

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 | $P_{\text{cons}} = V_{\text{DD}} I_{\text{D}} \leq 2.5 \text{ mW} \rightarrow I_{\text{SS}} \leq 2 \text{ mA}$
- 02 | $\text{LR} = 2\sqrt{2} V_{\text{ov}} \geq 300 \text{ mV}_{\text{pp}} \rightarrow V_{\text{ov}} \geq 106 \rightarrow \text{Replace } V_{\text{ov}} \text{ with } V^* \rightarrow V^* \geq 106 \text{ mV} \rightarrow \frac{g_m}{I_{\text{D}}} < 18.9$
- 03 | $\text{GBW} = \frac{g_m}{2\pi C_{\text{out}}} \geq 15 \text{ GHz} \rightarrow g_m \geq 9.5 \text{ mS} \rightarrow g_m = 14 \text{ mS} \rightarrow \frac{g_m}{I_{\text{D}}} = 14 \rightarrow I_{\text{D}} = 1 \text{ mA} \rightarrow I_{\text{SS}} = 2 \text{ mA}$
- 04 | $A_v = g_m R_{\text{out}} \geq 1 \rightarrow R_{\text{out}} \geq 75 \Omega \rightarrow R_{\text{D}} = 90 \Omega \rightarrow r_o \geq 425 \rightarrow g_m r_o \geq 6$
- 05 | $V_{\text{out}} = 1.2 - I_{\text{D}} R_{\text{D}} = 1.1 \text{ V} \rightarrow \text{Assume } V_{\text{DS1}} = 600 \text{ mV} \rightarrow V_{\text{p}} = 500 \text{ mV}$

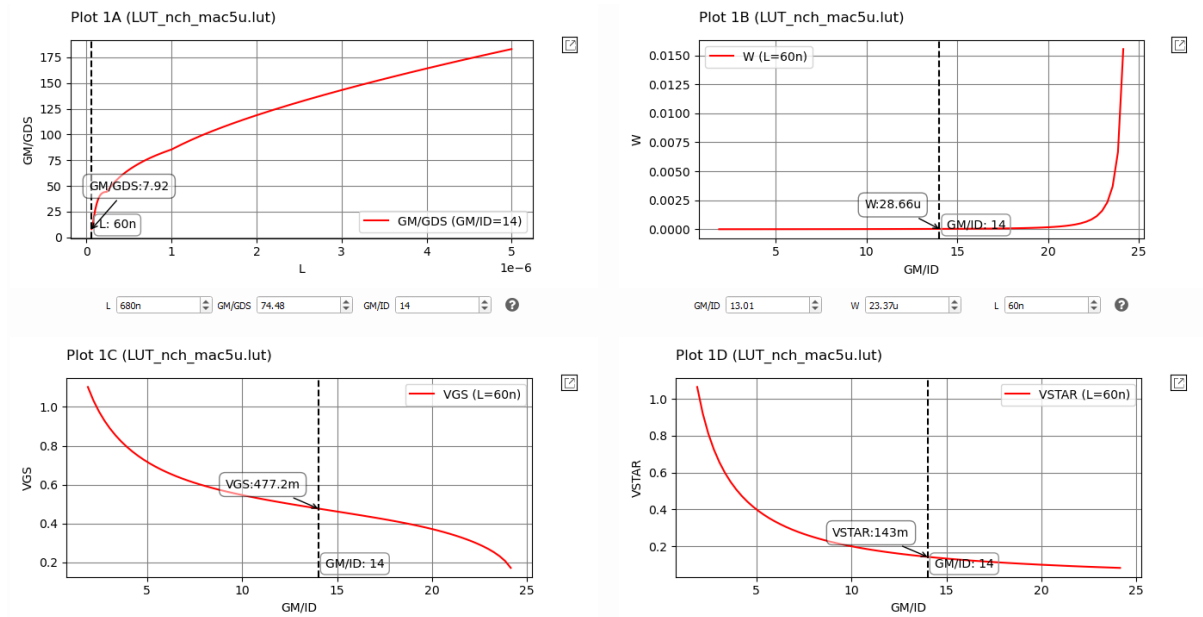
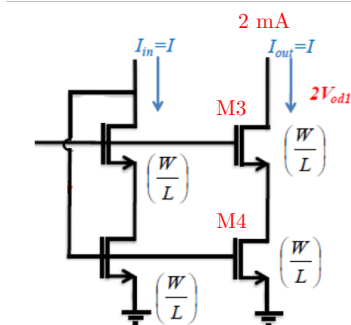


Fig. Sizing of M1,2

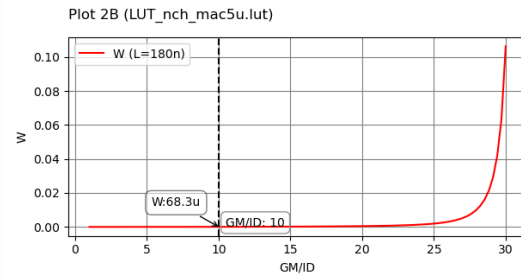
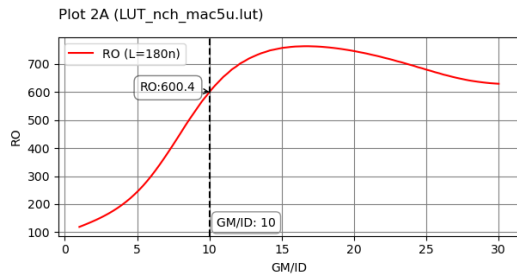
Sizing of M3,4

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

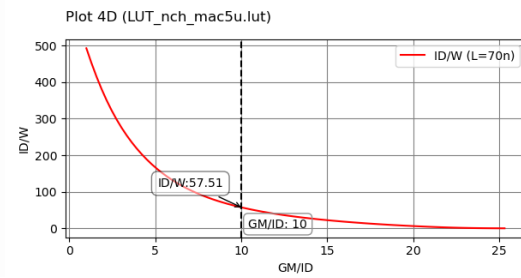
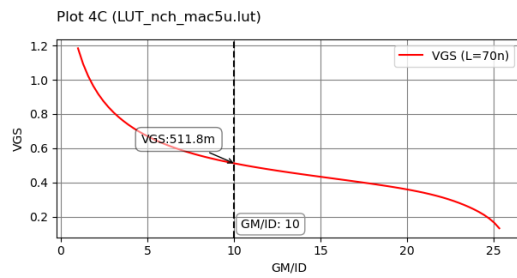
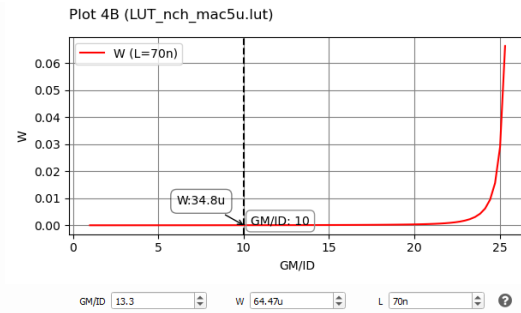
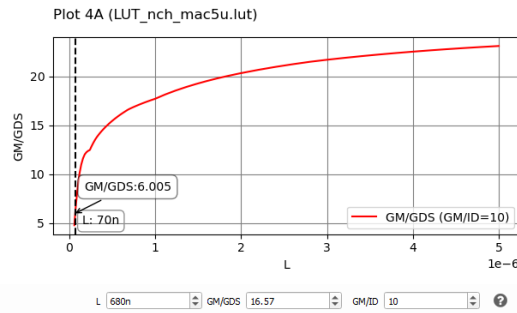


07 | $V_p = V_3^* + V_4^* \leq 500 \text{ mV} \rightarrow \text{Assume } V_3^* = V_4^* = 200 \text{ mV} \rightarrow \left(\frac{g_m}{I_D}\right)_3 = \left(\frac{g_m}{I_D}\right)_4 = 10$

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

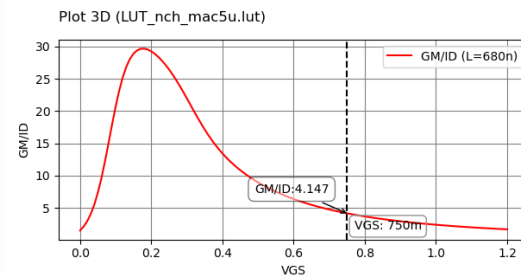
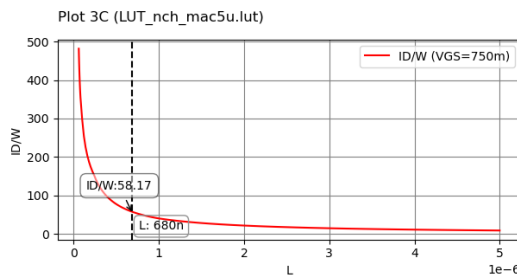


09 | $\therefore \text{CMRR} = 2 \times g_m R_{SS} \geq 40 \text{ dB} \rightarrow R_{SS} \geq 3.5 \text{ k}\Omega \rightarrow R_{SS} = r_{o4} \times g_{m3} r_{o3} \rightarrow g_{m3} r_{o3} \geq 5.85$



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

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



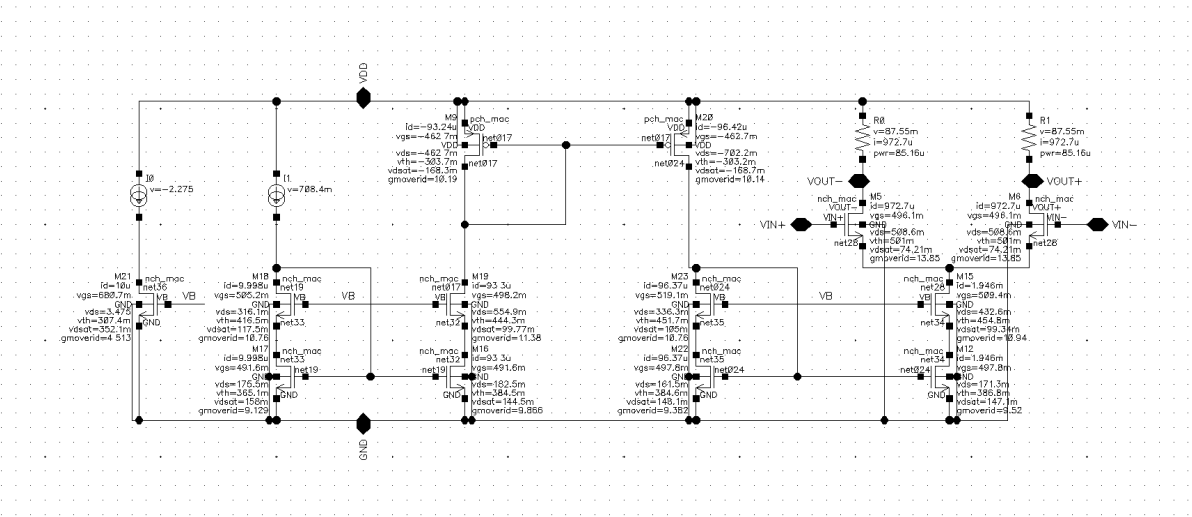
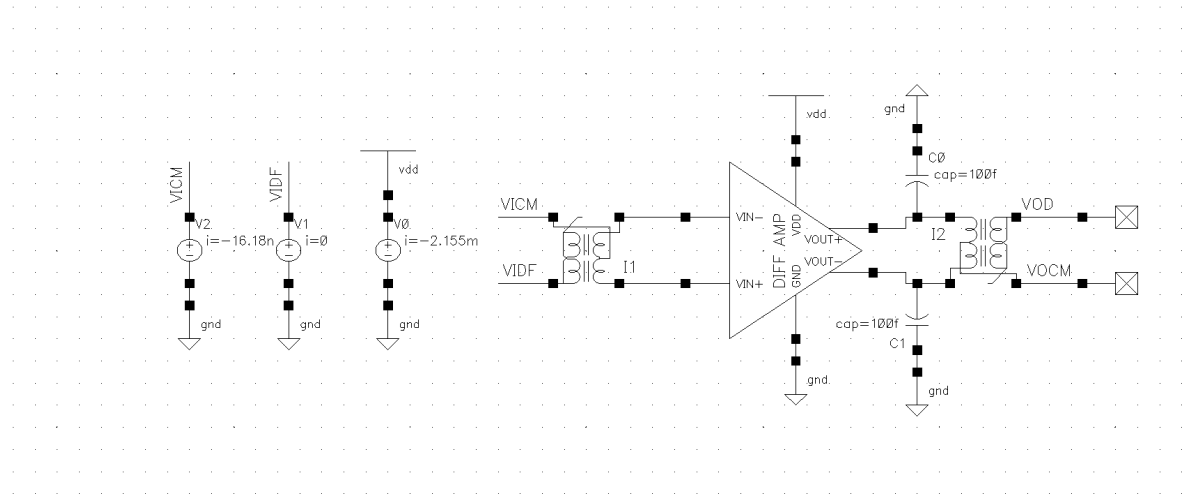
12 | $V_{GS1,2} + V_3^* + V_4^* \leq \text{CMIR} < V_{GS1,2} - V_{1,2}^* - V_{RD} + V_{DD} \rightarrow 0.8772 \leq \text{CMIR} < 1.44 \rightarrow \text{CMIR} = 1.1 \text{ V}$

Sizing Summary

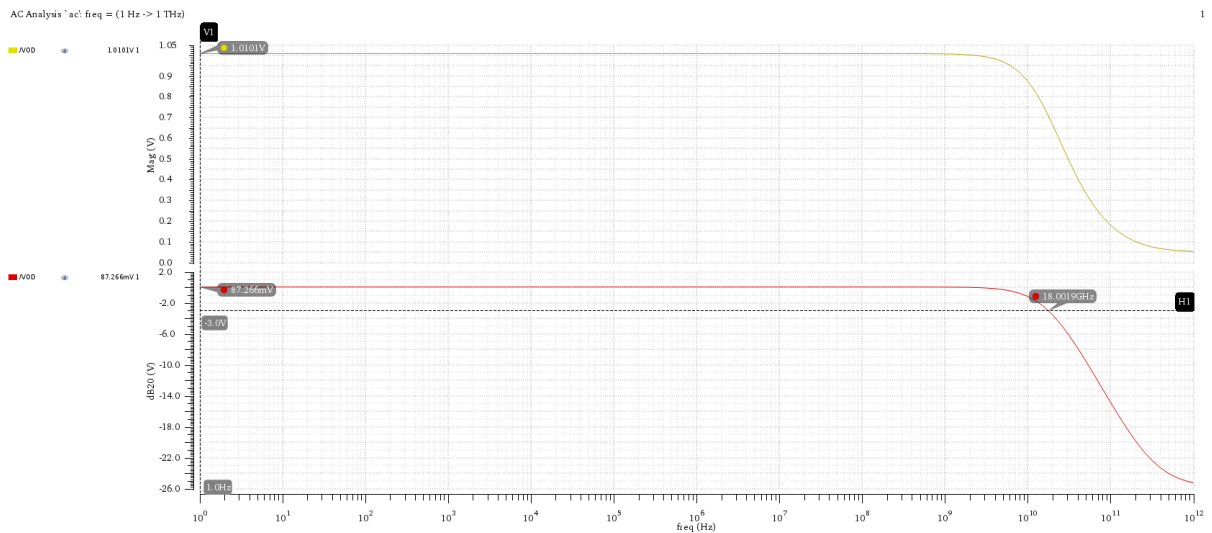
M	M1	M2	M3	M4	M5
Rule	Input pair	Input pair	Cascode device	Mirroring device	Magic battery
L	60 nm	60 nm	70 nm	180 nm	680 nm
W	28.66 um	28.66 um	34.8 um	68.3 um	175 nm
Gmoverid	14	14	10	10	4.147

- Results

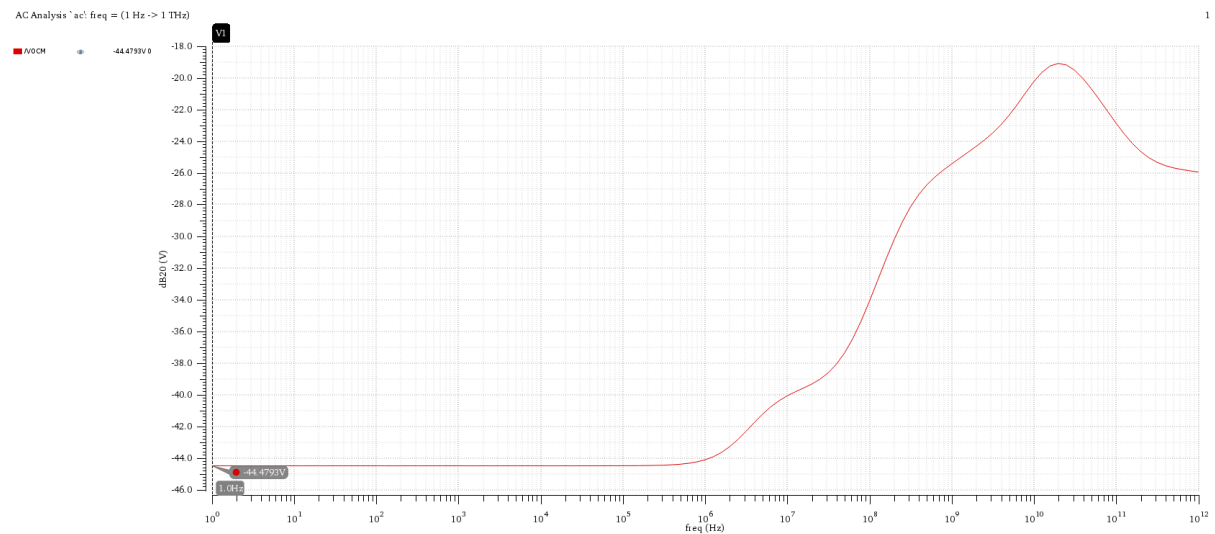
1. TB and DC Operating Point



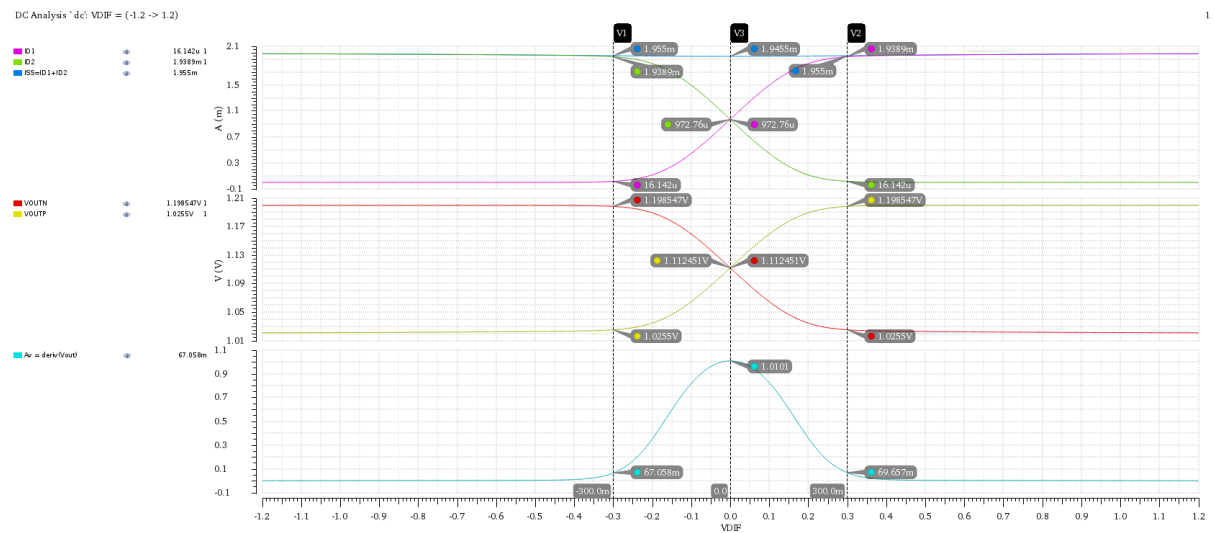
2. Differential Small Signal Analysis



3. Common Mode Small Signal Analysis



4. Differential Large Signal Analysis



5. Common Mode Large Signal Analysis

