INNOLUX CORP. v. PATENT OF SEMICONDUCTOR ENERGY LABORATORY CO., LTD.

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silicon solar cells in 1983. He completed his doctoral studies at North Carolina State University in 1988 under Jimmie J. Wortman. His Ph.D. dissertation was on germanium preamorphization and rapid thermal annealing for formation of ultra-shallow source/drain junctions. After graduation, he joined the faculty at North Carolina State University where he is now a Professor of Electrical and Computer Engineering. He became a presidential faculty fellow in 1995. Dr. Ozturk authored over 100 papers in journals and conference proceedings and holds 8 US patents. His current research interests center around advanced processes for new silicon based nanoelectronic devices, and innovations in undergraduate education in Electrical and Computer Engineering.

Michael Escuti, North Carolina State University

Michael Escuti received the BS degree in Electrical and Computer Engineering from Drexel University in 1997. He continued his studies at Brown University receiving his MS and and PhD degrees both in Electrical Engineering in 1999 and 2002 respectively. His PhD research at Brown University on organic electro-optical materials and their use in photonics and flat panel displays has been recognized by the International Liquid Crystal Society with the Glenn H. Brown award in 2004 and by the Optical Society of America with the OSA/New Focus student award at the CLEO/QELS conference. After graduation, he spent two years with the functional polymers group at Eindhoven University of Technology as a post-doctoral fellow. He joined NC State University in 2004 as an assistant professor of Electrical and Computer Engineering where he continues to pursue interdiciplinary research topics in photonics, organic electronics, optics, biophotonics and flat panel displays.

course that ECE majors take after they complete the required courses common to all engineering students during their first year in the college. This course is a prerequisite for two other required core courses offered during the second semester of the second year: a course on electric circuits and another course on mathematical foundations of electrical and computer engineering. The new course was first offered in Fall 2000 semester. Since then, the course contents were periodically reviewed and revised based on the results of the course instructors' assessment studies on student learning, discussions with the instructors of the follow-up courses and student feedback surveys.

BRIEF HISTORY OF THE COURSE

The new course is the result of an evolutionary process, which started as a one-semester course to introduce different specialization areas in electrical and computer engineering. The need for such a course came about as a result of a new ECE curriculum, which emphasized junior and senior level elective courses to achieve depth in at least one of the ECE specialization areas. The new course was intended as a catalyst encouraging the students to consider their interests in different ECE specializations as early as possible to help them in choosing their elective courses.

At the time, the ECE faculty participating in the development effort for this course was strongly against creating just a survey course, which would most likely lack the rigor of a typical introductory course. A consensus was reached to create a course with a strong hardware laboratory component reviewing different ECE specializations while providing key fundamental concepts. It was decided to devote approximately one third of the course to introductory material followed by eight weeks on different specialization areas. According to the initial plan, two 75 minute lectures per week would be used to cover the theoretical material necessary to perform the experiments in laboratory, which would meet almost every week for three hours. The specializations to be included in the course were decided on based on the strengths of our department. The list included circuits, electric power, communication, digital signal processing, solid state electronics, logic design, computer architecture and computer networking.

One of the great challenges of this plan was to create the hardware laboratory: the experiments had to be representative of the respective specialization areas and they had to be chosen from exciting real-life applications. This approach required dedicated laboratory hardware to be designed and constructed in order to be able to demonstrate complex applications at a level that would be accessible to beginning students. In addition, a new textbook had to be written since none of the existing textbooks would fit the course contents. This job was assumed by several faculty members representing different specializations.

Soon after we began offering the course, we began to realize that the initial plan was too ambitious for a one-semester course. According to the results of the student surveys, the students enjoyed learning about different specializations, which gave them a better understanding instructions to run the specialization experiments they were unable to enjoy and benefit from them because they were still busy catching up with the basics.

After the first two years, it was clear that we had to make some changes. It was impossible to turn the course into a two-semester sequence because we did not have any room in the curriculum. Thus, the only option we had was to reduce the course material, which was not an easy task. After all, the changes required eliminating some of the specializations thus postponing students' first exposure to this material. Fortunately, because concepts related to logic design and computer architecture were already introduced in two other ECE courses, we were able to remove two chapters from the book and two experiments from the lab without experiencing a significant loss. Without the introductory material on digital signals, it was no longer possible to effectively discuss examples on computer networking; hence, it too had to be dropped. Also, we had always found it difficult to connect the material on networking to the introductory material covered during the first part of the course. Finally, the material on solid state electronics was also removed due to the lack of an organic link with the rest of the material.

We have found by removing approximately one fourth of the course material it was possible to teach the rest effectively. Some of the older material was also replaced with new material to improve the continuity within the course and continuity with the future ECE core courses. These changes required major changes in the textbook in the form of either writing new chapters or major revisions. One of the most successful additions was a chapter on operational amplifiers, which came with an accompanying experiment.

During this time, the lab manual and the experiments were continually revised based on the results of the student feedback surveys conducted after each experiment. The experiments, which were found too difficult were replaced with simpler experiments to help the students understand the concepts better. In the mean time, a virtual laboratory was created to allow the students experiment with virtual test instruments, which looked much like the equipment they used in the hardware laboratory. A semester-long mandatory hardware project was added to the laboratory, which also turned out to be a great success. Finally, an optional golden solder project was created for students interested in applying their new knowledge to a simple design project.

When the dust settled after these changes, we were left with a new introductory course on signals, circuits and systems, which is the subject of this paper. The first part of the course covers fundamental concepts such as Kirchoff's laws, Ohm's law, AC and DC voltage sources, linear and non-linear resistive elements, capacitors, and representation of periodic signals in both time and frequency domains. As such, aside from the coverage on frequency domain, the first part closely resembles a traditional course on circuits. This however is not entirely true because the inclusion of frequency domain at this level represents a major deviation from the traditional

1. Explain the concepts of electric charge, current, voltage, resistance, and capacitance.
2. Identify resistors, diodes and capacitors in circuit diagrams.
3. Interpret the basic current-voltage (I-V) characteristics of key circuit elements, including resistors, photocells, diodes, and capacitors.
4. Calculate the equivalent resistance of resistor circuits (i.e. series and parallel), and the equivalent capacitance of capacitive circuits (i.e. series and parallel).
5. Apply Ohm's Law and Kirchoff's Laws to simple circuits consisting of DC voltage sources, linear and non-linear resistive elements and capacitors.
6. Given a first order RC Circuit, calculate the time constant and the time required to charge/discharge the capacitor to a certain voltage level.
7. Given a first order RC Circuit, calculate the current flowing in the circuit at a given instant of time during charging or discharging.
8. Identify/Measure/Calculate time-varying waveform parameters including amplitude, peak-to-peak value, frequency, period, duty cycle, average (DC) value, root-mean-square, phase angle and time delay, from graphs, oscilloscope screenshots, and equations.
9. Apply Ohm's Law and Kirchoff's Laws to simple circuits consisting of AC & DC voltage sources, linear and non-linear resistive elements.
10. Apply Ohm's Law and Kirchoff's Laws to fully analize half and full-wave rectifier circuits consisting of resistors and diodes to find the key voltage and current waveforms in the circuit given an arbitrary periodic input signal
11. Determine and plot the instantaneous power dissipated on a resistive load given an arbitrary voltage waveform applied to the load in graphical or equation form, and use the instantaneous power to determine the real power.
12. Determine and plot the instantaneous power dissipated on a non-resistive load given the sinusoidal voltage waveform and the resulting sinusoidal current including the phase angle between the two waveforms, use the voltage and current waveforms to determine the real and apparent power and power factor.
13. Generate and analyze amplitude, phase and power spectra of periodic signals.
14. Given amplitude or power spectrum of a periodic signal identify the waveform parameters including frequencies of the harmonics, average (DC) value, signal amplitude and power of each harmonic and total signal power.

During the second half of the course, the fundamental concepts are applied to different examples of analog signal processing, which serve as exciting, real-life demonstrations of the material covered in the course. Applications include filtering, amplification, RF modulation/demodulation, sampling and reconstruction, which provide the natural platform to talk about different specialization areas. Fundamental concepts used under each application are shown in Figure 1 with links to other applications.

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