voltage drop across all parallel-connected resistors is the same.

[a] $R_{eq} = \{[(5\text{ k} + 7\text{ k})\|6\text{ k}] + 3\text{ k} + 8\text{ k}\}\|10\text{ k} = [(12\text{ k}\|6\text{ k}) + 11\text{ k}]\|10\text{ k}$

$= (4\text{ k} + 11\text{ k})\|10\text{ k} = 15\text{ k}\|10\text{ k} = 6\text{ k}\Omega$

[b] $R_{eq} = [240\|(180 + 300)] + 140 + 200 = (240\|480) + 340 = 160 + 340 = 500\,\Omega$

[c] $R_{eq} = (40 + 50 + 60)\|(30 + 45) = 150\|75 = 50\,\Omega$

P 3.6 Always work from the side of the circuit furthest from the source. Remember that the current in all series-connected circuits is the same, and that the voltage drop across all parallel-connected resistors is the same.

[a] $R_{eq} = 12\|20\|[18 + (28\|21)] = 12\|20\|(18 + 12) = 12\|20\|30 = 6\,\Omega$

[b] $R_{eq} = 4 + (9\|18) + [5\|30\|(20 + 40)] = 4 + 6 + (5\|30\|60) = 4 + 6 + 4 = 14\,\Omega$

[c] $R_{eq} = (100\text{ k}\|300\text{ k}) + (75\text{ k}\|50\text{ k}\|150\text{ k}) + 25\text{ k} = 75\text{ k} + 25\text{ k} + 25\text{ k} = 125\text{ k}\Omega$

P 3.7 [a] $12\,\Omega\|24\,\Omega = 8\,\Omega$ Therefore, $R_{ab} = 8 + 2 + 6 = 16\,\Omega$

[b] $$\frac{1}{R_{eq}} = \frac{1}{24\text{ k}\Omega} + \frac{1}{30\text{ k}\Omega} + \frac{1}{20\text{ k}\Omega} = \frac{15}{120\text{ k}\Omega} = \frac{1}{8\text{ k}\Omega}$$

$R_{eq} = 8\text{ k}\Omega;\qquad R_{eq} + 7 = 15\text{ k}\Omega$

$$\frac{1}{R_{ab}} = \frac{1}{15\text{ k}\Omega} + \frac{1}{30\text{ k}\Omega} + \frac{1}{15\text{ k}\Omega} = \frac{5}{30\text{ k}\Omega} = \frac{1}{6\text{ k}\Omega}$$

$R_{ab} = 6\text{ k}\Omega$

P 3.8 [a] $60\|20 = 1200/80 = 15\,\Omega$ $12\|24 = 288/36 = 8\,\Omega$

$15 + 8 + 7 = 30\,\Omega$ $30\|120 = 3600/150 = 24\,\Omega$

$R_{ab} = 15 + 24 + 25 = 64\,\Omega$

[b] $35 + 40 = 75\,\Omega$ $75\|50 = 3750/125 = 30\,\Omega$

$30 + 20 = 50\,\Omega$ $50\|75 = 3750/125 = 30\,\Omega$

$30 + 10 = 40\,\Omega$ $40\|60 + 9\|18 = 24 + 6 = 30\,\Omega$

$30\|30 = 15\,\Omega$ $R_{ab} = 10 + 15 + 5 = 30\,\Omega$

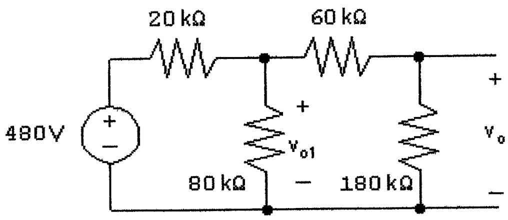
[c] $50 + 30 = 80\,\Omega$ $80\|20 = 16\,\Omega$

$16 + 14 = 30\,\Omega$ $30 + 24 = 54\,\Omega$

$54\|27 = 18\,\Omega$ $18 + 12 = 30\,\Omega$

$30\|30 = 15\,\Omega$ $R_{ab} = 3 + 15 + 2 = 20\,\Omega$

P 3.17 [a]



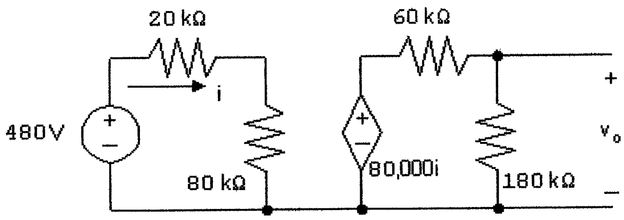
$$180\ \text{k}\Omega + 60\ \text{k}\Omega = 240\ \text{k}\Omega$$

$$80\ \text{k}\Omega \| 240\ \text{k}\Omega = 60\ \text{k}\Omega$$

$$v_{o1} = \frac{60{,}000}{(20{,}000 + 60{,}000)}(480) = 360\ \text{V}$$

$$v_o = \frac{180{,}000}{(240{,}000)}(v_{o1}) = 270\ \text{V}$$

[b]



$$i = \frac{480}{100{,}000} = 4.8\ \text{mA}$$

$$80{,}000i = 384\ \text{V}$$

$$v_o = \frac{180{,}000}{240{,}000}(384) = 288\ \text{V}$$

[c] It removes loading effect of second voltage divider on the first voltage divider. Observe that the open circuit voltage of the first divider is

$$v'_{o1} = \frac{80{,}000}{(100{,}000)}(480) = 384\ \text{V}$$

Now note this is the input voltage to the second voltage divider when the current controlled voltage source is used.

P 3.18 $\dfrac{(24)^2}{R_1 + R_2 + R_3} = 80,$ Therefore, $R_1 + R_2 + R_3 = 7.2\,\Omega$

$$\frac{(R_1 + R_2)24}{(R_1 + R_2 + R_3)} = 12$$

Therefore, $2(R_1 + R_2) = R_1 + R_2 + R_3$

Thus, $R_1 + R_2 = R_3$; $2R_3 = 7.2$; $R_3 = 3.6\,\Omega$

$$\frac{R_2(24)}{R_1 + R_2 + R_3} = 5$$

$$4.8R_2 = R_1 + R_2 + 3.6 = 7.2$$

Thus, $R_2 = 1.5\,\Omega$; $R_1 = 7.2 - R_2 - R_3 = 2.1\,\Omega$

P 3.19 [a] At no load: $v_o = kv_s = \dfrac{R_2}{R_1 + R_2}v_s$.

At full load: $v_o = \alpha v_s = \dfrac{R_e}{R_1 + R_e}v_s$, where $R_e = \dfrac{R_oR_2}{R_o + R_2}$

$$\text{Therefore } k = \frac{R_2}{R_1 + R_2} \quad \text{and} \quad R_1 = \frac{(1-k)}{k}R_2$$

$$\alpha = \frac{R_e}{R_1 + R_e} \quad \text{and} \quad R_1 = \frac{(1-\alpha)}{\alpha}R_e$$

$$\text{Thus} \quad \left(\frac{1-\alpha}{\alpha}\right)\left[\frac{R_2R_o}{R_o + R_2}\right] = \frac{(1-k)}{k}R_2$$

Solving for R_2 yields $R_2 = \dfrac{(k-\alpha)}{\alpha(1-k)}R_o$

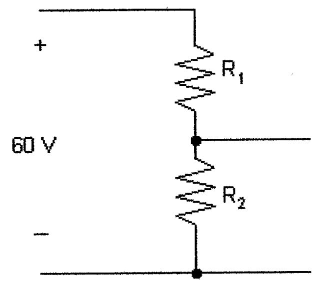
Also, $R_1 = \dfrac{(1-k)}{k}R_2 \quad \therefore \quad R_1 = \dfrac{(k-\alpha)}{\alpha k}R_o$

[b]

$$R_1 = \left(\frac{0.05}{0.68}\right)R_o = 2.5\ \text{k}\Omega$$

$$R_2 = \left(\frac{0.05}{0.12}\right)R_o = 14.167\ \text{k}\Omega$$

[c]



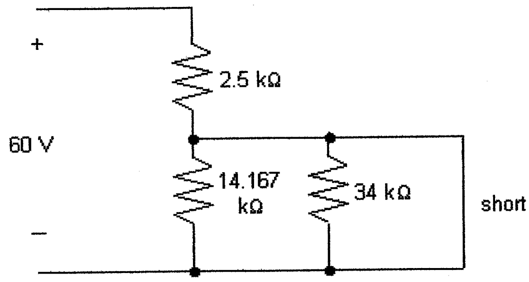
Maximum dissipation in R_2 occurs at no load, therefore,

$$P_{R_2(\text{max})} = \frac{[(60)(0.85)]^2}{14{,}167} = 183.6\ \text{mW}$$

Maximum dissipation in R_1 occurs at full load.

$$P_{R_1(\text{max})} = \frac{[60 - 0.80(60)]^2}{2500} = 57.60\ \text{mW}$$

[d]



$$P_{R_1} = \frac{(60)^2}{2500} = 1.44 \text{ W} = 1440 \text{ mW}$$

$$P_{R_2} = \frac{(0)^2}{14{,}167} = 0 \text{ W}$$

P 3.20 [a] Let v_o be the voltage across the parallel branches, positive at the upper terminal, then

$$i_g = v_oG_1 + v_oG_2 + \cdots + v_oG_N = v_o(G_1 + G_2 + \cdots + G_N)$$

It follows that $v_o = \dfrac{i_g}{(G_1 + G_2 + \cdots + G_N)}$

The current in the k^{th} branch is $i_k = v_oG_k$; Thus,

$$i_k = \frac{i_gG_k}{[G_1 + G_2 + \cdot + G_N]}$$

[b] $i_{6.25} = \dfrac{1142(0.16)}{[4 + 0.4 + 1 + 0.16 + 0.1 + 0.05]} = 32 \text{ mA}$

P 3.21 Begin by using the relationships among the branch currents to express all branch currents in terms of i_4:

$$i_1 = 4i_2 = 4(8i_3) = 5(32i_4)$$

$$i_2 = 8i_3 = 5(8i_4)$$

$$i_3 = 5i_4$$

Now use KCL at the top node to relate the branch currents to the current supplied by the source.

$$i_1 + i_2 + i_3 + i_4 = 5 \text{ mA}$$

Express the branch currents in terms of i_4 and solve for i_4:

$$5 \text{ mA} = 160i_4 + 40i_4 + 5i_4 + i_4 = 206i_4 \qquad \text{so} \qquad i_4 = \frac{0.005}{206} \text{ A}$$

Since the resistors are in parallel, the same voltage, 1 V appears across each of them. We know the current and the voltage for R_4 so we can use Ohm's law to calculate R_4:

$$R_4 = \frac{v_g}{i_4} = \frac{1\ \text{V}}{(5/206)\ \text{mA}} = 41.2\ \text{k}\Omega$$

Calculate i_3 from i_4 and use Ohm's law as above to find R_3:

$$i_3 = 5i_4 = \frac{25}{206}\ \text{A} \qquad \therefore\ R_3 = \frac{v_g}{i_3} = \frac{1\ \text{V}}{(25/206)\ \text{mA}} = 8240\,\Omega$$

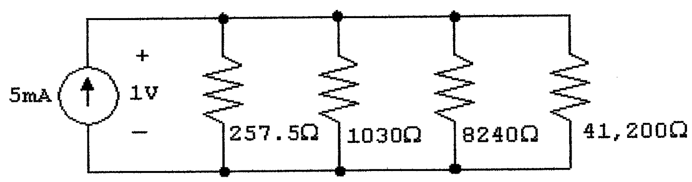
Calculate i_2 from i_4 and use Ohm's law as above to find R_2:

$$i_2 = 40i_4 = \frac{0.2}{206}\ \text{A} \qquad \therefore\ R_2 = \frac{v_g}{i_2} = \frac{1\ \text{V}}{(200/206)\ \text{mA}} = 1030\,\Omega$$

Calculate i_1 from i_4 and use Ohm's law as above to find R_1:

$$i_1 = 160i_4 = \frac{0.8}{206}\ \text{A} \qquad \therefore\ R_1 = \frac{v_g}{i_1} = \frac{1\ \text{V}}{(800/206)\ \text{mA}} = 257.5\,\Omega$$

The resulting circuit is shown below:



P 3.22 [a] The equivalent resistance to the right of the 10 kΩ resistor is $3\text{ k} + 8\text{ k} + [6\text{ k}\|(5\text{ k} + 7\text{ k})] = 15\ \text{k}\Omega$. Therefore,

$$i_{10\text{k}} = \frac{15\text{ k}\|10\text{ k}}{10\text{ k}}(0.002) = \frac{6\text{ k}}{10\text{ k}}(0.002) = 1.2\text{ mA}$$

[b] The voltage drop across the 10 kΩ resistor can be found using Ohm's law:

$$v_{10\text{k}} = (10,000)i_{10\text{k}} = (10,000)(0.0012) = 12\text{ V}$$

[c] The voltage $v_{10\text{k}}$ drops across the 3 kΩ resistor, the 8 kΩ resistor and the equivalent resistance of the 6 kΩ and the parallel branch containing the 5 kΩ and 7 kΩ resistors. Thus, using voltage division,

$$v_{6\text{k}} = \frac{6\text{ k}\|(5\text{ k} + 7\text{ k})}{3\text{ k} + 8\text{ k} + [6\text{ k}\|(5\text{ k} + 7\text{ k})]}(12) = \frac{4}{15}(12) = 3.2\text{ V}$$

[d] The voltage $v_{6\text{k}}$ drops across the branch containing the 5 kΩ and 7 kΩ resistors. Thus, using voltage division,

$$v_{5\text{k}} = \frac{5\text{ k}}{5\text{ k} + 7\text{ k}}(3.2) = 1.33\text{ V}$$