ECEN 489-502
Lab 3 – Sensing and Actuation I

Pre-Lab

1) Translate the H-Bridge bi-directional motor control circuit shown in Fig. 1 into a fully-wired breadboard implementation using a graphical editor such as Fritzing or an equivalently-featured layout tool and commit a picture of your diagram. Note: There are two symmetric circuits that can be split and their similar sub-circuits built adjacently on the breadboard; specifically, try placing sink next-to-sink on one side of terminal strips and source-next-to-source on the other side of terminal strips – this may help simplify wiring and clean-up the circuit or aid in visual inspection before applying power to the circuit.
2) Assemble the circuit according to the layout you created in the previous step. Note: Make sure your circuit is disconnected from power sources and ground, then begin assembly by placing the power and switch transistors and complete the circuit by connecting the motor.
3) Modify the Arduino example sketch "Fade" to first ramp-up and ramp-down the motor in one direction using the PWM capability of P9 while keeping P10 set to "0", next set P9 and P10 to "0" for 1s, then ramp-up and ramp-down the motor in the opposite direction using the PWM capability of P10 while keeping P9 set to "0", and finally set P9 and P10 to "0" for 1s.
4) Establish that the sketch will implement the correct fading and delays through the microcontroller by disconnecting the circuit at nodes A-D, then connecting Nodes A and B to ground (with P10 through the red LED and 1kΩ resistor and P9 through the green LED and 1kΩ resistor).

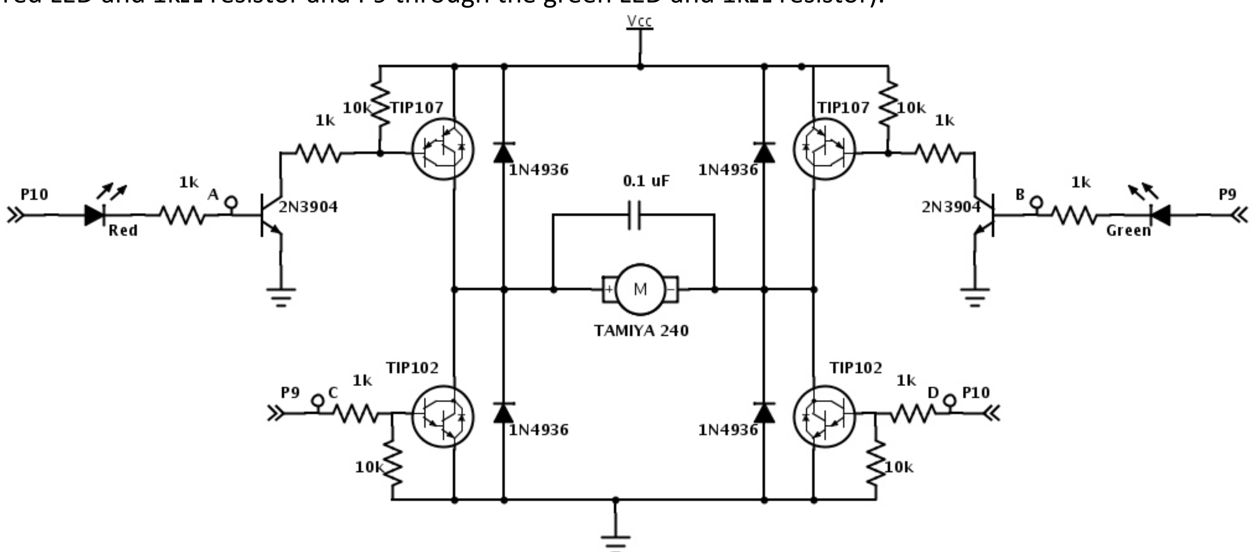

Fig. 1 Circuit diagram of the H-Bridge motor controller.

Light Sensor

1) Derive an expression for the voltage-divide at Node A in the circuit shown in Fig. 2 as a function of the light (in lumens) incident on the photo resister, then derive an expression for the luminosity as a function of the voltage at Node A. Note: Examine the data sheet of the CDS001-8001 and consider a polynomial or exponential expression that can be solved (in both the direct and inverse problems) with a minimum number of three initial conditions (data points)to calculate the unknown coefficients.
2) Use three data points from the design curves on the data sheet to calculate the unknown coefficients, then write an Arduino sketch which measures the input to P0 and maps the 10-bit ADC result to the appropriate voltage and then prints the calculated resistance of the photodiode and the calculated luminosity 'observed' by the photodiode every 100ms in the terminal window.

3) Assemble the circuit shown in Fig. 2 on the breadboard.
4) Verify the basic operation of the sketch by observing the output in a well-lit area before and after covering the photodiode with an opaque cover (such as a piece of thick paper) and commit the sketch.

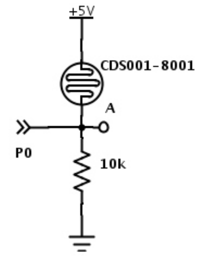

Fig. 2 Circuit diagram of the voltage divider using the photoresistor.

Temperature Sensor

1) Derive an expression for the resistance of the thermistor using the voltage difference across Nodes A and B from the Wheatstone bridge circuit shown in Fig. 3, then use this to derive an expression for the temperature of the thermistor as a function of the voltage difference across nodes A and B. function which calculate as a function which of the light (in lumens) incident on the photo resister, then derive an expression for the luminosity as a function of the voltage at Node A. Note: Examine the data sheet of the NTCLG100E2303JB and use the Steinhart-Hart Thermistor Equation.
2. Use three data points from the design curves on the data sheet to calculate the unknown coefficients, then write an Arduino sketch which determines the voltage difference between P0 and P1, then prints the calculated resistance of the thermistor and the calculated temperature every 100ms in the terminal window.
3) Assemble the circuit shown in Fig. 3 on the breadboard and commit your sketch.
4) Verify the basic operation of the sketch by observing the output and comparing it to other estimates of the ambient temperature and commit the sketch.

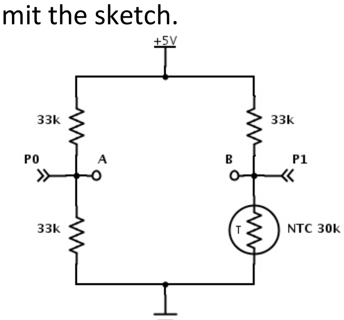

Fig. 3 Circuit diagram of the Wheatstone bridge using the 30kΩ NTC thermistor.

Lab Tasks

1) [H-Bridge] Reconnect Nodes A-D in the H-bridge after verifying the circuit performs correctly, then demonstrate the ability of the circuit to provide bi-directional control of the motor.
2) [Light Sensor] Use a multimeter to verify the utility of the expression derived in the pre-lab and make any changes to the calculated expression after calibration using three known-luminosity sources.
3) [Temperature Sensor] Use the thermistor to calculate the ambient temperature in the room with the expression derived in the pre-lab, then use the beaker of water on the hot plate, the ice bath, and the ambient temperature to make any changes to the calculated expressions.

Lab Follow-Up

1) Re-examine the H-bridge circuit in Fig. 1 to determine if any components in the circuit are unnecessary. Justify your answer by briefly describing why they can be removed and/or how the current circuit can be reconfigured to improve its performance.

2) Evaluate the maximum motor stall-current this circuit can safely handle (80% of maximum).

3) Commit your post-lab code for the light and temperature sensors after using the measured data.

4) Comment on the error in the temperature sensors arising from using 33kΩ resistors instead of 30 kΩ.

Parts List

H-Bridge

6x 1kΩ Resistor

4x 10kΩ Resistor

1x 0.1 μF Capacitor

2x 2N3904 NPN BJT General Purpose Amplifier/Switch

http://www.fairchildsemi.com/ds/2N/2N3904.pdf

2x TIP102 NPN Power Transistor

2x TIP107 PNP Power Transistor

http://www.st.com/web/en/resource/technical/document/datasheet/CD00001234.pdf

4x 1N4936 Fast-Switching Rectifier

http://www.vishay.com/docs/88508/1n4933.pdf

1x Tamiya 75026 Mini Motor Set

http://www.pololu.com/catalog/product/1688/specs

Light Sensor

1x 10kΩ Resistor

1x CDS001-8001 Cadmium Sulfur (CdS) Photocell

http://www.jameco.com/Jameco/Products/ProdDS/202403.pdf

Temperature Sensor

3x 33kΩ Resistor

1x NTCLG100E2303JB 30kΩ Thermistor

http://www.vishay.com/docs/29050/ntclg100.pdf