

# 國立中央大學 112 學年度碩士班考試入學試題

所別： 光電類

共 3 頁 第 1 頁

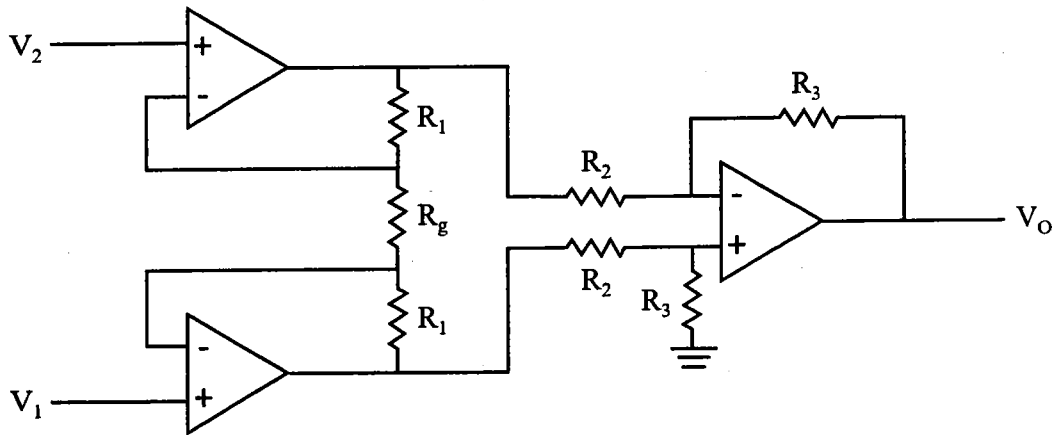
科目： 電子學

本試題共五大題計算題，無計算過程不予計分。答案請標示單位。

1. Following figure shows an instrumentation amplifier.

(a) Please DERIVE the gain of this amplifier. No points are given if you provide the result without derivation process. (10%)

(b) As  $R_1 = 5 \text{ k}\Omega$ ,  $R_2 = 2 \text{ k}\Omega$ ,  $R_3 = 4 \text{ k}\Omega$ ,  $R_g = 500 \Omega$ ,  $V_1 = 4.5 \text{ V}$  and  $V_2 = 4.25 \text{ V}$ , calculate  $V_O$ . (5%)



2. Please design an op-amp circuit to get an output voltage described by the following equation: (10%)

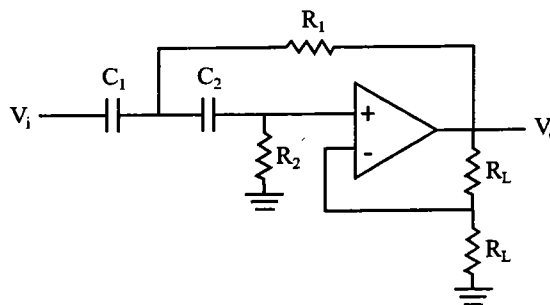
$$V_O = \frac{R_f}{R_1} V_1 + \frac{R_f}{R_2} V_2 + \frac{R_f}{R_3} V_3$$

3. The figure below shows an active filter. Please answer the following questions.

(a) Please DERIVE the transfer function  $H(\omega) = V_o/V_i$  of this circuit. (10%)

(b) Which type of filter is this circuit? What is the corner frequency? (10%)

(c) As  $R_1 = R_2 = 100 \Omega$ ,  $C_1 = C_2 = 0.1 \mu\text{F}$  and  $V_i = 5\cos(10000t)$ , please estimate the amplitude of  $V_o$ . (5%)



注意:背面有試題

所別： 光電類

共 2 頁 第 2 頁

科目： 電子學

4. For the following circuit, n-MOSFET  $Q_1 \sim Q_4$  works as a MOS differential pair with active load while  $Q_5$  and  $Q_6$  work as a current mirror. These transistors are identical with  $V_t = 1$  V,  $k_n = \mu_n C_{ox}(W/L) = 1$  mA/V<sup>2</sup>,  $V_A = 100$  V, the conducting current at  $R_{REF} = 2$  mA, and  $V_{DD} = V_{SS} = 5$  V.

- (a) Please find the corresponding  $R_{REF}$ . (5%)
- (b) If a common-mode signal  $v_{icm} = 1$  mV is applied to both  $v_{G1}$  and  $v_{G2}$ , how much small-signal current is induced through  $Q_6$ ? If a 10 k $\Omega$  is connected to the load, how much small-signal current is through the load? Assume all the MOSFETs are in the saturation regime and perfectly matched. The channel length modulation of the differential pair can be ignored. (10%)
- (c) Please find the output resistance (at  $v_o$ ). (5%)
- (d) How about the gain ( $A_v$ ) at the output with a 10 k $\Omega$  load? (5%)

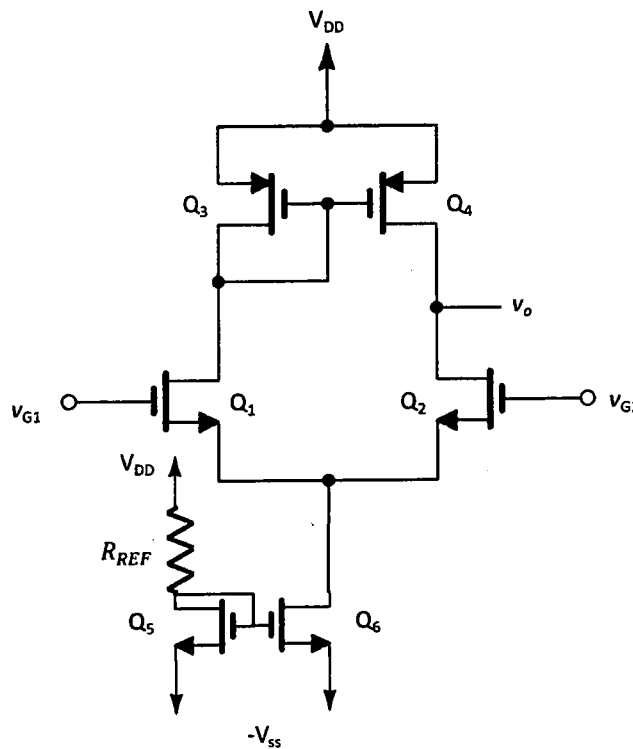


Figure 4

注意:背面有試題

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科目： 電子學

5. A BJT transistor is connected to the cascode MOS current mirror as shown below. Assume all MOSFETs are matched. The current conducted by BJT is followed by the exponential relationship  $V_{BE} = V_T \ln(I/I_S)$  and  $V_{BE} = 0.7V$  at  $I = 1mA$ . Please evaluate the following at room temperature ( $V_T = 25mV$ ):
- If the conducting current  $I = 0.1 mA$ , please find the resistance  $R_{ref}$ ? (5%)
  - If the  $k_n = \mu_n C_{ox}(W/L) = 0.2 mA/V^2$  and  $V_t = 1 V$  for all the MOSFETs, please find the corresponding  $V_1$  and  $V_2$ . (10%)
  - Followed by (b), please find transconductance  $g_m$  of M4 and the resistance  $R_{out}$  at the drain port of MOSFET M4. Assume the channel length modulation induced resistance  $r_o = 20 k\Omega$ . (10%)

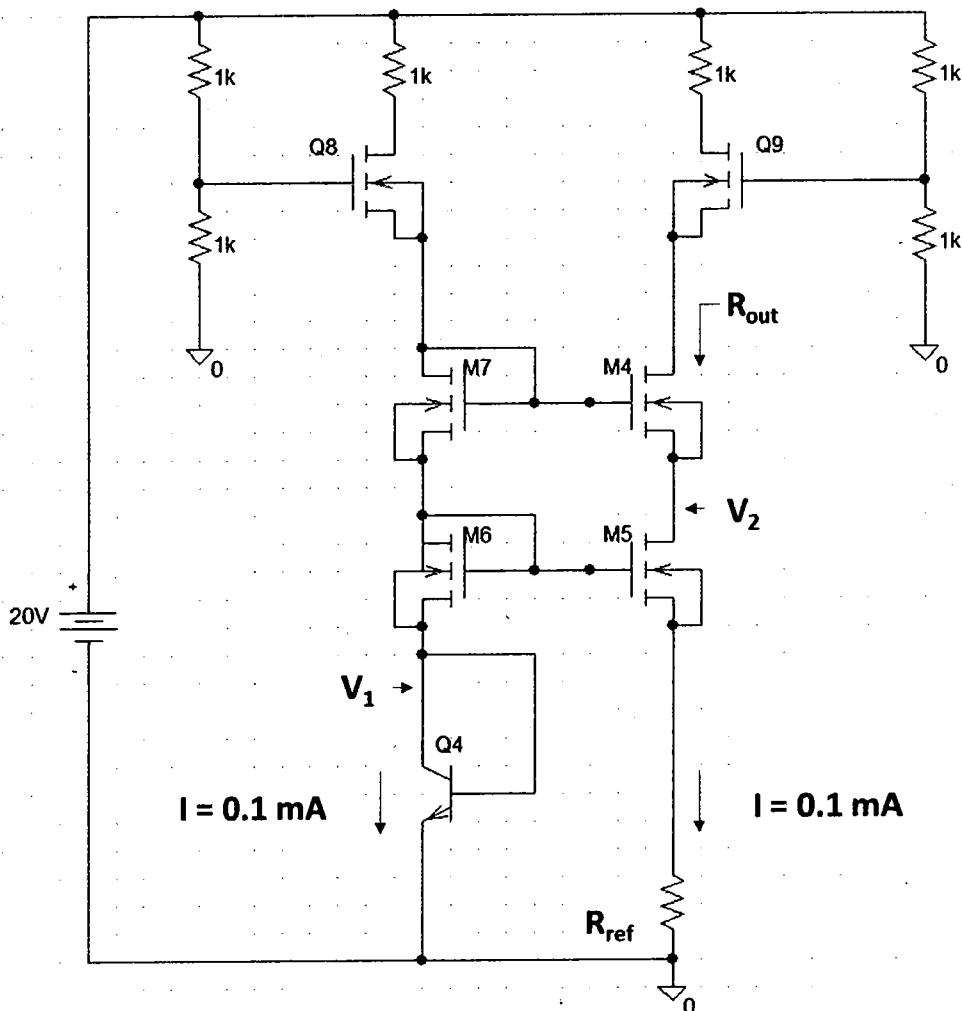


Figure 5