University of California, Davis

Electrical and Computer Engineering

California State Summer School for Mathematics & Science

Cluster 8: Internet-of-Things

Lab 4

The 555 timer and piezo buzzer

Introduction:

a. Purpose/ Scope

We live in the information age but how exactly does one define information? Although the concept of information is abstract, a practical definition would be the energetic representation of a given system. Consider the scenario where you just heated up a cup of coffee to study for your exams. Before taking a big drink, you need to see how hot it is, so you take a quick sip. In that sip, energy is transferred in the form of heat from the coffee into your skin, or more accurately your nerves. Your nerves transport this energy in the form of electro-chemical energy that is interpreted in your brain which tells you to stop drinking the coffee so you do not burn yourself. One of the cornerstones of electrical engineering is the extraction, manipulation, and transmission of information in a very similar manner. With this in mind and building on the previous lab, this lab introduces you to new sensors and transducers.

b. Resources/Lab Materials

Lab Materials:

- 1x breadboard
- 1x MSP432 MCU
- 1x 555 timer
- 1x red LED
- 1x passive buzzer
- 4x pushbuttons
- resistors (2x 100, 2x 330, 2x 1K, 1x 10K)
- capacitors (1x 0.01 μF, 1x 0.1 μF, 1x 10 μF, 1x 100 μF)
- wires

Energia Files:

- Lab4_buzzer_demo.ino

Description: In previous labs we used PWM from the MCU to generate analog signals. Another way to do this is with an IC known as a 555 timer. This IC is useful if someone wanted to repeatedly toggle something like an LED on or off, which is exactly what we intend to do for this exercise.

Procedure:

Part A: Buzzer Demo

To start this lab exercise, we begin with a simple, yet fun, example of how time varying electrical signals can be converted into mechanical energy in the form of sound. Build the following circuit using the passive buzzer component and pushbuttons illustrated. When connecting the buzzer, the longer leg will go to the MCU while the shorter leg will go to ground. This is also indicated by a plus sign on the top of the buzzer. Next, run the Energia program Lab4_buzzer_demo.ino . If done properly, the buzzer will play different songs depending on which button you press.

As you have done previously, demonstrate that the circuit is working correctly to the TA.

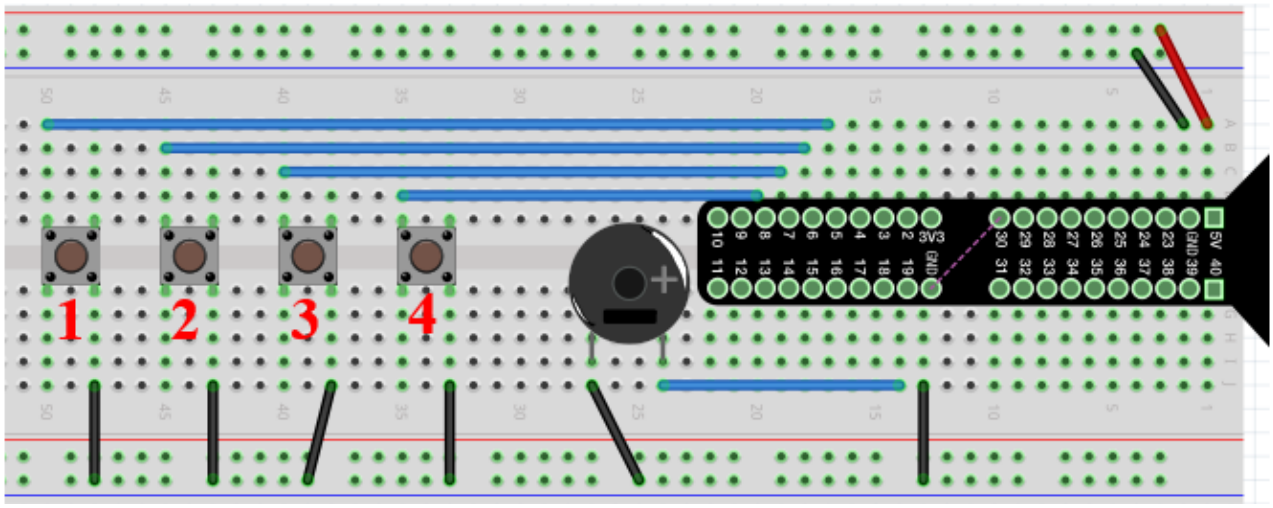

Fig. 1. Diagram of circuit for buzzer demo

Part B: 555 timer with LED and buzzer

The previous example used the MCU to generate the time varying signal necessary to make the buzzer play a set of notes, but what would you do if you did not have an MCU? One option is the 555 timer. At this step you will use a 555 timer to turn an LED on and off. Build the circuit shown below in Figure 2. Figure 2A displays a schematic representation of circuit, labeling the different pins that are illustrated in Figure 2D. The diagram of the constructed circuit can be seen in Figure

2B. Notice the red circles on the ICs in figures 2B and 2D. This will let you know how to place the IC in the circuit correctly when putting the circuit together.

You will notice two additional components you have not used before. These parts are capacitors. The large "can-shaped" capacitor is an electrolytic capacitor which is a polar device, meaning it matters which way you plug it in. If you plug it in backwards it can easily pop and leak chemicals onto the board. To use it correctly, you will notice the shorter leg has minus signs drawn by it telling you that this side should go to the lower potential i.e., ground. The other capacitors are ceramic capacitors which are non-polar. The capacitors you will be using are illustrated in Figure 2C.

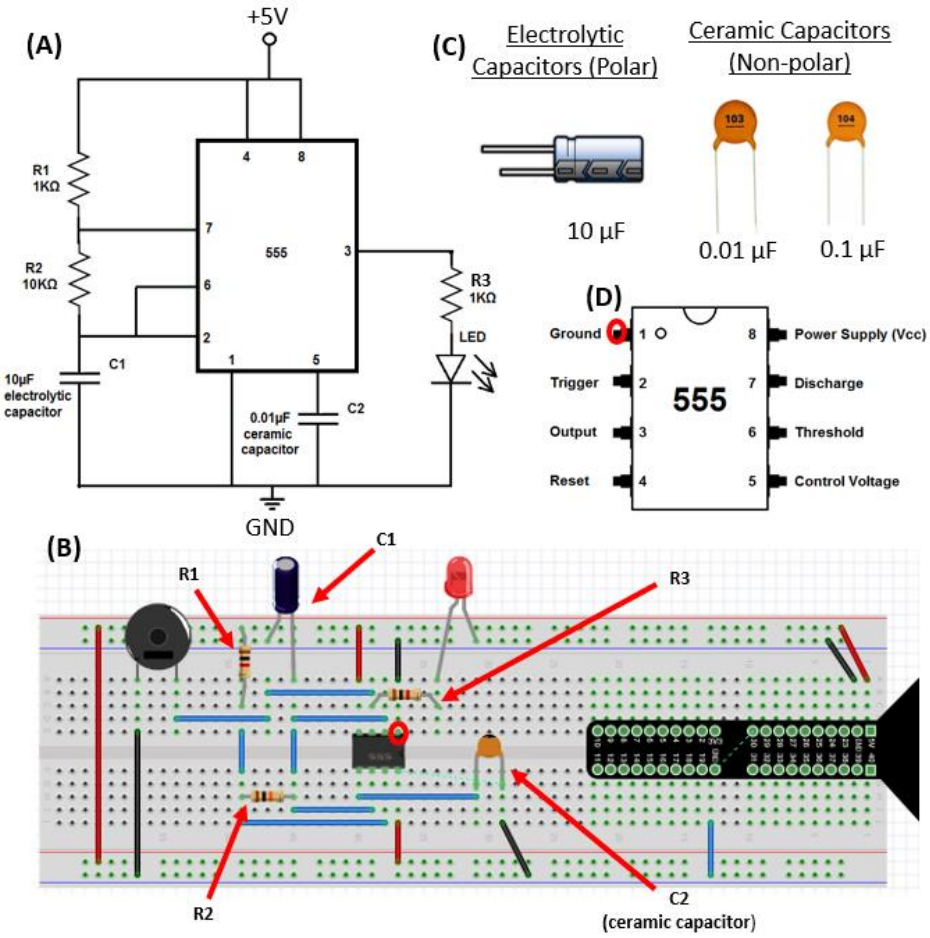

Fig. 2. (A) Schematic for a 555 timer circuit driving an LED and buzzer. **(B)** Diagram of circuit. **(C)** Illustration of capacitors used in the circuit. **(D)** Pin layout of the 555 timer IC. The red circle on pin 1 corresponds to the red circle on the IC of figure **(B)**.

If you have constructed the circuit above correctly, the LED will be blinking approximately 5 times per second. When an event occurs at a regular interval we can define it's frequency as the number of events that occur per second. Frequency has units of Hertz (Hz), so for this scenario, the light will blink at a frequency of approximately 5 times per second or 5 Hz.

Next, we wish to see how we can change the frequency at which the LED blinks. The frequency of a 555 timer signal depends on the values of R1, R2, and C1 and is given by the following formula:

$$Frequency = \frac{1.44}{(R_1 + 2R_2)C_1}$$

This formula will be used in the following questions.

Questions:

1. Now we want to see what happens when we change the values of the resistors and capacitor to control the frequency. Below you will see a table containing different combinations of resistors and capacitors that can be used in the circuit above. Make the changes and complete the table on Canvas.

R1 (Ohms)	R2 (Ohms)	C1 (µF)	f (Hz)
10k	1k	10	
1k	1k	10	
330	330	10	
330	100	10	
330	100	100	
1k	1k	100	
10k	1k	0.1	
1k	1k	0.1	
1k	10k	0.1	
330	100	0.1	

NOTE: When changing components, make sure you unplug the MCU from your computer before you make any changes. Once you exchange the components, plug the board back in and observe the LED blinking.

2. At what combination of R1, R2, and C1 were you unable to tell if the LED was blinking or not? What frequency does this correspond to? When did it become hard to hear the buzzer?

3. The eye works similar to a camera in the sense that it has an ideal framerate for visualizing motion. For instance, the monitor on your laptop has a refresh rate of 60 Hz so that image transitions look smooth to the human eye. Given the formula for the frequency output of a 555 timer and using only the values you have available to you, what is a possible combination of resistors and capacitors that will get you as close as possible to this value (Note: You may use resistor values that could be made if you configure a set of resistors in series or parallel)?