Digital Pulse Modulation

- **Merits of Digital Communication**

3. The signals lose power as they travel, which is called attenuation. When AM and FM signals are amplified, the noise also get amplified. But the digital signals can be cleaned up to restore the quality and amplified by the regenerators.

4. The noise may change the shape of the pulses but not the pattern of the pulses.

Digital Pulse Modulation

- Merits of Digital Communication:

5.AM and FM signals can be received by any one by suitable receiver. But digital signals can be coded so that only the person, who is intended for, can receive them.

6.AM and FM transmitters are 'real time systems'. i.e. they can be received only at the time of transmission. But digital signals can be stored at the receiving end.

7.The digital signals can be stored.

Digital Pulse Modulation

- The process of Sampling which we have already discussed in initial slides is also adopted in Digital pulse modulation.
- It is mainly of two types:
- ❑ Pulse Code Modulation(PCM)
- ❑ Delta Modulation(DM)

Pulse Code Modulation(PCM)

- Pulse-Code Modulation (PCM) is the most commonly used digital modulation scheme

- In PCM, the available range of signal voltages is divided into levels and each is assigned a binary number

- Each sample is represented by a binary number and transmitted serially

- The number of levels available depends upon the number of bits used to express the sample value

- The number of levels is given by: $N = 2^m$

Pulse Code Modulation(PCM)

- PCM consists of three steps to digitize an analog signal:
    1. Sampling
    2. Quantization
    3. Binary encoding

- Before we sample, we have to filter the signal to limit the maximum frequency of the signal .Filtering should ensure that we do not distort the signal, ie remove high frequency components that affect the signal shape.
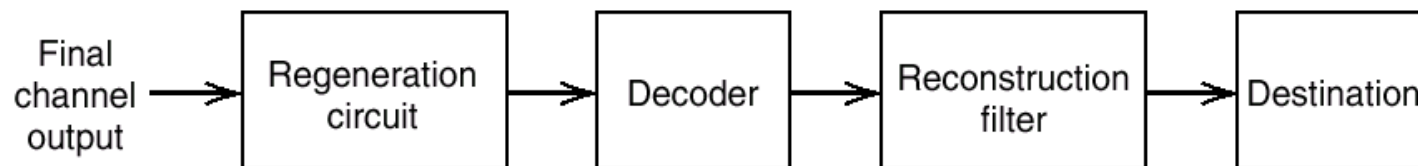
Pulse Code Modulation(PCM)
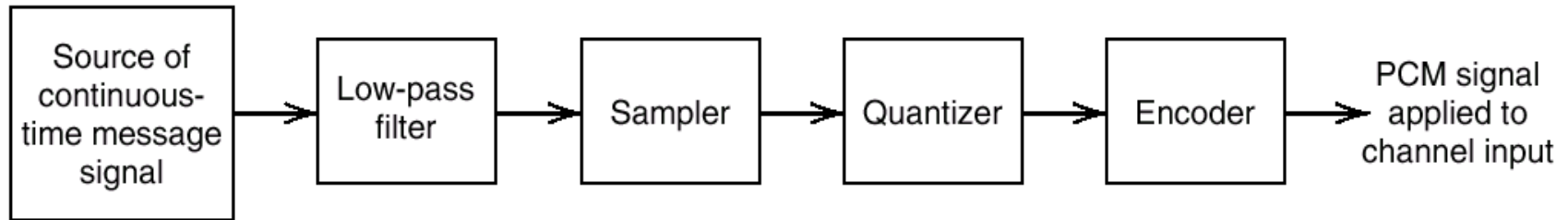
(a) Transmitter
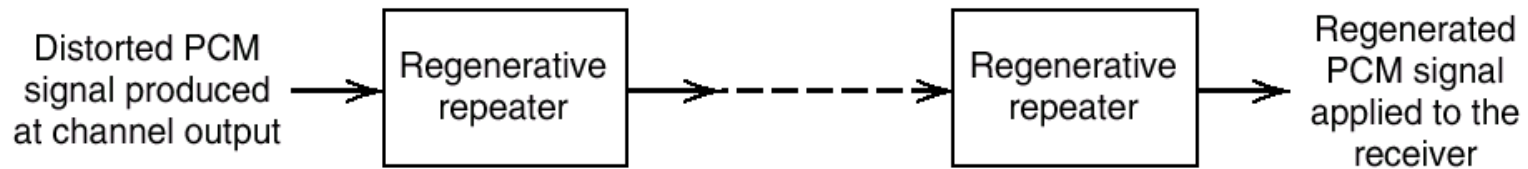
(b) Transmission path

(c) Receiver

The basic elements of a PCM system.

Pulse Code Modulation(PCM)

Analog to digital converter employs two techniques:

1. Sampling: The process of generating pulses of zero width and of amplitude equal to the instantaneous amplitude of the analog signal. The no. of pulses per second is called "sampling rate".
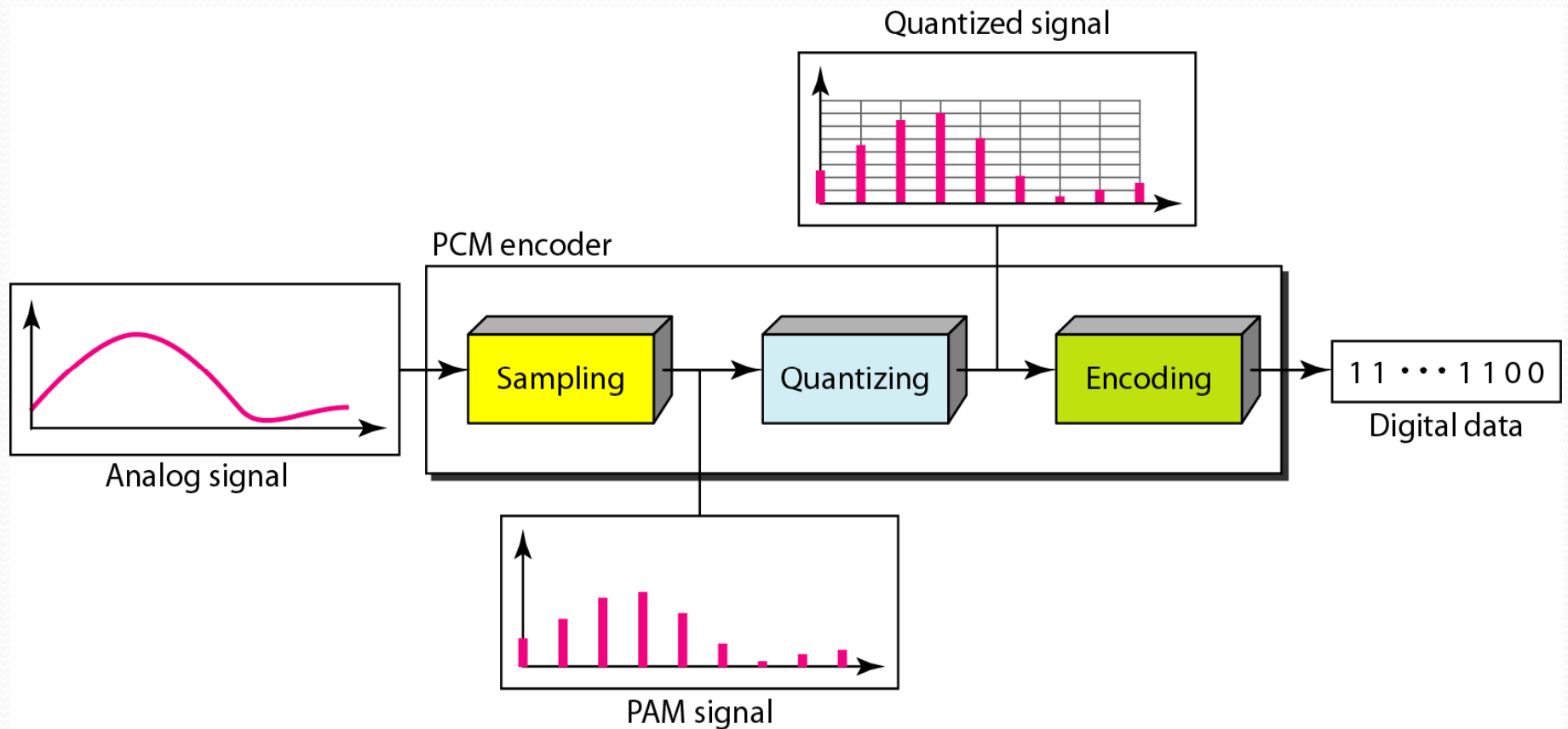
Pulse Code Modulation(PCM)

- 2. Quantization: The process of dividing the maximum value of the analog signal into a fixed no. of levels in order to convert the PAM into a Binary Code.

  The levels obtained are called "quanization levels".

Sampling, Quantization and Coding
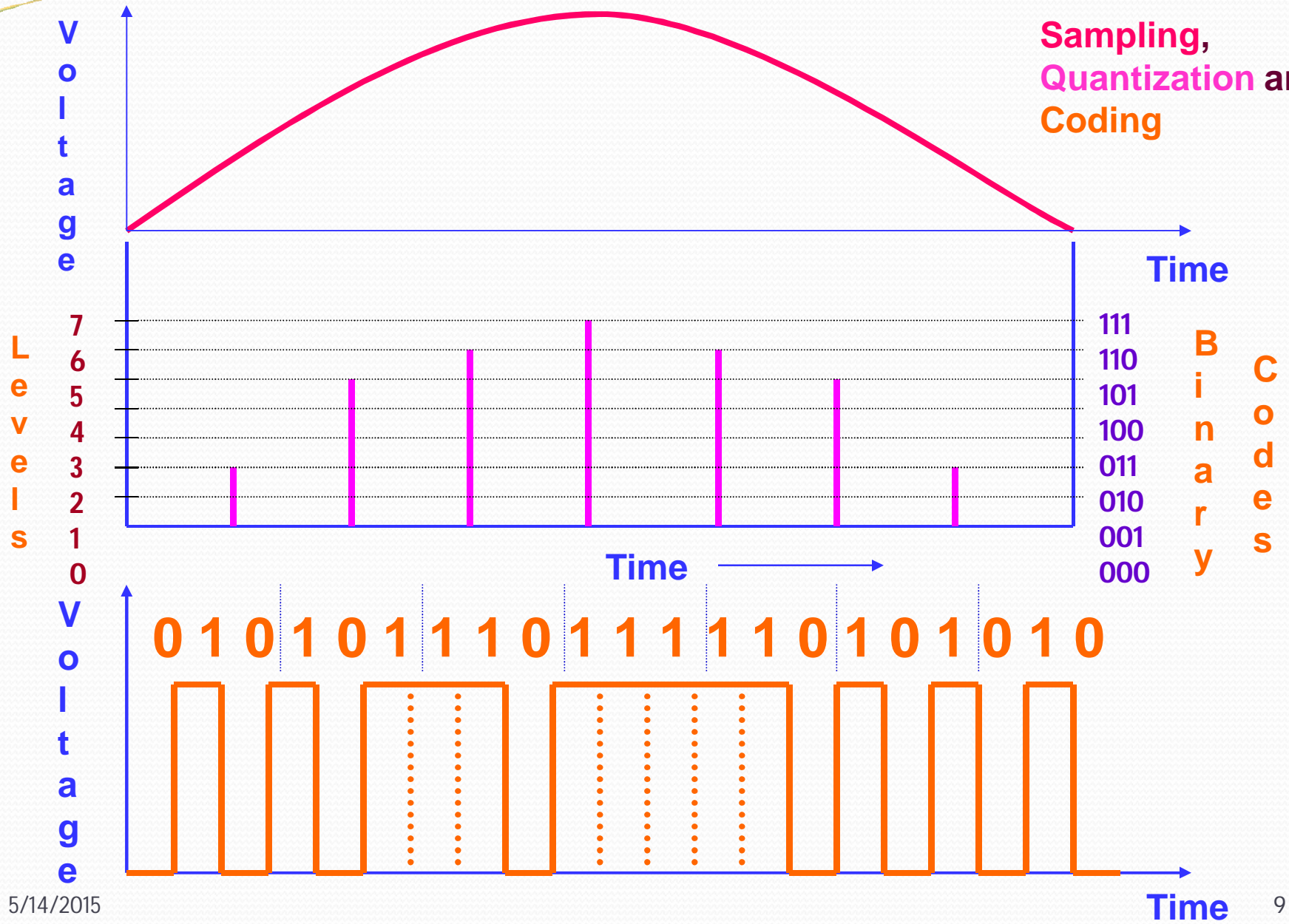
Pulse Code Modulation(PCM)

Quantization
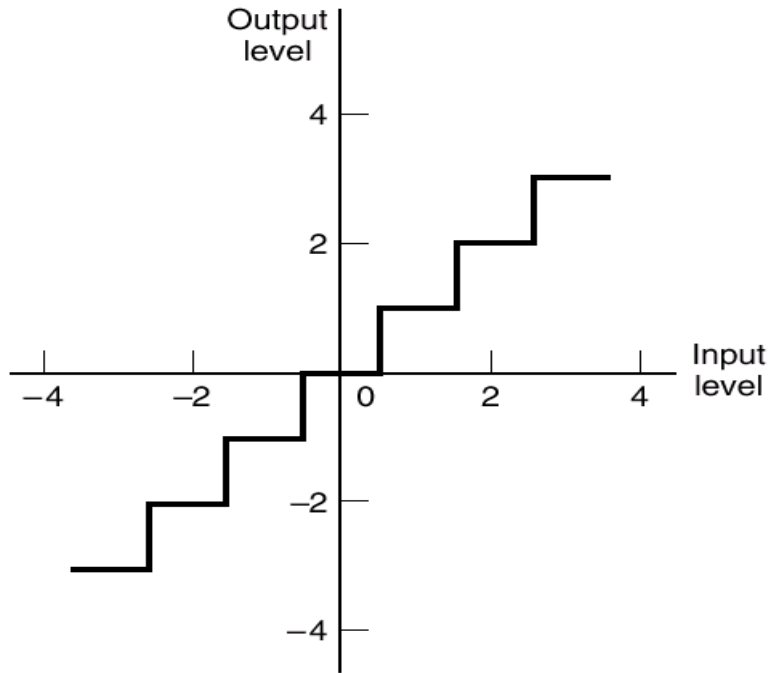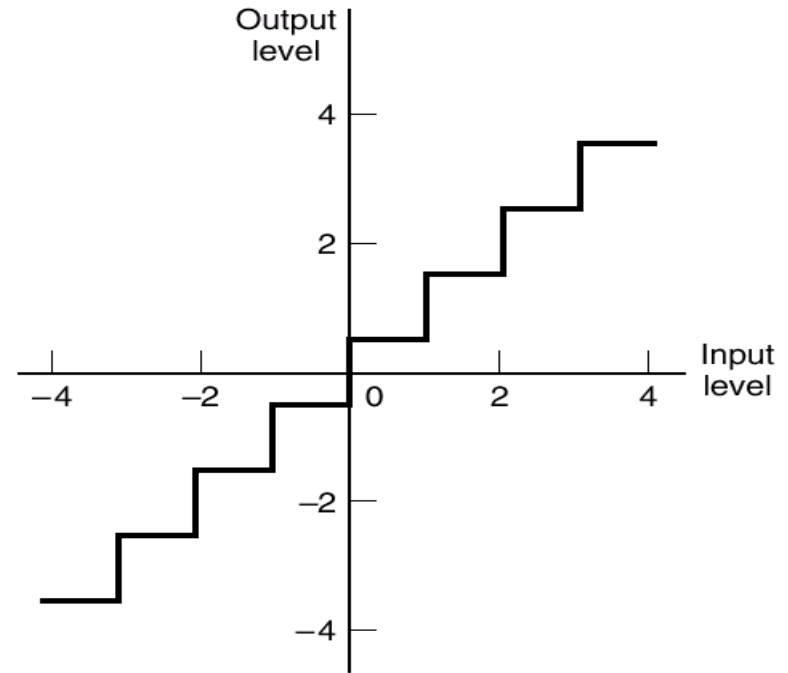
- By quantizing the PAM pulse, original signal is only approximated

- The process of converting analog signals to PCM is called *quantizing*

- Since the original signal can have an infinite number of signal levels, the quantizing process will produce errors called **quantizing errors** or **quantizing noise**

Quantization

Two types of quantization: (*a*) midtread and (*b*) midrise

Quantization

- Coding and Decoding
- The process of converting an analog signal into PCM is called coding, the inverse operation is called decoding
- Both procedures are accomplished in a **CODEC**

Quantization

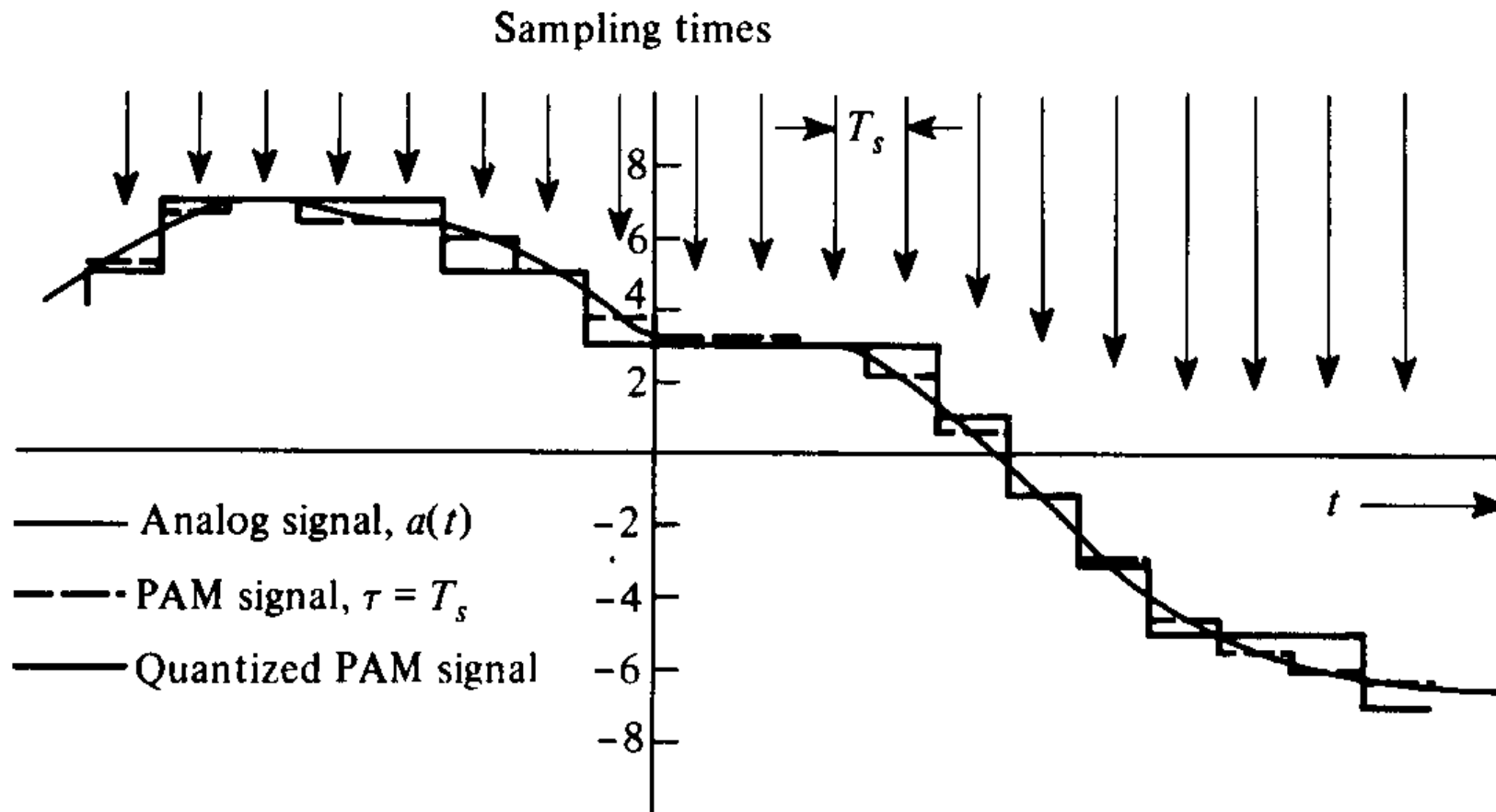| Quantization level number	Encoded output
7	111
6	110
5	101
4	100
3	011
2	010
1	001
0	000
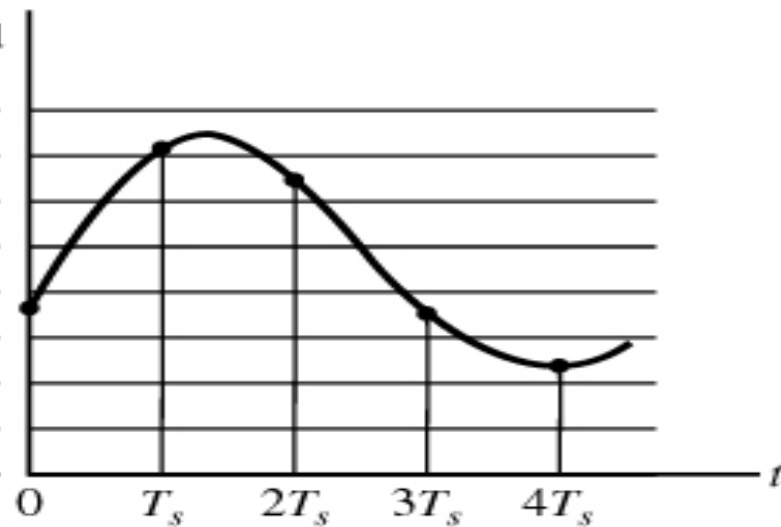
(b)

(c)

Quantization

(b) Analog Signal, Flat-top PAM Signal, and Quantized PAM Signal

Quantization and encoding of a sampled signal

Quantization codes	Normalized amplitude								
7									
6									
5									
4									
3									
2									
1									
0									

Values shown on graph: 7.5, 16.2, 19.7, 11.0, -6.1, -5.5, -11.3, -9.4, -6.0

Normalized PAM values	-1.22	1.50	3.24	3.94	2.20	-1.10	-2.26	-1.88	-1.20
Normalized quantized values	-1.50	1.50	3.50	3.50	2.50	-1.50	-2.50	-1.50	-1.50
Normalized error	-0.38	0	+0.26	-0.44	+0.30	-0.40	-0.24	+0.38	-0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010