ANSWER TO THE QUESTION NO 1

Line coding refers to the process of converting digital data into digital signals. Whenever we transmit data it is in the form of digital signals, so with the help of line coding, we can convert a sequence to bits (or encoding) into a digital signal which then again converted into bits by the receiver (or can be said as decoded by the receiver). For all this to happen we need line coding schemes which could also be able to avoid overlapping and distortion of signals.

Some necessary characteristics of line coding schemes:

- Less complexity.
- Should have noise and interference tolerance.
- No DC component (or say low-frequency component) should be there because it can't be transferred to larger distances.
- Least baseline wandering should be there (baseline wander: low-frequency noise having nonlinear and non-stationary nature).
- Should have error detection capability.
- Should be self-synchronized.

So in this article we are going to talk about three types of line coding schemes:
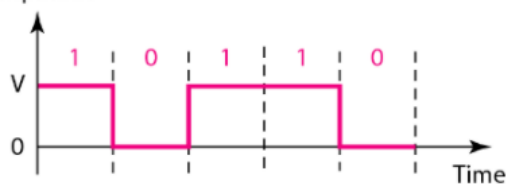
1. Unipolar
2. Polar
3. Bipolar
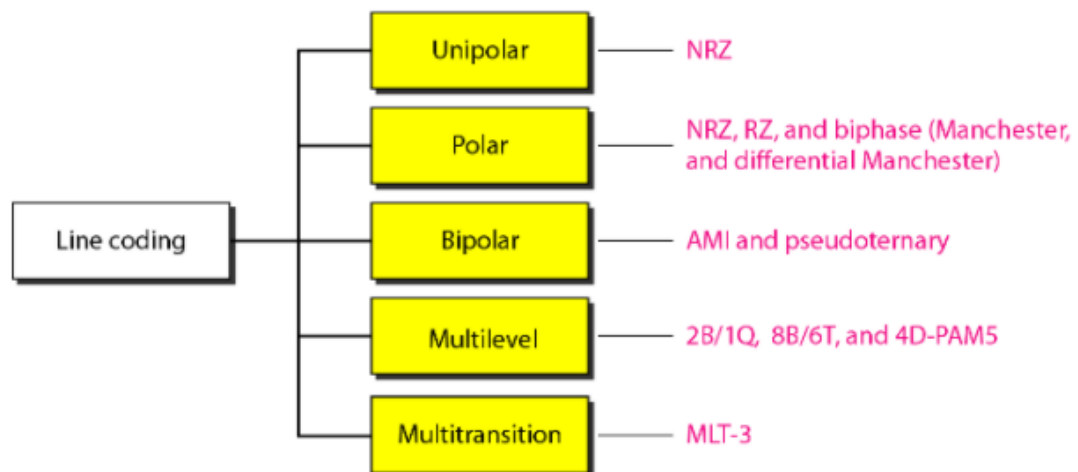
Unipolar Scheme

- One polarity: one level of signal voltage
- Unipolar NRZ (None-Return-to-Zero) is simple, but
  - DC component : Cannot travel through microwave or transformer
  - Synchronization : Consecutive 0's and 1's are hard to be synchronized →
    Separate line for a clock pulse
  - **Normalized power** is double that for polar NRZ
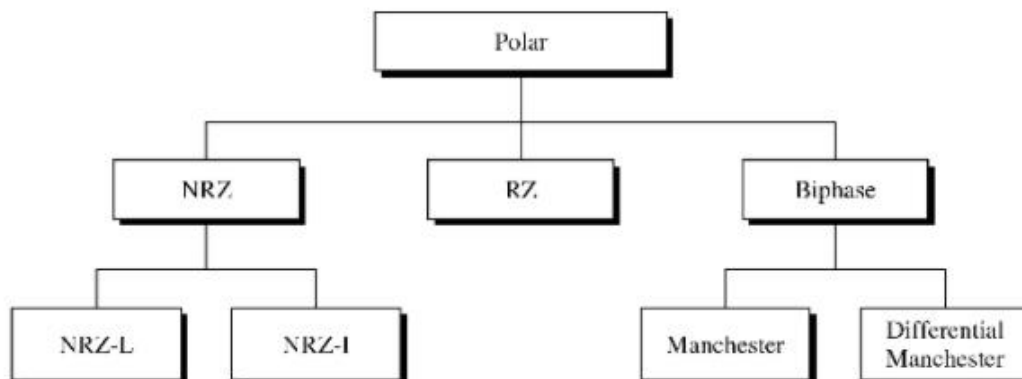
Amplitude

$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

Normalized power

Polar Scheme

- Two polarity: two levels of voltage
- Problem of DC component is alleviated (NRZ,RZ) or eliminated (Biphaze)

Bipolar Scheme

- Three levels of voltage, called "multilevel binary"
- Bit 0: zero voltage, bit 1: alternating +1/-1
  - (Note) In RZ, zero voltage has no meaning
- AMI (Alternate Mark Inversion) and pseudoternary
  - Alternative to NRZ with the same signal rate and no DC component problem
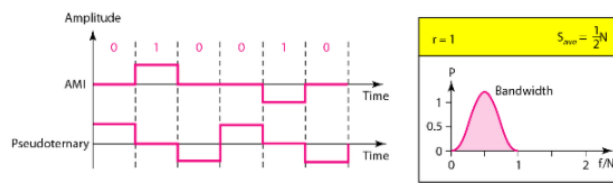
Multilevel Scheme

- To increase the number of bits per baud by encoding a pattern of m data elements into a pattern of n signal elements
- In $mBnL$ schemes, a pattern of m data elements is encoded as a pattern of n signal elements in which $2^m \leq L^n$
- 2B1Q (two binary, one quaternary)
- 8B6T (eight binary, six ternary)
- 4D-PAM5 (four-dimensional five-level pulse amplitude modulation)

ANSWER TO THE QUESTION NO 2

Summary of line coding schemes

Category	Scheme	Bandwidth (average)	Characteristics
Unipolar	NRZ	$B = N/2$	Costly, no self-synchronization if long 0s or 1s, DC
Unipolar	NRZ-L	$B = N/2$	No self-synchronization if long 0s or 1s, DC
	NRZ-I	$B = N/2$	No self-synchronization for long 0s, DC
	Biphase	$B = N$	Self-synchronization, no DC, high bandwidth
Bipolar	AMI	$B = N/2$	No self-synchronization for long 0s, DC
Multilevel	2B1Q	$B = N/4$	No self-synchronization for long same double bits
	8B6T	$B = 3N/4$	Self-synchronization, no DC
	4D-PAM5	$B = N/8$	Self-synchronization, no DC
Multiline	MLT-3	$B = N/3$	No self-synchronization for long 0s