

Notes on Signal and System

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# Signal and System

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# **Abstract**

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

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# 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  $\mathbf{x}$  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:**  $\mathbf{x}, \cos \frac{\pi}{4}[\cdot]$

## 1.2 DT and CT

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

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

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

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

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

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

## 2 Lecture2