Fundamentos de Redes de Computadores

Tema 3 – Técnicas de Codificação de Sinais

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Slides gerados à partir do Cap. SignalEncodingTechniques do livro Data and Computer Communications (Stallings)

Técnicas de Codificação

- Dados digitais em sinais digitais
- Dados digitais em sinais analógicos
- Dados analógicos em sinais digitais
- Dados analógicos em sinais analógicos

Dados digitais em sinais digitais

- Digital signal
  - Discrete, discontinuous voltage pulses
  - Each pulse is a signal element
  - Binary data encoded into signal elements

Termos (1)

- Unipolar
  - All signal elements have same sign
- Polar
  - One logic state represented by positive voltage the other by negative voltage
- Data rate
  - Rate of data transmission in bits per second
- Duration or length of a bit
  - Time taken for transmitter to emit the bit

Termos (2)

- Modulation rate
  - Rate at which the signal level changes
  - Measured in baud = signal elements per second
- Mark and Space
  - Binary 1 and Binary 0 respectively

Interpretação de Sinais

- É preciso saber
  - O tempo dos bits – quando eles iniciaram e quando terminaram
  - O nível dos sinais
- Fatores que afetam o sucesso na interpretação de sinais
  - Relação sinal/ruído
  - Taxa de dados
  - Largura de banda

Esquemas de Codificação – comparação(1)

- Signal Spectrum
  - Lack of high frequencies reduces required bandwidth
  - Lack of dc component allows ac coupling via transformer, providing isolation
  - Concentrate power in the middle of the bandwidth
- Clocking
  - Synchronizing transmitter and receiver
  - External clock
  - Sync mechanism based on signal

Esquemas de Codificação – comparação(2)

- Detecção de erros
  - —Can be built in to signal encoding
- Signal interference and noise immunity
  - —Some codes are better than others
- Cost and complexity
  - —Higher signal rate (& thus data rate) lead to higher costs
  - —Some codes require signal rate greater than data rate

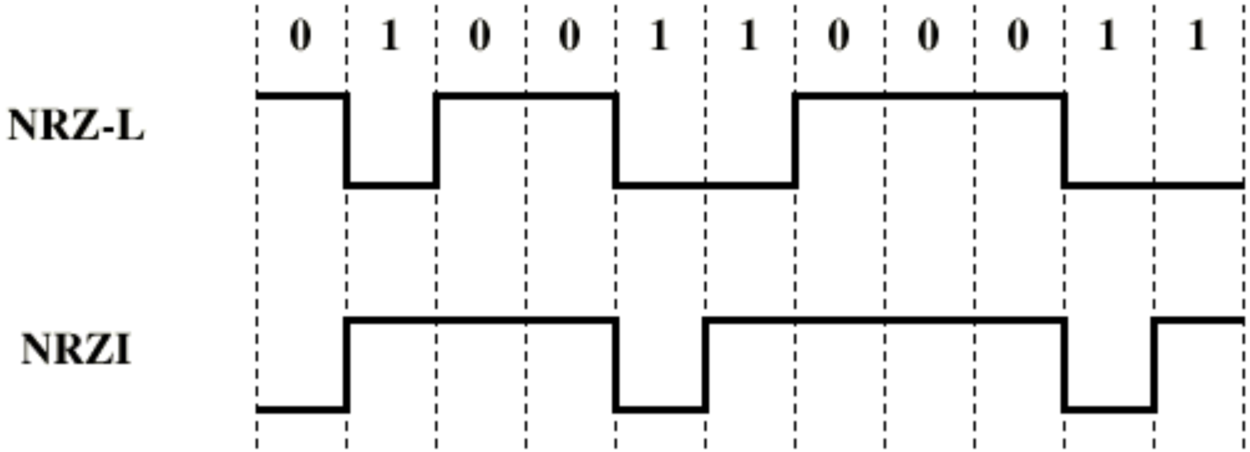
Esquemas de Codificação

- Serão vistos no curso:
  - ON-OFF ou Nonreturn to Zero-Level (NRZ-L)
  - Manchester
  - Differential Manchester
- Outros (não estudados aqui)
  - Nonreturn to Zero Inverted (NRZI)
  - Bipolar -AMI
  - Pseudoternary
  - B8ZS
  - HDB3

Nonreturn to Zero-Level (NRZ-L)

- Duas voltagens diferentes para os bits 0 e 1
- Voltagem constante durante o intervalo do bit
  - não há transição de voltagens
- e.g. Absence of voltage for zero, constant positive voltage for one
- More often, negative voltage for one value and positive for the other
- This is NRZ-L

NRZ



Codificação Diferencial

- Data represented by changes rather than levels
- More reliable detection of transition rather than level
- In complex transmission layouts it is easy to lose sense of polarity

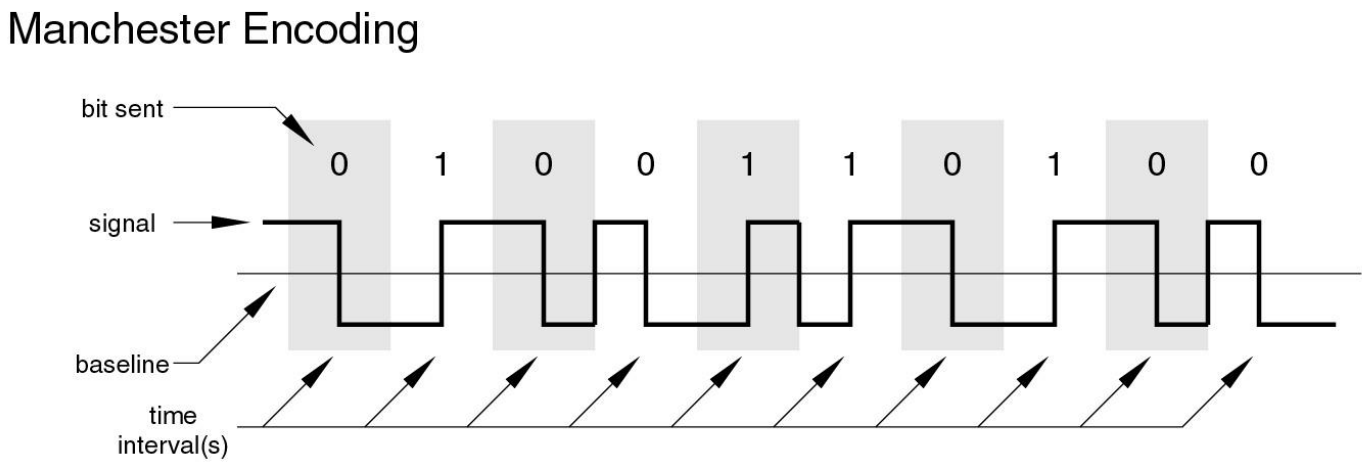
Prós e Contras da NRZ

- Pros
  - Easy to engineer
  - Make good use of bandwidth
- Cons
  - dc component
  - Lack of synchronization capability
- Used for magnetic recording
- Not often used for signal transmission

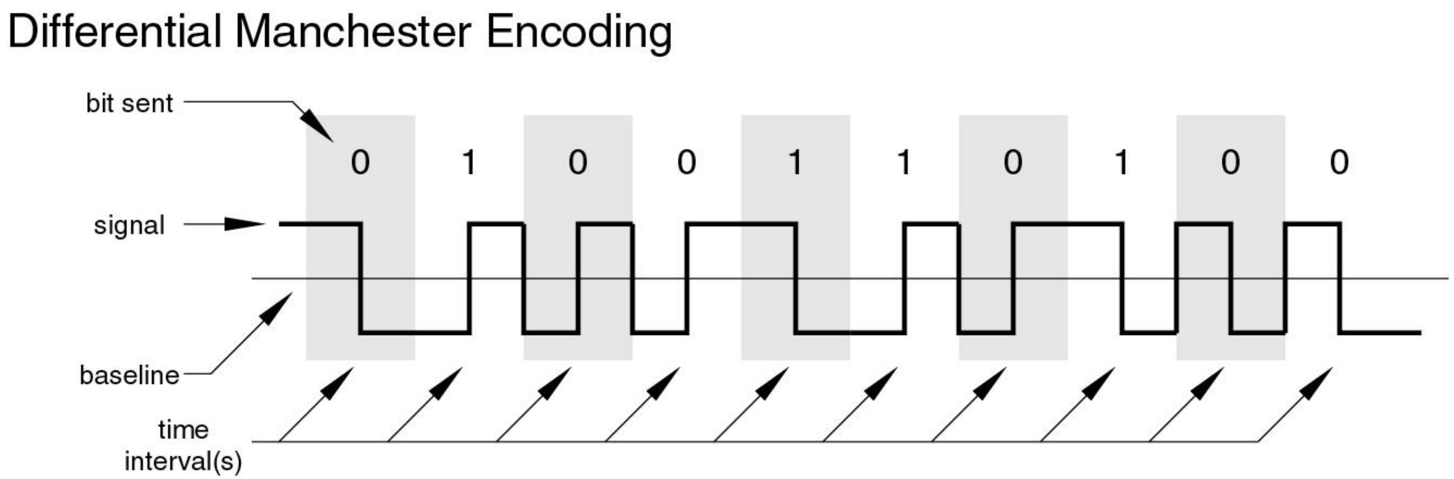
Biphase

- Manchester
  - Transition in middle of each bit period
  - Transition serves as clock and data
  - Low to high represents one
  - High to low represents zero
  - Used by IEEE 802.3
- Differential Manchester
  - Midbit transition is clocking only
  - Transition at start of a bit period represents zero
  - No transition at start of a bit period represents one
  - Note: this is a differential encoding scheme
  - Used by IEEE 802.5

Codificação Manchester



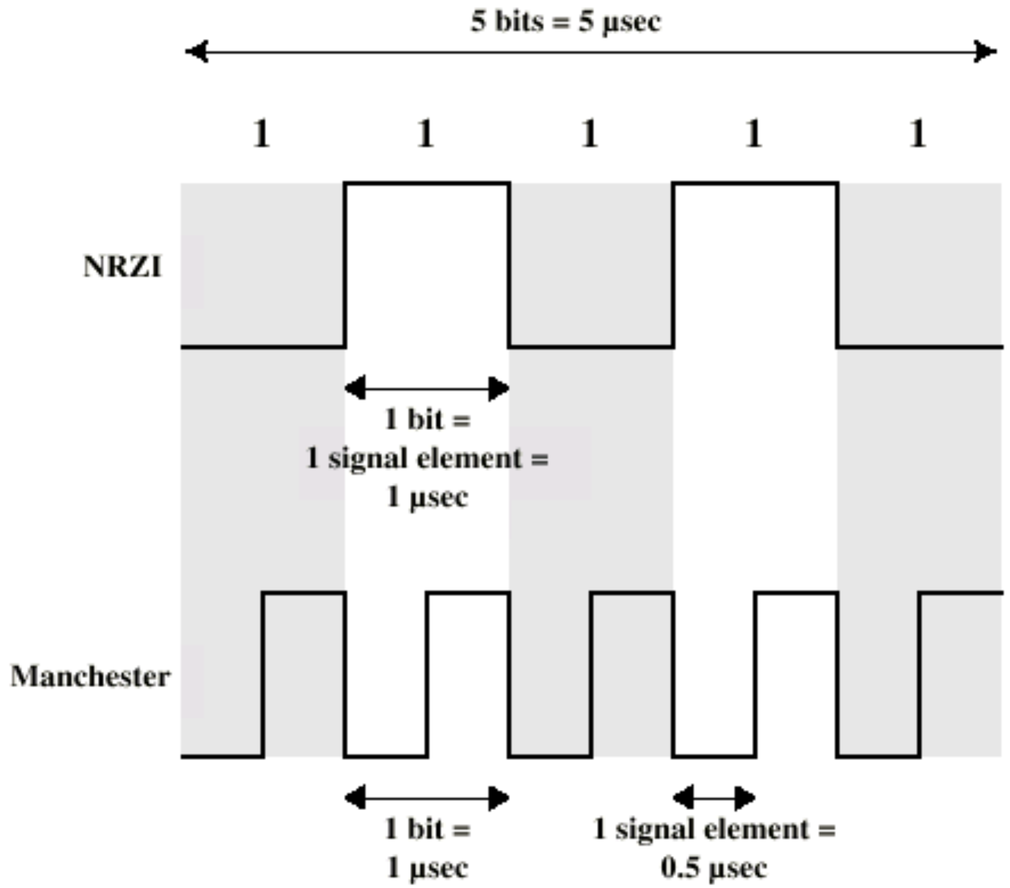
Differential Manchester Encoding



Biphase Pros and Cons

- Con
  - —At least one transition per bit time and possibly two
  - —Maximum modulation rate is twice NRZ
  - —Requires more bandwidth
- Pros
  - —Synchronization on mid bit transition (self clocking)
  - —No dc component
  - —Error detection
    - Absence of expected transition

Taxa de Modulação



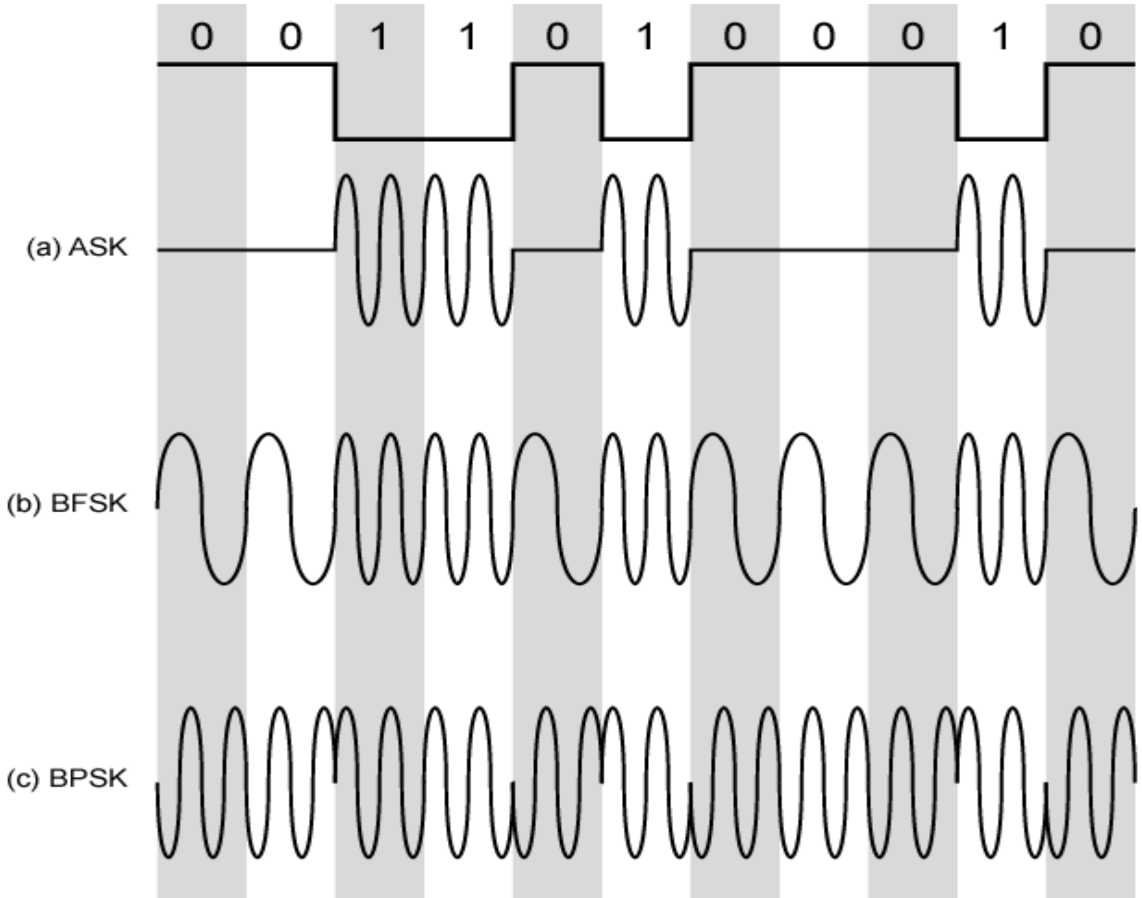
Embaralhamento

- Use scrambling to replace sequences that would produce constant voltage
- Filling sequence
  - Must produce enough transitions to sync
  - Must be recognized by receiver and replace with original
  - Same length as original
- No dc component
- No long sequences of zero level line signal
- No reduction in data rate
- Error detection capability

Dados digitais em sinais analógicos

- Public telephone system
  - 300Hz to 3400Hz
  - Use modem (modulator-demodulator)
- Amplitude shift keying (ASK)
- Frequency shift keying (FSK)
- Phase shift keying (PK)

Técnicas de Modulação



ASK – Mudulação pela Amplitude

- Values represented by different amplitudes of carrier
- Usually, one amplitude is zero
  - i.e. presence and absence of carrier is used
- Susceptible to sudden gain changes
- Inefficient
- Up to 1200bps on voice grade lines
- Used over optical fiber

Binary Frequency Shift Keying

- Most common form is binary FSK (BFSK)
- Two binary values represented by two different frequencies (near carrier)
- Less susceptible to error than ASK
- Up to 1200bps on voice grade lines
- High frequency radio
- Even higher frequency on LANs using co-ax

Multiple FSK

- More than two frequencies used
- More bandwidth efficient
- More prone to error
- Each signalling element represents more than one bit

FSK on Voice Grade Line

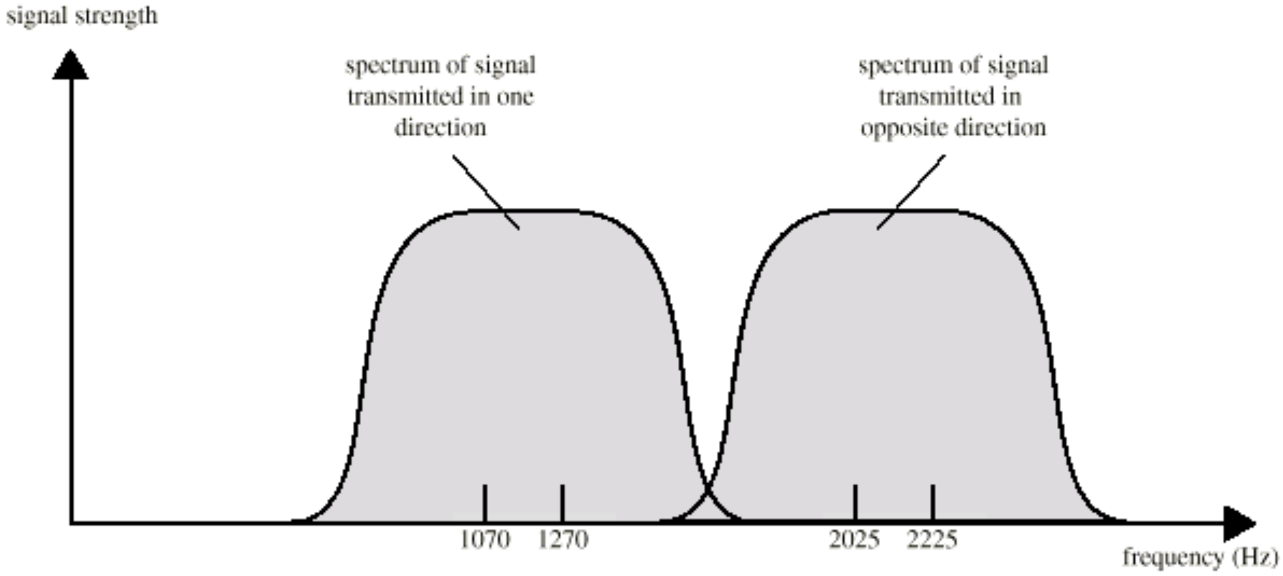
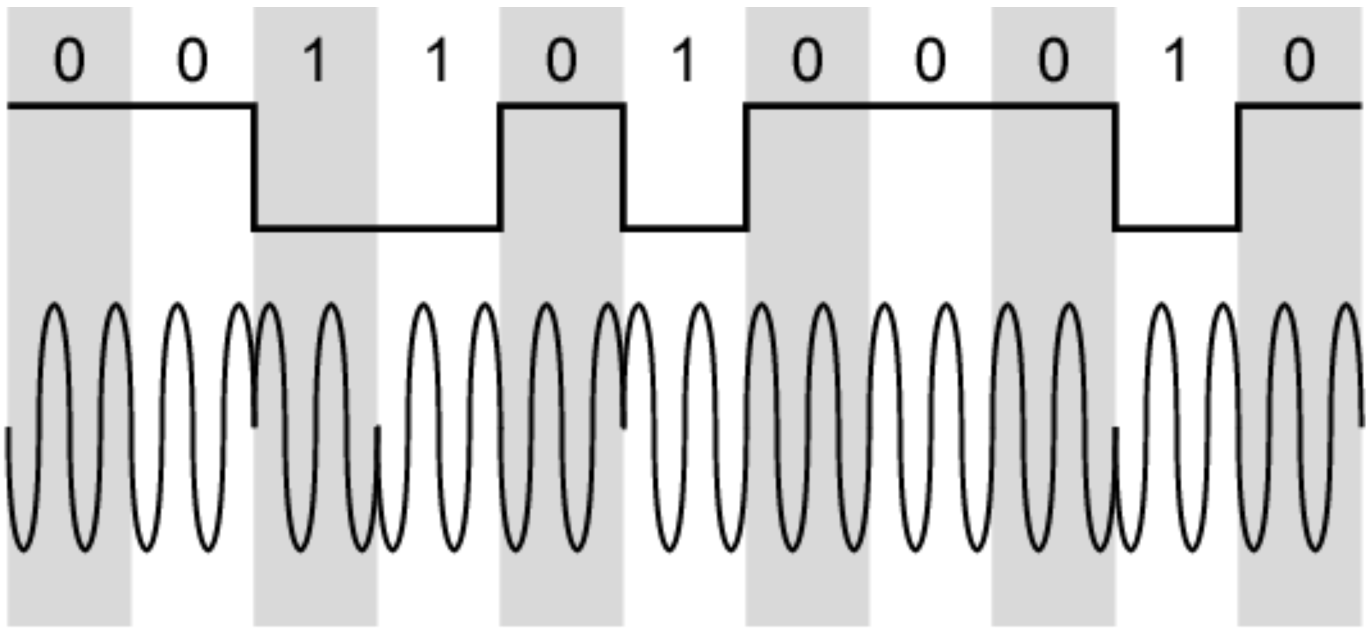


Figure 5.8 Full-Duplex FSK Transmission on a Voice-Grade Line

Modulação por Fase

- A fase da portadora é alterada para representar os dados
- PSK binário
  - Duas fases representam dois dígitos binários
- PSK diferencial
  - Phase shifted relative to previous transmission rather than some reference signal

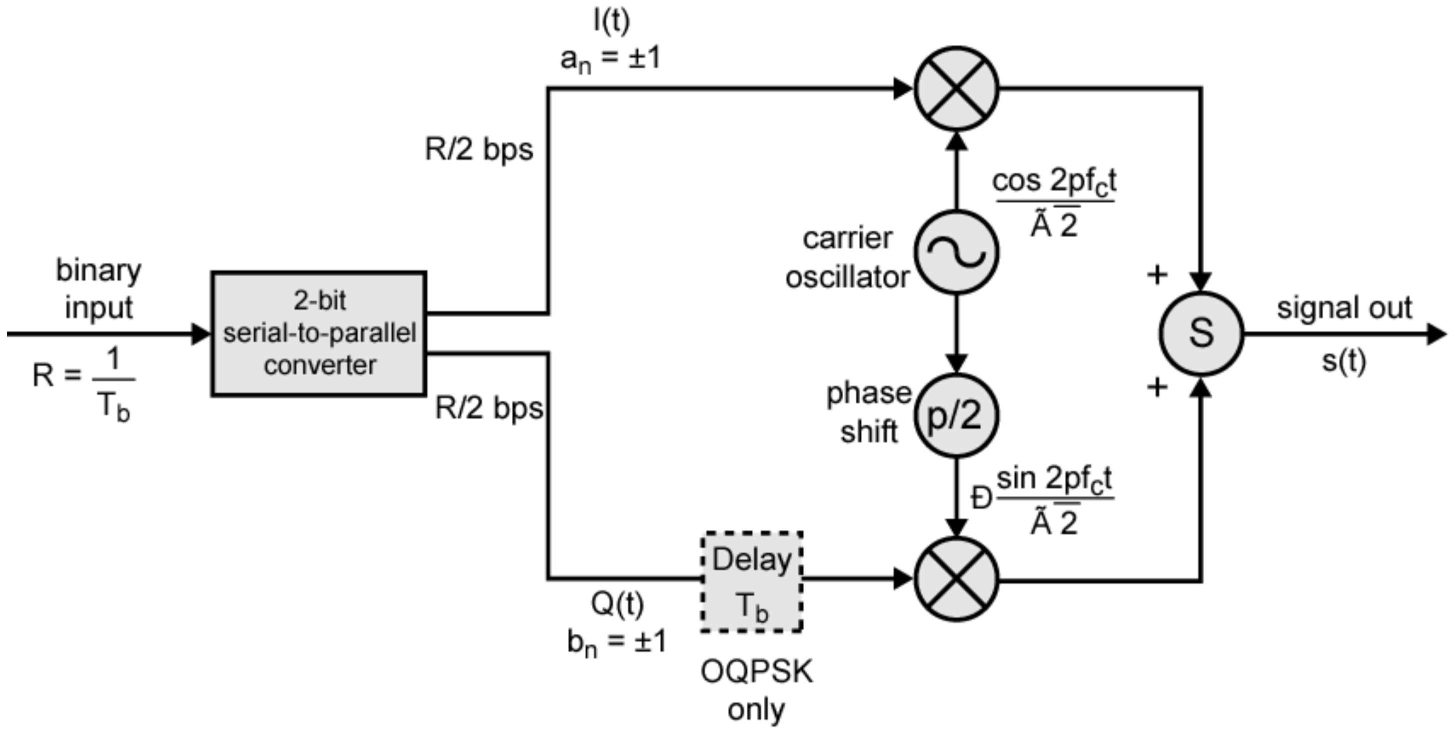
PSK Diferencial



Quadrature PSK

- More efficient use by each signal element representing more than one bit
  - e.g. shifts of $\pi/2$ (90^o)
  - Each element represents two bits
  - Can use 8 phase angles and have more than one amplitude
  - 9600bps modem use 12 angles , four of which have two amplitudes
- Offset QPSK (orthogonal QPSK)
  - Delay in Q stream

QPSK and OQPSK Modulators



Performance de modulação analógica para dados digitais

- Bandwidth
  - ASK and PSK bandwidth directly related to bit rate
  - FSK bandwidth related to data rate for lower frequencies, but to offset of modulated frequency from carrier at high frequencies
  - (See Stallings for math)
- In the presence of noise, bit error rate of PSK and QPSK are about 3dB superior to ASK and FSK

QAM - *Quadrature Amplitude Modulation*

- QAM used on asymmetric digital subscriber line (ADSL) and some wireless
- Combination of ASK and PSK
- Logical extension of QPSK
- Send two different signals simultaneously on same carrier frequency
  - Use two copies of carrier, one shifted 90°
  - Each carrier is ASK modulated
  - Two independent signals over same medium
  - Demodulate and combine for original binary output

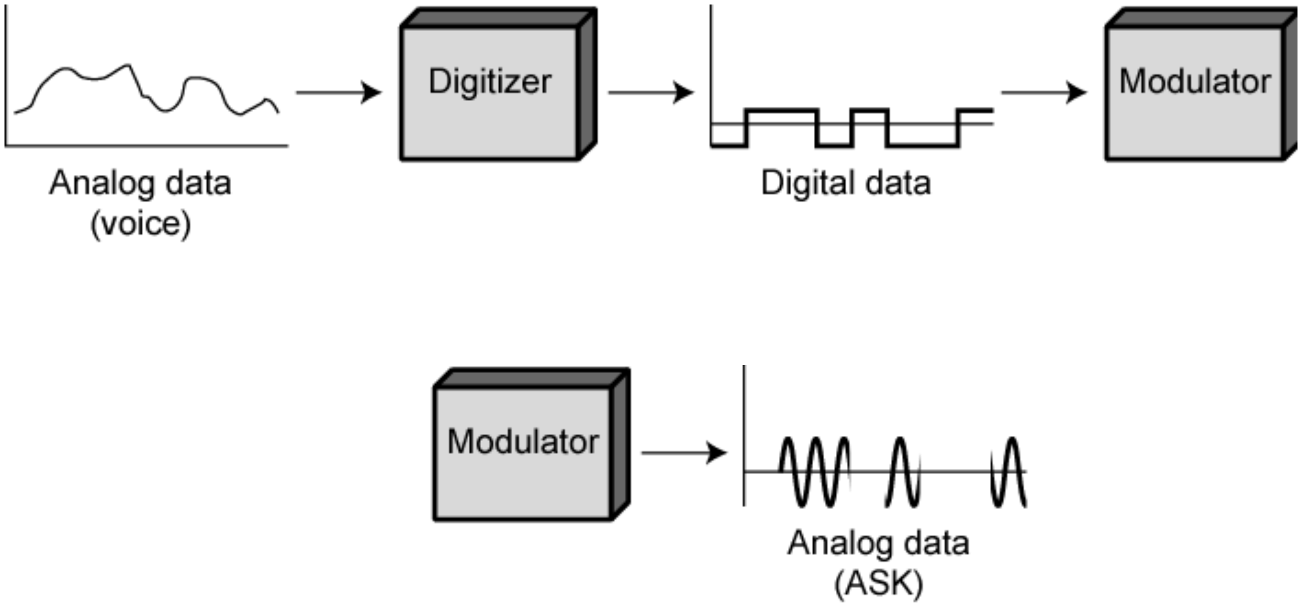
Níveis de QAM

- Two level ASK
  - Each of two streams in one of two states
  - Four state system
  - Essentially QPSK
- Four level ASK
  - Combined stream in one of 16 states
- 64 and 256 state systems have been implemented
- Improved data rate for given bandwidth
  - Increased potential error rate

Dados analógicos em sinais digitais

- Digitization
  - Conversion of analog data into digital data
  - Digital data can then be transmitted using NRZ-L
  - Digital data can then be transmitted using code other than NRZ-L
  - Digital data can then be converted to analog signal
  - Analog to digital conversion done using a codec
  - Pulse code modulation
  - Delta modulation

Digitizing Analog Data



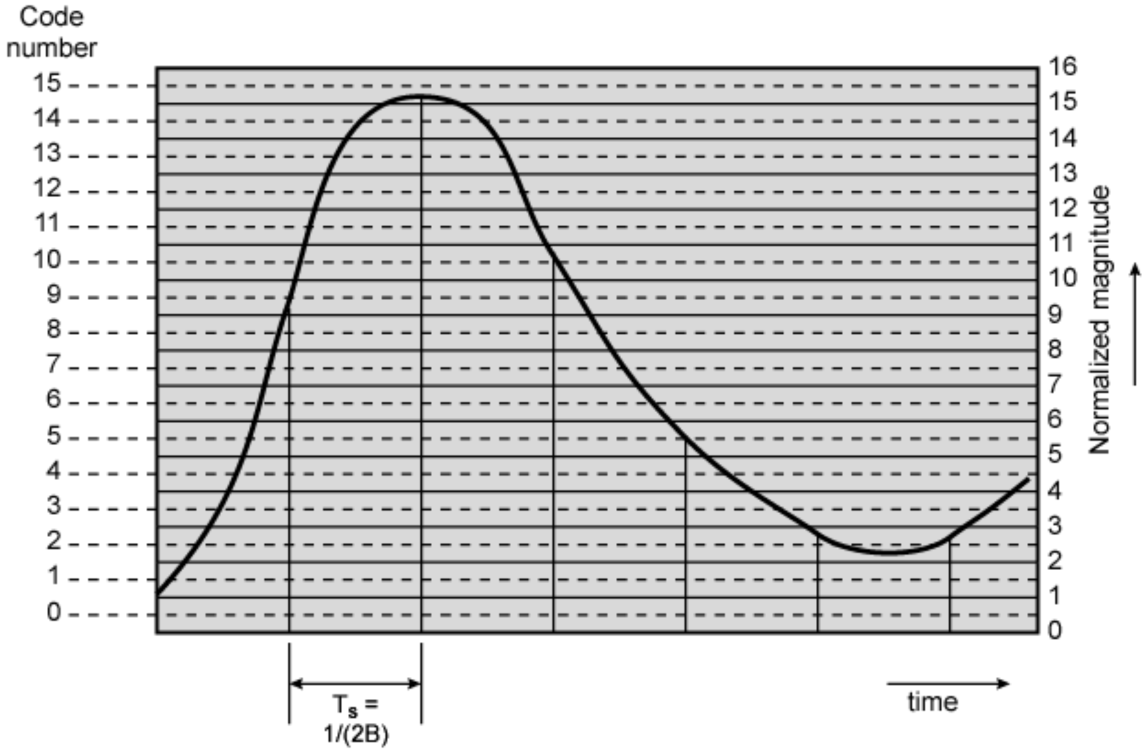
Pulse Code Modulation(PCM) (1)

- If a signal is sampled at regular intervals at a rate higher than twice the highest signal frequency, the samples contain all the information of the original signal
  - (Proof - Stallings appendix 4A)
- Voice data limited to below 4000Hz
- Require 8000 sample per second
- Analog samples (Pulse Amplitude Modulation, PAM)
- Each sample assigned digital value

Pulse Code Modulation(PCM) (2)

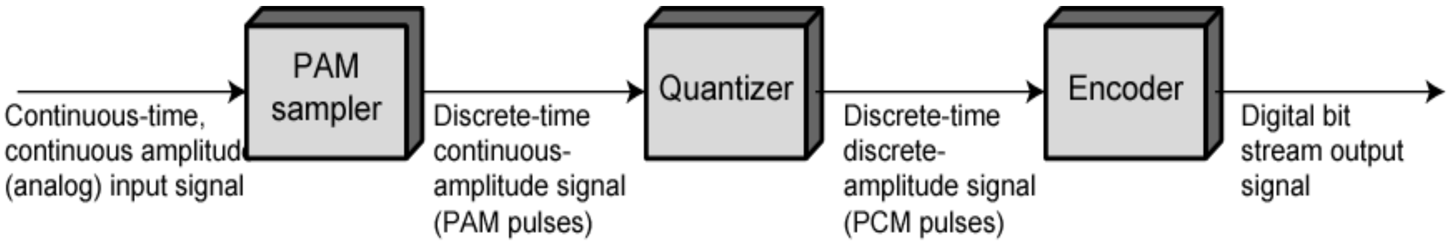
- 4 bit system gives 16 levels
- Quantized
  - Quantizing error or noise
  - Approximations mean it is impossible to recover original exactly
- 8 bit sample gives 256 levels
- Quality comparable with analog transmission
- 8000 samples per second of 8 bits each gives 64kbps

PCM Example



PAM value	1.1	9.2	15.2	10.8	5.6	2.8	2.7
quantized code number	1	9	15	10	5	2	2
PCM code	0001	1001	1111	1010	0101	0010	0010

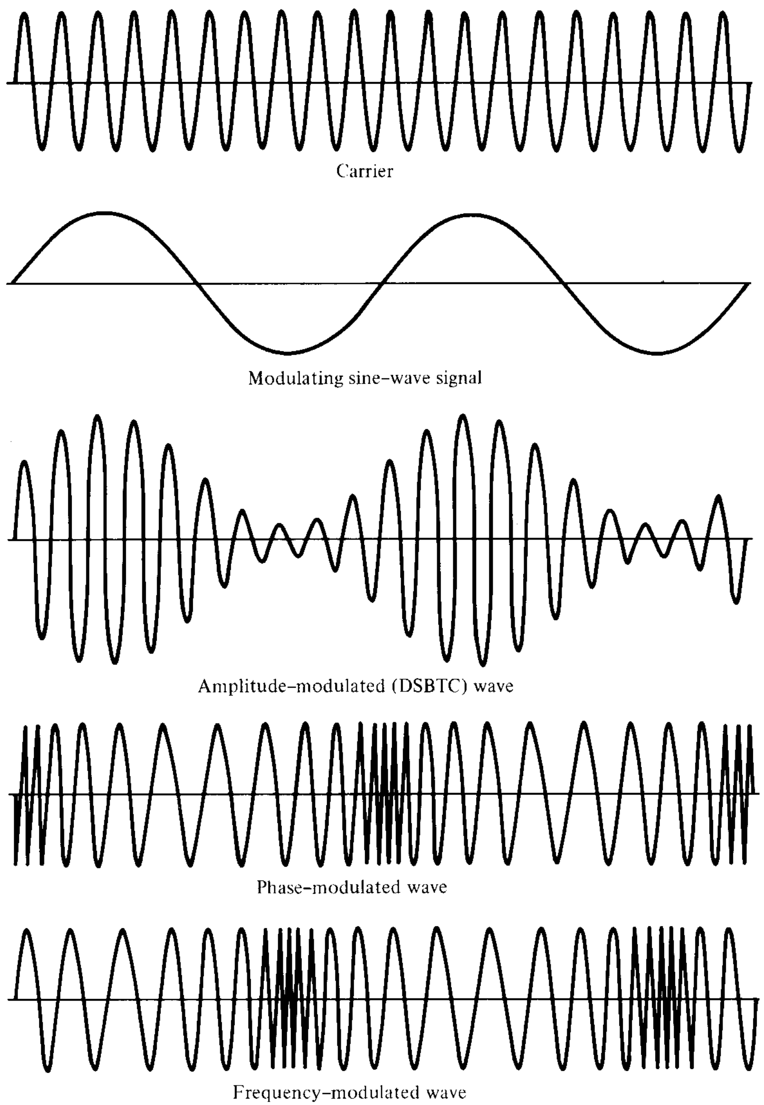
PCM Block Diagram



Dados analógicos em sinais analógicos

- Why modulate analog signals?
  - —Higher frequency can give more efficient transmission
  - —Permits frequency division multiplexing (chapter 8)
- Types of modulation
  - —Amplitude
  - —Frequency
  - —Phase

Modulação Analógica



Required Reading

- Stallings chapter 5