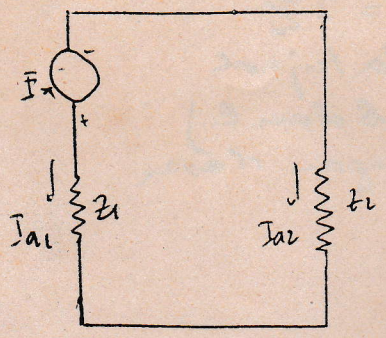


gangguan fase to fase (b : c):

$I_a = 0$

$I_b = -I_c$

$V_b = V_c$

$I_{ao} = 0$

$$I_{a1} = \frac{E_a}{Z_1 + Z_2} = \frac{1}{J0{,}10 + J0{,}15} = -J4 \text{ pu}$$

$$I_{a2} = -I_{a1} = J4 \text{ pu}$$

$$I_a = I_{ao} + I_{a1} + I_{a2} = 0 - J4 + J4 = 0$$

$$I_b = I_{ao} + a^2 I_{a1} + a I_{a2} = (a^2 - a) I_{a1}$$

$$= -J\sqrt{3}\,\frac{1}{J0{,}10 + J0{,}15} = +4\sqrt{3} \text{ pu}$$

$$= -6{,}928 \text{ pu} \quad \text{— } -6{,}928 \text{ Pu}$$

$$I_c = I_{ao} + a I_{a1} + a^2 I_{a2}$$

$$= (a - a^2) I_{a1} = -I_b = +6{,}928 \text{ pu}$$

$$I_{dasar} = \frac{30.000 \text{ KVA}}{\sqrt{3}\ 18 \text{ KV}} = 962{,}25 \text{ A}$$

Arus saluran :

$I_a = 0$

$I_b = 6{,}928 \times 962{,}25 \text{ A} = -6666{,}468 \text{ A}$

$I_c = +6{,}928 \times 962{,}25 \text{ A} = +6666{,}468 \text{ A}$

Arus gangguan :

$I_f = I_b = -I_c = 6666{,}468 \text{ A}$

Tegangan - tegangan saluran

$$V_a = 2\,\frac{Z_2}{Z_1 + Z_2} E_a = 2\,\frac{J0{,}15}{J0{,}10 + J0{,}15} \cdot 1 = 1{,}2 \text{ pu}$$

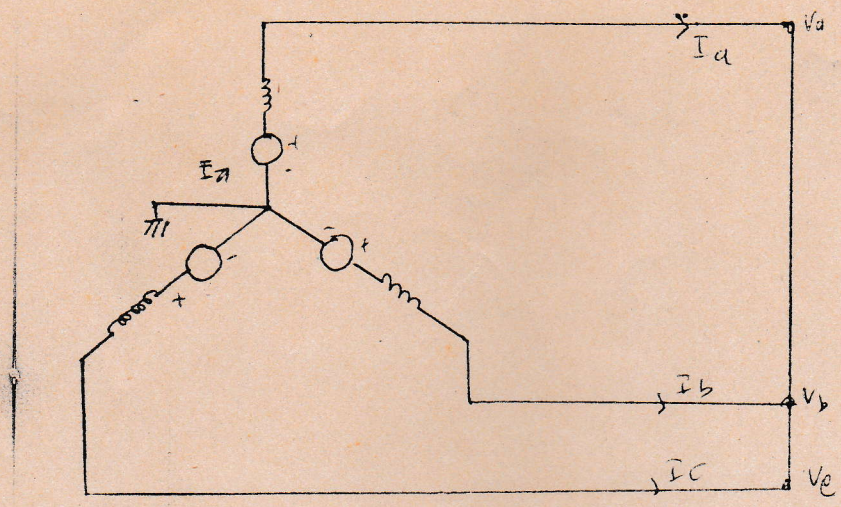
$$= 1{,}2 \times 18 \text{ KV} = 21{,}6 \text{ KV}$$

$$V_b = -\frac{Z_2}{Z_1 + Z_2} E_a = -\frac{J0{,}15}{J0{,}10 + J0{,}15} \cdot 1 = -0{,}6 \text{ pu}$$

$$= -0{,}6 \times 18 \text{ KV} = -10{,}8 \text{ KV}$$

$V_c = V_b = -10{,}8 \text{ KV}$

1.5. GANGGUAN 3 PHASA (THREE PHASE FAULT)



Persamaan - persamaan pada titik gangguan.

$$V_a - V_b = 0$$
$$V_a = V_b \quad (1)$$
$$V_a - V_c = 0$$
$$V_a = V_c \quad (2)$$
$$I_a + I_b + I_c = 0 \quad (3)$$

dari (1) & (2)

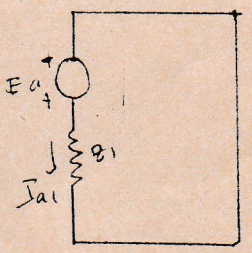
$$V_{ao} = \frac{1}{3}(V_a + V_b + V_c) = \frac{3V_a}{3} = V_a$$
$$V_{a1} = \frac{1}{3}(V_a + aV_b + a^2V_c) = \frac{1}{3}(1 + a + a^2)V_a = 0$$
$$V_{a2} = \frac{1}{3}(V_a + a^2V_b + aV_c) = \frac{1}{3}(1 + a + a^2)V_a = 0$$

dari (3)

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

dari persamaan umum :

$$V_{a1} = E_a - I_{a1}Z_1 = 0$$
$$E_a = I_{a1}Z_1$$
$$\boxed{I_{a1} = \frac{E_a}{Z_1}}$$



$$V_{a2} = -I_{a2}Z_2 = 0$$
$$I_{a2} = 0$$

arus - arus saluran :

$$I_a = I_{ao} + I_{a1} + I_{a2} = 0 + \frac{E_a}{Z_1} + 0 = \frac{E_a}{Z_1}$$
$$I_b = I_{ao} + a^2I_{a1} + aI_{a2} = 0 + a^2\frac{E_a}{Z_1} + 0 = a^2\frac{E_a}{Z_1}$$
$$I_c = I_{ao} + aI_{a1} + a^2I_{a2} = 0 + a\frac{E_a}{Z_1} + 0 = a\frac{E_a}{Z_1}$$

arus gangguan

$$\boxed{I_f = I_{a1} = \frac{E_a}{Z_1}}$$

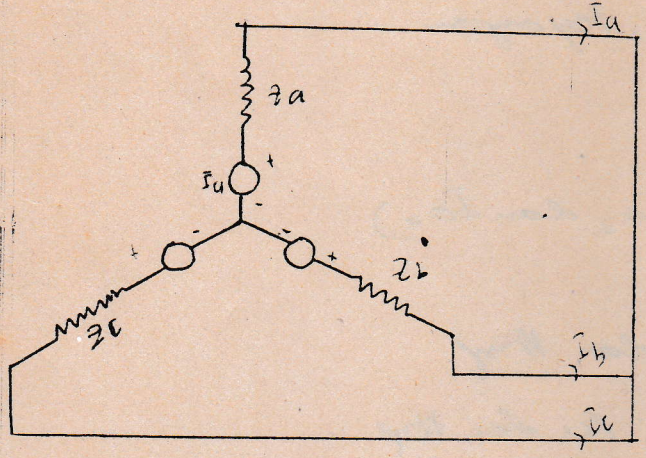
tegangan - tegangan saluran ; kalau Z_0 = terhubung $\rightarrow V_{ao} = 0$, maka

$$V_a = V_{ao} + V_{a1} + V_{a2} = V_{ao} + 0 + 0 = V_{ao} = 0$$
$$V_b = V_{ao} + a^2V_{a1} + aV_{a2} = V_{ao} + 0 + 0 = V_{ao} = 0$$
$$V_c = V_{ao} + aV_{a1} + a^2V_{a2} = V_{ao} + 0 + 0 = V_{ao} = 0$$

Contoh : I.5

Hitunglah arus - arus dua perahian pada keadaan dua perahian oleh suatu gangguan 3 phase tegadi pada generator yang telah dimaksud dalam contoh I.4.

Jawab :



$Z_1 = j0,10$ pu

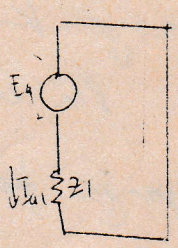
$Z_2 = j0,15$ pu

$Z_0 = j0,05$ pu

$I_a = 1$ pu

$I_{dasar} = \frac{30.000 \text{ KVA}}{\sqrt{3}\ 18 \text{ KV}} = 962,25 \text{ A}$

$$I_{a1} = \frac{E_a}{Z_1} = \frac{1}{j0,10} = -j10 \text{ pu}$$



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

$I_a = I_{a1} + I_{a2} + I_{a0} = -j10$ pu

I_a sebenarnya $= 10 \times 962,25 \text{ A} = 9622,5 \text{ A}$

$I_b = a^2 I_{a1} = (-0,5 - j0,866) \cdot -j10 = (5j - 8,66)$ pu

$= 10 \angle 150°$ pu

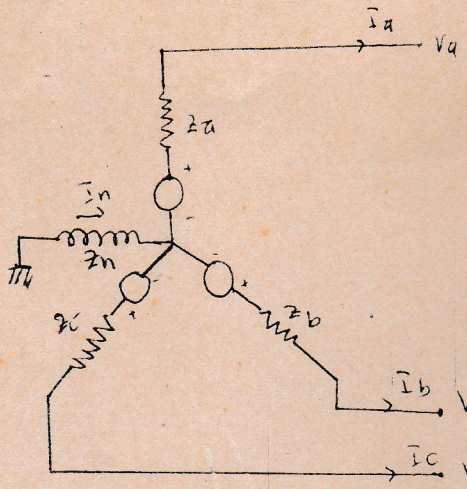
I_b sebenarnya $= 10 \angle 150° \times 962,25 \text{ A} = 9622,5 \angle 150° \text{ A}$

$I_c = a I_{a1} = (-0,5 + j0,866) - j10 = j5 + 8,66$ pu

$= 10 \angle 30°$ pu

I_c sebenarnya $= 10 \angle 30° \times 962,25 \text{ A} = 9622,5 \angle 30° \text{ A}$

II. GENERATOR NETRALNYA DITANAHKAN MELALUI IMPEDANSI REAKTOR



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

$V_{a2} = 0 - I_{a2} Z_2$

$V_{ao} = 0 - I_{ao} Z_o' - I_n Z_n$

$I_n = I_a + I_b + I_c$

$V_{ao} = -I_{ao} Z_o' - (I_a + I_b + I_c) Z_n$

$= -I_{ao} Z_o' - 3 I_{ao} Z_n$

$= -I_{ao} (Z_o' + 3 Z_n) = -I_{ao} Z_o$

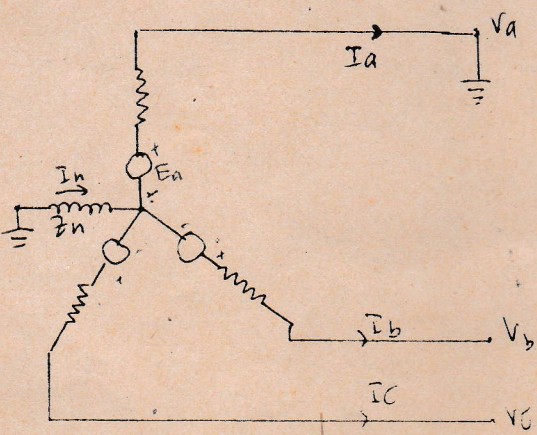
$Z_o = Z_o' + 3 Z_n$

Z_o' = impedansi urutan nol antara netral dan titik gangguan

Z_o = impedansi urutan nol antara titik gangguan dan tanah

Z_n = impedansi reaktansi netral generator ke tanah.

II.1. GANGGUAN SATU SALURAN KE TANAH (PHASA A)
(SINGLE LINE TO GROUND FAULT)



Persamaan - persamaan keadaan pada titik gangguan :

$V_a = 0$; (1)

$I_b = 0$ (2)

$I_c = 0$ (3)

dari (2) & (3) diperoleh :

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

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

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

$\therefore I_{ao} = I_{a1} = I_{a2} = 1/3\, I_a$.

dari (1)

$$V_a = V_{a1} + V_{a2} + V_{a0} = 0$$

$$V_{a1} = -(V_{a0} + V_{a2})$$

$$= -(-I_{a0} Z_0' - I_n Z_n - I_{a2} Z_2)$$

$$= I_{a0} Z_0' + I_n Z_n + I_{a2} Z_2$$

$$= I_{a0} Z_0' + 3 I_{a0} Z_n + I_{a2} Z_2$$

$$= I_{a0} (Z_0' + 3Z_n) + I_{a2} Z_2$$

$$= I_{a1} (Z_0' + 3Z_n + Z_2)$$

Persamaan umum

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

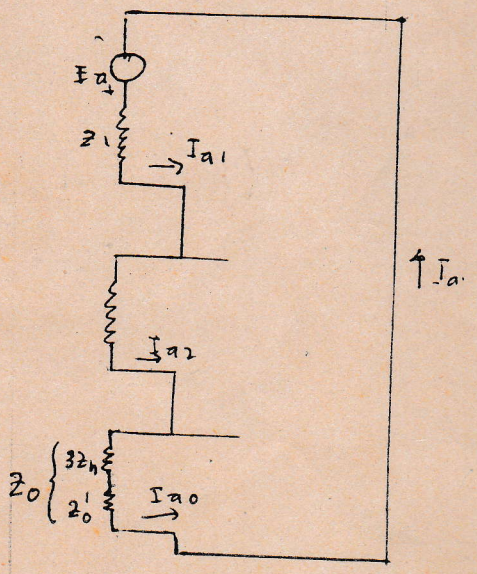
maka

$$E_a - I_{a1} Z_1 = I_{a1} (Z_0' + 3Z_n + Z_2)$$

$$I_{a1} (Z_0' + 3Z_n + Z_2 + Z_1) = E_a$$

$$I_{a1} = \frac{E_a}{(Z_0' + 3Z_n) + Z_2 + Z_1} = \frac{E_a}{Z_0 + Z_1 + Z_2} \longrightarrow I_{a1} = I_{a2} = I_{a0}$$

Rangkaian ekivalennya :



$$I_{a0} = I_{a2} = I_{a1} = \frac{E_a}{(Z_0' + 3Z_n) + Z_2 + Z_1}$$

$$V_{a0} = -I_{a0} Z_0 = -I_{a0} (Z_0' + 3Z_n)$$

$$= -\frac{Z_0' + 3Z_n}{(Z_0' + 3Z_n) + Z_2 + Z_1} E_a \longrightarrow I_{a0}$$

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

$$= E_a - \frac{Z_1 \quad E_a}{(Z_0' + 3Z_n) + Z_2 + Z_1}$$

$$= \frac{Z_0' + 3Z_n + Z_2}{Z_0' + 3Z_n + Z_2 + Z_1} E_a$$

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

$$= -\frac{Z_2 \quad E_a}{Z_0' + 3Z_n + Z_2 + Z_1}$$

Arus gangguan : $I_f = I_a$

$$I_a = I_{a0} + I_{a1} + I_{a2} = \frac{3 \; E_a}{Z_0' + 3Z_n + Z_2 + Z_1}$$

$Z_0 = Z_0' + 3Z_n$