

Data and Computer Communications

Chapter 3 – Data Transmission

Eighth Edition
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Data Transmission

- *Toto, I've got a feeling we're not in Kansas anymore.* Judy Garland in *The Wizard of Oz*

Transmission Terminology

- data transmission occurs between a transmitter & receiver via some medium



- TX
- Medium may be:
 - guided medium
 - eg. twisted pair, coaxial cable, optical fiber
 - unguided / wireless medium
 - eg. air, water, vacuum

Transmission Terminology

- direct link
 - no intermediate devices
- point-to-point
 - direct link
 - only 2 devices share link
- multi-point
 - more than two devices share the link

Transmission Terminology

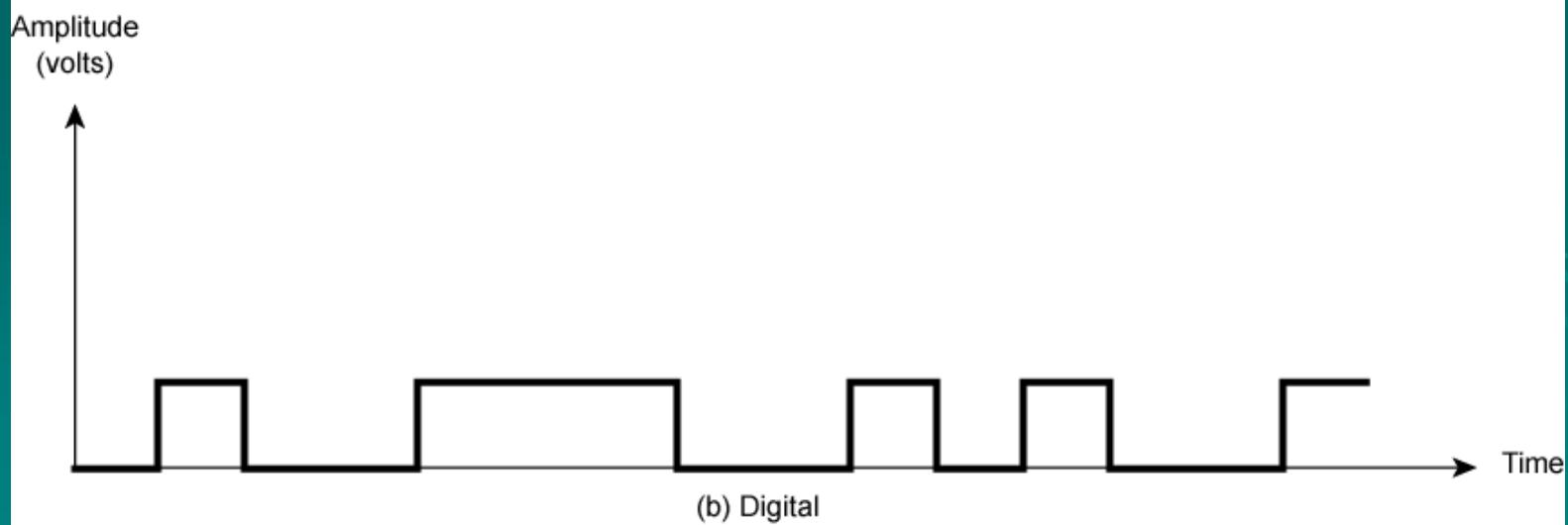
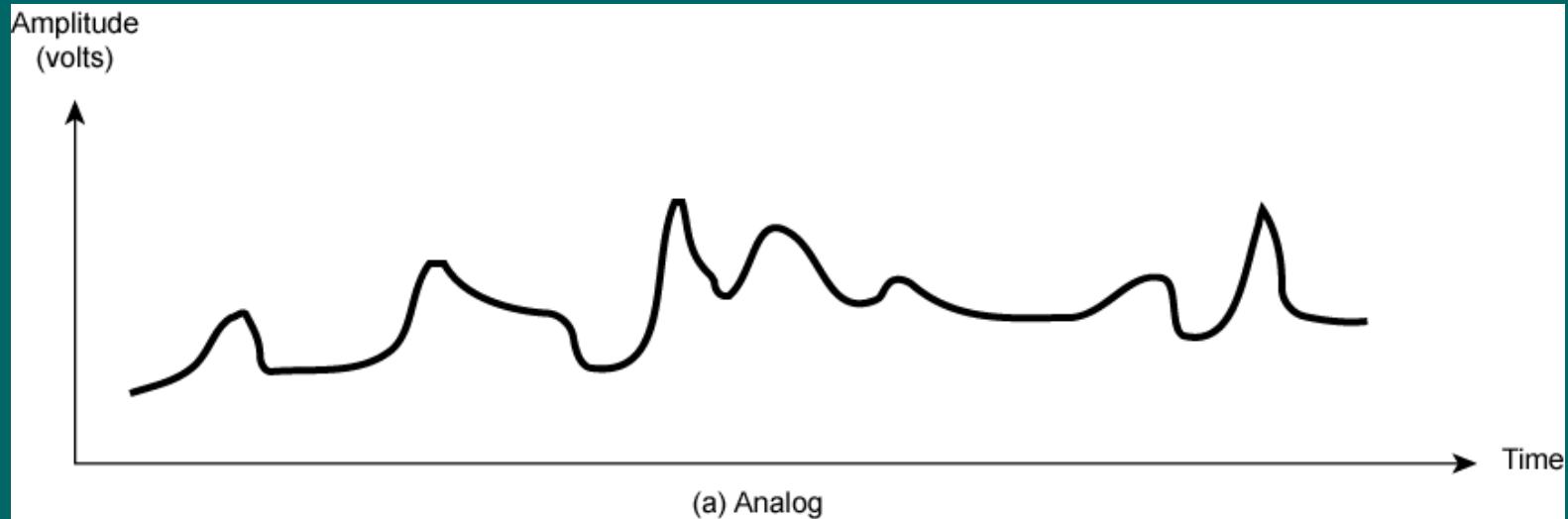
- **simplex**
 - one direction
 - eg. television
- **half duplex**
 - either direction, but only one way at a time
 - eg. police radio
- **full duplex**
 - both directions at the same time
 - eg. telephone

Frequency, Spectrum and Bandwidth

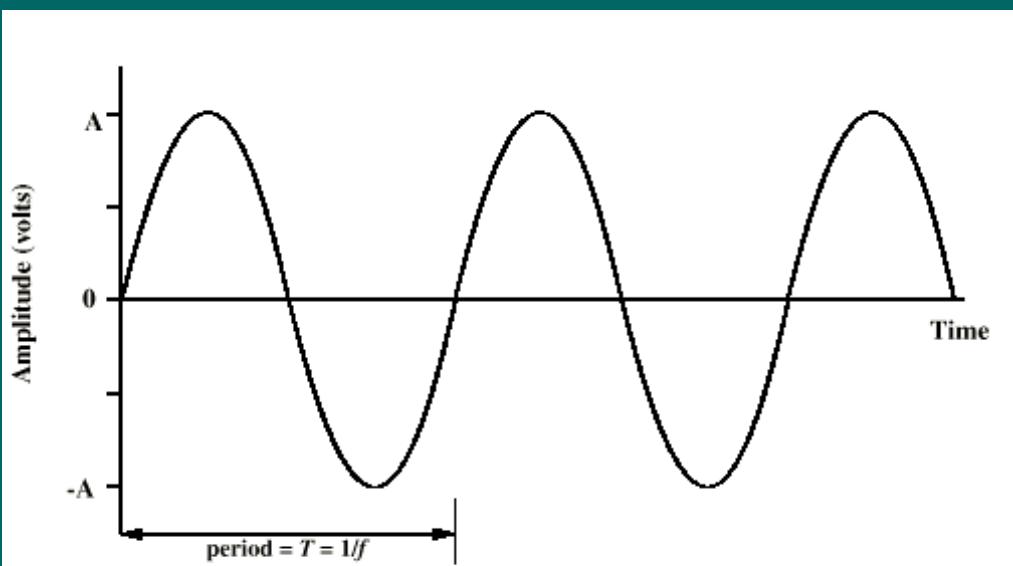
➤ time domain concepts

- analog signal
 - varies in a smooth way over time
- digital signal
 - maintains a constant level then changes to another constant level
- periodic signal
 - pattern repeated over time
- aperiodic signal
 - pattern not repeated over time

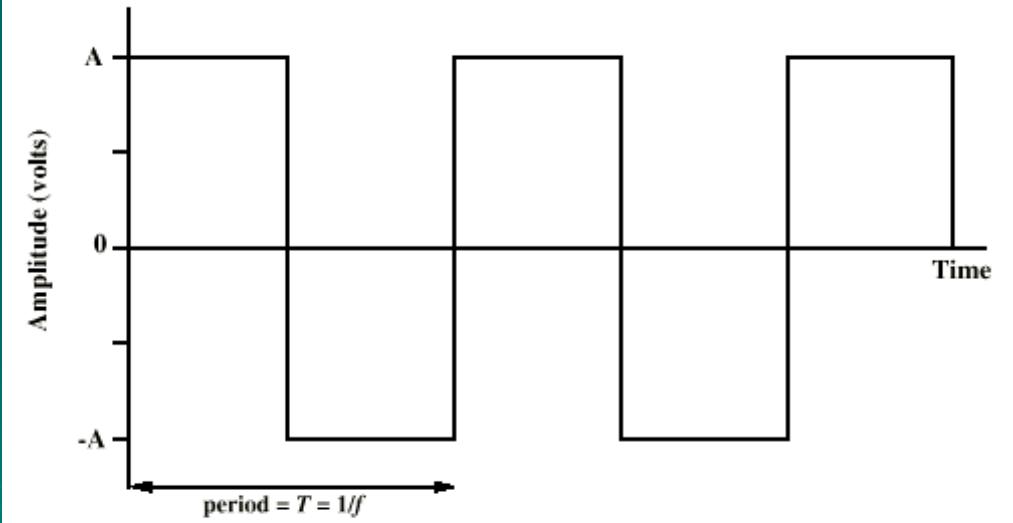
Analogue & Digital Signals



Periodic Signals



(a) Sine wave

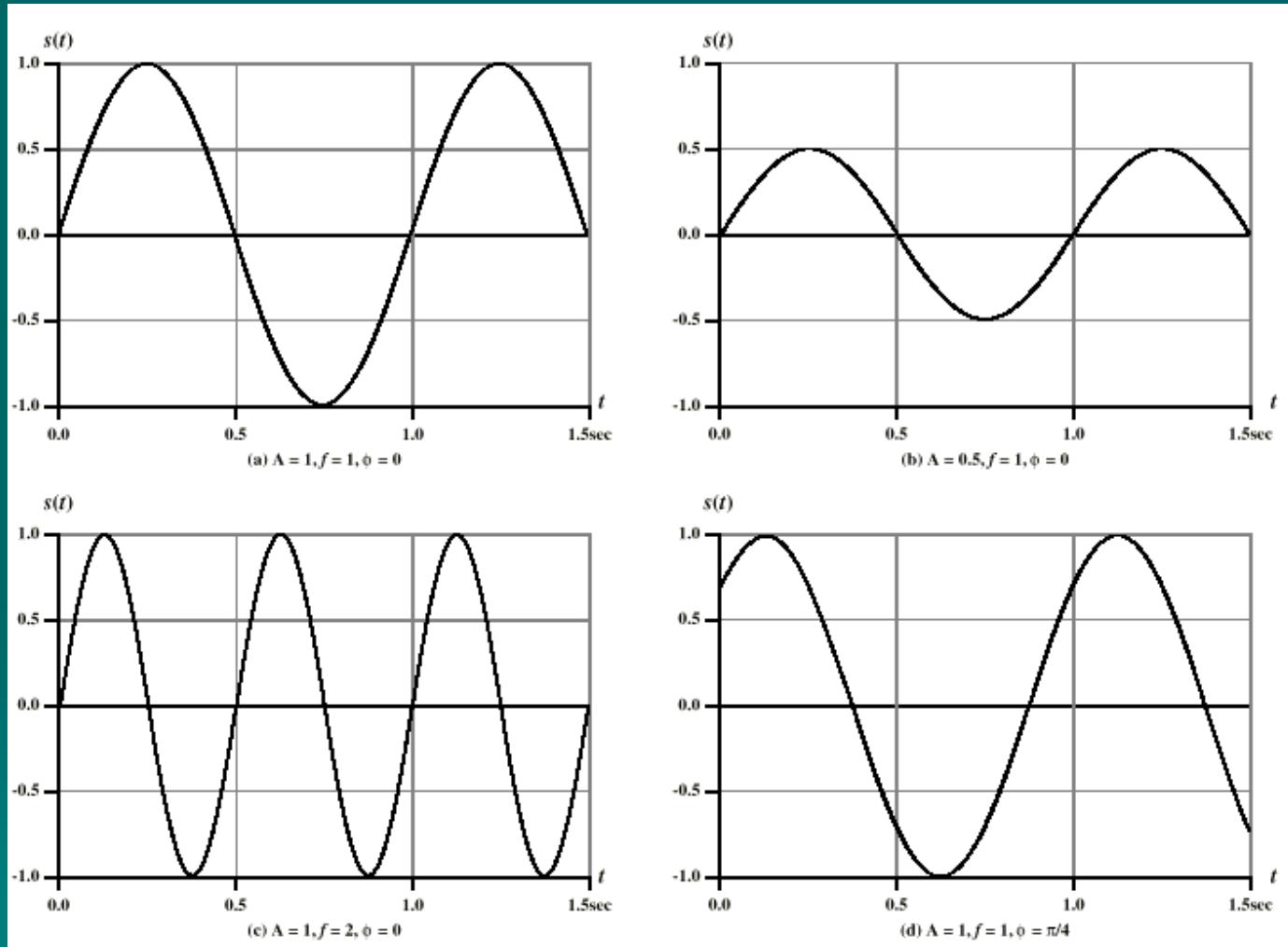


(b) Square wave

Sine Wave

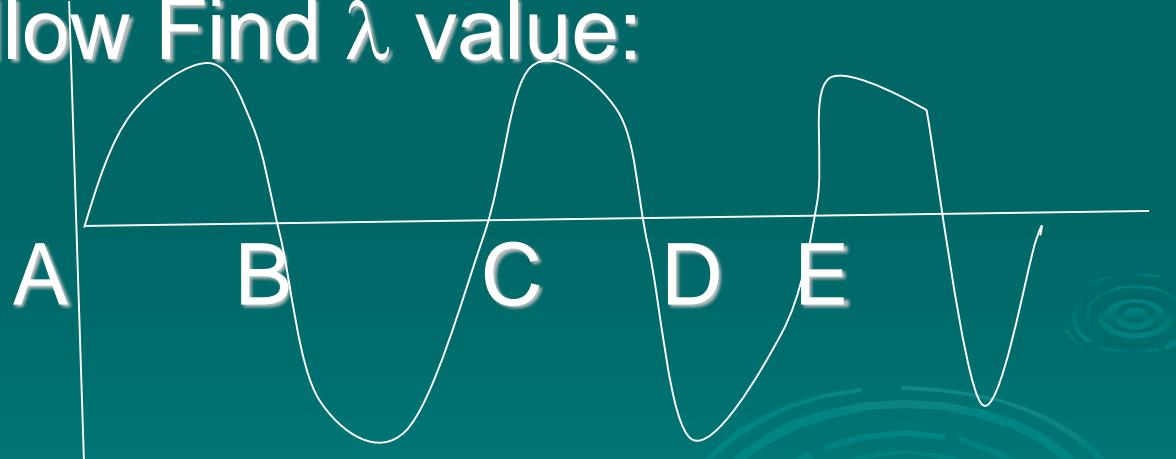
- peak amplitude (A)
 - maximum strength of signal
 - volts
- frequency (f)
 - rate of change of signal
 - Hertz (Hz) or cycles per second
 - period = time for one repetition (T)
 - $T = 1/f$
- phase (ϕ)
 - relative position in time

Varying Sine Waves

$$s(t) = A \sin(2\pi ft + \Phi)$$


Wavelength (λ)

- is distance occupied by one cycle
- between two points of corresponding phase in two consecutive cycles
- Assuming below Find λ value:
- A-E=8m
-
- A-B=2m
- A-D=6m
- $\lambda??$



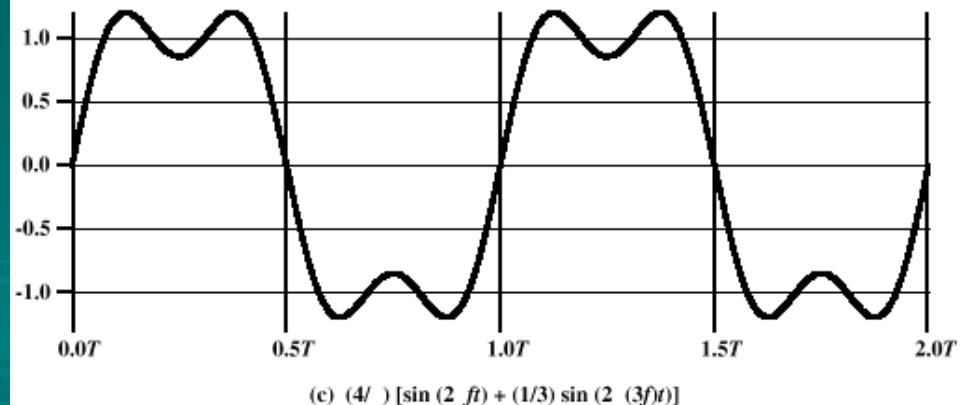
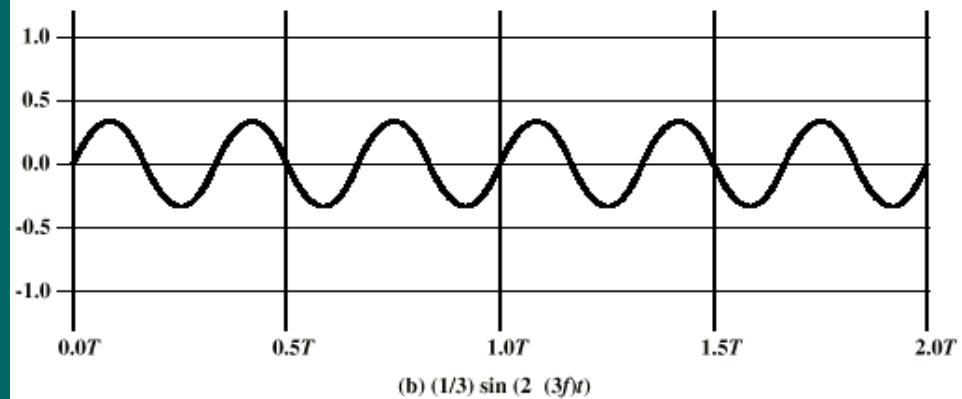
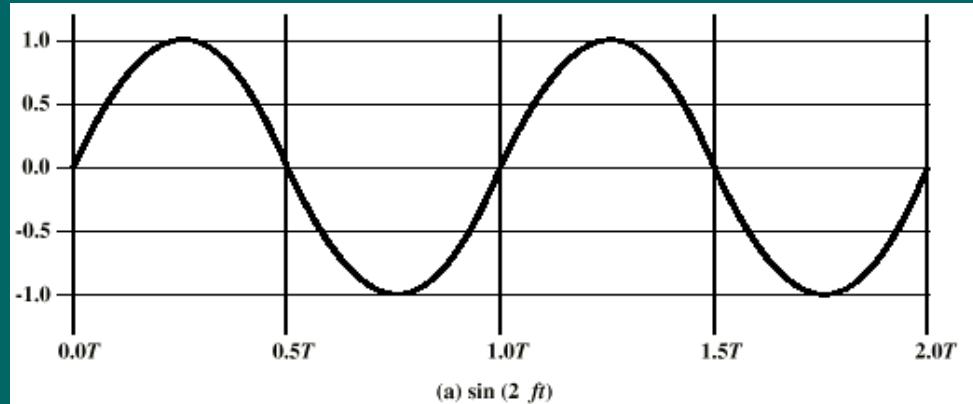
WHY IT IS IMPORTANT??

Frequency Domain Concepts

- signals are made up of many frequencies
- components are sine waves
- Fourier analysis can show that any signal is made up of component sine waves
- **USE FFT TO SHOW THAT???**
- can plot frequency domain functions

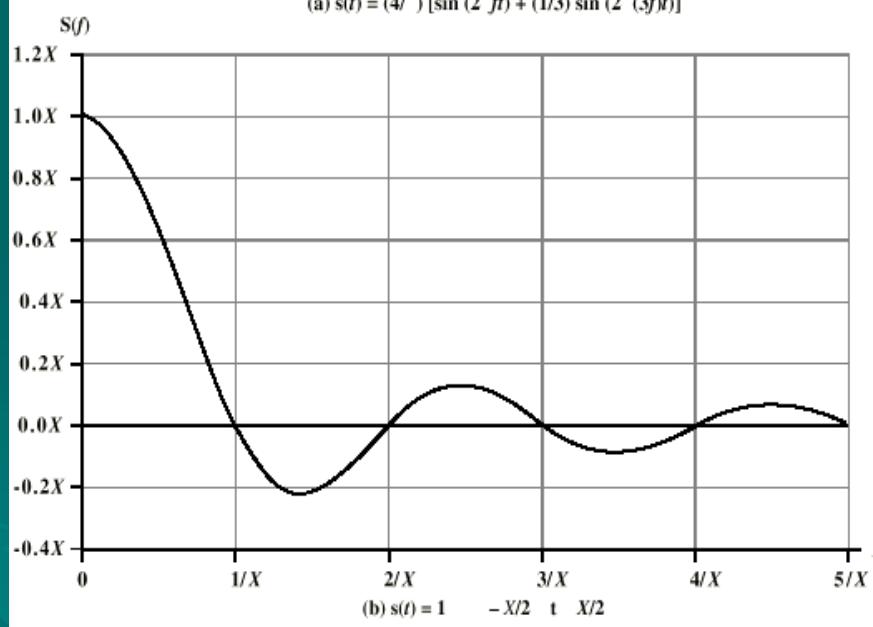
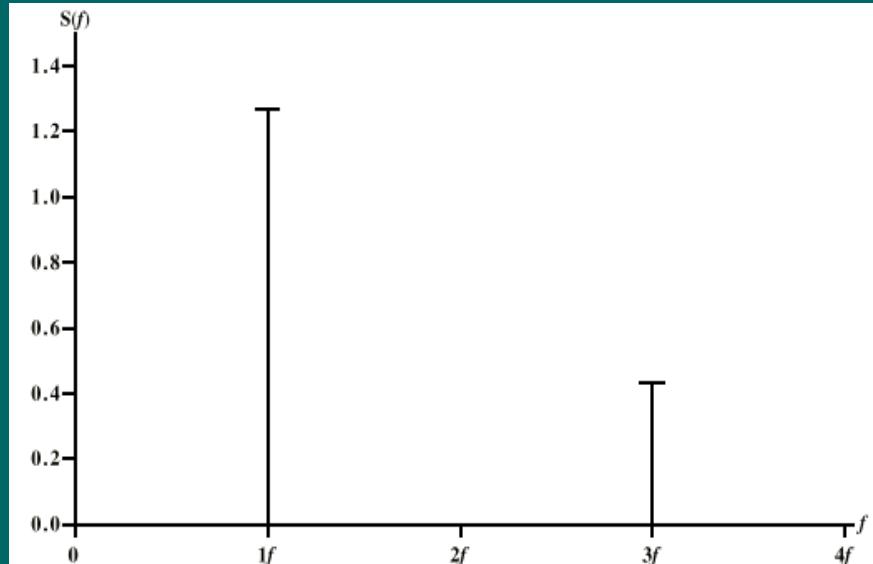
Addition of Frequency Components ($T=1/f$)

- c is sum of f & $3f$



Frequency Domain Representations

- freq domain func of Fig 3.4c
- freq domain func of single square pulse



Spectrum & Bandwidth

- spectrum
 - range of frequencies contained in signal

- absolute bandwidth

Bandwidth: range of frequencies that can pass through a medium.

- width of spectrum

- effective bandwidth

- often just *bandwidth*
 - narrow band of frequencies containing most energy

- DC Component

- component of zero frequency

Data Rate and Bandwidth

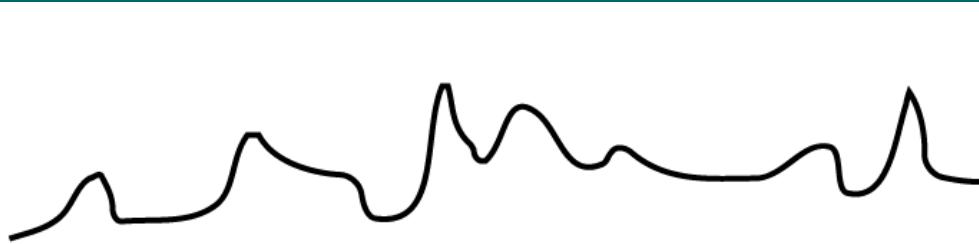
- any transmission system has a limited band of frequencies
- Data rate amount of data that passes through medium per unit time.
- this limits the data rate that can be carried
- but most energy in first few components
- limited bandwidth increases distortion
- have a direct relationship between data rate & bandwidth

Analog and Digital Data Transmission

- data
 - entities that convey meaning
- signals & signalling
 - electric or electromagnetic representations of data, physically propagates along medium
- transmission
 - communication of data by propagation and processing of signals

Audio Signals

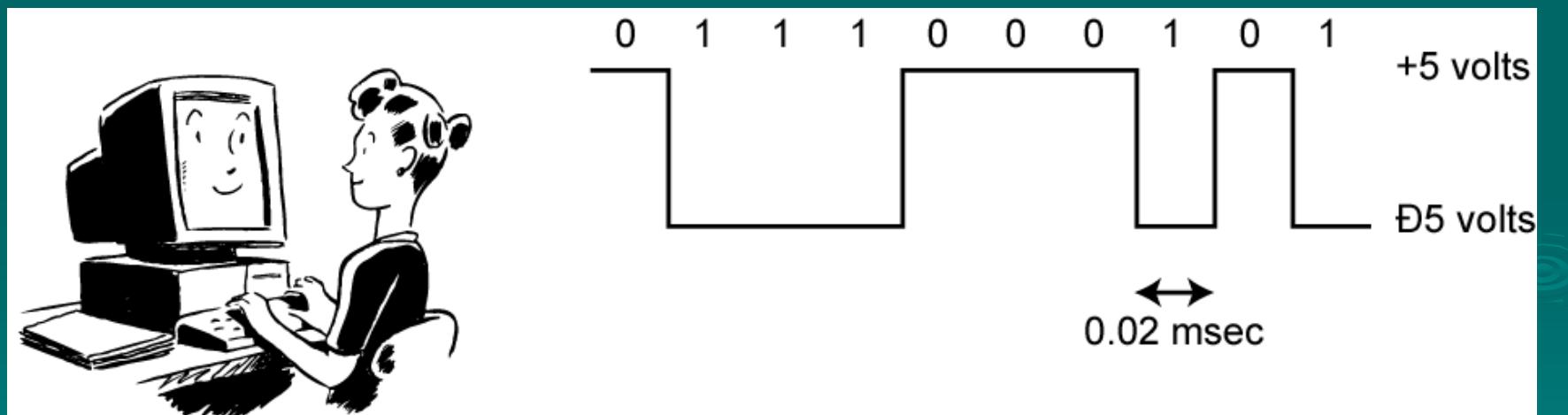
- freq range 20Hz-20kHz (speech 100Hz-7kHz)
- easily converted into electromagnetic signals
- varying volume converted to varying voltage
- can limit frequency range for voice channel to 300-3400Hz



In this graph of a typical analog signal, the variations in amplitude and frequency convey the gradations of loudness and pitch in speech or music. Similar signals are used to transmit television pictures, but at much higher frequencies.

Digital Data

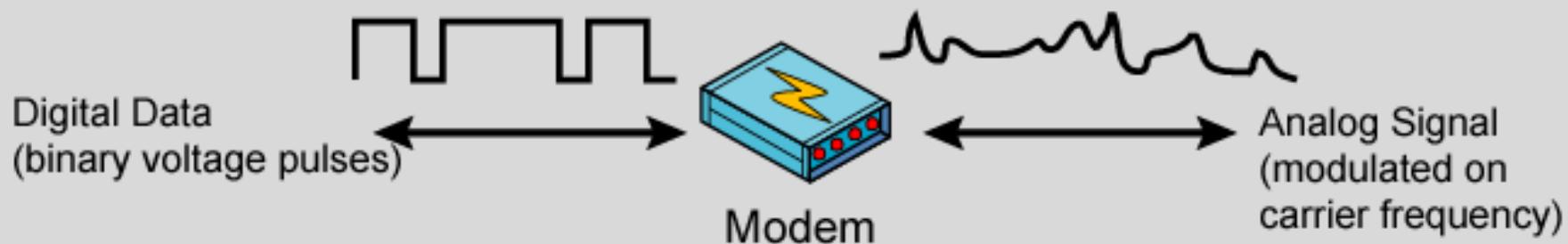
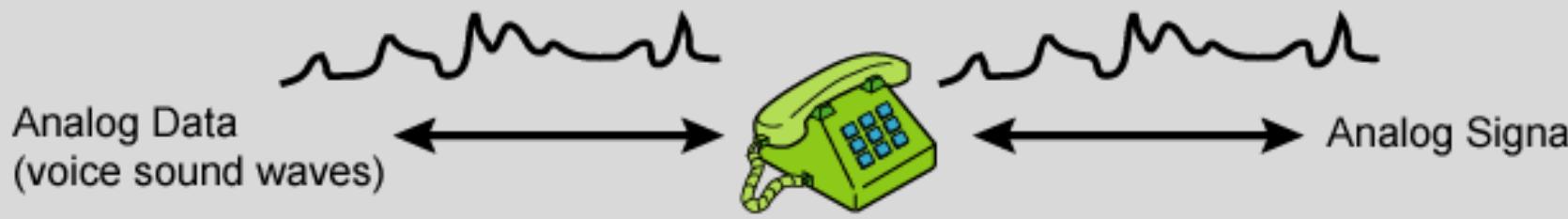
- as generated by computers etc.
- has two dc components
- bandwidth depends on data rate



User input at a PC is converted into a stream of binary digits (1s and 0s). In this graph of a typical digital signal, binary one is represented by D5 volts and binary zero is represented by +5 volts. The signal for each bit has a duration of 0.02 msec, giving a data rate of 50,000 bits per second (50 kbps).

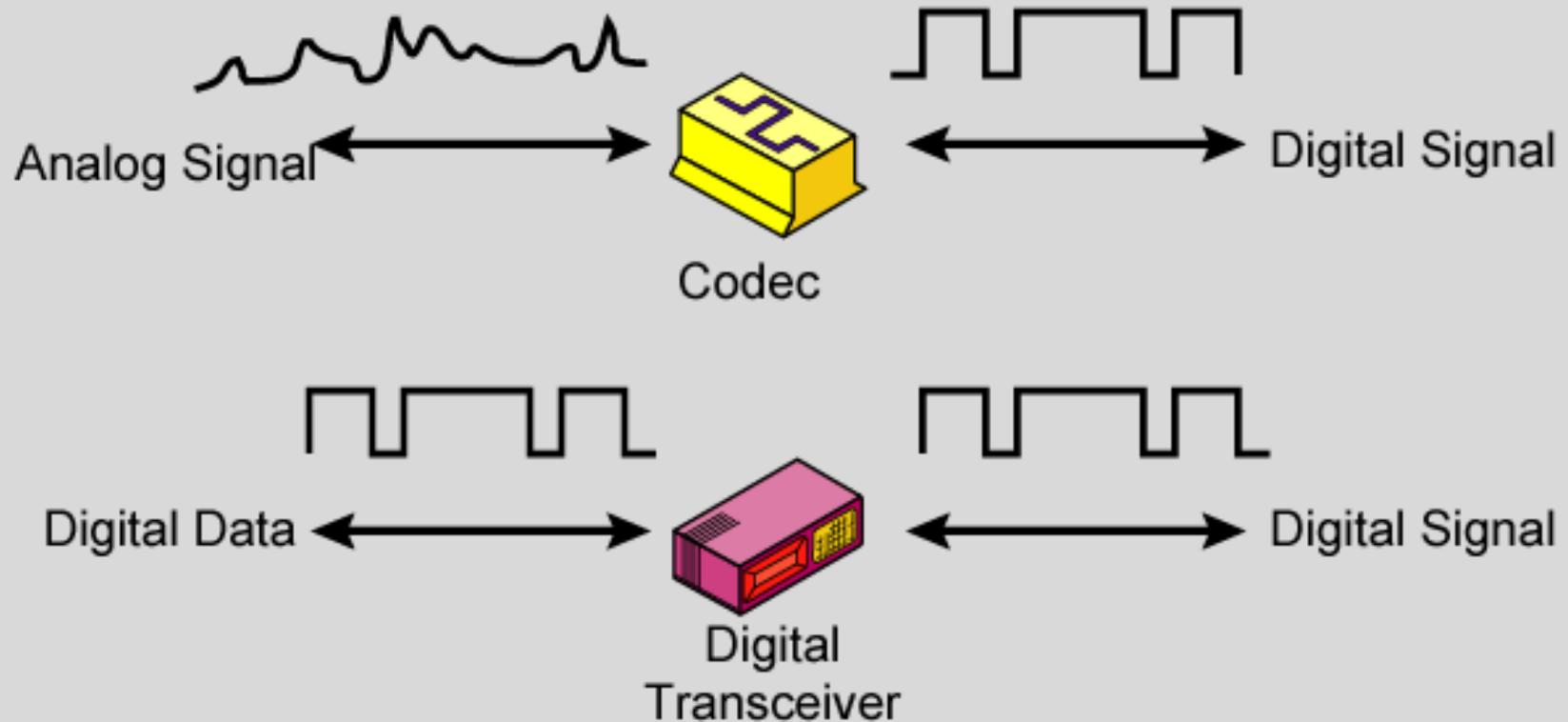
Analog Signals

Analog Signals: Represent data with continuously varying electromagnetic wave



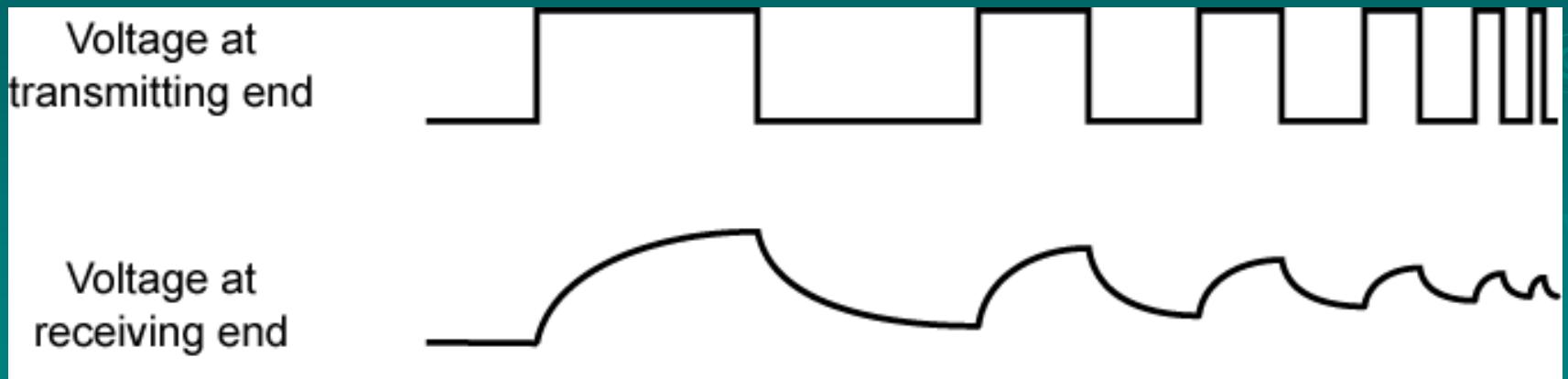
Digital Signals

Digital Signals: Represent data with sequence of voltage pulses



Advantages & Disadvantages of Digital Signals

- cheaper
- less susceptible to noise
- but greater attenuation
- digital now preferred choice



Transmission Impairments

- signal received may differ from signal transmitted causing:
 - analog - degradation of signal quality
 - digital - bit errors
- most significant impairments are
 - attenuation and attenuation distortion
 - delay distortion
 - noise

Attenuation

- where signal strength falls off with distance
- depends on medium
- received signal strength must be:
 - strong enough to be detected
 - sufficiently higher than noise to receive without error
- so increase strength using amplifiers/repeaters
- is also an increasing function of frequency
- so equalize attenuation across band of frequencies used
 - eg. using loading coils or amplifiers

Delay Distortion

- only occurs in guided media
- propagation velocity varies with frequency
- hence various frequency components arrive at different times
- particularly critical for digital data
- since parts of one bit spill over into others
- causing intersymbol interference

Noise

- additional signals inserted between transmitter and receiver
- thermal
 - due to thermal agitation of electrons
 - uniformly distributed
 - white noise
- intermodulation
 - signals that are the sum and difference of original frequencies sharing a medium

Noise

- crosstalk

- a signal from one line is picked up by another

- impulse

- irregular pulses or spikes
 - eg. external electromagnetic interference
 - short duration
 - high amplitude
 - a minor annoyance for analog signals
 - but a major source of error in digital data
 - a noise spike could corrupt many bits

Summary

- looked at data transmission issues
- frequency, spectrum & bandwidth
- analog vs digital signals
- transmission impairments