Digital transmission

Digital Transmission

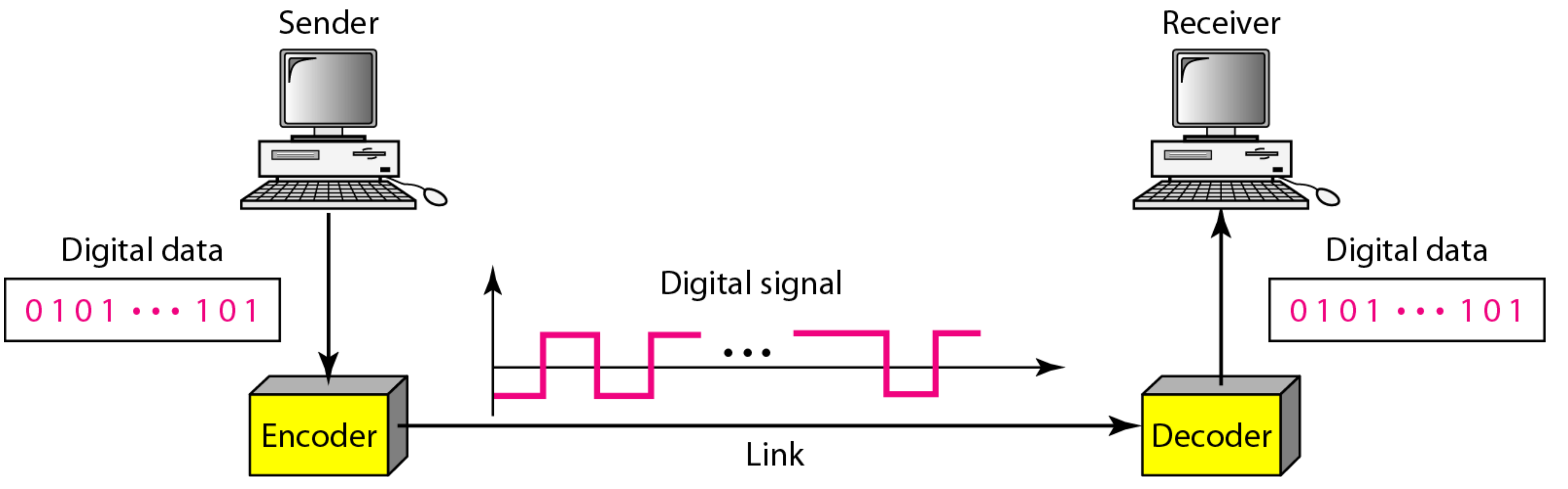
- **Digital to digital conversion**
- **Analog to digital conversion**

Digital to digital conversion

- **Line coding**
- **Block coding**
- **Scrambling**

optional

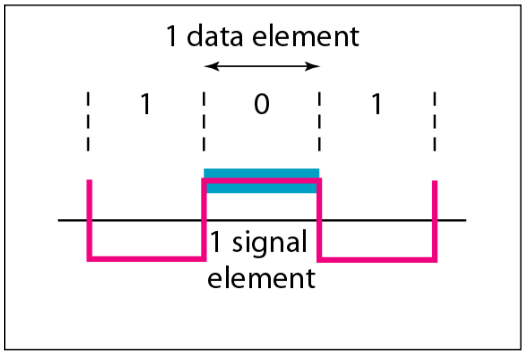
Line coding


Sender
Receiver
Digital data
0101 ••• 101
Digital signal
•••
Digital data
0101 ••• 101
Encoder
Link
Decoder

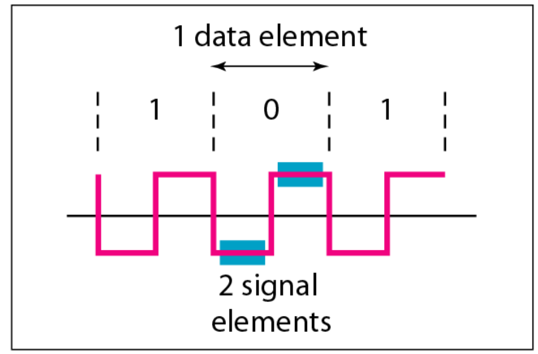
Characteristics of line coding

- Data element- smallest unit of data
- Signal element- smallest unit of signal
- Signal element carries data element
- Data elements are what we need to send and signal elements are what we can send
- Mapping of data symbols to Signals can be done based on r factor

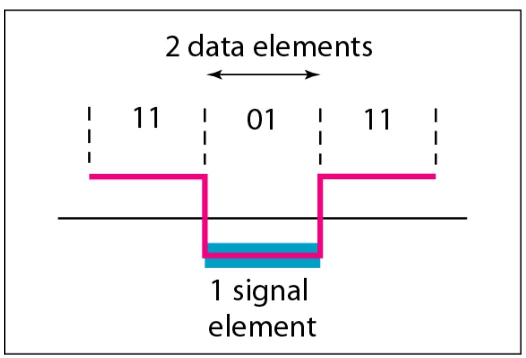
Signal element versus data element



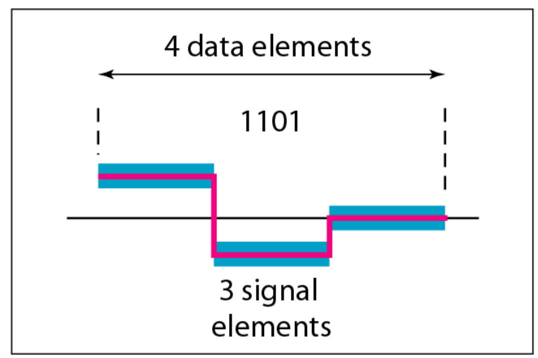
a. One data element per one signal element (r = 1)



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 Vs Signal rate

- Data rate(Bit rate)-no of data elements send /sec
- Signal rate- no of signal elements send/sec (pulse rate, modulation rate, baud rate)
- It is advisable to increase the data rate by reducing the signal rate

$$S = c*N*1/r$$

S-signal rate

N-Bit rate

c-case factor (worst, best & avg.)

r - ratio between data element & signal element

Data rate Vs Signal rate cont.

A data is carried by a signal element. If the bit rate is 100kbps, What is the baud rate if c is ½

$$S= c*N*1/2=50\text{kbaud}$$

Digital decoding issues

- **Baseline wandering**

  The running average of the received signal power is called baseline

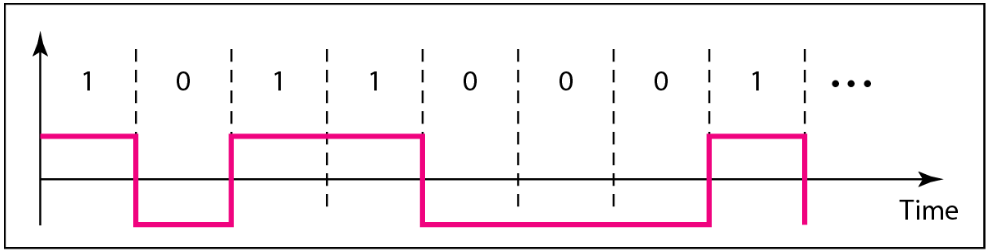
  Continuous zero or one leads to baseline wandering which prevent the receiver from interpreting the signal correctly

- **DC components**

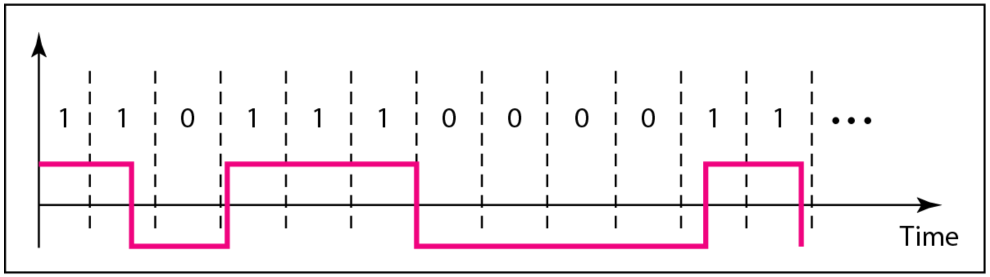
  When the signal voltage is constant for a while frequency will become zero(direct current component) .

  Some media wont support low frequencies(e.g. telephone line-below 200Hz)

- **Self Synchronization-** sender receiver clock should sync properly

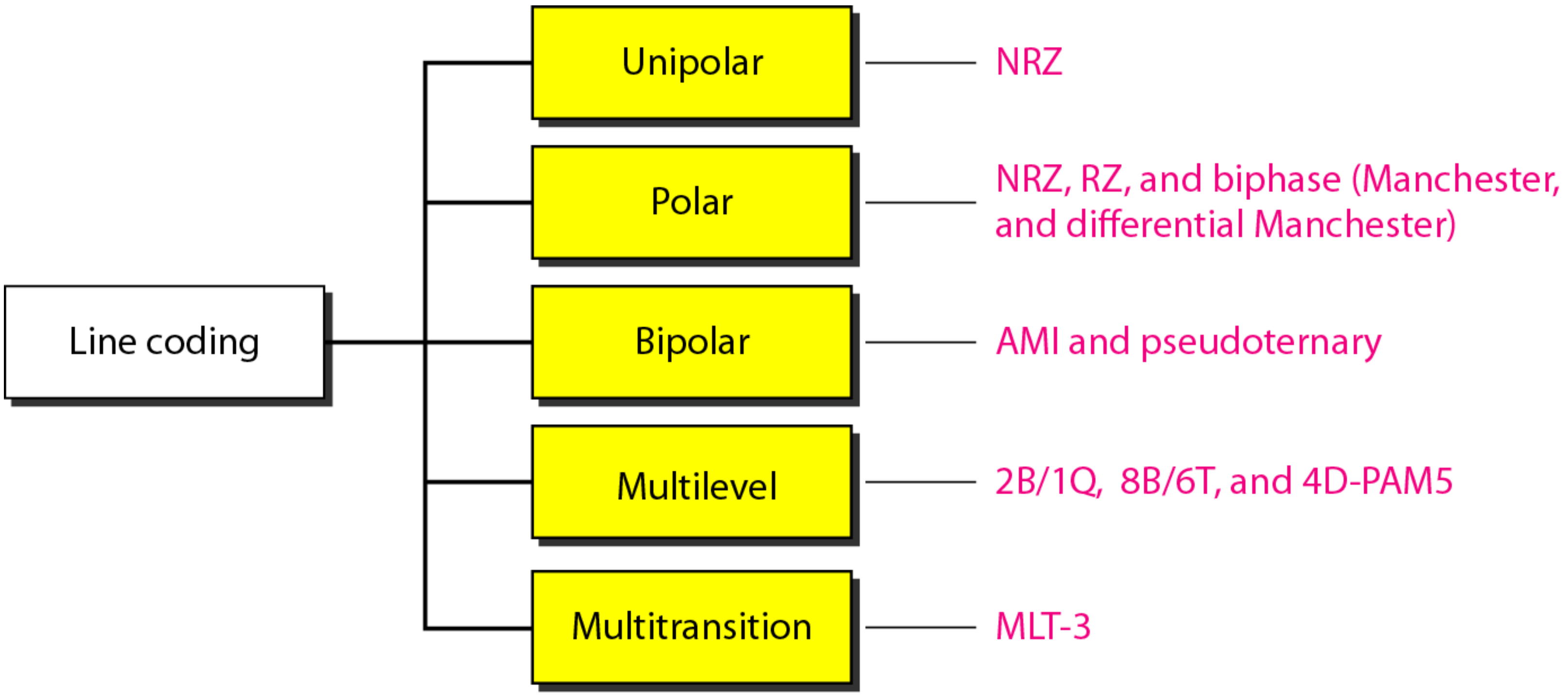


a. Sent



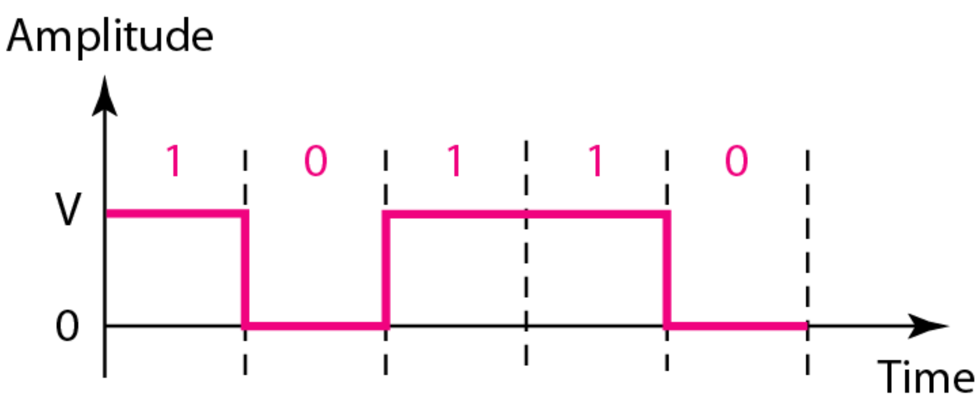
b. Received

Line coding methods



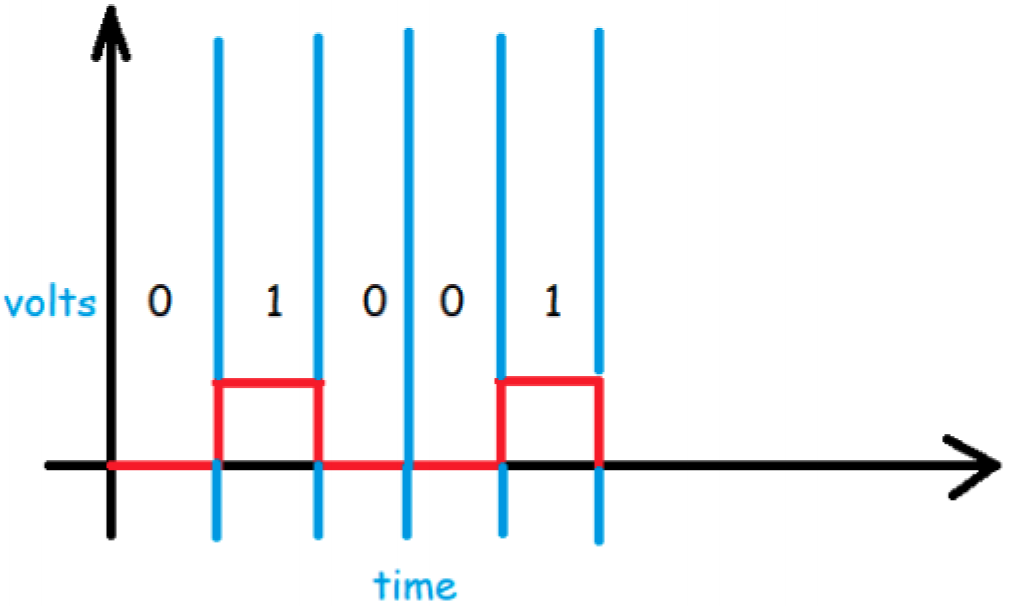
Unipolar

- All signal levels are on one side of the time axis - either above or below
- NRZ - Non Return to Zero scheme is an example of this code. The signal level does not return to zero during a symbol transmission.
- Scheme is prone to baseline wandering and DC components.
- It has no synchronization or any error detection.
- It is simple but costly in power consumption.



Unipolar example

Data: 01001



Polar

- NRZ
- RZ
- Biphase
  - Manchester
  - Differential Manchester

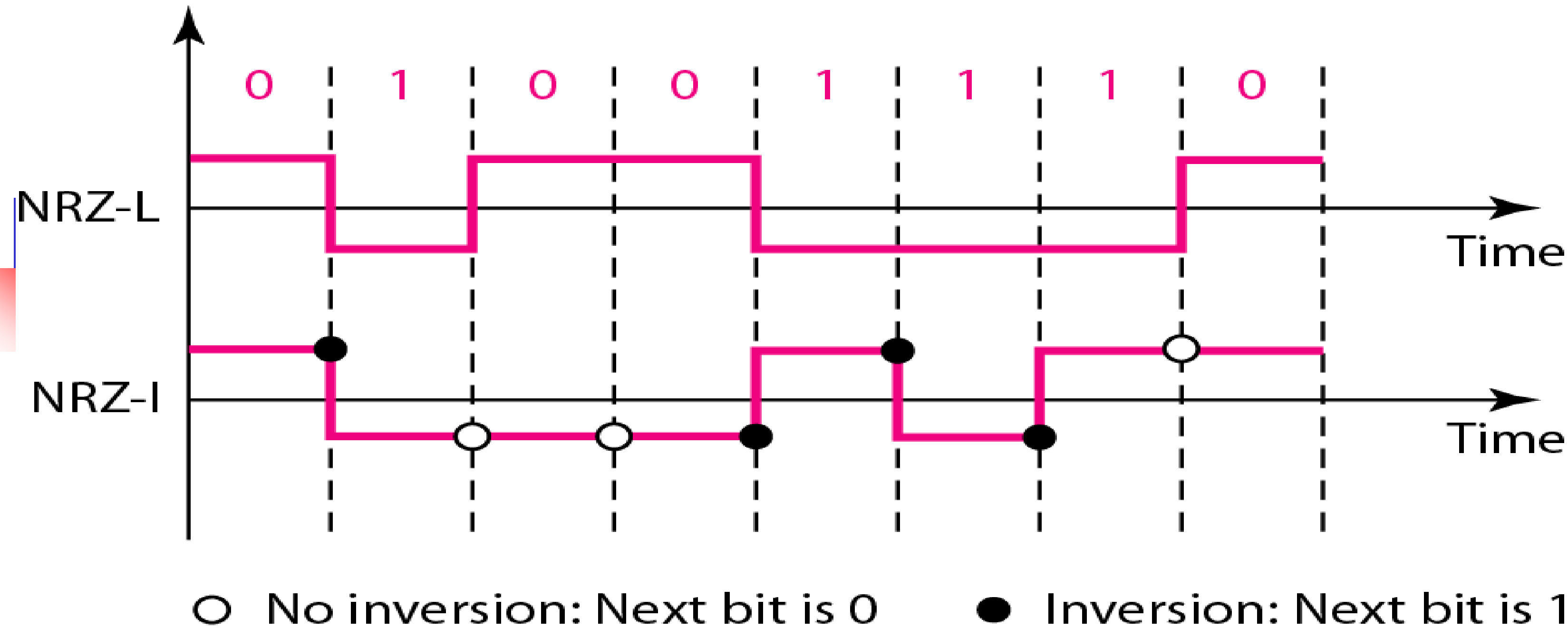
Polar NRZ

- The voltages are on both sides of the time axis.
- Polar NRZ scheme can be implemented with two voltages.
  E.g. +V for 1 and -V for 0.
- There are two versions:
  - NZR - Level (NRZ-L) - positive voltage for one symbol and negative for the other
  - NRZ - Inversion (NRZ-I) - the change or lack of change in polarity determines the value of a symbol. E.g. a “1” symbol inverts the polarity a “0” does not.

Polar NRZ

- In NRZ-L the level of the voltage determines the value of the bit.
- In NRZ-I the inversion or the lack of inversion determines the value of the bit.
- NRZ-L and NRZ-I both have a DC component problem and baseline wandering, it is worse for NRZ-L.
- Both have no self synchronization &no error detection. Both are relatively simple to implement.

Polar NRZ-L and NRZ-I schemes



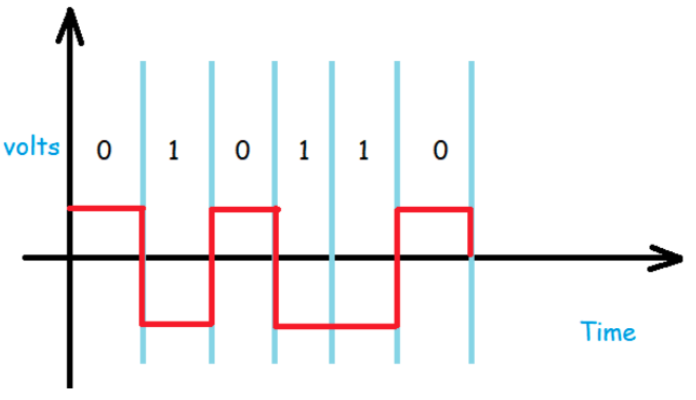
Example: NRZ-L - 010110

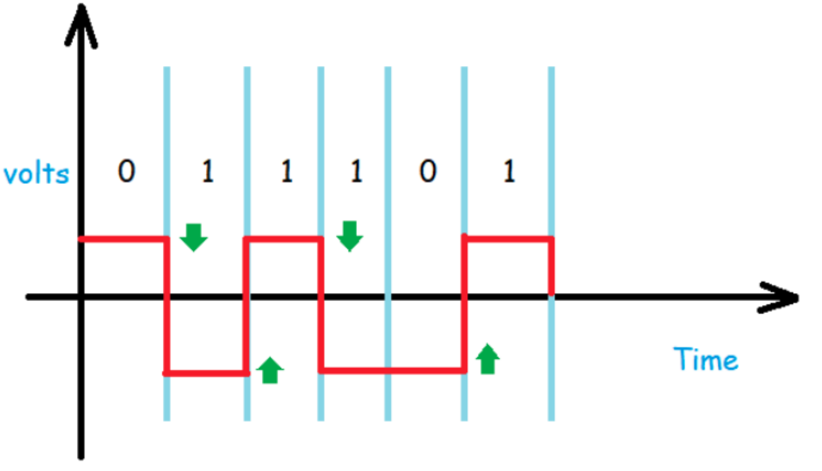
NRZ-I - 011101

Polar NRZ-L and NRZ-I schemes-Examples

Example: NRZ-L - 010110

NRZ-I - 011101

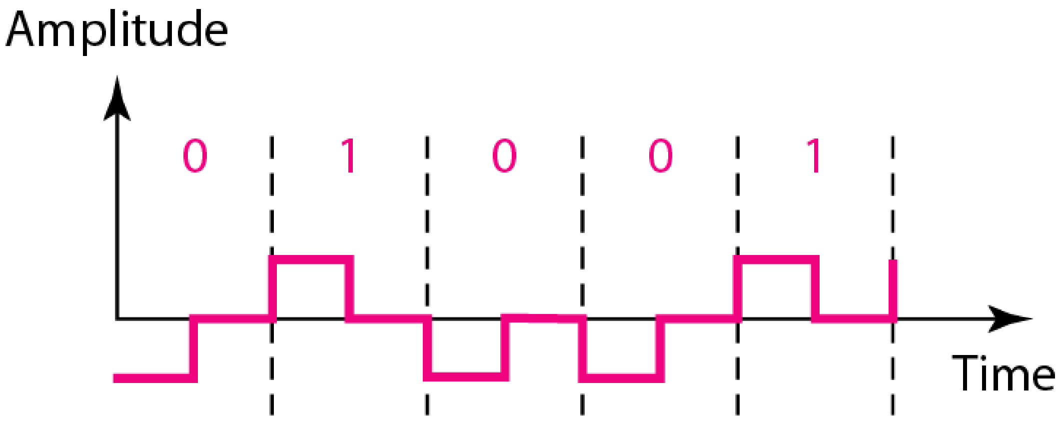




Polar RZ

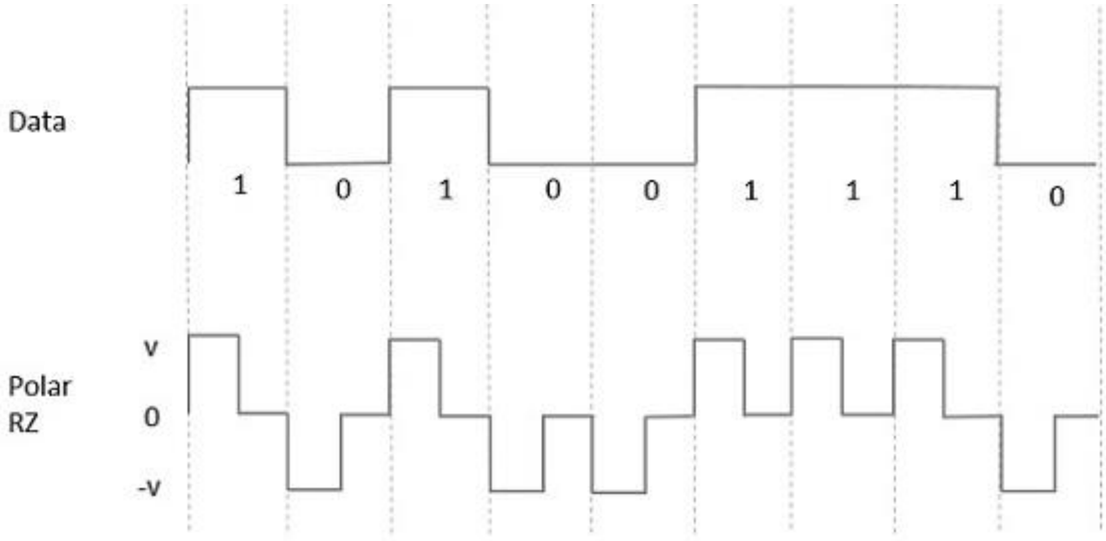
- The Return to Zero (RZ) scheme uses three voltage values. +, 0, -.
- Each symbol has a transition in the middle. Either from high to zero or from low to zero.
- This scheme has more signal transitions (two per symbol) and therefore requires a wider bandwidth.
- No DC components or baseline wandering.
- Self synchronization - transition indicates symbol value.
- More complex as it uses three voltage level. It has no error detection capability.

Polar RZ cont.



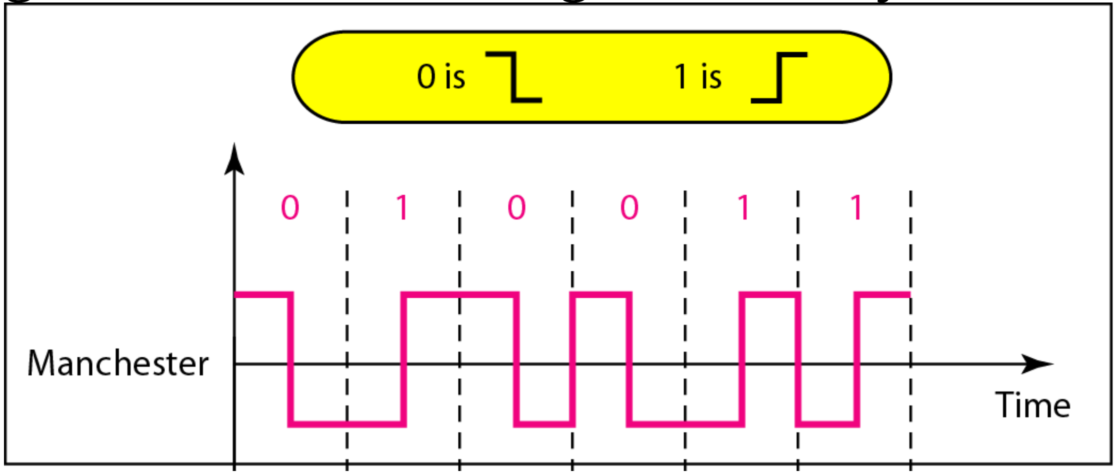
Example : 101001110

Polar RZ cont.



Polar - Biphase: Manchester

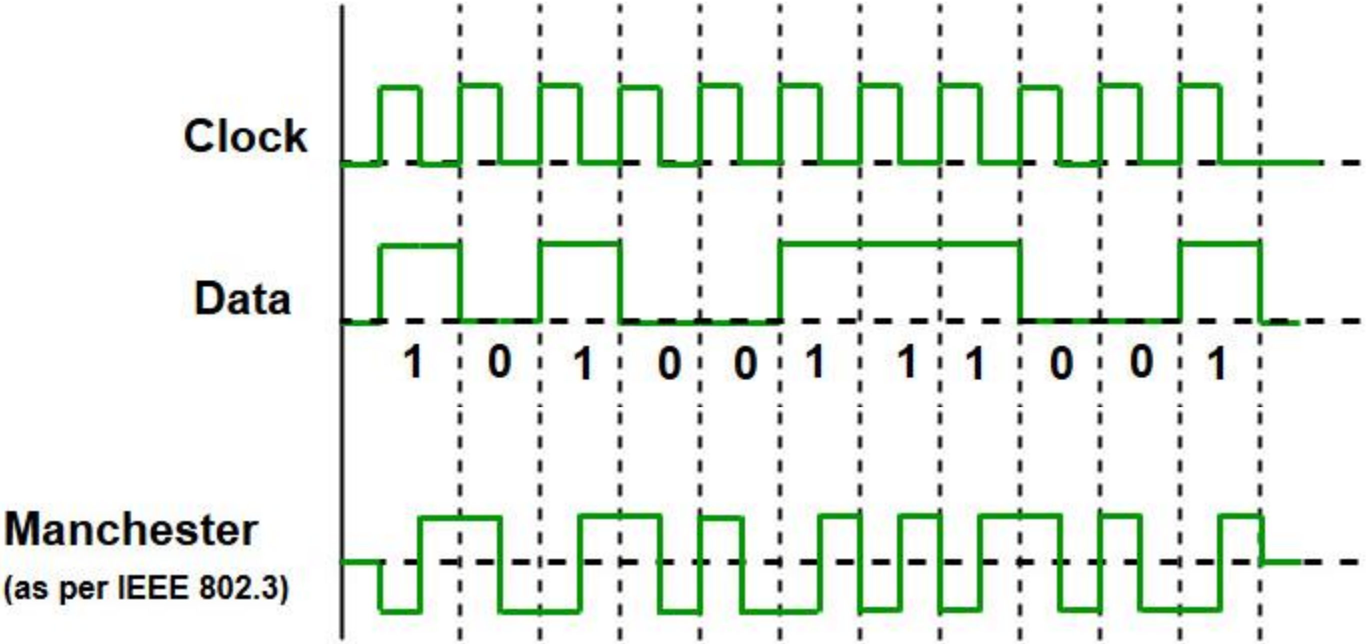
- Manchester coding consists of combining the NRZ-L and RZ schemes.
  - Every symbol has a level transition in the middle: from high to low or low to high. Uses only two voltage levels.



Example : 10100111001

Polar - Biphase: Manchester

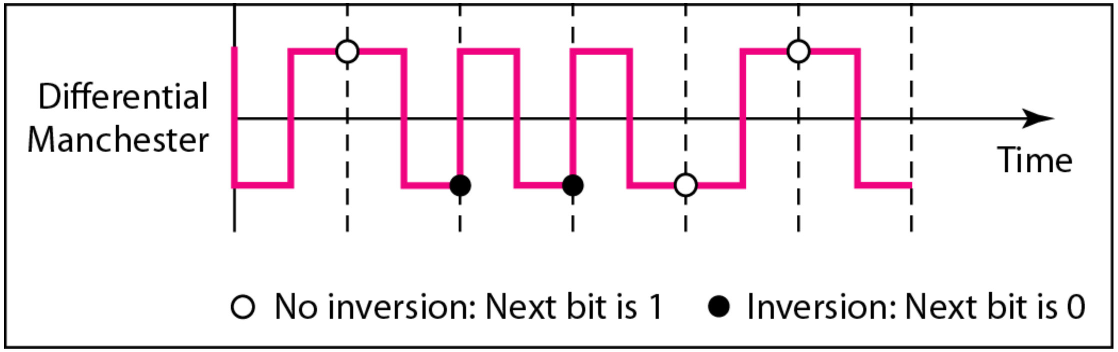
10100111001



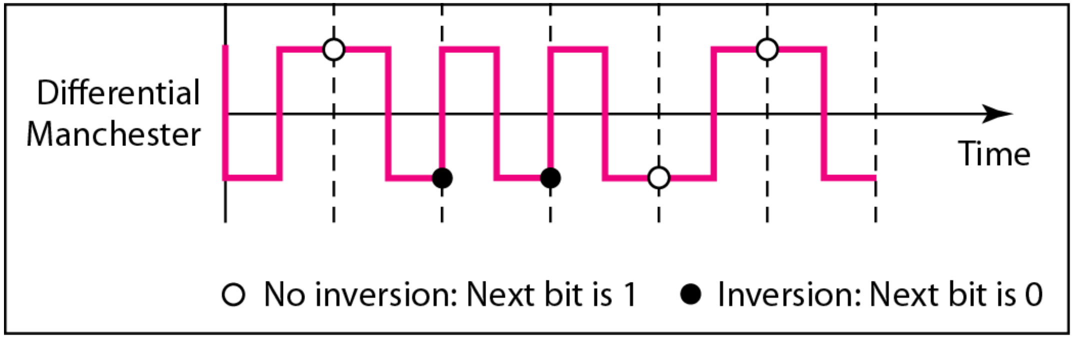
Polar - Biphase: Differential Manchester

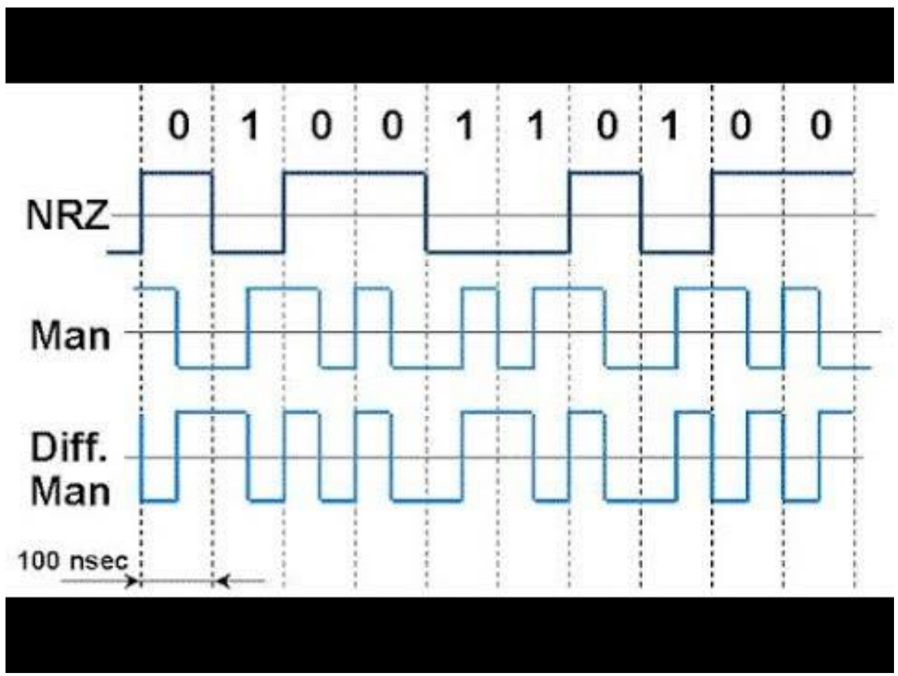
- Differential Manchester coding consists of combining the NRZ-I and RZ schemes.
  - Every symbol has a level transition in the middle. But the level at the beginning of the symbol is determined by the symbol value. One symbol causes a level change the other does not.

010011



Polar - Biphase: Differential Manchester





Polar – Biphase schemes

- No DC component problem
- No Baseline wandering
- Self synchronization
- Signal rate is high