

ICS Specialization in Bachelor Program

Core Recommendations:

"Integrated Circuits and Systems" (ICS) describe a small but coherent subset of core courses that pave the way for our students to learn how real world devices, microchips that sit inside and propel smart phones, tablet and laptop computers, automotive gyroscopes and accelerometers, biomedical and environmental monitors, digital audio and DVD players, etc., can be designed and implemented. The often cited Moore's law and the truly nanometer CMOS technologies that actually can be used to manufacture systems consisting of up to billions of transistors, are inextricably connected to the circuits and systems sitting inside those real world products by the word "integration" and the adjective "integrated".

- **"Analog Integrated Circuits"** lays the foundations for understanding how integrated circuits intended for low (moderate) frequency analog functions such as operational amplifiers, filters and analog-to-digital converters should be designed. Often one talks about analog and mixed signal ICs (AMIC) because even products that consist predominantly analog functions have a fair amount of digital circuits mixed into the chip.
- **"Communication Electronics"** lays the foundations for understanding how radio frequency integrated circuits (RFIC), such as those used in mobile phones, must be designed to perform and fulfill tough requirements, including excellent sensitivity, selectivity, minimum spurious emission and low power.
- **"VLSI I"** is the first of three courses that introduce students to very large scale digital circuits and systems integrated in a microchip. (VLSI II and III are offered in our master program.) The word "very large scale" has taken on different meanings during the past 5 decades. Today's VLSI systems often contain several hundred million transistors on a single microchip. (The word "micro" is stuck due to 5 decades of use, although the actual transistor dimensions can be as small as 16nm today.) Hardware description language (HDL), indispensable for describing very large number of transistors, will be taught in this course, and field programmable gate array (FPGA) chips will be taught both as a convenient device for realizing complex digital functions without designing an IC from scratch, and for practicing HDL based digital system design. This set of three courses, centered round different subdomains of integrated circuits (ICs), will give students a fairly comprehensive picture how contemporary electronic products are designed and realized. Indeed, in a typical system signals will propagate through the RF, analog and digital portions of the chip or chip set. An analog designer typically needs to be highly skilled in RFIC and AMIC, with a reasonable understanding of digital VLSI. A VLSI designer is expected to be excellent in digital circuits with a reasonable understanding of RF and analog IC. A "triathlon" athlete in IC design, who might be proficient in RF, analog as well as digital VLSI, would be highly sought after by the industry.

Recommendations for Complementary Courses:

Modern microchips are all about complex systems. It is therefore difficult to be a chip designer yet understand nothing of the system realized by the chip, or indeed to be a system architect yet understand nothing of the underlying integrated circuits. Many of the most useful / popular systems today are associated with (wireless) communications, therefore knowledge of system level theories in signals (Discrete-Time and Stochastic Signal Processing, High Speed Signal

Propagation) and communications (Communication Systems) complement the circuit design core courses above very well. Conversely, those students opting to specialize in information and signal processing and communications would also do very well to select some of the three ICS courses as complementary courses, which will give them a better appreciation of how theoretical systems will ultimately be realized by real nanoscale integrated circuits and systems.

Computer engineering courses, biomedical instrumentation, bio-electronic and power electronic courses also serve well as complementary courses for students interested in taking ICS as core subjects.