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

Theory & Introduction –

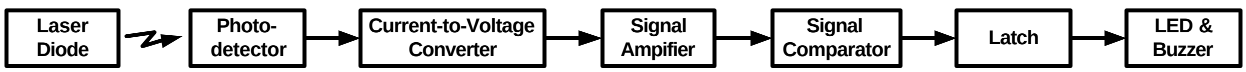


Figure 5.1: Stages of the Electronic Security System:

Goals for Lab #5 –
In this the second of the two experiments for putting together an electronic security system, you will build the last three stages of the system. First, you will build the comparator. Then, you will send the output of the comparator into a latch. Finally, you will send the output of the latch into a LED and Buzzer system.

Theory –
A comparator, as shown in Figure 5.2, compares signal voltage on one input with a reference voltage on the other input. Without feedback, an op amp operates in saturation whenever the inputs are not equal. If (+) input of an op amp, V_P, is *above* its (-) input, V_N, the output voltage, V_O, is pulled *up* to the positive saturation voltage. If (+) input of an op amp, V_P, is *below* its (-) input, V_N, the output voltage is pulled *down* to the negative saturation voltage.

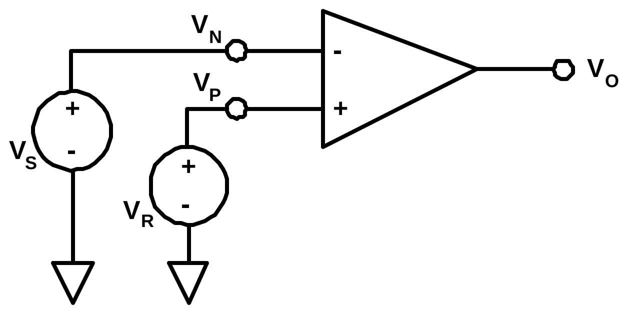


Figure 5.2.

Output of a general purpose op-amp such as 741 has limitations. Its output changes between the limits fixed by the saturation voltages, $+V_{sat}$ and $-V_{sat}$, that are typically about ±10V for ±12V power supply. Therefore, the output cannot drive devices that require voltage levels 0 and +5V (or, +12V), such as logic ICs or microcontrollers. This problem can be solved by ICs that have been specifically designed for comparators. One such device is the 319 comparator. This device has 2 comparators in one package. You will use one of them. The pin layout of the device is shown in Figure 5.3.

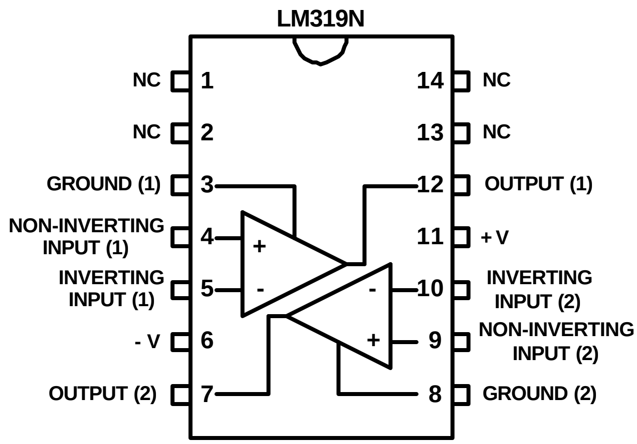
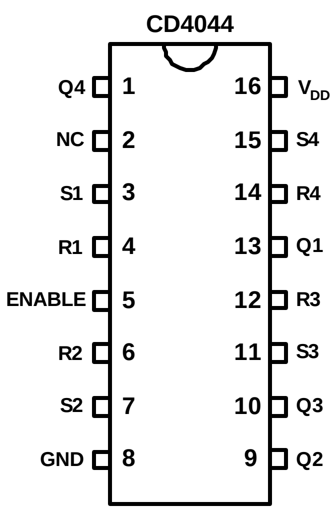


Figure 5.3

For the second part of today's experiment, we will be using a latch. The signal output of comparator changes when the input signal changes above/below the reference voltage. Sometimes you may need to hold the status, even if the input changes. CD4044 shown in Fig. 5.4 is one of such devices. When S terminal is low it sets the output Q as high. When R terminal is low it resets the output Q as low. When the S and R terminals are high the output Q keeps previous status. The output status for both S and R low is not defined. Therefore this input status should be avoided.

In this lab, the inputs of S and R stay *high* in normal condition. If the light beam is obstructed, the S input is pulled *low* and therefore the Q output goes *high*. If the obstruction is removed, the S input returns back to *high*. Since both of the S and R are *high*, the output Q stays high until the R input is pulled *low*. Once the R is *low*, the output Q goes *low*. Then, the S and R return back to *high* and the Q stays *low*.



(a)

Truth Table

S	R	Q
H	H	No Change
L	H	H
H	L	L
L	L	Undefined

(b)

Figure 5.4

Be sure you understand the information about the latch we will be using. See your TA before lab if you have questions about how this works.

Before the final stage of the system will be using a voltage follower as shown in figure 5.5 before the input to the LEDs and the buzzer. This voltage follower is a way to allow the output to draw a larger current. You will learn more about this in ELEN 325.

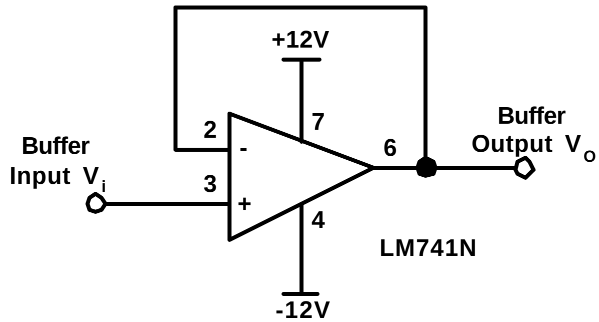


Figure 5.5

Prelab –

Read the entire experiment and be prepared to answer questions in the prelab quiz.

Draw the security system through the comparator in PSPICE and run a simulation to see what the output voltages should be. (You can use the u741 again for the comparator.) Print a copy of the schematic to turn in with all voltages and currents labeled.

For the circuit below, calculate the input voltage that will change the comparator from high to low. Show all calculations and explain your work. Simulate this stage alone in PSPICE using the uA741 op-amp. Use at least three different input voltages. Does it work the way it is expected to work. Comment on any discrepancies.

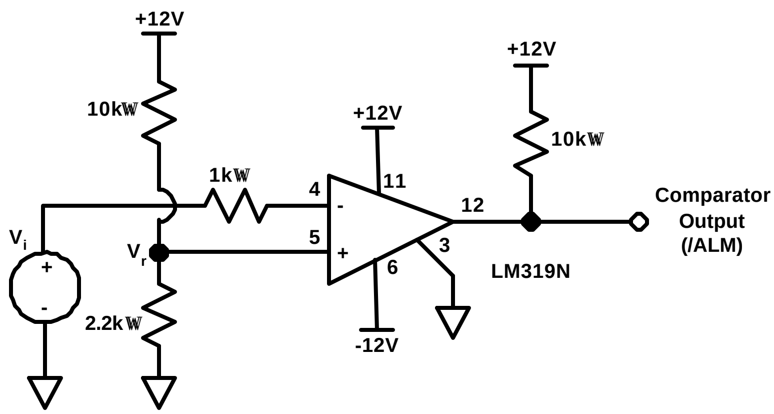


Figure 5.6

LabVIEW work: (Hint: You might want to view this on a color monitor for help.)
Consider the block diagram below in Figure 5.7

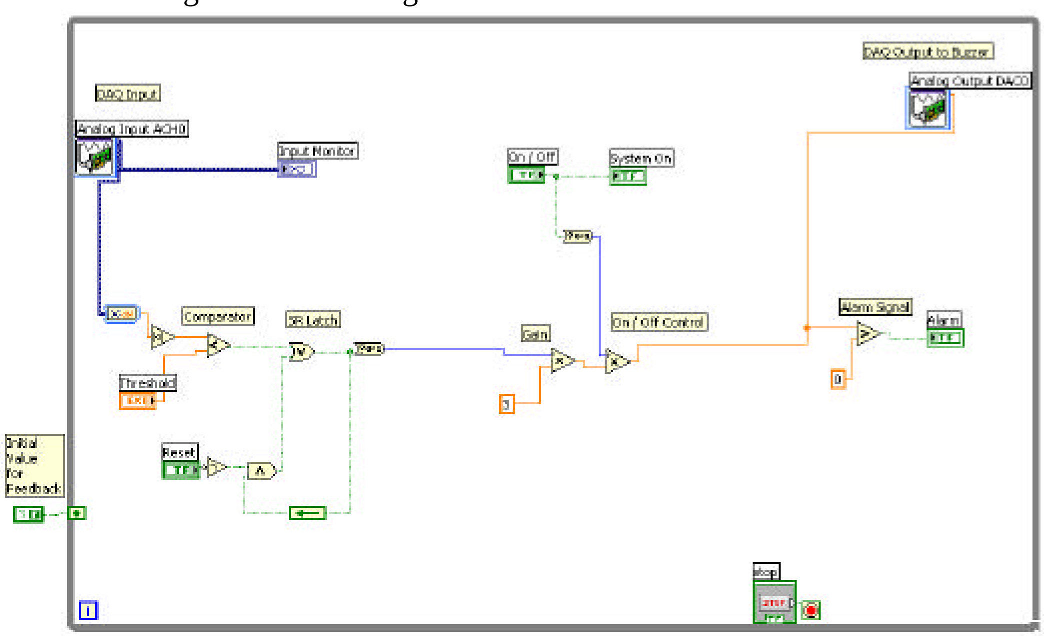


Figure 5.7

In this week's lab you will be using LabVIEW as a software controller for the buzzer. Basically, LabVIEW will replace almost all of the hardware you used to build the comparator and SR-latch system.

Although you will not need to design the program, you will need to be familiar with how the program operates. For the prelab, you will need to complete the wiring of a VI provided for you on WebCT so that it looks like Figure 5.7.

VI Procedure

Download the VI for Lab 5 from WebCT. Add in wires so that the VI looks like Figure 5.7. Print a copy of the block diagram to turn in at the beginning of lab.

Note that this VI is an example of a software control that follows a similar algorithm to the hardware design you will build in the lab. Other algorithms and designs may be more efficient or easier to program. If you think of another idea and would like to try it, go for it. Consult your TA for suggestions.

Make sure you understand how this VI works. Use the context help provided in LabVIEW to help answer questions. Quiz questions may cover the algorithm for this VI.

Procedure –

Task #1: Construct a comparator.

I. Be sure the NI ELVIS board is off, but launch the NI ELVIS instrument system on the computer. Be sure to connected the +12V and –12V variable power as indicated in Figure 5.8. Consult the theory section if you do not remember the numbering of the pins. Build a comparator circuit shown in Figure 5.8 on the breadboard. What is the reference voltage? Calculate V_r and measure V_r and record both in Table 5.1.

II. Apply a voltage at the input V_i (Here, you must use the bench triple output to vary this.). Slowly increase the input voltage V_i. Use steps of 0.5V starting at 0V. Find out the input voltage when the output voltage (/ALM) changes. Take several readings at 0.1V intervals around V_r. Record in Table 5.2

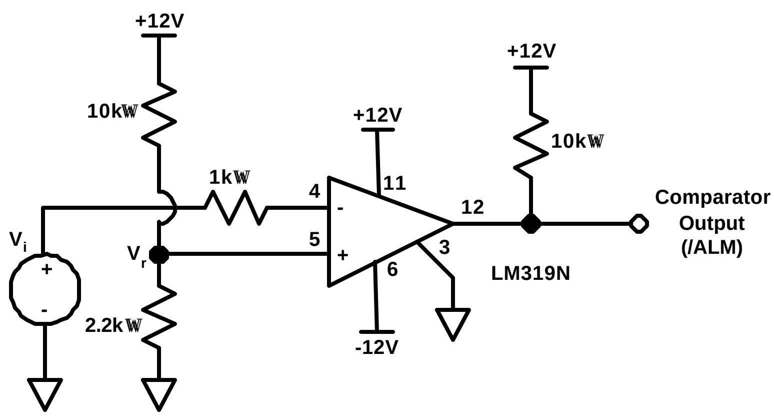


Figure 5.8

III. Turn off the NI ELVIS board. Consider the figure below:

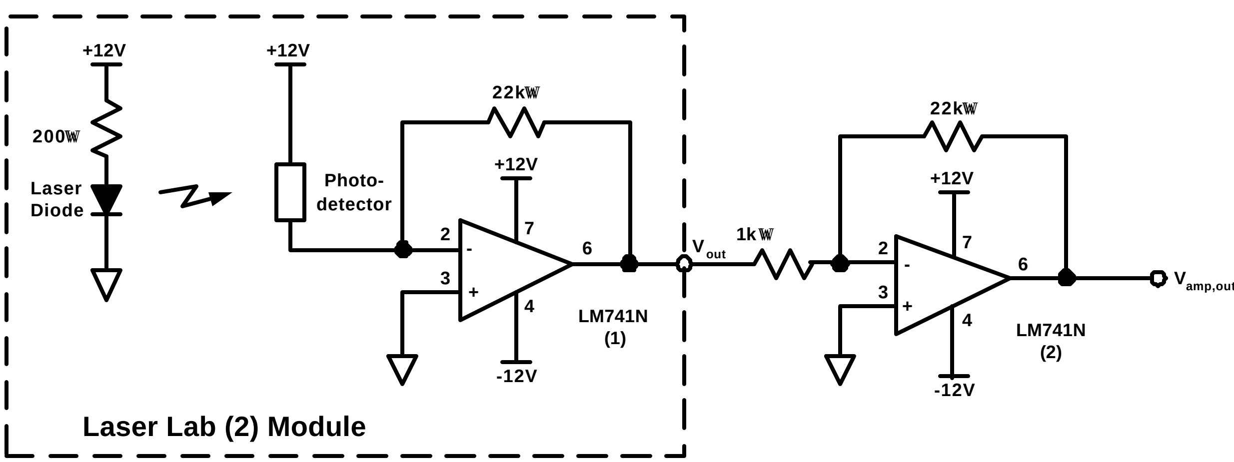


Figure 5.9

You will have a Printed Circuit Board (PCB) module that will cover the stage in the dashed rectangle. Connect the V_{OUT} from the module to a 1kΩ resistor and build the stage shown at the right of Figure 5.9. Remember to connect the PCB module that to the +12V and –12V variable power supplies. Disconnect the V_i in your comparator

circuit you already built and connect the output of the stage two you just built. When all the connections are made, turn on the NI ELVIS board. Record the voltage output of the comparator with the laser beam obstructed and unobstructed in Table 5.3.

Task #2: Construct the latch

I. Turn off the NI ELVIS board. Build the circuit shown in Figure 5.10. Be sure to connect Pin 5 (ENABLE) to high (+12V) to enable the device. You may need to push the /RESET button right after power on to initialize the circuit. Check the output (Q) level when you push /ALM switch or /RESET switch, and complete Table 5.4.

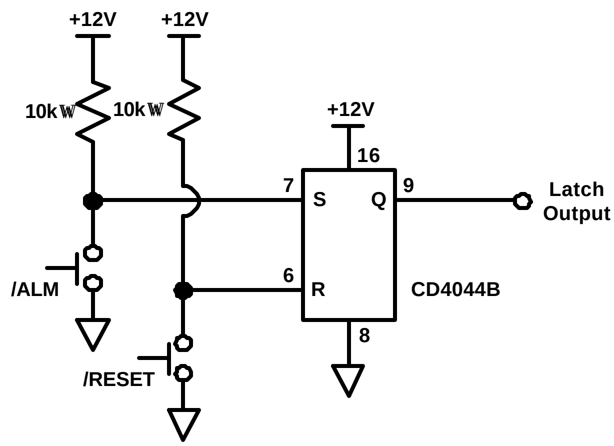


Figure 5.10

II. Build the circuit shown in Figure 5.11. The direction of LED is as in Figure. 5.12. The long lead is (+) and the short one (-). It is important to connect them correctly as shown in Figure 5.11. Measure the 4044 output voltage (Q) and the buffer output voltage and complete table 5.5. One of the LEDs should be on. If not check the direction of the LED.

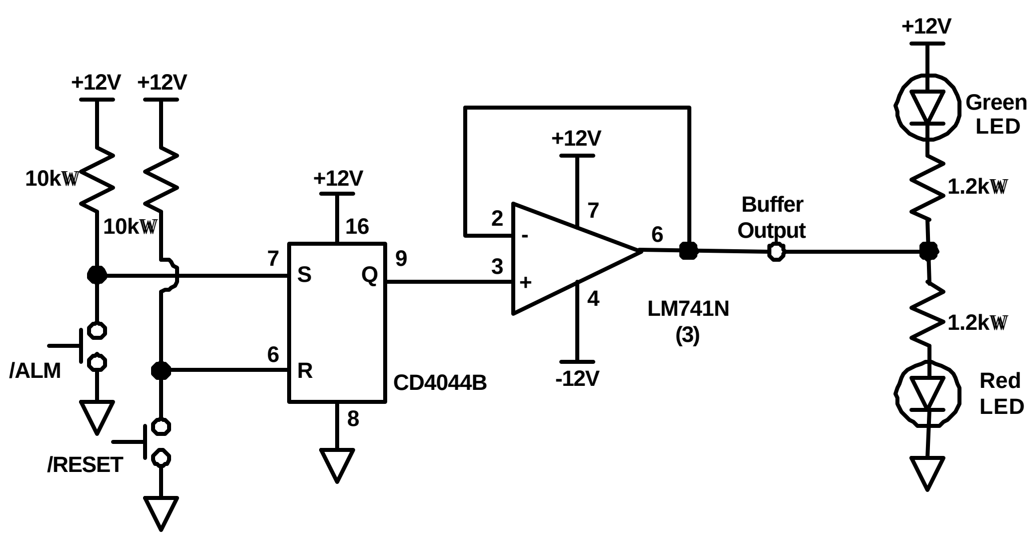
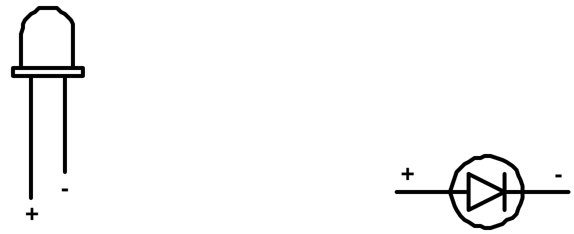


Figure 5.11



(a) (b)

Figure 5.12

III. Check the laser lab (3) module. Align the laser beam and check the comparator output. (/ALM).

IV. Attach the buzzer at the buffer output. Remove /ALM switch and 10kΩ resistor. Connect the comparator output the S input of the latch. Now you should have a whole system. Check if the buzzer sounds when you interrupt the laser beam.

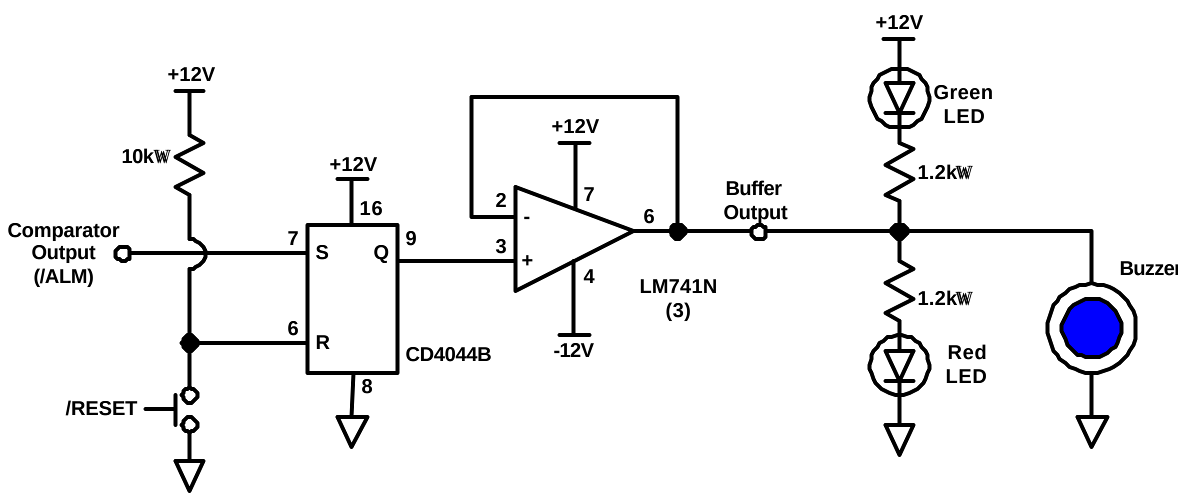


Figure 5.13.

Task #3: Implement your *.vi

I. Use the *.vi you built in the prelab to act as a software response from the laser input. Test the virtual instrument by obstructing the beam and setting off the buzzer.

Lab Report Requirements –

Be sure to include all of the lab report requirements given in the Introduction section.

Graph V_{IN} versus V_{OUT} of the comparator.

Comment on the security system as a whole. How would you improve it?

Tables and Results –

Table 5.1

Reference voltage V_r (Measured)	Reference voltage V_r (Calculated)	Output voltage changes at this input voltage

Table 5.2

V_{IN}	$V_{OUT, Comparator}$

Table 5.3

	Comparator Output voltage (Measured)
With laser beam at the photodetector	
Without laser beam at the photodetector	

Table 5.4

	S	R	Q
/ALM on			
/RESET on			

Table 5.5

	Q	Buffer Output	LED on
/ALM on			
/RESET on			