Transformer

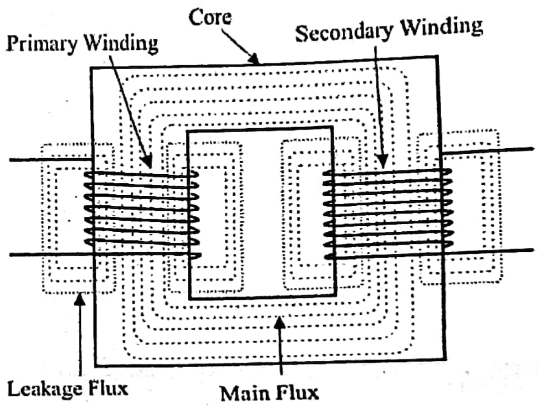
Definition of Transformer

Electrical power transformer is a static device which transforms electrical energy from one circuit to another without any direct electrical connection but with the help of mutual induction between two windings. It transforms power from one circuit to another without changing its frequency but may be in different voltage level.

Working Principle of Transformer

The working principle of transformer is very simple. It depends upon Faraday's law of electromagnetic induction. Actually, mutual induction between two or more winding is responsible for transformation action in an electrical 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 at right 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).

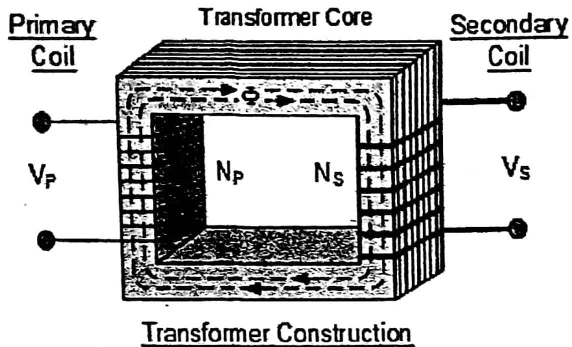
Main Constructional Parts of Transformer

The three main parts of a transformer are,

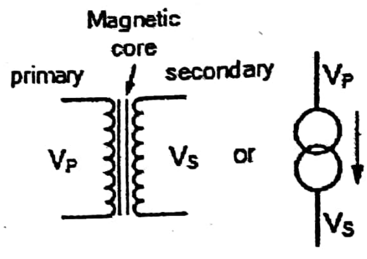
1. Primary Winding of Transformer-
   Which produces magnetic flux when it is connected to electrical source.
2. Magnetic Core of Transformer-
   The magnetic flux produced by the primary winding, that will pass through this low reluctance path linked with secondary winding and create a closed magnetic circuit.

3. Secondary Winding of Transformer-

The flux, produced by primary winding, passes through the core, will link with the secondary winding. This winding also wounds on the same core and gives the desired output of the transformer.



Transformer Construction



Transformer Symbols

- V_P - is the Primary Voltage
- V_S - is the Secondary Voltage
- N_P - is the Number of Primary Windings
- N_S - is the Number of Secondary Windings
- Φ (phi) - is the Flux Linkage

Notice that the two coil windings are not electrically connected but are only linked magnetically. A single-phase transformer can operate to either increase or decrease the voltage applied to the primary winding. When a transformer is used to "increase" the voltage on its secondary winding with respect to the primary, it is called a Step-up transformer. When it is used to "decrease" the voltage on the secondary winding with respect to the primary it is called a Step-down transformer.

However, a third condition exists in which a transformer produces the same voltage on its secondary as is applied to its primary winding. In other words, its output is identical with respect to voltage, current and power transferred. This type of transformer is called an "Impedance Transformer" and is mainly used for impedance matching or the isolation of adjoining electrical circuits.

The difference in voltage between the primary and the secondary windings is achieved by changing the number of coil turns in the primary winding (NP) compared to the number of coil turns on the secondary winding (NS).

Turns Ratio of Transformer

The voltage in primary and secondary of transformer is directly proportional to the number of turns in the respective winding, the transformation ratio of transformer is expressed in ratio of turns and referred as turns ratio of transformer. The ratio is denoted by K.

$$K = \frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$$

Uses of transformer

Reducing power loss in transmission line: The most obvious application of the electrical transformer is in power distribution. Recall that in an electrical circuit, *power loss* = I^2R. Thus, the power consumed by a circuit element is proportional to the *square* of the current flowing through it. In a transmission line, this is important because the line itself has some characteristic impedance. In order to reduce power losses in the transmission line, it is desirable to transmit the least amount of current possible. For a given amount of power, the best way to do this is by increasing the voltage.

Impedance matching: In electronics, impedance matching is the practice of designing the input impedance of an electrical load or the output impedance of its corresponding signal source to maximize the power transfer or minimize signal reflection from the load. Transformers are sometimes used to match the impedances of circuits. A transformer converts alternating current at one voltage to the same waveform at another voltage. The power input to the transformer and output from the transformer is the same (except for conversion losses). The side with the lower voltage is at low impedance (because this has the lower number of turns), and the side with the higher voltage is at a higher impedance (as it has more turns in its coil).

Electrical isolation: Electrical isolation is necessary to protect circuits, equipment, and people from shocks and short circuits as well as to make accurate measurements. An isolation transformer used to provide isolation of the powered device from the power source, usually for safety reasons. Isolation transformers provide galvanic isolation and are used to protect against electric shock, to suppress electrical noise in sensitive devices, or to transfer power between two circuits which must not be connected.