Experiment 10: Final Project

1.Proposal

Final project proposals must be in line with the learning objectives of ECE110. Specifically, the project proposal must have a relevant circuit component that is not too-closely tied to the core lab procedures and must not be a mere duplicate of an ***Explore More!* Module**.

Furthermore, please be aware that ECE110 only introduces Arduino but does not teach students extensively how to program. The learning objectives of ECE110 **do not include** conditionals, variables, loops, etc. If a student wishes to utilize Arduino (or another microprocessor) in their project, we gladly accept that. However, the project must be acceptable first according to its circuit component.

Since the Final Project is not very dependent upon the Arduino, students are allowed to use code taken from other resources (as allowed by copyright, etc.). However, improper attribution of the source of that code is considered **plagiarism** and will result in a grade of 0 for the assignment as well as a reduced grade in the course.

The ***results*** of any past project (by yourself or another student; in ECE110 or on the Internet) may not be used in your project proposal, design, or final report. This includes items like old data measurements and duplication of a past hardware design. The use of these materials will result in a grade of 0 for the assignment as well as a reduced grade in the course.

A student who is retaking the course for any reason may not complete a project similar in nature to his or her previous project.

MOSFET-based motor-drive circuits may be part of your project, but it's considered rather trivial given the core lab procedure. Do something more like using an H-bridge or an LED array.

The use of an active sensor (like the IR line sensor or the ultrasonic senor) is appropriate, but if that device is plugged directly into the Arduino which, in turn, controls the motor-drive circuits, the circuitry becomes trivial and unacceptable.

Acceptable projects should characterize a sensor and utilize that sensor to control a non-trivial circuit to accomplish a task.

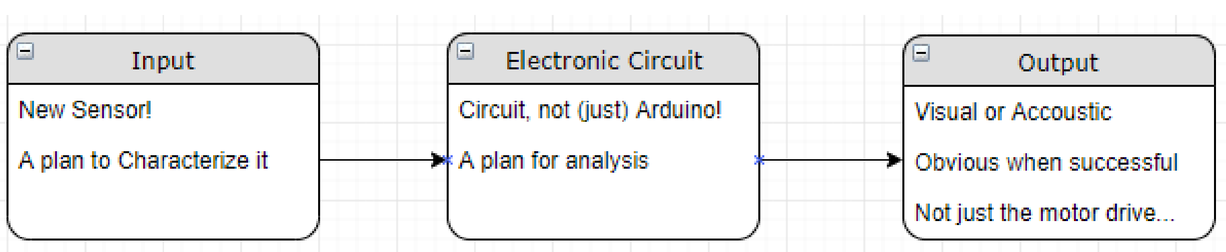

Figure 1: A generic block diagram depicting an acceptable final project.

Examples

1. **Not Acceptable**: A line follower sensor's output controls a motor-drive circuit. **Problem**: Biasing the sensor is trivial and the motor-drive circuit is straight out of the core lab procedure.
2. **Acceptable**: A line follower sensor's output controls a motor-drive circuit, but utilizes a button to back up (via an H-Bridge) and turn left when encountering a wall. **Comment**: Acceptable because it utilizes multiple components in a more-complex manner.
3. **Not Acceptable**: The Ultrasonic sensor is characterized by the distance computed by an Arduino library as a book is placed in front of it. Arduino controls the motor-drive circuits. **Problem**: The output of the echo pin is a PWM signal that changes duty cycle based on distance. The students can learn more about ECE110 topics by characterizing the PWM signal directly. Also, there is no interesting circuit in this design. It merely contains a single sensor, the motor-drive circuit(s), and Arduino carries the design.
4. **Acceptable**: A toy-model elevator is controlled by a motor-drive circuit that stops at each floor thanks to the feedback from a mounted Hall-effect sensor. **Comment**: Great! It is creative, uses a sensor from the kit, and requires circuitry that might not be too challenging to build but falls outside of the core procedures.

Below is a list of the sensors, actuators, and circuit elements available in your ECE 110 kit or typically available from your TA, along with some brief descriptions and potential applications. Look through the modules as well for great project ideas!

<u>Sensors and Inputs</u>

- Snap-action lever switches
  - Limit switches to detect when an object has reached a stopping point
  - Limit switch to detect a person is properly seated or that a safety device is properly located before operating a potentially-hazardous tool
- Pushbuttons
- Ultrasonic sensors
  - Measuring distance between the sensor and a solid object
- Photocell
  - Light sensor
- Infrared Emitter/Detector
  - Detect an object as it crosses the "beam"
  - Good for small distances (1 or 2 cm)
- Electret microphone
  - Low-output microphone; may require an amplifier to get a usable output signal
  - Clap-detector
  - Acoustic projects
- Thermistor
  - Temperature sensor
- Piezo vibration sensor
  - Pick up "table knocks", general vibrations, or even sound
- Flex sensor

  - Provides a variable change in resistance rather than just on/off like the snap action switch
  - Often used in glove-based controllers to sense bending of fingers
- Reed switch
  - Detects a nearby magnetic field
  - Often used to know if a door is open/closed
  - Might be used as a clever theft control device to disable a starter when magnet is absent
- Hall effect sensor
  - Also detects the presence of a magnetic field. Often used to detect the position of a rotating table, wheel, or other device.

<u>Actuators and Outputs</u>

- Servo Motor (PWM driven)
- H-Bridge-based Motor Drive
  - Often used to drive the car motors forward and backwards
  - Can reverse polarity/current through other devices
- LEDs
  - Used as indicators
  - Could be used in an array or cube configuration
    - Acceptable project output if used in one of these more complicated setups
- Speaker
- Hobby motor (DC)

<u>Circuit elements</u>

- Inverter
  - Used for logic devices, digital buffering, driving a loudspeaker (digital/PWM)
  - Oscillators
- Zener Diode (5.1 V)
  - Voltage regulator (change battery voltage to 5.1 V)
  - Signal conditioning/clipping
- Op-Amp
  - Used in voltage buffer circuits
  - Used in amplifiers
  - Used in equalizer
- Comparator
  - Comparison of two signal levels
  - Used to transform one oscillator waveform into another
  - Used in Analog-to-Digital Converters
  - Used as an event trigger (say, cause a delayed action to occur when a large capacitor finally charges to a preset voltage from a voltage divider)
- Transistors
  - NPN BJT and MOSFET
  - Oscillation, control, amplification

2.Final Report

Final Report Guidelines

The Final Project Report is due at the end of your demonstration during the final (full) week of laboratory sessions. Refer back to the lab syllabus (in this packet) for more details.

Below is a general outline of what things would be found in a good final report. The report should be typed and all figures (graphs and schematics) generated electronically. Please note that the outline shown below provides a recommendation of what things should be found in a report but the order of the sections/subsections does not need to match this outline. The goal of your report should be to provide enough detail about your design and methodology so that another engineer could read your report and duplicate your design (or pick up where you left off).

One report must be submitted **by each team of two students**. If your design is one piece of a larger group project, the reports may be submitted as one large document but the separate “team of two” reports must be clearly marked corresponding to its authors. There is no minimum page requirement but a good final report is often around 5-10 pages long, including figures.

Suggested Report Outline

1) Introduction

- ***Problem description***
  This should outline what goals your design must accomplish.
- ***Design concept***
  Give an overview of your design. This should be at a pretty high level and give a basic idea of how your design accomplishes your goals. It should include how your systems gets its inputs, what processing of that data will occur, and what we (the observers) will see, hear, feel, smell, or taste (? ☺) when the task is completed.

2) Analysis of Components

- ***Characterization of each sensor***
  Describe each sensor used in your design and what it does.
  Include tables of measurements made, the experimental setup used to collect those measurements, and any graphs, linear curve-fits or mathematical characterizations that are relevant to your design. Your collected data should be voltages and not, for example, merely distance values kicked out by an Arduino library.
- ***Design considerations***
  Describe the design decisions that resulted from the characterization of your sensors. Did the behavior or sensitivity of the sensor affect where the sensor was placed on the vehicle? Did you need to change sensors because of an unexpected limitation on the first device? Even “failed” attempts are worthy of documentation!

3) Design Description

- ***Block diagram***

Hierarchical graphical outline of your design. Each block in the diagram should represent a circuit or device.

- ***Circuit schematics***
  Schematics should correspond to blocks in the hierarchical diagram.
  If Arduino is used, block diagram of its functionality is required.
  A qualitative description of the circuit design should be included so that the circuit can be quickly and easily interpreted by the reader. (Please do not simply write a verbal description of how each circuit component is connected to each other component. This is neither useful nor worth any points.) By the way, signal “ground” has no business in your high-level block diagram…this is a common student mistake not to be repeated.
- **Physical/mechanical construction**
  Describe any relevant mechanical aspects of your design, e.g. how each sensor is mounted on the vehicle and where or the method used to mount a given actuator.
  Photographs of your vehicle/project are highly encouraged, especially if those photos are annotated with labels.

4) Conclusion

- ***Lessons learned***
  What unexpected obstacles did you encounter in your design process? How did you overcome them? Please note that this should only include lessons learned about your design, not your personal study habits.
- **Self-assessment**
  Make sure to directly address how well your design performed the tasks outlined in your introduction.

Optional: We have provided an additional customized circuit board, which you need to solder by yourself. If you use it correctly in final design, you will receive the extra credit.

Rubric to be used for your Final Project Demonstration

Keep this rubric in mind as you prepare for your demonstration. This is *not* the rubric used for grading your final report.

Final Demo Rubric

Project Title:

	Name	netID
Student #1		
Student #2		

Student #1	Points Possible	Score Given
Ability to explain in technical terms (language, course objectives)	4	
Use of the oscilloscope, other equipment (tech)	4	
Individual features (partial-functionality/troubleshooting)	4	
Full-system demo (functionality)	4	
Overall presentation appeal (planning, execution, equity)	4	
Extra Credit ("elegant solution" or "successful soldering circuit")	3	
	Total (/20):	

Comments:	

Student #2	Points Possible	Score Given
Ability to explain in technical terms (language, course objectives)	4	
Use of the oscilloscope, other equipment (tech)	4	
Individual features (partial-functionality/troubleshooting)	4	
Full-system demo (functionality)	4	
Overall presentation appeal (planning, execution, equity)	4	
Extra Credit ("elegant solution" or "successful soldering circuit")	3	
	Total (/20):	

Comments:	

Graded by: ______________________________

Final Report Rubric

The final report rubric will look something like this:

Total = 40 pts

1. Introduction [5 pts]
    a. Problem description [2.5]
    b. Design concept [2.5]
2. Analysis of components [15 pts]
    a. Sensor characterization [7.5]
    b. Design considerations [7.5]
3. Design description [15 pts]
    a. Block diagram and explanation [5]
    b. Circuit schematic and explanation [5]
    c. Design considerations [5]
4. Conclusions [5 pts]
    a. Lessons learned [2.5]
    b. Self-assessment [2.5]