Data Transmission, Transmission Media and Data Encoding

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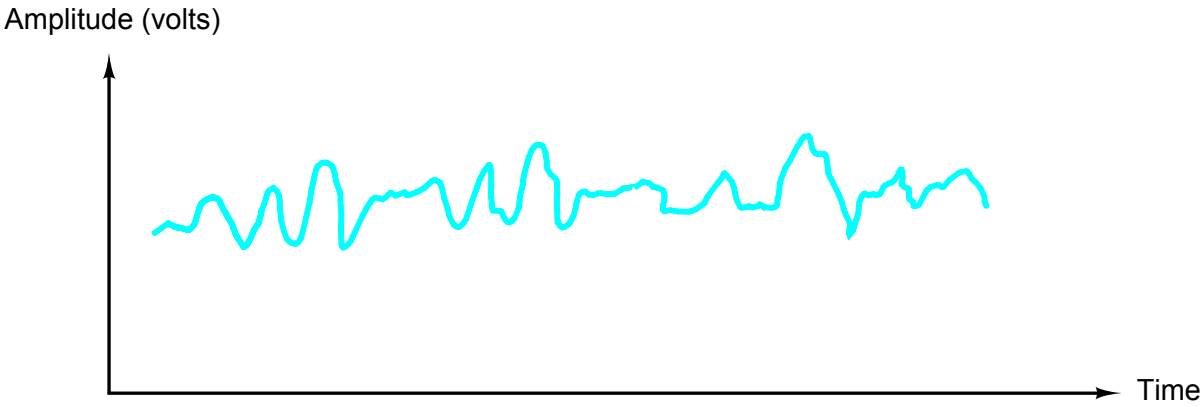
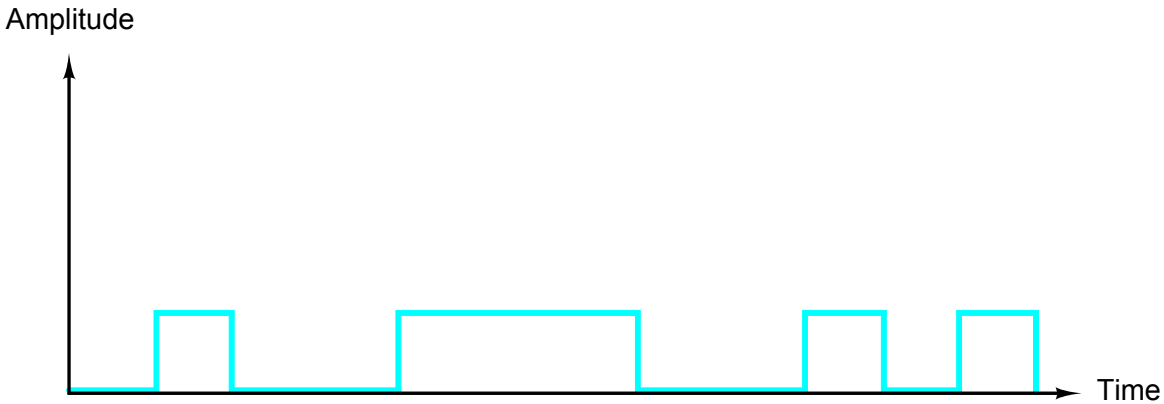
- Time Domain and Frequency Domain
- Decibels
- Data vs Signal
- Attenuation, Delay Distortion, Noise, Capacity
- Physical Media: Twisted pair, coaxial cable, optical fiber
- Bit, Hertz, and Baud
- Coding Design: Terminology + Considerations

Analog vs Digital



(a) Continuous



(b) Discrete

Fig 2.2

Frequency, Period, and Phase

- A Sin(2 p πft+ θ)

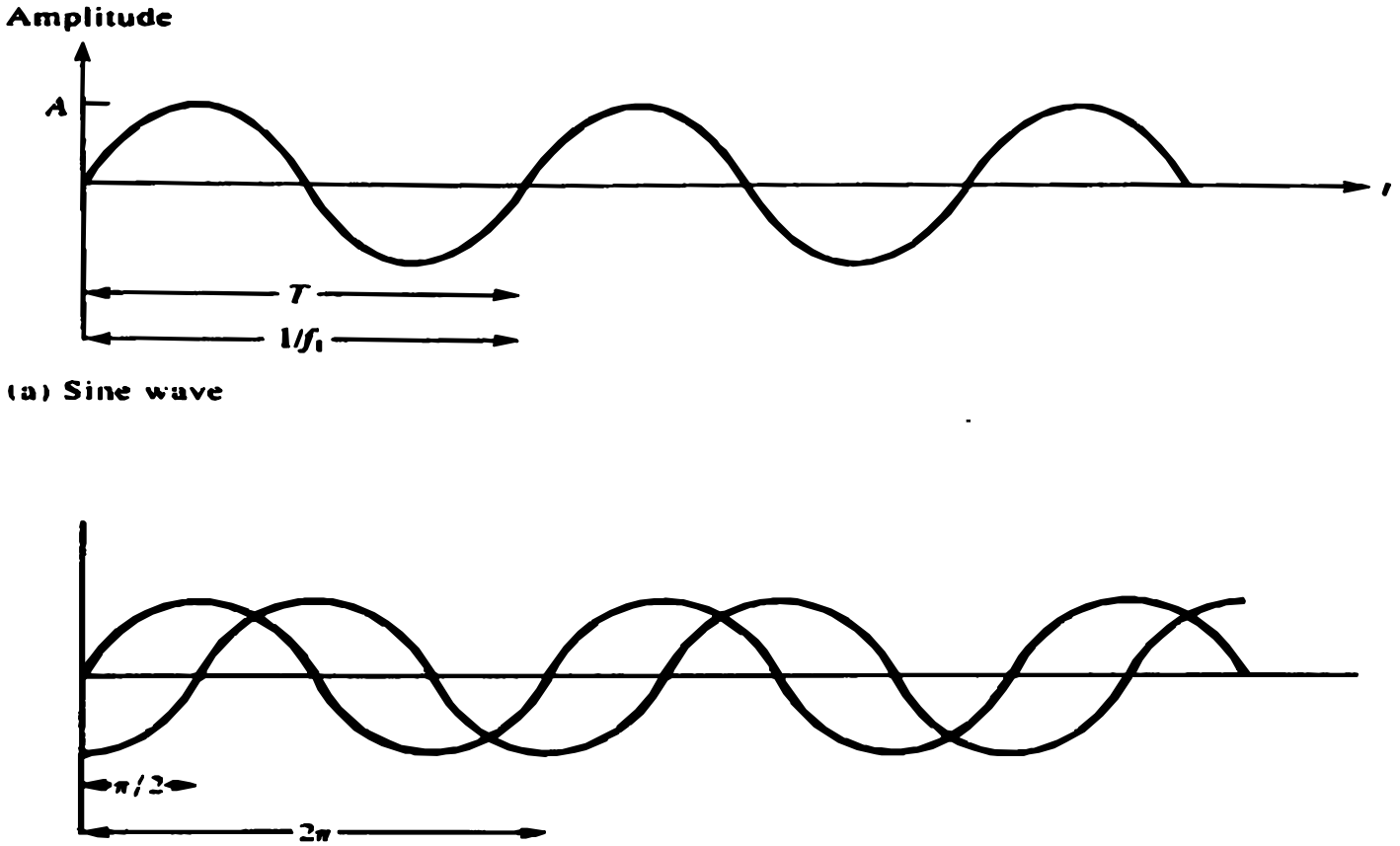
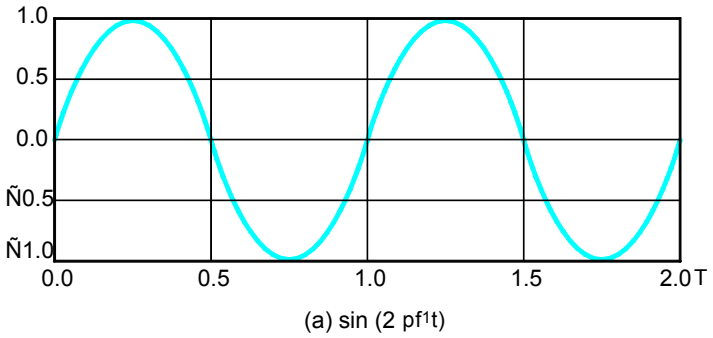
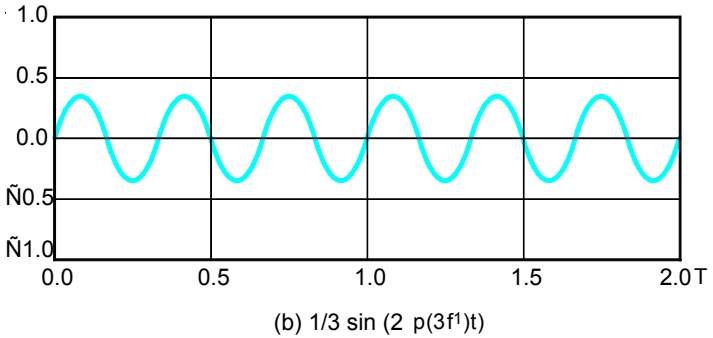


Fig 2.3a+2.4

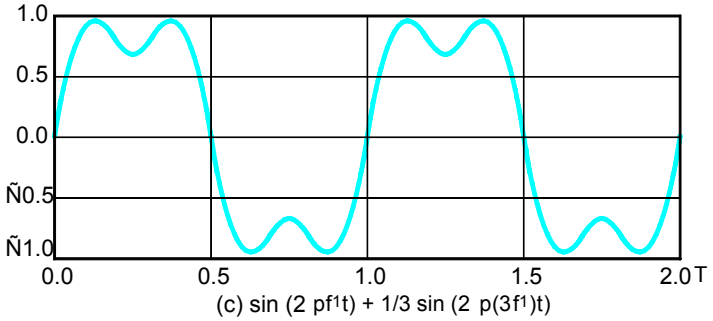
Time Domain vs Frequency Domain



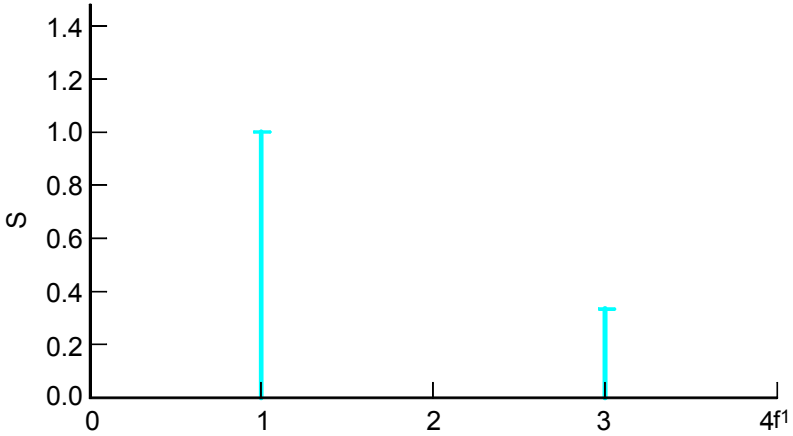
(a) sin (2 pf1t)



(b) 1/3 sin (2 p(3f1)t)

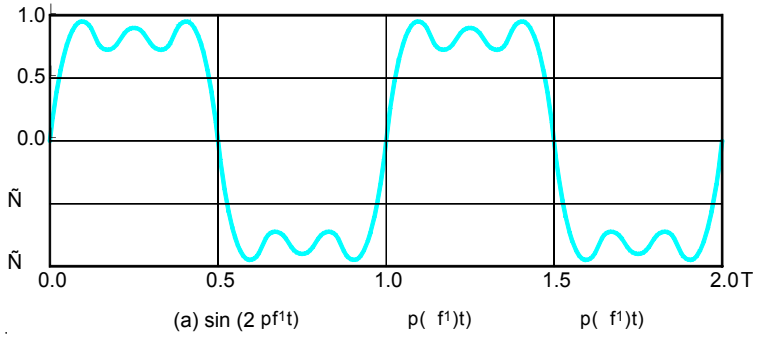


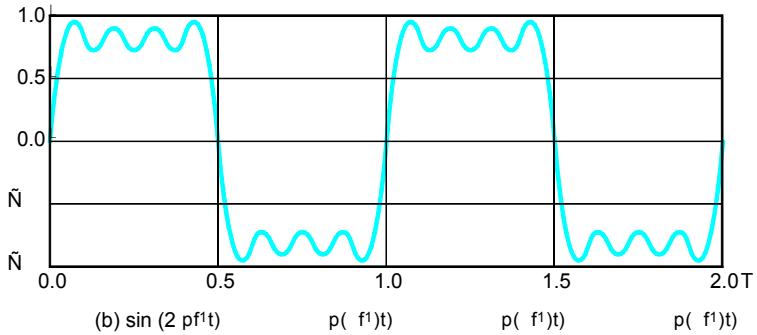
(c) sin (2 pf1t) + 1/3 sin (2 p(3f1)t)



)) (a) s(t) = sin (2pf1t) + 1/3 sin (3(2pf1t

Data Rate vs Bandwidth





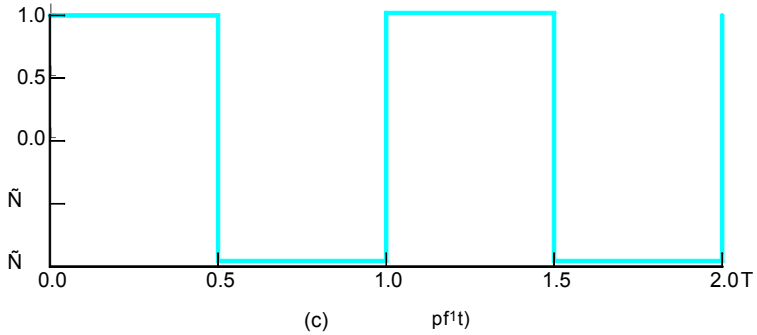
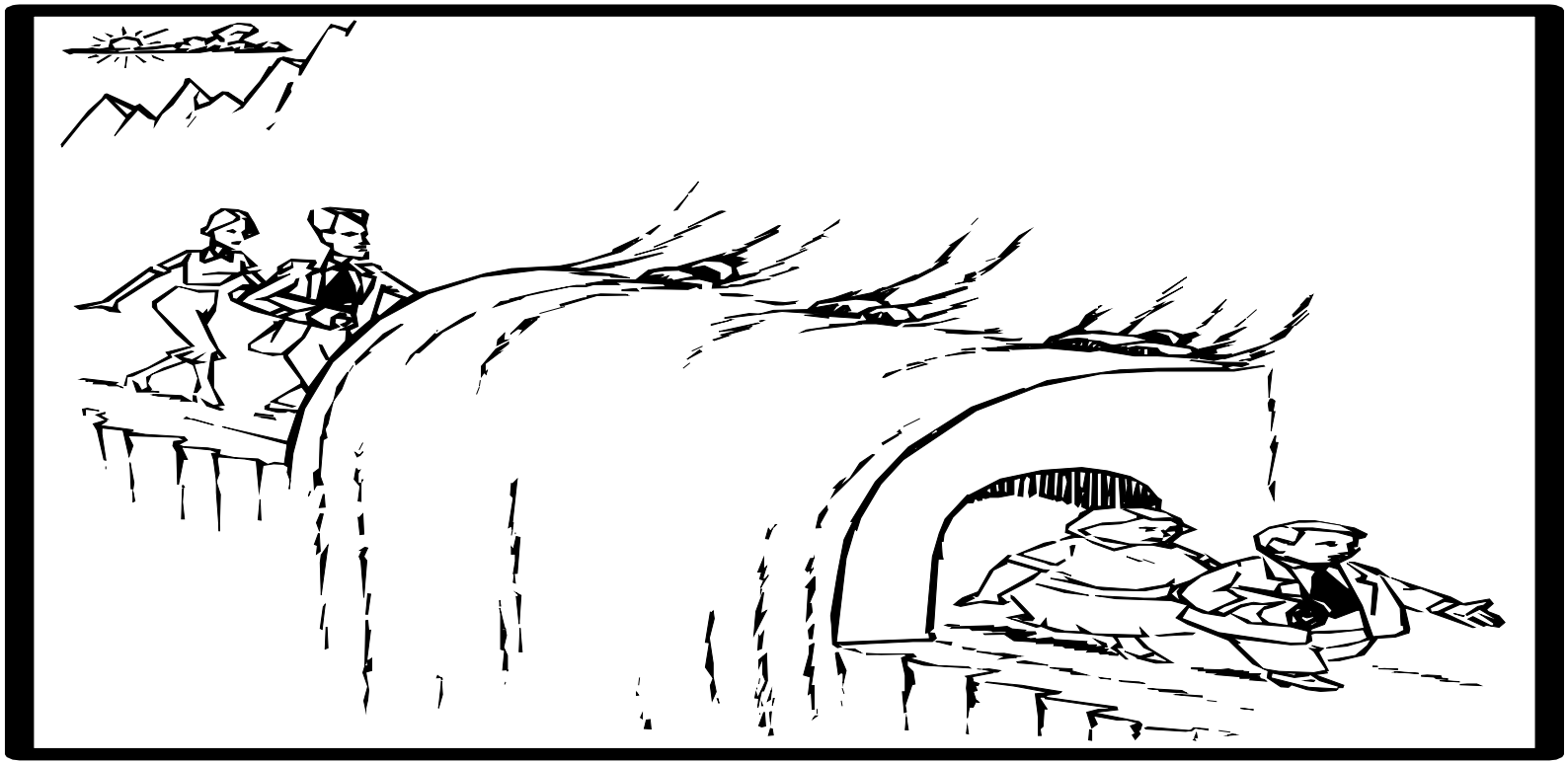


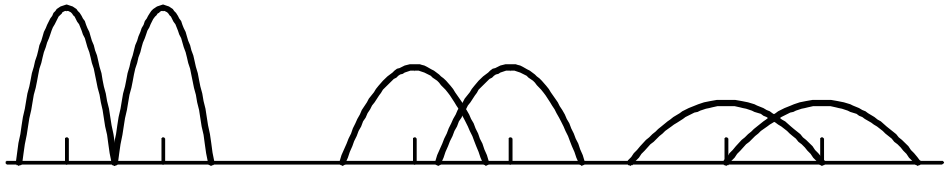
Fig 2.8

Data vs Signal

Data		Signal
Analog	Telephone	Analog
Digital	Modem	Analog
Analog	CODEC	Digital
Digital	Digital Transmitter	Digital

Attenuation and Dispersion (Delay Distortion)





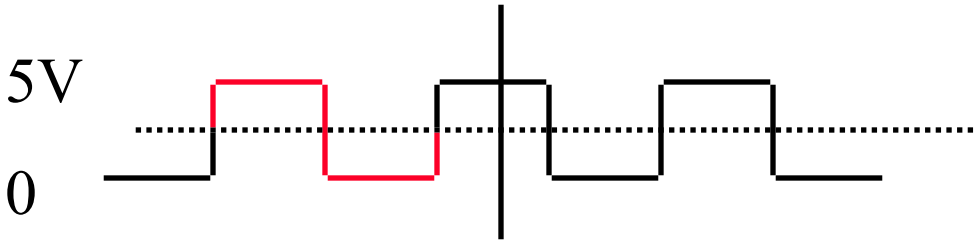
Distance →

Decibels

- Attenuation = $\text{Log}_{10} \frac{\text{Pin}}{\text{Pout}}$ Bel
- Attenuation = 10 $\text{Log}_{10} \frac{\text{Pin}}{\text{Pout}}$ decibel
- Attenuation = 20 $\text{Log}_{10} \frac{\text{Vin}}{\text{Vout}}$ decibel
- **Example 1**: Pin = 10 mW, Pout=5 mW
  Attenuation = 10 $\log_{10}(10/5) = 10 \log_{10} 2 = 3$ dB
- **Example 2**: Pin = 100mW, Pout=1 mW
  Attenuation = 10 $\log_{10}(100/1) = 10 \log_{10} 100 = 20$ dB

Channel Capacity

- Capacity = Maximum data rate for a channel
- **Nyquist Theorem**: Bandwidth = W
  Data rate $\leq$ 2 W
- Bilevel Encoding: Data rate = 2 × Bandwidth



- Multilevel Encoding: Data rate = 2 × Bandwidth × $\log_2$ M

Example: M=4, Capacity = 4 × Bandwidth

Shannon's Theorem

- Bandwidth = H Hz
  Signal-to-noise ratio = S/N
- Maximum number of bits/sec = $H \log_2 (1+S/N)$
- Example: Phone wire bandwidth = 3100 Hz

$$S/N = 30 \text{ dB}$$

$$10 \text{ Log}_{10} S/N = 30$$

$$\text{Log}_{10} S/N = 3$$

$$S/N = 10^3 = 1000$$

$$\text{Capacity} = 3100 \log_2 (1+1000)$$

$$= 30{,}894 \text{ bps}$$

Transmission Media

- Twisted pair
- coaxial cable
- Optical Fiber
- Terestrial Microwave
- Satellite Microwave
- Radio

Twisted Pair

- Unshielded Twisted Pair (UTP)
  - Voice Grade: Telephone wire
  - Data Grade: Better quality

  100 Mbps over 50 m possible

- Shielded Twisted Pair (STP)

Coaxial Cable

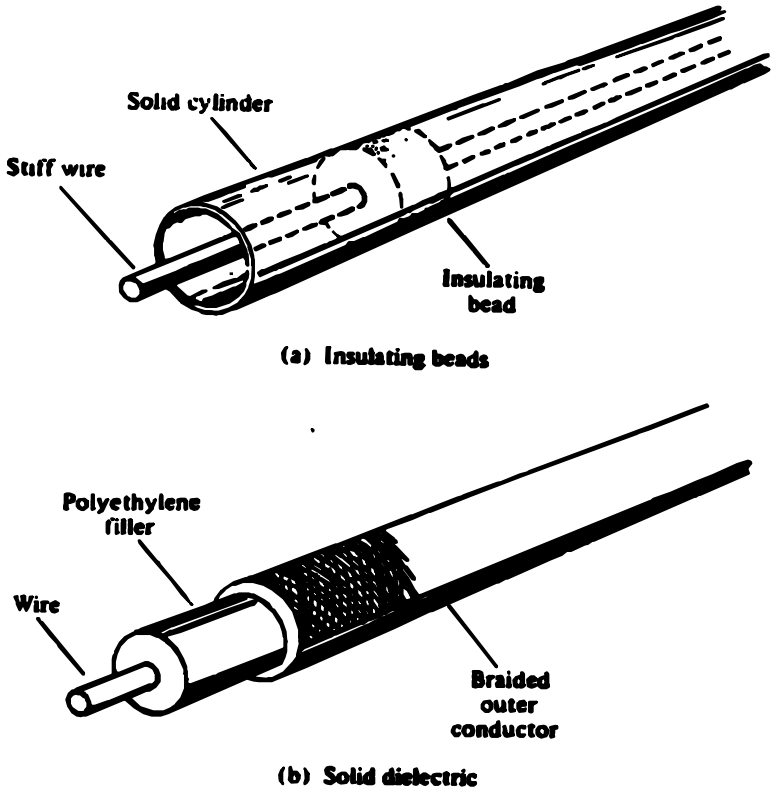
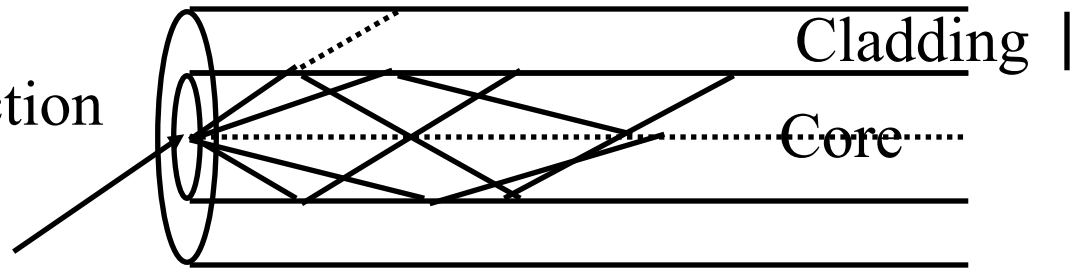


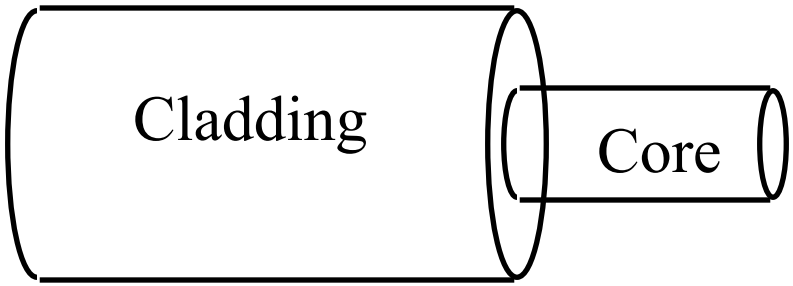
Fig 2.20

Optical Fiber

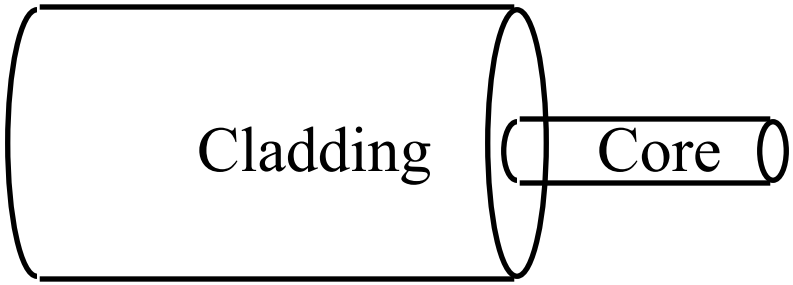
- Modes
  Index=Index of referection
  =Speed in Vacuum/
  Speed in medium



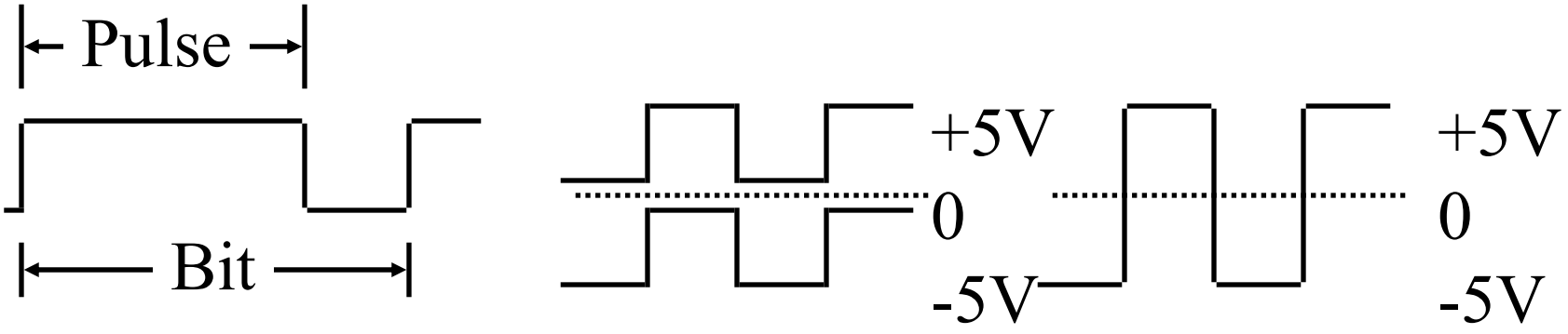
- Multimode



- Single Mode

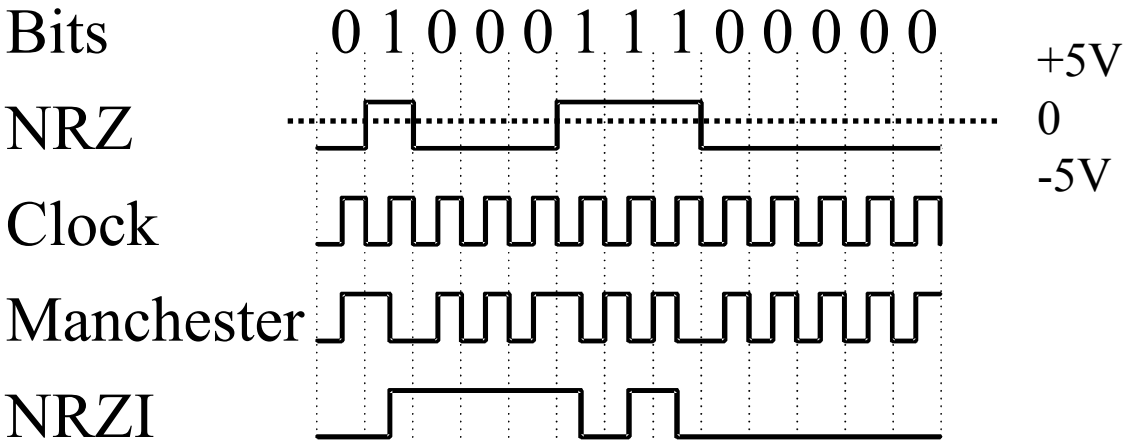


Coding Terminology



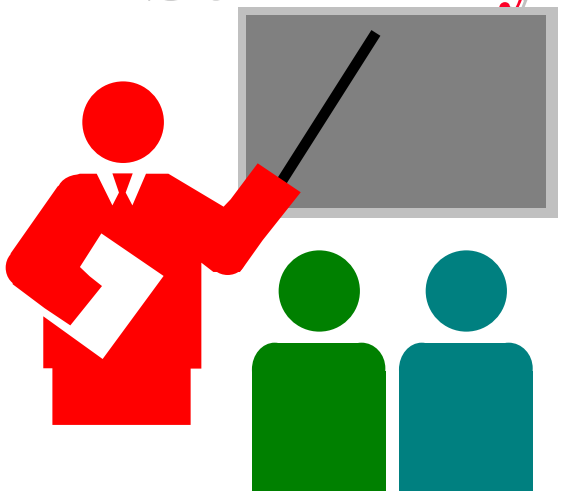
- Signal element: Pulse
- Modulation Rate: 1/Duration of the smallest element
  =Baud rate
- Data Rate: Bits per second
- Data Rate = Fn(Bandwidth, signal/noise ratio, encoding)

Coding Design



- Pulse width indeterminate: Clocking
- DC, Baseline wander
- No line state information
- No error detection/protection
- No control signals
- High bandwidth
- Polarity mix-up ⇒ Differential (compare polarity)

Summary



- Time domain vs frequency domain
- Data rate vs Bandwidth
- Data vs Signal, Analog vs Digital
- Attenuation, Dispersion (delay distortion)
- Media: Twisted pair, coaxial, fiber
- Coding: Higher data rate, error control, clock syncronization,
- NRZ, NRZI, Manchester, Multilevel

Homework

- Read Sections 2.3, 2B (appendix), 3.1, 4.1 of Stallings.