Basic Electrical Engineering (TEE 101)

Lecture 41: Transformer on NO - Load

By: Dr. Parmesh Saini

Content

This lecture covers:

- **Transformer on NO - Load**
- **Phasor Diagram of Transformer on NO - Load**
- **Numerical Examples**

Introduction

A transformer is said to be on *no-load* if its secondary side is open and primary is connected to a sinusoidal alternating voltage V_1.

Under No-Load condition, a low (about 2% to 5% of the rated primary current) current flows through the primary winding. It is denoted as I_0

This primary input current (I_0) under no-load conditions is responsible for :

(*i*) *Iron losses in the core* (*i.e.*, hysteresis loss and eddy current loss).

(*ii*) A very *small amount of copper losses in primary* (there being no copper loss in the secondary as it is open).

No-load current (I_0) consists of two components Iw and Iμ or Im.

Iw is the wattful/active component and it supplies for the core loss in the transformer.

Iμ or Im is the wattless/reactive component and it sets up flux in the core

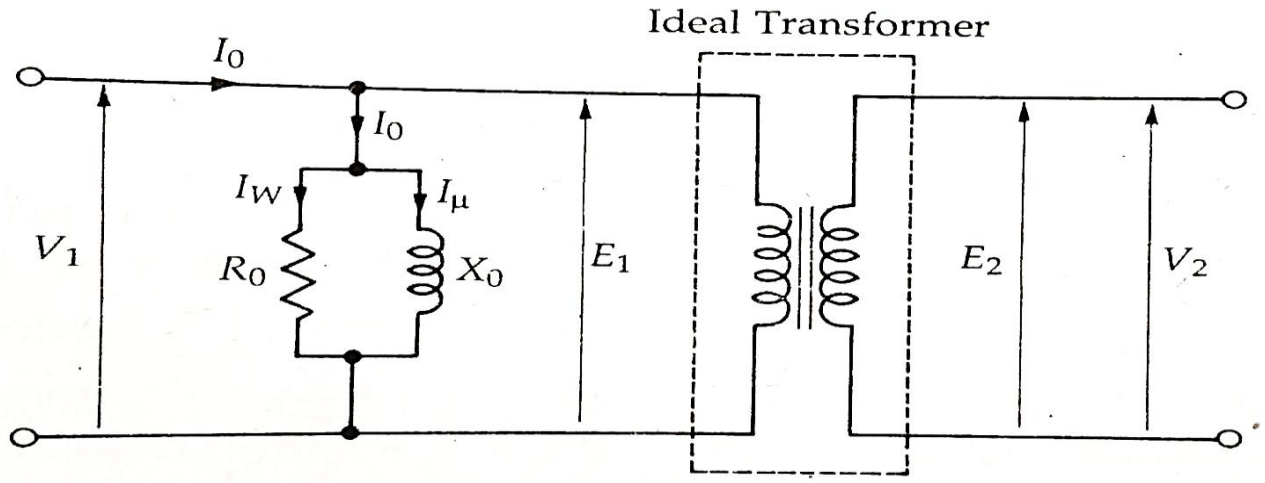

Figure 1: NO-LOAD EQUIVALENT CIRCUIT OF A TRANSFORMER

Phasor Diagram

Figure 1 represents the phasor diagram of transformer under NO - Load condition.

(*i*) ***Active component I_w***. This component is in *phase with* V_1 and mainly supplies the iron loss plus small quantity of primary copper loss. It is the wattful or active component of the primary no-load current. $I_w = I_0 \cos \varphi_0$ ...(*i*)

(*ii*) ***Reactive component I_μ or I_m*** This component lags V_1 *by 90°* and its function is to *sustain the alternating flux in the core*. It is *wattles component of the primary no-load current. It is also known as magnetizing component.* $I_m = I_0 \sin \varphi_0$ ...(*ii*)

Also $I_0 = \sqrt{I_w^2 + I_m^2}$ ...(*iii*)

Thus I_0 is not at 90° behind V_1, but lags it by an angle $\varphi_0 < 90°$.

No-load power input, $P_0 = V_1 I_0 \cos \varphi_0$

where $\cos \varphi_0$ = primary power factor under no-load conditions.

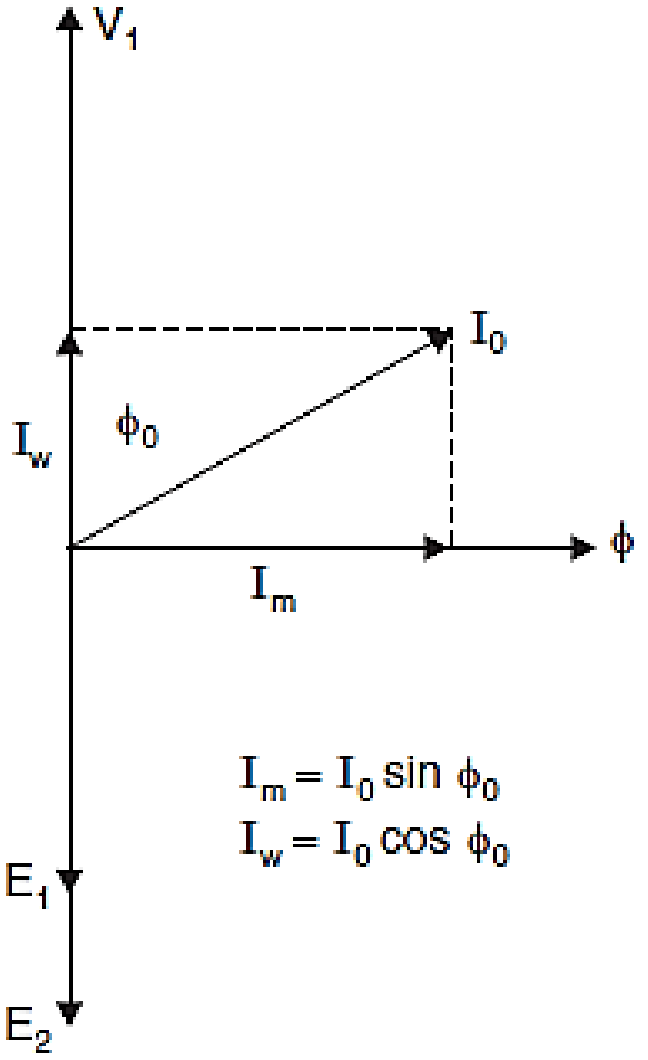

Figure 2:. No-load vector diagram

Example 1. *A 3300/300 V single-phase transformer gives 0.6 A and 60 W as ammeter and wattmeter readings when supply is given to the low voltage winding and high voltage winding is kept open, find* :
(*i*) *Power factor of no-load current.* (*ii*) *Magnetizing component.* (*iii*) *Iron loss component.*

Solution. No-load losses, $P_0 = 60$ W

No-load current, $I_0 = 0.6$ A

(*i*) $P_0 = VI_0 \cos \phi_0$

$\therefore$ $60 = 300 \times 0.6 \times \cos \phi_0$

$$\cos \phi_0 = \frac{60}{300 \times 0.6} = 0.33 \text{ (lagging)}$$

Hence, **power factor of no-load current = 0.33. (Ans.)**

(*ii*) Magnetising component, $I_m = I_0 \sin \phi_0 = 0.6 \sqrt{1 - \cos^2 \phi_0} = 0.6 \sqrt{1 - (0.33)^2} = 0.566$ A

$\therefore$ $I_m =$ **0.566 A. (Ans.)**

(*iii*) Iron loss component, $I_w = I_0 \cos \phi_0 = 0.6 \times 0.33 =$ **0.198 A. (Ans.)**

$I_w = \sqrt{I_0^2 - I_m^2} = \sqrt{(0.6)^2 - (0.566)^2} = 0.198$ A].

Example 2. *Find (i) active and reactive components of no-load current ; and (ii) no-load current of a 440/220 V single-phase transformer if the power input on no-load to the high voltage winding is 80 W and power factor of no-load current is 0.3 lagging.*

Solution. Primary, $E_1 = 440$ V

Secondary, $E_2 = 220$ V

Power factor, $\cos \phi_0 = 0.3$ (lagging)

No-load losses, $P_0 = 80$ W

(*i*) **Active component** (or *wattful component*),

$$I_w = (I_0 \cos \phi_0) = \frac{P_0}{V_1} = \frac{80}{440} = \mathbf{0.182\ A.} \quad \textbf{(Ans.)}$$

$$\cos \phi_0 = 0.3 \ ; \ \phi_0 = \cos^{-1}(0.3) = 72.54°$$

$\therefore$ $\tan \phi_0 = 3.18$

Reactive component (or *magnetising components*)

$$I_m = I_w \tan \phi_0 = 0.182 \times 3.18 = \mathbf{0.578\ A.} \quad \textbf{(Ans.)}$$

(*ii*) $I_w = I_0 \cos \phi_0$

$\therefore$ $$I_0 = \frac{I_w}{\cos \phi_0} = \frac{0.182}{0.3} = \mathbf{0.606.} \quad \textbf{(Ans.)}$$

[or $$I_0 = \sqrt{I_w^{\,2} + I_m^{\,2}} = \sqrt{(0.182)^2 + (0.578)^2} = 0.606 \text{ A}].$$

Example 3. *A 3300/220 V, 30 kVA, single-phase transformer takes a no-load current of 1.5 A when the low voltage winding is kept open. The iron loss component is equal to 0.4 A find* :
(*i*) *No-load input power.*
(*ii*) *Magnetizing component and power factor of no-load current.*

Solution. Rating of transformer = 30 kVA

Primary, $E_1 = 3300$ V

Secondary, $E_2 = 220$ V

No-load current, $I_0 = 1.5$ A

Iron loss component, $I_m = 0.4$ A

(*i*) **No-load input power,**

$$P_0 = V_1 I_0 \cos \phi_0 = V_1 I_w \qquad (\because \quad I_w = I_0 \cos \phi_0)$$

$$= 3300 \times 0.4 = \mathbf{1320\ W.} \quad \textbf{(Ans.)}$$

(*ii*) **Magnetising component,**

$$I_m = \sqrt{I_0^{\,2} - I_w^{\,2}} = \sqrt{1.5^2 - 0.4^2} = \mathbf{1.44\ A.} \quad \textbf{(Ans.)}$$

No-load power factor,

$$\cos \phi_0 = \frac{I_w}{I_0} = \frac{0.4}{1.5} = \mathbf{0.267.} \quad \textbf{(Ans.)}$$

Thank You