Electronics 2019 NCU/CM Exam-2 2019/4/19 DCChang

#1

Solution (Maximum Power): When no heat sink is used, the maximum device power dissipation is found from Equation (8.7) as

$$P_{D,\max} = \frac{T_{j,\max} - T_{\text{amb}}}{\theta_{\text{dev-case}} + \theta_{\text{case-amb}}} = \frac{150 - 30}{1.75 + 50} = 2.32\ \text{W}$$

When a heat sink is used, the maximum device power dissipation is found from Equation (8.6) as

$$P_{D,\max} = \frac{T_{j,\max} - T_{\text{amb}}}{\theta_{\text{dev-case}} + \theta_{\text{case-snk}} + \theta_{\text{snk-amb}}}$$
$$= \frac{150 - 30}{1.75 + 1 + 5} = 15.5\ \text{W}$$

Solution (Temperature): The device temperature is $T = 150\ ^\circ\text{C}$ and the ambient temperature is $T_{\text{amb}} = 30\ ^\circ\text{C}$. The heat flow is $P_D = 15.5$ W. The heat sink temperature (see Figure 8.11) is found from

$$T_{\text{snk}} - T_{\text{amb}} = P_D \cdot \theta_{\text{snk-amb}}$$

or

$$T_{\text{snk}} = 30 + (15.5)(5) \Rightarrow T_{\text{snk}} = 107.5\ ^\circ\text{C}$$

The case temperature is found from

$$T_{\text{case}} - T_{\text{amb}} = P_D \cdot (\theta_{\text{case-snk}} + \theta_{\text{snk-case}})$$

or

$$T_{\text{case}} = 30 + (15.5)(1 + 5) \Rightarrow T = 123\ ^\circ\text{C}$$

#2

There is a relationship between i_{Cn} and i_{Cp}. We know that

$$v_{BEn} + v_{EBp} = V_{BB} \qquad \textbf{(8.34(a))}$$

which can be written

$$V_T \ln\left(\frac{i_{Cn}}{I_S}\right) + V_T \ln\left(\frac{i_{Cp}}{I_S}\right) = 2V_T \ln\left(\frac{I_{CQ}}{I_S}\right) \qquad \textbf{(8.34(b))}$$

Combining terms in Equation (8.34(b)), we find

$$i_{Cn} i_{Cp} = I_{CQ}^2 \qquad \textbf{(8.35)}$$

#3

$v_o(\max) = 4.8\text{ V}$

$$i_{C3} = i_{C2} = \frac{-0.7-(-5)}{1} = 4.3\text{ mA}$$

$v_I = v_o + 0.7$ $\qquad$ $i_L(\max) = -4.3\text{ mA} = \dfrac{v_S(\min)}{1}$

so $-3.6 \le v_I \le 5.5\text{ V}$ $\qquad$ $\underline{v_o(\min) = -4.3\text{ V}}$

#4

We begin the analysis using the virtual short concept. The voltages at the inverting terminals of the voltage followers are equal to the input voltages. The currents and voltages in the amplifier are shown in Figure 9.27. The current in resistor R_1 is then

$$i_1 = \frac{v_{I1} - v_{I2}}{R_1} \tag{9.64}$$

The current in resistors R_2 is also i_1, as shown in the figure, and the output voltages of op-amps A_1 and A_2 are, respectively,

$$v_{O1} = v_{I1} + i_1 R_2 = \left(1 + \frac{R_2}{R_1}\right) v_{I1} - \frac{R_2}{R_1} v_{I2} \tag{9.65(a)}$$

and

$$v_{O2} = v_{I2} - i_1 R_2 = \left(1 + \frac{R_2}{R_1}\right) v_{I2} - \frac{R_2}{R_1} v_{I1} \tag{9.65(b)}$$

From previous results, the output of the difference amplifier is given as

$$v_O = \frac{R_4}{R_3}(v_{O2} - v_{O1}) \tag{9.66}$$

Substituting Equations (9.65(a)) and (9.65(b)) into Equation (9.66), we find the output voltage, as follows:

$$v_O = \frac{R_4}{R_3}\left(1 + \frac{2R_2}{R_1}\right)(v_{I2} - v_{I1}) \tag{9.67}$$

#5

At this specific voltage, we have

$$V_O = \left(1 + \frac{R_2}{R_1}\right) V_Z$$

and

$$I_F = \frac{V_O - V_Z}{R_F} = \frac{R_2 V_Z}{R_1 R_F}$$

#6

(1) $$I_X = \frac{V_X}{R_2} + \frac{V_X - v_O}{R_3}$$

(2) $$\frac{V_X}{R_1} + \frac{V_X - v_O}{R_F} = 0$$

From (2) $v_O = V_X \left(1 + \frac{R_F}{R_1}\right)$

Then (1) $I_X = V_X \left(\frac{1}{R_2} + \frac{1}{R_3}\right) - \frac{1}{R_3} \cdot V_X \left(1 + \frac{R_F}{R_1}\right)$

$$\frac{I_X}{V_X} = \frac{1}{R_0} = \frac{1}{R_2} + \frac{1}{R_3} - \frac{1}{R_3} - \frac{R_F}{R_1 R_3} = \frac{1}{R_2} - \frac{R_F}{R_1 R_3}$$

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

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

Note: If $\frac{R_F}{R_1 R_3} = \frac{1}{R_2} \Rightarrow R_2 R_F = R_1 R_3$ then $R_o = \infty$, which corresponds to an ideal current source.

#7

$$\upsilon_O = \left(\frac{-10}{1}\right)\left(\frac{-20}{1}\right) \cdot \upsilon_{I1} - \left(\frac{20}{1}\right) \cdot \upsilon_{I2} = 200\upsilon_{I1} - 20\upsilon_{I2}$$