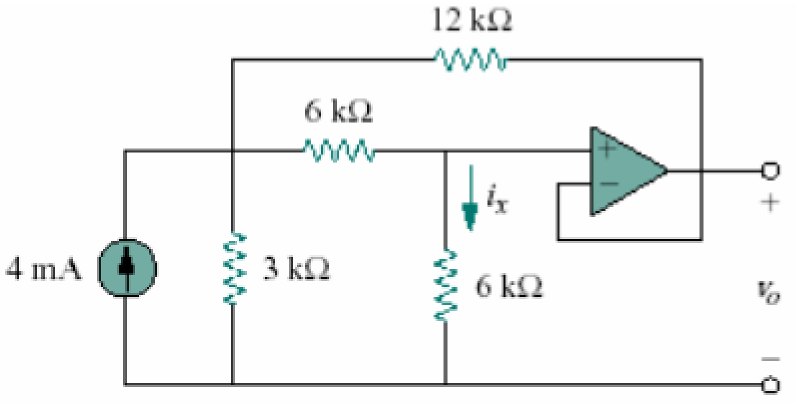
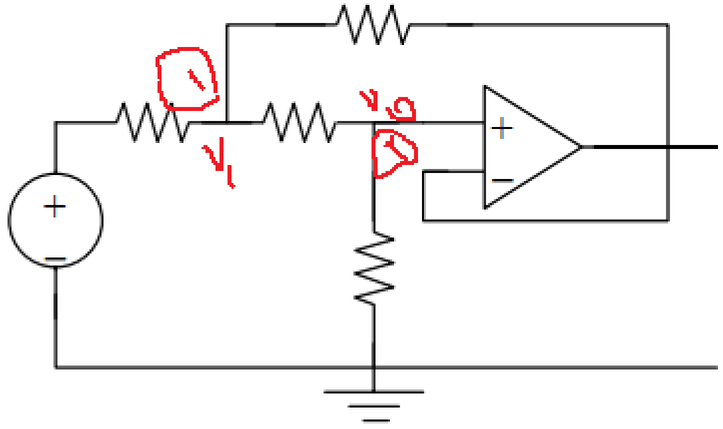
find i_x.





At node 1,

$$\frac{12 - v_1}{3} = \frac{v_1 - v_o}{6} + \frac{v_1 - v_o}{12} \longrightarrow 48 = 7v_1 - 3v_o \qquad (1)$$

At node 2,

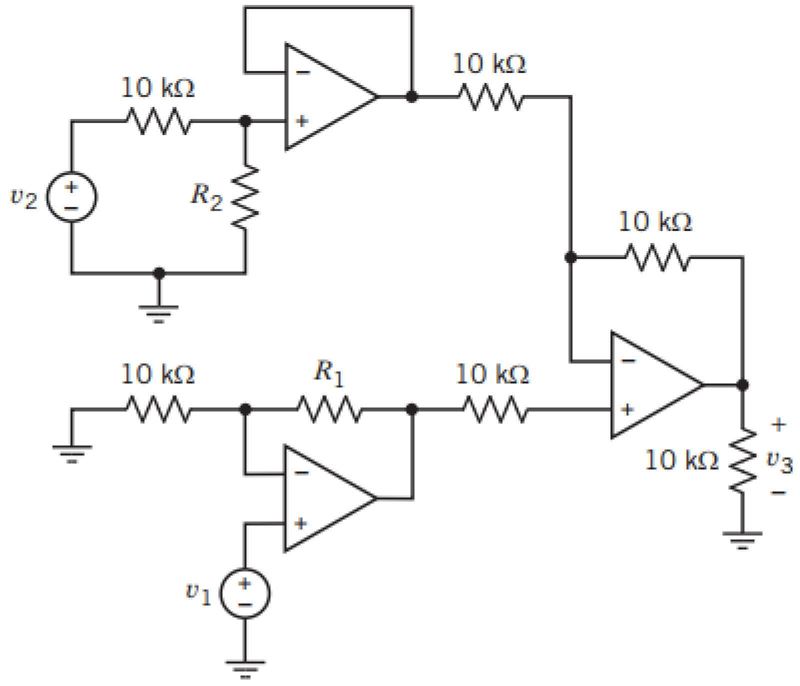
$$\frac{v_1 - v_o}{6} = \frac{v_o - 0}{6} = i_x \longrightarrow v_1 = 2v_o \qquad (2)$$

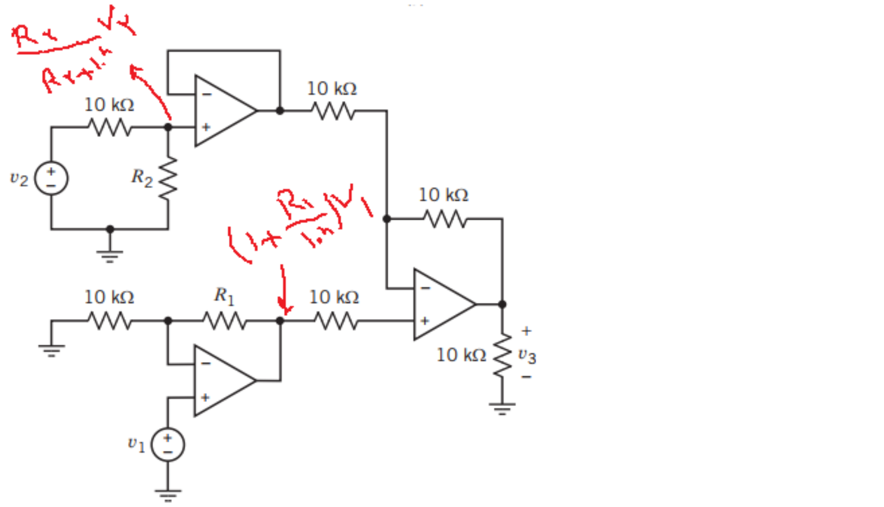
From (1) and (2),

$$v_o = \frac{48}{11}$$

$$i_x = \frac{v_o}{6k} = \underline{\mathbf{727.2\mu A}}$$

Specify the values of R_1 and R_2 in Figure E 6.6-1 that are required to cause v_3 to be related to v_1 and v_2 by the equation $v_3 = (6)v_1 - \left(\frac{4}{5}\right)v_2$.





$$V_3 = +\left(1+\frac{10}{10}\right)\left(1+\frac{R_1}{10}\right)V_1 + \left(-\frac{10}{10}\right)\frac{R_2}{R_2+10k}V_2$$

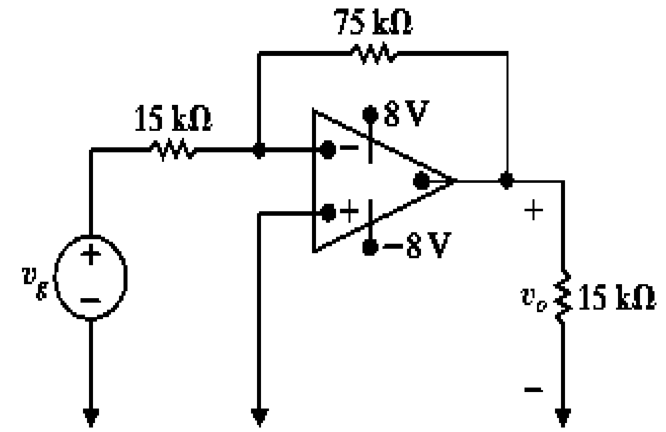
$$V_3 = \left(2+\frac{R_1}{5k}\right)V_1 - \frac{R_2}{R_2+10k}V_2$$

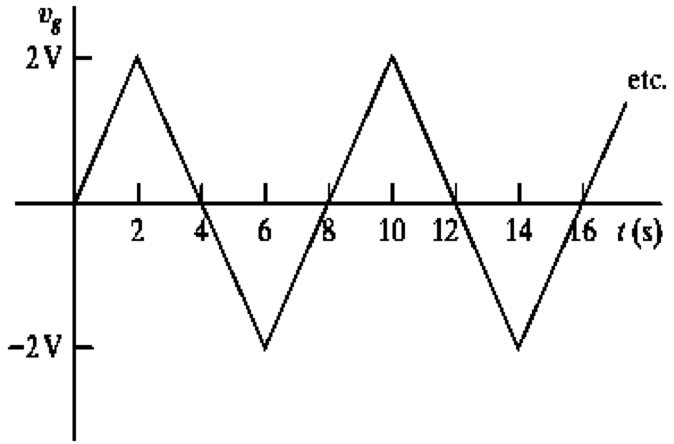
$$\underbrace{\left(2+\frac{R_1}{5k}\right)}_{6} \qquad \underbrace{\frac{R_2}{R_2+10k}}_{\frac{4}{5}}$$

$R_1 = 20k$

$R_2 = 40k$

ولتاژ ورودی در مدار شکل زیر نشان داده شده است، نمودار V_0 بر حسب زمان را رسم کنید.





It follows directly from the circuit that $v_o = -(75/15)v_g = -5v_g$

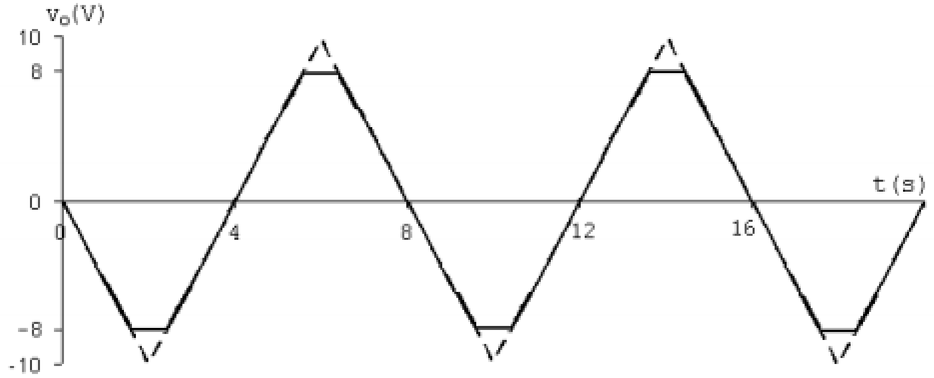
From the plot of v_g we have $v_g = 0, \quad t < 0$

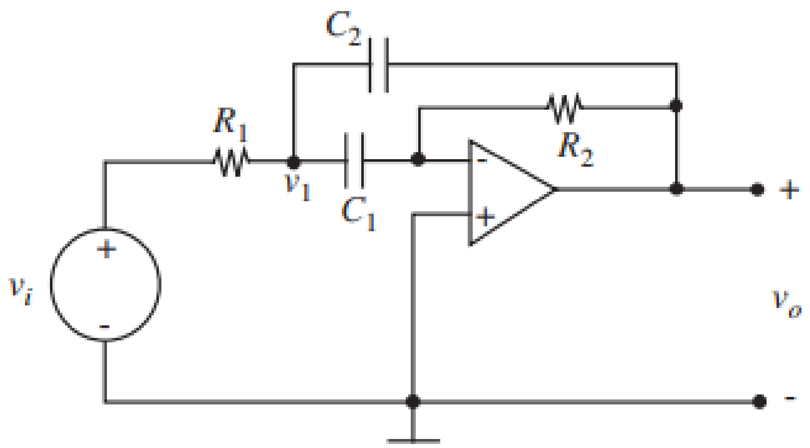
$$
\begin{aligned}
v_g &= t && 0 \le t \le 2 \\
v_g &= 4 - t && 2 \le t \le 6 \\
v_g &= t - 8 && 6 \le t \le 10 \\
v_g &= 12 - t && 10 \le t \le 14 \\
v_g &= t - 16 && 14 \le t \le 18, \quad \text{etc.}
\end{aligned}
$$

Therefore

$$
\begin{aligned}
v_o &= -5t && 0 \le t \le 2 \\
v_o &= 5t - 20 && 2 \le t \le 6 \\
v_o &= 40 - 5t && 6 \le t \le 10 \\
v_o &= 5t - 60 && 10 \le t \le 14 \\
v_o &= 80 - 5t && 14 \le t \le 18, \quad \text{etc.}
\end{aligned}
$$

These expressions for v_o are valid as long as the op amp is not saturated. Since the peak values of v_o are ± 9, the output is clipped at ± 9. The plot is shown below.





For Node v_1,

$$(v_i - v_1)g_1 - C_1\frac{dv_1}{dt} + C_2\frac{d(v_o - v_1)}{dt} = 0$$

and for Node v^-

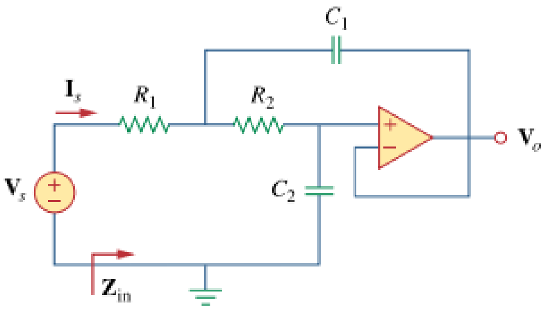
$$C_1\frac{dv_1}{dt} + v_o g_2 = 0.$$

$$v_i g_1 = g_1 v_1 + (C_1 + C_2)\frac{dv_1}{dt} - C_2\frac{dv_o}{dt}$$

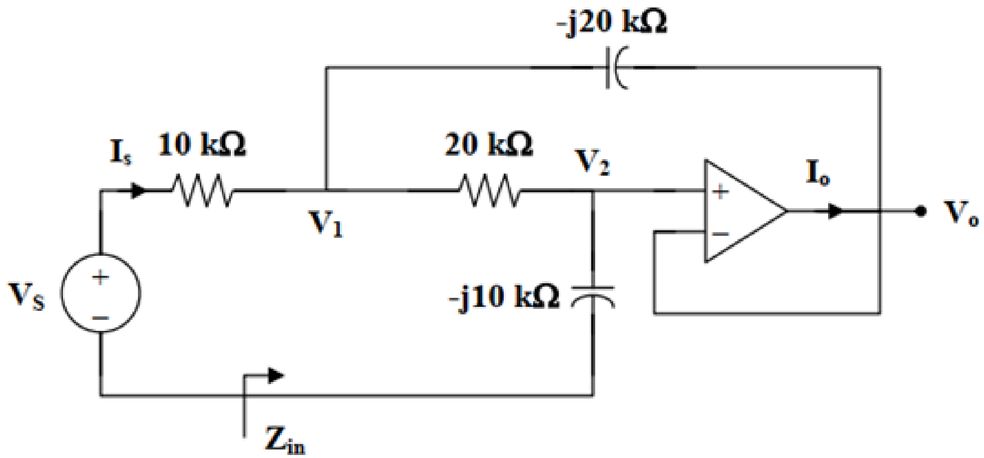
$$0 = C_1\frac{dv_1}{dt} + v_o g_2.$$

$$\frac{d^2v_o}{dt^2} + g_2\frac{C_1 + C_2}{C_1C_2}\frac{dv_o}{dt} + \frac{g_1g_2}{C_1C_2}v_o = -\frac{g_1}{C_2}\frac{dv_i}{dt}.$$

If the input impedance is defined as $\mathbf{Z}_{in} = \mathbf{V}_s / \mathbf{I}_s$ find the input impedance of the op amp circuit in Fig. 10.116 when $R_1 = 10\,\text{k}\Omega, R_2 = 20\,\text{k}\Omega, C_1 = 10\,\text{nF}$, and $\omega = 5000\,\text{rad/s}$.



Consider the circuit in the frequency domain as shown below.



As a voltage follower, $\mathbf{V}_2 = \mathbf{V}_o$

$$C_1 = 10\text{ nF} \longrightarrow \frac{1}{j\omega C_1} = \frac{1}{j(5\times10^3)(10\times10^{-9})} = \text{-j}20\text{ k}\Omega$$

$$C_2 = 20\text{ nF} \longrightarrow \frac{1}{j\omega C_2} = \frac{1}{j(5\times10^3)(20\times10^{-9})} = \text{-j}10\text{ k}\Omega$$

At node 1,

$$\frac{\mathbf{V}_s - \mathbf{V}_1}{10} = \frac{\mathbf{V}_1 - \mathbf{V}_o}{\text{-}j20} + \frac{\mathbf{V}_1 - \mathbf{V}_o}{20}$$

$$2\mathbf{V}_s = (3+j)\mathbf{V}_1 - (1+j)\mathbf{V}_o \qquad (1)$$

At node 2,

$$\frac{\mathbf{V}_1 - \mathbf{V}_o}{20} = \frac{\mathbf{V}_o - 0}{\text{-}j10}$$

$$\mathbf{V}_1 = (1+j2)\mathbf{V}_o \qquad (2)$$

Substituting (2) into (1) gives

$$2\mathbf{V}_s = j6\mathbf{V}_o \quad \text{or} \quad \mathbf{V}_o = \text{-}j\frac{1}{3}\mathbf{V}_s$$

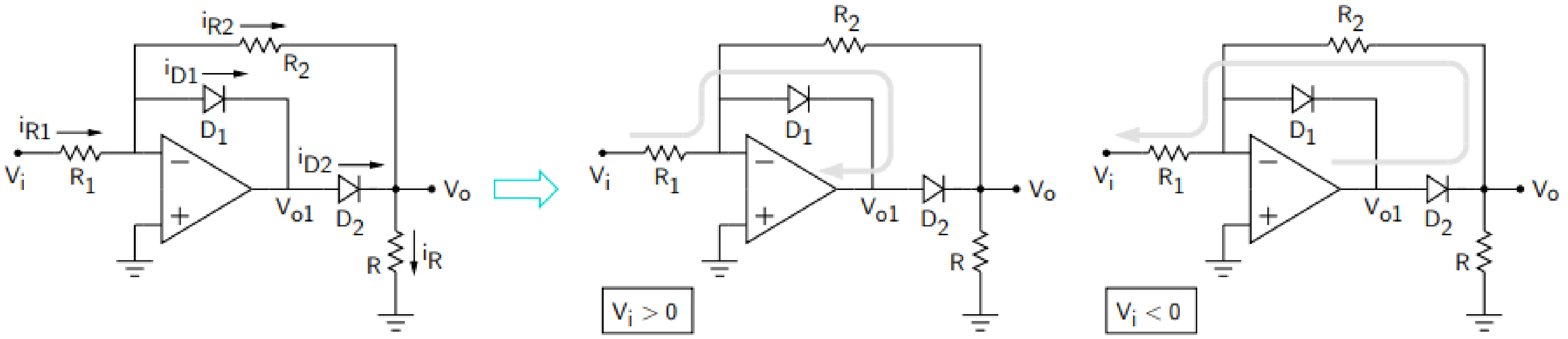
$$\mathbf{V}_1 = (1+j2)\mathbf{V}_o = \left(\frac{2}{3} - j\frac{1}{3}\right)\mathbf{V}_s$$

$$\mathbf{I}_S = \frac{\mathbf{V}_S - \mathbf{V}_1}{10\text{k}} = \frac{(1/3)(1+j)}{10\text{k}}\mathbf{V}_S$$

$$\frac{\mathbf{I}_S}{\mathbf{V}_S} = \frac{1+j}{30\text{k}}$$

$$\mathbf{Z}_{in} = \frac{\mathbf{V}_S}{\mathbf{I}_S} = \frac{30\text{k}}{1+j} = 15(1-j)\text{k}$$

$$\mathbf{Z}_{in} = \underline{\mathbf{21.21\angle{-45^\circ}\ k\Omega}}$$



(i) D_1 conducts: $V_- = V_+ = 0\ V$, $V_{o1} = -V_{D1} \approx -0.7\ V$.

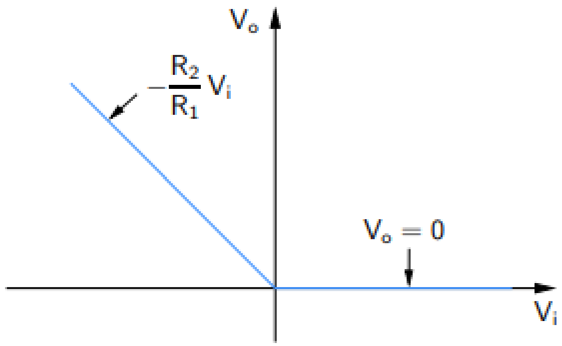
D_2 cannot conduct (show that, if it did, KCL is not satisfied at V_o).
$\rightarrow i_{R2} = 0$, $V_o = V_- = 0\ V$.

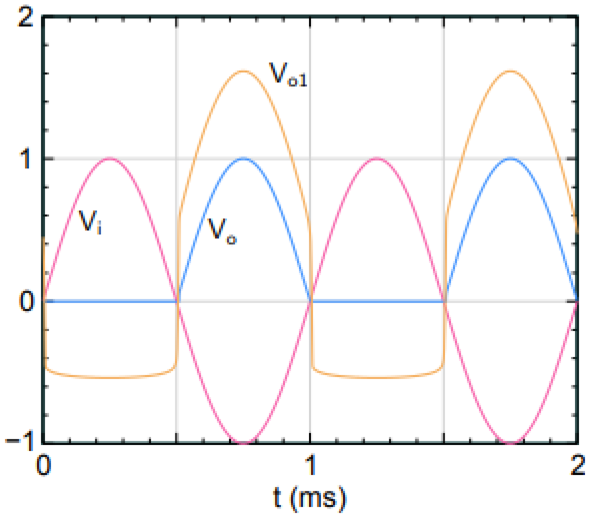
$i_{R1} = i_{D1}$ which can only be positive $\Rightarrow V_i > 0\ V$.

(ii) D_1 is off; this will happen when $V_i < 0\ V$.

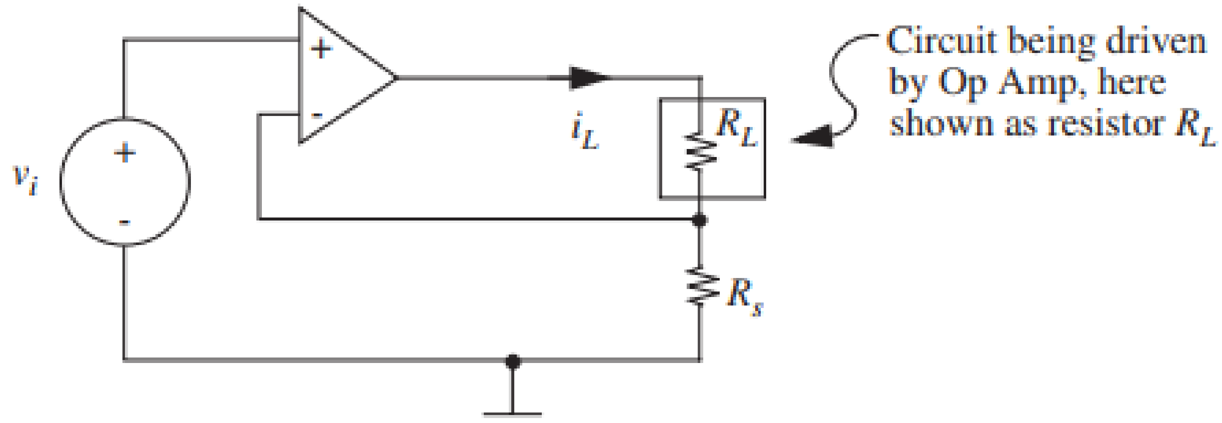
In this case, D_2 conducts and closes the feedback loop through R_2.

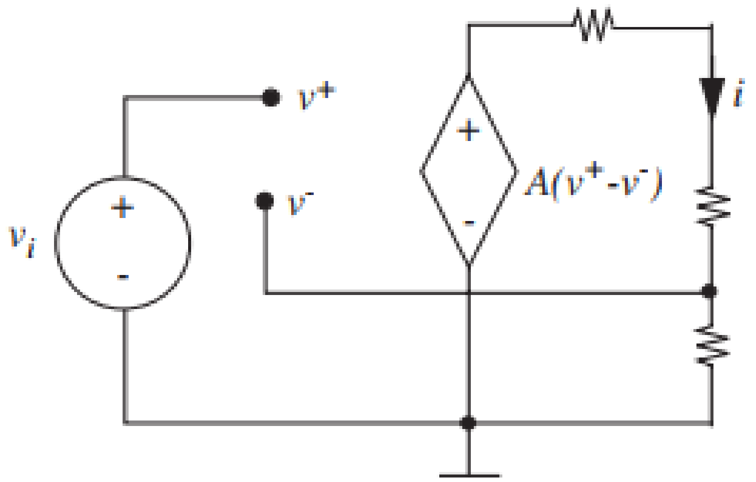
$$V_o = V_- + i_{R2}R_2 = 0 + \left(\frac{0 - V_i}{R_1}\right) R_2 = -\frac{R_2}{R_1} V_i \,.$$

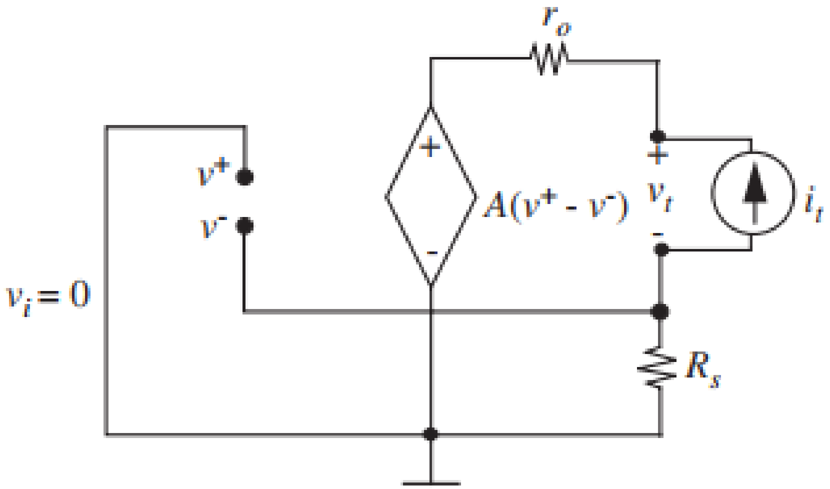




مقاومت معادل از دید R_L (آپ–امپ غیرایده‌آل)







$$v^- = -i_t R_s$$

$$v^+ = 0$$

$$\begin{aligned} v_t &= A(v^+ - v^-) + i_t r_o - v^- \\ &= (1 + A) i_t R_s + i_t r_o \end{aligned}$$

$$R_o = \frac{v_t}{i_t} = (1 + A) R_s + r_o.$$