Project 2 Report (updated)

Graded

Student

Julia Laine

Total Points

75 / 110 pts

Question 1

Title/Abstract/Introduction

20 / 20 pts

- ✔ **– 0 pts** Correct
- **– 5 pts** Title Not specific/Useful
- **– 5 pts** Objectives of experiment are not clearly outlined in Abstract
- **– 10 pts** Objectives Not clearly outlined in Introduction

Question 2

Theory

15 / 20 pts

- **– 0 pts** Correct
- **– 5 pts** Astable is not discussed
- **– 5 pts** Monostable Not Discussed
- **– 5 pts** Flow chart of timer not included
- ✔ **– 5 pts** Additional theory needed for 2nd project not discussed.

Question 3

Procedure

15 / 20 pts

- **– 0 pts** Correct
- **– 10 pts** No Intro
- **– 20 pts** No Theory
- ✔ **– 5 pts** Circuit schematic should be designed
- **– 10 pts** Procedure should be more descriptive
- **– 10 pts** Extracted images not cited
- **– 10 pts** Not in paragraph form/not full sentences.
- **– 10 pts** improper circuit images (should be schematics, not pictures of breadboard, not handdrawn)

Question 4

Results

15 / 30 pts

– 0 pts Correct

✔ **– 10 pts** No error with results

– 20 pts No discussion of results

– 15 pts No Conclusion

– 5 pts Results handwritten

– 5 pts physical pictures of breadboard

– 40 pts No results/discussion

– 5 pts Missing monostable results, missing simulation, missing potentiometer use in monostable and astable

1 oscilloscope proof for monostable?

Question 5

Conclusion

10 / 10 pts

✔ **– 0 pts** Correct

– 2 pts Insufficient Details

Question 6

Bonus Experiment

0 / 10 pts

– 0 pts Correct

✔ **– 10 pts** Not submitted

Question assigned to the following page: 1

555 Timer Report

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Section: 002 Raquel Sandoval
Date: 11/16/2023

Abstract

In this lab I created 4 circuits using a 555 timer: 1 mono-stable circuit, 2 astable circuits with different duty cycles, and 1 PWM generator. The goal was to have the mono-stable circuit, triggered by a button, turn an LED on for 3 seconds then turn it back off. The resistors were calculated after the capacitor in the circuit was chosen. The circuit was built using these values and then tested to see the LED stay on for 3 seconds. This experiment was successful. The 2 astable circuits goals were to flash an LED on a duty cycle of 60% and 75% and a period of 2 and 1 seconds, respectively. The LED flashed for the desired amount of time and the oscilloscope showed the duty cycle as 60% and 75%. This portion of the lab was also successful. Finally, a PWM generator for servo control was created using a 555 timer in astable mode. The values were found the same way as the last astable circuits resistance and capacitance values were found. When the circuit was plugged into the servo's signal pin, it moved. When the button that changed the resistance between pins 7 and 8 was pressed, the servo moved to a different position and back to the original when the button was released. The PWM generator circuit was also successful.

1. Objectives

The objective is to create mono-stable and astable 555 timer circuits and apply them to physical components.

1.1. General use of a 555 timer

The technical objective of this experiment is to verify the expected behavior of the circuits. There are 2 types of circuits that we are verifying, astable and mono-stable 555 timers. Mono-stable 555 timer circuits are single pulses. They are triggered by something outside of the circuit, like a button or switch, and run one cycle of their expected output. Astable circuits are self-resetting and will ideally continue to loop forever.

We can observe the different circuits using LEDs to see pulses changing from high to low and vice versa. Buttons will also be used to trigger the mono-stable circuit. There should be one mono-stable circuit that has a pulse time of three seconds after triggered, one astable circuit with a 60% duty cycle, and one astable circuit with a 75% duty cycle.

1.2. Exploring applications of a 555 Timer

In the second experiment, an astable circuit that can control a servo using a 555 timer as a PWM generator will be created. Servos require a PWM signal in the signal input pin in order to know where to move. Servos anticipate an update every 20ms and the duty cycle of the PWM signal they receive determines the position the servo goes to. This can be done quickly using an Arduino or other microcontrollers and programming it, or a 555 timer in astable mode can be used to generate the exact repetitive wave to move the servo to the desired position. 555 timers are far cheaper and smaller than microcontrollers but can be a pain to set up. They can also only do limited positions compared to the infinite angles that a microcontroller can produce.

2. Theory

Equation 1. describes the time it takes to complete one cycle (T_1) using the resistor value (R) and the capacitor value (C) in a mono-stable circuit.

$$T_1 = 1.1 * R * C \quad (1)$$

Equation 2. is derived from equation 1 and shows the relation between the period, T_1, and the capacitor value, C, to obtain R.

$$\frac{T_1}{1.1*C} = R \quad (2)$$

Equation 3. describes the time an astable circuit spends outputting high during its period. This equation was obtained from the xx555 datasheet.

$$T_{on} = .69 * C_1 * (R_1 + R_2) \quad (3)$$

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Equation 4. describes the time an astable circuit spends outputting low during its period. This equation was obtained from the xx555 datasheet.

$$T_{off} = .69 * R_2 * C_1 \quad (4)$$

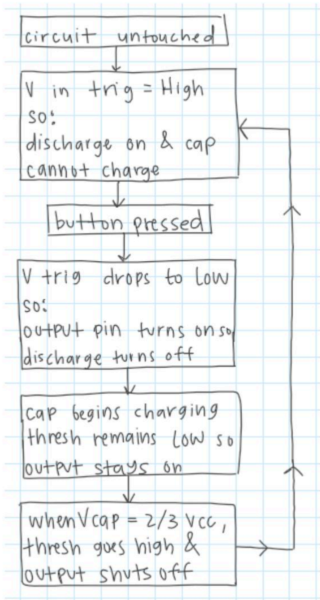

Figure 1: Monostable 555 circuit flow diagram

Figure 1 shows the flow diagram of a circuit in mono-stable mode. It begins untouched and finishes and does not loop until it is triggered again.

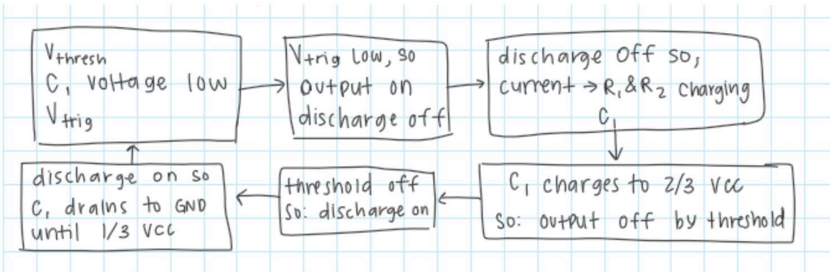

Figure 2: Astable 555 circuit flow diagram

Figure 2 shows the flow diagram of a circuit in astable mode. The circuit begins looping without external factors since pins 2 and 6 are connected.

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3. Procedure

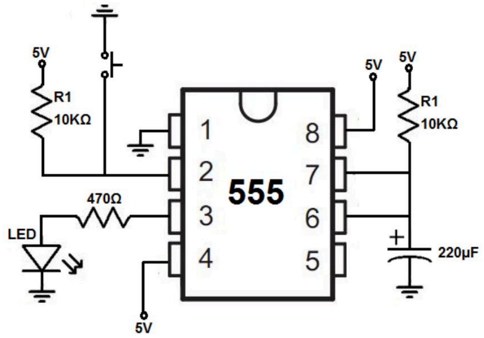

Figure 3: Monostable 555 circuit with LED [1]

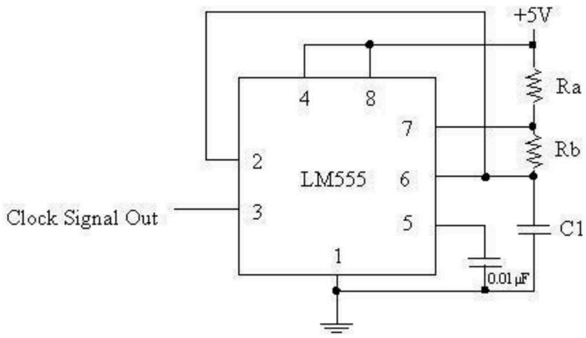

Figure 4: Astable 555 circuit with LED [2]

Table 1: Component values for circuit in Figure 3

Component	Experiment 1
R_1	10kΩ
R_2	20kΩ
C_1	220uf

Table 2: Component values for circuit in Figure 4

Component	60% Duty Cycle	75% Duty Cycle	PWM Generator
R_a	5.8kΩ	7 kΩ	14 kΩ
R_b	11.5kΩ	3.6 kΩ	220 kΩ
C_1	100uf	100uf	.1uf

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3.1. General use of a 555 timer | Monostable 3 second pulse

The first circuit that was made was a mono-stable circuit with a high output pulse of 3 seconds that was triggered by a button. Using equation 2 that was derived from equation 1, a capacitor value of 100µF was used to calculate the resistor value that would be used. The capacitor was chosen before the resistor because it is easier to find a resistor value that matches the capacitor than a capacitor that matches the resistor. Given a time constant of 3 and capacitor value of 100µF, the resistor is calculated to be 27kΩ.

The top of the 555 timer is signified by a cut out of the front or a small dot in the upper left hand corner. The pin at the top left of the timer is pin one. The pins count up as you go around the pins counterclockwise. The 555 timer is powered by pins 1 and 8, so pin 1 connects to ground and pin 8 connects to power in, I used +5v. Pin 2 is the trigger pin. This connects to the button. The button connects to a 10kΩ resistor to +5v and to negative on the other end. Pressing this button triggers the circuit. Pin 3 is the output, so it connects to the positive end of the LED, and the other leg connects to ground. Pin 4 connects to 8 and in return connects to +5v. Pin 6 connects to the 100µF capacitor and pin 7. Pin 7 not only connects to 6, but it also connects to +5v with the calculated 27kΩ resistor.

When the button is pressed, the LED turns on for 3 seconds and then turns back off. This is a normally off circuit. The LED is off until pin 3 triggers it to be in the temporary high state. This is because the LED is connected to pin 3 and ground. If it was intended to be a normally on circuit, where the temporary state is low, the LED would be connected to pin 3 and Vin.

3.2. General use of a 555 timer | Astable circuit – 60% and 75% duty cycle

Creating an astable circuit is similar to a mono-stable 555 timer circuit. The only difference is that since the circuit needs to repeat pins 2 and 6 get connected. The connection between 6 and 7 also changes to have a resistor. The resistor values in this circuit affect the duty cycle. For the first experiment, the duty cycle should be 60% with a period of 2 seconds. That means that $T_{on} = 1.2$s and $T_{off} = 0.8$s. The second experiment's duty cycle should be 75% with a period of 1 second. This makes $T_{on} = .75$s and $T_{off} = 0.25$s.

The astable circuit is similar to the mono-stable circuit where pin 1 connects to ground, 4 and 8 connect to +5v, and pin 5 has a .01µF capacitor to ground. All astable circuits with 555 timers will have pin 2 connecting to pin 6. It is different from the mono-stable circuit in the way that there is a resistor between 6 and 7 (R_2) and a resistor between 7 and 8 (R_1).

To calculate R_1 and R_2, equations 3 and 4 are used. Again, since it is easier to find a resistor value for a capacitor than a capacitor value for a resistor, the capacitor value will be set to 100µF. The 60% and 75% duty cycle circuit's R_1 and R_2 are found using the same equations with different time values.

For the 60% duty cycle circuit, the resistor value for R_2 is found to be 11.5kΩ using equation 4. To find the value for R_1, equation 3 is used with the calculated R_2 and the capacitor. This equation says that R_1 is 5.8kΩ. For the 75% duty cycle circuit, R_2 is found to be 3.6kΩ using equation 4. R_1 is found to be 7.2kΩ using equation 3.

3.3. Exploring applications of a 555 timer | PWM Generator

To create a PWM generator, the same procedure and schematic for the astable 555 timer is used. The values of the resistors and the value of the capacitor is different. The different values change the duty

Questions assigned to the following page: 4 and 3 cycle and the period so the servo can understand the signal. A button and resistor in series or a potentiometer can be added in parallel to R_a to change the servo's position.

4. Results

The mono-stable circuit functioned as calculated. When I pressed the button, the LED turned on for 3 seconds and then turned back off. While sometimes getting near the chip made it turn on, that was due to static and was unavoidable since I did not have grounding straps.

The 60% duty cycle circuit worked as expected. It had a very close duty cycle but was not exact since the resistor values in my kit were not exactly as I calculated were necessary for the 60% duty cycle.

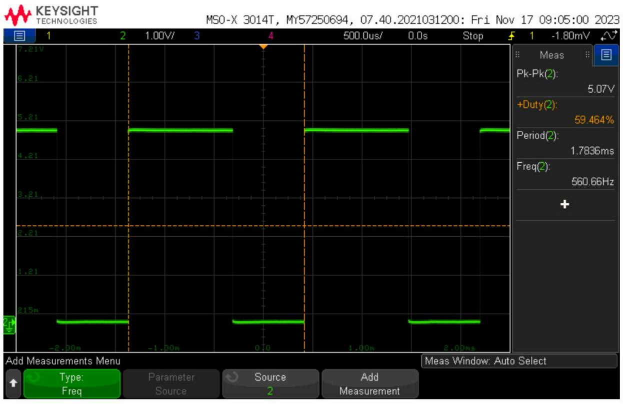

Figure 5: Astable 60% duty cycle 555 timer output.

The 75% duty cycle circuit worked as expected. It had a very close duty cycle but was not exact since the resistor values I calculated were not in my lab kit and I had to improvise and put a couple in series. The error is negligible in this case since it is close enough to the expected value.

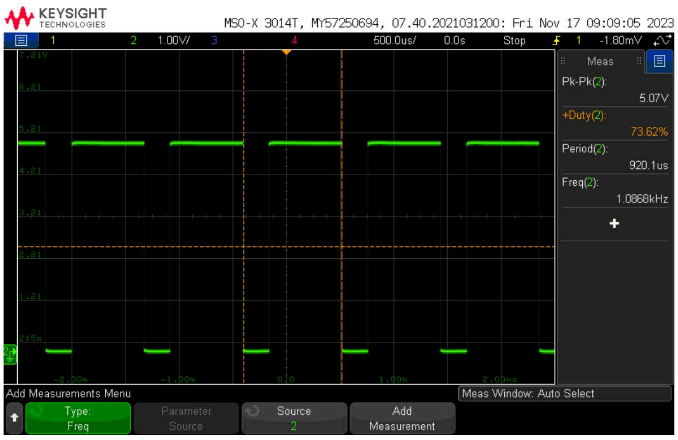

Figure 6: Astable 75% duty cycle 555 timer output.

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The servo controlling circuit worked as expected. A video is attached. The oscilloscope reading of the PWM generator is shown below (figure 7).

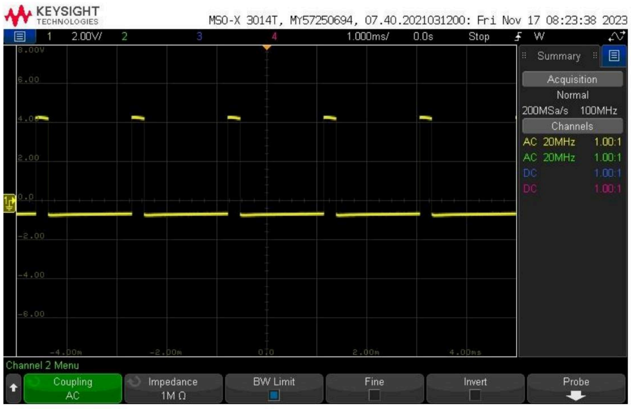

Figure 7: Astable 555 timer PWM output

I have attached a video of my PWM generator running a servo.

5. Conclusion

Overall, all of the goals for this project were reached. All of the mono-stable and astable circuits worked as intended. The goal for the mono-stable circuit were to have the LED turn on for 3 seconds when the button was pressed. This was completed by calculating the resistor values after choosing a capacitor value. With the calculated resistors, the circuit worked as intended and the LED turned on for 3 seconds after the button was pressed. A problem with this circuit was that I originally chose the wrong capacitor but after I fixed it the circuit worked. The objective of getting the light to stay on for only 3 seconds was met.

The goal for the astable portion of the lab was to make 2 circuits with one circuit having a 60% duty cycle and the other having a 75% duty cycle. I once again calculated the resistor values after choosing a capacitor value. I used equations 3 and 4 this time. Something I found interesting is that to lower the duty cycle with the same capacitor the resistor values get raised. This does make sense though since it takes longer for the capacitor to charge with higher values and therefore the duty cycle can be increased when one of the resistors is changed. A shortcoming I had in this portion was that I forgot to get oscilloscope graphs to show in this portion of the lab. I had to make the circuit again. Overall, the objectives of getting a correct duty cycle and turning on an led for 1.2s/.75s were achieved.

The PWM Generator's goal was to generate a PWM wave that could control a servo. I went an extra step and made it variable by a button so the servo could move. To make this circuit I used an astable circuit with a period of 20ms and duty cycle of 5% and 95%. To get the resistance I wanted at a specific servo position, I put a potentiometer in parallel with the resistor between 7 and 8 to change the duty cycle. The servo moves when the duty cycle changes. A shortcoming with this circuit is that it has very limited

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position when using a button and parallel resistor. It can only go to two positions in the way I have it set up. The objectives were met since I made a PWM wave, and the servo was successfully controlled using it.

Cites:

1: https://www.learningaboutelectronics.com/Articles/555-timer-monostable-circuit.php#google_vignette

2: https://hades.mech.northwestern.edu/index.php/555_Servo_Circuit