PRELAB #9: Moving Towards *Elegant Circuit Builds*

Elegant Circuit Build

Engineering done well utilizes art as much as it does science. When designing and constructing a device, one needs to especially consider “human factors” including such items as safety, perception, ergonomics, and interpretation. We need to consider these aspects from both the viewpoints of the final customer as well as other engineers working on your team. Here, we will focus specifically achieving a board layout and associated wiring that is attractive to the eye and easy to interpret and debug.

When prototyping an electronics project, your early prototype might appear to be a “rat’s nest” of wires as seen in Figure 1. You do not want your circuit in this state for very long. Long wires are easily knocked out, long bare component wires will short against each other, and poor selection of wire colors makes circuit debugging extremely difficult.

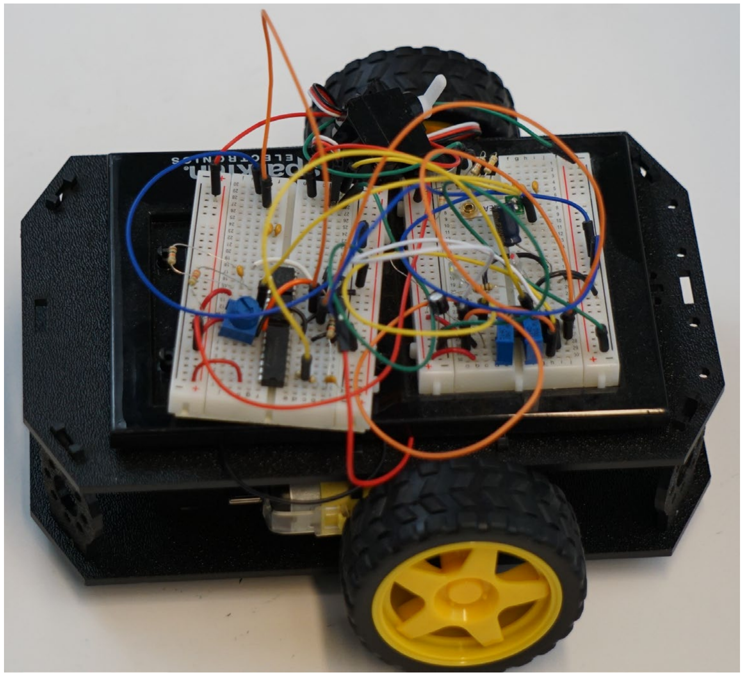

Figure 1: *Typical “Rat’s Nest” of wires.*

Notes:

Circuit Layout Plan for your Car

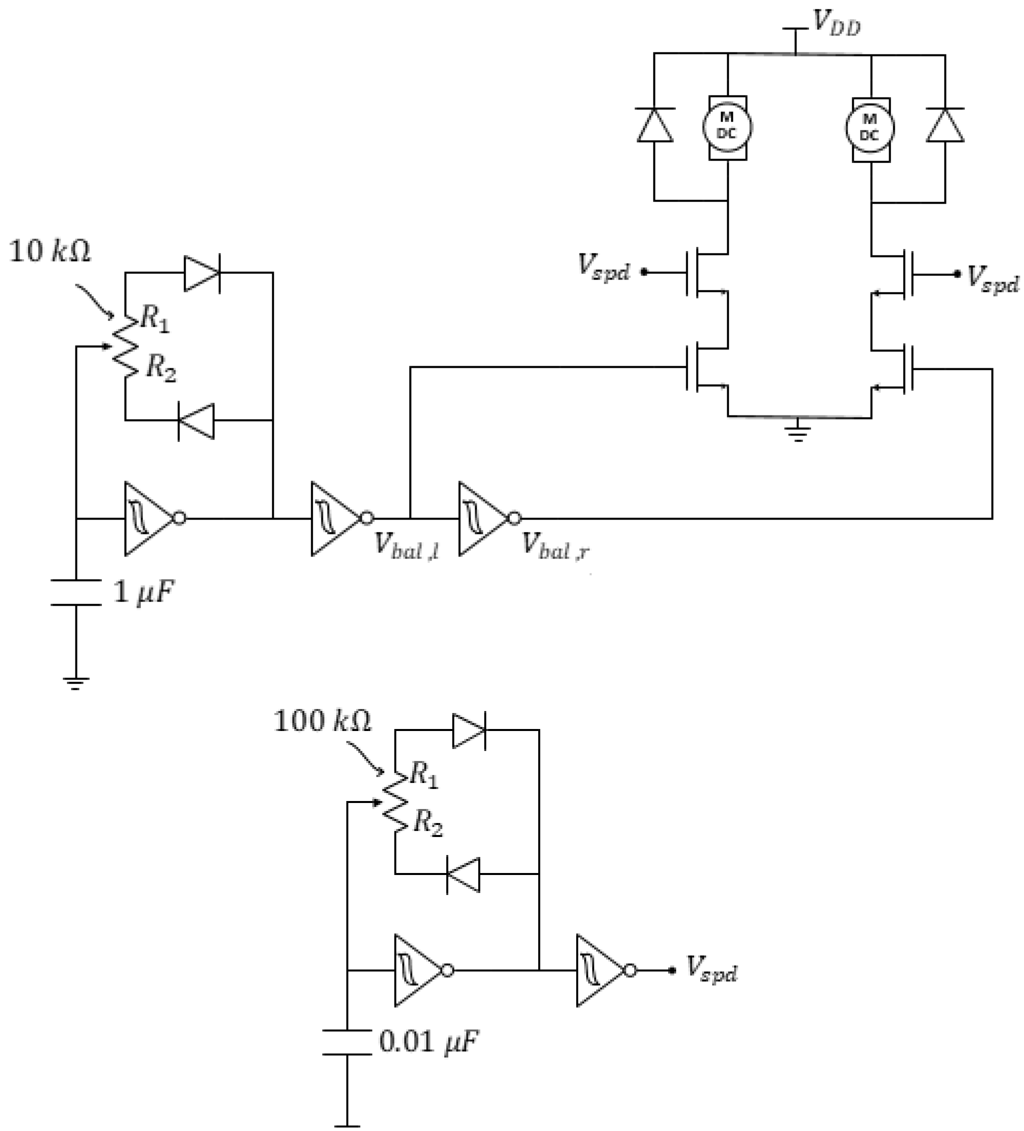

Figure 2: *PWM-based wheel balancer plus speed control. The signals labeled "V_{spd}" are all connected in a single node.*

Notes:

Consider your motor-drive circuit that now includes PWM-based wheel balance and speed control. Without the pressure of lab time, consider how you might improve the board layout by sketching a physical layout on one of the boards below. Indicate the wire color you would use and show how you would keep the wire and lead length short. How else might you use wire colors to make your board easier to read? This short video will give you an idea: https://www.youtube.com/watch?v=ver-Av8vr1Q

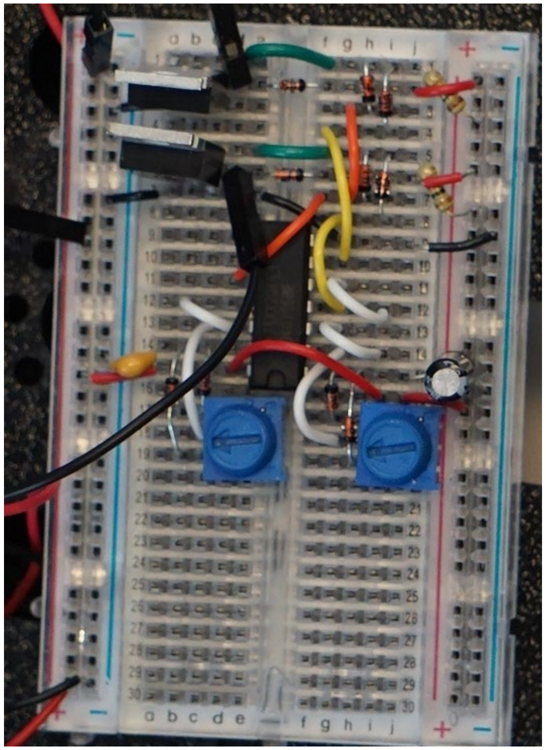

Figure 4: *A clean circuit implementation of everything in Figure 2. Your layout need not match.*

Final Project Proposal

TA and Student Guidelines for ECE110 Final Project Proposals

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 a ***Mini-Project*** **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. If you are unsure of how to properly attribute your code, discuss with your TA.

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.

Notes:

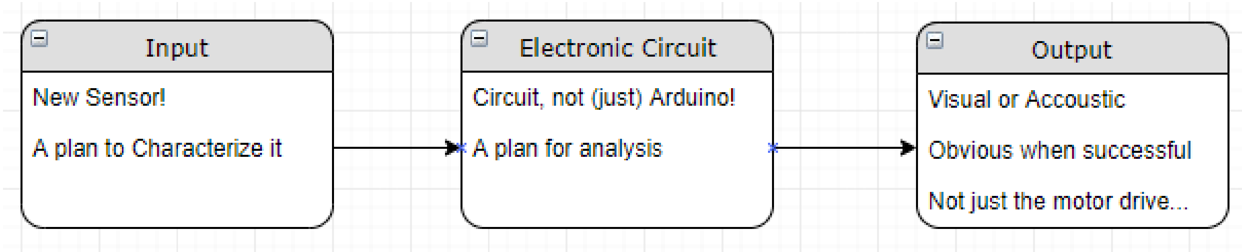

Figure 5: A generic block diagram depicting an acceptable final project.

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 sometimes 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

Notes:

Notes:

    - 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.

Actuators and Outputs

- Servo Motor (PWM driven)
- H-Bridge-based Motor Drive

Notes:

- 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

Notes:

What about grading?

- Analyze your data using a graph and use that analysis to model its behavior.
- Show proficiency with the equipment used to collect/analyze data.
- Properly document your procedure, data, observations, summary and conclusions in a well-written report.

The TAs will use a grading rubric on your final project demonstration and another on your final project report.

The final demonstration rubric will look something like this:

Student #1	**Points Possible**	**Score Given**
Two-minute video (submitted in advance)	5	
Ability to explain in technical terms (language, course objectives)	5	
Use of the oscilloscope, other equipment (tech)	5	
Individual features (partial-functionality/troubleshooting)	5	
Full-system demo (functionality)	5	
Overall presentation appeal (planning, execution, equity)	5	
Extra Credit (“elegant solution”)	Up to 5	
	Total (/30):	

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]

Notes:

If your final project deviates greatly from your proposal, points will be lost if the changes make the project deviate from the ECE 110 objectives.

Learning Objectives

- Learn and apply skills that will improve presentation of a circuit design.
- Final Project Proposal

Name:____________________ UIN: | | | | | | | | | Section AB/BB: | |

Notes:

Prelab 9 Summary

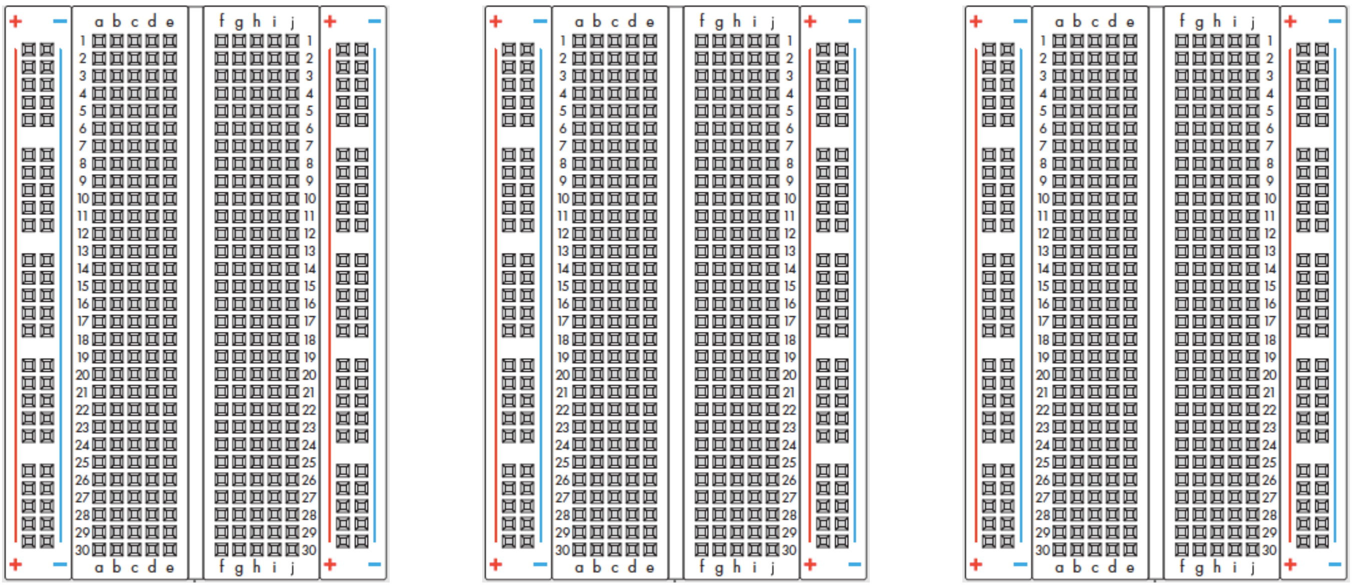

Figure 3:

Question 1: Use these breadboard images for planning one or more circuit layouts of Figure 2. Alternately, you might use a software like “Fritzing”. The extra boards are there if you want to “try again” since erasing can be messy!

Notes:

Question 2: Provide a short description of your proposed project. Include a block diagram that details the sensor, output, and central circuit. Include details how the circuit will be tested for correct operation (what devices/signals will be needed). If you have multiple ideas, feel free to express them here as well.