CND101: Introduction to Analog Design

Course Description:

This course provides a foundational understanding of analog circuits and electronic devices in electrical and electronic engineering. This course covers the fundamental concepts of P-N Junction Diodes, Special Purpose Diodes, Bipolar Junction Transistors, Field Effect Transistors, and Amplifier Circuits.

Learning Outcomes

After successful completion of this course, the student will be able to:

- Learn the fundamentals of solid-state electronics, such as diodes, MOSFETs, and BJTs.
- Analyze and create analog electronic circuits with discrete components.
- Examine the frequency and amplitude responses of common amplification circuits.
- Design, build, and measure various analog circuits in order to compare experimental results in the laboratory with simulation and theoretical analysis.

Lecture Schedule

- Electric Circuits Fundamentals
- Techniques for Circuit Analysis
- Transient Analysis
- Sinusoidal Steady-State Analysis
- Frequency-selective Circuits
- Diodes - Semiconductor Device
- Bipolar Junction Transistor (BJT) - Semiconductor Device
- MOSFET- Semiconductor Device

Lab Sessions

Students will utilize Cadence, and analog kits to simulate and investigate various solid-state electronics such as diodes, MOSFETs, and BJTs.

- **Lab 1**: Introduction to Cadence Design Flow
  This lab is a general introductory tutorial on Cadence Virtuoso, which is the simulation tool we will use for the rest of the training. The official program name is Virtuoso, but the common name among users is just Cadence. We will be using the name Cadence in this training. Simple circuits to verify Ohm's law, KCL, and KVL are also presented.

- **Lab 2**: Techniques of Circuit Analysis
  The purpose of this lab is to verify the findings of Thevenin's and Norton's Theorems for equivalent circuits. There will also be a problem on the maximum power transfer, to verify that the value of the load resistor R_L which leads to maximum P_L is the R_{TH}. Multi-source DC circuits may be analyzed using the nodal analysis technique. The process involves identifying all the circuit nodes; a node is a point where various branch currents combine.

- **Lab 3**: Transient Analysis
  In this experiment, we introduce the inductors and capacitors as passive elements of an electric circuit. DC analysis as well as AC (Transient) behavior will be examined. The charge/discharge behavior of the capacitor and inductor is verified.

- **Lab 4**: Frequency-Selective Circuits
  Passive RC filters "filter out" undesired signals by separating and allowing AC signals based on frequency to pass. Passive filters are built out of passive components like resistors, capacitors, and inductors, and because they lack amplifying devices (transistors, op-amps, etc.), their output level is always smaller than the input. Filters are named after the frequency range of signals that can travel through them while blocking or "attenuating" the remainder. In this lab, the students will study common filters such as low-pass, high-pass, band-pass, and band-stop filters.

- **Lab 5**: Diodes
  A diode is an electrical device that allows current to move through it in one direction with far greater ease than in the other. When placed in a simple battery-lamp circuit, the diode will either allow or prevent current through the lamp, depending on the polarity of the applied voltage. In this lab, the students will study the IV characteristics of the diode, showing the turn-on potential, diode signal rectifiers including half and full-wave, and voltage multipliers.

- **Lab 6**: Diodes
  In this lab, the students will study the reverse breakdown voltage of the Zener diode rectifiers, clippers, and clampers.

- **Lab 7**: Bipolar Junction Transistors
  Bipolar transistors work as current-controlled current regulators. In other words, transistors restrict the amount of current passed according to a smaller, controlling current. In this lab, the students will explore the BJT characteristics as well as different amplifiers such as: common-emitter, common-base, and common-collector amplifiers.

- **Lab 8**: MOSFET
  A MOSFET, or Metal-Oxide-Semiconductor Field-Effect Transistor, is a type of transistor that can be used as a switch or amplifier in electronic circuits. It consists of a metal gate, an insulating oxide layer, and a semiconductor channel, and operates by applying a voltage to the gate to control the flow of current through the channel. In this lab, the students will study the modes of operation of a MOSFET Common-source, common-gate, and common-drain amplifiers are also presented.