Chapter 11: AC (Alternatif Akım) Güç Analizi

11.1. Giriş

Vantilatör, motor, lamba, ütü, TV, Bilgisayarın Çalışması hep gücün bir yerden, bir yere aktarılması ile ilgilidir.

Elektrik Gücü santrallerden evlere 50-60Hz frekansile bir dalga ile aktarılır.

11.2 Anlık ve Ortalama Güç:

ELE 201: $p = v \cdot i$ (DC devrelerde)

genel: $p(t) = v(t) \cdot i(t)$

$$v(t) = V_m \cos(\omega t + \theta_v)$$

$$i(t) = I_m \cos(\omega t + \theta_i)$$

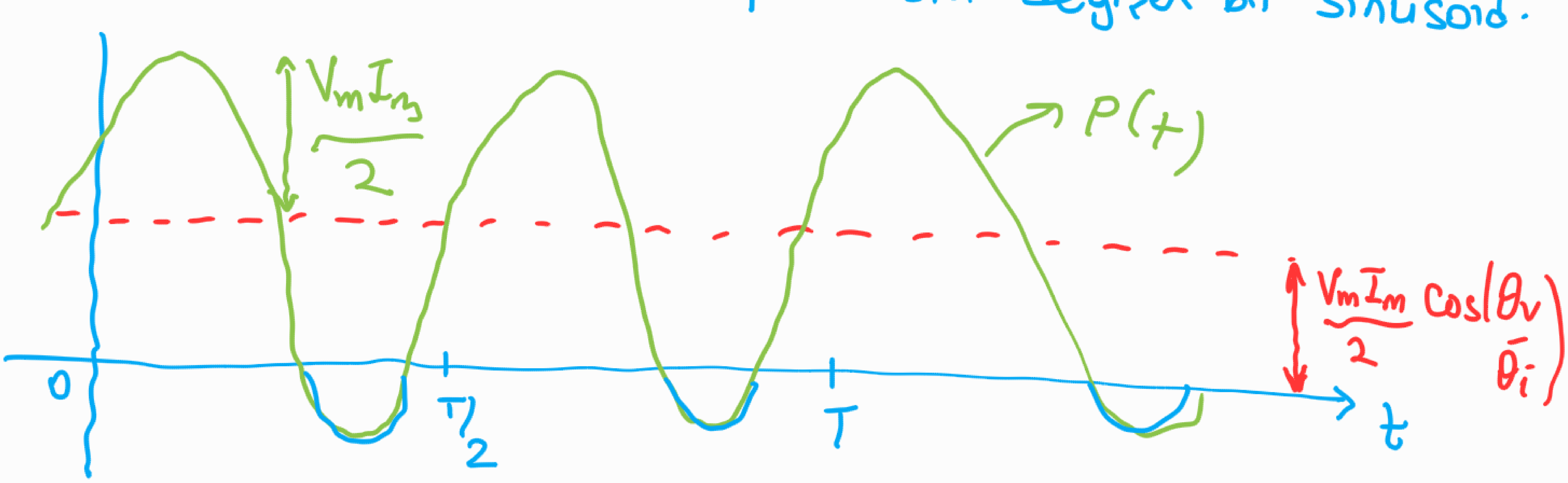
$$p(t) = v(t)\, i(t) = V_m I_m \cos(\omega t + \theta_v) \cos(\omega t + \theta_i)$$

(not: $\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$)

$$p(t) = \underbrace{\frac{V_m I_m}{2} \cos(\theta_v - \theta_i)} + \underbrace{\frac{V_m I_m}{2} \cos(2\omega t + \theta_v + \theta_i)}$$

Gözlemler:

1) Anlık gücün ilk kısmı sabit ve zamandan bağımsız.
2) İkinci kısım iki kat frekansla değişen bir sinüsoid.



3) Anlık güç bazen negatif olabilir.
Anlık güç negatif iken kaynak tarafından, pozitif iken devre tarafından güç emilir.
Devrenin kaynağa güç vermesi (anlık gücün negatif olması) devredeki kondansatör ve endüktörlerde biriken yüklerin boşalması ile olur.

Ortalama güç : $P = \frac{1}{T}\int_0^T p(t)\,dt$

$$P = \frac{V_m I_m}{2}\cos(\theta_v - \theta_i)$$

fazların sadece farkının mutlak değerine bağlıdır (hep ≥ 0)

Fazör alanında : $\mathbf{V} = V_m \angle \theta_v$

$\mathbf{I} = I_m \angle \theta_i$

$$\mathbf{V}\mathbf{I}^* = V_m I_m \angle \theta_v - \theta_i$$

$$\mathrm{Re}\{\mathbf{V}\mathbf{I}^*\} = V_m I_m \cos(\theta_v - \theta_i)$$

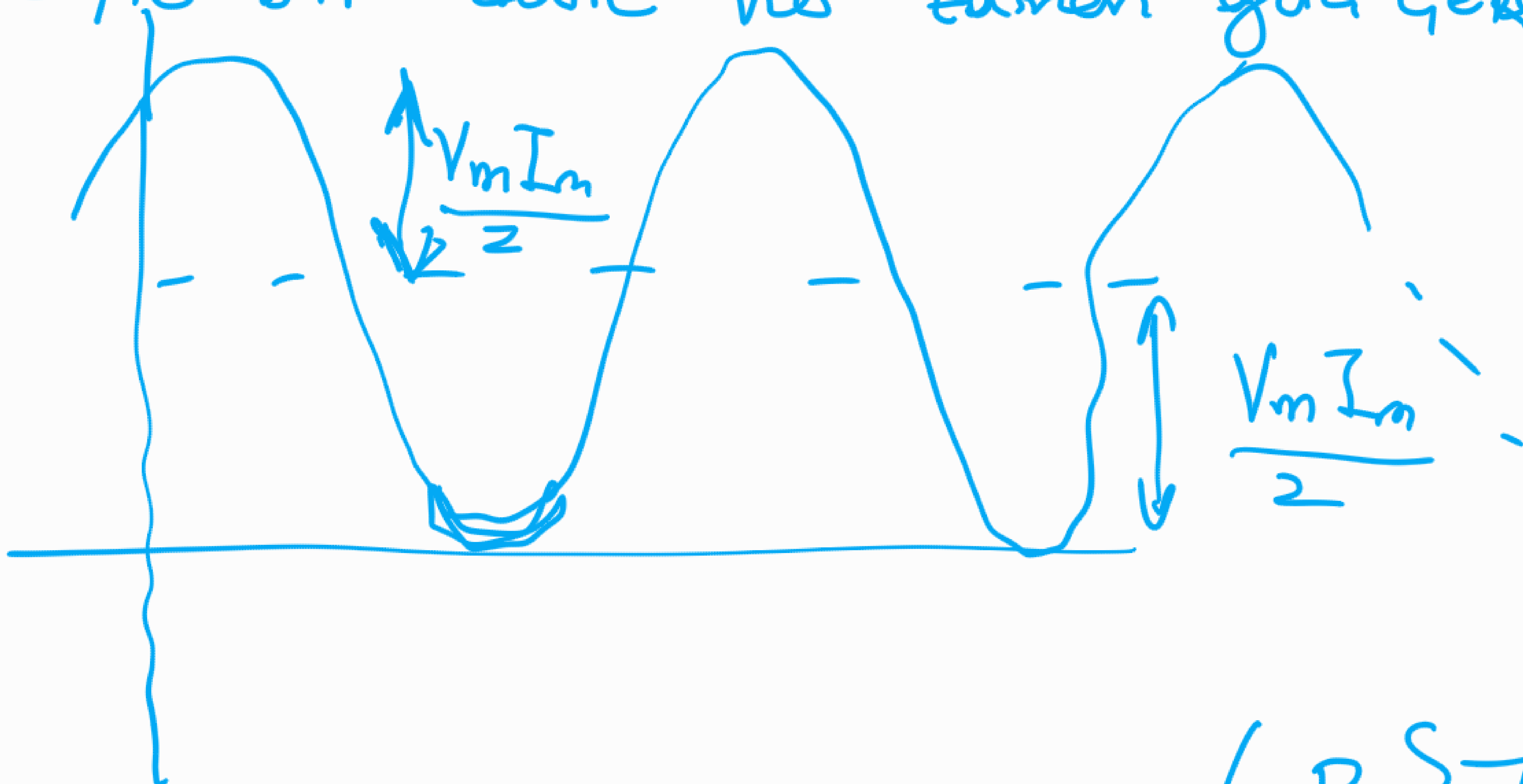
$$\frac{1}{2}\mathrm{Re}\{\mathbf{V}\mathbf{I}^*\} = \frac{V_m I_m}{2}\cos(\theta_v - \theta_i) = P$$

$$\boxed{P = \frac{1}{2}\mathrm{Re}\{\mathbf{V}\mathbf{I}^*\}}$$

Resistif devre: $(\mathrm{Im}\{\mathbf{Z}\} = 0)$ $\theta_v = \theta_i$ 'dir.

$V = \mathbf{I}R$ o zaman $P = \frac{V_m I_m}{2} = \frac{|\mathbf{I}|^2 R}{2}$

Böyle bir devre her zaman güç çeker.

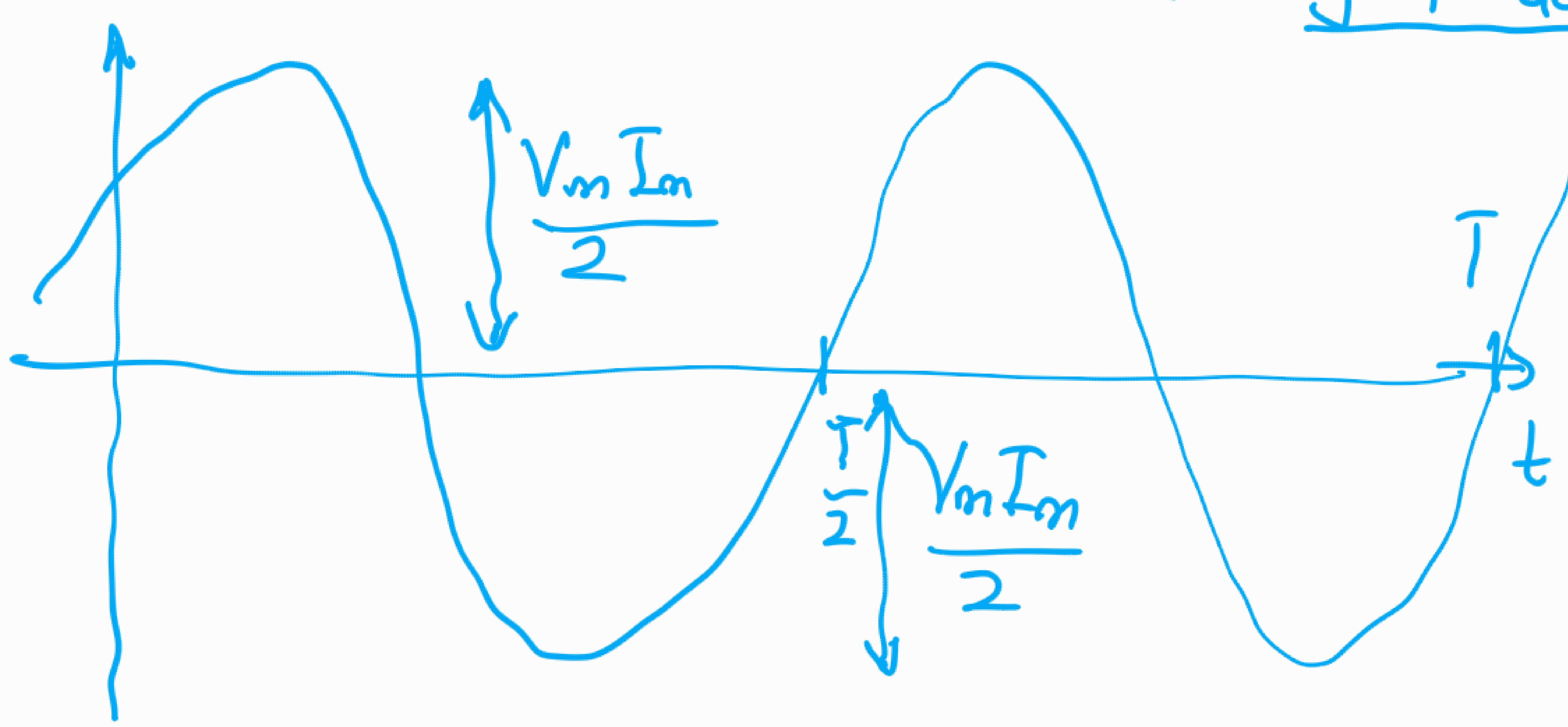


Tamamen reaktif bir devre : $(\mathrm{Re}\{Z\}=0)$

o zaman $\theta_v - \theta_i = \pm 90°$

bu durumda $P = \frac{V_m I_m}{2}\cos(\theta_v - \theta_i) = \emptyset$

böyle bir devre, ortalamada güç çekmez.



$P=0$

Example 11.1

Given that

$v(t) = 120\cos(377t + 45°)$ V and $i(t) = 10\cos(377t - 10°)$ A

find the instantaneous power and the average power absorbed by the passive linear network of Fig. 11.1.

$\theta_v - \theta_i = 55$ $\omega = 377$

$\theta_v + \theta_i = 35$

$$p(t) = \frac{V_m I_m}{2}\cos(\theta_v - \theta_i) + \frac{V_m I_m}{2}\cos(2\omega t + \theta_v + \theta_i)$$

$$p(t) = \underbrace{600\cos(55°)}_{P} + 600\cos(754t + 35°) \text{ W}$$

$$\boxed{p(t) = v(t)\, i(t)}$$

Practice Problem 11.1

Calculate the instantaneous power and average power absorbed by the passive linear network of Fig. 11.1 if

$$v(t) = 330 \cos(10t + 20^\circ)\ \text{V} \qquad \text{and} \qquad i(t) = 33 \sin(10t + 60^\circ)\ \text{A}$$

Answer: 3.5 + 5.445 cos(20t − 10°) kW, 3.5 kW.

$i(t) = 33\cos(10t - 30^\circ)$

$\theta_v = 20 \qquad \theta_i = -30 \qquad \theta_v - \theta_i = 50^\circ$

$\theta_v + \theta_i = -10^\circ$

$$P = \frac{330 \times 33}{2} \cos(50^\circ) = 3500$$

$$p(t) = 3500 + \frac{330 \times 33}{2} \cos(20t - 10^\circ)$$

$\rightarrow 5445$

Practice Problem 11.2

A current $\mathbf{I} = 33\underline{/30^\circ}$ A flows through an impedance $\mathbf{Z} = 40\underline{/-22^\circ}\ \Omega$. Find the average power delivered to the impedance.

Answer: 20.19 kW.

$$P = \frac{1}{2} \text{Re}\{V I^*\} = \frac{1}{2} \text{Re}\{Z I I^*\}$$

$V \rightarrow IZ$

ZI

$$= \frac{1}{2} \text{Re}\{40\underline{/-22^\circ}\, |I|^2\}$$

$$= \frac{1}{2} \text{Re}\{40\underline{/-22}\ 33^2\}$$

$$= \frac{1}{2} \times 40 \times 33 \times \cos(-22) = 20.19\,\text{kW}$$

Practice Problem 11.3

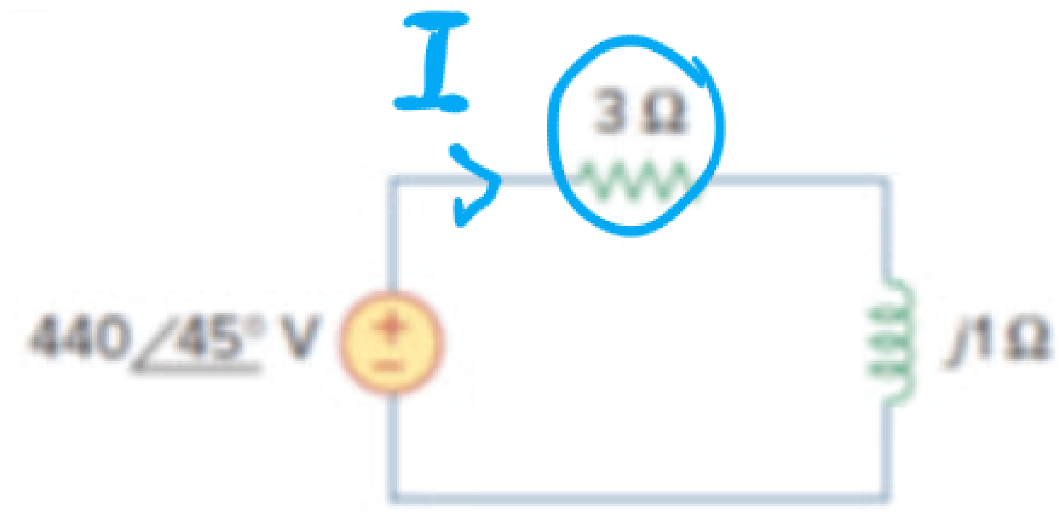


Figure 11.4

In the circuit of Fig. 11.4, calculate the average power absorbed by the resistor and inductor. Find the average power supplied by the voltage source.

Answer: 29.04 kW, 0 W, 29.04 kW.

$$P = \frac{1}{2} \operatorname{Re}\{V I^*\} = \frac{1}{2} \operatorname{Re}\{Z I I^*\}$$

$$= \frac{1}{2} \operatorname{Re}\{Z |I|^2\}$$

$$P = \frac{|I|^2}{2} \operatorname{Re}\{Z\}$$

$$P_{3\Omega} = \frac{|I|^2}{2} 3 \text{ W}$$

$$P_{j1\Omega} = \frac{|I|^2}{2} \cancel{\operatorname{Re}\{j1\}} = 0 \text{ W}$$

$$P_{440\angle 45^\circ} = \frac{1}{2} \operatorname{Re}\{-440\angle 45^\circ\, I^*\}$$

$$I = \frac{440\angle 45^\circ}{3+j} = \frac{440\angle 45^\circ}{\sqrt{10}\angle \tan^{-1}(1/3)} = 139.14\angle 26.65^\circ$$

$$\boxed{P_{3\Omega} = \frac{19360}{2} \times 3 = 29.04 \text{ kW}}$$

$$\boxed{P_{j1\Omega} = 0}$$

$P_{V_S} = -29.04 \text{ kW}$ → ortalama güç verir.

Practice Problem 11.4 Calculate the average power absorbed by each of the five elements in the circuit of Fig. 11.6.

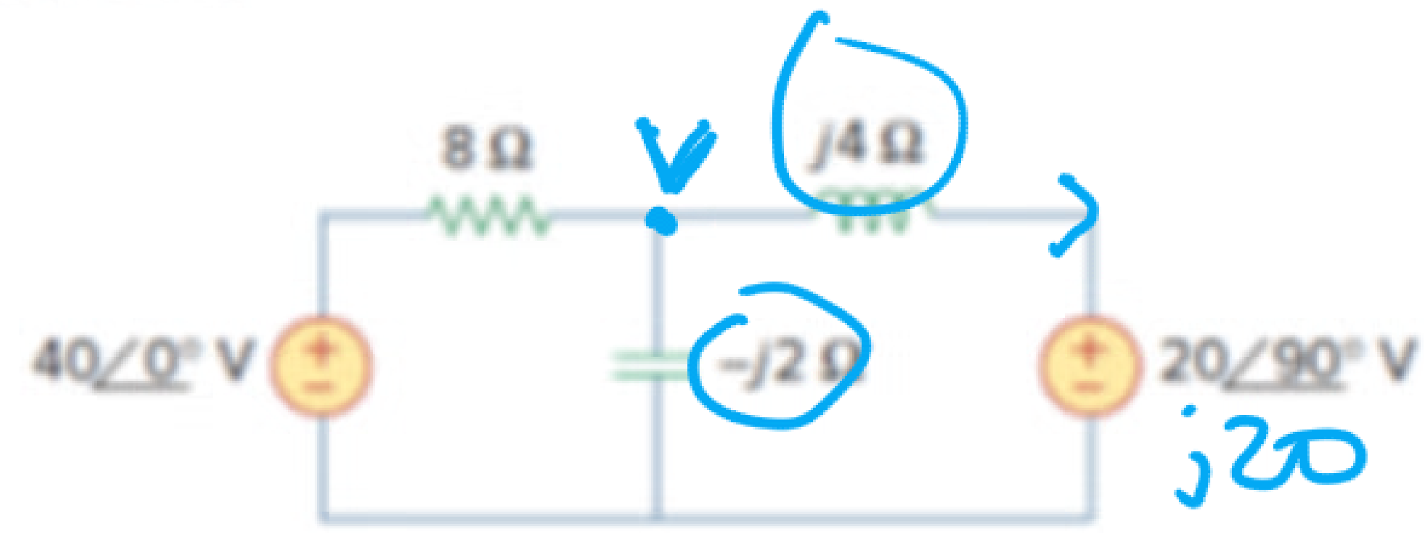


Figure 11.6
For Practice Prob. 11.4.

Answer: 40-V Voltage source: −60 W; j20-V Voltage source: −40 W; resistor: 100 W; others: 0 W.

$$\frac{V-40}{8} + \frac{V}{-j2} + \frac{V-j20}{j4} = 0$$

$$V - 40 + j4V - j2V - 40 = 0$$

$$(1+j2)V = 80 \qquad \boxed{V = \frac{80}{1+j2}}$$

$$P = \frac{1}{2}\mathrm{Re}\{V I^*\} \qquad I = \frac{V}{Z} \qquad I^* = \frac{V^*}{Z^*}$$

$$= \frac{1}{2}\mathrm{Re}\left\{V \frac{V^*}{Z^*}\right\} = \frac{1}{2}\mathrm{Re}\left\{\frac{|V|^2}{Z^*}\right\}$$

$P_{-j2} = 0$ yazılabilir

$P_{j4\Omega} = 0$ "

$$V = \frac{80}{1+j2} = \frac{80(1-j2)}{\cancel{(1+j2)(1-j2)}\ 5} = 16(1-j2)$$

$I_{8\Omega} = (40 - 16(1-j2))/8$

$= (24 + j32)/8 = \frac{40}{8}\angle 53^\circ = 5\angle 53^\circ$

$P_{8\Omega} = \frac{1}{2} \times 8 \times |I|^2 = \frac{1}{2} \times 8 \times 25 = 100\,W$ harcar.

~~Akr~~ $40\angle 0^\circ\,V$: $I_{8\Omega}$ akımı geçer.

$\frac{1}{2}\mathrm{Re}\{-40\angle 0^\circ \times 5\angle -53^\circ\}$

$\frac{1}{2}\mathrm{Re}\{-200\angle -53^\circ\} = -60\,W$ güç verir.

$20\angle 90^\circ\,V$: akım $I_{j4} = \frac{16(1-j2) - j20}{j4}$

$= \frac{16 - j32 - j20}{j4}$

$I_{j4} = \frac{16 - j52}{j4} = -j4 - 13$

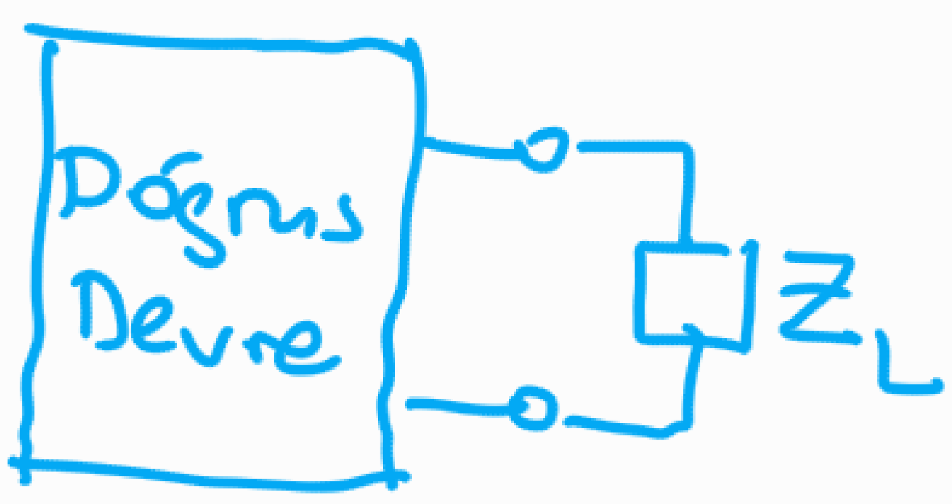
$P_{20\angle 90^\circ} = \frac{1}{2}\mathrm{Re}\{j20 \times (-13 + j4)\}$

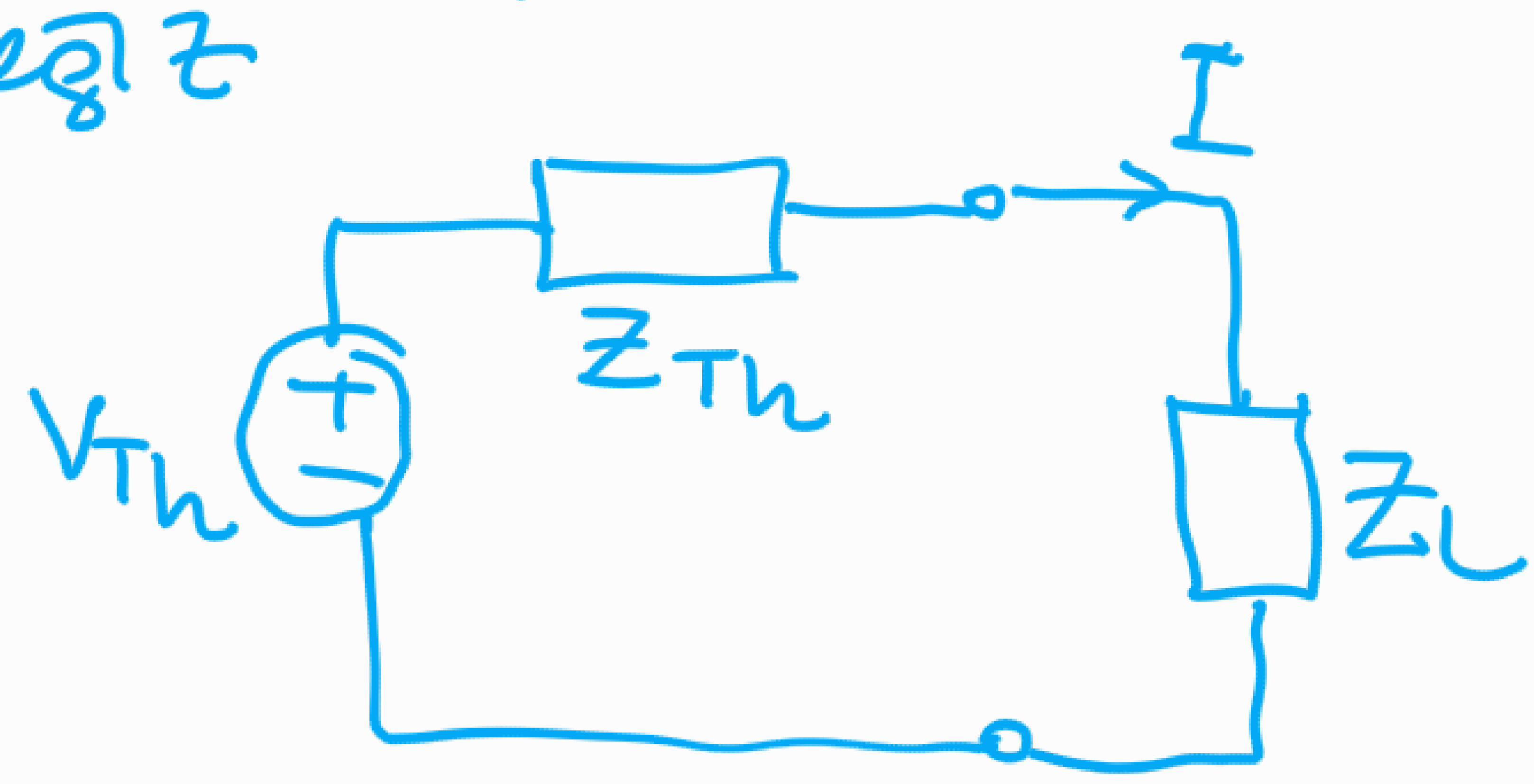
$= \frac{1}{2}\mathrm{Re}\{-j260 - 80\} = -40\,W$

güç verir.

11.3 Maksimum Ortalama Güç Aktarımı

Direnç devrelerinde yüke maksimum güç aktarımı için yükün direnç değerinin, yükün gördüğü Thevenin eşdeğer direncine eşit olması gerekir. Bu derste bunu AC kaynak ve R, L, C devreleri için genelleştireceğiz





$$Z_{Th} = R_{Th} + jX_{Th} \qquad Z_L = R_L + jX_L$$

Akım : $$\mathbf{I} = \frac{\mathbf{V}_{Th}}{Z_{Th}+Z_L} = \frac{\mathbf{V}_{Th}}{(R_{Th}+R_L)+j(X_{Th}+X_L)}$$

Yüke aktarılan ortalama güç.

$$P_L = \frac{1}{2}\mathrm{Re}\{\mathbf{V}_L \mathbf{I}^*\}$$

$$= \frac{1}{2}\mathrm{Re}\{\mathbf{I} Z_L \mathbf{I}^*\} = \frac{1}{2}\mathrm{Re}\{|\mathbf{I}|^2 Z_L\}$$

$$= \frac{|\mathbf{I}|^2}{2}\mathrm{Re}\{Z_L\}$$

$$P_L = \frac{|\mathbf{I}|^2}{2} R_L$$

$$P_L = \frac{|\mathbf{V}_{Th}|^2 R_L}{2\left[(R_{Th}+R_L)^2+(X_{Th}+X_L)^2\right]}$$ $\rightarrow$ bu maksimize edilecek.

değişkenler R_L , X_L

$$\frac{\partial P_L}{\partial R_L}=0 \quad , \quad \frac{\partial P_L}{\partial X_L}=0$$

$$\frac{\partial P_L}{\partial X_L}=-\frac{|V_{Th}|^2 R_L}{2}\,\frac{2(X_{Th}+X_L)}{\left[(R_{Th}+R_L)^2+(X_{Th}+X_L)^2\right]^2}=0$$

$\boxed{X_L=-X_{Th}}$ olmalıdır.

Yerine koyalım, bu durumda

$$P_L=\frac{|V_{Th}|^2 R_L}{2(R_{Th}+R_L)^2} \text{ olur}$$

$$\frac{\partial P_L}{\partial R_L}=\frac{|V_{Th}|^2}{2}\,\frac{(R_{Th}+R_L)^2-R_L\,2(R_{Th}+R_L)}{(R_{Th}+R_L)^4}=0$$

$$(R_{Th}+R_L)^{\cancel{2}}=2R_L\cancel{(R_{Th}+R_L)}$$

$\boxed{R_L=R_{Th}}$ olmalıdır.

$$Z_L=R_L+jX_L=R_{Th}-jX_{Th}=\underbrace{Z_{Th}^{*}}_{\text{eşleniği}} \text{ olmalıdır}$$

Bunu da yerine koyalım:

$$P_L=\frac{|V_{Th}|^2 R_{Th}}{2(2R_{Th})^2}=\frac{|V_{Th}|^2}{8R_{Th}} \text{ olur}$$ (Maksimum aktarılabilecek ort. güç)

* Eğer yükün tamamen resistif olması gibi bir kısıt varsa, bu durumda bu direnç $R_L=\sqrt{R_{Th}^2+X_{Th}^2}=|Z_{Th}|$ olmalıdır.

Practice Problem 11.5

For the circuit shown in Fig. 11.10, find the load impedance $\mathbf{Z}_L$ that absorbs the maximum average power. Calculate that maximum average power.

Answer: $3.415 - j0.7317\ \Omega$, 51.47 W.

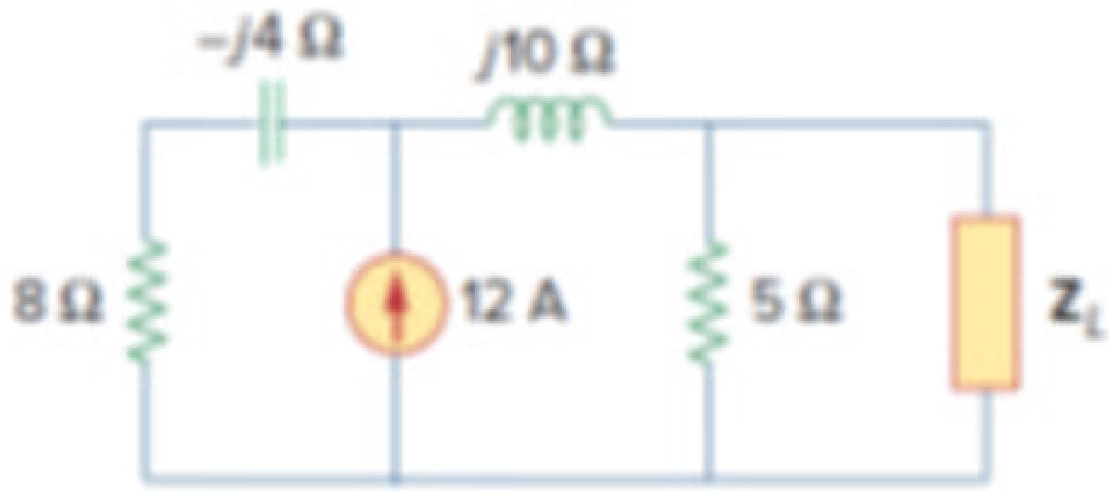
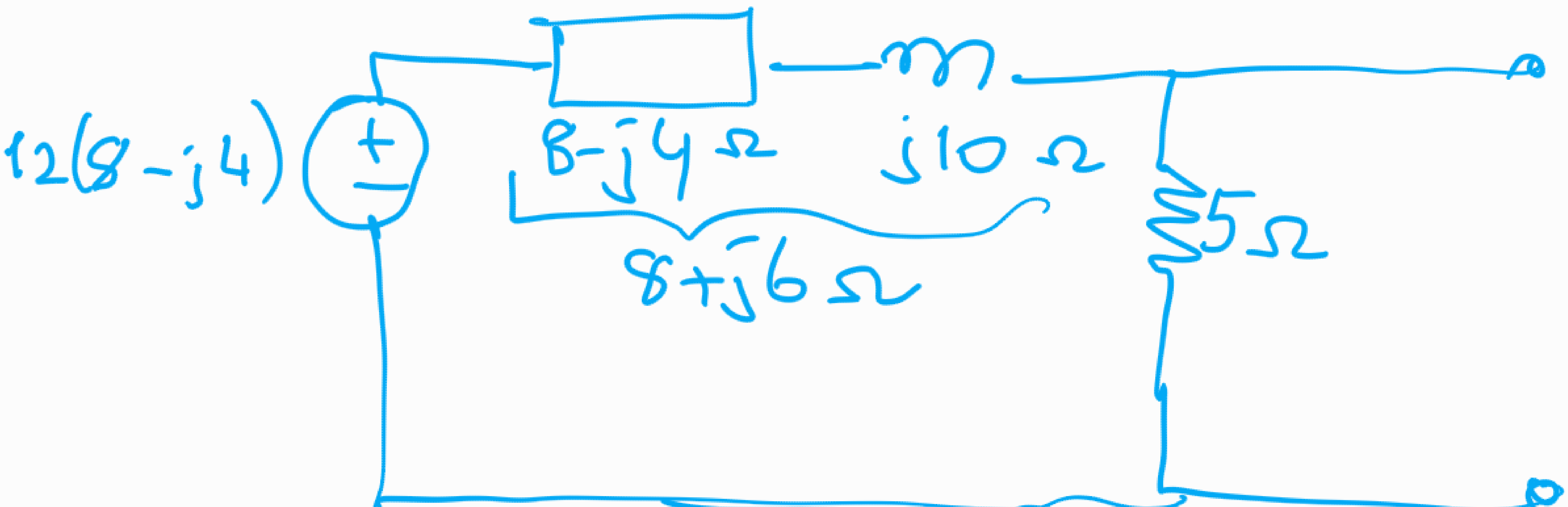
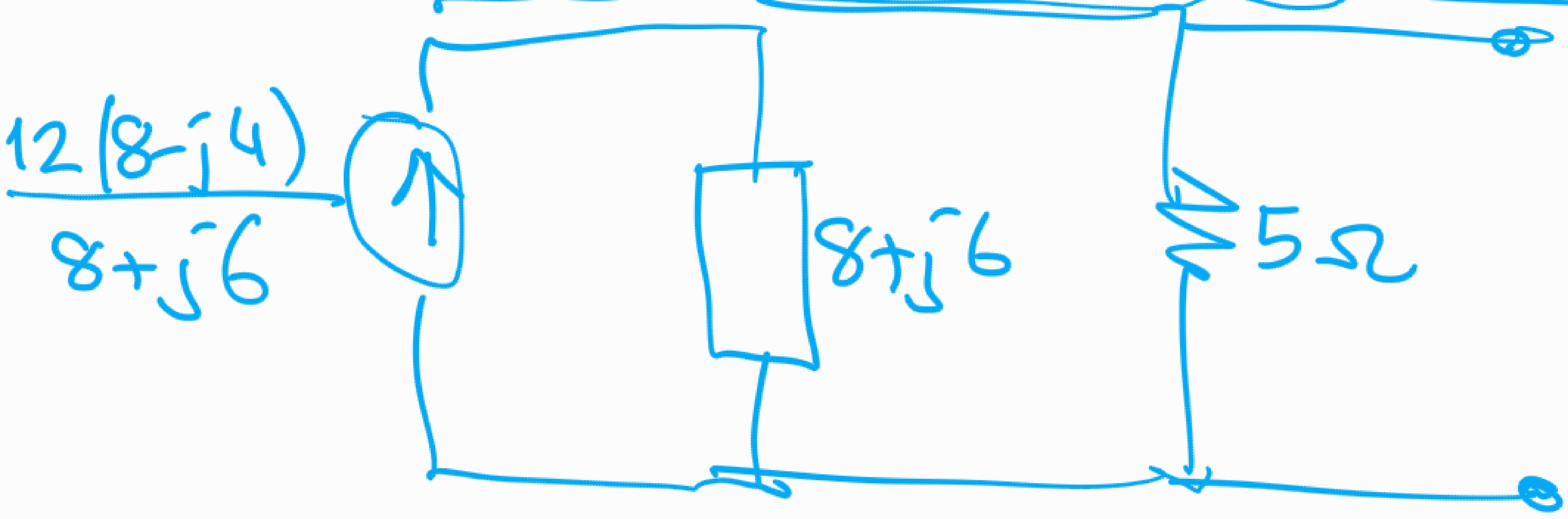
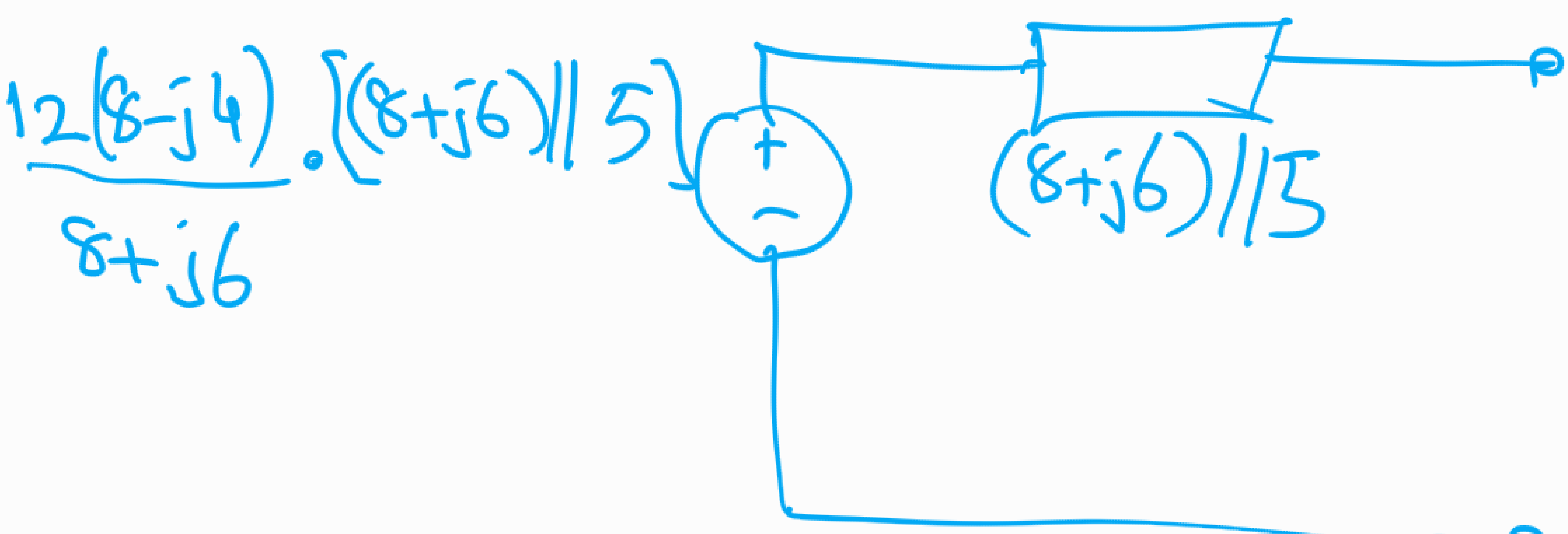


Figure 11.10

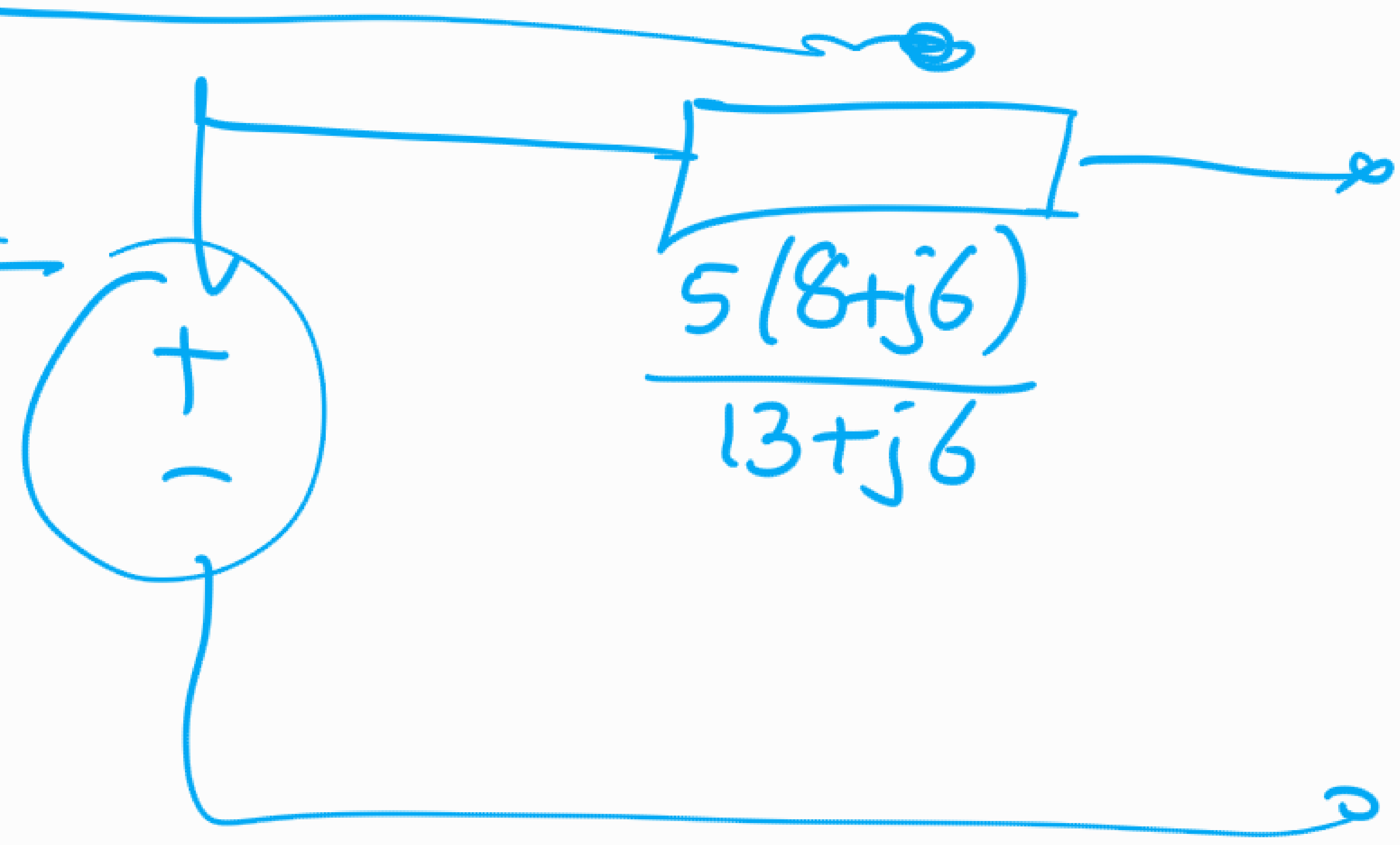
kaynak dönüşümü ile:







$$\underbrace{\frac{12(8-j4)\,5\,\cancel{(8+j6)}}{\cancel{(8+j6)}\,(13+j6)}}_{V_{Th}}$$



$$Z_{Th} = \frac{5(8+j6)}{\underbrace{13+j6}} \Rightarrow Z_L = \frac{5(8-j6)}{13-j6} = Z_{Th}^*$$

$$Z_{Th} = \frac{5(8+j6)(13-j6)}{13^2+6^2} = \underset{R_{Th}}{3.41} + j\underset{X_{Th}}{0.73}\ \Omega$$

$Z_L = 3.41 - j0.73\ \Omega$ olmalı.

$$P_L^{max} = \frac{|V_{Th}|^2}{8R_{Th}}$$

$$V_{Th} = \frac{60(8-j4)}{13+j6} \qquad |V_{Th}^2| = \frac{3600 \times 80}{205} = 1404.9$$

$$P_L^{max} = \frac{1404.9}{8 \times 3.41} = 51.42\ \text{Watt}$$

Practice Problem 11.6

In Fig. 11.12, the resistor R_L is adjusted until it absorbs the maximum average power. Calculate R_L and the maximum average power absorbed by it.

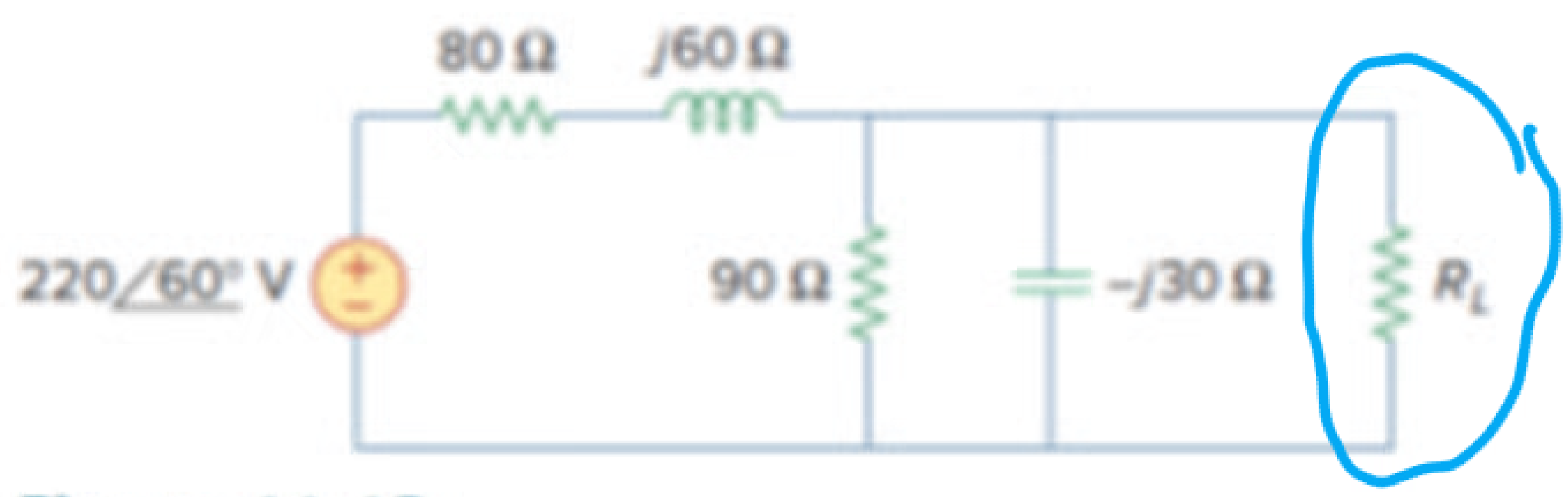
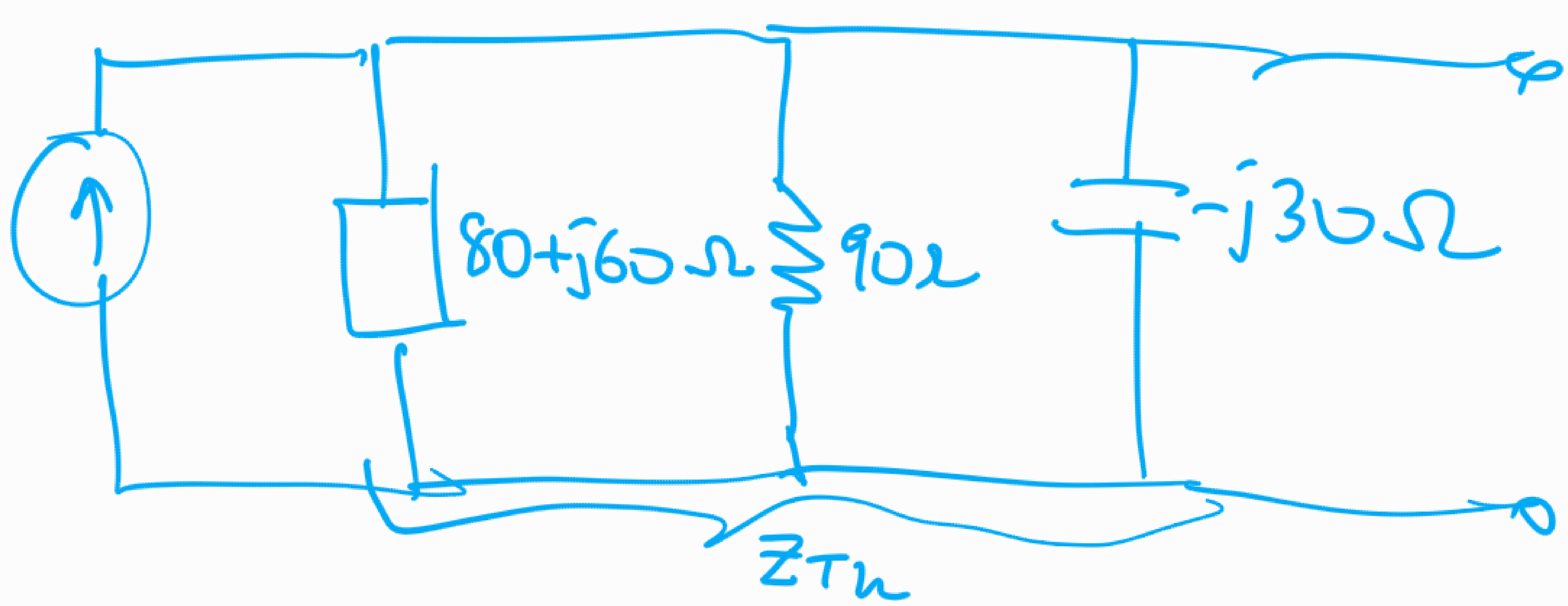


Figure 11.12
For Practice Prob. 11.6.

Answer: 30 Ω, 23.06 W.

Kaynak Dönüşümü

$$\frac{220\angle 60^\circ}{80+j60} = \frac{220\angle 60^\circ}{100\angle 37^\circ}$$



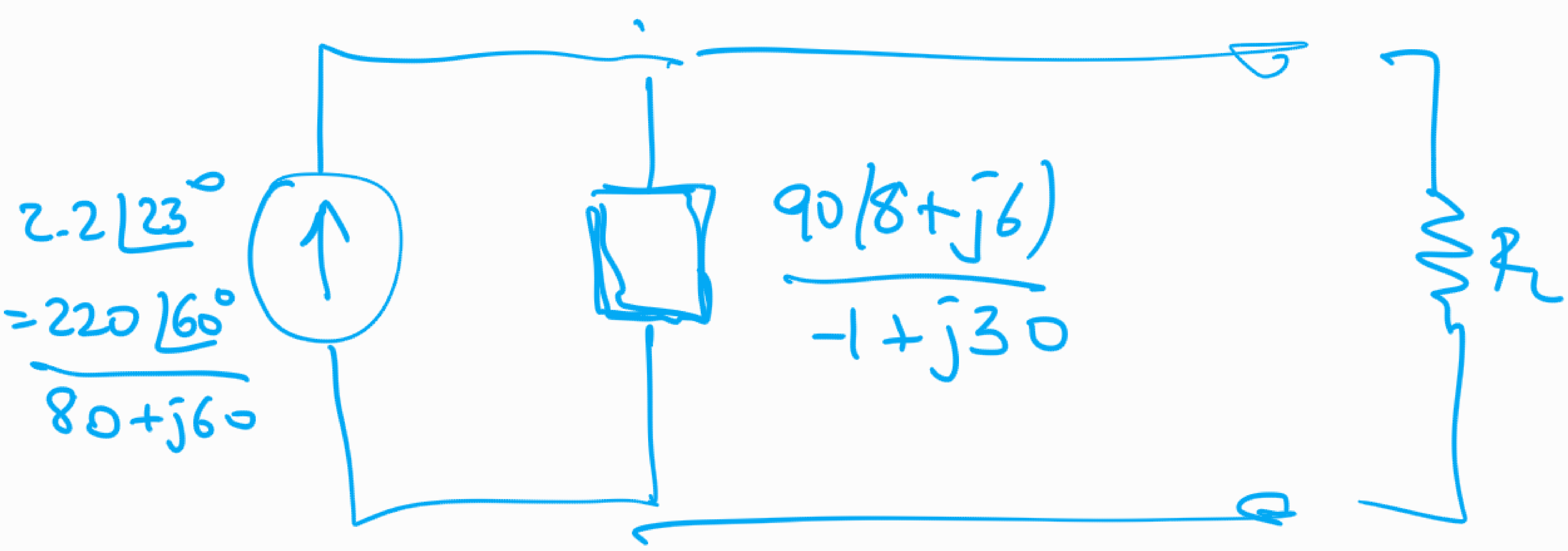
$$(80+j60) \parallel 90 \parallel (-j30) = \frac{1}{\frac{1}{80+j60}+\frac{1}{90}+\frac{1}{-j30}}$$

$$= \frac{1}{\frac{1}{80+j60}+\frac{1}{90}+\frac{j3}{90}} = \frac{1}{\frac{1}{80+j60}+\frac{1+j3}{90}}$$

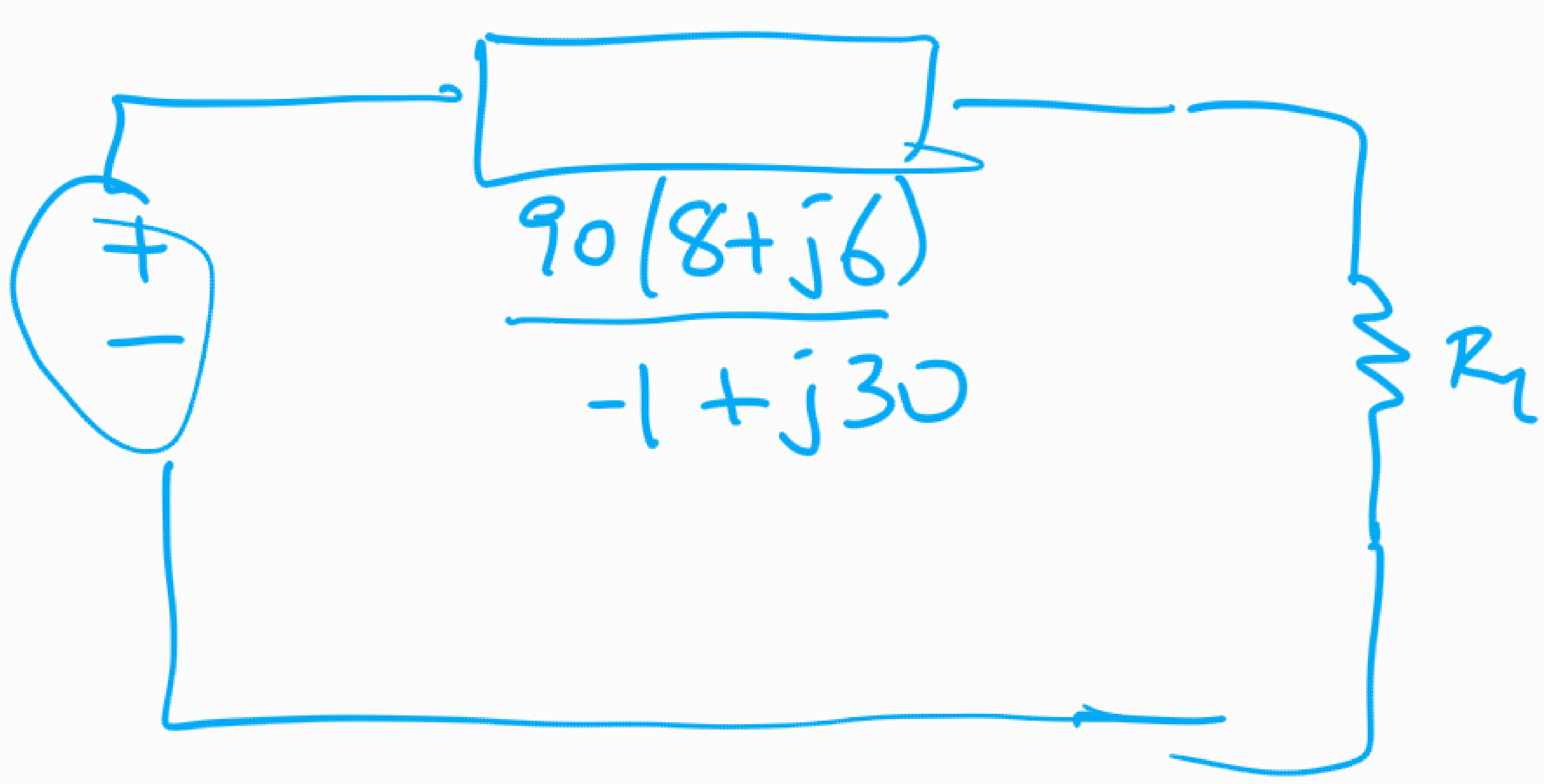
$$= \frac{90(80+j60)}{90+80+j60+j240-180}$$

$$= \frac{90(80+j60)}{-10+j300} = \frac{90(8+j6)}{-1+j30} = Z_{Th}$$

$R_{Th} = |Z_{Th}|$ olmalı yani $\frac{90\times 10}{\sqrt{1+900}} \cong 30\Omega$ olur.



$$\frac{220\angle 60^\circ}{\cancel{80+j60}} \times \frac{90\cancel{(8+j6)}}{-1+j30}$$



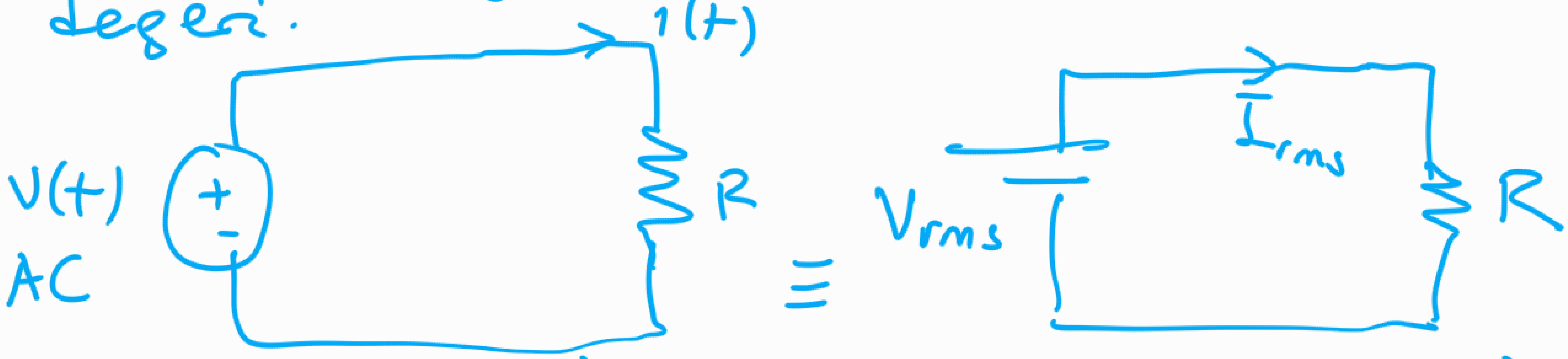
11.4 Efektif (RMS) Değeri:

R.M.S. : Root Mean Square

Karesinin Ortalamasının Karekökü

Bir sinüzoidal güç kaynağının güç sağlamak konusundaki etkinliğini ifade eder.

<u>Tanım</u>: Bir sinüzoidal güç kaynağının sağladığı güçle aynı gücü üreten DC kaynağın akım/gerilim değeri.



$$\underset{\text{ort güç}}{P} = \frac{1}{T}\int_0^T i^2(t)\,\cancel{R}\,dt \equiv P = I_{eff}^2\,\cancel{R}$$

$$I_{eff}^2 = \frac{1}{T}\int_0^T i^2(t)\,dt$$

$$I_{eff} = \sqrt{\frac{1}{T}\int_0^T i^2(t)\,dt} = I_{rms}$$

karesinin ortalamasının karekökü (R.M.S.)

- Sabit bir sinyalin rms'i kendisidir.
- Sinüzoidal bir sinyal:

$$I_{rms} = \sqrt{\frac{1}{\underset{\text{periyod}}{T}}\int_0^T \left(I_m\cos(\omega t)\right)^2 dt} = \sqrt{\frac{1}{T}\int_0^T \frac{I_m^2}{2}\left(1+\cos(2\omega t)\right)dt}$$

cos integrali sıfır.

$$\boxed{I_{rms} = \frac{I_m}{\sqrt{2}}}$$

Aynı şey gerilim için de geçerli.

- Farklı sinyal türlerinin rms değeri farklı olabilir

Find the rms value of the current waveform of Fig. 11.15. If the current flows through a 9-Ω resistor, calculate the average power absorbed by the resistor.

Answer: 9.238 A, 768 W.

Practice Problem 11.7

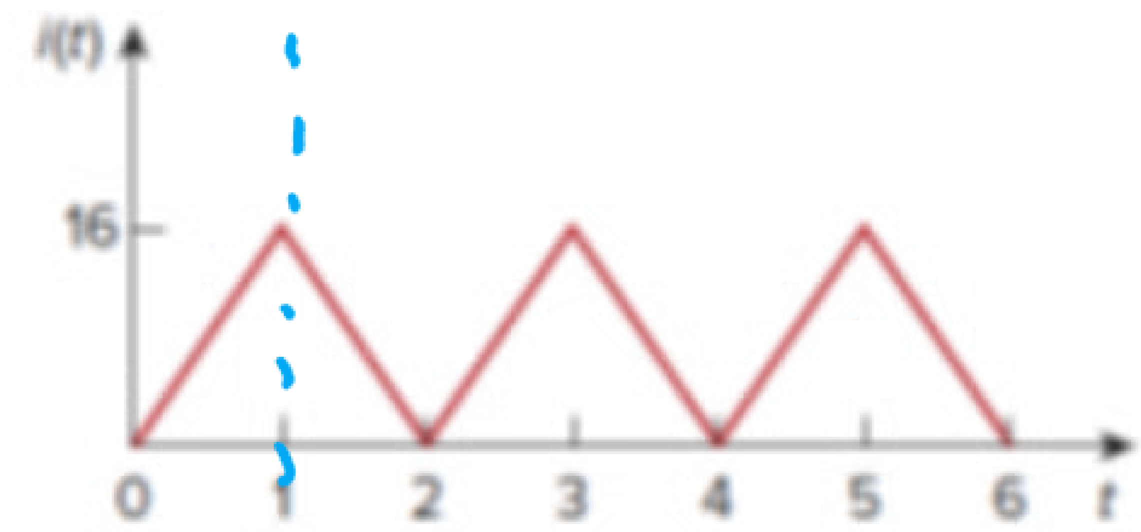
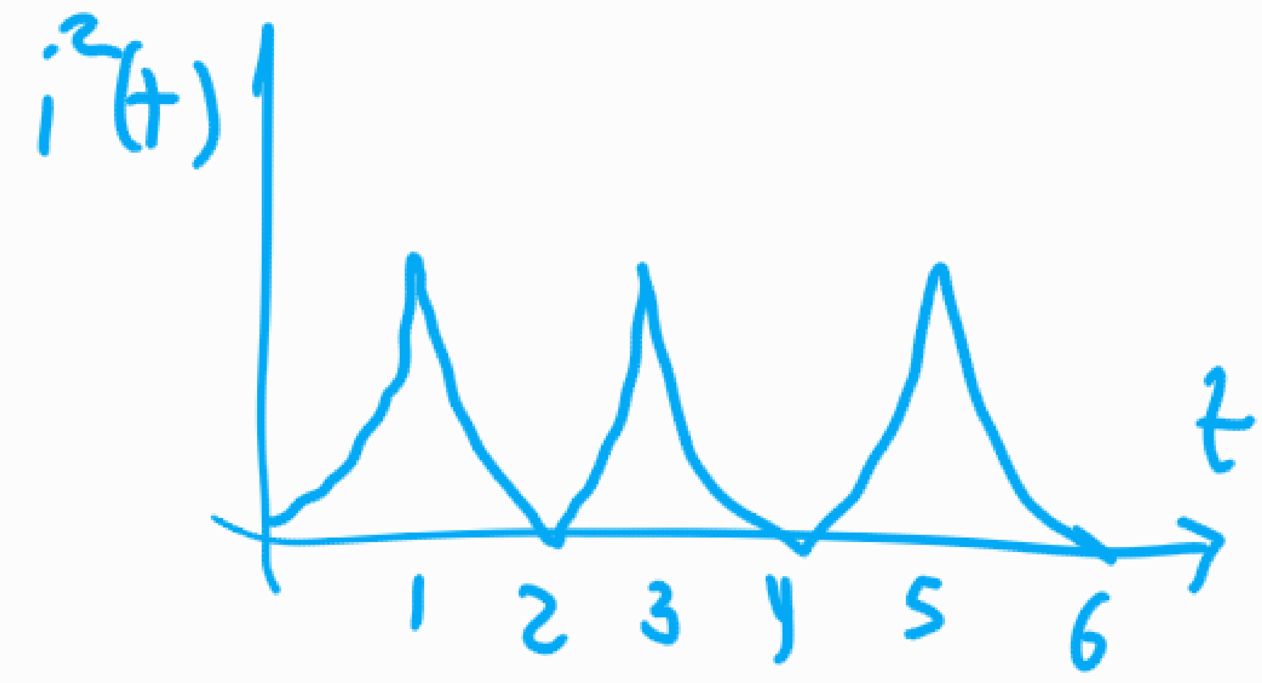


Figure 11.15

$$|I_{rms}|^2 9 = P$$

?



$$i(t) = \begin{cases} 16t & 0 \leq t \leq 1 \\ \vdots \end{cases}$$

$$\sqrt{\frac{1}{1}\int_0^1 (16t)^2\,dt} = I_{rms} = \sqrt{\int_0^1 256t^2} = \sqrt{\left.\frac{256t^3}{3}\right|_0^1}$$

$$= \sqrt{\frac{256}{3}} = \frac{16}{\sqrt{3}}$$

$$= 9.238$$

üçgen sinyalin rms'i: genliğinin $\sqrt{3}$'te biridir.

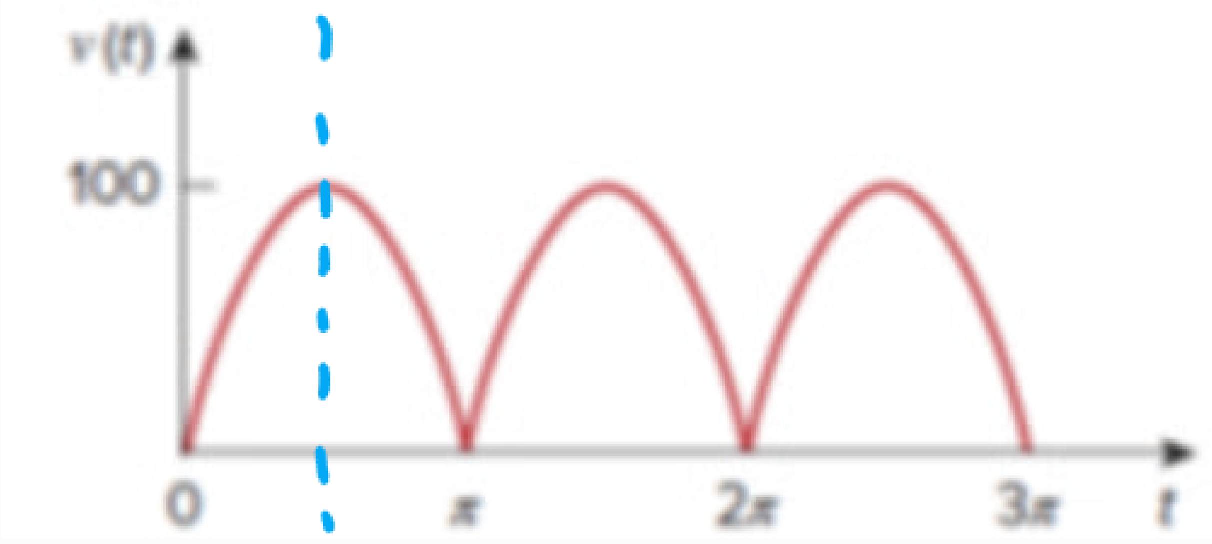
$$P = \left(\frac{16}{\sqrt{3}}\right)^2 \times 9 = \frac{256 \times 9}{3} = 768 \text{ Watt}$$

$$P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) = V_{rms} I_{rms} \cos(\theta_v - \theta_i)$$

$\frac{1}{2}$ ifadesinden kurtulmuş oluruz.

<u>Not</u>: Evlerimize gelen 220 Volt aslında rms değeridir. Gerçekte bu sinyal genliği $220\sqrt{2}$ V olan bir sinüzoidaldir.

Practice Problem 11.8



Find the rms value of the full-wave rectified sine wave in Fig. 11.17. Calculate the average power dissipated in a 6-Ω resistor.

Answer: 70.71 V, 833.3 W.

$$v(t) = \begin{cases} 100\sin(t), & 0 \le t \le \pi/2 \\ \vdots \end{cases}$$

100 sin(t) ✓

$$V_{rms} = \sqrt{\frac{1}{1}\int_0^1 10^4 \sin^2(t)\,dt} = \frac{100}{\sqrt{2}} \rightarrow \text{sin(t) ile aynı.}$$

$$1 - 2\sin^2 t = \cos(2t) \quad ?$$

$$\sin^2(t) = \frac{1-\cos(2t)}{2}$$

$$P_{6\Omega} = \frac{V_{rms}^2}{6} = \frac{10^4}{2\times 6}$$

11.5 Kompleks Güç, Görünen Güç (Apparent Power) ve Güç Faktörü

$$\mathbf{V} = V_m \angle \theta_v, \quad \mathbf{I} = I_m \angle \theta_i$$

$$P = \frac{V_m I_m}{2}\cos(\theta_v - \theta_i) = S\cos(\theta_v - \theta_i)$$

$$S = \frac{V_m I_m}{2} = V_{rms} I_{rms}$$ (görünen güç – apparent power)

birim: VA

$$\cos(\theta_v - \theta_i) = \frac{P}{S}$$: güç faktörü $(0 \le g.f. \le 1)$

g.f. 1'e ne kadar yakın olsa, o kadar iyidir.

Resistif : g.f. 1

Tamamen reaktif g.f. 0

$\theta_v - \theta_i > 0$: Takip eden g.f. (Lagging p.f.)
(akım geriden geliyor) (indüktif)

$\theta_v - \theta_i < 0$: Önde giden g.f. (Leading p.f.)
(akım önde gidiyor) (kapasitif)

Calculate the power factor of the entire circuit of Fig. 11.19 as seen by the source. What is the average power supplied by the source?

Answer: 0.936 lagging, 2.008 kW.

Practice Problem 11.10

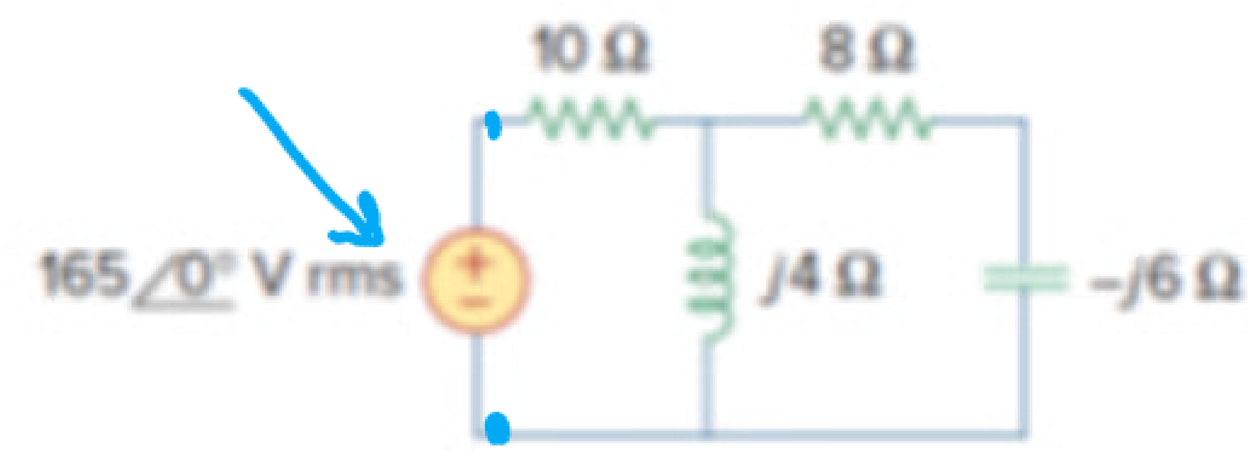


Figure 11.19

$$Z_{eş} = 10 + j4 \,//\, (8 - j6)$$

$$= 10 + \frac{j4(8-j6)}{8-j2} = \frac{80 - j20 + j32 + 24}{8 - j2}$$

$$= \frac{104 + j12}{8 - j2} = \underline{\underline{12.6 + j1.6\ \Omega}}$$

$$V = 165\angle 0^\circ$$

$$I = \frac{165\angle 0^\circ}{12.6 + j1.6} = \frac{165\angle 0^\circ}{12.7\angle 20.6} \cong 13\angle -20.6^\circ$$

$\theta_v = 0^\circ$ $\qquad \theta_i = -20.6$ $\qquad$ takip eden.

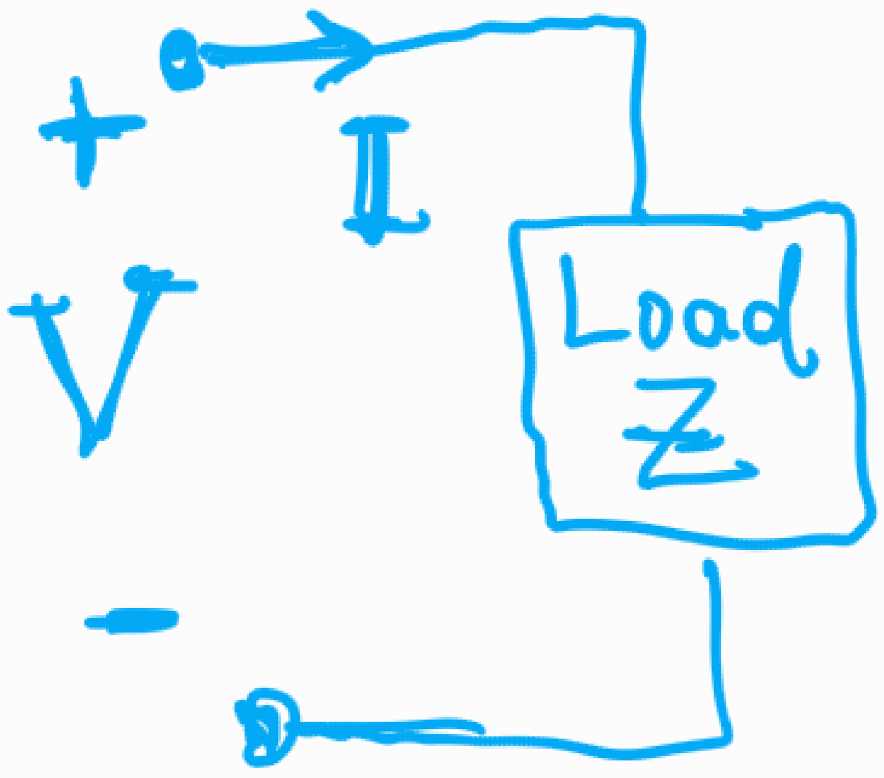
$$\cos(\theta_v - \theta_i) = \cos(20.6) = 0.936 \text{ pf}$$

yükün g.f. : 0.936 (takip eden)

$$P = V_{rms} I_{rms} \cos(\theta_v - \theta_i)$$

$$= \underbrace{165 \times 13}_{S} \times 0.936 = 2.008 \text{ kW}$$

11.6 Kompleks Güç



Kompleks Güç, bir yükün çektiği bütün güçler hakkında bilgi verir.

$$\mathbf{S} = \frac{1}{2}\mathbf{V}\mathbf{I}^*$$

$$\mathbf{S} = \mathbf{V}_{rms}\mathbf{I}^*_{rms}$$

$$\mathbf{S} = V_{rms} I_{rms} \angle \theta_v - \theta_i$$

$$= \underbrace{V_{rms} I_{rms}\cos(\theta_v-\theta_i)}_{P} + j\underbrace{V_{rms} I_{rms}\sin(\theta_v-\theta_i)}_{Q}$$

P: ort. güç (gerçek güç) (aktif güç) (W)

Q: reaktif güç (VAR)

$$|\mathbf{S}| = \sqrt{P^2+Q^2} = V_{rms} I_{rms} = \frac{V_m I_m}{2} = S$$ görünen güç

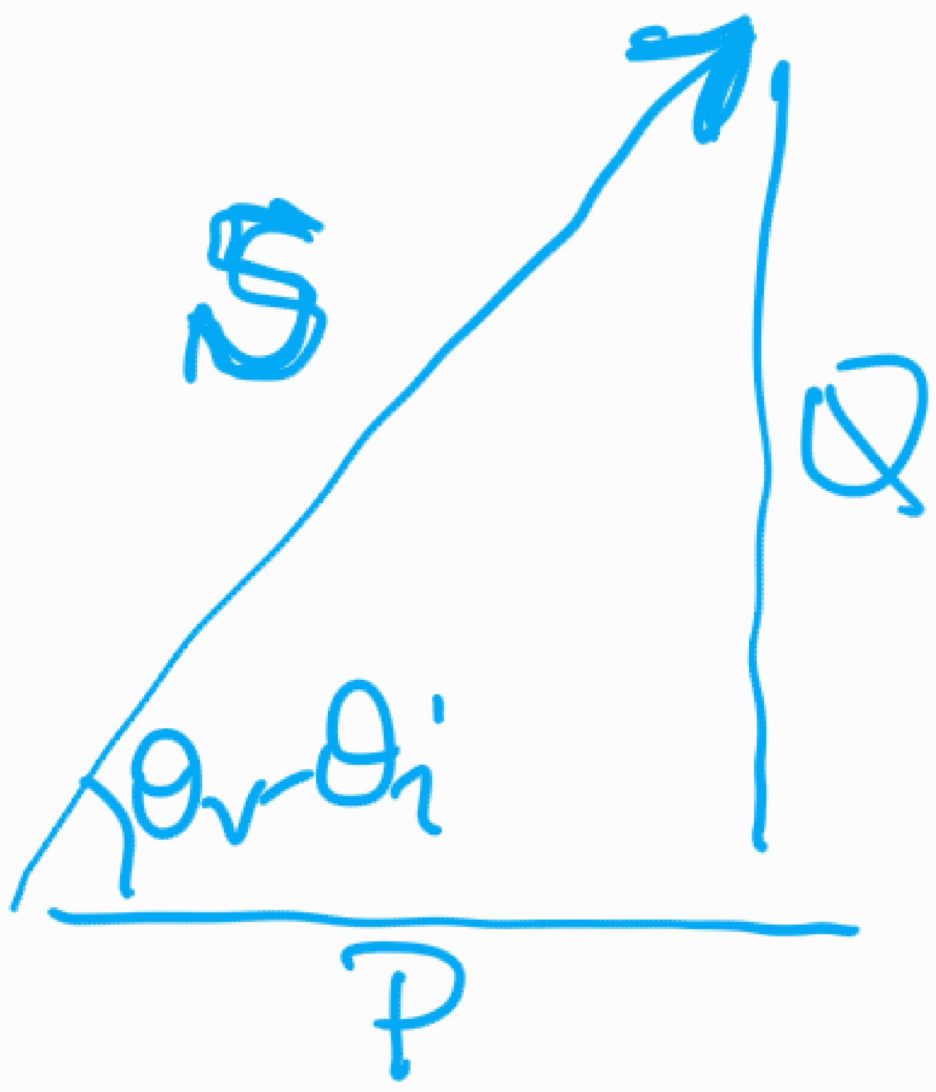
$$\mathbf{S} = \mathbf{V}_{rms}\mathbf{I}^*_{rms} = \underbrace{\mathbf{I}_{rms} Z}\, \mathbf{I}^*_{rms} = I_{rms}^2 \mathbf{Z}$$

$$= \mathbf{V}_{rms}\frac{\mathbf{V}^*_{rms}}{Z^*} = \frac{V_{rms}^2}{\mathbf{Z}^*}$$

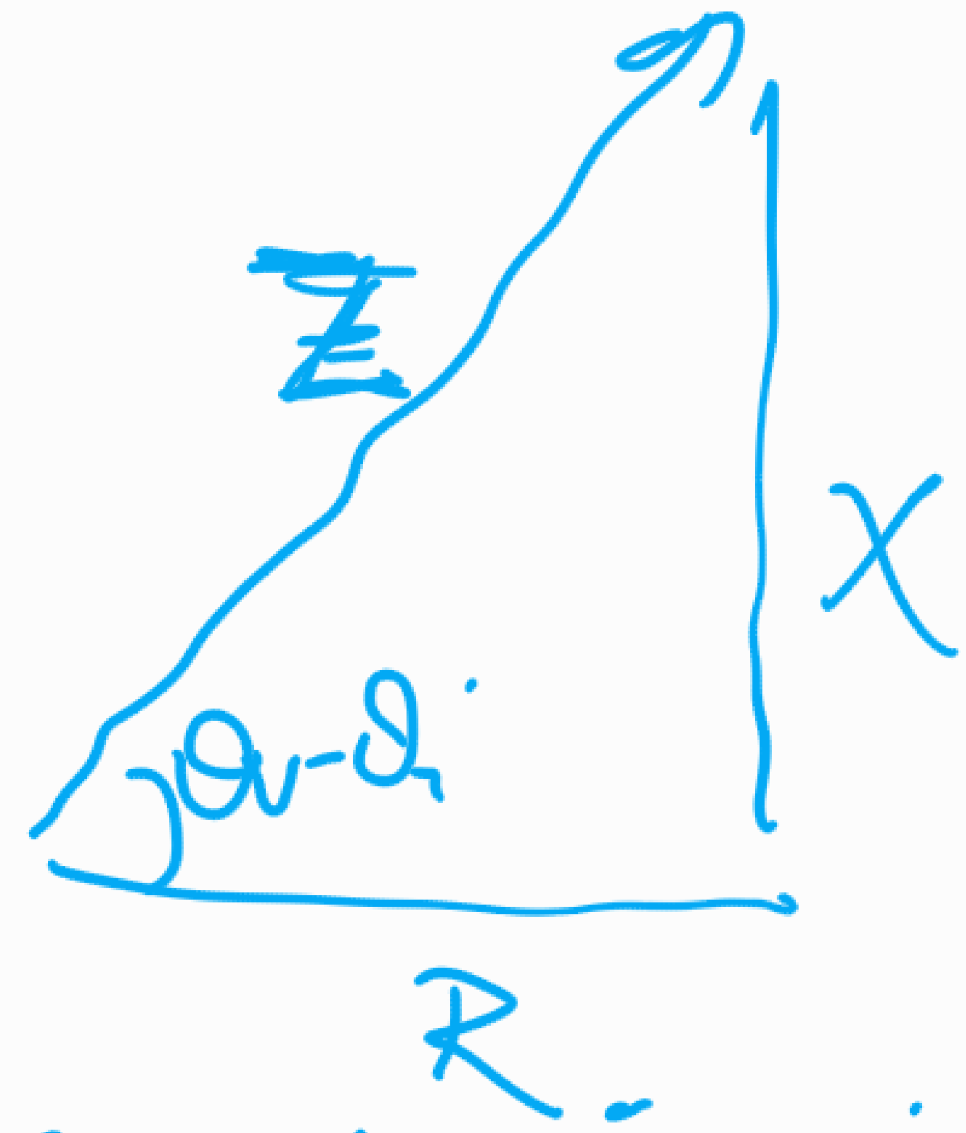
$$P = \mathrm{Re}\{\mathbf{S}\} = I_{rms}^2 R \quad (W)$$

$$Q = \mathrm{Im}\{\mathbf{S}\} = I_{rms}^2 X \quad (VAR)$$

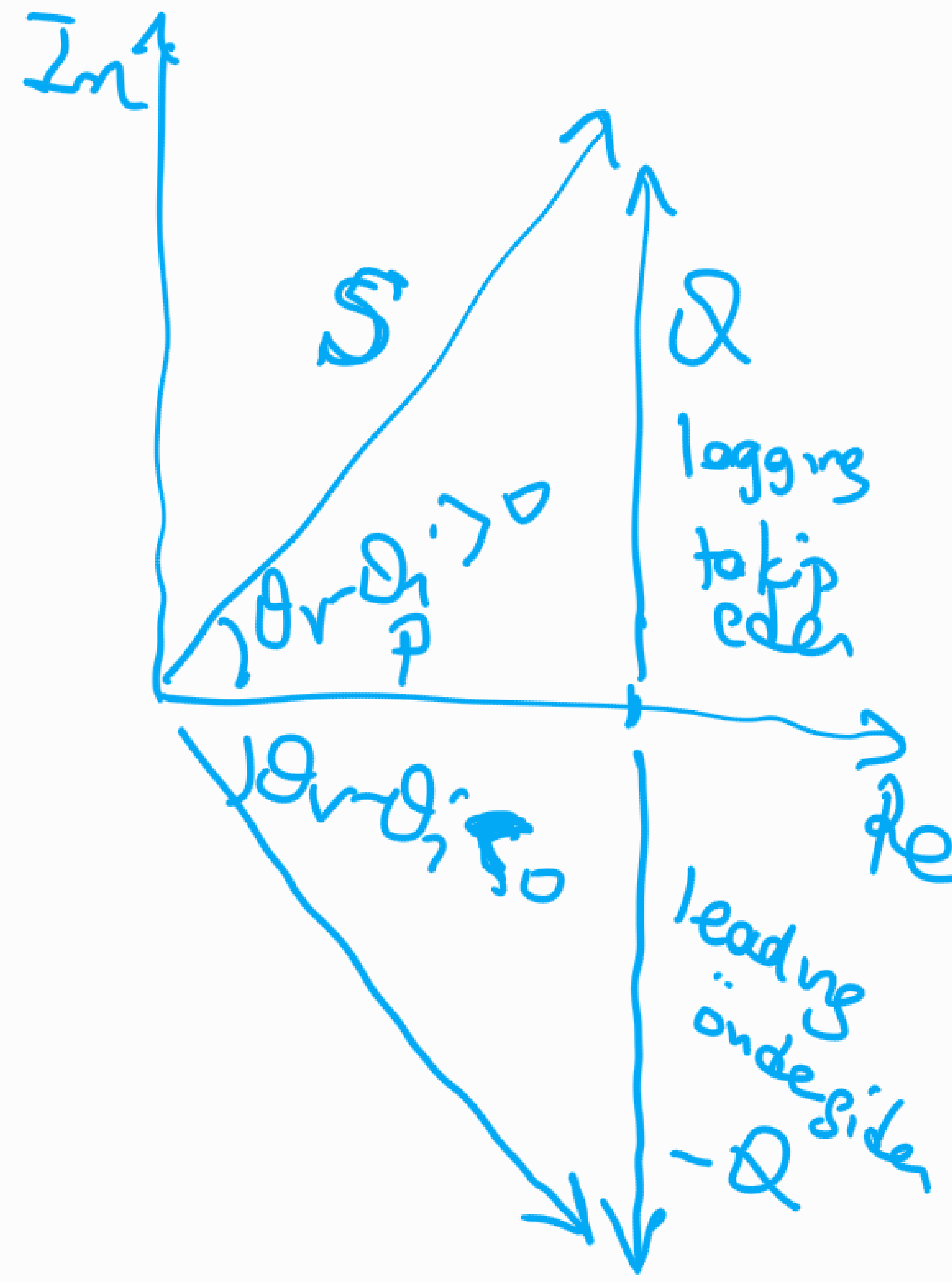
Sadece gerçek güç işe yarar. Sanal güç ise depolayıcı elemanlar ile kaynak arasında sürekli transfer edilen güçtür.



Güç üçgeni



Empedans üçgeni



lagging → indüktif
leading → kapasitif

Example 11.11

The voltage across a load is $v(t) = 60\cos(\omega t - 10°)$ V and the current through the element in the direction of the voltage drop is $i(t) = 1.5\cos(\omega t + 50°)$ A. Find: (a) the complex and apparent powers, (b) the real and reactive powers, and (c) the power factor and the load impedance.

$$\mathbf{V} = 60\angle{-10°}\ \text{V} \qquad \mathbf{I} = 1.5\angle{50°}\ \text{A}$$

$$\mathbf{S} = \frac{\mathbf{V}\mathbf{I}^*}{2} = \frac{60 \times 1.5}{2}\angle{-60°} = 45\angle{-60°}\ \text{VA}$$

$S = 45$ (görünen güç)

$P = \frac{45}{2}$ Watt

$Q = -\frac{45\sqrt{3}}{2}$ VAR

p.f. $\cos(-60°) = \frac{1}{2}$

$\theta_v - \theta_i < 0 \Rightarrow \theta_v < \theta_i$ önde giden

leading

kapasitif bir yük.

$$Z = \frac{V}{I} = \frac{60\angle -10^\circ}{1.5\angle 50^\circ} = 40\angle -60^\circ \ \Omega$$

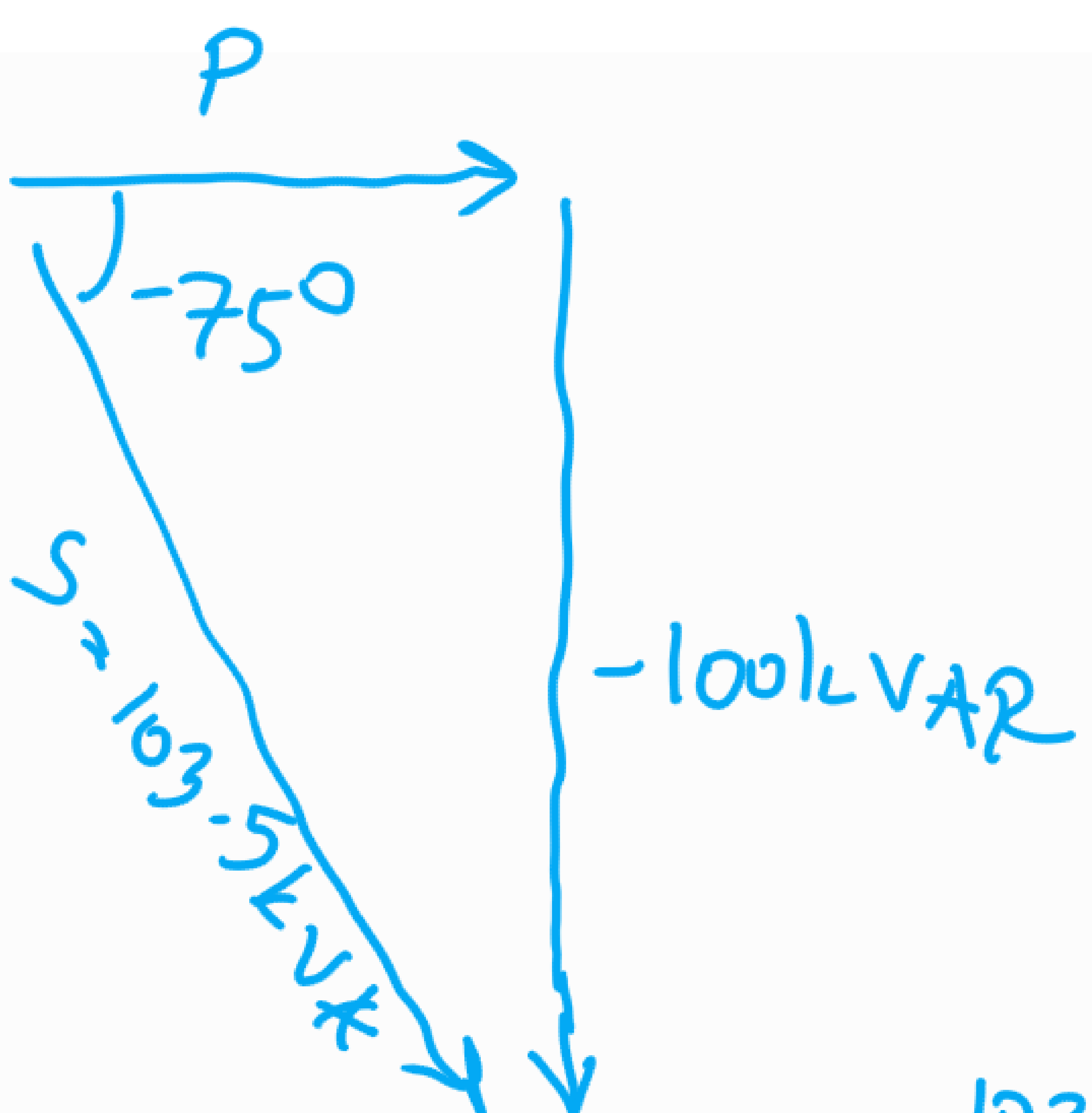
$$= 20 - j20\sqrt{3} \ \Omega$$

kapasitif bir yük.

A sinusoidal source supplies 100 kVAR reactive power to load $\mathbf{Z} = 250\angle -75^\circ \ \Omega$. Determine: (a) the power factor, (b) the apparent power delivered to the load, and (c) the rms voltage.

Practice Problem 11.12

Answer: (a) 0.2588 leading, (b) 103.53 kVA, (c) 5.087 kV.



g.f. $\cos(75^\circ) = 0.2588$

önde giden g.f.

$$S = \frac{100k}{\sin 75^\circ} \cong 103.5 \text{ kVA}$$

$$S = V_{rms} I_{rms}$$

$$103.5k = \frac{V_{rms}^2}{|Z|}$$

$$V_{rms} = \sqrt{103500 \times 250}$$

$$= 5.09 \text{ kV}$$