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Project 3: Turbidity Sensor

Introduction:

In this project we will be building a turbidity sensor using electronic components. We will then work to obtain an electrical voltage or current from sensing the physical quantity, and provide an indication on a threshold level. We will also be studying the operation of a switch to control a motor. This project will be one of the most challenging ones we do this quarter due to its complexity, involving the use of a wide variety of components we've used in past labs.

Part 1: Components of a Sensor

The LED we will be using is the RL50-PR543. Design a simple circuit to ensure you can power the LED to shine light through the water sample. Record your final circuit schematic and any measurements you take.

Important specifications for the LED

- Forward Voltage = 1.7-3.8
- Forward current 20 mA
- Max Forward Current 30-50mA

LED Circuit Design:

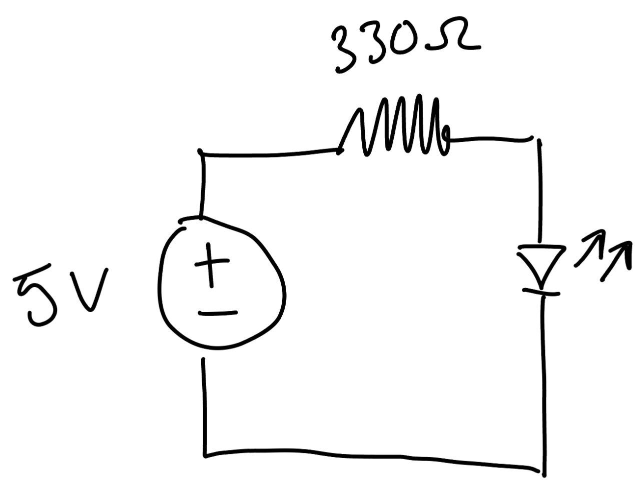


Fig 1. LED Circuit

The photoresistor we will be using is the CDS001-8006.

Important specifications for Photoresistor:

Max input voltage = 150VDC
Min resistance = 80KΩ
Max resistance = 240KΩ

<u>Measure the change in resistance as different amounts of light fall on the photoresistor. Design a simple circuit to ensure you can convert this "light" measurement to an electrical signal.</u>

Circuit design:

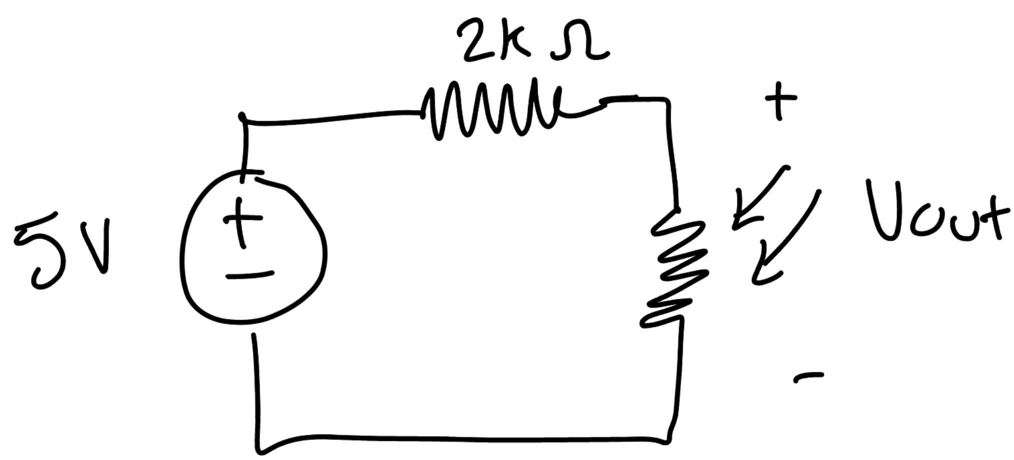


Fig. 2 Photoresistor Circuit (UPDATE to not voltage divider)

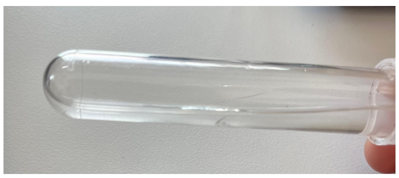
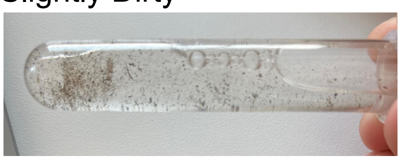
Measurements Outside Sensor:

- High Light: 2k Ω
- Room Light: 7.7k Ω
- Low Light: 10k Ω

In this lab we will be using a kit of parts to sense the turbidity of the water. We have been given a chamber which houses the sensor and allows us to place water samples inside. This chamber has side pockets which can hold a LED and Photoresistor. It also has two types of inserts: one to test its sensitivity and the other in which we will place the water sample.

First we will be testing the sensitivity with a variety of different water samples in the kit. When the water sample is more turbid, we should observe a higher voltage across the photoresistor. Results are displayed below:

Table 1: Testing the Sensitivity of the Photoresistor

Water Type	Photoresistor Resistance Value	Multimeter Reading
Clear 	94 KΩ	4.51 V
Slightly Dirty 	130 KΩ	4.75 V
Very Dirty 	1MΩ	4.99 V

<u>Are you able to distinguish clearly if your water sample is turbid or not? Do you need to make any adjustments to your design so far? Explain your answers.</u>

Yes, values range from 94KΩ to 1MΩ across the resistor, whose resistance increases as the turbidity increases. This results in a voltage change of approximately 0.5V across the spread of water samples. So far we do not need to make any major changes.

Part 2: Providing an indication on Turbidity

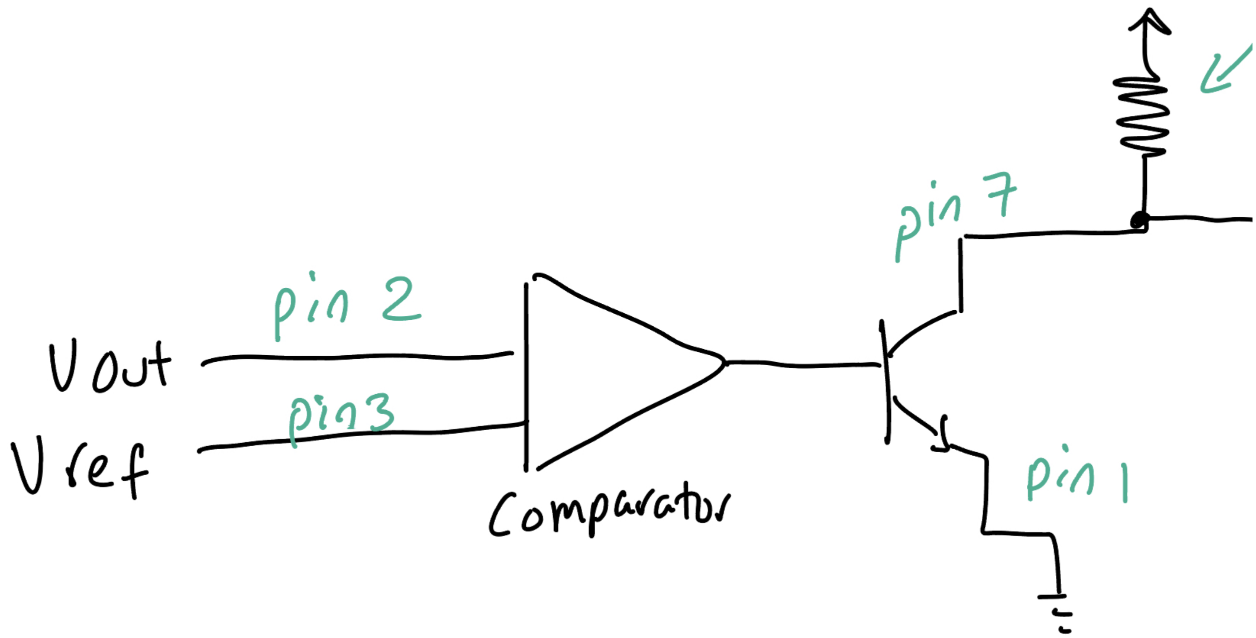


Fig. 3 Comparator and BJT Configuration

Important Specs: (Pin Layout)

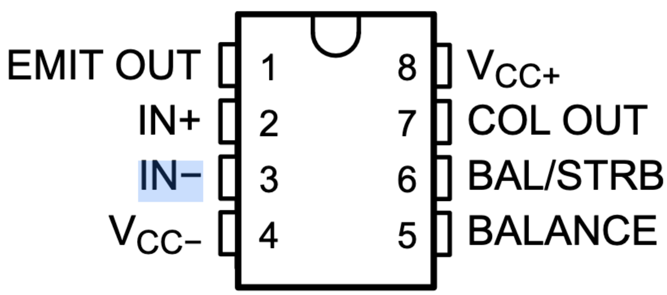


Fig. 4 LM311 Pinout Configuration

Part 3: Motor Drive Circuit

The motor we will be using is a Brushed DC Motor: 130-Size, 6V, 11.5kRPM.

Important Specifications:

- No load current = 70mA at 6V
- Stall current = 800mA at 6V

The switch we will use is the power MOSFET IRFZ20. 15A, 40W, Power MOSFET, TO-220 package.

Important Specifications:
NM MOSFET

- Maximum Drain-Source Voltage |Vds|: 50 V
- Maximum Gate-Source Voltage |Vgs|: 20 V
- Maximum Gate-Threshold Voltage |Vgs(th)|: 4 V
- Maximum Drain Current |Id|: 15 A

Designing the Motor Driver Circuit:

Below is the completed circuit we designed with the motor driver included.

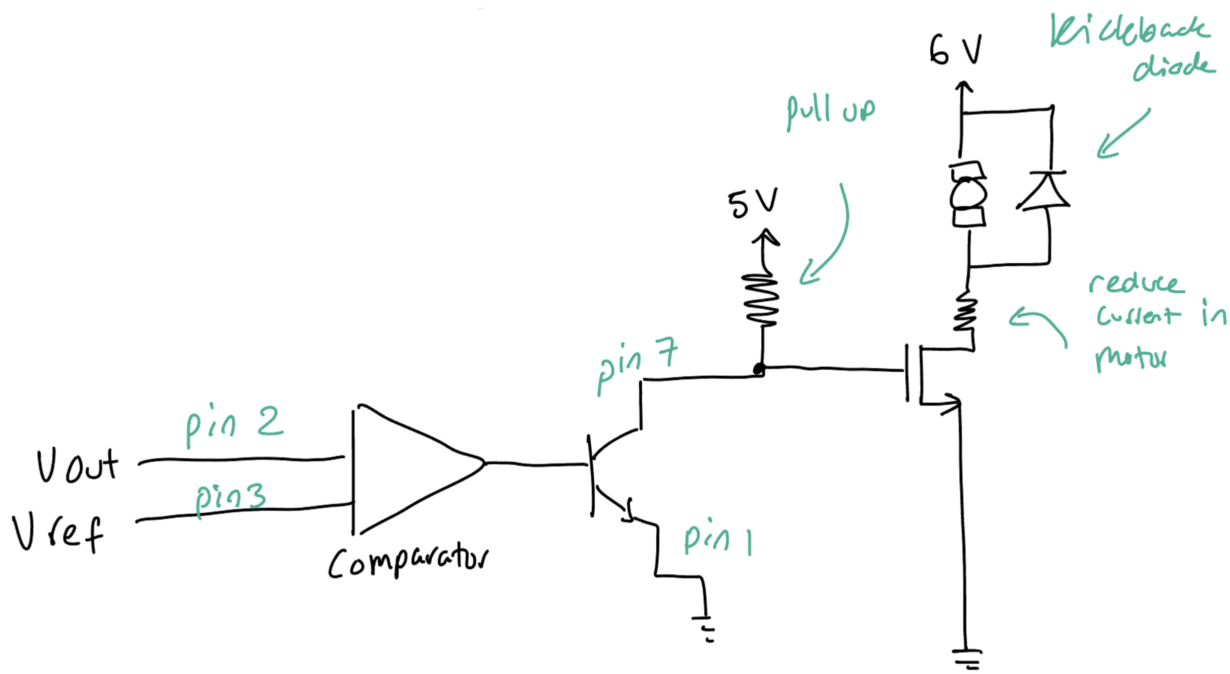


Fig 5. Turbidity Sensor Circuit

Determine the value of R1 in the drain to ensure that the motor does not exceed its current and voltage limits. Check the voltage drop across the FET when on. The motor is close to a short circuit when it is running.

The maximum current allowed by the motor is 800mA. The maximum operating voltage is 12V.

At 6V, we have a minimum resistance of 6V/800mA = 7.5Ohms

Calculate the power consumed by R1. Is this within the power rating of the real resistor?
The maximum power consumed by the resistor is 4.8W. The maximum power that may be consumed by the potentiometer is 10W.

Detail carefully your design process and how you calculate the resistor values.

We began by identifying the possible constraints for the current and voltage of the devices. First, we looked at the motor stall current and operating voltage range. The motor operated at a nominal voltage 6V, so we started with that value. We then identified the maximum resistance that is allowed for the motor circuit using Ohm's law. We then looked at the maximum power rating consumed by R1,

You will need to also connect a kickback diode to protect the circuit for when the switch turns off. You will use the 1N4001. What key specs of this diode are important for its use in this application?

The breakdown voltage is important for the specs of the diode, in order to see if the diode will continue to work as expected when the switch turns off. The forward voltage is also useful, because we need to see what the voltage drop we can expect across the diode is.

Part 4: Demonstration and report

Conclusion and Analysis:

In this lab we built a turbidity sensor using electronic components including an LED, photoresistor, comparator, MOSFET, and motor. We then worked to obtain an electrical voltage from sensing the light using a phototransistor, and provided an indication on a threshold level by using a motor. Using this circuit, we studied the operation of a switch to control a motor. One challenge we faced during this lab was managing to measure the correct voltage through the photoresistor, where we ran 5V through it but were unable to measure that voltage going through it. Ultimately this was resolved by switching breadboards, which showed us the importance of checking our circuits for faults. Overall this lab was challenging and enjoyable due to its complexity and high number of different stages that needed to be worked on.