

Physical Layer, Part 2

Digital Transmissions and Multiplexing

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Analog vs Digital

- ❑ Analog Data
 - continuous values
 - ex. Voice, video, temperature
- ❑ Digital Data
 - discrete values
 - ex. ASCII data, numeric data

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Analog Signal/Transmission

- ❑ continuously varying signal
- ❑ can be used to transmit analog data
 - Example ?
- ❑ use **amplifiers** to boost energy in signal due to attenuation
- ❑ amplification distorts analog signal because noise is also amplified

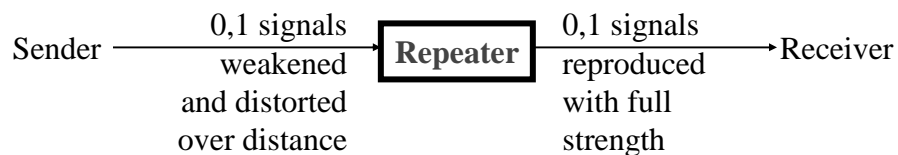


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Digital Signal/Transmission

- ❑ (ideally) sequence of discrete values
- ❑ can be used to transmit analog data
- ❑ can be used to transmit digital data
- ❑ **repeaters** are used to restore signal periodically
- ❑ repeaters do not disturb the signal (and data)
- ❑ Digital transmission is the future



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Digital Advantages

- ❑ Due to VLSI technology, price of digital circuitry is continually dropping; not as drastic in the cases of analog equipments
- ❑ Multiplexing is easier Multiplexing enables multiple low-bandwidth signals to share a high-bandwidth medium
- ❑ Encryption techniques can easily be applied
- ❑ Enable the integration of multiple communication forms, such as human interaction and computer communications, in one network.

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Digital Data, Digital Signals

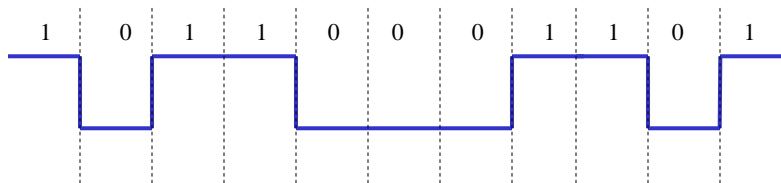
- ❑ **Data Rate:** number of bits/bytes transmitted per second
- ❑ **Modulation rate (baud):** the rate at which the signal is changed
- ❑ **Encoding:** mapping from data bits to signal elements
 - NRZ, Manchester, Delay Modulation, etc.

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Nonreturn to Zero (NRZ) Encoding

- ❑ a positive voltage represents 1; a negative 0
- ❑ easy to implement
- ❑ efficient use of bandwidth (modulation rate equals data rate in worst cases)
- ❑ Problem: no synchronization available from signal
 - Consider sending 1,000 consecutive 0s

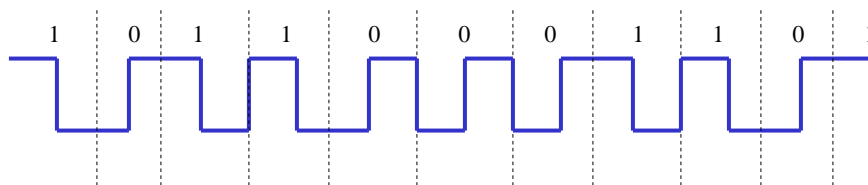


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Manchester Encoding

- ❑ in the middle of a bit period, a downward transition represents 1; an upward 0
- ❑ at least one transition per bit
 - self-clocking/synchronization; error detection
- ❑ modulation rate twice the bit rate -- inefficient use of bandwidth when sending a sequence of identical bits.

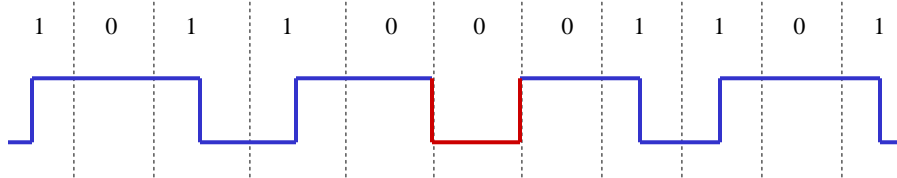


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Delay Modulation Encoding

- a transition in middle represents 1; no transition represents 0
- must have at least one transition per two bits
 - to enforce this, insert a transition at the beginning of a bit period when necessary

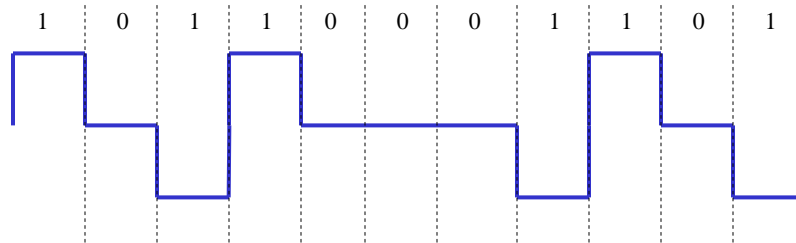


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Bipolar Encoding

- 0 volt represents 0; either positive or negative pulse represents 1
- The 1 pulses must alternate in polarity.
- used in T1 lines

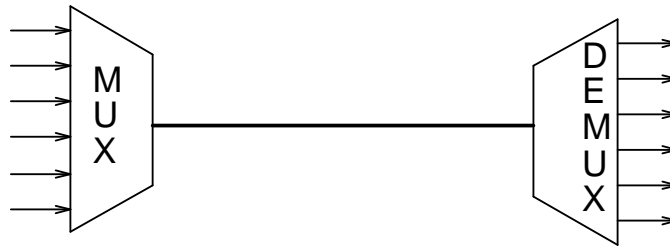


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Multiplexing

- ❑ A high capacity link carries n signals.
- ❑ At the transmitting end of the link, a **multiplexer** combines signals from n inputs.
- ❑ At the receiving end, a **demultiplexer** accepts the combined signal, separates the data, and delivers them to the appropriate output lines.



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Time Division Multiplexing

- ❑ Used in digital transmission
- ❑ The capacity of the link is divided into fixed-size **frames**.
- ❑ Each frame is further divided into fixed-size **slots**.
- ❑ Each slot is dedicated to an input signal.

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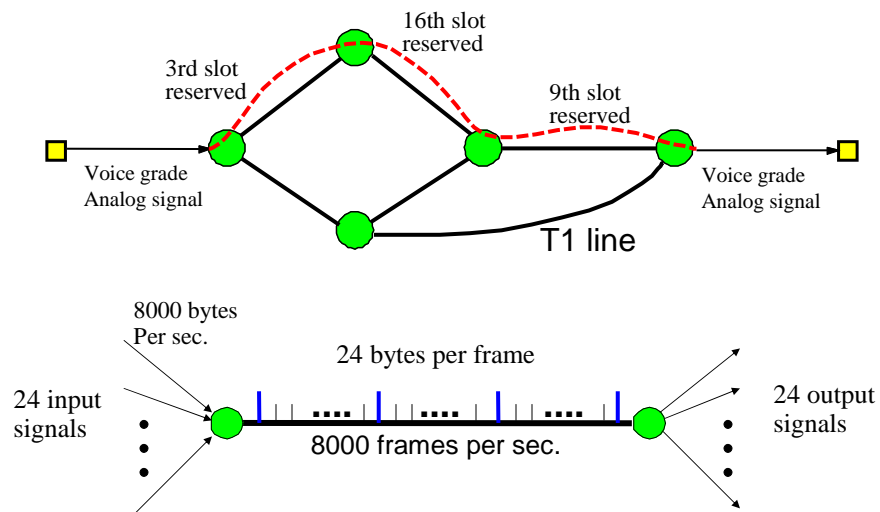
T1 Line

- ❑ Used by telephone networks to carry 24 voice signals
- ❑ Its 1.544 Mbps capacity is divided into 8000 frames per second.
- ❑ Each frame contains 193 bits, which are divided into 24 8-bit slots (the 193th bit is for framing).
- ❑ Each slot is assigned to a digitized voice signal and will contain one PCM code of that signal.

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T1 Line Illustrated



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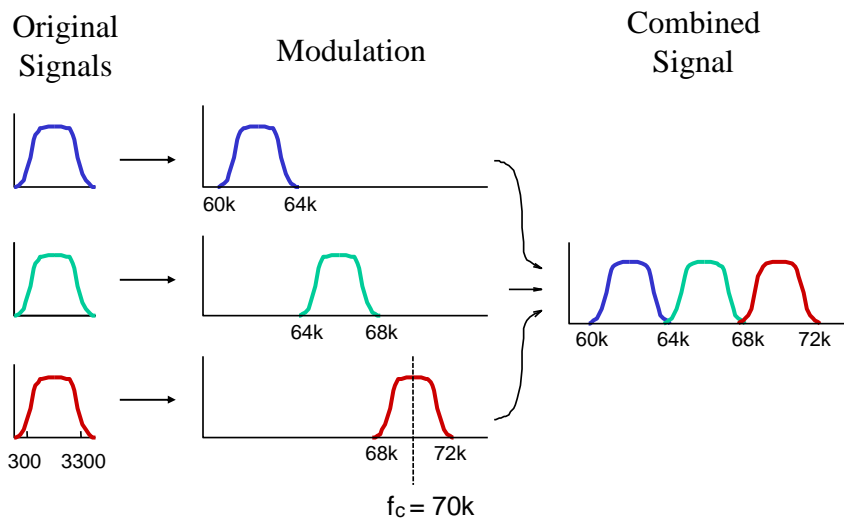
Frequency Division Multiplexing

- ❑ Used in analogue transmission
- ❑ Multiple signals are carried by modulating each onto a different carrier frequency
- ❑ The bandwidth of each modulated signal is centered around its carrier frequency, called a channel.
- ❑ Used in analog cable TV
- ❑ Modulation Techniques
 - **Amplitude Modulation**
 - **Frequency Modulation**
 - **Phase Modulation**

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An FDM Example



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A Simple AM Scheme

