Chapter 10, Solution 76.

Determine $\mathbf{V}_o$ and $\mathbf{I}_o$ in the op amp circuit of Fig. 10.119.

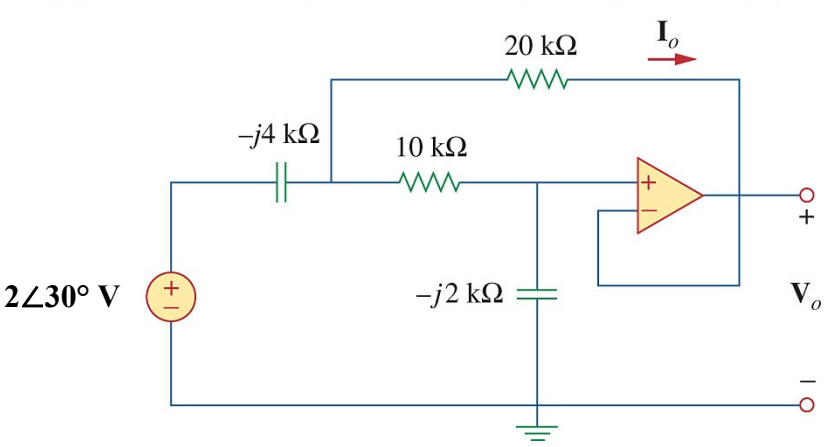

Figure 10.119
For Prob. 10.76.

Solution

Let the voltage between the -jk Ω capacitor and the 10k Ω resistor be $\mathbf{V}_1$.

$$\frac{2\angle 30^o - V_1}{-j4k} = \frac{V_1 - V_o}{10k} + \frac{V_1 - V_o}{20k} \longrightarrow$$

$$2\angle 30^o = (1 - j0.6)V_1 + j0.6V_o \qquad (1)$$

$$= 1.7321+j1$$

Also,

$$\frac{V_1 - V_o}{10k} = \frac{V_o}{-j2k} \longrightarrow V_1 = (1 + j5)V_o \qquad (2)$$

Solving (2) into (1) yields

$$2\angle 30° = (1 - j0.6)(1 + j5)V_o + j0.6V_o = (1 + 3 - j0.6 + j5 + j6)V_o$$

$$= (4+j5)V_o$$

$$V_o = \frac{2\angle 30°}{6.403\angle 51.34°} = \underline{0.3124\angle -21.34^o \text{ V}}$$

$$= \mathbf{312.4\angle -21.34^\circ\ mV}$$

$\mathbf{I}_o = (\mathbf{V}_1 - \mathbf{V}_o)/20k = \mathbf{V}_o/(-j4k) = (0.3124/4k)\angle(-21.43+90)^\circ$

$$= \mathbf{78.1\angle 68.57^\circ\ \mu A}$$

We can easily check this answer using MATLAM. Using equations (1) and (2) we can identify the following matrix equations:

YV = **I** where

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>> Y=[1-0.6i,0.6i;1,-1-0.5i]

Y =
   1.0000 - 0.6000i        0 + 0.6000i
   1.0000             -1.0000 - 5.0000i

>> I=[1.7321+1i;0]

I =
   1.7321 + 1.0000i
        0

>> V=inv(Y)*I

V =
   0.8593 + 1.3410i
   0.2909 - 0.1137i  = Vo = 312.3∠–21.35° mV.  The answer checks.
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