Ph 500 KVA 3ϕ TRANSFORMER. VOLTAGE RATIO 6600/440V. IRON loss = 2.9 kw.

Full load copper loss = 4 kw.

FIND % EFFICIENCY AT (a) Full load 0.6 P.F LAGGING

(b) $\frac{1}{2}$ load 0.8 pf LAGGING

(c) $\frac{1}{4}$ load 0.7 pf LAGGING

$$\text{TRANSFORMER \% EFFICIENCY} = \frac{\text{LOAD RATIO} \times \text{RATED V.A} \times \text{pf (OUTPUT)}}{\underbrace{\text{LOAD RATIO} \times \text{RATED V.A} \times \text{pf} + \text{IRON loss} + (\text{LOAD RATIO})^2 \times \text{Full Load copper loss}}_{\text{INPUT}}} \times$$

(a) Full Load 0.6 pf LAGGING

OUTPUT = LOAD RATIO x RATED V.A x pf =

= 1 x 500 KVA x 0.6 = 300 kw

IRON loss = 2.9 kw

COPPER loss = L^2 x Full Load copper loss = 1^2 x 4 kw = 4 kw

$$\text{\% EFFICIENCY} = \frac{300}{300 + 2.9 + 4} \times 100$$

$$= \frac{300}{306.9} \times 100$$

$$= 97.75\%$$

(b) OUTPUT $= \frac{1}{2} \times 500$ kVA $\times 0.8 = 200$ kW

IRON LOSS $= 2.9$ kW

COPPER LOSS $= L^2 \times$ FULL LOAD COPPER LOSS

$$= \left(\frac{1}{2}\right)^2 \times 4 = 1 \text{ kW}$$

$$\text{\% EFFICIENCY} = \frac{200}{200 + 2.9 + 1} \times 100$$

$$= \frac{200}{203.9} \times 100$$

$$= 98.08\%$$

(c) OUTPUT $= \frac{1}{4} \times 500 \times 0.7 = 87.5$ kW

IRONLOSS $= 2.9$ kW

COPPER LOSS $= \left(\frac{1}{4}\right)^2 \times 4 = 0.25$ kW

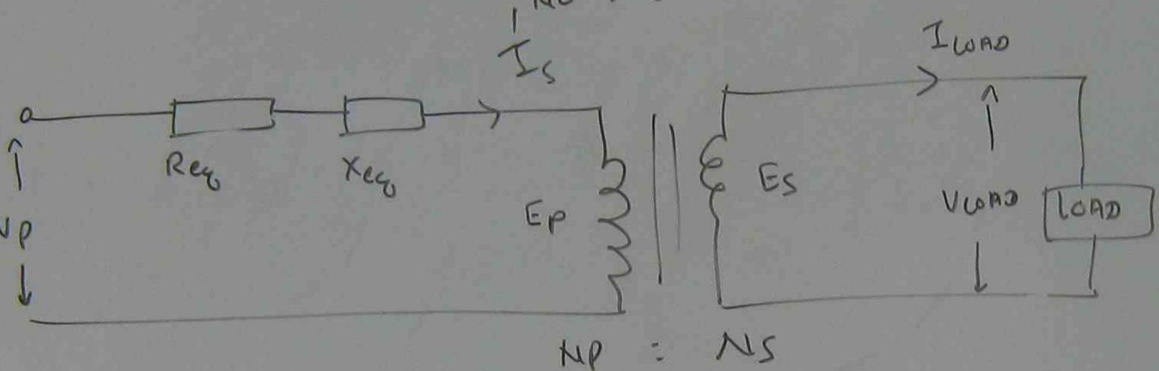
$$\text{\% EFFICIENCY} = \frac{87.5}{87.5 + 2.9 + 0.25} \times 100$$

$$= \frac{87.5 \times 100}{90.65}$$

$$= 96.5\%$$

TRANSFORMER % REGULATION

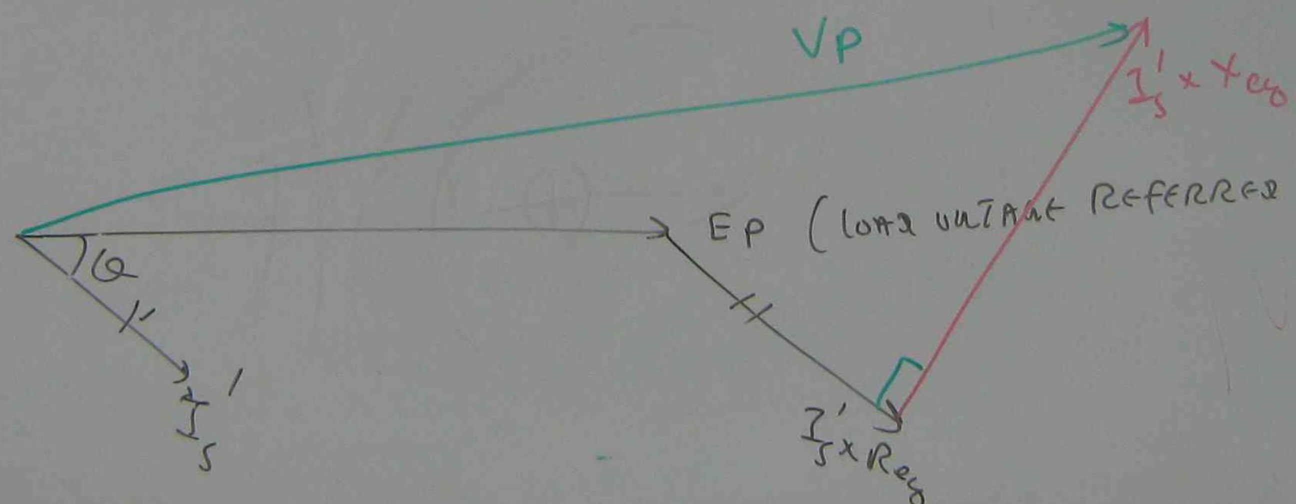
$$\text{\% REGULATION} = \frac{\text{NO LOAD VOLTAGE} - \text{FULL LOAD VOLTAGE}}{} \times 100$$



$$\boxed{E_p = \frac{N_p}{N_s} \times V_{LOAD}}$$

N_p = PRIMARY TURNS

N_s = SECONDARY TURNS.

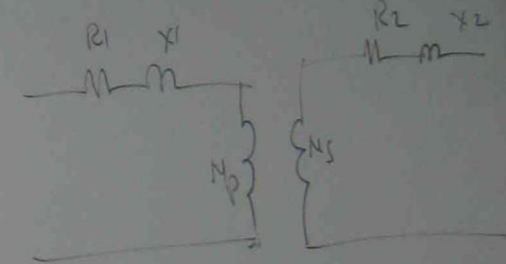


LAGGING P.F

$$\text{\% REGULATION} = \frac{I_s' \left(R_{eq}' \cos\theta + X_{eq}' \sin\theta \right)}{V_P} \times 100$$

LEADING P.F

$$\text{\% REGULATION} = \frac{I_s' \left(R_{eq}' \cos\theta - X_{eq}' \sin\theta \right)}{V_P} \times 100$$



$$R_{eq}' = R_1 + \left(\frac{N_P}{N_S}\right)^2 R_2$$

$$X_{eq}' = X_1 + \left(\frac{N_P}{N_S}\right)^2 X_2$$

$$\underbrace{\frac{I_s' R_{eq}' \cos\theta}{V_P} \times 100}_{\% R} + \underbrace{\frac{I_s' X_{eq}' \sin\theta}{V_P} \times 100}_{\% X} = \% R \cos\theta + \% X \sin\theta \leftarrow \text{LAGGING P.F} = \text{\% REGULATION}$$

$$\% R \cos\theta - \% X \sin\theta \leftarrow \text{LEADING P.F} = \text{\% REGULATION}$$

$X_L = 2\pi f L$

ph/ 100 KVA, 3ϕ TRANSFORMER. $N_p = 400$, $N_s = 80$, $R_p = 0.3\Omega$, $R_s = 0.01\Omega$

$X_p = 1.1\Omega$, $X_s = 0.035\Omega$, $V_p = 2200V$, $V_s = 440V$.

FIND (a) $Z_{eq}' = ?$ (b) $V_s' = ?$ (c) % REGULATION FOR 0.8 PF LAGGING & SECONDARY TERMINAL VOLTAGE

(d) % REGULATION FOR 0.8 PF LEADING & SECONDARY TERMINAL VOLTAGE.

$$\boxed{\frac{N_p}{N_s} = \frac{V_1}{V_2} = \underset{\substack{\uparrow \\ \text{TURN RATIO}}}{a} = \frac{I_2}{I_1}}$$

$$R_{eq}' = R_1 + \left(\frac{N_p}{N_s}\right)^2 \times R_s = 0.3 + \left(\frac{V_1}{V_2}\right)^2 \times 0.01 = 0.3 + \left(\frac{2200}{440}\right)^2 \times 0.01$$

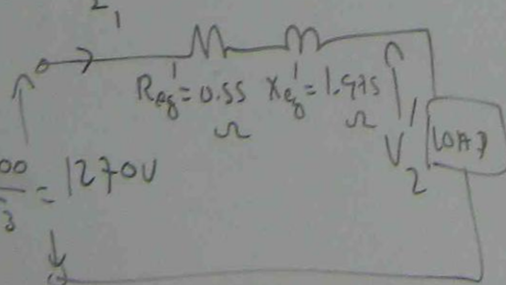
$$= 0.3 + 25 \times 0.01 = 0.55\Omega$$

$$X_{eq}' = X_1 + \left(\frac{N_p}{N_s}\right)^2 \times X_s = 1.1 + \left(\frac{2200}{440}\right)^2 \times 0.035 = 1.1 + 25 \times 0.035 = 1.975\Omega$$

$$Z_{eq}' = \sqrt{R_{eq}'^2 + X_{eq}'^2}\ \angle \tan^{-1}\frac{X_{eq}'}{R_{eq}'}$$

$$Z_{eq}' = \sqrt{0.55^2 + 1.975^2}\ \angle \tan^{-1}\frac{1.975}{0.55}$$

$$= 2.037\ \angle 74.43°\ \Omega$$



$$V_{p\,ph} = \frac{2200}{\sqrt{3}} = 1270V$$

$$I_1 = \frac{KVA \times 10^3}{\sqrt{3} \times V_p} = \frac{100 \times 10^3}{1.7321 \times 2200}$$

$$= 26.24\ \text{Amp.}$$

$\boxed{0.8\ \text{PF LAGGING}}$

$\cos\theta = 0.8 \rightarrow \theta = \cos^{-1} 0.8 = 36.8°$

LAGGING $\Rightarrow 26.24\ \angle -36.8$ Amp

1ϕ $VA = V \times I$

3ϕ $VA = \sqrt{3}\, V I$

$2\pi f L$

INAL VOLTAGE

MINAL VOLTAGE.

.01

$0.55\,\Omega$

$= 1.975\,\Omega$

$_0{}^3$

2200

4 Amp.

$.8 = 36.8$

-36.8 Amp.

$$V_p = V_2' + I_1 Z_{eq}'$$

$$1270 = V_2' + 26.24\angle -36.8 \times 2.037\angle 74.43$$

$$1270 = V_2' + 53.4\angle 74.43 + (-36.8)$$

$$1270 = V_2' + 53.4\angle 37.63$$

$$V_2' = 1270 - 53.4\angle 37.63$$

$$= 1270 - (53.4\cos 37.63 + j\,53.4\sin 37.63)$$

$$= 1270 - (42.29 + j32.6)$$

$$= 1270 - 42.29 - j32.6$$

$$= 1227.71 - j32.6$$

$$= \sqrt{1227.71^2 + 32.6^2}\ \angle -\tan^{-1}\frac{32.6}{1227.71}$$

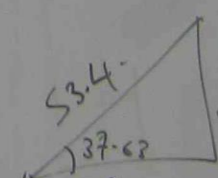
$$= 1228.14\angle -1.43\ V$$

$$V_{2\,LINE} = \sqrt{3} \times 1228.14 = 2127.6\ V$$

$$\%REG = \frac{V_1 - V_2'}{V_1} \times 100$$

$$= \frac{2200 - 2127.6}{2200} \times 100$$

$$= 3.29\%$$



$\Leftarrow 53.4\angle 37.63$

$j\,53.4\sin 37.63$

$53.4\cos 37.63$

8.14 = 2127.6 V

—— x100

127.6
—— x100

$53.4 \angle 37.65$

.4 sin 37.63

(b) 0.8 pf LEADING

$I = 26.24 \angle 36.8$ Amp

$V_p = V_2' + I_1 Z_{e_2}$

$1270 = V_2' + 26.24 \angle 36.8 \times 2.037 \angle 74.43$

$1270 = V_2' + 53.4 \angle 111.23$

$V_2' = 1270 - 53.4 \angle 111.23$

$= 1270 - 53.4 (\cos 111.23 + j \sin 111.23)$

$= 1270 - 53.4 (-0.362 + j0.932)$

$= 1270 + 19.33 - j49.76$

$= 1289.33 - j49.76$

$V_2' = \sqrt{1289\ldots}$

$= 129\ldots$

% REG =

=

$$V_2' = \sqrt{1289.33^2 + 49.70^2} \angle -\tan^{-1}\frac{49.70}{1289.33}$$

$$= 1290.2 \angle -2.2 \ V \longrightarrow V_{2\,LINE} = \sqrt{3} \times 1290.2 =$$

$$\%REG = \quad 2$$

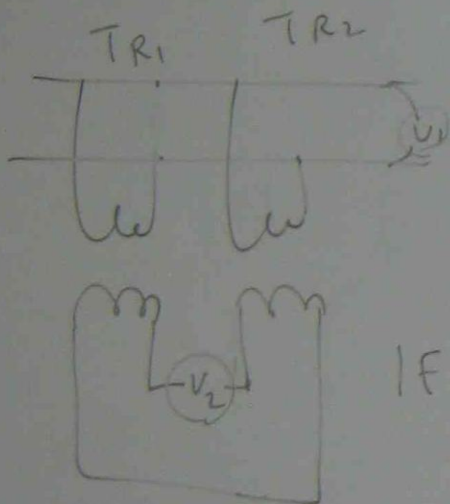
$$\%REG = \frac{V_1 - V_2'}{V_1} \times 100$$

$$= \frac{1270 - 1290.2}{1270} \times 100$$

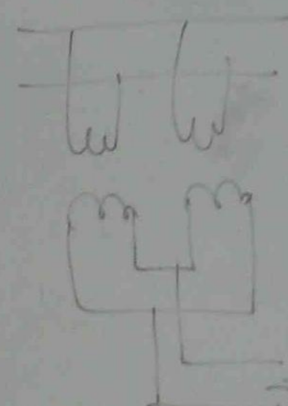
$$=$$

$$= -1.59\,\%$$

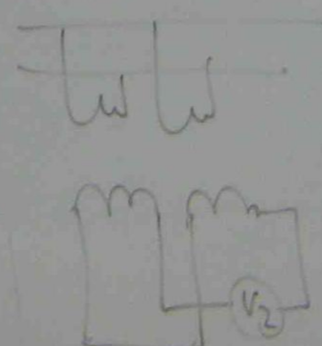
Transformer Parallel Operation and Sharing of Load between Parallel Connected Transformers



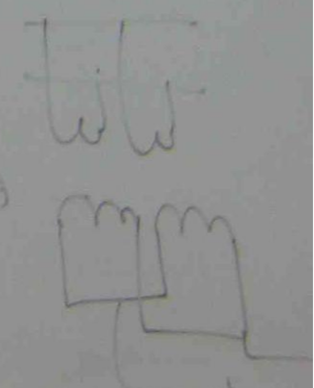
IF $V_2 \simeq 0$ THEN CONNECT



IF V_2 = LINE VOLTAGE → CHANGE CONNECTION



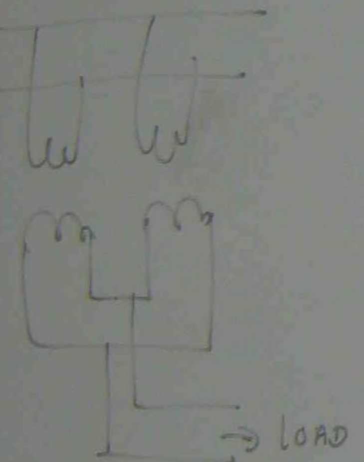
IF $V_2 \simeq 0$ →

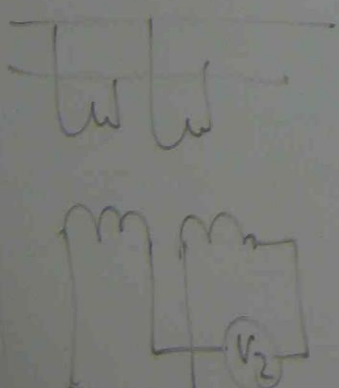


BOTH TRANSFORMERS HAVE SAME RATING

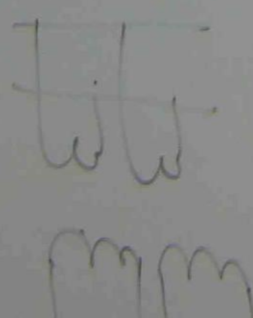
TR A LOAD =

TR B LOAD =

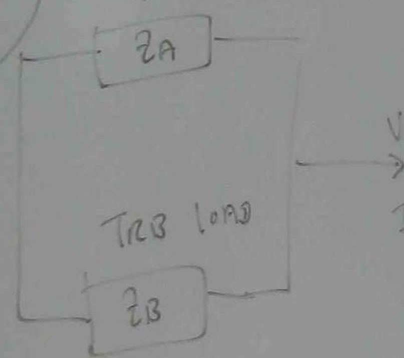




IF $V_2 \simeq 0 \rightarrow$



BOTH TRANSFORMERS HAVE SAME RATING



$$\text{TR A LOAD} = \text{VA TOTAL} \times \frac{Z_B}{Z_A + Z_B}$$

$$\text{TR B LOAD} = \text{VA TOTAL} \times \frac{Z_A}{Z_A + Z_B}$$

TRANSFORMERS HAVE DIFF

SELECT BASE V.

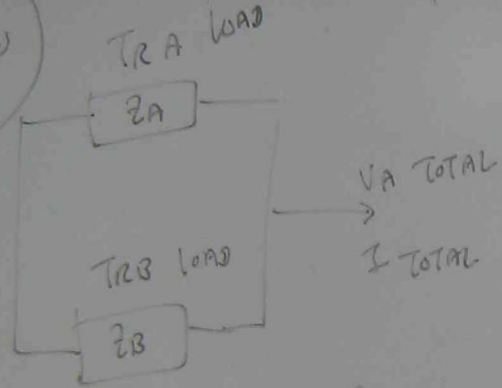
TR_A IMPEDANCE REFERRED TO B V.A

TR_B IMPEDANCE REFERRED TO B V.A

TR A LOAD = VA

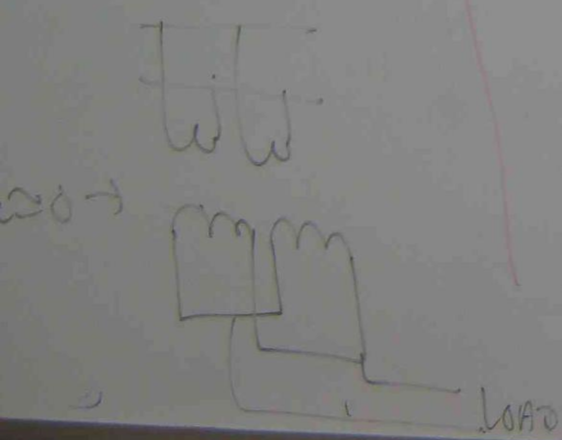
TR B LOAD = V

BOTH TRANSFORMERS HAVE SAME RATING



$$\text{TR A LOAD} = \text{VA TOTAL} \times \frac{Z_B}{Z_A + Z_B}$$

$$\text{TR B LOAD} = \text{VA TOTAL} \times \frac{Z_A}{Z_A + Z_B}$$



TRANSFORMERS HAVE DIFFERENT RATING

SELECT BASE V.A

TR_A IMPEDANCE REFERRED TO BASE V.A $\quad Z'_A = Z_A \times \frac{\text{BASE V.A}}{\text{TR A V.A}}$

TR_B IMPEDANCE REFERRED TO BASE V.A $\quad Z'_B = Z_B \times \frac{\text{BASE VA}}{\text{TR B VA}}$

$$\text{TR A LOAD} = \text{VA TOTAL} \times \frac{Z'_B}{Z'_A + Z'_B}$$

$$\text{TR B LOAD} = \text{VA TOTAL} \times \frac{Z'_A}{Z'_A + Z'_B}$$

pb ①

500 KW LOAD PF 0.85 LAGGING IS SUPPLIED BY TWO TRANSFORMERS CONNECTED IN PARALLEL.

TR A - 800 KVA $Z_A = 3 + j5\ \Omega$

TR B - 800 KVA $Z_B = 2 + j4\ \Omega$.

FIND LOAD SHARE OF EACH TRANSFORMER

pb ②

1000 KW LOAD, PF 0.9 LAGGING IS SUPPLIED BY TWO TRANSFORMERS CONNECTED IN PARALLEL.

TR A - 1000 KVA $Z = 4 + j6\ \Omega$

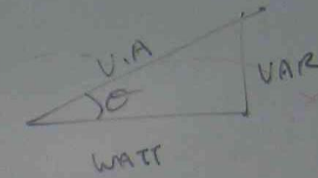
TR B - 500 KVA $Z = 3 + j2\ \Omega$

FIND LOAD ON EACH TRANSFORMER

VA

VA

$VA = \frac{WATT}{P.F} \longleftrightarrow WATT = V.A \times PF$



$PF = \cos\theta$

pb 1

$V.A_{TOTAL} = \frac{500}{0.85} = 588.2\ KVA$

SAME RATING

$TR\ A\ LOAD = V_{A\ TOTAL} \times \frac{Z_B}{Z_A + Z_B}$

$= 588.2 \times \frac{2 + j4}{3 + j5 + 2 + j4}$

$= 588.2 \times \frac{2 + j4}{5 + j9}$

$= 588.2 \times \frac{\sqrt{2^2 + 4^2}}{\sqrt{5^2 + 9^2}}$

$= 588.2 \times \frac{4.47}{10.29} = 255.5\ KVA$

$TR_B\ LOAD = V_{A\ TOTAL} \times \frac{Z_A}{Z_A + Z_B}$

$= 588.2 \times \frac{3 + j5}{10.29} = 588.2 \times \frac{\sqrt{3^2 + 5^2}}{10.29} = \frac{588.2 \times 5.83}{10.29} = 333.3\ KVA$

pb 2

TR A L

TR

VAR

$pf = \cos\theta$

$VA_{TOTAL} = \frac{1000}{0.9} = 1111$ kVA

$R_2 \quad X_2$

SELECT BASE V.A = 1000 kVA

ph 2

$\therefore Z'_A = Z_A \times \frac{\text{BASE V.A}}{\text{TR A VA}} = (4+j6) \times \frac{1000}{1000} = 4+j6$

$Z'_B = Z_B \times \frac{\text{BASE VA}}{\text{TR B VA}} = (3+j2) \times \frac{1000}{500} = 6+j4$

$\text{TR A LOAD} = V_{A\,TOTAL} \times \frac{Z_B}{Z_A + Z_B} = 1111 \cdot \frac{6+j4}{4+j6+6+j4} = 1111 \times \frac{\sqrt{6^2+4^2}}{10+j10}$

$= 1111 \times \frac{\sqrt{6^2+4^2}}{\sqrt{10^2+10^2}} = \frac{1111 \times 7.21}{14.14} = 566.55$ kVA

$\text{TR B LOAD} = VA_{TOTAL} \times \frac{Z_A}{Z_A + Z_B} = 1111 \times \frac{4+j6}{14.14} = \frac{1111 \times \sqrt{4^2+6^2}}{14.14}$

$= \frac{1111 \times 7.21}{14.14} = 566.55$ kVA

3 kVA