TRANSFORMER

Transformer :-

→ A transformer is a static piece of equipment used for either raising or lowering the voltage of an ac supply with a corresponding decrease or increase in current.

→ It consists of two windings, primary winding and secondary winding.

→ These windings are wound on a common laminated magnetic core.

→ The winding connected to A.C. supply is called primary winding. and the one connected to load is called secondary winding.

→ The alternating voltage V_p whose magnitude to be changed is applied to primary and alternating e.m.f induced in the secondary is V_s (or) E_s. (Ideally both are equal in magnitude).

→ The current in primary is I_p and in secondary is I_s.

→ The no. of turns in primary is N_p and in secondary is N_s.

Working of Transformer :-

→ When an alternating voltage V is applied to the primary winding, an alternating flux ϕ is set up in the core.

→ This alternating flux links both the windings and induces the e.m.fs E_p and E_s in them according to Faraday's law of electromagnetic induction.

→ The E.m.f E_p is termed as primary E.m.f and E_s is termed as secondary E.m.f

$$E_p = -N_p . \frac{d\phi}{dt}$$

$$E_s = -N_s . \frac{d\phi}{dt}$$

$$\therefore \boxed{\frac{E_s}{E_p} = \frac{N_s}{N_p}} \longrightarrow (1)$$

→ The magnitudes of E_s and E_p depends on number of turns on secondary and primary.

Types of Transformer :-

Step up transformer :-

The transformer in which primary voltage is less than secondary voltage (or) primary turns are less than secondary turns is known as step up transformer.

i.e $\boxed{N_p < N_s}$ or $\boxed{I_p > I_s}$ or $\boxed{E_p < E_s}$

Step down transformer :-

The transformer in which primary voltage is greater than secondary voltage (or) primary turns are greater than secondary turns is known as step down transformer.

i.e $\boxed{N_p > N_s}$ or $\boxed{E_p > E_s}$ or $\boxed{I_p < I_s}$

An Isolation transformer :-

An Isolation transformer passes the signal unchanged. (Refer Earl gates)

i.e $\boxed{N_p = N_s}$ or $\boxed{E_p = E_s}$ or $\boxed{I_p = I_s}$

THEORY OF AN IDEAL TRANSFORMER :-

In an Ideal transformer, the following cases will occur

i) No winding Resistance

ii) No leakage flux

iii) No iron losses.

In transformer (Ideal), the input power = output power.

i.e $E_p I_p = E_s I_s$.

$$\Rightarrow \boxed{\frac{E_p}{E_s} = \frac{I_s}{I_p}} \longrightarrow ②$$

From Eq ① and Eq ②.

$$\boxed{\frac{E_s}{E_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}}$$

Note :- A transformer changes the voltage and current of AC only but it can't Change their frequency.

TURN'S RATIO :-

The turns Ratio is the number of turns in the secondary winding divided by the number of turns in the primary winding. It can be expressed as following :

$$\boxed{\text{Turn's Ratio} = \frac{N_s}{N_p}}$$

As per Earl gate Text book.

Relation Between Input and output impedances :-

$$Z_i = \frac{E_p}{I_p} \quad ; \quad Z_o = \frac{E_s}{I_s}$$

where Z_o = load Impedance
Z_i = Source Impedance.

$$\frac{Z_o}{Z_i} = \frac{E_s}{I_s} \cdot \frac{I_p}{E_p}$$

$$= \frac{E_s}{E_p} \cdot \frac{I_p}{I_s} = \frac{N_s}{N_p} \cdot \frac{N_s}{N_p} = \left(\frac{N_s}{N_p}\right)^2$$

$$\boxed{\frac{Z_o}{Z_i} = \left(\frac{N_s}{N_p}\right)^2}$$

Applications of Transformer :-

Transformer applications include :

i) Impedance Matching.

ii) phase shifting.

iii) Isolation,

iv) Blocking DC while passing AC, and producing several signals at different voltage levels etc..

NUMERICALS :-

Q. A transformer has 500 turns in primary and 1000 turns in Secondary. If 120 volt ac is applied to primary

(a) what is the Induced Secondary voltage ?

(b) Is it step up or step down ?

Sol:- (a) $\frac{N_s}{N_p} = \frac{E_s}{E_p} \Rightarrow \frac{1000}{500} = \frac{E_s}{120} \Rightarrow E_s = \frac{1000}{500} \times 120 = 240V$ ac.

$\boxed{E_s = 240 \text{ volt ac}}$

(b) $E_s > E_p$. So It is Step up transformer.

Q A transformer has 500 turns in primary and 1000 turns in Secondary. If the primary has a current of 100 milli ampers, How much current flows in the Secondary ?

Sol:- $\frac{N_s}{N_p} = \frac{I_p}{I_s} \Rightarrow \frac{1000}{500} = \frac{100 \times 10^{-3}}{I_s}$

$\Rightarrow I_s = \frac{50\cancel{0}}{10\cancel{00}} \times 10\cancel{0} \times 10^{-3} A = 50 \times 10^{-3} A$

$= 50$ milli Ampere.

Q) what must the turns ratio of a transformer be to match a 4-ohm Speaker to a 100 Ω ~~loa~~ Source ?

Sol:- $Z_o = 4\Omega$; $Z_i = 100\Omega$. $\frac{N_s}{N_p} = ?$

$$\frac{Z_o}{Z_i} = \left(\frac{N_s}{N_p}\right)^2 \Rightarrow \frac{N_s}{N_p} = \left(\frac{4}{100}\right)^{1/2} = \left(\frac{1}{25}\right)^{1/2} = \frac{1}{5}$$

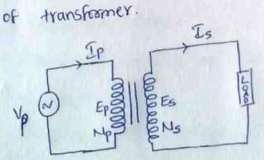
NOTE :-

1. Transformers are rated in VA. i.e Volt-Ampere (or) kVA. i.e kilo Volt-Ampere. (VIMP MCQ)
2. If we Apply DC Voltage to a transformer, output voltage is Zero (or) Transformer Coil burns. (VIMP MCQ)

IMP QUESTIONS (ETE)

1. Explain Construction, working, Types, Applications of transformer and its Numericals. Refer: Text book. for diagrams and theory.

In ETE exam, write diagramatic explination and More diagrams of transformer.



DC MACHINES

→ Generator :

An electrical generator is a machine which converts mechanical energy into electrical energy.

→ Motor :-

An electrical Motor is a machine which converts ele... into Mechanical energy.

→ Construction of DC Machine (generator or Motor) ;-

→ The d.c. generators and d.c Motors have Same general construction. Infact, when the Machine is being assembled, the workmen usually do not know whether it is dc generator or motor.

→ Any d.c. generator Can run as d.c motor. Vice-Versa.

→ The following are the essential parts of a dc Machine.

i) Magnetic frame or Yoke.
ii) pole-cores and pole-shoes
iii) pole coils or Field coils
iv) Armature Core
v) Armature winding or Conductors
vi) Commutator
vii) Brushes and Bearings.

1. YOKE :-

a) It provides Mechanical support for the poles and act as a protecting cover for whole Machine.

b) It Carries Magnetic flux produced by poles.

2. POLE CORES AND POLE SHOES :-

2. POLE CORES AND POLE SHOES :-

The field Magnets consists of pole cores and pole shoes. pole shoes serves the following purposes.

a) they spread out the flux in air-gap
b) They support the exciting coils.

3. POLE COILS OR FIELD COILS :-

When current is passed through these coils, they electromagnetise the poles which produce the necessary flux.

4. ARMATURE CORE :

The Armature core is keyed to the Machine shaft and rotates between the field poles. It consists of slotted soft-iron laminations that are stacked to form a cylindrical core. These laminations are individually coated with a thin insulating film so that they do not come in electrical contact with each other.

5. ARMATURE WINDING OR CONDUCTORS :-

→ The Armature windings are usually former-wound. These are first wound in the form of flat rectangular coils and are then pulled into their proper shape in a coil puller.

→ The conductors of the coils are insulated from each other and are placed in Armature slots which are lined with insulating material.

6. COMMUTATOR :-

→ The Function of commutator is to facilliate collection of current from armature conductors.

→ Commutator converts Alternating current induced in Armature conductors into unidirectional current in external load circuit.

7. BRUSHES AND BEARINGS :-

→ The Brushes function is to collect Current from commutator.

→ Brushes are usually Made of Carbon or graphite.

→ Because of their reliability, ball-bearings are frequently employed, though for heavy duties, roller bearings are preferrable.

AC GENERATOR WORKING PRINCIPLE :- (Alternator).

→ Generator works on the principle of Fleming's Right hand Rule. where as Motor works on the principle of Fleming's left hand Rule.

Fleming's Right hand Rule :-

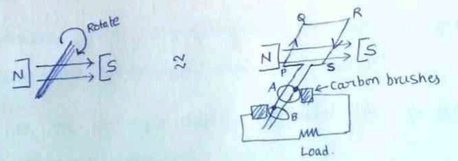
When you keep the fingers Thumb, First finger and Second finger of Right hand perpendicular, The Thumb finger indicates Force
First finger indicates Field direction,
Second finger indicates Current direction.

→ Let's take N, S pole of a magnet to create Magnetic field. (N → S)

N ⇉ S

→ Take some bunch of wires and place them in between field, then if we move & rotate that wires, then current will be generated in the wire.

Eg:

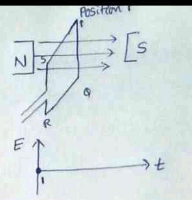


where A and B are slip rings.

→ slip ring concept explained in class (Refer B.L. THERAJA for Exp).

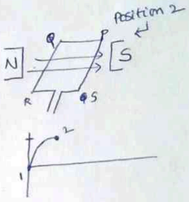
→ When the shaft is in position 1, The plane of the coil is at right angles to line of flux, then the flux linked with coil is maximum but rate of change of flux is minimum.

$$E = N\frac{d\phi}{dt} = \text{Minimum} \quad (\phi = \text{Max})$$

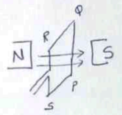


→ When shaft is in position 2, Flux linked with coil is Minimum but rate of change of flux is Maximum.

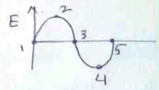
$$E = N\frac{d\phi}{dt} = \text{Maximum}$$



→ When shaft is in position 3, Flux linked is Maximum. So Rate of Change of flux is minimum.



→ When shaft is in position 4, Flux linked is Minimum, so rate of change of flux maximum.



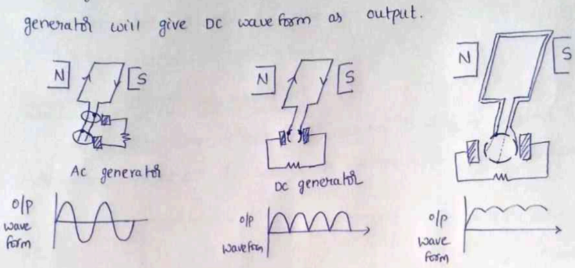
→ From position 4 to position 5, Rate of change of flux slowly Reduced to minimum. From Now again position 1 to 4 Scenario will be Repeated.

∴ The generated is of Alternating wave form and is generated by using two slip rings (concept Explained in class).

→ The above is the principle used in generator for generating Alternating Current wave form.

Principle of working of DC generator :-

In AC generator, we are using two slip rings. Instead of using two slip rings if we use single ring as two parts (split ring), then that generator will give DC wave form as output.



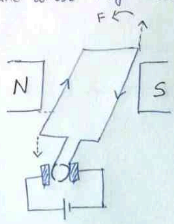
→ Explination was done in Class. (Refer Text book).

DC MOTOR WORKING PRINCIPLE AND OPERATION :-

→ An electric Motor is a machine which converts electrical energy into Mechanical energy.

→ Its action is based on the principle that when a current c[arrying conductor] is placed in a magnetic field, it experiences a mechanical [force whose] direction is given by Fleming's Left hand rule and whose magnitude is given by $F = BIl$ Newton.

where B = Magnetic flux density
I = Current passing through Conductor
l = length of conductor which experiences Magnetic field.



(Explination Done in class)

Types of DC generators :-

Generators are generally Classified according to their methods of following two classes:

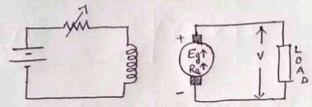
Types of DC generators ;-

Generators are generally classified according to their methods of field excitation. on this basis, they are divided into following two classes:

1. Seperately excited d.c. generators
2. Self excited d.c. generators.

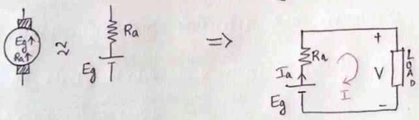
Seperately excited d.c. generators ;-

A d.c. generator whose field magnet winding is supplied from an independent external d.c. Source is called a separately excited generator.



E_g = Generated e.m.f

R_a = Armature Resistance.



$\Rightarrow -E_g + I_a R_a + V = 0$

$\Rightarrow \boxed{V = E_g - I_a R_a}$

Voltage Equation is given by

$$\boxed{V = E_g - I_a R_a}$$

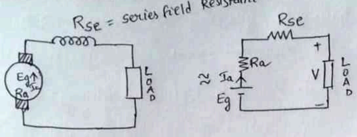
Self Excited d.c. generators ;-

A d.c. generator whose field magnet winding is supplied current from the output of generator itself is called Self excited d.c. generator. They are of three types.

1. Series generator
2. Shunt generator
3. Compound generator

Series generator

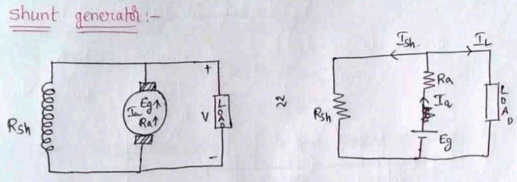
R_{se} = series field Resistance.



Voltage Equation of series generator is given by

$V = E_g - I_a(R_a + R_{se})$.

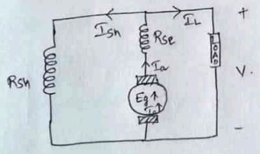
Shunt generator :-



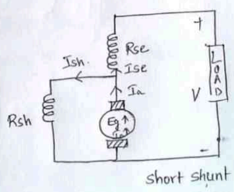
$\boxed{V = E_g - I_a R_a}$

Compound generators ;- (Refer Material)

Two types : Long shunt &
short shunt.



Long shunt - generator



short shunt generator

For short shunt → Voltage Equation is $V = E_g - I_a R_a - I_{se} R_{se}$.

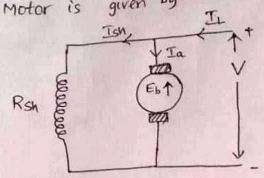
For Long shunt → Voltage Equation is $V = E_g - I_a(R_a + R_{se})$

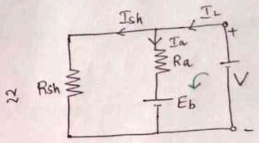
(Refer Material uploaded on UMS for Derivations).

VOLTAGE ... D.C MOTOR :- (SHUNT)

VOLTAGE EQUATION OF A D.C. MOTOR :- (SHUNT)

A DC Motor is given by





By Applying KVL,

$$-V + I_a R_a + E_b = 0.$$

$$\Rightarrow V = E_b + I_a R_a$$

The Voltage Equation of a dc Motor is given by

$$\boxed{V = E_b + I_a R_a}$$

where E_b = Back emf
R_a = Armature Resistance
I_a = Armature Current.

TYPES OF DC MOTORS :-

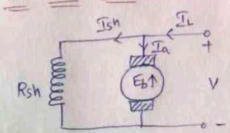
DC Motors are divided into three types. They are

i) DC Shunt Motor (or) Shunt wound Motor

ii) DC Series Motor (or) ~~DC~~ Series wound Motor

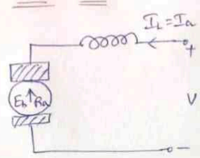
iii) ~~DC~~ Compound Motor (or) Compound-wound Motor.

DC Shunt Motor :-



$$V = E_b + I_a R_a$$

DC Series Motor



$$V = E_b + I_a(R_a + R_{se})$$

→ For Compound Motors (Refer Textbook).

Applications of DC Motors :-

Shunt Motors :- (Constant Speed Motor)

1. This Motor is used where speed is required to remain almost constant from no load to Full-load.
2. It is used in Lathes, drills, boring mills, shapers, spinning and weaving machines etc.

Series Motors :- (variable Speed Motor)

1. This Motor has a high starting torque. So It is used where large starting torque is required.
   E.g: Elevators and electric traction.
2. It is used in cranes, elevators, air compressors, vaccum cleaners, hair drier etc...

Compound Motors :-

1. These are used where a fairly constant speed is required with irregular loads or suddenly applied heavy loads.
2. These are used in presses, shears, reciprocating machines. etc..

— GURU GOVIND —