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ECEN 214 Section 516

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Operational Amplifier Application: Electronic Security System Design

Introduction:

The main task is to build a circuit that will detect an interruption in a light beam and trigger an indicator. In the process of designing this system, I will learn to use op-amps to serve various purposes.

The block diagram of the system is shown in Figure 4.1. The stages to be built and tested this week are enclosed in the dashed box. An IR emitter is employed to send a (non-visible) light beam to a photo detector. The photodetector current induced by the light beam depends on the strength of the beam. The first stage in the design will be to build a circuit to convert the current produced by the photodetector to a voltage. Since the output of this first stage may be very small, I will design and build an op-amp based amplifier to bring the signal strength up to a usable level. After the voltage is amplified, it will be sent into a comparator which basically decides whether the light beam is present or is being interrupted. A latch will be used to lock the signal and a system of LEDs will serve as the alarm. In the end, whenever the beam is obstructed, the comparator output will be changed. It will then be locked by a latch circuit and the appropriate LED will light.

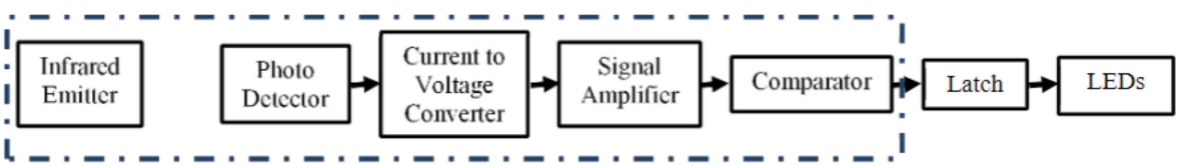


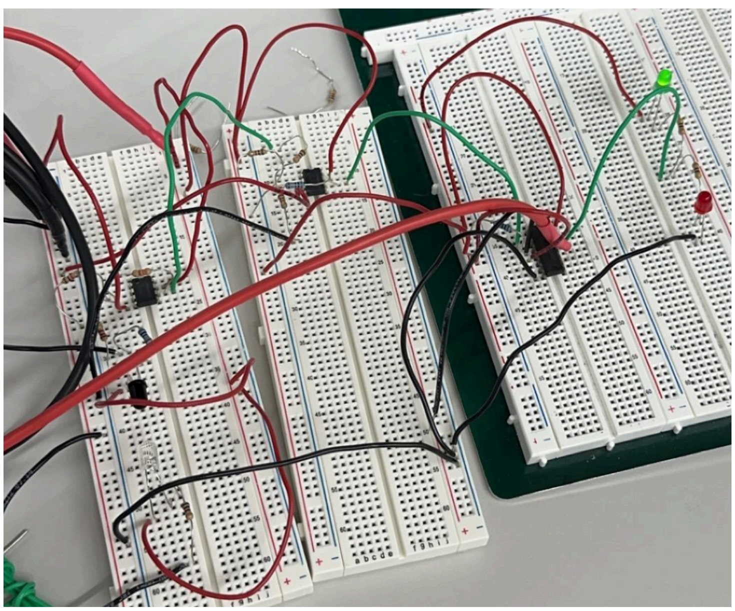
Figure 4.1 – Block Diagram of Alarm Circuit

Procedure:

For our procedure, I started by combining the emitter/detector, current to voltage converter, signal amplifier, and comparator into one circuit on our breadboard. I then tested the output of the comparator to see if the voltage went from high to low when obstructing the emitter/detector.

Next, I created the latch component of the circuit and implemented it into the combined circuit by using the output of the circuit from task 1 as the input of the latch. I then measured and recorded the output, Q, of the latch with different states: unobstructing with reset, obstructing without reset, unobstructing without reset, and reset. For the final task, I added LED lights to indicate whether the security system is turned on or off. To do this I placed the latch output in parallel with the two LED lights with resistors in between the latch and the LEDs. After supplying power to the circuit the LEDs turned on accordingly with the detector, showing red if there was any obstruction, green if there wasn't or if the reset was on.

Circuit Implementation:



Description:

The security system lights up as green or red depending on if there is any obstruction from the emitter/detector if the reset input is toggled off. If the reset input is on, then the security system lights up as green and will not be affected by any obstruction from the emitter/detector. The SR (set reset) latch is responsible for maintaining the state of the security system. The emitter/detector senses any obstruction. The current to voltage converter converts the output of the detector to a voltage signal. The signal amplifier increases the input voltage and produces a higher output voltage. The voltage comparator compares the input voltage with our reference voltage. When the security system needs to be reset after it has been tripped, I put the reset input back to ground in order to turn the green light back on.

Measurements:

Measurements that I took when I completed the security system to ensure that it was working:

	State of System	Q output (V)
1.	Unobstructed	1.15 (Green)
2.	Obstructed	3 (Red)
3.	Unobstructed	3 (Red)
4.	Reset unobstructed	1.15 (Green)

Discussion:

For the emitter I used a 100Ω resistor in order to produce a higher current. For the current to voltage converter I used a 100kΩ resistor to connect from the detector to the signal amplifier. For the signal amplifier I used a non-inverting input so that the output would be positive. The voltage for the supply rail was +5V and -5V. I also used a 2.2K resistor to connect to the negative terminal input and a 1K resistor to connect the input voltage into the positive terminal input. For the feedback resistor I used a 3.3K resistor. The reference voltage for the voltage comparator was 2.5V. After trying out two configurations I decided to use the reference voltage as the input going into the positive input terminal, and connected the input voltage from the signal amplifier to the negative input terminal. I used this configuration in order to make the output high whenever the emitter/detector was unobstructed and low whenever the emitter/detector was obstructed.

Conclusion:

In this lab, I successfully constructed an electronic security system by combining various electrical components. The primary goal was to design a successful system that could detect obstructions in an IR light beam and trigger an alarm, which would remain active until manually reset (by the SR latch). I made design choices, such as selecting appropriate resistor values, amplifier configurations, and reference voltage levels, to ensure that the system functioned properly.

Through careful assembly, the security system effectively detected obstructions and provided visual feedback using green and red LEDs. I also gained valuable troubleshooting experience from analyzing the entire system and fixing small errors in the circuit by testing individual components.