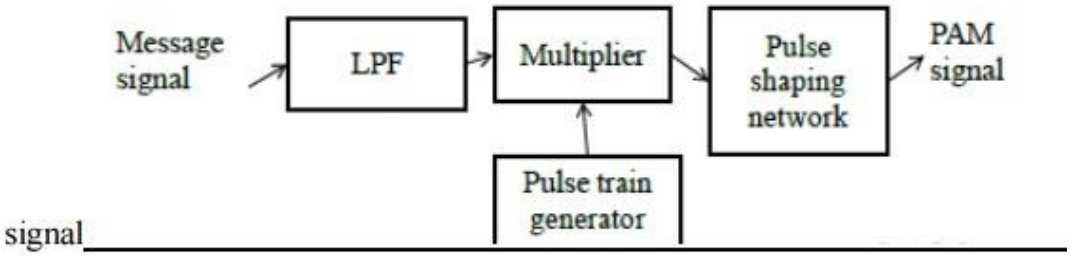
2.2 PULSE AMPLITUDE MODULATION

PAM Modulator

The amplitude of a carrier pulse is altered in accordance to that of amplitude of message signal to make it accommodate the information signal.

- Message signal is transmitted to LPF
- LPF performs band limiting.
- Band limited signal is then sampled at the multiplier.
- Multiplier samples with the help of pulse train generator
- Pulse train generator produces the pulse train
- The multiplication of message signal and pulse train produces PAM



PAM DEMODULATOR:

PAM SIGNAL --→ RECONSTRUCTION FILTER ------→ RECONSTRUCTED PAM SIGNAL

Figure 2.2.1 PAM Modulator

LINE CODING:

Line coding (also called **digital baseband modulation** or digital baseband transmission) is a process carried out by a transmitter that converts data, in the form of binary digits, into a baseband digital signal that will represent the data on a transmission line.

Types of Line Coding

There are 3 types of Line Coding

- Unipolar
- Polar
- Bi-polar

Unipolar Signaling

Unipolar signaling is also called as **On-Off Keying** or simply **OOK**.

The presence of pulse represents a **1** and the absence of pulse represents a **0**.

There are two variations in Unipolar signaling −

- Non Return to Zero NRZNRZ
- Return to Zero RZRZ

Unipolar Non-Return to Zero NRZNRZ

In this type of unipolar signaling, a High in data is represented by a positive pulse called as **Mark**, which has a duration T_0 equal to the symbol bit duration. A Low in data input has no pulse.

The following figure clearly depicts this.

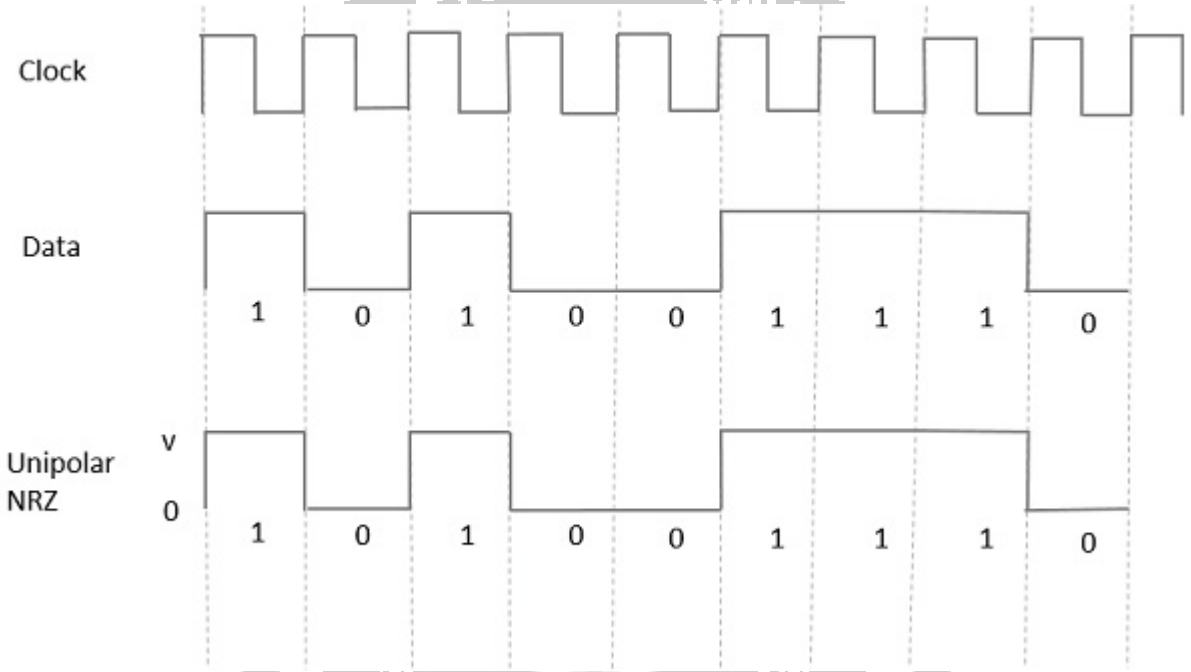


Figure 2.2.2 Unipolar Non-Return to Zero NRZNRZ

Advantages

The advantages of Unipolar NRZ are −

- It is simple.
- A lesser bandwidth is required.

Disadvantages

The disadvantages of Unipolar NRZ are −

- No error correction done.
- Presence of low frequency components may cause the signal droop.
- No clock is present.

- Loss of synchronization is likely to occur (especially for long strings of **1s** and **0s**).

Unipolar Return to Zero RZRZ

In this type of unipolar signaling, a High in data, though represented by a **Mark pulse**, its duration $\mathbf{T_0}$ is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration.

It is clearly understood with the help of the following figure.

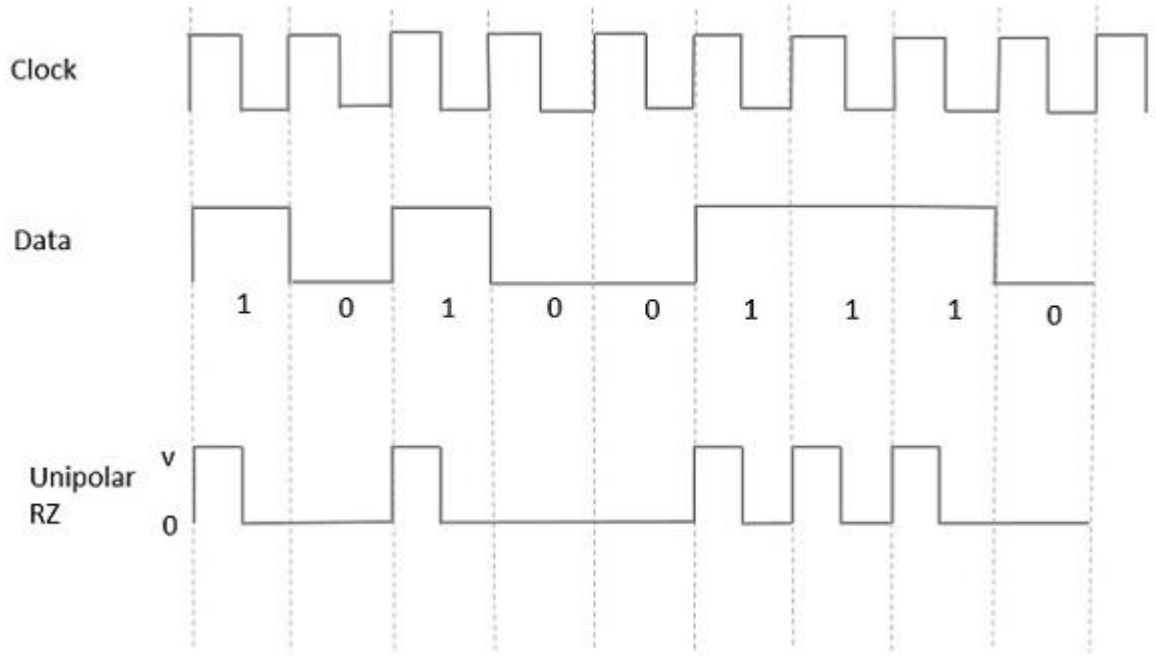


Figure 2.2.3. Unipolar Return to Zero RZRZ

Advantages

The advantages of Unipolar RZ are −

- It is simple.
- The spectral line present at the symbol rate can be used as a clock.

Disadvantages

The disadvantages of Unipolar RZ are −

- No error correction.
- Occupies twice the bandwidth as unipolar NRZ.
- The signal droop is caused at the places where signal is non-zero at 0 Hz.

Polar Signaling

There are two methods of Polar Signaling. They are −

- Polar NRZ
- Polar RZ

Polar NRZ

In this type of Polar signaling, a High in data is represented by a positive pulse, while a Low in data is represented by a negative pulse. The following figure depicts this well.

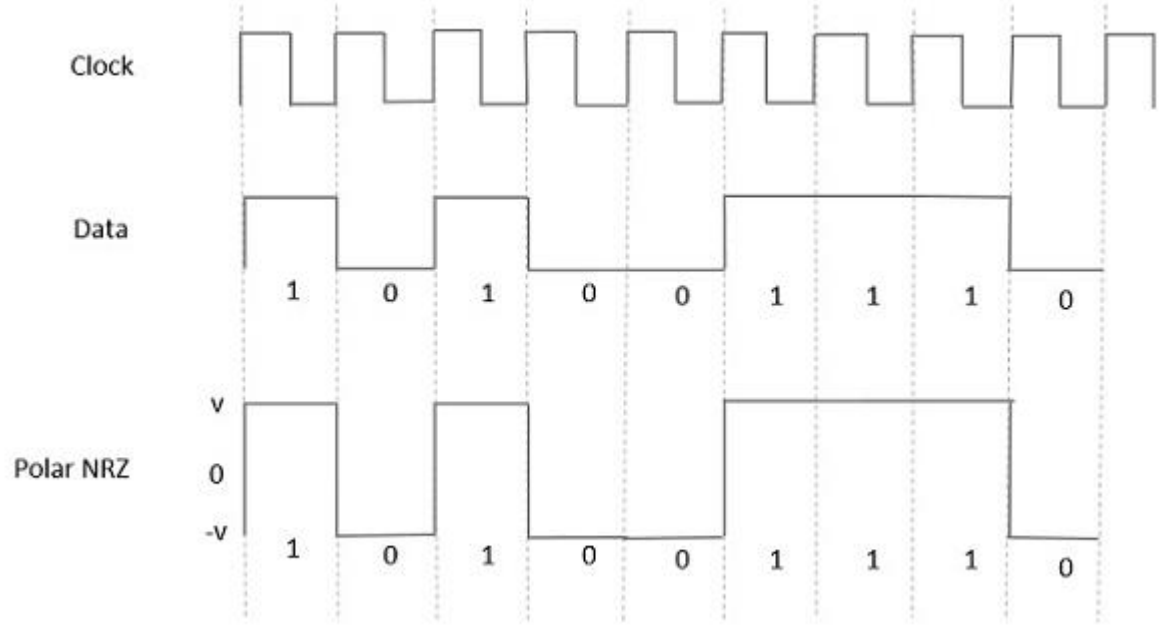


Figure 2.2.4 Polar NRZ

Advantages

The advantages of Polar NRZ are −

- It is simple.
- No low-frequency components are present.

Disadvantages

The disadvantages of Polar NRZ are −

- No error correction.
- No clock is present.

- The signal droop is caused at the places where the signal is non-zero at **0 Hz**.

Polar RZ

In this type of Polar signaling, a High in data, though represented by a **Mark pulse**, its duration $\mathbf{T_0}$ is less than the symbol bit duration. Half of the bit duration remains high but it immediately returns to zero and shows the absence of pulse during the remaining half of the bit duration.

However, for a Low input, a negative pulse represents the data, and the zero level remains same for the other half of the bit duration. The following figure depicts this clearly.

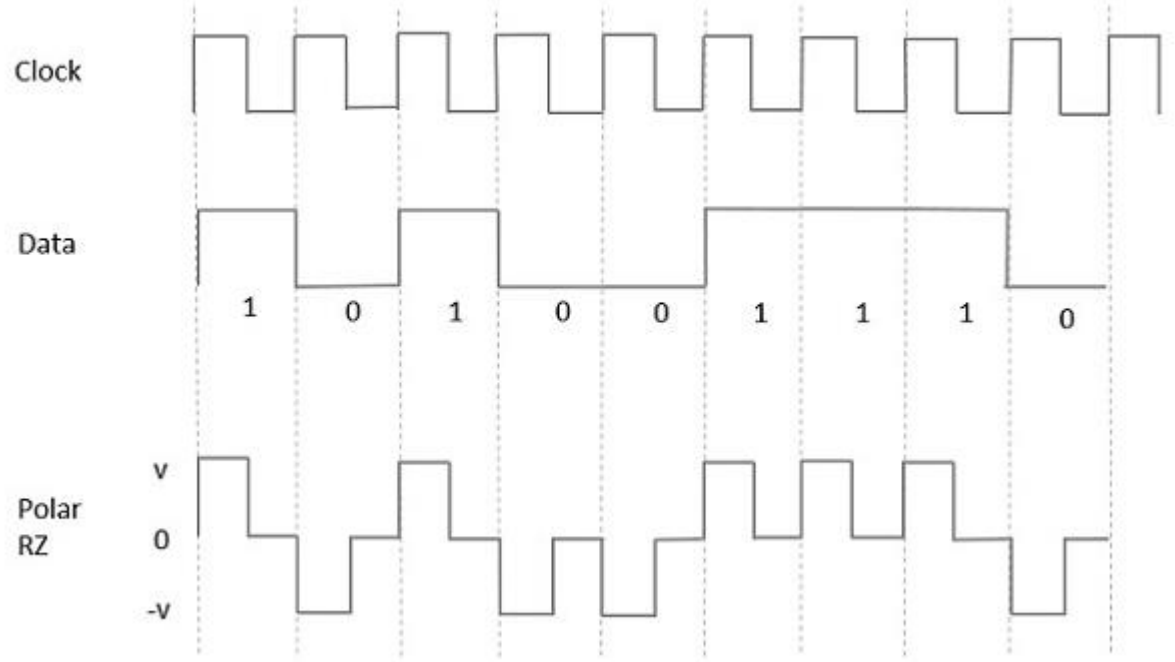


Figure 2.2.5 Polar RZ

Advantages

The advantages of Polar RZ are −

- It is simple.
- No low-frequency components are present.

Disadvantages

The disadvantages of Polar RZ are −

- No error correction.
- No clock is present.

- Occupies twice the bandwidth of Polar NRZ.
- The signal droop is caused at places where the signal is non-zero at **0 Hz**.

Bipolar Signaling

This is an encoding technique which has three voltage levels namely **+, -** and **0**. Such a signal is called as **duo-binary signal**.

An example of this type is **Alternate Mark Inversion** AMIAMI. For a **1**, the voltage level gets a transition from + to – or from – to +, having alternate **1s** to be of equal polarity. A **0** will have a zero voltage level.

Even in this method, we have two types.

- Bipolar NRZ
- Bipolar RZ

From the models so far discussed, we have learnt the difference between NRZ and RZ. It just goes in the same way here too. The following figure clearly depicts this.

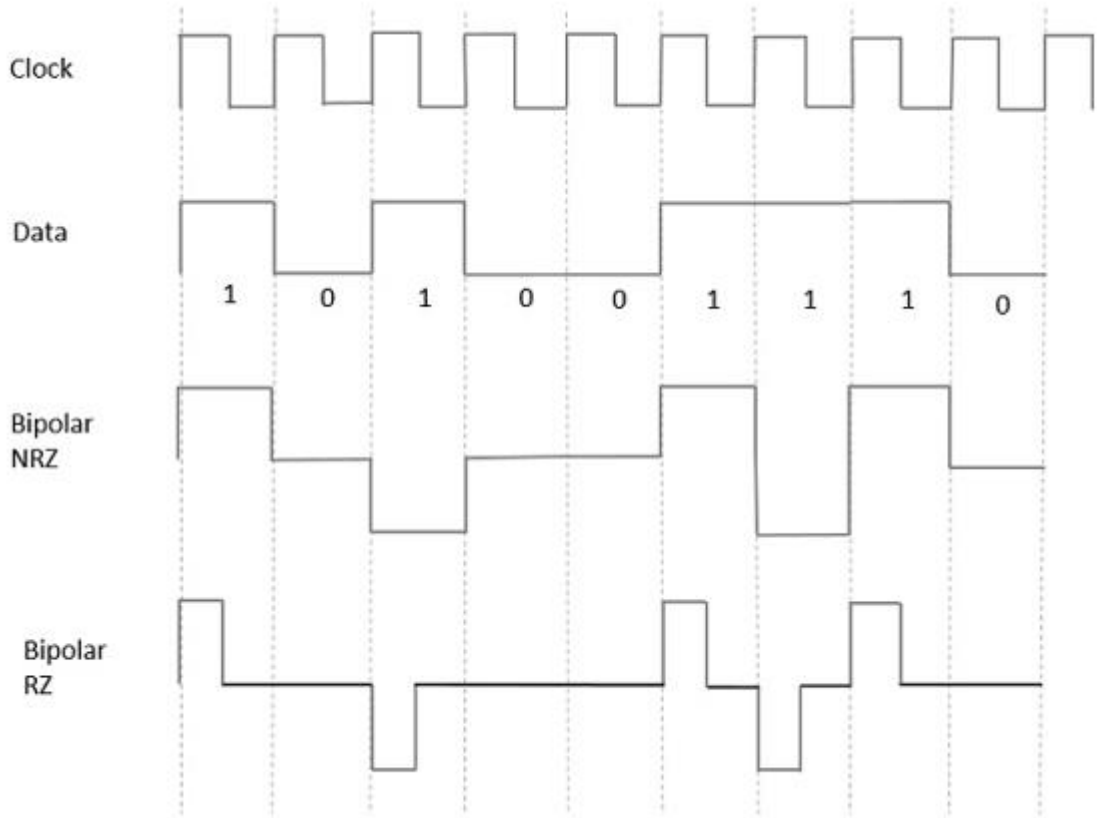


Figure 2.2.6 Bipolar NRZ

The above figure has both the Bipolar NRZ and RZ waveforms. The pulse duration and symbol bit duration are equal in NRZ type, while the pulse duration is half of the symbol bit duration in RZ type.

Advantages

Following are the advantages −

- It is simple.
- No low-frequency components are present.
- Occupies low bandwidth than unipolar and polar NRZ schemes.
- This technique is suitable for transmission over AC coupled lines, as signal drooping doesn't occur here.
- A single error detection capability is present in this.

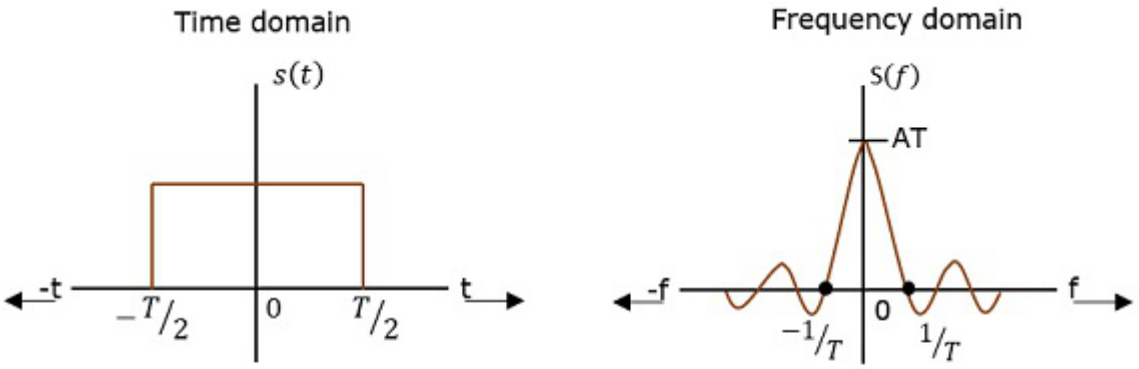
Disadvantages

Following are the disadvantages −

- No clock is present.
- Long strings of data causes loss of synchronization.

Power Spectral Density

The function which describes how the power of a signal got distributed at various frequencies, in the frequency domain is called as **Power Spectral Density** PSDPSD.
PSD is the Fourier Transform of Auto-Correlation SimilaritybetweenobservationsSimilaritybetweenobservations. It is in the form of a rectangular pulse.



$$s(t) = A \quad |t| < T/2$$
$$= 0 \quad |t| > T/2$$

$$s(f) = AT\frac{\sin(\pi Tf)}{\pi Tf}$$

Figure 2.2.7 Power Spectral Density