Analog and Digital Transmission

- Data
- Signaling
- Transmission

- Encoding
  - Digital → analog
  - Analog →digital
  - Digital →digital
  - Analog →analog

Data and Signals

- Analog **data**
  - Takes on continuous values. Ex. Voice or video
- Digital **data**
  - Takes on discrete values. Ex. Text and integers

- Analog **Signal**
  - Continuously varying electromagnetic wave representing data carried over a variety of medium
- Digital **Signal**
  - Sequence of voltage pulses representing data transmitted over a wire medium

Examples

- Analog to analog
  - Voice (Analog Data) →Telephone → Analog Signal
- Digital to analog
  - PC (Digital Data) →Modem → Analog Signal
- Analog to digital
  - Voice (Analog Data) → CODEC → Digital Signal
- Digital to Digital
  - PC (Digital Data) →Digital Transmitter → Digital Signal

Important

Analog or Digital Data Can Be Represented By Either Analog or Digital Signals. These Signals Can Then Be Propogated (Moved Along a Medium). Optical Fiber Only Propogates Analog Signals

Reasons for Conversions

- Digital data → Digital Signal
  - Easy and simple to implement
- Analog data → Digital Signal
  - Allows the use of digital transmission and switching equipment
- Digital data → Analog Signal
  - Allows us of the public telephone system
  - Allows use of optical fiber
- Analog Data → Analog Signal
  - Easy
  - Telephone system was primarily analog

Transmission Systems

- Analog Transmission
  - Not used with digital signal
  - Transmits analog signals without regard whether it represents digital or analog data
  - Uses amplifiers – also boosts noise
  - Okay for voice
  - Can distort digital data

Transmission Systems

- Digital Transmission
  - Concerned with the content of the signal
  - Uses repeaters which recover the pattern of 0's and 1's and re-transmits
  - Can be used with analog signals if it carries digital data
    - Again it recovers the digital data from the analog signal and generates a new clean analog signal
  - Is becoming more standard

Data Encoding Techniques

Analog Encoding of **Digital** Information (cont)

- Amplitude shift keying
  - Two binary numbers (0,1) represented by two different amplitudes of the carrier wave
  - Rather inefficient
  - Used up to 1200 bps on voice grade lines
  - Used to transmit digital data over optical fiber
- Frequency shift keying
  - Two binary numbers (0,1) represented by two different frequencies of the carrier wave
  - Less susceptible to error than ASK
  - Used up to 1200bps on voice grade lines
  - Commonly used for high frequency (4 to 30mhz) radio

Data Encoding Techniques

Analog Encoding of **Digital** Information

- Phase shift keying
  - Two binary numbers (0,1) represented by phase shift of the carrier wave
  - More efficient and noise resistant than FSK
  - Used up to 9600 on voice grade lines

Data Encoding Techniques

Analog Encoding of **Digital** Information

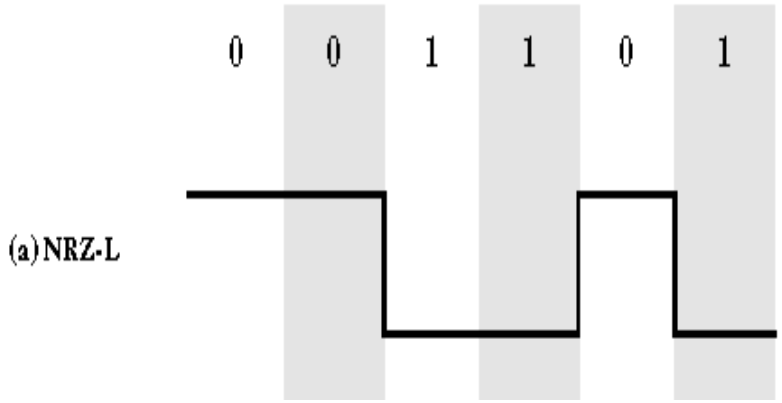
- Techniques can be combined
- Common to combine phase shift and amplitude shift
- Can get 56kps on a voice grade line
- With some techniques called multilevel signaling each signal represents more than one bit
- Baud rate = signal changes per second
- Bit rate = bits per second

Data Encoding Techniques

Digital Encoding of **Analog** Information

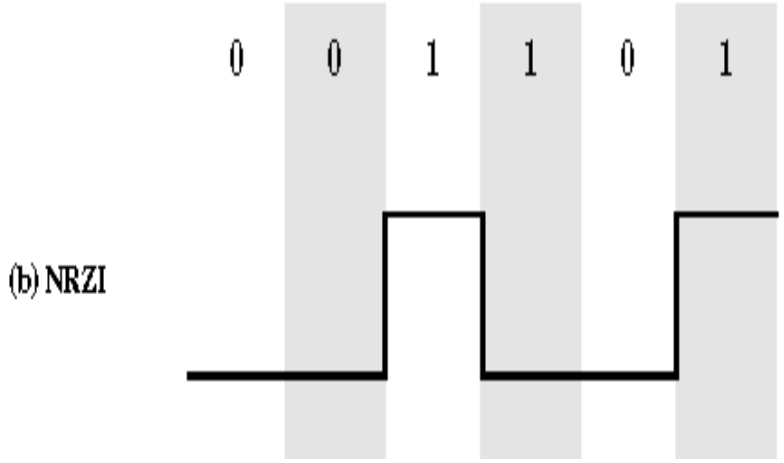
- Commonly used in digitizing voice.
- Technique is called Pulse Code Modulation (PCM)
  - Sampling theory states if a signal is sampled at a rate twice the highest frequency then the samples contain all the information of the original signal
  - Voice data in the telephone system is limited to a maximum of 4KHz
  - 8000 samples /sec would be sufficient
  - Each of these samples is assigned a binary code (8 bits)
  - Typically 8 bits are used which gives 256 levels

Data Encoding Techniques



- **Digital** Encoding of **Digital** Information
- Nonreturn–to-zero-level
  - Uses two different voltage levels to represent (0's and 1's)
  - Typically negative voltage =1 and positive voltage =0
  - The signal never returns to zero voltage
  - The value during a bit time is level voltage
  - Short distances

Data Encoding Techniques



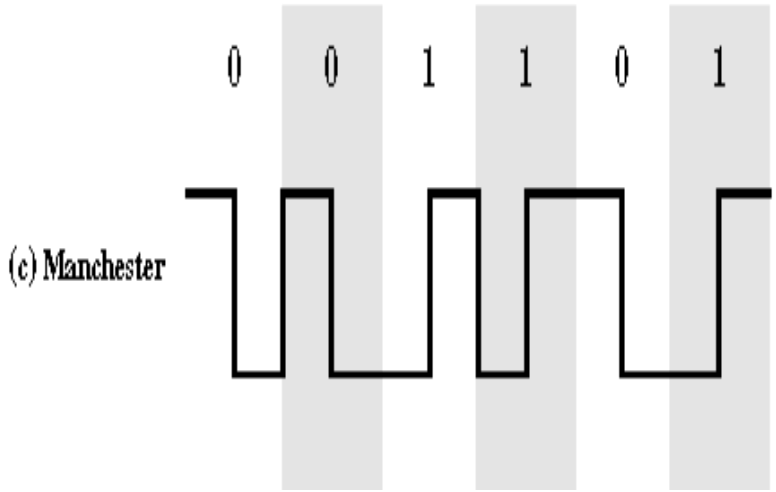
- **Digital** Encoding of **Digital** Information
- NRZI (NRZ, invert on ones)
  - Constant voltage during bit time
  - No transition =0
  - Transition form lo to hi or hi to lo =1
  - Compares polarity of signals
  - Doesn't matter if accidentally switch leads

Data Encoding Techniques

Digital Encoding of **Digital** Information

- Disadvantages of NRZ Codes
  - Hard to tell where one bit ends or starts
  - With long string of 0's or 1's any drift between timing of transmitter and receiver results in errors
- Bi-Phase Encoding
  - Use at least one transition per bit time
  - Known as self clocking codes
    - Predictable bit transitions during each bit time
  - Absence of a transition indicates an error
  - Manchester and Differential Manchester are two examples

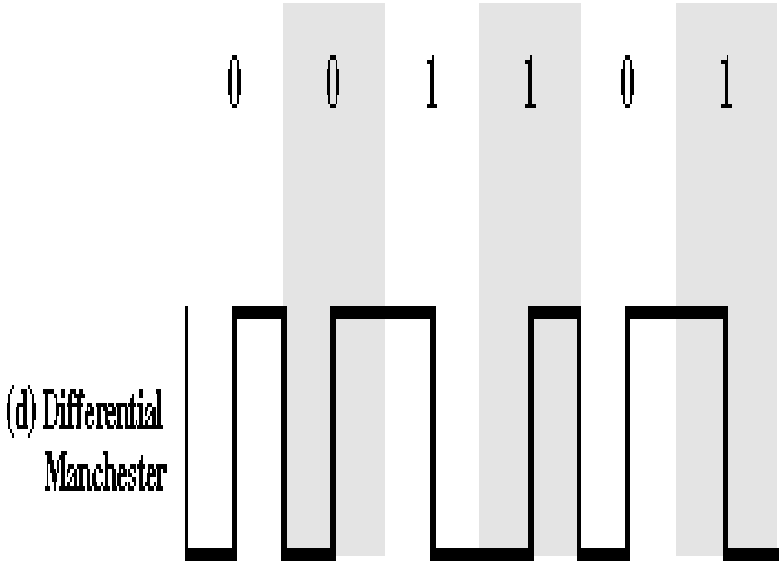
Data Encoding Techniques



Digital Encoding of **Digital** Information

- Manchester
  - Transition at the middle of each bit period
  - Lo to hi transition=1
  - Hi to lo transition =0
  - Used in Ethernet and LANS

Data Encoding Techniques



- **Digital** Encoding of **Digital** Information
- Differential Manchester
  - Midbit transition is clocking only
  - Transition at beginning of bit period =0
  - Absence of transition at beginning of bit period =1
  - Used in Token Ring networks

Data Encoding Techniques

Analog Encoding of **Analog** Information

- Can be converted directly into an analog signal
- Ex. Voice is represented by electromagnetic signal with same frequency components and transmitted on voice grade line
- Can also produce a new analog signal at higher frequency
- Techniques used to modulate include
  - AM – Amplitude Modulation
  - FM – Frequency Modulation
  - PM – Phase Modulation