DATA COMMUNICATION CONCEPTS

CHAPTER 5

DATA ENCODING – DIGITAL AND ANALOG TRANSMISSION

5.0 OBJECTIVES

At the end of this chapter, you should be able to:

1. Identify the modes of binary data transmission.
2. Data encoding techniques:
   a. Digital-to-digital Encoding
   b. Digital-to-analog Encoding
3. Understand digital data transmission

DATA ENCODING TECHNIQUES

DATA ENCODING TECHNIQUES

- 4 different types of conversion method (scheme):

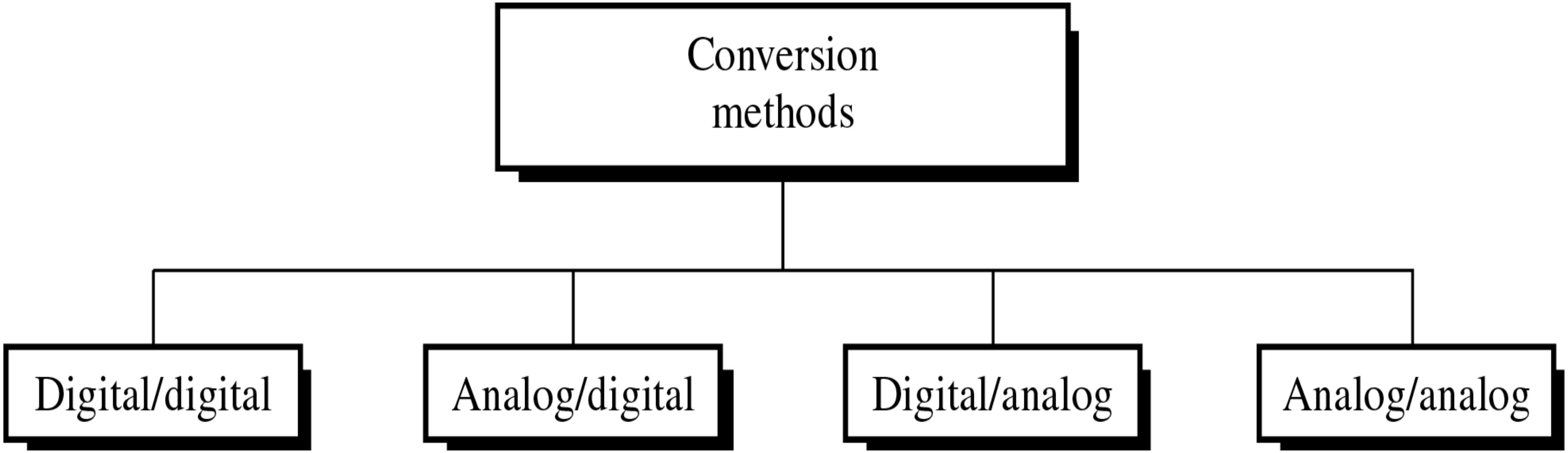
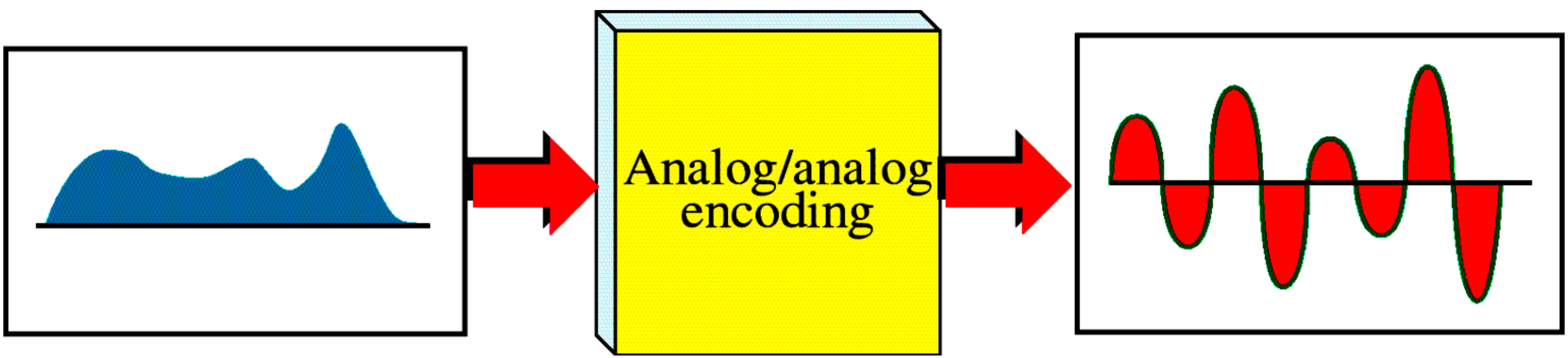


Figure 4.1 :Conversion Methods

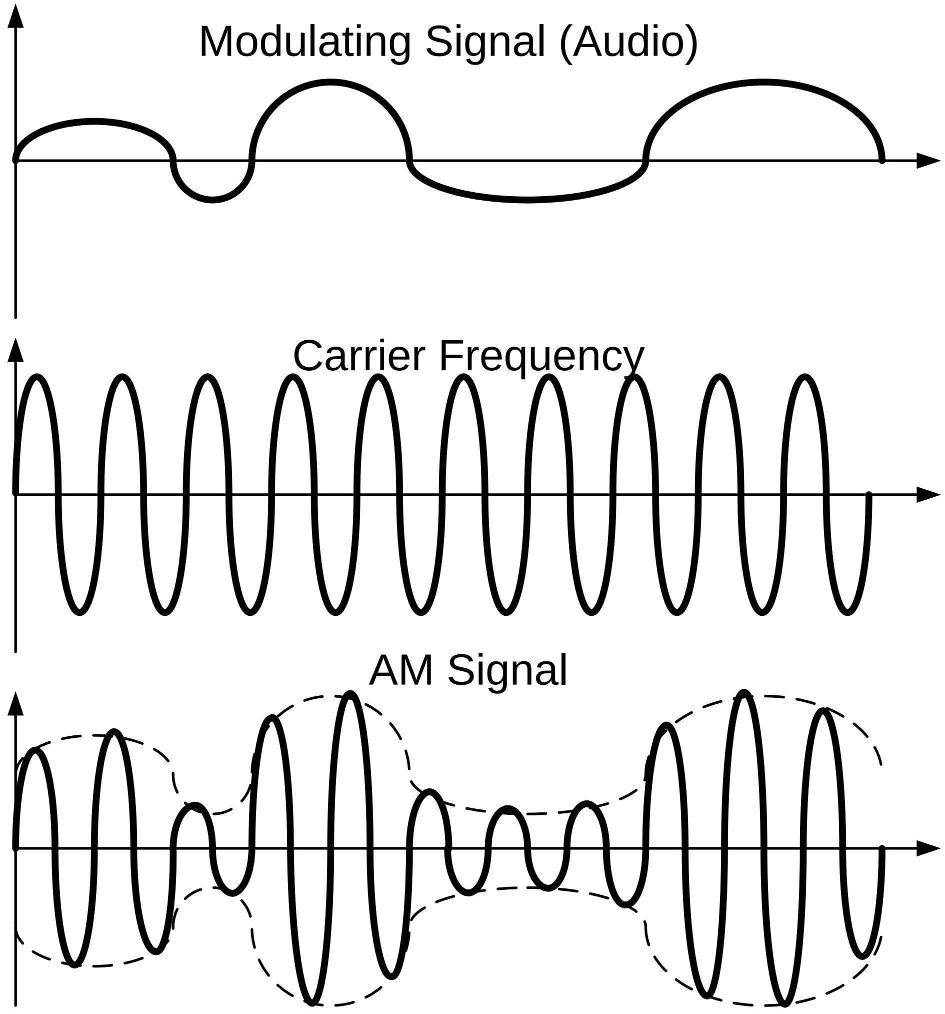
5.1 ANALOG TO ANALOG ENCODING

- ***Def*** : Refers to the representation of **analog information** by an **analog signal.**
- 3 ways to accomplish analog-to-analog conversion:
  i. AM (Amplitude modulation)
  ii. FM (Frequency modulation)
  iii. PM (Phase modulation)
- E.g.: radio



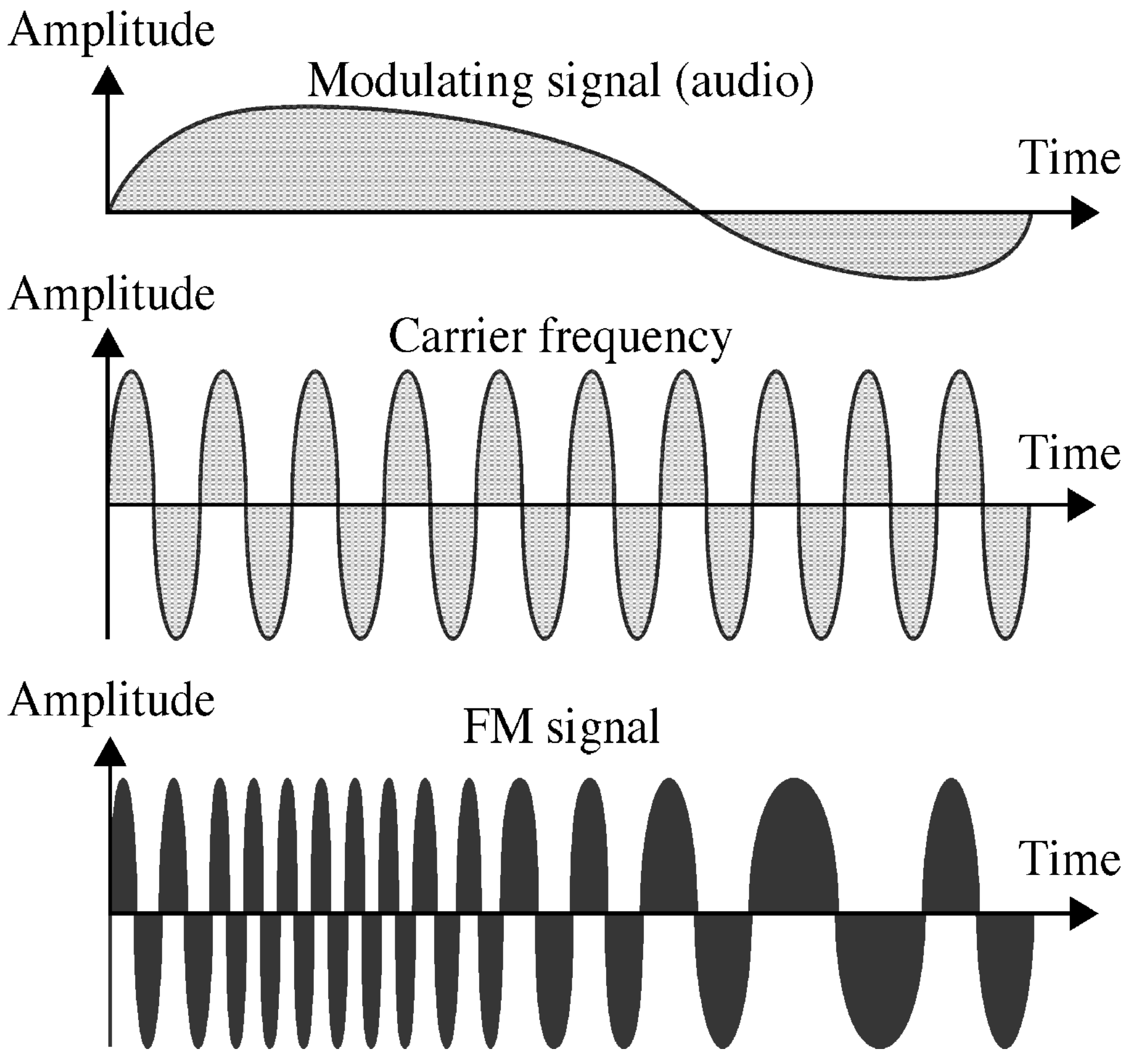
5.1.1 AM (Amplitude Modulation)

- ***Def:*** The carrier signal is modulated so that its **amplitude** varies with the **changing amplitudes of the modulating signal.**
- The **frequency** and **phase** of the carrier remain the same.


Modulating Signal (Audio)
Carrier Frequency
AM Signal

5.1.2 FM (Frequency Modulation)

- ***Def:*** The **frequency** of the carrier signal is modulated to follow the changing voltage level (amplitude) of the modulating signal.

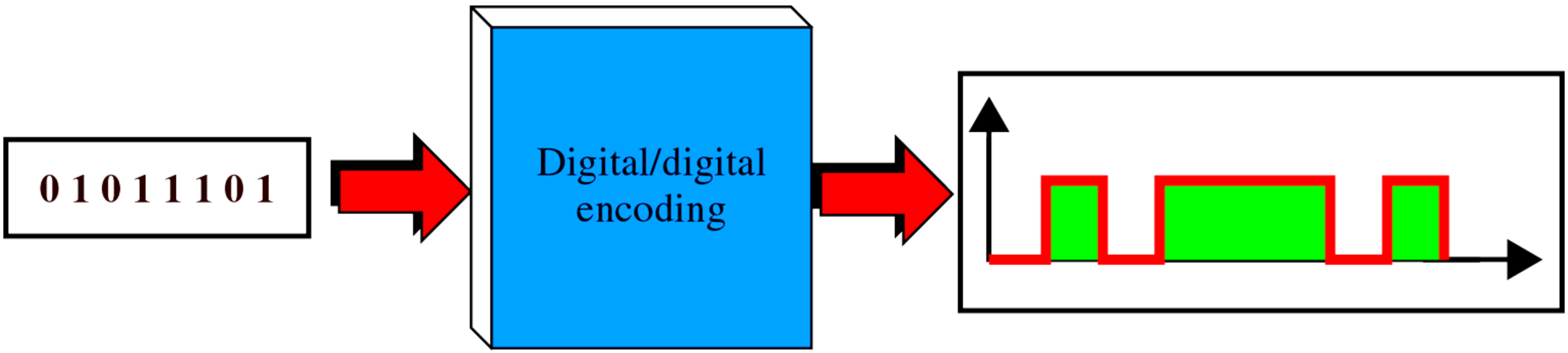

Amplitude
Modulating signal (audio)
Time
Amplitude
Carrier frequency
Time
Amplitude
FM signal
Time

5.1.3 PM (Phase Modulation)

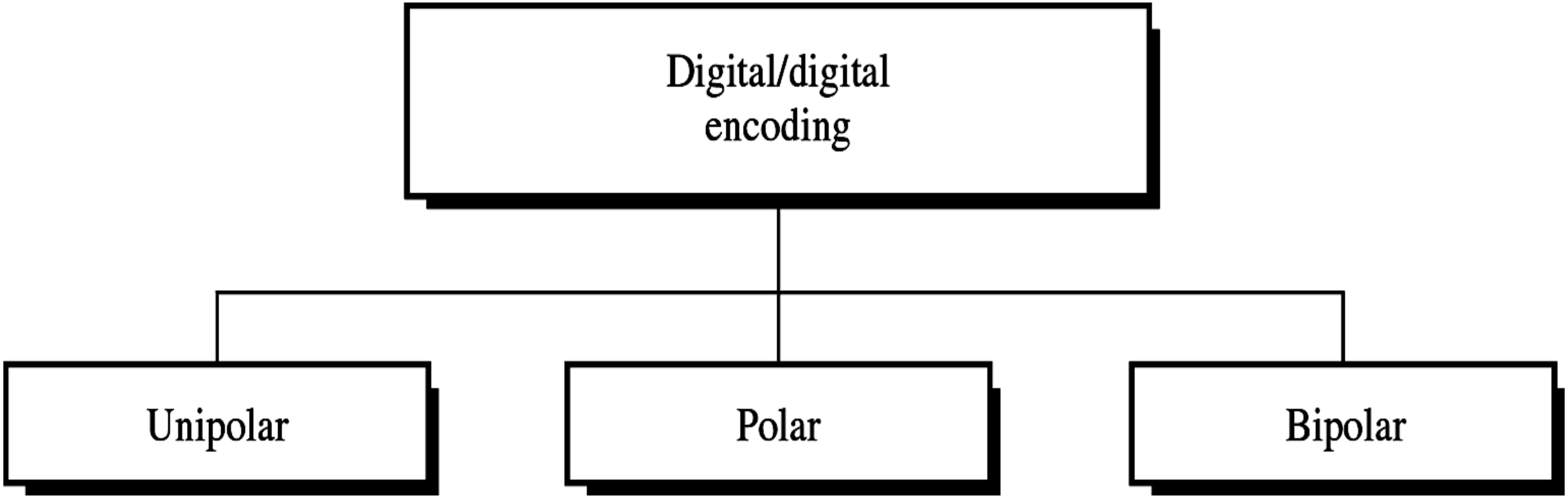
- ***Def:*** Modulate the **phase** of the carrier signal to follow the changing voltage level (amplitude) of the modulating signal.
- Amplitude & frequency constant.

5.2 DIGITAL TO DIGITAL ENCODING

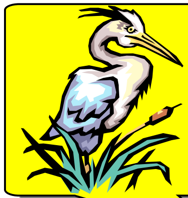
- ***Def*** : the representation of **digital information** by **digital signal**.



- ***Types of Digital to Digital Encoding:***



5.2.1 UNIPOLAR ENCODING



Note:

Unipolar encoding uses only one voltage level.

In unipolar,

- Bit 1: represent **positive** (+ve) voltage
- Bit 0: represent **zero** (0) voltage

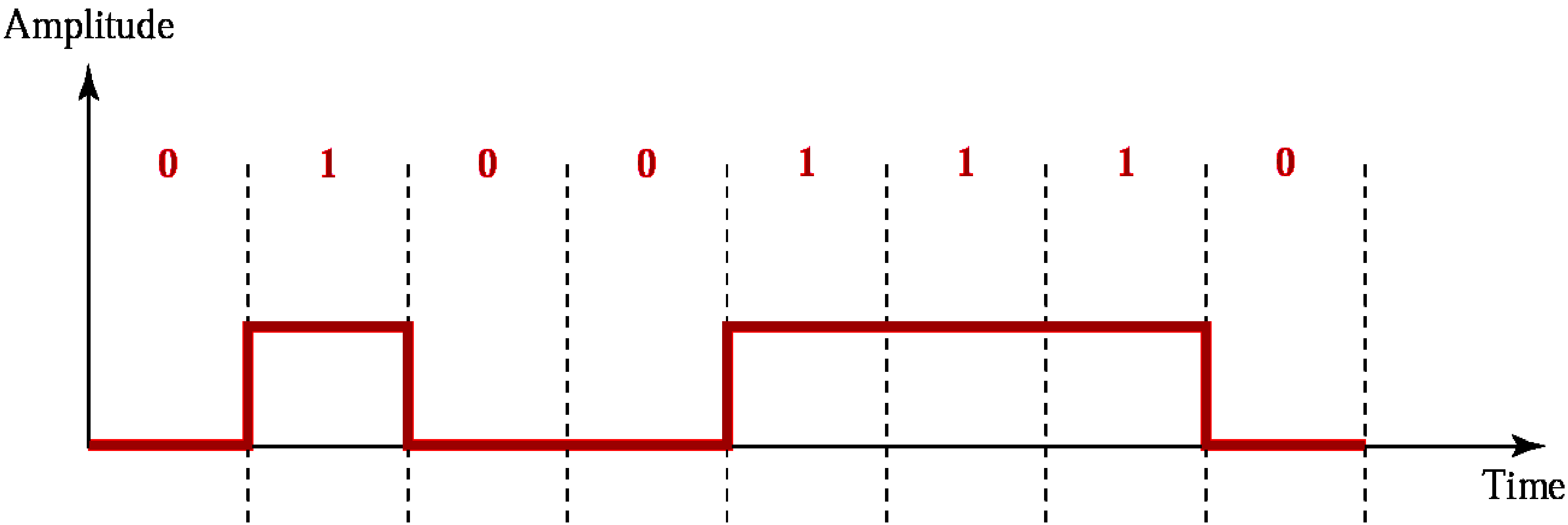
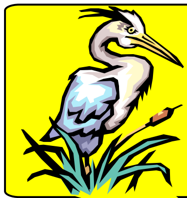


Figure 4.2 :Unipolar Encoding

5.2.2 POLAR ENCODING

- A digital to digital encoding which uses 2 voltage/amplitude level.



Note:

Polar encoding uses two voltage levels (positive and negative).

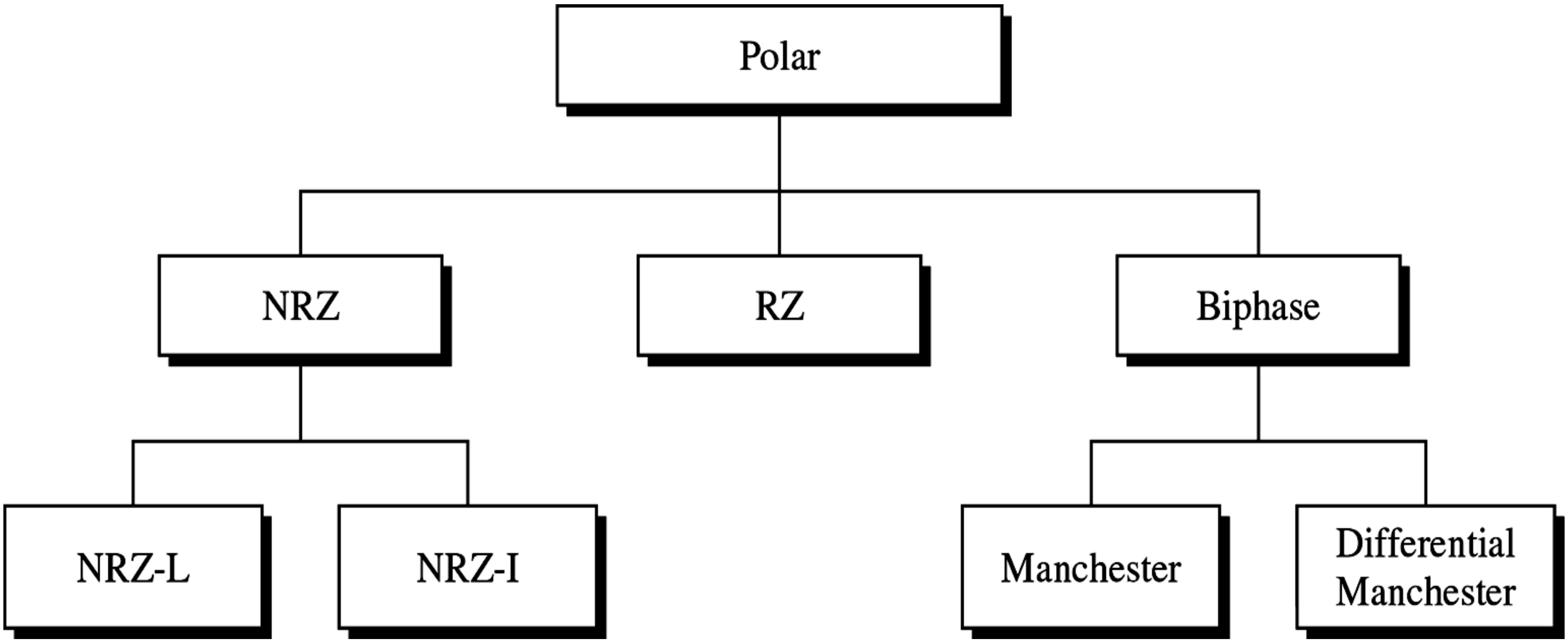
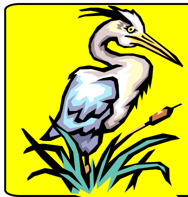


Figure 4.3 :Types of Polar Encoding

NRZ (Non-return to zero)

- A digital-to-digital polar encoding method in which the signal level is **always either positive or negative**.
- 2 types of NRZ:
  i. NRZ-L (Non-return to zero, level)
  ii. NRZ-I (Non-return to zero, invert)
- Bit 0 represent +ve voltage
- Bit 1 represent –ve voltage



Note:

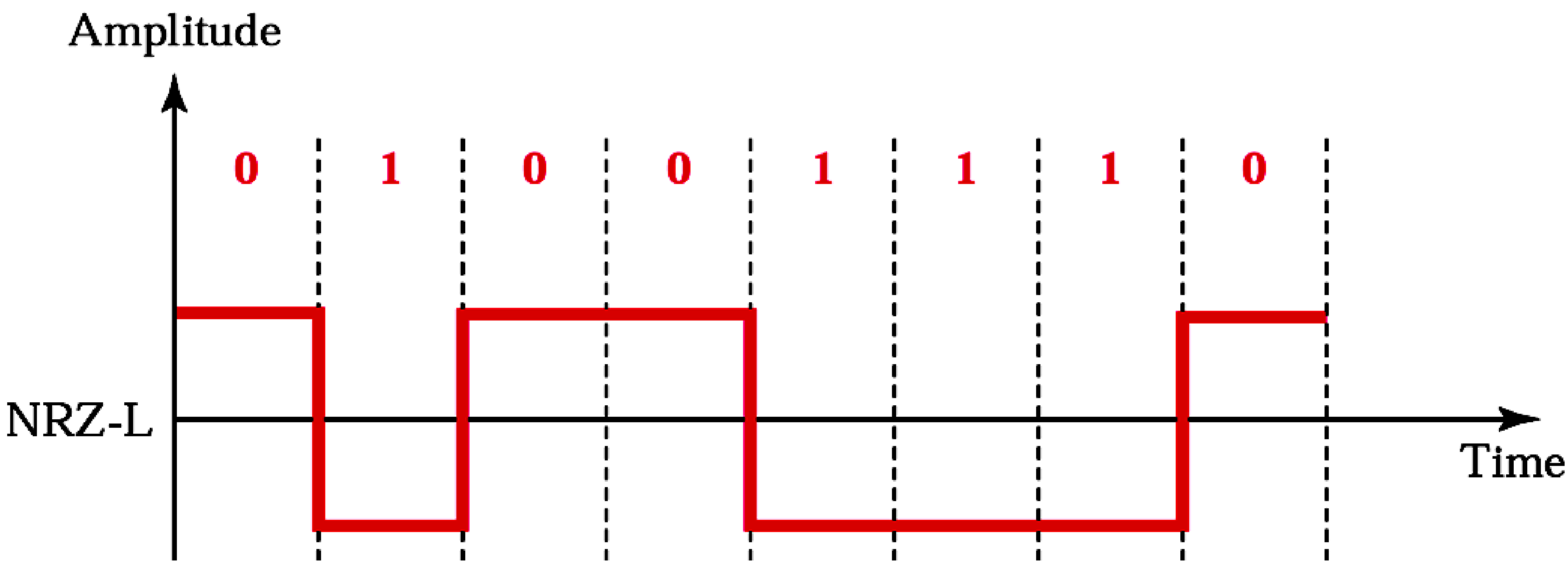
In NRZ-L the level of the signal is dependent upon the state of the bit.

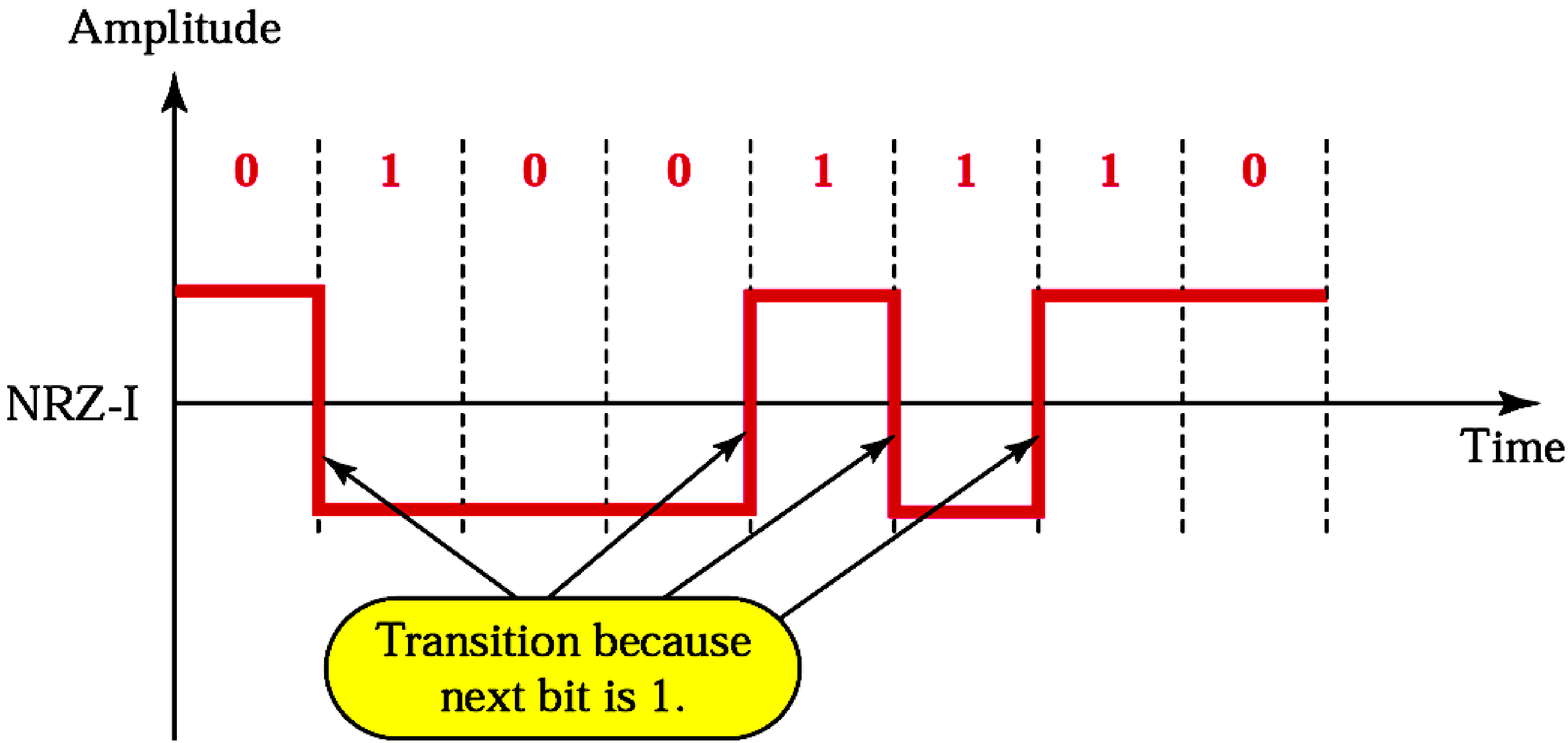
Note:

In NRZ-I the signal is inverted if a 1 is encountered.

Example 1:

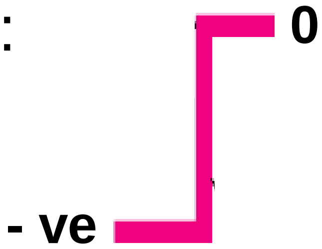
Encode the bit stream 01001110 using NRZ-L and NRZ-I encoding scheme.



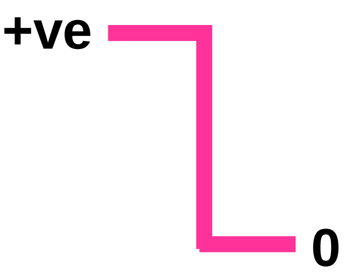

Amplitude
0
1
0
0
1
1
1
0
NRZ-I
Time
Transition because next bit is 1.

RZ (Return to zero)

- A digital-to-digital encoding in which the voltage of the signal is zero for the **second half** of the bit interval.
- Bit 0:

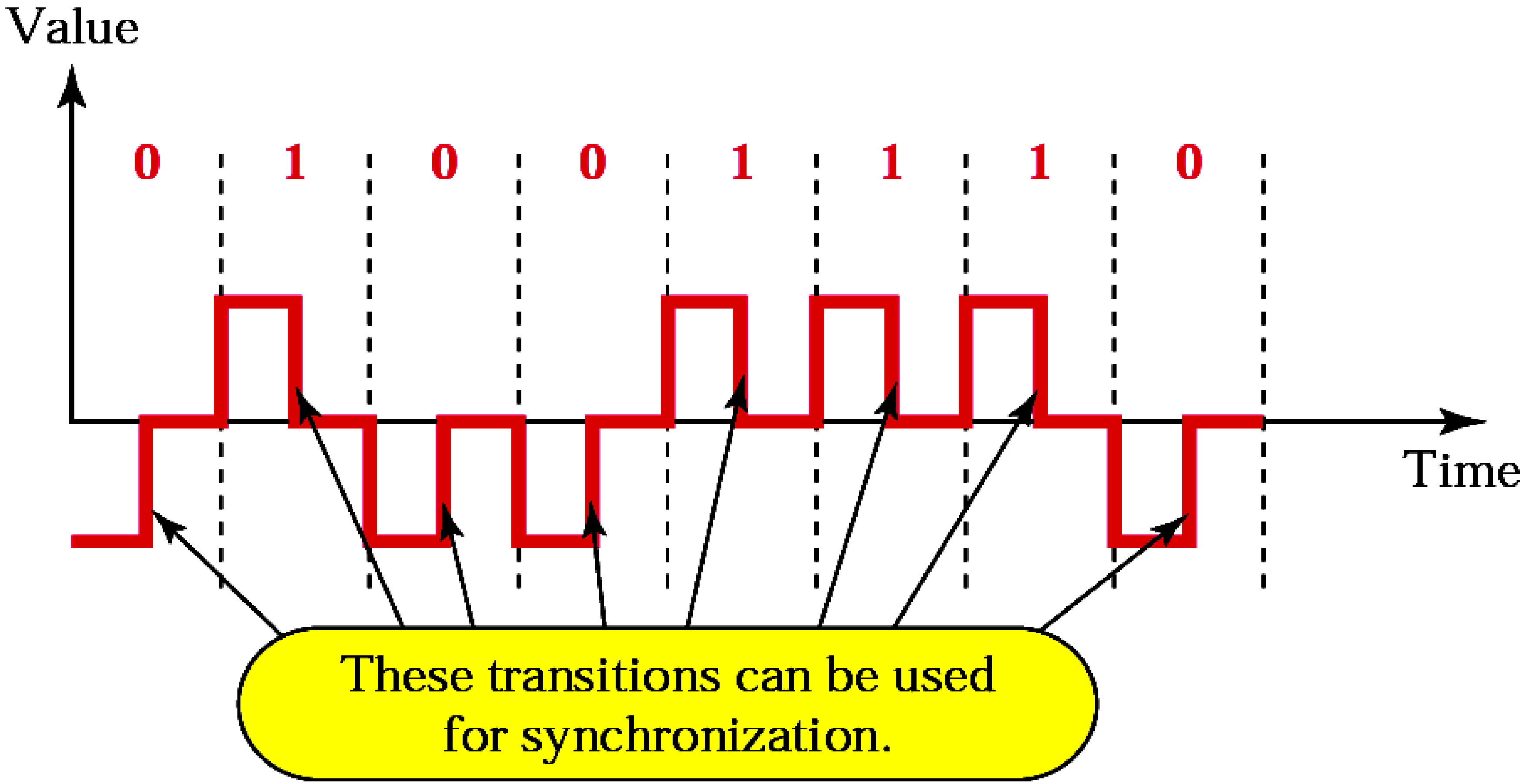


- Bit 1:



Example 2:

Encode the bit stream 01001110 using RZ encoding scheme.

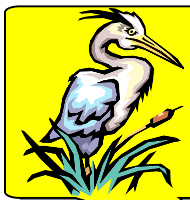


BIPHASE

- 2 types of biphase polar encoding scheme:
  i. Manchester encoding
  ii. Differential Manchester encoding

Manchester Encoding

- A digital-to-digital polar encoding in which a **transition occurs at the middle of each bit interval** for the purpose of synchronization.

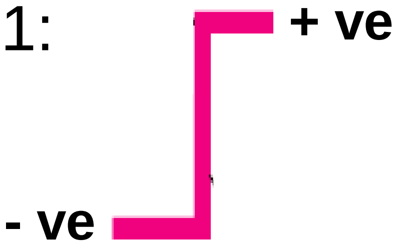


Note:

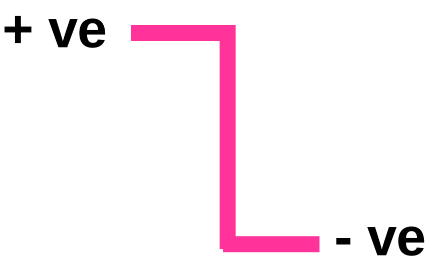
In Manchester encoding, the transition at the middle of the bit is used for both synchronization and bit representation.

- 2 level of amplitude/voltage:

i. Bit 1:

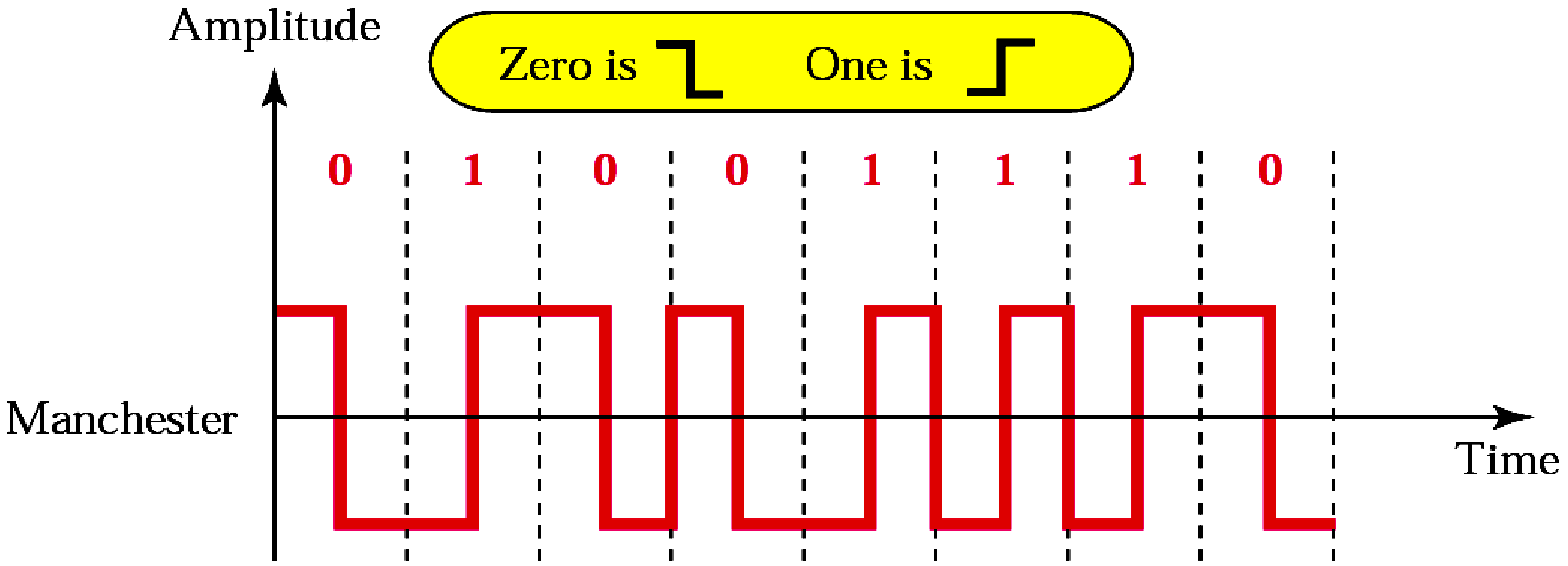


ii. Bit 0:



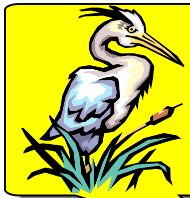
Example 3:

Encode the bit stream 01001110 using Manchester encoding scheme.



Differential Manchester Encoding

- A digital-to-digital encoding method that features a transition at the middle of the bit interval as well as an **invertion at the beginning of each 1 bit**.
- Invert when encounter **0**.

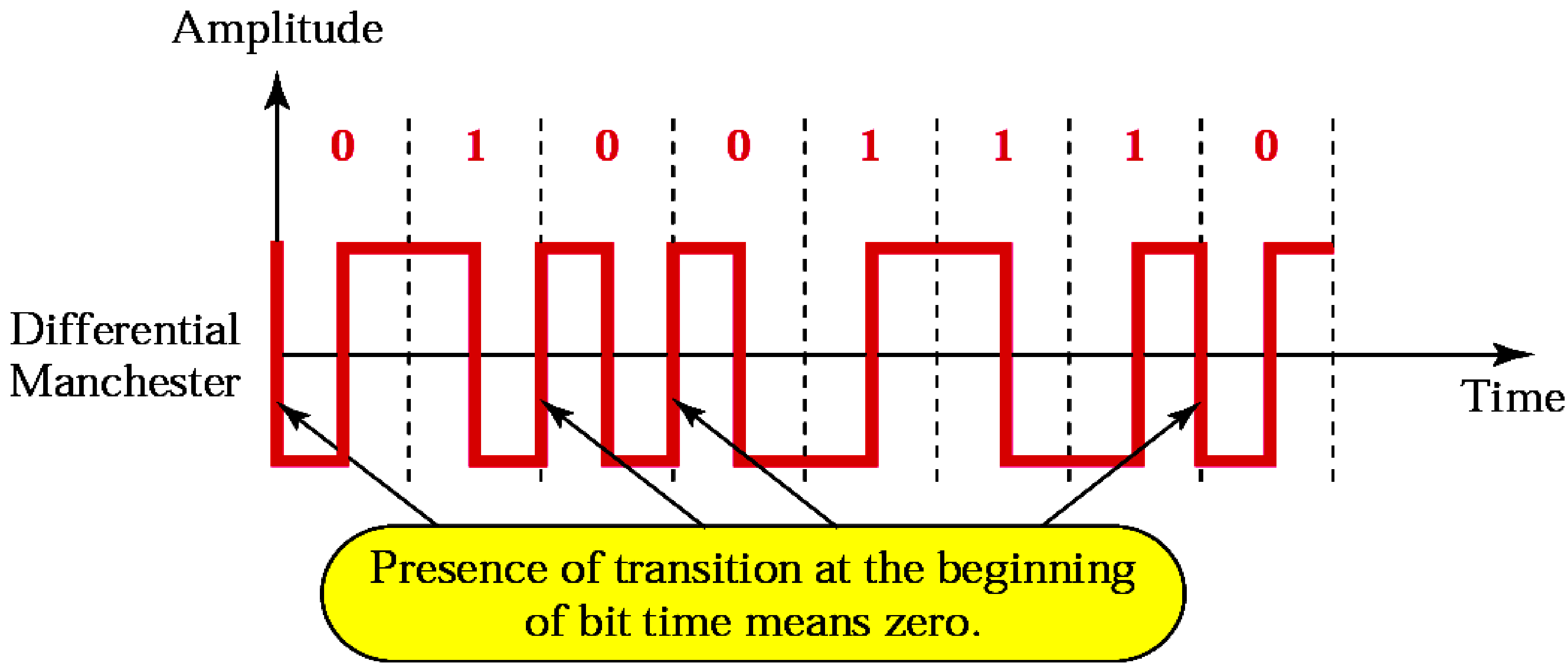


Note:

In differential Manchester encoding, the transition at the middle of the bit is used only for synchronization.
The bit representation is defined by the inversion or noninversion at the beginning of the bit.

Example 4:

Encode the bit stream 01001110 using Differential Manchester encoding scheme.

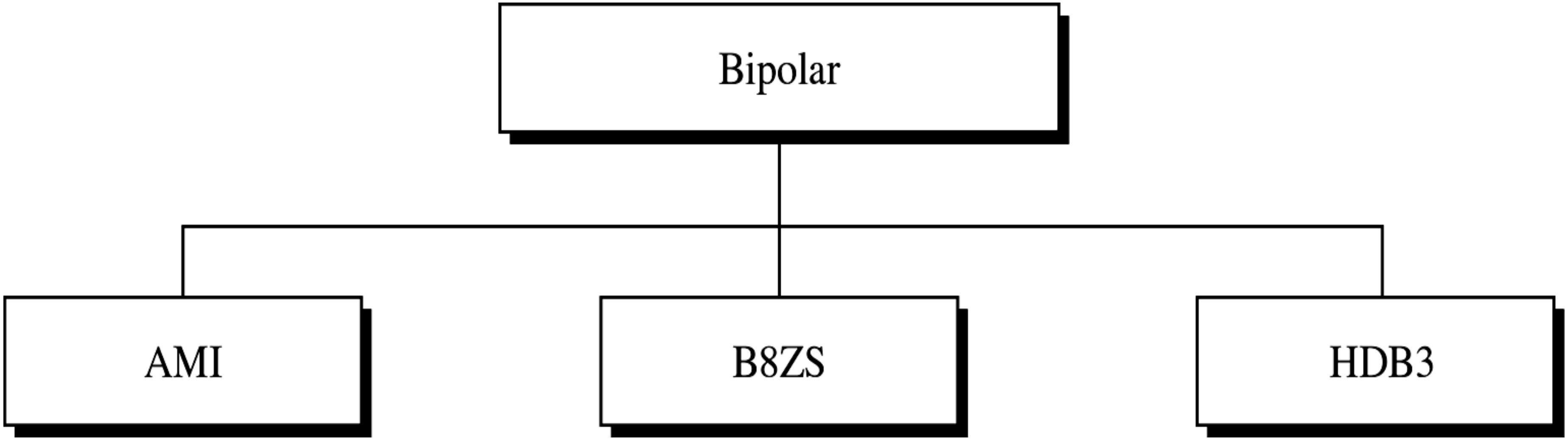


5.2.3 BIPOLAR ENCODING

- A digital-to-digital encoding method in which:
  - **0 amplitude** represent: **binary 0**.
  - **+ve and –ve amplitude** represent **alternate 1**.

Note:

In bipolar encoding, we use three levels: positive, zero, and negative.



Alternate Mark Inversion

Bipolar 8-Zero Substitution

High-Density Binary 3

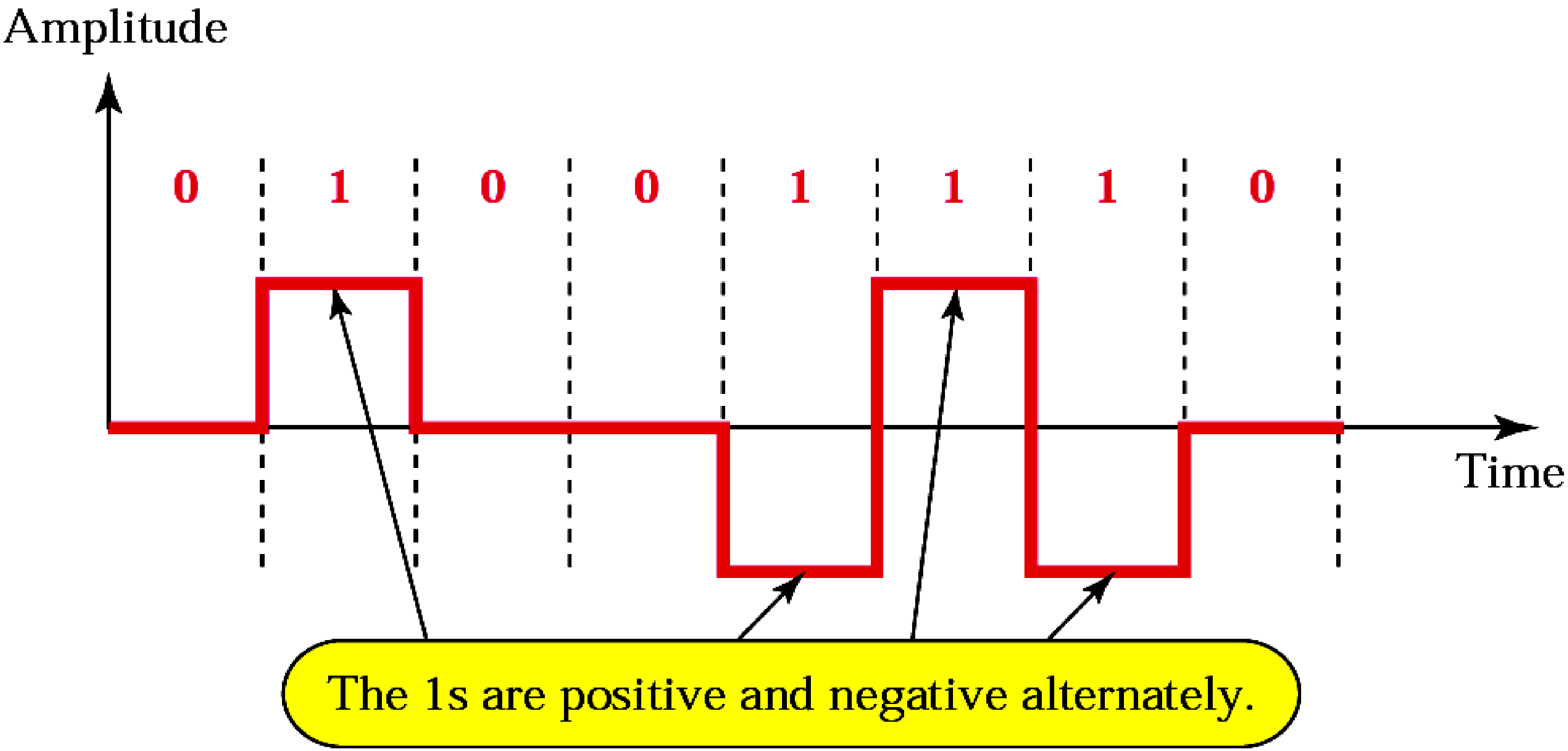
Figure 4.4 :Types of Bipolar Encoding

AMI (Alternate Mark Inversion)

- A digital-to-digital bipolar encoding method in which the amplitude representing 1 alternates between +ve and –ve voltages.
- Bit 0 represent: zero (0) voltage
- Bit 1: alternating +ve and -ve

Example 5:

Encode the bit stream 01001110 using bipolar AMI encoding scheme.



5.4 DIGITAL DATA TRANSMISSION

- 2 mode of binary data transmission:

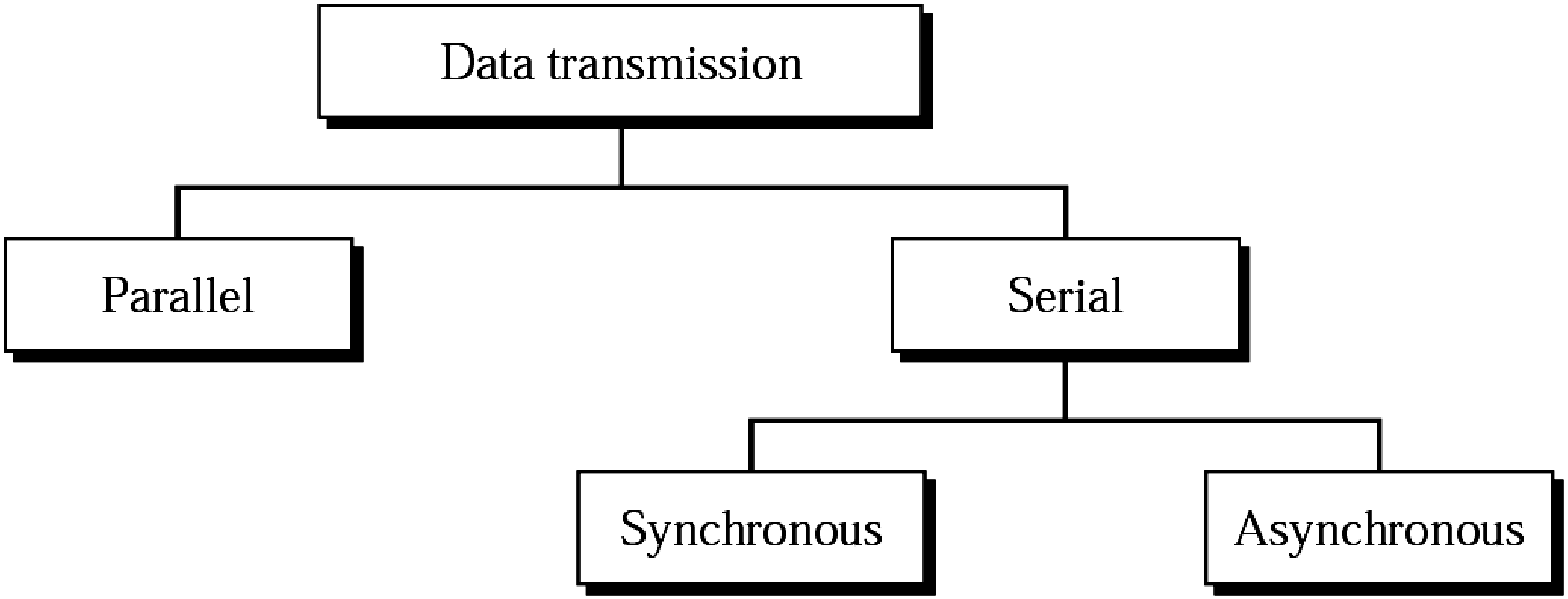


Figure 4.5 : Data Transmission

5.4.1 PARALLEL TRANSMISSION

- ***Parallel mode*** : *multiple bits* are sent with *each clock pulse.*
- ***Def*** : transmission in which bits in a group are sent simultaneously, each using a separate link.

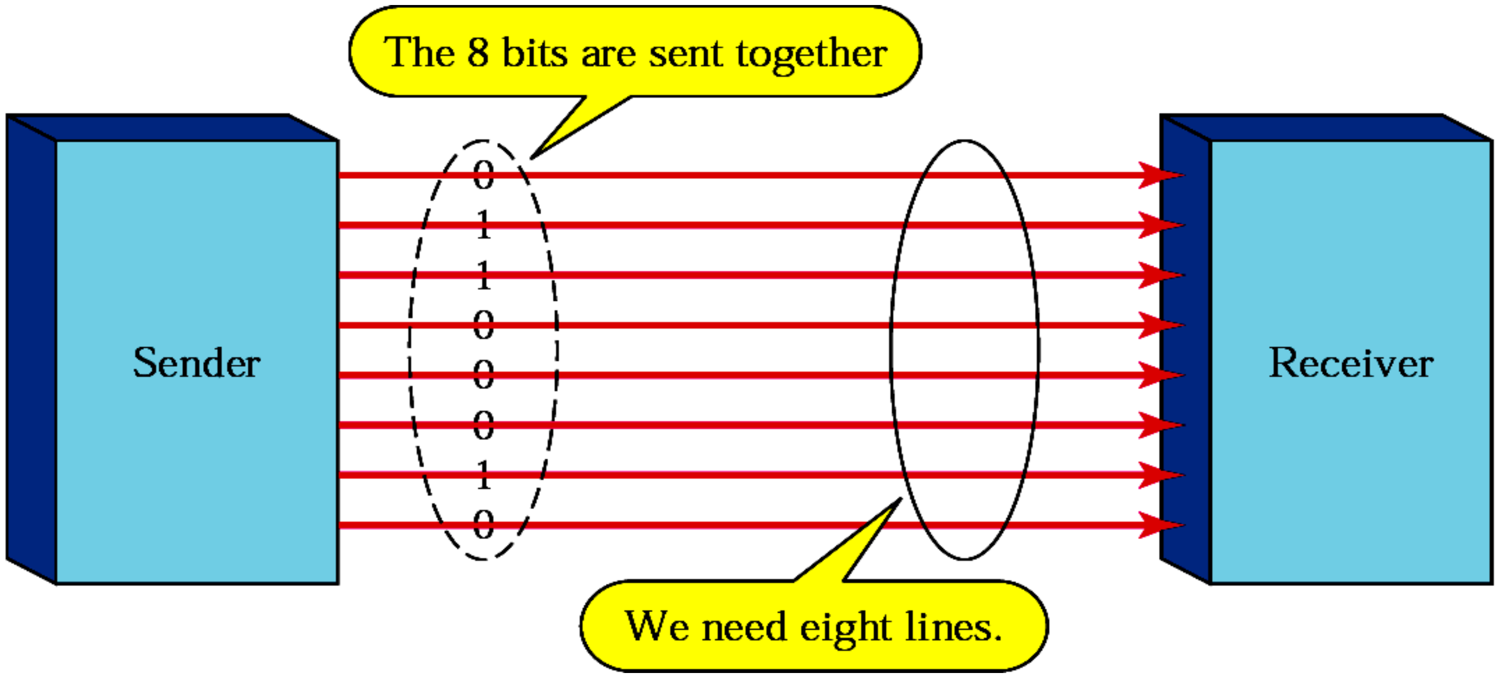


Figure 4.6: Shows how parallel transmission works for n=8 (use n wires to send n bits at one time)

- ***Advantage*** :
  - **speed** : increase the transfer speed by a factor of *n.*
- ***Disadvantage*** :
  - **cost** : requires *n* communication lines (wires) just to transfer the data stream.
  - limited to short distance – Why? Because it is expensive.

Figure: A DB-25 parallel printer port on the back of a laptop

5.4.2 SERIAL TRANSMISSION

- ***Serial mode*** : *one bit* is sent with *each clock pulse.*
- One bit follows another.

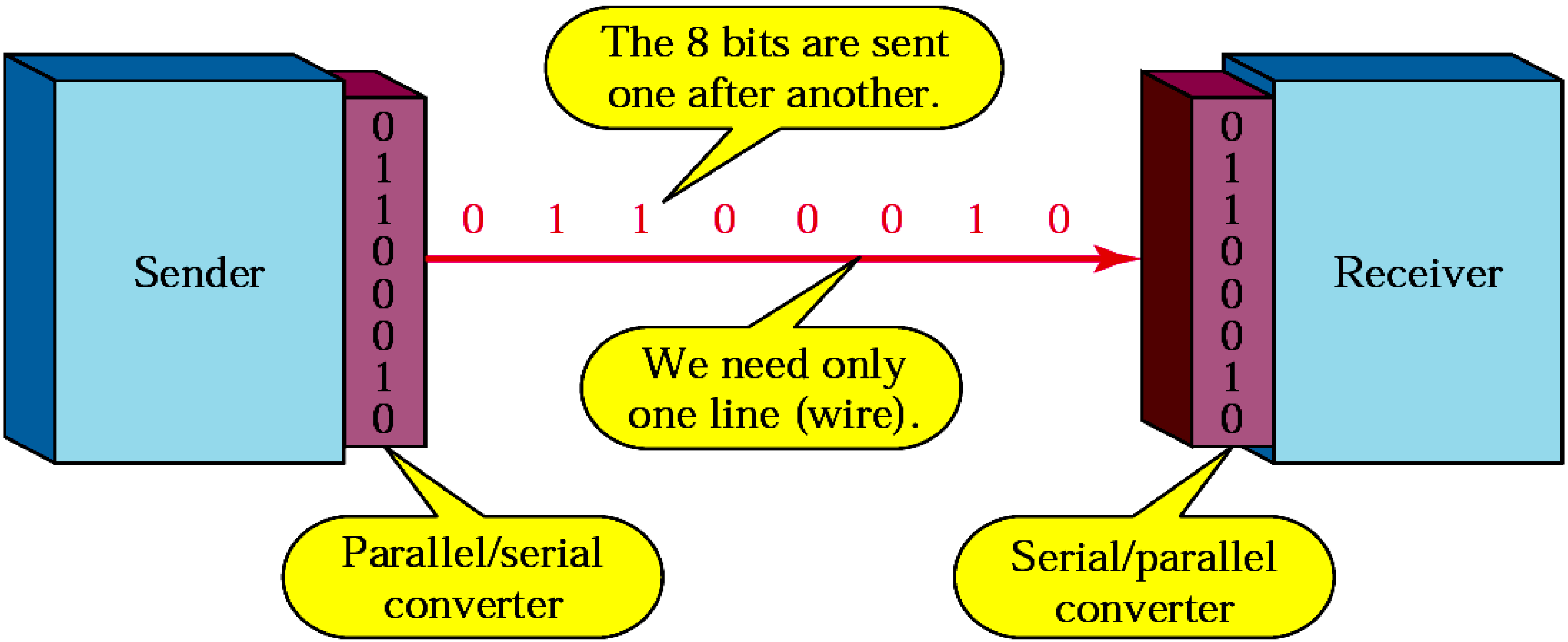


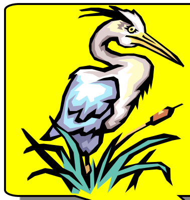
Figure 4.7: Serial Transmission

- ***Def*** : transmission of data one bit at a time using only one single link.
- ***Advantage*** :
  - reduce the cost of transmission (Because use only one communication channel)
  - slow but easier to design and clock speed can be increased to make up for lower efficiency.
- 2 ways of serial transmission:
  i. Asynchronous
  ii. Synchronous
- Why uses *parallel/serial converter* and vice versa?
  - because communication within devices is *parallel.*

- Throughout most of the history of personal computers, data transfer through serial ports connected the computer to devices such as terminals or modems, Mice, keyboard and other peripheral devices.

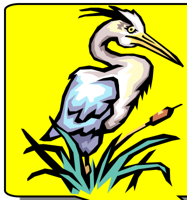
Figure: Serial port

Asynchronous Transmission



Note:

In asynchronous transmission, we send 1 start bit (0) at the beginning and 1 or more stop bits (1s) at the end of each byte. There may be a gap between each byte.



Note:

Asynchronous here means "asynchronous at the byte level," but the bits are still synchronized; their durations are the same.

- Characteristics:
  - i. Receiving device can retrieve the information w/o regard to the rhythm in which it is sent.
  - ii. There may be a variable-length gap btw each byte.

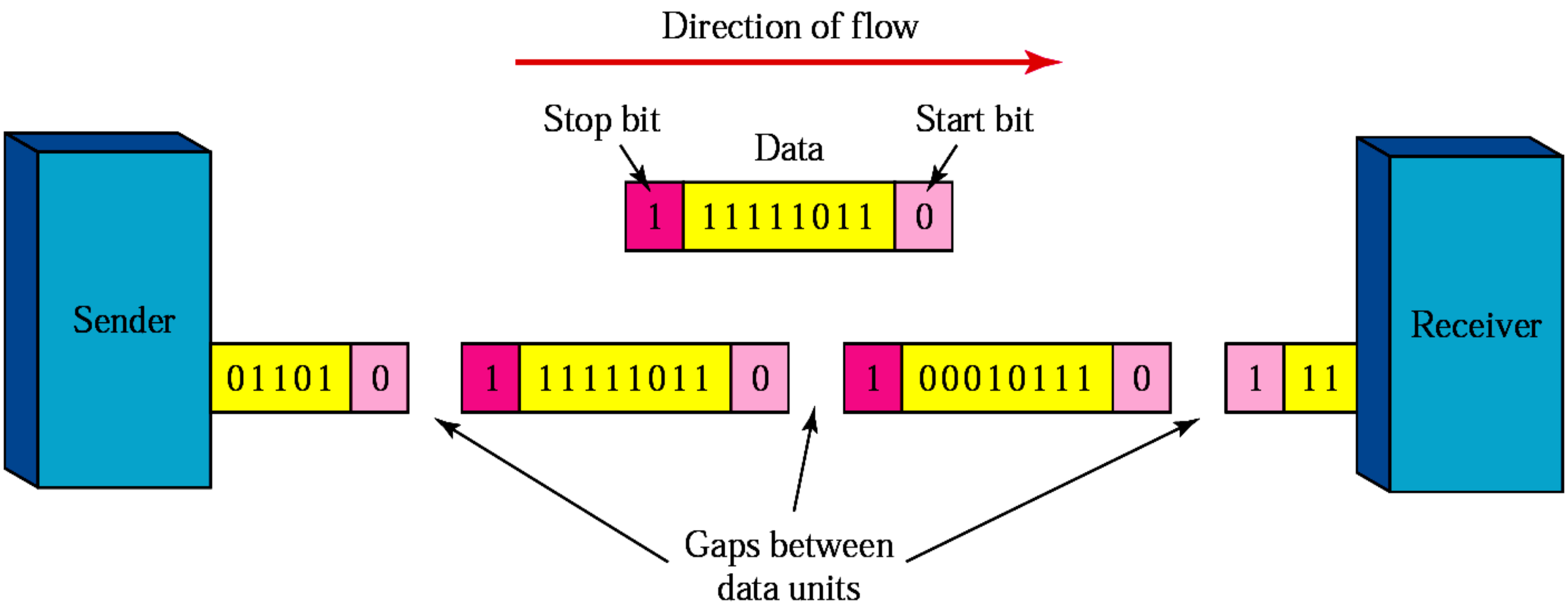
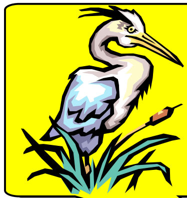


Figure 4.8: Asynchronous Transmission (Serial)

Synchronous Transmission



Note:

In synchronous transmission,
we send bits, one after another without start/stop bits or gaps.
It is the responsibility of the receiver to group the bits.

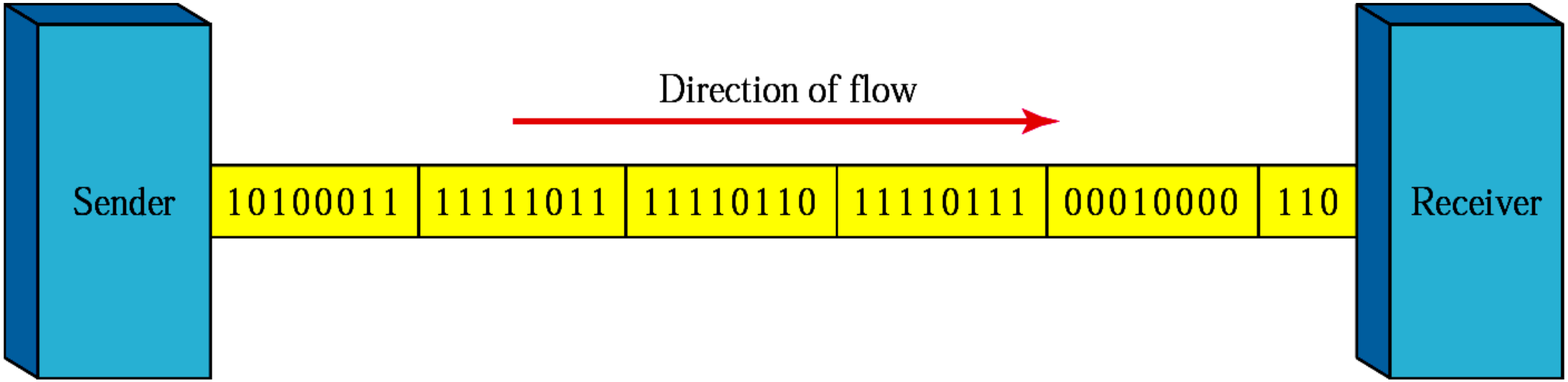


Figure 4.9: Synchronous Transmission (Serial)

- Characteristics:
  i. Send bits, one after another w/o start/stop bits or gaps.
  ii. It is the responsibility of the receiver to group the bits.