Sumedh

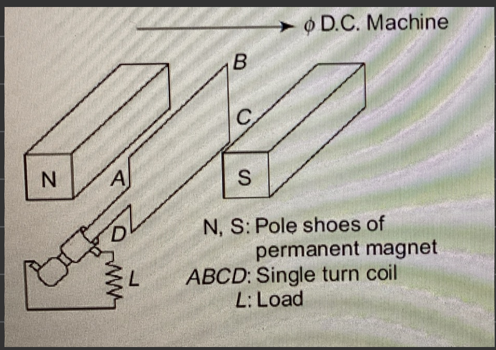
• DC Generator

Principle :

Dynamic Machine in which mech energy is converted to elec. energy. Based on Faraday's law of EM induction. The emf generated is dynamically induced emf

Working principle :-

i) Steady mag. fld
ii) Conductor capable of carrying current
iii) Conductor to move in mag. fld



- Steady mag fld produced by N & S
- Single turn coil ABCD b/w poles
- Moved by prime mover
- emf generated as per faraday's law

Construction :

Consists of Stator and rotator

Stator — accomodates yoke, main fld & brushes

rotator — armature & Commutator

i) yoke : Outermost solid metal part of the machine, protects inner parts

ii) Field System : field poles, field winding

field poles — made of lamination of magnetic material

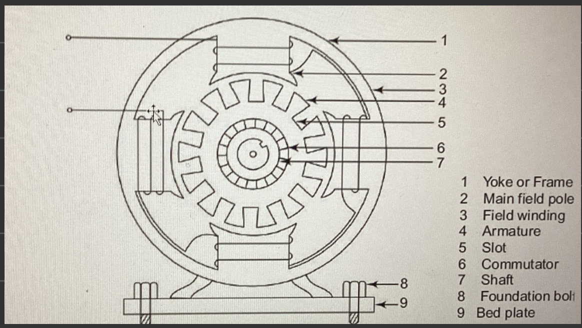
field winding — used to magnetise poles

iii) brushes : made of carbon / graphite, connects generator to external circuit

iv) armature : form of laminated slotted drum

v) Commutator : Converts bidirectional induced emf to unidirec. induced emf

AC → DC



- Generator Working principle

i) Case - 1 $\theta = 0°$

The velocity component is parallel with flux line i.e $0°$

$\therefore$ $e = 0$

ii) Case - 2 $0° < \theta < 90°$

V has 2 comp $V\cos\theta$ (parallel with flux)
$V\sin\theta$ ($\perp$ with flux)

for $V\cos\theta$: $e = 0$ (min)
$V\sin\theta$: $e = 1$ (max)

$\therefore$ $e_{min} < e < e_{max}$

iii) Case - 3 : $\theta = 90°$

e_{max}

* Why emf induced across the brush

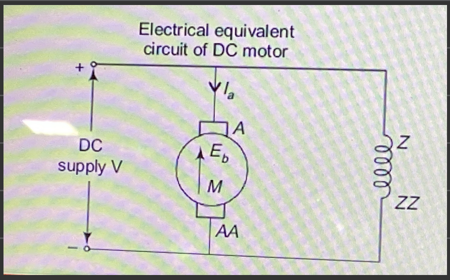
during (+ve) half cycle , conductor comes under influence of North pole
(-ve) South pole

- DC Motor

Principle : When a current carrying conductor is placed in a magnetic field, an EM force is produced. The force is exerted on the conductor and hence it's moved.

Construction : same as dc gen

Working : i) Both armature & field winding connected to dc supply
ii) Current carrying conductor placed in stationary $\vec{B}$
iii) due to EM torque, the armature starts revolving
iv) Thus elec → mech
v) due to this emf gen in armature conductors as per faraday's law
vi) As per lenz's law emf opposes voltage (called back emf)
vii) ∴ voltage drop, applied voltage > back emf to produce necessary torque for rotation.



Applications : elevators, steel mills, rolling mills, locomotives and excavators

• Single phase Transformer

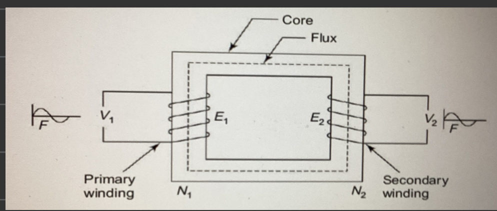
Principle :-

statically induced emf

Works on the principle em induction, transfers elec. energy from 1 circuit to another

Two circuits are magnetically coupled, one is energized by volt, freq & waveform supply

Second one has mutually induced voltage



Construction :-

i) A good magnetic core → laminated & made of steel / silicon steel
or of iron
ii) Two windings
iii) Time varying magnetic flux

material with high rel. permeability & low hysteresis loss

Working :-

Primary Winding : N_1, V_1, I_1, Self induced emf (E_1)
Secondary Winding : N_2, V_2, I_2, Mutually induced emf (E_2)
ϕ set up is AC & sinusoidal

$K = \frac{N_1}{N_2}$ (ratio)

$E_2 > E_1$ (step-down)
$E_2 < E_1$ (step-up)

equal turns

$N_1 I_1 = N_2 I_2$

$\therefore \frac{N_1}{N_2} = \frac{I_1}{I_2} = \frac{E_2}{E_1} = \frac{V_2}{V_1} = k$

• Three-phase Induction Motor

Principal : When a 3-phase balanced voltage is applied to a three-phase balanced winding, a rotating $\vec{B}$ produced. If a stationary conductor is placed in a mag field, an emf is induced, By creating closed path, em torque exerted on the conductor which rotates.

Construction: i) Stator: Stationary part of the motor, consists of an outer solid circular metal part called the yoke / frame and laminated cylindrical drum called stator drum

ii) Rotor: Rotating part of the motor.

Working: i) A 3-phase balanced voltage is applied across the three phase winding

ii) Rotating $\vec{B}$ prod

iii) Rotor conductor placed in the $\vec{B}$

iv) EMF is induced.

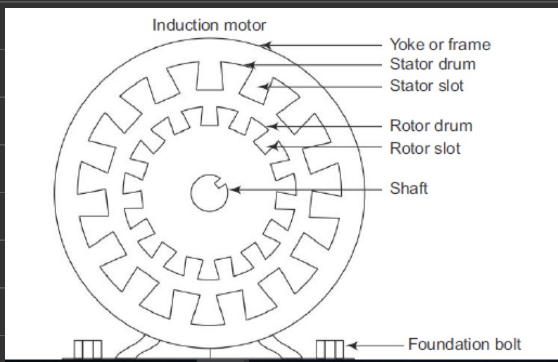
v) If the circuit forms a closed path, rotor current circulated

vi) Hence, now the conductor is in rotating $\vec{B}$

vii) As per law of interactⁿ, force produced on conductors

viii) Rotor starts revolving

ix) Acc. to len'z law, rotor induced current opposes the rotating mag field due to which they both move in same directⁿ



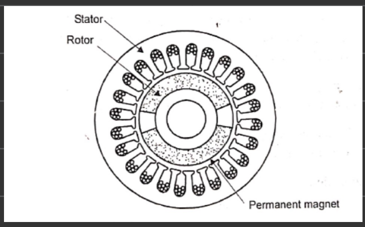
- **PMSM**

Principle: PMSM is a type of synchronous motor that uses permanent magnets on the rotor to create $\vec{B}$. It works on the principle of synchronizing the rotating mag field, generated stator windings

Construction: i) Stator: it contains three-phase windings that are evenly spaced around stator core.
Winding made of copper with 3-phase AC curr

ii) Rotor: Consists of permanent magnets of samarium cobalt.

Working : i) It operates in synchronous manner
ii) The speed of rotating $\vec{B}$ gen by Stator windings is synchronised with speed of rotor's $\vec{B}$
iii) They require position sensors to get feedback on the rotor position.
iv) A drive system is used to control the operation of the PMSM
v) The controller adjusts the amplitude and phase of the AC current supplied to the stator windings based on feedback
vi) This ensures proper alignment & sync of rotating mag field.

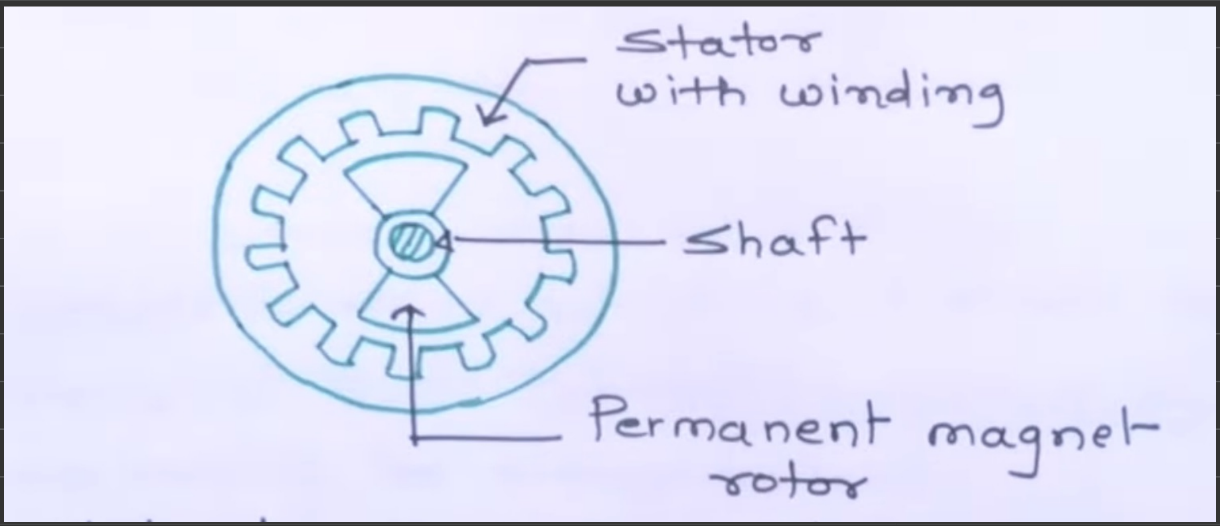


Apps : i) EV's
ii) robotics
iii) renewable energy

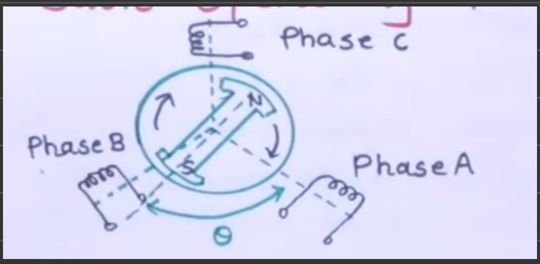
- **BLDC (Brushless DC Motor)**

Principle : Polyphrase Synchronous motor with a permanent rotor.
Cannot operate w/o its electric controller or commutator
It combines AC motor, solid state invertor & rotor position sensor

Construction : i) Stator : 3-phase winding
ii) Rotor in form of per Mag
iii) Sensors to indicate current pos of the rotor
iv) Both stator n rotor with same no. of poles



Working : i) Based on the attraction / repulsion principle b/w mag poles
ii) Using 3-phase motor, the current flows thru one of the 3 windings and generates a magnetic field
iii) It attracts closest permanent mag. of opposite pole



Adv : i) No commutator, brushes req., hence longer life
ii) More efficient
iii) Can run at higher speeds
iv) No field winding, field copper is neglected

disadv : motor field can't be controlled
req. rotor positⁿ sensor

Apps : Computer & robotics
Automotive appl
Textile & glass industries

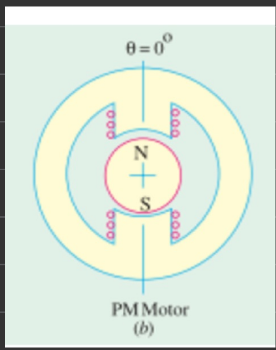
- **Stepper Motor**

Principle :-

Pulse driven motor that chages angular momentum of the rotor in steps and not continuously

$$\theta_s = \frac{360°}{m N_r}$$

θ_s : step angle
m : no. of stator phases
N_r : rotor teeth



Rotated thru fixed angular steps
Torque of 1micro Nm
Power (1 to 2500 watt)
Has No windings, brush, commutators

Construction :-

Permanent mag. as rotor in center which rotates on force.
Surrounded by stator with mag. coil all over it

Working :-

Each stator will be powered one by one as it'll magnetise and act as EM pole. It exerts a repulsive force on the rotor

Alternating magnetizing & Demagnetizing of Stator will move the rotor step by step to rotate it with good control.

Types of SM :-

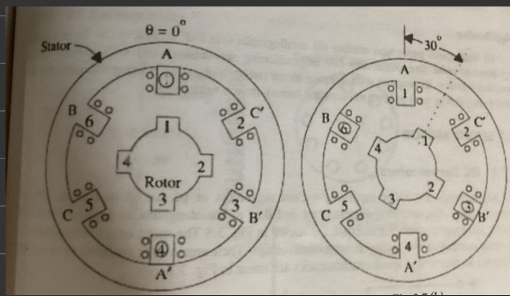
i) Permanent Mag. SM : Common type of SM as permanent mag used in rotor to operate on attractn & repulsion

ii) Variable Reluctane SM : rotor is of iron and works on principle of minimum reluctance & min gap

iii) Hybrid : Combination of above 2 i.e permanent & variable rotor SM set up in opposite poles.

- **Variable Reluctance Steppor Motor**

Construction : i) Constructed from a ferromagnetic material with salient poles
ii) Stator made frm stack of steel laminations and has 6 projecting poles
iii) The rotor has 4 poles
iv) Both stator & rotor poles have same width
v) Stator has 3 phases A, B, C, each can be energised



Working : i) Phase A is excited
ii) Rotor attempts to seek minimum reluctance postion (at origin) from its original position
iii) An em torque is produced which rotates it till axis of phase A coincide
iv) phase B excicited, disconnecting phas A, it rotates 30° anitclock
v) Same for C
vi) Total 12 phases till complete revolution

Apps : i) Robotics
ii) line printer
iii) Type writer

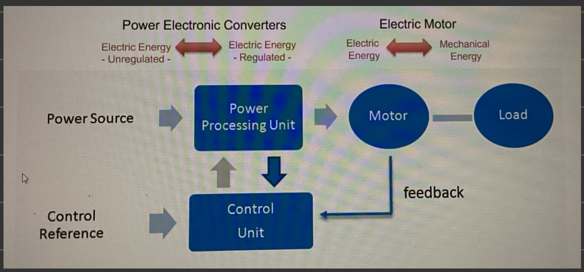
- Electric drives

- Drive

i) drives are system employed for motion control
ii) Motion control requires prime movers
(Diesel, petrol, engines, elec motors)

iii) Electric drives - Prime mover is elec motor

- Block diagram



- Components

i) Motors :-

- DC motor : per mag (wound fld)
- AC : inducth sync
- brushless DC
- Apps / cost
- Natural speed -torque

ii) Power sources :-

DC : batteries, fuel
AC : 1/3 phase gen

iii) Power processor :-

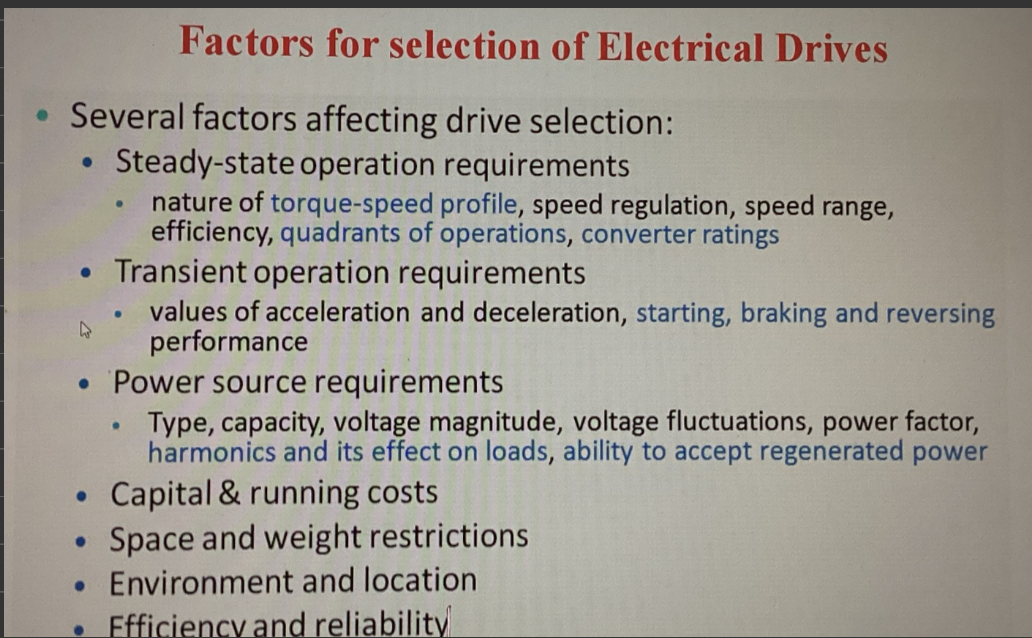
- To provide a regu power supply
- Combination of power ele convo
AC-DC, DC-DC, DC-AC, AC-AC

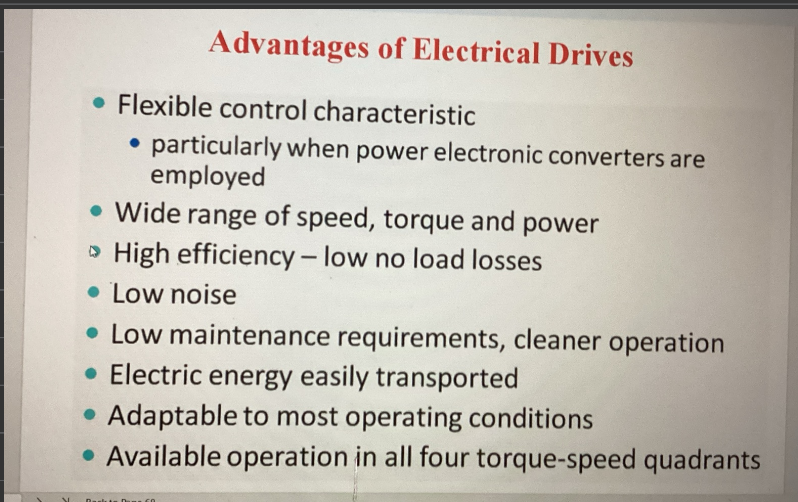
iv) Control Unit

- Complexity depends on performance req.
- analog – noisy, inf bandwidth
- DSP / microprocessor – flexible, low bandw, DSP faster that micro
- Electric isolation b/w control & power circuit needed

v) Sensors :-

- req. for closed-loop operation
- elec isolation b/w sensor & control unit needed





- Servo Motors

  - Uses -ve feedback mech to convert elec sig to controlled motion
  - provides control over velocity, acc, position
  - Gear mech provides feedback to position sensor. It is made up of plastic, in high power servos, made up of metal

Types on basis of rotation :

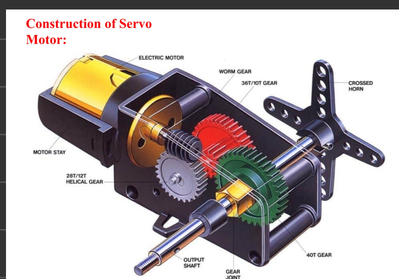
i) Continuous rotation : moves both in anticlk / clk direction
used in robots

ii) linear : Has additional gear to adjust output frm circular to back & forth.
Used in high model airplanes

Based on operating signal

i) Analog : operated over PWM (pulse width modulation) signals

ii) Digital : receives signals, acts as high freq voltage pulses
Gives smooth response & consistent torque



Based on operating power

DC & AC servo motor

Construction : i) Stator winding : stationary part of motor (field winding)

ii) Polar : Rotating part of motor (Armature

iii) Shaft : Armature winding coupled on the iron rod

iv) Encoder : Has approximate sensor, determines the rotation speed

Working :-

- DC motor runs at high speed & low torque while getting power frm batteries
- Position sensor senses position & supplies info to Control Circuit
- Reduction gearbox decreases RPM of motor
- It is connected to shaft. It's output connected to encoder's output control to control circuit
- Due to signals in the form of PWM, the control circuit rotates the motor in req. angle (clk/anticlk). Shaft also rotate

Adv :
i) Produces high torque
ii) does not overheat at lower speeds
iii) Can acc & dece quickly
iv) can hold a static position

Apps :
i) Maintain speed of vehicles
ii) Hydraulic system
iii) Radio controlled toys.