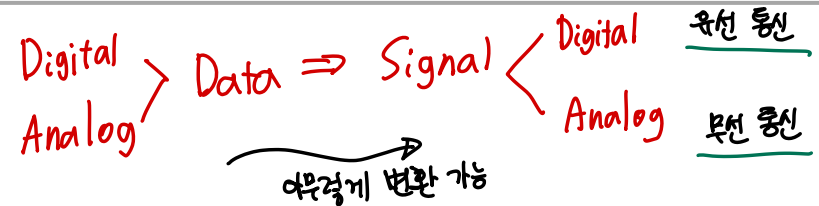


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# Data Communications

-Data and Signal- 이더넷 LAN

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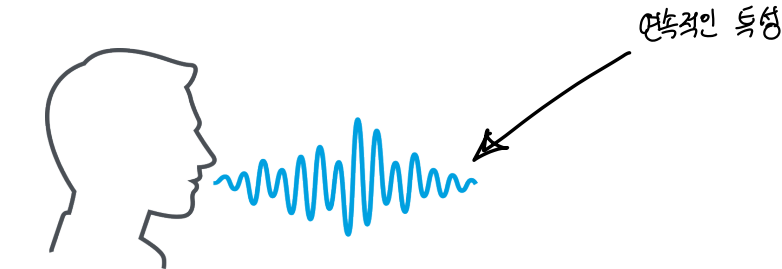


2024. 10. 8

Young Deok Park (박영덕)

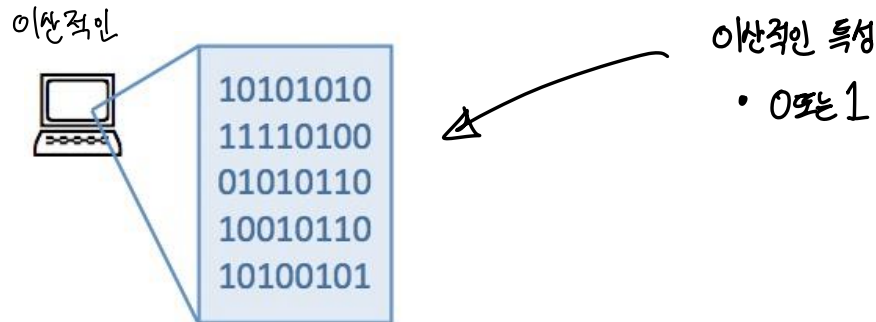
# Analog and Digital Data

- Analog data are continuous and take continuous values



Voice: analog data

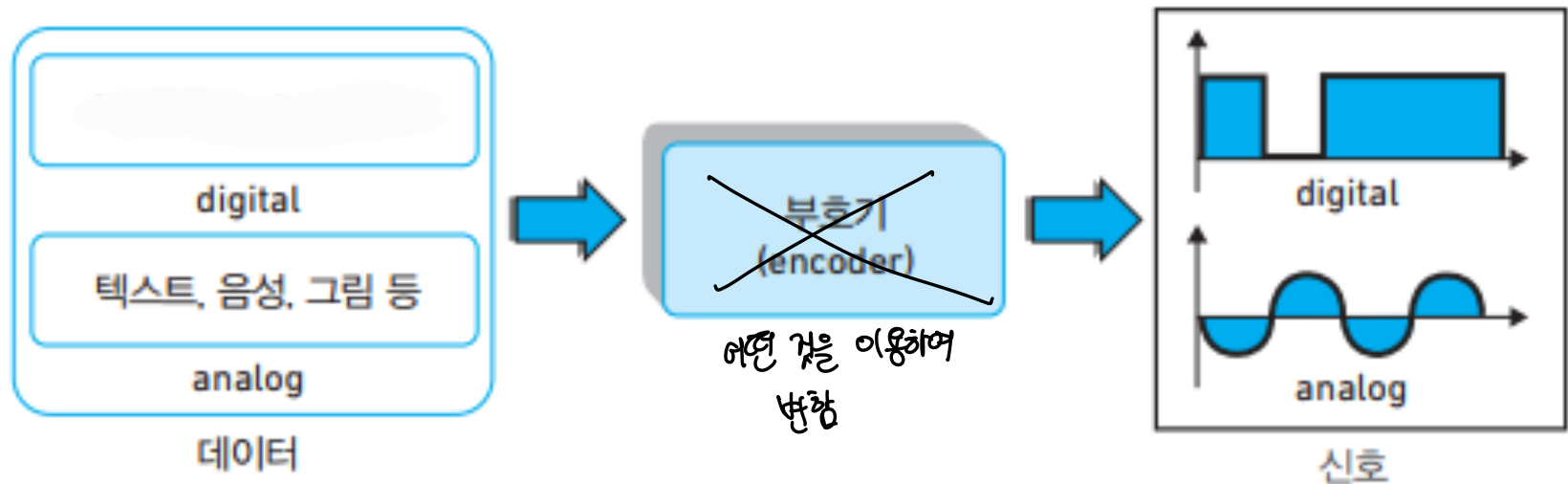
- Digital data have discrete states and take discrete values



Files in our PC: digital data

# Data and Signals

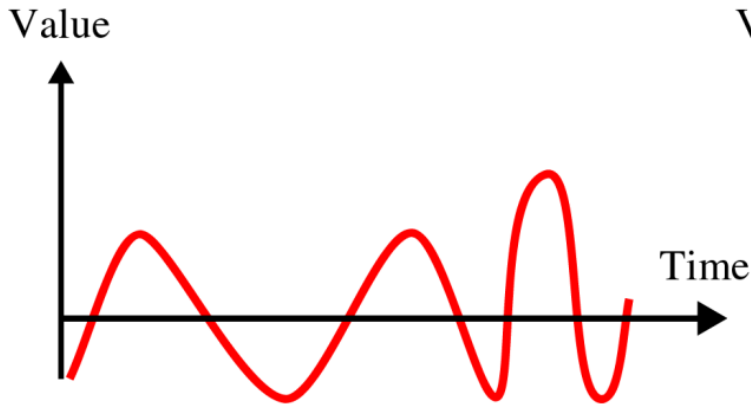
- To be transmitted, data must be transformed to electromagnetic signals  
전동  
전자기 신호



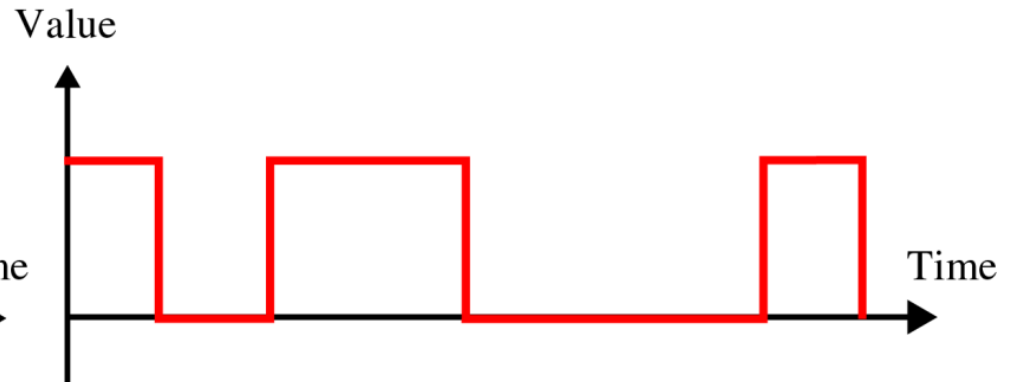
- Data can be analog or digital
- Signals can be analog or digital

# Analog and Digital Signal

- Analog signal
  - Continuous
  - Infinite number of values in a range 무한량
- Digital signal
  - Discrete 이산적
  - A limited number of values 유한량



a. Analog signal



b. Digital signal

# Periodic and Non-periodic Signals

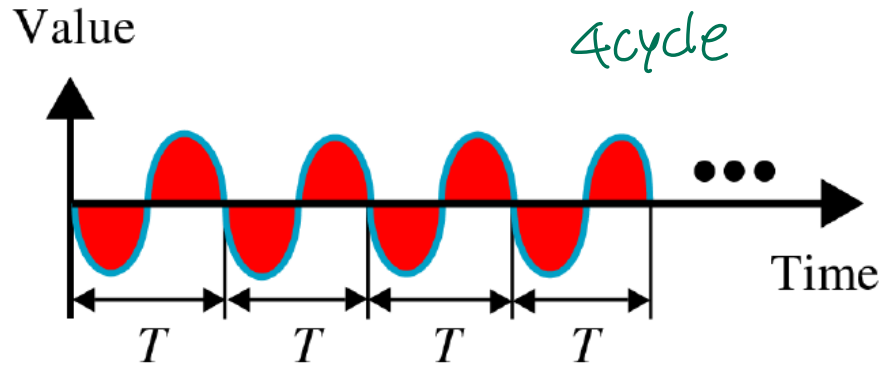
주기적

비주기적

## ■ Periodic signal 주기적으로 반복

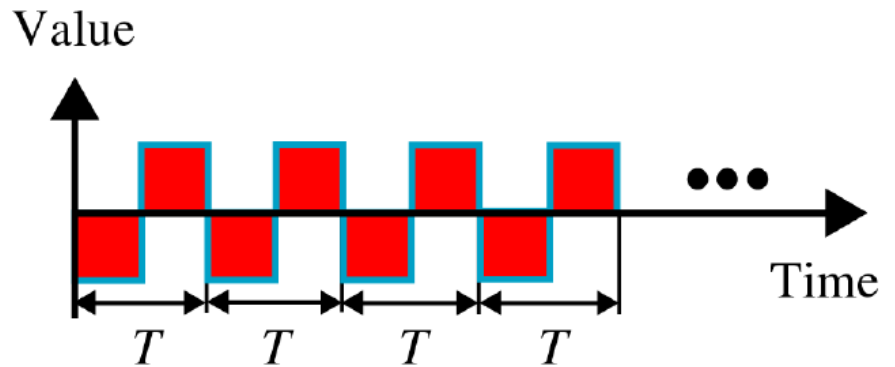
- Repeats a pattern of signal over identical subsequent periods
- Cycle: the completion of a full pattern 동안 동일한 반복 기간  
완료 완전한

## ■ Example (Duration period: $T$ )



a. Analog

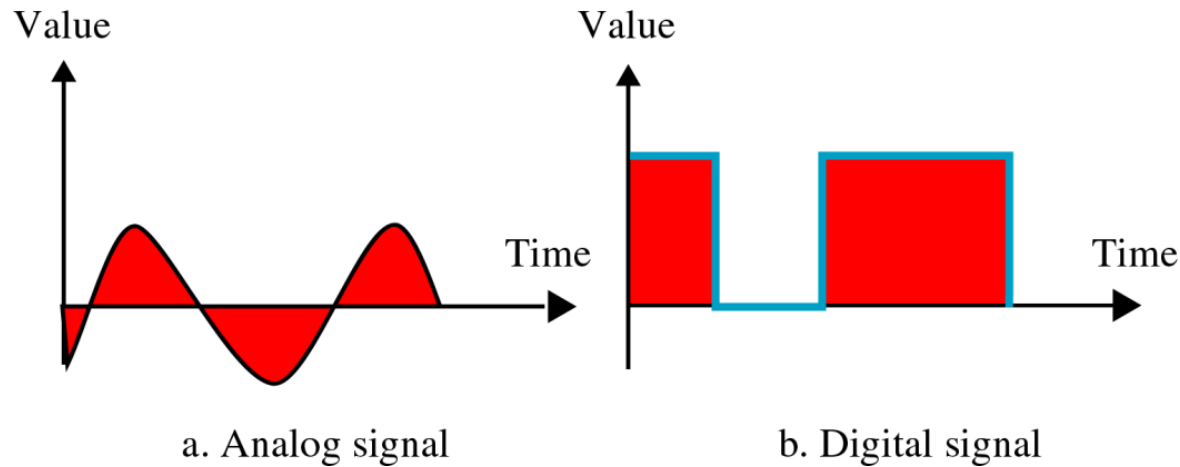
Periodic Analog Signal



b. Digital

# Periodic and Non-periodic Signals

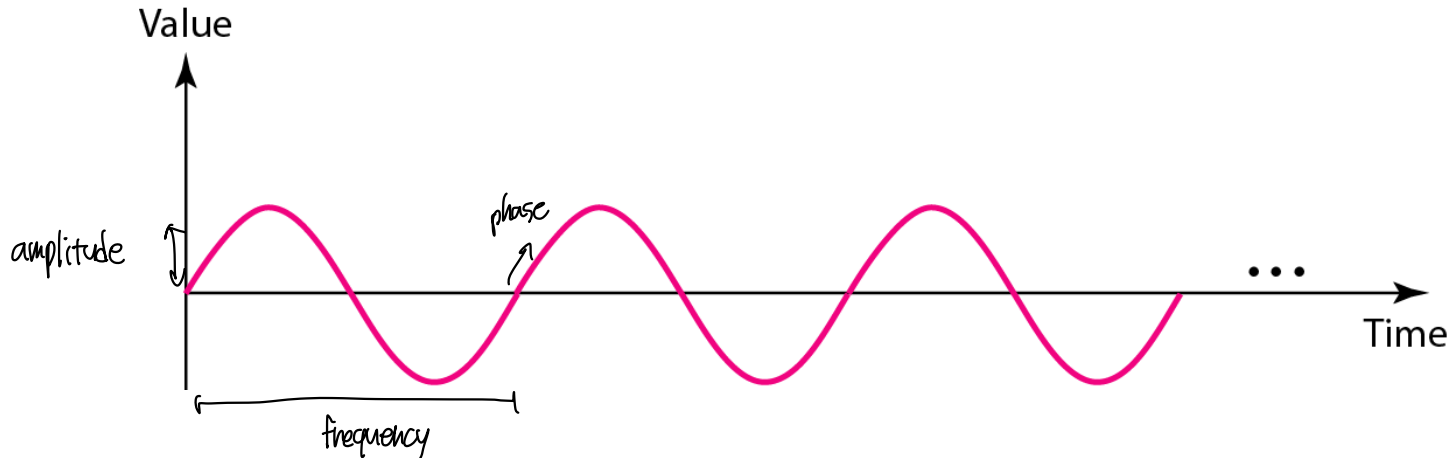
- Non-periodic signal (aperiodic signal)
  - Has no repetitive pattern



*Non-periodic Analog signal*

# Analog Signals

- The most fundamental form of analog signal: sine wave 기본적인 형태로 구성



- Sine wave
  - Described by the amplitude, frequency (or period), and phase  
설명됨 진폭 주파수 위상

# Peak Amplitude, Frequency, and Phase

절대값

## ■ Peak amplitude of signal

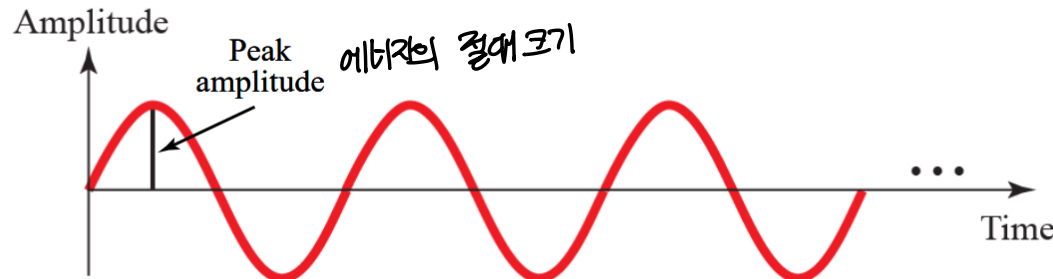
- Absolute value of its highest intensity
  - Proportional to the energy it carry

절대값

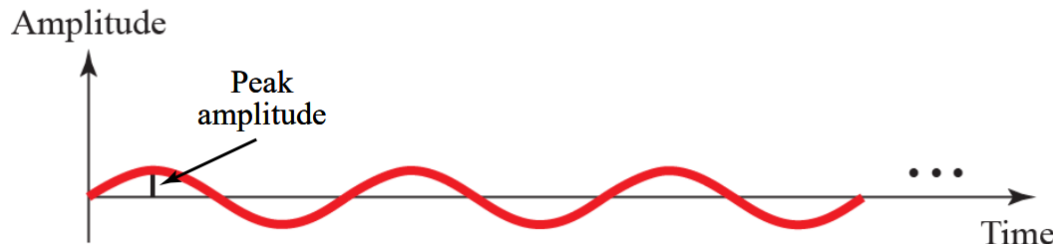
비례

강도

운반하는



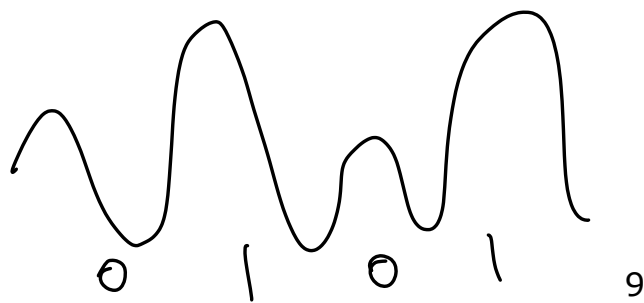
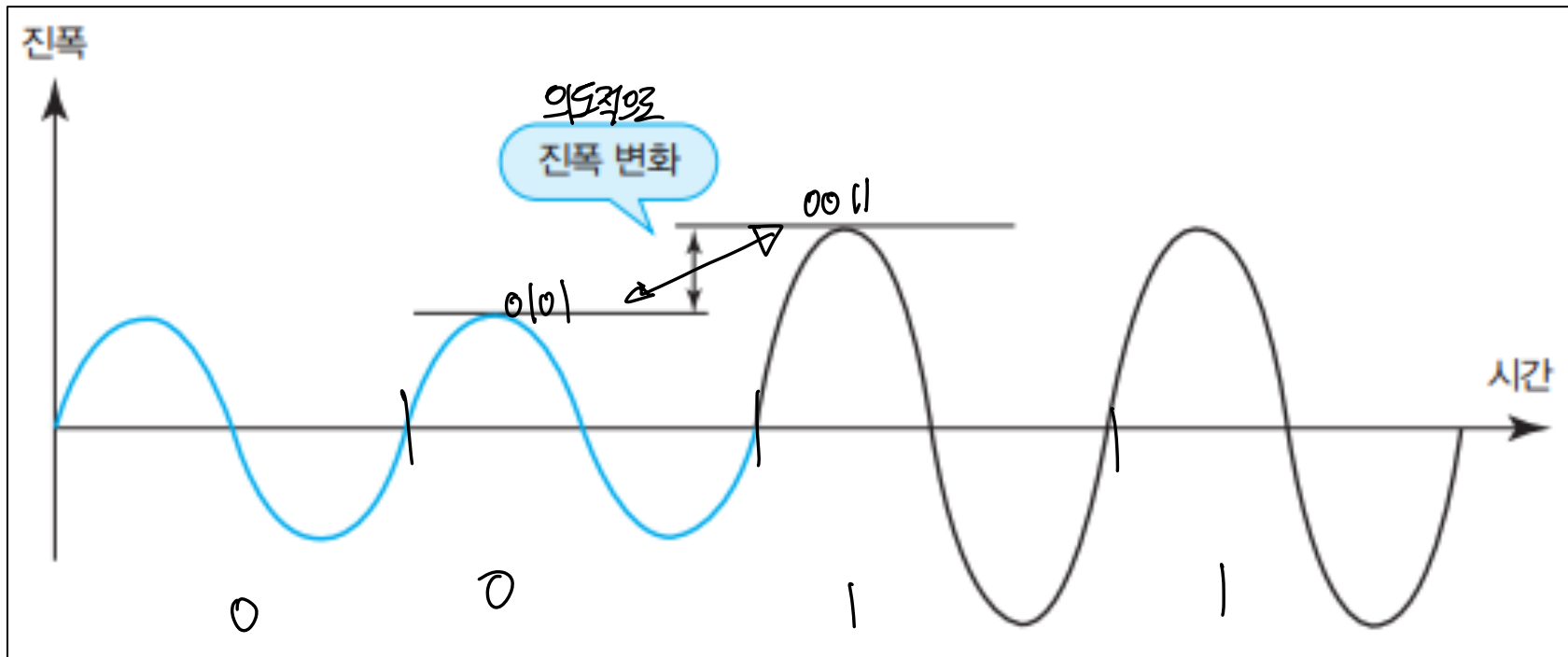
a. A signal with high peak amplitude



b. A signal with low peak amplitude



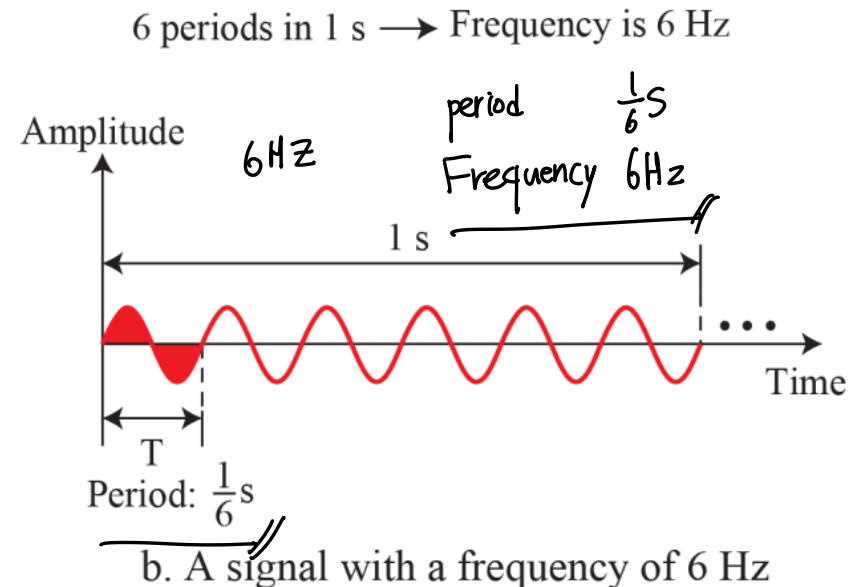
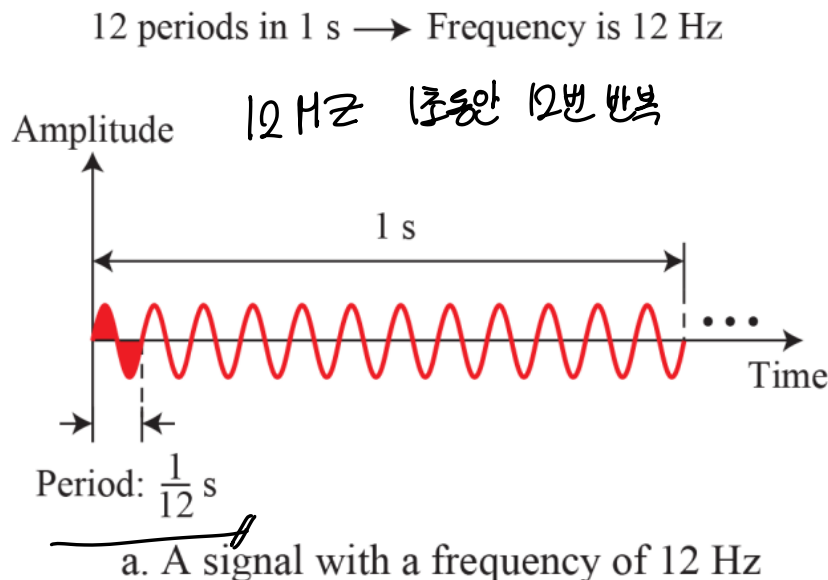
# 참고: 진폭 변화 (Amplitude Change)



# Peak Amplitude, Frequency, and Phase

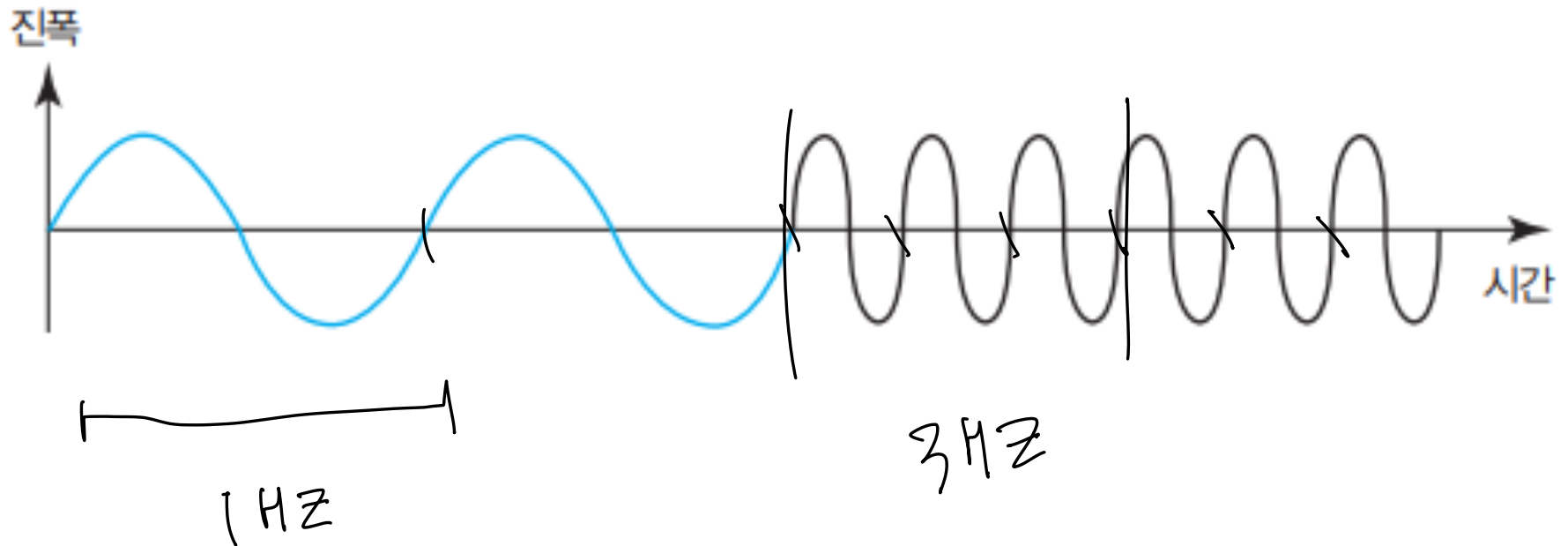
## ■ Period and frequency

- Period: amount of time in sec, a signal needs to complete 1-cycle
- Frequency: The number of periods in 1 sec



# 참고: 주파수 변화 (Frequency Change)

데이터를 빠르게 전달



# Peak Amplitude, Frequency, and Phase

## ■ Phase

- Describes the position of the waveform relative to time zero

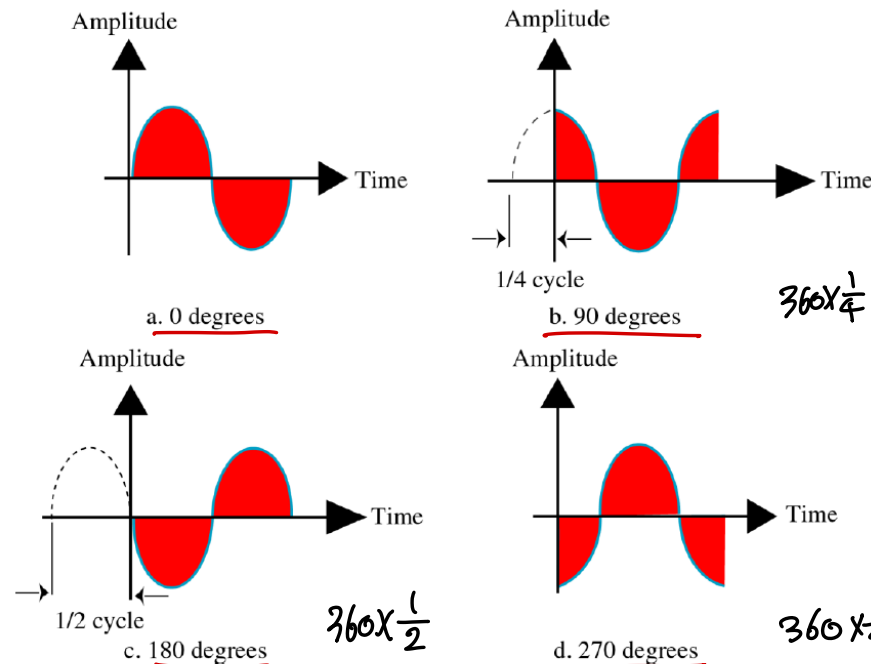
주(2)

위상

기준점

## ■ Example

- Four sine waves with the same amplitude and frequency, but different phases



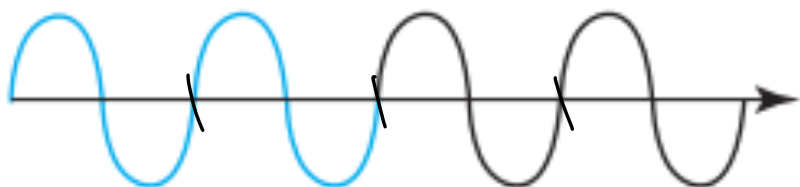
0 : 00  
90 : 01  
180 : 10  
270 : 11

0 : 0  
180 : 1

# 참고: 위상 변화 (Phase Change)

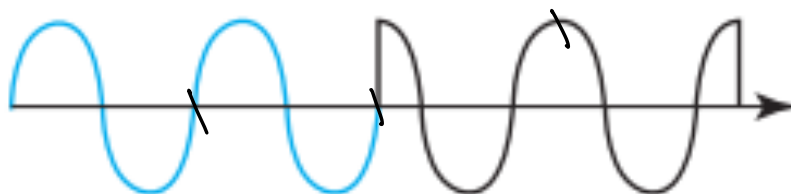
위상 변할 수 있다

00 00 00 00

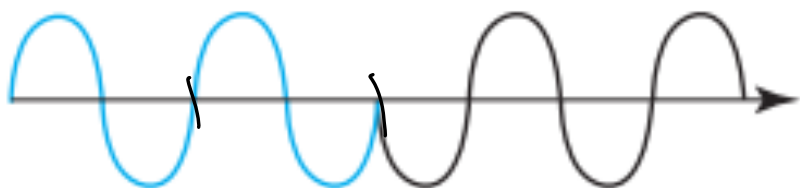


a. 위상 변화 없음

00 00 01 01

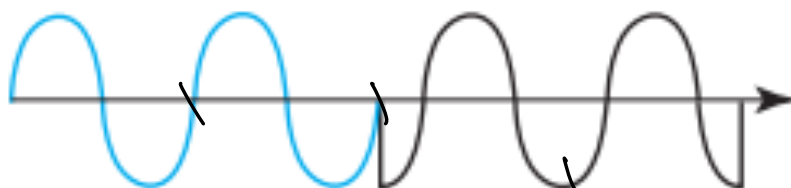


b. 90도 위상 변화



c. 180도 위상 변화

00 00 10 10



d. 270도 위상 변화

00 00 11 11

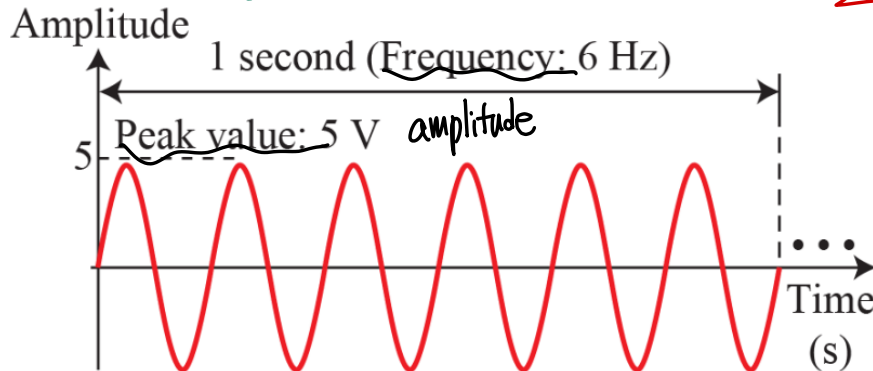
# Time-domain and Frequency-domain

시간

주파수

- We have been showing a sine wave by using what is called a time-domain plot
  - Time-domain shows the relationship between the amplitude and the time
- Frequency-domain shows the relationship between the amplitude and the frequency

시간 정보

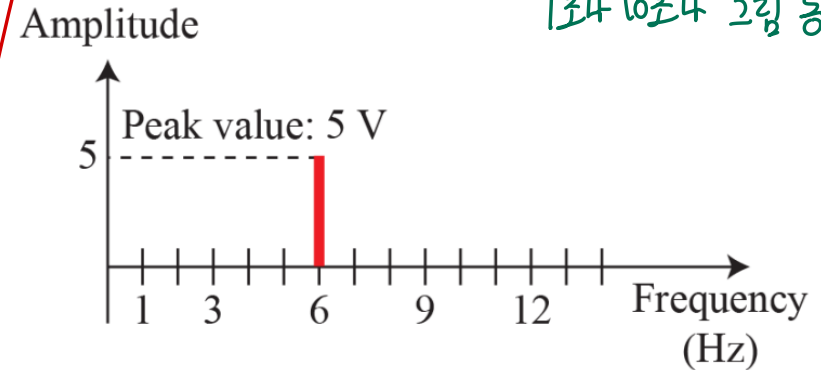


a. A sine wave in the time domain



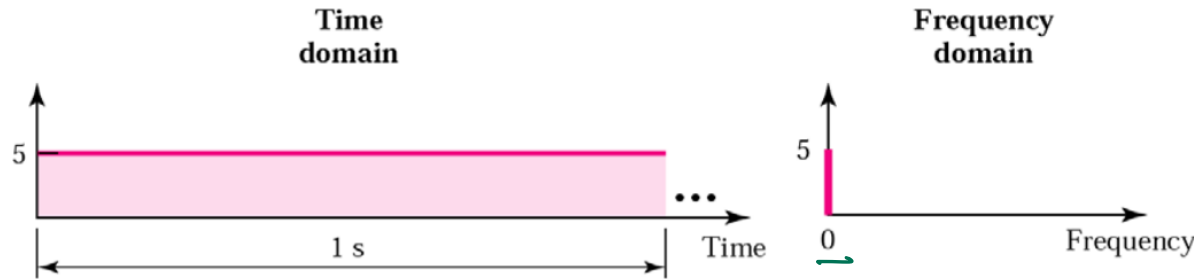
시간 정보 사라짐 (1초 동안 발생 X)

1초나 10초나 그림 동일

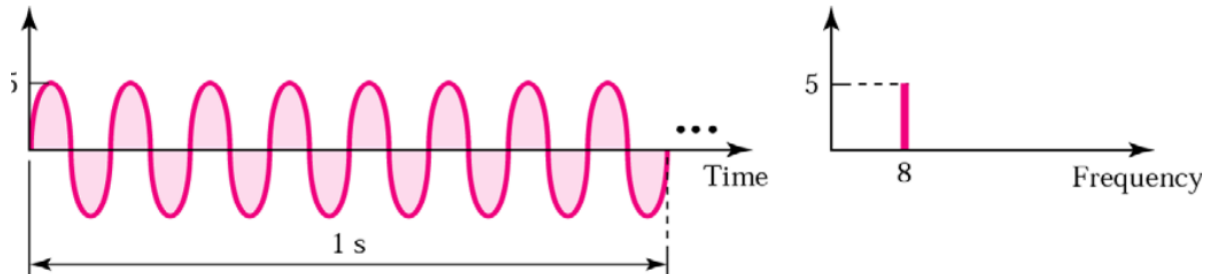


b. The same sine wave in the frequency domain

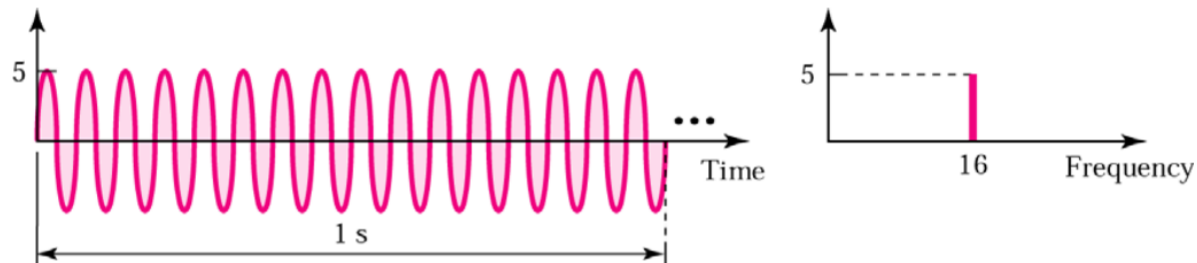
# Time-domain and Frequency-domain



a. A signal with frequency 0



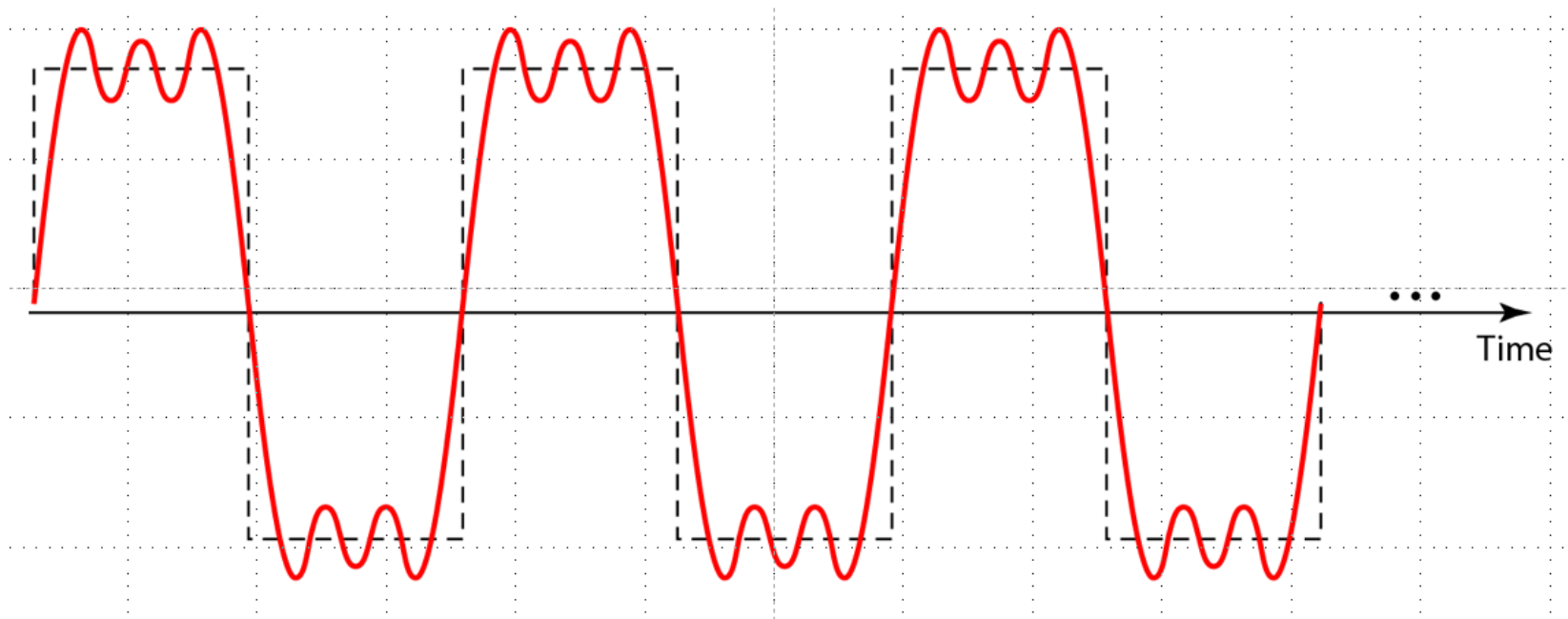
b. A signal with frequency 8



c. A signal with frequency 16

# Time-domain and Frequency-domain

- Composite signal (복합신호) *복합 신호일때 frequency 보기 힘들*
  - A combination of simple sine waves with different frequencies, amplitudes, and phases

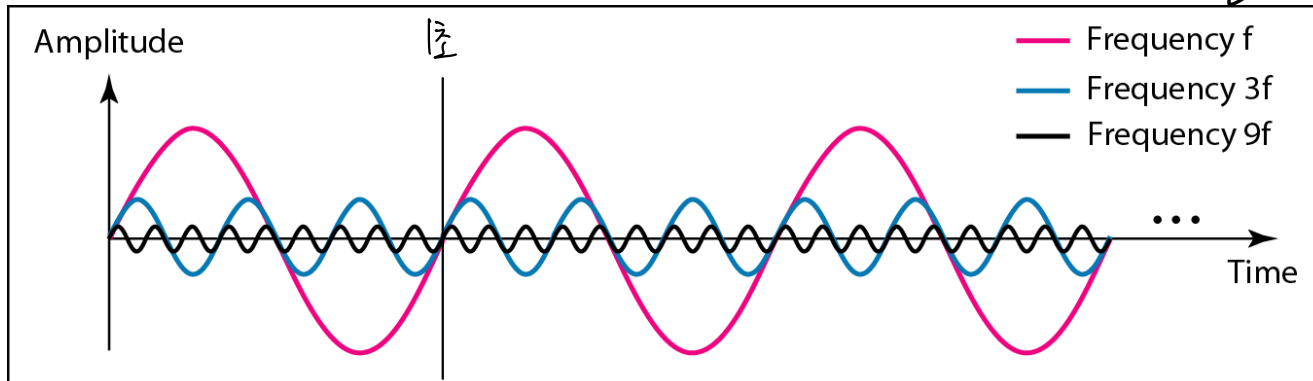




# Time-domain and Frequency-domain

## ■ Composite signal (복합신호)

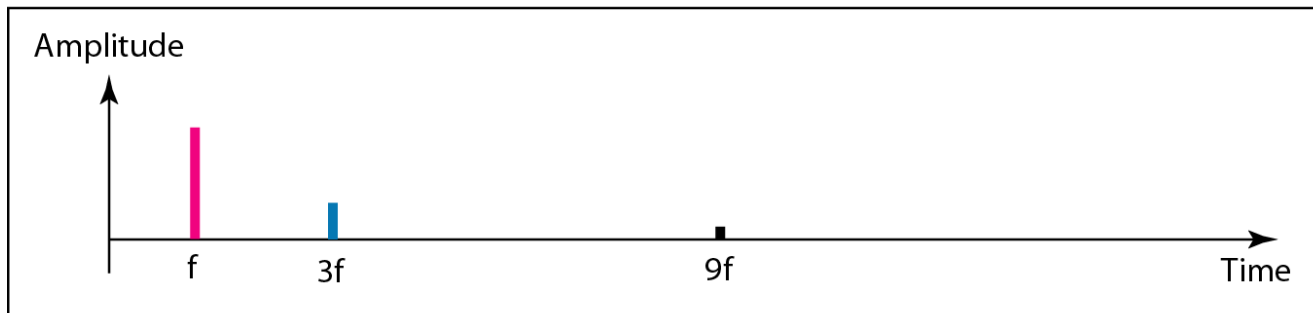
- A combination of simple sine waves with different frequencies, amplitudes, and phases



a. Time-domain decomposition of a composite signal

분해      복합

↕ 왔다 갔다 봄



b. Frequency-domain decomposition of the composite signal

# Frequency Spectrum and Bandwidth

## ■ Frequency spectrum

- The collection of all the component of frequencies

특정

구성요소

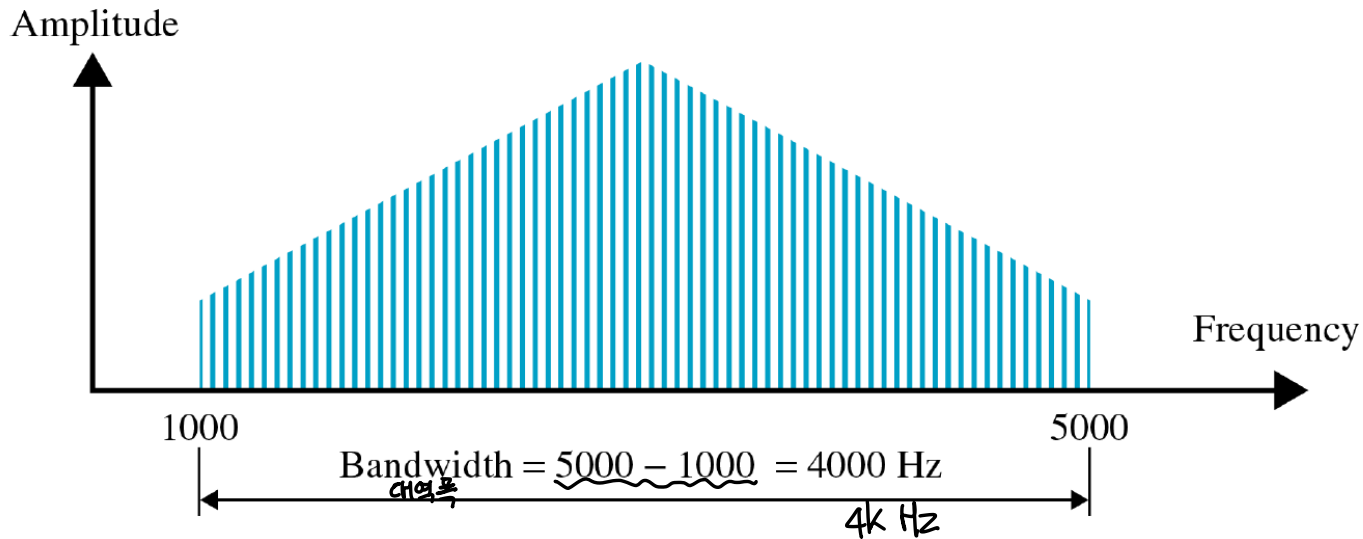
주파수

## ■ Bandwidth

- The width of the frequency spectrum

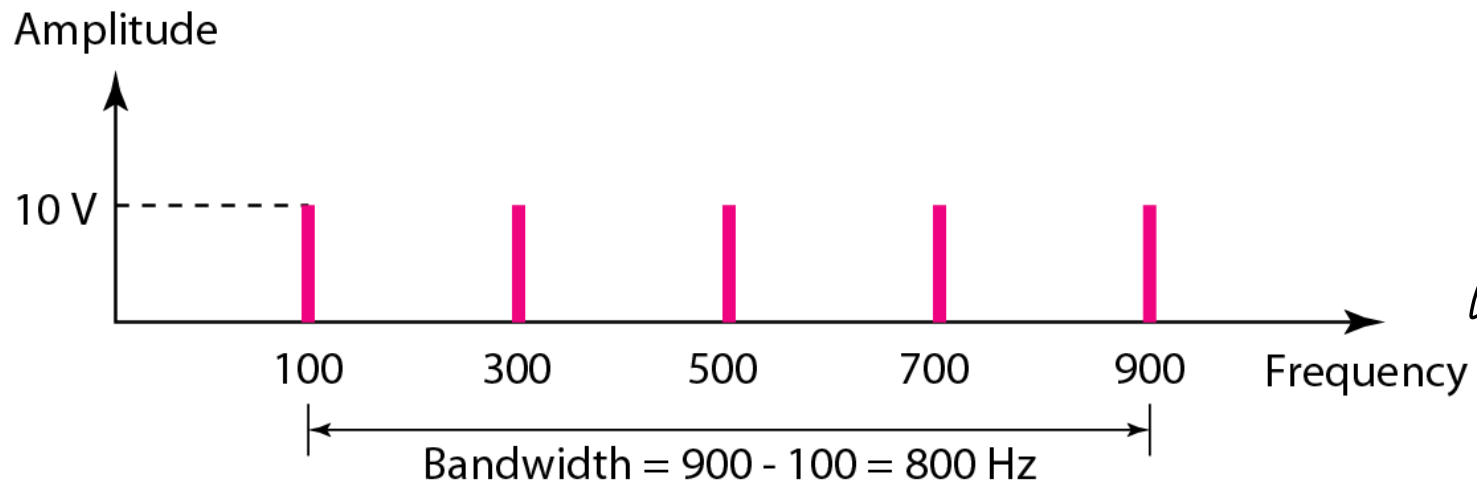
대역폭

폭



# Bandwidth: Example

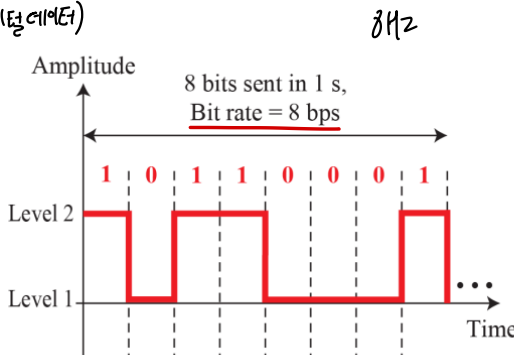
- If a periodic signal is decomposed into five sine waves with frequencies of 100, 300, 500, 700, and 900 Hz, what is its bandwidth?
- Draw the spectrum, assuming all components have a maximum amplitude of 10 V



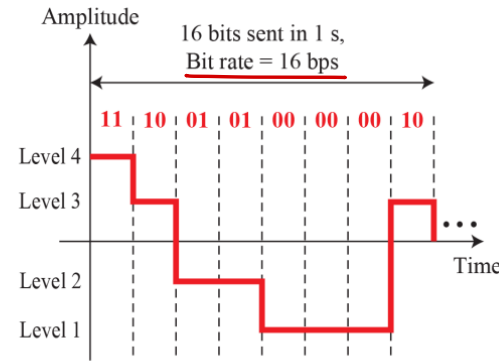
# Digital Signals

- Information can also be represented by a digital signal
- A 1 can be encoded as a positive voltage/ and a 0 as zero voltage. Furthermore, a digital signal can have more than two levels. In this case, we can send more than 1 bit for each level

bps: 초당 전송되는 비트 수 (디지털 데이터)  
frequency: 초당 진동 횟수



a. A digital signal with two levels



b. A digital signal with four levels

이상적으로는 동일  
중간에 에러

전송 속도

## Bitrate

- # of transmitted bits per second (bps, bit per sec)

## Throughput

- # of processed (received) bits per second (bps)

1bit < 2bit

메트릭: 성능을 측정하기 위한 지표

받은 비트 수 초당