Experiment 5
System PCB Layout
ECE 482

The objectives of this experiment are:

- To gain experience with good practices of PCB layout including digital, analog, and power circuitry
- To use knowledge develop in Experiments 1-4 to formulate and implement system improvements

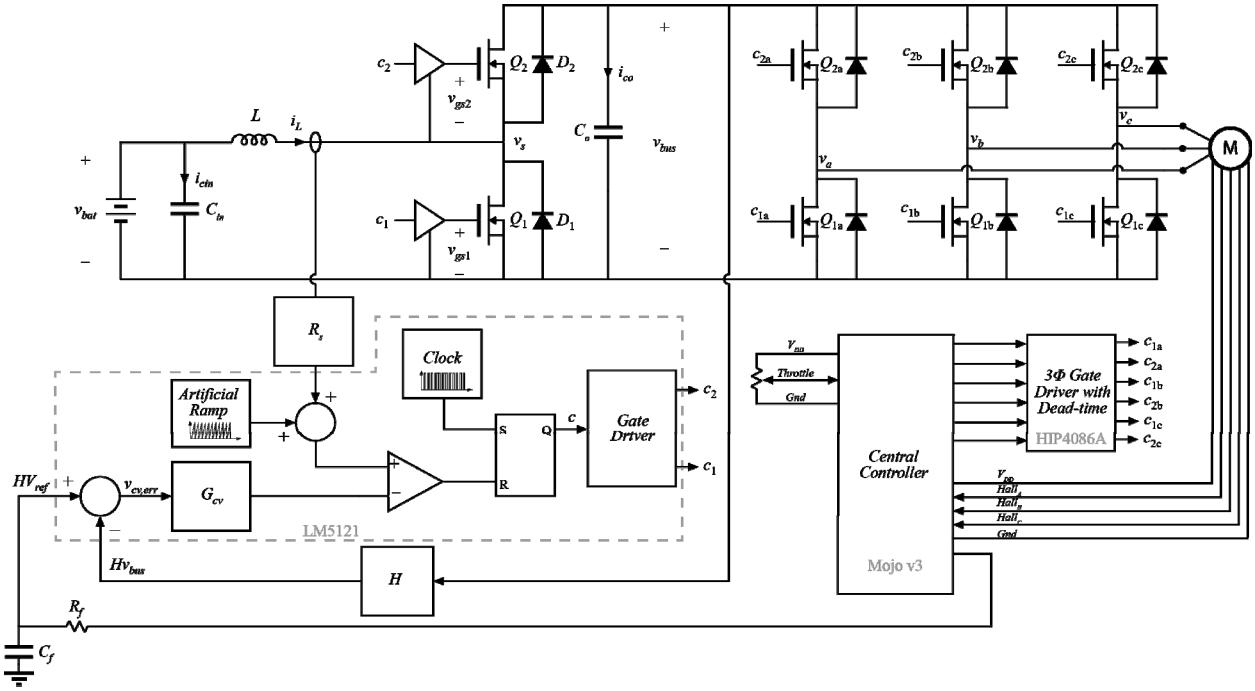

Figure 1: Nominal system diagram for drivetrain power conversion including DC-DC boost, motor driver, and central controller

In this lab, you will use Altium Designer to create a two-layer printed circuit board which implements your electric vehicle drive train. This will include both the DC-DC boost converter which you have previously constructed in experiments 3 and 4, as well as the motor driver.

I. PCB layout

Read through the materials on Altium Designer on the course website linked from the experiment 5 page. The PCBs ordered will be two-layer, standard specification boards from Advanced Circuits, under their "$33 each" student deal. A design rule file to include these specifications in Altium Designer has been posted on this page.

Additionally, PCB footprint and schematic libraries and a starter project for the experiment are provided. These files contain information on many of the parts included in the nominal system, and start with a nominal schematic. You will need to alter these and make additional connections; use these as a starting point for your PCB design. As you select new components for this lab, include the schematic symbols and PCB footprints that you create in these libraries for better organization.

II. Motor Driver Implementation

The motor driver must consist of a three phase inverter with each leg comprised by a transistor half-bridge. Additionally, relevant high- and low-side transistor drivers should be selected so that the devices may be switched on and off. Your driver circuit implementation must be capable of switching each half bridge into one of three states, and must be controlled digitally by outputs from the Mojo v3 central controller. The states are given in Table I; the circuit must be able to hold each half bridge independently in any one of the three states for an arbitrary time (i.e. an adjustable dead time alone is not sufficient to implement State 0).

TABLE I: HALF BRIDGE STATES IN DRIVE TRAIN INVERTER

State	High Side Device	Low side Device
0	Off	Off
1	Off	On
2	On	Off

An example gate drive chip is included in the diagram of Fig. 1, which you may choose to use or may replace as you see fit. The power semiconductors used to implement the three half bridges are also subject to your design.

III. Circuit Connections and Protection

Figs. 2 and 3 detail the electric bicycle platform to which you will attach your completed power converter drivetrain PCB, as well as the included circuit protection devices.

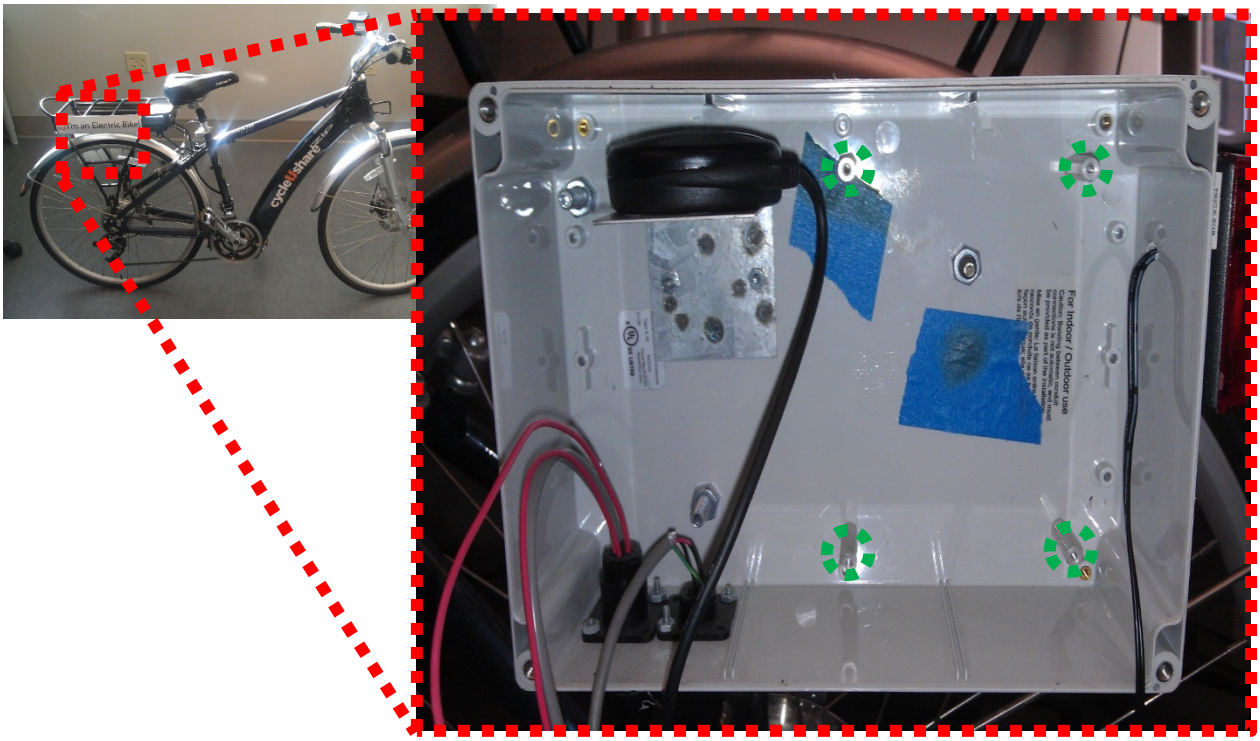

Figure 2: Circuit Box on E-bike Platform. Mounting standoffs are highlighted in green.

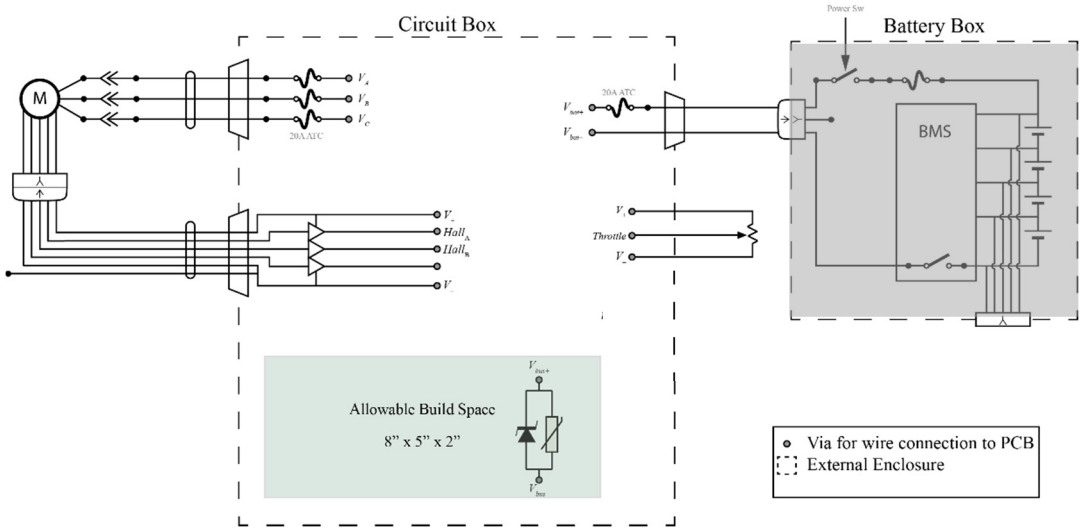

Figure 3: Included circuit protection and connections diagram

Your PCB should stick to the board size defined by the starter files in order to fit within the build space in the circuit box. Holes are identified for mounting to the included standoffs. You will not have access to the Battery Box. Note that you may not remove fuses, V_{bus} MOV/zener, of the Schmitt buffer from the hall sensor, which constitute protection for the motor, battery, and your DC bus. Within the Circuit Box, all connections will be made by the included screw terminals. These connections are described in Table II, with the Type field

indicating whether the connection is an input, output, or internal connection from your designed PCB (input or output are considered for positive power flow operation for clarity).

TABLE II: CIRCUIT CONNECTION DESCRIPTIONS

Name	Type	Desc
$V_{A\text{-}C}$	Output	Three phase motor leg currents
$Hall_{A\text{-}C}$	Input	Three digital hall sensor outputs
V_{bat+}	Input	Battery pack positive terminal
V_{bat-}	Input	Battery pack negative terminal
Throttle	Input	Analog voltage from throttle. Should be connected to Mojo v3 ADC input
V_{bus+}/ V_{bus-}	Internal	DC/DC output bus voltage. The MOV and Zener shown here should be included *on your PCB* for protection

IV. Auxiliary Supplies

To allow the electric bicycle to be a fully contained system, all components must obtain power from the battery pack itself. A pair of 9V and 5V isolated power supplies are included in the design. Depending on your design, you may be able to operate without these, or may require additional supplies. The Mojo can be powered internally through a 4-12V supply given on a two-pin header.

V. Deliverables

For this lab, you will turn in your completed PCB schematic, layout, and a spreadsheet containing the part number, quantity, distributor, and price of any components you intend to use which are not available in the circuits store or in the Experiment 3 parts kit. Be aware that excessive component cost will not be permissible; new purchases must be justified with analysis showing why the benefits outweigh the additional costs. Your grade for this lab will be based on the timely completion of an errorless PCB layout which exhibits good layout practices, as discussed in lecture/notes, and proper implementation of system modification as developed in the prelab assignment.