Experiment 1: Basic Inverting Linear Amplifier LM741 Part 1

Circuit #1 Notes:

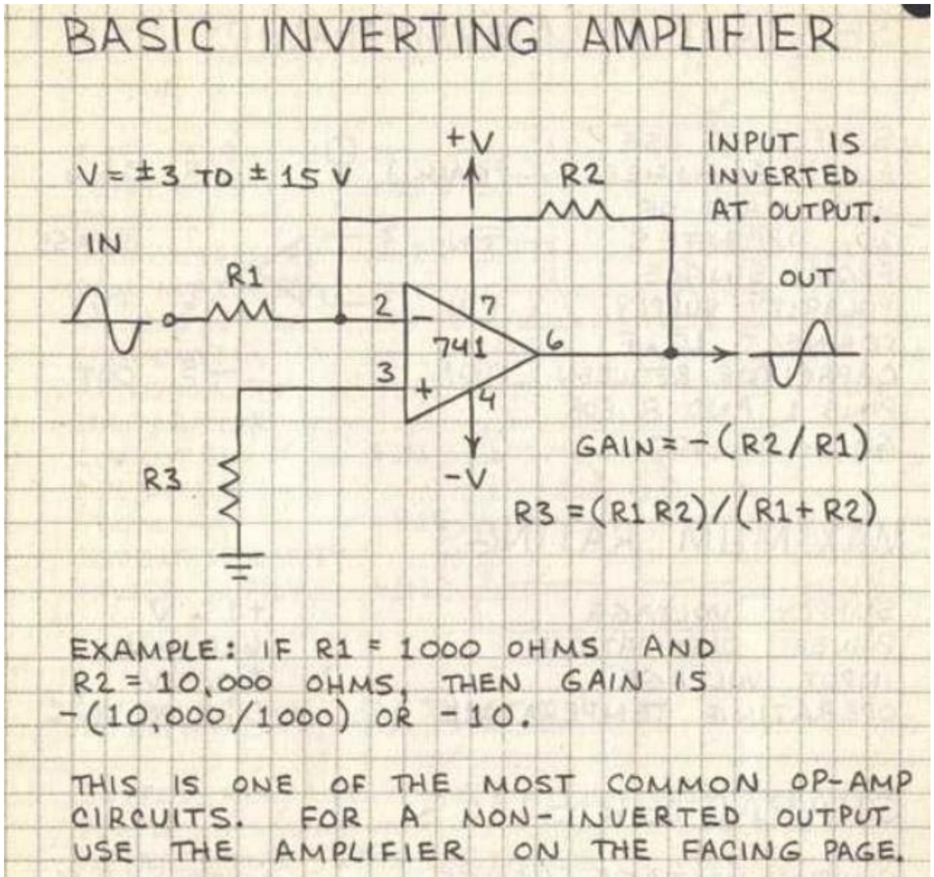
***Never** apply an input signal unless power is on. Always turn off input signal before turning off battery power.*

Always use fresh batteries with the same voltage.

Here is an inverting amplifier circuit. R1= 1000, R2 = 10K , R3 = 1000. This gives a gain of about -10.

Input signal: 3kHz , 1V pk-pk.

The red trace is the input and the yellow shows the amplified AND inverted output. The scope shows 9v output, so gain is ~ -9 (negative denotes inverted output).Power: 2-9V batteries as configured in Figure 2 below.



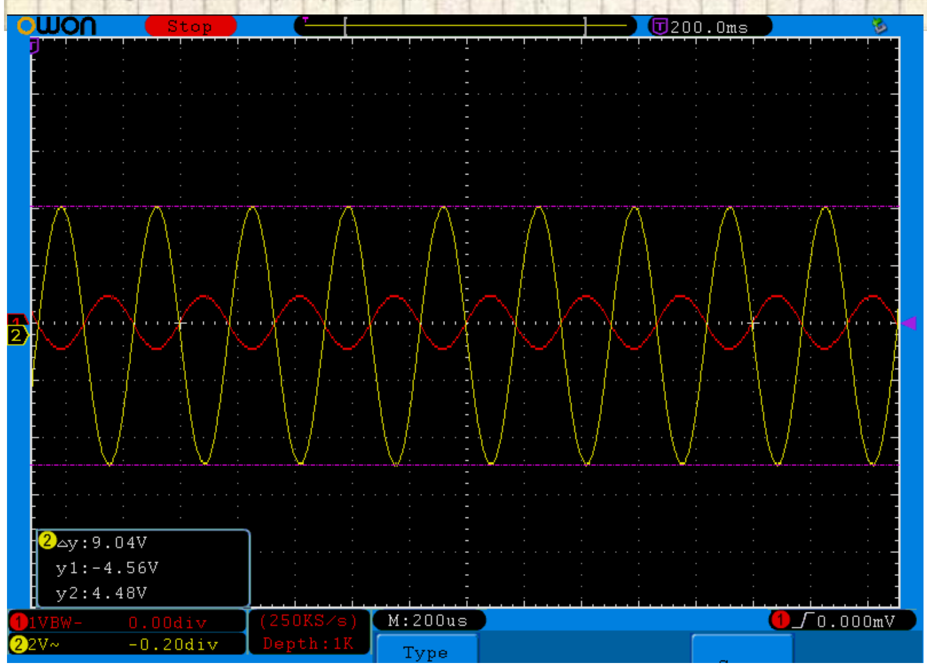
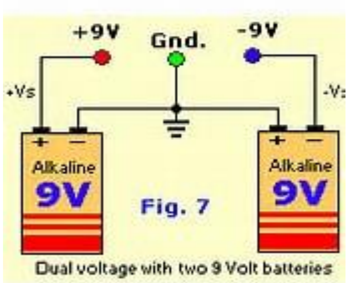


Figure 1: Schematic and Scope Image of amplified signal. Notice the output is 180 degrees out of phase with the input.



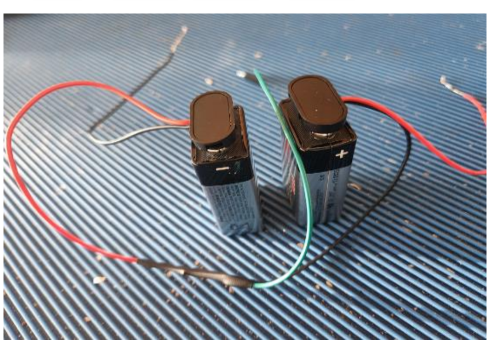


Figure 2: Custom battery harness connects two batteries in series and provides 18V. We use the common ground to provide +9v and – 9v to the op amp. The green wire is our reference voltage (0V) for the IC.

Breadboard Layout

1. Connect red wire from battery harness to breadboard.
2. Connect black wire to breadboard.
3. **Common Battery Ground**: Connect green wire from battery harness to pin 3 via a 1K (R3) resistor. THIS WIRE IS NOT CONNECTED TO B- .
   R1 = 1K
   R2 = 10K from pin 2 to pin 6 provides negative feedback.
   R3 = 1K from pin 3 to ground gives ~9x amplification.

Red Clip: Function generator input signal to pin 2 via 1K resistor.
Orange wire: Output of IC and Channel 2 of scope.
The .1uF ceramic by-pass caps are used on both power rails to provide stability for the op amp.

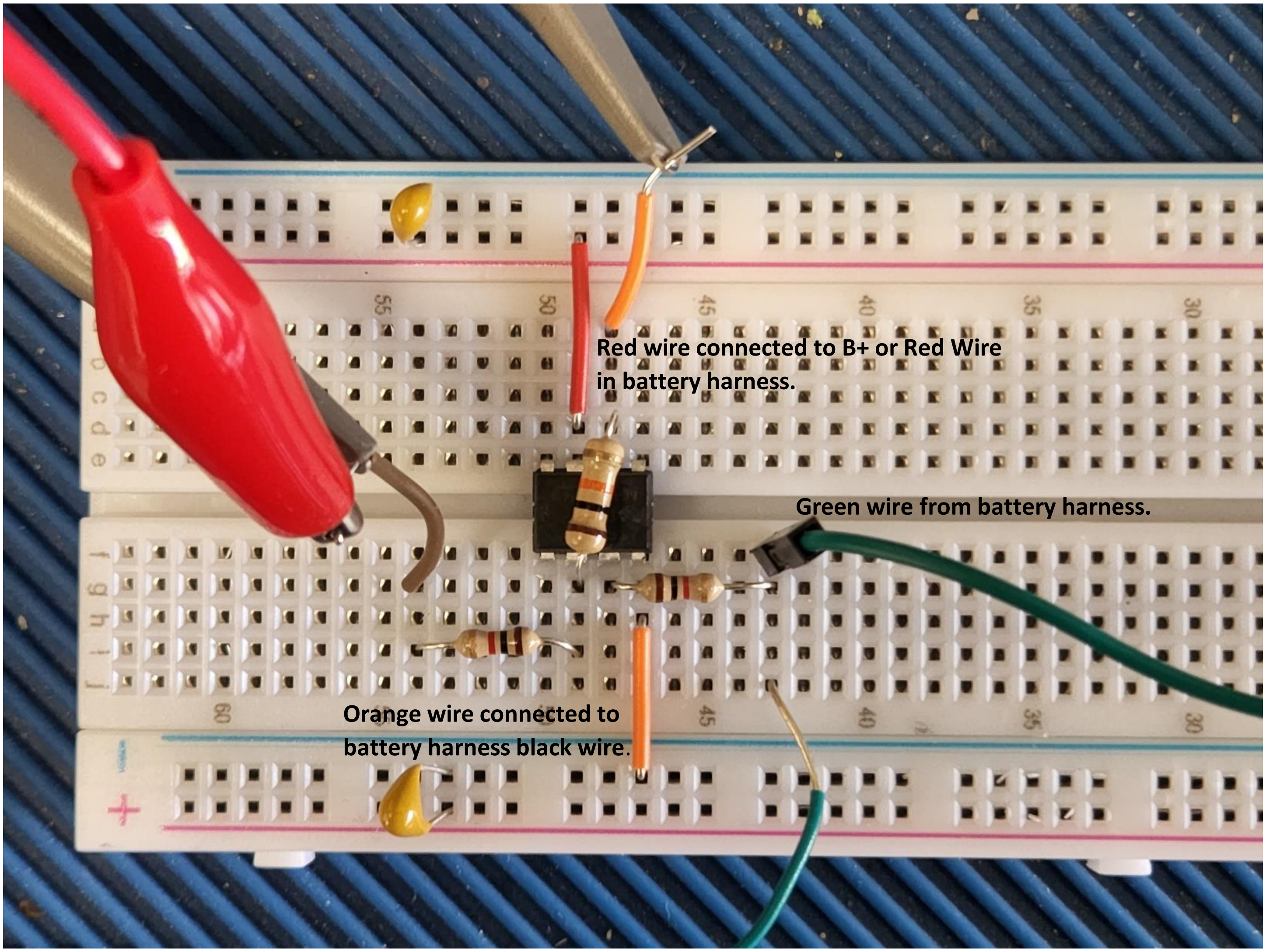


Figure 3: Breadboard view. Pin 1 is orientated to the left.

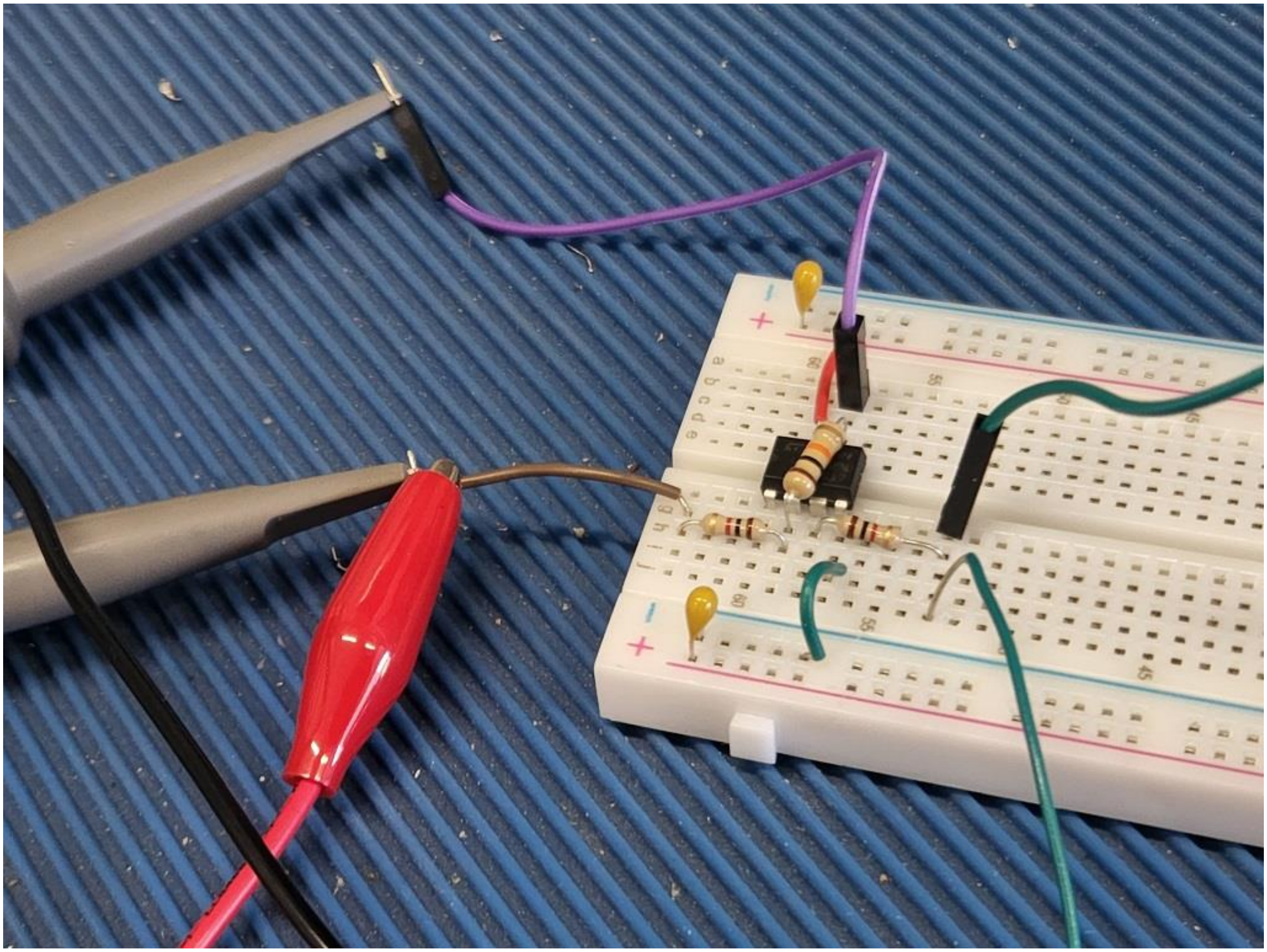


Figure 4: Close up of scope connections. Red clip is signal generator input.

Measuring Dual or Split Power Supply Voltages

Many op-amp circuits require a positive and negative supply voltage. The battery harness I made in Figure 2 provides connections for +9V, -9V, and 0V. One battery will supply +9V and the other supplies –9V. The green wire in my harness is the circuit ground. I call this the *reference* or *common* ground to distinguish it from the black (-) battery wires that we normally associate with ground.

R3 is attached to this common ground in the breadboard in Figure 3. In this circuit, the output of the IC can only approach the supply rail voltages. In other words, the amplified output can never exceed ±9V in my circuit. The 741 cannot generate voltage so it is limited to the supply voltage we provide. Most op-amps function between ±5v - ±18v.

So, in Figure 2, I connect my Red and Black lead to the breadboard as we always do. But I do not ever connect my Green wire to the breadboard power rails. That would create a short circuit. The common ground is connected to R3 which is connected to Pin 3. The IC needs to measure the voltage difference between its input pins. To do that, it needs a reference voltage. In our case, that is the point where our two batteries are connected. Let’s take a closer look at how that works.

Let’s check our voltages so we can better understand how this split-power supply works.

1. Build a power harness like mine.
2. Touch your DMM’s positive probe to the red wire and the negative probe to the black wire. You should see about 18V if your batteries are fresh. This is the total battery voltage of both batteries connected in series .
3. Touch the negative probe to the green wire and your positive probe to the red one. You should see about +9V.
4. Leave your negative lead on the green wire and place your positive probe on the black wire. You should see about -9V.

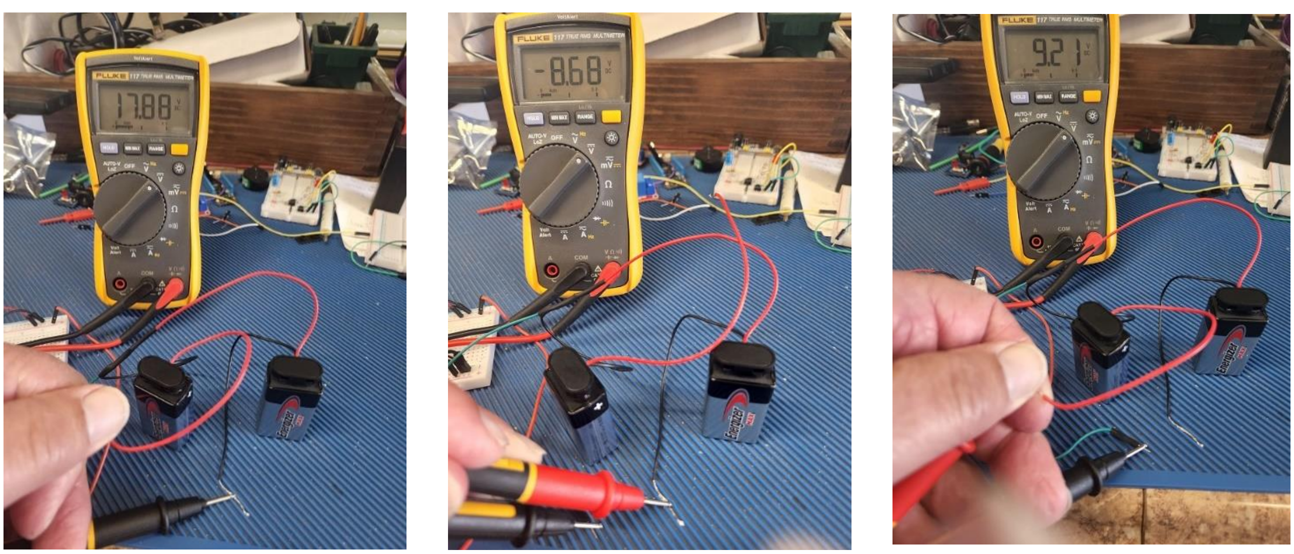


Figure 5: Measuring battery harness voltages.

Measuring Breadboard Split Power Supply Voltages

The +9V and -9V wires are called the supply rail. The op amp can only operate correctly between these two voltage ranges. It monitors these supply rails in order to perform its amplification process accurately. In a normal breadboard circuit, our B- is the black battery wire (0V). But here, our 0V reference is the green wire in my battery harness. You can see it is the point where the B+ of one battery connects to the B- of the other battery. This is the only place we have a common ground to utilize both a positive and negative voltage. The op amp needs a reference to the common ground so it can measure the input signal voltages. The op amp is never connected to the full 18V of my two batteries.

Just be very careful when using a power supply like this because it is easy to get confused and ruin a battery or your circuit.

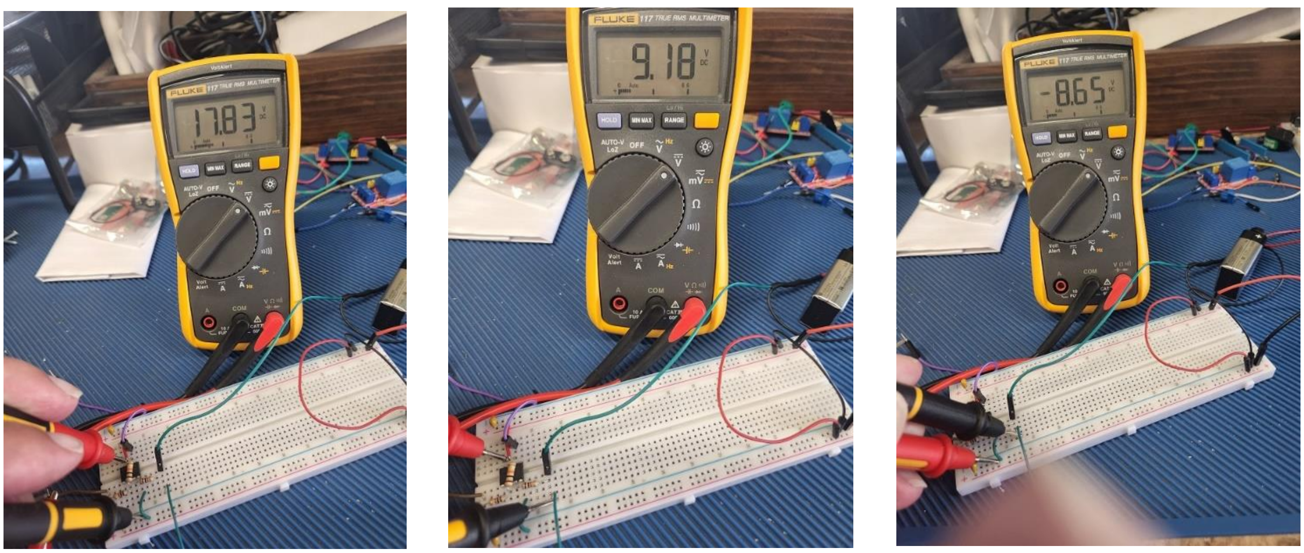


Figure 6: Measuring breadboard voltages.

Experiment 2: Basic Inverting Linear Amplifier LM741 Part 2

Evil Mad Scientist 741 Discreet Kit

This shows the results of the 741 discreet kit. This kit uses transistors and resistors to create the 741 op amp. This allows us to explore signals and voltages inside the "IC" that would not be available in the actual chip. It is a great learning tool. It can be purchased here: The XL741 Discrete Op-Amp Kit (evilmadscientist.com).

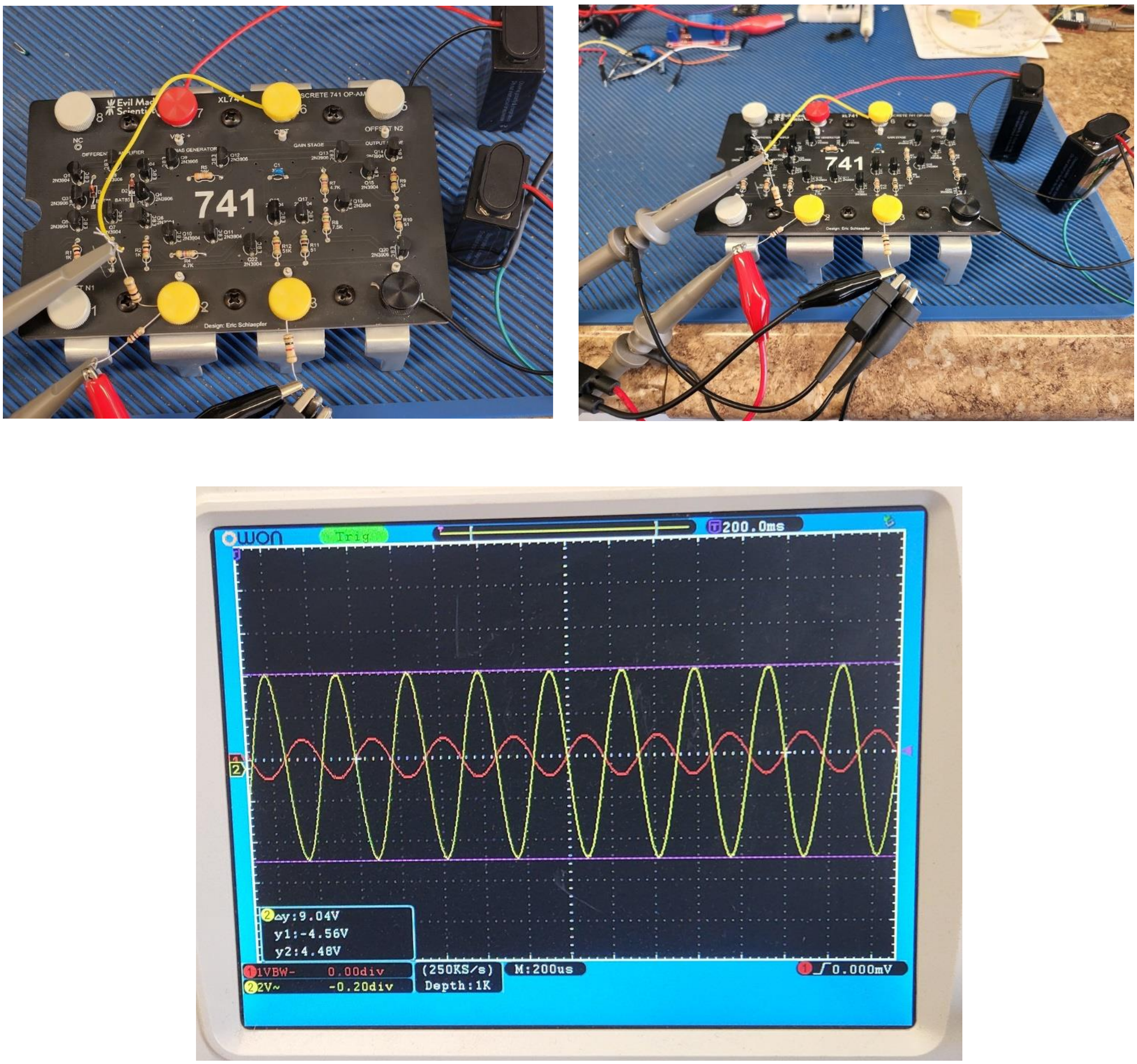


Figure 7: The wiring for the kit and the scope signals. These are identical to the results in experiment #1.