BE1M13VES

Manufacturing of Electrical Components

Michal Brejcha

CTU in Prague

Prague, 2017

Overview

TOPIC

Phasors

Phasor is representation of sinusoidal function by complex number. Transformation can be defined by the equation:

$$u = U_m \cdot sin\left(\omega \cdot t + \varphi\right) = Im\left\{U_m \cdot e^{j(\omega t + \varphi)}\right\}$$

Complex number, phasor:

$$\hat{U} = U_m \cdot e^{j\varphi}$$

Rewritten transformation with phasor:

$$u = U_m \cdot sin\left(\omega \cdot t + \varphi\right) = Im\left\{\hat{U} \cdot e^{j\omega t}\right\}$$

Phasors - Features

- Part $e^{j\omega t}$ is time dependence of the phasor and its value is the same in a moment for all phasor at the same frequency. Phasors are analyzed, summed and multiplied without considering this part.
- Phasor are time independent in harmonic stable state.
- Time derivations change the value of the phasor by multiplying it by $j\omega$:

$$\frac{\partial u}{\partial t} = \frac{\partial}{\partial t} Im\left\{\hat{U} \cdot e^{j\omega t}\right\} = Im\left\{j\omega \cdot \hat{U} \cdot e^{j\omega t}\right\}$$

- Time integration change the value of the phasor by dividing it by $j\omega$:

$$\int u dt = \int Im\left\{\hat{U} \cdot e^{j\omega t}\right\} dt = Im\left\{\frac{\hat{U} \cdot e^{j\omega t}}{j\omega}\right\}$$

Complex Impedance

Complex impedance can be defined only for ideal components where nominal values of resistance R, inductance L and capacitance C are constant.

- Capacitive reactance:

$$i(t) = C \cdot \frac{\partial u(t)}{\partial t} \Longrightarrow \hat{I} = j\omega C \cdot \hat{U}$$

$$X_C = \frac{-j}{\omega C}$$

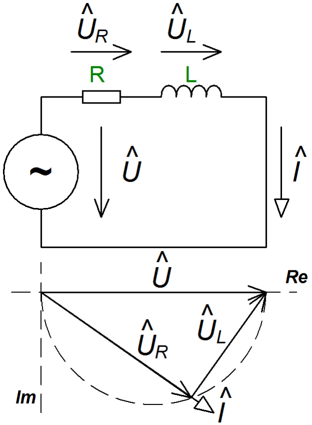
- Inductive reactance:

$$u(t) = L \cdot \frac{\partial i(t)}{\partial t} \Longrightarrow \hat{U} = j\omega L \cdot \hat{I}$$

$$X_L = j\omega L$$

Phasors and Complex Impedance

Phasors and complex impedance make analysis of circuits in harmonic stable state simple:



According to 2nd Kirchhoff's law:

$$\hat{U} = \hat{U}_R + \hat{U}_L = R \cdot \hat{I} + j\omega L \cdot \hat{I}$$

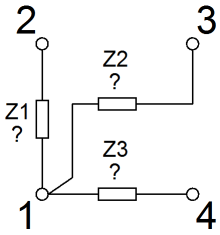
Complex impedance:

$$\hat{Z} = R + j\omega L$$

TOPIC

Behavior of Components at Harmonic Supply

1. Identify unknown components in the black-box through their response to a harmonic signal.



Voltage, current and frequency dependency for each component:

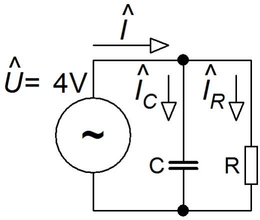
$$\hat{U} = R \cdot \hat{I}$$

$$\hat{U} = X_L \cdot \hat{I} = j\omega L \cdot \hat{I}$$

$$\hat{U} = X_C \cdot \hat{I} = \frac{-j}{\omega C} \cdot \hat{I}$$

Behavior of Components at Harmonic Supply

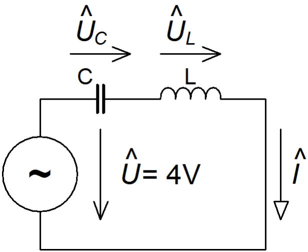
2. Create parallel connection of capacitor and resistor. Connect the circuit to the voltage source 4 V. Measure the current in each branch.



- Do the current values respect 1st Kirchhoffs law?
- Write the measured currents as a phasors (complex numbers).
- Draw a phasor diagram. Think about dissipation factor *D*, where is angle δ?

Behavior of Components at Harmonic Supply

3. Create serial connection of capacitor and inductor. Connect the circuit to the voltage source 4 V. Measure the current and voltage drop over each component.



- Do the voltage values respect 2nd Kirchhoffs law?
- Write the measured voltages as a phasors (complex numbers).
- Draw a phasor diagram. Think about qulity factor *Q*. How can you determine it?