Microelectronics Circuit Analysis and Design Homework(10th)

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8.24 Consider the class-B output stage with complementary MOSFETs shown in Figure P8.24. The transistor parameters are $V_{TN} = V_{TP} = 0$ and $K_n = K_p = 0.4\text{mA}/N^2$. Let $R_L = 5$ kΩ. (a) Find the maximum output voltage such that M_n remains biased in the saturation region. What are the corresponding values of i_L and υ_I for this condition? (b) Determine the conversion efficiency for a symmetrical sine-wave output signal with the peak value found in part (a).

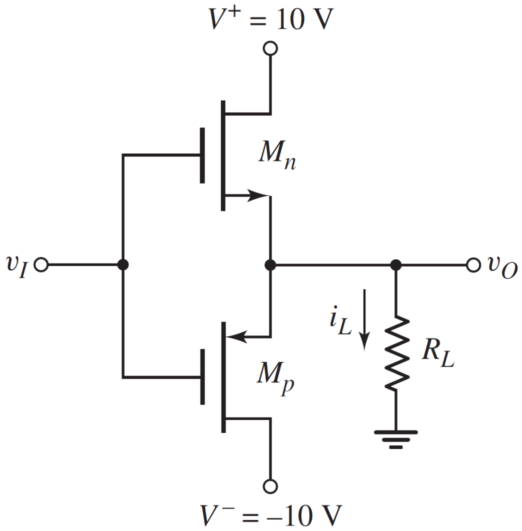

Figure 1: Problem 8.24

Solution:

(a)If we want get the maximum output voltage, The V_{DS} must be equal to the minimum. In fact, the minimum we can easily solve:

$$V_{DS\min} = V_{DS(sat)} = V_{GS} - V_T = V_{GS}$$

Just consider the positive half a cycle, we have equations as follow:

$$\begin{cases} I_D = K_n V_{GS}^2 \\ I_D = I_L & \Rightarrow V_O = 8V \\ 10 - V_{GS} = V_O = I_L R_L \end{cases}$$

So we can solve out V_I, I_L:

$$V_I = V_O + V_{GS} = 10\text{V}, I_L = \frac{V_O}{R_L} = 1.6\text{mA}$$

(b)Average Power is follow:

$$\overline{P}_L = \frac{V_{o(\max)}^2}{2R_L} = 6.4\text{mW}, \overline{P}_S = \frac{2V_S I_D}{\pi} = 10.2\text{mW}, \eta = \frac{\overline{P}_L}{\overline{P}_S} = 62.7\%$$

8.29 An enhancement-mode MOSFET class-AB output stage is shown in Figure P8.29. The threshold voltage of each transistor is $V_{TN} = -V_{TP} = 1$V and the conduction parameters of the output transistors are $K_{n1} = K_{p2} = 5$ mA/V^2. Let $I_{\text{Bias}} = 200\ \mu$ A. (a) Determine $K_{n3} = K_{p4}$ such that the quiescent drain currents in M_1 and M_2 are 5 mA. (b) Using the results of part (a), find the small-signal voltage gain $A_v = dv_O/dv_I$ evaluated at: (i) $v_O = 0$, and (ii) $v_O = 5$V.

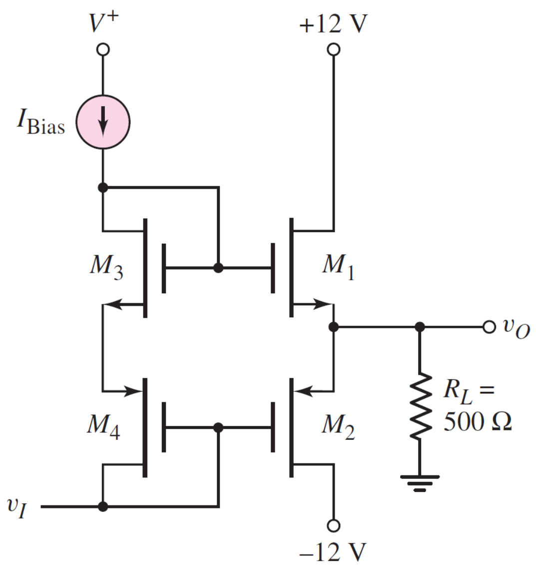

Figure 2: Problem 8.29

(a)First, solve out V_{GS1}:

$$I_D = K_{n1}(V_{GS1} - 1)^2 \Rightarrow V_{GS1} = 2\text{V}$$

Then, solve out K_{n3}:

$$I_{Bias} = K_{n3}(V_{GS1} - V_{TN})^2 \Rightarrow K_{n3} = 200\mu\text{A}/\text{v}^2 = K_{p4}$$

(b)Because of KVL, the equation is as follow:

$$v_I + V_{GS3} + V_{SG4} = V_{GS1} + v_O \Rightarrow v_I + 2 + 2 = 2 + \sqrt{\frac{v_o}{R_L K_{n1}}} + V_{TN}$$

Then Differentiating both sides of the equation:

$$1 = \frac{dv_0}{dv_I} + \frac{1}{2\sqrt{2.5v_0}} \cdot \frac{dv_0}{dv_I} \Rightarrow \frac{dv_0}{dv_I} = \frac{2\sqrt{2.5v_0}}{2\sqrt{2.5v_0}+1}$$

Answer is as follow:

$$v_o = 0, \frac{dv_0}{dv_I} = 0; v_o = 5\text{V}, \frac{dv_0}{dv_I} = 0.88$$