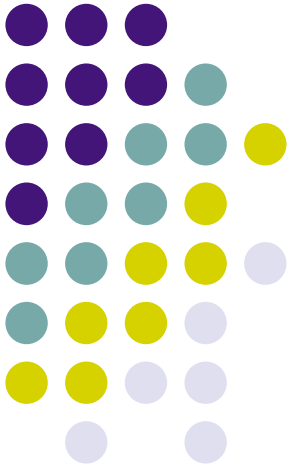
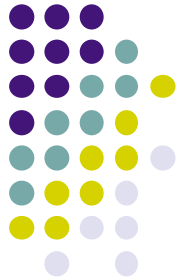
Physical layer



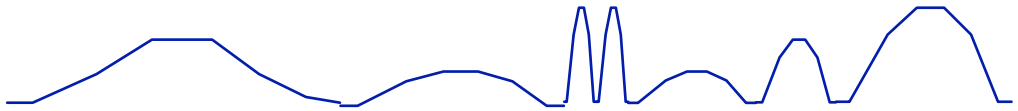
Overview



- Physical layer is responsible for transmission of a stream of bits
  - Put bits from a machine to a medium
  - Pick bits from the medium give to receiver
- Some issues
  - Medium
  - Line Encoding: representing the digital logic levels using the physical attributes associated with the media.
  - Multiplexing

From signal to packet

Analog Signal

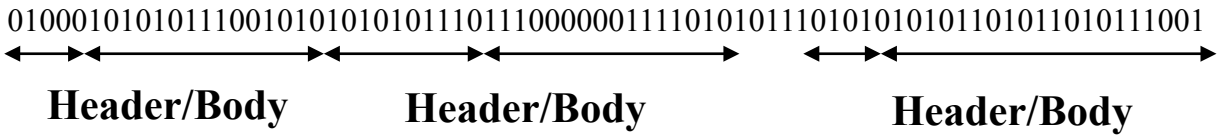


"Digital" Signal

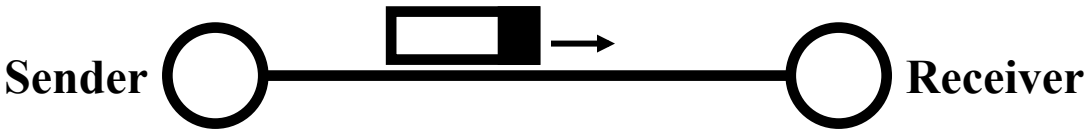
Bit Stream

0 0 1 0 1 1 1 0 0 0 1

Packets

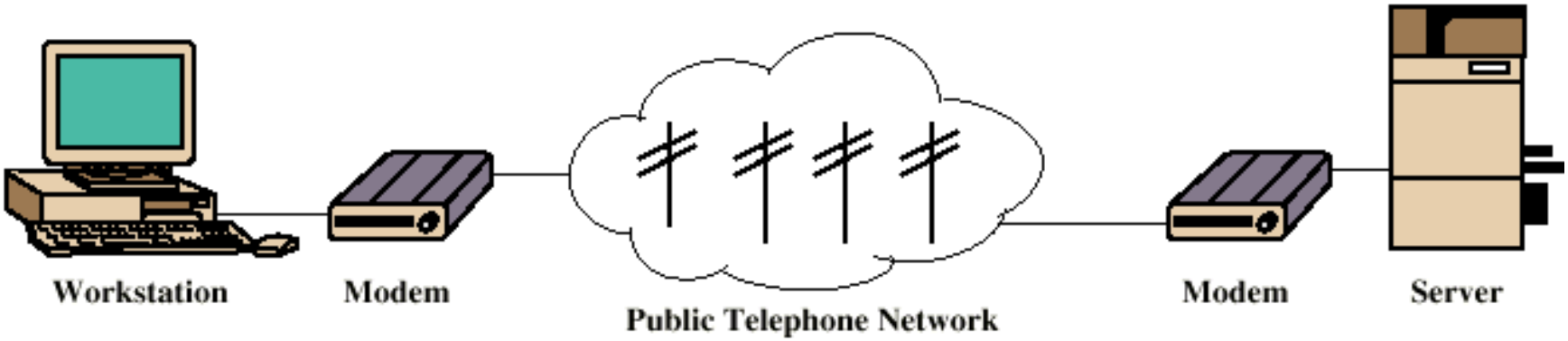


Packet Transmission



Model of data transmission system

(a) General block diagram



(b) Example

Data Communication networks

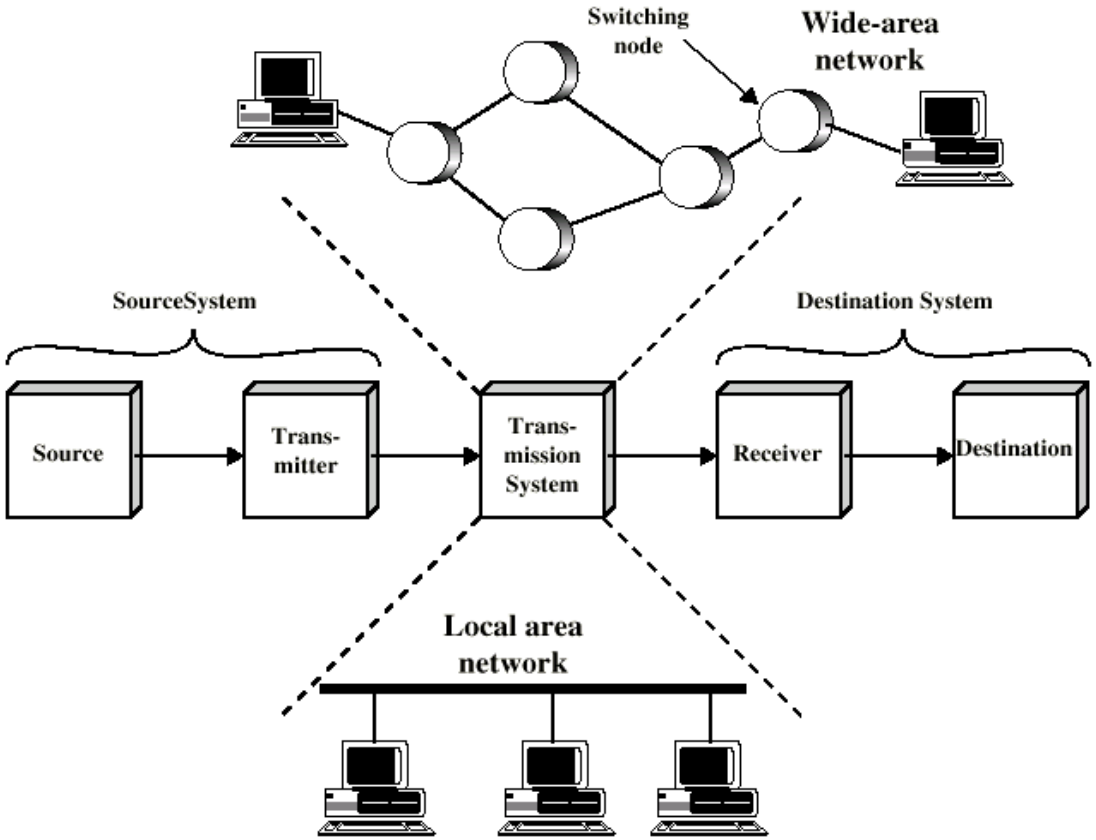
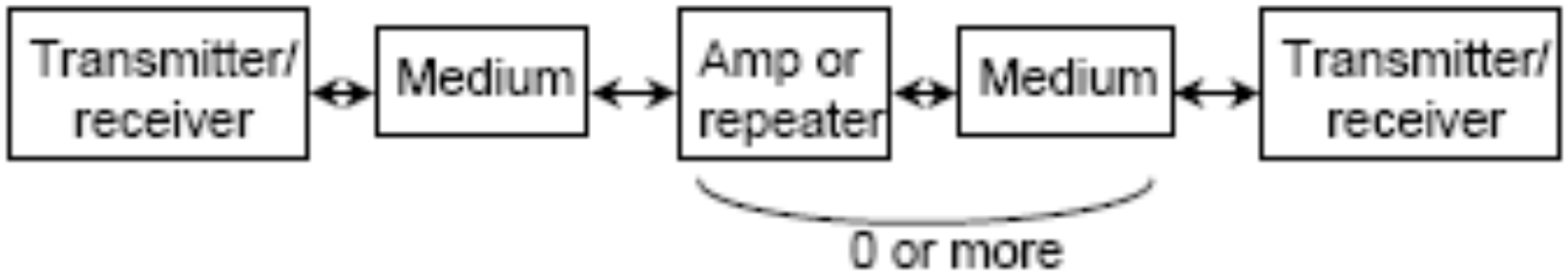
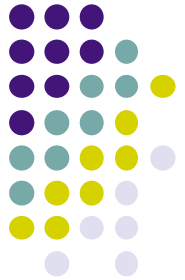


Figure 1.3 Simplified Network Models

Direct Data transmission system

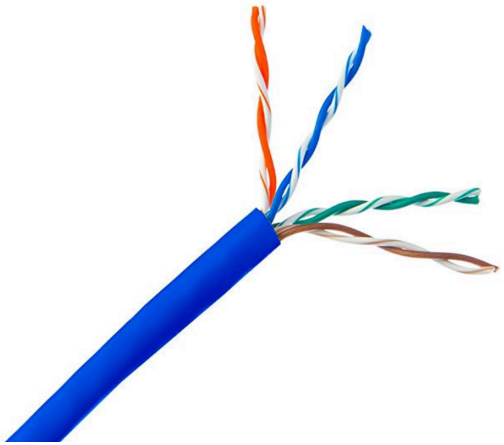


Media



- Wired
  - Twisted Pair
  - Coaxial Cable
  - Fiber Optics
- Wireless
  - Radio
  - Infra red
  - Light
  - …

Twisted pair

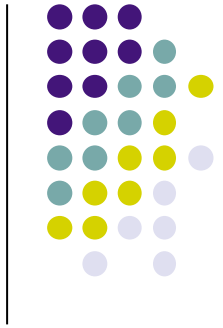


(a)

(b)

(a) Category 3 UTP.
(b) Category 5 UTP.

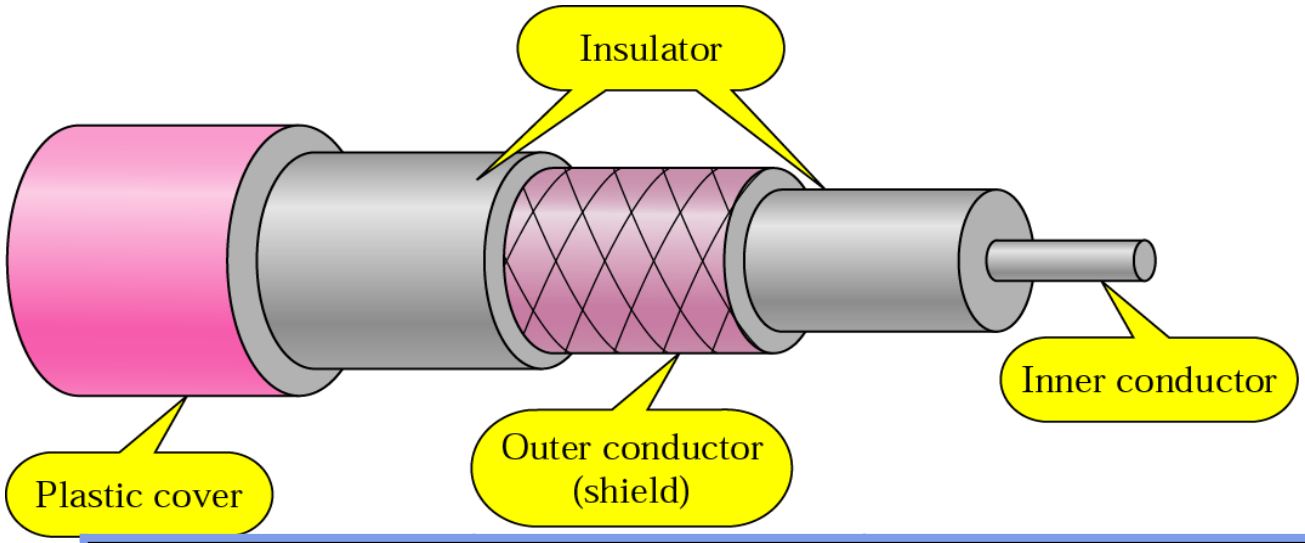
Evaluation



- Cheap, simple
- Widely used
- Weak resistance to noice
- Short Transmission distance

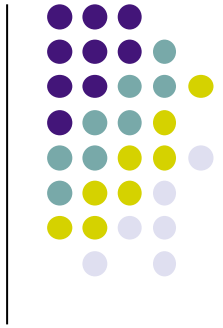
- Need amplification after each 5km in analog transmission
- In digital transmission
  - Need repeater after each 2 km
- Limited speed (100MHz)
- Noice

II. Coaxial



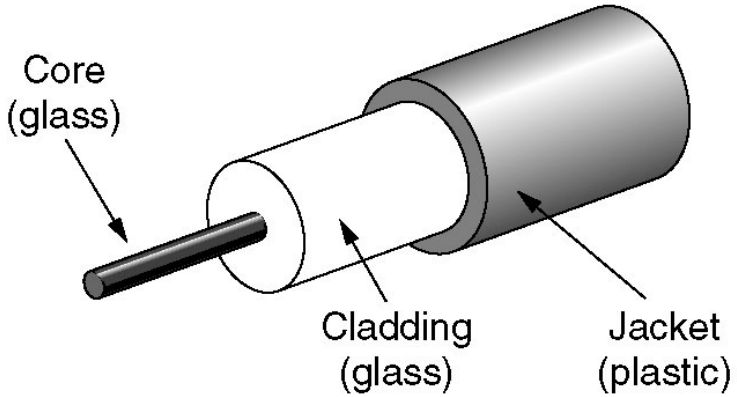
Category	Impedance	Use
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

Application

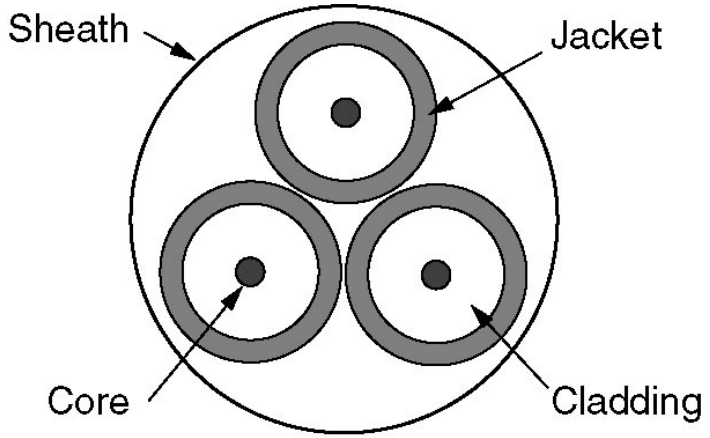


- Using in TV transmission
- For transmission of telephone signal
  - 10,000 calls in the same time
  - Is being replaced by fiber optics
- Linking the computers of the short distance
- LAN 10BaseT, 100BaseT, …
- For digital transmission
  - Repeater should be used after each 1km
  - More repeater is needed for high speed transmission

Optical fiber



(a)

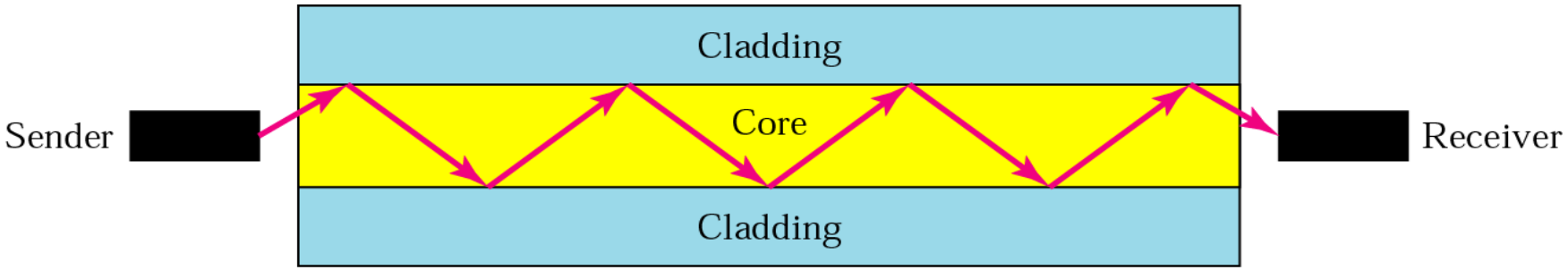


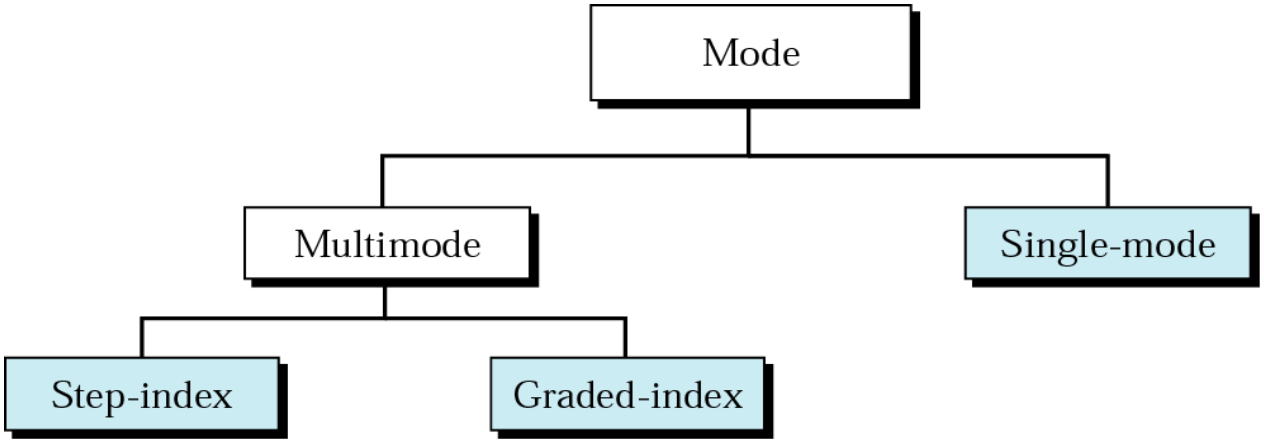
(b)

(a) Single core

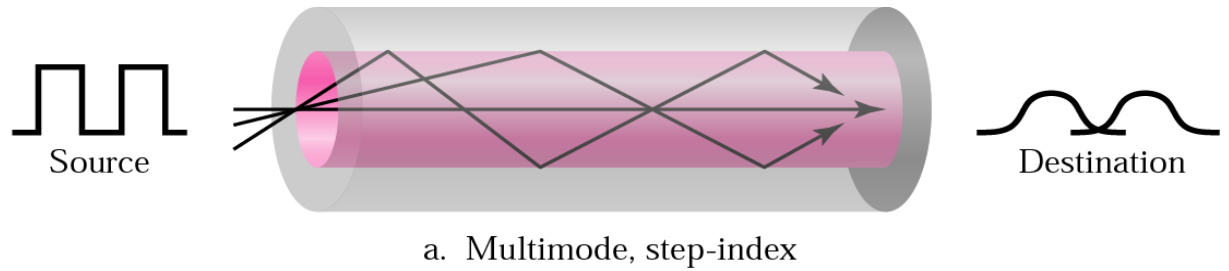
(b) Cable with 3 cores

Optical fiber transmission mode

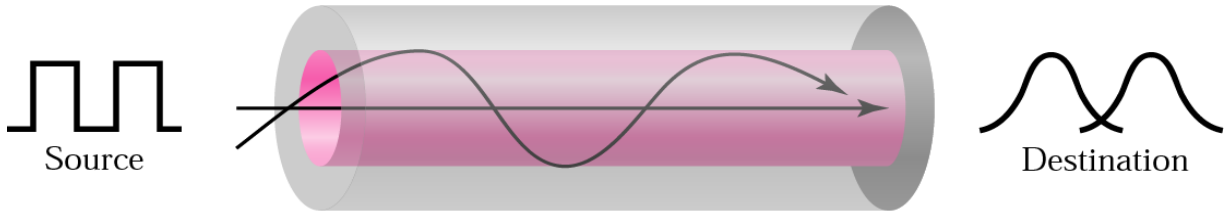




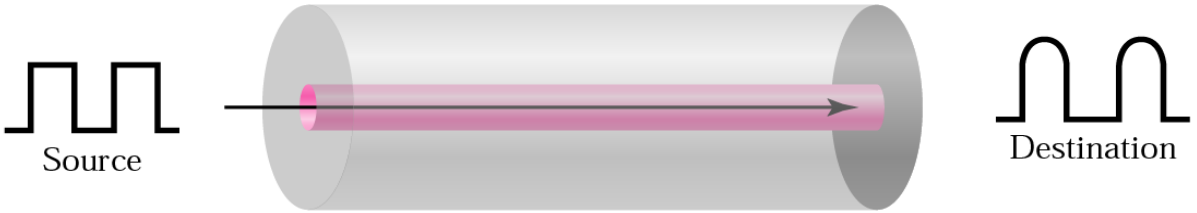
Optical fiber



a. Multimode, step-index

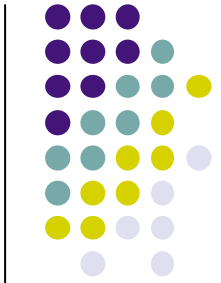


b. Multimode, graded-index



c. Single-mode

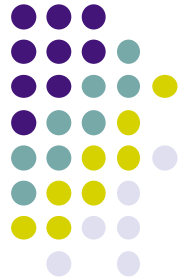
Application of optical fiber



- Used for long distance transmission
- Used for communication in metropolitan networks
- Used for connecting routers of ISP
- Used in backbone part of a LAN

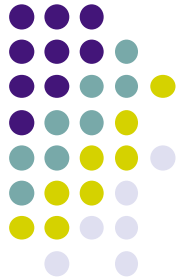
- Advantage in comparison with other cables
  - Large data rate
  - Small and light cable
  - Low attenuation
  - Better isolation from electromagnetic environment
  - Large distance between repeaters (10km)

Wireless media



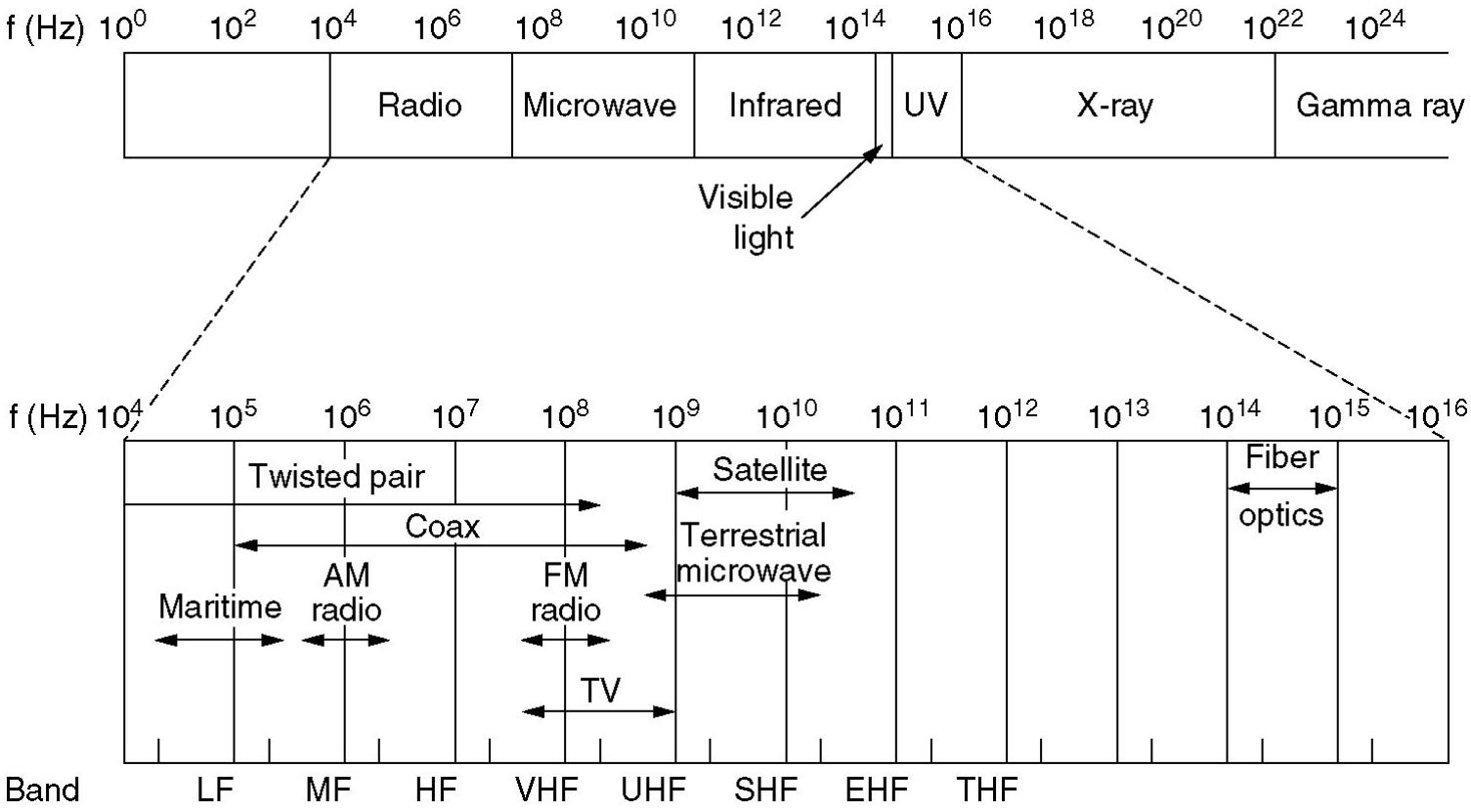
- Terrestrial microwave
  - Used for metropolitan connection, for cellular network
- Microwave satellite
  - Used in TV, Long distance telephone communication
- Radio broadcast
- Infrared
  - Small scope, low data rate, unable to travel through the wall

Wireless media

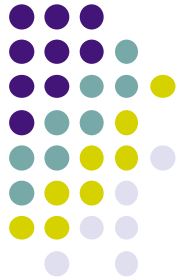


- Microwave: 1GHz đến 40GHz
- Radio: 30MHz đến 1GHz
- Infrared: 300GHz đến 200 THz
- Antenna: wireless transceiver

Frequency range of transmission chanels



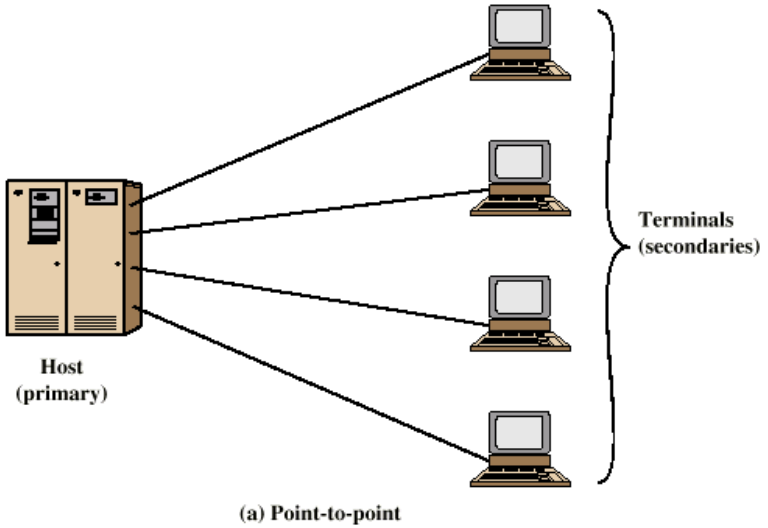
Data encoding



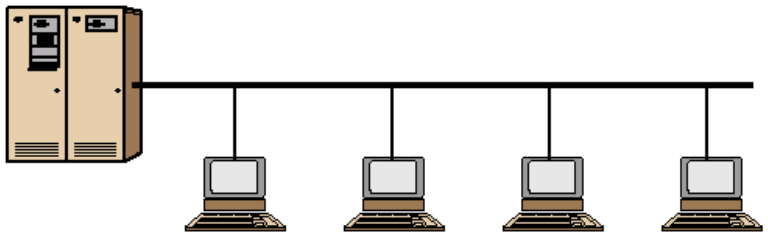
- Use different discrete signal, different voltage level for representing bit 0 and 1.
- Data transmission should be synchronized between sender and receiver: clock synchronization
- Encoding could be performed by bit or by a group of bit e.g., 4 or 8 bits.
- There are many way to represent 0 and 1 → See data transmission technique.

Topology

- Point-to-point
  - Star
  - Ring
  - Mesh
- Point-to-multipoint
  - Bus
  - Ring
  - Star

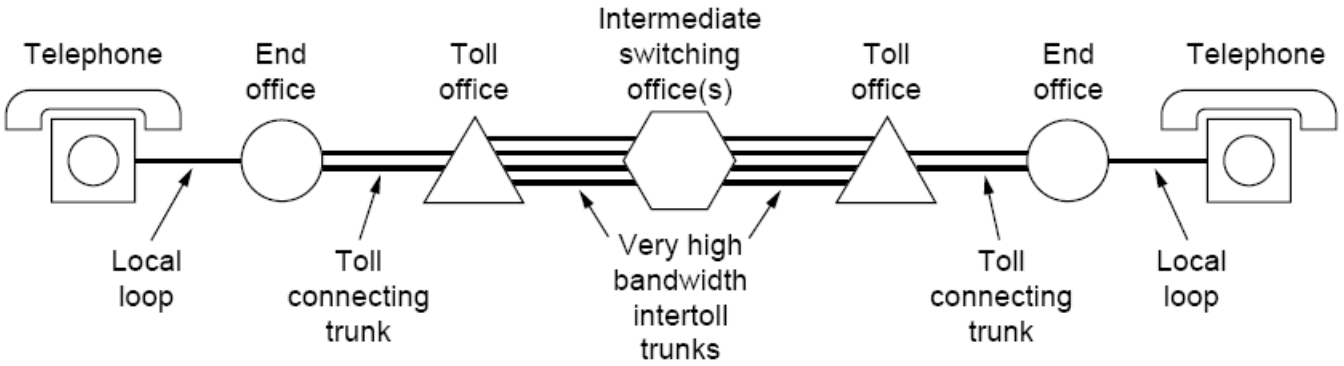


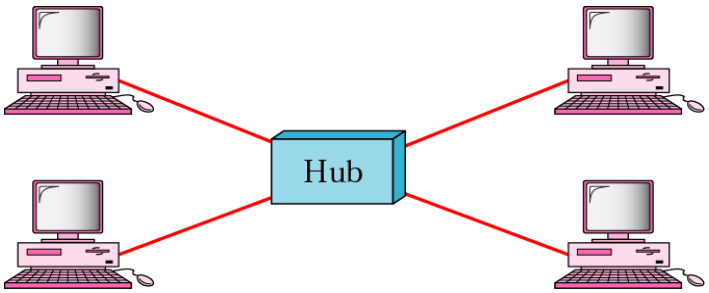
(a) Point-to-point

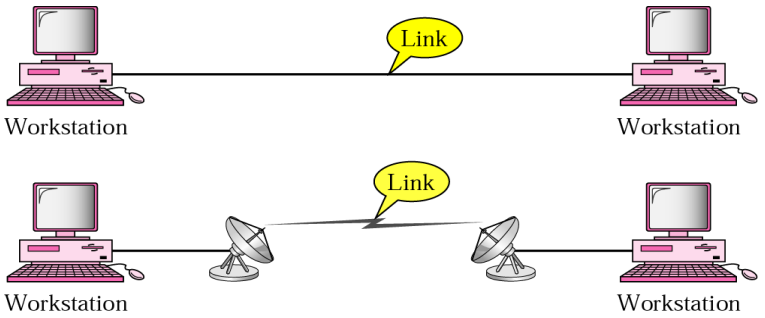


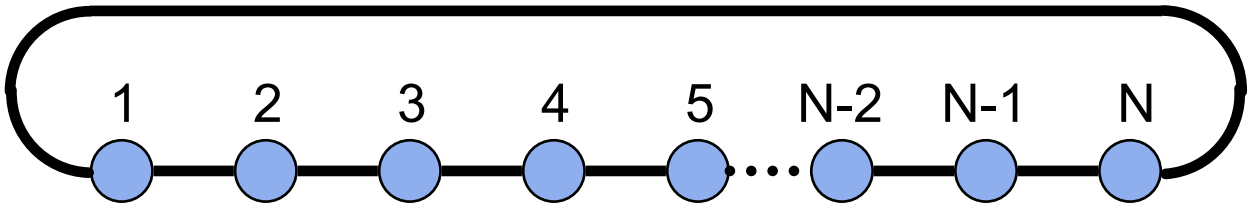
(b) Multipoint

Point -to-Point

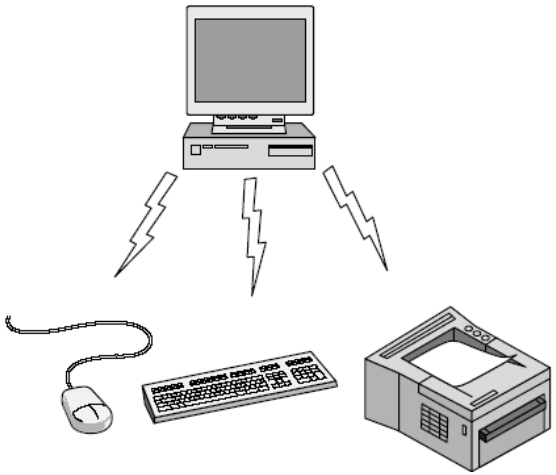


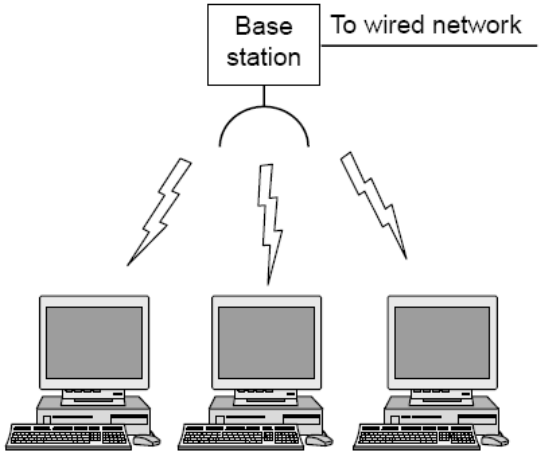


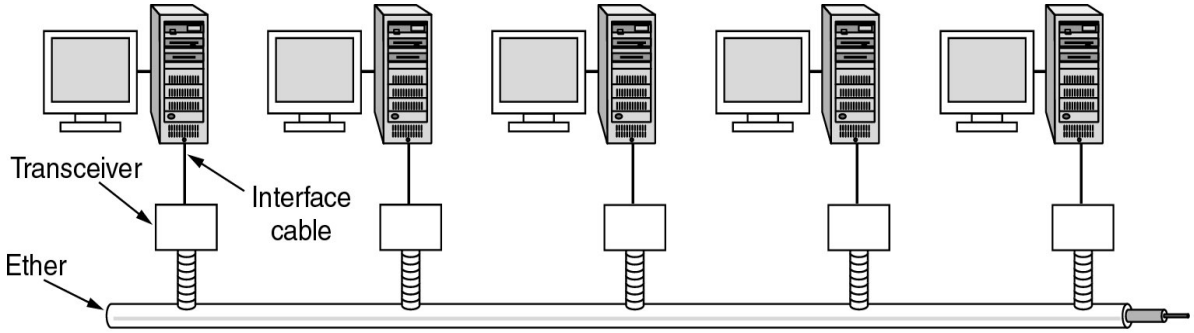




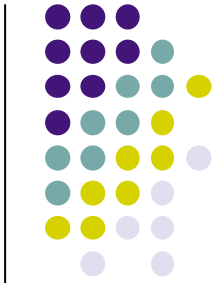
Point-to-multipoint



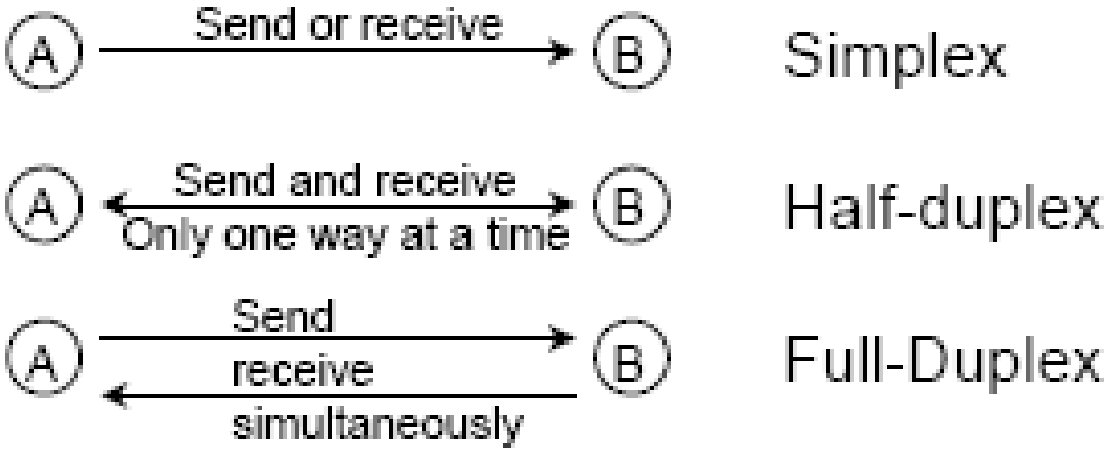




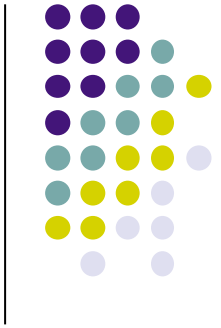
Transmission methods



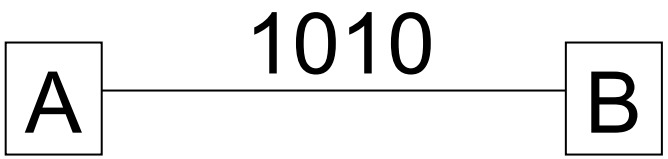
- Simplex: Data is trasmitted in one direction
- Full Duplex: Data can be transmitted in both directions in the same time
- Half duplex: Data can be transmitted in both directions but one direction at a time.

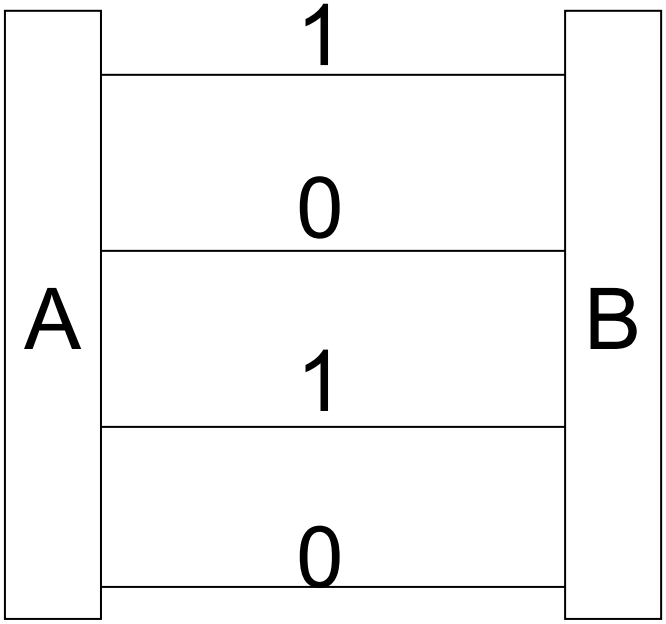


Transmission format

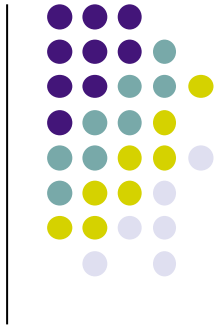


- Sequent transmission: Transmit 1 bit at a moment (over a signal line)
- Parallel transmission: Trasmit multiple bits in the same time (over multiple signal lines)



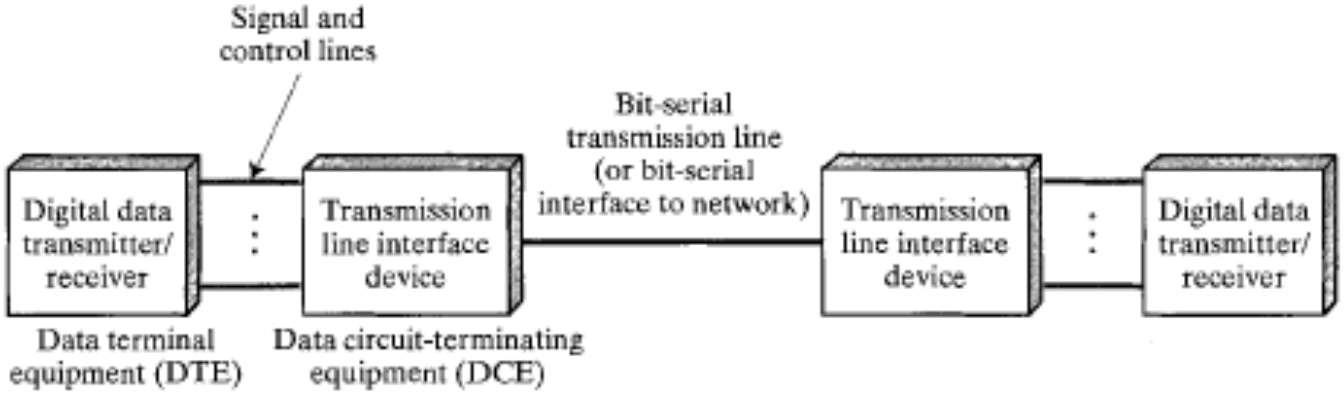


Medium interface



- Data terminal equipment (DTE)
  - Have data to transmit but has no feature for transmission
  - Need an additional device for accessing the media
- Data circuit terminating equipment (DCE)
  - Transmit bits on the media
  - Transmit data and control information with DCE through connection the media
- Need a clear interface standard between DTE, DCE

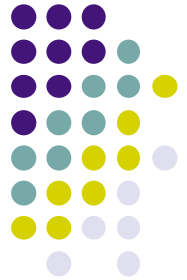
DTE-DCE



(a) Generic interface to transmission medium

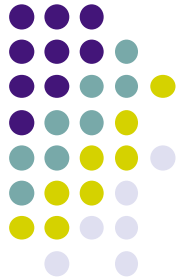
(b) Typical configuration

Media interface



- Mechanism
  - Define the form of the interface, number of pins for assuring the interfaces match together
- Electrics
  - Define the level of voltage to be used
  - Define the length of pulse (frequency)
  - Define enconding method
- Functionalities
  - Functionality of each pins
  - There are 4 groups of pins: data, control, synchronization, ground
- Procedure
  - Lists of events to perform for transmitting data

Example: EIA-232-E/RS-232



- Define for serial communication
- Mechanism: ISO 2110
- Electrics: V. 28
- Functionality: V. 24
- Procedure: V. 24

Example: V.24 /EIA-232-E

- Mechanic:
  - 25 or 15 pins
  - Transmission distance 15m
- Electrics
  - Digital data
  - 1=-3v, 0=+3v (NRZ-L)
  - Data rate 20kbps
  - Transmission distance< 15m

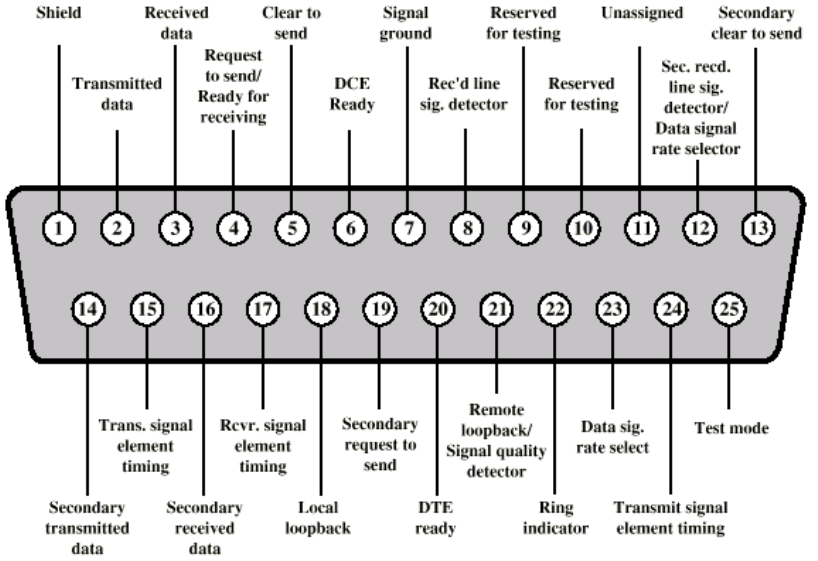


Figure 6.5 Pin Assignments for V.24/EIA-232 (DTE Connector Face)

Data Encoding

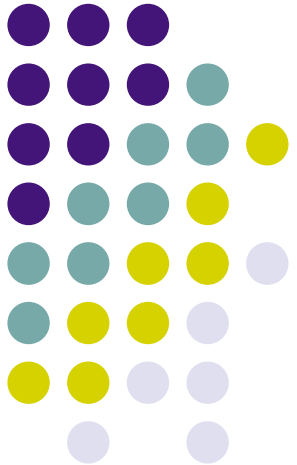
Introduction

Encoding digital data to digital signal

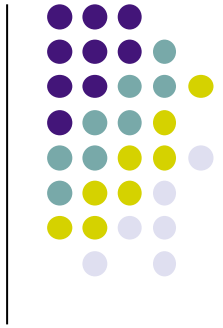
Encoding digital data to analogical signal

Encoding analogical data to digital signal

Encoding analogical data to digital signal



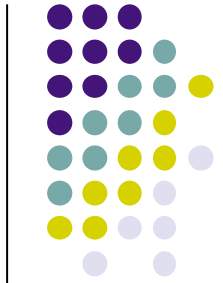
Fundamental concepts



- Objective
  - Transform the data into some signals that is suitable for transmission media

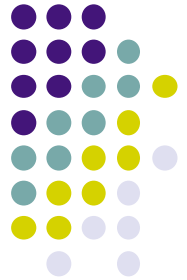
4 forms of encoding
digital data to digital signal
digital data to analogical signal
analogical data to digital signal
analogical data to digital signal

1. Digital data- Digital signal



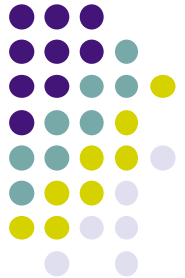
- Data unit: 1 bit
- Digital data is a digital signal
  - Each pulse is considered as a signal unit.
  - A signal unit can be considered as 1 bit
- Data encoding: mapping data to signal
- Set of mapping is called Encoding scheme
- Mark:1, Space:0

Line encoding method

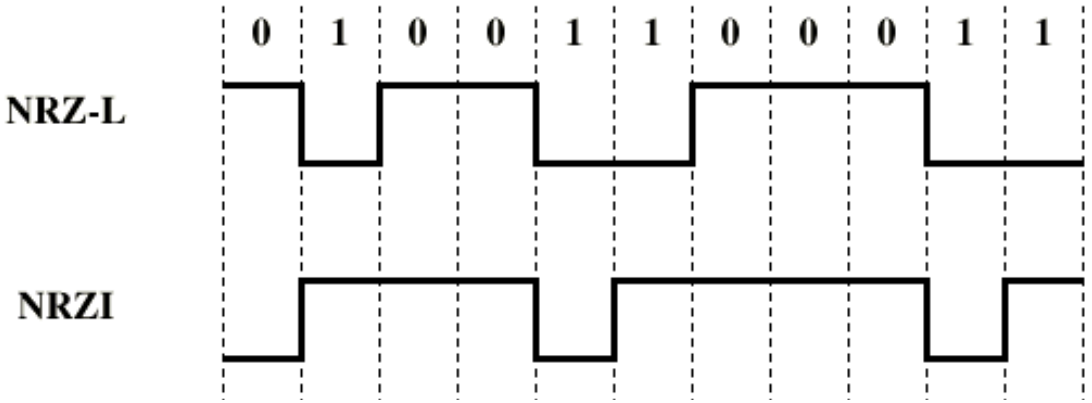


- NRZ
  - NRZ-L,NRZI
- Bipolar
  - Bipolar alternate mark inversion
  - Pseudoternary
- Phase encoding
  - Manchester
  - Manchester vi sai

NRZ-L Non Return to Zero Level

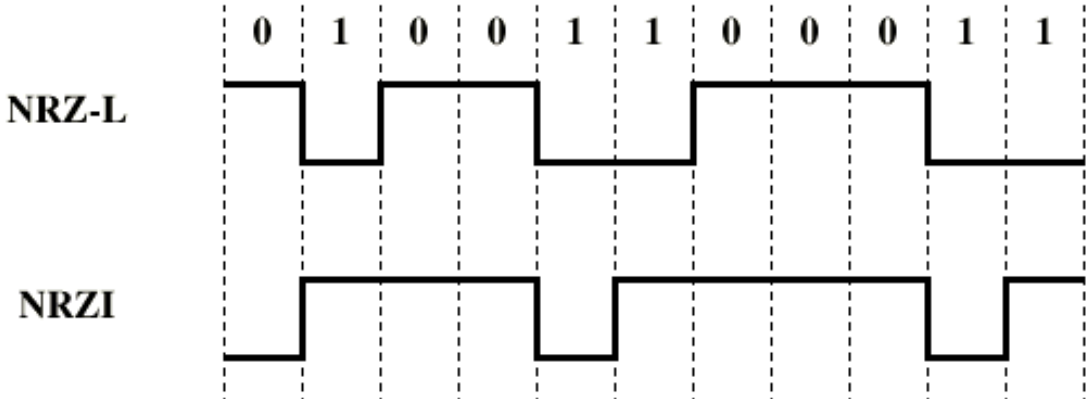


- During bit time, signal does not go back to 0 level
- Signal level is not changed during bit time.
- NRZ-L Non return to zero level
  - Bit 1 signal is in low/high level
  - Bit 0 signal is in high/low level

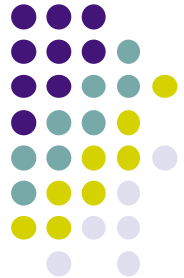


NRZ-I Non return to zero invert

- Bit 0: signal level is not changed at the begining of bit time
- Bit 1: signal level is changed at the begining of bit time
- A differential encoding method :
  - 0 and 1 represent by the signal level change, not by the level itself.
  - Reliable/ simple.

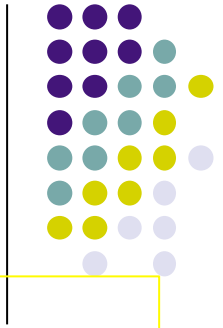


Line encoding consideration



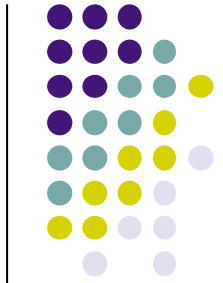
- Two aspects should be consider in any encoding methods:
  - **Clock recovery on receiver side**: If the clock recovery is not ideal, then the signal to be decoded will not be sampled at the optimal times. This will increase the probability of error in the received data.
  - **DC-component**: Directed Current vontage component.
    - DC-component makes recepter mistakenly detect level of signal
    - Encoding should avoid DC-component by having signal mean altitude to be around 0.

NRZ



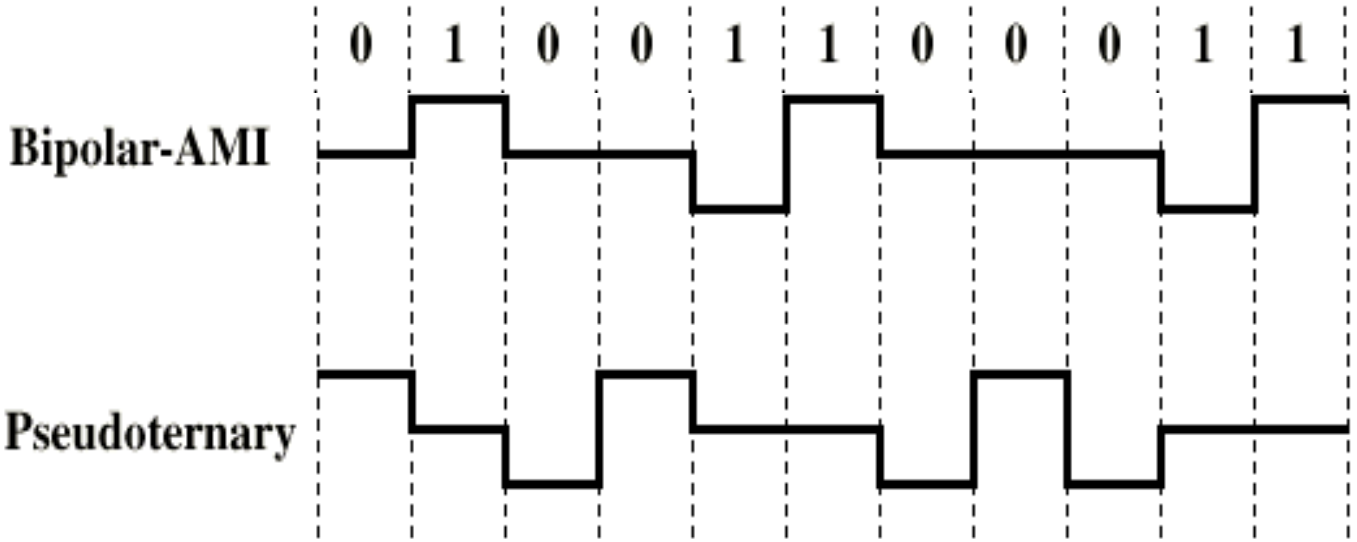
- NRZ Advantage
  - Simple, utilise the maximum capacity of the line
- NRZ Weakness
  - NRZ does not contain element supporting clock synchorization
    - Example: when sending a suit of 1 or 0
  - Contain DC-component when sending a suit of 1.
- Application
  - Encoding data on magnetic storage
  - Not popular in data transmission

Bipolar AMI

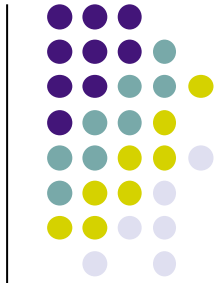


- Use more than 2 signal level for 1 bit
- Bipolar alternate mark inversion
  - 0 : No signal
  - 1: Presence of signal. Two consequent 1 have two different signal levels
- pseudoternary
  - 1 : No signal
  - 0 : Presence of signal. Two consequent 0 have two different signal levels

Bipolar-AMI

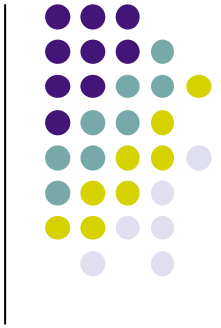


Bipolar AMI



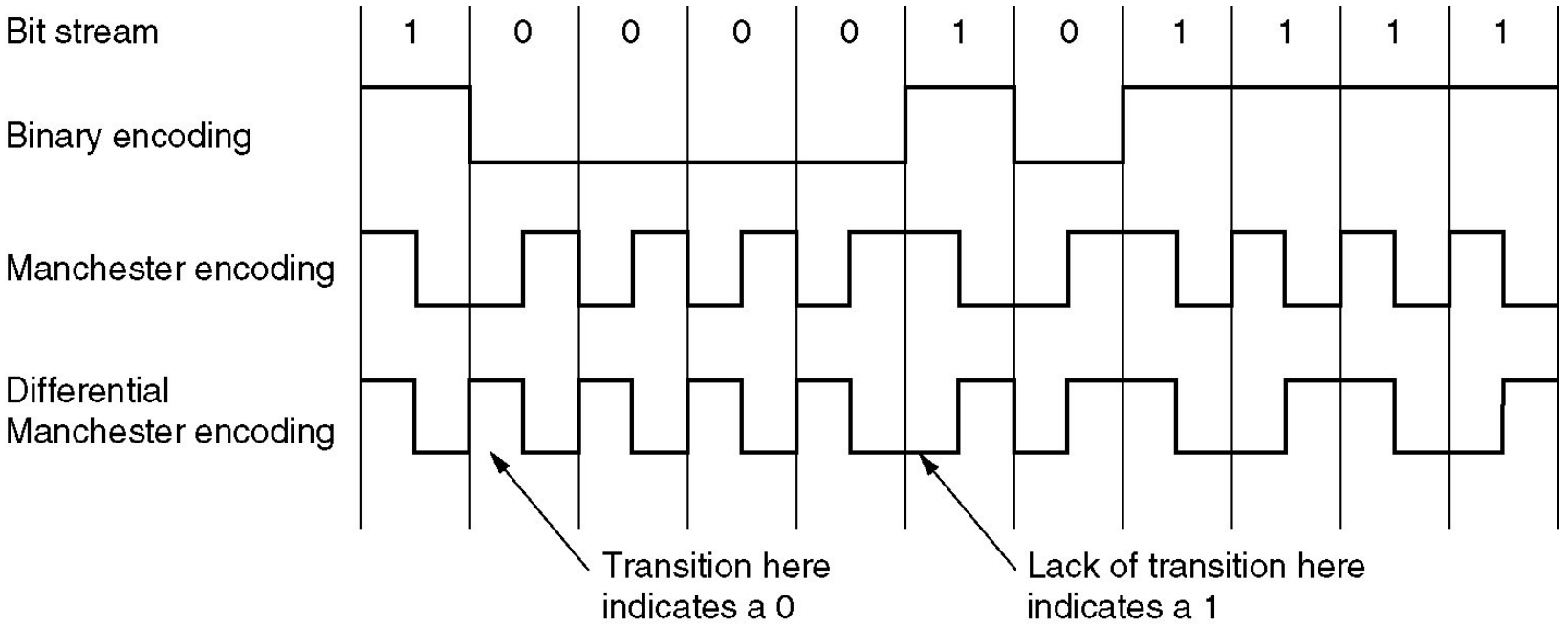
- DC component =0
- Good synchronization when there are many bit 1(0), lost of synchronization when there are many bit 0(1)
- 3 possible signal levels for 1 bit:
  - Not optimal in using transmission line.
  - Receipter needs to distingush 3 levels of signal

Biphase: Manchester

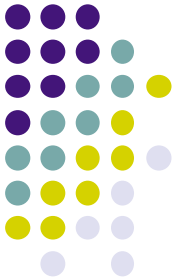


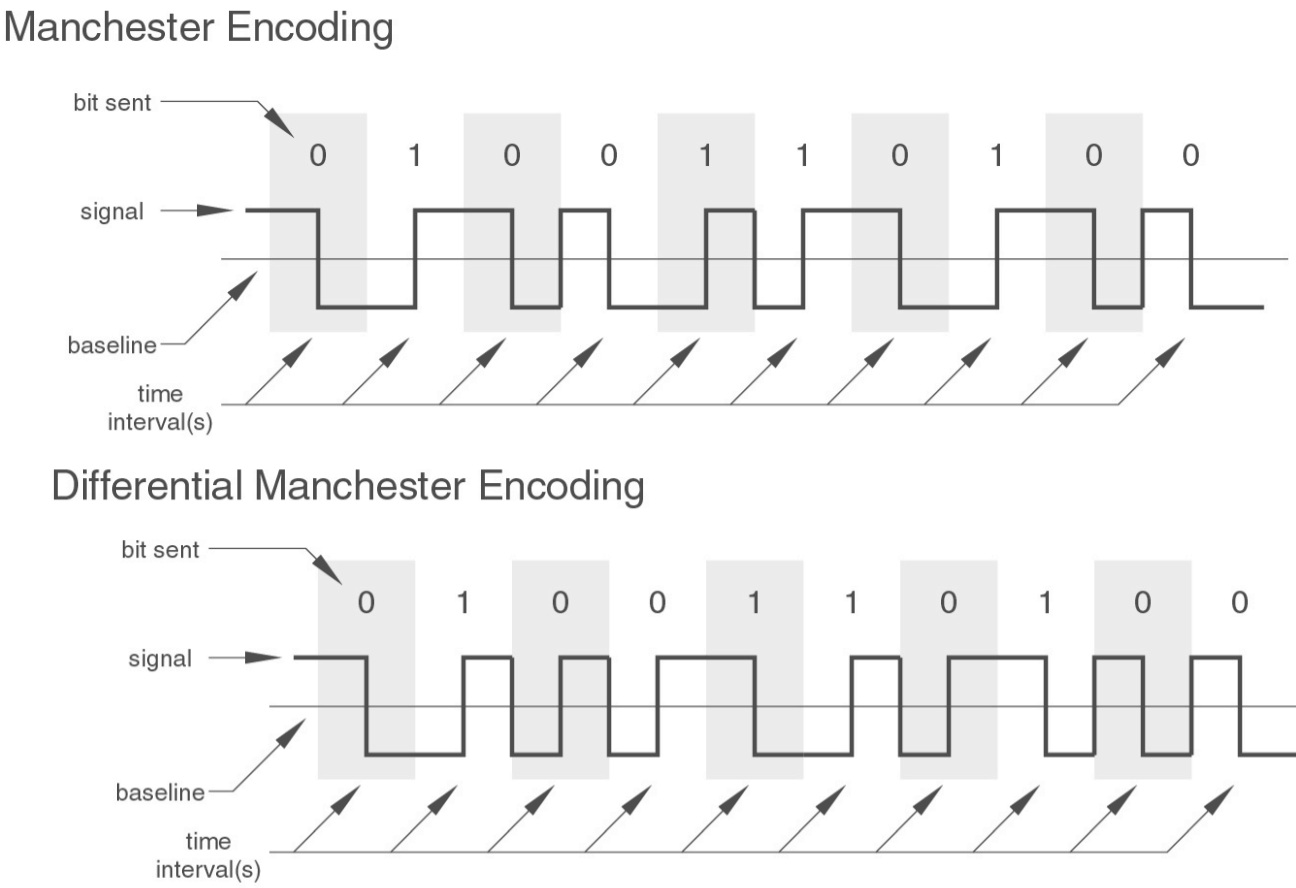
- Manchester: Always change signal level in the middle of bit time
  - Bit 1: Signal change from low level to high level
  - Bit 0: Signal change from high level to low level
  - Level change provide synchonisation mechanism.
- Differential Manchester:
  - 0: signal level change at the begining of bit
  - 1: **no** signal level change at the begining of bit
  - Always change signal level in the middle of bit time for synchronization purpose

Manchester encoding

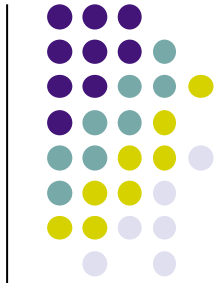


Manchester encoding

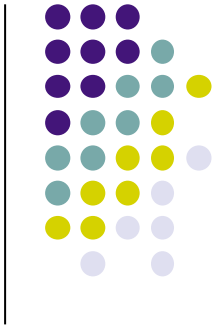




Units in transmitting digital data in digital transmission



Term	*Units*	*Definition*
Data unit	bit	A single bit, Value 0 or 1
Data rate	bit/s	Rate transmitting bit
Signal unit	Pulse a sinus	Part of the signal correspond to the smallest duration of a symbol
Symbol rate/ Rate of modulation	Number of symbol/s (baud)	Number of symbols generated in a unit of time

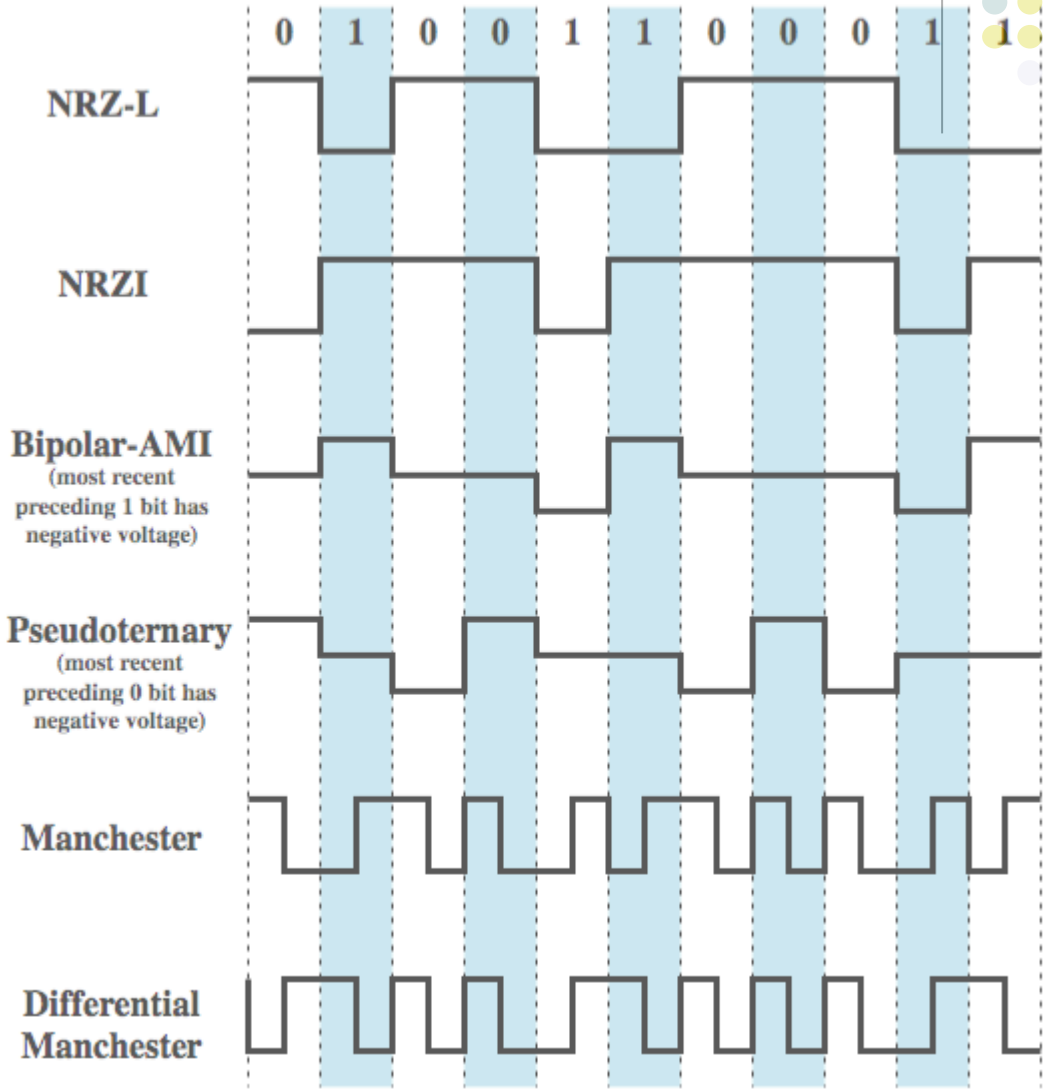


Encoding rate: Baud rate

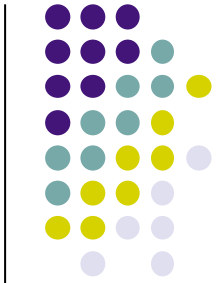
- Number of symbol changes, waveform changes, or signaling events across the transmission medium per unit of time
- Unit: Baud/s = symbol/s

	Minimum	101010…	Maximum
NRZ-L	0 (all 0's or 1's)	1.0	1.0
NRZI	0 (all 0's)	0.5	1.0 (all 1's)
Binary-AMI	0 (all 0's)	1.0	1.0
Pseudoternary	0 (all 1's)	1.0	1.0
Manchester	1.0 (1010…)	1.0	2.0 (all 0's or 1's)
Diff Manchester	1.0 (all 1's)	1.5	2.0 (all 0's)

Line encoding



2. Điều chế số-liên tục

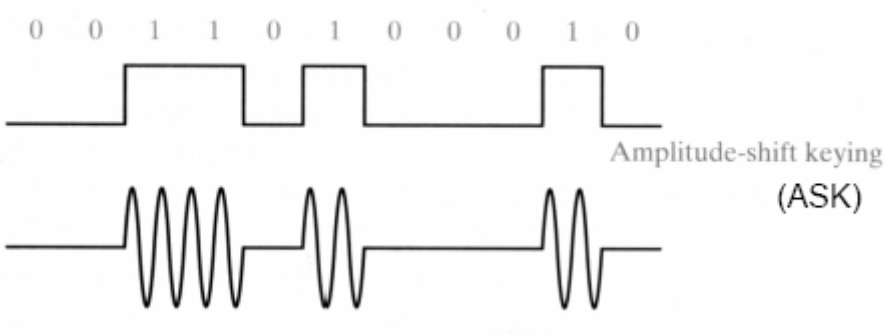


- Ví dụ: truyền số liệu thông qua hệ thống điện thoại
  - Hệ thống điện thoại truyền, chuyển tiếp tín hiệu điện có tần số 300Hz đến 3400Hz
  - Tại nguồn và đích, dữ liệu số cần được điều chế thành tín hiệu liên tục để truyền trên đường điện thoại
- Căn cứ vào tính chất của tín hiệu, chúng ta có 3 kỹ thuật điều chế
  - Điều chế khóa dịch biên độ
  - Điều chế khóa dịch pha
  - Điều chế khóa dịch tần số

Điều chế khóa dịch biên độ (ASK)

- 0 và 1 tương ứng với hai biên độ tín hiệu, thông thường một trong hai biên độ=0
- Dễ bị ảnh hưởng bởi nhiễu (1200bps cho đường thoại)
- Khó đồng bộ
- Thường được dùng trong cáp quang (LED hoặc laser

$$s(t) = \begin{cases} A\cos(2\pi ft) \ cho\ 1 \\ 0 \ cho\ 0 \end{cases}$$



Điều chế khóa dịch tần số (FSK)

$$s(t) = \begin{cases} A\cos(2\pi f_1 t) \\ A\cos(2\pi f_2 t) \end{cases}$$

- Hai giá trị nhị phân được biểu diễn bởi hai tín hiệu tần số khác nhau
- Ví dụ về điều tần song công
- Tỷ suất lỗi thấp hơn
- Dùng trong truyền số liệu qua đường điện thoại (tần số thấp), hoặc trong mạng không dây (tần số cao)

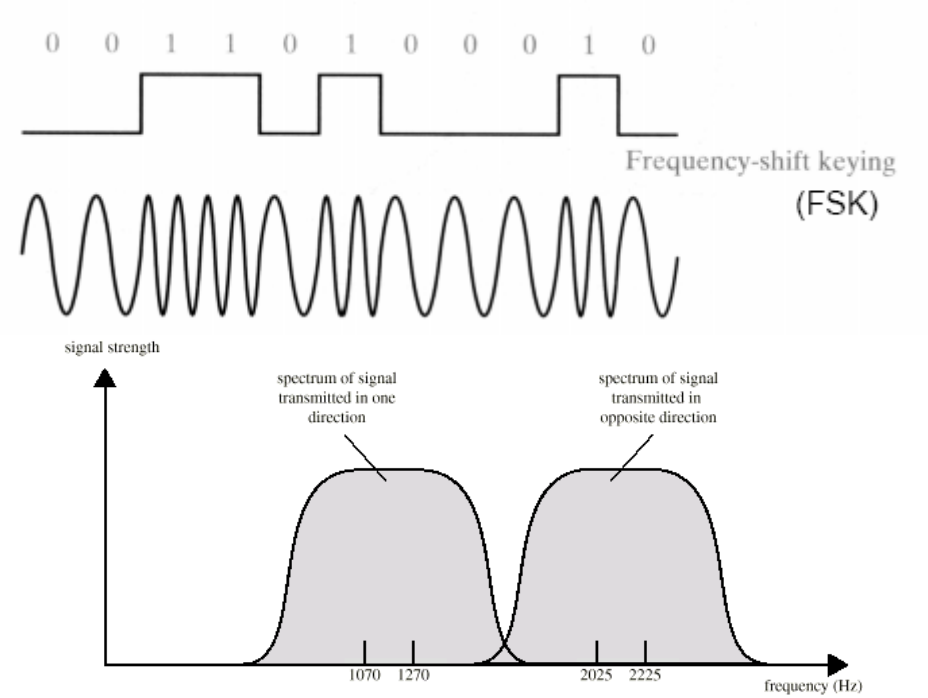


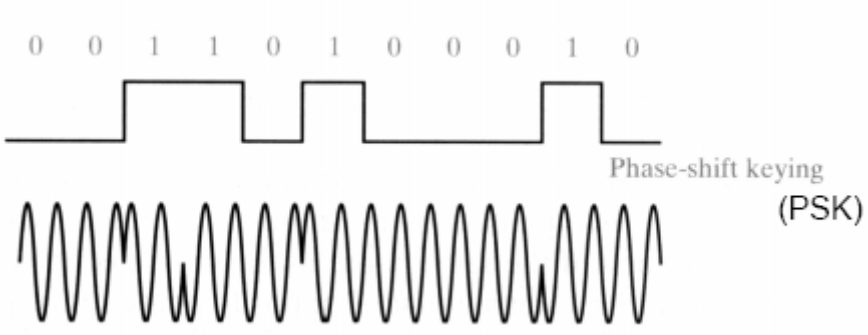
Figure 5.8 Full-Duplex FSK Transmission on a Voice-Grade Line

Điều chế khóa dịch pha (PSK)

- 0,1 tương ứng với hai độ lệch pha khác nhau
- 0,1 tương ứng với chuyển pha (vi sai)
- Có thể sử dụng giải thông một cách hiệu quả hơn khi mã hóa cùng lúc nhiều bít
- Có thể kết hợp với điều biên
- Nếu tốc độ dữ liệu là 9600 bps, tốc độ điều chế là ?

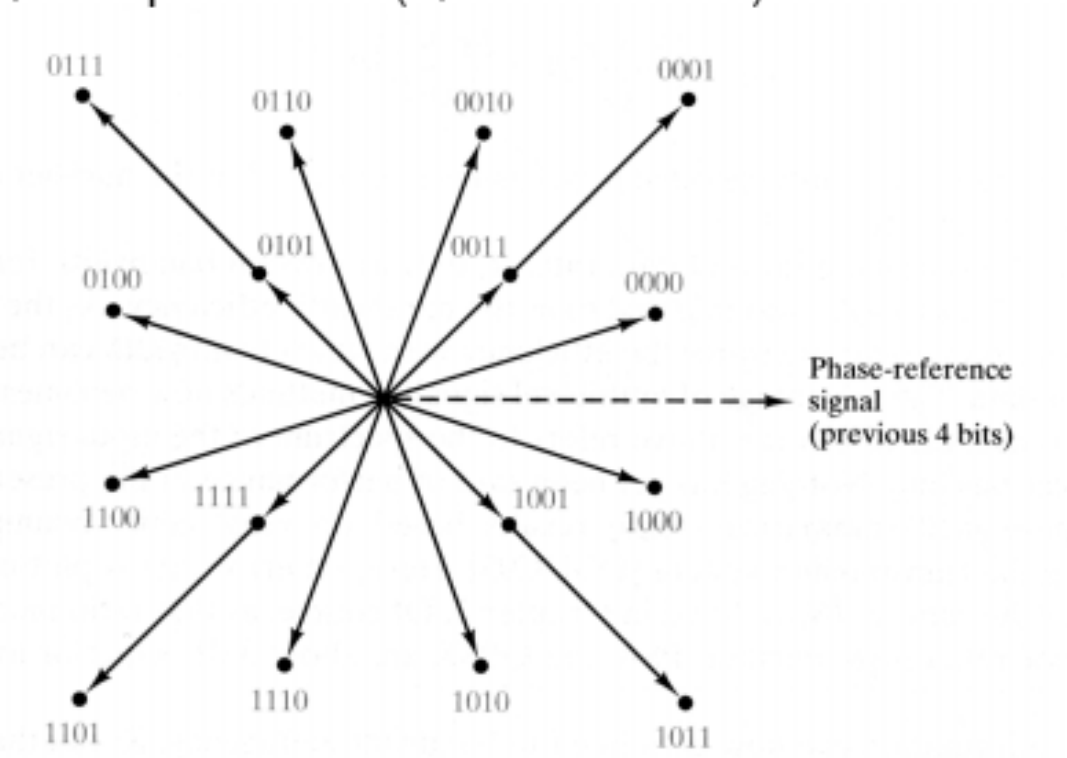
$$s(t) = \begin{cases} A\cos(2\pi f_c t + \pi) & \text{binary 1} \\ A\cos(2\pi f_c t) & \text{binary 0} \end{cases}$$

$$s(t) = \begin{cases} A\cos(2\pi f_c t + 45°) & 11 \\ A\cos(2\pi f_c t + 135°) & 10 \\ A\cos(2\pi f_c t + 225°) & 00 \\ A\cos(2\pi f_c t + 315°) & 01 \end{cases}$$

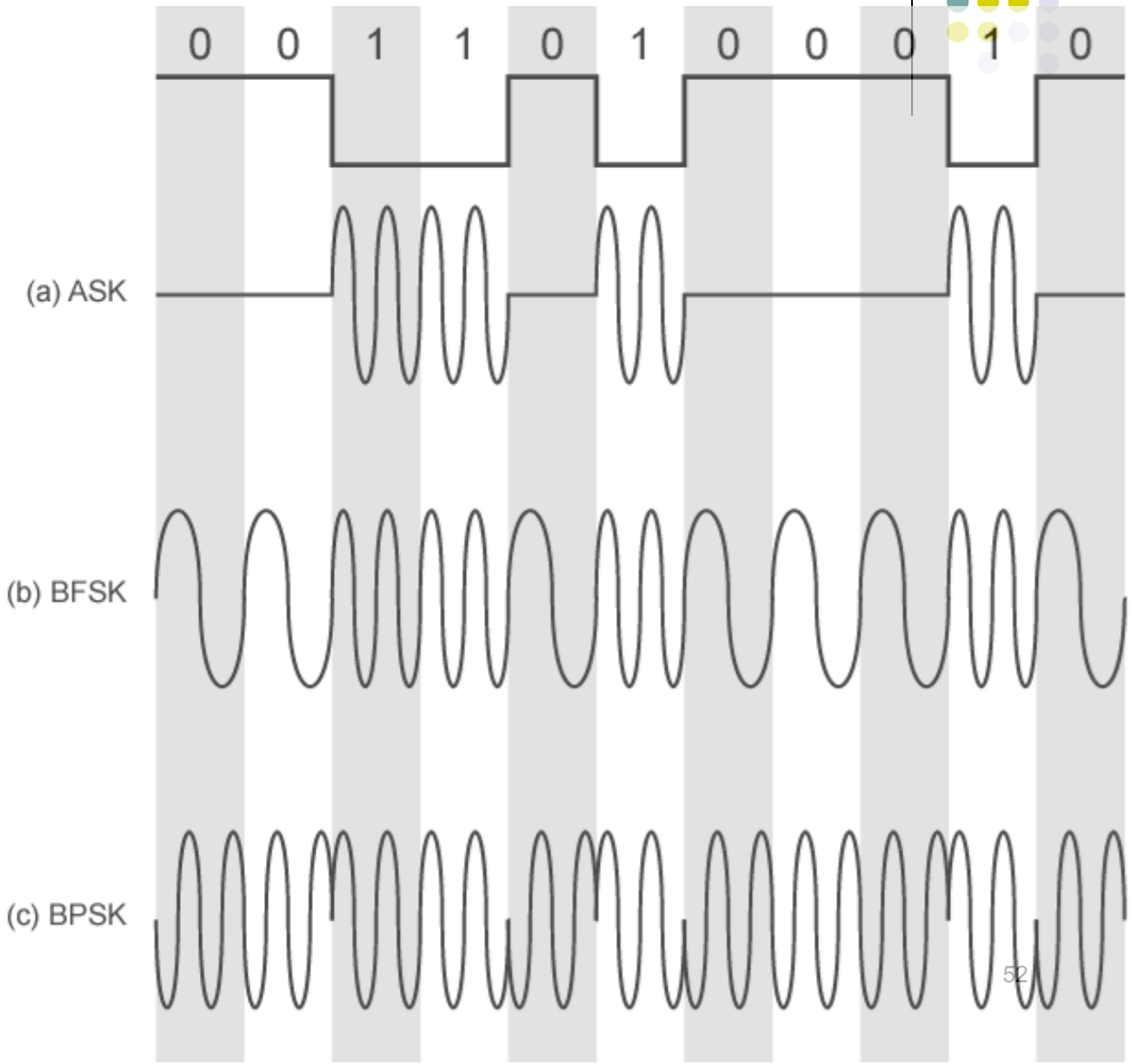


Kết hợp với điều biên

– 9,600 bps modem (2,400 baud x 4)



Điều chế số/liên tục

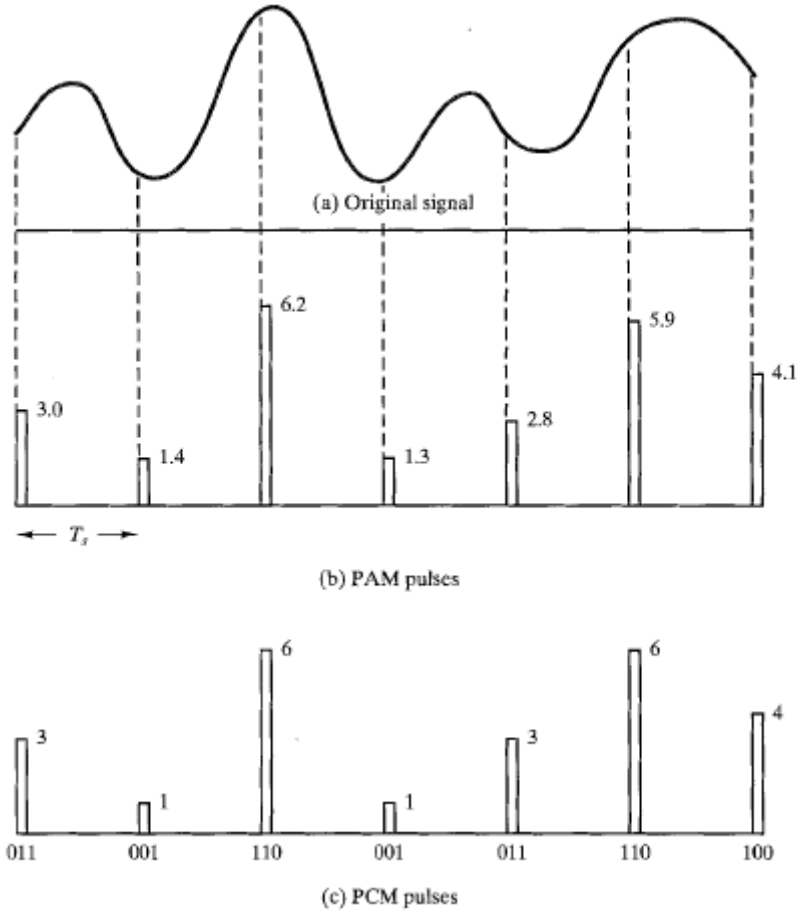


3. Điều chế dữ liệu liên tục- số

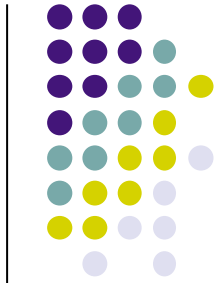
- Điều chế dữ liệu liên tục thành dữ liệu số, sau đó
  - Điều chế thành tín hiệu số
    - Mã hóa trực tiếp bằng NRZ-L
    - Sử dụng phương pháp mã hóa tín hiệu số khác
  - Điều chế thành tín hiệu liên tục
    - Sử dụng các biện pháp điều chế số-liên tục đã học
- Có hai phương pháp chính điều chế dữ liệu liên tục thành dữ liệu số
  - Điều chế mã xung
  - Điều chế Delta

Điều chế mã xung (PCM)

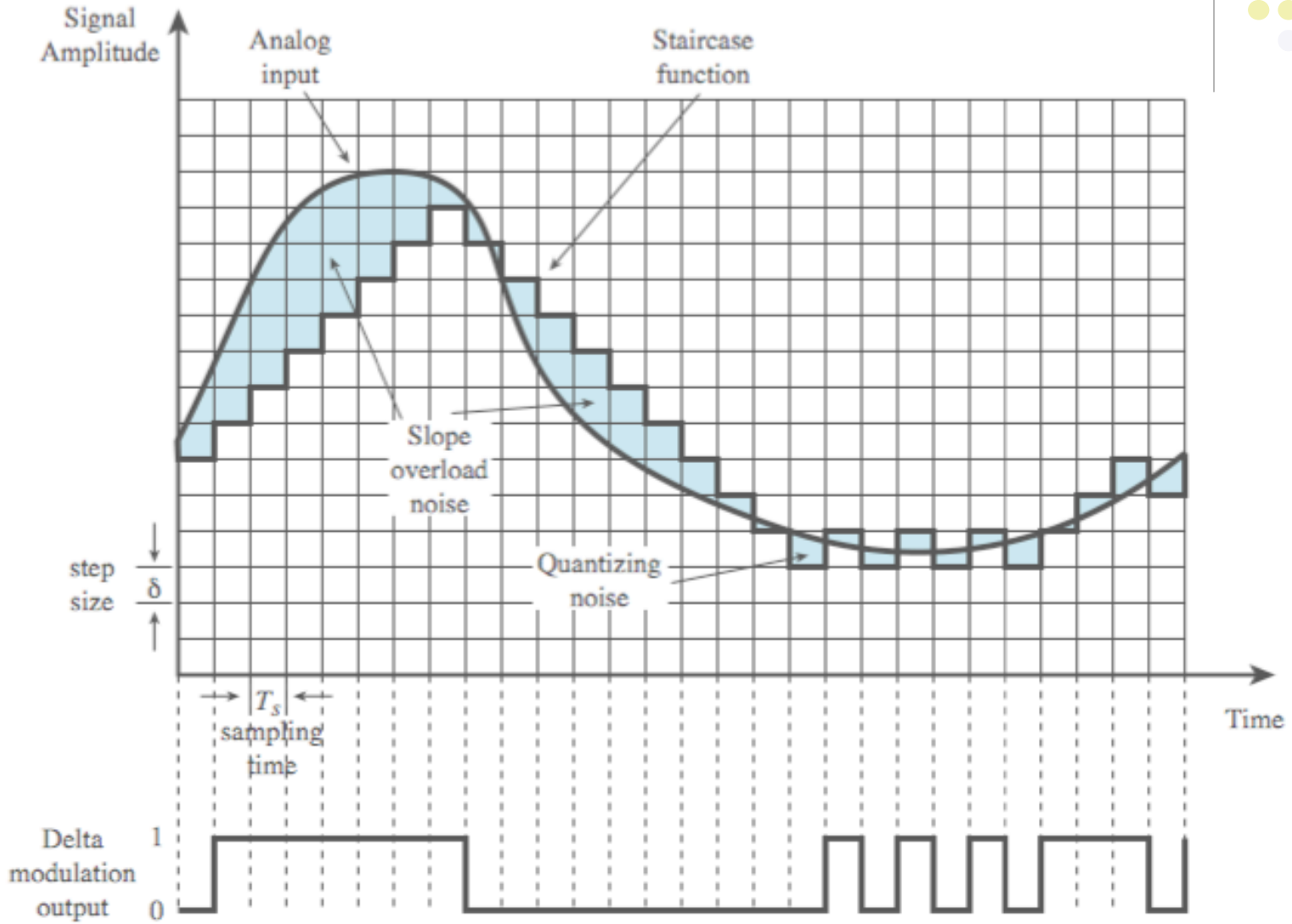
- Pulse Code Modulation
- Lấy mẫu tín hiệu dựa trên định luật lấy mẫu của Shannon
  - Nếu tần số lấy mẫu >= 2 lần tần số (có ý nghĩa) cao nhất của tín hiệu, phép lấy mẫu bảo toàn thông tin của tín hiệu
  - Vd: Tiếng nói tần số tối đa 4300Hz, cần lấy mẫu với tần số min 8600Hz
- Tiến hành theo hai bước
  - Lấy mẫu (PAM)
  - Lượng tử hóa



Điều chế delta (Delta Modulation)

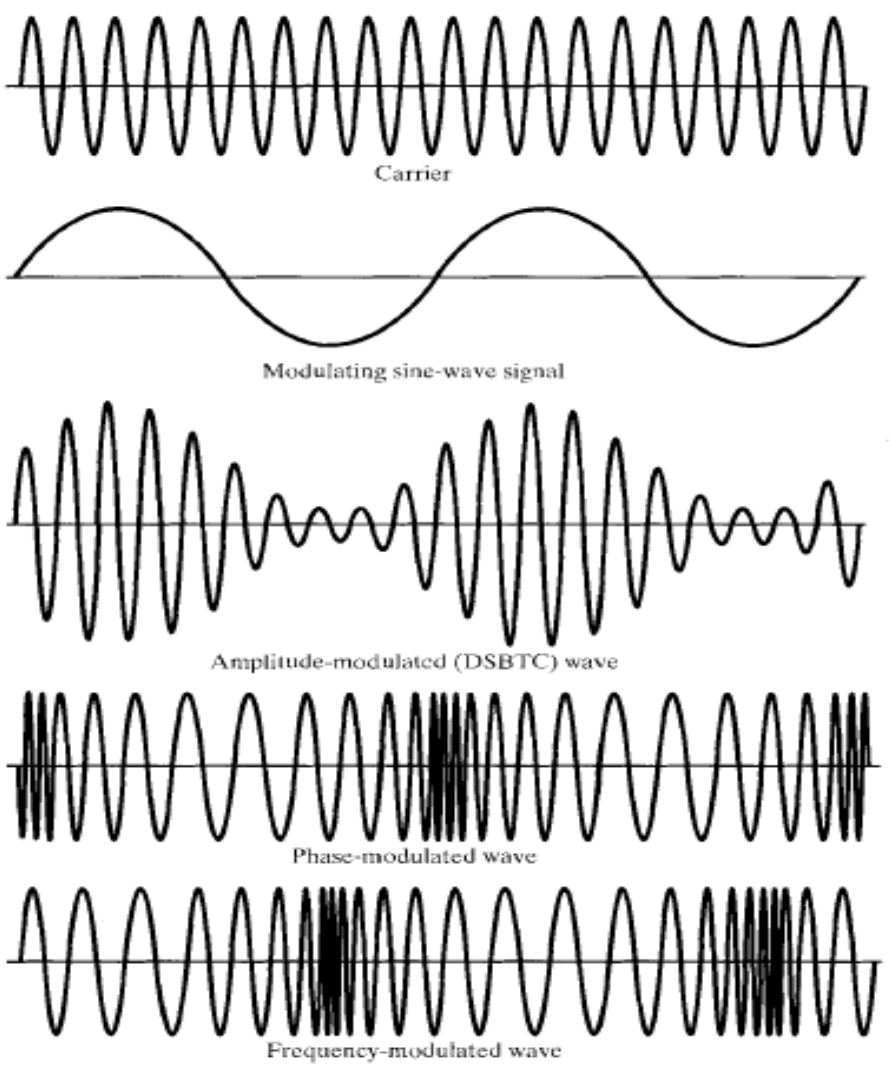


- Sử dụng hàm bậc thang
  - Khi hàm số tăng, xung=1
  - Khi hàm số giảm, xung=0
- Tổng quát
  - Biểu diễn giá trị của đạo hàm theo bít
- Tham số
  - Bậc thang
  - Tốc độ lấy mẫu
- Sai số
  - Khi tín hiệu thay đổi chậm: nhiễu lượng tử
  - Khi tín hiệu thay đổi nhanh: nhiễu tràn


Signal
Amplitude
Analog
input
Staircase
function
Slope
overload
noise
Quantizing
noise
step
size
δ
T_s
sampling
time
Time
Delta
modulation
output
1
0

Dữ liệu liên tục tín hiệu liên tục

- Kết hợp tín hiệu m(t) và sóng mang có tần số Fc thành một tín hiệu tập trung xung quanh Fc
- Cho phép chuyển tín hiệu trên một tần số khác phù hợp với kênh truyền
- Cho phép dồn kênh bằng các tần số sóng mang khác nhau
- 3 phương pháp chính dựa vào đặc điểm của tín hiệu
  - Điều biên
  - Điều tần
  - Điều chế góc pha

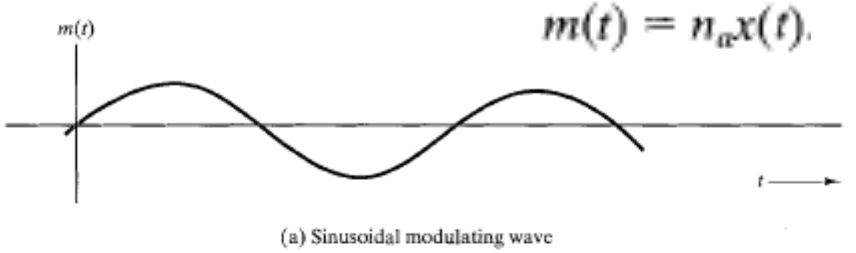


Điều biên

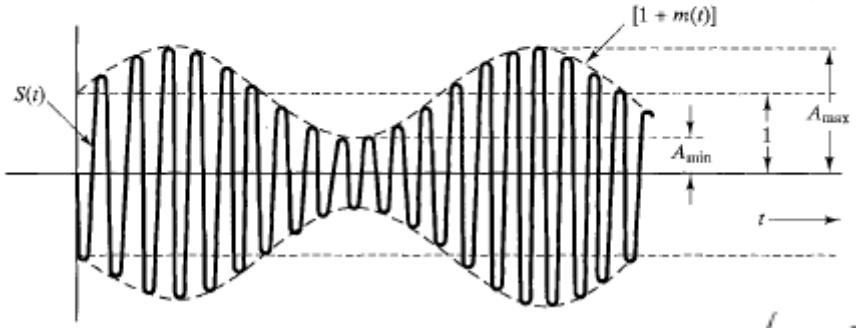
- Biến đổi biên độ sóng mang theo đầu vào
- Nếu đầu vào cũng là hình sin
  - Tín hiệu đầu ra sẽ có hai thành phần lệch với tần số sóng mang một khoảng bằng tần số đầu vào
  - Na<1 điều biên hợp lệ
  - Na>1 mất thông tin
- Giải thông=2 lần giải thông đầu vào
- Điều biên một chiều: 1 lần giải thông

$$s(t) = [1 + m(t)]\cos 2\pi f_c t$$

$$m(t) = n_a x(t)$$

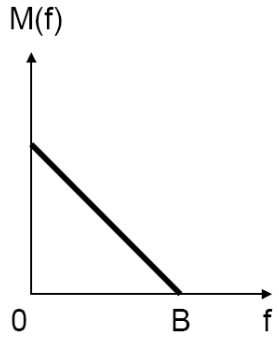


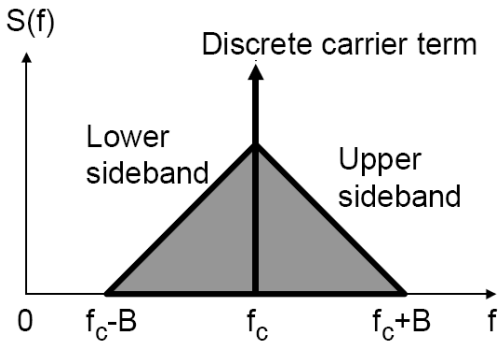
(a) Sinusoidal modulating wave



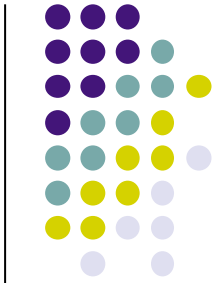
(b) Resulting AM signal

$$P_t = P_c\left(1 + \frac{n_a^2}{2}\right)$$





Bài tập-01



- Biểu diễn các tín hiệu mã hóa chuỗi dữ liệu sau đây bằng các phương pháp mã hóa đã học
  - 11000000 00000010 11001101 01010101

Bài tập-02

- Dữ liệu mã hóa bằng mã manchester (không vi sai) cho tín hiệu
  - Xác định thời gian của từng bít
  - Xác định dữ liệu ban đầu

Bài tập-04

- Biểu diễn phương pháp điều chế pha-biên độ sau bằng công thức
- Tốc độ ký hiệu là 2400 baud. Tốc độ dữ liệu là bao nhiêu?