3.4 SINGLE PHASE TRANSFORMER

Transformer : A **Transformer** is a static device which Transfer the electric power from one circuit to another circuit at same frequency. It can Rise or lower the voltage in a circuit and produces corresponding decrease or increase in current.

The transformer which works based on the **Principle of Mutual Inductance** between the circuits with common magnetic flux linkage. According to the

Faraday's Law of Electro-magnetic Induction $e = M\frac{dI}{dt}$

(3.35)

The Circuit diagram of a Single phase Transformer as shown in Fig 3.22. The transformer basically consists of 3-main parts: 1. Primary winding 2. Secondary winding and 3. Laminated iron core.

1. **Primary Winding** : The winding in which the input voltage or AC supply given and called as **Primary Winding**.
2. **Secondary Winding** : The winding from which the electrical output voltage taken and called as **Secondary Winding**.
3. **Core** : The two windings are wound on an iron core. The iron core is laminated and insulated with varnish.

It is concluded that a transformer :

1. Transfer electric power from one circuit to another circuit
2. The Frequency does not change.
3. It works based on the principle of Electro-magnetic Induction.
4. The two circuits (Primary and Secondary windings) are produces mutual inductance with each other.

The two windings such as Primary winding and Secondary windings are wound over an Iron core. The core is laminated to reduce eddy current loss.

The transformer which works on the **Principle of Mutual Induction**. When an AC supply is given to pri... winding an alternating flux is set-up in the core. The alternating flux cuts both primary and secondary wi...

According to **Faraday's Mutual Induction** principle an emf is induced in the secondary winding. If the ... is connected the secondary current will flow through the load. By this way, the electric energy is trans... from the primary circuit to secondary circuit The Induced emf in the winding which depends on the N... of turns of winding.

1. **Step up Transformer :** If the Number of turns in the secondary winding (N_2) is more than that of Pri... winding, (N_1) the emf induced in the secondary winding (E_2) will be higher than the voltage ap... to the primary winding (E_1). This type of transformer is said to be **Step up Transformer**. The vo... transformer ratio is given by

$$K=\frac{E_2}{E_1}=\frac{N_2}{N_1}=\frac{I_1}{I_2}$$

Where

E_2 = Transformer secondary or output voltage
E_1 = Input voltage applied to the transformer
N_2 = Number of turns in secondary winding
N_1 = Number of turns in primary winding
I_1 = Input current to the transformer
I_2 = Output current product by the transformer

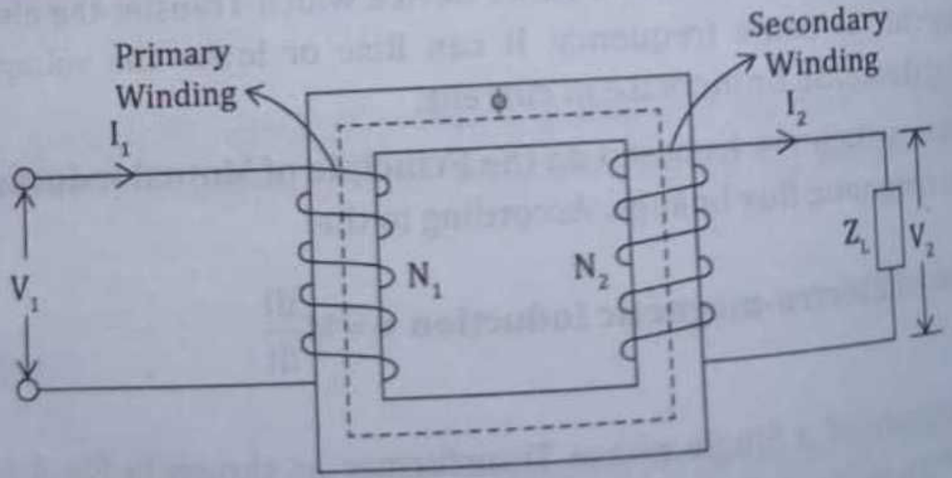


Fig 3.22 Circuit diagram of Single phase Transformer

2. **Step down Transformer :** If the Number of turns in the Secondary winding (N_2) is less than the p... winding (N_1) the emf induced in the Secondary winding (E_2) is less than the voltage applied to p... winding. This type of transformer is said to be **Step down Transformer**. The Voltage transformat... is given by

$$K=\frac{E_1}{E_2}=\frac{N_1}{N_2}=\frac{I_2}{I_1}$$

Working

When the alternating voltage is applied to the primary winding produces the alternating flux (φ) is in the core. The alternating flux linkage in both winding induced emf (E_1 and E_2) according to **Faraday's Law of Electro-Magnetic Induction**

$$E_1 = N_1 \frac{d\varphi}{dt} \tag{3.38}$$

$$E_2 = N_2 \frac{d\varphi}{dt} \tag{3.39}$$

$$\frac{E_2}{E_1} = \frac{N_2}{N_1} \tag{3.40}$$

The magnitude of emf E_2 and E_1 which depends on number of turns in primary and secondary winding.

(i) **Step up Transformer** : The Transformer in which $N_2 > N_1$ and $V_2 > V_1$, then the transformer is said to **Step up Transformer**. The Voltage transformation ratio $(K) = \frac{E_2}{E_1} = \frac{N_2}{N_1} = \frac{I_1}{I_2}$

(ii) **Step down Transformer** : The Transformer in which $N_2 < N_1$ and $V_2 < V_1$, then the transformer is said to be **Step up Transformer.**

If the load is connected across the secondary winding, the secondary emf (V_2) will cause a current (I_2) flow through the load.

The following points are listed for Transformer

1. The transformer action is based on the Law of Electro-magnetic Induction.
2. Basically, there is No electrical connection between the primary and secondary winding. The power transferred from primary secondary winding through magnetic flux (ϕ).
3. In Transformer, there is No change in frequency between the primary and secondary power.
4. The Losses occurs in Transformer may be:
   (i) **Core loss** : The Core losses occur due to Eddy current and Hysteresis losses.
   (ii) **Copper loss** : The Copper loss is the losses occurs in the resistance of winding.

3.4.2 CONSTRUCTIONAL PRINCIPLE AND CLASSIFICATION OF TRANSFORMER

According to Constructional vice the transformer can be classified into:

1. Core type Transformer
2. Shell type Transformer

1. Core Type Transformer

The Core type transformer is in the shape of hollow rectangle with completed magnetic circuit as shown in Fig 3.23. In which the no load current (I_0) and flux produced (ϕ) and N_1 and N_2 are the turns of primary and secondary side respectively.

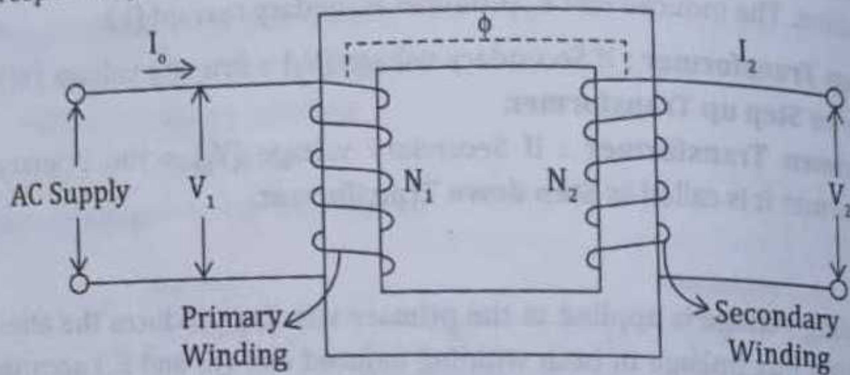


Fig 3.23 Magnetic circuit for Core type the Transformer

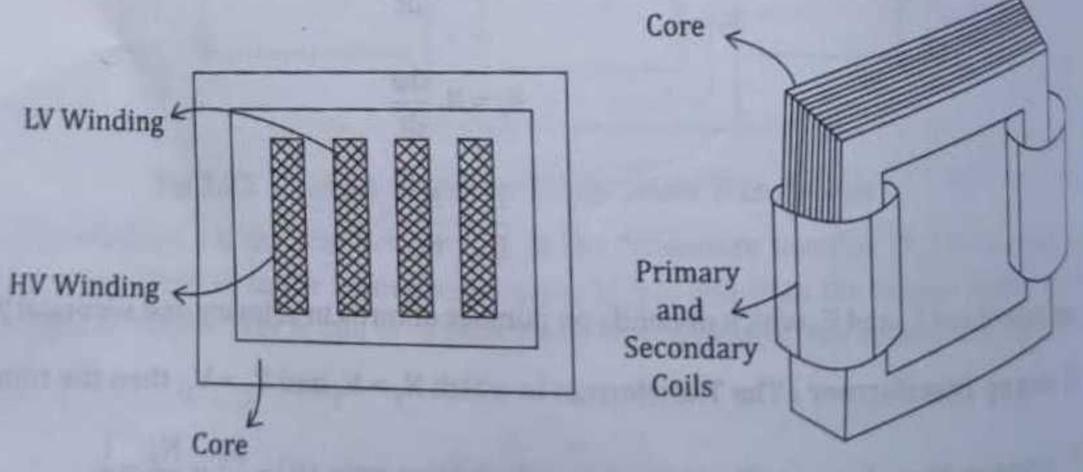


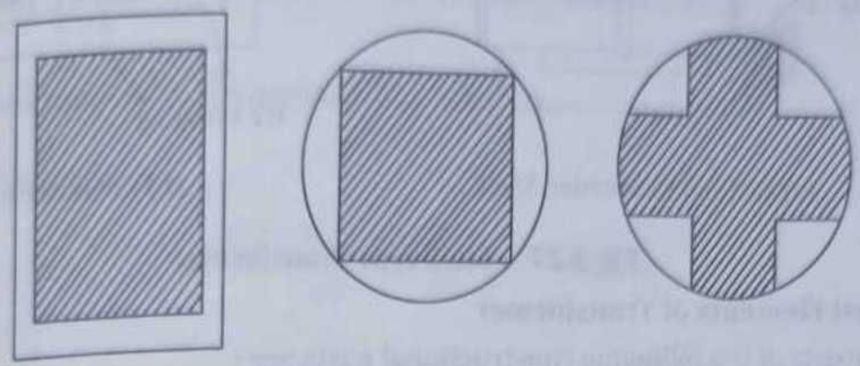
Fig 3.24 Core type Transformer

The Core type transformer cross sectional view as shown in Fig 3.24. The Core is made up of Silicon steel lamination either in the form of Rectangle or L-shaped. In the above method, the coils may be of high and low voltage coils and the leakage reactance should be more.

In Core type transformer, half of primary and secondary windings are placed round each link. The above method reduces: (i) Leakage flux (ii) Low voltage winding is below high voltage winding for mechanical consideration.

The various types of core for a transformer as shown in Fig 3.25. The Different types of cores are :

(i) Rectangular cores used with small size core transformer and circular cylindrical coil is preferred.
(ii) Square core forms circle which represents the tubular former carrying coils.
(iii) 'Cruciform core' which demands atleast two or more core strips.



(a) Rectangular Core **(b)** Square Core **(c)** Cruciform Shape

Fig 2.4 Various types of Core

The main advantages are: (i) More suitable for high voltage (ii) Copper requirement is less (iii) Leakage flux is high (iv) Easy to carryout repeater.

Shell Type Transformer

The **Shell Type Transformer** which produces a Double magnetic circuit. In which the both winding are placed round the central limb as shown in Fig 3.26. The other two links forms low reluctance flux path.

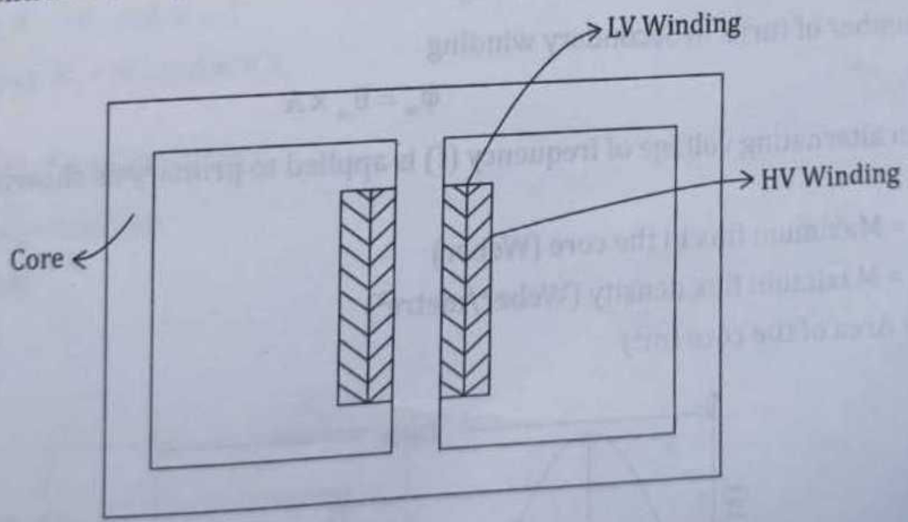


Fig 3.26 Basic diagram of shell type transformer

The coil and lamination of Shell type transformer and Cross-section as shown in Fig.2.27. The Main elements are: Core, HV Winding and LV Winding. In Shell type, the both windings are placed around a central limb, the two other limbs forms low reluctance path for the flux. The Shell type transformer has the following advantages: (i) Better coating facility (ii) Less leakage reactance (iii) Greater mechanical strength (iv) Less magnetic loss. The Main drawbacks are: (i) More difficult to manufacture (ii) Difficult to repair the Transformer.

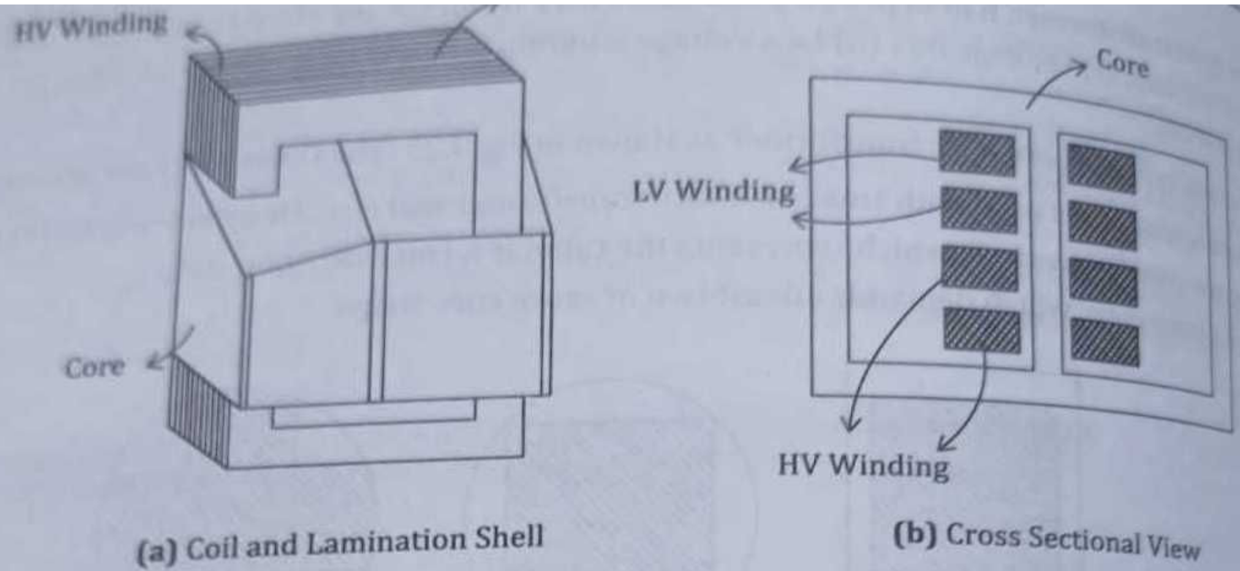


Fig 3.27 Shell type Transformer

Main Constructional Elements of Transformer

The transformer consists of the following constructional parts are :

1. Magnetic part - Core (U, I, E) limb, yoke and clamping structure.
2. Electrical part – Primary winding, Secondary winding. Tertiary winding and Tapping winding
3. Insulating part – Primary Insulation, Secondary insulation and Terminal insulation.
4. Cooling part - Tank and cooling devices.
5. Protective devices and accessories - Breather, Explosion vent, Buchholz relay