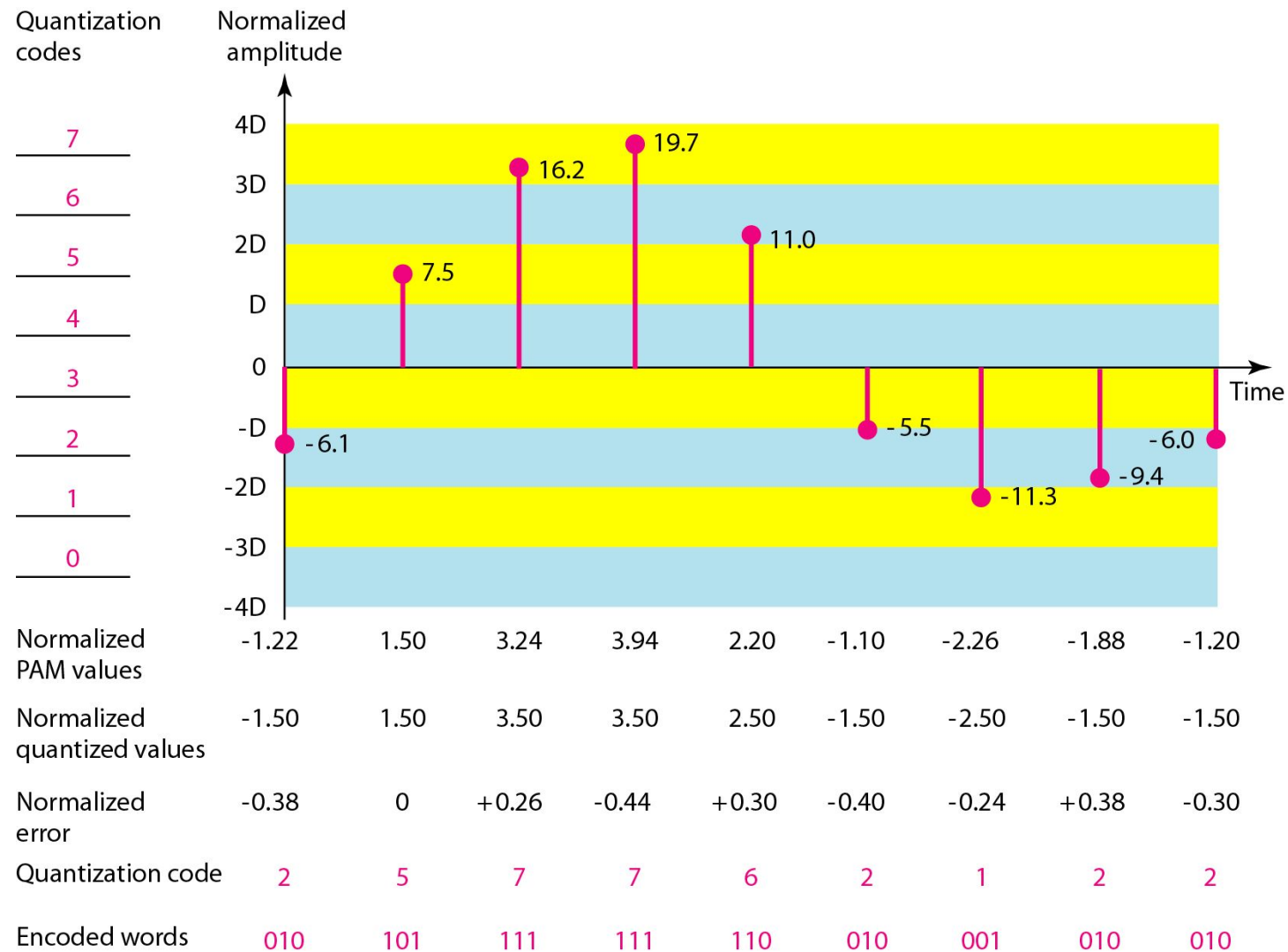
Assigning Codes to Zones

- Each zone is then assigned a binary code.
- The number of bits required to encode the zones, or the number of bits per sample as it is commonly referred to, is obtained as follows:

$$n_b = \log_2 L$$

- Given our example, $n_b = 3$
- The 8 zone (or level) codes are therefore: 000, 001, 010, 011, 100, 101, 110, and 111
- Assigning codes to zones:
 - 000 will refer to zone -20 to -15
 - 001 to zone -15 to -10, etc.

Figure 4.26 *Quantization and encoding of a sampled signal*



c- Encoding

- Encoding: converting of the quantized samples amplitude to binary.
- Bits per sample(Encoding word length), V
- The number of bits per samples determine the number of quantization levels, q
- They related by

$$q = 2^V$$

There are some applications of PCM (pulse code modulation) which are given below,

- The PCM is used in the satellite **transmission** system.
- It is used in space **communication**.
- It is used in telephony.
- The compact disc (CD) is a recent application of PCM.