Sophomore Circuits Lab: Lab 6: Op Amps

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Objectives:

In this lab we utilized Op Amps in order to better understand their functions and effects when implemented in circuits.

Conclusion / Results:

Among the types of circuits we designed, we built amplifiers such as the non-inverting amplifier, the inverting amplifier, the inverting summing amplifier, the differential amplifier and a 4 stage amplifier. From our rubric we performed a number of Pspice simulations and oscilloscope trials to examine things such as frequency vs. amplitude, and Vout, as well as, Vin over time, for each of these circuits. We found that our results matched our simulations, and that there were slight variations in numbers due to the imperfect nature of hardware. Overall, our data agreed with these simulations and, this trend can be observed when comparing our Pspice simulations to our oscilloscope images. For our rf and ri values in our non-inverting op amp we had a 30k resistor (rf) and 7.5k resistor in series, additionally, there was a feedback loop. This resulted in an output that was 5 times larger. Next for our inverting amplifier, we had an rf of 30k, and an ri of 7.5 k. The transfer function for this amp resulted in a value – 4 times the amplitude, and phase shifted the Vout from the Vin.

The summing inverting rf (30k), and the ri (two 15k resistors in parrallel) resulted in an amplitude – 4 times in size than the original Vin. Again, for the summing inverting, we once again saw a 180 degree phase shift for Vout from Vin. It was interesting to note that the waveform output as Vout, was, in fact, just an inversion of the a square wave and triangle wave put toghether (i.e. when the triangle was high the inverted sum would be go low, and when the square wave was high the Vout would go in the opposite direction from the input). For the differential amplifier the resistors were all 10k resulting in an rf/ri value of unity; this resulted in an equal amplitude for Vo and Vin. Finally, in part two, we used 3 cascading op amps, each fed a gain of 11k Ohms, and a final buffering op amp to achieve an output gain of 1331 V (or 11^3), to simulate a value close to the lab rubrics guideline.

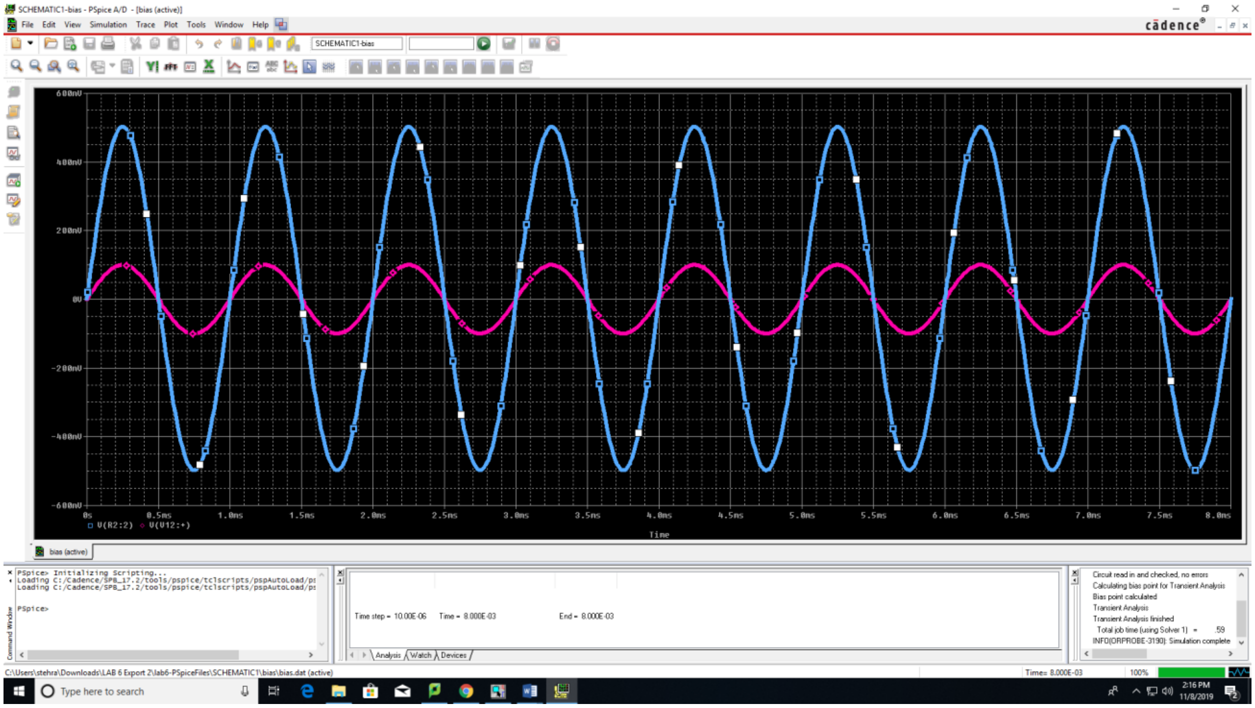
The aforementioned results detail some of the data as outlined in the following report. In addition to our results from the previous section, our frequency vs. amplitude simulations matched our expectations for the circtuits as well. Overall, in performing our calculations, our simulations and our hardware based trials, our understanding of Op amps, as implemented in circuits has been greatly enhanced.

Outline:

I.) Vout and Vin Simulations for Part 1
II.) Vout and Vin Simulations (4 Stage Amplifier) for Part 2
III.) Frequency versus Amplitude Simulations Part 1
IV.) Frequency versus Amplitude Simulations (4 stage Amplifier) Part 2
V.) Oscilloscope Images (Parts 1, Parts 2)
VI.) Transfer Functions Part 1

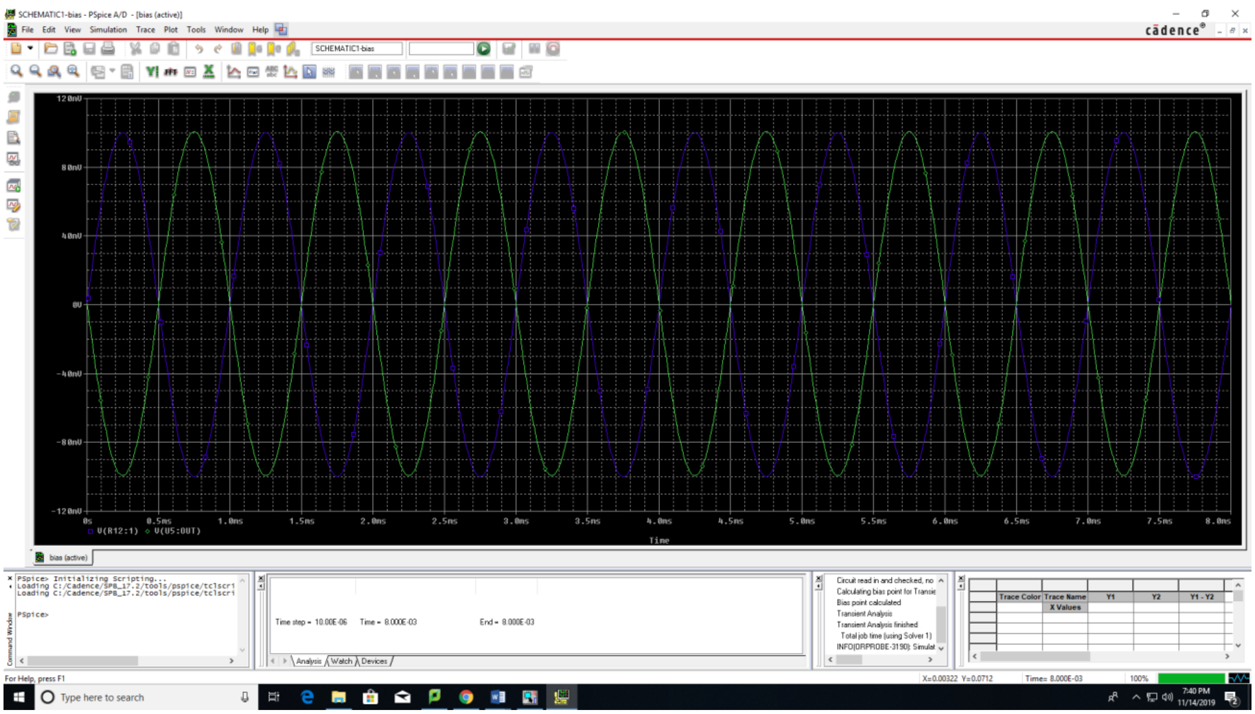
I.) Part 1.) Vout and Vin Simulations

Part 1.) A.) Non-Inverting Amplifier (Vout and Vin):

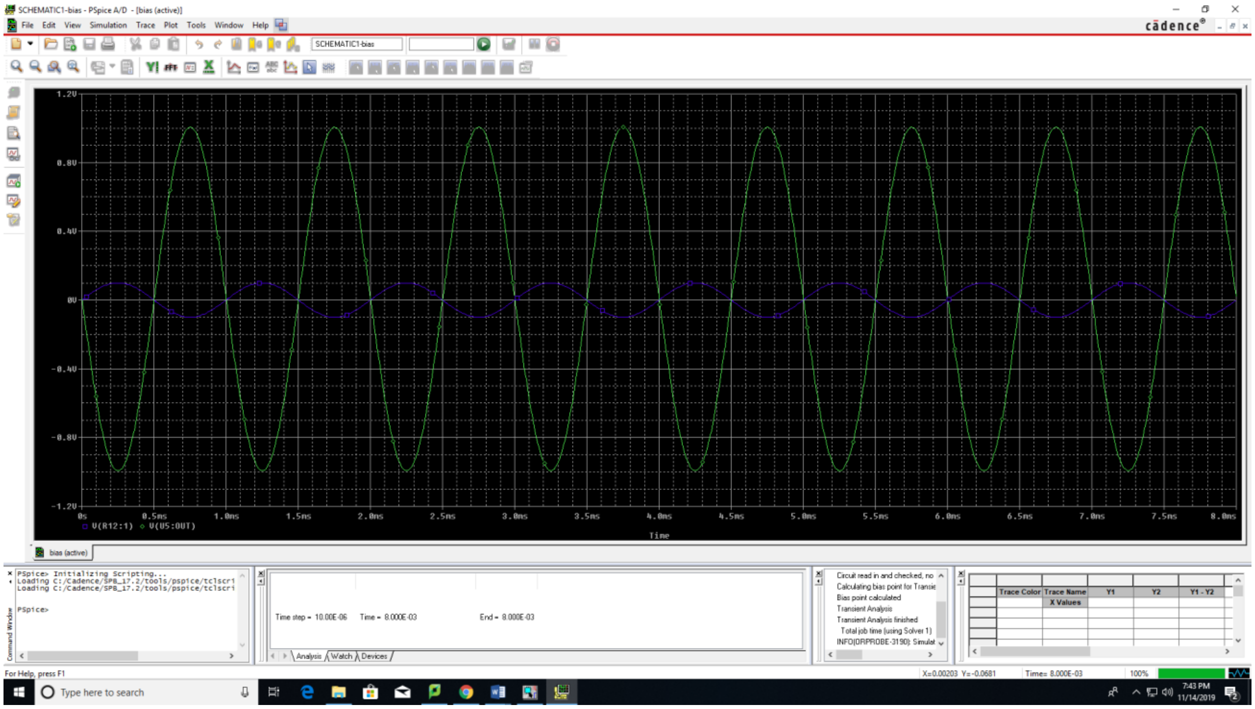


Part 1.) B.) Inverting Amplifier (Vout and Vin):

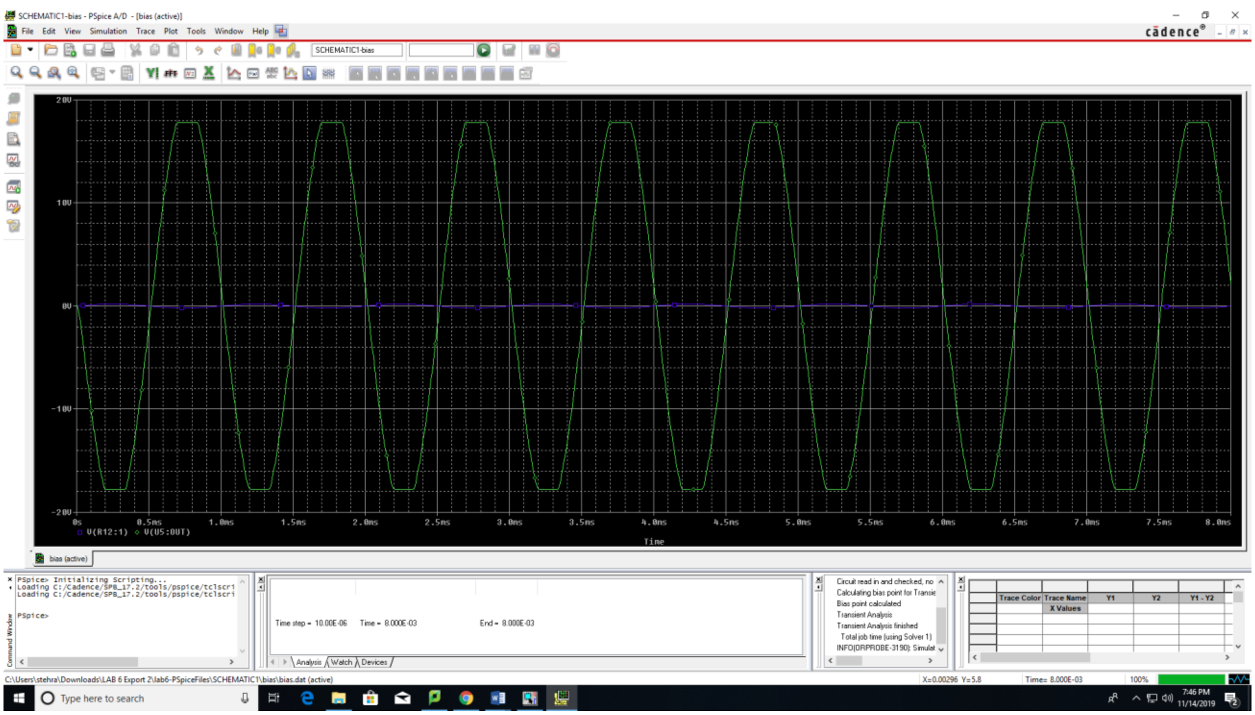
Gain 1



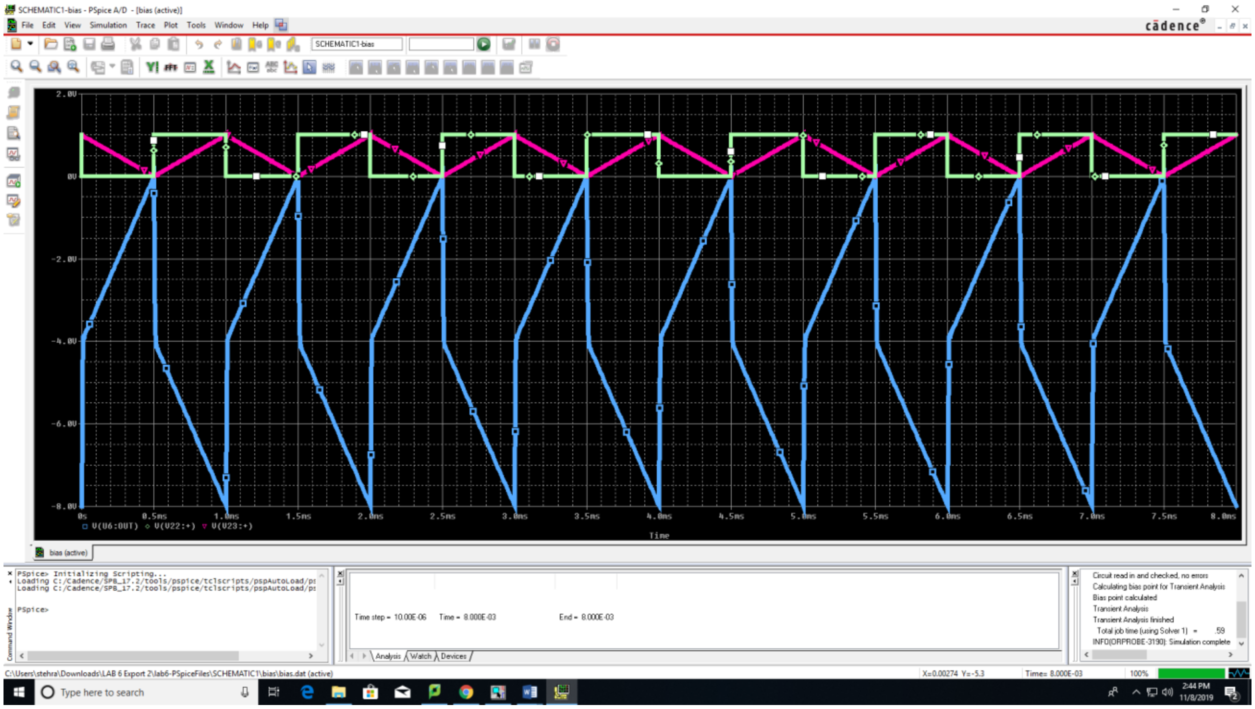
Gain 10



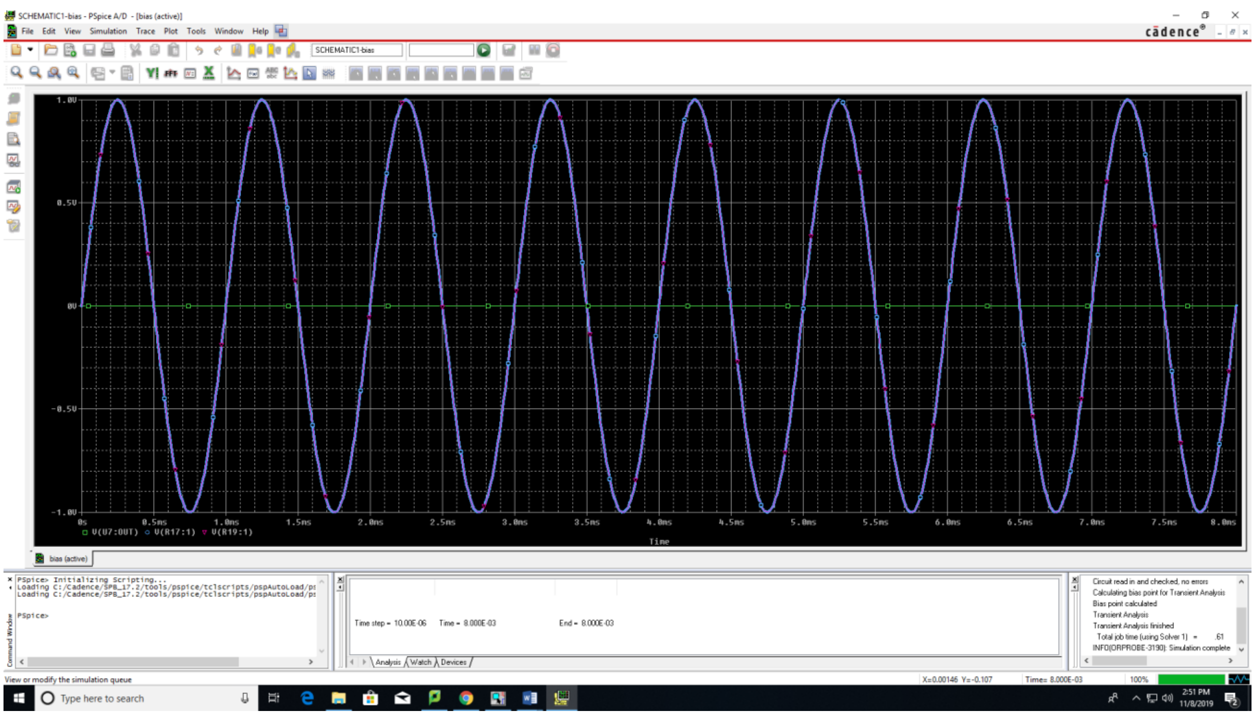
Gain 100 (increased input voltage to .2V to clip output. Rails at 18v, (.2V*100=20V) 2v over rail voltage



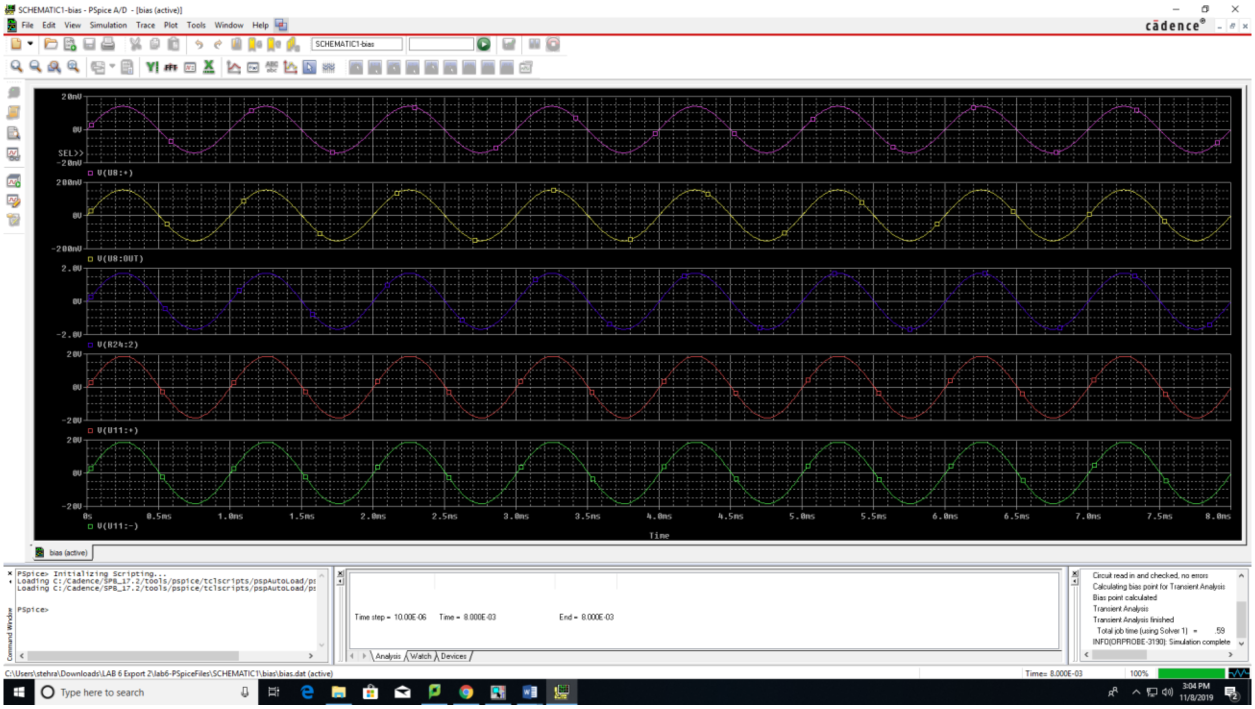
Part 1.) C.) Inverting Summing Amplifier (Vout and Vin):



Part 1.) D.) Difference Amplifier (Vout and Vin):



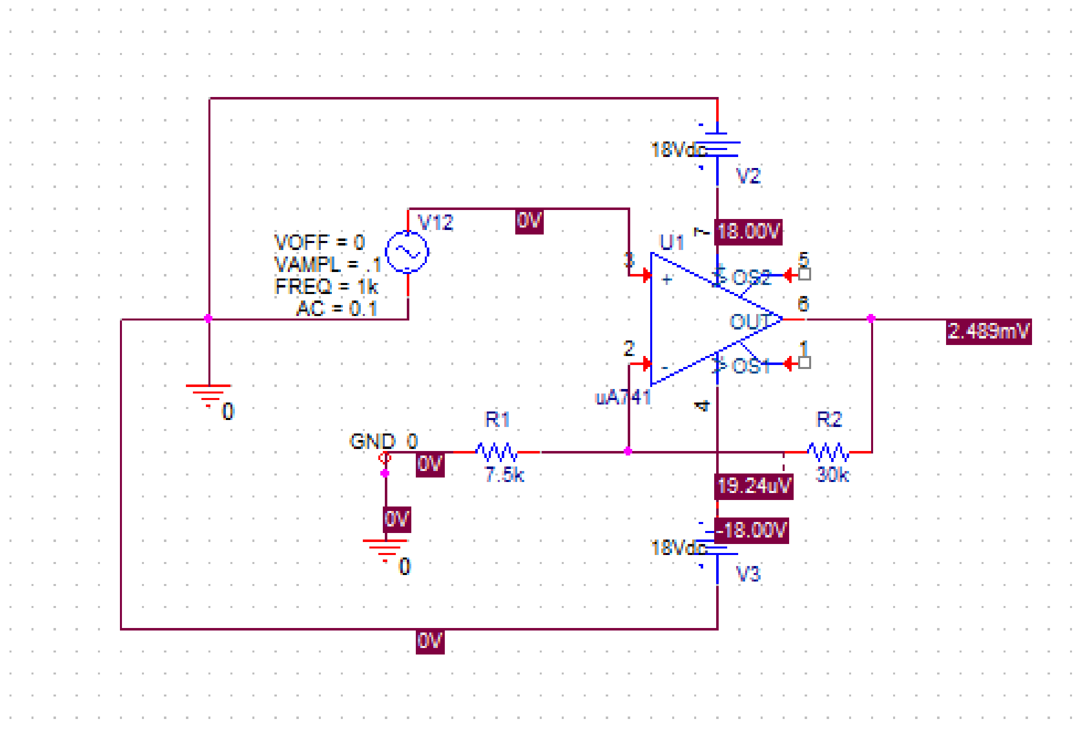
II.) Part 2.) Vout and Vin Simulations (4 Stage Amplifier)



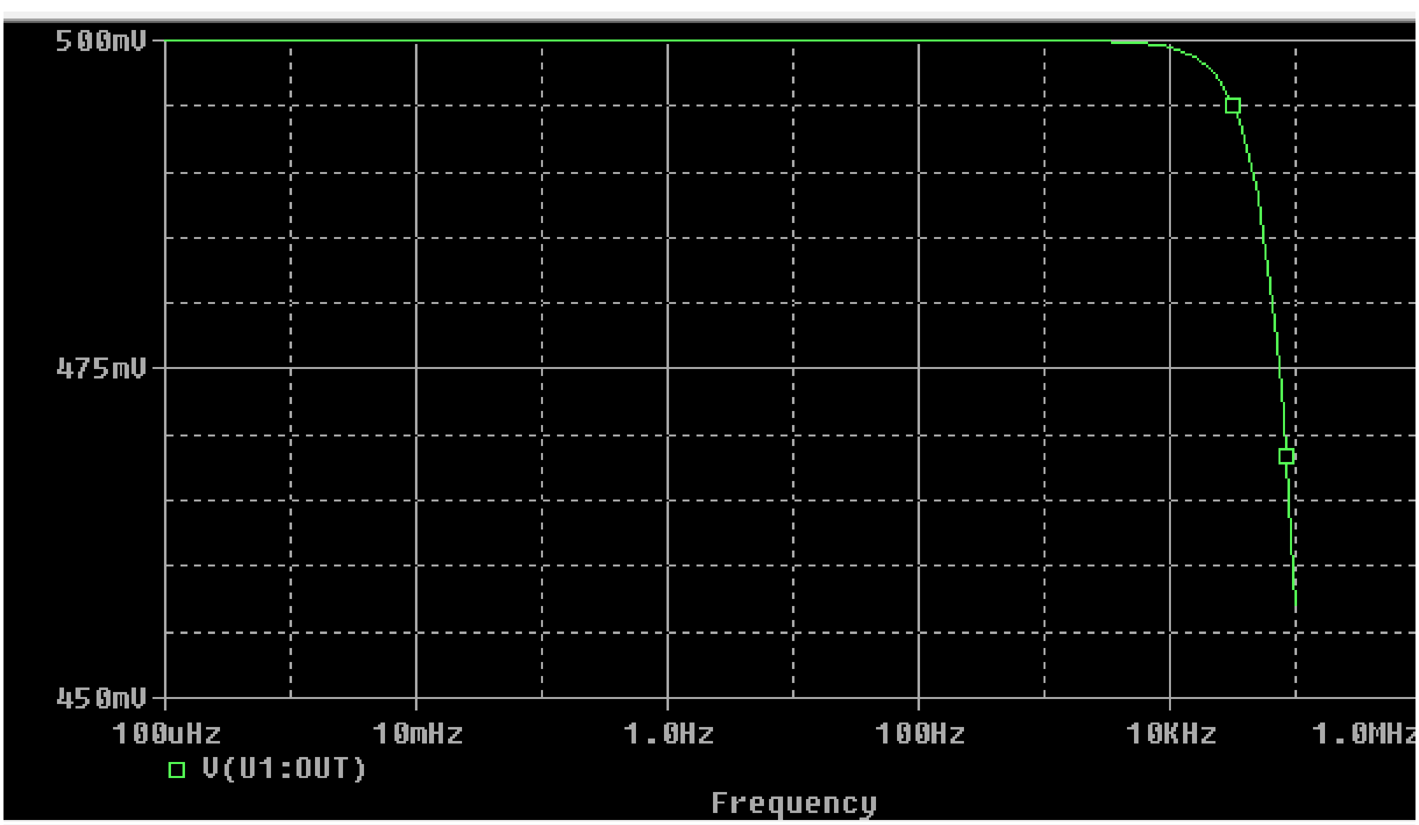
III.) Part 1.) Frequency versus Amplitude Simulations

Part 1 A.) Frequency versus Amplitude Simulations: Non-Inverting Amplifier

Non-Inverting Amplifier Schematic:

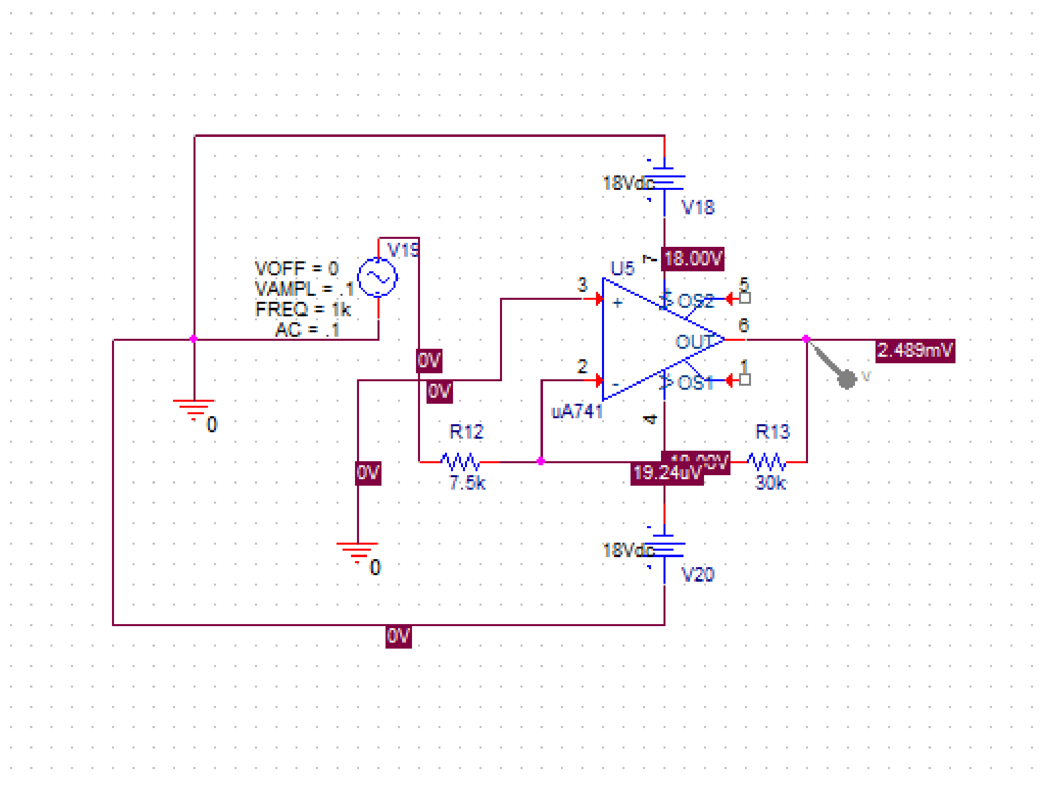


Non-Inverting Simulation (Frequency versus Amplitude Simulations:):



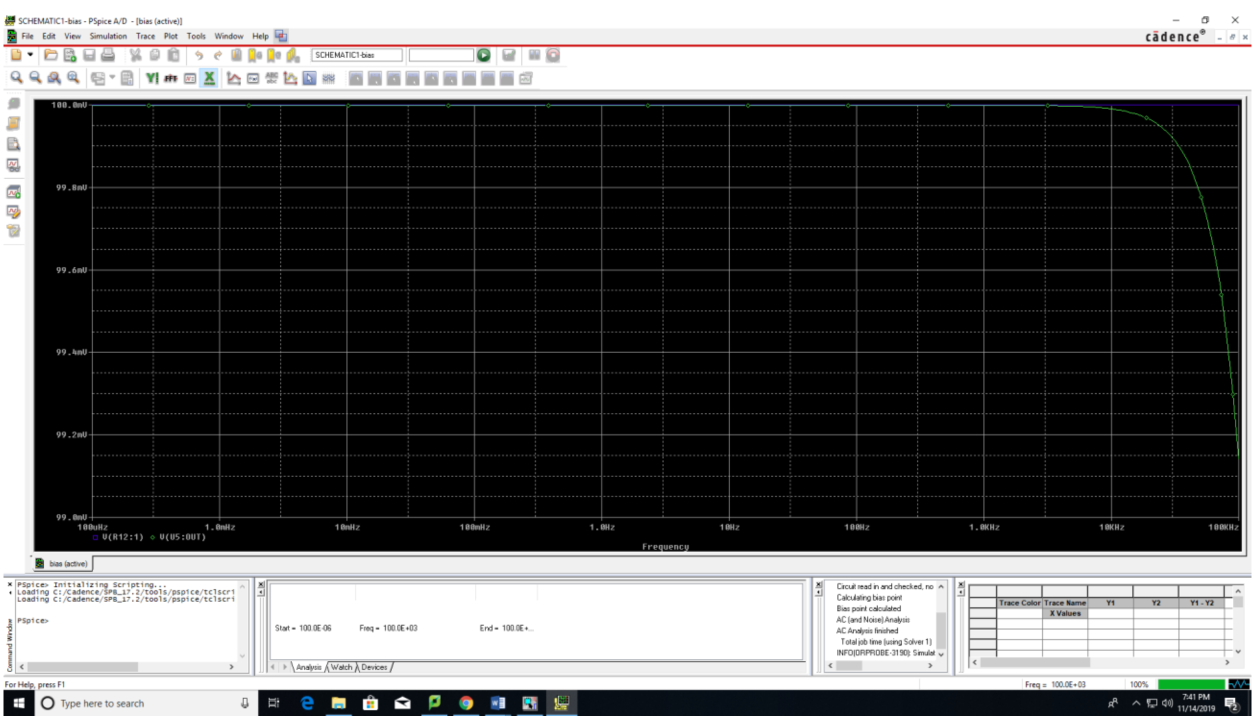
Part 1 B.) Frequency versus Amplitude: Inverting Amplifier

Inverting Amplifier Schematic:

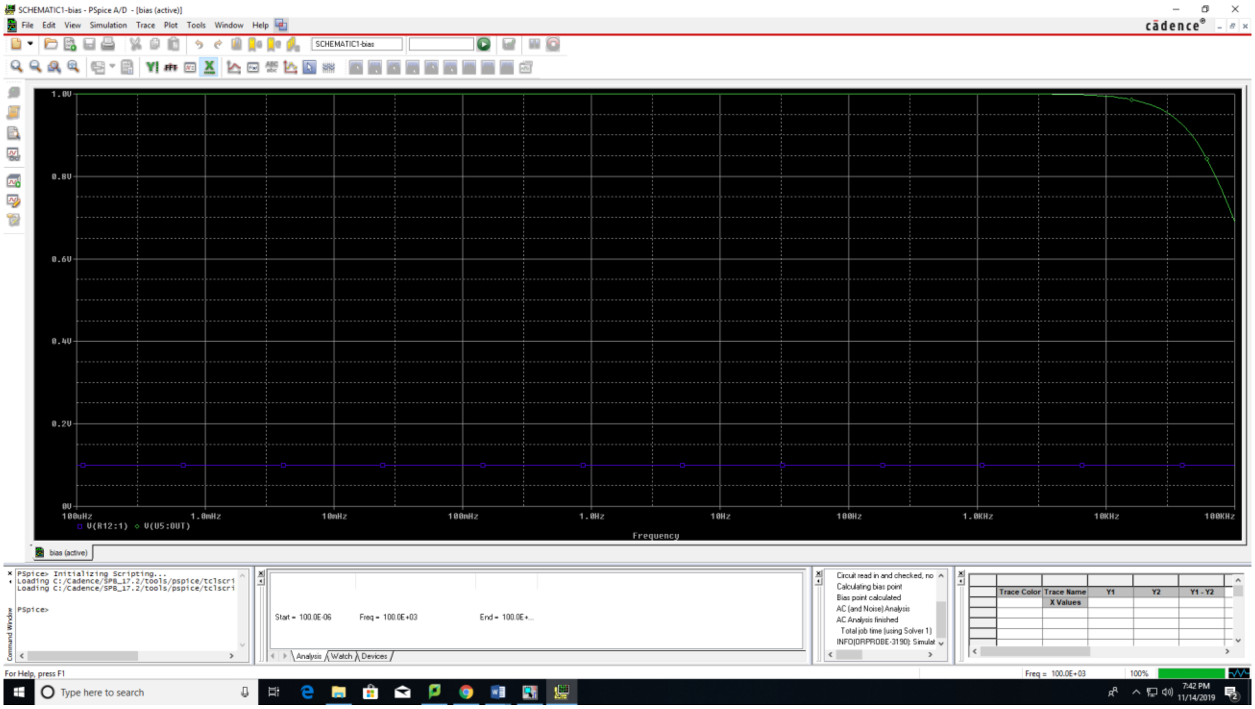


Inverting Simulation (Frequency versus Amplitude Simulations:):

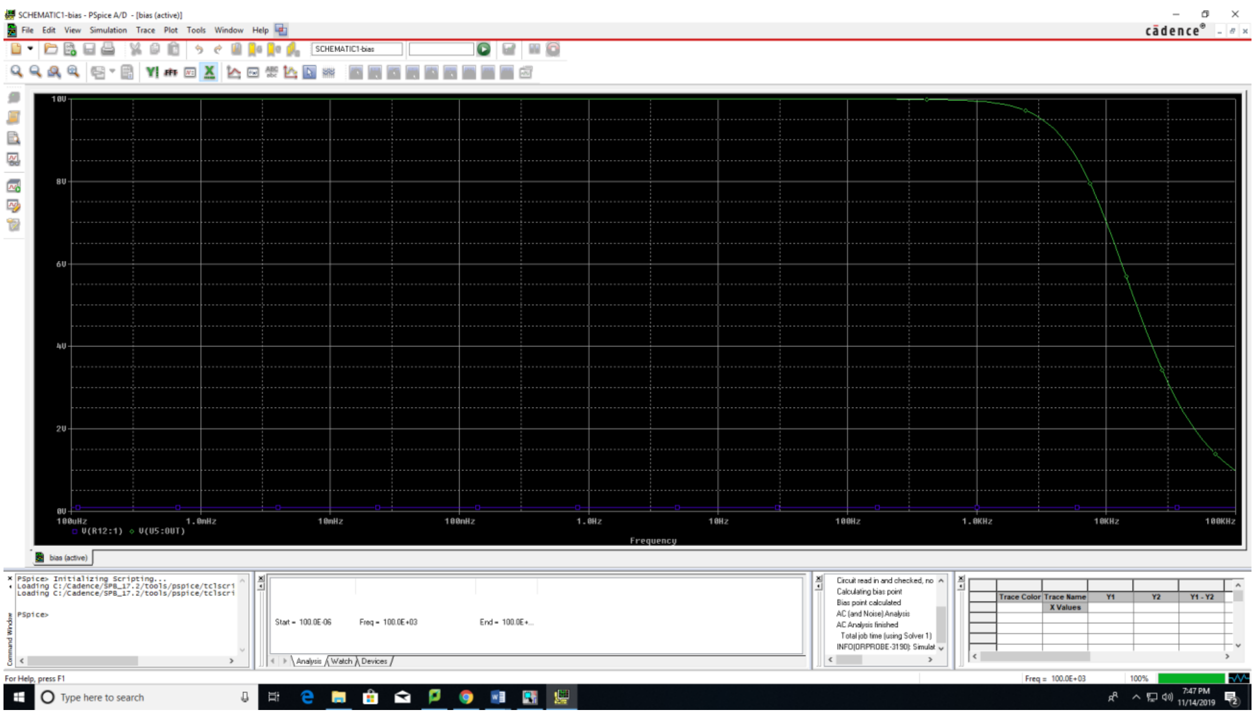
Freq vs Amp Gain 1



Freq vs Amp Gain 10

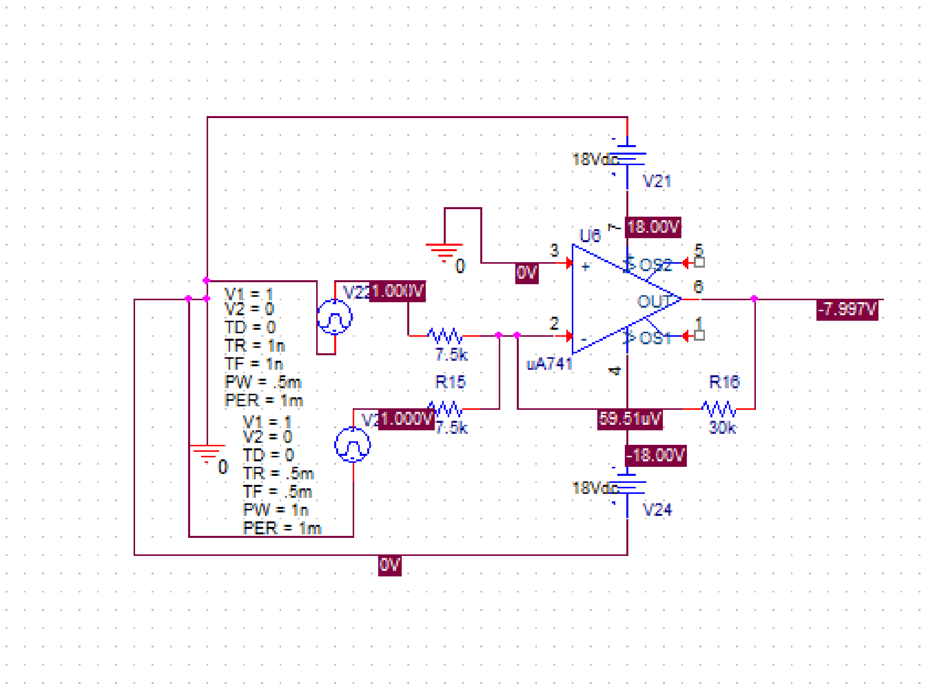


Freq vs Amp Gain 100

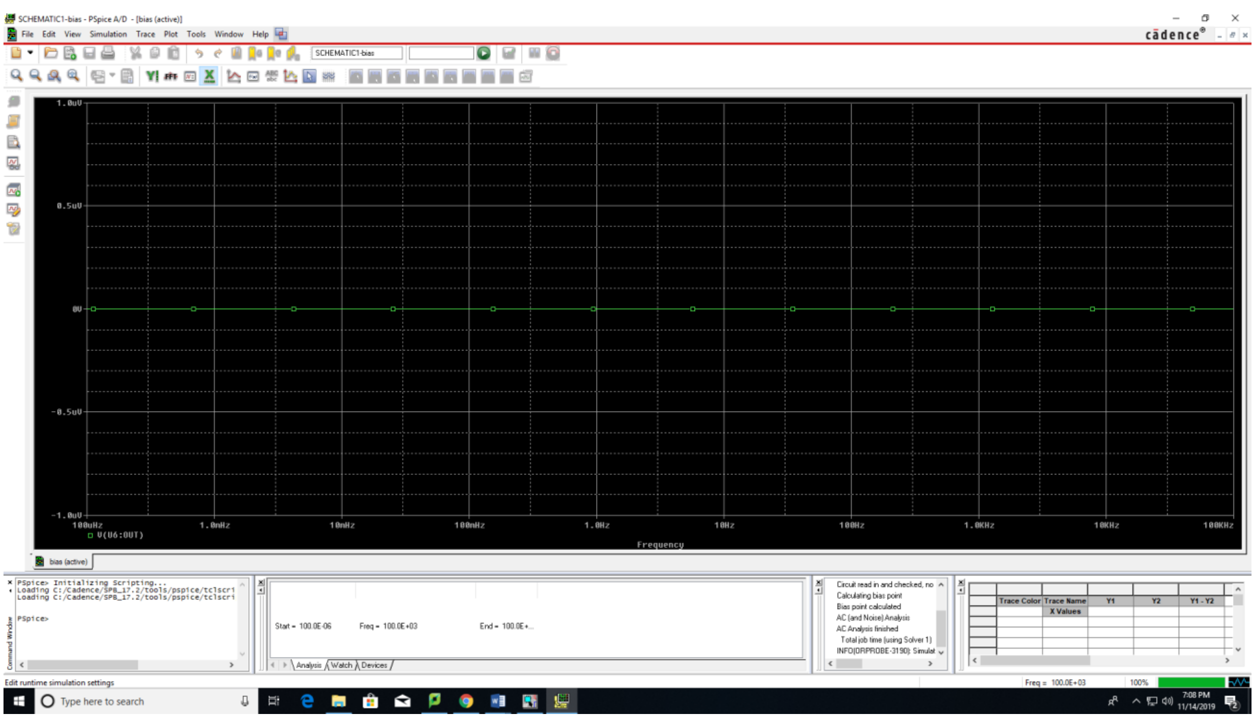


Part 1 C.) Frequency versus Amplitude Simulations: Inverting-Summing Amplifier

Inverting Summing Amplifier Schematic:

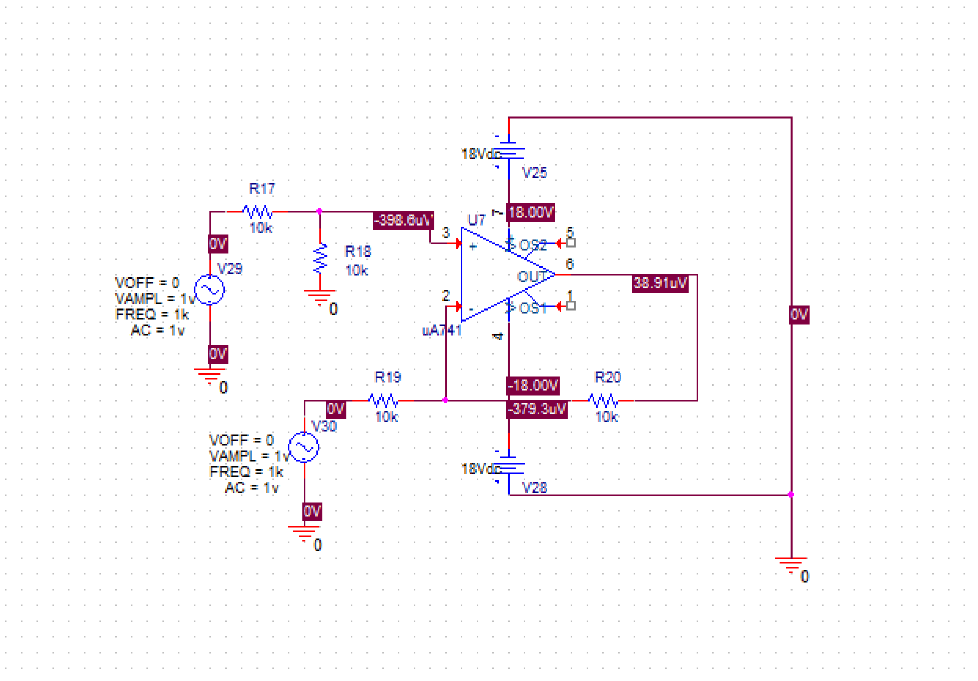


Inverting Summing Amplifier (Frequency versus Amplitude Simulations):

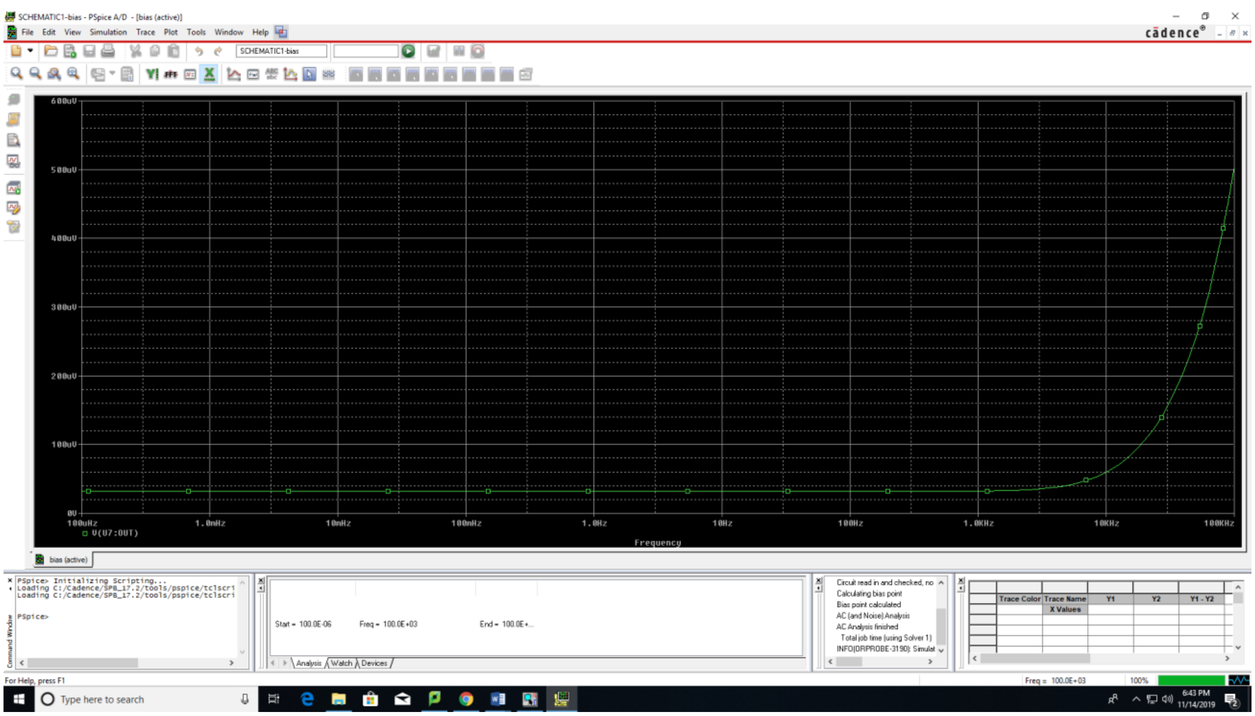


Part 1 D.) Frequency versus Amplitude Simulations: Difference Amplifier

Difference Amplifier Schematic:

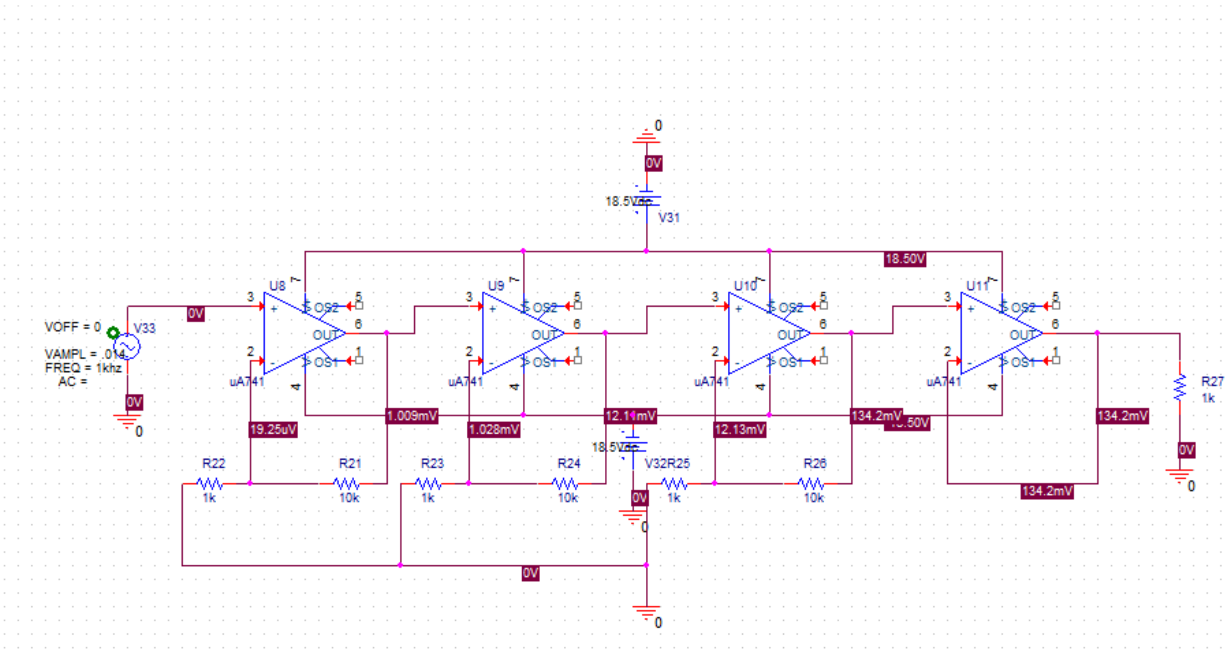


Difference Amplifier Schematic (Frequency versus Amplitude Simulations):

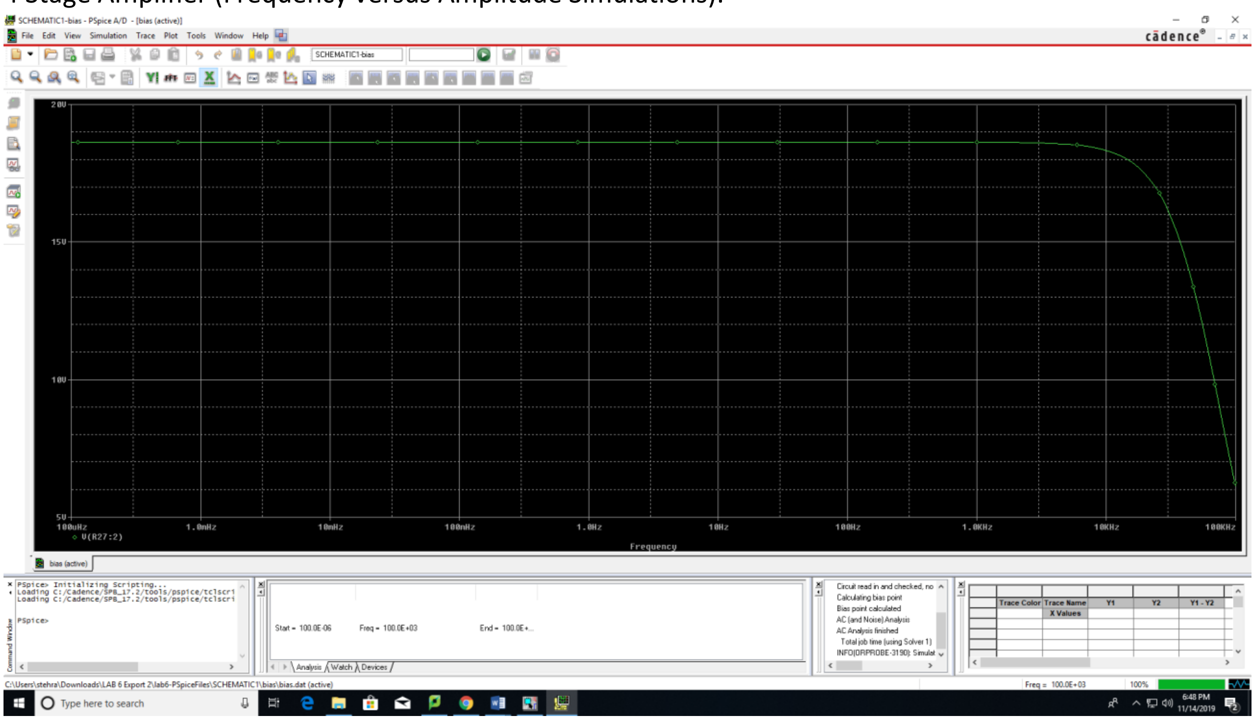


IV.) Part 2.) Frequency versus Amplitude Simulations (4 stage Amplifier):

4 Stage Amplifier Schematic:

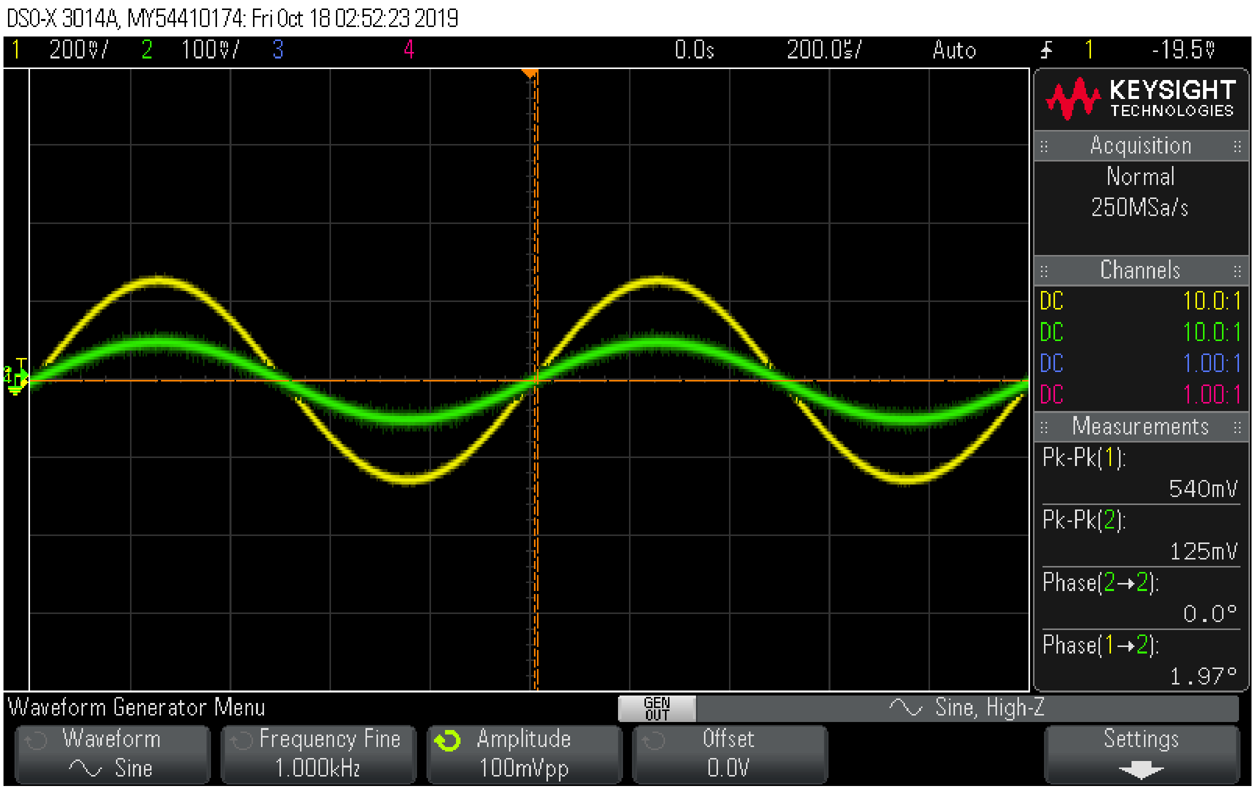


4 Stage Amplifier (Frequency versus Amplitude Simulations):

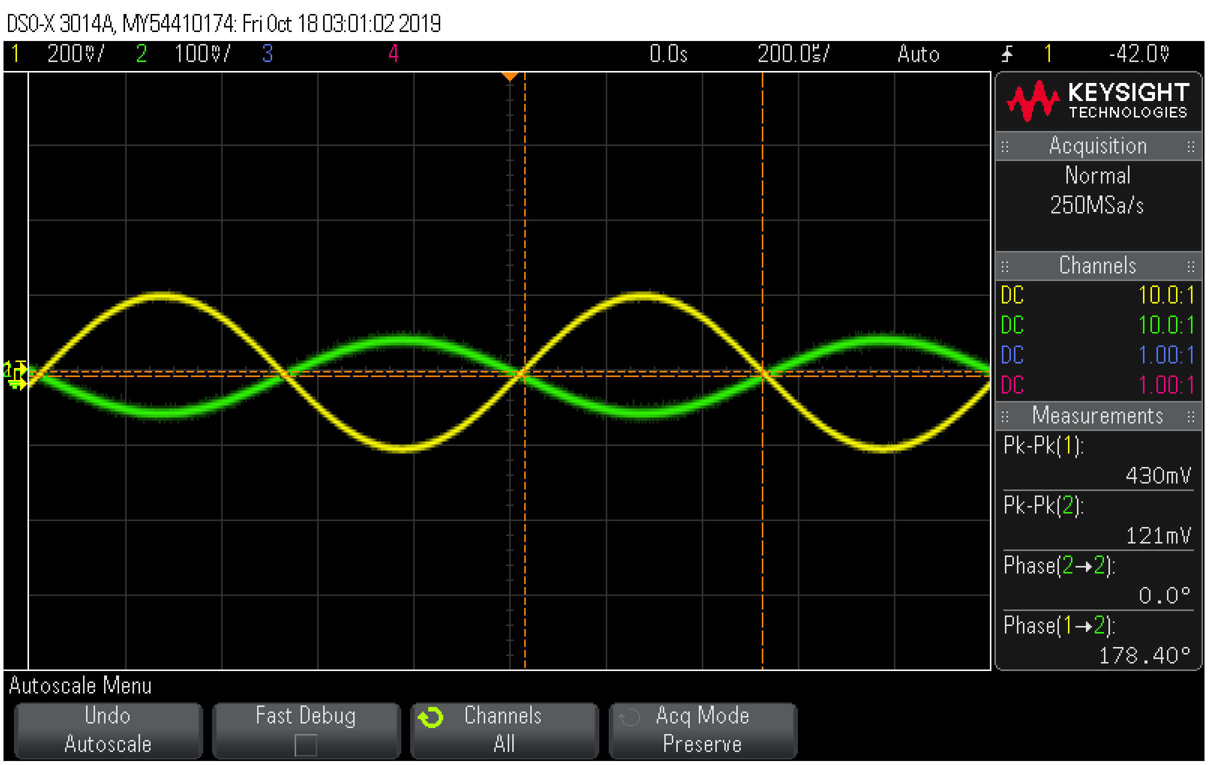


V.) Oscilloscope Images, All Parts (Parts 1, Parts 2):

Non-Inverting Op Amp:

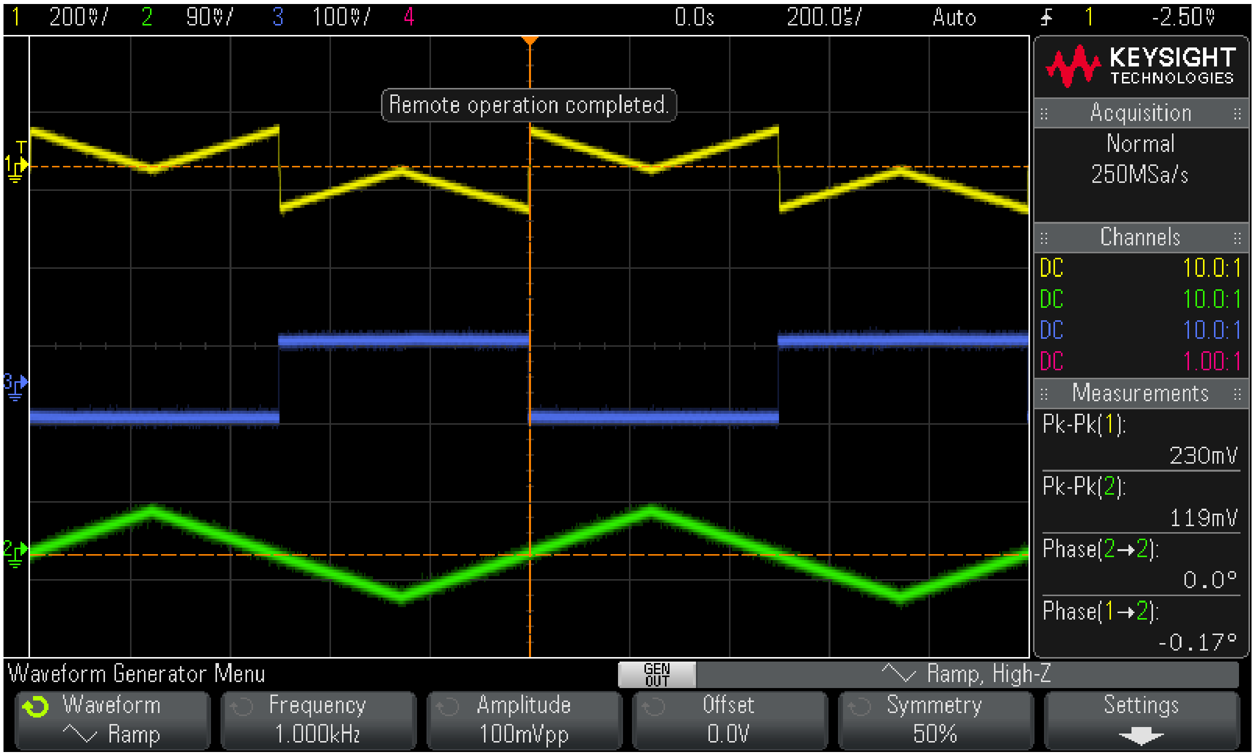


Inverting Op Amp



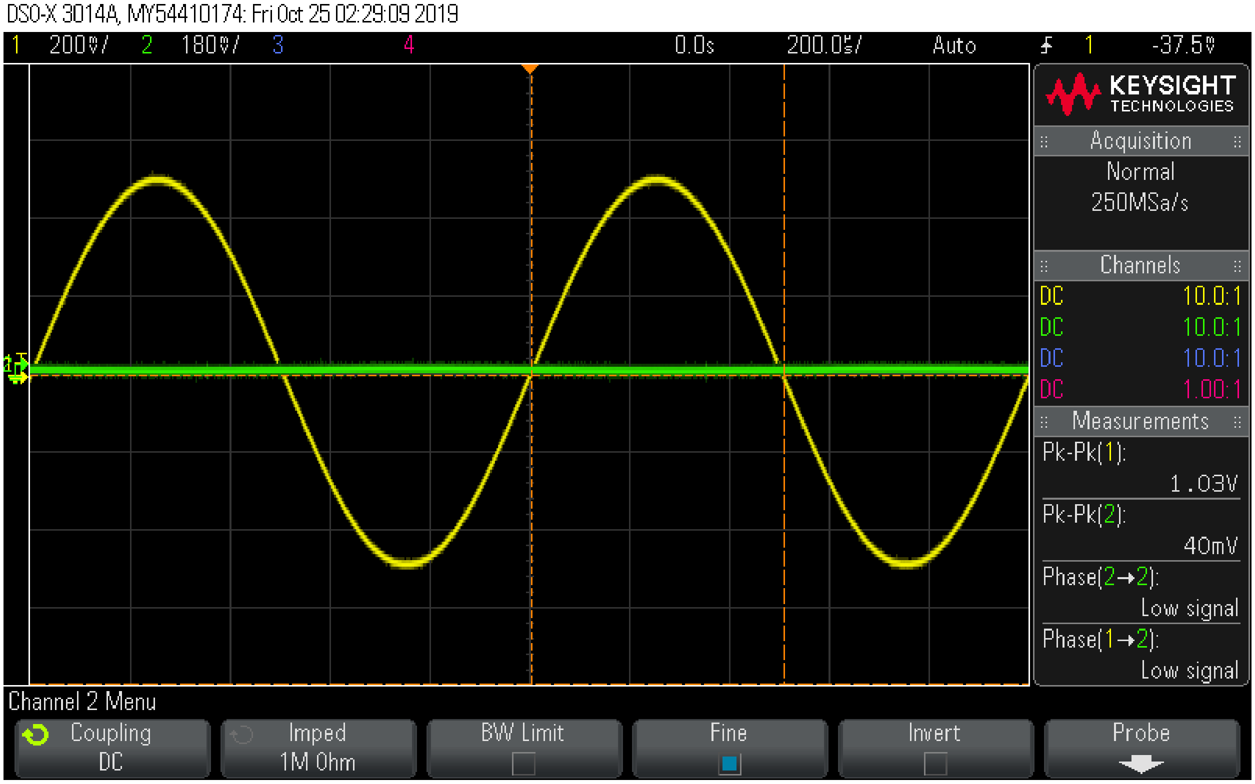
Inverting Summing Op Amp

DSO-X 3014A, MY54410174: Fri Oct 18 03:34:42 2019



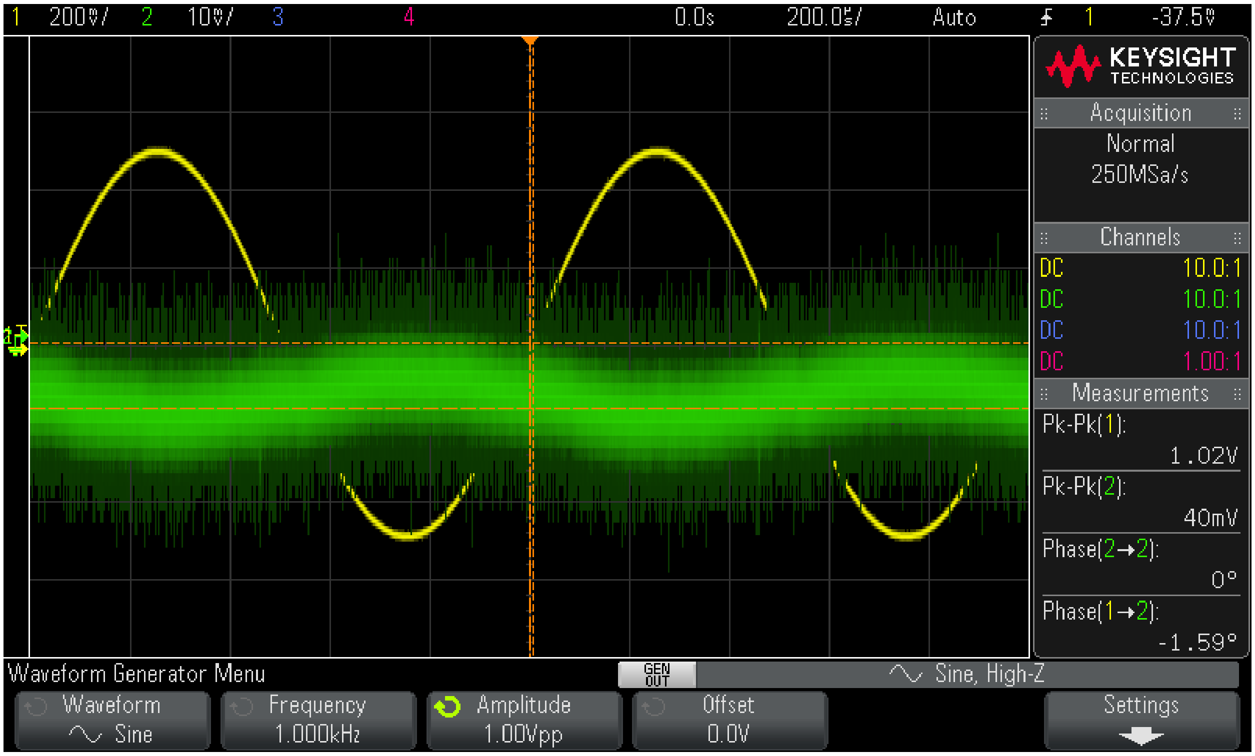
Difference Amplifier:

DSO-X 3014A, MY54410174: Fri Oct 25 02:29:09 2019



The same difference amplifier from before, common mode rejection ratio causes cancellation from the 2sources being the same

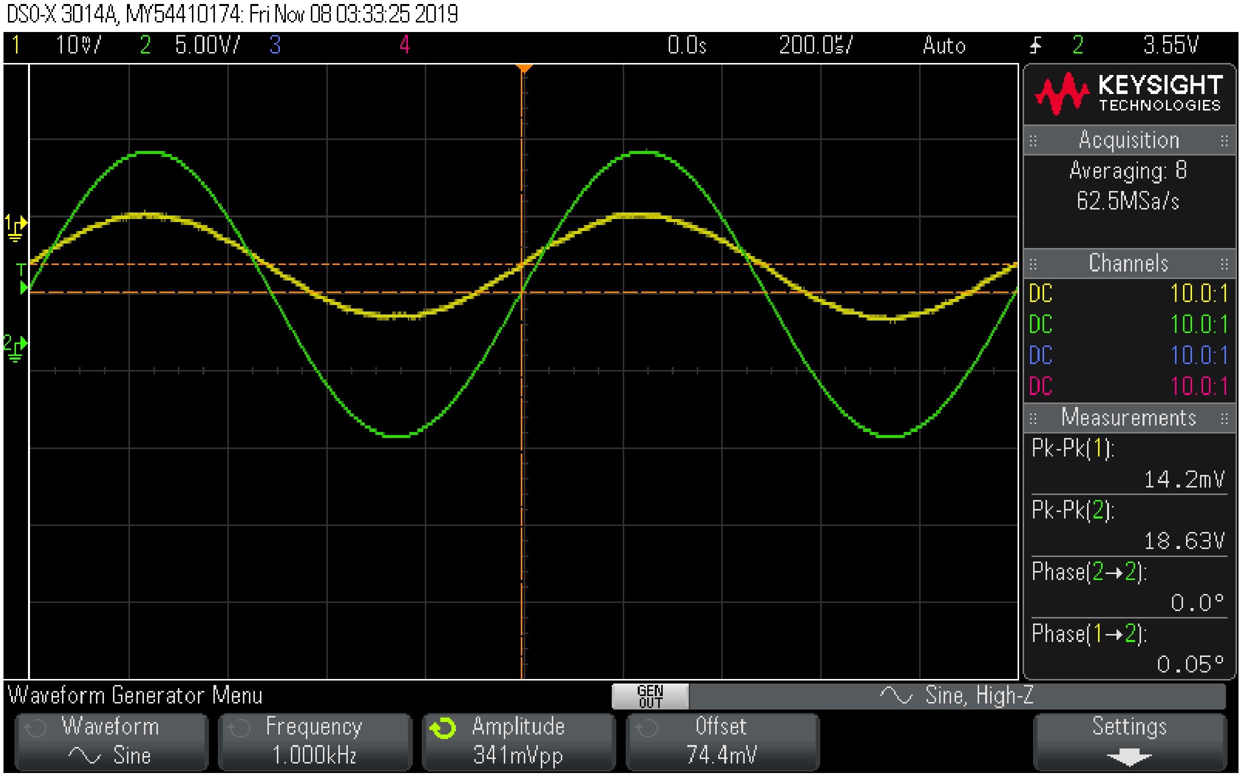
DSO-X 3014A, MY54410174: Fri Oct 25 02:33:38 2019



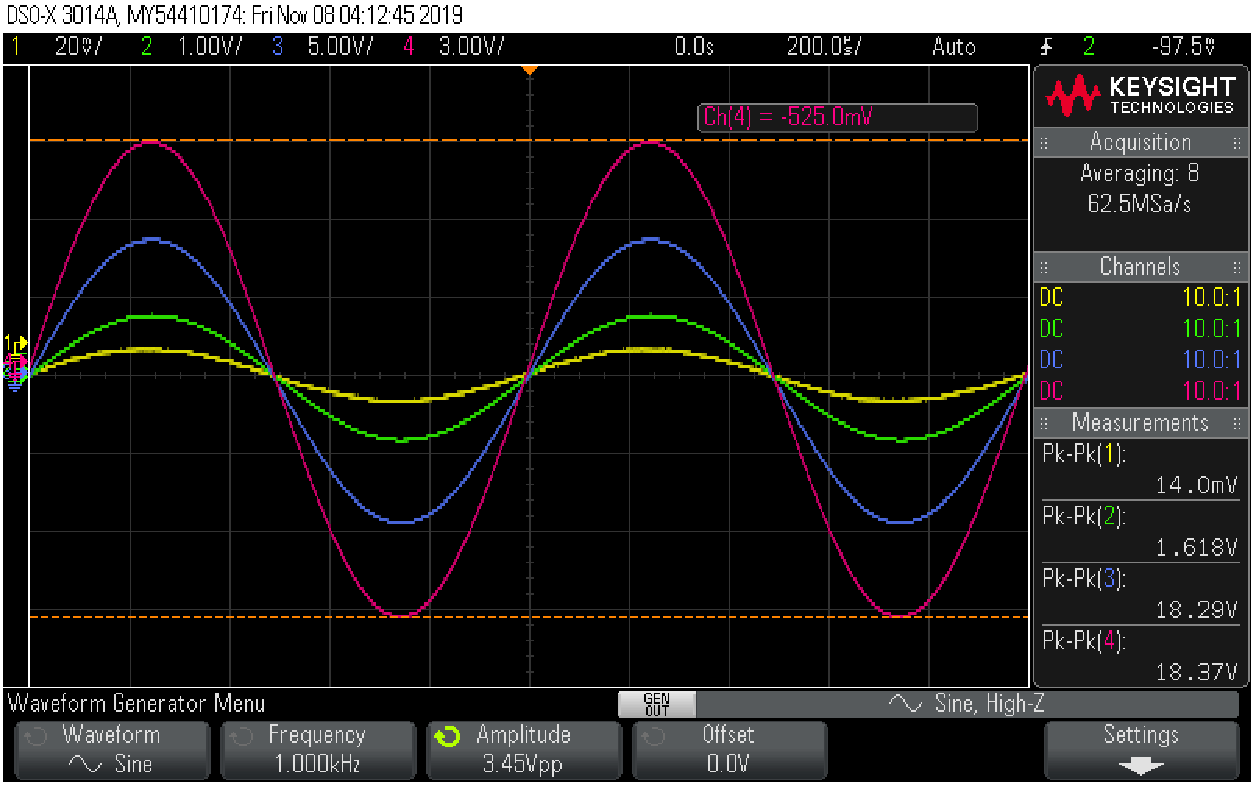
4 stage amplifier 1k +10k ==11k, 1331 v output

Output Stage: 14.1mV for the four stage voltage: (18.66/(14.1*10^-3)) = 1311.97

DSO-X 3014A, MY54410174: Fri Nov 08 03:33:25 2019



All “Stages”: Four stage Amplifier: 18.5/(14*10^-3) = 1321.43



VI.) Part 1.) Transfer Functions

Non-Inverting

$R_f = 30k \approx 30.31k\Omega$

$R = 7.5k = 7.39k\Omega$

$A_v = 1 + \frac{30k}{7.5k} = 5$

Inverting

$R_f = 30k = 30.31k$

$R = 7.5k = 7.39k$

$A_v = \frac{-30k}{7.5k} = -4$

Summing Inverted

$R_f = 30k$

$R_1 = 15k$

$R_2 = 15k$

$A_v = \frac{-30k}{15k \| 15k} = -4$

Differential

$V_o = (V_{in_2} - V_{in_1}) \frac{R_2}{R_1}$

$A_v = \frac{10k}{10k} = 1$