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ELECTRONICS I

Lab 4 Op Amp II

TRADITIONAL LAB

A. Active Filters
    1. Low Pass Filter
    2. High Pass Filter
    3. Band Pass Filter
    4. Band Stop Filter

B.   Wave-Shaping Circuits

    Combination of the op-amps and diodes can generate several wave functions for some applications (e.g. electronic thermometer, comparator or limiter circuits).

Design, build and test an op-amp circuit with the transfer characteristic shown in Fig.1. Operation is an unsymetrical full wave rectifier.

Find its transfer characteristic experimentally with $-2 \leq v_i \leq 2$ volts (dc). Compare your results with the theoretical results shown.

Test its ac response with input voltage of 4-volts p-p at 60-hz, and 600-hz. Sketch input and output waveforms for both frequencies. Comment on your results and find an application for an unsymmetrical full wave rectifier.
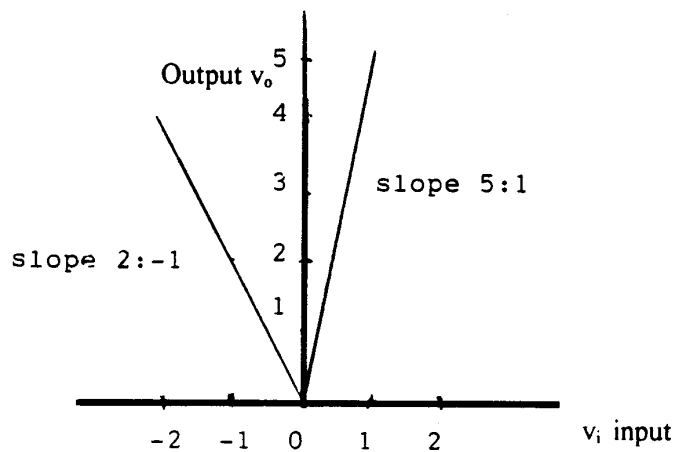

Fig. 4.1   Transfer Characteristic

MOBILE STUDIO LAB

A. Active Filters

Do we need explanation here, especially, for the first two filters?
Find a good reference (for example, Network Analysis II class notes on Active Filters) and work on this sample filters. Connection with IOBoard is now familiar to your I guess. The only thing we have to keep in mind is that the max/min output cannot be above +2.5V (if you use +/-2.5V outputs from the board.). So let's focus on the next part of designing an unsymmetrical full wave rectifier circuit using OP Amps and a few Diodes.

B. Wave-Shaping Circuit ---- Unsymmetrical Full-Wave Rectifier

1. Understanding the Problem

The problem is well illustrated in Fig 4.1 in which the two different slopes of the ratio of output over input. At the right side, the curve (in terms of elementary algebra as in **y=ax+b**, the slope **a** is 5 and the intercept **b** is 0) tells us that **a=y/x=5**. The term y/x, which is, output/input is nothing but the ratio and in EE terms, **gain**. However the gain of 5 stands only when the input is in the positive side.

Now let's look at the left side, which is the curve for input with negative values. In this case the slope (ratio, i.e., gain) is -1. That means the output is just the inverting input. Further, the output is the same as the input magnitude but with positive polarity.

If you combine above two, now you can picture an input which has positive and negative value (sine curve is a typical example of this) and the output which has different magnitude alternating every half cycle, first half magnitude with 5 times bigger than the input, followed by the other half cycle with the same magnitude as the input.
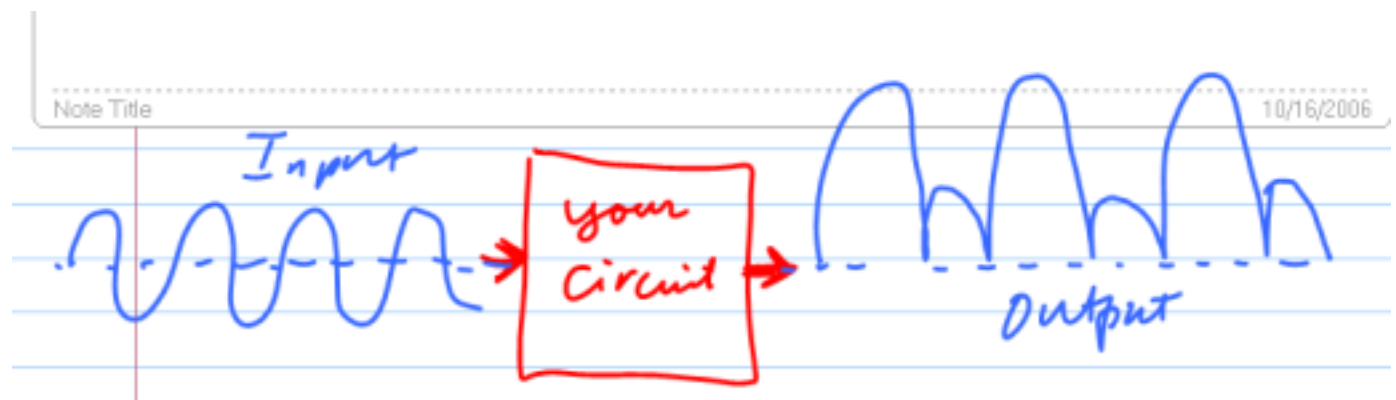
2. Idea Formation

Now it's apparent that we have to separate positive part and negative part of input, and these two components must be fed into two different Op Amp circuits, each to one Amp circuit. Also, there must be a summer (or Summing Amp) at the very end to add the two outputs from the Op Amp circuits.   Since the final stage Op Amp summer is with inverting circuit (since the gain of 1 with inverting amp is much simpler. Mind you that the gain for inverting is {- R_f/R_s}, while that of non-inverting is {1 + R_f/R_s}. This arrangement forced to have negative outputs at the Op Amp circuits.   As a chain reaction, this forced us to send positive part of input signal to the inverting amp with gain 1, and negative part of signal to the non-inverting amp with gain of 5.
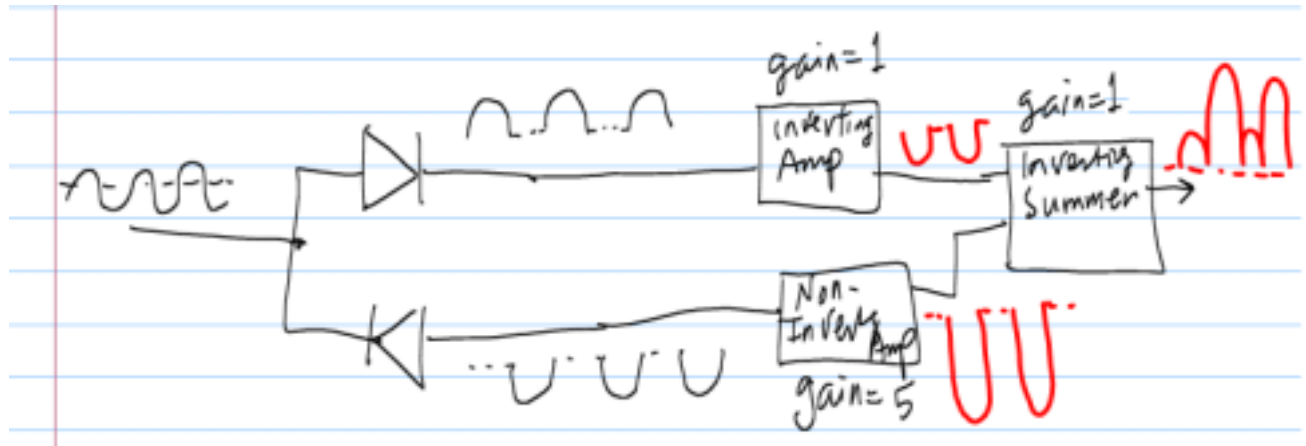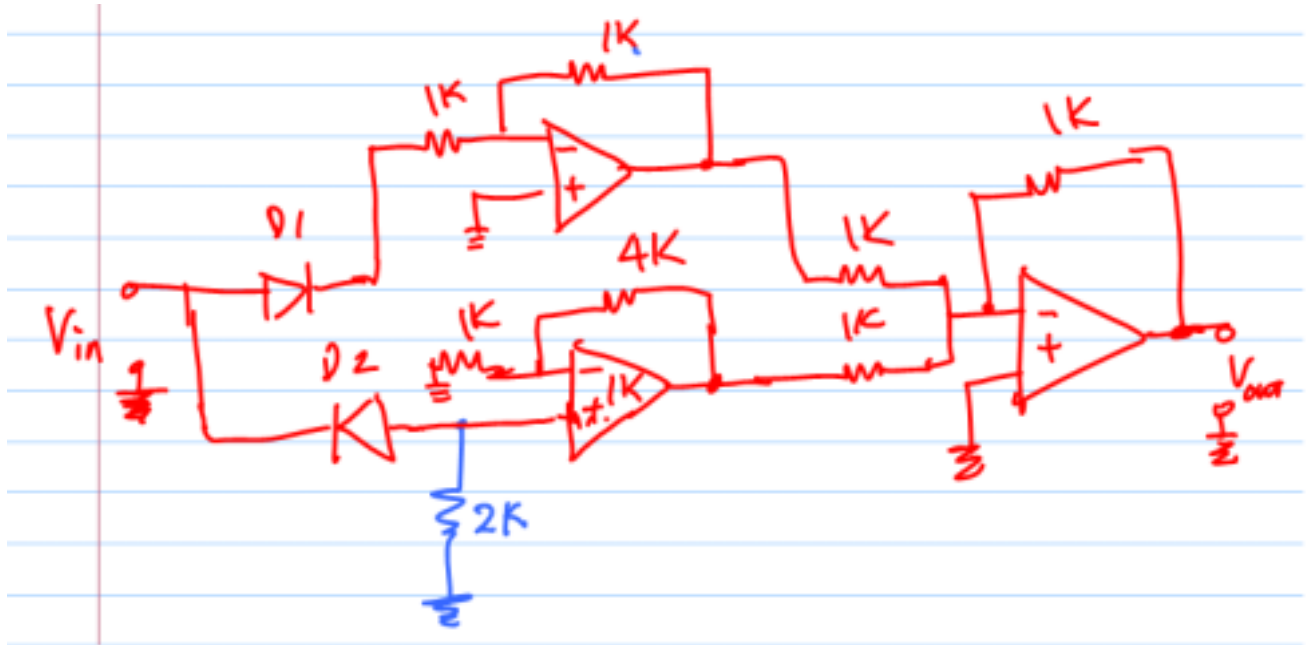

3. Detailed Circuit Formation
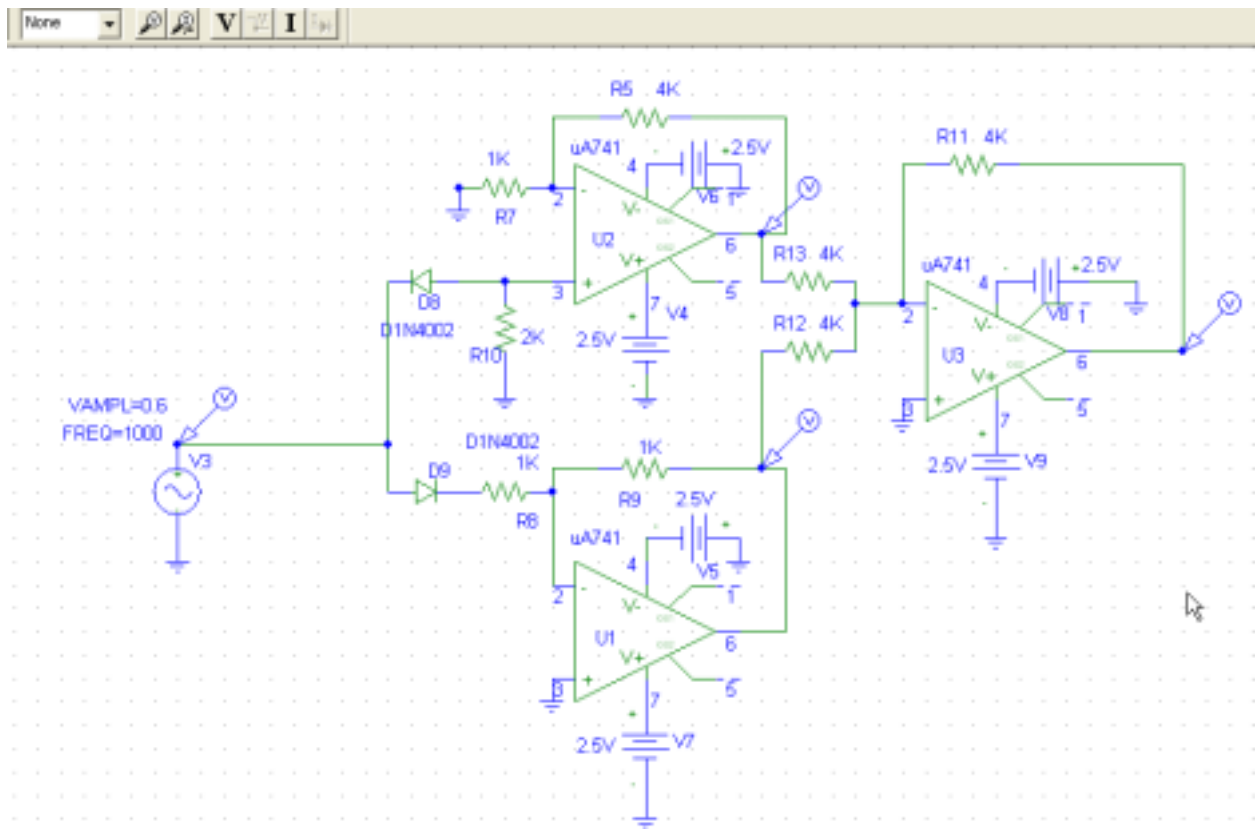
Now let's draw a schematic to realize the idea.
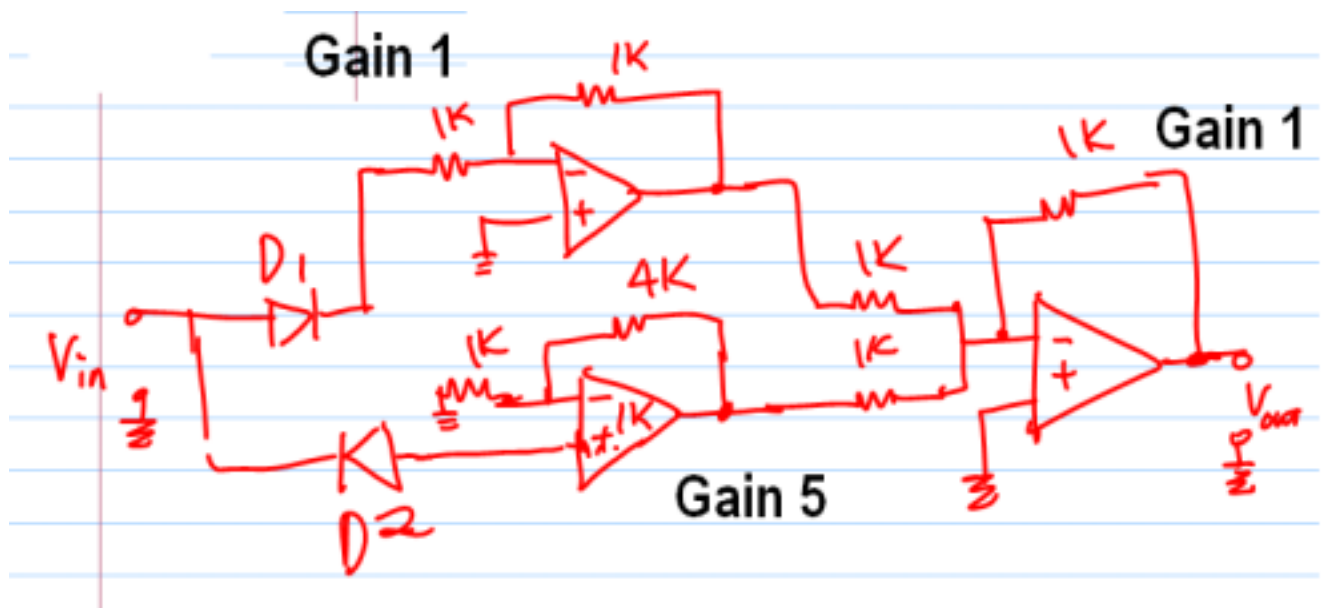
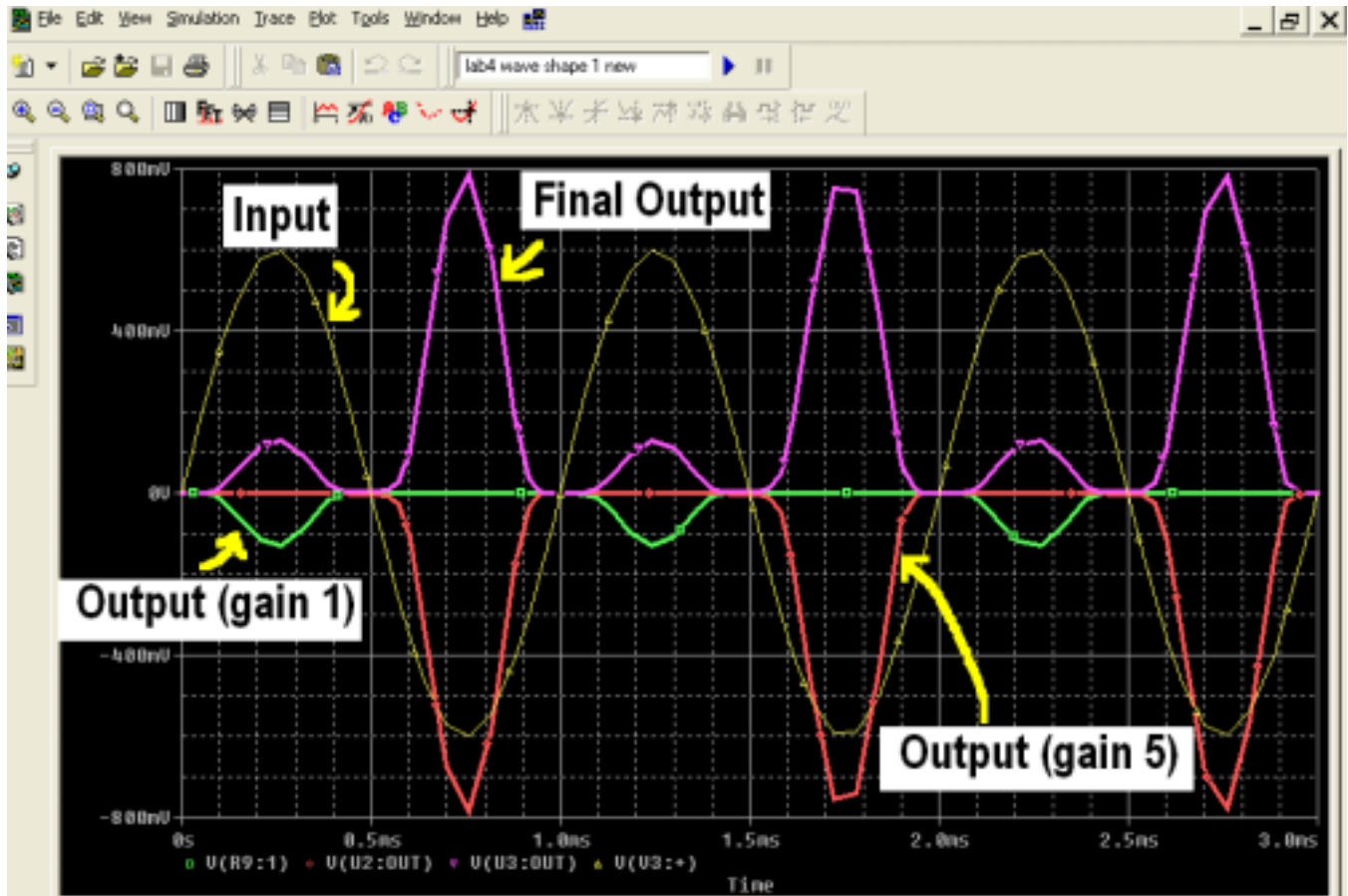Do you think the above circuit work? Give it some thought.

The new circuit with an added resistor works. Why?

4. Pspice Simulation

5. Pspice Transient Analysis

6. Review of Design

Does the result of simulation satisfy the design objective? Apparently not. Especially the intermediate outputs are not upto the gain we needed. why is it that? Have we considered the voltage drop across the diode? So what do we have to do here? Increase the gain so that we compensate the voltage drop across the diodes. I leave this to you before moving to the next step.

7. Implementation using Mobile Studio Lab

Preparation: From the circuits we see that we need 3 Op Amps. This means if you use single Op Amp IC like uA741, you need 3 of them. Also, you need 2 generic diodes. Also, you need several resistors with different values.

Implementation of the circuit on your breadboard: Roughly assign places for each element of the circuit. Do not over-crowd them into a small area. Give enough space for each Op Amp so that you can freely move your elements and your two fingers around the chips.

Connection from IOBoard: Cut wires long enough so that you can connect the wires for scope 1, scope 2, function gen 1, +2.5V, -2.5V, and all GND wires from *IOBoard*.
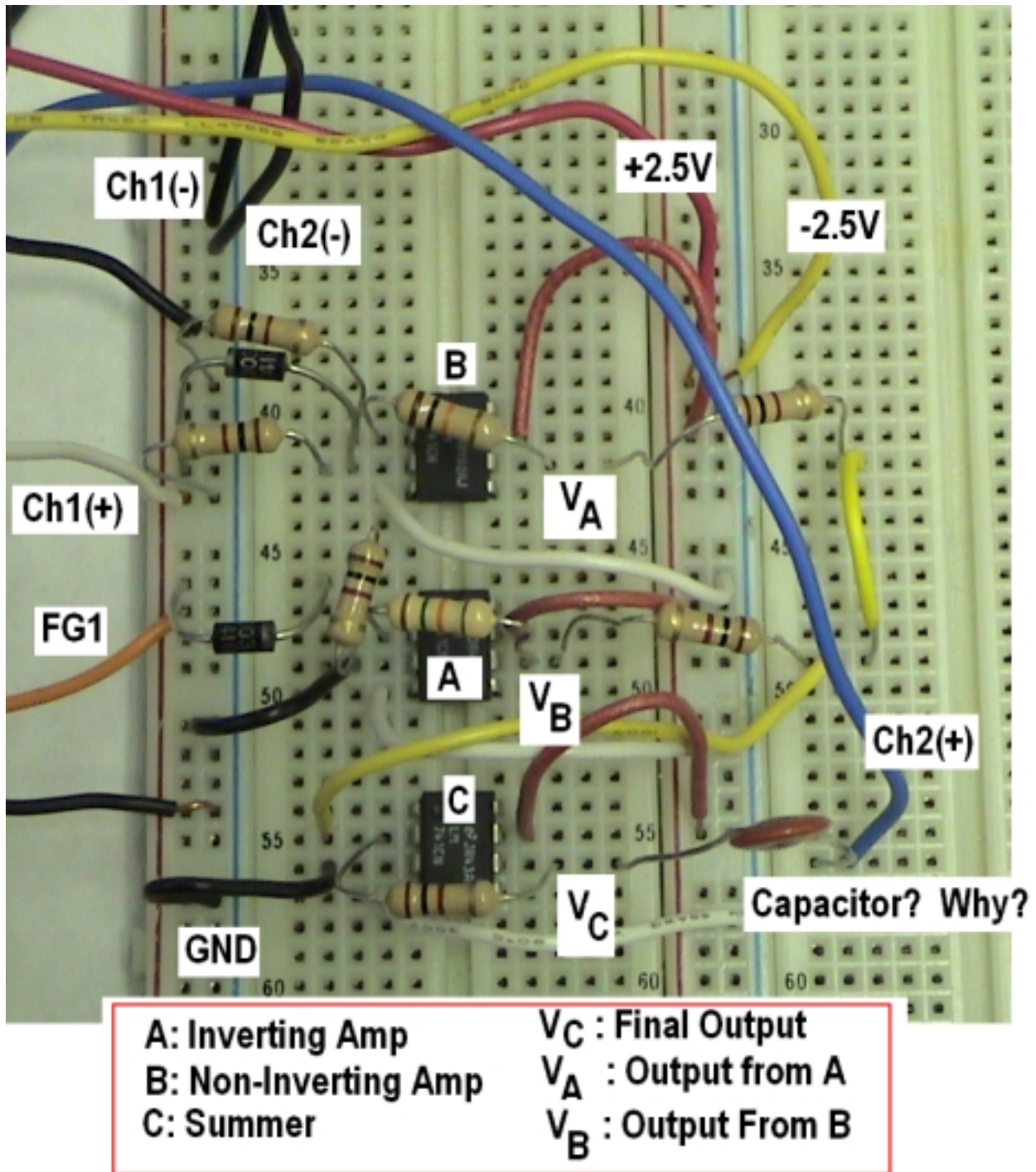
Now hopefully you have the following arrangement soon.
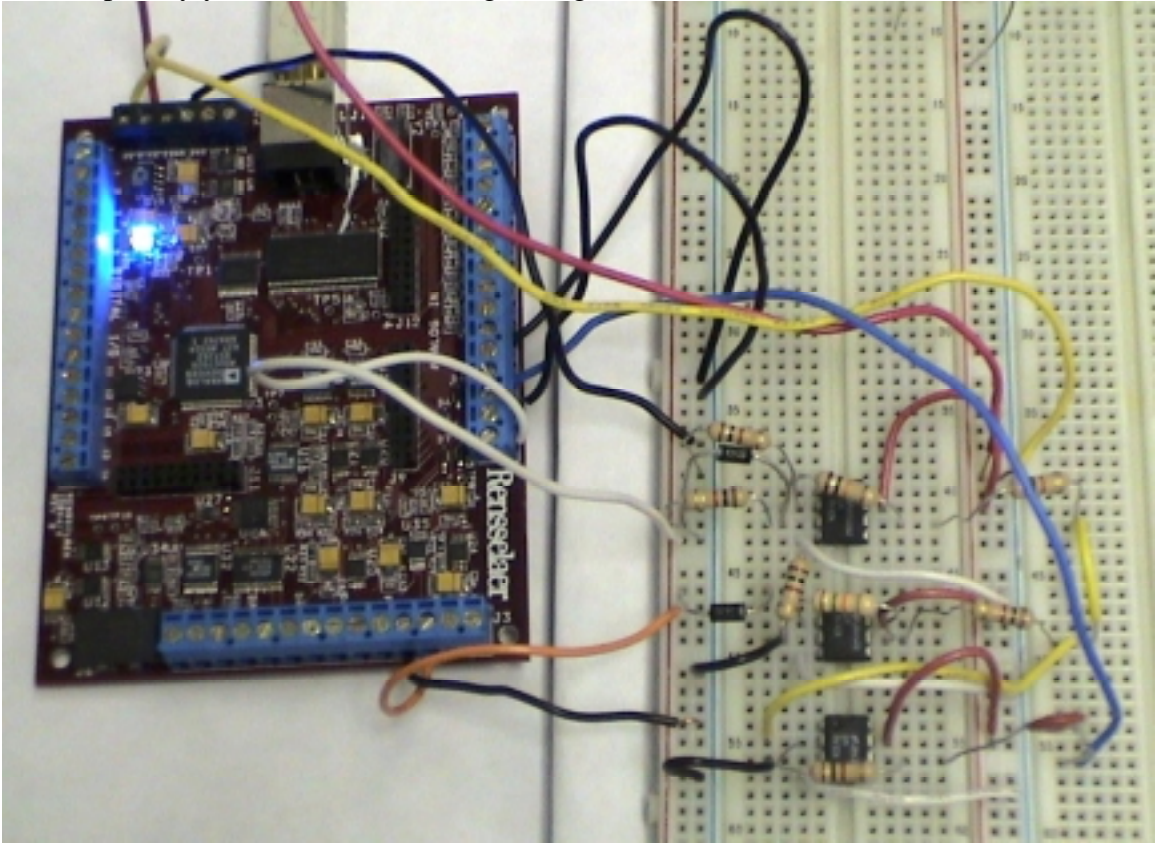
Details around the upper two Op Amps is shown below.
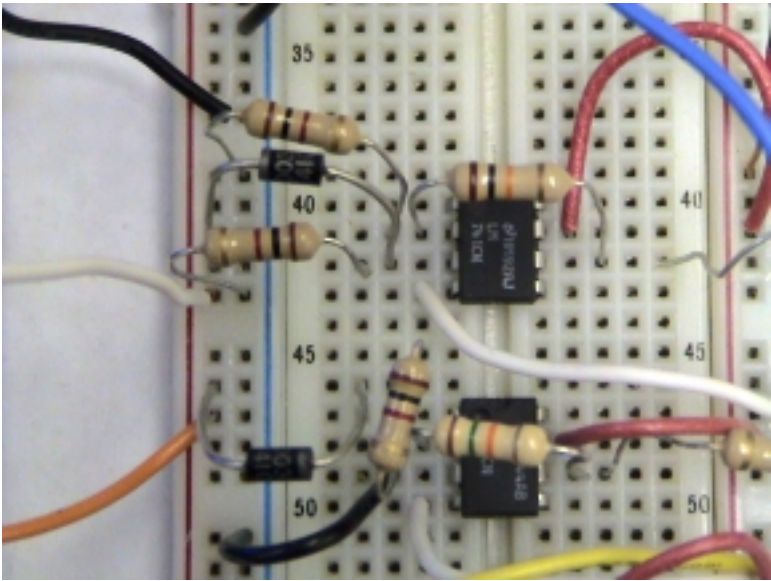
And the whole board is now labeled and explained for convenience.

In the above screen shot, channel 1 measure the input signal and channel 2 the final output of the circuit.

Run and Shoot: Now run the show by connecting the IOBoard to the PC and double clicking the icon of the Mobile Studio Desktop. Then open up the scope first and then open the function generator device. Set the frequency and peak-to-peak value (about 0.5 or 0.6 as a starter), then click the START button of the scope.   Do you see the waveform like this? It's not pretty but not that ugly.   Channel 1 with green trace is the input sinusoid and the green trace is the final output. A lot of noise as you see in the plot!
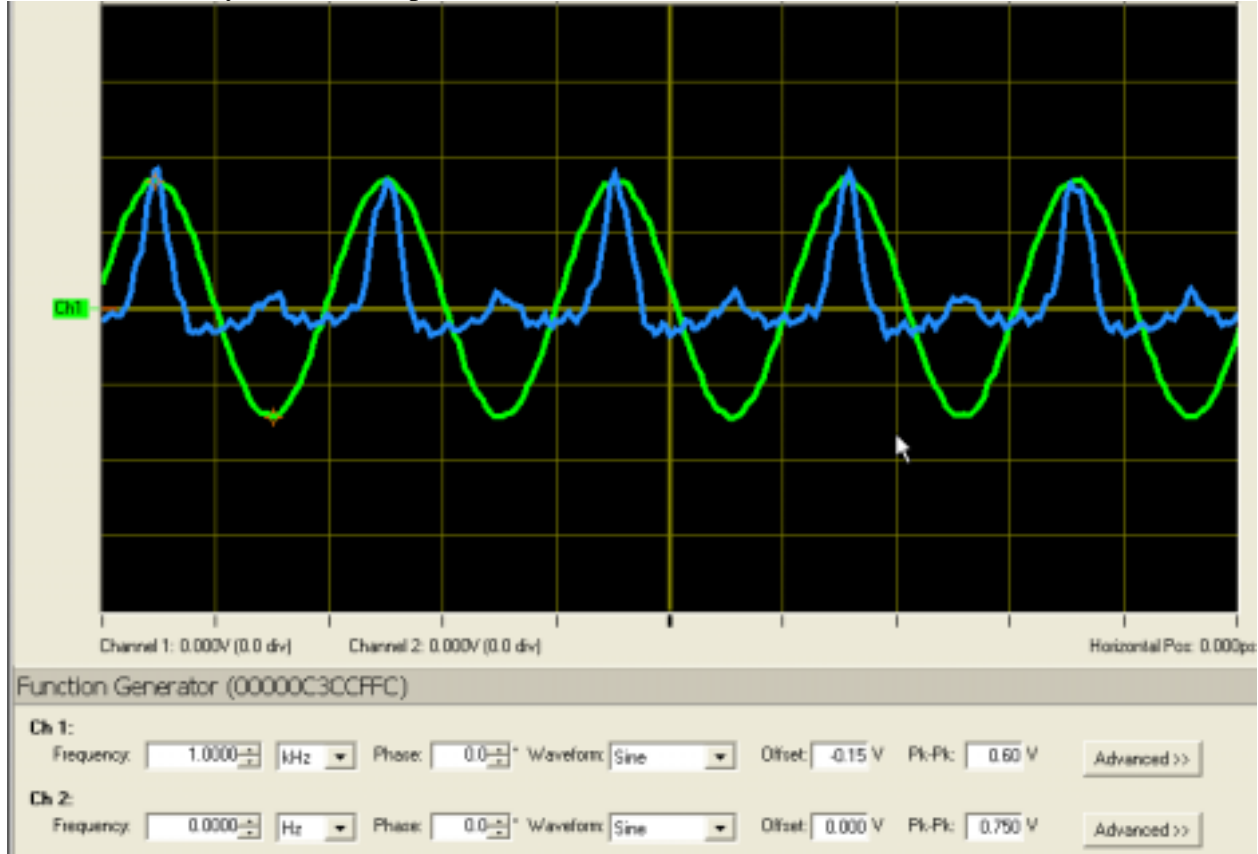
8. Troubleshooting

What if you do not have a screen like above? A good question! Where do we start when we do not have desired output? I do not have a sure fire answer to all your questions, but my experiences may be able to lead you to find some problems by yourself, if you're systematic and you do not have a fashion show or 'Heroes to watch in only 30 minutes.   It takes time to find fault, even your own fault. Anyway let's get it started.

(a) Using the Ch1(+) probe (which you originally connected to the final output voltage point in the board), measure all input signals including FG1, +2.5V, and -2.5V. If you do not see them, check if all necessary GNDs are tied together into a point.

(b) Check if all elements are in the right places. Hold up your board then scan the legs of each element of they are at the places they are supposed to be.

(c) If you finally have something but not quite correct, you may want to replace one of the Op Amps on the board by new one. Op Amp chips are silent all the time even when they die. So we

do not know if the chip is good or cooked unless your expected output is not confirmed by the experiment. But take this as your last resort, not first definitely.

(d) All the attempts do not work, and you're pretty much dismayed and you found your lab partner look his watch the third time, then you simply pull out the USB connection of the IOBoard and shut down your computer, and get some fresh air for 30 seconds, then turn on your PC. And resume your work. Hopefully this works for you and salvage your lab day.

(f) Take a good care of your IOBoard as if it is your flower vase. It is no unbreakable.

(g) Please report any other ways/methods/cases/events you met and solved during the lab. Thanks in advance for your effort of reporting.