國立成功大學
111學年度碩士班招生考試試題

編　號：41

系　所：光電科學與工程學系

科　目：電子學

日　期：0220

節　次：第 1 節

備　註：不可使用計算機

編號： 41

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※ 考生請注意：本試題不可使用計算機。　請於答案卷(卡)作答，於本試題紙上作答者，不予計分。

1. A reverse-biased photodiode is specified to have a dark current of 100 pA and a responsivity of 0.5 A/W. It is connected to the transresistance amplifier shown in Fig. 1. Assume op amp is ideal. (20%)
   (a) Please show five characteristics of ideal op amp. (10%)
   (b) What is the output voltage v_o with 10 μW of light incident on the photodiode? (10%)

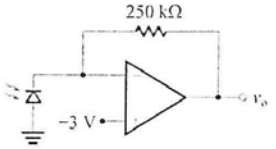

Fig. 1

2. For the circuit shown in Fig. 2, EBJ operated at 0.7 V for Q_1 and Q_2, find V_1, V_2, and V_3. (15%)

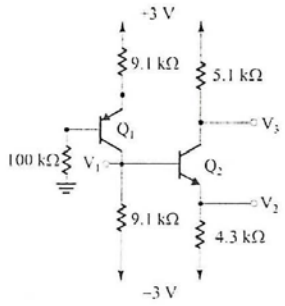

Fig. 2

3. In the circuit of Fig. 3, transistors Q_1 and Q_2 have V_t=0.7 V, $(W/L)_1$=1.5$(W/L)_2$=20, and the process transconductance parameter k_n'=125 μA/V^2. Find V_1, V_2, and V_3. (15%)

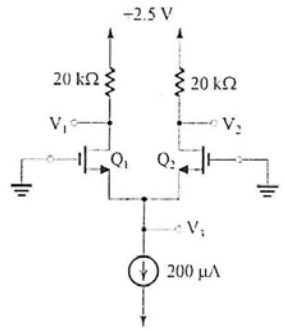

Fig. 3

4. The MOSFET (with aspect ratio of 10) in the amplifier circuit (Fig. 4) has threshold voltage (V_t) of 0.4 V, the process transconductance parameter (k_n') of 0.5 mA/V^2, and the associated value of λ of 0.02 V^{-1}. The signal V_{sig} has a zero average. (25%)

(a) It is required to bias the transistor to operate at an overdrive voltage V_{ov} = 0.1 V. What must the dc voltage at the drain be? Calculate the dc drain current I_D taking into account λ. Now, what value must the drain resistance R_D have? (3 X 3% =9%)

(b) Calculate the values of transconductance (g_m) and output resistance (r_o) at the bias point established in (a) (2 X 3% =6%)

(c) Derive the expression for the voltage gain (V_o/V_{sig}) using the small signal equivalent circuit of the amplifier. And find the value of the gain by using the r_o ~2 MΩ. (10%)

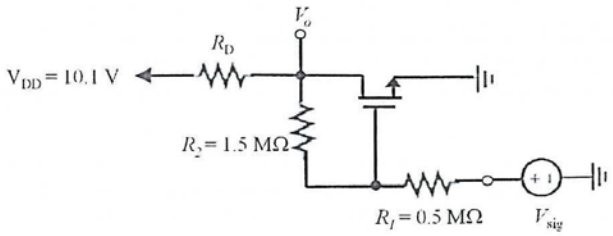

Fig. 4

5. The circuit of Fig. 5 shows a differential amplifier. (15%)

(a) Find the differential half-circuit for the amplifier and use it to drive an expression for the differential gain $A_d = v_{od}/v_{id}$ in terms of g_m, R_D, and R_S. Neglect the early effect. (8%)

(b) The resistance R_S in the circuit can be implemented by using a MOSFET (Q_3) operated in the triode region. Here Q_3 implements R_S, with the value of R_S determined by the gate voltage v_{G3} of Q_3. Consider the case $v_{G1} = +v_{id}/2$ and $v_{G2} = -v_{id}/2$, where v_{id} is a small signal. Assume that Q_3 now conducts current and operates in the triode region with a small v_{DS}. What resistance r_{DS} does it have, expressed in terms of the overdrive voltage V_{ov3} at which it is operating? This is the resistance R_S. Now if all three transistors have the same aspect ratio W/L, express R_S in terms of V_{ov}, V_{ov3}, and $g_{m1,2}$. (7%)

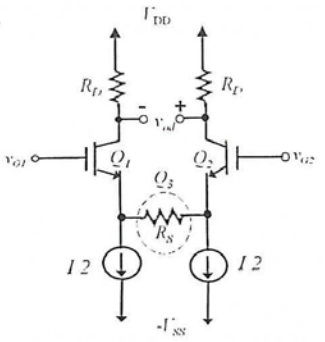

Fig. 5

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6. The transistors in the circuit (Fig. 6) have $\beta = 100$ and $V_A = 50$ V. What is the effect of the increasing the bias currents by a factor of 10 on R_{in} and the overall voltage gain G_v? (10%)

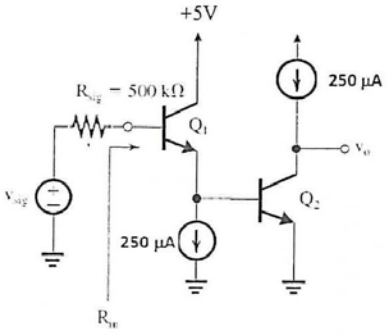

Fig. 6