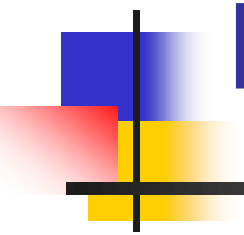
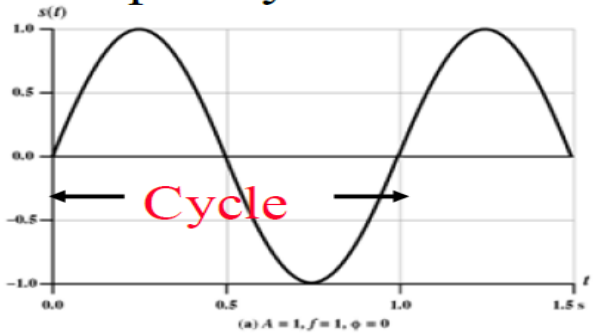


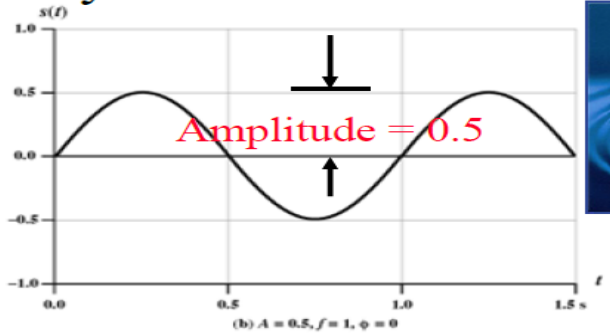
Meios Físicos

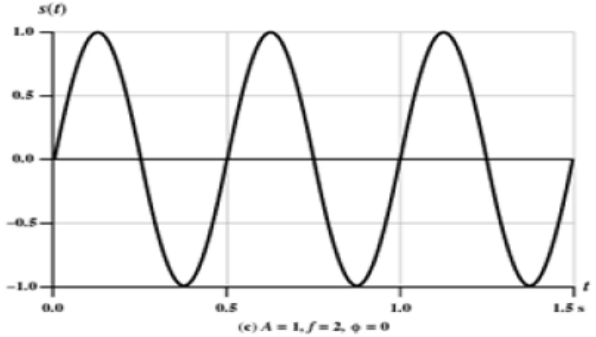
MC822 – Nelson Fonseca

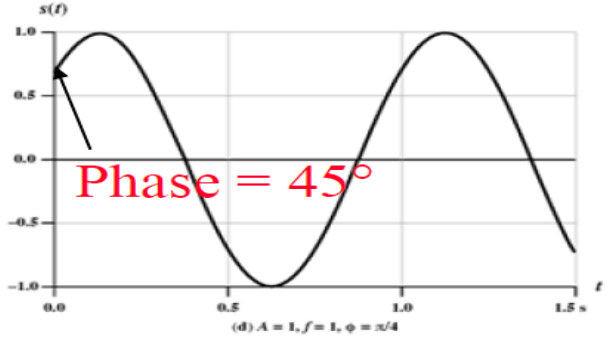
Frequency, Period, and Phase

- A $\sin(2\pi ft + \theta)$, A = Amplitude, f=Frequency, θ = Phase, Period T = 1/f,
  Frequency is measured in Cycles/sec or **Hertz**







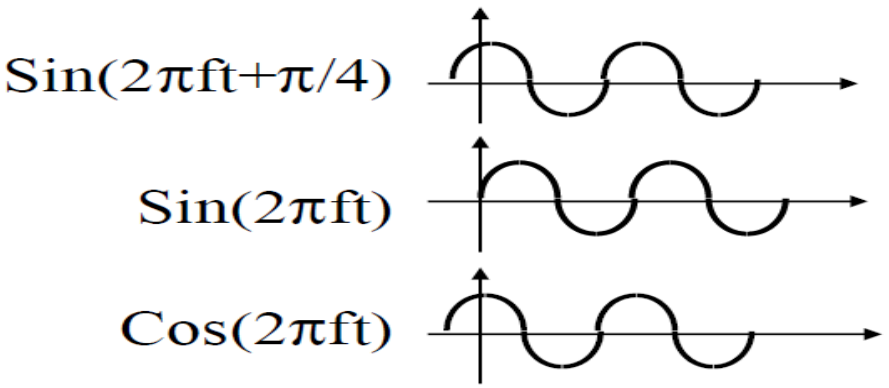


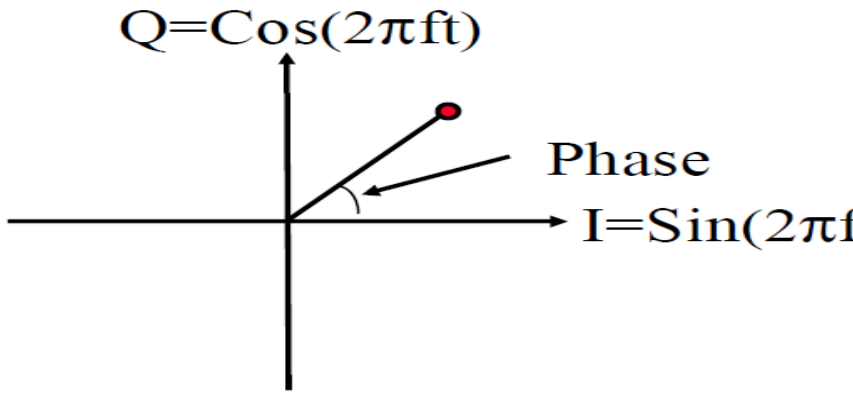
Phase

- Sine wave with a phase of 45°

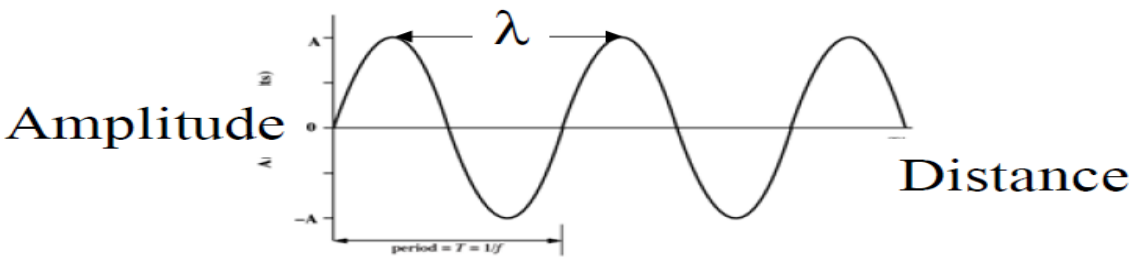
$$\sin(2\pi ft + \frac{\pi}{4}) = \sin(2\pi ft)\cos(\frac{\pi}{4}) + \cos(2\pi ft)\sin(\frac{\pi}{4})$$
$$= \frac{1}{\sqrt{2}}\sin(2\pi ft) + \frac{1}{\sqrt{2}}\cos(2\pi ft)$$

In-phase component I + Quadrature component Q





Wavelength



- Distance occupied by one cycle
- Distance between two points of corresponding phase in two consecutive cycles
- Wavelength = λ
- Assuming signal velocity v
  - $\lambda = vT$
  - $\lambda f = v$
  - c = 3×10^8 m/s (speed of light in free space) = *300 m/μs*

Example

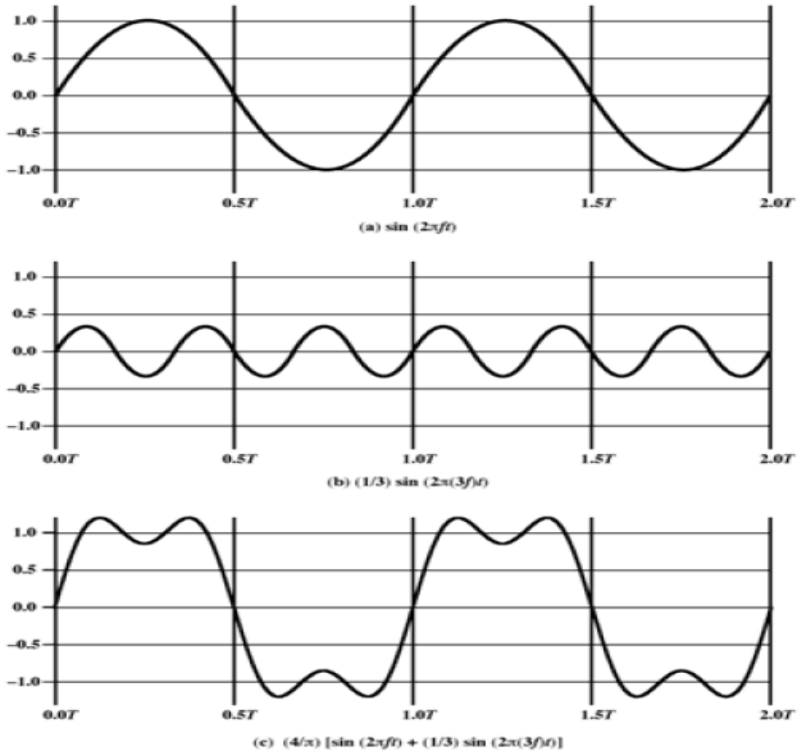
- Frequency = 2.5 GHz

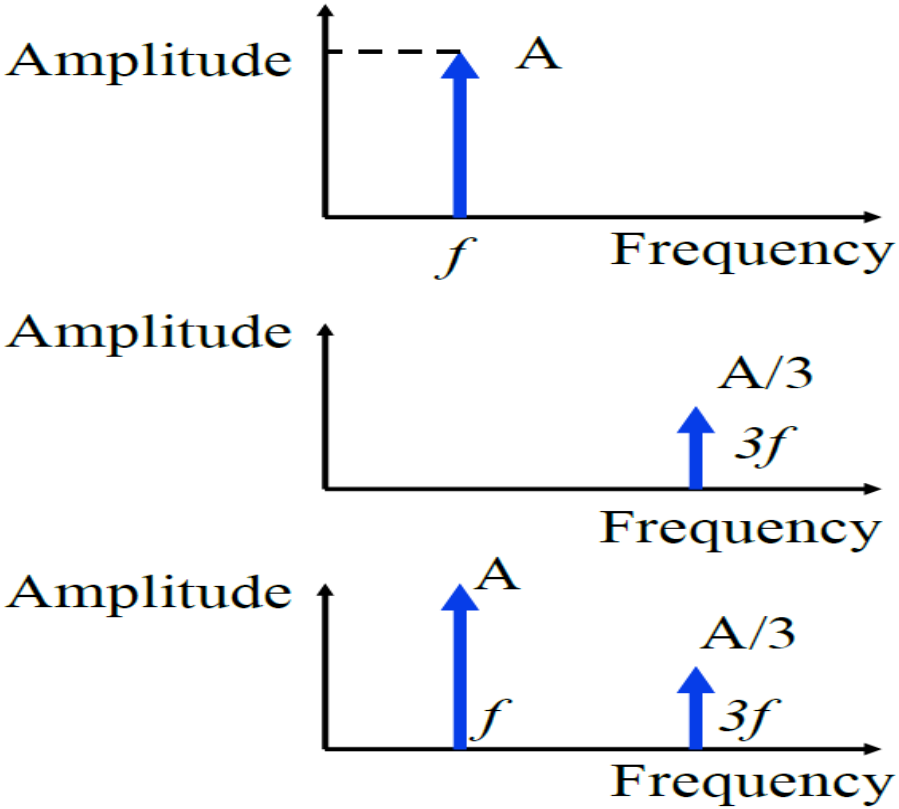
$$\text{Wavelength} = \lambda = \frac{c}{f}$$

$$= \frac{300 \text{ m}/\mu\text{s}}{2.5 \times 10^9}$$

$$= 120 \times 10^{-3} = 120 \text{ mm} = 12 \text{ cm}$$

Time and Frequency Domains

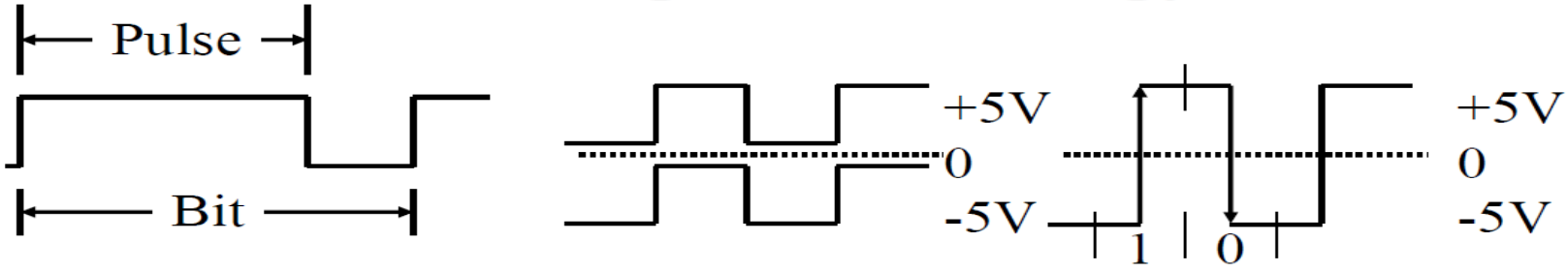




Decibels

- 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

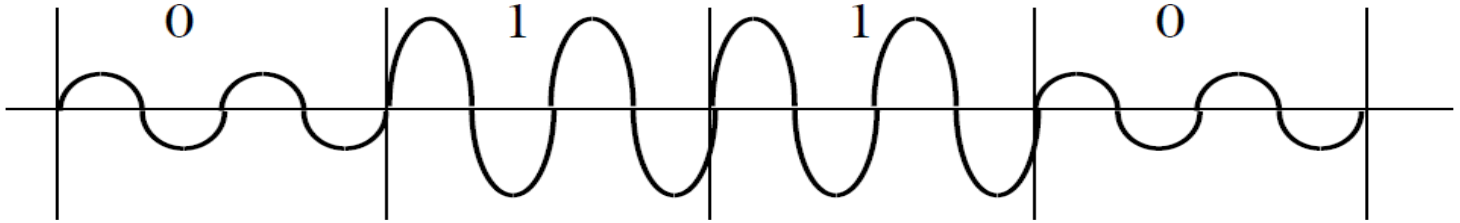
Coding Terminology



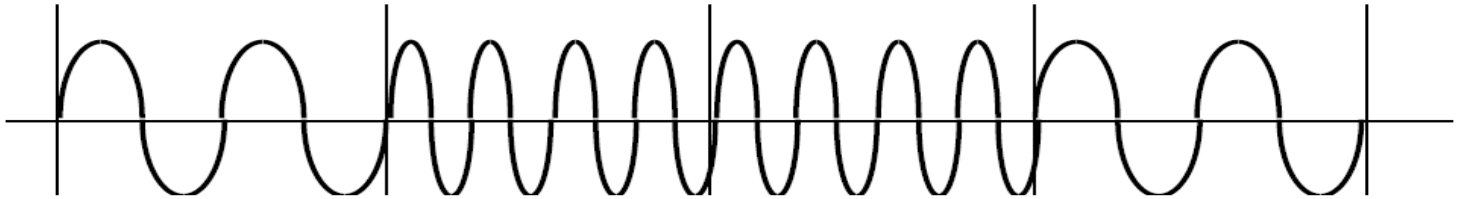
- **Signal element**: Pulse (of constant amplitude, frequency, phase) = **Symbol**
- **Modulation Rate**: 1/Duration of the smallest element =Baud rate
- **Data Rate**: Bits per second

Modulation

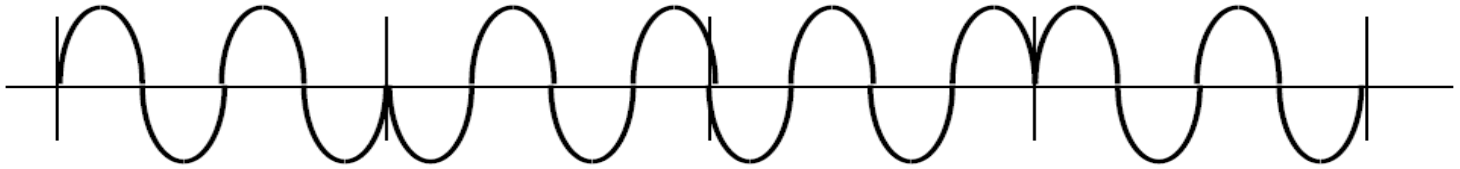
- Digital version of modulation is called **keying**
- **Amplitude Shift Keying (ASK):**



- **Frequency Shift Keying (FSK):**

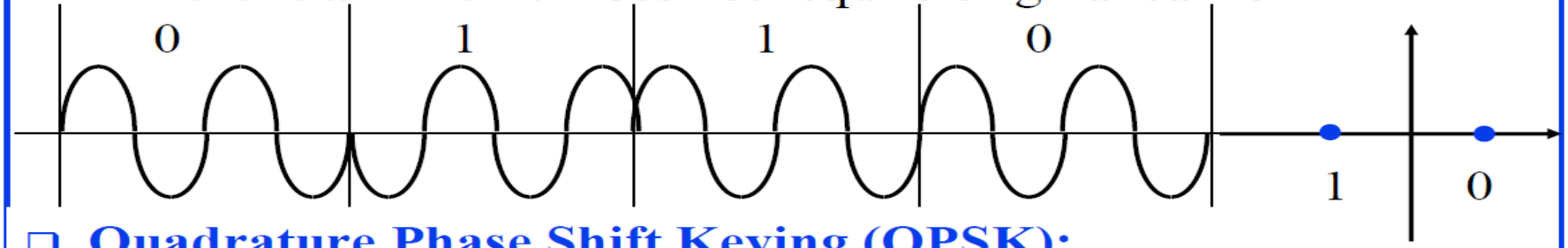


- **Phase Shift Keying (PSK):** Binary PSK (BPSK)

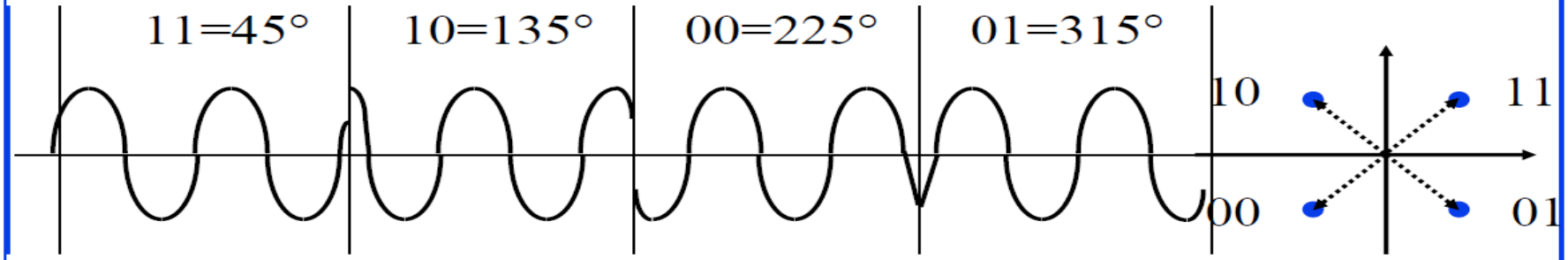


Modulation (Cont)

- **Differential BPSK:** Does not require original carrier



- **Quadrature Phase Shift Keying (QPSK):**

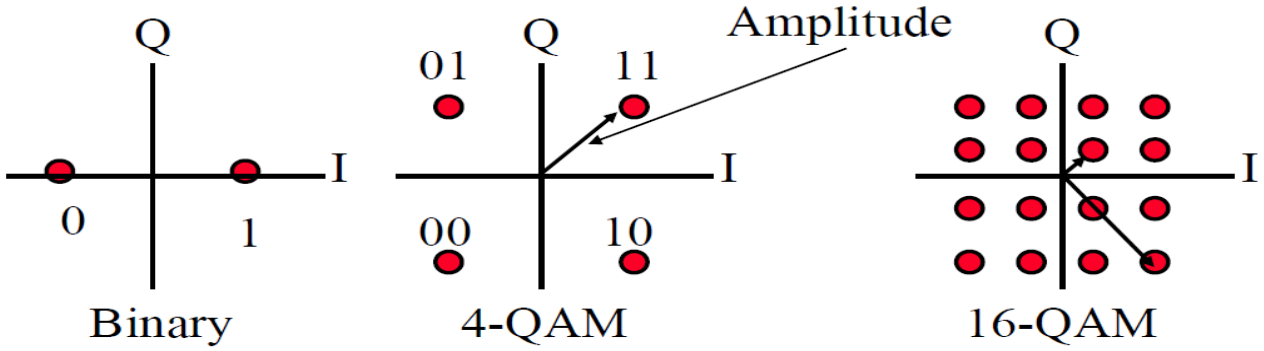


- In-phase (I) and Quadrature (Q) or 90 ° components are added

Ref: Electronic Design, "Understanding Modern Digital Modulation Techniques,"
http://electronicdesign.com/communications/understanding-modern-digital-modulation-techniques

QAM

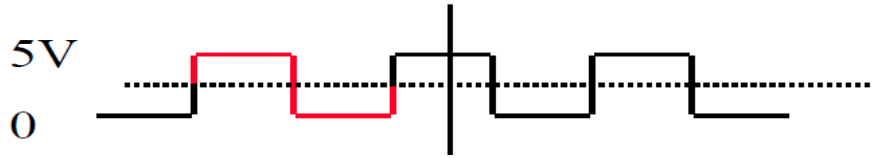
- Quadrature Amplitude and Phase Modulation
- 4-QAM, 16-QAM, 64-QAM, 256-QAM
- Used in DSL and wireless networks



- 4-QAM⇒ 2 bits/symbol, 16-QAM ⇒4 bits/symbol, …

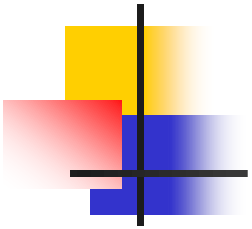
Channel Capacity

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



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

Example: M=4, Capacity = 4 × Bandwidth



Shannon's Theorem

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

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

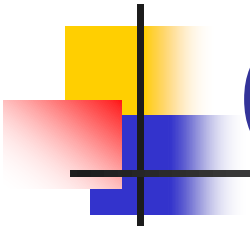
$$10 \text{ Log}_{10} S/N = 30$$

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

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

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

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

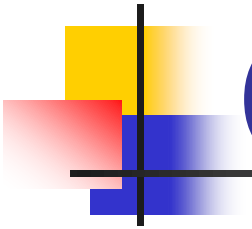


(3) The Nyquist Limit

For a noiseless channel, the maximum data rate is:

$$2H \log_2 V \text{ bits/sec}$$

,where H is the channel bandwidth (in Hz) and V is the number of discrete levels of the signal.



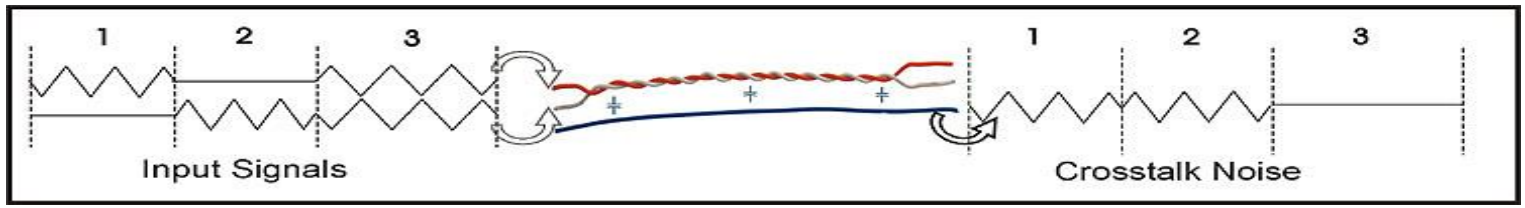
(4) The Shannon Limit

The maximum data rate of a noisy channel whose bandwidth is *H* Hz, and whose signal-to-noise ratio is *S/N*, is given by

$$H \log_2 (1+S/N).$$

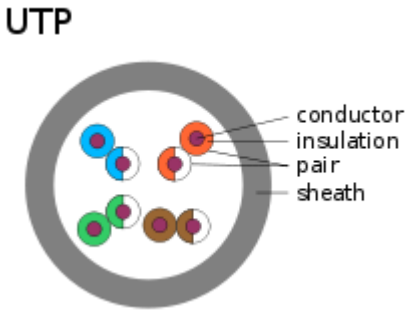
Par Trançado

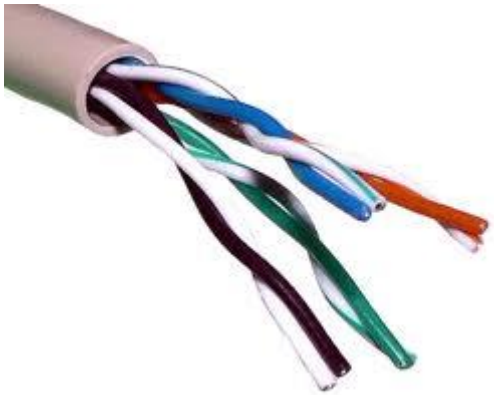
- Longas distâncias sem repetidores
- Banda passante depende do diâmetro do fio e distância percorrida
- Crosstalk e atenuação
- Usado em telefonia e redes ethernet
- Para transmissão de vídeo introduz skew – introdução de linhas de atraso



Par Trançado

- Categoria 3, 5 e 6 (UTP, Unshield Twisted Pair)
- UTP 25 pares





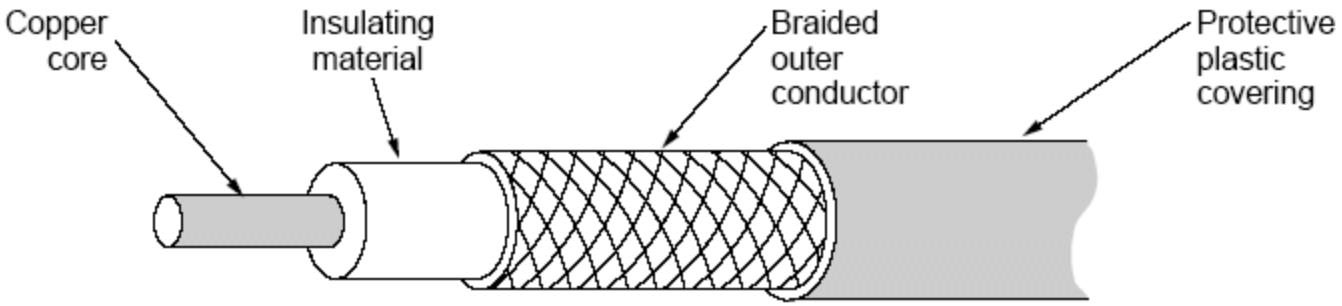
Par Trançado

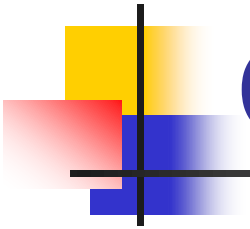
- Cat3 (16 MHz) 10BASE TX e 100BASET
- Cat5 (100 MHz) 100BASE TX e 1000BASET
- Cat 6 (250 MHz) 1000Base T (1 Gbps)
- Cat 6e 10000Base T (10 gbps)
- CAT8 40 gbps (em desenvolvimento)
- Distância máxima – 100 metros

Cabo Coaxial

Oliver Heaviside

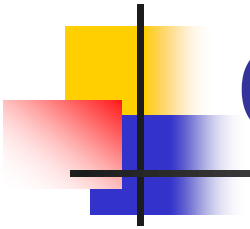
- Cabo Coaxial Banda Básica
  - 50 ohms
  - Transmissão digital
  - Máximo entre 1 e 2 Gbits em cabos de 1





Cabo Coaxial

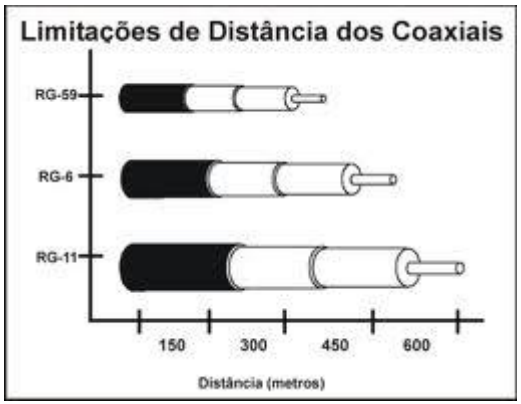
- Cabo Coaxial Banda Larga
  - 75 ohms
  - Transmissão analógica
  - TV a cabo, canais de 6 MHz - 3 Mbps
  - Repetidores transmitem em uma única direção: sistema com cabo duplo e sistema com cabo único

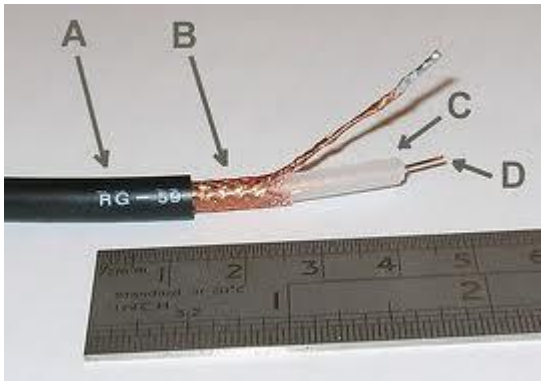


Cabo Coaxial

- Cabo Coaxial Banda Larga
  - Cabo duplo - transmissões em cabo são retransmitidas pelo head-end no outro cabo.
  - Cabo simples - Head-end recebe em uma freqüência e retransmite em outra.
    - Subsplit: entrada 5 a 30 MHz, saída 40 a 300 MHz.
    - Midsplit: entrada 5 a 116 MHz, saída 168 a 300 MHz.
  - Banda passante: freqüência fixa entre pares, disputa pelo meio, etc.

Cabo Coaxial



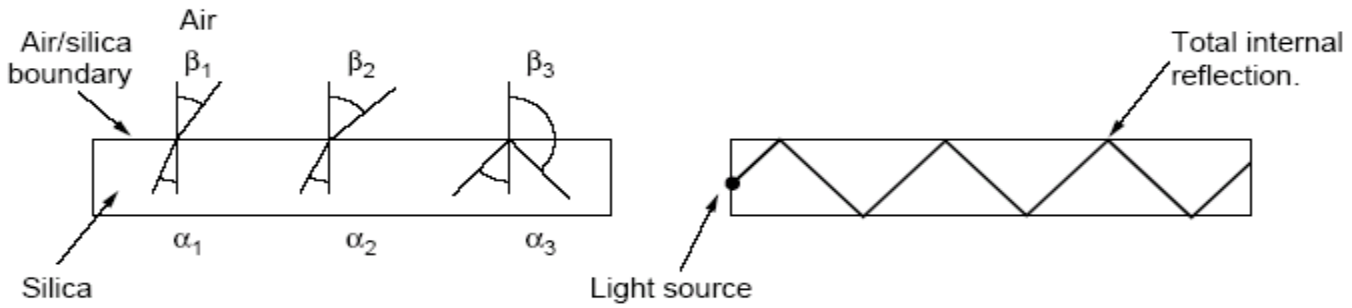


Fibras Ópticas

Fibras Óticas

- Princípio: refração.
- Multimodais e unimodais.
- 100Gbps por 100Km sem necessidade de amplificação

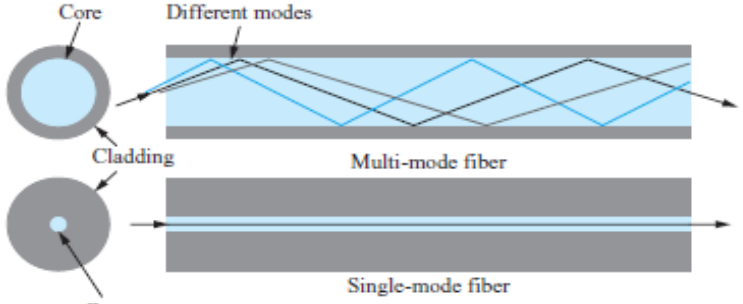
- ✓ Três componentes: fonte de luz, fibra e detector.
- ✓ Solitons: pulsos com formato inverso ao seno hiperbólico - grandes distâncias sem distorção.



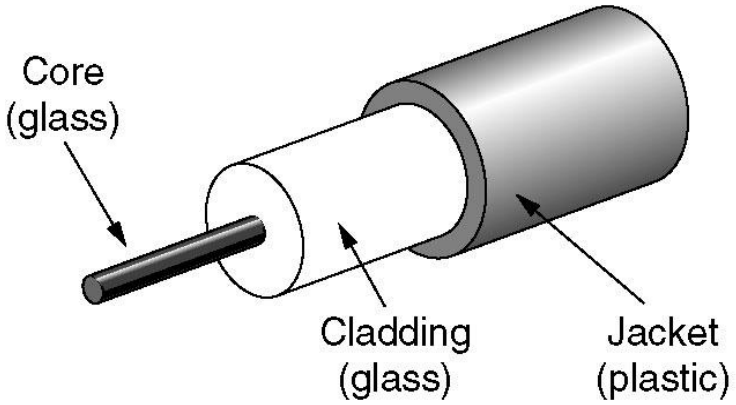
Fibras Ópticas

Fibras Ópticas

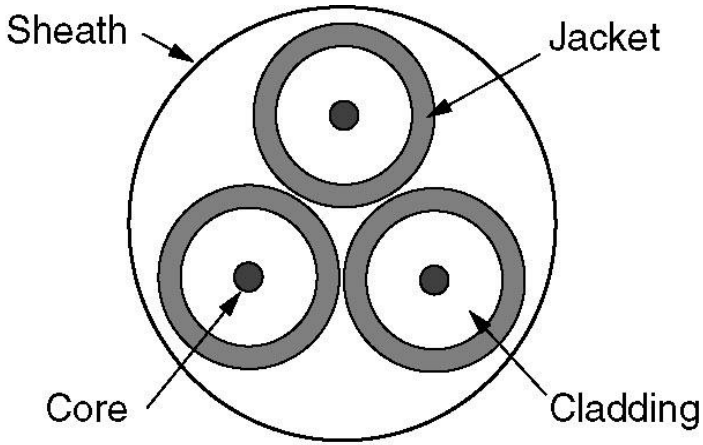
- Fibras Óticas
  - Diâmetro: multimodais (50 micra), unimodais (10 micra).
  - Conexões: conexões (10% a 20% de perda), encaixadores (10% de perda), fusão.
  - Fontes de luz: diodos emissores de luz, lasers e semicondutores.
  - Recepção fotodiodo: 100 Gbps.



Fiber Cables



(a)

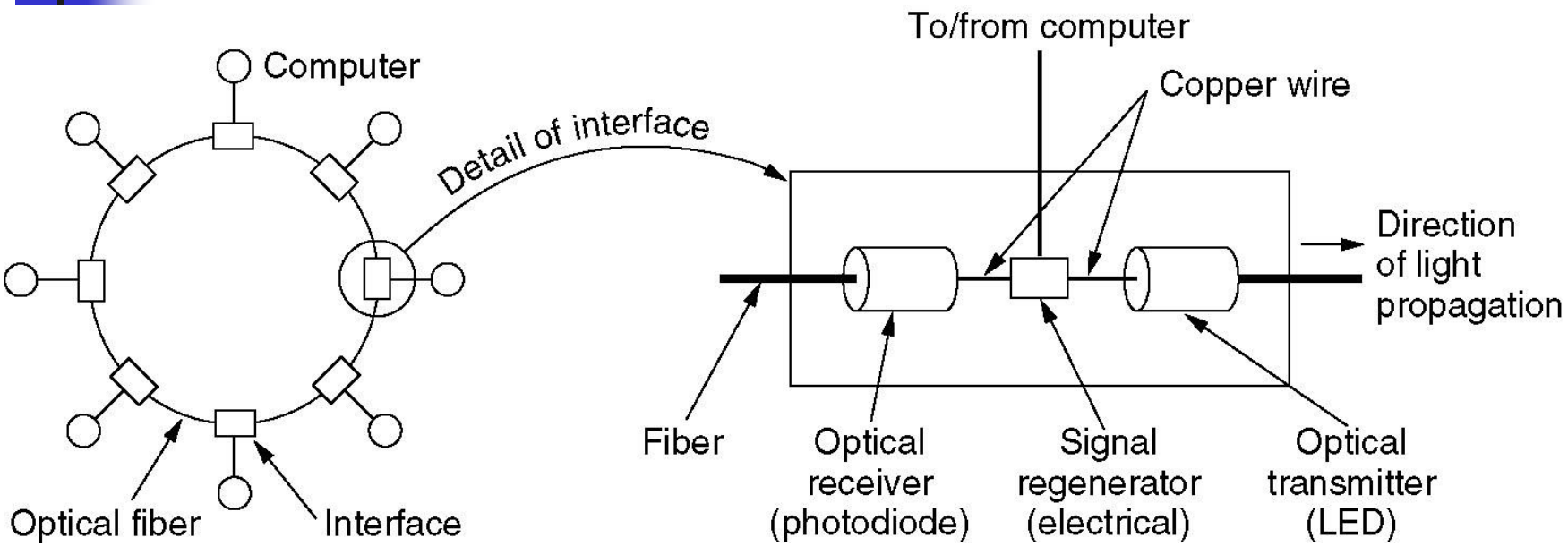


(b)

Fiber Cables (2)

Item	LED	Semiconductor laser
Data rate	Low	High
Fiber type	Multimode	Multimode or single mode
Distance	Short	Long
Lifetime	Long life	Short life
Temperature sensitivity	Minor	Substantial
Cost	Low cost	Expensive

Redes de Fibras Ópticas



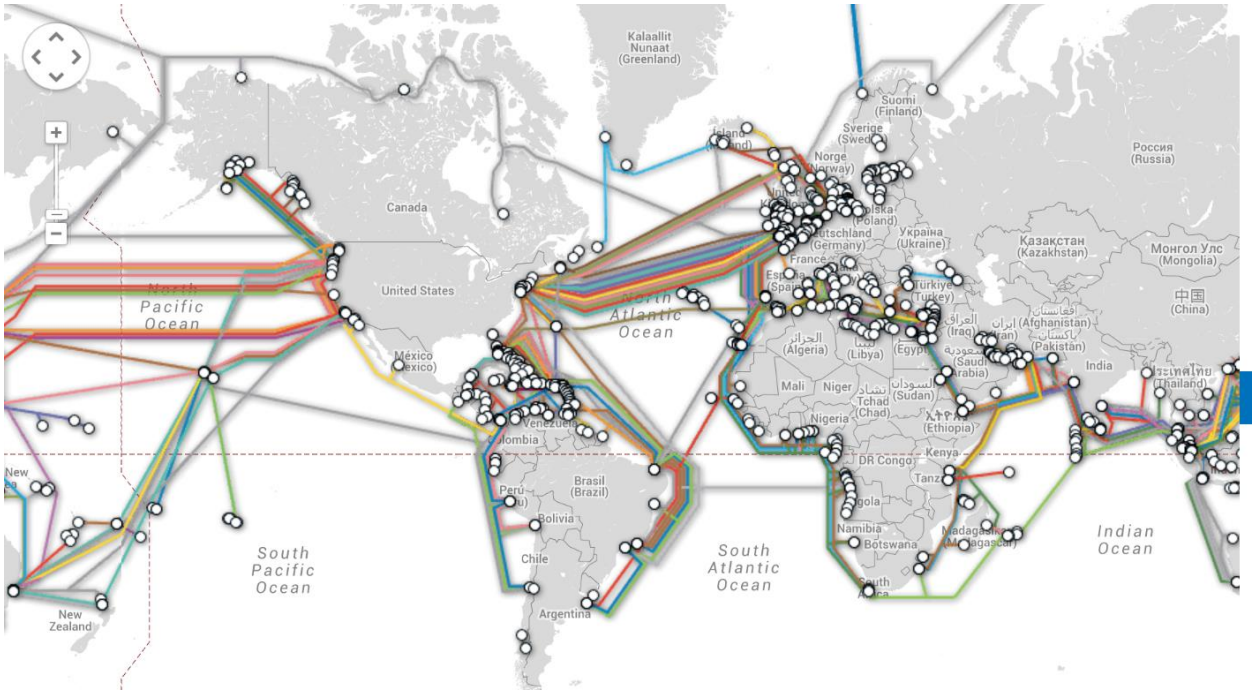
Redes Fibras Ópticas

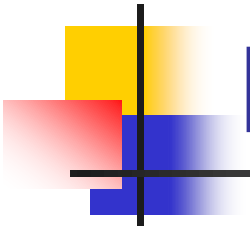
- Fibras Óticas
  - Interface passiva:
    - Conectores fundidos a fibra, diodos emissores de luz e fotodiodos.
    - Em caso de falha na interface passiva, não compromete transmissão
    - Perdem luz nas junções.

Redes Fibras Ópticas

- Fibras Óticas
  - Repetidor ativo:
    - Converte sinal ótico em elétrico, regenera potência e converte sinal elétrico em ótico
    - Podem operar com altas bandas passantes
    - Em caso de falha, compromete o anel
    - Longas distâncias

Interligação Redes Continentais

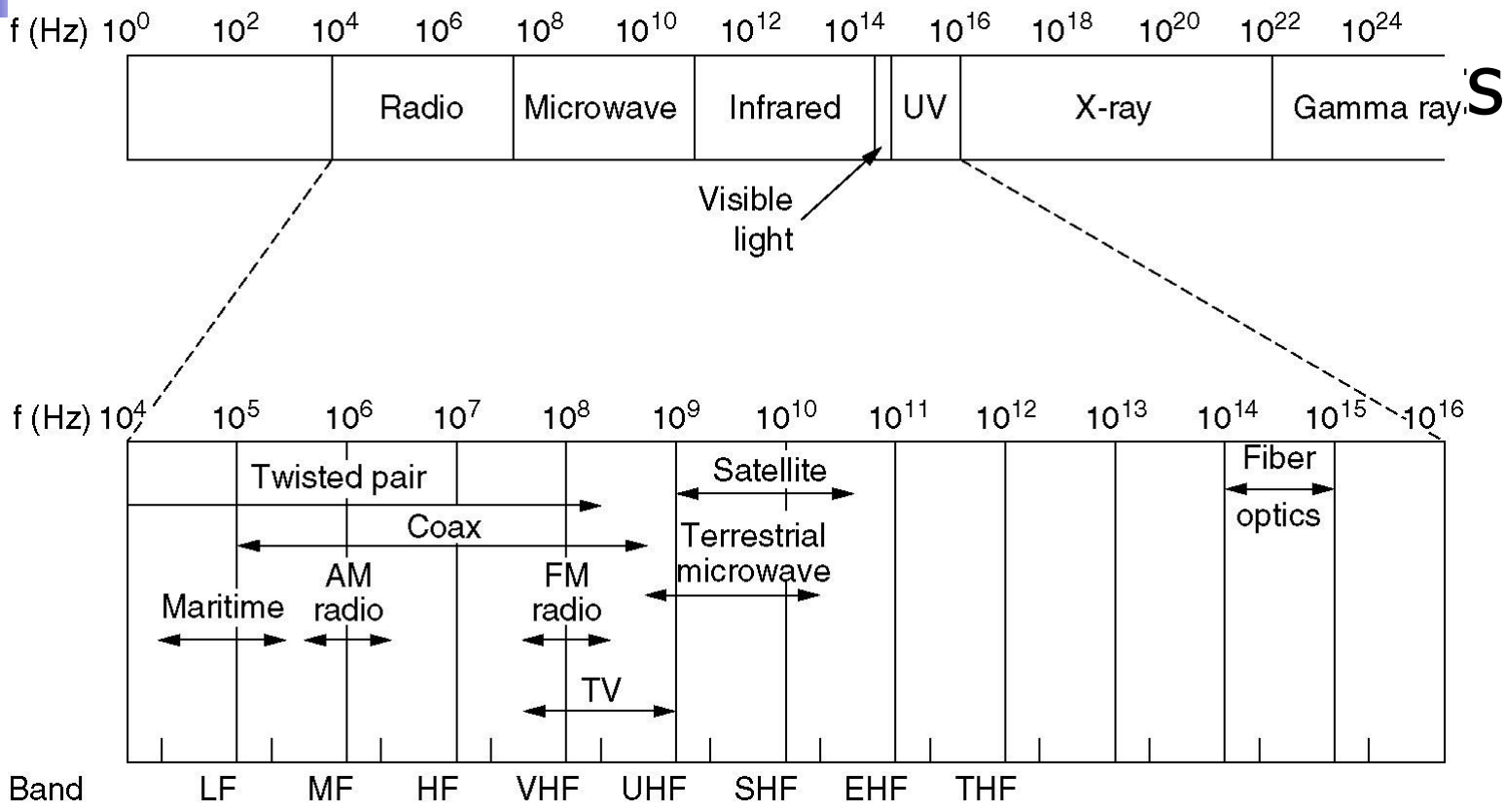




Fibras Ópticas

- Desvantagens Fibras:
  - Engenharia não muito disseminada.
  - Interfaces caras.
  - Comunicação unidirecional.

Spectrum Eletromagnético



Spectrum Eletromagnético

- Espectro Eletromagnético
  - Velocidade no ar 3 x 10^8 m/s (2/3 no cabo)
  - $\lambda f = c$
  - majora transmissões, banda estreita
  - spread spectrum - transmissão muda de frequência

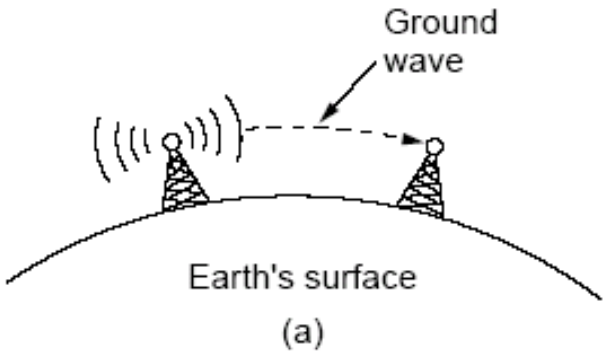
Hedy Lamarr

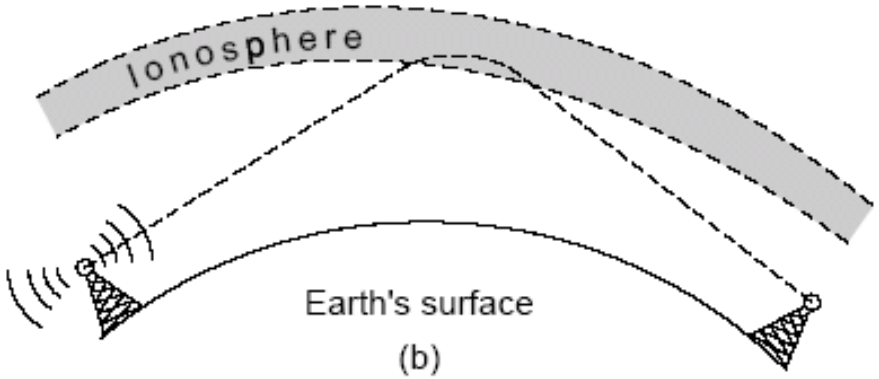
Rádio

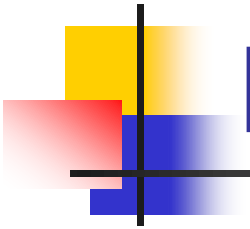
Rádio

- Onidirecional: transmissor e receptor não precisam estar alinhados.
- Baixas freqüências atravessam prédios.

- ✓ Altas freqüências tendem a viajar em linha reta e ricochetear, interferência.
- ✓ AM utiliza faixa MF, 1000 Km raio.
- ✓ HF, VHF - ondas são ricocheteadas na ionosfera.

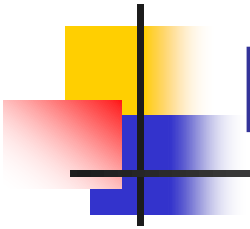






Microondas

- Microondas
  - Acima de 100 MHz ondas propagam em linha reta.
  - Alinhamento de transmissor e receptor.
  - Torres mais altas, maior distância necessita repetidores. Torres 100 m, repetidores a cada 80 Km.
  - Fading por múltiplos caminhos, ondas refratadas nas camada baixas da atmosfera.



Microondas

- Microondas
  - Alta freqüência (10 GHz): absorção pela chuva.
  - Dispensa direito de uso do caminho.
  - Baixo custos.
  - banda industrial/científica/médica - não necessita permissão 902 a 928 MHz 5.725 a 5.850 GHz - telefones sem fio, portão garagem.