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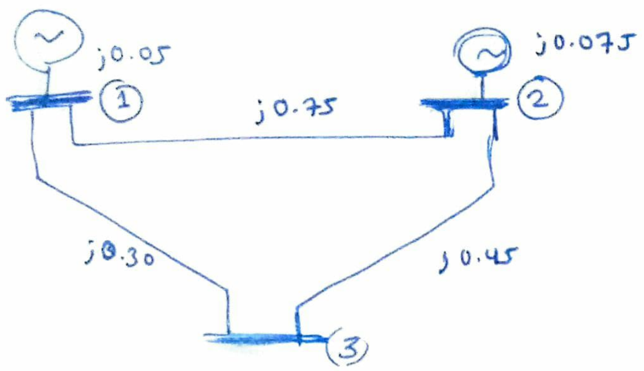
2020EEY7525

ELL 770 : POWER SYSTEMS ANALYSIS

ASSIGNMENT 6

1.



- $Z_{bus} = [\ ]$
- Add new bus ① to ref. via $z = j0.05$ (I)

$Z_{bus} = j\,[0.05]$

- Add new bus ② to ref. via $z = j0.075$ (I)

$$Z_{bus} = j\begin{bmatrix} 0.0500 & 0.0000 \\ 0.0000 & 0.0750 \end{bmatrix}$$

- Add link ~~btw~~ of $z = j0.75$ b/w existing buses ① and ② (IV)

$$\Delta Z = [Z_{bus}(:,1) - Z_{bus}(:,2)] = j\begin{bmatrix} 0.0500 \\ -0.0750 \end{bmatrix}$$

$$Z_{\ell\ell} = Z_{bus}(1,1) + Z_{bus}(2,2) - 2Z_{bus}(1,2) + z$$

or $Z_{\ell\ell} = j0.8750$

$$Z_{bus}^{new} = Z_{bus} - \frac{\Delta Z . \Delta Z^{T}}{Z_{\ell\ell}}$$

or $Z_{bus}^{new} = j\begin{bmatrix} 0.0470 & 0.0043 \\ 0.0043 & 0.0686 \end{bmatrix}$

- Add new bus 3 to existing bus 1 via $z = j0.30$ (II)

$$Z_{bus} = j\begin{bmatrix} 0.0471 & 0.0043 & 0.0471 \\ 0.0043 & 0.0686 & 0.0043 \\ 0.0471 & 0.0043 & 0.3471 \end{bmatrix}$$

- Add a link of $z = j0.45$ b/w existing buses 2 and 3 (IV):

$$Z_{bus} = j\begin{bmatrix} 0.0450 & 0.0075 & 0.0300 \\ 0.0075 & 0.0638 & 0.0300 \\ 0.0300 & 0.0300 & 0.2100 \end{bmatrix}$$

Symmeterical fault at bus 3, $Z_f = j0.19$!

~~Is~~ For unloaded generators, $V_0 = \begin{bmatrix} 1.00 \\ 1.00 \\ 1.00 \end{bmatrix}$ (pre-fault voltage).

Fault current (at bus 3): $I_{3f} = \dfrac{V_0(3)}{Z_{bus}(3,3) + Z_f}$

or $\boxed{I_{3f} = -j2.5000}$ Ans

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~~Post~~ During fault voltages :

$$V = V_0 - \frac{Z_{bus}(:,3)}{Z_{bus}(3,3) + Z_f} \cdot V_0$$

or $$\boxed{V = \begin{bmatrix} 0.9250 \\ 0.9250 \\ 0.4750 \end{bmatrix}}$$ Ans

Line current during fault:

$$I_{12} = \frac{V(1) - V(2)}{Z_{12}} = 0$$

$$I_{13} = \frac{V(1) - V(3)}{Z_{13}} = -j1.5000$$

$$I_{23} = \frac{V(2) - V(3)}{Z_{23}} = -j1.0000$$

Ans

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$\boxed{2.}$

$$I_a^{012} = \begin{bmatrix} 3 \angle -30^\circ \\ 5 \angle 90^\circ \\ 4 \angle 30^\circ \end{bmatrix}$$

$$\boxed{I_a^{abc} = A I_a^{012} = \begin{bmatrix} 8.1854 & \angle 42.2163^\circ \\ 4.0000 & \angle -30.0000^\circ \\ 8.1854 & \angle -102.2163^\circ \end{bmatrix}}$$ Ans.

where $A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha^2 & \alpha \\ 1 & \alpha & \alpha^2 \end{bmatrix}$

$\alpha = 1\angle 120^\circ$.

$\boxed{3.}$ Converting balanced Y load to balanced Δ load and drawing the circuit. (Fig. 1)

$Z_\Delta = 3 Z_Y = 111\angle 0\ \Omega$

$V_{ab} = 600\angle 36.87^\circ$ V

$V_{bc} = 800\angle 126.87^\circ$ V

$V_{ca} = 1000\angle -90^\circ$ V

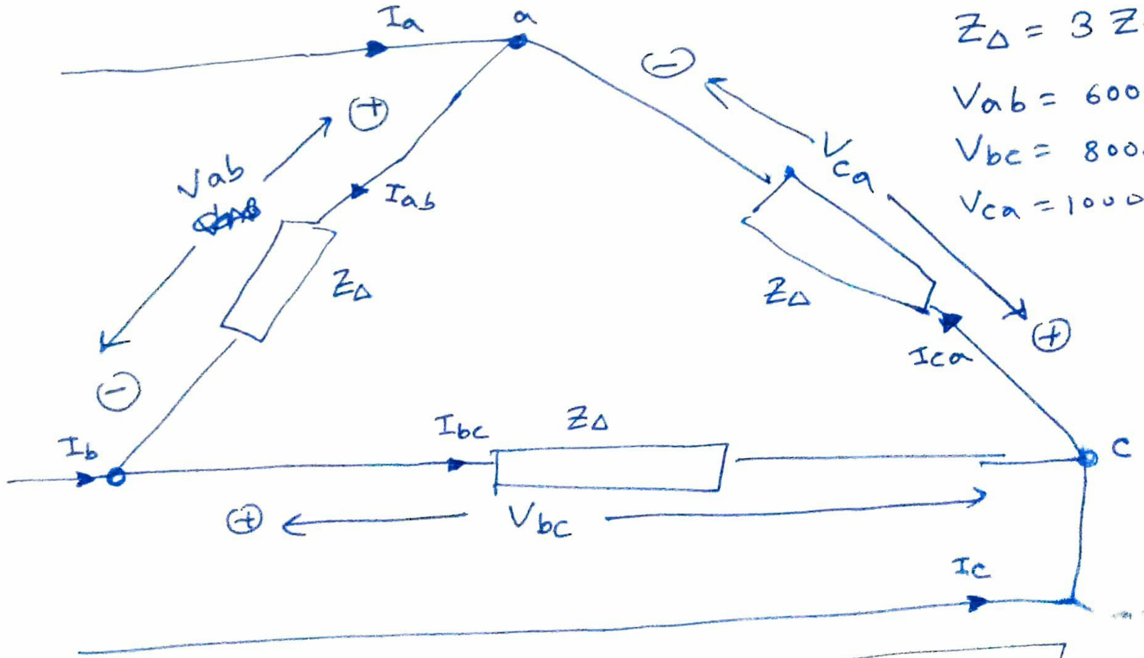

Fig. 1: Delta configuration

(a) < will be shown later >

(b) < will be shown later >

(c) Line currents:

(c)

$$I_a = I_{ab} - I_{ca} = \frac{V_{ab} - V_{ca}}{Z_\Delta} = 12.9930\angle 70.5600^\circ \text{ A}$$

$$I_b = I_{bc} - I_{ab} = \frac{V_{bc} - V_{ab}}{Z_\Delta} = 9.0090\angle 163.7393^\circ \text{ A}$$

$$I_c = I_{ca} - I_{bc} = \frac{V_{ca} - V_{bc}}{Z_\Delta} = 15.3946\angle -73.6861 \text{ A}$$

Ans

~~(c)~~ (b) Converting ckt. back to original Y connected load.

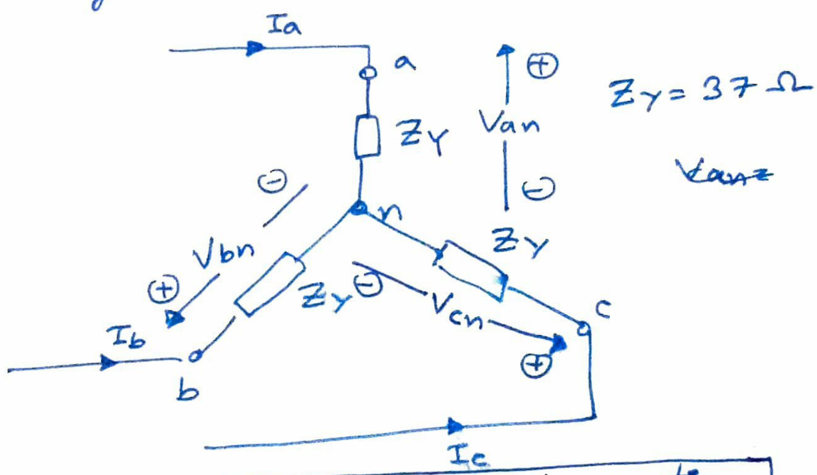

Fig. 2 : Star configuration

(b) Phase voltages:

(b)

$$V^{abc} = \begin{bmatrix} V_{an} \\ V_{bn} \\ V_{cn} \end{bmatrix} = \begin{bmatrix} I_a Z_Y \\ I_b Z_Y \\ I_c Z_Y \end{bmatrix} = \begin{bmatrix} 480.7404\angle 70.5600^\circ \text{ V} \\ 333.3333\angle 163.7393^\circ \text{ V} \\ 569.6001\angle -73.6861^\circ \text{ V} \end{bmatrix}$$

Ans

PTO

(a) The symmetrical components of voltage.

As it isn't clear which voltage (phase or line) and which phase (a/b/c or ab/bc/ca) is required, all components are derived here.

Sequence phase voltages are:

$$V_a^{012} = A^{-1} V^{abc} = \begin{bmatrix} 0.0000 \angle 180.0000^\circ \text{ V} \\ 136.8760 \angle 139.9342^\circ \text{ V} \\ 451.0955 \angle 54.0621^\circ \text{ V} \end{bmatrix}$$

where

$$A^{-1} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix}$$

$$\alpha = 1 \angle 120^\circ$$

$$V_b^{012} = \begin{bmatrix} V_a^0 \\ V_a^1 \angle -120^\circ \\ V_a^2 \angle 120^\circ \end{bmatrix} = \begin{bmatrix} 0.0000 \angle 180.0000^\circ \text{ V} \\ 136.8760 \angle 19.9342^\circ \text{ V} \\ 451.0955 \angle 174.0621^\circ \text{ V} \end{bmatrix}$$

$$V_c^{012} = \begin{bmatrix} V_a^0 \\ V_a^1 \angle 120^\circ \\ V_a^2 \angle -120^\circ \end{bmatrix} = \begin{bmatrix} 0.0000 \angle 180.0000^\circ \text{ V} \\ 136.8760 \angle 259.9342^\circ \text{ V} \\ 451.0955 \angle -65.9379^\circ \text{ V} \end{bmatrix}$$

Ans

PTO

=ly , ~~line~~ sequence line voltages are:

$$V_{ab}^{012} = A^{-1} \begin{bmatrix} V_{ab} \\ V_{bc} \\ V_{ca} \end{bmatrix} = \begin{bmatrix} 0.0000\angle 0.0000^\circ \text{ V} \\ 237.0762\angle 169.9342^\circ \text{ V} \\ 781.3204\angle 24.0621^\circ \text{ V} \end{bmatrix}$$

$$V_{bc}^{012} = \begin{bmatrix} 0.0000\angle 0.0000^\circ \text{ V} \\ 237.0762\angle 49.9342^\circ \text{ V} \\ 781.3204\angle 144.0621^\circ \text{ V} \end{bmatrix}$$

$$V_{ca}^{012} = \begin{bmatrix} 0.0000\angle 0.0000^\circ \text{ V} \\ 237.0762\angle -70.0658^\circ \text{ V} \\ 781.3204\angle -95.9379^\circ \text{ V} \end{bmatrix}$$

Ans

END OF ASSIGNMENT