國立成功大學 108 學年度碩士班招生考試試題

系　　所：光電科學與工程學系

考試科目：電子學

考試日期：0224，節次：1

※ 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. (10 %) (Circuit Models for Amplifiers) An amplifier with an input resistance of 10 kΩ, when driven by a current source of1 μA and a source resistance of 100 kΩ, has a short-circuit output current of 10 mA and an open-circuit output voltage of 10 V. The device is driving a 4-kΩ load. Give the values of the voltage gain, current gain, and power gain expressed as ratios.

2. (10 %) (The OP Amplifier)

(A) Please plot the configuration of inverting amplifier.

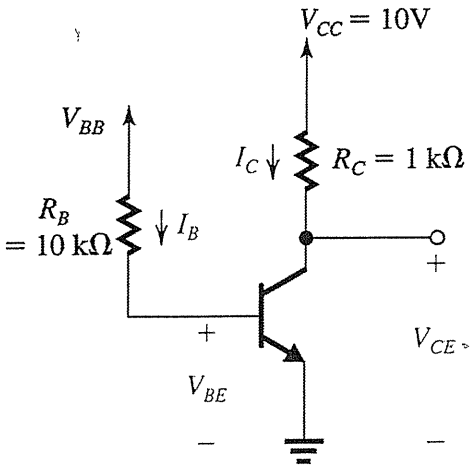
(B) Show that for the inverting amplifier if the op-amp gain is A, the input resistance is given by

$$R_{in} = R_1 + \frac{R_2}{A+1}$$

3. (10 %) (Rectifier Circuits) Consider a half-wave rectifier circuit with a triangular-wave input of 5-V peak-to-peak amplitude and zero average, and with R=1 kΩ. Assume that the diode can be represented by the constant-voltage-drop model with $V_D = 0.65$ V and $r_D = 20$ Ω. Find the average value of υ_0.

4. (10 %) (BJT Circuits) For the circuit with BJT (shown in below), to determine the value of the voltage V_{BB} that results in the transistor operating

(a) in the active mode with $V_{CE} = 5\ V$; (b)at the edge of saturation; (c) deep in saturation with $\beta_{\text{forced}} = 10$. For simplicity, assume that V_{BE} remains constant at 0.7 V. The transistor is specified to be 50.



5. (10 %) (MOS Transistor) An NMOS transistor with $k_n = 1$ mA/V^2 and $V_t = 1$ V is operated with $V_{GS} = 2.5$ V. At what value of V_{DS} does the transistor enter the saturation region? What value of I_D is obtained in saturation.

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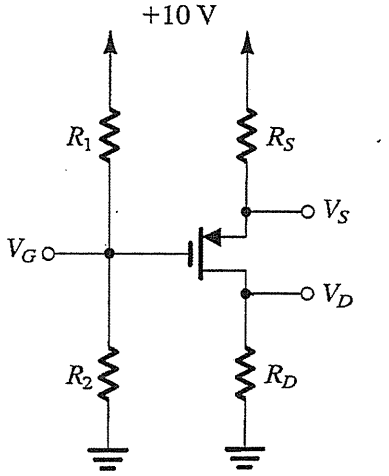
6. Design the following circuit so that the transistor operates in saturation with V_D biased 1 V from the edge of the triode region, with $I_D = 1$ mA and $V_D = 3$ V, for each of the following two devices (use a 10-mA current in the voltage divider):

(a) $|V_t| = 1$ V and $k'_pW/L = 0.5$ mA/V^2

(b) $|V_t| = 2$ V and $k'_pW/L = 1.25$ mA/V^2

For each case, specify the values of V_G, V_D, V_S, R_1, R_2, R_S, R_D. (14%)



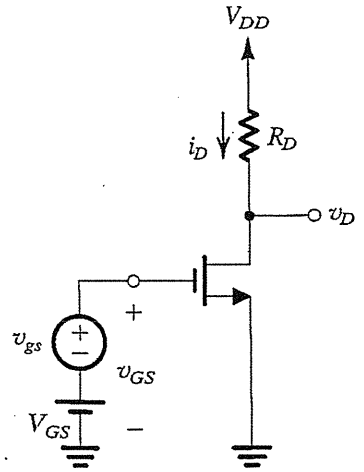
7. Consider the FET amplifier of the following Figure for the case, $V_t = 2$ V, $k'_n(W/L) = 1.0$ mA/V^2, $V_{GS} = 4$ V, $V_{DD} = 10$ V, and $R_D = 3.6$ kΩ. (12%)

(a) Find the dc quantities I_D and V_D.

(b) Calculate the value of g_m at the bias point.

(c) Calculate the value of the voltage gain.

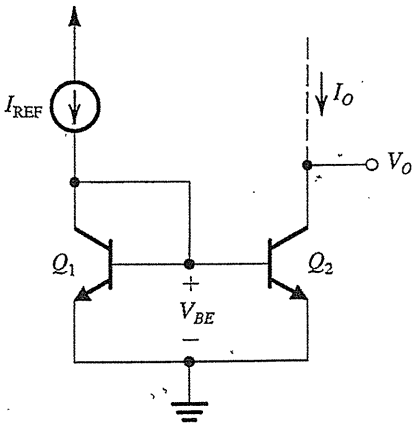
(d) If the MOSFET has $\lambda = 0.01$ V^{-1}, find output resistance r_o at the bias point and calculate the voltage gain. (λ is called the "channel-length modulation coefficient").



8. Consider the basic bipolar current mirror of the following figure for the case in which Q_1 and Q_2 are identical devices having $I_S = 10^{-15}$ A. (12%)

(a) Assuming the transistor β is very high, find the range of V_{BE} and I_O corresponding to I_{REF} increasing from 10 μA to 10 mA. Assume that Q_2 remains in the active mode, and neglect the Early effect.

(b) Find the range of I_O corresponding to I_{REF} in the range of 10 μA to 10 mA, taking into account the finite β. Assume that β remains constant at 100 over the current range 0.1 mA to 5 mA but that at $I_C \cong 10$ mA and at $I_C \cong 10$ μA , $\beta = 70$. Specify I_O corresponding to $I_{REF} = 10$ μA, 0.1 mA, 1 mA, and 10 mA. Note that β variation with current causes the current transfer ratio to vary with current.



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9. Consider the CMOS amplifier of the following figure when fabricated with a process for which $k'_n = 2.5k'_p = 250\ \mu A/V^2$, $|V_t| = 0.6$ V, and $|V_A| = 10$ V. Find I_{REF} and $(W/L)_1$ to obtain a voltage gain of -40 V/V and an output resistance of 100 kΩ. If Q_2 and Q_3 are to be operated at the same overdrive voltage as Q_1, what must their W/L ratios be? (12%)