William Stallings
Komunikasi Data dan Komputer

Bab 3

Transmisi Data

Terminologi (1)

- Transmitter
- Receiver
- Medium
  - Media terarah (Guided medium)
    - Misalnya twisted pair, serat optik
  - Media tak berarah (Unguided medium)
    - Misalnya udara, air, dan hampa udara

Terminologi (2)

- Link langsung (Direct link)
  - Tidak ada peralatan lanjutan
- Point-to-point
  - Direct link
  - Hanya dua peralatan yang berbagi link
- Multi-point
  - Lebih dari dua peralatan yang berbagi link

Terminologi (3)

- ⌘ Simplex
  - ⌃ Satu arah
    - ☒ Misalnya televisi
- ⌘ Half duplex
  - ⌃ Dua arah, namun bergantian di satu waktu
    - ☒ Misalnya radio polisi
- ⌘ Full duplex
  - ⌃ Dua arah dalam satu waktu
    - ☒ Misalnya telepon

Frekuensi, Spektrum dan Bandwidth

⌘ Konsep domain waktu

- ⌃ Sinyal kontinu (Continuous signal)
  - ☒ Beragam tingkatan dengan perubahan yang halus sepanjang waktu

- ⌃ Sinyal diskrit (Discrete signal)
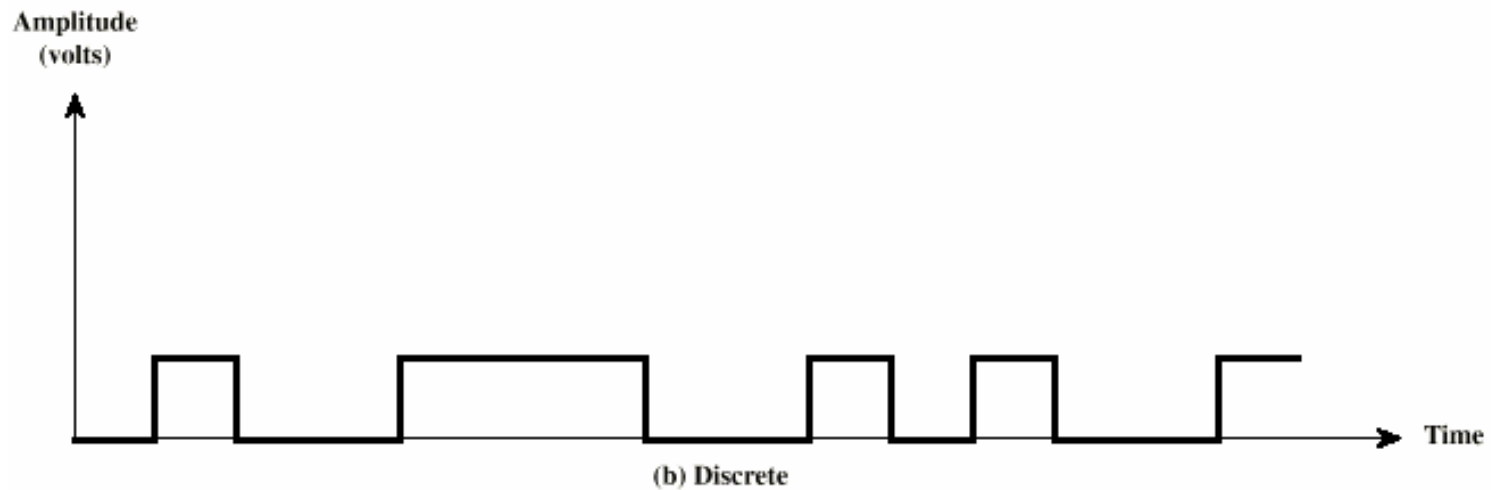 - ☒ Mempertahankan sebuah tingkatan konstanta dari perubahan tingkatan konstanta yang lain
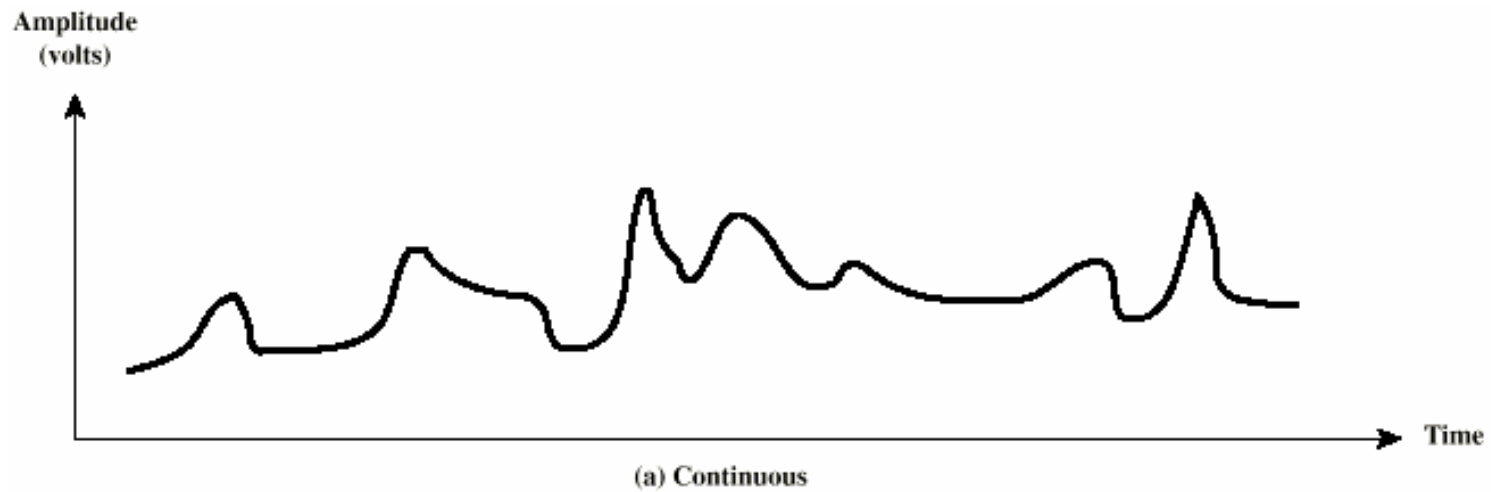
- ⌃ Sinyal periodik (Periodic signal)
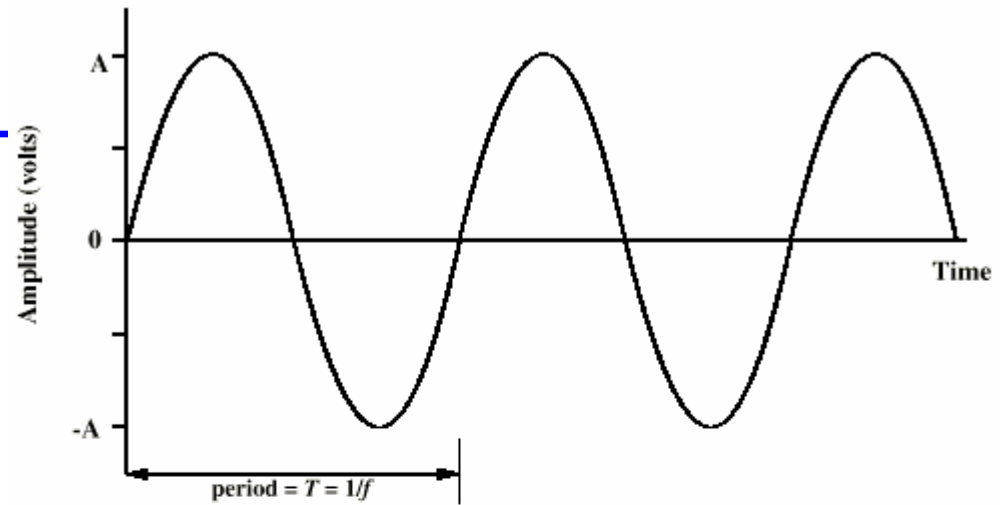 - ☒ Pola yang berulang pada sepanjang waktu yang teratur

- ⌃ Sinyal aperiodik (Aperiodic signal)
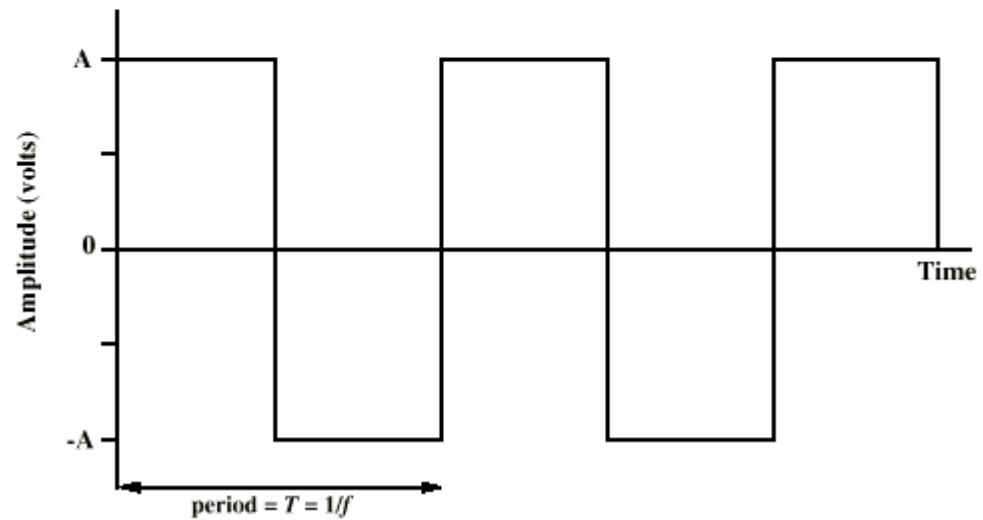 - ☒ Pola yang tidak berulang sepanjang waktu

Sinyal-sinyal Kontinu & Diskrit

Amplitude (volts)

Time

(a) Continuous

Amplitude (volts)

Time

(b) Discrete

Sinyal Periodik

(a) Sine wave

(b) Square wave

Gelombang Sinus

⌘ Amplitudo puncak 'Peak Amplitude (A)'
  ⌂ Kekuatan maksimum sinyal
  ⌂ volts

⌘ Frekuensi (f)
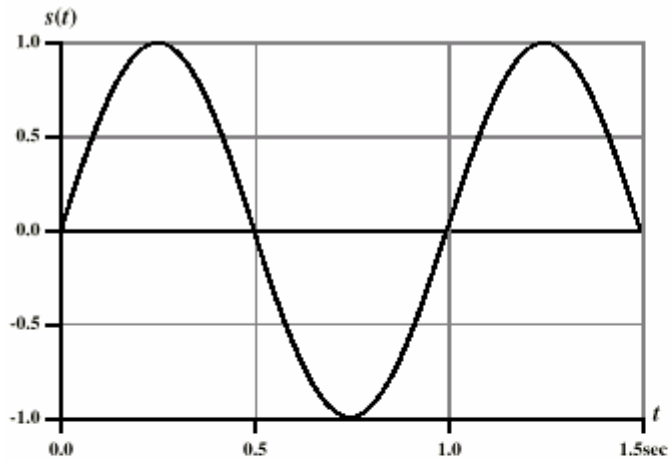 ⌂ Nilai dari perubahan sinyal
  ⌂ Hertz (Hz) atau siklus per detik
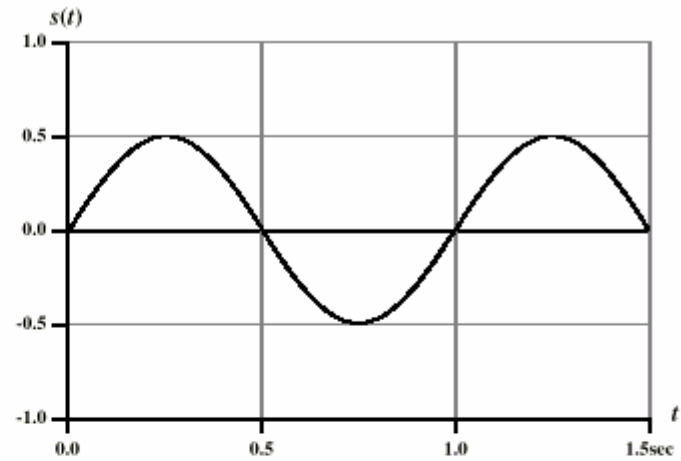 ⌂ Periode = waktu untuk satu perulangan (T)
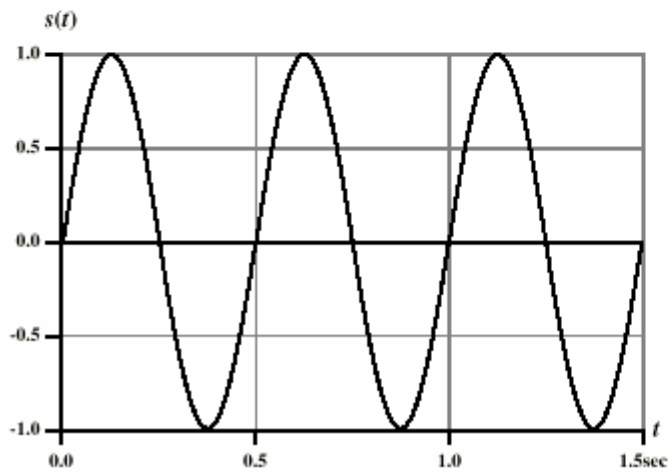 ⌂ T = 1/f

⌘ Fase (ϕ)
  ⌂ Posisi relatif dari waktu

Keragaman Gelombang Sinus
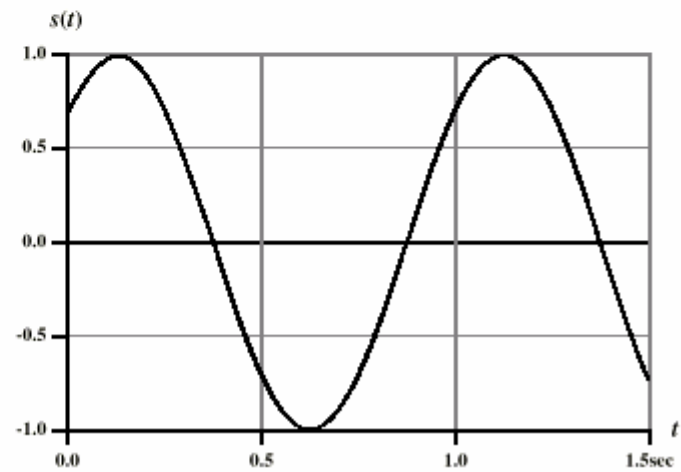

(a) A = 1, f = 1, φ = 0

(b) A = 0.5, f = 1, φ = 0

(c) A = 1, f = 2, φ = 0

(d) A = 1, f = 1, φ = π/4

Panjang Gelombang (Wavelength)

- ⌘ Jarak Distance occupied by one cycle
- ⌘ Distance between two points of corresponding phase in two consecutive cycles
- ⌘ λ
- ⌘ Assuming signal velocity v
  - $\lambda = vT$
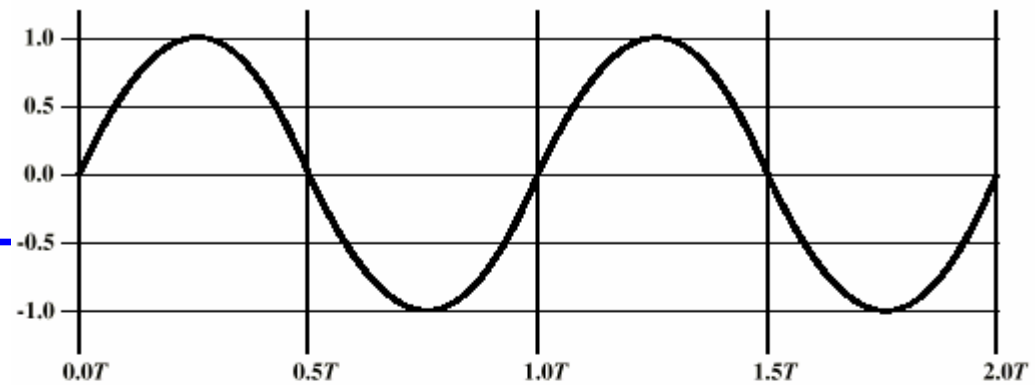 - $\lambda f = v$
  - $c = 3*10^8$ ms^{-1} (speed of light in free space)
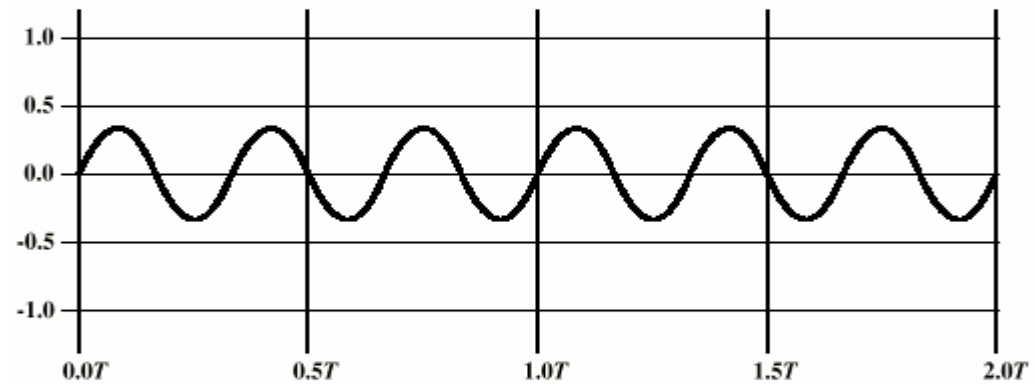
Frequency Domain Concepts

- ⌘ Signal usually made up of many frequencies
- ⌘ Components are sine waves
- ⌘ Can be shown (Fourier analysis) that any signal is made up of component sine waves
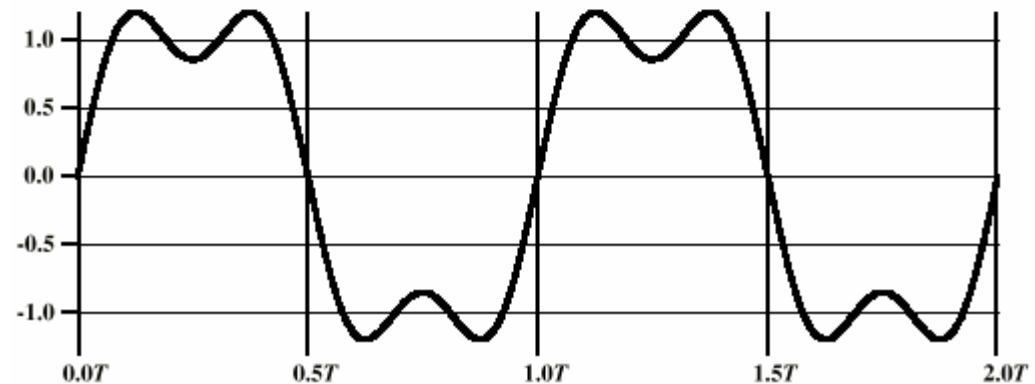- ⌘ Can plot frequency domain functions

Addition of Frequency Components

(a) $\sin(2\pi ft)$

(b) $(1/3)\sin(2\pi(3f)t)$

(c) $(4/\pi)[\sin(2\pi ft) + (1/3)\sin(2\pi(3f)t)]$

Frequency Domain
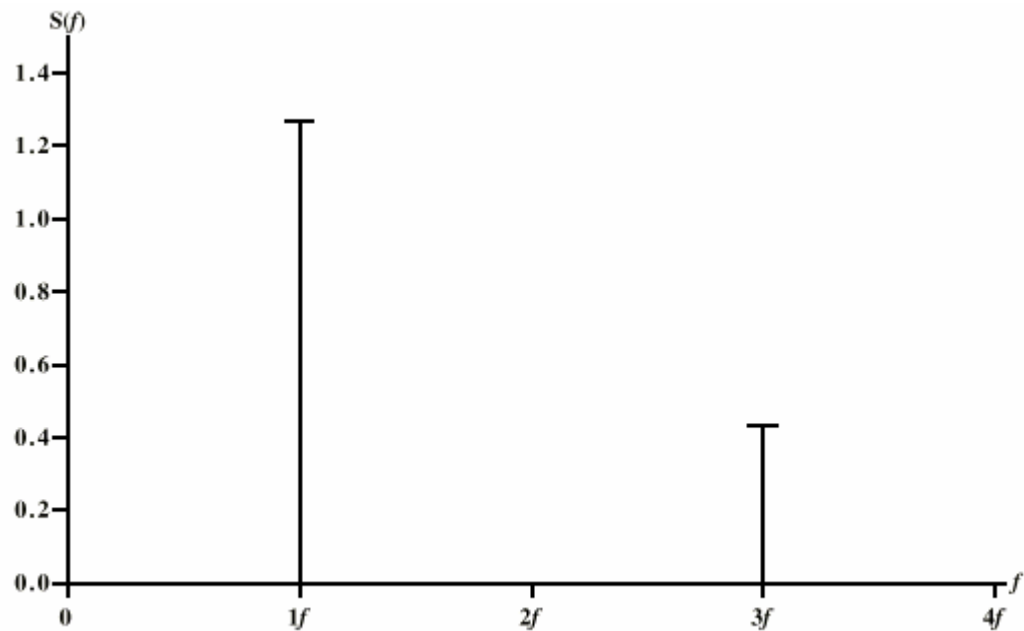
(a) $s(t) = (4/\pi)[\sin(2\pi ft) + (1/3)\sin(2\pi(3f)t)]$

(b) $s(t) = 1 \quad -X/2 < t < X/2$

13
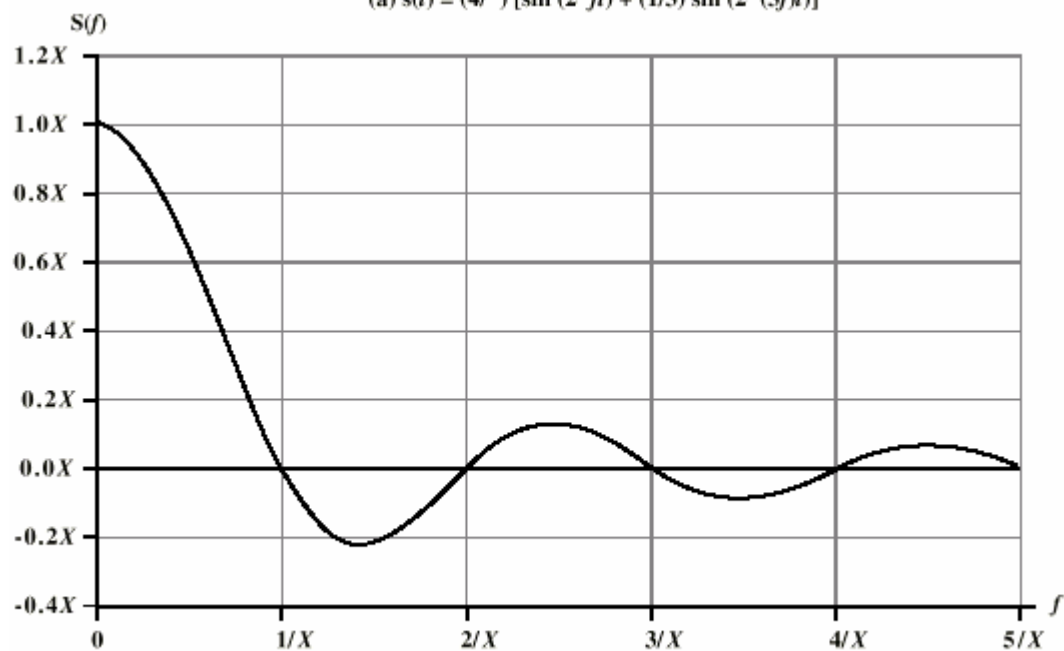
Spectrum & Bandwidth

⌘ Spectrum

⌂ range of frequencies contained in signal

⌘ Absolute bandwidth

⌂ width of spectrum

⌘ Effective bandwidth

⌂ Often just *bandwidth*

⌂ Narrow band of frequencies containing most of the energy

⌘ DC Component

⌂ Component of zero frequency

Signal with DC Component
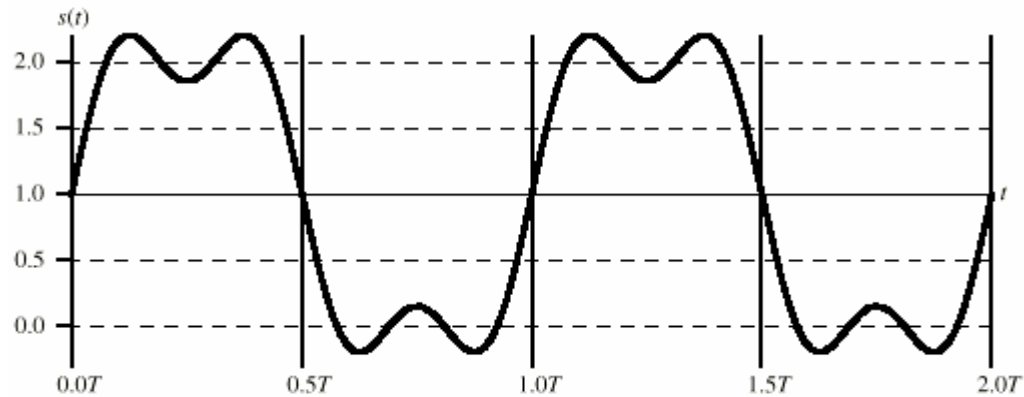
(a) $s(t) = 1 + (4/\pi) [\sin (2\pi ft) + (1/3) \sin (2\pi (3f)t)]$
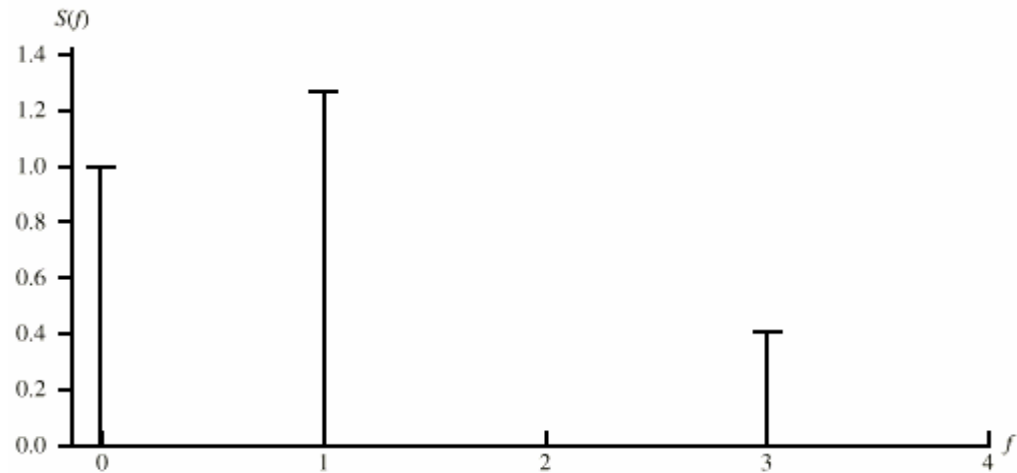
(b) S(f)

Data Rate and Bandwidth

- Any transmission system has a limited band of frequencies

- This limits the data rate that can be carried

Analog and Digital Data Transmission

- ⌘ Data
  - ⬔ Entities that convey meaning
- ⌘ Signals
  - ⬔ Electric or electromagnetic representations of data
- ⌘ Transmission
  - ⬔ Communication of data by propagation and processing of signals

Data

- Analog
  - Continuous values within some interval
  - e.g. sound, video
- Digital
  - Discrete values
  - e.g. text, integers

Acoustic Spectrum (Analog)
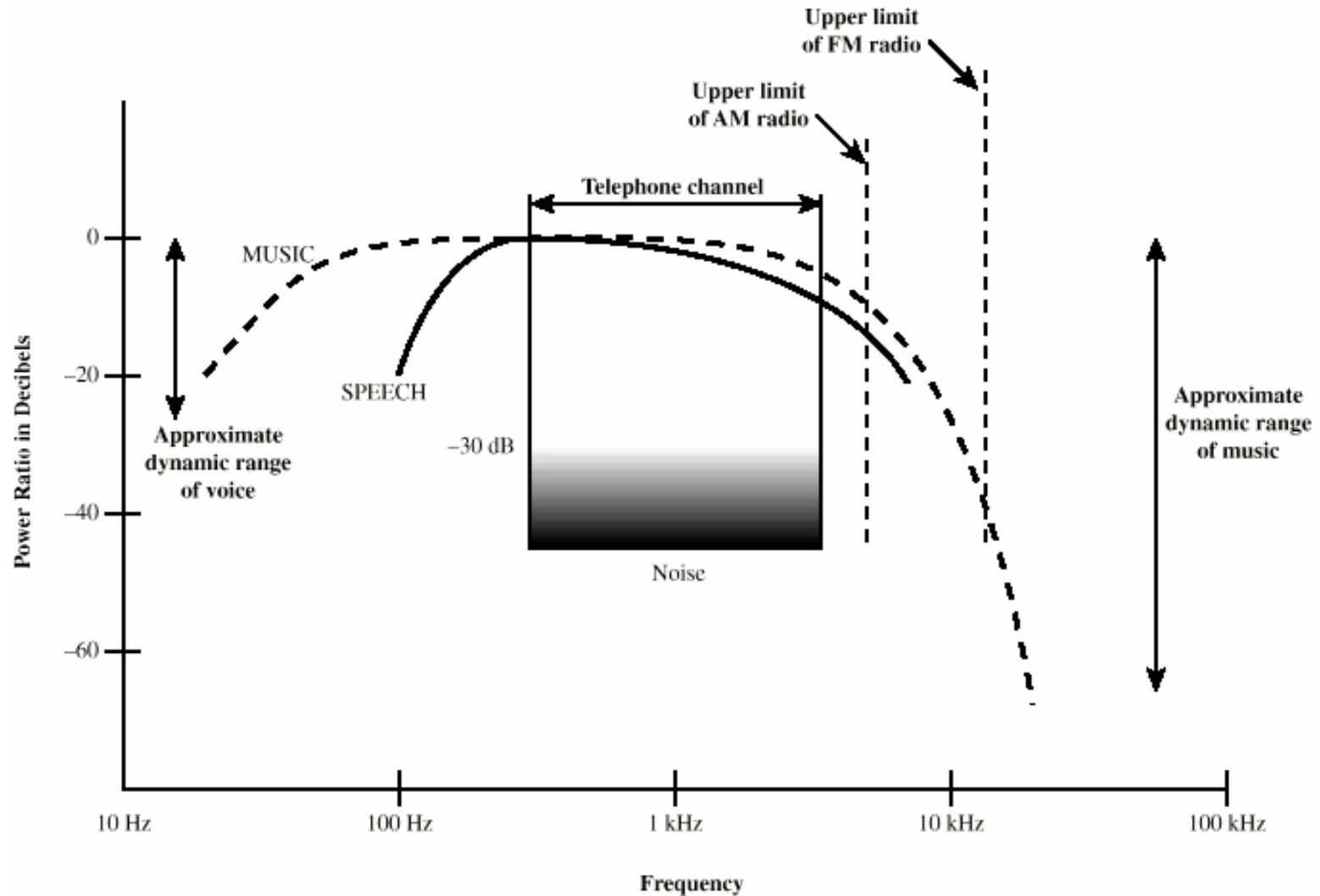
Signals

- ⌘ Means by which data are propagated
- ⌘ Analog
  - ⌃ Continuously variable
  - ⌃ Various media
    - ☒ wire, fiber optic, space
  - ⌃ Speech bandwidth 100Hz to 7kHz
  - ⌃ Telephone bandwidth 300Hz to 3400Hz
  - ⌃ Video bandwidth 4MHz
- ⌘ Digital
  - ⌃ Use two DC components

Data and Signals

- ⌘ Usually use digital signals for digital data and analog signals for analog data

- ⌘ Can use analog signal to carry digital data
  - ⌃ Modem

- ⌘ Can use digital signal to carry analog data
  - ⌃ Compact Disc audio

Analog Signals Carrying Analog and Digital Data

Analog Signals: Represent data with continuously
varying electromagnetic wave

Analog Data
(voice sound waves) → Telephone → Analog Signal

Digital Data
(binary voltage pulses) → Modem → Analog Signal
(modulated on
carrier frequency)
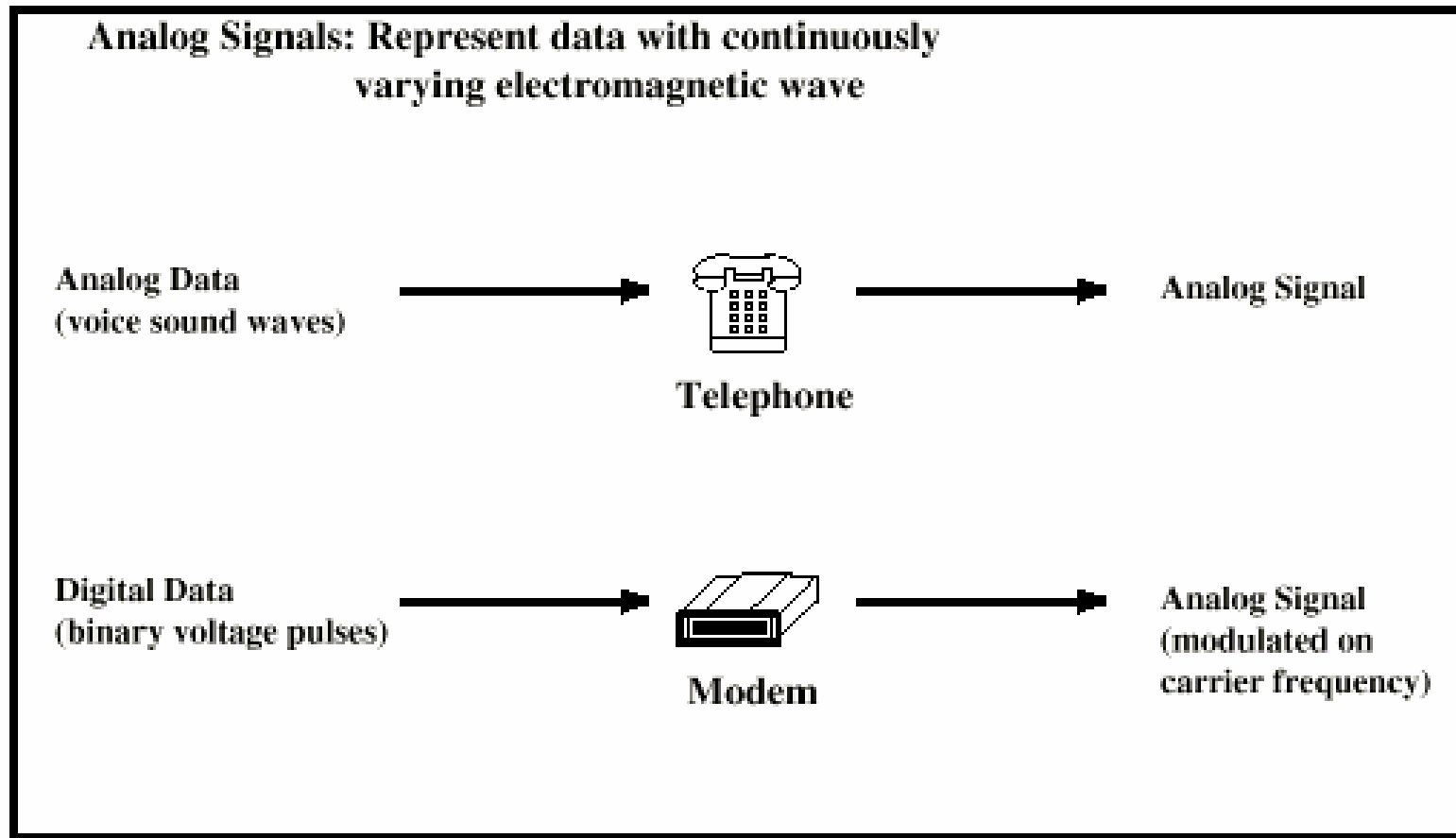
Digital Signals Carrying Analog and Digital Data

Digital Signals: Represent data with sequence of voltage pulses

Analog Signal → CODEC → Digital Signal

Digital Data → Digital Transmitter → Digital Signal
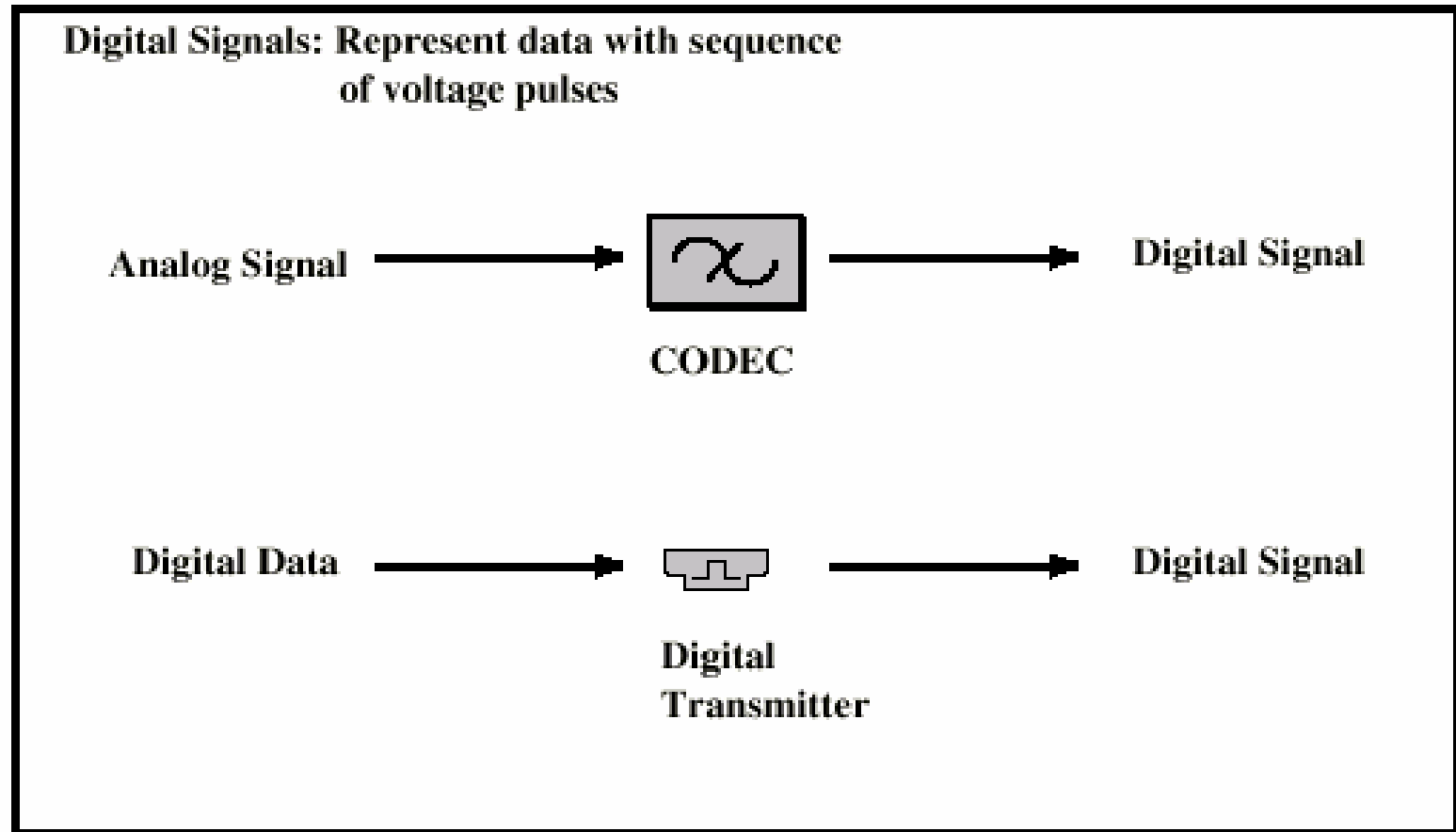
Analog Transmission

- Analog signal transmitted without regard to content
- May be analog or digital data
- Attenuated over distance
- Use amplifiers to boost signal
- Also amplifies noise

Digital Transmission

- ⌘ Concerned with content
- ⌘ Integrity endangered by noise, attenuation etc.
- ⌘ Repeaters used
- ⌘ Repeater receives signal
- ⌘ Extracts bit pattern
- ⌘ Retransmits
- ⌘ Attenuation is overcome
- ⌘ Noise is not amplified

Advantages of Digital Transmission

- ✤ Digital technology
  - ⌂ Low cost LSI/VLSI technology
- ✤ Data integrity
  - ⌂ Longer distances over lower quality lines
- ✤ Capacity utilization
  - ⌂ High bandwidth links economical
  - ⌂ High degree of multiplexing easier with digital techniques
- ✤ Security & Privacy
  - ⌂ Encryption
- ✤ Integration
  - ⌂ Can treat analog and digital data similarly

Transmission Impairments

- ⌘ Signal received may differ from signal transmitted
- ⌘ Analog - degradation of signal quality
- ⌘ Digital - bit errors
- ⌘ Caused by
  - ⌃ Attenuation and attenuation distortion
  - ⌃ Delay distortion
  - ⌃ Noise

Attenuation

- ⌘ Signal strength falls off with distance

- ⌘ Depends on medium

- ⌘ Received signal strength:
  - ⌂ must be enough to be detected
  - ⌂ must be sufficiently higher than noise to be received without error

- ⌘ Attenuation is an increasing function of frequency

Delay Distortion

- ⌘ Only in guided media
- ⌘ Propagation velocity varies with frequency

Noise (1)

- ⌘ 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 (2)

⌘ Crosstalk

⬡ A signal from one line is picked up by another

⌘ Impulse

⬡ Irregular pulses or spikes

⬡ e.g. External electromagnetic interference

⬡ Short duration

⬡ High amplitude

Channel Capacity

⌘ Data rate

⬆ In bits per second

⬆ Rate at which data can be communicated

⌘ Bandwidth

⬆ In cycles per second of Hertz

⬆ Constrained by transmitter and medium

Required Reading

⌘ Stallings chapter 3