Comp 346 / Comp 446
Telecommunications -
Signal Encoding

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Some Terms

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

Terms and Definitions

- Data Elements (Bits)
  - Single binary one or zero
- Data Rate (often Bits per second - bps)
  - Rate of transmission of data elements
- Signal Element (electrical)
  - The shortest or smallest meaningful part of the transmission
- Signaling Rate (signal elements per second – baud)
  - Rate of transmission of signal elements
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

Encoding Schemes

Multilevel Binary
Bipolar-AMI

- Use more than two levels
- Bipolar-AMI
  - zero represented by no line signal
  - one represented by positive or negative pulse
  - one pulses alternate in polarity
  - no loss of sync if a long string of ones
  - long runs of zeros still a problem
  - no net dc component
  - lower bandwidth
  - easy error detection
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

B8ZS and HDB3

Amplitude Shift Keying
- encode 0/1 by different carrier amplitudes
  - usually have one amplitude zero
- susceptible to sudden gain changes
- inefficient
- used for
  - up to 1200bps on voice grade lines
  - very high speeds over optical fiber
Multiple FSK
- each signalling element represents more than one bit
- more than two frequencies used
- more bandwidth efficient
- more prone to error

Quadrature PSK
- get more efficient use if each signal element represents more than one bit
  - eg. shifts of $\pi/2$ (90°)
  - each element represents two bits
  - split input data stream in two & modulate onto carrier & phase shifted carrier
- can use 8 phase angles & more than one amplitude
  - 9600bps modem uses 12 angles, four of which have two amplitudes

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 samples per sec
- strictly have analog samples
  - Pulse Amplitude Modulation (PAM)
- so assign each a digital value
World Wide Use – With differences

- **North America and Japan**
  - T1 24 voice channels, mu-law encoding, companded, bit robbing for signals
  - 64Kbps per channel, 1.544Mbps total
- **Much of rest of world**
  - E1 32 voice channels (31 for use 1 for signaling), a-law
  - 64Kbps, 2.048Mbps total
- **In Common**
  - Support voice, data, multimedia
  - Also transmit maintenance signals, alarm, controls
PCM in Use

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PCM for Voice (TDM-Law, A-Law)

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Digital Phone

PCM in Use

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Digital Video