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Class: B.Sc. Computer Science (Entire)- III **Semester : 5**

Course Title: Data Communication

UNIT 4
Physical Layer

1. Digital to analog Conversion:

Concept:

- A computer network is designed to send information from one point to another.
- This information needs to be converted either a digital signal or an analog signal for transmission.
- To send the digital data over an analog media , it needs to be converted into analog signals.
- The process or technique of converting digital signal into analog signal is called digital to analog conversion or **Modulation or Shift Keying.**
- Digital to analog conversion is the process of changing one of the characteristic of an analog signal in the digital data.
- An analog signal is characterized by its amplitude, frequency and phase.

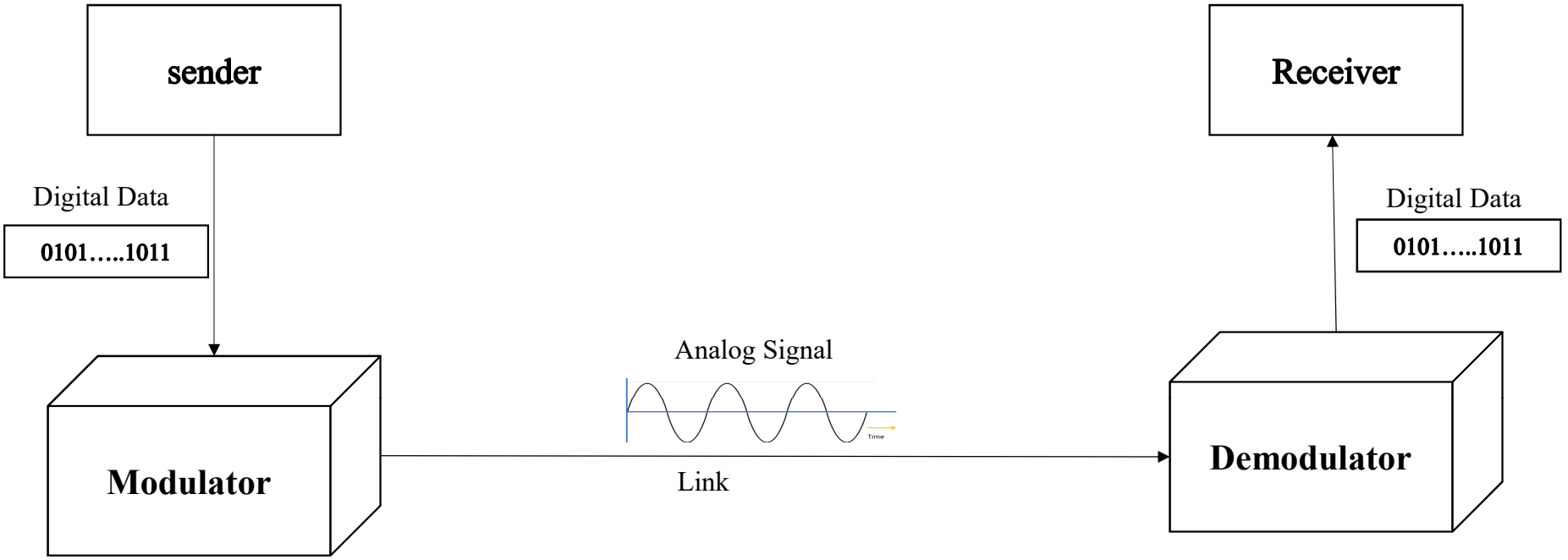


Fig. Digital to Analog Conversion

- **Digital to analog Conversion Methods:**

There are 3 kinds of digital to analog conversion methods.

1. Amplitude Shift Keying (ASK)
2. Frequency Shift Keying (FSK)
3. Phase Shift Keying (PSK)

The two basic issues must be reviewed in Digital to analog conversion .

1. **Bit rate/Data rate:**

   The number of bits of data that are sent each second.

2. **Baud Rate:**

   Baud rate refers to the number of signal or symbol changes that occur per second. A symbol is one of several voltage, frequency, or phase changes.

Amplitude Shift Keying

- Amplitude Shift Keying is a technique in which carrier signal is analog and data to be modulated is digital.
- The **amplitude** of analog carrier signal **is modified** to reflect binary data.
- The binary signal when modulated gives a zero value when the binary data represents 0 while gives the carrier output when data is 1.
- The **frequency and phase** of the carrier signal remain **constant.**
- The main aim of the amplitude shift keying modulation is to changing or improving the voltage characteristics of the input binary signal concerning the carrier signal.
- In amplitude shift keying theory, input binary signal amplitude varies according to the carrier signal voltage.
- In ASK, the input binary signal is multiplied with the carrier signal along with its time intervals.
- Between the first time interval of input binary signal multiplied with the first time interval of carrier signal voltage and the same process continues for all time intervals.

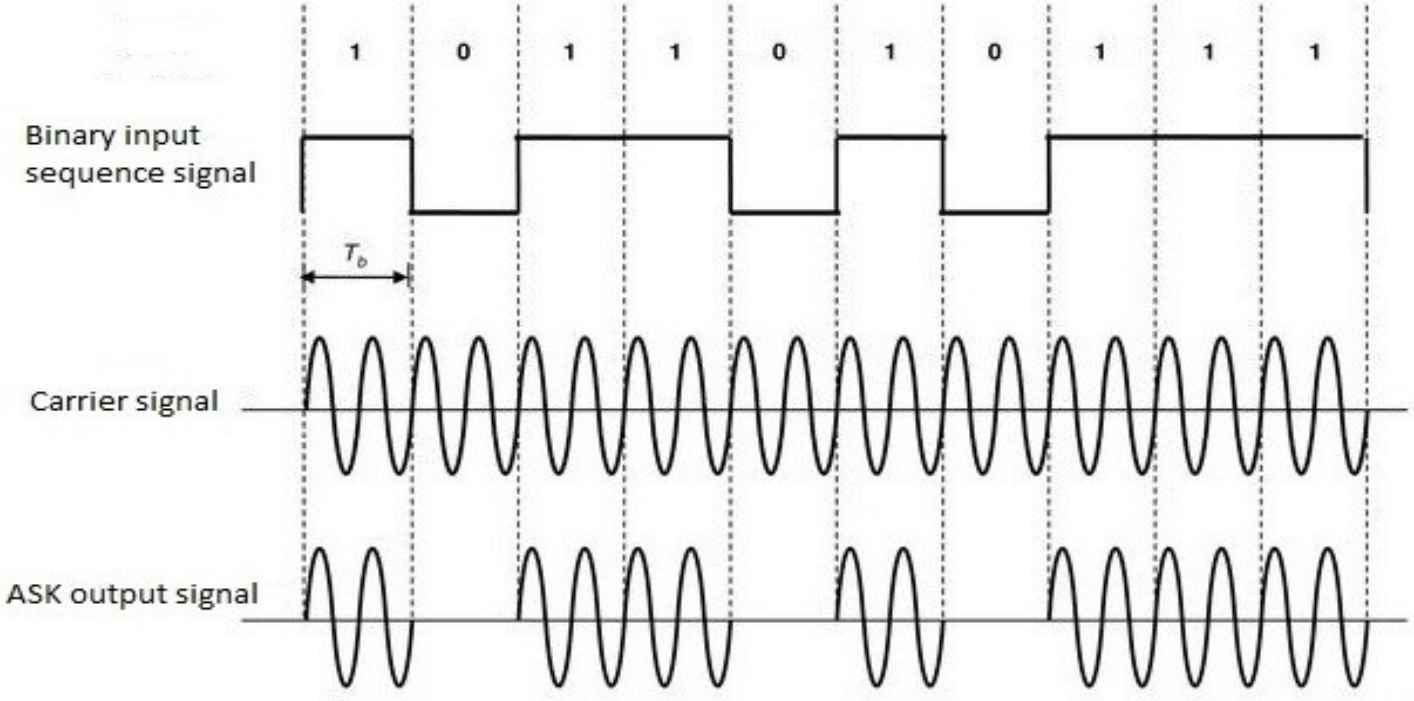


Fig. Amplitude Shift Keying

Diagram Explanation:

- When the switch is closed – for all the logic HIGH time intervals i.e. when the input signal having logic 1 during those intervals the switch is closed and it is multiplied with the carrier signal which is generating from the function generator for the same duration.
- When the switch is opened – when the input signal having logic 0, the switch is opened and there is no output signal will be generated. Because the input binary signal logic 0 having no voltage, so during these intervals when the carrier signal multiples with it, zero output will come. The output is zero for all logic 0 intervals of the input binary signal.

Advantages of amplitude shift Keying :

1. It can be used to transmit digital data over optical fiber.
2. The receiver and transmitter have a simple design which also makes it comparatively inexpensive.
3. It uses lesser bandwidth as compared to FSK thus it offers high bandwidth efficiency.

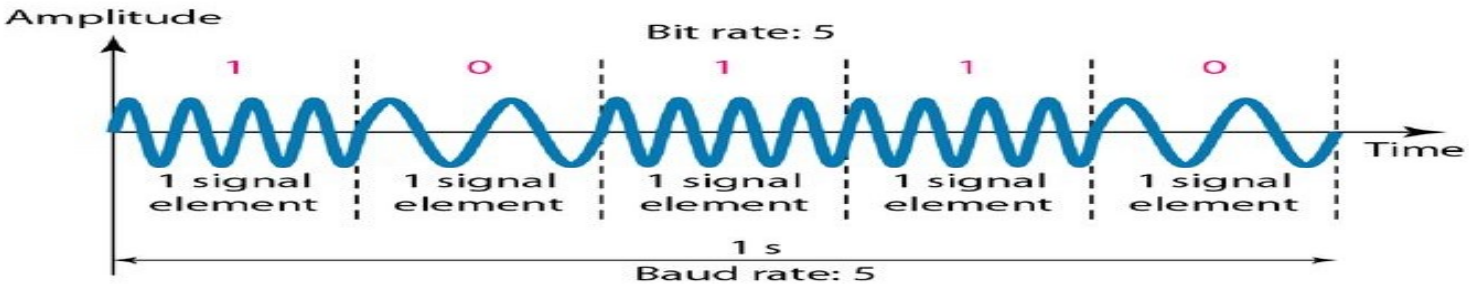
Disadvantages of amplitude shift Keying:

1. It is susceptible to noise interference and entire transmissions could be lost due to this.
2. It has lower power efficiency.

2. Frequency Shift Keying (FSK)

- The frequency shift keying is the most important digital modulation technique, and it is also known as FSK.
- It is defined as the changing or improving the frequency characteristics of an input binary signal according to the carrier signal.
- Amplitude variation is one of the major drawbacks in ASK. So, due to this ask modulation technique used in a few applications only.
- And its spectrum power efficiency also low. It leads to wastage of power.
- So to overcome these drawbacks , Frequency Shift Keying is preferred.
- FSK is also known as Binary Frequency Shift Keying (BFSK).

- The frequency of the carrier signal is varied to represent binary 1 or 0.
- Both peak amplitude and phase remain constant while the frequency changes.
- The frequency of the signal during each bit duration is constant, and its value depends on the bit (0 or 1).



The **output** of a frequency shift keying modulated wave is **high** in frequency **for a binary high input** (i.e. binary 1) and is **low** in frequency **for a binary low input** (i.e. binary 0). The amplitude and phase of the carrier signal remain constant.

- **Advantages of frequency shift Keying :**

1. Frequency shift keying modulated signal can help avoid the noise problems set by ASK.
2. It has lower chances of an error.
3. It provides high signal to noise ratio.
4. The transmitter and receiver implementations are simple for low data rate application.

- **Disadvantages of frequency shift Keying**

1. It uses larger bandwidth as compared to ASK thus it offers less bandwidth efficiency.
2. It has lower power efficiency.

3. Phase Shift keying –

In this modulation the phase of the analog carrier signal is modified to reflect binary data. The amplitude and frequency of the carrier signal remains constant.

It is further categorized as follows:

1. Binary Phase Shift Keying (BPSK):

BPSK also known as phase reversal keying or 2PSK is the simplest form of phase shift keying. The Phase of the carrier wave is changed according to the two binary inputs. In Binary Phase shift keying, difference of 180 phase shift is used between binary 1 and binary 0. This is regarded as the most robust digital modulation technique and is used for long distance wireless communication.

2. Quadrature phase shift keying:

This technique is used to increase the bit rate i.e we can code two bits onto one single element. It uses four phases to encode two bits per symbol. QPSK uses phase shifts of multiples of 90 degrees. It has double data rate carrying capacity compare to BPSK as two bits are mapped on each constellation points.

In phase shift keying, the phase of the carrier is varied to represent two or more different signal elements (Both peak amplitude and frequency remain constant).

In binary PSK, we have only two signal elements: one with a phase of 0° , and the other with a phase of 180°

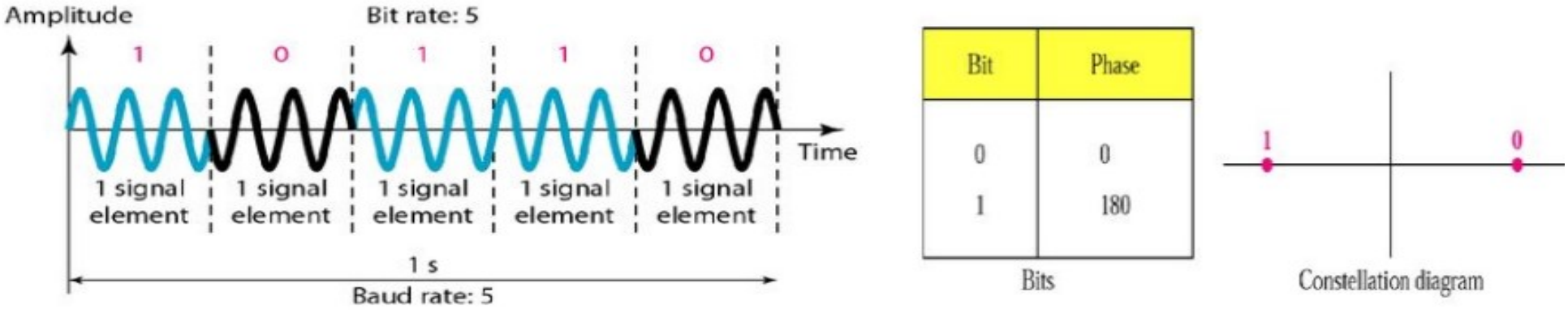


Fig. Phase Shift Keying

Advantages of phase shift Keying –

1. It is a more power efficient modulation technique as compared to ASK and FSK.
2. It has lower chances of an error.
3. It allows data to be carried along a communication signal much more efficiently as compared to FSK.

Disadvantages of phase shift Keying –

1. It offers low bandwidth efficiency.
2. The detection and recovery algorithms of binary data is very complex.
3. It is a non coherent reference signal.

Analog to Digital Conversion:

- If we have an analog signal such as one created by a microphone or camera
- Analog to Digital Conversion is the process in which a continuously variable signal (i.e. analog signal) is changed without altering its essential contents into multilevel (i.e. digital) signal.
- It is also called as Digitization.
- Information in an analog form can't be processed by digital computers so its necessary to convert them into digital form.

- **Analog to Digital Conversion Techniques:**

1. **Pulse Code Modulation (PCM)**
2. **Delta Modulation (DM)**

1. Pulse Code Modulation (PCM)

PCM is the most common technique used to change an analog signal to digital data (digitization).

A PCM encoder has three processes as shown in the following Figure.

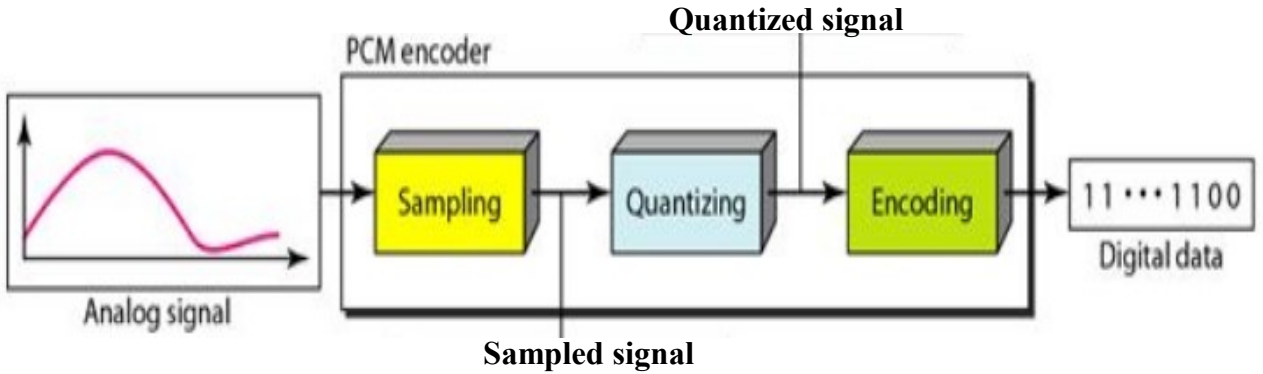


Fig. Components of PCM Encoder

1. **Sampling**
2. **Quantization**
3. **Encoding**

1. Sampling

- The first step in PCM is sampling. The analog signal is sampled every Ts s, where Ts is the sample interval or period.
- The inverse of the sampling interval is called the sampling rate or sampling frequency and denoted by fs,

  Where fs = 1/ Ts.

  Here, fs is minimum sampling frequency and is sometimes called as **Nyquist rate.**

There are three sampling methods:

(i) Ideal Sampling: In ideal Sampling also known as Instantaneous sampling pulses from the analog signal are sampled. This is an ideal sampling method and cannot be easily implemented.

(ii) Natural Sampling: Natural Sampling is a practical method of sampling in which pulse have finite width equal to T. The result is a sequence of samples that retain the shape of the analog signal.

(iii) Flat top sampling: In comparison to natural sampling flat top sampling can be easily obtained. In this sampling technique, the top of the samples remains constant by using a circuit. This is the most common sampling method used.

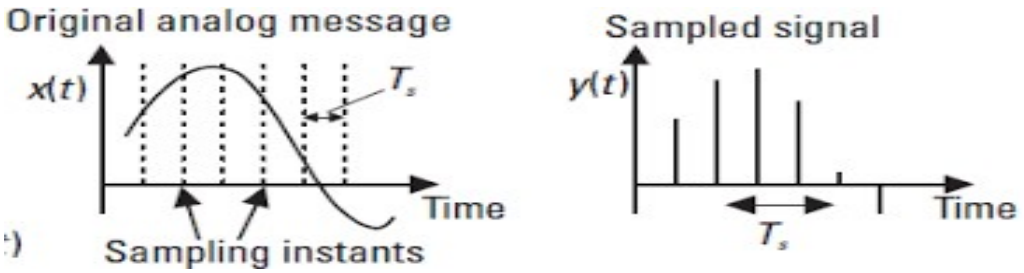


Fig. Sampling in PCM

The sampling rate or frequency must be at least twice the highest frequency in original signal i.e.

$$f_s > f_{max}$$

This is called sampling theorem

2. Quantization:

- To transmit the sampled values via a digital system, we have to represent each sample value in numerical form.
- This requires quantizing where each accurate sample value is rounded off to the closest numerical value in a given numerical set.
- In the quantizing process the information in accurate signal values is lost because of rounding off and the original signal cannot be reproduced exactly any more.
- The more quantum levels we use, the better performance we get.
- For binary coding, the number of quantum levels is

$$q = 2^n$$

where q denotes the number of quantum levels and n is the length in bits of the binary codeword that describe the sample values.

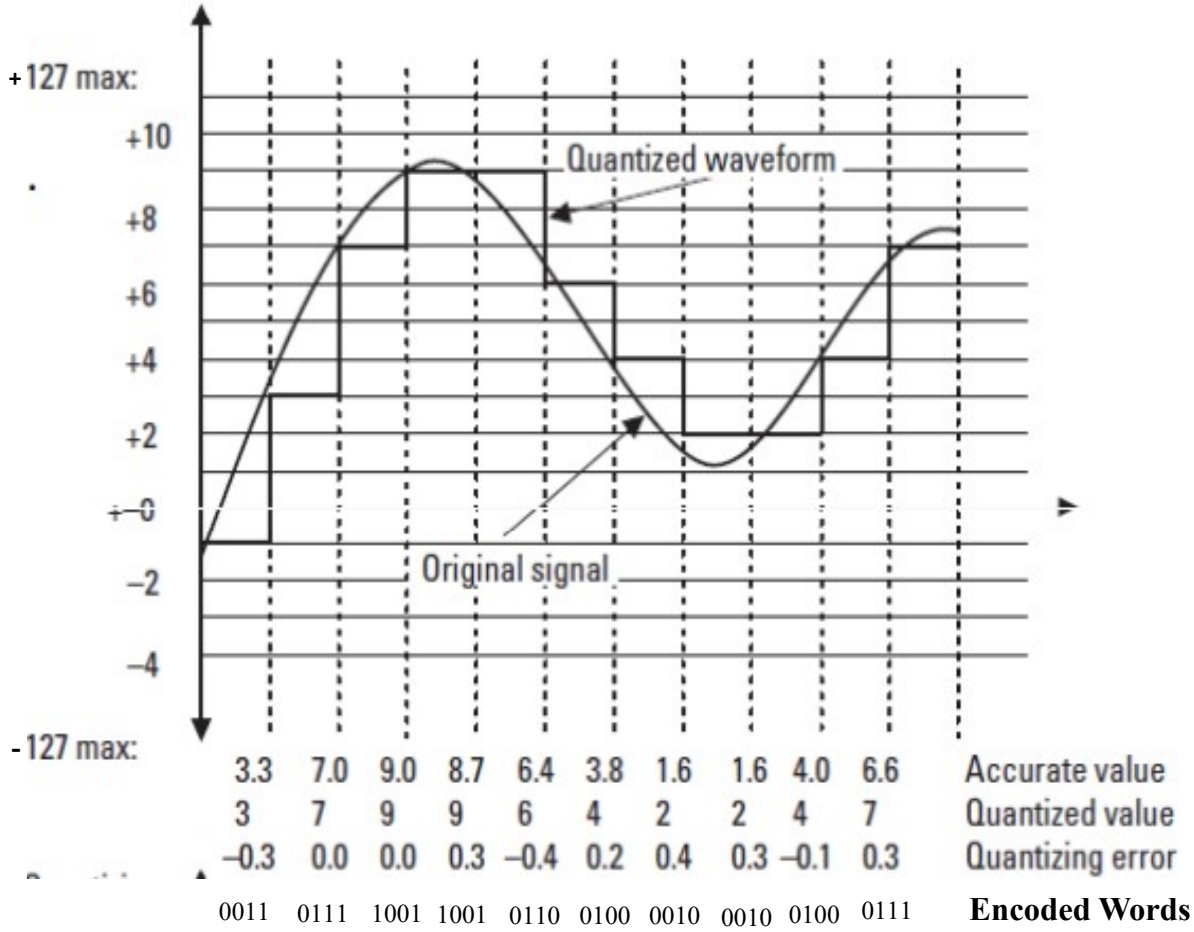


Fig. Quantization and Encoding in PCM

3. Encoding:

- The last step in PCM is encoding.
- After each sample is quantized and the number of bits per sample is decided, each sample can be changed to binary code word.
- As shown in figure a the encoded words are shown in the last row.
- A quantization code of 3 is encoded as 0011, 7 is encoded as 0111 and so on.
- Note that the number of bits for each sample is determined from the number of quantization levels.
- Bit rate can be found from the formula

Bit rate= sampling rate × no.of bits per sample

Bit rate= fs * n

where,

fs=sampling rate

n= no.of bits

- **Advantages of PCM:**

1. Effect of noise is reduced.
2. PCM permits the use of pulse regeneration.
3. Multiplexing of various PCM signal is possible.

- **Disadvantages of PCM:**

1. It has high bandwidth.
2. It is based on the observation that voice signal changes slowly.
3. So the difference between two consecutive sample values instead of sample values may be sent.

2. Delta Modulation (DM)

- DM is another Analog to Digital (A to D) technique that have been developed to reduce the complexity of PCM
- PCM finds the value of the signal amplitude for each sample.
- It is the special case of Differential PCM (DPCM).

Fig. shows the Delta Modulation process.

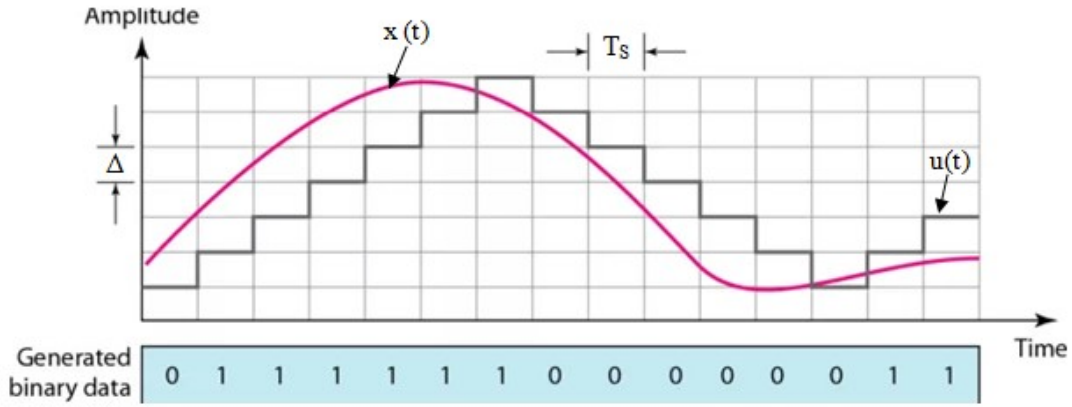


Fig. Delta Modulation

Note that there are no code words here, bits are sent one after another.

- **DM Modulator**

1. The modulator is used at sender site to create a stream of bits from an analog signal.
2. This process records the small positive or negative changes called delta.
3. If delta is **positive**, the process **records 1** and if it is **negative** then it **records 0**.
4. The process needs a base against which the analog signal is compared.
5. The modulator builds a second signal that resembles a staircase.
6. Finding the change is then reduced to compare the input signal with the gradually made staircase signal.

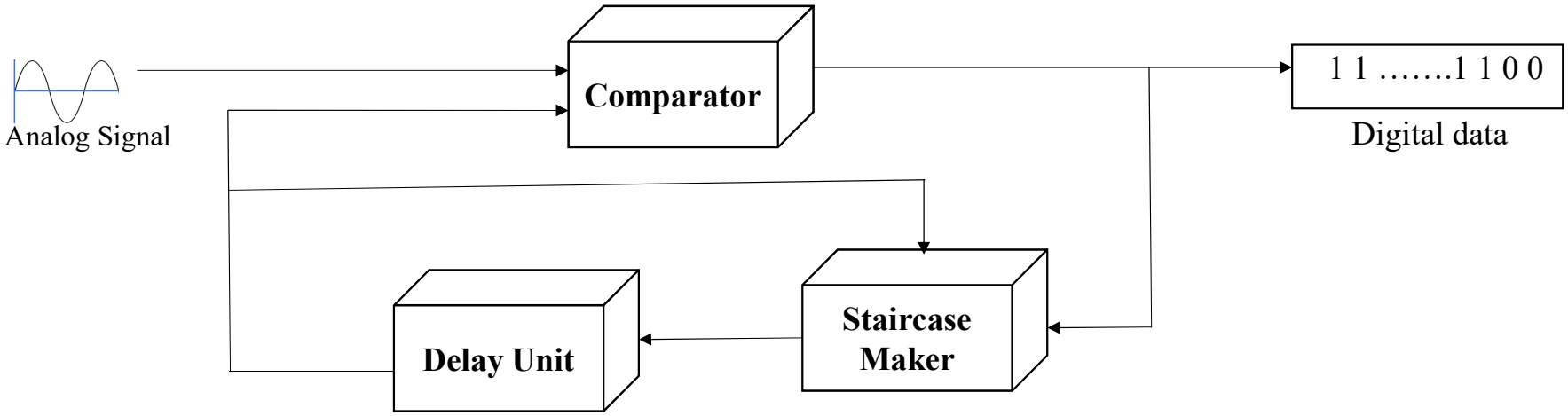


Fig a. Delta Modulation Components

7. The modulator, at each sampling interval compares the value of an analog signal with last value of the staircase signal .
8. If the amplitude of the analog signal is larger , the next bit in the digital data is 1 otherwise it is 0.
9. The output of the comparator, however also makes the staircase itself.
10. If the next bit is 1 the staircase maker moves the last point of staircase signal delta up.
11. If the next bit is 0 then it moves it delta down.
12. Note that we need a delay unit to hold the staircase function for a period between two comparisons

- **Advantages of DM:**

1. Simple to implement.
2. Each sample represented by a single binary digit which makes it more efficient than PCM.
3. It is widely used in voice transmission application such as telephone and TV communication.
4. It is applied, where timely data delivery at receiver end is more important than data quality.
5. Lower bandwidth consumption.
6. Lower noise.
7. Cost effective.

- **Disadvantages of DM**

1. Fixed step size leads to overloading.
2. Slope overloaded.

THANK YOU…