Boise State University
Electrical Engineering Department

EE 210: Circuits I

Solution 1

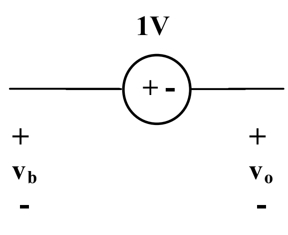
(a) Let v_a and v_b be respectively the voltages at the inverting and noninverting terminals of the op amp

$$v_a = v_b = 4V$$

At the inverting terminal,

$$1mA = \frac{4 - v_0}{2k} \longrightarrow v_0 = \mathbf{2V}$$

(b)



Since $v_a = v_b = 3V$,

$$-v_b + 1 + v_o = 0 \longrightarrow v_o = v_b - 1 = \mathbf{2V}$$

Solution 2

(a) Let v_1 be the voltage at the node where the three resistors meet. Applying KCL at this node gives

$$i_s = \frac{v_1}{R_2} + \frac{v_1 - v_o}{R_3} = v_1\left(\frac{1}{R_2} + \frac{1}{R_3}\right) - \frac{v_o}{R_3} \quad (1)$$

At the inverting terminal,

$$i_s = \frac{0 - v_1}{R_1} \longrightarrow v_1 = -i_s R_1 \quad (2)$$

Combining (1) and (2) leads to

$$\boldsymbol{i_s\left(1 + \frac{R_1}{R_2} + \frac{R_1}{R_3}\right) = -\frac{v_o}{R_3} \longrightarrow \underline{\frac{v_o}{i_s} = -\left(R_1 + R_3 + \frac{R_1 R_3}{R_2}\right)}}$$

(b) For this case,

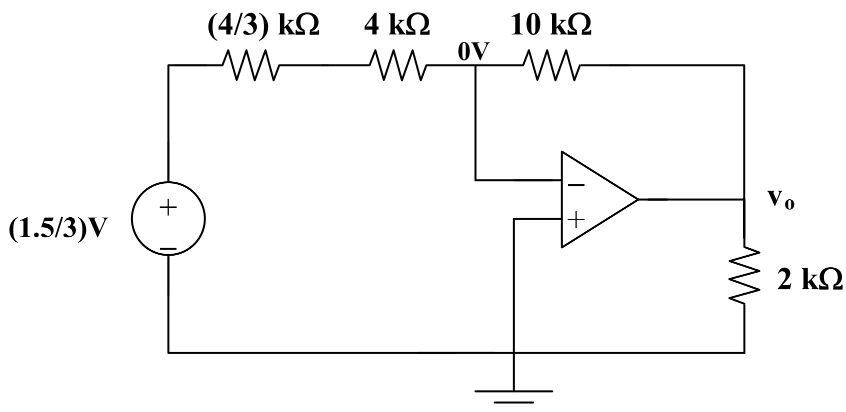
$$\frac{v_o}{i_s} = -\left(20 + 40 + \frac{20x40}{25}\right)\text{k}\Omega = \underline{-92\ \text{k}\Omega}$$

$$= \mathbf{-92\ k\Omega}$$

Solution 3

We convert the current source and back to a voltage source.

$$2 \| 4 = \frac{4}{3}$$

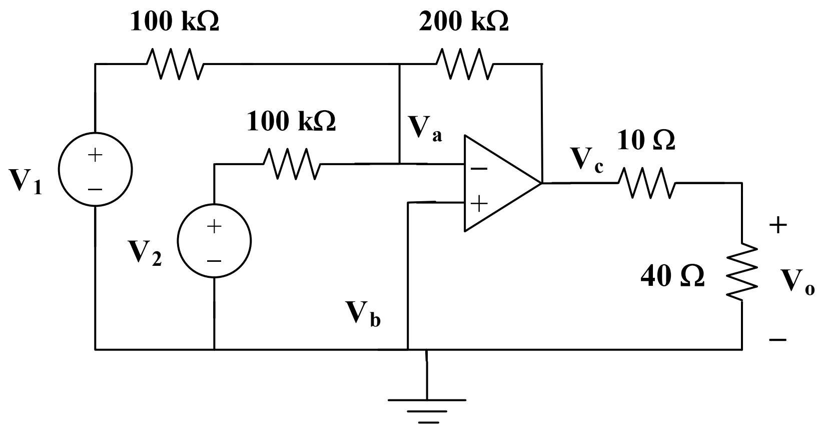


$$v_o = -\frac{10k}{\left(4+\frac{4}{3}\right)k}\left(\frac{1.5}{3}\right) = –937.5 \text{ mV}.$$

$$i_o = \frac{v_o}{2k} + \frac{v_o - 0}{10k} = \mathbf{–562.5\ \mu A}.$$

Solution 4

Determine V_o in terms of V_1 and V_2.



Step 1. Label the reference and node voltages in the circuit, see above. Note we now can consider nodes a and b, we cannot write a node equation at c without introducing another unknown. The node equation at a is $[(V_a–V_1)/10^5] + [(V_a–V_2)/10^5] + 0 + [(V_a–V_c)/2x10^5] = 0$. At b it is clear that $V_b = 0$. Since we have two equations and three unknowns, we need another equation. We do get that from the constraint equation, $V_a = V_b$. After we find V_c in terms of V_1 and V_2, we then can determine V_o which is equal to $[(V_c–0)/50]$ times 40.

Step 2. Letting $V_a = V_b = 0$, the first equation can be simplified to,

$$[–V_1/10^5] + [–V_2/10^5] + [–V_c/2x10^5] = 0$$

Taking V_c to the other side of the equation and multiplying everything by $2x10^5$, we get,

$$V_c = –2V_1 – 2V_2$$

Now we can find V_o which is equal to $(40/50)V_c = 0.8[–2V_1–2V_2]$

$$V_o = \mathbf{–1.6V_1–1.6V_2}.$$