Open system Interconnection (OSI)

Digital to Diigital Conversion or Line Coding

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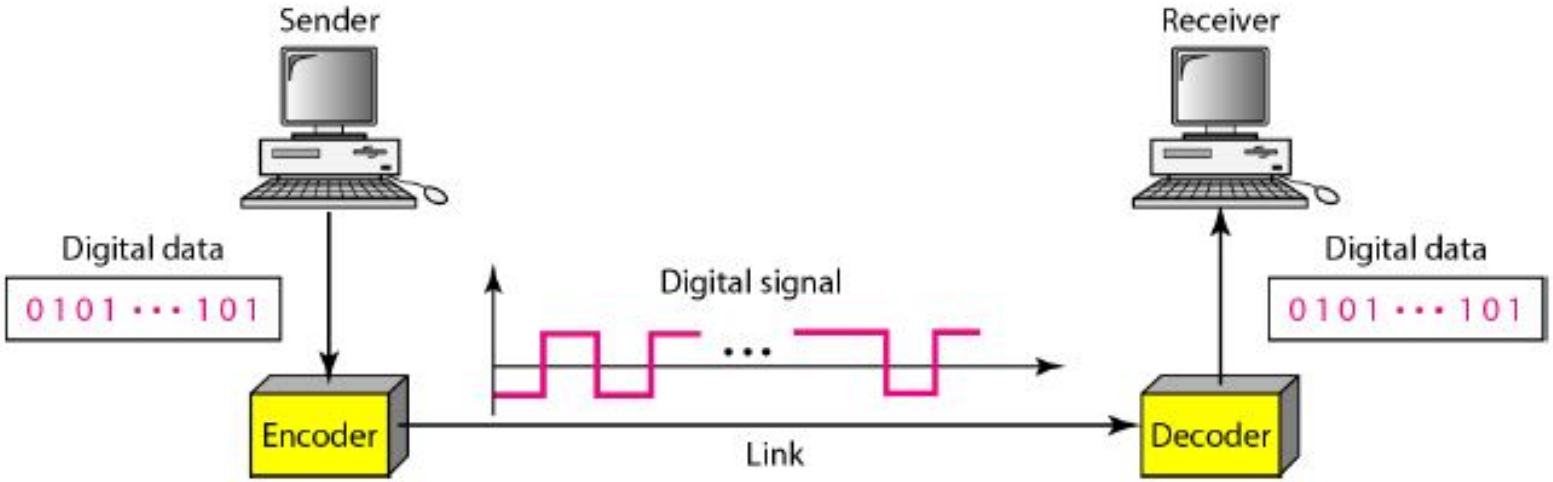
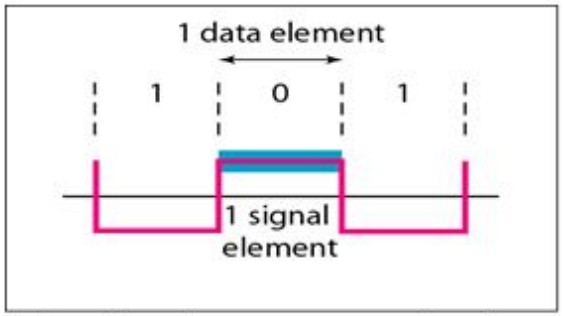
Line Coding

- Line coding is the process of converting digital data to digital signals.
- We assume that data, in the form of text, numbers, graphical images, audio, or video, are stored in computer memory as sequences of bits.
- At the sender, digital data are encoded into a digital signal; at the receiver, the digital data are recreated by decoding the digital signal

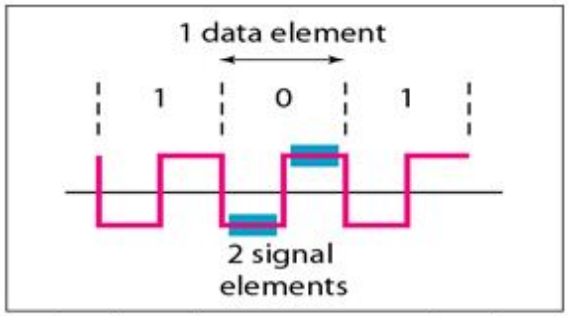


Signal Element Versus Data Element

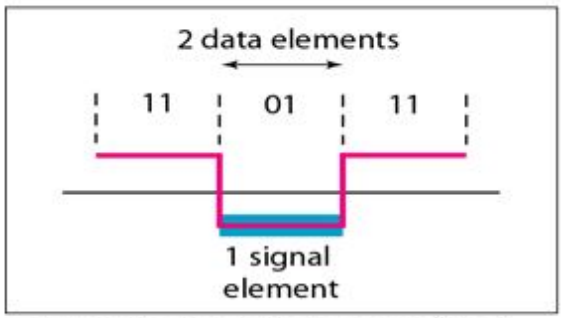
- A data element is the smallest entity that can represent a piece of information (bits).
- Signal element carries data elements (timewise)



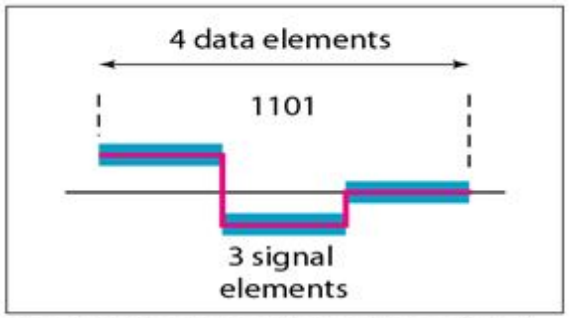
a. One data element per one signal element (r = 1)



b. One data element per two signal elements $\left(r = \frac{1}{2}\right)$



c. Two data elements per one signal element (r = 2)



d. Four data elements per three signal elements $\left(r = \frac{4}{3}\right)$

Data Rate Versus Signal Rate

- The data rate defines the number of data elements (bits) sent in Is (bps).
- The signal rate is the number of signal elements sent in Is (baud rate)
- The data rate is sometimes called the **bit rate**.
- Signal rate is sometimes called the **pulse rate**, the **modulation rate**, or the **baud rate**.
- **Increasing the data rate increases the speed of transmission**
- **Decreasing the signal rate decreases the bandwidth requirement**
- We can formulate the relationship between data rate and signal rate as:

$$S = c \times N \times \frac{1}{r}$$

where N is the data rate (bps);
c is the case factor, which varies for each case;
S is the number of signal elements;
and r is the previously defined factor

Bandwidth Vs Baud rate

- The bandwidth of a nonperiodic signal is continuous with an infinite range
- Most digital signals we encounter in real life have a finite bandwidth.
- The **baud rate**, not the bit rate, **determines the required bandwidth for a digital signal**.
- The bandwidth reflects the range of frequencies we need.
- A relationship between the baud rate (signal rate) and the bandwidth.

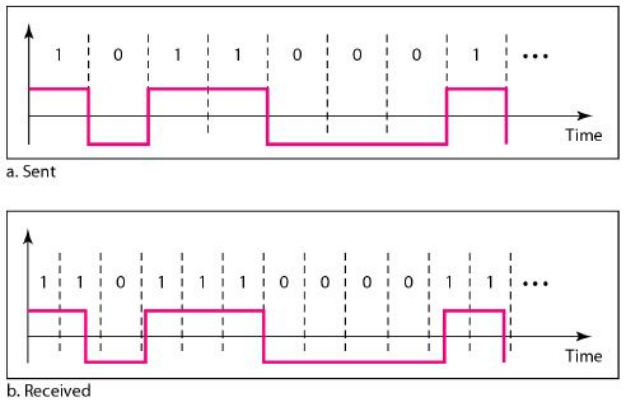
$$B_{min} = cxNx\frac{1}{r}$$

We can solve for the maximum data rate if the bandwidth of the channel is given.

$$N_{max} = \frac{1}{c}xBxr$$

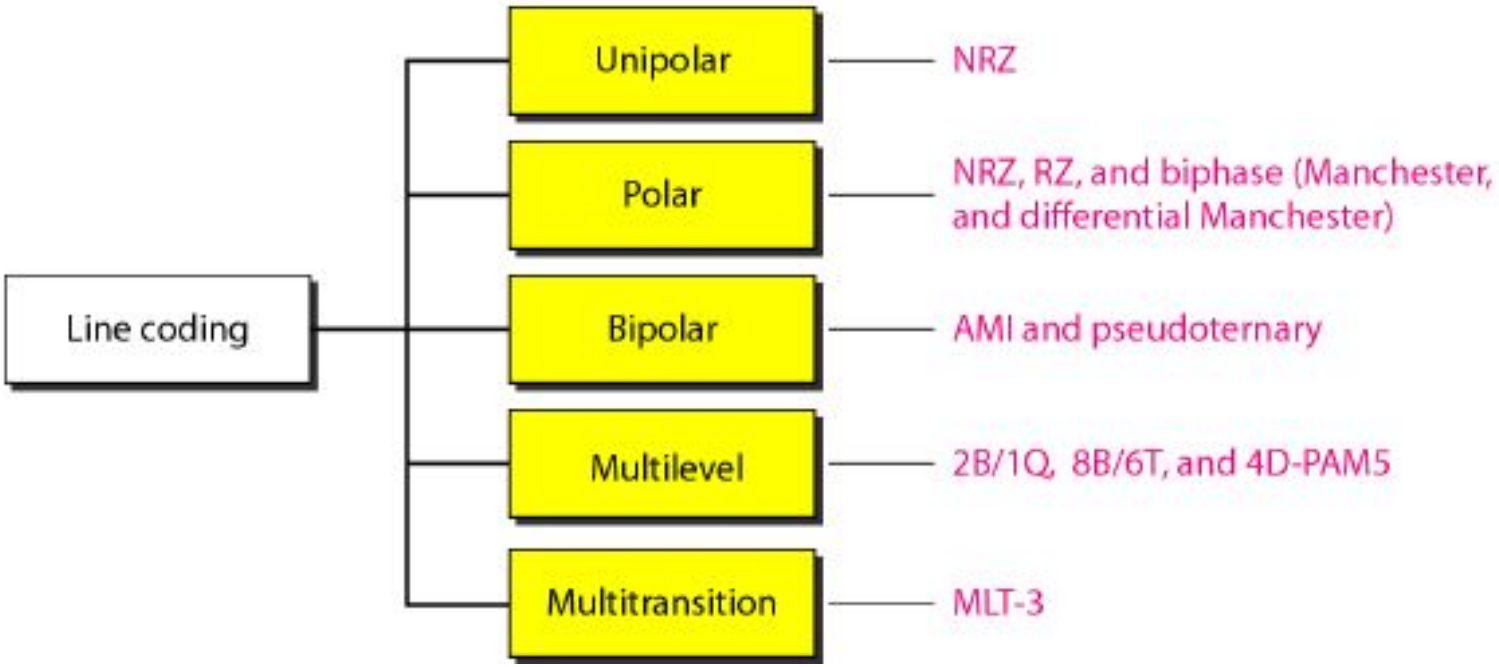
Baseline Wandering

- In decoding a digital signal, the receiver calculates a running average of the received signal power.
- A long string of 0s or 1s can cause a drift in the baseline (baseline wandering) and make it difficult for the receiver to decode correctly
- A good line coding scheme needs to prevent baseline wandering and also support the following:
  - **DC Components**
  - **Self-synchronization**
  - **Built-in Error Detection**
  - **Immunity to Noise and Interference**
  - **Complexity**



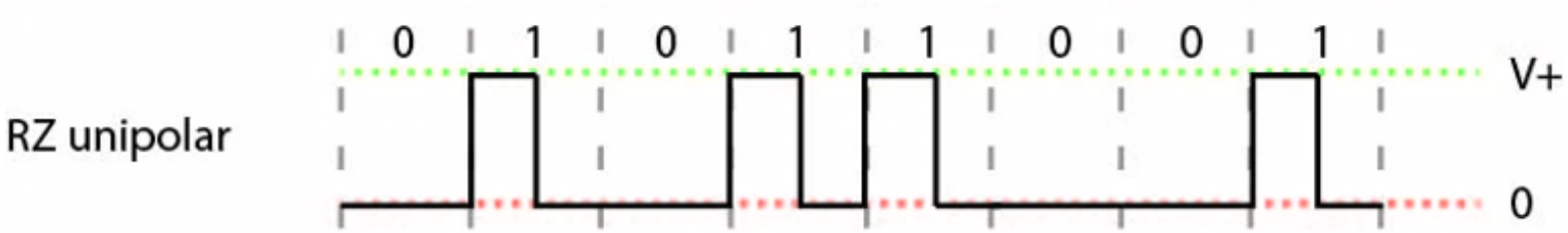
Line Coding Schemes

- We can roughly divide line coding schemes into five broad categories:
  - **Unipolar:** Only one voltage level (+v) other than 0
  - **Polar:** It uses two voltage level (+v/2,-v/2) other than 0
  - **Bipolar:** It uses three voltage level (+v,-v) other than 0

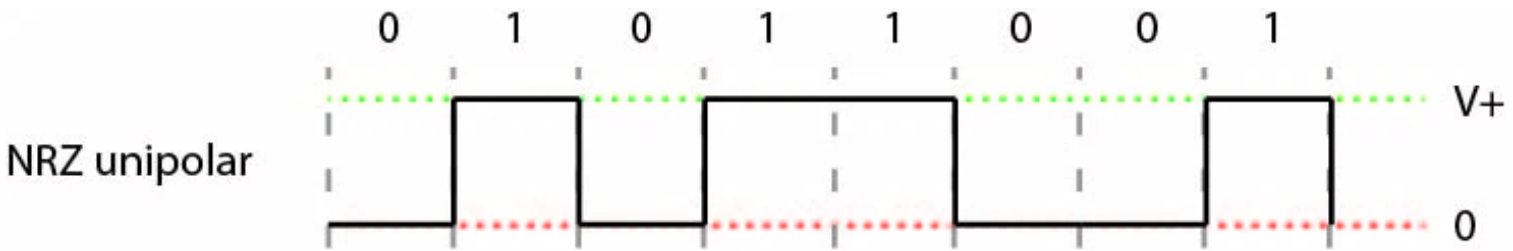


Unipolar RZ & NRZ format

- **RZ format:**
  - Each 0 off pulse with zero amplitude (A) for entire bit period (Tb).
  - Each 1 on pulse with positive amplitude (+A) for half bit period (Tb/2).

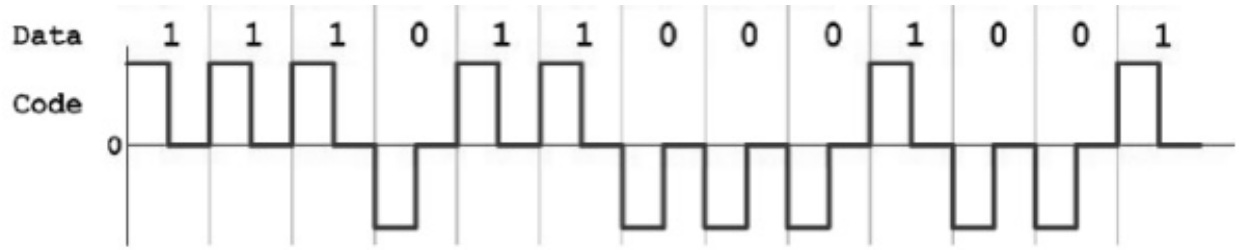


- **NRZ format:**
  - Each 0 off pulse with zero amplitude (A) for entire bit period (Tb).
  - Each 1 on pulse with pos amplitude (+A) for entire bit period (Tb).



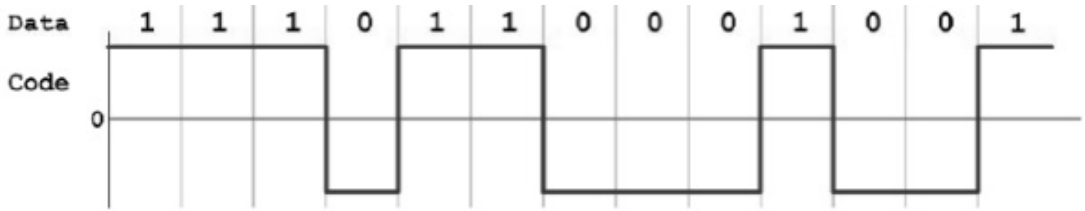
Polar RZ & NRZ format

- **RZ format:**
  - Each 0 off pulse with neg half amplitude (-A/2) for half bit period (Tb/2).
  - Each 1 on pulse with pos half amplitude (+A/2) for half bit period (Tb/2).



Polar RZ Code

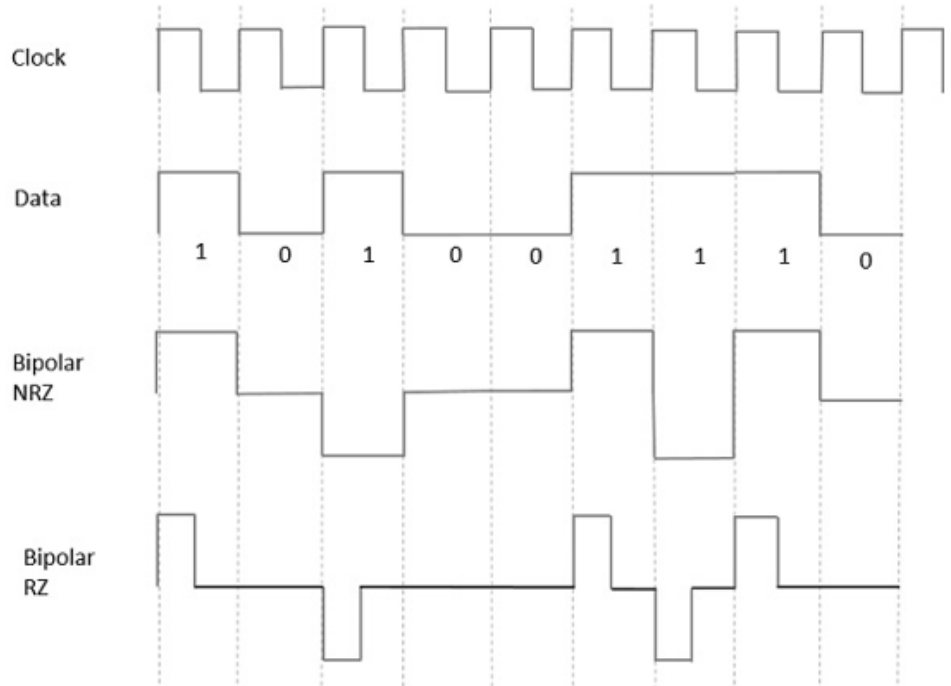
- **NRZ format:**
  - Each 0 off pulse with neg half amplitude (-A/2) for entire bit period (Tb).
  - Each 1 on pulse with pos half amplitude (+A/2) for entire bit period (Tb).



Polar NRZ Code

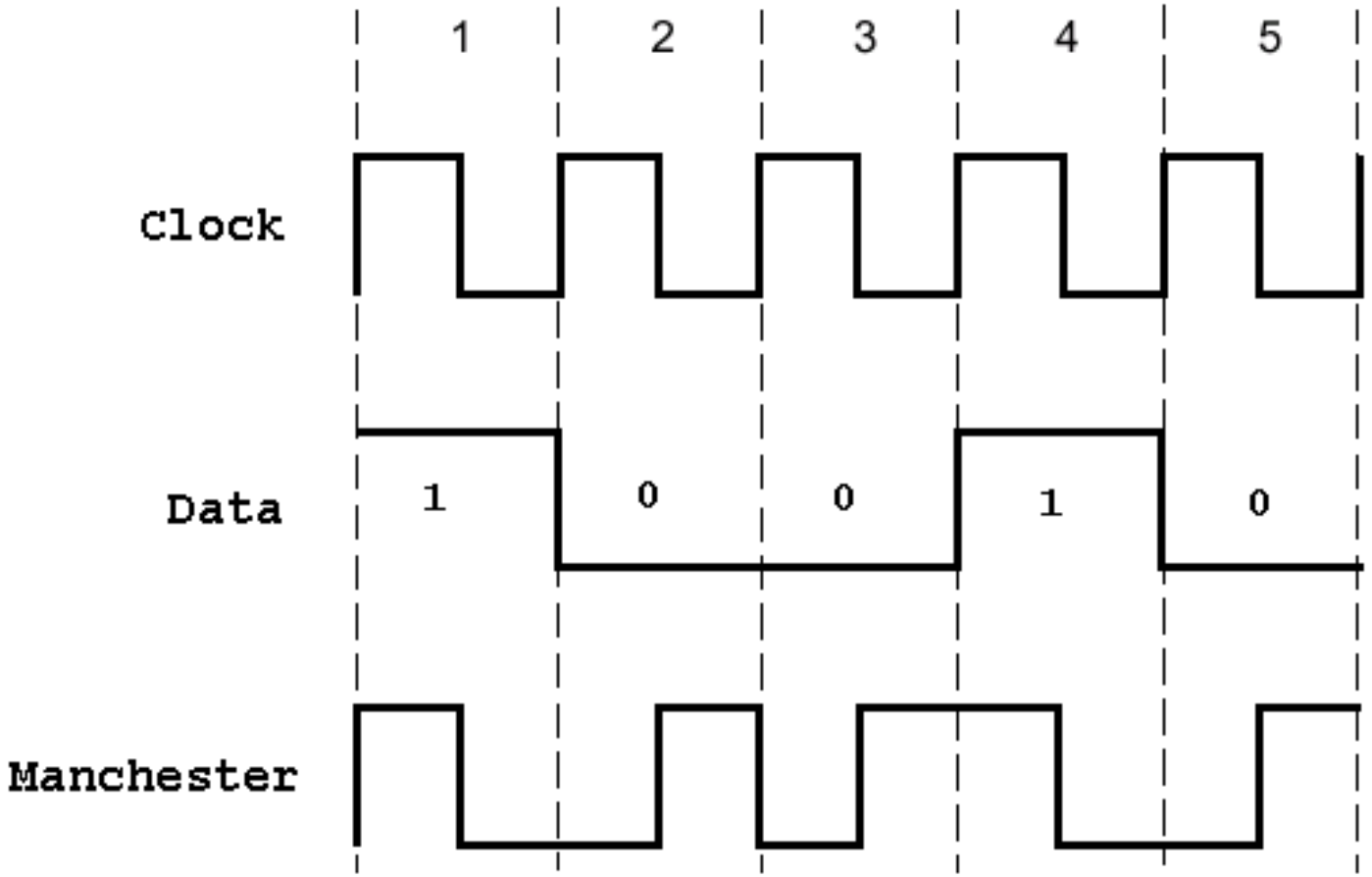
BiPolar NRZ format

- **RZ format:**
  - Each 0 off pulse with for entire bit period (Tb).
  - Successive 1 on pulse are represented with reverse polarity with amplitude (+A,-A) for half bit period (Tb/2)
- **NRZ format:**
  - Each 0 off pulse with for entire bit period (Tb).
  - Successive 1 on pulse are represented with reverse polarity with amplitude (+A,-A) for entire bit period (Tb).



Split Phase Manchester Encoding

- Each 1 on pulse with amplitude of (+A/2) for bit period of (Tb/2) and rest amplitude of (-A/2) for bit peiod of (Tb/2)
- Each 0 off pulse is reserves of 1



Assignement

- Find out rest of the other line coding format.
- Map the encoding scheme with transmission media interfaces:
  - Ethernet
  - Fiber optics
  - Wireless media
  - Other medias
- Find out the merits and demerits of each line coding format.
- You all can decided and fix the deadline for submission of this assignment, and let me know the deadline.

Thank You