1	a) Why transformer rating is in KVA and Explain the OC test of a single-phase transformer with neat diagram
	(OR)
	b) what is the working principle and derive emf equation of transformer
2	a)Explain the construction and working principle DC generator.
	(OR)
	b) i)Develop the EMF equation of a Generator ii) Calculate the emf generated by a 6 pole dc generator having 480 conductors and driven at a speed of 1200 rpm. The flux per pole is 0.012 wb. Assume the generator to be i) lap wound ii) wave wound.
3	A) Write short notes on ELCB'S?
	(OR)
	b) Write a detail note on types of Batteries. 1:21 pm

Why transformer Rating in KVA

→ Any transformer includes core losses and Copper losses.

→ ~~Copper~~ Core losses are based on input voltage.

→ Copper losses are based on current flowing through winding.

→ Therefore, total losses are based on voltage in addition to current.

Thus, the rating of transformer is done in KVA

1) Open circuit test :

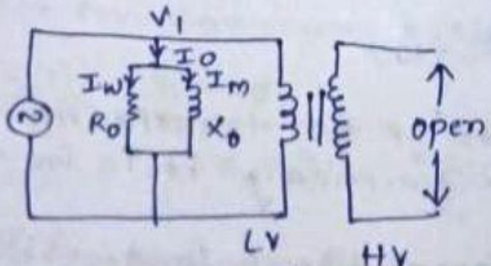
→ The purpose of open circuit test is to determine the iron losses at no load current of the transformer

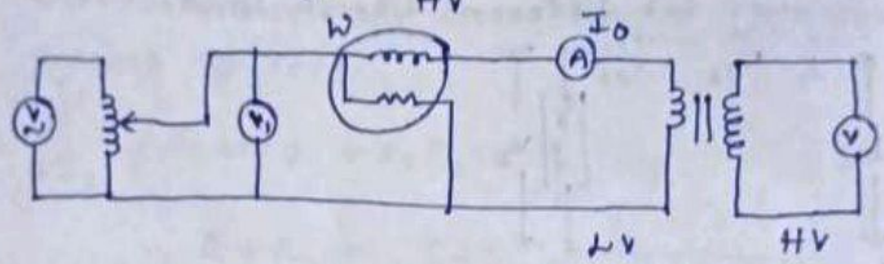
→ The no load parameters are I_m, I_w, R_0 and X_0

→ this test should be conducted on LV side of the transformer by open ciricuiting on HV side.

→ Connect voltmeter, ammeter, and wattmeter on LV side and apply the rated voltage with the help auto transformer. And take the readings of voltmeter(V_1) ammeter (I_0) and wattmeter(P_0).

→ The Reading of the wattmeter only represents the iron losses.





Iron loss W_I = no load power = P_0

$$P_0 = V_1 I_0 \cos\phi_0$$

$$\cos\phi_0 = \frac{P_0}{V_1 I_0}$$

No load working current $I_w = I_0 \cos\phi$

$$I_w = I_0 \frac{P_0}{V_1 I_0} = \frac{P_0}{V_1}$$

No load magnetising current $I_m = I_0 \sin\phi_0$

$$I_m = \sqrt{I_0^2 - I_w^2}$$

Resistance $R_0 = \frac{V_1}{I_w} = \frac{V_1}{\frac{P_0}{V_1}} = \frac{V_1^2}{P_0}$

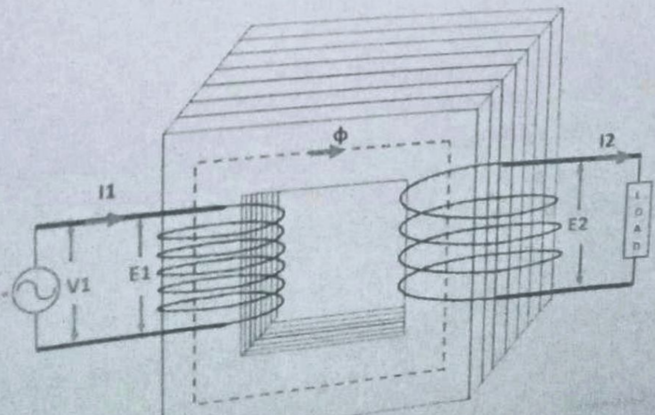
$I_0 = I_w + I_m$

Reactance $X_0 = \frac{V_1}{I_m} = \frac{V_1}{\sqrt{I_0^2 - I_w^2}}$

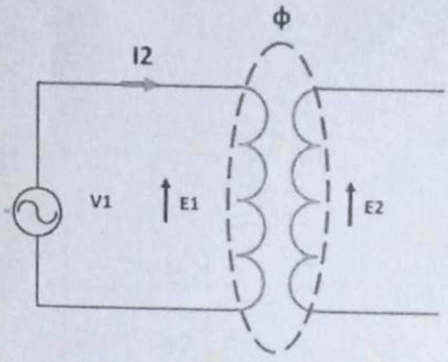
Working Principle of a Transformer

The basic principle on which the transformer works is **Faraday's Law of Electromagnetic Induction** or mutual induction between the two coils. The working of the transformer is explained below. The transformer consists of two separate windings placed over the laminated silicon steel core.

The winding to which AC supply is connected is called primary winding and to which load is connected is called secondary winding as shown in the figure below. It works on the **alternating current only** because an alternating flux is required for mutual induction between the two windings.



When the AC supply is given to the primary winding with a voltage of V_1, an alternating flux ϕ sets up in the core of the transformer, which links with the secondary winding and as a result of it, an emf is induced in it called **Mutually Induced emf**. The direction of this induced emf is opposite to the applied voltage V_1, this is because of the Lenz's law shown in the figure below:



Physically, there is no electrical connection between the two windings, but they are magnetically connected. Therefore, the electrical power is transferred from the primary circuit to the secondary circuit through mutual inductance.

The induced emf in the primary and secondary windings depends upon the rate of change of flux linkage that is ($N\, d\phi/dt$). $d\phi/dt$ is the change of flux and is same for both the primary and secondary windings. The induced emf E_1 in the primary winding is proportional to the number of turns N_1 of the primary windings ($E_1 \propto N_1$). Similarly induced emf in the secondary winding is proportional to the number of turns on the secondary side. ($E_2 \propto N_2$).

Transformer on DC supply

The transformer works on AC supply, and it cannot work not DC supply. If the rated DC voltage is applied across the primary winding, a constant magnitude flux will set up in the core of the transformer and hence there will not be any self-induced emf generation, as for the linkage of flux with the secondary winding there must be an alternating flux required and not a constant flux.

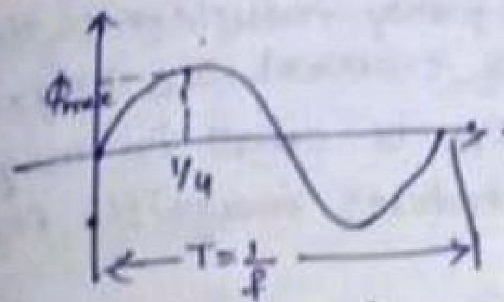
According to Ohm's Law

The resistance of the primary winding is very low, and the primary current is high. So this current is much higher than the rated full load primary winding current. Hence, as a result, the amount of heat produced will be greater and therefore, eddy current loss (I^2R) loss will be more.

Because of this, the insulations of the primary windings will get burnt, and the transformer will get damaged.

EMF Equation of Transformer:

When an Alternating voltage is supplied to primary winding an alternating flux is set up in the iron core which links both primary and Secondary windings.



→ The magnetic flux increases from zero to max.value in 1/4 th of cycle (in $\frac{1}{4f}$ sec).

→ So after rate of change of flux = $\frac{d\phi}{dt}$

$$= \frac{\phi_{max}}{\frac{1}{4f}} = 4f\,\phi_{max}.$$

→ since the avg emf induced per turn = avg rate of change of flux.

→ Avg emf induced per turn = $4f\,\phi_{max}$.

$$\text{form factor} = \frac{\text{Rms value}}{\text{avg. value}} = 1.11$$

$$\Rightarrow \text{Rms value} = 1.11 \times \text{avg. value}$$

Therefore Rms value of Emf induced perturn = $1.11 \times 4f\phi_{max}$

$$E = 4.44 \times f\,\phi_{max}$$

→ If the no. of turns on primary and secondary windings are N_1 and N_2 respectively then the rms value of Emf induced in primary $(E_1) = 4.44\,\phi_{max} f N_1$

Similarly, rms value of Emf induced in secondary $(E_2) = 4.44\,\phi_{max} f N_2$

$\boxed{E = 4.44\,\phi_{max} f N}$ volts

Transformer on No load

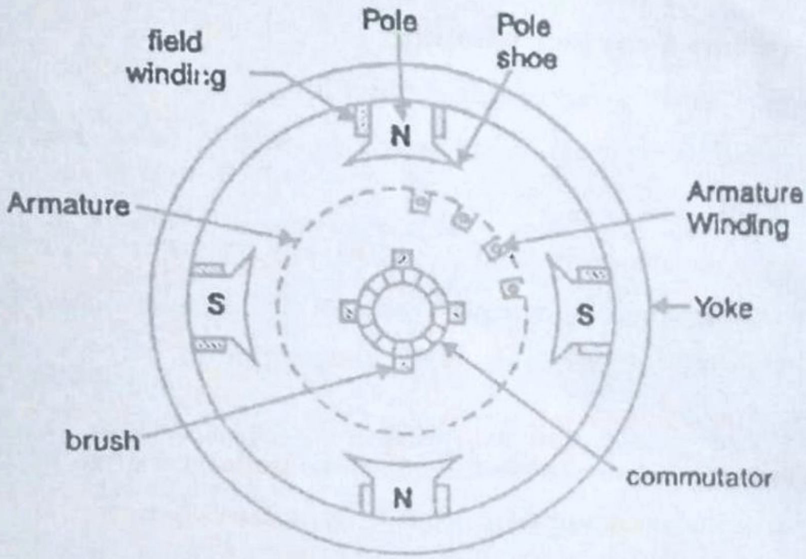
DC MACHINES

Constructional details of a DC Machine:

• A DC machine can be used as a DC generator or a DC motor without any constructional changes. Thus, a DC generator or a DC motor can be broadly termed as a DC machine.

• when the machine is being assembled, we do not know whether it is a dc generator or motor. Any dc generator can be run as a dc motor and vice-versa.

• The following figure shows the constructional details of a simple **4-pole** DC machine



A DC machine consists of two basic parts, stator and rotor.

The other important parts are described below.

1. Yoke:

- The outer frame of a D.C Machine (Generator or Motor) is called as yoke. Yoke is made up of cast iron or steel.
- Yoke provides mechanical strength for whole assembly of the D.C Machine
- It also carries the magnetic flux produced by the poles.

2. Poles:

- Poles are to support field windings or coils which are wound around it.
- Poles are joined to the yoke with the help of screws or welding.

3. Pole shoe:

- Pole shoe is an extended part of the pole which serves two purposes,

  (i) To prevent field coils from slipping and

  (ii) To spread out the flux in air gap uniformly.

4. Field winding:

- Field winding is wound on poles and connected in series or parallel with armature winding.
- Field coils are mounted on the poles and carry the dc exciting current.
- The field coils are connected in such a way that adjacent poles have opposite polarity.

5. Armature core and Armature winding:

- Armature core is the rotor of a D.C Machine.
- Armature core is cylindrical in shape on which slots are provided to carry armature winding.
- The armature core is laminated to reduce the eddy current loss.
- Armature winding can be wound by one of the two methods known as

  Lap winding (A=P) and Wave winging (A=2)

6. Commutator:

- In DC Generator, commutator is a mechanical rectifier which converts the alternating voltage generated in the armature winding into direct voltage across the brushes.
- In DC Motor, commutator acts as mechanical inverter which converts direct voltage into alternating voltage.
- The commutator is made of copper segments insulated from each other by mica sheets and mounted on the shaft of the machine.

7. Brushes:

- The purpose of brushes is to ensure electrical connections between the rotating commutator and stationary external load circuit.
- The brushes are made of carbon and rest on the commutator.
- Thus brushes are physically in contact with armature conductors hence wires can be connected to brushes.

D.C GENERATOR

An electrical Generator is a machine which converts mechanical energy (or power) into electrical energy (or power).

Principle of Operation of D.C Generator:

According to Faraday's Laws of Electromagnetic Induction

"Whenever a conductor cuts magnetic flux, dynamically induced e.m.f. is produced in it".

The magnitude of the EMF is given by

$$E=Bl\upsilon \text{ (Volts)}$$

Where, B= Magnetic filed

l = Effective length of conductor

υ = Velocity of conductor in magnetic field

The direction of the induced emf / current is given by Fleming's Right Rule

Fleming's Right Rule:

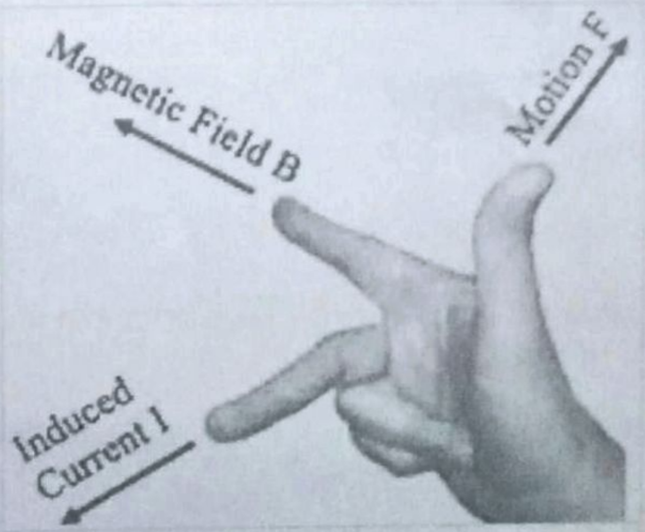
Stretch the thumb, fore finger and centre finger of Right hand in mutually perpendicular directions such that

When

- The Thumb represents the direction of the Motion of the Conductor (F).
- The Fore finger represents the direction of the magnetic Field (B).

Then

- The Centre finger represents the direction of the Current (I).



EMF equation of DC Generator :

→ Let P = no. of poles of Generator

ϕ = flux produced by each pole

N = Speed of armature in RPM (Revalution per minute)

Z = total no. of conductors.

A = no. of parallel paths

$A = P$ → Lap winding

$A = 2$ → Wave winding

→ Now according to Faraday's Law electromagnetic induction an emf is induced in the each conductor

$$e = \frac{d\phi}{dt}$$

e = rate of flux cutting

→ In one revaluation the conductor will cuts total flux produced by all the ~~flu~~ poles.

i.e $\phi \times P$.

→ Time required for completing one revaluation is

$\frac{60}{N}$.

$$\therefore e = \frac{d\phi}{dt}$$

$$= \frac{\phi \times P}{\frac{60}{N}}$$

$$e = \frac{\phi NP}{60}$$ (this is the emf induced in one conductor)

→ There are total Z conductors with 'A' parallel paths then the total emf generated in the Generator is

$$e = \frac{\phi NP}{60} \times \frac{Z}{A}$$

Then $$\boxed{e = \frac{\phi ZNP}{60 \times A} \text{ volts}} = \frac{\phi PNZ}{60A}$$ *

$$e = \frac{\phi ZN}{60}$$ ⇒ Lap winding since $A = P$

$$e = \frac{\phi ZNP}{60 \times 2}$$ ⇒ wave winding since $A = 2$

b) Given

$P = 6$ poles

$N = 1200$ rpm

$\phi = 0.012$ wb

$Z = 50$

we know that

$$e = \frac{\phi Z N P}{60 \times A}$$

i) lap wound

$A = P$ for lap wound $= 6$

$$\Rightarrow e = \frac{0.012 \times 50 \times 1200 \times \cancel{6}}{60 \times \cancel{6}} = 12 \text{ volts}$$

ii) wave wound

$A = 2$ for wave wound

$$e = \frac{0.012 \times 50 \times \cancel{1200}^{60} \times \cancel{6}^{1}}{\cancel{60}_{10} \times \cancel{2}_{1}} = 36 \text{ volts}$$

EARTH LEAKAGE CIRCUIT BREAKER (ELCB)

None of the protection devices like MCB, MCCB, etc can protect the human life against electric shocks or avoid fire due to leakage current. An earth circuit breaker is a device used to directly detect currents leaking to earth from an installation and cut the power.

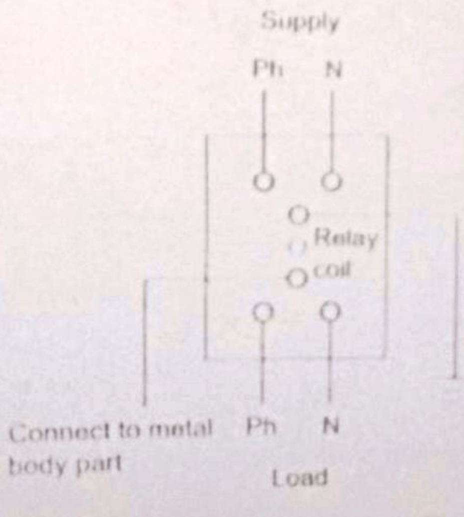
There are two types of ELCBs:

1. Voltage earth leakage circuit breaker

2. Current earth leakage circuit breaker

1. Voltage earth leakage circuit breaker

It is a voltage operated circuit breaker. The voltage-ELCB constricts relay coil and one end of the coil is connected to metallic load body and the other end is connected to the ground wire. If the voltage of the equipment body rises, which causes the difference between earth and load body voltage and the danger of electric shock will occur. This voltage differences will produce an electric current from the load metallic body and passes through the relay Loop to the earth. When the voltage on the equipment metallic body rises to danger level i.e., which exceeds 50V, the flowing current through the relay loop could move the relay contact by disconnecting the supply current to avoid from any danger electric shock.



2. Current earth leakage circuit breaker

It is the current operated circuit breaker which is commonly usually ELCB. Current-ELCB consists of a three winding transformer, which has two primary winding and one secondary winding. Neutral and line wires act as two primary winding. A wire wound coil is a secondary winding.

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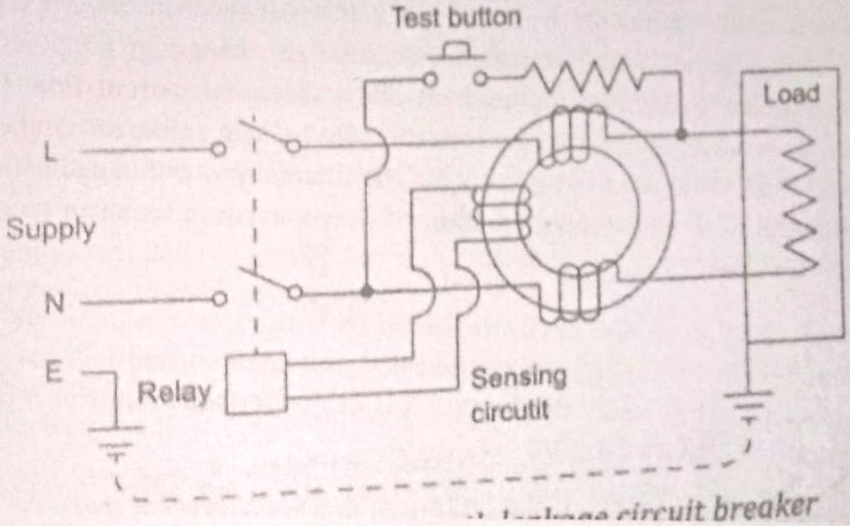

circuit breaker

The current through the secondary winding is zero at a balanced condition. In the balance condition the flux due to the current through the phase wire will be neutralized by the current through the neutral wire since the current which flows from the phase will be written back to the neutral. When a fault occurs, a small current will flow through the ground also. This makes an imbalance between line and neutral currents and creates an unbalanced and magnetic field. This includes a current through secondary winding which is connected to secondary winding.

This will sense the leakage and sends a signal to the tripping system to trip the circuit.

Types of Primary Cells/Batteries:

There are several types of primary cells are:

1. Carbon zinc Dry cell
2. Alkaline cell
3. Zinc chloride cell
4. Mercury cell
5. Silver oxide Cell
6. Lithium cell

(i) Carbon-zinc dry cell

- This is one of the most popular primary cells (often used for type AAA, AA, C, D).
- The negative electrode is made of zinc.
- The positive electrode is made of carbon.
- The output voltage of a single cell is about 1.5 V.
- Performance of the cell is better with intermittent operation.

(ii) Alkaline cell

- The alkaline cell is another popular type also used for type AA, C, D, etc.
- It has the same 1.5V output as carbon-zinc cells, but they are longer-lasting:
- It consists of a zinc anode and manganese dioxide cathode in an alkaline electrolyte (potassium hydroxide).
- It works with high efficiency even with continuous use, due to low internal resistance.

(iii) Zinc chloride cell

- This cell is also referred to as a "heavy-duty" type battery.
- It is a modified zinc-carbon cell.
- It has little chance of liquid leakage because the cell consumes water along with the chemically active materials. The cell is usually dry at the end of its useful life.

(iv) Mercury cell

- This cell consists of a zinc anode, mercury compound cathode, and potassium or sodium hydroxide electrolyte.
- It is becoming obsolete due to the hazards associated with proper disposal of mercury.

(v) Silver oxide cell

- This cell consists of a zinc anode, silver oxide cathode, and potassium or sodium hydroxide electrolyte.
- It is typically available as 1.5V, miniature button form.
- Applications include hearing aids, cameras, and watches

(vi) Lithium cell

- This cell offers high output voltage, long shelf life, low weight, and small volume.
- It comes in two forms of 3V output in widespread use:
  (a) Lithium-sulfur dioxide ($LiSO_2$).
  (b) Lithium-thionyl chloride.
- $LiSO_2$ type batteries contain methyl cyanide liquid solvent; if its container is punctured or cracked, it can release toxic vapors.
- Safe disposal of these cells is critical.