555 Timers

Our Second IC!

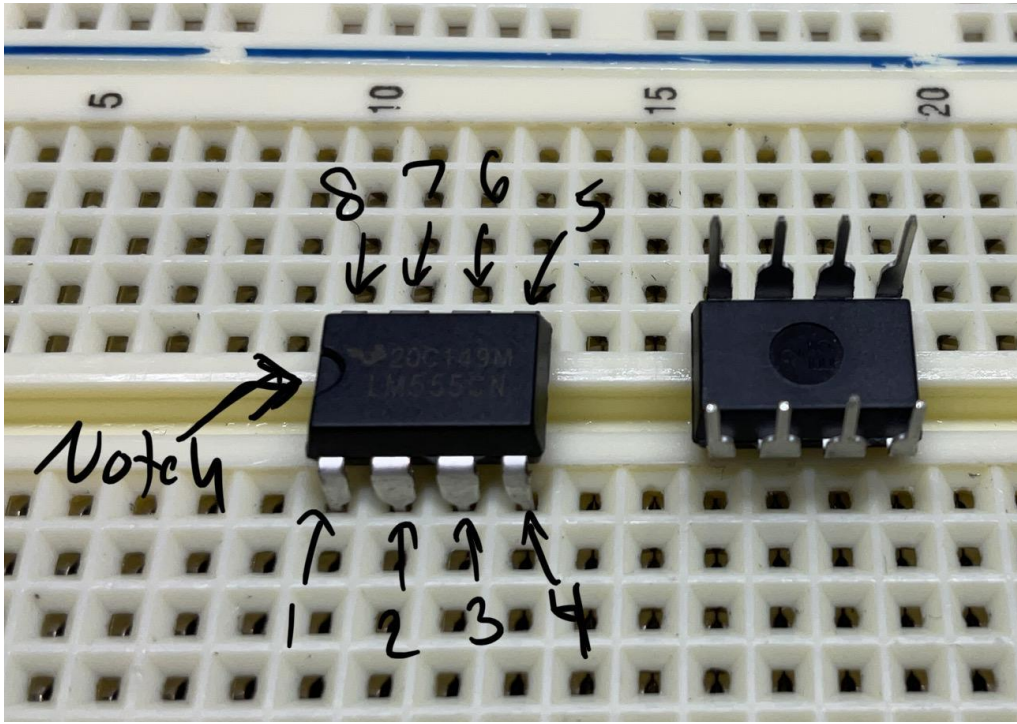
What is a 555 Timer?

555 Timers

- The **555 timer** is an integrated circuit chip used in a variety of timer, delay, pulse generation, and oscillator applications.
- The chip can be run in three primary modes.
  - **Bistable mode** – the 555 operates as a flip-flop which can be used as an on/off switch.
    - We will manually turn the chip on and off.
  - **Monostable mode** – the 555 functions as a "one-shot" pulse generator. The duration of this single pulse can be adjusted with an RC circuit.
    - We will manually turn the chip on but it will turn itself off.
  - **Astable mode** – the 555 can operate as an electronic oscillator. The frequency of this oscillation can be adjusted with an RC circuit.
    - The chip will turn itself on and off!

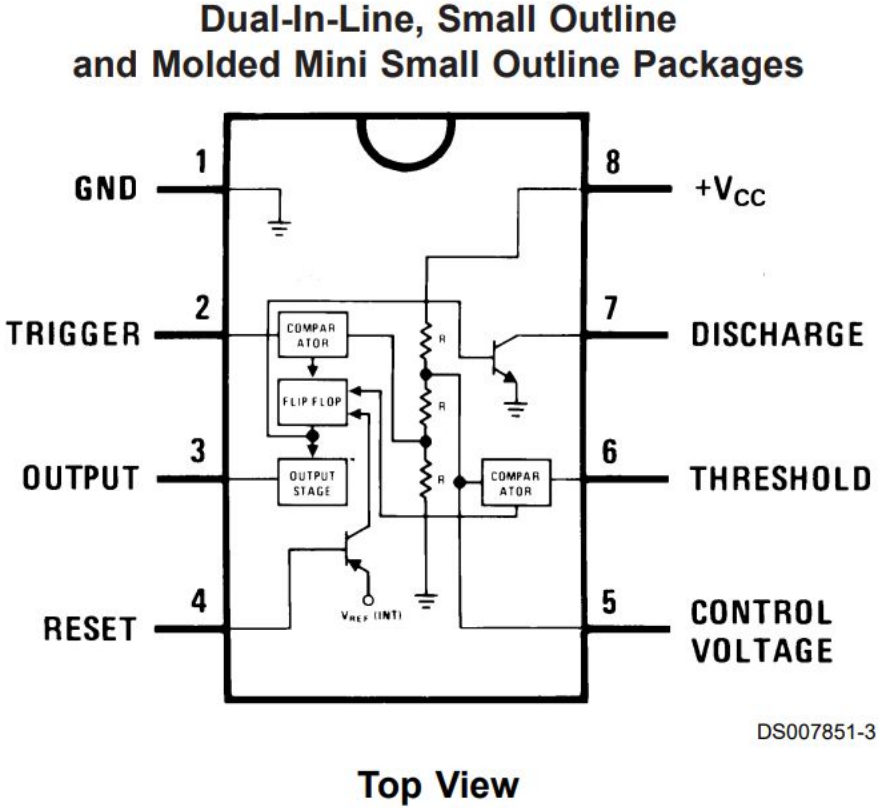
555 Timers

- Just like our op amps, the 555 timer has 8 pins, each with a specific role and purpose in the operation of the chip.
- Also note the orientation of the notch on the chip.
- Inside this little chip is about 25 transistors, 2 diodes, and roughly 16 resistors!



The Data Sheet: 555 Timer

- We can safely operate with an input voltage Vcc from 4.5 to 16 volts.
- A 9 volt battery will work perfectly!



The Data Sheet: 555 Timer

Pin Functions

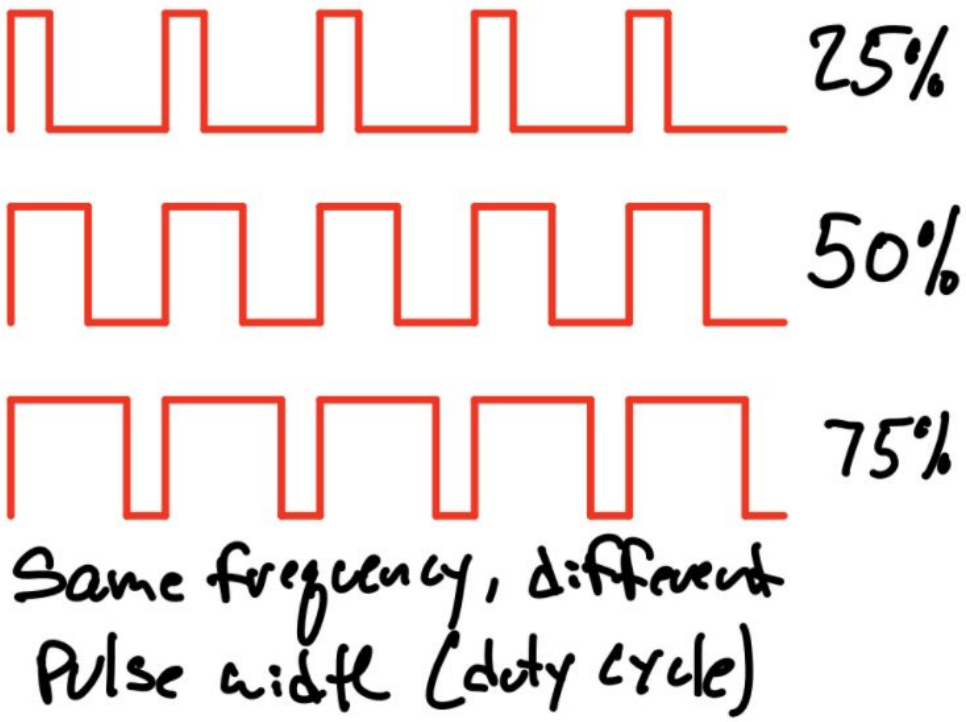
PIN		I/O	DESCRIPTION
NO.	NAME		
5	Control Voltage	I	Controls the threshold and trigger levels. It determines the pulse width of the output waveform. An external voltage applied to this pin can also be used to modulate the output waveform
7	Discharge	I	Open collector output which discharges a capacitor between intervals (in phase with output). It toggles the output from high to low when voltage reaches 2/3 of the supply voltage
1	GND	O	Ground reference voltage
3	Output	O	Output driven waveform
4	Reset	I	Negative pulse applied to this pin to disable or reset the timer. When not used for reset purposes, it should be connected to VCC to avoid false triggering
6	Threshold	I	Compares the voltage applied to the terminal with a reference voltage of 2/3 Vcc. The amplitude of voltage applied to this terminal is responsible for the set state of the flip-flop
2	Trigger	I	Responsible for transition of the flip-flop from set to reset. The output of the timer depends on the amplitude of the external trigger pulse applied to this pin
8	V+	I	Supply voltage with respect to GND

555 Timer Pins:

- **Pin 1 - Ground**: Connect this pin to ground!
- **Pin 8 - Vcc**: Connect this pin to Vcc (9 volts)!
- **Pin 3 - Output**: This is the output of the chip. The output will be some type of square wave or pulse (either on - **high** or off - **low**).

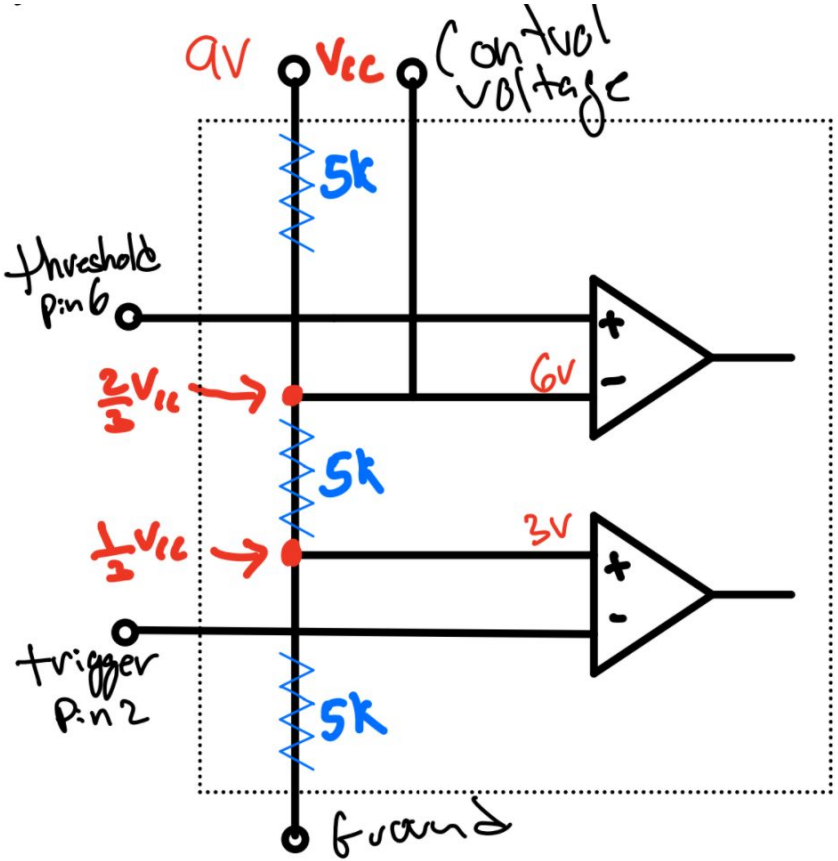
555 Timer Pins

- **Pin 4 - Reset**: This pin is used to reset the state of the chip. It is an “active low” pin. This means that if pin 4 is brought “low” or to ground, the chip will reset. We often don’t want the chip to reset so we will keep this pin “high” by connecting it to Vcc.
- **Pin 5 - Control Voltage:** This pin controls the threshold and trigger levels; essentially how long the chip should produce an output (be on) and how long it should not produce an output (be off). Changing this alters the width of the pulse created. When not in use, it should be connected to ground through a capacitor to eliminate any noise.



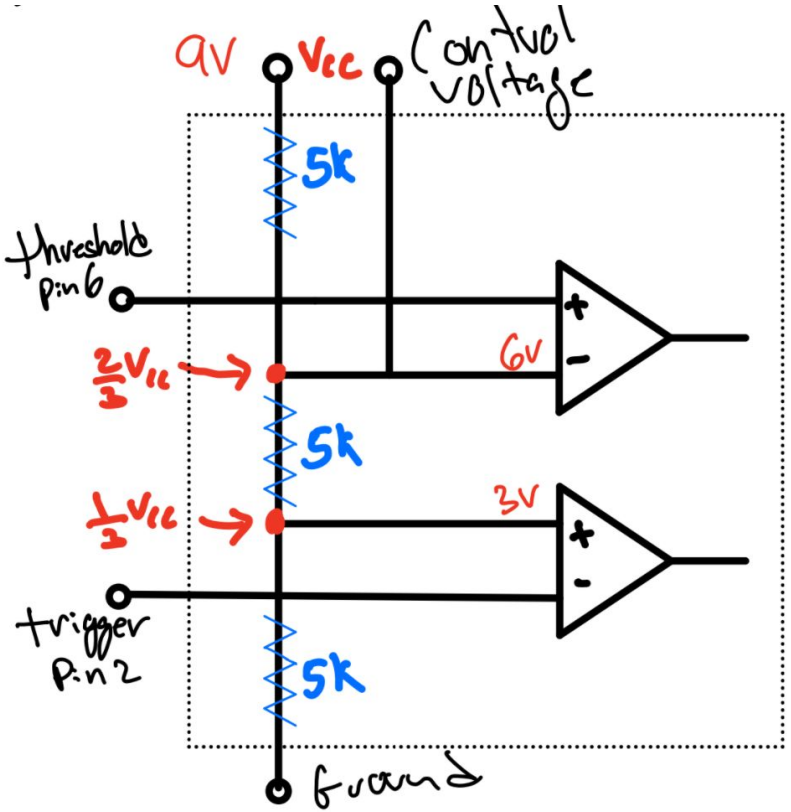
555 Timer Pins

- **Pin 2 - Trigger**: One of the main pins of the chip; it is how the chip gets “triggered” to create a pulse. The pin is an active low pin. This means that the pin is only activated when the voltage being fed into it is low, or less than ⅓ of the supply voltage.
- Since we are supplying the 555 timer with 9 volts, once the voltage at this pin gets to 3 volts or lower, the pin activates.
- When the 555 timer is triggered via pin 2, the output at pin 3 goes HIGH and turns on.



555 Timer Pins

- **Pin 6 - Threshold**: Another main pin of the chip; it is how the chip gets turned off to stop a pulse. This pin is an active high pin. This means that the pin is only activated when the voltage being fed into it is high, or greater than ⅔ the supply voltage; we can alter this ⅔ Vcc value using the control voltage.
- Since we are supplying the 555 timer with 9 volts, once the voltage at this pin gets to 6 volts or higher, the pin activates.
- When this happens, the output at pin 3 goes LOW and turns off.



555 Timer Pins

- **Pin 7 - Discharge**: If you put a capacitor on this pin, the capacitor will take time to charge/discharge.
- This capacitor in conjunction with external resistors can create an RC timing network used to control how long an output pulse lasts.

Now that we have an overview of each pin, let’s see if we can wire up the 555 timer in each of its three modes of operation!

Bistable Mode

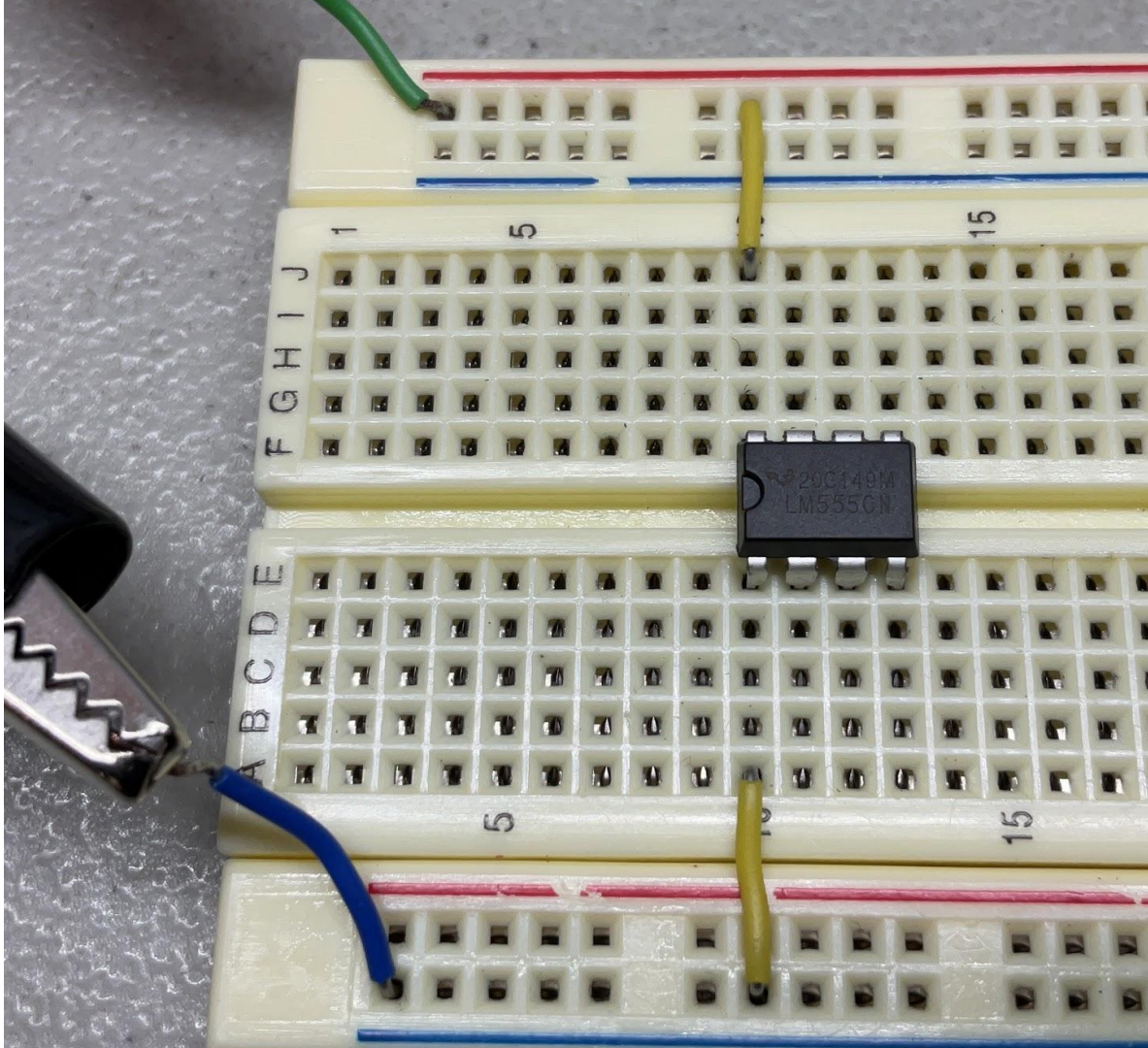
Bistable Mode

- We are going to create a 555 timer circuit in **bistable mode**.
  - When you press a button, you will send the trigger pin LOW resulting in the chip turning on.
  - When you press a second button, you will send the reset pin LOW resetting the chip and turning it off.

- A bistable system has two equilibrium states that it can remain in.
- In our case, the bistable 555 timers equilibrium states are either on or off.

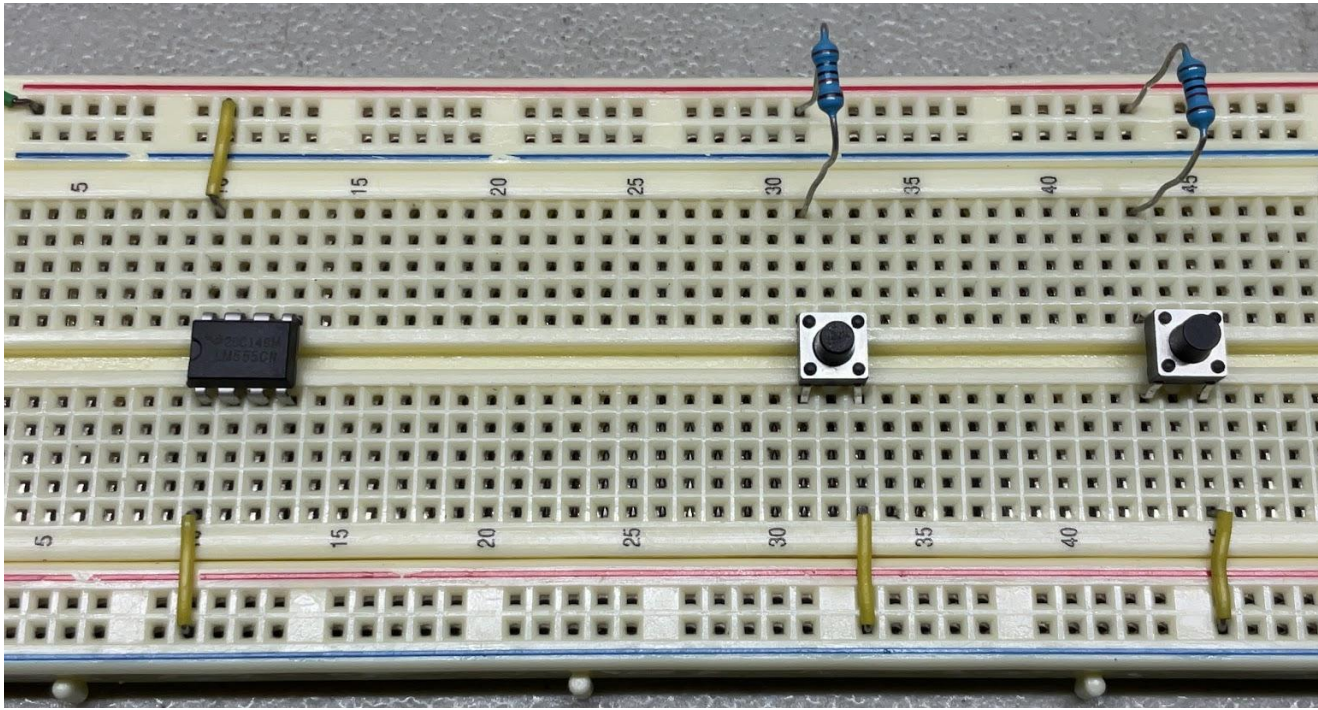
Bistable Mode

- Connect pin 1 (ground) to ground.
- Connect pin 8 (Vcc) to Vcc.



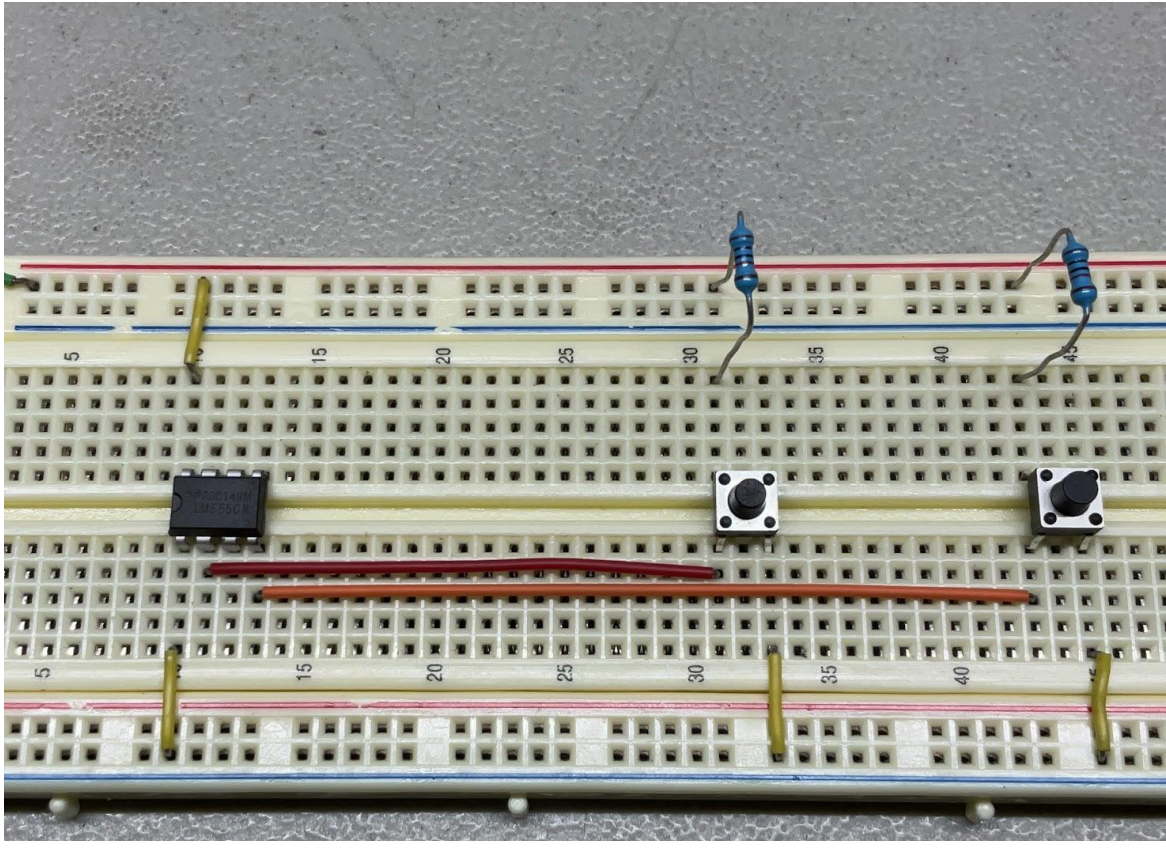
Bistable Mode

- Connect two push buttons to Vcc each through a 10K (brown, black, black red) resistor.
- Ground the opposite side of each push button.
- We will use these buttons to manually turn the 555 timer on and off.



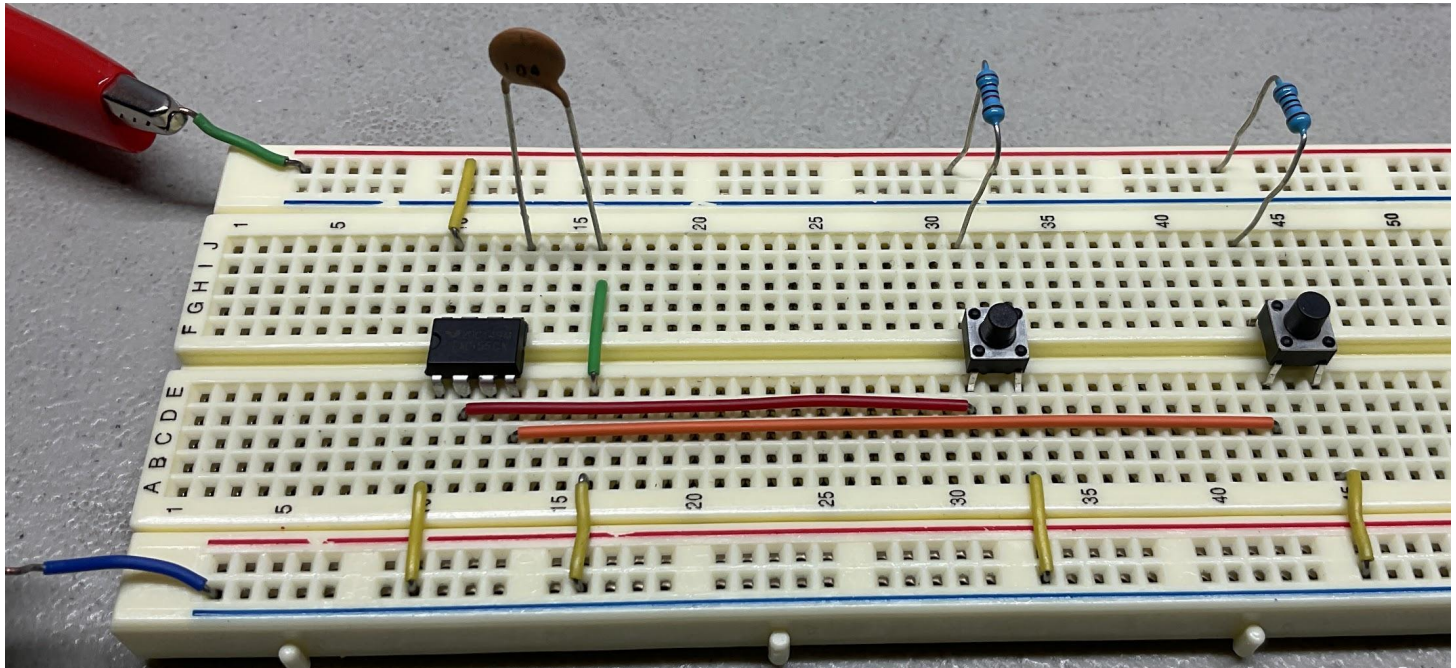
Bistable Mode

- On the same side as Vcc, connect the push buttons to pin 2 (trigger) and pin 4 (reset).
- Pin 2 (trigger) is kept high as it is connected to Vcc. When the button is pressed, pin 2 will go low causing the chip to trigger and turn on.
- Pin 4 (reset) is kept high as it is connected to Vcc. When the button is pressed, pin 4 will go low causing the chip to reset and the output to turn off.



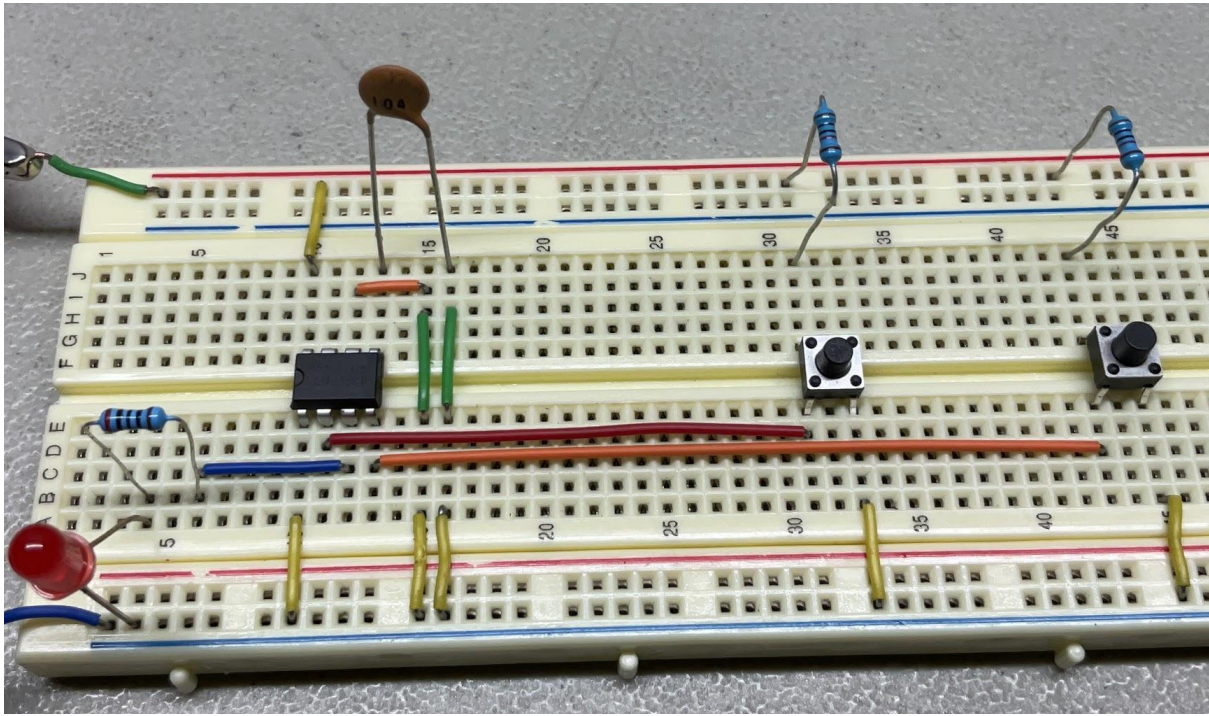
Bistable Mode

- Pin 5 (control voltage) can be used to vary the width of the pulse created.
- We won’t be using pin 5.
- We should ground pin 5 through a 100 nanoFarad (104) capacitor to reduce noise.



Bistable Mode

- Pin 6 (threshold) in conjunction with pin 7 (discharge) are in control of keeping the chip on for a specific amount of time.
- We want the chip to stay on forever until we reset by pressing our push button.
- Since, pin 6 is an active high pin, we will ground pin 6 so the chip never turns off unless we press our push button.
- Lastly, we'll take pin 3 (output) away from the chip and connect a 200 ohm resistor (red, black, black, black) to ground through an LED.



Monostable Mode

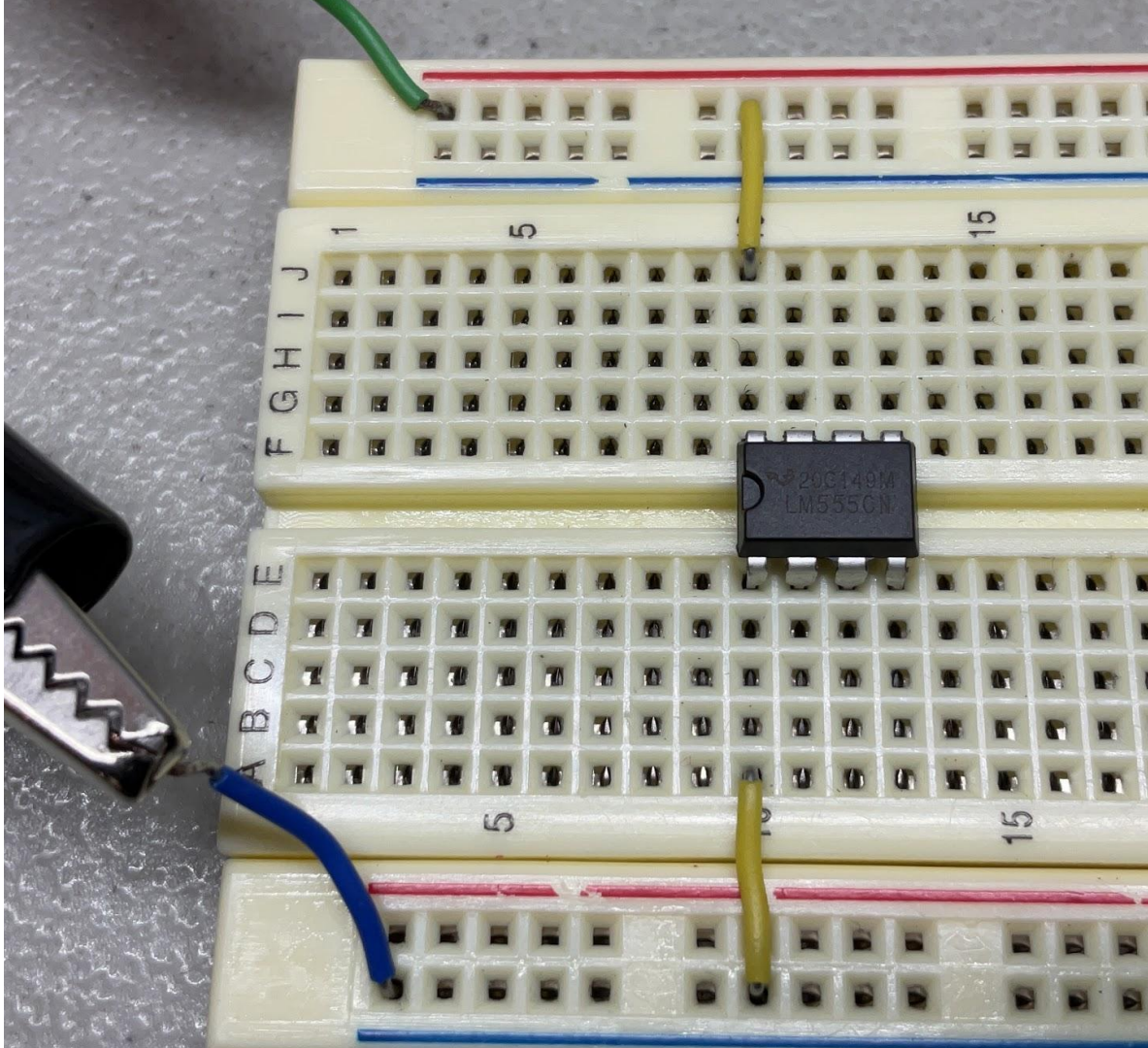
Monostable Mode

- We are going to create a 555 timer circuit in **monostable mode**.
  - When you press a button, you will send the trigger pin LOW resulting in the chip turning on.
  - The chip will stay on for a predetermined amount of time based on an RC circuit connected to the threshold and discharge pins and then the chip will turn off on its own.

- A monostable system has one equilibrium state that it can remain in.
- In our case, the monostable 555 timers equilibrium state is when it is off.

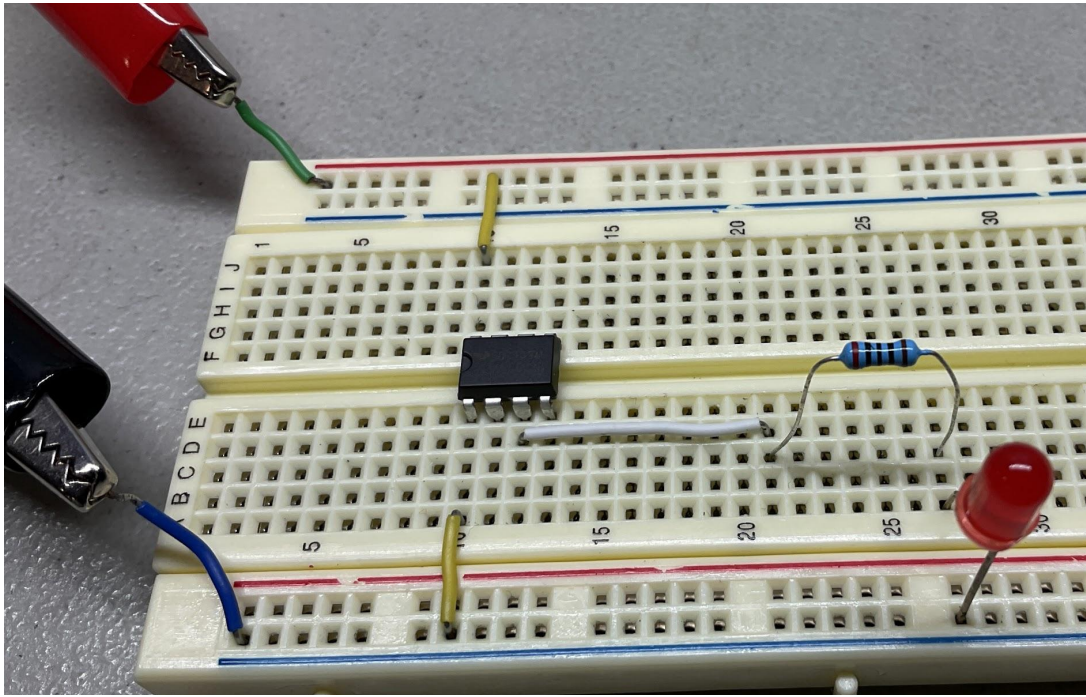
Monostable Mode

- Connect pin 1 (ground) to ground.
- Connect pin 8 (Vcc) to Vcc.



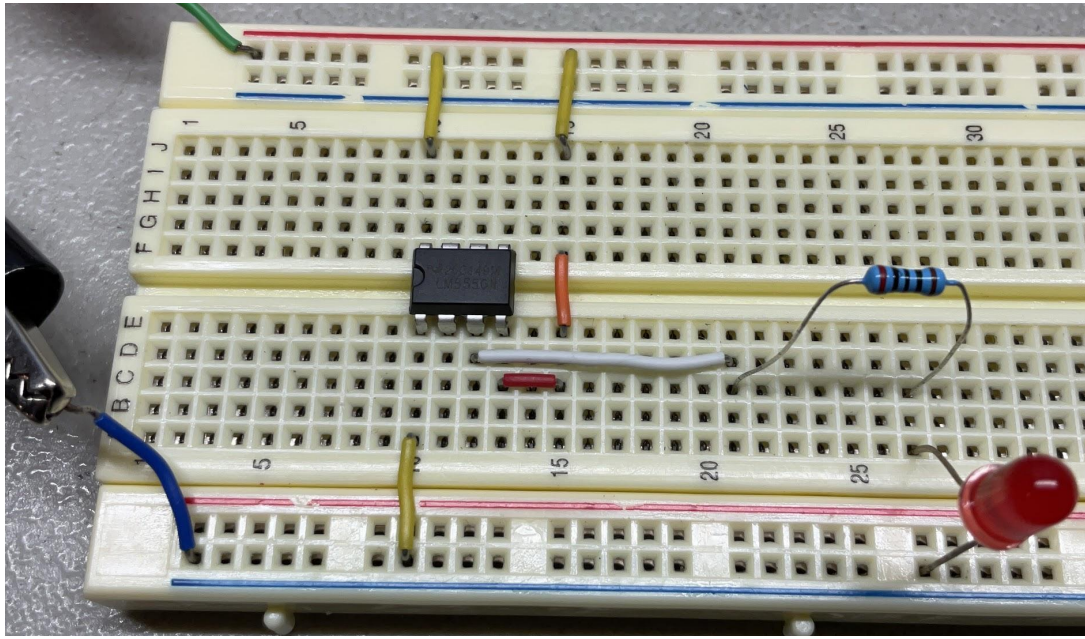
Monostable Mode

- Move pin 3 (output) away from the chip with a jumper wire for easy access.
- Connect a 200 ohm (red, black, black, black) resistor to the output with an LED going to ground.
- When our chip outputs a high signal or is on, the LED should turn on.



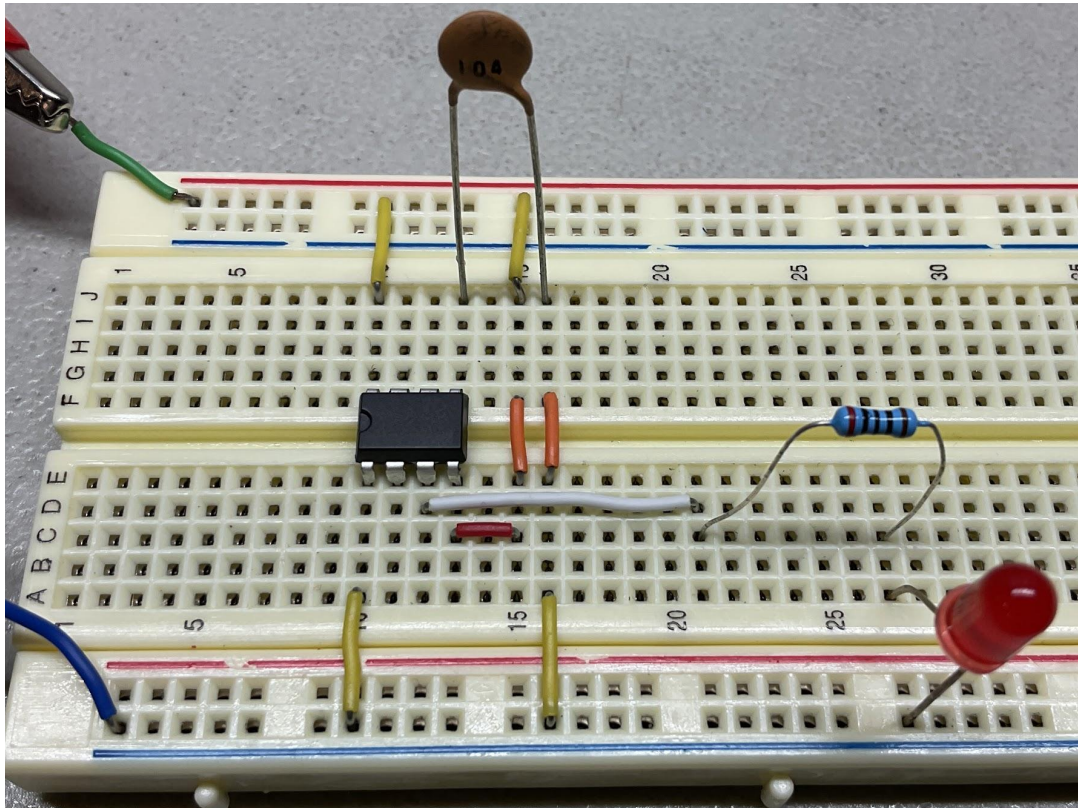
Monostable Mode

- Connect pin 4 (reset) to Vcc.
- We do not want our chip resetting.
- Pin 4 is an active low pin so connecting it to Vcc or high will ensure that the chip does not reset.



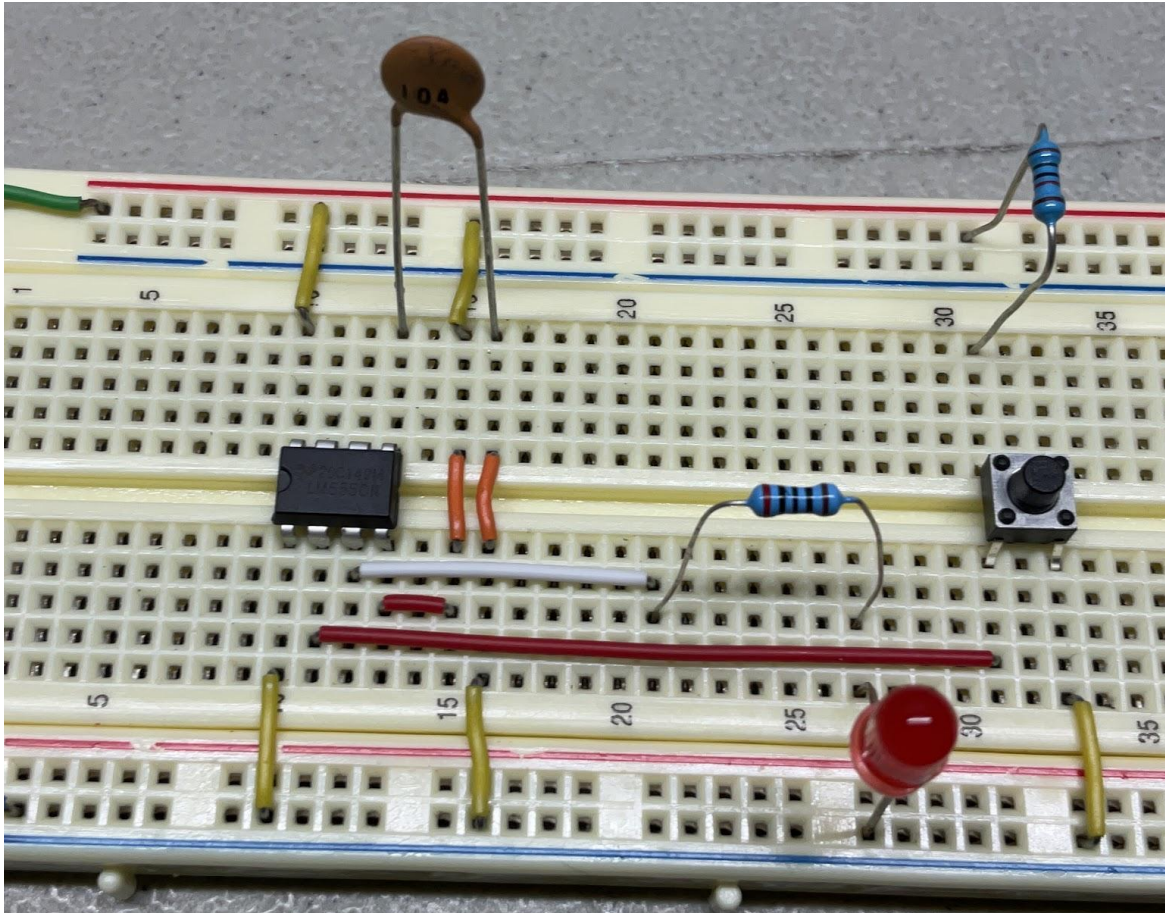
Monostable Mode

- Pin 5 (control voltage) can be used to vary the width of the pulse created.
- We won’t be using pin 5.
- It’s good practice to put pin 5 to ground through a capacitor to reduce noise.
- Connect pin 5 to ground through a 100 nanoFarad capacitor (104).



Monostable Mode

- Pin 2 (trigger) is an active low pin.
- Anytime the voltage at this pin drops below ⅓ Vcc, the chip is “triggered” and the output at pin 3 will go high (the chip turns on).
- Take a 10K (brown, black, black red) resistor from Vcc into a push button.
- On the same side of the button, connect pin 2. This ensure that the voltage at pin 2 is higher than 3 volts.
- Ground the other side of the button. When the button is pressed, the voltage at pin 2 will drop below 3 volts and the chip will be triggered turning on.



Monostable Mode

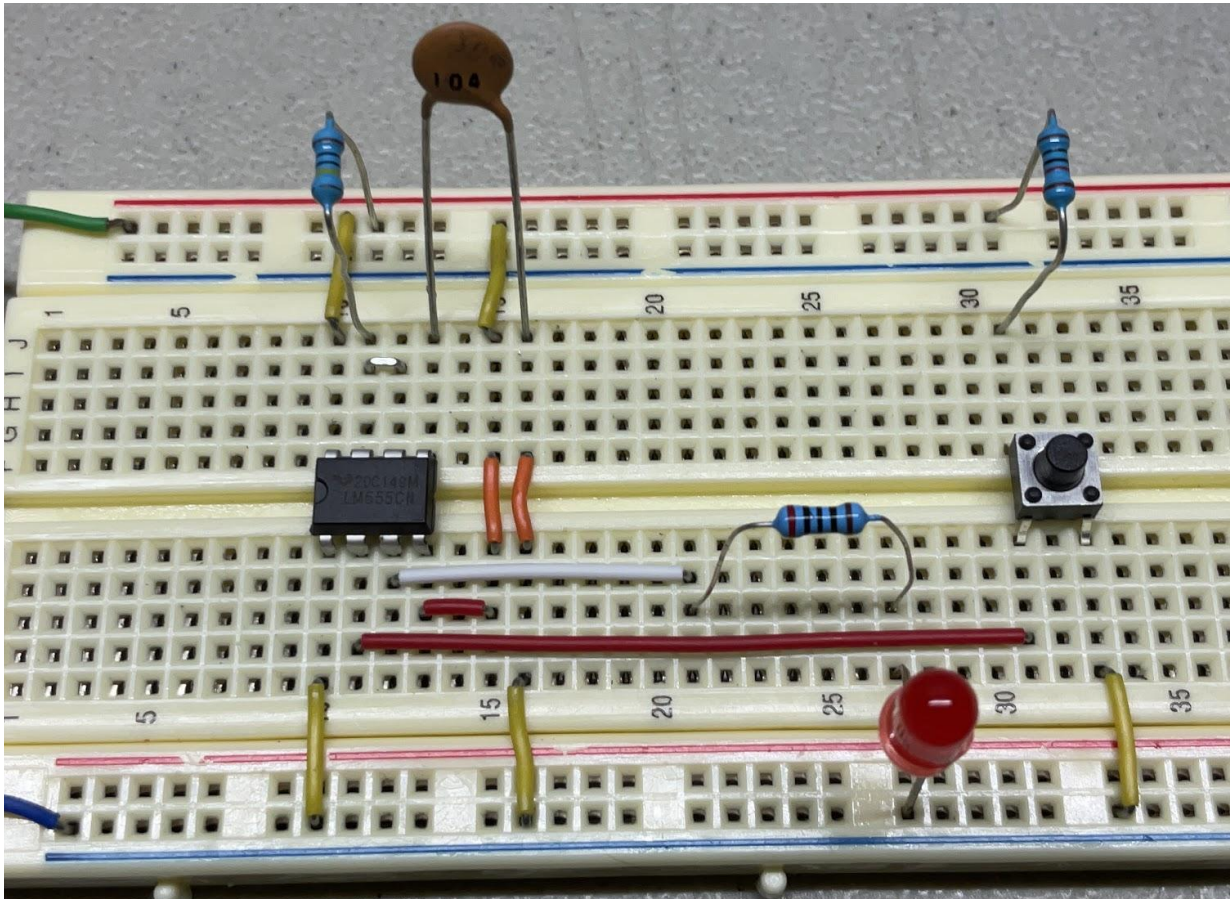
- To turn the chip off and end our pulse, we have to get the voltage at pin 6 (threshold) to be higher than ⅔ Vcc.
- We also want the duration of our pulse to last a specific amount of time, which we can do with a capacitor on pin 7 (discharge).
- We are going to create an RC network through pins 6 and 7.
- The time of the duration or pulse width is given as:

Output Pulse Width (secs) = 1.1 x R C

- We'll use a 1M resistor and 1 microFarad capacitor for a pulse width of approximately 1.1 seconds.

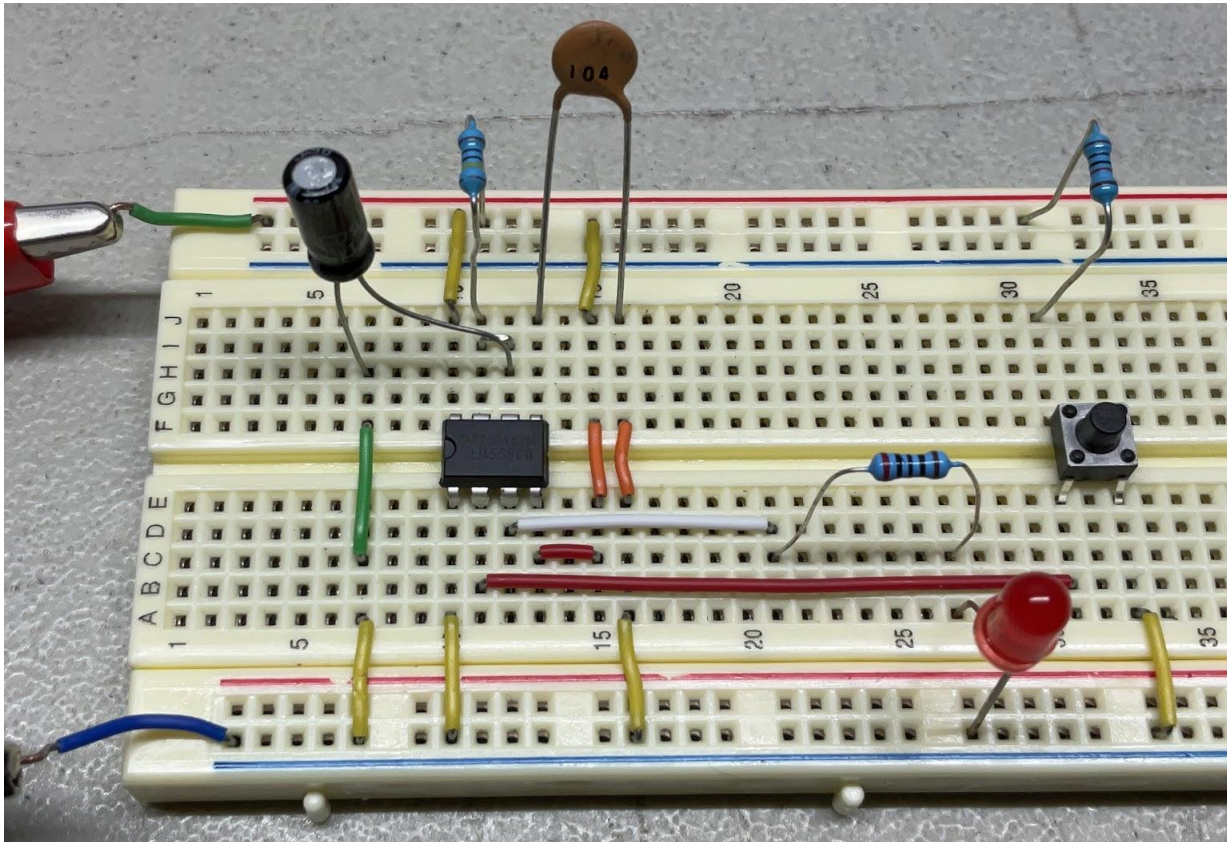
Monostable Mode

- Connect pin 7 (discharge) to Vcc through a 1M (brown, black, black, yellow) resistor.
- Connect pin 7 (discharge) to pin 6 (threshold) via a jumper wire.



Monostable Mode

- Connect pin 6 (threshold) to ground through a 1 microFarad capacitor.
- The RC circuit is now complete.
- Play around with different values of R and C to see how the timing of the pulse is affected.



Astable Mode

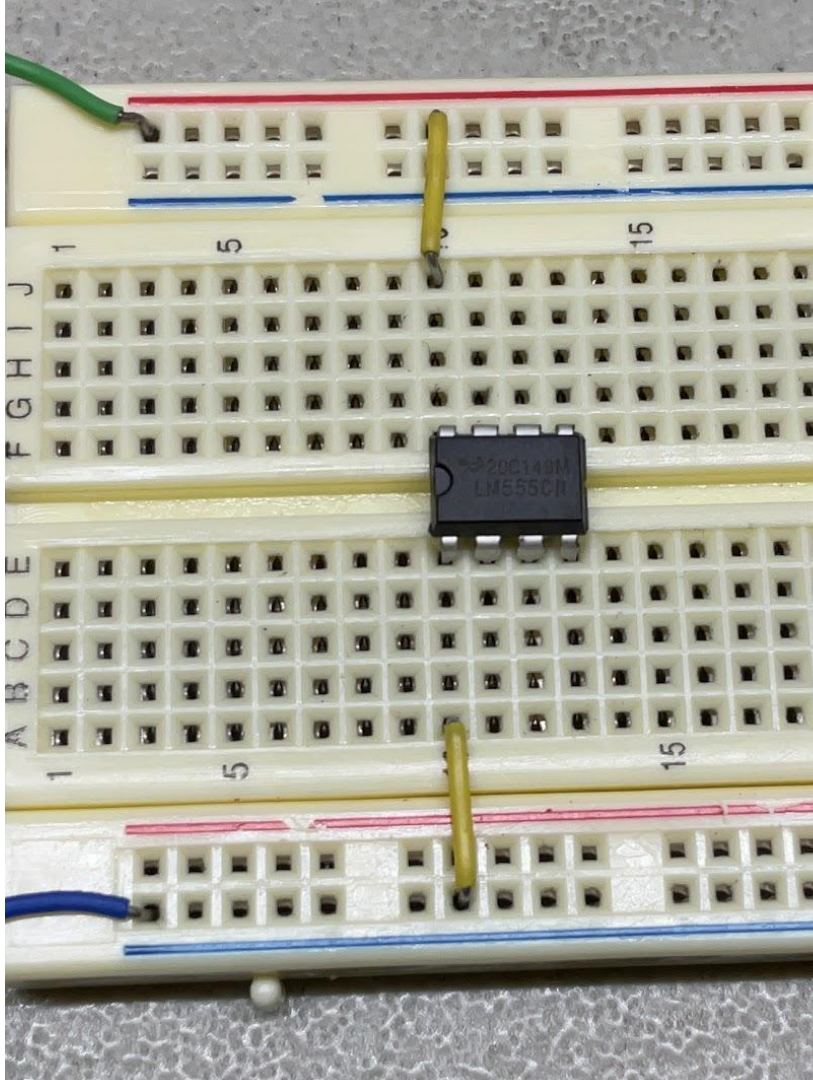
Astable Mode

- We are going to create a 555 timer circuit in **astable mode**.
  - No buttons will be pressed to turn the chip on.
  - No buttons will be pressed to turn the chip off.
  - The chip will turn itself on/off at a predetermined rate creating an oscillation.

- An astable system has zero equilibrium states that it can remain in. It continuously oscillates between unstable states.
- In our case, the astable 555 timer will oscillate between on and off.

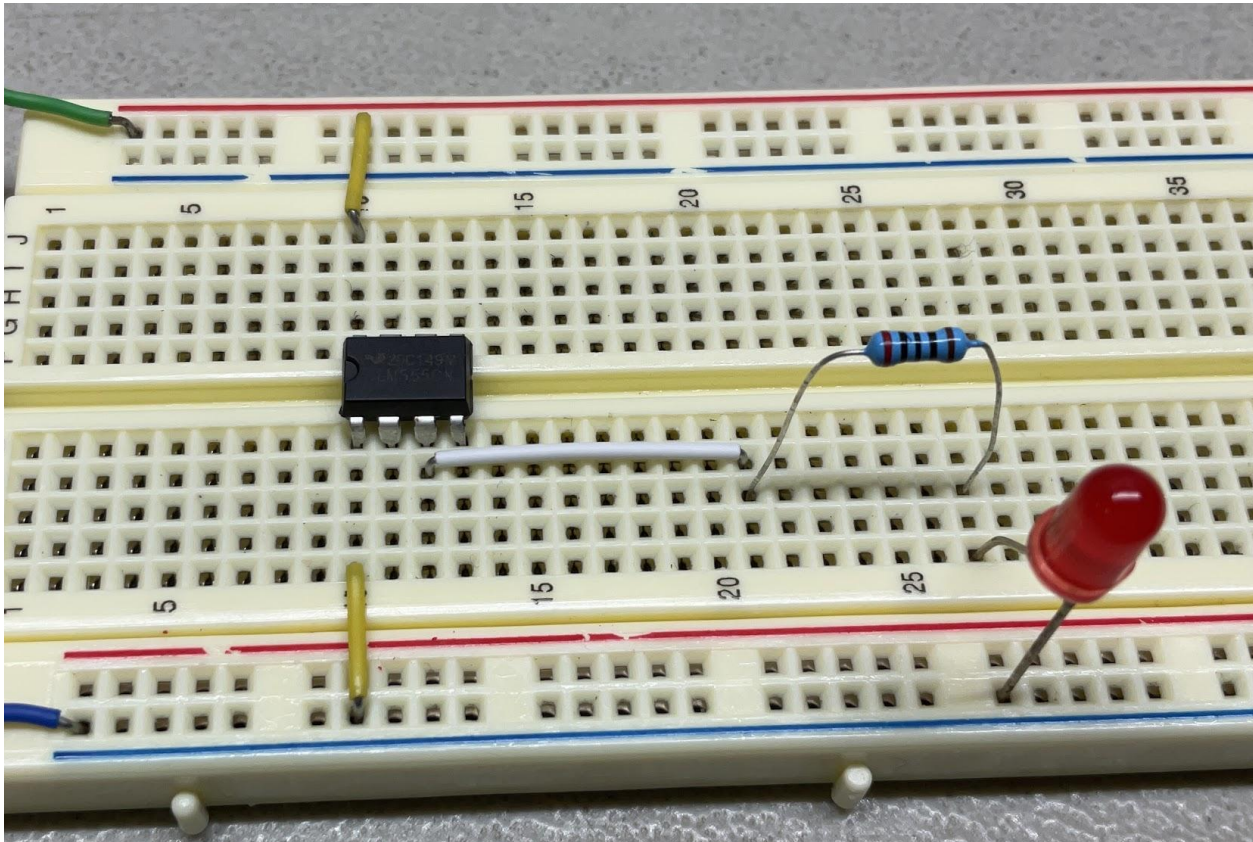
Astable Mode

- Connect pin 1 (ground) to ground.
- Connect pin 8 (Vcc) to Vcc.



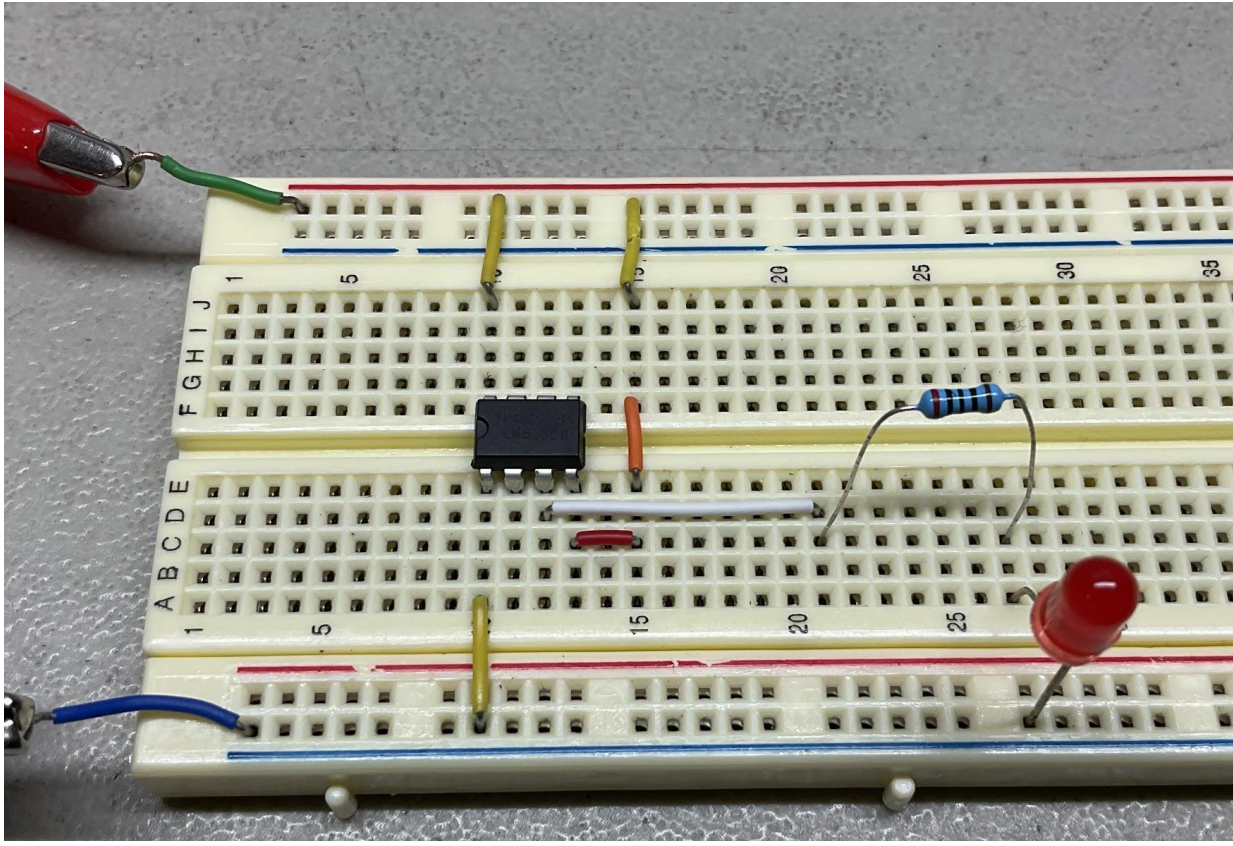
Astable Mode

- Move pin 3 (output) away from the chip for easy access with a jumper wire.
- Connect a 200 ohm (red, black, black, black) resistor to ground through an LED.



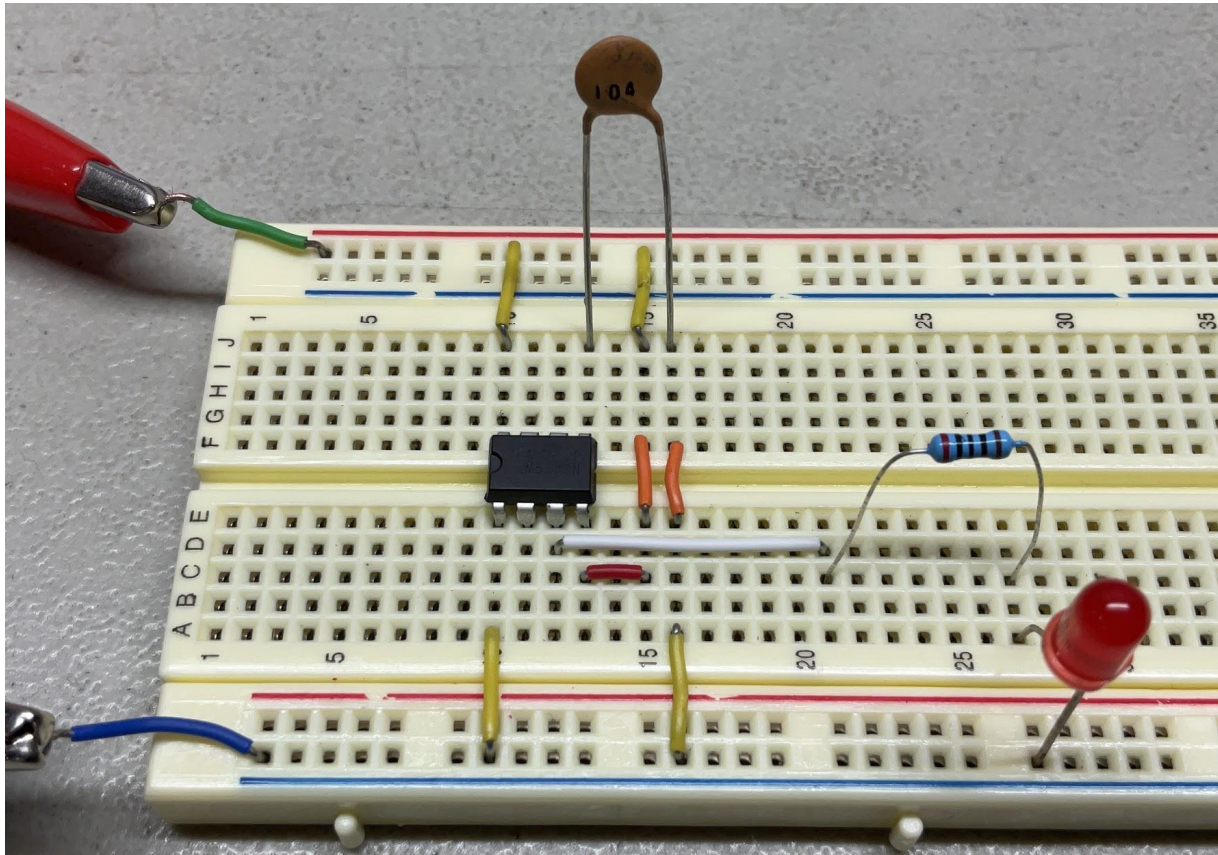
Astable Mode

- We do not want the chip to reset at any point.
- Connect pin 4 (reset) to Vcc.
- This will keep pin 4, which is an active low pin, high at all times ensuring that the chip does not reset.



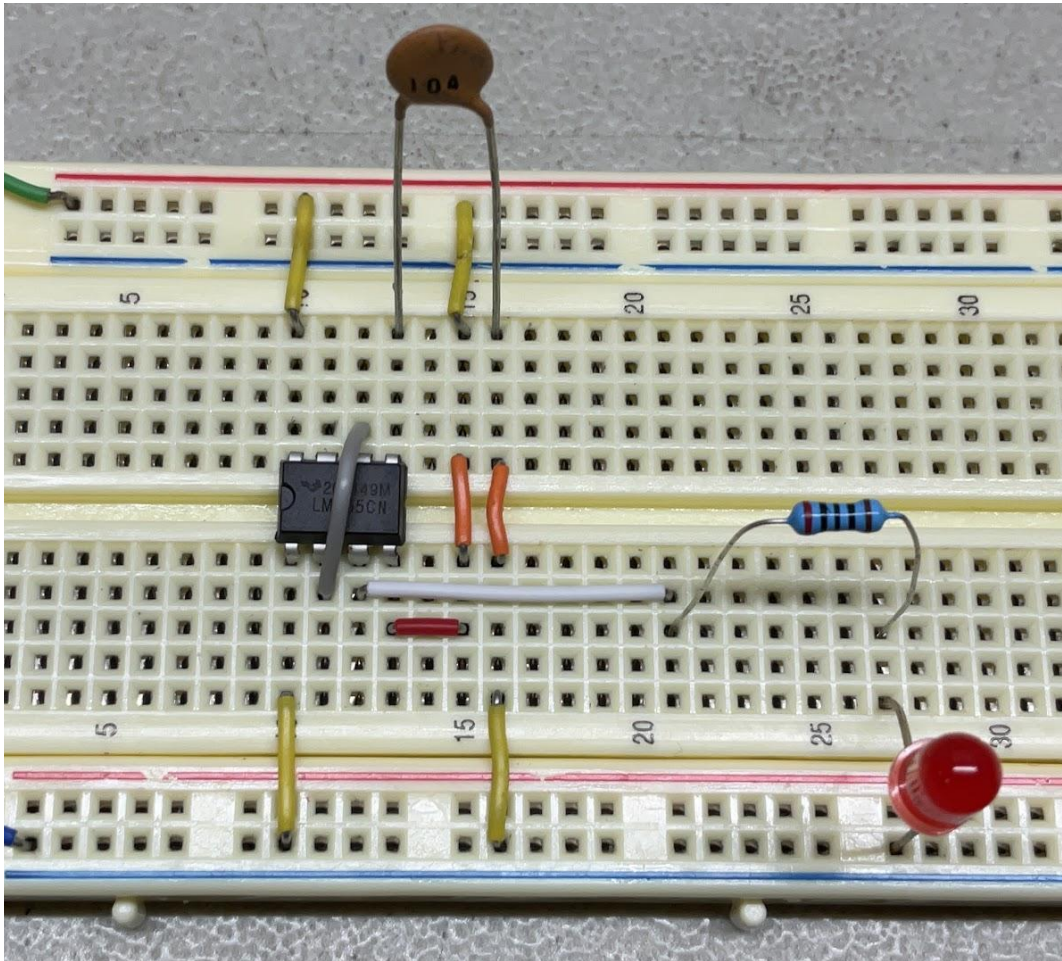
Astable Mode

- Connect pin 5 (control voltage) to ground through a 100 nanoFarad (104) capacitor.
- Later, we will use the control voltage to vary the pulse width of our signal.



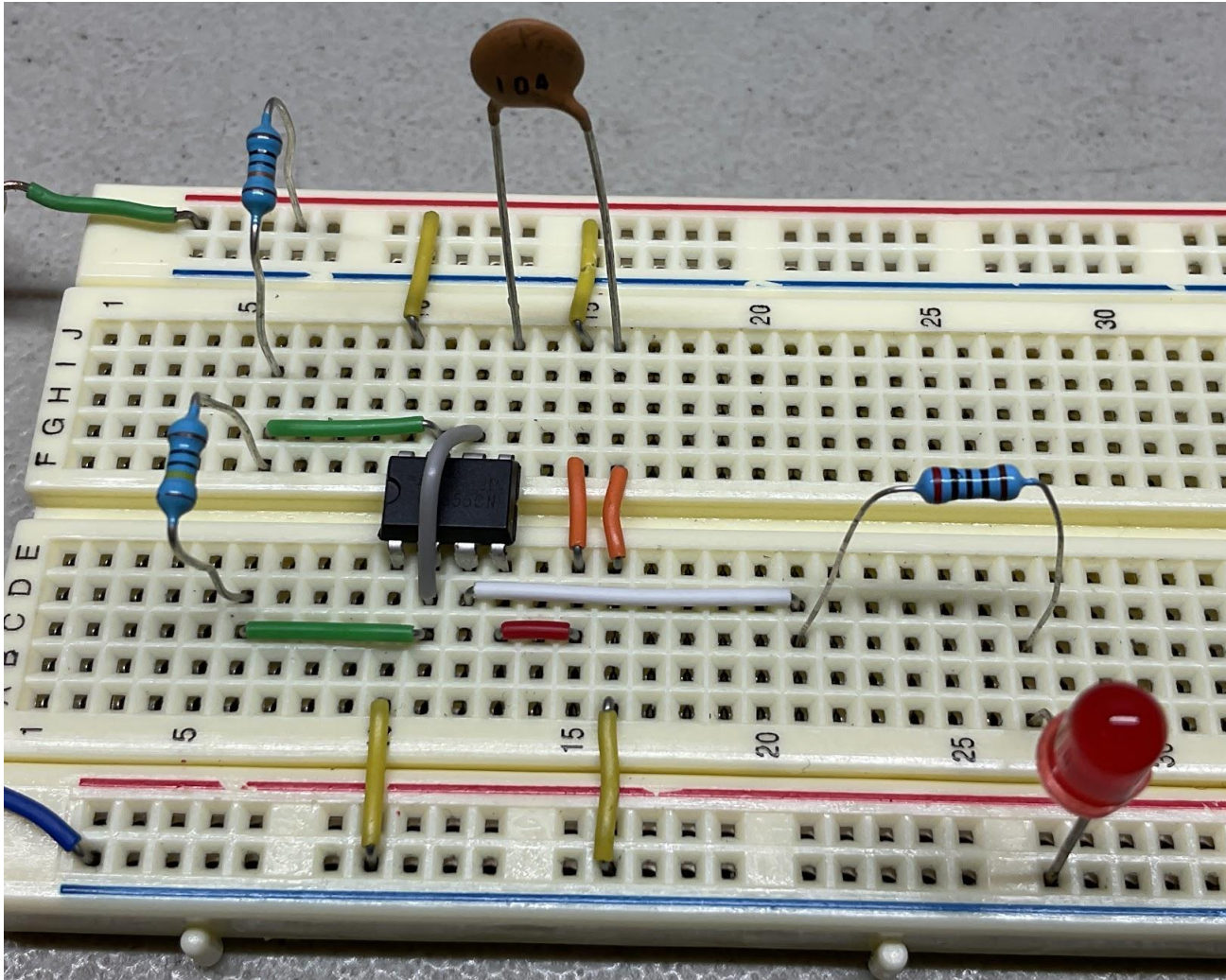
Astable Mode

- Connect pins 2 (trigger) and 6 (threshold) together via a jumper.
- The voltage at these pins will constantly vary between 0 and 9 volts by using a voltage divider with a capacitor eventually connected to these pins.
- If pin 2 (trigger) drops below ⅓ Vcc, the chip will turn on.
- If pin 6 (threshold) exceeds ⅔ Vcc, the chip will turn off.
- The RC circuit we connect to these two pins will vary our voltage for us so the chip is constantly turning on and off as the connected capacitor charges and discharges.



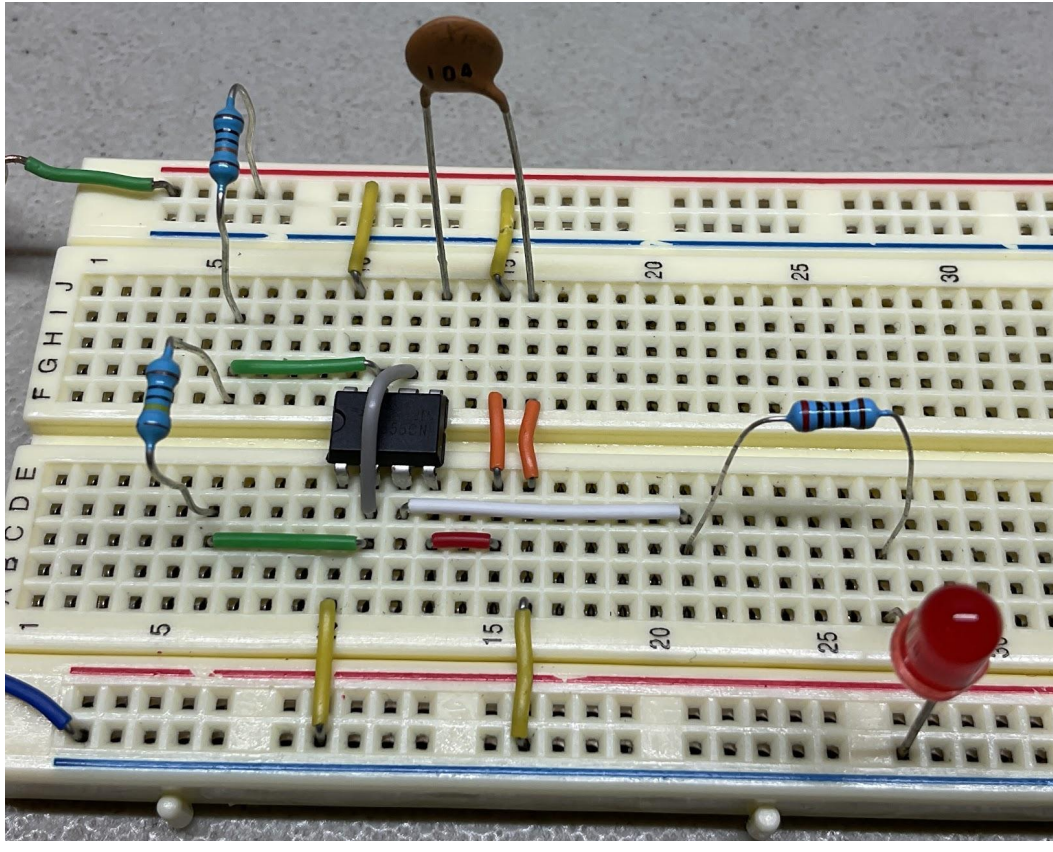
Astable Mode

- Create a voltage divider using a 100K (brown, black, black, orange) and 1M (brown, black, black, yellow) resistor starting at Vcc.
- Send the midpoint of the voltage divider to pin 7 (discharge).
- Send the end of the voltage divider to pin 2 (trigger).



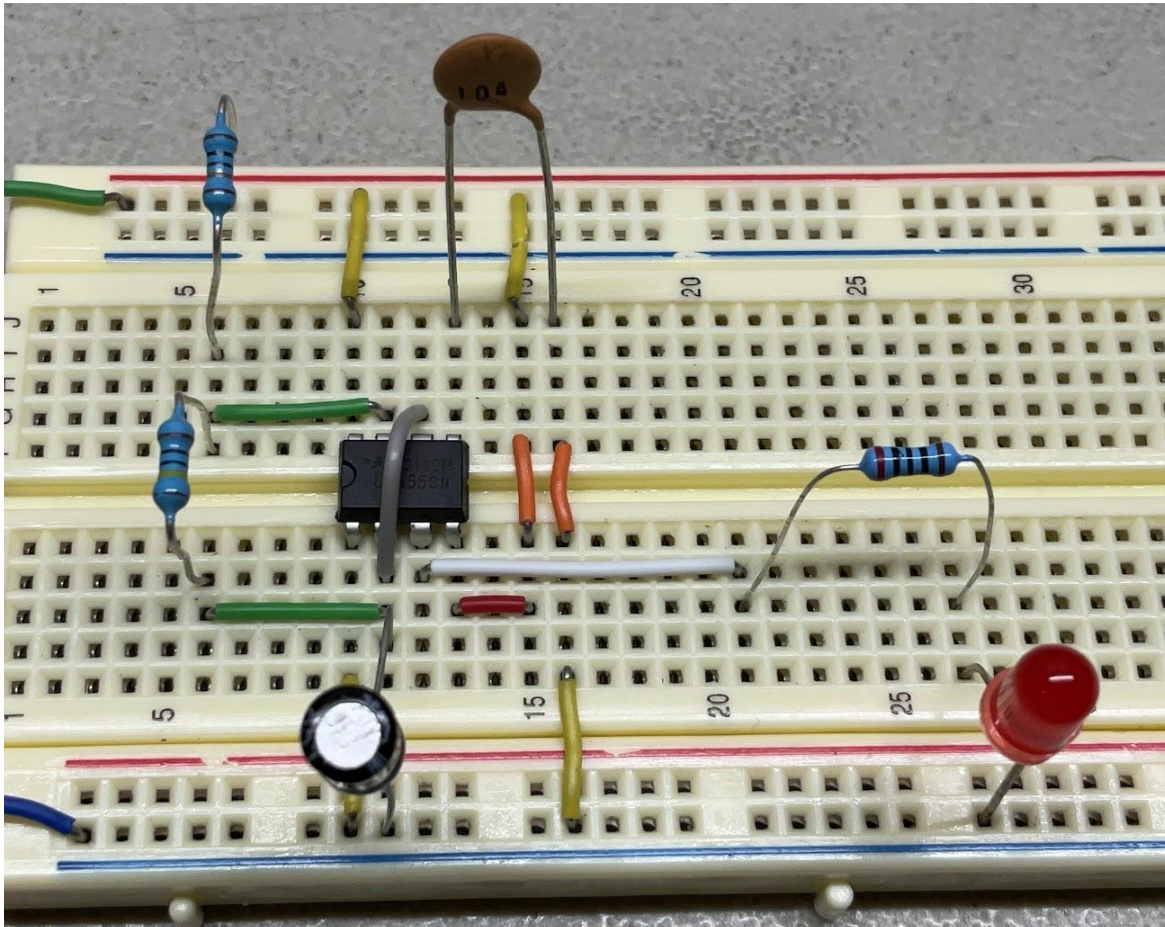
Astable Mode

- This voltage divider sets up a larger voltage at pin 7 (discharge) and a smaller voltage at pin 2 (trigger).
- Recall that pin 6 (trigger) is tied to pin 2 (trigger) so pin 6 is also at smaller voltage.
- We need a way to vary the voltage at pin 2/6.



Astable Mode

- Connect a 1 microFarad capacitor to ground through pin 2 (trigger).
- This capacitor will charge and discharge as the circuit runs.
- Recall that pin 2 (trigger) and pin 6 (threshold) are connected via the gray jumper wire.
- Once the voltage is above ⅔ Vcc, pin 6 (threshold) will be sent high and the chip will turn off.
- Once the voltage is below ⅓ Vcc, pin 2 (trigger) will be sent low and the chip will turn on.
- This oscillation will continue on until Vcc is removed.



Astable Mode

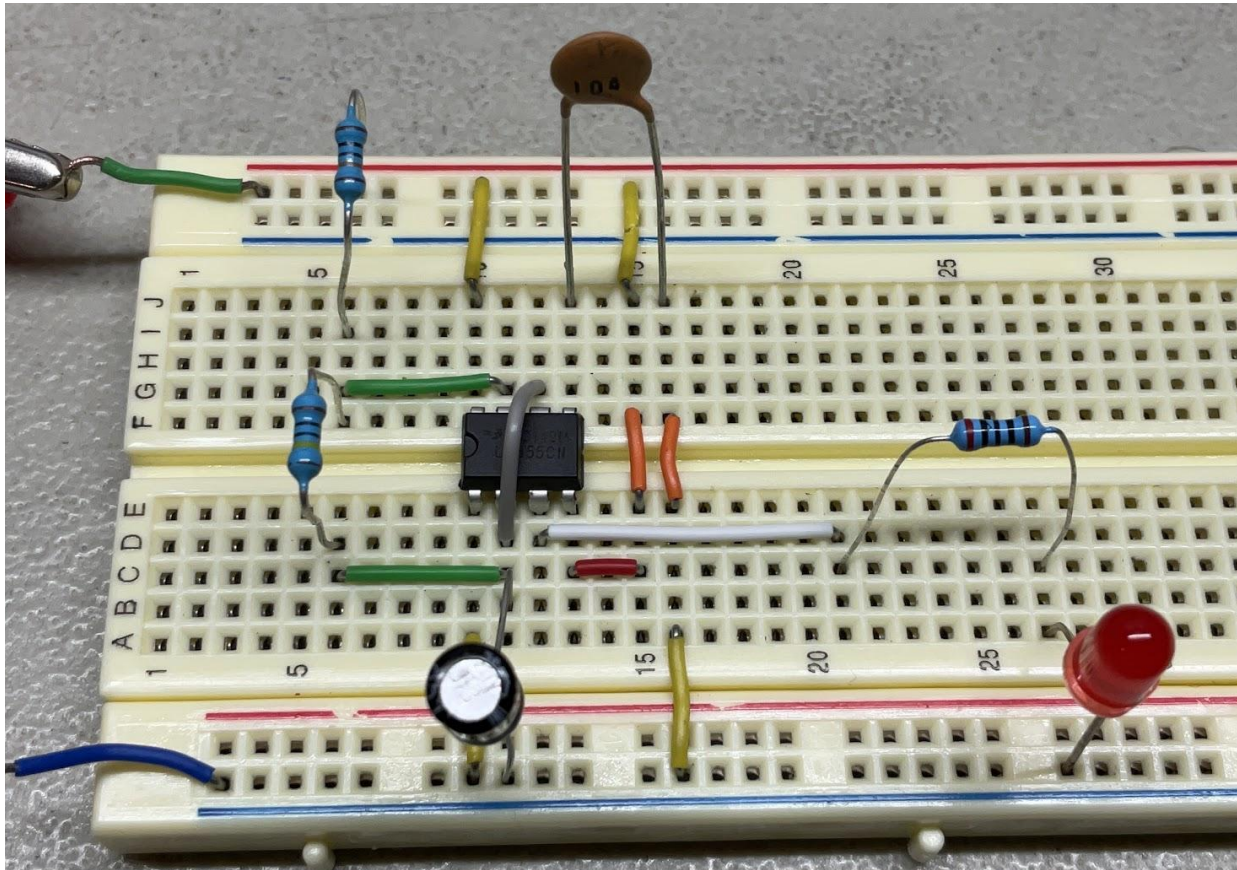
- Our RC circuit consists of R1 = 100K, R2 = 1M, and C = 1 microFarad.
- The output frequency of this wave (on, off, on, off) can be found using the following formula:

$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

- The frequency of our output oscillation should be about 0.7 seconds?

Astable Mode

- Play around with resistor and capacitor values to see how the timing of the pulse is affected.



What About Control Voltage?

- Up until now we have kept pin 5 (control voltage) tied to ground through a 100 nanoFarad capacitor.
- We previously stated that pin 5 (control voltage) can be used to vary the pulse width created at the output.
- It will also vary the output frequency.
- This happens because we are overriding the values of ⅓ Vcc and ⅔ Vcc to start and stop the pulse.
- Replace your 100 nanoFarad capacitor with a light dependent resistor.
- Use your hand to vary the light on the LDR and note the changes in the LED.
- In the next video, note the changes in the duration of the pulse and the frequency of the pulse.