Beni Suef Technological University

# Electric Circuit

# Syllabus

# Syllabus

**Course Title**: Electric Circuits

**Course Code**: N/A

**Course Followers**:

Students of Mechatronics Department in 2nd semester of 1st year

## Course Meeting Times

Lectures: 1 session / week, 2 hours / session

Labs: 1 session / week, 4 hours / session

**Course Credits**: 3

## Course Introduction

This course gives Mechatronics students necessary knowledge and skills of the electric circuits. Another purpose of the course is to equip students with capabilities for designing and analyzing the circuitry essentials to construct automation / control systems through many techniques with which students can master complex circuits easily.

## Course Objectives

After successfully studying this course, students will have to:

1. Understand the basic electrical engineering principles and abstractions on which the design of electric systems is based. These include lumped circuit models, basic concepts of electric circuits and characteristics of circuit elements.
2. Use these engineering abstractions to analyze and design simple electric circuits by the Simulation Software tools such as “Capture” and “P-Spice”.
3. Formulate the time behavior of circuits containing energy storage elements. Implement basic circuits using Passive Elements such as resistors, capacitors, inductors.
4. Use intuition to describe the approximate time and frequency behavior of circuits containing energy storage elements.
5. Build circuits and take measurements of circuit variables using tools such as oscilloscopes, digital multi-meters (DMM), and signal (or function) generators.
6. Compare the measurements with the behavior predicted by mathematic models and explain the discrepancies.
7. Understand the relationship between the mathematical representation of circuit behavior and corresponding real-life effects.
8. Appreciate the practical significance of the systems developed in the course.
9. Design applied circuits using circuit laws.

## Learning Outcomes

After successfully studying this course, students will be able to:

1. Employ simple lumped circuit models for resistors, sources, inductors and capacitors in circuits.
2. Analyze circuits made up of linear lumped elements. Specifically, analyze circuits containing resistors and independent sources using techniques such as the node / loop (or mesh) method, superposition and the Ohm's law and Kirchhoff's laws.
3. Employ the Simulation Software tools such as "Capture" and "P-Spice" to draw and analyze linear electric circuits.
4. Build circuits and take measurements of circuit variables using appropriate tools such as oscilloscopes, digital multi-meters (DMM), and function generators.
5. Determine the maximum power transferred to the output load for a given set of inputs.
6. Find an equivalent one to a given complex circuit by way of the Thévenin or Norton method.
7. Calculate the time behavior of first order circuits containing resistors, capacitors or inductors.
8. Calculate the time behavior of second order circuits containing resistors, capacitors and inductors.
9. Calculate the frequency response of circuits containing resistors, capacitors and inductors by using P-Spice.
10. Determine in the laboratory the time-domain and frequency-domain behavior of an RLC circuit.
11. Build and analyze basic electronic circuits of diodes including Zener diode.

## Prerequisites

Mathematics for Technicians

Application of Math and Science in Technology

Physics for Technicians

## Textbooks

The course textbooks are:

1. Charles K. Alexander and Matthew N. O. Sadiku, Fundamentals of Electric Circuits ($5^{th}$ edition), McGraw-Hill, 2009, New York. ISBN: 978-0-07-338057-5
2. Jimmie J. Cathy, Theory and Problems of Electronic Devices and Circuits ($2^{nd}$ edition), Schaum's Outline Series, McGraw-Hill, 2002, New York. DOI: 10.1036/0071398309
3. Wael Z. Tawfik and Sammar N. Mohammed, Electric Circuits (Practice Manual), BST, 2020.

## Homework

- Homework will be issued in lectures and collected a week later in recitation.
- Corrected homework with solutions will be returned in labs the week after it is collected. You are welcome and encouraged to discuss the homework among your colleagues. However, the final formulation and write up of your homework answers must be your own.
- Submitting homework copied from someone else is a breach of ethics, and will be handled by the Committee on Discipline. More importantly, although homework counts for only 5 percent of the grade, they are critical to learning the material and to doing well on the quizzes and final exam. **One homework problem will appear in each of the tests**, and homework performance will be taken into account during grade assignment for cases that are on letter-grade boundaries.
- **Late homework will not be accepted for grading**. However, total homework grades will be based on the best nine out of eleven individual homework grades. Thus, with one exception, two homework assignments may be missed without a grading penalty.
- All homework will be graded on a coarse scale of 0 to 3 points. 3 points if all or nearly all problems are correct, 2 points if homework is approximately half correct, 1 point if mostly incorrect, and 0 points if late or not submitted.

## Labs (or Tutorials/Exercise, Workshop)

- Labs will be conducted during the weeks shown in the schedule. Each lab assignment involves one or more accomplishments which must be checked off by an instructor in the lab. The instructor will be available for help and lab check-off during those weeks in which a lab is in progress.
- No written work will be due for the last lab.
- Students are welcome and encouraged to discuss the labs among your colleagues. You are also welcome to team up in pairs to execute a lab. However, the write up of your lab must be done on your own. Skipping the lab and submitting work copied from someone else is a serious breach of ethics, and will be handled by the Committee on Discipline.
- Lab assignments will be graded on a scale of 0 to 3 (3: lab complete, works, good job on pre- and post-lab; 2: lab mostly complete, reasonable job on pre and post lab; 1: lab partially done, marginal to poor job on pre- and post-lab; 0: lab not done, poor job on pre- and post-lab).

## Lab Books

- You must obtain the contents of a few pages for every lab (from Lab #1 to lab #15) for recording measurements, observations and graphs of data taken during the in-lab exercises.
- Written pre-lab and post-lab exercises are also to be completed in your own papers.

## Midterm Exam

- One closed-book midterm exam will be given in this term. The exam will take place few days after Lab #7 for a two-hour duration.
- There will be no lecture or lab on the day. **You may bring one two-sided sheet of notes written by your own hands to the exam**. You may also bring a calculator, eraser, pencil or ball pens.

## Final Exam

- A three-hour final exam will be given during the end-of-term exam week. Timing and room assignments will be announced later. **You may bring three two-sided sheets of notes written by your own hands to the exam**.

# Calendar

The calendar provides information on the course's lecture class (L), lab (Lab #), and exam (E) sessions.

| SES # | TOPICS | KEY DATES |
|---|---|---|
| L1 | Introduction | Homework #1 in |
| Lab #1 | Introduction to Simulation Software P-SPICE | Lab report #1 in |
| L2 | Basic Concepts: Systems of Units, Charge & Current, Voltage | Homework #1 out<br>Homework #2 in |
| Lab #2 | Digital Multimeter (DMM) -based Resistance Measurement | Lab report #1 out<br>Lab report #2 in |
| L3 | Power & Energy, Circuit Elements | Homework #2 out<br>Homework #3 in |
| Lab #3 | Using Function Generators and Oscilloscopes | Lab report #2 out<br>Lab report #3 in |
| L4 | Ohm's Law & Equivalent Resistance | Homework #3 out<br>Homework #4 in |
| Lab #4 | Digital Multimeter (DMM): DC Voltage and DC Current Measurement | Lab report #3 out<br>Lab report #4 in |
| L5 | Nodes, Branches and Loops, Kirchhoff's Laws | Homework #4 out<br>Homework #5 in |
| Lab #5 | P-Spice Analysis of DC Circuits | Lab report #4 out<br>Lab report #5 in |
| L6 | Series Resistors and Voltage Division Law / Parallel Resistors and Current Division Law | Homework #5 out<br>Homework #6 in |
| Lab #6 | Series and Parallel Connection | Lab report #5 out<br>Lab report #6 in |
| L7 | Maximum Power Transfer Theory | |

| SES # | TOPICS | KEY DATES |
|---|---|---|
| Lab #7 | Study and Verification of Maximum Power Transfer | Lab report #6 out<br>Lab report #7 in |
| **E1** | **Midterm Exam** | |
| L8 | Linearity, Superposition, Source Transformation | |
| Lab #8 | Verification of Superposition | Lab report #7 out<br>Lab report #8 in |
| L9 | Methods of Analysis Nodal and Mesh Analysis | |
| Lab #9 | Mesh vs. Nodal Analysis | Lab report #8 out<br>Lab report #9 in |
| L10 | Thévenin's and Norton's Theorems | |
| Lab #10 | Thévenin's and Norton's Theorems (P-Spice & Manual) | Lab report #9 out<br>Lab report #10 in |
| L11 | Capacitors, first order circuits, examples | Homework #10 out<br>Homework #11 in |
| Lab #11 | RC and RL Circuits' Transient Analysis | Lab report #10 out<br>Lab report #11 in |
| L12 | Inductors, second order circuits, examples | Homework #11 out<br>Homework #12 in |
| Lab #12 | Second Order RLC Circuits Examples | Lab report #11 out<br>Lab report #12 in |
| L13 | DC Electronic Circuits: Transistor, Diode, and Zener Diode Circuits | Homework #12 out<br>Homework #13 in |
| Lab #13 | Curves of Diode Circuits | Lab report #12 out<br>Lab report #13 in |
| **E2** | **Final Exam** | |

## Grading (or Assessment) Policy

Initial grading will be based on the following weighting:

| ACTIVITIES | PERCENTAGES |
|---|---|
| Homework | 5% |
| Labs (performance & reports) | 35% |
| Midterm | 30% |
| Final exam | 30% |

- Lab assignments will be graded on a scale of 0 to 3
  - i) 3: lab complete, works, good job on pre- and post-lab;
  - ii) 2: lab mostly complete, reasonable job on pre and post lab;
  - iii) 1: lab partially done, marginal to poor job on pre- and post-lab;
  - iv) 0: lab not done, poor job on pre- and post-lab.
- All homework will be graded on a coarse scale of 0 to 3 points,
  - i) 3 points if all or nearly all problems are correct,
  - ii) 2 points if homework is approximately half correct,
  - iii) 1 point if mostly incorrect, and
  - iv) 0 points if late or not submitted.

· This will be followed by considerable discussion among the entire teaching staff to factor in your diligence on the homework and labs, and your participation in class and labs. This discussion can affect your letter grade for the course, particularly if your initial grade is on a letter-grade boundary.

· Furthermore, failure to complete the labs in this subject will result in an overall grade that is one letter grade lower (not an Incomplete).

· This subject has been designed so that lectures, homework and labs are integral and essential parts of the learning process. Although there is no specific reward for participation, there is a clearly defined penalty for not participating. Students who consistently miss lectures, homework and labs will not be included in the grading discussions.

# Lecture notes

This section contains lecture notes from some chapters of the following books,

I) "Charles K. Alexander and Matthew N. O. Sadiku, Fundamentals of Electric Circuits (5th edition), McGraw-Hill, 2009"

II) Jimmie J. Cathy, Theory and Problems of Electronic Devices and Circuits (2nd edition), Schaum's Outline Series, McGraw-Hill, 2002, New York. DOI: 10.1036/0071398309

| LEC # | TOPICS | LECTURE NOTES (BOOK I FOR L1 TO L12 & BOOK II FOR L13) |
|---|---|---|
| L1 | Introduction | Chapter 1: Basic Concepts (Introduction) |
| L2 | Basic Concepts: Systems of Units, Charge & Current, Voltage | Chapter 1: Basic Concepts |
| L3 | Power & Energy, Circuit Elements | Chapter 1: Basic Concepts |
| L4 | Ohm's Law & Equivalent Resistance | Chapter 2: Basic Laws |
| L5 | Nodes, Branches and Loops, Kirchhoff's Laws | Chapter 2: Basic Laws |
| L6 | Series Resistors and Voltage Division Law / Parallel Resistors and Current Division Law | Chapter 2: Basic Laws |
| L7 | Maximum Power Transfer Theory | Chapter 4: Circuit Theorems |
| L8 | Linearity, Superposition, Source Transformation | Chapter 4: Circuit Theorems |
| L9 | Methods of Analysis Nodal and Mesh Analysis | Chapter 3: Methods of Analysis |
| L10 | Thévenin's and Norton's Theorems | Chapter 4: Circuit Theorems |
| L11 | Capacitors, first order circuits, examples | Chapter 6: Capacitors and Inductors<br>Chapter 7: First-Order Circuits |
| L12 | Inductors, second order circuits, examples | Chapter 6: Capacitors and Inductors<br>Chapter 8: Second-Order Circuits |
| L13 | DC Electronic Circuits: Transistor, Diode, and Zener Diode Circuits | Chapter 2: Semiconductor Diodes<br>Chapter 3: Characteristics of Bipolar Junction Transistors |

# Lab notes (or Practice Manual)

This section contains lab notes from every chapter of the practice manual, "Wael Zakaria Tawfik and Sammar Naddy Mohammed, Electric Circuits (Practice Manual), 2020."

| LAB # | TOPICS | LAB NOTES (PRACTICE MANUAL CHAPTER) |
|---|---|---|
| Lab #1 | Introduction to Simulation Software P-SPICE | Module 1 Chapter 1 |
| Lab #2 | Digital Multimeter (DMM) -based Resistance Measurement | Module 1 Chapter 2 |
| Lab #3 | Using Function Generators and Oscilloscopes | Module 1 Chapter 3 |
| Lab #4 | Digital Multimeter (DMM): DC Voltage and DC Current Measurement | Module 1 Chapter 4 |
| Lab #5 | P-Spice Analysis of DC Circuits | Module 2 Chapter 1 |
| Lab #6 | Series and Parallel Connection | Module 2 Chapter 2 |
| Lab #7 | Study and Verification of Maximum Power Transfer | Module 2 Chapter 3 |
| Lab #8 | Verification of Superposition | Module 3 Chapter 1 |
| Lab #9 | Mesh vs. Nodal Analysis | Module 3 Chapter 2 |
| Lab #10 | Thévenin's and Norton's Theorems (P-Spice & Manual) | Module 3 Chapter 3 |
| Lab #11 | RC and RL Circuits' Transient Analysis | Module 4 Chapter 1 |
| Lab #12 | Second Order RLC Circuits Examples | Module 4 Chapter 2 |