

$$I_{a1} = \frac{E_a}{z_1 + \frac{z_2 z_0}{z_2 + z_0}}$$

$$= \frac{j63,510}{j(33,62 + \frac{38,37 \times 39,95}{78,32})}$$

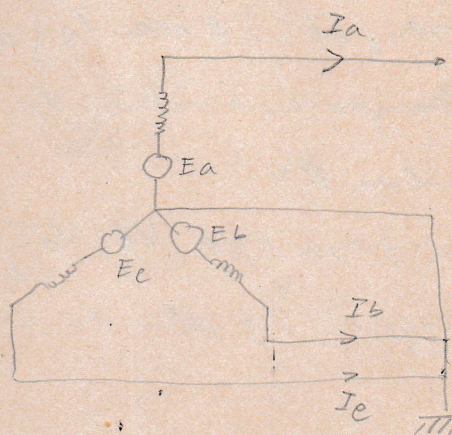
$$= \frac{j63,510}{j(33,62 + 19,57)} = 1194,1 \text{ A}$$

$$I_{a2} = -I_{a1} \left(\frac{z_0}{z_0 + z_2} \right)$$

$$= -1194,1 \left(\frac{j39,95}{j78,32} \right) = -609 \text{ A}$$

$$I_{a0} = -I_{a1} \left(\frac{z_2}{z_0 + z_2} \right)$$

$$= -1194,1 \left(\frac{j38,37}{j78,32} \right) = -585,1 \text{ A}$$



ans. ans phasa :

$$I_a = I_{a1} + I_{a2} + I_{a0} = 1194,1 - 609 - 585,1 = 0$$

$$I_b = I_{a0} + a^2 I_{a1} + a I_{a2} = -585,1 + a^2(1194,1) + a(-609)$$

$$= -877,6 - j1561,5$$

$$I_c = I_{a0} + a I_{a1} + a^2 I_{a2} = -585,1 + a(1194,1) + a^2(-609)$$

Voltage - voltage unitan :

$$V_{a1} = \frac{z_2 z_0}{z_1 z_2 + z_1 z_0 + z_2 z_0} E_a$$

$$= \frac{j38,37 \cdot j39,95}{j33,62 \cdot j38,37 + j33,62 \cdot j39,95 + j38,37 \cdot j39,95} \cdot j63,510$$

$$= j23,37$$

$$V_{a2} = V_{a0} = V_{a1} = j23,37$$

Voltage salman

$$V_a = V_{a0} + V_{a1} + V_{a2} = 3 \cdot j23,37 = j70,11$$

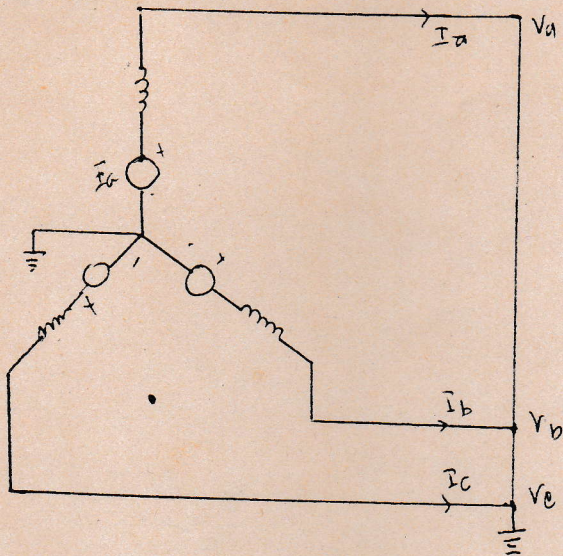
$$V_b = V_{a0} + a^2 V_{a1} + a V_{a2} = V_{a1} (1 + a^2 + a) = 0$$

$$V_c = V_{a0} + a V_{a1} + a^2 V_{a2} = V_{a1} (1 + a + a^2) = 0$$

$$a = 1 \angle 120^\circ = -0,5 + j0,866$$

$$a^2 = 1 \angle 240^\circ = -0,5 - j0,866$$

1.3. HUBUNG SINGKAT TIGA SAKURAN KE TANAH
(TRIPLE LINE TO GROUND FAULT)



Persamaan - persamaan pada titik gangguan :

$$V_a = V_b = V_c = 0 \quad (1)$$

$$I_a + I_b + I_c = 0 \quad (2)$$

dari (1)

$$V_{a0} = \frac{1}{3}(V_a + V_b + V_c) = 0$$

$$V_{a1} = \frac{1}{3}(V_a + aV_b + a^2V_c) = 0$$

$$V_{a2} = \frac{1}{3}(V_a + a^2V_b + aV_c) = 0$$

dari persamaan umum

$$V_{a1} = E_a - I_{a1}z_1 = 0 \rightarrow V_{a1} = E_a - I_{a1}z_1 \rightarrow E_a = I_{a1}z_1$$

$$E_a = I_{a1}z_1$$

$$\parallel I_{a1} = \frac{E_a}{z_1} \parallel$$

$$V_{a2} = -I_{a2}z_2 = 0$$

$$I_{a2} = 0$$

$$V_{a0} = -I_{a0}z_0 = 0$$

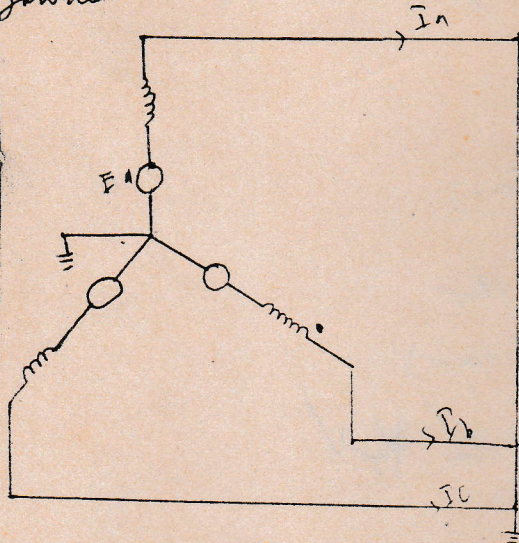
$$I_{a0} = 0$$

$$\begin{aligned} I_a + I_b + I_c &= \frac{E_a}{z_1} + a^2 \frac{E_a}{z_1} + a \frac{E_a}{z_1} \\ &= \frac{E_a}{z_1} (a^2 + a + 1) = 0 \end{aligned}$$

Contoh : I.3

Untuk suatu gangguan (busung single) tiga saluran ke tanah dari generator pada contoh I.2. Hitung arus-arus sub perantara.

Jawab :



$$E_a = \frac{110}{\sqrt{3}} = j63,510$$

$$Z_1 = j33,62$$

$$Z_2 = j38,37$$

$$Z_0 = j39,05$$

$$I_{a1} = \frac{E_a}{Z_1} = \frac{j63,510}{j33,62} = 1,889$$

$$I_{a2} = I_{a0} = 0$$

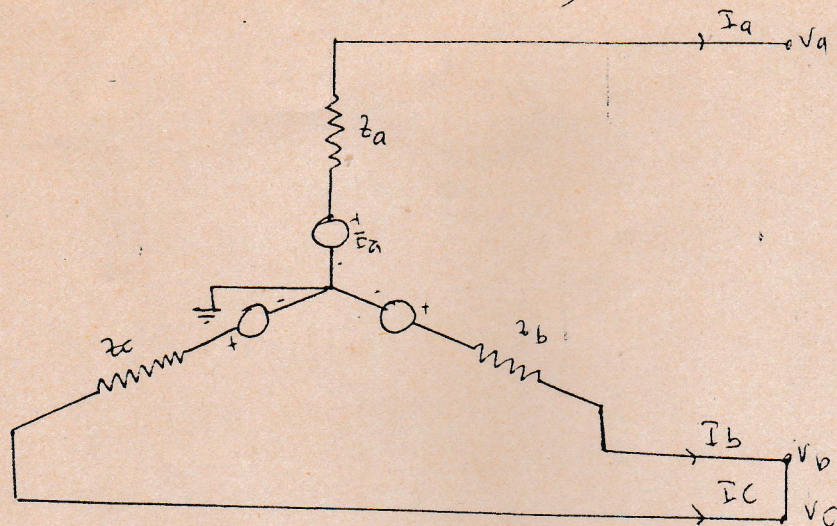
$$I_a = I_{a1} + I_{a2} + I_{a0} = \frac{E_a}{Z_1} = 1,889$$

$$I_b = I_{a0} + a^2 I_{a1} + a I_{a2} = a^2 I_{a1} = (-0,5 - j0,866) 1,889$$

$$= -0,9445 - j1,636 = 1,889 \angle 240^\circ$$

$$I_c = I_{a0} + a I_{a1} + a^2 I_{a2} = a I_{a1} = 1,889 \angle 120^\circ$$

I.4. GANGGUAN ANTARA DUA SAKURAN (PHASA B & C) (LINE TO LINE FAULT)



Persamaan - persamaan
pada titik gangguan:

$$I_a = 0 \quad (1)$$

$$I_b = -I_c \quad (2)$$

$$V_b = V_c \quad (3)$$

dan (1) dan (2)

$$I_{a0} = \frac{1}{3} (I_a + I_b + I_c) = \frac{1}{3} (0 - I_c + I_c) = 0$$

$$I_{a1} = \frac{1}{3} (I_a + aI_b + a^2I_c) = \frac{1}{3} (0 + I_b(a - a^2)) \rightarrow a - a^2 = -1$$

$$= \frac{a^3 - a^2}{3} I_b = j \frac{I_b}{\sqrt{3}} \rightarrow \frac{j^2}{3} I_b$$

$$I_{a2} = \frac{1}{3} (I_a + a^2I_b + aI_c) = \frac{1}{3} (0 + I_b(a^2 - a)) \rightarrow a^2 - a = 1$$

$$= \frac{a^3 - a}{3} I_b = -j \frac{I_b}{\sqrt{3}} \rightarrow -\frac{j^2}{3} I_b$$

$$\therefore I_{a0} = 0 \quad I_{a1} = -I_{a2}$$

dan (3)

$$V_b = V_c$$

$$a^2 V_{a1} + a V_{a2} + V_{a0} = a V_{a1} + a^2 V_{a2} + V_{a0}$$

$$(a^2 - a) V_{a1} = (a^2 - a) V_{a2}$$

$$V_{a1} = V_{a2}$$

dari persamaan umum

$$E_a - I_{a1} Z_1 = -I_{a2} Z_2$$

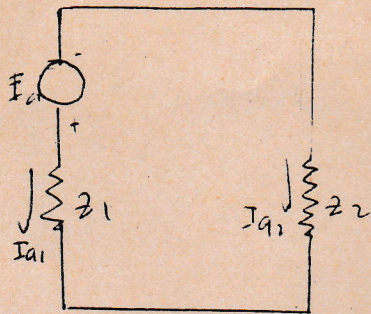
$$E_a - I_{a1} Z_1 = I_{a1} Z_2$$

$$E_a = I_{a1} (Z_1 + Z_2)$$

$$I_{a1} = \frac{E_a}{Z_1 + Z_2} = -I_{a2}$$

$$I_{a0} = 0$$

Rangkaian derivasinya :



$$V_{a1} = V_{a2} = -I_{a2} Z_2$$

$$= \frac{Z_2}{Z_1 + Z_2} E_a$$

$$V_{a0} = -I_{a0} Z_0 = 0$$

Kegangan - kegangan saluran :

$$V_a = V_{a0} + V_{a1} + V_{a2} = 2 \cdot \frac{Z_2}{Z_1 + Z_2} E_a$$

$$a^2 + a = -1$$

$$a + a^2 = 1$$

$$V_b = V_{a0} + a^2 V_{a1} + a V_{a2} = (a^2 + a) V_{a1} = - \frac{Z_2}{Z_1 + Z_2} E_a$$

$$V_c = V_{a0} + a V_{a1} + a^2 V_{a2} = (a + a^2) V_{a1} = - \frac{Z_2}{Z_1 + Z_2} E_a$$

Arus gangguan

$$I_f = I_b = -I_c = a^2 I_{a1} + a I_{a2} + I_{a0}$$

$$= (a^2 - a) I_{a1} \quad I_{a1} = \frac{E_a}{Z_1 + Z_2}$$

$$= -j\sqrt{3} \frac{E_a}{Z_1 + Z_2}$$

$$I_{a1} = -I_{a2} \rightarrow I_{a2} = -I_{a1}$$

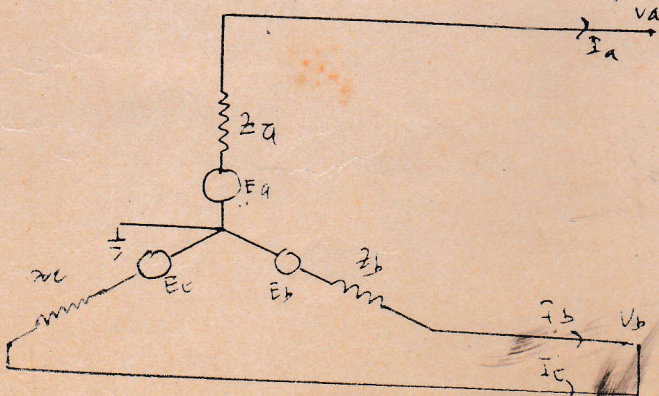
Contoh : I.4

Sebuah generator yang netralnya ditambatkan dengan bus mempunyai rating 30 MVA, 18 kV dengan reaktansi reaktansi $X'' = 10\%$ $X_2 = 15\%$ $X_0 = 5\%$

Bila terjadi gangguan phase ke phase ; hitung arus gangguan dan tegangan - tegangan saluran.

Jawab

Gangguan pada phase b ke phase c



$$Z_1 = j0,10 \text{ pu}$$

$$Z_2 = j0,15 \text{ pu}$$

$$Z_0 = j0,05 \text{ pu}$$

$$E_a = 1 \text{ pu}$$

$$X'' = X_1 = Z_1$$