AC power 002

Unlimited Attempts.

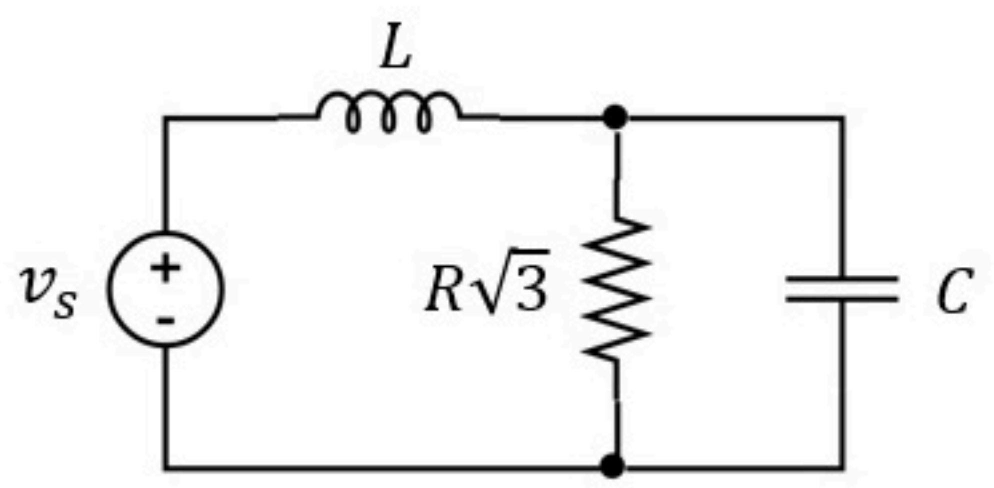
$v_s(t) = A_1 \cos(1000t + B_1)$

(a) Find the instantaneous power supplied by the power supply

$$p = A_2\sqrt{3} + A_3 \cos(2000t + B_3) \quad \text{with } -180° < B_3 \leq 180$$

(b) Find the instantaneous power received by the inductor

$$p = A_4\sqrt{3} + A_5 \cos(2000t + B_5) \quad \text{with } -180° < B_5 \leq 180$$



Given Variables:

A1 : 6 V

B1 : 45 degrees

R : 2 ohm

C : 500 uF

L : 1 mH

Calculate the following:

A2 (W) :

9

A3 (W) :

18

B3 (degrees) :

120

A4 (W) :

0

A5 (W) :

18

B5 (degrees) :

-120

Hint: Find the v(t) and i(t), or use the equations (video lecture)

$v_s(t) = A_1 \cos(1000t + B_1)$

A1 : 8 V

B1 : 135 degrees

R : 2 ohm

C : 500 uF

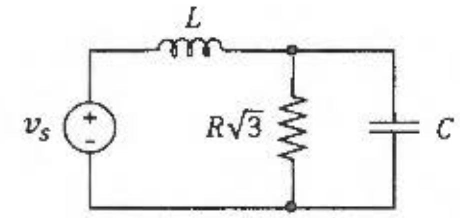
L : 1 mH

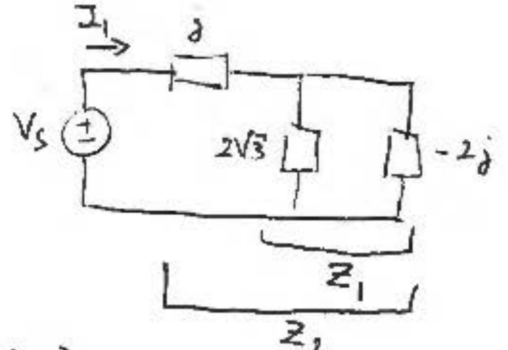
(a) Find the <u>instantaneous</u> power supplied by the power supply

$$p = A_2\sqrt{3} + A_3 \cos(2000t + B_3)$$

(b) Find the <u>instantaneous</u> power received by the inductor

$$p = A_4\sqrt{3} + A_5 \cos(2000t + B_5)$$





$$V_s = 8\, e^{j135°}$$

$$Z_1 = \frac{1}{\frac{1}{2\sqrt{3}} + \frac{j}{2}} = \frac{2\sqrt{3}}{1+\sqrt{3}j} = \frac{\sqrt{3}}{2}\left(1 - \sqrt{3}j\right)$$

$$Z_2 = Z_1 + j = \frac{\sqrt{3}}{2} - \frac{j}{2} = 1 \cdot e^{-30°} \qquad I_1 = \frac{V_s}{Z_2} = 8\, e^{j165°}$$

<u>INSTANTANEOUS POWER</u>

$$P = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) + \frac{1}{2} V_m I_m \cos(2\omega t + \theta_v + \theta_i)$$

(a) $V = V_s \Rightarrow V_m = 8\,V \quad \theta_v = 135°$

$I = I_1 \Rightarrow I_m = 8\,A \quad \theta_i = 165°$

$$A_2\sqrt{3} = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) = \frac{1}{2}\cdot 8 \cdot 8 \cdot \cos(-30°) = 16\sqrt{3} \Rightarrow \boxed{A_2 = 16W}$$

$$A_3 = \frac{1}{2} V_m I_m = \frac{1}{2}\cdot 8 \cdot 8 \Rightarrow \boxed{A_3 = 32W} \qquad B_3 = \theta_v + \theta_i = 300° \quad \boxed{B_3 = -60°}$$

(b) $I = I_1 \Rightarrow I_m = 8A \quad \theta_i = 165°$

$V = j I_1 \Rightarrow V_m = 8V \quad \theta_v = 165° + 90° = 255°$

$$A_4\sqrt{3} = \frac{1}{2} V_m I_m \cos(\theta_v - \theta_i) = \frac{1}{2}\cdot 8 \cdot 8 \cos(90°) = 0 \Rightarrow \boxed{A_4 = 0W}$$

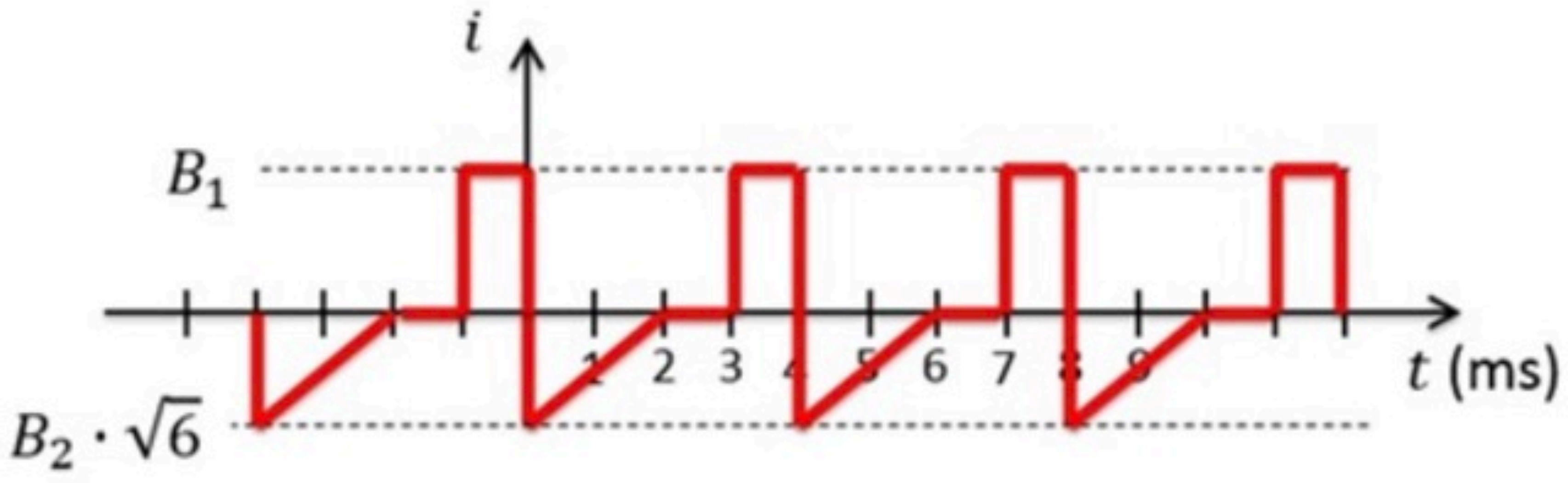
$$A_5 = \frac{1}{2} V_m I_m = \frac{1}{2}\cdot 8 \cdot 8 \Rightarrow \boxed{A_5 = 32W} \qquad B_5 = \theta_v + \theta_i = 420°$$

$$\boxed{B_5 = 60°}$$

AC power 003

Problem has been graded.

Find I_{rms} for this waveform.



Given Variables:

B1 : 6 A

B2 : -4 A

Calculate the following:

Irms (A) :

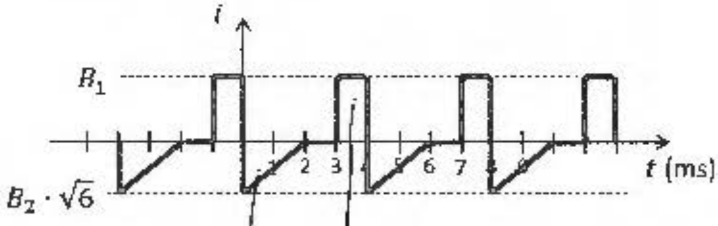
5

Hint: Square the time waveform, integrate, average and take sqrt()

Find I_{rms} for this waveform.

B1 : 6 A

B2 : -4 A



$$i(t) = 6 \Rightarrow i(t)^2 = 36$$

$$i(t) = 2\sqrt{6}(t-2) \Rightarrow i(t)^2 = 24(t-2)^2$$

$$\int_0^4 i^2 dt = \int_0^2 24(t-2)^2 dt + \int_3^4 36\, dt$$

$$= 24 \left. \frac{(t-2)^3}{3} \right|_0^2 + 36$$

$$= 8 \cdot (0 - (-2)^3) + 36$$

$$= 64 + 36$$

$$= 100$$

$$\sqrt{\frac{1}{4}\int_0^4 i^2 dt} = \sqrt{\frac{1}{4} \cdot 100} = 5 \Rightarrow \boxed{I_{rms} = 5A}$$

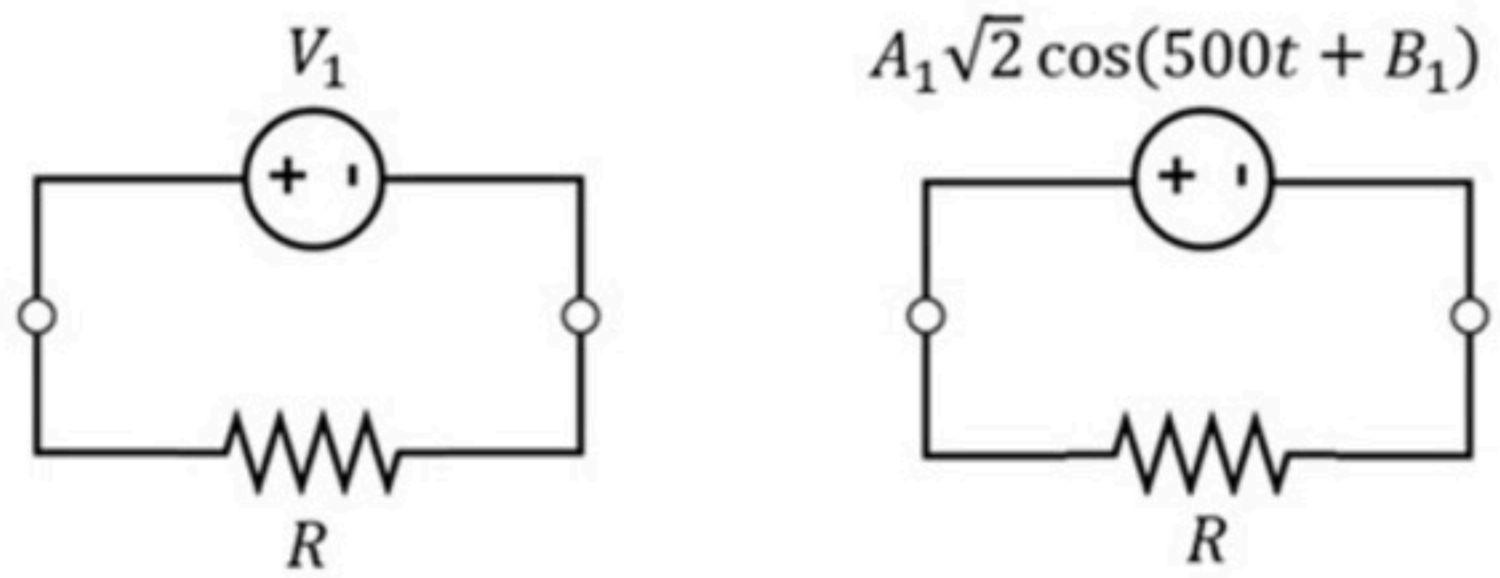
AC power 004

Problem has been graded.

You are told that the sources in the two circuits below supply the same average power.

(a) Find the average power P supplied.

(b) Find A_1.



Given Variables:

V1 : 10 V

R : 5 ohm

B1 : 135 degrees

Calculate the following:

P (W) :

20

A1 (V) :

10

Hint: What is the definition of Vrms?

You are told that the sources in the two circuits below supply the same average power.

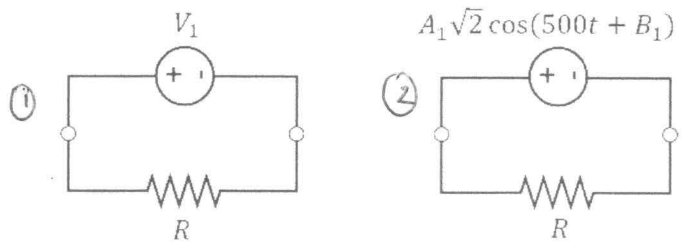
V1 : 6 V

R : 2 ohm

B1 : 60 degrees

(a) Find the average power P supplied.

(b) Find A_1.



(a) CIRCUIT 1 : $P = \frac{V_1^2}{R} = \frac{36}{2} \Rightarrow \boxed{P = 18\,W}$

(b) FOR THE SAME AVERAGE POWER

$V_{RMS} = V_1 = 6\,V$

$V_{RMS} = \frac{V_m}{\sqrt{2}} = \frac{A_1 \cancel{\sqrt{2}}}{\cancel{\sqrt{2}}}$

$\Rightarrow \boxed{A_1 = 6\,V}$

AC power 005

0 of 5 attempts made

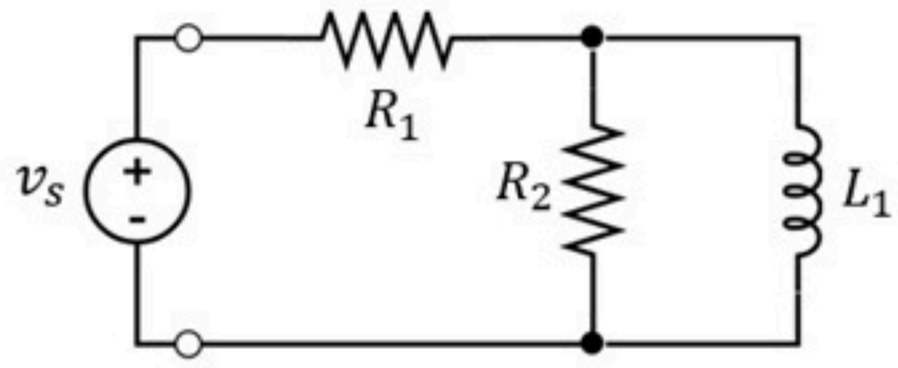
$v_s(t) = A_1 \cos(500t + B_1)$

Find the complex power $\mathbf{S_1} = a_1 + b_1 j$ received by the source v_S.

Find the complex power $\mathbf{S_2} = a_2 + b_2 j$ received by the resistor R_1.

Find the complex power $\mathbf{S_3} = a_3 + b_3 j$ received by the resistor R_2.

Find the complex power $\mathbf{S_4} = a_4 + b_4 j$ received by the inductor L_1.



Given Variables:

A1 : 6 V

B1 : 45 degrees

R1 : 4 ohm

R2 : 4 ohm

L1 : 8 mH

Calculate the following:

a1 (W) :

-2.7

b1 (VAR) :

-0.9

a2 (W) :

1.8

b2 (VAR) :

0

a3 (W) :

0.9

b3 (VAR) :

0

a4 (W) :

0

b4 (VAR) :

0.9

$v_s(t) = A_1 \cos(500t + B_1)$

A1 : 3 V

B1 : 30 degrees

R1 : 1 ohm

R2 : 2 ohm

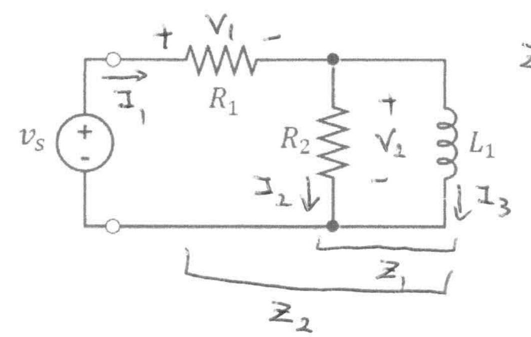
L1 : 4 mH

Find the complex power $\mathbf{S_1} = a_1 + b_1 j$ received by the source v_S.

Find the complex power $\mathbf{S_2} = a_2 + b_2 j$ received by the resistor R_1.

Find the complex power $\mathbf{S_3} = a_3 + b_3 j$ received by the resistor R_2.

Find the complex power $\mathbf{S_4} = a_4 + b_4 j$ received by the inductor L_1.



$Z_L = 2j$

$$Z_1 = \frac{1}{\frac{1}{2} - \frac{j}{2}} = \frac{2}{1-j} = 1 + j$$

$$Z_2 = Z_1 + 1 = 2 + j$$

$$V_S = 3e^{j30°} \qquad I_1 = \frac{V_S}{Z_2} \qquad V_1 = 1 \cdot I_1 \qquad V_2 = Z_1 I_1 \qquad I_2 = \frac{V_2}{2} \qquad I_3 = \frac{V_2}{2j}$$

(a) $$S_1 = \frac{1}{2} V_S (-I_1^*) = -\frac{1}{2}\frac{V_S \cdot V_S^*}{Z_2^*} = -\frac{|V_S|^2}{2}\frac{Z_2}{|Z_2|^2} = -\frac{9}{2}\frac{(2+j)}{5}$$

$\boxed{a_1 = -1.8\,W}$ $\boxed{b_1 = -0.9\,VAR}$

(b) $$S_2 = \frac{1}{2} V_1 I_1^* = \frac{I_1 I_1^*}{2} = \frac{|I_1|^2}{2} = \frac{|V_S|^2}{2|Z_2|^2} = \frac{9}{2 \cdot 5}$$

$\boxed{a_2 = 0.9\,W}$ $\boxed{b_2 = 0\,VAR}$

(c) $$S_3 = \frac{1}{2} V_2 I_2^* = \frac{1}{2} V_2 \frac{V_2^*}{2} = \frac{|V_2|^2}{4} = \frac{|Z_1|^2 |I_1|^2}{4} = \frac{|Z_1|^2}{4} \frac{|V_S|^2}{|Z_2|^2} = \frac{2 \cdot 9}{4 \cdot 5}$$

$\boxed{a_3 = 0.9\,W}$ $\boxed{b_3 = 0\,VAR}$

(d) $$S_4 = \frac{1}{2} V_2 I_3^* = \frac{1}{2} \frac{V_2 V_2^*}{(2j)^*} = j\frac{|V_2|^2}{4} = j\frac{|Z_1|^2}{4} \cdot \frac{|V_S|^2}{|Z_2|^2} = j\frac{2 \cdot 9}{4 \cdot 5}$$

$\boxed{a_4 = 0\,W}$ $\boxed{b_4 = 0.9\,VAR}$

CHECK: $$S_1 + S_2 + S_3 + S_4 = \begin{matrix} -1.8 & + 0.9 & + 0.9 & + 0 \\ -0.9j & + 0j & + 0j & + 0.9j \end{matrix} = 0$$

$(\sum \text{REC.} = \sum \text{SUPPL.})$

AC power 006

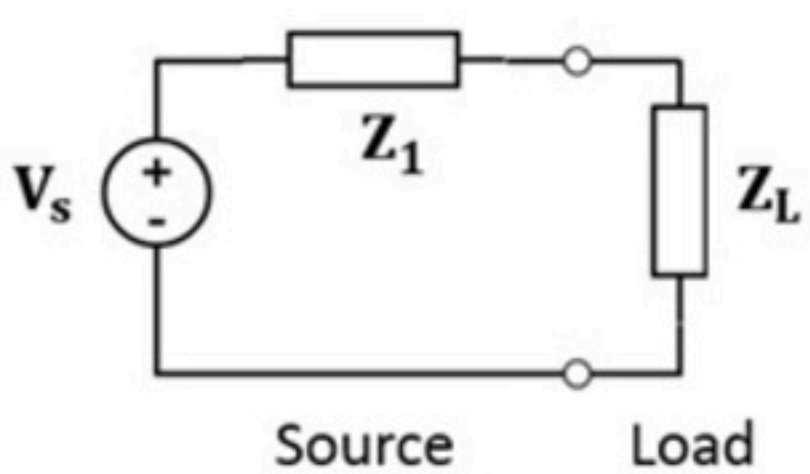
No more attempts left.

For the system below, the source is represented in phasor-notation as:

$$\mathbf{Z_1} = A_1 + jB_1 \qquad \mathbf{V_S} = A_2 \cdot e^{jB_2}$$

(a) Find the load impedance $\mathbf{Z_L} = A_3 + jB_3$ that results in the maximum power being received by this load.

(b) Find the maximum average power P received by the load.



Given Variables:

A1 : 5 ohm

B1 : 4 ohm

A2 : 2 V

B2 : 75 degrees

Calculate the following:

A3 (ohm) :

5

B3 (ohm) :

-4

P (W) :

0.1

Hint: Keep your calculations algebraic as long as you can.

For the system below, the source is represented in phasor-notation as:

A1 : 1 ohm

B1 : -8 ohm

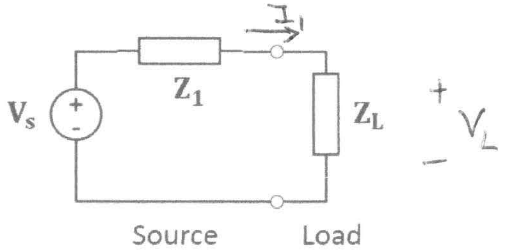
A2 : 4 V

B2 : 65 degrees

$$\mathbf{Z_1} = A_1 + jB_1 \qquad \mathbf{V_S} = A_2 \cdot e^{jB_2}$$

(a) Find the load impedance $\mathbf{Z_L} = A_3 + jB_3$ that results in the maximum power being received by this load.

(b) Find the maximum average power P received by the load.



(a) $Z_L = Z_1^* \Rightarrow Z_L = 1 + j8$

$\boxed{A_3 = 1\Omega}$

$\boxed{B_3 = 8\Omega}$

(b) $I_1 = \dfrac{V_S}{Z_1 + Z_L}$ $\qquad Z_1 + Z_L = 2$

$V_s = 4e^{j65°}$ $\qquad V_L = Z_L \cdot I_1$

$$S_L = \frac{1}{2} V_L \cdot I_1^* = \frac{1}{2} Z_L \cdot I_1 \cdot I_1^* = \frac{Z_L}{2} |I_1|^2 = \frac{Z_L}{2} \frac{|V_S|^2}{|Z_1 + Z_L|^2}$$

$$= \frac{(1+j8)}{2} \cdot \frac{4^2}{2^2} = (1+j8) \cdot 2 = \underbrace{2}_{P} + \underbrace{16j}_{Q}$$

$\boxed{P = 2W}$

AC power 008

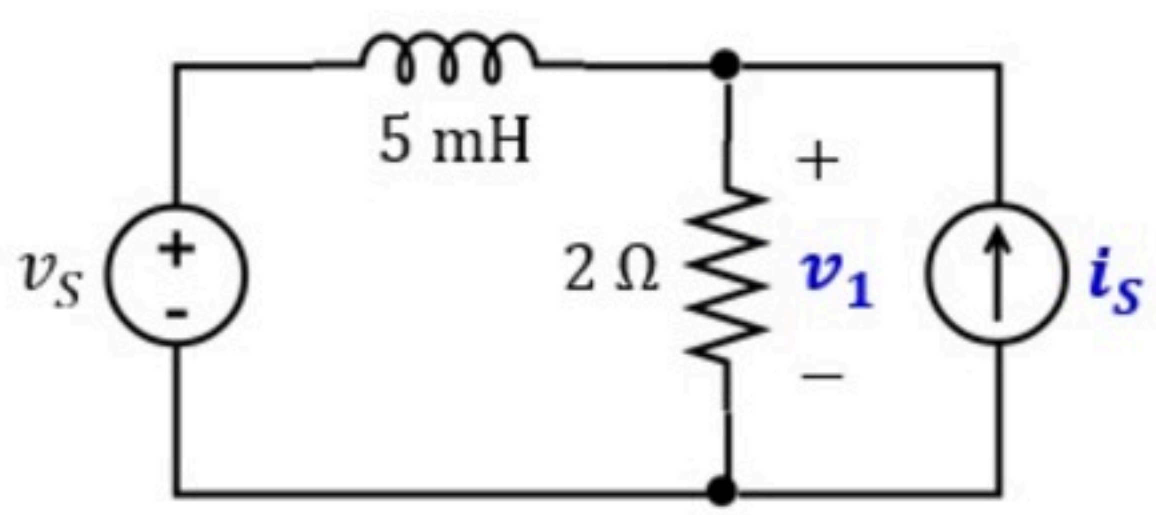
Problem has been graded.

Both v_S and i_S are AC sources with $\omega = 400$ rad/s. Someone did two measurements on the circuit and found:

$$v_1(t) = A_1 \cos(400t + B_1) \qquad \textit{(this is } v_1\textit{, not } v_S\textit{ !)}$$

$$i_S(t) = 2\cos\left(400t + \frac{\pi}{6}\right)$$

(a) Find the average power P_1 <u>received</u> by the resistor
(b) Find the average power P_2 <u>supplied</u> by current source i_S
(c) Find the average power P_3 <u>received</u> by the inductor



Given Variables:

A1 : 8 V

B1 : 90 degrees

Calculate the following:

P1 (W) :

16

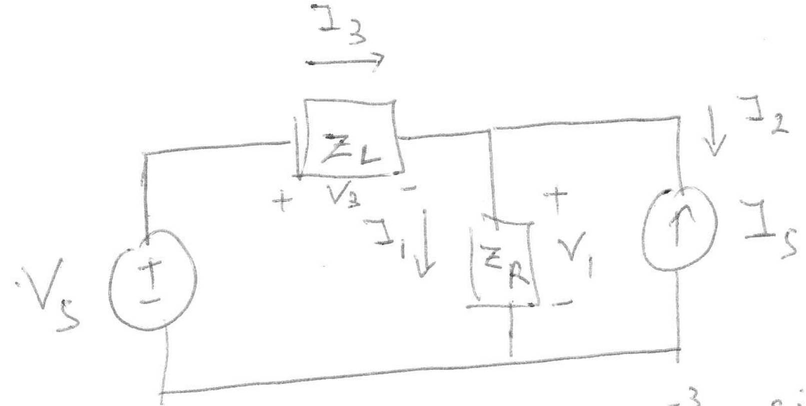
P2 (W) :

4

P3 (W) :

0

Hint: Find S symbolically first. Find phasors and plug in. For c, what do you know about the element?



$A_1 : 10V$

$B_1 : -90°$

$Z_L = j\omega L = j \cdot 400 \cdot 5 \cdot 10^{-3} = 2j$ $\qquad Z_R = 2$

(a) $S_1 = \frac{1}{2} V_1 \cdot I_1^*$ $\qquad I_1 = \frac{V_1}{Z_R}$

$= \frac{1}{2} V_1 \left(\frac{V_1}{Z_R}\right)^* = \frac{1}{2} \frac{V_1 V_1^*}{Z_R} = \frac{|V_1|^2}{2} \cdot \frac{1}{Z_R} = \frac{A_1^2}{2} \cdot \frac{1}{Z_R} = \frac{100}{2 \cdot 2} = 25$

$P_1 = Re[S_1]$ $\qquad \boxed{P_1 = 25\ W}$ received

(b) $S_2 = \frac{1}{2} V_1 I_2^*$ ⇝ PASSIVE SIGN CONVENTION (POWER RECEIVED)

$= \frac{1}{2} V_1 (-I_S)^*$ $\qquad \left(\begin{array}{l} V_1 = A_1 e^{jB_1} = 10 e^{-j\frac{\pi}{2}} \\ I_S = 2 e^{j\frac{\pi}{6}} \end{array} \right.$

$= -\frac{1}{2} V_1 I_S^*$

$= -\frac{1}{2} \cdot 10 e^{-j\frac{\pi}{2}} \cdot 2 e^{-j\frac{\pi}{6}} = -10 e^{-j\frac{4\pi}{6}} = -10 e^{-j\frac{\pi 2}{3}}$

$P_2 = Re[S_2] = -10 \cos\left(-\frac{2\pi}{3}\right) = -10\left(\frac{-1}{2}\right) = +5$ ⇝ received

$\boxed{P_2 = -5\ W}$ supplied

(c) $\boxed{P_3 = 0\ W}$ inductor always has $P = 0$

we can check : $S_3 = \frac{1}{2} V_3 I_3^*$ $\qquad V_3 = Z_L \cdot I_3$

$= \frac{1}{2} Z_L I_3 \cdot I_3^* = \frac{Z_L |I_3|^2}{2} = \underbrace{\frac{|I_3|^2 \cdot (2j)}{2}}$

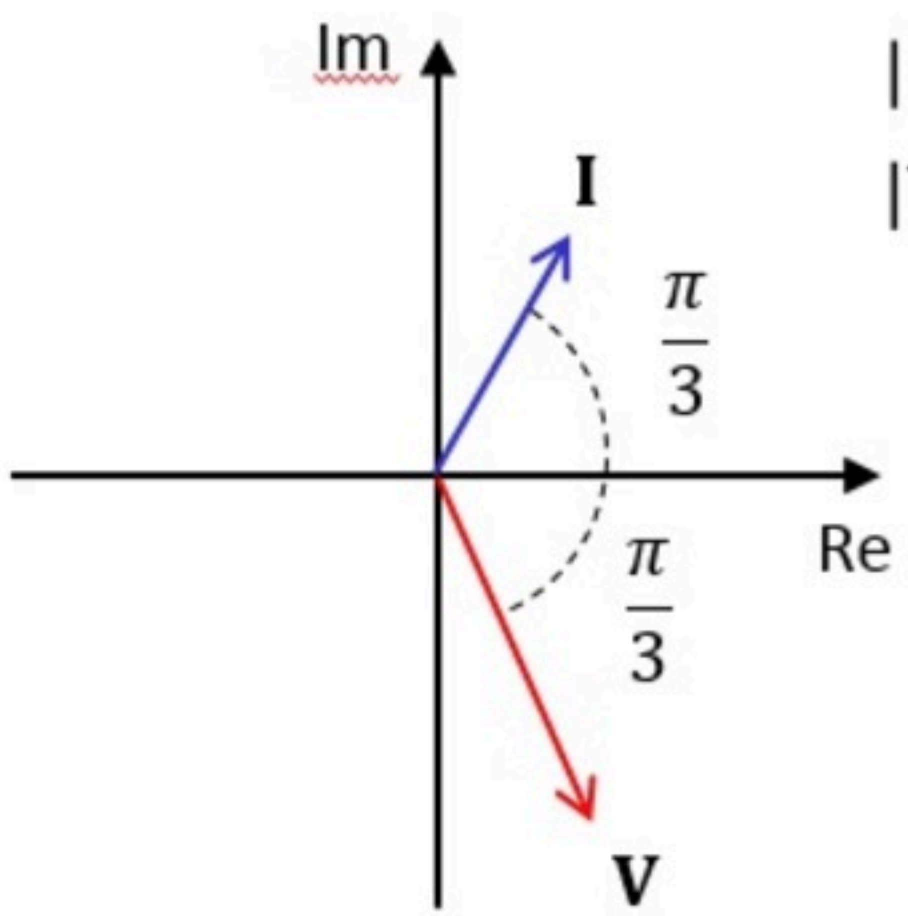
no real part $\Rightarrow P = Re[S] = 0$

PP AC power 001

Unlimited Attempts.

In the diagram are the phasors of the voltage across an element and the current through that element (according to the passive sign convention).

What is the average power P received by the element?



$|\mathbf{I}| = 3$ A

$|\mathbf{V}| = 4$ V

Given Variables:

. : . .

Calculate the following:

P (W) :

-3

Hint: Write average power as a function of the angle between the voltage and current.

$$I = 3e^{j\frac{\pi}{3}}$$

$$V = 4e^{-j\frac{\pi}{3}}$$

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

$$= \frac{1}{2} \cdot 4 \cdot 3 \cdot \cos\left(-\frac{\pi}{3} - \frac{\pi}{3}\right)$$

$$= \frac{1}{2} \cdot 4 \cdot 3 \cdot \cos\left(-\frac{2\pi}{3}\right)$$

$$= \frac{1}{2} \cdot 4 \cdot 3 \left(-\frac{1}{2}\right)$$

$$= -3$$

$$\boxed{P = -3W}$$

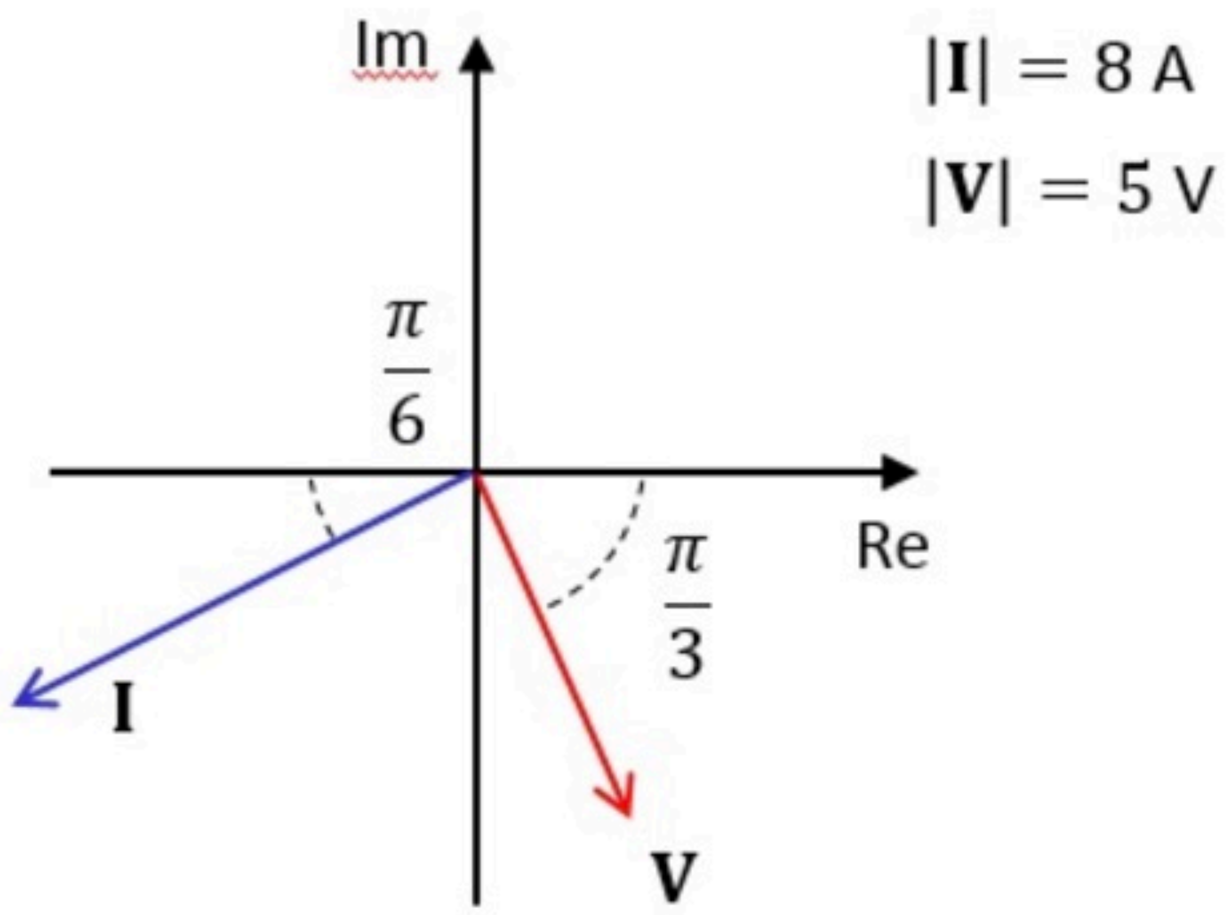
↳ SO THIS ELEMENT SUPPLIES POWER

PP AC power 002

Unlimited Attempts.

In the diagram are the phasors of the voltage across an element and the current through that element (according to the passive sign convention).

What is the average power *P* received by the element?



Given Variables:

. : . .

Calculate the following:

P (W) :

0

Hint: Write average power as a function of the angle between the voltage and current.

$$I = 8 e^{-j\frac{5\pi}{6}}$$

$$V = 5 e^{-j\frac{\pi}{3}}$$

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

$$= \frac{1}{2} \cdot 8 \cdot 5 \cdot \cos\left(-\frac{\pi}{3} + \frac{5\pi}{6}\right)$$

$$= \frac{1}{2} \cdot 8 \cdot 5 \cdot \cos\left(\frac{\pi}{2}\right)$$

$$= \frac{1}{2} \cdot 8 \cdot 5 \cdot 0$$

$\boxed{P = 0\ W}$ ⇝ AS EXPECTED SINCE V & I ARE ORTHOGONAL

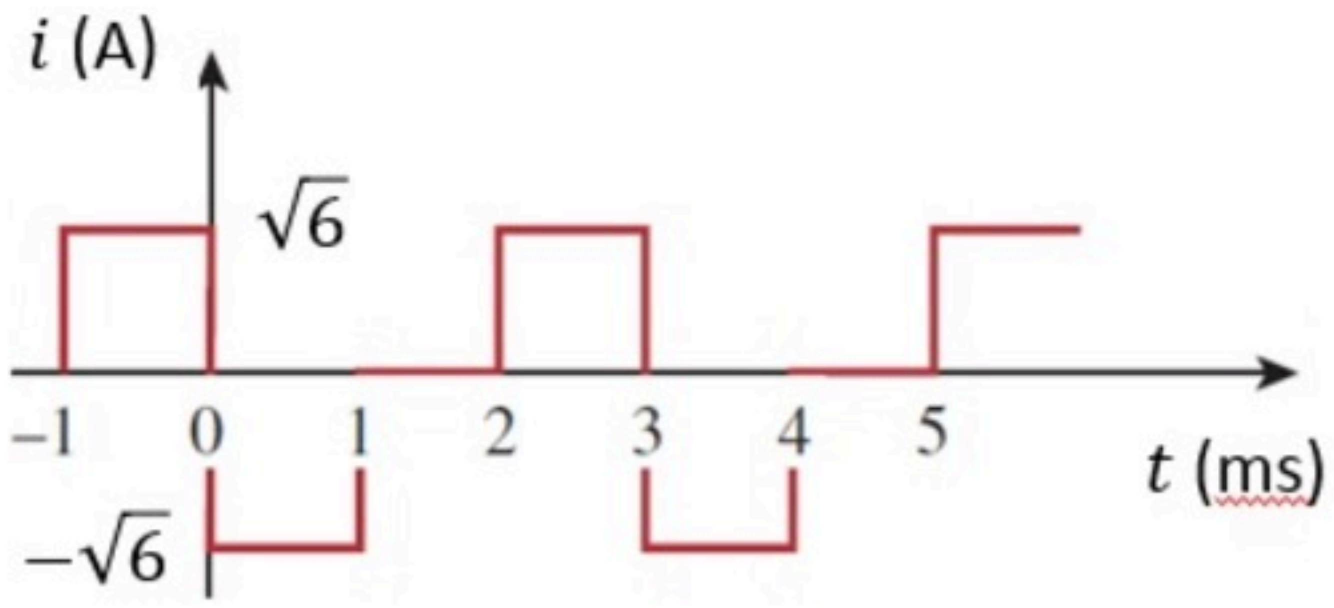
IN THIS CASE, "I LAGS V" BY 90° ⇒ THE ELEMENT IS AN INDUCTOR

$$I = \frac{V}{j\omega L} = \frac{V}{\omega L} e^{-j\frac{\pi}{2}}$$

PP AC power 003

Unlimited Attempts.

Find I_{rms} for this waveform.



Given Variables:

. : . .

Calculate the following:

Irms (A) :

2

Hint: Square the waveform first.

$$A = \frac{1}{T} \int_0^T i^2 \, dt$$

$$= \frac{1}{3.10^{-3}} \cdot \left[(-\sqrt{6})^2 \cdot 10^{-3} + 0 + (\sqrt{6})^2 \cdot 10^{-3} \right]$$

$$= \frac{1}{3} [6 + 6]$$

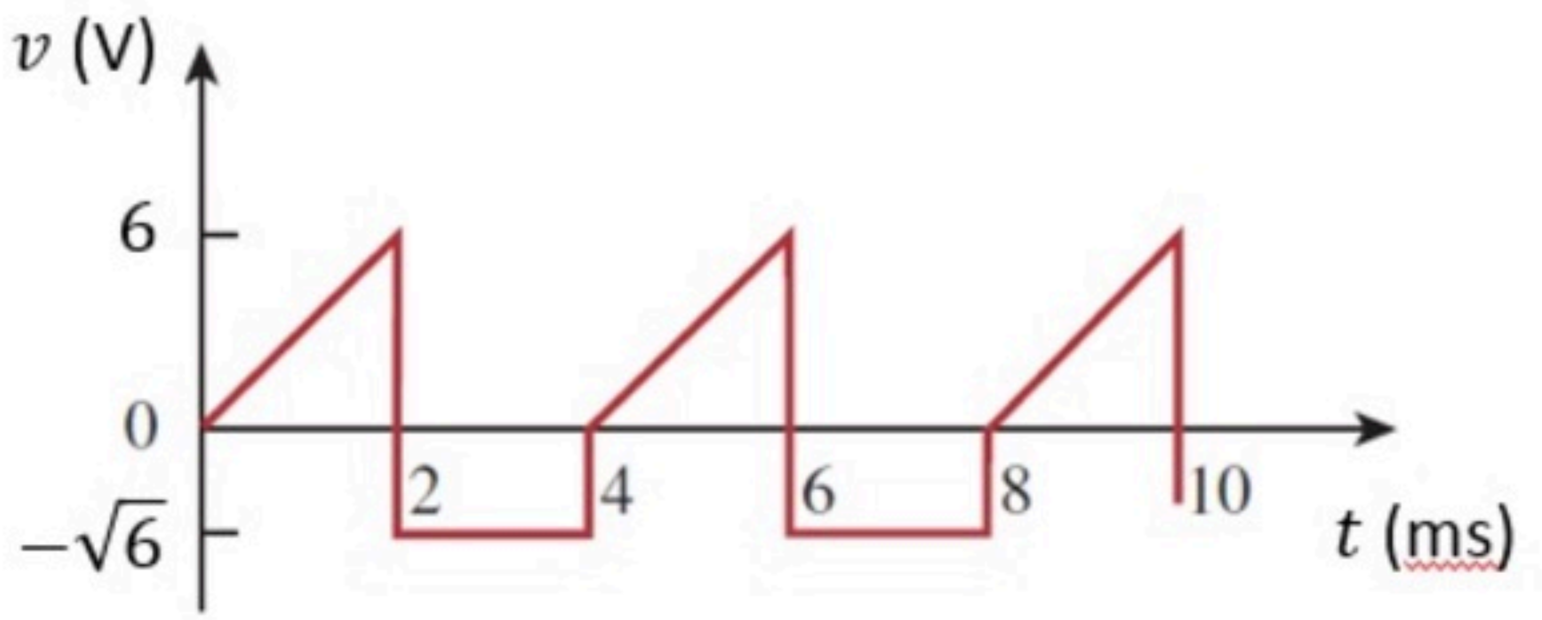
$$= 4$$

$$I_{RMS} = \sqrt{A} \implies \boxed{I_{RMS} = 2}$$

PP AC power 004

Unlimited Attempts.

Find V_{rms} for this waveform.



Given Variables:

. : . .

Calculate the following:

Vrms (V) :

3

Hint: Write the equation of the waveform in parts.

$\boxed{\text{OPTION 1}}$ t EXPRESSED IN SECONDS

$$f(t) = 3 \cdot 10^{3} \cdot t \quad , \quad 0 \leq t < 2 \cdot 10^{-3}$$
$$= -\sqrt{6} \quad , \quad 2 \cdot 10^{-3} \leq t < 4 \cdot 10^{-3}$$

$$\frac{1}{T}\int_0^T f^2(t)\,dt = \frac{1}{4 \cdot 10^{-3}}\left[\int_0^{2\cdot 10^{-3}} (3 \cdot 10^{3}\, t)^2\, dt + \int_{2\cdot 10^{-3}}^{4 \cdot 10^{-3}} (-\sqrt{6})^2\, dt\right]$$

$$= \frac{1}{4\cdot 10^{-3}}\left[9 \cdot 10^{6} \cdot \frac{t^3}{3}\Big|_0^{2\cdot 10^{-3}} + 6 \cdot 2 \cdot 10^{-3}\right]$$

$$= \frac{1}{4 \cdot 10^{-3}}\left[\frac{9 \cdot 8}{3} \cdot 10^{-3} + 12 \cdot 10^{-3}\right]$$

$$= \frac{24 + 12}{4} = \frac{36}{4} = 9$$

$$\sqrt{\frac{1}{T}\int_0^T f^2(t)\,dt} = \boxed{V_{RMS} = 3V}$$

$\boxed{\text{OPTION 2}}$ t EXPRESSED IN ms

$$f(t) = 3 \cdot t \quad , \quad 0 \leq t < 2$$
$$= -\sqrt{6} \quad , \quad 2 \leq t < 4$$

$$\frac{1}{T}\int_0^T f^2(t)\,dt = \frac{1}{4}\left[\int_0^2 (3t)^2\,dt + \int_2^4 (-\sqrt{6})^2\,dt\right] = \frac{1}{4}\left[9\,\frac{t^3}{3}\Big|_0^2 + 6 \cdot 2\right]$$

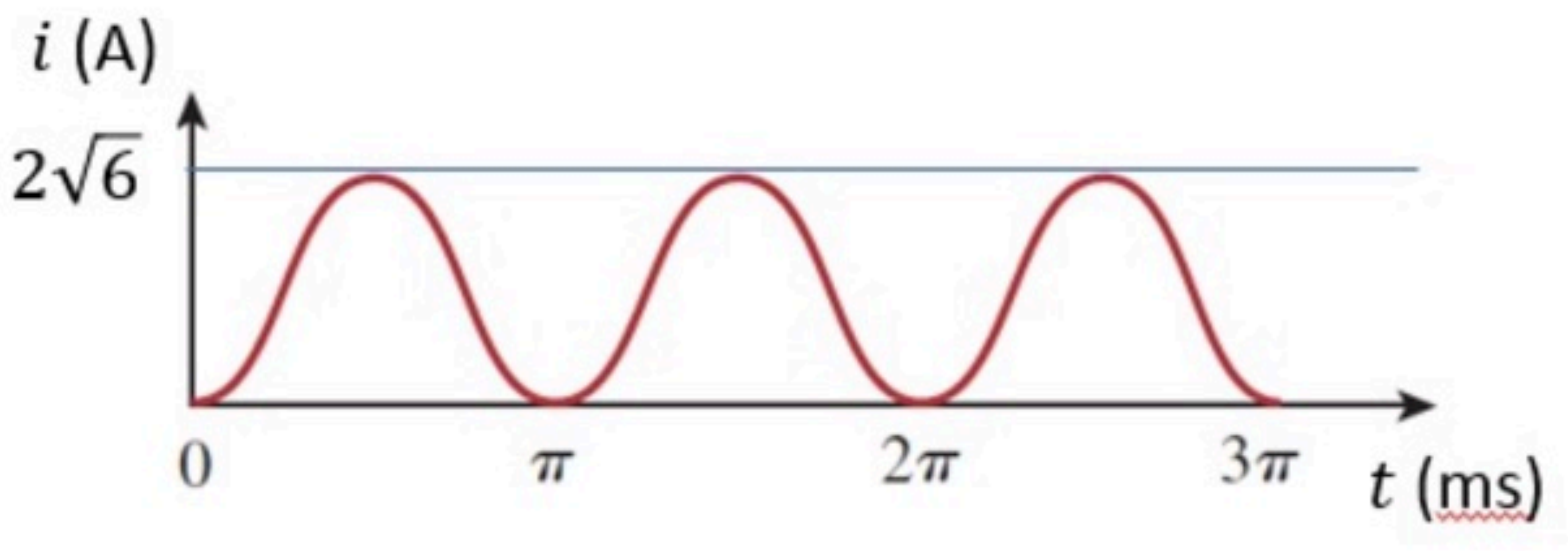
$$= \frac{1}{4}\left[\frac{9 \cdot 8}{3} + 12\right] = \frac{36}{4} = 9$$

$$\boxed{V_{RMS} = 3\,V}$$

PP AC power 005

Unlimited Attempts.

Find I_{rms} for this waveform (it is a sine wave that has an offset, i.e., it is shifted up).



Given Variables:

. : . .

Calculate the following:

Irms (A) :

3

Hint: Utilize the fact that you know the Irms for a sine wave.

$$i = \sqrt{6} - \sqrt{6}\cos(\omega t) = \sqrt{6}\,(1 - \cos(\omega t))$$

$$i^2 = 6\,(1 - \cos(\omega t))^2$$

$$A = \frac{1}{T}\int_0^T i^2\,dt = \frac{6}{T}\int_0^T \left[1 - 2\cos(\omega t) + \cos^2(\omega t)\right] dt$$

$$= \frac{6}{T}\int_0^T dt - \frac{12}{T}\int_0^T \cos(\omega t)\,dt + \frac{6}{T}\int_0^T \cos^2(\omega t)\,dt$$

$$= \frac{6}{T}\cdot T - \frac{12}{T}\cdot 0 + 6\cdot\frac{1}{2}$$

$\hookrightarrow$ WE KNOW FOR A COS

$$I_{RMS} = \frac{I_M}{\sqrt{2}} \Rightarrow I_{RMS}^2 = \frac{I_M^2}{2}$$

$$I_{RMS}^2 = \frac{I_M^2}{T}\int_0^T \cos^2(\omega t)\,dt$$

$$\Rightarrow \frac{1}{T}\int_0^T \cos^2(\omega t)\,dt = \frac{1}{2}$$

$$A = 6 + \frac{6}{2} = 9$$

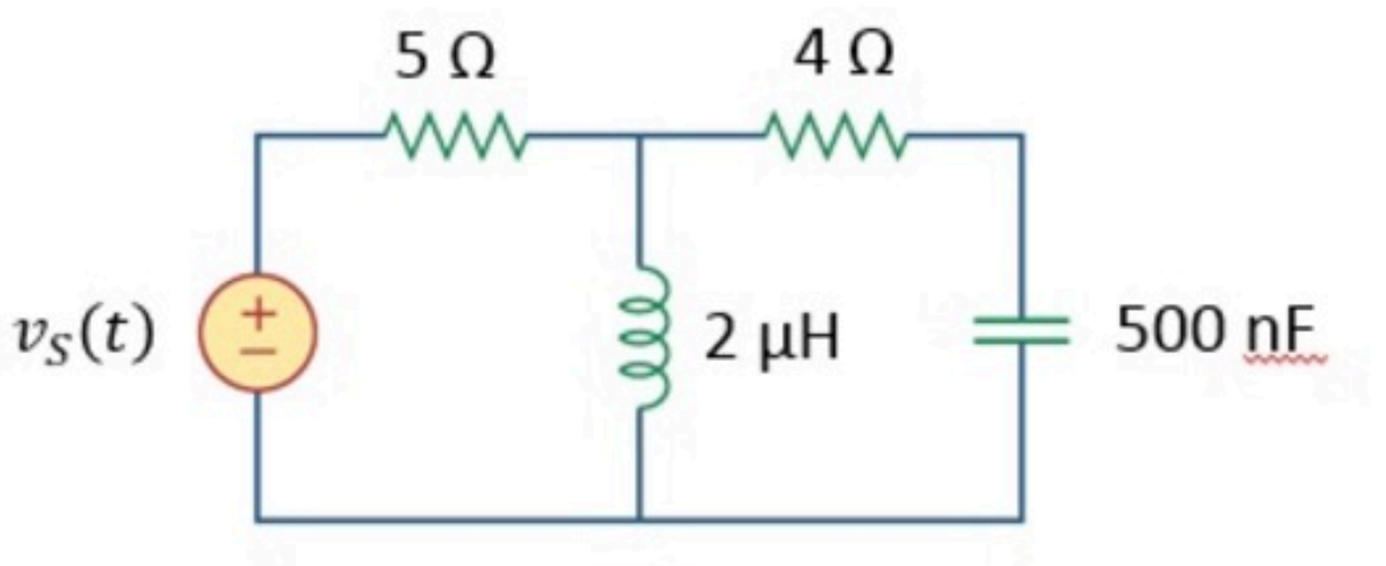
$$I_{RMS} = \sqrt{A} \Rightarrow \boxed{I_{RMS} = 3\,A}$$

PP AC power 006

Unlimited Attempts.

$$v_S(t) = 10\sqrt{2} \cdot \cos\left(10^6 t + \frac{\pi}{6}\right) \text{ V}$$

Find the average power P_1 supplied by the source v_S.
Find the average power P_2 received by the 5 Ω resistor.
Find the average power P_3 received by the 4 Ω resistor.
Find the average power P_4 received by the capacitor.
Find the average power P_5 received by the inductor.



Given Variables:

. : . .

Calculate the following:

P1 (W) :

15

P2 (W) :

12.5

P3 (W) :

2.5

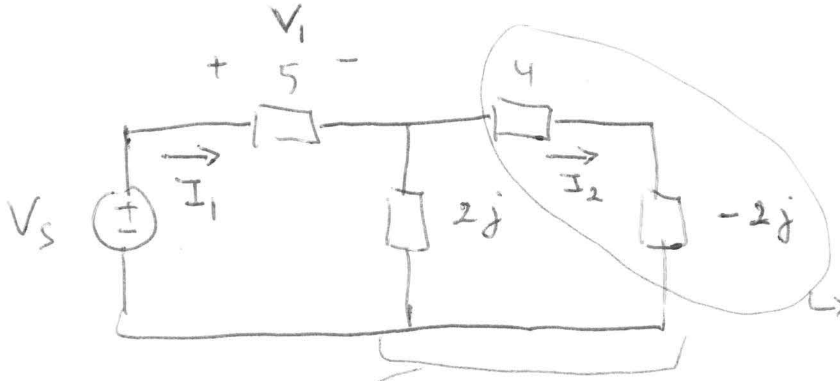
P4 (W) :

0

P5 (W) :

0

Hint: Find S first for each element. Keep Vs algebraic. Can you predict P for the cap and inductor? Check.



$\hookrightarrow Z_1 = 4 - 2j$

$$\hookrightarrow Z_2 = \frac{1}{\frac{1}{2j} + \frac{1}{4-2j}} = \frac{2j(4-2j)}{4 - \cancel{2j} + \cancel{2j}} = j(2-j) = 1 + 2j$$

$$I_1 = \frac{V_s}{5 + Z_2} = \frac{V_s}{6 + 2j}$$

① $S_1 = \frac{1}{2} V_s \cdot I_1^*$ (SUPPLIED !) $V_s \pm \uparrow I_1$

$$= \frac{1}{2} V_s \frac{V_s^*}{6-2j} = \frac{|V_s|^2}{2} \cdot \frac{6+2j}{40} = \frac{100 \cdot 2}{2} \left(\frac{6+2j}{40}\right) \qquad P_1 = Re[S_1]$$

$\boxed{P_1 = 15 W}$

② $S_2 = \frac{1}{2} V_1 I_1^* = \frac{1}{2} \cdot Z_{5\Omega} \cdot I_1 \cdot I_1^* = \frac{1}{2} Z_{5\Omega} |I_1|^2$

$$S_2 = \frac{1}{2} \cdot 5 \cdot \frac{|V_s|^2}{|6+2j|^2} = \frac{5}{2} \cdot \frac{100 \cdot 2}{40} = 12.5 \qquad \boxed{P_2 = 12.5 W}$$

③ $I_2 = I_1 \cdot \frac{2j}{2j + Z_1} = I_1 \cdot \frac{2j}{2j + 4 - 2j} = I_1 \frac{\cancel{2}j}{\cancel{4}} = I_1 \frac{j}{2}$

$$S_3 = \frac{1}{2} Z_{4\Omega} |I_2|^2 = \frac{1}{2} \cdot 4 \cdot |I_1|^2 \cdot \frac{|j|^2}{4} = \frac{|I_1|^2}{2} = \frac{1}{2} \cdot \frac{|V_s|^2}{|6+2j|^2}$$

$$= \frac{1}{2} \cdot \frac{100 \cdot 2}{40} = 2.5 \qquad \boxed{P_3 = 2.5 W}$$

WE KNOW A CAPACITOR AND INDUCTOR ONLY HAVE REACTIVE POWER $\Rightarrow$ $\boxed{P_4 = P_5 = 0}$

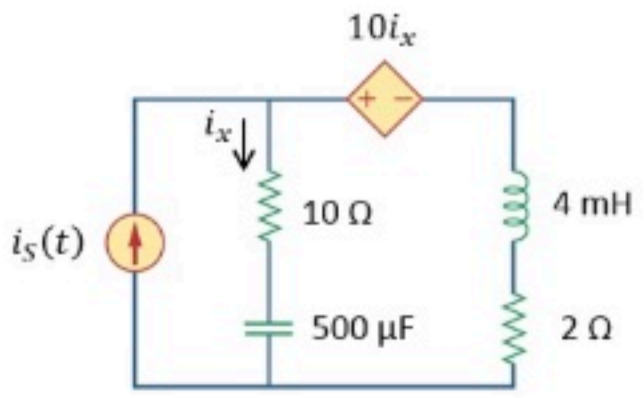
<u>CHECK</u> : $P_{REC.} = P_{SUPPLIED} \Rightarrow 12.5 + 2.5 = 15$ <u>OK</u>

PP AC power 007

Unlimited Attempts.

$$i_S(t) = 2 \cdot \cos\left(10^3 t + \frac{\pi}{4}\right) \text{ A}$$

Find the complex power $\mathbf{S_1} = a_1 + b_1 j$ supplied by the source i_S.
Find the complex power $\mathbf{S_2} = a_2 + b_2 j$ received by the 10 Ω resistor.
Find the complex power $\mathbf{S_3} = a_3 + b_3 j$ received by the 2 Ω resistor.
Find the complex power $\mathbf{S_4} = a_4 + b_4 j$ received by the CCVS.
Find the complex power $\mathbf{S_5} = a_5 + b_5 j$ received by the inductor.
Find the complex power $\mathbf{S_6} = a_6 + b_6 j$ received by the capacitor.



Given Variables:

. : . .

Calculate the following:

a1 (W) :

32

b1 (VAR) :

4

a2 (W) :

50

b2 (VAR) :

0

a3 (W) :

2

b3 (VAR) :

0

a4 (W) :

-20

b4 (VAR) :

10

a5 (W) :

0

b5 (VAR) :

4

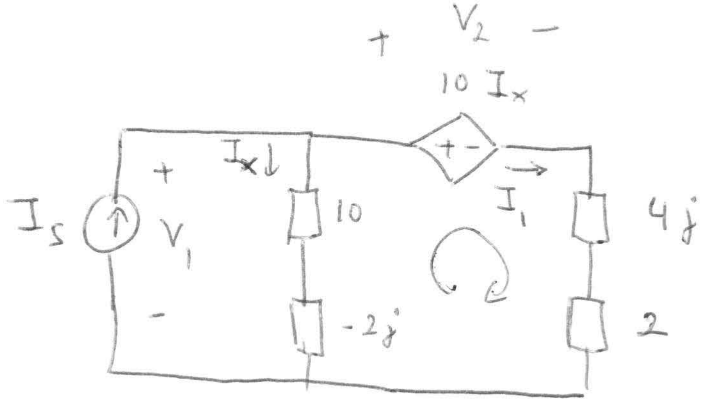
a6 (W) :

0

b6 (VAR) :

-10

Hint: Keep Is algebraic.



$I_1 = I_s - I_x$

$|I_s|^2 = 4$

KVL: $I_x(10-2j) = 10 I_x + (2+4j) I_1$
$= 10 I_x + (2+4j)(I_s - I_x)$

$I_x(\cancel{10} - 2j - \cancel{10} + 2 + 4j) = (2+4j) I_s$

$I_x(2+2j) = I_s(2+4j) \Rightarrow I_x = I_s \frac{(1+2j)}{(1+j)} = I_s \frac{(3+j)}{2}$

① $V_1 = I_x(10-2j) = I_s \frac{(3+j)(10-2j)}{2} = I_s(16+2j)$

NOTE DIRECTION OPPOSITE PASSIVE SIGN CONVENTION

$S_1 = \frac{1}{2} V_1 \cdot I_s^* = \frac{1}{2} I_s (16+2j) I_s^* = |I_s|^2 (8+j) \Rightarrow \boxed{S_1 = 32+4j}$

② $S_2 = \frac{1}{2} \cdot Z_{10\Omega} \cdot |I_x|^2 = \frac{1}{2} \cdot 10 \cdot |I_s|^2 \cdot \frac{(10)}{4} \Rightarrow \boxed{S_2 = 50 + 0j}$

AS EXPECTED

③ $I_1 = I_s - I_x = I_s\left(1 - \frac{(3+j)}{2}\right) = I_s \frac{(-1-j)}{2}$

$S_3 = \frac{1}{2} Z_{2\Omega} |I_1|^2 = \frac{1}{2} \cdot 2\, |I_s|^2 \cdot \frac{|-1-j|^2}{4} = \frac{|I_s|^2}{4} \cdot 2 \Rightarrow \boxed{S_2 = 2 + 0j}$

④ $S_4 = \frac{1}{2} V_2 I_1^* = \frac{1}{2} \cdot 10 I_x \cdot I_1^* = 5 \cdot I_s \frac{(3+j)}{2} \cdot I_s^* \frac{(-1+j)}{2} = |I_s|^2 \cdot \frac{5}{4}(-4+2j)$

$\Rightarrow \boxed{S_4 = -20 + 10j}$ RECEIVED SINCE WE USED PASSIVE SIGN CONVENTION

⑤ $S_5 = \frac{1}{2} Z_L \cdot |I_1|^2 = \frac{1}{2} \cdot 4j\, |I_s|^2 \cdot \frac{|-1-j|^2}{4} = 2j \cdot 4 \cdot \frac{2}{4} \Rightarrow \boxed{S_5 = 0 + 4j}$

AS EXPECTED

⑥ $S_6 = \frac{1}{2} Z_c\, |I_x|^2 = \frac{1}{2}(-2j)\,|I_s|^2\, \frac{|3+j|^2}{4} = -j \cdot 4 \cdot \frac{10}{4} \Rightarrow \boxed{S_6 = 0 - 10j}$

CHECK: $\sum P_{REC} = \sum P_{SUPPL} \Rightarrow 50 + 2 - 20 = 32$ OK

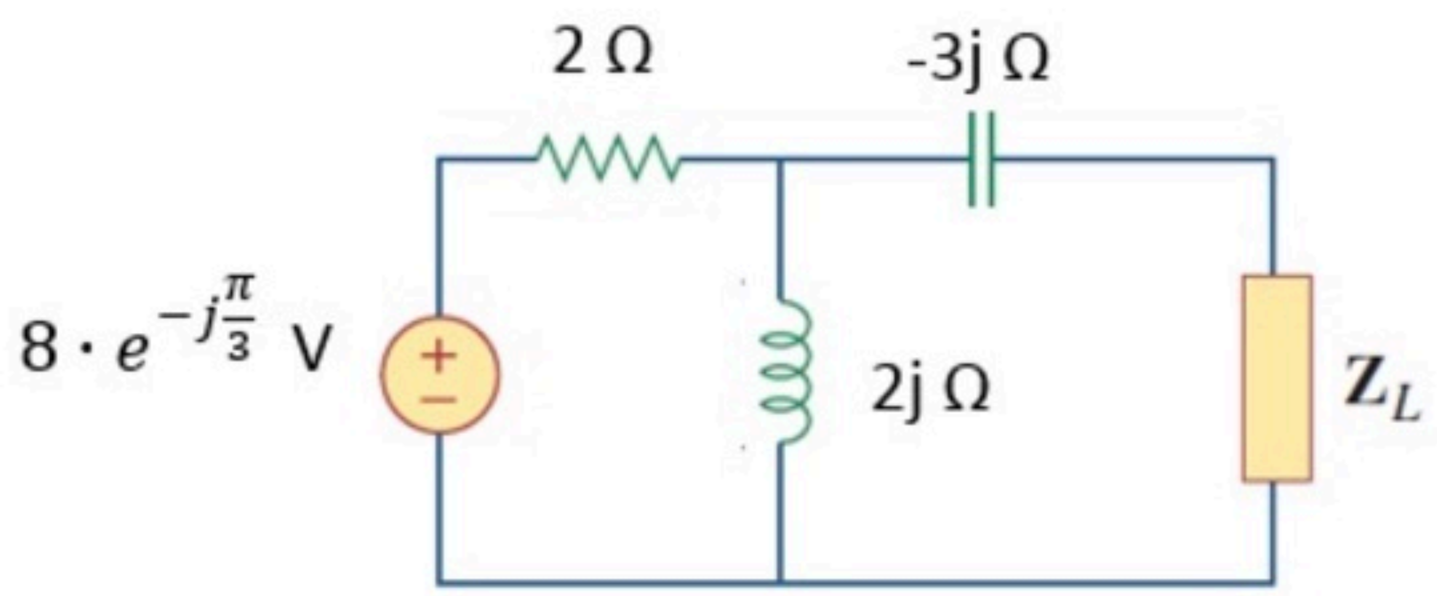
$\sum Q_{REC} = \sum Q_{SUPPL} \Rightarrow 10 + 4 - 10 = 4$ OK

PP AC power 008

Unlimited Attempts.

Find the value of $\mathbf{Z_L} = a + jb$ that will receive the maximum amount of power

Find the resulting complex power $\mathbf{S} = c + jd$ received by the load.



Given Variables:

. : . .

Calculate the following:

a (ohm) :

1

b (ohm) :

2

c (W) :

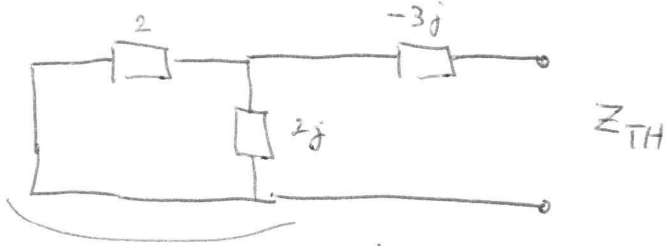
4

d (VAR) :

8

Hint: Set the independent source to zero. Find Zth.

(1)

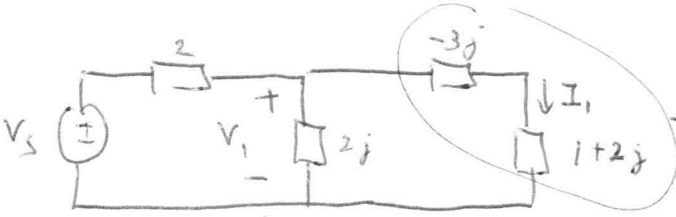


$$\hookrightarrow Z_1 = \frac{1}{\frac{1}{2}+\frac{1}{2j}} = \frac{4j}{2+2j} = \frac{2j}{1+j} = \frac{2j(1-j)}{2} = 1+j$$

$$\Rightarrow Z_{TH} = Z_1 - 3j = 1-2j$$

MAX POWER: $\boxed{Z_L = Z_{TH}^* = 1+2j}$

(2) OPTION 1:



$\rightarrow Z_2 = 1-j$

$$\hookrightarrow Z_3 = \frac{1}{\frac{1}{2j}+\frac{1}{1-j}} = \frac{2j(1-j)}{1-j+2j} = \frac{2j+2}{1+j} = 2$$

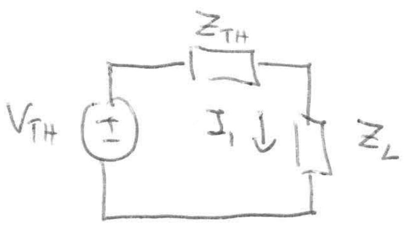
$$V_1 = V_s \frac{Z_3}{Z_3+2} = \frac{V_s}{2}$$

$$I_1 = \frac{V_1}{Z_2} \quad \Rightarrow \quad S_L = \frac{1}{2} Z_L \cdot |I_1|^2 = \frac{1}{2}(1+2j)\frac{|V_s|^2}{4} \cdot \frac{1}{|Z_2|^2}$$

$$= \frac{1}{2} \cdot \frac{64}{4} \cdot \frac{1}{2}(1+2j)$$

$$\boxed{S_L = 4+8j}$$

OPTION 2: FIND $V_{TH} \Rightarrow V_{OC} = V_s \cdot \frac{2j}{2+j} = V_s \frac{j}{1+j} = V_{TH}$



$$I_1 = \frac{V_{TH}}{Z_{TH}+Z_L} = \frac{V_{TH}}{\underbrace{(1-2j)+(1+2j)}_{\text{AS EXPECTED}}} = \frac{V_{TH}}{2}$$

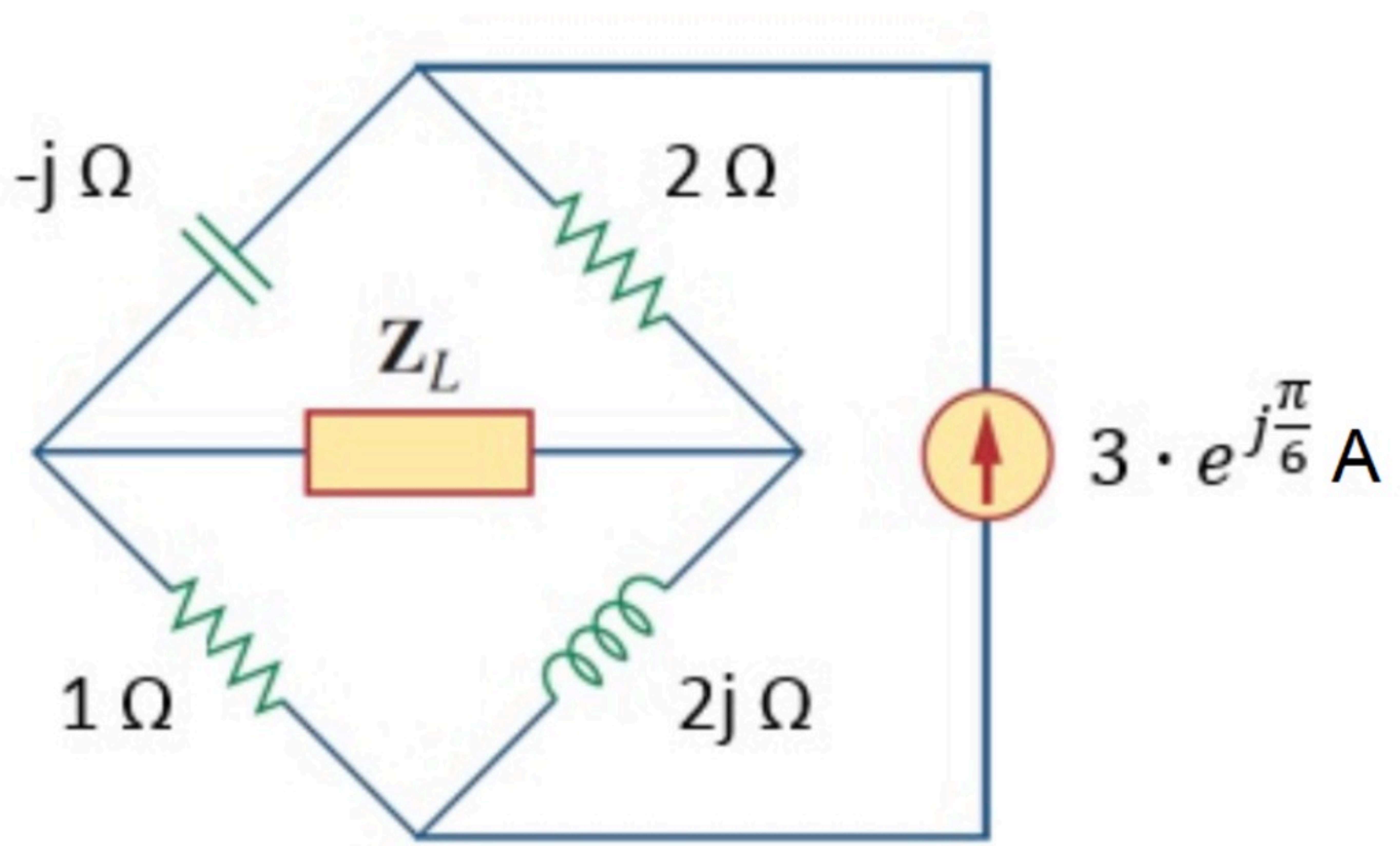
$$S_L = \frac{1}{2} Z_L |I_1|^2 = \frac{1}{2}(1+2j)\frac{|V_{TH}|^2}{4} = \frac{(1+2j)}{8}|V_s|^2 \frac{|j|^2}{|1+j|^2}$$

$$S_L = (1+2j) \cdot \frac{64}{8} \cdot \frac{1}{2} \quad \Rightarrow \quad \boxed{S_L = 4+8j}$$

PP AC power 009

Unlimited Attempts.

Find the value of $\mathbf{Z_L} = a + jb$ that will receive the maximum amount of power



Given Variables:

. : . .

Calculate the following:

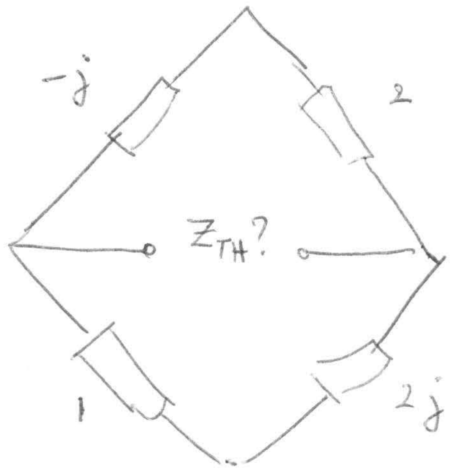
a (ohm) :

1.5

b (ohm) :

-0.5

Hint: Find ZTh by setting independent sources to zero.



$$Z_{TH} = (2-j) \,//\, (1+2j) = \frac{1}{\frac{1}{2-j} + \frac{1}{1+2j}}$$

$$= \frac{(2-j)(1+2j)}{2-j+1+2j} = \frac{2-j+4j+2}{3+j} \cdot \frac{3-j}{3-j}$$

$$= \frac{1}{10} \cdot (4+3j)(3-j)$$

$$= \frac{1}{10}(12+9j-4j+3)$$

$$= 1.5 + 0.5j$$

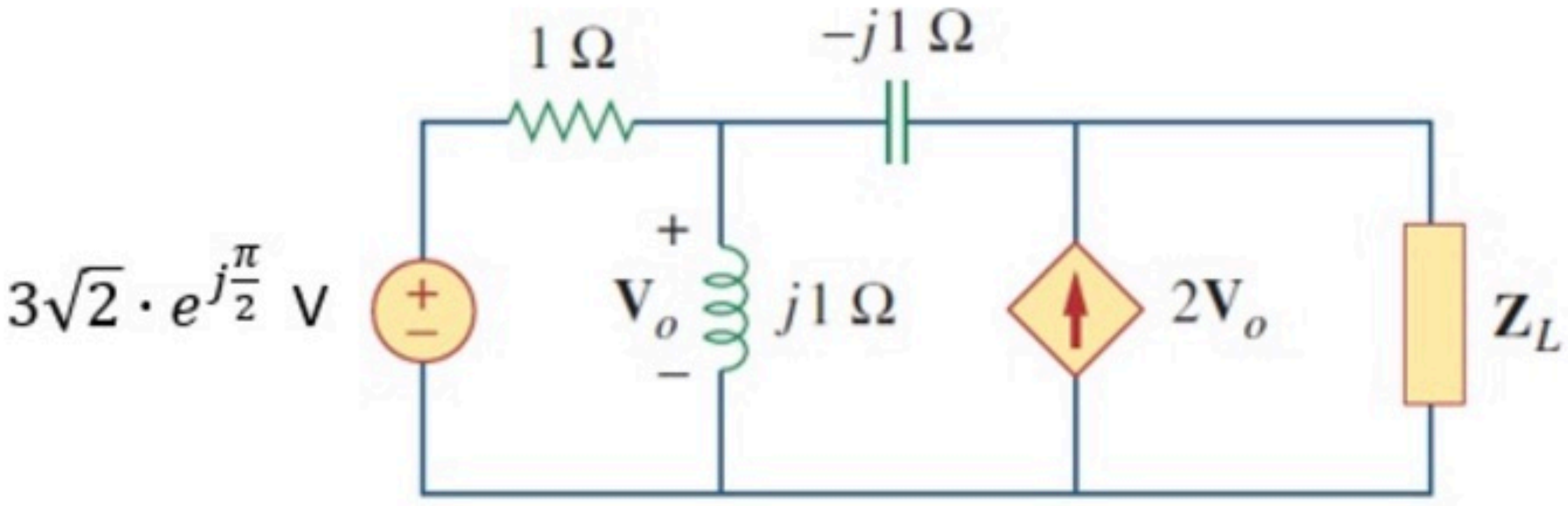
$Z_L^* = Z_{TH}$ FOR MAX POWER

$$\boxed{Z_L = 1.5 - 0.5j}$$

PP AC power 010

Unlimited Attempts.

Find the value of $\mathbf{Z_L} = a + jb$ that will receive the maximum amount of power



Given Variables:

. : . .

Calculate the following:

a (ohm) :

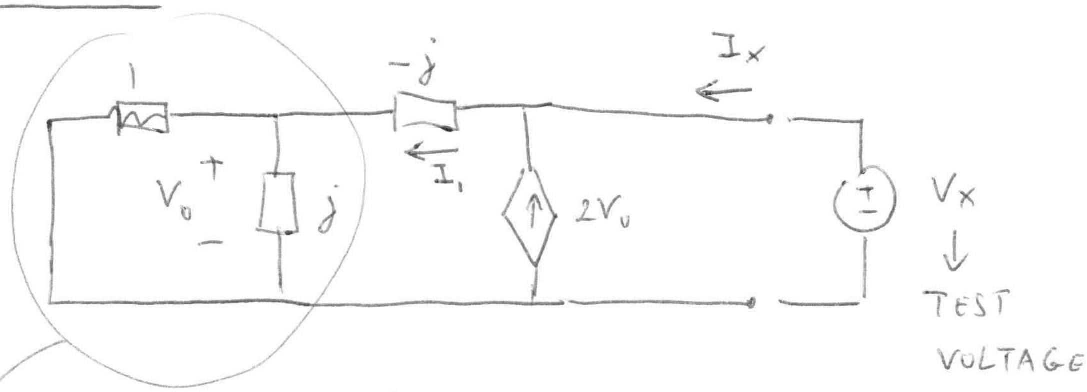
0.5

b (ohm) :

-0.5

Hint: Use a test source to find the ZTh.

FIND Z_{TH}:



$$Z_1 = \frac{1}{\frac{1}{1} + \frac{1}{j}} = \frac{j}{1+j} = \frac{j(1-j)}{2} = \frac{1+j}{2}$$

$$I_1 = \frac{V_x}{Z_1 - j} = \frac{V_x}{\frac{1-j}{2}}$$

$$V_0 = V_x \cdot \frac{Z_1}{Z_1 - j} = V_x \frac{(1+j)}{(1-j)}$$

$$I_x = I_1 - 2V_0 = \frac{2V_x}{1-j} - 2V_x \frac{(1+j)}{1-j} = V_x \frac{(-2j)}{1-j}$$

$$Z_{TH} = \frac{V_x}{I_x} = \frac{V_x(1-j)}{V_x(-2j)} = \frac{1-j}{-2j} = \frac{(1-j)\cdot j}{2} = \frac{1+j}{2}$$

MAX POWER: $Z_L = Z_{TH}^*$

$$\boxed{Z_L = 0.5 - 0.5j}$$