PROBLEM 1

Positive sequence:

According to the diagram above, $HAn = 3.61 \angle 13.90^\circ$, $MAn = 1.73 \angle -90^\circ$

Therefore, HA leads MA by $103.9^\circ$

Negative sequence:

According to the diagram above, $HAn = 3.61 \angle -13.90^\circ$, $MAn = 1.73 \angle 90^\circ$

Therefore, HA lags MA by $103.9^\circ$
PROBLEM 2

A three-phase impedance load consists of a balanced-Δ load in parallel with a balanced-Y load. The impedance of each leg of the Δ load is \( Z_\Delta = 9 + j12 \)Ω, and the impedance of each leg of the Y load is \( Z_Y = 2 + j3 \)Ω. The Y load is ground through a neutral impedance \( Z_n = j1.5 \)Ω. An unbalanced line to ground source voltage \( V_{ag} \), \( V_{bg} \), and \( V_{cg} \) with sequence component \( V_o = 10\angle60^\circ \), \( V_1 = 100\angle0^\circ \), and \( V_2 = 15\angle175^\circ \) volts are supplied through a line having an impedance of \( 0.5\angle85^\circ \)Ω per phase. Determine the total complex power delivered to the three-phase load. (Assume no mutual among loads and the negative and zero sequence impedances of the line are the same as the positive sequence)

- \( Z_\Delta (9 + j12) \rightarrow Z_Y (3 + j4) \)
- Positive and Negative Sequence Load Impedance = \( 1.2027 + j1.7162 \)Ω
- Zero Sequence Load Impedance = \( 2 + j7.5 \)Ω
- \( I_o = \frac{10\angle60^\circ}{(0.5\angle85^\circ + 2 + j7.5)} = 1.1664 - j0.3271 = 1.2114\angle-15.667^\circ \)
- \( I_1 = \frac{100\angle0^\circ}{(0.5\angle85^\circ + 1.2027 + j1.7162)} = 39.3557\angle-60.6278^\circ \)
- \( I_2 = \frac{15\angle175^\circ}{(0.5\angle85^\circ + 1.2027 + j1.7162)} = 5.9034\angle114.3722^\circ \)
- Power to the Load = \( 3 (|I_0|^2Z_0 + |I_1|^2Z_1 + |I_2|^2Z_2) = 5.723 \) kW + 8.187 kVAR
PROBLEM 3

Consider the single line diagram of the power system shown below. Equipment ratings are:

- **Generator 1**: 500 MVA, 13.8 kV, \(X_d \gamma = X_2 = 0.2\) pu, \(X_0 = 2\) pu
- **Generator 2**: 750 MVA, 13.8 kV, \(X_d \gamma = X_2 = 0.2\) pu, \(X_0 = 2\) pu
- **Load (Balance Y-grounded load)**: 1200 MVA, Power factor = 0.8 lagging
- **Three-phase Δ-Y transformers**: 450 MVA, 345 kV Y/13.8 kV Δ, \(X_1 = X_2 = 0.1\) pu
- **Three-phase Y-Y transformer**: 1500 MVA, 345 kV Y/25 kV Y, \(X_1 = X_2 = 0.1\) pu

(a) Use 100 MVA and 345 kV for the 40 Ω line, determine the per unit sequence networks of the system.

(b) A three phase-to-ground fault happens at point “A”, calculate 1) the fault current and 2) the contribution from G1 and G2. [(1) Ignore the contribution from load. (2) Generators are operated at rated voltage]

\[
Z_{\text{base}} = \frac{345^2}{100} = 1190.25\Omega
\]

- 40Ω \(\rightarrow 0.0336\) pu; 20Ω \(\rightarrow 0.0168\) pu
- **G1**: \(X_d \gamma = X_2 = 0.04\) pu, \(X_0 = 0.4\) pu
- **G2**: \(X_d \gamma = X_2 = 0.0267\) pu, \(X_0 = 0.2667\) pu
- **Δ-Y Transformer**: \(X_1 = X_2 = 0.0222\) pu
- **Y-Y Transformer**: \(X_1 = X_2 = 0.0067\) pu
- **Load**: 12 pu, 0.8 lagging
(b) Three-Phase-to-Ground Fault at A

Fault Current

\[ 1.0 = 0.0595* I_{G1 \text{ Fault}} + 0.0098*(I_{G1 \text{ Fault}} + I_{G2 \text{ Fault}}) \]

\[ 1.0 = 0.0693* I_{G1 \text{ Fault}} + 0.0098*I_{G2 \text{ Fault}} \]

\[ 1.0 = 0.0098*I_{G1 \text{ Fault}} + 0.0560* I_{G2 \text{ Fault}} \]

\[ I_{G1 \text{ Fault}} = 12.207 \text{ pu} \]

\[ I_{G2 \text{ Fault}} = 15.721 \text{ pu} \]

\[ I_{\text{Fault}} = 12.207 + 15.721 = 27.928 \text{ pu} \]

Base Current: \[ 100 \times 10^6 / \sqrt{3} \times 345 \times 10^3 = 167.35 \text{ A} \]

The actual fault current:

\[ I_F = 27.928 \times 167.35 \text{ A} = 4673.75 \text{ A} \]

\[ I_{G1} = 12.207 \times 167.35 \text{ A} = 2042.84 \text{ A} \]

\[ I_{G2} = 15.721 \times 167.35 \text{ A} = 2630.91 \text{ A} \]