1. In the 3-phase system below, the elements have the following values:

- G1: 3-phase transformer, 50 MVA, 15 kV, \( X_g = 0.08 \), \( X_r = 25 \), \( X_t = 20 \)
- G2: 200 MVA, 15 kV, \( X_g = 0.08 \), \( X_r = 25 \), \( X_t = 20 \)
- T1: three single-phase units, high voltage side connected wye, low voltage side connected delta, each unit is 15 kV/230 kV, 50 MVA, with a reactance of 10.
- T2: a three-phase transformer, 50 MVA, 15 kV, 25 kV delta, 500 MVA, with a reactance of 10.
- Load: \( Z_L = 60 \) ohm/phase, \( Z_L = 30 \) ohm/phase.
- Load: \( Z_L = 20 \) ohm/phase, \( Z_L = 15 \) ohm/phase.

Choose a base of 145 kV, 1.000 MVA at the load and draw the phasor diagram with positive, negative, and zero sequences. Show all the importance values on the diagram. Assume all pre-fault bus voltages are 1.0 per unit. Neglect the lead.

2. Construct the Thévenin equivalent zero, positive, and negative sequence networks for the system of problem 1 looking into the networks at bus 3.

3. For a 1-L-O fault with an impedance of 50 ohm per unit on bus 3 in the problem above, find the a-b-c line currents flowing toward the fault.
   - A. Coming from bus 1.
   - B. Coming from generating G1.

4. Repeat problem 3 for a solid 1-L-O fault on bus 3.

5. Repeat problem 3 for a solid 2-L-G fault on bus 3.

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**Diagram: 3-phase system with elements and loads.**

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6. The 3-bus system shown below has the bus impedance matrix:

\[
\begin{bmatrix}
12847 & 0.5431 & 0.0197 \\
0.5431 & 12847 & 0.0197 \\
0.0197 & 0.0197 & 12847 \\
\end{bmatrix}
\]

Choose a base of 145 kV, 1.000 MVA at the load and draw the phasor diagram with positive, negative, and zero sequences. Show all the importance values on the diagram. Assume all pre-fault bus voltages are 1.0 per unit. Neglect the lead.

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**Diagram: 3-bus system with impedance matrix.**

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7. For a 1-L-O fault with an impedance of 1.0 ohm per unit on bus 3 in the problem above, find the a-b-c per unit line currents.
   - A. In the fault itself.
   - B. From generator 2, which has \( X_r = 0.15 \), \( X_t = 0.30 \), \( X_s = 0.05 \).
   - C. In bus 1, which has \( X_r = X_s = 0.15 \).

8. Repeat problem 6 for a 1-L-O fault on bus 3 with an impedance of 1.5 ohm per unit.