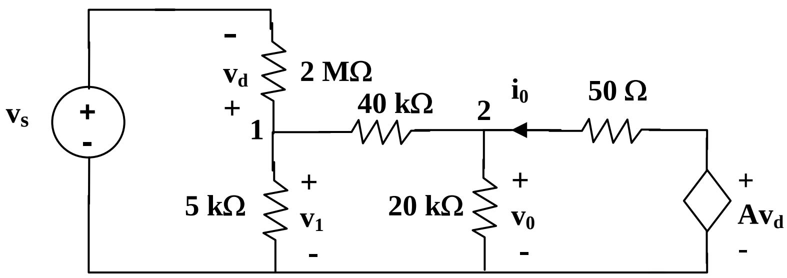
CHAPTER 5

P.P.5.1 The equivalent circuit is shown below:



At node 1, $\frac{v_s - v_1}{2x10^6} = \frac{v_1}{5x10^3} + \frac{v_1 - v_0}{40x10^3} \longrightarrow v_1 = \frac{v_S + 50v_0}{451}$ (1)

At node 2, $\frac{Av_d - v_0}{50} + \frac{v_1 - v_0}{40x10^3} = \frac{v_0}{20x13^3}$

But $v_d = v_1 - v_S$.

$[2 \text{ x } 10^5 (v_1 - v_S) - v_0]\ 4000/(5) + v_1 - v_0 = 2v_0$

$1600 \text{ x } 10^5 (v_S - v_1) + 803v_0 \cong 0$ (2)

Substituting v_1 in (1) into (2) gives

$1.5914523 \text{ x } 10^8\ v_S - 17737556v_0 = 0$

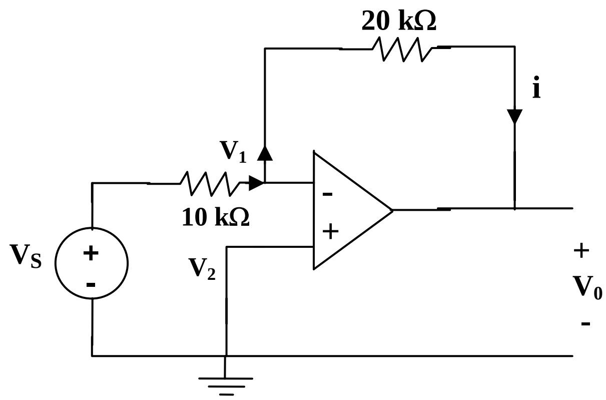
$\frac{v_0}{v_S} = \frac{1.5964523x10^8}{17737556} =$ **9.00041**

If $v_S = 1$ V, $v_0 = 9.00041$ V, $v_1 = 1.0000455$

$v_d = v_S - v_1 = - 4.545 \text{ x } 10^{-5}$

$Av_d = - 9.0909$, $i_0 = \frac{Av_d - v_0}{50} =$ **657 μA**

P.P.5.2



At node 1, $\frac{v_S - v_1}{10} = \frac{v_1 - v_0}{20}$

But $v_1 = v_2 = 0$,

$$\frac{v_S}{10} = -\frac{v_0}{20} \longrightarrow \frac{v_0}{v_S} = \underline{\mathbf{-2}}$$

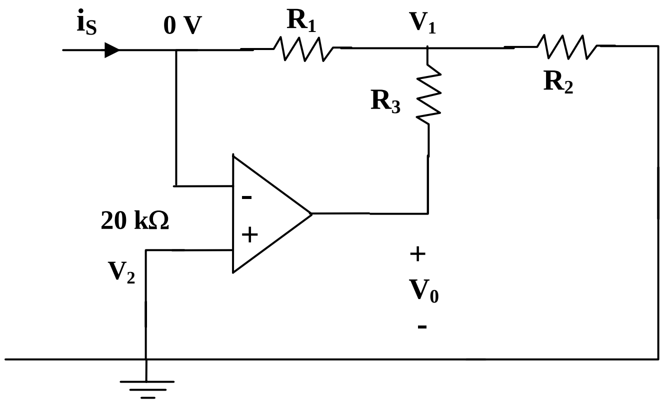
$$i_0 = \frac{0 - v_0}{20x10^3} = -\frac{v_0}{20x10^3}$$

When v_s = 2V, v_0 = -4, $i_0 = \frac{4x10^{-3}}{20} = \underline{\mathbf{200\ \mu A}}$

P.P.5.3 $v_0 = -\frac{R_2}{R_1} v_i = \frac{-15}{5}(40mV) = \underline{\mathbf{-120\ mV}}$

$$i = \frac{0 - v_0}{15k} = \underline{\mathbf{8\ \mu A}}$$

P.P.5.4 (a) $i_S = \frac{0 - v_0}{R} \longrightarrow \frac{v_0}{i_S} = -R$



(b) At node 2, $i_S = \frac{0 - v_1}{R_1} \longrightarrow v_1 = -i_S R_1$ (1)

At node 1, $\frac{0 - v_1}{R_1} = \frac{v_1 - 0}{R_2} + \frac{v_1 - v_0}{R_3}$

$$-v_1 \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right) = \frac{-v_0}{R_3}$$

$$v_0 = -i_S R_1 R_3 \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right)$$

$$\underline{\frac{v_0}{i_S} = -R_1 \left(1 + \frac{R_3}{R_1} + \frac{R_3}{R_2} \right)}$$

P.P.5.5 By voltage division

$$v_1 = \frac{8}{4+8}(3) = 2\text{V}$$

where v_1 is the voltage at the top end of the 8kΩ resistor. Using the formula for noninverting amplifier,

$$v_0 = \left(1 + \frac{5}{2} \right)(2) = \underline{\mathbf{7\ V}}$$

P.P.5.6 This is a summer.

$$v_0 = -\left[\frac{8}{20}(1.5) + \frac{8}{10}(2) + \frac{8}{6}(1.2)\right] = \underline{\mathbf{-3.8\ V}}$$

$$i_0 = \frac{v_0}{8} + \frac{v_0}{4} = -\frac{3.8}{8} - \frac{3.8}{4} = \underline{\mathbf{-1.425\ mA}}$$

P.P.5.7 If the gain is 4, then

$$\frac{R_2}{R_1} = 4 \longrightarrow R_2 = 4R_1$$

But $\frac{R_2}{R_1} = \frac{R_4}{R_3} \longrightarrow R_4 = 4R_3$

If we select $\underline{\mathbf{R_1 = R_3 = 10k\Omega}}$, then $\underline{\mathbf{R_2 = R_4 = 40k\Omega}}$

P.P.5.8 $v_0 = \frac{R_2}{R_1}\left(1 + \frac{2R_3}{R_4}\right)(v_2 - v_1)$

$R_3 = 0$, $R_4 = \infty$, $R_2 = 40k\Omega$, $R_1 = 20k\Omega$

$$v_0 = \frac{40}{20}(8.01 - 8) = 0.02$$

$$i_0 = \frac{v_0}{10k} = \frac{0.02}{10x10^3} = \underline{\mathbf{2\mu A}}$$

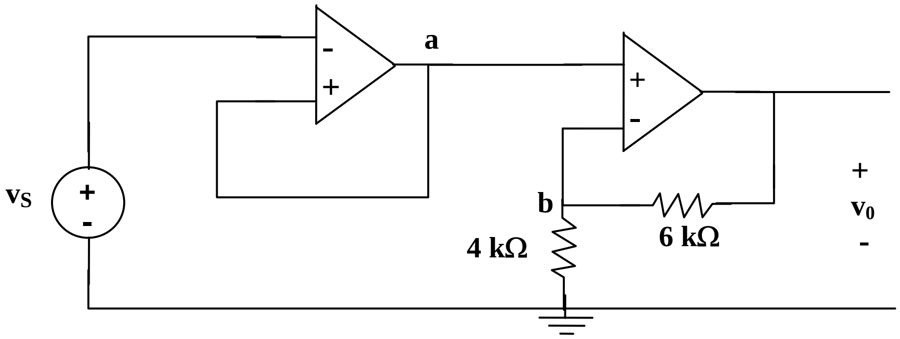
P.P.5.9 Due to the voltage follower

$$v_a = 4V$$

For the noninverting amplifier,

$$v_0 = \left(1 + \frac{6}{4}\right)v_a = (1 + 1.5)\ (4) = \underline{\mathbf{10V}}$$

$$i_0 = \frac{v_b}{4}\ mA$$



But $v_b = v_a = 4$

$$i_0 = \frac{4}{4} = \underline{\mathbf{1mA}}$$

P.P.5.10 As a voltage follower,

$$v_a = v_1 = 2V$$

where v_a is the voltage at the right end of the 20 kΩ resistor.

As an inverter, $v_b = -\frac{50}{10}v_2 = -7.5V$

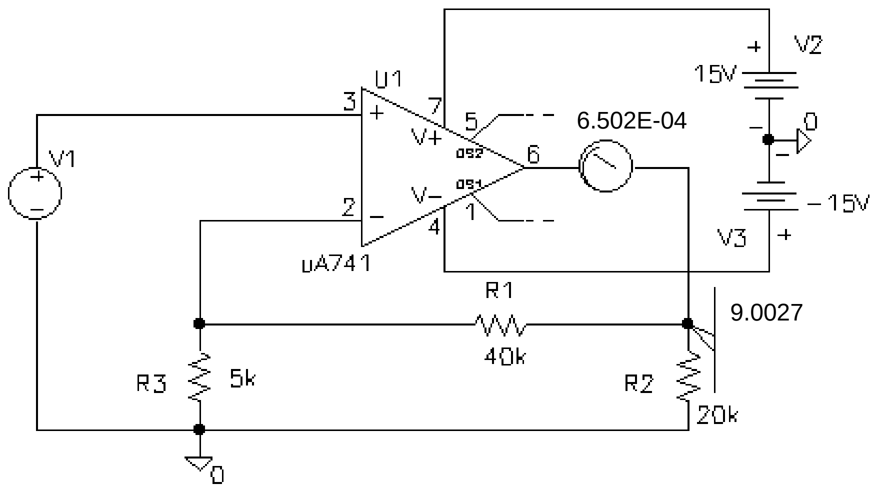
Where v_b is the voltage at the right end of the 50kΩ resistor. As a summer

$$v_0 = -\left[\frac{60}{20}v_a + \frac{60}{30}v_b\right]$$

$$= [6 - 15] = \underline{\mathbf{9V}}$$

P.P.5.11 The schematic is shown below. When it is saved and run, the results are displayed on 1PROBE and VIEWPOINT as shown. By making v_s = 1V, we obtain

v_0 = **9.0027V** and i_0 = **650.2 μA**



P.P.5.12 $-V_0 = \frac{R_f}{R_1}V_1 + \frac{R_f}{R_2}V_2 + \frac{R_f}{R_3}V_3$

or $|V_0| = V_1 + 0.5V_2 + 0.25V_3$

(a) If $[V_1V_2V_3] = [010]$, $|V_0|$ = **0.5V**

(b) If $[V_1V_2V_3] = [110]$, $|V_0|$ = 1 + 0.5 = **1.5V**

(c) If $|V_0|$ = 1.25, then $V_1 = 1$, $V_2 = 0$, $V_3 = 1$, i.e.
$[V_1V_2V_3]$ = **[101]**

(d) $|V_0|$ = 1.75, then $V_1 = 1$, $V_2 = 1$, $V_3 = 1$, i.e.
$[V_1V_2V_3]$ = **[111]**

P.P.5.13 $A_v = 1 + \frac{2R}{R_G} \longrightarrow R_G = \frac{2R}{A_v - 1}$

$$R_G = \frac{2x25x10^3}{142 - 1} = \mathbf{354.6\ \Omega}$$