Electrical Technology

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Transformer

Basic Working of Transformer

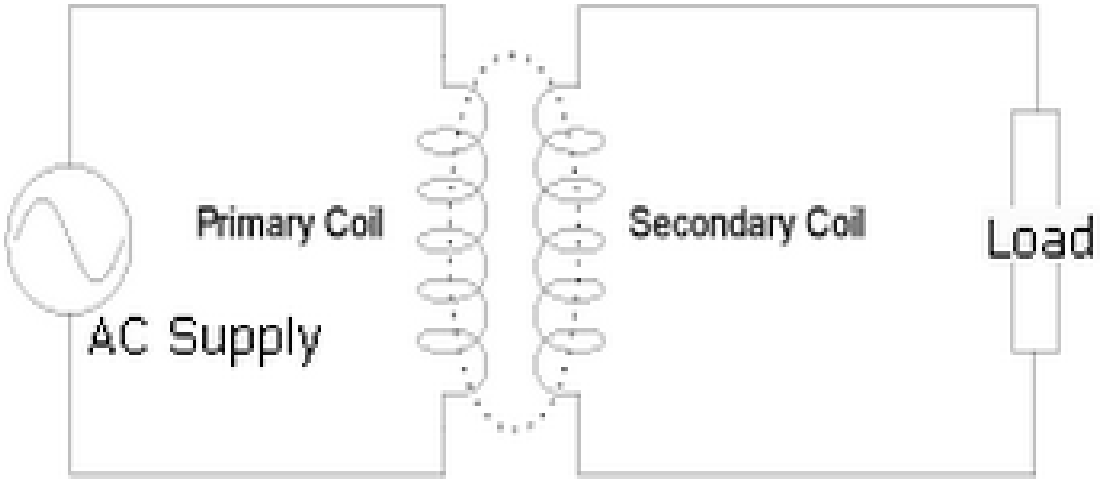
E.M.F Equation of transformer

Voltage Transformation ratio (K)

Introduction

A transformer is a static piece of apparatus by means of which electric power in one circuit is **transformed** into electric power of the same frequency in another circuit. It can **raise** or **lower** the voltage in a circuit but with a corresponding **decrease or increase in current** .

It has an input side (primary) and an output side (secondary). Electrical energy applied to the primary is converted to a **magnetic field** which in turn, induces a current in the secondary which carries energy to the load connected to the secondary. The energy applied to the primary must be in the form of a **changing voltage** which creates a constantly **changing current** in the primary, since only a **changing magnetic field** will produce a current in the secondary.



In brief, a transformer is a device that

(a) transfers electric power from one circiut to another.

(b) it does so without a change of frequency.

(c) it accomplishes this by electromagnetic induction and

(d) where the two circuit are in mutual inductive influence of each other.

The Basic Working of Transformer

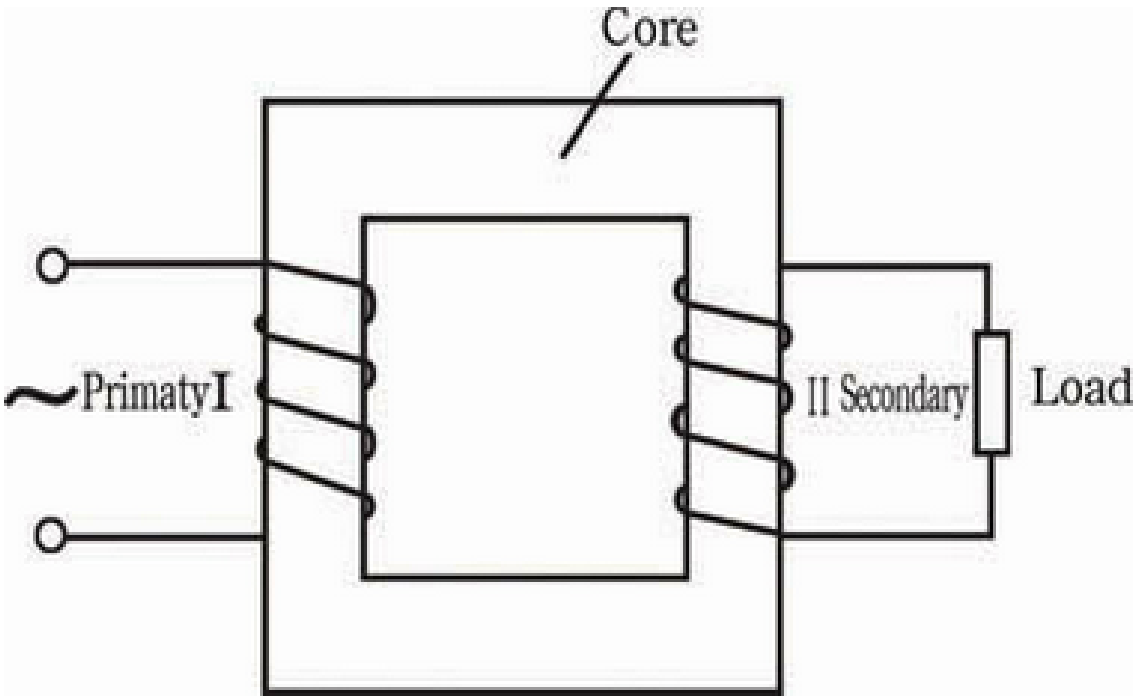
In its most basic form a transformer consists of :

(1)A **primary coil** or winding.
(2)A **secondary coil** or winding.
(3)A **core** that supports the coils or windings.

It consist of **two inductive coils** which are electrically separated but magnetically linked through a path of low reluctance. If one coil (primary) is connected to source of **alternating voltage** , an **alternating flux** is set up in the laminated core, most of which is linked with the other coil in which it produces mutually-induced e.m.f. (according to **Faraday's Laws of Electromagnetic Induction**) . If the second coil (secondary) circuit is closed, a current flows in it and so electric energy is transferred (entirely magnetically) from the first coil to the second coil.

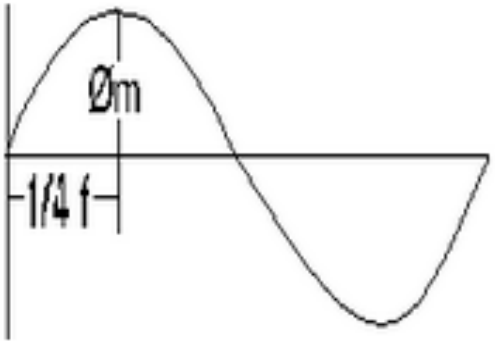
Operating Principle of Transformer

- Mutual induction



E.M.F Equation of transformer

Let **N1** = No. of turns in primary
N2 = No. of turns in secondary
Øm = Maximum flux in core in webers = Bm x A
f = Frequency of a.c. input in Hz.



The **flux increases** from it's **zero** value to maximum value **Øm** in one quarter of the cycle i.e. in **1/4 f** second.

Therefore, r.m.s value of e.m.f./turn = 4.44 Øm volts

Now, r.m.s value of induced e.m.f in the whole primary winding
= (induced e.m.f. / turn) x No. of primary winding

E1 = 4.44 f N1Øm ---------- (i)

Similarly, r.m.s. value of e.m.f. induced in secondary is,

$$E_2 = 4.44\, f\, N_2 \emptyset_m \quad \text{---------- (ii)}$$

Voltage Transformation ratio (K)

From the above equations (i) and (ii), we get

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

(i) If $K > 1$, then the transformer is called **step-up** transformer.

(ii) If $K < 1$, then the transformer is called **step-down** transformer.

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Voltage & Current Transformation Ratios

- It is clear that volts per turn is exactly the same for both the primary & secondary windings in any transformer.
- Thus,

$$\frac{V_2}{V_1} = \frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

- For step up transformer, $V_2 > V_1$, or $K > 1$.
- For step down transformer, $V_2 < V_1$, or $K < 1$.
- Also, for ideal transformer:

Output VA = Input VA

$$V_2 I_2 = V_1 I_1$$

Ideal Transformer

- **No winding resistance -** i.e PW & SW have zero resistance means no ohmic power loss and no resistive voltage drop in an ideal transformer.

- **No magnetic leakage-** i.e. no leakage flux means all flux setup is confined to the core which only links with both windings

Conti…

- **No iron loss –** i.e **hysteresis and eddy current loss** in transformer core are zero

(Hysteresis loss- The Lagging Of An Effect Behind Its Cause; Especially The Phenomenon In Which The Magnetic Induction Of A Ferromagnetic Material Lags Behind The Changing Magnetic Field, **and**

Eddy Current loss - An Induced Electric Current Formed Within The Body Of A Conductor In A Varying Magnetic Field**)**

- **Zero magnetizing current –** i.e. core has infinite permeability & zero reluctance means zero magnetizing current is required for establishing the requisite amount of flux in the core.