North South University

Assignment 01

Power Systems

Course Code: EEE362

Section: 02

Course Instructor

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(1.4) $R = 10\cos 60° = 5\,\Omega$.

$X = 1\sin 60° = 8.65\,\Omega$.

$I = \dfrac{140 \angle 0°}{10\angle 60°} = 24\angle -60°$ A.

$P = (24)^2 \times 5 = 2880$ W.

$Q = (24)^2 \times 8.66 = 4988$ War.

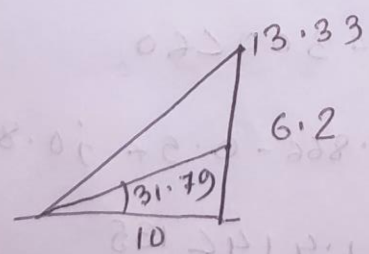
P.F $= \cos(\tan^{-1} X/R) = 0.50$.

(1.6) $\frac{10}{0.6} \sin(\cos^{-1} 0.6) = 13.33$.

$\cos^{-1} 0.85 = 31.79°$.

$\therefore 10 \tan 31.79° = 6.2$ var.

$Q_c = -(13.33 - 6.2) = -7.13$ Var.



1.8 $I = \dfrac{100 + j0 - (86.6 + j50)}{-j5}$

$= 10 + j2.68$

$= 10.35 \angle 15^\circ$ A

$E_1 I^* = 100(10 - j2.68) = 1000 - j268$

$E_2 I^* = (86.6 + j50)(10 - j2.68) = 1000 + j268$

Machine 1 generates 1000W, receives 268 var.

Machine 2 absorbs 1000W, receives 268 var.

Capacitor in line supplies $(10.35)^2 \times 5$

$= 536$ Var. Answer

1.12 (a) $(a - 1) = 0.5 + j0.866 - 1 = 1.73 \angle 150^\circ$

(b) $1 - a^2 + a = 1 - (-0.5 - j0.866) - 0.5 + j0.866$

$= 1 + 1.73 = 3.00 \angle 60$

(c) $a^2 + a + j = -0.5 - j0.866 - 0.5 + j0.866 + j1$

$= -1 + j1 = 1.414 \angle 135$

(d) $ja + a^2 = 1 \angle 210^\circ + 1 \angle 240^\circ = -0.866 - j0.5 - 0.5 - j0.867$

$= -1.366 - j1.366$

$= 1.932 \angle 225^\circ$

1.16 $|I| = \dfrac{15 \times 746}{\sqrt{3} \times 440 \times 0.9 \times 0.8}$

$= 20.39\ A.$

$P = \sqrt{3} \times 440 \times 20.39 \times 0.8.$

$= 12431\ W$ [drawn from line].

$Q = \sqrt{3} \times 440 \times 20 \times 0.39 \times 0.6$

$= 9324$ var [drawn from line].

1.20 $\theta = \cos^{-1} 0.9 = 25.84.$

$14.14 \tan 25.84 = 6.85.$

$14.14 - 6.85 = 7.29$ kvar.

with Capacitor,

$|I| = \dfrac{20000}{\sqrt{3} \times 220} = 52.5A.$

$|I| = \dfrac{\sqrt{14.14^2 + 6.85^2} \times 1000}{\sqrt{3} \times 220}$

$= 41.2\ A.$

(1.24) Per unit base:

$$\text{Base } Z = \frac{(0.44)^2 \times 1000}{20} = 9.68 \text{ per unit.}$$

$$R = \frac{0.3}{9.68} = 0.031 \text{ per unit.}$$

$$X = \frac{1}{9.68} = 0.1033 \text{ per unit.}$$

$$\text{Base } I = \frac{20000}{\sqrt{3} \times 440} = 26.24 A.$$

$$\therefore I = \frac{20.39}{26.24} = 0.777 \text{ per unit.}$$

Voltage:

$$V = 1 + 0.78(0.8 - j0.6)(0.031 + j0.1033)$$

$$= 1.0 + 0.78 \times 0.1079 \angle 36.43$$

$$= 1.0686 \angle 2.97^\circ \text{ per unit.}$$

$$|V_{LL}| = 1.0686 \times 440 = 470 V.$$

Chapter: 2

(2.6)

(a) turn ratio, $a = 1.2\times10^{3}/120 = 10$

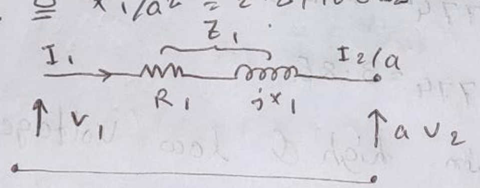
$R_1 = r_1 + a^2 r_2 = 0.8 + 100\times0.01\ \Omega = 1.8\ \Omega$

$X_1 = x_1 + a^2 x_2 = 1.2 + 100\times0.01\ \Omega$

$= 2.2\ \Omega$.

(b) $R_2 \triangleq R_1/a^2 = 1.8/100\ \Omega = 0.018\ \Omega$.

$X_2 \triangleq X_1/a^2 = 2.2/100\ \Omega = 0.022\ \Omega$.



(c) $Z_1 = (1.8 + j2.2)\ \Omega$

$I_{2,FL} = |S_2/V_2| \angle -\theta = \dfrac{7200}{120}\angle -36.9^\circ\ A = 60\angle -36.9^\circ\ A$.

$I_{1\,FL} = \dfrac{I_{2.FL}}{a} = 6.0\angle -36.9^\circ\ A$.

$aV_{2.FL} = 1200\ V$.

$V_{1\,FL} = aV_{2\,FL} + I_{1\,FL} Z_1$

$= 1200 + 6\angle -36.9^\circ(1.8 + j2.2)\ V = (1216.57\angle 0.19^\circ)\ V$

$|V_{2.FL}| = 120\ V$.

$|V_{2.NL}| = V_{1FL}/a = 121.66\ V$.

% Regulation $= (121.66 - 120)/120 = 1.38\%$.

(2.2) (a) $S_2 = |S_2| \angle \theta = 6 \times 10^3 \angle 36.9^\circ$ VA.

$I_2 = \left(S_2 / V_2 \right)^*$.

$Z_2 = V_2 / I_2 = \dfrac{V_2}{S_2^* / V_2^*} = \dfrac{|V_2|^2}{S_2^*}$

$= \dfrac{120^2}{6 \times 10^3 \angle -36.9} \Omega = 2.4 \angle 36.9^\circ \Omega = (1.92 + j1.44)\Omega$

(b) $Z_2' = (N_1/N_2)^2 Z_1 = (V_1/V_2)^2 Z_1 = 100 \times 2.4 \angle 36.9^\circ \Omega$.

$= 192 + j144 \Omega$

(c) $|I_1| = |V_2'| / |Z_2'| = (1.2 \times 10^3)/240$ A $= 5$ A

$S_1 = |V_1||I_1| = 1.2 \times 10^3 \times 5$ VA $= 6$ KVA

2.7 Rated $I = \frac{5000}{220} = 22.72\,A$ (low V).

$I = \frac{5000}{440} = 11.36\,A$ (high V).

$R = \frac{100}{11.36^2} = 0.774\,\Omega$.

$Z = 35/11.36 = 3.08\,\Omega$ [R, Z, x high V].

$x = \sqrt{3.08^2 - 0.774^2} = 2.98\,\Omega$

$x/R = 2.98/0.774 = 3.85$

For equal loss in high & low voltage windings

High V, $r = \frac{0.774}{2} = 0.387\,\Omega$.

$x = 3.85 \times 0.387 = 1.49\,\Omega$.

Low V, $r = (0.387) \times (220/440)^2 = 0.097\,\Omega$.

$x = 1.49\,(220/440)^2 = 0.373\,\Omega$

$S_1 = |V_1||I_1| = 1.2 \times 10^3 \times 5\ VA = 6\ kVA$

2.10 (a) Transformer A-B.

primary : $\frac{500^2}{9.6 \times 10^3} \times j0.05 = j1.302\ \Omega$.

Secondary : $\frac{1.5^2 \times 10^6}{9.6 \times 10^3} \times j0.05 = j11.719\ \Omega$.

Transformer BC :

Primary : $\frac{1.2^2 \times 10^6}{7.2 \times 10^3} \times j0.04 = j8.0\ \Omega$.

Secondary : $\frac{120^2}{7.2 \times 10^3} \times j0.04 = j0.08\ \Omega$.

Load : $\frac{|V|^2}{|S|} \angle\theta = \frac{120^2}{6 \times 10^3} \angle \cos^{-1} 0.8 = 2.4 \angle 36.9°\ \Omega$.

(b) Circuit B: $\frac{1.2^2 \times 10^6}{10 \times 10^3} \Omega = 144 \Omega$.

Circuit C: $\frac{120^2}{10 \times 10^3} \Omega = 1.44 \Omega$

per unit impedances on new bases.

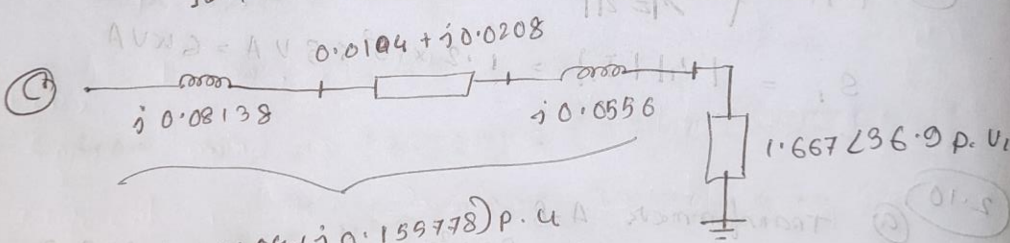
Transformer A-B: $j \frac{11.719}{144} = j\,0.08138$ per unit.

Transformer B-C: $j \frac{8}{144} = j\,0.0556$ per unit.

Line B: $\frac{1.5 + j3.0}{144} = 0.0104 + j0.0208$ per unit.

Load: $\frac{2.4}{1.44} \angle 36.9° = 1.667 \angle 36.9°$ per unit.

(c)



$V_R = 120\,V = 1.0$ per unit.

$$V_S = 1.0 \times \frac{1.667 \angle 36.9° + (0.0104 + j\,0.15778)}{1.667 \angle 36.9}$$

$= 1.0692$ pu.

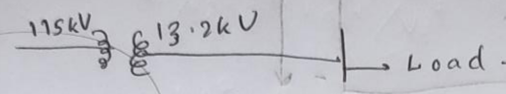
$$V_{S\,base} = \frac{500}{1.5 \times 10^3} \times 1.2 \times 10^3 = 400\,V.$$

$\therefore V_S = 400 \times 1.0642 = 425.69\,V$.

(2.11) $|I_{line}| = \dfrac{8000}{\sqrt{3}\times 138} = 33.47\,A.$

$R = \dfrac{138{,}000/\sqrt{3}}{33.47} = 2380\,\Omega.$

(2.15)



Transformer $Z = 10/5\,(0.007 + j0.075) = 0.014 + j0.150$ pu.

$V_S = 1.0$ pu.

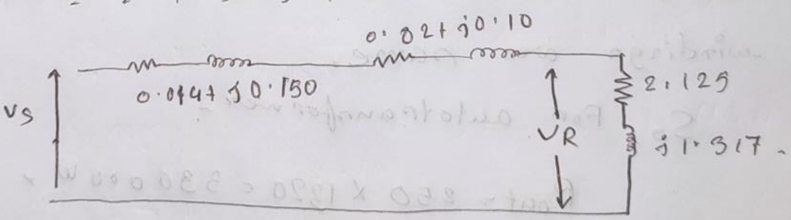
Line $Z = 0.02 + j0.10$ pu.

Load $|Z| = \dfrac{(13.2)^2 \times 1000}{3400/0.85} = 43.56\,\Omega.$

Base Z at load $= \dfrac{(13.2)^2}{10} = 17.42\,\Omega.$

Load $Z = \dfrac{43.56}{17.42} \angle \cos^{-1} 0.85 = 2.50\angle 31.8^\circ$

$= 2.125 + j\,1.317$ pu



(b) $I = \dfrac{1}{0.014 + 0.02 + 2.125 + j(0.150 + 0.10 + 1.317)}$

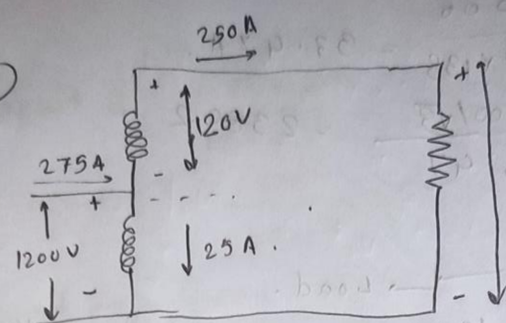
$= 1.0/(2.668\angle 35.97^\circ). = 0.375\angle -35.97^\circ$ pu.

$V_{R,FL} = 0.375\angle -35.97^\circ \times 2.5\angle 31.8^\circ = 0.937\angle -4.17$ pu.

$V_{R,NL} = V_S = 1.0$

$VR = \dfrac{1 - 0.937}{0.937} \times 100 = 6.72\%.$

(2.19)



$$I_{HV} = \frac{30{,}000}{1200} = 25A.$$

$$I_{LV} = \frac{30000}{120} = 250A.$$

Connected for 1200/120V operation

$P_{out} = 30000\,W$, $P_{in} = 30{,}928\,W$.

$Loss = 928\,W$

Here,
Loss remains in the same autotransformer because current in the windings & voltage across the windings are same.

So, For autotransformer :-

$P_{out} = 250 \times 1320 = 330\,000\,W$, $P_{in} = 330{,}928\,W$

$$\eta = \frac{330000}{330928} \times 100 = 99.7\%.$$

Rated kVA = 330000.