Communication Theory - 2026

Chapter 2. Signals and Signal Space

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Definitions: Signals and Systems

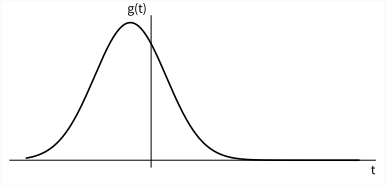
Signals

A signal is a set of information or data.
Examples: Audio signals, video signals, sensor data, etc.
In all these examples, the signals are functions of the independent variable **time** *t*.

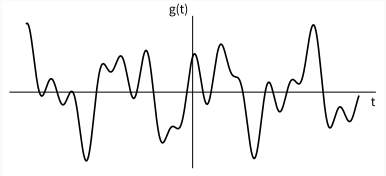
Systems

Signals may be processed further by systems, which may modify them or extract additional infromation from them.
For example, an antiaircraft radar system processes the received signals (inputs) to determine the position and velocity of an aircraft (outputs).
Thus, a system is an entity that processes signals (**inputs**) to yield another set of signals (**outputs**).
More examples: Amplifiers, filters, modulators, demodulators, etc.

Size of Signal



(a) Signal with finite energy



(b) Signal with finite power

Figure 1. Examples of signals.

Energy Signal

A signal is said to be an energy signal if its energy is finite and its average power is zero.

$$E = \int_{-\infty}^{\infty} |x(t)|^2 dt < \infty, \quad P = 0$$

Power Signal

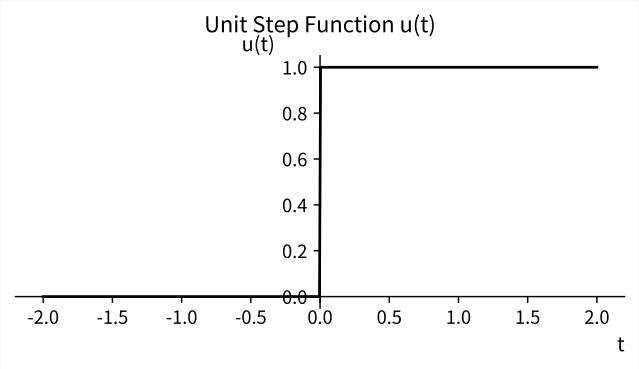
A signal is said to be a power signal if its average power is finite and its energy is infinite.

$$P = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} |x(t)|^2 dt < \infty, \quad E = \infty$$

Overview

- **Basic Signals:** 단위 계단 함수 $u(t)$와 델타 함수 $\delta(t)$
- **Signal Operations:** 시간 이동(Shifting)과 스케일링(Scaling)
- **Correlation:** 신호의 유사도(Similarity) 측정

1. Basic Signals: Unit Step Function



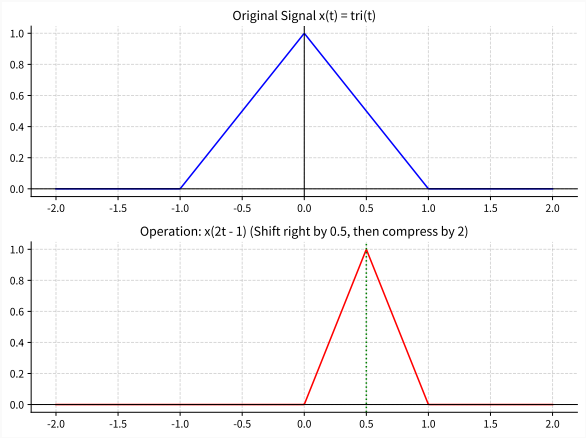
Definition

$$u(t) = \begin{cases} 1, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

Key Property:

시스템의 스위칭 동작(Switching)을 수학적으로 모델링할 때 사용됨.

2. Signal Operations: $x(at - b)$



해석 순서 (Order of Operations):

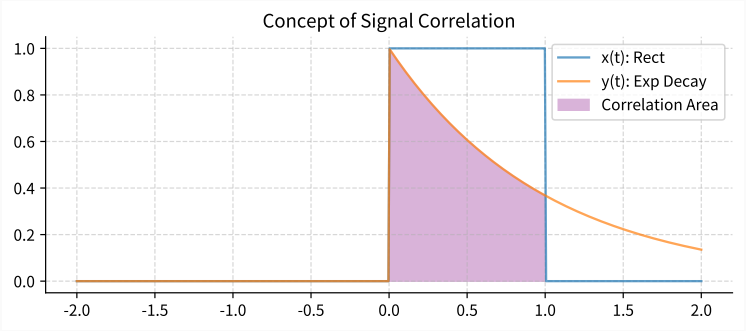
1. **Shifting:** $t \rightarrow t - t_0$
   (Right if $t_0 > 0$)
2. **Scaling:** $t \rightarrow at$
   (Compression if $a > 1$)

Caution

$x(2t - 1)$은 $x(t)$를 1만큼 이동 후 2배 압축하는 것이 아님!

→ $x(2(t - 0.5))$로 생각해야 함.

3. Signal Correlation



Correlation Coefficient (C_n)

두 신호가 얼마나 닮았는가? (Measure of Similarity)

$$\rho = \frac{\int x(t)y^*(t)dt}{\sqrt{E_x E_y}}$$

Summary

- **Unit Step** $u(t)$**:** 인과성(Causality) 표현의 핵심
- **Operations:** $x(at - b)$ 꼴의 변환을 자유자재로 다뤄야 함
- **Correlation:** 통신 시스템에서 수신 신호를 검출(Detection)하는 기본 원리