



Signals

รศ.ดร. อนันต์ ผลเพิ่ม

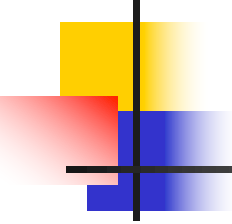
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TCP/IP Protocol Suite (Internet Model)

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)

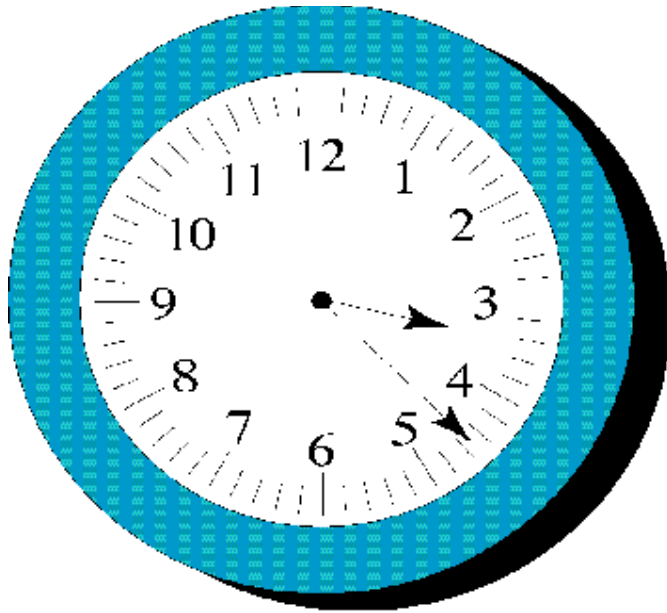


Outline

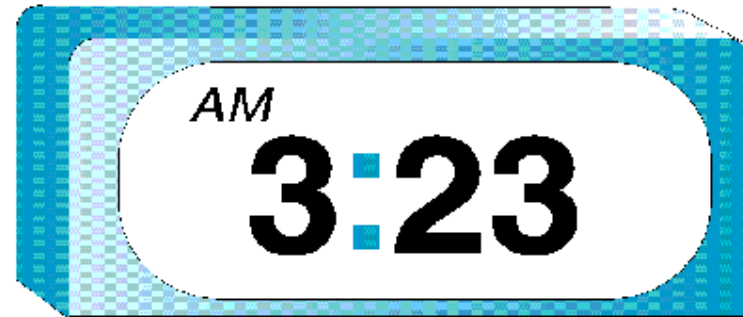
- Analog and Digital
- Periodic and Aperiodic signals
- Analog Signals
- Digital Signals



Analog and Digital



a. Analog



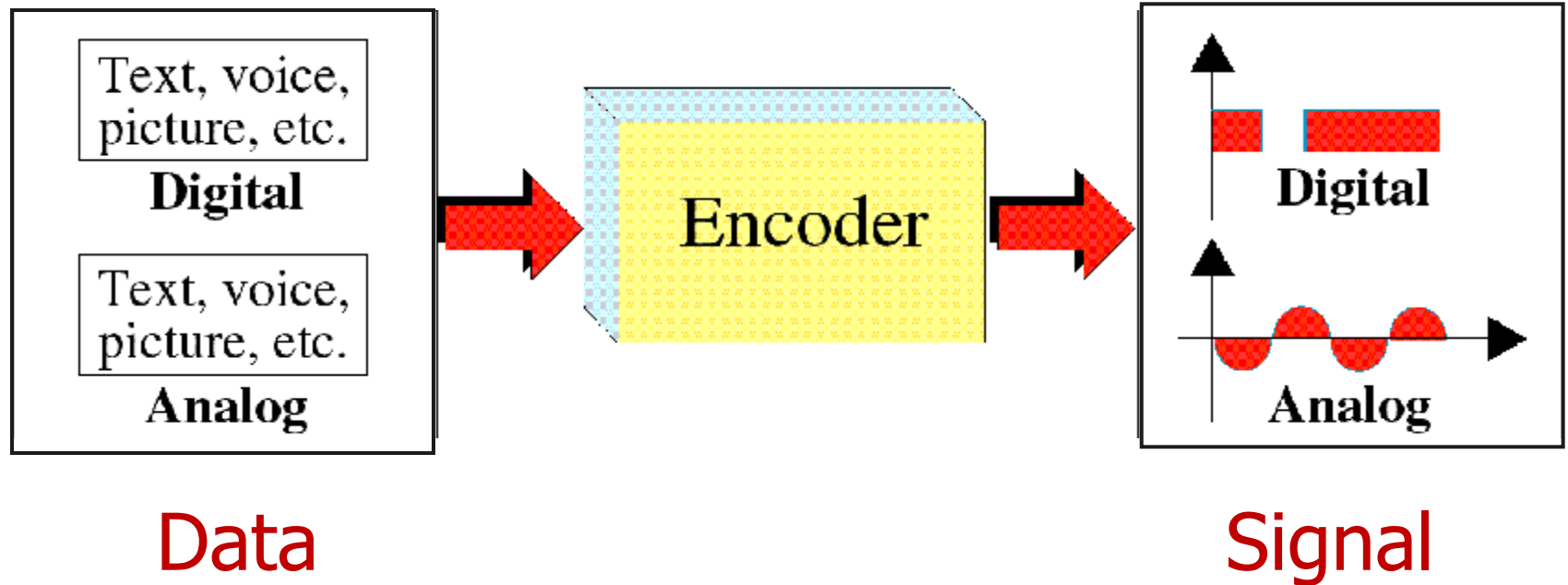
b. Digital



Analog and Digital

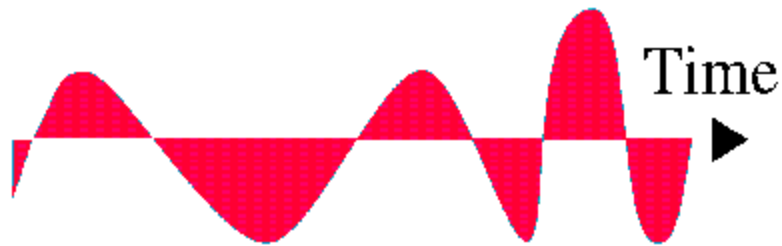
- Definition
 - Analog – continuous
 - Digital – discrete
- Data
 - Analog Data – voice
 - Digital Data – 010101
- Signals
 - Analog Signal – Wave form changes over time
 - Digital Signal – Limited value (e.g., 0 and 1)

Transformation (Data → Signal)



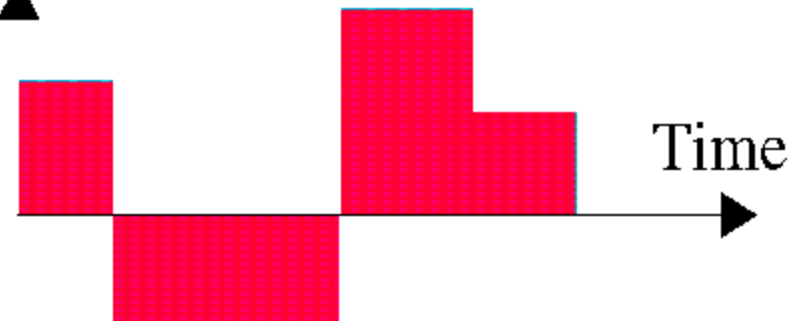
Analog and digital signal

Value



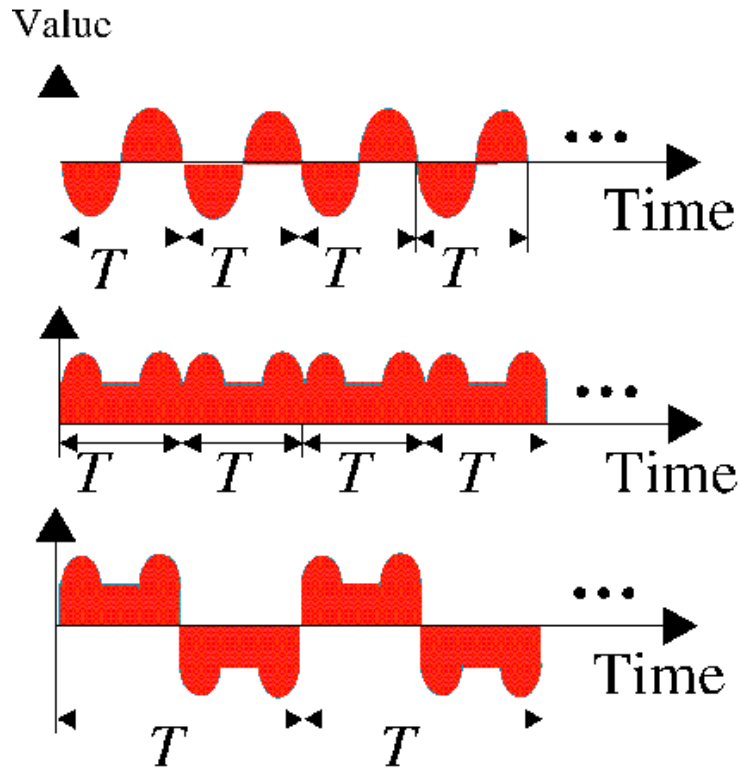
a. Analog signal

Value

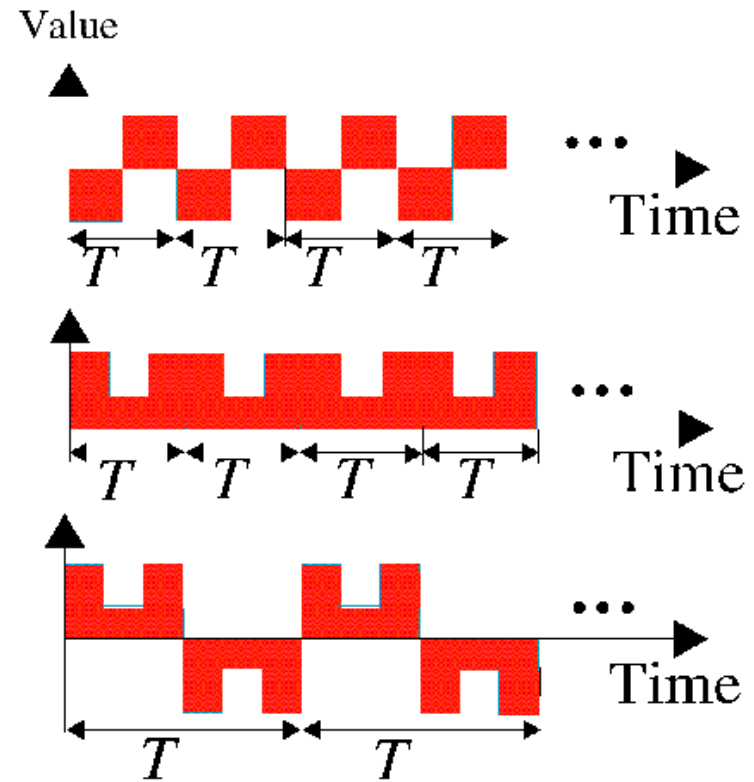


b. Digital signal

Periodic Signals (Period – T)



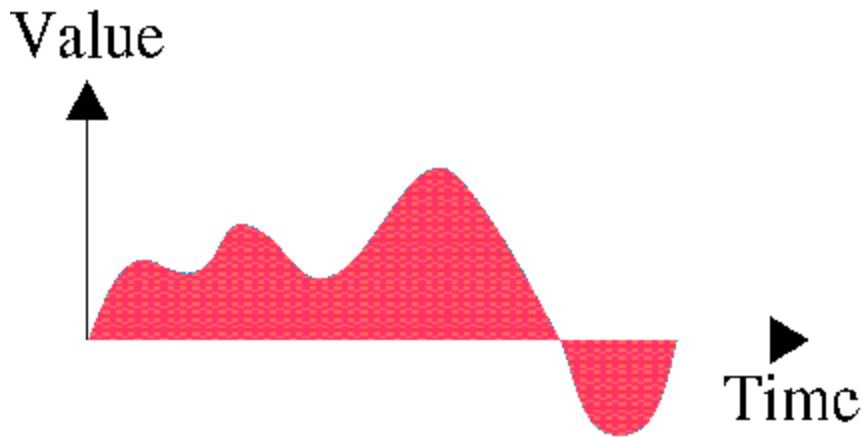
a. Analog



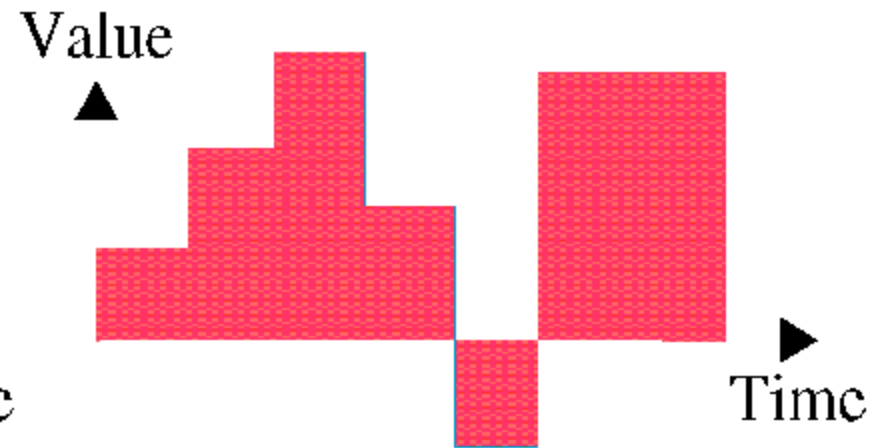
b. Digital



Aperiodic Signals

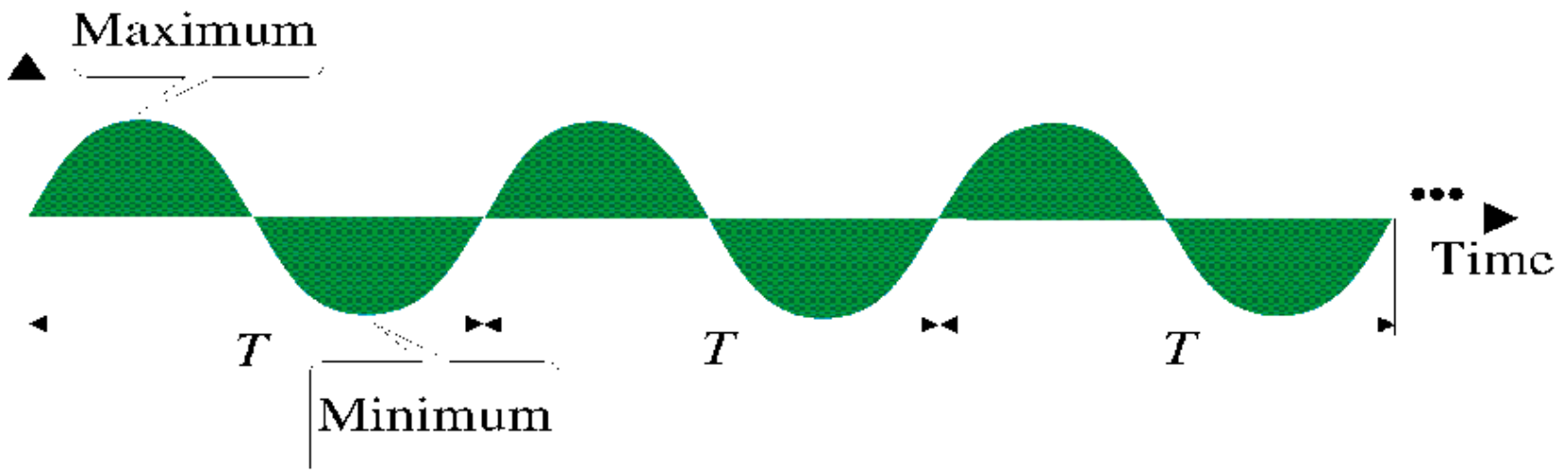


a. Analog



b. Digital

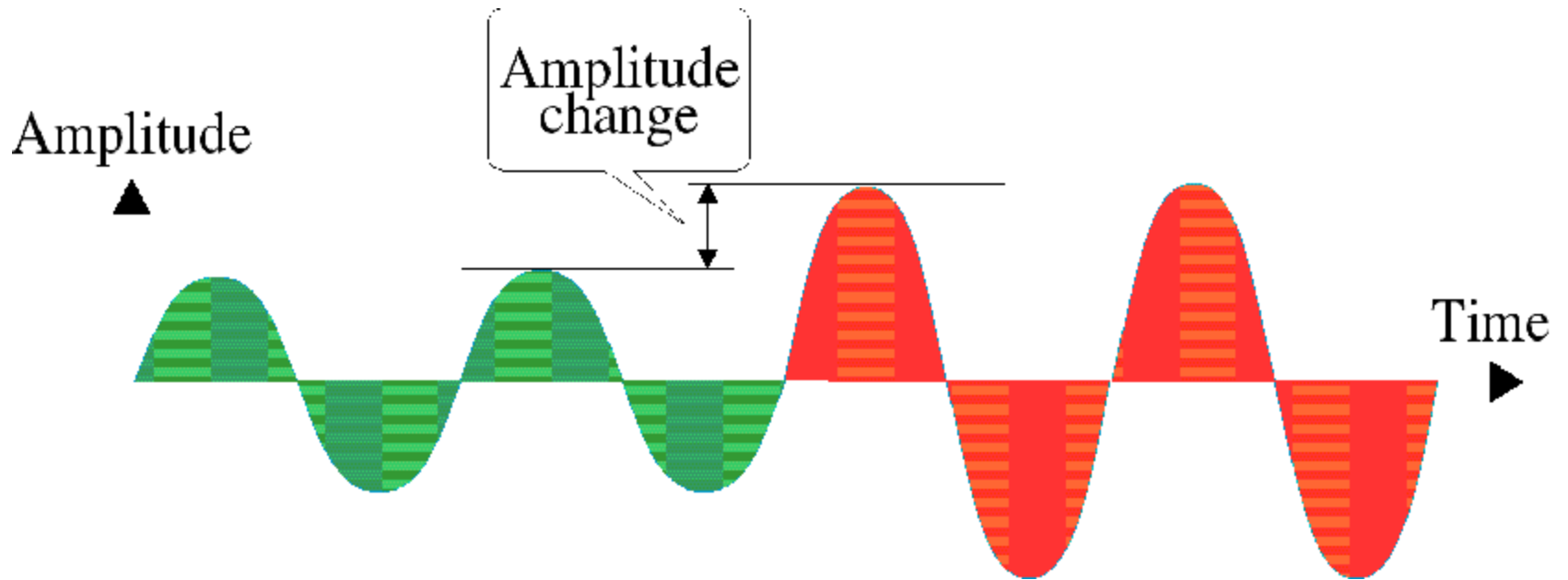
Analog Signals



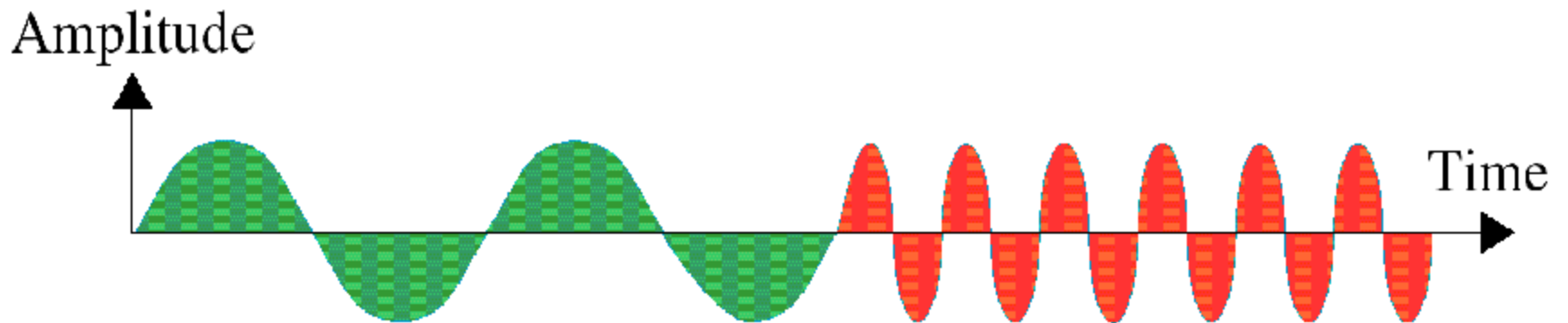
- ✦ 1. Amplitude
- ✦ 2. Frequency
- ✦ 3. Phase

$$T = 1/F$$

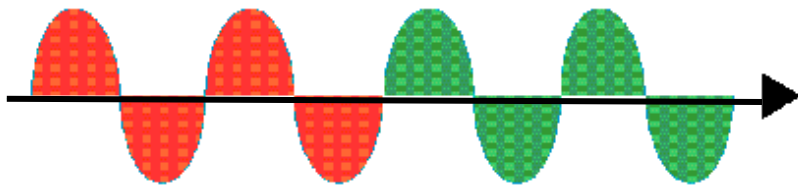
1. Amplitude Change



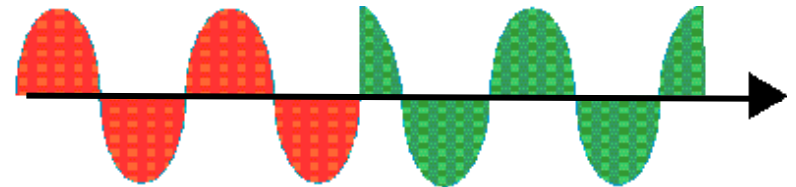
2. Frequency Change



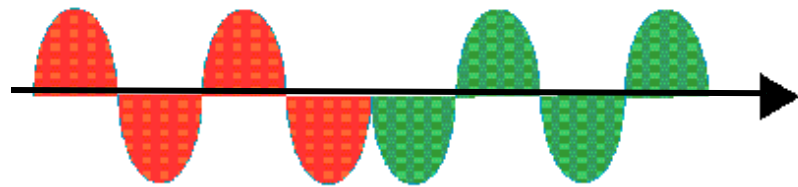
3. Phase Change



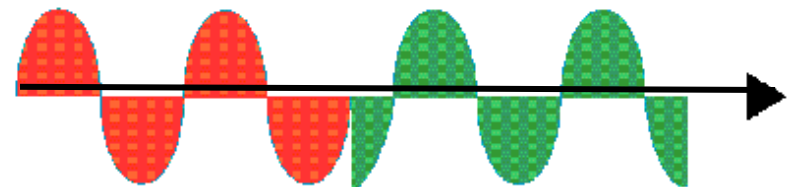
a. No phase change



b. 90 degree phase change



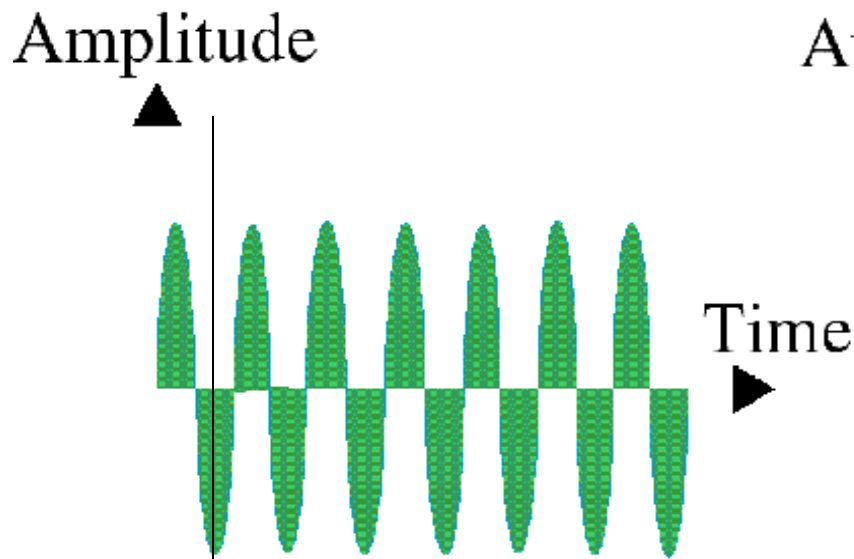
c. 180 degree phase change



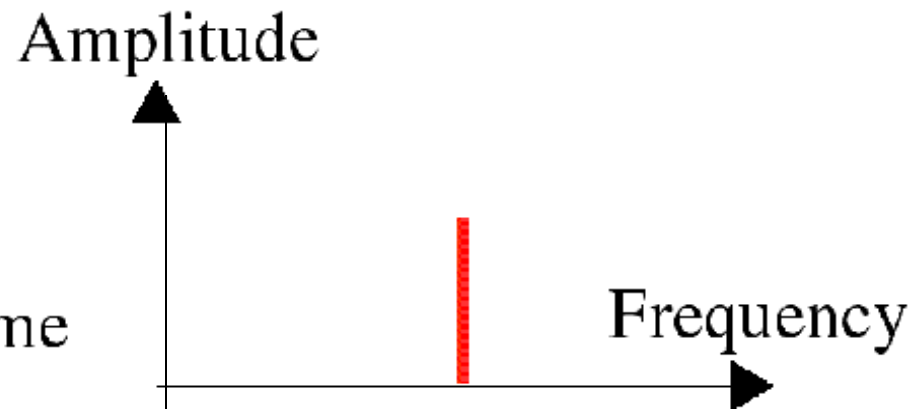
d. 270 degree phase change



Time and Frequency Domain

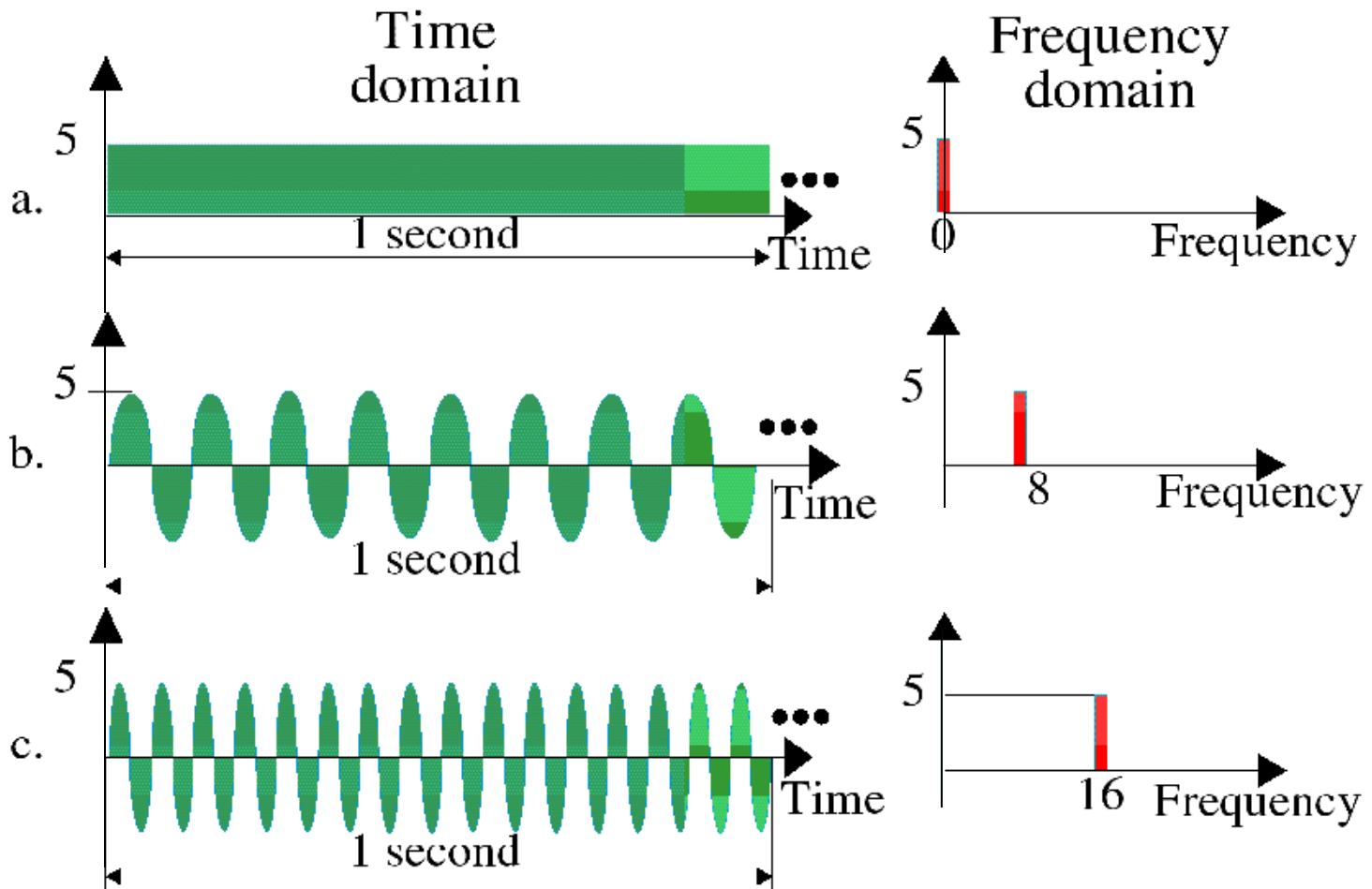


a. Time domain

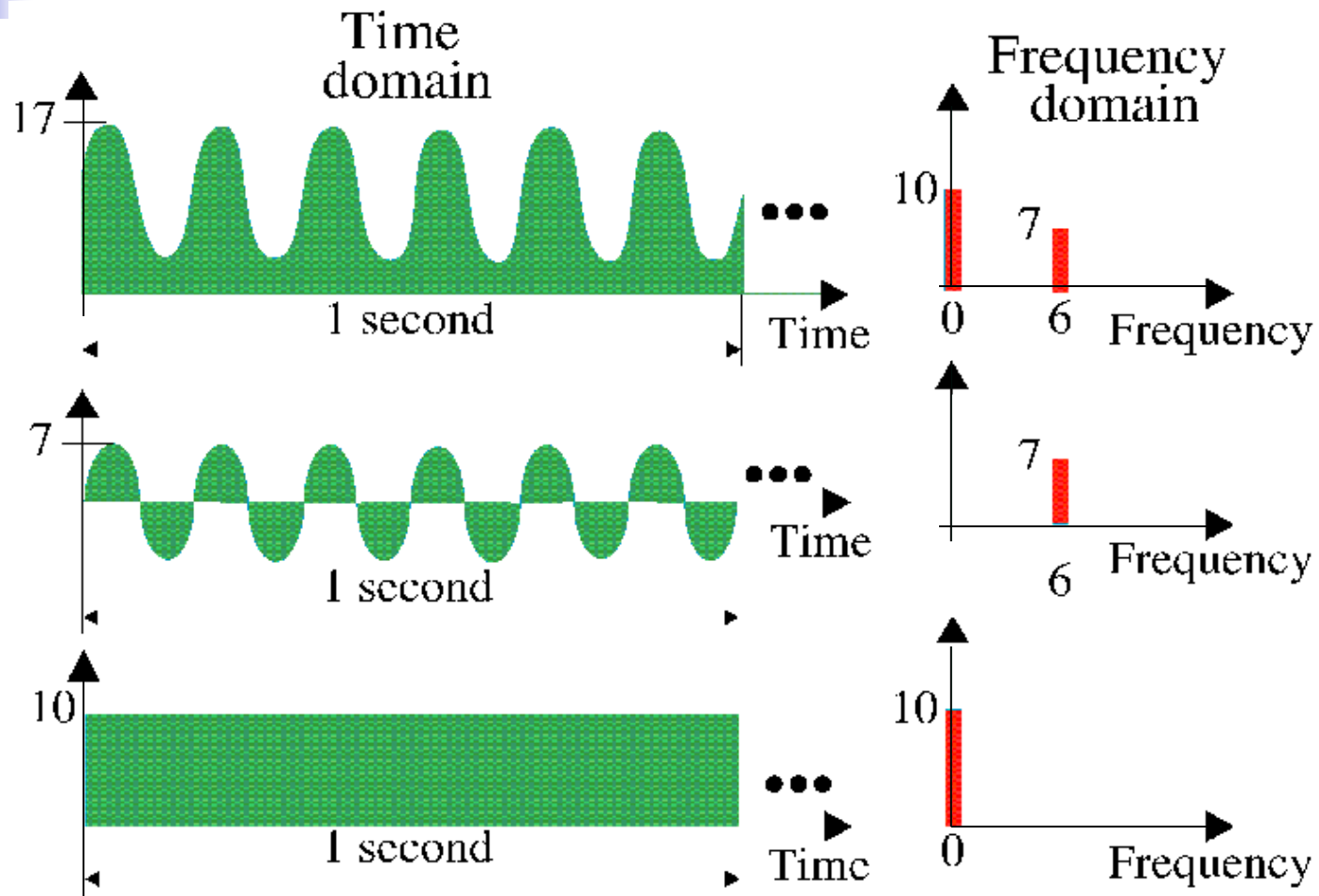


b. Frequency domain

Time and Frequency domain



Composite Signals



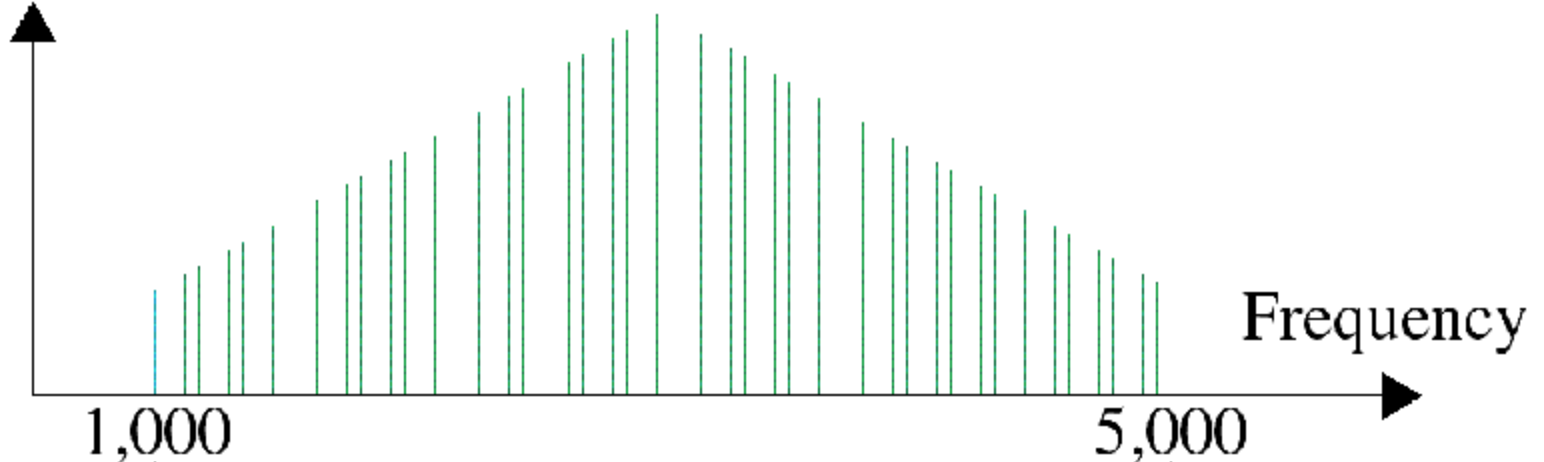


Frequency Spectrum and Bandwidth

- **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



1,000

5,000

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



Digital Signals

Amplitude



1

0

1

1

0

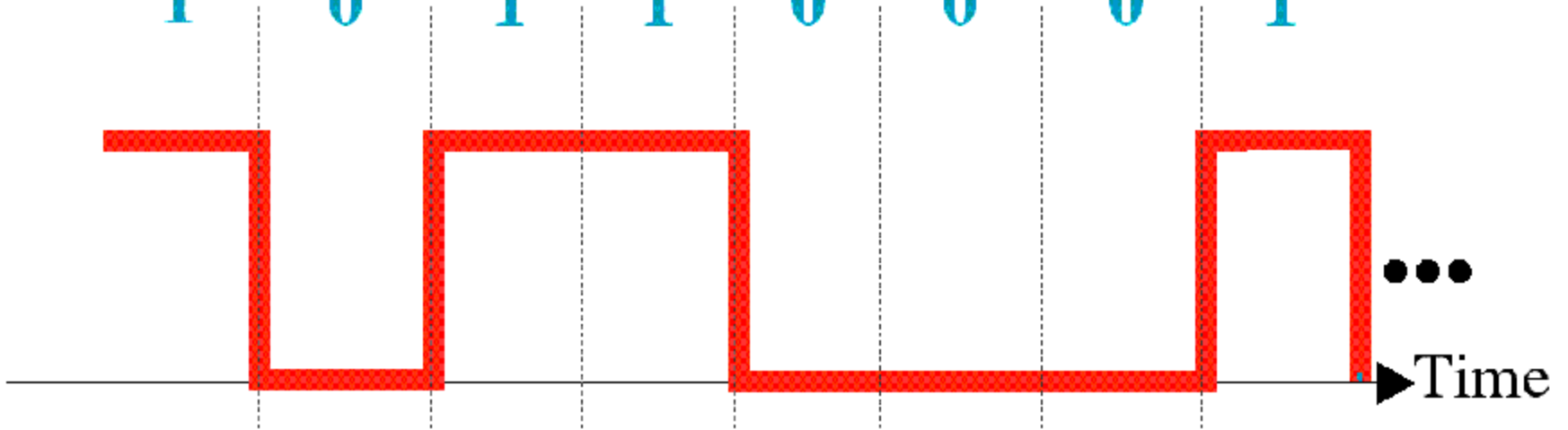
0

0

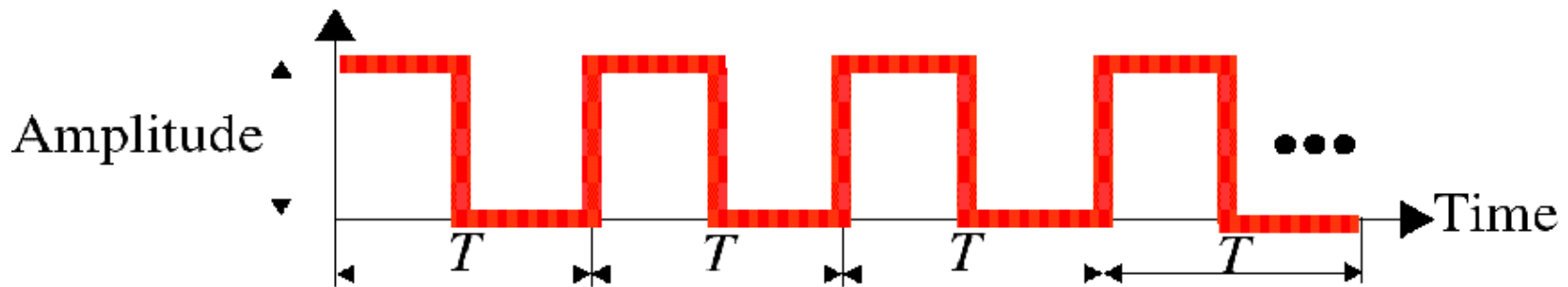
1



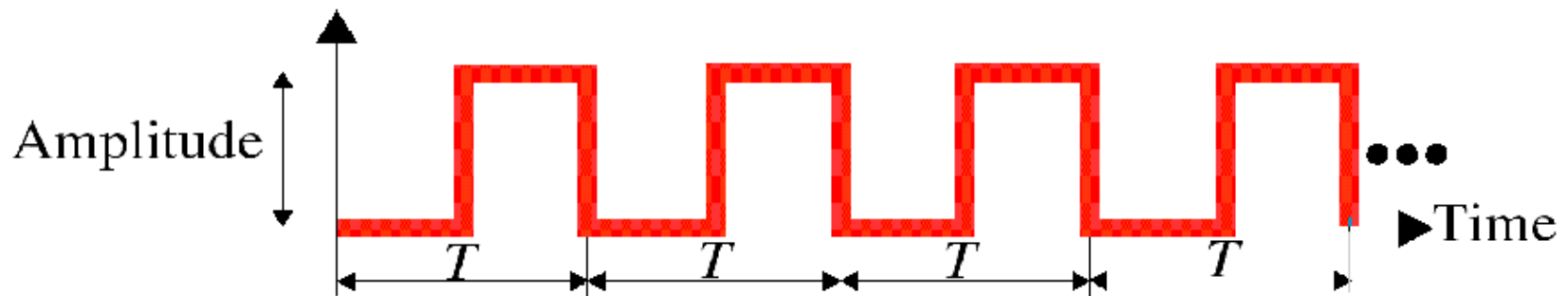
Time



Amplitude, Period, and Phase for a Digital Signal

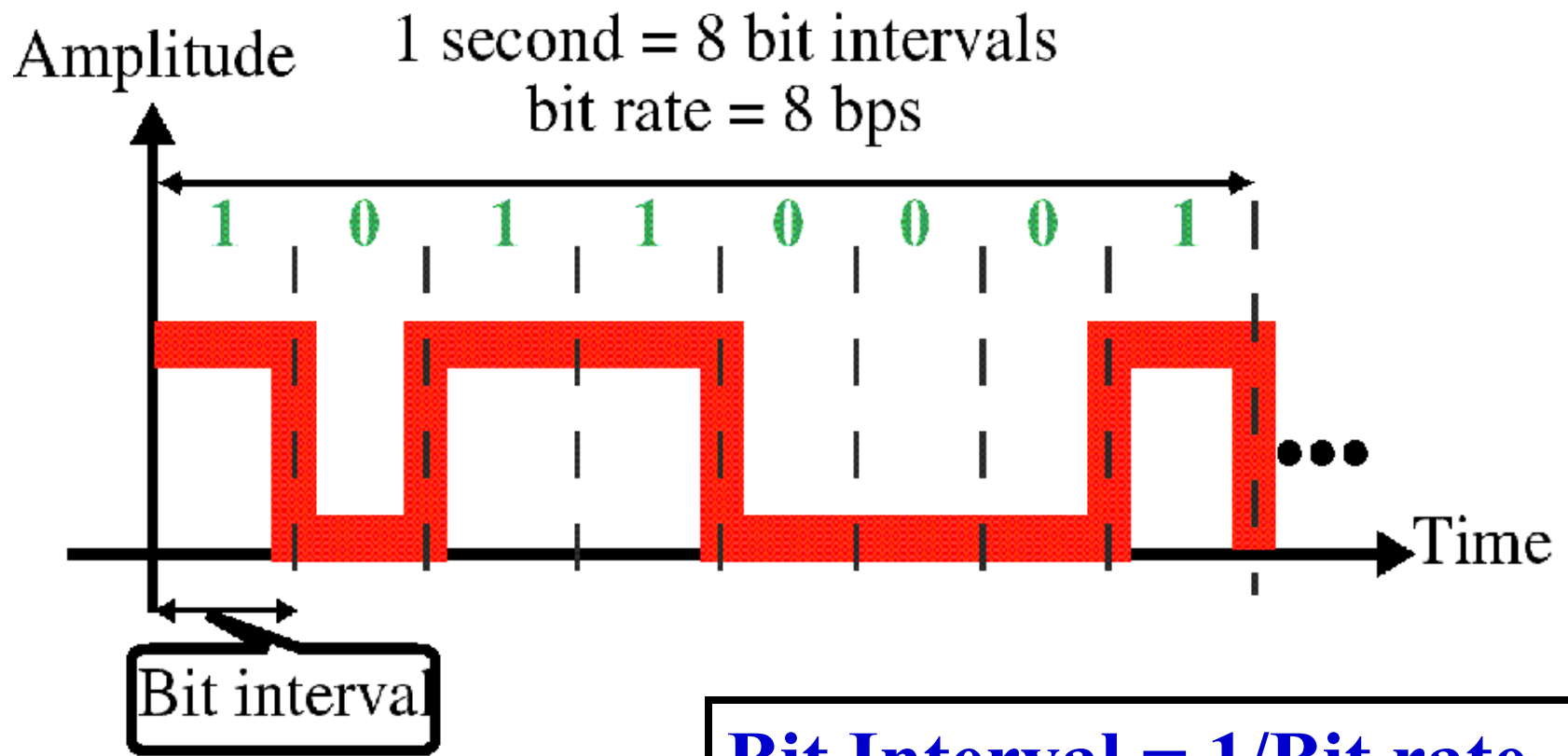


a. No phase shift

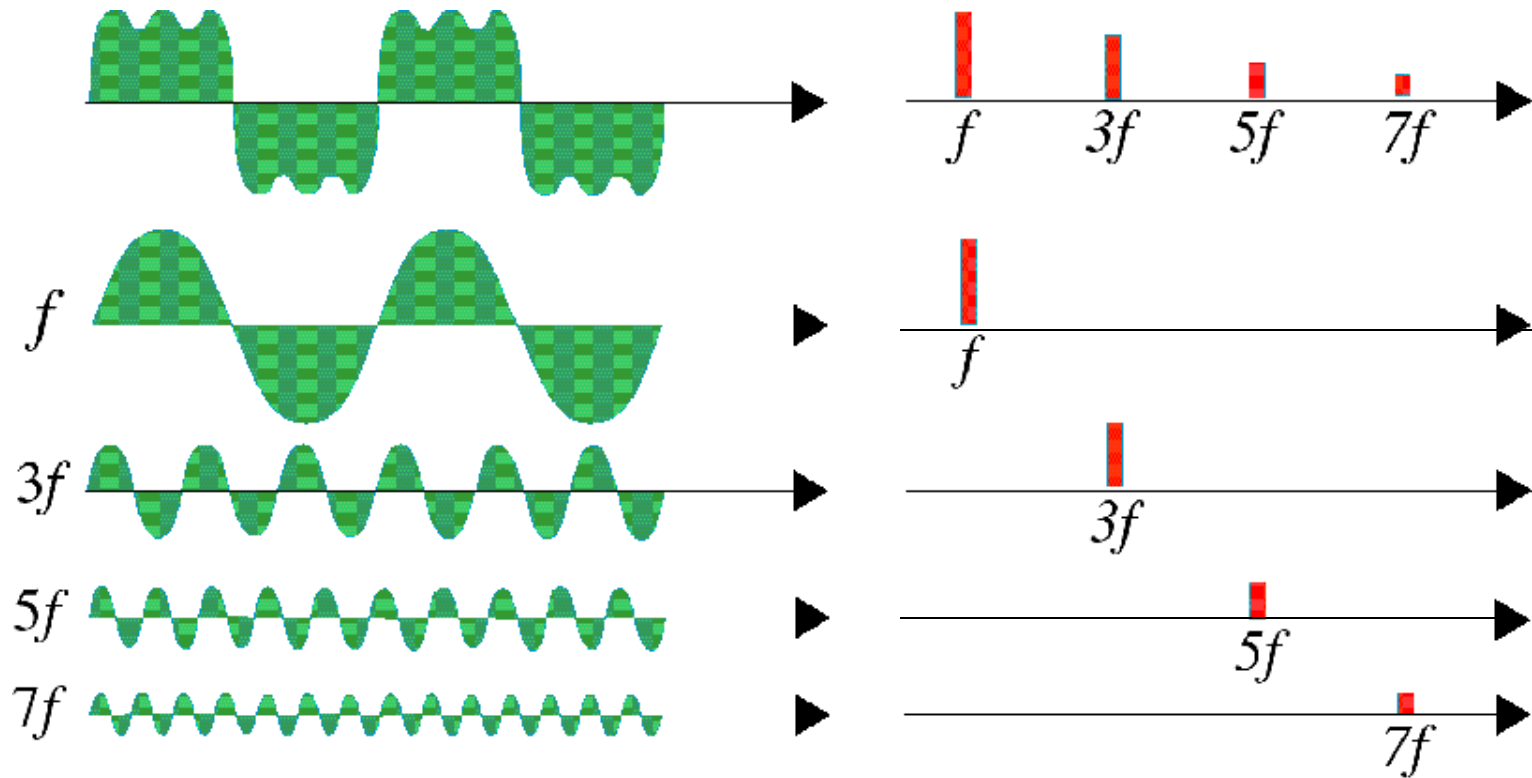


b. 180 degree phase shift

Bit Rate and Bit Interval



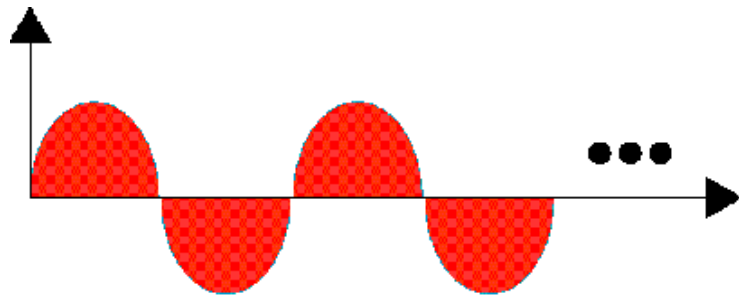
Composite Waveform (Square)



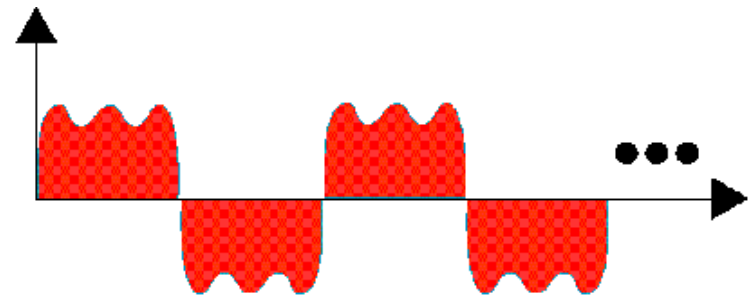
a. Time domain

b. Frequency domain

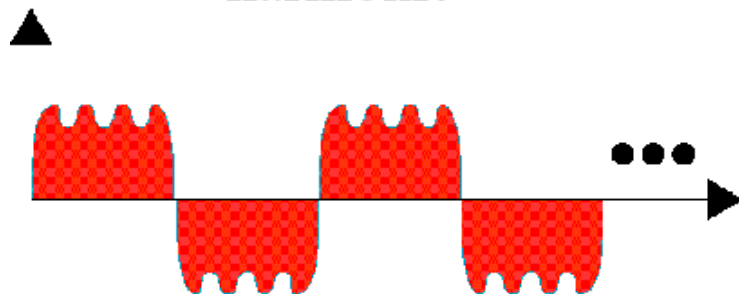
Harmonics of a digital signal



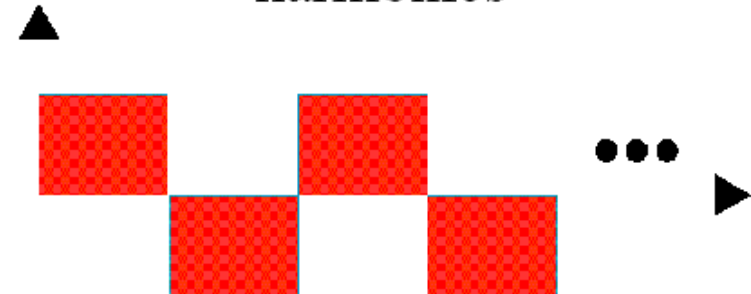
a. Only first harmonic



b. First, third, and fifth harmonics

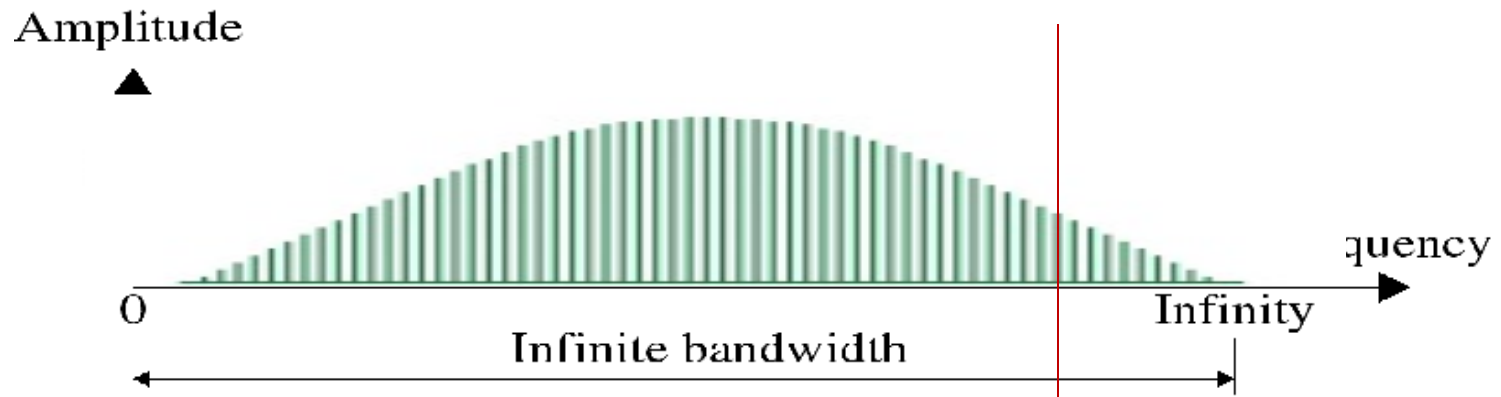


c. First, third, fifth, and seventh harmonics

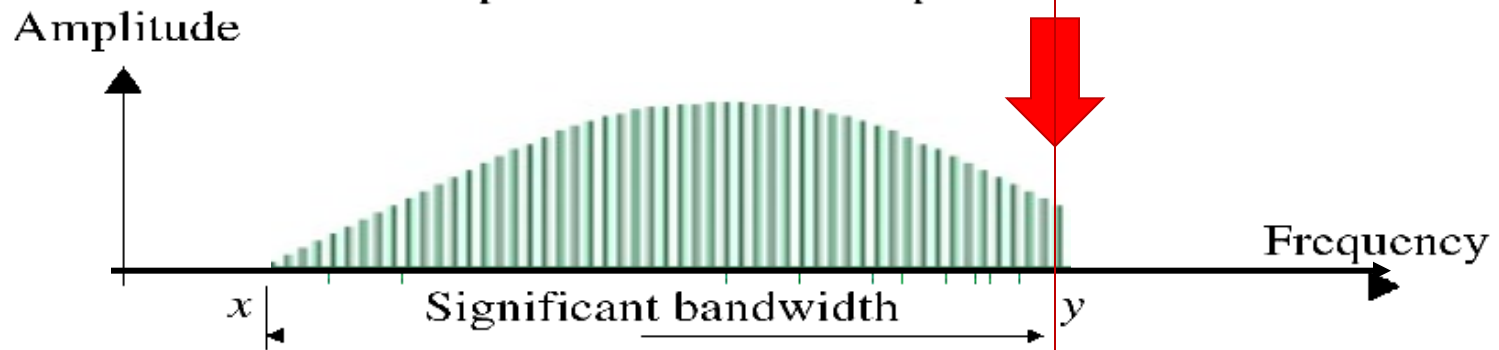


d. Infinite number of harmonics

Exact and Significant spectrums



a. Spectrum for exact replica



b. Significant spectrum

Bandwidth of a Medium

- Most transmission media have bandwidth limit

