Circuits, Semiconductor Devices, and Electrical System

Harvard University

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Recommendation: This project is for students who are interested in the exciting and powerful world of electrical engineering and are wondering how the electronics behind sensors and actuators actually work. After the project, students can design their own electrical systems and use the knowledge in the fields such as bioengineering, computer science, artificial intelligence, and Microelectronics.

Introduction: This program introduces the fundamentals of circuit theory for the analysis of electrical circuits and the fundamentals of semiconductor devices for the understanding of transistors circuits and other useful actuators and sensors (i.e., transducers). Building on the principles from these two core fundamental areas of electrical engineering, the analog behavior of electronic circuits and physical devices will be modeled, analyzed, and applied. Experiments in this course will focus on the design, implementation, and measurement of analog electronic circuits. Each student will pursue an appropriate capstone project which involves both engineering design and quantitative analysis.

Techniques that would be conveyed in this program:

- Understand the basic electrical engineering principles and abstractions on which the design of electronic systems is based. These include lumped circuit models, digital circuits, and operational amplifiers.
- Use these engineering abstractions to analyze and design simple electronic circuits.
- Understand the concepts of employing simple models to represent non-linear and active elements-such as the MOSFET-in circuits.
- Employ Boolean algebra to describe the function of logic circuits.
- Design circuits that represent digital logic expressions. Specifically, design a gate-level digital circuit to implement a given Boolean function.
- Understand the state-of-the-art semiconductor fabrication processes, including lithography, deposition of metals and dielectrics, etching, oxidation, implantation, and diffusion of dopants
- Understand the relationship between the mathematical representation of circuit behavior and corresponding real-life effects.
- Build circuits and take measurements of circuit variables using tools such as oscilloscopes, multimeters, and signal generators. Compare the measurements with the behavior predicted by mathematic models and explain the discrepancies.