SİNÜZOİDAL YATIŞKIN DURUM ANALİZİ

10.1 GİRİŞ

1) Devreyi fazör eşdeğerine çevir.
2) Bilinen devre analiz teknikleriyle (DGY, ÇAY) devreyi çöz.
3) Sonuçta bulunan fazörü zaman alanına çevir.

10.2 DÜĞÜM ANALİZİ

Example 10.1

Find i_x in the circuit of Fig. 10.1 using nodal analysis.

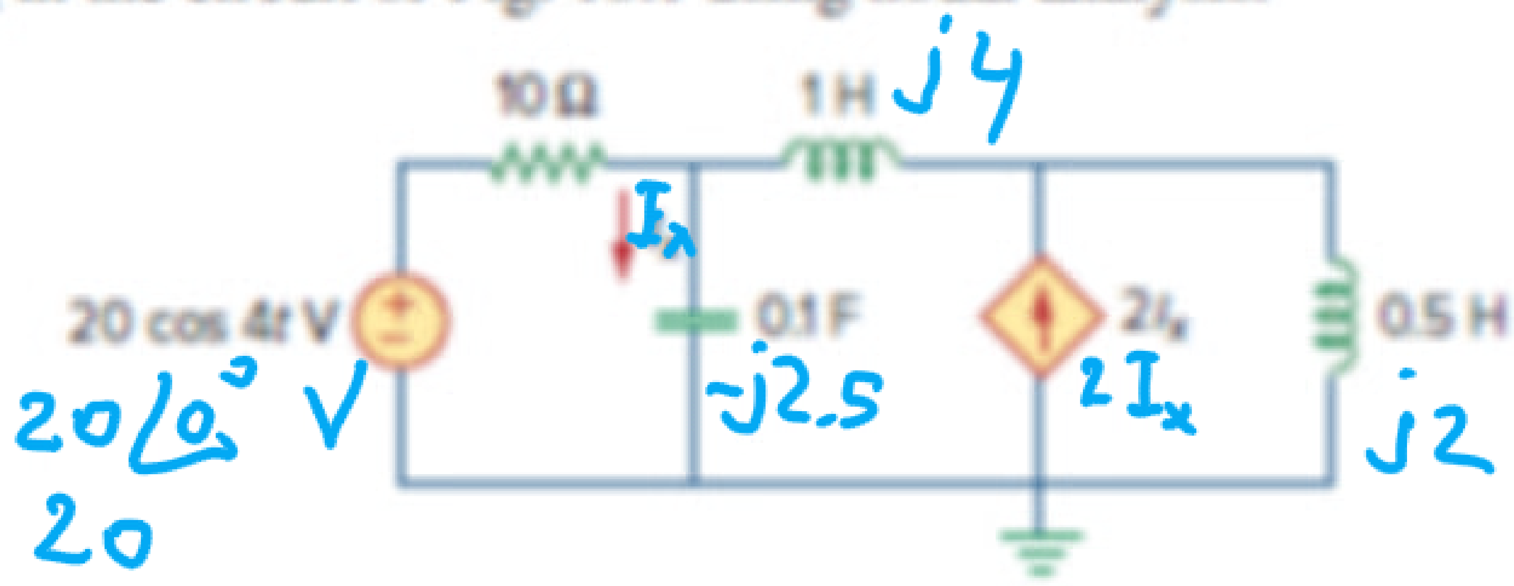


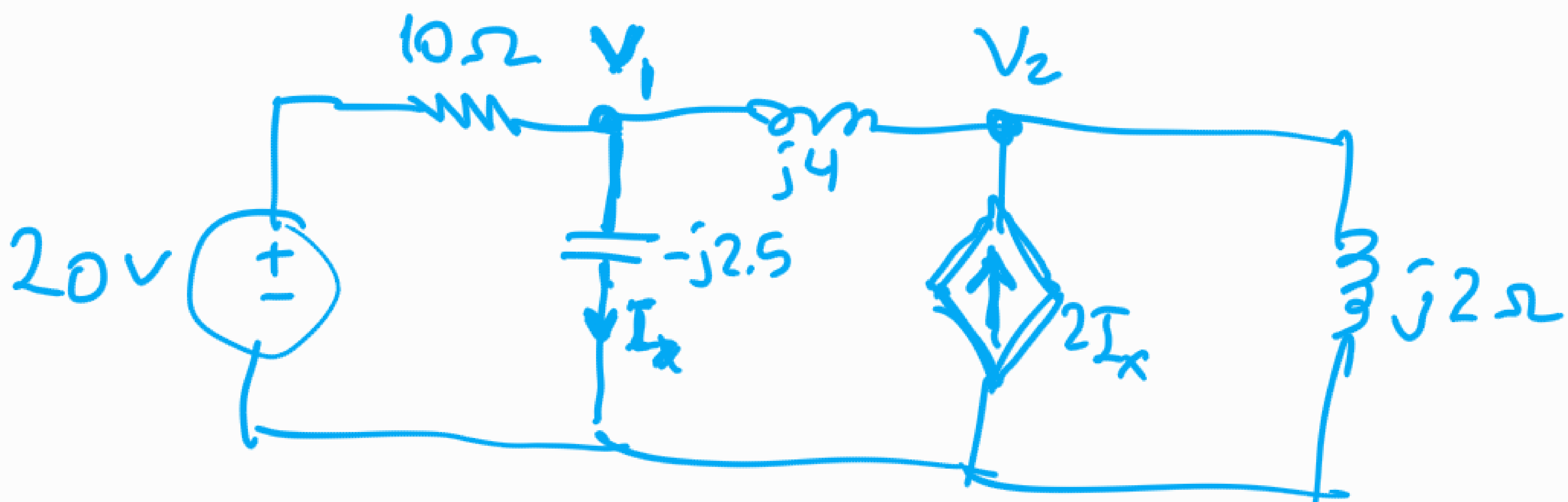
Figure 10.1
For Example 10.1.

$\omega = 4$ rad/sn

$1H \rightarrow j4\ \Omega$

$0.1F \rightarrow \dfrac{-j}{\omega C} = \dfrac{-j}{4\times 0.1} = -j2.5\ \Omega$

$0.5H \rightarrow j2\ \Omega$



$I_x = \dfrac{V_1}{-j2.5}$

(1) $\dfrac{V_1 - 20}{10} + \dfrac{V_1}{\underset{(j4)}{-j2.5}} + \dfrac{V_1 - V_2}{\underset{(-j2.5)}{j4}} = 0$

(2) $\dfrac{V_2 - V_1}{\underset{(-j2.5)}{j4}} + \dfrac{V_2}{\underset{(-j5)}{j2}} = 2I_x = \dfrac{2V_1}{\underset{(j4)}{-j2.5}}$

(1) $V_1 - 20 + j4V_1 - j2.5V_1 + j2.5V_2 = 0$

$V_1(1 + j1.5) + j2.5V_2 = 20$

(2) $-j2.5V_2 + j2.5V_1 - j5V_2 = j8V_1$

(2) $j7.5V_2 = -j5.5V_1$

$-7.5V_2 = 5.5V_1$

$\boxed{-\frac{15}{11}V_2 = V_1}$ $\qquad V_2 = -\frac{11}{15}V_1$

(1) $V_1(1+j1.5) + j2.5\left(\frac{-11}{15}\right)V_1 = 20$

$V_1\left(1+j1.5-j2.5\times\frac{11}{15}\right) = 20$

$V_1 = \frac{20}{1-\frac{j}{3}} \rightarrow I_x = \frac{V_1}{-j2.5} = \frac{20}{-j2.5-\frac{2.5}{3}}$

$= \frac{20}{2.63\angle -108.4}$

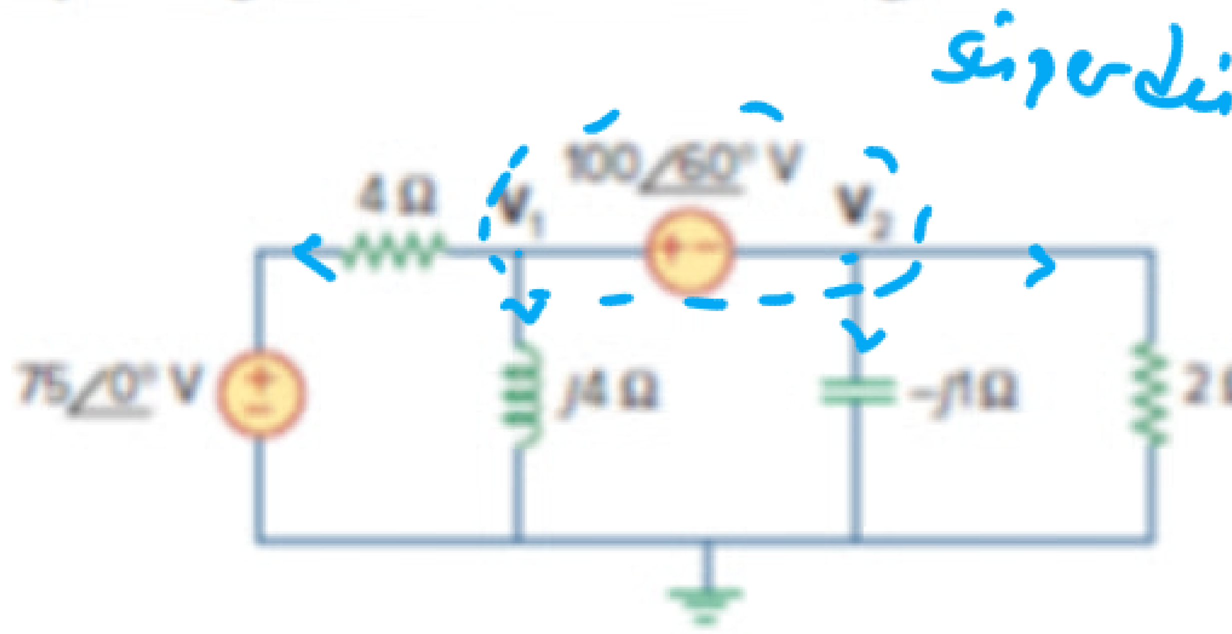
$I_x = 7.59\angle 108.4^\circ$

$i_x(t) = 7.59\cos(4t-108.4^\circ)$

Calculate V_1 and V_2 in the circuit shown in Fig. 10.6.

Practice Problem 10.2

süperdüğüm



Bu soruda devreyi doğrudan fazör alanında vermiş.

Figure 10.6
For Practice Prob. 10.2.

Answer: $V_1 = 96.8\angle 69.66^\circ$ V, $V_2 = 16.88\angle 165.72^\circ$ V.

(1) $\frac{V_1-75}{4} + \frac{V_1}{j4} + \frac{V_2}{-j} + \frac{V_2}{2} = 0$

(1) $\quad$ (−j) $\quad$ (j4) $\quad$ (2)

(2) $V_1 - V_2 = 100\angle 60^\circ$

① $V_1 - 75 - jV_1 + j4V_2 + 2V_2 = 0$

① $V_1(1-j) + V_2(2+j4) = 75$

$-$ ② $(V_1 - V_2 = 50 + j50\sqrt{3})\,(1-j)$

$$V_2(2+j4+1-j) = 75 - 50 + 50j - j50\sqrt{3} - 50\sqrt{3}$$

$$V_2 = \frac{25-50\sqrt{3} + j(50-50\sqrt{3})}{3+j3}$$

$$= -16.4 + j4.2$$

$$V_2 = 16.9 \angle 165.7^\circ \text{ V}$$

10.3 ÇEVRE ANALİZİ (Ç.A.Y.)

Practice Problem 10.3 Find I_o in Fig. 10.8 using mesh analysis.

Answer: $5.969\angle 65.45^\circ$ A.

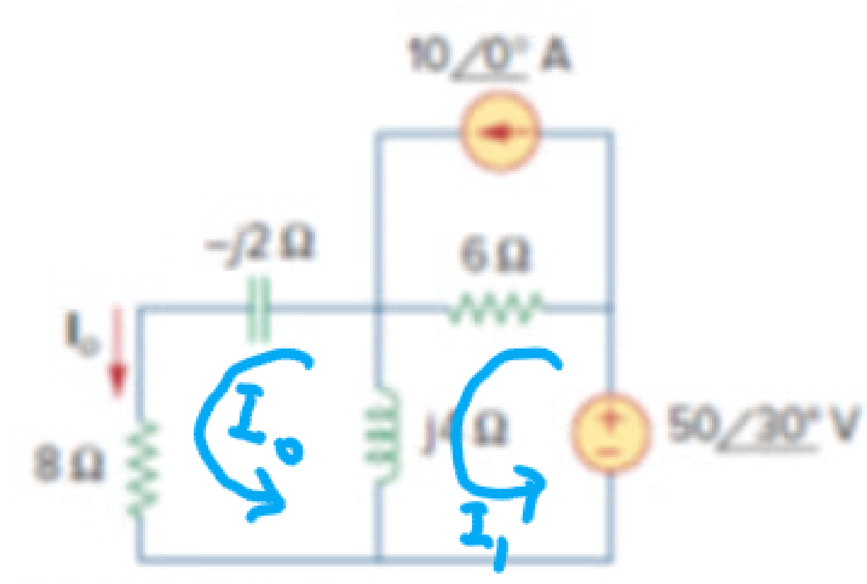


Figure 10.8
For Practice Prob. 10.3.

deme fazör eşdeği verilmiş

① $(8-j2)I_o + j4(I_o - I_1) = 0$

② $-50\angle 30^\circ + 6(I_1 - 10) + j4(I_1 - I_o) = 0$

① $I_o\dfrac{(8+j2)}{j4} = I_1 \rightarrow I_o\dfrac{4+j}{j2} = I_1 \rightarrow \boxed{\dfrac{1-j4}{2}I_o = I_1}$

② $(6+j4)I_1 - j4I_o = 60 + 50\angle 30^\circ$

② $\left(\dfrac{(6+j4)(1-j4)}{2} - j4\right) I_o = 60 + 25\sqrt{3} + j25$

② $\dfrac{6-j24+j4+16-j8}{2}\, I_o = 60 + 25\sqrt{3} + j25$

$\dfrac{22-j28}{2}\, I_o = 60 + 25\sqrt{3} + j25$

$11 - j14$

$I_o = 2.36 + j5.27$
$= 5.78\angle 65.9^\circ$

SÜPERPOZİSYON İLKESİ

Devrenin birden fazla güç kaynağı olup, her biri farklı frekansta olabilir.

R, L, C devreleri doğrusaldır. (neden? çünkü türev, integral)

$$\underbrace{f(a.x_1 + b.x_2) = a\,f(x_1) + b\,f(x_2)}_{\text{süperpozisyon ilkesi}}$$

EXAMPLE 10.6

Find v_o in the circuit in Fig. 10.13 using the superposition theorem.

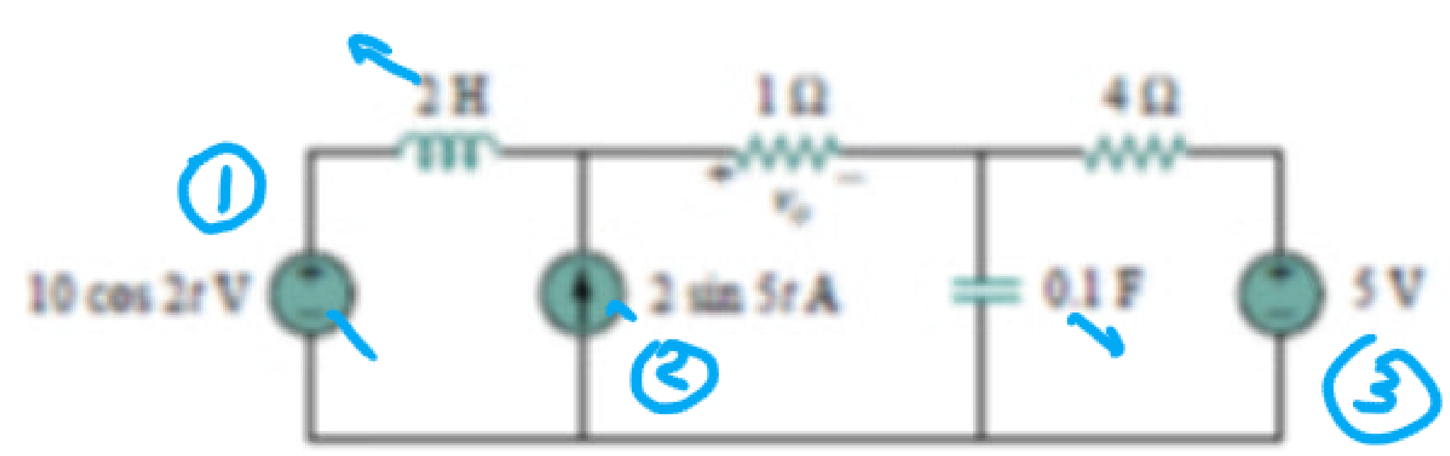
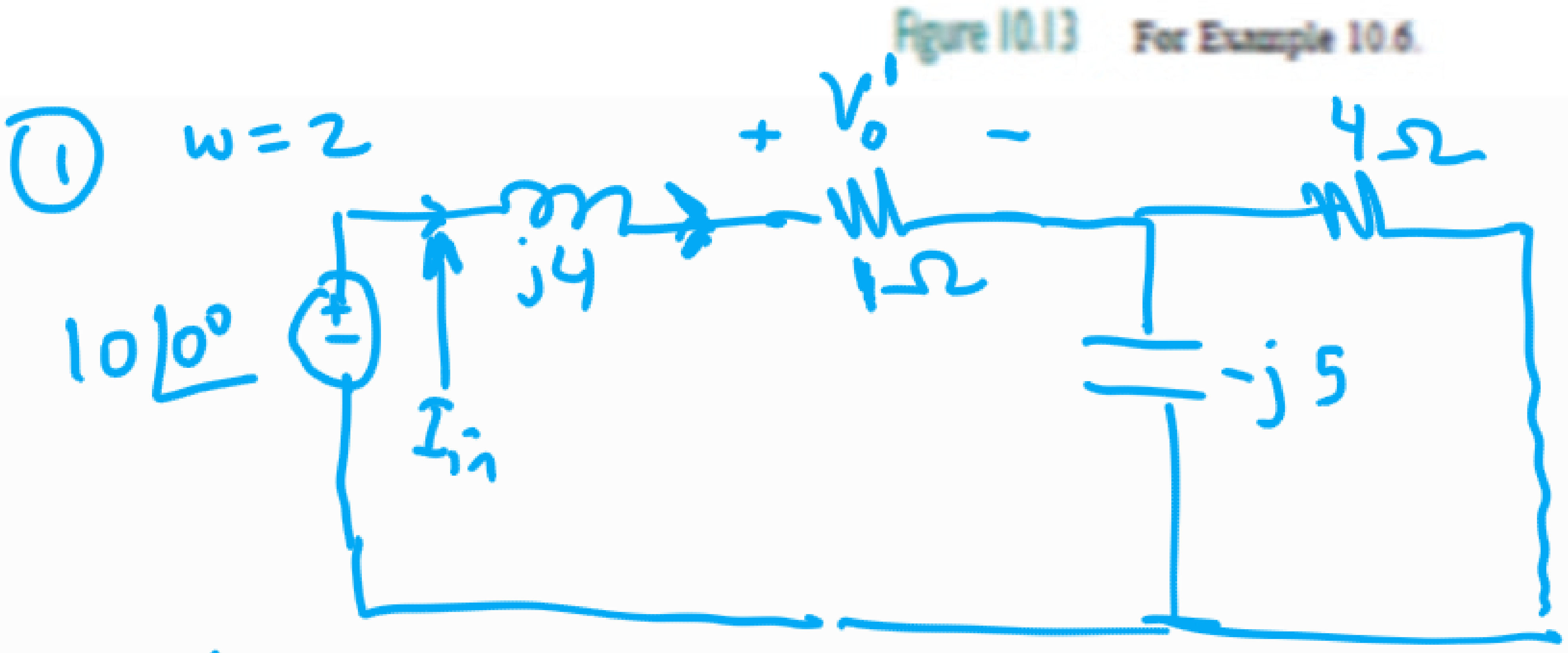


Figure 10.13 For Example 10.6.

① $w = 2$



$$\frac{-j}{2\times 0.1}$$

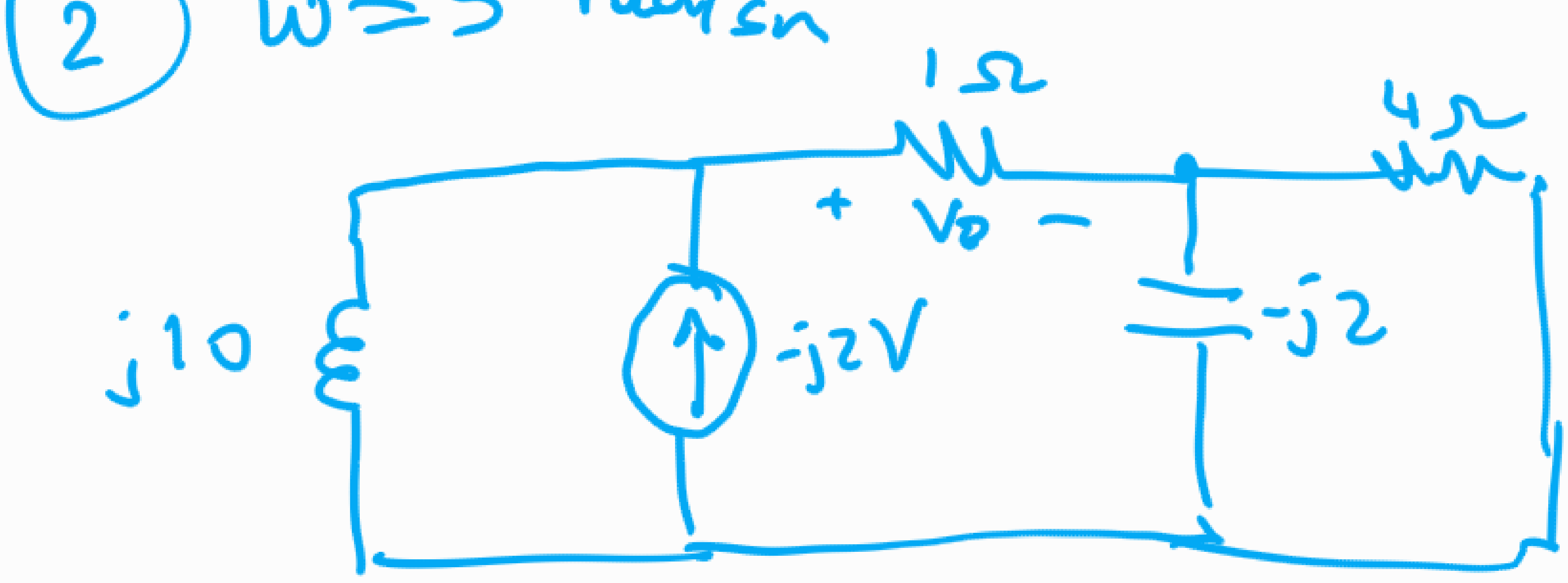
$$1\Omega \times I_{in} = V_o' = \frac{10}{1+j4+(-j5 \parallel 4)} = \frac{10}{1+j4-\frac{j20}{4-j5}}$$

$$= \frac{10(4-j5)}{4-j5+j16+20-j20} = \frac{10(4-j5)}{24-j9}$$

$$V_o' = 2.498\angle -30.78^\circ$$

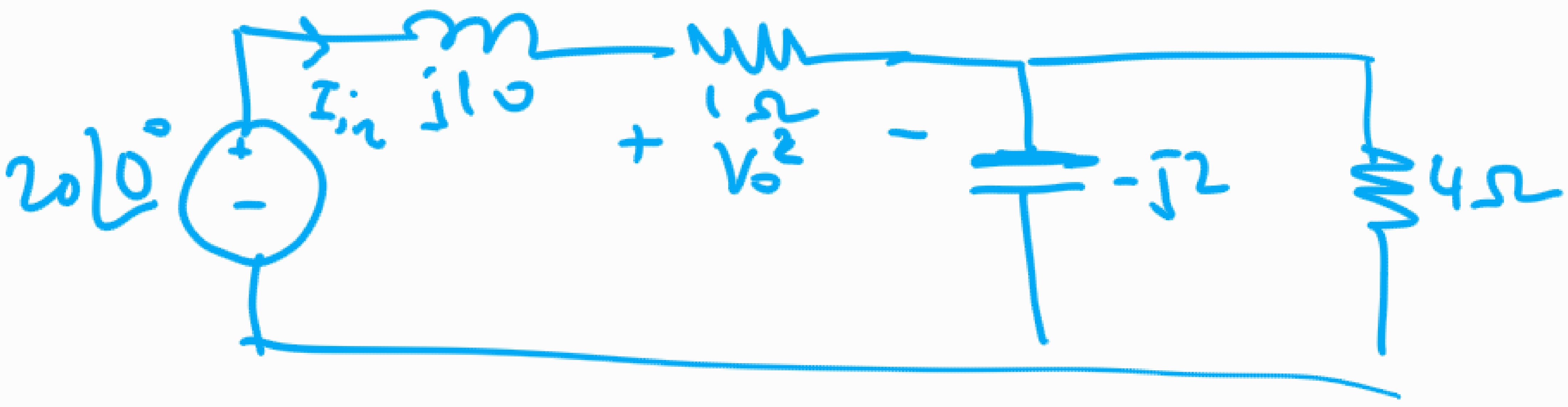
$$v_o'(t) = 2.498\cos(2t-30.78^\circ)\ \text{V}$$

② $w = 5$ rad/sn



$$2\sin 5t = 2\cos(5t-90) \xrightarrow{\mathcal{P}} -j2$$

$(-j2)(j10) = 20\,V$



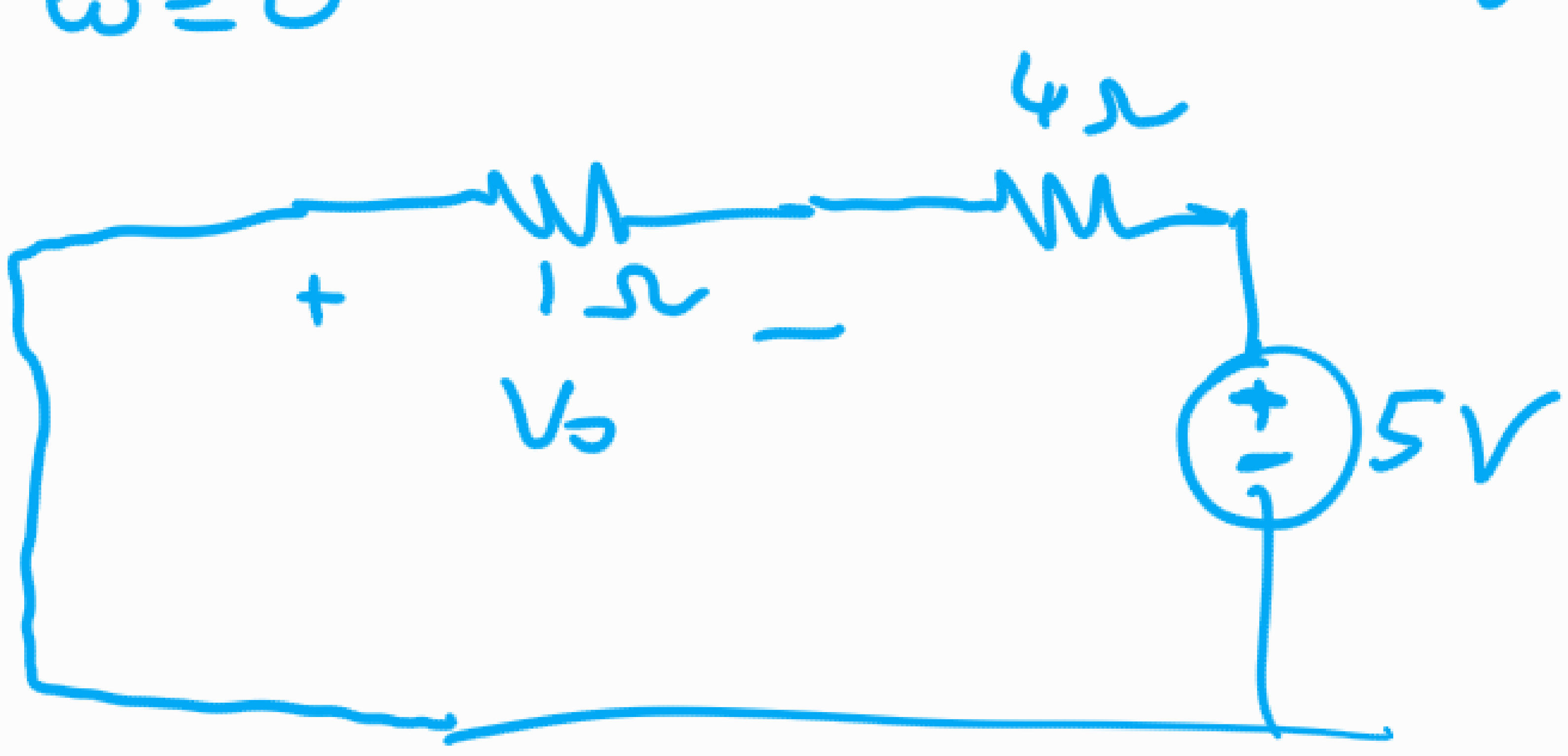
$$V_o^2 = \frac{20}{j10+1+(-j2\|4)} = \frac{20}{-j10+1-\frac{j8}{4-j2}} = \frac{20(4-j2)}{-j40-20+4-j2-j8}$$

$$= \frac{40(2-j)}{-16-j50}$$

$$= 1.7\angle 81.2^\circ$$

$v_o^2(t) = 1.7\cos(5t+81.2^\circ)\ V$

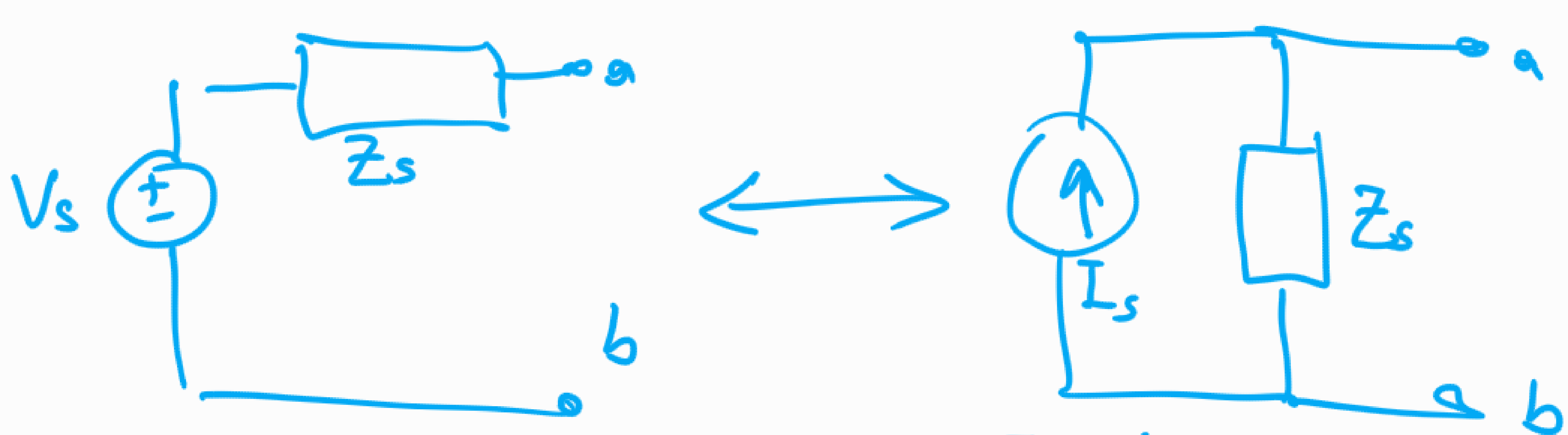
(3) $\omega = 0$



$v_o^3(t) = -1\ V$

$$v_o(t) = v_o^1(t) + v_o^2(t) + v_o^3(t) = -1 + 2.5\cos(2t - 30.78) + \underbrace{1.7\cos(5t+81.2^\circ)}\ V$$

KAYNAK DÖNÜŞÜMÜ



$I_s = \frac{V_s}{Z_s}$

Practice Problem 10.7 Find I_o in the circuit of Fig. 10.19 using the concept of source transformation.

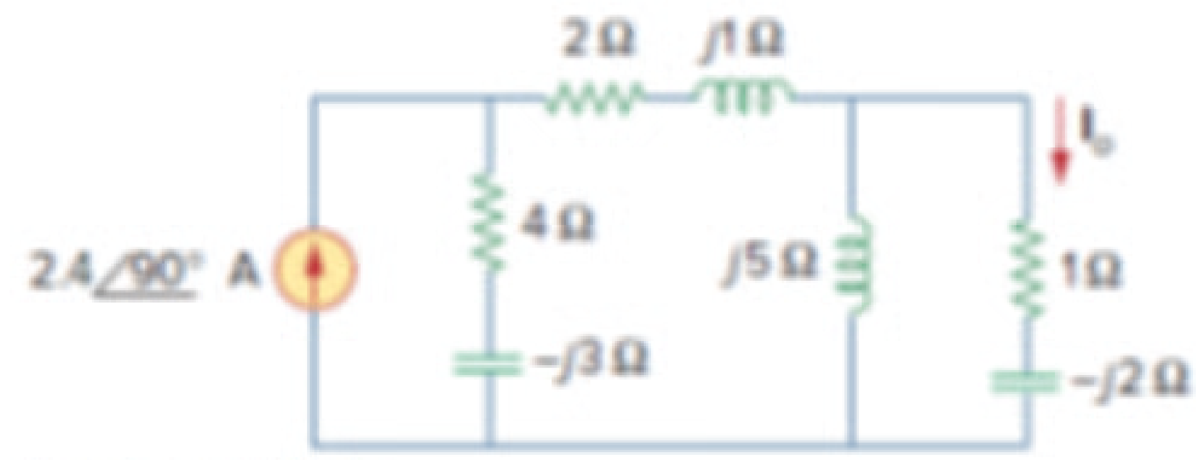
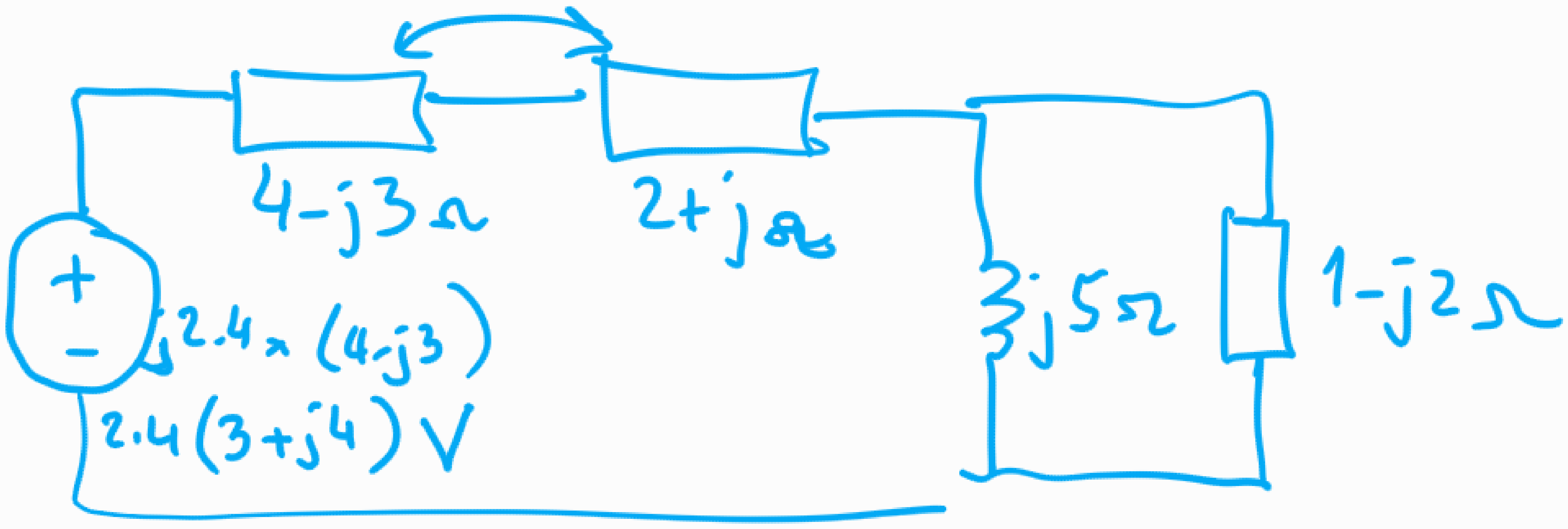
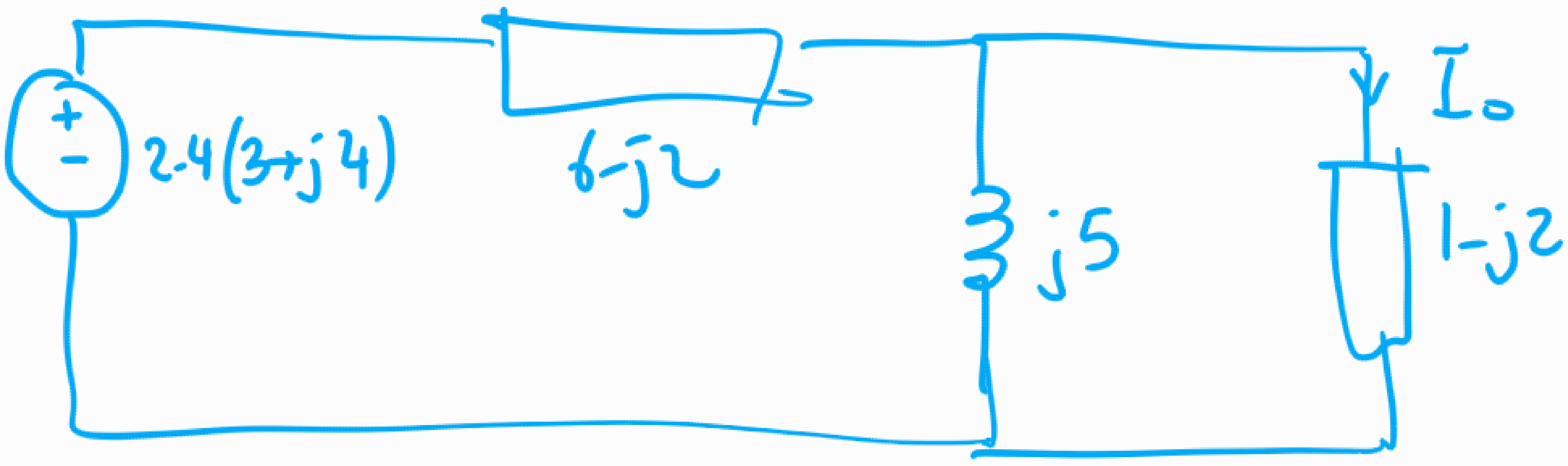
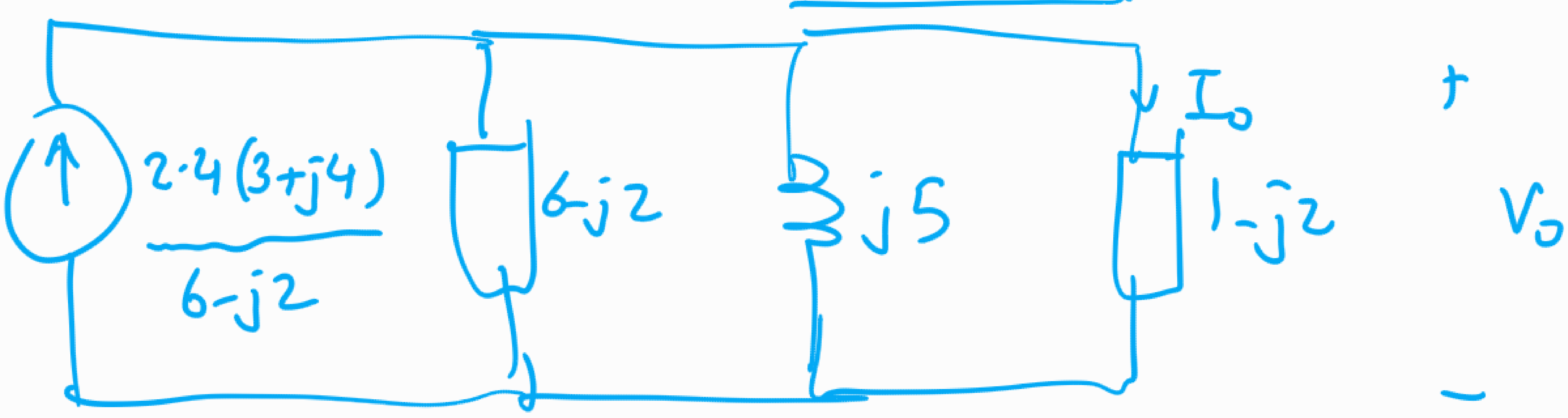


Figure 10.19
For Practice Prob. 10.7.

Answer: $1.9727\angle 99.46^\circ$ A.







$$\searrow I_o = \frac{2.4(3+j4)}{6-j2} \times \frac{\left((6-j2)\,/\!/\, j5 \,/\!/\, (1-j2)\right)}{1-j2}$$

$$= \frac{2.4(3+j4)}{6-j2} \; \frac{1}{\left(\frac{1}{6-j2} + \frac{1}{j5} + \frac{1}{1-j2}\right)(1-j2)}$$

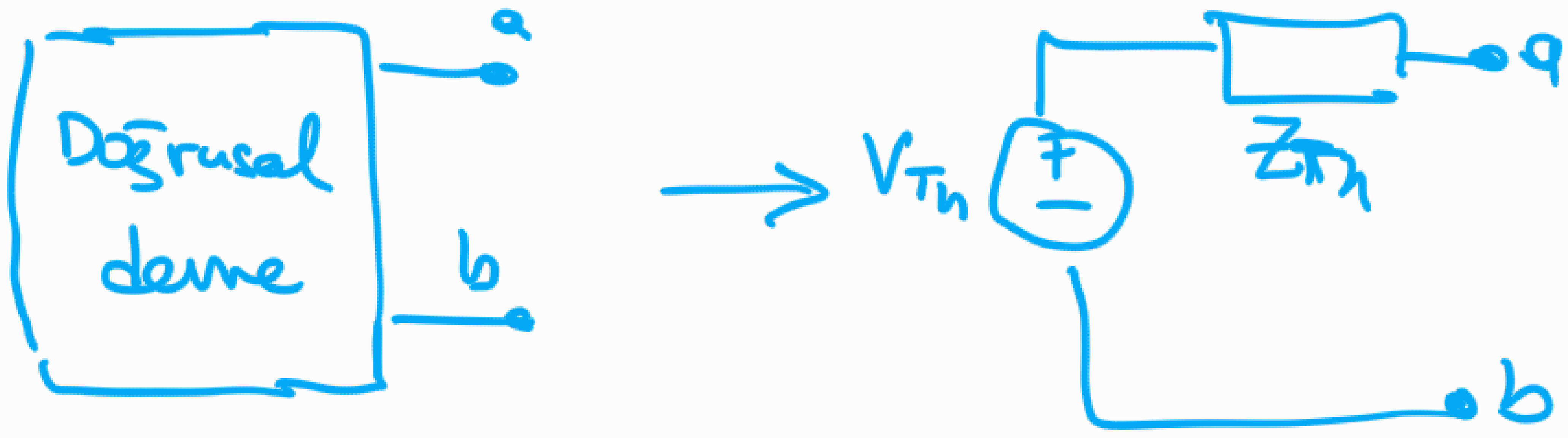
$$= \frac{2.4(3+j4)}{6-j2} \; \frac{1}{\frac{1-j2}{6-j2} + \frac{1-j2}{j5} + 1}$$

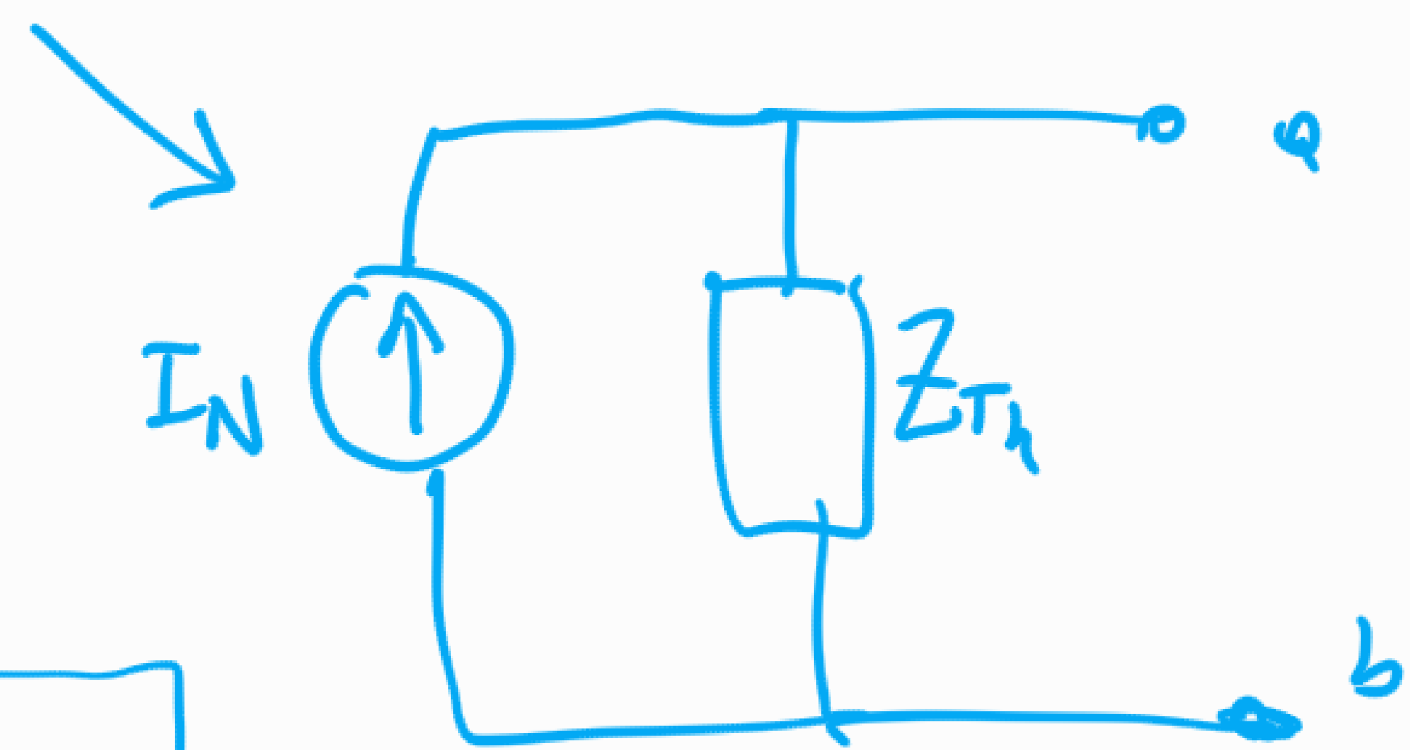
$$= \frac{2.4(3+j4)}{1-j2 + \frac{(1-j2)(6-j2)}{j5} + 6-j2} = \frac{2.4(j5)(3+j4)}{j5+10+6-j2-j12-4+6-j2}$$

$$= \frac{j12\,(3+j4)}{18-j11}$$

$$= 2.84\,\angle 174.56^\circ$$

Thevenin ve Norton Eşdeğer Devreleri:





$$\boxed{V_{Th} = Z_{Th} I_N}$$

$V_{Th} = V_{ad}$ = açık devre gerilimi

$I_N = I_{kd}$ = kısa devre akımı)

$$Z_{Th} = \frac{V_{ad}}{I_{kd}}$$

(devrede bağımlı kaynaklar varsa V_T test gerilimi bağlanır, üzerinden geçen akım bulunur. $\frac{V_T}{I_T} = Z_{Th}$

sadece bağımsız kaynak varsa, bütün kaynaklar sıfırlanır ve eşdeğer empedans bulunur.

EXAMPLE 10.8

Obtain the Thevenin equivalent at terminals a-b of the circuit in Fig. 10.22.

$V_{Th} = V_{ad}$

$V_a = 120\angle 75^\circ - I_1(-j6)$

$V_b = 120\angle 75^\circ - I_2\, 4$

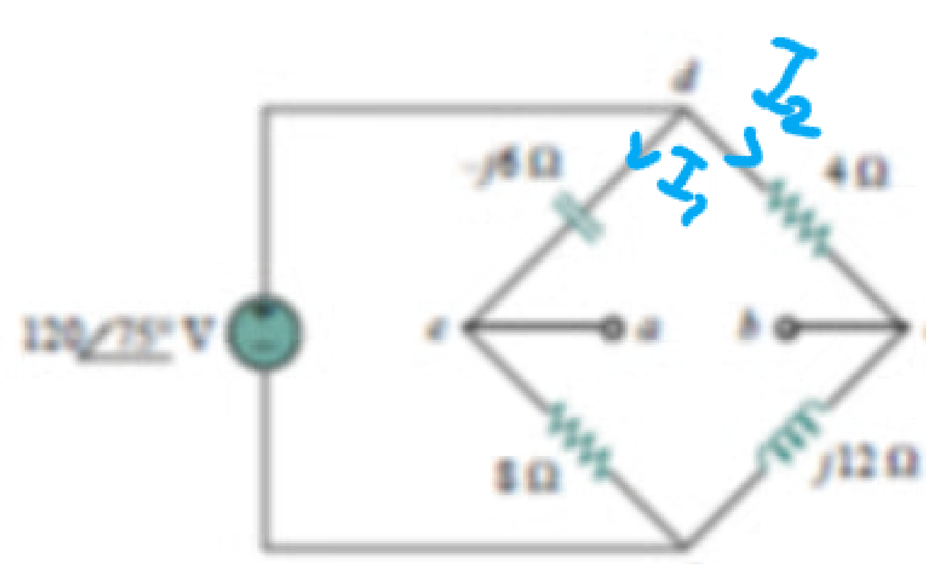


Figure 10.22 For Example 10.8.

$V_{Th} = V_a - V_b$

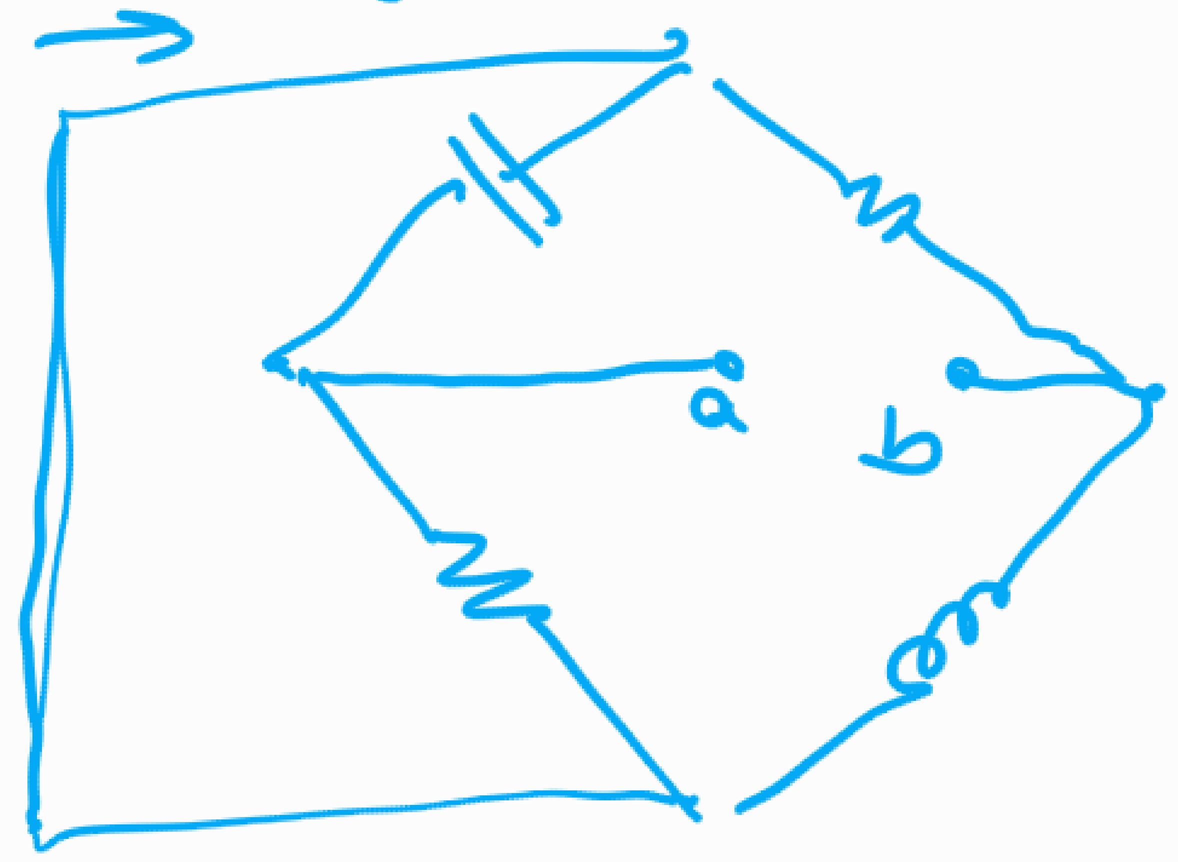
$= 4 I_2 - I_1(-j6)$

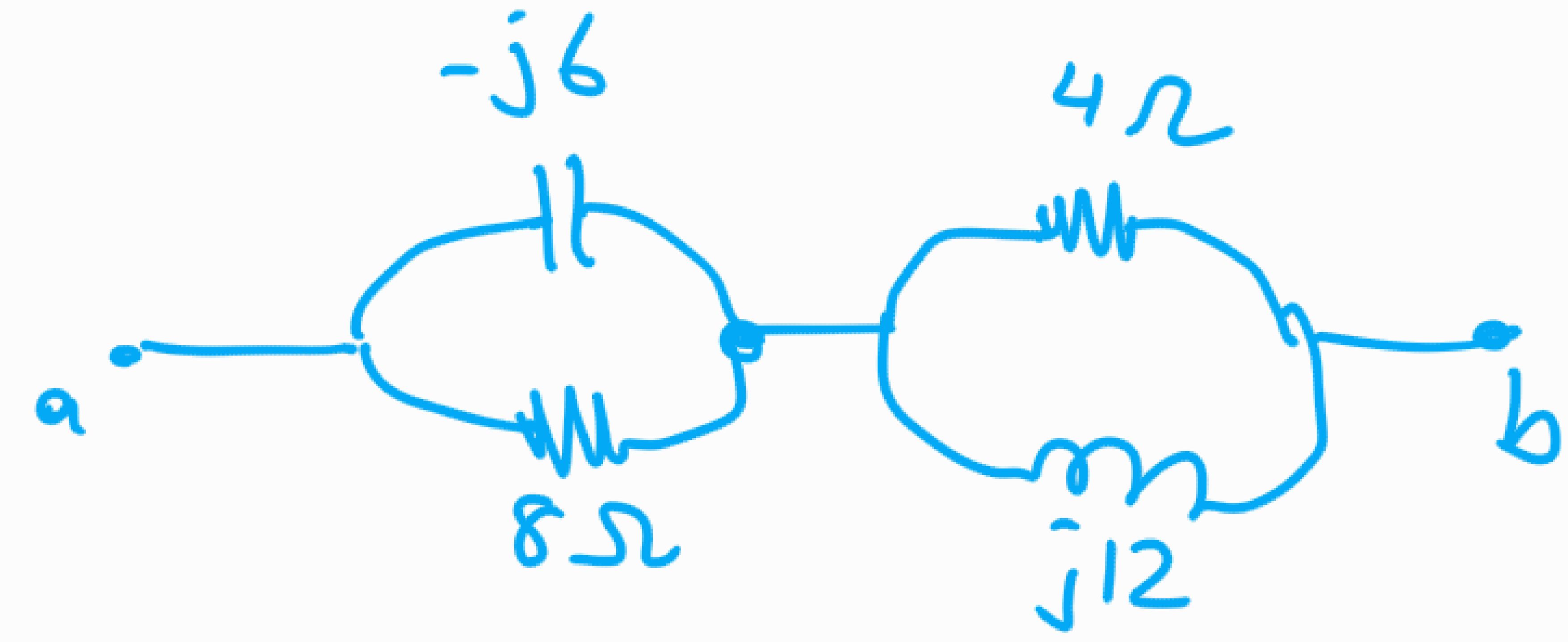
$I_1 = \dfrac{120\angle 75^\circ}{8 - j6}$ $\qquad$ $I_2 = \dfrac{120\angle 75^\circ}{4 + j12}$

$$V_{Th} = \frac{480\angle 75^\circ}{4 + j12} - \frac{120\angle 75^\circ}{10\angle -37^\circ}\, 6\angle -90^\circ$$

$$V_{Th} = \frac{480\angle 75^\circ}{4+j12} - 72\angle 22^\circ = 38\angle -139.5^\circ$$

$Z_{Th} \rightarrow$





$$Z_{Th} = Z_{ab} = -j6 \parallel 8 + 4 \parallel j12$$

$$= \frac{-j48}{8-j6} + \frac{j48}{4+j12}$$

$$= 6.48 - 2.64j$$

Determine the Thevenin equivalent of the circuit in Fig. 10.27 as seen from the terminals *a-b*.

Practice Problem 10.9

Answer: $Z_{Th} = 4.473\angle -7.64^\circ\ \Omega$, $V_{Th} = 11.763\angle 72.9^\circ$ volts.

$V_{Th} = V_{ab} = V_{ad}$

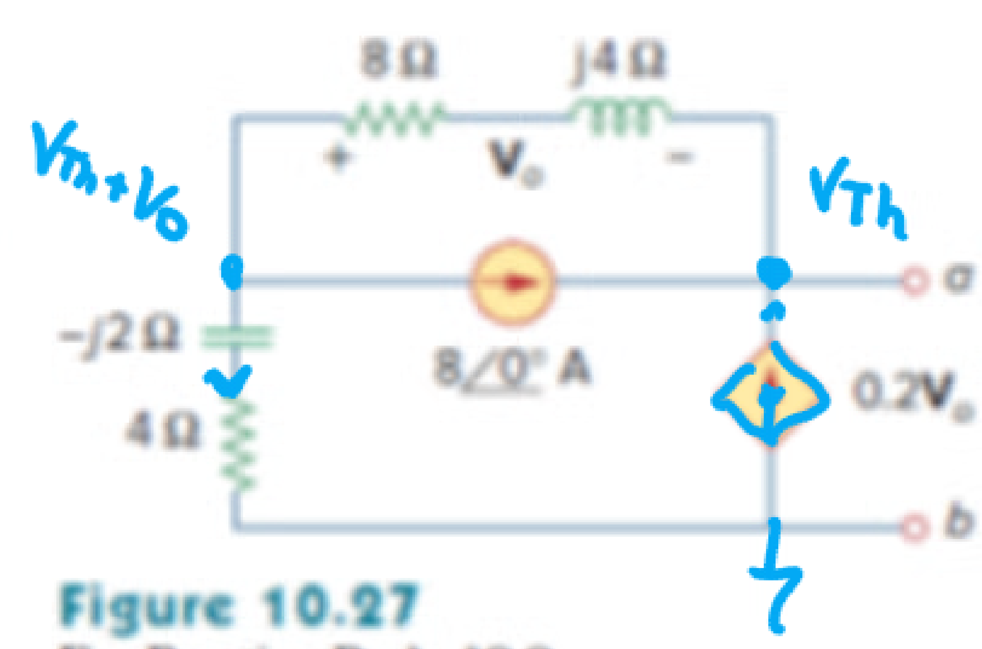


Figure 10.27
For Practice Prob. 10.9.

(1) $8 + \frac{V_o}{8+j4} + 0.2V_o = 0 \rightarrow V_o$ bulunabilir.

(2) $\frac{V_{Th}+V_o}{4-j2} = 0.2V_o$

$$-8 = V_o\left(\frac{1}{8+j4} + 0.2\right) \rightarrow V_o = \frac{-8}{\frac{1}{8+j4}+0.2} = \frac{-8(8+j4)}{2.6+j0.8}$$

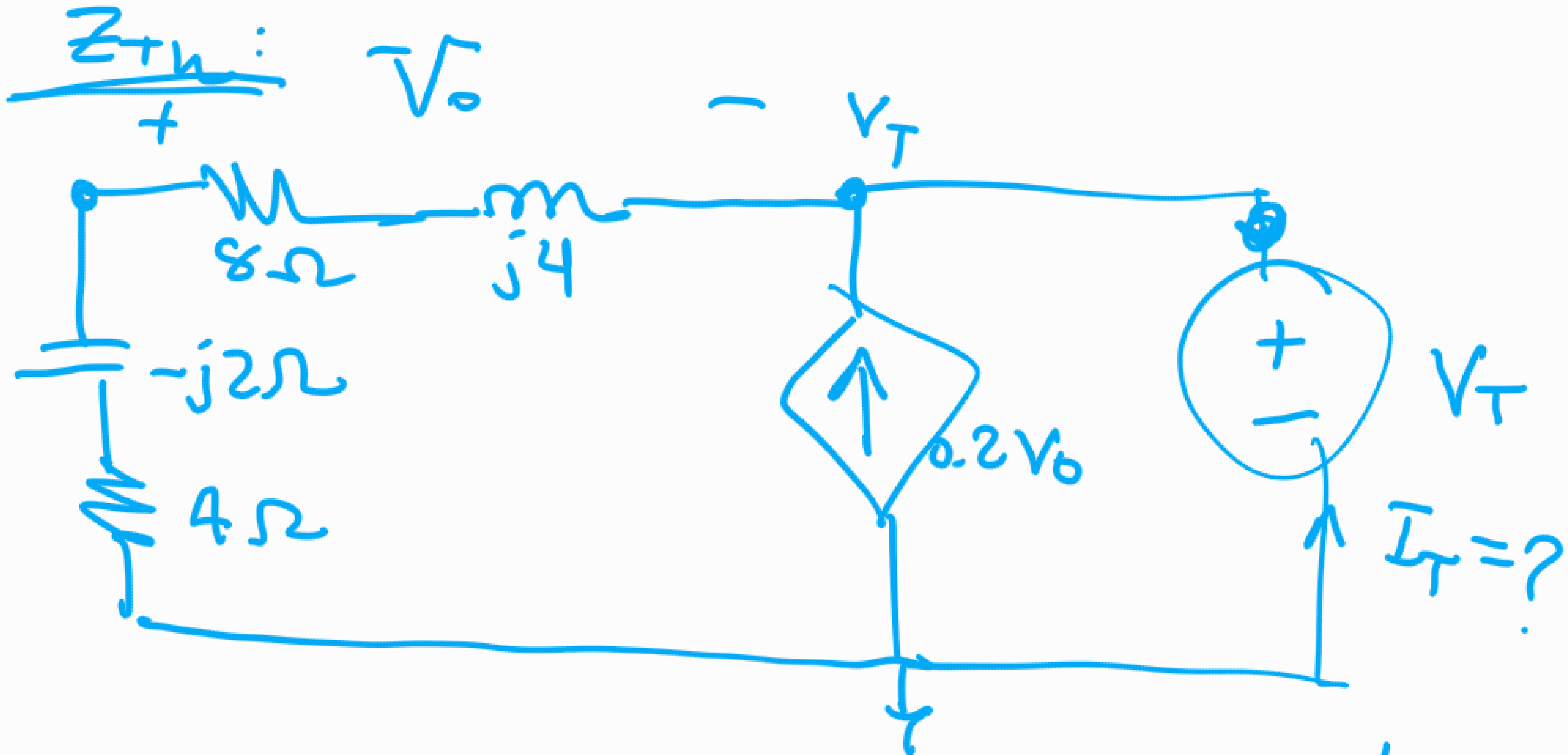
(2) $V_{Th} + V_o = (0.8 - j0.4)V_o$

$$V_{Th} = (-0.2 - j0.4)V_o$$

$$= \frac{-8(8+j4)(-0.2-j0.4)}{2.6+j0.8} = 3.46 + 11.24j$$

$$= 11.76\angle 72.9^\circ\ V \checkmark$$

Z_{Th}:



$$\frac{V_T}{8+j4+4-j2} - 0.2V_o = I_T \qquad \left(V_o = \frac{-V_T\,(8+j4)}{8+j4+4-j2} \right)$$

$$\frac{V_T}{12+j2} + \frac{0.2\,V_T\,(8+j4)}{12+j2} = I_T$$

$$\frac{V_T}{I_T} = Z_{Th} = \frac{1}{\frac{1}{12+j2} + \frac{0.2(8+j4)}{12+j2}} = \frac{12+j2}{2.6+j0.8}$$

$$= 4.43 - 0.59j$$

$$Z_{Th} = 4.47\angle -7.64^\circ\ \Omega$$

$v_1 \quad 4\cos(377t+10^\circ)$

$v_2 \quad -20\cos(377t) = 20\cos(377t-180^\circ)$

$= 20\cos(377t+180^\circ)$

v_1 190° önde veya v_2 170° önde

ikisi de doğru.