6.012 - Microelectronic Devices and Circuits (02/26/01 revision)

Course Objectives

In 6.012 students will learn to do the following:

A. Semiconductor physics. Explain and apply basic concepts of semiconductor physics

B. Semiconductor devices. Describe, explain, and analyze the operation of important semiconductor microelectronic devices in terms of their physical structure

C. Physics-based models. Explain, describe, and use physics-based device and circuit models for semiconductor devices of varying levels of complexity, select models appro-priate to a specific need, and apply those models to analyze multi-component circuits

D. Circuit analysis. Analyze and design electronic circuits for linear amplifier and digital applications

E. Design. Confront integrated device and/or circuit design problems, identify the design issues, and develop solutions

Measurable Course Outcomes

A student completing 6.012 will be able to:

1. explain and apply the semiconductor concepts of drift, diffusion, donors and acceptors, majority and minority carriers, excess carriers, quasi-neutrality, and quasi-statics;
2. explain the underlying physics and principles of operation of p-n junction diodes, metal-oxide-semiconductor (MOS) capacitors, bipolar junction transistors (BJTs), and MOS field effect transistors (MOSFETs), and describe and apply simple large signal circuit models for these devices which include charge storage elements;
3. create an incremental (small signal) linear equivalent circuit (LEC) model for a multi-terminal non-linear electronic device knowing its large signal characteristics, and understand and apply standard LEC models for p-n diodes, BJTs, and MOSFETs, including capacitances;
4. determine parameter values for large signal and incremental LEC models for p-n diodes, BJTs, and MOSFETs based on knowledge of the device structure and dimensions, and of the bias condition;
5. explain how devices and integrated circuits are laid out and fabricated, and describe modern trends in the microelectronics industry;
6. explain, compare, and contrast the input, output, and gain characteristics of single-transistor, differential, and common two-transistor linear amplifier building block stages;
7. use large signal and incremental LEC device models to analyze analog electronic circuits of moderate complexity, including circuits with multiple stages, nonlinear and active loads, and current source bias circuits;
8. determine the frequency range of simple electronic circuits and understand the high frequency limitations of BJTs and MOSFETs;
9. explain the operation and features of common MOS logic inverter stages;
10. calculate the transfer characteristics of a CMOS inverter and explain how device dimensions and parameters impact them and inverter switching speed;
11. understand the limitations of the various device models, identify the appropriate model for a given problem or situation, and justify the selection; and
12. design simple devices and circuits to meet stated operating specifications.