EE40LX – Electronic Interfaces: Bridging the Digital and Physical Worlds

Welcome

Our modern life is filled with devices that communicate between the digital and physical worlds. Everything from the automobile to the refrigerator is highly instrumented, taking measurements from many sensors and analyzing the data to make automatic decisions. At the heart of this activity is the interface: the electronic front end that measures a physical signal, filters it, then sends the information to a digital computer.

Throughout EE40LX, you will build a robot around the MSP430G2 LaunchPad, learning the fundamental principles underlying these electronic interfaces. This journey starts small – a few craft sticks, springs, and a voltage regulator – but eventually you will have a complete robot capable of bouncing around while responding to light and sound inputs. We are excited to be your guides for this learning experience!

Instructors

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Objectives

Analyze, design, build and test electronic circuits, and understand their capabilities and limitations.

1. Understand fundamental circuit principles
    - Lumped circuit model (Kirchhoff's laws)
    - Energy storage (capacitors and inductors)
    - Time and frequency domain signal representations
    - Analog and digital signals, conversion
2. Design, build, and test electronic circuits
    - Laboratory practices (breadboarding, test equipment)
    - Guided laboratories + robot project

Prerequisites

High school level algebra and trigonometry is required. High school physics is recommended, but not required. Some exposure to computer programming would be useful for those who want to dive further into modifying the robot's code design. The most important requirement is a willingness and desire to build things with your hands!

Course Format

The course is divided into eight modules which will all be released once the course begins. You will be able to go through the modules at your own pace. Though the courseware will be open for six months, the course should take eight to ten weeks of effort to complete. We urge you to follow along the videos with your own kits and build the circuits along with us. Each module will consist of the following content types:

- *Lecture Videos*
  Cover essential theory in a traditional, conversational format
- *Bench Videos*
  Demonstrate physical circuits that you can build and test
- *Debug Videos*
  Show common problems you may encounter while building the circuits, how to diagnose them, and how to fix them
- *Notes*
  Short written one-page texts that supplement the information presented in the videos
- *Quizzes*
  These short problems are sprinkled throughout the module to give you an opportunity to test your understanding. Answering these quiz questions is not required to complete the course but participation will help the learning process.

Robot Project

The lab-based videos presented in the class largely concern the building of a craft-stick vibrating hopper robot controlled by the MSP430G2 LaunchPad. This robot as completed in the course has the following subsystems:

- Voltage regulator
- Photocell front ends (2)
- Speaker driver
- Microphone front end
- DC motor drivers (2)

These systems communicate with the MSP430G2 LaunchPad in order to allow the robot to move in response to its environment. Refer to the Robot Project document for details.

Grading

Grading will be based on Problem Sets and a peer-graded Final Project.

- Problem Sets (6): 50 %
- Final Project: 50 %

We will grade the course on a pass/fail scale. You need a total score of 50% or above for a passing grade. The Final Project points will be awarded for students who successfully assemble the robot. Notice that either 100% completion of the final project, 100% completion of the problem sets, or some combination of the two is required to pass the course.

Students who earn a passing grade will receive a certificate of completion issued by Edx.

Course Outline

Section		Robot Part
Module 0: Prologue		
0.1	**Definitions**	
0.2	**The Robot**	
0.3	**MSP430G2 LaunchPad**	
0.4	**Breadboards**	
D0	**Debug 0: myDAQ**	
E0	**Energia 0: Tutorial**	
Module 1: Fiat Lux!		
1.1	**LED Circuit**	
1.2	**Charge, Current, and Voltage**	
1.3	**Verifying Circuit Laws**	
1.4	**Voltage Regulator**	**Voltage regulator**
D0	**Debug 1: Voltage Regulator**	
E0	**Energia 1: LED Blink**	
Module 2: Resistors		
2.1	**Resistors**	
2.2	**Ohm's Law**	
2.3	**Variable Resistors**	
2.4	**Wheatstone Bridge Analysis**	**Photocell Front End**
D2	**Debug 2: Wheatstone Bridge**	
E2	**Energia 2: Serial**	
Module 3: Amplifiers		
3.1	**Comparators**	

3.2	**Comparator Front Ends**	
3.3	**Amplifier Models**	**Speaker Driver**
3.4	**Speaker Driver**	
3.5	**Ideal Amplifier Models**	**Electret Mic Front End**
3.6	***Microphone Front End**	
D3	**Debug 3: Comparators and Amplifier circuits**	
E3	**Energia 3: Power blocking, tone generation, and analog read**	
Module 4: Capacitors		
4.1	**Capacitors**	
4.2	**Capacitance**	
4.3	***Bypass Capacitors**	**Voltage Regulator Revisited**
4.4	**Three Observations**	
4.5	**RC Circuits**	
4.6	***Filters**	
4.7	**Phasors**	
4.8	***Microphone Amp Revisited**	**Electret Mic Front End Revisited**
D4	**Debug 4: Measuring Frequency Responses**	
E4	**Energia 4: Tri-Stating**	
Module 5: Inductors		
5.1	**Inductors**	
5.2	**Inductance**	
5.3	**Four Observations**	
5.4	**RL Circuits**	
5.5	**Motors and the Flyback Diode**	
5.6	**Phasors Revisited**	
Module 6: Transistors		
6.1	**Switches**	
6.2	**FETs**	
6.3	**BJTs**	**Motor Driver**
6.4	**Adding the Motors**	
6.5	**Transistor Amplifier**	
Module 7: Epilogue		
7.1	**Final Robot**	**Final Project**
7.2	**Hacks**	
7.3	**Thank you!**	
E7	**Energia 7: Robot Code**	

*** Denotes modules where use of an oscilloscope is demonstrated. The use of an oscilloscope is optional for the course, but would enhance these sections.**