國立中正大學 105 學年度碩士班招生考試試題

電磁晶片組

系所別：電機工程學系-計算機工程組
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科目：電子學

第 2 節

1. Consider a process technology for which V_t = 0.6 V, μ_n = 450 cm²/Vs, t_{ox} = 8 nm, L_{min} = 0.25 μm.

   (a) Find C_{ox} (4%)

   (b) For a MOSFET with W/L = 5 μm/0.5 μm, calculate the values of V_{GS} and V_{DSmin} needed to operate the transistor in the saturation region with a dc current I_D = 80 μA. (6%)

   (c) For the device in (b), find the value of V_{GS} required to cause the device to operate as a 500-Ω resistor for very small V_{DS}. (5%)

2. Design the circuit below so that the transistor operates in saturation with I_D = 0.4 mA and V_D = +2 V. Let the PMOS have V_t = -1 V and $k_p'(W/L)$ = 0.8 mA/V². Assume λ= 0.

   (a) Calculate V_G, R_D, R_{G1}, and R_{G2}. (12%)

   (b) What is the largest value of R_D while maintaining saturation-region operation? (3%)

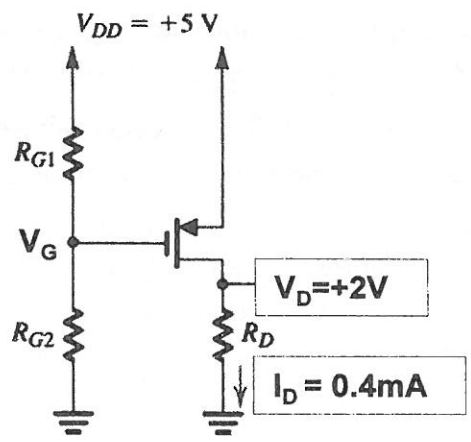

Fig. P2

3. For the cascode amplifier, let Q_1 and Q_2 be identical with V_t = 0.6 V, k_n' = 160 μA/V², λ = 0.05 V⁻¹, $\chi = g_{mb}/g_m$ = 0.2, W/L = 100, and V_{OV} = 0.2 V.

   (a) Calculate the bias current I and the values of g_{m1}, g_{m2}, r_{o1}, r_{o2}. (6%)

   (b) Find the open-circuit voltage gain. (3%)

   (c) Calculate the value of the effective short-circuit transconductance, G_m, and the value of output impedance R_{out} of the cascode. (4%)

   (d) If the constant-current source I is implemented with a cascode circuit with an output resistance of 10 MΩ, find the voltage gain Av. (4%)

   (e) Ignoring the small signal swing at the input and at the drain of Q_1, find the lowest value that V_{BIAS} should have to operate Q_1 and Q_2 in saturation. (3%)

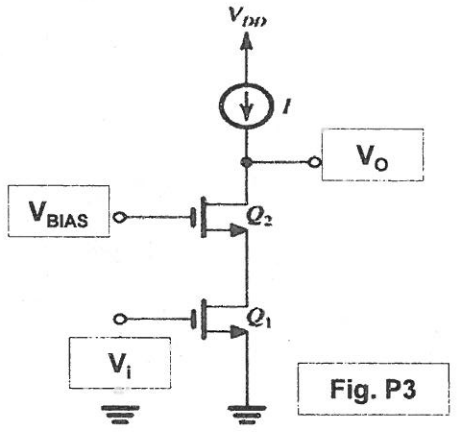

Fig. P3

4. Consider the voltage regulation circuit shown in Fig. P4, where four identical diodes in forward bias produce a total voltage of $V_O \approx 2.8$ V and a total current of I = 8 mA. Please compute V_O if the supply voltage (V_{IN}) becomes 3.35 V. (Note: thermal voltage V_T = 25 mV) . (15%)

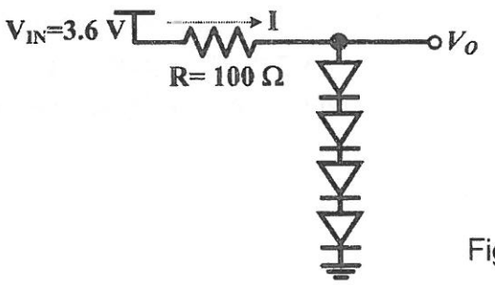

Fig. P4

5. The circuits in Fig. P5 is fabricated with the following process parameters: $\mu_n C_{ox}$ = 150 μA/V², $\mu_p C_{ox}$ = 75 μA/V², $V_{tn} = |V_{tp}| = 0.5$ V, and $\lambda = 0$ V^{-1}, while supply voltage (V_{DD}) is 1.8 V.
(a) In the circuit shown in Fig. P5(a), assume $(W/L)_{Q1}=10$, $(W/L)_{Q2}=20$, and V_{IN} = 1.8 V. In case Q1 operates in the saturation region, determine the output voltage (V_{OUT}). (8%)
(b) Considering the channel length modulation with $\lambda = 0.02$ V^{-1} for both Q_1 and Q_2 of the circuit shown in Fig. P5(b), determine a relationship between $(W/L)_{Q1}$ and $(W/L)_{Q2}$ that set the trip point to 0.9 V with a biasing current of 120 μA, thus providing a "symmetric" voltage transfer characteristic (VTC). In addition, determine the small-signal gain under this biasing condition. (12%)

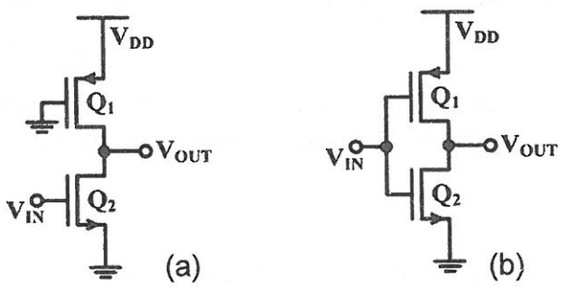

Fig. P5

6. (a) The circuit in Fig. P6(a) has V_{i1} = 0.4 V, V_{i2} = 0.6 V, V_{i3} = 0.9 V, and V_{i4} = 1.1 V, R = 5 KΩ, and R_f = 1 KΩ. Find V_o in case the operational amplifier is ideal. (3%)
(b) An operational amplifier with an output resistance of 100 Ω was configured as the unity-gain buffer shown in Fig. P6(b) to drive a 10 Ω Load, please find the required gain (A_0) to achieve a gain error of 1% for the unity-gain buffer. (6%)

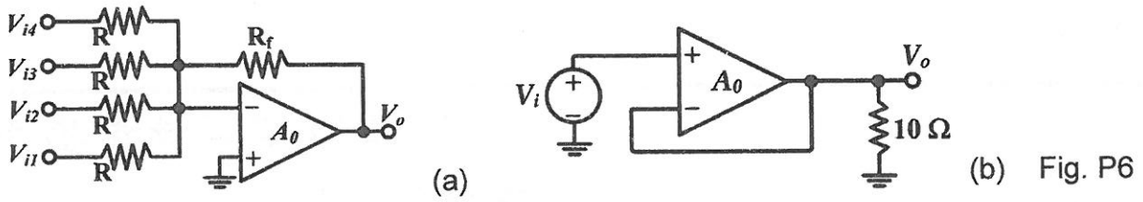

Fig. P6

7. In each of the following statements, determine whether the statement is "True" or "False".
   a) We can increase the reverse bias voltage of a PN Junction to increase the charge stored in the depletion region. (2%)
   b) The definition of the small signal parameter r_o of a MOSFET is $\left[\left.\frac{\partial i_D}{\partial v_{GS}}\right|_{v_{GS}=V_{GS}}\right]^{-1}$. (2%)
   c) The increase in temperature will result in a corresponding increase in drain current of a MOSFET. (2%)