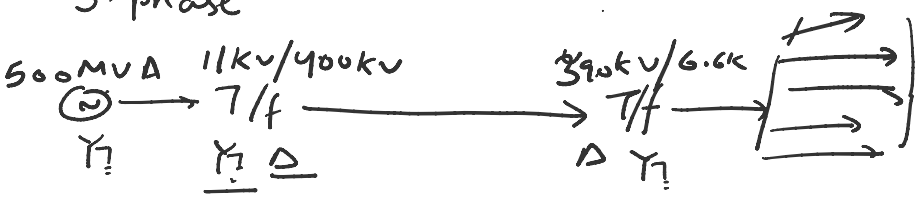
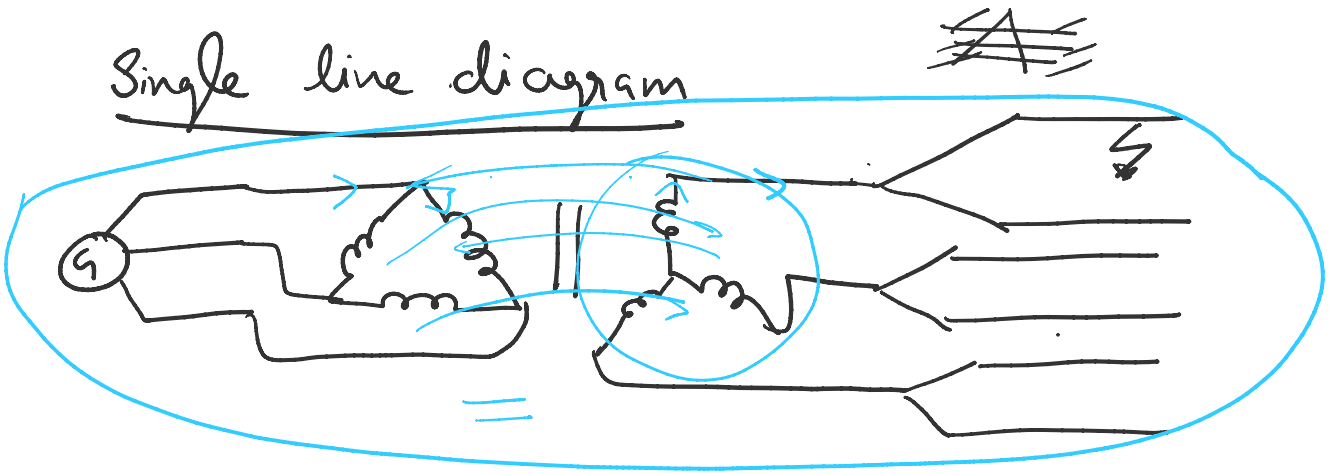
Per Unit System : MVA, KV, KV

03 May 2021 15:45

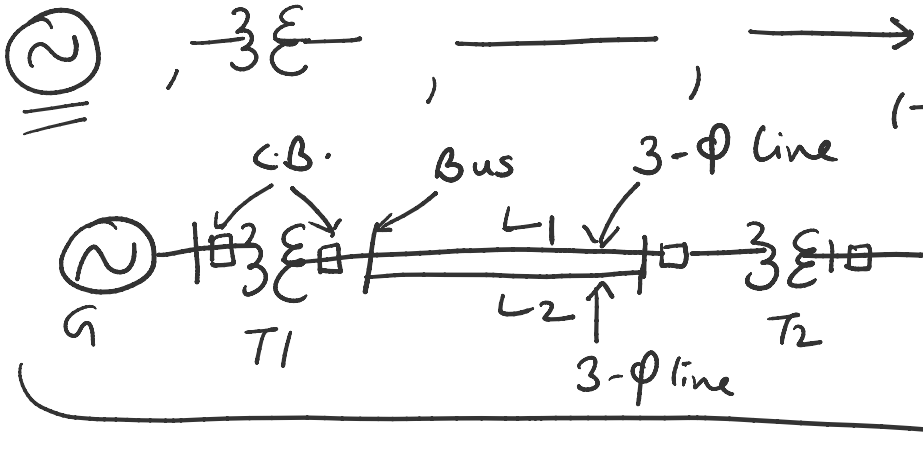
3-phase



Single line diagram



Single line Diagram : —— 3-ϕ circuit



$$\% = \frac{\text{Actual Value}}{\text{Reference}} \times 100 = \frac{4000}{5000} \times 100 = 80\%$$

$$\text{per unit (p.u.)} = \frac{\text{Actual Value}}{\text{Base Value}}$$

Unit less quantity

★ In our power System, only 4 quantities are

★ In our power System, only 4 quantities are consider for Base.

V, I, S, Z are choosen as base Values

$$R_{pu} = \frac{R_a}{R_b} = \frac{R_a}{Z_b}$$

$$R_{pu} + jX_{pu} = Z_{pu} = \frac{Z_a}{Z_b} = \frac{R + jX_L}{Z_b} = \frac{R}{Z_b} + j\frac{X_L}{Z_b}$$

$$R_{pu} = \frac{R}{Z_b} \quad , \quad X_{pu} = \frac{X_L}{Z_b}$$

$(5 + j3)\ \Omega$

$Z_b = 15\ \Omega$

R_{pu}, X_{pu}

$$R_{pu} = \frac{R_a}{Z_b} = \frac{5}{15} = 0.3\ pu$$

$$X_{pu} = \frac{X_a}{Z_b} = j\frac{3}{15} = j\,0.2\ pu$$

$$S = P \pm jQ$$

P_{pu}, Q_{pu}

$$S_{pu} = \frac{S_a}{S_b} = \frac{P_a + jQ_a}{S_b}$$

$$P_{pu} + jQ_{pu} = S_{pu} = \frac{P_a}{S_b} + j\frac{Q_a}{S_b}$$

$$P_{pu} = \frac{P_a}{S_b} \quad , \quad Q_{pu} = \frac{Q_a}{S_b}$$

If S_b , , S_b

$$R_{pu} = \frac{R_a}{Z_b}, \quad X_{pu} = j\frac{X_a}{Z_b}, \quad Z_{pu} = \frac{Z_a}{Z_b}$$

$$P_{pu} = \frac{P_a}{S_b}, \quad Q_{pu} = j\frac{Q_a}{S_b}, \quad S_{pu} = \frac{S_a}{S_b}$$

$$V_{pu} = \frac{V_a}{V_b}, \quad I_{pu} = \frac{I_a}{I_b}$$

If V, I, S, Z,

* In P.S only V_b and S_b are mentioned

Z_b in terms of V_b and S_b

$$S_b = \frac{V_b^2}{Z_b} \Rightarrow \boxed{Z_b = \frac{V_b^2}{S_b}}$$

$$Z_{pu} = \frac{Z_a}{Z_b} \leftarrow \text{ohmic} = \frac{Z\Omega}{Z_b} = \frac{Z\Omega}{V_b^2/S_b}$$

$$\boxed{Z_{pu} = Z_a * \frac{S_b}{V_b^2}}$$

120 kΩ

A ——— j0.3Ω/km ——— B

$V_b = 100\,kV$

$S_b = 500\,MVA$

$Z_{pu} = ?$

$X_a = j0.3 * 120 = j36\ \Omega$

$$X_{pu} = X_a * \frac{S_b}{V_b^2} = j36 * \frac{500 \times 10^6}{(100 \times 10^3)^2} = j\frac{36 \times 500 \times 10^6}{10000 \times 10^6}$$

$$\boxed{X_{pu} = j\frac{9}{5}\,pu = j1.8\,pu}$$

$V_b = 150\,kV, \quad S_b = 1000\,MVA$

$$X_{pu} = j36 \times \frac{1000 \times 10^6}{150 \times 150 \times 10^6} = j\frac{360}{15 \times 15} = j\frac{8}{3}\ pu.$$

I_b in terms of V_b and S_b

1-ϕ System: $S_{b_{1-\phi}} = V_b I_b$ —

$$\Rightarrow I_b = \frac{S_b}{V_b} —$$

$$I_{pu} = \frac{I_a}{I_b} = \frac{I_a}{S_{b1\phi}/V_b} = \frac{I_a \times V_b}{S_{b1-\phi}}$$

3-ϕ System: $S_{b3\phi} = \sqrt{3}\, V_{lb}\, I_{lb}$

$$I_{lb} = \frac{S_{b3\phi}}{\sqrt{3}\, V_{lb}}$$

$$I_{pu} = \frac{I_{la}}{I_{lb}} = \frac{I_{la} * \sqrt{3}\, V_{lb}}{S_{b3\phi}}$$

$$\frac{I_{la}}{I_{lb}} = \frac{\sqrt{3}\, I_{pa}}{\sqrt{3}\, I_{pb}}$$

$$I_{lpu} = I_{ppu}$$

Δ Y → $\frac{V_{la}}{V_{lb}} = \frac{\sqrt{3}\,V_{pa}}{\sqrt{3}\,V_{pb}}$

$V_{lpu} = V_{ppu}$

☆ In p.u. System per unit value line current / voltage = p.u. value phase voltage/current

---

Summarise : $A_{pu} = \frac{A_a}{A_b}$

→ V_b, I_b, Z_b, S_b

→ V_b, S_b

→ $I_{b_1} = \frac{S_{b1-\phi}}{V_b}$, $I_{lb} = \frac{S_{b3-\phi}}{\sqrt{3}\,V_{lb}}$

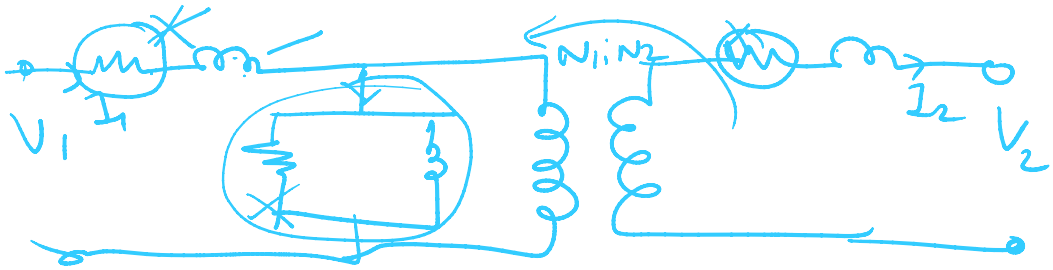
→ $Z_b = \frac{V_b^2}{S_b}$

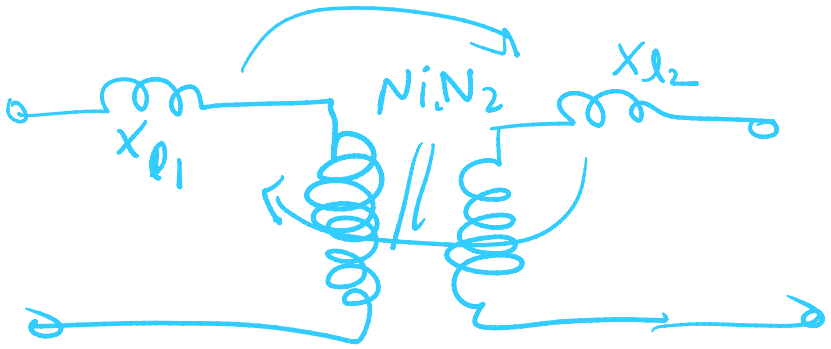
→ $R_{pu} = \frac{R_a}{Z_b}$, $X_{pu} = \frac{X_a}{Z_b}$

→ $P_{pu} = \frac{P_a}{S_b}$, $Q_{pu} = \frac{Q_a}{S_b}$

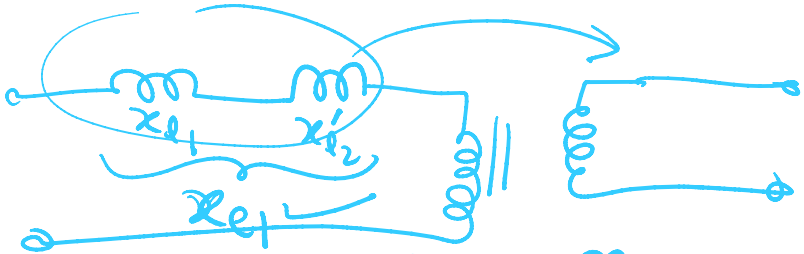
→ $V_{lpu} = V_{ppu}$, $I_{lpu} = I_{ppu}$

☆





$$x'_{l_2} = x_{l_2} * \left(\frac{N_2}{N_1}\right)^2$$



$$x'_{l_1} = x_{l_1} * \left(\frac{N_1}{N_2}\right)^2$$

$x_{e_1} \neq x_{e_2}$ in actual values

If I convert x_{e_1} and x_{e_2} in p.u.

$$x_{e_1 pu} = x_{e_2 pu}$$

→ 5000 MVA

220 kV

$V_b = 220$ kV

$S_b = 1000$ MVA

$$I_l = \frac{5000 \times 10^6}{\sqrt{3} \times 220 \times 10^3} = \text{——}$$

$$V_{pu} = \frac{220\text{kV}}{220\text{ kV}} = 1 \text{ pu}$$

$$S_{pu} = \frac{5000 \text{ MVA}}{1000 \text{ MVA}} = 5 \text{ pu}$$

$$I_{lpu} = \frac{5}{\sqrt{3} \times 1} = \frac{5}{\sqrt{3}} =$$

$0.\overline{6} = \frac{5}{3} = 1.667 = 1.6667$

$I_{pu} = 2.3165$ pu

$= 2.32$ pu

$I_{pu} = \frac{I_a}{I_b}$

$I_a = I_{pu} * I_b$

$I_b = 15000$ A

$I_a = 2.32 * 15000 = 34,800$ A

$I_a = 2.3165 * 15000 = 34747.50$

$S_b = 1000$ MVA

$S_{pu} = 0.6935$

$S_{pu} = 0.7$

$S_a = 693.5$ MVA

$S_a = 700$ MVA

$0.\overline{7}$

7 MVA