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Laboratory 5: Differential Amplifiers

Introduction

This lab reviews differential amplifiers and compares the expected results obtained from equations learned in class to simulation results to results obtained with physical lab components. It examines where error might come from in both our calculations and in the physical system.

Procedure

Exercise 5.1: IC1, IC2 curves – Linear region of operation (Simulation)

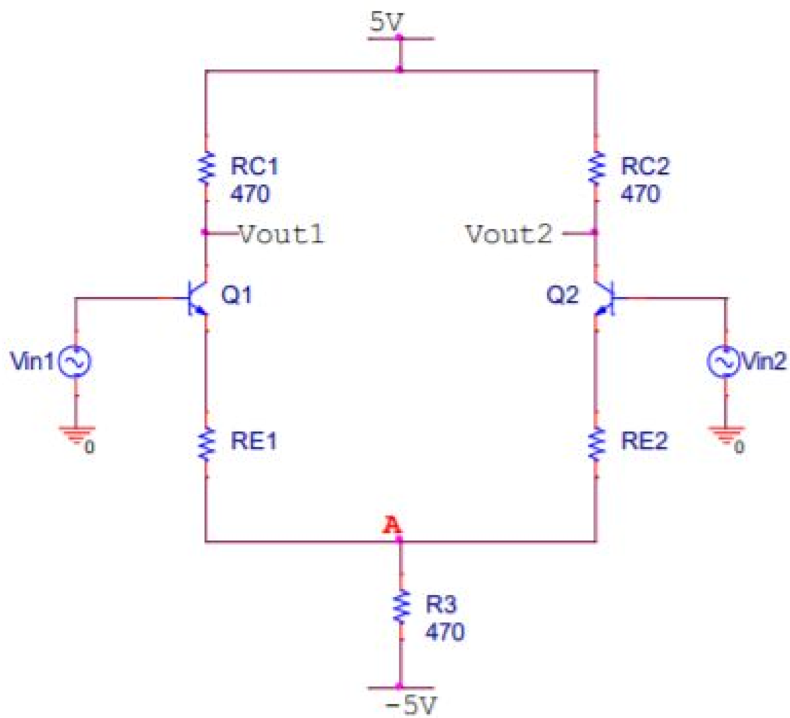


Figure 5.1.1 Circuit used for simulation

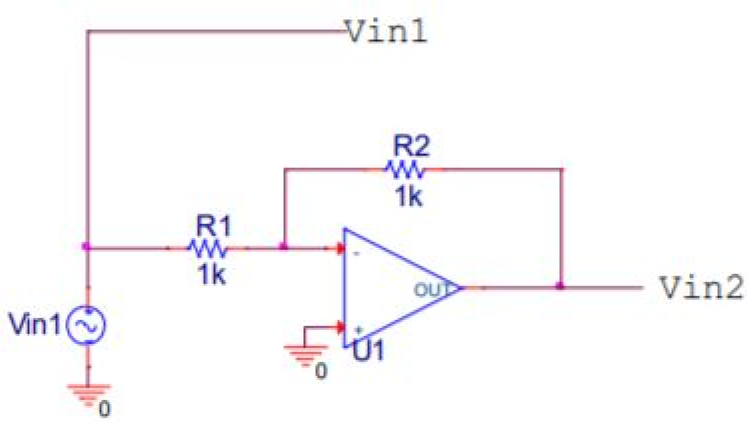


Figure 5.1.2 Inverting Op Amp used to get Vin1 and Vin2

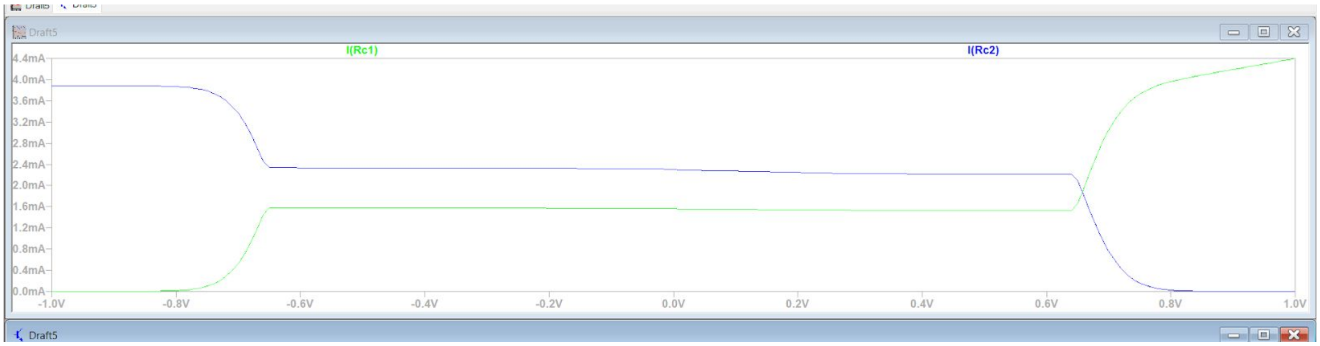


Figure 5.1.3 I(Rc1) and I(Rc2) vs Vin1

The range of VDM is about .62V to .7V.

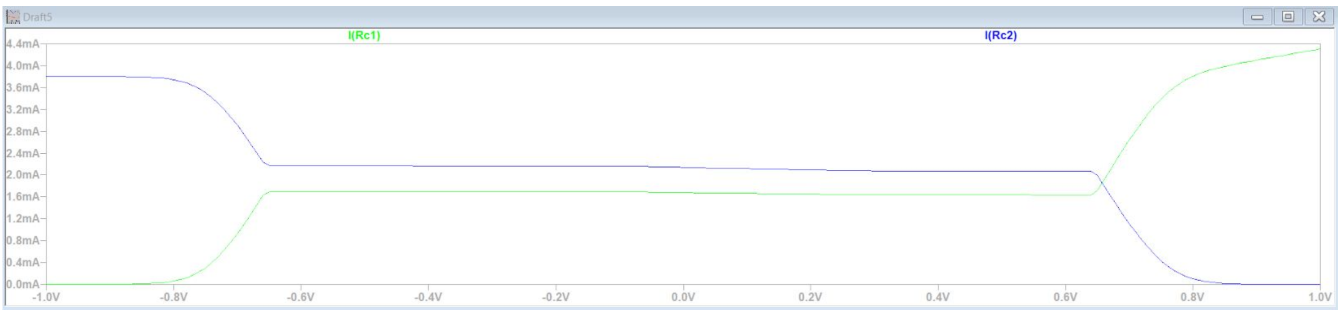


Figure 5.1.4 I(Rc1) and I(Rc2) vs Vin1 RE1 = RE2 = 10Ω

The range of VDM is about .62V to .78V.

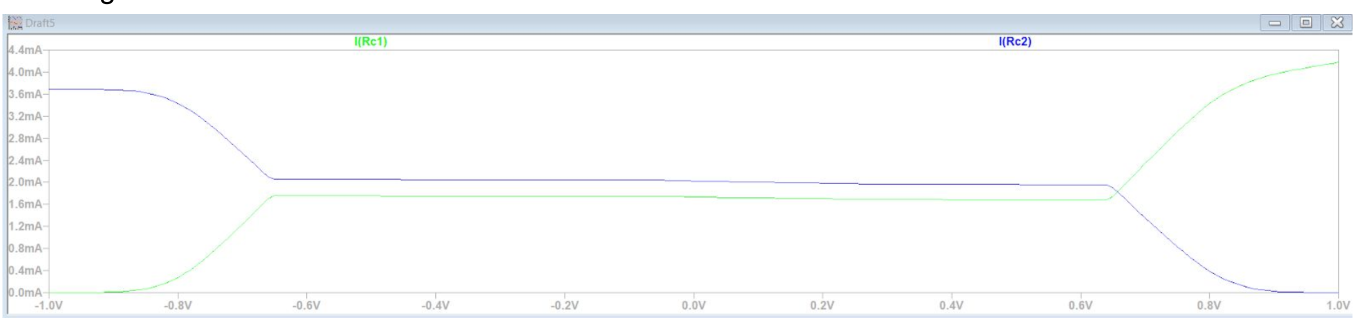


Figure 5.1.5 I(Rc1) and I(Rc2) vs Vin1 RE1 = RE2 = 25 Ω

The range of VDM is about .65V to .82V.

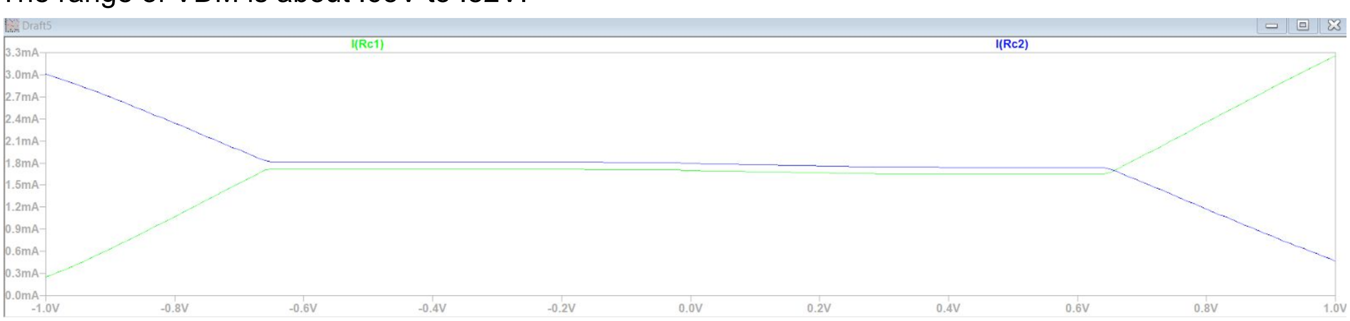


Figure 5.1.6 I(Rc1) and I(Rc2) vs Vin1 RE1 = RE2 = 100Ω

The range of VDM is about .65V to 1V.

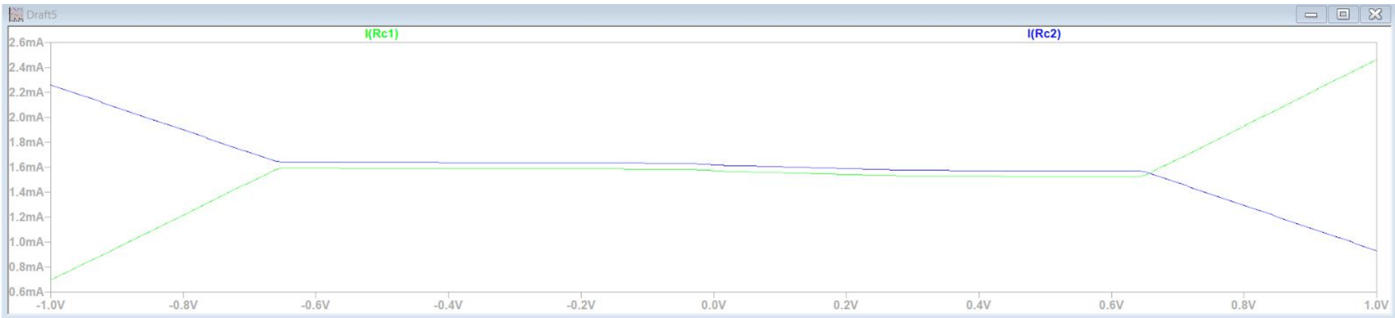
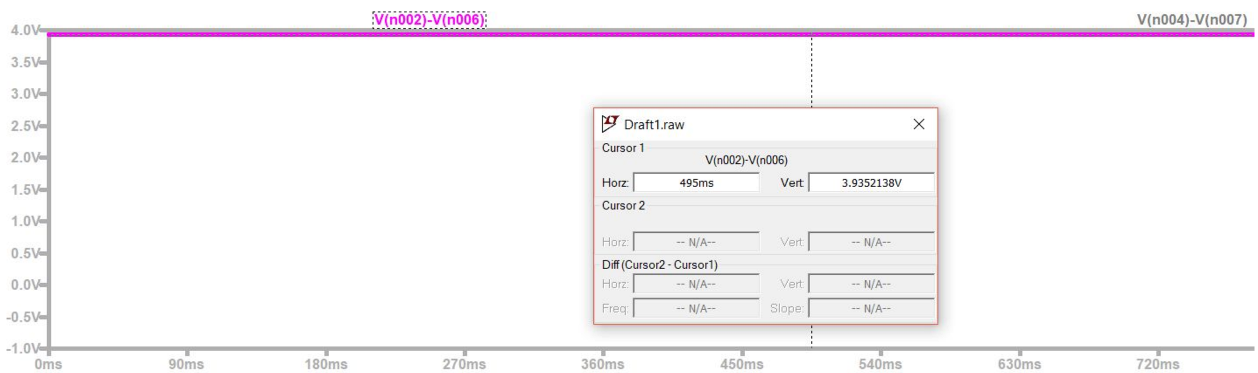


Figure 5.1.6 I(Rc1) and I(Rc2) vs Vin1 RE1 = RE2 = 200Ω

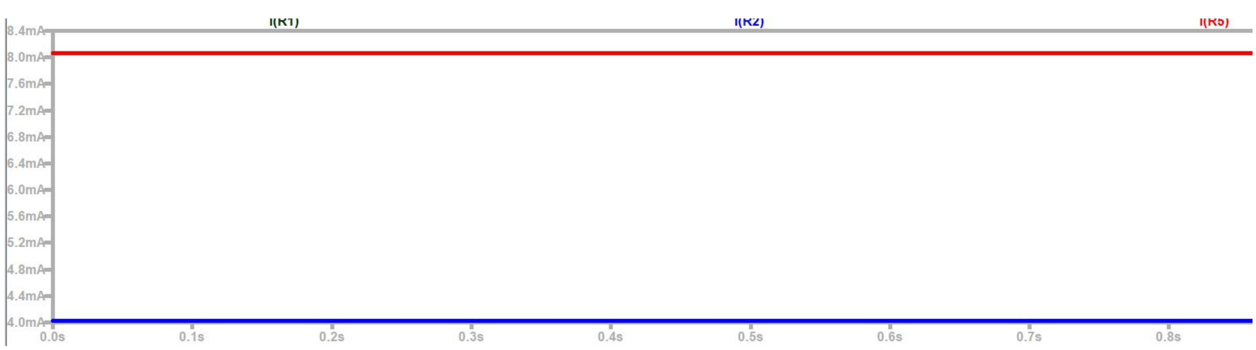
The range of VDM is about .65V to 1V.

Exercise 5.2:

Simulation of Common Mode Inputs

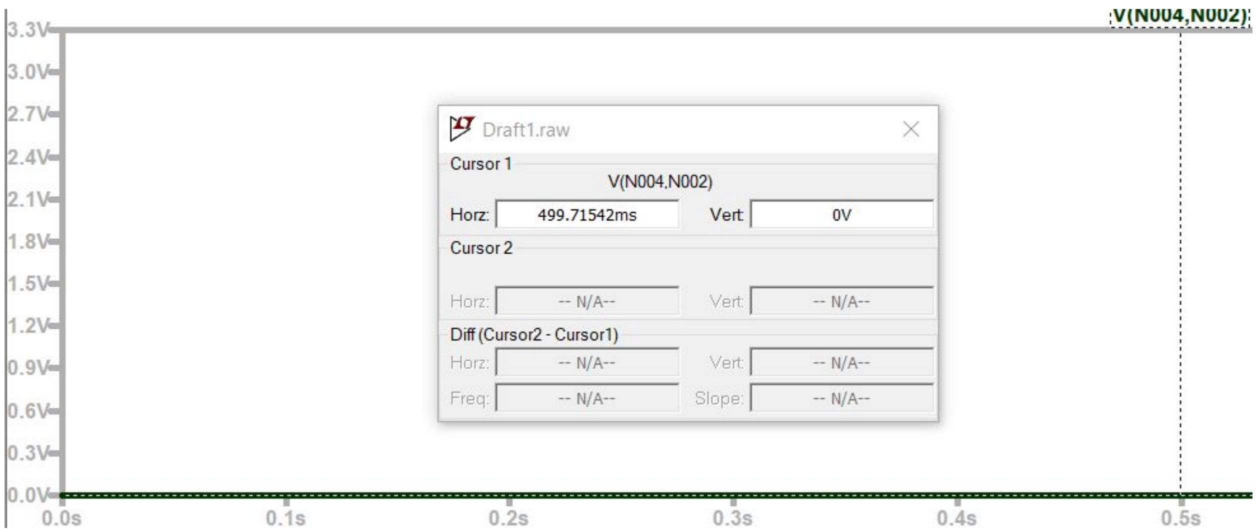


We that VC - VE for both transistors are greater than 0.2 so they are both forward active.



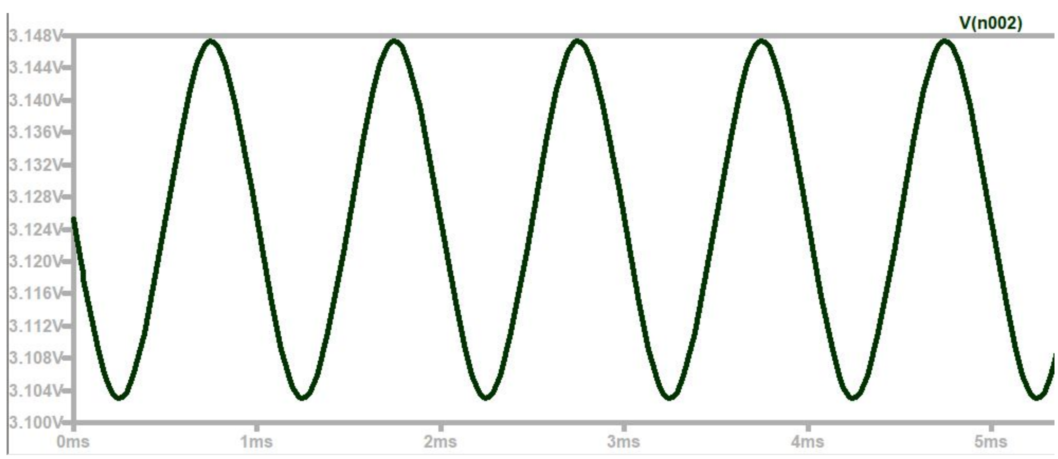
We see that I_RE1 and I_RE2 are equal and IR3 = I_RE1 + I_RE2

KCL does apply at Node A for the given currents.



We see that the output (Vout in black) is 0V. This means that our simulated gain Acm = Vout/Vin = 0

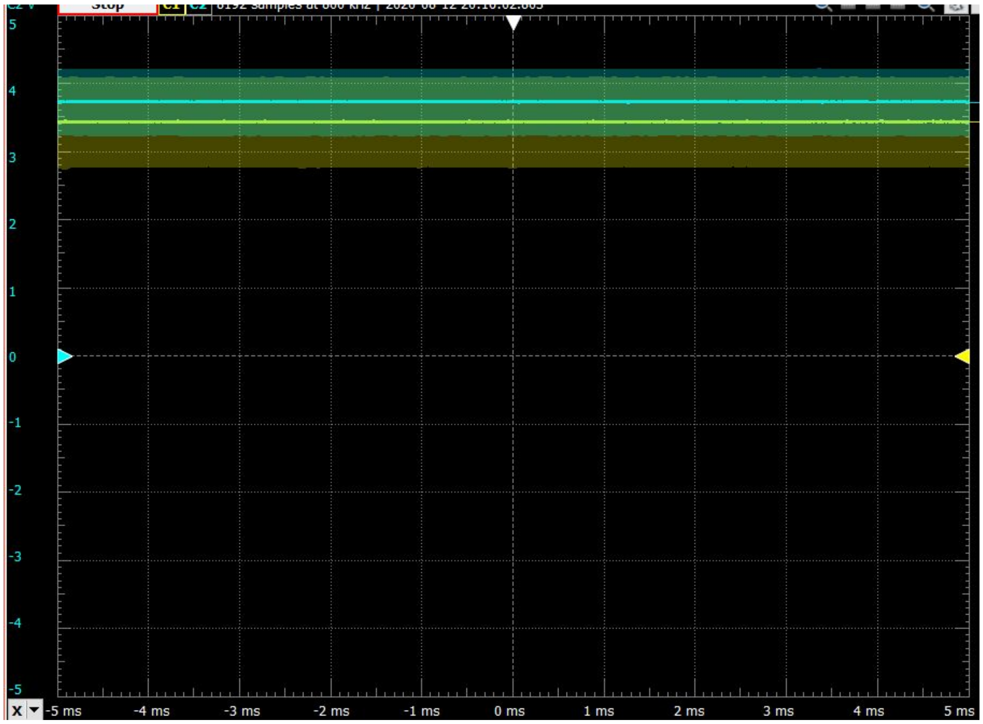
For ideal simulation this is what we expect.



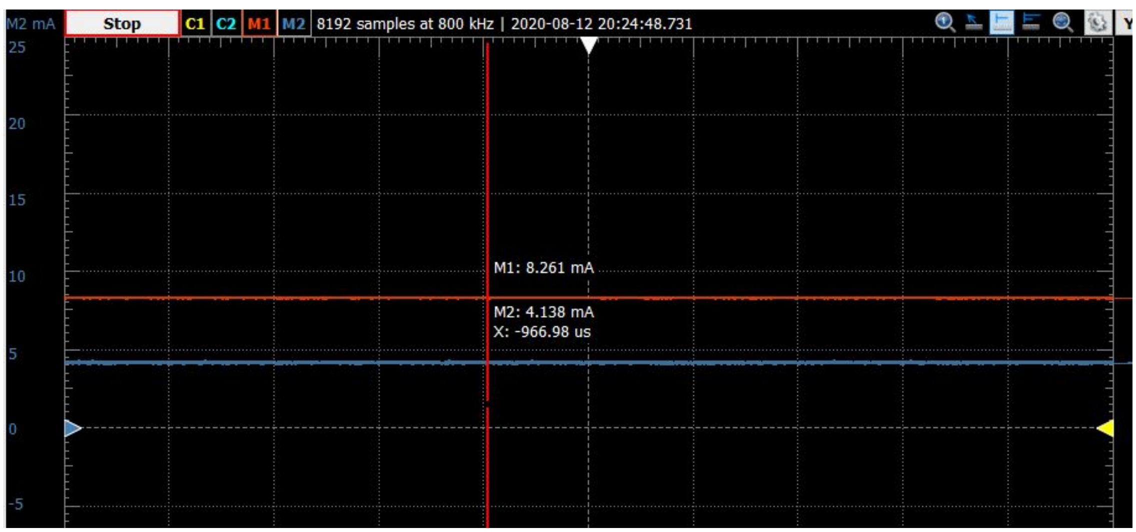
We have Vout = (3.148-3.104)/2 = 0.022 (amplitude). Thus Acmhc = 0.44

This value is consistent with the analytical values

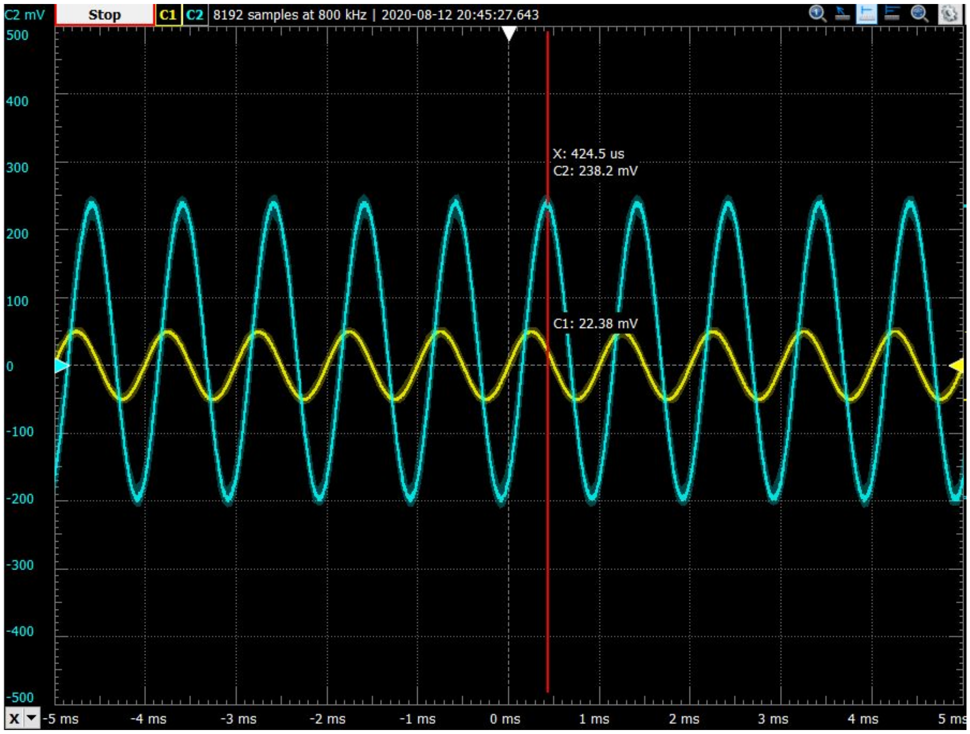
Experiment of Common Mode Inputs:



Both Transistors are clearly in the forward active operation



Above we have IR3 = 8.2mA and I_RE1 = 4.1mA. We know from KCL that IR3 = I_RE1 + I_RE2. Thus from our above values we have I_RE2 = 4.1mA. So KCL still applies and it matches simulation



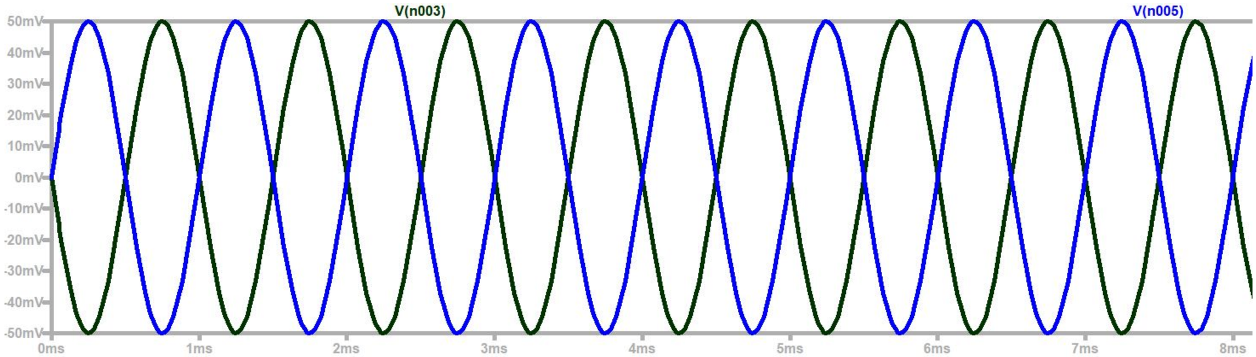
We have Vout /Vin = 0.238/0.05 = 4.76 = Acm

The experimental Acm is nonzero because of the tolerances of the components. At certain voltages, or if they run for a long time, or at certain frequencies the components begin to change how they act. We even see a phase shift from output to input to show that the component is not 100% working as intended.

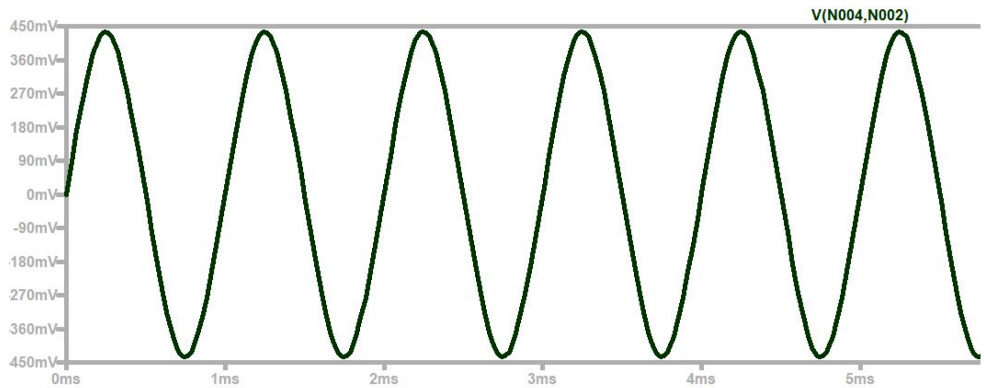
As stated in lab document simulation of Acmhc is sufficient

Exercise 5.3

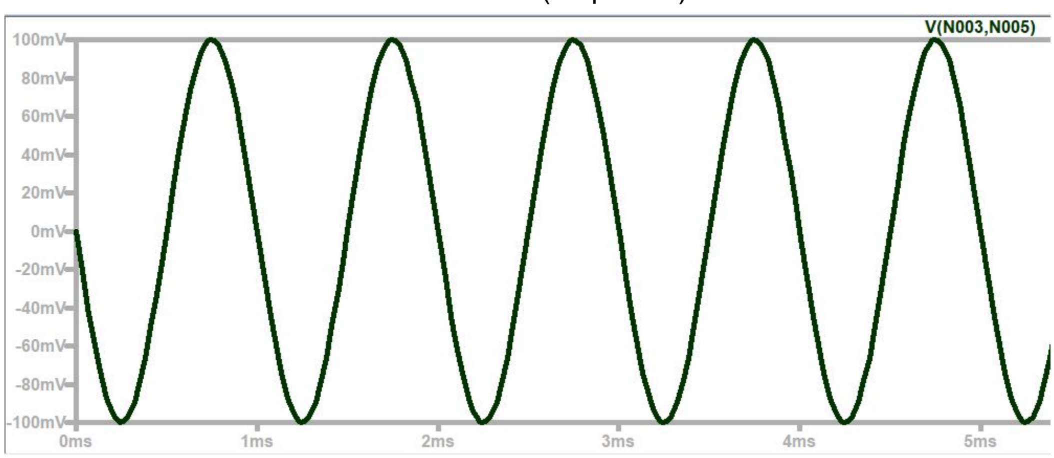
Simulation of Differential gain



From the above picture we know that the input voltages are 180 degrees out of phase.



We have that Vout2 - Vout1 = Vout = 450mV (amplitude)

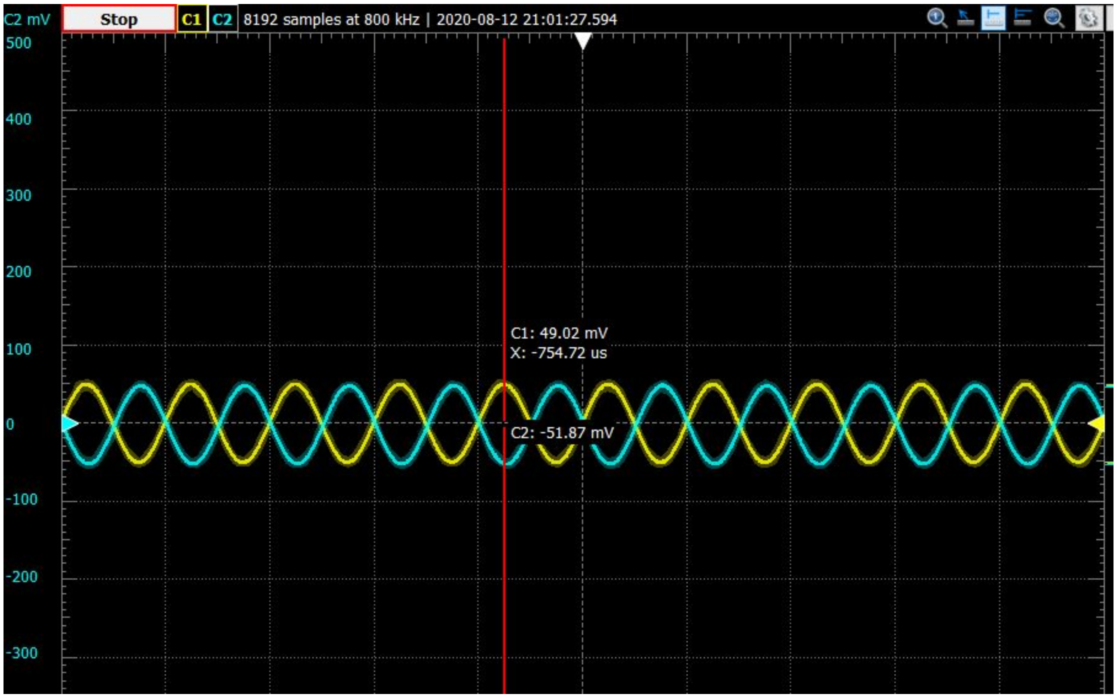


We measure Vdm = 100mV (amplitude)

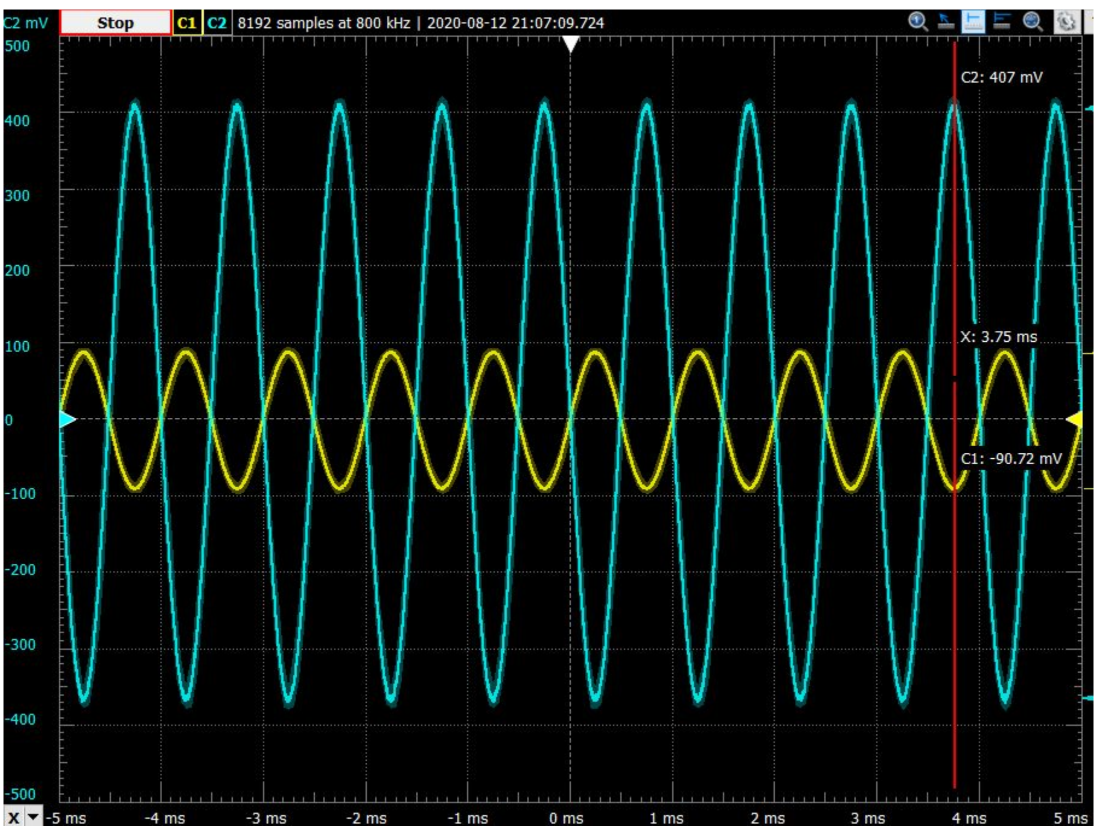
Thus we get the differential gain as A_DM = 4.5

From these simulated values we get CMRR = 20.20

Experiment of Differential Inputs:



We see that both inputs are 180 degrees out of phase.



We have C2 (Blue) as Vout and C1 (Yellow) as Vdm. Thus our Adm = Vout/Vdm = 4.47
This matches our simulation. From this we calculate CMRR = -0.5

Conclusion

Through this lab we were able to see the use of differential amplifiers and how they can be analyzed using half circuit models and comparing common mode outputs with differential mode outputs. With the common mode and differential mode half circuit gains we can determine the CMRR of the half circuit models and ultimately of the differential amplifier.