# Single Phase Transformer: Construction and Its Working

What it is:-

A single-phase transformer is an electrical device that accepts single-phase AC power and outputs single-phase AC. This is used in the distribution of power in non-urban areas as the overall demand and costs involved are lower than the 3-phase distribution transformer. They are used as a step-down transformer to decrease the home voltage to a suitable value without a change in frequency. For this reason, it is commonly used to power electronic appliances at residences. This article discusses an overview of a single-phase transformer.

## What is a Single Phase Transformer?

**Definition:** 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, they are 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. The single-phase transformer diagram is shown in Fig 1.

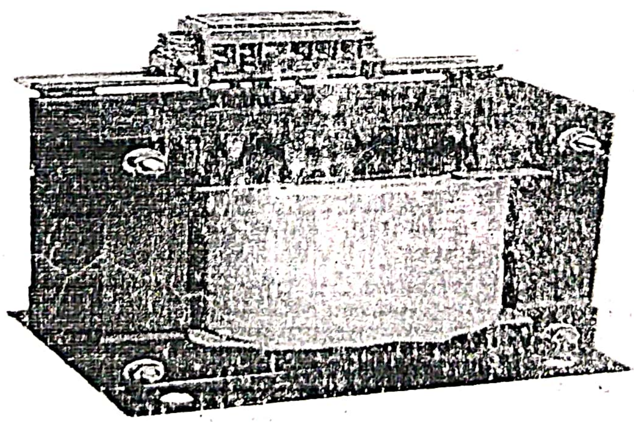


Fig 1: Single phase Transformer

## Principle of Single Phase Transformer

The single-phase transformer works on the principle of Faraday's Law of Electromagnetic Induction. Typically, mutual induction between primary and secondary windings is responsible for the transformer operation in an electrical transformer.

Working:-

## Working of Single Phase Transformer

A transformer is a static device that transfers electric power in one circuit to another circuit of the same frequency. It consists of primary and secondary windings. This transformer operates on the principle of mutual inductance.

When the primary of a transformer is connected to an AC supply, the current flows in the coil and the magnetic field build-up. This condition is known as mutual inductance and the flow of current is as per the Faraday's Law of electromagnetic induction. As the current increases from zero to its maximum value, the magnetic field strengthens and is given by dϕ/dt.

This electromagnet forms the magnetic lines of force and expands outward from the coil forming a path of magnetic flux. The turns of both windings get linked by this magnetic flux. The strength of a magnetic field generated in the core depends on the number of turns in the winding and the amount of current. The magnetic flux and current are directly proportional to each other.Shown in Figure 2

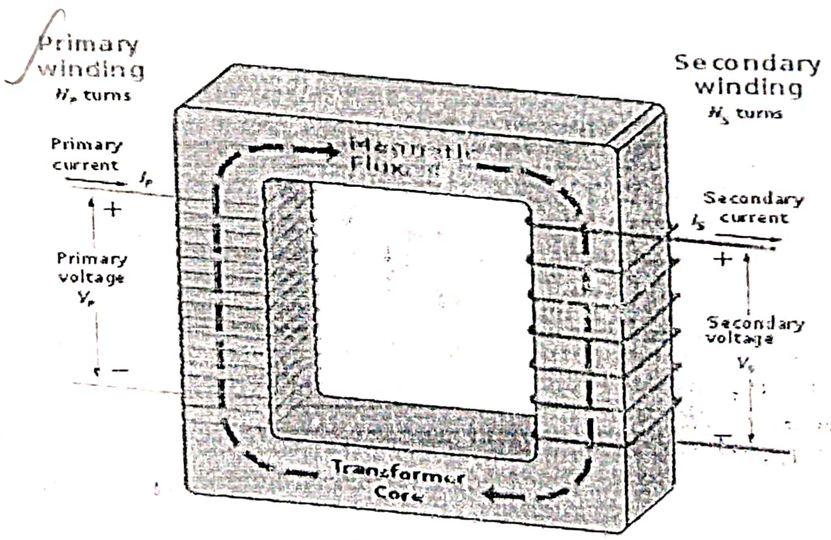



Fig 2:Working-of-single-phase-transformer

As the magnetic lines of flux flow around the core, it passes through the secondary winding, inducing voltage across it. The Faraday's Law is used to determine the voltage induced across the secondary coil and it is given by:

$$N.\ d\phi/dt$$

where,

'N' is the number of coil turns

The frequency is the same in primary and secondary windings.

Thus, we can say that the voltage induced is the same in both the windings as the same magnetic flux links both the coils together. Also, the total voltage induced is directly proportional to the number of turns in the coil.

Let us assume that the primary and secondary windings of the transformer have single turns on each. Assuming no losses, the current flows through the coil to produce magnetic flux and induce voltage of one volt across the secondary.

Due to AC supply, magnetic flux varies sinusoidally and it is given by,

$$\phi = \phi_{max} \text{ Sin } \omega t$$

The relationship between the induced emf, E in the coil windings of N turns is given by,

$E=N\ (d\emptyset)/dt$

$E=N*\omega*\phi_{max}\ \cos\omega t\varphi$

$Emax=N\omega\phi_{max}$

$Erms=N\omega/\sqrt{2}*\phi_{max}=2\pi/\sqrt{2}*f*N*\phi_{max}$

$Erms=4.44\ fN\phi_{max}$

Where,

'f' is the frequency in Hertz, given by $\omega/2\pi$.

'N' is the number of coil windings

'$\phi$' is s the amount of flux in Webers

The above equation is the Transformer EMF Equation. For emf of a primary winding of a transformer E, N will be the number of primary turns (NP), while for the emf, E of a secondary winding of a transformer, the number of turns, N will be (NS).

# Construction of Single Phase Transformer

A simple single-phase transformer has each winding being wound cylindrically on a soft iron limb separately to provide a necessary magnetic circuit, which is commonly referred to as "transformer core". It offers a path for the flow of the magnetic field to induce voltage between two windings.

As seen in the figure2, the two windings are not close enough to have an efficient magnetic coupling. Thus, converging and increasing the magnetic circuit near the coils can enhance the magnetic coupling between primary and secondary windings. Thin steel laminations shall be employed to prevent power losses from the core.

Based on how the windings are wound around the central steel laminated core, the transformer construction.

## Shell-type Transformer

In this type of transformer construction, the primary and secondary windings are positioned cylindrically on the center limb resulting in twice the cross-sectional area than the outer limbs. There are two closed magnetic paths in this type of construction and the outer limb has the magnetic flux $\phi/2$ flowing. Shell type transformer overcomes leakage flux, reduces core losses and increases efficiency. It shown in Fig 3

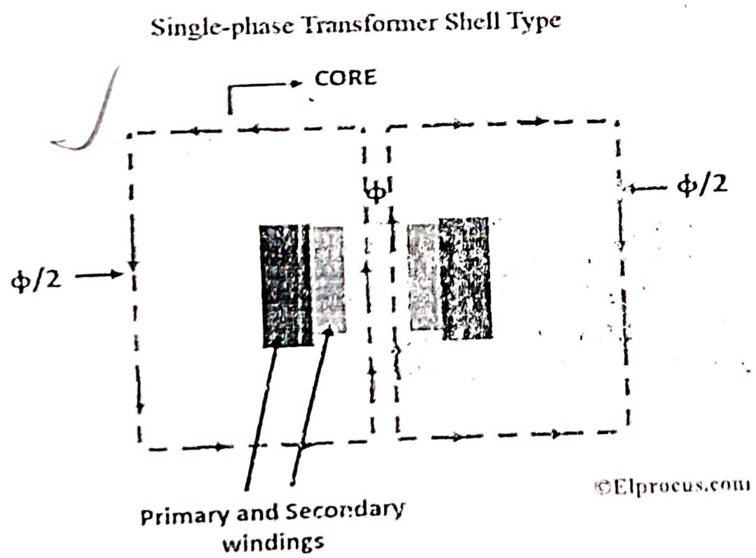



**Fig 3: Single-phase-transformer-shell-type**

# MAJOR PARTS OF TRANSFORMER

1. Core of Shell Type Transformer

We use 'E's and 'L's shape laminations to make the core of the **shell-type transformer** shown in Fig: 4

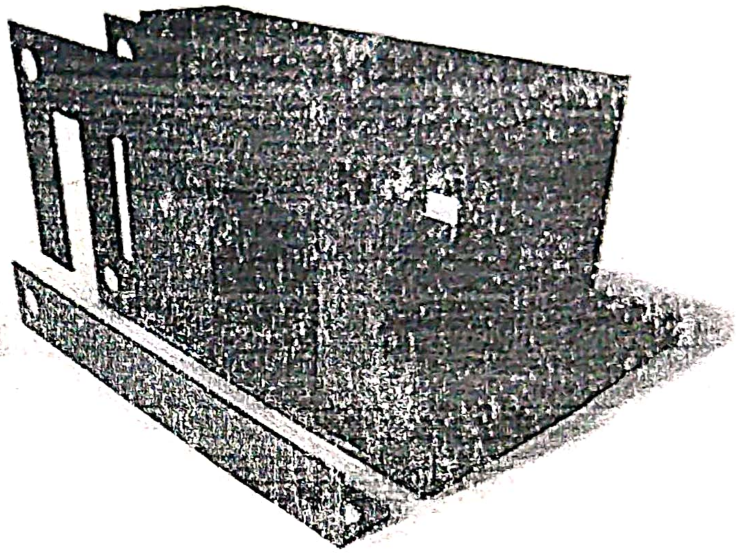


Fig 4:E's and 'L's shape laminations

2. BOBIN

In electrical applications, transformers, inductors, solenoids, and relay coils use bobbins as permanent containers for the wire to retain shape and rigidity, and to ease assembly of the windings into or onto the magnetic core. (Such coils of wire carrying current create the induced currents and magnetic fields required in these devices.

Bobbins in these applications may be made of thermoplastic or thermosetting materials (for example, phenolics). This plastic often has to have a TÜV, UL, or other regulatory agency flammability rating for safety reasons

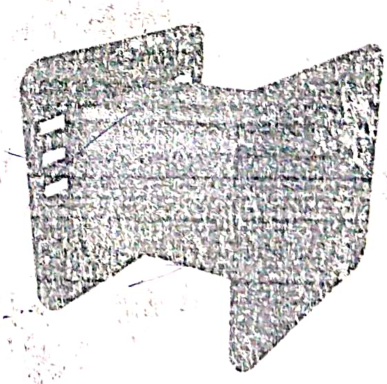
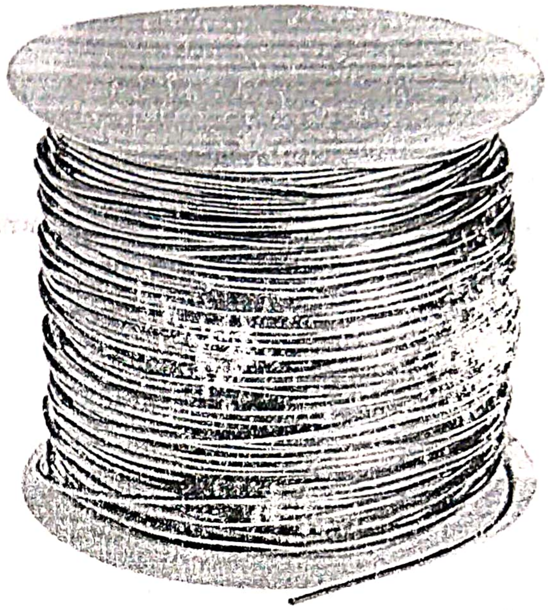


Fig 5:Bobin

### 3. Copper wire



Copper wiring is heavier than aluminum wiring, it is often used to make smaller and lighter transformers. This is because copper offers higher electrical conductivity levels than aluminum. The resistivity of copper is 0.6 times that of aluminum. Therefore, the cross-section of an aluminum conductor needs to be 1.66 times larger than that of a copper conductor to demonstrate the same amount of resistance. As a result, an aluminum wound transformer would need to be much larger than a copper wound one to handle the same load.

Some of the other advantages copper wiring offers over aluminum wiring include:

- Lower losses (due to better electrical conductivity) and temperatures (due to better thermal conductivity)
- Greater reliability with regard to line and load connections
- Better manufacturability since the generally smaller-diameters conductors are easier to handle

**Working Procedure of Cut Section Model of Transformer:**

1. Connect AC mains 220V to the primary side of transformer.
2. Connect the multimeter to the secondary side of the transformer and check the output voltage of transformer.

## Cut Section Model Of Single Phase Transformer

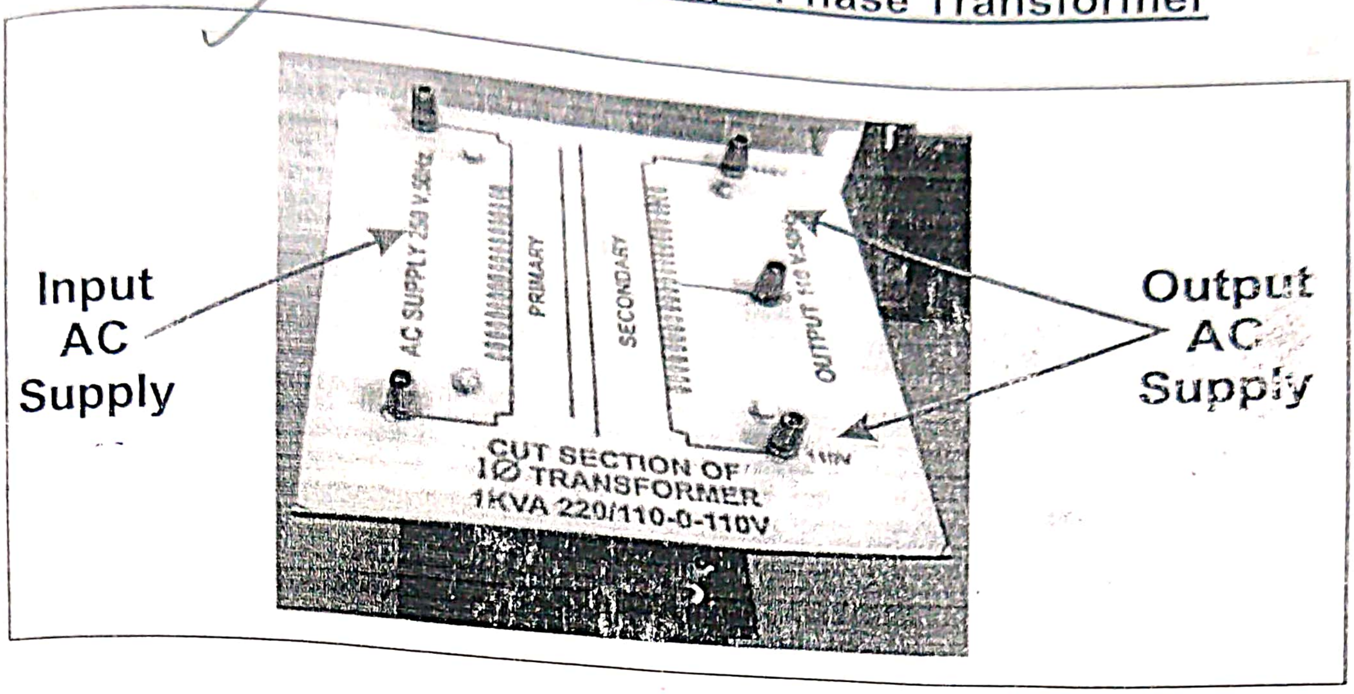



Fig 6: Front view of Transformer

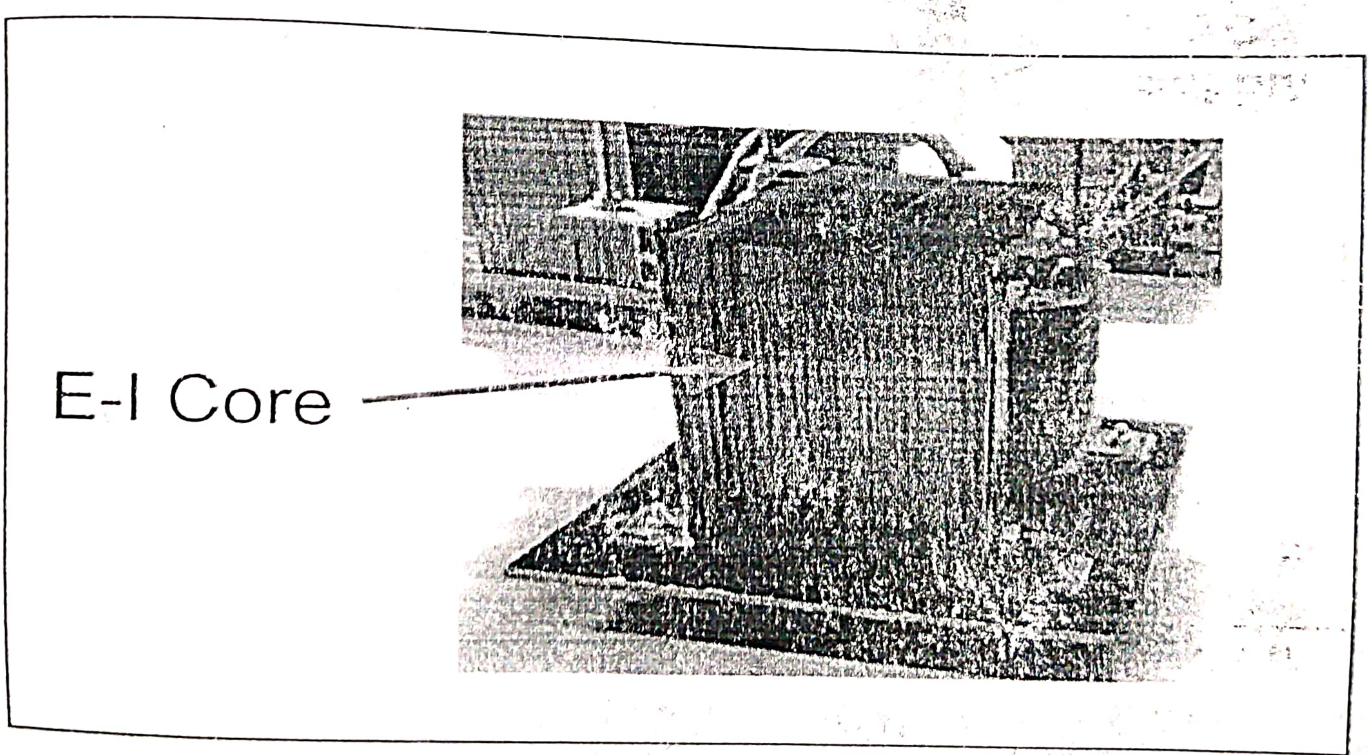



Fig 7: Side view of Transformer

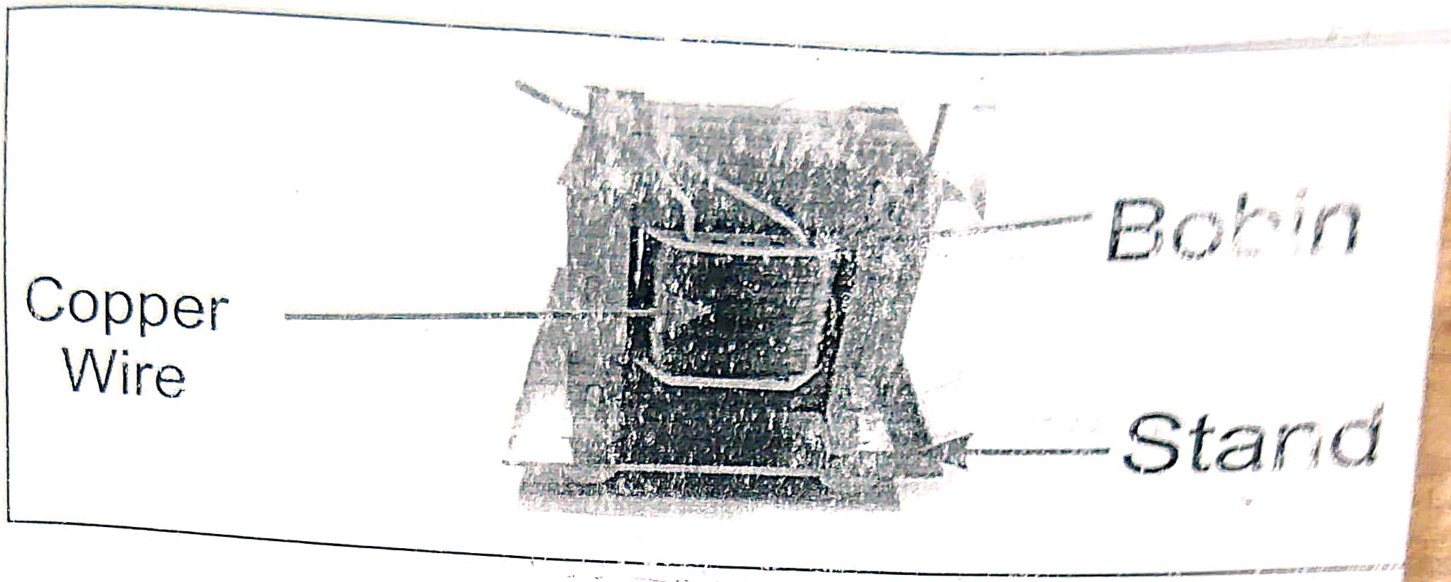



Fig 8: Side view of Transformer