ELCT 201 – EE LABORATORY [#6]

ANALOG AND DIGITAL ELECTRONICS IN SYSTEMS OF SYSTEMS

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ABSTRACT

To create a circuit that is turned on with either a start button or a light sensor. When the circuit is on a motor is activated. The circuit is stopped with a certain amount of torque load to the motor, a thermistor, or a stop button. The circuit is then modified to not work properly twice. The problems are diagnosed manually using a troubleshooting diagram.

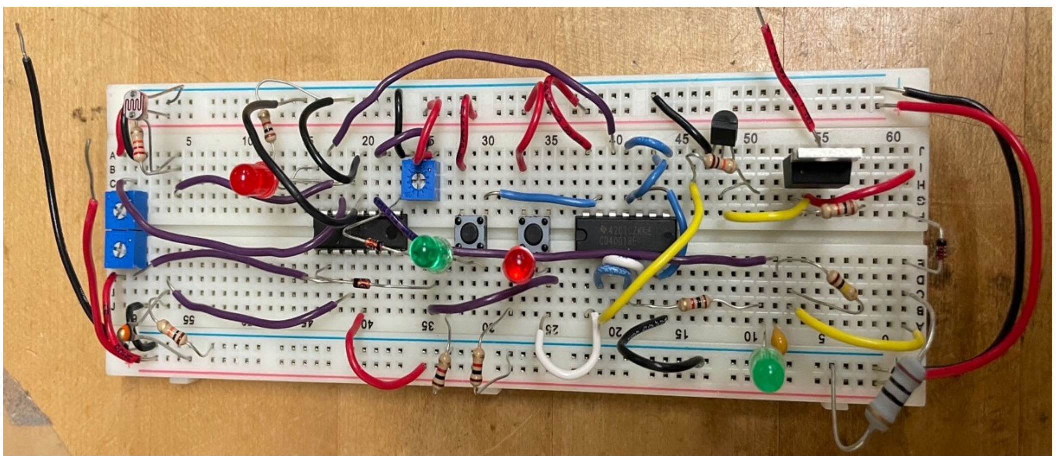

Figure 1: Complete final circuit

INTRODUCTION

This project involves arranging various components of a circuit to create functional buttons connected to a thermistor, light sensor, LEDs, and a motor. To create a system with these components a performance checklist is implemented to test and validate each subsystem. One is made for the user input, sensor inputs, digital logic, and power output. When all these subsystems are connected and tested to work properly together, it is then altered to not work properly. The skills for troubleshooting the system are developed using intuitive logic that involves knowing how each subsystem in connected to each other, and how they affect each function of the system.

CIRCUIT OPERATION

Figure 2 below is a circuit diagram of the entire system separated into 5 subsystems.

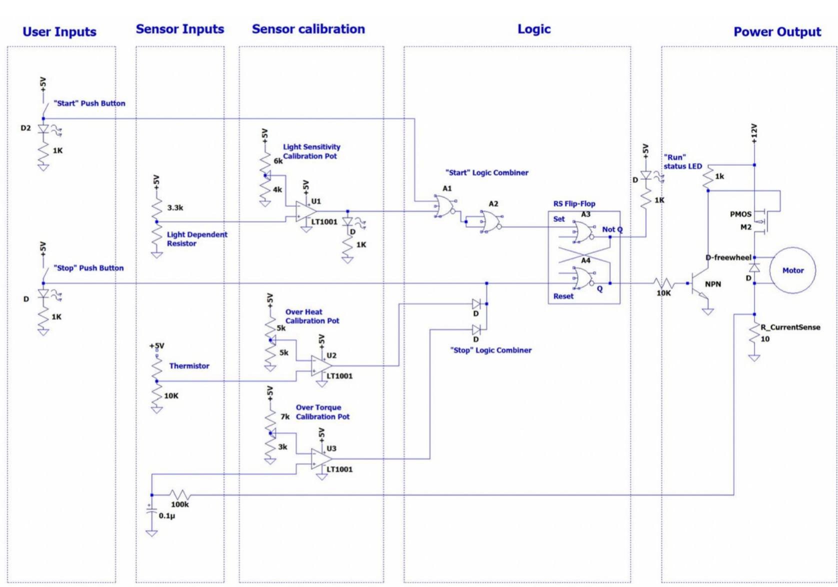

Figure 2:Circuit diagram of motor control system

The system was built initially and troubleshooted for issues that caused errors in the circuit. First two switches are set up in series to act as start and stop buttons. Each of these buttons are powered by 5v and connected to a green and red button respectively to indicate the function of each button. The red led corresponded to the stop button while the green led connected to the start switch. Each button also had a 1k resistor that was grounded and there was a wire between each switch and led. The second sensor input subsystem is connected with 3.3k resistors in series with a light dependent resistor. A thermistor sensor was also added to the circuit connected with a 10k ohm resistor. A sensor for excess torque was created by first connecting the negative lead of the motor with a 10k resistor leading to ground. Then an RC filter was also connected to an op-amp. The third subsystem for sensor calibration included the addition of 3 potentiometers for every sensor. There was also an op-amp included in this system. Each sensor was connected to the op-amp with inverting input. The potentiometers were all calibrated by looking at the oscilloscope. The thermistor potentiometer was adjusted to work with body temperature. The thermistor datasheet can be used to find the temperatures corresponding to resistances. The bias resistor selection for the thermistor was found using the equation

$$UREF=UIN,MAX=RB/(RB+RT,MIN)\times VCC$$

$$R_B=U_{REF}\times R_{T,MIN}V_{CC}-U_{REF}$$

The fourth subsystem included connecting the outputs from the start switch and the ldr op amp input to the input of the start logic combiner. The output wire was connected to the output of the of the thermistor op amp and the output of the over torque op amp. Both go through a diode to prevent excess current from going back into the circuit and turns off the circuit. If high temperatures or excess torque is sensed then a stop logic combiner from thermistor, over torque and stop circuitry is activated. This is the input to the RS-flip flop, and the start logic's output turns into the input of the nor gate. The 5th subsystem is the power output section that takes a 12V dc motor along with an npn transistor and diode for energy dissipation from the motor inductor, and a mosfet used like a power switch. Ohms law of V=IR can be used to understand how the motor is working.

The circuit could act unexpectedly in a variety of ways that make it unsafe. Most would happen based off the calibrations of the potentiometers. If the one for the light sensor is set too low then it would continuously keep the circuit on and cause overheating of the motor. The sensor for the thermistor can also be calibrated in a way that the temperature is too high for sensing and it never senses the circuit overheating.

TROUBLESHOOTING

Figure 3 below shows the initial results of the performance test checklist

USER INPUTS - START AND STOP BUTTONS

Does the "start" LED illuminate when the "start" button is pressed?	yes	no	
Does the "stop" LED illuminate when the "stop" button is pressed?	✓		

SENSOR INPUTS

Does the light sensor LED illuminate when the light sensor is shaded?	✓		
Does the "stop" LED illuminate when the thermistor is heated above room temperature?	✓		
Does the "stop" LED illuminate when the motor current exceeds 150 mA?	✓		

DIGITAL LOGIC

	yes	no	
Does the Q output of the RS flipflop switch between logic high and logic low appropriately when each of the functions is activated?	✓		
Does the "run" status LED illuminate whenever the Q output is logic high?	✓		

POWER OUTPUT

	yes	no	value
Is the voltage at the collector of the NPN transistor less than 1V when the Q output of the RS flipflop is logic high (true)?	✓		112mV
Is the voltage at the collector of NPN transistor close to power supply voltage when the Q output of the RS flip flop is low?	✓		11v
Does the motor run when the Q output of the RS flipflop is logic high (true)?	✓		
Does the motor stop when the Q output of the flipflop is logic low (false)?	✓		

Figure 3: performance checklist

After this list was verified, the circuit is then broken, and a troubleshooting diagram is used to solve the issue as shown in figure 4 below.

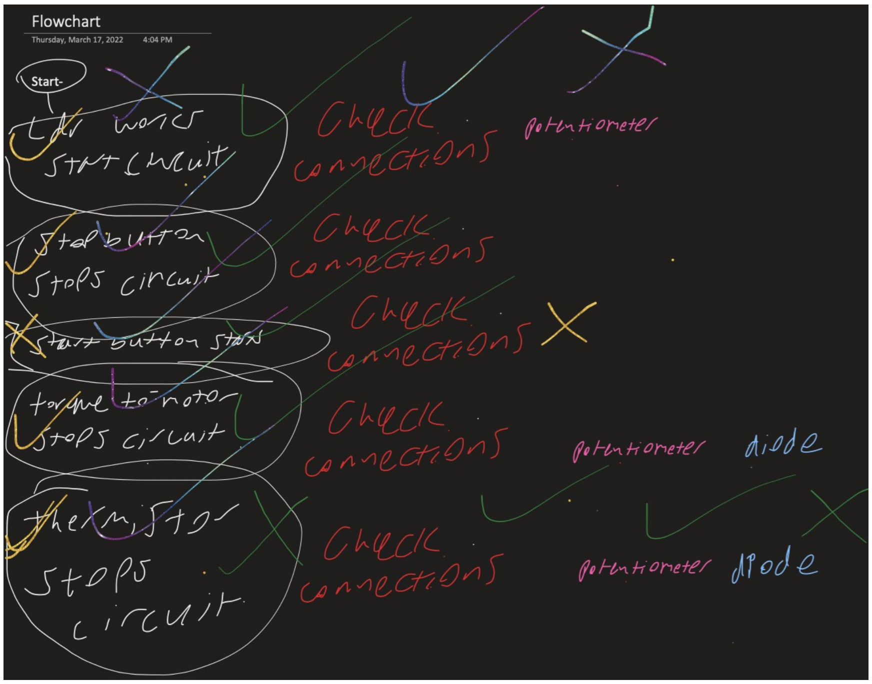

Figure 4: troubleshooting diagram

To start the troubleshooting process the entire circuit functionality was altered. To find the first issue the ldr is checked to ensure working functionality. This is confirmed from the green checkmarks. The stop button is then checked to see if it works which it does. Then the start button is checked to work properly. When the torque of the motor stops the circuit also the last thing checked is the thermistor to see if it works. The thermistor did not stop the circuit so then the connections are checked along with the potentiometer connected to it. After careful inspection it is found that the diode connected to the op amp logic was turned backwards. After reversing the direction, the circuit works properly.

The circuit is then broken again, and the exact same steps are taken to diagnose the problem. Immediately with the light sensor an issue is found which is shown by the rainbow x. the connections are checked and it’s found that the potentiometer is not working properly which can be solved by calibrating the trumpet. The circuit is put through the process again and with the gold checkmarks its found that the start button does not work. To fix this the connections are checked, and it’s found that the button was disconnected. After fixing this issue all the connections work properly.