Friday, March 15, 2024 12:25 AM

60 Hz Step-down transformer [Non-Ideal]

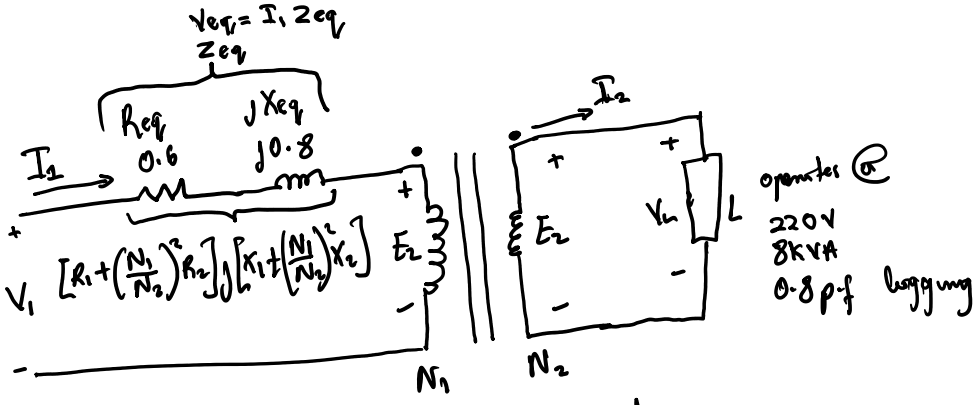
$E_1 / E_2 = 480V / 240V$ @10KVA

Load: $V_L = 220V$

$S_L = 8KVA$ @ 0.8 p.f lagging

$Z_{eq} = 0.6 + j0.8$ [Ω]

1a



Neglecting exciting Current

1b Load Current = I_L

$S_L = V_L \times I_L$

$I_L = \frac{S_L}{V_L}$

$S_L = 8KVA \angle \cos^{-1}(0.8)$

$S_L = 8KVA \angle 36.87°$

$V_L = 220V \angle 0°$

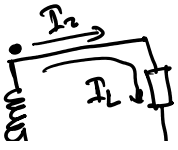
$I_L = \frac{8KVA}{220V} \angle 36.87° - 0°$

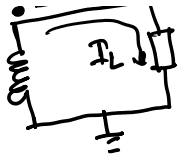
$I_L = 36.36A \angle 36.87°$

Primary Current $I_1 = \frac{N_2}{N_1} \times I_2 = \frac{1}{a_t} I_2$

$a_t = \frac{E_1}{E_2} = \frac{480V}{240V} = 2$

$I_2 = I_L$ since N_2 winding is in series with Load



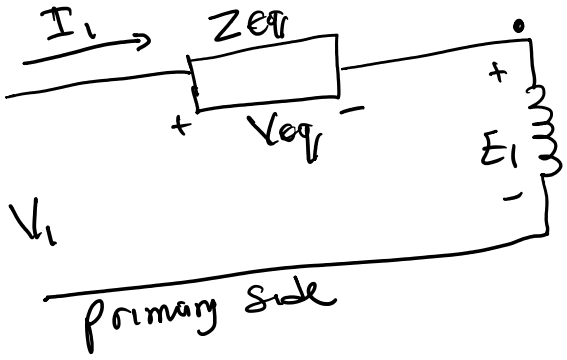


$$I_1 = \frac{1}{a_t} I_L$$

$$I_1 = \frac{1}{2}\left(36.36 \angle 36.87^\circ \text{ [A]}\right)$$

$$I_1 = 18.18 \angle 36.87^\circ \text{ [A]}$$

10



$$V_1 = V_{eq} + E_1$$

$E_1 = 480\text{V}$

$$V_{eq} = I_1 (Z_{eq}) = \left(18.18 \angle 36.87^\circ \text{[A]}\right)\left(0.6 + j1.8\right)$$

$$V_{eq} = \left(18.18 \angle 36.8^\circ \text{[A]}\right)\left(1.897 \angle 71.56^\circ \text{[}\Omega\text{]}\right)$$

$$V_{eq} = 34.49 \angle 108.36^\circ \text{[V]} = -10.86 + j32.73$$

$E_1 = V_p$ rating of transformer

$E_1 = 480\text{V}$

$$V_1 = \left[-10.86 + j32.73\right]\text{V} + \left[480 + j0\right]\text{V}$$

$$V_1 = 469.14 + j32.73 \text{ [V]}$$

1d

$$S_1 = I_1 V_1 = \left(18.18 \angle 36.8^\circ \text{ [A]}\right) \times \left(469.14 + j\,32.73 \text{ [V]}\right)$$

$$S_1 = \left(18.18 \angle 36.8^\circ \text{ [A]}\right)\left(470.28 \angle 3.99^\circ \text{ [V]}\right)$$

$$S_1 = 8549.69 \angle 40.79^\circ \text{ [VA}$$

$$S_1 = 8.55 \angle 40.79^\circ \text{[KVA]}$$

$$P_1 = 8.55 \cos(40.79) \text{ [KW]}$$

$$P_1 = 6.47 \text{[KW]}$$

$$Q_1 = j8.55 \sin(40.79) \text{[KVAR]}$$

$$Q_1 = j\,5.59 \text{ [KVAR]}$$

1e

$$S_1 = I_1^2 Z_{in}$$

$$Z_{in} = \frac{S_1}{I_1^2} = \frac{8.55 \angle 40.79^\circ \text{ [KVA]}}{\left(18.18 \angle 36.8^\circ \text{[A]}\right)^2}$$

$$Z_{in} = 25.87 \angle 40.79^\circ - 2(36.8^\circ) \text{ [}\Omega\text{]}$$

$$Z_{in} = 25.87 \angle -32.81^\circ \text{ [}\Omega\text{]}$$

$$Z_{in} = 21.74 - j14.02 \text{ [}\Omega\text{]}$$

$$Z_{eq} = Z_{in} + Z_L$$

$$Z_L = Z_{eq} - Z_{in}$$

$$(\quad\quad) - (21.74 - j14.02) \text{ [}\Omega\text{]}$$

$$Z_L = Z_{eq} - Z_{in}$$

$$Z_L = (0.6 + j1.8) - (21.74 - j14.02) \quad [\Omega]$$

$$Z_L = 21.14 + j15.82$$

$R_L = 21.14\ \Omega \qquad X_L = j15.82\ [\Omega]$

$$Z_L = R_2 + jX_2$$

$$R_{eq} = R_1 + \left(\frac{N_1}{N_2}\right)^2 R_2 \qquad X_{eq} = X_1 + \left(\frac{N_1}{N_2}\right)^2 X_2$$

$$R_2 = \sqrt{R_{eq} - R_1}\left(\frac{N_2}{N_1}\right) \qquad X_2 = \sqrt{X_{eq} - X_1}\left(\frac{N_2}{N_1}\right)$$

$R_{eq_1} = 0.6\ \Omega$

$$R_1 = \frac{P_1}{I_1^2} = \frac{6.47\ kW}{(18.18 \angle 36.4^\circ [A])^2}$$