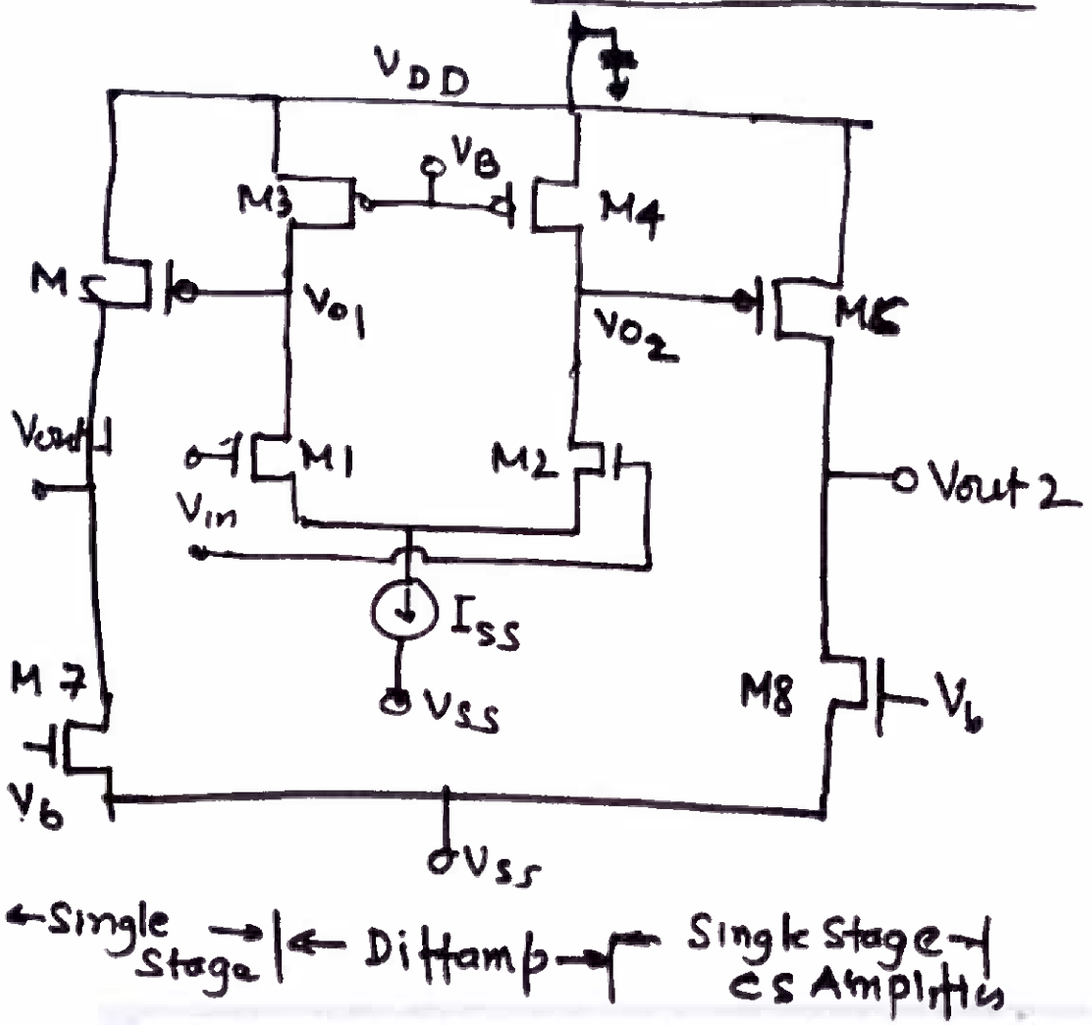
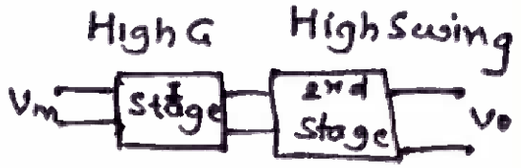
Two Stage OPAMP





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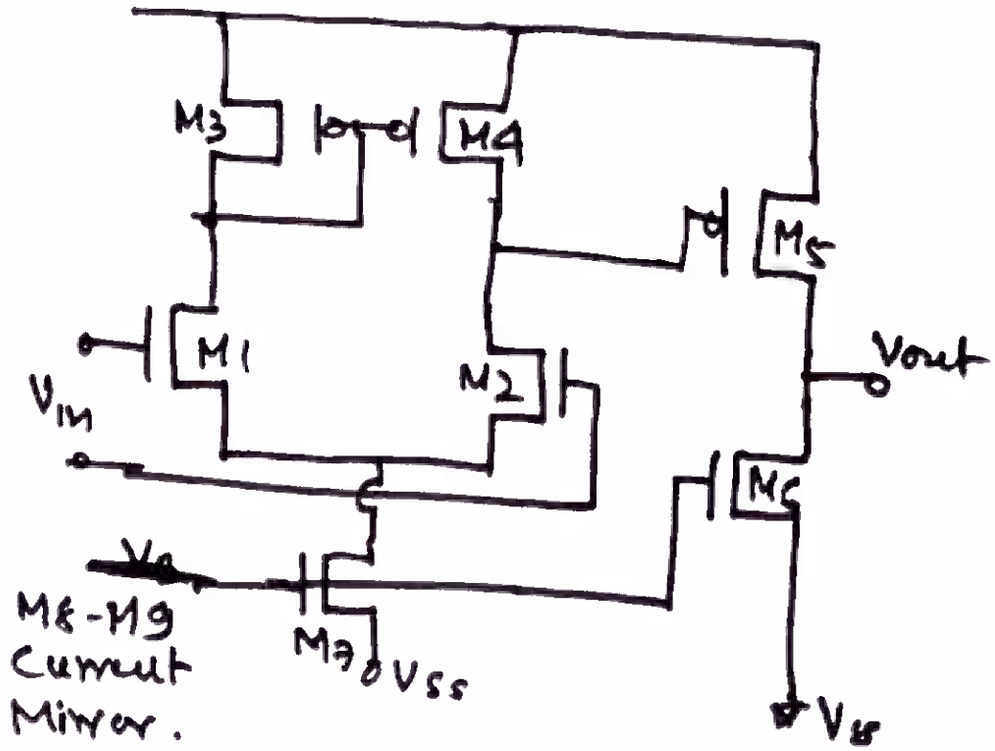
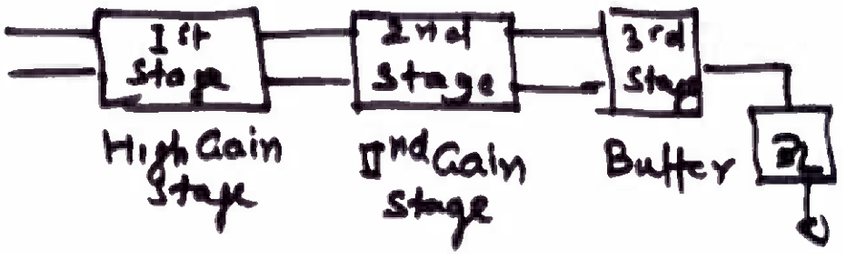


Three Stage OPAMP



Buffer is Class AB Amplifier with Large Drive Capability

$$v_{o1} = -g_{m1}(r_{o1} \| r_{o3})\, v_{in}$$

$$v_{o2} = -g_{m2}(r_{o2} \| r_{o4})\, v_{in}$$

$$v_{out1} = -g_{m5}(r_{o5} \| r_{o7})\, v_{o1}$$

$$= +g_{m1} g_{m5} (r_{o5} \| r_{o7})(r_{o1} \| r_{o3})\, v_{in}$$

$$A_{v1} = \frac{v_{out1}}{v_{in}} = g_{m1} g_{m5} (r_{o5} \| r_{o7})(r_{o1} \| r_{o3})$$

Similarly

$$A_{v2} = \frac{v_{out2}}{v_{in}} = g_{m2} g_{m6} (r_{o6} \| r_{o8})(r_{o2} \| r_{o4})$$

For Single ended case

$$A_v = g_{m1} (r_{o2} \| r_{o4})\, g_{m5} (r_{o5} \| r_{o6})$$

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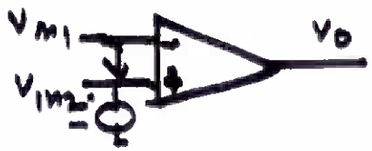
Characteristics of OPAMP

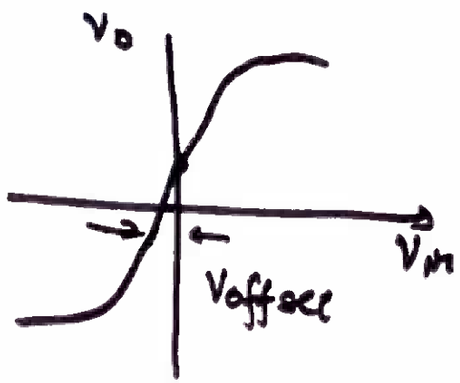


① Input Offset

If $V_{in1} = V_{in2} = 0$ then $V_o = 0$ But

In reality V_o exists. Due to Mismatches in Input Stage

Worst case $V_{offset} = \frac{V_{DD}}{A_{OL}}$ or $\frac{V_{SS}}{A_{OL}}$



② $CMRR = 20 \log \frac{A_d}{A_c}$

(3) Power Dissipation

$$\text{Total } P = (V_{DD} - V_{SS}) \cdot (I_{DS} + I_{DS_1} + I_{DS_2} - \cdot)$$

Vertical paths.

(4) Power Supply Rejection Ratio (PSRR):

Rejection parameter related to variation in V_{DD} or V_{SS}

$$PSRR^+ = \frac{A_{OL}}{V_{out}/\Delta V^+}$$

V^+ variation in V_{DD}

$$PSRR^- = \frac{A_{OL}}{V_{out}/V^-}$$

V^- is " " V_{SS}

(5) Slew Rate : $\frac{dV_{out}}{dt} = \frac{I_{SS}}{C_L}$

From KCL

$$\frac{V_1 - V_o}{R_2} = g_m V_1 \quad \text{or} \quad V_1\left(\frac{1}{R_2} - g_m\right) = \frac{V_o}{R_2}$$

$$\therefore \quad V_1 = \frac{V_o}{R_2} \cdot \frac{1}{\left(\frac{1}{R_2} - g_m\right)}$$

$$\frac{V_o}{V_1} \to$$

$$\therefore \quad \frac{V_{in}}{R_1} + \frac{V_o}{R_2} = \frac{V_o}{R_2}\left(\frac{1}{\frac{1}{R_2} - g_m}\right)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

$$\therefore \quad \frac{V_o}{V_{in}} = -\frac{R_2}{R_1} \cdot \frac{\left(1 - \frac{1}{g_m R_2}\right)}{\left(1 + \frac{1}{g_m R_2}\right)}$$

If $g_m \to \infty$

$$A_V = -\frac{R_2}{R_1}$$

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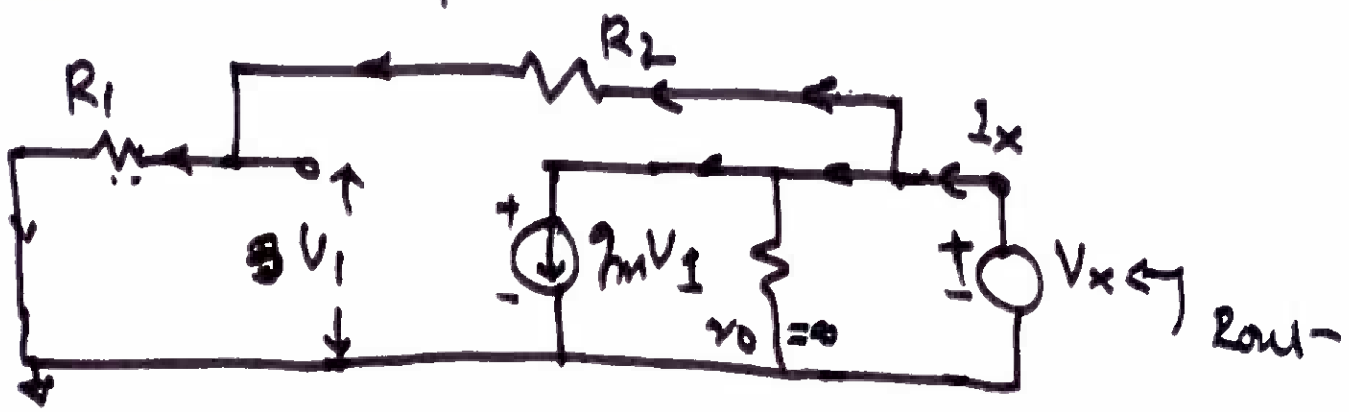
Output Resistance



Load

r_o is very high for MOS Amplifiers. & $V_1 = V_{gs}$

$$R_{out} = \frac{V_x}{I_x}$$

$$I_x = g_m v_{gs} + \frac{V_x - 0}{R_1 + R_2}$$

$$\text{But } v_{gs} = \frac{R_2}{R_2 + R_1} V_x.$$

$$\therefore I_x = \frac{g_m R_2}{R_1+R_2} V_x + \frac{V_x}{R_1+R_2}$$

$$I_x = \frac{(1+g_m R_2) V_x}{R_1+R_2}$$

$$\text{or} \quad R_{out} = \frac{V_x}{I_x} = \frac{R_1+R_2}{1+g_m R_2}$$

If open loop Gain is very high, $g_m \to \infty$

Then $R_{out} \to 0$