NATIONAL UNIVERSITY OF SINGAPORE

Department of Electrical Engineering

EE2029 ELECTRICAL ENERY SYSTEMS

(Tutorial: Three-Phase Circuit Analysis)

Problems 1 to 5 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. A balanced three-phase Y load has one phase voltage of $V_{cn}=277\angle 45^0$ V. If the phase sequence is negative sequence i.e. acb, find the line voltages V_{ca}, V_{ab}, and V_{bc}.

   (Answer: $V_{ca}=480\angle 15^0$ V, $V_{ab}=480\angle 135^0$ V, and $V_{bc}=480\angle -105^0$ V)

2. What are the phase voltages for a balanced three-phase Y load, if $V_{ba}=12470\angle -35^0$ V? The phase sequence is positive sequence i.e. abc.

   (Answer: $V_{bn}=7200\angle -5^0$ V, $V_{an}=7200\angle 115^0$ V, and $V_{cn}=7200\angle -125^0$ V)

3. A balanced Y load of 40 Ω resistors is connected to a 480 V, three-phase, three-wire source. Find the rms line current.

   (Answer: 6.93 A)

4. In a three-phase, three-wire circuit, find the phasor line currents to a balanced Y load for which $Z_Y=60\angle -30^0$ Ω and $V_{cb}=480\angle 65^0$ V. The phase sequence is abc.

   (Answer: $I_a=4.62\angle 5^0$ A, $I_b=4.62\angle -115^0$ A, and $I_c=4.62\angle 125^0$ A)

5. Calculate the total average power delivered by a three-phase source with the line to line voltage of 500 V to each of the following balanced Y connected loads with Z_L equal to:
   a) (30+j0) Ω;
   b) (30+j72) Ω;
   c) (30-j12.5) Ω.

   (Answer: (a) 8333.33 W, (b) 1232.75 W, (c) 7100.58 W)

6. Find the rms line voltage ($V_{Line-Line}$) at the source of the circuit in Fig. 1. As shown, rms phase voltage is 100V and each line impedance is 2+j3 Ω.

(Answer: 173 V)

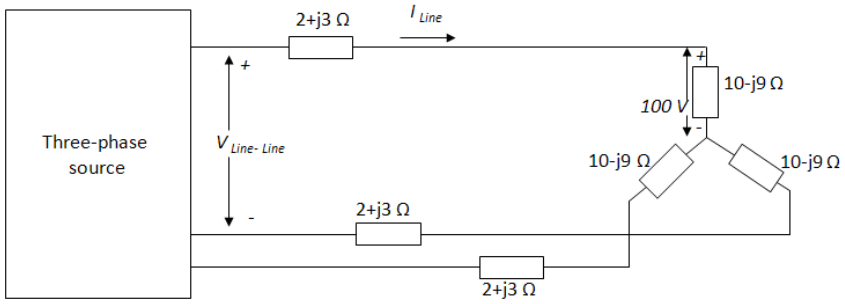

Fig. 1

7. A 208-V three-phase circuit has two balanced loads, one a Δ-connected load of $21\angle 30^0$ Ω impedances and the other a Y-connected load of $9\angle -60^0$ Ω impedances. Find the total rms line current and also the total average power absorbed by the two loads.

(Answer: 21.7 A, 7744.15 W)

8. In a 208-V three-phase circuit a balanced Δ load absorbs 2 kW at a 0.8 leading power factor. Find Z_{Δ}.

(Answer: $51.9\angle -36.87^0$ Ω)

9. Two balanced three-phase motor loads comprising of an induction motor and a synchronous motor are connected in parallel. An induction motor draws 400 kW at 0.8 power factor lagging and a synchronous motor draws 150 kVA at 0.9 power factor leading. Both motor loads are supplied by a balanced three-phase 4160 V source. If the cable impedance between the source and load is neglected,
   a) Draw the power triangle for each motor and for the combined-motor load.
   b) Determine the power factor of the combined-motor load.
   c) Determine the magnitude of the line current delivered by the source.
   d) A delta connected capacitor bank is now installed in parallel with the combined-motor load. What value of capacitive reactance is required in each phase of the capacitor bank to make the source power factor unity?
   e) Determine the magnitude of the line current delivered by the source with the capacitor bank installed.

(Answer: (b) 0.916 lagging, (c) 81.1 A, (d) -j221.3 Ω, (e) 74.3 A)