EE4010

Electrical Power Systems

Problems on Symmetrical Component

1. Evaluate the following in polar form:

    (a) $\dfrac{1+\bar{a}}{1+\bar{a}-\bar{a}^2}$

    (b) $\dfrac{\bar{a}^2+\bar{a}+j}{j\bar{a}-\bar{a}^2}$

    (c) $\left(1-\bar{a}\right)\left(1+\bar{a}^2\right)$

    (d) $(\bar{a}+\bar{a}^2)(1+\bar{a}^2)$

    (e) $\bar{a}^{10}$

    (f) $(j\bar{a})^{10}$

    (g) $(1-\bar{a})^3$

    (h) $e^{\bar{a}}$

2. An unbalanced three-phase star-connected load with phase impedances $\bar{Z}_a, \bar{Z}_b, \bar{Z}_c$ are connected to a balanced three-phase supply resulting in phase voltages across the corresponding impedances. Choosing $\bar{V}_{ab}$ as the reference phasor, prove that

$$\bar{V}_{ab\,0} = 0 \qquad \bar{V}_{ab\,1} = \sqrt{3}\bar{V}_{a1}\,e^{j30°} \qquad \bar{V}_{ab\,2} = \sqrt{3}\bar{V}_{a2}\,e^{-j30°}$$

3. Given the set of symmetrical components

$$\bar{V}_0 = 10\angle 0° \text{ V}, \quad \bar{V}_1 = 80\angle 30° \text{ V}, \quad \bar{V}_2 = 40\angle -30° \text{ V}$$

calculate the corresponding set of actual phase voltages $\bar{V}_a, \bar{V}_b, \bar{V}_c$.

Hence, determine the line voltages $\bar{V}_{ab}, \bar{V}_{bc}, \bar{V}_{ca}$. Thus, calculate the symmetrical components of these line voltages and, from these symmetrical components, derive the symmetrical components of the corresponding phase voltages and subsequently, the actual values of the phase voltages corresponding to this set of symmetrical components. Comment on the implications of the results of your calculations.

4. Given the line-to-ground voltages $\overline{V}_{ag} = 280\angle 0°$ V, $\overline{V}_{bg} = 290\angle -130°$ V, $\overline{V}_{cg} = 260\angle 110°$ V calculate

   (a) the sequence components of the line-to-ground voltages, $\overline{V}_{Lg0}, \overline{V}_{Lg1}, \overline{V}_{Lg2}$

   (b) the line-to-line voltages $\overline{V}_{ab}, \overline{V}_{bc}, \overline{V}_{ca}$

   (c) the sequence components of the line-to-line voltages $\overline{V}_{LL0}, \overline{V}_{LL1}, \overline{V}_{LL2}$

Hence, verify the general relationships

$$\overline{V}_{LL0} = 0 \qquad \overline{V}_{LL1} = \sqrt{3}\overline{V}_{Lg1}\, e^{j30°} \qquad \overline{V}_{LL2} = \sqrt{3}\overline{V}_{Lg2}\, e^{-j30°}$$

between the symmetrical components of line to ground voltages and the corresponding symmetrical components of the line-to-line voltages.

5. A balanced, star-connected load bank with a three-phase rating of 500 kVA and 10 kV consists of three-identical power resistors of $200\ \Omega$. The load bank has the following set of three-phase line-to-line voltages: $\overline{V}_{ab} = 8000\angle 82.8°$ V, $\overline{V}_{bc} = 12000\angle -41.4°$ V, $\overline{V}_{ca} = 10000\angle 180°$ V. Determine (a) the symmetrical components of the line-to-line voltages, (b) the symmetrical components of the phase-to-neutral voltages and (c) the symmetrical components of the line currents. The star point of the balanced three-phase load is isolated.

6. The currents in an industrial three-phase load which is delta-connected are measured to be $\overline{I}_{ab} = 10\angle 0°$ A, $\overline{I}_{bc} = 20\angle -90°$ A, $\overline{V}_{ca} = 15\angle 90°$ A. Calculate

   (a) the sequence components of the delta connected load currents, $\overline{I}_{\Delta 0}, \overline{I}_{\Delta 1}, \overline{I}_{\Delta 2}$

   (b) the line components which feed the delta connected load, $\overline{I}_a, \overline{I}_b, \overline{I}_c$

   (c) the sequence components of the line currents $\overline{I}_{L0}, \overline{I}_{L1}, \overline{I}_{L2}$

Hence, verify the general relationships

$$\overline{I}_{L0} = 0 \qquad \overline{I}_{L1} = \sqrt{3}\,\overline{I}_{\Delta 1}\, e^{-j30°} \qquad \overline{I}_{L1} = \sqrt{3}\,\overline{I}_{\Delta 2}\, e^{j30°}$$