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# Definition and Basic Concepts of Discrete Control Systems

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**Abstract:** This article analyzes the theoretical foundations, structure, and operating principles of discrete control systems. Discrete systems operate by converting continuous signals into discrete forms in terms of time and amplitude. During the study, fundamental concepts such as discretization, sampling, quantization, and Z-transformation were examined. In addition, the structural elements of discrete control systems and their interactions were analyzed. The results indicate that discrete systems are characterized by high accuracy, flexibility, and advanced digital control capabilities.

**Keywords:** discrete system, discretization, sampling, quantization, Z-transformation, ADC, DAC, microprocessor, control system

## 1. Introduction

In modern automated control systems, the role of digital technologies is steadily increasing. In particular, discrete control systems are widely used in industries such as manufacturing, energy, transportation, and robotics. Unlike continuous (analog) systems, discrete control systems process signals only at specific time intervals [1].

The development of such systems is closely related to the widespread use of microprocessors and microcontrollers. Discrete systems make it possible to implement complex mathematical algorithms, reprogram systems, and ensure high-precision control [2].

The purpose of this article is to study the fundamental concepts of discrete control systems and to analyze their operating principles and structural components [3].

## 2. Materials and Methods

The following research methods were used in this study:

a. Theoretical analysis — scientific literature on discrete systems was reviewed;
b. Mathematical modeling — discrete signals and their representations were analyzed[4];
c. Comparative method — analog and discrete systems were compared;
d. Computational method — the sampling process was demonstrated through an example[5].

The main concepts of discrete control systems include:

a. Discretization — the process of converting a continuous signal into a discrete form
b. Sampling — dividing a signal in time
c. Quantization — converting signal amplitude into discrete levels
d. Z-transformation — a mathematical method for analyzing discrete systems[6]

System Structure
A discrete control system consists of the following main components:

a. Sensor
b. Analog-to-Digital Converter (ADC)[7]
c. Microprocessor or microcontroller
d. Digital-to-Analog Converter (DAC)[8]
e. Actuator

## 3. Results

During the study, the operation of a discrete system was demonstrated using a mathematical example.[8]

**Sampling Process**

Given signal:

$$x(t) = 5\sin(2\pi * 2t)$$

Where:

- Amplitude = 5
- Frequency = 2 Hz[9]

According to the Nyquist theorem:

$$f_s \geq 2fmax = 4Hz$$

We choose:

$$f_s \geq 8\ Hz$$

Sampling period:

T-1/8=0.125 s

Discrete signal:[10]

$$x[n] = 5\ sin(0.5\pi n)$$

Calculated values:

| n | x[n] |
|---|---|
| 0 | 0 |
| 1 | 5 |
| 2 | 0 |
| 3 | -5 |
| 4 | 0 |
| 5 | 5 |

The results show that the continuous signal was successfully converted into a discrete signal.[11]

**Quantization Results**

During quantization, the signal amplitude was divided into discrete levels. It was determined that smaller quantization steps lead to higher system accuracy.

## 4. Discussion

Discrete control systems offer the following advantages:

a. High accuracy
b. Flexibility
c. Programmability
d. Resistance to noise [12]

However, some limitations also exist:

a. Discretization errors
b. Quantization noise
c. High computational requirements [13]

The efficiency of discrete systems depends on the sampling frequency and quantization level. Incorrect parameter selection may lead to signal distortion (aliasing .[14].

Modern systems increasingly integrate discrete control with artificial intelligence and digital signal processing techniques [15].

## 5. Conclusion

This study explored the theoretical and practical aspects of discrete control systems. Discrete systems demonstrate high efficiency in processing continuous signals and have become an essential part of modern automated systems.

The results show that:

a. Discrete systems provide high accuracy;
b. They can be controlled programmatically;
c. They are widely used in industry and technology.

In the future, integrating discrete control systems with artificial intelligence, IoT, and big data technologies will be an important direction for further development.

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