SNS COLLEGE OF TECHNOLOGY

Coimbatore-35
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 & COMMUNICATION ENGINEERING

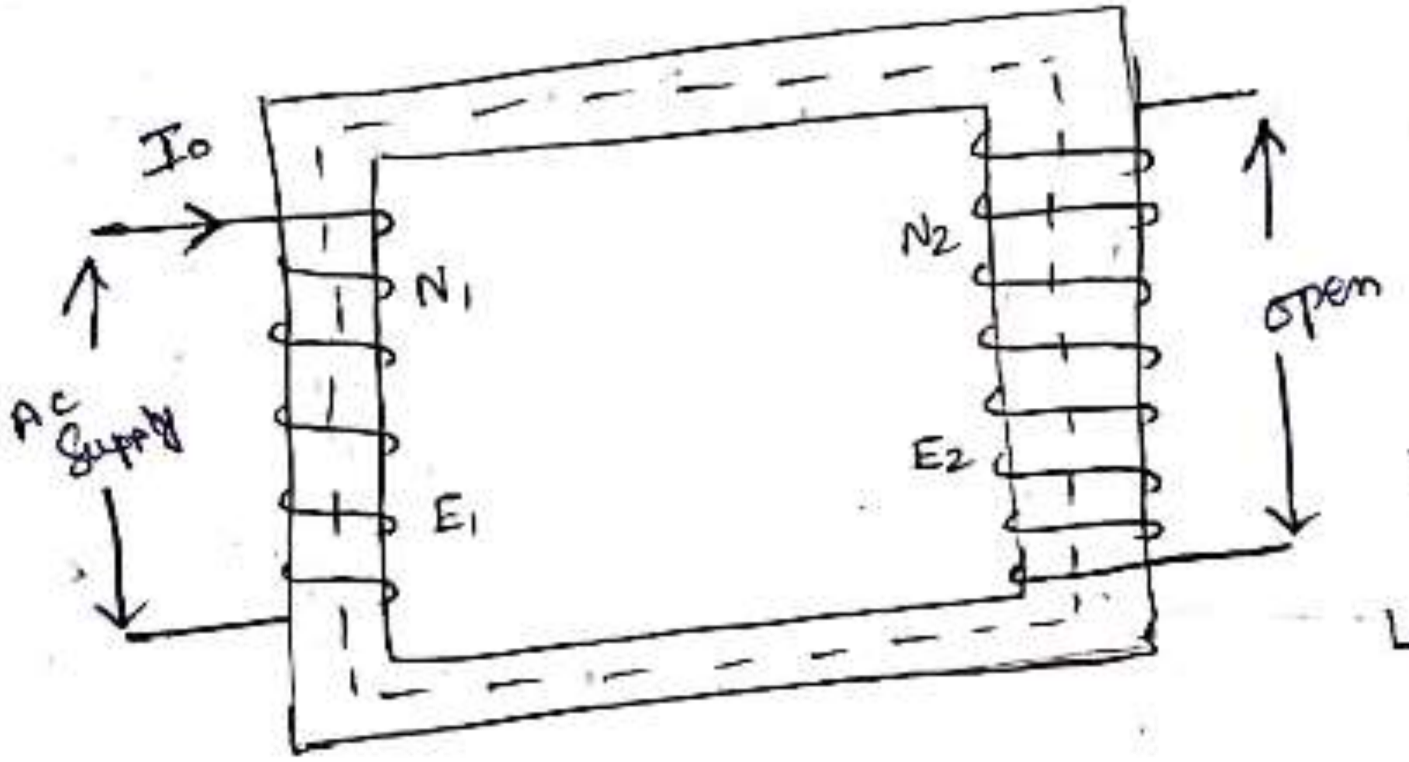
19ECT201 –ELECTRICAL ENGINEERING & INSTRUMENTATION

II YEAR/ III SEMESTER

UNIT 2 – TRANSFORMER

TOPIC 5 – TRANSFORMER ON LOAD NO LOAD-EQUIVALENT CIRCUIT - REGULATION OF TRANSFORMER

IDEAL TRANSFORMER ON NO LOAD



No load Current 2 to 10% of rated Current

Io - No load current

Losses:

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

Io is divided as

Iw - Working Component Current or Active Current.

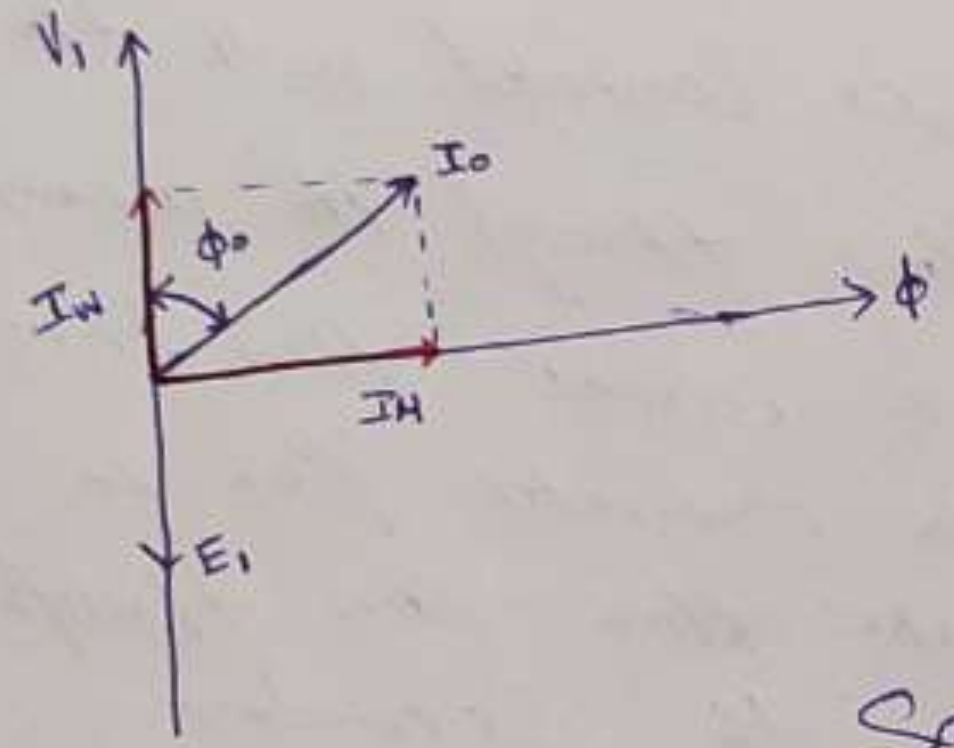
IM - Magnetizing Current or reactive Current.

V1 - Supply voltage

E1, E2 - Rms value of primary & Secondary voltage.

IDEAL TRANSFORMER ON NO LOAD

PHASOR DIAGRAM:-



From the phasor diagram

$$\cos\phi_0 = \frac{I_W}{I_0}$$

$$I_W = I_0 \cos\phi_0 \rightarrow (1)$$

$$\sin\phi_0 = \frac{I_H}{I_0}$$

$$I_H = I_0 \sin\phi_0 \rightarrow (2)$$

Square and add eqn (1) & (2)

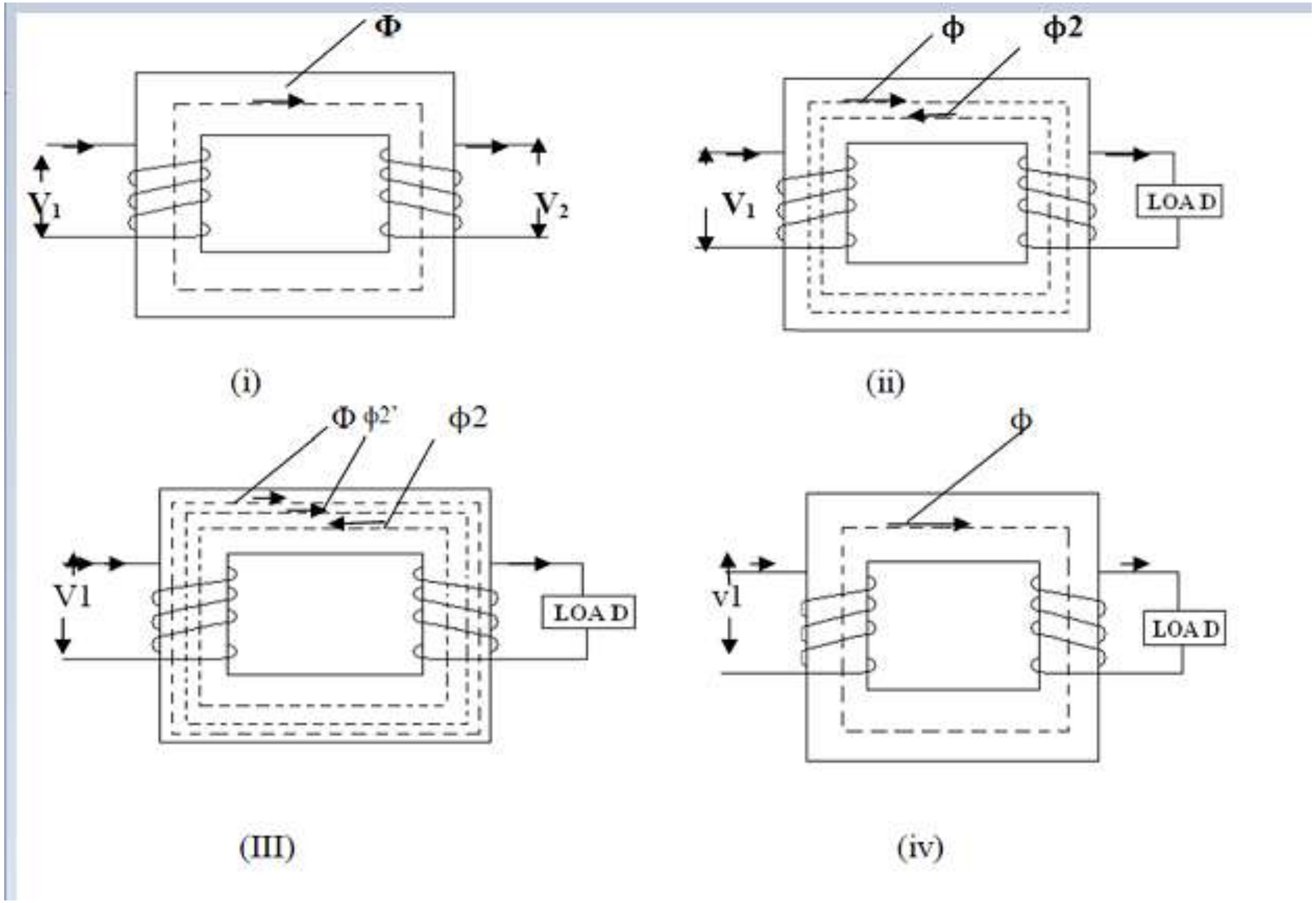
$$I_W^2 + I_H^2 = I_0^2 \cos^2\phi_0 + I_0^2 \sin^2\phi_0$$

$$= I_0^2 (\cos^2\phi_0 + \sin^2\phi_0)$$

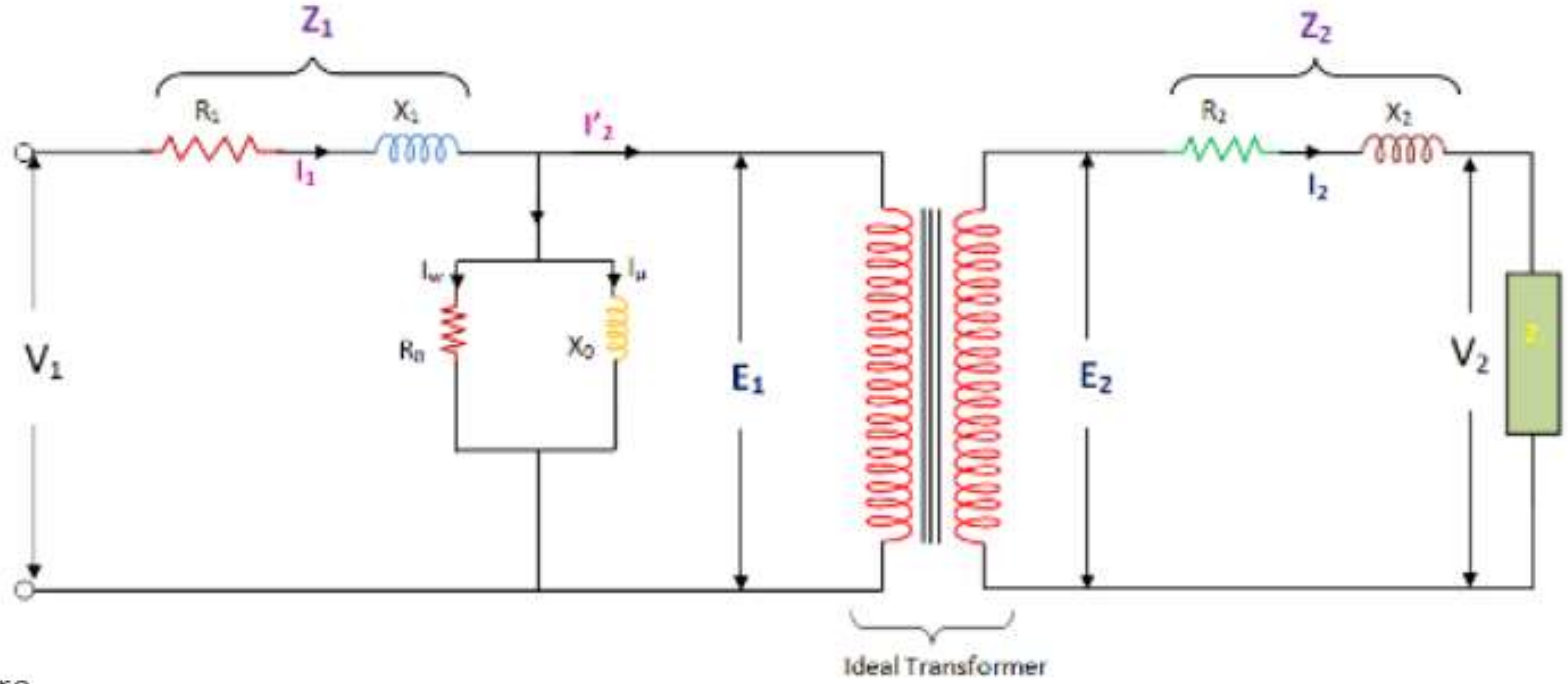
$$= I_0^2$$

$$\therefore I_0 = \sqrt{I_W^2 + I_H^2}$$

IDEAL TRANSFORMER ON LOAD



EQUIVALENT CIRCUIT OF TRANSFORMER



Where,

R_1 = Primary Winding Resistance.

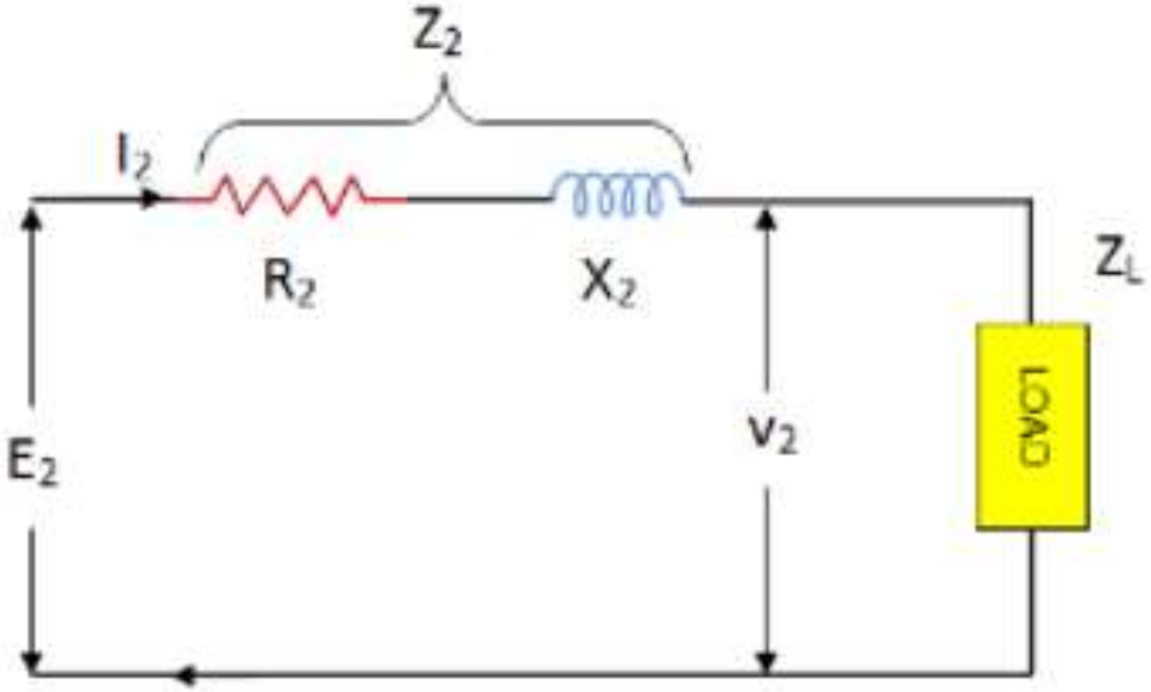
R_2= Secondary winding Resistance.

I_0= No-load current.

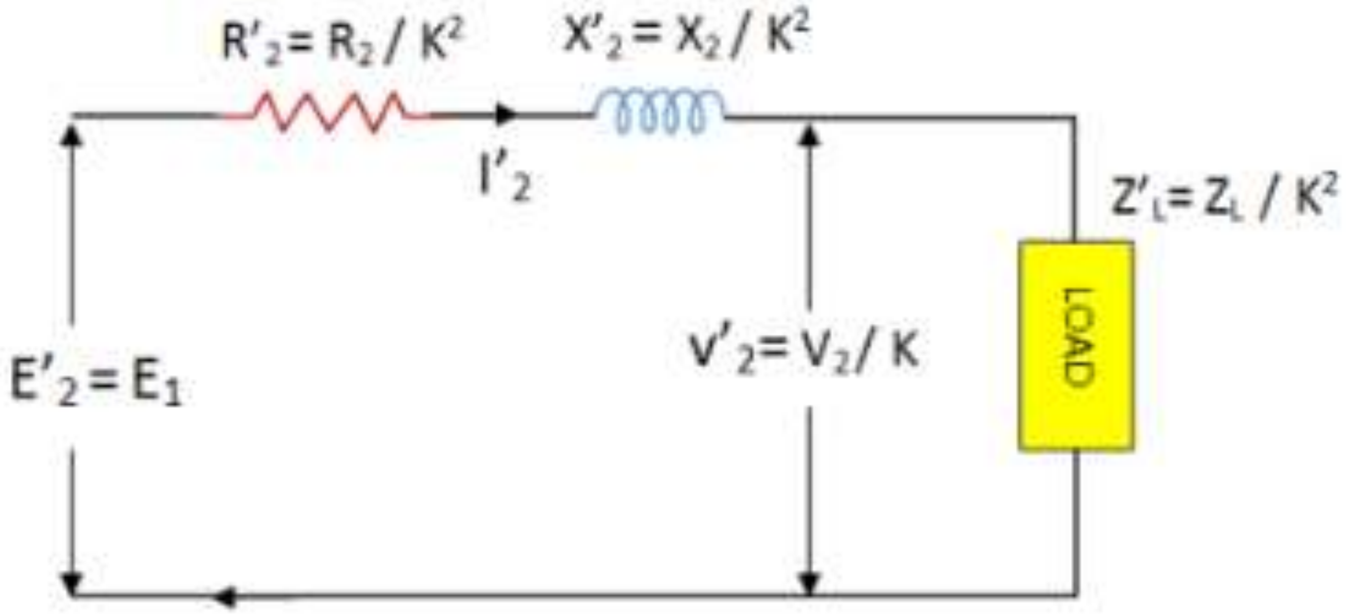
I_μ = Magnetizing Component,

I_w = Working Component,

EQUIVALENT CIRCUIT OF TRANSFORMER



SECONDARY CIRCUIT



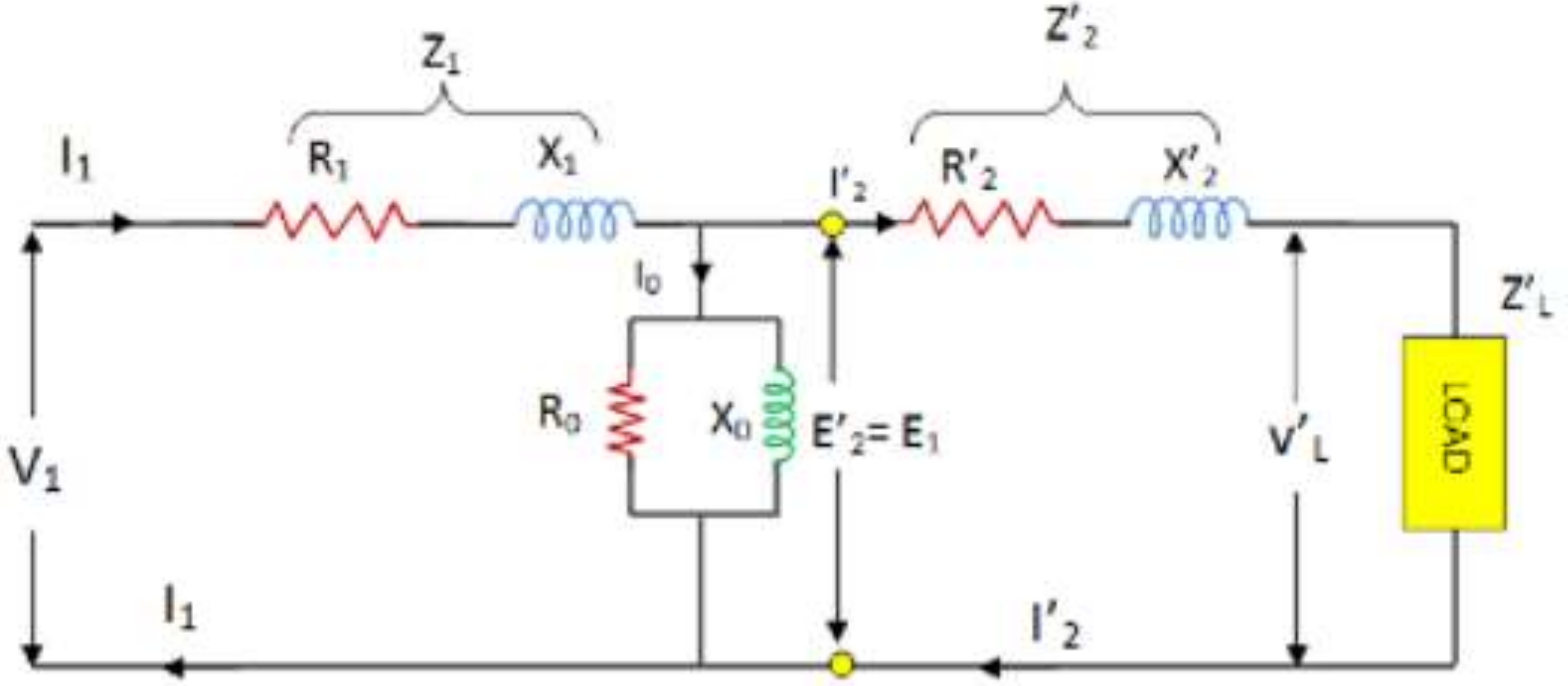
SECONDARY CIRCUIT EQUIVALENT PRIMARY VALUE

- ➢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

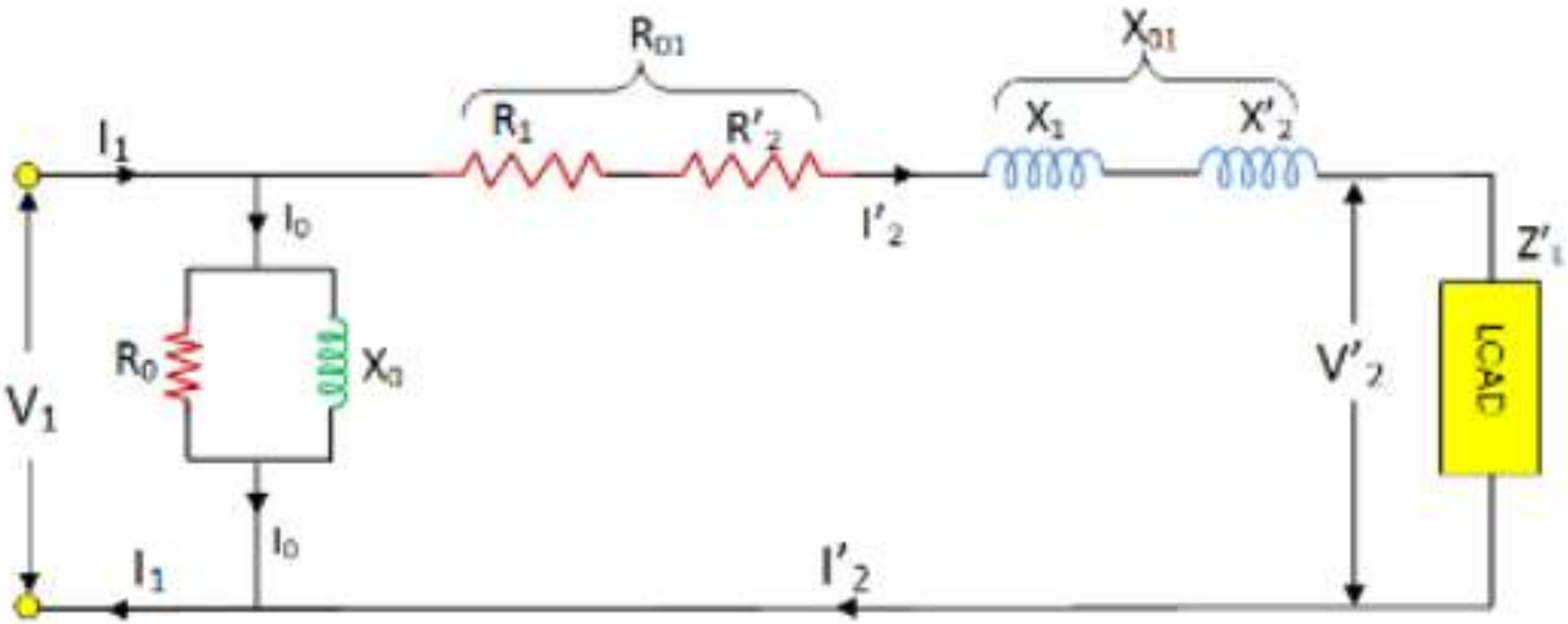
$$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

$$E_1 = 4.44\, f\, N_1\, \phi_m$$
$$E_2 = 4.44\, f\, N_2\, \phi_m$$

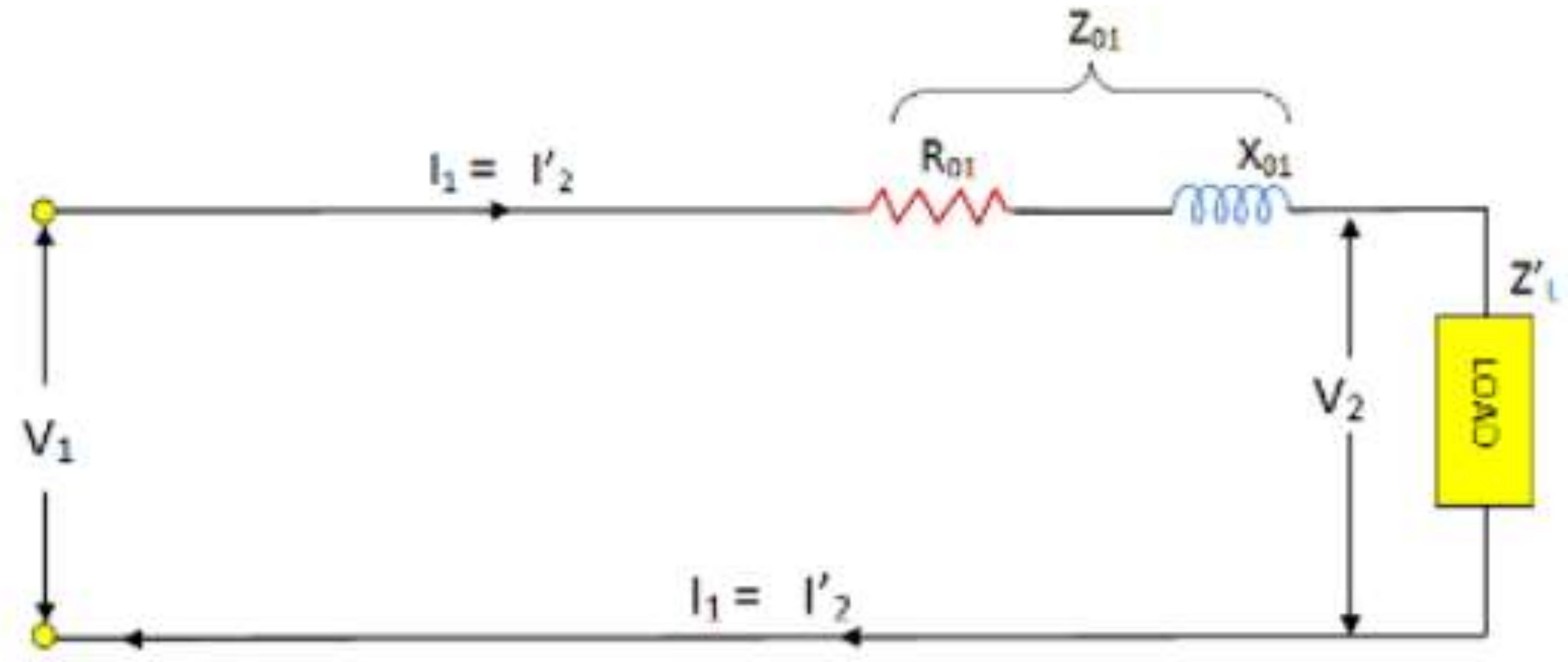
EQUIVALENT CIRCUIT OF TRANSFORMER



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

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

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

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

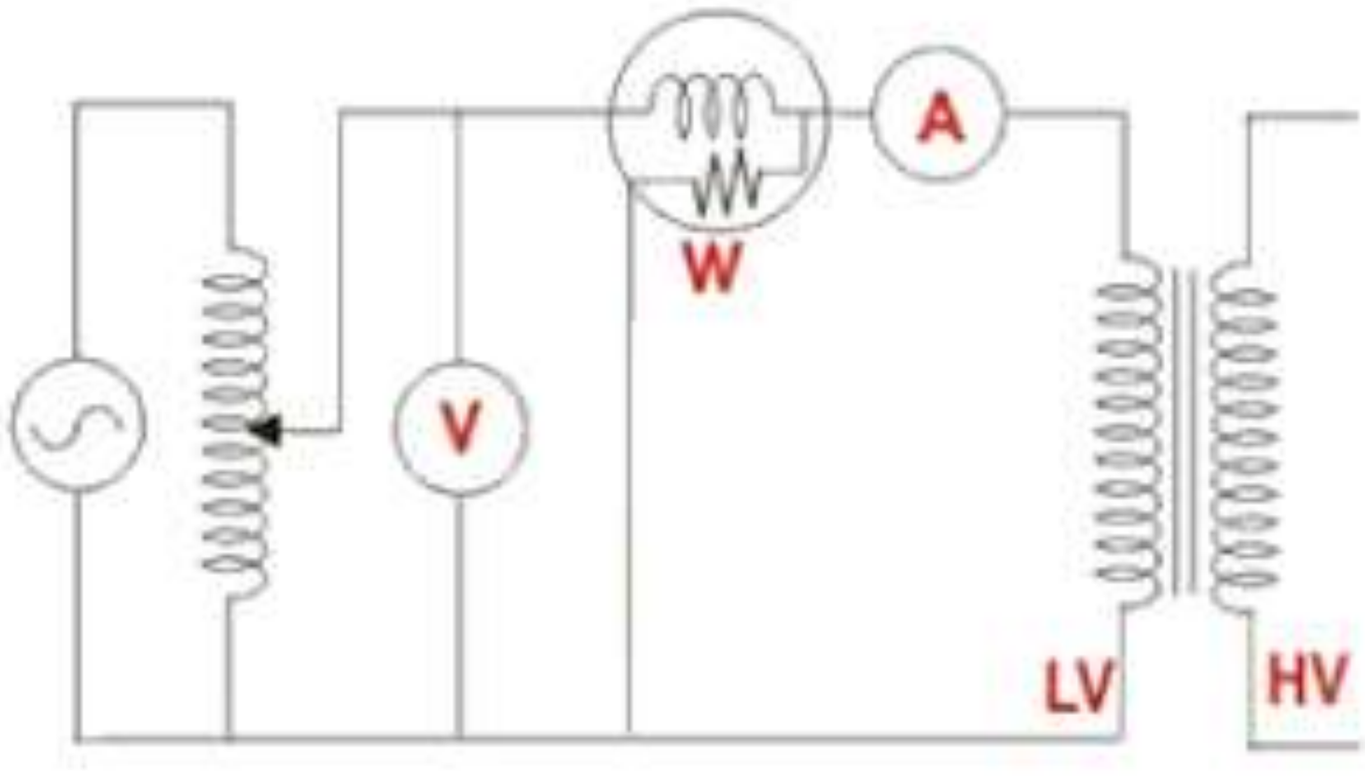
This is full load efficiency and I_2 = full load current.

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%**

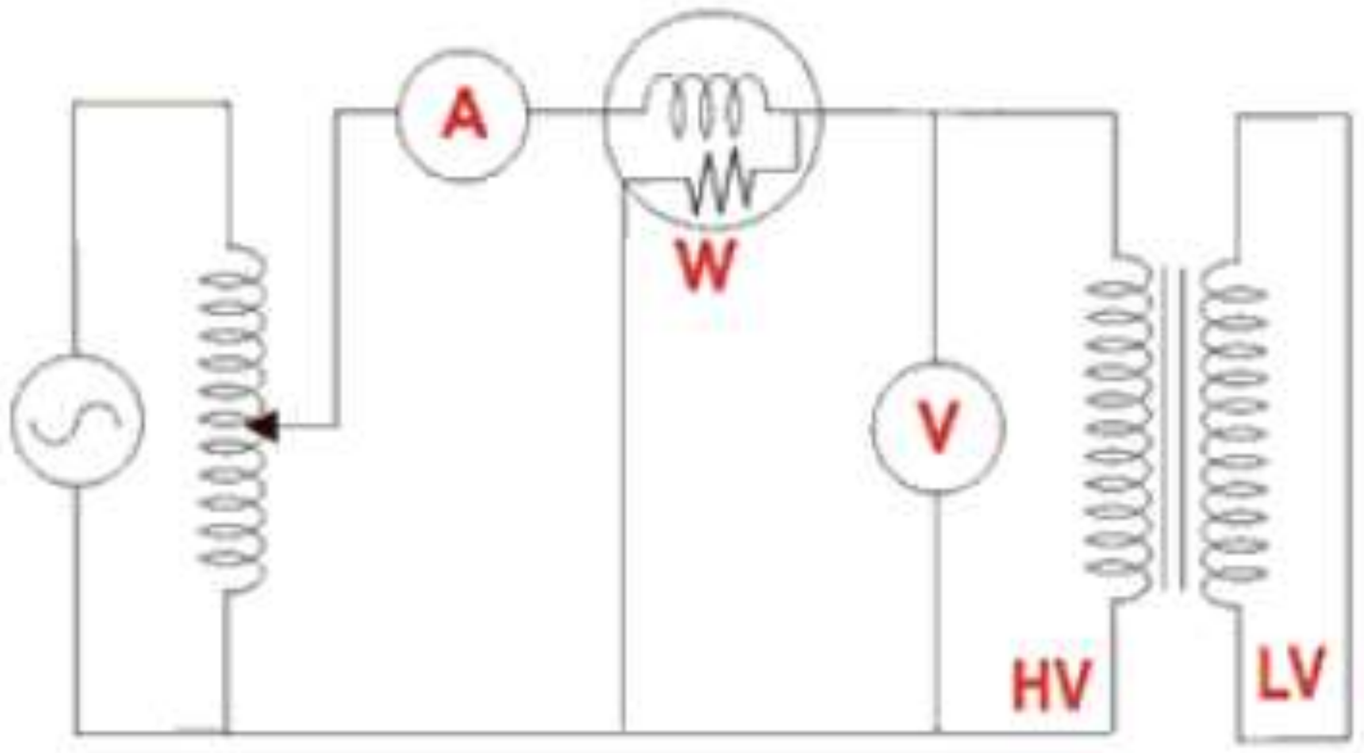
Thank You

OPEN CIRCUIT TEST ON TRANSFORMER



Open Circuit Test on Transformer

SHORT CIRCUIT TEST ON TRANSFORMER



Short Circuit Test on Transformer

WHY TRANSFORMER IS RATED IN KVA?

Example:1KVA Transformer 115/230V

- Numerator will be always primary
- Denominator will be always secondary

$V_1I_1=V_2I_2=VA$

$115(I_1)=1000=8.69A$

$230(I_2)=1000=4.347A$