ECEN 214-302 – Electric Circuit Theory

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Summer 2020

Lab 4: Operational Amplifier Application: Electronic Security System Design: Part 1 of 2

**Submitted by:**

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| **Table 1.** UIN, names, and section numbers. | | | |
| **Student Name** | **UIN** | **Section #** | **Group #** |
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**Date Performed: June 24th, 2020**

1. Objective

The objective of the lab is to implement op-amps to make a security system. The security system will “go off “when the detector and the emitter get blocked by an object therefore detecting motion.

1. Procedure

**Materials**

* 1 - LM319 Comparator
* Selection of resistors
* 2 – LM741 Amplifier
* 1 – Infra-red emitter LED
* 1 – Photodetector LED
* A selection of wires
* 2 – breadboards
* Analog Discovery 2
* Power source for AD2
* USB cord

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**Figure 1.** LM741N Op-Amp.

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**Figure 2.** LM319N Comparator.

**Procedure**

**Task One**

1. Collect the materials listed above.
2. Connect the short lead of the IR emitter to a 5 V voltage source connected to the positive strip of the breadboard.
3. Connect the long lead of the IR emitter to the resistor .
4. Choose a Resistor with a resistance greater than 50 ohms.
5. Measure the voltage across the IR emitter and the resistor .
6. Repeat steps 3 to step 5 three more times using a total of 4 different values.
7. Connect the short lead of the detector to a 5 V voltage source.
8. Connect the long lead of the detector to the resistor
9. Choose a Resistor with a resistance greater than 50 ohms.
10. Align the top of the emitter and detector to point at each other.
11. Record their distance apart and the value of
12. Measure the voltage across the resistor .
13. Repeat step 9 to step 12 several times using a different value each time.
14. Experiment with both resistors and to find the largest difference in the voltage that is created when the beam is obstructed and unobstructed.
15. Then observe the farthest distance that still allows for a difference in the to be found when performing the process from step 15.
16. Finally build the Op-amp circuit from Figure 3. on a breadboard to replace the component in Figure 2.
17. Align the top of the emitter and detector to point at each other.
18. Measure the voltage of the Op-amp for several values. A circuit board

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**Task Two**

1. Collect all the materials above.
2. Supply the +5V and -5V from the supply voltages from the PMD.
3. Choose R1 and R2 for figure 4.a and figure 4.b and include it in the circuit.
4. Choose at least seven input voltages from -5 to 5 and measure the and record the output voltage.
5. Build the non-inverting amplifier circuit in figure 4.b
6. Supply the +5V and -5V from the supply voltages from the PMD.
7. Use the R1 and R2 resistor values that you chose for figure 4.a.
8. Choose at least seven input voltages from -5 to 5 and measure the and record the output voltage.
9. Create a Vo vs Vin graph from the data collected from both circuits.

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**Task Three**

1. Collect all the materials above.
2. Supply -5V and 5V from the supply voltages from the PMD.
3. Use the R1 and R2 chosen from task two.
4. Choose at least seven voltages from 0 to 5V to be your input voltages.
5. Measure and record the output voltage given from the circuit.
6. Create a Vo vs Vin graph with the data collected.

A circuit board

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1. Difficulties

I had some difficulties with the 3033 chips because the output voltage would not drop to zero or the binary 0. I could not use the calculated because the value is actually 111.11 and not 100, which is the value I chose.

1. Results

**Task One: Emitter and Detector**

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 100 | 1.14 | 0.0114 |
| 220 | 3.19 | 0.0145 |
| 330 | 3.8 | 0.0115 |
| 470 | 4.21 | 0.00896 |
| 570 | 4.454 | 0.00781 |
| 790 | 4.555 | 0.005765 |
| 1,000 | 4.801 | 0.00489 |
| 2,000 | 4.864 | 0.00323 |
|  |  |  |
| 100 | 3.688 | 0.03688 |
| 220 | 3.76 | 0.01709 |
| 330 | 3.781 | 0.01146 |
| 470 | 3.8 | 0.008085 |
| 570 | 3.808 | 0.00668 |
| 790 | 3.826 | 0.00484 |
| 1,000 | 3.837 | 0.003837 |
| 2,000 | 3.867 | 0.0019335 |

is chosen to be 100 ohms and is kept constant throughout the changing of . The distance between the emitter and the detector is 0 inches.

The unobstructed voltage is 1.2V with the emitter and detector being one inch away. The obstructed voltage is 25mV when being blocked by a plastic cover of a calculator. The

**Figure 3.** Re vs. Ie of the detector circuit

I have chosen Re to be 100 ohms and Rd to be 2,000 ohms.

**Task Two: Inverting and Non – Inverting Amplifier**

|  |  |  |
| --- | --- | --- |
| Inverting Amplifier | | Non – Inverting Amplifier |
|  | (Inverting) | (non-inverting) |
| -5 | 4.105 | -2.985 |
| -4.5 | 4.116 | -2.985 |
| -4 | 4.12 | -2.985 |
| -3.5 | 4.13 | -2.985 |
| -3 | 4.136 | -2.985 |
| -2.5 | 4.145 | -2.987 |
| -2 | 4.078 | -2.985 |
| -1.5 | 3.07 | -2.985 |
| -1 | 2.061 | -2.943 |
| -0.5 | 1.052 | -1.495 |
| 0 | 40mV | 11mV |
| 0.5 | -0.966 | 1.524 |
| 1 | -1.974 | 3.034 |
| 1.5 | -2.91 | 4.186 |
| 2 | -2.94 | 4.186 |
| 2.5 | -2.928 | 4.186 |
| 3 | -2.917 | 4.184 |
| 3.5 | -2.905 | 4.186 |
| 4 | -2.893 | 4.186 |
| 4.5 | -2.883 | 4.186 |
| 5 | -2.871 | 4.186 |
| A = -2 | | A = 3 |

**Figure 4.** Inverting Amplifier circuit

**Figure 5.** Non – Inverting Amplifier circuit

The Non – Inverting Amplifier would be the best in conjunction with the detector circuit because since “A” is higher it gives the detector more range in the distance with also working as a detector.

**Task Three: Comparator**

|  |  |
| --- | --- |
|  |  |
| 0 | 4.26 |
| 0.5 | 4.26 |
| 0.6 | 122mV |
| 1 | 122mV |
| 1.5 | 122mV |
| 2 | 122mV |
| 2.5 | 122mV |
| 3 | 122mV |
| 3.5 | 122mV |
| 4 | 122mV |

The calculated is 0.5 V and is 1,000Ω and is 100Ω

**Figure 6.** Comparator voltage change

is chosen to be 1,000 0hms and is chosen to be 100 ohms because it gives a reference voltage of 0.5 volts. The reason for the values chosen is I thought 0.5 volts was a low enough value to be the beginning of what is called “high” of the comparator. I thought anything below 0.5 volts would definitely be blocked and voltages in the 0.5 to 1 volts range could just mean the emitter is far. From 0 V to 0.5 V the signal is considered high then 0.6 V to 4V the signal is low.

Conclusion

The experiment used op – amps to implement circuits that will be used in lab five. The circuits will be made to make a security system from all the circuits made in this lab. I have found that using the 741 chip and the detector is help full to have a large range of distance that the emitter and the detector can be without voltage decreasing substantially. I chose in Task Two the non – inverting amplifier to be the best choice in the security system because it has the largest “A”, so it amplifies the most. The comparator is binary logic circuit because it analog, it either gives a high or a low signal.