Basics

1)CURRENT MIRROR CIRCUIT:

The beside circuit represents a current mirror

Assume that V_{gs1} *is provided in such a way that* I_{ref} *is the current through M1*

$$But\ I_{ds1} = \frac{k}{2}\left(\frac{W}{L}\right)_1 [\,(V_{gs1} - V_t)V_{ds1} - \frac{V_{ds1}^2}{2}\,]$$

For mosfet M1 $V_{gs1} = V_{ds1}$

and $V_{gs1} - V_t < V_{ds1}$

M1 is operating in saturation region acting as a constant current source providing a current of I_{ref}

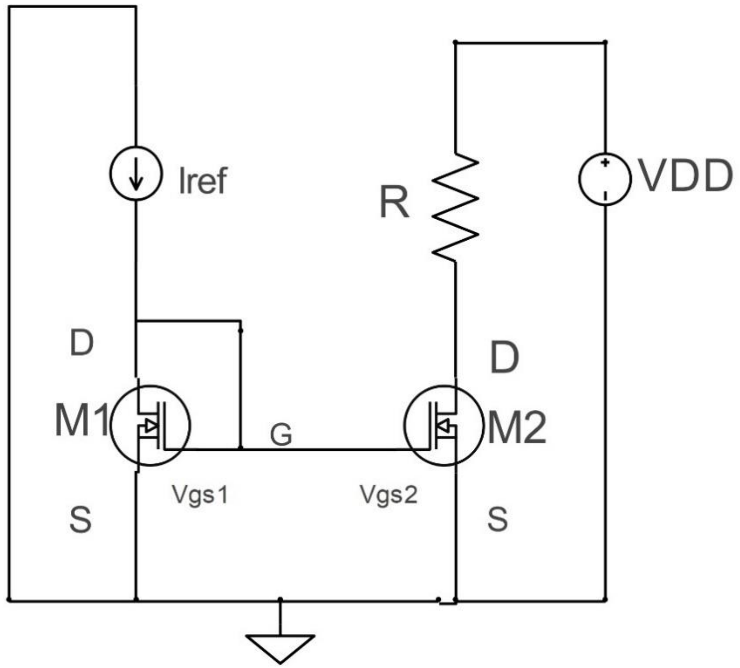
$$I_{ref} = \frac{k}{2}\left(\frac{W}{L}\right)(V_{gs1} - V_t)^2 \quad \text{------}\rightarrow (1)$$

For mosfet M2 $V_{gs2} = V_{gs1}$

and $V_{gs2} - V_t < V_{ds2}$

$$I_{ds2} = \frac{k}{2}\left(\frac{W}{L}\right)_2 (V_{gs1} - V_t)^2$$

Since the both mosfets have same V_{gs} *and have same k values when it is driven by a load it will allow the same current* I_{ref} *through it.*



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These circuits are widely used where a single voltage source is used to drive multiple units in a integrated circuit.

$$I_{d1} = \frac{k}{2}\left(\frac{W}{L}\right)\left(V_{gs} - V_t\right)^2 \text{ ------}\rightarrow (2)$$

Divide equation 1 by 2

$$\frac{I_{ref}}{I_{d1}} = \frac{\left(\frac{W}{L}\right)_1}{\left(\frac{W}{L}\right)_2}$$

$$I_{ref} = \frac{\left(\frac{W}{L}\right)_1}{\left(\frac{W}{L}\right)_2} . I_{d1}$$

If $\left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2$

Then $I_{ref} = I_{d1}$

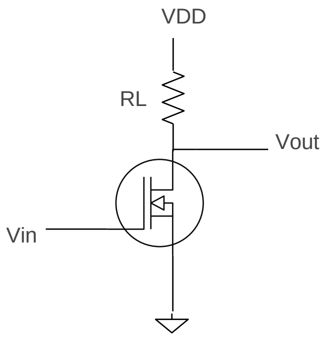
Cont…

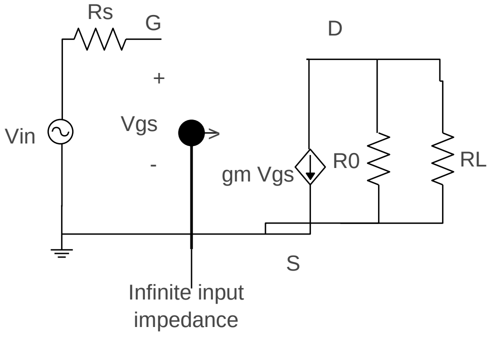
MOSFET COMMON SOURCE AMPLIFIER:

$$V_{out} = -g_m V_{gs}.\ R_L{}'$$

$$V_{out} = -g_m V_{in}.\ R_L{}'$$

$$\frac{\boldsymbol{V_{out}}}{\boldsymbol{V_{in}}} = -\boldsymbol{g_m}(\boldsymbol{R_0}||\boldsymbol{R_L})$$





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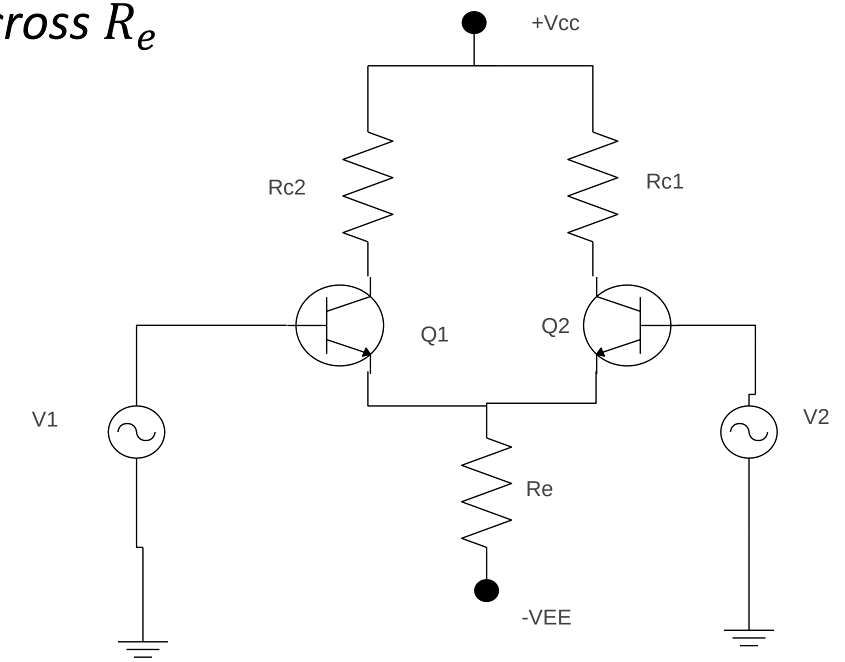
BALANCED OUTPUT DUAL INPUT DIFFERENTIAL AMPLIFIER(BJT):

→*During positive half cycle there is a positive voltage drop across* R_e *and during negative half cycle there is a negative half cycle there is a negative voltage drop across* R_e

→*Hence these both combine and there is no voltage drop across* R_e

→R_e *is used to operate the transistors in stable condition*

→*Similar implementation can be done with Mosfets*



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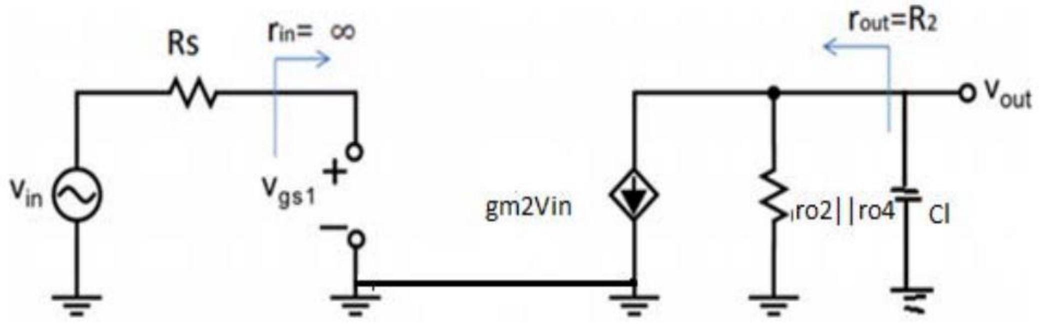
SMALL SIGNAL ANALYSIS OF SINGLE STAGE :



now, current division rule

$$V_{out} = -g_{m2}V_{in}\frac{(r_{02}||r_{04})*\frac{1}{SC_L}}{(r_{02}||r_{04})+\frac{1}{SC_L}}$$

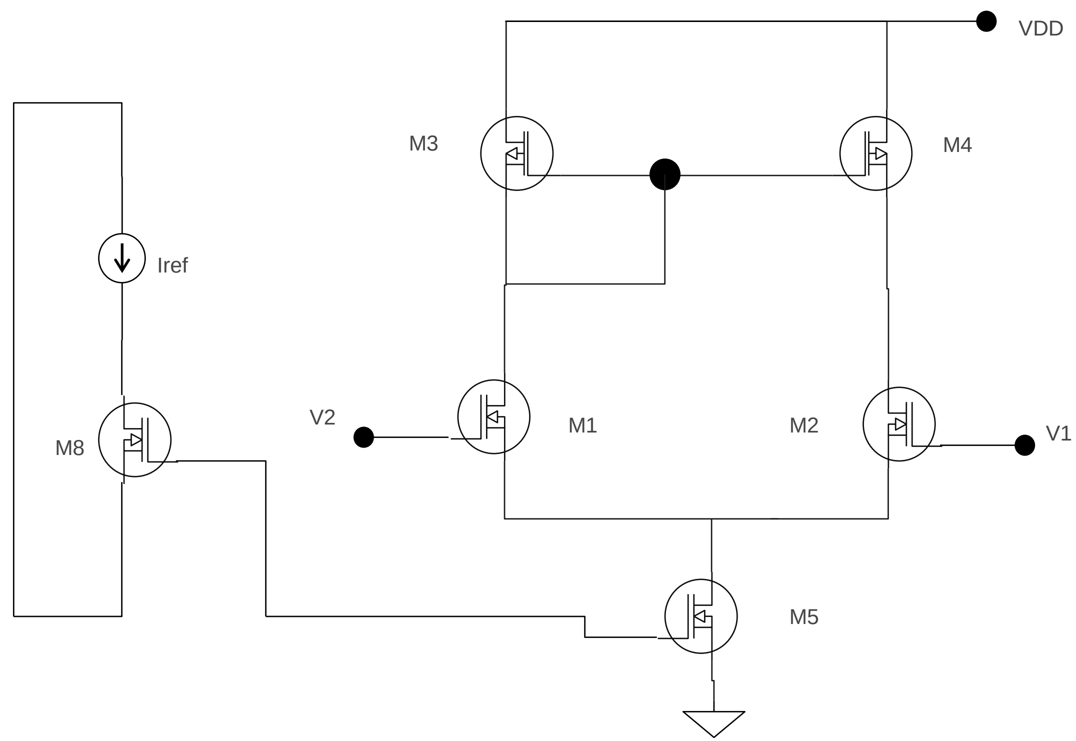
$$V_{out} = -g_{m2}V_{in}\frac{(r_{02}||r_{04})}{1+(r_{02}||r_{04})*SC_L}$$

$$\frac{V_{out}}{V_{in}} = -g_{m2}\frac{(r_{02}||r_{04})}{1+(r_{02}||r_{04})*SC_L}$$

$$-g_{m2} * (r_{02}||r_{04}) \rightarrow A_{OL}$$

$$A = \frac{A_{OL}}{1+(r_{02}||r_{04})*SC_L} \qquad \text{--------}\rightarrow (1)$$

SINGLE STAGE AMPLIFIER:



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Equation (1) has a pole at $S = \frac{-1}{(r_{02}||r_{04}).C_L} = P_1$

$$A = \frac{A_{OL}}{1+\frac{S}{P_1}} \quad \text{----------------}\rightarrow (2)$$

SUMMARY:

→*In this single stage amplifier we got good enough phase margin*

$$A = \frac{A_{OL}}{1+\frac{jw}{P_1}}$$

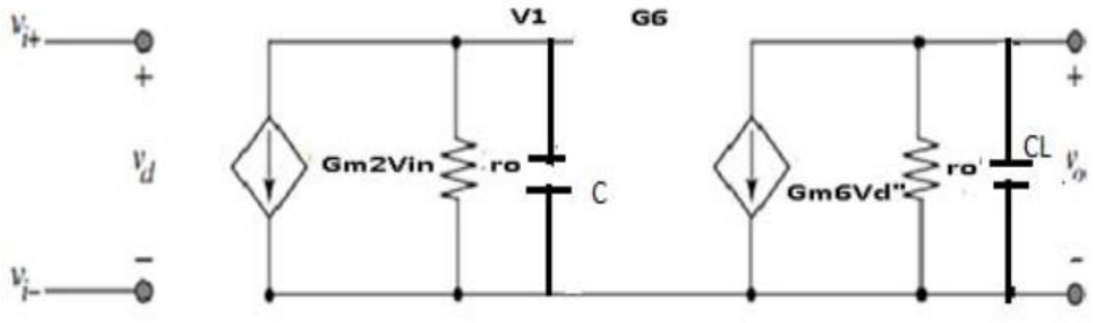
Phase margin$=180^0 + \measuredangle A \,|_{w=P_1}$

$= 135^0$

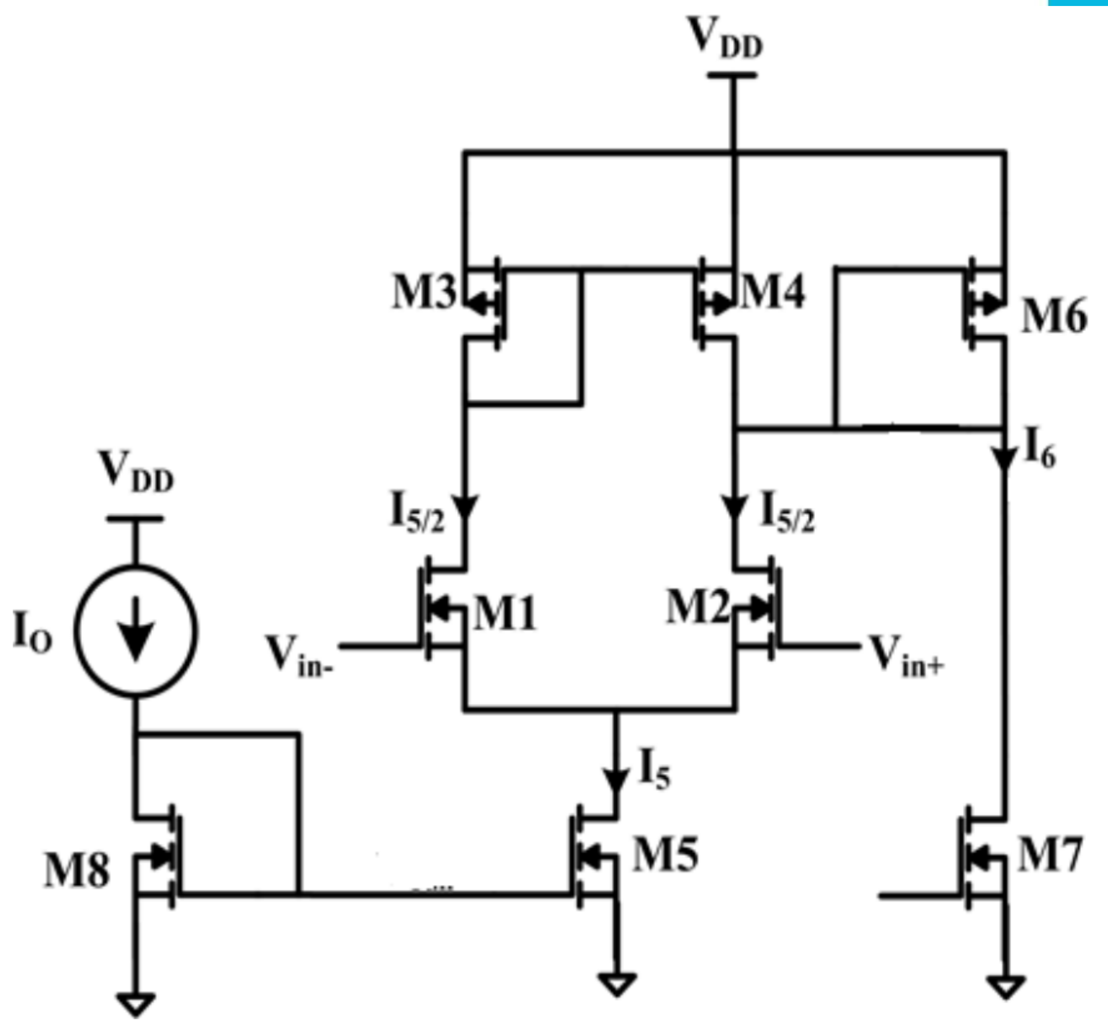
→ *But we need better gain, for better gain we are adding* 2^{nd} *Stage*

Cont..

Small signal analysis:



TWO STAGEE OPERATIONAL AMPLIFIER :



$r_0 = r_{02} || r_{04}$

$r_0' = r_{06} || r_{07}$

$C_L' = C_L || C_6 || C_7$

$V_d'' = \dfrac{-g_{m2} V_{in} (r_{02} + r_{04})}{1 + \frac{S}{P_1}}$ → (1)

Cont..

$\frac{V_{d''}}{V_{in}} = -\frac{A_{dcl}}{1+\frac{S}{P_1}}$ *where* $P_1 = \frac{1}{(r_{02}||r_{04})C_1} = \frac{1}{r_0 C_1}$

$$V_0 = \frac{-g_{m6} V_{d''} r_0'}{r_0' + \frac{1}{SCl}}$$

$$V_0 = \frac{-(g_{m6} r_0')}{1+\frac{S}{P_2}} \frac{(g_{m2} r_0) V_{in}}{1+\frac{S}{P_1}}$$ *from (1)*

Where $P_2 = \frac{1}{r_0' C_L}$

Take $A_{dc} = g_{m6} r_0' . g_{m2} r_0$

$$A = \frac{V_0}{V_{in}} = \frac{A_{dc}}{(1+\frac{S}{P_1})(1+\frac{S}{P_2})}$$