



# Signals

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รศ.ดร. อนันต์ ผลเพิ่ม

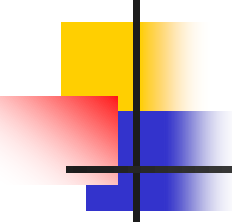
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<http://www.cpe.ku.ac.th/~anan>

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# TCP/IP Protocol Suite (Internet Model)

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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

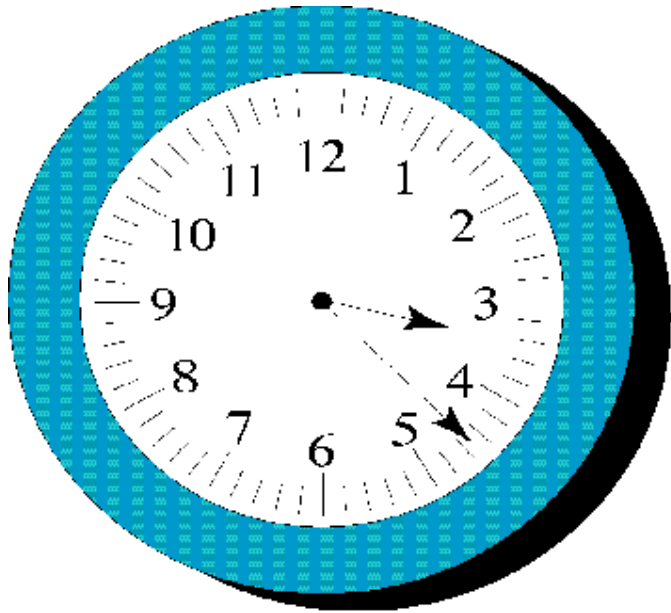
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- Analog and Digital
- Periodic and Aperiodic signals
- Analog Signals
- Digital Signals

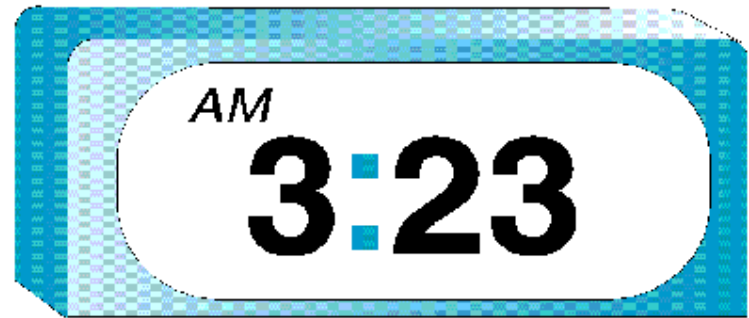


# Analog and Digital

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a. Analog



b. Digital

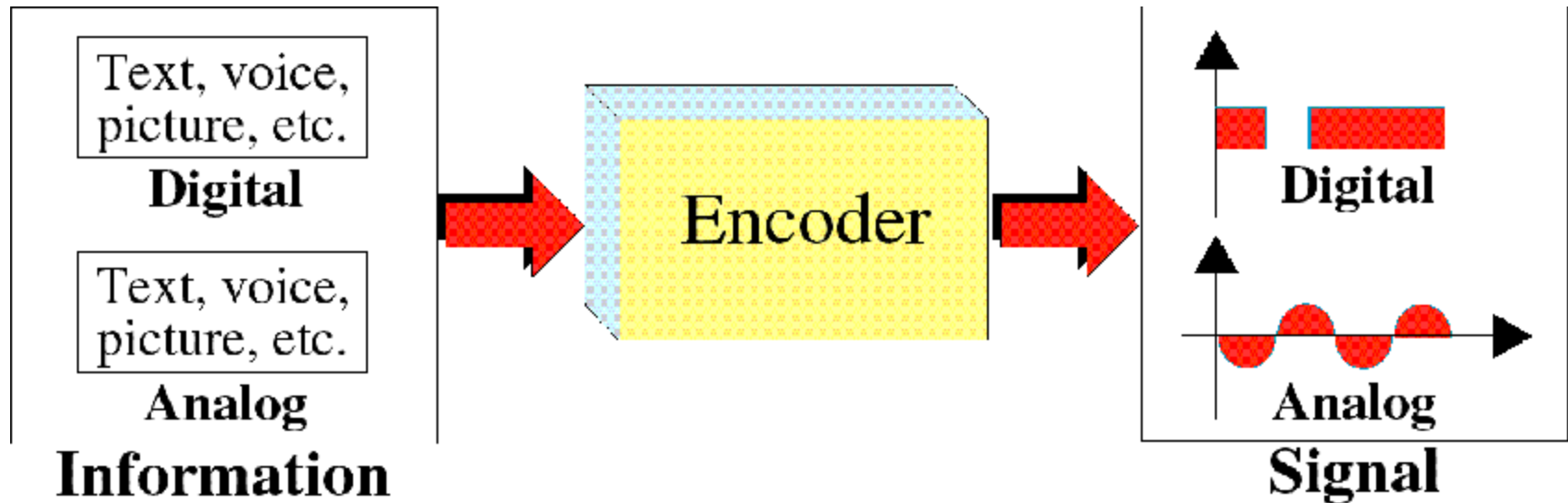


# Analog and Digital

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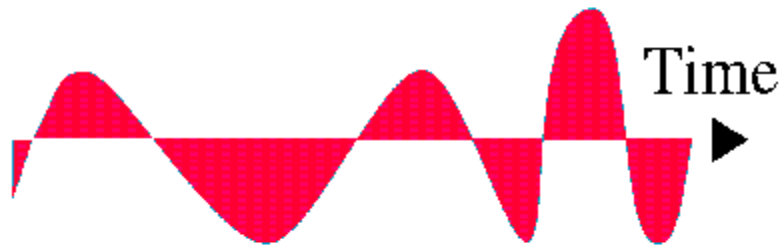
- Definition
  - Analog – continuous
  - Digital – discrete
- Data
  - Analog Data – voice
  - Digital Data – 010101
- Signals
  - Analog Signal – Wave form changes over time
  - Digital Signal – Limited value (e.g., 0 and 1)

# Transformation (Data $\rightarrow$ Signal)



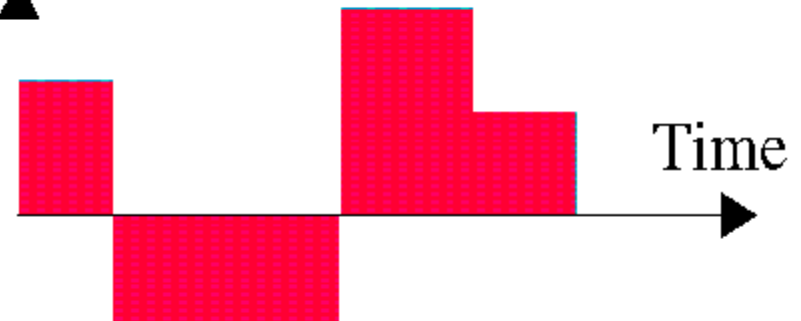
# Analog and digital signal

Value



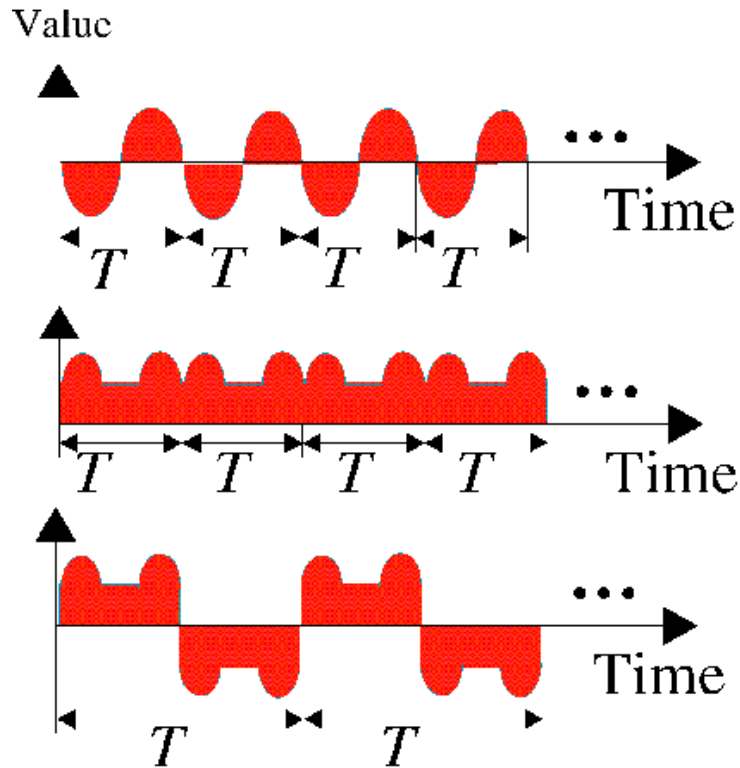
a. Analog signal

Value

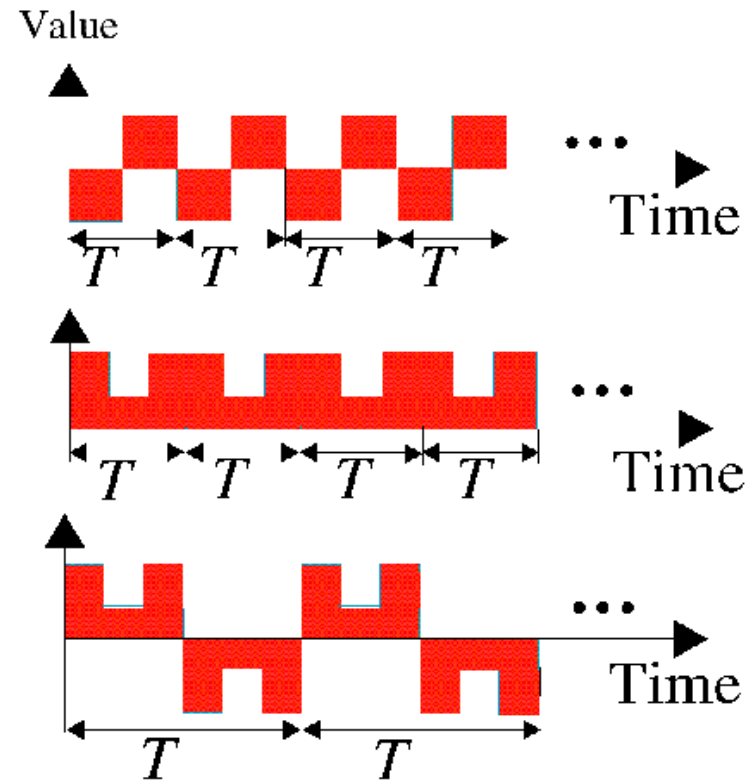


b. Digital signal

# Periodic Signals (Period – $T$ )



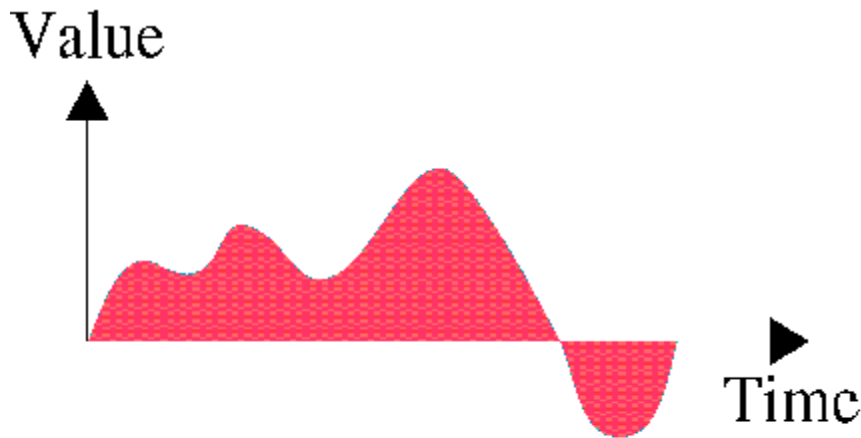
a. Analog



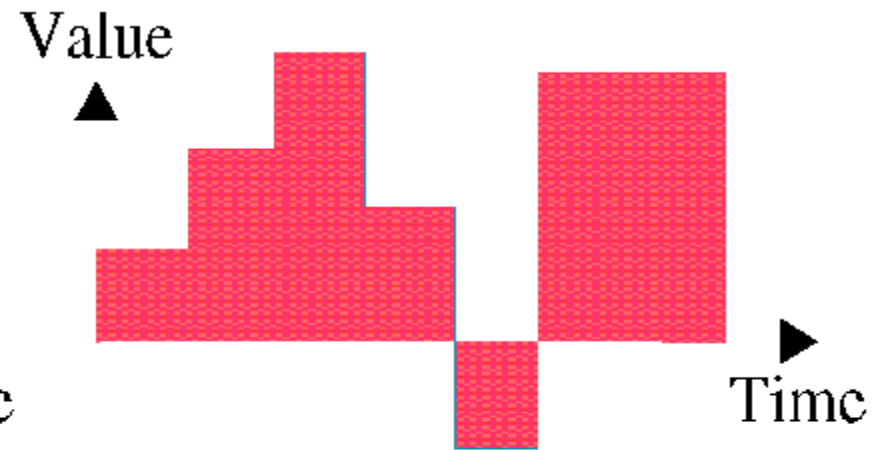
b. Digital



# Aperiodic Signals

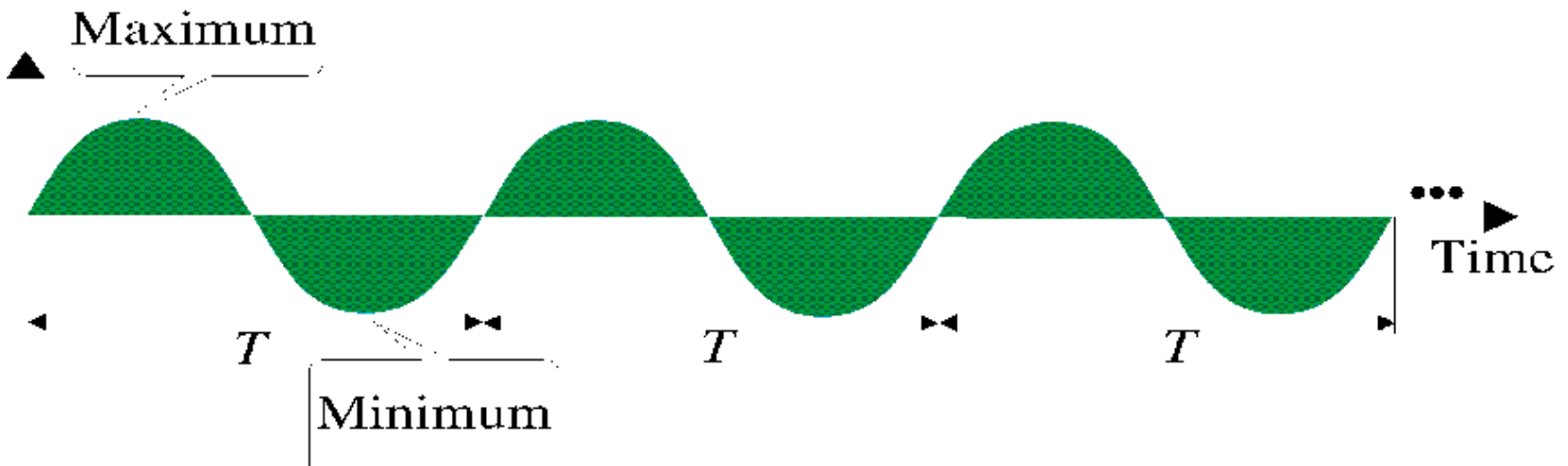


a. Analog



b. Digital

# Analog Signals



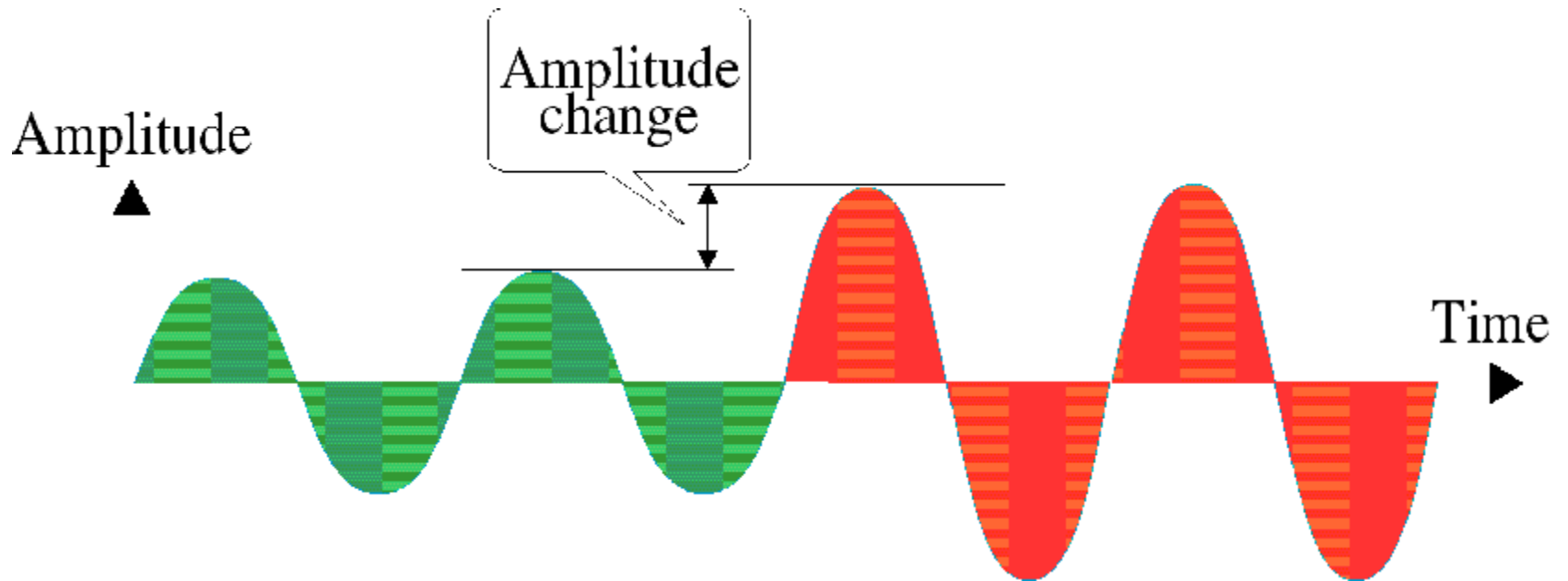
✦ Amplitude

✦ Frequency

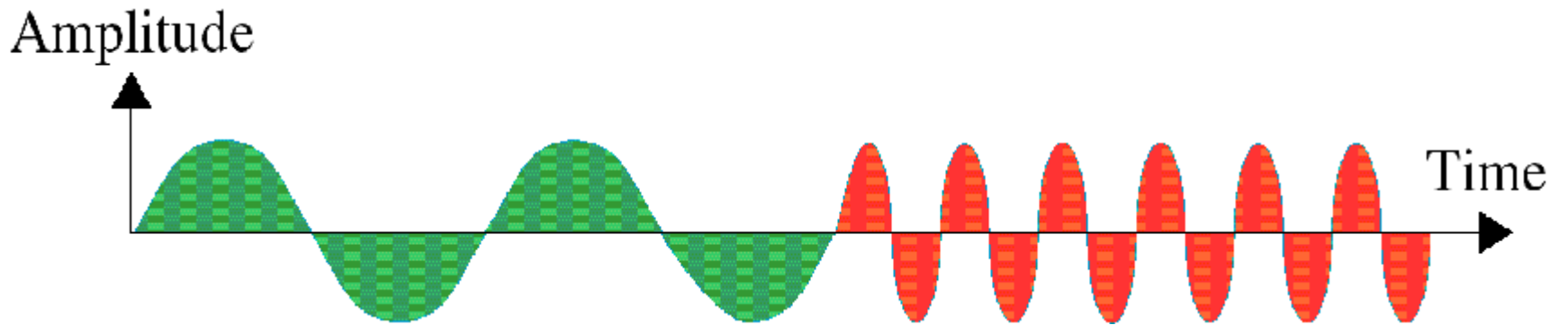
✦ Phase

$$T = 1/F$$

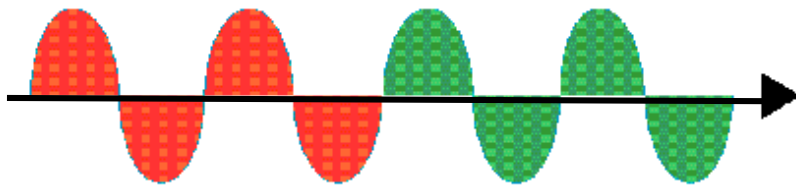
# Amplitude Change



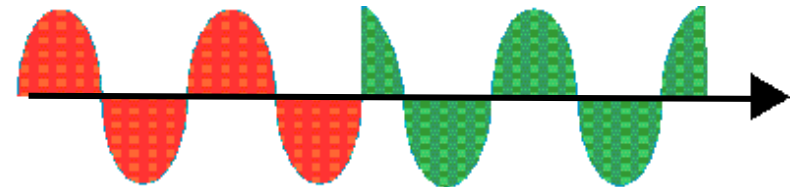
# Frequency Change



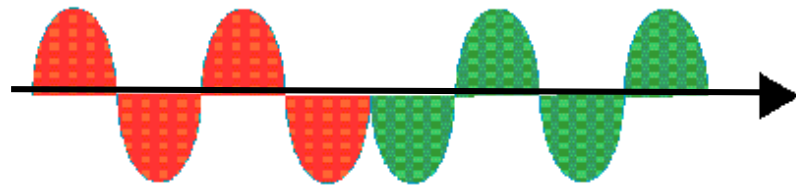
# Phase Change



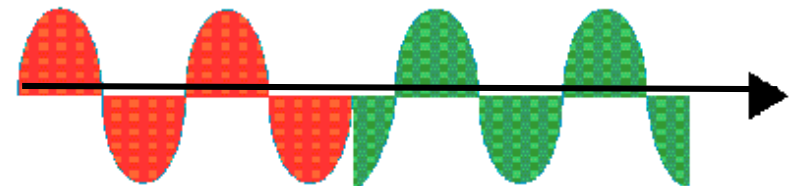
a. No phase change



b. 90 degree phase change

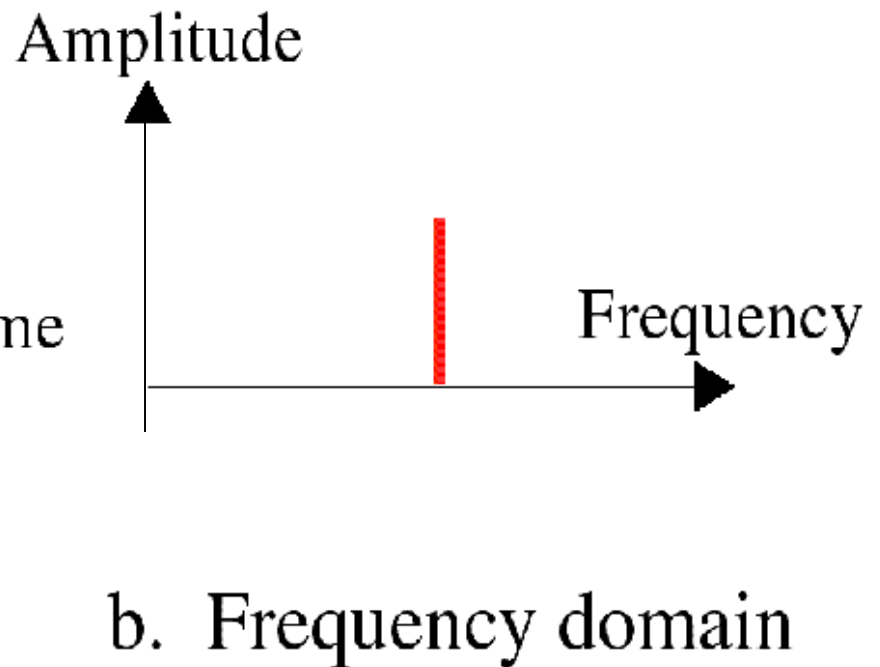
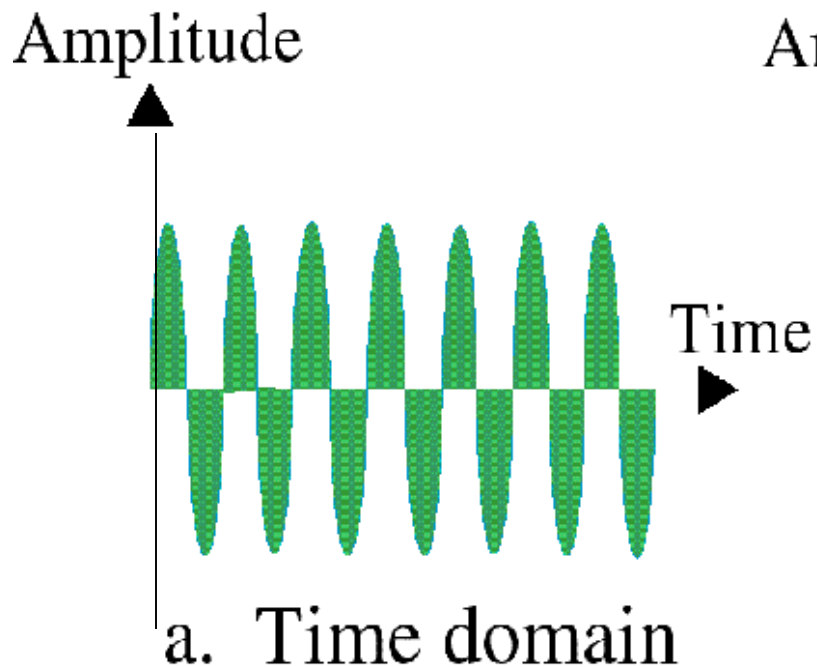


c. 180 degree phase change

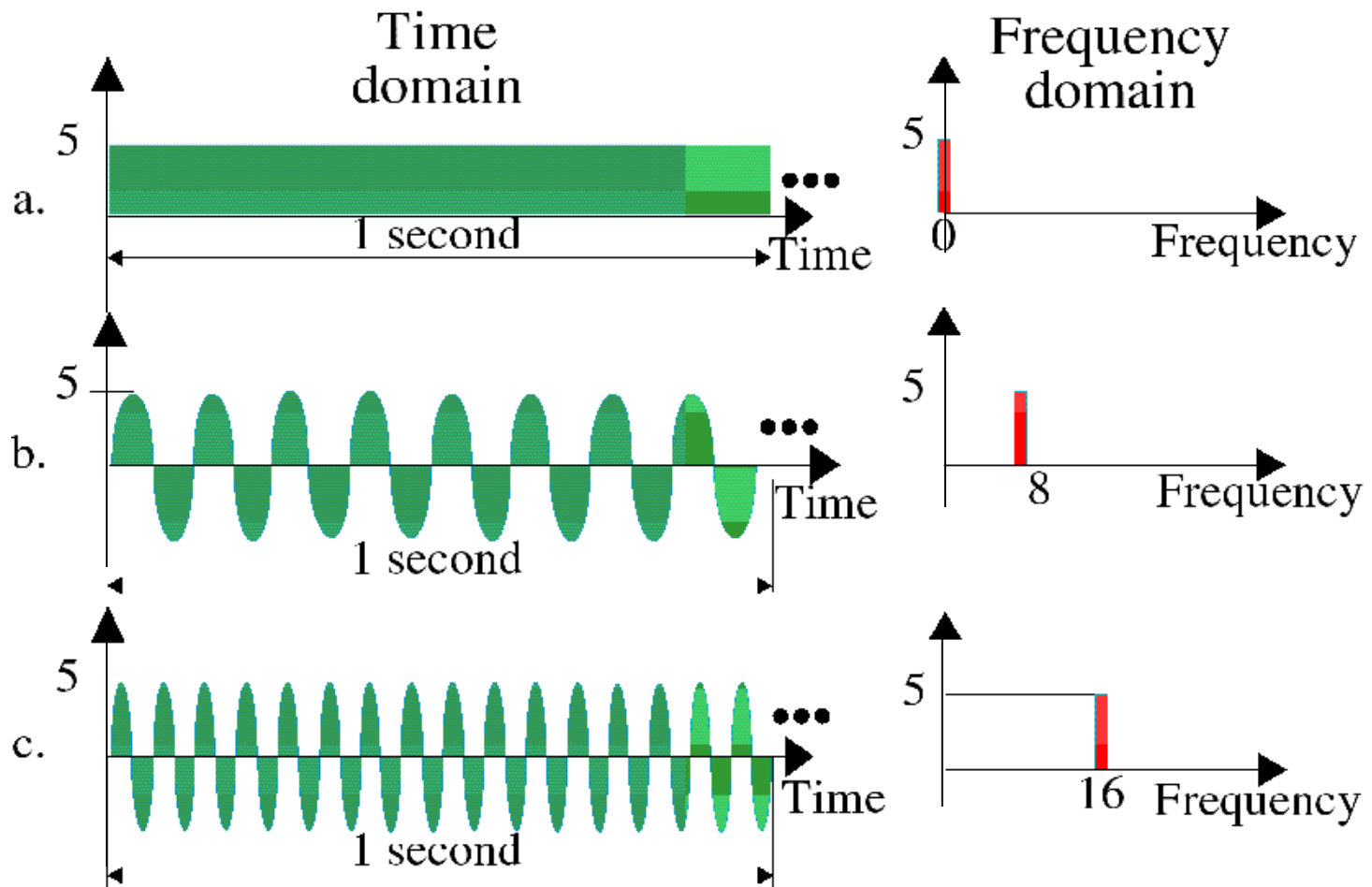


d. 270 degree phase change

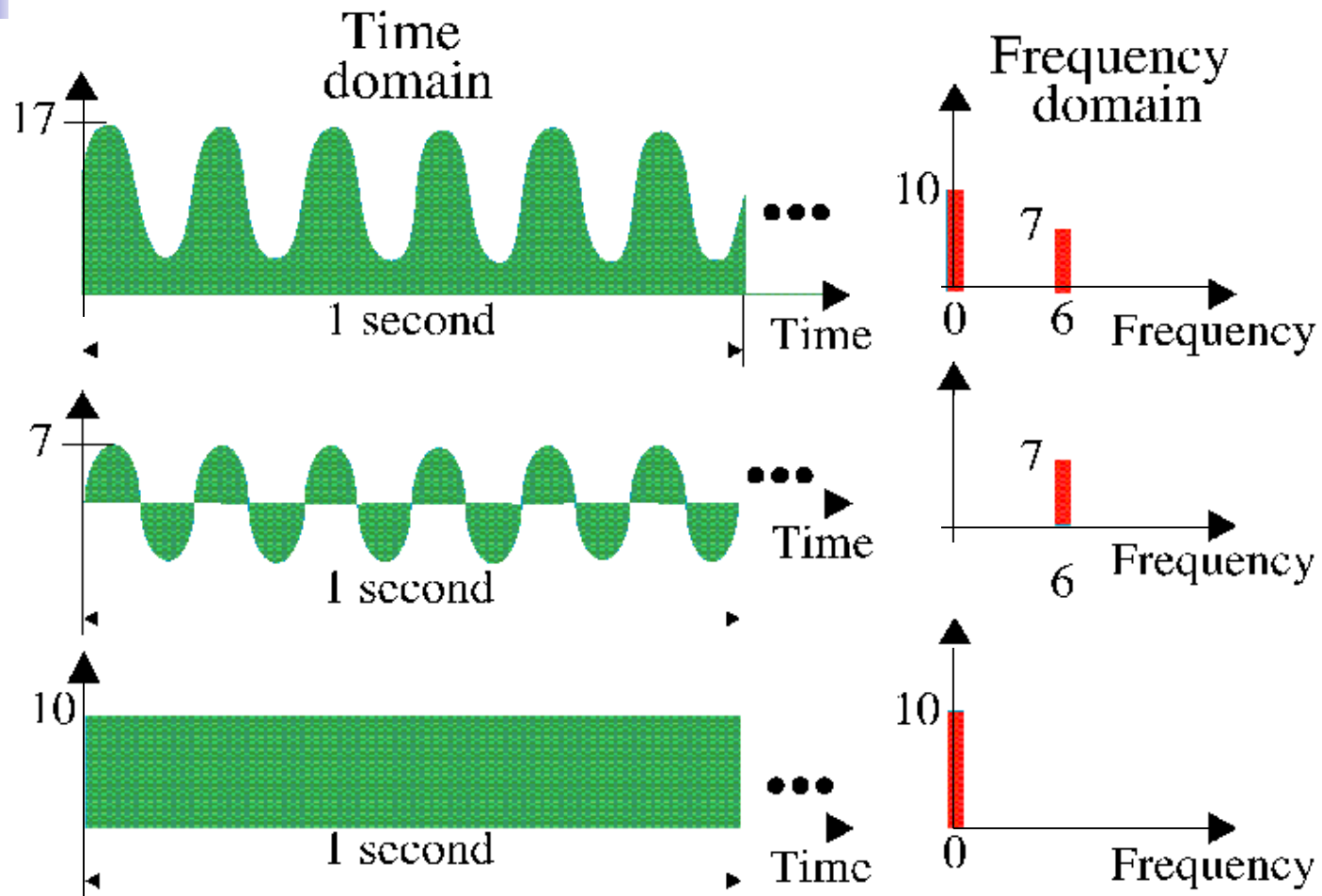
# Time and Frequency Domain



# Time and Frequency domain

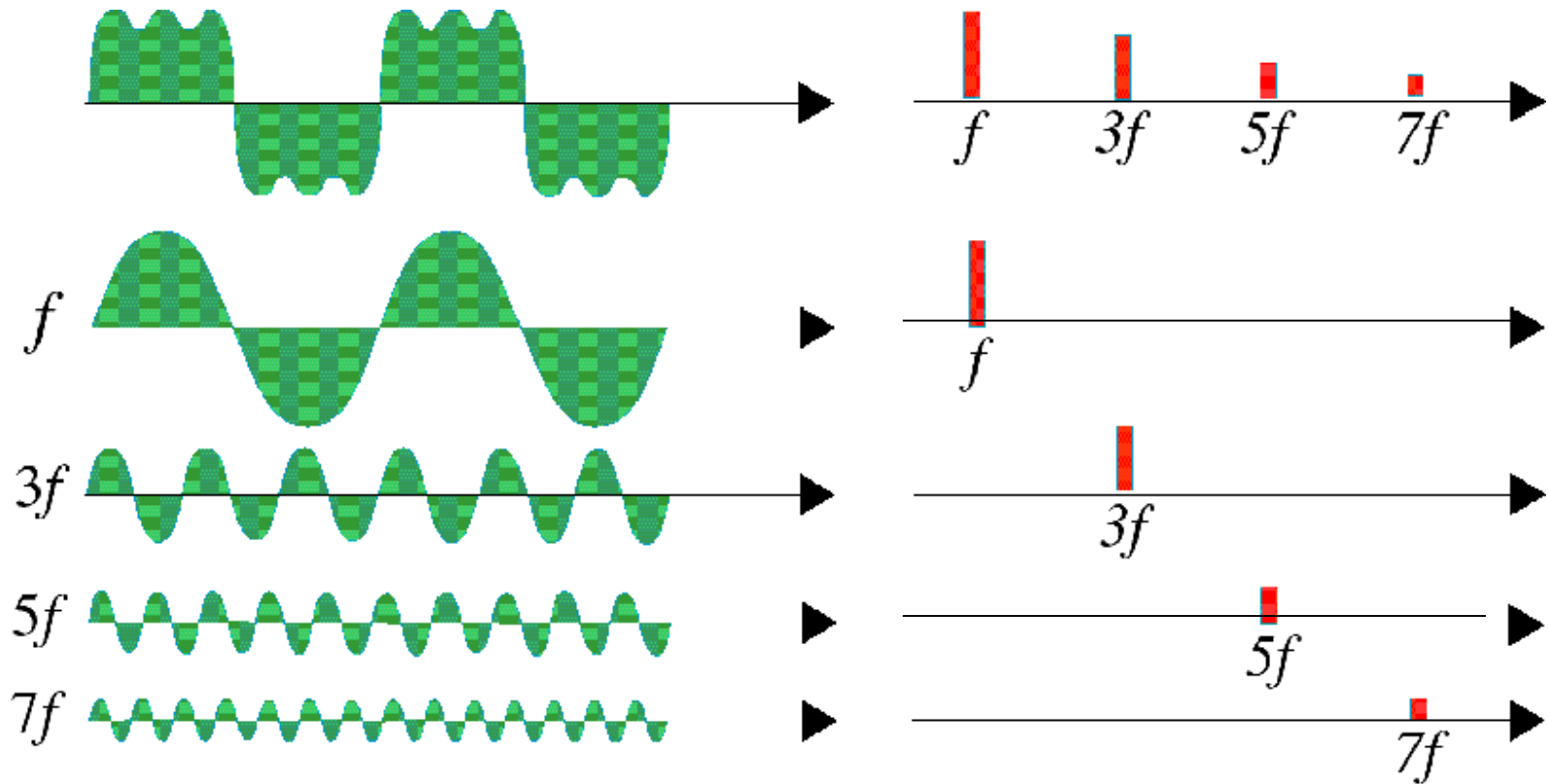


# Composite Signals





# Composite Waveform (Square)



a. Time domain

b. Frequency domain



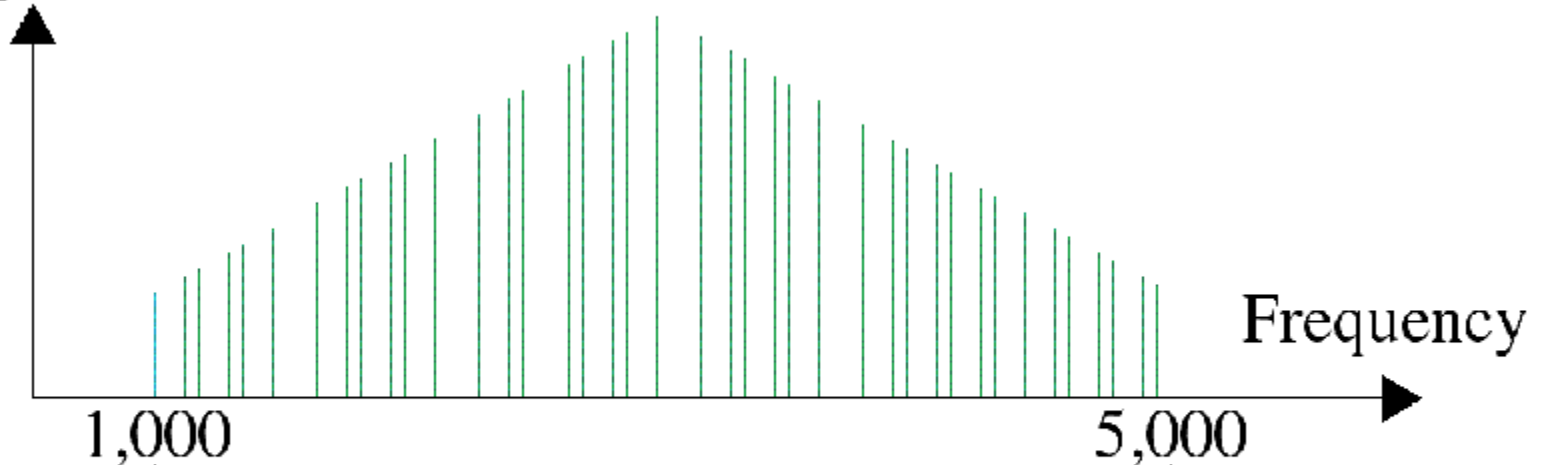
# Frequency Spectrum and Bandwidth

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- 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



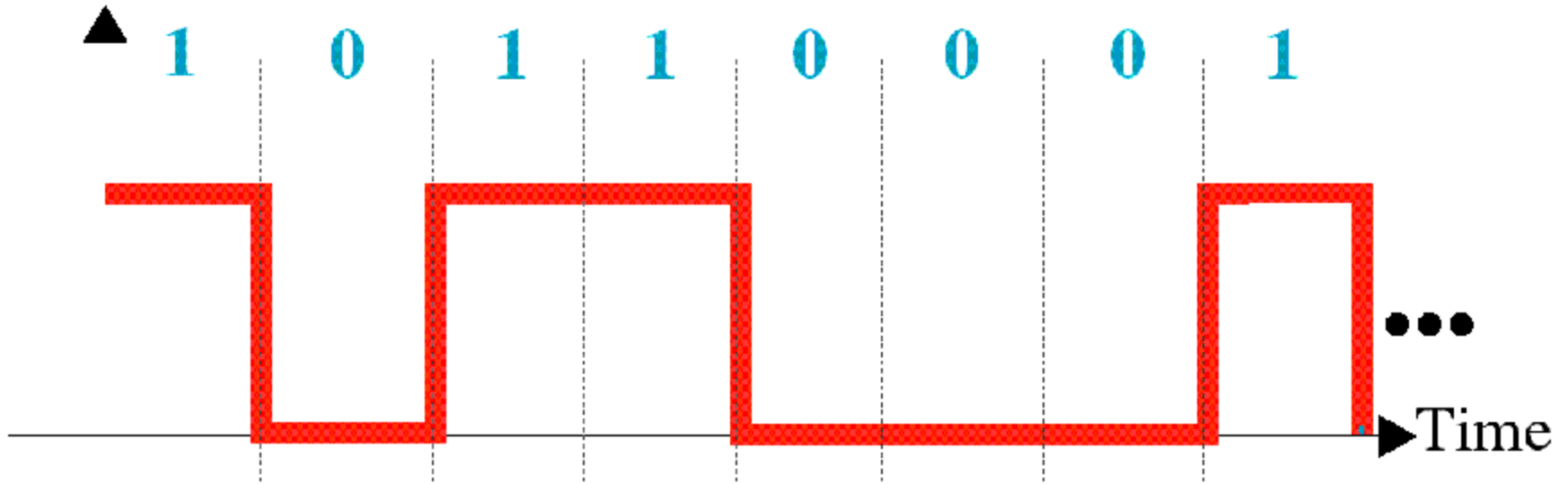
1,000

5,000

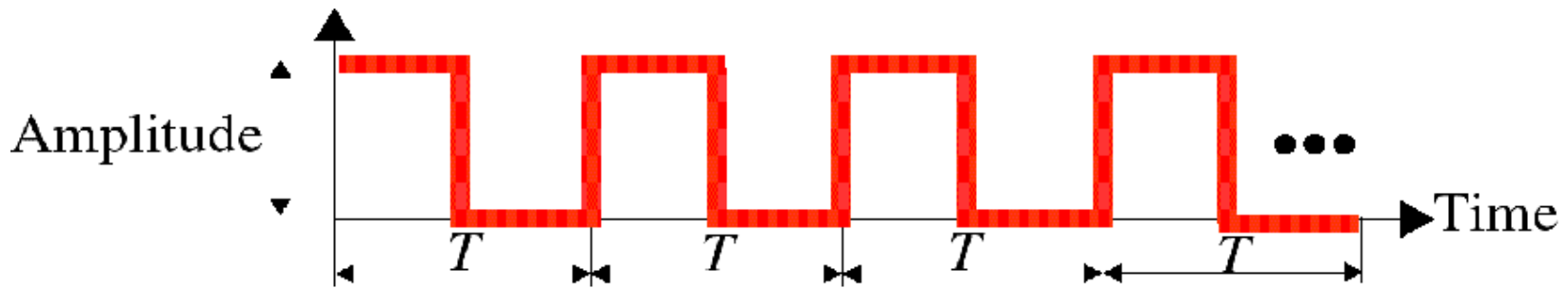
$$\text{Bandwidth} = 5,000 - 1,000 = 4,000 \text{ Hz}$$

# Digital Signals

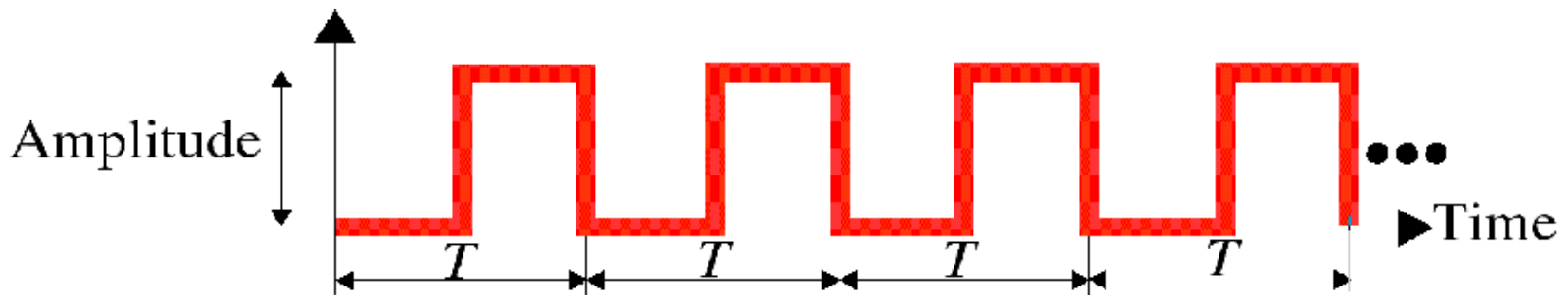
Amplitude



# Amplitude, Period, and Phase for a Digital Signal

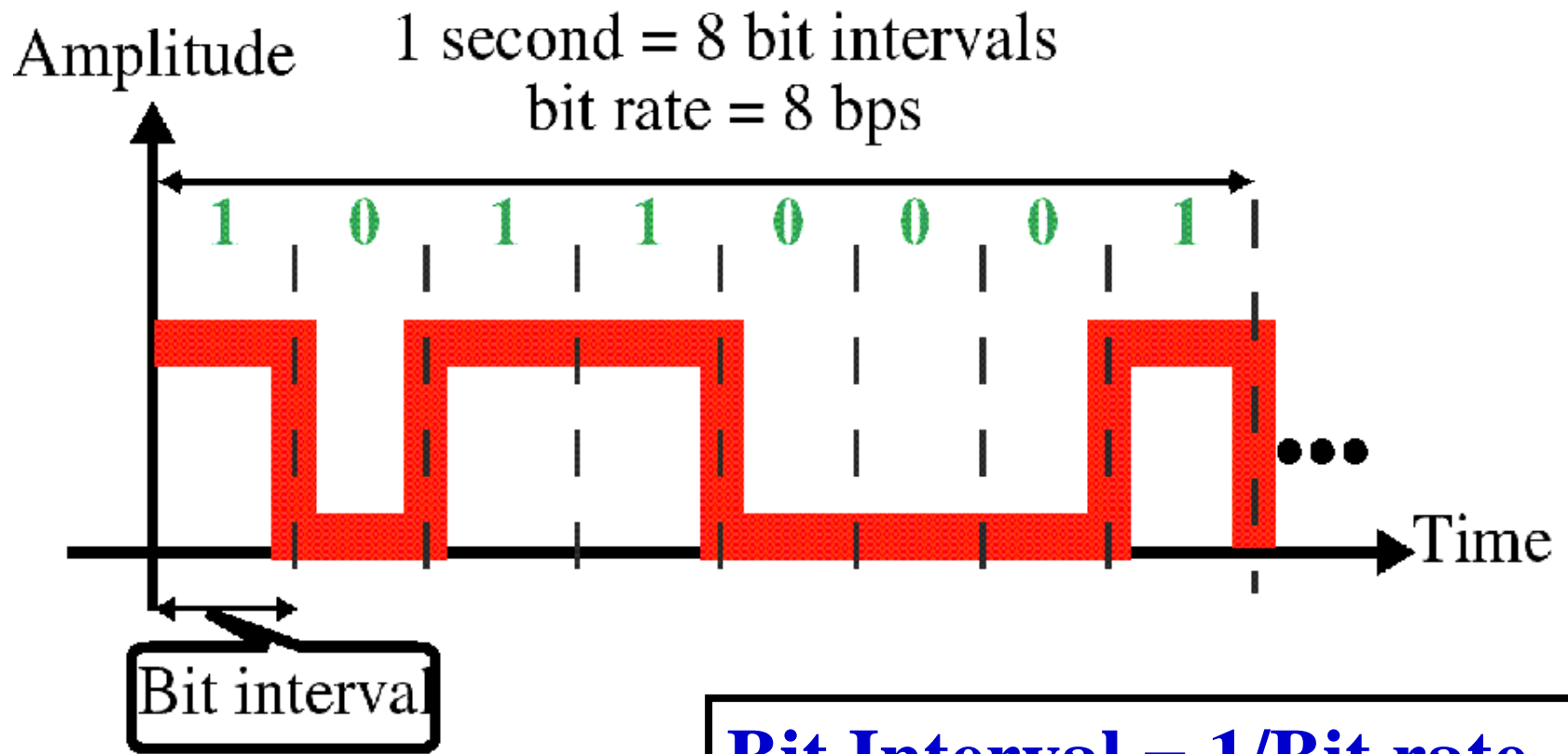


a. No phase shift

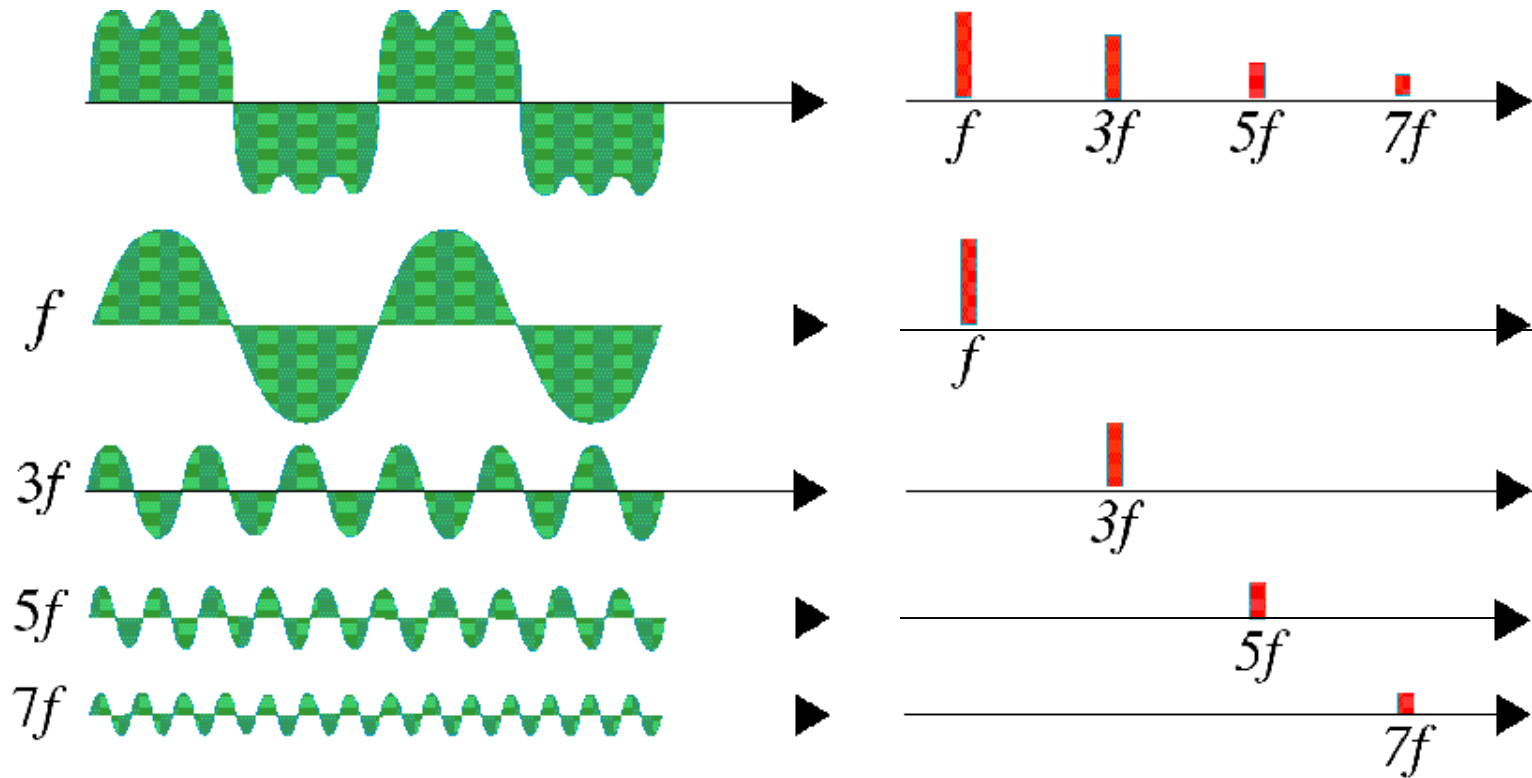


b. 180 degree phase shift

# Bit Rate and Bit Interval



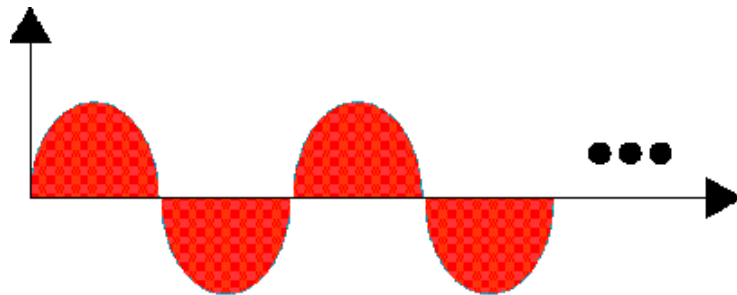
# Composite Waveform (Square)



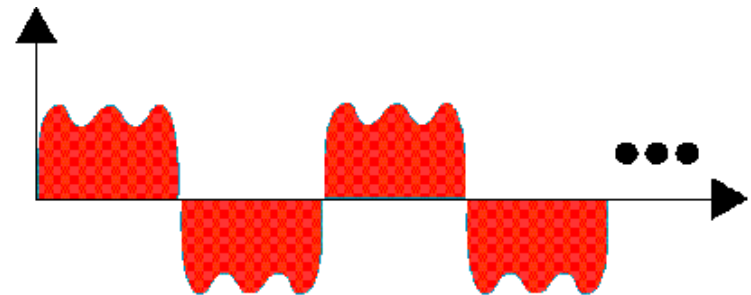
a. Time domain

b. Frequency domain

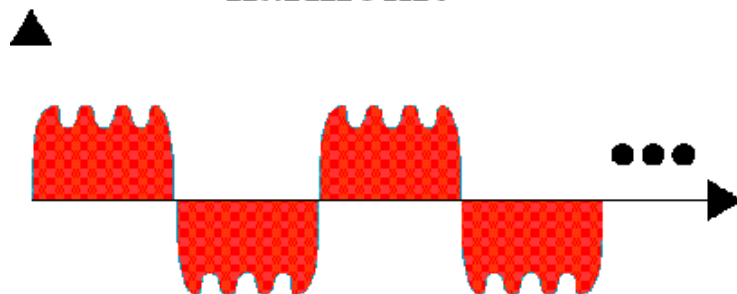
# Harmonics of a digital signal



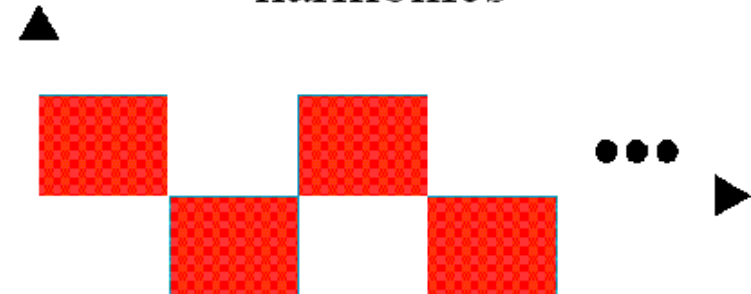
a. Only first harmonic



b. First, third, and fifth harmonics



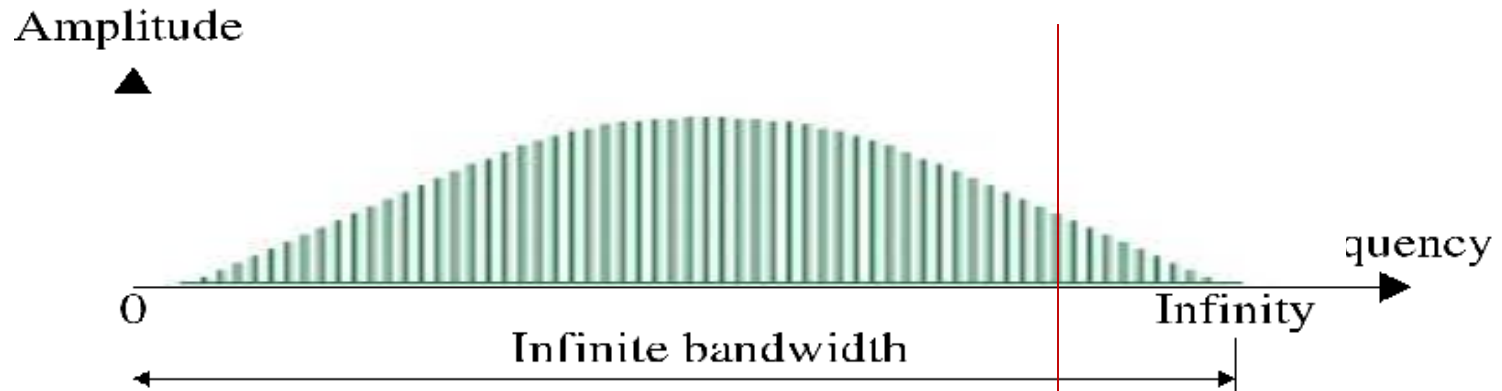
c. First, third, fifth, and seventh harmonics



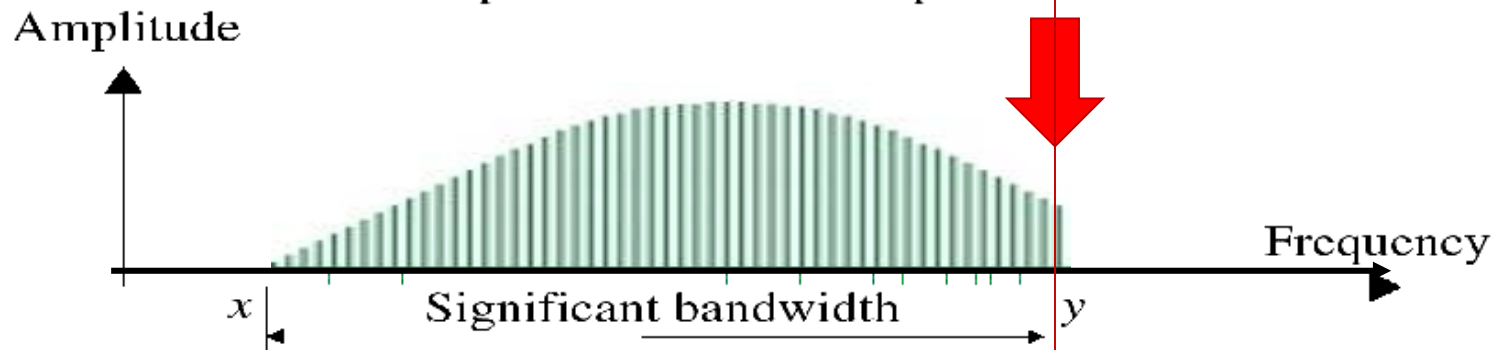
d. Infinite number of harmonics



# Exact and Significant spectrums



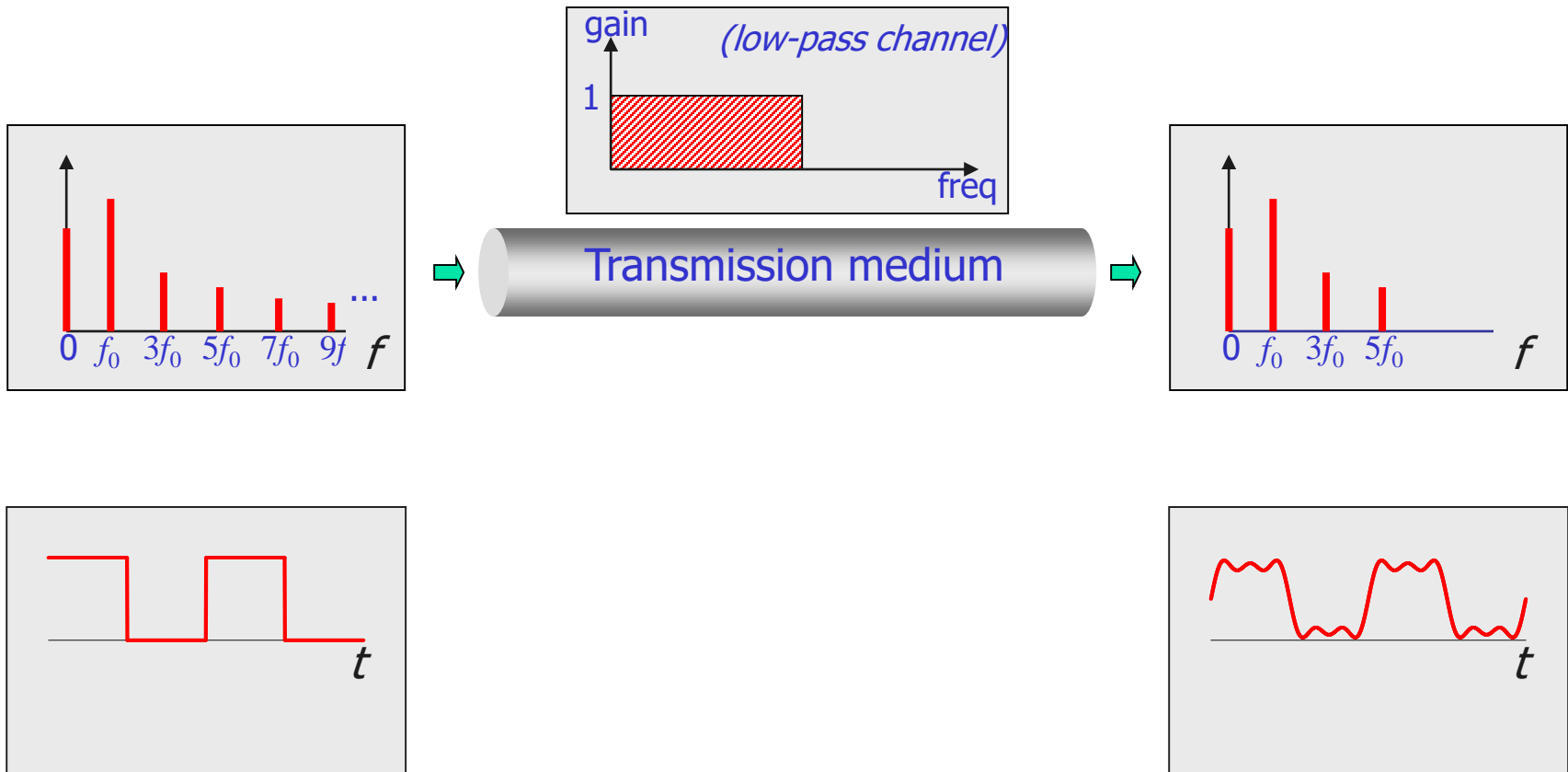
a. Spectrum for exact replica



b. Significant spectrum

# Bandwidth of a Medium

- Most transmission media have bandwidth limit



# Insufficient Bandwidth

