Phasors 005

Unlimited Attempts.

Each voltage-current pair below is the voltage across an element and the current through that element, adhering to the passive sign convention (ω is in units of rad/s).

$$v_1(t) = A_1 \cdot \cos(400t + 25°) \qquad i_1(t) = B_1 \cdot \sin(400t + 25°)$$
$$v_2(t) = A_2 \cdot \sin(500t + 70°) \qquad i_2(t) = B_2 \cdot \sin(500t + 160°)$$
$$v_3(t) = A_3 \cdot \cos(700t + 30°) \qquad i_3(t) = B_3 \cdot \sin(700t + 120°)$$

For each element:

a) Indicate the type of element. Enter 1 for resistor, 2 for inductor, and 3 for capacitor.

b) Find the value of the element. Assume the units are mΩ, mH or mF respectively.

Given Variables:

A1 : 12 V

B1 : 3 A

A2 : 20 V

B2 : 4 A

A3 : 2 V

B3 : 4 A

Calculate the following:

Type 1 (.) :

2 ✓

Value 1 (.) :

10 ✓

Type 2 (.) :

3 ✓

Value 2 (.) :

0.4 ✓

Type 3 (.) :

1 ✓

Value 3 (.) :

500 ✓

Hint: Convert to phasors and check if current lags or leads.

Each voltage-current pair below is the voltage across an element and the current through that element, adhering to the passive sign convention.

A1 : 16 V

B1 : 2 A

A2 : 32 V

B2 : 8 A

A3 : 3 V

B3 : 30 A

$v_1(t) = A_1 \cdot \cos(400t + 25) \quad i_1(t) = B_1 \cdot \sin(400t + 25)$

$v_2(t) = A_2 \cdot \sin(500t + 70) \quad i_2(t) = B_2 \cdot \sin(500t + 160)$

$v_3(t) = A_3 \cdot \cos(700t + 30) \quad i_3(t) = B_3 \cdot \sin(700t + 120)$

For each element:

a) Indicate the type of element. Enter 1 for resistor, 2 for inductor, and 3 for capacitor.

b) Find the value of the element. Assume the units are mΩ, mH or mF respectively.

$Z_L = j\omega L \Rightarrow \angle Z = 90^\circ$

$Z_C = \frac{1}{j\omega C} \Rightarrow \angle Z = -90^\circ$

$Z_R = R \Rightarrow \angle Z = 0^\circ$

$\sin(\alpha) = \cos(\alpha - 90^\circ)$ $\qquad V = Z \cdot I$

1. $V_1 = 16 e^{j25^\circ} \qquad I_1 = 2 e^{j(25^\circ - 90^\circ)}$

$\angle Z_1 = \angle V_1 - \angle I_1 = 25^\circ - (25^\circ - 90^\circ) = 90^\circ \Rightarrow \boxed{\text{INDUCTOR}}$

$|Z_1| = \frac{|V_1|}{|I_1|} = \frac{16}{2} = \omega L \Rightarrow L = \frac{16}{2} \cdot \frac{1}{400} \Rightarrow \boxed{L = 20\ mH}$

2. $V_2 = 32 e^{j(70^\circ - 90^\circ)} \qquad I_2 = 8 e^{j(160^\circ - 90^\circ)}$

$\angle Z_2 = \angle V_2 - \angle I_2 = (70^\circ - 90^\circ) - (160^\circ - 90^\circ) = -90^\circ$

$\Rightarrow \boxed{\text{CAPACITOR}}$

$|Z_2| = \frac{|V_2|}{|I_2|} = \frac{32}{8} = \frac{1}{\omega C} \Rightarrow C = \frac{1}{500} \frac{8}{32} \Rightarrow \boxed{C = 0.5\ mF}$

3. $V_3 = 3 e^{j30^\circ} \qquad I_3 = 30 e^{j(120^\circ - 90^\circ)}$

$\angle Z_3 = \angle V_3 - \angle I_3 = 30^\circ - (120^\circ - 90^\circ) = 0^\circ \Rightarrow \boxed{\text{RESISTOR}}$

$|Z_3| = \frac{|V_3|}{|I_3|} = \frac{3}{30} = R \Rightarrow R = \frac{1}{10} \Rightarrow \boxed{R = 100\ m\Omega}$

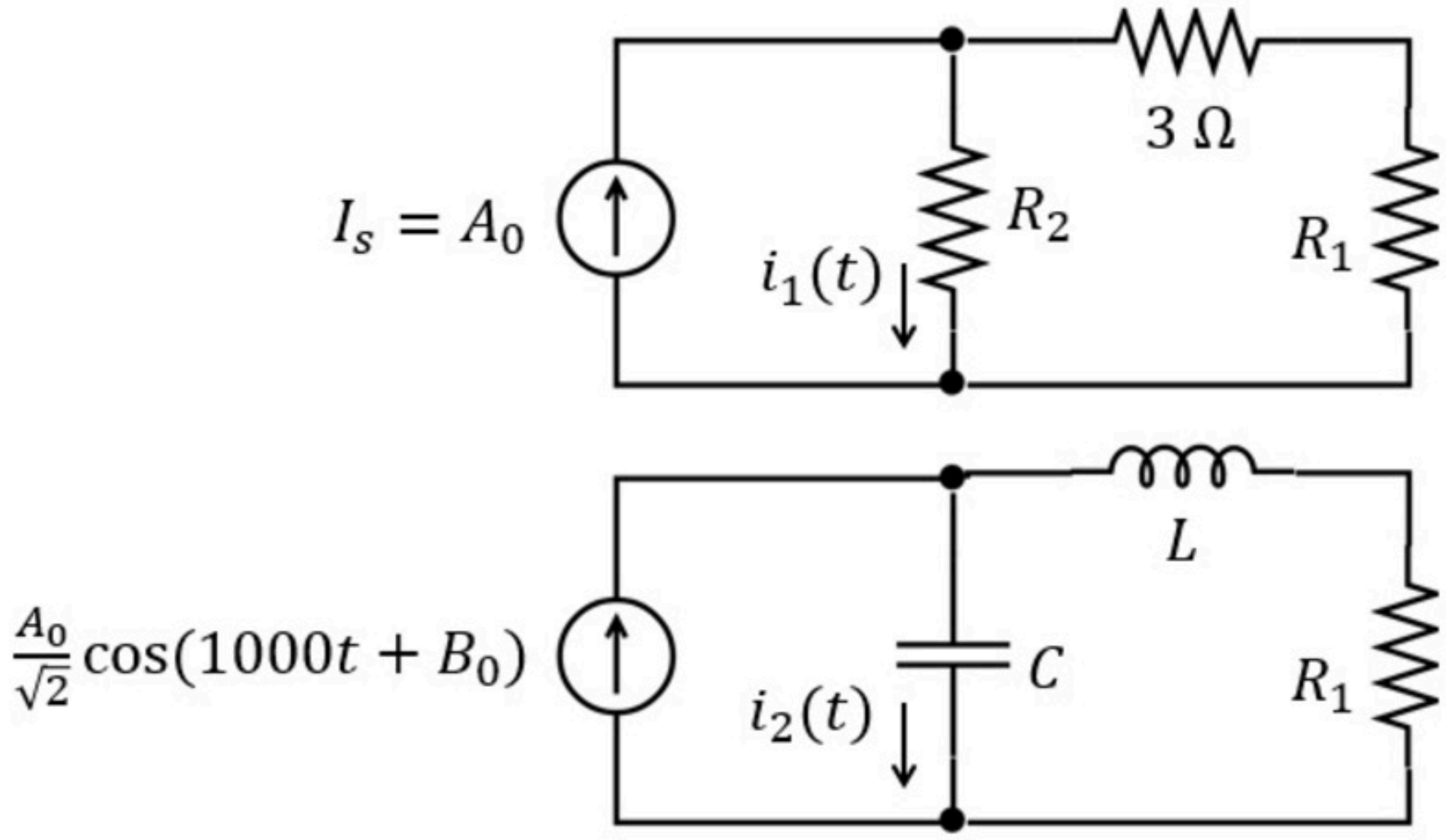
Phasors 006

Problem has been graded.

Find the steady-state currents $i_1(t)$ and $i_2(t)$.

$$i_1(t) = A_1$$

$$i_2(t) = A_2\cos(1000t + B_2) \quad \text{with } -180° < B_2 \leq 180°$$



Given Variables:

A0 : 2 A

B0 : 25 degrees

C : 200 uF

L : 3 mH

R1 : 6 ohm

R2 : 3 ohm

Calculate the following:

A1 (A) :

1.5

A2 (A) :

1.5

B2 (degrees) :

70

Hint: Solve the second circuit with phasors.

Find the steady-state currents $i_1(t)$ and $i_2(t)$.

$i_1(t) = A_1$

$i_2(t) = A_2\cos(1000t + B_2)$ with $-180° < B_2 \le 180°$

A0 : 2 A

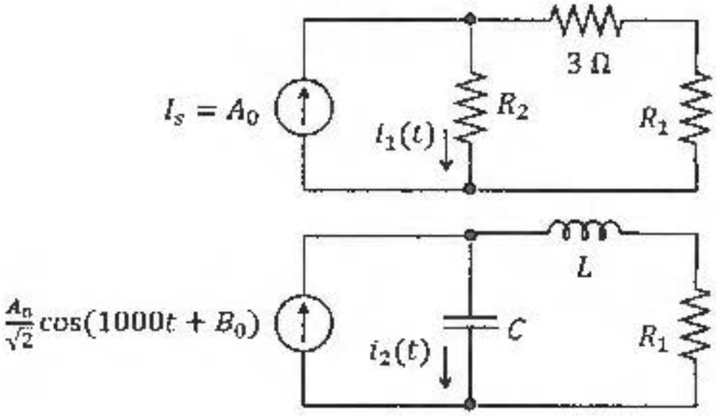
B0 : 20 degrees

C : 250 uF

L : 4 mH

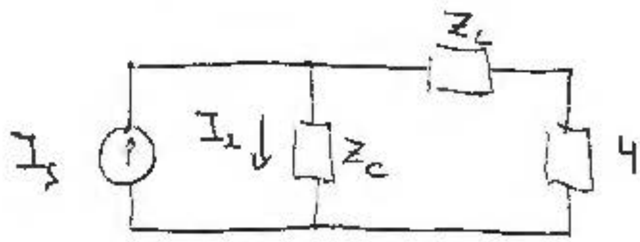
R1 : 4 ohm

R2 : 3 ohm



① CURRENT DIVIDER. $i_1 = 2 \cdot \frac{3+4}{3+4+3} = \frac{14}{10}$ $\boxed{A_1 = 1.4\ A}$

②



$Z_L = j\omega L = j\,1000 \cdot 4 \cdot 10^{-3} = 4j$

$Z_C = \frac{1}{j\omega C} = \frac{1}{j\,1000 \cdot 250\,10^{-6}} = -4j$

$I_s = \frac{2}{\sqrt{2}} \cdot e^{j20°}$

$$I_2 = I_s \cdot \frac{4j+4}{4j+4-4j} = I_s \cdot \frac{\cancel{4}(1+j)}{\cancel{4}} = \frac{2}{\sqrt{2}}\, e^{j20°}\, \sqrt{2}\, e^{j45°}$$

$$I_2 = 2\, e^{j65°}$$

$i_2(t) = 2\cos(1000t + 65°)$ $\boxed{A_2 = 2\ A}$

$\boxed{B_2 = 65°}$

Phasors 007

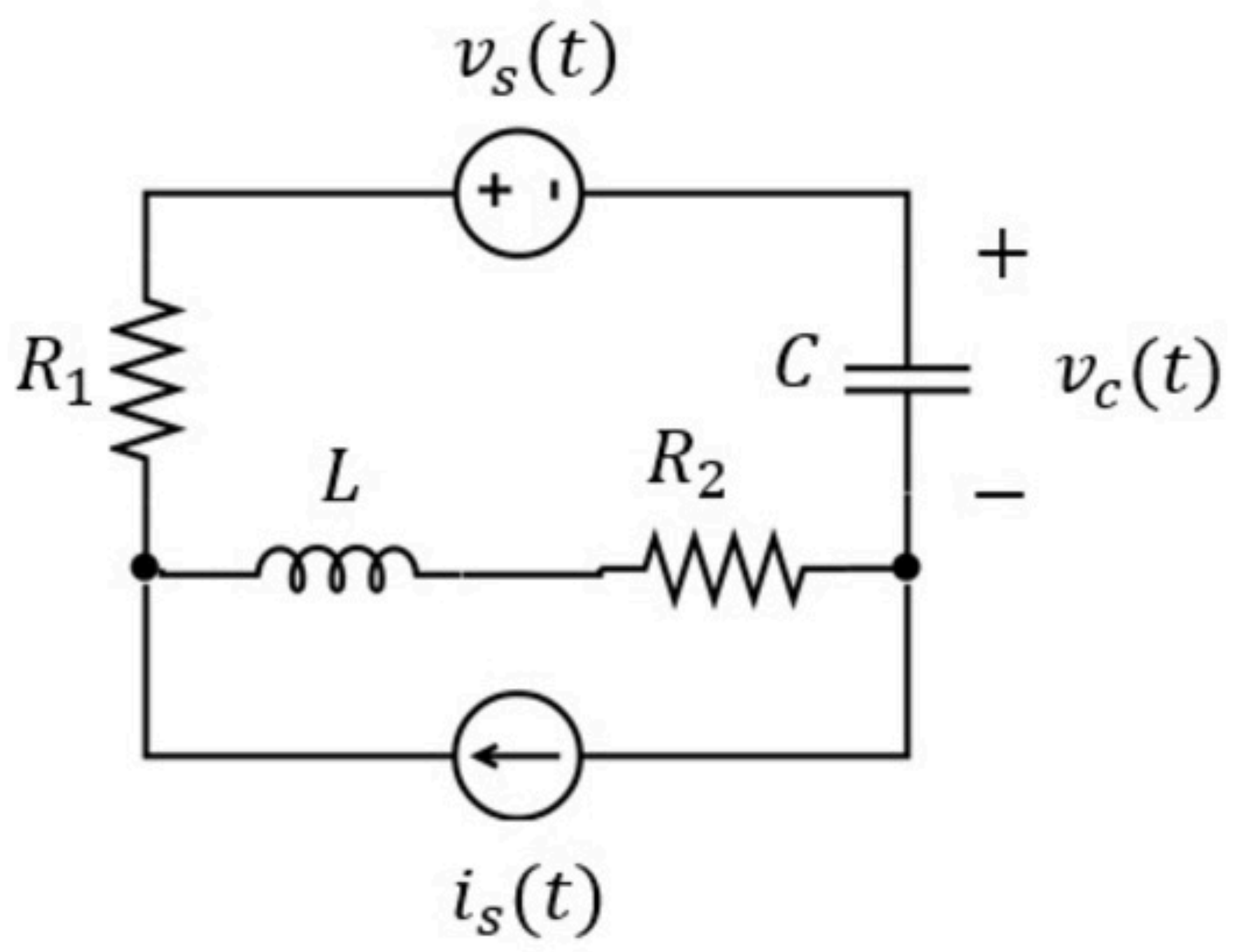
Problem has been graded.

$$v_s(t) = A_1\sqrt{2} \cdot \cos(W_1 t + B_1)$$

$$i_s(t) = 2 \cdot \cos(W_1 t - 90°) \quad \text{A}$$

Find steady state voltage

$$v_c(t) = A_2\sqrt{2} \cdot \cos(W_2 t + B_2) \quad \text{with } -180° < B_2 \leq 180°$$



Given Variables:

A1 : 14 V

B1 : -45 degrees

W1 : 2000 (1/s)

C : 125 uF

L : 2 mH

R1 : 4 ohm

R2 : 4 ohm

Calculate the following:

A2 (V) :

3

B2 (degrees) :

45

W2 (1/s) :

2000

> Hint: We do not need to use superposition, but we could if we wanted to.

$v_s(t) = A_1\sqrt{2}\cdot\cos(W_1 t + B_1)$

$i_s(t) = 2\cdot\cos(W_1 t - 90°)$ A

Find steady state voltage

$v_c(t) = A_2\sqrt{2}\cdot\cos(W_2 t + B_2)$ with $-180° < B_2 \le 180°$

A1 : 32 V

B1 : -45 degrees

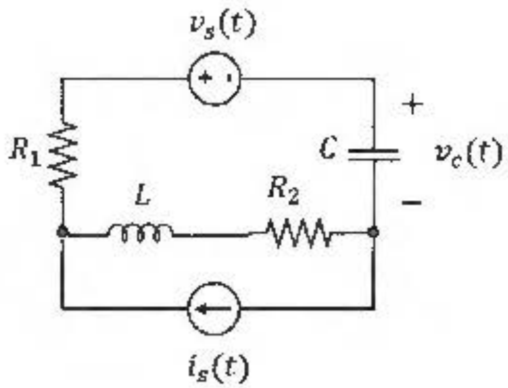
W1 : 2000 1/s

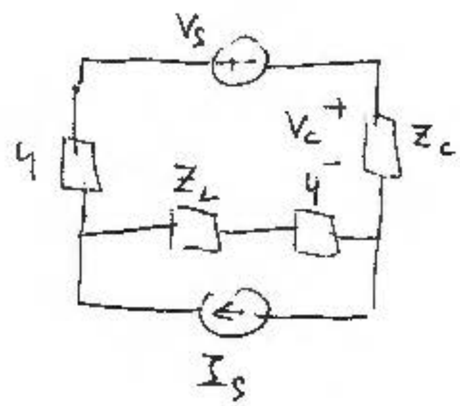
C : 125 uF

L : 2 mH

R1 : 4 ohm

R2 : 4 ohm





$$Z_c = \frac{1}{j\omega C} = \frac{10^6}{j\,2000\cdot 125} = -4j$$

$$Z_L = j\omega L = j\,2000\cdot 2\cdot 10^{-3} = 4j$$

$$V_s = 32\sqrt{2}\,e^{-j45°} = 32\sqrt{2}\left(+\frac{\sqrt{2}}{2} - j\frac{\sqrt{2}}{2}\right) = 32 - 32j$$

$$I_s = 2\,e^{-j90°} = -2j$$

① ONLY V_s

$$V_{c_1} = -V_s\cdot\frac{Z_c}{Z_c + Z_L + 4 + 4} = \frac{(-32+32j)\cdot(-4j)}{\cancel{-4j}+\cancel{4j}+4+4} = \frac{-j}{2}(-32+32j) = 16 + 16j$$

② ONLY I_S :

$$V_{c_2} = I_S\cdot\frac{Z_L + 4}{Z_L + 4 + Z_c + 4}\,Z_c = (-2j)\,\frac{4+4j}{4\cancel{-4j}+\cancel{4j}+4}\cdot(-4j)$$

$$= -\frac{8\,(4+4j)}{8} = -4 - 4j$$

③ SUPERPOSITION :

$$V_c = V_{c_1} + V_{c_2} = 12 + 12j = 12\sqrt{2}\,e^{j45°}$$

$$v_c(t) = 12\sqrt{2}\,\cos(2000t + 45°)$$

$\boxed{A_2 = 12\,V}$ $\boxed{B_2 = 45°}$ $\boxed{W_2 = 2000\ 1/s}$

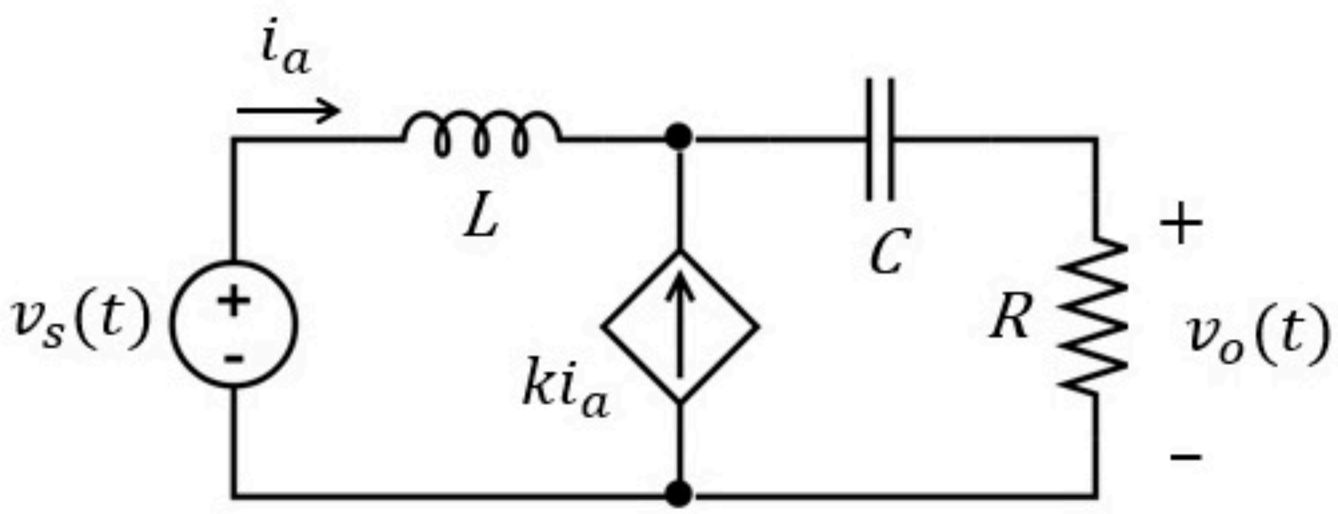
Phasors 008

Unlimited Attempts.

$$v_s(t) = A_1 \cdot \cos(1000t)$$

Find steady state voltage

$$v_o(t) = A_2\sqrt{2} \cdot \cos(1000t + B_2) \quad \text{with } -180^\circ < B_2 \leq 180^\circ$$



Given Variables:

A1 : 5 V

L : 20 mH

C : 20 uF

R : 45 ohm

k : 3 A/A

Calculate the following:

A2 (V) :

2.5

B2 (degrees) :

45

Hint: Use nodal analysis or KVL/KCL.

$v_s(t) = A_1 \cdot \cos(1000t)$

A1 : 2 V

L : 150 mH

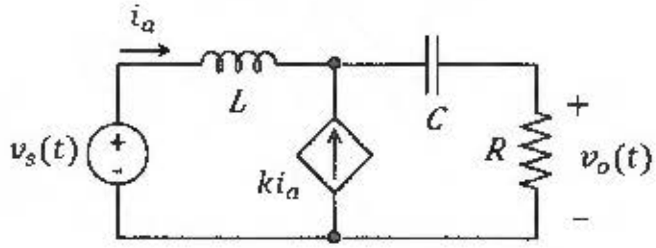
C : 20 uF

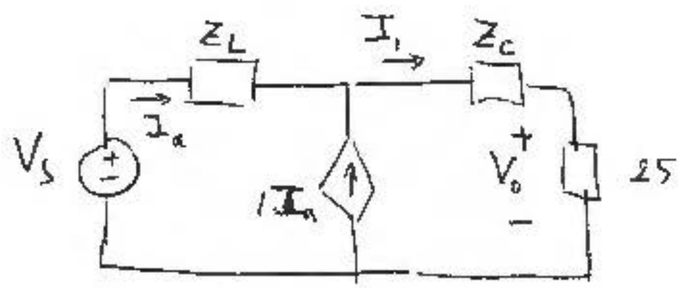
R : 25 ohm

k : 1 A/A

Find steady state voltage

$v_o(t) = A_2\sqrt{2} \cdot \cos(1000t + B_2)$ with $-180° < B_2 \le 180°$





$I_1 = I_a + I_a = 2 I_a$

$Z_L = j\omega L = j150$

$Z_C = \frac{1}{j\omega C} = -j50$

$V_s = 2$

$\underline{KVL}$: $V_s - I_a \cdot Z_L = I_1(Z_C + 25) = 2 I_a (Z_C + 25)$

$$\Rightarrow I_a = \frac{V_s}{Z_L + 2Z_C + 50} = \frac{V_s}{150j - 100j + 50} = \frac{V_s}{50 + 50j}$$

$$V_o = I_1 \cdot 25 = 2 I_a \cdot 25 = \frac{50 \cdot V_s}{50 + 50j} = \frac{2}{1+j}$$

$$= \frac{2}{\sqrt{2}} e^{-j45°} = \sqrt{2}\, e^{-j45°}$$

$v_o(t) = \sqrt{2} \cos(1000t - 45°)$

$\boxed{A_2 = 1\ V}$

$\boxed{B_2 = -45°}$

Phasors 009

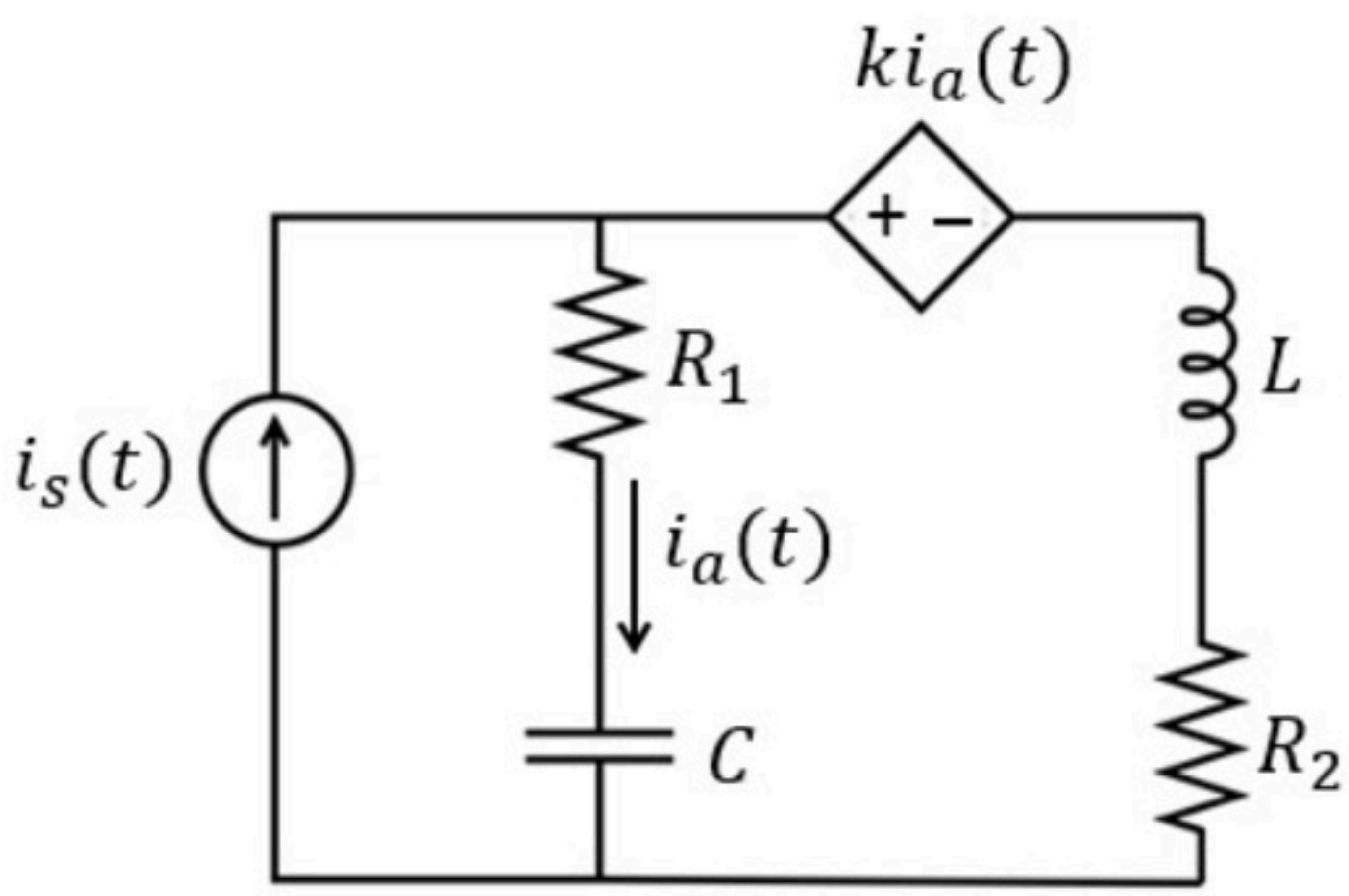
0 of 5 attempts made

$$i_s(t) = A_1 \cdot \cos\left(1000t + \frac{\pi}{2}\right) + A_2 \cdot \cos\left(2000t - \frac{\pi}{2}\right)$$

Assume the system is in steady state. Find the current i_a at times

$t_1 = 4\pi$ ms: $i_a(t_1) = B_1$

$t_2 = 5\pi$ ms: $i_a(t_2) = B_2$



Given Variables:

A1 : 1 A

A2 : 1 A

L : 1 mH

C : 250 uF

R1 : 1 ohm

R2 : 2 ohm

k : 4 V/A

Calculate the following:

B1 (A) :

-2.5

B2 (A) :

-1.5

$i_s(t) = A_1 \cdot \cos(1000t + 90) + A_2 \cdot \cos(2000t - 90)$

Assume the system is in steady state. Find the current i_a at times

$t_1 = 4\pi$ ms: $i_a(t_1) = B_1$

$t_2 = 5\pi$ ms: $i_a(t_2) = B_2$

A1 : 6 A

A2 : 9 A

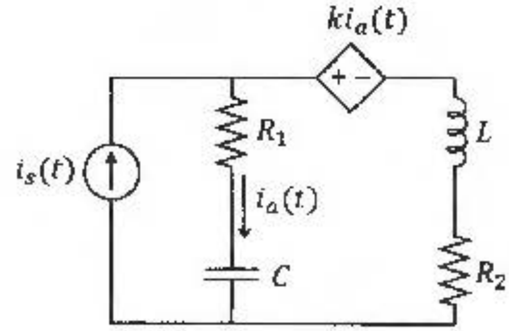
L : 1 mH

C : 250 uF

R1 : 8 ohm

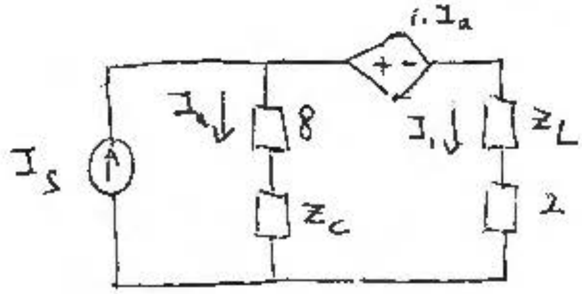
R2 : 2 ohm

k : 1 V/A



2 DIFFERENT ω !

WE NEED TO USE SUPERPOSITION



$\underline{\omega = 1000}$. $Z_L = j \cdot 1000 L = j$

$Z_C = \frac{1}{j\omega C} = -4j$

$I_s = 6 e^{j\frac{\pi}{2}} = 6j$

$\underline{\omega = 2000}$. $Z_L = j 2000 L = 2j$

$Z_C = \frac{1}{j 2000 C} = -2j$

$I_s = 9 e^{-j\frac{\pi}{2}} = -9j$

$$I_1 = I_s - I_a \Rightarrow I_a(8 + Z_C) = 1 \cdot I_a + (I_s - I_a)(2 + Z_L)$$

$$\Rightarrow I_a = I_s \frac{2 + Z_L}{9 + Z_C + Z_L}$$

① $\underline{\omega = 1000}$: $I_a = 6j \frac{(2+j)}{(9-4j+j)} = \frac{6(-1+2j)(3+j)}{3(3-j)(3+j)} = \frac{2}{10}(-5+5j) = -1+j$

$$i_{a_1}(t) = \sqrt{2} \cos(1000t + 135°)$$

② $\underline{\omega = 2000}$: $I_a = (-9j)\frac{2+2j}{9+\cancel{2j-2j}} = 2(1-j) \Rightarrow i_{a_2}(t) = 2\sqrt{2}\cos(2000t - 45°)$

③ $i_a(t) = i_{a_1}(t) + i_{a_2}(t) = \sqrt{2}\cos\left(1000t + \frac{3\pi}{4}\right) + 2\sqrt{2}\cos\left(2000t - \frac{\pi}{4}\right)$

④ $\underline{t = 4\pi \cdot 10^{-3}}$ $i_a = \sqrt{2}\cos\left(4\pi + \frac{3\pi}{4}\right) + 2\sqrt{2}\cos\left(8\pi - \frac{\pi}{4}\right) = \sqrt{2}\cos\left(\frac{3\pi}{4}\right) + 2\sqrt{2}\cos\left(-\frac{\pi}{4}\right)$

$= \sqrt{2}\left(-\frac{\sqrt{2}}{2}\right) + 2\sqrt{2}\left(\frac{\sqrt{2}}{2}\right) = -1 + 2 = 1$ $\boxed{B_1 = 1\text{ A}}$

$\underline{t = 5\pi \cdot 10^{-3}}$. $i_a = \sqrt{2}\cos\left(5\pi + \frac{3\pi}{4}\right) + 2\sqrt{2}\cos\left(10\pi - \frac{\pi}{4}\right) = \sqrt{2}\cos\left(-\frac{\pi}{4}\right) + 2\sqrt{2}\cos\left(-\frac{\pi}{4}\right)$

$= \sqrt{2}\left(\frac{\sqrt{2}}{2}\right) + 2\sqrt{2}\left(\frac{\sqrt{2}}{2}\right) = 1 + 2 = 3$ $\boxed{B_2 = 3\text{ A}}$

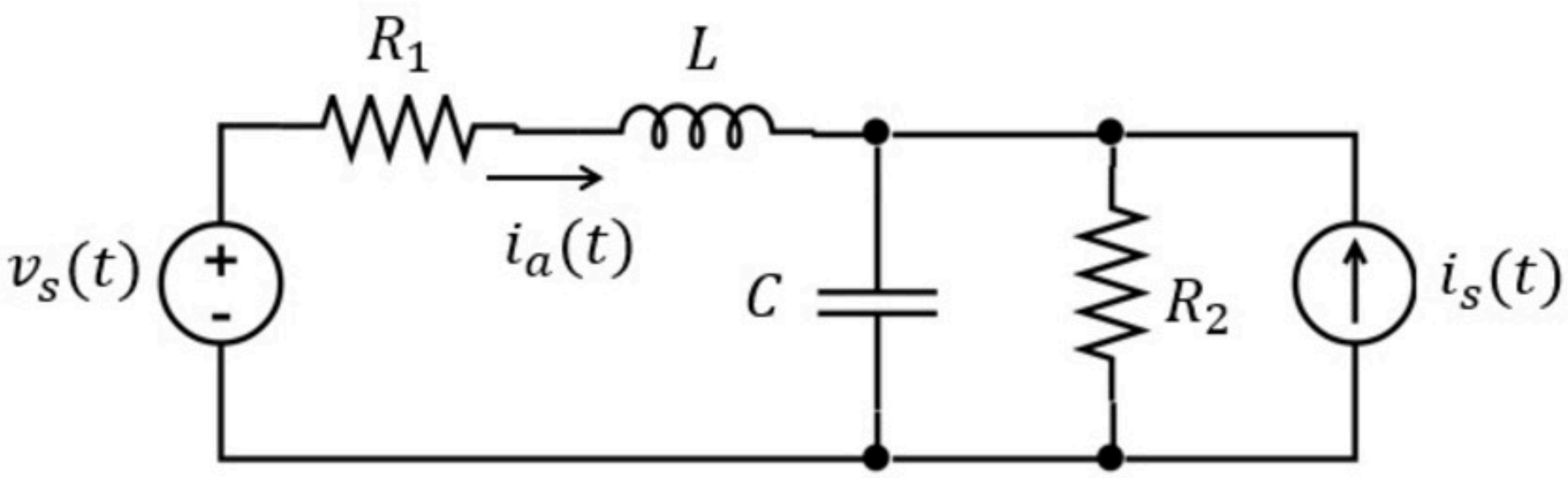
Phasors 010

Problem has been graded.

$$v_s(t) = A_1 \cdot \cos(100t) \quad \text{and} \quad i_s(t) = A_2$$

$$\text{Find } i_a(t) = A_3\sqrt{2} \cdot \cos(100t + B_3) + A_4$$

$$\text{with } -180^\circ < B_3 \leq 180^\circ$$



Given Variables:

A1 : 100 V

A2 : 6 A

C : 0.1 mF

L : 1.5 H

R1 : 50 ohm

R2 : 100 ohm

Calculate the following:

A3 (A) :

0.5

B3 (degrees) :

-45

A4 (A) :

-4

Hint: Use superposition

$v_s(t) = A_1 \cdot \cos(100t)$ and $i_s(t) = A_2$

Find $i_a(t) = A_3\sqrt{2} \cdot \cos(100t + B_3) + A_4$

with $-180° < B_3 \leq 180°$

A1 : 100 V

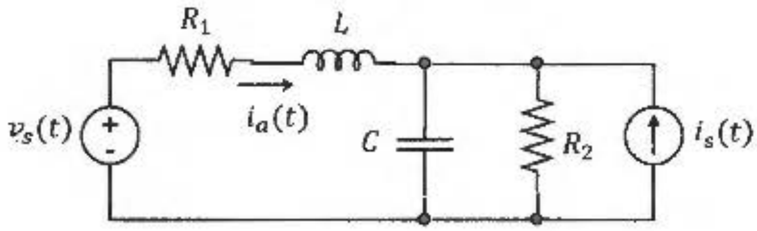
A2 : 6 A

C : 0.1 mF

L : 1.5 H

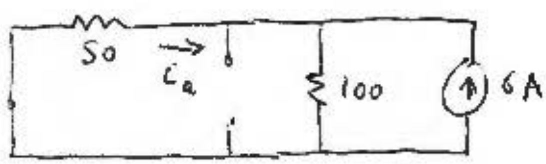
R1 : 50 ohm

R2 : 100 ohm



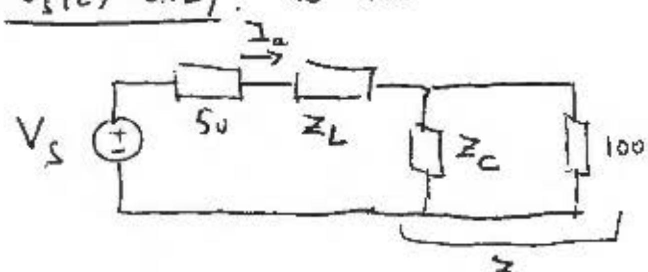
DIFFERENT ω ! WE NEED TO USE SUPERPOSITION

① $\underline{i_s(t) \text{ ONLY}}$ · $\omega = 0$ DC $\Rightarrow$ L SHORT / C OPEN



$$i_{a_1} = -\frac{100}{100+50} \cdot 6 = -4A$$

② $\underline{v_s(t) \text{ ONLY}}$: $\omega = 100$



$$Z_L = j\,100\,L = 150j$$

$$Z_C = \frac{1}{j\,100C} = -100j$$

$$V_s = 100$$

$$Z_1 = \frac{1}{\frac{1}{100} + \frac{1}{-j100}} = \frac{100}{1+j} = 50(1-j)$$

$$I_a = \frac{V_s}{Z_1 + 50 + Z_L} = \frac{100}{50 - 50j + 50 + 150j} = \frac{100}{100 + 100j} = \frac{\sqrt{2}}{2} e^{-j45°}$$

$$i_{a_2} = \frac{\sqrt{2}}{2} \cos(100t - 45°)$$

③ $i_a(t) = i_{a_1} + i_{a_2} = \frac{\sqrt{2}}{2} \cos(100t - 45°) - 4$

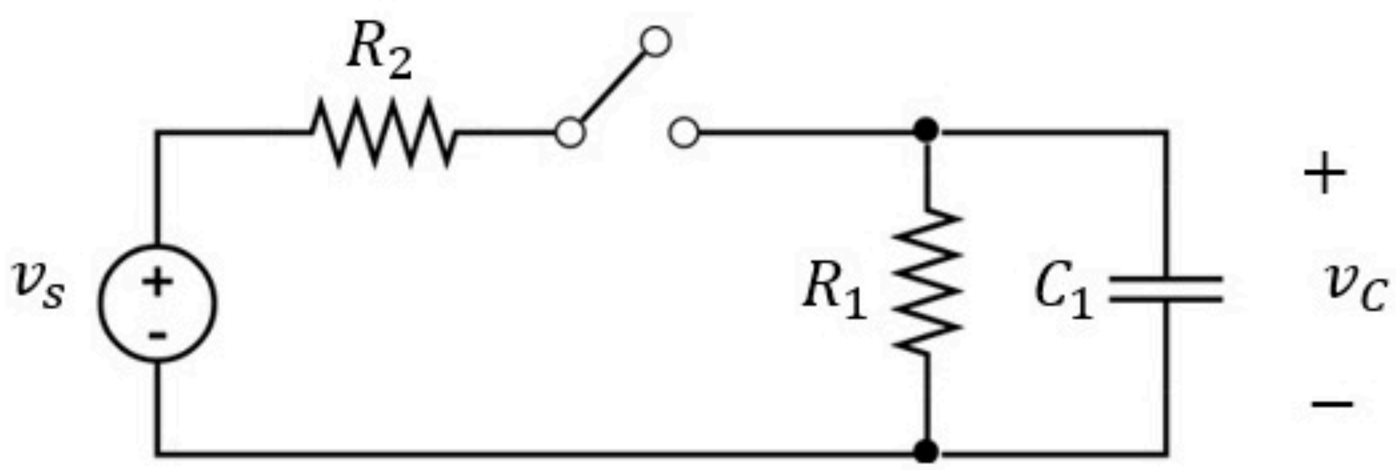
$A_3 = 0.5$ A
$B_3 = -45°$
$A_4 = -4$ A

Phasors 011

Unlimited Attempts.

In the circuit below, $v_s(t) = A_1 \cdot \cos(25 \cdot 10^4 \cdot t)$.

The switch is closed for $t < 0$, and opens at time $t = 0$ s.



Find these voltages:

$$v_1 = v_C(0^+) \qquad v_2 = v_C(t_0)$$

Note, for your calculations, use: $e^{-1/1.5} \approx 0.5$

Solve without a calculator

Given Variables:

R1 : 6 kohm

R2 : 12 kohm

C1 : 1 nF

A1 : 12 V

to : 8 us

Calculate the following:

v1 (V) :

2

v2 (V) :

0.5

Hint: Solve steady state with phasors; use it to find the initial condition for the RC transient analysis.

In the circuit below, $v_s(t) = A_1 \cdot \cos(25 \cdot 10^4 \cdot t)$.

The switch is closed for $t < 0$, and opens at time $t = 0$ s.

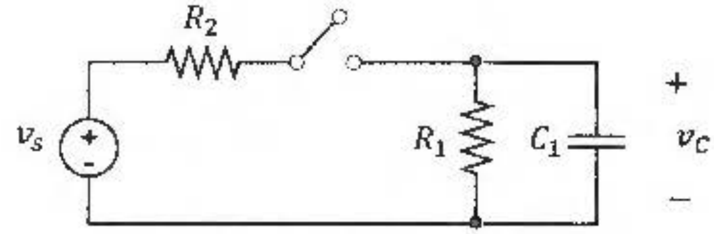
R1 : 6 kohm

R2 : 12 kohm

C1 : 1 nF

A1 : 12 V

to : 8 us



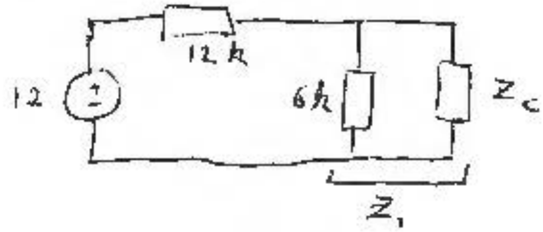
Find these voltages:

$v_1 = v_C(0^+) \qquad v_2 = v_C(t_0)$

Note, for your calculations, use: $e^{-1/1.5} \approx 0.5$

Solve without a calculator

(1) $\underline{t<0}$ ASSUME STEADY STATE @ $t = 0^-$



$$Z_C = \frac{1}{j\,25 \cdot 10^4 \cdot 10^{-9}} = -(4k)\cdot j$$

$$Z_1 = \frac{1}{\frac{1}{6k} + \frac{j}{4k}} = \frac{24k}{4+6j} = \frac{12k}{2+3j}$$

$$V_C = V_S \frac{Z_1}{Z_1 + R_2} = 12 \cdot \frac{12}{12 + 12(2+3j)} = \frac{12}{3+3j} = \frac{4}{1+j} = \frac{4}{\sqrt{2}} e^{-j45°}$$

$$v_c(t) = \frac{4}{\sqrt{2}} \cos\left(25 \cdot 10^4 - \frac{\pi}{4}\right) \Rightarrow v_c(0^-) = \frac{4}{\sqrt{2}} \cos\left(-\frac{\pi}{4}\right) = \frac{4}{\sqrt{2}} \cdot \frac{\sqrt{2}}{2} = 2V$$

(2) $\underline{t = 0^+}$ $\quad v_c(0^+) = v_c(0^-) = 2V \quad \Rightarrow \boxed{v_1 = 2V}$

(3) $\underline{t>0}$: TRANSIENT RESPONSE OF RC CIRCUIT

$v_c(0^+) = 2V \qquad R_{TH} = R_1 \Rightarrow \tau = R_1\, C$

$\qquad = (6k)\cdot(1n) = 6\ \mu s$

$v_c(\infty) = 0\,V$

$$v_c(t) = 2e^{-t/6\mu s} \quad \text{FOR } t>0$$

$$v_c(t_0) = v_c(8\mu s) = 2e^{-8/6} = 2\left(e^{-\frac{1}{1.5}}\right)^2 = \frac{2}{4} = \frac{1}{2}V \qquad \boxed{v_2 = 0.5\,V}$$

Phasors 016

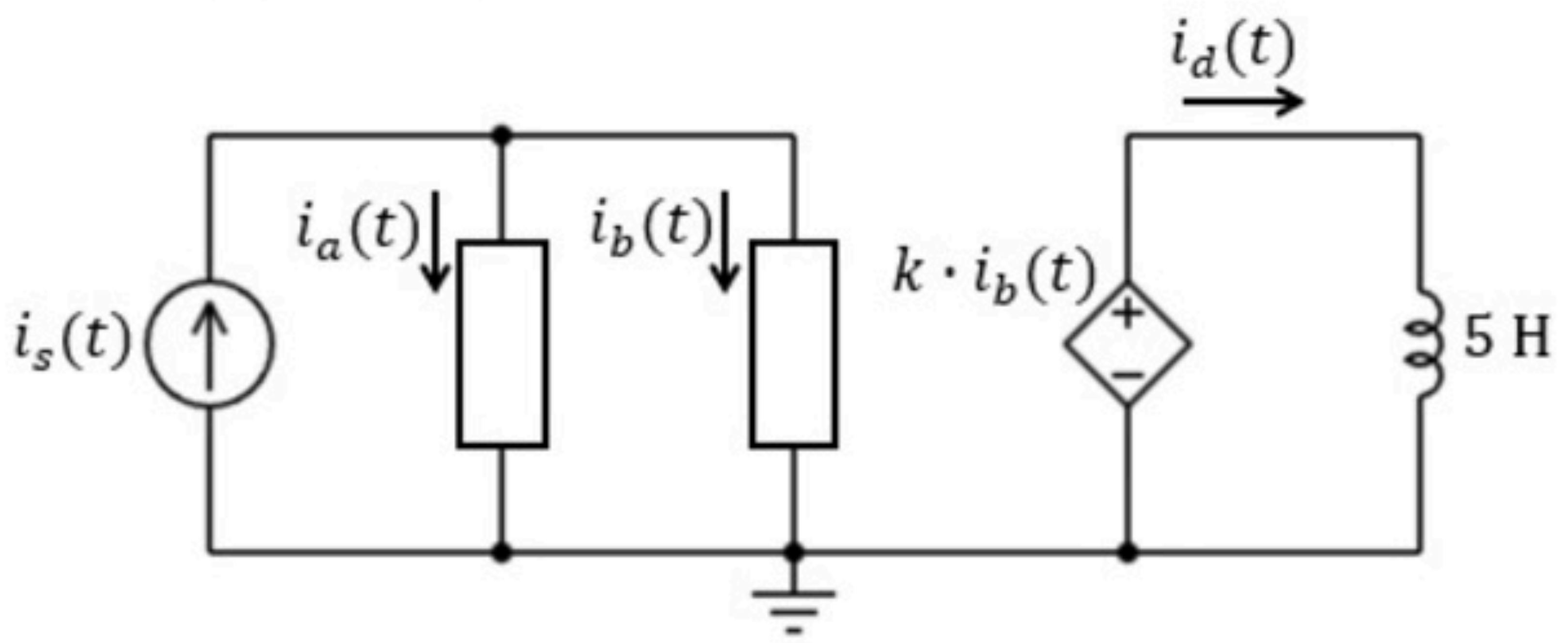
2 of 5 attempts made

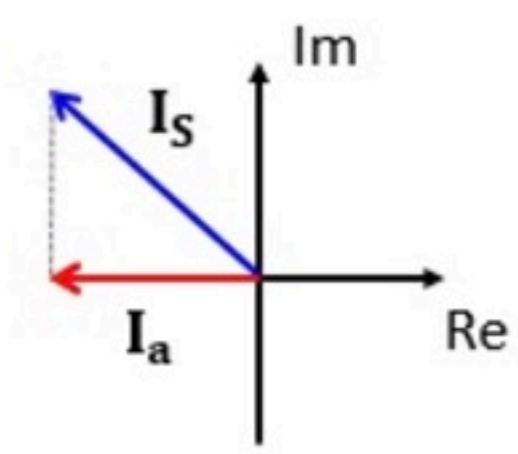
The AC circuit below is in steady-state, and you are not told the ω of the source. The phasor diagram shows the phasors of $\boldsymbol{i_S}$ and $\boldsymbol{i_a}$.
The rectangular boxes represent two circuit elements. One of them is an inductor L_1 (but you don't know if it corresponds to i_a or i_b). The other can be a resistor R_2, a capacitor C_2 or an inductor L_2.
You are also told that the maximum value of $i_a(t)$ is A_1 and the maximum value of $i_S(t)$ is A_2.

a. What is the maximum value of the $i_b(t)$ waveform, i_{bmax}?

b. With $i_d(t)$ expressed as $A \cdot \cos(\omega t + B_1)$, what is B_1? Constraints: $A > 0$ and $-180° < B_1 \leq 180°$.

c. What is the value of ω?





Given Variables:

A1 : 4 A

A2 : 5 A

L1 : 2 mH

R2 : 3 ohm

C2 : 10 mF

L2 : 3 mH

k : -5 V/A

Calculate the following:

ibmax (A) :

3

B1 (degrees) :

180

omega (rad/s) :

2000

The AC circuit below is in steady-state, and you are not told the ω of the source. The phasor diagram shows the phasors of $\boldsymbol{i_S}$ and $\boldsymbol{i_a}$.

The rectangular boxes represent two circuit elements. One of them is an inductor L_1 (but you don't know if it corresponds to i_a or i_b). The other can be a resistor R_2, a capacitor C_2 or an inductor L_2.

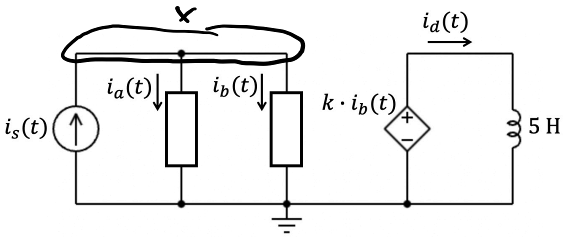
You are also told that the maximum value of $i_a(t)$ is A_1 and the maximum value of $i_S(t)$ is A_2.

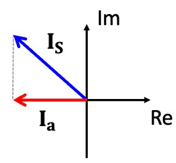
$A_1 = 4\,A$
$A_2 = 5A$
$L_1 = 2\,mH$
$R_2 = 3\Omega$
$C_2 = 10\,mF$
$L_2 = 3\,mH$
$k = -5\,V/A$

a. What is the maximum value of the $i_b(t)$ waveform, i_{bmax}?

b. With $i_d(t)$ expressed as $A \cdot \cos(\omega t + B_1)$, what is B_1? Constraints: $A > 0$ and $-180° < B_1 \le 180°$.

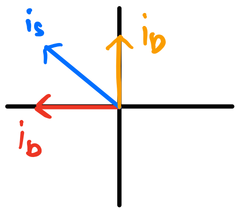
c. What is the value of ω?





a. The max value of a sinusoidal waveform is its amplitude $\Rightarrow i_{bmax} = |I_b|$

KCL@X : $i_s = i_a + i_b \Rightarrow$



$\Rightarrow |I_s|^2 = |I_a|^2 + |I_b|^2$

$|I_b| = \sqrt{|I_s|^2 - |I_a|^2} = \sqrt{5^2 - 4^2} = \sqrt{25-16} = \sqrt{9} = 3 \Rightarrow \boxed{i_{b,max} = 3A}$

b. we can see that $I_d = \frac{k \cdot I_b}{j\omega 5}$

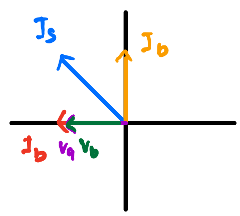
from part a, $|I_b| = 3 \Rightarrow I_b = 3e^{j\frac{\pi}{2}}$

$I_d = \frac{-\cancel{5} \cdot 3e^{j\frac{\pi}{2}}}{j\omega \cancel{5}} = \frac{-3\cancel{e^{j\pi/2}}}{\cancel{e^{j\pi/2}}\omega} = -\frac{3}{\omega} = \frac{3}{\omega}e^{j\pi} \Rightarrow i_d(t) = \frac{3}{\omega}\cos(\omega t + \pi) \Rightarrow \boxed{B_1 = 180°}$

c. Assume Z_a is a resistor and Z_b is the known inductor (I_a goes through Z_a, I_b goes through Z_b)

Define V_a as voltage across Z_a, and V_b across $Z_b \Rightarrow V_a = V_b$ since they are in parallel

Plot the phasors roughly and see if assumption holds



we can see that the resistor current is in phase with the voltage and inductor voltage is ahead of the current

$\Rightarrow$ our assumption is correct ✓

$Z_a = R_2$, $Z_b = j\omega L_1$

$V_a = R_2 I_a$, $V_b = j\omega L_1 I_b$

$V_a = V_b \Rightarrow 3 \cdot 4e^{j\pi} = j\omega \cdot (2\times10^{-3}) \cdot 3e^{j\pi/2}$

$\omega = \frac{3 \cdot 4}{(2\times10^{-3}) \cdot 3}$

$\boxed{\omega = 2000 \text{ rad/s}}$

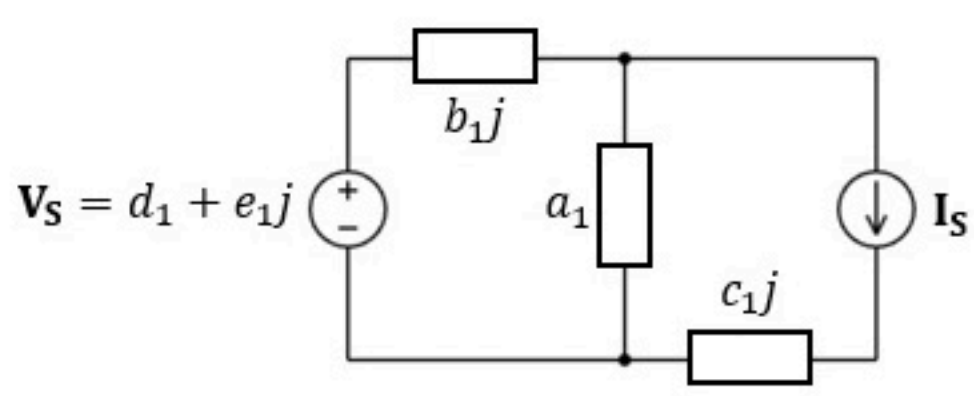
Phasors 017

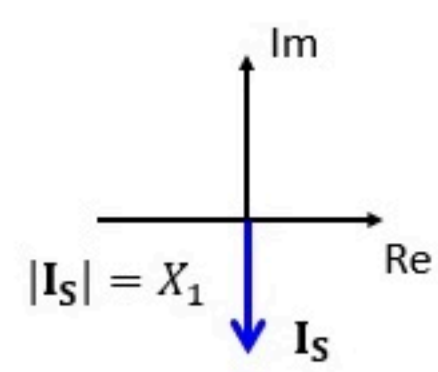
Problem has been graded.

The circuit below represents an AC circuit in steady-state in the phasor domain (for the complex numbers, you may assume units are V, A, Ω, etc. as appropriate). Both sources in the circuit have the same ω, but you are not told the value of ω. Each box represents the impedance of a single circuit element (a resistor, capacitor or inductor).

a. What are the maximum values of waveforms $v_S(t)$ and $i_S(t)$? Enter your answers as Y_1 and Y_2, with $Y_1 = \frac{v_{Smax}}{\sqrt{2}}$ and $Y_2 = i_{Smax}$.

b. We now double ω of both sources but keep everything else the same (such as the capacitor, inductor and resistor values; the amplitude and phase of the sources, etc.). Find the new value of all complex numbers in the circuit (the new value of a_1 is called a_2, etc.) as well as the new magnitude of the current source $|\mathbf{I_S}| = X_2$.





Given Variables:

a1 : 30
b1 : -10
c1 : 5
d1 : 6
e1 : 6
X1 : 5 A

Calculate the following:

Y1 (V) :

5.999999999999999

Y2 (A) :

5

a2 :

30

b2 :

-5

c2 :

10

d2 :

6

e2 :

6

X2 (A) :

5

Hint: Which complex numbers are phasors, which are impedances. Omega is implicit for phasors.

The circuit below represents an AC circuit in steady-state in the phasor domain (for the complex numbers, you may assume units are V, A, Ω, etc. as appropriate). Both sources in the circuit have the same ω, but you are not told the value of ω. Each box represents the impedance of a single circuit element (a resistor, capacitor or inductor).

$a_1 = 50$

$b_1 = -20$

$c_1 = 10$

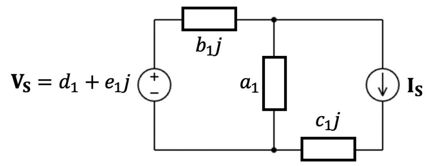
$d_1 = 1$

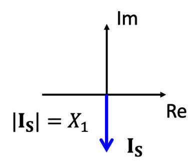
$e_1 = 1$

$X_1 = 5A$

a. What are the maximum value of $v_S(t)$ and $i_S(t)$, called v_{Smax} and i_{Smax} respectively? For v_{Smax}, find Y_1 such that $v_{Smax} = Y_1\sqrt{2}$.

b. We now double ω of both sources but keep everything else the same (such as the capacitor, inductor and resistor values; the amplitude and phase of the sources, etc.). Find the new value of all complex numbers in the circuit (the new value of a_1 is called a_2, etc.) as well as the new magnitude of the current source $|\mathbf{I_S}| = X_2$.





a. The max value of a sinusoidal waveform is its amplitude

$V_{S,max} = |V_S| = \sqrt{d_1^2 + e_1^2} = \sqrt{1^2+1} = \sqrt{2} \Rightarrow Y_1 = 1$

$i_{s,max} = |I_S| = X_1 \Rightarrow \boxed{i_{s,max} = 5A}$

b. Analyze which elements have a dependence on ω

a_1 is the impedance of a resistor $\Rightarrow Z_R = 50$, this has no dependence on ω so if $\omega \to 2\omega$, $50 \to 50 \Rightarrow \boxed{a_2 = 50}$

$b_1 j \Rightarrow -20j$ is the impedance of a capacitor

$Z_C = \frac{1}{j\omega C} \Rightarrow$ if $\omega \to 2\omega$, then $\frac{1}{j2\omega C} = \frac{1}{2(j\omega C)} = \frac{1}{2}\cdot\frac{1}{j\omega C} = \frac{1}{2} Z_C$

if $\omega \to 2\omega$, then $-20j \to \frac{1}{2}(-20j) = -10j \Rightarrow \boxed{b_2 = -10}$

$c_1 j \Rightarrow 10j$ is the impedance of an inductor

$Z_L = j\omega L \Rightarrow$ if $\omega \to 2\omega$, then $j2\omega L = 2(j\omega L) = 2Z_L$

if $\omega \to 2\omega$, then $10j \to 2(10j) = 20j \Rightarrow \boxed{c_2 = 20}$

$V_s = d_1 + e_1 j = 1 + j$ is the phasor for a source $v_s(t) = \frac{\sqrt{2}}{2}\cos(\omega t + \frac{\pi}{4})$

if $\omega \to 2\omega$, then $v_s(t) = \frac{\sqrt{2}}{2}\cos(2\omega t + \frac{\pi}{4}) \Rightarrow V_s = \frac{\sqrt{2}}{2} e^{j\pi/4} = 1 + j \Rightarrow \boxed{\begin{array}{l} d_2 = 1 \\ e_2 = 1 \end{array}}$

$\Rightarrow$ the phasor for a voltage waveform does not depend on ω

Similarly, $i_S(t) = 5\cos(\omega t - \frac{\pi}{2})$ if $\omega \to 2\omega$, $i_S(t) = 5\cos(2\omega t - \frac{\pi}{2}) \Rightarrow \boxed{X_2 = 5A}$

Phasors 018

0 of 5 attempts made

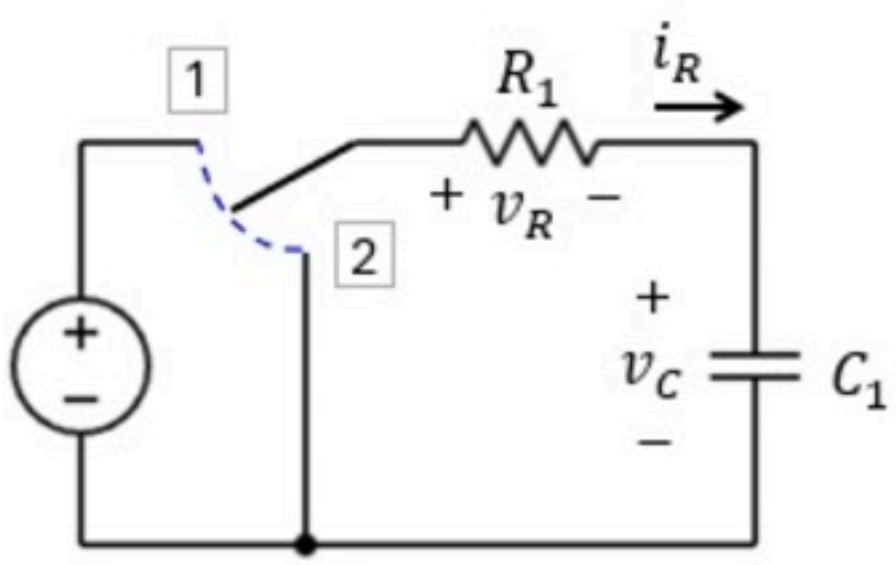
In the circuit below, the switch moves from position 1 to position 2 at time $t = 0$. For $t < 0$ (switch in position 1), you may assume that the system is in steady state. The voltage source is sinusoidal with $\omega = W_1$.

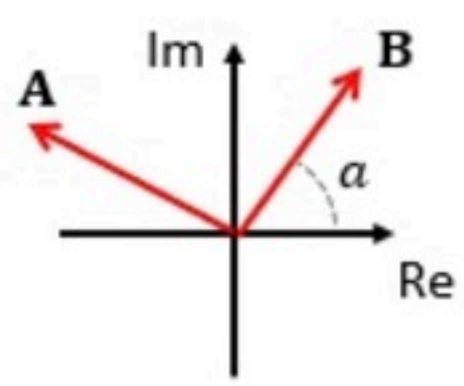
The diagram shows two phasors, **A** and **B**. (Note that the phasors are not drawn to scale. Also, we show three diagrams to illustrate the situation depending on the value of a you were given. You need to select the diagram that corresponds to your given value.) In your diagram, one phasor represents the capacitor voltage v_C and the other the resistor voltage v_R (but you are not told which one is which).

a. Find $i_1 = i_R(0^-)$ (i.e., just before the switch moves to position 2).

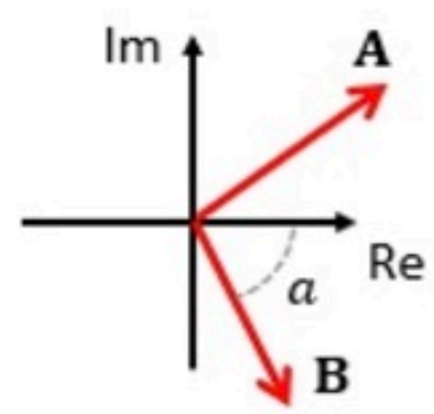
b. Find $i_2 = i_R(0^+)$ (i.e., just after the switch moves to position 2).

$|\mathbf{A}| = X\sqrt{2}$

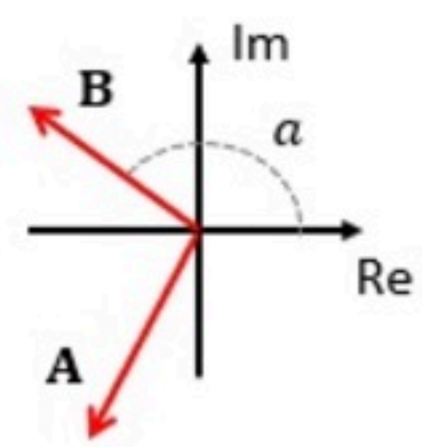




If $0 < a < \pi/2$



If $-\pi/2 < a < 0$



If $\pi/2 < a < \pi$

Given Variables:

W1 : 1 rad/s

X : 25

a : -45 degrees

R1 : 5 ohm

C1 : 1 F

Calculate the following:

i1 (A) :

5

i2 (A) :

-1

In the circuit below, the switch moves from position 1 to position 2 at time $t = 0$. For $t < 0$ (switch in position 1), you may assume that the system is in steady state. The voltage source is sinusoidal with $\omega = W_1$.

$W_1 = 1$ rad/s

$X = 10$

$a = 45°$

$R_1 = 2\Omega$

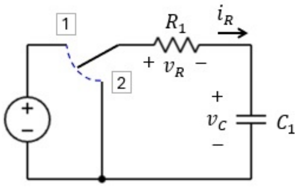
$C_1 = 1F$

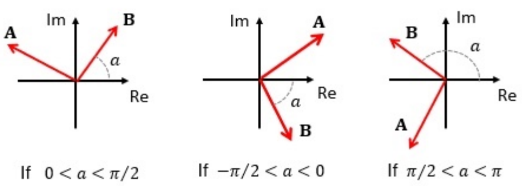
The diagram shows two phasors, **A** and **B**. (Note that the phasors are not drawn to scale. Also, we show three diagrams to illustrate the situation depending on the value of a you were given. You need to select the diagram that corresponds to your given value.) In your diagram, one phasor represents the capacitor voltage v_C and the other the resistor voltage v_R (but you are not told which one is which).

a. Find $i_1 = i_R(0^-)$ (i.e., just before the switch moves to position 2).

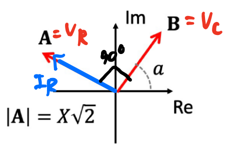
b. Find $i_2 = i_R(0^+)$ (i.e., just after the switch moves to position 2).

$|\mathbf{A}| = X\sqrt{2}$





a. Assume $A = V_R$ and $B = V_C$



We plot I_R such that it is in phase with V_R

$I_R = I_C$ since the resistor is series with the capacitor

$\Rightarrow$ the capacitor current is ahead of the capacitor voltage $\Rightarrow$ our assumption is correct ✓

At $t = 0^-$

$$V_R = X\sqrt{2}\, e^{j(a+90)} = 10\sqrt{2}\, e^{j135}$$

$$i_R = \frac{V_R}{R_1} = \frac{10\sqrt{2}\, e^{j135}}{2} = 5\sqrt{2}\, e^{j135}$$

$$i_R(t) = 5\sqrt{2}\cos(t + 135)$$

$$i_R(0^-) = 5\sqrt{2}\cos(0 + 135) = 5\sqrt{2}\cdot\left(-\frac{\sqrt{2}}{2}\right) \Rightarrow \boxed{i_1 = -5A}$$

b. At $t = 0^+$, the capacitor voltage cannot change instantaneously

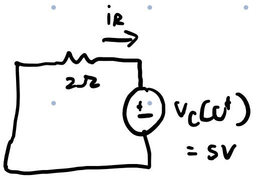
$$Z_C = \frac{1}{j\omega_1 C_1} = \frac{1}{j(1)(1)} = -j$$

$$V_C = i_R \cdot Z_C = 5\sqrt{2}\, e^{j135} \cdot -j = 5\sqrt{2}\, e^{j45}$$

$$V_C(t) = 5\sqrt{2}\cos(t + 45)$$

$$V_C(0^-) = 5\sqrt{2}\cos(0 + 45) = 5\sqrt{2}\cdot\left(\frac{\sqrt{2}}{2}\right) = 5V \Rightarrow V_C(0^+) = 5V$$

at $t = 0^+$



$$i_R(0^+) = \frac{-5}{2} A$$

$$\boxed{i_2 = -2.5 A}$$

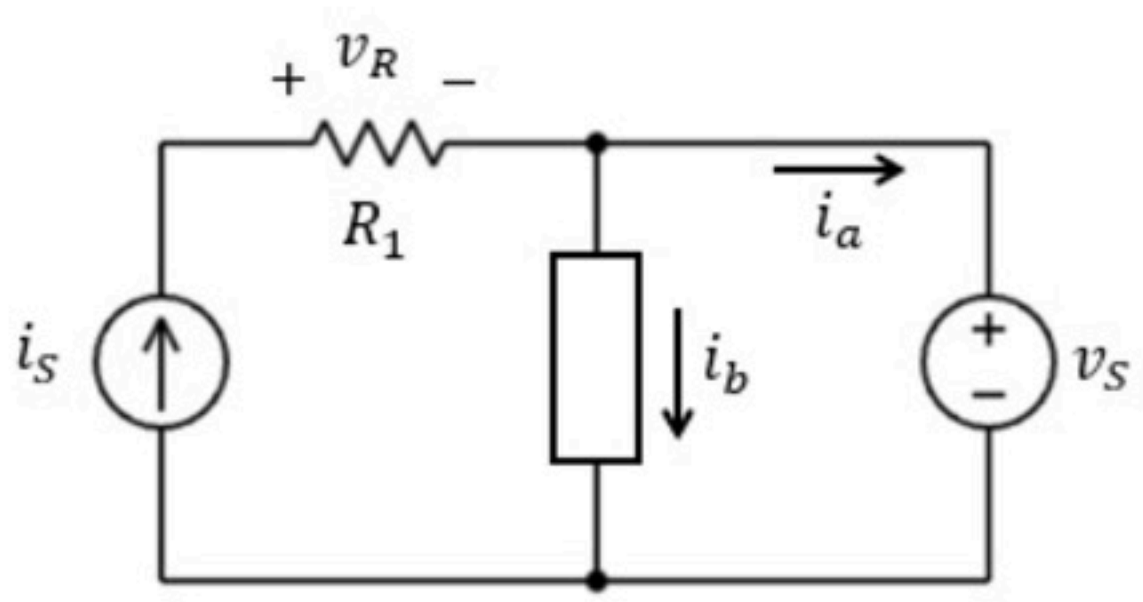
Phasors 019

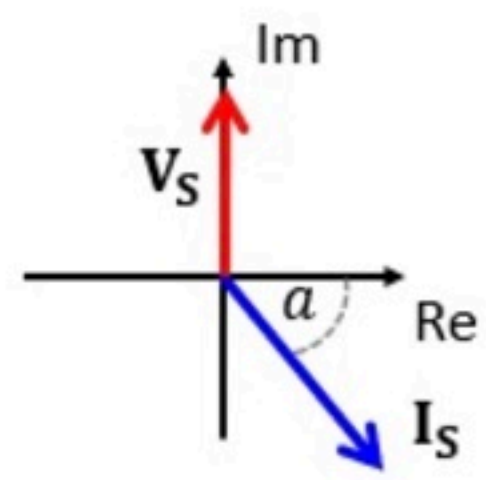
0 of 5 attempts made

The AC circuit below has $\omega = W_1$ and is in steady state. The phasor diagram shows the phasors of v_S and i_S. You are given the angle a, and vector lengths $|\mathbf{I_S}| = A_1$ and $|\mathbf{V_S}| = A_2\sqrt{b}$. The diagram is not necessarily drawn to scale (but $\mathbf{V_S}$ is along the imaginary axis). The element in the center (rectangular box) is either an inductor or a capacitor but you are not told which.

a. At what time does v_R reach its maximum value? Enter $k = t_0 \cdot \frac{12}{\pi}$, where t_0 is the first time that the maximum is reached, for $t_0 \geq 0$. (Hint: convert a to radians first)

b. We select the mystery element such that $|\mathbf{I_a}|$ is minimized (note that this is the current through the voltage source). What is the mystery element type (enter 1 for capacitor, 2 for inductor)? What is its value X (i.e., either the capacitance or the inductance value, in F or H respectively)?





$-\pi/2 < a < 0$

Given Variables:

W1 : 4 rad/s

a : -30 degrees

A1 : 1 A

A2 : 10 V

b : 3

R1 : 1 ohm

Calculate the following:

k (s) :

0.5

Type :

2

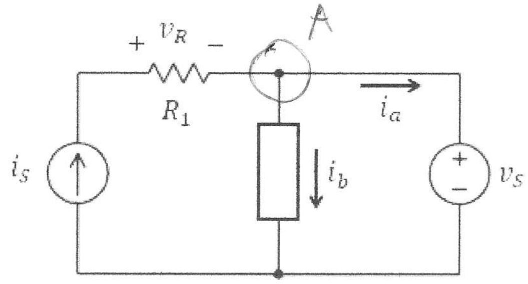
X :

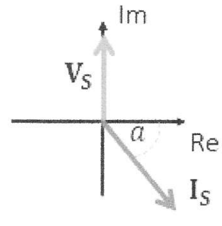
5

The AC circuit below has $\omega = W_1$ and is in steady state. The phasor diagram shows the phasors of v_S and i_S. You are given the angle a, and vector lengths $|\mathbf{I_S}| = A_1$ and $|\mathbf{V_S}| = A_2\sqrt{b}$. The diagram is not necessarily drawn to scale (but $\mathbf{V_S}$ is along the imaginary axis). The element in the center (rectangular box) is either an inductor or a capacitor but you are not told which.

a. At what time does v_R reach its maximum value? Enter $k = t_0 \cdot \frac{12}{\pi}$, where t_0 is the first time that the maximum is reached, for $t_0 \geq 0$. (Hint: convert a to radians first)

b. We select the mystery element such that $|\mathbf{I_a}|$ is minimized (note that this is the current through the voltage source). What is the mystery element type (enter 1 for capacitor, 2 for inductor)? What is its value X (i.e., either the capacitance or the inductance value, in F or H respectively)?





$-\pi/2 < a < 0$

$W_1 = 2$ rad/s
$a = -30°$
$A_1 = 2$ A
$A_2 = 10$ V
$b = 3$
$R_1 = 1\,\Omega$

(a) $V_R = R_1 I_S = R_1 \cdot A_1 e^{ja} = 2e^{-j30°}$

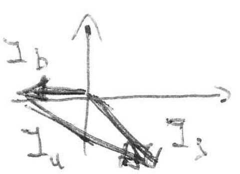
$v_{R\,MAX} = |V_R|$ $\qquad v_R(t) = 2\cos(2t - 30°)$ $\qquad$ MAX WHEN $\cos\theta = 1$

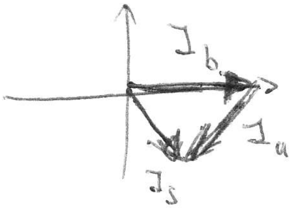
$\theta = 0 \Rightarrow 2t_0 - \frac{\pi}{6} = 0 \Rightarrow t_0 = \frac{\pi}{12} \Rightarrow k = t_0 \cdot \frac{12}{\pi} = 1$ $\quad \boxed{k = 1}$

(b) KCL @ A: $I_S = I_B + I_A$

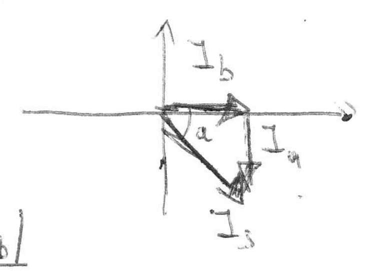
If the mystery element is a capacitor or inductor: I_b is perpendicular to V_S

Let's look at different options $\qquad$ smallest I_a





etc. ...



$\cos(-a) = \frac{|I_b|}{|I_s|} \Rightarrow \cos\left(\frac{\pi}{6}\right) = \frac{\sqrt{3}}{2} = \frac{|I_b|}{2}$

$|I_b| = \sqrt{3}$ $\quad$ on the real axis $\Rightarrow I_b = \sqrt{3}$

also: $V_s = Z \cdot I_b \Rightarrow Z = \frac{V_s}{I_b} = \frac{10\sqrt{3}\,j}{\sqrt{3}} = 10j$

This must be an inductor: $Z = j\omega L = 10j$

$\Rightarrow \omega L = 10 \Rightarrow L = \frac{10}{2} = 5$ H

$\boxed{X = 5}$

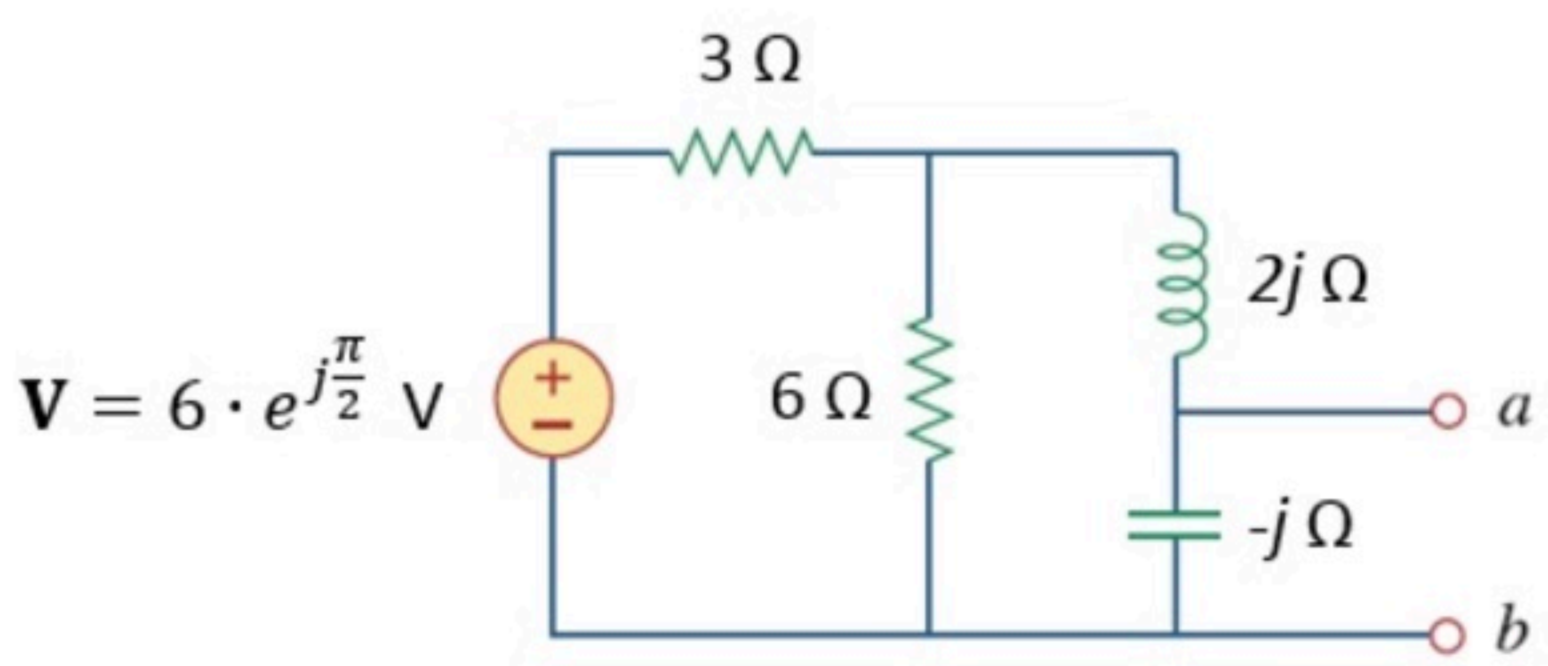
PP Phasors 021

Unlimited Attempts.

Find the Thevenin equivalent model between a and b, in phasor notation:

$\mathbf{V_{Th}} = a + jb$

$\mathbf{Z_{Th}} = c + j\mathrm{d}$



Given Variables:

. : . .

Calculate the following:

a (V) :

1.6

b (V) :

-0.8

c (ohm) :

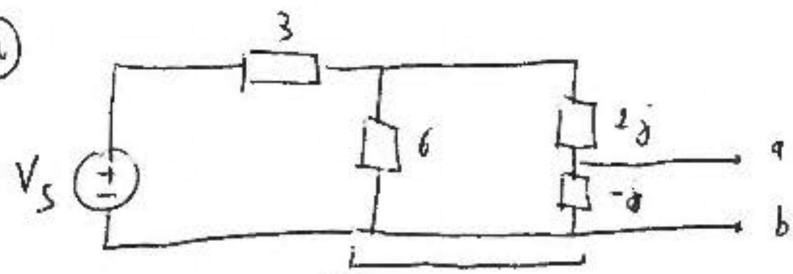
0.4

d (ohm) :

-1.2

Hint: You can use voltage divider and series/parallel connections of impedances

(a)



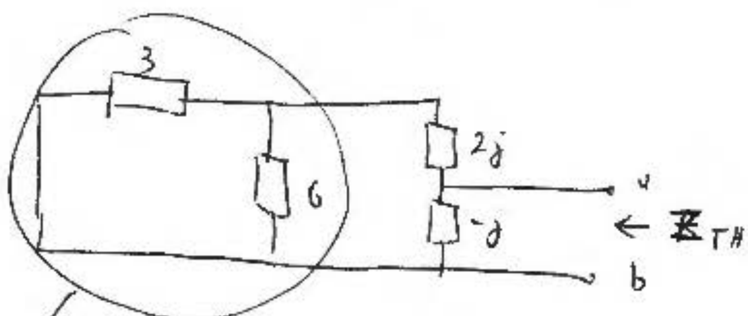
$$Z_1 = 6 \parallel (2j - j) = 6 \parallel j = \frac{1}{\frac{1}{6} + \frac{1}{j}} = \frac{6j}{6+j}$$

$$V_{ab} = V_s \frac{Z_1}{Z_1 + 3} \cdot \frac{-j}{2j - j} = V_s \cdot \frac{6j}{6j + 3(6+j)} \frac{-j}{j} = -V_s \frac{6j}{18 + 9j}$$

$$= \frac{-6e^{j\frac{\pi}{2}} \cdot 6j}{9(2+j)} \frac{(2-j)}{(2-j)} = \frac{-6j \cdot 6j}{9} \frac{(2-j)}{(4+1)} = \frac{36}{9} \cdot \frac{2-j}{5} = \frac{4}{5}(2-j)$$

$$V_{TH} = V_{ab} = \frac{8}{5} - \frac{4}{5} j \qquad \boxed{a = 1.6\,V} \quad \boxed{b = -0.8\,V}$$

(b)



$$3 \parallel 6 = \frac{1}{\frac{1}{3} + \frac{1}{6}} = \frac{6}{3} = 2\,\Omega$$

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

$$= \frac{(2-2j)(2-j)}{(2+j)(2-j)} = \frac{(4 - 2j - 4j - 2)}{5} = \frac{2}{5} - \frac{6}{5} j$$

$$Z_{TH} = \frac{2}{5} - \frac{6}{5} j \qquad \boxed{c = 0.4\,\Omega} \quad \boxed{d = -1.2\,\Omega}$$