(1)

A 100-kVA 8000/277-V distribution transformer has the following resistances and reactances:

$R_P = 5\ \Omega$ $\qquad R_S = 0.005\ \Omega$

$X_P = 6\ \Omega$ $\qquad X_S = 0.006\ \Omega$

$R_C = 50\ \text{k}\Omega$ $\qquad X_M = 10\ \text{k}\Omega$

The excitation branch impedances are given referred to the high-voltage side of the transformer.

(The values on the nameplate are rated line voltage and line current)

(a) Find the equivalent circuit of this transformer referred to the low-voltage side.

(b) Assume that this transformer is supplying rated load at 277 V and 0.85 PF lagging. What is this transformer's input voltage? What is its voltage regulation?

(c) What are the copper losses and core losses in this transformer under the conditions of part *(b)*?

(d) What is the transformer's efficiency under the conditions of part *(b)*?

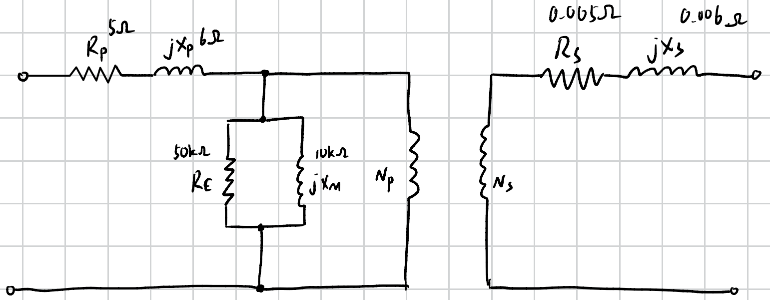
(2)

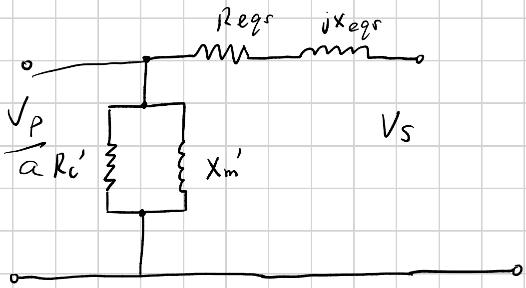
The nameplate on a 25-MVA, 60-Hz single-phase transformer indicates that it has a voltage rating of 8.0-kV:78-kV. A short-circuit test from the high-voltage side (low-voltage winding short circuited) gives readings of 4.53 kV, 321 A, and 77.5 kW. An open-circuit test is conducted from the low-voltage side and the corresponding instrument readings are 8.0 kV, 39.6 A, and 86.2 kW.

a. Calculate the equivalent series impedance of the transformer as referred to the high-voltage terminals.

b. Calculate the equivalent series impedance of the transformer as referred to the low-voltage terminals.

(1) (a)





$a = \frac{8000}{277} = 28.88$

$R_p' = \frac{R_p}{a^2} = \frac{5}{28.88^2} = 5.99 \times 10^{-3}\,\Omega$

$X_p' = \frac{X_p}{a^2} = \frac{6}{28.88^2} = 7.19 \times 10^{-3}\,\Omega$

$R_c' = \frac{R_c}{a^2} = \frac{50000}{28.88^2} = 59.94\,\Omega$

$X_m' = \frac{X_m}{a^2} = \frac{10000}{28.88^2} = 11.99\,\Omega$

$R_{eqs} = \frac{R_p}{a^2} + R_s = 0.01099\,\Omega$

$X_{eqs} = \frac{X_p}{a^2} + X_s = 0.01319\,\Omega$

(b) $\dot{V}_s = 277\angle 0°\,V$

$I_s = \frac{S_s}{V_s} = \frac{100k}{277} = 361\,A$

$\theta = \cos^{-1}(0.85) = 31.79°$

$\dot{I}_s = 361\angle -31.79$

$\dot{V}_s' = \dot{V}_s + \dot{I}_s(R_{eqs} + jX_{eqs})$

$= 277 + (361\angle -31.79°)(0.01099 + j0.01319)$

$= 282.9\angle 0.3964\ V$

Input voltage : $V_s' = 282.9$

$V_R = \frac{V_s - V_s'}{\dot{V}_s} \times 100\% = \frac{282.9 - 277}{277} \times 100\% = 2.130\%$

(c) $P_{cu} = I^2 R_{eq}$

$= 361^2 \times 0.01099$

$= 1432\ W$

$P_{Fe} = \frac{(V_s')^2}{R_c'}$

$= \frac{282.9^2}{59.94}$

$= 1335\ W$

(d) $P = V_s I_s \cos\theta$

$= S \cos\theta$

$= 85\,kW$

$$\eta = \frac{P}{P + P_{cu} + P_{Fe}} \times 100\%$$

$$= \frac{85000}{85000 + 1452 + 1335} \times 100\%$$

$= 96.85\%$

(2) (a) $|Z_{eq,H}| = \frac{V_{sc,H}}{I_{sc,H}} = \frac{4530}{321} = 14.11\,\Omega$

$R_{eq,H} = \frac{P_{sc,H}}{I_{sc,H}^2} = \frac{7750}{321^2} = 0.7521\,\Omega$

$\Rightarrow X_{eq,H} = \sqrt{|Z_{eq,H}|^2 - R_{eq,H}^2} = 14.10\,\Omega$

$\therefore Z_{eq,H} = 0.7521 + j\,14.10\,\Omega$

(b) $N = \frac{78}{8} = 9.75$

$R_{eq,L} = \frac{R_{eq,H}}{N^2} = \frac{0.7521}{9.75^2} = 0.007912\,\Omega$

$X_{eq,L} = \frac{X_{eq,H}}{N^2} = \frac{14.10}{9.75^2} = 0.1483\,\Omega$

$\Rightarrow Z_{eq,L} = 0.007912 + j\,0.1483\,\Omega$