Lecture 7

Monday, 31 August 2009
10:36 AM

Open cct Test

- measure V_1, V_2, I, P

$$\therefore \frac{N_1}{N_2} = \frac{V_1}{V_2}$$

$$R_0 = \frac{V_1^2}{P}$$

$$S = VI$$

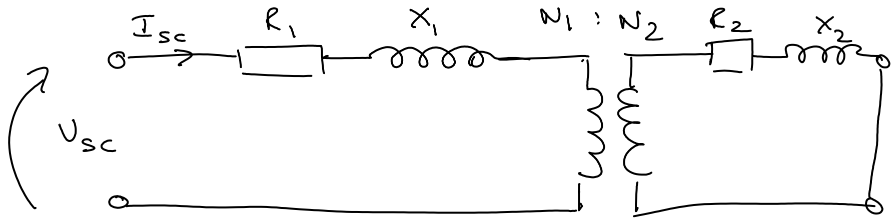
$$Q = \sqrt{S^2 - P^2}$$

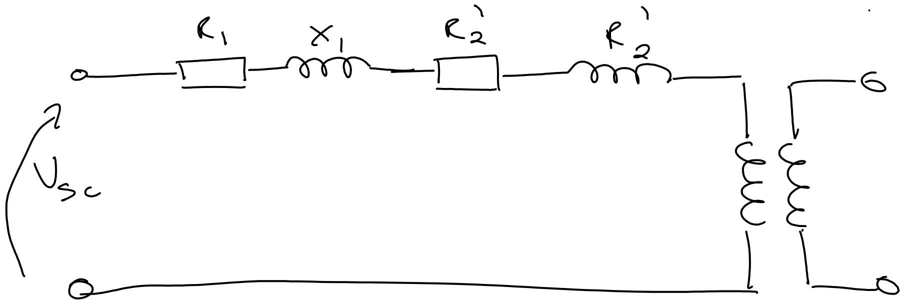
$$X_0 = \frac{V_1^2}{Q}$$

Short cct test

with the terminals of winding 2 s/cct increase the applied voltage on winding 1 until rated primary current flows at rated frequency.

Since R_0, X_0 are very much higher than the winding impedence the exciting current may be ignored





$$R_T = R_1 + R_2' = R_1 + a R_2$$

$$X_T = X_1 + X_2' = X_1 + a X_2$$

take measurements of V_{sc}, I_{sc}, P_{sc}

take measurements of V_{sc}, I_{sc}, P_{sc}

$$P_{sc} = I_{sc}^2 R_T \quad \therefore \quad R_T = \frac{P_{sc}}{I_{sc}^2}$$

$$S_{sc} = V_{sc} I_{sc}$$

$$Q_{sc} = \sqrt{S_{sc}^2 - P_{sc}^2}$$

$$\therefore \quad X_T = \frac{Q_{sc}}{I_{sc}^2}$$

it is usually assumed that $X_1 = X_2' = \frac{1}{2} X_T$

$\Rightarrow$ leakage flux paths are the same for each winding

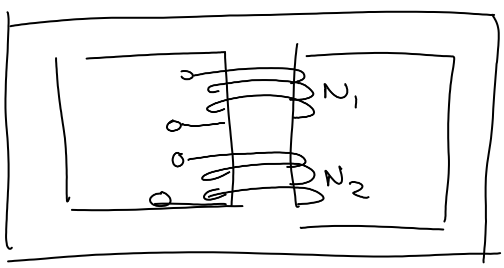
$$X_1 = \omega L_1 = \frac{\omega N_1^2}{R_\ell}$$

$$X_2 = \omega L_2 = \frac{\omega N_2^2}{R_\ell}$$

$$X_2' = \left(\frac{N_1}{N_2}\right)^2 X_2$$

$$= \left(\frac{N_1}{N_2}\right)^2 \frac{\omega N_2^2}{R_\ell}$$

$$= \frac{\omega N_1^2}{R_\ell} = X_1$$



$$L_1 = \frac{N_1^2}{R_l} \qquad L_2 = \frac{N_2^2}{R_l}$$

$$L'_2 = \left(\frac{N_1}{N_2}\right)^2 \times \left(\frac{N_2^2}{R_l}\right)$$

$$= \frac{N_1^2}{R_l}$$

Winding resistance measurements.

R_1 & R_2 may be measured directly using d.c.

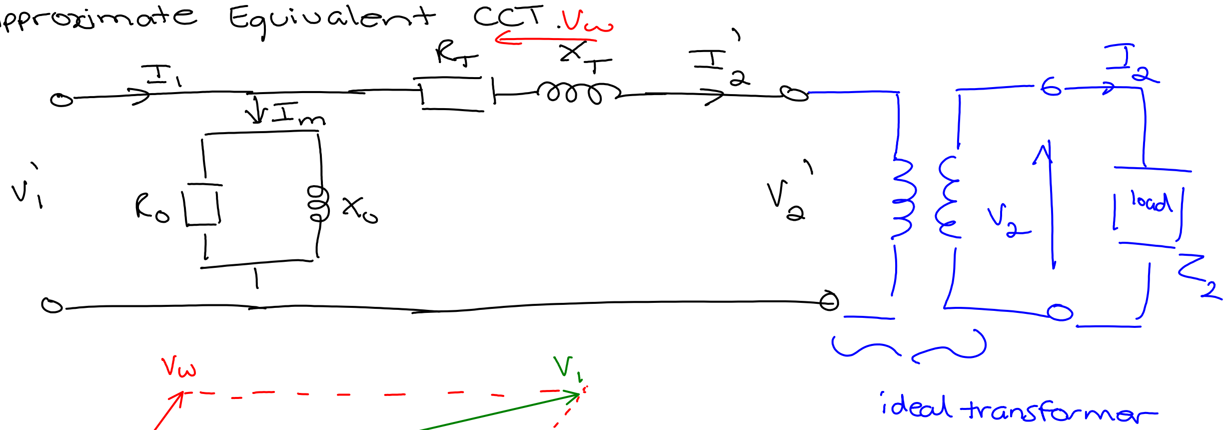
This will give the DC resistance only and may be different to AC resistance (due to skin effect).

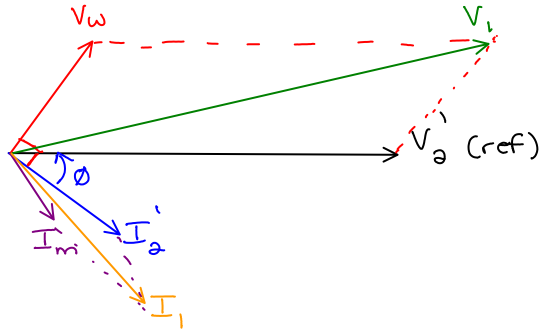
$$R_{DC} = R_{1_{DC}} + \left(\frac{N_1}{N_2}\right)^2 R_{2_{DC}}$$

if the values of R_T & R_{DC} vary appreciably, then the AC winding resistance could be divided into the ratio of the DC resistance 3 windings.

Transformer Phase Diagrams

Approximate Equivalent CCT





Transformer Efficiency

$$\text{Efficiency } (\eta) = \frac{\text{output power}}{}$$

Efficiency (η) = $\frac{\text{output power}}{\text{input power}}$

$$= \frac{\text{output power}}{\text{output power + losses}}$$

$$= \frac{\text{input power} - \text{losses}}{\text{input power}}.$$

can get v high efficiency

efficiency is a function of the load and the power factor so these quantities must be stated when the efficiency is stated.

eg $\eta = 0$ for zero load. ← eta

$\eta \to 1$ for loads near to the transformer rating.

usually quoted as a %

can't measure the difference between input and output power for v high η so can't use $\frac{\text{output power}}{\text{input power}}$.

hence we need to determine the losses independently.

Losses in R_0 & R_T

R_0 ↑ core loss, R_T ↑ winding loss

core losses are constant ie independant of load.

$$P_c = \frac{V_1^2}{R_0} \quad \text{fixed loss}$$

winding losses are dependant on load.

$$P_w = I_2'^2 R_T \quad \text{variable loss}$$

Core Losses

$$P_c = \frac{V_1^2}{R_0} \quad \text{watts.}$$

should be constant for a given V_1

may be determined through open cct test

<u>Winding losses</u>

$P_w = (I_2')^2 R_T$ (watts)

this is a function of the operating condition and may be determined for any given operating condition.

let the secondary load be

$P_{out} = V_2' I_2' \cos \phi_2$

$\Rightarrow \eta = \dfrac{V_2' I_2' \cos \phi_2}{V_2' I_2' \cos \phi_2 + P_C + (I_2')^2 R_T}$