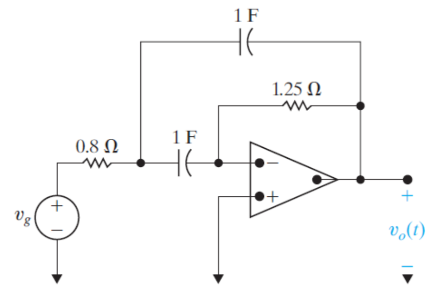
Example #5 (p13.48)

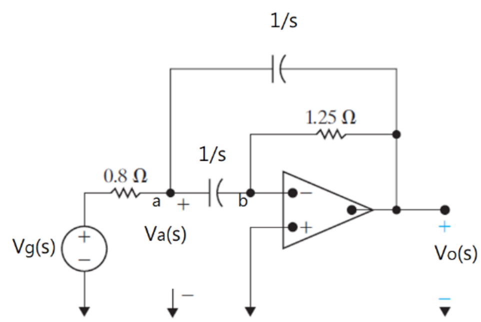


Find $v_0(t)$ in the circuit shown above if the ideal op amp operates

within its linear range and $v_g = 4.8u(t)\ mV$. (The initial energy stored in the circuit is zero)

Solution:

Because the initial energy stored in the circuit is zero, the voltages across the two capacitors in the above circuit, at $t = 0^+$, are equal to zero. Therefore, the circuit in the s domain is



Because the op amp is ideal, $I_n = I_p = 0\ and\ V_n = V_p$. Here $V_p = 0$, so $V_n = 0$.

Writing the node-voltage equations at node **a** and **b**, we have:

$$\frac{V_a(s) - V_g(s)}{0.8} + \frac{V_a(s) - V_o(s)}{1/s} + \frac{V_a(s) - V_n(s)}{1/s} = 0 \quad (1)$$

$$\frac{V_n(s) - V_a(s)}{1/s} + \frac{V_n(s) - V_o(s)}{1.25} = 0 \quad (2)$$

From (2), we have:

$$V_a(s) = -\frac{V_o(s)}{1.25s} \quad (3)$$

From (1), we have:

$$V_a(s)\left(\frac{1}{0.8} + s + s\right) - sV_o(s) = \frac{V_g(s)}{0.8} \quad (4)$$

Plugging (3) into (4), yield:

$$-\frac{V_o(s)}{1.25s}\left(\frac{1}{0.8}+2s\right)-sV_o(s)=\frac{V_g(s)}{0.8} \quad (5)$$

From (5), we have:

$$V_o(s)\left(\frac{s^2+1.6s+1}{s}\right)=-1.25V_g(s) \quad (6)$$

Plugging $V_g(s)=\mathcal{L}\{v_g\}=\frac{4.8}{s}$ into (6), yield:

$$V_o(s)\left(\frac{s^2+1.6s+1}{s}\right)=-1.25\times\frac{4.8}{s}$$

Therefore:

$$V_o(s)=\frac{-6}{s^2+1.6s+1}=\frac{-6}{(s^2+1.6s+0.64)+0.32}=\frac{-6}{(s+0.8-j0.6)(s+0.8+j0.6)}$$
$$=\frac{k}{s+0.8-j0.6}+\frac{k^*}{s+0.8+j0.6}$$

$$k=V_o(s)(s+0.8-j0.6)|_{s=-0.8+j0.6}=j5=5e^{j90^0}$$

The output voltage of the circuit is

$$v_0(t)=2\times 5e^{-0.8t}\cos(0.6t+90^0)=10e^{-0.8t}\cos(0.6t+90^0)\,u(t)\ \ V$$