An Evolution Towards System-on-Chip Oriented Curriculum

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Abstract

Systems on chip (SoCs) as well as network on chip (NoCs) are becoming pervasive technologies that are used at a wide scale in many computer, communications and consumer electronics applications. Educating undergraduate students enrolled in electrical and computer engineering (ECE) programs about SoC design at an early stage of their program of study prepare them with timely skill sets allowing them to pursue final year design projects and/or conduct graduate level research on topics more relevant to current trends in the semiconductor industry. This requires a paradigm shift in ECE curriculum design and implementation in a way that gives students the opportunity to deal with complex circuits and systems early in their undergraduate education towards learning the challenges of system on chip design and gaining the needed skill sets to meet these challenges. A starting point of the process is a digital design course that is based on reconfigurable devices.

Digital Logic Design tends to be one of the early engineering design courses that students majoring in ECE engineering take. It is considered a building block for students to gain fundamental knowledge in digital system design and SoCs. In the traditional approach, which is still applied in many universities, the students spend considerable time learning some of the fundamentals such as Boolean algebra and the various minimization techniques. They then apply such techniques to the classical design of combinational and sequential finite state machines. High level synthesis and relatively small complete system design are covered in a separate course. In the classical delivery of a digital systems design course students learn how to build basic logic circuits in the laboratory using discrete components which tends to limit the complexity of the circuitry that can be implemented. However, in these classical approaches be it in the classroom or the laboratory the student will end up missing learning about how the fundamentals knowledge gets applied in real modern digital circuits and systems. They will also not have the opportunity to use the new software reconfigurable devices that enable synthesis of digital circuitry of relatively high level of complexity through the availability of the equivalent of many thousands of discrete gates in a single chip.

To address the shortcomings of the traditional approach we, at Khalifa University of Science, Technology and Research (KUSTAR), developed and subsequently delivered a new Digital Logic Design course and associated laboratory. In addition to building the fundamental knowledge needed to design a digital system, the coverage then expands in a transparent manner to the modular design approach and the use of a high level description language (HDL) to synthesize a digital circuit from the top down early in the course. This early exposure to HDL is highly beneficial as it gives the students an appreciation to the way modern complex chips are designed. The laboratory experiments are organized to be synchronized with the material delivered in the class. This process consolidates the learning process by giving students the chance to implement the circuits learned in class. The laboratory experiments starts with physical discrete components, simulation using schematic capture, to solidify the fundamentals and get a sense of basics. Then synthesis using HDL for FPGA (field programmable gate array) implementation is introduced to enable more complex circuits and small SoCs to be realized. All the experiments have a design element to promote innovation and prevent a traditional approach of students following instructions. A mini project is also incorporated in the lab so the students go through the full process from problem description to actual synthesis and verification.

The advantage of such approach in addition to the ability to design a relatively real life based project is that it trains students to approach the engineering challenges as a hierarchy with different levels of abstraction. Once a concept has been introduced and the detail is discussed, going to the next level only the relevant information concerning the new topic from the old will be discussed and emphasized. The usage of real life examples based on modern SoC throughout the class help the student relate and make the subject interesting to them.

The above approached received a mixed response, particularly with regard to the laboratory component, from the students at both campuses of KUSTAR. In general, the students were enthusiastic and valued the hands-on engineering skills that they acquired and they found the overall experience rewarding.