EE 414 INTRODUCTION TO ANALOG INTEGRATED CIRCUITS

Example

Common Mode Feedback

Q1. Fig. 1 shows common mode feedback network.

a) Obtain common mode output expression in terms of I_D, V_{b4} and transistor parameters.

b) Define possible handicaps of these type of CMFB networks

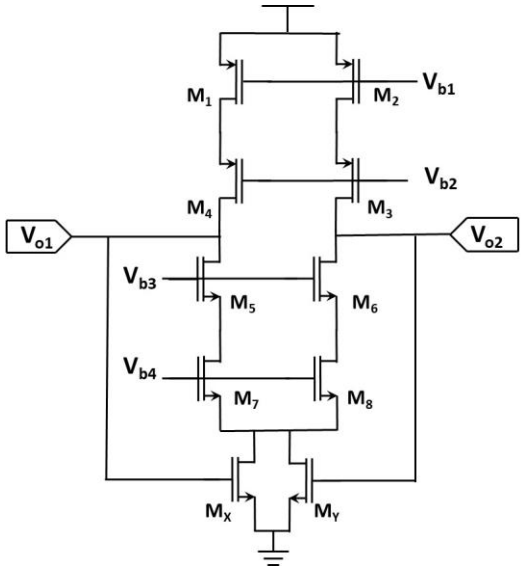
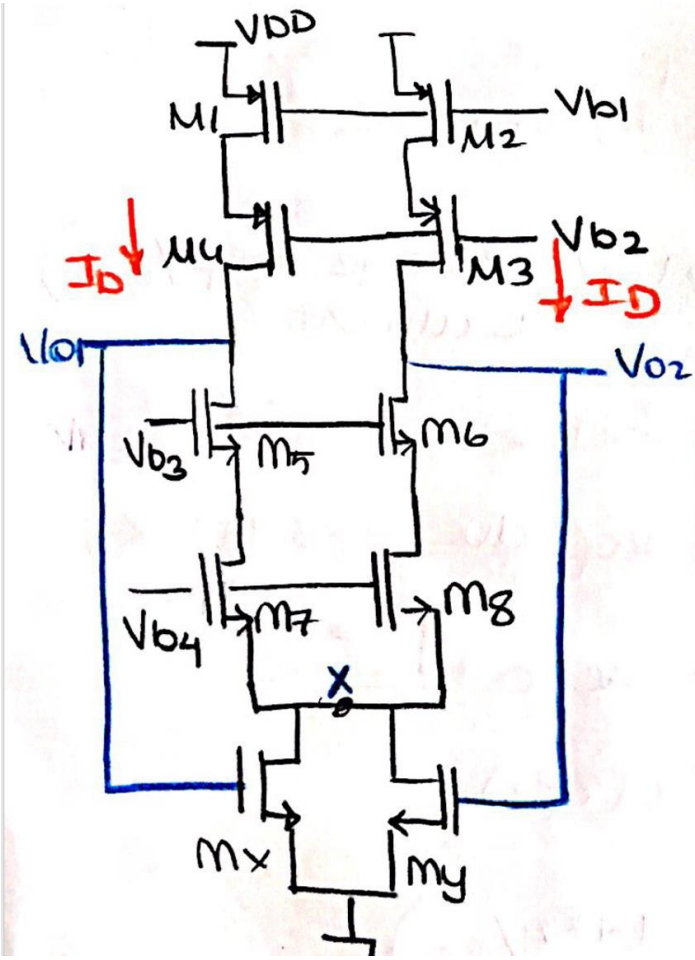


Fig 1. CMFB network



If M operates in linear region, it can be assumed as a resistor

$$I_D = K_N\left[(V_{GS}-V_{TN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

If V_{DS} is small.

$$I_D = K_N\left[(V_{GS}-V_{TN})V_{DS}\right]$$

$$R_{ON} = \frac{V_{DS}}{I_D} = \frac{1}{K_N(V_{GS}-V_{TN})}$$

In our circuit, MX & MY can be used as resistors.

$$I_D = K_N\left[(V_{GSX} - V_{TN})V_{DSX} - \frac{V_{DSX}^2}{2}\right]$$

$$\Rightarrow R_{ONX} = \frac{1}{K_N(V_{GSX} - V_{TN})}$$

K_N: $\mu_n C_{ox}(W/L)_{X,Y}$; V_{GSX}: V_{O1}

$$R_{ONX} = \frac{1}{\mu_n C_{ox}(W/L)_X(V_{O1} - V_{TN})}$$

$$R_{ONY} = \frac{1}{\mu_n C_{ox}(W/L)_Y(V_{O2} - V_{TN})}$$

At node X: $R_{ONX} \parallel R_{ONY}$

$(W/L)_X = (W/L)_Y$

$$R_{ONX} \parallel R_{ONY} = \frac{\left(\frac{1}{\mu_n C_{ox}(W/L)_X(V_{O1} - V_{TN})}\right)\left(\frac{1}{\mu_n C_{ox}(W/L)_X(V_{O2} - V_{TN})}\right)}{\frac{1}{\mu_n C_{ox}(W/L)_X}\left(\frac{1}{V_{O1} - V_{TN}} + \frac{1}{V_{O2} - V_{TN}}\right)}$$

$$R_{ONX} \parallel R_{ONY} = \frac{1}{\mu_n C_{ox}(W/L)_{X,Y}(V_{O1} + V_{O2} - 2V_{TN})} = \frac{V_{b4} - V_{GS7}}{2I_D}$$

(I_D due to M7)

$$\rightarrow V_{O1} + V_{O2} = \frac{2I_D}{\mu_n C_{ox}(W/L)_{X,Y}(V_{b4} - V_{GS7})} + 2V_{TN} \quad \text{(I)}$$

I_D flows through M7

$$I_D = \frac{K_{N7}}{2}(V_{GS7} - V_{TN})^2 \rightarrow V_{GS7} = \sqrt{\frac{2I_D}{\mu_n C_{ox}(W/L)_7}} + V_{TN} \quad \text{(II)}$$

Using (I) and (II)

Since circuit is symmetric $V_{O1} = V_{O2}$

$$V_{O1} = V_{O2} = \frac{I_D}{\mu_n C_{ox} \left(W/L\right)_{X,Y} \left(V_{b4} - \sqrt{\frac{2 I_D}{\mu_n C_{ox} (W/L)_7}} - V_{TN}\right)} + V_{TN}$$

b) There are some drawbacks of CMFB.

I.) Output voltage is a function of device parameters. There might be differences between the components during manufacturing.

II.) Voltage drop on M_X and M_Y $\longrightarrow$ $R_{ONX} \| R_{ONY}$ limits the output voltage swing.

III.) In order to improve the voltage drop on X & Y, their size can be increased. However, in that case capacitance appears at the output.