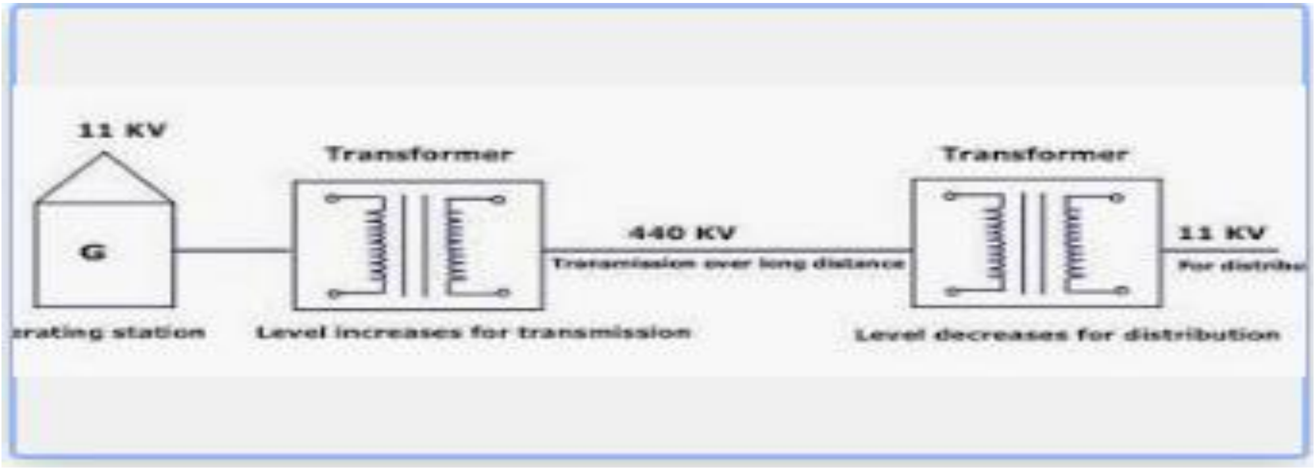
Transformer

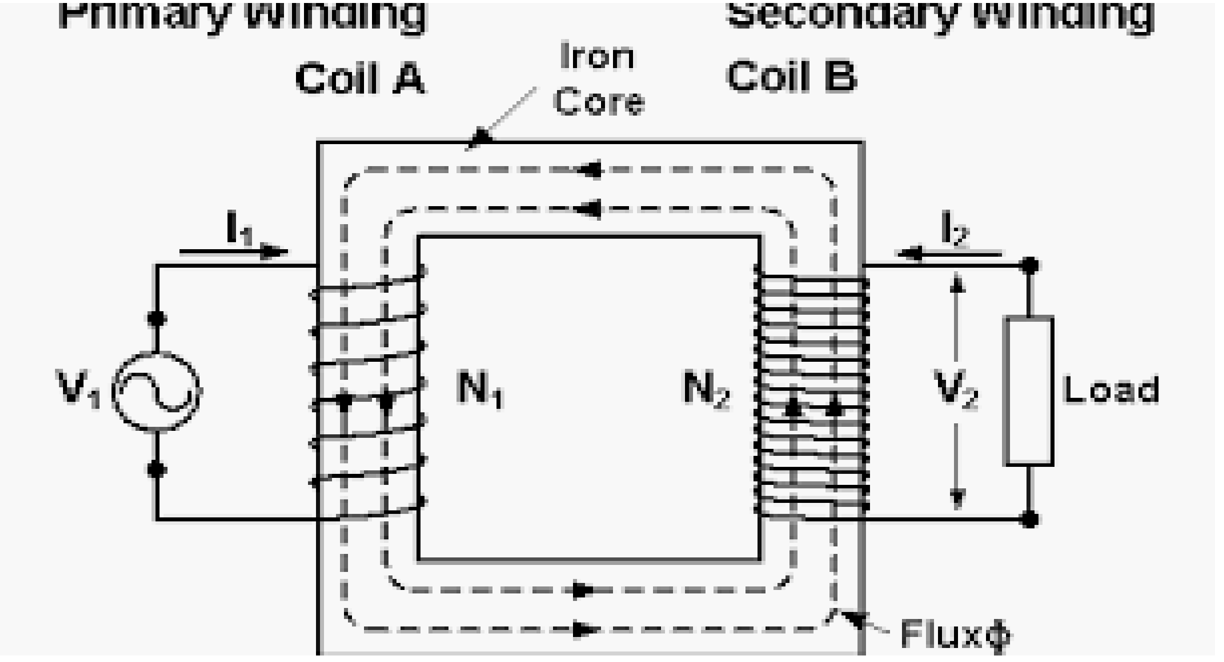
1.Introduction
2.Types and construction
3.Working principle of ideal transformer
4.E.m.f equation

Introduction

- **Electrical transformer** is a static electrical machine which transforms electrical power from one circuit to another circuit, without changing the frequency. Transformer can increase or decrease the voltage with corresponding decrease or increase in current.



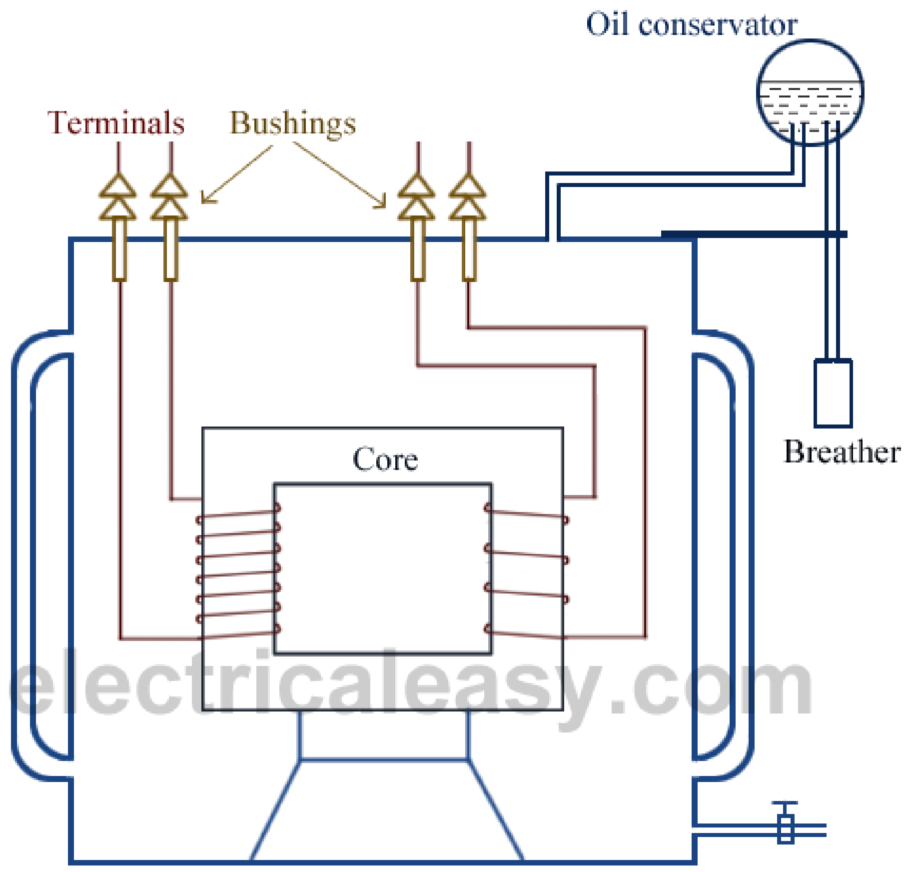
Working Principle Of Transformer



- The basic principle behind working of a transformer **when two coils are inductively coupled and if current in one coil is changed uniformly then e.m.f get induced in other coil**
- 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(has N1 number of turns)
- secondary winding is connected to load(has N2 number of turns)

- when primary winding is excited by alternating voltage it circulates an alternating current.
- This produces an alternating flux which links with secondary winding
- As flux is alternating according to Faraday’s law of electromagnetic induction mutually induced e.m.f gets developed in secondary winding
- D.C supply cannot be used for transformers
- As transformers works on principle of mutual induction ,for which current in one coil must change uniformly.
- If D.C supply is given current will not change due to constant supply and transformer will not work.

construction



Construction

Various parts of transformer

1.CORE

Made up of high grade silicon steel lamination

Used to carry flux produced by winding

2. Limb

Vertical portion of core

Carry windings

3. Yoke

Top and bottom horizontal portion of core

Used to carry flux in one winding to other winding

4. Windings

Coils used are wound on limbs and insulated from one another

Used to carry current and produce necessary flux for functioning of transformer

5.Conservator

Oil in transformer expands when temperature inside transformer increases due to heat and contracts when temperature decreases

Function of conservator is to take up the expansion and contraction of oil

6.Breather

Smaller transformers are not fully filled with oil there will be small space between oil level and tank

Tank is connected to atmosphere by vent pipe

When oil expands air will go out and when oil contracts air is taken in.

Function :

It is a device extracts moisture from air when air is taken in and does not allow oil to come in contact with moisture

It contains silica gel to absorb moisture

7.Explosion vent

It is a bent pipe fitted on main tank

It act as a relief valve

It uses non metallic diaphragm which bursts when pressure inside transformer becomes excessive ,it relaeases pressure and protects transformer

8.Buchholz relay

It is a safety gas operated relay connected to transformer

When faults gets developed inside transformer gases released

Buchholz relay operated with these gases and trips circuits breaker to protect device

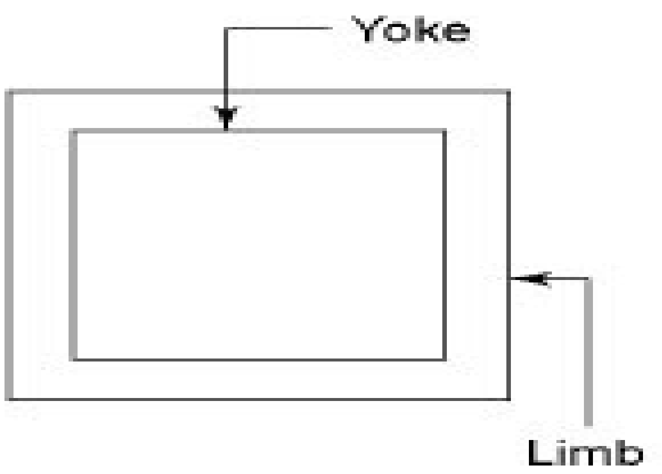
2 basic parts of transformer

1.Magnetic core

2. Winding or coils

1.Magnetic core

Square or rectangle in size



It is further divided in to

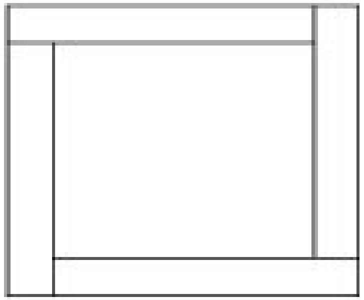
LIMB Vertical portion on which coils are wound

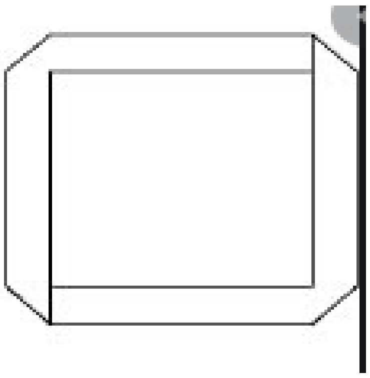
YOKE top and bottom horizontal portion

Core is made up of laminations to minimize eddy current losses

Laminations are overlapped to avoid air gaps at joint generally I shaped and L shaped laminations

I shaped and L shaped

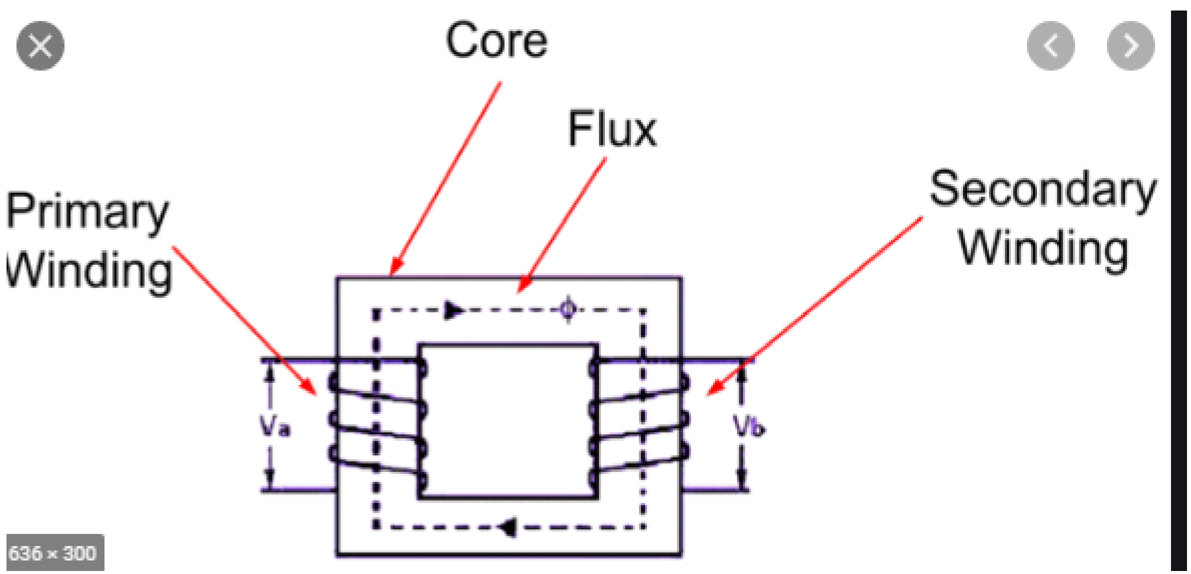




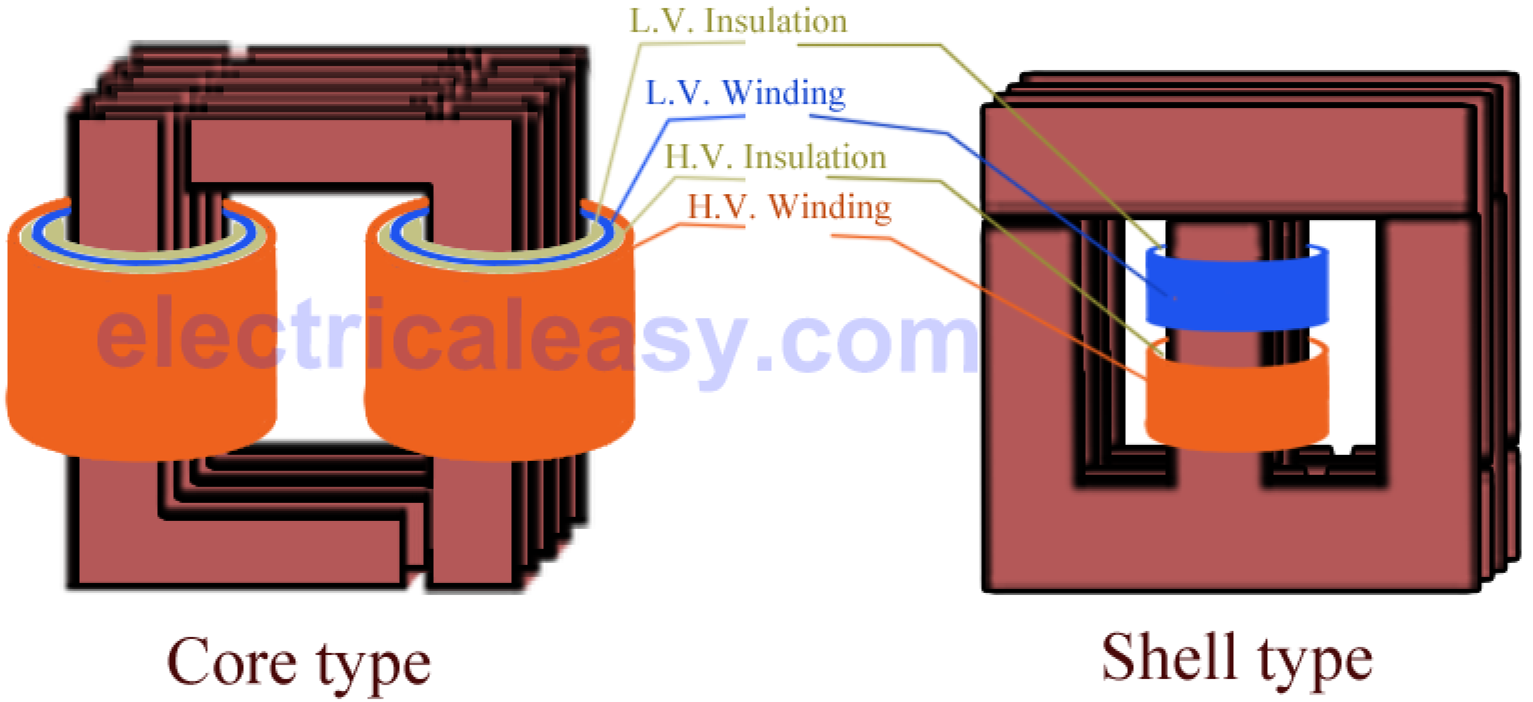
Types

1. Core type
2. shell type

Core type transformer



- Core is rectangular having 2 limbs
- core is made up of large number of thin laminations
- windings are uniformly distributed over core
- coils are cylindrical in type wound in helical layer with different layers insulated from each other by paper or mica
- coils are placed on both limbs



L.V. Insulation
L.V. Winding
H.V. Insulation
H.V. Winding
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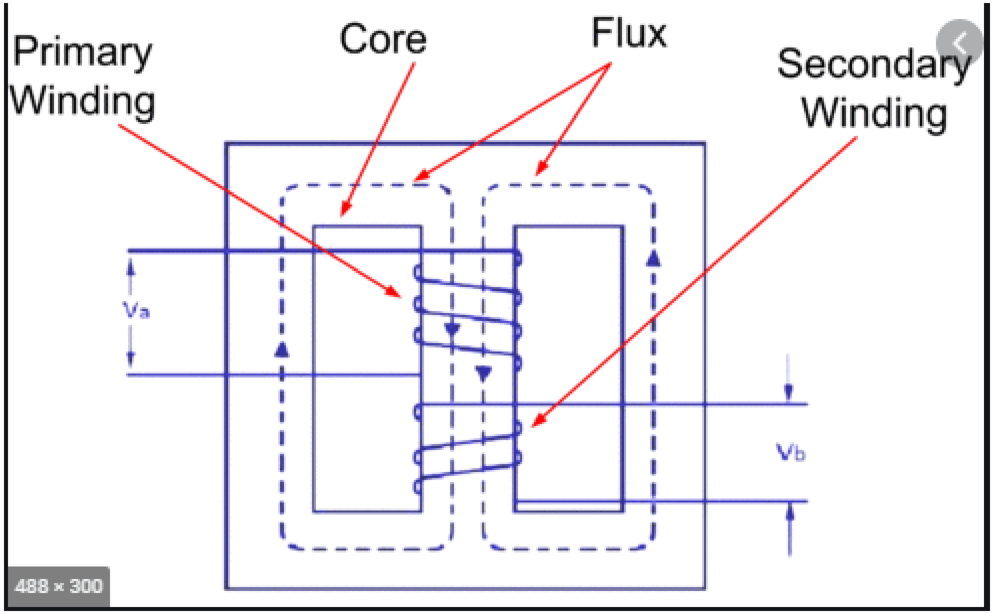
Core type
Shell type

- Shell type



Both windings are placed on central limb

Core encircles windings

Core is laminated

For very high voltage transformations shell type is preferred

Winding is surrounded by core so natural cooling does not exits

Comparison of core and shell

Sr. No.	Core Type	Shell Type
1.	The winding encircles the core.	The core encircles most part of the windings.
2.	The cylindrical type of coils are used.	Generally, multilayer disc type or sandwich coils are used.
3.	As windings are distributed, the natural cooling is more effective.	As windings are surrounded by the core, the natural cooling does not exist.
4.	The coils can be easily removed from maintenance point of view.	For removing any winding for the maintenance, large number of laminations are required to be removed. This is difficult.
5.	The construction is preferred for low voltage transformers.	The construction is used for very high voltage transformers.
6.	It has a single magnetic circuit.	It has a double magnetic circuit.
7.	In a single phase type, the core has two limbs.	In a single phase type, the core has three limbs.

E.M.F equation

32.6. E.M.F. Equation of a Transformer

Let N_1 = No. of turns in primary

N_2 = No. of turns in secondary

Φ_m = Maximum flux in core in webers

$= B_m \times A$

f = Frequency of a.c. input in Hz

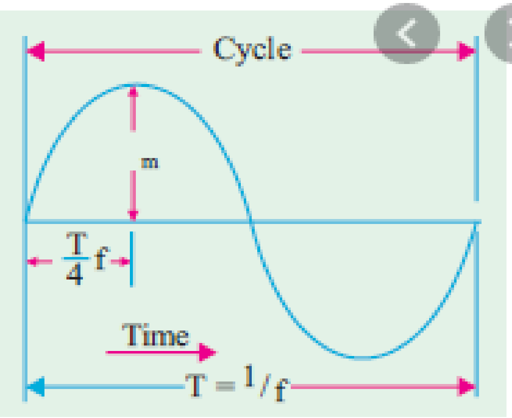


Fig. 32.14

As shown in Fig. 32.14, flux increases from its zero value to maximum value Φ_m in one quarter of the cycle *i.e.* in 1/4 f second.

$$\therefore \quad \text{Average rate of change of flux} = \frac{\Phi_m}{1/4f}$$

$$= 4f\Phi_m \text{ Wb/s or volt}$$

Now, rate of change of flux per turn means induced e.m.f. in volts.

$$\therefore \quad \text{Average e.m.f./turn} = 4f\Phi_m \text{ volt}$$

If flux Φ varies *sinusoidally*, then r.m.s. value of induced e.m.f. is obtained by multiplying the average value with form factor.

$$\text{Form factor} = \frac{\text{r.m.s. value}}{\text{average value}} = 1.11$$

$$\therefore \quad \text{r.m.s. value of e.m.f./turn} = 1.11 \times 4f\Phi_m = 4.44f\Phi_m \text{ volt}$$

Now, r.m.s. value of the induced e.m.f. in the whole of primary winding

$$= \text{(induced e.m.f/turn)} \times \text{No. of primary turns}$$

$$E_1 = 4.44fN_1\Phi_m = 4.44fN_1B_mA \quad \text{...(i)}$$

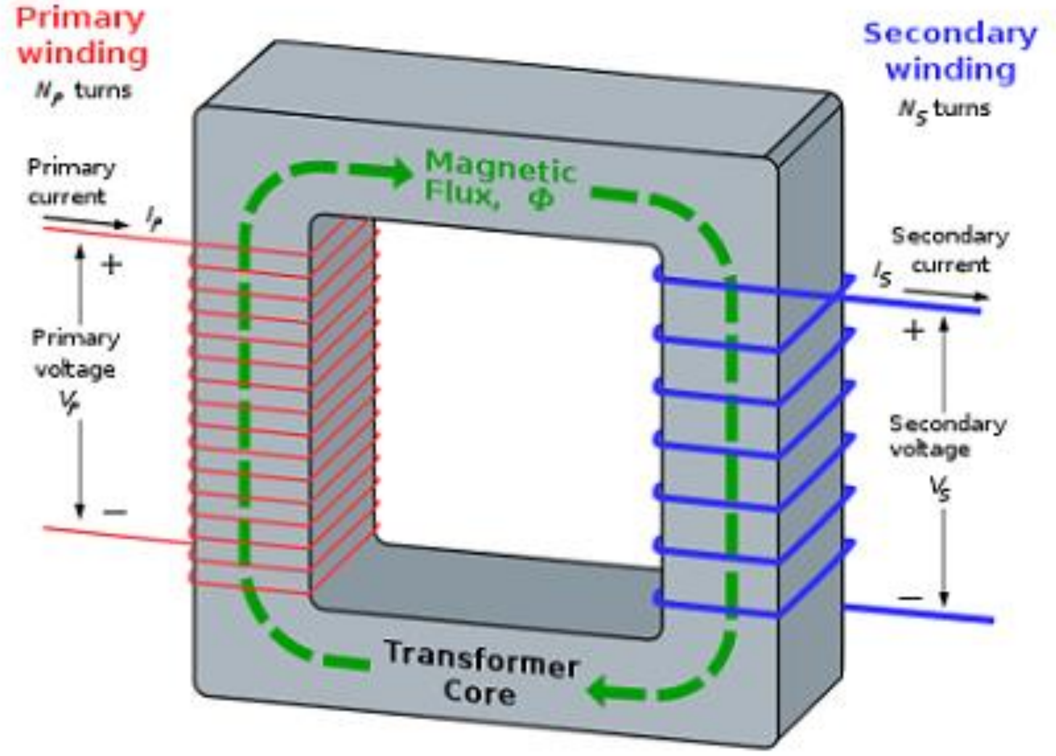
$E_2 = 4.44f\, N_2\, \Phi_m$ volts

An ideal Transformer

- An **ideal transformer** is an imaginary transformer which has
  - no copper losses (no winding resistance)
  - no iron loss in core
  - no leakage flux

  In other words, an ideal transformer gives output power exactly equal to the input power.
  The **efficiency of an idea transformer** is 100%.

Working principle of ideal transformer



Working principle of ideal transformer

- When an alternating voltage V_p is applied to the primary coil, an a.c. current flows in the primary coil.
- This a.c. current sets up a changing magnetic field in the iron core. The flux through the primary coil is linked to the flux in the secondary coil through the iron core.
- This alternating magnetic field induces an e.m.f. in both the coils.
- The output voltage in the secondary coil V_s will give rise to an a.c. current in the coil itself. Thus, electrical energy can be delivered to any device at the output.
- Since there is no flux leakage, the rate of flux change of flux at the primary coil and the secondary coil must be the same.
- In addition, an ideal transformer is 100% efficient. Hence, power output from the secondary coil = power supplied to the primary coil.