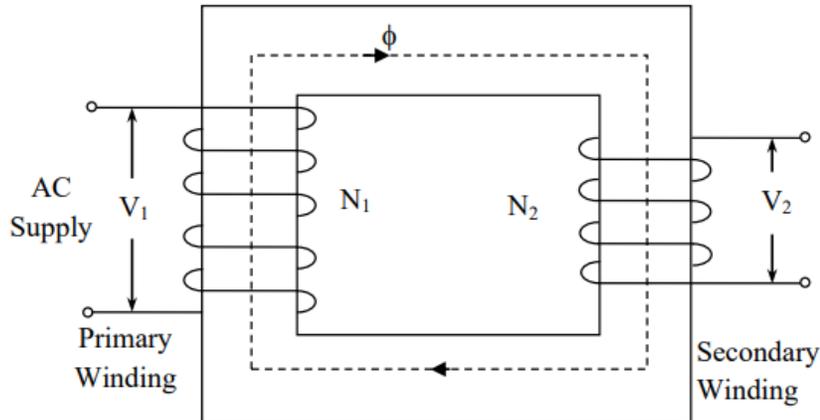


Construction, Working principle and Applications of Transformer

TRANSFORMERS

Transformer works on the principle of electromagnetic induction. A transformer is an electrical device, having no moving parts, which by mutual induction transfers electric energy from one circuit to another at the same frequency, usually with changed values of voltage and current. It consists of two windings insulated from each other and wound on a common core made up of magnetic material.



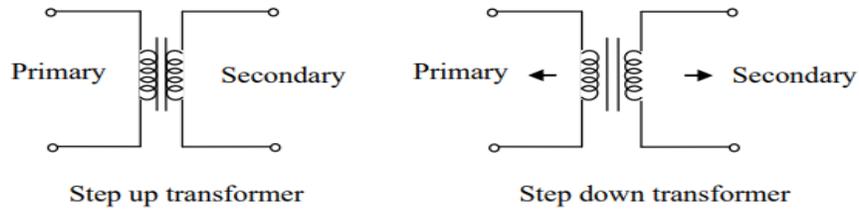
Alternating voltage is connected across one of the windings called the primary winding. In both the windings emf is induced by electromagnetic induction. The second winding is called secondary winding.

Working Principle of a Transformer

When the primary winding is connected to an AC source an exciting current flows through the winding. As the current is alternating, it will produce an alternating flux in the core which will be linked by both the primary and secondary windings. The induced emf in the primary winding (E_1) is almost equal to the applied voltage V_1 and will oppose the applied voltage. The emf induced in the secondary winding (E_2) can be utilized to deliver power to any load connected across the secondary. Thus power is transferred from the primary to the secondary circuit by electromagnetic induction.

The flux in the core will alternate at the same frequency as the frequency of the supply voltage. The frequency of induced emf in the secondary is the same as that of the supply voltage. The magnitude of the emf induced in the secondary winding will depend upon its number of turns.

In a transformer, if the number of turns in the secondary winding is less than that in the primary winding, it is called a step-down transformer. When the number of turns in the secondary winding is higher than the primary winding it is called a step-up transformer.



Construction Details

A transformer is a static device and its construction is simple as there are no moving parts.

The main components of a transformer are

- (i) The magnetic core
- (ii) Primary and Secondary windings
- (iii) Insulation of windings

Magnetic core

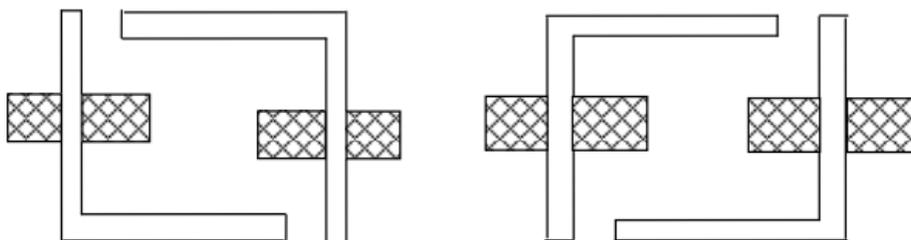
Magnetic circuit consists of an iron core. The transformer core is generally laminated and is made out of a good magnetic material like silicon steel. The thickness of laminations or stampings varies from 0.35mm to 0.5mm. The laminations are insulated from each other by coating them with a thin coat of varnish.

The two types of transformer cores are

- a. Core type
- b. Shell type

Core type transformer

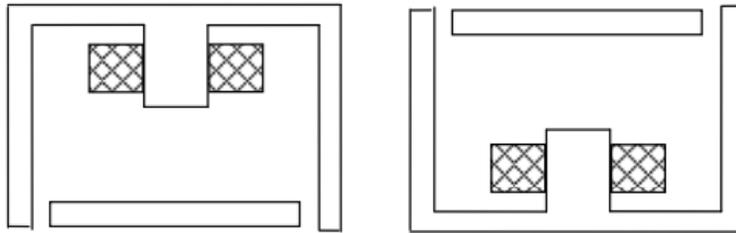
Here the windings surround a considerable part of core. It has only one magnetic path. It has two limbs for the two windings and is made up of two L-type stampings. The coils used usually are of cylindrical type and are usually wound. For transformers of higher rating stepped core with core of square or rectangular cross section is used. Insulating cylinders are used to separate windings from the core and from each other.



Shell type transformer

Here the core surrounds the considerable part of windings. The two windings are carried by central limb. The core is made up of E and I stampings and has three limbs. It has two parallel paths for magnetic flux.

The coils used are of multilayer disc type and are former wound in the form of pancakes. Each layer is insulated from each other by paper.



Windings

There are two windings in a transformer. They are called primary and secondary windings. Generally the windings are made up of copper.

Insulation

Paper is still used as the basic conductor insulation. Enamel insulation is used as the inter-turn insulation for low voltage transformer. For power transformer enameled copper with paper insulation is also used.

EMF Equation of a Transformer

Consider a transformer arrangement as follows:

N_1 – Number of primary turns

N_2 – Number of secondary turns

Φ_m – Maximum Value of flux in the core in Wb

B_m – Maximum Value of flux density in the core in Wb/m²

A - Area of the core in m²

f – Frequency of the AC supply in Hertz

V_1 – Supply Voltage across primary in Volts

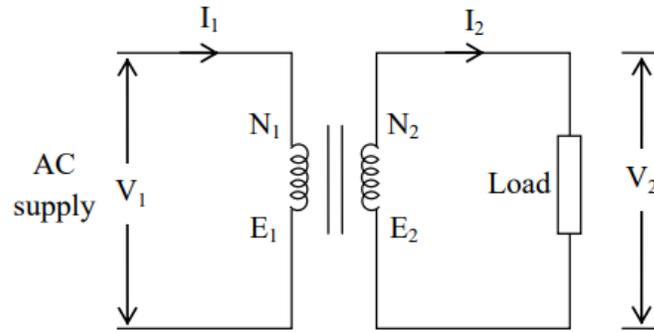
V_2 – Terminal Voltage across secondary in Volts

I_1 – Full load primary current in amperes

I_2 – Full load secondary current in amperes

E_1 – Emf induced in the primary in Volts

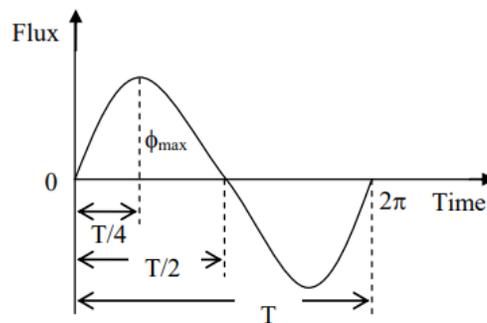
E_2 – Emf induced in the secondary in Volts



Since applied Voltage is alternating in nature, the flux established is also an alternating one. The flux will attain its maximum Value in one quarter of the cycle.

We know that $T = 1/f$, Where 'f' is the frequency in Hertz.

If we assume single turn coil, then according to Faradays laws of electromagnetic induction, the average Value of emf induced / turn = $4f \times \phi_m$ Volts.



$$\text{Form factor} = \frac{\text{RMS value}}{\text{Average value}} = 1.11 \quad (\text{since } \phi_m \text{ is sinusoidal})$$

$$\text{RMS Value} = \text{Form factor} \times \text{Average value}$$

$$\text{RMS Value of emf induced / turn} = (1.11) (4f\phi_m) = 4.44f\phi_m \text{ Volts}$$

RMS value of emf induced in the entire primary winding,

$$E_1 = 4.44f\phi_m \times N_1$$

$$E_1 = 4.44fB_m A N_1 \text{ Volts}$$

Similarly RMS Value of emf induced in the secondary,

$$E_d = 4.44f\phi_m N_d \text{ Volts.}$$

$$\text{(or)} \quad E_2 = 4.44fB_m A N_2 \text{ Volts}$$

Transformation Ratio (K)

For an ideal transformer,

$$V_1 = E_1, V_2 = E_2, V_1 I_1 = V_2 I_2$$

$$\frac{V_2}{V_1} = \frac{I_1}{I_2}, \frac{E_2}{E_1} = \frac{I_1}{I_2}$$

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

Where 'K' is called transformation ratio.

Note

If $N_2 > N_1$ ie $K > 1$, then transformer is a step up transformer. If $N_2 < N_1$, ie $K < 1$, then transformer is a step down transformer.

$$\text{Voltage ratio} = \frac{E_2}{E_1} = K$$

$$\text{Current ratio} = \frac{I_2}{I_1} = \frac{1}{K}$$

Classifications of Transformers

Transformers are classified on the basis of

(i) Duty they perform

1. Power transformer – for transmission and distribution purpose.
2. Current transformer – instrument transformer
3. Potential transformer – instrument transformer

(ii) Construction

1. Core type transformer
2. Shell type transformer
3. Berry type transformer

(iii) Voltage Output

1. Step down transformer (Higher to Lower)
2. Step Up transformer (Lower to Higher)
3. Auto transformer (Variable to '0' to rated value)

(iv) Application

1. Welding Transformer
2. Furnace Transformer

(v) Cooling

1. Duct type transformer (Air natural or Air blast)
2. Oil immersed
 - a. Self cooled
 - b. Forced air cooled
 - c. Water cooled
 - d. Forced oil cooled

(vi) Input supply

1. Single phase transformer
2. Three phase transformer
 - a. Star – Star
 - b. Star – Delta
 - c. Delta – Delta
 - d. Delta – Star
 - e. Open – Delta
 - f. Scott connection

Application of Transformer

Transformers are used in a variety of applications, including power generation, transmission and distribution, lighting, audio systems, and electronic equipment.

- Power generation: Transformers are used in power plants to increase the voltage of the electricity generated by the plant before it is sent to the grid.
- Transmission and distribution: Transformers are used in the transmission and distribution of electricity to increase or decrease the voltage of electricity as it is sent from power plants to homes and businesses.
- Lighting: Transformers are used in lighting systems to decrease the voltage of electricity before it is sent to light bulbs.
- Audio systems: Transformers are used in audio systems to increase or decrease the voltage of electricity before it is sent to speakers.
- Electronic equipment: Transformers are used in a variety of electronic devices, including computers, TVs, radios, and cell phones.

Unit 3

Two marks Questions

1. What do you mean by motor?
2. What do you mean by Generator?
3. What is the use of Yoke in DC machines?
4. What is the use of inter pole in DC machines?
5. What are the applications of DC Motor?
6. What is transformer?
7. List the types of transformers
8. Compare Core and Shell type Transformers
9. What is the working principle of transformer
10. Define the turns ratio of the transformer

16 marks Questions

1. Explain the construction and working principle of DC Generator with neat sketch
2. Classify the types of DC Generator with neat sketch.
3. Explain the construction and working principle of DC motor with neat sketch.
4. Classify the types of DC Motor with neat sketch.
5. Explain the construction and working principle of Transformer with neat sketch
6. Classify and explain the types of transformers with neat sketch.
7. Explain the structure of power systems with neat sketch.
8. Explain the operation of Electric vehicle with the help of block diagram.