DATA AND COMPUTER COMMUNICATIONS

Lecture 2 Physical Layer - Signal Encoding Techniques

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Based on Lecture slides by William Stallings

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SIGNAL ENCODING TECHNIQUES

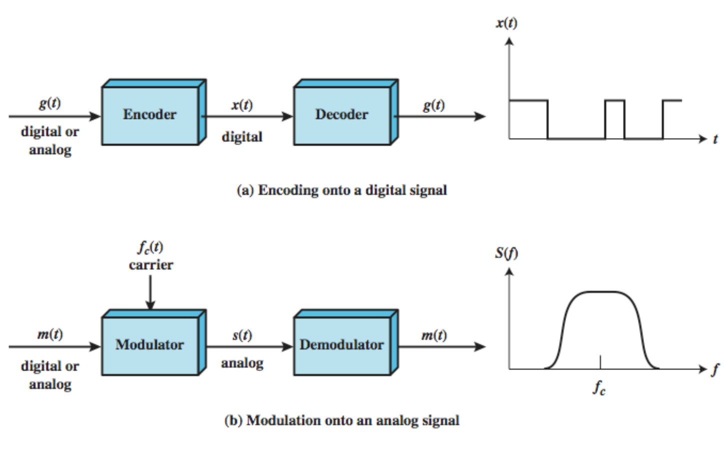

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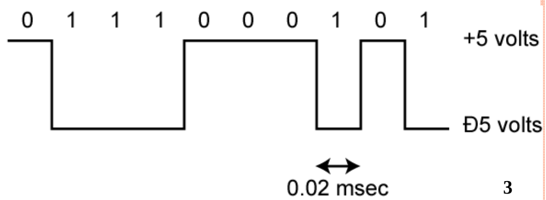
Figure 5.1 Encoding and Modulation Techniques

Digital Data, Digital Signal

- Digital signal
  - discrete, discontinuous voltage pulses
  - each pulse is a signal element
  - binary data encoded into signal elements



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Some Terms

- unipolar
- polar
- data rate
- duration or length of a bit
- modulation rate
- mark and space

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Interpreting Signals

- need to know
  - timing of bits - when they start and end
  - signal levels
- factors affecting signal interpretation
  - signal to noise ratio
  - data rate
  - bandwidth
  - encoding scheme

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Encoding Schemes

signal spectrum
- good signal design should concentrate the transmitted power in the middle of the transmission

clocking
- need to synchronize transmitter and receiver either with an external clock or sync

error detection
- responsibility of a layer of logic above the signaling level that is known as

signal interference and noise immunity
- certain codes perform better in the presence of noise
- cost and complexity
- the higher the signaling

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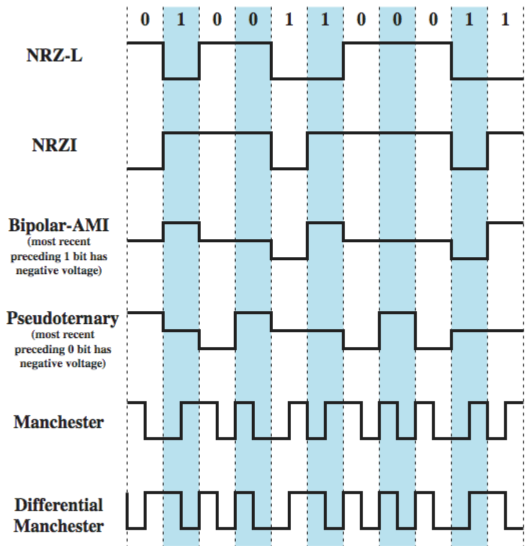
Encoding Schemes



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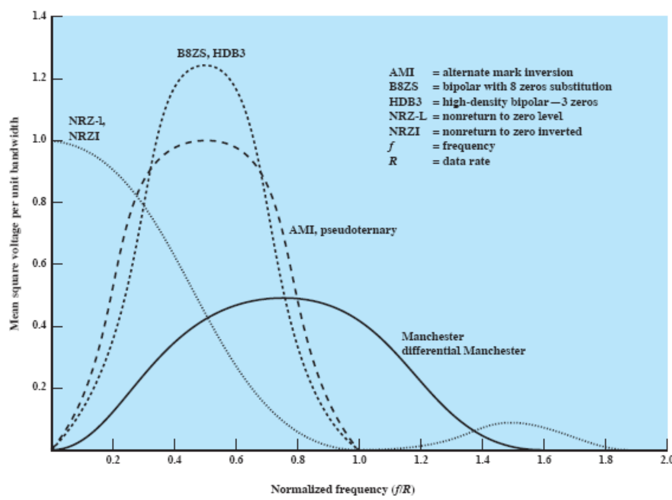

Figure 5.3 Spectral Density of Various Signal Encoding Schemes

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Nonreturn to Zero-Level (NRZ-L)

- two different voltages for 0 and 1 bits
- voltage constant during bit interval
  - no transition I.e. no return to zero voltage
  - such as absence of voltage for zero, constant positive voltage for one
  - more often, negative voltage for one value and positive for the other

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Nonreturn to Zero Inverted

- nonreturn to zero inverted on ones
- constant voltage pulse for duration of bit
- data encoded as presence or absence of signal transition at beginning of bit time
  - transition (low to high or high to low) denotes binary 1
  - no transition denotes binary 0
- example of differential encoding since have
  - data represented by changes rather than levels
  - more reliable detection of transition rather than level
  - easy to lose sense of polarity

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NRZ Pros & Cons

Pros

- easy to engineer
- make efficient use of bandwidth

Cons

- presence of a dc component
- lack of synchronization capability

- used for magnetic recording
- not often used for signal transmission

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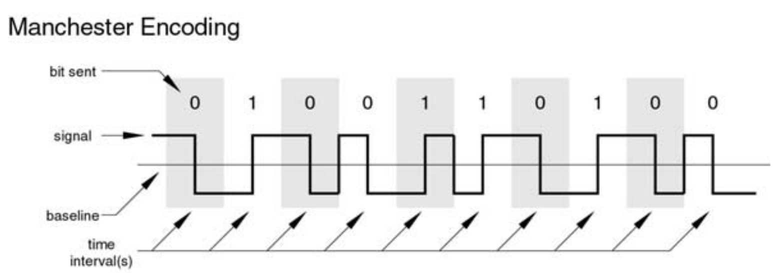
Manchester Encoding

- has 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



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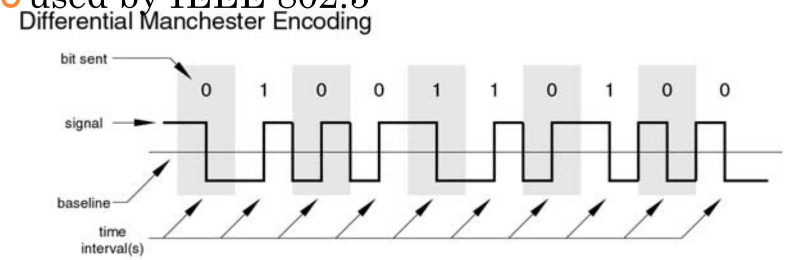
Differential Manchester Encoding

- midbit transition is clocking only
- transition at start of bit period representing 0
- no transition at start of bit period representing 1
  - this is a differential encoding scheme
- used by IEEE 802.5



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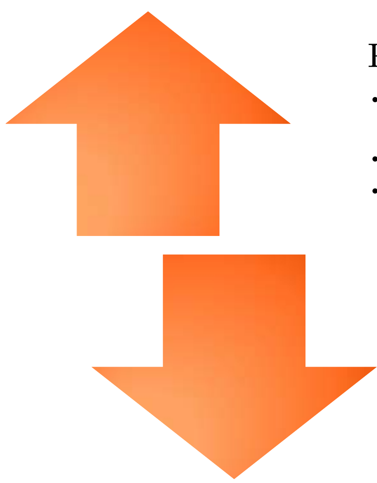
Biphase Pros and Cons



Pros

- synchronization on midbit transition (self clocking)
- has no dc component
- has error detection

Cons

- at least one transition per bit time and may have two
- maximum modulation rate is twice NRZ
- requires more bandwidth

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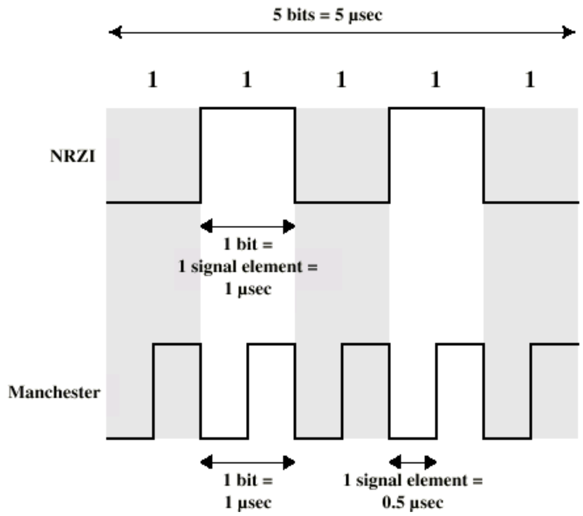
Modulation Rate



D = R/L

= R/log M

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Analog Data, Digital Signal

- digitization is conversion of analog data into digital data which can then:
  - be transmitted using NRZ-L
  - be transmitted using code other than NRZ-L
  - be converted to analog signal
- analog to digital conversion done using a codec
  - pulse code modulation
  - delta modulation

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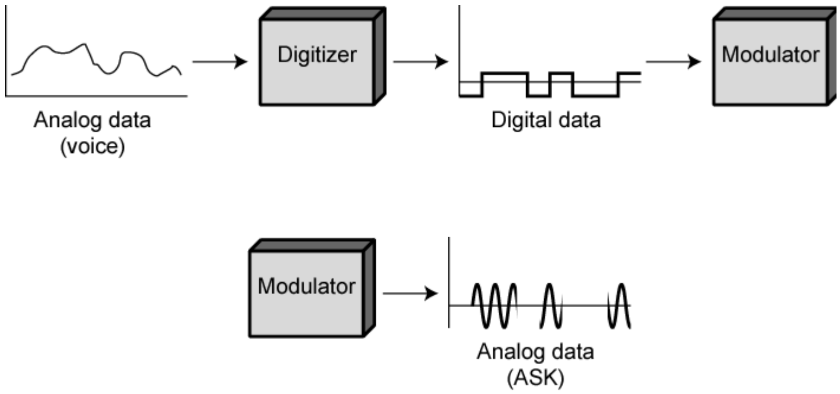
DIGITIZING ANALOG DATA



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PULSE CODE MODULATION (PCM)

- sampling theorem:
  - "If a signal is sampled at regular intervals at a rate higher than twice the highest signal frequency, the samples contain all information in original signal"
  - eg. 4000Hz voice data, requires 8000 sample per sec
- strictly have analog samples
  - Pulse Amplitude Modulation (PAM)
- so assign each a digital value

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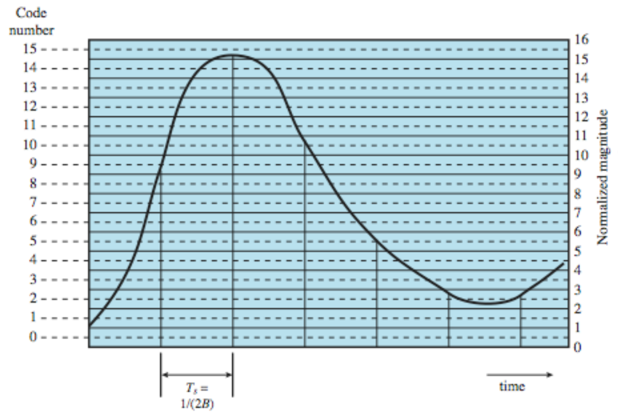
PCM Example



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

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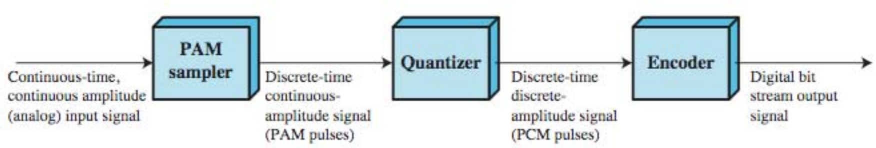
PCM Block Diagram



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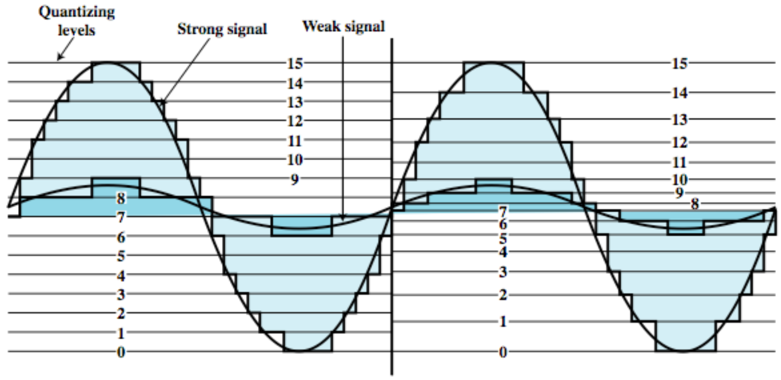
Non-Linear Coding



(a) Without nonlinear encoding (b) With nonlinear encoding

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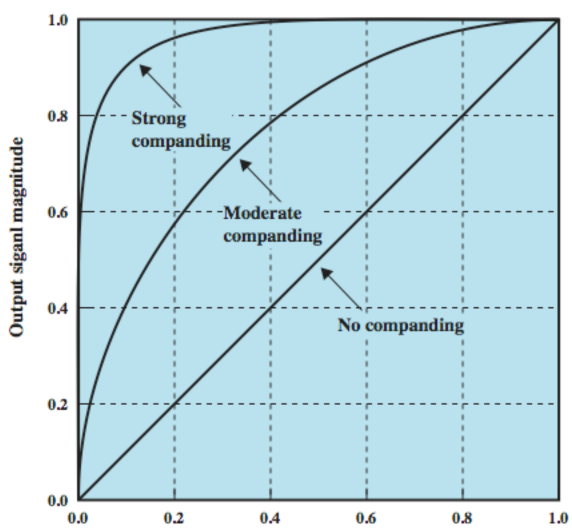
Companding



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Analog Data, Analog Signals

- modulate carrier frequency with analog data
- why modulate analog signals?
  - higher frequency can give more efficient transmission
  - permits frequency division multiplexing (chapter 8)
- types of modulation
  - Amplitude
  - Frequency
  - Phase

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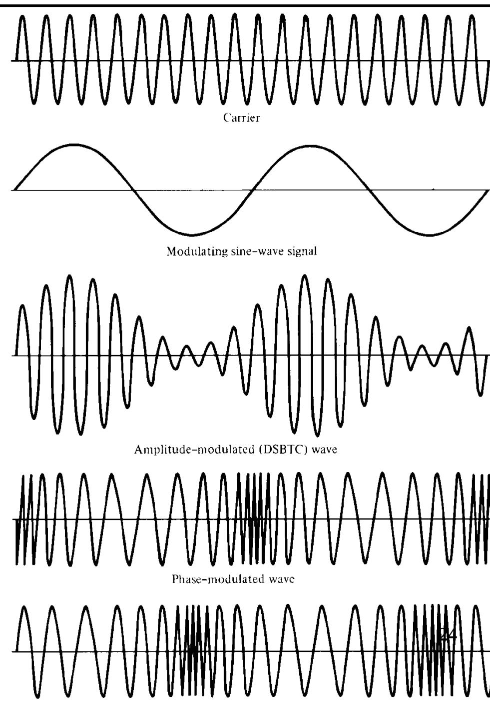
Analog Modulation Techniques

- Amplitude Modulation
- Frequency Modulation
- Phase Modulation



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Summary

- looked at signal encoding techniques
  - digital data, digital signal
  - analog data, digital signal
  - digital data, analog signal
  - analog data, analog signal

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