

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

## **Fall 2021**

**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 synchronously using a videoconferencing system, like zoom. Office hours will be conducted synchronously using the same system.

No special technical requirements are needed other than access to the videoconferencing system.

**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.

### **Text Book and other Teaching Material:**

1. 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 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 embedded mixed-signal architectures.*

#### 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 and 3 on various embedded design tasks.*

#### **Other Course Material:**

- 1) Other relevant papers will be provided in class.

#### **Grading:**

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

**Academic Integrity Measures:** Exams will be scheduled face-to-face on campus, if possible. Otherwise, exams will be carried out using a videoconferencing system, like zoom. Also, a significant part of the grade is based on course projects.

**Americans with Disabilities Act:** If you have a physical, psychological, medical or learning disability that may impact your course work, please contact Disability Support Services, ECC(Educational Communications Center) Building, Room 128, (631)632-6748. They will determine with you what accommodations, if any, are necessary and appropriate. All information and documentation is confidential. <http://studentaffairs.stonybrook.edu/dss/index.shtml>.

**Academic Integrity:** 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 Technology Management, 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:** Stony Brook University expects students to respect the rights, privileges, and property of other people. Faculty are required to report to the Office of University 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.