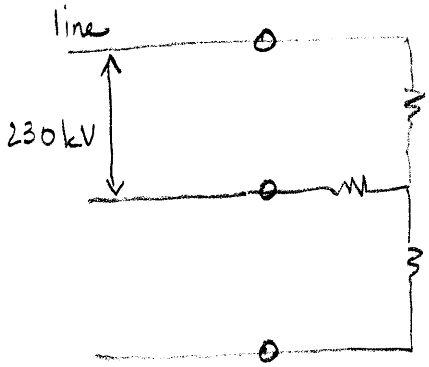
Chapter 5 Power Systems.

Delta

1. A 230 kV (line-to-line), three phase system delivers 200 MVA to a balanced load with a 0.9 power factor (lagging). Determine the line current and the reactance necessary to achieve unity power factor.



$\cancel{I_{phase} = \frac{|S|/3}{V} = \frac{(200\times10^6)/3}{230\times10^3}}$

$\cancel{P_{total} = \sqrt{3}\,|V_{\ell-\ell}|\,|I_\ell|\cos\theta}$

do single line analysis since balanced

$\cancel{\text{apparent power/phase} = \frac{200\text{ MVA}}{3}}$

~~line current = phase current (wye) = apparent power/phase / phase voltage~~

$$S_{phase} = \frac{200\text{ mVA}}{3.}$$

$$|I_{phase}| = \frac{S_{phase}}{V_{line}} = \frac{\frac{1}{3}(200\times10^6)}{230\times10^3} = 289.9\text{ A.}$$

use line-line ? Not sure.

$$|I_{line}| = \sqrt{3}\,|I_{phase}| = \sqrt{3}\,(289.9) = 502\text{ A.}$$

Correct on a phase basis.

$$I_{phase} = I_p + j I_q.$$

$$I_p = |I_{phase}|\cos\theta = 289.9\,(.9) = \quad \text{lagging}$$

$$I_q = |I_{phase}|\sin\theta = 289.9\,\sin(-25.8^\circ) = -126.4$$

to cancel out reactive current

$$I_{comp} = +j\,126.4\text{ Amps.}$$

$$= \frac{V}{Z} = \frac{230\times10^6}{-jX_c} = \frac{230\times10^6}{-jX_c} = +j\,126.4$$

$$X_c = \frac{230\times10^6}{126.4} = 1820\,\Omega.$$

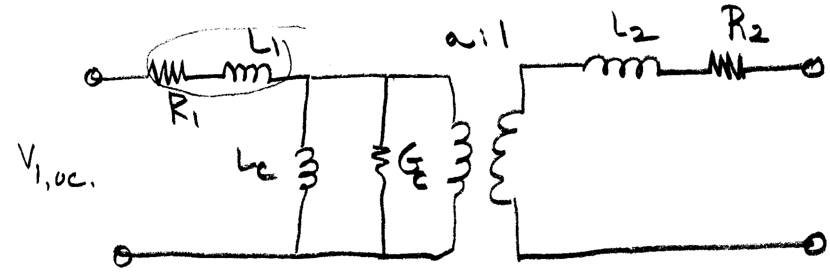
2. A 13.8 kV single phase transformer is subjected to an open circuit test with the following results:

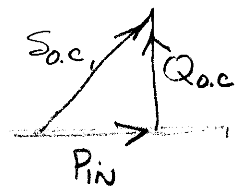
$P_{in} = 900$ Watts.

$I_{in} = 0.2$ A.

$V_{out} = 460$ V (secondary).

Determine the values of the equivalent circuit parameters which can be found from this test.





since open circuit primary winding impedance is negligible.
i.e. R_1 L_1 is negligible

apparant power $S_{oc} = V_{1,oc} I = (13.8 \times 10^3)(0.2)$.

reactive power $Q_{oc}^2 = \underbrace{S_{oc}^2}_{\text{apparant power}} - \underbrace{P_{oc}^2}_{\text{power, real}} = (13.8 \times 10^3 \times .2)^2 - (900)^2 = 2609$ Var.

real power dissipated in G_c $\quad G_c = \dfrac{P_{oc}}{V_{1,oc}^2} = \dfrac{900}{(13800)^2} = 4.73 \times 10^{-6}$ ℧

$B_c = \dfrac{Q_{oc}}{V_{1,oc}^2} = \dfrac{2609}{(13800)^2} = 13.7 \times 10^{-6}$ ℧ technically negative

voltage is easy.

$$\frac{N_P}{N_S} = \frac{V_P}{V_S} = \frac{13800}{460} = 30.$$

3/ A 32 kVA single phase transformer is rated at 1.5 kV on the primary. A 60 Hz short circuit test on the primary indicates

$P_{IN} = 1\,kW$

$I_{in} = 20A$

$I_{sec} = 100A.$

$V_{pri} = 80V.$

Determine the winding resistances and the leakage inductances,

Conducted at rated current of winding to which voltage is applied.

$$N_p I_p = N_s I_s$$

$$a = \frac{N_p}{N_s} = \frac{I_s}{I_p} = \frac{100\,A}{20\,A} = 5A.$$

$$P_{sc} = I_{sc}^2 (R_p + a_{ps}^2 R_s)$$

$$\therefore R_p + a^2 R_s = \frac{P_{sc}}{I_{sc}^2} = \frac{1000\ W}{(20)^2} = 2.5\Omega.$$

for effeciency $R_p = a^2 R_s = \frac{2.5}{2} = 1.25\Omega.$

$$\therefore R_p = 1.25\Omega.$$

$$R_s = \frac{1.25}{5^2} = 0.05\Omega.$$

determine the apparant and reactive power.

$$I_{rated} = \text{[redacted]} \quad \frac{32\,000\ VA}{1\,500}$$

$$|S| = V_p I_p = (80V)(20) = 1600\ VA.$$

inductive

$$S = P + jQ \qquad Q = \sqrt{S^2 - P^2} = \sqrt{(1600)^2 - (1000)^2} = \pm 1249$$