

Cascode Device:

Calculation of output impedance of cascode device:

Current flowing through cascode structure: 422uA

Cascode amplifier

$R_D = 1 \text{ k}\Omega$
 $R_{out} \approx (g_{m2} r_{o2} r_{o1} || R_D)$

DC operating points \rightarrow $V_{b2} (V_{in})_{DC} = 0.8 \text{ V}$
 $(V_{b2}) = 1.6 \text{ V}$

$i_d = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS1} - V_T)^2$
 $= \frac{1}{2} \times (471.11) \times 10^{-6} \times 20 \times (0.8 - 0.45)^2 \approx 467 \mu\text{A}$

$g_{m1} = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T) = 0.002965$ (from simulation, $g_{m1} = 0.0022$)

$\therefore i_d \text{ flows thru } M2 \Rightarrow V_{GS2} = V_{GS1} = 0.8 \text{ V}$
 $\therefore g_{m2} = 0.002965$

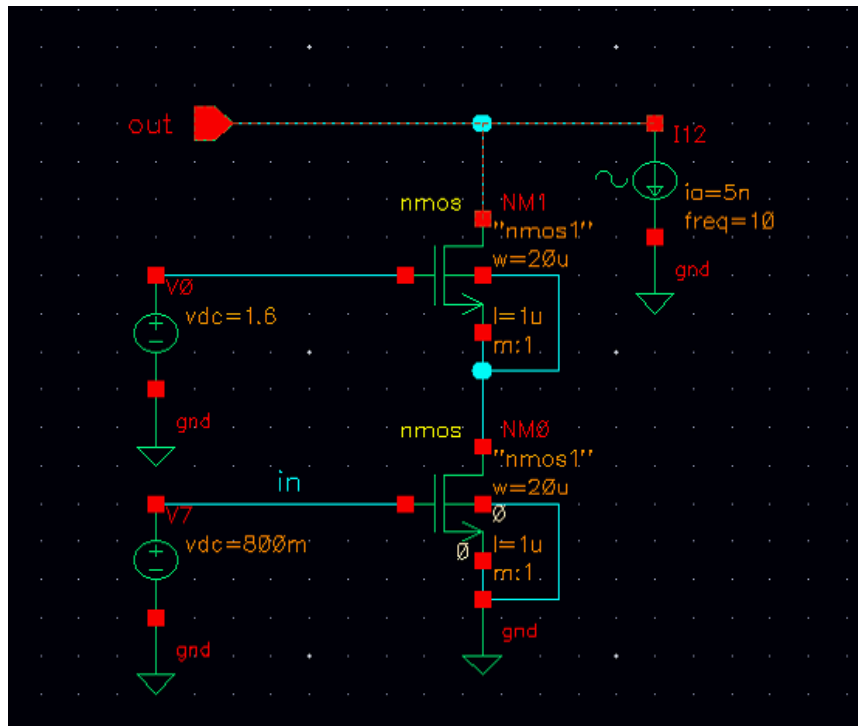
$r_{o1} = r_{o2} = \frac{1}{\lambda I_D} = \frac{V_{early}}{I_D} = 6 \text{ k}\Omega$

$\therefore R_{out} \approx (g_{m2} r_{o2} r_{o1} || R_D) = 999.99 \text{ k}\Omega$
 $\therefore A_v = -g_{m1} (g_{m2} r_{o2} r_{o1} || R_D) = -2959$

Simulated gain $\rightarrow 2.2$

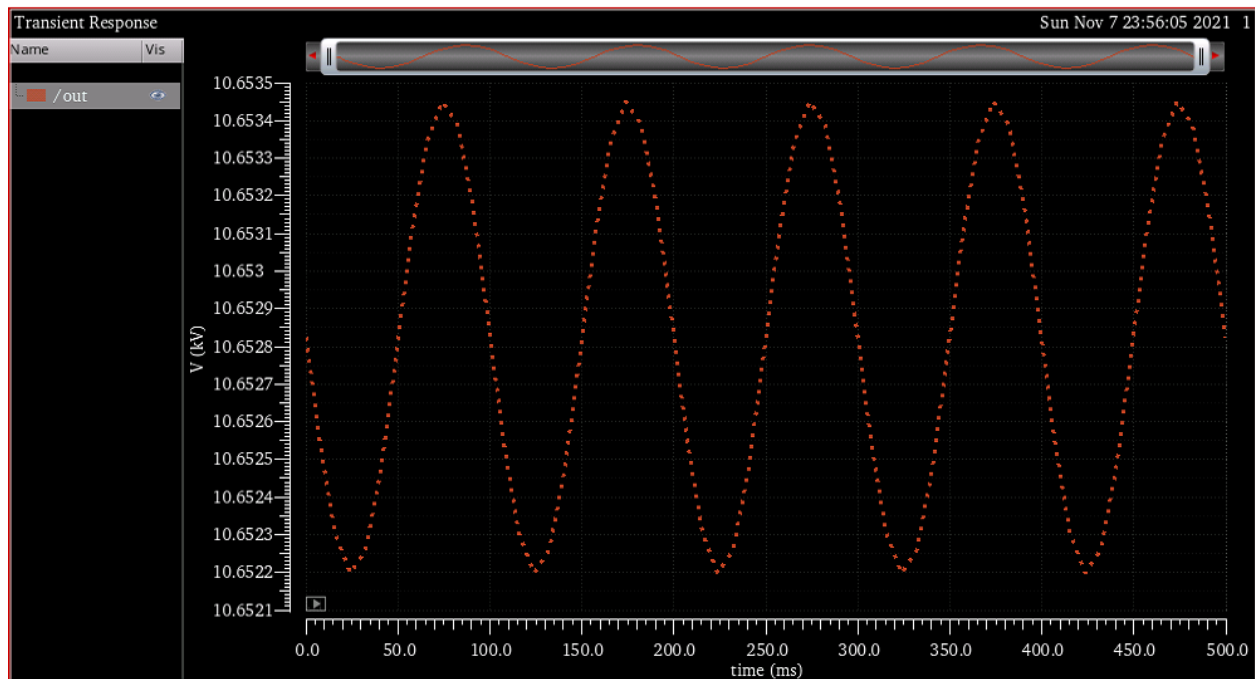
Rout (for cascode only) by calculation is : $g_{m2} * r_{o1} * r_{o2} = 11 \text{ MOhms}$

Setup:



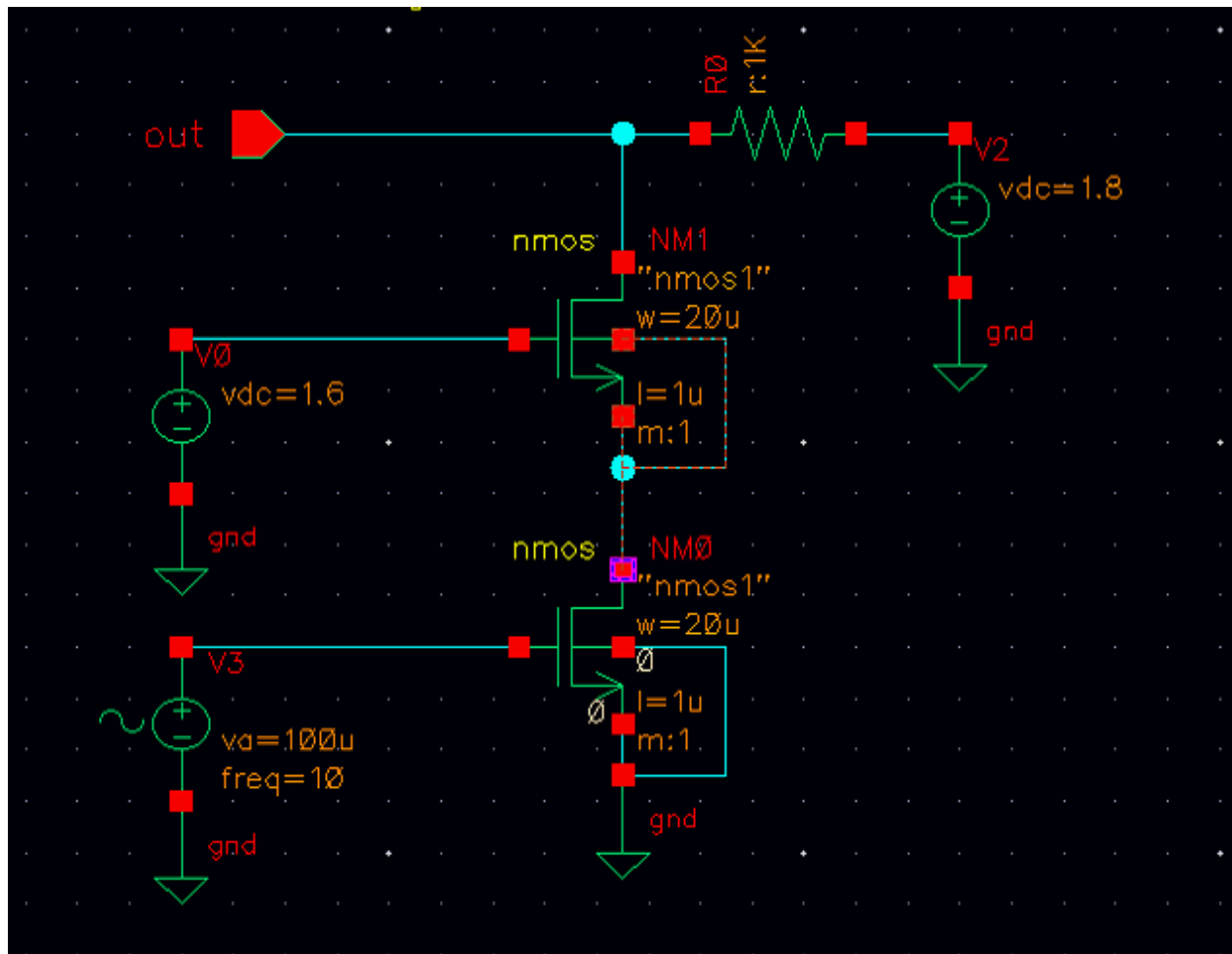
From analysis: Input current => DC: 467uA, AC: 5nA 10Hz

Output voltage: $dV = 0.6V$

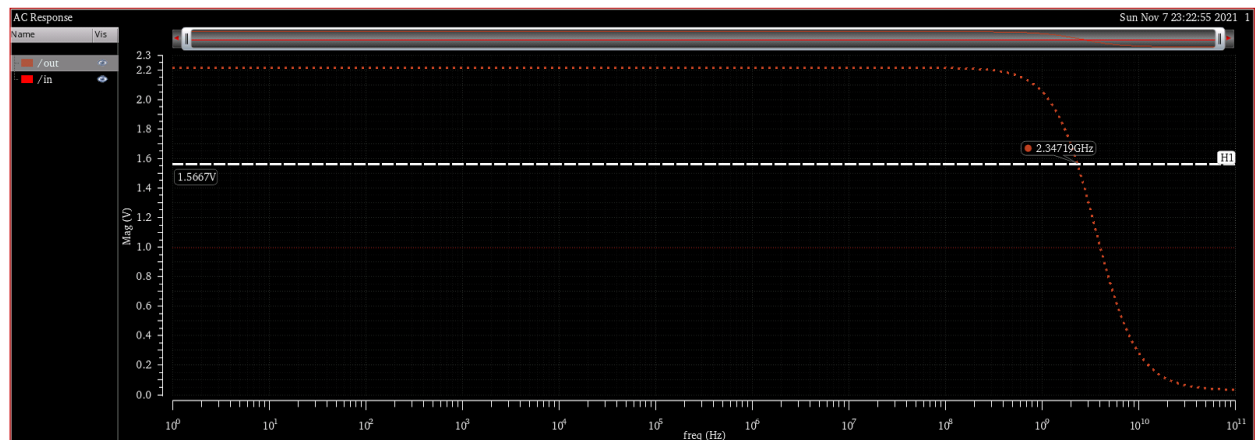


According to simulation => 120 MOhms (error by a magnitude of 10)

Frequency Analysis:

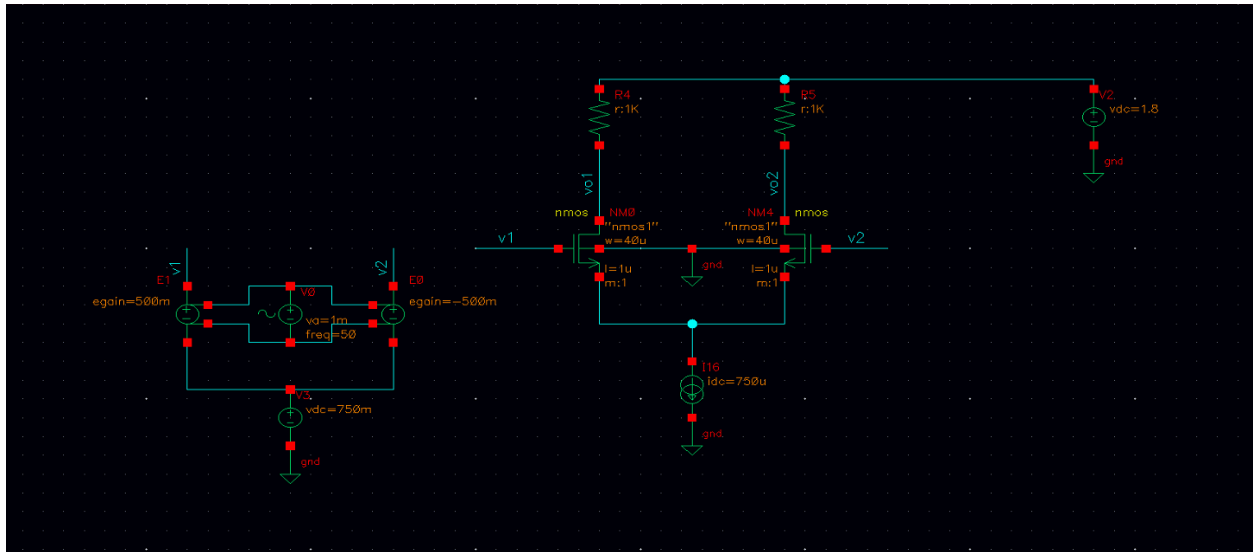


Magnitude of output: (Magnitude of input is 1, hence output magnitude is gain)

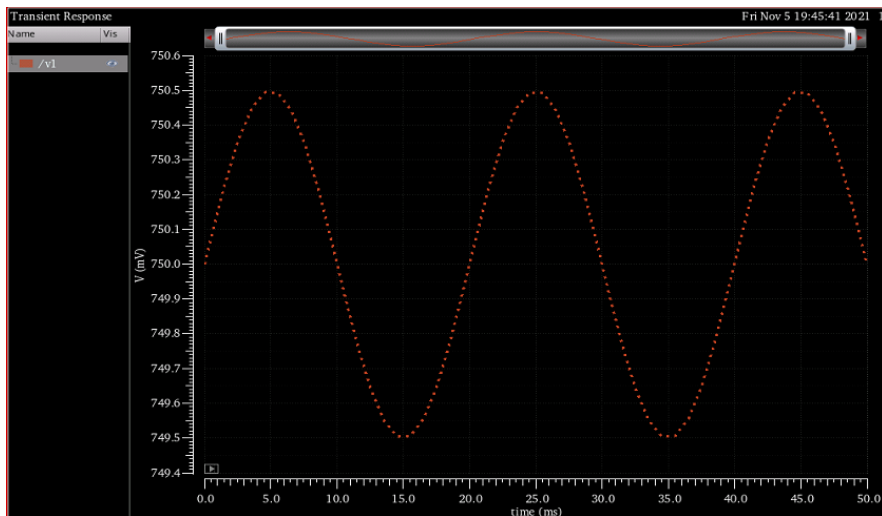
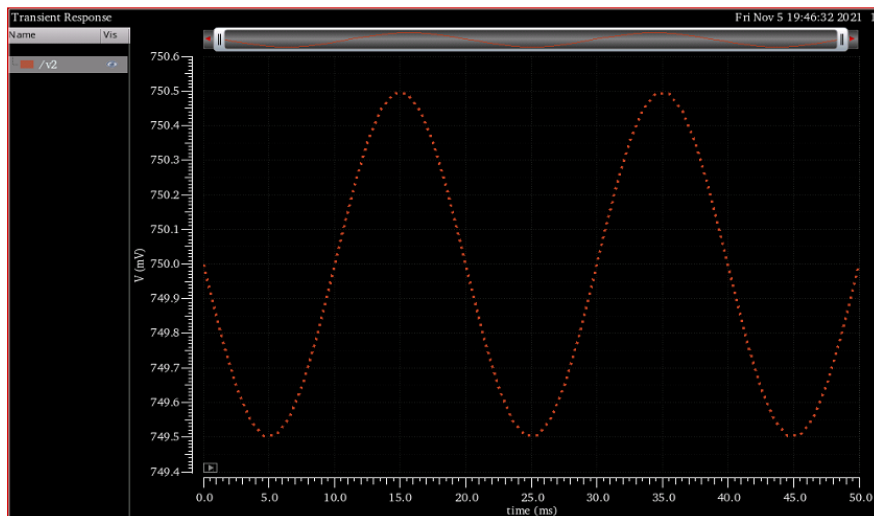


3dB frequency is 2.34 GHz

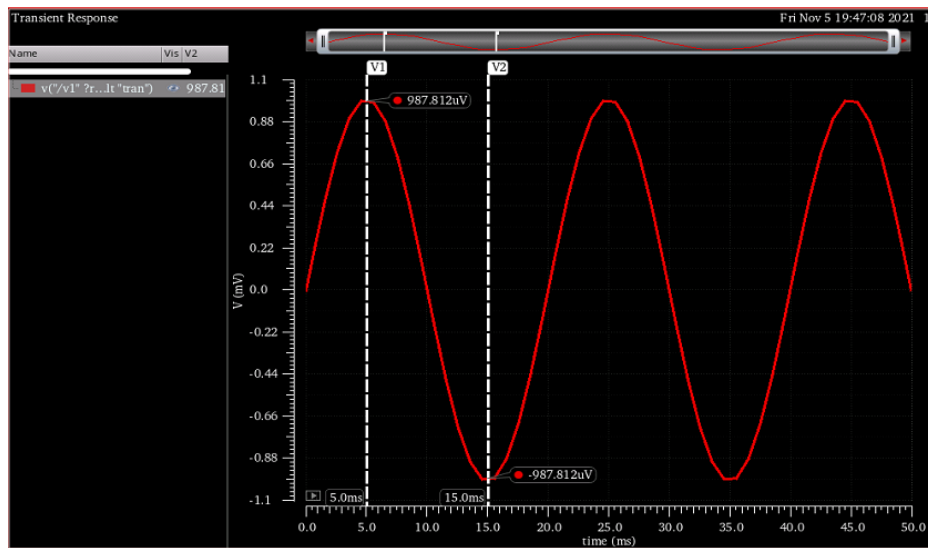
Differential amplifier:



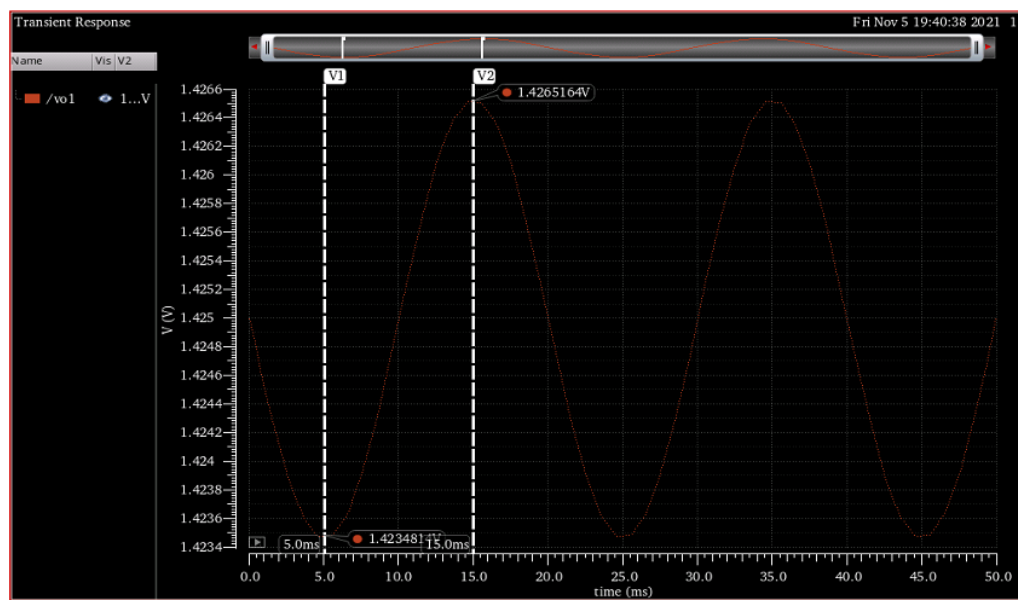
Inputs:

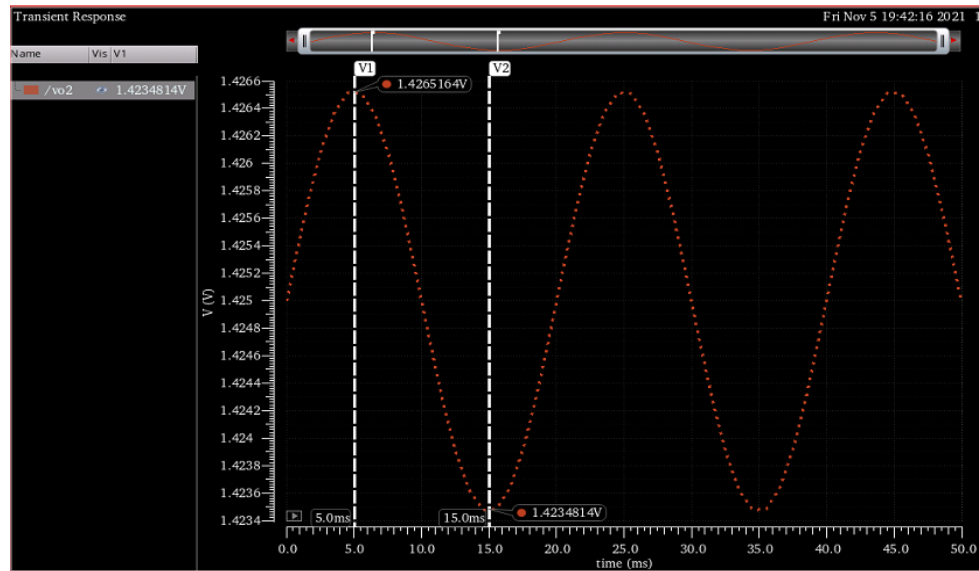


Differential input: approximately 1mV 50Hz

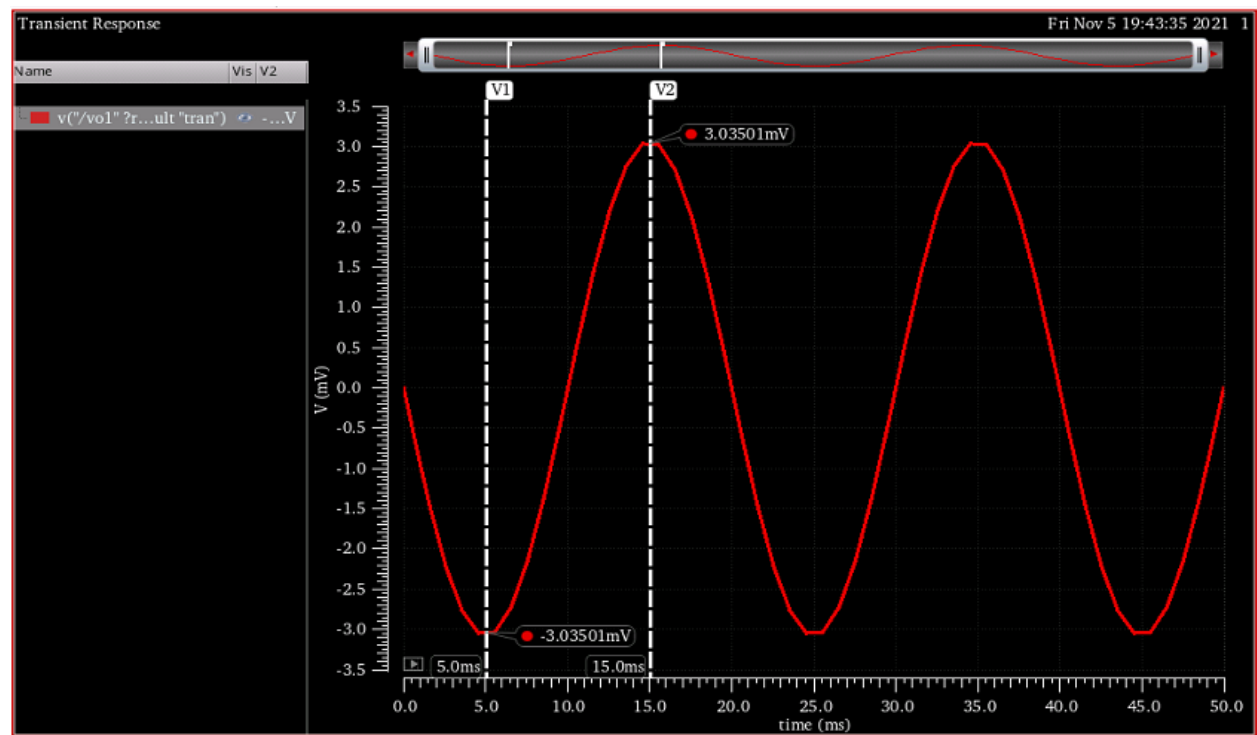


Outputs:



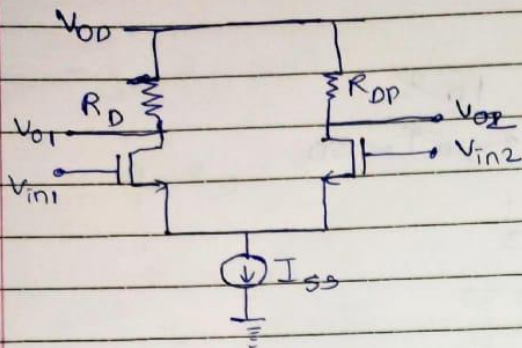


Differential output: Gain of approximately 3V/V



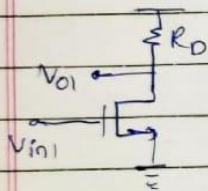
Hand calculations:

Calculation



$$I_{D1} = I_{D2} = \frac{I_{SS}}{2} \quad (\text{if } (V_{in1})_{cm} = (V_{in2})_{cm} > V_{th})$$

Using half circuit analysis (\because they are identical)



$$\frac{V_{O1}}{V_{in1}} = -g_m R_D$$

$$\text{also} \rightarrow \frac{V_{O2}}{V_{in2}} = -g_m R_D \quad (\because I_{D1} = I_{D2} \Rightarrow g_m = g_m)$$

$$\therefore \frac{V_{O1} - V_{O2}}{V_{in2} - V_{in1}} = -g_m R_D$$

$$R_D = 1 \text{ k}\Omega \quad g_m = \sqrt{2\mu_n C_{ox} \frac{W}{L} I_{SS}}$$

$$3 = 10^3 \times \left(\sqrt{300 \times 10^{-6} \times \frac{W}{L} I_{SS}} \right)$$

$$\text{Chosen} \rightarrow I_{SS} = 0.75 \text{ mA} \Rightarrow \frac{W}{L} = 40$$

$$V_{GS} = V_{th} + \sqrt{\frac{I_{SS}}{2\mu_n C_{ox} \frac{W}{L}}} = 0.485 + 0.25 = 0.735 \text{ V}$$