Line Coding Techniques

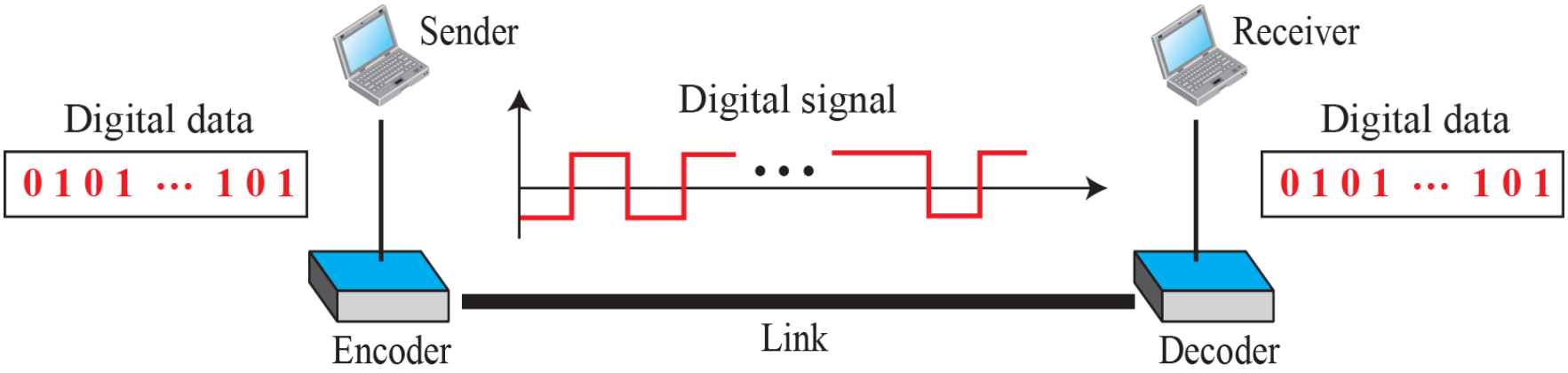
Session Objectives

After going through this session you will be able to understand:

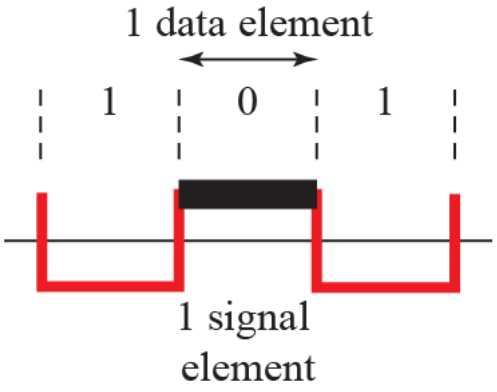
- ✓ Digital data and digital signal representation
- ✓ Technique for Line Coding

Line Coding

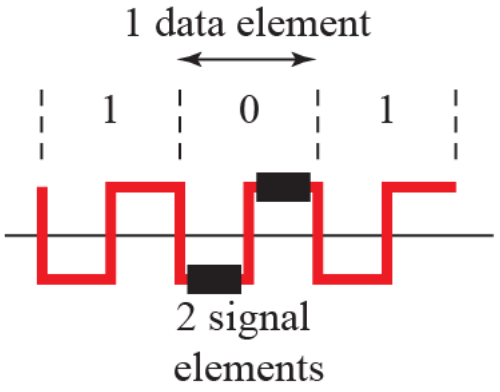
- ✓ Line coding is the process of converting digital **data** to digital **signals**.
- ✓ It is assumed that data, in the form of text, numbers, graphical images, audio, or video, are stored in computer memory as sequences of bits.
- ✓ Line coding converts a sequence of bits to a digital signal. At the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



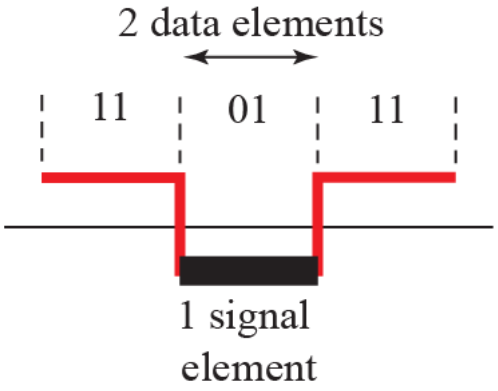
Digital signal representation



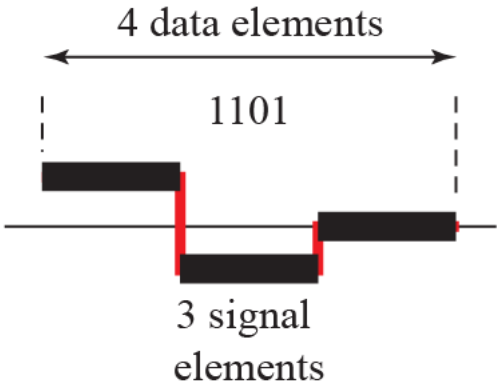
a. One data element per one signal element (r = 1)



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



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

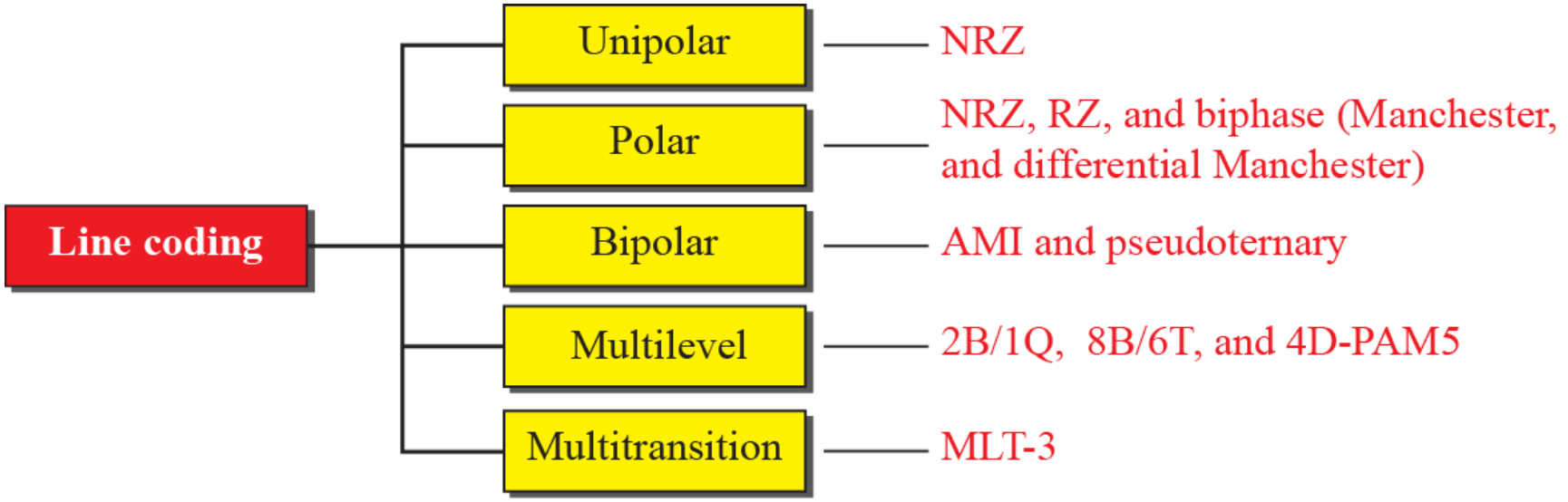


d. Four data elements per three signal elements $\left(r = \frac{4}{3}\right)$

Line Coding Schemes

Polarity
The separation, alignment or orientation of something into two opposed poles.

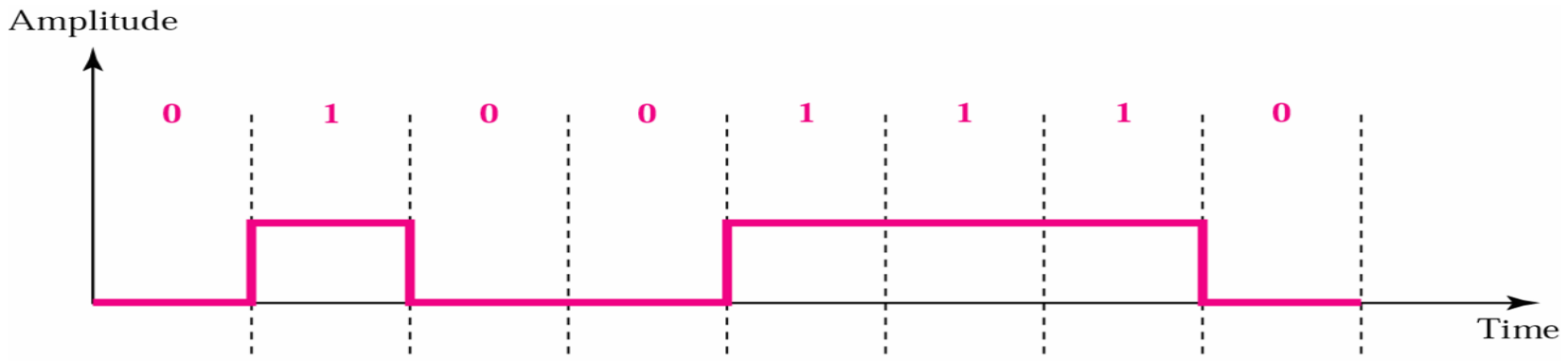
We can roughly divide line coding schemes into five broad categories, as shown below



NRZ: Non return to zero
NRZ-I: non return to zero inverted
AMI: Alternate Mark Inversion
2B1Q: Two-binary, one-quaternary
4D-PAM5: 4-data line, 5-level pulse amplitude modulation
MLT-3: Multi-Level Transmit

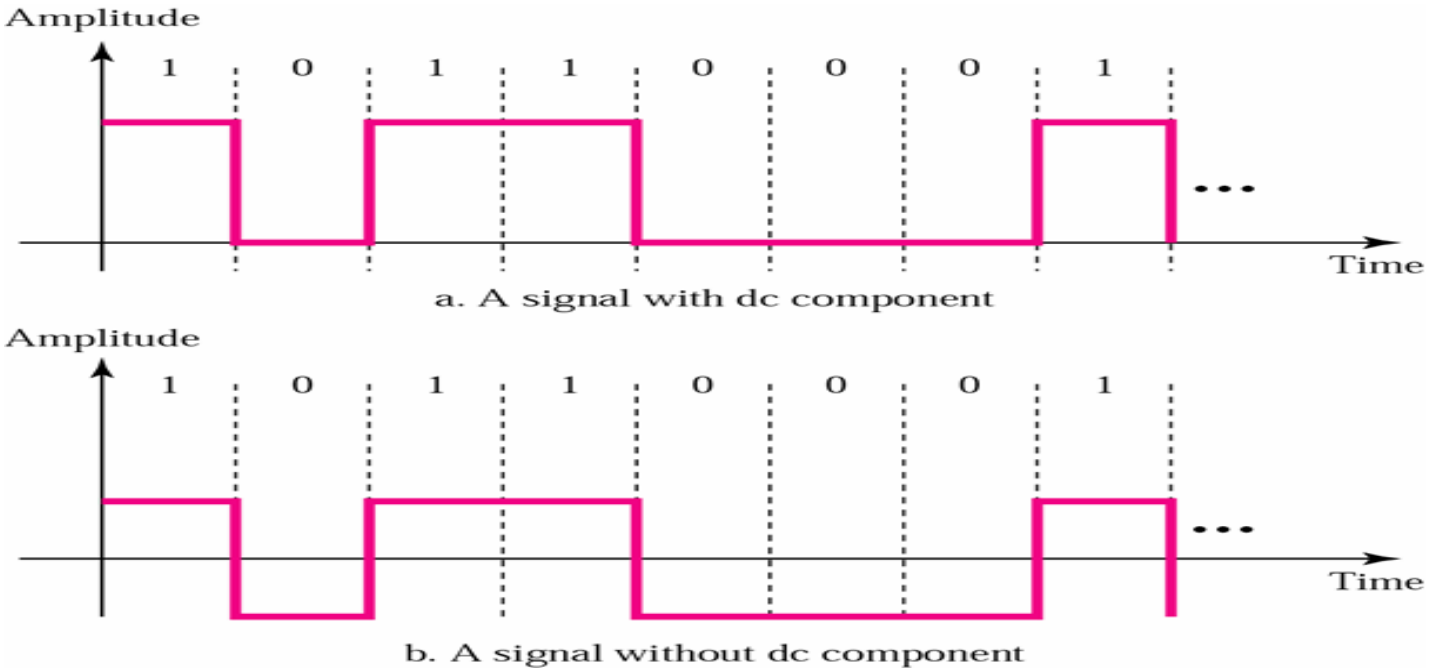
Unipolar

- Digital transmission system sends the voltage pulses over the medium link such as wire or cable.
- In most types of encoding, one voltage level represents 0, and another voltage level represents 1.
- The polarity of each pulse determines whether it is positive or negative.
- This type of encoding is known as Unipolar encoding as it uses only one polarity.
- In Unipolar encoding, the polarity is assigned to the 1 binary state.
- In this, 1s are represented as a positive value and 0s are represented as a zero value.
- In Unipolar Encoding, '1' is considered as a high voltage and '0' is considered as a zero voltage.
- Unipolar encoding is simpler and inexpensive to implement.



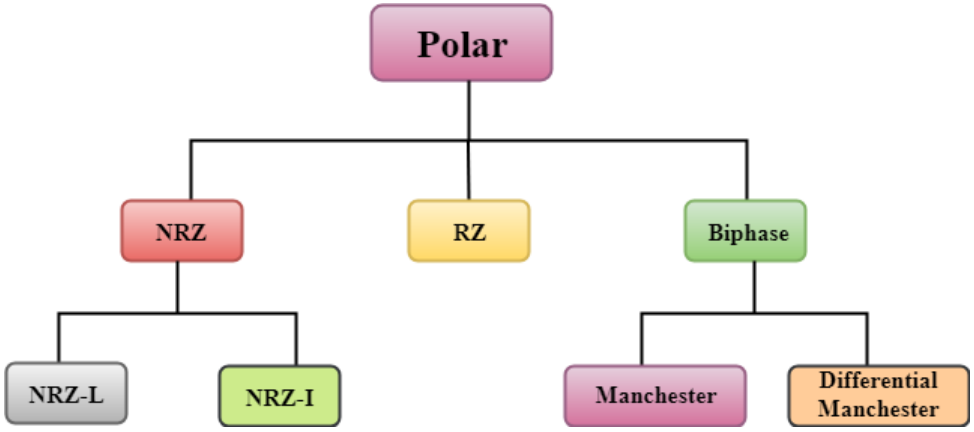
Unipolar encoding has two problems that make this scheme less desirable:

- DC Component
- Synchronization



Polar Encoding

- Polar encoding is an encoding scheme that uses two voltage levels: one is positive, and another is negative.
- By using two voltage levels, an average voltage level is reduced, and the DC component problem of unipolar encoding scheme is alleviated.



Non Return to Zero

NRZ

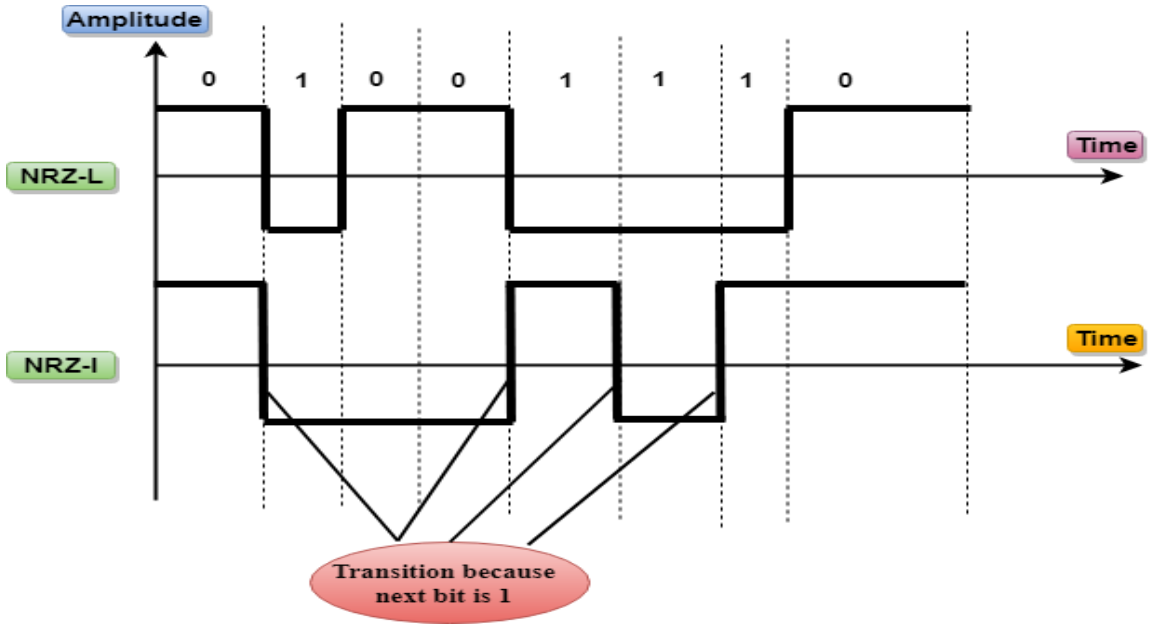
- Non-return to Zero (NRZ) -- signal is always positive or negative.
- Two main types of NRZ: NRZ-L and NRZ-I

NRZ-L

- In NRZ-L encoding, the level of the signal depends on the type of the bit that it represents.
- If a bit is 0 or 1, then their voltages will be positive and negative respectively. Therefore, we can say that the level of the signal is dependent on the state of the bit.
- Good for short and well- shielded transmission paths.

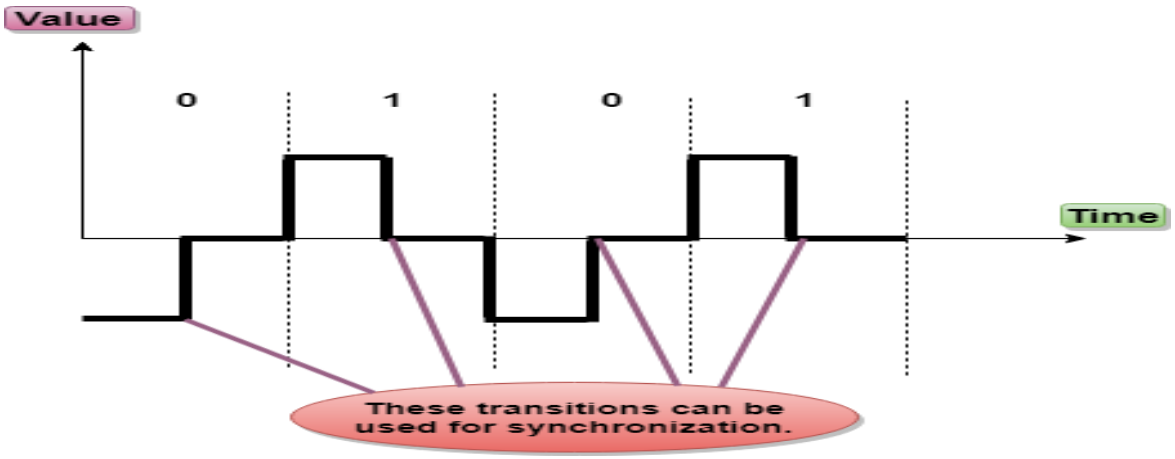
NRZ-I:

- NRZ-I is an inversion of the voltage level that represents 1 bit.
- In the NRZ-I encoding scheme, a transition occurs between the positive and negative voltage that represents 1 bit.
- In this scheme, 0 bit represents no change and 1 bit represents a change in voltage level.
- Provides more synchronization than NRZ-L because there is a transition for each 1 bit.



RZ

- RZ stands for Return to zero.
- There must be a signal change for each bit to achieve synchronization. However, to change with every bit, we need to have three values: positive, negative and zero.
- RZ is an encoding scheme that provides three values, positive voltage represents 1, the negative voltage represents 0, and zero voltage represents none.
- In the RZ scheme, halfway through each interval, the signal returns to zero.
- In RZ scheme, 1 bit is represented by positive-to-zero and 0 bit is represented by negative-to-zero.



Disadvantage of RZ:

It performs two signal changes to encode one bit that acquires more bandwidth.

Biphase

- Biphase is an encoding scheme in which signal changes at the middle of the bit interval but does not return to zero.
- Biphase encoding is implemented in two different ways:

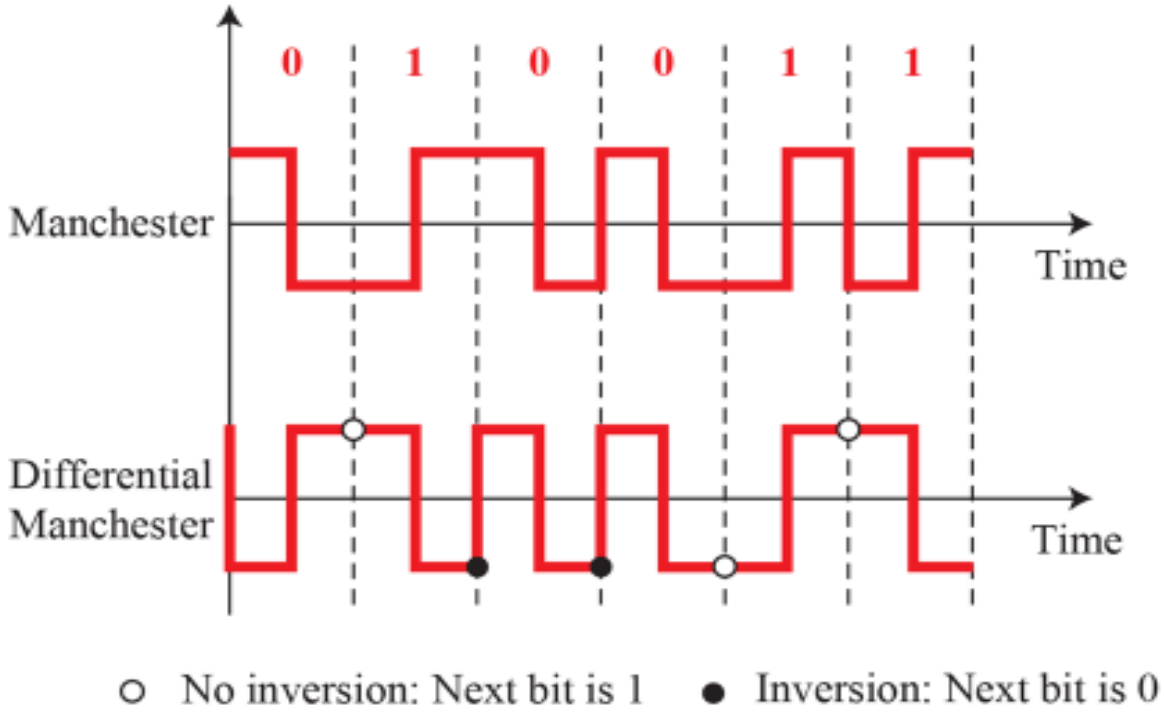
Manchester

- It changes the signal at the middle of the bit interval but does not return to zero for synchronization.
- In Manchester encoding, a negative-to-positive transition represents binary 1, and positive-to-negative transition represents 0.
- Manchester has the same level of synchronization as RZ scheme except that it has two levels of amplitude.

Differential Manchester

- It changes the signal at the middle of the bit interval for synchronization, but the presence or absence of the transition at the beginning of the interval determines the bit. A transition means binary 0 and no transition means binary 1.
- In Manchester Encoding scheme, two signal changes represent 0 and one signal change represent 1.

Polar Manchester and Differential Manchester Coding



Bipolar

- In bipolar encoding (sometimes called *multilevel binary),* there are three voltage levels: positive, negative, and zero.
- In Bipolar encoding scheme, zero level represents binary 0, and binary 1 is represented by alternating positive and negative voltages.
- If the first 1 bit is represented by positive amplitude, then the second 1 bit is represented by negative voltage, third 1 bit is represented by the positive amplitude and so on. This alternation can also occur even when the 1bits are not consecutive.

Bipolar can be classified as:

AMI

- AMI stands for alternate mark inversion where mark work comes from telegraphy which means 1. So, it can be redefined as alternate 1 inversion.
- In Bipolar AMI encoding scheme, 0 bit is represented by zero level and 1 bit is represented by alternating positive and negative voltages.

Advantage:

- DC component is zero.
- Sequence of 1s bits are synchronized.

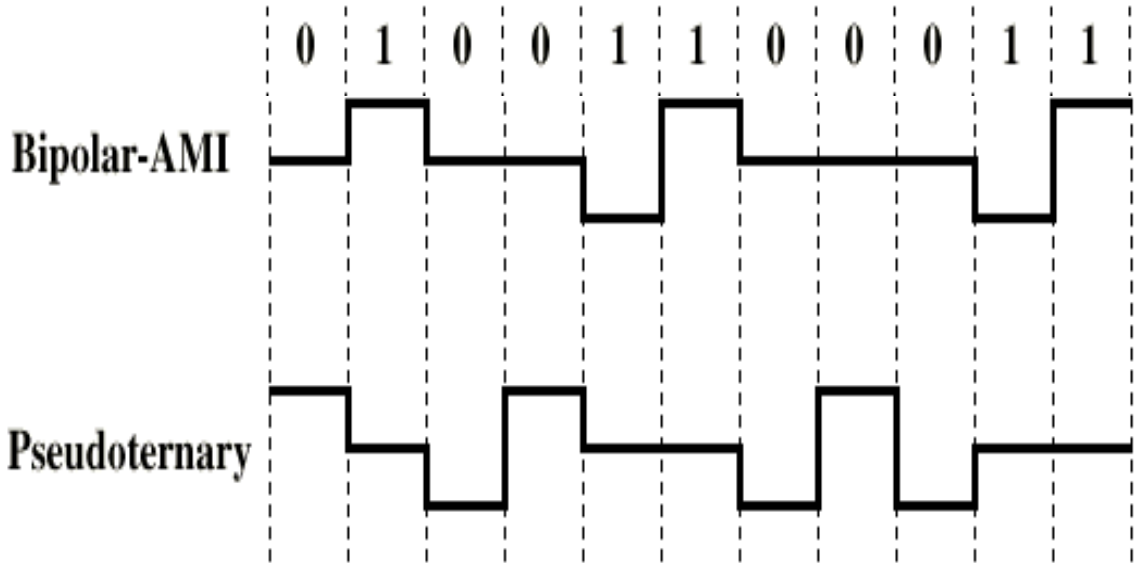
Disadvantage:

- This encoding scheme does not ensure the synchronization of a long string of 0s bits.

Pseudoternary

- A variation of AMI encoding is called pseudoternary.
- In this, the 1 bit is encoded as a zero voltage and the 0 bit is encoded as alternating positive and negative. Example: Data = 010010.

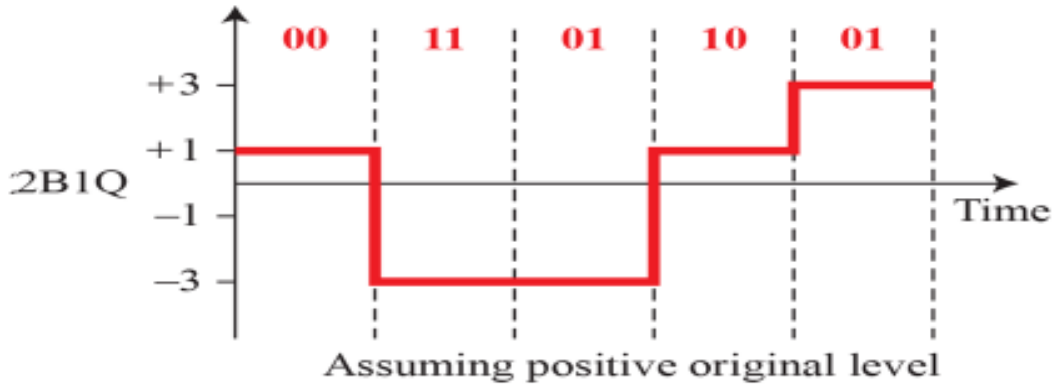
Bipolar-AMI and Pseudoternary



Multlevel 2B1Q

- The **two binary, one quaternary (2B1Q)**, uses data patterns of size 2 and encodes the *2-bit patterns as one signal element belonging to a four-level signal.*
- In this type of encoding m = 2, n = 1, and L = 4 (quaternary). Figure shows an example of a 2B1Q signal.
- The 2B1Q scheme is used in DSL (Digital Subscriber Line) technology to provide a high-speed connection to the Internet by using subscriber telephone lines.

Multlevel 2B1Q



	previous Level: Positive	Previous Level: Negative
Next Bit	Next Level	Next Level
00	+1	-1
01	+3	-3
10	-1	+1
11	-3	+3

Activity

For the give data pattern

a) 1011001011000111

b) 1111000010110101

Apply the following Algorithms

1. NRZ, NRZ-I, NRZ – L
2. RZ
3. Manchester and Differential Manchester
4. AMI
5. Pseudoternary
6. 2B1Q

Summary

In this section we have discussed the following:

- ✓Line Coding Techniques
- ✓Polar and bi-polar technique for coding


Thank
you!