Electronics II, Exam-2, Spring 2023

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April 14, 2023, Prof. Dah-Chung Chang (E1-311)

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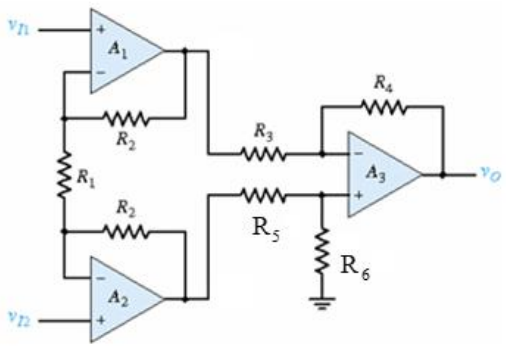
1. (25%) Consider the following instrumentation amplifier.

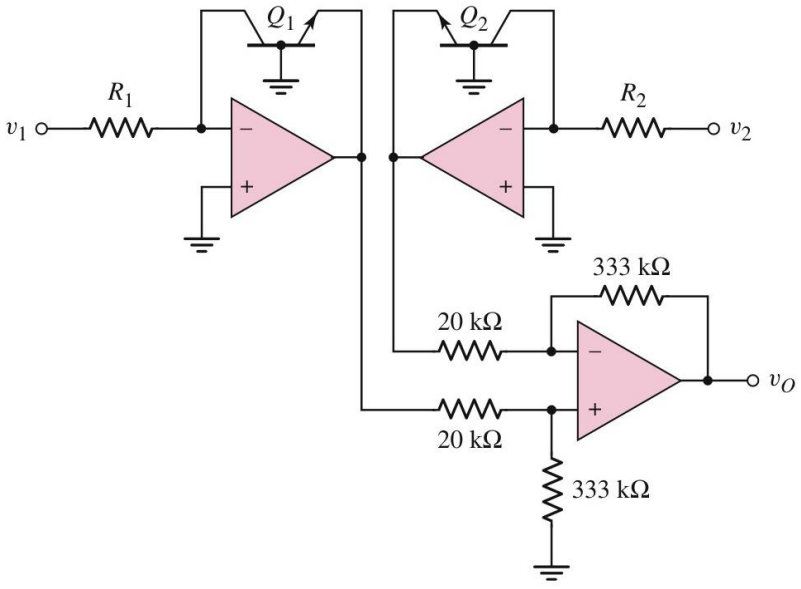


   (a) Assume that $R_4 / R_3 = R_6 / R_5$. Find v_O in relation of v_{I1} and v_{I2}. (10%)

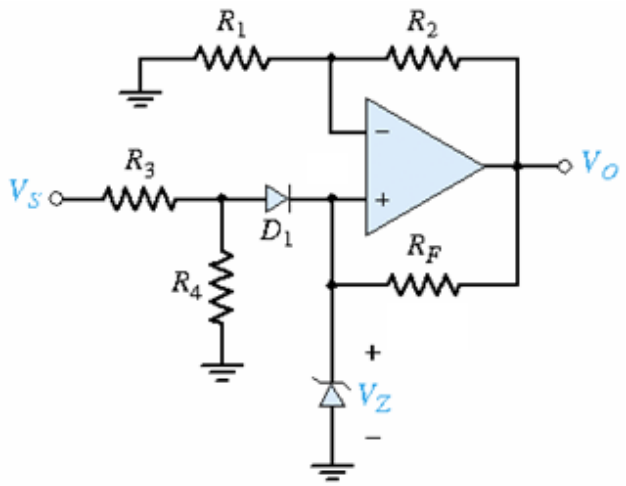
   (b) Assume that $R_2 / R_1 = 1$, $R_4 / R_3 = 10$, and $R_6 / R_5 = 12$. Determine CMRR(dB). (15%)

2. (25%) Let the semiconductor parameter for the transistor be $V_T = 0.026V$. Derive the following result

$$v_O = 0.4329 \ln\left(\frac{v_2 R_1}{v_1 R_2}\right).$$



3. (20%) The output of the voltage reference circuit is 10V. Use a Zener diode with a breakdown voltage of 6V. Assume that the Zener diode is biased at the current range of 1 mA to 1.5mA and the PN diode cut-in voltage is 0.6V. The resistor parameters are $R_3 = 10K\Omega$ and $R_4 = 30K\Omega$.
   (a) Find the ratio of R_2 / R_1 and the value of R_F. (10%)
   (b) Find the possible current values supplied by V_S. (10%)



4. (20%)

Consider a power MOSFET for which the thermal resistance parameters are:

$\theta_{\text{dev–case}} = 1.75\,^{\circ}\text{C/W}$ $\theta_{\text{case–snk}} = 1\,^{\circ}\text{C/W}$

$\theta_{\text{snk–amb}} = 5\,^{\circ}\text{C/W}$ $\theta_{\text{case–amb}} = 50\,^{\circ}\text{C/W}$

The ambient temperature is $T_{\text{amb}} = 30\,^{\circ}\text{C}$, and the maximum junction or device temperature is $T_{j,\text{max}} = T_{\text{dev}} = 150\,^{\circ}\text{C}$.

Determine

(a) the maximum power dissipation in a transistor, with and without the heat sink. (10%)

(b) the temperature of the transistor case and heat sink. (10%)

5. (10%) For the common-emitter output stage shown on the right, let V_{CC} = 12 V and R_L = 1 kΩ. Assume the transistor *Q*-point is in the center of the load line. Assume the sinusoidal output voltage is limited to a 9 V peak-to-peak value. Determine the power conversion efficiency.