EE 361 ELECTROMECHANICAL ENERGY CONVERSION I

HOMEWORK 2 (DUE: 20/12/2022, 23:59)

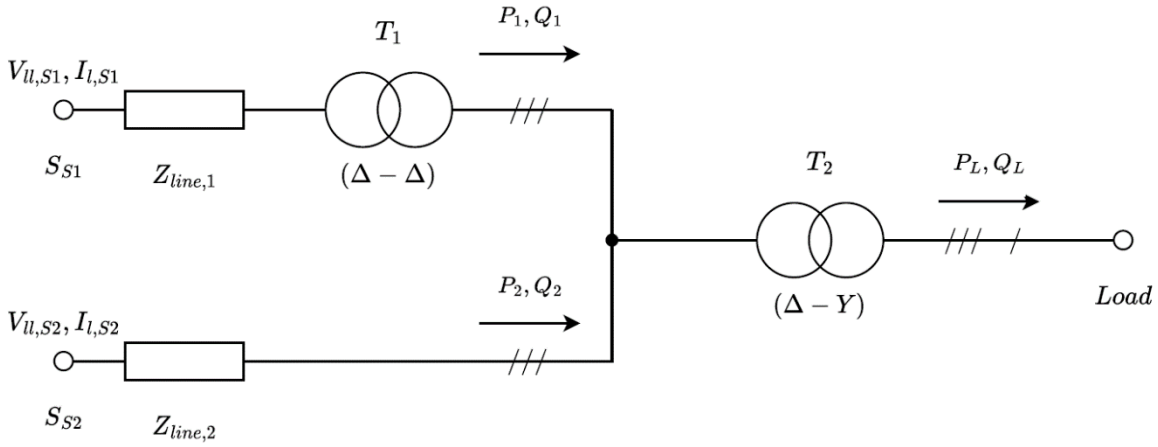

Figure 1 Single-line diagram of a part of a power system

The given single-line diagram shows a part of a power system with two source connections and one load connection.

Transformer 1 (T_1) is built with a single-piece core and has the following characteristics and parameters: - $\Delta - \Delta$ connected - $1\ MVA$ - $15kV: 6.9kV$ - $Z_{T1-HV} = j15.0\ \Omega$ - $Z_{T1-LV} = j3.5\ \Omega$	Transformer 2 (T_2) is composed of three identical single-phase transformers with the following characteristics and parameters: - 0.5 MVA - $6.9kV: 230V$ - $Z_{T2-HV} = 3.0 + j3.0\ \Omega$ - $Z_{T2-LV} = 0.003 + j0.003\ \Omega$ The single phase transformers are $\Delta - Y$ connected

Line impedances are $Z_{line1} = 5.0 + j5.0\ \Omega$ and $Z_{line2} = 1.0 + j1.0\ \Omega$. Core losses and core excitation current of both transformers can be neglected.

The operating condition of the system is given below:

- The power values as denoted in the figure, are as follows:

$$P_1 = 0.8\ MW, Q_1 = 0.6\ MVar \text{ inductive}$$

$$P_L = 1.2\ MW, Q_L = 0.9\ MVar \text{ inductive}$$

- The system is regulated in such a way that rated (nominal) voltage is provided to the load.

According to the given structure and operation conditions, answer the following questions.

Hint: You can use MATLAB Live Script for all type of complex calculations. It will be very convenient to define variables for impedances, voltages, currents and powers.

a) Why $\Delta - Y$ connection is selected for T_2?

b) Draw an equivalent single-phase circuit referred to as the load side (LV side of T_2) and calculate all impedances of the equivalent circuit.

   Hint: In the equivalent circuit leave the referred line impedances in parallel.

c) Calculate load current (complex) at the defined condition.

d) Calculate the power factor of the load.

e) Calculate the voltage regulation of T_2 for the given load case.

f) Calculate the complex power of source 1 (S_{s1}) and source 2 (S_{s2}).

   Hint: You can do calculations by adding up the powers. Do not forget to multiply powers calculated from per-phase equivalent circuit by 3.

g) Calculate the efficiency of the whole system for the operating condition. Do not forget to account for all three phases.

h) Calculate source 1 voltage and current amplitudes.

   Hints:

   In three-phase systems, line currents and line-line voltages are meant if otherwise stated.

   You need to calculate the actual values from the values found from per-phase equivalent circuit. Use of line-line voltage ratio is highly suggested.

i) Calculate source 2 voltage and current amplitudes.