

**1. (total 20 points: 10 points, 10 points)**

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

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

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

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

- (a) Determine the maximum power dissipation in a transistor, with and without the heat sink.
- (b) With sink, determine the temperature of the transistor case and the heat sink.

**2. (total 10 points: 10 points)**

Derive the relationship between  $i_{Cn}$  and  $i_{Cp}$  in the following figure, assuming the quiescent collector current is  $I_{CQ}$ .

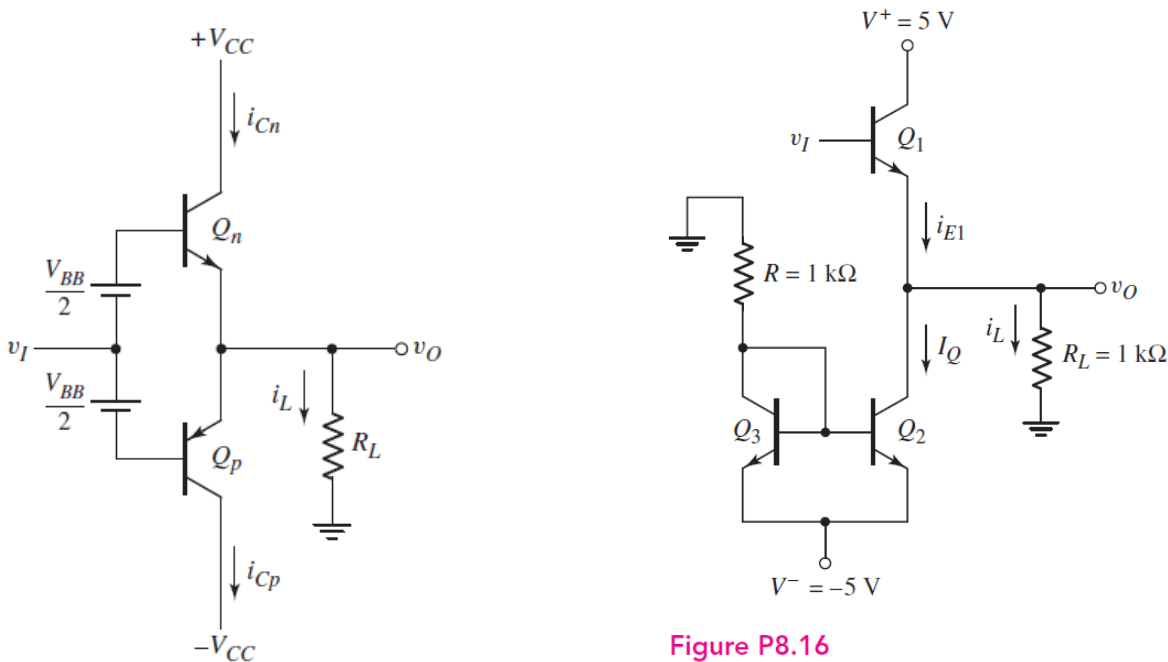


Figure P8.16

**3. (total 20 points: 10 points, 10 points)**

Consider the class-A emitter-follower circuit shown in Figure P8.16. Assume all transistors are matched with  $V_{BE(\text{on})} = 0.7 \text{ V}$ ,  $V_{CE(\text{sat})} = 0.2 \text{ V}$ , and  $V_A = \infty$ . Neglect base currents. Determine the maximum and minimum values of output voltage and the corresponding input voltages for the circuit to operate in the linear region.

**4. (total 10 points: 10 points)**

Find the relationship between  $v_o$  and  $v_{I1} - v_{I2}$  in Figure 9.26.

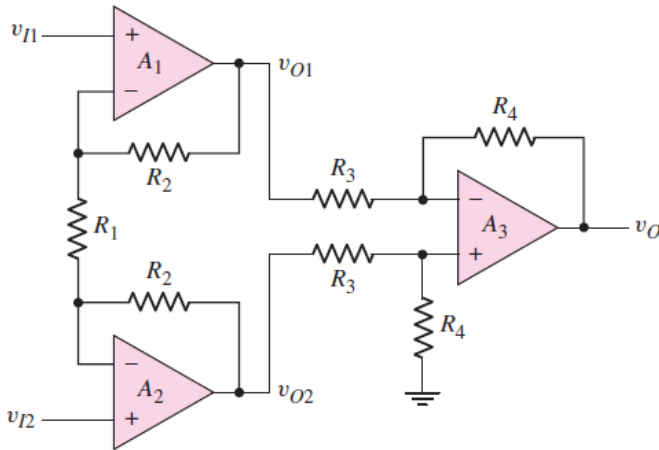


Figure 9.26 Instrumentation amplifier

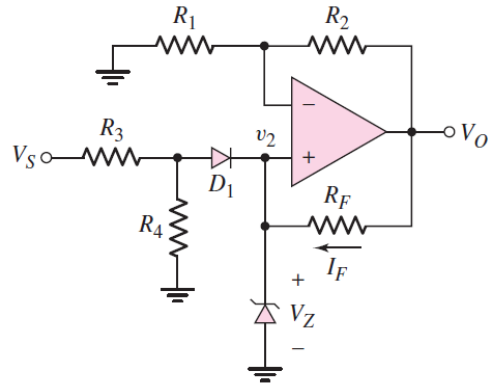


Figure 9.42 Op-amp voltage reference circuit

**5. (total 10 points: 5 points, 5 points)**

In Figure 9.42,  $D_1$  is a diode with cut-in voltage  $0.7V$  and the Zener diode breakdown voltage is  $V_Z$ . Find the output voltage  $v_o$  and  $I_F$ , assuming  $\frac{R_4}{R_3 + R_4} V_S > V_Z + 0.7$ .

**6. (total 20 points: 20 points)**

Show that the output resistance in Figure P9.59 is given by

$$R_o = \frac{R_1 R_2 R_3}{R_1 R_3 - R_2 R_F}$$

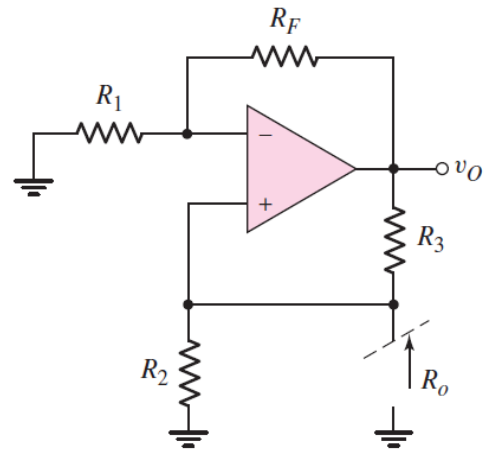


Figure P9.59

**7. (total 10 points: 10 points)**

Find the output  $v_o$  in terms of  $v_{I1}$  and  $v_{I2}$ .

