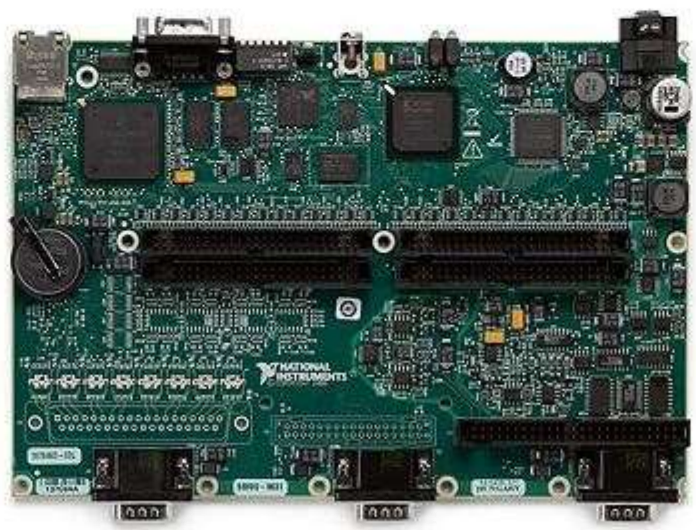
ELECTRONICS LAB
PREPARATION FOR SB-RIO TESTING



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Objective
The objective of this lab is to construct and understand simple circuits using LEDs, transistors, resistors, and Op Amps. This practice is to later prepare the techniques required for later testing and wiring the necessary components to the SB-Rio.

Electronics: Actuation

Led Indicator Lab
SB-Rio 9632 data:
- Max Digital Output Current: 3 mA
- Digital Output Voltage: 3.3 V

Led wp710A10id data:
- Minimum Voltage On: 1.7 V
- Minimum Current On: 2 mA
- Maximum Current On: 30 mA
- Positive Side: Longer Leg

Transistor 2N5551BU:
1. Minimum On Drive Current (can our board provide it?):
1 mA (Yes the board could provide it)

2. Minimum On Input Voltage (can our board provide it?): 1 V (Yes the board could provide it)

3. Max Output current (can it run our actuator?): 600 mA
Yes, we can run our actuator since our actuator in this case is our led with minimum on current at 2 mA.
4. Max Output Voltage (can it run our actuator?): 6 V
Yes, we can run our actuator since our actuator in this case is our led with minimum on voltage at 1.7 V.
5. What is the current amplification: 30-80

From the data above we can tell that the minimum current requirements are easily met but the maximum is not met. If we are powering it with the SB-Rio then 3 mA is clearly not enough. In our experiment we are using the battery so it is enough.

1. Allowable range of resistor values: 229 – 3425 Ohms
Derive using V = IR where our
V = 6.85 V
Note: after subtracting 2 V (voltage drop caused by led resistance) and 0.15 V (voltage drop caused by transistor resistance)
I = 2 mA to 30 mA
Note: Range base on what our led could support

2. Why do we subtract 2.15 volts?
The subtraction of the 2.15 V comes from the 2 V (voltage drop caused by led resistance) and 0.15 V (voltage drop caused by transistor resistance) adding both of this up give us 2.15 V (voltage drop across both component) which we now need to subtract from the 9 V.

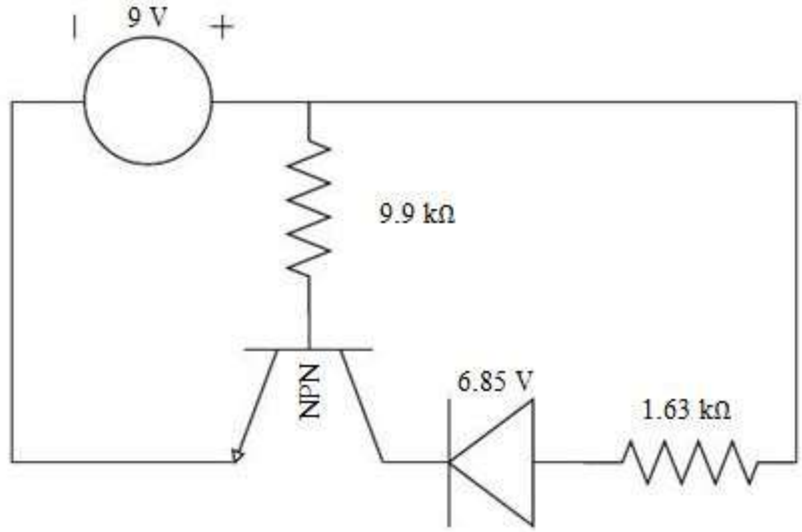

Figure 1: LED Circuit Diagram

Running a Motor

Darlington transistors are used to boost the amount of current we can transfer to the motor (or any device we plan to connect it to) especially using the Darlington pair configuration. Apparently in this lab we didn't use the Darlington pair since we used the battery to power LED and that provide enough current.

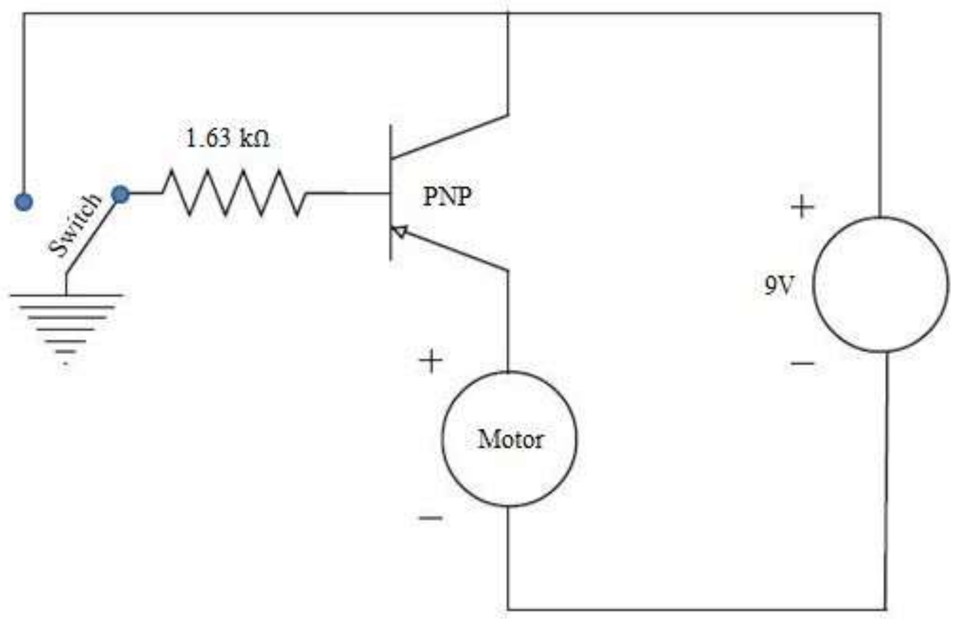

Figure 2: Motor Circuit Diagram

ELECTRONICS: SENSORS

Button

To make sure the SB-Rio can support the LED we need to look at the digital rating. The statistic for the SB-Rio digital inputs are listed below:
1. Minimum Digital Low Input Voltage: 0.0 V
2. Maximum Digital Low Input Voltage: 0.8 V
3. Minimum Digital High Input Voltage: 2.0 V
4. Maximum Digital High Input Voltage: 5.25 V

When using regulators we need to make sure the battery can support the regulators.

1. The input voltage range: will our batteries provide enough voltage?

Yes the battery will supply enough voltage. 9 V is larger than 5.25 V even with the voltage drop.

2. Max current: will there be enough current to power all of our devices?

Yes there will be enough current to support all of our devices. Since the current is coming directly from the 9V battery. Also, all of the devices work properly during our experiments signaling our success.

3. Heating issues: will we need a heat sink? How will we know if we need a heat sink?

Each device has a current rating and if it passes that rating (due to high current withdrawal) some devices needs heat sink. Examples would be some H-bridges. Some need heat sink if it passes a certain current threshold example 5 A. This can be calculated from the circuit diagram.

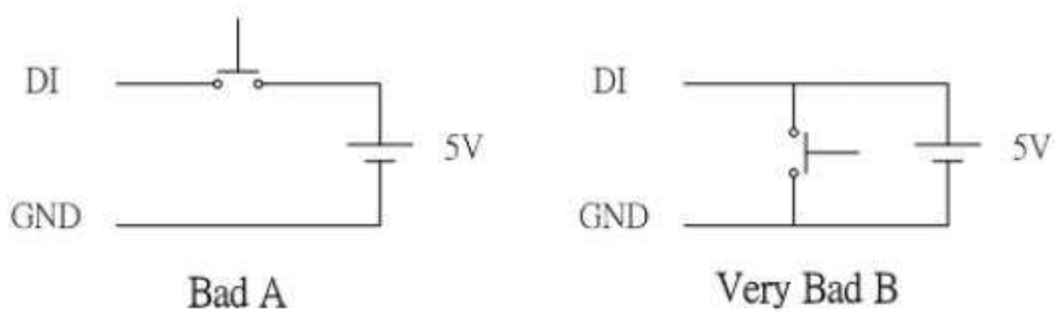

Figure 3: Poor configurations for buttons.

- Design A is not good because it is not grounded when it is open and there could be some charge giving it floating values.
- Design B is not good as well because it is a short circuit when it is closed. (Causes many problems and failures)

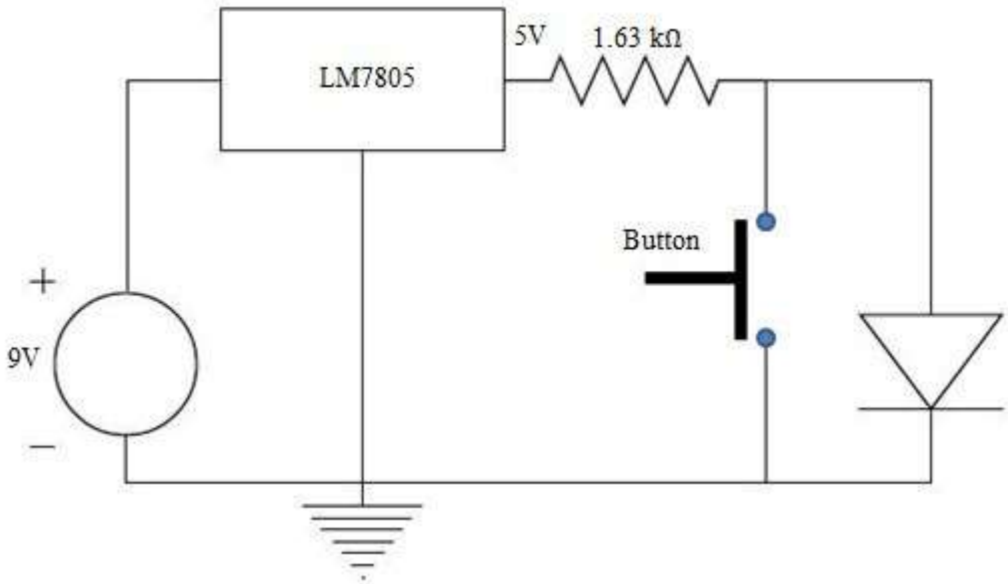

Figure 4: Button Circuit Diagram

Encoder

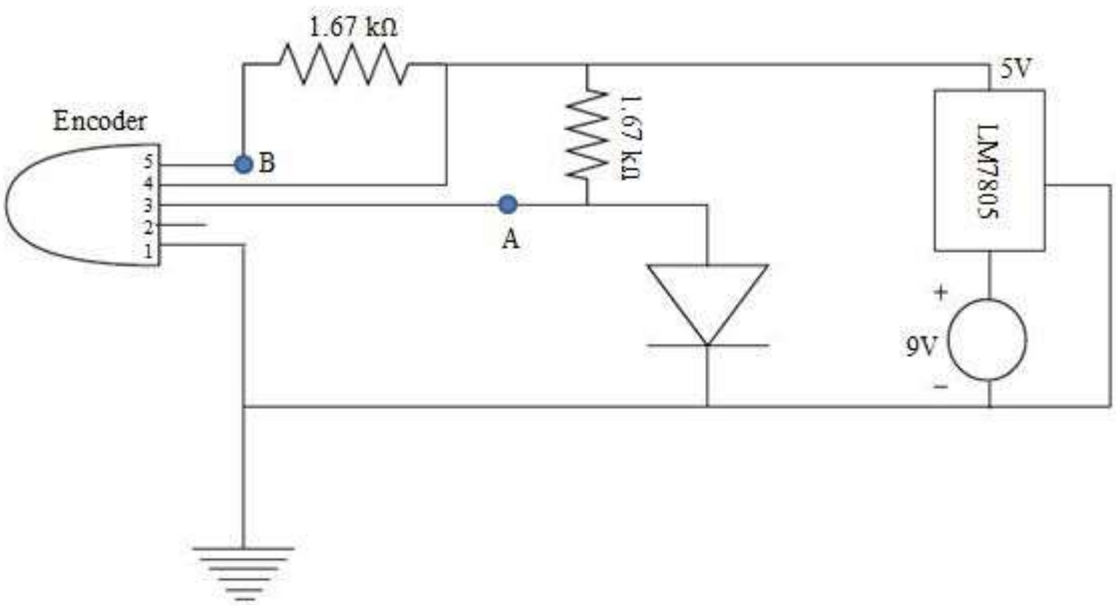

Figure 5: Encoder Circuit Diagram

Analog Sensor Data and Potentiometer Setup

This section deals with the analog sensing data but the potentiometer needs to be setup first.

Analog input to SB-Rio data:

Minimum Analog Input Voltage: 0.2 V
Maximum Analog Input Voltage: 10 V

Too Small a Range

To get a voltage range from 0 to 3 V only we can use a voltage divider to get a 3 V output and connect the potentiometer to the 3 V output. This makes the 3 V be the maximum voltage and the potentiometer can now range from 0 V – 3 V as we desired.

Another way is to just connect the potentiometer to the higher voltage directly and find the resistance range that give out 0 to 3 V. (This is precisely what we did in this lab as shown in the circuit diagram below).

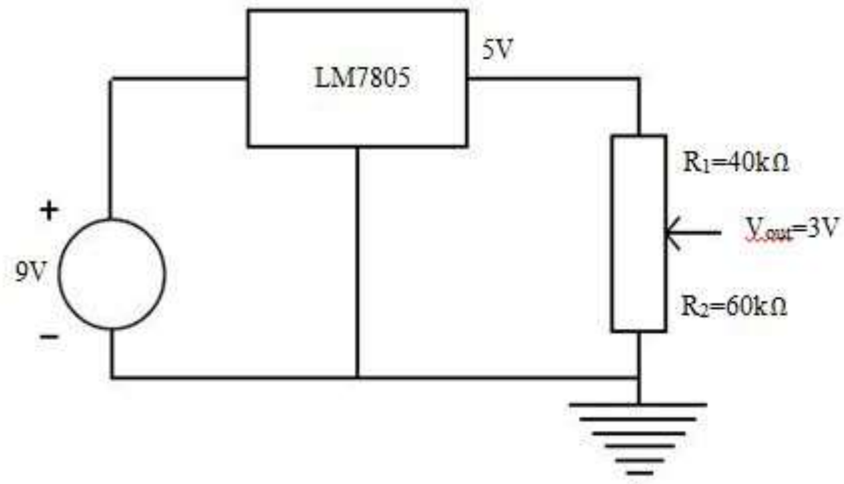

Figure 6: Potentiometer Circuit Diagram with V_{out} at 3V

Too Large a Range

To increase the voltage above 5 V we will have to implement an Op-Amp. In this experiment we will be powering it with a 9 V battery (answer to Q. 3).

The configuration is illustrated below.

Lab Report Data

Questions and diagrams are answered and illustrated above. Below are details to implement motor amplification.

Motor Amplification

When connecting the motor we first have to look up all the requirements to make sure the board can support it and if not find alternatives and use op-amp and Darlington pair as necessary to boost voltage or current. The things to check are:
For SB-Rio:

- Max digital output current
- Digital output voltage

For Motor:

- Minimum voltage on
- Minimum current on
- Maximum current on

(Base on max current data for our motor of 25A we need a fuse)
(Also make sure if the battery can provide enough current to drive our load. This shouldn't be a problem in our case. Clearly the board cannot support the motor our group picked so transistors are necessary.)
For transistor:

- Minimum drive current
- Minimum drive voltage
- Maximum output current
- Maximum output voltage
- Current Amplification

i. In our experiment the transistor can be driven by the SB-Rio.
ii. In our experiment we didn't have a second transistor because we power the motor from the battery and the battery provided enough current. If we were to power it using the SB-Rio two transistors are needed to significantly boost up the current.
iii. Assuming the first transistor have gain of B_1 and the second transistor have gain of B_2 then the total amplification is $B_{total} = B_1 * B_2$.

This circuit diagram is display in Figure 2. Again note that we didn't use the Darlington pair to power the motor.

Analog Signal Manipulation

a. Circuit diagram of original potentiometer and amplification circuit

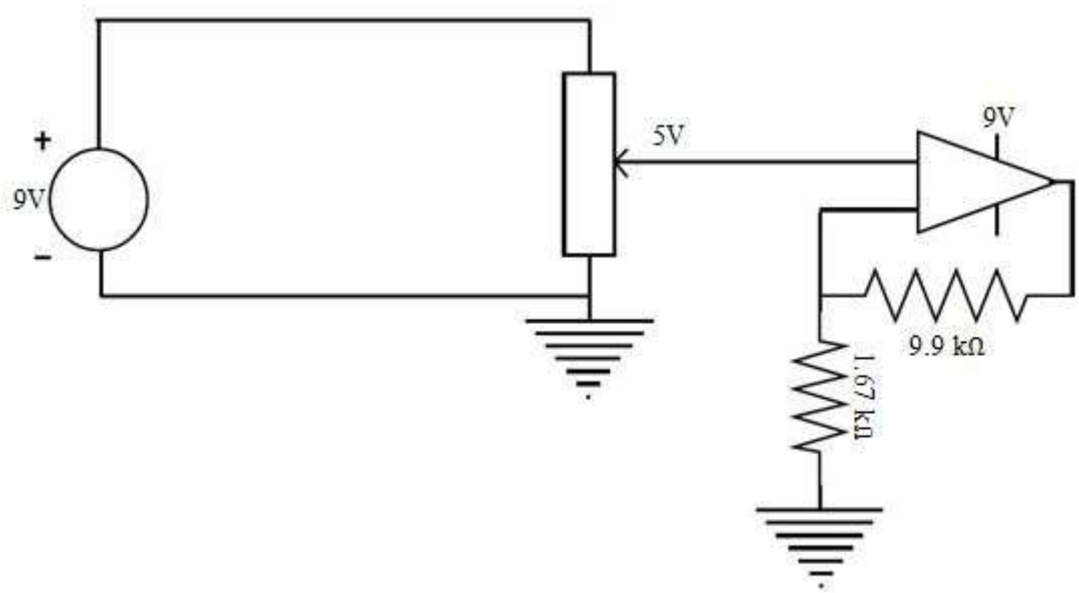

Figure 7: Combined circuit diagram of potentiometer and op-amp

- The attenuation circuit is the potentiometer which reduces the 5V to 3V a gain of 3/5.
- The op-amp has a gain of 7.25
- The total is therefore 3/5*7.25 = 4.35