

# TKE212201

## Digital Signal Processing Teknik Pengolahan Isyarat Digital

### BASIC INFORMATION

<b>Course Credit</b>	3 / 150 minutes per Week
<b>Course Type</b>	Required
<b>Course Classification</b>	Engineering Topics
<b>Prerequisites</b>	Signals and Systems; Differential Equations; Complex Variable Analysis; Linear Algebra

### STUDENT AND LEARNING OUTCOMES

#### Covered Student Outcomes

Fundamental and Engineering Knowledge (KP.1)      Development of Engineering Solution (KP.2)

#### Learning Outcomes

- LO1** The students are able to apply Z-Transform and to identify the characteristic of a discrete-time linear system including its stability, frequency response, causality and other important properties.
- LO2** The students are able to analyze the frequency response of discrete-time system.
- LO3** The students are able to understand the concept discrete time Fourier transform as well implement it in the form of fast Fourier transform.
- LO4** The students are able to design digital FIR and IIR filter and understand its properties.

### COURSE DESCRIPTION

In this course, the students study about the characterization of discrete-time signal and system using Z-transform, discrete-time Fourier transform and discrete Fourier transform. The students also learn the implementation of discrete Fourier transform in the form of fast Fourier transform algorithm and design a digital FIR and IIR filter.

### TOPICS

#### 1. Review on Discrete Time LTI System and Signals

- 1.1 Discrete Time Signal and Review on Sampling Theory
- 1.2 Discrete Time System and Block Diagram Representation
- 1.3 Discrete Time LTI System, Convolution, FIR and IIR System
- 1.4 Representation of Discrete Time LTI System using Difference Equation
- 1.5 Implementation of Discrete Time LTI System
- 1.6 Correlation of Discrete Time Signal

#### 2. Z-Transform (First Part)

- 2.1 Review of Discrete Time Fourier Transform (DTFT)
- 2.2 Introduction to Z Transform and its relationship with DTFT

- 2.3 Direct Z-Transform
- 2.4 Region on Convergence
- 2.5 Property of Region of Convergence
- 2.6 Rational Function Z Transform
- 2.7 The use of Pole and Zero Concept to analyze Discrete-Time LTI System and Signal

### **3. Z-Transform (Second Part)**

- 3.1 Inverse Z-Transform (Contour Integration, Power Series Expansion, Partial Fraction Expansion)
- 3.2 Properties of Z-Transform
- 3.3 Analysis of LTI System using Z-Transform (Causality and Stability Analysis, Transient and Steady State Response)
- 3.4 Design of Discrete-Time LTI System from Z-Transform Point of View
- 3.5 Unilateral (One-Sided) Z-Transform

### **4. Analysis of Discrete-Time LTI System in the Frequency Domain**

- 4.1 Frequency Response of Discrete-Time LTI System
- 4.2 Signal Distortion (Magnitude and Phase Distortion, Group Delay)
- 4.3 Ideal Filter and Practical Filter
- 4.4 Relationship between Magnitude and Phase Response, Frequency Response of Rational LTI System Function
- 4.5 All-Pass Filter and Minimum Phase Filter

### **5. Discrete Fourier Transform (DFT)**

- 5.1 Review of DTFT and its relationship with DFT: Frequency Domain Sampling and Reconstruction of Discrete-Time Signal
- 5.2 DFT Formulation
- 5.3 Properties of DFT: Periodicity, Linearity, Symmetry etc.
- 5.4 Multiplication Property and Circular Convolution
- 5.5 Analysis of Filtering Process using DFT
- 5.6 Analysis of Signal Frequency using DFT
- 5.7 Windowing and Zero Padding

### **6. Implementation of DFT using Fast Fourier Transform (FFT) Algorithm**

- 6.1 Direct DFT Computation
- 6.2 Divide and Conquer Approach
- 6.3 FFT Radix-2 Algorithm
- 6.4 FFT Radix-4 Algorithm
- 6.5 Split-Radix FFT Algorithm
- 6.6 Implementation of FFT
- 6.7 Application of FFT

### **7. Structure of Digital Filter**

- 7.1 Structure of FIR Filter (Direct-Form, Cascade-Form, Frequency-Sampling, and Lattice)
- 7.2 Structure of IIR Filter (Direct-Form, Signal Flow Graph and Transpose, Cascade-Form, Parallel-Form, Lattice, and Lattice-Ladder)

## **8. Digital Filter Design**

8.1 Design of FIR Filter

8.2 Design of IIR Filter

### **REFERENCES**

- [1] Proakis, J.G., Manolakis, D.G., Dimitris G., Applied Digital Signal Processing : Theory and Practice, Cambridge University Press 2011
- [2] Digital Signal Processing, J.G Proakis and D. Manolakis, 4th edition, 2007, Pearson
- [3] Introduction to Digital Signal Processing, R. Kuc, 1988, Mc Graw Hill
- [4] Discrete-Time Signal Processing, A.V. Oppenheim and R. Schaffer, 3th edition, 2009, Pearson