

Test 1 (10/23/07)

Total # Pages 6

Total # Problems 5

Attach your one page of notes to this test

Name SOLUTION

- 1. (25 points) _____
 - 2. (30 points) _____
 - 3. (25 points) _____
 - 4. (10 points) _____
 - 5. (10 points) _____
- Total (100 points) _____

GOOD LUCK

Note: All bulk connections that are not shown are tied to the appropriate supply voltage.

$$I_d = \begin{cases} k' \frac{W}{L} \left[(V_{gs} - V_T) V_{ds} - \frac{V_{ds}^2}{2} \right] (1 + \lambda V_{ds}) & V_{gs} \geq V_T, V_{ds} \leq V_{gs} - V_T, \text{ linear} \\ \frac{k' W}{2 L} (V_{gs} - V_T)^2 (1 + \lambda V_{ds}) & V_{gs} \geq V_T, V_{ds} \geq V_{gs} - V_T, \text{ saturation} \\ 0 & V_{gs} < V_T, \text{ cutoff} \end{cases}$$

$$V_T = V_{T0} + \gamma \left(\sqrt{V_{sb} + \phi} - \sqrt{\phi} \right)$$

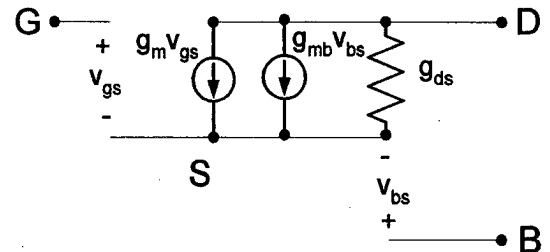
In saturation, $V_{gs} = V_T + \sqrt{\frac{2I_d}{k' \frac{W}{L}}}$

Small-signal parameters:

$$g_{ds} = g_o = \lambda I_d$$

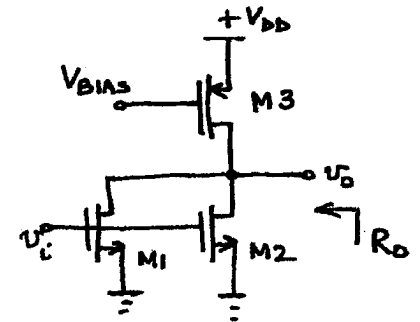
$$g_m = \sqrt{2I_d k' \frac{W}{L}} = \frac{2I_d}{V_{gs} - V_T}$$

$$g_{mb} = \chi g_m \quad \text{where} \quad \chi = \frac{\gamma}{2\sqrt{V_{sb} + \phi}}$$

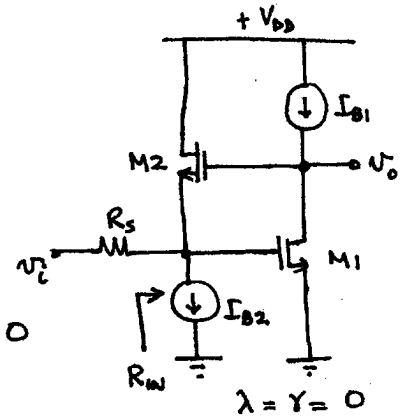
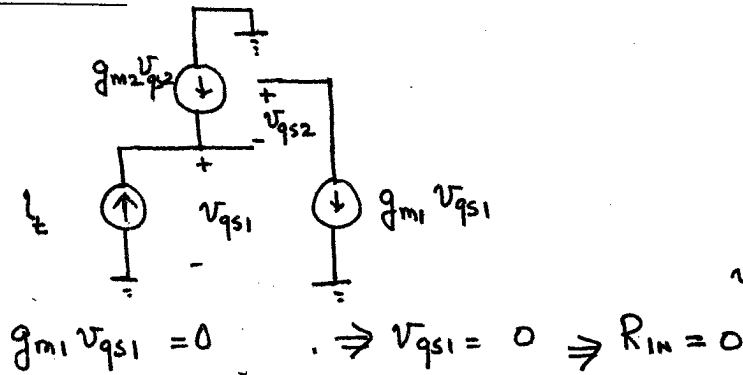


2. Write the expressions for the small-signal low-frequency quantities as shown. Assume identical transistors biased in saturation. Ignore the body effect and assume that $g_m r_o \gg 1$ except for the R_{in} calculation where r_o is infinity (30 points).

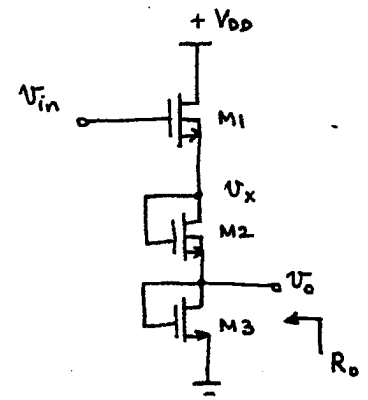
G_m (effective g_m) = _____ R_o = _____



$R_{in} = 0$

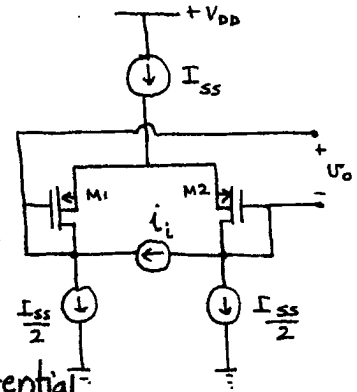
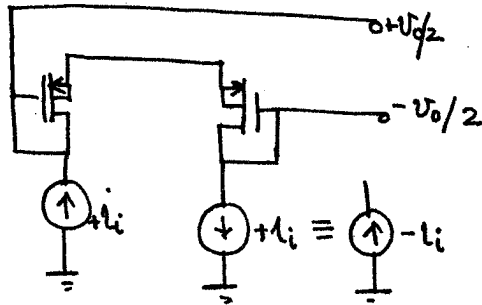


$\frac{V_o}{V_{in}} =$ _____ $R_o =$ _____



4. For the amplifier shown below answer the following questions. Assume M1 and M2 are identical and biased in saturation. i_i is an input signal current (10 points).
- a) Explain how the concept of a differential half circuit can be applied to this problem.

consider the ac circuit

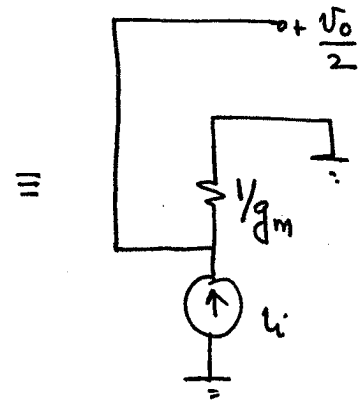
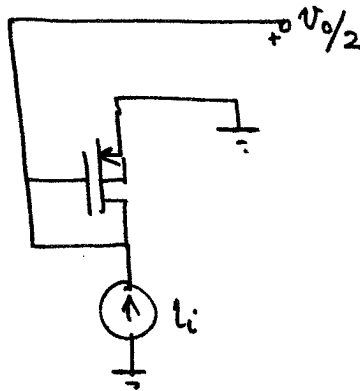


circuit is symmetrical and input is differential

- b) Draw the differential half circuit and use it to calculate the low-frequency gain v_o/i_i . Assume that $g_m r_o \gg 1$.

$$v_o/i_i = -2/g_m$$

Half circuit



$$\frac{v_o}{2} = -\frac{1}{g_m} i_i \Rightarrow \frac{v_o}{i_i} = -\frac{2}{g_m}$$