

ELECTROTECHNICS

AC CIRCUITS 1

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1 AC CIRCUITS

Example 1

Assignment

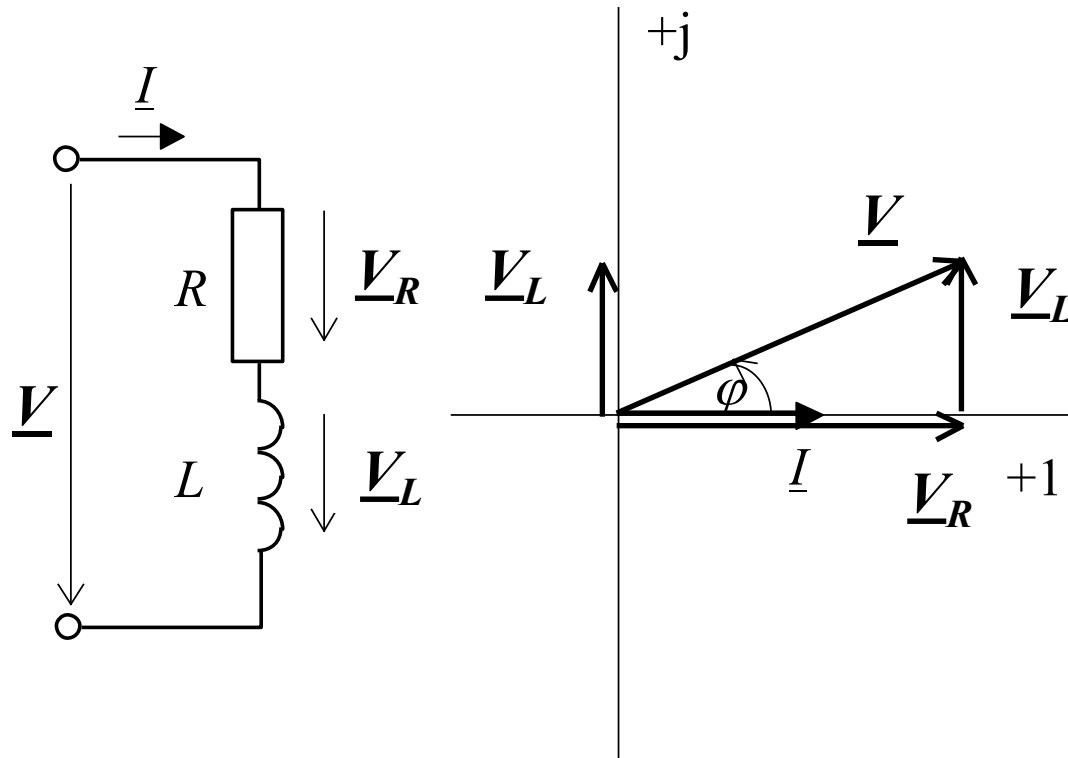
A coil with inductance $L = 64 \text{ mH}$ and resistance $R = 6,8 \Omega$ is connected to the AC source of $V = 230 \text{ V}$, $f = 50 \text{ Hz}$.

Calculate coil impedance, current, voltage on the coil inductance and resistance, phase shift between voltage and current.

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Example 1

Wiring diagram (substitution diagram of a real coil)



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Example 1

Solution

Impedance calculation of the circuit:

- **Reactance of the coil:**

$$X_L = \omega \cdot L = 2 \cdot \pi \cdot f \cdot L = 2 \cdot \pi \cdot 50 \cdot 0,064 = 20,2 \, \Omega$$

- **Resistance of the coil:**

$$R = 6,8 \, \Omega$$

- **Impedance absolute value: :**

$$Z = \sqrt{R^2 + X_L^2} = \sqrt{6,8^2 + 20,2^2} = 21,4 \, \Omega$$

Current: $I = \frac{V}{Z} = \frac{230}{21,4} = 10,8 \, \text{A}$

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Example 1

Solution

Voltage on the coil inductance:

$$V_L = X_L \cdot I = 20,2 \cdot 10,8 = 218,2 \text{ V}$$

Voltage on the coil resistance:

$$V_R = R \cdot I = 6,8 \cdot 10,8 = 73,4 \text{ V}$$

Phase shift between voltage and current:

$$\operatorname{tg} \varphi = \frac{V_L}{V_R} = \frac{X_L}{R} = \frac{20,2}{6,8} = 2,97 \rightarrow \varphi = 71,4^\circ$$

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Example 2

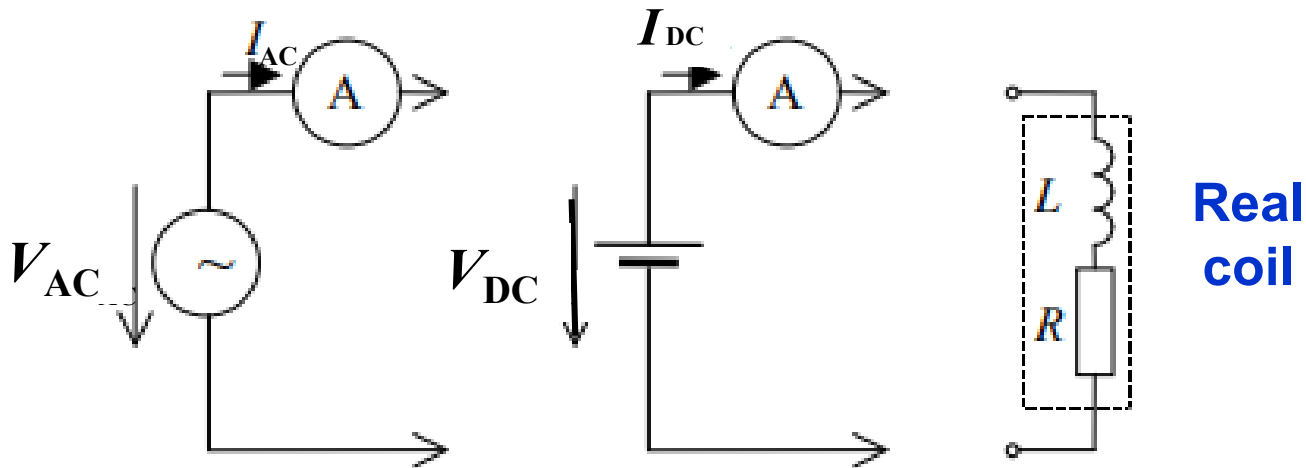
Assignment

If we connect a real coil to a DC source of voltage $V_{DC} = 10 \text{ V}$ the current $I_{DC} = 2,5 \text{ A}$ will flow across it. After disconnecting we connect it to an AC source of voltage $V_{AC} = 10 \text{ V}$, $f = 50 \text{ Hz}$ and now the current $I_{AC} = 2 \text{ A}$ will flow. Calculate inductance of the coil.

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Example 2

Wiring diagram



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Example 2

Solution

1. DC voltage: coil resistance is calculated from voltage and current:

$$R = \frac{V_{DC}}{I_{DC}} = \frac{10}{2,5} = 4 \, \Omega \quad (X_L = 0, f = 0)$$

2. AC voltage: coil impedance is calculated from voltage and current, then inductance:

$$Z = \frac{V_{AC}}{I_{AC}} = \frac{10}{2} = 5 \, \Omega$$

$$Z = \sqrt{R^2 + X_L^2} \rightarrow X_L = \sqrt{Z^2 - R^2} = \sqrt{5^2 - 4^2} = 3 \, \Omega$$

$$X_L = \omega \cdot L \rightarrow L = \frac{X_L}{\omega} = \frac{3}{2 \cdot \pi \cdot 50} = 9,55 \cdot 10^{-3} \, \text{H} = 9,55 \, \text{mH}$$

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Example 3

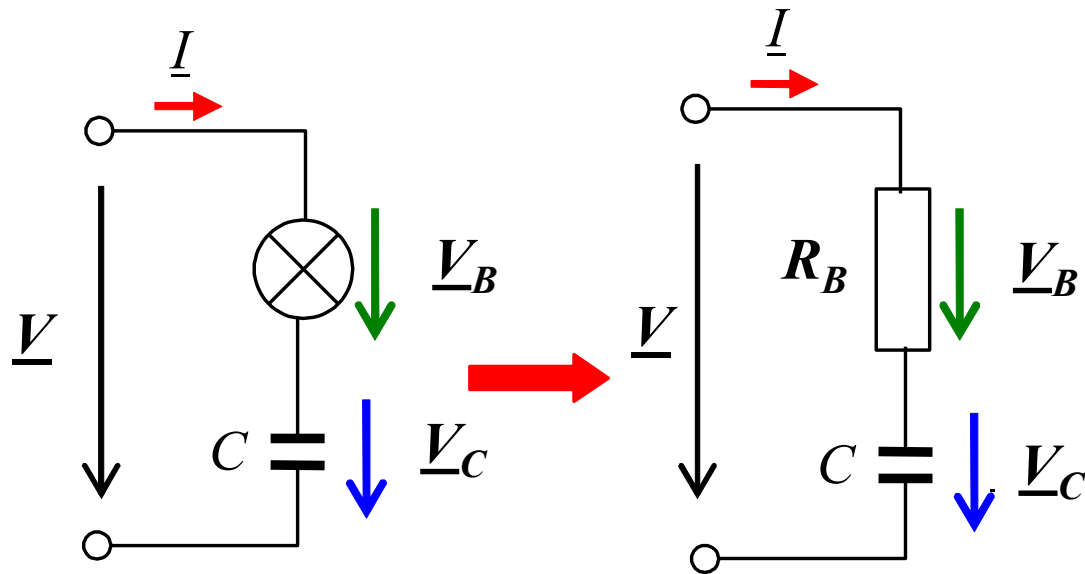
Assignment

Calculate capacity of capacitor which must be connected into series with a bulb of input power $P_B = 60 \text{ W}$ and of voltage $V_B = 24 \text{ V}$ to be connected to a source of AC voltage $V = 230 \text{ V}$, $f = 50 \text{ Hz}$.

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Example 3

Wiring diagram



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Example 3

Solution

To calculate capacitor capacity its voltage and current must be known:

Voltage on the capacitor:

$$\underline{V} = \underline{V}_B + \underline{V}_C \rightarrow V = \sqrt{V_B^2 + V_C^2} \rightarrow V_C = \sqrt{V^2 - V_B^2} = \sqrt{230^2 - 24^2} = 228,7 \text{ V}$$

Capacitor current: $P_B = V_B \cdot I \rightarrow I = \frac{P_B}{V_B} = \frac{60}{24} = 2,5 \text{ A}$

Capacitor reactance: $X_C = \frac{V_C}{I} = \frac{228,7}{2,5} = 91,5 \Omega$

Capacity: $X_C = \frac{1}{\omega \cdot C} \rightarrow C = \frac{1}{\omega \cdot X_C} = \frac{1}{91,5 \cdot 2\pi \cdot 50} = 34,8 \cdot 10^{-6} \text{ F}$

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Example 4

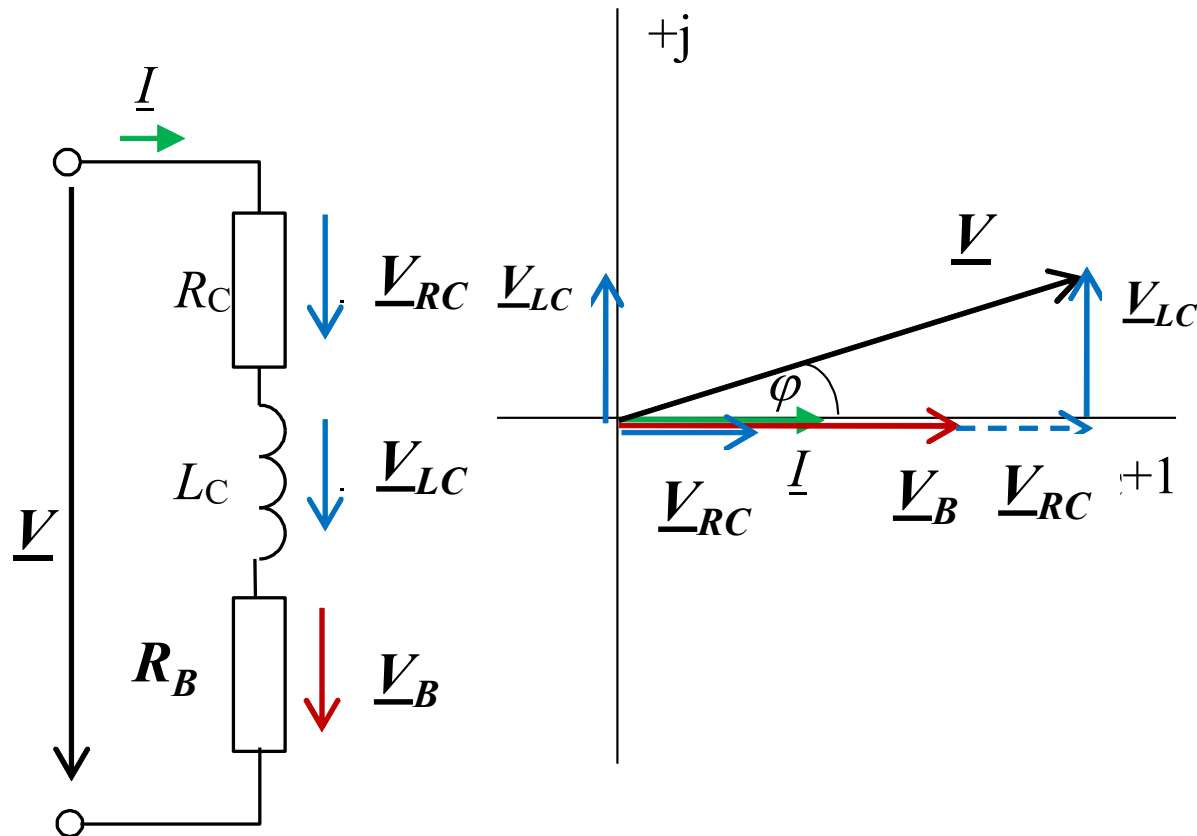
Assignment

Into series with a real coil of winding resistance $R = 5 \, \Omega$ and inductance $L = 100 \, \text{mH}$ a bulb is connected. The bulb resistance is equal to $R_B = 25 \, \Omega$ (during operation). Supply voltage is $V = 88 \, \text{V}$, frequency $f = 50 \, \text{Hz}$. Calculate bulb input power.

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Example 4

Wiring diagram



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Example 4

Solution

Circuit impedance:

- **Resistance of the coil and the bulb can be added up:**

$$R = R_C + R_B = 5 + 25 = 30 \, \Omega$$

- **Reactance of the coil:**

$$X_{LC} = \omega \cdot L = 2\pi \cdot 50 \cdot 0,1 = 31,4 \, \Omega$$

- **Impedance:** $Z = \sqrt{R^2 + X_{LC}^2} = \sqrt{30^2 + 31,4^2} = 43,4 \, \Omega$

Circuit current: $I = \frac{V}{Z} = \frac{88}{43,4} = 2 \, \text{A}$

Bulb input power: $P_B = V_B \cdot I = R_B \cdot I \cdot I = 25 \cdot 2 \cdot 2 = 100 \, \text{W}$