San José State University
Computer Engineering Department
CMPE 242 Embedded Hardware Systems, Section 1, S2022

Course and Contact Information

Instructor:	Hua Harry Li, Ph.D.
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Office Hours:	Mondays and Wednesdays 4:30 – 5:30 pm Zoom link for the Office Hours `Join Zoom Meeting https://us04web.zoom.us/j/9841607683?pwd=UlA3aEk1TnV4bjNLQk5CQkw0dDk4UT09 Meeting ID: 984 160 7683 Passcode: 121092`
Class Days/Time:	Monday and Wednesday 3:00 – 4:15 pm
Classroom:	On Zoom (Link to be shared in Email and SJSU Canvas)
Prerequisites:	CMPE 180A and 180D, classified standing, or instructor consent

Course Format

Technology Intensive, Hybrid, and Online Courses (Required if applicable)

This course requires use of computer/laptop, special microprocessor/ARM hardware for system prototyping, and C/C++ compiler for software programming. Students must have to participate in classroom activities and after class homework and projects assignment.

Faculty Web Page and MYSJSU Messaging (Optional)

Copies of the course reference materials such as datasheets, project references etc. can be found on line at https://github.com/hualili and/or SJSU CANVAS. Office hours Zoom link (during the Pandemic): Join Zoom Meeting https://us04web.zoom.us/j/9841607683?pwd=UlA3aEk1TnV4bjNLQk5CQkw0dDk4UT09 Meeting ID: 984 160 7683 Passcode: 121092

Course Description (Required)

Advanced topics dealing with microprocessor and microcontroller hardware and firmware including processor architecture, advanced memory and I/O systems design, multilevel bus architecture, interrupt systems. Design project. Prerequisites: CMPE 180A and 180D, classified standing, or instructor consent.

Course Learning Outcomes (CLO) (Required)

Course Learning Objectives (CLO):

CLO 1	Understand embedded hardware systems, to be able to utilize industrial development platform for the target RISC CPU.
CLO 2	Understand how to design and build interface prototype board to communicate with RISC CPU and realize firmware and device driver functions;
CLO 3	Understand interrupt and interface techniques and implement analog/digital sensor interface with OpAmp preprocessing unit, UART, SPI and PWM interface protocols.

Upon successful completion of this course, students will be able to:

1. Understand embedded hardware systems, to be able to utilize industrial development platform for the target RISC CPU.
2. Understand how to design and build interface prototype board to communicate with RISC CPU and realize firmware and device driver functions;
3. Understand interrupt and interface techniques and implement analog/digital sensor interface with OpAmp preprocessing unit, UART, SPI and PWM interface protocols.

Required Texts/Readings (Required)

Textbook

1. S3C6410 RISC Processor datasheets, Samsung Electronics https://github.com/hualili/CMPE244/blob/main/2021F-105-%230-cpu-arm11-2018S-29-CPU_S3C6410X.pdf and Development Board schematics https://github.com/hualili/CMPE244/blob/main/2021F-105b-%232018S-29-SCH-Tiny6410SDK-1111-PCB.pdf
2. Nvidia Jetson NANO datasheets.
   (a) Jetson Nano development kit document https://github.com/hualili/CMPE244/blob/main/2021F-108-%231NVIDIA_Jetson_Nano_Developer_Kit_User_Guide.pdf
   (b) Jetson NANO System-on-Module https://github.com/hualili/CMPE244/blob/main/2021F-108b-%23JetsonNano_DataSheet.pdf
   (c) Optional (not used) SoC Park CPU reference https://github.com/hualili/CMPE244/blob/main/2021F-106-tx2-%23Parker_TRM_DP07821001p.pdf
3. Broadcom Raspberry Pie CPU datasheets, BCM2835 CPU https://github.com/hualili/CMPE244/blob/main/2021F-104-%230-cpu-pie-BCM2835-ARM-Peripherals.pdf and https://github.com/hualili/CMPE244/blob/main/2021F-104d-simplifiedCPU-datasheet-%23rpi_DATA_CM_1p0.pdf

Other Readings

1. Professor Li's PPT, handout materials, lecture notes on line https://github.com/hualili/CMPE242-Embedded-Systems-
4. *Datasheets, lab design reference materials will be posted on line at https://github.com/hualili . Optional material: 16 Mbit Multipurpose FLASH data sheet, Document number SST39VF160Q/160, by Silicon Storage Technology; 64 Mbit SDRAM data sheet, K4S641632 CMOS SDRAM;*

Other technology requirements / equipment / material

Students are quired to have adequate embedded hardware and/or microprocessor systems background, to be able to implement system prototype with hardware prototyping board and software C/C++ programming capability. C/C++ compiler are open source and are free accessible to the class.

Course Requirements and Assignments (Required)

Course requirements and assignments: (1) to understand the basic concepts of embedded hardware systems, (2) to be able to conduct mathematical formulation and design verification, (3) to be able to design, build, and debug embedded systems, and (4) to be able to complete the homework and projects and pass the examinations. The students will be required to finish the homework independently, and submit the homework and project on time. Teamwork is encouraged and team will be formed throughout the semester, but all the homework and project will have to be finished independently. The projects are: (1) design, implement and build embedded system with prototype board to demonstrate GPP based input/output debugging and device driver functionality; (2) design and implement ADC sensor interface for IoT applications with interrupt technical to control sampling rate and with FFT to compute power spectrum to validate the ADC data; (3) design and implement PID controller for motor control applications such as for the applications in self-driving. These assignment and project will allow the students to have a good understanding of Course Learning Objectives (CLOs) from 1 to 3. The total homework and project weights 30% of the entire class grade (see details in the following grading section.) The due date of these homework and projects are given in class, usually, each homework is due one week after the assigned date, and the projects are due 10 days to 2 weeks after the assigned date, which is to be formally announced in class and in-writing on line (CANVAS). The general expectations, roles and responsibilities of the students include finishing the homework/project and make in-class demo on time, finish programming and system prototyping assignment on time, submit the programs and report on time.

The hands-on projects will be assigned during the semester, each student is required to work independently on these hands-on project. For each project, the student writes IEEE style report and make in-class demo. The project will cover the following topics:

1. Design, implement and build embedded system with prototype board to demonstrate GPP based input/output debugging and device driver functionality;
2. Design sensor interface with ADC and FFT power specturm enabled data validattion technique. In particular, ISE (Ion Selective Electrode) sensors. This project integrates the sensor interface and signal with cicuitry consisting of P.O.T and OpAmp preprocessing, then through computation of FFT and its power spectrum to adjust the sampling frequency per validation requirement.
3. Design and implement PID controller for motor control applications such as for the applications in self-driving to realize embedded close loop control function.

The University Policy S16-9, Course Syllabi (http://www.sjsu.edu/senate/docs/S16-9.pdf) requires the following language to be included in the syllabus:"Success in this course is based on the expectation that

students will spend, for each unit of credit, a minimum of 45 hours over the length of the course (normally three hours per unit per week) for instruction, preparation/studying, or course related activities, including but not limited to internships, labs, and clinical practica. Other course structures will have equivalent workload expectations as described in the syllabus."

Final Examination or Evaluation

Final examination at the end of semester will be given on the date defined by the university final examination schedule. The final examination is close book, close notes, however, one paper formula sheet will be allowed. No cellphone will be permitted in the final examination, and calculators are allowed. The weight of the final examination is given in the Grading Section in the following.

Grading Information (Required)

Midterm Examination	30%
Homework and Projects	30%
Final Examination	40%

The examination grades are given based on the written answer in the examination. The homework and projects grades are given based on the work submitted, prototype system demonstration, project report, as well as programming source code. The detailed rubrics for each homework and project are posted on line when each assignment is given, check online both CANVAS and https://github/hualili The grade for each assignment and project will be given to students for each submission with multiple opportunities of the feedback of the student learning. Rubrics examples for project 1 submission, for example, hardware board prototyping counts 40%, software implementation counts 40%, report counts 20%, so the total add up to 100% for a project assignment.

Determination of Grades

Grade	*Points*	*Percentage*
A plus	*96 to 100*	*96 to 100%*
A	*93 to 95.9*	*93 to 95%*
A minus	*90 to 92.9*	*90 to 92%*
B plus	*86 to 89.9*	*86 to 89 %*
B	*83 to 82.9*	*83 to 85%*
B minus	*80 to 82.9*	*80 to 82%*
C plus	*76 to 79.9*	*76 to 79%*
C	*73 to 75.9*	*73 to 75%*
C minus	*70 to 72.9*	*70 to 72%*
D plus	*66 to 69.9*	*66 to 69%*
D	*63 to 65.9*	*63 to 65%*
D minus	*60 to 62.9*	*60 to 62%*

Note: F for below 60%.

- No Extra credit options.
- Penalty for late submission of project is 10% per week.

Classroom Protocol

(1) Participation in class activities and attendance are required;

(2) Arrival in the class on time is required, a few minutes ahead is encouraged;

(3) No cell phone use in class and cellphone has to be submitted to the professor in class during examinations.

University Policies (Required)

Academic integrity

Your commitment as a student to learning is evidenced by your enrollment at San Jose State University. The University's Academic Integrity policy, located at http://www.sjsu.edu/senate/S07-2.htm, requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sa.sjsu.edu/judicial_affairs/index.html.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person's ideas without giving proper credit) will result in a failing grade and sanctions by the University. For this class, all assignments are to be completed by the individual student unless otherwise specified. If you would like to include your assignment or any material you have submitted, or plan to submit for another class, please note that SJSU's Academic Policy S07-2 requires approval of instructors.

Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities requesting accommodations must register with the Disability Resource Center (DRC) at http://www.drc.sjsu.edu/ to establish a record of their disability.

CMPE 242 Embedded Hardware Systems Spring 2019 Course Schedule

Course Schedule

Week	Date	Topics	Project
1	1st week	Organizational Meeting and Introduction to embedded hardware architecture and its development kit, Ubuntu based Linux development platform set up.	
2	2nd week	Overview of a tool chain, embedded Linux OS source code distribution and software development environment	Homework (1 point, 1% of total score)
3	3rd week	Building prototype board, with GPP I/O design based on device driver programming, special purpose registers , init and config.	Homework (1 point, 1% of total score)
4	4th week	Debugging technique based on the console to prototype communications via serial RS232 link, putty on the host and user APP and device driver on the development kit with prototype board	Homework (1 point, 1% of total score)
5	5th week	Memory subsystem design, ROM with 8-, 16-, 32-bit data bus, and introduction to Flash memory	Project 1 Report due
6	6th week	Flash memory interface via SPI interface, SPI communication protocol, and Flash memory dependent opcode implementation	
7	7th week	Interrupt controller techniques, build a prototype board with external interrupt function triggered by an event and handled by driver program	Homework (1 point, 1% of total score)
8	8th week	Midterm Exam	
9	9th week	ADC techniques, special purpose register setting, init and config, ADC characterization, ADC sampling rate and Nyquest theorem.	
10	10th week	ADC data validation based FFT and power spectrum computation, combination of ADC and ExINT techniques	Project 2 Report due
11	11th week	Industrial analog sensor interface design, prototype board with preprocessing circuit of OpAmps.	Homework (1 point, 1% of total score)
12	12th week	Interface techniques and PWM techniques, special purpose registers and their init and config, frequency settings for PWM	
13	13th week	Interface technique application to control applications, form close loop system based on the development kit and prototype board (as actuator), mapping control actions to PWM signals	Homework (1 point, 1% of total score)

Week	Date	Topics	Project
14	14th week	Interface technique application with numerical technique to map control function to PWM, integration of prototype board with full control functionality	
15	15th week	Power management with DS device to control system power, Implementation of a device driver for high speed serial interfaces to the DS device.	Project 3 Report due
		Final exam	