EE-110
Introduction to Engineering & Laboratory Experience
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Lab 9
555 Timer: Blinking LED Lights and Pulse Generator

In many digital and analog circuits it is necessary to create a clock pulse (square signal) using a DC battery or power source. A very common and inexpensive component for this purpose is the 555 timer. This timer comes in different specifications and in this lab we will use a LM555CM chip. The pin diagram of generic 555 timers is shown below. These timers can be used to create a single pulse signal (monostable) or a repetitive pulse signal (multistable). The monostable application is used when a light or motor is to be turned on for a specific period of time and the multistable application is utilized in circuits requiring a clock signal or for turning lights or devices "on" and "off" repeatedly. In this lab we will experiment with the multistable features of the timer. Online you may be able to find many applications for the monostable operation of the timer.

The role of the RC time-constant can be observed visually and quite clearly in the following example, which is one of many circuits employing the charging and discharging of a capacitor through a resistor. The role of various values of R and C can be nicely displayed in applications utilizing an integrated circuit called the 555 timer. This timer is used commonly in circuits that generate oscillating square wave signals. One can adjust the duty cycle of the signals by adjusting the values of the capacitors and resistors. The timer is also used in circuits that use a trigger signal to turn on the output for a desired length of time. The values of R and C in the circuit will determine the length of the time that the output will remain on or "high". However, in this part we will construct a circuit that makes two or more LEDs blink alternatively. The blinking speed is controlled by the values of a resistor and capacitor in the circuit. Let us first become familiar with the pin diagram of a 555 timer:
A Multistable 555 Timer Circuit

The purpose of this experiment is three-fold: The first is to enjoy observing the blinking lights and the second (and more serious) is to control the blinking speed by changing $R_4$ and $C_1$ values. Finally, try to find appropriate $C_1$ and $R_4$ values to have an approximate blinking frequency of one second. Correlate the $(R_4C_1)$ time-constant to the blinking period of 1s.

Use online resources to obtain the specification sheet of the 555 timer. Make yourself familiar with the current and voltage ranges suitable for this device. What is the maximum output current and input voltage for this device? What is its maximum power rating?

Carefully draw the circuits in your lab book and record your calculations. List the component values and record the waveforms as observed on the scope.

Part 1

**Measurement:** Construct the above circuit. Note that 555 timer is a chip with 8 pins. When looking at the chip from above (top view), the pin to the left of the notch is pin #1. In this part of the experiment we will not use pins # 4 (lower left) and pin #5 (lower right). The chip is powered by a 5 V DC source. You can use the Discovery Scope as the 5 V source. Borrow a ceramic capacitor from the lab if your toolbox does not include capacitors. The RC combinations control the timer's threshold at pin #6. The output of the timer (pin#3) oscillates between high (on) and low (off). The oscillation frequency is obviously a function of the values of the resistors and the capacitor. A large RC time constant results in lower blinking frequency (longer duration). Select $C_1$ in the range of 1 $\mu$F - 100 $\mu$F. Choose a larger capacitance if the blinking speed is too fast.
Make sure you connect the diodes in such a way that their anodes (usually the longer legs) are closer to the power source and their cathodes (usually shorter legs) closer to the ground. You can adjust the brightness of the diodes by adjusting the current limiting resistors connected to them in series.

Observation: Observe the blinking lights controlled by the 555 timer and the resistors and capacitors connected to it. Select three different values of $C_1$ and observe the corresponding change in the blinking speed. Create a table and note your observation of the “off” and “on” periods.

Calculation: For the values given in the circuit diagram, monitor the blinking "off" and "on" intervals. Estimate the "off" and "on" times (N) by counting the number of time the diodes blink in one minute. The duration one blink would be $60/N$. Calculate $R_4 C_1$ or $R_3 C_1$ time constants and compare these time constants with your estimation of the length of “on” and “off” times.

### Part 2

In this part construct a slightly different circuit using only one LED. The idea here is: (1) to design a different "on" time compared to "off" time, and (2) to create fast pulses by reducing the RC time constant. Choose the capacitor $C_1$ in the range $10 \mu F - 100 \mu F$.

![Circuit Diagram](image)

Note that the pin arrangement for the timer is a different compared to the circuit of the first part of the experiment. The "on" and "off" times (duty cycle) for the generated pulses of this circuit should follow the following formula.

$$t_{off} = 0.693 \times R_3 \times C_1 \quad \text{and} \quad t_{on} = t_{off} + 0.693 \times R_2 \times C_1$$

According to the above formula, for a perfectly square wave of 50% duty cycle $R_2$ should have zero resistance (shorted).
**Calculation:** Calculate $t_{off}$ and $t_{on}$ using the capacitance and resistance values that you used in the circuit. Do the calculated “on” and “off” times correspond to your observation of the times in the next part?

**Measurement 2:** Construct the circuit with the given values of resistances and capacitance $C_1$ and observe the blinking light. Use the simple time measurement technique described above to estimate the “on” and “off” times and compare your calculation with the actual observation.

**Observation:** Change the value of $R_3$ and observe a shift in the duty cycle.

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**A Monostable 555 Timer Circuit (optional)**

![555 Timer as a Monostable Multivibrator](image)

The purpose of this circuit is to generate a single pulse (monostable) using a push-button switch or other means of triggering the output pulse. The trigger pulse in the diagram is delivered to the trigger pin (# 2) and the reset pin (#4). The duration of the output pulse can be adjusted with the values of $R_1$ and $C_1$. The LED in the above circuit is attached to the output of the times and will light up for the duration determined by the 10 k resistor and 0.01 µF capacitor.