System-on-Chip Design
EEL 4930
Class Periods: T, R, Period 4, (10:40 AM - 11:30 AM)
Location: LAR0330
Academic Term: Spring 2023

Instructor:
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Office Hours: Monday, 12:00 PM, LAR 336A

Teaching Assistant/Peer Mentor/Supervised Teaching Student:
Please contact through the Canvas website
- Sujan Saha Kumar, sujansaha@ufl.edu, Lar 331, on appointment

Course Description
The specification, design, implementation, and verification of complex hardware-software systems on chip. Overview of transaction-level modelling (TLM) with refinement down to register-transfer level (RTL). Review of state-of-the-art languages and tools and practice on an FPGA project. Credits: 3.

Course Pre-Requisites / Co-Requisites
- EEL4712C- Digital Design
- EEL3744C- MicroP

Course Objectives
To provide the fundamentals of designing system-on-chip, from the high-abstraction level and refine it down to the implementation. The course will discuss and practice the various state-of-the-art languages and tools used in the industry. Course content is built around a complex SoC-Project (example hardware-accelerated video game with embedded FPGA) that students will design, from the high-abstraction level using SystemC TLM and implement in the target FPGA-Platform.

Materials and Supply Fees
FPGA Board

Relation to Program Outcomes (ABET):
The table below is an example. Please consult with your department's ABET coordinator when filling this out.

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	High
3. An ability to communicate effectively with a range of audiences	
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	

5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	Medium
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

*Coverage is given as high, medium, or low. An empty box indicates that this outcome is not covered or assessed in the course.

Required Textbooks and Software
- None

Recommended Materials
- TLM-Driven Design and Verification Methodology, Brian Bailey, Felice Balarin , Michael McNamara, Guy Mosenson, Michael Stellfox , Yosinori Watanabe, Publisher: lulu.com; 1ST edition (July 20, 2010), ISBN-10: 0557539064, ISBN-13: 978-0557539062
- ESL Design and Verification: A Prescription for Electronic System Level Methodology. Grant Martin, Brian Bailey, Andrew Piziali. Publisher: Morgan Kaufmann; 1st edition, March 9, 2007 ISBN-10: 0123735513, ISBN-13: 978-0123735515
- Bashir M. Al-Hashimi (Ed.) , "System On Chip: Next Generation Electronics ", Institution of Engineering and Technology (January 31, 2006)
- SystemC-TLM: http://www.accellera.org/
- https://opentitan.org/

Course Schedule

Week	Class Topic	Outcome
1	Introduction	• Trends in Computer Systems • SoC definition, benefits, challenges • Class objectives, syllabus, discussions
2, 3	SoC Components	• Processing (CPU, Accelerators, IPs) • Memory and peripherals • On-chip interconnect • Homework (Pong Game HW Implementation)
4,5	SoC-Implementation (ASIC, FPGAs)	• FPGA overview and System on FPGA with Xilinx/Intel • VLSI design overview • Homework (Practice of SoC with FPGA, Component integration, Bus implementation, use of DMA and documentation)
6	OS & Software Integration	• OS Basics, resource management, multithreading • Linux installation and configuration on a FPGA SoC • Homework (Pong Game SoC Implementation)
7, 8	System-Level Design	• Models of computation • SystemC overview • Transaction-Level Modeling (initiators, transactors) • Homework (OS image creation using petalinux, driver development and Linux Software application development)

9,10	SoC Verification	• Overview of verification techniques • Verification flow • Verification tools (UVM, SCV) • Case Studies • Homework (OpenCV tutorial + virtual hardware integration, SystemC-TLM, Virtual prototyping with OpenCV+SystemC)
11.12	SoC Security	• HW/SW Multi-Level Security • Overview of hardware security • IP protection, Encryption, etc… • Homework (System level verification using UVM, Opentitan)
13, 14, 15		

Attendance Policy, Class Expectations, and Make-Up Policy
Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies. Click here to read the university attendance policies:
https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/

Evaluation of Grades
This course is co-listed with the graduate class. The homework portion of the graduate section will involve additional work and more advanced concepts with respect to the undergraduate section. The exams will also involve additional questions for the graduate section with respect to the undergraduate section. The final project will have additional task to design and implement. The graduate and undergraduate sections will be graded separately, for which the graduate section has additional problems and different weights for all problems.

Assignment	Total Points	Percentage of Final Grade
Class Attendance		10%
Homework		30%
Final Exam		20%
Final Project		50%
		100%

- Homework will be mix of fundamental design problem and small project to practice concepts and tools presented in the class
- Class participation is assess using random quizzes.
- The final exam will be provided in paper form and will cover the core concepts learned during the semester.
- The final project will use a RC car with embedded FPGA, camera, and ultrasound sensor. Students will used this platform to design an application, from the high-abstraction level using SystemC TLM and implement in the target FPGA-Platform.
- Project work will be equally distributed among participating students. The assessment of individual students in a group project will be done according to the level of participation of each student.

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00

80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Students Requiring Accommodations
Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation
Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording
Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment
The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
• Your academic advisor or Graduate Program Coordinator
• Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu.
https://lss.at.ufl.edu/help.shtml.

Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling; https://career.ufl.edu.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring.
https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers.
https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/;https://care.dso.ufl.edu.

On-Line Students Complaints*: https://distance.ufl.edu/state-authorization-status/#student-complaint*.