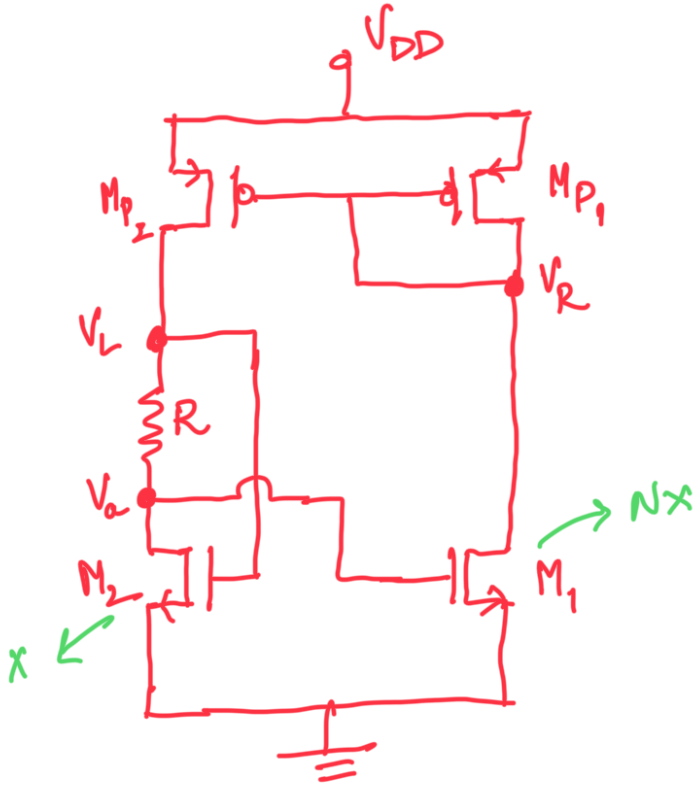
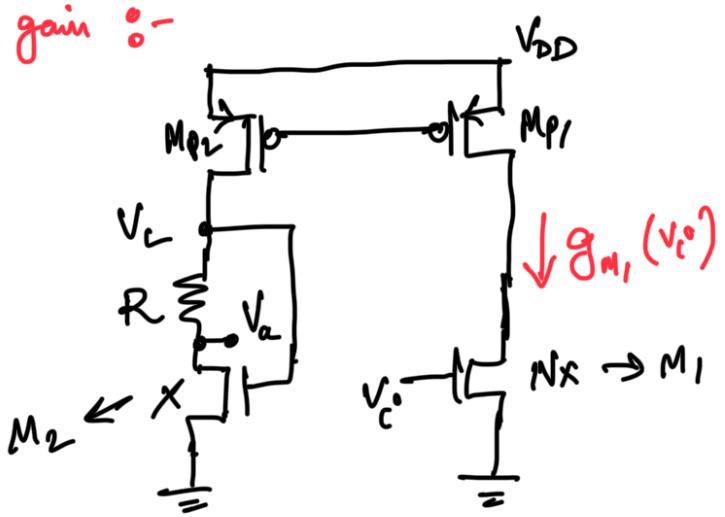
Analysis of Beta - Multiplier [Variant - II]



Assume,
Pmos current mirrors identical.
$\lambda = 0$ for all devices

open loop gain :-



$$I_{MP_1} = g_{m_1}(V_i)$$

$$I_{MP_2} = g_{m_1}(V_i)$$ (since identical Pmos - current mirror)

$$V_L = \frac{1}{g_{m_2}} \cdot I_{MP_2} = \frac{g_{m_1}}{g_{m_2}} \cdot V_i$$

$$V_L = \frac{g_{m_1}}{g_{m_2}} \cdot V_i$$

$$V_a = V_L - I_{MP_2} \cdot R$$

$$= \frac{g_{m1}}{g_{m2}} v_i - g_{m_1} v_i R$$

$$V_a = g_{m_1} v_i \left[\frac{1}{g_{m_2}} - R \right]$$

$$= g_{m_1} \left[\frac{1 - g_{m_2} R}{g_{m_2}} \right]$$

$$= \frac{g_{m_2} \sqrt{N} \left[1 - g_{m_2} R \right]}{g_{m_2}}$$

$$\left(\text{Since, } \left(\frac{W}{L} \right)_{M_1} = N \left(\frac{W}{L} \right)_{M_2} \right)$$

$$\boxed{\frac{V_a}{V_i} = \sqrt{N} \left[1 - g_{m_2} R \right]}$$

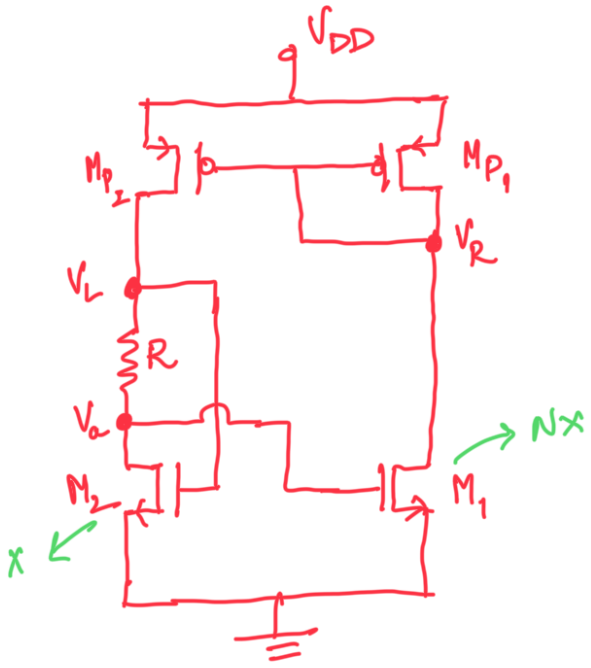
(or)

$$\boxed{\frac{V_a}{V_i} = \sqrt{N} - g_{m_1} R}$$

The primary focus of this topology is to servo the g_m of the mosfet with precise off-chip resistor 'R' in the circuit.

If the topology is stable, then $I_{MP_1} = I_{MP_2}$.

•) Let $V_{OD,M1}$ is the overdrive voltage of M_1



$$V_a = V_{OD,M1}$$

$$\Rightarrow V_L = \sqrt{N}\left[V_{OD,M1}\right]$$

$$V_L - V_a = \sqrt{N}\left[V_{OD,M_1}\right] - V_{OD,M1}$$

$$V_L - V_a = IR$$

$$V_{OD,M_1}\left[\sqrt{N}-1\right] = IR$$

$$\frac{\left[\sqrt{N}-1\right]}{R} = \frac{I}{V_{OD,M1}}$$

$$\frac{2\left[\sqrt{N}-1\right]}{R} = \frac{2I}{V_{OD,M1}}$$

$$\frac{2\left[\sqrt{N}-1\right]}{R} = g_{M1}$$

$$\boxed{g_{M_1}R = 2\left[\sqrt{N}-1\right]}$$

Constant

$$g_{m_2}R = \frac{2\left[\sqrt{N}-1\right]}{\sqrt{N}}$$ → Constant

For a given, N, if the topology is stabilized, then the A_{OL} is,

$$A_{OL} = \sqrt{N}\left[1 - g_{m_2}R\right]$$

$$= \sqrt{N}\left[1 - \frac{2\left[\sqrt{N}-1\right]}{\sqrt{N}}\right]$$

$$= \sqrt{N} - 2\sqrt{N} + 2$$

$$\boxed{A_{OL} = 2 - \sqrt{N}}$$

This can be,

+ve feed back with $A_{OL} > 1$

+ve feedback with $A_{OL} < 1$

-ve feedback [but low gain]

depending on N, nothing but how we size

If N is increased from N = 1 (N:1 means size of M_1 and M_2 are same),

then the open loop gain greater than 1 (unstable)

and then it will be < 1 (Stable) to very low open loop gain (negative feed back)