VLSI Summer School Project Documentation 2025

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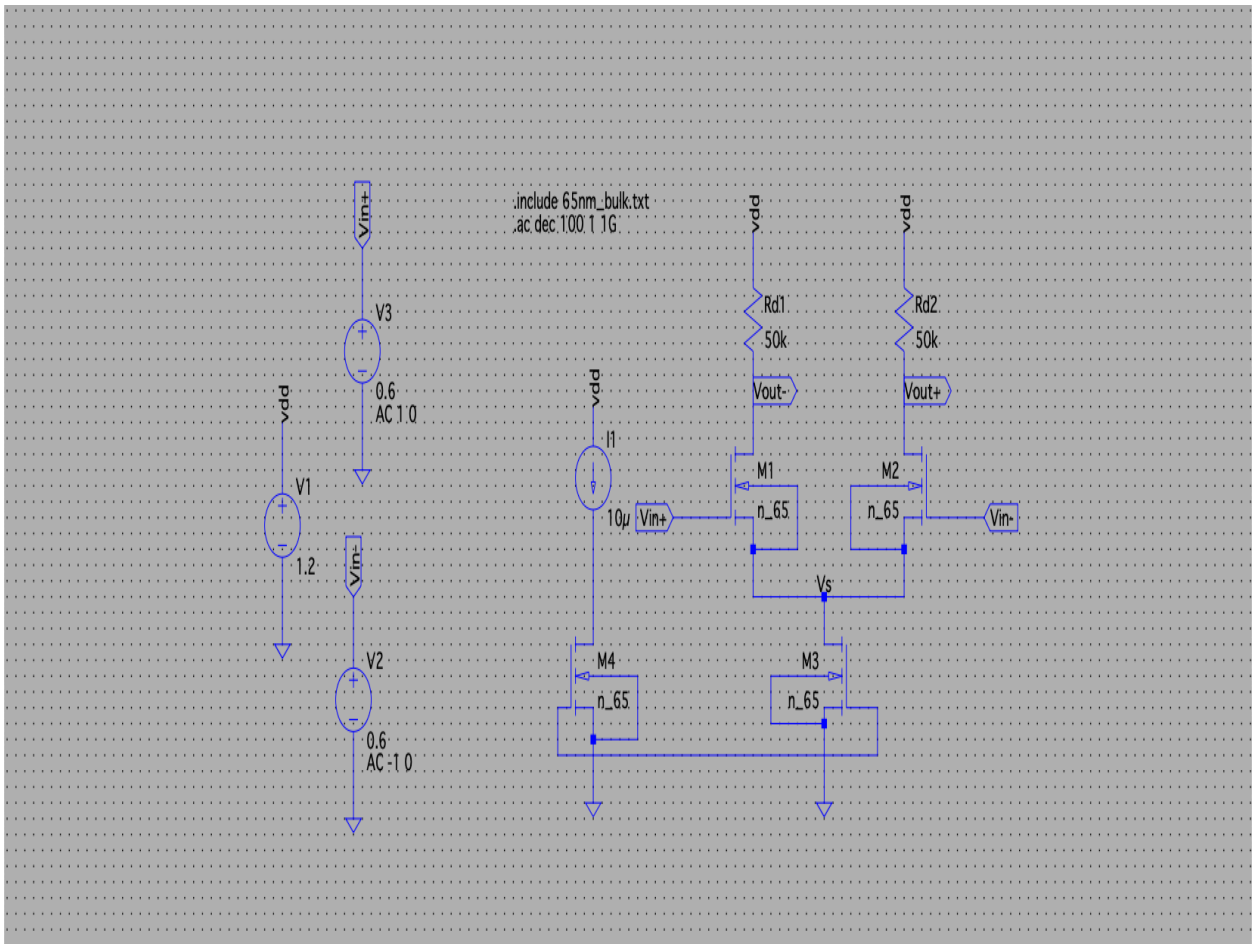
Assignment 5: Differential amplifier

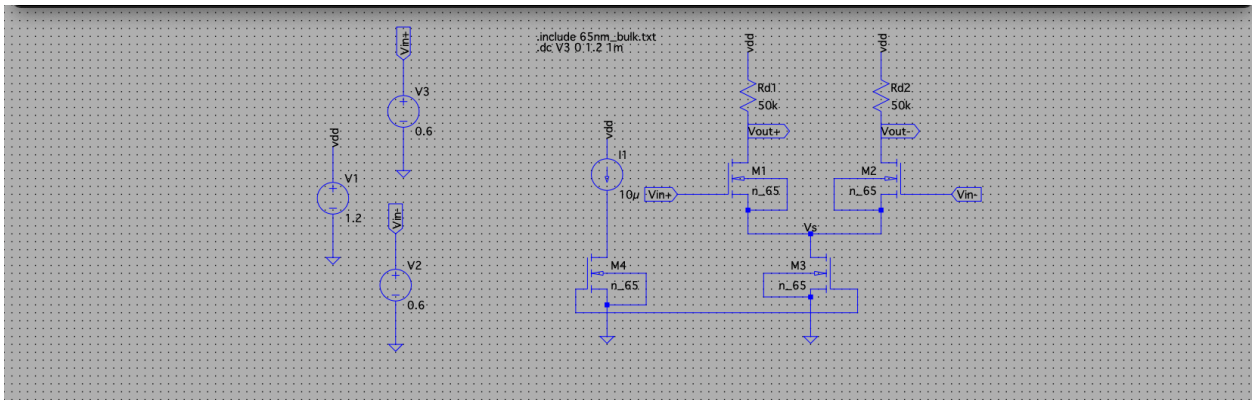
Part A:

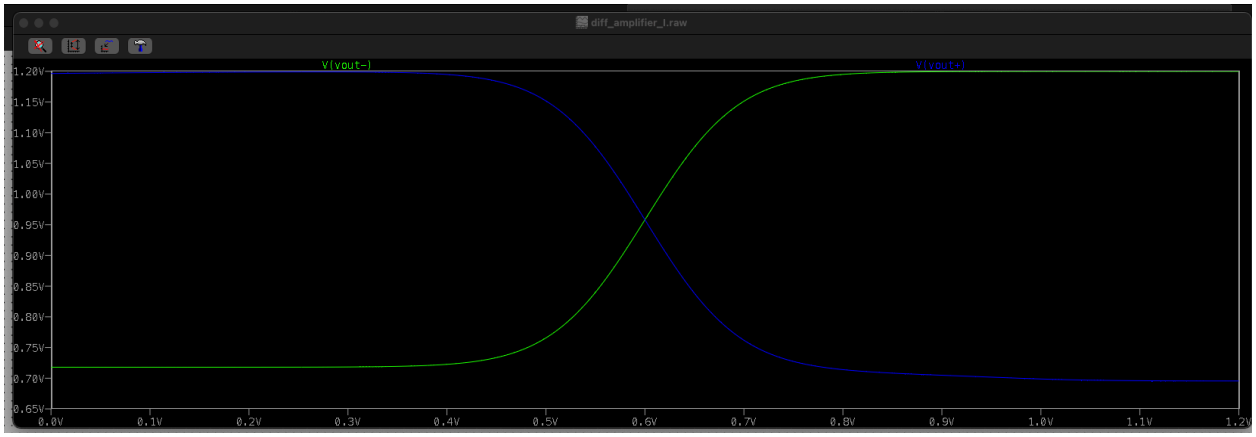
- Circuit Diagram:

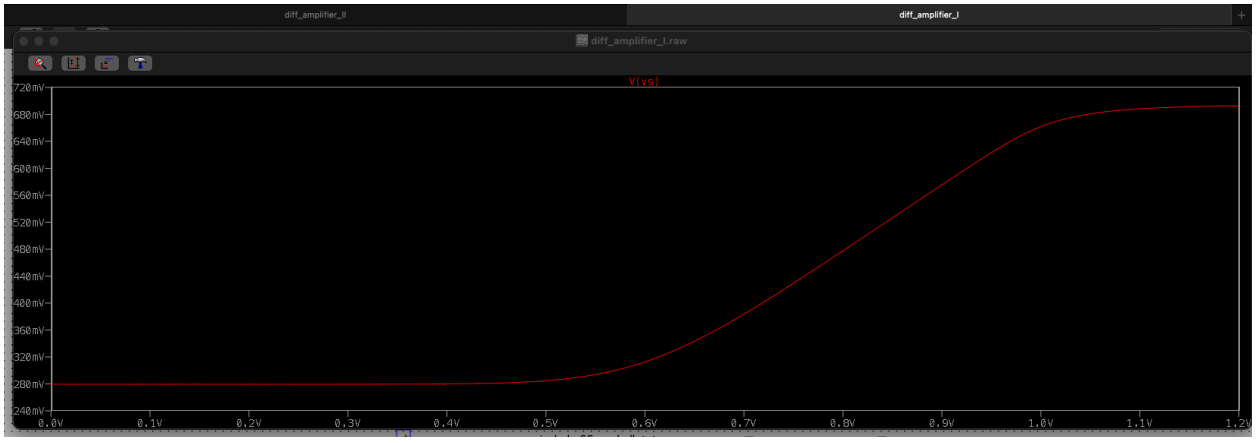


Assignment 5: Differential amplifier

a.i)Fix Vin-=0.6V,sweep Vin+ from 0 to VDD(1.2v).obtain the plot for Vout(-/+) and Vs.





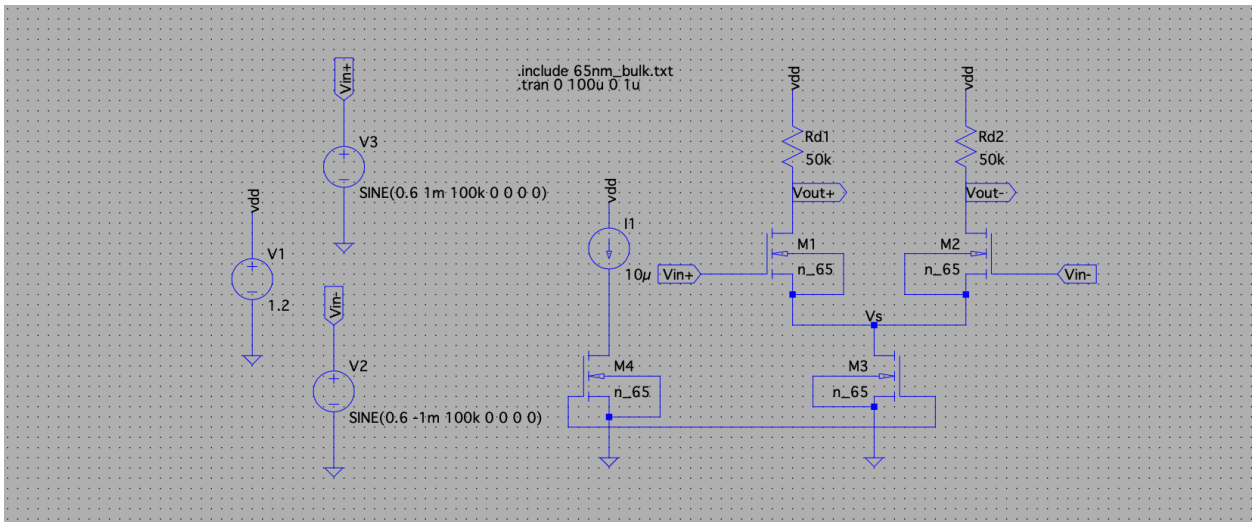


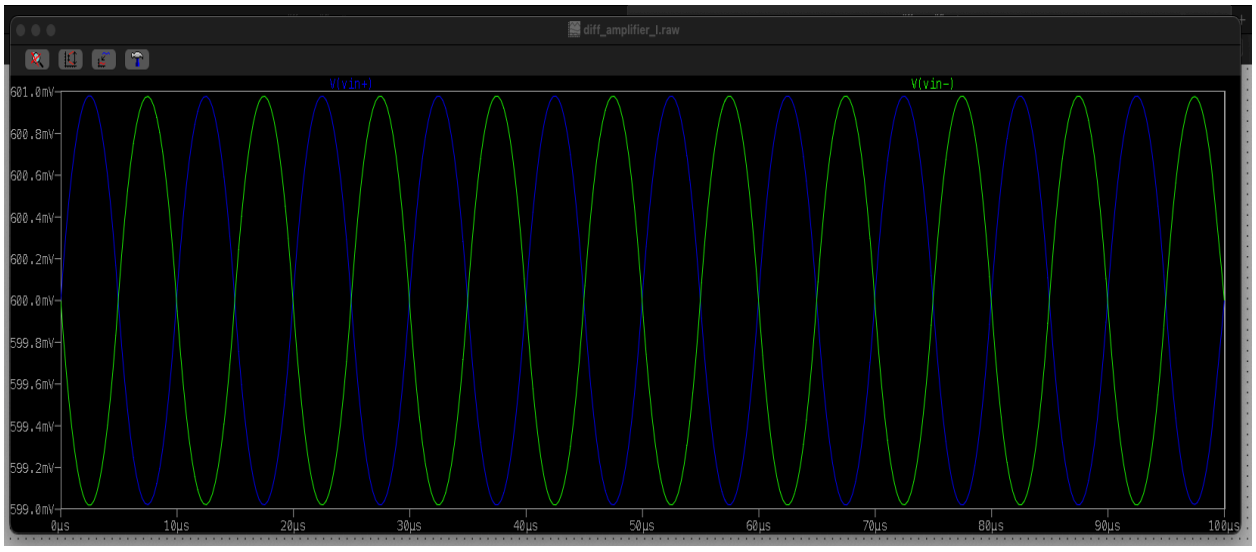
Vout-(blue) , Vout+(green) and Vs(red).

Assignment 5: Differential amplifier

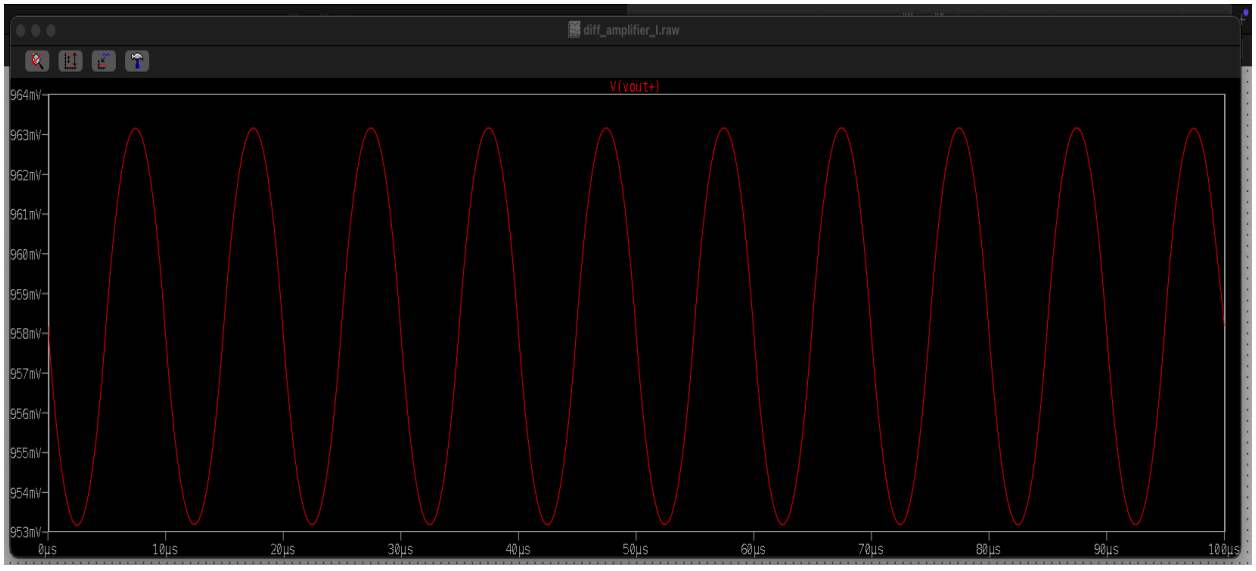
a.ii) Apply a fully differential signal Vint-= -1mV p-p and Vint+ = 1mV p-p with common mode DC= 0.6V .Obtain output plots.

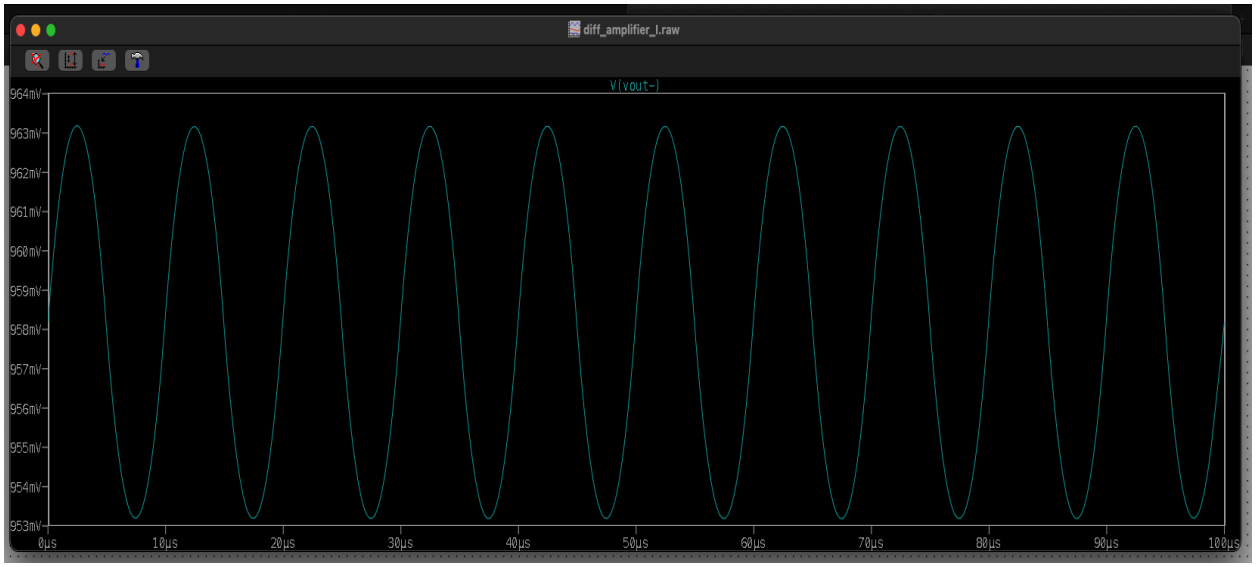
Circuit Diagram:

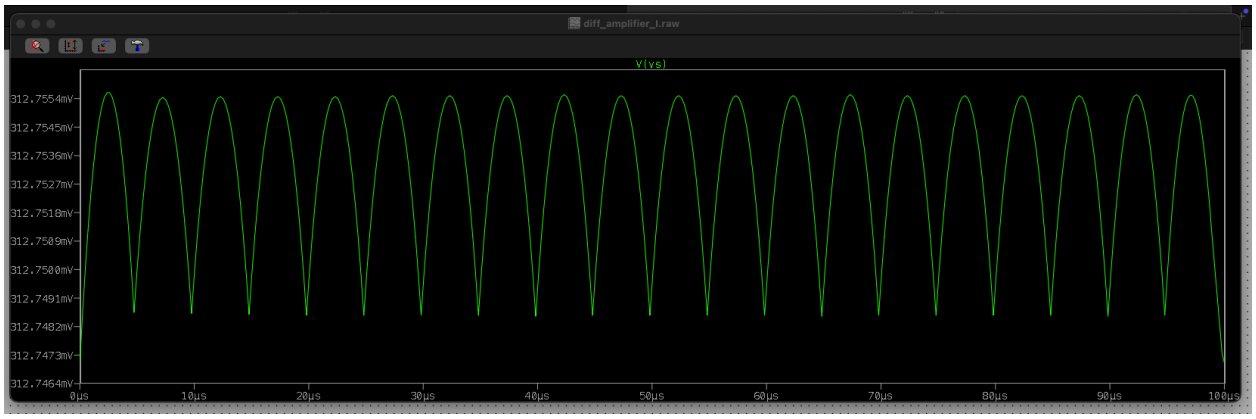




Vin-(green) and Vin+(blue)





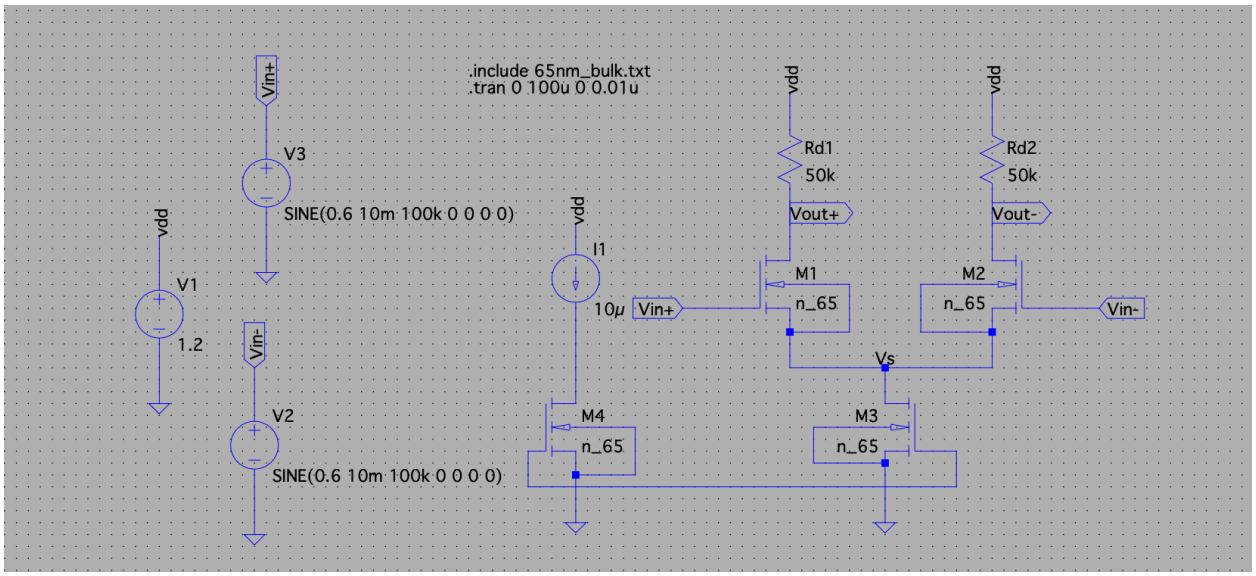


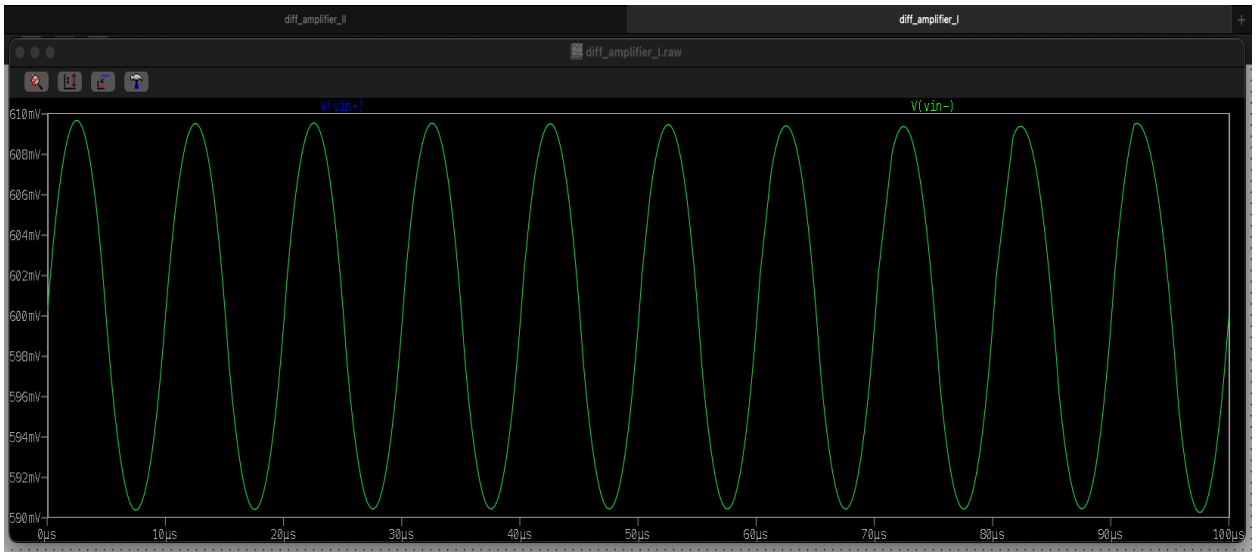
Vout-(red),Vout+(peacock green) and Vs(green)

Assignment 5: Differential amplifier

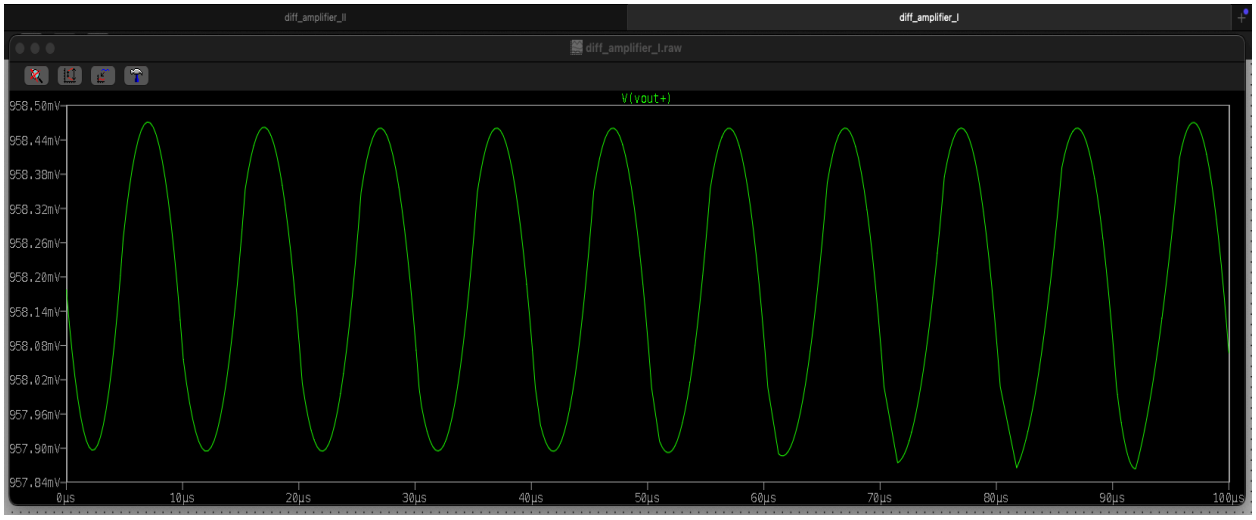
a.iii) Apply a common-mode sine signal of magnitude 10mV p-p with common mode DC =0.6V ,obtain the common mode output signal.

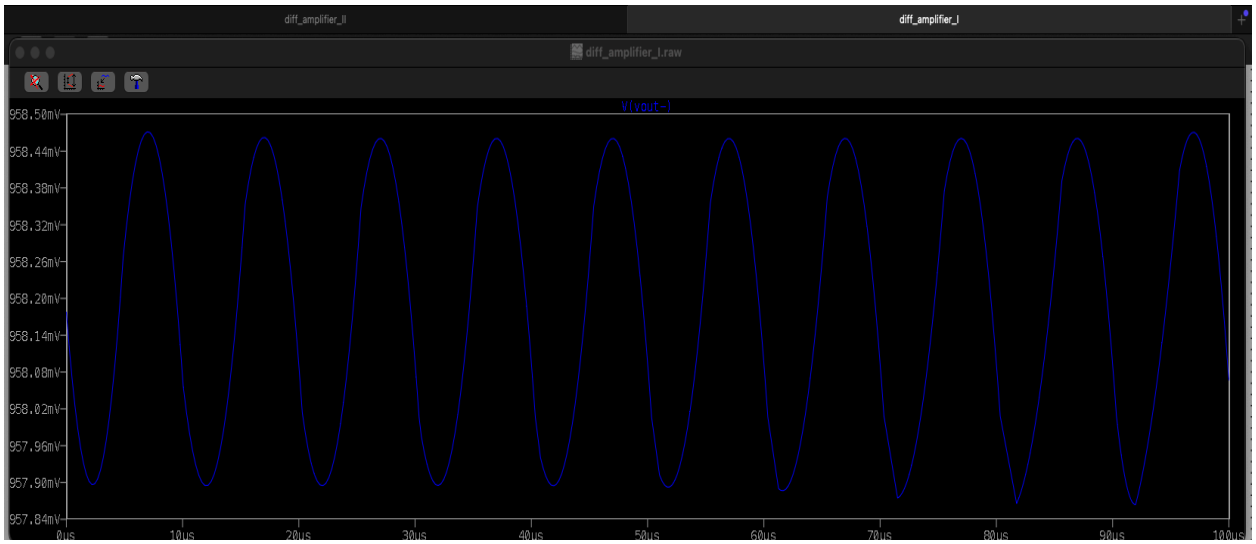
Circuit Diagram:

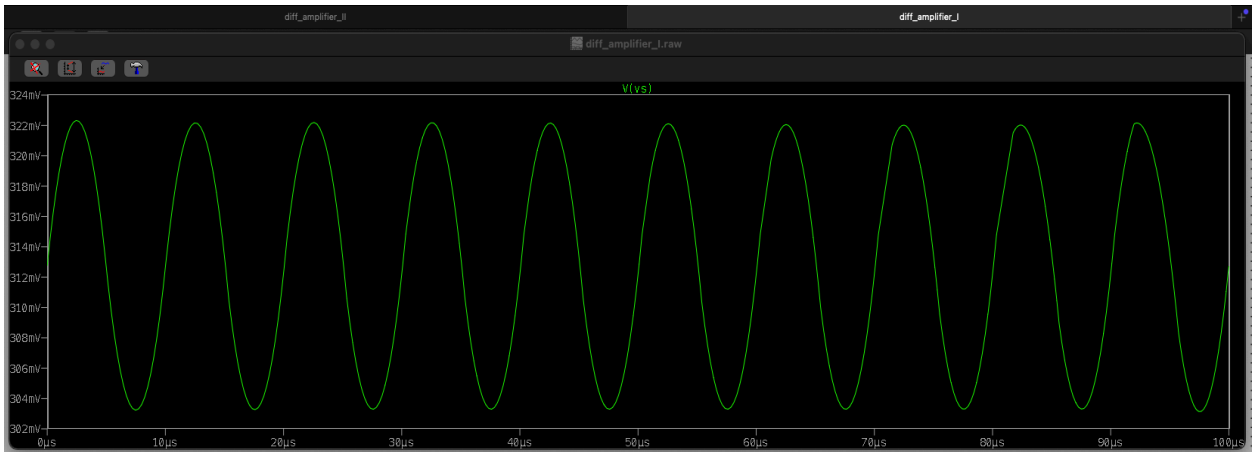




Vin(+/-) ~> same plot.





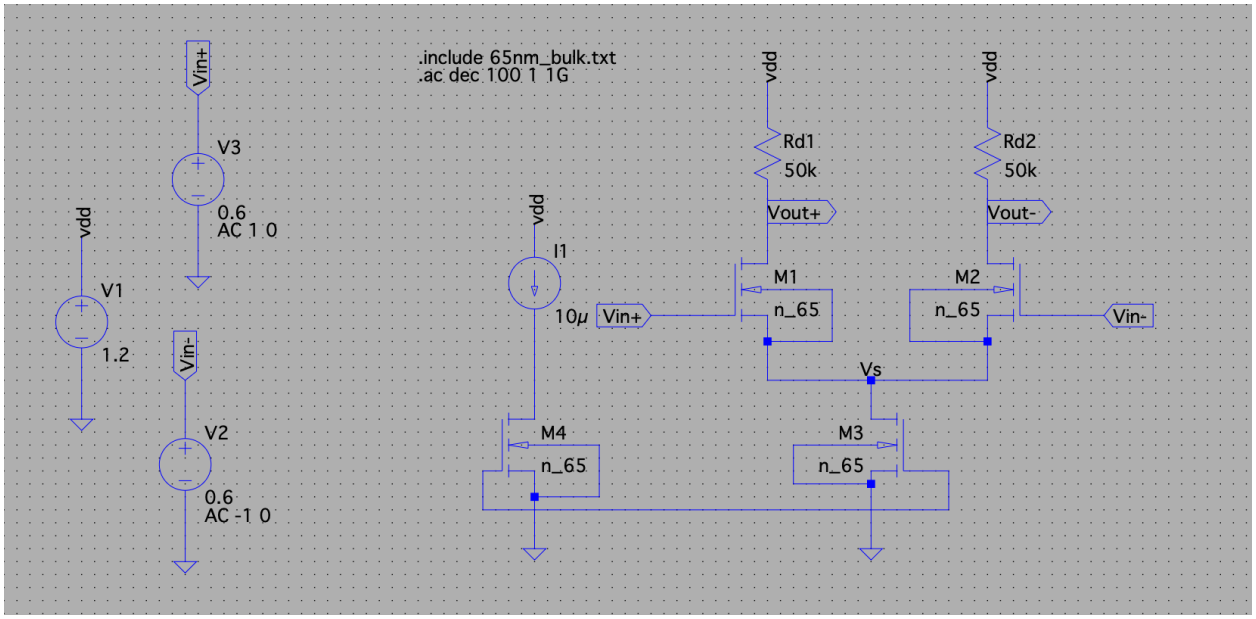


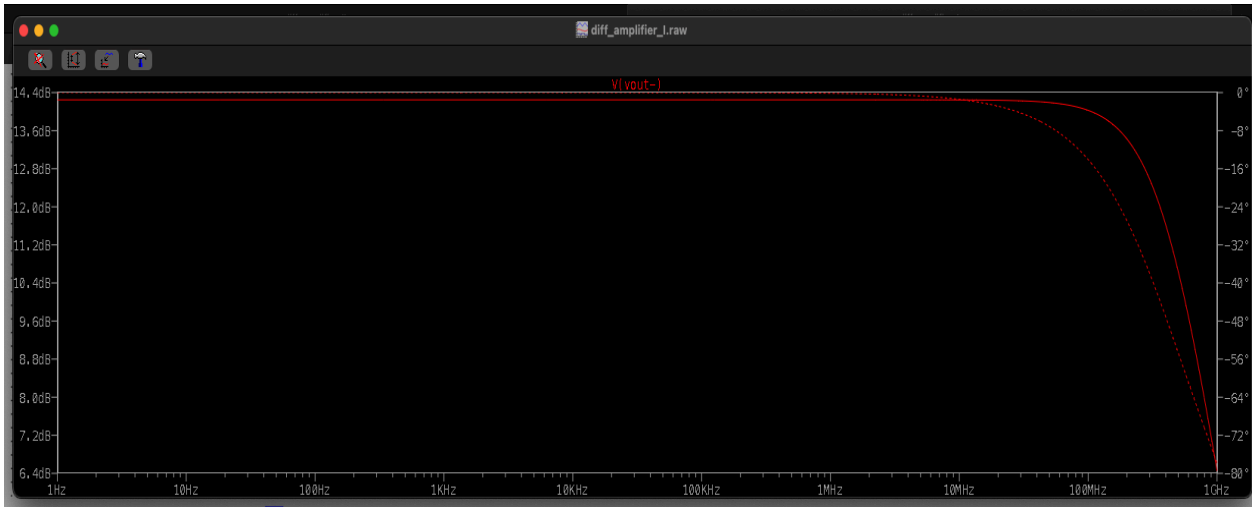
Vout-(green),Vout+(blue) and Vs(green)

Assignment 5: Differential amplifier

a.iv) Increase the gain of differential amplifier by 2x (with appropriate changes).

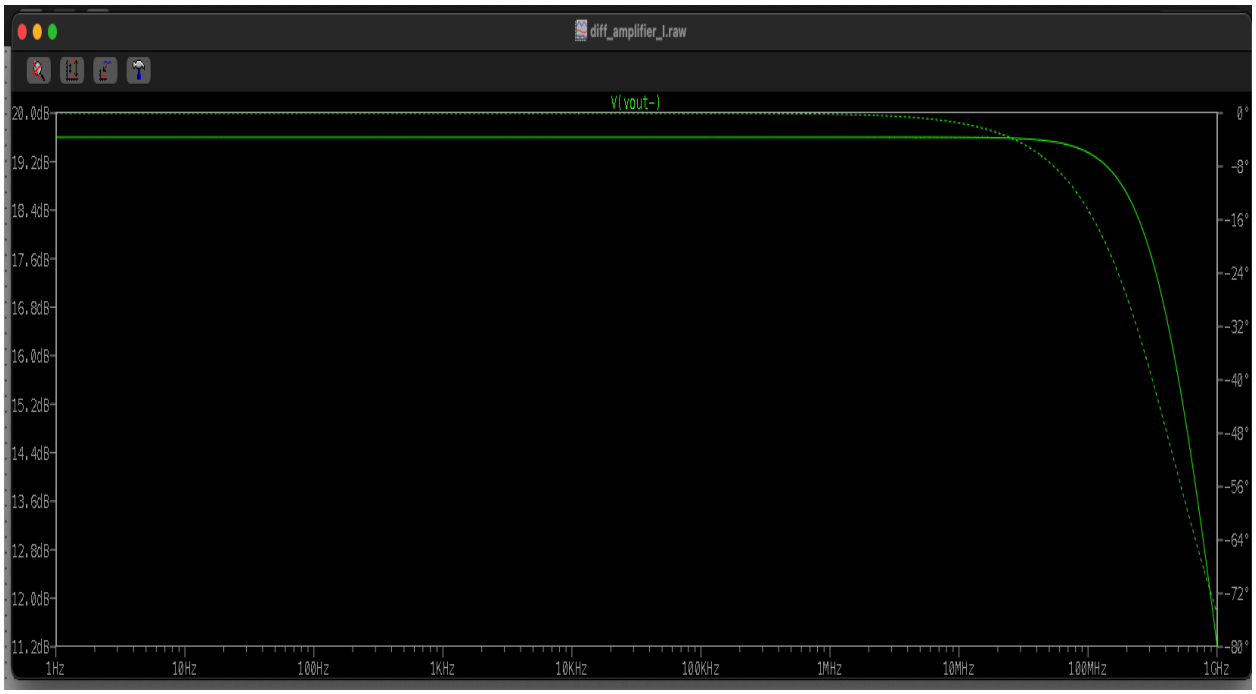
Circuit Diagram:





Gain(dB) ~ 14.2 dB.

For gain (~2x), we change the width of M3 by twice (i.e new width = 40um)

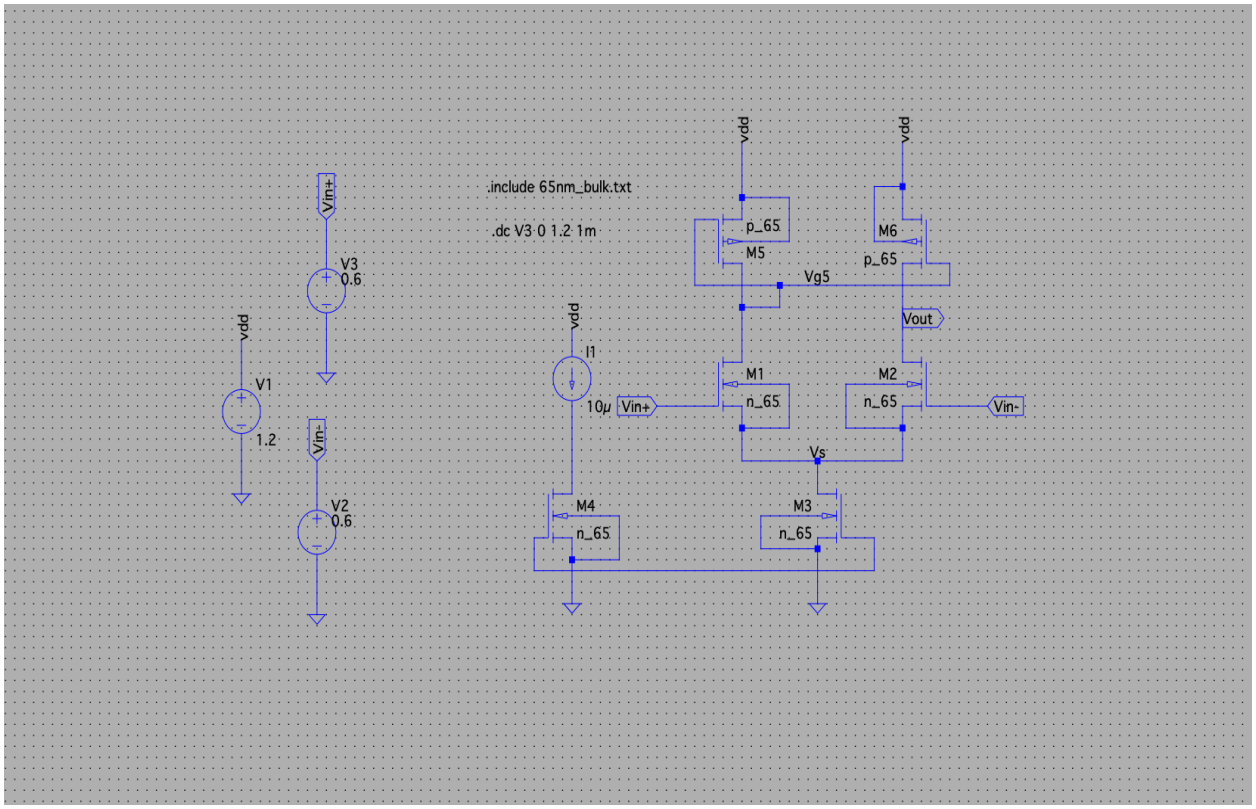


Gain(dB) ~ 19.52 dB.

Assignment 5: Differential amplifier

Part B:

- Circuit Diagram:



W/L ratios of different transistors used :

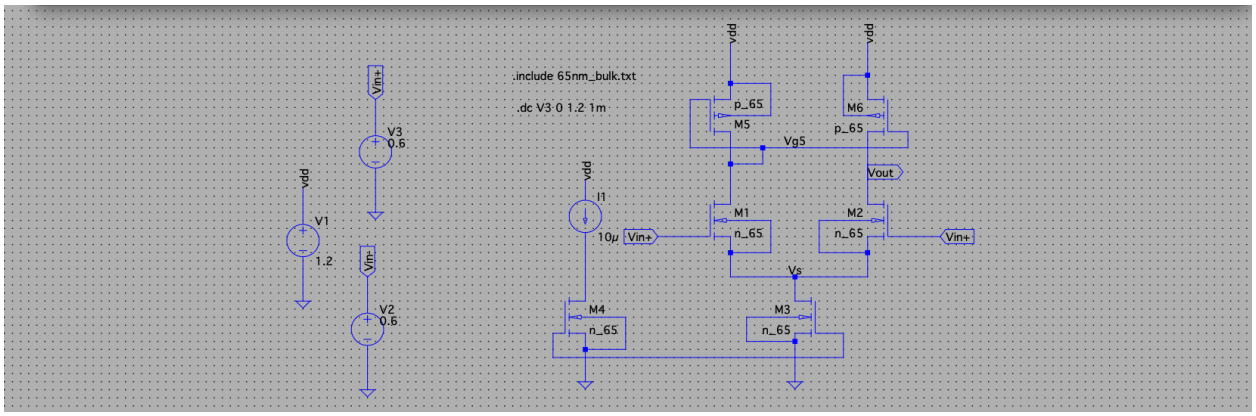
M1 = M2 = 10um/180nm

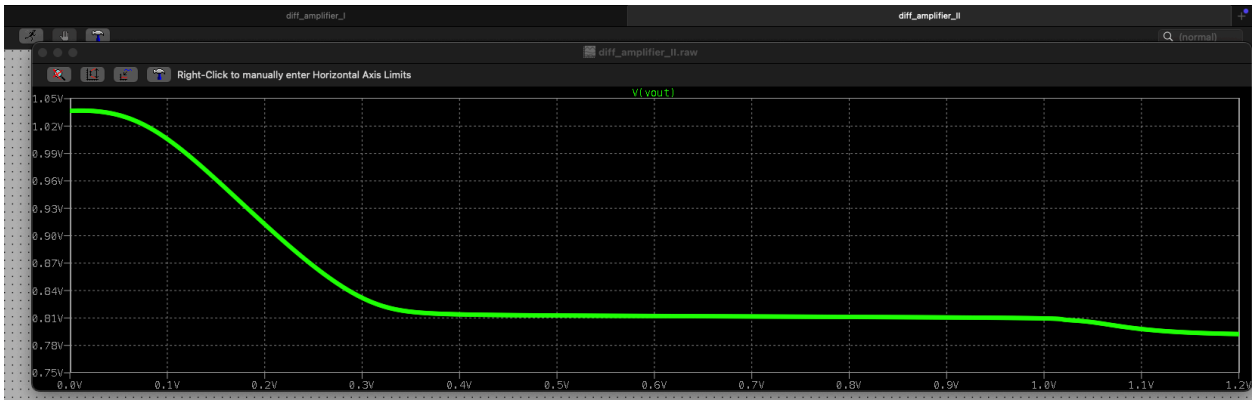
M3 = M4 = 20um/300nm

M5 = M6 = 5um / 180nm

Assignment 5: Differential amplifier

b.i) Find the ICMR using DC sweep.



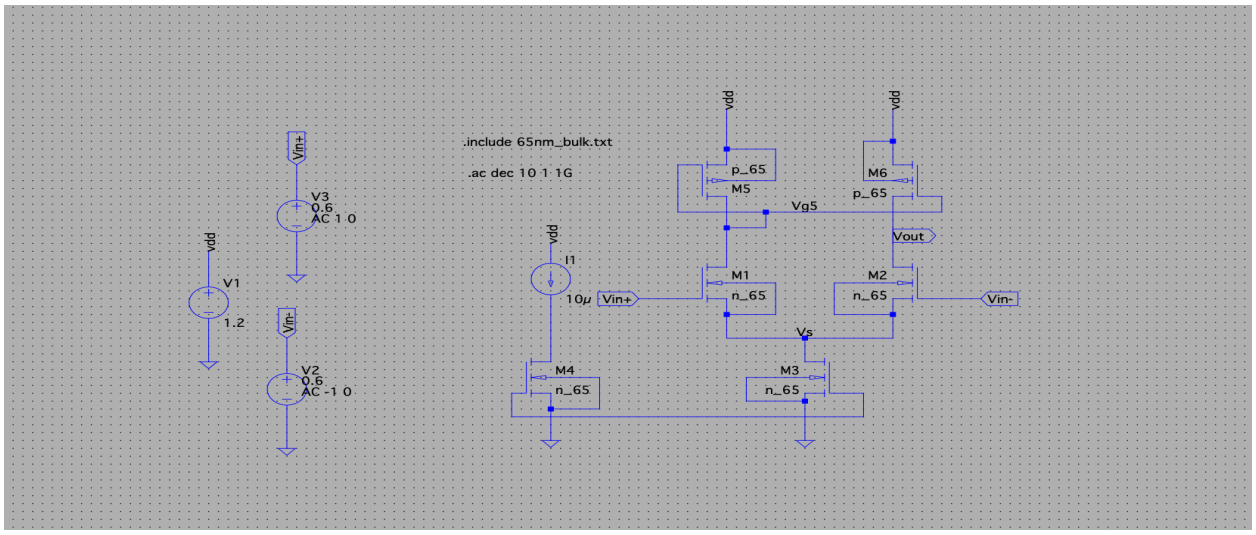


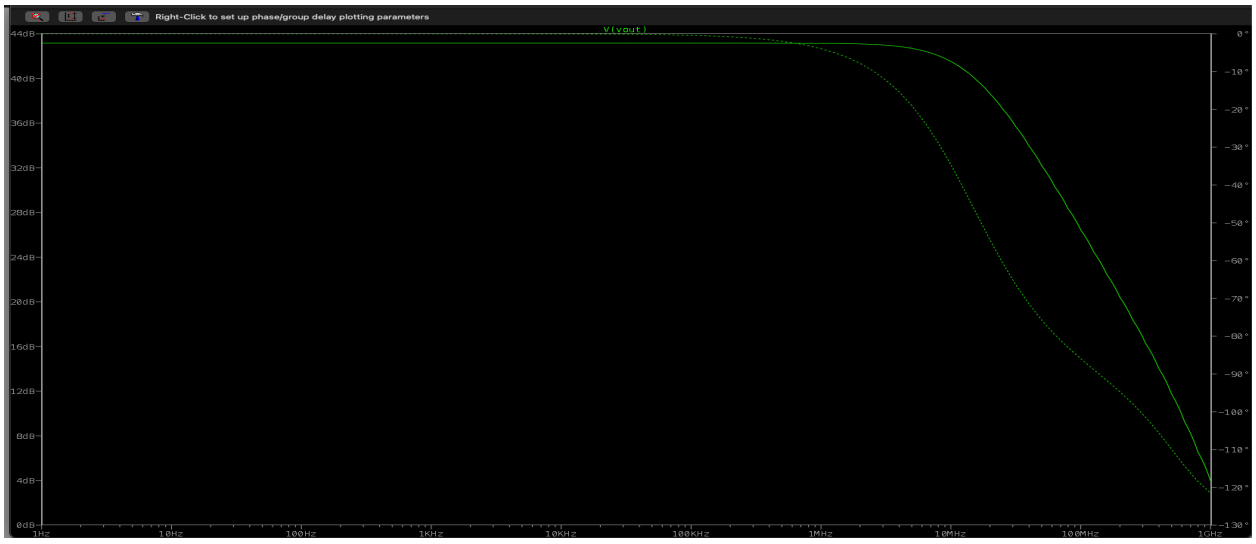
ICMR range ~(0.100 V – 0.300 V).

Assignment 5: Differential amplifier

b.ii) For Vin_DC=0.6 V, find the Adiff and Acm using frequency response (AC analysis).
Validate using transient response and also at Vgs.

- Circuit Diagram:

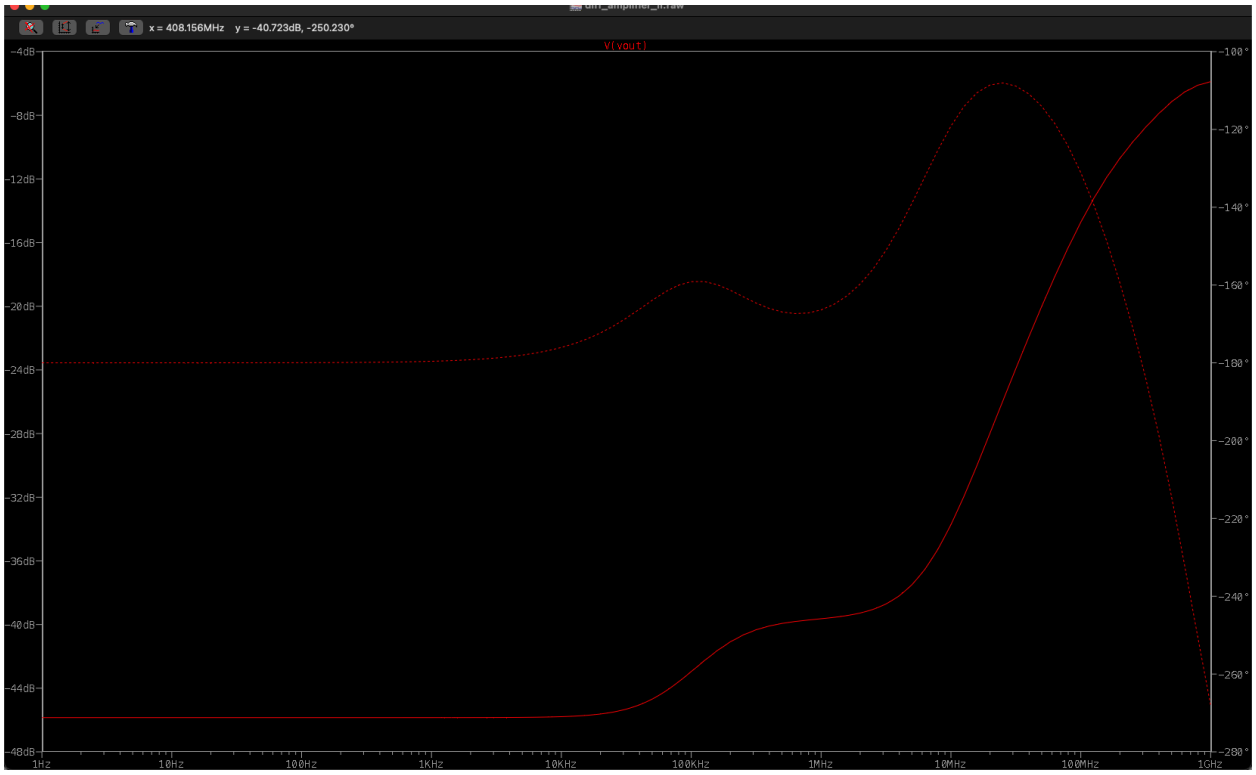




Gain(Adiff) ~ 42.95 dB i.e (Vout / Vin) = 140.44

Assignment 5: Differential amplifier

Acm:



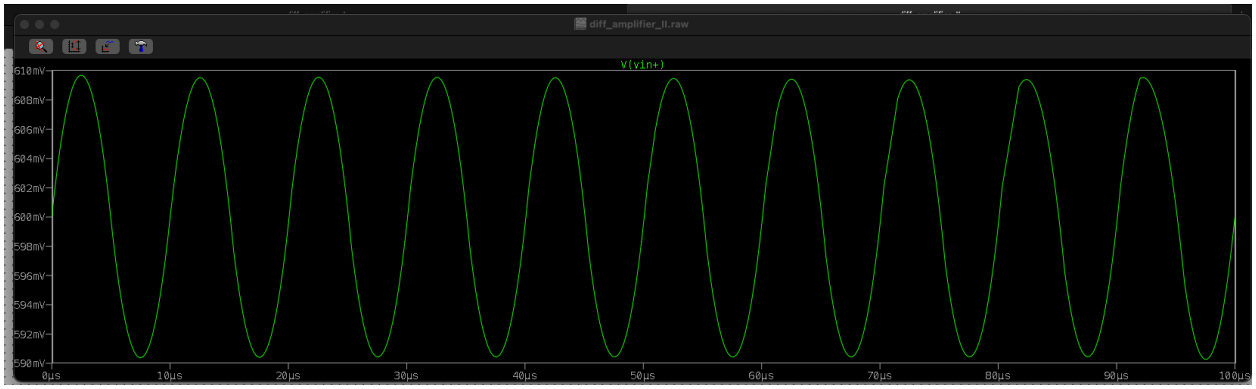
Gain(Acm)~ -46dB (for Frequency range - 1 Hz to 10k Hz) and

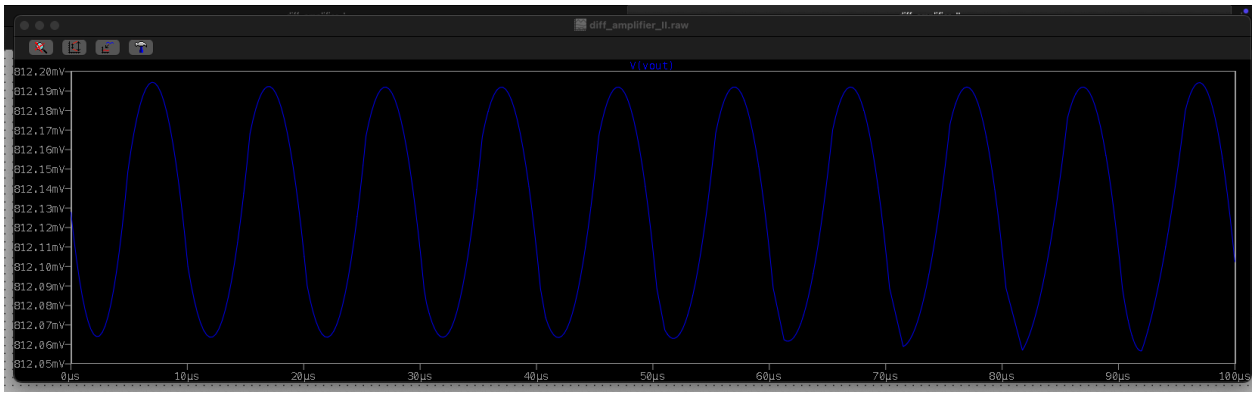
Gain (Acm) = -43 dB at 100k Hz i.e Vout/Vin=0.0071.

Assignment 5: Differential amplifier

- Transient response(at 100k frequency):

For common mode gain:



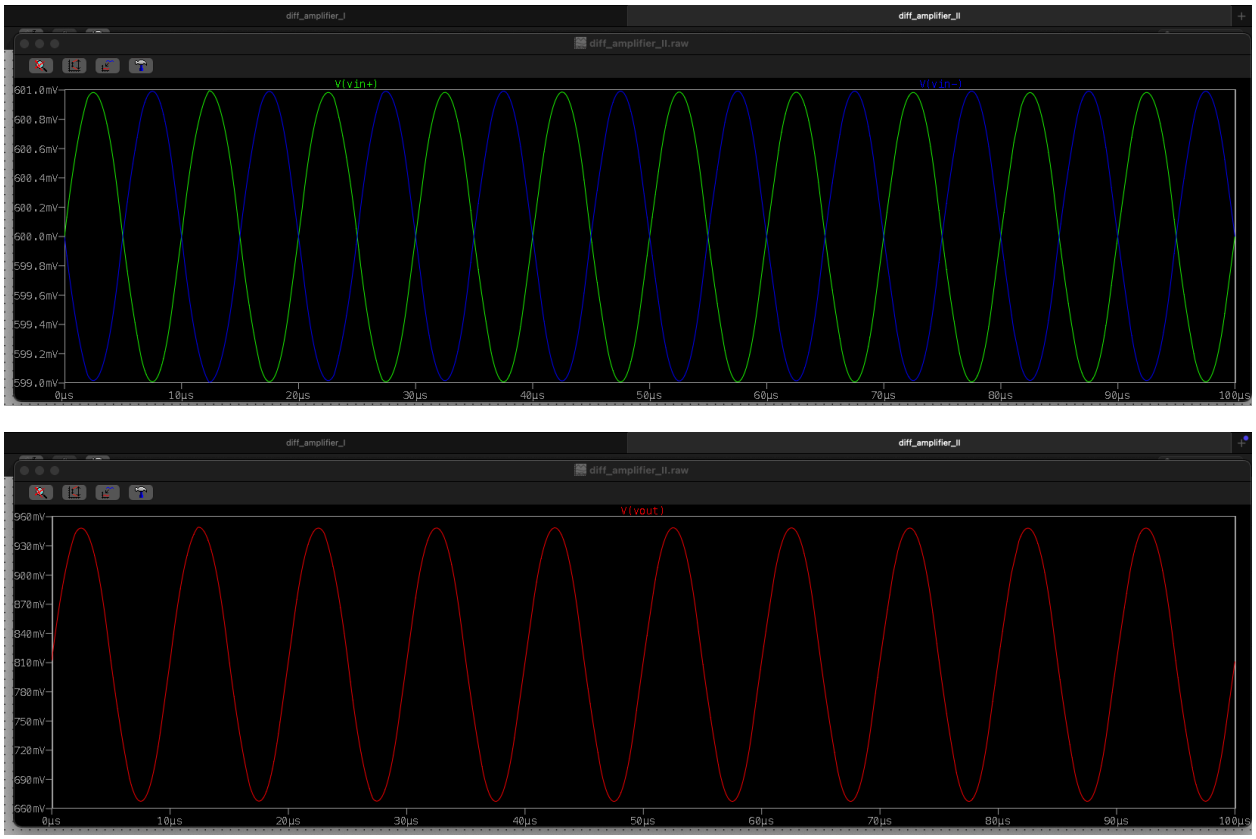


Hence ,Vin(p-p) = 20mV.
Vout(p-p) = 0.130mV.
Then ,Gain(V/V) = .0065, i.e -43.74dB which is nearly equal to that of AC analysis i.e -43 dB.

Assignment 5: Differential amplifier

- Transient response(at 100k frequency):

For differential gain:



Hence ,Vin(p-p) = 2mV.

Vout(p-p) = 284mV.

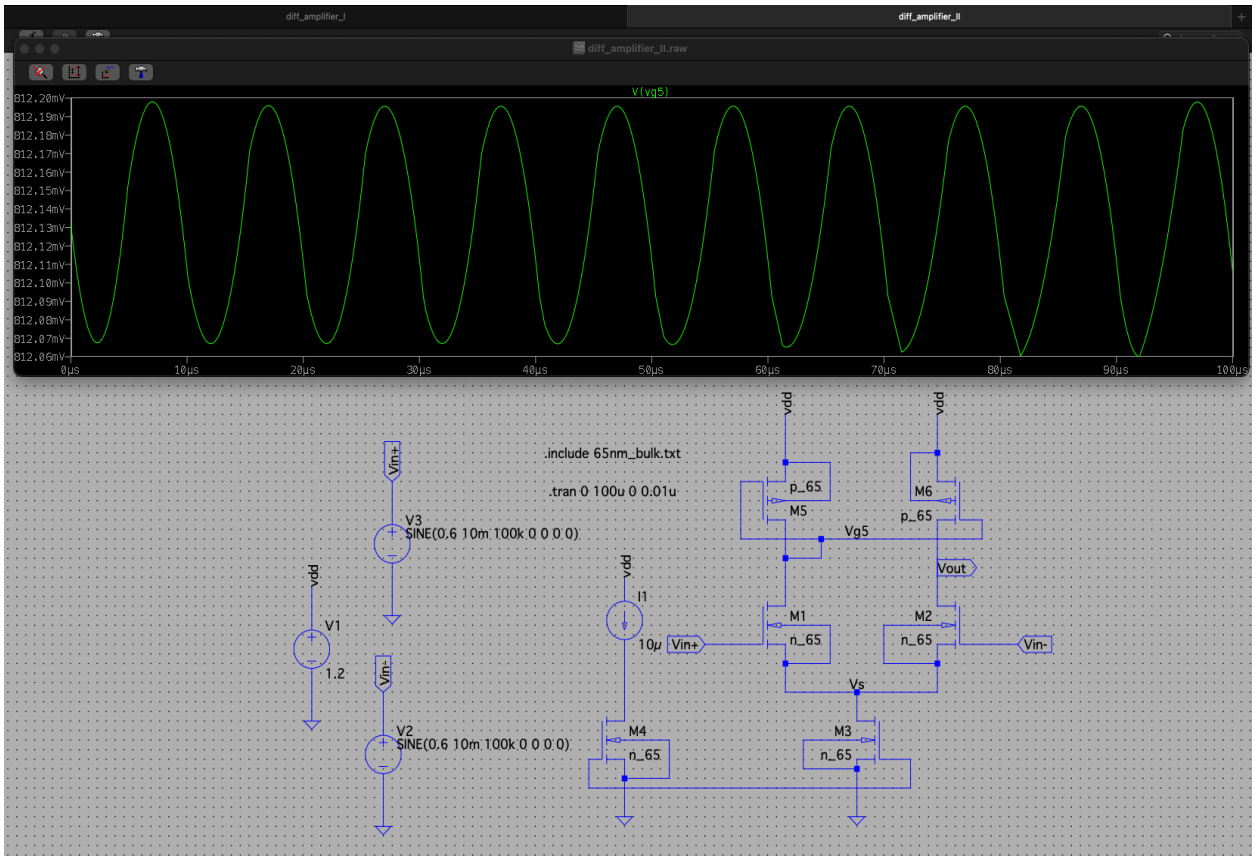
Then ,Gain(V/V) = 142, i.e 43.04dB which is nearly equal to that of AC analysis i.e 42.95dB.

Assignment 5: Differential amplifier

- Transient response(at 100k frequency):

Vg5:

(common mode response at Vin (p-p) =20mV).



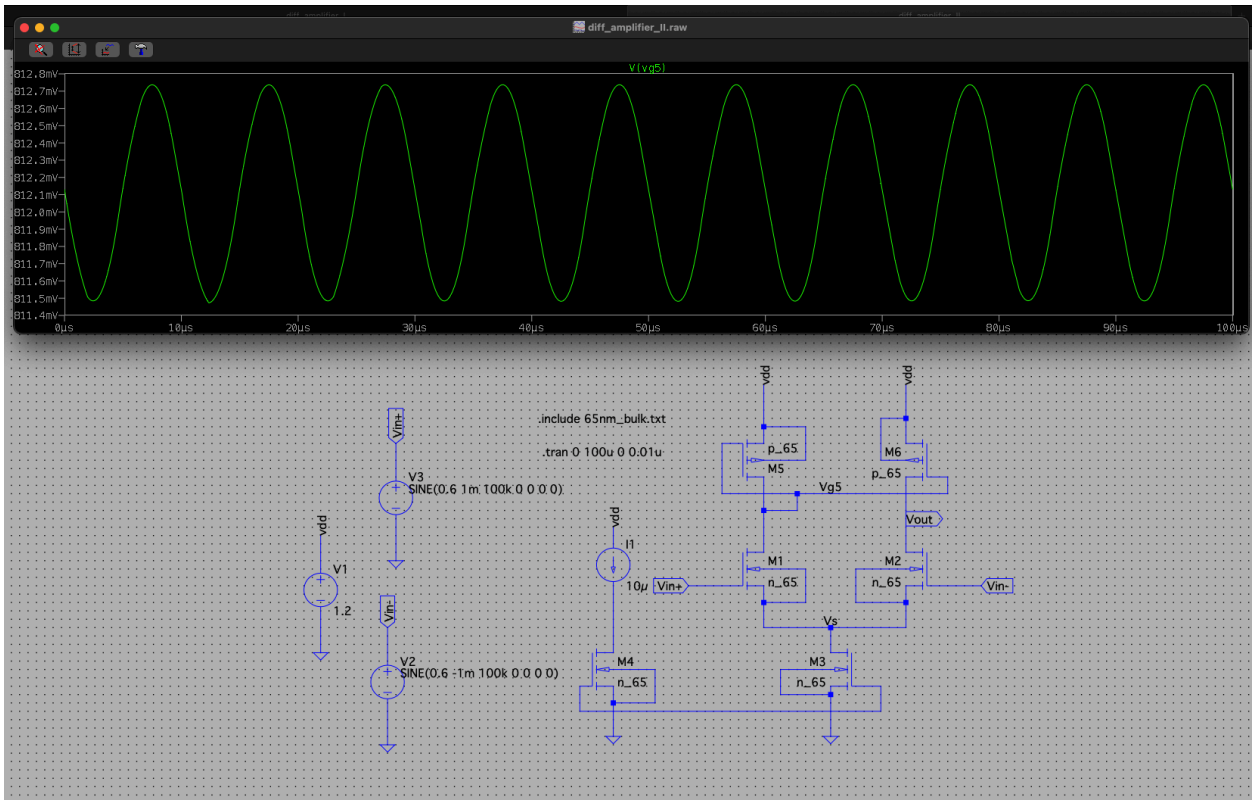
Vg5(p-p) =0.13mV.

Assignment 5: Differential amplifier

- Transient response(at 100k frequency):

Vg5:

(differential response at Vin (p-p) =2mV).

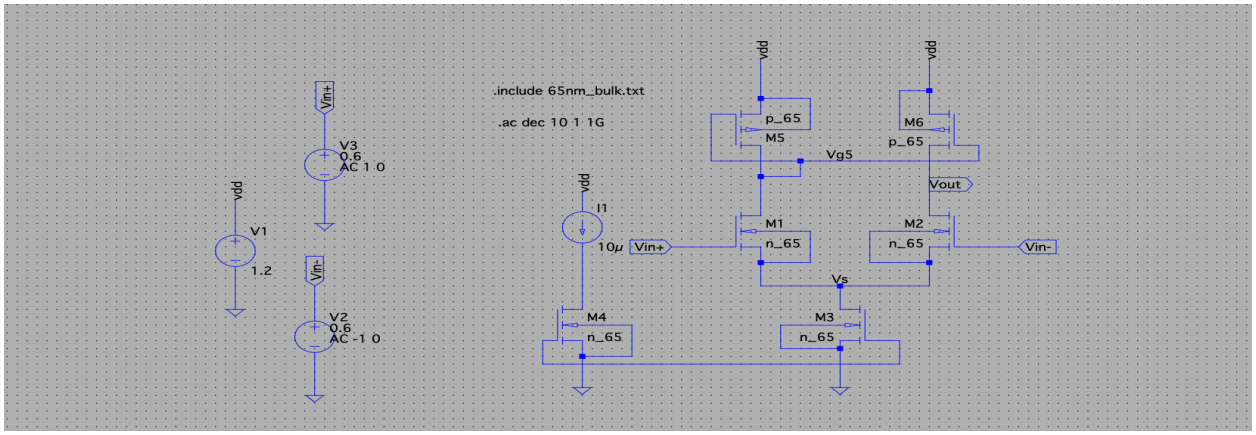


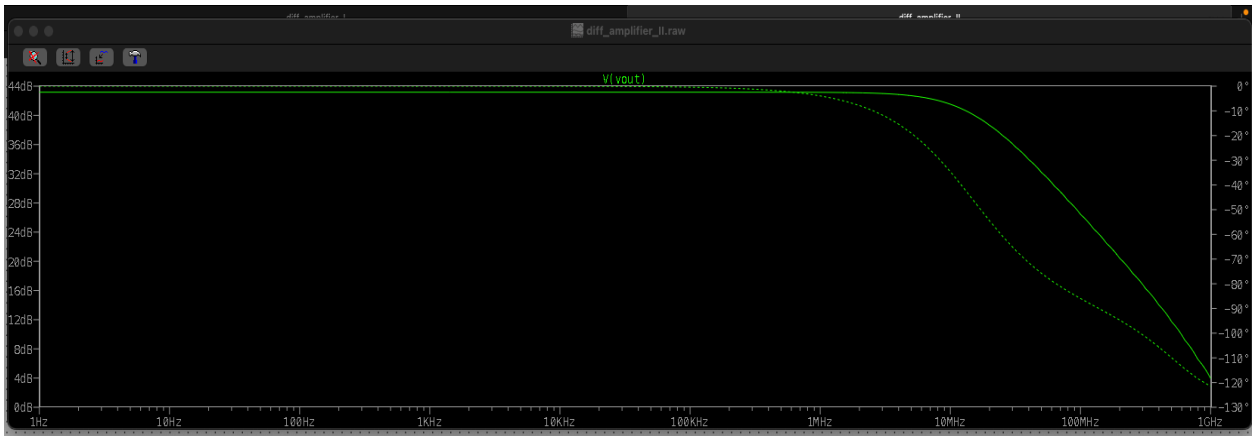
Vg5(p-p) = 1.2 mV.

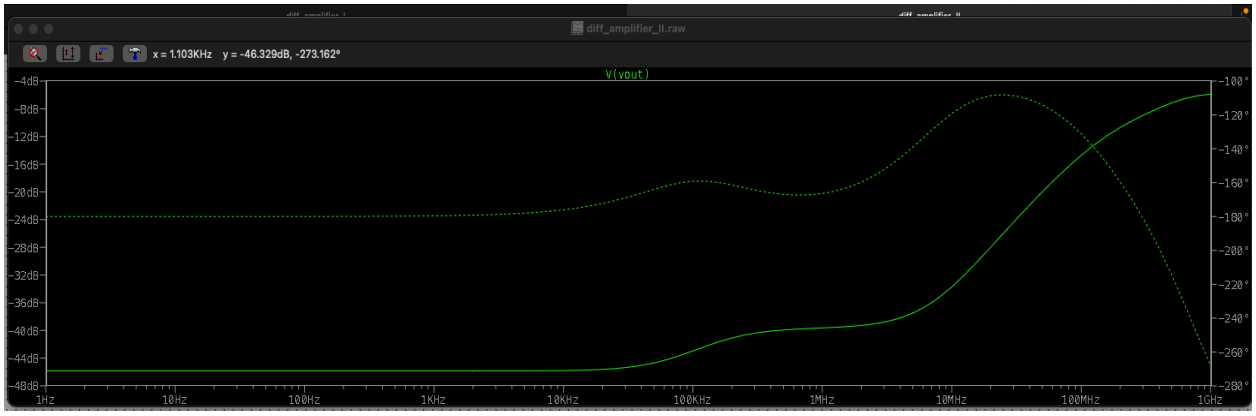
Assignment 5: Differential amplifier

b.iii) Increase the Adiff by 2x and reduce Acm by 2x using appropriate modifications.

- Circuit Diagram:



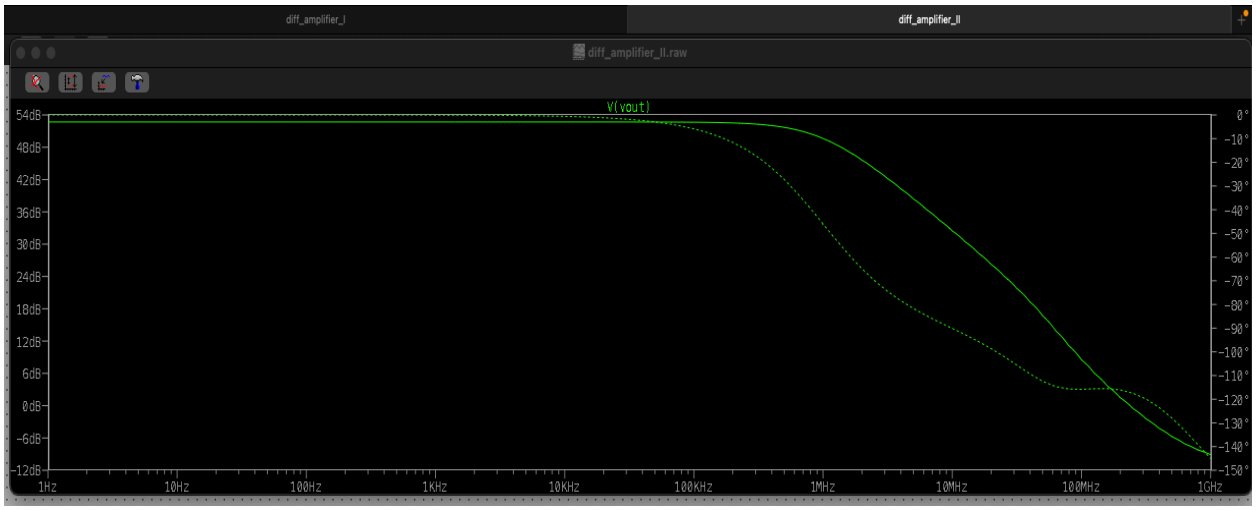


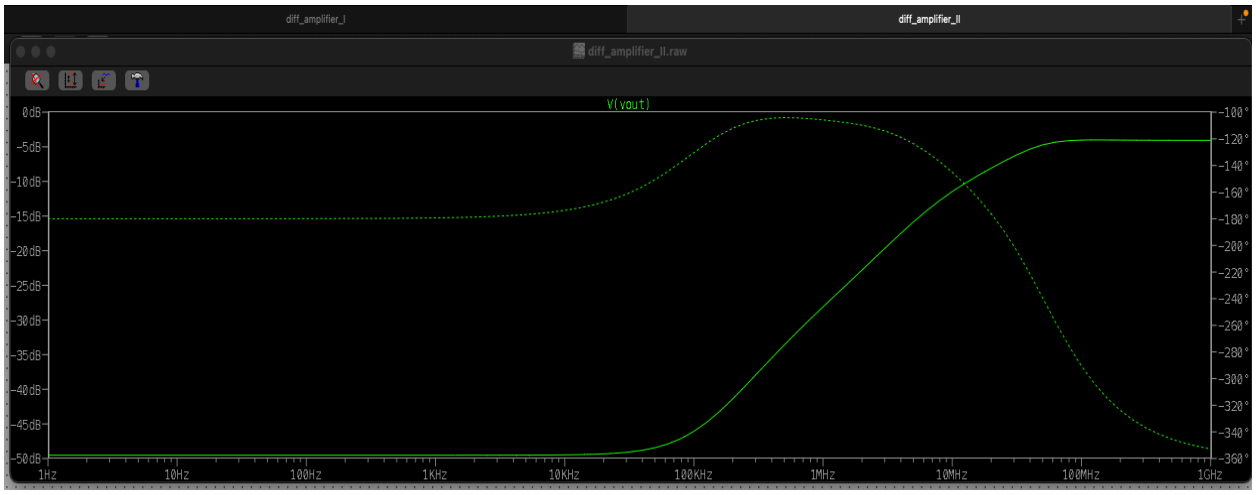


Acm =-46.5dB and Adiff = 43.45dB

Assignment 5: Differential amplifier

- After changing W/L parameters of all transistors in the circuit by 5x.



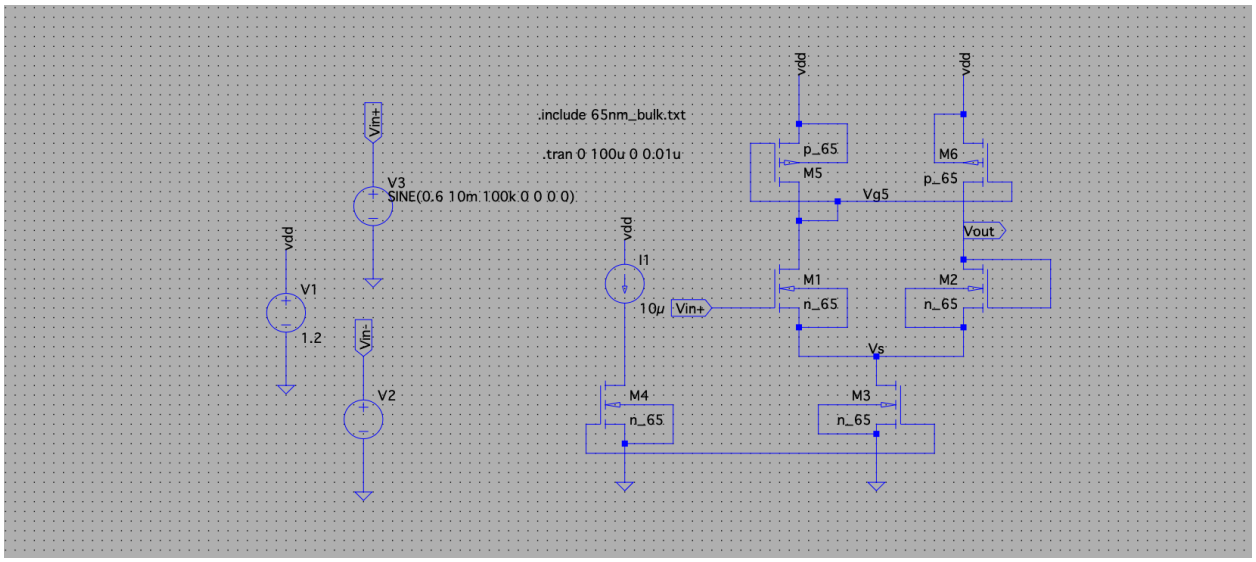


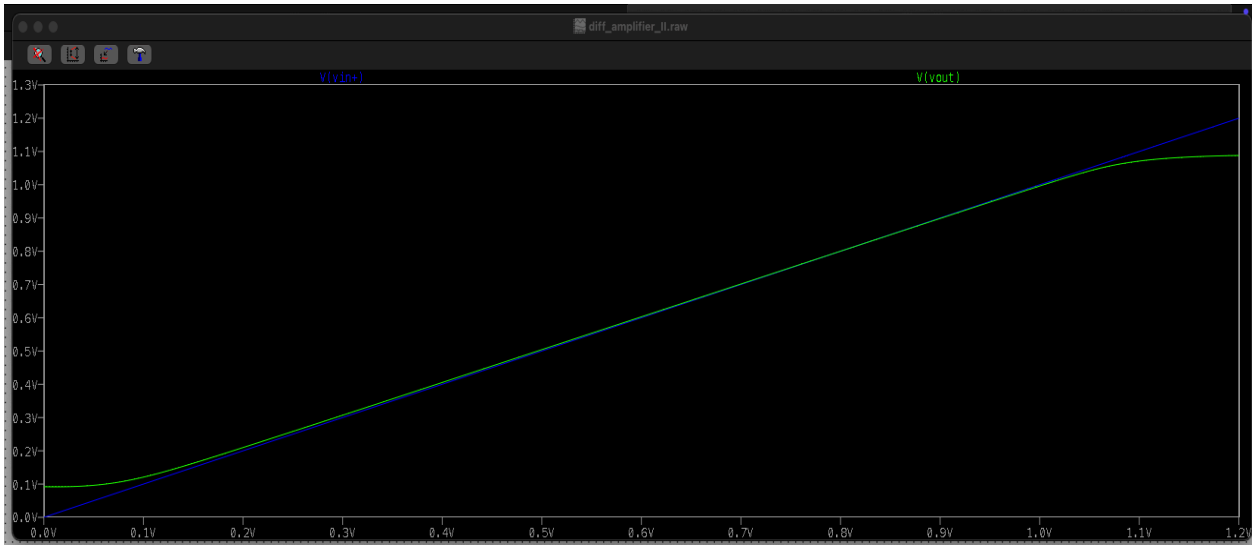
Now ,the new Acm value is -49.92dB and the new Adiff value is 53.25dB which is nearly an increase of 6dB in the Adiff value which is equivalent to 2x gain. And also Acm decreases by nearly 4dB which is also nearly equivalent to decrease in gain by 2x.

Assignment 5: Differential amplifier

b.iv) Connect the diffamp in unity gain configuration and obtain Vout vs Vin curve using DC sweep.

Circuit Diagram:





Vin(blue) and Vout (green).