EE2000 Signals and Systems

1. Course Title: Signals and Systems

2. Course Number: EE2000

3. Credits: 3(3-0-1-6)

- Lecture + Assignments: 45 hours
- Labs: 15 hours

4. Participation: Junior students in engineering from 3rd semester (compulsory for students in Control Engineering&Automation)

5. Prerequisites

- MI1110 Analytics III (or former MI1040), MI1140 Algebra (or former MI1030)

6. Learning Objectives and Outcomes

This course equips the students with basic knowledge on signal representation, analysis and process and linear system modeling; this knowledge makes a basis for other courses in engineering program, especially in Electrical Engineering, Control Engineering and Automation. The students will gain methods for describing and solving problems based on systematic approaches that are independent of and supplementary for physical and chemical approaches.

Upon completing the course, the students will be able to:

- Identify signal types and characteristics.
- Identify system types and characteristics.
- Present and explain the meaning of the Fourier analysis methods, point out their relationships and limitations, apply the Fourier transform and inverse Fourier transform to some typical functions.
- Present and explain the meaning of the Laplace transform and its relation to the Fourier transform , apply the Laplace transform and inverse Laplace transform to some typical functions.
- Present and explain the meaning of the Z transform and its relation to the Laplace transform , apply the Z transform and inverse Z transform to some typical functions.
- Calculate the impulse response and step response of a linear system given its differential or difference equation, then determine the system response to an arbitrary input.
- Apply the Fourier and Laplace transforms to representing, analyzing the dynamic characteristics of electrical circuits and some simple mechanical, hydraulic systems.
- Model electrical circuits and some simple mechanical, hydraulic systems as differential equations from which other representations are derived such as the impulse response, transfer function, frequency response and state-space model.
- Construct the frequency response plots (Bode and Nyquist plots), relate the frequency response characteristic to filtering property.

- Derive the relationships between differential/difference equation, frequency response, transfer function and state-space model of a (continuous-time or discrete-time) linear system.
- Relate the basic system properties (system order, poles, zeros, static gain) to its dynamic characteristics (stability, causality, impulse response, step response).
- Present the signal sampling process and aliasing phenomenon, apply the sampling theory to select the appropriate sampling period.

Indicate the student outcomes (listed in Program Criteria) addressed by the course: <3 levels: IN (Introduce), LE (Lecture) or AP (require students to apply or practice) to match the sub-criteria of the Program's Student Outcomes >

Sub-criterion	1.1	1.2	1.3	2.1	2.2	2.3	2.4	2.5	2.6	3.1	3.2	3.3	4.1	4.2	4.3	4.4	4.5
Level	LE	LE	LE	LE	LE	LE	IN							IN	IN		

7. Brief Contents

The concepts of signals and systems, signal types and characteristics, some typical signals, systems types and characteristics. Signal modeling and analysis in the time domain and the frequency domain: real-valued and complex-valued functions, Fourier series, Fourier transform, Laplace transform, signal sampling and reconstruction, Z transform. System representation and response determination in the time domain: differential/difference equation, impulse response, state-space model; System representation and analysis in the frequency domain: frequency response, transfer function. Problem solving and practice using Matlab.

8. Required Materials

- Textbook:
- Lecture notes (pdf):
- MATLAB software
- References:
    1. B. P. Lathi: *Signal Processing and Linear Systems*. Berkeley-Cambrigde, 1998.
    2. Sundararajan, D.: *Practical approach to signals and systems*. John Wiley & Son, 2008.
    3. Hwei P. Hsu: SCHAUM'S OUTLINES OF Theory and Problems of Signals and Systems. McGraw-Hill, 1995.

9. Learning Methods and Student Obligation

- The students are required to attend the lectures, read materials and actively do assignments following the learning objectives and outcomes.
- The students are required to complete 6 labs using Matlab, do the pre-lab, following the instruction at lab and write reports.

10. Grading

- Labs (test at lab): condition to attend the final examination
- Midterm: 0.3

- Final examination: 0.7

11. Detailed Content and Schedule

Week	Content	Textbook	Labs
1	INTRODUCTION CHAPTER 1. SIGNAL AND SYSTEM CONCEPTS 1.1 Signal and system definitions 1.2 Signal characteristics and classification 1.3 Some basic signal operations 1.4 System characteristics and classification 1.5 System Interconnections – Block diagram	Chapter 1	
2-3	CHAPTER 2. SYSTEM REPRESENTATION AND RESPONSE IN THE TIME DOMAIN 2.1 Differential equation 2.2 Difference equation 2.3 Impulse response and convolution 2.4 Continuous-time (CT) state-space model • Derivation from differential equation • Impulse response • Natural and forced responses 2.5 Discrete-time (DT) state-space model • Derivation from difference equation • Impulse response • Natural and forced responses	Chapter 2	Lab 1
4-5	CHAPTER 3. THE CONTINUOUS-TIME FOURIER SERIES AND TRANSFORM 3.1 Sinusoidal signals and complex-valued function representation 3.2 The continuous-time Fourier series • Idea: the superposition property of LTI systems • Fourier series for CT signals • Determination of (CT) Fourier series coefficients • Dirichlet conditions • Properties of (CT) Fourier series 3.3 The continuous-time Fourier transform • Derivation of the CT Fourier transform • Conditions for the Fourier transform • Properties of the CT Fourier transform • Inverse Fourier transform	Chapter 3	Lab 2
6	CHAPTER 4. THE DISCRETE-TIME FOURIER SERIES AND TRANSFORM 4.1 The discrete-time Fourier series • The (DT) Fourier series for DT signals • Determination of the DT Fourier series	Chapter 4	

	coefficients • Comparison of the CT Fourier series and DT Fourier series 4.2 The discrete-time Fourier transform • Derivation of the DT Fourier transform • Comparison with the CT Fourier transform • Properties of the DT Fourier transform 4.3 Fast Fourier transform algorithm (FFT)		
7-8	CHAPTER 5. FREQUENCY REPONSE OF CT SYSTEMS 5.1 Frequency response to periodic signals • Definition of frequency response • Frequency response of CT systems 5.2 Relationship between impulse response and frequency response 5.3 Magnitude-phase vs. frequency plot 5.4 Bode and Nyquist plots 5.5 Frequency response of interconnected systems 5.6 Signal filters	Chapter 5	Lab 3
9-10	CHAPTER 6. THE LAPLACE TRANSFORM 6.1 Derivation of the Laplace transform • The convergence of the Fourier transform/series • The Laplace transform and region of convergence • Some examples of the Laplace transform 6.2 Properties of the Laplace transform 6.3 The inverse Laplace transform 6.4 System response using the Laplace transform	Chapter 6	Lab 4
11-12	CHAPTER 7. TRANSFER FUNCTION OF CT SYSTEMS 7.1 Definition of transfer functions 7.2 Determination of transfer function from differential equation 7.3 Transfer functions of some typical systems 7.4 Transfer functions and system dynamical response • Poles and zeros • Static gain • Stability property and time-domain characteristics 7.5 Relationship between transfer function and frequency response. 7.6 Derivation of transfer function from state-space model	Chapter 7	

13	CHAPTER 8. THE Z TRANSFORM 8.1 Derivation of the Z transform from the Laplace transform • The Z transform and region of convergence • Some examples of the Z transform 8.2 Properties of the Z transform 8.3 The inverse Z transform	Chapter 8	Lab 5
14	CHAPTER 9. FREQUENCY RESPONSE AND TRANSFER FUNCTION OF DT SYSTEMS 9.1 Frequency response and transfer function of DT systems 9.2 Determination of transfer function from difference equation 9.3 Transfer functions of some typical systems 9.4 Transfer functions and system dynamical response • Poles and zeros • Static gain • Stability property and time-domain characteristics 9.5 Relationship between transfer function and frequency response. 9.6 Derivation of transfer function from DT state-space model	Chapter 9	
15	CHAPTER 10. SIGNAL SAMPLING AND RECONSTRUCTION 10.1 Signal sampling • Sampling of sinusoidal signals • Sampling process analysis • Aliasing phenomenon 10.2 Signal reconstruction • Causal methods • Non-causal methods 10.3 Nyquist-Shannon sampling theorem and application	Chapter 10	Lab 6

12. Lab sessions

- Lab 1: Signal and system representation with MATLAB
- Lab 2: Determination of time-domain system response
- Lab 3: Fourier analysis methods and signal spectra
- Lab 4: Determination and description of frequency response
- Lab 5: Transfer function and dynamical response of CT systems
- Lab 6: Transfer function and dynamical response of DT systems

Syllabus Development Group

(Full name and signature)

Assoc. Prof. Dr. Hoang Minh Son Assoc. Prof. Dr. Nguyen Doan Phuoc

Day month year

Chair of Science and Education Committee

School of …

(Full name and signature)