Signals

รศ.ดร. อนันต์ ผลเพิ่ม

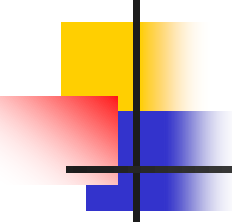## Asso. Prof. Anan Phonphoem, Ph.D.

anan.p@ku.ac.th

http://www.cpe.ku.ac.th/~anan

Computer Engineering Department

Kasetsart University, Bangkok, Thailand

TCP/IP Protocol Suite
(Internet Model)

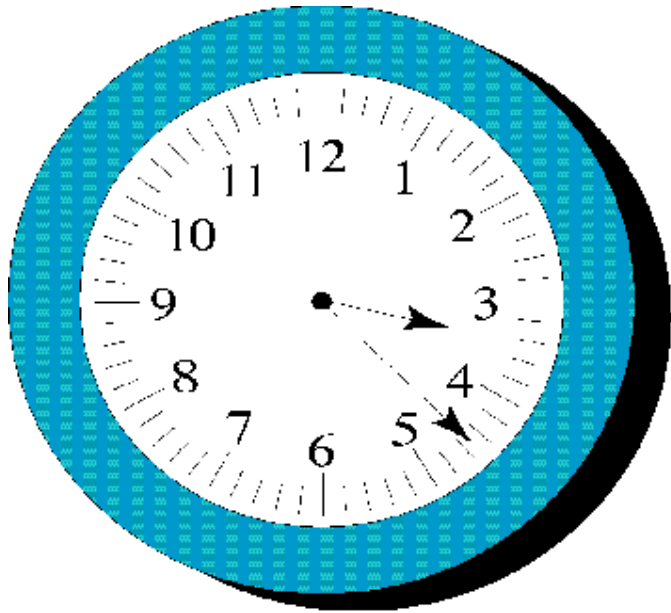|		
5	**Applications**	User service and interface
4	**Transport**	Process delivery + Error (TCP/UDP) Reliable end-to-end (whole message)
3	**Network**	Move packets from source to destination Packet end-to-end (across network)
2	**Data Link**	Provide frames Node-to-node (same network segment)
1	**Physical**	Transmission bit streams (mechanical and electrical spec)

Outline

- Analog and Digital
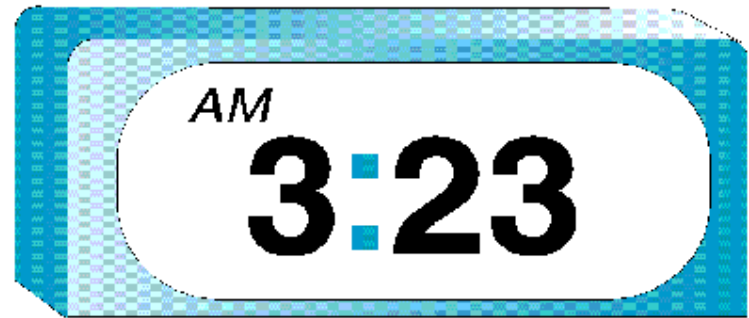- Periodic and Aperiodic signals
- Analog Signals
- Digital Signals
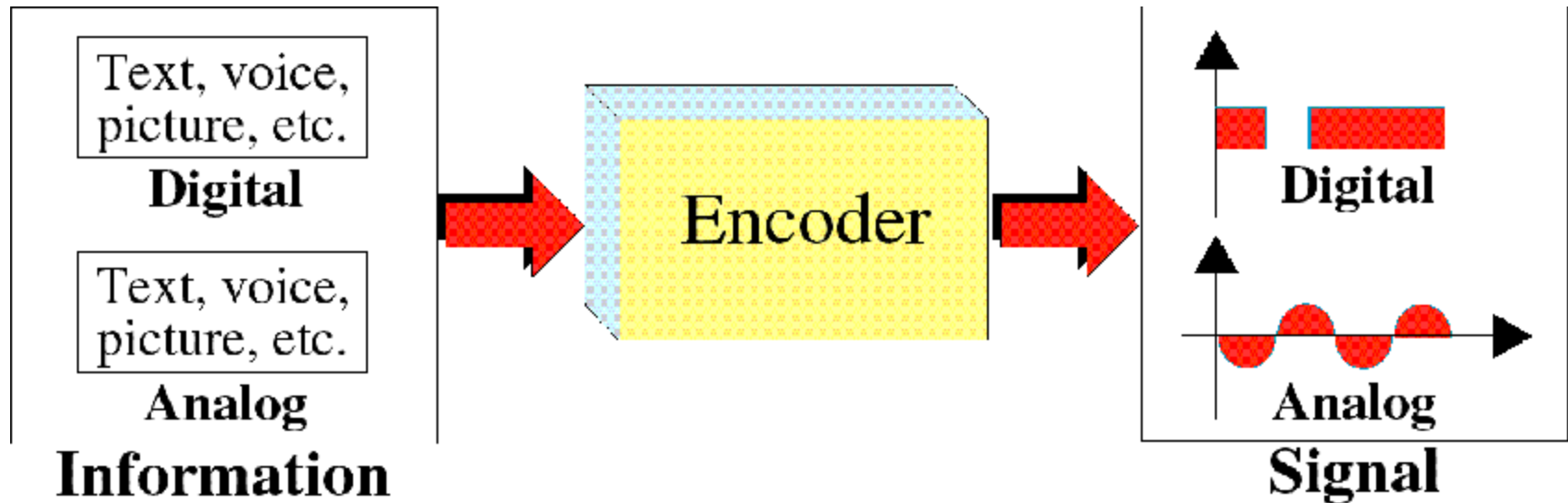
Analog and Digital

a. Analog

b. Digital
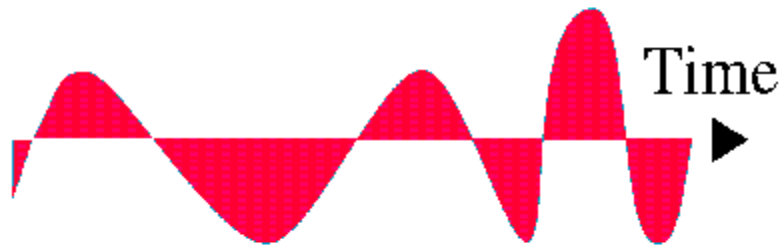
4

Analog and Digital

- Definition
  - Analog – continuous
  - Digital – discrete
- Data
  - Analog Data – voice
  - Digital Data – 010101
- Signals
  - Analog Signal – Wave form changes over time
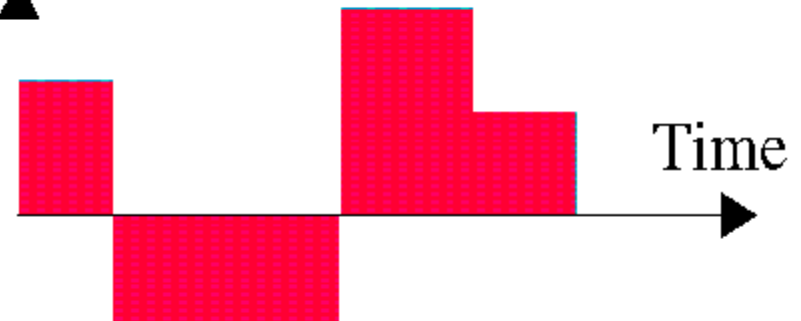 - Digital Signal – Limited value (e.g.,0 and 1)

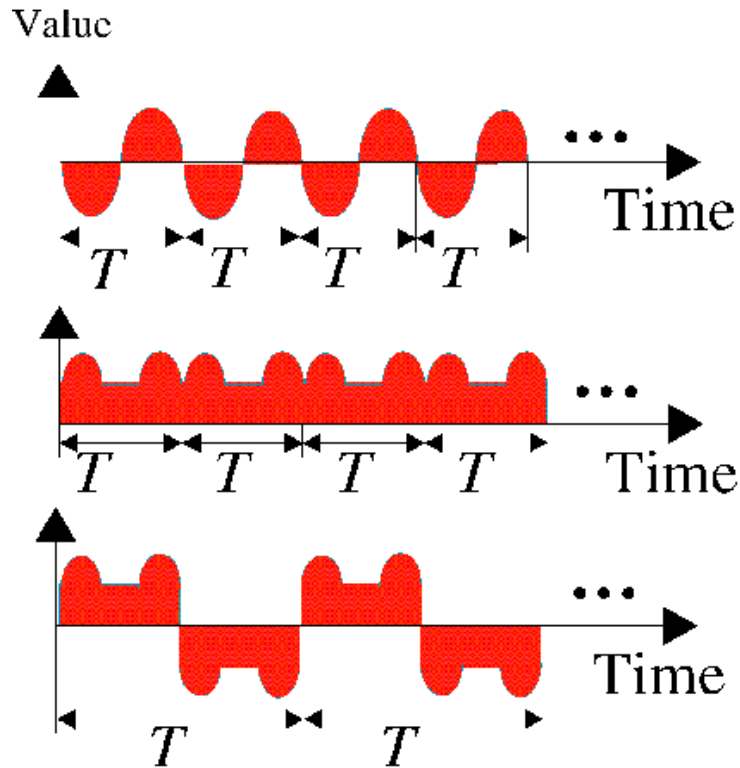# Transformation (Data → Signal)
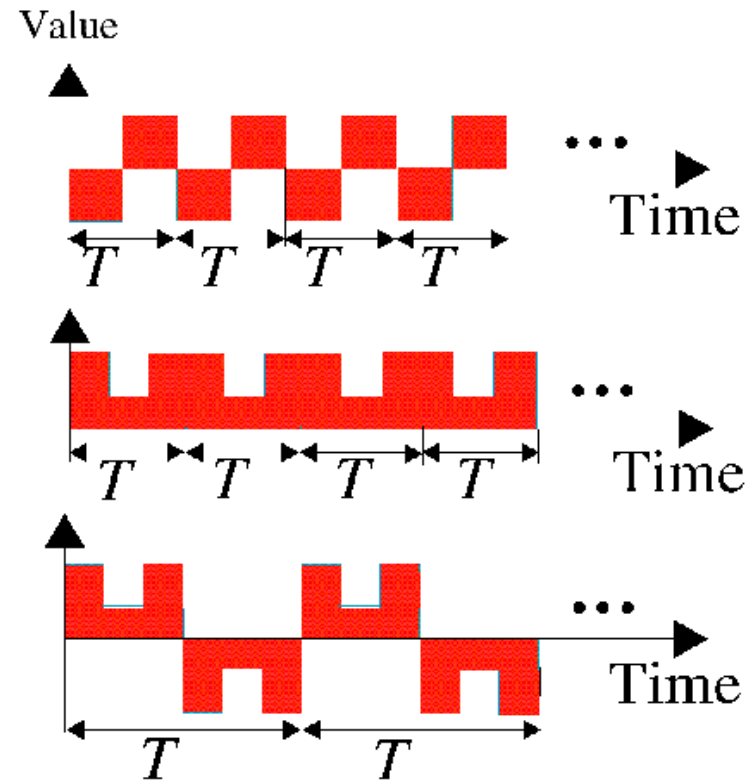
Analog and digital signal

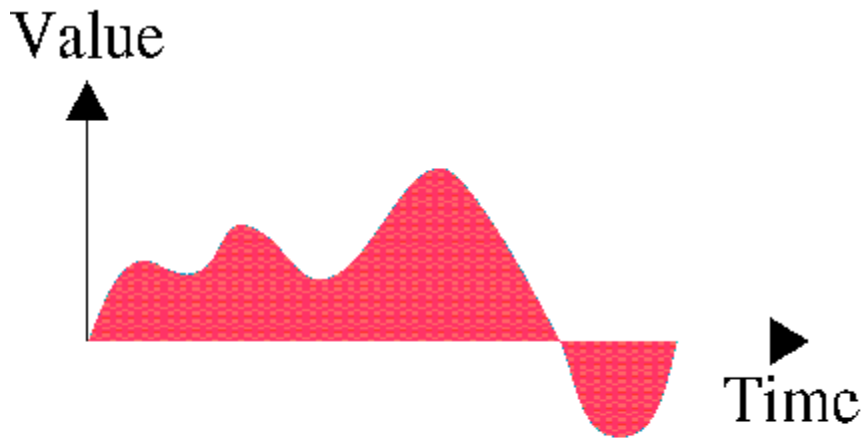a. Analog signal

b. Digital signal

Periodic Signals (Period – T)

a. Analog

b. Digital
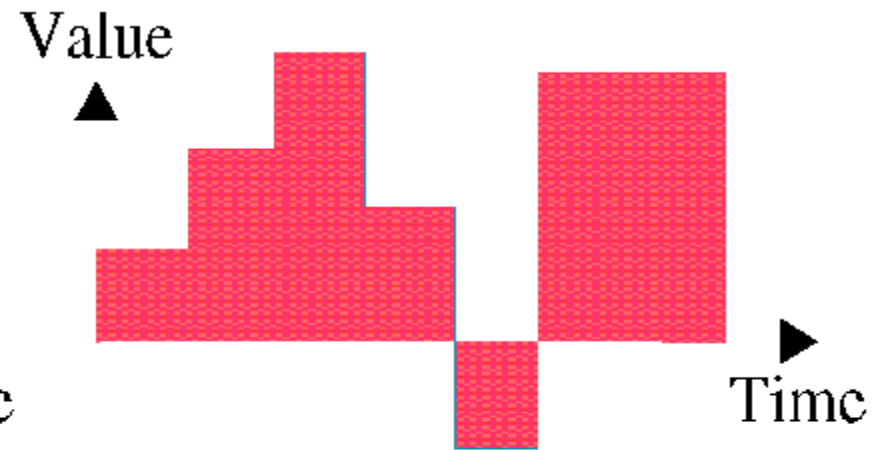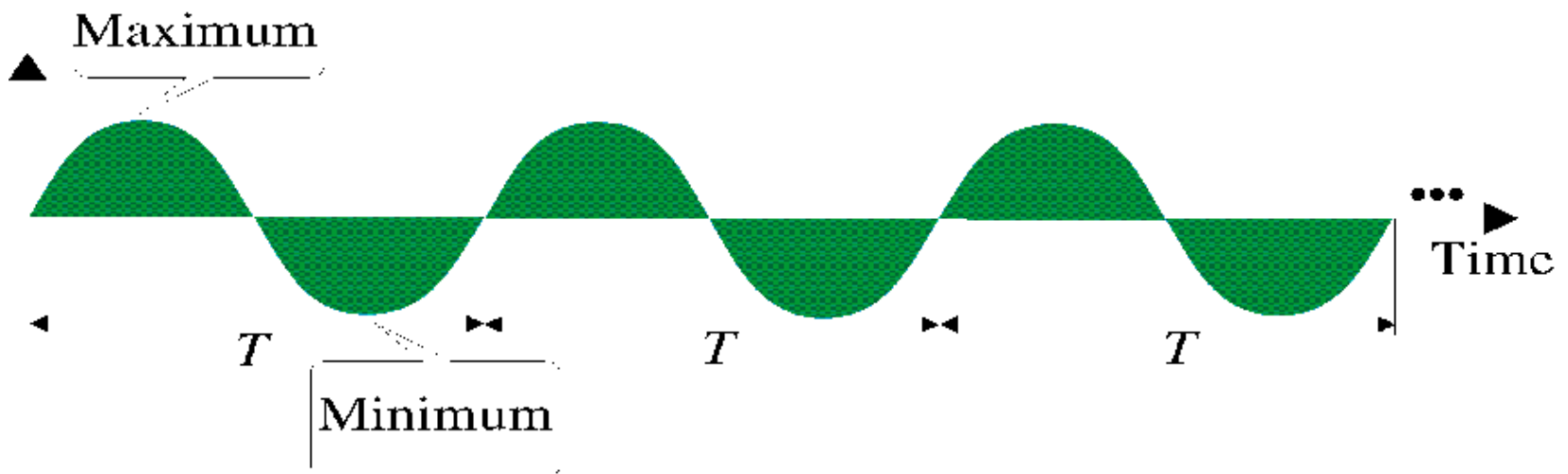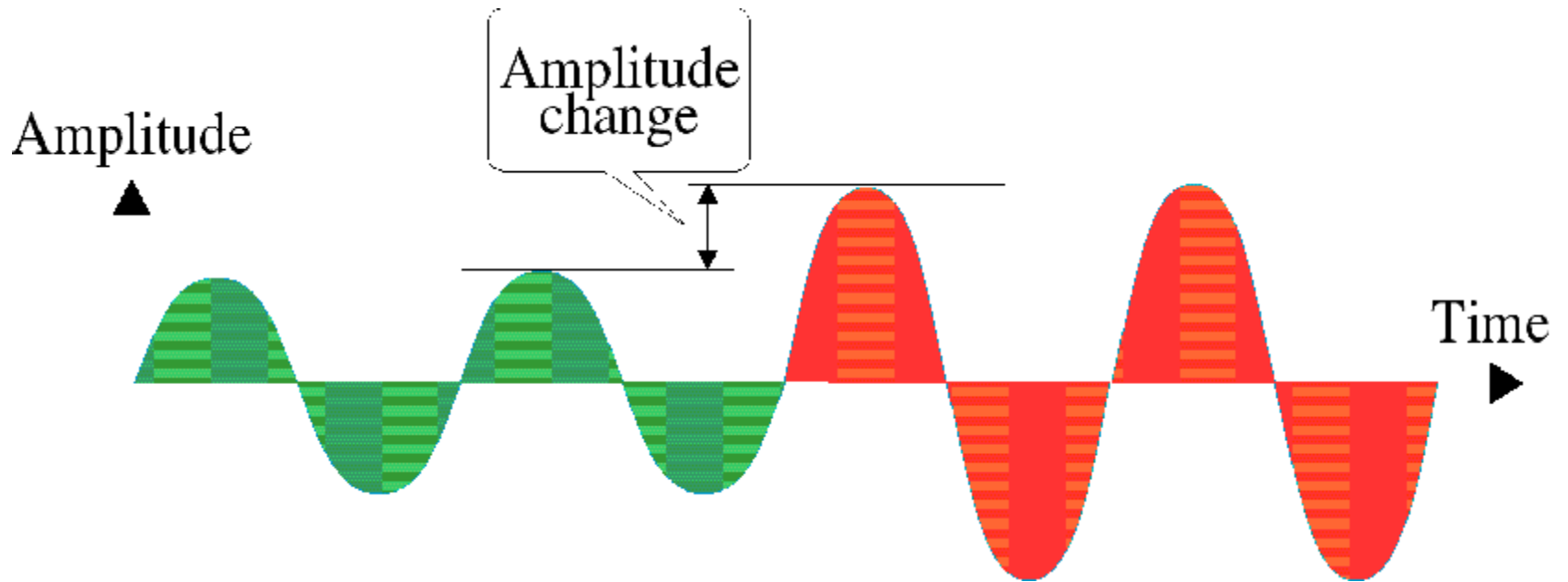
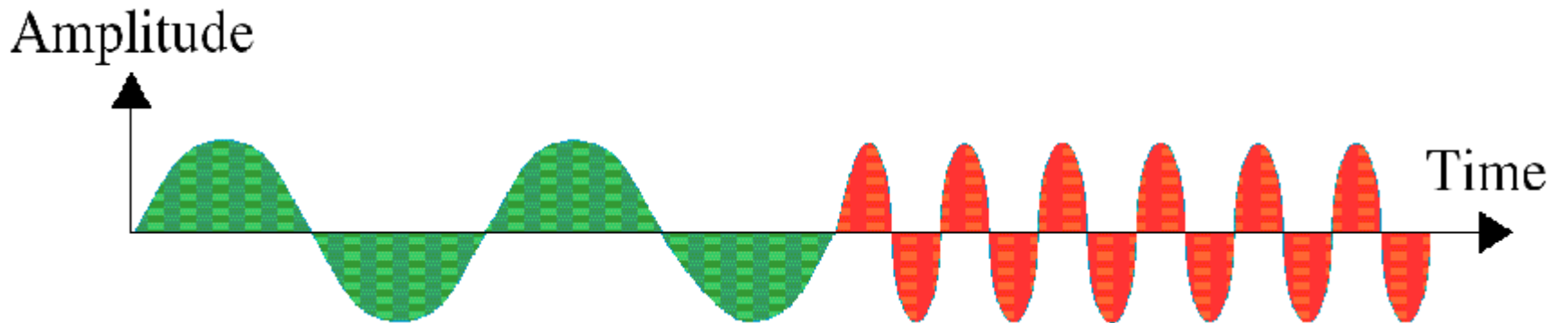# Aperiodic Signals

a. Analog

b. Digital

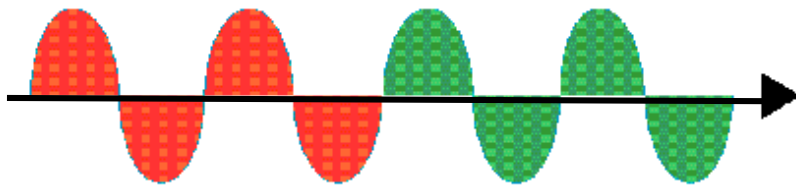# Analog Signals

* Amplitude
* Frequency
* Phase
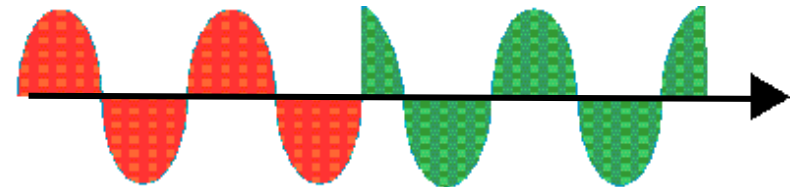
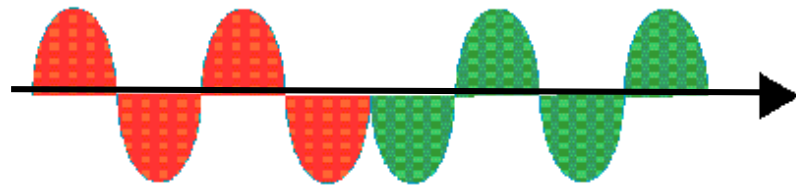$$T = 1/F$$

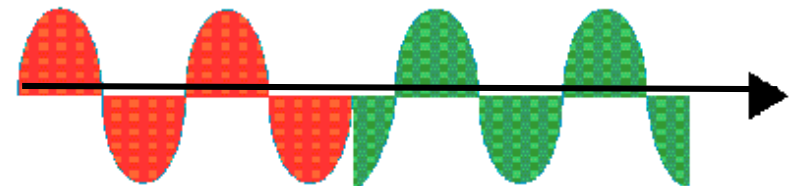# Amplitude Change

Frequency Change

Phase Change

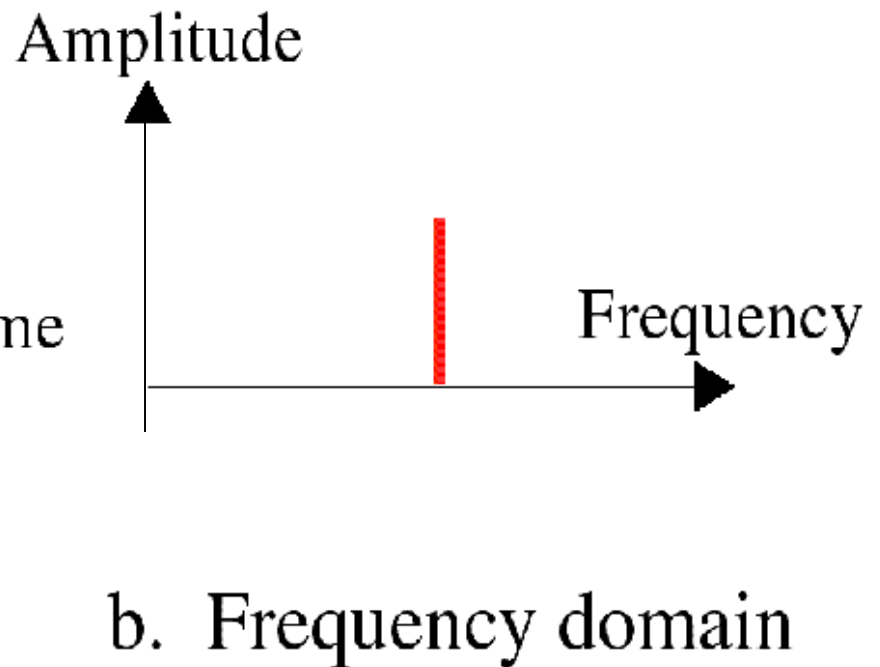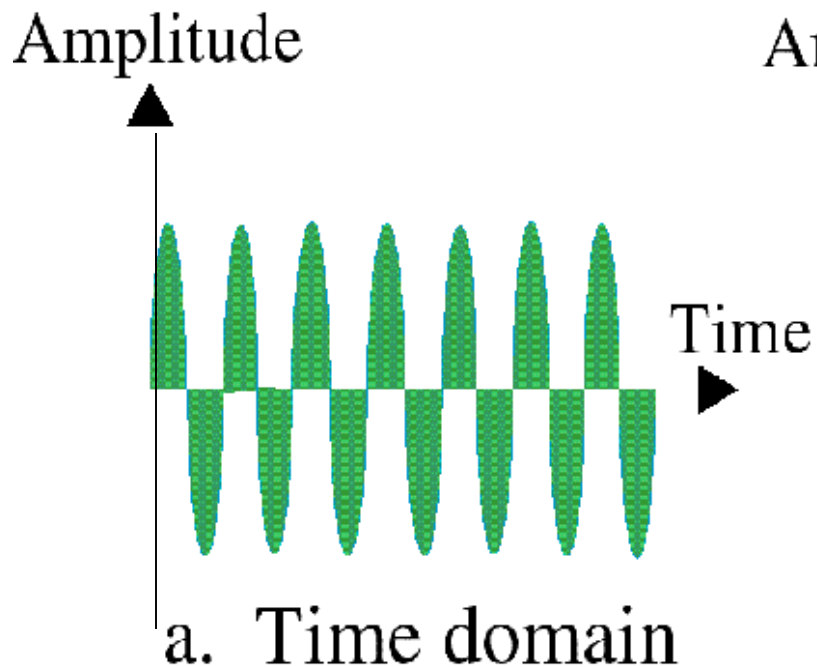a. No phase change
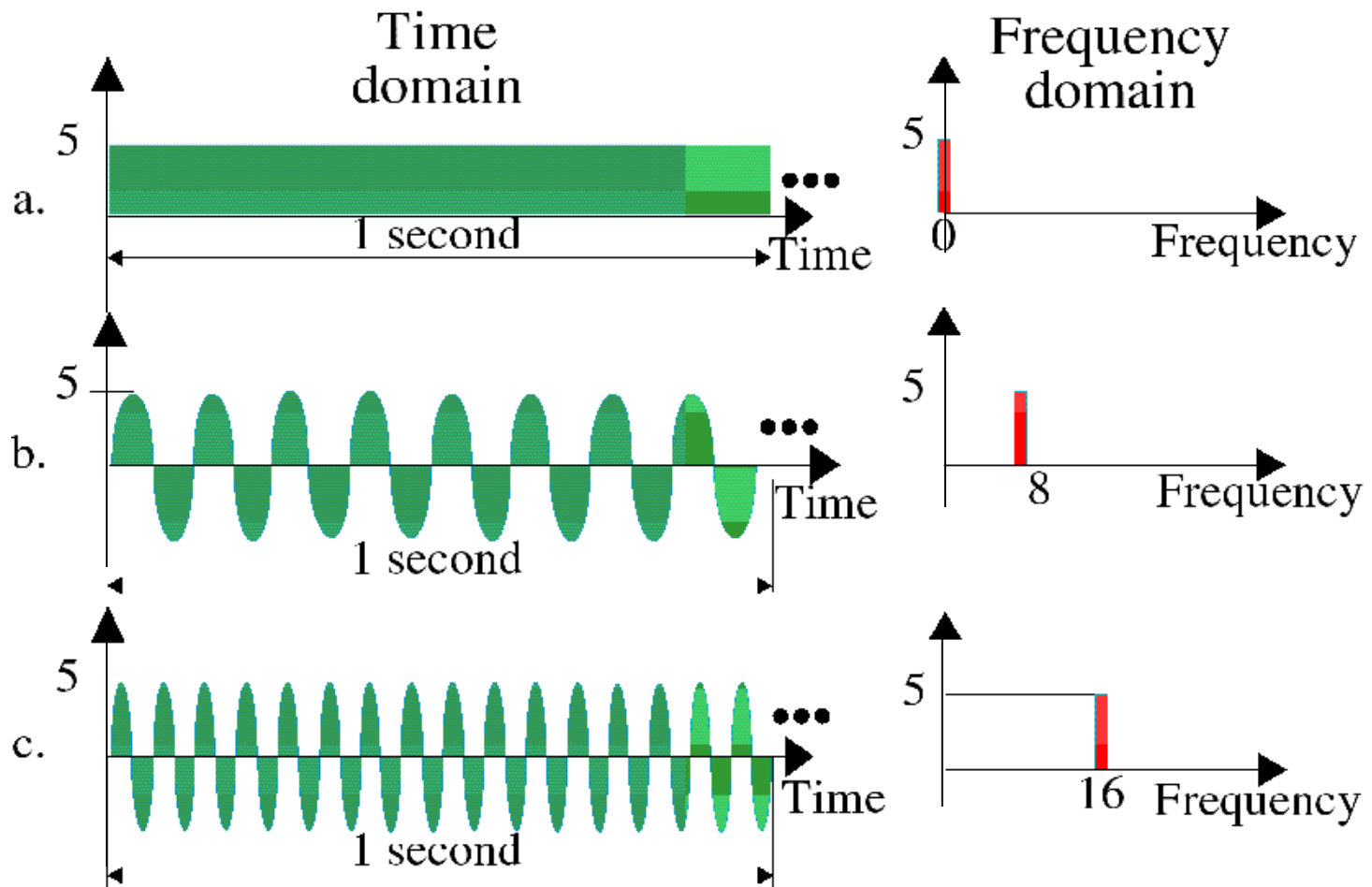
b. 90 degree phase change
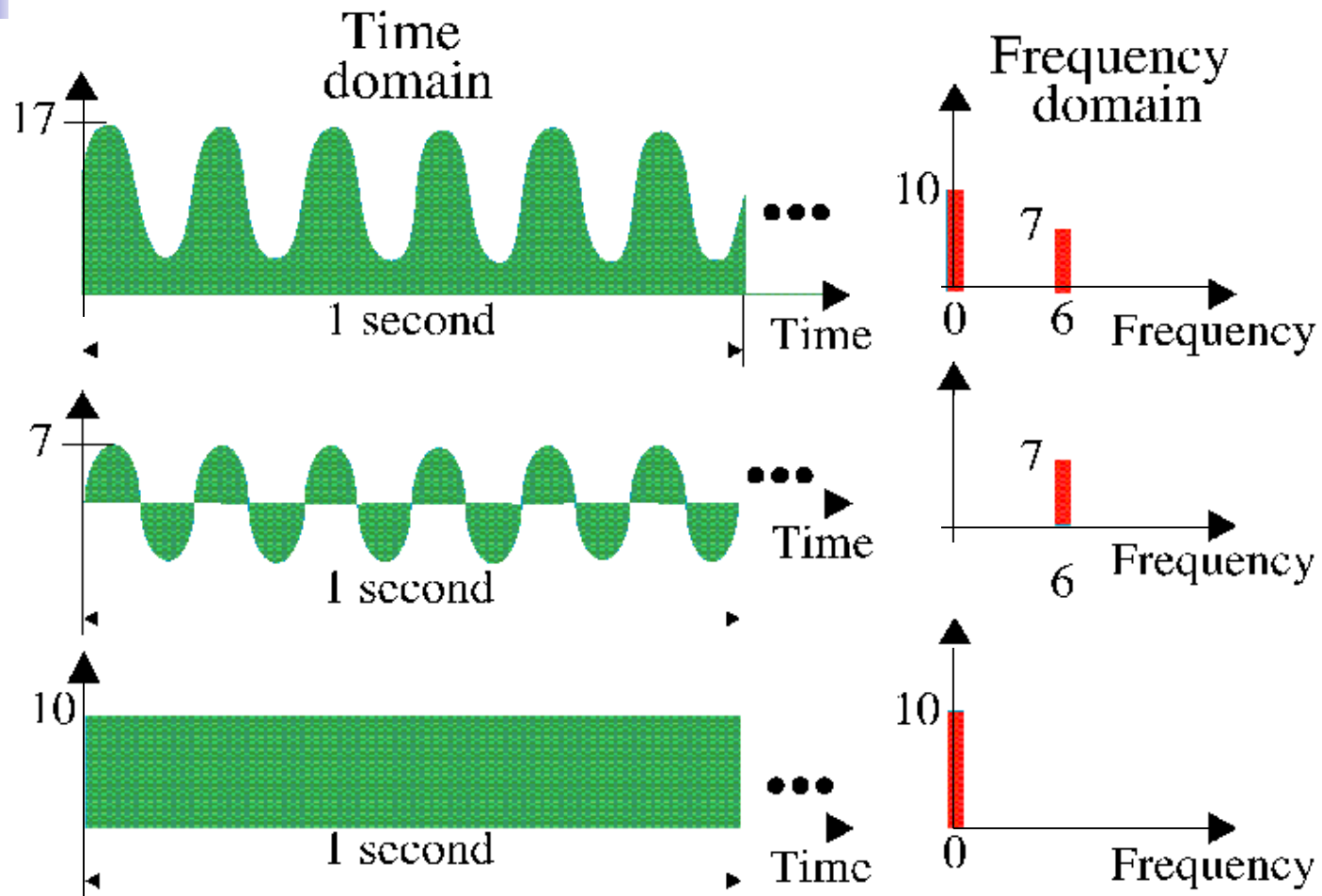
c. 180 degree phase change

d. 270 degree phase change

Time and Frequency Domain

a. Time domain
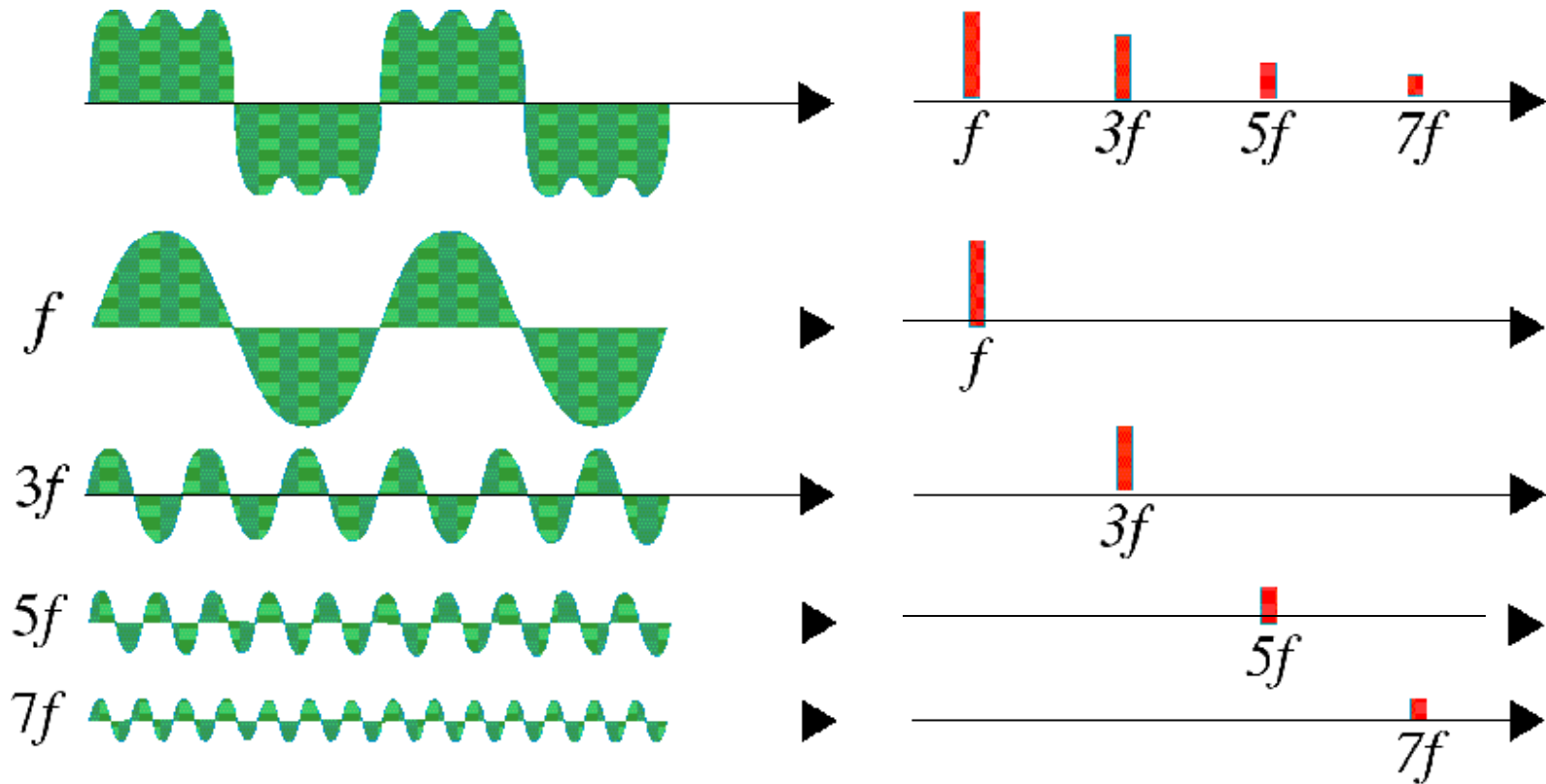
b. Frequency domain

Time and Frequency domain

Composite Signals

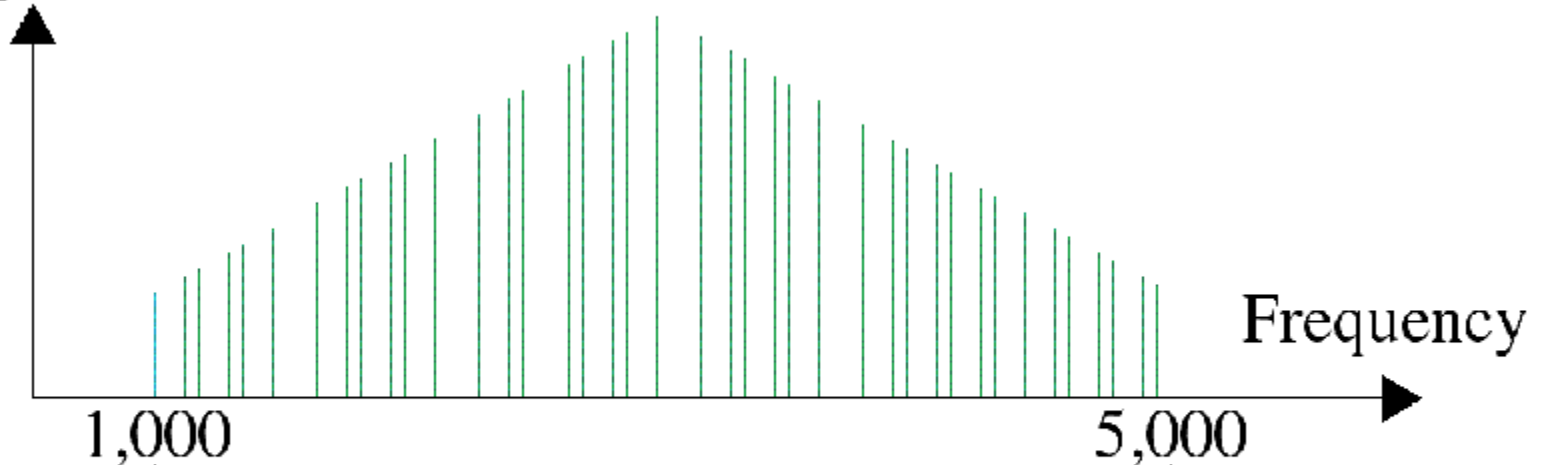# Composite Waveform (Square)

a. Time domain

b. Frequency domain

Frequency Spectrum and Bandwidth

- Frequency Spectrum of a signal
    - Collection of all the component frequencies of the signal
- Bandwidth of a signal
    - The width of the frequency spectrum

Bandwidth

Amplitude

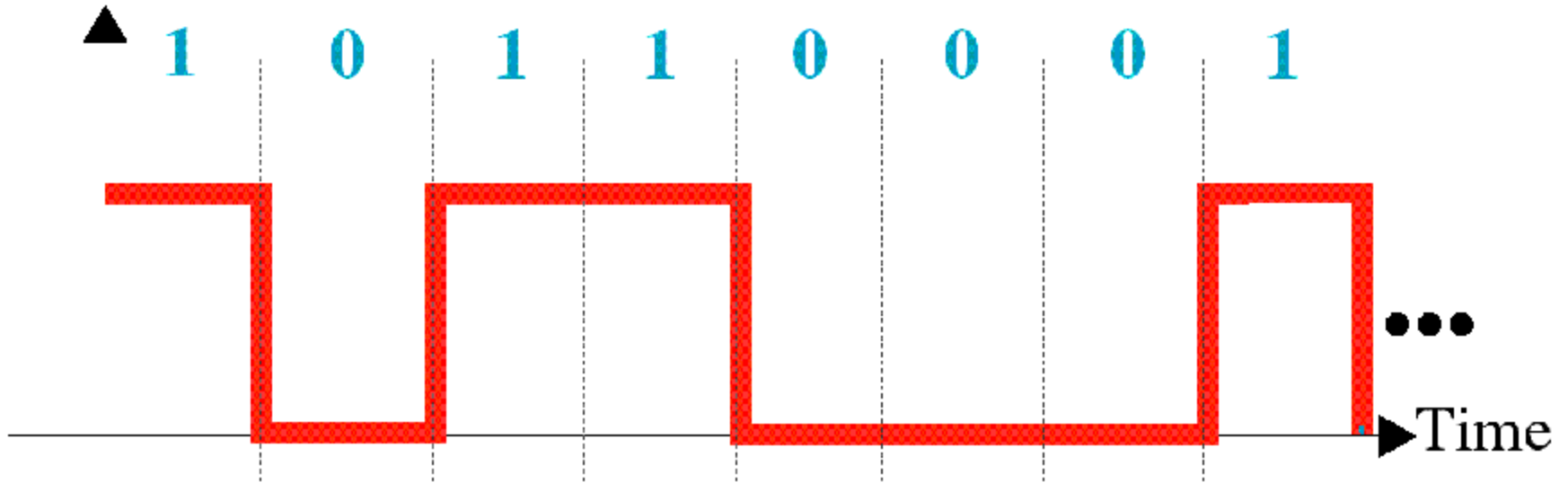Frequency

1,000   5,000

Bandwidth = 5,000 − 1,000 =
4,000 Hz
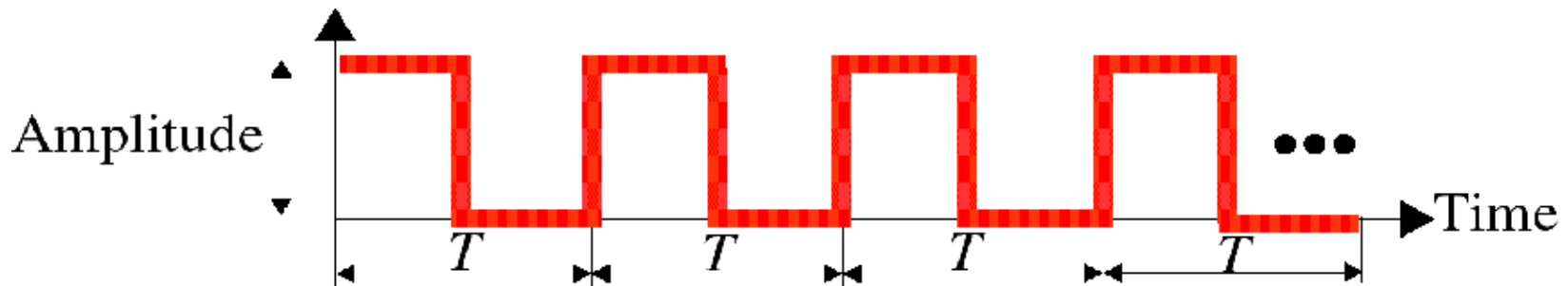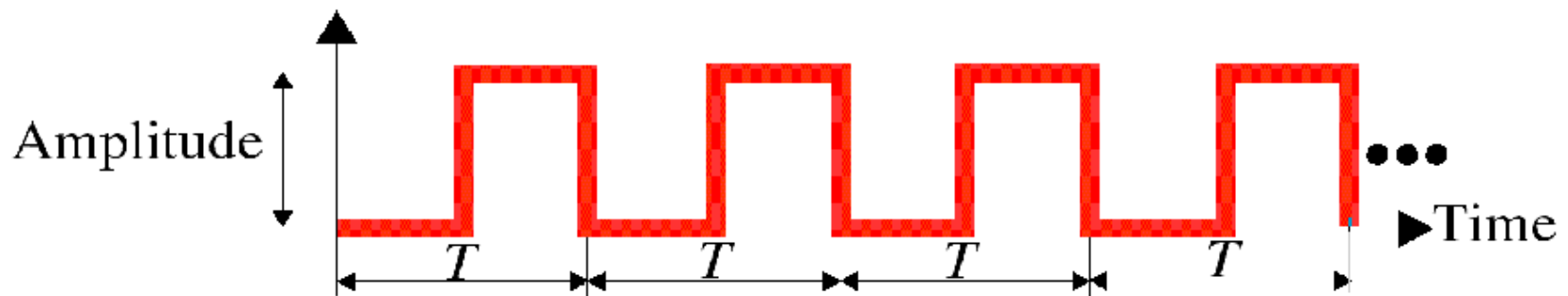
Digital Signals

Amplitude, Period, and Phase for a Digital Signal
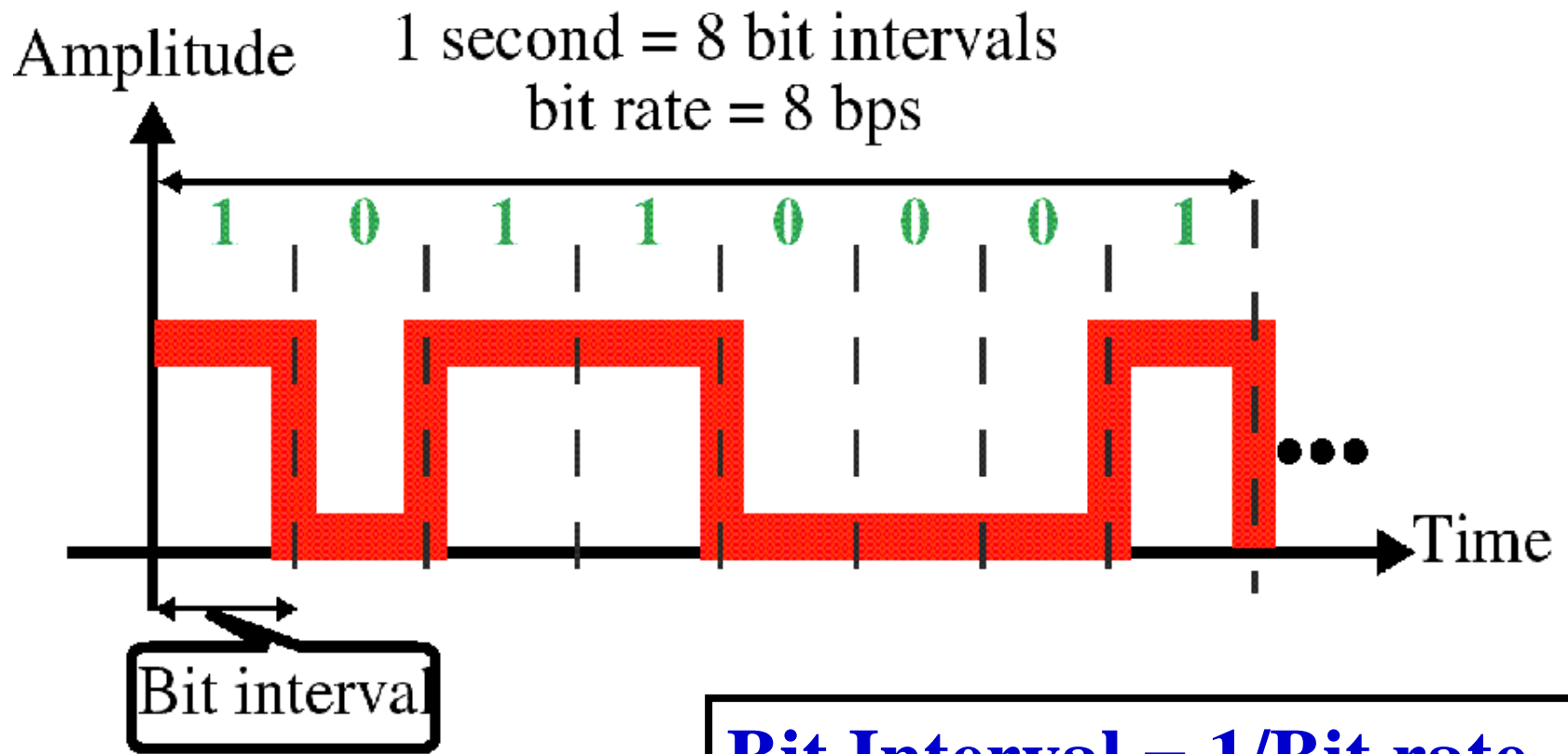

a. No phase shift

b. 180 degree phase shift

Bit Rate and Bit Interval

Amplitude

1 second = 8 bit intervals
bit rate = 8 bps

1   0   1   1   0   0   0   1

Bit interval

Time

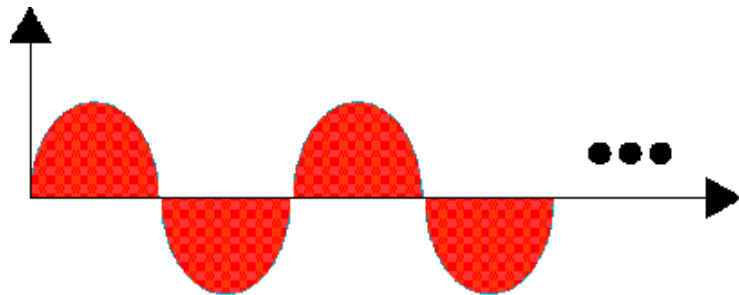**Bit Interval = 1/Bit rate**

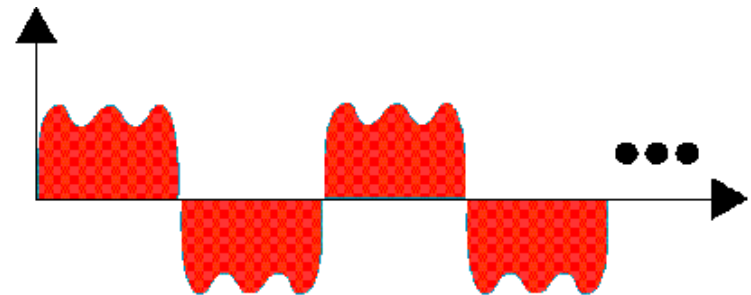# Composite Waveform (Square)

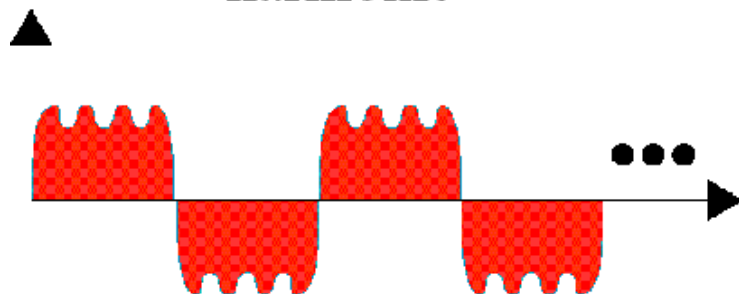

a. Time domain

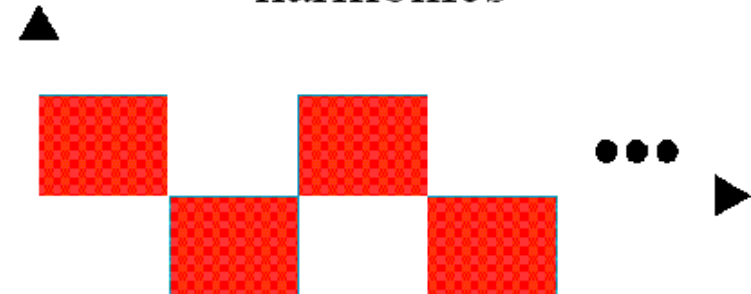b. Frequency domain

Harmonics of a digital signal

a. Only first harmonic

b. First, third, and fifth harmonics

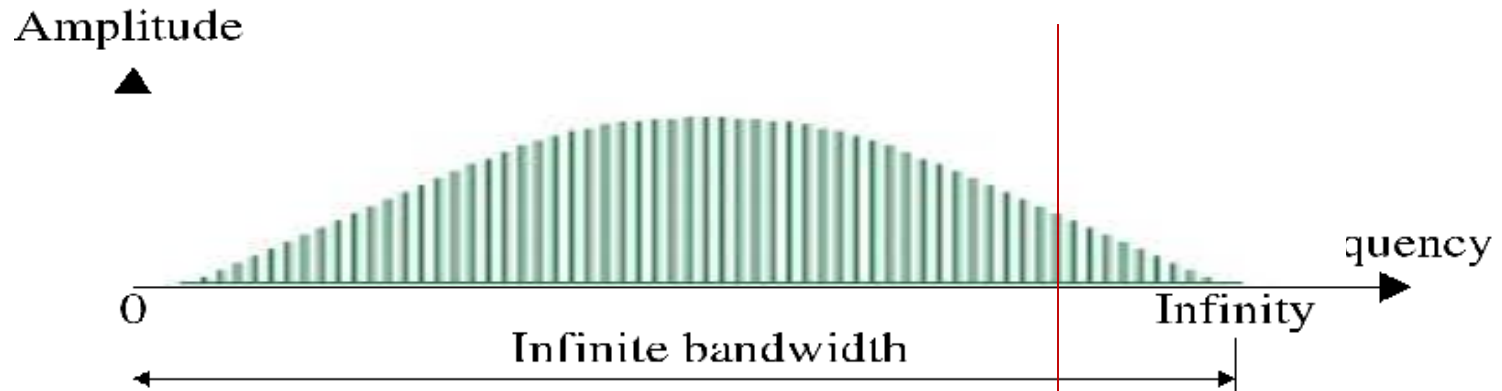c. First, third, fifth, and seventh harmonics

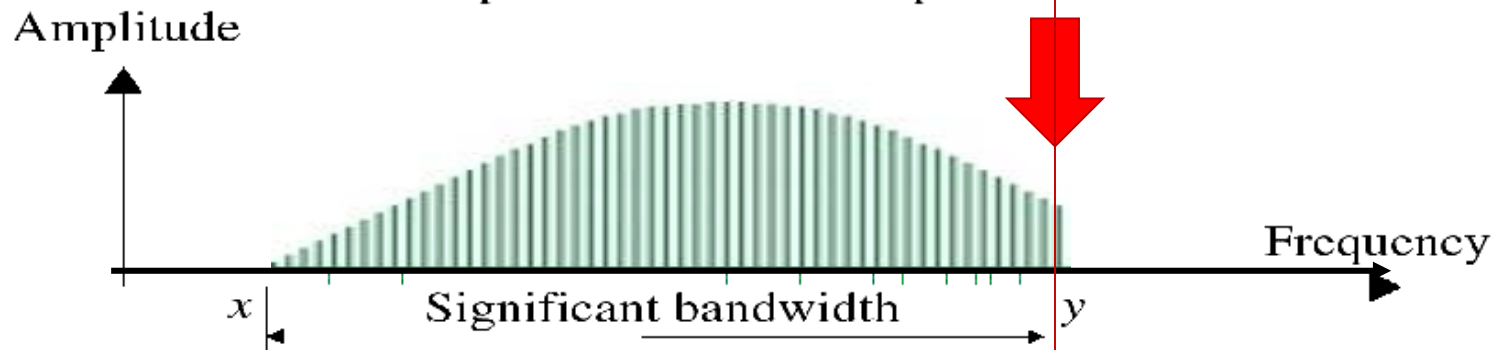d. Infinite number of harmonics

Exact and Significant spectrums
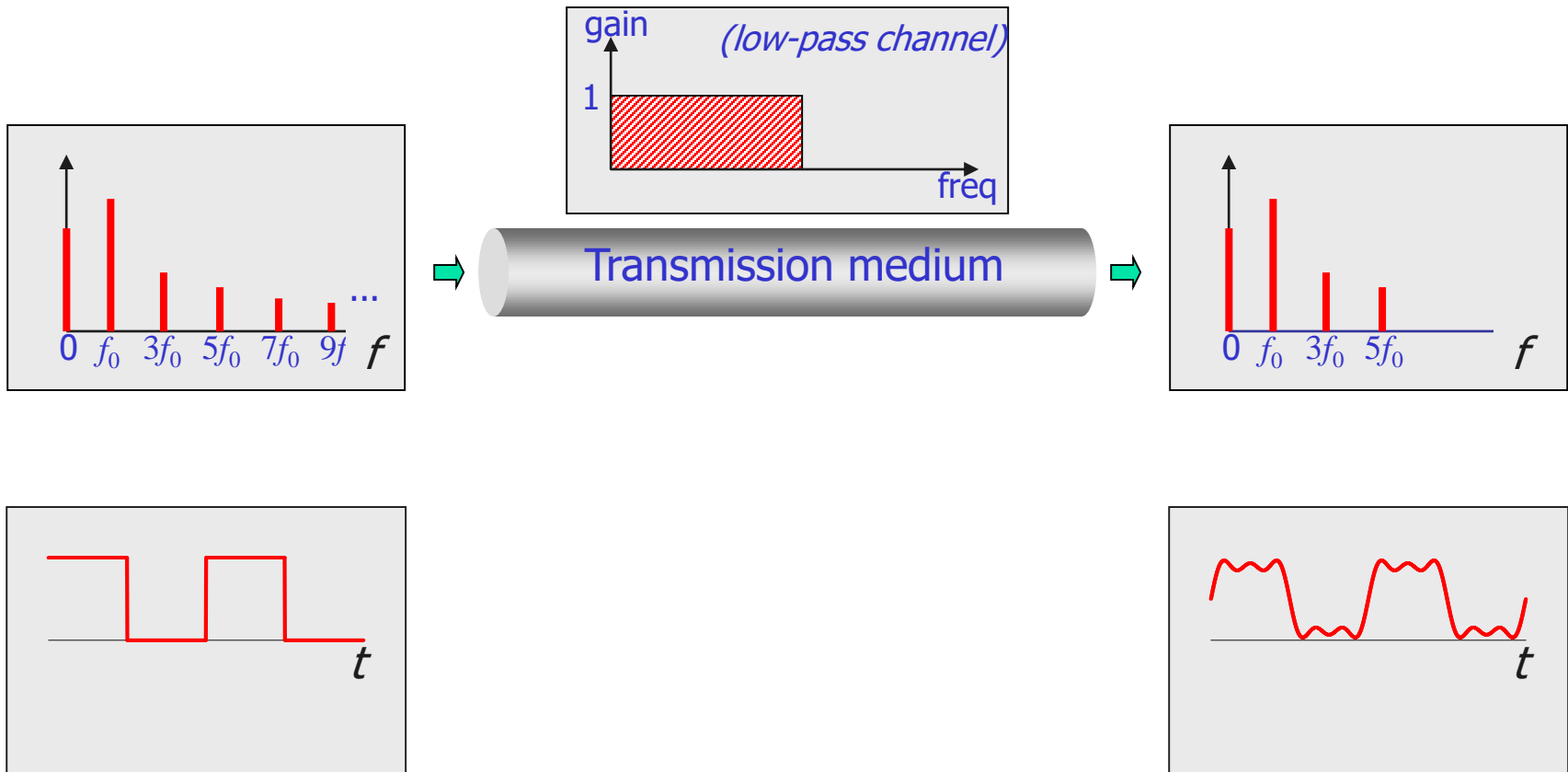

Amplitude

quency

0

Infinity

Infinite bandwidth

a. Spectrum for exact replica

Amplitude

Frequency

x

Significant bandwidth

y

b. Significant spectrum

Bandwidth of a Medium

- Most transmission media have bandwidth limit

Insufficient Bandwidth

Significant spectrum

Received spectrum

Medium bandwidth

Original signal

Received spectrum

Transmission medium