NATIONAL UNIVERSITY OF SINGAPORE

Department of Electrical Engineering

EE2022 ELECTRICAL ENERY SYSTEMS

(Tutorial #6 Transformer and Per Unit Analysis)

Tutors will discuss problem 5 to 7.

Problems 1 to 4 are meant for you to practice on your own. Solving these problems will help you to check your understanding of the basic concepts. You are advised to work on all problems before the tutorial class.

1. Find the turns ratio of a single-phase transformer that transforms the primary voltage 12,740 V of a power line to the secondary voltage 240 V supplied to a house.

   (Answer: 53)

2. The output stage of an audio system has an output resistance of 2 kΩ. An output transformer provides resistance matching with a 6 Ω speaker. If this transformer has 400 primary turns, how many secondary turns does it have?

   (Answer: 22 turns)

3. A single phase transformer is rated 110/440V, 2.5 kVA. Leakage reactance measured from the low voltage side is 0.06 Ω. What is the base impedance in Ohm at the low-voltage side of the transformer? Determine leakage reactance in per unit.

   (Answer: 4.84 Ω, 0.0124 per unit)

4. The reactance of a single-phase generator designated *X"* is given as 0.25 per unit based on the generator's name plate rating of 18 kV, 500 MVA. What is the reactance value in ohm? If the new base for calculations is 20 kV, 100 MVA, find *X"* on the new base.

   (Answer: 0.162 Ω, 0.0405 per unit)

5. Find i_1, i_2 and i_3 for the circuit shown in Fig. 1. The transformers are ideal.

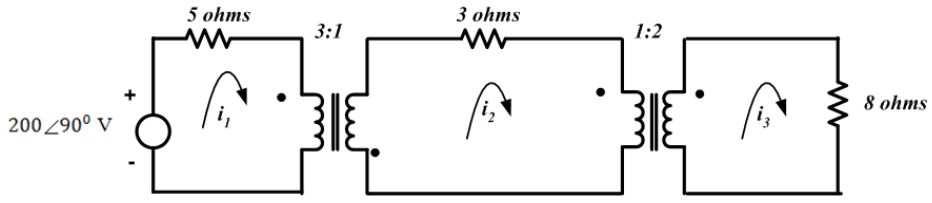

Fig. 1

(Answer: $4\angle\ 90^0\ A, 12\angle\ 270^0\ A, 6\angle\ 270^0\ A$)

6. Three parts of a single phase electric system are designated A, B and C and are connected to each other through transformers, as shown in Fig. 2. The transformers are rated as follows. Note that the transformer reactances are given in percent; for example, 10% = 0.1 p.u.

   A-B 10,000 kVA, 13.8/138 kV, leakage reactance 10%

   B-C 10,000 kVA, 138/69 kV, leakage reactance 8%

   If the base in circuit B is chosen as 10,000 kVA, 138 kV, find the per unit reactance of both transformers and per unit impedance of the 300 Ω resistive load in circuit C referred to circuits C, B and A. Draw the impedance diagram neglecting magnetizing current, transformer resistance and line impedance.

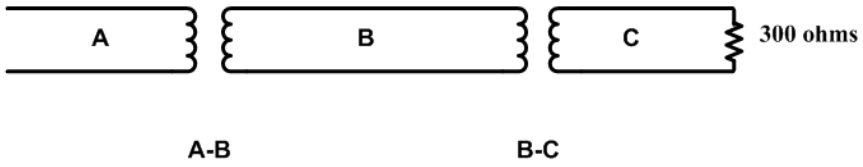

Fig. 2

(Answer: j0.1 per unit, j0.08 per unit, 0.63 per unit)

7. Consider a system with the single line diagram shown in Fig. 3. The three phase transformer name plate ratings are listed. The transformer reactances are given in percent; 10% = 0.1 p.u. The transmission line impedance Z_L is 10 + j100 ohms and load impedance Z_{load} is 440 ohms. The generator has a terminal voltage (magnitude) of 13.2 kV (line-line). Find the power delivered to the load, the power supplied by the generator and the efficiency.

   [Suggestions: In your calculation, use the 3-phase complex power base value of 10 MVA for the entire system and a base line-to-line voltage value of 138 kV for the transmission section. What about the phase-shift induced by the two transformers?]

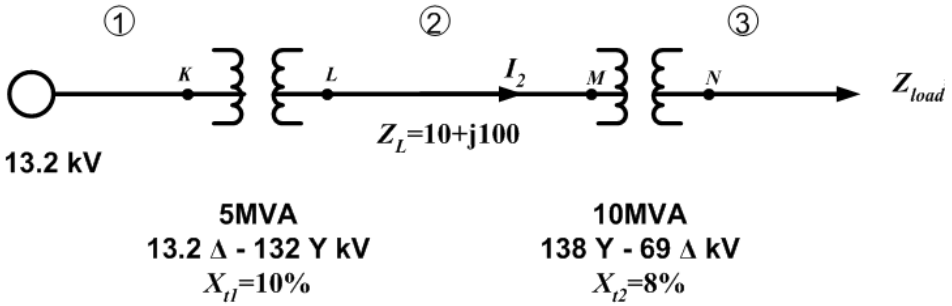

Fig. 3

(Answer: 8.78 MW, 8.83 MW, 99.4%)