DIFFERENTIAL AMPLIFIERS USING TRANSISTOR LOADS.

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DIFFERENTIAL AMPLIFIER USING NMOS LOAD.

- The advantage over resistive load is that gain is a ratio of like components, so the variations are less.
- The gain is $\frac{g_{m1}}{g_{m3}+g_{mbs3}}$.

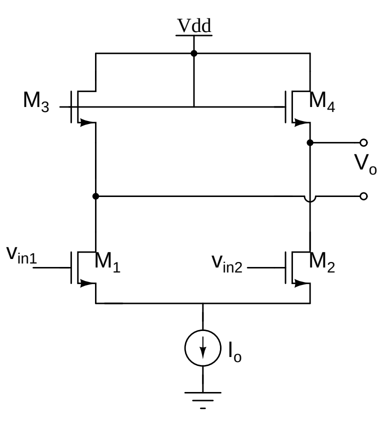

Figure 1: DIFFERENTIAL AMPLIFIER USING NMOS TRANSISTOR LOAD.

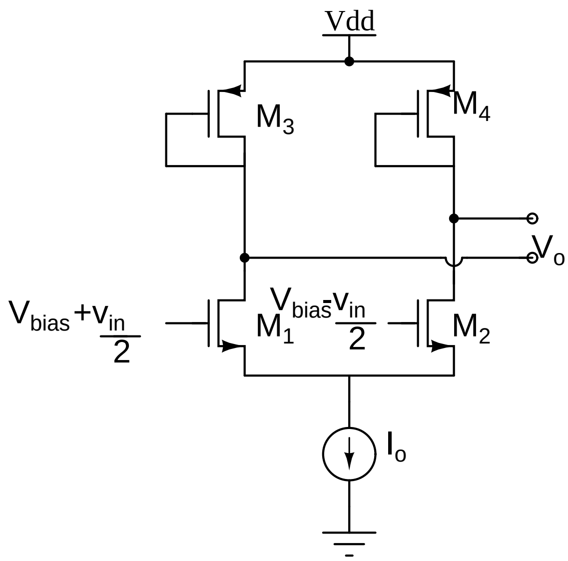

Figure 2: DIFFERENTIAL AMPLIFIER USING PMOS TRANSISTOR LOAD.

☛ To avoid the body effect we can use PMOS transistors.The gain is then $\frac{g_{m1}}{g_{m3}}$

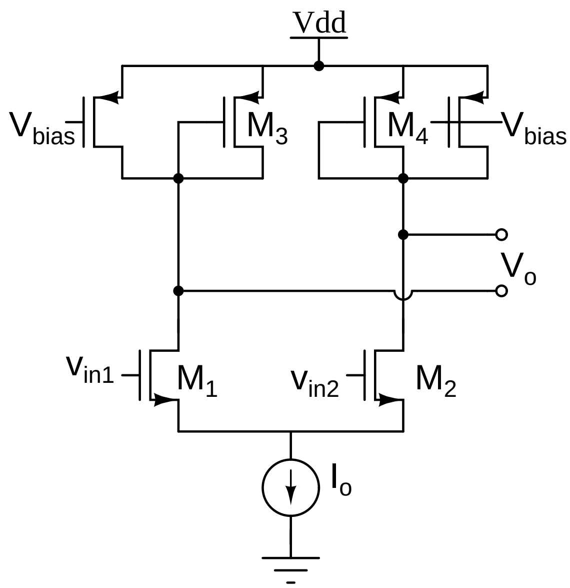

Figure 3: DIFFERENTIAL AMPLIFIER USING PMOS TRANSISTOR AND A PMOS CURRENT SOURCE AS LOAD.

- ☛ We can increase gain by reducing g_{m3}.This can be done by reducing the current through M_3,so we connect a current source in parallel.

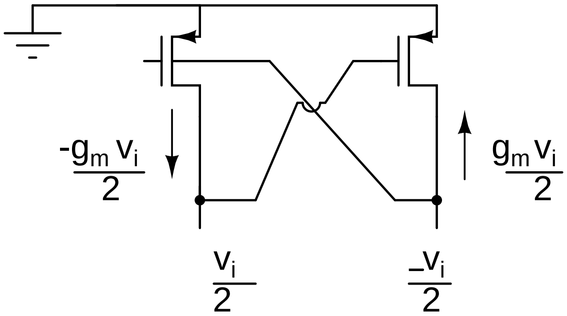

Figure 4: NEGATIVE RESISTANCE

- Another option to increase gain is by connecting negative resistance in parallel across the load.

  Negative small signal resistance = $\frac{-2}{g_m}$

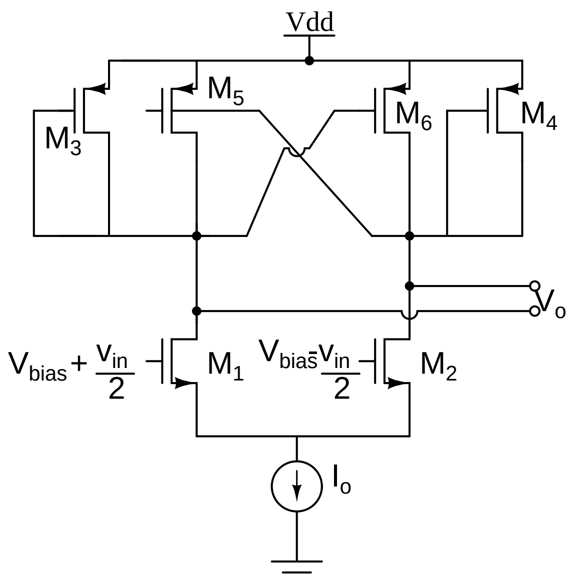

Figure 5: DIFFERENTIAL AMPLIFIER WITH NEGATIVE RESISTANCE IN PARALLEL AS LOAD

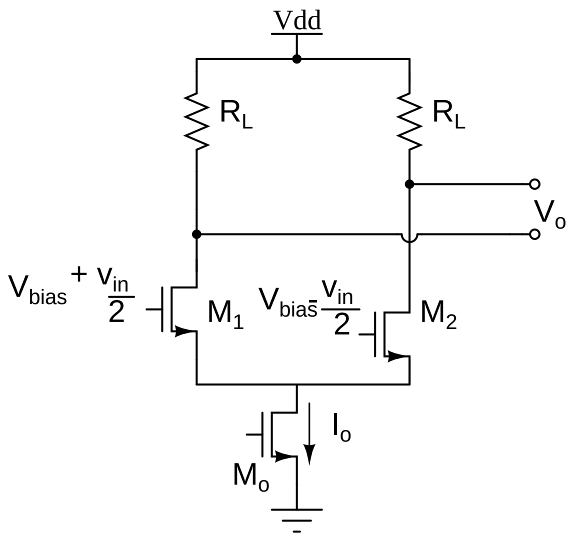

Figure 6: DIFFERENTIAL AMPLIFIER WITH RESISTANCE AS LOAD

- For a differential amplifier using R_L as load,

$$V_{bias} > V_T + \sqrt{\frac{2\frac{I_o}{2}}{\mu_n C_{ox}\frac{W}{L}}} + \sqrt{\frac{2I_o}{\mu_n C_{ox}\frac{W}{L}}} \tag{1}$$

Also,

$$V_{bias} + \frac{v_{in}}{2} - v_{th} \;<\; V_{DD} - \frac{I_o R_L}{2} - \frac{g_m v_{in} R_L}{2} \tag{2}$$

$$V_{bias} \;<\; V_{DD} - \frac{I_o R_L}{2} - (1 + g_m R_L)\frac{v_{in}}{2} + v_{th} \tag{3}$$

  - V_{bias} should be such that the transistors M_0 and M_1 are kept in saturation.
  - To maximise signal swing V_{bias} must be at the lowest possible value.
  - With V_{bias} at the minimum value

$$V_{DD} > V_{DSAT1} + V_{DSAT0} + \frac{I_o R_L}{2} + (g_m R_L + 1)\frac{v_{in}}{2}$$

- For a differential pair using current sources as load the lower constraint is the same but the upper constraint is given by the sum of overdrive of M_3 and v_{th}.

$$V_{bias} < V_{DD} - \left(\sqrt{\frac{2\frac{I_o}{2}}{\mu_n C_{ox}\frac{W}{L}}} + v_{th3}\right) + v_{th1} \tag{4}$$