## 4.6 Construction of single phase Transformer :-

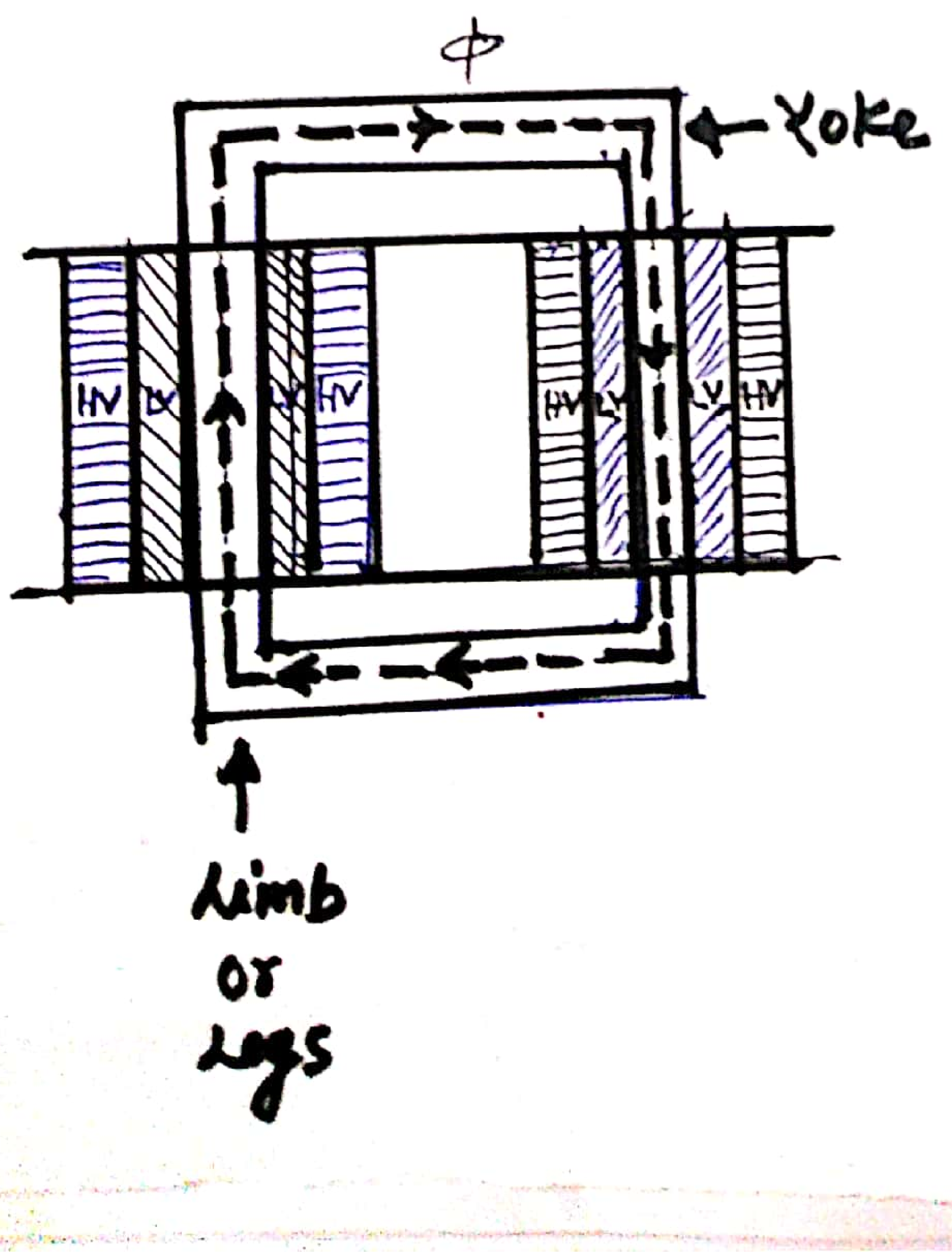
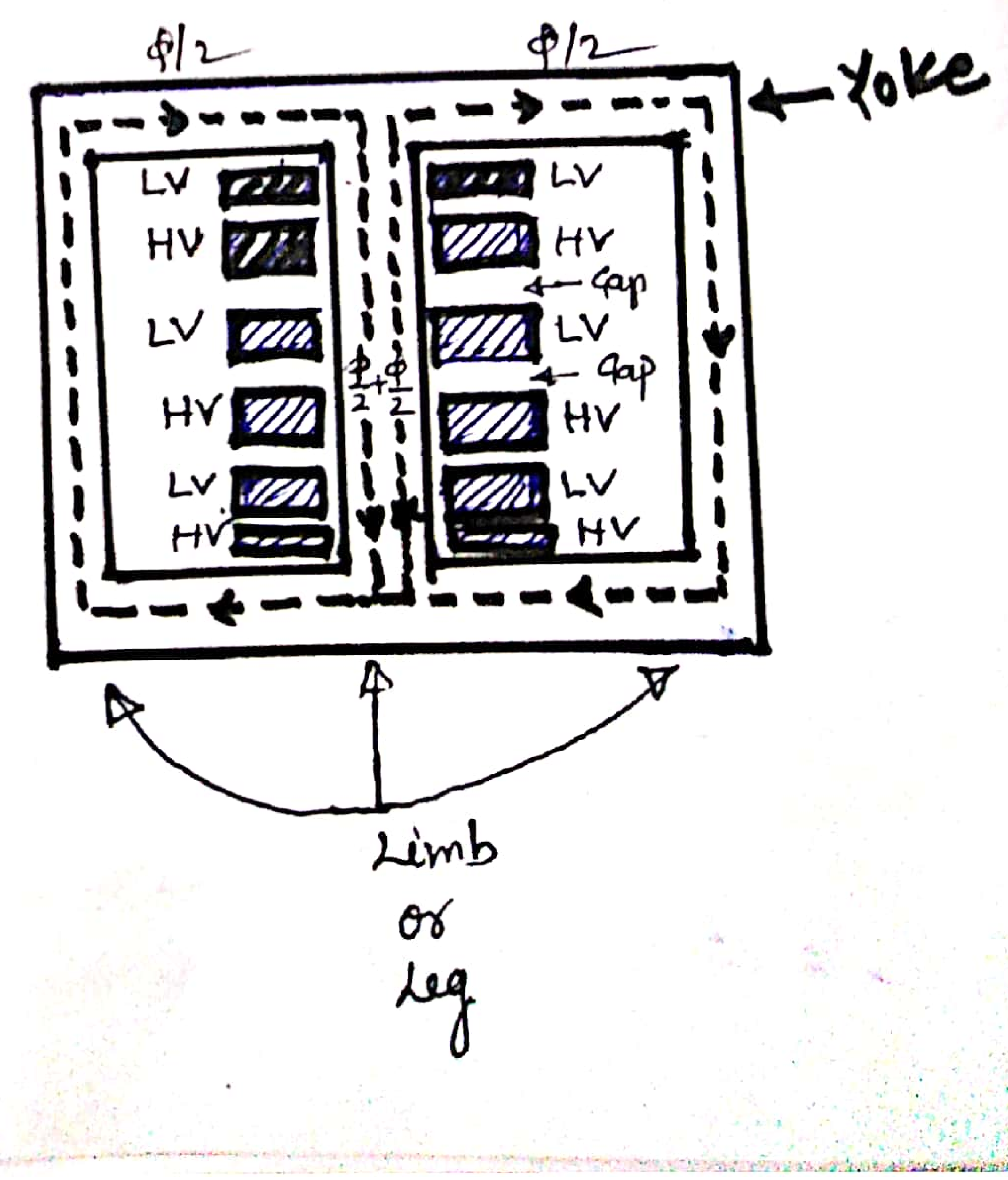
(1) A single phase transformer has three main parts.

(I) Core
(II) Primary winding
(III) Secondary winding

(2) The core of the transformer is made of thin sheets (called laminations) of high grade of silicon. These laminations are provided in the transformer to reduce eddy current loss, and silicon steel reduces hysteresis loss. The laminations present in the transformer are insulated from one another by heat resistant enamel coating. L-type and E-type laminations are used for constructions.

There are two basic types of transformer constructions

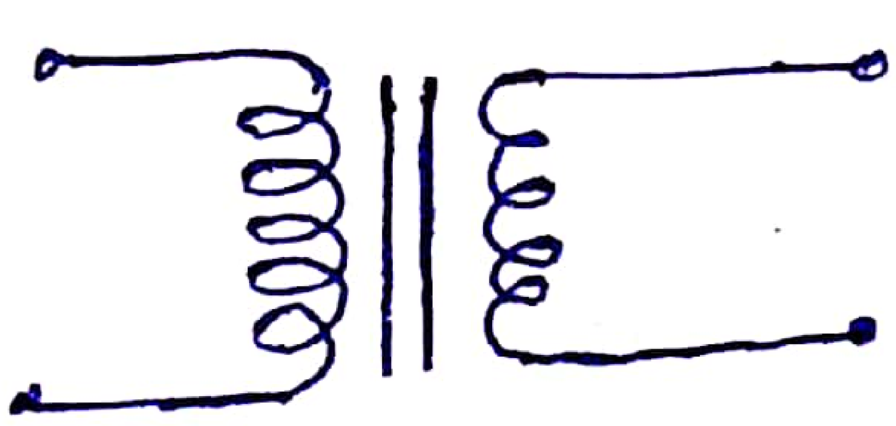
(I) Core type construction
(II) Shell type construction

| Core type | Shell type |
| --- | --- |
|  |  |

| Core Type | Shell type |
|---|---|
| 1. It has two Yoke and two limbs | 1. It has two Yoke and three limbs |
| 2. concentric winding is used. | 2. Interleaved or sandwiched winding is used |
| 3. It represent series magnetic ckt. | 3. It represent parallel magnetic ckt. |
| 4. It is used for high voltage and high power ~~applications~~. Transformers | 4. It is preferred for low voltage and low power ~~applications~~. ~~transformers~~. |
| 5. The coils can be easily removed from maintenance point of view | 5. The coils can not removed easily. |
| 6. The windings are uniformly distributed on two limbs hence natural cooling is effective. | 6. The natural cooling does not exist as the windings are surrounded by the core. |

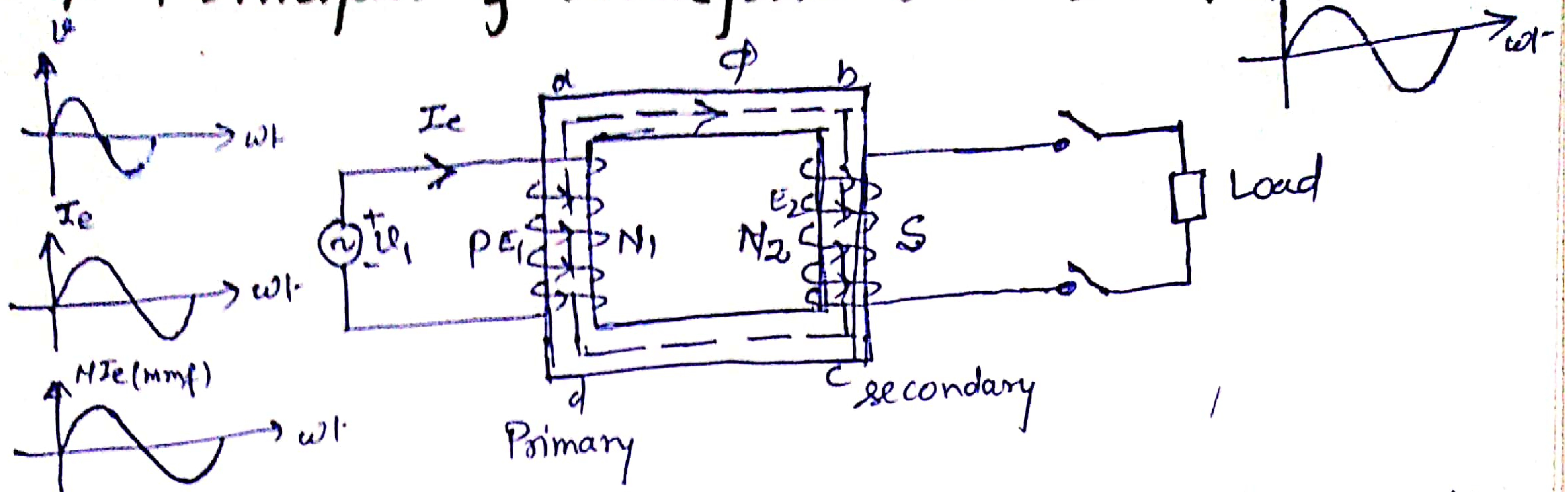
Note :-

1. For reducing the core losses, nearly all transformers have their magnetic core made from cold-rolled grain-oriented sheet steel (C.R.G.O.). This material when magnetized in the rolling direction has low core loss and high permeability.
2. Half of the low voltage (LV) winding is placed over one leg and another half over the second leg or limb to reduce the leakage flux.
3. symbolic representation of transformer is –



The vertical line indicates that the two coils are magnetically coupled with the help of magnetic core.

## 4.7 Principle of Transformers Action:-




Transformers works on the principle of electromagnetic induction between two or more coupled circuits or coils. According to this principle, an e.m.f. is induced in a coil if it links a changing flux.

→ When the primary winding P is connected to an alternating voltage source, an alternating current Ie starts flowing through $N_1$ turns. The alternating mmf ($I_e N_1$) ~~sto~~ setup alternating flux ϕ which is confined to high permeability iron path abcd. The alternating flux induces voltage $E_1$ in the primary P and $E_2$ in the secondary S.

→ If the load is connected across the secondary, a load current starts flowing.

→ The transformer action requires the existence of alternating mutual flux linking the various winding on a common magnetic core.

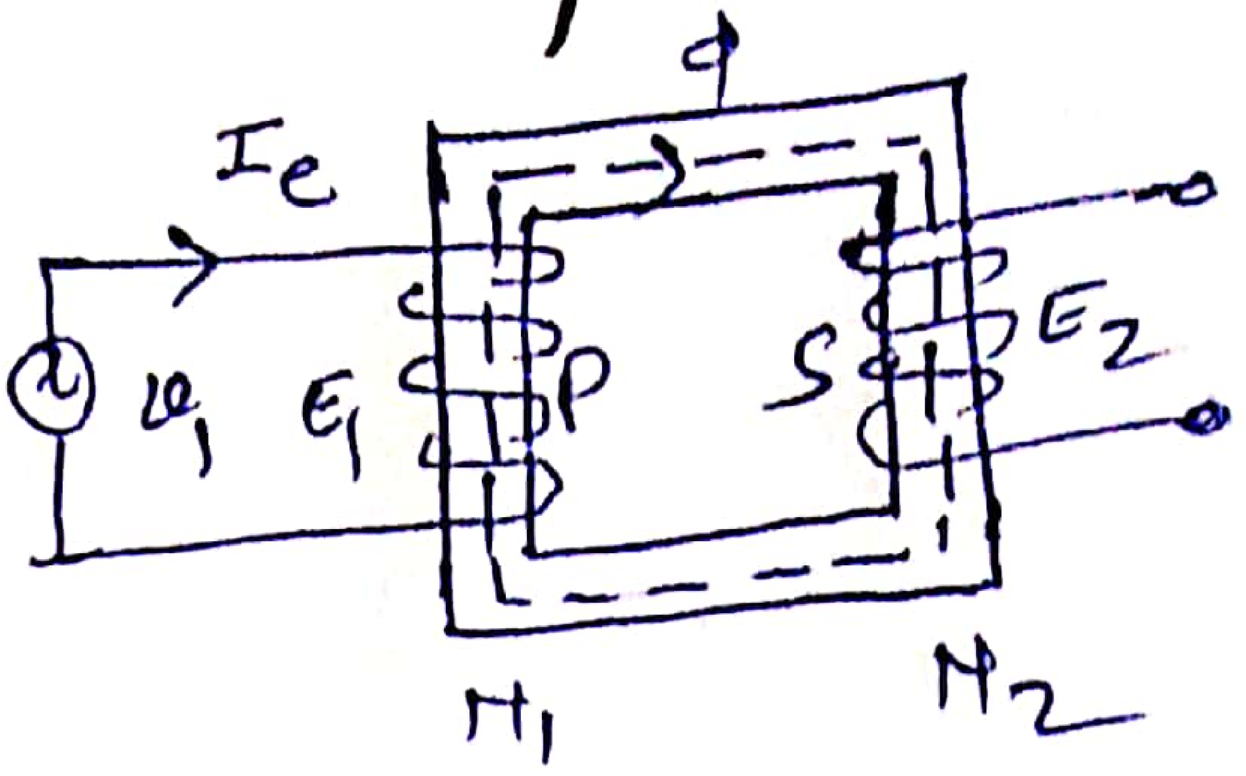
## 4.8 emf equation of an ideal Transformer :-

$v_1 \rightarrow V_m \sin\omega t \rightarrow$ sinusoidal

$I_e \rightarrow$ sinusoidal

mmf $N_1 I_e \rightarrow$ sinusoidal

$\phi \rightarrow$ sinusoidal




Let $\phi = \phi_m \sin\omega t$

The e.m.f. $e_1$, induced in Primary winding -

$$e_1 = -N_1 \frac{d\phi}{dt} = -N_1 \frac{d}{dt}(\phi_m \sin\omega t)$$

$$e_1 = -N_1 \omega \phi_m \cos\omega t$$

$$e_1 = +N_1 \omega \phi_m \sin\left(\omega t - \frac{\pi}{2}\right) \quad \text{--- (1)}$$

Its maximum value, $E_{1max}$ occures when $\sin(\omega t - \frac{\pi}{2}) = 1$

$$E_{1max} = N_1 \omega \phi_m$$

$$\therefore e_1 = E_{1max} \sin\left(\omega t - \frac{\pi}{2}\right) \quad \text{--- (2)}$$

rms value of e.m.f. $e_1$ -

$$E_1 = \frac{E_{1max}}{\sqrt{2}} = \frac{N_1 \omega \phi_m}{\sqrt{2}} = \frac{2\pi f N_1 \phi_m}{\sqrt{2}}$$

$$\boxed{E_1 = 4.44 f N_1 \phi_m} \rightarrow \text{emf equation of Transformer}$$

from Lenz's law $v_1 = -e_1$

$$V_1 = -E_1 \quad \text{--- (3)}$$

The e.m.f $e_2$ induced in secondary winding

$$e_2 = -N_2 \frac{d\phi}{dt} = -N_2 \omega \phi_m \cos\omega t = N_2 \omega \phi_m \sin\left(\omega t - \frac{\pi}{2}\right)$$

$$e_2 = E_{2max} \sin\left(\omega t - \frac{\pi}{2}\right) \quad \text{--- (4)}$$

## 4.9 Ideal Transformer :-

An ideal transformer has following features –

(I) The primary and secondary winding have zero resistance. There is no ohamic ($I^2R$) loss and no resistive voltage drop.

(II) There is no leakage flux so that all the flux is confined to the core and links both the winding.

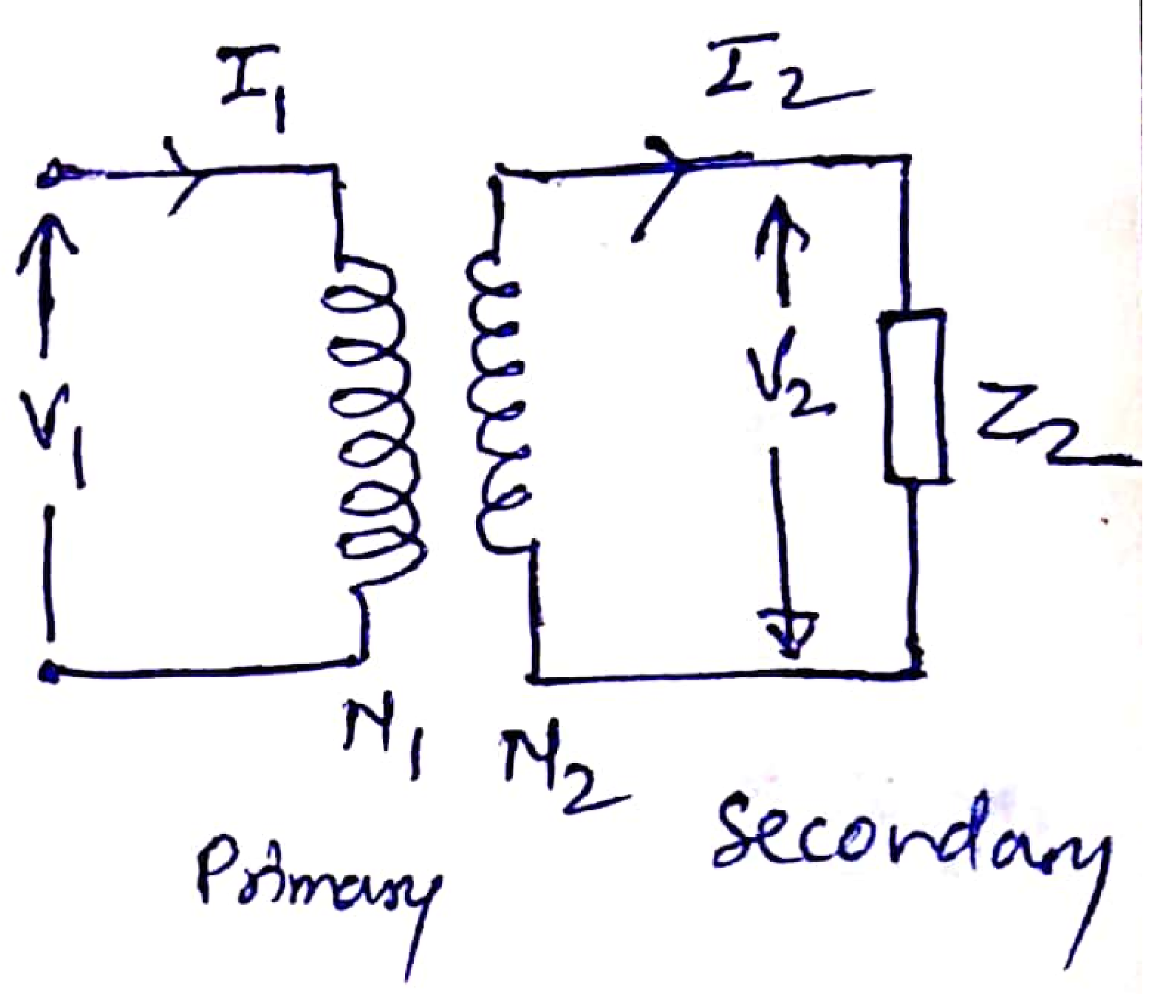
(III) The core has infinite permeability so that zero magnetizing current is needed to establish the requisite amount of flux in the core.

(IV) The hysterosis and eddy current loss is considered to zero.

## 4.10 Impedance Transformation :-

From Secondary to Primary :-

$$Z_2 = \frac{V_2}{I_2} \quad \text{--------} \; (1)$$




$$\frac{V_1}{V_2} = \frac{I_2}{I_1}$$

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

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

$$\frac{I_1}{I_2} = \frac{N_2}{N_1}$$

$$I_1 = \frac{N_2}{N_1} \times I_2$$

$$\frac{V_1}{I_1} = \left(\frac{N_1}{N_2}\right)^2 \frac{V_2}{I_2}$$

$$\frac{V_1}{I_1} = \left(\frac{N_1}{N_2}\right)^2 Z_2$$

$$\boxed{Z_2' = \left(\frac{N_1}{N_2}\right)^2 Z_2}$$

$$R_2' = \left(\frac{N_1}{N_2}\right)^2 R_2$$

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