Data Communication

#2 Line Coding

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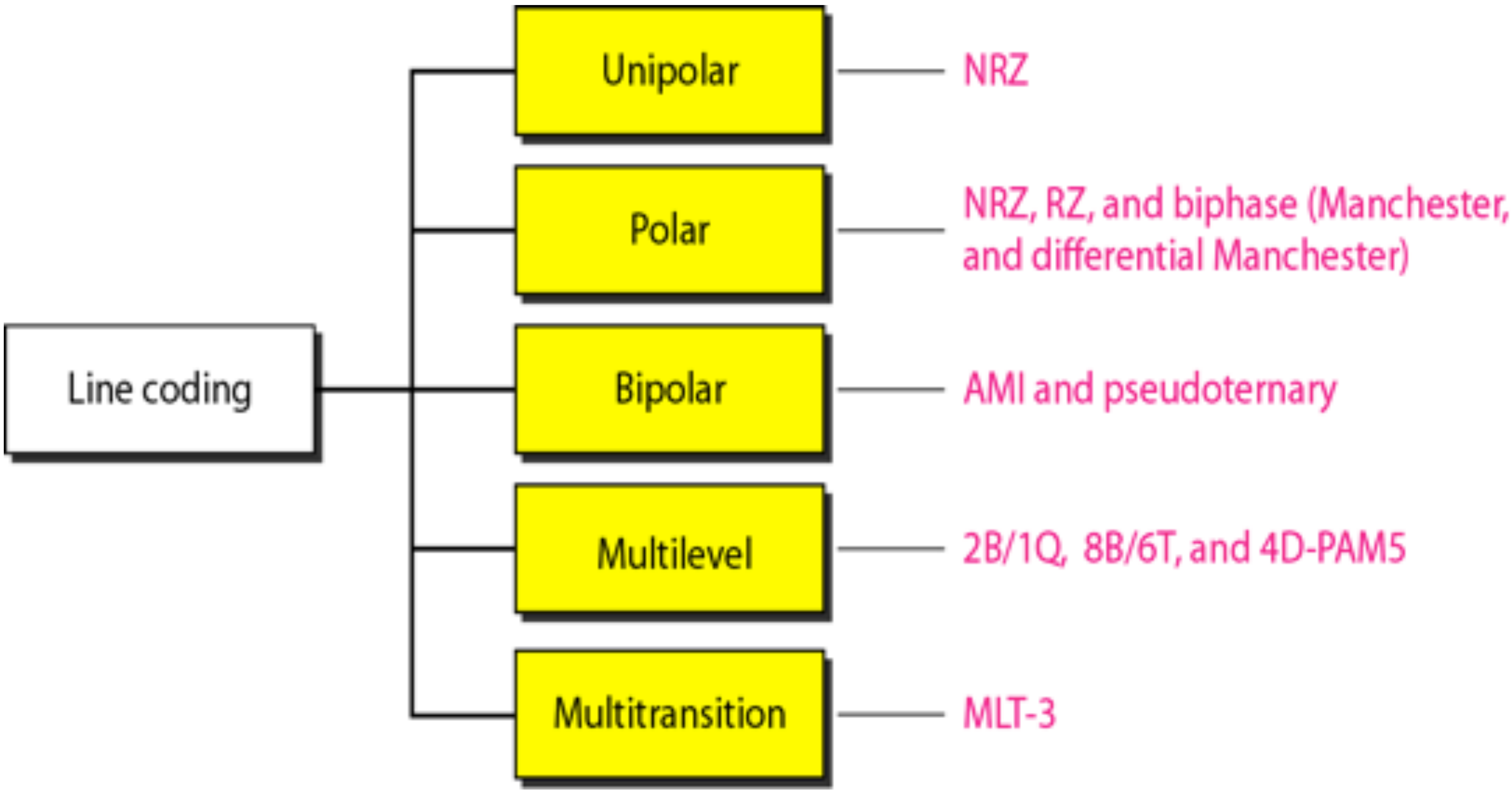
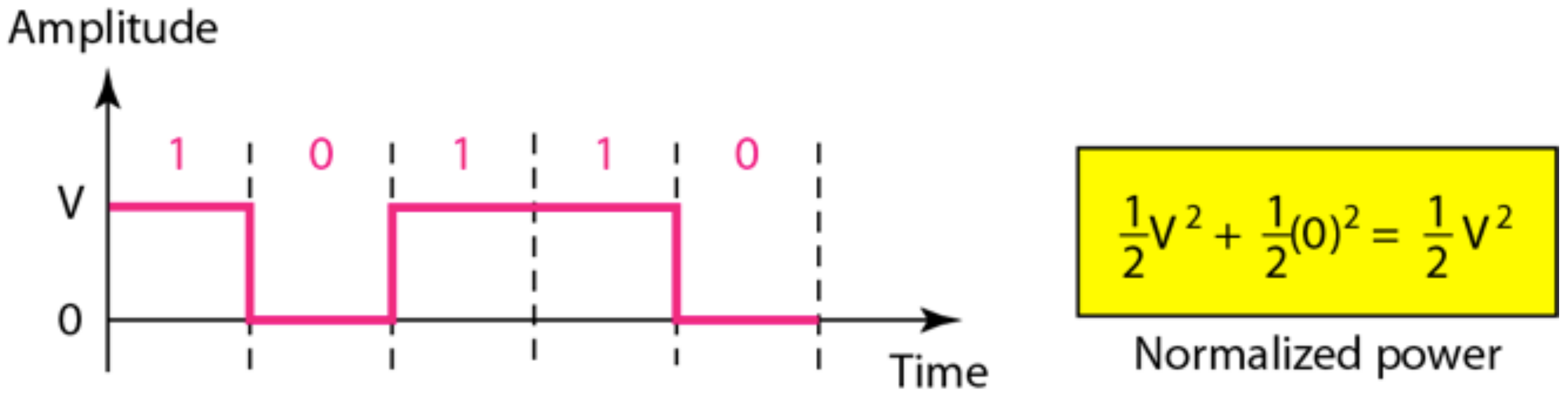
Line Coding Scheme



Unipolar Scheme

- In a unipolar scheme, all the signal levels are on one side of the time axis, either above or below



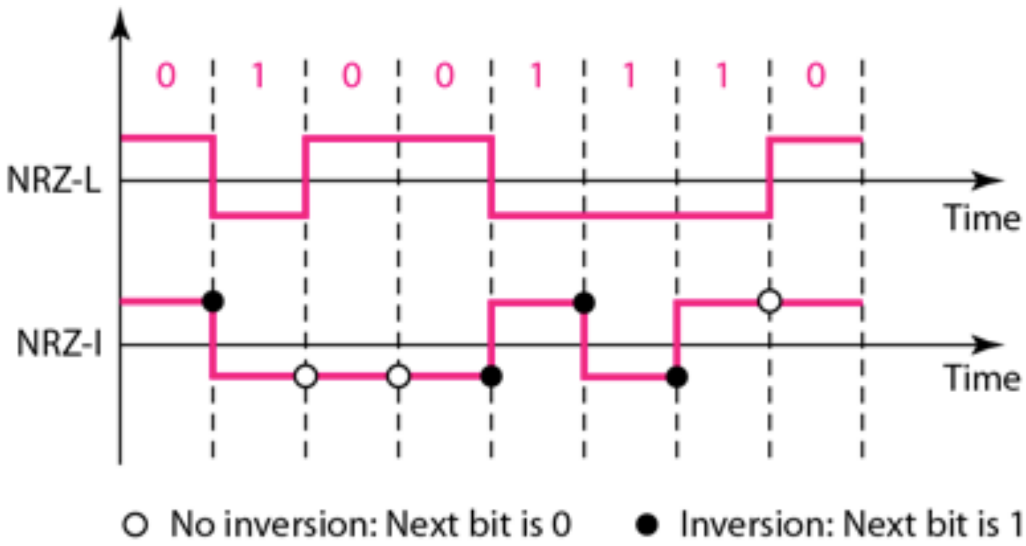
$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

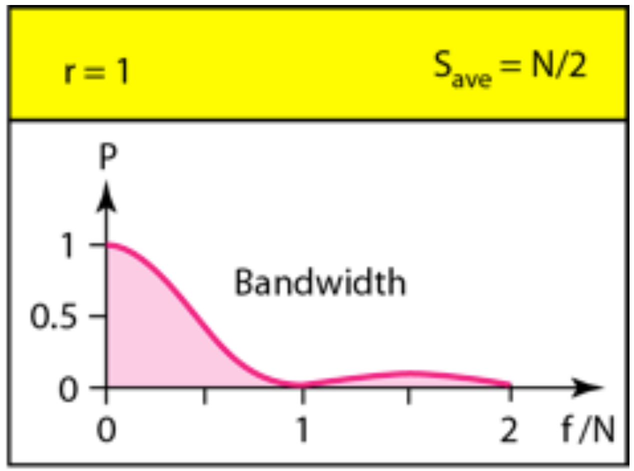
Polar Scheme

- In polar scheme, the voltages are on the both sides of the time axis. For example, the voltage level for 0 can be positive and the voltage level for 1 can be negative.

Non Return to Zero (NRZ)

- It is called NRZ because the signal does not return to zero at the middle bit of the bit.
- In polar encoding, we use two level of voltage amplitude.
- We can have two versions of polar NRZ: NRZ-L and NRZ-I
- NRZ-Level (NRZ-L), the level of the voltage determines the value of the bit.
- NRZ-Inverted (NRZ-I), the change or lack of change in the level of the voltage determines the value of the bit. If there is no change, the bit is 0, if theres a change the bit is 1.

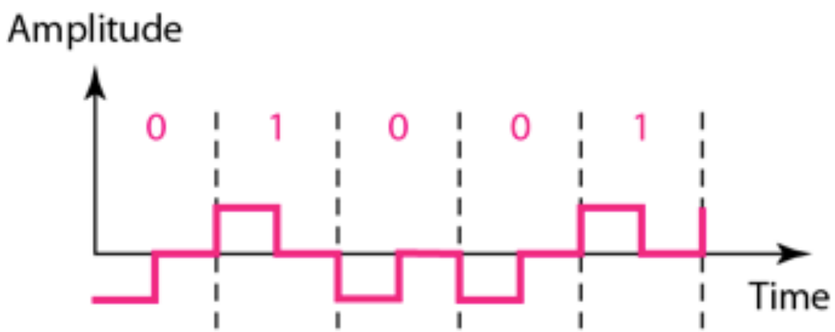


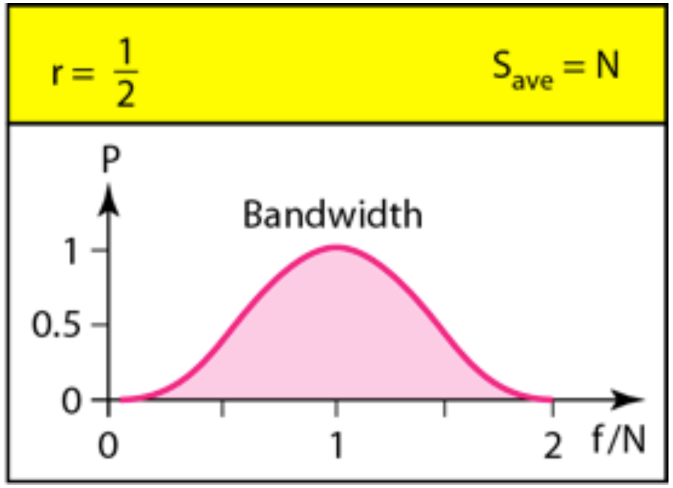


- although the baseline wandering is a problem for both variations, it is twice as severe in NRZ-L.
- If there is a long sequence of 0s or 1s in NRZ-L, the average signal power becomes skewed. the receiver might have difficulty discerning the bit value.
- In NRZ-I, this problem occurs only for a long sequence of 0's. If somehow we can eliminate the long sequence of 0s, we can avoid the baseline wandering.
- The synchronisation problem (sender and receiver clocks are not synchronised) also exist in both scheme. This problem is more serious in NRZ-L than in NRZ-I. While long sequence of 0s can cause a problem in both schemes, a long sequence of 1s affects only NRZ-L.

Return to Zero

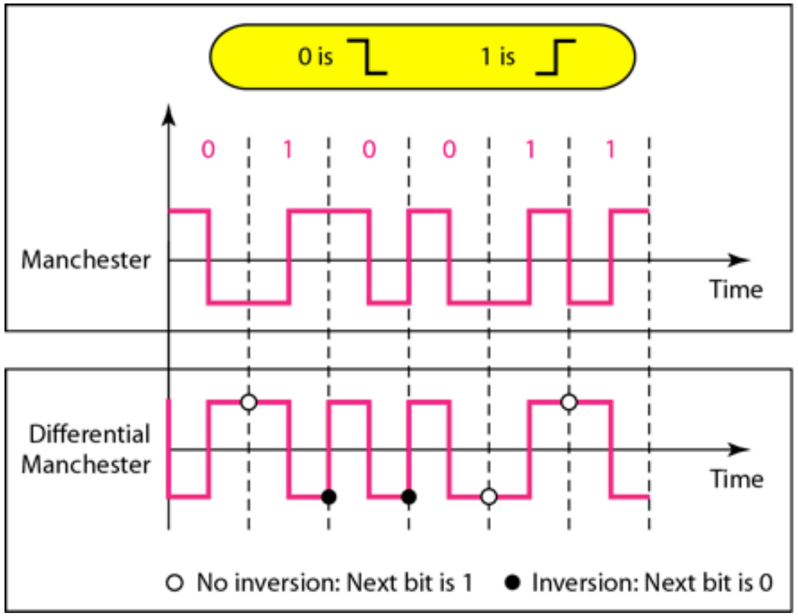
- The main problem with NRZ encoding occurs when the sender and receiver clocks are not synchronised. The receiver does not know when one bit has ended and the next bit is starting.
- One solution is the return to zero scheme., which use three values: positive, negative and zero.
- The main disadvantage of RZ encoding is that it requires two signal changes to encode a bit and therefore occupies greater bandwidth.
- The advantage is there is no DC Component problem.
- Another problem is complexity: RZ uses three levels of voltage, which more complex to create and discern.
- This scheme is not used today. Instead, it has been replaced by the better performing Manchester and Differential Manchester schemes.

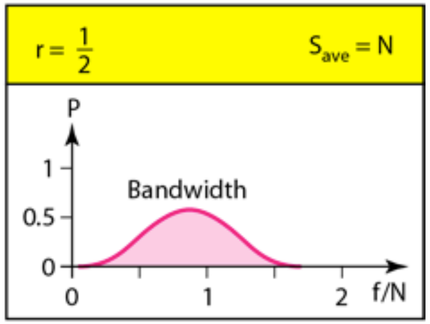




Biphase: Manchester and Differential Manchester

- The idea of RZ (transition in the middle of the bit) and the idea of NRZ-L are combined into the Manchester Scheme.
- In Manchester encoding, the duration of the bit is divided into two halves. The voltage remains at one level during the first half and moves to the other level in the second half. The transition at the middle of the bit provides synchronization.
- Differential Manchester, on the other hand, combines the idea of RZ and NRZ-I. There is always a transition at the middle of the bit, but the bit values are determined at the beginning of the bit. If the next bit is 0, there is a transition; if the next bit 1, there is none.





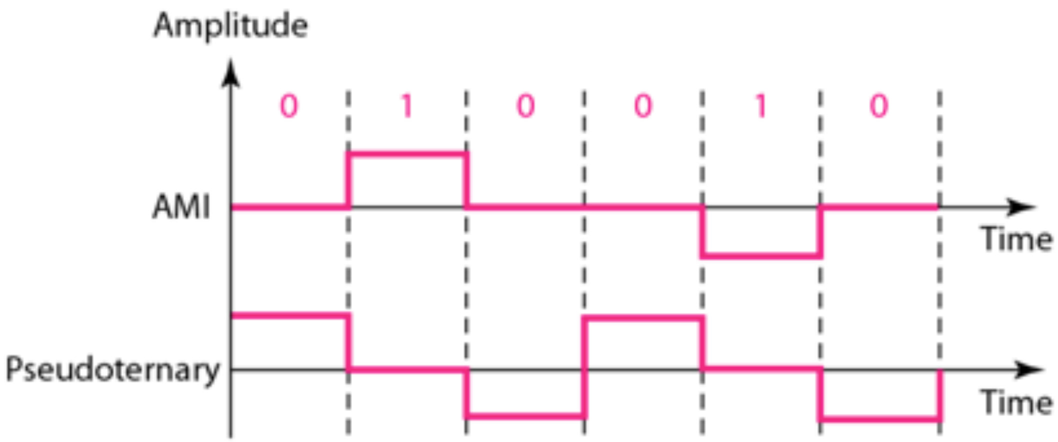
In Manchester and Differential Manchester encoding, the transition at the middle of the bit is used for synchronization

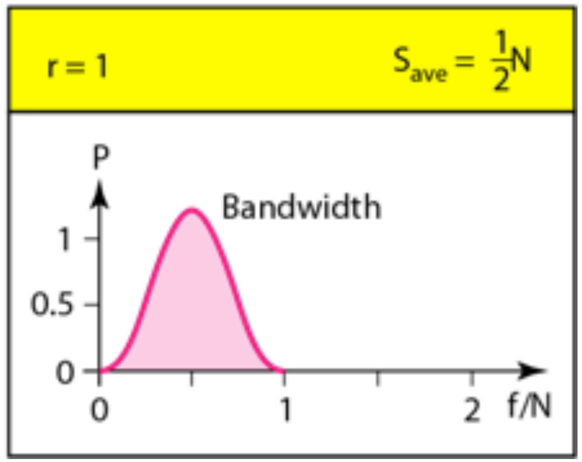
- The Manchester scheme overcomes several problem associated with NRZ-L, and differential Manchester overcomes several problems associated with NRZ-I.
- First there is no baseline wandering. There is no components DC because each bit has a positive and negative voltage contribution.
- The only drawback is the signal rate. The signal rate for Manchester and differential Manchester is double that for NRZ. The reason is that there is always one transition at the middle of the bit and maybe one transition at the end of each bit.

The minimum bandwidth of Manchester and Differential Manchester is 2 times that of NRZ

Bipolar Schemes: AMI and Pseudoternary

- Two variations of bipolar encoding: Alternate Mark Inversion (AMI) and Pseudoternary.
- AMI:
  - the neutral zero voltage represent binary 0. Binary 1s are represented by alternating positive and negative voltages.
- A variation of AMI encoding is called Pseudoternary in which the 1 bit is encoded as a zero voltage and the bit 0 is encoded as alternating positive and negative voltages.





- The bipolar scheme was developed as an alternative to NRZ.
- The bipolar scheme has the same rate as NRZ, but there is no DC component.
- If we have a long sequence of 1s, the voltage level alternates between positive and negative; it is not constant. Therefore, there is no DC component. For a long sequence of 0s, the voltage remain constant, but its amplitude is zero, which is the same as having no DC component. In other words, a sequence that creates a constant zero voltage does not have a DC component.
- AMI is commonly used for long-distance communication, but it has a synchronisation problem when a long sequence of 0s is present in the data. Later in the chapter we will see how a scrambling technique can solve this problem.

1. In a digital transmission, the sender clock is 0.2 percent faster than the receiver clock. How many extra bits per second does the sender send if the data rate is 1 Mbps?
2. Draw the graph of the NRZ-L scheme using each of the following data streams, assuming that the last signal evel has been positive. From the graphs, guess the bandwidth for this scheme using the average number of changes in the signal level.
    a. 00000000
    b. 11111111
    c. 01010101
    d. 00110011
3. Repeat Exercise 2 is for the NRZI Scheme
4. Repeat Exercise 2 for the Manchester Scheme
5. Repeat Exercise 2 for Repeat Exercise for the differential Manchester scheme.