



NAME :

ID :

--	--	--	--	--	--	--

BRANCH :

SECTION :

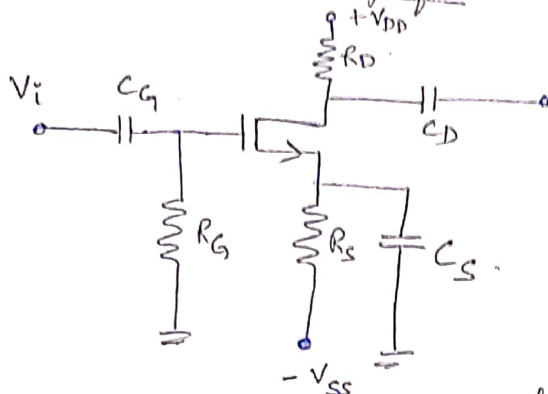
SUBJECT :

Unit - 3

MAX. 10 MARKS

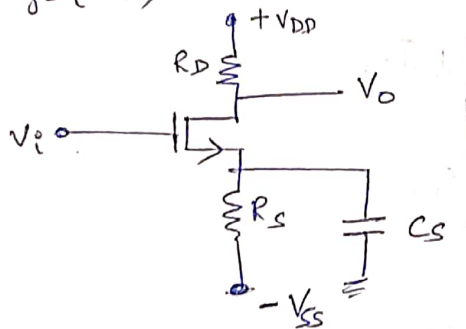


Common Source amplifiers



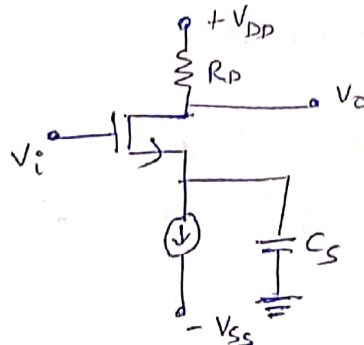
To fabricate the above amplifier we require a lot of space hence we minimise the resistors & capacitors value to nano farad instead of microfarad.

* We use direct coupling method but this makes designing of biasing ckt to be complicated. Hence the i/p voltage (V_i) & o/p voltage (V_o) include DC bias.



Direct coupling

Here, replace R_S with current source so that space is minimised.

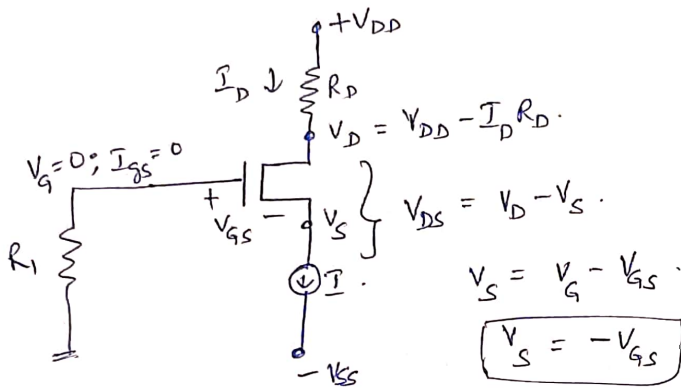


We further need to work on R_D & C_S .

By removing R_S we are using source degeneration which is implemented in IC. But practically this is not possible because I_D & V_{DS} are fixed for a biasing ckt. If I_D & V_{DS} changes then operating point also changes.

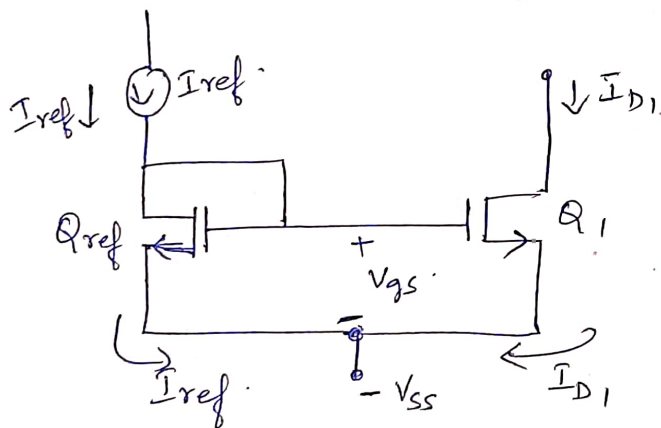
→ To make I_D constant we use constant current source

$$I_D = I$$



$$\therefore I_D = \frac{\mu_n C_{ox}}{2} \left(\frac{W}{L} \right) (V_{GS} - V_{th})^2$$

Current Mirror ckt



① Ideal MOSFET:

For ideal MOSFET, both transistors have same $\mu_n C_{ox}$ & V_{th} .

② Q_{ref} is always in saturation region.

We know that $V_{DS,ref} = V_{GS,ref}$ in saturation.

$$\Rightarrow V_{GS,ref} > V_{DS,ref} + V_{th}$$

$$\Rightarrow V_{GS,ref} = V_{GS1}$$



NAME :

ID :

SECTION :

BRANCH :

SUBJECT :

MAX, 10 MARKS

2

Overdrive voltage $V_{ov, ref} = V_{GS, ref} - V_{th}$

$$(3) I_{ref} = I_{D, sat} = \frac{\mu_n C_{ox}}{2} \left(\frac{W}{L} \right)_{ref} V_{ov}^2$$

$$I_1 = I_{D, 1} = \frac{\mu_n C_{ox}}{2} \left(\frac{W}{L} \right)_{ov}^2$$

$$\frac{I_1}{I_{ref}} = \frac{\left(\frac{W}{L} \right)}{\left(\frac{W}{L} \right)_{ref}}$$

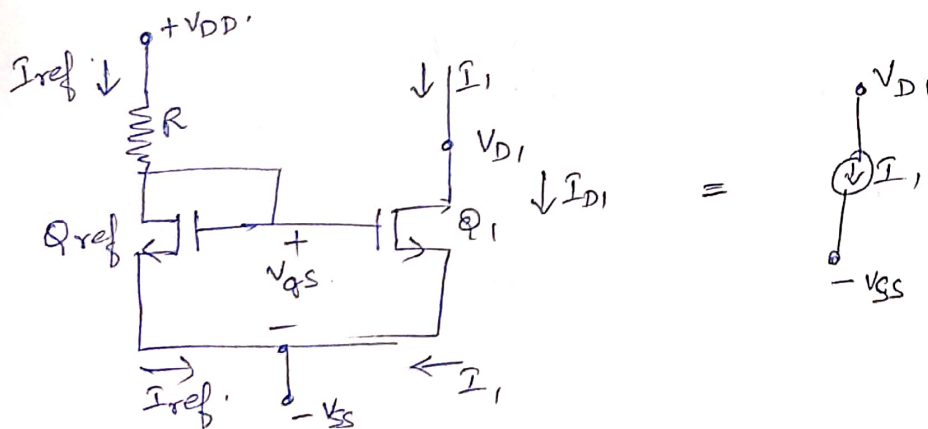
Q_1 is in saturation.

If Q_{ref} is in saturation region.

$$V_{DS, 1} > V_{ov} = V_{GS} - V_{th}$$

This is called current mirror circuit.

→ Implementation of current mirror ckt :-



In BJT we know that $I_C = \beta I_B$.

So $I_{ref} = \frac{V_{CC} - V_{BE}}{R_C}$ and

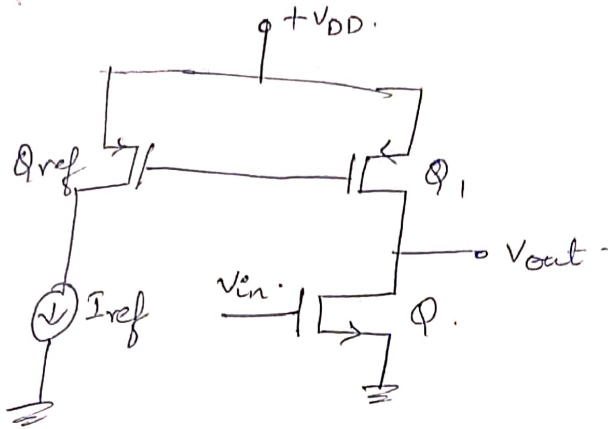
$$I_{out} = \frac{I_{ref}}{1 + \frac{2}{\beta}}$$

But current is less in BJT when compared with MOSFET

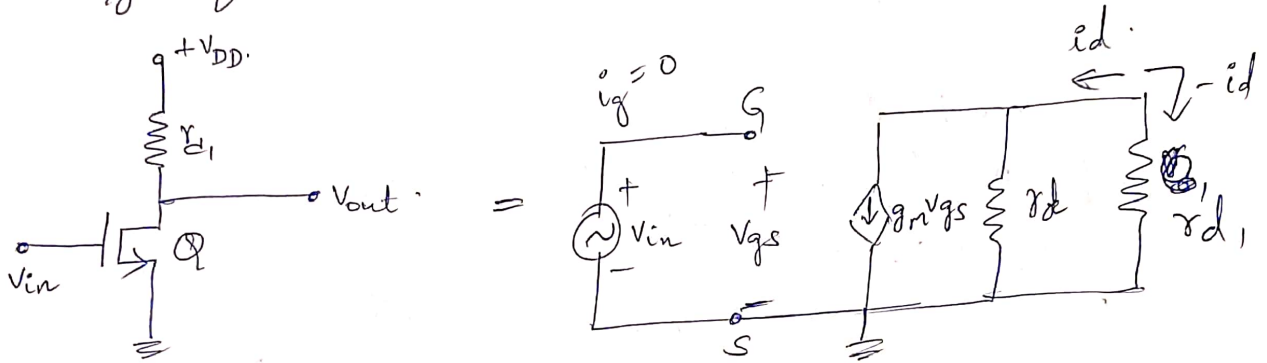
its more than BJT cos in MOSFET we have $(\frac{W}{L})$ ratio.

$\therefore I_1$ is constant regulator of voltage.

Common Source Amplifier with Active load :-



Small s/g equivalent.



From o/p.

$$V_{out} = -g_m V_{gs} [r_d \parallel r_{d1}]$$

From i/p

$$V_{gs} = V_{in}$$

$$\therefore V_{out} = -g_m V_{in} [r_d \parallel r_{d1}]$$

$$1) \text{ Voltage gain } (A_v) = \frac{V_{out}}{V_{in}} = -g_m [r_d \parallel r_{d1}]$$

$$2) \text{ current gain } (A_i) = \frac{i_{out}}{i_{in}} = \frac{i_{out}}{0} = \infty$$

$$3) \text{ Input impedance } (R_i) = \frac{V_{in}}{i_{in}} = \frac{V_{in}}{0} = \infty$$



Rajiv Gandhi University of Knowledge Technologies, A.P.

ONGOLE CAMPUS

Weekly Assessment Test

NAME :

BRANCH :

SUBJECT :

ID :

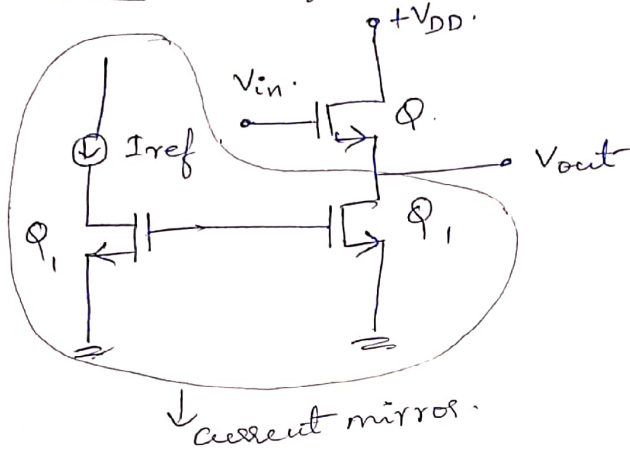
SECTION :

MAX. 10 MARKS

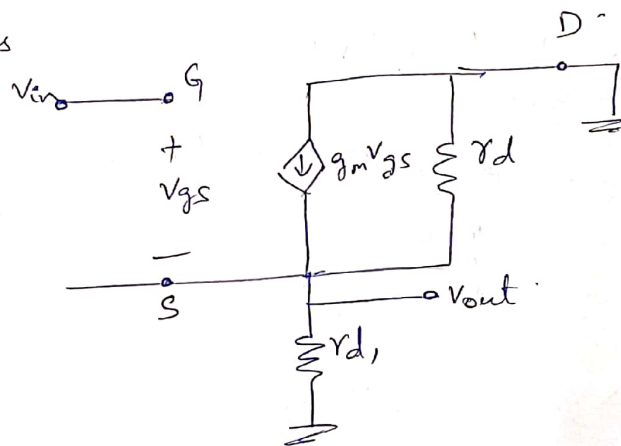
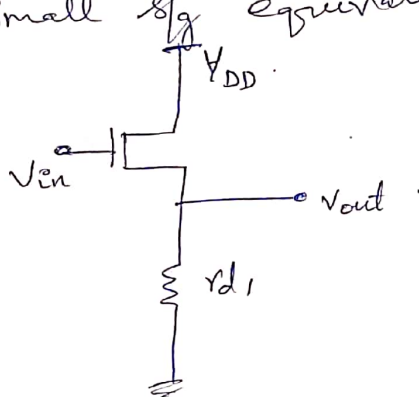
3

4) of impedance (R_o) = $R_o = r_d // r_{d1}$

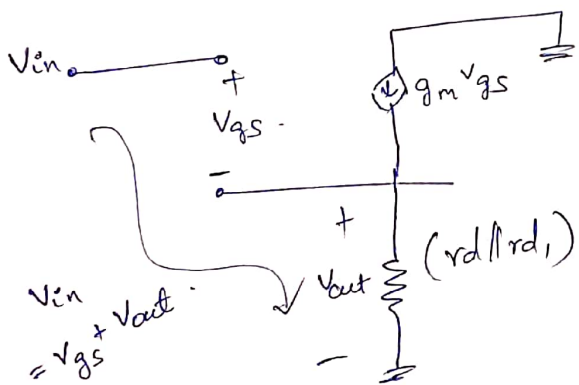
Common drain Amplifier with active load :-



Small signal equivalent is



Simplify the ckt.



$$V_{out} = g_m V_{gs} [r_d // r_{d1}]$$

$$V_{in} = V_{gs} + V_{out}$$

$$V_{in} = V_{gs} + g_m V_{gs} [r_d // r_{d1}]$$

$$V_{in} = V_{gs} [1 + g_m (r_d // r_{d1})]$$

1) Voltage gain (A_v)

$$A_v = \frac{V_{out}}{V_{in}} = \frac{g_m V_{gs} [r_d || r_{d1}]}{V_{gs} [1 + g_m (r_d || r_{d1})]}$$

$$A_v = \frac{g_m (r_d || r_{d1})}{g_m (r_d || r_{d1})} \approx 1 \quad (\because g_m (r_d || r_{d1}) \gg 1)$$

(2) Input impedance (R_i).

$$R_i = \frac{V_{in}}{i_{in}} = \frac{V_{in}}{i_g} = \frac{V_{in}}{0} = \infty$$

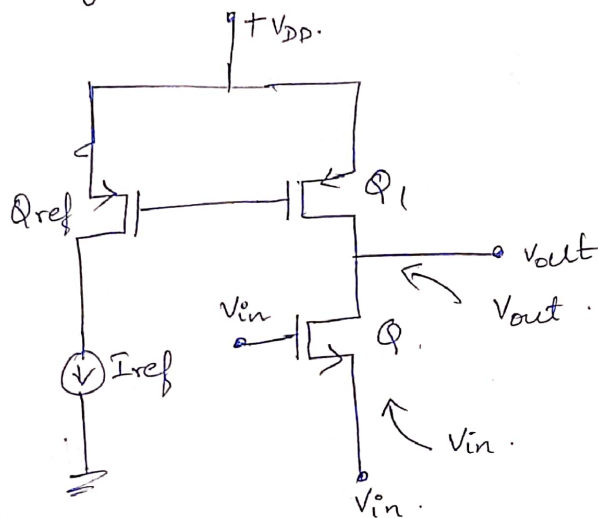
3) Current gain (A_i).

$$A_i = \frac{i_{out}}{i_{in}} = \frac{i_{out}}{0} = \infty$$

4) o/p impedance (R_o).

$$R_o = \frac{1}{g_m} || r_d || r_{d1}$$

Common gate amplifier with active load :-





Rajiv Gandhi University of Knowledge Technologies, A.P.

ONGOLE CAMPUS

Weekly Assessment Test

NAME :

BRANCH :

SUBJECT :

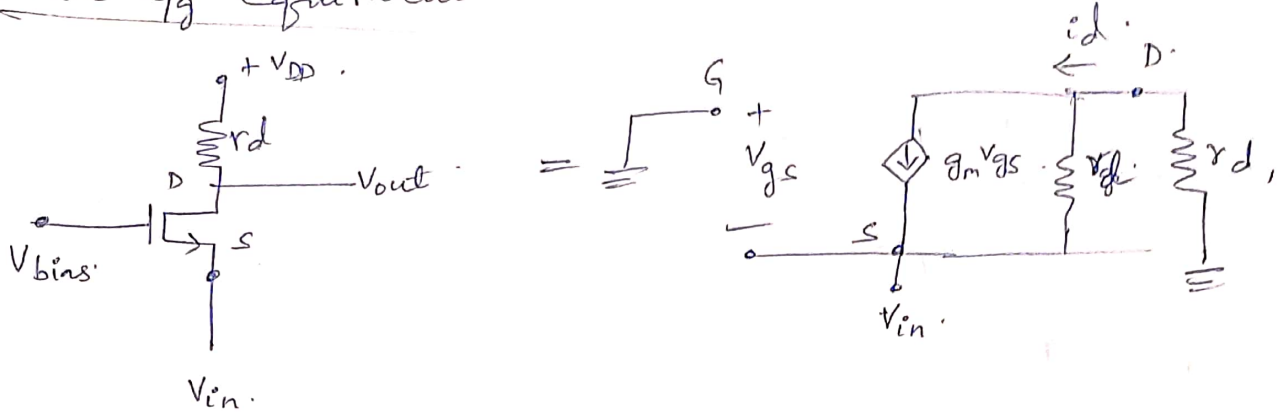
ID :

SECTION :

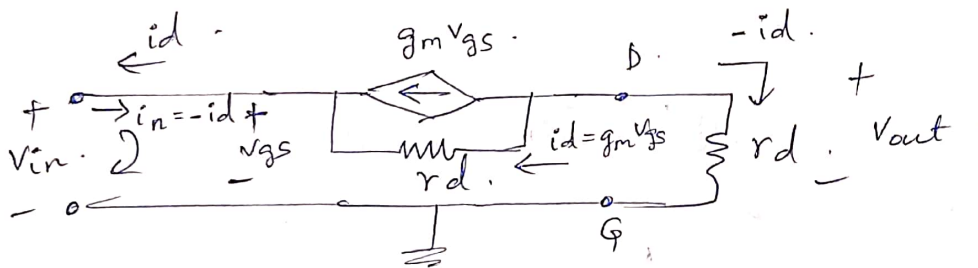
MAX. 10 MARKS

4

Small s/g equivalent



V_{bias} = DC Bias voltage.



$$V_{out} = -id r_{d1}$$

$$V_{in} = -V_{gs} = -(id - g_m V_{gs}) r_d + (-id) r_{d1}$$

$$V_{in} + g_m r_d V_{in} = -id r_d - id r_{d1}$$

$$V_{in} [1 + g_m r_d] = -id [r_d + r_{d1}]$$

$$V_{in} = \frac{-id [r_d + r_{d1}]}{1 + g_m r_d} \rightarrow (1)$$

(i) Voltage gain (A_v)

$$A_v = \frac{V_{out}}{V_{in}} = \frac{-id r_{d1}}{\frac{-id [r_d + r_{d1}]}{1 + g_m r_d}} = \frac{(1 + g_m r_d) r_{d1}}{r_d + r_{d1}} \quad \left(\because g_m r_d \gg 1 \right)$$

$$\therefore A_v = \frac{g_m r_d r_{d1}}{r_{d1} + r_d} = g_m [r_d \parallel r_{d1}]$$

2) Current gain (A_i)

$$A_i = \frac{i_{out}}{i_{in}} = \frac{-i_d}{-i_d} = 1$$

3) Input impedance (R_i)

$$R_i = \frac{V_{in}}{i_{in}} = \frac{V_{in}}{-i_d}$$

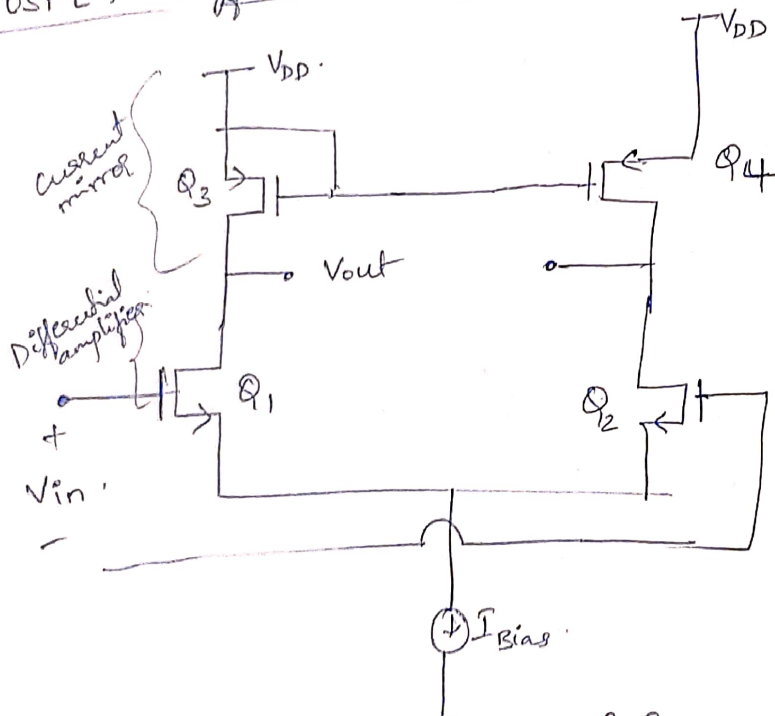
from eq (1)

$$\frac{V_{in}}{-i_d} = \frac{r_d + r_{d1}}{1 + g_m r_d} = R_i$$

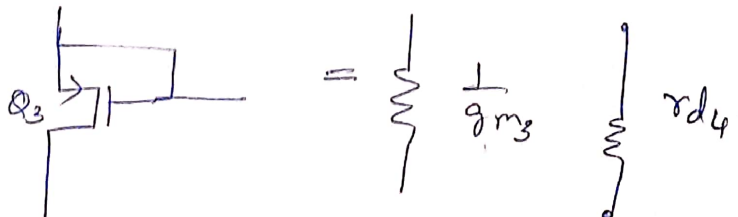
4) o/p impedance (R_o)

$$R_o = r_d \parallel r_{d1}$$

*** MOSFET Differential amplifier with active load:-



Small s/g equivalent of Q_3 & Q_4 .





NAME: _____

BRANCH: _____

SUBJECT: _____

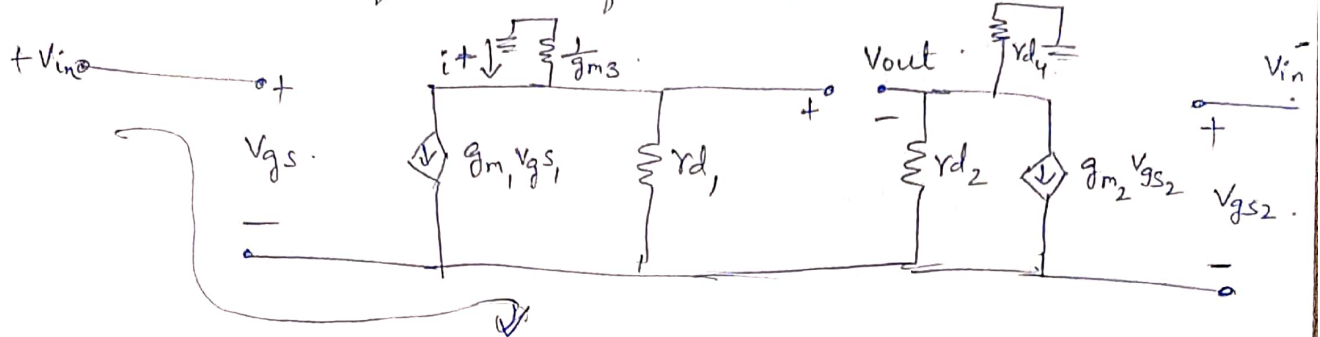
ID:

SECTION: _____

MAX. 10 MARKS

5

Now take small equivalent of remaining Q_1 & Q_2 .



Apply KVL.

$$i+ = i' + g_{m1} V_{gs1} \quad V_{gs1} = V_{in+} - V_x$$

$$\frac{0 - V_{out}}{1/g_{m3}} = \frac{V_{out} - V_x}{r_{d1}} + g_{m1} [V_{in} - V_x]$$

$$-V_{out} + \left[g_{m3} + \frac{1}{r_{d1}} \right] V_{out} = V_{in} + g_{m1} - V_x \left[g_{m1} + \frac{1}{r_{d1}} \right] \Rightarrow (1)$$

Similarly for Q_2 .

$$-V_{out} \left[\frac{1}{r_{d4}} + \frac{1}{r_{d2}} \right] = V_{in} - g_{m2} - V_x \left[g_{m2} + \frac{1}{r_{d2}} \right] \Rightarrow (2)$$

Let us take Q_1 & Q_2 are identical.

$$\therefore g_{m1} = g_{m2} = g_m \quad \{ r_{d1} = r_{d2} = r_d$$

$\therefore$ eq (1) & (2) can be written as.

$$-V_{out} + \left[g_{m3} + \frac{1}{r_d} \right] V_{out} = V_{in} + g_m - V_x \left[g_m + \frac{1}{r_d} \right] \Rightarrow (3)$$

$$-V_{out} - \left[\frac{1}{r_{d4}} + \frac{1}{r_d} \right] V_{out} = V_{in} - g_m - V_x \left[g_m + \frac{1}{r_d} \right] \Rightarrow (4)$$

$$\therefore (3) - (4)$$

$$-V_{out} + \left[g_{m3} + \frac{1}{r_d} \right] V_{out} - \left[\frac{1}{r_{d4}} + \frac{1}{r_d} \right] V_{out} = V_{in} + g_m - V_x \left[g_m + \frac{1}{r_d} \right] - V_{in} + g_m - V_x \left[g_m + \frac{1}{r_d} \right]$$

$$= \left(V_{in+} - V_{in-} \right) g_m$$

$$V_{out} = V_{out+} - V_{out-}$$

$$\text{No } g_m \quad A_d = \frac{V_{out}}{V_{in}} = \frac{V_{out+} - V_{out-}}{V_{in+} - V_{in-}}$$

$$\left[A_d = \frac{g_m}{\frac{1}{r_d} + \frac{1}{r_{dy}}} \right] \rightarrow \text{balanced .}$$

$$\left[A_d = \frac{g_m r_d \parallel r_{dy}}{2} \right] \rightarrow \text{unbalanced .}$$