555 Timers

ECE 320 Electronics I

Jake Glower - Lecture #25

Please visit Bison Academy for corresponding lecture notes, homework sets, and solutions

555 Timers

- Common
- Inexpensive
- Easy to use (been used since 1972)

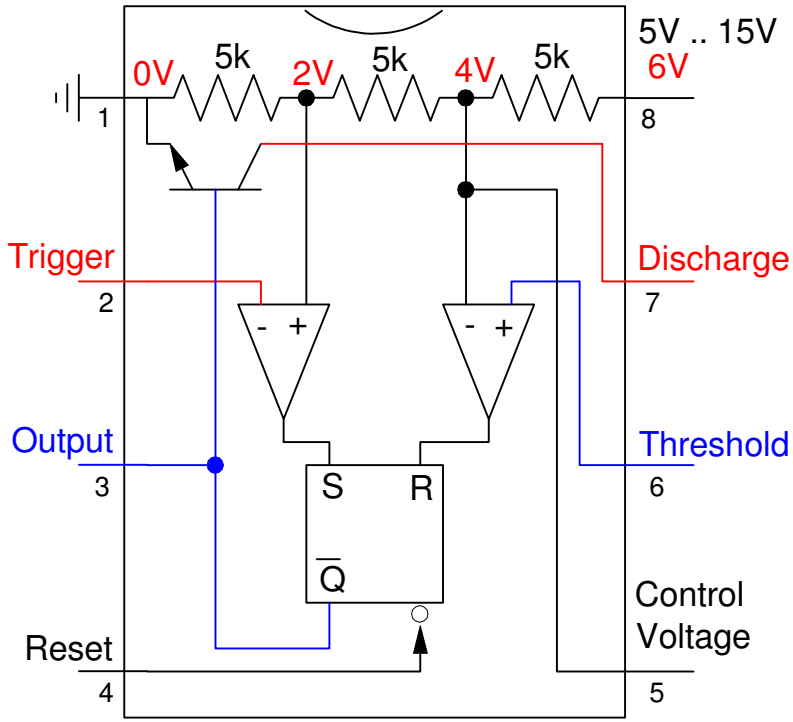
Easy way to generate waveforms

- Square Wave
- PWM
- Triangle Wave

Applications

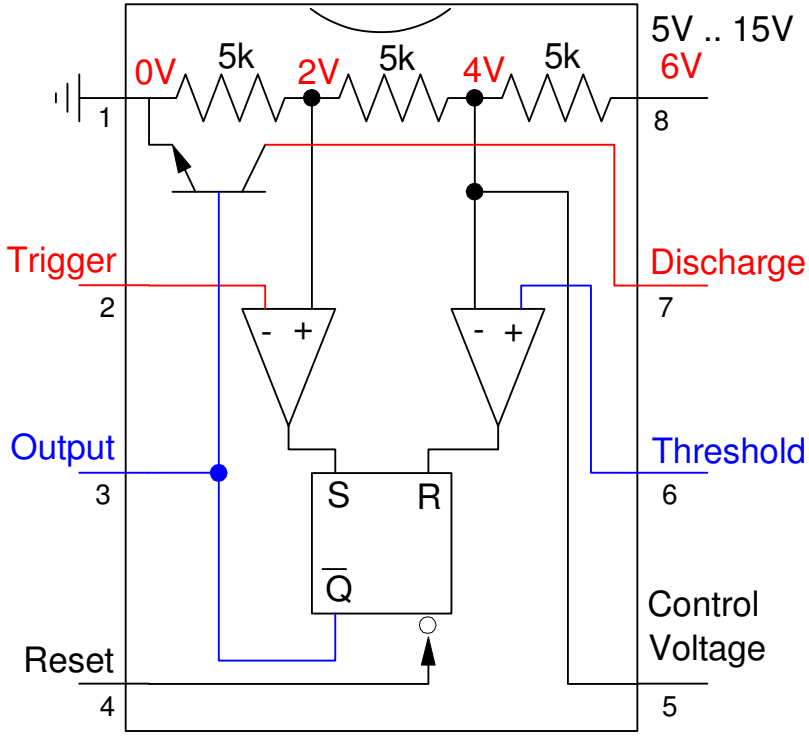
- Voltage controlled oscillator (siren)
- Temperature controlled oscillator (sensor)
- One-Shot (buzz a door if left open)

No software to write, no program to crash



555 Timer:

- Power and Ground: 5V to 15V.
- Trigger: When Trigger < 2V
  - SR flip-flop sets
  - Output goes high.
- Threshold: When Threshold > 4V
  - SR flip flop clears
  - Output goes low
- Control Voltage:
  - Adjust threshold voltage from 4V
- Discharge: When 0V
  - Ground pin 7

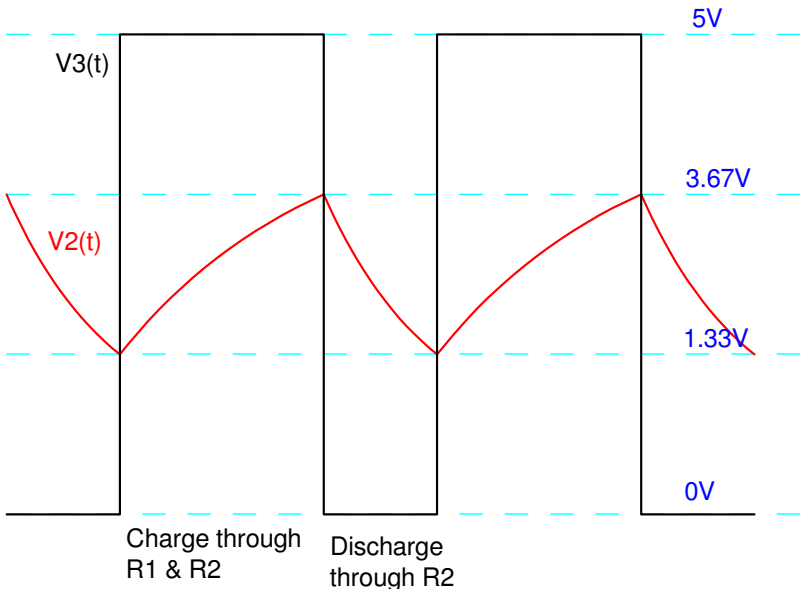


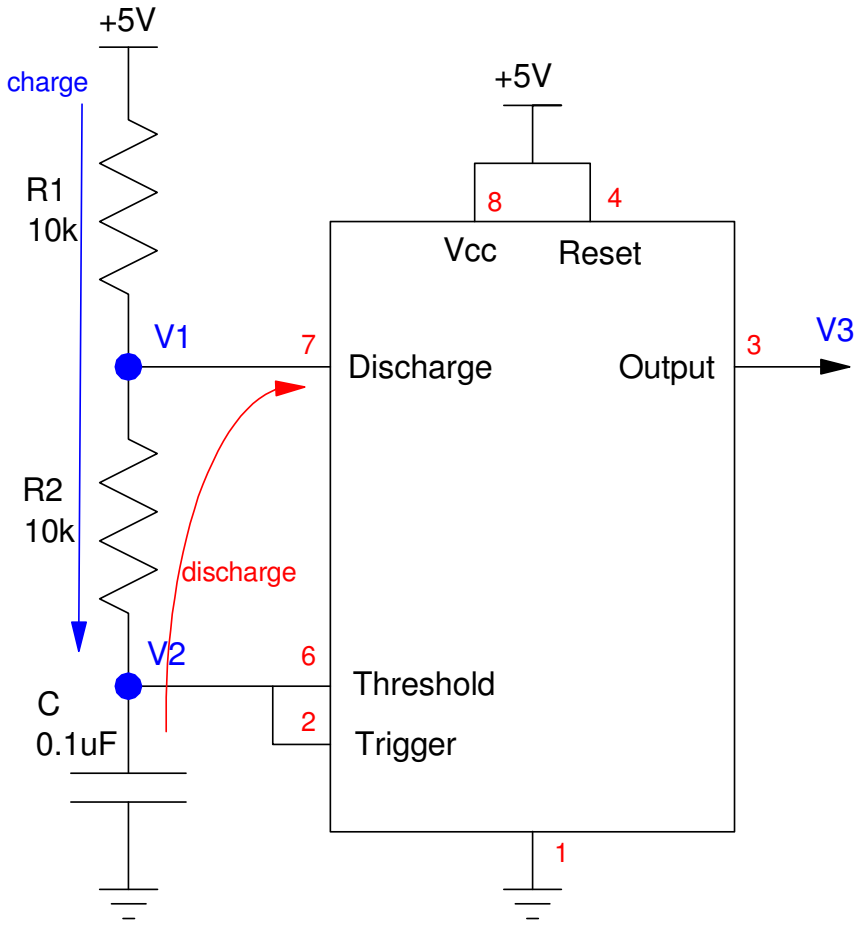
555 Oscillator (take 1):

- Charge C through R1 & R2
- Discharge C through R2

Resulting Waveform

- Square Wave at V3
- Triangle Wave at V2





Calculations

On-Time: (charge)

- $t_{on} = (R_1 + R_2) \cdot C \cdot \ln(2)$
- $t_{on} = 1.386ms$

Off-Time: (discharge)

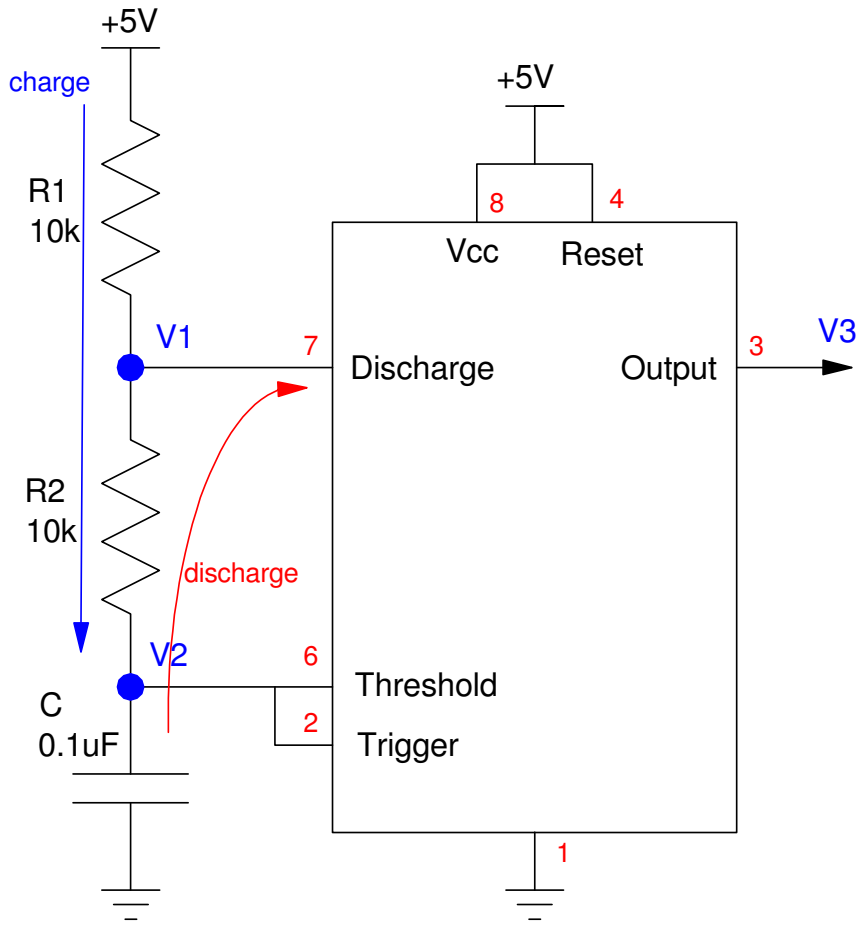
- $t_{off} = R_2 \cdot C \cdot \ln(2)$
- $t_{off} = 0.693ms$

Period & Frequency

- $T = (R_1 + 2R_2) \cdot C \cdot \ln(2)$
- $f = \frac{1}{T} = 480.9Hz$

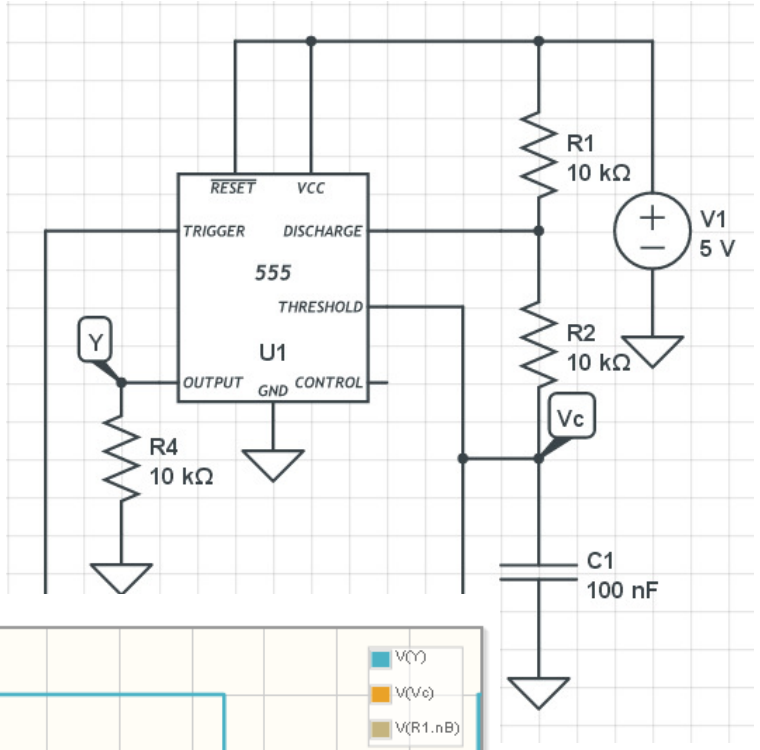
Duty Cycle

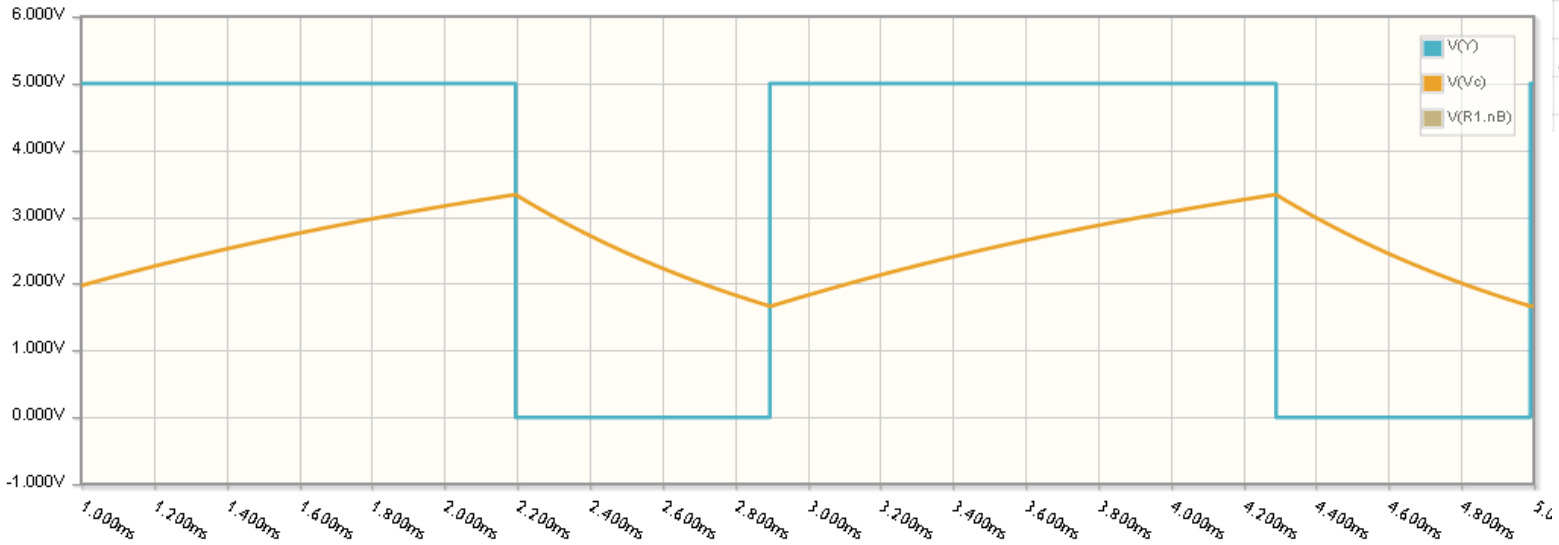
- $d = \left(\frac{R_1+R_2}{R_1+2R_2}\right) = 66.7\%$



CircuitLab Simulation

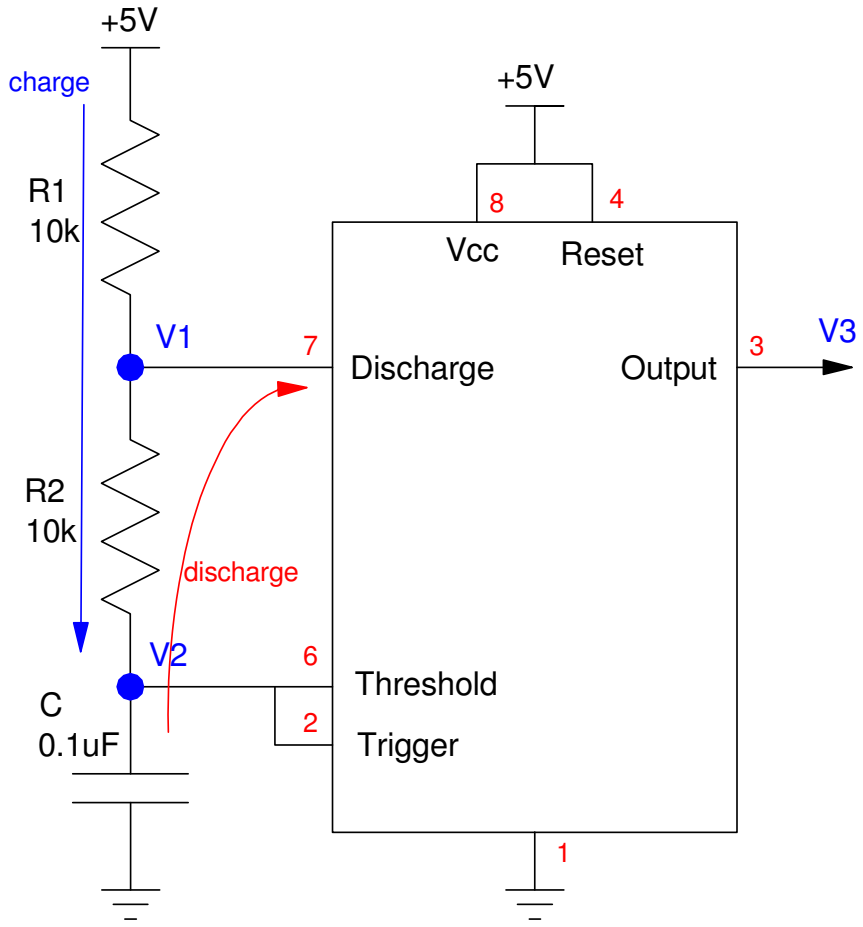
- On Time: 1.396ms
  - 1.386ms calculated
- Off Time: 0.702ms
  - 0.693ms calculated
- Frequency: 476.6Hz
  - 480.9Hz calculated
- Duty Cycle: 66.5%
  - 66.7% calculated





Experimental (Hardware)

- Build the circuit on your breadboard
- Take measurements
  - Should match with calculations
  - Should match with simulations



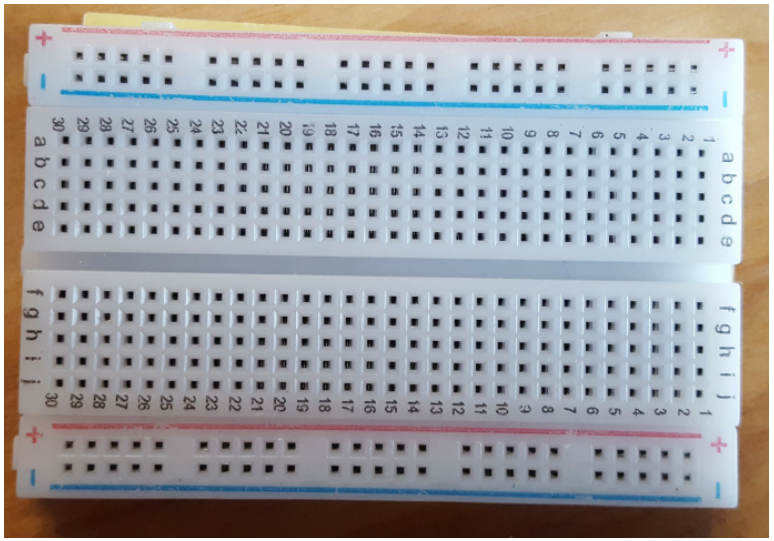
Breadboards (Front & back)

Edges are used for power & ground

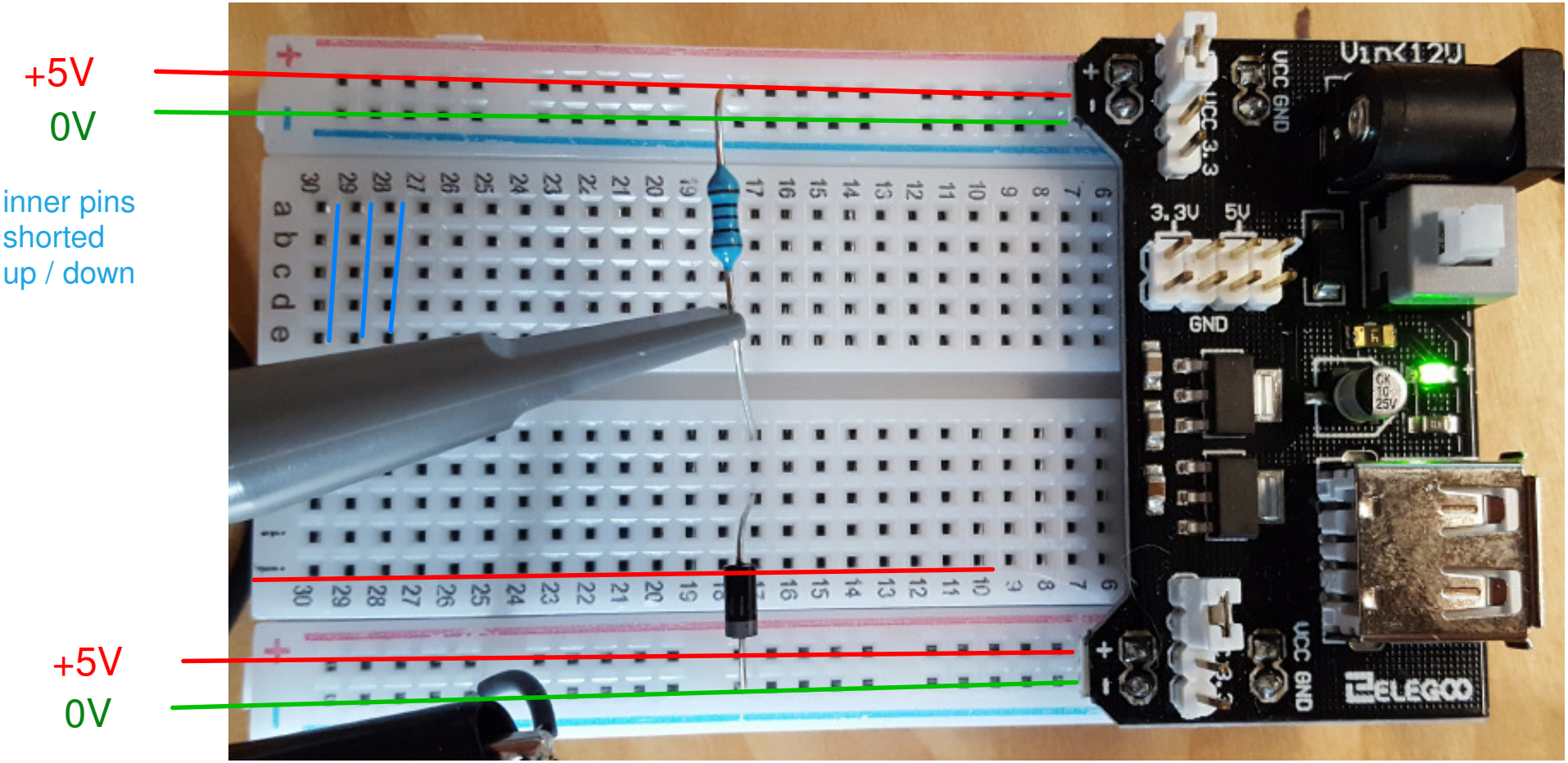
- Two separate nodes
- Shorted horizontally along length of board

Middle is used for signals

- 30 nodes (top)
- 30 nodes (bottom)
- Each is shorted vertically

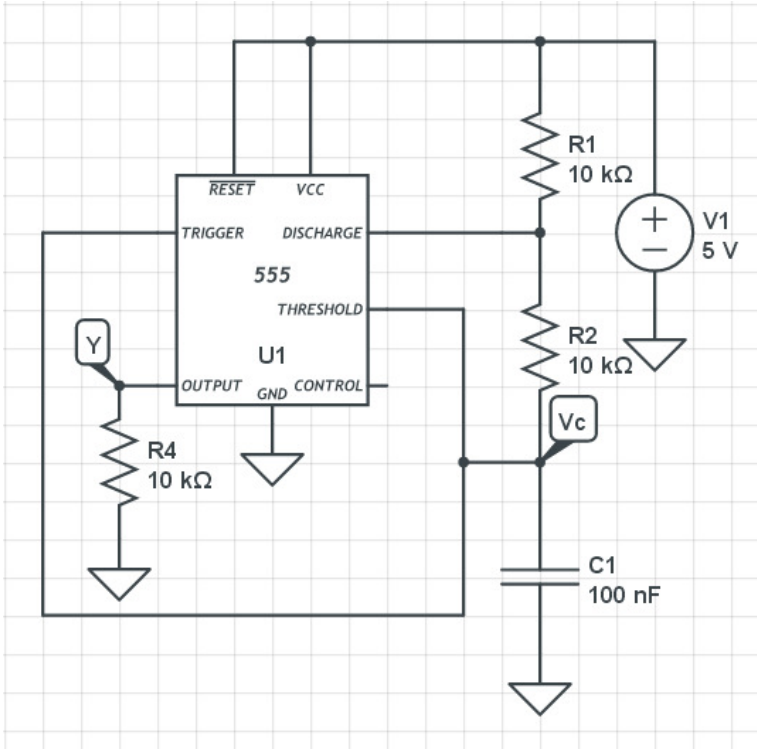


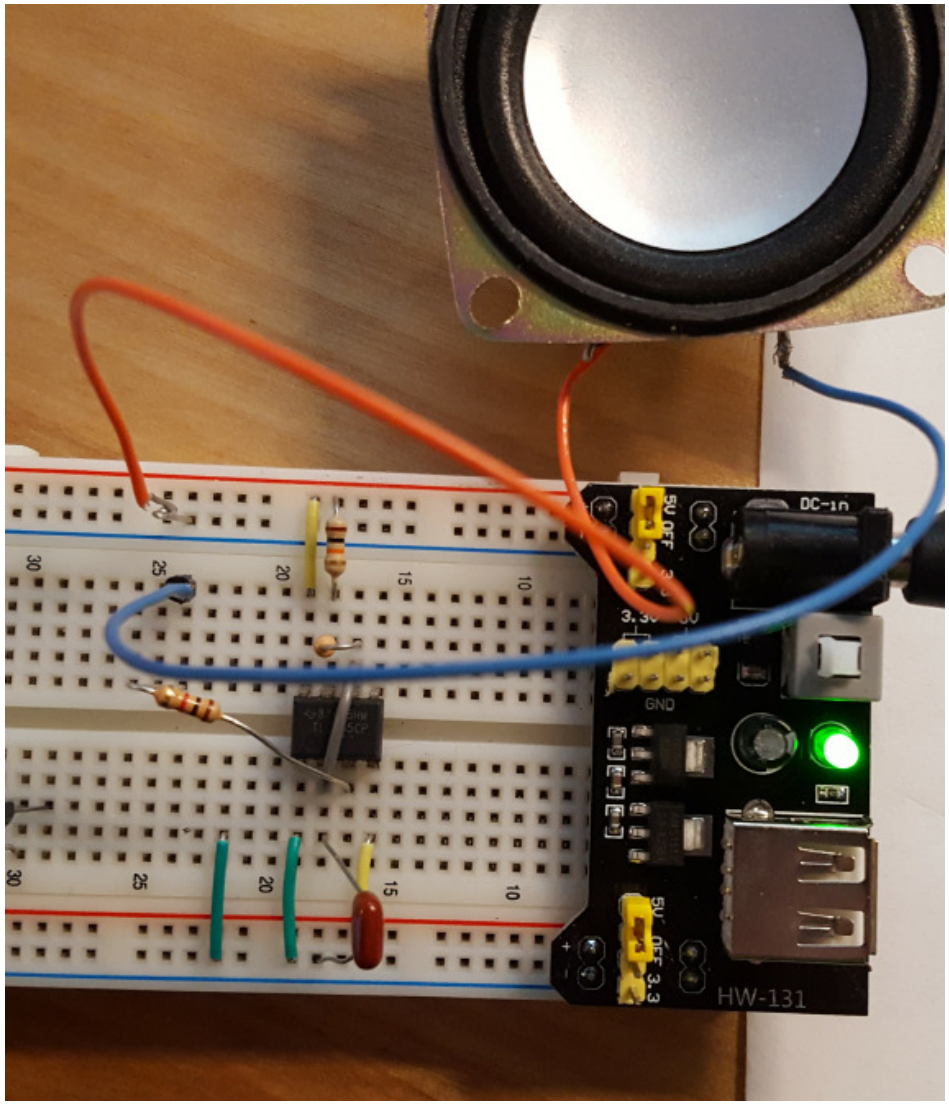
Electronics Kits: Powered Breadboard



555 Timer on a Breadboard

1 = ground
2 = Trigger
3 = Output
4 = Reset
5 = Control
6 = Threshold
7 = Discharge
8 = Power





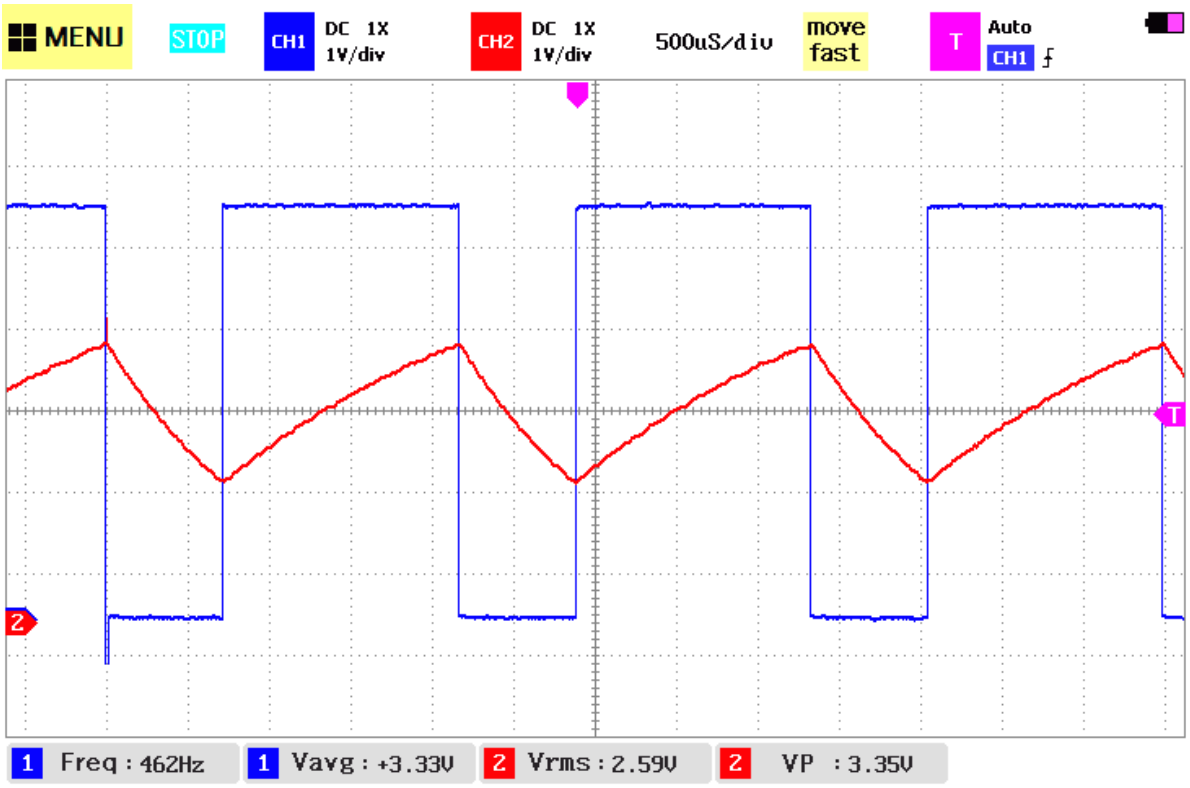
Experimental Results (With an Oscilloscpoe)

Vout (blue)

- DC = 3.33V
  - Average = DC
  - Duty cycle (67%)
- Freq = 462Hz
  - 480Hz calculated
  - 476Hz simulated
  - Changes with temperature

Vc (red)

- 3.35Vpp
  - 3.33Vpp calculated
  - 3.33Vpp simulated



Experimental Results (Without an Oscilloscope)

Multi-Meter

- Vout = 3.33V (DC)
    - Duty Cycle = 66%

Pano Tuner (free cell phone app)

- Connect Output to an 8 Ohm speaker through a 200 Ohm resistor
- Limits the current to 20mA
- Measure the frequency with Piano Tuner app

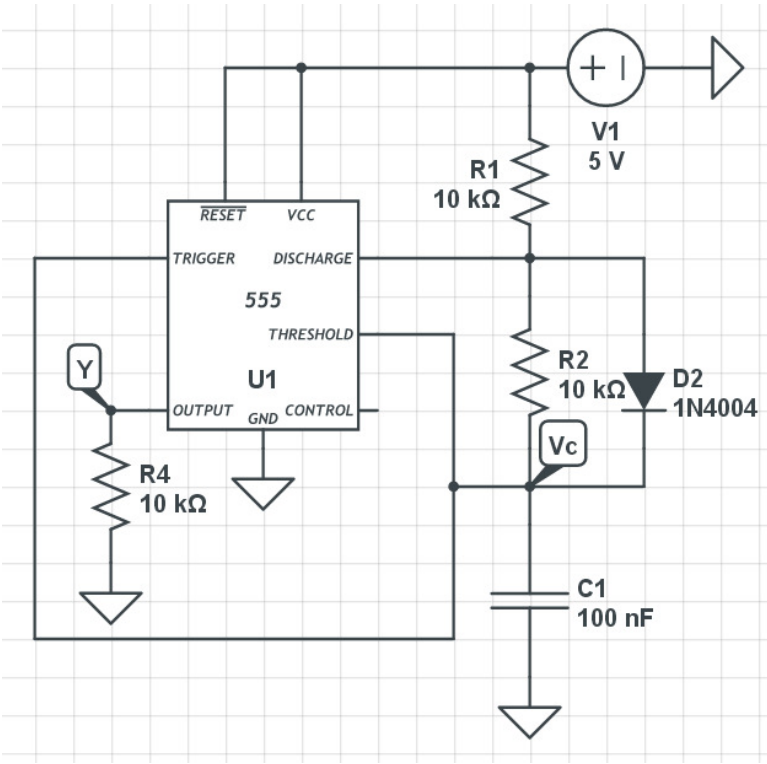
555 Oscillator: Adjustable on/off times

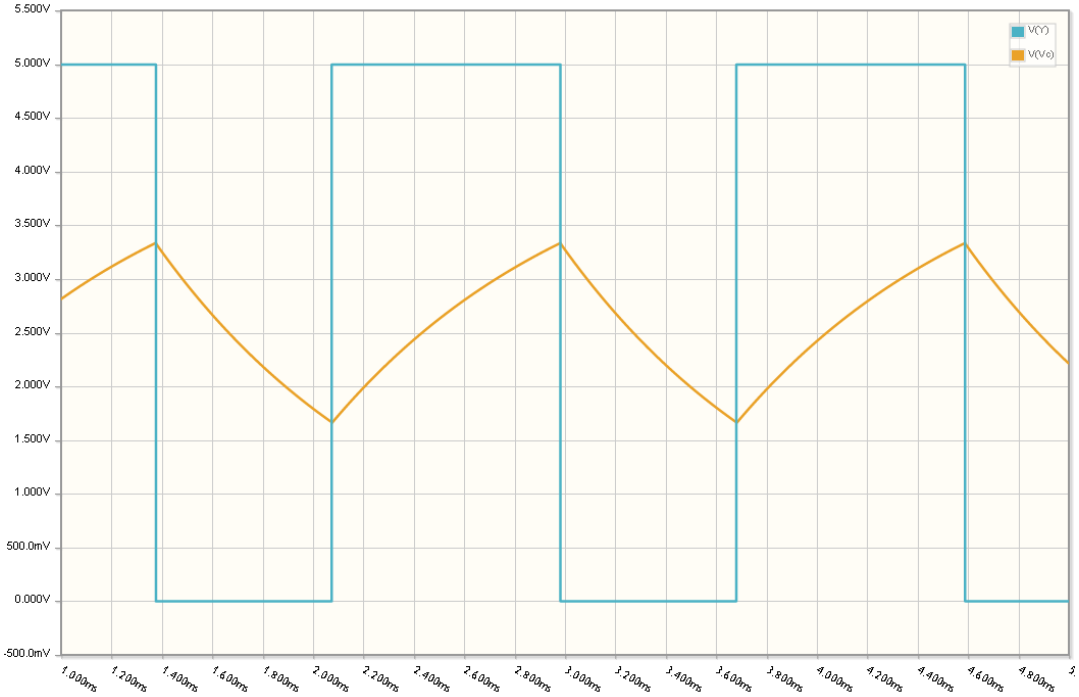
Charge through R1 & D2

- $t_{on} = R_1 C \ \ln(2.58) = 948\mu s$

Discharge through R2

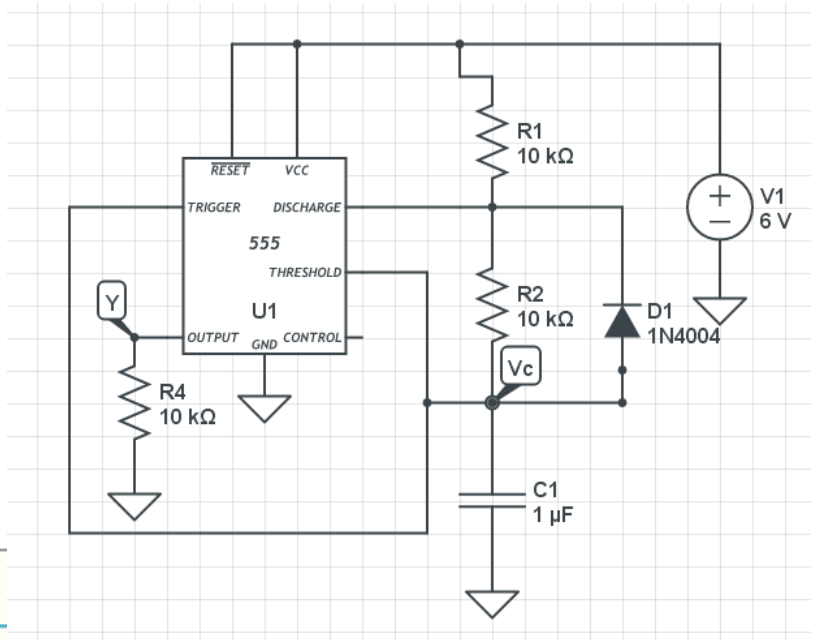
- $t_{off} = R_2 C \ \ln(2) = 693\mu s$

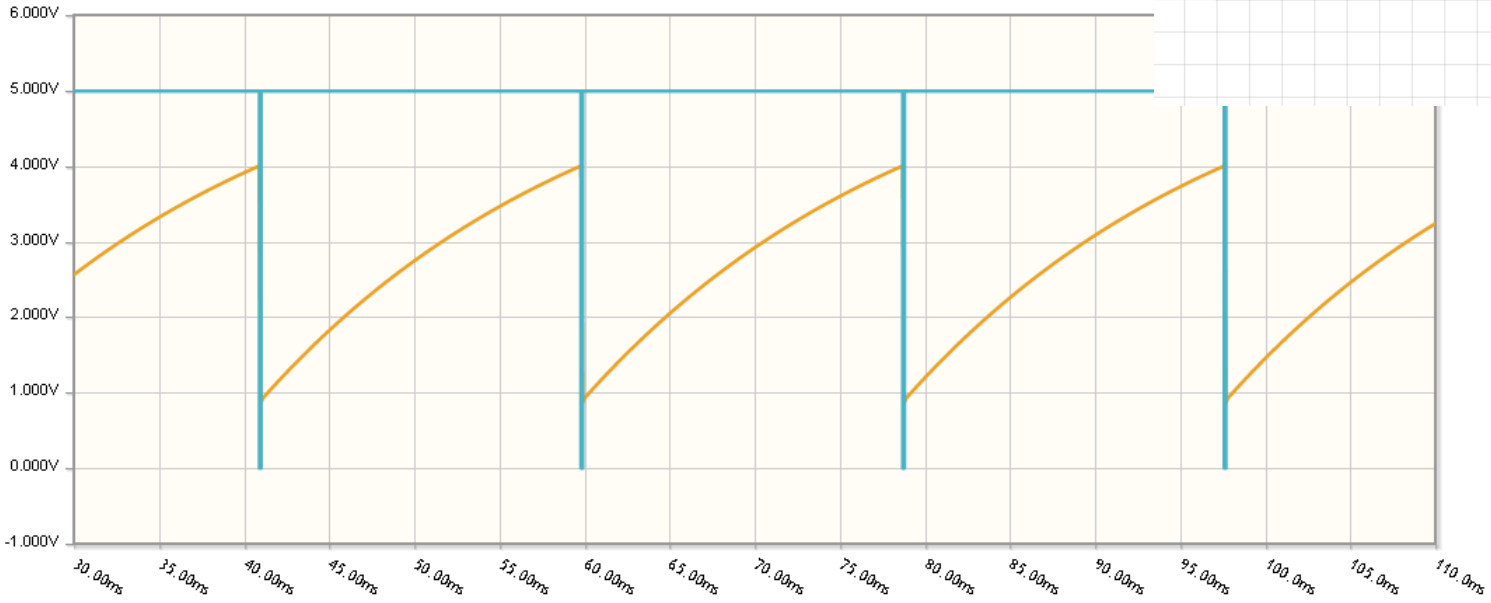




555 Oscillator: Sawtooth Wave

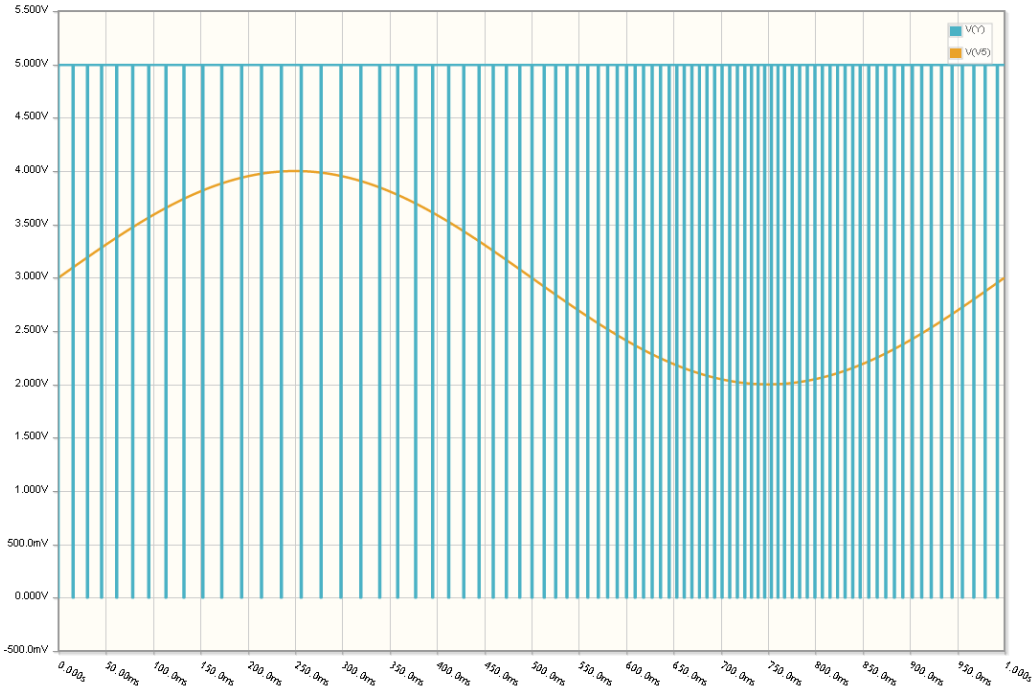
- Flip the diode
- $t_{on} = (R_1 + R_2) \cdot C \cdot \ln(2)$
- $t_{off} \approx 0$

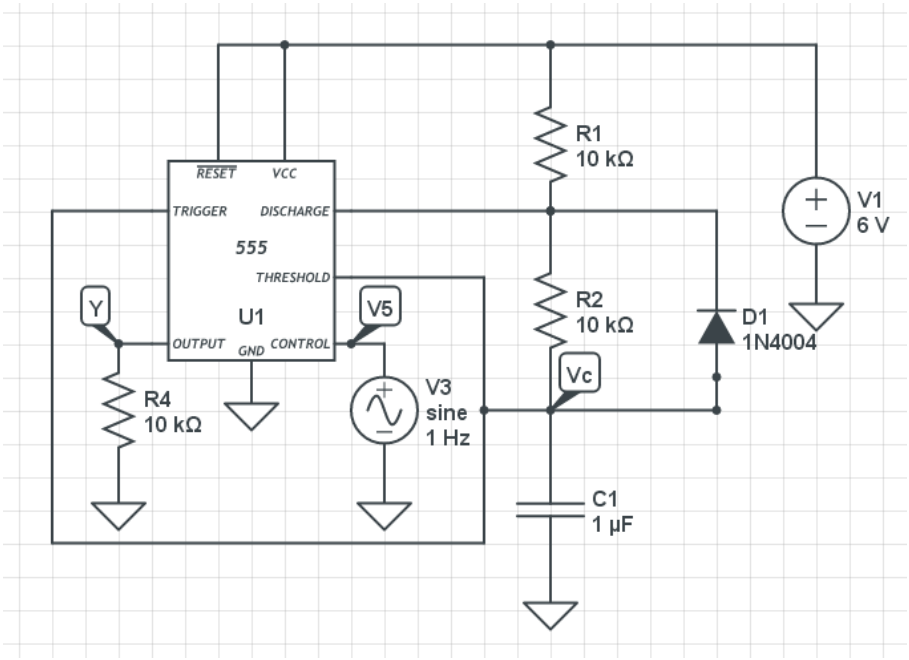




555 Timer: Votlage Controlled Oscillator

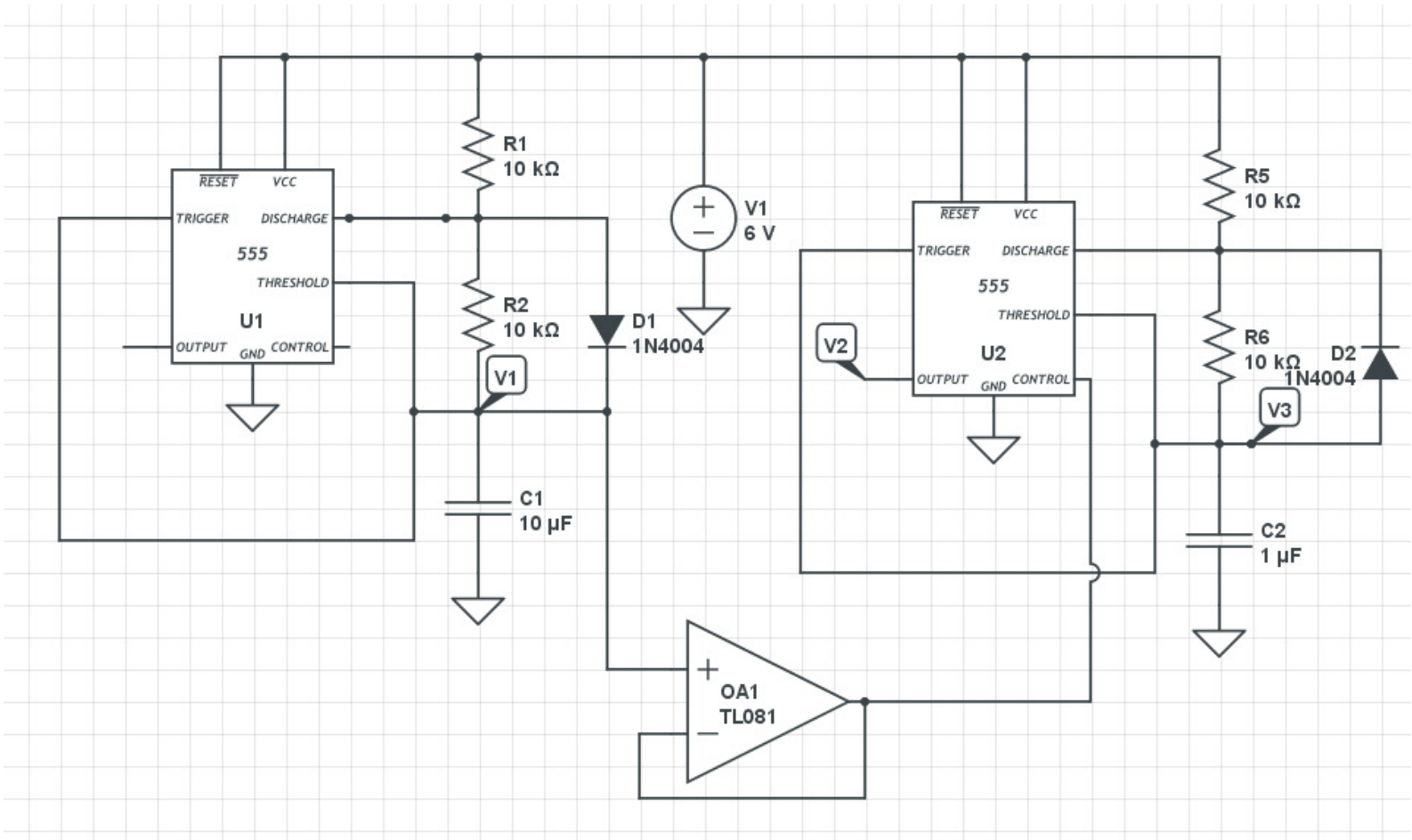
- Voltage goes to pin 5 (Control Voltage)
- Also serves as a sensor
  - Voltage divider to produce V5
  - Frequency = f(R)

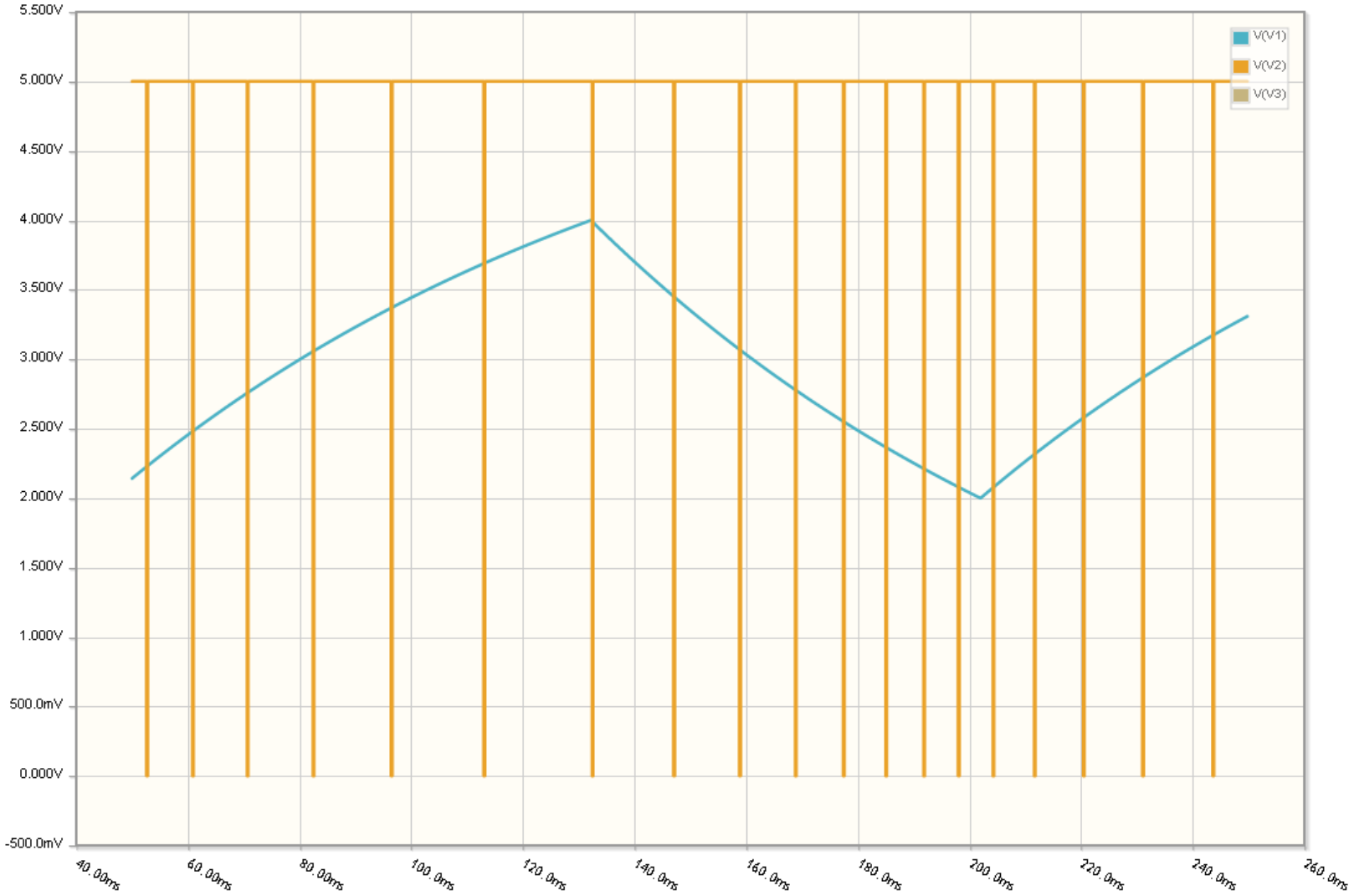




Siren

- 555 #1 outputs a triangle wave
- 555 #2 is a voltage-controlled oscillator




5.500V
5.000V
4.500V
4.000V
3.500V
3.000V
2.500V
2.000V
1.500V
1.000V
500.0mV
0.000V
-500.0mV
40.00ms
60.00ms
80.00ms
100.0ms
120.0ms
140.0ms
160.0ms
180.0ms
200.0ms
220.0ms
240.0ms
260.0ms
V(V1)
V(V2)
V(V3)

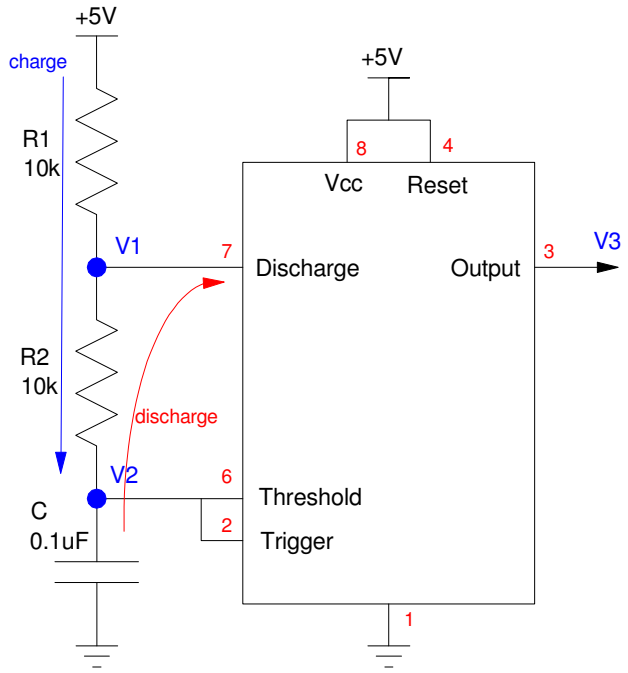
Summary

555 Timers are useful for generating

- Square waves
- Triangle waves
- Sawtooth waves

The frequency depends upon resistors and capacitors

- Allows you to convert resistance to frequency
- Allows you to convert capacitance to frequency

This in turn allows you to build

- Temperature-controlled oscillators
- Light-controlled oscillators
- Voltage controlled oscillators