EEO353 Lab 3
Differential Amplifier

Pete Mills

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Copy of Original Assignment

Assignment 3 - Differential Amplifier

This Assignment aims at verifying and expanding, with experiments and supporting simulations, your knowledge and understanding of the input stage of the differential amplifier.

Please document each step with snapshots, pictures, and your observations. Wherever possible please include the date and time field and the AD S/N. Please include this page.

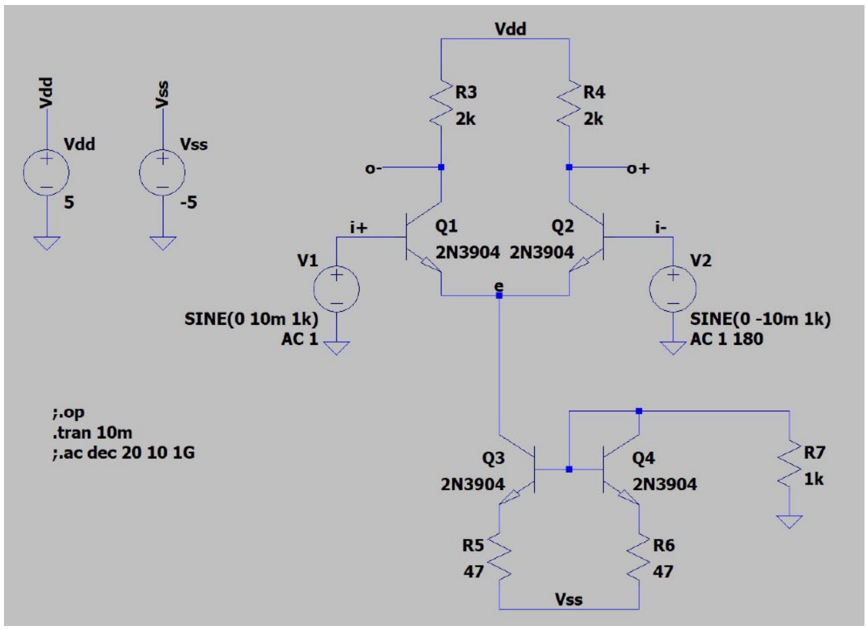

Figure 1

1) Using the simulator, design the configuration in Fig. 1 and simulate as follows (**30pts**)

a) simulate the response at Q2 collector to a 10mV, 1kHz sinusoidal input at Q1 base, simulate the frequency response and calculate the -3dB

b) simulate the response at Q2 collector to a 10mV, 1kHz sinusoidal input at Q1 base and a synchronized and in-phase 10mV, 1kHz sinusoidal input at Q2 base (i.e. a common-mode input)

c) simulate the response at Q2 collector to a 10mV, 1kHz sinusoidal input at Q1 base and a synchronized and 180deg-phase 10mV, 1kHz sinusoidal input at Q2 base (i.e. a fully-differential input), simulate the frequency response and calculate the -3dB

d) simulate the response at Q2 collector minus the response at Q1 collector (i.e. differential output) to a 10mV, 1kHz sinusoidal common-mode input

e) simulate the differential output to a 10mV, 1kHz sinusoidal fully-differential input, simulate the frequency response and calculate the -3dB

Note: You can disable a signal by setting the amplitude to 0V. You can shift 180-deg the signal (inversion) by inverting the amplitude into -10mV or by setting the phase to 180.

2) Build the circuit at (1) and experimentally reproduce all the simulations except for the frequency response of case (e) (**60pts**)

3) Explain in your own words why the configuration (d) has a much lower gain than the configuration (e) (**10pts**)

Summary

In this lab we explore differential amplifiers and gain a deeper understanding thru simulation and experimentation.

1 Using the simulator, design the configuration in Fig. 1 and simulate as follows

a)

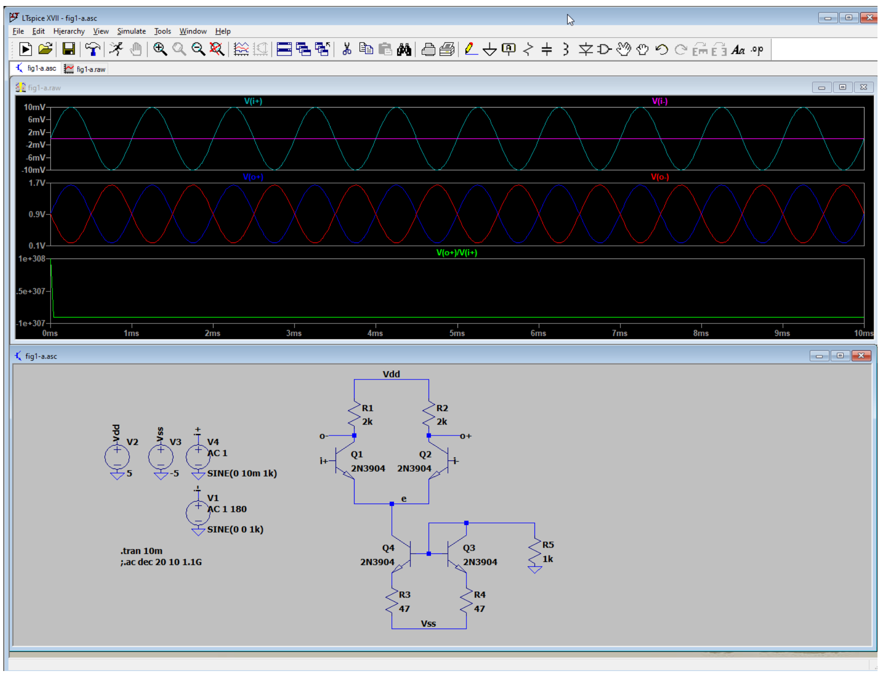

Figure 1: Transient Response

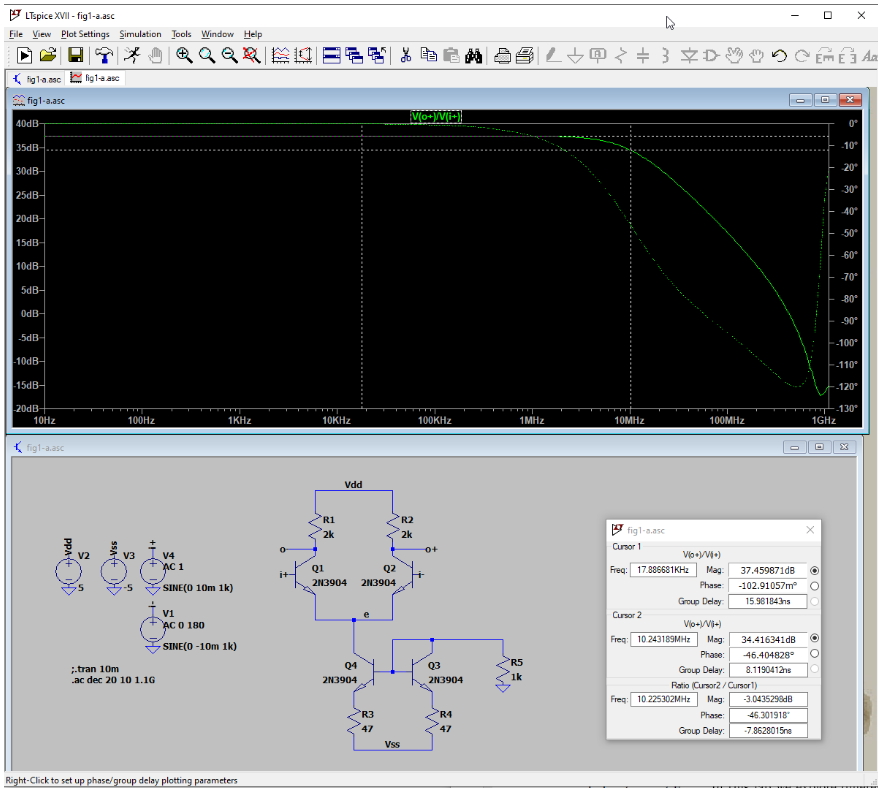

Figure 2: Frequency Response

b)

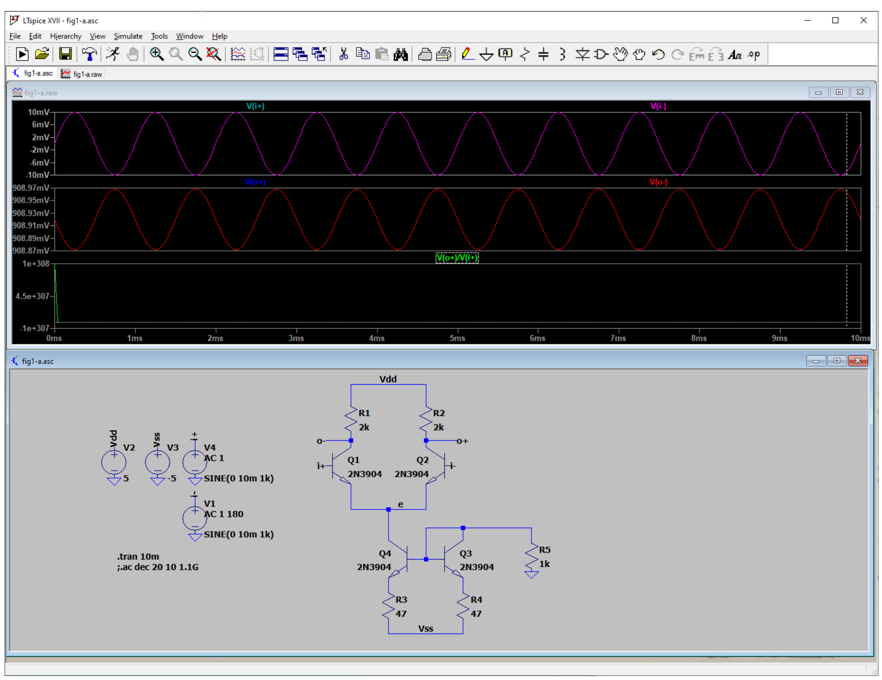

Figure 3: Transient Response

c)

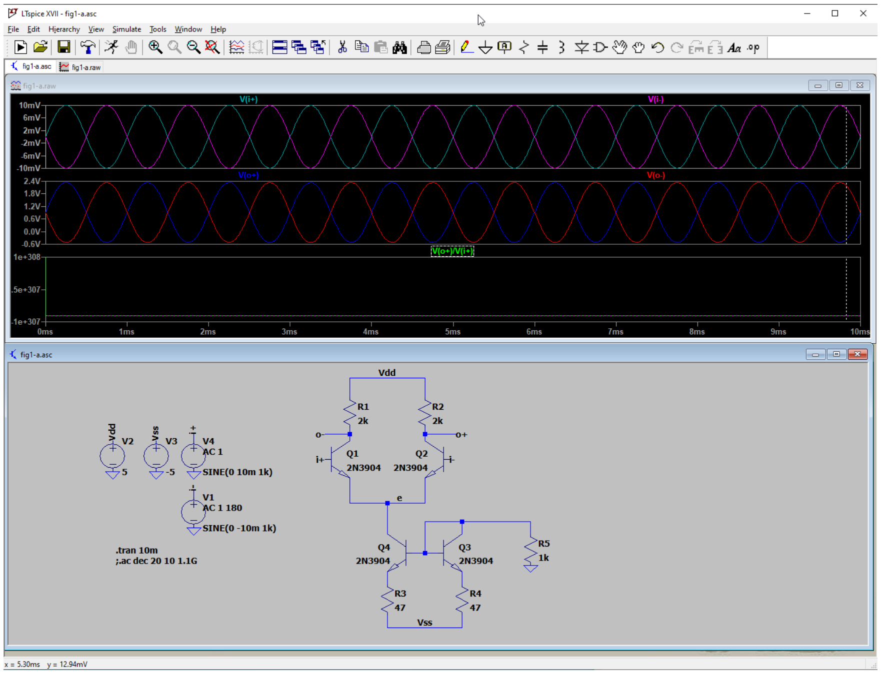

Figure 4: Transient Response

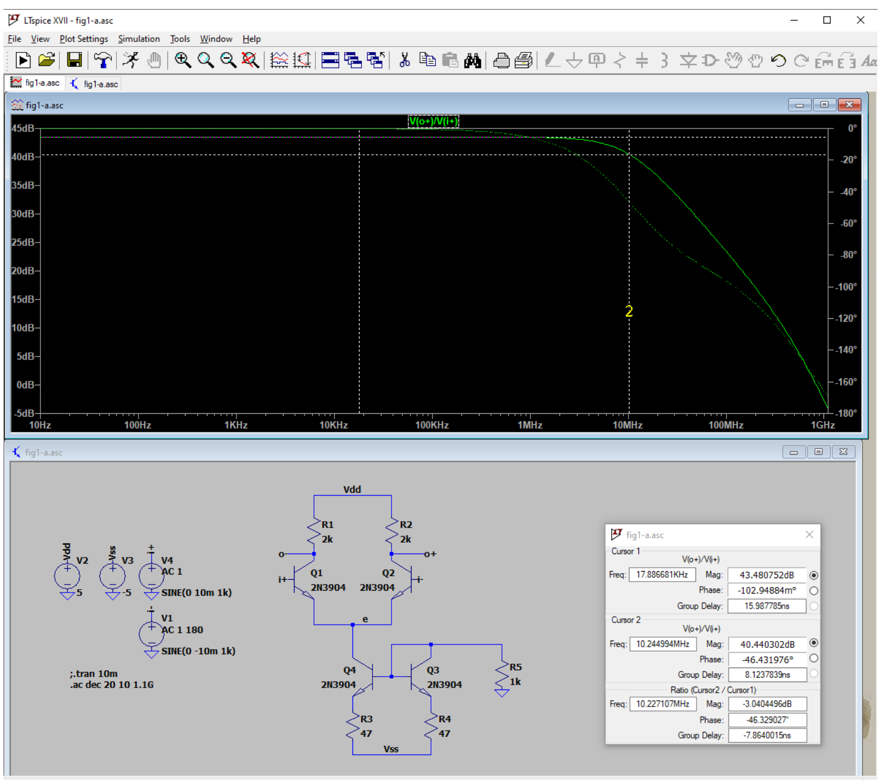

Figure 5: Frequency Response

d)

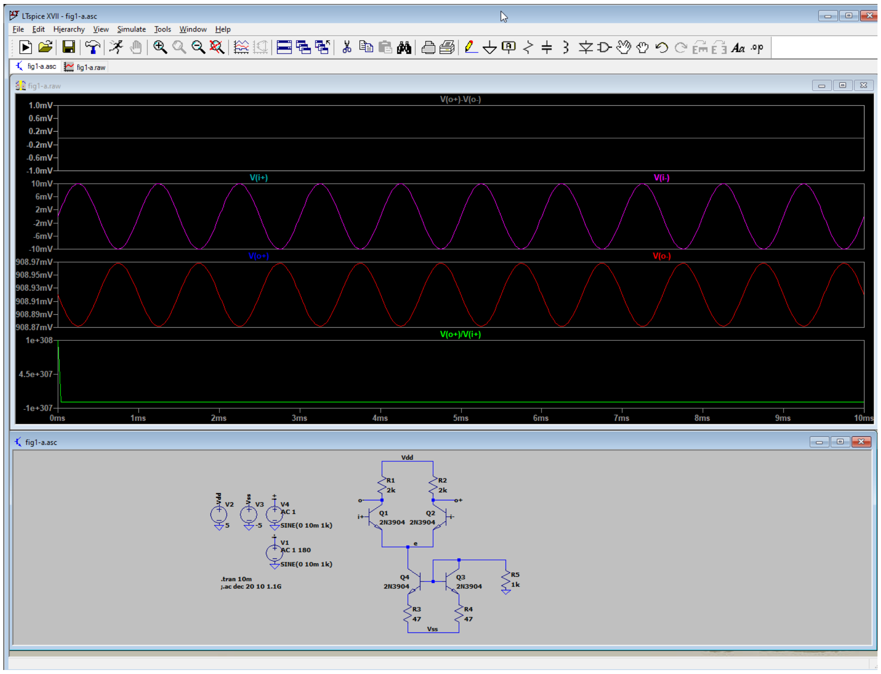

Figure 6: Transient Response

e)

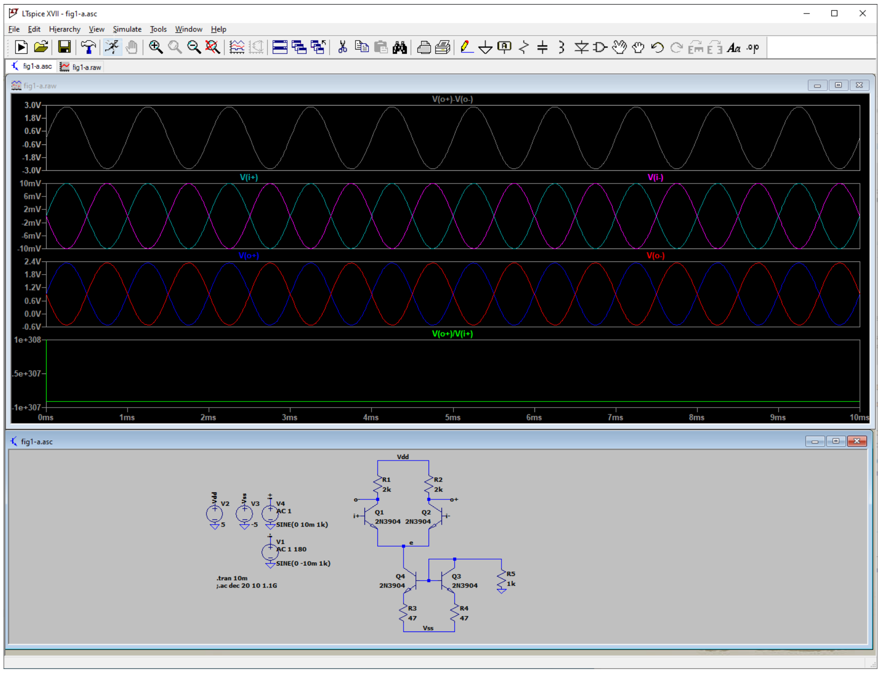

Figure 7: Transient Response

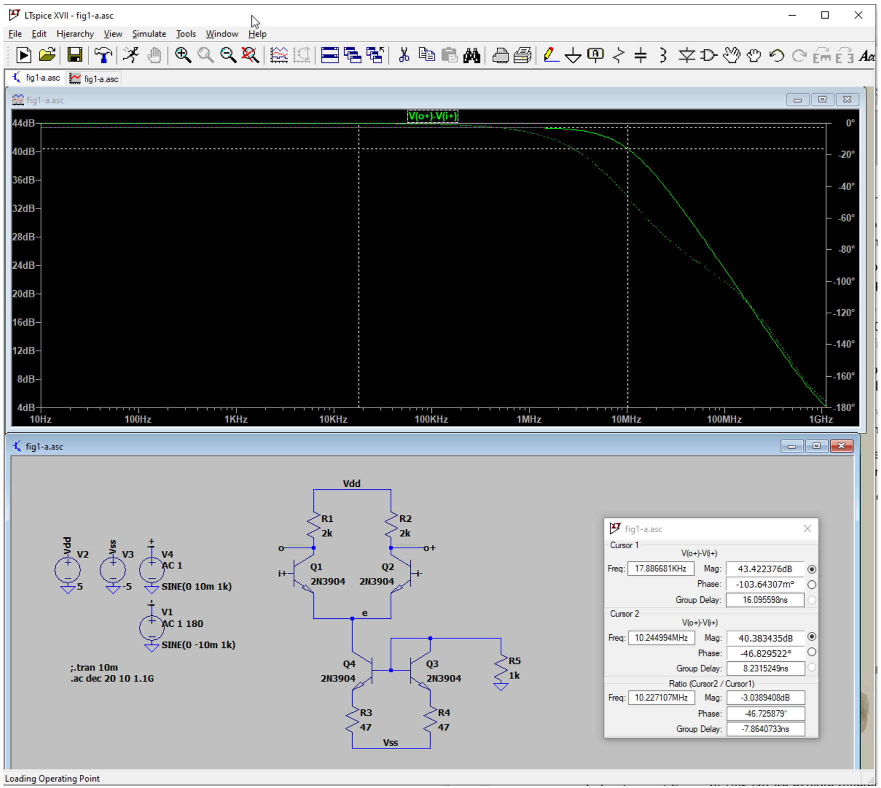

Figure 8: Frequency Response

2 Build the circuit at (1) and experimentally reproduce all the simulations except for the frequency response of case (e)

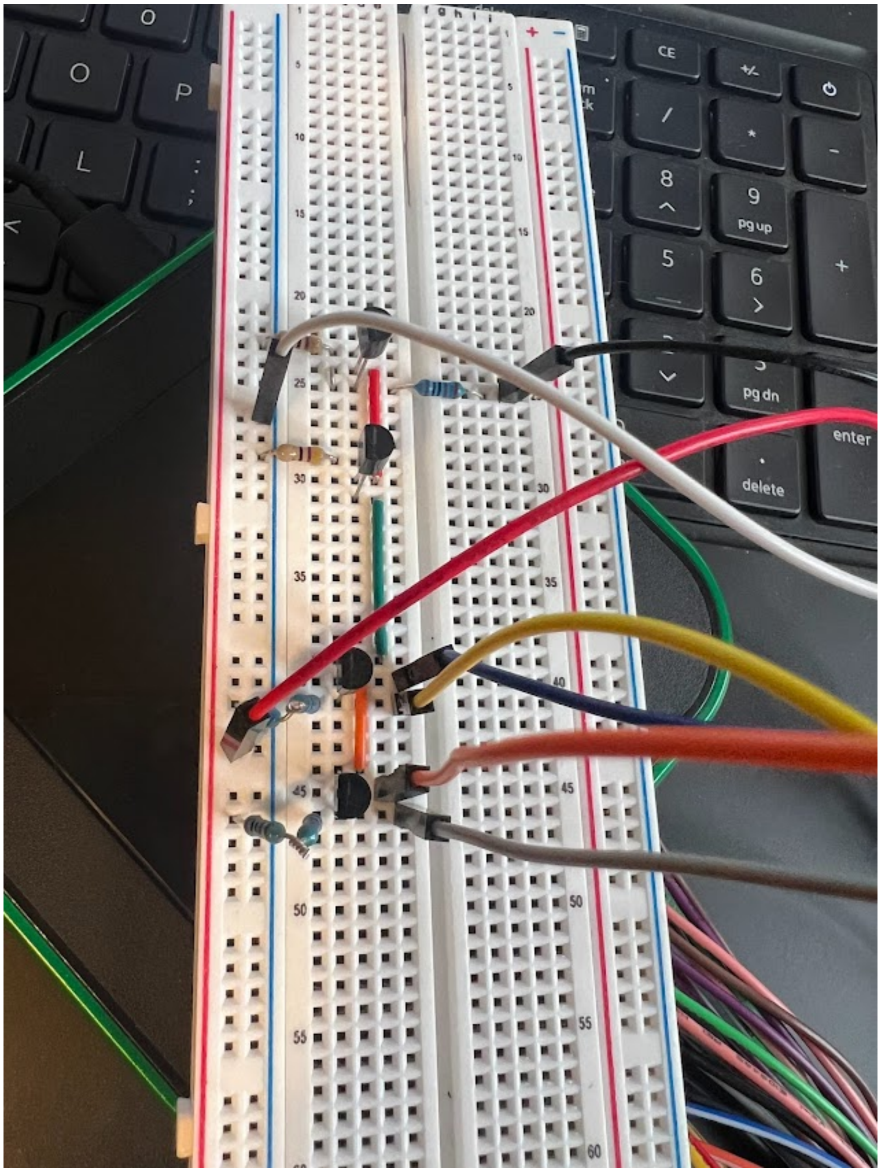

Figure 9: Discrete differential amplifier on breadboard

a)

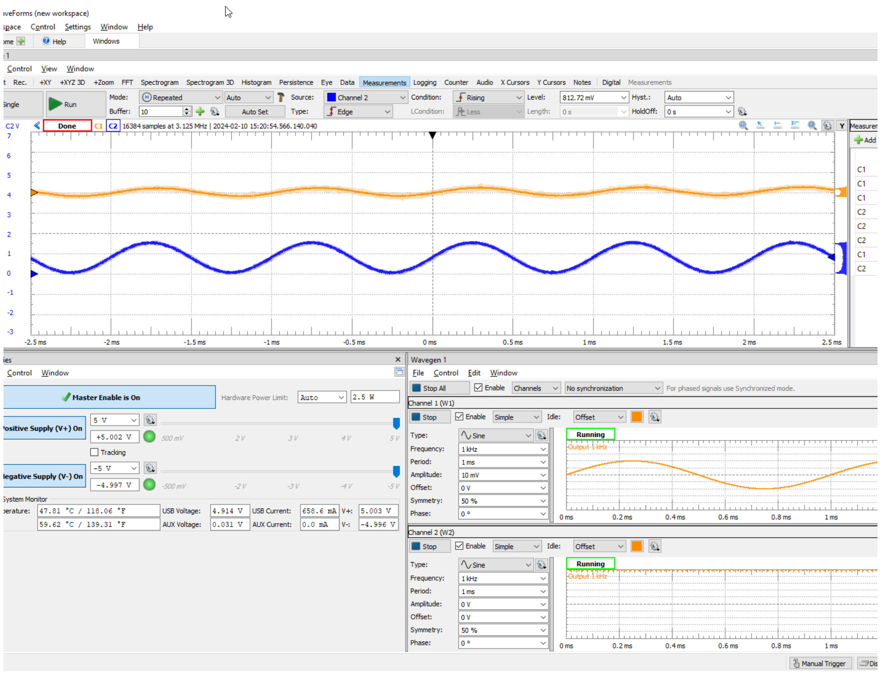

Figure 10: Transient Response

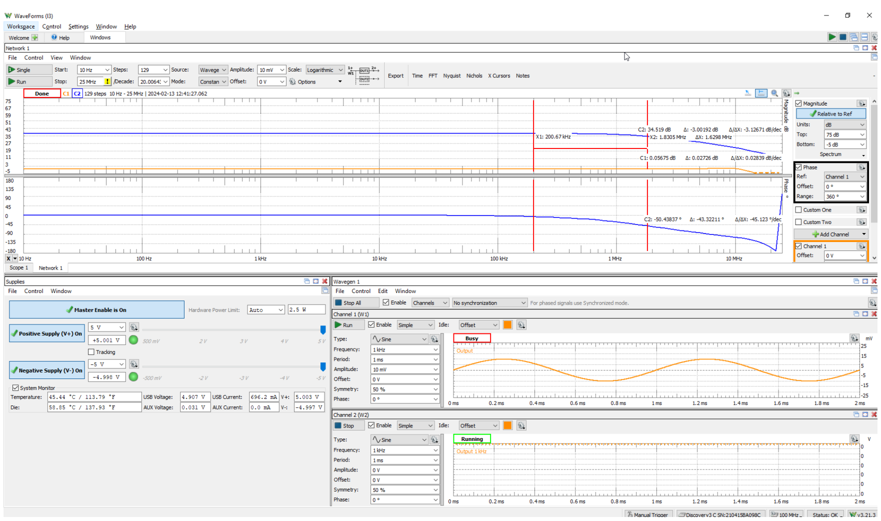

Figure 11: Frequency Response

b)

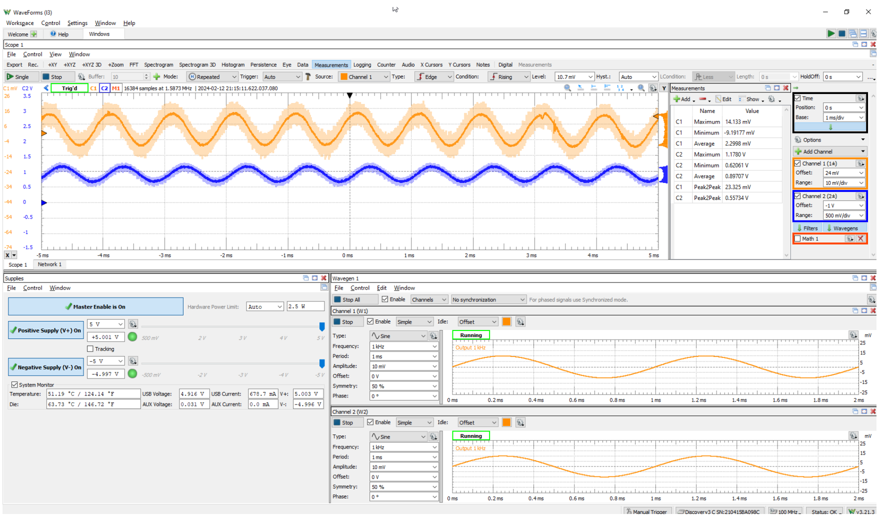

Figure 12: Transient Response

c)

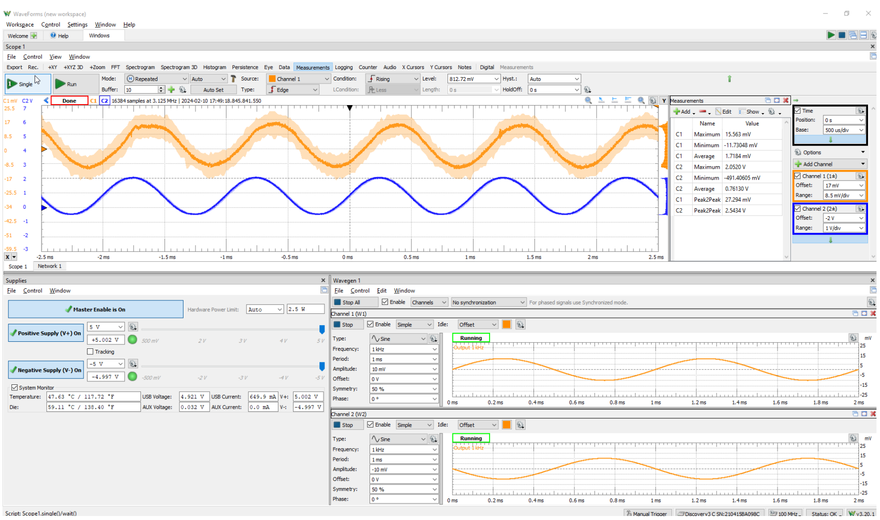

Figure 13: Transient Response

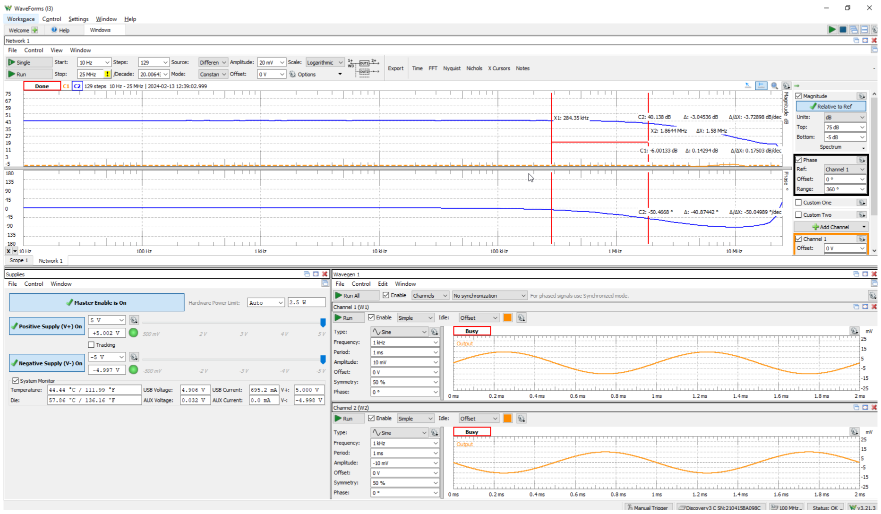

Figure 14: Frequency Response

d)

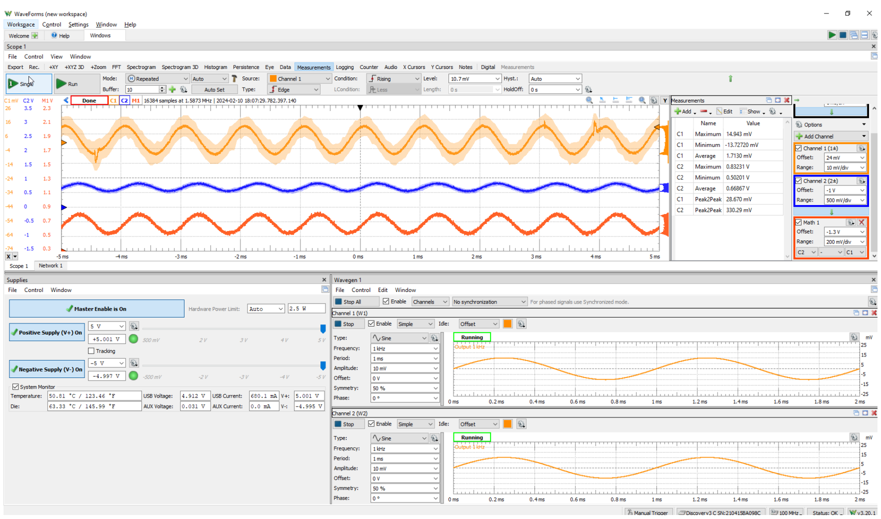

Figure 15: Transient Response

e)

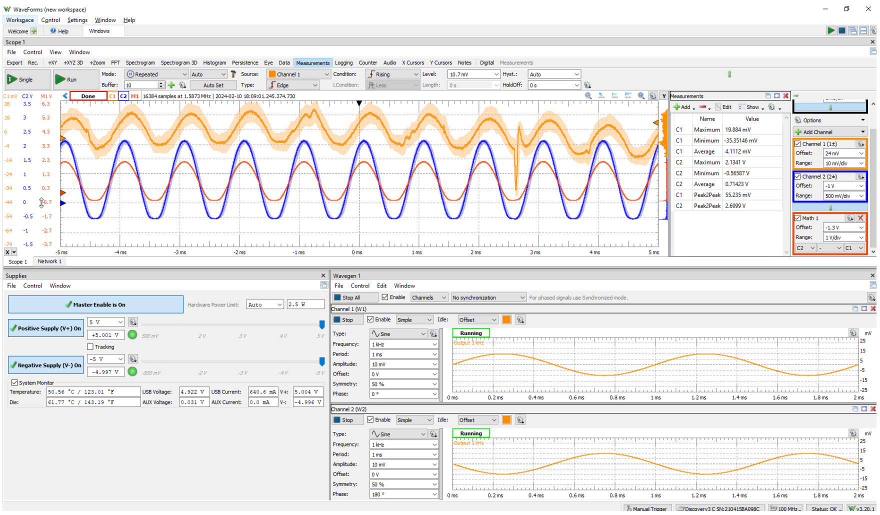

Figure 16: Transient Response

3 Explain in your own words why the configuration (d) has a much lower gain than the configuration (e)

The circuit built is a differential amplifier. It is designed to amplify the difference between its two inputs. In configuration d) the inputs are in-phase and of the same amplitiude, therefore there is no difference to amplify. In configuration e) the signals are of the same amplitude, but 180deg out of phase. Therefore, these signals have a difference everywhere except at the zero crossing nodes at 0 deg and 180 deg.

Of particular interest is the frequency shift of the -3db point when comparing the simulation to the prototype circuit. The analog discovery leads add 30pF to the circuit output. This additional capacitance shifted the -3dB point to 18% of the original frequency. This change was so dramatic that I did not originally believe that it could be a factor. Only after discussions with Professor Gianluigi and subsequent modeling was this phenomenon understood.