ECEN 214-302 – Electric Circuit Theory

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Summer 2020

Lab 5: Operational Amplifier Application: Electronic Security System Design: Part 2 of 2

**Submitted by:**

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| **Table 1.** UIN, names, and section numbers. | | | |
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1. Objective

The purpose of the lab is to design and create a circuit that operates as an alarm system that can be implemented in someone’s house for security. The lab will teach me how to use a current to voltage converter, an Op - amp, and an active low SR-latch. The lab also helped me understand how to that LEDs work both by having the resistor connected the long pin and the long pin straight to power and vice versus.

1. Procedure

**Materials**

* 741 chip
* 319 chip
* 4044B chip
* Selection of colored wires
* Analog Discovery 2 device (PMD)
* Green and red LED
* Selection of resistors
* Emitter LED
* Detector LED
* Breadboards
* USB cord
* Colored posted notes

**Setup**

1. Collect materials given above.
2. Open waveform program on computer and connect USB cord to Analog Discovery 2.
3. Connect the power wire of wavegen 1 to the left power strip of the breadboard and connect the power wire of wavegen 2 to the right power strip of the breadboard.
4. Connect the proper ground wires of the wavegen to the left and right ground strips of the beadboard.
5. Place the 741 chip at top of the breadboard and the 319 chip in the middle of the breadboard and the 4044B chip below the 319 chip.

**Task One**

1. Create a design using the parts from the previous lab. The emitter, detector, current to voltage converter the signal amplifier, and the comparator.
2. Write design onto paper one design have a gate schematic and one have wiring for chips.

**NOTE:** It helps a lot to write down the chip diagrams and color code curtain input and output wires.

1. Connect the emitter LED to power and the other pin to a resistor then the resistor to ground.
2. Place the photo detector to a separate breadboard and connect it to power and 3.3kΩ resistor.
3. Connect the resistor above to ground and have branches to R3 and R1 on the 741 chip.
4. Connect R3 in series to pin three and R1 to pin 2 of the 741 chip.
5. Connect R2 to Vo and pin 2 of the chip.
6. Connect Vo of the 741 chip to a 1kΩ resistor also in series with pin 4 of the 319 chip.
7. Connect pin 3 of the 319 chip to ground.
8. Connect Rc2 to ground and pin 5 of the 319 chip and Rc1 to five volts and to pin 5 of the 319 chip.
9. Connect pin 11 of the 319 chip to five volts and pin 6 to negative five volts.
10. Connect pin 12 in parallel to the select input to the latch and to a 10kΩ resistor that is connected to five volts.

**Task Two and task three**

1. Power the latch my connecting the power pin to five volts and ground pin to ground.
2. Connect the enable pin of the latch to five volts.
3. Connect the reset pin to a 10kΩ resistor that is connected to five volts and connect a wire to the reset pin also.

**NOTE:** When need to rest Q connect the loose wire to ground.

1. Place a green LED and a red LED a good distance from each other,
2. Connect the long in of the green LED to five volts and the short pin to 430Ω,
3. Connect the short pin of the red LED to ground and the long pin to 430Ω.
4. Connect where the two 430Ω resistors connect to the Q output from the SR-latch.
5. Now with the emitter and the photo detector unobstructed observe which LED turns on and measure Q voltage.
6. Now obstruct the emitter and the photo detector and observe which LED turns on and measure Q voltage.
7. Remove obstructing and observer the LED and measure Q voltage.
8. Reset the SR-latch and observe the change in LED and measure Q.
9. Difficulties

I had some problems making the comparator because I couldn’t get to be exactly what I wanted because of the tolerance of the resistors. It took some time making the comparator because the ‘+’ and the ‘-‘ was opposite of what I thought it was.

1. Results

**Emitter**

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**Figure 1.** Emitter

The resistor is 100 ohms connected to ground and the long lead of the emitter. I chose the emitter resistor to be 100 ohms because it maximized the emitter voltage and below 100 ohms would risk damaging the emitter LED.

**Detector**

A circuit board

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**Figure 2.** Detector

The detector uses a 741 chip and the detector resistor is 2,000 ohms and the output of the op-amp is connected to a 1,000-ohm resistor. I chose to use the op-amp circuit because its detector voltage more constant when moving the LEDs with varying distance. I chose the detector resistor to be 2,000 ohms because it maximizes the detector voltage.

**Inverting Amplifier**

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**Figure 3.** Inverting Amplifier

The is 1,000 ohm and the is 2,000 ohms, creating amplification of -2. The positive terminal is connected to ground and the output of the op-amp is connected to a 1,000-ohm resistor. I chose the inverting amplifier because the current to voltage convertor gave a negative output, so I chose inverting amplifier to give a positive output. I chose a amplification of -2 part to negate the negative output of the convertor and to make the maximum voltage output to go from 2.5 volts to 5 volts, to be right at the edge of saturation to increase the difference between the obstruction and obstruction voltages.

**Comparator**

A circuit board

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**Figure 4.** Comparator

In order to get a reference voltage of 1 volts for the comparator is chosen to be 1,000 ohms and is chosen to be 500 ohms. The output of the comparator has a 10,000-ohm resistor connected in parallel. I chose the reference voltage to be 1 volts because after doing a few experiments and observing what the obstructed voltages are I saw the closes the obstructed voltage would be around 200mV so I thought it would be fair to say any voltage below 1 volt is a obstructed voltage. I put the reference voltage on the negative terminal because it wouldn’t invert the output. I didn’t want to invert the output when its already positive.

**Latch**

A circuit board

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**Figure 5.** SR - Latch

The SR – latch is connected to the comparator output to the latchs’ select input. The RESET input is connected to 10,000-ohm resistor that is also connected to 5 volts. The enable is also connected to 5 volts and the ground of the latch is connected to ground. The latch must be reset by connecting the RESET input to ground temporarily. The reason that to reset the latch you just give it a “impulse” of ground is because latch’s work of impulse signals then store the previous value.

**LEDs**

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**Figure 6.** Indicator LEDs

The red posted note attached to the long lead of the LED to show where the cathode is. The 2 resistors shown above is 2 different sets of 2 1,000-ohm resistors connected in parallel to make a 500-ohm resistor. The purpose of making the red resistor and the green resistor is make the equal amount of current go through each LED equally.

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**Figure 7.** Full circuit diagram

**Measurements**

I measured the detectors voltage to be 2.501 volts when the emitter and detectors LEDs were at the closest distance and 22 mV when obstructed, so I knew the detector circuit worked. I then also knew what amplification value I wanted since I already knew the saturation voltage. The output of the amplifier was around 4.8 volts so I knew I was getting the correct amplification. The latch reset back to around values of -11mV or 22mV then went to 4.8 volts when obstructed so I knew the latch and the comparator worked. The RED LED turned on when there was an obstruction, so I knew the whole circuit worked together.

**Performance**

The circuit works all the way up to 13 inches until the indicator just shows as an obstruction.

I didn’t detect any false alarms I think its credit to using an op-amp for the detector.

1. Conclusion

The experiment combined multiple separate circuits into a functioning alarm system. The purpose is use and understand how to use different op-amps on conjunction with each other to complete a function. The alarm worked better then I thought, the alarm still worked when the emitter and the detector was a food away from each other, I contribute this to using the op-amp for the detector. Sometimes I wouldn’t get the correct voltages when a wire was loose, or the correct source voltage wasn’t connected to the chip. The actual reference voltage is slightly above the calculated reference voltage because of the tolerances of the resistors.