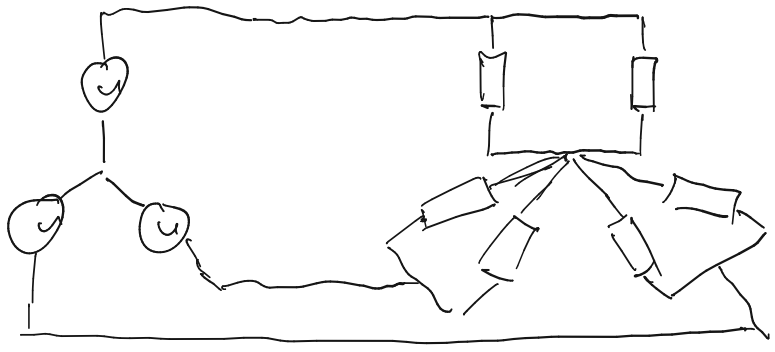
Homework 2 Haoang Wang mw814

Q1.

Transferring Δ to Y ⇒ $Z_Y = \frac{Z_\Delta^2}{3Z_\Delta} = 15 - j6$

The circuit becomes:



$Z_{eq} = Z_Y \| Z_{\Delta Y} = (30+j15) \| (15-j6)$

$= 11.81 \angle -6.55^\circ$

(a) $I_S = \frac{V_S}{Z_{eq}} = \frac{227\angle 0^\circ}{11.81\angle -6.55^\circ} = 23.459 \angle 6.55^\circ$ A

(b) $P_S + jQ_S = 3V_S I_S^* = 3 \times 227\angle 0^\circ \times 23.459\angle 6.55^\circ = (19.36 - j2.223)$ kVA

⇒ Real power $P_S = 19.36$ kW

Reactive Power $Q_S = -2.223$ kVAR

Q2. (a) $U_1 = \frac{23}{\sqrt{3}}$ kV, $\frac{U_2}{U_1} = \frac{230}{23}$ ⇒ $U_2 = 230/\sqrt{3}$ kV

$U_3 = 230/\sqrt{3}$, $U_3/U_4 = 230/69$ ⇒ $U_4 = 230/\sqrt{3} \times 69/230 = 69/\sqrt{3}$ kV

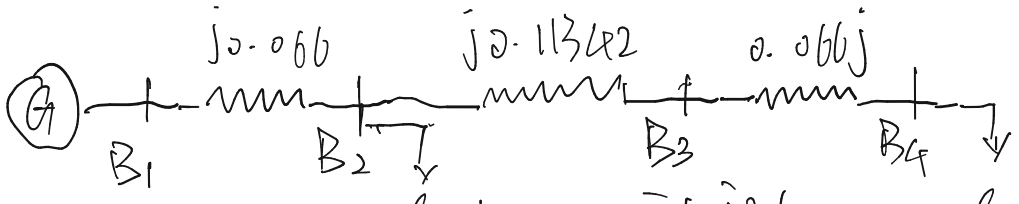
⇒ $(X_{T1})_{new} = (X_{T1})_{old} \times \left(\frac{V_{old}}{V_{new}}\right)^2 \times \left(\frac{MVA_{new}}{MVA_{old}}\right) = 0.066$ PU

$(X_{T2})_{new} = (X_{T2})_{old} \times \left(\frac{V_{old}}{V_{new}}\right)^2 \times \left(\frac{MVA_{new}}{MVA_{old}}\right) = 0.066$ PU

⇒ $Z_{PU} = \frac{Z_{line}}{V_{base}/MVA} = \frac{j60}{\frac{230/\sqrt{3}}{200}} = j0.11342$

load 1 in pU is $\frac{150\text{ mW} + j60\text{ mVAR}}{100} = 1.5 + j0.6$

load 2 in PU is $(120\text{ mW} + j60\text{ mVAR})/100 = 1.2 + j0.6$



(b) The line voltage for load 2 needs 69 kV

$$\Rightarrow V_{PU} = \frac{V_4}{V_{base}} = \frac{69/\sqrt{3}}{69/\sqrt{3}} = 1$$

$$I_{PU} = |I_4| / V_{PU} \cos\left(\tan^{-1}\left(\frac{0.6}{1.2}\right)\right) = 1.3416 \angle -24.56 \text{ PU}$$

$$\Rightarrow V_2 = V_4 + (0.066j + 0.11342j + 0.066j) \times 1.3416 \angle -24.56$$

$$= 1.18442 \angle 14.397 \text{ PU}$$

$$\Rightarrow V_2 = (V_2)_{PU} \times V_{base}$$

$$(V_1)_{phase} = 1.18442 \times 23/\sqrt{3} = 15.727 \text{ kV}$$

$$|V_1|_{line} = |V_1)_{phase} \times \sqrt{3} = 27.2416 \text{ V}$$

(c) $I_2 = I_4 = 1.3416 \angle -24.56$. $V_2 = 1.18442 \angle 14.397$

$$\Rightarrow S = V_2 I_2^* = (1.18442 \angle 14.397) \times (1.3416 \angle 24.56) = 1.2 + j\,1.0415$$

$$\Rightarrow P = 120 \text{ MW}, \quad Q = 104.15 \text{ MW}$$

Q3. (a1) On second T_1 = base $\times$ high voltage / low voltage $= 20 \times \frac{200}{20}$

$$\Rightarrow T_1 \text{ second} = 200 \text{ kV}$$

$$\Rightarrow Z_b = (kV)^2 / (MVA)_b = 400\,\Omega \Rightarrow Z_{PU} = \frac{Z_{actual}}{Z_b} = \frac{j120}{400} = j0.3$$

(a2) T_1 $(X_{PU})_{new} = (X_{PU})_{old} \times \frac{(MVA)_{new}}{(MVA)_{old}} \times \frac{(kV)^2_{b\,old}}{(kV)^2_{b\,new}}$

$$= 0.16 \times \frac{100}{80} \times \left(\frac{200}{200}\right)^2 = j0.2 \text{ PU}$$

T_2 $(X_{PU})_{new} = 0.2 \times \frac{100}{80} \times \left(\frac{200}{200}\right)^2 = j0.25 \text{ PU}$

$(X_{PU})_{G1} = 0.09 \times \frac{100}{90} \times \left(\frac{20}{20}\right)^2 = j0.1 \text{ PU}$

$(kV)_b$ on second T_2 = base $\times$ $\frac{\text{low voltage}}{\text{high voltage}} = 20 \text{ kV}$

$\Rightarrow (X_{PU})_{G2} = 0.09 \times \frac{100}{90} \times \left(\frac{18}{20}\right)^2 = j0.081$

(b) load power = 48 MW + j64 Mvar

$\Rightarrow$ apparent power = $\sqrt{(48)^2 + (64)^2} = 80 \text{ MVA}$

$\Rightarrow$ PU power = $80/100 = 0.8$ PU

(c) $Z_2 = \frac{|V_2|^2}{P + jQ} = \frac{(200 \times 10^3)^2}{80 \times 10^6} = 500\,\Omega$

$$Z_b = \frac{(kV)^2}{(MVA)_b} = \frac{(200)^2}{100} = 400\,\Omega$$

$$\Rightarrow Z_{PU} = \frac{Z_L}{Z_b} = \frac{500}{400} = 1.25 \text{ PU}$$

(d) V×I = PU value of load

$$\Rightarrow I = \frac{\text{PU value of load}}{V}$$

$$= 0.8 \text{ PU}$$