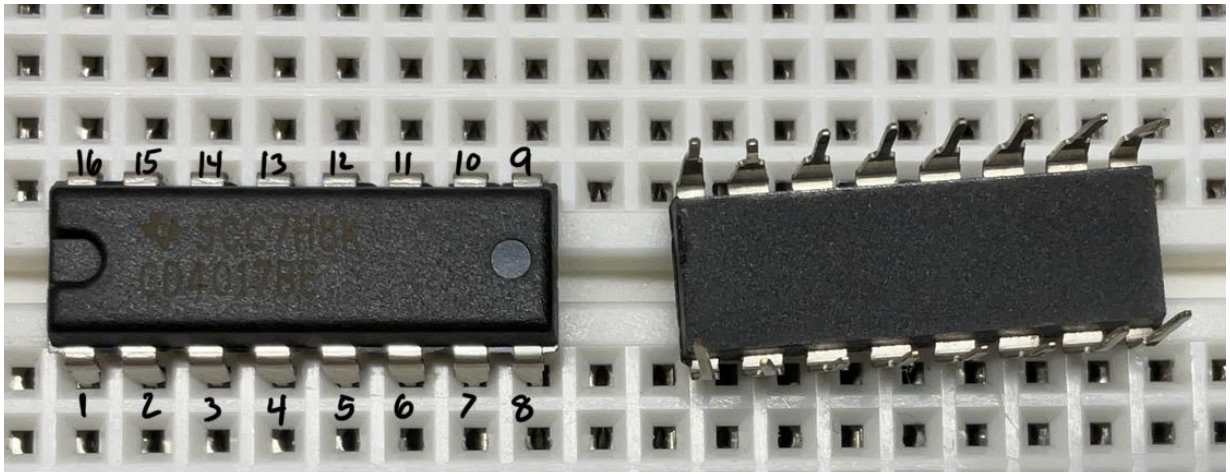
4017 Decade Counters

Our Third IC!

What is a Decade Counter?

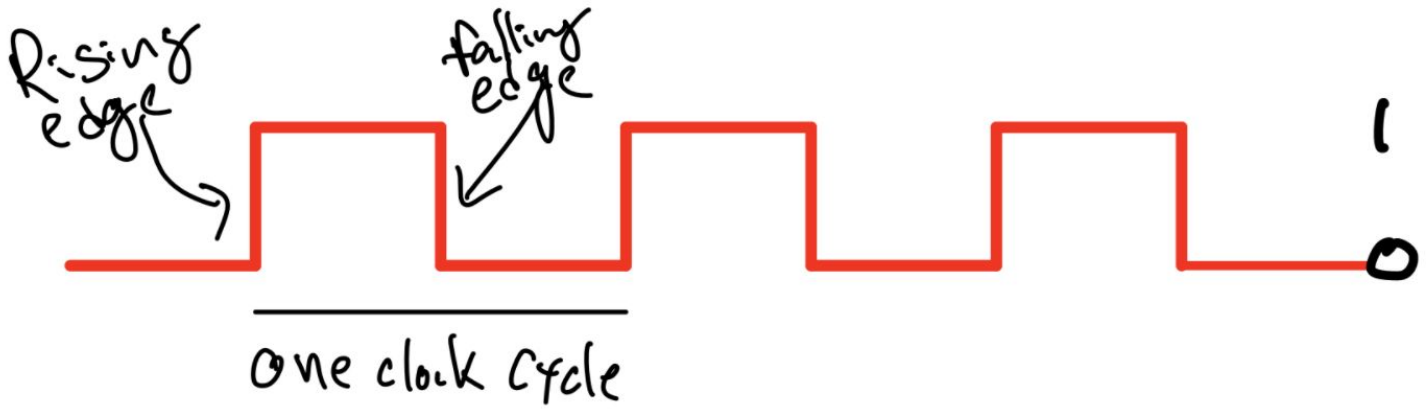
What is a 4017 Decade Counter

- A 4017 decade counter is a 16 pin chip with 10 individual outputs.
- Each of the chip outputs are turned on/off one at a time sequentially or in succession based on a clock signal. We don't have to use all 10 outputs. We can choose how many are included in the cycle.
- So, if we build a circuit with a decade counter and 10 LEDs, the decade counter will cycle through and turn on an LED one at a time, at a rate set by a the clock or timing circuit.



What is a 4017 Decade Counter

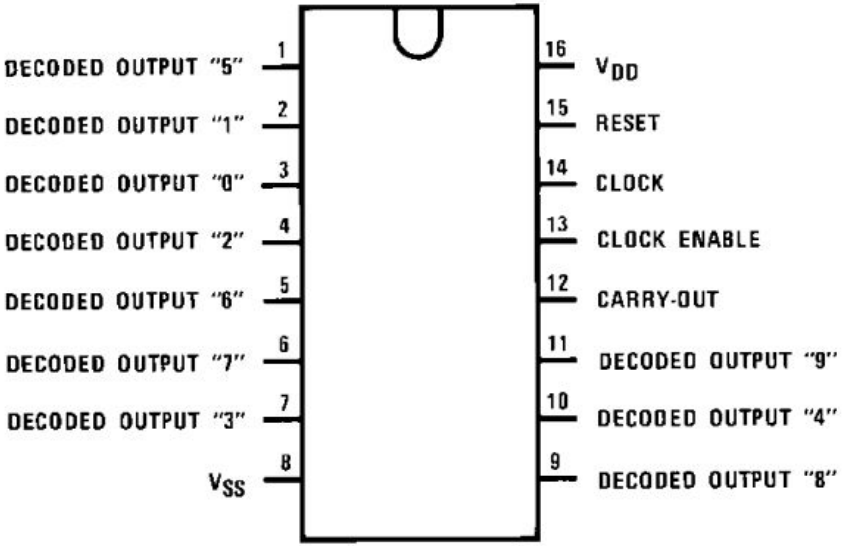
- A clock signal is a signal that oscillates back and forth between high and low and can be used to control when the outputs of a decade counter switch on.
- The rising edge of the clock is when the clock goes from low to high.
- The falling edge of the clock is when the clock goes from high to low.
- Different events can be triggered on the rising or falling edge of the clock.



The Data Sheet: 4017 Decade Counter

Connection Diagrams

Pin Assignments for DIP, SOIC and SOP
CD4017B



Top View

Recommended Operating Conditions (Note 2)

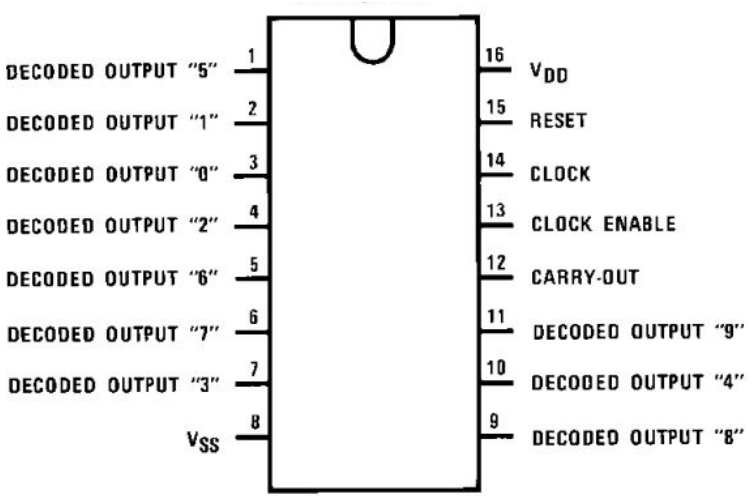
DC Supply Voltage (V_{DD})	+3 V_{DC} to +15 V_{DC}
Input Voltage (V_{IN})	0 to V_{DD} V_{DC}
Operating Temperature Range (T_A)	–40°C to +85°C

Note 1: "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed, they are not meant to imply that the devices should be operated at these limits. The table of "Recommended Operating Conditions" and "Electrical Characteristics" provides conditions for actual device operation.

Note 2: V_{SS} = 0V unless otherwise specified.

4017 Decade Counter Pins

- **Pin 16 (VDD)** is our supply voltage which we have been calling Vcc.
- **Pin 8 (Vss)** is ground.
- Note that our **10 output pins** are labeled “output 0” to “output 9” and are NOT in sequential order.
- When the circuit is running, the cycle moves through each output in sequential order, not each pin in sequential order.
- Note the output of each pin:
  - Pin 3 - Output 0
  - Pin 2 - Output 1
  - Pin 4 - Output 2
  - Pin 7 - Output 3
  - Pin 10 - Output 4
  - Pin 1 - Output 5
  - Pin 5 - Output 6
  - Pin 6 - Output 7
  - Pin 9 - Output 8
  - Pin 11 - Output 9



4017 Decade Counter Pins

- **Pin 12 (carry out)** is sort of like an output pin except it is not part of the cycle of the 4017. Instead, it is an output that turns high once output 9 (the last output) has been reached in the cycle. It then remains high for outputs 0 to 4 in the cycle and goes low for coutputs 5 to 9.

- **Pin 13 (clock enable)** is an active low pin. When tied to ground it ensures that the circuit is enabled meaning the circuit will operate and cycle through the outputs. When this pin is brought high, all operations will stop and the clock will be ignored.

4017 Decade Counter Pins

- **Pin 14 (clock)** is the most important part of the 4017. Without a clock signal, the 4017 won't know when to switch from one output to the next. When a clock signal is present at pin 14, the 4017 will cycle through its outputs on the rising edge of the clock signal; going from low to high. The faster or slower the clock signal, the faster or slower the 4017 will cycle through the outputs.

4017 Decade Counter Pins

- **Pin 15 (reset)** resets the cycle of the 4017 back to output 0. This is an active high pin. This means that it will reset the chip anytime there is a high signal.

- We can ground pin 15 to ensure that the chip does not reset and the cycle will move through all 10 outputs.
- We can also tie a specific output to the reset to ensure that our cycle only lasts a specific duration.
- For example, if we only wanted to use 4 outputs, we could send our 5th output to pin 15 so when the output of the 5th output went high, the chip would reset and go back to zero.

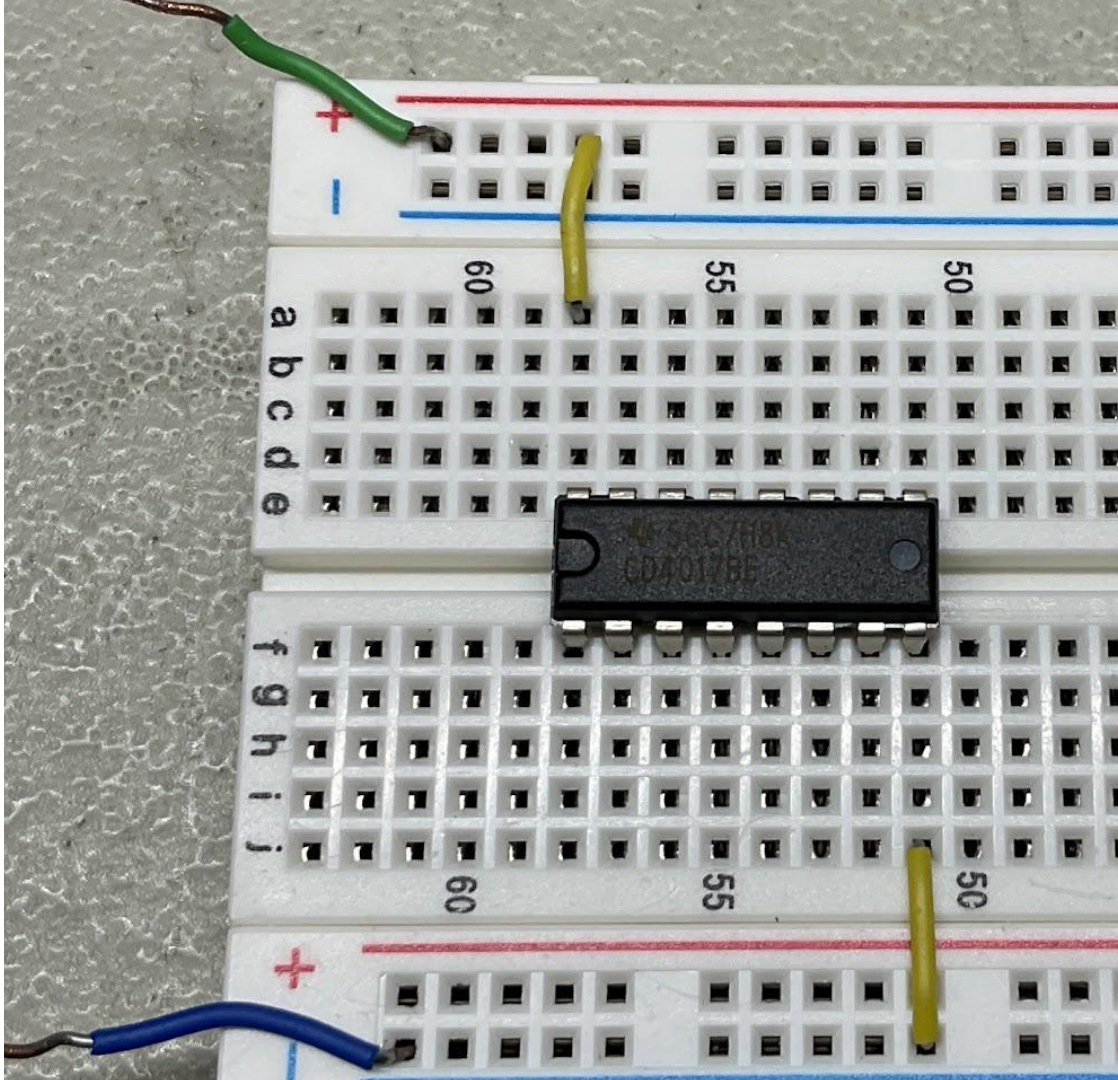
Manual LED Chaser

Manual LED Chaser

- We are going to create an 8 LED chaser using the 4017 decade counter.
- You will have a row of 8 LEDs that individually light up down a line whenever a button is pressed.

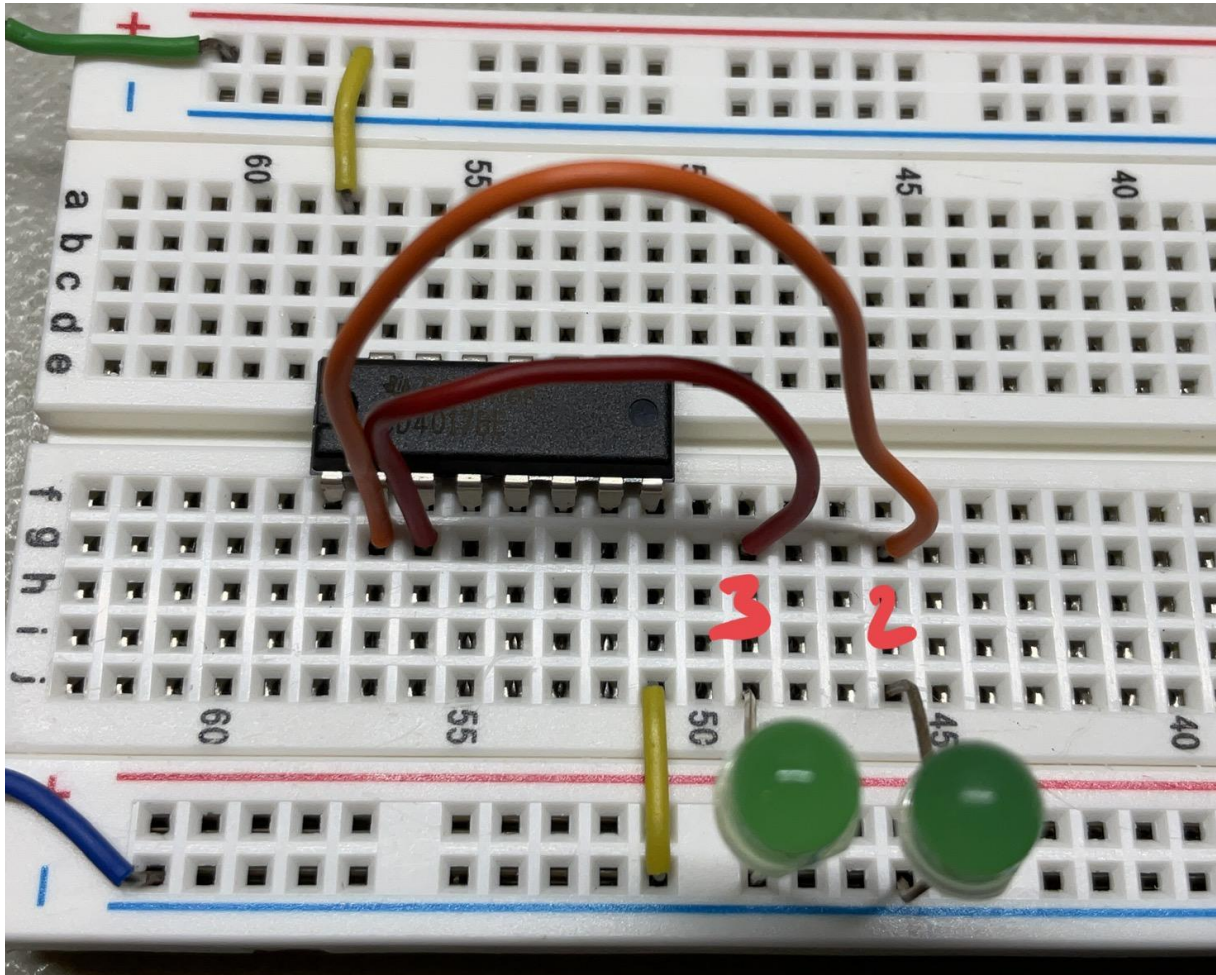
Manual LED Chaser

- Connect pin 16 (Vdd) to our supply voltage Vcc.
- Connect pin 8 (ground) to ground.



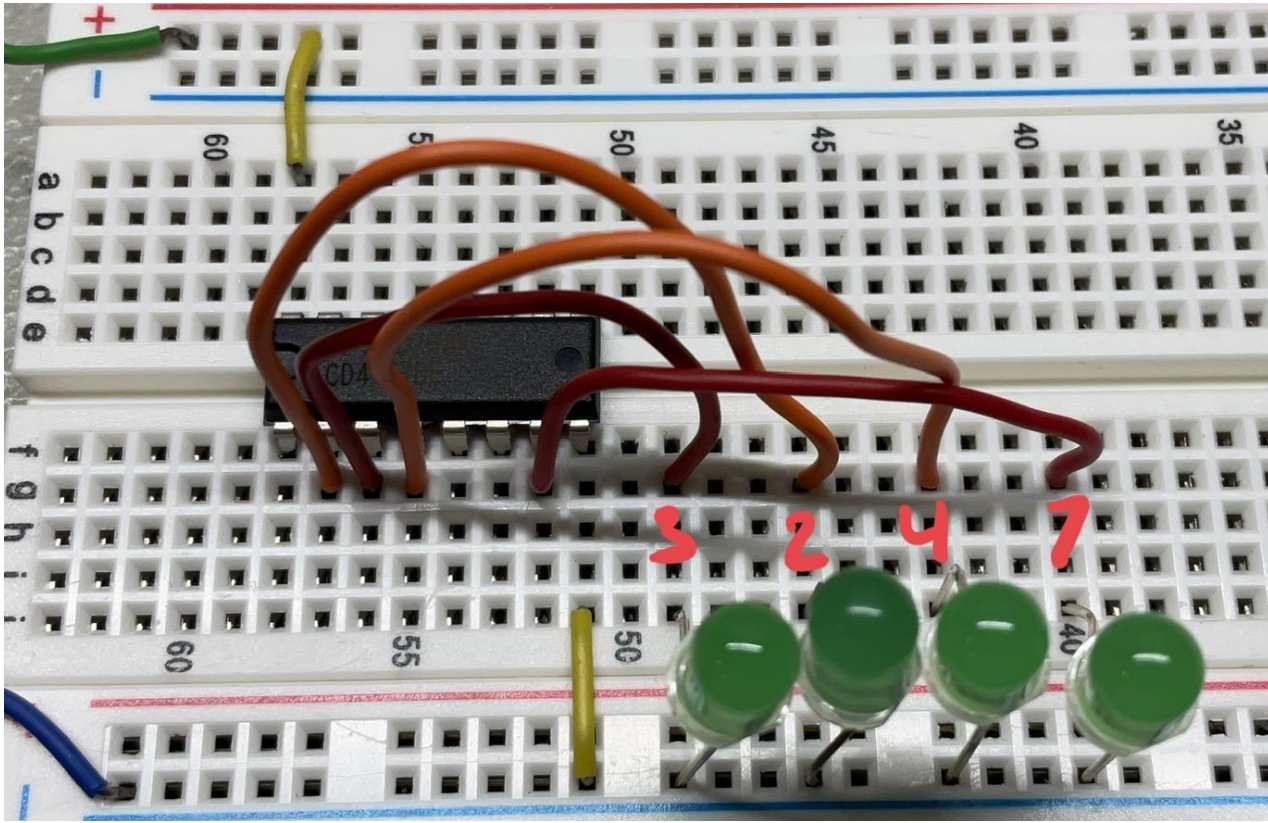
Manual LED Chaser

- Wire up our first 2 output pins.
- Pin 3 (output 0) is the red wire going to an LED to ground.
- Pin 2 (output 1) is the orange wire going to an LED to ground.



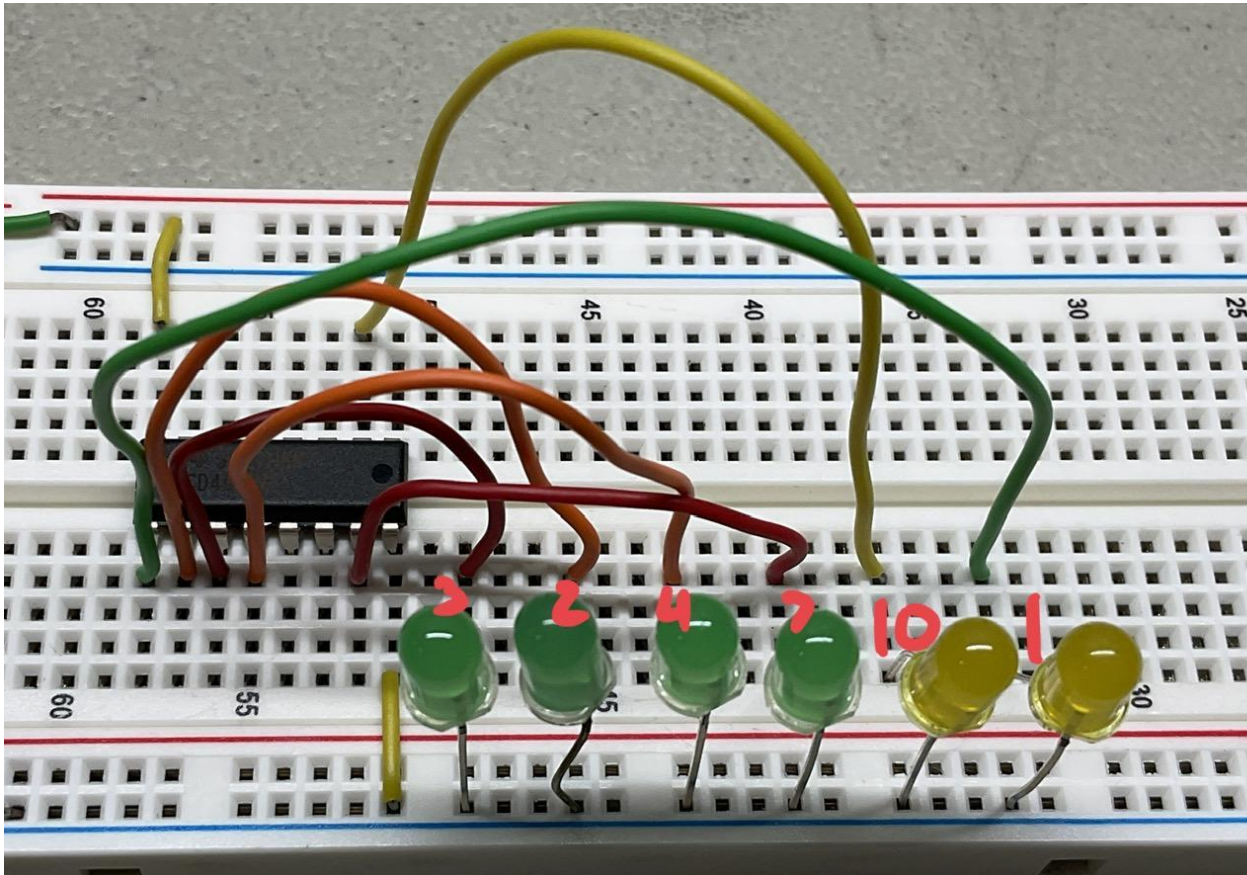
Manual LED Chaser

- Wire up our next 2 output pins.
- Pin 4 (output 2) is the orange wire going to an LED to ground.
- Pin 7 (output 3) is the red wire going to an LED to ground.



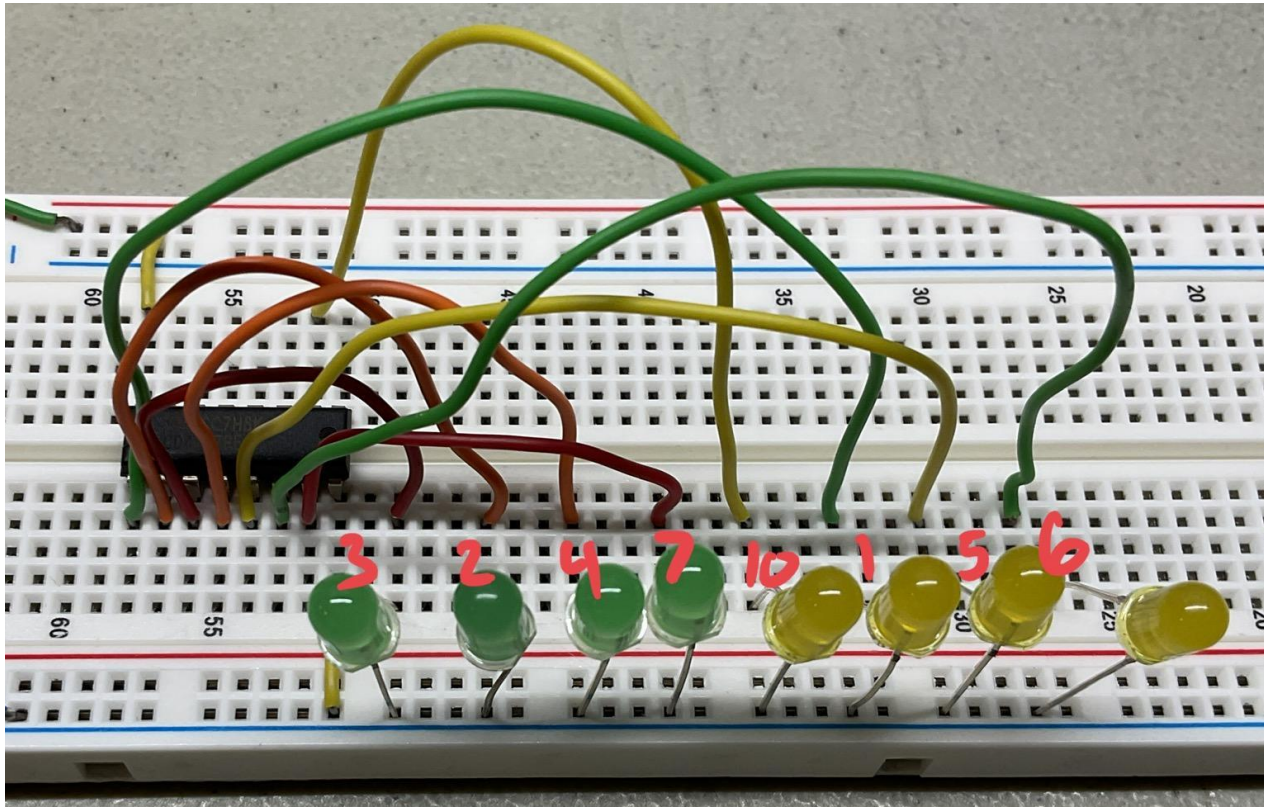
Manual LED Chaser

- Wire up our next 2 output pins.
- Pin 10 (output 4) is the yellow wire going to an LED to ground.
- Pin 1 (output 5) is the green wire going to an LED to ground.



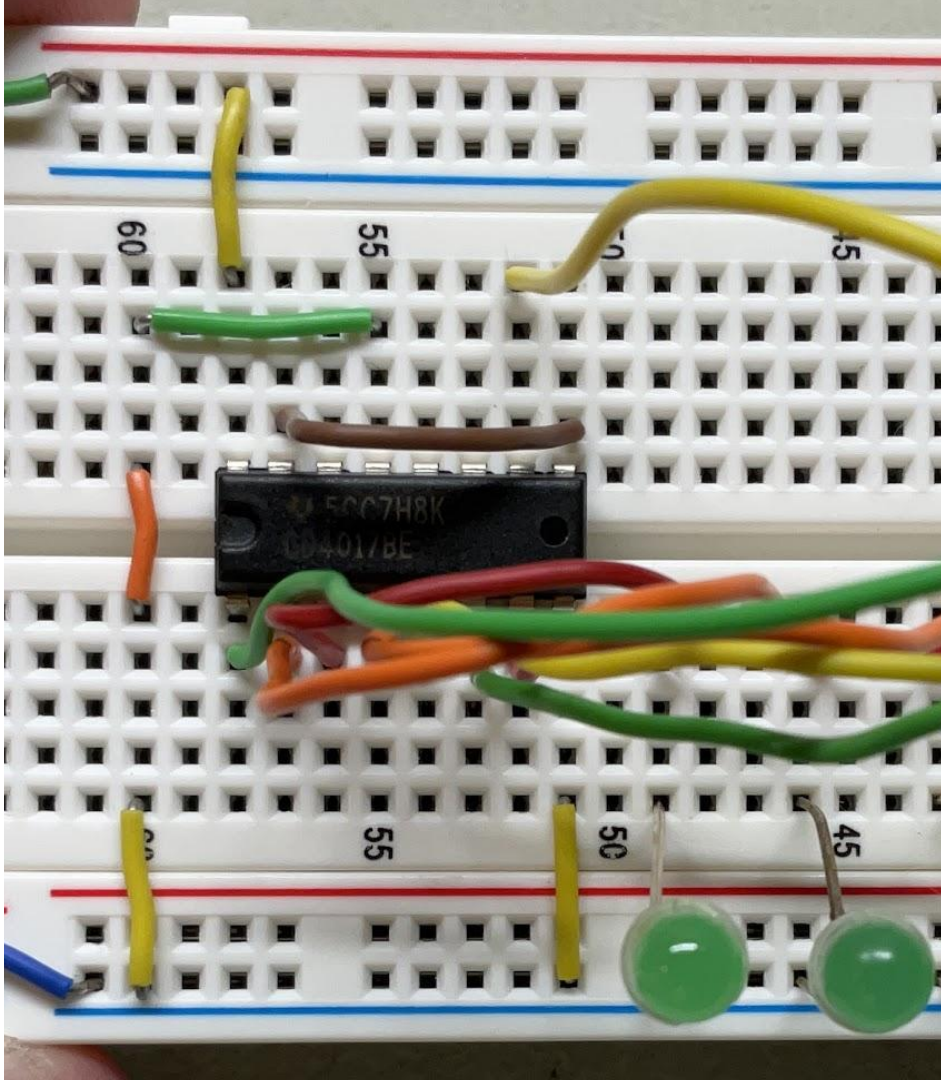
Manual LED Chaser

- Wire up our last 2 output pins.
- Pin 5 (output 6) is the yellow wire going to an LED to ground.
- Pin 6 (output 7) is the green wire going to an LED to ground.



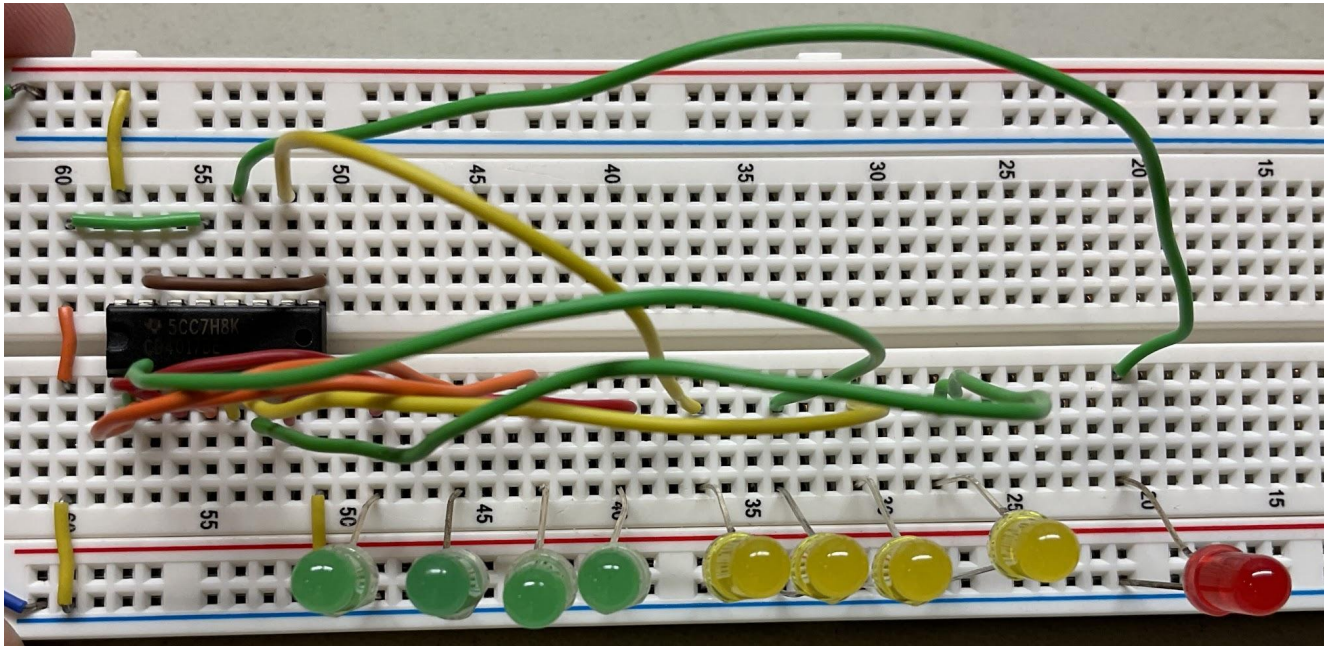
Manual LED Chaser

- Since we don’t want to cycle through all 10 outputs, but rather only 8 outputs, we will have to reset the 4017 after we’ve reached the 8th output.
- To do this, connect pin 9 (output 8) to pin 15 (reset).
- This is the brown wire.
- Now when, pin 9 goes high the chip will be reset!
- Also, ground pin 13 (clock enable) to ensure that the chip will be active and follow whatever clock signal we set up.



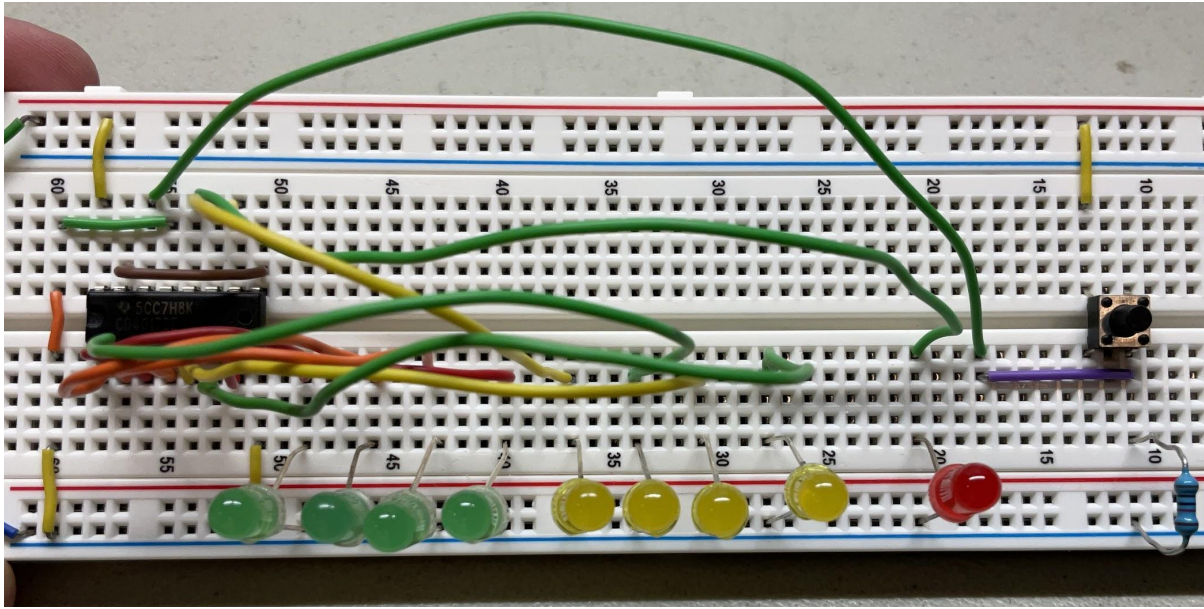
Manual LED Chaser

- Connect pin 12 (carry out) to an LED to ground.
- This is the green wire.
- We don’t need to do this, but it will be nice to see how the carry out functions.
- We should see the red LED turn on for a portion of the cycle.



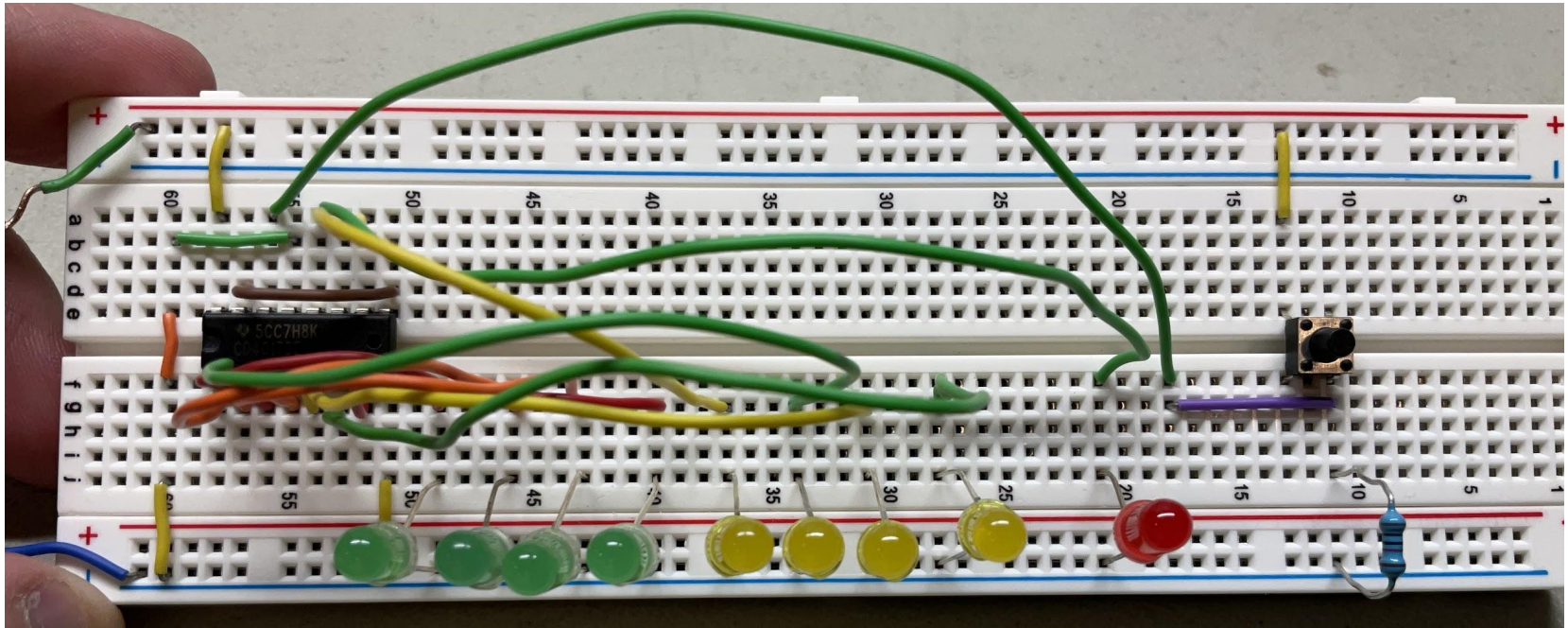
Manual LED Chaser

- We now need something to serve as the clock signal for the 4017.
- Wire up a push button with one side connected to Vcc and the other side connected to ground via a 10K (brown, black, black red) resistor.
- Take the side of the button connected to ground and join it to pin 14 (clock) of the 4017.
- This is the purple and green wire.



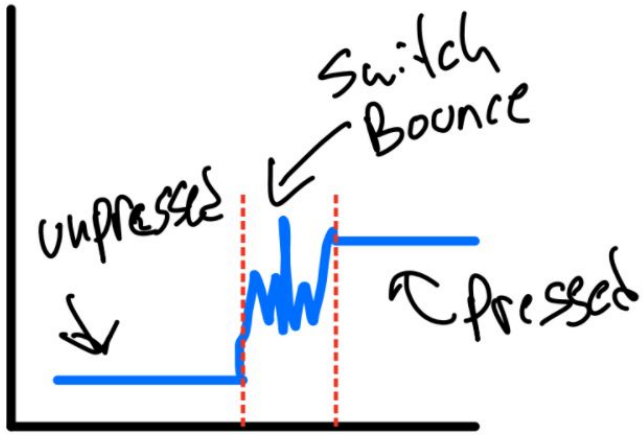
Manual LED Chaser

- A push button may not be the best clock….why?



Shortcomings of the Manual LED Chaser

- A manual push button is a bad clock for a few reasons.
  - We can only go so fast! What if we wanted the clock to trigger at a faster frequency?
  - We have to physically interact with the circuit. What if we wanted the clock to trigger automatically?
  - We have “bouncing” occurring where the outputs sort of skip over each other sometimes. This occurs because the contacts of the button don’t connect and disconnect instantly. Rather, they connect and disconnect several times before a stable connection is made. This results in the clock being triggered when it shouldn’t be.



- We need a more reliable and functional clock signal!

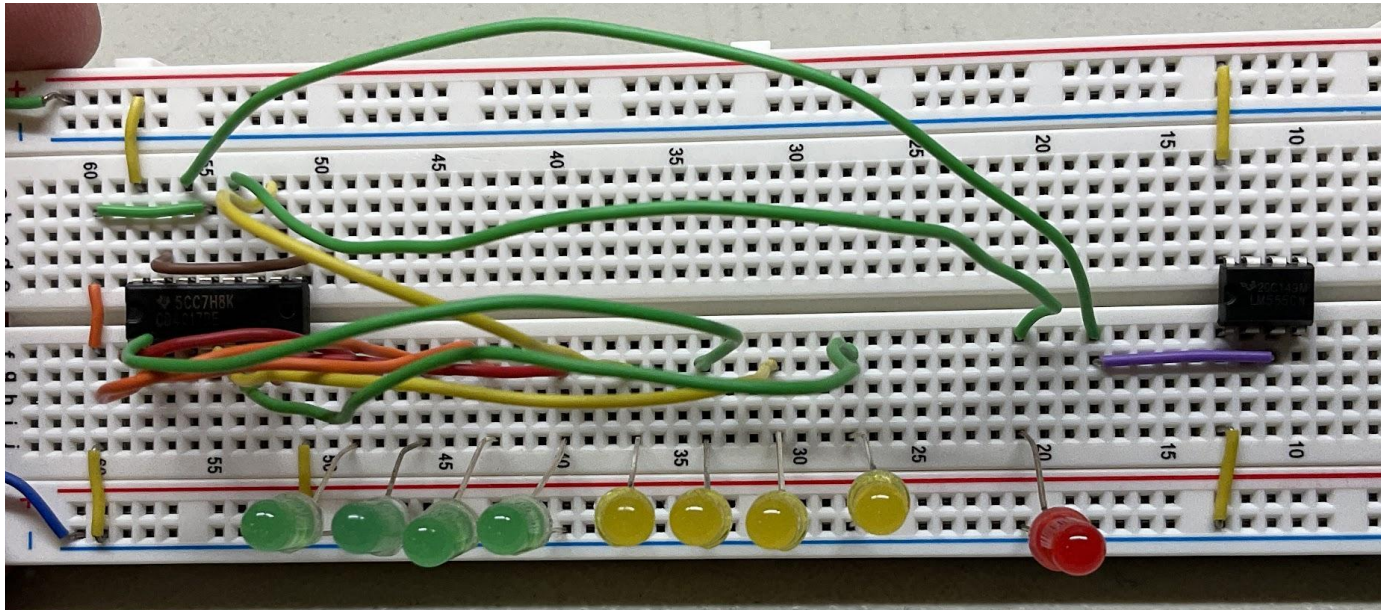
Automatic LED Chaser

Automatic LED Chaser

- Can you think of a way to clock the 4017 without using a manual push button?
- Is there some way to make a reliable and stable output wave that oscillates from high to low?
- Of course there is! We can use a 555 timer in astable mode!

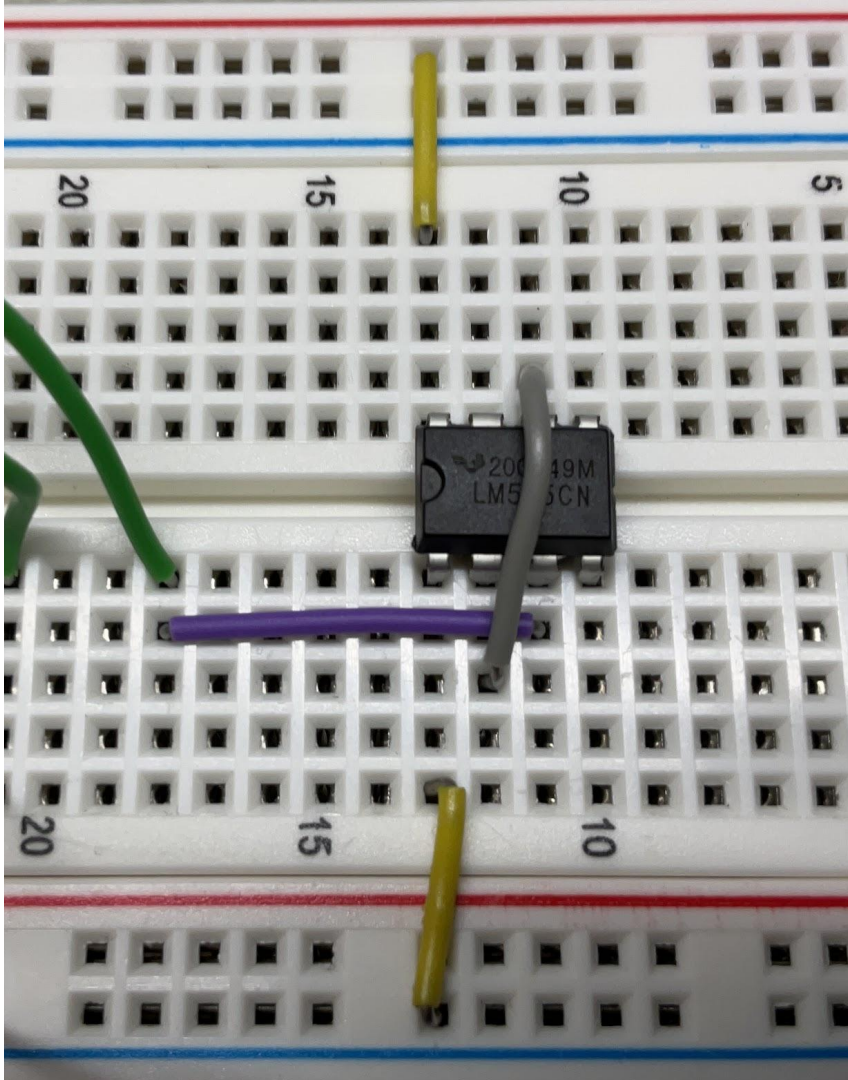
Automatic LED Chaser

- Remove the push button circuit from the bread board.
- Replace with a 555 timer.
- Connect pin 8 (vcc) to Vcc.
- Connect pin 1 (ground) to ground.
- Connect pin 3 (output) to the jumper wire connected to pin 14 (clock) of the 4017.



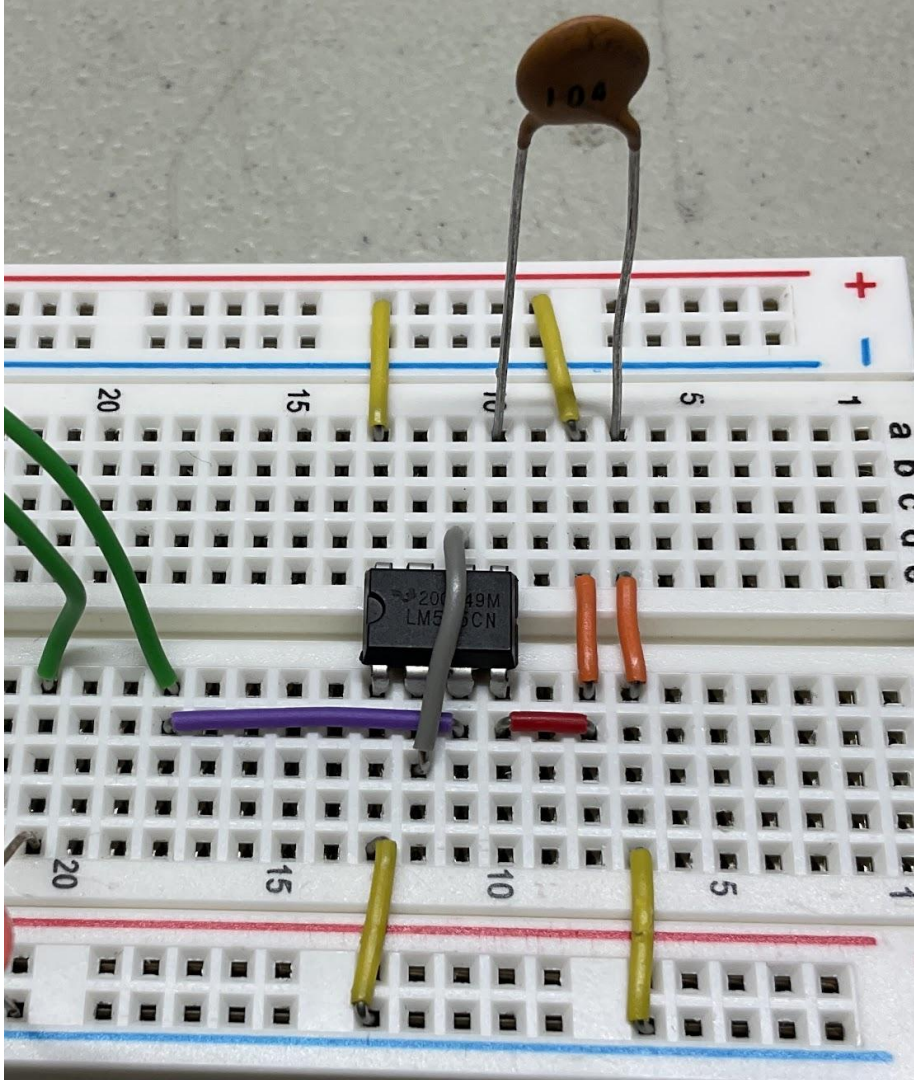
Automatic LED Chaser

- We will wire the 555 timer up in astable mode so it oscillates continuously.
- First, we have to tie pins 2 (trigger) and pin 6 (threshold) together at the same voltage.



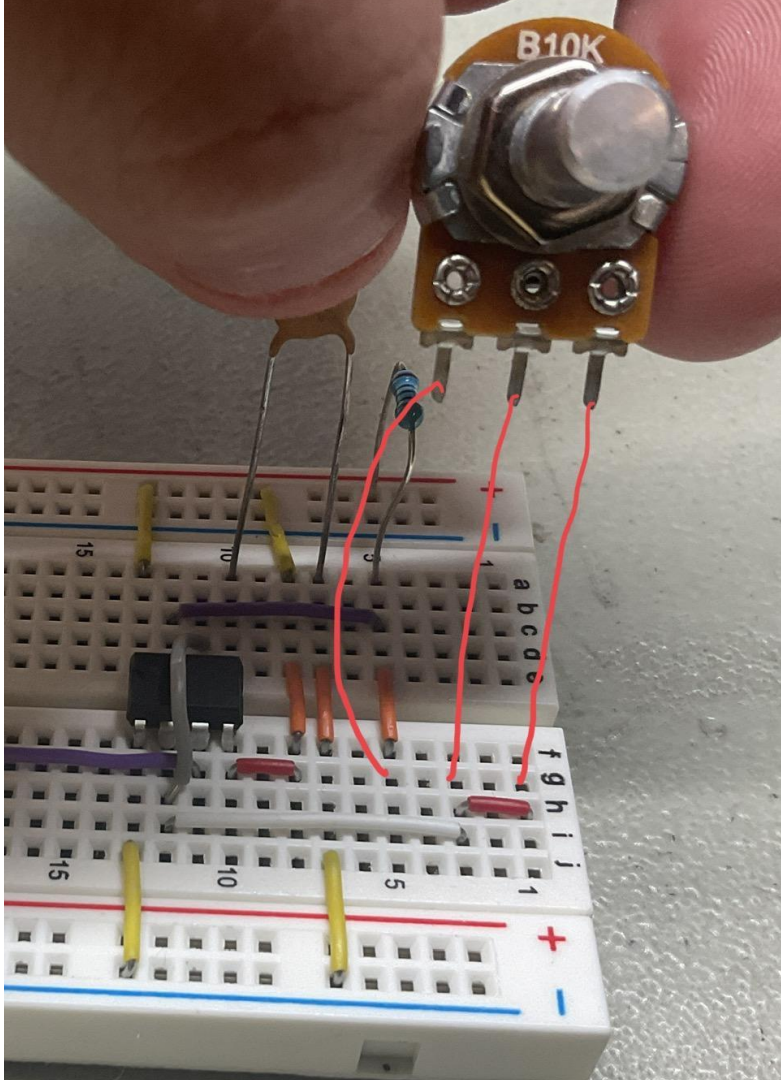
Automatic LED Chaser

- Connect pin 4 (reset) to Vcc to ensure that the 555 timer does not reset on its own.
- We will not be using pin 5 (control voltage). Ground pin 5 through a 100 nanoFarad (104) capacitor.



Automatic LED Chaser

- Create a voltage divider that will be used to determine the frequency of the oscillation at the output.
- The voltage divider is made of a 1K (brown, black, black, brown) resistor and a 10K potentiometer.
- Connect pin 7 (discharge) to the midpoint of the voltage divider.
- Connect pin 2 (trigger) to the bottom of the voltage divider.
- We will wire up the potentiometer as a variable resistor so we can easily vary the frequency of the output.

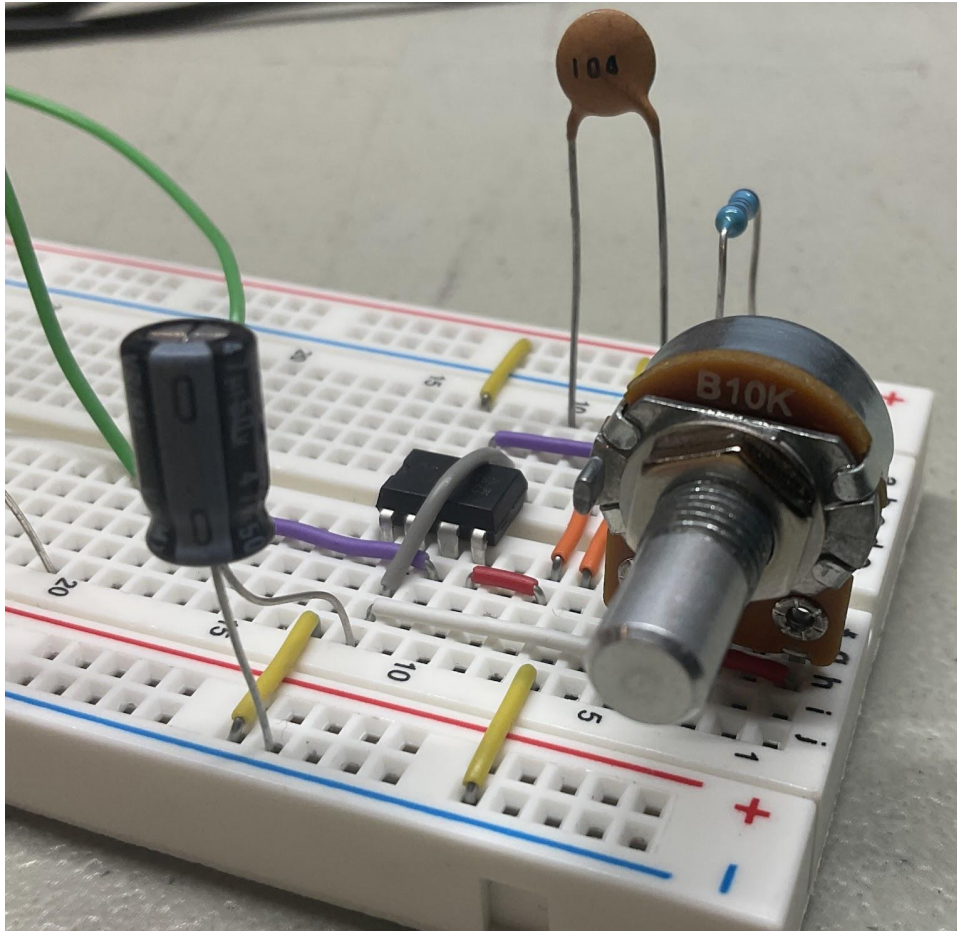


Automatic LED Chaser

- Connect a 47 microFarad capacitor to pin 2 (trigger) to ground.
- The output frequency is given as:

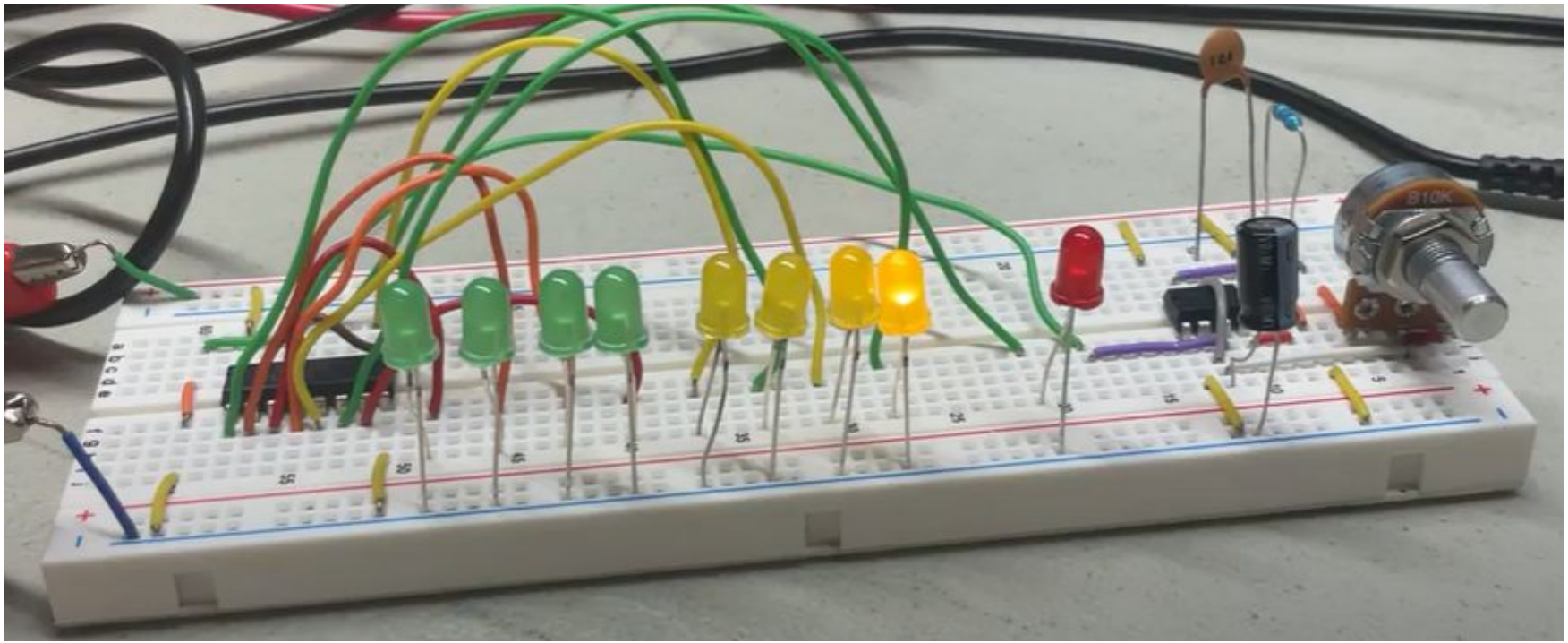
$$f = \frac{1.44}{(R_1 + 2R_2)C}$$

- As we vary R2, the potentiometer, the output frequency of the 555 timer will vary.
- Since this is connected to the clock of the 4017, the rate at which our LEDs turn on/off will also vary.



Automatic LED Chaser

- Vary the rate of the clock with the potentiometer.



A Decade is 10!

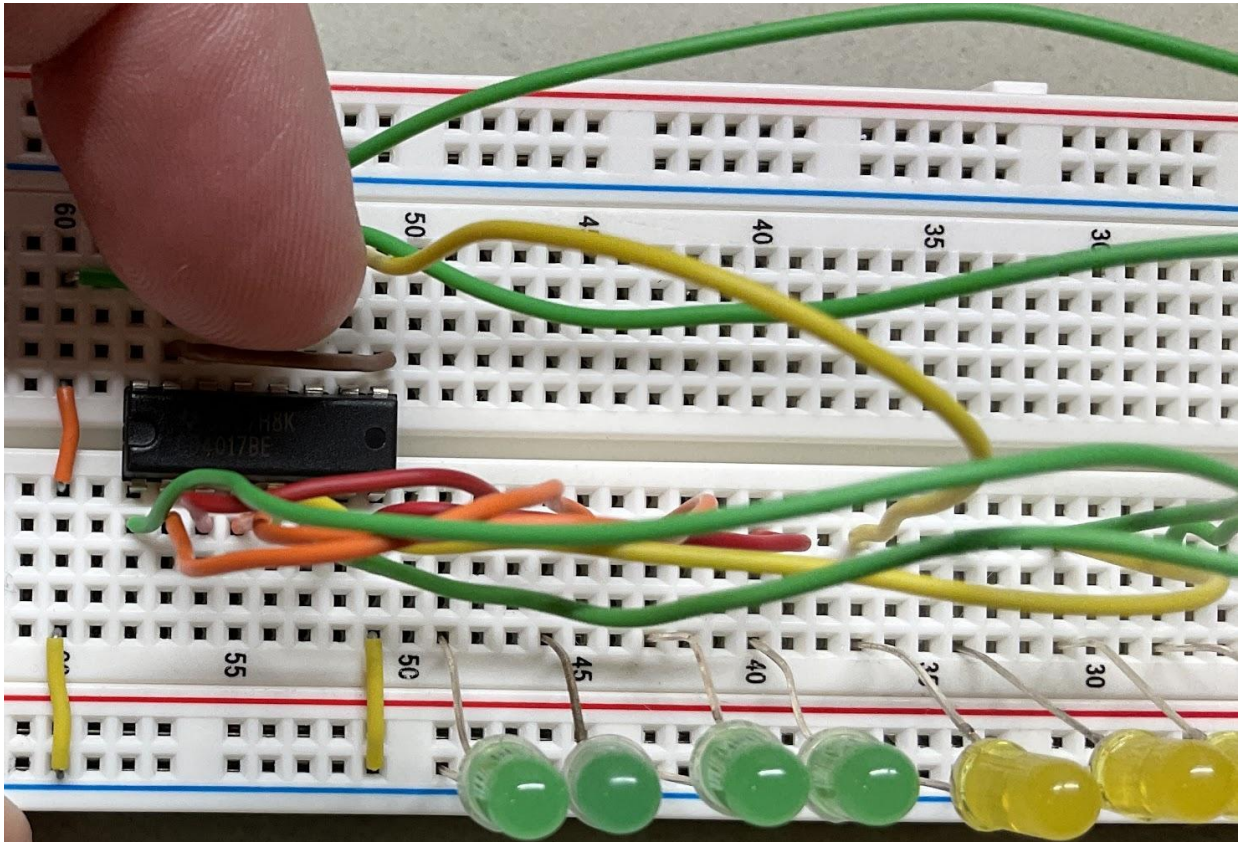
A Decade is 10!

- Let's change the previous circuit to go from using 8 LEDs to using 10. After all, that is what a decade is!
- Also, can you make the cycle faster?

- Since we want the 4017 to cycle through all 10 outputs a great question is what should we do with the reset pin?

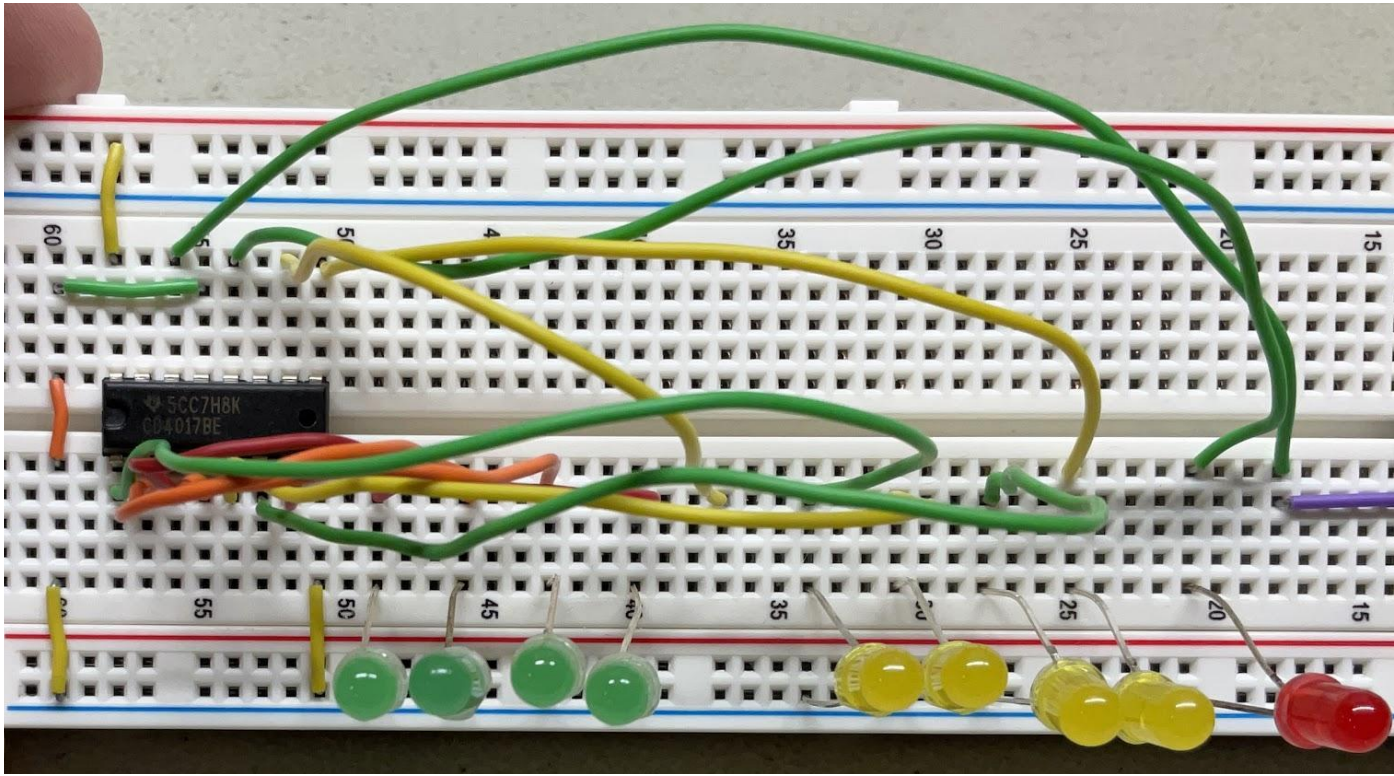
Removing the Reset

- First, we have to remove the high voltage going to the reset since we do not want the chip to reset at all during the cycle but rather continually cycle through all ten outputs.
- Pin 15 (reset) was originally connected to our pin 9 (output 8).
- Remove that jumper wire.



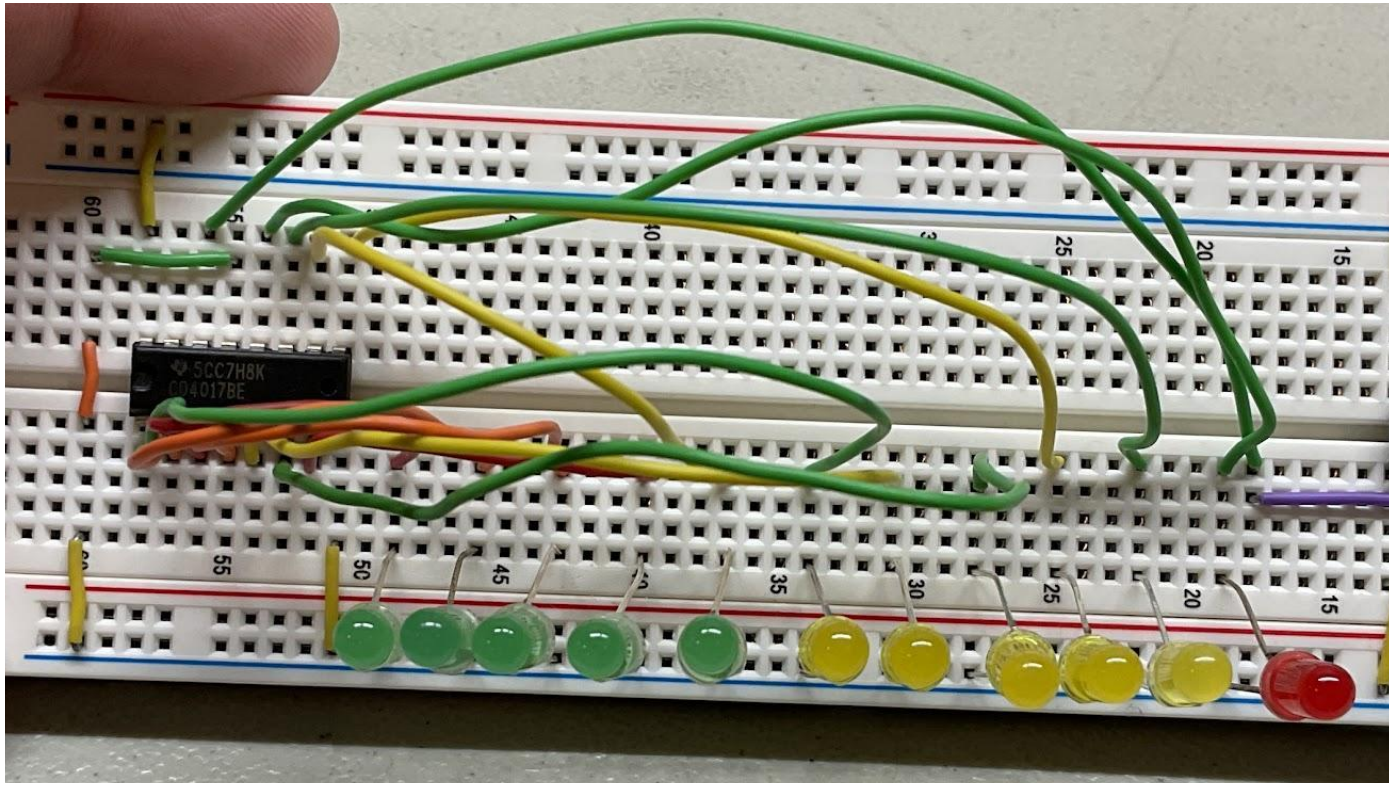
Adding More Outputs

- Next, wire pin 9 (output 8) as an output pin by connecting another LED to ground.
- This is the yellow wire.
- I simply moved my first yellow LED to the end here so I now have room for another green LED in my row.



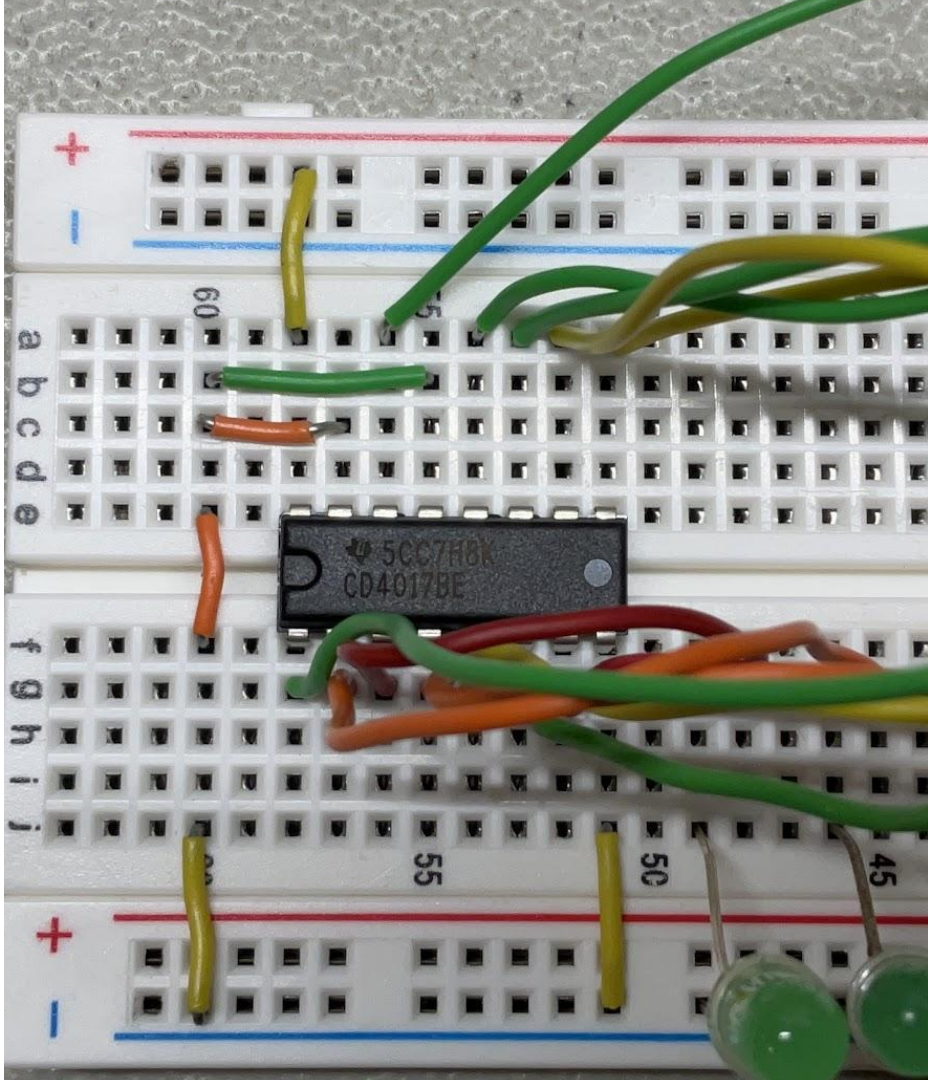
Adding More Outputs

- Connect pin 11 (output 9) to another LED to ground.
- This is the new green wire on my last yellow LED.
- I've also put a 5th green LED to ground off pin 10 (output 4).
- I now have 5 green and 5 yellow LEDs.



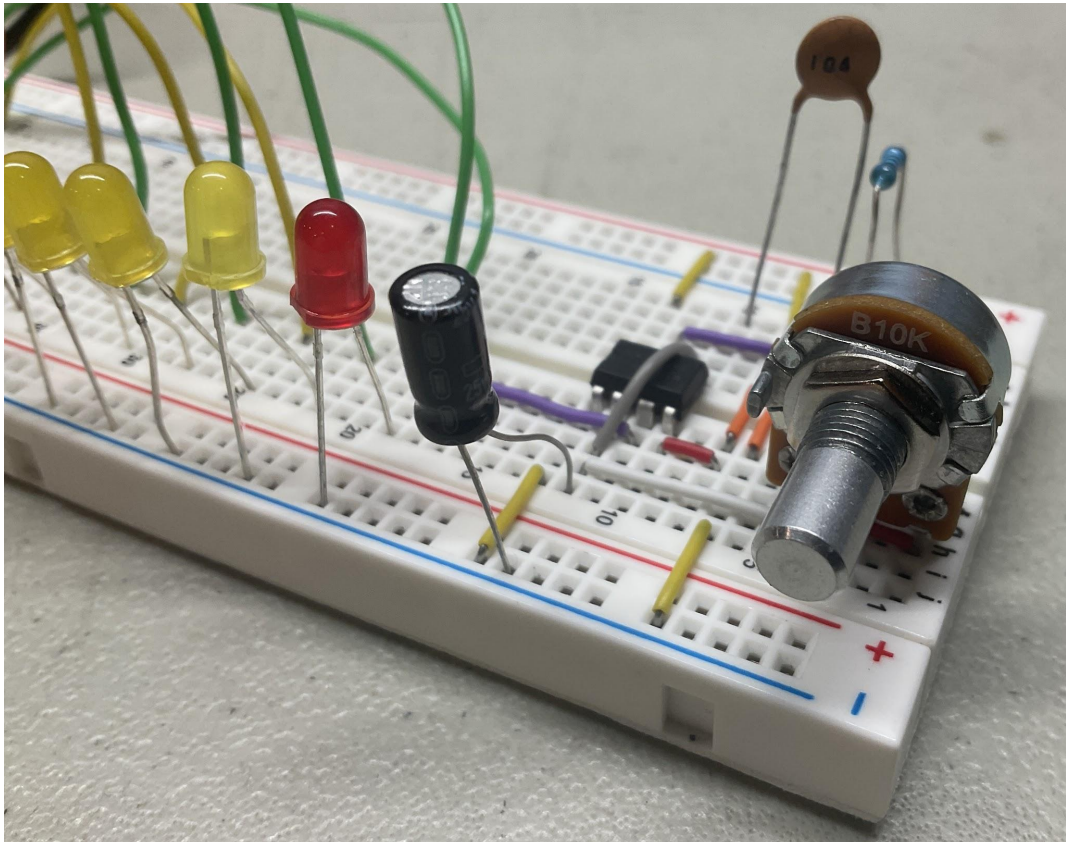
Grounding the Reset

- Prior, we were resetting the chip by sending a high signal to pin 15 (reset).
- The reset pin is an active high pin.
- If we do not want the chip to reset, then we need to keep it low by grounding the pin 15 (reset).



Speeding Up the Cycle

- Lastly, to increase the speed of our cycle we can replace the 47 microFarad capacitor with a 1 microFarad capacitor on our 555 timer.



A Decade is 10!

- Swap out the capacitor to see the effect on the rate of the clock.