SNS COLLEGE OF ENGINEERING

Coimbatore
An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC
with 'A' Grade
Approved by AICTE, New Delhi & Affiliated to Anna
University, Chennai

DEPARTMENT OF ELECTRONICS & ELECTRONICS ENGINEERING

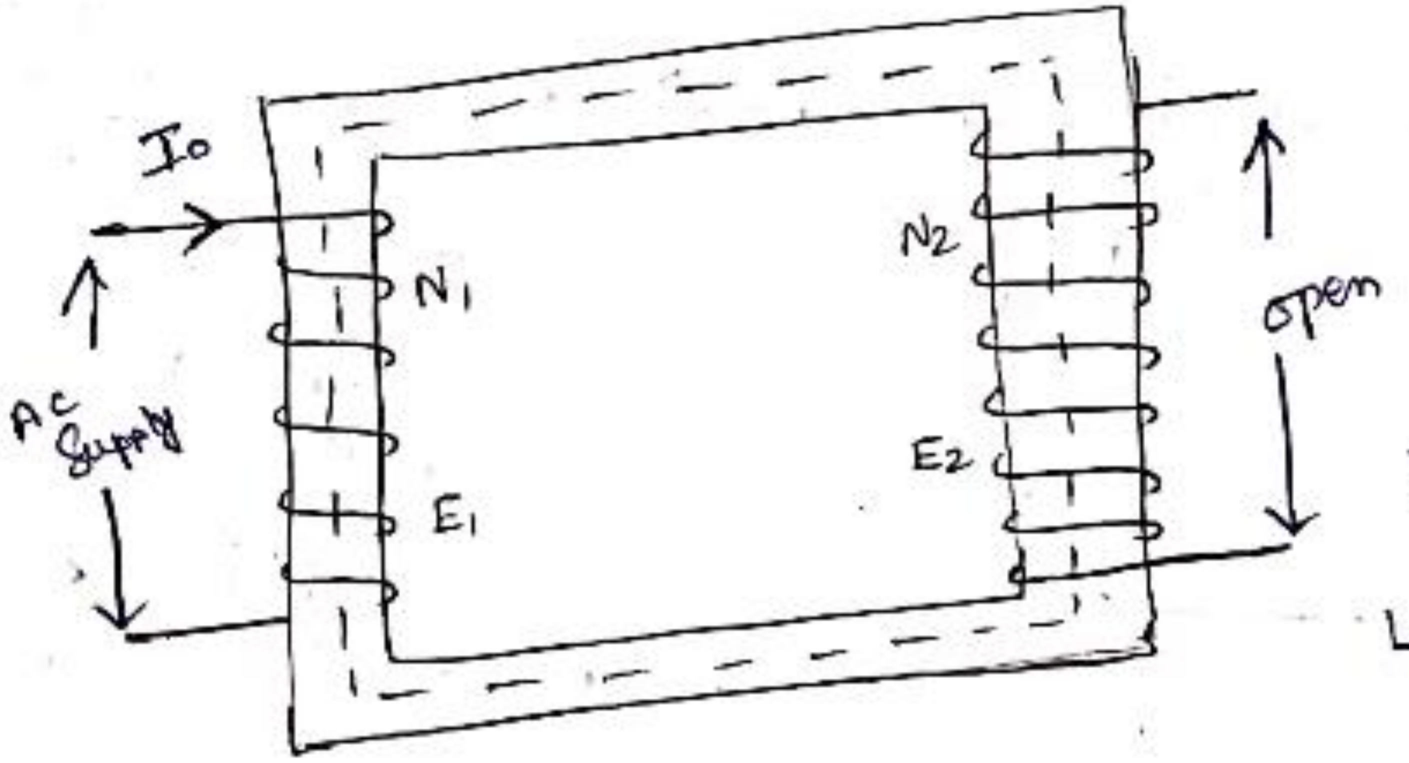
ELECTRICAL ENGINEERING & INSTRUMENTATION

II YEAR/ III SEMESTER

UNIT 2 – TRANSFORMERS

TOPIC 4 – EQUIVALENT CIRUCIT OF TRANSFORMER

IDEAL TRANSFORMER ON NO LOAD



No load Current 2 to 10% of rated Current

I_0 - No load current

Losses :

* Core loss
* Copper loss in secondary - 0 & will be lesser in primary winding

I_0 is divided as

I_W - Working Component Current or Active Current.

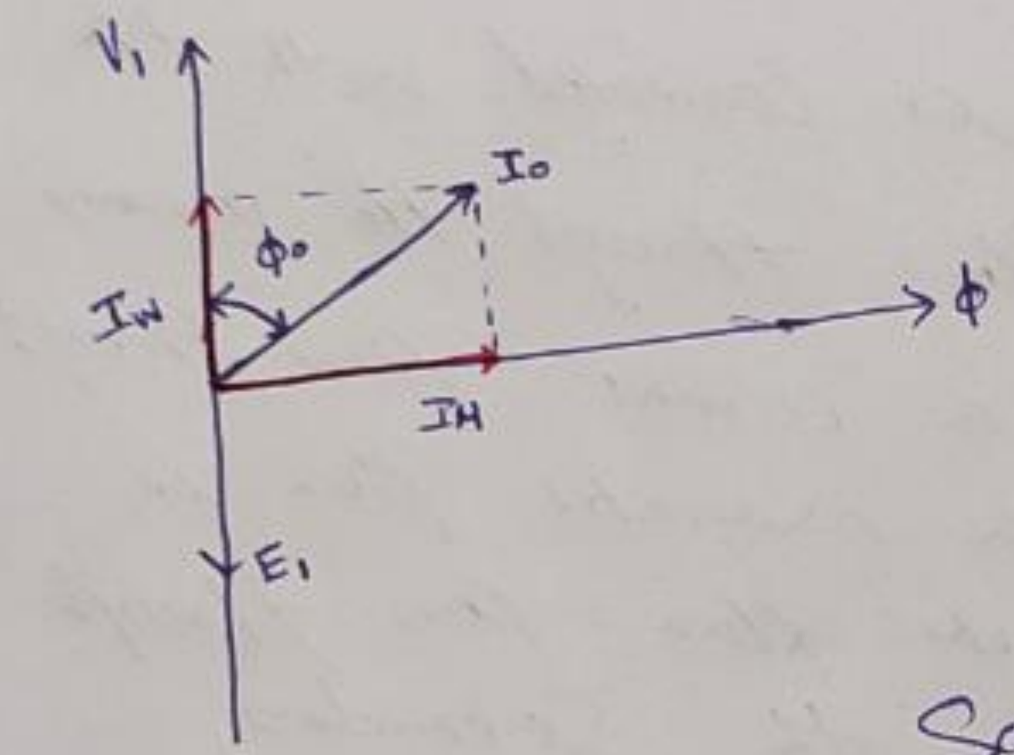
I_M - Magnetizing Current or reactive Current.

V_1 - Supply voltage

E_1, E_2 = Rms Value of primary & Secondary voltage.

IDEAL TRANSFORMER ON NO LOAD

PHASOR DIAGRAM:-



From the phasor diagram

$$\cos\phi_o = \frac{I_w}{I_o}$$

$$I_w = I_o \cos\phi_o \rightarrow (1)$$

$$\sin\phi_o = \frac{I_H}{I_o}$$

$$I_H = I_o \sin\phi_o \rightarrow (2)$$

Square and add eqn (1) & (2)

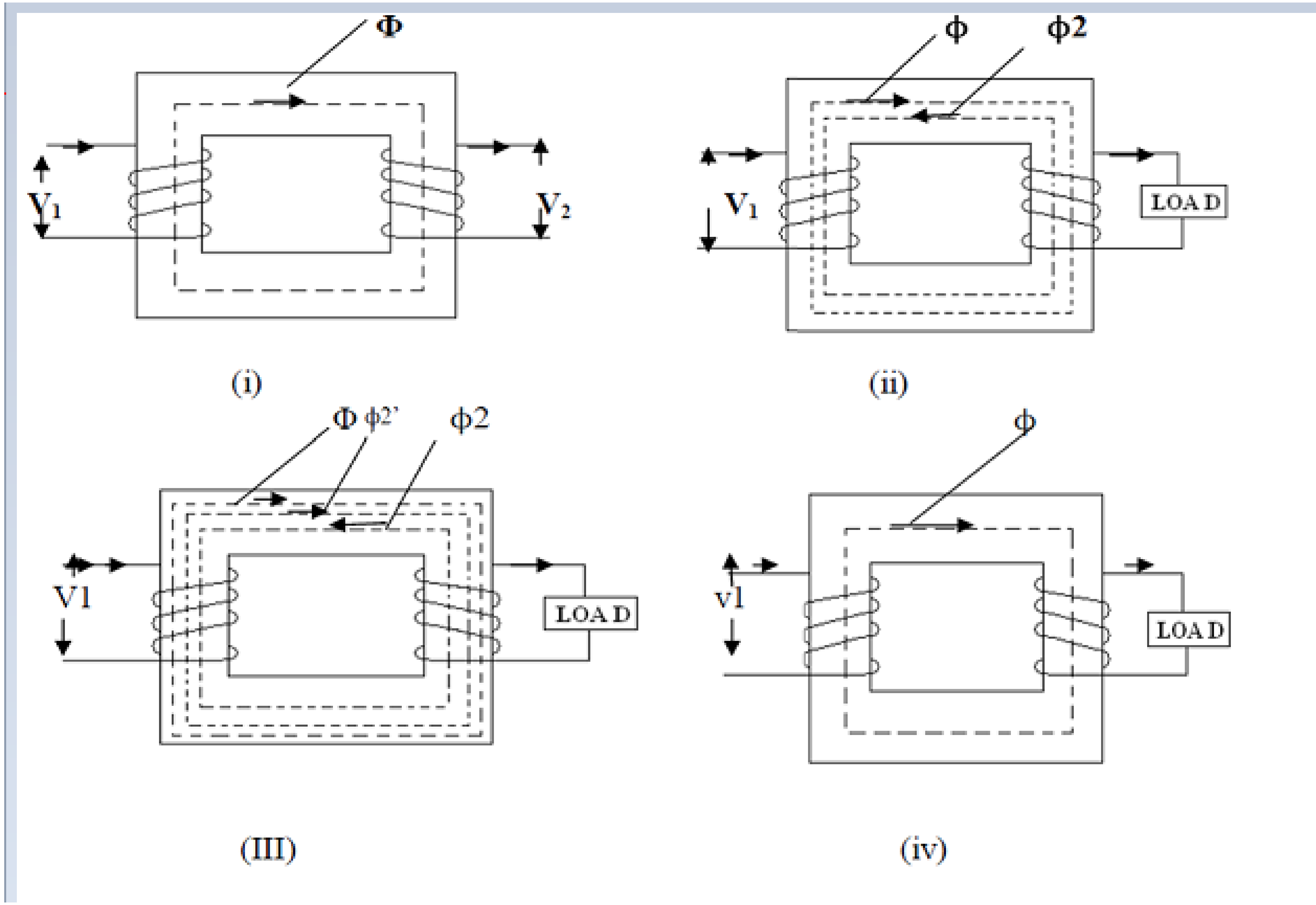
$$I_w^2 + I_H^2 = I_o^2\cos^2\phi_o + I_o^2\sin^2\phi_o$$

$$= I_o^2(\cos^2\phi_o + \sin^2\phi_o)$$

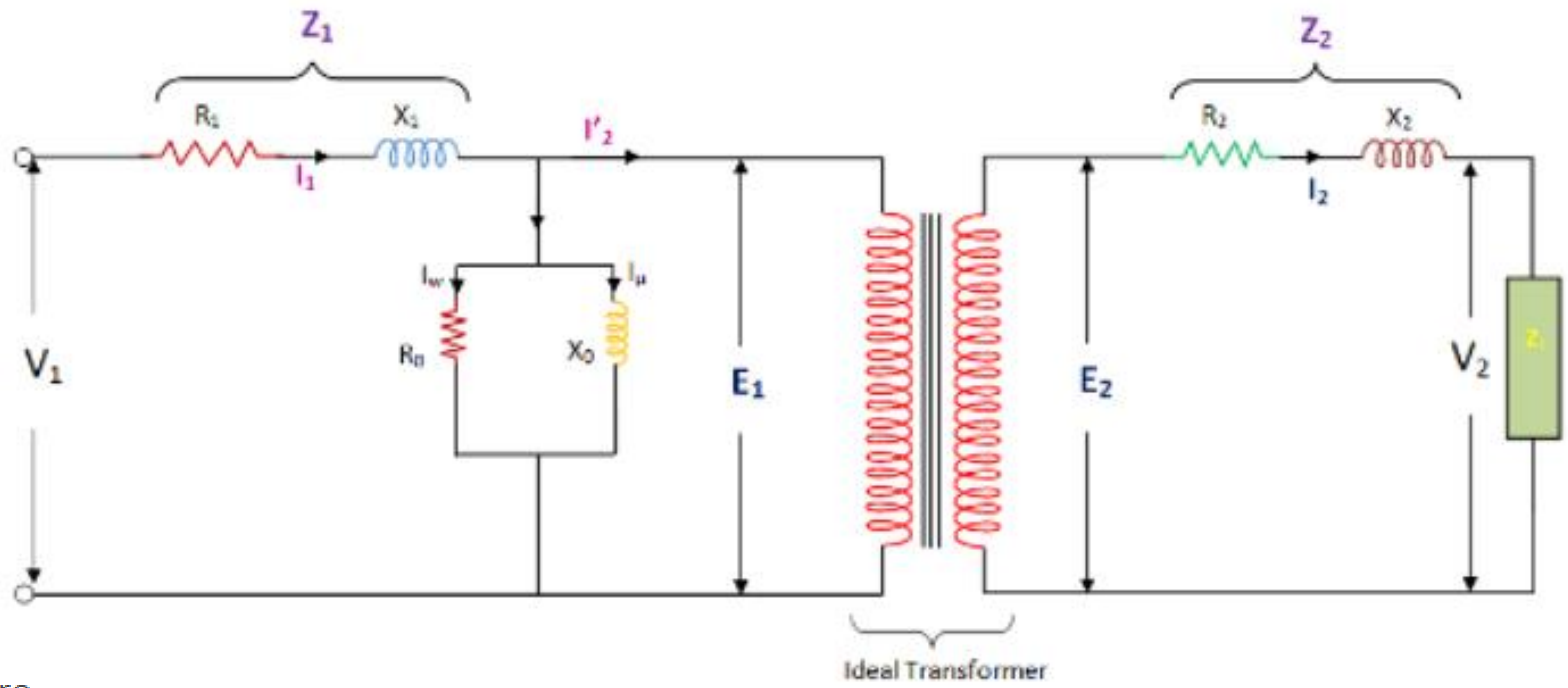
$$= I_o^2$$

$$\therefore I_o = \sqrt{I_w^2 + I_H^2}$$

IDEAL TRANSFORMER ON LOAD



EQUIVALENT CIRCUIT OF TRANSFORMER



Where,

R_1 = Primary Winding Resistance.

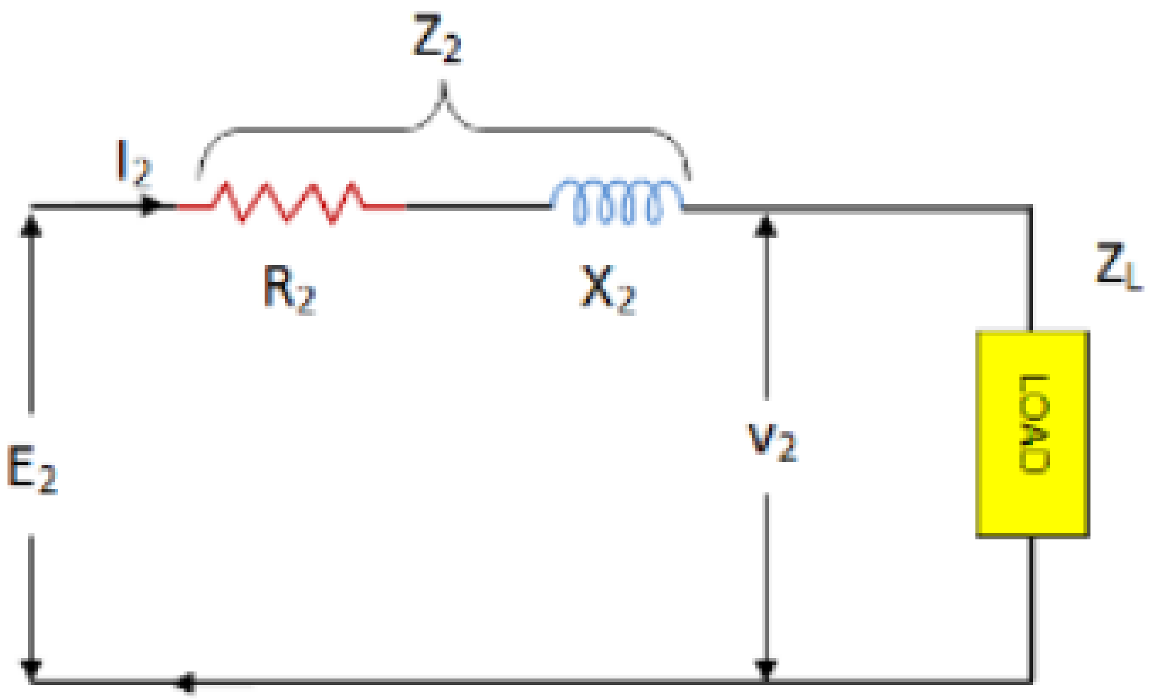
R_2= Secondary winding Resistance.

I_0= No-load current.

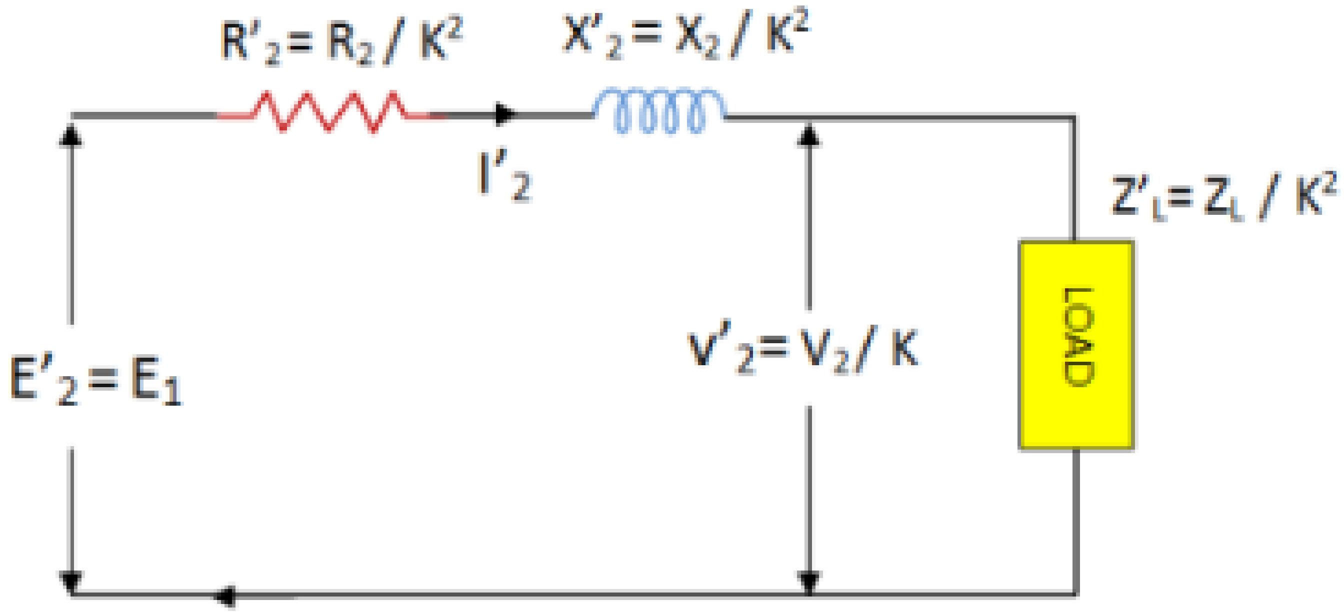
I_μ = Magnetizing Component,

I_w = Working Component,

EQUIVALENT CIRCUIT OF TRANSFORMER



SECONDARY CIRCUIT



SECONDARY CIRCUIT EQUIVALENT PRIMARY VALUE

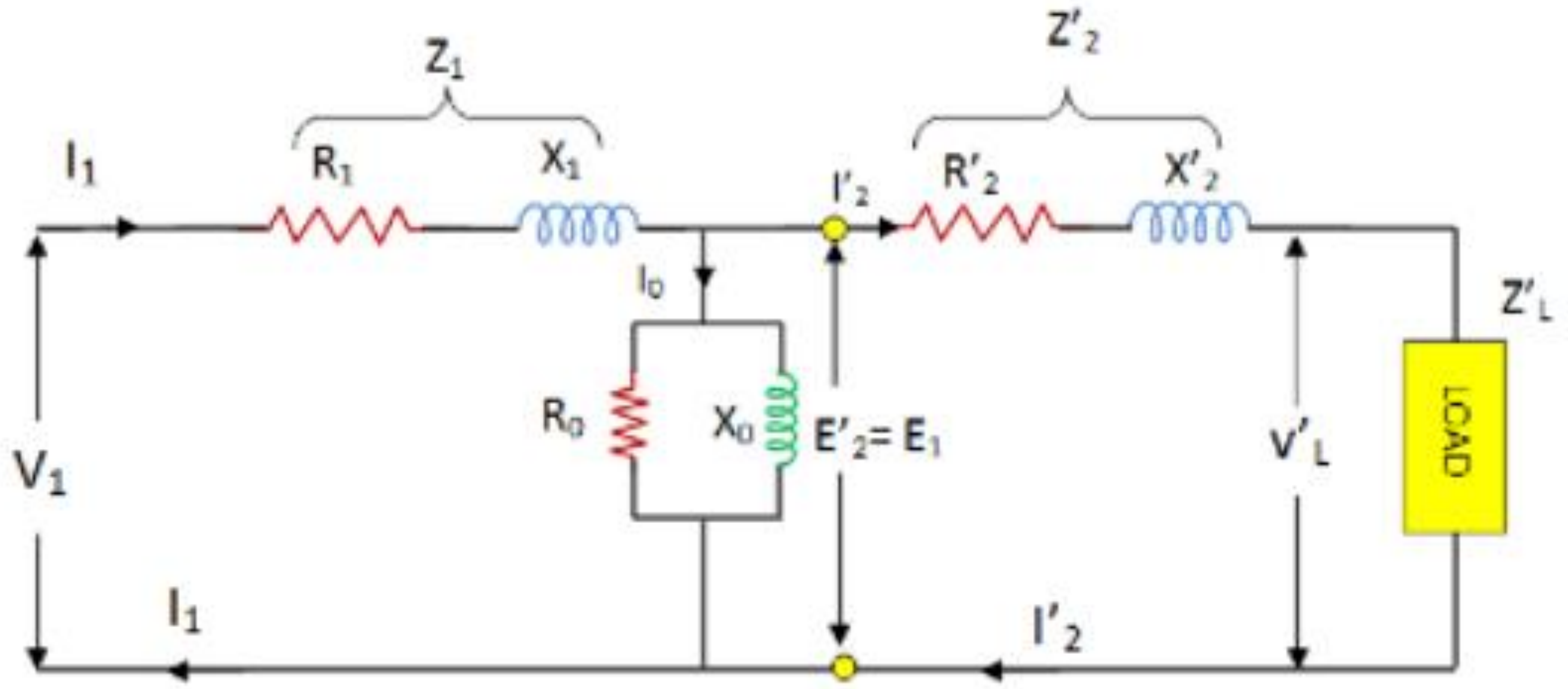
- ➢Transferring resistance or reactance from primary to secondary, multiply it by K^2
- ➢Transferring resistance or reactance from secondary to primary, divide it by K^2
- ➢Transferring voltage or current from one winding to other,only K is used By EMF Eqn

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

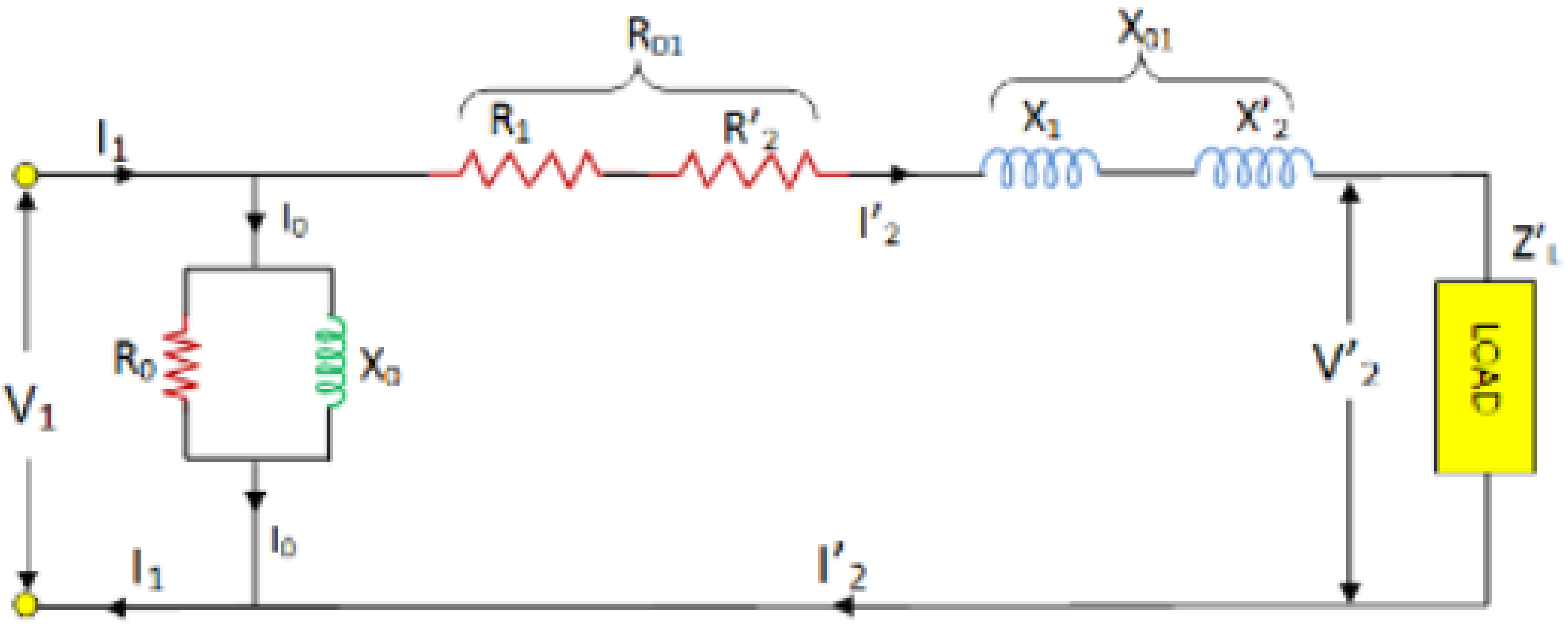
$$E_1 = 4.44 f N_1 \Phi_m$$

$$E_2 = 4.44 f N_2 \Phi_m$$

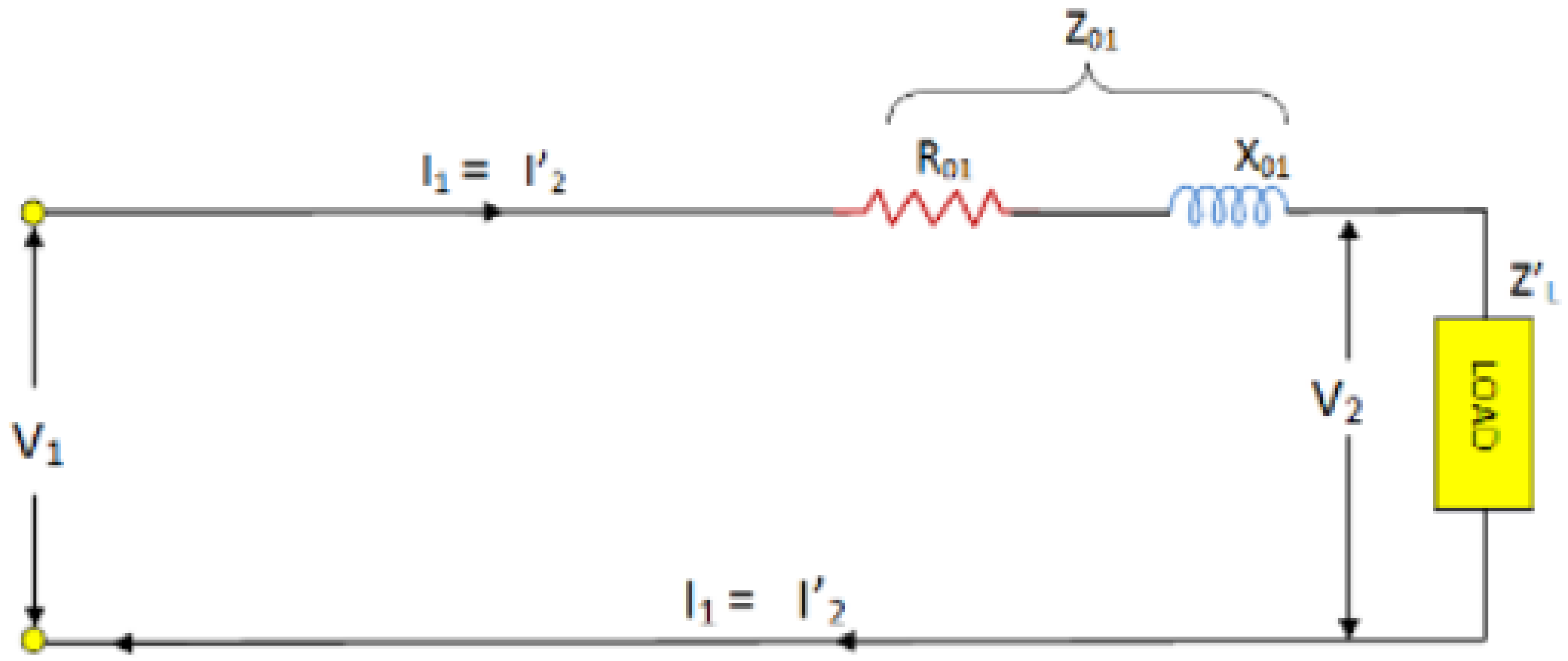
EQUIVALENT CIRCUIT OF TRANSFORMER



EQUIVALENT CIRCUIT OF TRANSFORMER



SIMPLIFIED EQUIVALENT CIRCUIT OF TRANSFORMER



VOLTAGE REGULATION OF TRANSFORMER

The voltage regulation of a transformer is the arithmetic difference between the no – load secondary voltage (E_2) and the secondary voltage on load expressed as percentage of no – load voltage.

$$\% R = \frac{E2-V2}{V2} X100$$

The ratio $(E2 - V2)/V2)$ is called per unit regulation.

E_2 = no load secondary voltage = KV_1
V_2 = secondary voltage on load

The secondary voltage also depends on the power factor of the load

$V_2 < E_2$ - lagging power factor - '+'ve Regulation

$E_2 < V_2$ - leading power factor - '-'ve Regulation

EXPRESSION FOR VOLTAGE REGULATION

$$\% \text{ R} = \frac{E2 - V2}{V2} \text{X100} = \frac{\text{Total voltage drop}}{V2} \text{X100}$$

By using the expression of voltage drop from approximate voltage drop

Total voltage drop = $I_2R_{2e}\cos\phi \pm I_2X_{2e}\sin\phi$.

Substitute in above we get

$$\% R = \frac{I_2 R_{02} \cos\phi \pm I_2 X_{02} \sin\phi}{V_2} \times 100$$

Note:

'+'ve – sign for lagging power factor
'-'ve - sign for leading power factor

EFFICIENCY OF TRANSFORMER

Efficiency of a Transformer

Like any other electrical machine, the efficiency of a transformer is defined as the ratio of output power (in watts or kW) to input power (watts or kW) i.e.,

Power output = power input – Total losses

Power input = power output + Total losses

= power output + Pi + Pcu

$$\text{Efficiency} = \frac{power\ output}{power\ input}$$

$$\text{Efficiency} = \frac{power\ output}{power\ input + Pi + Pcu}$$

Power output = $V_2 I_2 \cos\phi$, $\cos\phi$ = load power factor

Transformer supplies full load of current I_2 and with terminal voltage V_2

Pcu = copper losses on full load = $I_2^2 R_{2e}$

➢IN ELECTRICAL MACHINE EFFICIENCY:99% IS COMMON AT SAFER OPERATING CONDITIONS

EFFICIENCY OF TRANSFORMER

$$\text{EFFICIENCY} = \frac{V_2 I_2 \cos\phi}{V_2 I_2 \cos\phi + P_i + I_2^2 R_{02}}$$

$V_2 I_2$ = VA rating of a transformer

$$\text{EFFICIENCY} = \frac{(\text{VA rating}) \times \cos\phi}{(\text{VA rating}) \times \cos\phi + P_i + I_2^2 R_{02}}$$

This is full load efficiency and I_2 = full load current.

We can now find the full-load efficiency of the transformer at any p.f. without actually loading the transformer.

- **TRANSFORMER FAILURE RATE IN INDIA IS 20% .WERE IT SHOULD BE ONLY 4%**

Thank You