

ELECTROTECHNICS

AC CIRCUITS 2

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1 AC CIRCUITS

Example 5

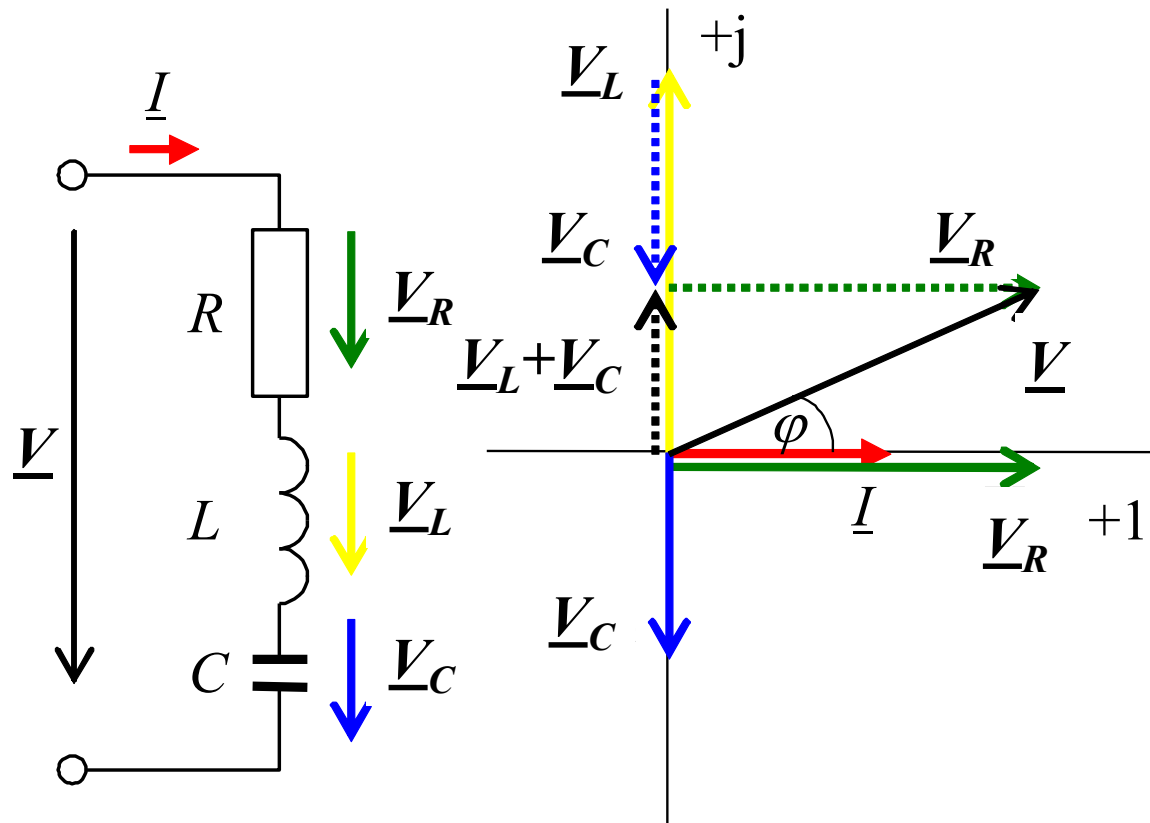
Assignment

In a series circuit resistor with resistance $R = 120 \, \Omega$, inductor with inductance $L = 96 \, \text{mH}$ and capacitor with capacity $C = 40 \, \mu\text{F}$ are connected. The circuit is supplied from a source of AC voltage $V = 230 \, \text{V}$, $f = 50 \, \text{Hz}$. Calculate circuit impedance, current, voltages on the loads, phase shift between voltage and current, active, reactive and apparent power.

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Example 5

Wiring diagram



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Example 5

Solution

Circuit impedance:

- Reactance of the inductor:

$$X_L = \omega \cdot L = 2\pi \cdot f \cdot L = 2\pi \cdot 50 \cdot 96 \cdot 10^{-3} = 30,2 \, \Omega$$

- Reactance of the capacitor:

$$X_C = \frac{1}{\omega \cdot C} = \frac{1}{2\pi \cdot 50 \cdot 40 \cdot 10^{-6}} = 79,6 \, \Omega$$

- Impedance:

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{120^2 + (30,2 - 79,6)^2} = 129,8 \, \Omega$$

Circuit current: $I = \frac{V}{Z} = \frac{230}{129,8} = 1,8 \, \text{A}$

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Solution

Voltage on the resistor:

$$V_R = R \cdot I = 120 \cdot 1,8 = 216 \text{ V}$$

Voltage on the inductor:

$$V_L = X_L \cdot I = 30,2 \cdot 1,8 = 54,4 \text{ V}$$

Voltage on the capacitor:

$$V_C = X_C \cdot I = 79,6 \cdot 1,8 = 143,3 \text{ V}$$

Phase shift: $\varphi = \arctg \frac{V_L - V_C}{V_R} = \arctg \frac{X_L - X_C}{R} =$

$$\arctg \frac{30,2 - 79,6}{120} = -22,4^\circ$$

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Solution

Active power:

$$P = V \cdot I \cdot \cos\varphi = 230 \cdot 1,8 \cdot \cos 22,4^\circ = 383 \text{ W}$$

Reactive power:

$$Q = V \cdot I \cdot \sin\varphi = 230 \cdot 1,8 \cdot \sin 22,4^\circ = 158 \text{ var}$$

Note: reactive power is negative, which means that it is capacitive one, but absolute value is calculated.

Apparent power:

$$S = V \cdot I = 230 \cdot 1,8 = 414 \text{ VA}$$

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Example 6

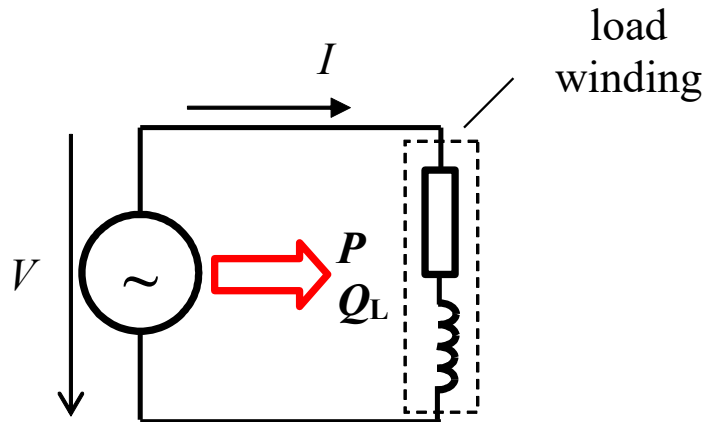
Assignment

For one-phase appliance of R - L type (e.g. electrical motor) with active input power $P = 10$ kW and power factor $\cos\phi = 0,75$ design a power-factor capacitor to compensate the power factor to the standardized value of $\cos\phi_k = 0,95$. Supply voltage is $V = 230$ V. Calculate capacitor reactive power, its capacity and current.

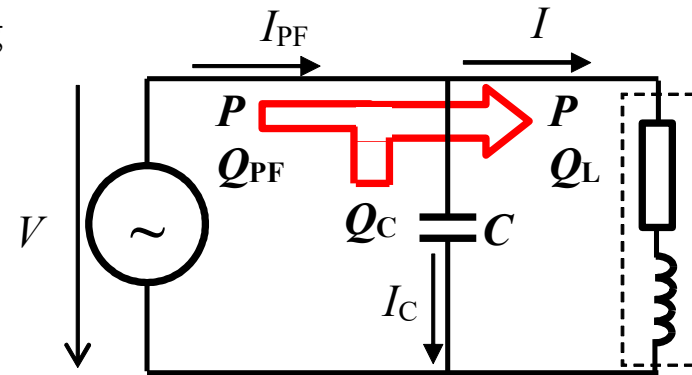
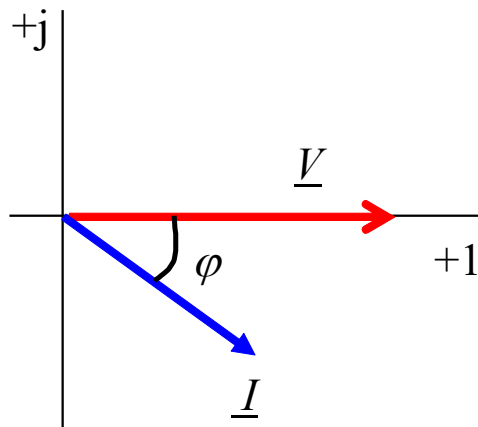
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Example 6

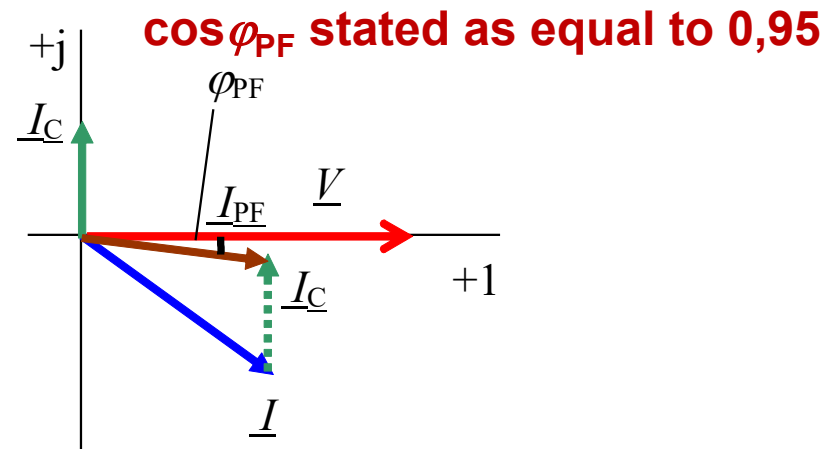
Wiring diagram



without power factor correction



with power factor correction



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Example 6

Solution

Phase shifts calculation:

$$\cos\varphi = 0,75 \rightarrow \varphi = 41,4^\circ$$

$$\cos\varphi_K = 0,95 \rightarrow \varphi_K = 18,2^\circ$$

Calculation of power-factor capacitor power:

- **Appliance reactive power:**

$$Q_S = P \cdot \operatorname{tg}\varphi = 10000 \cdot \operatorname{tg}41,4^\circ = 8819 \text{ var}$$

- **Reactive power drawn from the source at PF correction:**

$$Q_K = P \cdot \operatorname{tg}\varphi_K = 10000 \cdot \operatorname{tg}18,2^\circ = 3286 \text{ var}$$

- **Required reactive power of the capacitor:**

$$Q_C = Q_K - Q_S = 3286 - 8819 = -5533 = 5533 \text{ var} \rightarrow \text{capacitive type}$$

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Example 6

Solution

Current of the power-factor capacitor:

$$Q_C = V \cdot I_C \cdot \sin\varphi_C = V \cdot I_C \rightarrow I_C = \frac{Q_C}{V} = \frac{5533}{230} = 24 \text{ A}$$

Capacity of the power-factor capacitor:

- Reactance:

$$X_C = \frac{V}{I_C} = \frac{230}{24} = 9,58 \Omega$$

$$X_C = \frac{1}{2\pi \cdot f \cdot C} \rightarrow C = \frac{1}{2\pi \cdot f \cdot X_C} = \frac{1}{2\pi \cdot 50 \cdot 9,58} \\ = 3,32 \cdot 10^{-4} \text{ F}$$