# Homework 4

# Solution

P 5.5 **[a]** $i_a = \dfrac{25 \times 10^{-3}}{5000} = 5\,\mu\text{A}$

$$v_a = -50 \times 10^3 i_a = -250\,\text{mV}$$

**[b]** $\dfrac{v_a}{50{,}000} + \dfrac{v_a}{10{,}000} + \dfrac{v_a - v_o}{40{,}000} = 0$

$$\therefore \quad 4v_a + 20v_a + 5v_a - 5v_o = 0$$

$$\therefore \quad v_o = 29v_a/5 = -1.45 \text{ V}$$

**[c]** $i_a = 5\,\mu\text{A}$

**[d]** $i_o = \dfrac{-v_o}{30{,}000} + \dfrac{v_a - v_o}{40{,}000} = 78.33\,\mu\text{ A}$

P 5.16 **[a]** This circuit is an example of an inverting summing amplifier.

**[b]** $v_o = -\dfrac{220}{33}v_a - \dfrac{220}{22}v_b - \dfrac{220}{80}v_c = -8 + 15 - 11 = -4 \text{ V}$

**[c]** $v_o = -19 - 10v_b = \pm 6$

$$\therefore \quad v_b = -1.3 \text{ V} \quad \text{when} \quad v_o = -6 \text{ V};$$

$$v_b = -2.5 \text{ V} \quad \text{when} \quad v_o = 6 \text{ V}$$

$$\therefore \quad -2.5 \text{ V} \le v_b \le -1.3 \text{ V}$$

P 5.25 **[a]** The circuit is a non-inverting summing amplifier.

**[b]** $$\frac{v_p - v_a}{3.3\times 10^3} + \frac{v_p - v_b}{4.7\times 10^3} = 0$$

$$\therefore\quad v_p = 0.5875 v_a + 0.4125 v_b$$

$$\frac{v_n}{10{,}000} + \frac{v_n - v_o}{100{,}000} = 0$$

$$\therefore\quad v_o = 11 v_n = 11 v_p = 6.4625 v_a + 4.5375 v_b = 8.03\ \text{V}$$

**[c]** $$v_p = v_n = \frac{v_o}{11} = 730\ \text{mV}$$

$$i_a = \frac{v_a - v_p}{3.3\times 10^3} = -100\,\mu\text{A}$$

$$i_b = \frac{v_b - v_p}{4.7\times 10^3} = 100\,\mu\text{A}$$

**[d]** 6.4625 for $v_a$

4.5375 for $v_b$

P 5.31 **[a]** $$v_o = \frac{R_d(R_a + R_b)}{R_a(R_c + R_d)} v_b - \frac{R_b}{R_a} v_a = \frac{47(110)}{10(80)}(0.80) - 10(0.67)$$

$$v_o = 5.17 - 6.70 = -1.53\ \text{V}$$

**[b]** $$v_n = v_p = \frac{(800)(47)}{80} = 470\,\text{mV}$$

$$i_a = \frac{(670 - 470)10^{-3}}{10\times 10^3} = 20\,\mu\text{A}$$

$$R_a = \frac{v_a}{i_a} = \frac{670\times 10^{-3}}{20\times 10^{-6}} = 33.5\,\text{k}\Omega$$

**[c]** $$R_{\text{in b}} = R_c + R_d = 80\,\text{k}\Omega$$

P 5.32 $$v_p = \frac{v_b R_b}{R_a + R_b} = v_n$$

$$\frac{v_n - v_a}{4700} + \frac{v_n - v_o}{R_f} = 0$$

$$v_n\left(\frac{R_f}{4700} + 1\right) - \frac{v_a R_f}{4700} = v_o$$

$$\therefore \quad \left(\frac{R_f}{4700} + 1\right)\frac{R_b}{R_a + R_b} v_b - \frac{R_f}{4700} v_a = v_o$$

$$\therefore \quad \frac{R_f}{4700} = 10; \qquad R_f = 47\,\text{k}\Omega$$

$$\therefore \quad \frac{R_f}{4700} + 1 = 11$$

$$\therefore \quad 11\left(\frac{R_b}{R_a + R_b}\right) = 10$$

$$11R_b = 10R_b + 10R_a \qquad R_b = 10R_a$$

$$R_a + R_b = 220\,\text{k}\Omega$$

$$11R_a = 220\,\text{k}\Omega$$

$$R_a = 20\,\text{k}\Omega$$

$$R_b = 220 - 20 = 200\,\text{k}\Omega$$