Operational Amplifier Applications

Build Together 2

The Motion Detector

Build Together 2: Motion Detection

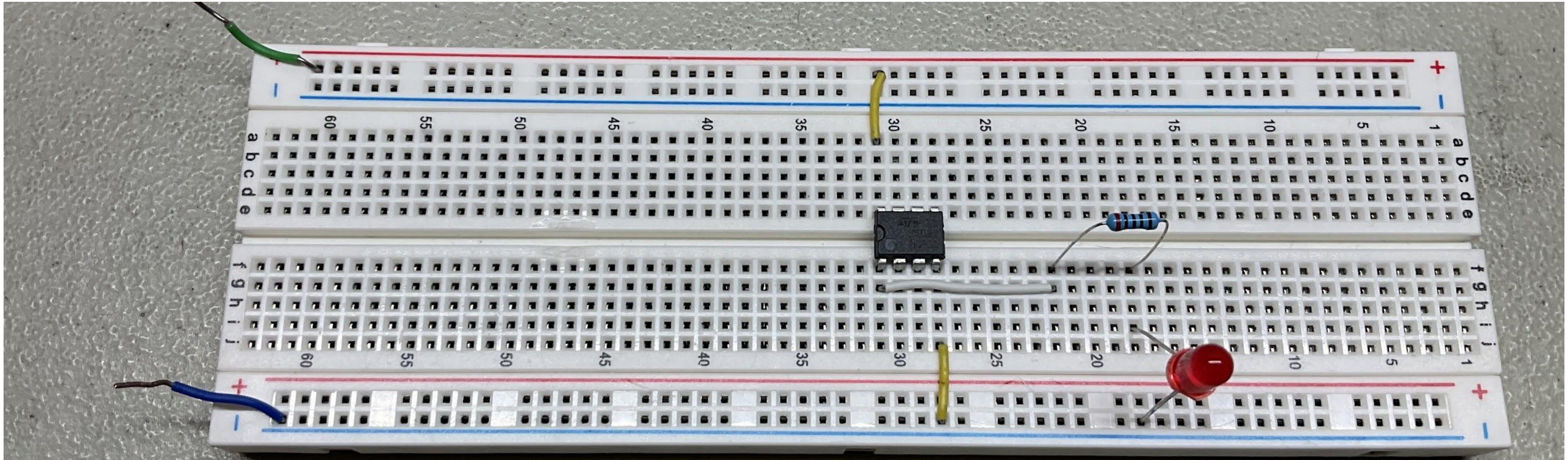
- Lets create a “motion” detector that will turn on an LED for approximately 5 seconds.
- This circuit will have the following:
  - An op amp comparator comparing two voltages.
  - One input should have a “tunable” voltage that we can adjust depending on the amount of light in the room.
  - The other input should have an light dependent resistor to detect motion.
  - The output should go into a timed RC switch to keep an LED on for 5 seconds.

- As you are building, try to think about what you are doing and why the circuit is designed the way that it is.

ADVANCE to the next slide, let’s build this together!

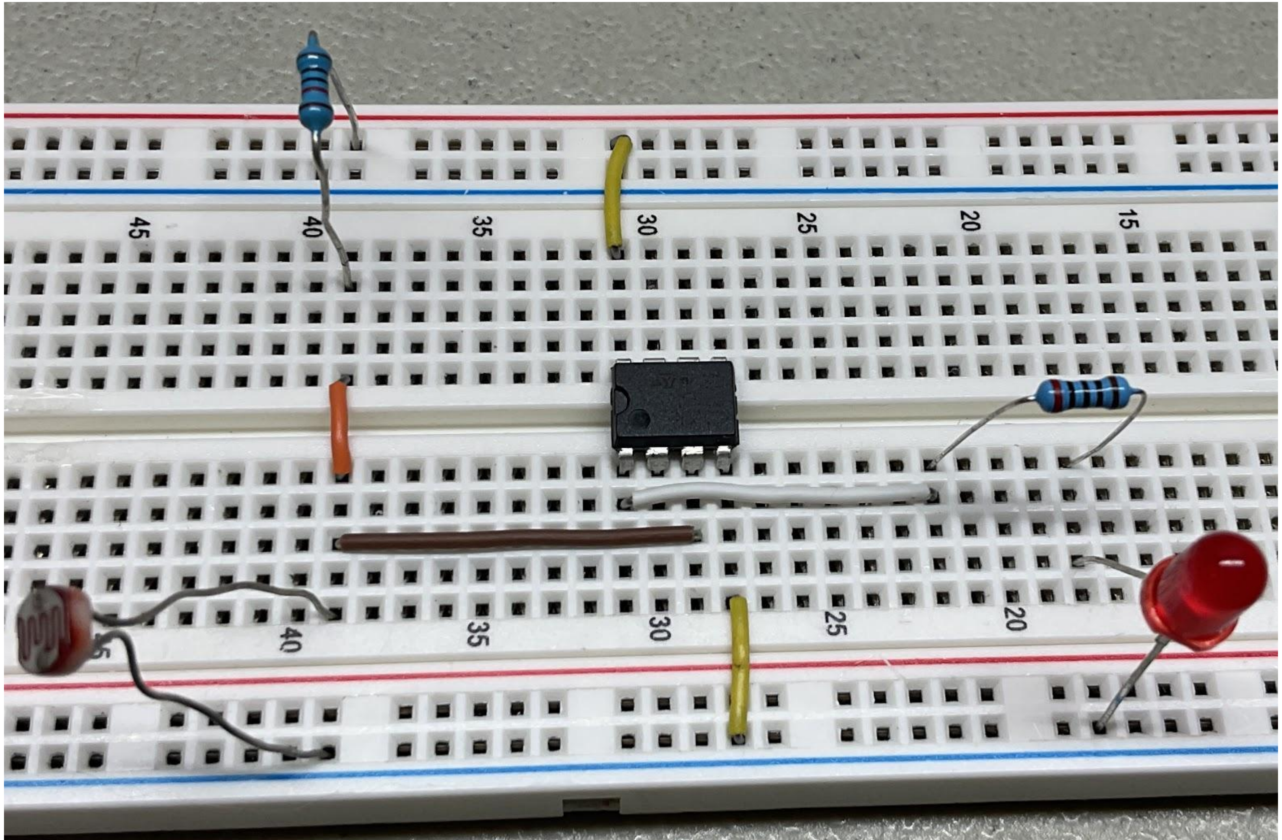
The Motion Detector

- Put an op amp in the breadboard. We will use this op amp as a comparator to compare two voltage values.
- Connect pin 8 (Vcc) to Vcc.
- Connect pin 4 (ground) to ground.
- Move pin 1 (output) away from the chip for easy access and connect a 200 ohm (red, black, black, black) resistor to an LED to ground.



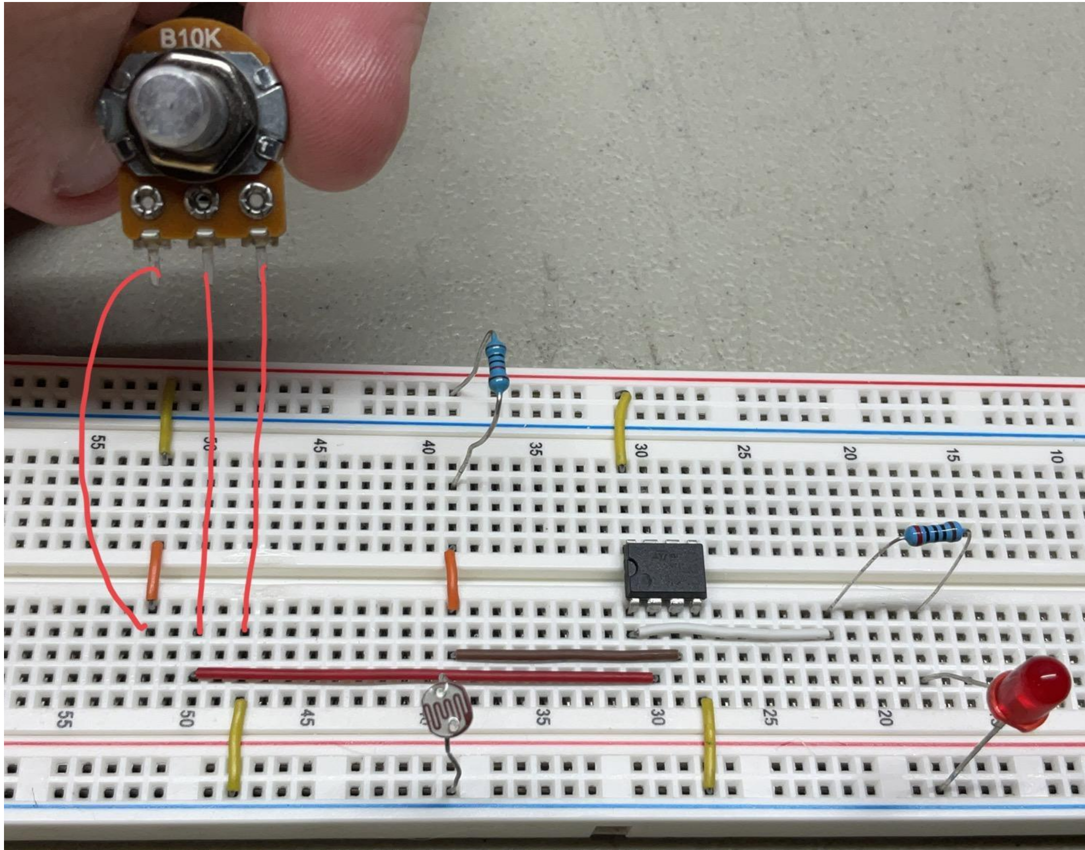
The Motion Detector

- Create a voltage divider using a 10K (brown, black, black, red) resistor and a Light dependent resistor.
- Connect the midpoint of the voltage divider to pin 3 (the non-inverting input).
- When we block the light hitting the LDR, the resistance of the LDR increases. This results in more voltage being at the midpoint of our voltage divider going into the non-inverting input.
- In short, block the light and the non-inverting input voltage increases.



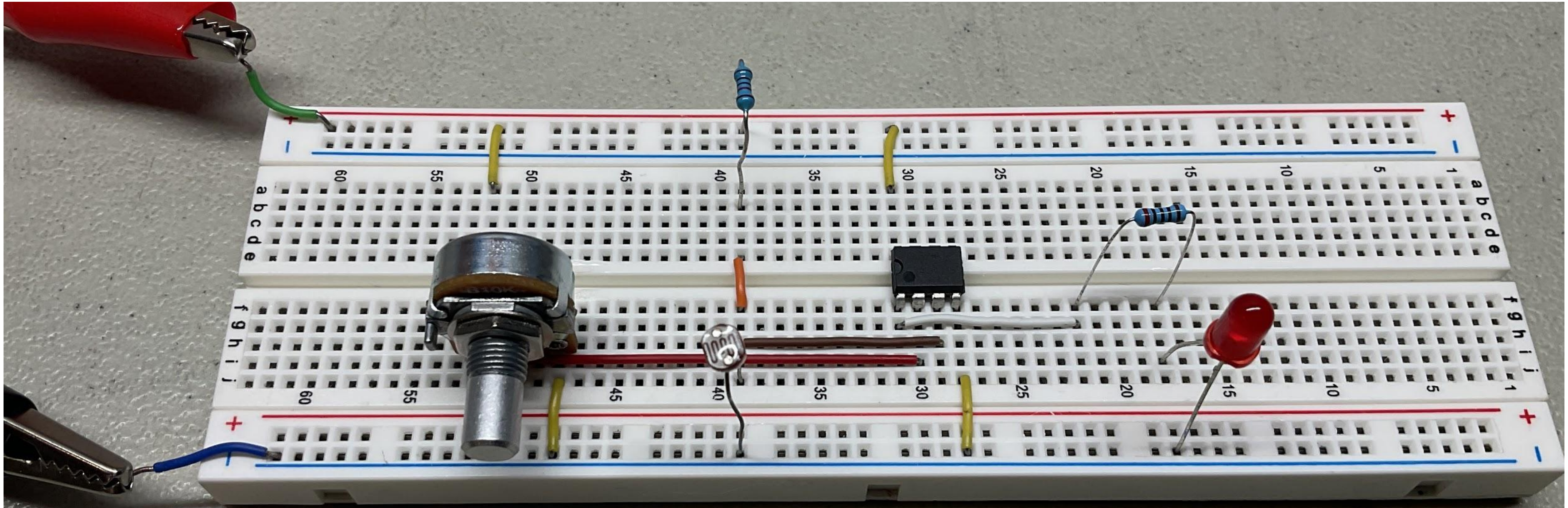
The Motion Detector

- We want to use the op amp as a comparator so that it compares the voltage at the inverting input and non inverting input.
- Only when the non inverting input voltage is large, should the output go high.
- Since the light hitting the LDR will not be constant, we need a way to fine tune the voltage at the inverting to ensure that the LED stays off when we want it off.
- We can do that with a potentiometer!
- Wire up a 10K potentiometer as a potentiometer this time by grounding the third terminal; it will serve as the voltage divider.
- The wiper, or middle terminal is the midpoint of the voltage divider. Connect this to pin 2 (inverting input) of the op amp.



The Motion Detector

- Given the light in your room, you can tune the potentiometer just until the LED automatically comes on.
- Then you can dial the potentiometer back just a little bit. This will ensure that the comparative voltages at the inverting and non inverting inputs are almost equal.
- By blocking any light on the LDR, the non-inverting input will go higher, resulting in the op amp outputting a high signal, lighting up the LED.

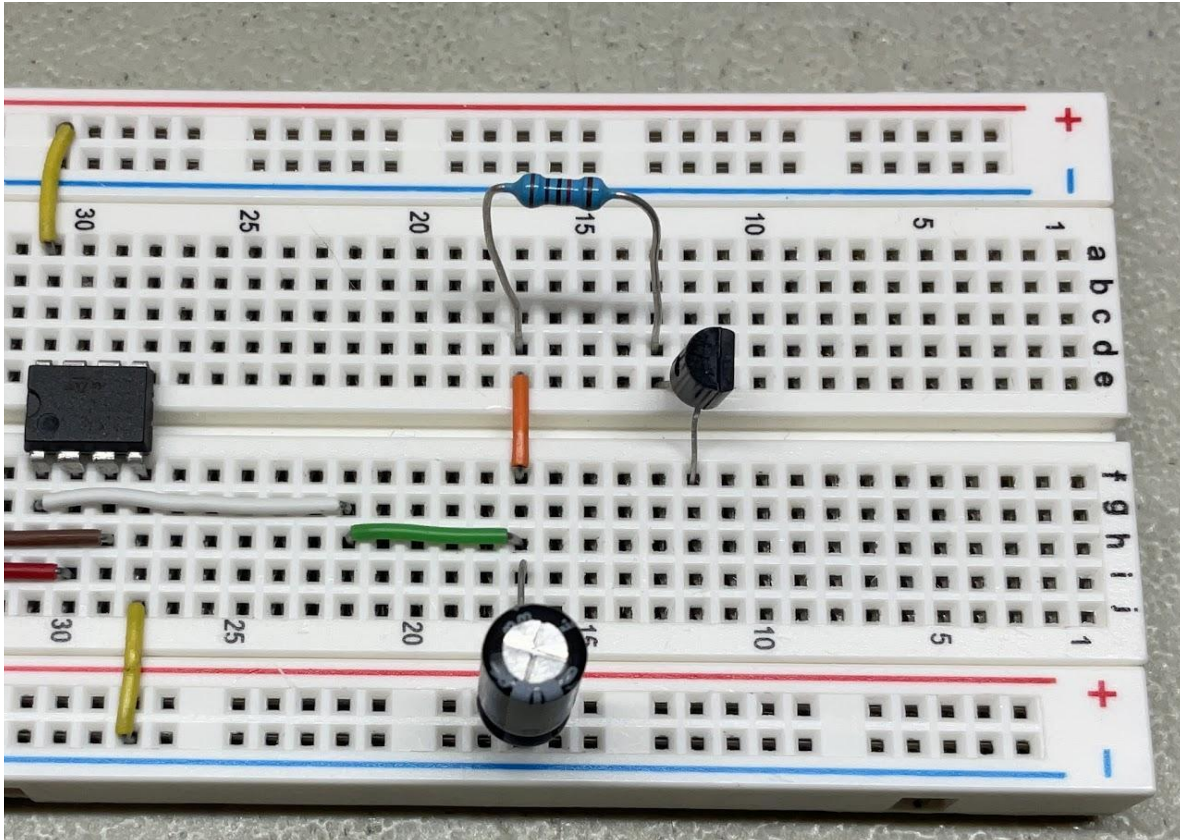


The Motion Detector

- Most motion lights don't just flash on and off; they stay on for some duration.
- We can create an RC timed switch with a transistor to do just this.
- Take the output of the op amp into a 100 microFarad capacitor to ground. (I've used a green jumper which we will replace soon!)
- Also take the output of the op amp into a 10K (brown, black, black, red) resistor into the base of a transistor.
- The time constant of the RC circuit is:

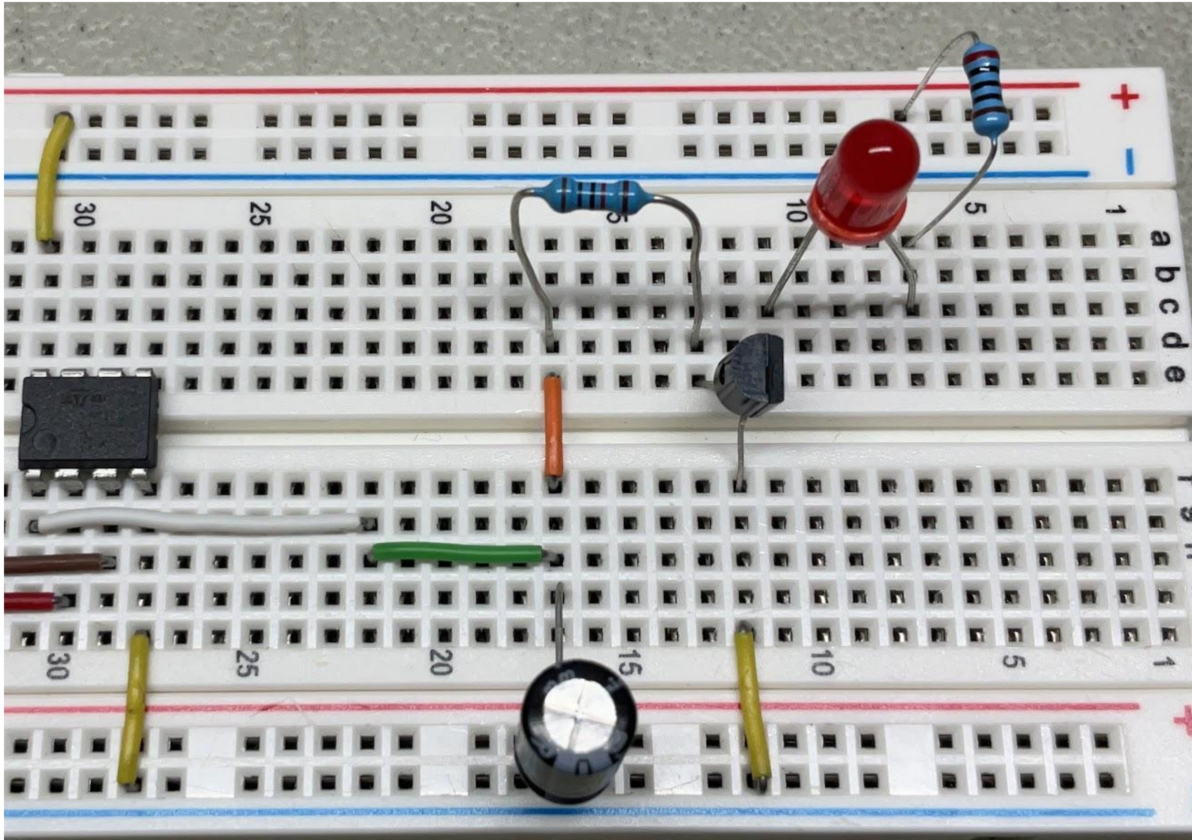
T = 10,000 * 0.0001 = 1 second

- This means our light should stay on for 5*T = 5 seconds!



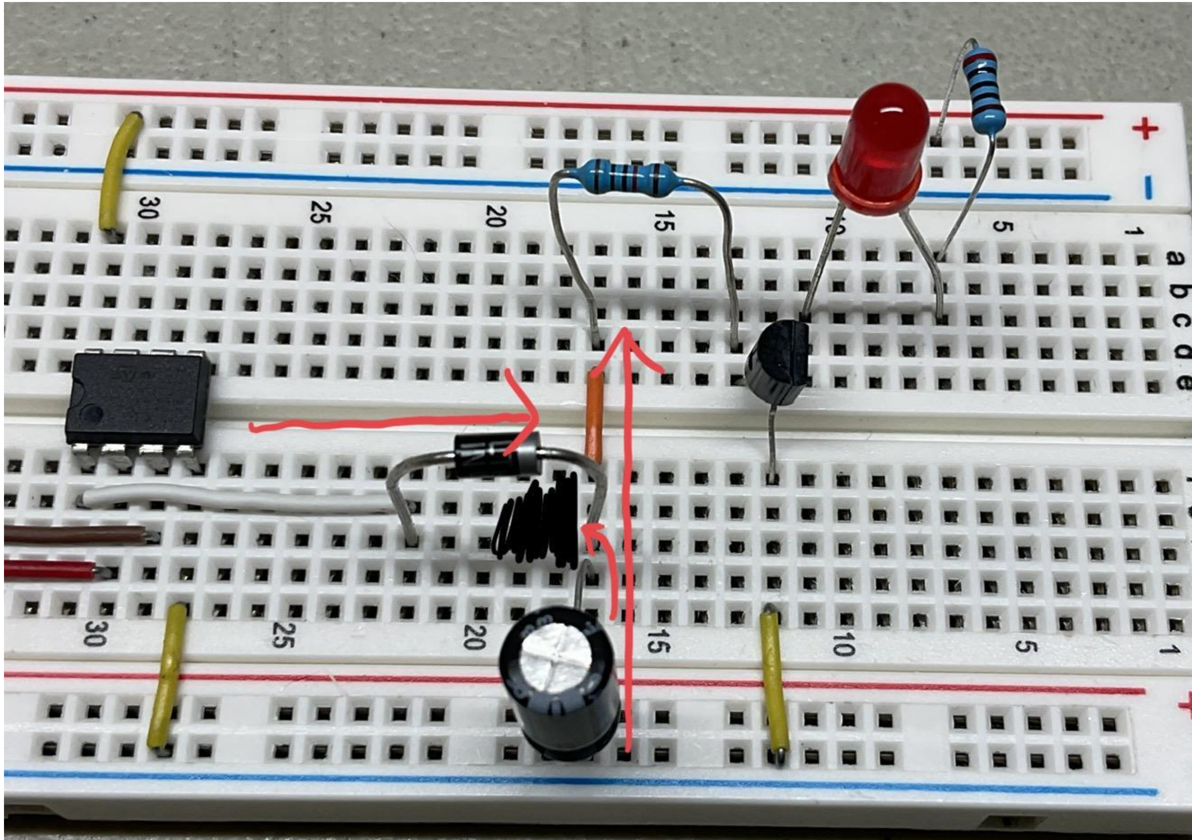
The Motion Detector

- Connect a 200 ohm (red, black, black, black) resistor to Vcc.
- Connect an LED to the 200 ohm resistor in the collector of the transistor.
- Ground the emitter of the transistor.
- If you try your circuit now, you will notice that the LED does not stay on for 5 seconds. It flashes just like before.
- Why do you think this is?



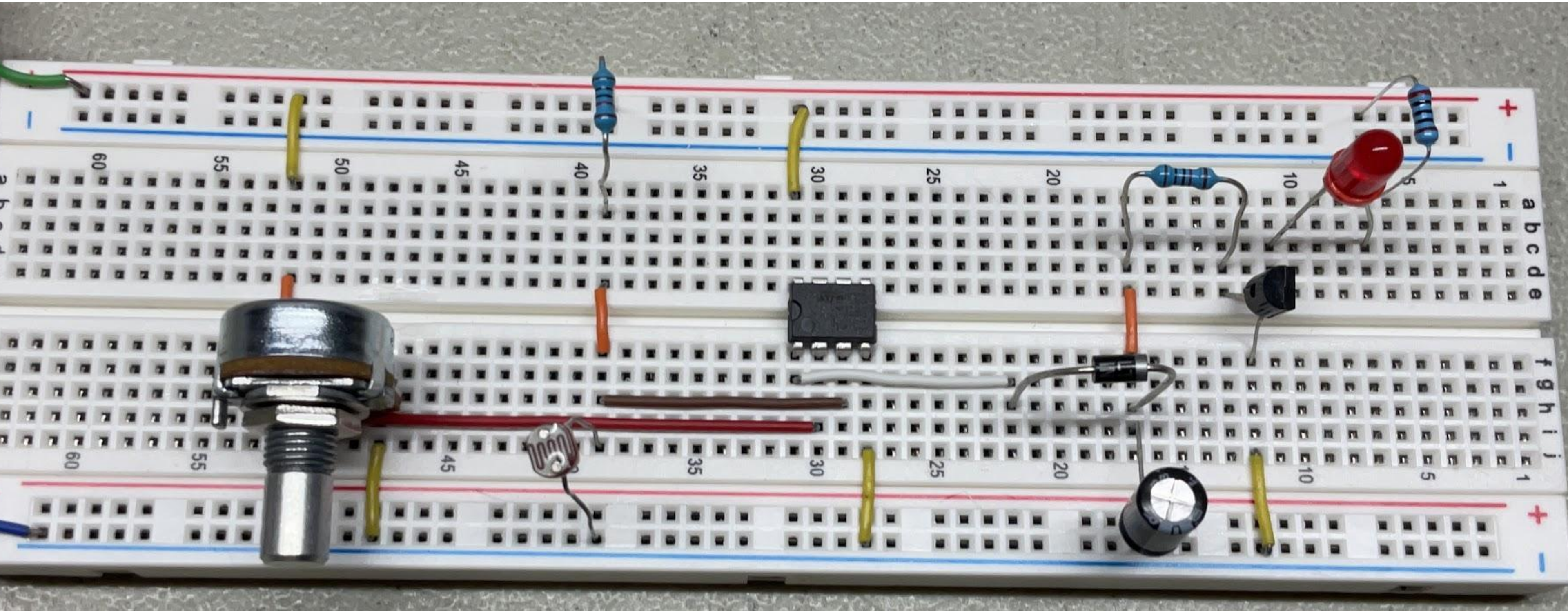
The Motion Detector

- The capacitor is charging when the output of the op amp goes high.
- However, it is not discharging through our resistor into the base of the transistor like we want it to.
- Instead, current is most likely flowing back into the op amp.
- To prevent this current flow, I've replaced my green jumper with a diode.



Build Together 2: Final Circuit

- Make sure you tune the circuit for the given light in your room!



Build Together 3

Rock and Roll Light Show Part II

Build Together 3: Rock and Roll Light Show Part II

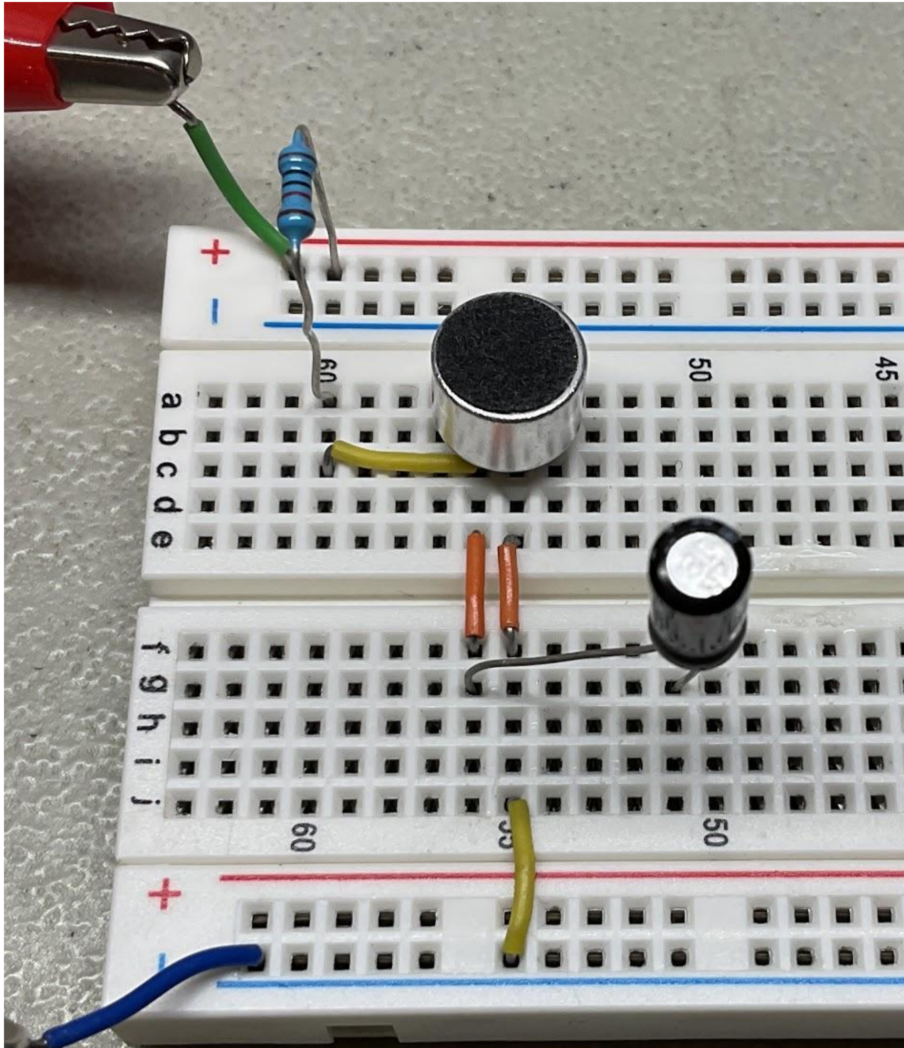
- Lets recreate our rock and roll light show with a few improvements.
- We will use an op amp instead of transistor for amplification.
- We will add a sensitivity knob using a 10K potentiometer.
- This circuit should will have the following sections:
  - A microphone circuit to pick up a signal
  - An amplifier circuit to amplify the signal
  - A volume sensitivity circuit to control the sensitivity of the LEDs
  - A transistor switch circuit to light up LEDs

- As you are building, try to think about what you are doing and why the circuit is designed the way that it is.

ADVANCE to the next slide, let's build this together!

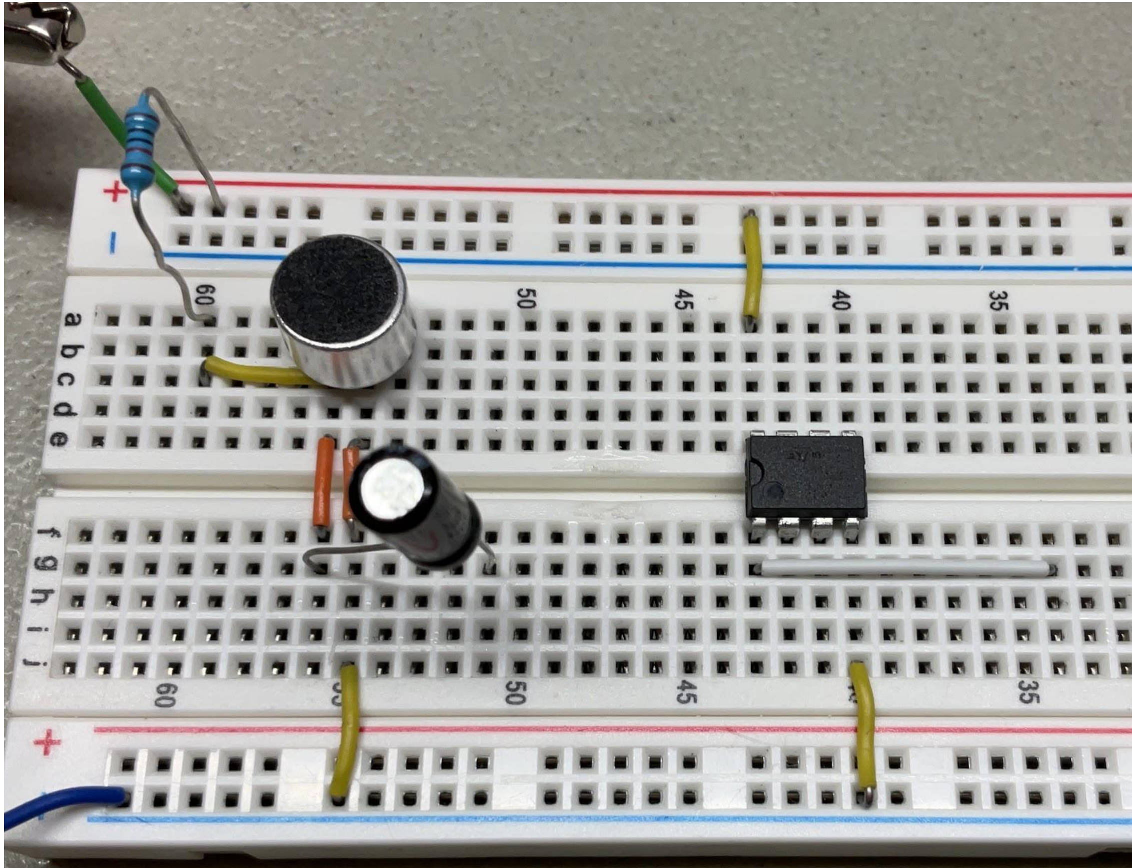
Rock and Roll Light Show Part II - The Microphone

- Connect a 10K (brown, black, black red) resistor from Vcc into the non-ground pin of a microphone.
- Connect the ground pin to ground (look for the metal attaching to the rim of the microphone).
- Connect the non-ground pin to a 1 microFarad capacitor to block any DC signal coming from Vcc.
- You should have a working microphone now.



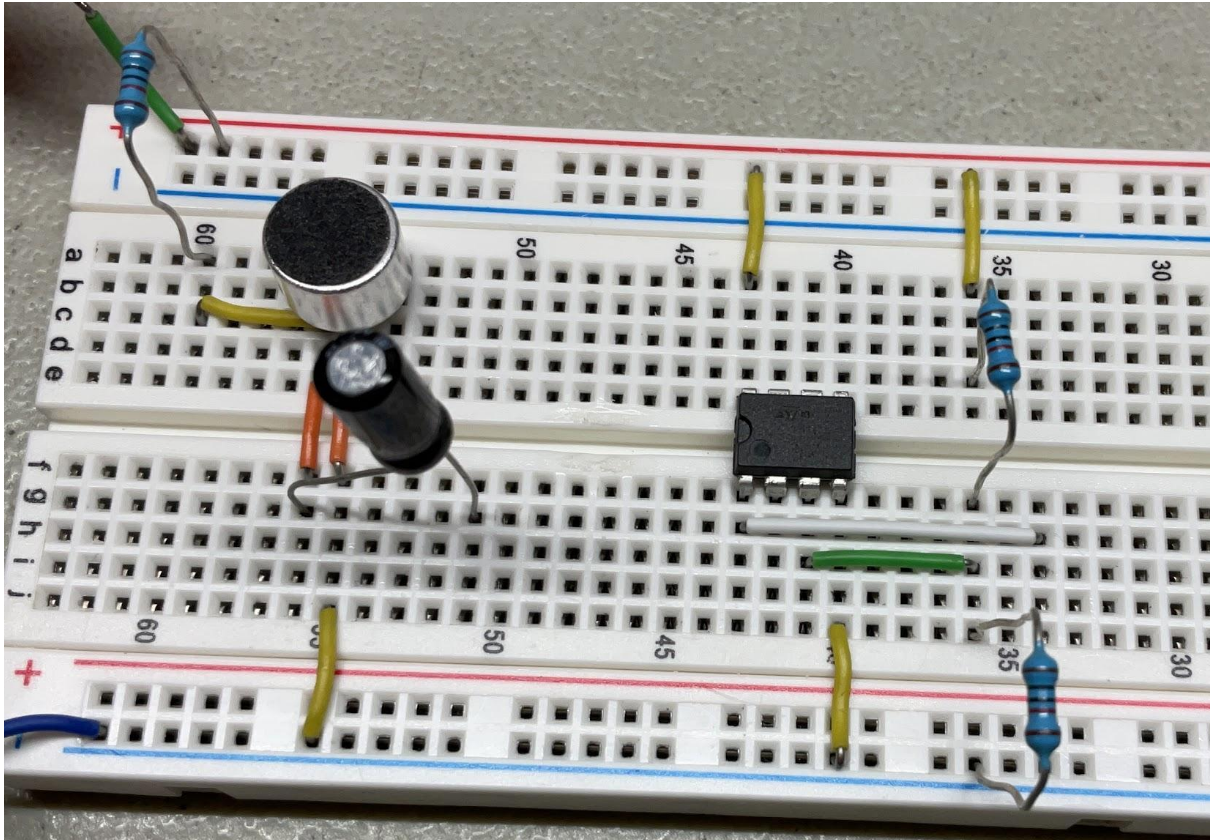
Rock and Roll Light Show Part II - The Amplifier

- Add an LM 358 op amp into the breadboard.
- Connect pin 8 (Vcc) to Vcc.
- Connect pin 4 (ground) to ground.
- Move pin 1 (output) away from the chip for easy access.



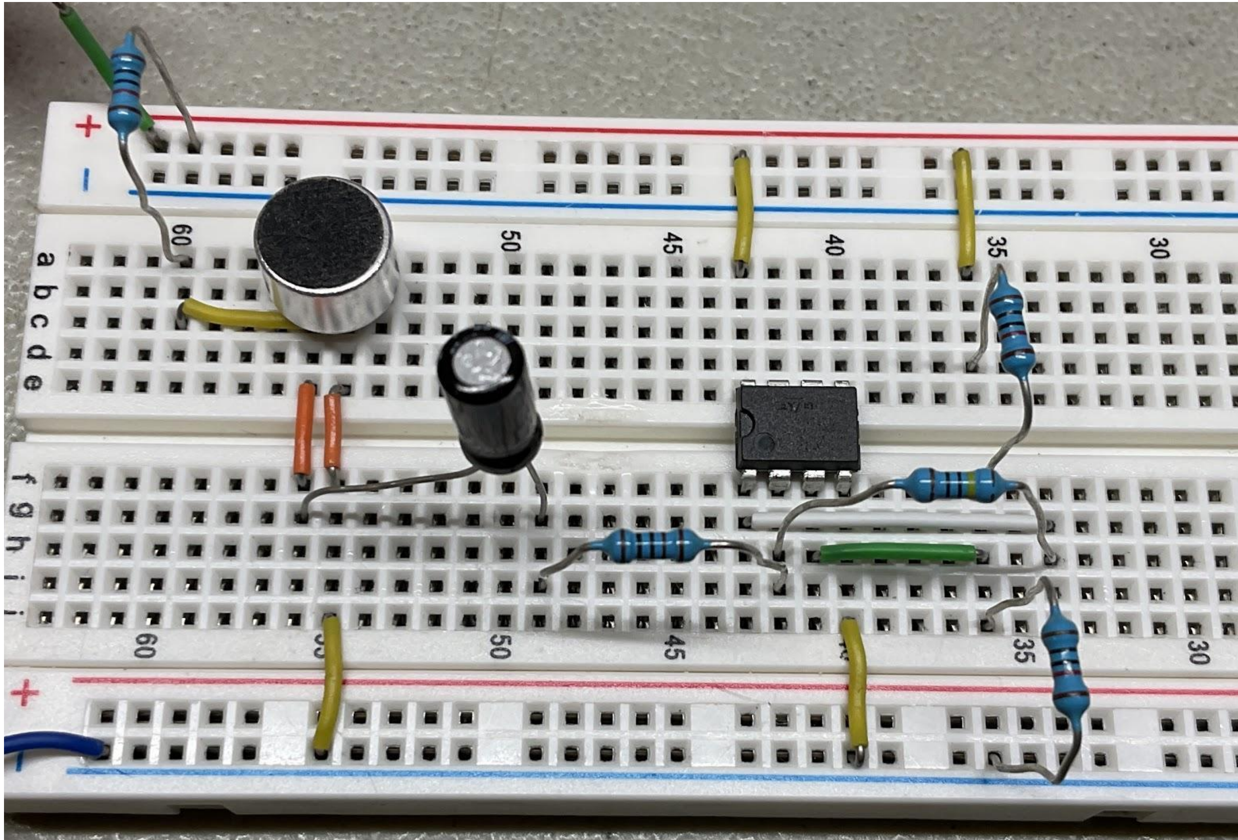
Rock and Roll Light Show Part II - The Amplifier

- I will be creating an inverting amplifier off a single supply.
- This means I need to pin my non-inverting input, pin 3 at Vcc/2 to give maximum room for amplification.
- To do this, create a voltage divider using two 10K (brown, black, black red) resistors.
- Connect the midpoint of the voltage divider to pin 3 (non-inverting input).



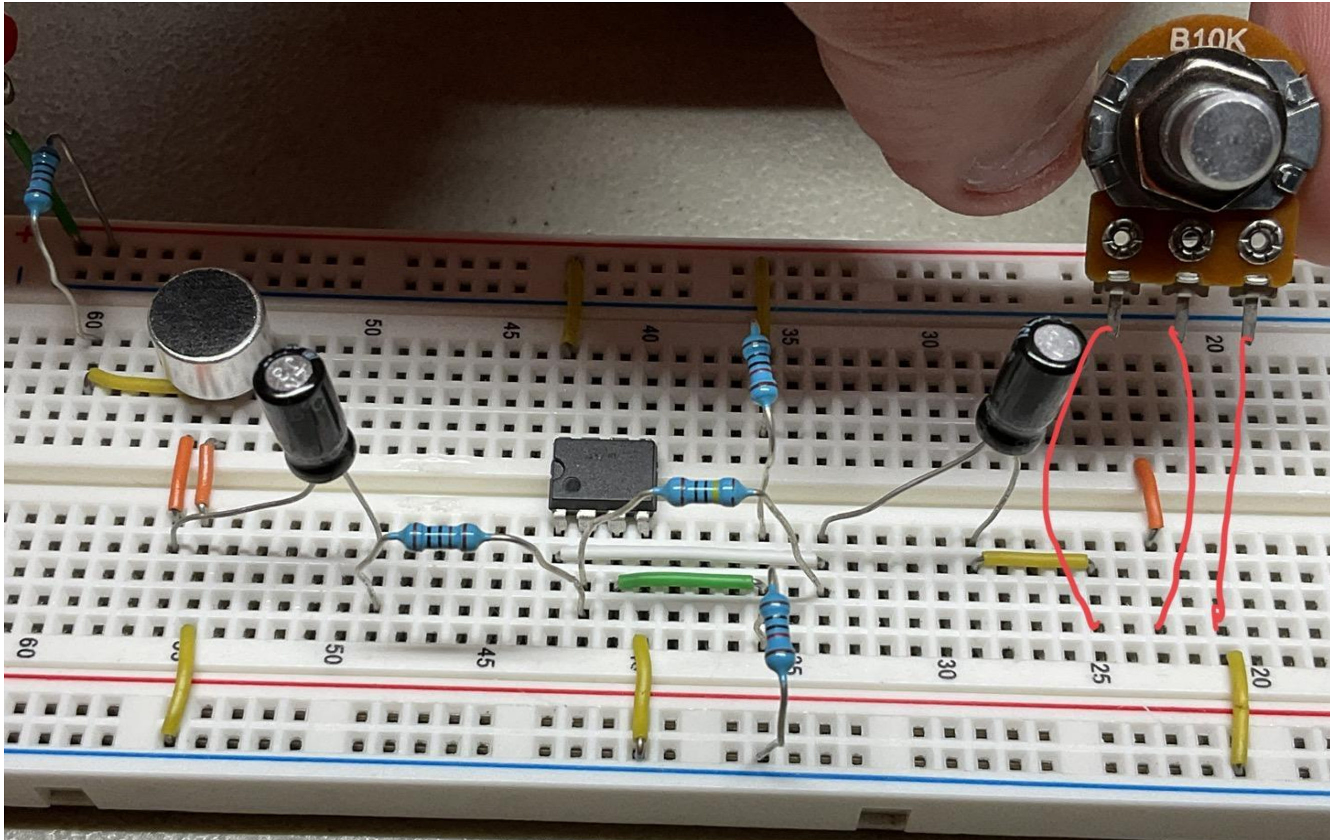
Rock and Roll Light Show Part II - The Amplifier

- Create a feedback network for the amplifier.
- From the output (pin 1), via our jumper wire, connect a 1M (brown, black, black, yellow) resistor back to the pin 2 (inverting input).
- Connect a 1K (brown, black, black, brown) resistor from pin 2 (inverting input) to the capacitor or our microphone circuit.
- Our amplifier is now complete and we should have a gain of roughly 1,000.



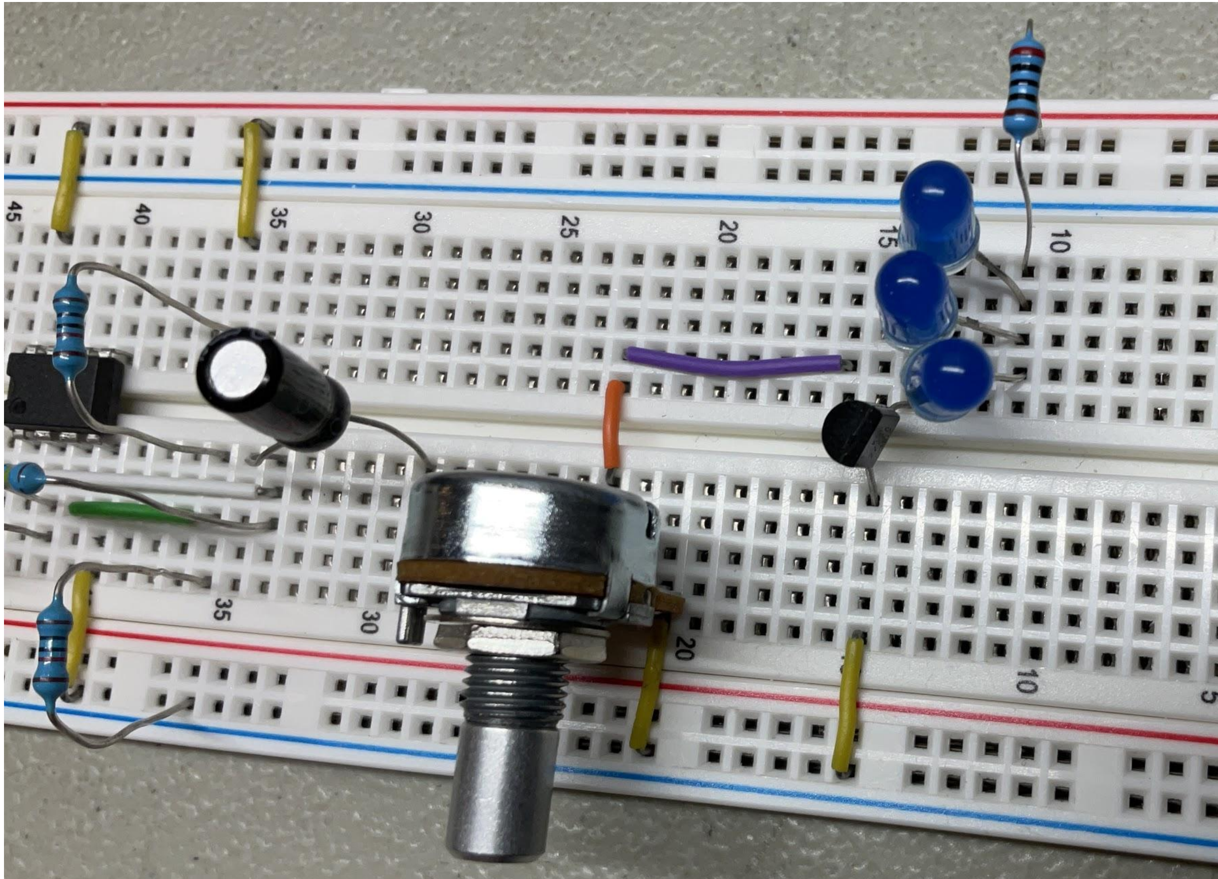
Rock and Roll Light Show Part II - Volume Sensitivity

- Create a high pass filter that will serve as a way to adjust the sensitivity of our circuit.
- At the output of the op amp, connect a 1 microFarad capacitor into a 10K potentiometer.
- Wire the potentiometer up as an actual potentiometer by grounding the third terminal.
- By adjusting the potentiometer, we will vary the cutoff frequency of the high pass filter. This will provide our sensitivity controls as we try to drive LEDs with the outgoing signal.



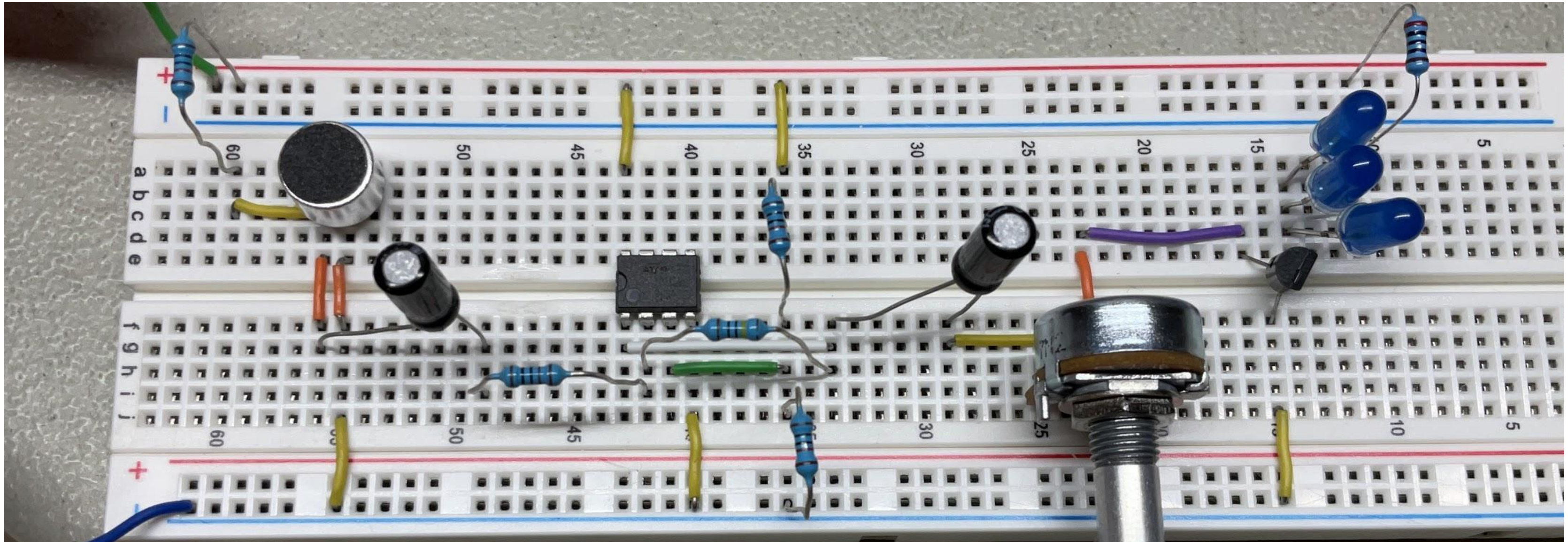
Rock and Roll Light Show Part II - Transistor Switch

- Connect the output of the potentiometer (middle terminal) to the base of a transistor.
- Connect the emitter to ground.
- At the collect, connect three blue LEDs to Vcc via a 200 ohm (red, black, black, black) resistor.
- The transistor switch is complete.



Build Together 3: Final Circuit

- This is a much improved version over our transistor amplifier version.
- The amplifier is more robust, and yet somehow simpler.
- We have increased sensitivity controls.
- Make sure you tune your circuit for the given volume levels of your signal source.



Build Together 4

The Volume Meter

Build Together 4: The Volume Meter

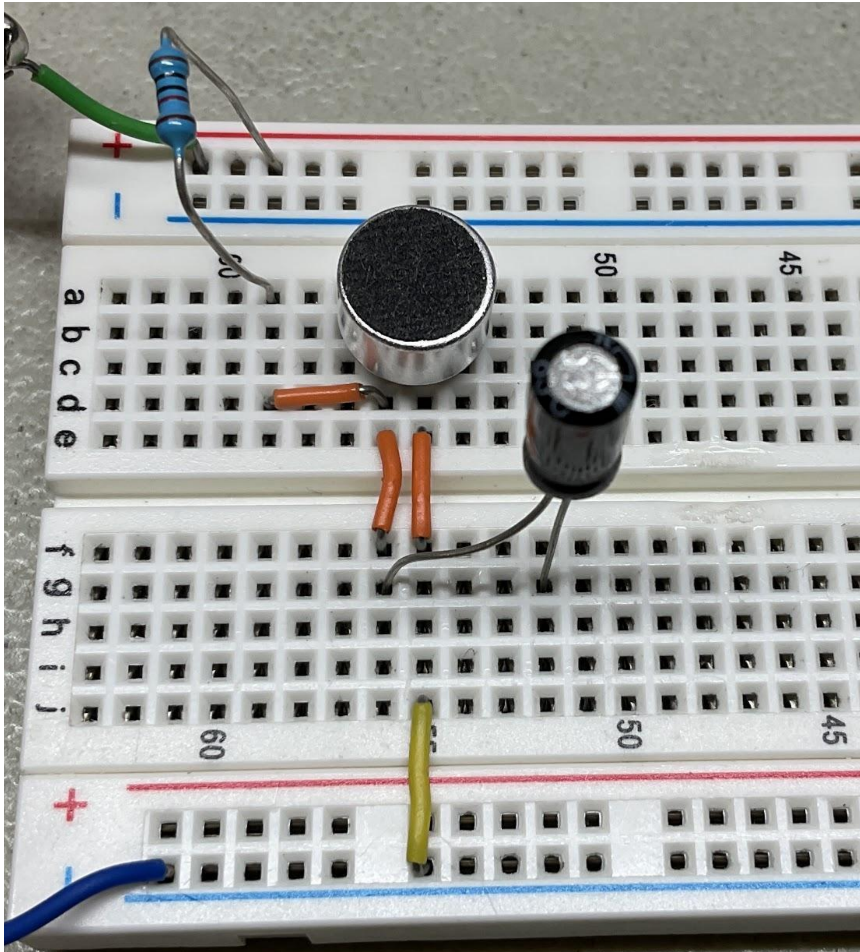
- Lets create a volume meter that will control three LEDs:
  - Green for quiet sounds.
  - Yellow for medium volume sounds.
  - Red for loud sounds.
- This circuit should consist of the following:
  - A microphone circuit to pick up sounds.
  - An op amp amplifier circuit to amplify the signal.
  - A volume control circuit to reduce the signal to the desired levels.
  - Three op amp comparator circuits to compare the signal to some reference voltage.
  - An LED network that lights up according to the volume of the audio signal.

- As you are building, try to think about what you are doing and why the circuit is designed the way that it is.

ADVANCE to the next slide, let’s build this together!

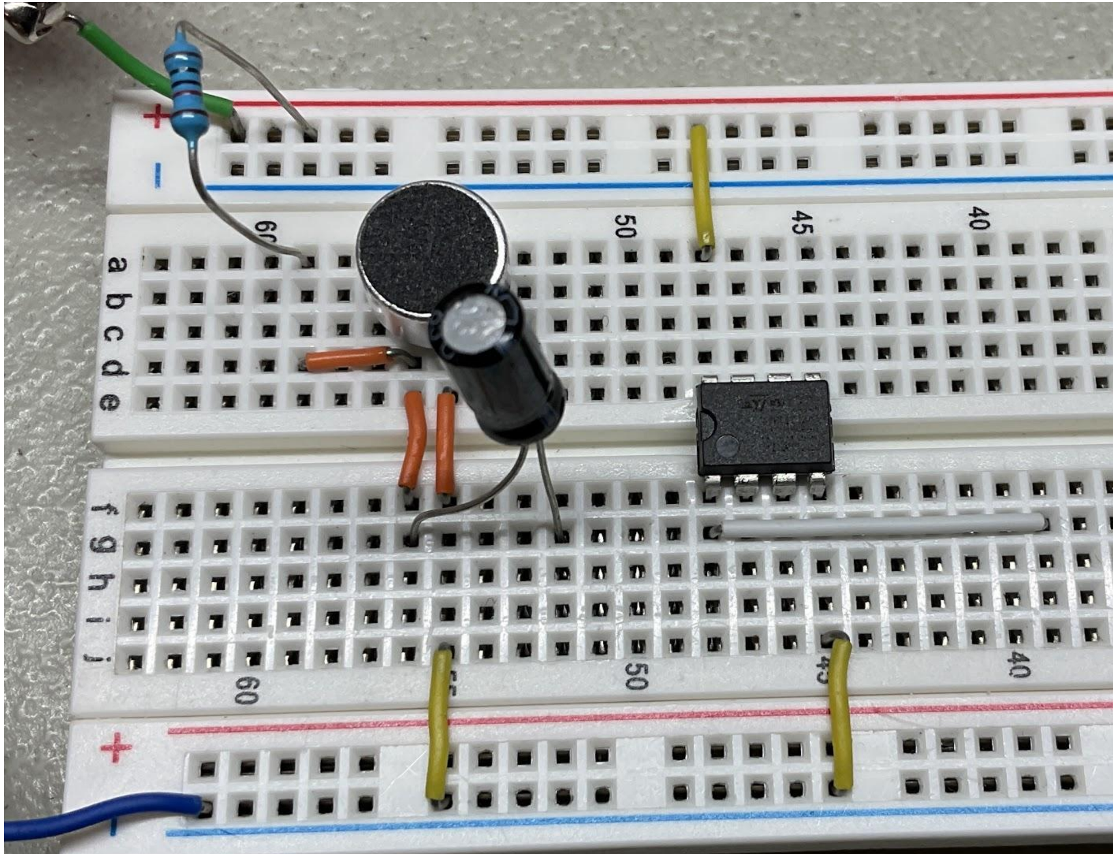
Volume Meter - The Microphone

- Connect a 10K (brown, black, black red) resistor from Vcc into the non-ground pin of a microphone.
- Connect the ground pin to ground (look for the metal attaching to the rim of the microphone).
- Connect the non-ground pin to a 1 microFarad capacitor to block any DC signal coming from Vcc.
- You should have a working microphone now.



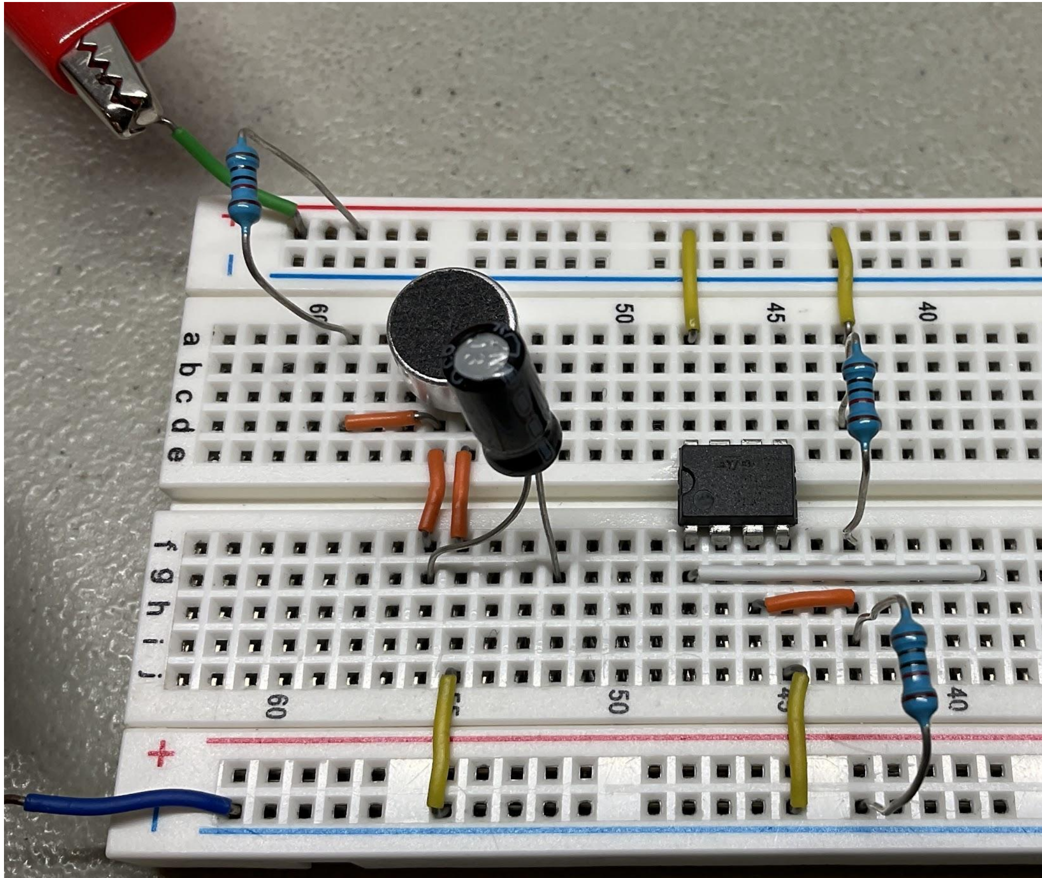
Volume Meter - The Amplifier

- Add an LM 358 op amp into the breadboard.
- Connect pin 8 (Vcc) to Vcc.
- Connect pin 4 (ground) to ground.
- Move pin 1 (output) away from the chip for easy access.



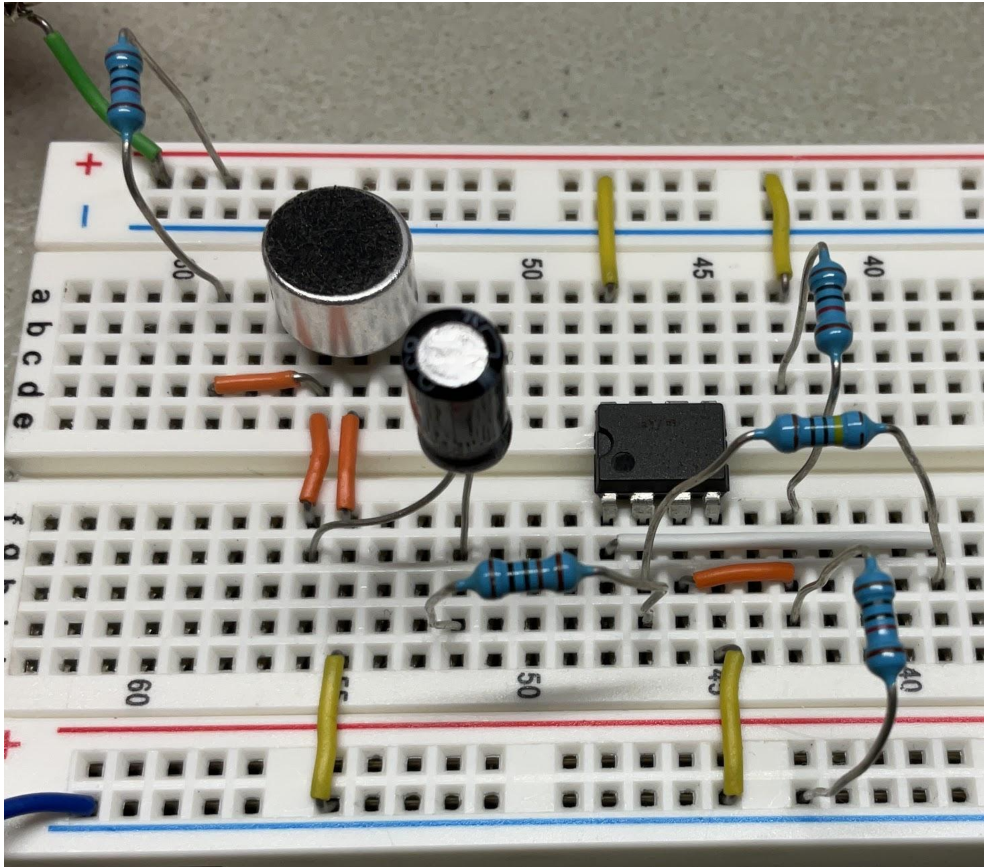
Volume Meter - The Amplifier

- I will be creating an inverting amplifier off a single supply.
- This means I need to pin my non-inverting input, pin 3 at Vcc/2 to give maximum room for amplification.
- To do this, create a voltage divider using two 10K (brown, black, black red) resistors.
- Connect the midpoint of the voltage divider to pin 3 (non-inverting input).



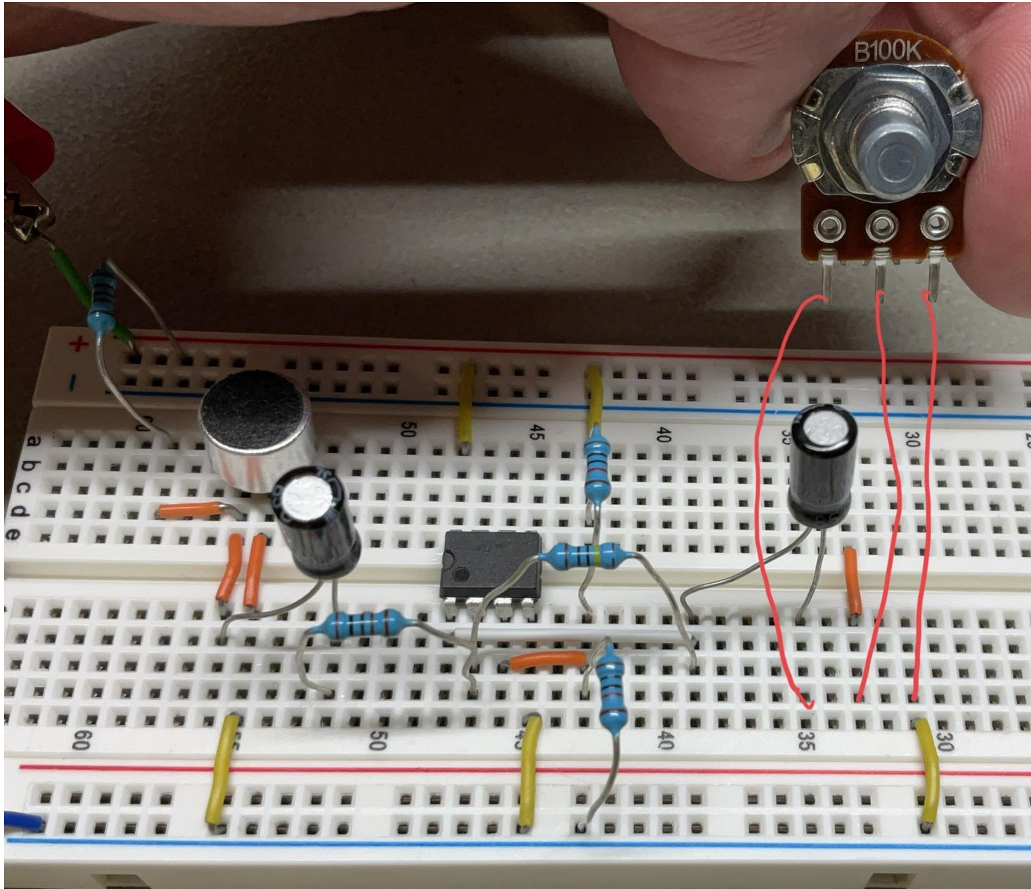
Volume Meter - The Amplifier

- Create a feedback network for the amplifier.
- From the output (pin 1), via our jumper wire, connect a 1M (brown, black, black, yellow) resistor back to the pin 2 (inverting input).
- Connect a 1K (brown, black, black, brown) resistor from pin 2 (inverting input) to the capacitor or our microphone circuit.
- Our amplifier is now complete and we should have a gain of roughly 1,000.



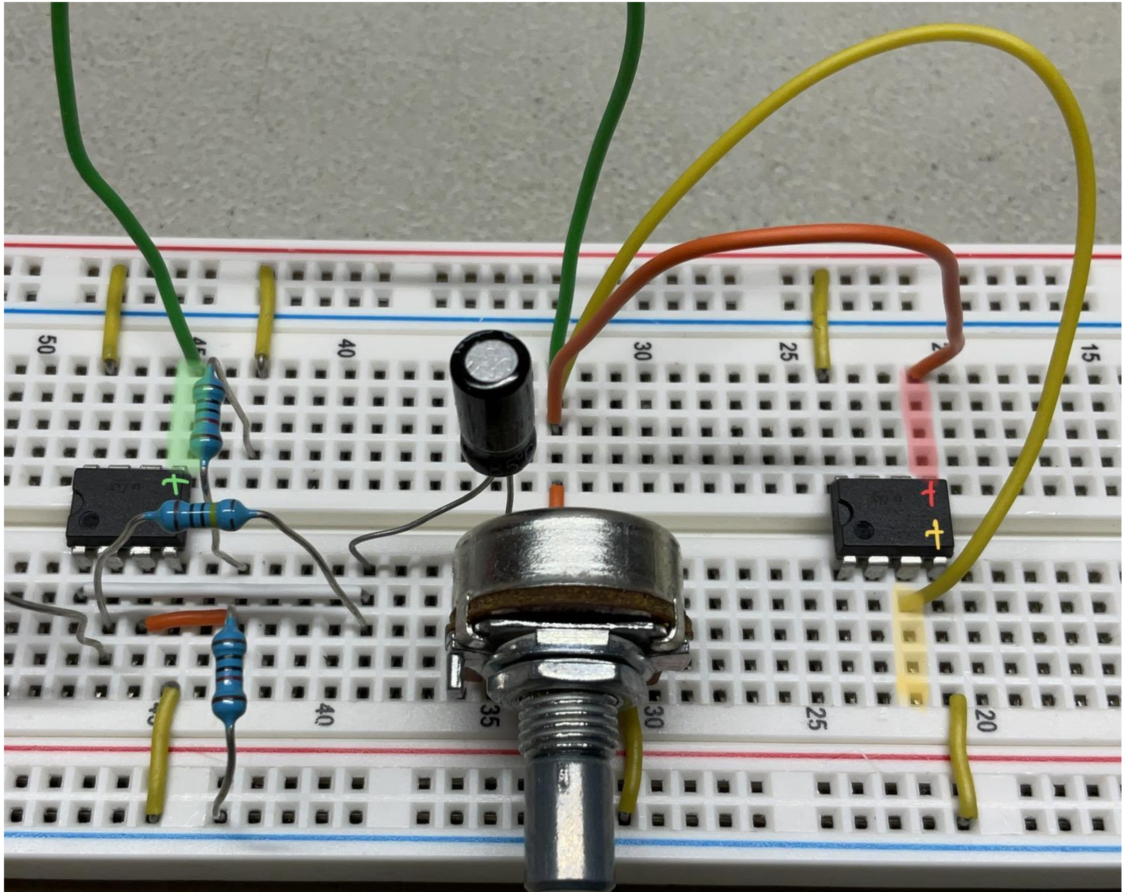
Volume Meter - Sensitivity Control Part 1

- Create a high pass filter that will serve as a way to adjust the sensitivity of our circuit.
- At the output of the op amp, connect a 1 microFarad capacitor into a 100K potentiometer.
- Wire the potentiometer up as an actual potentiometer by grounding the third terminal.
- By adjusting the potentiometer, we will vary the cutoff frequency of the high pass filter. This will provide our sensitivity controls as we try to feed our signal into op amp comparators.



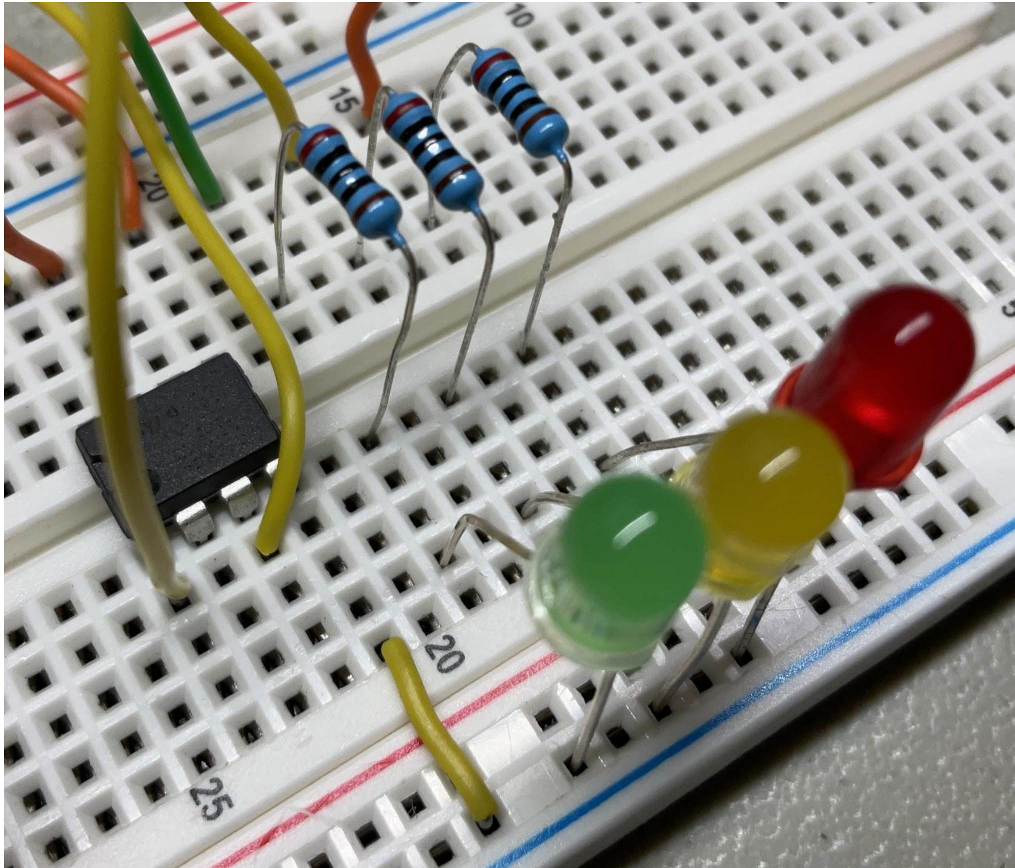
Volume Meter - Comparators Non-Inverting Input (+)

- Place a second LM 358 in the breadboard.
- We now have 3 op amps available to us that we will use as comparators.
- We will send our signal coming out of our high pass filter into the non-inverting input (+) of each op amp and compare this voltage to some reference voltage at the inverting input (-) that we set up.
- Connect the output of the high pass filter into the non-inverting pins (+) of each op amp.
- Note the pins are pins 3 and 5.
- When our voltage at the non-inverting input is greater than the voltage at the inverting input, we will output a high signal of roughly Vcc.
- We will use this signal to light up a specific LED.



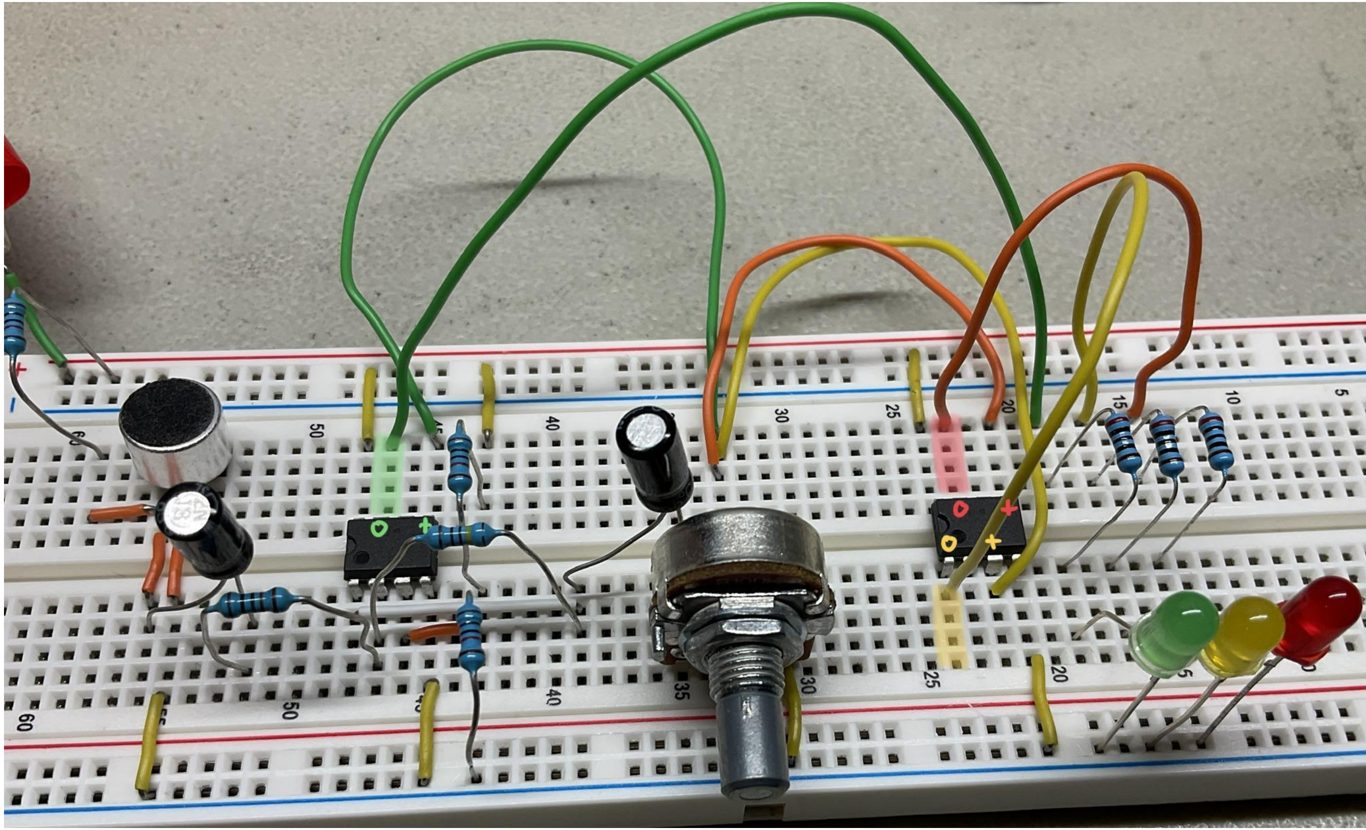
Volume Meter - Comparators Output (o)

- Connect three 200 ohm (red, black, black, black) resistors into an LED into ground.
- We'll use a green LED for low volumes, yellow for medium volumes, and red for high volumes.
- Here I've placed three jumper wires at the top of my resistors. We will connect these to our various op amp comparators.



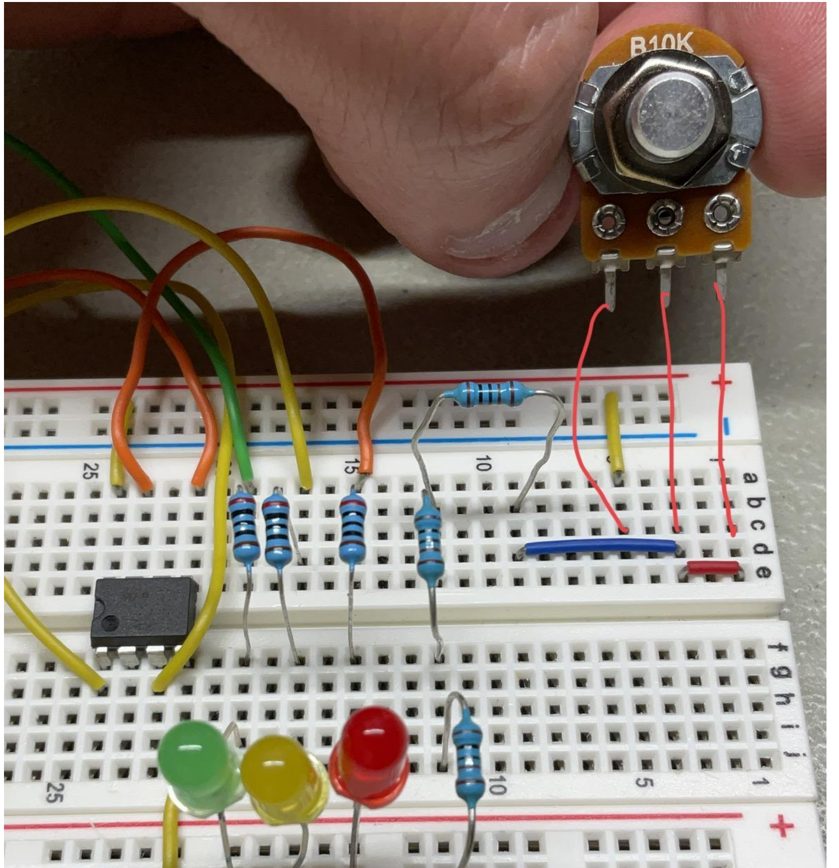
Volume Meter - Comparators Output (o)

- Connect the green LED to an output of an op amp comparator.
- Connect the yellow LED to an output of an op amp comparator.
- Connect the red LED to an output of an op amp comparator.



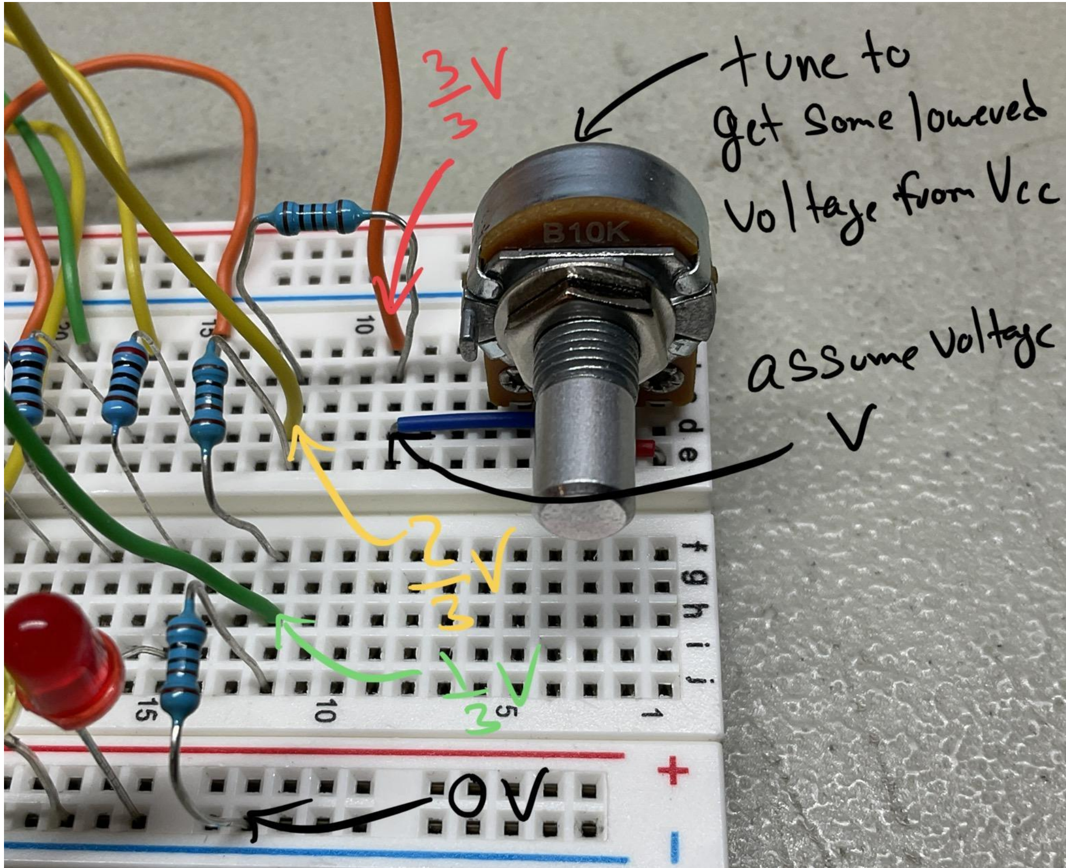
Volume Meter - Comparators Inverting Input (-)

- Now that we have the non-inverting input and the output of each op amp comparator hooked up, we have to provide a signal to the inverting input.
- When the signal at the inverting input is greater than the signal at the non-inverting input (our audio signal) then the output will be low and the LEDs will be off.
- When the signal at the non-inverting input (our audio signal) is greater than the signal at the inverting input, our output signal will be high and the LEDs will light up.
- We'll start by creating a voltage divider using a 10K potentiometer wired up as a variable resistor.
- We will go into three 1K (brown, black, black, brown) resistors going to ground.



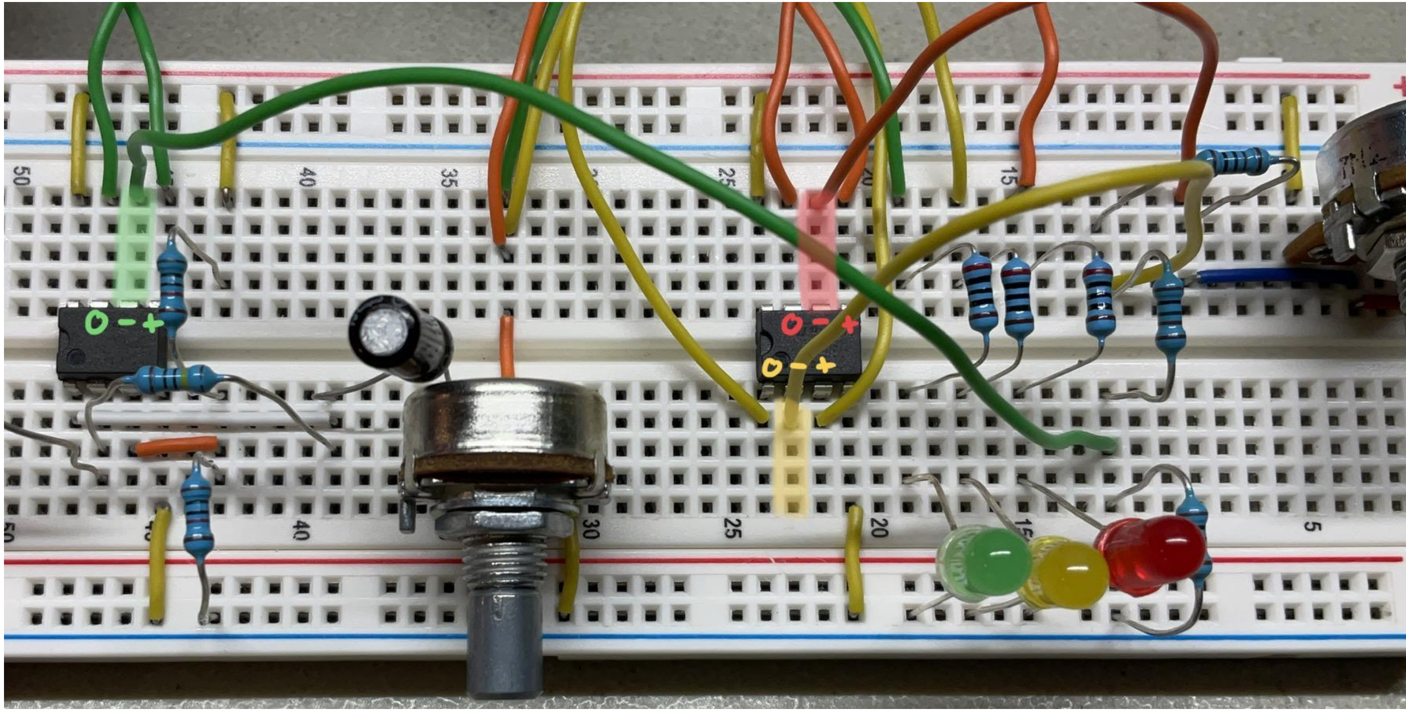
Volume Meter - Comparators Inverting Input (-)

- The potentiometer is there to allow us to fine turn the voltages at various points in out voltage divider network.
- If we assume a voltage of V after the potentiometer, we have 3 different points within the voltage divider; each ⅓ V lower than the previous voltage.
- Since we are sending these to our inverting input, the largest voltage (orange wire) will go to our red LED op amp. The smallest voltage (green wire) will go to our green LED op amp.



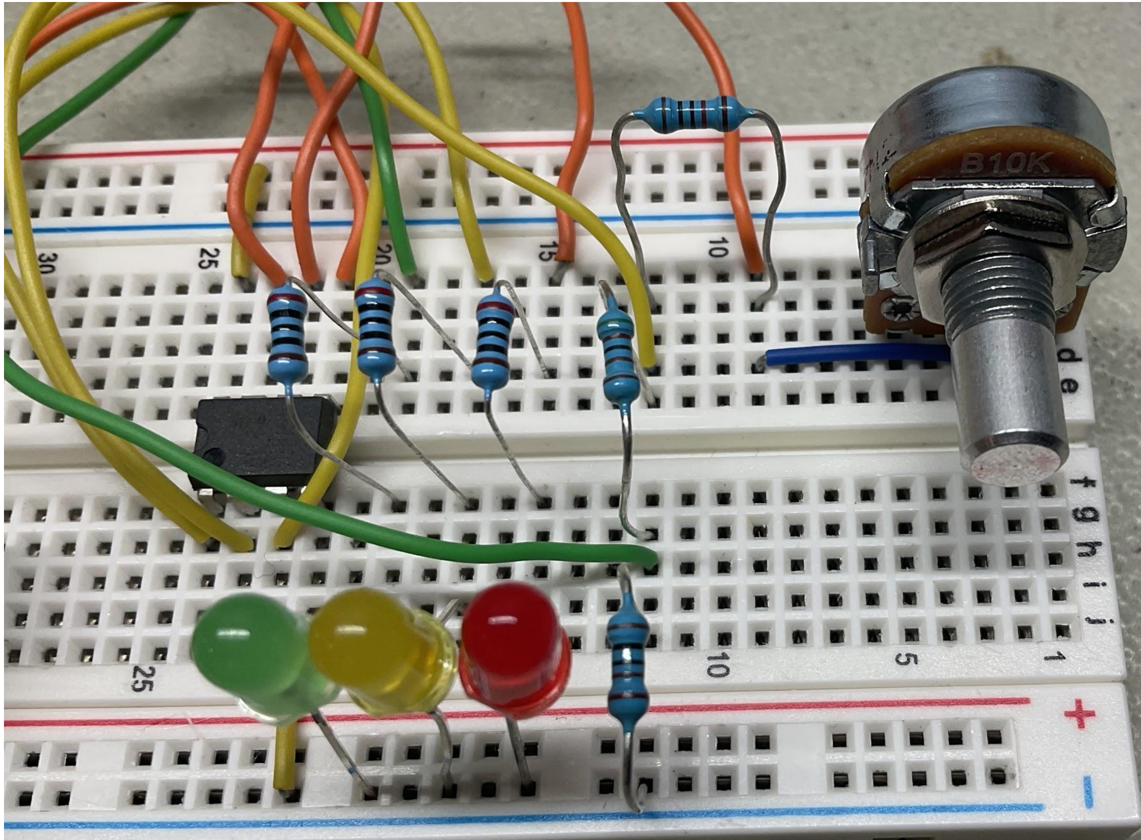
Volume Meter - Comparators Inverting Input (-)

- Connect the three points in the voltage divider to the corresponding op amp comparators inverting input.



Volume Meter - Comparators Inverting Input (-)

- I originally used three 1K ohm resistors in our voltage divider for simplicity on how the voltages will drop from one inverting input to the next.
- For improved performance, I have changed the resistor values to 10K (brown, black, black, red), 5.1K (green, brown, black, brown), 1K (brown, black, black brown).



Build Together 4: Final Circuit

- Tune your volume meter by ensuring the loudest sound you want turns the red LED on and the quietest sound has all LEDs off.
- To do this, adjust the amplified signal with the 100K potentiometer and the sensitivity of the LEDs with the 10K potentiometer.