Electrical Power Systems

Problems on Symmetrical Component II

1.   A three-phase balanced load consists of three equal phase impedances $\bar{Z}_s$ connected in star and the star point is grounded via an impedance $\bar{Z}_n$. Each of the phases is coupled by a mutual impedance $\bar{Z}_m$. Derive the equations for the phase voltages in terms of the phase currents and determine the elements of the phase impedance matrix. Hence, deduce the positive, negative and zero sequence impedances.

2.   A three-phase balanced voltage source is applied to a balanced three-phase load with an ungrounded neutral. The star-connected load consists of three mutually coupled reactances where the reactance of each phase is $j12.0\,\Omega$ and the mutual coupling between phases is $j4.0\,\Omega$. The line-to-line source voltage magnitude is $\sqrt{3}\,230$ V. Determine the line currents drawn by the load.

3.   An item of three-phase equipment can be represented by a balanced three-phase, three-wire, star-connected load consisting of an impedance of $(18+j6)\ \Omega$ in each phase. This load is fed from a balanced three-phase star-connected voltage source with a line voltage defined by $400\angle0°$ V. Calculate the current in phase *a* if the impedance in Phase *b* of the load is directly short circuited by an internal fault.

4.   In a three-phase system, a synchronous generator supplies power to a 400 V synchronous motor through a transmission line having a series impedance of $0.5\angle80°\ \Omega$ per phase. The motor draws 10 kW at 0.8 power factor leading while operating at its rated voltage. The neutrals of both the generator and motor are grounded through impedances of $j5.0\ \Omega$. The sequence impedances of both machines are $\bar{Z}_0 = j5.0\ \Omega$, $\bar{Z}_1 = j15.0\ \Omega$, $\bar{Z}_2 = j10.0\ \Omega$. Draw the sequence impedance networks for the system and find the line-to-line voltage at the generator terminals. Assume balanced three-phase operation.