ELEC-E8422 An Introduction to Electric Energy

Homework 7: Basic Components of Power system

Explain the calculation of real and reactive power in a three phase power system. Give an example of a load having both resistance and inductive reactance. Give the power factor of the load. How can reactive power be compensated?

Solution of Homework 7

a) In a three phase power system, the active and reactive powers can be calculated as

$$P_{3\Phi} = \sqrt{3} V_{l-l} I_l \cos(\Phi)$$

$$Q_{3\Phi} = \sqrt{3} V_{l-l} I_l \sin(\Phi)$$

where

$P_{3\Phi}$: Active power of a three phase system

$Q_{3\Phi}$: Reactive power of a three phase system

V_{l-l} : Line-to-line voltage

I_l : Line current

Φ : Phase angle difference between the voltage and current waveforms.

b) Usually, loads are in a power system is inductive. Motors can be given as an example of a load including both resistance and inductive reactance. In that case, the equivalent circuit diagram can be shown in Fig. 1.

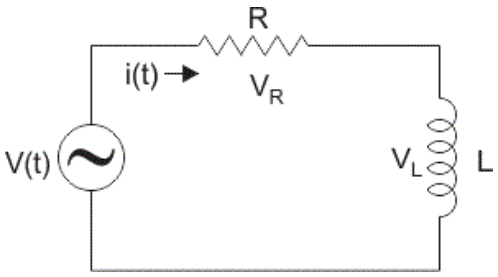

Fig. 1: *Illustration of a RL circuit*

c) The equivalent impedance of a load consisting of resistance and inductance is expressed as:

$$Z = R + jX_L$$

$$X_L = \omega L$$

Therefore, the impedance triangle becomes:

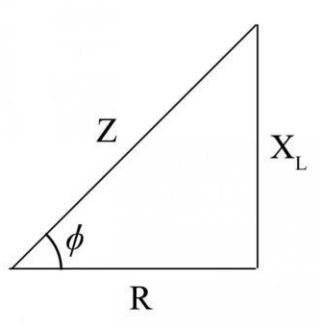

Fig. 2: *Impedance Triangle of an RL Load*

From the impedance triangle, the power factor can be expressed as:

$$PF = \cos\Phi$$

$$PF = \cos(\tan^{-1}\frac{X_L}{R})$$

or

$$PF = \frac{R}{|Z|} = \frac{R}{\sqrt{X_L^2 + R^2}}$$

d) The reactances of the capacitors and inductors are in the opposite sides. Therefore, in order to compensate the reactive power, shunt capacitors are often used in power systems.