A MASTERS COURSE IN SYSTEM-ON-CHIP

Theory, Design and Practice

PETER WILSON, BASHIR M. AL-HASHIMI, MARK ZWOLINSKI, ANDREW BROWN, *School of Electronics and Computer Science, University of Southampton, Highfield, Southampton, UK, SO17 1BJ.*

1. ABSTRACT

In this paper we describe the curriculum design of a new one-year taught postgraduate programme in System on Chip that is currently being run at the University of Southampton. We report on the different teaching methods and practical approaches that are being employed to meet the course aims and objectives leading to improved graduates' employment opportunities and effective contribution to the industry.

2. INTRODUCTION

Advances in technology force departments of Electronics, and Computer Science world-wide to adapt their educational programmes and the contents thereof in order to equip students with the right skills and knowledge needed by the industry. Recent examples include ASIC design and CAD tools in the mid 80's to programmable devices and hardware languages in the mid 90's and more recently system design emphasis. Electronic systems are shrinking in size to the extent that the vast majority of the system is required to be implemented as a single integrated circuit. This level of integration is known as System on Chip (SoC). The pace of change in the current electronics market is also driving the design cycle time (the time it takes to get from product specification to delivery to the market) to be ever shorter. The skills that are required to support this level of design are rapidly changing, as are the software and hardware tools required for engineers.

A significant aspect of technology that enables SoC is the fact of increasingly small integrated circuit transistors. The size of transistors has been decreasing by orders of magnitude every few years allowing vastly greater numbers of transistors to be placed on the same chip area (in the 1980s thousands of transistors, 1990s hundreds of thousands and now millions). A well known issue resulting from this is the "design gap" where the current generation of design tools and methods have not kept pace with the increasing size and complexity of SoC. We feel strongly that the continuing research in SoC will continue to play an important role in the training of tomorrow's chip designers, through its impact on future undergraduate and postgraduate curricula at the University of Southampton.

The current MSc in Microelectronics Systems Design at the University of Southampton has run successfully for over 25 years and provides a good grounding in hardware design. An MSc in System-on-chip has been designed to address topics such as verification, higher level integration, IP and software engineering; reducing the emphasis on lower level techniques such as device technology. This paper develops the educational rationale for the design of the new course and results are presented of its implementation and delivery.

3. PREVIOUS WORK IN THIS AREA

European and US educational institutions have developed similar courses for System on Chip. A good example is Socware [13] a collaborative programme in Sweden between Linköping University, Lund University, and Royal Institute of Technology. Also, there have been a number of workshops on embedded systems educational [9],[10],[11] and the general area has been reviewed by Wolf [12]. In our course design, we have built on these approaches, and in addition using our own extensive experience in the area of microelectronics education at Masters level.

4. COURSE STRUCTURE

In a standard Microelectronics course, there has been a significant element of device-level and low-level design. For most practical SoC applications, this is not as important as the need to understand EDA techniques for system-level design *applying* fundamental technology. Prior to the introduction of this course a twofold consultation exercise was undertaken. The first item was a presentation to industrialists from Philips, IBM, EDA companies and other interested parties. Changes in course content to meet current needs were then specifically introduced into the course. Secondly, previous MSc students were consulted to establish the level of interest in the course and what they would have liked to have seen in the course if they had taken it. As such we proposed a course structure (table 1) that had the same core modules as a standard Microelectronics MSc, but replacing device and technology modules with system level and SoC specific ones.

Semester one		**Semester two**	
SoC EDA 100% Coursework	5 ECTS *Core Module*	**SoC HW/SW co-design** 50%/50%Coursework/Exam	10 ECTS *Core Module*
Digital Systems Design 100% Examination	5 ECTS *Core Module*	**Applied Synthesis** 50%/50%Coursework/Exam	10 ECTS *Core Module*
Research Methods 100% Coursework	10 ECTS *Core Module*		
IC Design 50%Coursework/50%Exam	5 ECTS *Core Module*	**Optional Module**	10 ECTS *Choice*
SoC Design Techniques 50%Coursework/50%Exam	5 ECTS *Core Module*		

Table 1: MSc-SoC Module Structure – syllabus available online [14]

As can be seen from table 1, there are 50 ECTS of core modules (compulsory) that require the students to have a broad understanding of IC design, Research Methods and SoC design techniques. The semester 1 modules are prerequisites for the more advanced second semester modules. The second semester modules are Hardware/Software Systems Design and Applied Synthesis. The optional module in semester 2 allows the student to tailor the course to their own specific interests and may include Analogue IC Design, RF transceiver Design, Cryptography for example. The course (90 ECTS, 60 taught part and 30 ECTS project) is one year, starts in October with two semesters (Oct-Jan, Feb-May). The course has a 1st (taught) part from October to May, with lectures, labs, and invited talks from industry leaders. The 2nd part is an individual project from June, submitting a thesis in October. The project is carried out in a research group, taking advantage of the world-leading expertise in our Nanoscale Integration and Electronics Systems Design research groups. The School is research-led and this world leading research is firmly embedded in our taught courses, particularly the Masters courses. Many of the projects will be directly linked to research teams.

5. LEARNING STRATEGY

5.1. EXPERIENTIAL LEARNING

A key part of the strategy for learning has been to provide a solid experiential learning platform based on the Kolb learning cycle [1], and by using small groups [2]. The strength of this approach is clearly the tutorial style with students able to progress at their own pace with a structured work plan to facilitate learning. Providing literature prior to the session [3] enables students to take a less linear approach to the design process and enable much more iteration and creativity to take place. This is to produce students that can do design – not just rote type learning. Biggs [4] provides a useful framework to assist in the strategy of preparation and we apply different methods of delivery and assessment [6] to engage large classes more directly. A key aspect of this approach is to use student-oriented learning [5]. In our courses collaborative group work and peer review prove effective and useful.

5.2. LEARNING OUTCOMES, KEY SKILLS & ASESSMENT

In order to ensure that the individual student's experience is satisfactory, learning outcomes have been designed in the context of an integrated process of teaching, learning and assessment. This is essential to provide the student with a high quality of learning in a rapidly changing field. In this course we have taken a view of learning that considers the academic aspects of the work and links this to the industrially oriented aspects. Fourteen specific learning outcomes were devised for this course. The integration of key skills for industry is critical [7] for engineering students in general, but in this particular field it is even more acute. In order to assess the learning outcomes in relation to the proposed course structure, a matrix based approach was employed [8] to analyze the course structure in relation to learning outcomes. In this course, we have identified the relevant key skills and tied them into specific learning outcomes in a coherent manner that will provide the basic framework for the students to achieve a successful outcome and assessment has been considered in the context of the variety of skills, platforms and learning outcomes required [5].

6. IMPLEMENTATION AND DELIVERY

In academic session 2005-6, the first cohort of 25 students has successfully been taught this new MSc course, with very positive outcomes in student responses.

The students were surveyed at the end of each individual module with an evaluation from allowing the students to rate the course across a wide range of aspects from course content, delivery, material, lecturer, difficulty and overall rating. The students also have the opportunity to make specific comments and suggestions for improvement. The overall ratings of the course in terms of content and delivery were 4.0/5.0 and the ratings for the course lecturers were 4.2/5.0. There were some areas for improvement that were identified by the students. These included smaller lab sessions to make learning easier and spread more evenly over the modules.

7. CONCLUSIONS

In this paper we have described a new Masters Level course in System-on-Chip (SoC) that has been implemented in the current academic year at the University of Southampton, School of Electronics and Computer Science. The structure of the course has been rigorously planned and scheduled with a transition plan that has enabled a smooth introduction of the new course, with minimal impact on existing teaching loads and resources. In parallel with the introduction of the course, new resources for practical use of SoC EDA software have been developed including computer teaching labs, high performance computing clusters and lab facilities. The students have been able to select a course of study that meets their individual needs, whether system or device level oriented. The initial indications are that the teaching approach is leading to good attainment of learning outcomes and the student take-up and response has been excellent. The use of proven educational techniques such as group work and experiential learning has enabled an effective teaching environment to flourish.

8. REFERENCES

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