Stopping Mechanism

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Abstract

This paper serves to document the purpose, function, and design of the stopping mechanism circuit used in Cornell Chem-E car, so that future members can access this document for technical guidance and reference.

1 Purpose

Converts chemical energy (battery/fuel cell) into electrical energy that supplies power to the motor and allows the car to move in a forward direction.

2 What does the circuit do?

The circuit provides power to the motor while the iodine reaction is in process and cuts off the motor connection once the reaction is complete. The circuit uses a photoresistor, a light controlled resistor, to detect the reaction's color change which sends a signal to the circuit to keep the connection to the motor or cut it off.

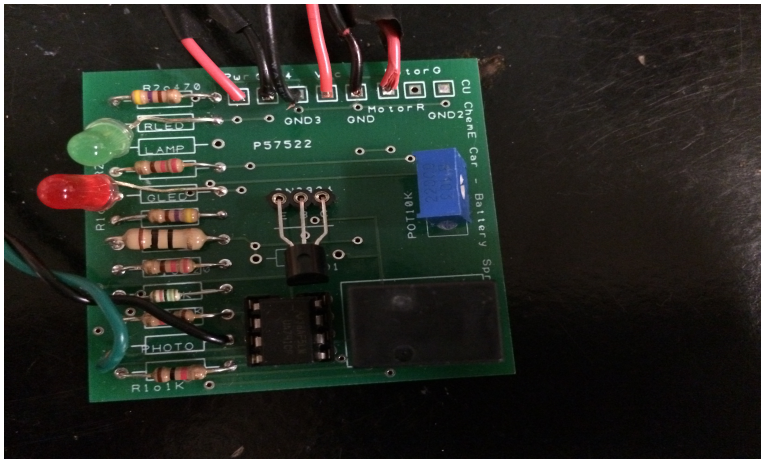

Figure 1: The Stopping Mechanism Circuit PCB

3 How to connect everything for operation

The 9V battery, or Vcc, provides power to four different branches in the circuit. The first branch has the photoresistor in series with the 10k potentiometer and 15k resistor. The second branch has two 1k resistors in series, and the third branch has the op-amp which has the Vcc+ terminal connected to Vcc and Vcc- to ground. In+ is connected to the voltage output of the first branch and In- is connected to that of the second branch. The out terminal is connected to the 220 ohm resistor (Look up terminal numbers on datasheet). The fourth branch has the NPN transistor. Pin 3 of the transistor is connected to Vcc, and pin 2 and pin 1 are connected to R8 and R9 respectively(Look up Datasheet) .The relay has 3 pins on one side and two on the other(Bottom View on Datasheet). On the three pin side the top pin is connected to R9 and the bottom pin to ground. On the two pin side, the pin to southeast of the middle pin on the

first side is connected to the positive side of the green LED. The pin to the northeast is connected to the positive side of the red LED. The negative side of the two LEDs are connected to ground. The lamp which is in series with the 220 ohm resistor is not part of the stopping mechanism anymore and along with the resistor forms the potions light bulb circuit.

4 How does it work?

4.1 How the comparator works

This light activated motor circuit uses the properties of light dependent resistors to power the motor. The photoresistor is a photo-conductive cell whose resistance is inversely proportional to the light intensity that it is subjected to. Therefore as the light intensity on the resistor increases the resistance of the photoresistor becomes very small. The photoresistor forms a voltage divider with the potentiometer and 15k resistor so that the output voltage becomes 0V when no light is shining on the photoresitor and the voltage becomes 4.5-5V when light is shining on the resistor.

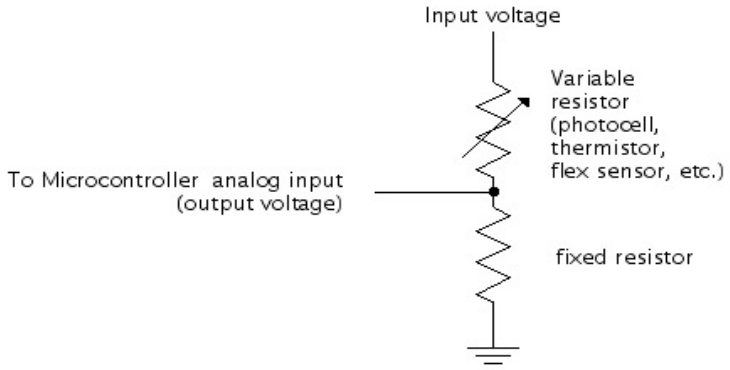

Figure 2: Photoresistor and 15k voltage divider

$$Vout(OutputVoltage) = Vin * \frac{Rfixed}{Rphoto + Rfixed} \tag{1}$$

The output voltage from the second branch stays at a constant 4.5V. The second branch voltage becomes Vref and the first branch voltage becomes Vin for the op-Amp. The op-amp comparator circuit compares Vref to Vin such that if Vin is greater than Vred, Vout is pulled to Vcc otherwise Vout is pulled to ground. Therefore the output voltage from the op-amp is 9V when the photoresistor is receiving light and 0V when it is not.

4.2 How the Transistor acts as a switch

The output voltage from the op-amp determines if the transistor turns on or off. If the voltage drop across the base and emitter of the transistor(pin2 and 1) is around 9V the transistor will be on otherwise if it is around 0V the transistor will be off.

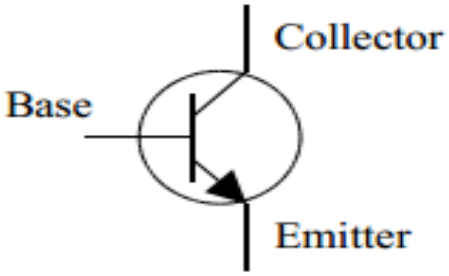

Figure 3: NPN Transistor Schematic

4.3 How the Relay functions with the output

When the transistor is on, current flows freely from the collector to the emitter (pin 3 to 1) of the NPN, and the relay gets activated thus powering the motor and the green LED which turns on to indicate that the car is running. Since the middle pin of the relay is short circuited to the pin connected to the green LED, the green LED will be powered until the relay switches to the pin connected to the red LED. When the transistor is off, the relay is deactivated and switches through a magnetic field that is induced on the relay's inductor causing the motor connection to be cut off and the red LED to be powered. The red LED signals that the car has stopped.

5 Reference Table for Components

Components	Datasheets
Op-Amp	http://www.ti.com/lit/ds/symlink/ua741.pdf
NPN Transistor	https://www.sparkfun.com/datasheets/Components/2N3904.pdf
Relay	http://www.digikey.com/product-detail/en/1461069-5/PB1321-ND/3318145

Components	How does it work?
Op-Amp	http://www.electronics-tutorials.ws/opamp/opamp$_1$.*html*
NPN Transistor	http://www.electronics-tutorials.ws/transistor/tran$_2$.*html*
Relay	http://www.galco.com/comp/prod/relay.htm

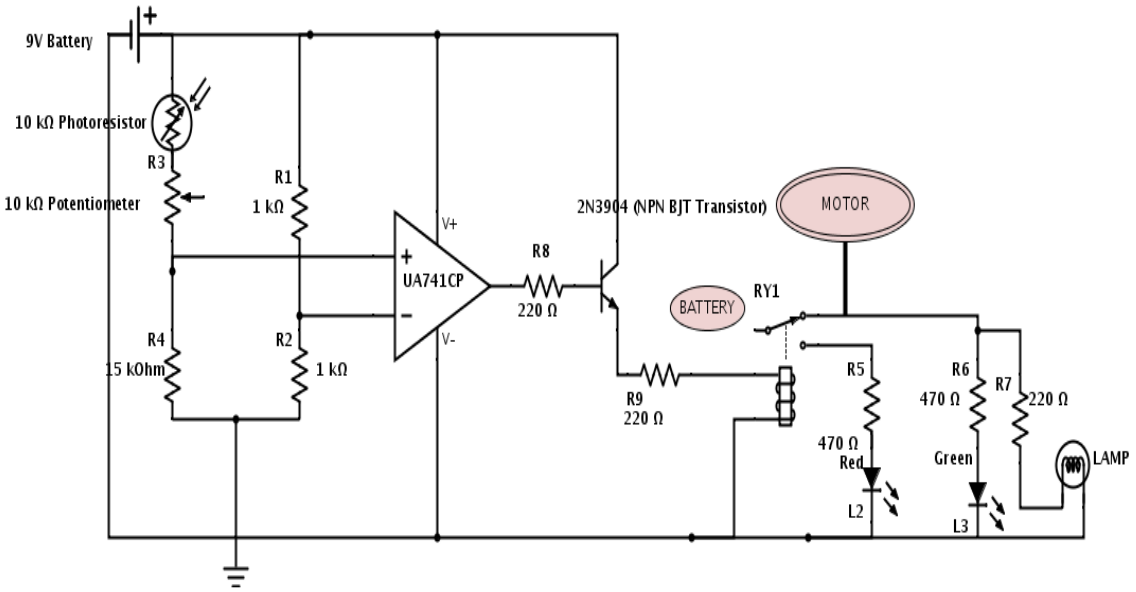

Figure 4: The Stopping Mechanism Circuit Schematic