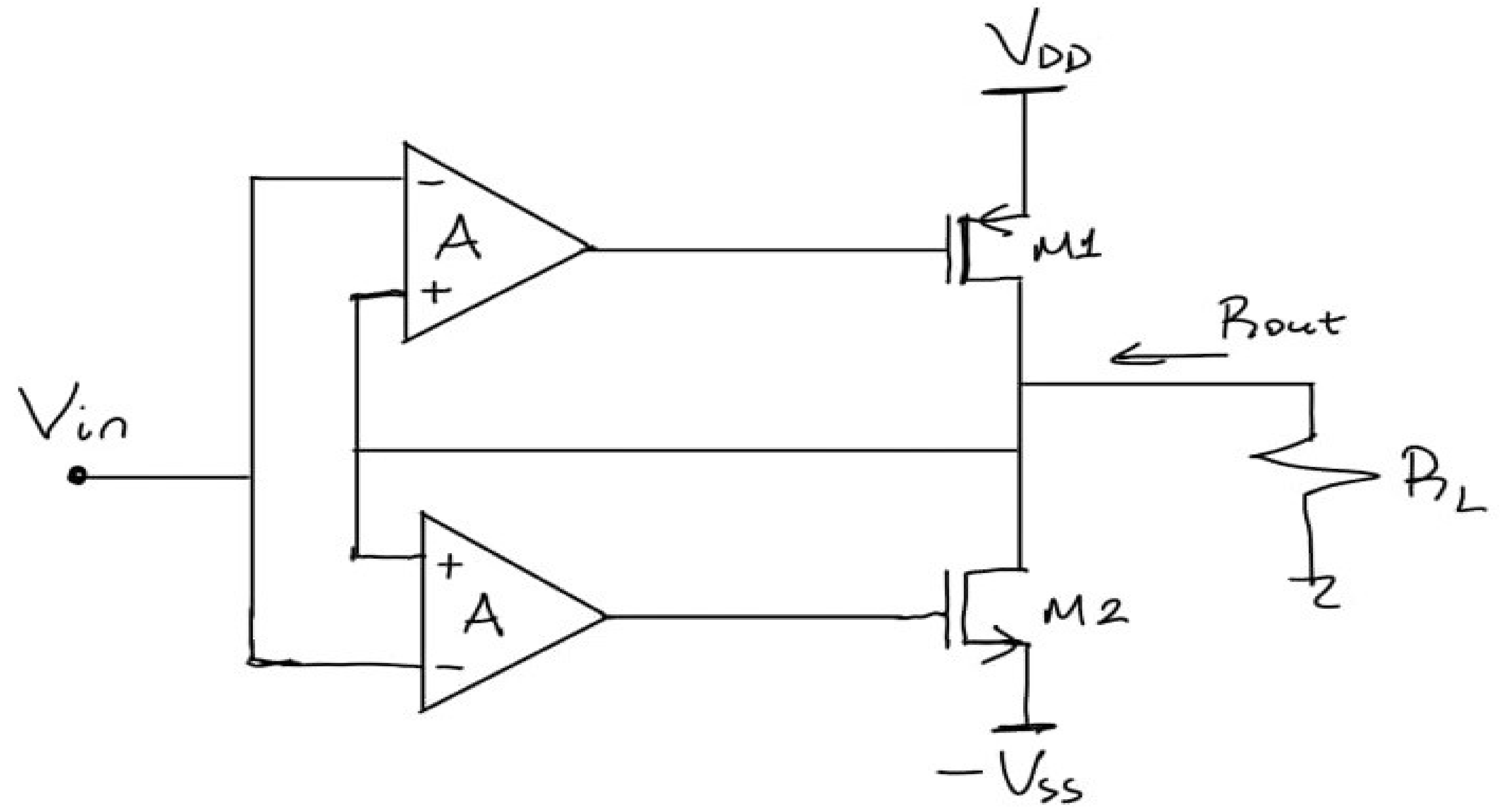
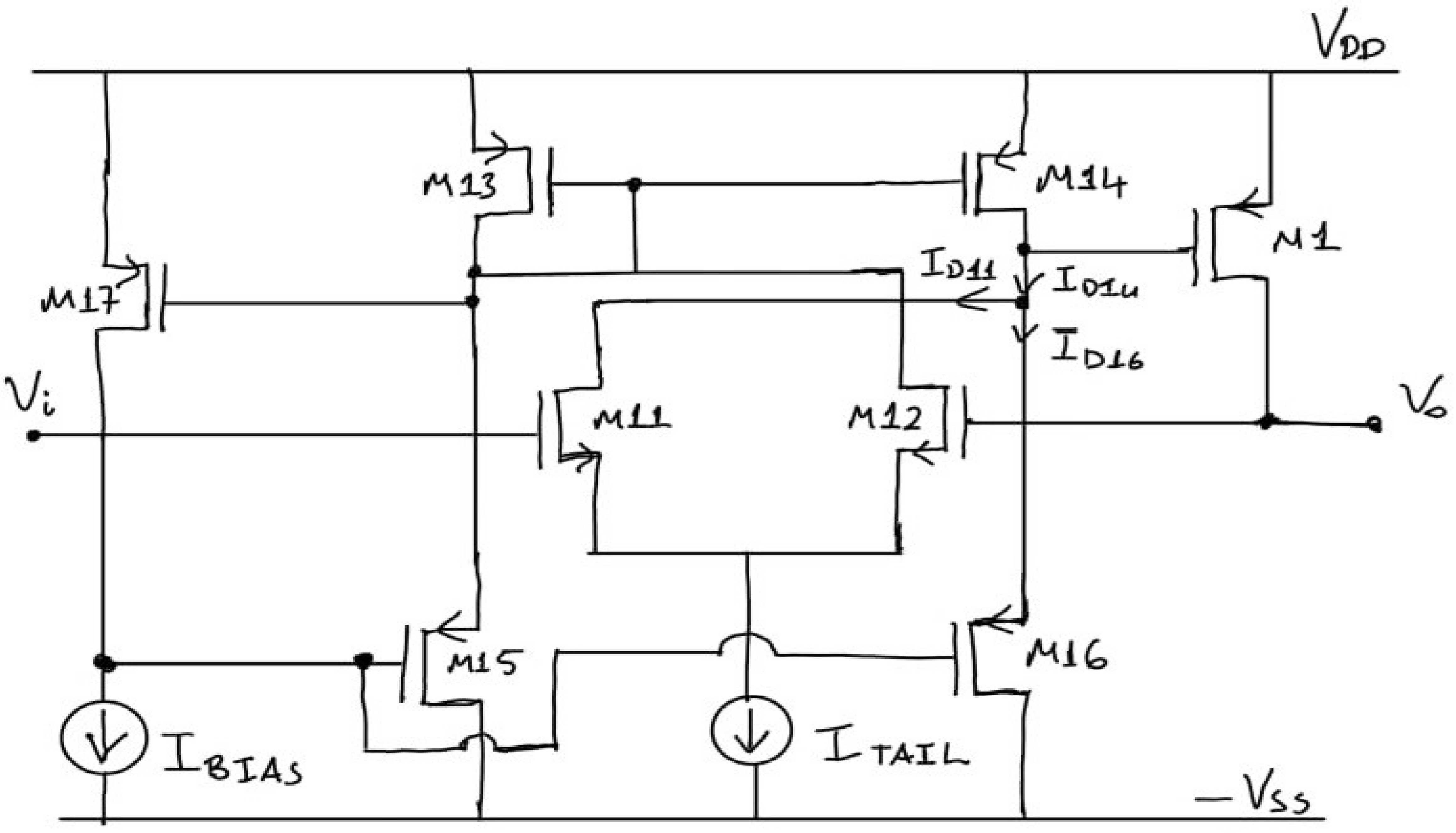
HW10

ARDA ÜNAL





$$A = \frac{g_{m11}}{g_{m16} + g_{mb16}}$$ → Our aim is to find an appropriate value of gain A.

$2 A g_m R_L >> 1$, since $R_L = 100\,\Omega$

$\Rightarrow A g_m >> 5\times10^{-3}$, Let $V_{DD} - V_{SS} = 3V$, then

$$I_D^{max} = \frac{1.5}{100} = 15mA \text{ , since } V_{TN} = 0.8V$$

$$g_m = \frac{2I_D^{max}}{0.7} \Rightarrow g_m = 42.8\ mS$$

$$\Rightarrow \left(\frac{W}{L}\right)_1 = 488.49 \Rightarrow \begin{array}{l} L_1 = 0.15\mu m \\ W_1 = 73.27 \end{array}$$

$\Rightarrow A >> 0.1168 \Rightarrow$ Let us choose $A = 1$ then

$$\Rightarrow A = \frac{g_{m11}}{g_{m16} + g_{mB16}} \Rightarrow$$

$g_{mB16} = 0.35\, g_{m16}$ for $n = 1.35$

$$\Rightarrow A = \frac{g_{m11}}{1.35\, g_{m16}} \Rightarrow \frac{g_{m11}}{g_{m16}} = 1.35$$

$\rightarrow$ Thus let $g_{m11} = 1.35mS$ and $g_{m16} = 1mS$

$\Rightarrow I_{D16} = 100\mu A$ and $I_{D11} = 135\mu A$

$$\Rightarrow I_{D14} = I_{D16} + I_{D11} = 235\ \mu A$$

$$\left(\frac{W}{L}\right)_{14} = \frac{g_{m14}^2}{2k' I_D} = 94, \quad \left(\frac{W}{L}\right)_{11} = 22.5$$

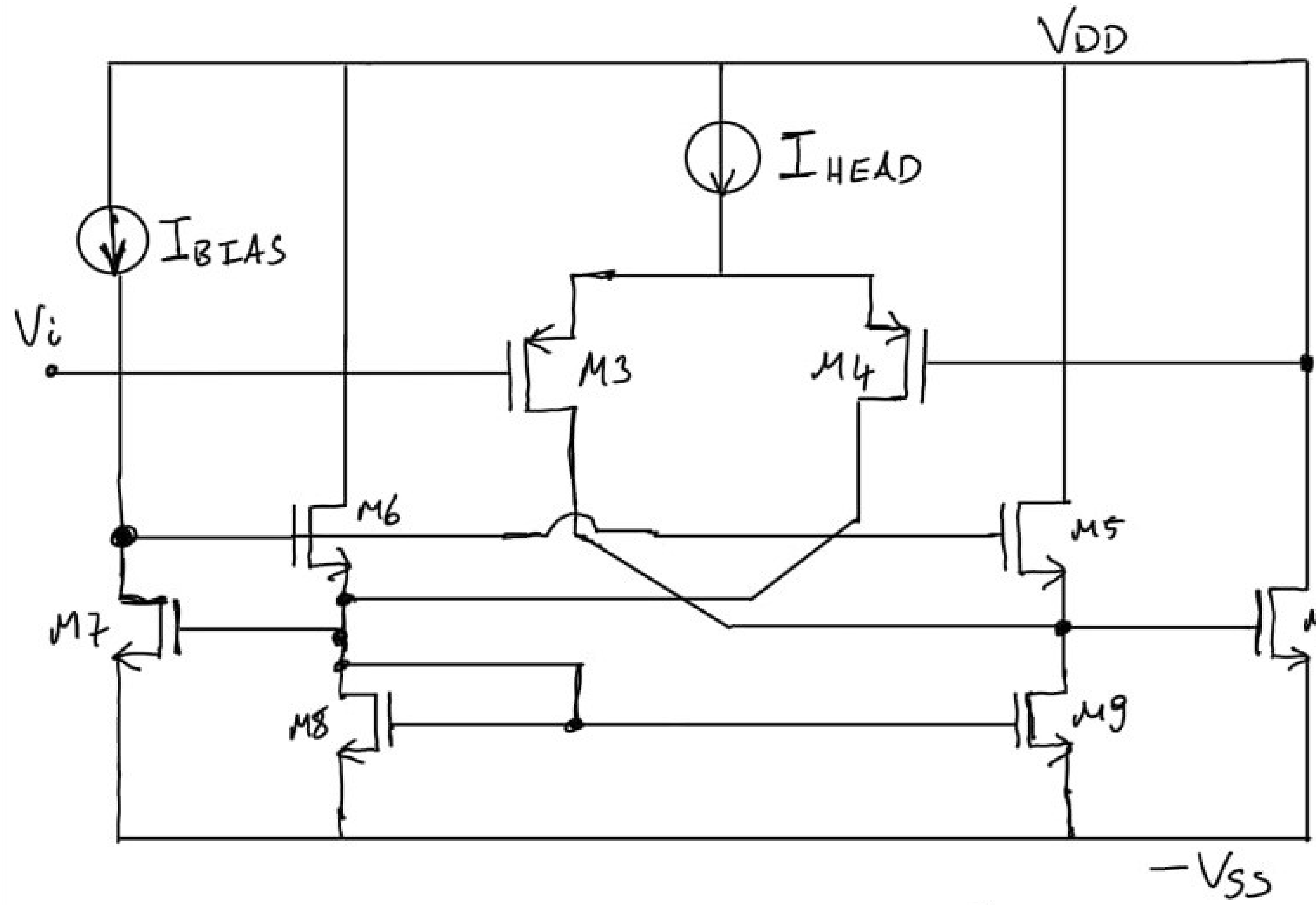
$$\left(\frac{W}{L}\right)_{16} = 16.667, \quad I_{TAIL} = 270\mu A$$

$$\Rightarrow I_{D1} = I_{BIAS} \frac{(W/L)_2}{(W/L)_{17}} \Rightarrow \frac{I_{BIAS}}{(W/L)_{17}} = 3.07 \times 10^{-5}$$

$\Rightarrow$ For $I_{BIAS} = 100\mu A$, $\left(\frac{W}{L}\right)_{17} = 3.25$

$$\left(\frac{W}{L}\right)_2 = \frac{0.625}{1.5} \left(\frac{W}{L}\right)_1 = 203.5$$

$$\Rightarrow L_1 = 0.5\mu m, \quad W_1 = 30.5\ \mu m$$



$I_3 + I_5 = I_9 \qquad I_3 = \frac{I_{HEAD}}{2}$

$A = \frac{g_{m3}}{g_{m5} + g_{mb5}} = 1 \Rightarrow$ Again $g_{m5} + g_{mb5} = 1.35 g_{m5}$

$\rightarrow$ Let $g_{m3} = 1.35\,mS$

$\Rightarrow \frac{g_{m3}}{g_{m5}} = 1.35 \qquad \Rightarrow g_{m5} = 1\,mS$

$\Rightarrow I_{D3} = 135\,\mu A$ and $I_{D5} = 100\,\mu A$

$\Rightarrow I_9 = 235\,\mu A \;,\; I_{HEAD} = 270\,\mu A$

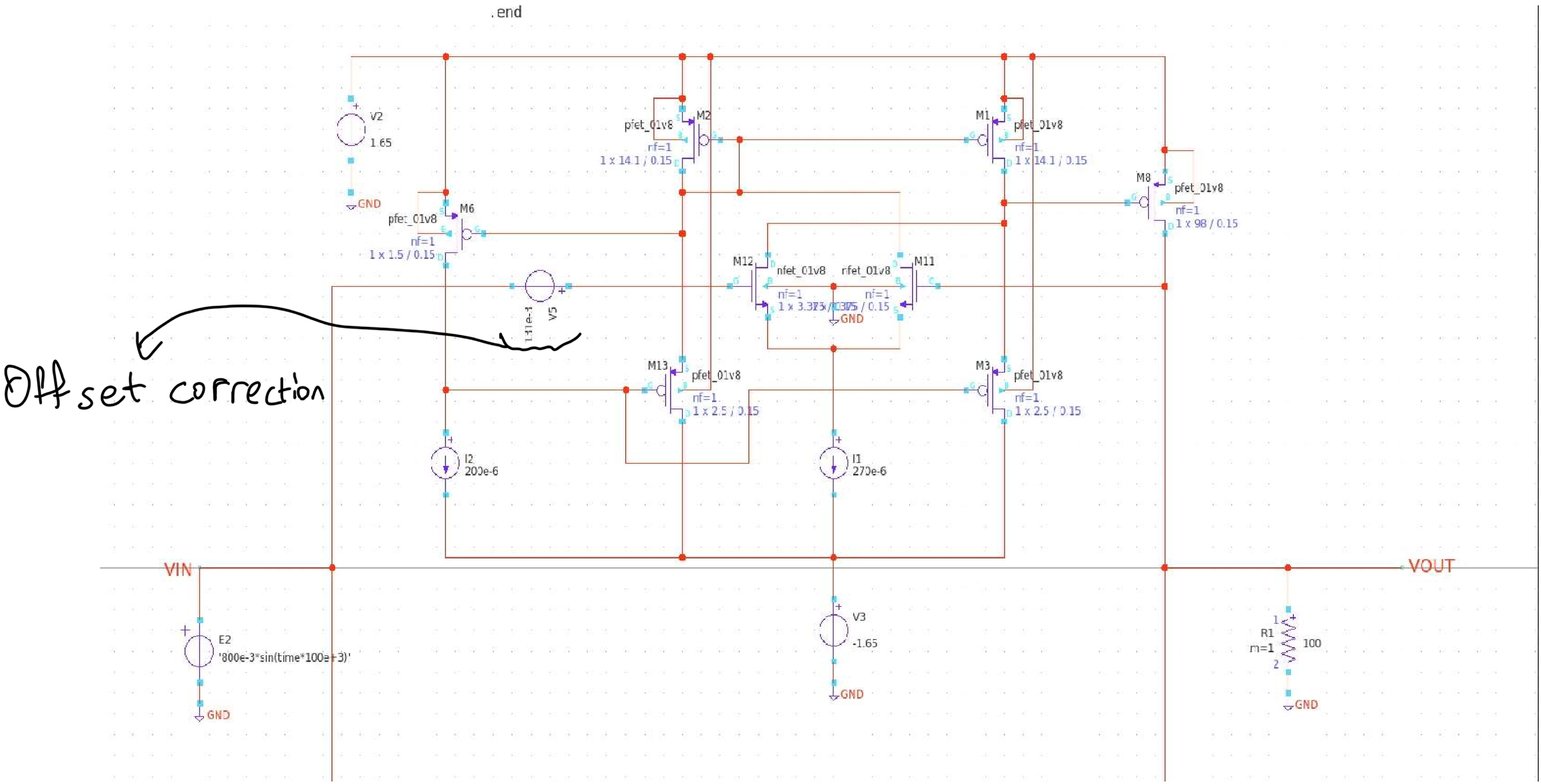
$\Rightarrow \left(\frac{W}{L}\right)_{3,4} = 54, \; \left(\frac{W}{L}\right)_{5,6} = 16.667$

$\Rightarrow (W/L)_{8,9} = 39.1667$

$I_{D1} = I_{BIAS} \frac{(W/L)_1}{(W/L)_7} \qquad \Rightarrow \frac{I_{BIAS}}{(W/L)_7} = 7.37 \times 10^{-5}$

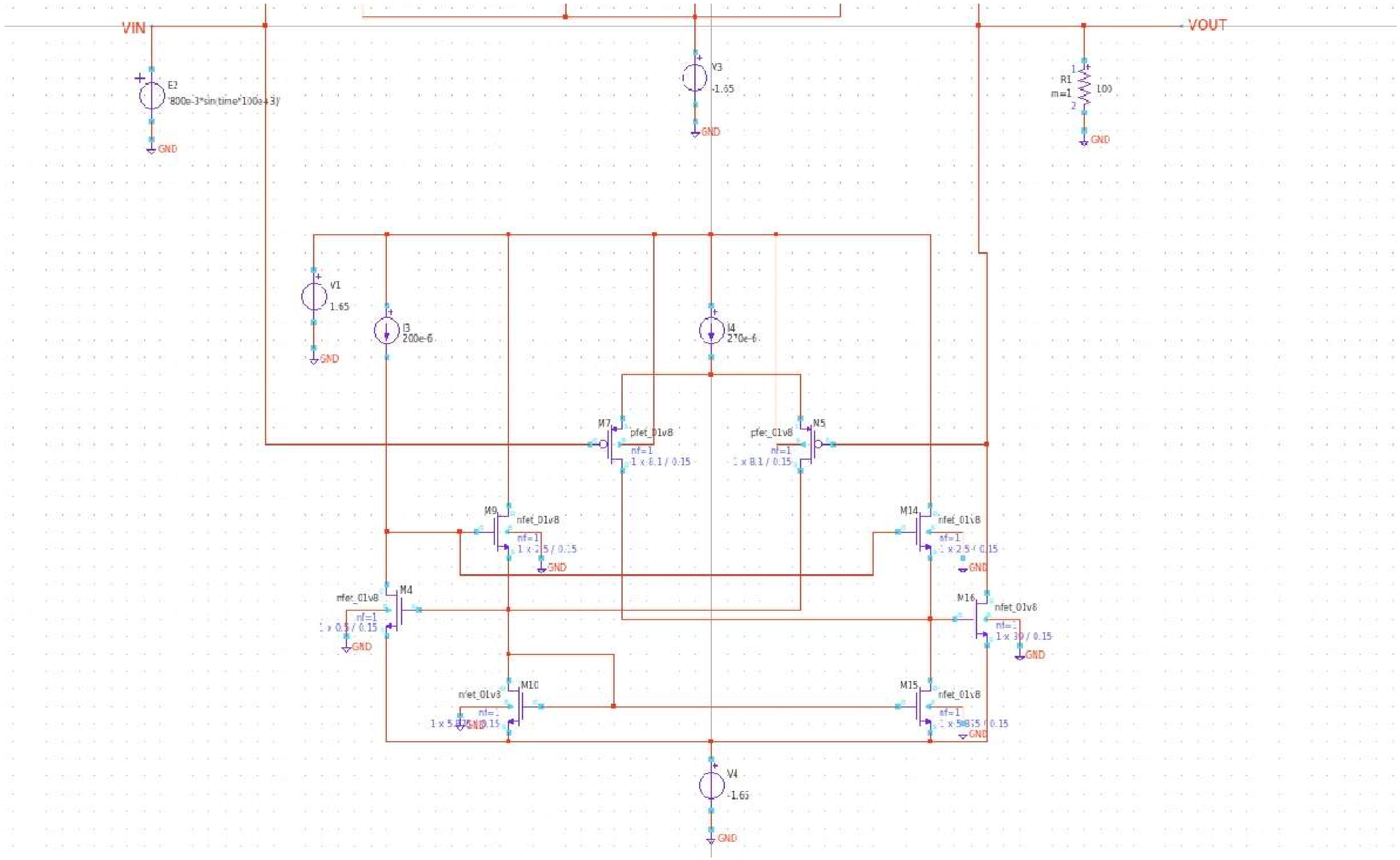
For $I_{BIAS} = 100\,\mu A \quad (W/L)_7 = 1.35$

Upper side of the circuit



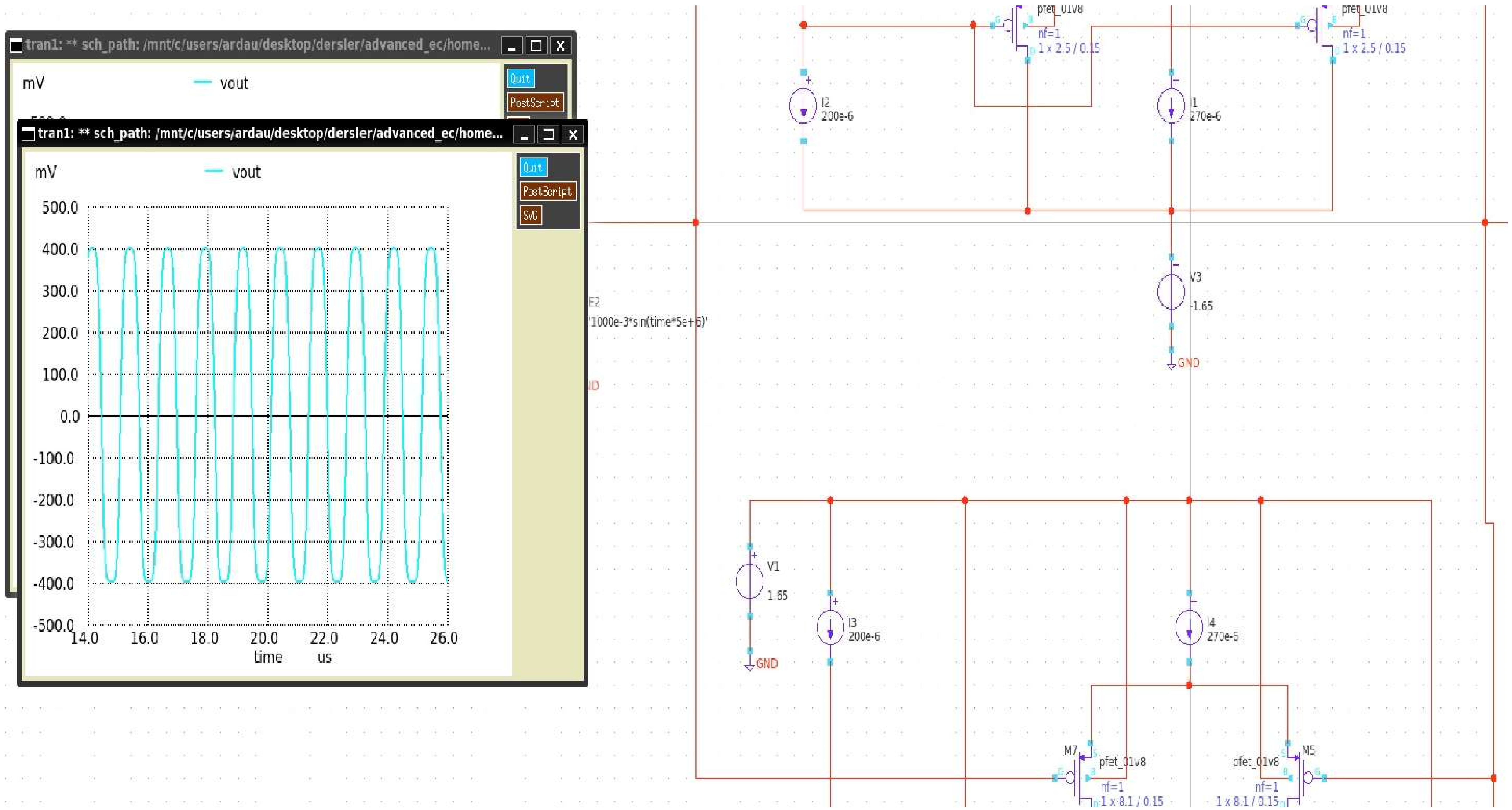
→ I did some corrections by playing IBIAS, W_{M6}, and W_{M8}. Addition to that I added voltage source V5 to remove the offset.

Below side of the circuit

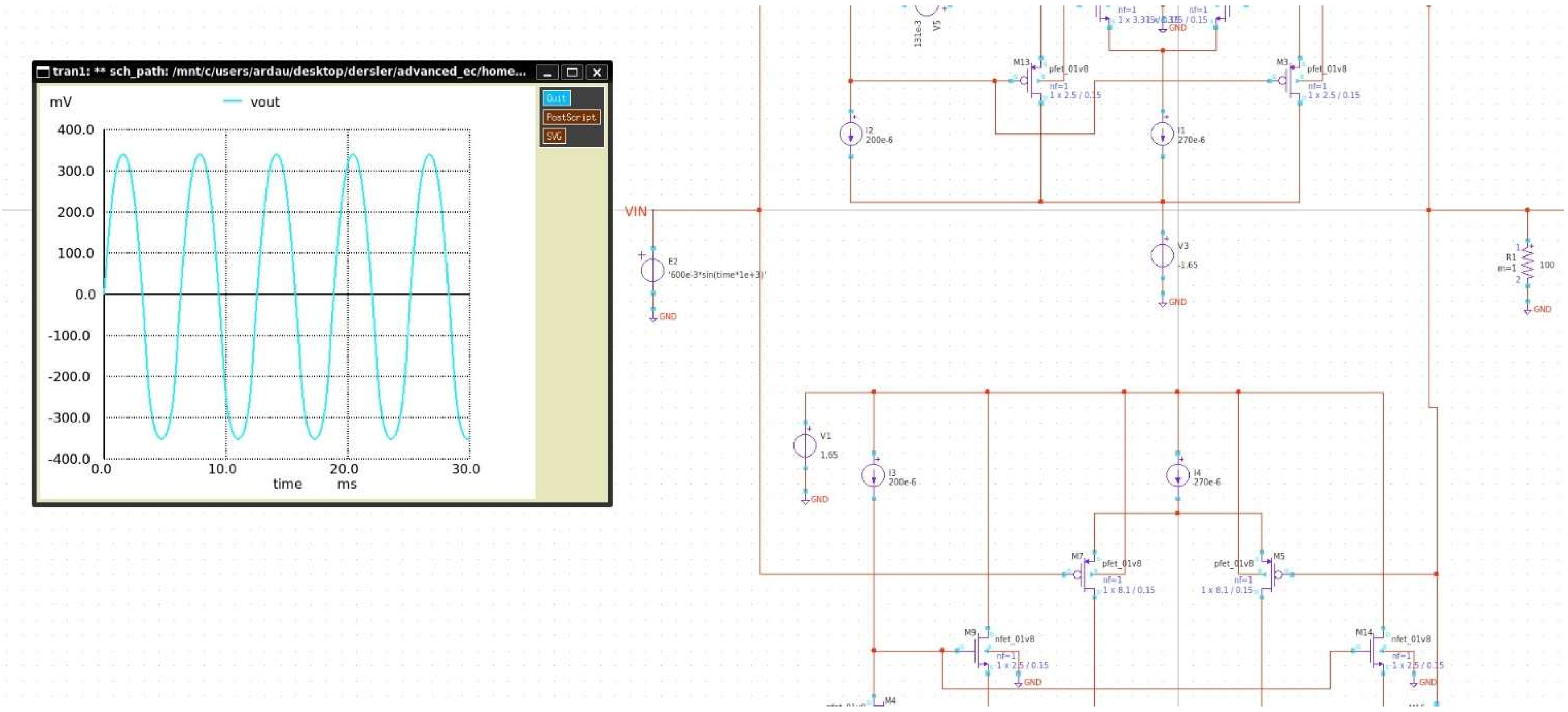


→ I also did some corrections here by changing I_{BIAS}, W_{M4} and W_{M16}

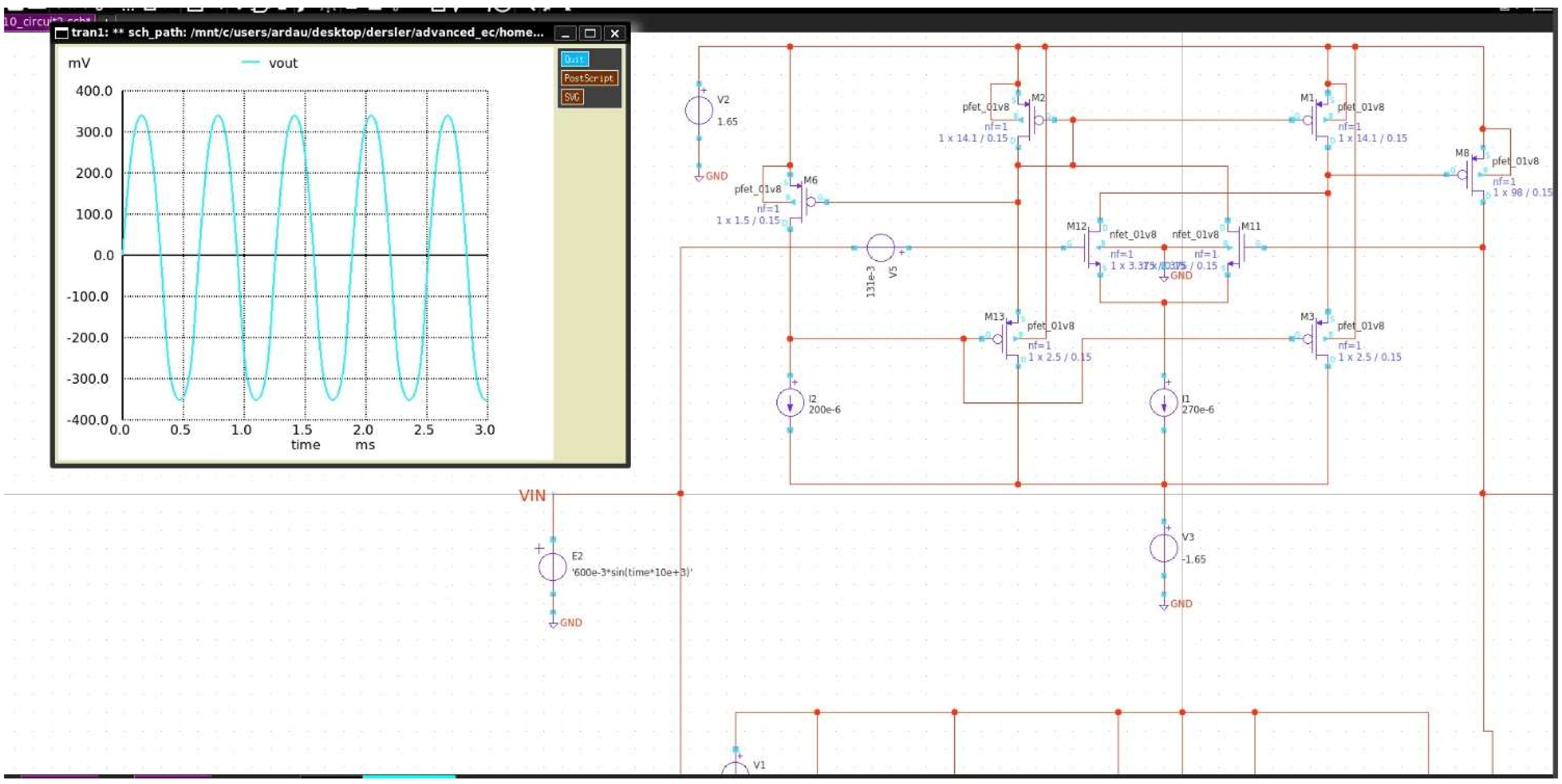
→ This is the maximum output that is available for this circuit.



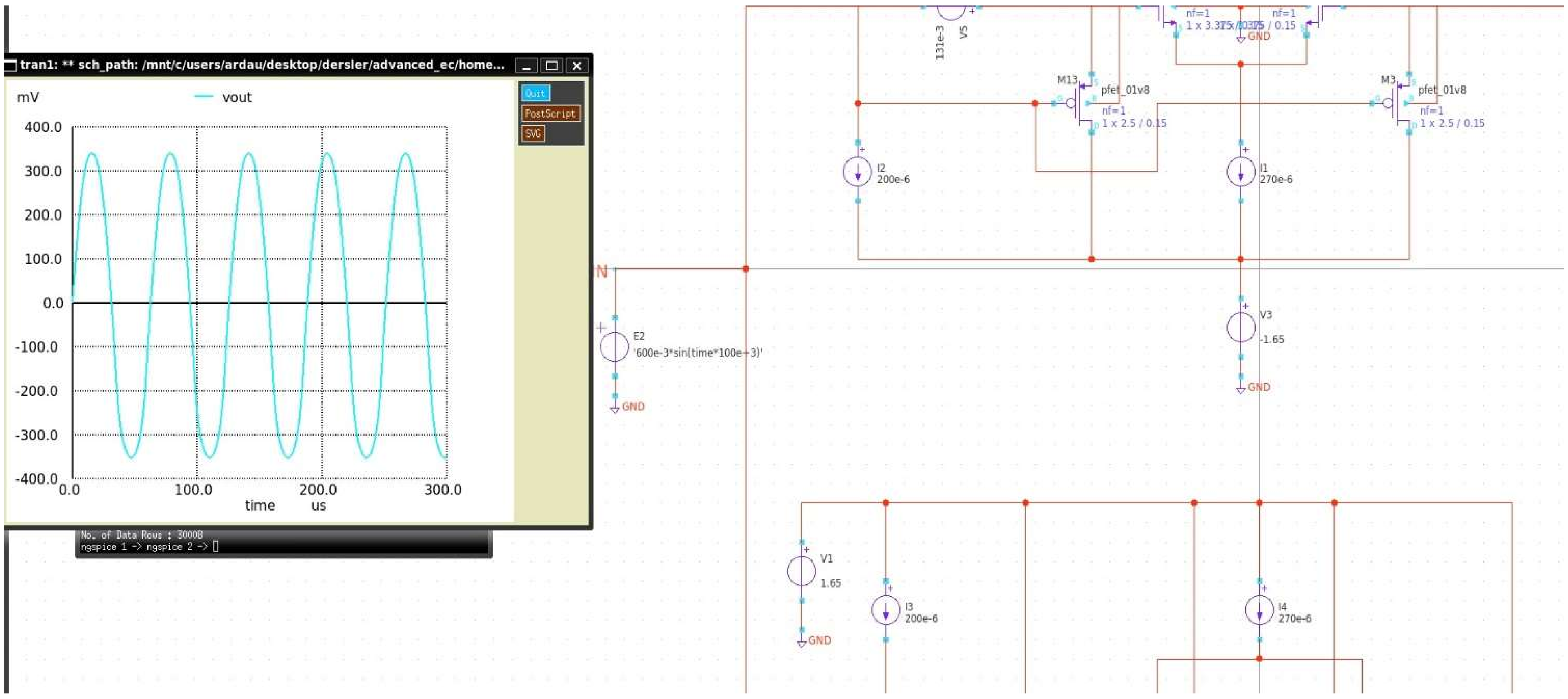
$f_{V_{in}} = 1\ kHz$



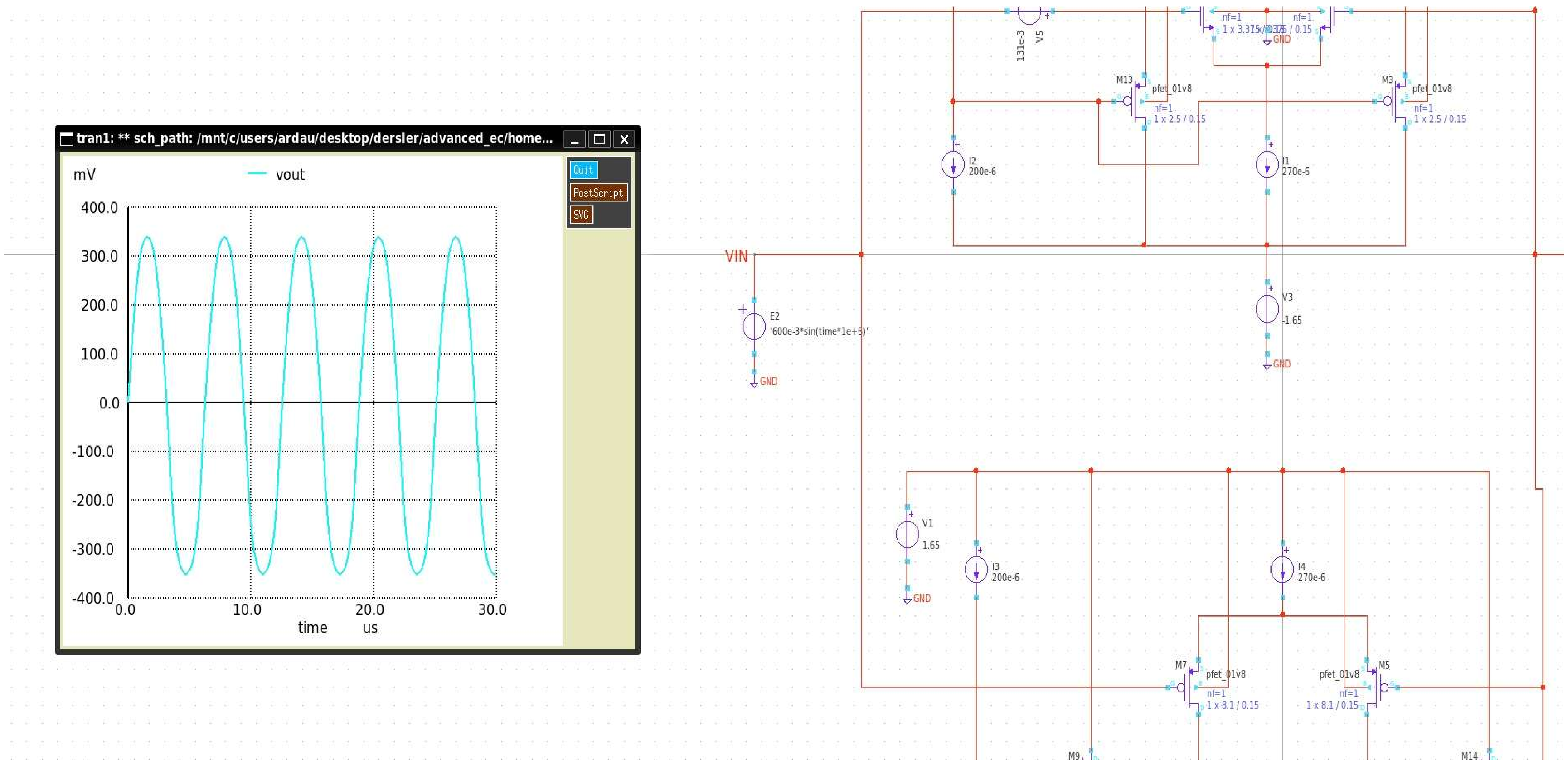
$f_{V_{in}} = 10\ kHz$



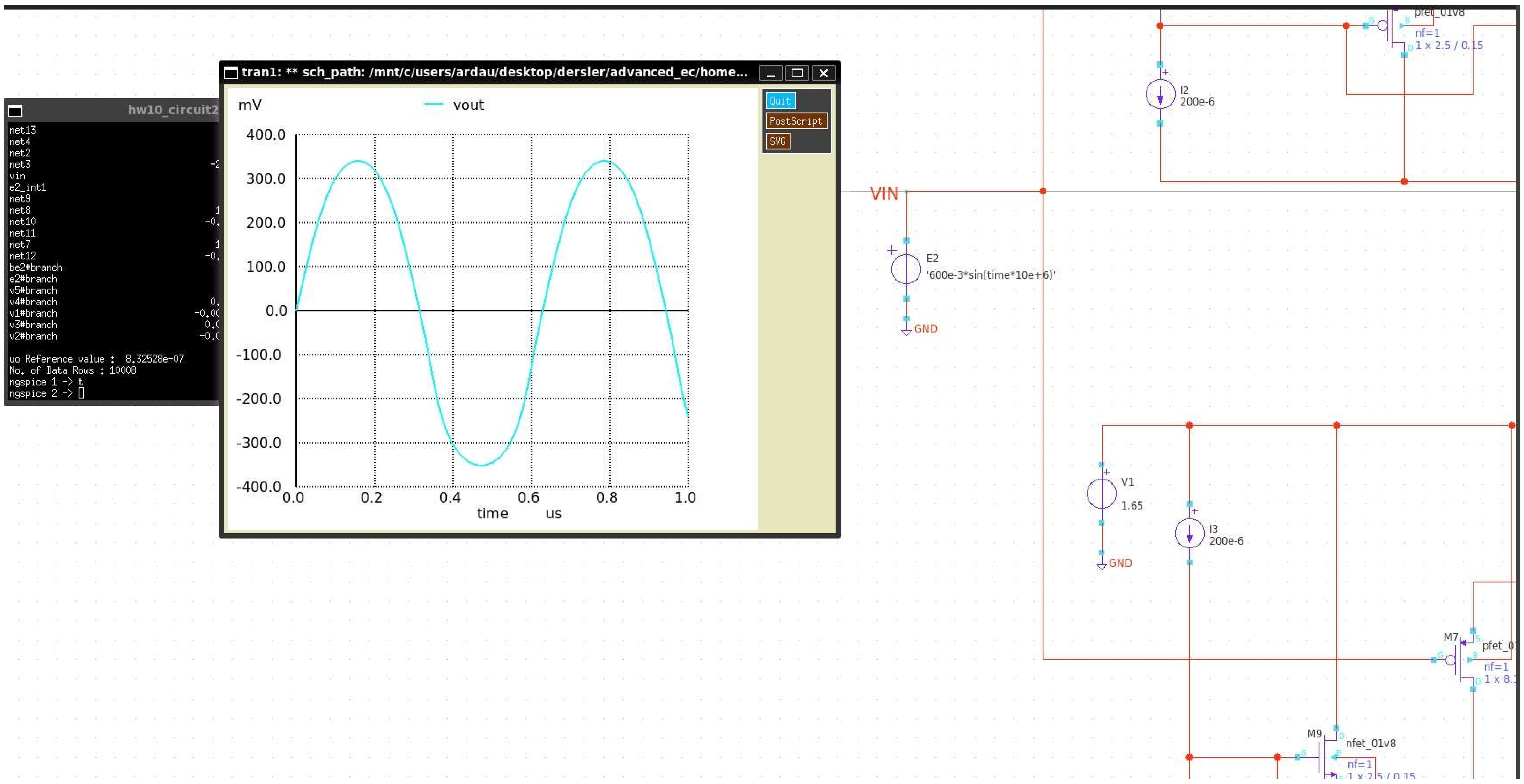
$f_{V_{in}} = 100\,kHz$



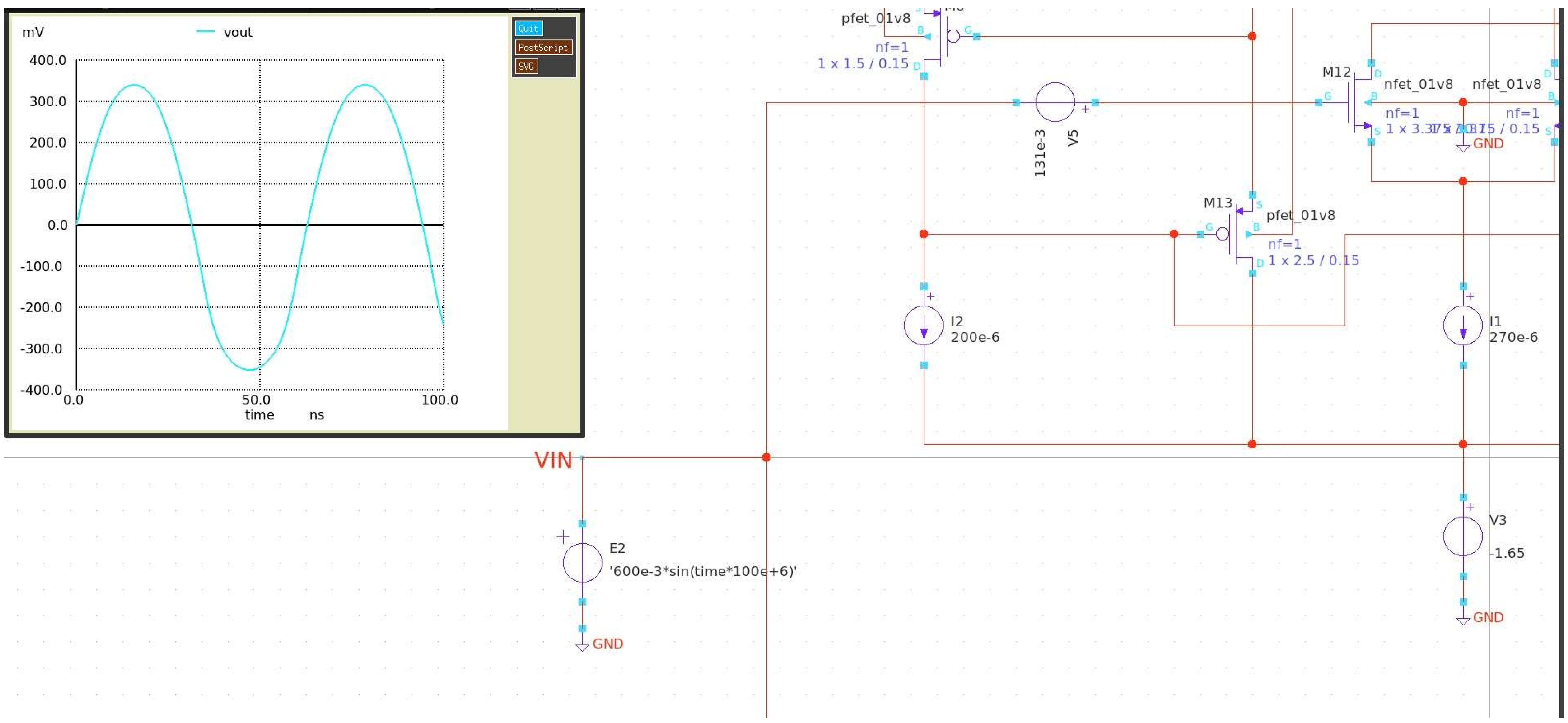
$f_{V_{in}} = 1\,MHz$



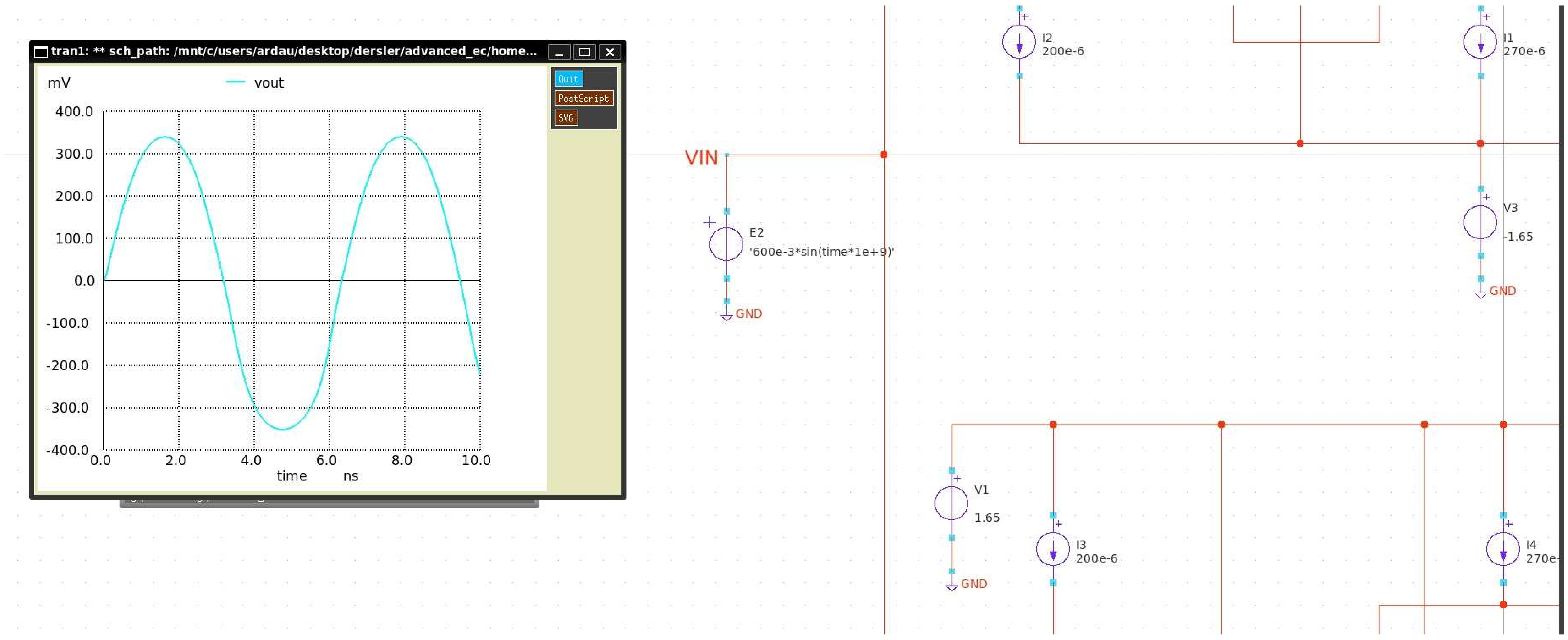
$f_{V_{in}} = 10\,MHz$



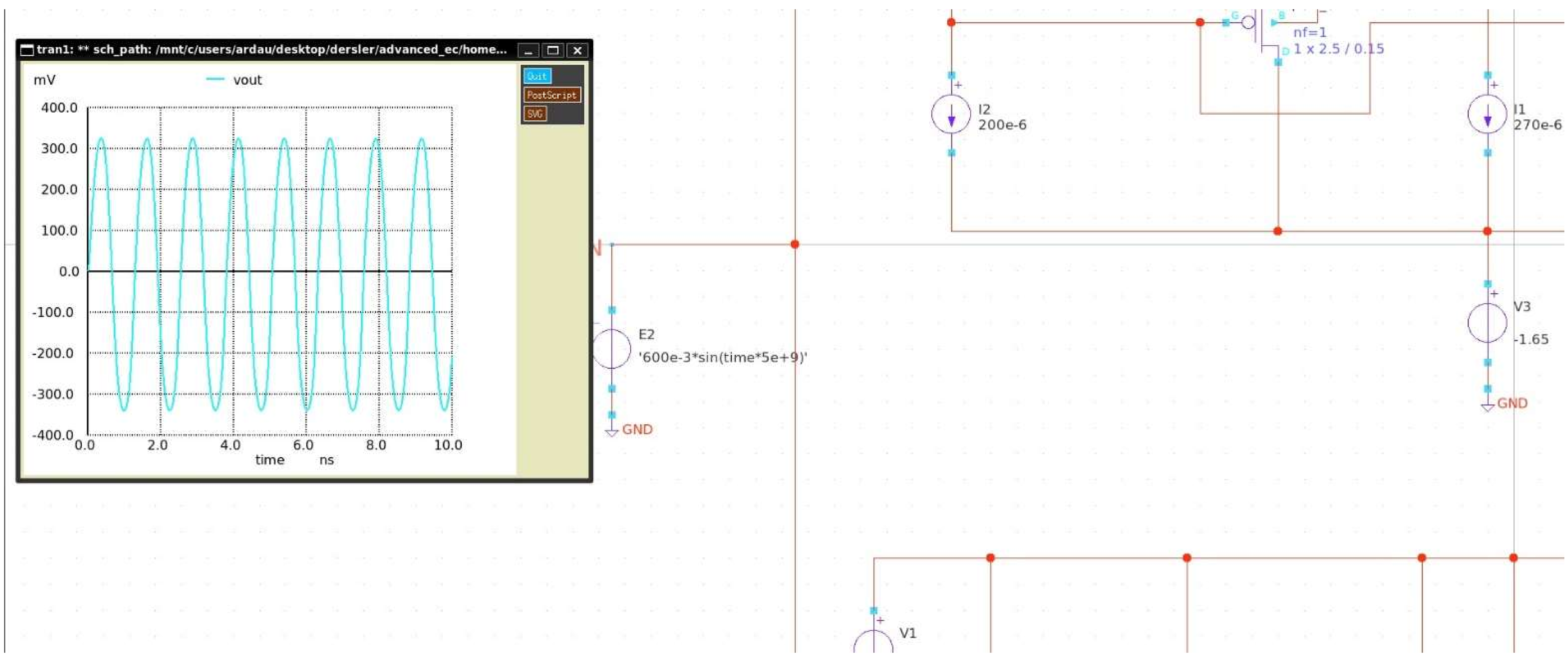
$f_{V_{in}} = 100\,MHz$



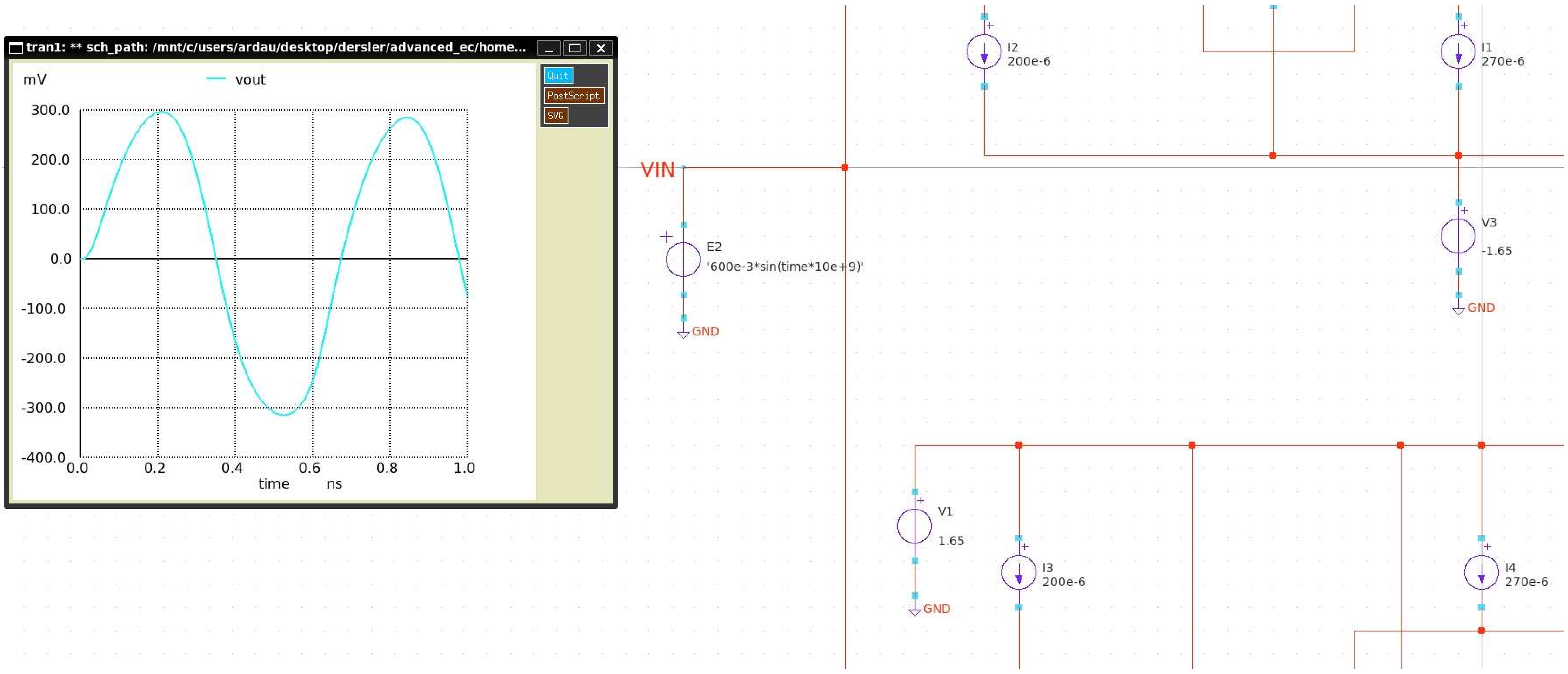
$f_{V_{in}} = 1\,GHz$



$f_{V_{in}} = 5\,GHz$



$f_{V_{in}} = 10\ GHz \rightarrow$ Distortion starts



$$P_{in} = 2 \times 200 \times 10^{-6} \times 3.3 = 1.32\ mW$$

$$P_{out} = \frac{V_{RMS}^2}{R} = \frac{(350 \times 10^{-3}/\sqrt{2})^2}{100} = 0.6125\ mW$$

$$\Rightarrow \eta = \frac{P_{out}}{P_{in}} \times 100\% = 46.4\ \% \rightarrow \text{up to } 5\ GHz$$

For $f = 5\ GHz$

$$\eta = 37.585\ \%$$

For $f = 10\ GHz$

$$\eta = 34.1\ \%$$