1 Introduction

A transformer is a device which converts magnetic energy into electrical energy. It consists of two electrical coils called as a primary winding and secondary winding. The primary winding of a transformer receives power, while the secondary winding delivers power. A magnetic iron circuit called "core" is commonly used to wrap around these coils. Though these two coils are electrically isolated but magnetically linked.

An electric current when passed through the primary of a transformer then a magnetic field is created, which induces a voltage across the secondary of a transformer. Based on the type of application, the single-phase transformer is used to either step-up or step-down the voltage at the output. This transformer is typically a power transformer with high-efficiency and low losses.

A transformer is a static machine. Although it is not an energy conversion device, it is essential in many energy conversion systems. It is a simple device, having two or more electric circuits coupled by a common magnetic field. Ferromagnetic cores are used to provide tight magnetic coupling and high flux densities. Such transformers are known as *iron-core transformers*. They are invariably used in high-power applications. *Air-core transformers* have poor magnetic coupling and are sometimes used in low power electronic applications.

2 Transformer Construction

There are basically three components of a Transformer:

1- Iron Core

2- Primary Winding

3- Secondary Winding

2.1 Core

The core of the transformer is rectangular in shape and laminated. During the transformer construction, it has to be designed in such a way that there are fewer core losses during the operation of the Transformer. Core losses and iron losses are a combination of all the losses that happen inside the core.

The core lets an alternating flux drive through it. This might cause energy loss in the core due to hysteresis loss. So, you should choose a high-quality Silicon Steel with low hysteresis loss to construct the core of a Transformer. This steel is termed the Soft Steel Core of the Transformer.

The alternating flux produces certain currents known as Eddy currents. These currents use electrical energy and cause certain losses, known by the name of eddy current losses of the Transformer. The core must be manufactured as a group of laminations. These successive laminations are electrically insulated to reduce eddy currents. The insulation layer is made up of Varnish, which offers high resistance to eddy currents.

2.2 Windings

There are two windings on the transformer i.e. Primary Winding and Secondary Winding. The Primary Winding is connected to the input terminal and is

responsible for generating a self-induced EMF. The Secondary Winding is connected to the output load. These windings are placed on the core and are electrically insulated from each other and the core for proper functioning and reduction in losses.

These coils have different numbers of turns compared to each other. The Primary Winding of the Transformer has N_1 turns. Similarly, the Secondary Winding of the Transformer has N_2 turns. Depending upon the operation of the transformer, $N_1 < N_2$, $N_1 > N_2$, and $N1 = N_2$.

3 Types of transformers

Transformers can be classified on different basis, like types of construction, types of cooling etc. **On the basis of their purpose.**

1. Step up transformer: Voltage increases (with subsequent decrease in current) at secondary.

2. Step down transformer: Voltage decreases (with subsequent increase in current) at secondary.

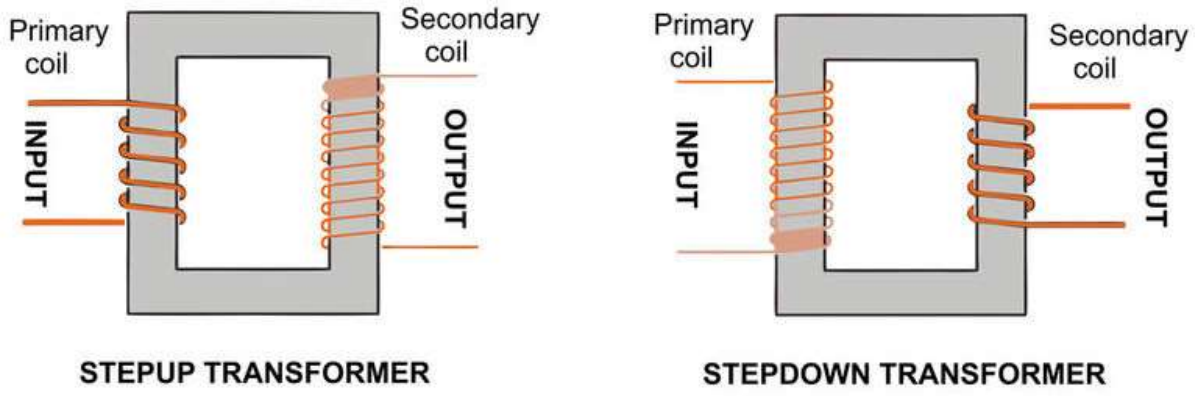

Fig 1. Step-up and step-down transformers.

On the basis of type of supply

1- Single phase transformer.

2- Three phase transformers.

On the basis of their use

1- Power transformer: Used in transmission network, high rating.

2- Distribution transformer: Used in distribution network, comparatively lower rating than that of power transformers.

3- Instrument transformer: Used in relay and protection purpose in different instruments in industries.

- Current transformer (CT)
- Potential transformer (PT)

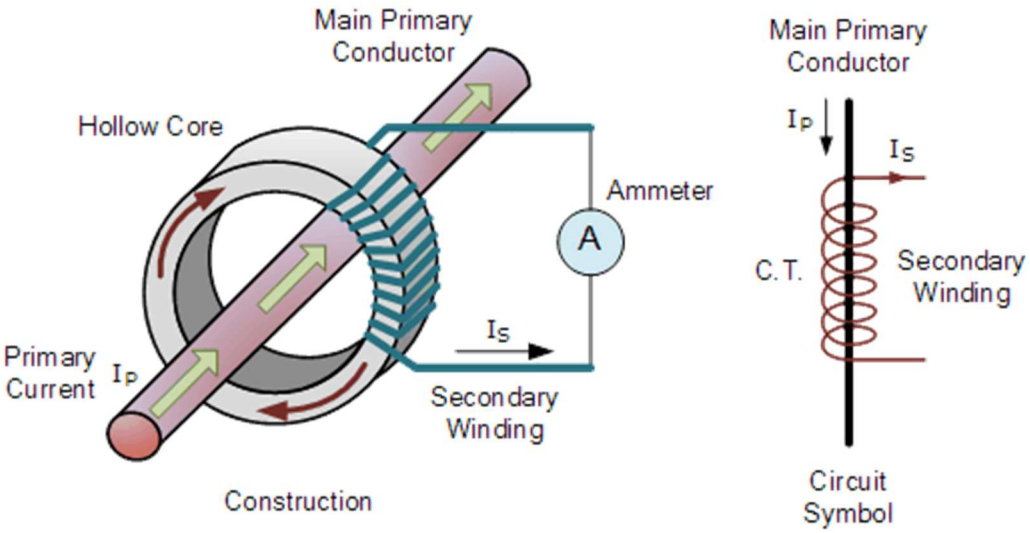

Fig 2. CT transformer.

On the basis of construction, transformers can be classified into two types as;

1- Core type transformer.

2- Shell type transformer.

3.1 Core type transformer

In core type transformer, windings are cylindrical former wound, mounted on the core limbs as shown in figure 3. The cylindrical coils have different layers and each layer is insulated from each other. Materials like paper, cloth or mica can be used for insulation. Low voltage windings are placed nearer to the core, as they are easier to insulate.

3.2 Shell type transformer

The coils are former wound and mounted in layers stacked with insulation between them. A shell type transformer may have simple rectangular form or it may have a distributed form.

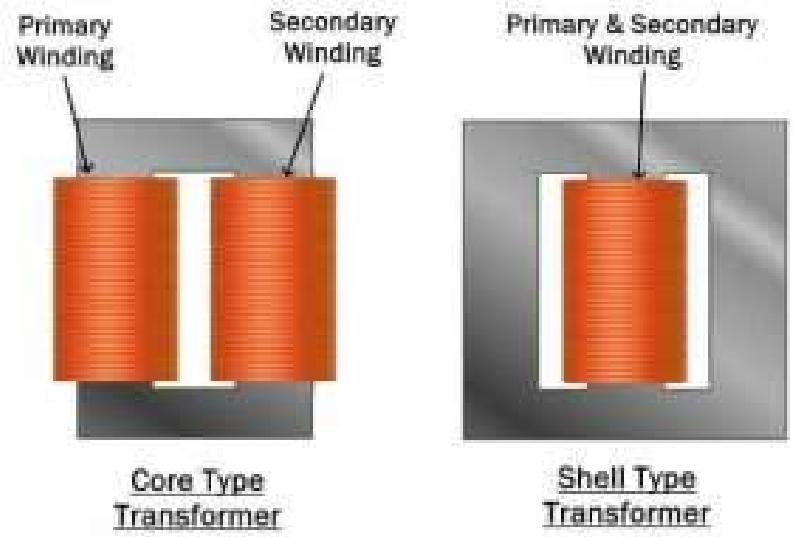

Fig 3. Shell and Core type.

4 Working principle of transformer

The **basic principle behind working of a transformer** is the phenomenon of mutual induction between two windings linked by common magnetic flux. The figure shows the simplest form of a transformer. Basically, a transformer consists of two inductive coils; primary winding and secondary winding. The coils are electrically separated but magnetically linked to each other. When, primary winding is connected to a source of alternating voltage, alternating magnetic flux is produced around the winding. The core provides magnetic path for the flux, to get linked with the secondary winding. Most of the flux gets linked with the secondary winding which is called as 'useful flux' or main 'flux', and the flux which does not get linked with secondary winding is called as 'leakage flux'. As the flux produced is alternating (the direction of it is continuously changing), EMF gets induced in the secondary winding according to Faraday's law of electromagnetic induction. This emf is called 'mutually induced emf', and the frequency of mutually induced emf is same as that of supplied emf. If the secondary winding is closed circuit, then mutually induced current flows through it, and hence the electrical energy is transferred from one circuit (primary) to another circuit (secondary).

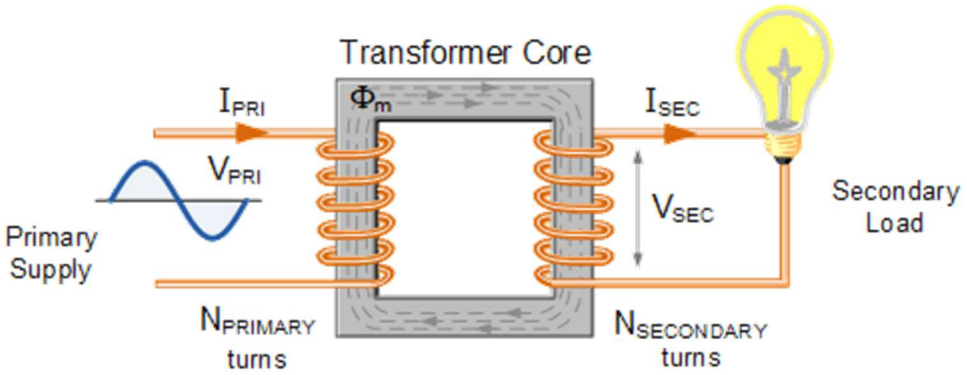

Fig 4. Single phase transformer.