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 $\boldsymbol{i_a}$.

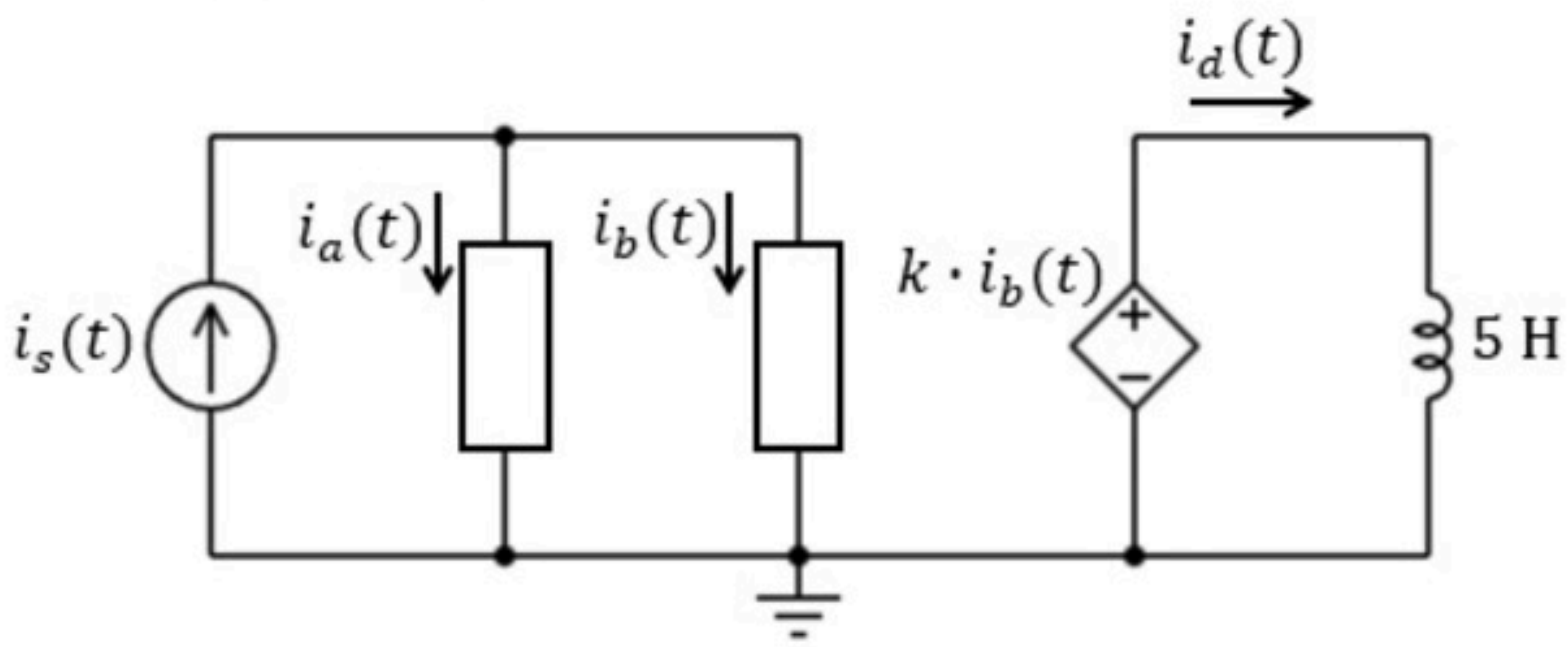
The rectangular boxes represent two circuit elements. One of them is an inductor L_1 (but you don't know if it corresponds to i_a or i_b). The other can be a resistor R_2, a capacitor C_2 or an inductor L_2.

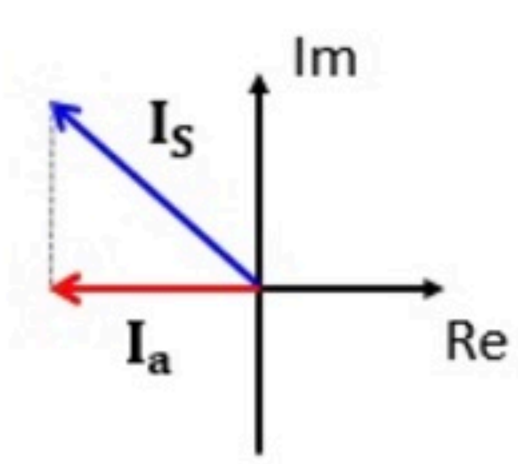
You are also told that the maximum value of $i_a(t)$ is A_1 and the maximum value of $i_S(t)$ is A_2.

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

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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.

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

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 $-180° < B_1 \le 180°$.

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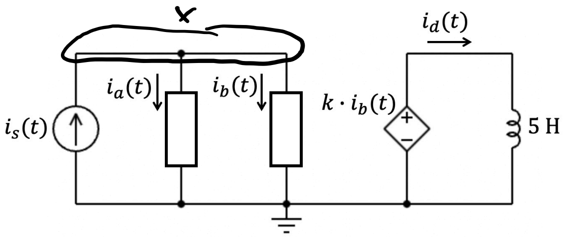
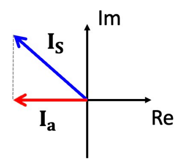
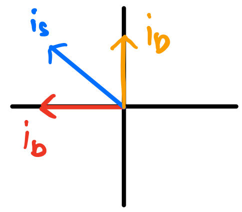




a. The max value of a sinusoidal waveform is its amplitude $\Rightarrow i_{bmax} = |I_b|$

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 $I_d = \dfrac{k \cdot I_b}{j\omega 5}$

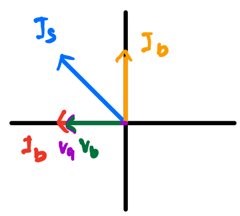
from part a, $|I_b| = 3 \Rightarrow I_b = 3e^{j\frac{\pi}{2}}$

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

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 ✓

$\left.\begin{array}{l} Z_a = R_2, \; Z_b = j\omega L_1 \\ V_a = R_2 I_a, \; V_b = j\omega L_1 I_b \end{array}\right\}$

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

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

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