Symmetrical fault analysis through bus impedance matrix

(i). Adding branch of impedance from new bus to reference bus Zbus = [Zb]

(ii). Adding brance of impedance from new bus to existing bus Zbus = [Zorg ….

…… Zb+Zqq]

(iii). Adding branch of impedance from existing bus to ref bus

(iv). Adding branch of impedance between 2 existing bus

Bus impedance matrix

Bus impedance matrix is the inverse of the bus admittance matrix. The matrix consisting of driving point impedance and transfer impedances of the network is called as bus impedance matrix. Bus impedance matrix is symmetrical.

Methods available for forming bus impedance matrix

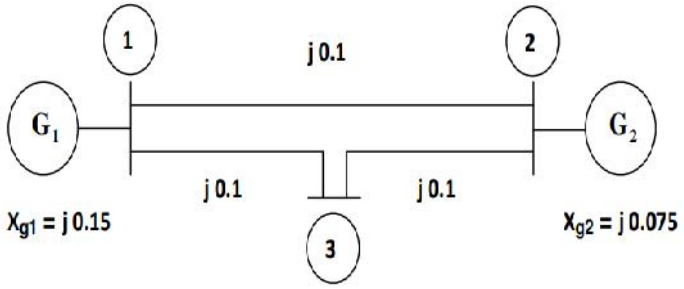
(i). Form bus admittance matrix and take the inverse to get bus impedance matrix.

(ii). Using bus building algorithm.

(iii). Using L-U factorization of Y-bus matrix.

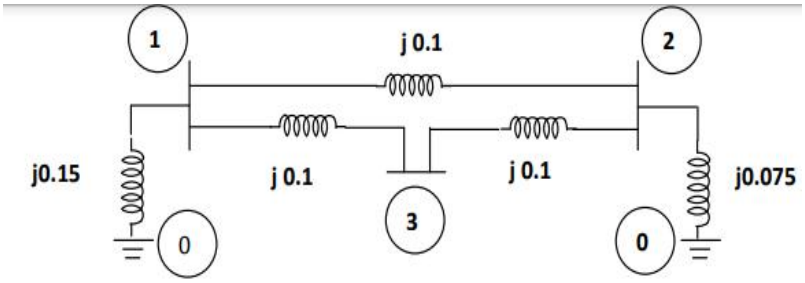
Problem:1

Consider the power system shown in Fig. The values marked are p.u. impedances. The p.u. reactances of the generator 1 and 2 are 0.15 and 0.075 respectively. Compute the bus impedance matrix of the generator – transmission network.



Solution :

The ground bus is numbered as 0 and it is taken as reference bus. The p.u. impedance diagram is shown in Fig.



When element 0 – 1 is included

$$Z_{bus} = j\ \begin{matrix} 1 \\ 1 \end{matrix} \begin{bmatrix} 1 \\ 0.15 \end{bmatrix}$$; **When element 0 – 2 is included** $$Z_{bus} = j \begin{matrix} 1 \\ 2 \end{matrix} \begin{bmatrix} 1 & 2 \\ 0.15 & 0 \\ 0 & 0.075 \end{bmatrix}$$

Element 1 – 2 is added; it is a link between buses 1 and 2. With bus ℓ

$$Z_{bus} = j \begin{matrix} 1 \\ 2 \\ \ell \end{matrix} \begin{bmatrix} 1 & 2 & \ell \\ 0.15 & 0 & 0.15 \\ 0 & 0.075 & -0.075 \\ 0.15 & -0.075 & 0.325 \end{bmatrix}$$;

Eliminating the ℓ^{th} bus

$$Z_{bus} = j \begin{matrix} 1 \\ 2 \end{matrix} \begin{bmatrix} 1 & 2 \\ 0.08077 & 0.034615 \\ 0.034615 & 0.05769 \end{bmatrix}$$

Add element 1 – 3. It is a branch from bus 1 and it creates bus 3.

$$Z_{bus} = j \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} 0.08077 & 0.034615 & 0.08077 \\ 0.034615 & 0.05769 & 0.034615 \\ 0.08077 & 0.034615 & 0.18077 \end{bmatrix} \end{array}$$

Finally add element 2 – 3. It is a link between buses 2 and 3. With bus ℓ

$$Z_{bus} = j \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ \ell \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & \ell \end{array} \\ \left[\begin{array}{cccc} 0.08077 & 0.034615 & 0.08077 & -0.046155 \\ 0.034615 & 0.05769 & 0.034615 & 0.023075 \\ 0.08077 & 0.034615 & 0.18077 & -0.146155 \\ \hline -0.046155 & 0.023075 & -0.146155 & 0.26923 \end{array}\right] \end{array}$$

$$Z_{bus} = j \begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array} \begin{array}{c} \begin{array}{ccc} 1 & 2 & 3 \end{array} \\ \begin{bmatrix} 0.07286 & 0.03857 & 0.05571 \\ 0.03857 & 0.05571 & 0.04714 \\ 0.05571 & 0.04714 & 0.10143 \end{bmatrix} \end{array}$$