Department of Electronic and Telecommunication Engineering
The University of Moratuwa, Sri Lanka
EN1020 Circuits, Signals, and Systems
Course Outline—October 2020

1 Introduction

Signals and systems find many application in communications, automatic control, and form the basis for signal processing, communication, machine vision, and pattern recognition. Electrical signals (voltages and currents in circuits, electromagnetic communication signals), acoustic signals, image and video signals, and biological signals are all example of signals that we encounter. They are functions of independent variables and carry information. We define a system as a mathematical relationship between an input signal and an output signal. We can use systems to analyze and modify signals. We can realize any systems using electrical and electronic circuits (in addition to other systems like mechanical systems): The theoretical analysis that we do manifests in such circuits. Circuits, Signals, and systems have brought about revolutionary changes. In this course we will study the fundamentals of circuits, signals, and systems. Types of signals in continuous time and discrete time, linear time-invariant (LTI) systems, Fourier series analysis and realizing these systems in circuits are the core components of the course.

Chouse modules such as Signals and Systems, Digital Signal Processing, many chouse modules in the telecommunications pathway build on the fundamental knowledge that we would gain from this course module.

2 Learning Outcomes

After completing this course you will be able to do the following:

- Explain the fundamental tools in electrical circuit analysis.

- Apply network theorems in analysing electrical circuits.

- Differentiate between continuous-time, discrete-time and digital signals, and techniques applicable to the analysis of each type.

- Use Fourier series techniques to understand frequency domain characteristics of signals.

- Apply appropriate theoretical principles to characterize the behaviour of Linear Time Invariant (LTI) systems.

3 Contents

1. Circuit Theory [6 hours]

   Circuit vs. wavelength, circuit as a graph/network. Charge, current, voltage, power, and energy. units of measurement. LTI resistor, capacitor, and inductor. KCL and KVL. Ideal current and voltage sources, dependent sources, device modelling, RLC transient solutions using differential equations, concepts of transients vs. steady state. Resonance, mutual inductance, electromagnetic coupling, and analysis. Transformer as a coupled element.

2. Circuit Analysis Using Network Theorems [8 hours]

Ground as a node, nodal analysis, Y matrix, node voltage and stimulus vector, super nodes, mesh analysis. Network theorems: superposition, Thevenin's, Norton's, Millman's. Source transformation and network equivalence, source transportation, substitution theorem, maximum power transfer, $Y - \Delta$ transformation. Two-port theory: impedance, admittance, hybrid, and ABCD parameters.

3. Introduction to Signals and Systems [4 hours]

   Classification of signals as continuous-time, discrete-time and digital. Introduction to impulse and step functions. Introduction to systems and input-output relationships. Simple classes of signals such as sinusoid and exponential signals. Characterizing Linear Time-Invariant (LTI) systems. Overview of the analysis techniques applicable to each type of signal/system and their interrelationships.

4. Linear Time-Invariant (LTI) Systems [4 hours]

   Characteristics of LTI systems. Characterizing the input-output relationship of continuous- and discrete-time LTI systems in the time domain. The convolution theorem and its application to LTI systems. RLC circuit an LTI system.

5. Fourier Series [6 hours]

   Overview of Fourier analysis as the representation of signals with complex sinusoids. The Fourier series representation of periodic signals. Properties of the Fourier series. Characterizing LTI systems in the frequency domain. Introduction to Fourier transform.

4 Prerequisites

Calculus.

5 Contact Hours, Course Material, Etc.

Instructors:	Dr. Ranga Rodrigo.
	Electronics Building, Room 111.
	ranga@uom.lk, 011 264 0422.
	Mr. Ashwin De Silva.
	Electronics Building, Compter Vision Laboratory.
	ashwind@uom.lk.
Lectures:	2 hours per week: Tuesdays 8:00 am. to 10:00 am.
Tutorials:	Every Wednesday from 1:00 pm. to 3:00 pm.
Labs:	As scheduled in EN1093.
Office hours (drop in):	Please call me to set up an online appointment due to the current situation. Set up an appointment if you wish to meet outside office hours.
Moodle page	https://online.uom.lk/course/view.php?id=14237

Item	Date	Weight	Minimum
In-class quizzes (5 out of 8)	Surprise	10%	50%
Mid-semester examination	To be decided	20%	50%
Final examination	to be scheduled	70%	50%

6 Evaluation Scheme

7 Schedule

Event	Date	Description	Material
Lecture 1	15-Dec	Introduction to signals and systems	a Signals and Systems Introduction, Oppenheim 1.0, 1.1, 1.2
Lecture 2	16-Dec	Signals	b Signals and Systems Signals, Oppenheim 1.3, 1.4, 1.5, 1.6
Lecture 3	17-Dec	Continuous-time Fourier series	c Signals and Systems Fourier Series, Oppenheim 3.0, 3.1, 3.3
Lecture 4	18-Dec	Continuous-time Fourier series properties	Oppenheim 3.5
Lecture 5	19-Dec	Continuous-time Fourier transform	d Signals and Systems Fourier Transform, Oppenheim 4.3, 4.4, 4.4, 4.5, 4.6
Lecture 6	20-Dec	Fourier transform properties	e Signals and Systems Fourier Transform Properties, Oppenheim 4.0, 4.1, 4.3
Lecture 7	21-Dec	Linear time-invariant systems	f Signals and Systems Linear Time Invariant Systems, Oppenheim 2.0
Lecture 8	22-Dec	Convolution	Oppenheim 2.1, 2.2, 3.3
Lecture 9	23-Dec	Properties of LTI systems	Oppenheim 2.3
Lecture 10	24-Dec	Discrete-time Fourier series	g Signals and Systems Discrete Time Fourier Series, Oppenheim 3.6
Lecture 11	25-Dec	Discrete-time Fourier transform	h Signals and Systems Discrete Time Fourier Transform, Oppenheim 5.0, 5.1
Lecture 12	26-Dec	The Laplace transform	i Signals and Systems Laplace Transforms, Oppenheim 9.0, 9.1, 9.2, 9.3, 9.4, 9.5, 9.6, 9.7
Lecture 13	27-Dec	Systems with Laplace transform, z Transform	j Signals and Systems z Transfroms, Oppenheim 9.7, 10.0, 10.1, 10.4, 10.5, 10.6, 10.7
Lecture 14	28-Dec	Systems with z Transform, Sampling and reconstruction	k Signals and Systems Sampling, Oppenheim 10.6, 10.7 , 7.0, 7.1

References
8 Text Books

[1] A. V. Oppenheim and A. S. Willsky, *Signals and Systems*, 2nd ed. Englewood Cliffs, New Jersey: Prentice Hall, 1997.

[2] H. P. Hsu, *Schaum's Outline of Signals and Systems.* McGraw-Hill, 1995.