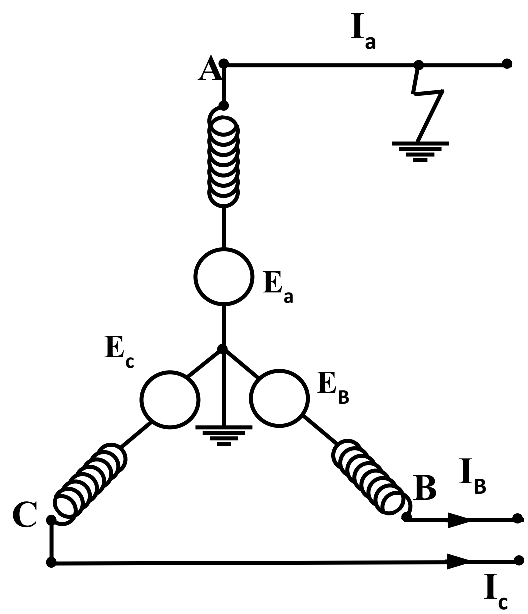
Single line to ground fault (LG)

For line to ground fault, consider the following 3 phase system:



From the figure we have:

$$V_A = 0 \quad , I_B = 0 \quad , I_C = 0$$

And the sequence Network equations are:

$$V_A^{(0)} = -I_A^{(0)} Z^{(0)}$$
$$V_A^{(1)} = E_A - I_A^{(1)} Z^{(1)}$$
$$V_A^{(2)} = -I_A^{(2)} Z^{(2)}$$

The solution of these equation will give six unknowns $V_A^{(0)}, V_A^{(1)}, V_A^{(2)}, I_A^{(0)}, I_A^{(1)}, I_A^{(2)}$.

We know

$$\begin{bmatrix} I_A^{(0)} \\ I_A^{(1)} \\ I_A^{(2)} \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & a & a^2 \\ 1 & a^2 & a \end{bmatrix} \begin{bmatrix} I_A \\ I_B \\ I_C \end{bmatrix} \qquad I_A^{(0)} = I_A^{(1)} = I_A^{(2)} = \frac{1}{3} I_A$$

Substituting the values of $I_B$and I_C

$$I_A^{(0)} = I_A^{(1)} = I_A^{(2)} = \frac{1}{3} I_A$$

In terms of symmetrical components

$$V_A = 0 = V_A^{(0)} + V_A^{(1)} + V_A^{(2)} = 0$$

Now substituting the values of 1 eq ts in eqs 2:

$$E_A - I_A^{(1)} Z^{(1)} - I_A^{(2)} Z^{(2)} - I_A^{(0)} Z^{(0)} = 0$$

Since

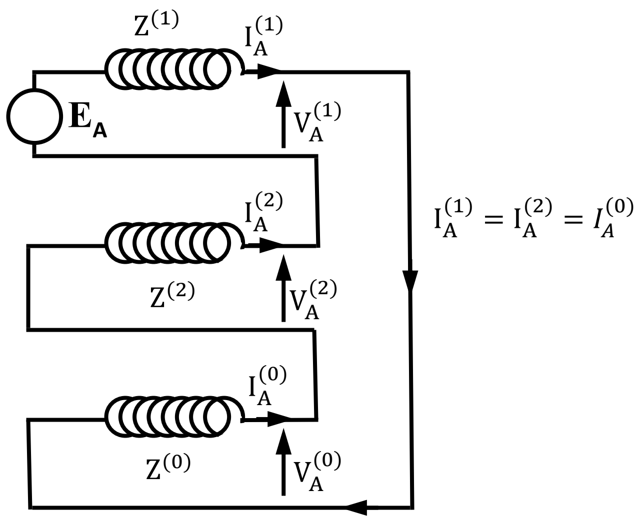
$$I_A^{(0)} = I_A^{(1)} = I_A^{(2)}$$

Equation 3 becomes

$$E_A - I_A^{(0)} Z^{(1)} - I_A^{(0)} Z^{(2)} - I_A^{(0)} Z^{(0)} = 0$$

$$\boxed{I_A^{(0)} = \frac{E_A}{Z^{(1)} + Z^{(2)} + Z^{(0)}}}$$

From this equation, it is clear that to simulate a LG fault for all the three sequence networks are required and since the currents are all equal in magnitude and phase angle.



now in case of the line to ground fault the fault current at the neutral current is:

$$I_n = I_f = I_A^{(0)} + I_A^{(1)} + I_A^{(2)}$$

in same case we have:

$$I_A^{(0)} = I_A^{(1)} = I_A^{(2)}$$

$$I_n = I_A^{(0)} + I_A^{(1)} + I_A^{(2)} = 3I_A^{(0)}$$

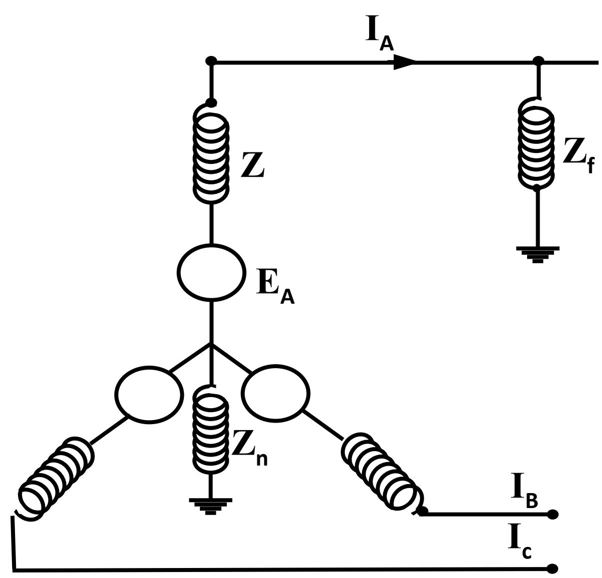
In case the neutral is not grounded the zero-sequence impedance $Z^{(0)}$ becames infinite and, therefore, from equation

$$I_A^{(0)} = \frac{E}{Z^{(1)} + Z^{(2)} + \infty} = 0 = I_A^{(1)} = I_A^{(2)}$$

when the neutral is isolated, there is no return path from the current this means not for the system the fault current

$$\boxed{I_A = 0}$$

now in case of the line to ground faults with Z_f,, the fault impedance is Z_f and the neutral impedance is Z_n



The boundary conditions are:

$V_A = I_A Z_f$

$I_B = 0$

$I_C = 0$

Now:

$V_A^{(0)} = -I_A(Z_g^{(0)} + 3Z_n)$

$V_A^{(1)} = E_A - I_A^{(1)} Z^{(1)}$

$V_A^{(2)} = -I_A^{(2)} Z^{(2)}$

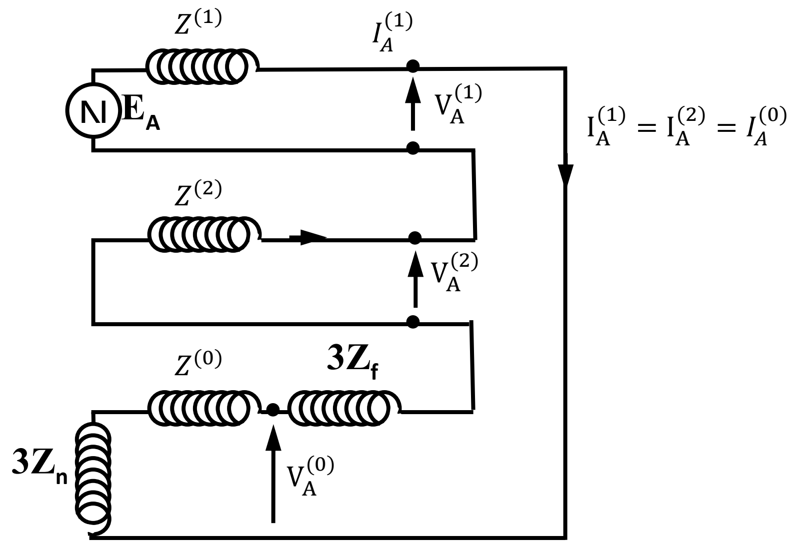
$I_A^{(0)} = I_A^{(1)} = I_A^{(2)} = \frac{I_A^{(0)}}{3}$

$$V_A^{(1)} + V_A^{(2)} + V_A^{(0)} = V_A = 3I_A^{(1)} Z_f$$

$$E_A - I_A^{(1)} Z^{(1)} - I_A^{(2)} Z^{(2)} - I_A(Z_g^{(0)} + 3Z_n) = 3I_A^{(1)} Z_f$$

$$E_A = I_A^{(1)}[Z^{(1)} + Z^{(2)} + (Z_g^{(0)} + 3Z_n) + 3Z_f]$$

$$I_A^{(0)} = I_A^{(1)} = I_A^{(2)} = \frac{E_A}{[Z^{(1)} + Z^{(2)} + (Z_g^{(0)} + 3Z_n) + 3Z_f]}$$



Exercise:

A 11KV ,30MVA generator has $x_1 = x_2 = 0.2pu$ and $x_0 = 0.05pu$ a line to ground fault occurs on the generator terminal.

Find the fault current in Line-to-ground voltages during fault conditions, assume that the generator natural is solidly grounded.