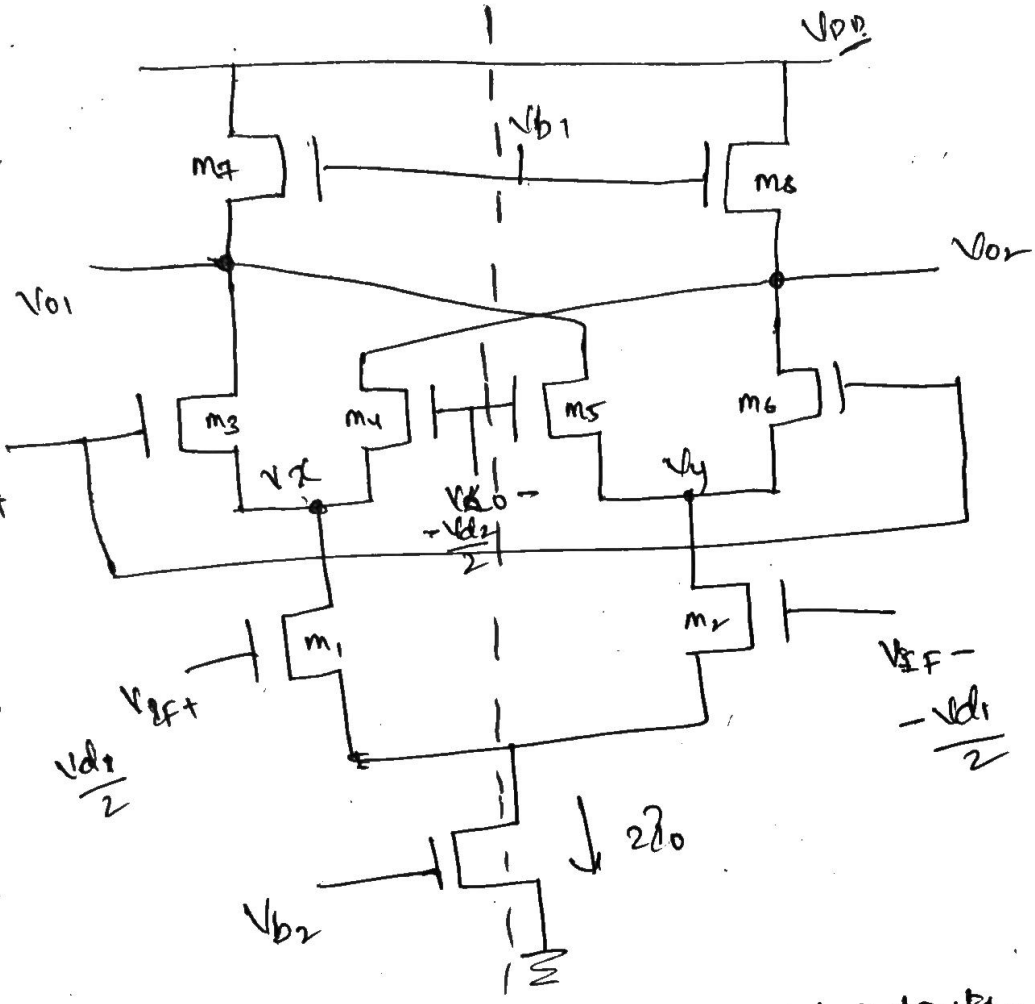


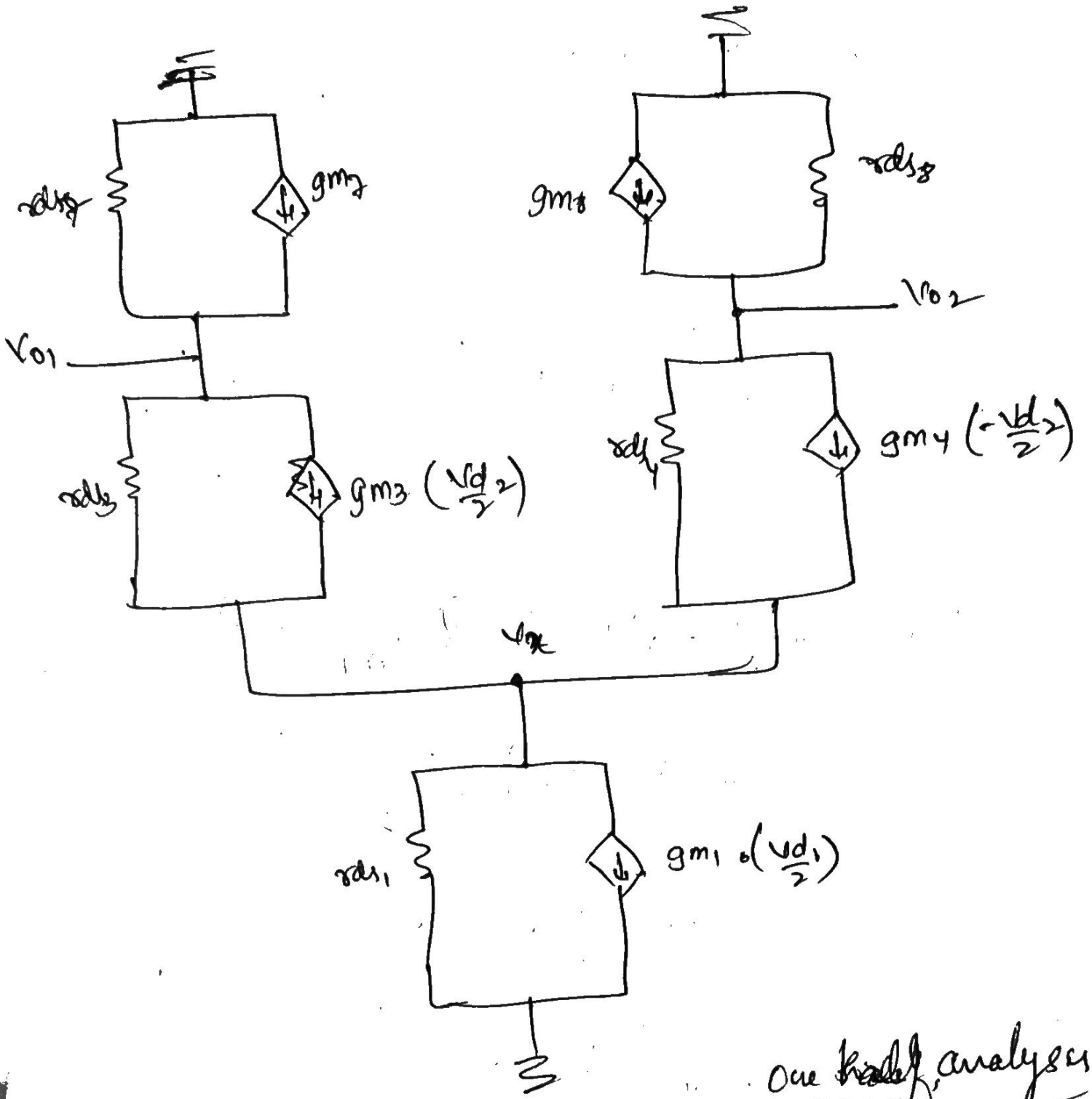
Differential Inputs & Differential outputs.

let , $\frac{Vd_1}{2}$ & $\frac{-Vd_1}{2}$ be differential iputs to V_{EF}

$\frac{Vd_2}{2}$ & $\frac{-Vd_2}{2}$ be differential inputs to V_{LO}

an also place an symmetry line and analyse thro

ric half analysis.



One half analysis.

$$V_x = -g_{m1}\frac{V_{d1}}{2}\left(r_{ds1} \parallel \left[\left(\frac{1}{g_{m3}} \parallel r_{ds3}\right) + \left(\frac{1}{g_{m7}} \parallel r_{ds7}\right)\right] \parallel \left[\left(\frac{1}{g_{m4}} \parallel r_{ds4}\right) + \left(\frac{1}{g_{m8}} \parallel r_{ds8}\right)\right]\right.$$

$$= -g_{m1}\frac{V_{d1}}{2}\left(r_{ds1} \parallel \left(\frac{1}{g_{m3}} + \frac{1}{g_{m7}}\right) \parallel \left(\frac{1}{g_{m4}} + \frac{1}{g_{m8}}\right)\right.$$

Since $\frac{1}{g_m}$ is much much smaller than r_{ds}.

- Let us consider,

$$\Rightarrow \left(r_{ds1} \parallel \left(\frac{1}{g_{m3}} + \frac{1}{g_{m7}}\right) \parallel \left(\frac{1}{g_{m4}} + \frac{1}{g_{m8}}\right)\right]$$

$$\Rightarrow \left(r_{ds} \parallel 2\left(\frac{1}{g_{m3}} + \frac{1}{g_{m7}}\right)\right] \quad \text{as they are identical.}$$

$$\Rightarrow \left(2\frac{1}{g_{m3}} + \frac{1}{g_{m7}}\right) \quad \text{because}$$

So we get,

$$= -g_{m1}\frac{V_{d1}}{2}\left(2\frac{1}{g_{m3}} + \frac{1}{g_{m7}}\right)$$

$$\boxed{V_x = -g_{m1}\left(\frac{g_{m7} + g_{m3}}{g_{m3}\, g_{m7}}\right) \cdot V_{d1}}$$

$$V_{out_1} = -g_{m_3} \cdot V_x \cdot \frac{V_{d_2}}{2} \cdot \left(r_{ds_3} + \left(r_{ds_1} \parallel \frac{1}{g_{m_1}} \right) \parallel \left[r_{ds_7} \parallel \frac{1}{g_{m_7}} \right) \right]$$

$$= \frac{-g_{m_3} \cdot V_x \cdot V_{d_2}}{2}$$

Consider,

$$\Rightarrow \left[r_{ds_3} + \left(r_{ds_1} \parallel \frac{1}{g_{m_1}} \right) \right] \parallel \left[\left(r_{ds_7} \parallel \frac{1}{g_{m_7}} \right) \right]$$

$$\Rightarrow \left[r_{ds_3} + \frac{1}{g_{m_1}} \right] \parallel \left[\frac{1}{g_{m_7}} \right]$$

$$\Rightarrow \frac{1}{g_{m_7}}$$

because $\frac{1}{g_m}$ is much much smaller than any r_{ds}.

So, we have,

$$= -g_{m_3} \cdot V_x \cdot \frac{V_{d_2}}{2} \cdot \left(\frac{1}{g_{m_7}} \right)$$

$$= -g_{m_3} \cdot \frac{V_{d_2}}{2} \cdot \left(\frac{1}{g_{m_7}} \right) \cdot \left[-g_{m_1} \left(\frac{g_{m_7} + g_{m_3}}{g_{m_7} \cdot g_{m_3}} \right) \cdot V_{d_1} \right]$$

$$\boxed{V_{o_1} = \frac{V_{d_2}}{2} g_{m_1} \frac{V_{d_2}}{2} \cdot V_{d_1} \cdot \frac{g_{m_7} + g_{m_3}}{(g_{m_7})^2}}$$