Spec.			
Differential Amplifier with Resistive Load			
DC Gain	≥ 0 dB	IREF	10 uA
BW	≥ 15 GHz	CMRR	≥ 40 dB
Linear Range	≥ 300 mVpp	Cap Load	100 fF
Power Consumption	≤ 2.5 mW	Max current mirroring	20

- Steps

Sizing of M1,2

01 | $P_{cons} = V_{DD}\, I_D \leq 2.5\ mW \rightarrow I_{SS} \leq 2\ mA$

02 | $LR = 2\sqrt{2}\, V_{ov} \geq 300\ mV_{pp} \rightarrow V_{ov} \geq 106 \rightarrow$ Replace V_{ov} with $V^* \rightarrow V^* \geq 106\ mV \rightarrow \frac{g_m}{I_D} < 18.9$

03 | $GBW = \frac{g_m}{2\pi C_{out}} \geq 15\ GHz \rightarrow g_m \geq 9.5\ mS \rightarrow g_m = 14\ mS \rightarrow \frac{g_m}{I_D} = 14 \rightarrow I_D = 1\ mA \rightarrow I_{SS} = 2\ mA$

04 | $A_v = g_m R_{out} \geq 1 \rightarrow R_{out} \geq 75\ \Omega \rightarrow R_D = 90\ \Omega \rightarrow r_o \geq 425 \rightarrow g_m r_o \geq 6$

05 | $V_{out} = 1.2 - I_D R_D = 1.1\ V \rightarrow$ Assume $V_{DS1} = 600\ mV \rightarrow V_p = 500\ mV$

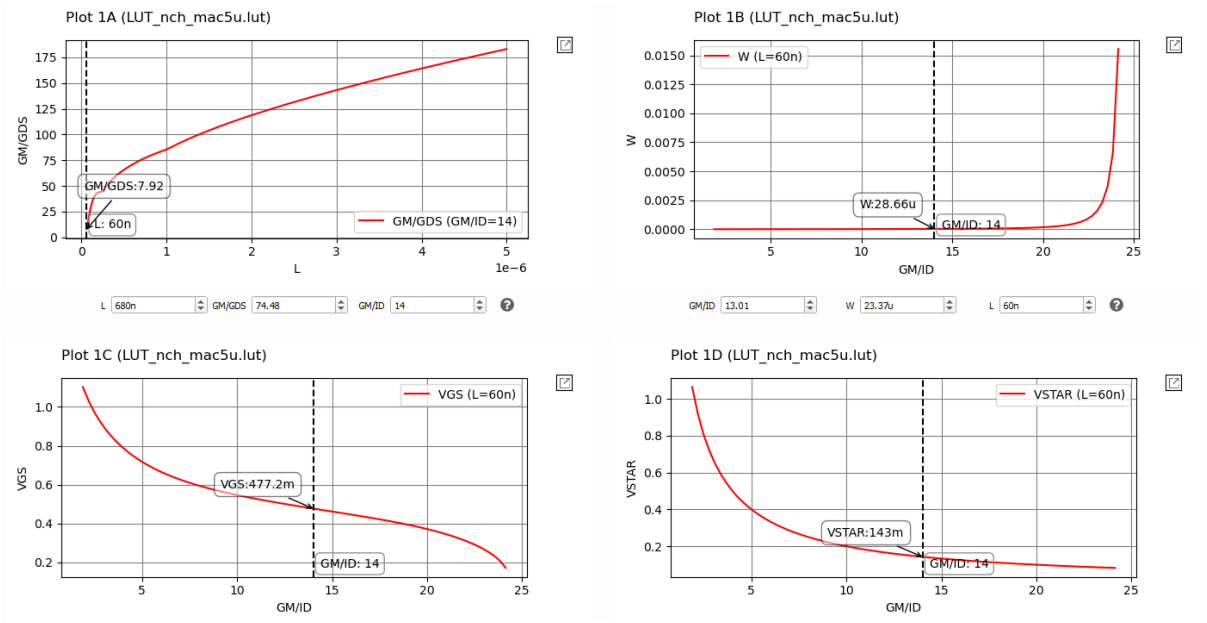
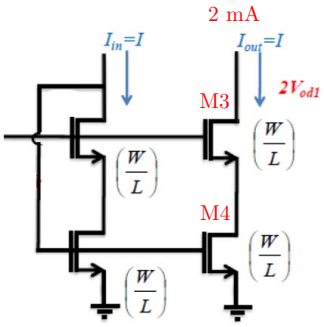


Fig. Sizing of M1,2

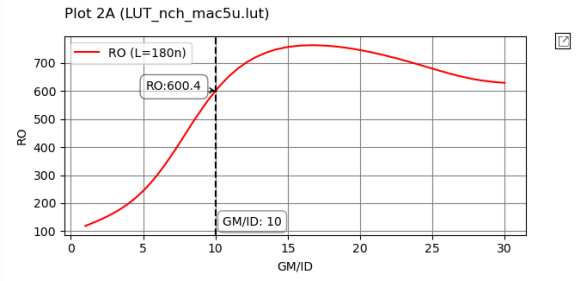
Sizing of M3,4

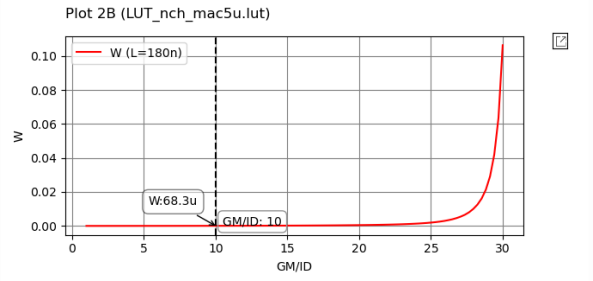
06 | As $I_{ref} = 10\ uA$, we will mirror the current with two stage 10 uA to 100 uA and 100 uA to 2 mA



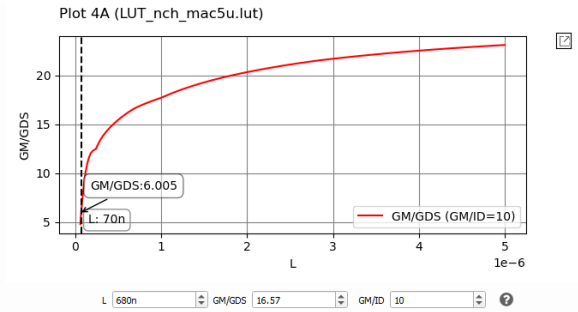
07 | $V_p = V_3^* + V_4^* \leq 500\ \text{mV} \rightarrow \text{Assume } V_3^* = V_4^* = 200\ \text{mV} \rightarrow \left(\frac{g_m}{I_D}\right)_3 = \left(\frac{g_m}{I_D}\right)_4 = 10$

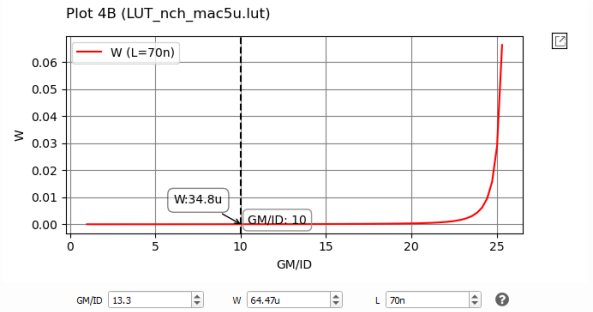
08 | Assume $L_4 = 3 \times L_{min} = 180\ \text{nm} \rightarrow r_{o4} = 600\ \Omega$

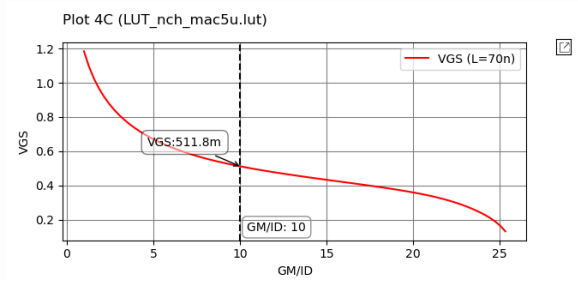


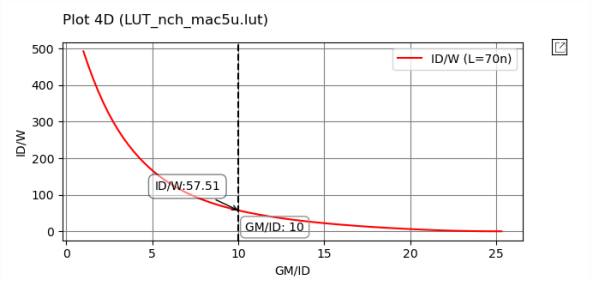


09 | $\because \text{CMRR} = 2 \times g_m R_{SS} \geq 40\ \text{dB} \rightarrow R_{SS} \geq 3.5\ \text{k}\Omega \rightarrow R_{SS} = r_{o4} \times g_{m3} r_{o3} \rightarrow g_{m3} r_{o3} \geq 5.85$



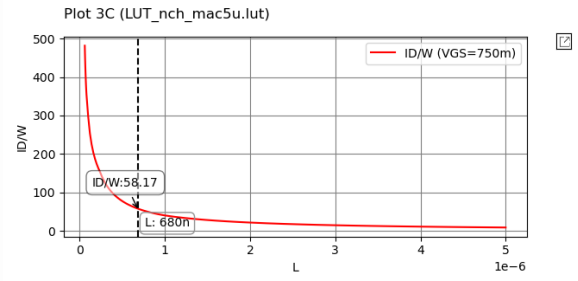


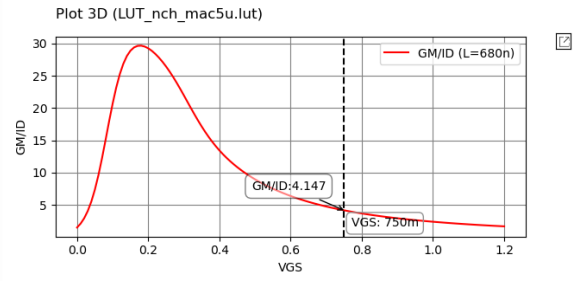




10 | $\because V_{GS5} = V_{GS3} + V_4^* = 711.8\ \text{mV} \rightarrow V_{GS5} = 750\text{mV}$ a littel deeper into saturation and JD = 57.51

11 | Sweeping L_5 that gives the same JD @ same $W_3 \rightarrow L_5 = 680\ \text{nm}$



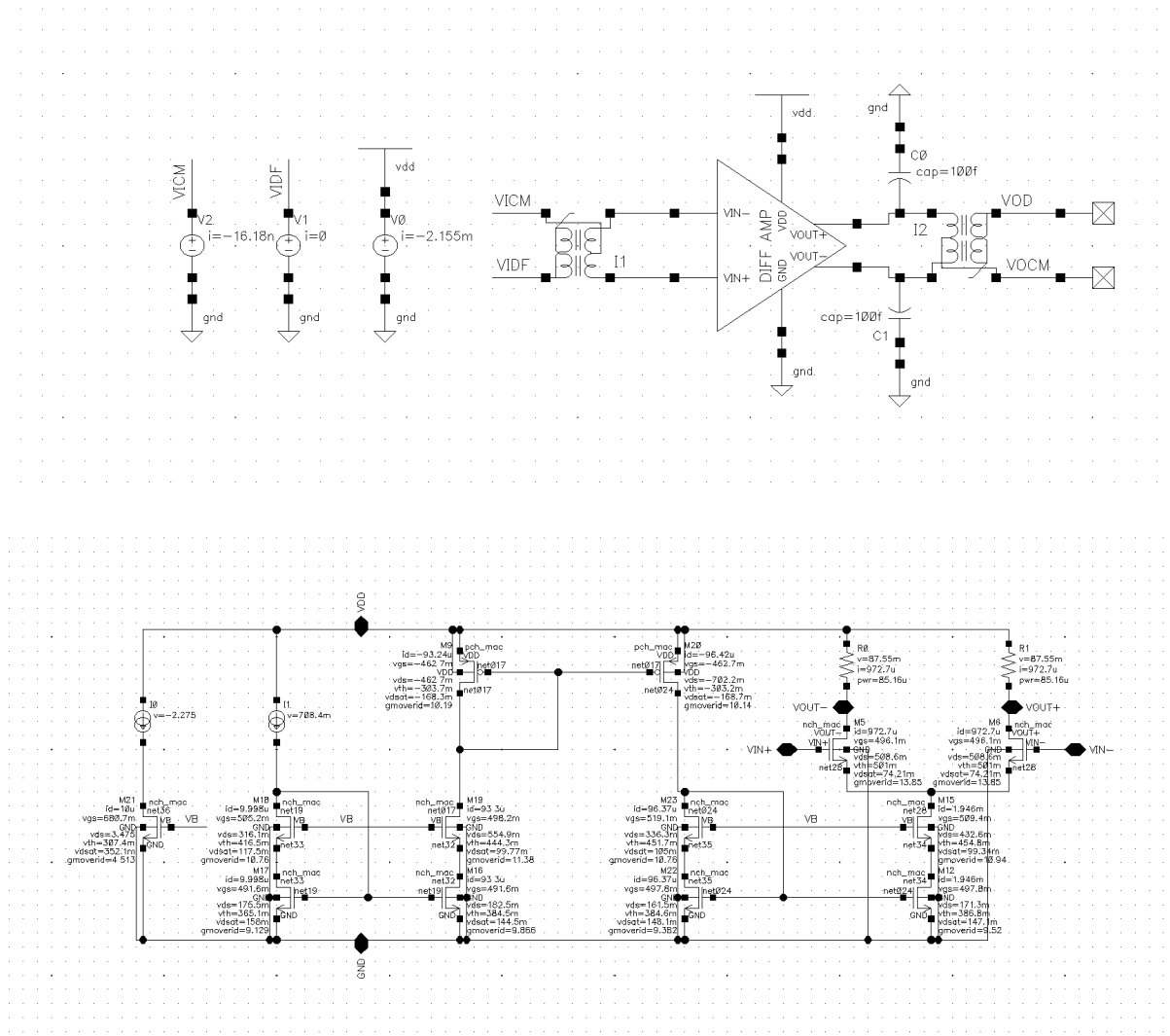


12 | $V_{GS1,2} + V_3^* + V_4^* \leq \text{CMIR} < V_{GS1,2} - V_{1,2}^* - V_{RD} + V_{DD} \rightarrow 0.8772 \leq \text{CMIR} < 1.44 \rightarrow \text{CMIR} = 1.1\ \text{V}$

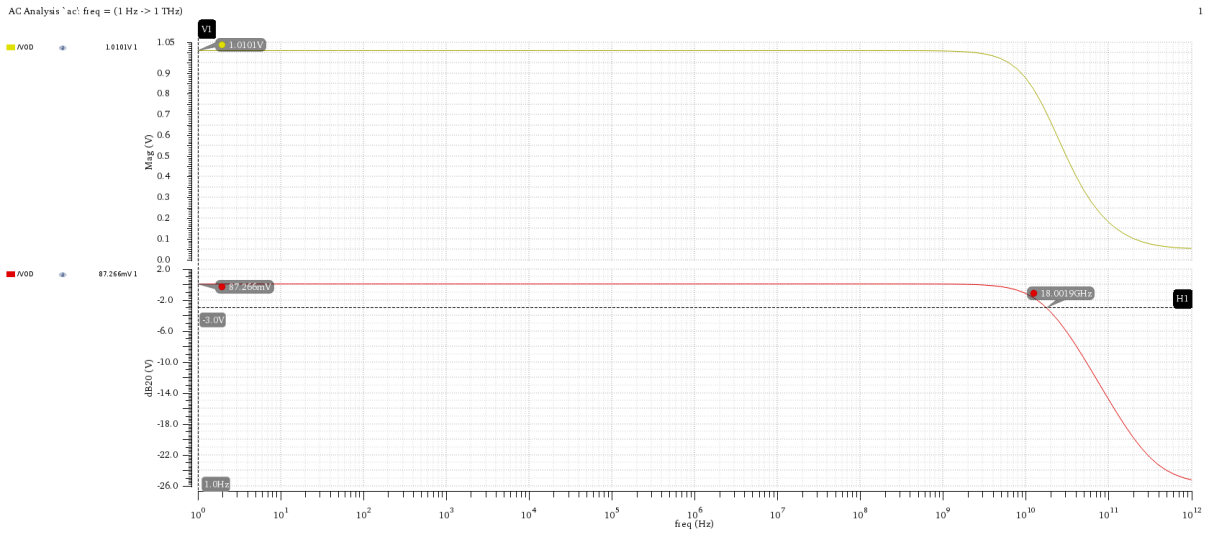
Sizing Summary					
M	M1	M2	M3	M4	M5
Rule	Input pair	Input pair	Cascode device	Mirroring device	Magic battery
L	60 nm	60 nm	70 nm	180 nm	680 nm
W	28.66 um	28.66 um	34.8 um	68.3 um	175 nm
Gmoverid	14	14	10	10	4.147

- Results

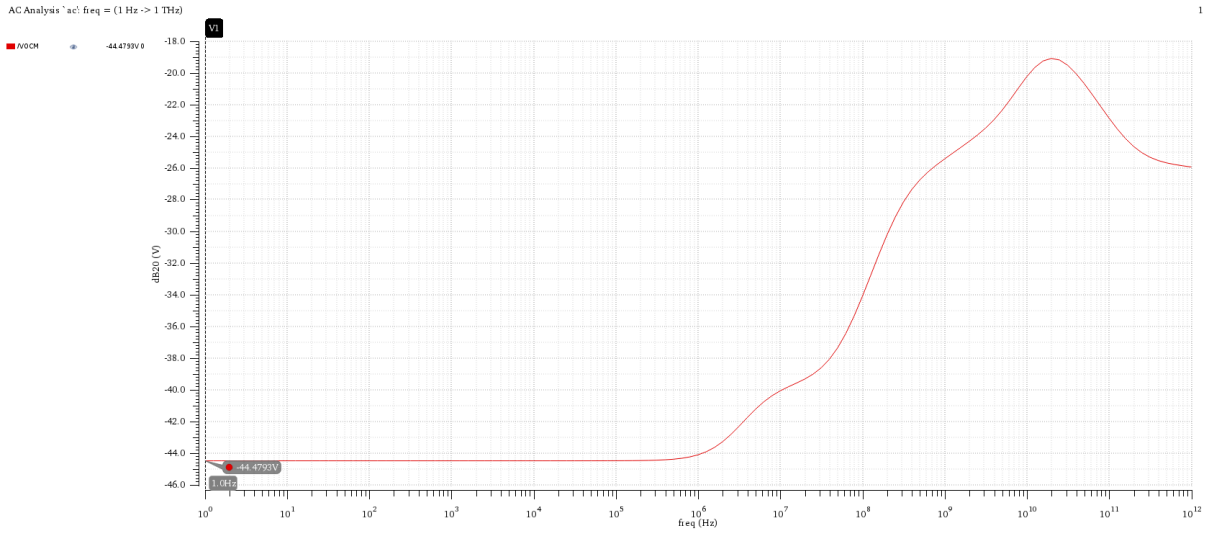
1. TB and DC Operating Point



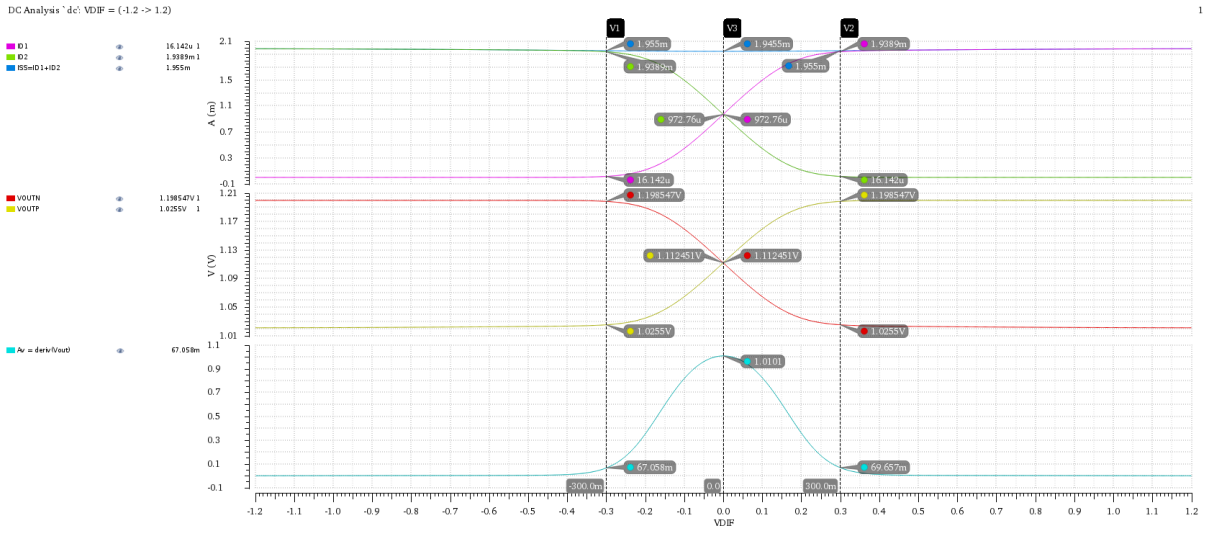
2. Differential Small Signal Analysis



3. Common Mode Small Signal Analysis



4. Differential Large Signal Analysis



5. Common Mode Large Signal Analysis