Chapter - 4

DIGITAL TRANSMISSION

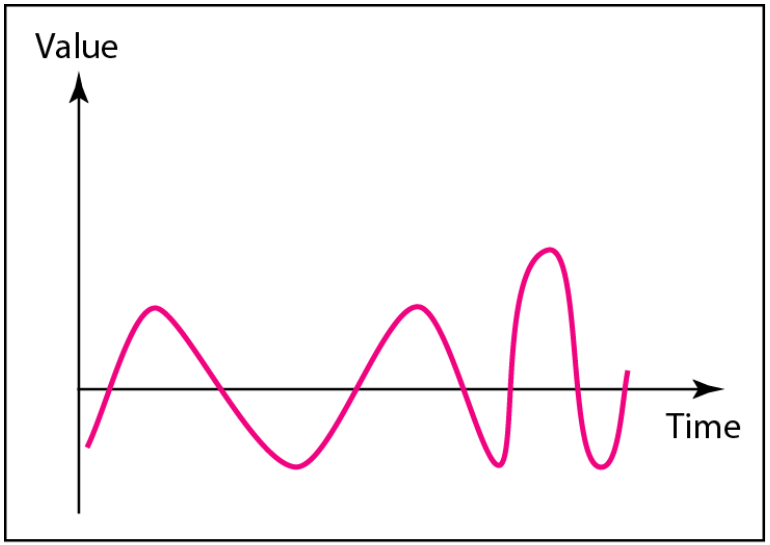
Digital transmission

- Digital transmission is the physical transfer of data/information over a communication channel.
- Information can be voice, image, numeric data or message.
- Information must be transformed into electromagnetic signals.

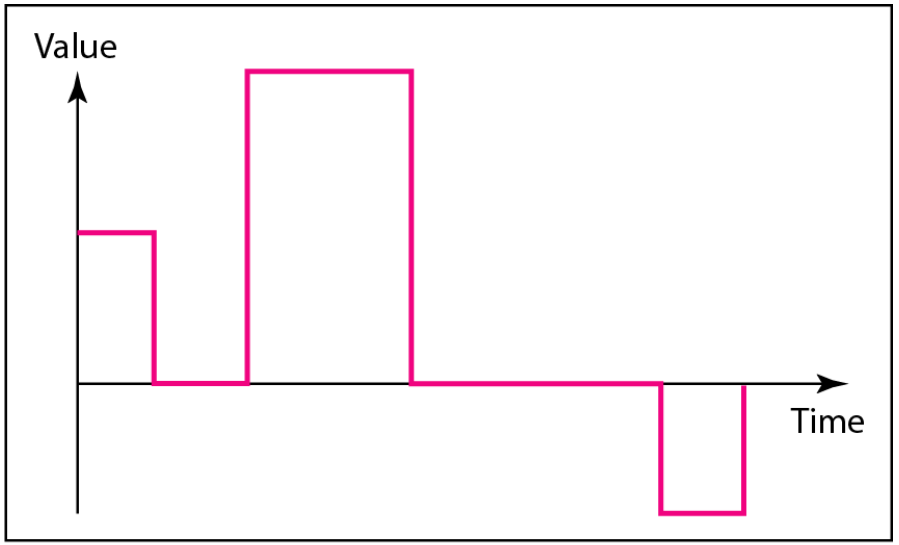
Analog and Digital Signal

- Signal can be analog or digital.
- Analog signals are continuous waves and take infinite number of values. (e-x) voice, video
- Digital signal is discrete and take limited number of values.(0 and 1) (e-x) text

Analog and Digital signal



a. Analog signal



b. Digital signal

Digital representation of information

- Block information

That occurs naturally in the form of blocks.

Block is represented by a certain number of

bits.

(e-x) data files (text , numerical and graphical

information) , documents

Stream oriented information

- That is produced continuously and that needs to be transmitted as it is produced.

E-x voice , music and sound

Digital transmission

- This system is used to transfer 0’s and 1’s from a transmitter to the receiver.
- This system uses sinusoids that are variations in voltages , current or light intensity to transfer the bits

- **Bandwidth** – The range of frequencies passed by a channel. It is the difference between upper and lower limit.
- **Noise** – It consists of extraneous signals added to the desired signals at the input to the receiver.
- **Bit interval** – The time taken to send one single bit
- **Bit Rate** - The number of bits set per time unit

- **Signal to Noise Ratio** (SNR)

  Ratio between desired signal to noise.

- **Pulse Code Modulation** (PCM)

  Transmitting from analog signal to digital signal.

- **Baud rate**

  Baud rate refers to the number of signal units per second that are required to represent those bits.

Attenuation

- Means loss of energy -> weaker signal
- When a signal travels through a medium it loses energy overcoming the resistance of the medium
- Amplifiers are used to compensate for this loss of energy .

Measurement

- To show the loss or gain of energy the unit “decibel” is used.

$$dB = 10\log_{10}P2/P1$$

P1 - input signal

P2 - output signal

Data rate

- Data rate is the speed at which we can send data in bits per second.
- Data rate depends on three factors:

  The bandwidth available

  The level of the signals we use

  The quality of the channel

- Data rate is calculated using two formulas

  nyquist signaling rate for **noiseless channel**

  Shannon channel capacity for a **noisy channel**

Nyquist signaling rate

- Bit rate = 2 * Bandwidth * log2L

L--- number of signal levels used to represent the data

Shannon capacity

- Capacity = bandwidth * log 2 (1+SNR) bits/sec

  SNR = average signal power/average noise power

CHAPTER - 5

ENCODING

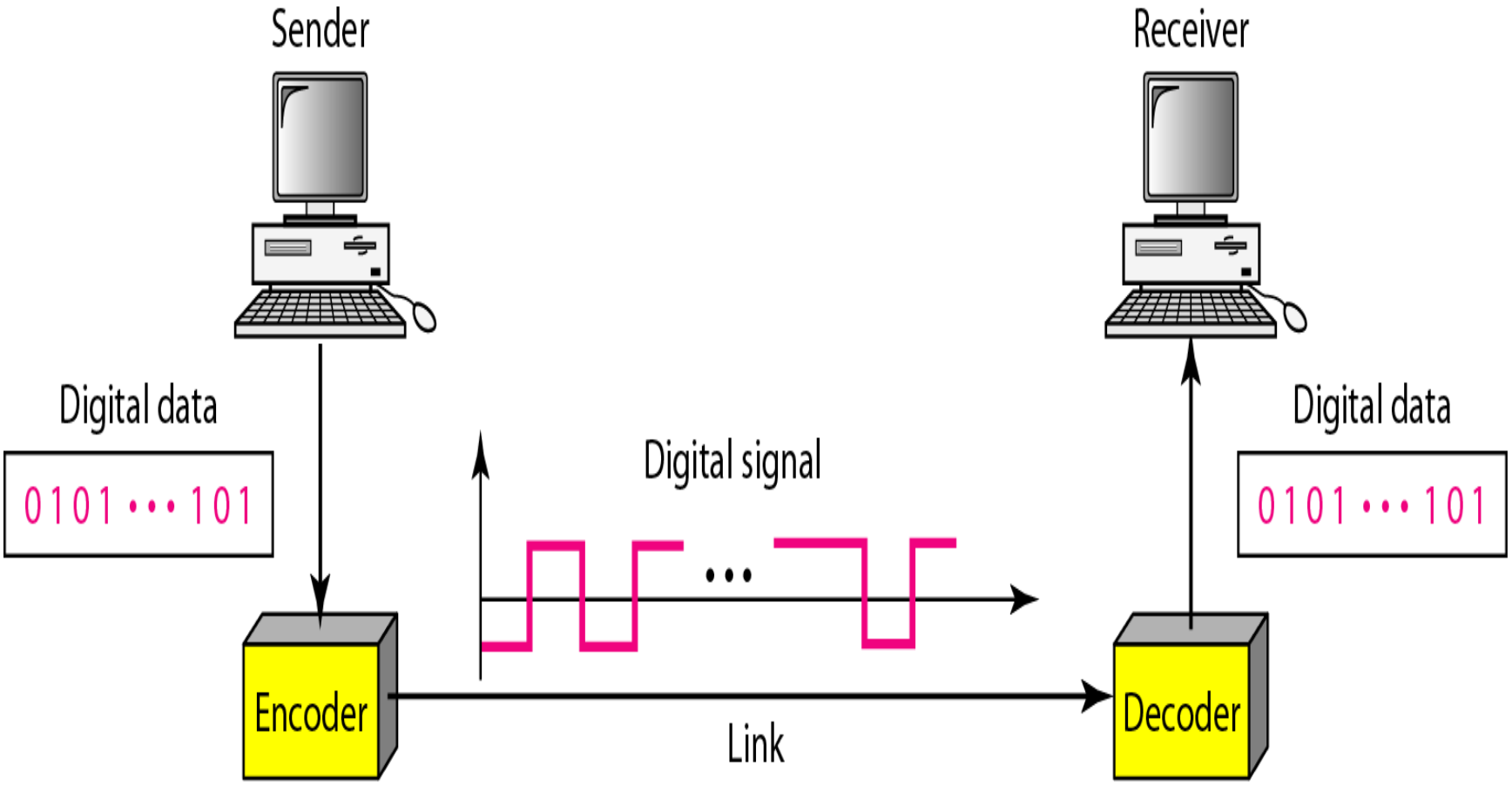
Encoding

Conversion of information to be transmitted into signals. The types of encoding are

- Digital/Digital
- Analog/digital
- Digital/analog
- Analog/analog

Line coding(Digital information to Digital signal)

- A high voltage level (+V) could represent a “1” and a low voltage level (0 or -V) could represent a “0”.


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

Line encoding schemes

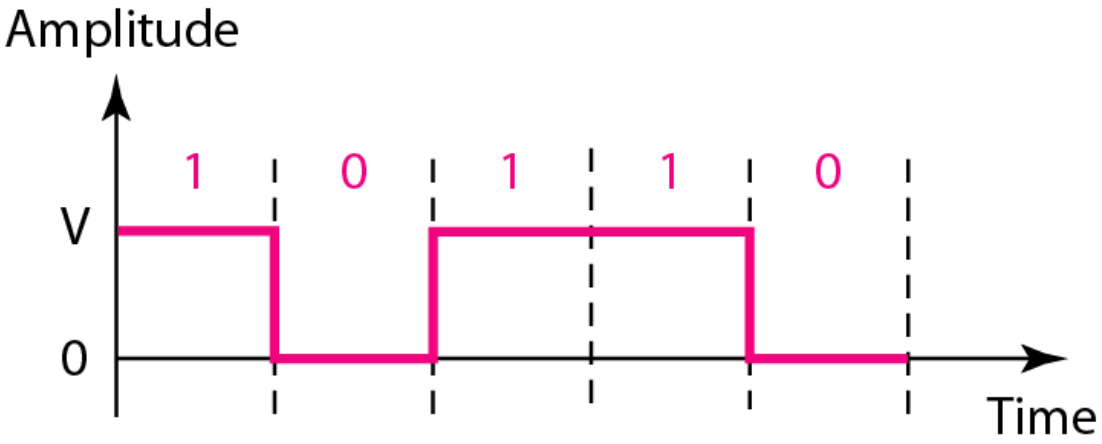
- Unipolar encoding
- Polar encoding
- Bipolar encoding

Unipolar

- It uses only one polarity.
- Only one of the binary states is encoded, usually the 1.The other state 0 is represented as zero voltage.

Advantages

1. It is simple.
2. It is inexpensive.

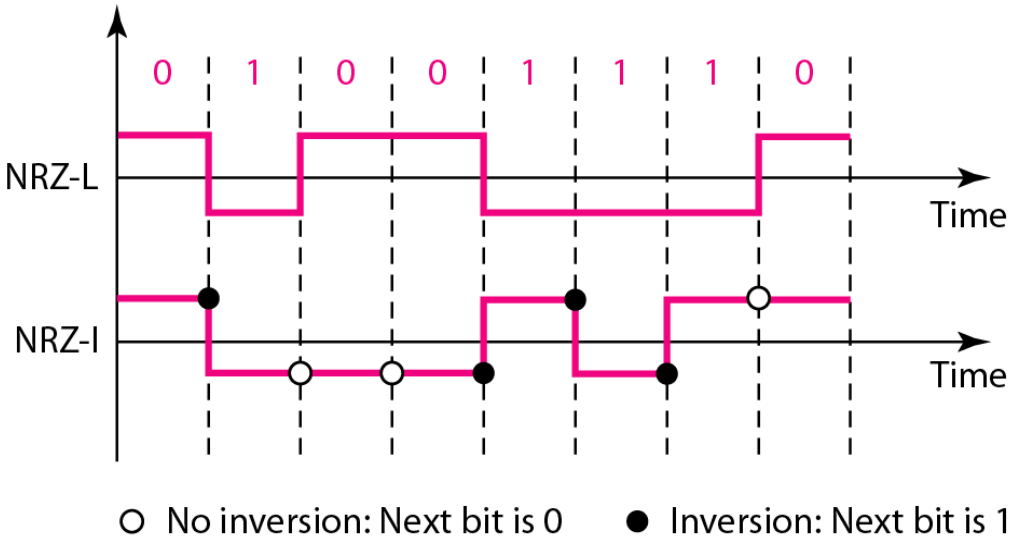


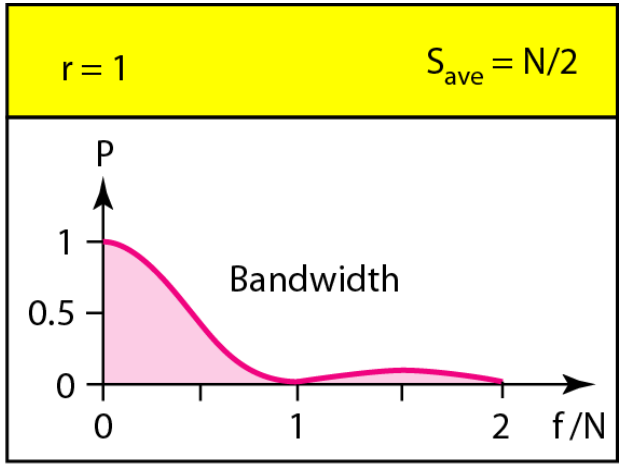
$$\frac{1}{2}V^2 + \frac{1}{2}(0)^2 = \frac{1}{2}V^2$$

Normalized power

Polar

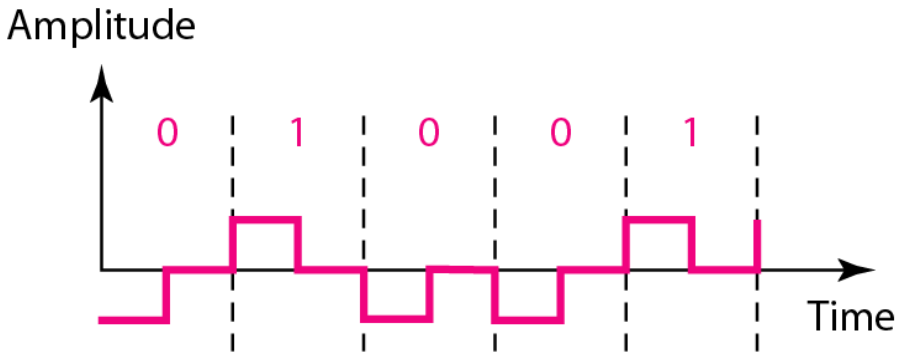
- The voltages are on both sides of the time axis.
- There are two versions:
  - **NRZ - Level (NRZ-L)** - positive voltage means the bit is 0 and negative voltage means bit is 1 for the other
  - **NRZ - Inversion (NRZ-I)** – The receiver looks for changes from one level to another as its basis for recognition of 1’s.

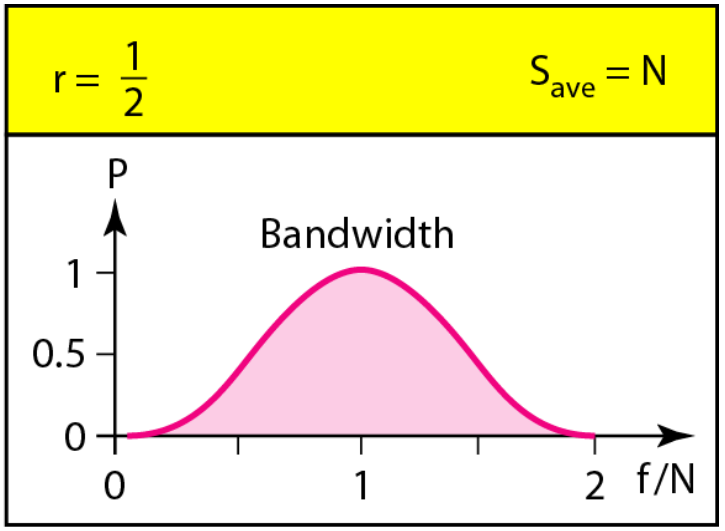

0 1 0 0 1 1 1 0
NRZ-L
Time
NRZ-I
Time
No inversion: Next bit is 0
Inversion: Next bit is 1


r = 1
S_{ave} = N/2
P
1
0.5
0
Bandwidth
0
1
2
f/N

Polar - RZ

- The Return to Zero (RZ) scheme uses three voltage values. +, 0, -.
- A 1 bit is represented by positive to zero transition.
- A 0 bit is represented by a negative to zero transition.

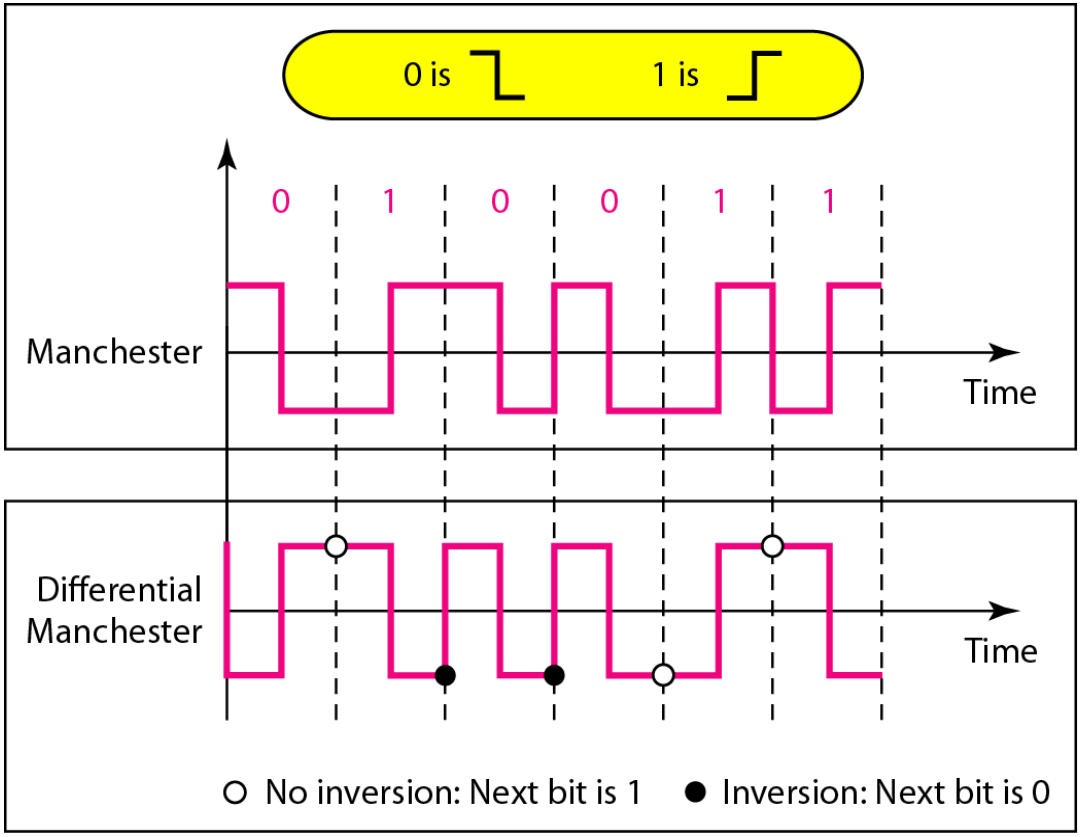

Amplitude
0
1
0
0
1
Time

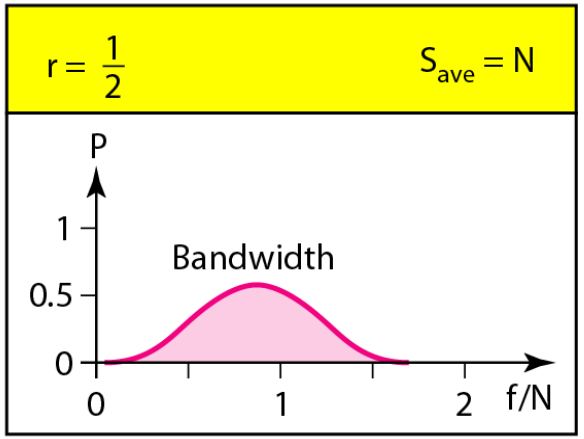

r = 1/2
S_ave = N
P
Bandwidth
1
0.5
0
0
1
2
f/N

Polar - Biphase: Manchester and Differential Manchester

- Manchester coding consists of combining the NRZ-L and RZ schemes.
  - Binary 1 – negative to positive transition
  - Binary 0 – positive to negative transition

- Differential Manchester coding consists of combining the NRZ-I and RZ schemes.
  - Every symbol has a level transition in the middle.
  - It requires two signal changes to represent the binary 0 but only one to represent a 1.


0 is
1 is
0 1 0 0 1 1
Manchester
Time
Differential Manchester
Time
No inversion: Next bit is 1
Inversion: Next bit is 0


r = 1/2
S_ave = N
P
1
0.5
0
Bandwidth
0
1
2
f/N

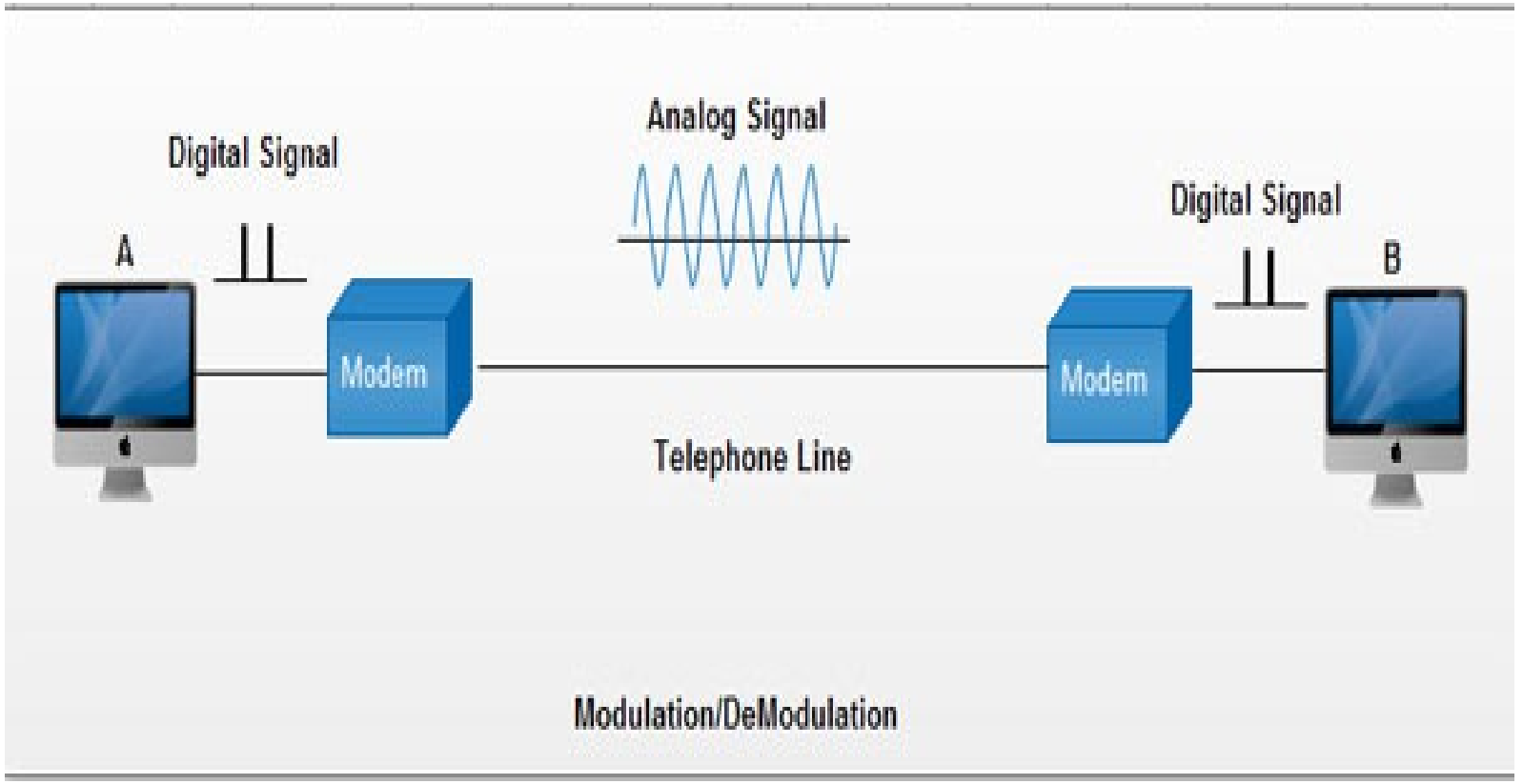
Bipolar encoding

- Three voltage levels – positive , negative and zero
- The 1’s are represented by alternating positive and negative voltages.
- Common bipolar encoding scheme - AMI (Alternate mark inversion)

MODEMS

- **Modem is abbreviation for Modulator – Demodulator.** Modems are used for data transfer from one computer network to another computer network through telephone lines.
- The computer network works in digital mode, while analog technology is used for carrying massages across phone lines.

- **Modulator** converts information from **digital mode to analog mode** at the transmitting end and demodulator converts the same from **analog to digital at receiving end**.


Digital Signal
Analog Signal
Digital Signal
A
B
Modem
Modem
Telephone Line
Modulation/DeModulation

- Modems can be of several types and they can be categorized in a number of ways.
- • Categorization is usually based on the following basic modem features:
- 1. Directional capacity: half duplex modem and full duplex modem.
- 2. Connection to the line: 2-wire modem and 4-wire modem.
- 3. Transmission mode: asynchronous

Categories of modems

- External modem
- Internal modem

Any external modem is attached to any computer has an RS-232 port.

An internal modem comes as an expansion board that can be inserted into a vacant expansion slot.

Characteristics of modems

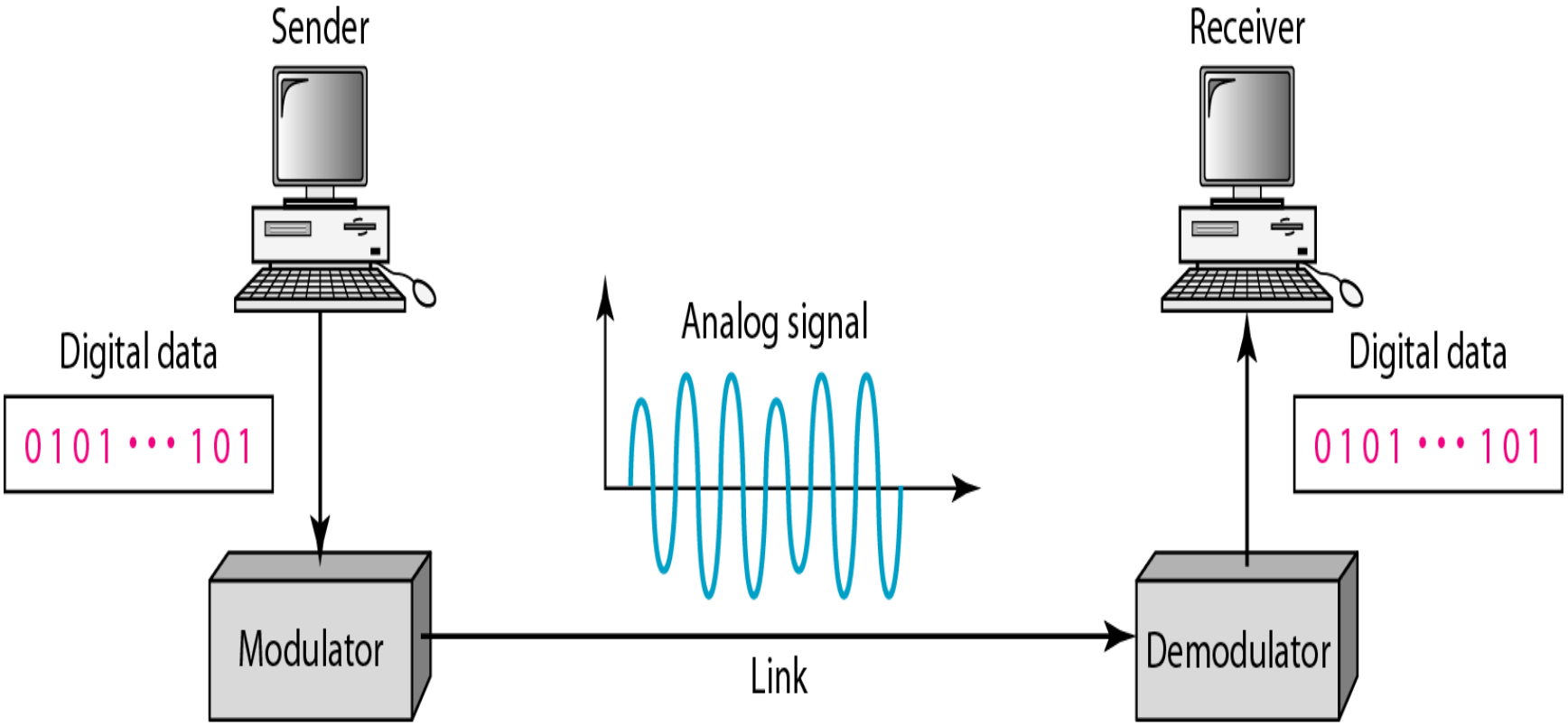
- Bps
- Voice/data
- Data compression
- Fax capability

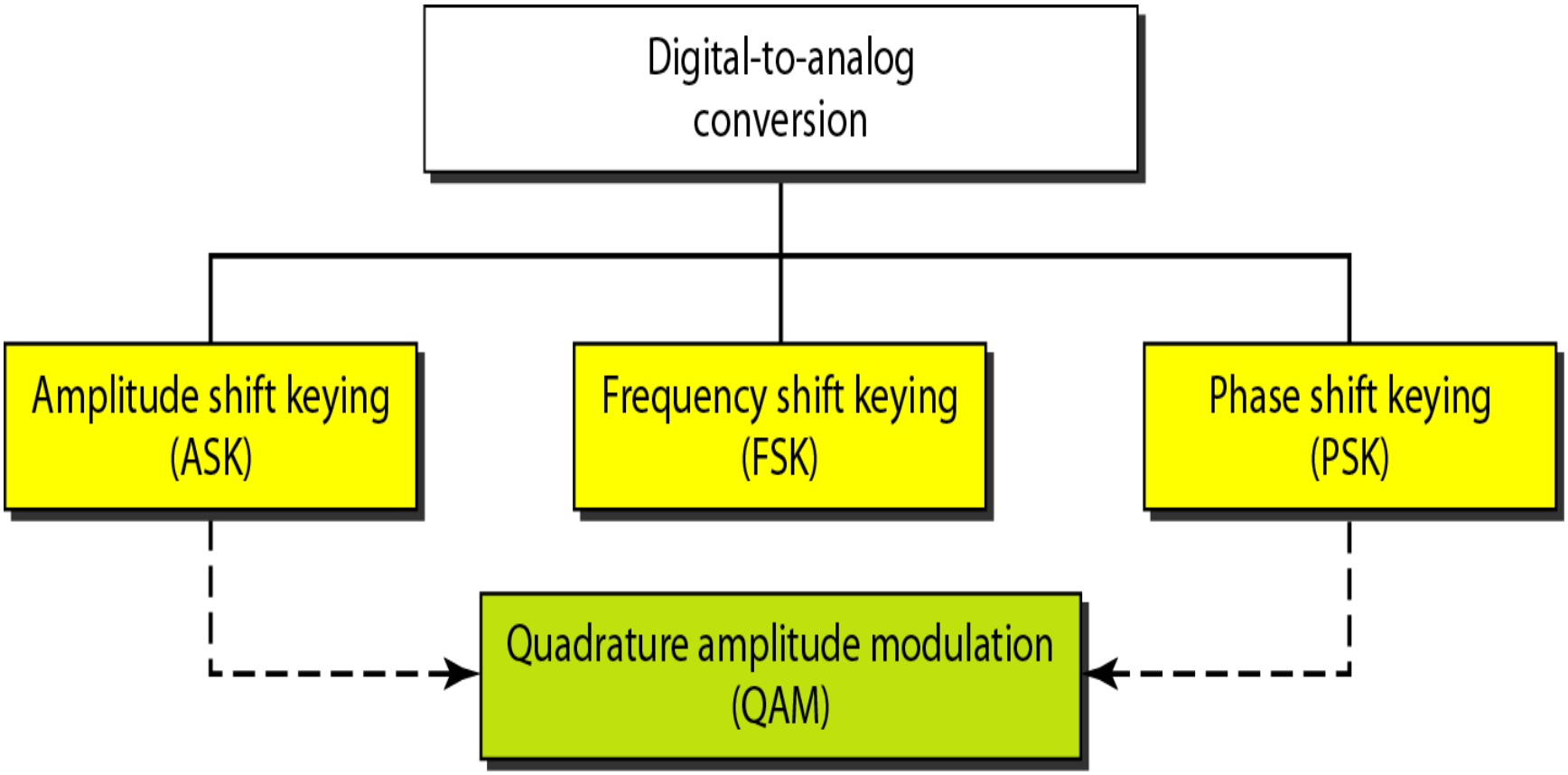
Types of modem

- Standard fax modem
- Digital cable modem
- ISDN modem
- Digital subscribes line modem
- Satellite modem

Digital to Analog conversion

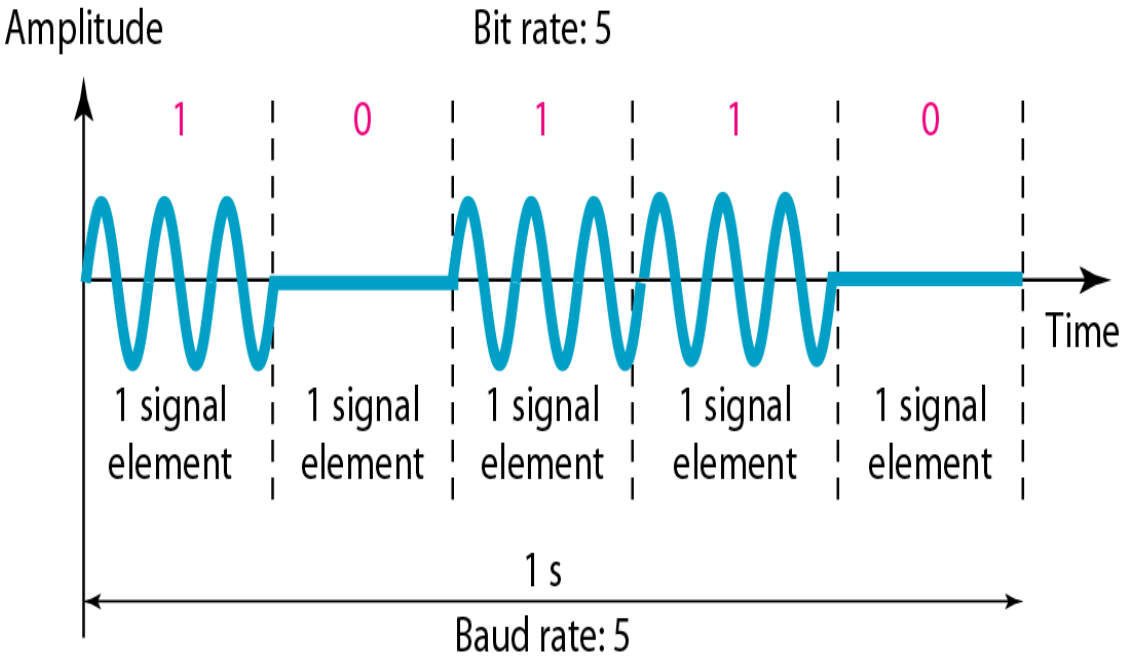
- Digital data needs to be carried on an analog signal.
- A carrier signal (frequency fc) performs the function of transporting the digital data in an analog waveform.

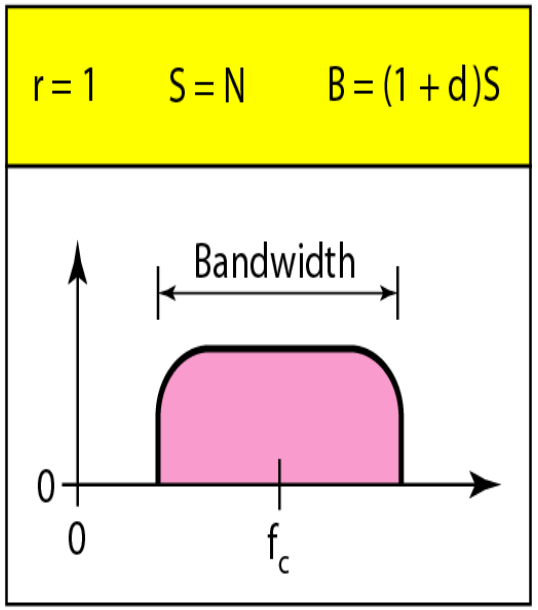

Sender
Receiver
Digital data
0101 • • • 101
Analog signal
Digital data
0101 • • • 101
Modulator
Link
Demodulator


Digital-to-analog conversion
Amplitude shift keying (ASK)
Frequency shift keying (FSK)
Phase shift keying (PSK)
Quadrature amplitude modulation (QAM)

Amplitude Shift Keying (ASK)

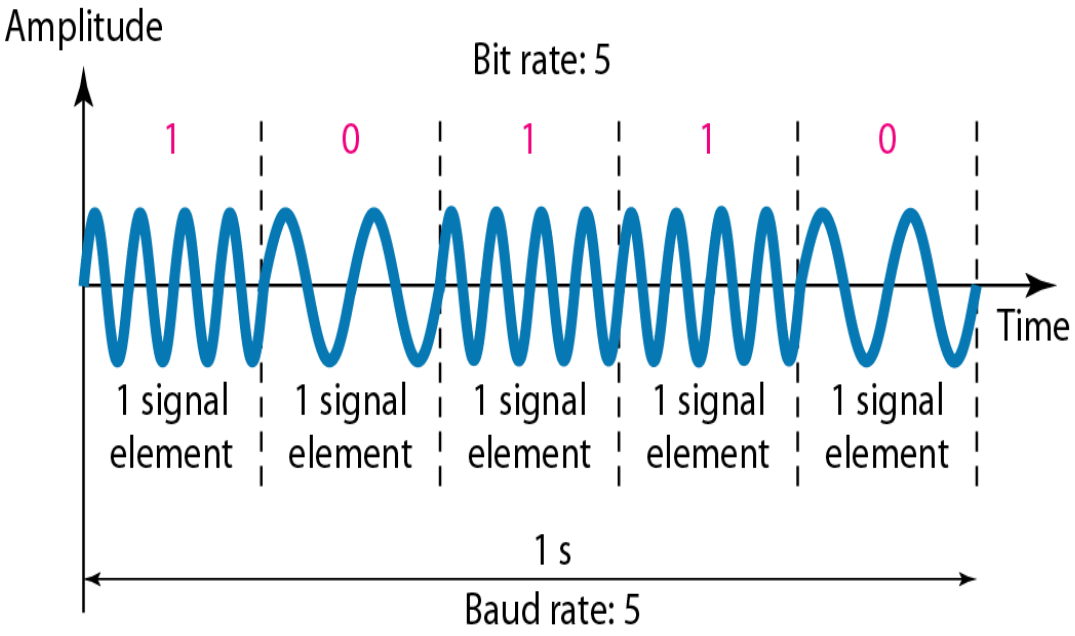
- ASK is implemented by changing the amplitude of a carrier signal to reflect amplitude levels in the digital signal.
- For example: a digital “1” could not affect the signal, whereas a digital “0” would, by making it zero.

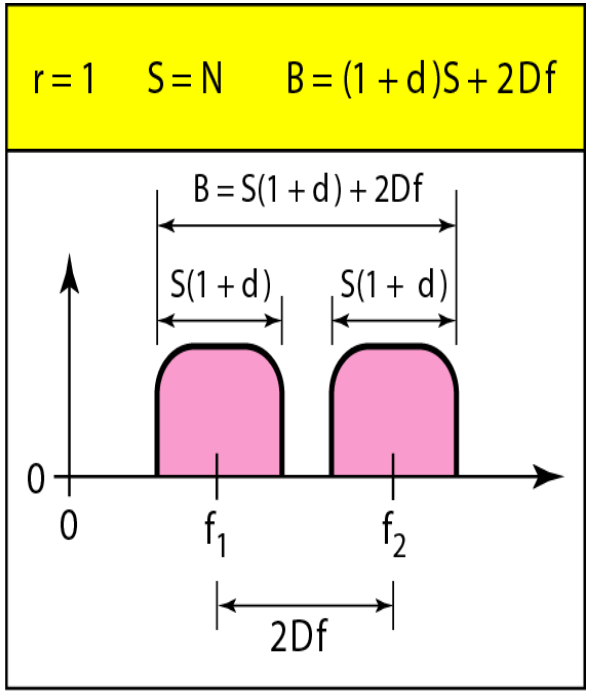

Amplitude
Bit rate: 5
1
0
1
1
0
Time
1 signal element
1 signal element
1 signal element
1 signal element
1 signal element
1 s
Baud rate: 5


r = 1
S = N
B = (1 + d)S
Bandwidth
0
0
f_c

Frequency shift keying

- The two binary values are represented by two different frequencies.


Amplitude
Bit rate: 5
1
0
1
1
0
Time
1 signal element
1 signal element
1 signal element
1 signal element
1 signal element
1 s
Baud rate: 5


r = 1 S = N B = (1 + d)S + 2Df
B = S(1 + d) + 2Df
S(1 + d)
S(1 + d)
0
0
f1
f2
2Df

Phase shift keying

- The phase of carrier signal is shifted to represent the data.