University of Colorado Boulder

Electrical and Computer Engineering

ECEN3730 Practical PCB Design Manufacture

LABORATORY REPORT

Lab 2 Report: SSB-build 555 Timer

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1 Introduction

Building prototypes of boards using solderless breadboards is a useful tool to gain insight into what will be needed for a board design. Our objective is to build an astable multi-vibrator 555 timer circuit, with a frequency of about 500Hz and a 60% duty cycle. This lab is largely for gaining experience with using the Keysight 4024 scope, and solderless breadboards.

2 Objectives and Learning Outcomes

2.1 Objectives:

1. The power is from the 5 V rail on the Arduino board.
2. Build a 555 timer oscillator circuit with a fast, then a slow 555 timer chip. The slow 555 is bipolar and labeled NE555.
3. Design the components for about 500 Hz and 60% duty cycle.
4. Drive LED's with a series of resistors.
5. Estimate the currents in the LED in each case.
6. Measure the signal features with the slow and fast 555 timer.
7. Calculate the Thevenin output resistance of the 555 timer.

2.2 Learning Outcomes:

1. Design and conduct an experiment to analyse the frequency, amplitude and responses of a 555 timer circuit.
2. Use best practices when building and measuring the circuit.
3. To become familiar with the Keysight 4024 scope.

3 Methodology

3.1 555 Timer Circuit

1. The circuit for the 555 timer operating in astable mode was borrowed from the LMC555 CMOS Timer's datasheet 1.

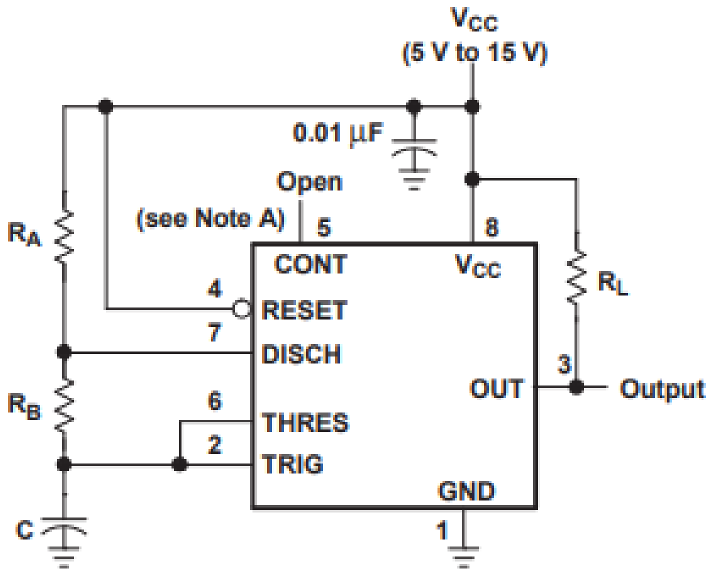

Figure 1: 555 timer set up for a-stable operation

3.1.1 Building the circuit

1. To obtain a frequency of around 500Hz and a Duty cycle of 60% we can use the equations paired with the circuit found from the LMC555 CMOS Timer's datasheet.
2. $Frequency = \frac{1.44}{(Ra+2Rb)C}$
3. $DutyCycle = \frac{Rb}{Ra+2Rb}$
4. Starting with a common capacitor value of 1uF, we find the values of the resistors need to be around 1kΩ. After simplifying resistor values, we are left with 1k resistors for both Ra, and Rb. This leaves us with a calculated duty cycle of 66%.

3.2 Measurements and Outcomes

1. The measured duty cycle came to be around 68%, and the frequency was 474Hz for the fast 555(LMC555), and 470 for the slow 555(NE555). These were both within 2% of the predicted measurements 4, 3.
2. One big discrepancy between the two 555 timers can be seen in their rise time. The fast 555 voltage on the rising edge overshoots, and ripples 7 8. This is exaggerated with a load attached 9.
3. Using the multi meter in series with the output of the 555 timers, we can measure the current through the 555 timers. This was about 13ma with 4 LEDs attached to the output 2. We can see under load, the voltage drops from the output of the 555 timer 9 10.
   (a) We can find the Thevenin resistance of the 555 timer.
   (b) Thevenin resistance $Rth = Rl\frac{Vth-Vld}{Vld}$.

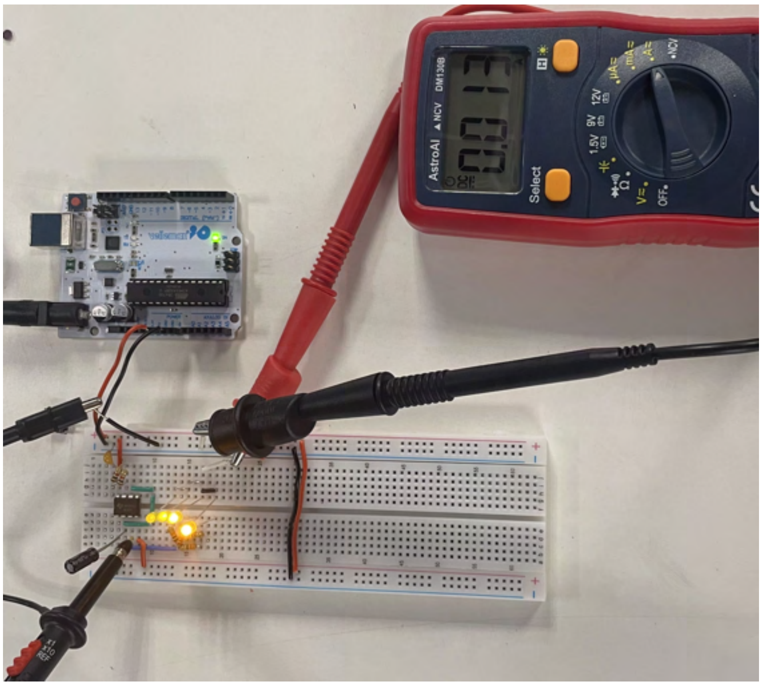

Figure 2: 555 Timer circuit setup with measurements

(c) Load resistance, $Rl = 100\Omega||330\Omega||2200\Omega||10000\Omega \;= 73\Omega$

(d) LMC555:

i. No load voltage, $Vth = 4.9V$

ii. Load voltage, $Vld = 3.8V$

iii. Calculated, $Vth = 21\Omega$

(e) NE555:

i. No load voltage, $Vth = 5.0V$

ii. Load voltage, $Vld = 2.8V$

iii. Calculated, $Vth = 57\Omega$

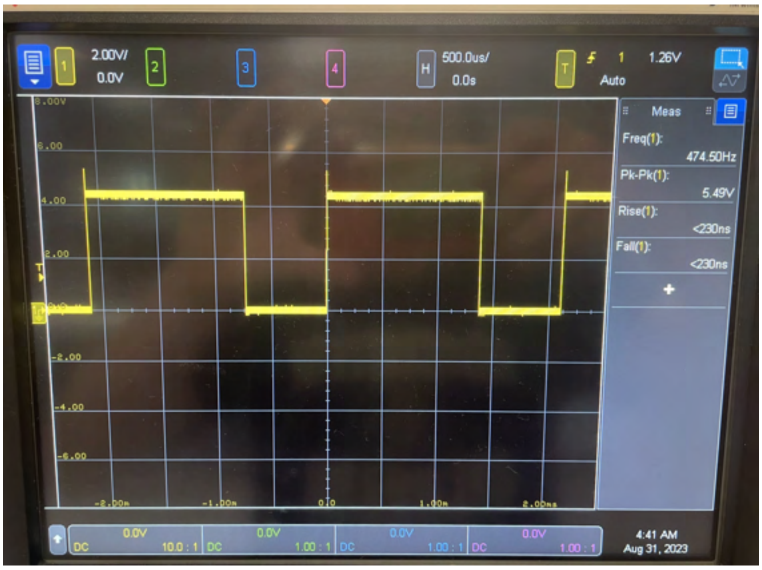

Figure 3: NE555 no load output

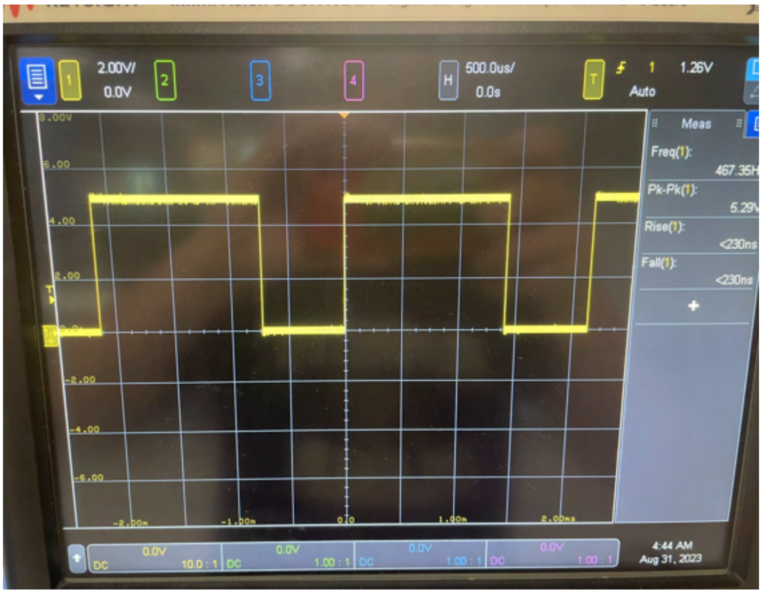

Figure 4: LMC555 no load output

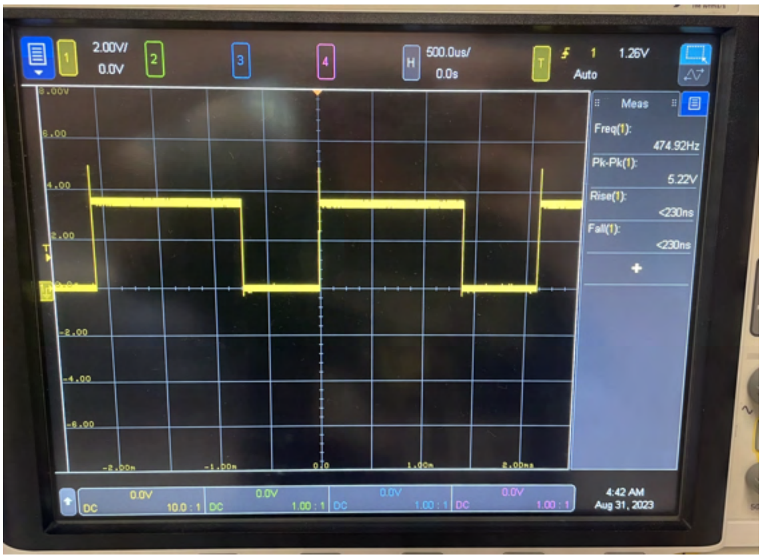

Figure 5: NE555 loaded output

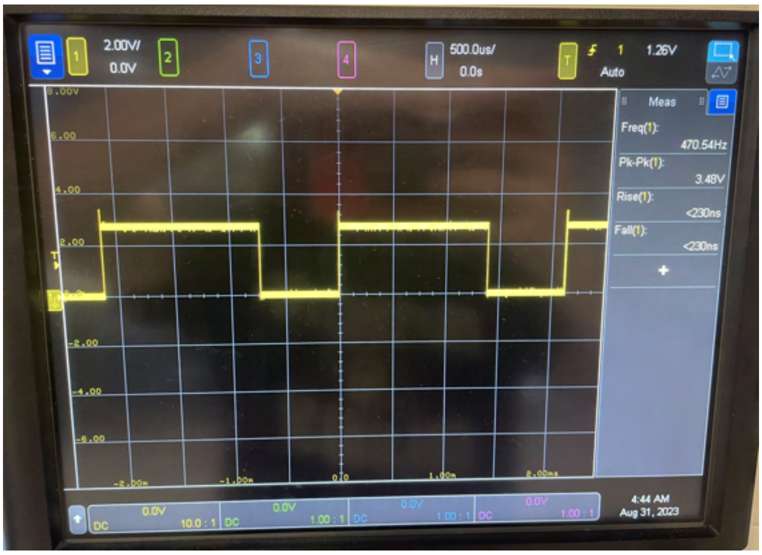

Figure 6: LMC555 loaded output

Figure 7: NE555 rise time no load

Figure 8: LMC555 rise time no load

Figure 9: NE555 rise time with load

Figure 10: LMC555 rise time with load

4 Result

4.1 Experimental Results

1. The NE555 delayed switching time reduces the amount of noise on the output.
2. The LMC555 uses CMOS technology, whereas the NE555 timer uses BJT technology technology.
3. The NE555 can not source as much current as the LMC555.
4. Solderless breadboards are a useful tool to speed up prototyping.
5. Using rule#9 is a very useful tool and debugging technique.

5 References

[1] NE555 Datasheet ti.com/lit/ds/symlink/ne555.pdf?ts=1693795681068&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FNE555%252Fpart-details%252FNE555DR.

[2] LMC555 Datasheet https://www.ti.com/lit/ds/symlink/lmc555.pdf?ts=1693795678904&ref_url=https%253A%252F%252Fwww.ti.com%252Fproduct%252FLMC555%252Fpart-details%252FLMC555CMX%252FNOPB.