3.17. Sketch V_{out} versus V_{in} for the circuits of Fig. 3.69 as V_{in} varies from 0 to V_{DD}. Identify important transition points.

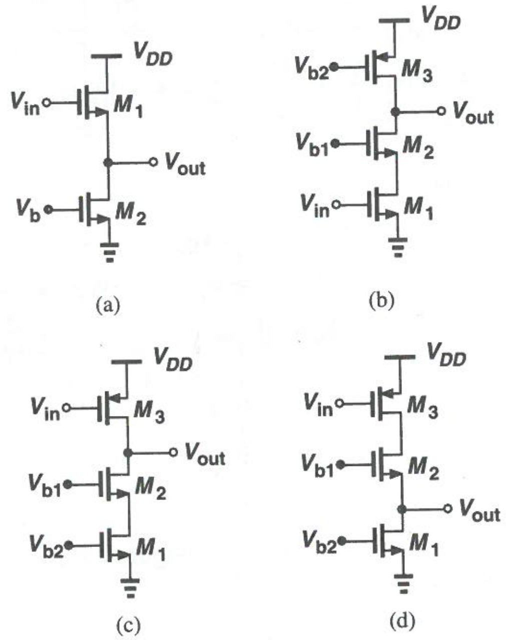

Figure 3.69

3.18. Sketch I_X versus V_X for the circuits of Fig. 3.70 as V_X varies from 0 to V_{DD}. Identify important transition points.

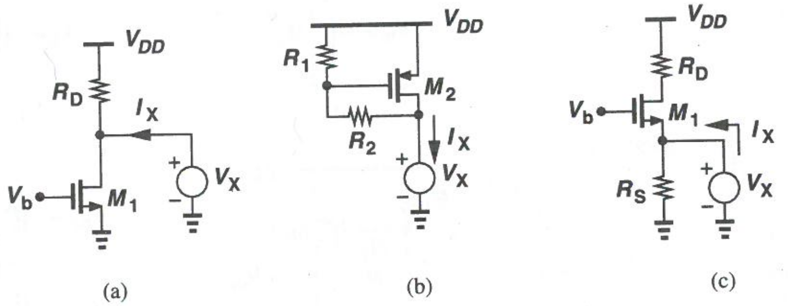

Figure 3.70

3.19. Sketch I_X versus V_X for the circuits of Fig. 3.71 as V_X varies from 0 to V_{DD}. Identify important transition points.

3.20. Assuming all MOSFETs are in saturation, calculate the small-signal voltage gain of each circuit in Fig. 3.72 ($\lambda \neq 0, \gamma = 0$).

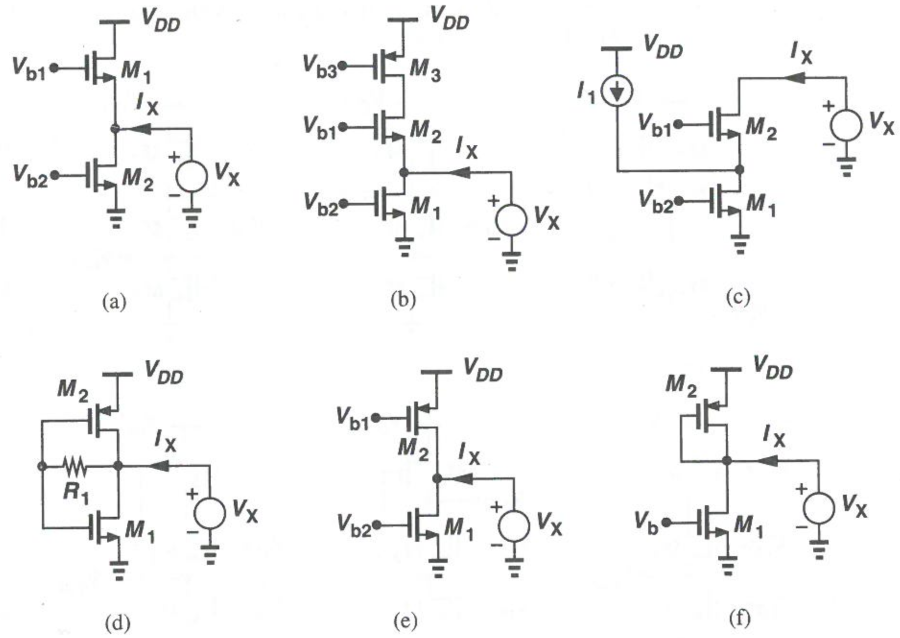

Figure 3.71

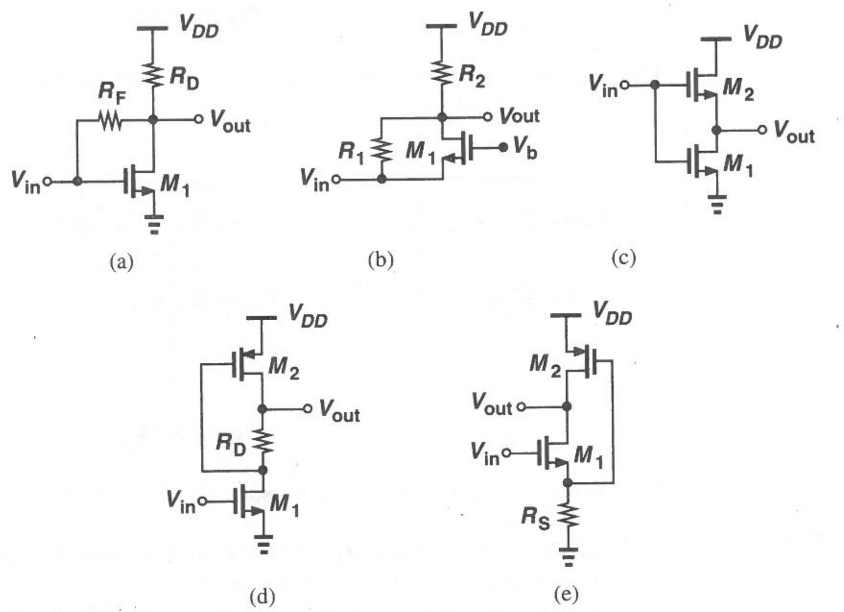

Figure 3.72

3.21. Assuming all MOSFETs are in saturation, calculate the small-signal voltage gain of each circuit in Fig. 3.73 ($\lambda \neq 0, \gamma = 0$).

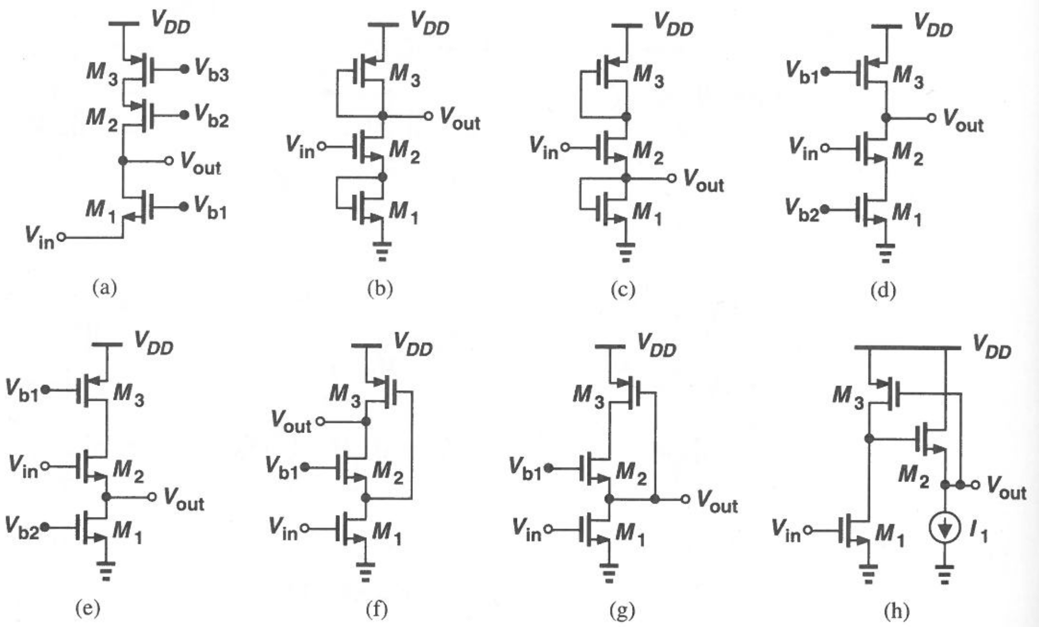

Figure 3.73

3.22. Sketch V_X and V_Y as a function of time for each circuit in Fig. 3.74. The initial voltage across C_1 is equal to V_{DD}.

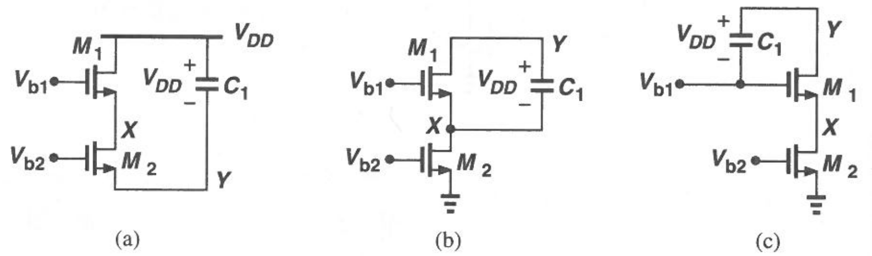

Figure 3.74

3.23. In the cascode stage of Fig. 3.50, assume $(W/L)_1 = 50/0.5$, $(W/L)_2 = 10/0.5$, $I_{D1} = I_{D2} =$ 0.5 mA, and $R_D = 1\ \text{k}\Omega$.

(a) Choose V_b such that M_1 is 50 mV away from the triode region.

(b) Calculate the small-signal voltage gain.

(c) Using the value of V_b found in part (a), calculate the maximum output voltage swing. Which device enters the triode region first as V_{out} falls?

(d) Calculate the swing at node X for the maximum output swing obtained above.

3.24. Consider the circuit of Fig. 3.16 with $(W/L)_1 = 50/0.5$, $R_D = 2\ \text{k}\Omega$, and $R_S = 200\ \Omega$.

(a) Calculate the small-signal voltage gain if $I_D = 0.5$ mA.

(b) Assuming $\lambda = \gamma = 0$, calculate the input voltage that places M_1 at the edge of the triode region. What is the gain under this condition?

3.25. Suppose the circuit of Fig. 3.15 is designed for a voltage gain of 5. If $(W/L)_1 = 20/0.5$, $I_{D1} =$ 0.5 mA, and $V_b = 0$ V.

(a) Calculate the aspect ratio of M_2.

(b) What input level places M_1 at the edge of the triode region. What is the small-signal gain under this condition?

(c) What input level places M_2 at the edge of the saturation region? What is the small-signal gain under this condition?

3.26. Sketch the small-signal voltage gain of the circuit shown in Fig. 3.15 as V_b varies from 0 to V_{DD}. Consider two cases: (a) M_1 enters the triode region before M_2 is saturated; (b) M_1 enters the triode region after M_2 is saturated.

3.27. A source follower can operate as a level shifter. Suppose the circuit of Fig. 3.30(b) is designed to shift the voltage level by 1 V, i.e., $V_{in} - V_{out} = 1$ V.

(a) Calculate the dimensions of M_1 and M_2 if $I_{D1} = I_{D2} = 0.5$ mA, $V_{GS2} - V_{GS1} = 0.5$ V, and $\lambda = \gamma = 0$.

(b) Repeat part (a) if $\gamma = 0.45\ \text{V}^{-1}$ and $V_{in} = 2.5$ V. What is the minimum input voltage for which M_2 remains saturated?

3.28. Sketch the small-signal gain, V_{out}/V_{in}, of the cascode stage shown in Fig. 3.50 as V_b goes from 0 to V_{DD}. Assume $\lambda = \gamma = 0$.

3.29. The cascode of Fig. 3.60 is designed to provide an output swing of 1.9 V with a bias current of 0.5 mA. If $\gamma = 0$ and $(W/L)_{1-4} = W/L$, calculate V_{b1}, V_{b2}, and W/L. What is the voltage gain if $L = 0.5\ \mu$m?