University of Colorado - Boulder

ECEN 5730
Practical PCB Design Manufacture — Fall 2024

Lab 2 Report - TLC555 vs NE555

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Introduction

In this lab, we compare the performance and characteristics of two popular 555 timer variants: the TLC555 and the NE555. The NE555 is a widely used timer integrated circuit known for its robustness and versatility, but it operates using bipolar transistors, which results in higher power consumption and slower response times. On the other hand, the TLC555, which is a CMOS version of the 555 timer, offers several improvements including lower power consumption, faster switching speeds, and better noise immunity due to its CMOS construction. The primary goal of this experiment is to build and characterize circuits using both the TLC555 and the NE555, and to compare their performance in terms of power consumption, timing accuracy, and waveform generation. This comparison will provide insights into the advantages and trade-offs of using one timer over the other in various applications.

Circuit Design

The first challenge of this lab was determining which circuit design to use. My first idea was to try and implement the most simplistic one.

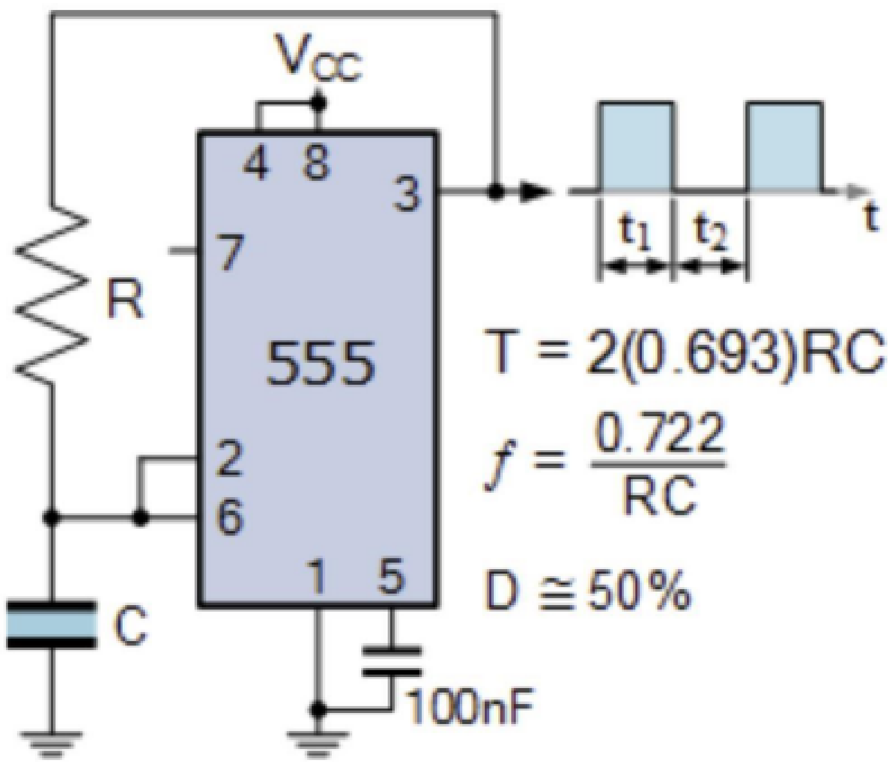

Figure 1: Simplistic 50% Duty Cycle Circuit

To calculate R and C for the desired frequency of 500 Hz we let the capacitor have a value of 1uF which results in a resistance of 1444. We can approximate this value with a 1 kOhm and 470 Ohm in series. The result of building this circuit resulted in around a 50% duty cycle with massive overshoot of about 40%. When tested with a 5V input this resulted in a 7V peak without a load connected. Both 555 timers had this problem with this circuit so we moved on to a more controllable circuit.

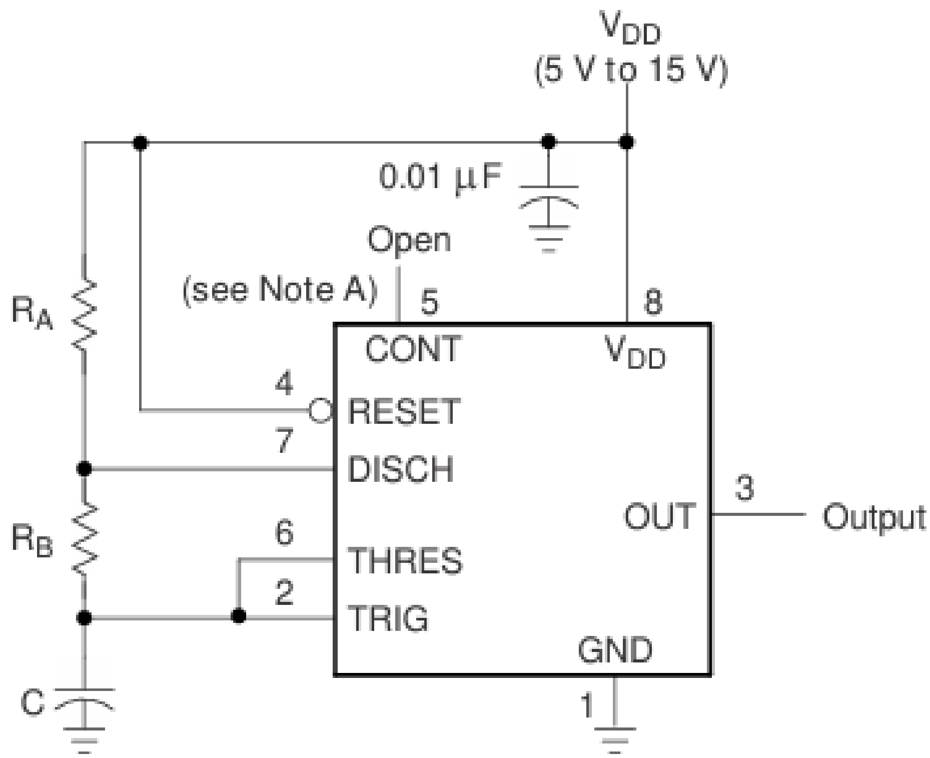

Figure 2: Better Circuit Design

This circuit adds a decoupling capacitor and another resistor. This process also allows the capacitor to have a seperate charging and discharging path which helps to remove overshoot and other inconsistencies.

$$\text{period} = t_H + t_L = 0.693(R_A + 2R_B)C$$

$$\text{frequency} \approx \frac{1.44}{(R_A + 2R_B)C}$$

$$\text{Output driver duty cycle} = \frac{t_L}{t_H + t_L} = \frac{R_B}{R_A + 2R_B}$$

$$\text{Output waveform duty cycle} = \frac{t_H}{t_H + t_L} = 1 - \frac{R_B}{R_A + 2R_B}$$

$$\text{Low-to-high ratio} = \frac{t_L}{t_H} = \frac{R_B}{R_A + R_B}$$

Figure 3: Circuit Calculations

Using these calculations we can pick values for Ra, Rb, and C. Choosing C to be 1uF and Ra to be 1 kOhm and a desired frequency of 1000 Hz we find Rb to be 940. For this we choose to use a 1 kOhm resistor. When plugging this into the output waveform duty cycle equation we get that the duty cycle should be approximately 66%.

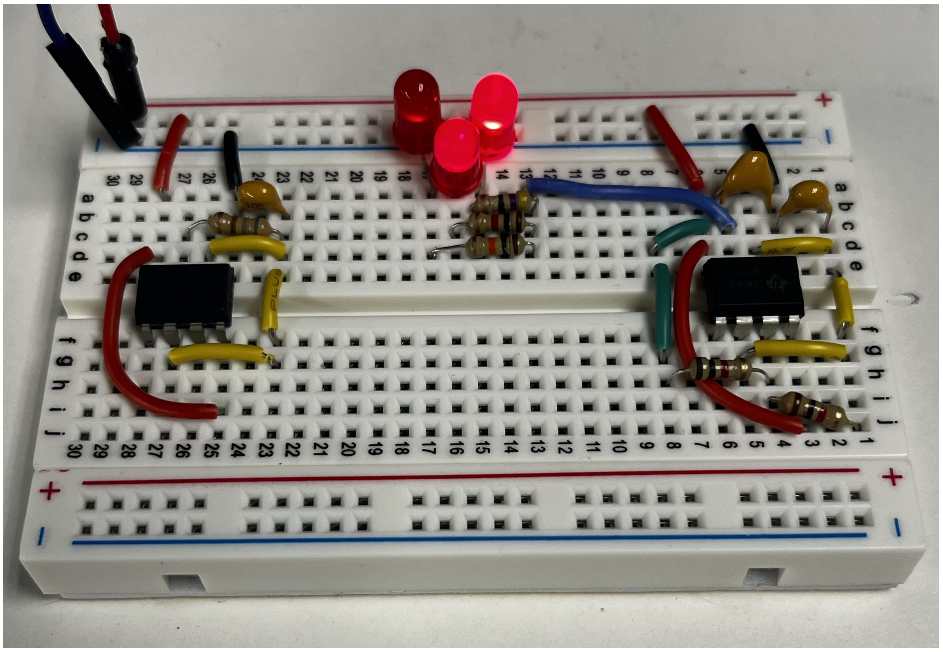

Figure 4: Circuit built on SBB

Here is both circuits fully built with the first option on the left and the second driving 3 leds (50ohm,1kohm,10kohm) on the right.

Results

All of the following screenshots and results are of the output from the circuit mentioned previously with both the NE555 and the TLC555 with the 3 LED and resistor combo load (50,1000,10000ohm).

TLC555

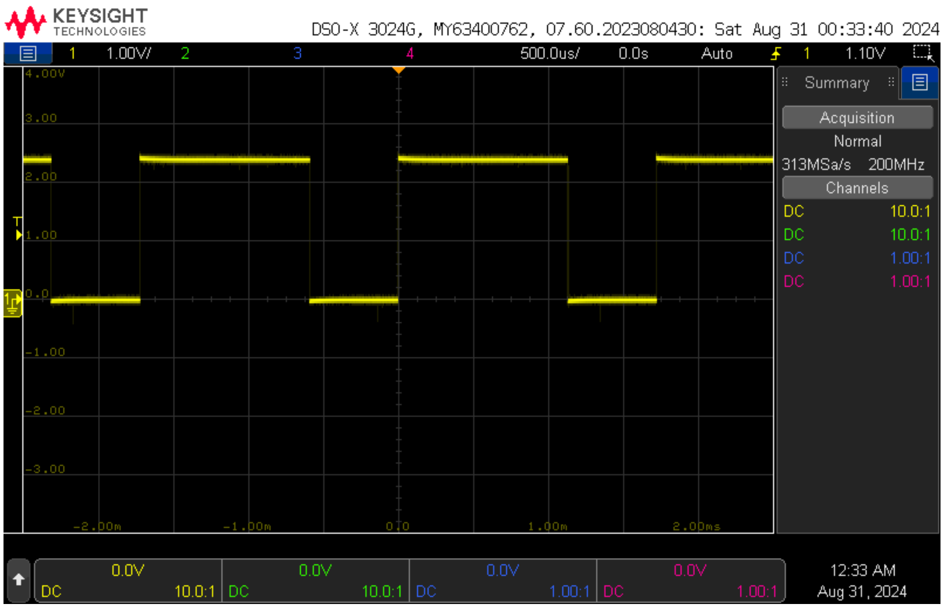

Figure 5: TLC555 Period Scope Screenshot

From this scope trace we can see immediately that it is a pretty clean square wave. We can extract a couple of figures of merit from it such as the period, duty cycle, and amplitude. The period is 3 and a half divisions with each division being 500us that means that it is 1.75ms period, which cooresponds to a 570Hz signal. The duty cycle can be approximated as 66% by seeing the over 2 divisions of it being 'on' and just over 1 division 'off'. The amplitude is simply 2.5V due to the load decreasing the output voltage.

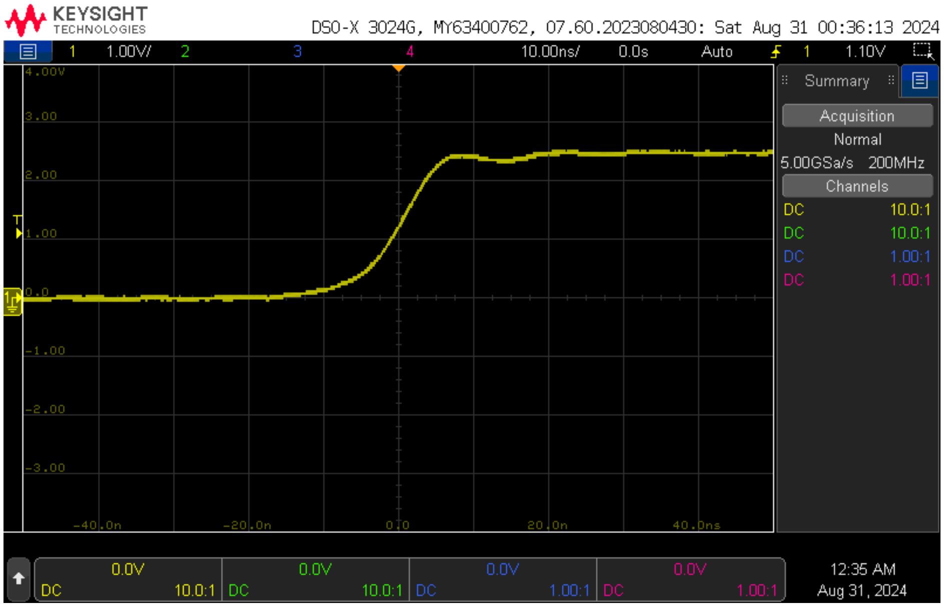

Figure 6: TLC555 Rise Time Scope Screenshot

From this scope trace we can see the rise time of the TLC555. The rise time appears to be approximately 1 and a half divisions which is 15ns. We can see from the graph that it has a smooth rise with minimal ripple.

NE555

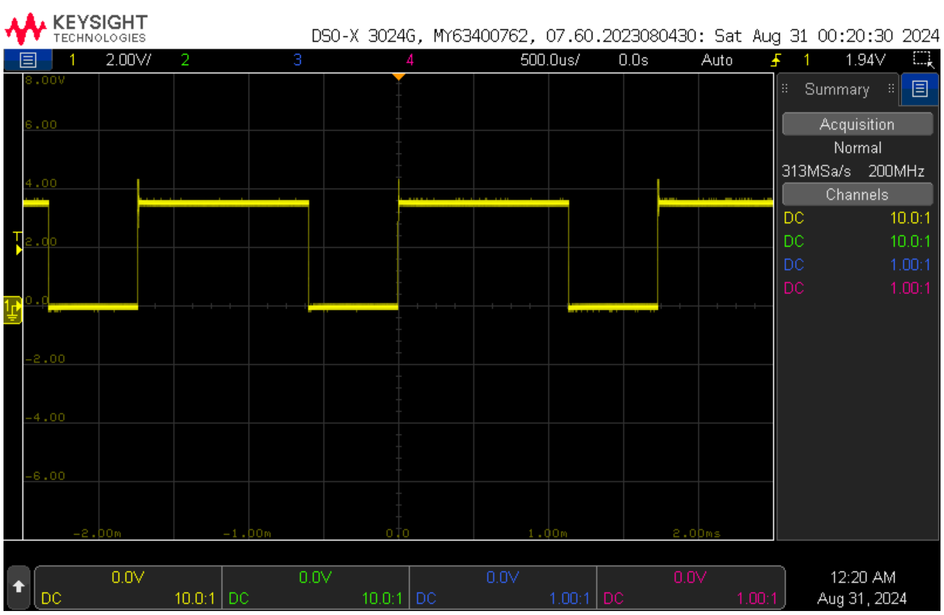

Figure 7: NE555 Period Scope Screenshot

From this scope trace we can see immediately that it is a clean square wave with a bit of overshoot that we will talk about in the next figure. We can extract a couple of figures of merit from it such as the period, duty cycle, and amplitude. The period, frequency, and duty cycle are visually the same as the TLC555, thus the period is 1.75ms, which cooresponds to a 570Hz signal. The duty cycle can again be approximated as 66%. The amplitude, however, is different. On the same load as the TLC555, the NE555 has a higher voltage at around 3.5V.

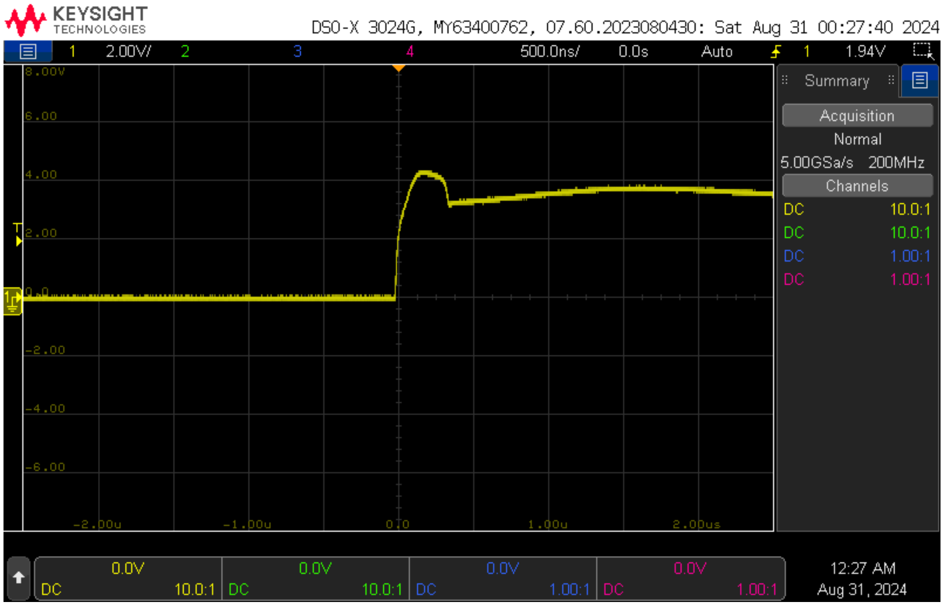

Figure 8: NE555 Rise Time Scope Screenshot

From this scope trace we can see the rise time of the TLC555. It is extremely clear that it is not as smooth as the TLC555 rise. We can see an overshoot of about half a division or 1V and a little bit of ripple after the rise. The rise time appears to be about a fifth of a division or 100ns and finally settles after the overshoot in about 3/5 of a division or 300ns.

Key Differences

The TLC555 has CMOS rather than bipolar transistors which means that the TLC has a much faster rise time, however, the tradeoff is that the NE555 has a much higher drive current which results in the load LED's being brighter. This higher drive current results in brighter LED's and causes the differences in amplitude between both 555 timers. In conclusion, it seems there is a pretty simple design choice, where if a high drive current is necessary it makes sense to use the NE555, whereas most applications the TLC555 would behave better with its faster rise time and greater accuracy.