

# **ESE 566: Hardware/Software Co-Design of Embedded Systems**

## **Fall 2022**

**Instructor:** Dr. Alex Doboli.

**Credits:** 3 credits

**Schedule:** TBD.

**Description:** The course presents state-of-the-art concepts and techniques for design of embedded systems consisting of analog, hardware and software components. Discussed topics include system modeling and specification, architectures for embedded mixed-signal systems, performance evaluation, and system optimization. The course follows the top-down design paradigm based on IP cores. Course requirements include three reports on system specification and various co-design tasks.

**Delivery:** The instructor will lecture in person.

**Office hours:** Mon, Wed [ 1PM - 2.30PM ], Room 241, Light Engineering Building. Please email me at [alex.doboli@stonybrook.edu](mailto:alex.doboli@stonybrook.edu) before coming to office hours.

**Goal:** Upon completion of the course, students will possess knowledge about state-of-the-art methodologies and techniques for hardware/software co-design of embedded systems. They will be able to (1) develop system-level specifications using high-level languages, (2) model system performance, and (3) implement algorithms for co-design.

### **Teaching Material:**

1. **Textbook:** A. Doboli, E. Currie, “Introduction to Mixed-Signal Embedded Design”, Springer, 2010.

### **Other Material:**

2. G. De Micheli, R. Ernst, W. Wolf, “Readings in Hardware/Software Co-Design”, *Morgan Kaufman*, 2002.
3. Other published research papers will be provided in class.

**Prerequisites:** ESE 545 (Computer Architectures), ESE 554 (Computational Models), and ESE 333 (Real-Time Operating Systems) or equivalent. Upon request, the instructor might wave the prerequisites.

### **Covered Topics:**

- 1) **Introduction to Co-Design:**
  - a. Problem description, goals of co-design, co-design steps, existing co-design approaches, and present challenges.
- 2) **System Modeling and Specification:**
  - a. Models of computation (Signal flow graphs, Data flow model, Task graphs, Finite State Machines, hierarchical models).
- 3) **Architectures for Embedded Systems:**

- a. Single processor – coprocessor architecture, mixed-signal architectures, multiprocessor architectures, reconfigurable architectures, Systems on Chip.
  - b. Report 1 on using an embedded mixed-signal architecture to design and implement a multi-mode application.
- 4) **Performance Modeling:**
- a. System-level performance modeling vs. low-level performance modeling.
  - b. Modeling of system latency, energy consumption etc for hardware and software.
  - c. Modeling of analog and mixed-signal systems.
  - d. Estimation of memory requirements.
- 5) **System-Level Synthesis and Trade-off Analysis:**
- a. Design of customized digital and analog blocks.
  - b. Hardware/software partitioning. Task binding.
  - c. IP core integration and communication synthesis: Hardware and software interface synthesis.
  - d. Hardware IP core synthesis: High-level synthesis: behavioral specification of hardware, module set allocation, resource binding, operation scheduling, controller design.
  - e. Reports 2 on exploring the tradeoffs and optimizing the design realized in Project 1.

**Grading:**

$$\text{Final grade} = 0.25 \text{ Report}_1 + 0.25 \text{ Report}_2 + 0.25 \text{ Midterm} + 0.25 \text{ Final}$$

**Note:** I will take attendance during some of my lectures. Your grade will be lowered if you miss more than 5 lectures during the semester.

**Electronic Communication Statement**

Email and especially email sent via Blackboard (<http://blackboard.stonybrook.edu>) is one of the ways the faculty officially communicates with you for this course. It is your responsibility to make sure that you read your email in your official University email account. For most students that is Google Apps for Education (<http://www.stonybrook.edu/mycloud>), but you may verify your official Electronic Post Office (EPO) address at <http://it.stonybrook.edu/help/kb/checking-or-changing-your-mail-forwarding-address-in-the-epo>.

If you choose to forward your official University email to another off-campus account, faculty are not responsible for any undeliverable messages to your alternative personal accounts. You can set up Google Mail forwarding using these DoIT-provided instructions found [at http://it.stonybrook.edu/help/kb/setting-up-mail-forwarding-in-google-mail](http://it.stonybrook.edu/help/kb/setting-up-mail-forwarding-in-google-mail).

If you need technical assistance, please contact Client Support at (631) 632-9800 or [supportteam@stonybrook.edu](mailto:supportteam@stonybrook.edu).

## **Student Accessibility Support Center Statement**

*(must be the following language)*

If you have a physical, psychological, medical, or learning disability that may impact your course work, please contact the Student Accessibility Support Center, Stony Brook Union Suite 107, (631) 632-6748, or at [sasc@stonybrook.edu](mailto:sasc@stonybrook.edu). They will determine with you what accommodations are necessary and appropriate. All information and documentation is confidential.

[ *In addition, this statement on emergency evacuation is often included, but not required: ]*

Students who require assistance during emergency evacuation are encouraged to discuss their needs with their professors and the Student Accessibility Support Center. For procedures and information go to the following website: <https://ehs.stonybrook.edu//programs/fire-safety/emergency-evacuation/evacuation-guide-disabilities> and search Fire Safety and Evacuation and Disabilities.

## **Academic Integrity Statement**

*(must be the following language as approved by the undergrad council)*

Each student must pursue his or her academic goals honestly and be personally accountable for all submitted work. Representing another person's work as your own is always wrong. Faculty is required to report any suspected instances of academic dishonesty to the Academic Judiciary. Faculty in the Health Sciences Center (School of Health Professions, Nursing, Social Welfare, Dental Medicine) and School of Medicine are required to follow their school-specific procedures. For more comprehensive information on academic integrity, including categories of academic dishonesty please refer to the academic judiciary website at [http://www.stonybrook.edu/commcms/academic\\_integrity/index.html](http://www.stonybrook.edu/commcms/academic_integrity/index.html)

## **Critical Incident Management**

*(must be the following language as approved by the undergrad council)*

Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of Student Conduct and Community Standards any disruptive behavior that interrupts their ability to teach, compromises the safety of the learning environment, or inhibits students' ability to learn. Faculty in the HSC Schools and the School of Medicine are required to follow their school-specific procedures. Further information about most academic matters can be found in the Undergraduate Bulletin, the Undergraduate Class Schedule, and the Faculty-Employee Handbook.