Signal and System

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Abstract

These are notes on **Signal and System**.

Contents

1 Lecture1

1.1 What is a Signal

In this subsection, we will introduce some notions in **SS** course.

First, what is a signal? A signal is a **function**. Suppose **x** is a signal, then it can represent the following mapping relationship:

$$\begin{aligned} \mathbb{R}(\text{reals}) &\longrightarrow \mathbb{R}(\text{reals}) \\ \mathbb{Z}(\text{integers}) &\longrightarrow \mathbb{R}(\text{reals}) \\ \mathbb{Z}(\text{reals}) &\longrightarrow \mathbb{C}(\text{complexes}) \end{aligned} \tag{1}$$

In the above formula, we call the left **domain or input space**, we call the right **range or output sapce**, referring to the definition in the function,

At the same time, an element in domain is called **independent variable**, an element in range is called **dependent variable or the value of function**.

After we give the doamin and the range, we need a **rule** to map every element in the domain to the range, which says what we operate on the the independent variable. The rule is also called the **function relation**.

For example, considering the following euqation:

$$x(n) = \cos \frac{\pi}{4} n \tag{2}$$

we have the following relations:

- **domain**: $\mathbb{Z}$, a set of all integers;
- **independent variable**: n, integers;
- **range**: all real numbers in [-1,1];
- **value of function**: $x(n)$;
- **function relation**: $\boldsymbol{x}$, $\cos \frac{\pi}{4}[\cdot]$

1.2 DT and CT

Now let's introduce **DT** and **CT**.

For a signal **x**, if the domain is $\mathbb{Z}$ or the set of all integers, then the signal **x** is called **Discrete-Time** signal (**DT**). For example:

$$x(n) = \cos\frac{\pi}{4}n, \quad n \in \mathbb{Z} \tag{3}$$

For a signal $\boldsymbol{x}$, if the domain is $\mathbb{R}$ or the set of all reals, then the signal $\boldsymbol{x}$ is called **Continuous-Time** signal (**CT**). For example:

$$x(t) = \mathrm{e}^{-t}, \quad t \in \mathbb{R} \tag{4}$$

Meanwhile:

- if we use n as the independent variable, that means the signal is **DT**;
- if we use t as the independent variable, that means the signal is **CT**;

these are the conventions.

Supplement: Does the signal have to be the function of **only time**? The answer is **No**. For example, the independent variables can be **space coordinates**.

1.3 Examples and Conventions