[gather it]

Form three groups. Each group will need the following:

1. A computer.
2. An Arduino Uno, and USB cable.
3. An oscilloscope with 2 probes.
4. A digital multimeter and 2 probes.
5. A piece of paper, and a 6B pencil.
6. A breadboard, and connecting wires.
7. Four battery packs with header pins, and 12 AAA batteries.
8. Two 0.1μF capacitors, four 10kΩ, one 100kΩ, and one 200Ω resistors, one LED, and one 1N4001 diode.
9. Two 10kΩ variable resistors.
10. One LM324 operational amplifier chip.
11. One IRF740 MOSFET type transistor.
12. One Schmitt Trigger chip, an MC74AC14NG

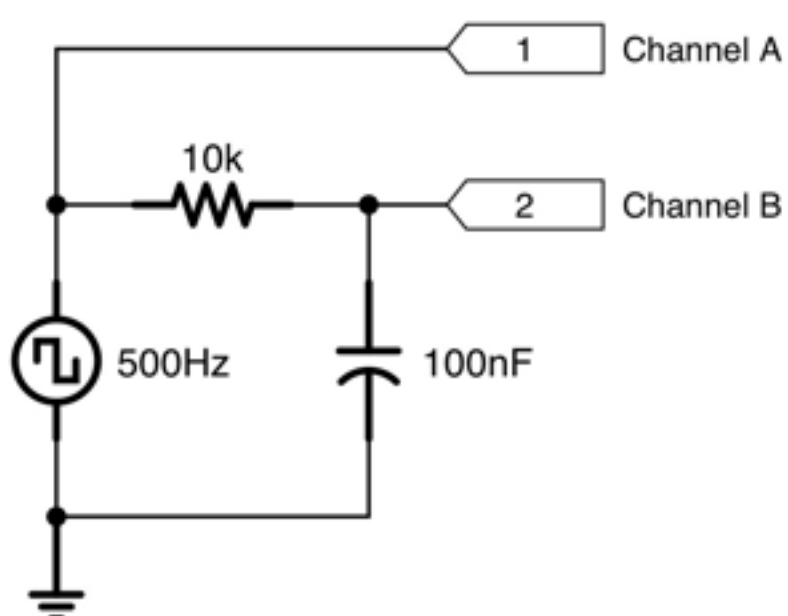
[make it]

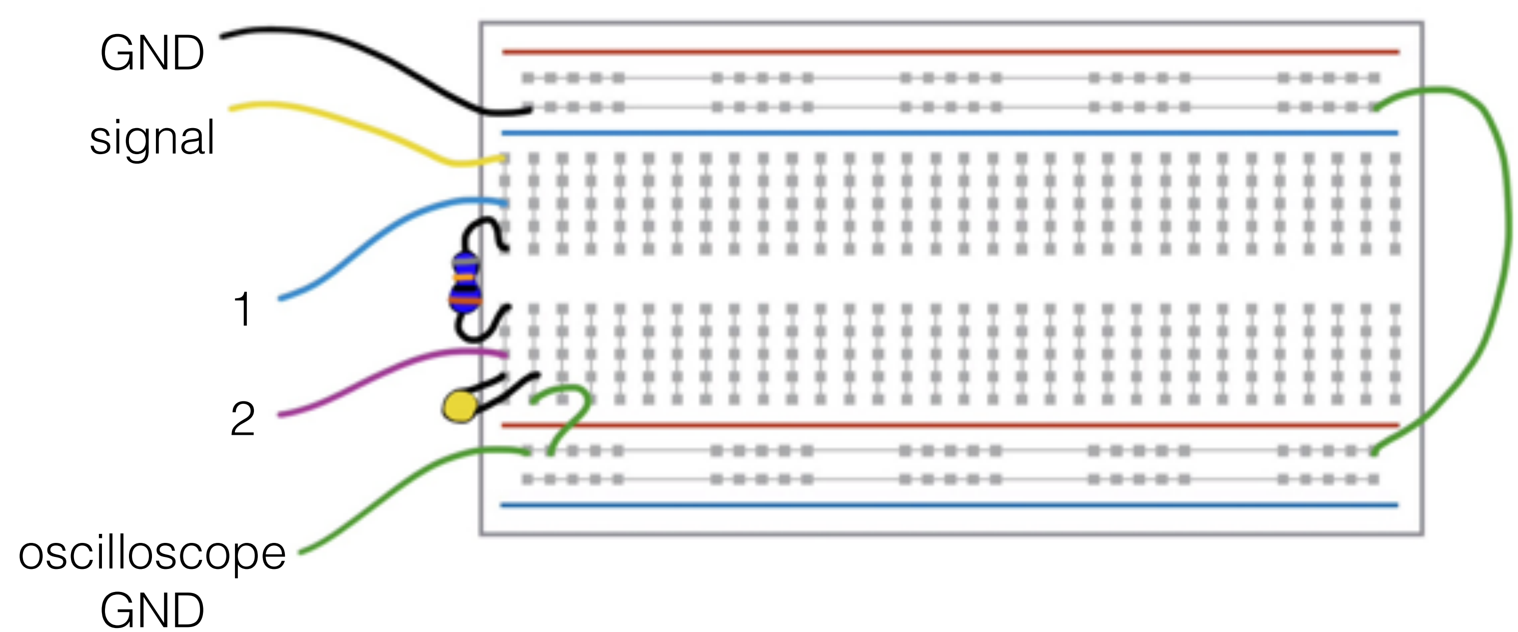
1. Load the “MICA-oscillator” sketch code onto the Uno.
2. Power the Uno using a battery pack. Connect to 5V and GND.
3. Connect a wire to pin 8, and one to GND.
4. Display the wave form on the oscilloscope.

Add a hookup diagram

[smooth it]

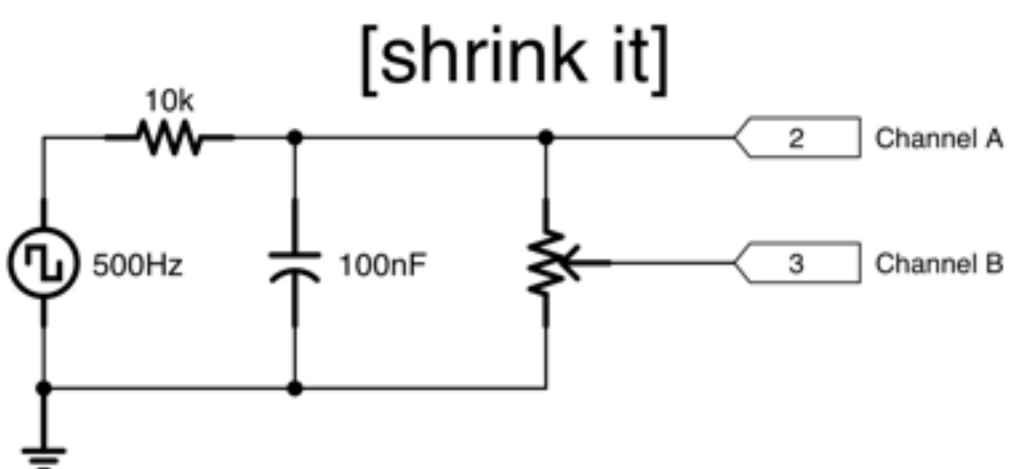
1. Connect the two innermost bus bars on the breadboard. (green wire)
2. Connect one of the GND pins on the Arduino to either of the inner bus bars. (black wire)
3. Connect the signal wire from pin 8 on the Arduino to the breadboard as shown. (yellow wire)
4. Add a capacitor and resistor to make the circuit shown, to slow the rise and fall of the signal.
5. Connect additional wires to display the signals on the oscilloscope. (blue, purple, and green wires)





[shrink it]

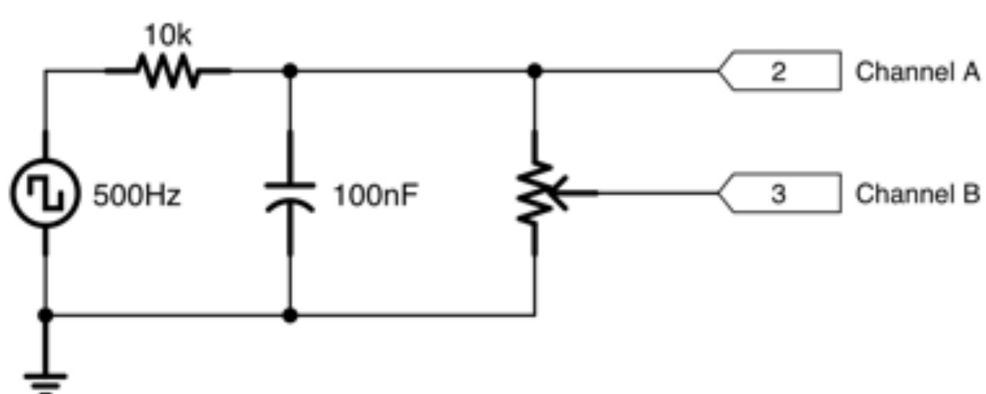
1. Draw a thick line on a piece of paper with a soft pencil.
2. Hold one wire from the Signal and one from the GND to each end of the pencil line.
3. Touch the oscilloscope probe to the middle of the pencil line. As you move the probe toward the Signal end of the line, the signal trace should get larger in amplitude. The amplitude should get smaller when you move the probe toward the GND end of the line.

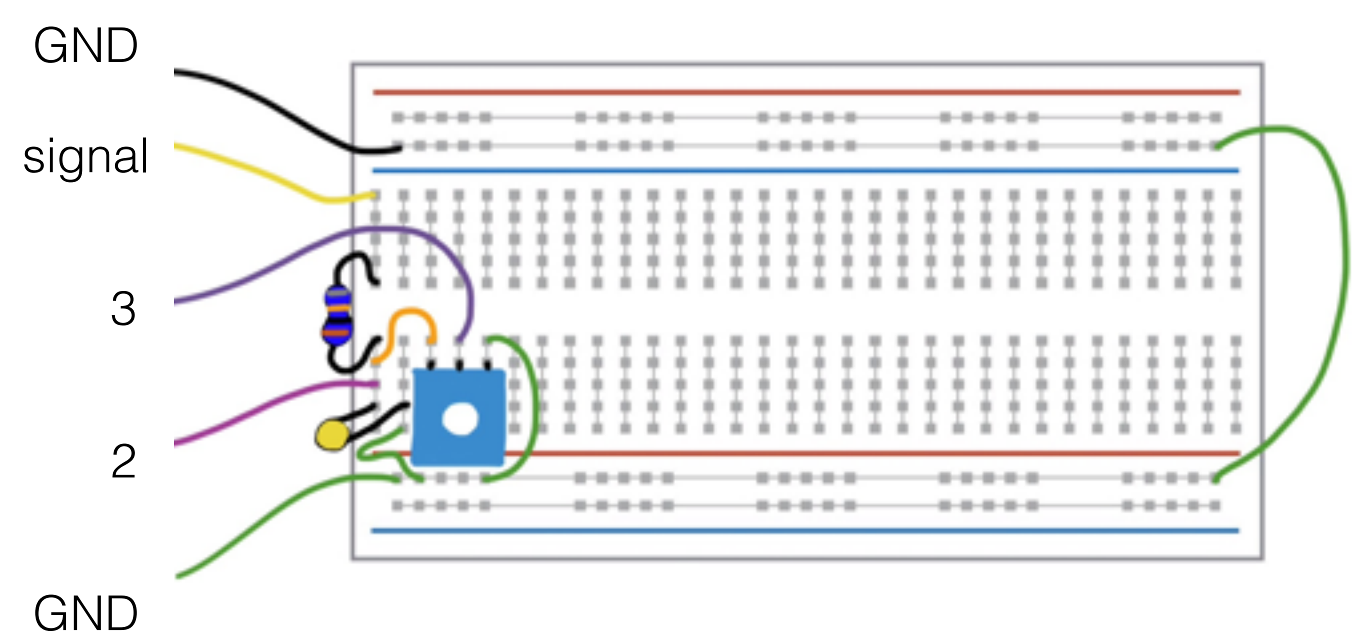


Photo

[shrink it]

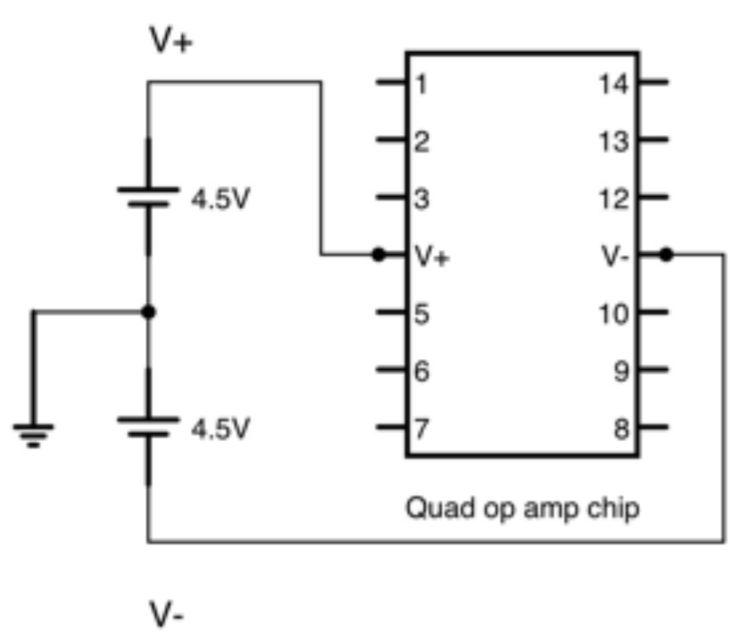
5. Connect the 10kΩ variable resistor the same way, and show that you have control over the voltage.
6. Connect the 500Hz signal to the variable resistor in the same way, and connect the oscilloscope to show you can control the waveform voltage amplitude. Set it to be much smaller than the original waveform.

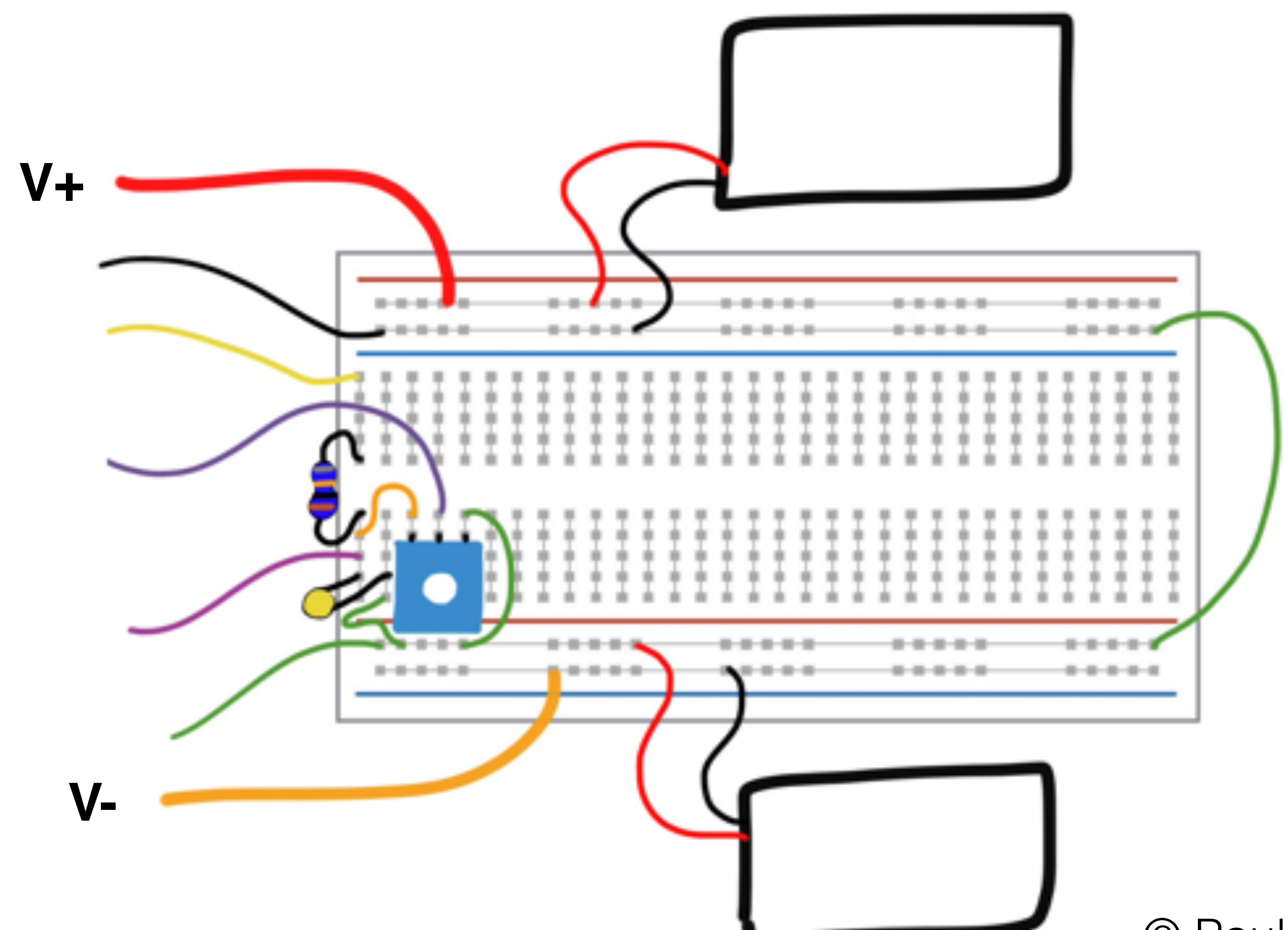




[power it]

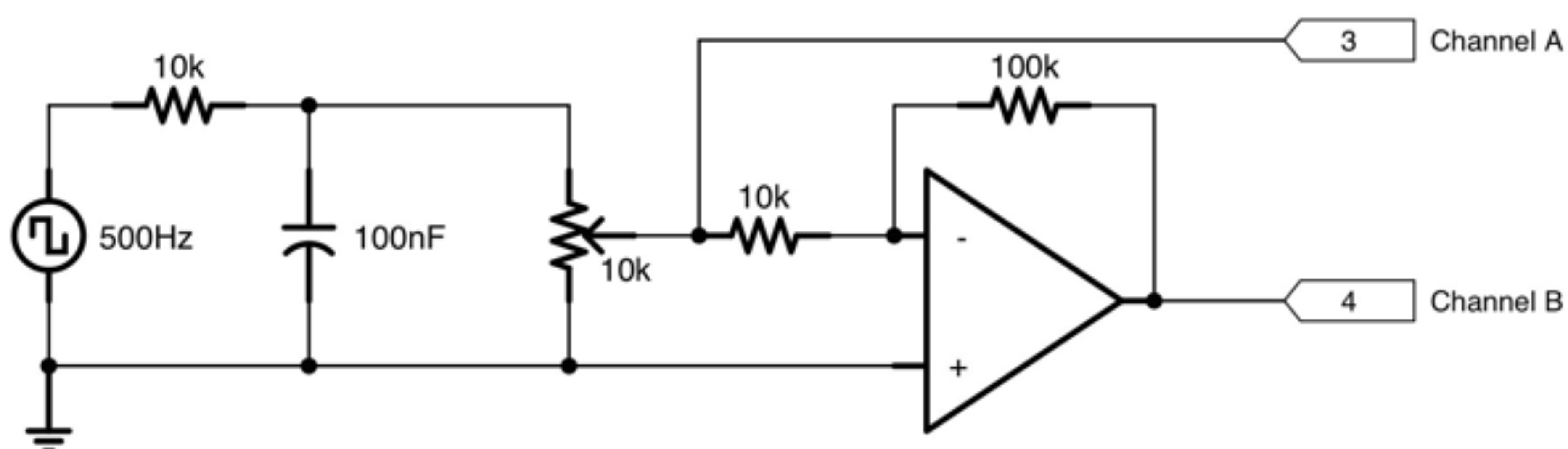
1. Connect two additional battery packs to the breadboard as shown. This wiring plan creates a bipolar (positive and negative) power supply.
2. Test the supply with a volt meter. Connect the negative lead of the volt meter to GND. Connect the positive lead to V+, and it should show a positive voltage. Disconnect from V+, and connect the positive lead of the volt meter to V-. You should see a negative voltage.



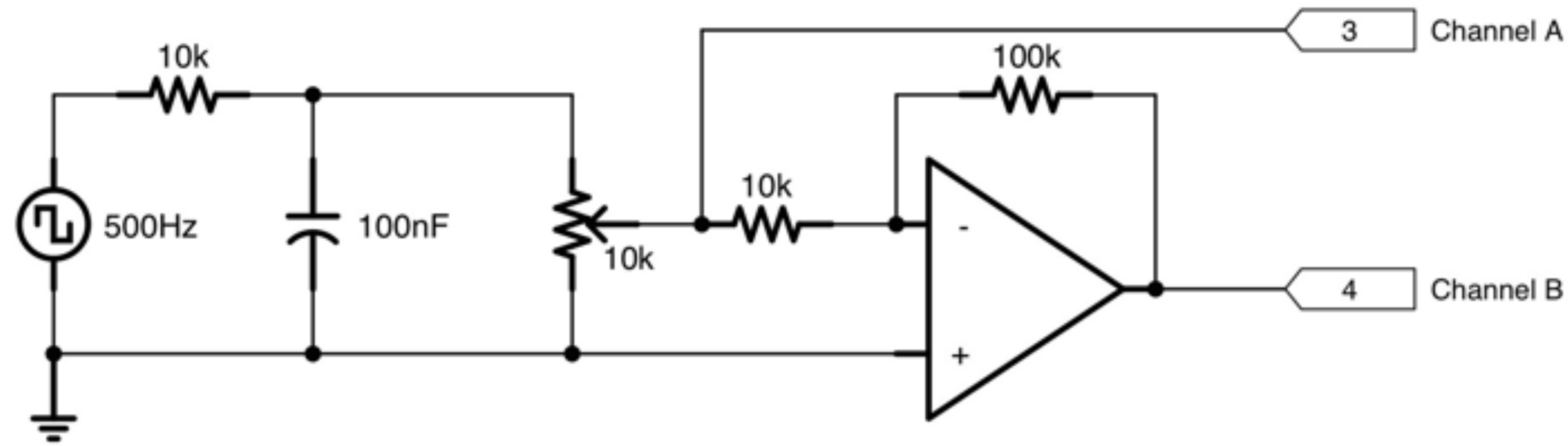


[amplify it]

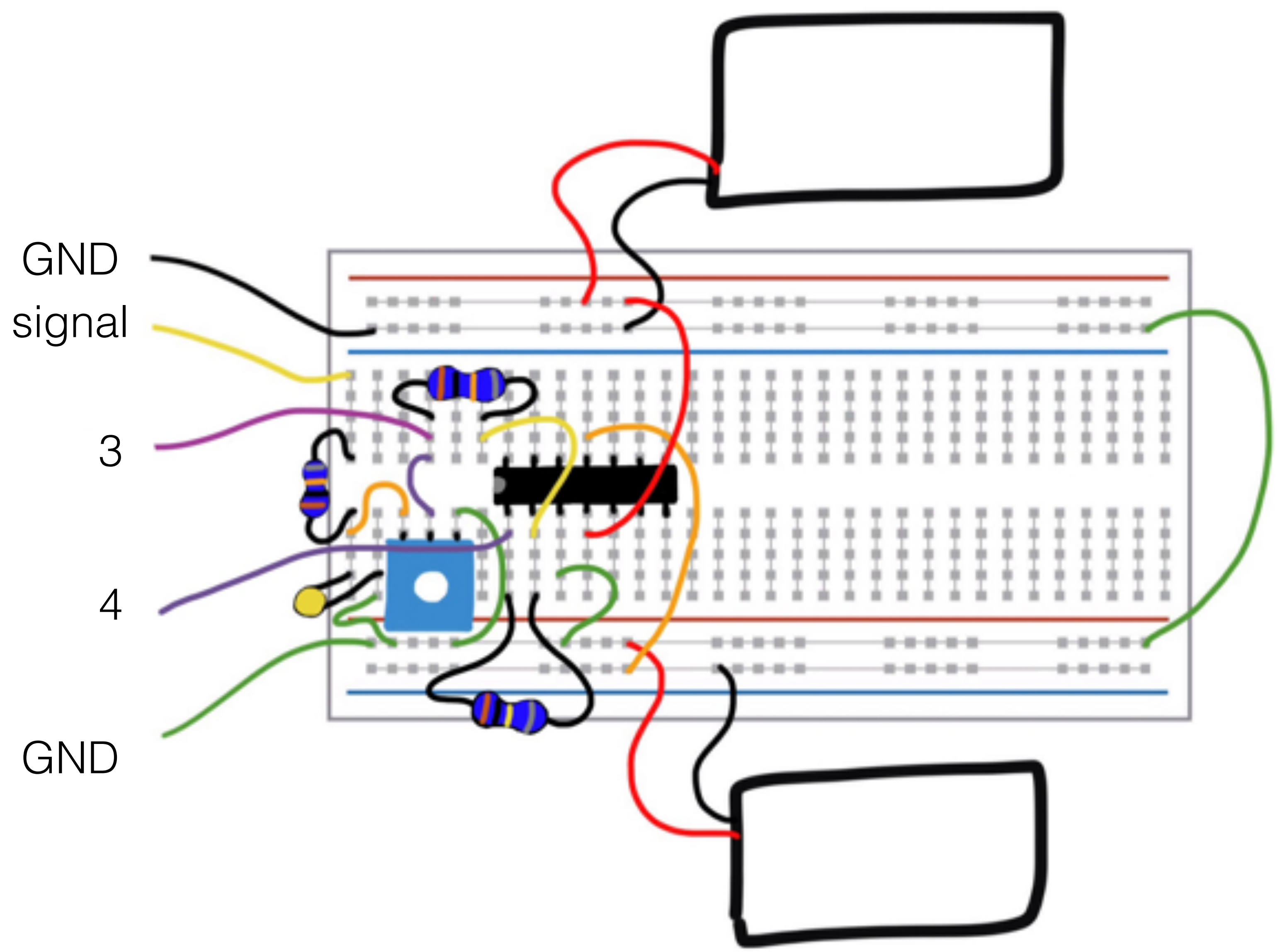
4. Connect the output to the second channel of the oscilloscope. The signal should be larger in amplitude and inverted in sign.
5. Adjust the variable resistor to change the size of the output signal. When the amplitude of the signal tries to exceed the power supply voltage, the signal gets chopped off. This is known as “clipping”, and it is clipping that makes over-amplified voices so hard to understand. Move back from the microphone, please, so we can understand you.



[amplify it]



10k
500Hz
100nF
10k
10k
100k
3
Channel A
4
Channel B
-
+

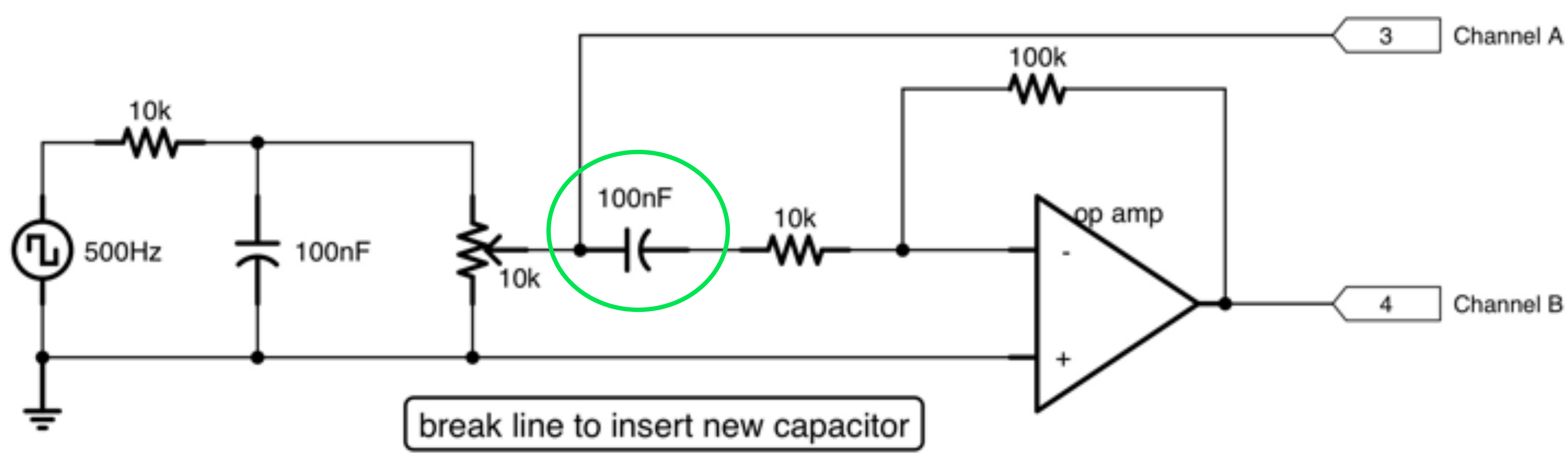


GND
signal
3
4
GND

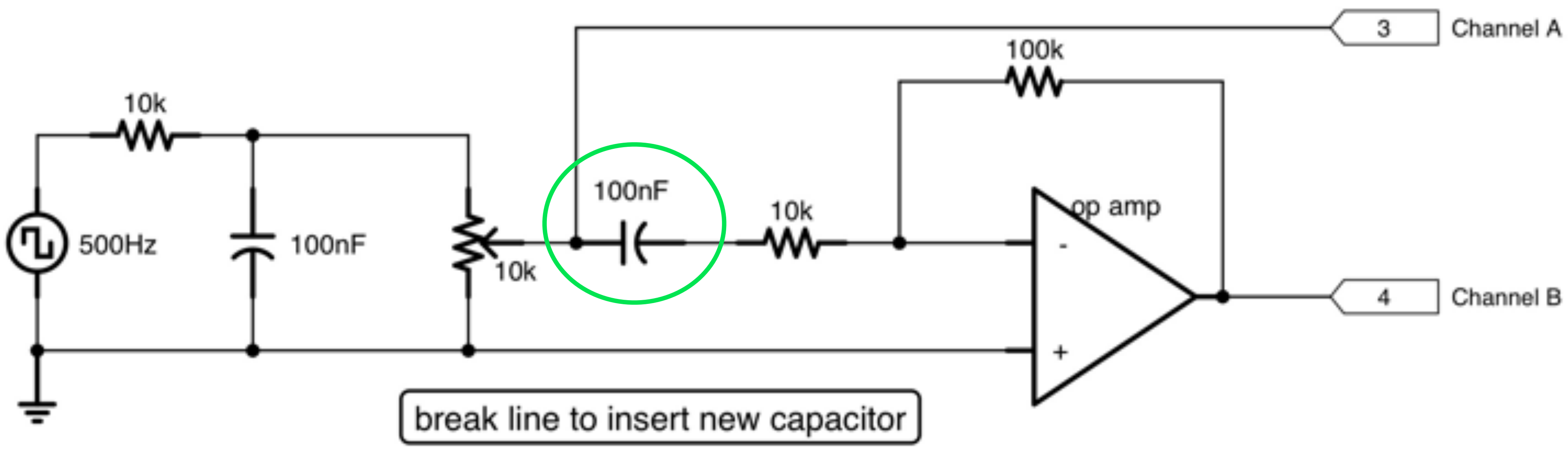
[shift it]

1. Insert a 0.1μF = 100nF capacitor into the circuit as shown.
2. The output wave form should now be symmetric about GND.

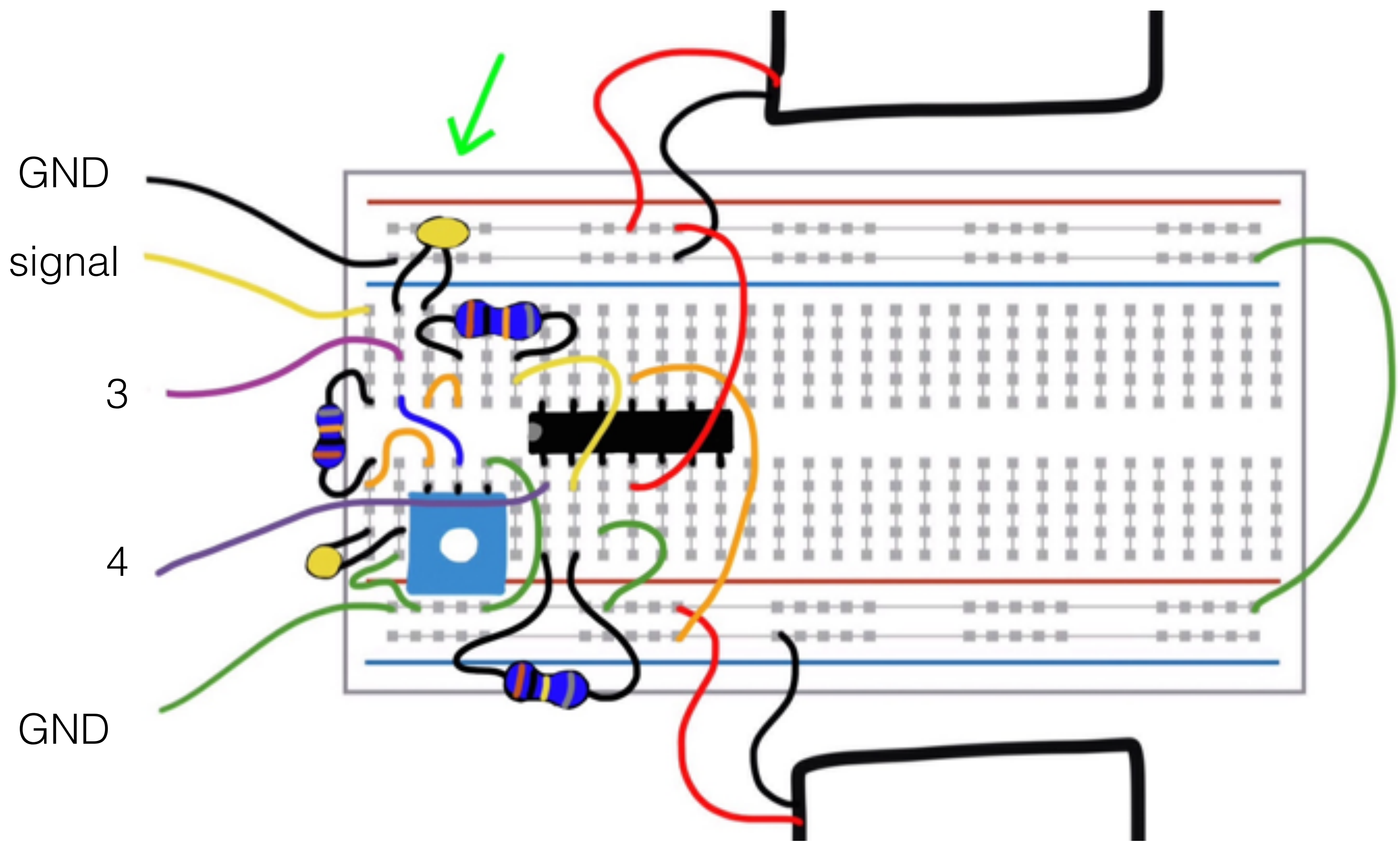
This technique of removing the DC offset is known as “AC coupling”.



[shift it]



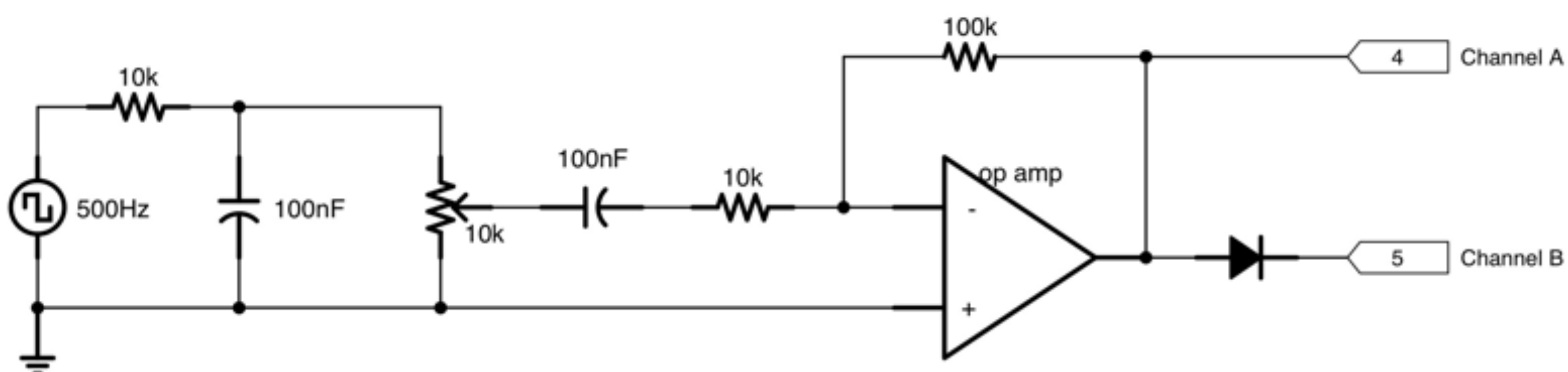
10k
500Hz
100nF
10k
100nF
10k
100k
op amp
-
+
3
Channel A
4
Channel B
break line to insert new capacitor



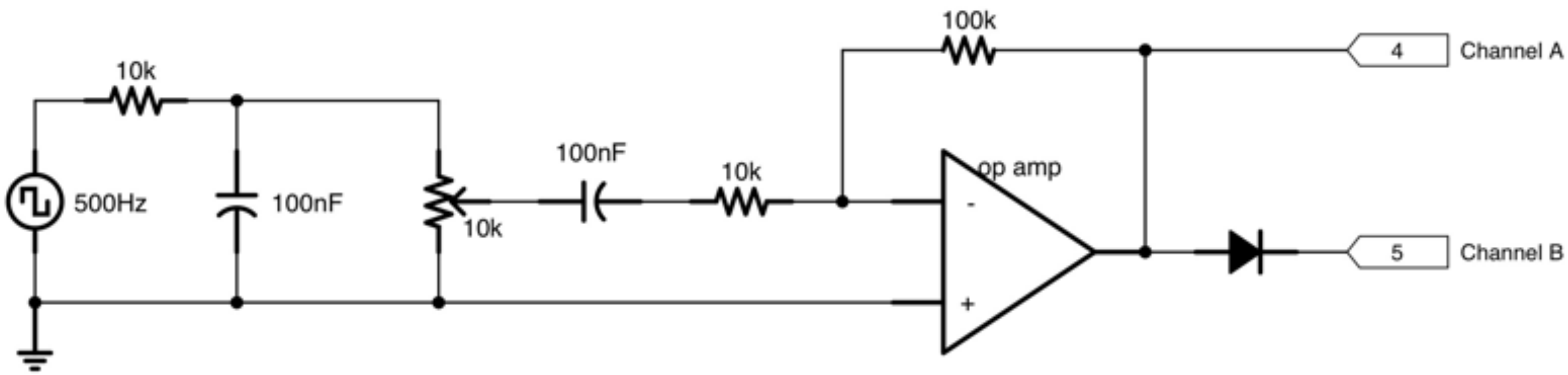
GND
signal
3
4
GND

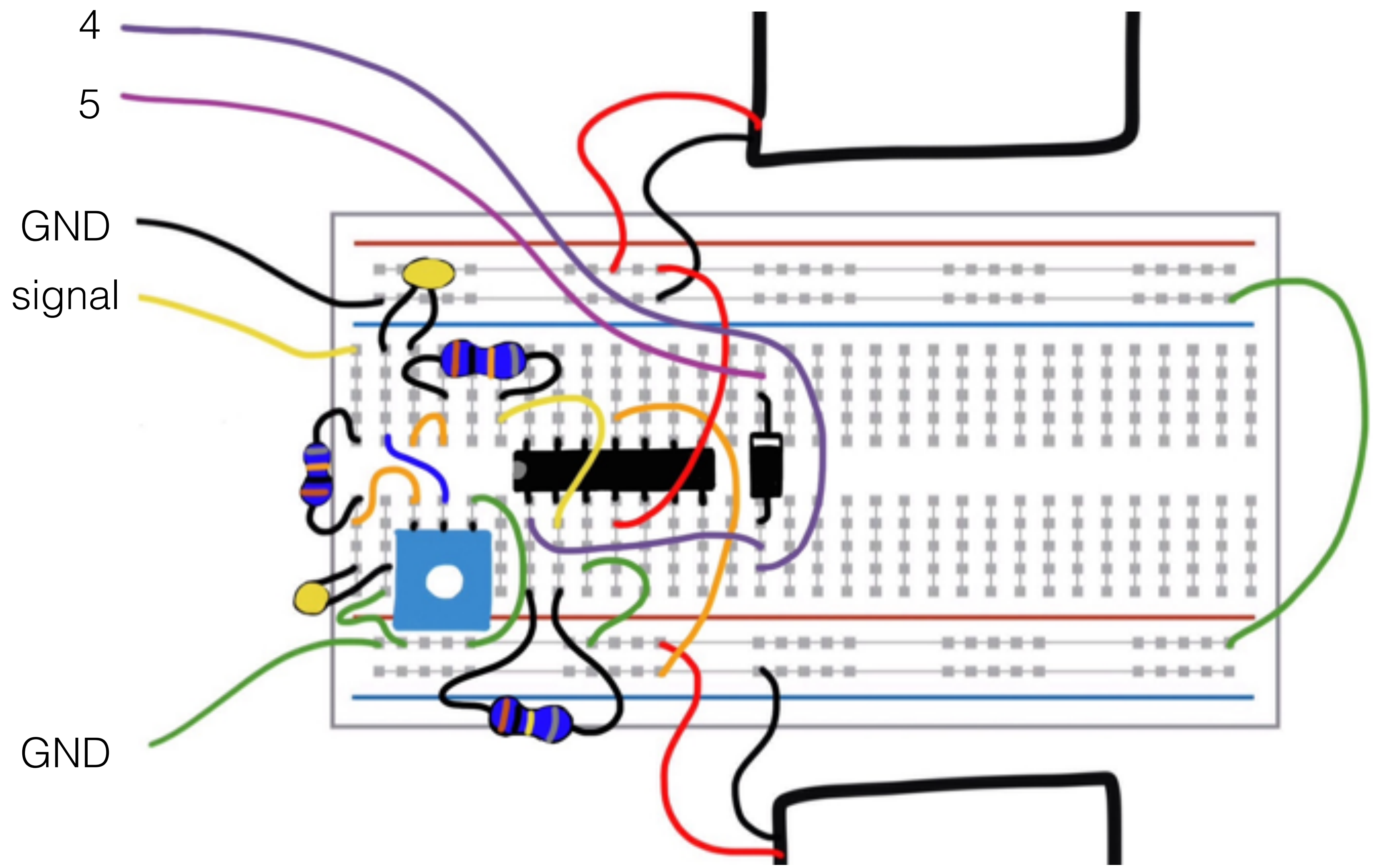
[slice it]

1. Add a diode to the circuit as shown.
2. Connect the far side of the diode to the oscilloscope. Since the diode prevents current from flowing in one direction, it blocks the negative-going half the signal. This type of signal modification is known as “half wave rectification” and is the basis of radio reception. A “crystal set” radio receiver was a diode, a coil antenna, and an earphone. It was powered by the radio signal itself.



[slice it]


10k
500Hz
100nF
10k
100nF
10k
100k
op amp
-
+
4
Channel A
5
Channel B


4
5
GND
signal
GND