Data Communication (CSX-208)

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Physical Layer

Digital Transmission and Analog Transmission

Digital transmission

- We shall understand, how we can represent digital data by using digital signals.
- The conversion involves three techniques: line coding, block coding, and scrambling.
- Line coding is always needed; block coding and scrambling may or may not be needed.

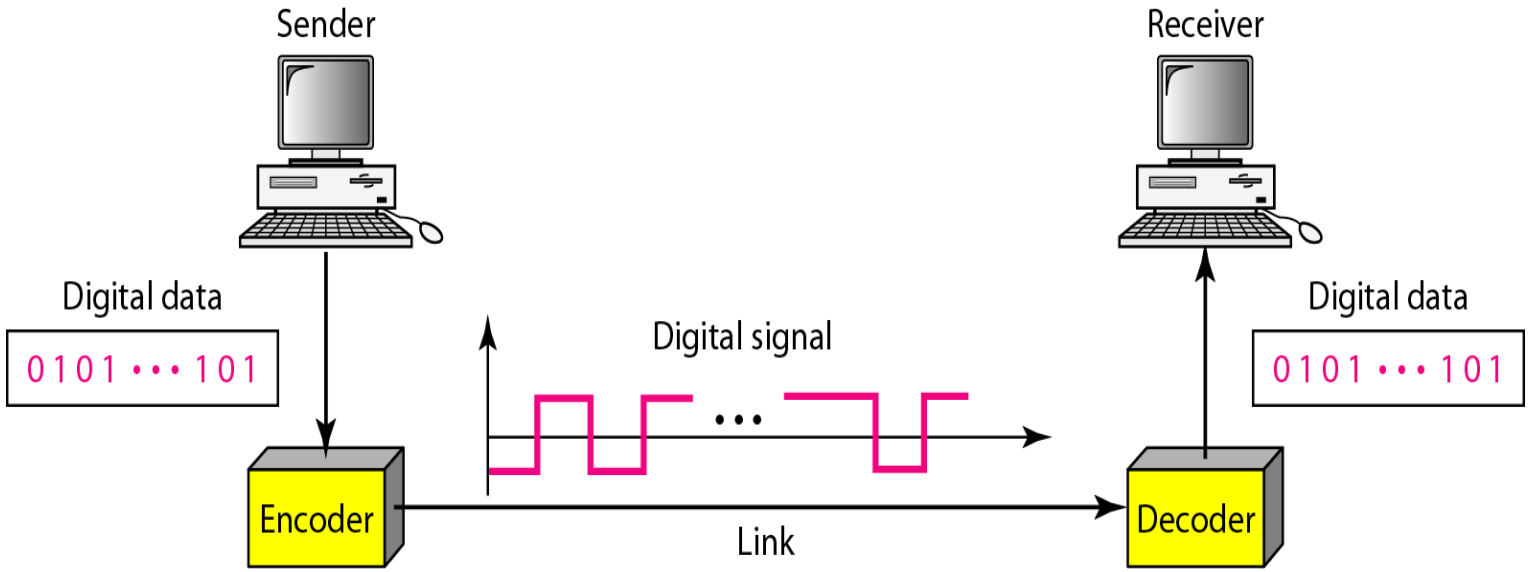


Figure: Digital communication

Data rate and signal rate

- Data rate is number of data elements (bits) transmitted per second
  - Units is bits per second (bps)
  - Also called bit rate

- Signal rate is number of signal elements transmitted per second.
  - Units is baud
  - Also called pulse rate/modulation rate/ baud rate

- Goal of signal communication is increase the data rate while decreasing the signal rate.
  - Increasing data rate increases speed of transmission
  - Decreasing signal rate decreases band width requirements

Examples:

- A digital signal has eight levels. How many bits are needed per level? Calculate the number of bits from the formula?

- Assume we need to download text documents at the rate of 100 pages per second. A page is an average of 24 lines with 80 characters in each line. What is the required bit rate of the channel?

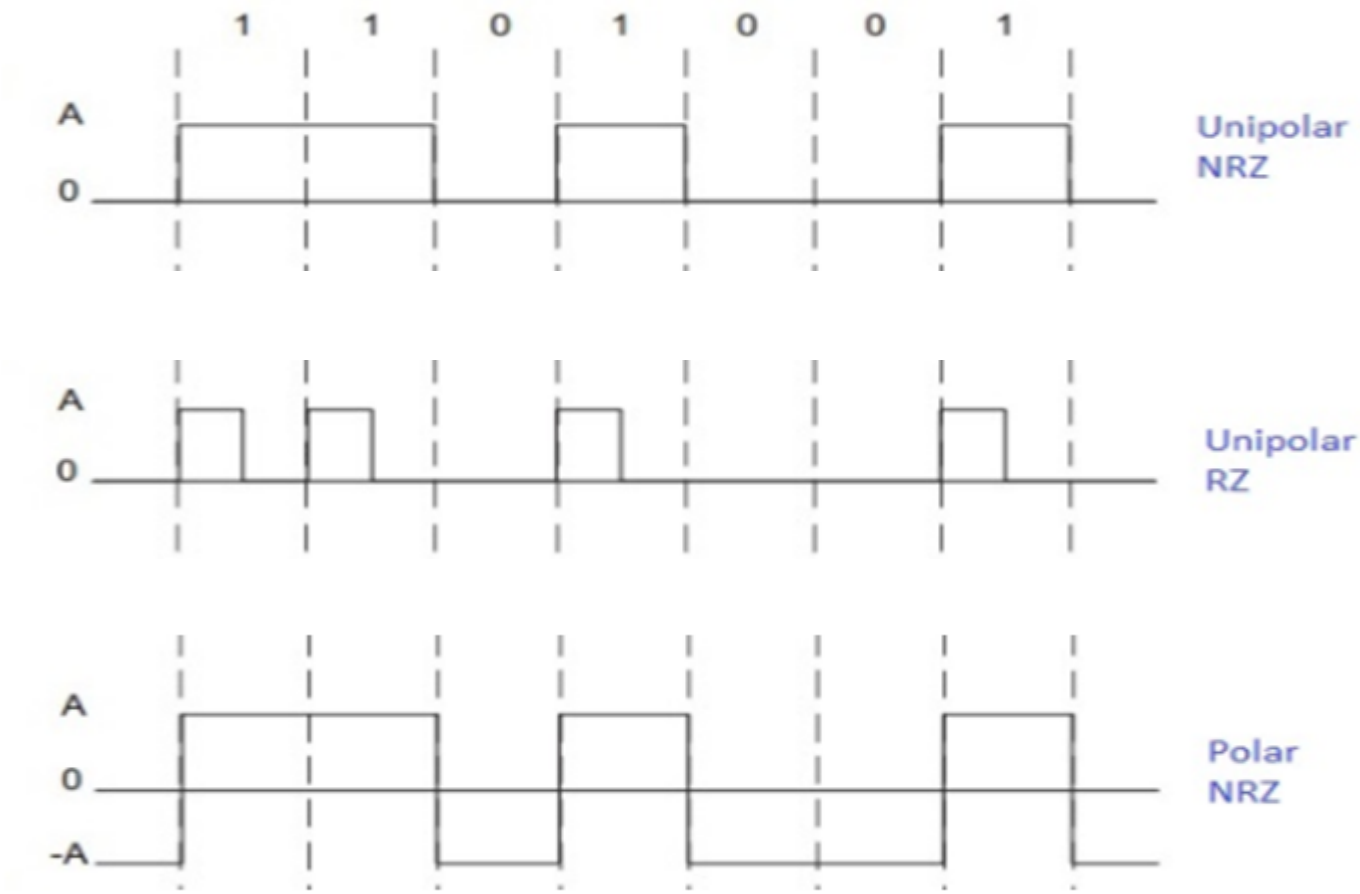
- We have a channel with a 1-MHz bandwidth. The SNR for this channel is 63. What are the appropriate bit rate and signal level?

Line Coding

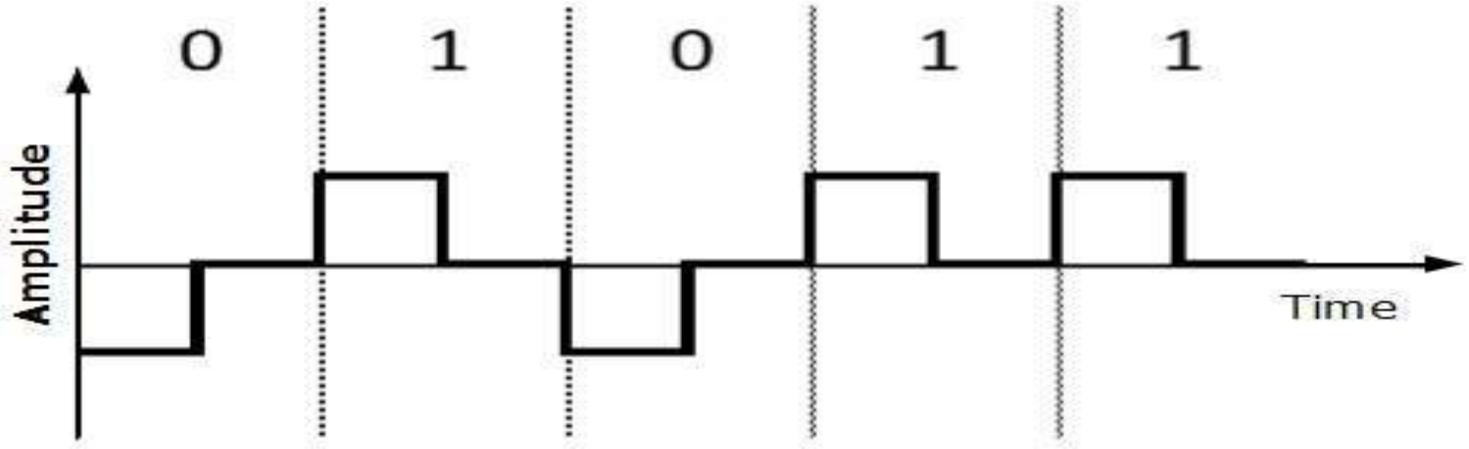
- Line coding is the process of converting digital data into digital signals.

- Types of line coding
  - Unipolar line coding
  - Polar line coding
  - Bipolar line coding
  - Multilevel line coding

Unipolar NRZ & RZ and Polar NRZ & RZ

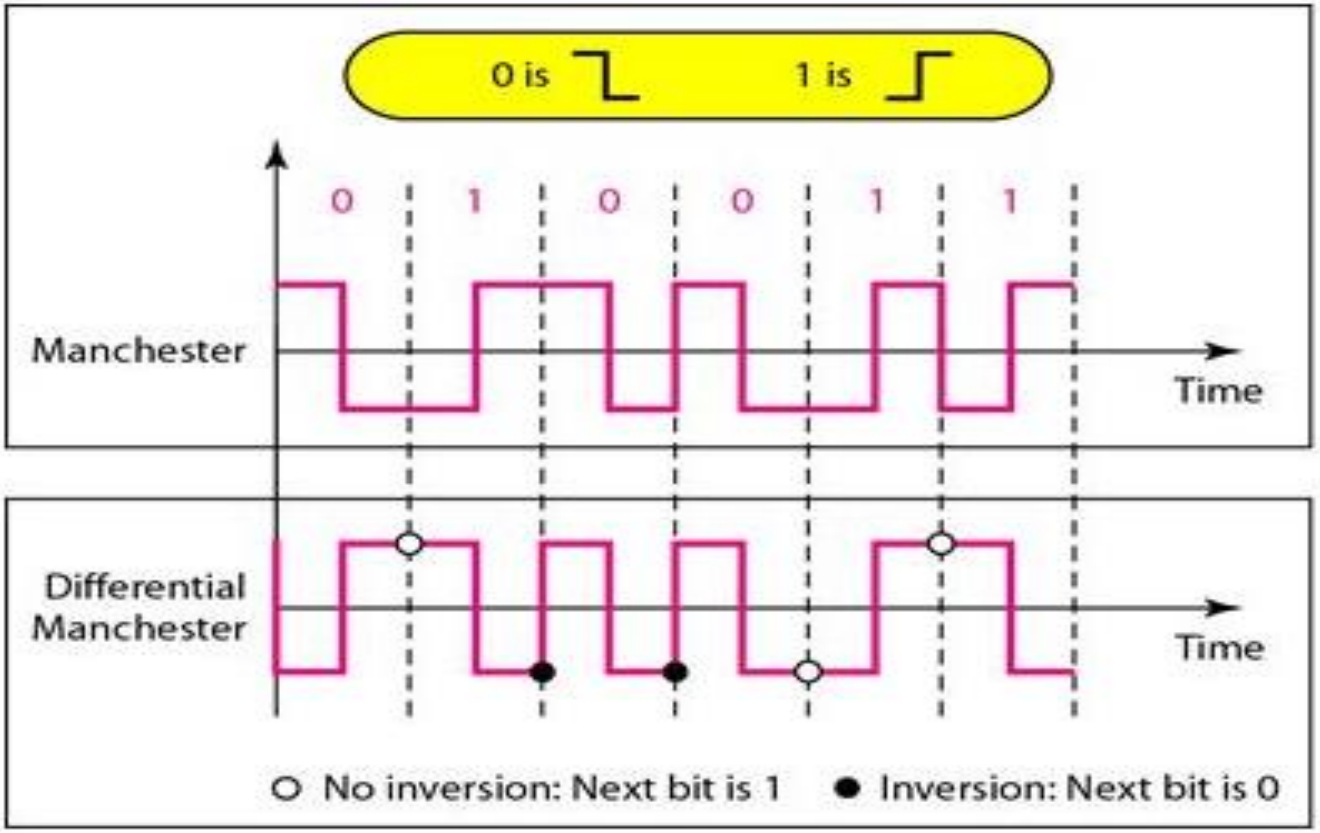


Polar RZ



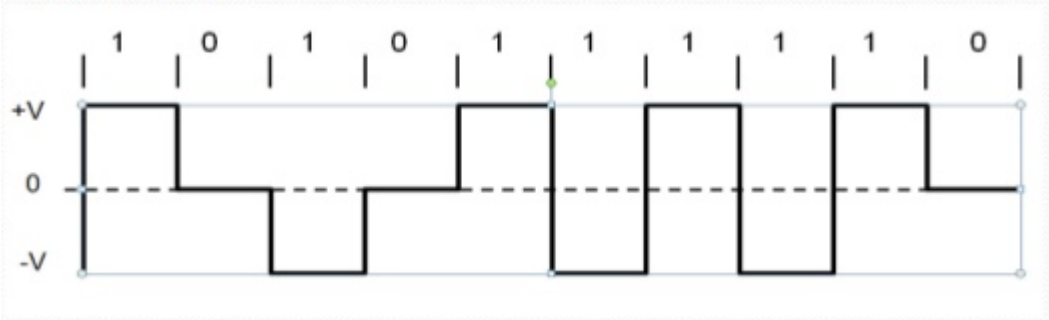
Manchester & Differential Manchester

- Manchester and differential manchester coding are the type of polar line coding.

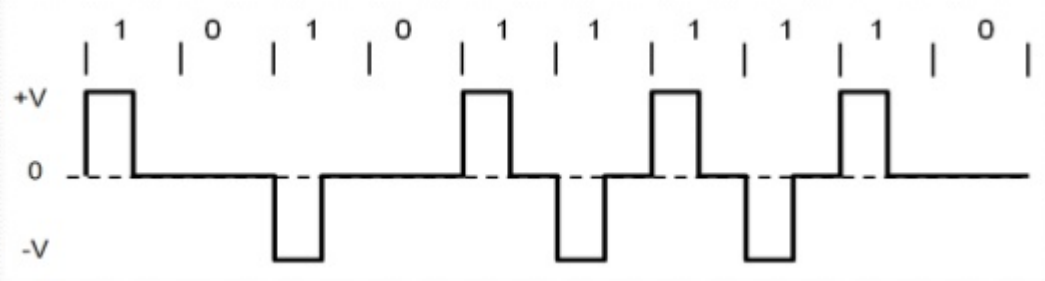


Bipolar NRZ and RZ

- Bipolar NRZ



- Bipolar RZ



Polar Quaternary

- It employs with four distinct symbols

Analog Transmission

- Digital-to-analog conversion is the process of changing one of the characteristics of an analog signal based on the information in digital data.

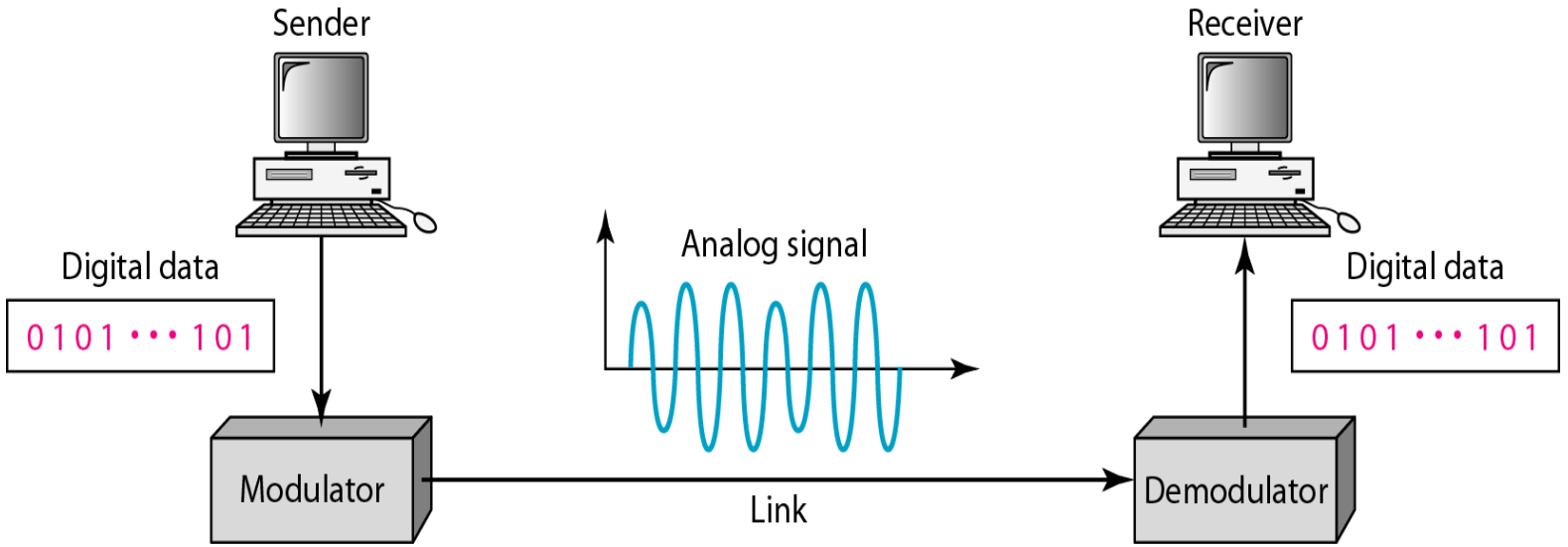
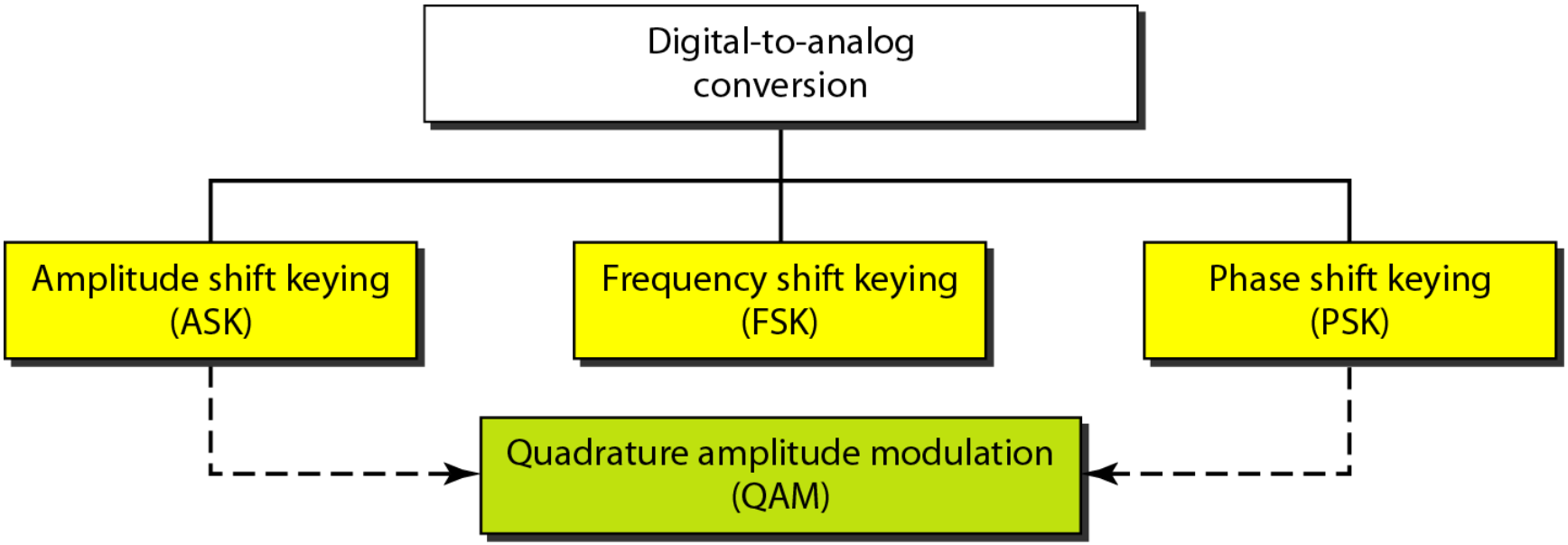
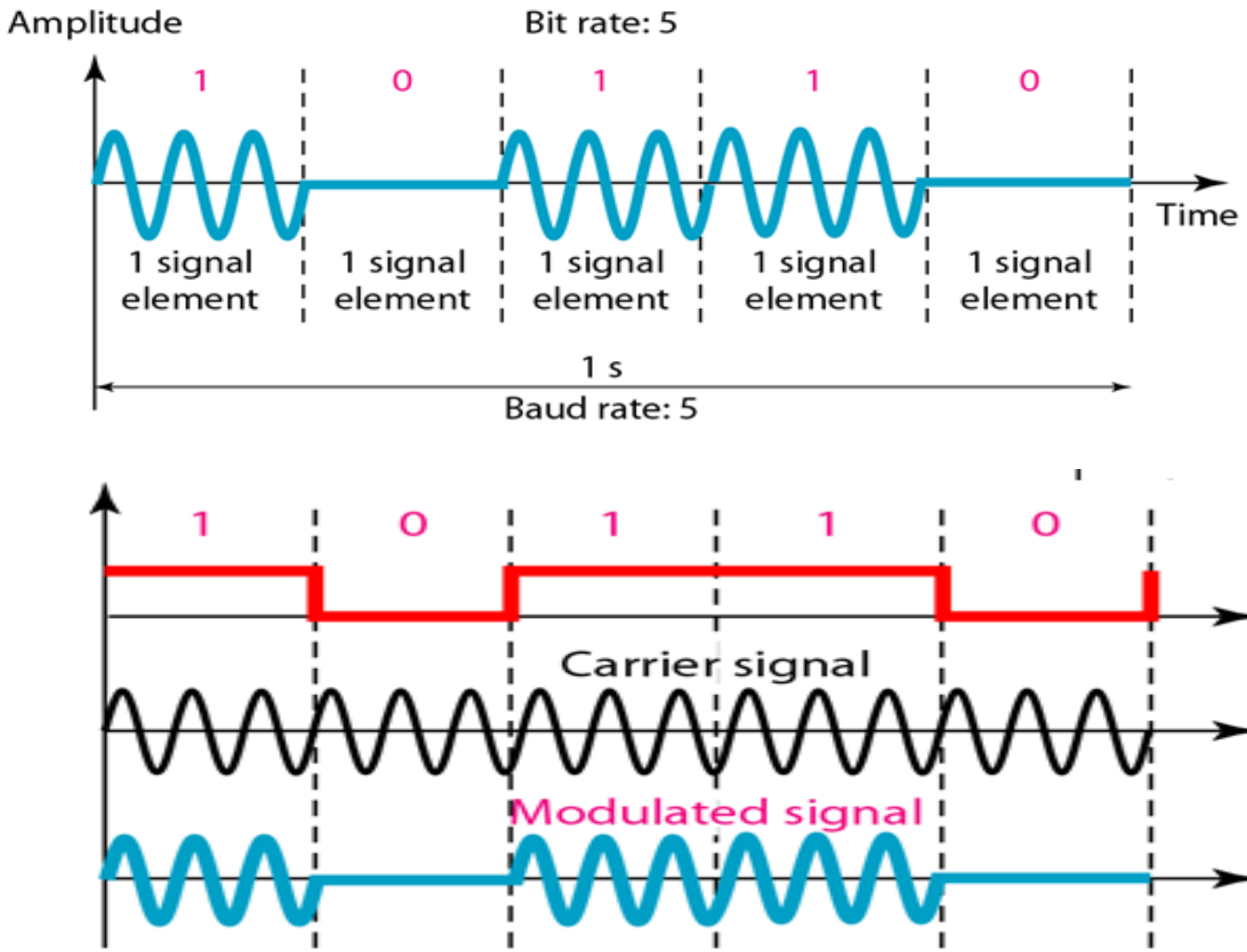


Figure: Analog Communication

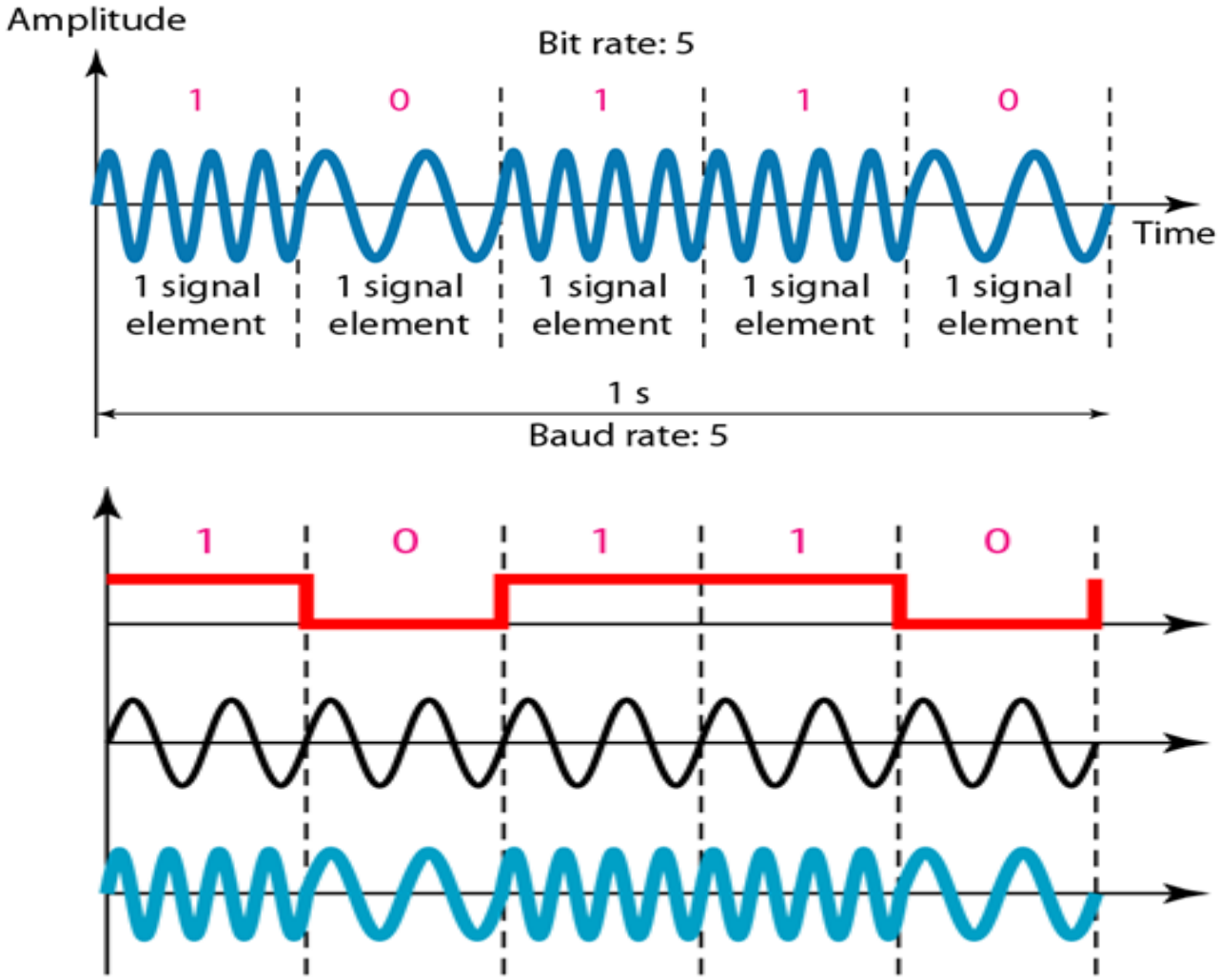
Types of digital-to-analog conversion



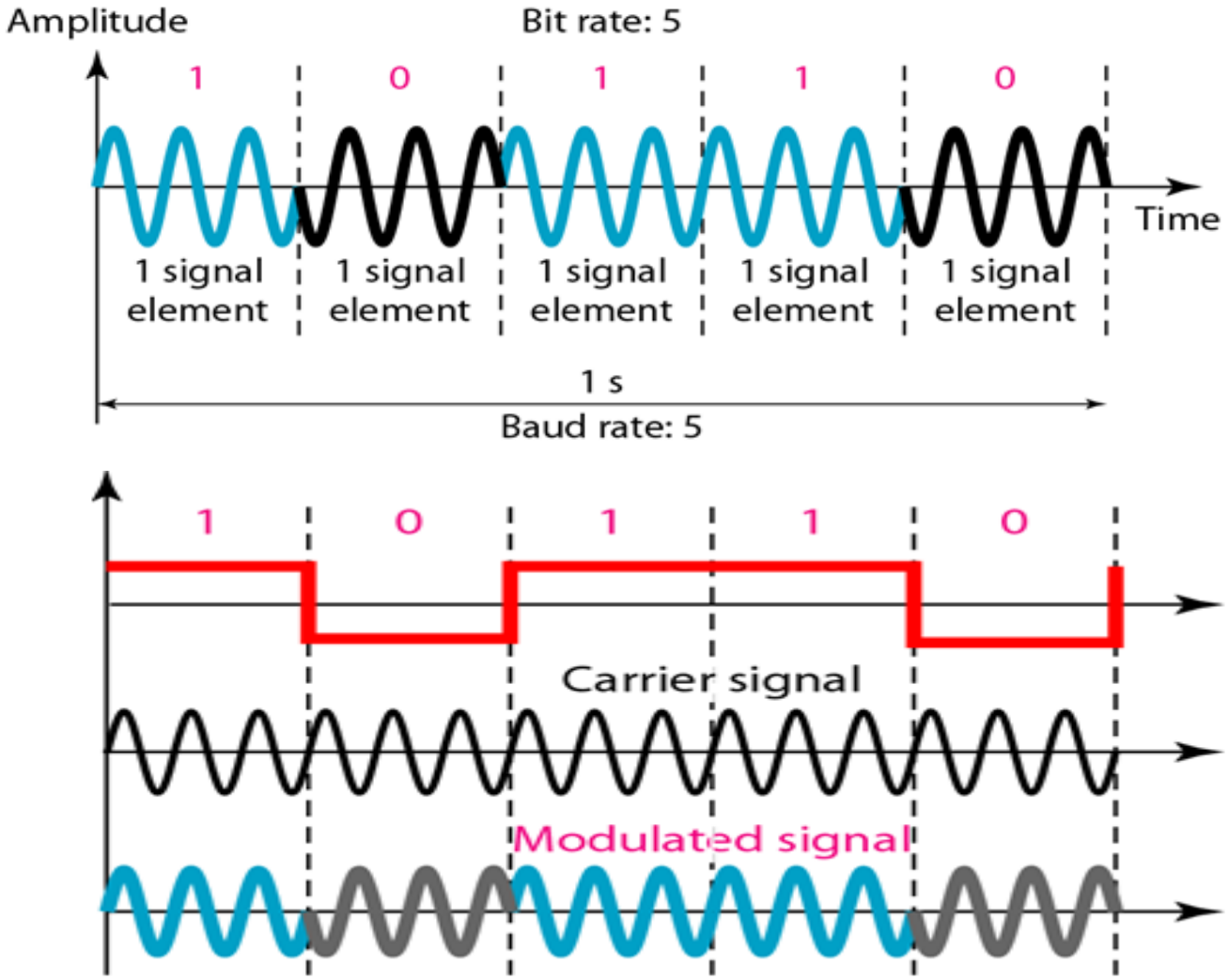
Amplitude Shift Keying (ASK)



Frequency Shift Keying

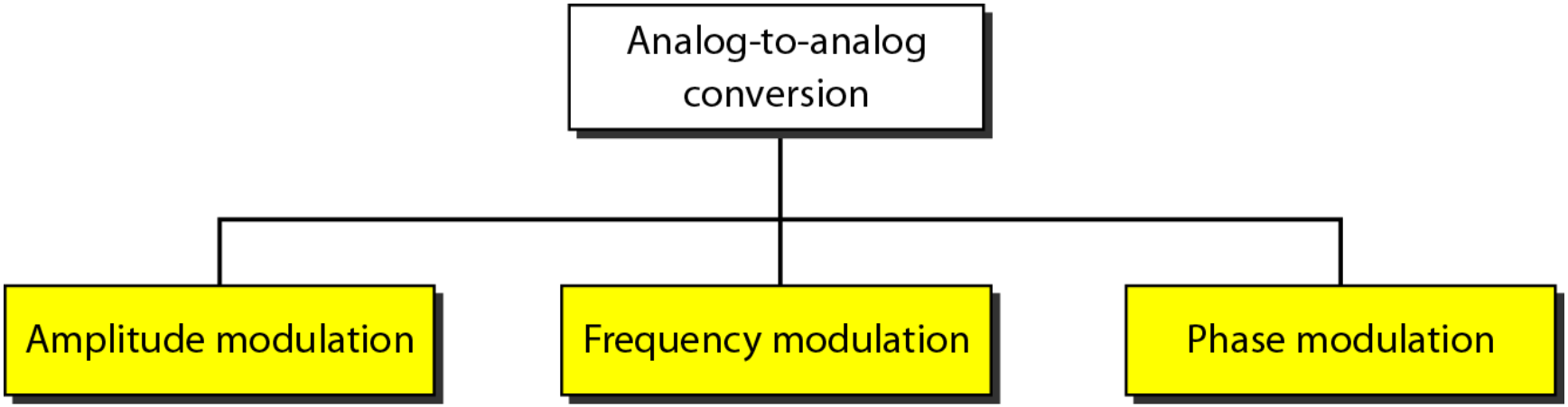


Phase Shift Keyeing

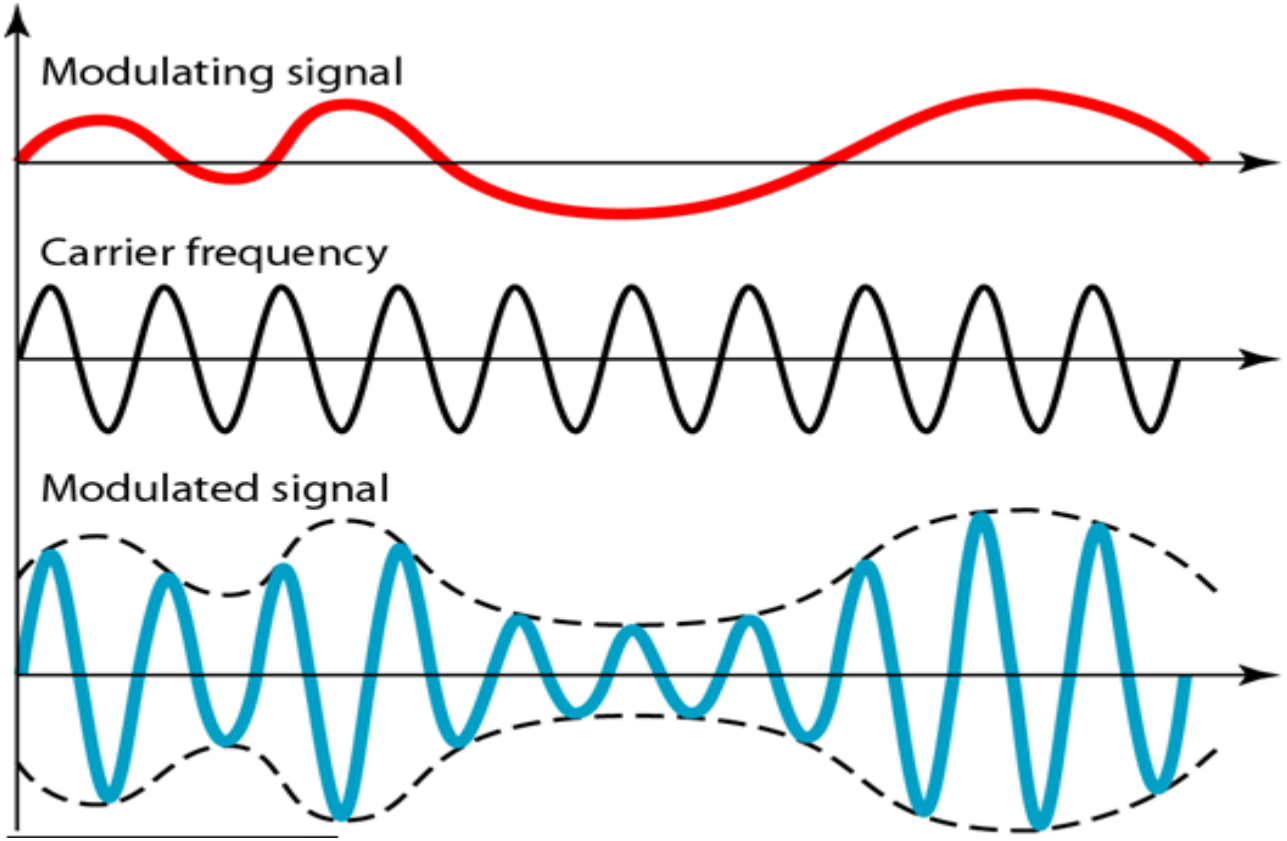


Analog to analog conversion

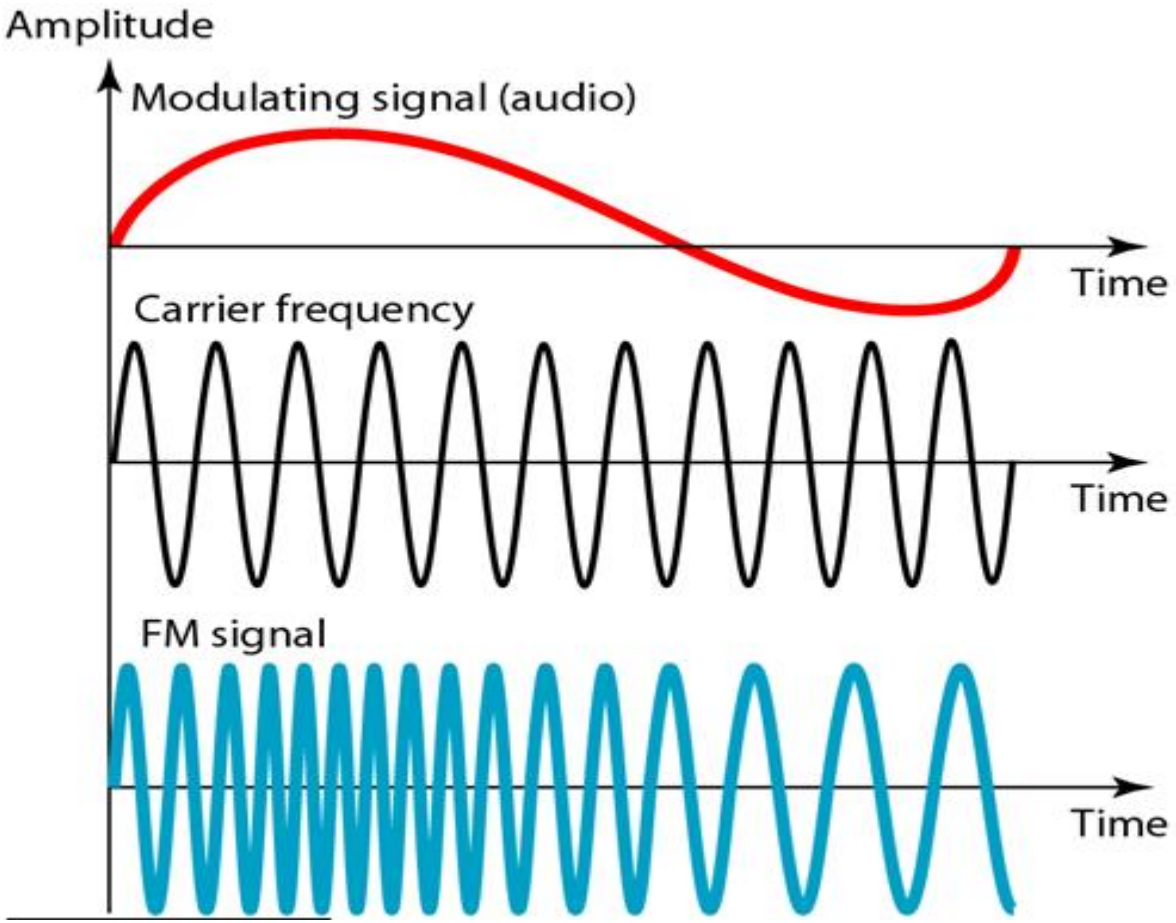
- Analog-to-analog conversion is the representation of analog information by an analog signal.



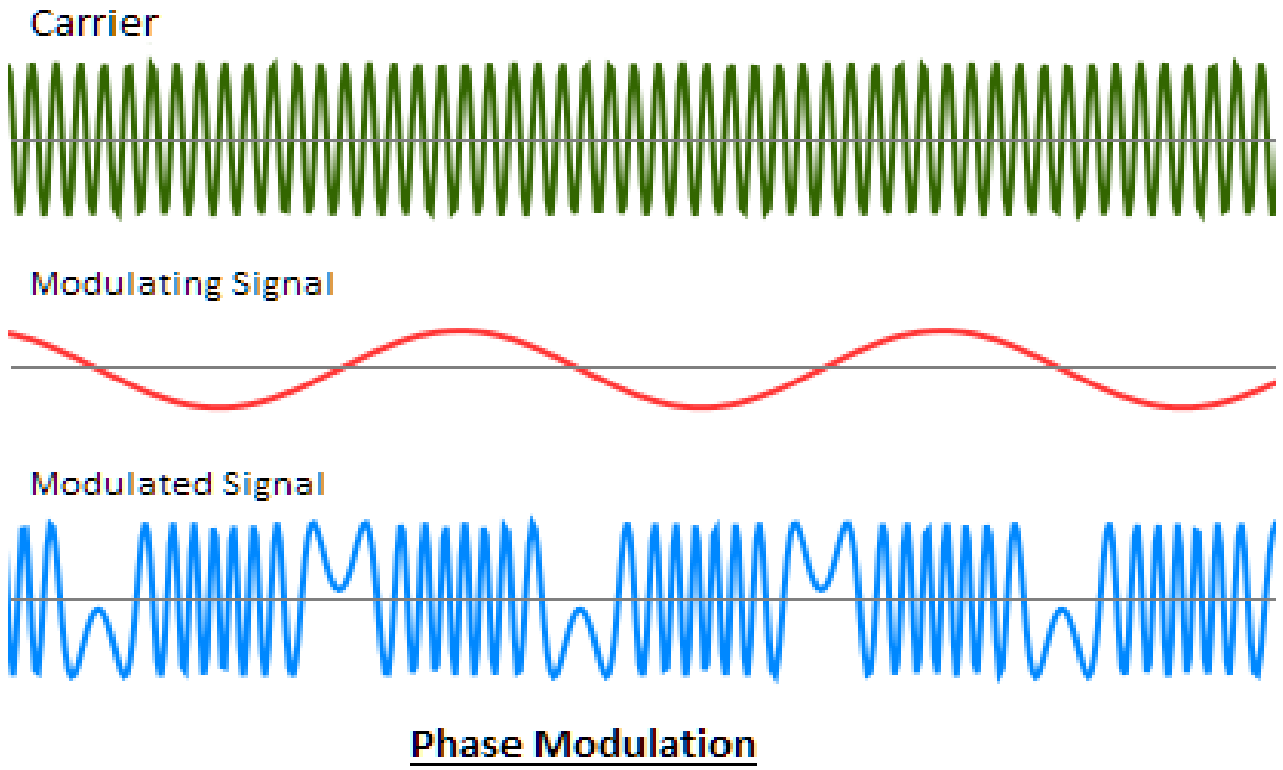
Amplitude Modulation



Frequency Modulation



Phase Modulation (PM)



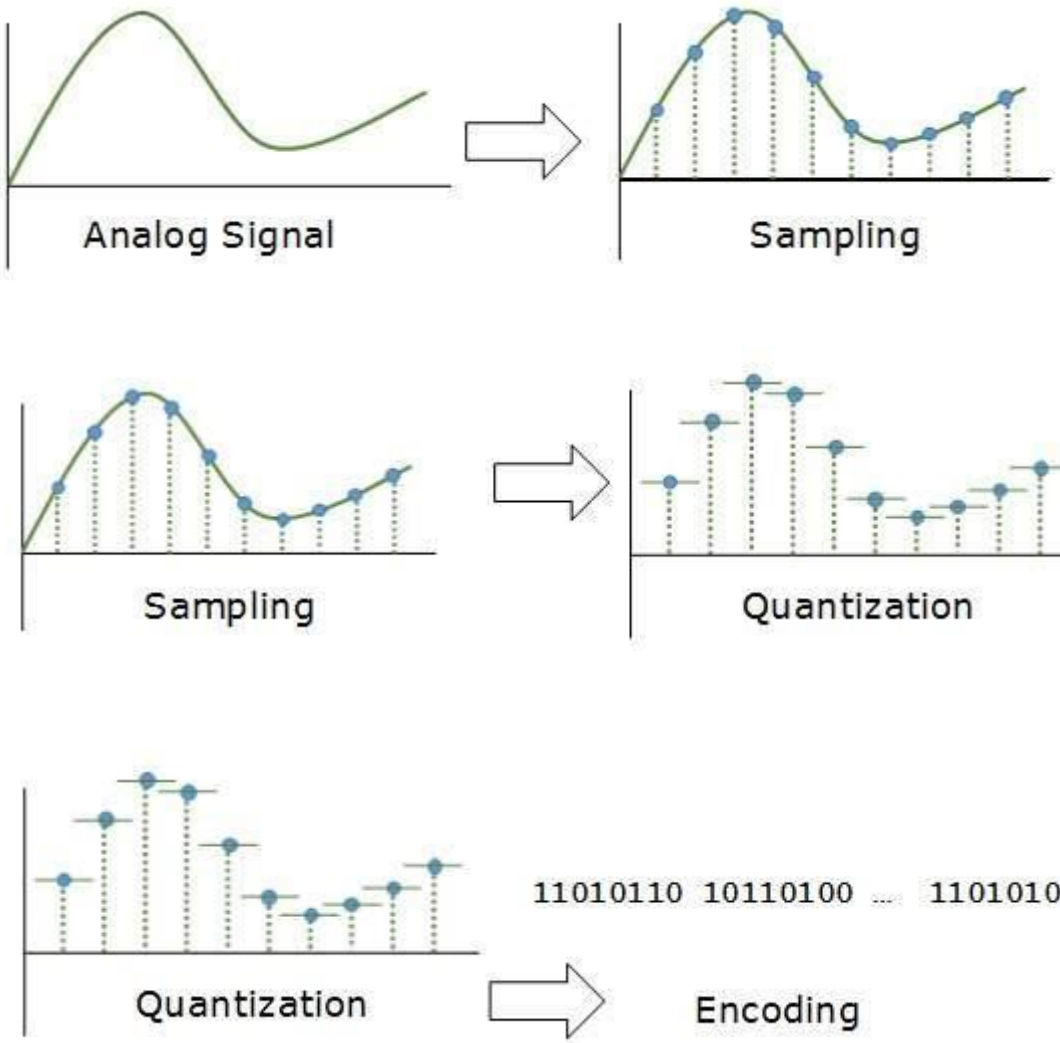
Phase Modulation

Analog-to-Digital Conversion

- Microphones create analog voice and camera creates analog videos, which are treated is analog data. To transmit this analog data over digital signals, we need analog to digital conversion.

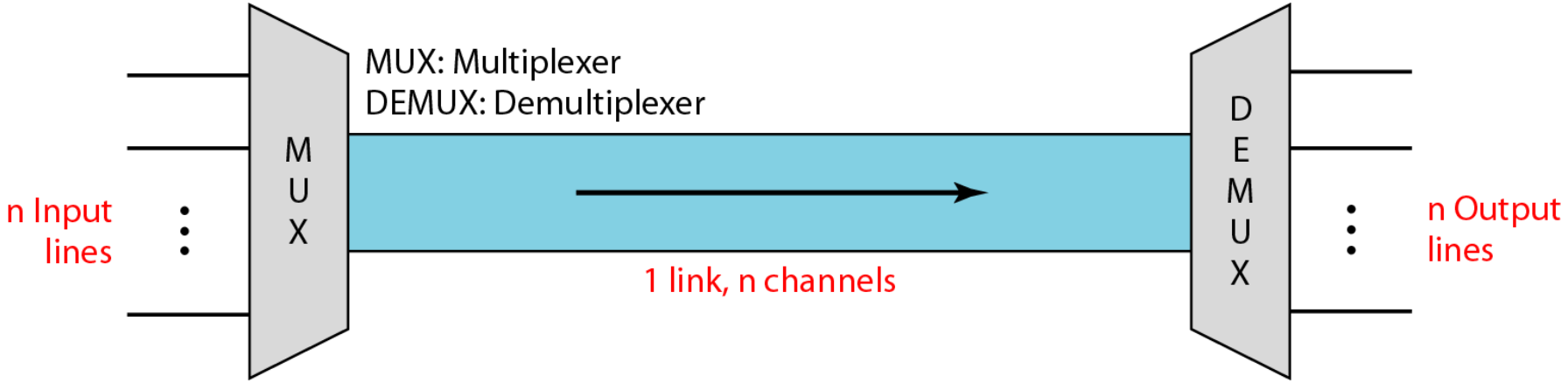
- To convert analog wave into digital data, we use Pulse Code Modulation (PCM).

- PCM is one of the most commonly used method to convert analog data into digital form. It involves three steps:
    - Sampling
    - Quantization
    - Encoding.

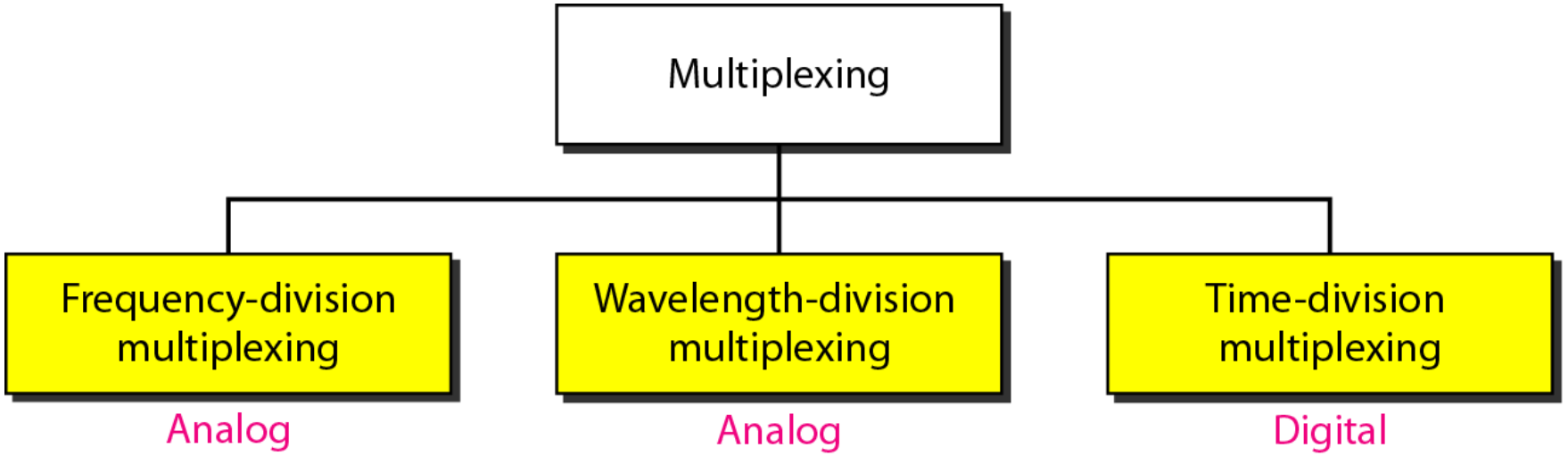

Analog Signal
Sampling
Sampling
Quantization
Quantization
11010110 10110100 ... 11010101
Encoding

MULTIPLEXING

- Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared.
- Multiplexing is the set of techniques that allows the (simultaneous) transmission of multiple signals across a single data link.
- Dividing a link into channels



Categories of multiplexing



Frequency-division multiplexing (FDM)

- Analog multiplexing technique
- For digital signals, they must be converted to analog signals first
- Individual signals modulates different carrier frequencies
- Each carrier frequency is separated by a guard band (unused bandwidth) to prevent signals from overlapping In addition, choice of carrier frequencies must ensure that they do not interfere with data being carried
- These are then combined into a single composite signal that can be transported over the data link

WDM

- WDM is conceptually the same as FDM, except that the multiplexing and demultiplexing involve optical signals transmitted through fiber-optic channels.
- The idea is the same: We are combining different signals of different frequencies. The difference is that the frequencies are very high.
- WDM is designed to use the high-data-rate capability of fiber-optic cable.
- The optical fiber data rate is higher than the data rate of metallic transmission cable.
- Using a fiber-optic cable for one single line wastes the available bandwidth. Multiplexing allows us to combine several lines into one.

Time Division Multiplexing

- Digital Multiplexing technique
- Analog data should be digitized prior of TDM
- Instead of sharing portion of bandwidth, time is shared