[gather it]

Form three groups. Each group will need the following:

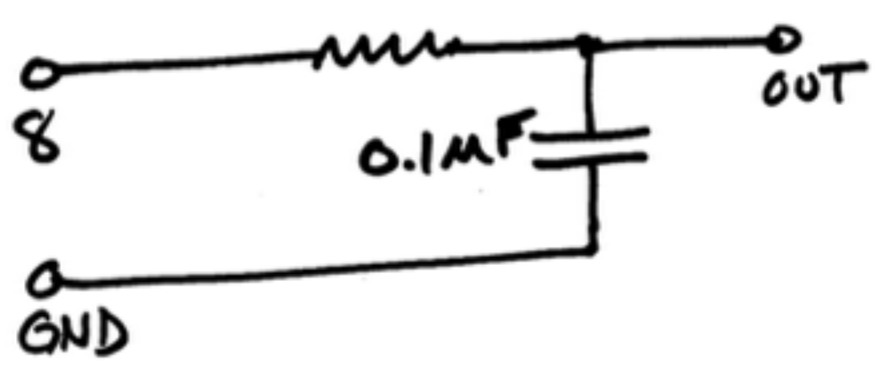
1. A computer.
2. An Arduino Uno, and USB cable.
3. An oscilloscope with 2 probes.
4. A digital multimeter and 2 probes.
5. A piece of paper, and a 6B pencil.
6. Two breadboards, and wires.
7. Four battery packs with header pins, and 12 AAA batteries.
8. Two 0.1μF capacitors, four 10kΩ, one 3.6kΩ, and one 200Ω resistors, one LED, and one 1N4001 diode.
9. Three 10kΩ variable resistors.
10. One LM324 operational amplifier chip.
11. One IRF740 MOSFET type transistor.
12. One Schmitt Trigger chip, NNNNNN

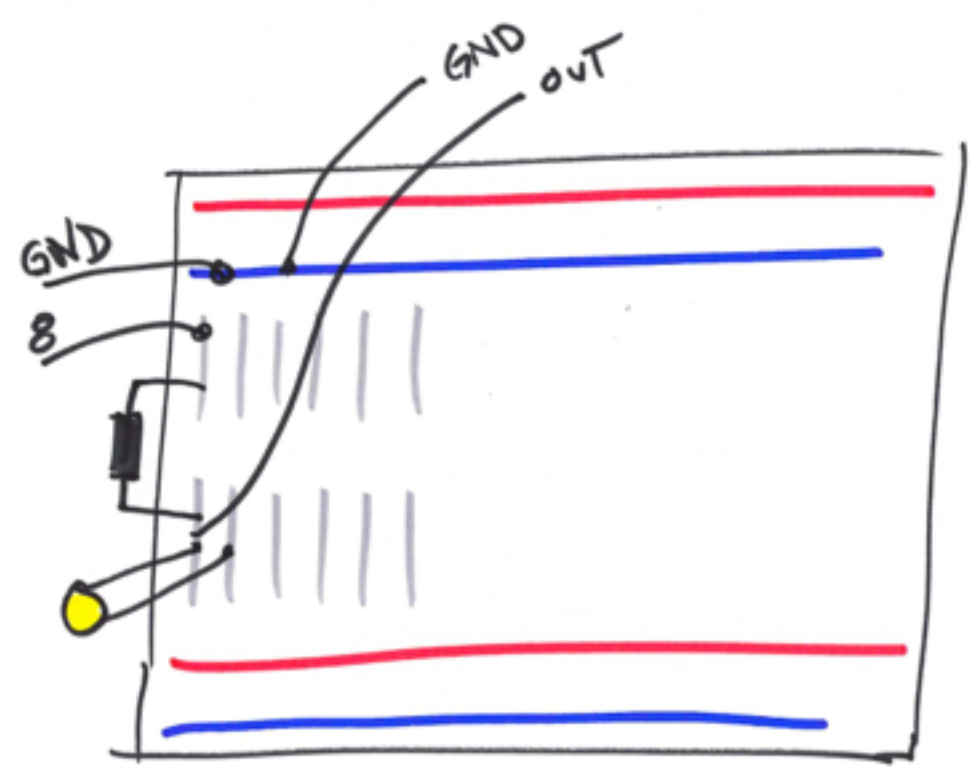
[make it]

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.
5. Calculate the waveform period and frequency in a spreadsheet.

[smooth it]

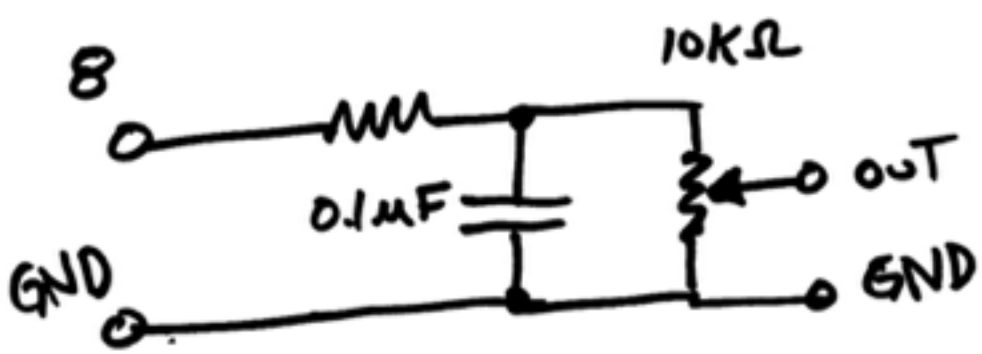
1. Connect the GND wire to the - bar on a breadboard.
2. Connect the signal wire (from pin 8) to the A30 location on the breadboard
3. Connect additional wires to display the signal on the oscilloscope.
4. Add a capacitor and resistor to make the circuit here to make it look a bit more like a sine wave.

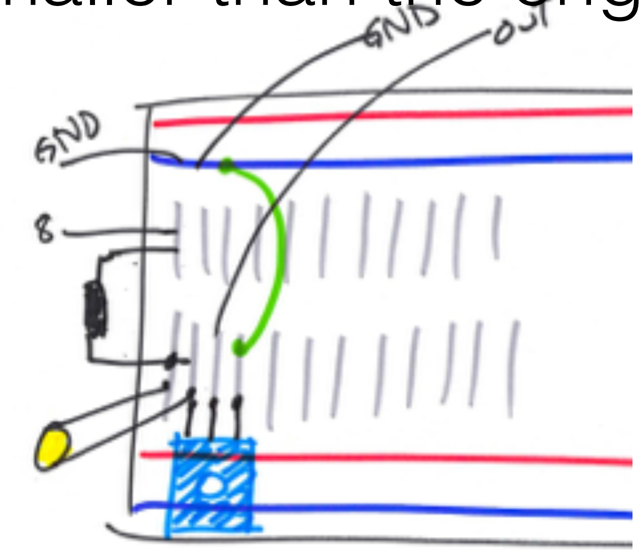




[shrink it]

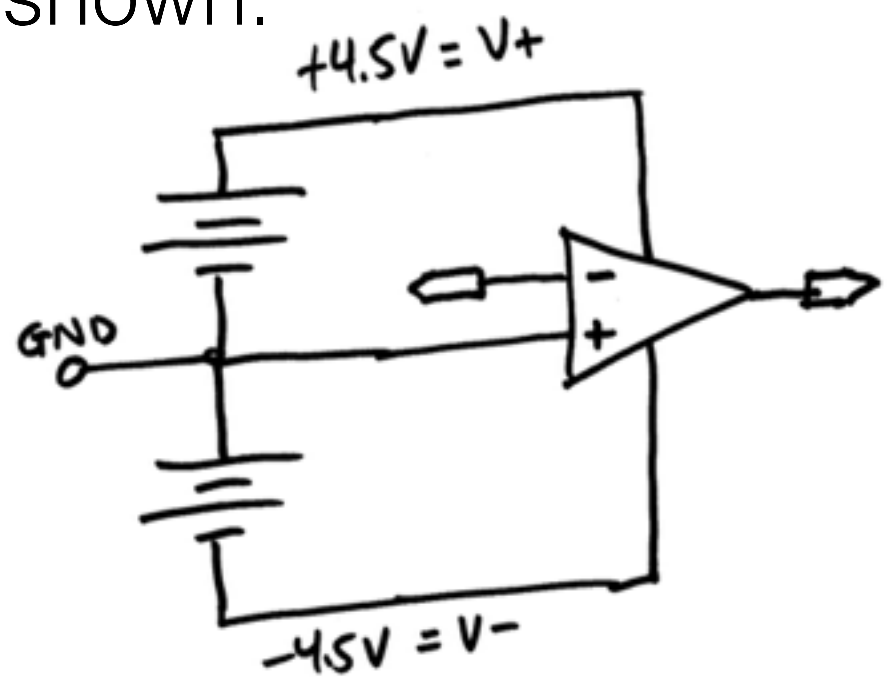
1. Draw a thick line on a piece of paper with a soft pencil.
2. Hold one wire from the + supply and one from the GND supply to each end of the pencil line.
3. Set the meter to read DC Voltage. Connect [-] from the meter to GND.
4. Touch the [+] probe to the middle of the pencil line. As you move the probe toward the + end of the line, the voltage should go up, and the voltage should go down when you move the probe toward the GND end of the line.
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.

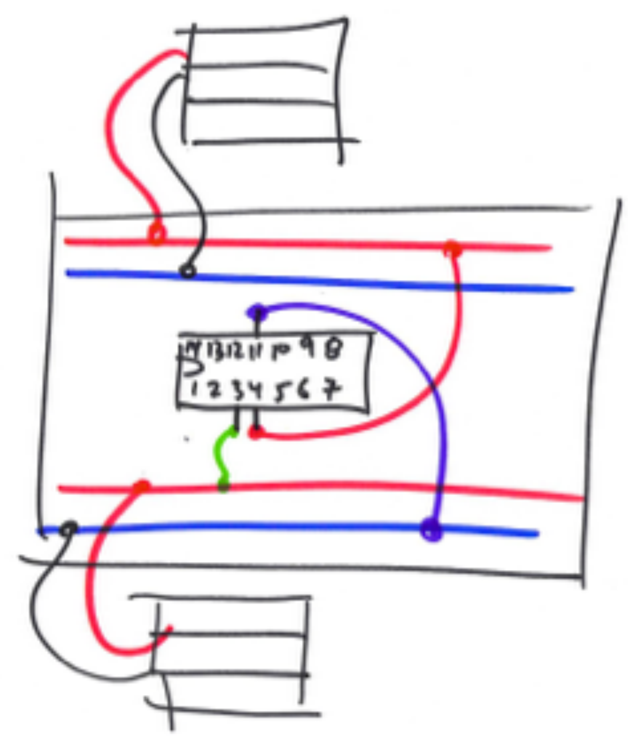




[connect it]

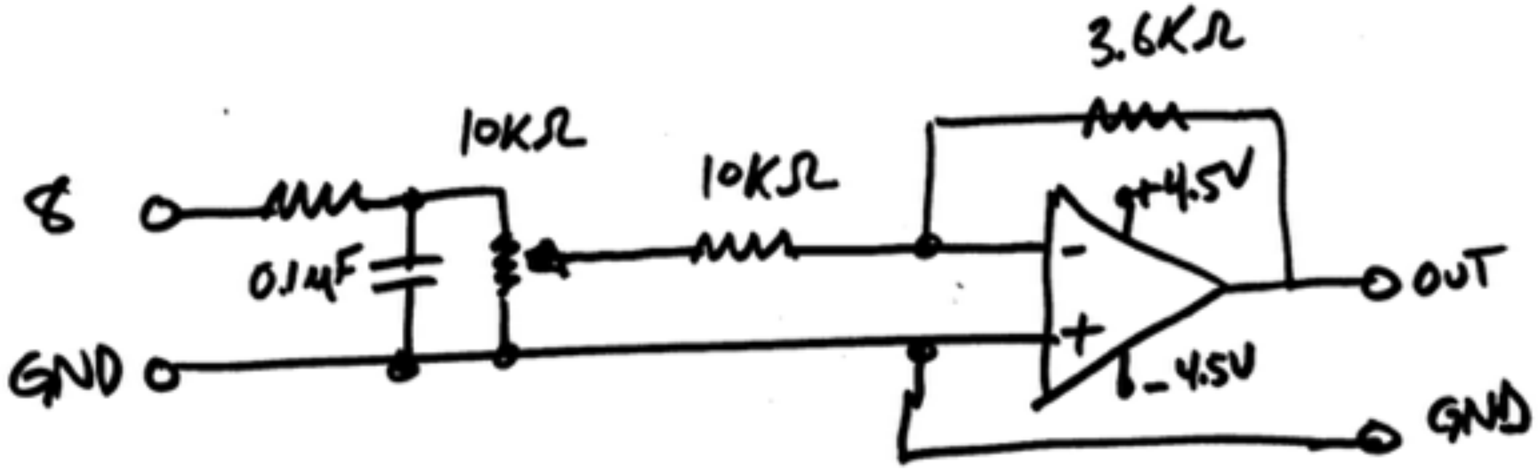
1. Connect two additional battery packs to the breadboard, each to the + bar and - bar on either side of the breadboard.
2. Connect a wire from the innermost + bar to the innermost - bar. That network will be GND. The outermost + bar will be V+, and the outermost - bar will be V-.
3. Connect the operational amplifier chip and resistors as shown.

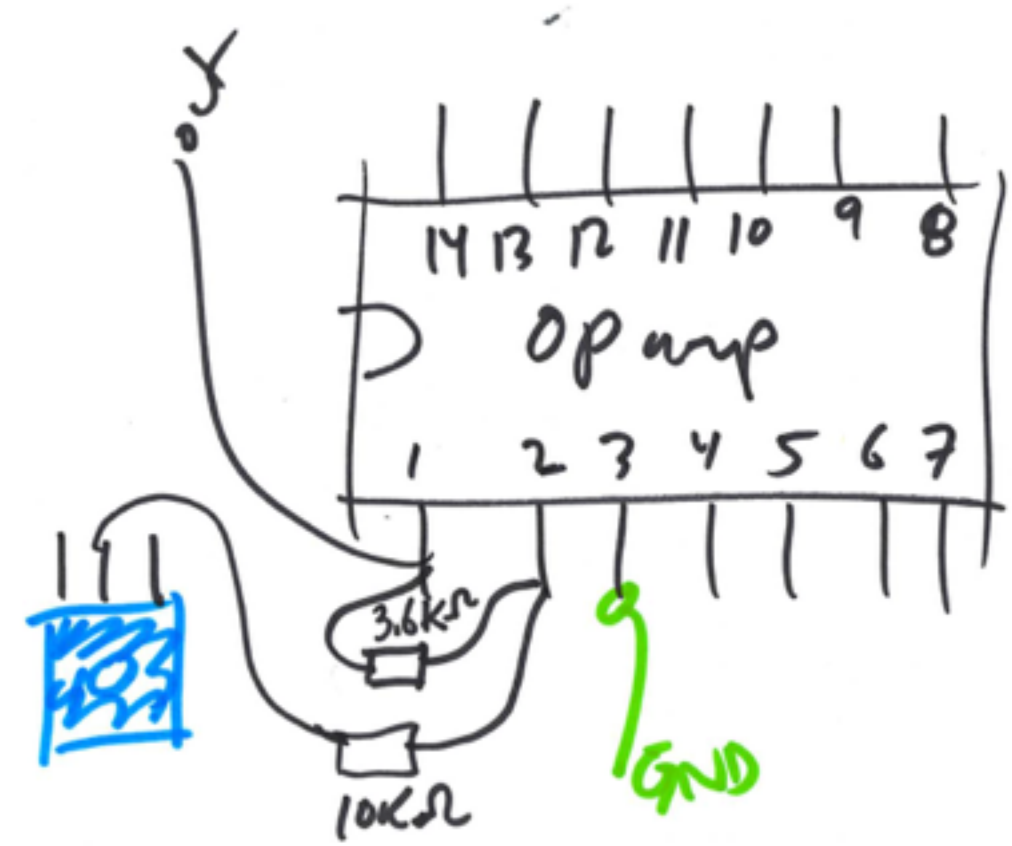




[amplify it]

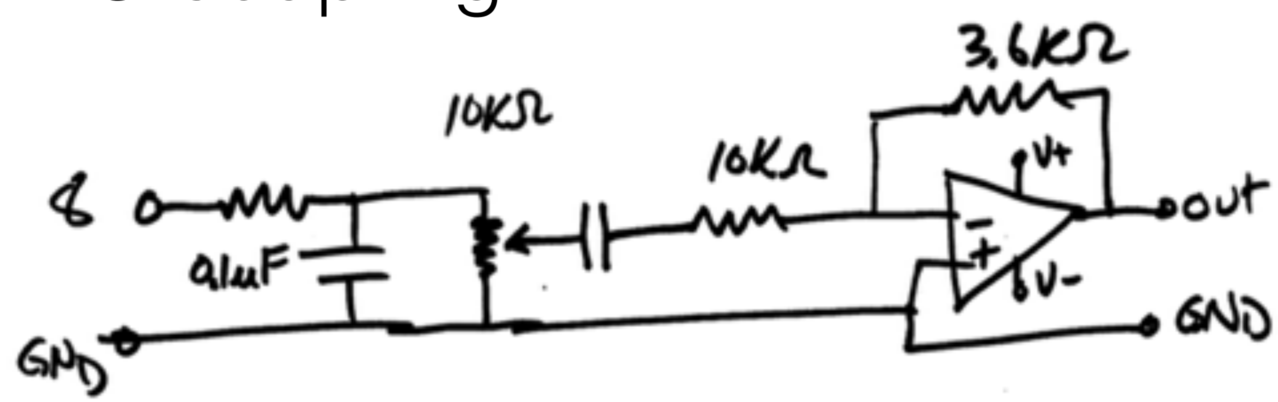
4. Connect the output to the second channel of the oscilloscope. The signal should be larger in amplitude and inverted in sign.

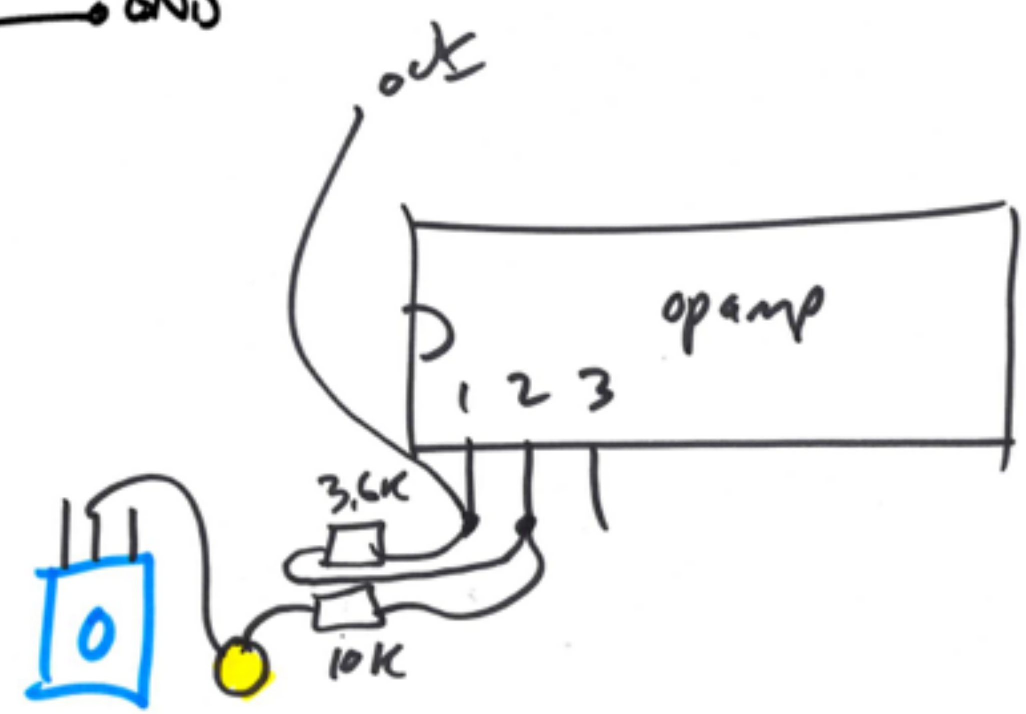




[shift it]

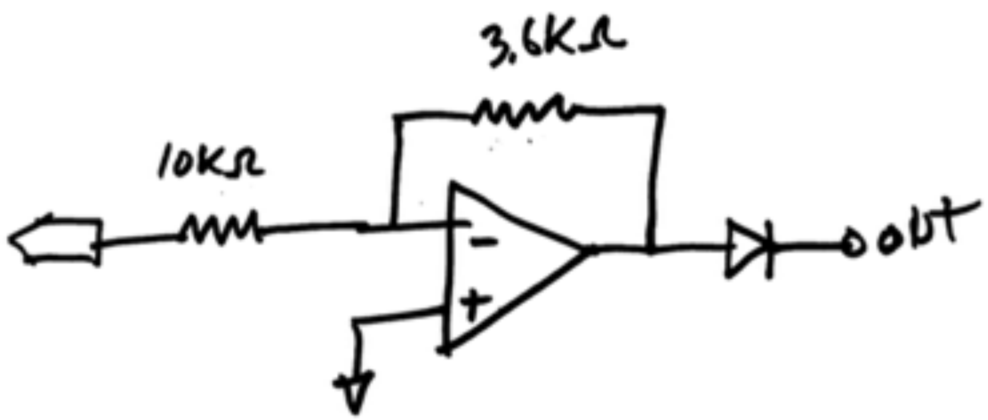
1. Add a 0.1μF capacitor to the input as shown.
2. The wave form should now be symmetric about GND. This technique of removing the DC offset is known as “AC coupling”.

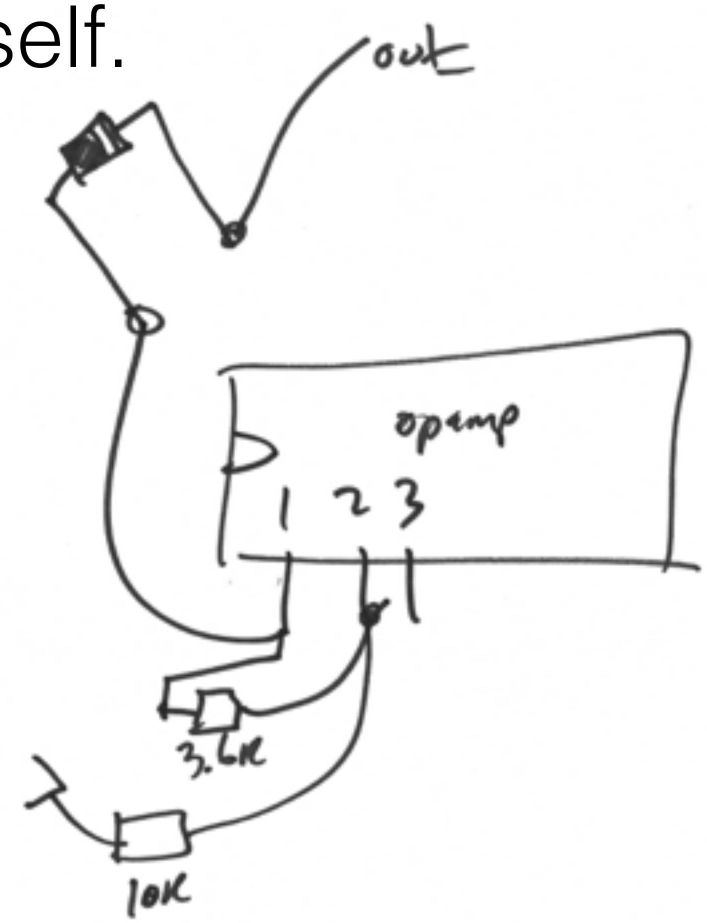




[slice it]

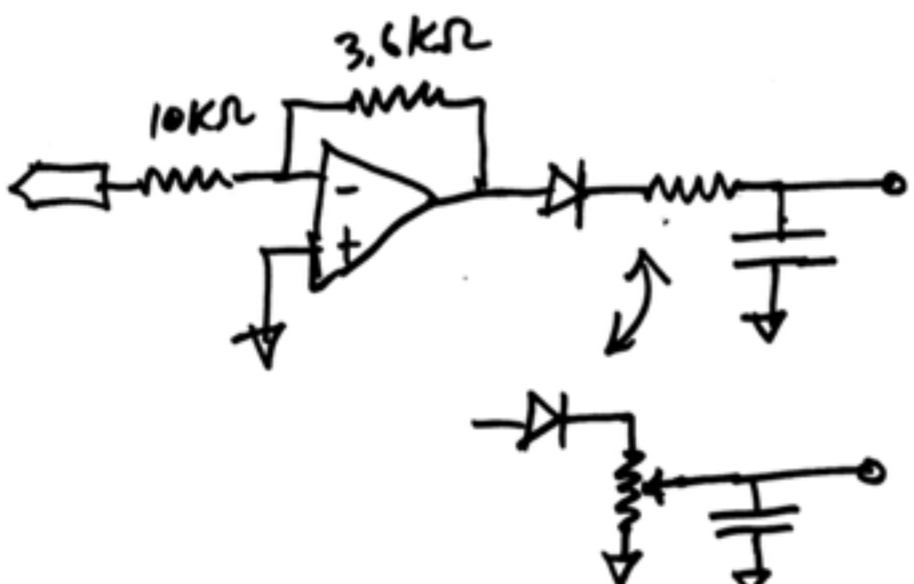
1. Add a diode to the circuit as shown.
2. Connect the far side of the diode to the oscilloscope. Since the diode prevents current from flowing in one direction, it blocks half the signal. This type of signal modification is known as “half wave rectification” and is the basis of radio reception. A “crystal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

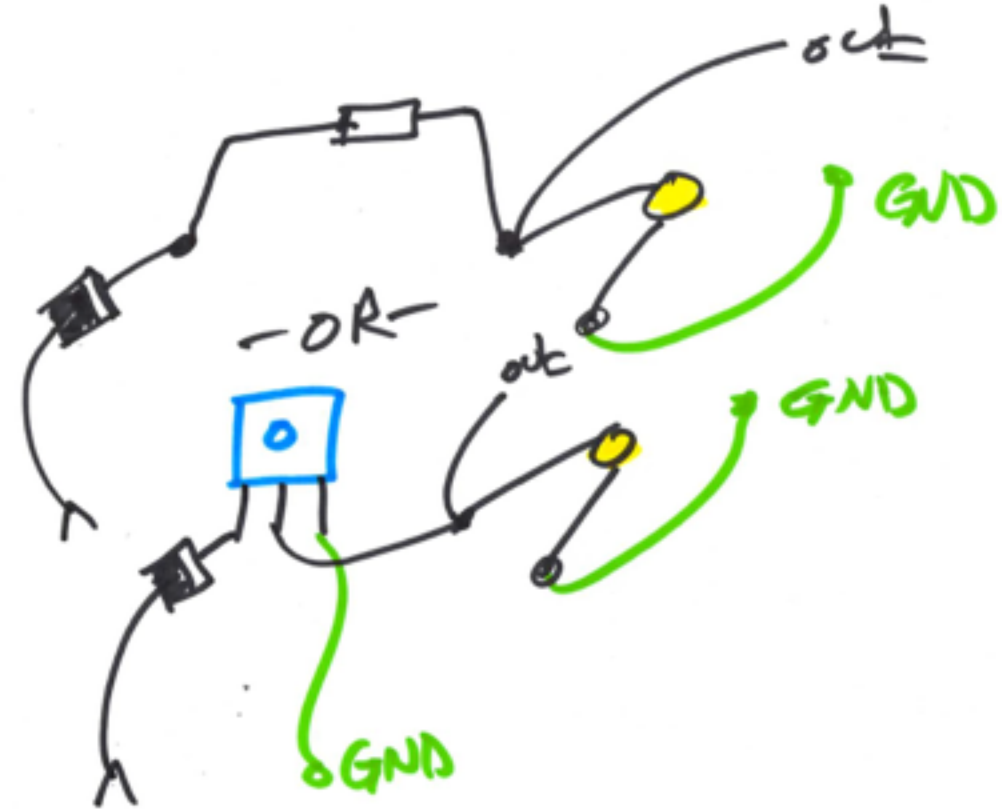




[smooth it]

1. Add a 10kΩ resistor and 0.1µF capacitor after the diode as shown.
2. Connect the oscilloscope to the new output. The waveform should look like a ripple.
3. Replace the resistor with a variable resistor. Now you can vary the smoothness of the ripple to make it look almost like a DC voltage.



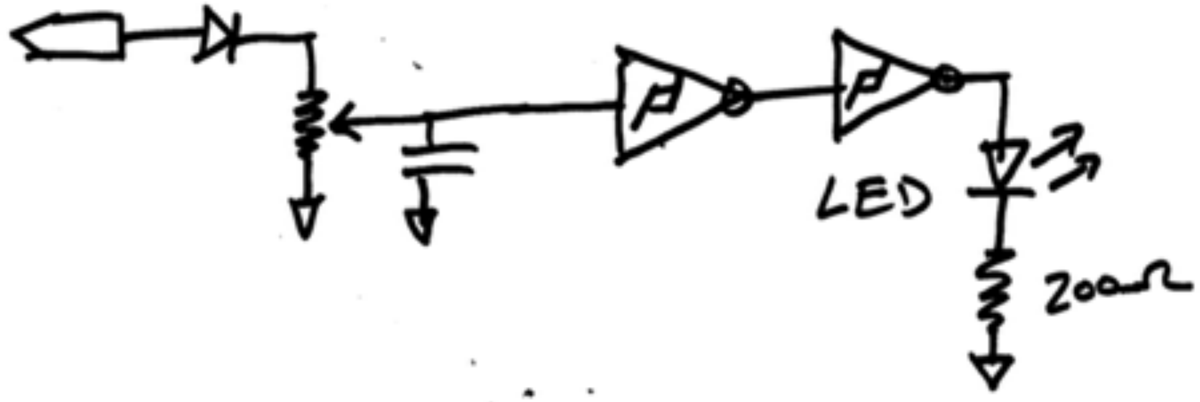


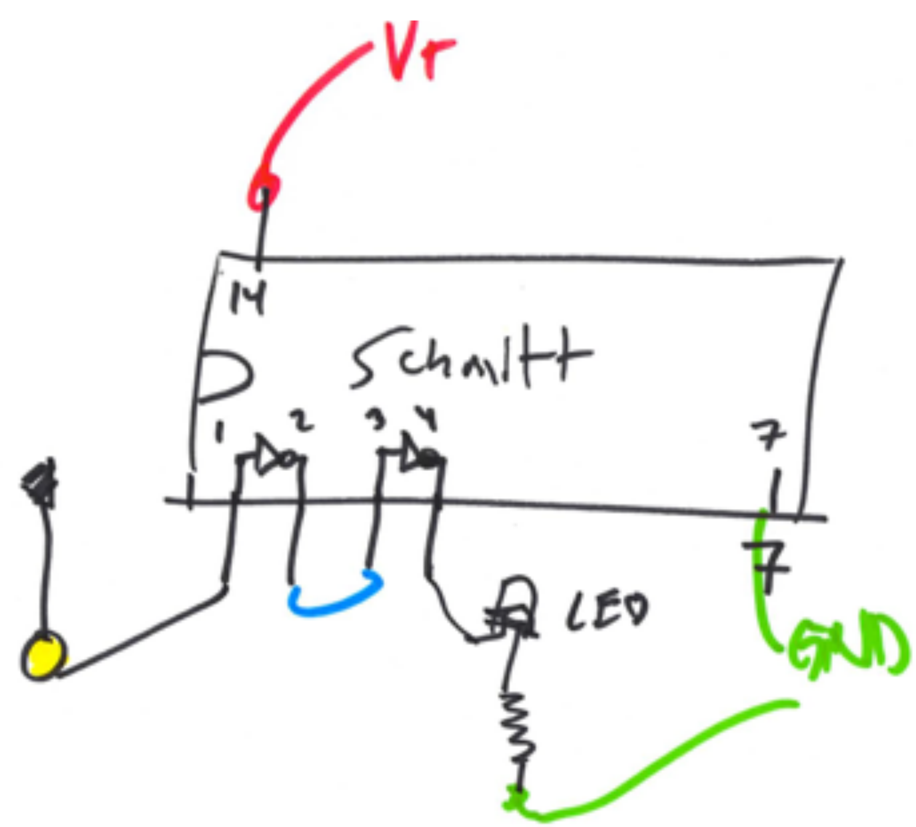
[detect it]

1. Connect the Schmitt Trigger chip as shown.
2. Connect the LED and resistor as shown.

This configuration is a Tone Detector, which can be used to detect audio frequency tones in the soundtrack of a video presentation.

Tone?	OUT
Y	H
N	L

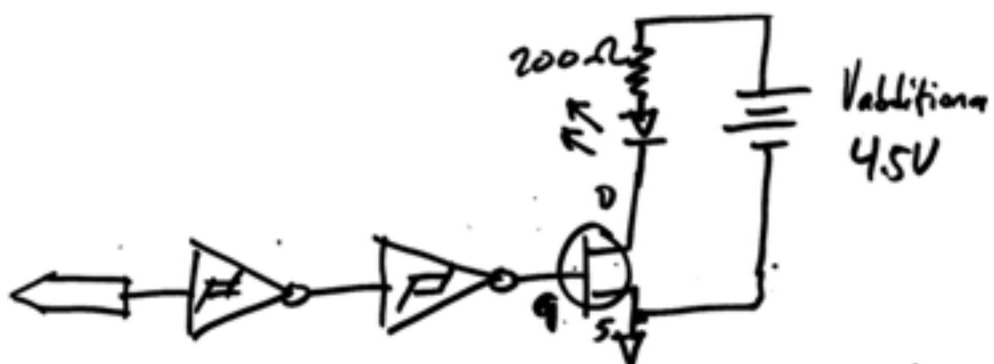


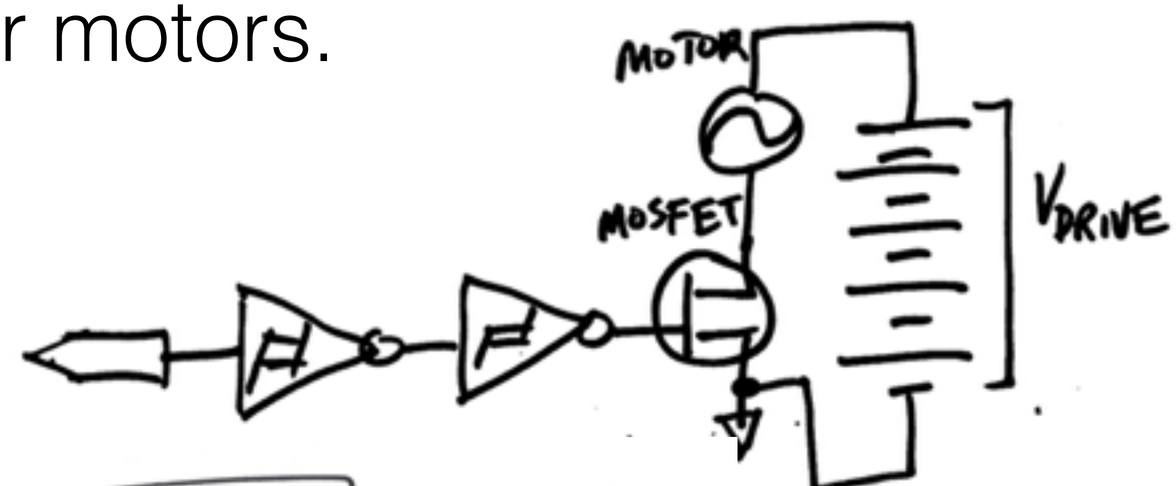


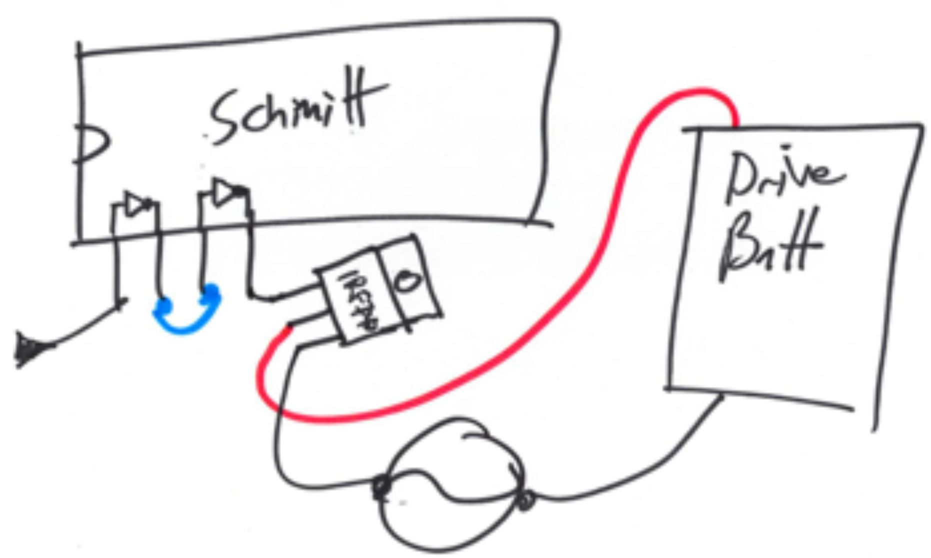
[drive it]

1. Connect the IRF740 MOSFET transistor and an additional battery pack as shown.
2. Move the LED to the new location, as shown.

This MOSFET output can control up to 40V and 10A, much more than the 5V and 24 mA that the Schmitt Trigger chip can. You can use it to control high power devices like telegraph coils or motors.

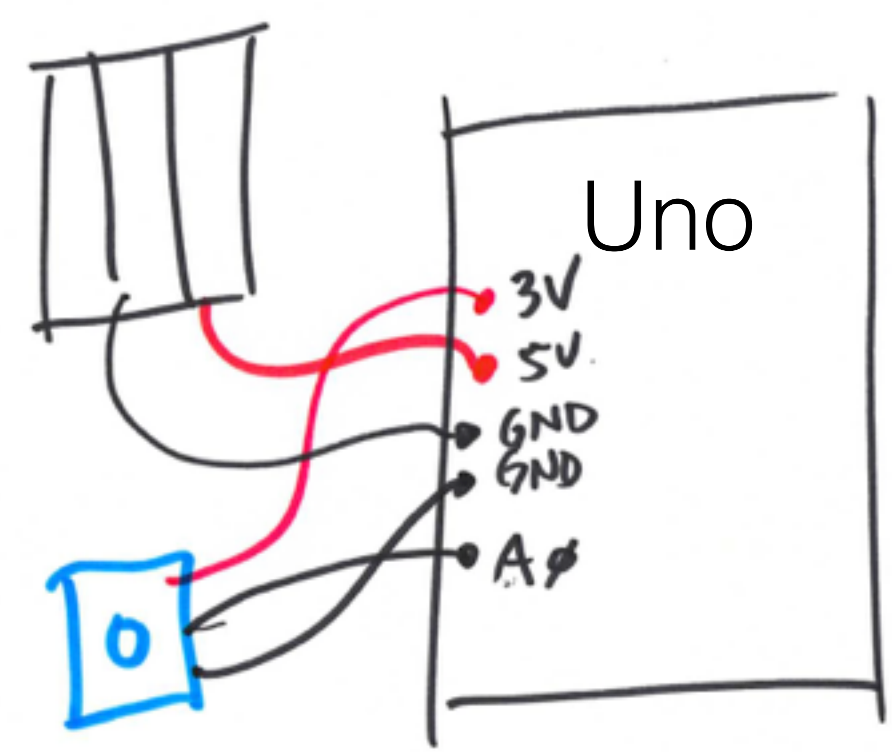






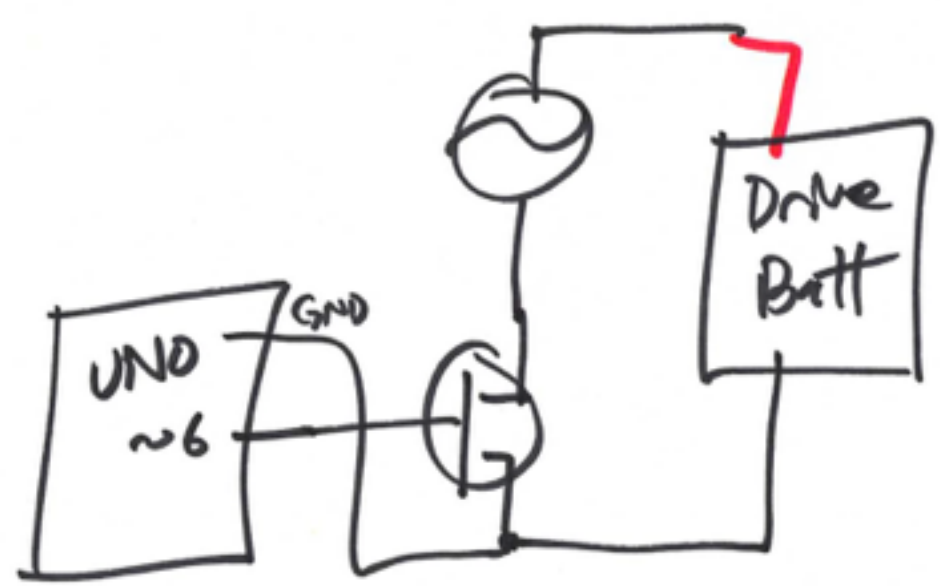
[sense it]

1. Disconnect the Arduino from the previous circuit, disconnect the battery from it, and connect it to the USB port.
2. Upload the “MICA_analog” sketch code to the Arduino.
3. Connect a variable resistor to the analog input of the Arduino as shown.
4. Open the “Serial Monitor”. Watch the value change as you adjust the variable resistor.



[vary it]

1. Disconnect the Arduino from the USB cable, and power it with the battery pack as before.
2. Connect the PWM output from pin 6 to the oscilloscope. Watch the duty-cycle change as you adjust the variable resistor.
3. Connect the MOSFET as shown. Use it and a second battery pack to control an LED.
4. Replace the second battery pack with the external power supply, and replace the LED with a whopping big motor. Show that you can vary the motor speed by varying the setting on the variable resistor.



[true it]

1. Disconnect the motor.
2. Reinstall the low pass filter before the MOSFET in the circuit.
3. Connect the output of the MOSFET to the oscilloscope. Show that you have made a nice smooth analog output voltage from the nasty choppy PWM digital output.

Note: If you control a high power device in true analog, the MOSFET will heat up as it dumps a lot of power.